Ministry for Primary Industries
Manatū Ahu Matua

Fishery characterisation and standardised CPUE analyses for silver warehou (*Seriolella punctata*) in SWA 1, 3 and 4, 1997–98 to 2010–11

New Zealand Fisheries Assessment Report 2016/07

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ISSN 1179-5352 (online)
ISBN 978-1-77665-176-4 (online)

March 2016

New Zealand Government

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EXECUTIVE SUMMARY

McGregor, V. (2016). Fishery characterisation and standardised CPUE analyses for silver warehou (*Seriolella punctata*) in SWA 1, 3 and 4, 1997–98 to 2010–11.

***New Zealand Fisheries Assessment Report 2016/07*. 220 p.**

This report follows the standardised reporting format used in middle depth fishery characterisations for species or stocks for which no robust stock assessment has been developed. It is based on the previous characterisation and CPUE (catch per unit effort) analyses for silver warehou, with additional information and analyses where appropriate.

Silver warehou has been exploited since the mid-1960s, with significant development in the 1970s. Since the QMS was introduced, silver warehou has been mainly a bycatch component of bottom trawl fisheries both on the shelf and in middle depths to 500 m. However, the last four years (2008–2011) have shown an increased proportion of silver warehou target fishing. Commercial harvest has been well below the TACC in SWA 1 since 2003, after being well above prior to 2003. In SWA 3 and SWA 4, the commercial harvest has generally exceeded the TACC, until the last four years (2008–2011) where it has been below or close to the TACC in both areas. This coincides with an increased deemed value for silver warehou from October 2007.

The distribution of silver warehou catch roughly conforms to the 100–400 m slope area, with the catch of smaller fish in shallower waters and larger fish in deeper waters. Although they occur around both North and South islands of New Zealand, their distribution is predominantly around the South Island. Four main areas of catch are discernible. The west coast of the South Island (mainly associated with the winter hoki fishery); Southland, which encompasses the Stewart-Snares shelf, Puysegur region, and the Campbell Plateau (and is mainly driven by target silver warehou fishing or bycatch in the squid fishery); the east coast of the South Island focussing on the area surrounding Banks Peninsula to Mernoo Bank; and the eastern Chatham Rise, centred around the Chatham Islands. Catch in these areas is seasonal depending on the target fishery, and targeting of SWA occurs by some vessels throughout the year, especially in Southland. Most catch is by bottom trawl, though some catch using midwater gear is also observed in each region. In addition to the hoki and squid fisheries, silver warehou is also taken as bycatch at low levels in shelf trawl fisheries around New Zealand.

Length frequency distributions are available from research bottom trawl surveys and from observer samples from larger offshore vessels in SWA 1, 3 and 4. Although noisy, strong length modes are often visible and these sometimes track from year to year as the fish grow. There is typically an adult length mode of 40–50 cm in all areas and often up to three modes of smaller lengths.

The catches in SWA 3 and SWA 4 have not changed significantly since 2008 and have been lower than in the years 1991–2007. This change coincided with the increased deemed value implemented at the beginning of the 2007–08 fishing year. The silver warehou catch in SWA 1 decreased from 2007 through to 2010 and while 2011 showed a slight increase, it is still historically low. The most likely explanation is the reduced bycatch in the hoki fishery as the silver warehou catch in WCSI (West Coast South Island) is related to the hoki catch.

A standardised catch per unit effort (CPUE) analysis of fisheries in Chatham Rise, ECSI (East Coast South Island), Southland and WCSI was conducted using data stratified by statistical area, target species and trip (merged data), or tow-level data (unmerged data) from 1998 through to 2011. Standardised CPUE indices for each area and dataset fit the data poor-to-moderately, explaining 19% to 49% of the null deviance of the various datasets. The trend in standardised CPUE is slightly increasing for ECSI, very slightly increasing for Chatham Rise, flat for Southland and decreasing for WCSI until 2003, after which it is flat. However, all CPUEs are fairly noisy, so these trends may be misleading. There are some similar multi-year trends and peaks between the regions, especially between ECSI and Chatham Rise,

and WCSI and Southland. The model diagnostics suggest that the model assumptions are generally met, except in the model for the WCSI stratified dataset in which the errors are not normally distributed.

The CPUE abundance indices for ECSI and Southland are supported by the western part of the Chatham Rise and Southland trawl survey biomass estimates respectively. Links between the CPUE index for Chatham Rise East and the eastern part of the Chatham Rise trawl survey biomass estimates are less convincing, but given the standard errors are generally not in conflict. The Chatham Rise survey was divided into east and west biomass estimates.

The CPUE indices are not likely to reflect trends in abundance in Southland or Chatham Rise due to high standard errors and inter-year variability. The CPUE indices from the tow-level WCSI and ECSI models are more promising, although there are still factors affecting the fishery that are not allowed for in the model such as juvenile and adult movement and mixing and schooling. Creating a biologically focussed length-structured stock assessment model may prove more reliable if the appropriate biological and fishery data are collected for each area in the future.

1. INTRODUCTION

Many of New Zealand's middle depth fisheries are not routinely monitored or assessed despite their moderate size and value. This project is designed to ensure that data available for monitoring important middle depth species are routinely summarised and assessed on a five-year rotating schedule as described in the Ministry of Fisheries 10-year Research Programme for deepwater fisheries. Assessment of silver warehou (*Seriolella punctata*) comes under project DEE201007.

Parker & Fu (2011) carried out the previous characterisation of New Zealand silver warehou fisheries for QMAs SWA 3 and 4, covering years 1989–90 to 2007–08.

This report summarises the analyses carried out for the Ministry of Fisheries (now Ministry for Primary Industries) under project DEE201007, Objectives 1–6:

1. To characterise the fisheries by analysis of commercial catch and effort data up to the preceding year.
2. To carry out standardised CPUE analyses for the major fisheries (Fishstocks) where appropriate.
3. To review the indices from CPUE analyses, all relevant research trawl surveys and Observer logbooks to determine any trends in biomass estimates, size frequency distributions or catch rates.
4. To review stock structure using data accessed above and any other relevant biological or fishery information, including biological data collected through the objectives above.
5. To assess the availability and utility of developing a series of age frequency distributions from otoliths collected by researchers on trawl surveys or by observers on commercial fishing vessels, when this data is not being utilised.
6. To make recommendations on future data requirements (including recommendations for annual levels of observer sampling) and methods for monitoring the stocks.

The report follows the previous report (Parker & Fu 2011), except where additional information and analyses have been included to meet the specific objectives of this project. The report contains sections of text and tables that can be transferred to the Ministry for Primary Industries Plenary report as appropriate. Tables and figures are provided in five appendices: A, Survey data; B, Observer data; C. Summaries of catch and effort data grooming; D. Summaries of catch and effort data; and E, Catch-per-unit-effort analyses.

2. FISHERY SUMMARY

2.1 Commercial fisheries

Silver warehou (also recorded as *S. maculate* Forster) are caught in coastal waters mainly around the South Island of New Zealand, as well as on the Chatham Rise and Campbell Plateau at depths to about 500 m (Anderson et al. 1998). Most of the commercial catch is taken from the Chatham Rise, Canterbury Bight, southeast of Stewart Island, and the west coast of the South Island. Throughout the fishery history, most of the silver warehou catch has been taken as a bycatch of the hoki (*Macruronus novaezelandiae*), squid (*Nototodarus sloanii, N. gouldi*), barracouta (*Thyrsites atun*), and jack mackerel (*Trachurus* spp.) trawl fisheries, although some targeting occurs (Knuckey et al. 1998, Phillips 2001). In recent years, the proportion of catch coming from targeting silver warehou has been greater. Fishing years 2007–08 and 2008–09 had the largest proportion, with approximately 50% of the catch from tows targeting silver warehou.

The fishery is currently managed as three separate fish stocks based on the Quota Management Areas: North Island and the west coast of the South Island (SWA 1), southeast coast of the South Island (SWA 3), and sub-Antarctic, Southland, and the eastern Chatham Rise (SWA 4) (Figure 1).

An administrative stock has been established for the Kermadec area (SWA 10), but no catch of silver warehou has been recorded from that area.

Commercial fishing for silver warehou developed in the late 1960s and early 1970s. Before the establishment of the Exclusive Economic Zone (EEZ), silver warehou, common or blue warehou, and white warehou were all lumped under the category of "warehous". Estimated total annual catches of silver warehou based on area of capture were about 13 000 t in 1976, 1977, and 1978 (Paul 1980, table 1 in Livingston 1988). Concern about overfishing on the eastern Stewart-Snares shelf led to closure of this area to trawlers between October 1977 and January 1978. Initially, effort shifted to the Chatham Rise and total estimated catch did not change (Ministry of Fisheries 2010). The catches did drop significantly after the establishment of the EEZ, and the reported landings fluctuated between 3 000 t and 8 000 t from 1978–79 to 1985–86 (table 1 and table 3 in Livingston 1988).

After the introduction of the EEZ, an initial TAC of 18 000 t was set but this was subsequently halved in 1980–81 (Livingston 1988). The foreign licensed fleet was assigned area and species limits and their allocation of silver warehou was gradually reduced from 5 500 t in 1978–79 to 2 000 t in 1982–83 (Norris, unpublished data). At this time, 7 000 t of the overall TAC of 9 000 t was allocated to domestic and charter operations (Ministry of Agriculture and Fisheries 1982). In April 1983, silver warehou was one of seven species included under the Deepwater Policy which introduced quotas into the deepwater fishery, allocating quota to New Zealand owned or chartered "deepwater" vessel operators.

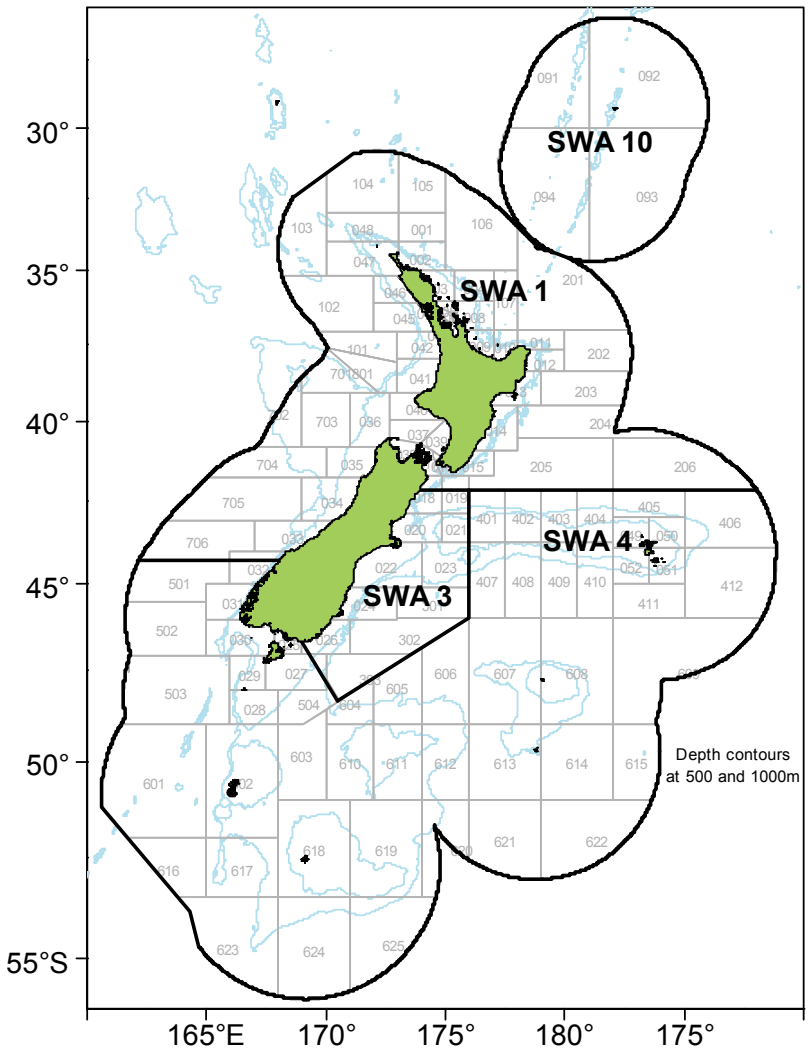

Figure 1: Map showing the administrative fishstock boundaries for SWA 1, SWA 3, SWA 4, and SWA 10, including statistical areas, and the 200 m, 500 m, and 1000 m depth contours.

On 1 October 1986, Individual Transferable Quotas were introduced under the Quota Management System (QMS). The total allowable commercial catch (TACC) for silver warehou was initially set to be 8010 t, based on existing allocations and allowances under the Deepwater Policy. Reported landings history and actual TACC levels are in Figures 2, C1, and Table C5.

The TACC in SWA 1 was increased in 1991–92 under the Adaptive Management Programme (AMP). After five years, a review concluded that an appropriate monitoring programme was not in place and it was not known if the TACC was sustainable (Ministry of Fisheries 2008). SWA 1 was removed from the AMP in October 1997 and the TACC was reduced to 2132 t. SWA 1 entered a new AMP in October 2002, with the TACC increasing to 3 000 t. However, catches have not approached the new TACC level since inception. SWA 1 is currently monitored using biological information and total mortality (Z) estimates based on the age structure of the catch, as the CPUE (catch per unit effort) was determined to be unlikely to track abundance. The 2007 review of the AMP for SWA 1 (SeaFIC 2007) suggested that fishing mortality was substantially lower than natural mortality and had not increased from 1992 to 2005 based on catch curve analysis. The catch in SWA 1 has been much less over the last 10 years than the previous 10 years (Figure 2, C1). Much of the decrease in catch in SWA 1 is likely to be due to the decrease in West Coast South Island

(WCSI) hoki catch, as silver warehou is mainly a bycatch in the hoki fishery. If WCSI (West Coast South Island) hoki catch is increased, silver warehou catch may increase as well. SWA 1 CPUE was also evaluated as part of the AMP by Cordue (2009), who found that although a large signal in CPUE existed in the middle of the time series, the overall CPUE model did not explain much of the variation in the data.

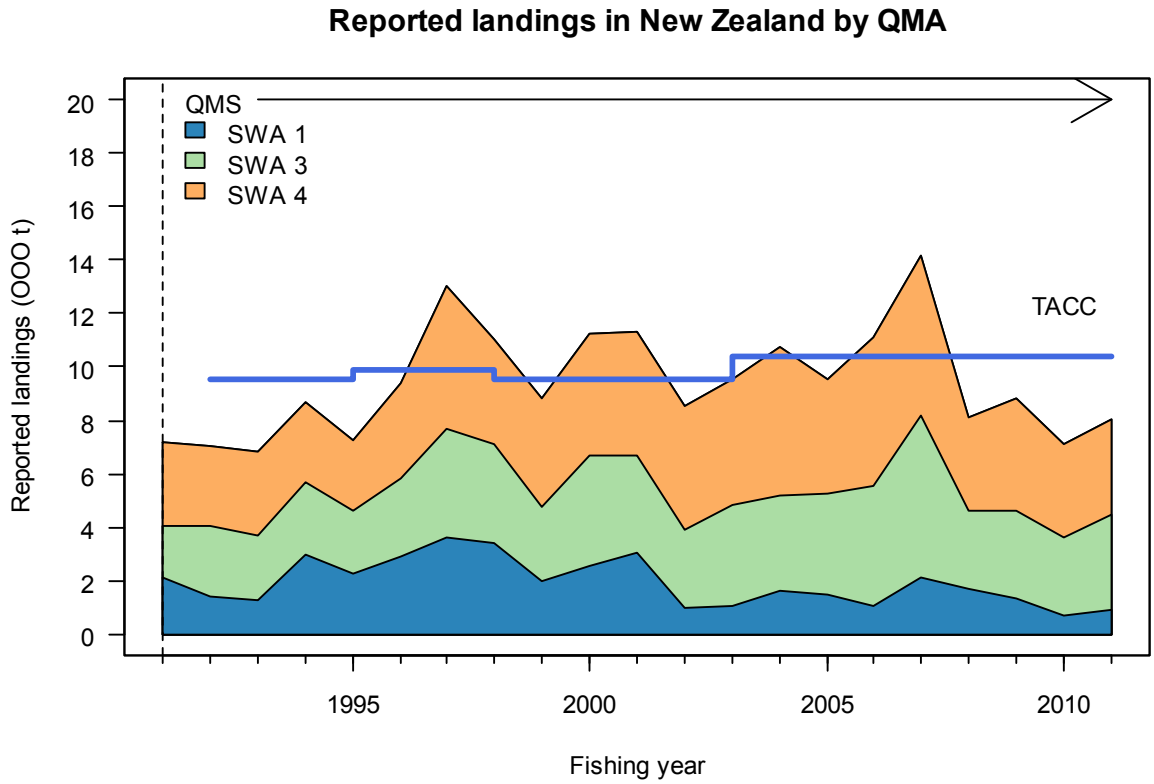

Figure 2: Total reported landings by QMA (shaded regions) and TACC from fishing years 1991 through to 2011.

The TACC was last increased to 3280 t in SWA 3 and 4090 t in SWA 4 in the 1994–95 fishing year by the Quota Appeal Authority (following several adjustments in the late 1980s and early1990s) and has remained unchanged since. Landings in both stocks increased to levels well above the TACC in most years from 1996–97 to 2006–07, and then dropped to below or around the TACC for years 2007–08 to 2010–11 (Figure C1). Landings in 2006–07 in SWA 3 were nearly double the TACC, but then below the TACC in 2007–08. From 1 October 2007 the deemed values were increased for all SWA stocks (Ministry of Fisheries 2008). This is likely to be the cause of the substantial drop in catches in 2007–08 for SWA 3 and SWA 4.

The silver warehou fisheries in SWA 3 and SWA 4 up to 1998–99 were reviewed by Parker & Fu (2011). They examined trends in CPUE for ECSI (East Coast South Island) and Southland and concluded that the CPUE indices did not reflect relative changes in abundance. SeaFIC's (2007) analysis of SWA 1 concluded that fishing mortality was likely to be sustainable, being lower than the estimate of natural mortality.

2.2 Recreational fisheries

There are no current recreational fisheries for silver warehou.

2.3 Maori customary fisheries

Quantitative information of the current level of customary non-commercial catch is not available.

2.4 Illegal and misreported catch

Silver warehou have been misreported as white or blue warehou in the past. In addition, juvenile silver warehou are commonly caught in shallower coastal waters which could lead to non-retention of unmarketable fish. The extent of these practices is unknown and could lead to under-reporting of silver warehou catches.

2.5 Other sources of mortality

Other sources of mortality are unknown.

3. BIOLOGY

3.1 Distribution

Globally, *Seriolella punctata* can be found throughout the southern hemisphere 33–47° S in waters less than approximately 600 m deep (Paulin et al. 1989, Pequeño 1989). The distribution of adult silver warehou in New Zealand waters is fairly well mapped by commercial catches throughout the past 14 years (Figure D1). The adults are found in deeper waters than the juveniles and are often targeted around Mernoo Bank and at the 200 m depth contour, sometimes known as the "silver street" off Southland. However, their distribution is much more dispersed with respect to depth than that term implies, with catches occurring across the Chatham Rise (especially between Banks Peninsula and Mernoo Bank), the Stewart-Snares shelf, and the northern west coast of the South Island with a depth distribution centred on 200 m (Figure D1, O' Driscoll et al. 2003). Minor catches occur around the North Island also.

Quantitative trawl surveys show similar distributions to commercial catch distributions in their respective areas (Figures A13-17). The surveys occur only at particular times of the year and could be unrepresentative of changes in distribution during the year. However, scientific observer data do not show large differences in spatial distribution of adult fish by season, with the caveat that little sampling has occurred in winter months outside the WCSI and the ECSI (Figure B12).

Juvenile and 0+ silver warehou are found in shallower waters and are concentrated on the west, north and east sides of the South Island in waters shallower than 200 m (Figures A13-17, Hurst et al. 2000, Horn et al. 2001, O'Driscoll et al. 2003). Zero-plus juveniles have been observed in shallow waters around the North Island also, especially the south-east coast, Bay of Plenty, and Taranaki Bight in research trawls. Their distribution tends to shift south as 1+ fish, and as 2–4 year olds they become much more prevalent around the northern end of the South Island (O'Driscoll et al. 2003). Observer samples have also reported juvenile fish (under 44 cm) around Taranaki Bight, and adult size fish all around the North Island (Figures A13–17). Their distribution is consistent with a preference for shallow water, as juveniles are found in areas such as Tasman Bay or Taranaki Bight where spawning does not appear to occur. Occurrence of juveniles in the Sub-Antarctic, on the Challenger Plateau and around the North Island (except the Wairarapa coast) is sporadic.

3.2 Spawning

3.2.1 Maturation

Gavrilov (1979) indicated an age of maturity of 3–4 years based on histological analysis, corresponding to a length of 46–48 cm. Observations of developmental stage have been collected on survey and commercial vessels for many years. The staging system has five levels for females (1: immature or resting, 2: maturing, 3: ripe, 4: running ripe, 5: spent). Because immature and resting fish both score 1 (and are difficult to separate, especially during non-reproductive seasons), it is not possible to estimate maturity ogives with these data. However, very few females smaller than 25 cm have been staged as "maturing". Numbers of maturing fish rise sharply both in absolute

number of observations and as a percentage of the total number of observations, indicating significant reproductive development when fish are 30–40 cm. It is likely that 47 cm is close to the size at 100% maturity, with the size at 50% maturity closer to 44 cm. Currently, 47 cm is widely cited as the length at 50% maturity. It is interesting to note that the size distributions (1968–1976) of the fish characterised by Gavrilov were larger than those reported later, with many fish over 60 cm and average lengths of approximately 53–54 cm.

Distributions of spawning fish in the winter/spring months indicate spawning areas on the WCSI near Westport, Mernoo Bank, Eastern Chatham Rise, and Stewart-Snares shelf (Figure B12). There is some evidence for maturing fish off the east coast of the North Island (ECNI) (O'Driscoll et al. 2003), but these fish are not very far from Mernoo Bank and given the protracted spawning season could easily spawn on the Chatham Rise.

3.2.2 Timing

Observations of mature silver warehou indicate that they are winter/spring spawners, with ripe fish present by June, and spent fish appearing by September (Figure B11). Gavrilov (1979) conducted a histological analysis of silver warehou oogenesis on the Chatham Rise and classified the species as batch spawners, producing three batches of eggs (October, November and December) with decreasing numbers of eggs released in each batch. We assume the same process occurs in other regions. The peak timing for spawning is earliest on the WCSI, and otherwise a south to north progression appears to take place, with a peak occurring later to the north and in shallower water (Figure B12). A summary of research survey and observer information (O'Driscoll et al. 2003) gave similar results.

Later spawning in shallower water is likely to be an artefact of younger fish in shallower water maturing later in the season (Berkeley et al. 2004). There is some evidence that they spawn on the east coast of the North Island (Annala et al. 1999, Hurst et al. 2000). Eggs have been recorded off Kaikoura in autumn (Robertson 1975). Eggs hatch after about 6 days (146 hours at 10–13°C) and emergent yolk-sac larvae are about 3 mm long (Grimes & Robertson 1981).

3.3 Stocks and spatial distribution

Gavrilov (1979) gave the first description of the biology and distribution of silver warehou off New Zealand. Based on life history characteristics and developmental timing, he proposed a single Chatham Rise stock. Nearly 10 years later, Livingston (1988) summarized fishery and biological data and suggested that up to four spawning areas existed (WCSI, Chatham Islands, Mernoo Bank, and Stewart-Snares shelf). Spawning migrations were not indicated because catches of adult fish were made year round in all four locations (Livingston 1988). She suggested that these spawning areas could represent separate spawning stocks and recommended separate TACs to manage harvest. However, the administrative boundaries were already set and remain today (Ministry of Fisheries 2008).

With a validated ageing methodology, Horn et al. (2001) investigated growth rates, gonad staging information, and age structure with regard to stock structure, but found no evidence for separate reproductive units. The only study to examine silver warehou genetic structure has been off Southeast Australia, and no differentiation was observed (Bruce et al. 2001). The current consensus is that despite the knowledge of several spawning areas (some with different timing than others), and that largely distinct adult distributions exist, the overall distribution of silver warehou is continuous within their preferred depth range.

3.4 Climate and recruitment

No analyses have examined any link between climate characteristics and recruitment.

3.5 Ageing

Age determination using otoliths was validated by Horn & Sutton (1996). Earlier ageing work by Gavrilov used scales and was not considered reliable for fish over approximately 8 or 9 years of age. Ages have been determined for several thousand samples collected during bottom trawl surveys (mostly from Southland and the WCSI). Additional samples, collected from the WCSI hoki fishery by scientific observers, have been aged by SeaFIC and analysed as part of the AMP monitoring program for SWA 1 (SeaFIC 2007). Catch-at-age distributions were developed by Horn (2012) for the Chatham Rise fishery in fishing years 2004–05 and 2009–10 (Figure B13, Table B15). These show the peak for males and females to be around age 3 to 4. The number of otolith pairs sampled from the Scientific Observer Programme each year was highest around 1999–2007 and has since dropped in most areas (Table B0).

3.6 Growth curves

Von Bertalanffy growth curve parameter estimates for each sex were derived for silver warehou off the southeast coast of the South Island by Horn & Sutton (1996) (Table 1).

Table 1: Von Bertalanffy estimated parameters (Horn & Sutton 1996).

Parameter	Male	Female
L_∞	55.4	51.8
K	0.33	0.41
t_0	-1.04	-0.71

3.7 Natural mortality

Horn & Sutton (1996) estimated instantaneous natural mortality (M) to be approximately 0.25.

3.8 Length-weight relationships

The length-weight relationship was reported for samples from the Chatham Rise and from Southland by Horn & Sutton (1996). They observed no difference between sexes and reported a single relationship (Table 2).

Table 2: Length weight relationship parameter values for silver warehou from Horn & Sutton (1996).

	a	b
Chatham Rise	0.00848	3.214
Southland	0.00473	3.380

Combined sexes (no difference in length-weight relationships noted.)

3.9 Feeding and trophic status

Gavrilov & Markina (1970) described the progression of juveniles into deeper water with increasing size and in relation to the distribution of their prey. Very young fish of 12–14 cm in length feed on plankton, juveniles 14 – 15.5 cm feed on Amphipoda and Chaetognatha in coastal waters. At 24–31 cm they move into the deeper part of the shelf, feeding on zooplankton - especially salps. Fish greater than 30 cm long feed on macroplanktonic organisms of the upper slope region. A summary of feeding information prior to 2000 from the Chatham Rise and Southland research surveys (Horn 2011) found that over 95% of stomachs with food contained salps and that this was consistent across

all size classes (20–60 cm); the remaining items were crustacean (euphausiid, amphipod, isopod, natant decapod), teleost (unidentified) and squid.

4. FISHERY INDEPENDENT OBSERVATIONS

4.1 Research surveys

4.1.1 Biomass indices

Bottom trawl surveys have been conducted since the early 1990s using either the *Tangaroa* (Chatham Rise survey or Sub-Antarctic Survey) or the *Kaharoa* (ECSI or WCSI). These surveys all encounter silver warehou, but are not optimized to estimate biomass for this species. A discontinued survey of Southland (1993–1996) did attempt to optimise for silver warehou (Hurst & Bagley 1997). The inshore *Kaharoa* surveys occur in areas and depths where juveniles are present, and so may not represent adult biomass trends.

Survey catches vary for this patchily distributed species and accordingly the 95% confidence intervals (CIs) are typically large. The Chatham Rise index suggests an overall upward trend, although the 2010 and 2011 years are difficult to interpret given the very large CIs (Figure A1). The ECSI inshore surveys also suggest an upward trend, but estimates are highly uncertain (Figure A2). The Sub-Antarctic index is fairly flat, with the possible exception of 2008 and 2009, although the CIs on these years are very large (Figure A3).

The WCSI survey includes the TBGB (Tasman Bay Golden Bay) area, which is a shallow area and dominated by juvenile SWA. When separated out, the TBGB index shows a downward trend (Figure A4) while the WCSI index with TBGB omitted (Figure A5) is fairly flat, with highly variable CIs. Figures for WCSI (TBGB omitted), TBGB, and WCSI/TBGB combined are all included in the appendices, but only the WCSI (TBGB omitted) series was considered in these analyses.

There is also a *Tangaroa* survey for WCSI from which there are biomass estimates for 2000 and 2012. These have the biomass estimate for 2012 more than double that for 2000 (Figure A6).

The ECSI survey was first conducted as a winter survey (1991–1996) then as a summer survey (1996–2000) (Beentjes et al. 2004). It was then discontinued, but restarted as a winter survey in 2007. Only the winter surveys are included here.

Because these surveys were not optimized for silver warehou and average CIs are high, they have not been considered good monitoring tools for these stocks (Ministry of Fisheries 2008). They may, however, be useful in interpreting CPUE indices.

4.1.2 Length and age sampling

The South Island bottom trawl surveys also collect length, sex and subsamples of gonad stage information for silver warehou which is useful in evaluating stock structure, monitoring progression of year classes through time, and identifying spawning periods and areas. Each survey measures several hundred to several thousand individuals depending on catch; but because silver warehou are a schooling species and occur in a patchy manner, these samples may not describe the size distribution of the overall population (see Section 4.1.3 below). Otoliths have been collected from silver warehou during surveys and were used by Horn & Sutton (1996) and Horn et al. (2001) to estimate growth rates and examine evidence for stock structure. Those samples were collected from Southland and WCSI surveys only in the early 1990s and are not useful for long term monitoring of age structure. Since 1995, no silver warehou otoliths have been collected during bottom trawl surveys. Otoliths have been collected through the scientific observer programme (Table B0) and

were aged and analysed by SeaFIC (2007) and Horn et al. (2012), but collections do not exist for other regions. Therefore, although length distributions exist, annual age-length keys from trawl surveys for the different regions are not available.

4.1.3 Length and age frequency distributions

The Chatham Rise survey length distributions typically show an adult mode between 40 and 50 cm, with sporadic modes usually between 20 and 40 cm (Figure A7). In 1991–1998 the 40–50 cm mode is usually the dominant mode. This mode is still present but becomes less dominant in 1999–2002 and 2005–2007. Several times during the time series, a distinct smaller mode near 25 cm is present which can then be observed as larger fish around 35 cm the following year (which fits in with the expected growth in Table 3). The clearest examples of this are in years 2000/2001, 2001/2002, 2005/2006 and 2008/2009. This mode in 2002 also progresses to a mode near 42 cm in 2003, and the mode in the 2006 years links to a mode of 45 cm in 2007.

The ECSI survey samples mainly juvenile depth ranges, so modes at shorter lengths are present (Figure A8). There are modes at around 20 cm, 30 cm, 40 cm and 45 cm for years 2007–2012 with good evidence of modal progression between years. Before1996, length distributions often have modes around 20 cm and 30 cm, but no modes of longer fish. Note, that only ECSI winter surveys are included here.

The sub-Antarctic time series typically shows an adult size mode of around 50 cm only, with the exception of an additional smaller mode in 2007 (Figure A9).

The WCSI series typically has a dominant 20 cm mode and a smaller mode or larger fish around 35 cm (Figure A11).

Table 3: Expected rate of growth for male and female silver warehou, calculated using Von Bertalanffy growth equation and estimated parameters from Horn et al. (1996) (table 3).

	Expected growth rate (cm/year)	
Length	**Male**	**Female**
20	13.04	11.38
25	10.99	9.74
30	8.94	8.09
35	6.89	6.44
40	4.84	4.79
45	2.79	3.14
50	0.74	1.49
55	-	-
60	-	-

An additional feature of these time series, especially with the Chatham Rise and ECSI series, is that the size distributions are extremely variable among years. The Chatham Rise survey sometimes completely lack the typical 50 cm size class, and often lacks the 25 or 35 cm modes even though the appropriate mode is present in the subsequent year. The variability is highest in the ECSI survey, which shows up to four distinct size modes, but usually only one or two simultaneously (Figure A8). Variability in adult size classes captured in this survey is a common feature and is thought to be a result of either environmental influences on fish distribution, fish schooling by size, or the result of problems with gear performance (Beentjes et al. 2004).

Strong year classes are not consistently coincident between the survey areas, suggesting that these populations are not strongly linked. However, these time series are fraught with missing modes making progression difficult to see when a strong year class does appear in one series.

It was noted by Horn et al. (2001) that the surveys did not adequately sample the populations due to low sample sizes and the schooling behaviour of silver warehou. It is likely that the patchy, schooling nature of silver warehou makes characterising the population size structure with a relatively small number of tows problematic. To address this, more tows would need to be allocated to depth strata where silver warehou occur (i.e., include SWA as a target when optimizing the survey).

4.2 Other data

Other research concerning population dynamics and stock structure of *Seriolella punctata* includes genetic work by Robinson et al. (2008) which indicated no genetic differentiation among silver warehou sampled in eastern and western Victoria, Australia. Data from a study of larval distribution in southeastern Australia also suggested that larvae were widely distributed and that little spatial differentiation existed within the region studied (Bruce et al. 2001). Horn et al. (2001) examined age structure and spawning status but other than documenting four putative spawning regions, no evidence for separate stocks was found. Horn (2012) analysed catch-at-age for silver warehou in fishing years 2005 and 2010 in Southland and Chatham Rise and found very different distributions in the two years in terms of modal age and age range.

5. FISHERY DEPENDENT OBSERVATIONS

5.1 Observer data

The Ministry of Fisheries Observer Programme has collected silver warehou length, weight, female gonad stage, and otoliths from various fisheries since 1985 (1991 and later are in Table B1). Otoliths from commercial catch have been collected from the hoki fishery on the WCSI (see SeaFIC 2007) and on the Chatham Rise and Southland fisheries 1992–2012. Additional otoliths were collected on *Tangaroa* trawl surveys in 1992–1995 and in 2012 (Table B0).

Scaled length frequency distributions from observer data (following the procedure of SeaFIC (2007)) typically show an adult mode around 45–50 cm and sporadic smaller modes. The tail of the large mode rarely exceeds 60 cm and shows no evidence of truncation, suggesting that this upper limit is not due to fishing selectivity. Gavrilov's data (1979) from 1968–1976 showed much larger fish, with a mode in the mid-50s and many fish over 60 cm.

Overall, the size distributions from the Chatham Rise (Figure B7) show a single mode of adult fish. In years 2003–2011 this mode tends to be around 45 cm and in years prior to 2003 it tends to be close to 50 cm. In some years (2005, 2006 and 2009) there is a smaller mode around 30–35 cm. If these fish followed the estimated growth rates in Table 3, they would be expected to be apparent as a mode near 40 cm in the following year. In some years this does happen (2002/2003), but not always. In some cases it is possible that this smaller mode has been absorbed into the tail of the dominant mode when this is near 45 cm (2009/2010).

The East Coast South Island distributions (Figure B8) tend to have a dominant mode around 45 cm and a smaller mode near 30 cm in years 2003 and later. For years prior to 2003 there are modes around 30 cm, 40 cm and 50 cm, each of which is dominant in different years. Some years show progression of a mode, such as 1993/1994/1995. There is a mode around 35 cm in 1993 which then shows as a mode near 40 cm in 1994, and then 45 cm in 1995.

The Sub-Antarctic distributions (Figure B9) typically have a dominant mode around 50 cm, with smaller modes around 30 cm and 40 cm. In some years, the 30 cm or 40 cm mode is dominant

(1996, 1997, and 2004). In 1996 there is a 30+ cm dominant mode which goes on to become a 40 cm dominant mode in 1997. The same pattern does not happen in 2004/2005, however, where there is a dominant mode near 30 cm in 2004, which not apparent at all in the 2005 distribution.

In years 1999 and later, the West Coast South Island distributions (Figure B10) consistently show a dominant mode around 50 cm, though very few tows have been sampled. In 1994 there are modes of similar size around 25 cm and 35 cm. These then show up in 1995 as two modes of similar size around 40 cm and 50 cm. No data were collected in 1997 or 1998.

Comparing Observer Programme and trawl survey length frequency distributions sometimes show different patterns, with one source sometimes showing a mode missing in the other source. When there is a mode of around 25 cm in the trawl series, this mode is often missing from the observer series (e.g. Chatham Rise years 2000, 2001, 2008 which may be due to the smaller size selectivity of the smaller-mesh lined trawl survey gears. Areas fished within a region can also be different between surveys and the fishery. For example, the ECSI survey, despite its reconfiguration in 1996, probably does not index a similar area to the observer data, which typically come from larger offshore vessels. In Southland, silver warehou catches in the survey are fairly infrequent whereas observer samples are huge. For example, the 2000 distributions are very similar between Figures A9 and B9, but sample size constraints prevent a robust comparison.

The representativeness of observer sampling in CHAT, ECSI, SUBA and WCSI was evaluated by plotting the proportion of landed catch for each year by month as bubbles, and overlaying this with the proportion of the observed catch for those same cells as crosses (Figures B2 to B6). If the proportions are the same, the crosses and bubbles align. Over sampling is indicated if the crosses are larger than the bubbles, and under sampling if they are smaller. An examination of Figure B2 suggests that observer sampling of all areas is good. However, examination of Figures B3 to B6 shows that many months are either over or under sampled. It is very difficult to predict the actual month in which a given percentage of the catch occurs, making it difficult to assign observer effort at the proper scale. The only way to improve this match is to have a very high constant percentage of observer coverage, so that variation in catch by particular vessels, or unpredictable effort by vessels does not determine the percentage of catch observed. Currently, most observer coverage is assigned to the hoki target fisheries.

5.2 Catch and effort data sources

Catch and effort data were requested from the Ministry of Fisheries catch-effort database "warehou" as extract 8527. The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive landing of silver warehou in SWA 1, 3 and 4 between 1 October 1991 and 30 September 2011. The fishing year extends from October 1 through September 30 of the next calendar year. In this report, fishing year is labelled as the most recent year (i.e., the 1998–1999 fishing year is referred to as 1999). The fields from the database tables requested are listed in Table C1.

Up to 1 October 2007, the estimated catch associated with the fishing events were reported on the general Catch Effort Landing Returns (CELR) and the more detailed Trawl Catch Effort and Processing Return (TCEPR). The greenweight associated with landing events were reported on the bottom part of the CELR forms, or where fishing was reported on the TCEPR, on the associated Catch Landing Return (CLR). TCEPR forms record tow-by-tow data and summarise the estimated catch for the top five species (by weight) for individual tows. CELR forms summarise daily catches, which are further stratified by statistical area, method of capture, and target species. Trawl vessels less than 28 m in length can use either CELR or TCEPR forms; trawl vessels over 28 m use TCEPR forms. From 1 October 2007, CELR forms were replaced by Trawl Catch Effort Return (TCER) forms, which summarise daily estimated catches up to the top eight species and give individual tow locations for all vessel sizes longer than 6 m.

Information on total harvest levels are provided via the QMR/MHR system, but only at the resolution of Quota Management Area. The catch-effort returns report catches at the level of individual fishing events, but the fishers are only required to report the top five or eight species in their catch. This has led to concerns (e.g. Phillips 2001) that bycatch species, such as silver warehou, may not be well reported at the fishing event level. The AMP review on SWA 1 found that trips that landed to SWA 1 and reported no estimated catch on TCEPR/CELR forms tended to be those with small landings (less than 1 t), and that the estimated catch at the individual tow level showed strong correlation with observer reported catch (SeaFIC 2007).

The "daily processed" part of the TCEPR contains information regarding the catch (of all quota species) that was caught and processed that day, and these data may provide a more accurate account of low and zero catch observations (Phillips 2001). However, it was suggested (SeaFIC 2007) that processed catch data for SWA 1 suffer from similar problems as the estimated catch data: trips that have no estimated catch, also tend to have no processed catch recorded. In addition, daily processed catch data suffer from the inability to assign processed catch to a specific day or amount of effort because catch is not always processed on the day it was caught and can be split among days. The daily processed catch is not examined in this study.

The extracted data were groomed and re-stratified to derive the datasets required for the characterisation and CPUE analyses using a variation of Starr's (2003) data processing method as implemented by Manning et al. (2004), with refinements by Blackwell et al. (2006), Manning (2007), and Parker & Fu (2011) and further modified for this study. The method allows catch-effort and landings data collected using different form types that record data with different spatial and temporal resolutions to be combined. It also addresses the main limitation of the CELR and TCEPR reporting systems (frequent non-reporting of species that make up only a minor component of the catch). The procedure has been developed for monitoring bycatch species in the AMP, and is comprehensively described by Manning et al. (2004) and Starr (2007). The major steps are as follows.

Step1: The fishing effort and landings data are first groomed separately. Outlier values in key variables that fail a range check are corrected using median imputation. This involves replacing missing or outlier values with a median value calculated over some subset of the data. Where grooming fails to find a replacement, all fishing and landing events associated with the trip will be excluded.

Step 2: The fishing effort within each valid trip is then re-stratified by statistical area, method, and target species.

Step 3: The greenweight landings for each fish stock for each trip are then allocated to the effort strata. The greenweight landings are mapped to the effort strata using the relationship between the statistical area for each effort stratum and the statistical areas contained within each fish stock.

Step 4: The greenweight landings are then allocated to the effort strata using the total estimated catch in each effort stratum as a proportion of the total estimated catch for the trip. If estimated catches are not recorded for the trip although a landing was recorded for the trip, then the total fishing effort in each effort stratum as a proportion of the total fishing effort for the trip is used to allocate the greenweight landings.

Step 5: The original intent of the merging process was to allow trip level landings data to be mapped to CELR effort strata. However, many species are captured in fisheries reporting using a combination of form types, and some may use TCEPR forms almost exclusively. The grooming and merging process also allows an evaluation of the amount of catch and effort that is not captured using TCEPR forms at the fishing event level. If significant, the best characterisation dataset is likely to be the merged trip-level data. But if the amount of lost catch and effort is predictable, minor, and stable over time and area, the estimated

catch at the level of the fishing event provides a much more detailed dataset for characterisation and CPUE analysis.

6. DESCRIPTIVE ANALYSIS OF CATCH

6.1 Summary of catches

The reported QMR/MHR landings, the catch-effort landings (un-groomed), and TACC for SWA 1, 3, and 4 from 1983–84 through to the 2010–11 fishing year are shown in Figure C1. The spatial distribution of commercial catch is depicted in Figure D1. For all three stocks, the catch-effort landings in the raw dataset usually exceed the reported MHR landings throughout the time series, but generally conform in trend. Until fairly recently (2002 for SWA 1 and 2008 for SWA 3 and 4) the MHR have often overrun the TACC (Figure C1).

The landings data provide a verified calculated greenweight landed for a fish stock on a trip basis. However, landings data include all final landing events – where a vessel offloads catch to a Licensed Fish Receiver, and interim landing events, where catch is transferred or retained, and may therefore appear subsequently as a final landing event (SeaFIC 2007). Starr's procedure separates final and interim landings based on the landing destination code, and only landings with destination codes which indicate a final landing are retained (see table 2 in Starr (2007)).

Table C2 summarises the number of landing events for the major destination codes in the dataset. There are a significant number of landing events recorded under "T" (transferred to another vessel) and "R" (retained on board) destination codes (both are defined as interim landing events by Starr (2007)). For all three fish stocks, the "T" events appear in the early part of the series through to the late 1990s and were recorded by vessels using TCEPR forms. It was unknown how the catches from those trips are recorded, as the transferred catches could be landed by foreign vessels to ports outside New Zealand. The "T" landing events were dropped from this analysis. This does bring the retained landings significantly below the MHR landings for fishing years prior to 1998, but leaves them almost the same for years following 1998 (Table C2, Figure C2). Because of this, the characterisation and CPUE analyses are carried out for fishing years 1998 and later. The weight, number of records, and disposition of catch for each potential landed state is given in Table C3. The previous characterisation kept the "T" events (Parker & Fu 2011), as the years prior to 1998 were required for a time series of sufficient length.

The transferred landings, retained landings, interim landings, and total landings dropped during data grooming are shown in Figure C2. The grooming process excluded a small number of trips with invalid codes in fishing method, target species, statistical area, and trip date which cannot be estimated using the median imputation method (Table C4). The estimated catch and landings removed from the dataset in this process were generally insignificant throughout the time series. For the three stocks, the retained landings were less than the reported MHR in the early 1990s, but match closely from 1998 onwards.

The groomed and unmerged landings are summarised by processed state in Figure C3. For all three stocks, the bulk of catches have been processed to the "DRE" state since 1990–91 (In this report, "Dressed", "Headed, gutted, and tailed", and "Trunked" are treated as "DRE"); a small but consistent proportion of catches were landed green in recent years. The conversion factors for some processed states of silver warehou have been changed over time since the full implementation of the QMS (Ministry of Fisheries 2012). The conversion factor for the "DRE" state was increased from 1.60 to 1.65 from 1 October 1995, and to 1.70 from 1 October 2000, but decreased back to 1.65 with effect from 1 October 2006. This means that different amounts of greenweight catch are associated with the same amount of processed catch for particular product forms throughout the database. Therefore the greenweights are standardised using the most recent conversion factor for each processed state, based on the assumption that the changes in conversion factors reflect improving estimates of the actual conversion when processing silver warehou, rather than real changes in processing methodology across the fleet. The adjustment has slightly increased the greenweight for the early part of the series (Figure C4), where the conversion factor had been set to 1.60. Similarly, from 2000 to 2006 where

the conversion factor had been set to 1.70, the adjustment slightly decreases the greenweight. Where the set conversion factor was 1.65 (1995 to 2000 and 2006 and later), there is no adjustment and hence the conversion factor correction ratio is 1.

The retained landings adjusted for the change of conversion factors were allocated to the effort strata using the relationship between the statistical area for each effort stratum and the statistical areas contained within each fish stock. Difficulties arise with effort strata associated with statistical areas that straddle stock management area boundaries (e.g. Statistical Areas 018, 019, and 027), as the proportion of catches to be allocated to each QMA cannot be determined. Where a trip had fished in a straddling area and only reported to a single Fishstock, the catches of the straddling statistical area were assumed to be from that Fishstock. Where a trip fished in a straddling statistical area, but reported to multiple Fishstocks, all the fishing and landing events from that trip were excluded. Records, trips and weight removed as a result are in Table C4.

The annual landings present in the raw dataset, retained landings in the groomed and unmerged dataset, and retained landings and estimated catches in the groomed and merged dataset are summarised in Table C5 and plotted in Figure C5. Manning et al. (2004) calculated the recovery rate, defined as the groomed and merged landings as a proportion of the groomed and unmerged landings. The recovery rate was close to 100% in most years for SWA 1, 3 and 4 (Figure C4), indicating a consistent match between the recorded statistical areas on the CELR/TCEPR and the stocks reported on the CELR/CLR on a trip basis.

The reporting rate was calculated, defined to be the annual estimated catch as a proportion of the retained landings in the groomed and merged dataset (Figure C6). In SWA 1, the reporting rate under the CELR has been on average roughly 20% lower than that under the TCEPR, indicating that the reporting level was lower for vessels using CELRs. In SWA 3, the reporting rate under the CELR was below that for the TCEPR until 1997, they then became similar until the switch to TCER forms in 2008, when the reporting rates under TCER became higher than the CELR form. In SWA 4, which was dominated by vessels using TCEPR forms, the reporting rate has been consistently near 1 since 1997. The reporting rate under the CELR, when used, was well below that of the TCEPR.

The estimated catches and retained landings by form type for each fish stock are shown in Figure C7. For all three stocks the bulk of estimated catches are recorded on TCEPR (with the landings recorded on the corresponding CLR forms). SWA 1 and SWA 3 also have a small proportion of catch recorded on CELR forms, presumably by smaller vessels fishing in inshore areas. In the 2008 fishing year, all vessels previously reporting SWA catch on CELR forms switched to TCER forms. In SWA 4, there has been little to no catch recorded on CELR forms.

The 2007 AMP review of SWA 1 examined trips that had landed silver warehou but reported no estimated catch, and suggested that this relates to trips with small catches and vessels using CELR forms (SeaFIC 2007). Figure C8 shows something similar, with the proportion of trips with no estimated SWA catch (yet positive landings) much lower for TCEPR than CELR. SWA 1 is the least convincing, where around 40% of trips by vessels using TCEPR reported no catch and 60% of trips by vessels using CELR. For SWA 3 and 4 the difference is greater with the TCEPR proportion generally around 20% and CELR around 60%.

Though estimated catches tend not to be recorded when catches are small (as vessels only reported the top five (now eight) species caught in each tow, overall, the estimated catches capture approximately 80% of the harvest reported via the MHR/QMR system for SWA 1, 3, and 4. There also appears to be a reasonably close match between estimated catch and reported landings at trip level (Figure C9).

The catch of SWA in 2010–11 was similar in SWA 3 and 4 to the previous few years (2008 and later). The catch from 2008 onwards is much lower than previous years, which coincides with an increased deemed value. The silver warehou catch in SWA 1 has been decreasing since 2007 and while 2011 showed a slight increase, it is still quite low. The most likely explanation is the reduced hoki bycatch as the silver warehou catch in WCSI seems to mirror the hoki catch in WCSI (Figure C1, Figure 2a in (Ballara & O'Driscoll 2012)).

6.2 Fishery summary

The silver warehou fisheries in QMAs 1, 3 and 4 are clearly visible in the distribution of commercial tows catching silver warehou (Figures D1, D1b and D1c). The distribution of silver warehou nominal stocks does not match the administrative boundaries used for management purposes as noted by Livingston (1988). The objectives here are to characterise the fisheries and conduct CPUE analyses, requiring the distribution of fishing effort and catch to dictate the regions defined for analysis. Four major regions were defined utilizing discontinuities in the spatial distribution of catch. The characterisation was therefore split into Chatham Rise, East Coast South Island (ECSI), Southland and West Coast South Island (WCSI). SWA 1 contributes to WCSI, SWA 3 contributes to ECSI and Southland and SWA 4 contributes to ECSI, Chatham Rise and Southland (Figure D0). The total estimated catch for each region around New Zealand from the groomed and merged dataset are shown in Table D1.

The silver warehou fishery on the western Chatham Rise is continuous with the ECSI and focussed on the region between Banks Peninsula and Mernoo Bank. Given the bathymetry, Reserve Bank is also likely to hold silver warehou, but much of the substrate is not amenable to bottom trawling. South of Banks Peninsula, silver warehou catch declines and there is a natural break point at Statistical Area 024 (Otago Peninsula) with almost no catch recorded in Statistical Area 302 (Figure D11). Beginning with Statistical Area 026, catch and effort is continuous and grows to the south and continues to the south of Auckland Island (Figure D16). The eastern region of Chatham Rise appears to be distinct from the western part, with a strong decrease in catch near 179°E (Figures D1b, D6). This discontinuity has been described previously, leading Philips (2001) to separate his CPUE analyses for East and West Chatham Rise fisheries. Although his recommendations were to aggregate the two regions, it was due to a perceived lack of data. With additional years of catch data, it makes sense for this analysis to separate Chatham Rise East into its own region, split at 179^{o}longitude. Chatham Rise West is combined with East Coast South Island.

Vessels landing silver warehou are predominantly Korean and New Zealand flagged (Figure D2a, Table D2). The size of these vessels are mostly 55–105 m in length, ranging from 300 to almost 6000 kilowatts, and mostly less than 2000 t, with some up to almost 5000 t (Figure D2a).

In 2007–08, the Ministry of Fisheries introduced the TCER form, which provides tow-level location information for a class of vessels that was previously only required to report statistical area of the catch. Therefore, the last four years of data used in this analysis provides an opportunity to see where, in relation to the overall SWA catch, these vessels fish. Figure D1b shows the distribution of catches reported on the TCER form compared to the TCEPR fishery distribution of catches. The distribution was shallower and more coastal than the TCEPR data available previously. The catch locations showed a similar distribution to the larger vessels on the South Island, but the North Island showed effort concentrated near the East Cape region and light effort around the North Island that was not apparent in the TCEPR data. The distribution of West Coast South Island tows was also different, with the TCER data south and inshore compared to the TCEPR catch from the hoki fishery.

6.2.1 Chatham Rise region

Silver warehou is caught throughout the year on the eastern Chatham Rise, but historically more catch was taken in November to January, and sporadically in April to June (Figure D3a). The major statistical area of the catch varied annually but catch was rare in areas 405, 406, 411 and 412 (Figures D3a, D6). Catch on the Chatham Rise was mostly caught by bottom trawl, with a small amount captured using mid-bottom water trawl gear (Figure D3a). In recent years, the amount of silver warehou captured during targeted tows has increased to be comparable with that caught from tows targeting hoki. Previously, most catch was taken as bycatch in the hoki, hake and barracouta fisheries (Figure D3a). Within a statistical area and target species, there is no strong trend in the amount of silver warehou

catch though time (Figure D3b). There is also no strong trend in the amount of silver warehou catch through time within a month and target species (Figure D3c).

The proportion of silver warehou caught in targeted silver warehou tows has increased through time in Statistical Area 049 and possibly also in Statistical Area 410, although this was a bit more sporadic (Figure D4). There was no strong pattern in the proportion of targeted silver warehou catch through time by month, although there was a strong indication of silver warehou targeting in May and June from 2005 to 2009 (Figure D4). This lack of pattern made it difficult to characterise SWA catch as either a bycatch or a target fishery.

The occurrence of SWA in the catch of tows targeting other species varies depending on the target species and also varies through time. The proportion of hoki target tows not capturing SWA was stable at about 50% up until 2009, after which it appears to be dropping off. The proportion of hake target tows not catching SWA was stable at about 50% until 2011 where it jumped up to above 90%. The proportion of barracouta target tows not catching SWA is highly variable, ranging from around 20–90% and with no discernible pattern in the timespan shown (Figure D5).

There is no apparent change in the location of SWA catch within the Chatham Rise area over recent years (Figure D6). Figure D7 shows the combined distribution of the major target species encountering SWA within the Chatham Rise region. Target tows for several species are spatially segregated, indicating that silver warehou are widespread among those areas (Figure D7).

6.2.2 East Coast South Island

Silver warehou on the ECSI were mainly taken with bottom trawl and a small amount of mid-bottom water trawl, as in the Chatham Rise region (Figure D8a). They were encountered all year round, with predominance in recent years of October to December (Figure D8a). The catch in October to December was mostly from the targeted silver warehou and the hoki tows (Figure D8c). Most of the catch was from Statistical Areas 020, 022 and 023. Statistical Area 021 previously had fairly high catches, but this declined in recent years (Figures D8a, D11). Silver warehou have been taken largely as bycatch from the hoki fishery up until 2007, after which this decreased. In recent years, the silver warehou targeted catch increased. Silver warehou were also often caught as bycatch from the squid fishery up until 2007, after which this also dropped off. The SWA targeted catch is largely from Statistical Area 022 with a smaller amount from Statistical Area 020 (Figure D8b). The silver warehou bycatch from the hoki fishery decreased mainly in Statistical Area 020 and that from the squid fishery decreased mainly in Statistical Area 022 (Figure D8c).

The proportion of tows with zero reported SWA catch is fairly constant in all the major fisheries. The proportion sits around 20% for silver warehou target and squid target and around 50% for tows targeting hoki and barracouta (Figure D10).

Locations of the fishery catches have not changed in the last six years (Figure D11). Silver warehou catch mainly occurs around the slope areas of the western Chatham Rise, Mernoo and Reserves Banks, and southwest towards Canterbury Bight centred at 200 m.

The SWA catch from the hoki, barracouta and red cod fisheries extend further inshore than that from the other target species, including silver warehou (Figure D12).

6.2.3 Southland

The Southland fishery has a more definitive structure than either Chatham Rise or East Coast South Island. Silver warehou were captured mainly between December and May and in three main Statistical Areas: 026, 027, and 028 (Figure D13a). Catch has also been reported from area 030, but this has declined in recent years while the catch in area 504 increased. This was a possible shift to the southeast, although in the same time period the catch also increased in area 602 and decreased in area 028. Again, the catch was dominated by bottom trawl. There was also a small amount caught

by mid-bottom trawl gear and a smaller and decreasing amount of mid-water catch. Catches were highest from tows targeting squid or silver warehou, with a much smaller and temporally decreasing amount of catch from the hoki fishery (Figure D13a).

The proportion of silver warehou catch as targeted silver warehou has generally been around 50% for the main Statistical Areas 026, 027, and 028 and 25–50% in Statistical Area 504 during the last seven years (Figure D14). March, April, and (less consistently) May also often have around 50% of the catch coming from silver warehou target tows.

Bycatch levels in the hoki fishery have been stable over time, with about 50% of the tows not reporting SWA catch (Figure D15). The proportion of zero tows in the squid fishery has generally decreased, and stabilised near 20% in the last few years. The proportion of tows targeting SWA and not reporting any SWA catch remains fairly constant and low, near 10%. The proportion of zero tows from the white warehou fishery is highly variable and with no apparent pattern.

Areas fished in Southland have also been fairly stable through time, with an obvious concentration along the 300 m depth contour, i.e. along the silver line (Figures D16, D1). A discrete area of bycatch occurred around Puysegur bank (Statistical Area 030), although the catch in this area has decreased over the last eight years (Figure D13a).

Catch from targeting squid, hoki, ling and scampi extended further south than that from any other target species, including silver warehou. Most of the spatial distribution from squid target overlapped fairly closely with silver warehou target.

6.2.4 West Coast South Island

The West Coast South Island fishery occurred almost entirely in May to September and in Statistical Areas 035 and 034 (Figure D18a). The catch was mostly bycatch from the hoki fishery, although in recent years there was an increasing amount from targeting silver warehou. There was also a small amount from the hake and barracouta fisheries. The catch was dominated in recent years by bottom trawl, but in the late 1990s-early 2000s, there was a large amount coming from mid water and mid-bottom water trawls (Figure D18a).

The proportion of silver warehou coming from silver warehou target has increased in Statistical Area 035 over the last 10 years, but remained low in Statistical Area 034. It was sporadic for all months but became high in August in 2007 to 2009.

The proportion of tows with zero silver warehou catch was close to one in 1998 when targeting silver warehou, but otherwise has varied between about 0–30% (Figure D20). The proportion for the hoki fishery was generally around 20–40%. The proportion of zero tows from the hake fishery decreased from around 50% in 1998 to around 20% in 2011. The proportion of zero tows from the barracouta fishery varied from around 20–80%.

Locations of fishery catches was stable over fishing years 2006–2011 (Figure D21). The distribution of catch doesn't extend as far south in 2009 and 2010.

The distribution of trawls targeting hoki is very similar to that targeting silver warehou (Figure D22). Silver warehou from the jack mackerel fishery extends further north than the catch from other targets, but there is generally high overlap between the fisheries suggesting that SWA are only caught in a fairly narrow area.

7. CPUE ANALYSES

As in the previous analyses, merged (stratified) and unmerged (tow-level) datasets are modelled separately. Using tow by tow data allows for the trend in catch rates to be modelled using smaller

spatial and temporal scales, and also enables additional factors influencing CPUE to be included (such as tow distance or bottom depth). However, it is noted that under-reporting of estimated catch was common among the fisheries, where trips that landed SWA had reported no estimated catch, although the landed catch from such trips is in general not substantial. This aspect of TCEPR data omission therefore significantly affects effort and recorded number of tows but not catch, therefore changing the CPUE.

TCEPR, CELR and TCER catch effort data were all included. CELR data were dropped in the previous CPUE analyses because they were minor (Parker & Fu 2011), but kept here as they were replaced with TCER from 2007 and this data covers the shallower and more coastal part of the fishery. For each region, each CPUE dataset was further defined to encompass a mixed-species fishery, which includes both SWA target and major target species. Indices were modelled separately and combined. It is possible that silver warehou were not targeted as frequently as the data suggest and that the recorded target species was simply the main species actually caught (whether it was targeted or not) rather than any pre-determined fishing behaviour (Paul & Bradford 2000). In the latter case, excluding non-target effort could result in a CPUE series which is not a fair representation of the trend in the underlying fish stock.

Estimates of relative year effects in each CPUE model were obtained from a stepwise multiple regression method in which the data were modelled using a lognormal generalised linear model following Dunn et al. (2000). A forward stepwise multiple-regression fitting algorithm (Chambers & Hastie 1991) implemented in the R statistical programming language (R Development Core Team 2003) was used to fit all models. The algorithm generates a final regression model iteratively and used the fishing year term as the initial or base model in all cases. The reduction in residual deviance relative to the null deviance, R^2, is calculated for each single term added to the base model. The term that results in the greatest reduction in residual deviance is added to the base model if this would result in an improvement in the residual deviance of more than 1%. The algorithm then repeats this process, updating the model, until no new terms can be added. A stopping rule of 1% change in residual deviance was used as this results in a relatively parsimonious model with moderate explanatory power.
Alternative stopping rules or error structures were not investigated.

For trip-level data, the variables offered to the model were fish_year, vessel_key, start_stats_area_code, target_species, month, and fishing_duration (as a 3rd order polynomial) and where appropriate form_type and primary_method. For tow-level data, additional variables of effort_depth, effort_width, and effort_height (all as 3rd order polynomials) were added. Although additional variables were available, they were not offered as explanatory variables because they were correlated with variables that were offered (e.g. latitude and start_stats_area_code, or vessel_power and vessel_key).Of course, it is possible that factors that drive SWA CPUE are not available. The variable fishing year was forced to be in the model as the relative year effects calculated from the regression coefficients represent the change in CPUE over time. Year indices were standardised to the mean and were presented in canonical form (Francis 1999).

Vessel effects were incorporated into the CPUE standardisations to allow for possible differences in fishing power between vessels. Vessels not involved in the fishery for consecutive years, or that had only participated for 1–3 years, were excluded because they provided little information for the standardisations (Knuckey et al. 1998), and their inclusion could result in model over-fitting (Francis 2001). Thus, CPUE analyses were undertaken for "core" vessels. Core vessels are those vessels that were involved in the defined fishery for at least four consecutive years, and reported about 80% of the catch. In some cases, such as limiting the dataset to a particular target species, the number of vessels was limited. To increase the number of vessels qualifying, those reporting 90% of the catch were used (Philips 2001). Vessels that have previously been identified as using twin trawling (Hurst 2009) were marked as potentially twin trawling, and this variable was also offered to the model. The amount of catch from these vessels is shown for each model in Figures E1a.1, E1b.1, E2a.1, E2b.1, E3a.1, E3b.1, E4a.1 and E4b.1. For the previous analyses, the catch from these vessels was removed from the data. However, since the current analyses include more years of data

not covered by Hurst (2009), and the vessels identified as likely to have twin trawled do not necessarily continue to twin trawl, it is better to retain the data.

Lognormal models were developed for merged (trip stratified) and unmerged (tow level) datasets within each region. For each of the unmerged datasets, delta-lognormal models were also developed. The dependent variable was the log-transformed landed catch per effort stratum when data were fitted on a trip-level resolution and the log-transformed estimated catch per tow when data were fitted on a tow-level resolution. These were fitted to data with only positive catches were retained. Delta-lognormal models were then fitted for the tow-level datasets, to examine the effect of including the probability of a zero-tow. A zero refers to a tow with no estimated catch for the unmerged data. Model fits were investigated using standard regression diagnostic plots. For each model, a plot of residuals against fitted values and a plot of residuals against quantiles of the standard normal distribution were produced to check for departures from the regression assumptions of homoscedasticity and normality of errors in log-space (i.e., log-normal errors).

7.1 Chatham Rise

The merged and unmerged datasets were restricted to core statistical areas, target species, form type and method (Table E1a.1).

To maintain a high percentage of catch in the retained vessels, vessels reporting 90% of the catch were included, which resulted in a core vessel set containing 35% of the vessels. The years most affected by twin trawl vessels were 2004–2007 in both the merged and unmerged datasets (Figures E1a.1b, E1b.1b).

The unstandardised arithmetic and geometric CPUE series for Model 1a (Chatham Rise, stratified trip level) shows a large increase in 2006 followed by a drop in 2007–2008, another large increase in 2009, followed by another drop in 2010 and a slight increase in 2011 (Figure E1a.1c). The years with high unstandardised CPUE tend to also have high catches resulting from targeting silver warehou (Figures D3a, E1a.3a). There is no suggested change in size distribution of the catch during high CPUE years from the Observer and Trawl survey data (Figures A7, B7). The observer length frequency distributions show a large proportion of females around 45 cm, but this comes from sampling only 9 tows (Figure B7). The trawl survey for the same year shows slightly more males than females and the length frequency distribution of both genders centred around 35 cm (Figure A7). The model retained all explanatory variables offered (Tables E1a.1, E1a.4) and explained 49% of the null deviance (Table E1a.4, Figure E1a.1). The standardised index tracked the geometric mean fairly closely, although it gave a larger peak in 2005, a lower peak in 2006, and missed the increase in 2011. The model diagnostic plots suggest constant variance as the residuals are fairly well uniformly distributed (Figure E1a.4). The quantile-quantile plot shows a slightly curved shape, but for the most part staying within the accepted boundaries, indicating that the errors are generally normally distributed.

Model 1b (Chatham Rise, unmerged tow-level) selected all explanatory variables offered except effort_height (Tables E1b.1, E1b.4 and explained 37% of the variance (Table E1b.4, Figure E1b.1c). The unstandardised arithmetic and geometric CPUEs are similar in trend to that of the merged dataset (Figures E1a.1, E1b.1). Target species explained a large part of the increases in 2006 and 2009, where there is a large amount of catch coming from targeting silver warehou (Figures D3a, E1b.2, E1b.3a). The diagnostic plots suggest fairly constant variance, with no strong pattern in the residuals (Figure E1b.4). The quantile-quantile plot is a little curved in the middle suggesting that the errors are not quite normally distributed. The residual density plots show that the means are always close to zero, but the distributions are sometimes quite asymmetrical and the variances vary from year to year.

The delta-lognormal version of Model 1b is influenced by a binomial model that has an upwards trend (Figure E1b.5). The peaks in 2005, 2007 and 2011 are also made more dramatic in the delta-

lognormal model. The explanatory variables selected for the binomial model are year, month, effort depth, vessel and target species, with 23% of the null deviance explained (Table E1b.6.

7.2 East Coast South Island

The merged and unmerged datasets were restricted to core statistical areas, target species, form type and method (Table E2a.1).

To maintain a high percentage of catch in the retained vessels, vessels reporting 90% of the catch were included, which resulted in a core vessel set containing 25% of the vessels. The years most affected by twin trawl vessels were 2003–2007 in both the merged and unmerged datasets (Figures E2a.1b, E2b.1b). The previous SWA Characterisation (Parker & Fu 2011) modelled the trip-stratified dataset CPUE for ECSI with data included from vessels using twin trawls.

The unstandardised arithmetic and geometric CPUE series for Model 2a (ECSI, stratified trip level) show a general upward trend with a peak at 2007, dropping throughout 2010, then increasing in 2011(Figure E2a.1c). The general increase in unstandardised CPUE corresponds to general increase in the amount of catch resulting from silver warehou targetting across the time series (Figure D8a). The standardised CPUE has assigned target species silver warehou a positive effect, thus accounting for some of the upward trend (Figures E2a.2, E2a.3b). The vessel effect also reduces the standardised CPUE for 2009 (Figures E2a.2, E2a.3a). The model selected all explanatory variables except fishing duration, form type and method, and explained 29% of the null deviance (Table E2a.4. The diagnostic scatter plot suggests a bias at larger values (Figure E2a.4). The quantile-quantile plot is slightly C-shaped suggesting that the distribution of the data is slightly skewed from normal. There is no apparent pattern in the length frequency plots for observer (Figure B8) or trawl survey (Figure A8) data that corresponds to the standardised CPUE.

The unstandardised arithmetic and geometric CPUE series for Model 2b (ECSI, unmerged tow level) was fairly flat, with a slight upward trend up until 2007 when it dropped, but then increased again through to 2011. The post-2008 increase is largely explained in the standardised CPUE by vessel and target species (Figure E2b.2) and the upward trend is a lot more subtle. In years 2008 and later, target species has a positive effect on the CPUE with high amounts of catch coming from silver warehou targetting (Figures D8a, E2b.3b). The explanatory variables selected for the model are vessel, target species and month, with 19% of the null deviance explained. No bias is apparent in the residual plots (Figure E2b.4). The quantile-quantile plot shows a departure from normality for small values, indicating a long tail to the distribution, but is otherwise fairly consistent with normally distributed errors.

The delta-lognormal version of Model 2b is similar, except that the higher values for 2004–2007 and 2011 also have a high probability of a non-zero tows, accentuating the index (Figure E2b.5). The binomial model selected explanatory variables effort depth, statistical area, month and vessel and explained 16% of the null deviance.

7.3 Southland

The merged and unmerged datasets were restricted to core statistical areas, target species, form type and method (Table E3a.1).

To maintain a high percentage of catch in the retained vessels, vessels reporting 90% of the catch were included, which resulted in a core vessel set containing about 35% of the vessels (Figures E3a.1a, E3b.1a).

The unstandardised arithmetic and geometric CPUE series for Model 3a (Southland, stratified trip level) is jagged but flat in trend. The standardised CPUE follows the unstandardised geometric CPUE closely, except for a higher peak in 2004, and a lower value at the start of the series. The peak in 2004 is largely attributed to the statistical area and target species effects. Statistical Areas

028 and 602 have a negative effect on the CPUE and these areas both have high catches in 2004, giving a higher standardised CPUE estimate (Figure E3a.3a). Targeting silver warehou has a positive effect on the CPUE and the catch from silver warehou is at its lowest in 2004 (Figure E3a.3b), hence lowering the estimated standardised CPUE for 2004. the low value in 1998 is associated with statistical area, vessel, and target factors (Figure E3a.2, E3a.3a and E3a.3c). The model retained explanatory variables statistical area, target species, vessel and month and explained 33% of the null deviance (Table E3a.4. The scatter diagnostic plot shows a bias to negative residuals for large values, and possibly a bias to negative residuals overall. (E3a.4). The quantile-quantile plot shows a poor distributional fit due to a skew to lower values.

The unstandardised arithmetic and geometric CPUE series for Model 3b (Southland, un-stratified tow level) is quite flat with a downward trend in the beginning of the series (Figure E3b.1). The standardised CPUE is similar, although as in the stratified model, there is an additional peak in 2004 and a lower estimate in 1998. The higher CPUE in 2004 is again attributed to the statistical area and target species (Figures E3b.2, E3b.3a and E3b.3b). The lower 1998 CPUE is largely due to the statistical area effect and to a lesser extent the vessel effects (Figure E3b.2). The model selected explanatory variables statistical area, target species and vessel and explained 31% of the null deviance (Table E3b.4. The scatter diagnostic plot shows a negative bias for large values, but otherwise simply a very poor fit (Figure E3b.4). The quantile-quantile plot looks good, suggesting normal errors.

The delta-lognormal version of Model 3b is jagged with no overall trend. The peaks and troughs have been accentuated due to the estimated probabilities of a non-zero tow being high for the same years that already had high estimated CPUE, suggesting that the two may be related. (Figure E3b.5). The binomial model selected explanatory variables statistical area, vessel and target species and explained 17% of the null deviance (Table E3b.6).

7.4 West Coast South Island

The datasets were restricted to months May-October, as very little catch occurred in other months and to core statistical areas, target species and form type (Table E4a.1).

To maintain a high percentage of catch in the retained vessels, vessels reporting 90% of the catch were included, which resulted in a core vessel set containing about 35% of the vessels (Figures E4a.1a, E4b.1a).

The unstandardised arithmetic and geometric CPUE series for Model 4a (WCSI, stratified trip level) are jagged and show no distinct trend. There are two main peaks: one in 2000–2001 and another smaller peak in 2007–2009. The standardised CPUE was similar, but with a higher peak in 2000–2001 and the 2007–2009 peak was flattened. The model retained vessel, method and target species as explanatory variables (Table E4a.4 and explained 34% of the null deviance. The diagnostic plots suggest a negative bias to residuals throughout the range (and a really poor fit). The quantile-quantile plot is curved, indicating that the data do not fit a log normal distribution.

The unstandardised arithmetic and geometric CPUE series for Model 4b (WCSI, un-stratified tow level) is quite flat except for a peak in 2008 (Figure E4b.1c). The standardised CPUE starts the series higher and flattens the peak in 2008, resulting in a possible downward trend across the series (Figure E4b.1c). The model retained explanatory variables target species, vessel and method and explained 25% of the null deviance (Table E4b.4). The quantile-quantile plot is straight, suggesting that the residuals follow the standard normal distribution.

The delta-lognormal version of Model 4b does not have a downward trend, as the probability of a nonzero catch is estimated to increase from 2002 onwards (Figure E4b.5). The binomial model used explanatory variables vessel, effort depth and statistical area and explained 17% of the null deviance (Table E4b.6).

7.5 Comparing CPUE and trawl survey biomass estimates

A biomass time series is available for the Southland area (the sub-Antarctic survey) (Figure A3), and the Chatham Rise area (Chatham Rise survey) (Figure A1). Although there is a survey for the ECSI, it does not overlap well in areas fished as it tends to fish shallower water and encounter juvenile silver warehou (Figure A2 and A8). However, the western part of the Chatham Rise survey overlaps considerably in area with the ECSI region (Figure D0), so the biomass estimates from western parts of this survey were compared with ECSI CPUE, and the eastern parts were compared with Chatham Rise East CPUE. There is also a WCSI inshore *Kaharoa* survey (Figure A5) and a WCSI *Tangaroa* survey (Figure A6), although this is only for years 2000 and 2012.

The standardised CPUE trends for merged and unmerged datasets for ECSI, Chatham Rise, Southland and WCSI were overlaid with the corresponding trawl survey biomass estimates (Figures E5.1, E5.2, E5.3 and E5.4).

The ECSI tow-level CPUE and western parts of the Chatham Rise trawl survey both show a similar upward trend, although the CPUE index does not match the sudden increase in the 2010 and 2011 trawl survey biomass estimates (Figure E5.1). The two series look a close match with the biomass estimates for 2010–2011 removed (Figures E5.1, A1). The biomass estimates have higher year to year variability, but the general trend is similar.

There is less in common between the CPUE indices for Chatham Rise East and the trawl survey biomass estimates for eastern Chatham Rise (Figure E5.2). The tow-level CPUE and trawl survey biomass estimates have peaks in one where there are troughs in the other, but both suggest a slight overall upward trend (Figure E5.2b).

The standardised CPUE indices for Southland are similar to the estimated biomass from the sub-Antarctic summer trawl survey (Figure E5.3). The general trend in both series is flat and the biomass estimates do not contradict the CPUE index.

Both of the WCSI surveys support a general upward trend from 2000, although the *Kaharoa* survey estimate drops off in the last few years (Figure E5.4). The CPUE indices are much flatter, although in the comparison plot, the unmerged series seems to support the upward trend from 2002. However the *Kaharoa* survey is not a useful comparison as the size frequency shows that the biomass estimate is only for juvenile fish.

7.6 CPUE summary

Although fishing year was forced into every CPUE model, it generally explained less than 10% of the null deviance, with the Chatham Rise models being the exception, explaining 17% for the merged data set and 13% for the un-merged dataset (Tables E1a.3, E1b.3). There was no variable consistently contributing more or less to the percentage of explained null deviance across the models. Total null deviance explained by the models ranged from 0.19 to 0.49.

The trend in standardised CPUE is slightly increasing for ECSI, very slightly increasing for Chatham Rise, flat for Southland and decreasing for WCSI until 2003, after which it is flat (Figures E5.1-E5.4).

There are some similarities in the standardised CPUE for unmerged datasets across all areas (Figure E5.4). The CPUE drops in 1999 across all areas, and then peaks in 2000. They all share another drop in 2002–2003 followed by another peak in 2004, although for WCSI this peak is a lot shallower. They all peak again in 2009, although for WCSI this peak is also in 2008. The years 2005–2006 are low points for WCSI and Southland and peaks for ECSI and Chatham Rise. In general, ECSI and Chatham Rise follow a similar pattern, as do WCSI and Southland. Only the unmerged (tow level) datasets were compared on the same plot as they generally had smaller

standard errors than the merged datasets and the catch is mostly from TCEPR forms (Figure C7) which supports using the tow-level data for CPUE analyses over the stratified data.

The western Chatham Rise trawl survey biomass estimates are similar to the ECSI tow-level CPUE index. The Southland and Chatham Rise East CPUE indices are not as similar to the corresponding trawl survey biomass estimates, although high standard errors in the Southland trawl survey estimates mean that these do not contradict the CPUE.

The standard errors for the models are small for ECSI, WCSI and Southland, but quite big for Chatham Rise. The amplitude of annual deviation is very large in Southland, quite large for Chatham Rise and moderate in ECSI and WCSI. Where there is large annual deviance, even if the CPUE is tracking abundance, a greater change in abundance is required for it to be apparent in the CPUE. The Southland and Chatham Rise CPUE series are not recommended as indices of abundance, but the ECSI and WCSI CPUE series are more promising.

8. SUMMARY AND RECOMMENDATIONS

8.1 Biology

Although silver warehou have been harvested commercially at significant levels for more than 40 years, many aspects of their biology, important to stock assessment, remain unknown. Foremost is their size and age at maturity. The most complete information on maturity is based on a single histological study of a few dozen fish in the 1970s. Although well done, ages were based on unvalidated scale reading methods, concerned females only, and maturity may have changed in the interim given the exploitation since the fishery started. It would be useful to update the size and age at maturity through a directed study that is spatially targeted at the multiple spawning areas at the appropriate time of year, uses a validated ageing methodology, and includes the male reproductive cycle. Because silver warehou are selected in the fishery long before they become sexually mature (based on current information) this information will be required for any form of spawning biomass-based stock assessment.

A second biological aspect in need of directed study is the stock structure. No genetic stock discrimination work has been done for silver warehou, yet multiple, isolated spawning sites with similar timing exist. Because the administrative stock units do not coincide with the spawning area boundaries or fishery distributions, knowledge of the degree of any stock isolation is important.

Although catch is dominated by areas around the South Island, significant silver warehou catch does occur all around the North Island as well. Observations of 0+and juveniles on the west coast of the North Island, and maturing adults on the east coast of the North Island, suggest that there may be more spawning sites (and possible fish stocks) further to the north. *Seriolella punctata* occur at latitudes lower than 35°S in Australia, suggesting that spawning could occur in more northern waters. Observer samples from the autumn and winter periods off the east coast of the north island may inform this aspect of silver warehou biology.

8.2 Status of the stocks

No estimates of current absolute biomass are available for any silver warehou fish stock. Biomass indices from *Tangaroa* and *Kaharoa* trawl surveys in QMAs 1, 3 and 4 since 1991 are variable between years and have high standard errors. Working groups have concluded that they are unsuitable for stock assessment in isolation, although their usefulness may improve as the time series grow in duration. Maximum Constant Yield (MCY) cannot be determined. Problems with historical misreporting of warehou catches and the lack of stable catch histories make MCY estimates based on catch data alone unreliable, and because an estimate of current biomass is not available, Current Annual Yield cannot be estimated. The sustainability of current TACCs and

recent catch levels for these fish stocks is therefore not known, and it is not known if they will allow the stocks to move towards a size that will support the maximum sustainability yield.

Length frequency distributions are variable among years, but a large size mode of between 40 and 50 cm is usually present in all areas in the observer length frequency data and in all areas except WCSI and TBGB in the trawl survey data series.

Catches in SWA 3 and 4 exceeded the TACC up until 2008. In fishing years 2008 and later, the catches in SWA 4 have always been under the TACC and have been under or slightly over in SWA 3. This change coincides with an increase in the deemed value. The sudden change in response to management pressure could make stock evaluation of these stocks difficult, depending on how it affects the CPUE. The ECSI CPUE drops in 2008, but then increases again and the Chatham Rise CPUE does not drop in 2008. The Southland CPUE is too jagged to show a response.

Catches in SWA 1 exceeded the TACC up until 2002, when there was a sudden drop. Unlike in SWA 3 and 4, this drop does not coincide with any management decisions such as decreased TACC or increased deemed value. The drop is however reflected in the WCSI CPUE, which also drops in 2002 then remains low (Ministry of Fisheries 2010). This suggests a drop in silver warehou abundance here.

Silver warehou catch should be well monitored because most vessels have used TCEPR forms. In addition, the fisheries encountering silver warehou are fairly discrete spatially and have several dominant vessels that account for most of the catch. Silver warehou are not long lived and length modes can be seen in the data for at least the first 3–4 years of life. Observer sampling in each area provides consistent length frequency distributions and could provide otoliths in the future. Biology is reasonably well understood, but a few directed studies of reproductive development will enable robust maturity ogives to be determined. And lastly, although CVs are usually high, a fishery independent biomass estimate exists for each fishery area and adding some survey effort to optimise silver warehou biomass CVs could make them more useable. The major limiting factor is the apparent variability in the size (and presumably age) distributions that are encountered in the fishery independent surveys and in the various fisheries. The degree to which increased sampling effort would improve the characterisation of the population size and age structure would need to be addressed as a first step.

8.3 Observer programme sampling

Sampling by the Observer Programme is very good, matching well on a spatial and inter-annual basis. Any under sampling is due to the extremely low levels of observer sampling on small vessels in inshore statistical areas. There is some oversampling and under sampling with respect to month fished, but this cannot be remedied without a large increase in observer coverage rates. Increasing observer sampling rates would also contribute to enhanced biological data collection from the fishery as suggested.

8.4 Future data needs and research requirements

To strengthen the likelihood of CPUE sufficiently providing a relative abundance indicator for silver warehou, and with the goal of developing a quantitative stock assessment in the future, the data collection needs for silver warehou are as follows:
1) Length and age at maturity for each fish stock.
2) Definitive stock unit identification.
3) Investigation of potential North Island spawning sites through observer and survey information.
4) Otolith sampling from SWA 1, SWA 3 and SWA 4 to develop length at age keys and monitor growth rates.
6) Development of a length-based stock assessment for each geographical area characterised, noting that SWA 1 is managed under an AMP.

9. ACKNOWLEDGMENTS

I thank Steve Parker for providing a thorough review of the document, Dan MacGibbon for supervising the project and the Ministry for Primary Industries for funding the project through DEE201007.

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APPENDIX A: SUMMARIES OF TRAWL SURVEY DATA

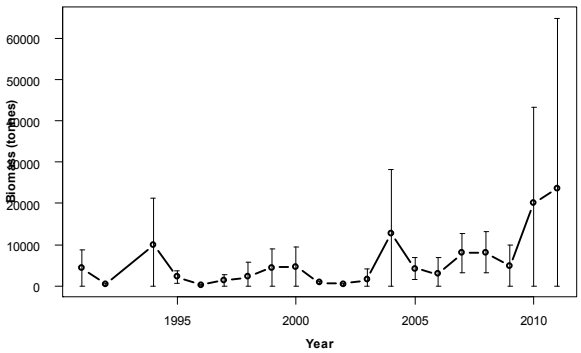


Figure A1: Doorspread biomass estimates of total silver warehou on the Chatham Rise, from *Tangaroa* surveys 1991–2011.

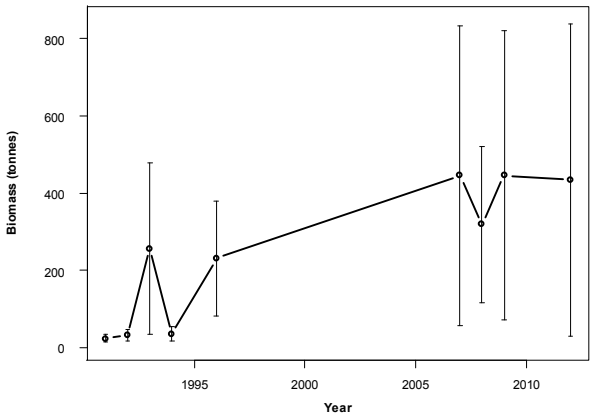


Figure A2: Doorspread biomass estimates of total silver warehou on the East Coast South Island, from *Kaharoa* surveys from 1991–2012.

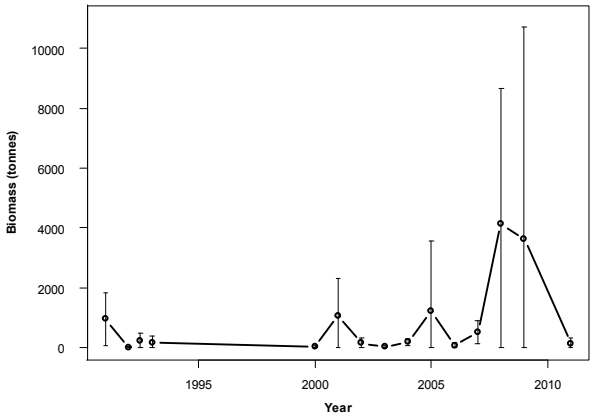


Figure A3: Doorspread biomass estimates of total silver warehou in the Sub-Antarctic, from *Tangaroa* surveys 1991–2011.

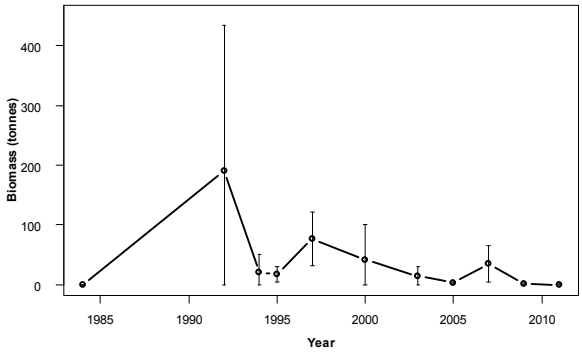


Figure A4: Doorspread biomass estimates of total silver warehou in Tasman Bay/Golden Bay, from *Kaharoa* surveys 1984–2011.

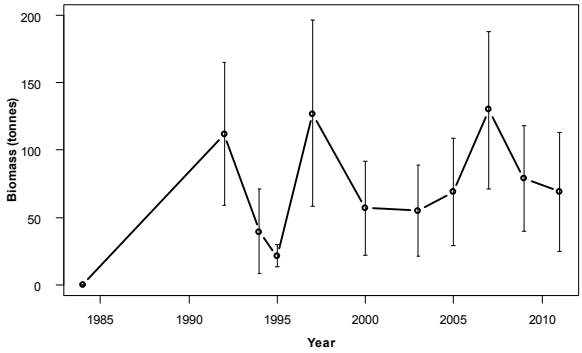


Figure A5: Doorspread biomass estimates of total silver warehou on the West Coast South Island, from *Kaharoa* surveys 1984–2011.

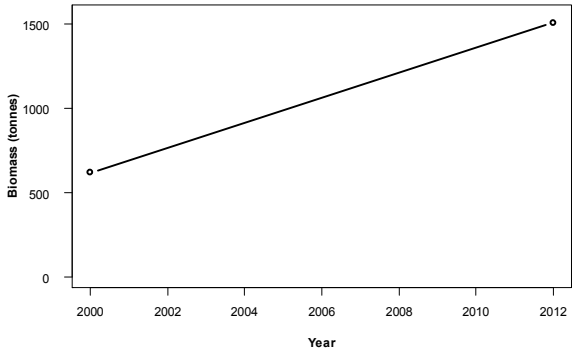


Figure A6: Doorspread biomass estimates of total silver warehou on the West Coast South Island, from *Tangaroa* surveys 2000 and 2012 (O'Driscoll et al. 2014).

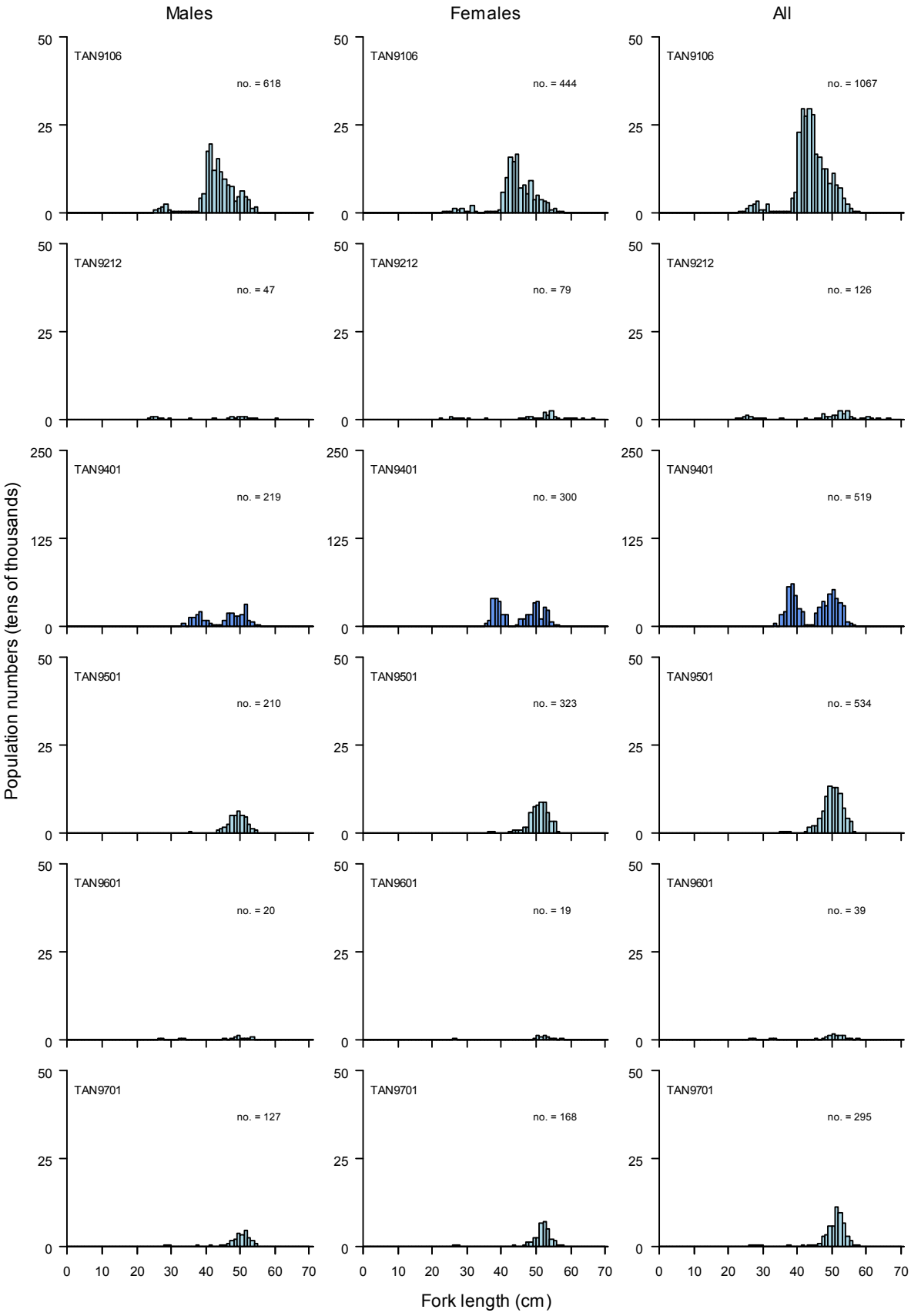


Figure A7: Scaled population length frequency distributions of male, female and unsexed silver warehou on the Chatham Rise from *Tangaroa* surveys from 1991 to 2011. no. , number of fish sampled.

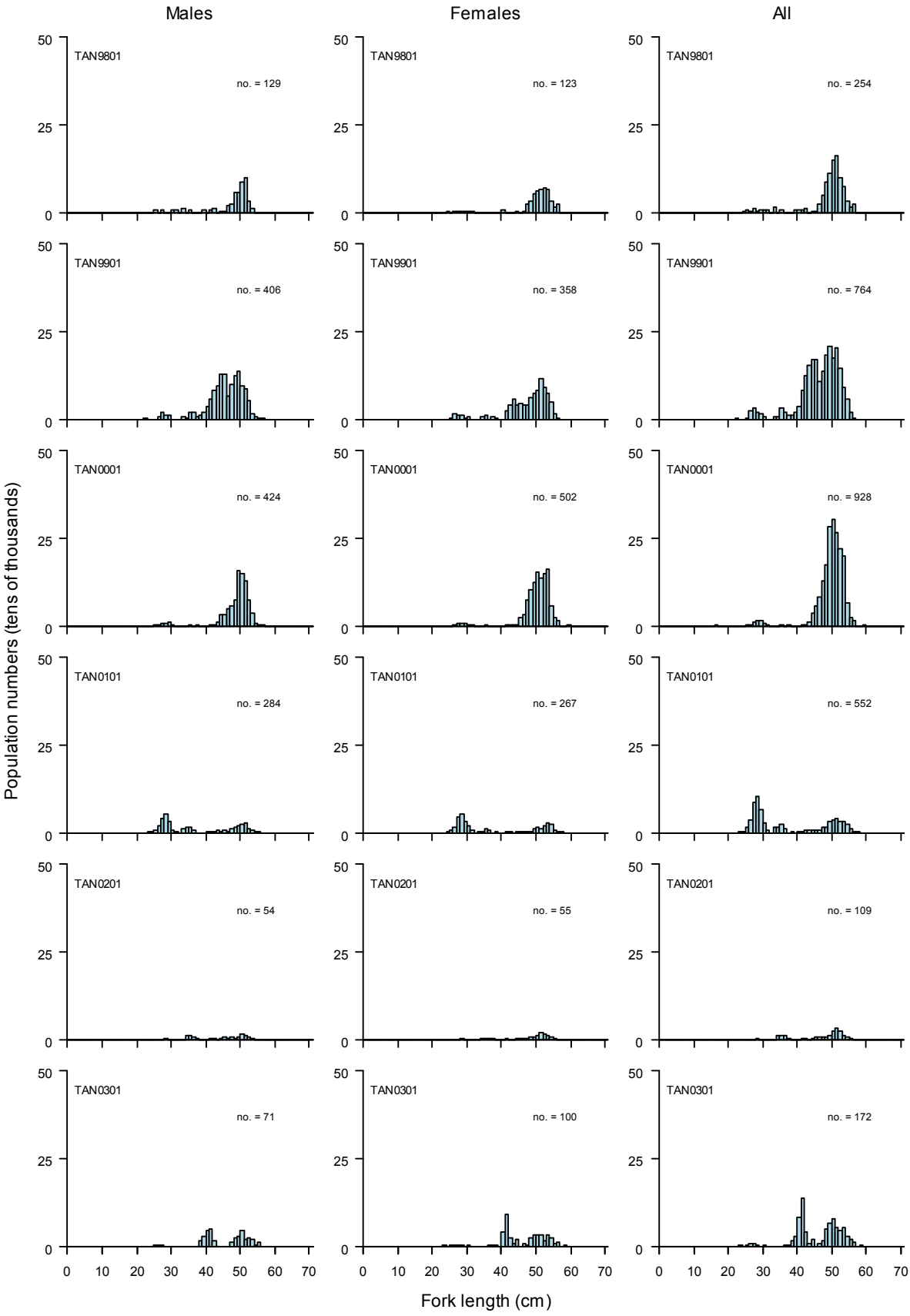


Figure A7: (Continued).

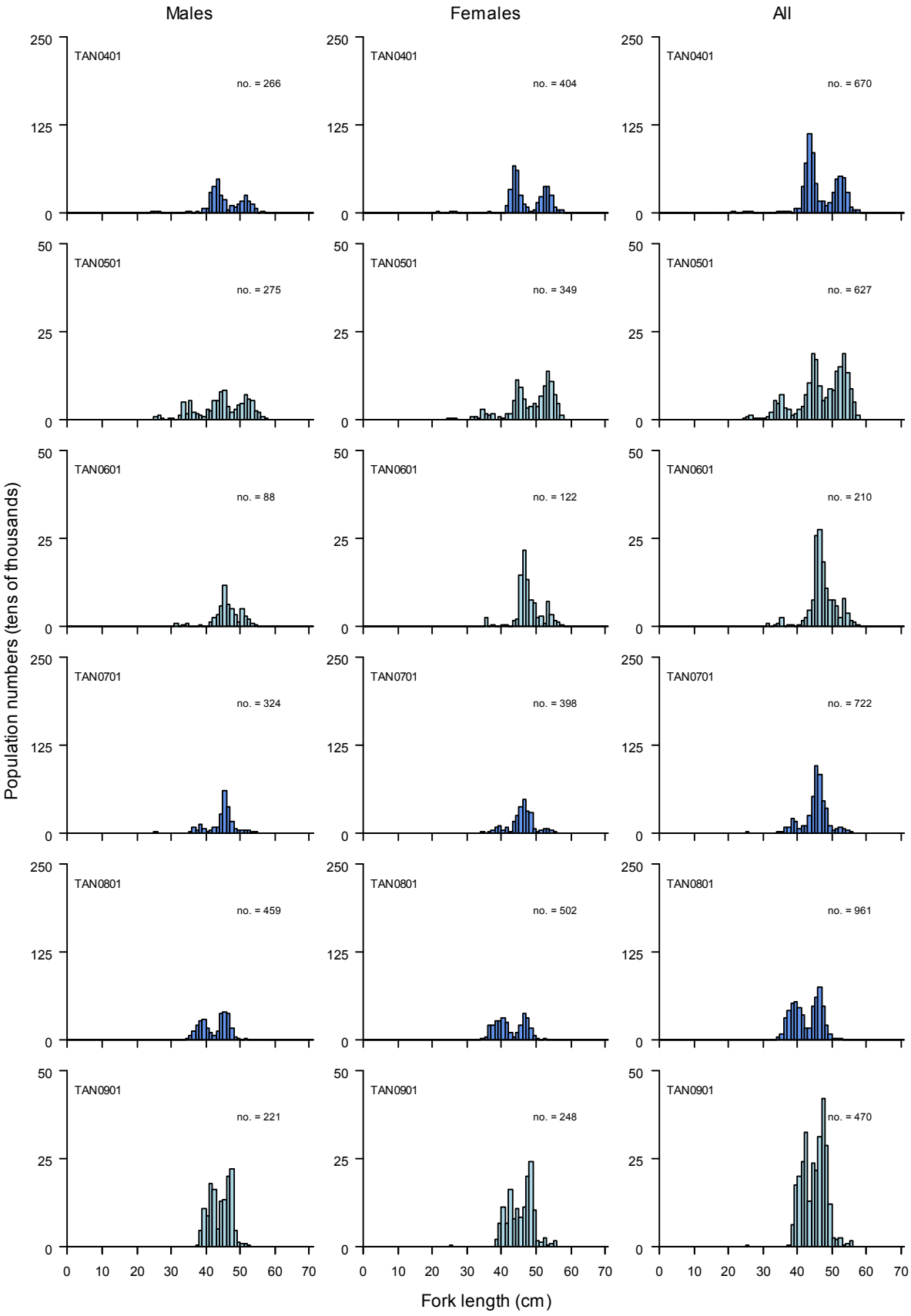


Figure A7: (Continued).

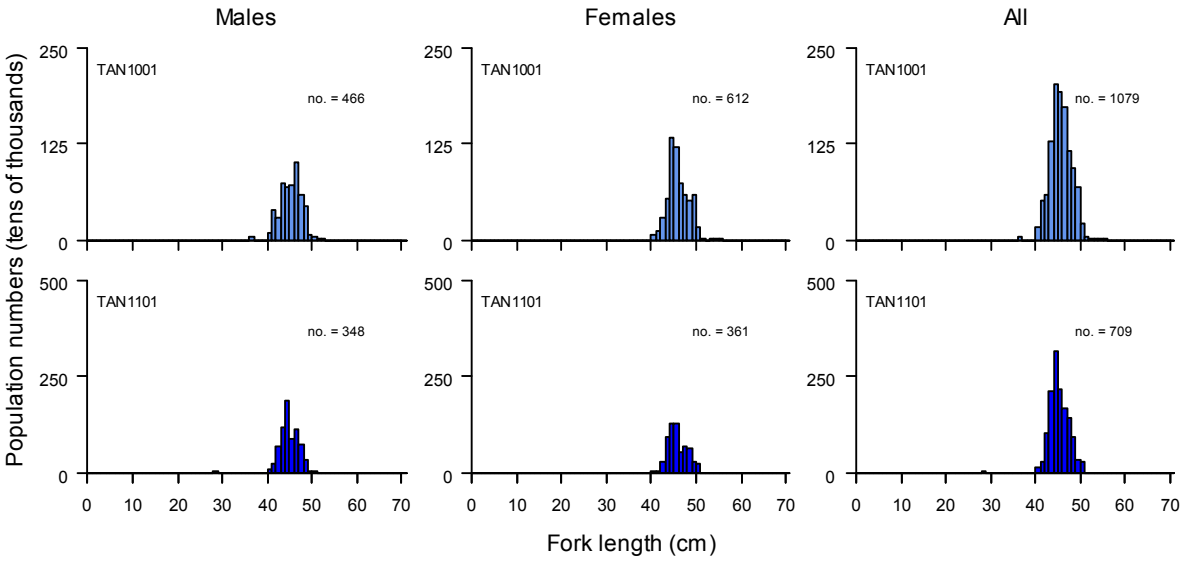


Figure A7: (Continued).

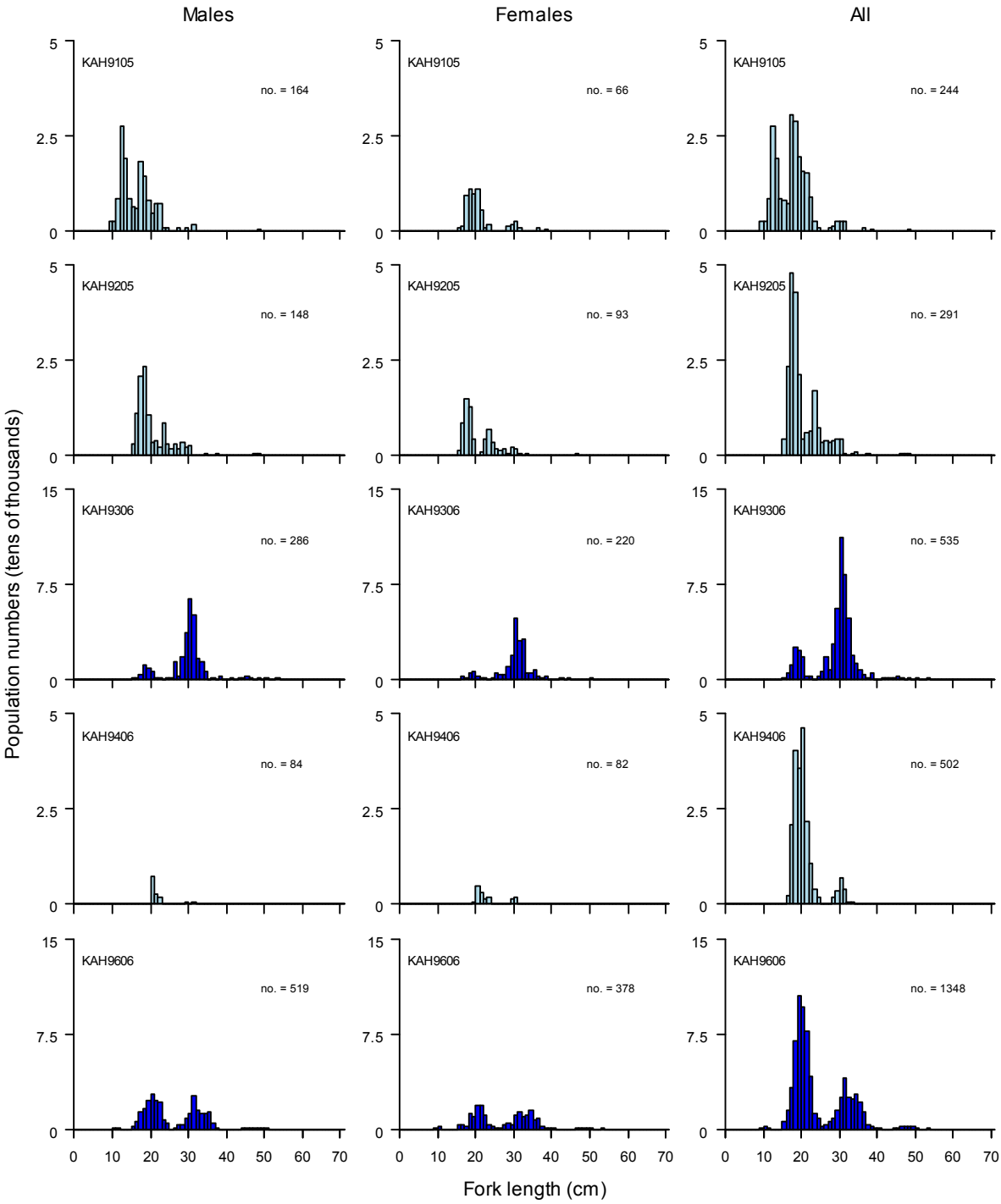


Figure A8: Scaled population length frequency distributions of male, female and unsexed silver warehou in the East Coast South Island from *Kaharoa* surveys from 1991 to 2012. no. , number of fish sampled.

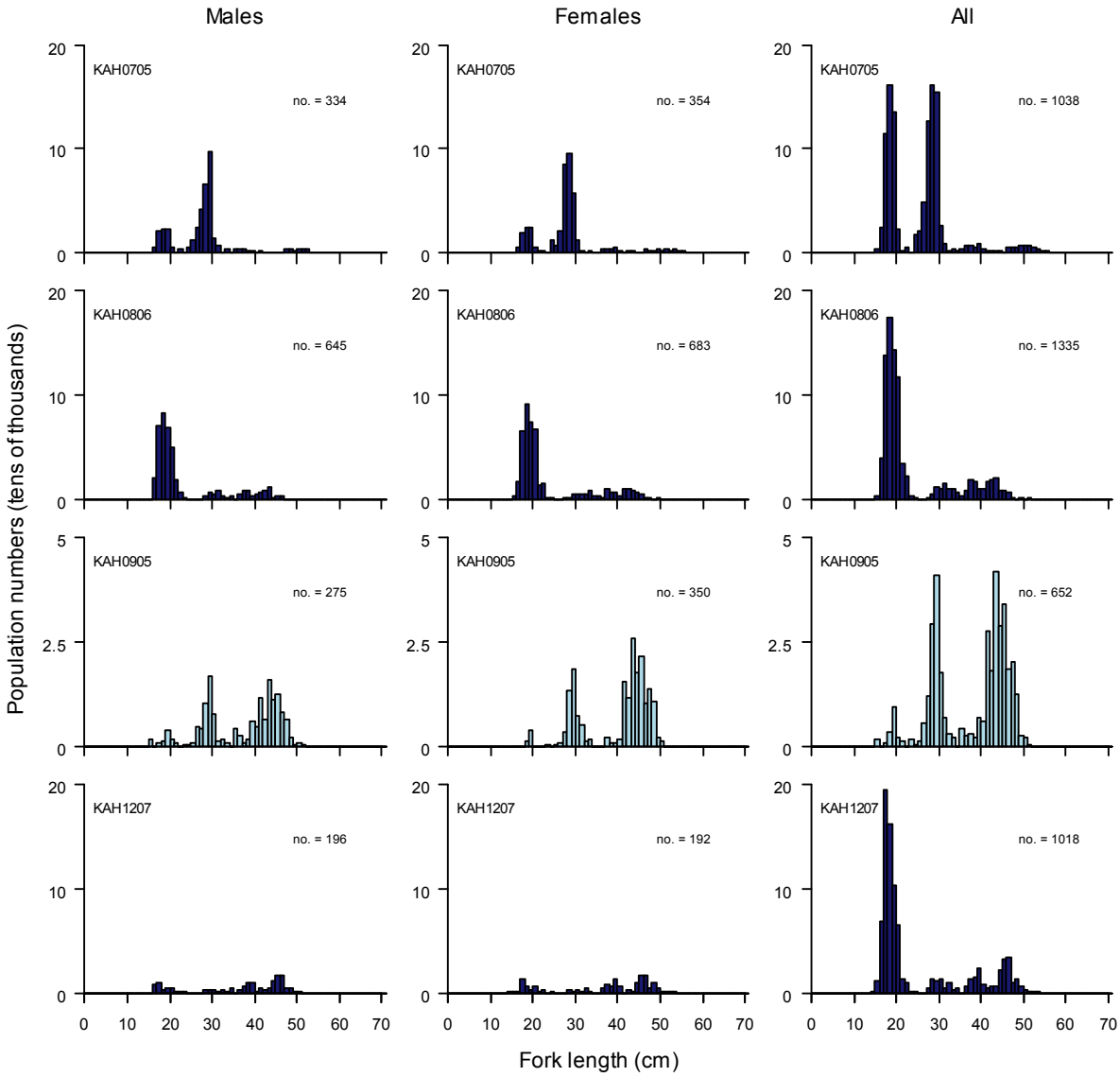


Figure A8: (Continued).

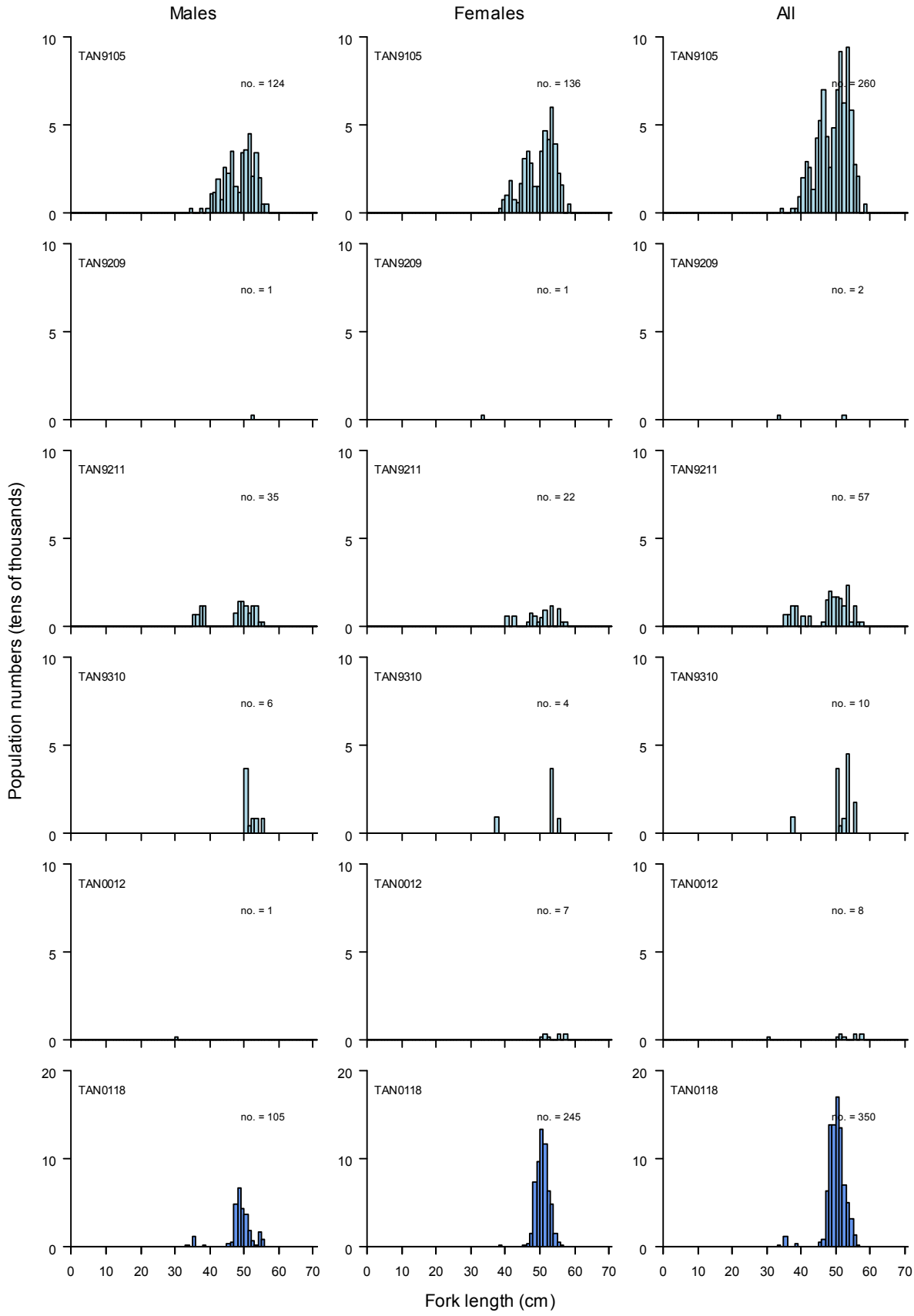


Figure A9: Scaled population length frequency distributions of male, female and unsexed silver warehou in the Sub-Antarctic from *Tangaroa* surveys from 1991 to 2011. no. , number of fish sampled.

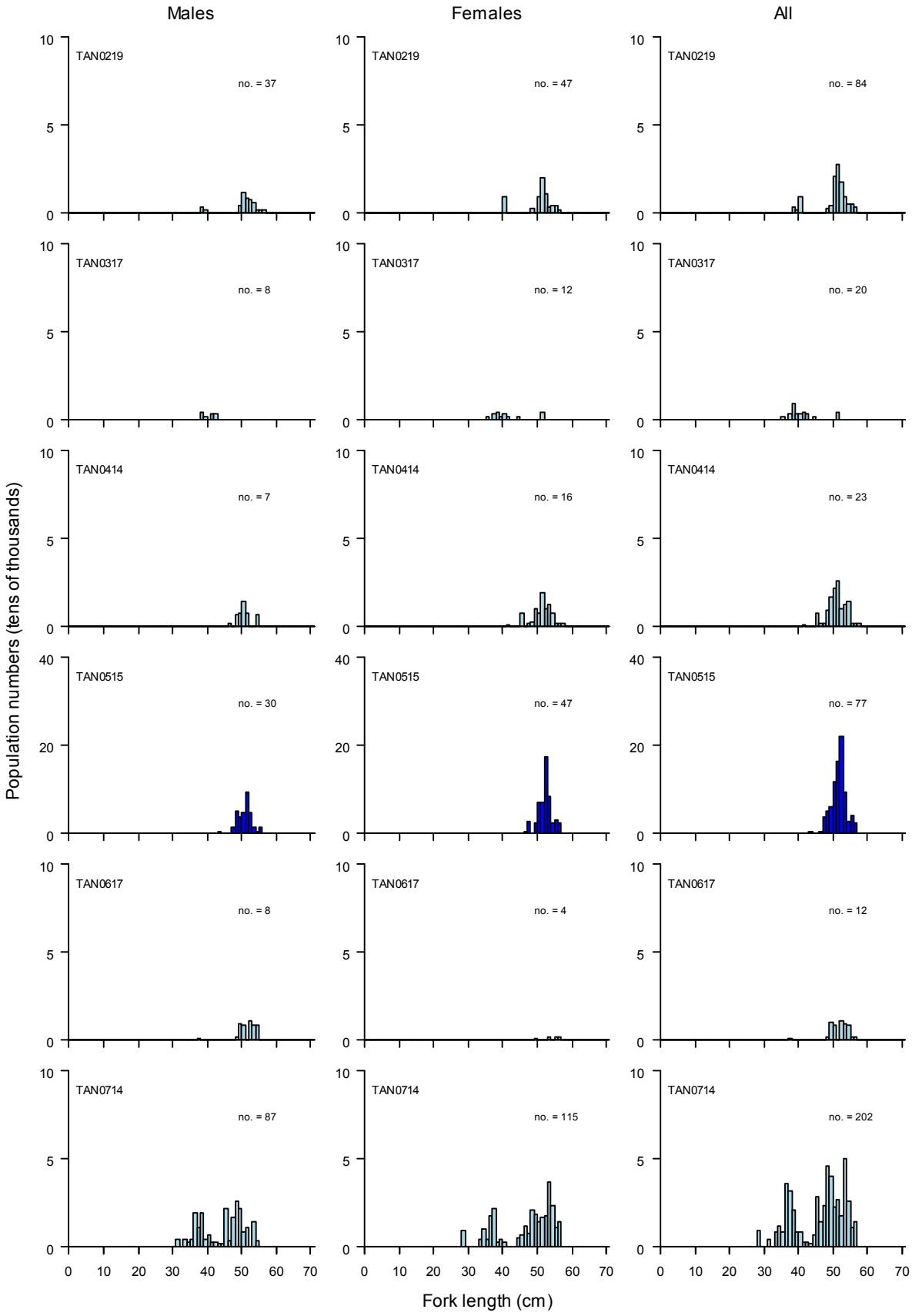


Figure A9: (Continued).

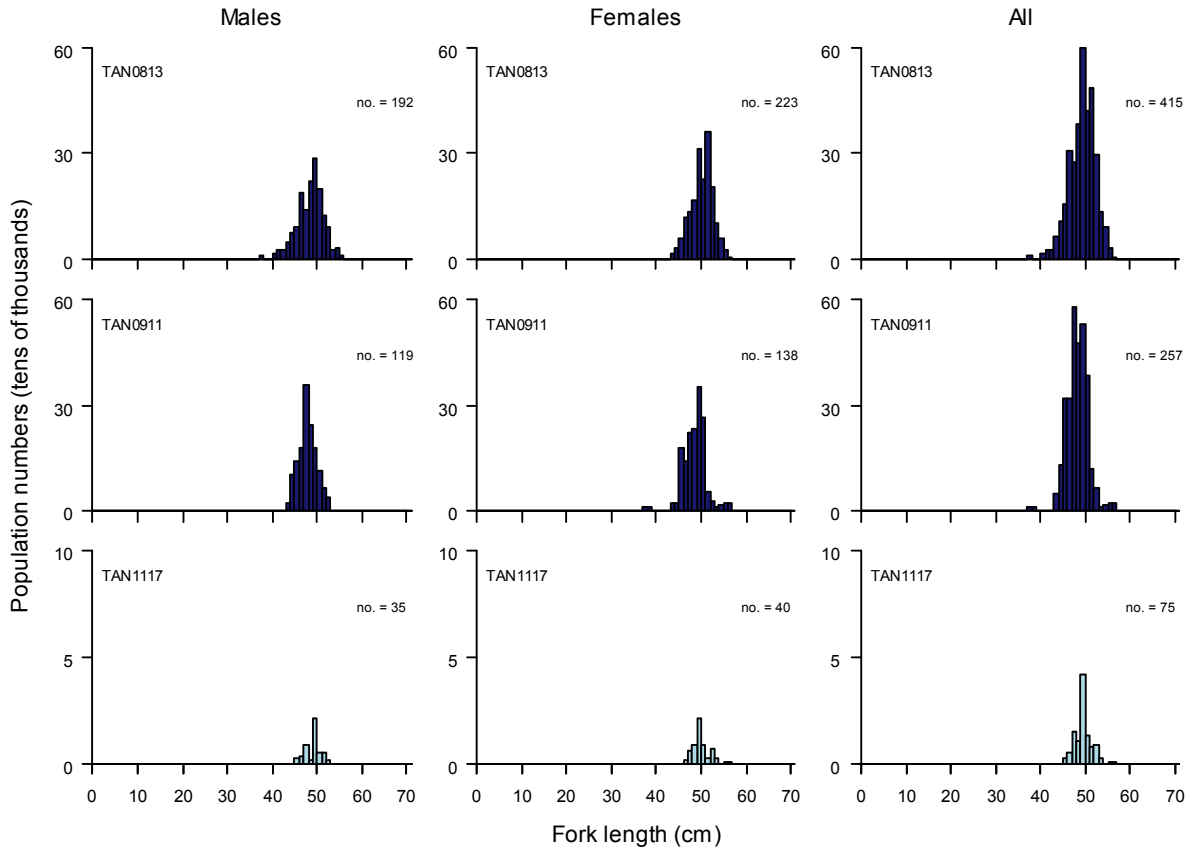


Figure A9: (Continued).

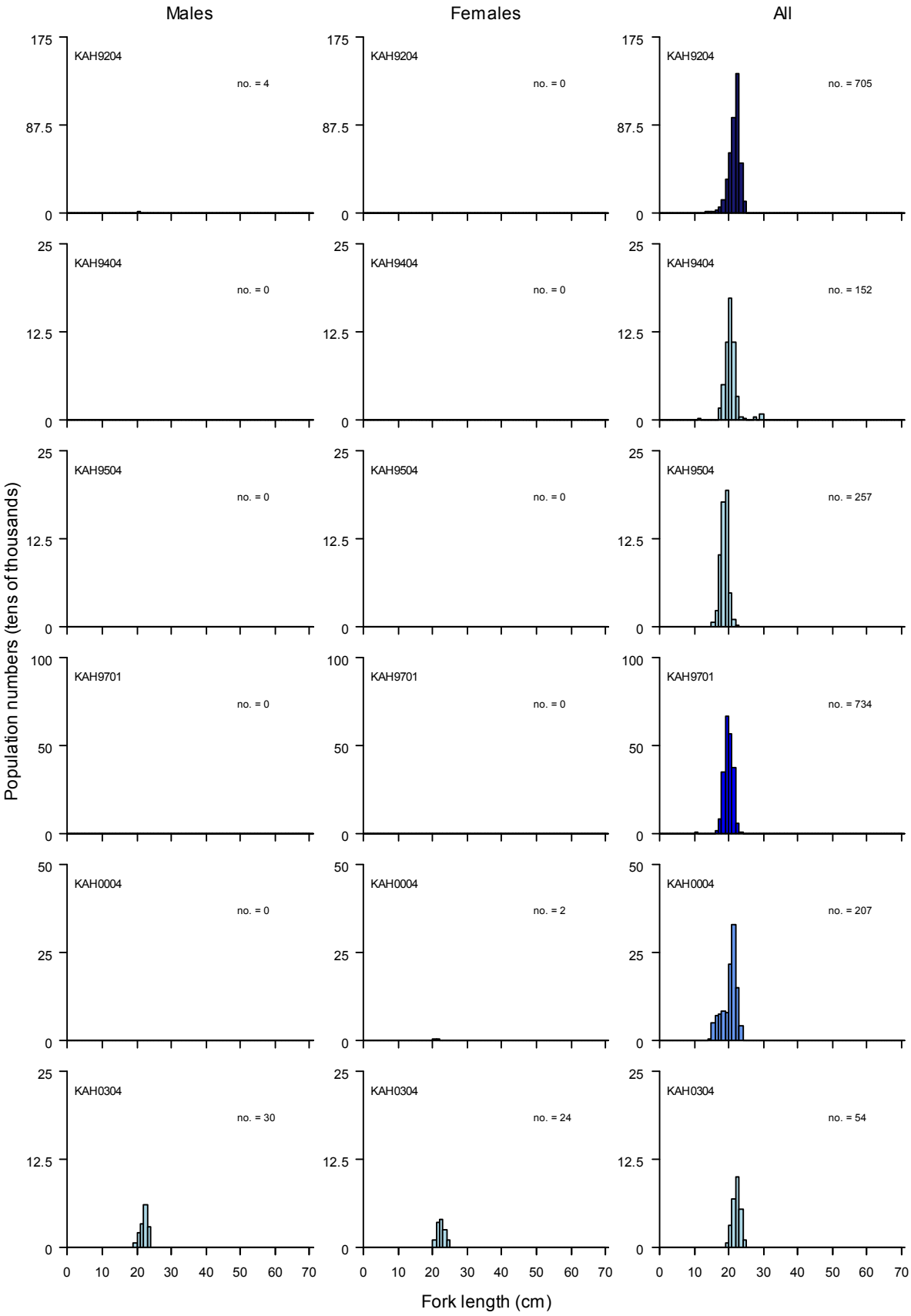


Figure A10: Scaled population length frequency distributions of male, female and unsexed silver warehou in the Tasman Bay/Golden Bay from *Kaharoa* surveys from 1991 to 2011. no. , number of fish sampled.

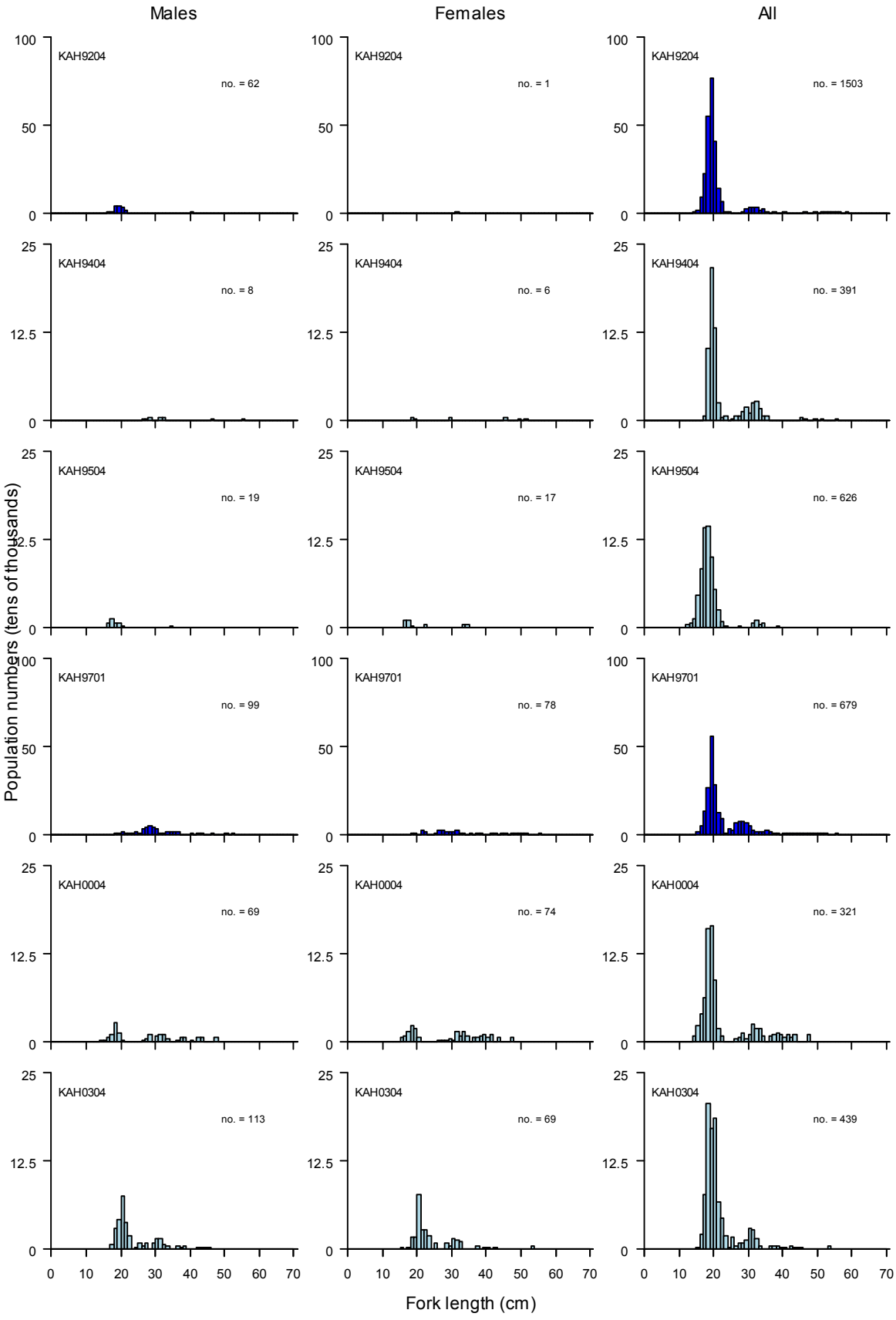


Figure A11: Scaled population length frequency distributions of male, female and unsexed silver warehou on the West Coast South Island from *Kaharoa* surveys from 1991 to 2011. no. , number of fish sampled.

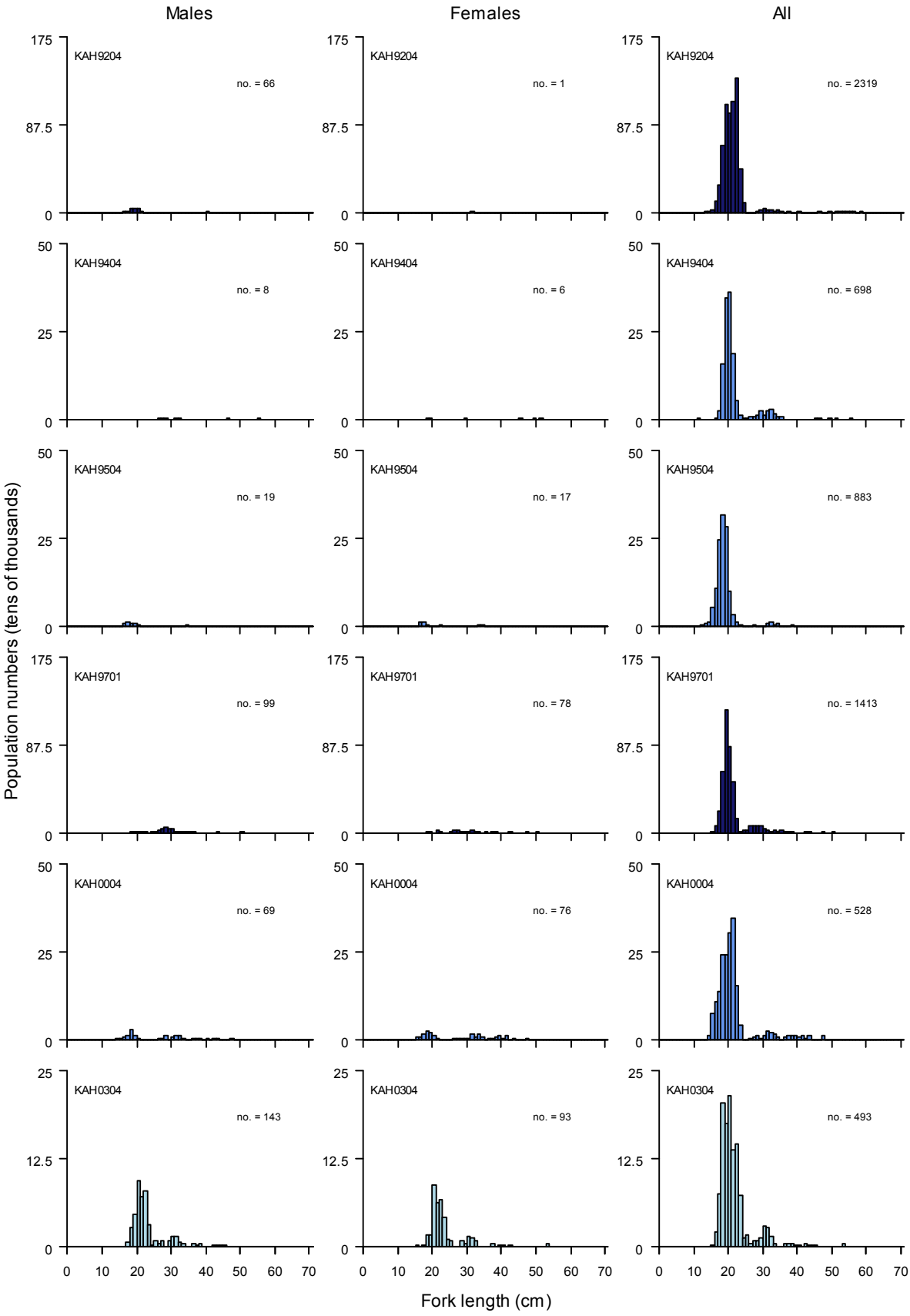


Figure A12: Scaled population length frequency distributions of male, female and unsexed silver warehou in the Tasman Bay/Golden Bay and West Coast South Island from *Kaharoa* surveys from 1984 to 2011. no., number of fish sampled.

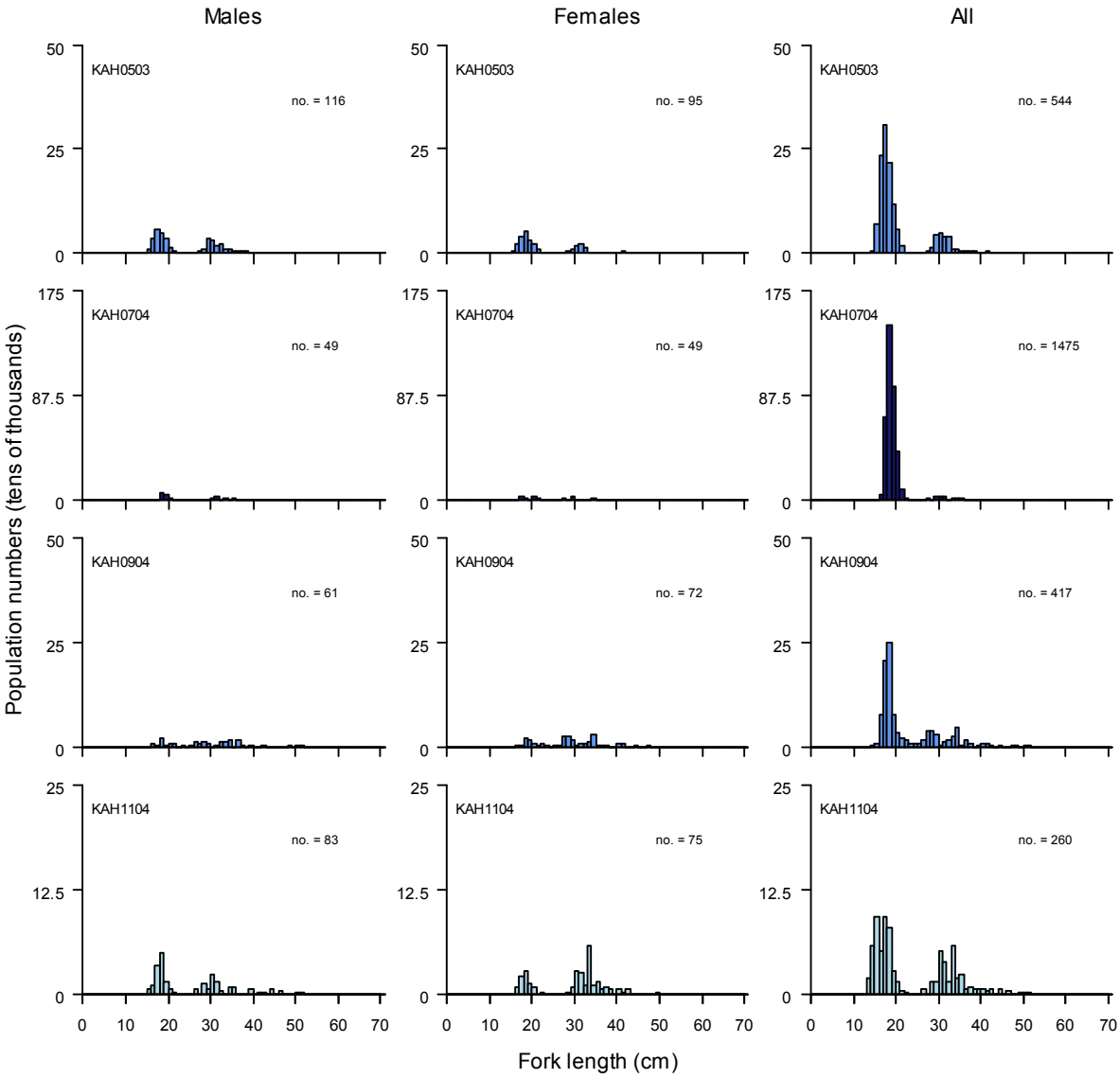


Figure A12: (Continued).

APPENDIX B: SUMMARIES OF OBSERVER PROGRAMME DATA

Table B0: Number of otolith pairs collected by the Observer programme and during *RV Tangaroa* surveys by region from 1992–2012.

	Scientific observer programme								*Tangaroa* surveys				Total
Year	CHA	SOU	SEC	SOE	CEE	SOI	CEW		STEW	SNAR	PUYS	WCSI	
1992	484	235	61	8		12							800
1993	184	466	121	57	5	3			228	9	12		1 085
1994	938	332	104	36	42	11	17		72	33	41		1 626
1995	524	250	10	110	27	1	9		81	45	27		1 084
1996	690	289	112	7	40	25							1 163
1997	428	119	54	7	1	6							615
1998	809	856	281	56	34	9							2 045
1999	1031	989	468	159	58	11							2 716
2000	1365	1167	571	217	12	462							3 794
2001	1193	2531	616	116	25	59	20						4 560
2002	595	1064	136	107	67	153	8						2 130
2003	910	1047	370	290	21	80	10						2 728
2004	510	1518	428	143		574							3 173
2005	681	1312	255	248	57	374							2 927
2006	368	1051	410	119		570	6						2 524
2007	684	1329	625	181	1	523	89						3 432
2008	500	768	211	170	81	261							1 991
2009	412	621	325	41	1	191	5						1 596
2010	216	713	231	192	5	46							1 403
2011	295	472	497	126	10	34							1 434
2012	274	271	132	151		134	5					574	1 541
Total	13091	17400	6018	2541	487	3539	169	0	381	87	80	574	44 367

Table B1: Total number of tows by fishing year sampled for silver warehou length by the observer programme for the fishing years 1990–91 to 2010–11 from each area CHAT=Chatham Rise, ECSI=East Coast South Island, SUBA=Sub Antarctic, WCSI=West Coast South Island.

	CHAT	ECSI	Other	SUBA	WCSI	Total
1990–91	8	18	-	14	127	167
1991–92	9	29	-	80	153	271
1992–93	21	20	13	168	81	303
1993–94	17	52	16	103	351	539
1994–95	21	8	31	94	125	279
1995–96	11	45	18	78	134	286
1996–97	7	17	13	44	103	184
1997–98	15	61	7	145	157	385
1998–99	42	111	22	210	185	570
1999–00	52	124	41	296	282	795
2000–01	37	156	16	616	283	1 108
2001–02	25	44	30	287	163	549
2002–03	44	68	9	275	214	610
2003–04	43	77	3	437	194	754
2004–05	59	65	16	368	140	648
2005–06	27	81	9	370	99	586
2006–07	33	73	22	399	120	647
2007–08	27	73	12	160	99	371
2008–09	11	42	2	184	90	329
2009–10	37	88	1	189	49	364
2010–11	23	89	6	126	60	304
Total	569	1 341	287	4 643	3 209	10 049

Table B2: Total number of tows sampled by the observer programme for silver warehou by fishing year and month for all areas combined for the fishing years 1990–91 to 2010–11.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	11	5	2	12	3	1	-	6	-	48	70	9	167
1991–92	2	-	-	11	35	29	28	-	2	81	68	15	271
1992–93	8	2	3	-	28	82	55	21	-	18	59	27	303
1993–94	30	10	4	1	16	43	36	22	17	119	225	16	539
1994–95	4	-	7	19	54	43	6	2	5	71	52	16	279
1995–96	26	-	4	5	11	16	26	31	15	10	85	57	286
1996–97	28	-	1	11	8	9	20	-	-	14	80	13	184
1997–98	10	8	38	34	74	18	29	13	-	51	99	11	385
1998–99	74	15	27	27	84	92	38	11	13	123	62	4	570
1999–00	37	34	12	31	112	96	34	91	35	99	166	48	795
2000–01	126	31	23	90	304	170	24	6	31	92	161	50	1 108
2001–02	30	23	12	4	119	119	41	16	14	62	104	5	549
2002–03	66	22	5	57	72	69	39	11	22	58	129	60	610
2003–04	23	13	10	95	209	108	39	4	1	46	163	43	754
2004–05	8	4	14	98	146	100	44	24	45	67	66	32	648
2005–06	30	15	32	45	107	126	45	22	41	37	52	34	586
2006–07	3	25	36	48	130	143	86	37	11	37	84	7	647
2007–08	25	19	1	11	69	28	33	32	5	36	72	40	371
2008–09	13	6	7	1	105	28	29	21	23	71	14	11	329
2009–10	24	10	28	47	27	53	23	52	11	28	32	29	364
2010–11	12	16	52	28	35	37	14	7	39	18	34	12	304
Total	590	258	318	675	1 748	1 410	689	429	330	1 186	1 877	539	10 049

Table B3: Total number of tows sampled for silver warehou by the observer programme by fishing year and month on the Chatham Rise for the fishing years 1990–91 to 2010–11.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	5	1	2	-	-	-	-	-	-	-	-	8
1991–92	-	-	-	-	5	-	3	-	-	-	-	1	9
1992–93	4	2	1	-	-	-	-	-	-	2	6	6	21
1993–94	-	-	3	-	-	-	7	6	1	-	-	-	17
1994–95	-	-	5	12	-	-	-	-	-	-	-	4	21
1995–96	11	-	-	-	-	-	-	-	-	-	-	-	11
1996–97	6	-	-	-	-	-	1	-	-	-	-	-	7
1997–98	5	4	1	-	-	-	1	4	-	-	-	-	15
1998–99	23	9	4	2	4	-	-	-	-	-	-	-	42
1999–00	4	15	3	-	-	-	-	19	5	-	-	6	52
2000–01	22	5	1	-	-	2	-	-	1	-	-	6	37
2001–02	4	16	2	-	-	-	-	3	-	-	-	-	25
2002–03	34	7	-	-	-	1	-	-	-	1	-	1	44
2003–04	13	11	1	-	-	-	14	2	-	2	-	-	43
2004–05	1	1	1	24	15	4	-	1	12	-	-	-	59
2005–06	15	-	3	-	-	-	4	-	4	1	-	-	27
2006–07	-	4	2	11	4	3	2	4	-	3	-	-	33
2007–08	-	4	-	-	1	-	-	7	-	2	3	10	27
2008–09	5	-	-	-	-	-	2	4	-	-	-	-	11
2009–10	1	3	-	-	-	2	-	-	-	-	6	25	37
2010–11	-	12	4	-	-	-	3	-	-	-	-	4	23
Total	148	98	32	51	29	12	37	50	23	11	15	63	569

Table B4: Total number of tows sampled for silver warehou by the observer programme by fishing year and month from the East Coast South Island for the fishing years 1990–91 to 2010–11.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	11	-	1	5	-	-	-	1	-	-	-	-	18
1991–92	-	-	-	1	10	3	11	-	-	4	-	-	29
1992–93	-	-	-	-	-	-	14	-	-	-	-	6	20
1993–94	30	2	-	-	-	-	4	16	-	-	-	-	52
1994–95	4	-	-	1	-	-	1	-	1	-	1	-	8
1995–96	11	-	4	5	-	-	4	8	2	-	-	11	45
1996–97	15	-	-	-	-	-	-	-	-	2	-	-	17
1997–98	5	3	10	6	-	4	21	9	-	-	-	3	61
1998–99	34	5	13	15	1	2	16	10	4	11	-	-	111
1999–00	7	13	9	2	-	3	11	62	7	-	-	10	124
2000–01	47	16	20	2	34	8	3	1	21	2	-	2	156
2001–02	22	-	2	-	-	-	9	11	-	-	-	-	44
2002–03	25	1	1	-	-	-	3	2	7	1	1	27	68
2003–04	8	-	3	2	-	4	5	2	-	9	23	21	77
2004–05	6	1	4	3	7	5	1	16	15	1	5	1	65
2005–06	15	1	1	-	5	10	-	4	19	8	5	13	81
2006–07	2	12	13	-	-	2	8	25	5	6	-	-	73
2007–08	15	7	-	-	1	-	1	21	5	2	5	16	73
2008–09	7	3	2	-	6	10	7	1	3	-	-	3	42
2009–10	22	4	27	25	1	3	1	2	1	-	-	2	88
2010–11	9	2	44	-	14	13	-	4	1	-	-	2	89
Total	295	70	154	67	79	67	120	195	91	46	40	117	1 341

Table B5: Total number of tows sampled for silver warehou by the observer programme by fishing year and month from the Sub Antarctic for the fishing years 1990–91 to 2010–11.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	-	-	5	3	1	-	5	-	-	-	-	14
1991–92	2	-	-	10	20	26	14	-	2	6	-	-	80
1992–93	4	-	2	-	28	82	41	8	-	-	1	2	168
1993–94	-	8	1	-	13	43	25	-	5	4	-	4	103
1994–95	-	-	-	2	54	33	5	-	-	-	-	-	94
1995–96	4	-	-	-	11	16	22	16	1	-	-	8	78
1996–97	7	-	-	11	8	9	9	-	-	-	-	-	44
1997–98	-	-	21	28	74	14	7	-	-	-	1	-	145
1998–99	-	-	10	10	76	90	22	1	-	-	-	1	210
1999–00	21	1	-	29	112	93	20	8	7	-	-	5	296
2000–01	45	-	-	88	270	160	21	3	7	-	-	22	616
2001–02	2	6	-	3	118	119	32	2	-	-	1	4	287
2002–03	4	14	1	57	72	68	36	9	12	-	-	2	275
2003–04	-	2	6	92	209	104	20	-	1	-	1	2	437
2004–05	1	2	9	71	124	91	43	6	18	-	3	-	368
2005–06	-	14	27	45	102	116	41	18	4	1	-	2	370
2006–07	1	9	10	31	126	138	75	7	-	1	-	1	399
2007–08	10	8	1	11	66	28	32	4	-	-	-	-	160
2008–09	-	3	4	1	99	18	19	16	15	9	-	-	184
2009–10	1	3	1	21	26	48	22	50	10	7	-	-	189
2010–11	3	2	4	28	21	24	11	3	23	7	-	-	126
Total	105	72	97	543	1 632	1 321	517	156	105	35	7	53	4 643

Table B6: Total number of tows sampled for silver warehou by the observer programme by fishing year and month from the West Coast South Island for the fishing years 1990–91 to 2010–11.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	-	-	-	-	-	-	-	-	48	70	9	127
1991–92	-	-	-	-	-	-	-	-	-	71	68	14	153
1992–93	-	-	-	-	-	-	-	-	-	16	52	13	81
1993–94	-	-	-	-	-	-	-	-	1	114	224	12	351
1994–95	-	-	-	-	-	1	-	-	4	61	47	12	125
1995–96	-	-	-	-	-	-	-	-	1	10	85	38	134
1996–97	-	-	-	-	-	-	-	-	-	12	80	11	103
1997–98	-	-	-	-	-	-	-	-	-	51	98	8	157
1998–99	-	-	-	-	-	-	-	-	9	112	62	2	185
1999–00	1	-	-	-	-	-	-	-	2	86	166	27	282
2000–01	12	-	-	-	-	-	-	2	-	90	159	20	283
2001–02	-	-	-	-	-	-	-	-	6	55	101	1	163
2002–03	2	-	-	-	-	-	-	-	3	56	126	27	214
2003–04	-	-	-	-	-	-	-	-	-	35	139	20	194
2004–05	-	-	-	-	-	-	-	-	-	66	57	17	140
2005–06	-	-	-	-	-	-	-	-	6	27	47	19	99
2006–07	-	-	1	-	-	-	1	-	2	27	84	5	120
2007–08	-	-	-	-	-	-	-	-	-	32	56	11	99
2008–09	1	-	-	-	-	-	-	-	5	62	14	8	90
2009–10	-	-	-	-	-	-	-	-	-	21	26	2	49
2010–11	-	-	-	-	-	-	-	-	14	11	29	6	60
Total	16	-	1	-	-	1	1	2	53	1 063	1 790	282	3 209

Table B7: Number of silver warehou measured by fishing year and month sampled from the Chatham Rise by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	62	16	51	-	-	-	-	-	-	-	-	129
1991–92	-	-	-	-	10	-	8	-	-	-	-	25	43
1992–93	101	18	30	-	-	-	-	-	-	21	115	82	367
1993–94	-	-	33	-	-	-	24	31	5	-	-	-	93
1994–95	-	-	76	216	-	-	-	-	-	-	-	25	317
1995–96	77	-	-	-	-	-	-	-	-	-	-	-	77
1996–97	70	-	-	-	-	-	2	-	-	-	-	-	72
1997–98	25	55	2	-	-	-	1	16	-	-	-	-	99
1998–99	230	94	24	6	12	-	-	-	-	-	-	-	366
1999–00	16	77	9	-	-	-	-	384	165	-	-	132	783
2000–01	259	49	10	-	-	31	-	-	13	-	-	141	503
2001–02	33	129	10	-	-	-	-	30	-	-	-	-	202
2002–03	587	140	-	-	-	110	-	-	-	12	-	5	854
2003–04	74	59	2	-	-	-	170	20	-	24	-	-	349
2004–05	20	23	2	223	170	18	-	20	60	-	-	-	536
2005–06	108	-	175	-	-	-	50	-	55	20	-	-	408
2006–07	-	40	36	238	32	15	20	21	-	110	-	-	512
2007–08	-	146	-	-	20	-	-	109	-	40	40	380	735
2008–09	90	-	-	-	-	-	3	320	-	-	-	-	413
2009–10	48	60	-	-	-	40	-	-	-	-	445	1 158	1 751
2010–11	-	250	158	-	-	-	61	-	-	-	-	216	685
Total	1 738	1 202	583	734	244	214	339	951	298	227	600	2 164	9 294

Table B8: Number of silver warehou measured by fishing year and month sampled from the East Coast South Island by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	315	-	59	79	-	-	-	26	-	-	-	-	479
1991–92	-	-	-	16	41	16	121	-	-	57	-	-	251
1992–93	-	-	-	-	-	-	524	-	-	-	-	372	896
1993–94	260	10	-	-	-	-	163	272	-	-	-	-	705
1994–95	35	-	-	51	-	-	1	-	5	-	27	-	119
1995–96	227	-	75	136	-	-	10	68	20	-	-	657	1 193
1996–97	1 049	-	-	-	-	-	-	-	-	10	-	-	1 059
1997–98	30	77	399	164	-	32	103	40	-	-	-	82	927
1998–99	606	144	239	212	42	19	135	99	12	46	-	-	1 554
1999–00	65	64	33	39	-	36	60	1 765	59	-	-	94	2 215
2000–01	607	197	108	22	652	166	16	118	639	4	-	25	2 554
2001–02	207	-	27	-	-	-	294	252	-	-	-	-	780
2002–03	321	16	6	-	-	-	192	194	71	2	1	220	1 023
2003–04	86	-	50	95	-	193	51	20	-	61	571	113	1 240
2004–05	51	24	33	20	39	13	101	343	121	5	56	5	811
2005–06	86	5	2	-	72	225	-	334	337	177	65	185	1 488
2006–07	39	451	108	-	-	15	360	730	45	224	-	-	1 972
2007–08	289	80	-	-	2	-	20	290	68	30	100	440	1 319
2008–09	329	50	113	-	60	371	89	20	181	-	-	146	1 359
2009–10	1 286	80	615	286	20	60	8	27	10	-	-	40	2 432
2010–11	410	110	3 361	-	161	250	-	134	87	-	-	30	4 543
Total	6 298	1 308	5 228	1 120	1 089	1 396	2 248	4 732	1 655	616	820	2 409	28 919

Table B9: Number of silver warehou measured by fishing year and month sampled from the Sub Antarctic by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	-	-	127	45	20	-	89	-	-	-	-	281
1991–92	171	-	-	274	146	489	190	-	8	82	-	-	1 360
1992–93	87	-	92	-	436	1 614	551	37	-	-	25	7	2 849
1993–94	-	76	9	-	230	1 150	337	-	65	45	-	163	2 075
1994–95	-	-	-	99	662	566	150	-	-	-	-	-	1 477
1995–96	54	-	-	-	83	369	728	322	8	-	-	80	1 644
1996–97	52	-	-	125	82	143	491	-	-	-	-	-	893
1997–98	-	-	1 338	1 166	2 360	265	76	-	-	-	1	-	5 206
1998–99	-	-	599	323	1 506	2 124	264	1	-	-	-	41	4 858
1999–00	734	19	-	435	1 626	1 771	588	58	181	-	-	155	5 567
2000–01	1 200	-	-	2 304	6 904	4 092	105	22	404	-	-	583	15 614
2001–02	84	136	-	50	2 536	2 299	624	7	-	-	10	152	5 898
2002–03	105	132	12	928	1 449	1 466	903	227	142	-	-	26	5 390
2003–04	-	2	66	1 319	4 261	2 298	373	-	22	-	6	5	8 352
2004–05	20	9	737	1 573	1 590	1 126	1 270	460	709	-	16	-	7 510
2005–06	-	530	987	369	961	1 770	761	520	55	19	-	35	6 007
2006–07	5	90	612	361	1 593	1 570	1 728	215	-	99	-	20	6 293
2007–08	190	100	14	195	1 291	377	600	102	-	-	-	-	2 869
2008–09	-	140	160	3	2 190	428	396	903	391	276	-	-	4 887
2009–10	10	115	14	228	368	686	316	2 462	542	253	-	-	4 994
2010–11	177	40	138	649	535	657	562	107	769	222	-	-	3 856
Total	2 889	1 389	4 778	10 528	30 854	25 280	11 013	5 532	3 296	996	58	1 267	97 880

Table B10: Number of silver warehou measured by fishing year and month sampled from the West Coast South Island by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	-	-	-	-	-	-	-	-	1 226	2 973	125	4 324
1991–92	-	-	-	-	-	-	-	-	-	1 169	1 914	297	3 380
1992–93	-	-	-	-	-	-	-	-	-	212	886	103	1 201
1993–94	-	-	-	-	-	-	-	-	16	1 768	7 015	228	9 027
1994–95	-	-	-	-	-	2	-	-	105	1 298	793	206	2 404
1995–96	-	-	-	-	-	-	-	-	10	318	2 362	1 019	3 709
1996–97	-	-	-	-	-	-	-	-	-	178	2 150	147	2 475
1997–98	-	-	-	-	-	-	-	-	-	740	1 778	105	2 623
1998–99	-	-	-	-	-	-	-	-	135	2 249	810	25	3 219
1999–00	7	-	-	-	-	-	-	-	31	892	3 227	771	4 928
2000–01	65	-	-	-	-	-	-	11	-	1 499	2 224	145	3 944
2001–02	-	-	-	-	-	-	-	-	40	327	759	49	1 175
2002–03	45	-	-	-	-	-	-	-	20	382	1 131	206	1 784
2003–04	-	-	-	-	-	-	-	-	-	326	1 489	178	1 993
2004–05	-	-	-	-	-	-	-	-	-	1 267	677	279	2 223
2005–06	-	-	-	-	-	-	-	-	71	328	363	181	943
2006–07	-	-	5	-	-	-	15	-	13	408	1 072	70	1 583
2007–08	-	-	-	-	-	-	-	-	-	614	1 531	179	2 324
2008–09	75	-	-	-	-	-	-	-	80	1 193	422	384	2 154
2009–10	-	-	-	-	-	-	-	-	-	412	824	30	1 266
2010–11	-	-	-	-	-	-	-	-	213	213	718	206	1 350
Total	192	-	5	-	-	2	15	11	734	17 019	35 118	4 933	58 029

Table B11: Number of female silver warehou gonads staged by fishing year and month sampled from the Chatham Rise by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	44	10	23	-	-	-	-	-	-	-	-	77
1991–92	-	-	-	-	9	-	5	-	-	-	-	17	31
1992–93	37	7	20	-	-	-	-	-	-	5	61	32	162
1993–94	-	-	13	-	-	-	12	16	2	-	-	-	43
1994–95	-	-	34	116	-	-	-	-	-	-	-	18	168
1995–96	42	-	-	-	-	-	-	-	-	-	-	-	42
1996–97	30	-	-	-	-	-	2	-	-	-	-	-	32
1997–98	10	30	-	-	-	-	1	9	-	-	-	-	50
1998–99	129	36	11	4	8	-	-	-	-	-	-	-	188
1999–00	6	31	3	-	-	-	-	242	100	-	-	107	489
2000–01	137	32	8	-	-	14	-	-	3	-	-	65	259
2001–02	17	83	5	-	-	-	-	14	-	-	-	-	119
2002–03	337	84	-	-	-	60	-	-	-	5	-	1	487
2003–04	53	31	1	-	-	-	98	13	-	15	-	-	211
2004–05	11	15	1	149	95	9	-	14	37	-	-	-	331
2005–06	59	-	83	-	-	-	35	-	46	15	-	-	238
2006–07	-	24	22	117	18	10	7	16	-	77	-	-	291
2007–08	-	87	-	-	14	-	-	72	-	22	19	178	392
2008–09	57	-	-	-	-	-	1	176	-	-	-	-	234
2009–10	29	39	-	-	-	36	-	-	-	-	188	488	780
2010–11	-	135	85	-	-	-	50	-	-	-	-	145	415
Total	954	678	296	409	144	129	211	572	188	139	268	1 051	5 039

Table B12: Number of female silver warehou gonads staged by fishing year and month sampled from the East Coast South Island by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	69	-	27	35	-	-	-	10	-	-	-	-	141
1991–92	-	-	-	-	14	7	72	-	-	40	-	-	133
1992–93	-	-	-	-	-	-	263	-	-	-	-	141	404
1993–94	110	1	-	-	-	-	86	96	-	-	-	-	293
1994–95	15	-	-	15	-	-	-	-	5	-	7	-	42
1995–96	106	-	32	52	-	-	5	29	11	-	-	440	675
1996–97	422	-	-	-	-	-	-	-	-	6	-	-	428
1997–98	16	33	144	61	-	20	40	16	-	-	-	44	374
1998–99	348	38	91	73	19	2	64	60	6	28	-	-	729
1999–00	23	16	9	14	-	13	25	1 010	38	-	-	22	1 170
2000–01	194	76	23	6	173	90	10	69	411	3	-	8	1 063
2001–02	97	-	4	-	-	-	154	88	-	-	-	-	343
2002–03	127	6	1	-	-	-	88	111	43	1	-	117	494
2003–04	50	-	29	32	-	87	32	8	-	39	372	62	711
2004–05	32	6	16	13	18	9	50	167	67	2	36	5	421
2005–06	28	1	2	-	39	95	-	156	215	145	38	86	805
2006–07	18	172	49	-	-	10	190	399	24	102	-	-	964
2007–08	153	25	-	-	2	-	13	180	42	12	65	304	796
2008–09	189	8	15	-	41	196	54	11	108	-	-	110	732
2009–10	584	33	341	155	10	33	1	14	8	-	-	12	1 191
2010–11	171	43	1 506	-	93	143	-	88	45	-	-	23	2 112
Total	2 752	458	2 289	456	409	705	1 147	2 512	1 023	378	518	1 374	14 021

Table B13: Number of female silver warehou gonads staged by fishing year and month sampled from the Sub Antarctic by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	-	-	65	21	6	-	34	-	-	-	-	126
1991–92	112	-	-	139	63	236	90	-	7	36	-	-	683
1992–93	54	-	33	-	246	839	283	22	-	-	13	6	1 496
1993–94	-	40	2	-	85	628	159	-	33	16	-	84	1 047
1994–95	-	-	-	47	352	261	45	-	-	-	-	-	705
1995–96	26	-	-	-	35	157	363	162	6	-	-	26	775
1996–97	27	-	-	41	53	78	218	-	-	-	-	-	417
1997–98	-	-	708	601	1 291	141	36	-	-	-	1	-	2 778
1998–99	-	-	332	192	792	1 087	132	-	-	-	-	21	2 556
1999–00	418	9	-	218	1 040	1 032	307	46	93	-	-	70	3 233
2000–01	646	-	-	1 087	3 236	2 181	55	8	230	-	-	253	7 696
2001–02	59	83	-	24	1 319	1 246	353	3	-	-	4	81	3 172
2002–03	54	70	7	465	763	969	507	115	66	-	-	11	3 027
2003–04	-	2	42	721	2 321	1 228	207	-	17	-	3	4	4 545
2004–05	16	3	344	823	873	603	682	247	406	-	9	-	4 006
2005–06	-	281	531	196	533	927	442	295	40	14	-	21	3 280
2006–07	3	43	334	172	760	854	950	112	-	60	-	10	3 298
2007–08	80	48	9	100	624	184	317	57	-	-	-	-	1 419
2008–09	-	67	90	1	1 207	240	224	469	211	158	-	-	2 667
2009–10	5	57	9	140	188	390	185	1 384	305	146	-	-	2 809
2010–11	110	21	87	357	284	346	318	70	430	128	-	-	2 151
Total	1 610	724	2 528	5 389	16 086	13 633	5 873	3 024	1 844	558	30	587	51 886

Table B14: Number of female silver warehou gonads staged by fishing year and month sampled from the West Coast South Island by the observer programme, for fishing years 1991–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990–91	-	-	-	-	-	-	-	-	-	459	1 383	43	1 885
1991–92	-	-	-	-	-	-	-	-	-	603	1 133	118	1 854
1992–93	-	-	-	-	-	-	-	-	-	94	519	46	659
1993–94	-	-	-	-	-	-	-	-	3	893	4 546	137	5 579
1994–95	-	-	-	-	-	1	-	-	49	674	391	112	1 227
1995–96	-	-	-	-	-	-	-	-	2	139	1 305	533	1 979
1996–97	-	-	-	-	-	-	-	-	-	94	1 303	48	1 445
1997–98	-	-	-	-	-	-	-	-	-	417	1 072	51	1 540
1998–99	-	-	-	-	-	-	-	-	57	1 117	446	3	1 623
1999–00	4	-	-	-	-	-	-	-	13	475	1 964	375	2 831
2000–01	32	-	-	-	-	-	-	4	-	772	1 260	78	2 146
2001–02	-	-	-	-	-	-	-	-	14	167	356	12	549
2002–03	20	-	-	-	-	-	-	-	11	220	556	97	904
2003–04	-	-	-	-	-	-	-	-	-	187	793	76	1 056
2004–05	-	-	-	-	-	-	-	-	-	717	387	152	1 256
2005–06	-	-	-	-	-	-	-	-	42	166	207	101	516
2006–07	-	-	5	-	-	-	8	-	6	201	663	52	935
2007–08	-	-	-	-	-	-	-	-	-	406	778	64	1 248
2008–09	35	-	-	-	-	-	-	-	52	629	260	198	1 174
2009–10	-	-	-	-	-	-	-	-	-	271	476	13	760
2010–11	-	-	-	-	-	-	-	-	121	139	482	129	871
Total	91	-	5	-	-	1	8	4	370	8 840	20 280	2 438	32 037

Table B15: Calculated number-at-age, separately by sex, with CVs, for silver warehou caught during commercial trawl operations on Chatham Rise during the 2004–05 and 2009–10 fishing years. Summary statistics for the samples are also presented (Horn et al. 2012).

	2004–05				2009–10				
Age	Male	CV	Female	CV	Age	Male	CV	Female	CV
1	46 410	1.154	41 898	1.270	1	3 857	1.059	526	2.329
2	144 712	0.610	151 056	0.633	2	41 748	0.557	25 812	0.520
3	213 571	0.499	187 004	0.404	3	118 744	0.332	50 833	0.330
4	202 484	0.234	312 575	0.238	4	330 544	0.240	169 932	0.180
5	82 549	0.293	115 264	0.203	5	108 833	0.232	62 717	0.272
6	45 648	0.359	67 382	0.216	6	122 659	0.228	84 474	0.209
7	45 780	0.291	60 411	0.216	7	76 732	0.248	48 401	0.236
8	31 468	0.385	20 558	0.357	8	83 963	0.376	31 354	0.280
9	25 636	0.406	30 555	0.271	9	44 911	0.343	52 787	0.266
10	19 030	0.385	34 864	0.312	10	49 663	0.364	50 432	0.216
11	23 505	0.373	17 422	0.359	11	20 650	0.478	24 895	0.338
12	10 684	0.447	16 860	0.314	12	1 235	1.054	6 774	0.500
13	27 473	0.341	25 802	0.327	13	7 096	0.690	2 610	0.783
14	14 297	0.436	13 340	0.416	14	2 366	1.142	2 132	1.047
15	4 243	1.132	22 172	0.315	15	0	–	0	–
16	6 085	0.510	7 648	0.453	16	0	–	0	–
17	3 305	1.109	1 607	0.818	17	0	–	0	–
18	5 645	0.831	2 381	0.899	18	2 365	1.128	0	–
19	3 456	0.680	1 551	1.176	19	0	–	817	1.276
20	0	–	1 884	1.844	20	0	–	0	–
21	0	–	0	–	21	0	–	0	–
22	0	–	2 065	0.709	22	0	–	0	–
23	0	–	0	–	23	0	–	0	–
24	0	–	47	1.856	24	0	–	0	–
No. measured males			598						2 158
No. measured females			765						1 958
No. aged males			222						235
No. aged females			307						276
No. of tows sampled			127						125
Mean weighted CV (sexes pooled)			34.9						20.0

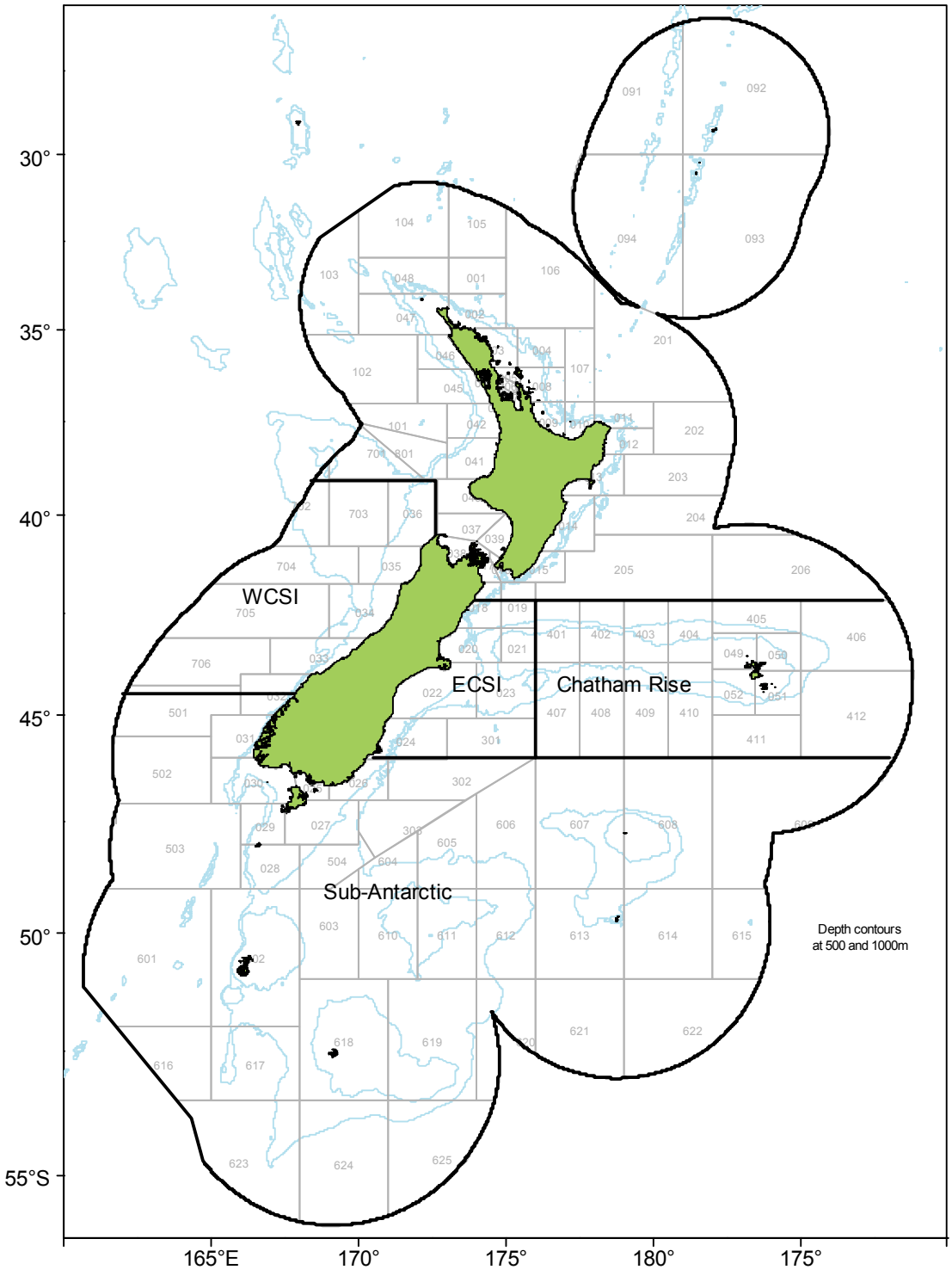


Figure B1: Area boundaries for analysis of observer data.

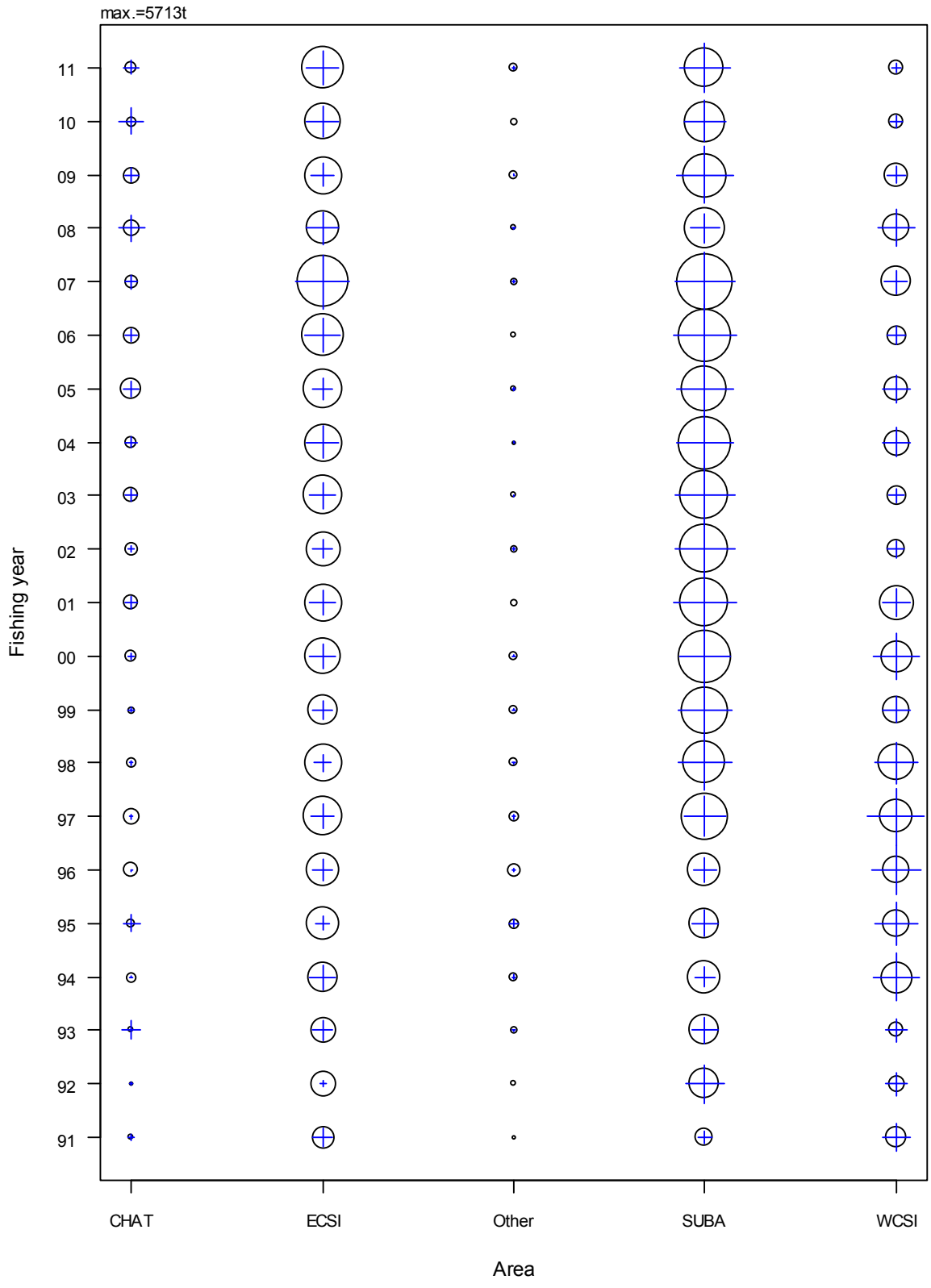


Figure B2: Representativeness of observer sampling of silver warehou catch by fishing year and area for fishing years 1991–2011. Circles show the proportion of silver warehou catch by area within a fishing year; crosses show the proportion of observed silver warehou catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter. CHAT= Chatham Rise, ECSI= East Coast South Island, SUBA=Sub Antarctic, WCSI= West Coast South Island.

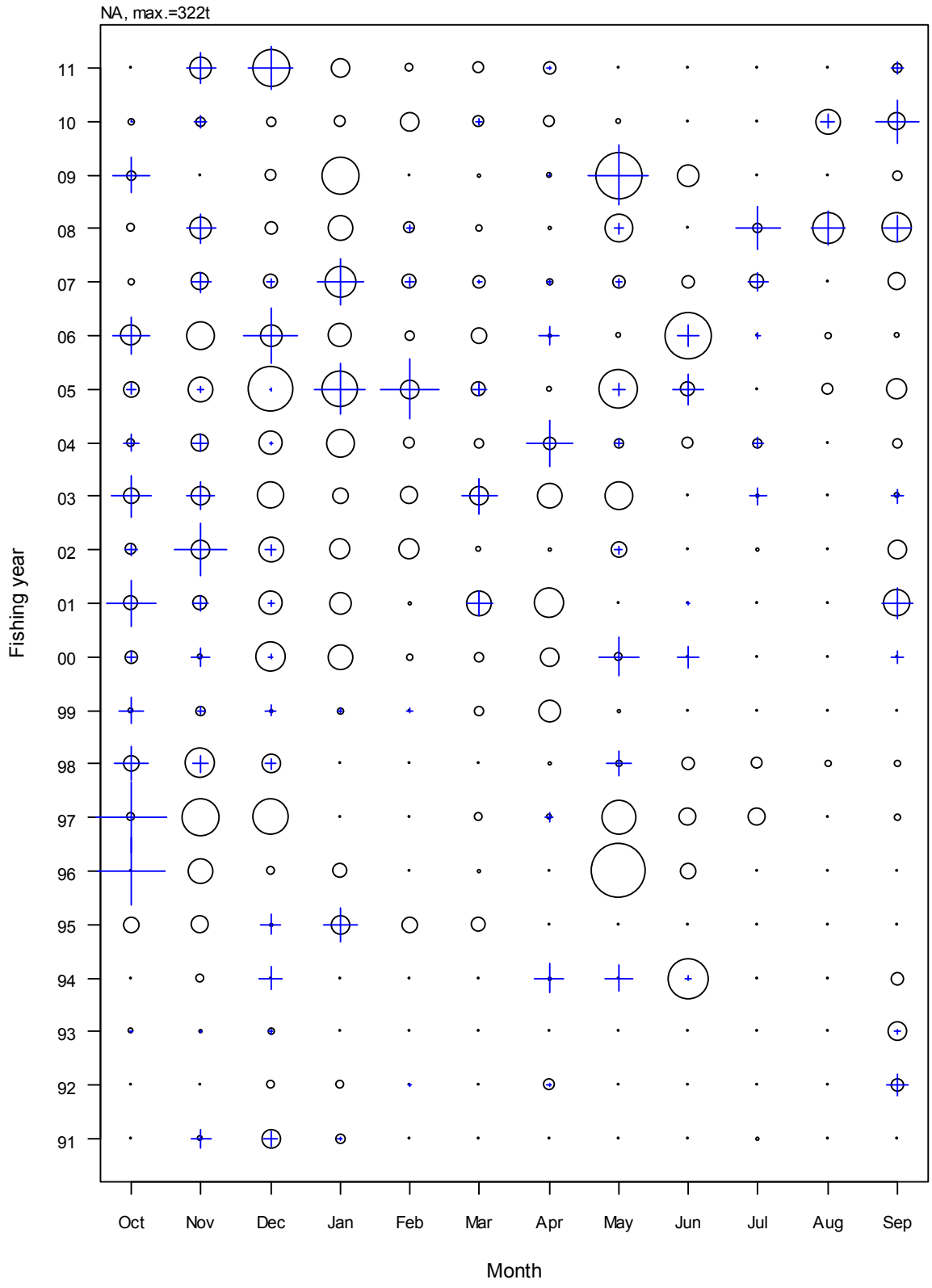


Figure B3: Representativeness of observer sampling of silver warehou catch by fishing year and month for the Chatham Rise for fishing years 1991–2011. Circles show the proportion of silver warehou catch by area within a fishing year; crosses show the proportion of observed silver warehou catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

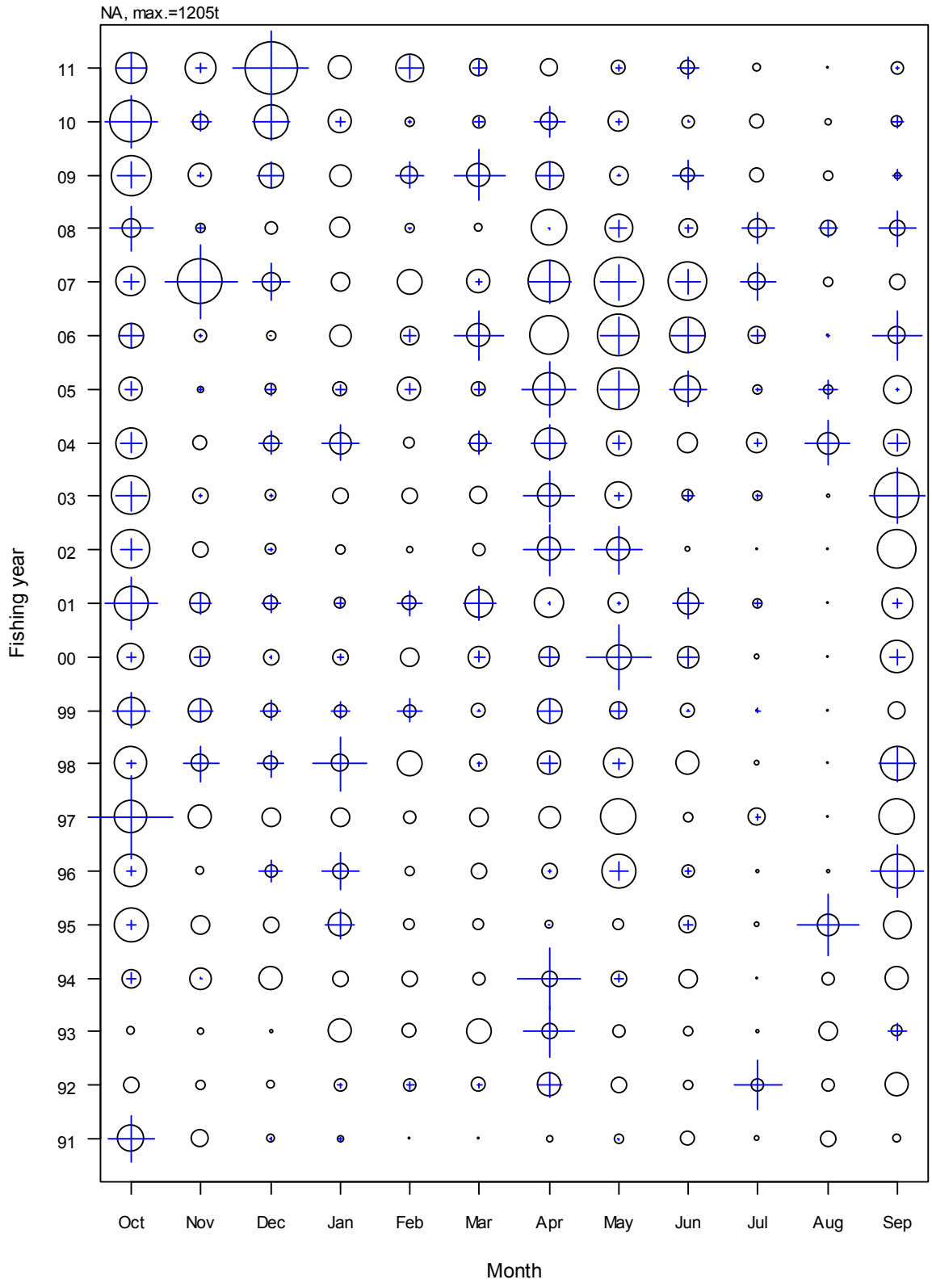


Figure B4: Representativeness of observer sampling of silver warehou catch by fishing year and month for the East Coast South Island for fishing years 1991–2011. Circles show the proportion of silver warehou catch by area within a fishing year; crosses show the proportion of observed silver warehou catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

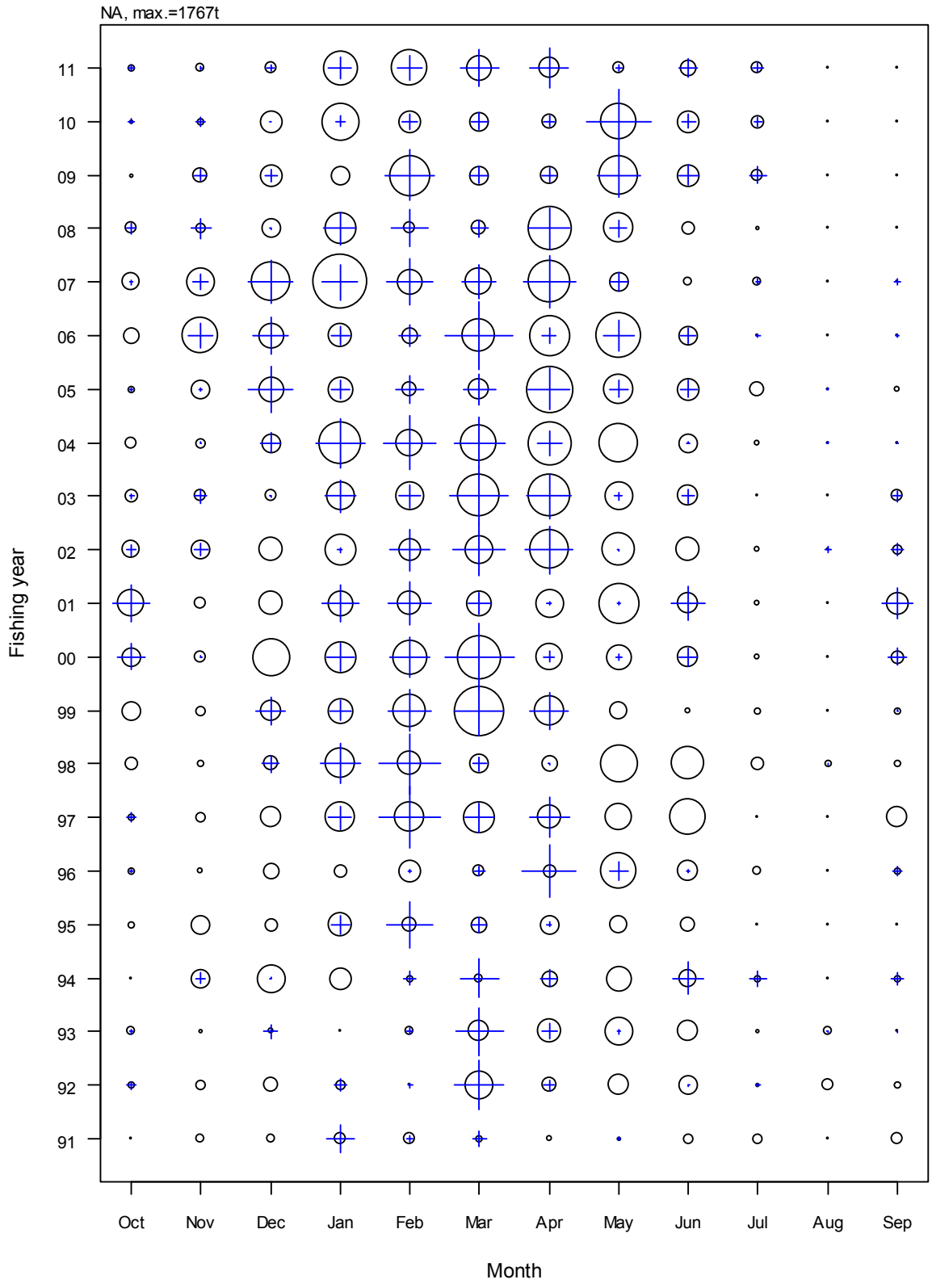


Figure B5: Representativeness of observer sampling of silver warehou catch by fishing year and month for the Sub Antarctic for fishing years 1991–2011. Circles show the proportion of silver warehou catch by area within a fishing year; crosses show the proportion of observed silver warehou catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

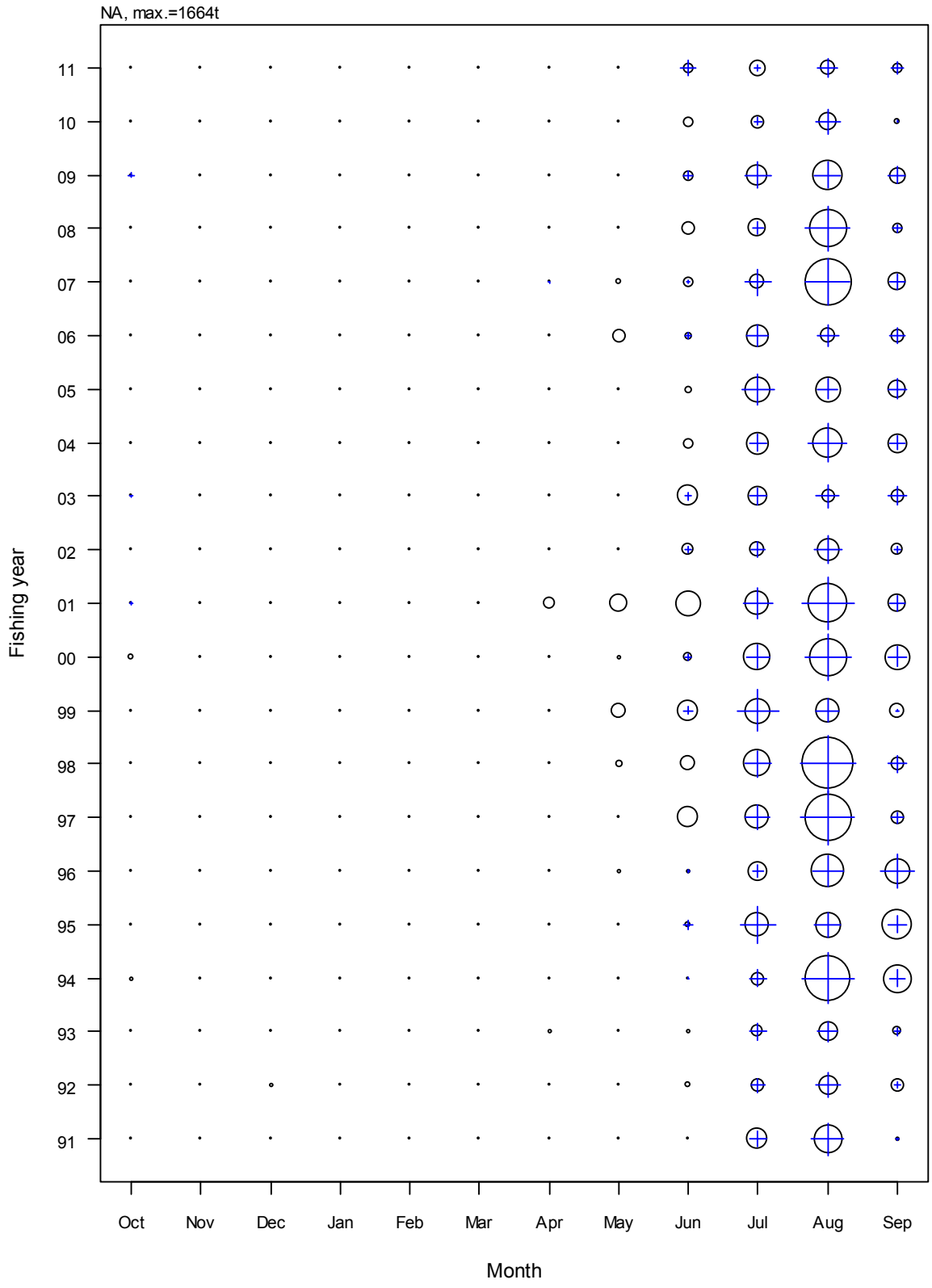


Figure B6: Representativeness of observer sampling of silver warehou catch by fishing year and month for the West Coast South Island for fishing years 1991–2011. Circles show the proportion of silver warehou catch by area within a fishing year; crosses show the proportion of observed silver warehou catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

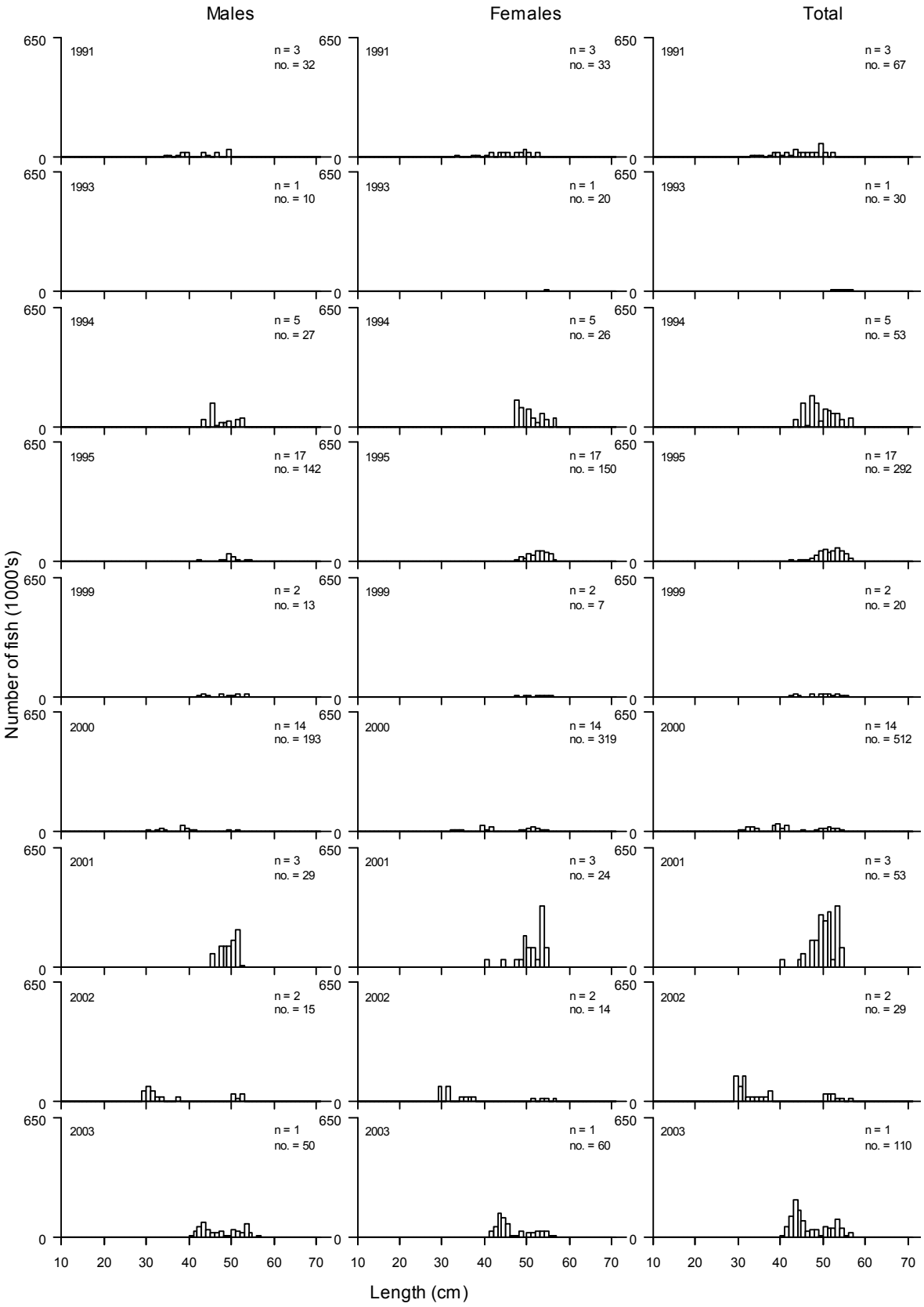


Figure B7: Scaled length frequency distributions of silver warehou taken in commercial catches from the Chatham Rise fishery sampled by the Observer Programme, for fishing years 1991–2011. n, number of tows sampled; no., number of fish sampled.

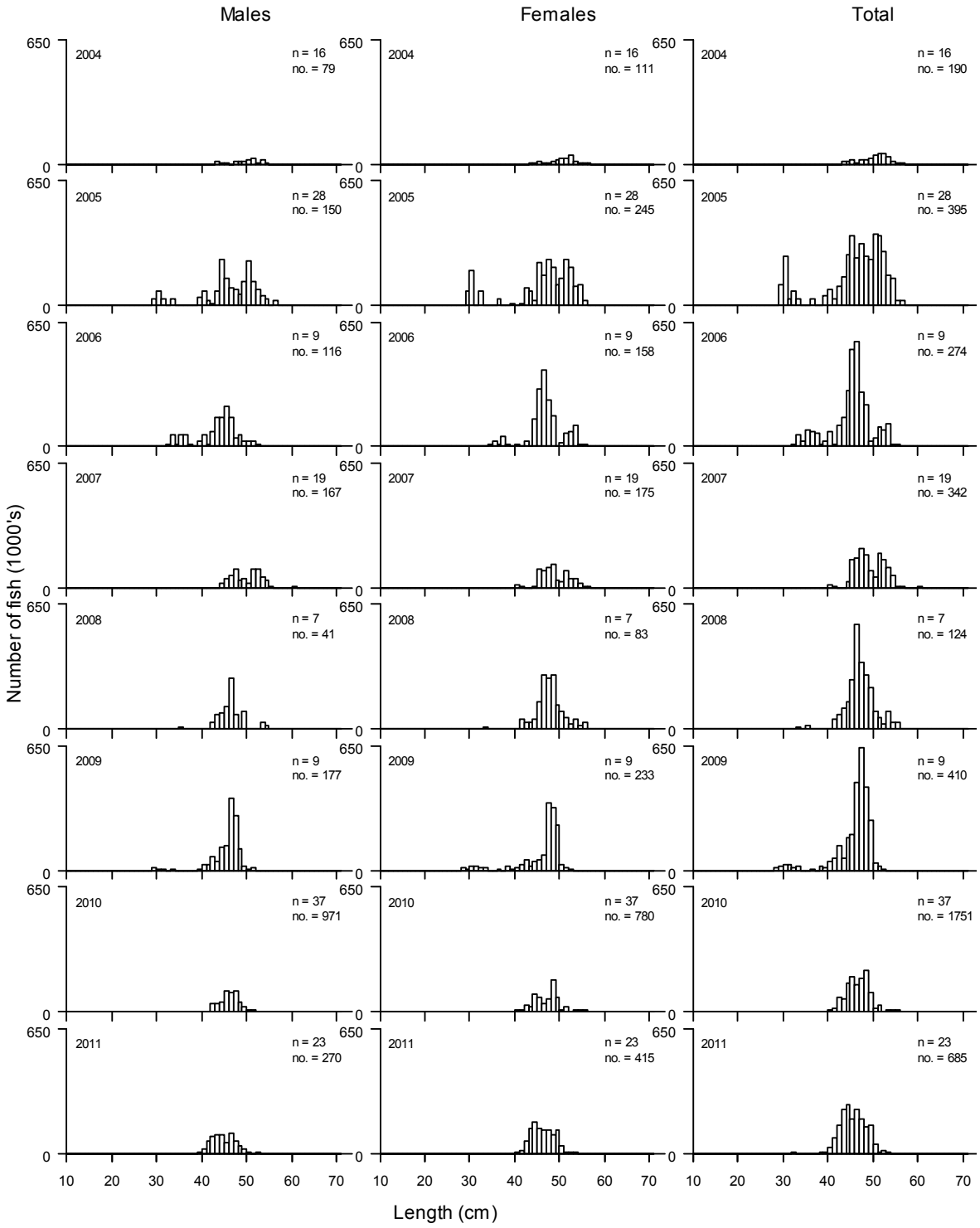


Figure B7: (Continued).

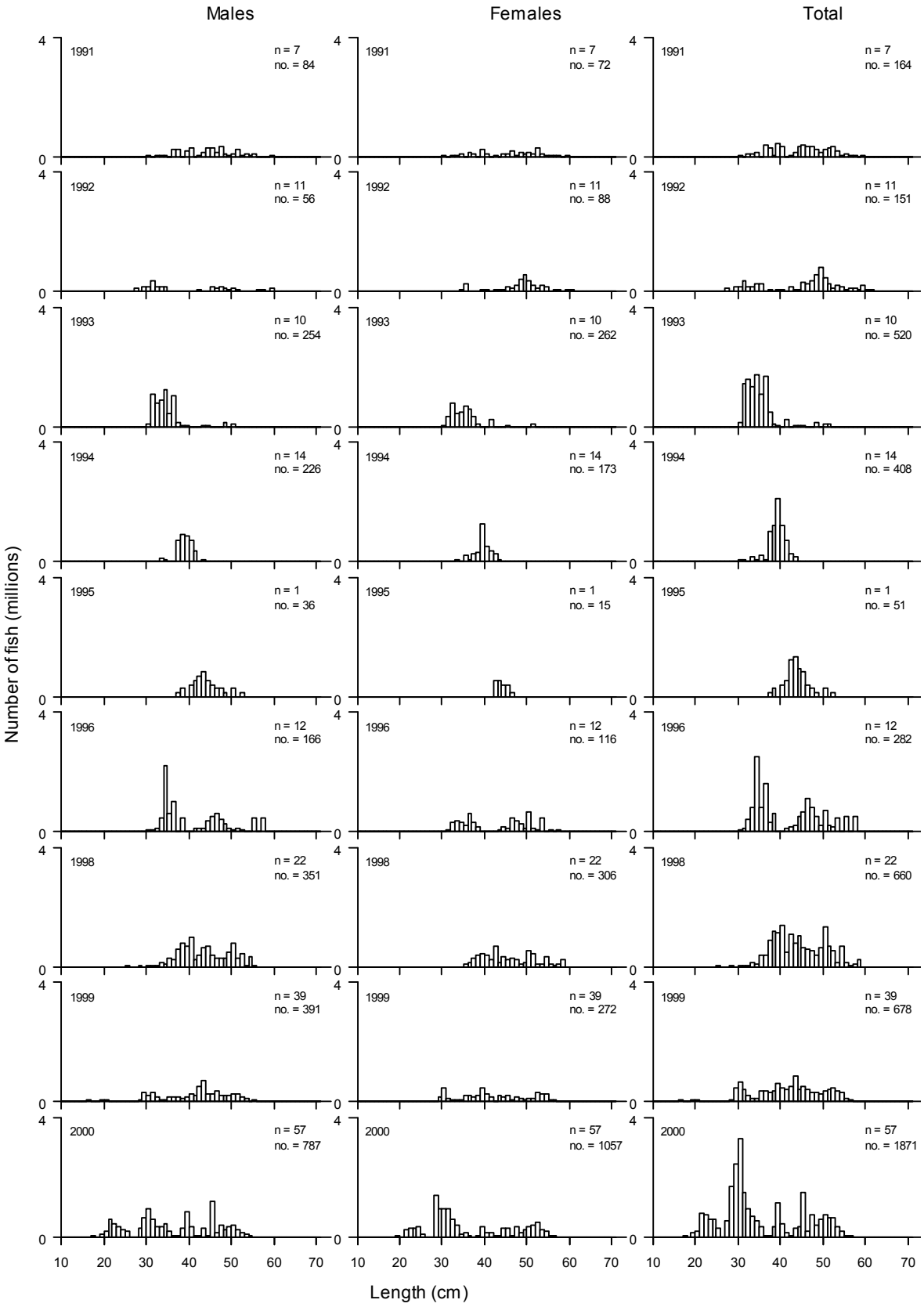


Figure B8: Scaled length frequency distributions of silver warehou taken in commercial catches from the East Coast South Island fishery sampled by the Observer Programme, for fishing years 1991–2011. n, number of tows sampled; no., number of fish sampled.

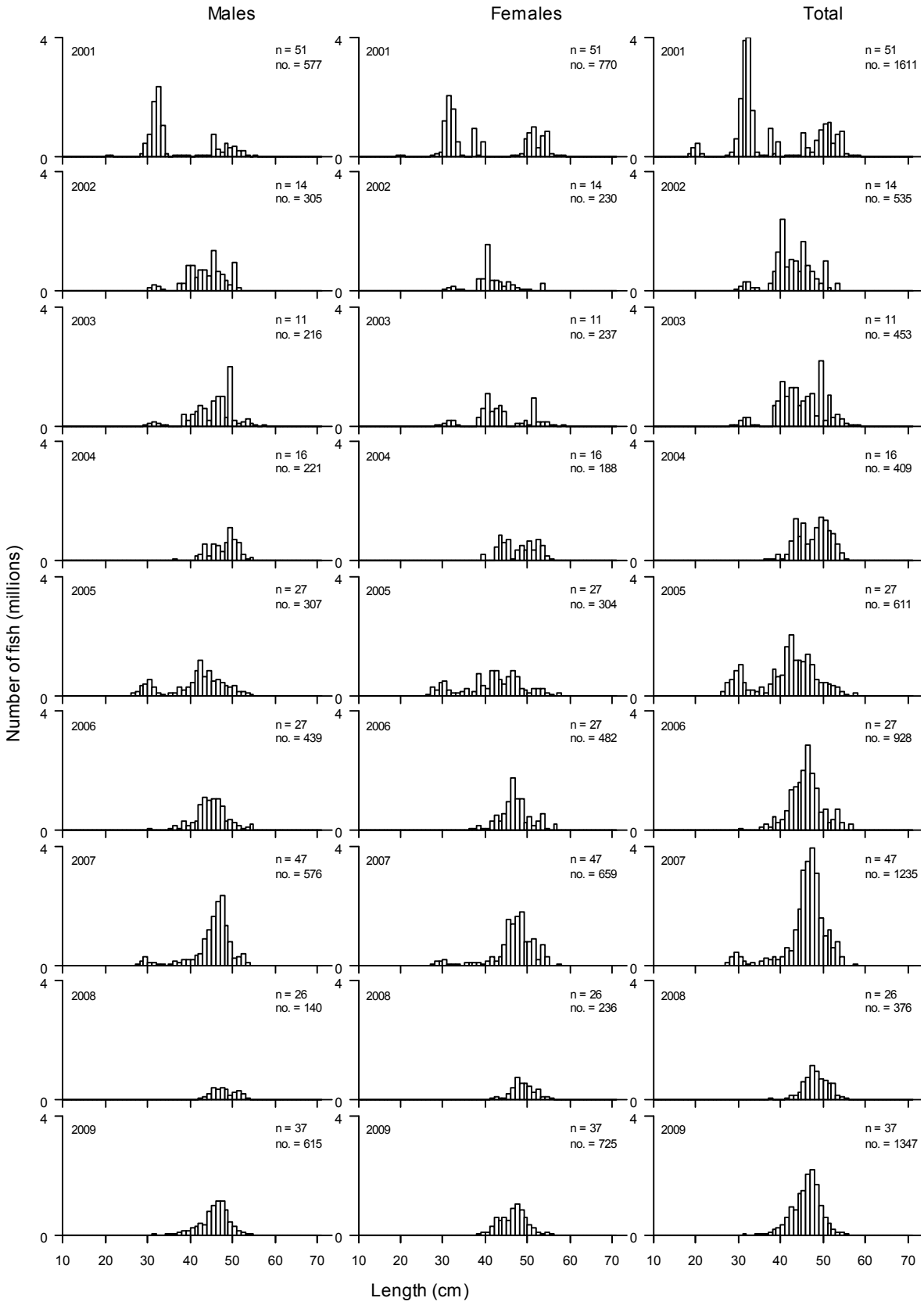


Figure B8: (Continued).

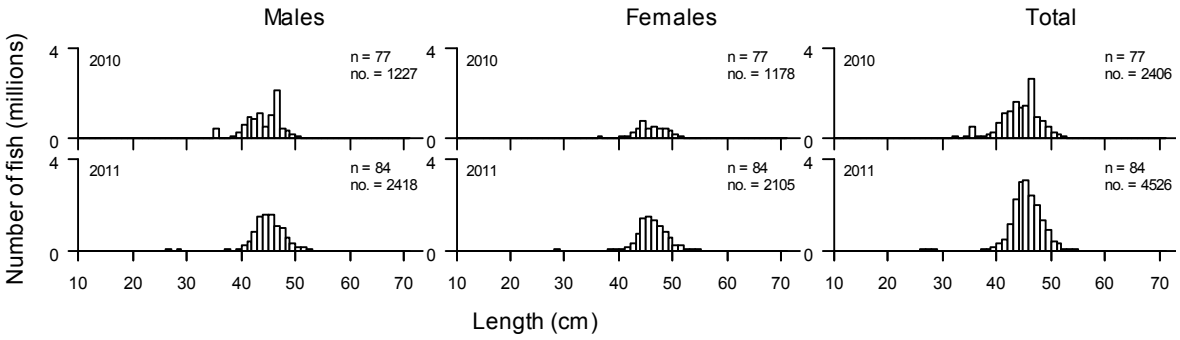


Figure B8: (Continued).

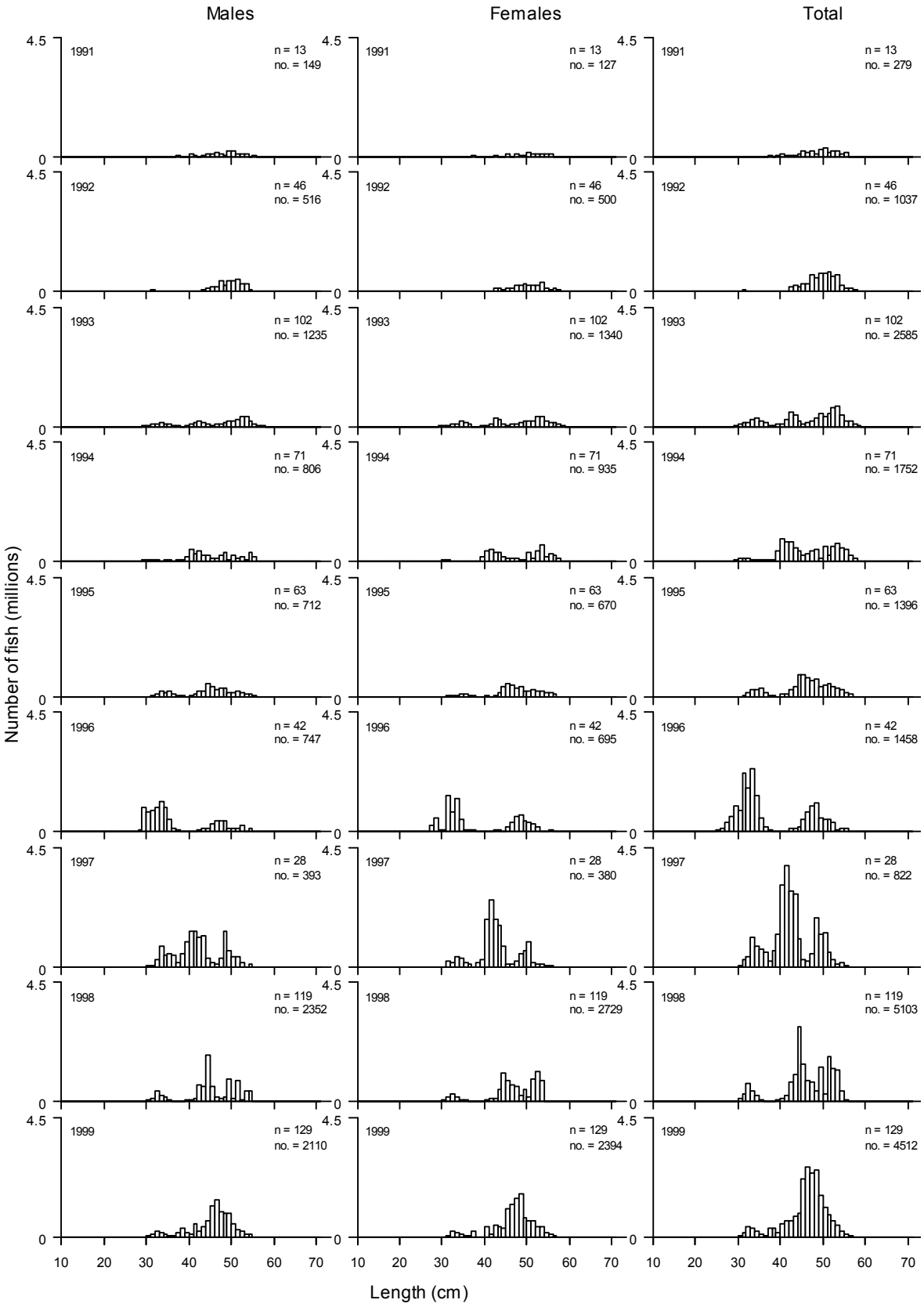


Figure B9: Scaled length frequency distributions of silver warehou taken in commercial catches from the Sub Antarctic fishery sampled by the Observer Programme, for fishing years 1991–2011. n, number of tows sampled; no., number of fish sampled.

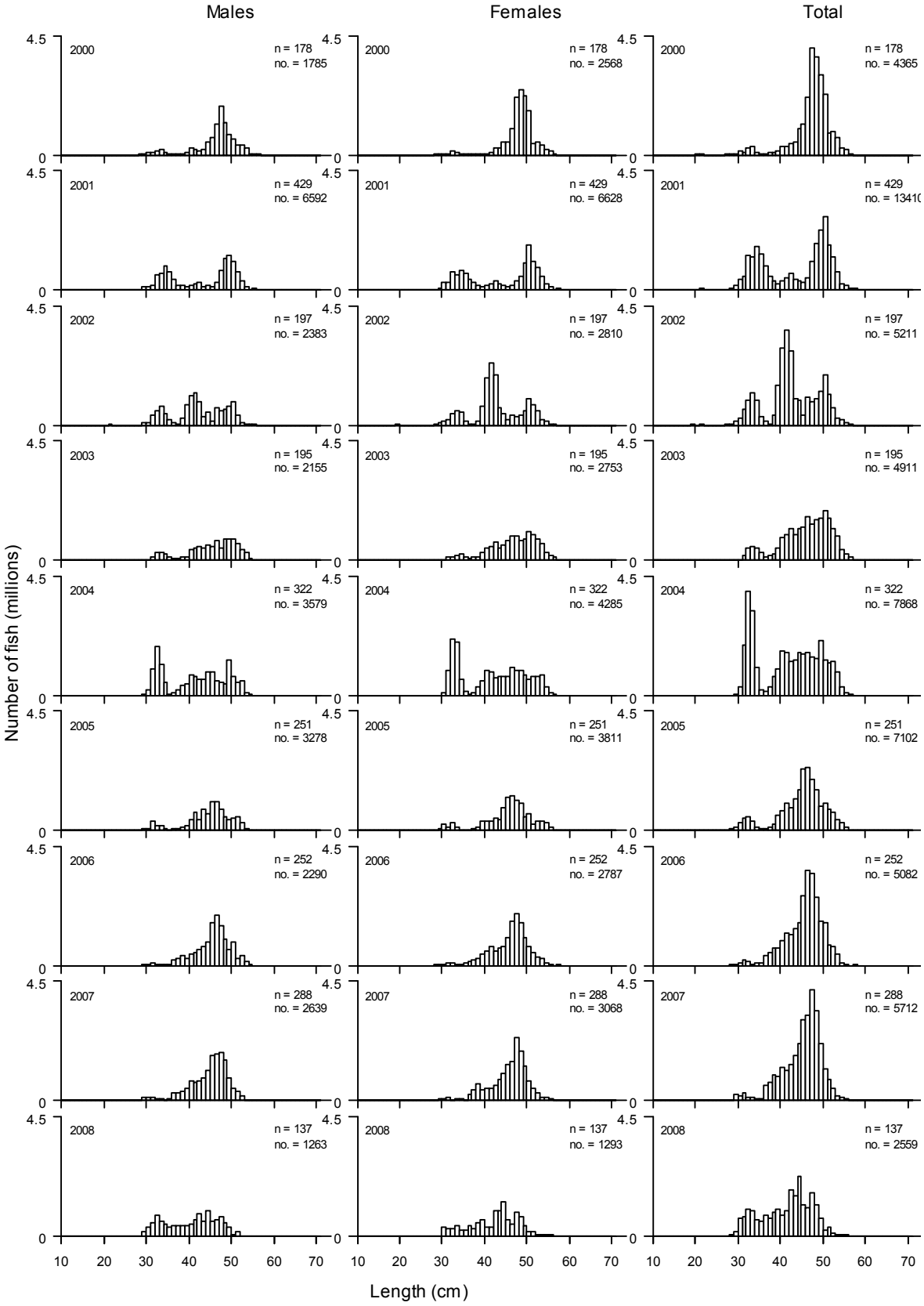


Figure B9: (Continued).

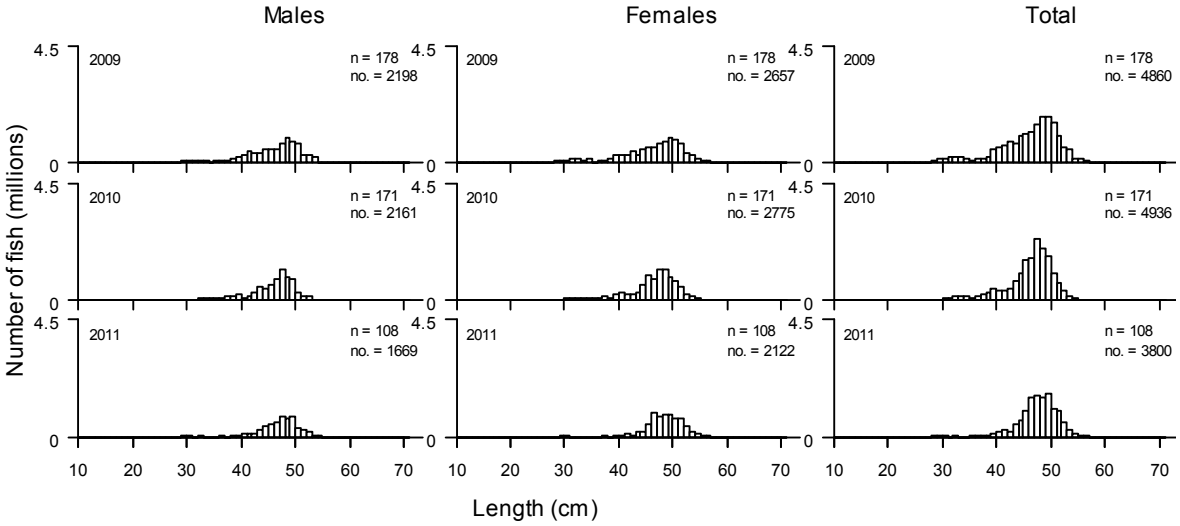


Figure B9: (Continued).

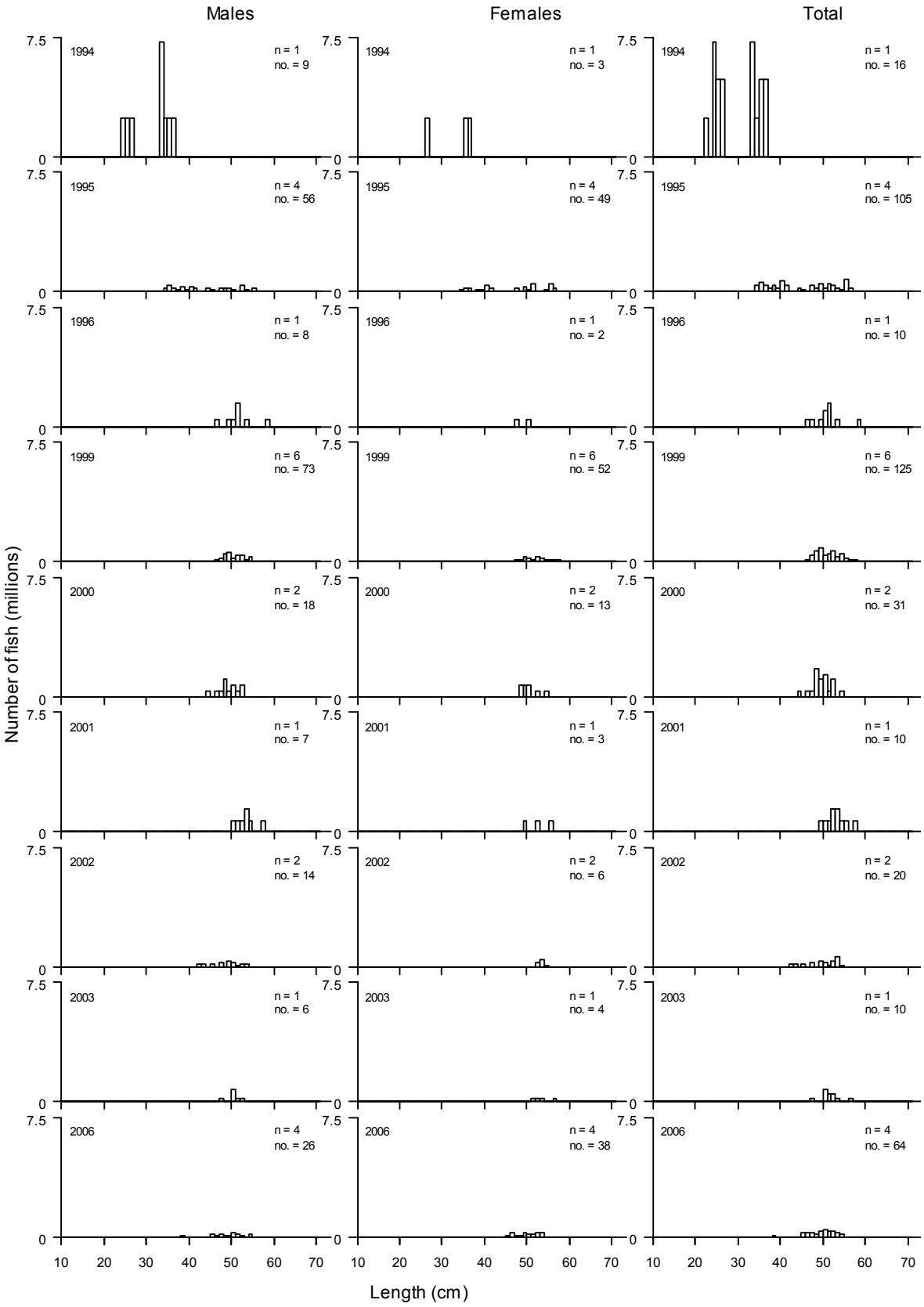


Figure B10: Scaled length frequency distributions of silver warehou taken in commercial catches from the West Coast South Island fishery sampled by the Observer Programme, for fishing years 1991–2011. n, number of tows sampled; no., number of fish sampled.

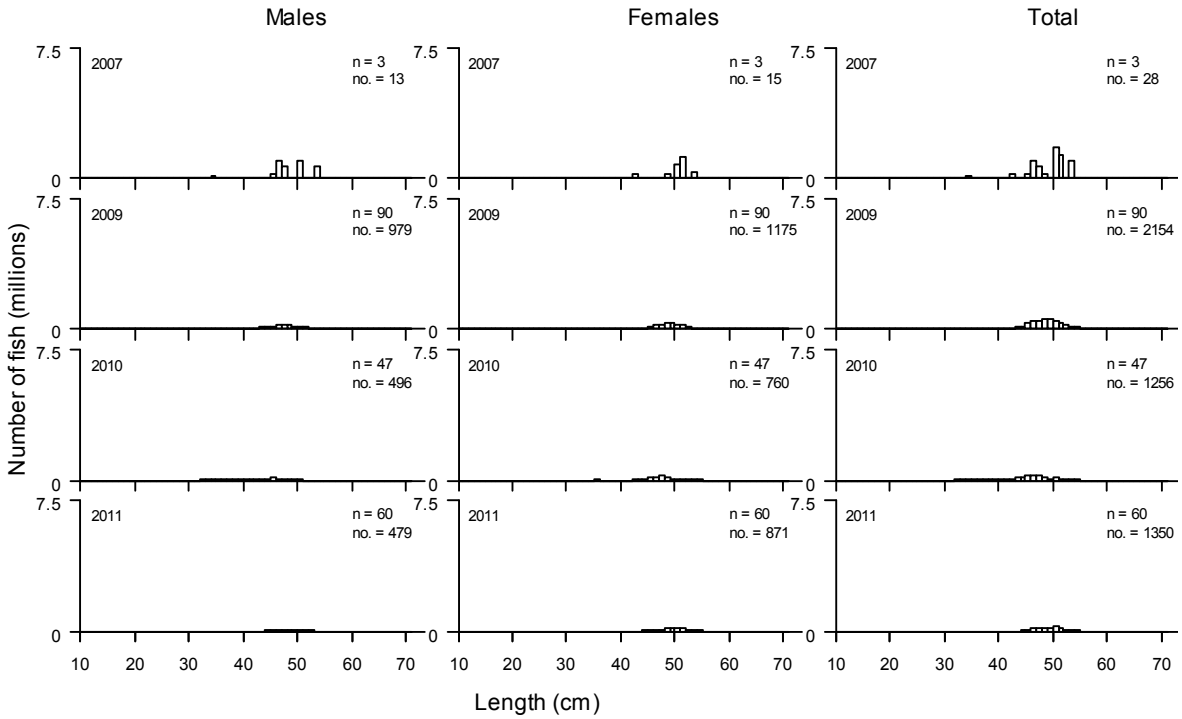


Figure B10: (Continued).

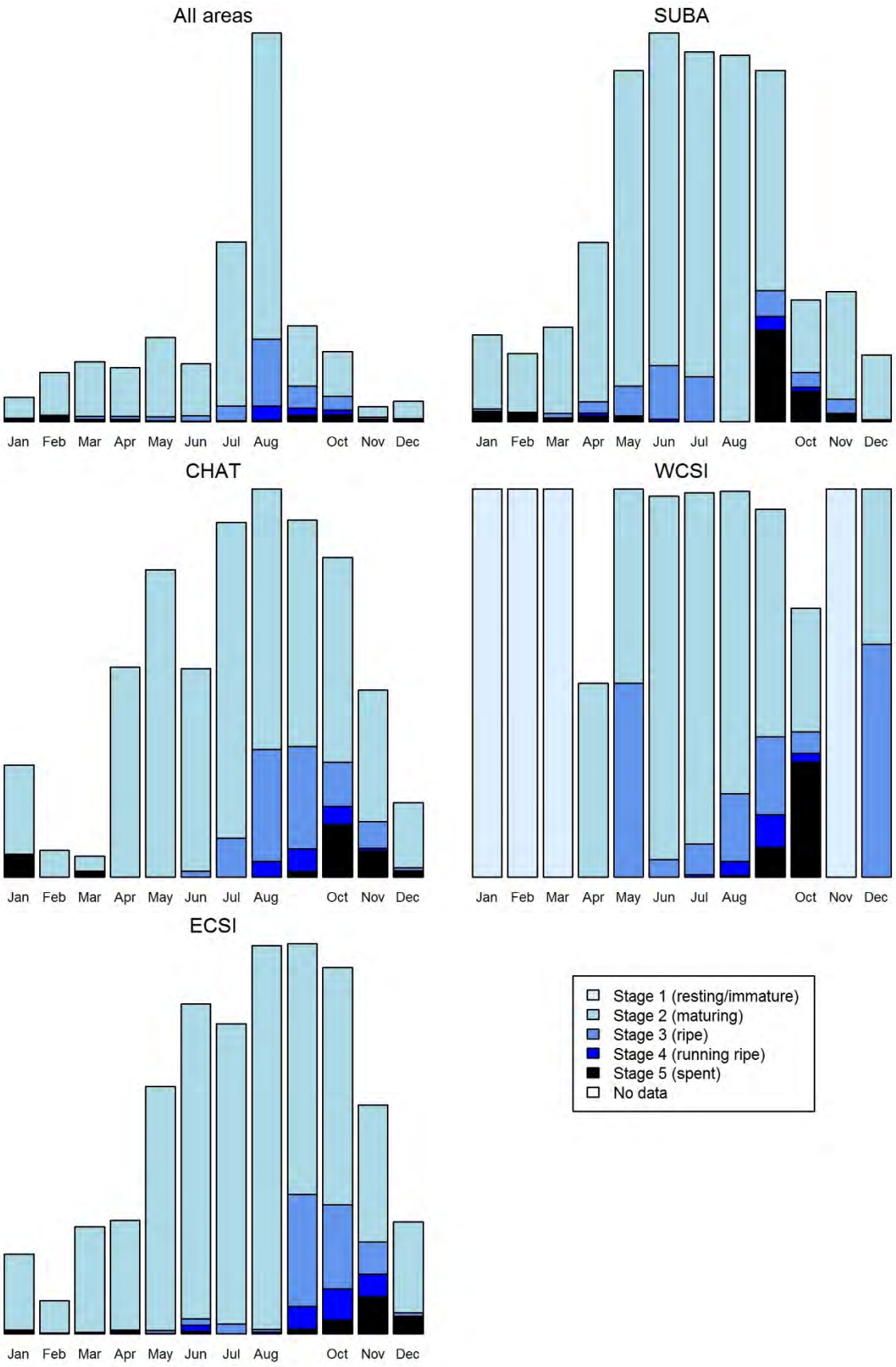


Figure B11: Gonad stages of female silver warehou taken in commercial catches and sampled by the Observer Programme, by month and area for fishing years 1991–2011. Stages are: 1, resting/immature; 2, maturing; 3, ripe; 4, running ripe 5, spent. The numbers of observations for each area are given in Tables B11–14.

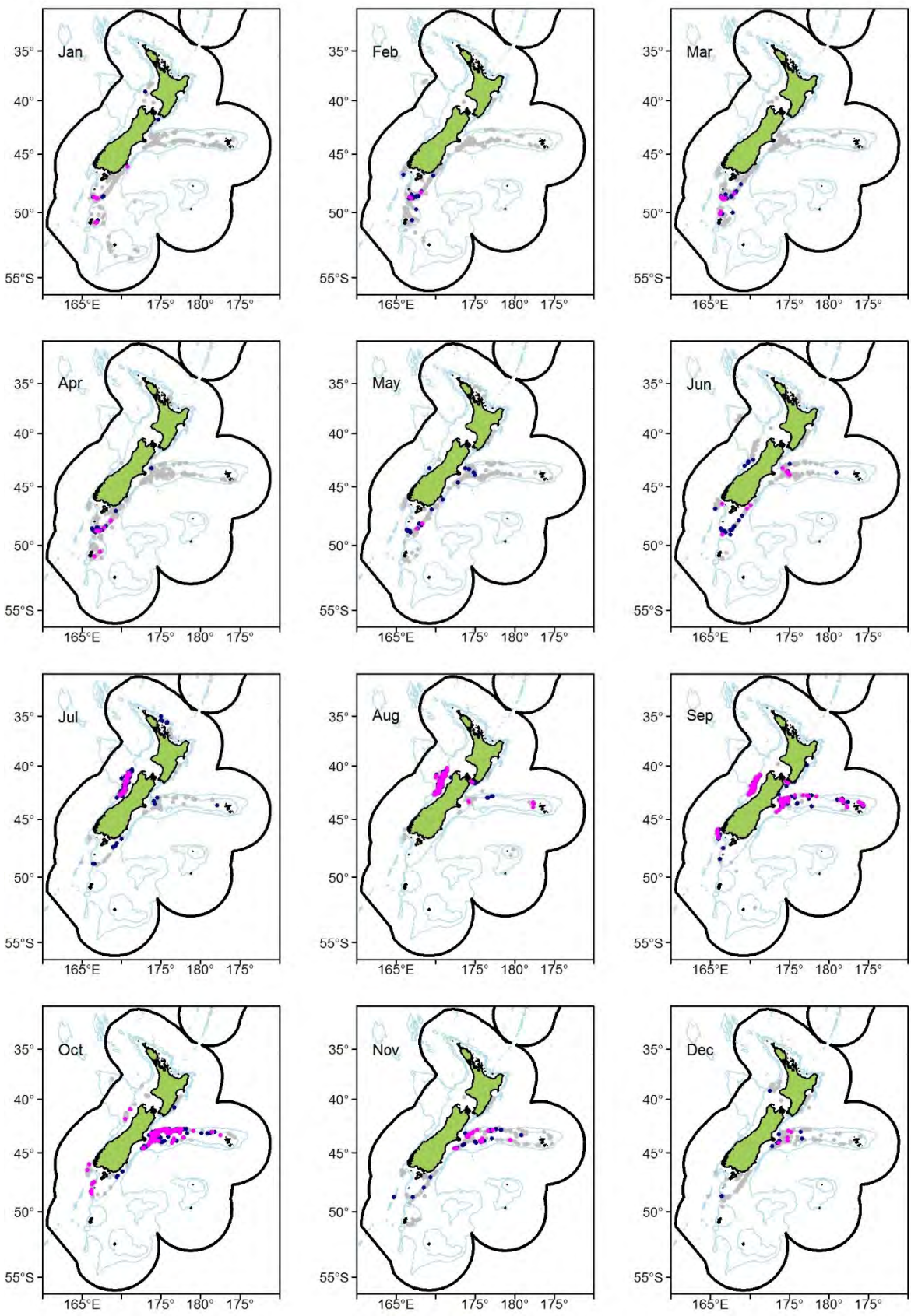


Figure B12: Locations of observed silver warehou catches by month for all years combined. Grey dots=immature/resting, maturing and spent fish; blue dots=ripe fish; pink dots=running ripe fish.

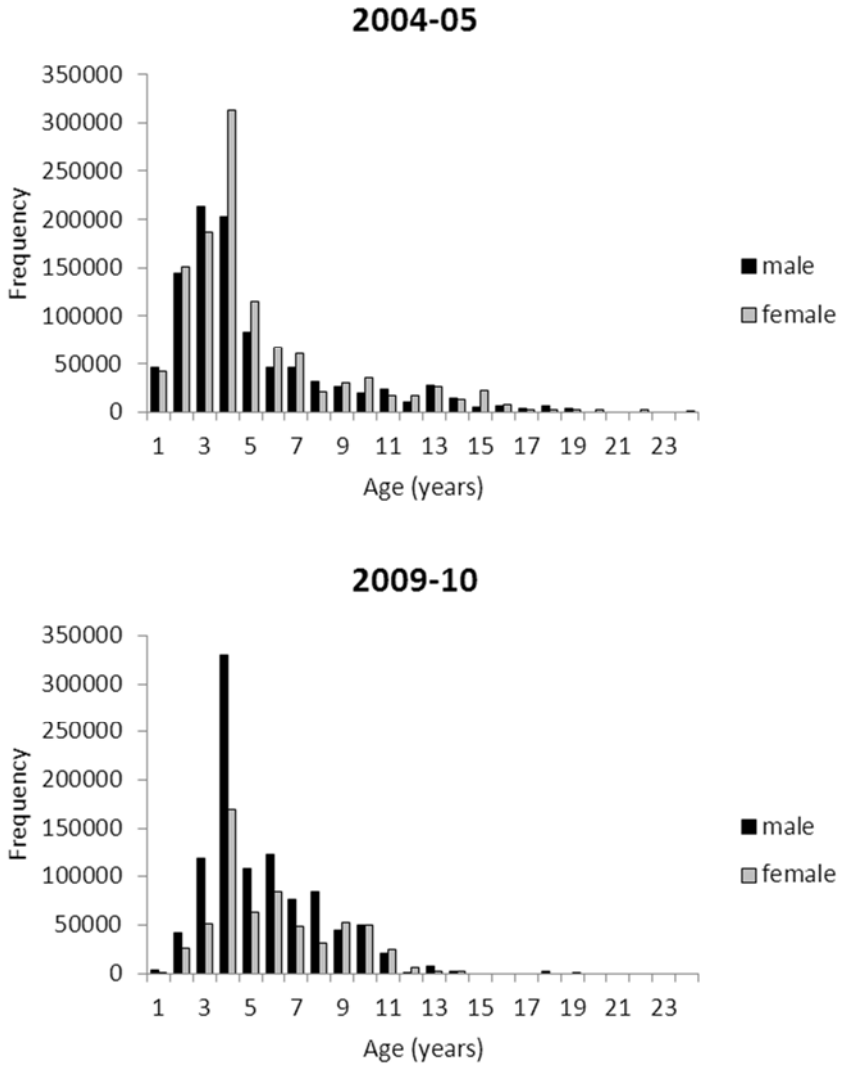


Figure B13: Silver warehou — commercial catch-at-age distributions for the Chatham Rise trawl fishery, 2004–05 and 2009–10 (Horn 2012).

APPENDIX C: SUMMARIES OF CATCH AND EFFORT DATA GROOMING

Table C1: List of tables and fields requested in the Ministry of Fisheries extract 8527.

Fishing_events table

Event_Key	Effort_seqno	Bottom_depth
Version_seqno	Effort_total_num	Column_a
DCF_key	Effort_width	Column_b
Start_datetime	Effort_speed	Column_c
End_datetime	Total_net_length	Column_d
Primary_method	Total_hook_num	Display_fishyear
Target_species	Set_end_datetime	Start_stats_area_code
Fishing_duration	Haul_start_datetime	Vessel_key
Catch_weight	Start_latitude (full accuracy)	Form_type
Effort_depth	Start_longitude (full accuracy)	Trip
Effort_height	End_latitude (full accuracy)	Literal_yn
Effort_num	End_longitude (full accuracy)	Interp_yn
Effort_num_2	Pair_trawl_yn	Resrch_yn

Landing_events table

Event_Key	Destination_type	Form_type
Version_seqno	Unit_type	Trip_key
DCF_key	Unit_num	Trip_start_datetime
Landing_datetime	Unit_weight	Trip_end_datetime
Landing_name	Conv_factor	Vessel_key
Species_code	Green_weight	Form_type
Species_name	Green_weight_type	Literal_yn
Fishstock_code (ALL fish stocks)	Processed_weight	Interp_yn
State_code	Processed_weight_type	Resrch_yn

Estimated subcatch table

Event_Key	Species_code (ALL species for each	Literal_yn
Version_seqno	fishing event)	Interp_yn
DCF_key	Catch_weight	Resrch_yn

Process data table

Event_Key	Unit_type	Processed_weight_type
Version_seqno	Unit_num	Vessel_key
DCF_key	Unit_weight	Form_type
Spec_prod_action_type	Conv_factor	Trip_key
Processed_datatime	Green_weight	Literal_yn
Species_code	Green_weight_type	Interp_yn
State_code	Processed_weight	Resrch_yn

Vessel_history table

Vessel_key	Gross_tonnes
Flag_nationality_code	Overall_length_metres
Built_year	History_start_datetime
Engine_kilowatts	History_end_datetime

Table C2: Number of landing events by major destination code and form type for SWA 1, 3 and 4 from fishing years 1991-2011. L= landed in NZ; T= transferred to another vessel; R= retained on board.

SWA1

	CLR form			CELR form			
	L	T	R	L	T	R	Total
1991	180	91	156	189	-	-	669
1992	183	77	98	263	-	-	649
1993	258	85	80	340	1	-	805
1994	354	90	107	334	-	2	972
1995	437	108	49	369	-	-	1 031
1996	573	88	36	325	-	-	1 076
1997	764	73	55	380	-	-	1 339
1998	733	41	41	263	-	1	1 158
1999	598	18	41	223	-	1	956
2000	590	5	58	250	-	-	975
2001	675	21	43	252	-	2	1 085
2002	676	11	33	188	-	-	992
2003	602	-	33	210	-	-	919
2004	544	-	27	202	-	-	846
2005	460	-	27	257	-	-	810
2006	424	-	27	226	-	2	757
2007	500	-	27	309	-	1	948
2008	803	-	33	6	-	1	951
2009	778	-	18	14	-	-	902
2010	837	-	17	19	-	-	979
2011	902	-	17	21	-	-	1 039
Total	11 871	708	1 023	4 640	1	10	19 858

SWA3

	CLR form			CELR form			
	L	T	R	L	T	R	Total
1991	206	66	23	242	-	3	554
1992	319	79	34	477	-	-	935
1993	336	97	34	559	-	-	1 045
1994	318	63	56	554	-	-	1 023
1995	310	99	32	666	-	-	1 170
1996	407	86	45	794	-	-	1 396
1997	463	38	43	541	-	-	1 144
1998	532	15	34	640	-	-	1 279
1999	476	1	27	639	-	-	1 210
2000	504	-	55	384	-	-	1 029
2001	621	-	42	648	-	-	1 407
2002	549	-	41	305	-	-	961
2003	603	-	63	399	-	-	1 131
2004	479	1	72	362	-	-	974
2005	436	-	40	373	-	-	910
2006	417	-	25	290	-	-	801
2007	429	-	40	179	-	1	892
2008	459	-	45	36	-	-	811
2009	470	-	39	107	-	2	881
2010	571	-	17	101	-	-	970
2011	539	-	18	115	-	-	957
Total	9 444	545	825	8 411	-	6	21 480

Table C2: (Continued).

SWA4

	CLR form			CELR form			
	L	**T**	**R**	**L**	**T**	**R**	**Total**
1991	155	88	58	-	-	-	324
1992	164	83	49	-	-	-	324
1993	176	97	58	4	-	-	379
1994	150	64	53	3	-	-	332
1995	219	79	43	13	-	-	438
1996	262	71	40	6	-	-	449
1997	329	39	44	3	-	-	499
1998	303	14	50	-	-	-	449
1999	356	-	52	2	-	-	519
2000	411	-	45	7	-	-	548
2001	510	-	46	17	-	-	729
2002	594	-	42	17	-	-	797
2003	508	-	52	10	-	-	680
2004	557	-	57	10	-	-	780
2005	520	-	46	19	-	-	759
2006	462	-	40	16	-	-	688
2007	443	-	38	10	-	-	648
2008	432	-	27	-	-	-	606
2009	361	-	36	-	-	-	540
2010	360	-	17	-	-	-	527
2011	388	-	21	-	-	-	571
Total	7 660	535	914	137	-	-	11 586

Table C3: Destination codes, total landing weight, number of landings and if the records were kept or discarded to all SWA catch 1991–2011 for SWA 1, 3 and 4.

SWA1

Destination code	Greenweight (t)	No. records	Description	Action
L	33 785.38	16 548	Landed in New Zealand to a Licensed Fish Receiver	Keep
O	1 003.14	97	Conveyed outside New Zealand	Keep
E	177.40	1 192	Eaten	Keep
C	172.12	17	Disposed to the Crown	Keep
A	35.62	65	Accidental loss	Keep
D	23.12	42	Discarded	Keep
S	21.47	4	Seized by the Crown	Keep
F	0.87	80	Recreational catch	Keep
W	0.27	39	Sold at wharf	Keep
H	0.00	1	Loss from holding pot	Keep
U	-	1	Used as bait	Keep
T	5 255.70	709	Transferred to another vessel	Drop
R	4 440.77	1 033	Retained on board	Drop
Null	105.10	17	Missing destination type code	Drop
Q	0.15	13	Holding receptacle on land	Drop

SWA3

Destination code	Greenweight (t)	No. records	Description	Action
L	61 328.73	18 399	Landed in New Zealand to a Licensed Fish Receiver	Keep
O	813.97	59	Conveyed outside New Zealand	Keep
C	334.27	50	Disposed to the Crown	Keep
A	90.91	77	Accidental loss	Keep
E	53.26	1 141	Eaten	Keep
D	13.18	23	Discarded	Keep
W	0.02	2	Sold at wharf	Keep
S	0.01	5	Seized by the Crown	Keep
T	7 387.79	545	Transferred to another vessel	Drop
R	6 460.58	848	Retained on board	Drop
Null	56.57	16	Missing destination type code	Drop
Q	1.80	315	Holding receptacle on land	Drop

Destination code	Greenweight (t)	No. records	Description	Action
L	72 535.24	7 797	Landed in New Zealand to a Licensed Fish Receiver	Keep
O	961.26	76	Conveyed outside New Zealand	Keep
C	605.81	41	Disposed to the Crown	Keep
E	222.55	2 039	Eaten	Keep
A	142.38	137	Accidental loss	Keep
D	35.00	38	Discarded	Keep
S	0.01	2	Seized by the Crown	Keep
F	0.00	1	Recreational catch	Keep
T	10 309.57	535	Transferred to another vessel	Drop
R	4 339.85	914	Retained on board	Drop
Null	33.84	6	Missing destination type code	Drop

Table C4: Details of data corrections by imputation and invalid record removal during the grooming process for each QMA.

SWA 1

	Effort			Landings		
	Records	**Trips**	**Catch**	**Records**	**Trips**	**Catch**
Original extract	392 678	15 824	56 966	24 992	15 581	49 429
Missing keys	392 677	15 823	56 966	24 991	15 580	49 429
Unmatched trip number	392 677	15 823	56 966	24 795	15 448	48 950
Duplicate form number	390 423	15 678	56 929	24 635	15 304	48 908
Invalid processed date	388 747	15 268	56 684	24 563	15 268	48 750
Invalid primary method	388 591	15 261	56 679	24 555	15 261	48 746
Invalid target methodA	388 591	15 261	56 679	24 555	15 261	48 746
Invalid stats area	380 394	15 080	55 234	24 200	15 080	47 827
Restratify effort	66 799	15 080	55 234	24 200	15 080	47 827
Remove BQRT destination types	63 183	14 485	47 880	21 309	14 485	35 344
Remove multiple states	63 183	14 485	47 880	19 903	14 485	35 335
Remove invalid green weight	63 182	14 484	47 880	19 902	14 484	35 335
Remove NA green weight	63 182	14 484	47 880	19 902	14 484	35 335
DQSS	63 182	14 484	47 880	19 902	14 484	35 335
Drop straddle stats area	63 132	14 477	47 866	19 902	14 484	35 335

SWA 3

	Effort			Landings		
	Records	**Trips**	**Catch**	**Records**	**Trips**	**Catch**
Original extract	939 931	36 749	185 567	30 664	17 059	80 150
Missing keys	939 930	36 748	185 567	30 664	17 059	80 150
Unmatched trip number	406 670	17 332	130 591	30 482	16 934	79 731
Duplicate form number	404 192	16 916	130 442	29 951	16 518	79 668
Invalid processed date	402 338	16 492	130 159	29 873	16 492	79 450
Invalid primary method	402 254	16 491	130 157	29 871	16 491	79 448
Invalid target methodA	402 254	16 491	130 157	29 871	16 491	79 448
Invalid stats area	395 417	16 381	128 130	29 489	16 381	78 341
Restratify effort	62 767	16 381	128 130	29 489	16 381	78 341
Remove BQRT destination types	57 622	15 730	114 399	26 332	15 730	63 135
Remove multiple states	57 622	15 730	114 399	25 010	15 730	63 127
Remove invalid green weight	57 611	15 729	114 335	25 005	15 729	63 104
Remove NA green weight	57 611	15 729	114 335	25 005	15 729	63 104
DQSS	57 611	15 729	114 335	25 005	15 729	63 104
Drop straddle stats area	57 582	15 727	114 236	25 005	15 729	63 104

Table C4: (Continued).

SWA 4

	Effort			Landings		
	Records	**Trips**	**Catch**	**Records**	**Trips**	**Catch**
Original extract	939 931	36 749	185 567	20 571	5 904	93 572
Missing keys	939 930	36 748	185 567	20 571	5 904	93 572
Unmatched trip number	484 831	6 306	140 394	20 481	5 870	93 000
Duplicate form number	484 235	6 294	140 239	20 454	5 858	92 922
Invalid processed date	482 729	5 844	139 972	20 397	5 844	92 875
Invalid primary method	482 562	5 840	139 969	20 391	5 840	92 871
Invalid target methodA	482 562	5 840	139 969	20 391	5 840	92 871
Invalid stats area	474 184	5 737	137 732	19 983	5 737	91 686
Restratify effort	48 711	5 737	137 732	19 983	5 737	91 686
Remove BQRT destination types	43 846	5 269	122 754	16 812	5 269	75 877
Remove multiple states	43 846	5 269	122 754	15 413	5 269	75 735
Remove invalid green weight	43 821	5 267	122 671	15 405	5 267	75 667
Remove NA green weight	43 821	5 267	122 671	15 405	5 267	75 667
DQSS	43 821	5 267	122 671	15 405	5 267	75 667
Drop straddle stats area	43 742	5 258	122 558	15405	5 267	75 667

Table C5: The reported MHR, annual retained landings in the groomed and unmerged dataset, and retained landings in the groomed and merged dataset, and estimated catches in the groomed and merged dataset for SWA1, 3 and 4 from 1991 to 2011.

	SWA1				SWA3			
Year	MHR	Unmerged landings	Merged landings	Merged estimated catch	MHR	Unmerged landings	Merged landings	Merged estimated catch
1991	2 121	1 225	1 247	830	1 889	699	714	686
1992	1 388	692	710	532	2 661	1 480	1 517	1 367
1993	1 231	660	674	464	2 432	1 006	1 026	1 140
1994	2 960	1 785	1 827	1 882	2 724	1 371	1 392	1 516
1995	2 281	1 564	1 597	1 528	2 336	1 177	1 203	1 637
1996	2 884	1 913	1 913	1 728	2 939	1 654	1 653	1 983
1997	3 636	2 919	2 919	2 493	4 063	3 313	3 312	2 808
1998	3 380	3 176	3 176	2 622	3 721	3 549	3 545	3 119
1999	1 980	1 853	1 849	1 535	2 796	2 634	2 630	2 227
2000	2 525	2 253	2 252	1 818	4 129	3 707	3 688	2 964
2001	3 025	2 965	2 883	2 463	3 664	3 755	3 660	3 359
2002	1 004	1 110	1 082	780	2 899	2 832	2 759	2 512
2003	1 029	1 085	1 058	812	3 772	3 499	3 329	2 890
2004	1 595	1 487	1 412	1 225	3 606	3 702	3 606	3 347
2005	1 467	1 457	1 422	1 219	3 797	4 069	3 965	3 299
2006	1 023	1 062	1 034	772	4 524	4 379	4 259	3 582
2007	2 093	2 076	2 076	1 852	6 059	5 921	5 921	5 108
2008	1 679	1 705	1 705	1 450	2 918	2 654	2 654	2 106
2009	1 366	1 463	1 463	1 226	3 264	3 294	3 294	2 897
2010	712	743	743	569	2 937	2 870	2 870	2 684
2011	938	965	965	650	3 559	3 531	3 531	3 114

Table C5: (Continued).

				SWA4
Year	**MHR**	**Unmerged landings**	**Merged landings**	**Merged estimated catch**
1991	3 176	845	861	879
1992	3 018	1 299	1 336	1 266
1993	3 137	1 709	1 757	1 768
1994	2 993	1 474	1 517	1 984
1995	2 638	1 397	1 439	1 881
1996	3 581	1 747	1 745	2 228
1997	5 336	4 036	4 035	3 871
1998	3 944	3 691	3 690	3 461
1999	4 021	3 922	3 922	3 499
2000	4 606	4 469	4 468	4 233
2001	4 650	4 343	4 219	3 808
2002	4 648	4 997	4 855	4 376
2003	4 746	4 634	4 504	4 472
2004	5 529	5 705	5 545	5 124
2005	4 279	4 245	4 128	4 207
2006	5 591	5 366	5 213	5 331
2007	6 022	5 931	5 931	5 820
2008	3 510	3 331	3 331	3 323
2009	4 213	3 579	3 579	3 859
2010	3 429	3 222	3 222	3 020
2011	3 507	3 300	3 300	3 114

Table C6: Total number of trips, number of trips with zero daily processed catch and proportion of trips with zero daily processed catch, for TCEPR and CEL forms for SWA 1, 3 and 4 from 1991 to 2011.

SWA 1

	CELR/TCE			TCEPR		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1991	182	110	0.60	163	42	0.26
1992	262	181	0.69	160	56	0.35
1993	330	199	0.60	211	88	0.42
1994	319	203	0.64	319	137	0.43
1995	333	217	0.65	367	129	0.35
1996	293	176	0.60	479	192	0.40
1997	362	224	0.62	621	228	0.37
1998	244	141	0.58	586	191	0.33
1999	220	137	0.62	455	137	0.30
2000	240	139	0.58	428	127	0.30
2001	246	117	0.48	481	180	0.37
2002	188	124	0.66	507	221	0.44
2003	206	134	0.65	468	210	0.45
2004	200	128	0.64	414	187	0.45
2005	254	154	0.61	355	162	0.46
2006	229	158	0.69	338	167	0.49
2007	303	202	0.67	363	151	0.42
2008	339	152	0.45	290	100	0.34
2009	358	141	0.39	267	91	0.34
2010	408	177	0.43	266	118	0.44
2011	407	199	0.49	288	121	0.42

Table C6: (Continued).

SWA 3

	CELR/TCE			TCEPR		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1991	233	140	0.60	184	79	0.43
1992	471	312	0.66	269	87	0.32
1993	551	278	0.50	320	108	0.34
1994	547	228	0.42	311	78	0.25
1995	656	296	0.45	300	72	0.24
1996	761	353	0.46	364	87	0.24
1997	526	303	0.58	387	55	0.14
1998	630	380	0.60	450	85	0.19
1999	633	388	0.61	379	69	0.18
2000	373	243	0.65	381	64	0.17
2001	644	360	0.56	393	38	0.10
2002	302	175	0.58	348	70	0.20
2003	391	212	0.54	367	42	0.11
2004	360	202	0.56	296	26	0.09
2005	368	231	0.63	257	31	0.12
2006	290	206	0.71	253	34	0.13
2007	176	117	0.66	254	32	0.13
2008	216	78	0.36	139	5	0.04
2009	197	74	0.38	199	20	0.10
2010	272	88	0.32	191	13	0.07
2011	229	82	0.36	216	13	0.06

Table C6: (Continued).

SWA 4

	CELR/TCE			TCEPR		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1991	-	-	-	140	30	0.21
1992	-	-	-	149	36	0.24
1993	4	3	0.75	152	33	0.22
1994	3	2	0.67	155	29	0.19
1995	12	4	0.33	203	27	0.13
1996	6	1	0.17	201	31	0.15
1997	3	2	0.67	238	27	0.11
1998	-	-	-	237	18	0.08
1999	2	1	0.50	246	21	0.09
2000	7	4	0.57	248	23	0.09
2001	17	13	0.76	283	27	0.10
2002	17	6	0.35	291	32	0.11
2003	11	6	0.55	297	33	0.11
2004	10	3	0.30	305	29	0.10
2005	18	7	0.39	317	46	0.15
2006	16	5	0.31	284	36	0.13
2007	10	6	0.60	259	35	0.14
2008	1	-	-	231	40	0.17
2009	4	3	0.75	214	32	0.15
2010	2	1	0.50	217	22	0.10
2011	20	2	0.10	233	45	0.19

Table C7: Reported landings and TACC levels for all stocks in fishing years 1984-2011.

Fishing	SWA 1		SWA 3		SWA 4		SWA 10		Total		TACC
Year	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	TACC
1984	541	-	725	-	1 829	-	-	-	3 095	-	-
1985	587	-	1 557	-	4 563	-	-	-	6 707	-	-
1986	806	-	2 284	-	3 966	-	-	-	7 056	-	-
1987	1 337	1 800	1 931	2 600	2 779	3 600	-	10	6 047	8 010	0.75
1988	2 947	1 815	3 810	2 601	2 600	3 600	-	10	9 357	8 026	1.17
1989	1 605	1 821	1 476	2 640	2 789	3 745	-	10	5 870	8 216	0.71
1990	2 316	2 128	2 713	3 140	3 596	3 855	-	10	8 625	9 133	0.94
1991	2 121	2 128	1 889	3 144	3 176	3 855	-	10	7 186	9 137	0.79
1992	1 388	2 500	2 661	3 144	3 018	3 855	-	10	7 066	9 509	0.74
1993	1 231	2 504	2 432	3 145	3 137	3 855	-	10	6 800	9 514	0.71
1994	2 960	2 504	2 724	3 145	2 993	3 855	-	10	8 677	9 514	0.91
1995	2 281	2 504	2 336	3 280	2 638	4 090	-	10	7 255	9 884	0.73
1996	2 884	2 504	2 939	3 280	3 581	4 090	-	10	9 404	9 884	0.95
1997	3 636	2 504	4 063	3 280	5 336	4 090	-	10	13 035	9 884	1.32
1998	3 380	2 132	3 721	3 280	3 944	4 090	-	10	11 045	9 512	1.16
1999	1 980	2 132	2 796	3 280	4 021	4 090	-	10	8 797	9 512	0.92
2000	2 525	2 132	4 129	3 280	4 606	4 090	-	10	11 260	9 512	1.18
2001	3 025	2 132	3 664	3 280	4 650	4 090	-	10	11 339	9 512	1.19
2002	1 004	2 132	2 899	3 280	4 648	4 090	-	10	8 551	9 512	0.90
2003	1 029	3 000	3 772	3 280	4 746	4 090	-	10	9 547	10 380	0.92
2004	1 595	3 000	3 606	3 280	5 529	4 090	-	10	10 730	10 380	1.03
2005	1 467	3 000	3 797	3 280	4 279	4 090	-	10	9 543	10 380	0.92
2006	1 023	3 000	4 524	3 280	5 591	4 090	-	10	11 138	10 380	1.07
2007	2 093	3 000	6 059	3 280	6 022	4 090	-	10	14 174	10 380	1.37
2008	1 679	3 000	2 918	3 280	3 510	4 090	-	10	8 107	10 380	0.78
2009	1 366	3 000	3 264	3 280	4 213	4 090	-	10	8 843	10 380	0.85
2010	712	3 000	2 937	3 280	3 429	4 090	-	10	7 078	10 380	0.68
2011	938	3 000	3 559	3 280	3 507	4 090	-	10	8 004	10 380	0.77

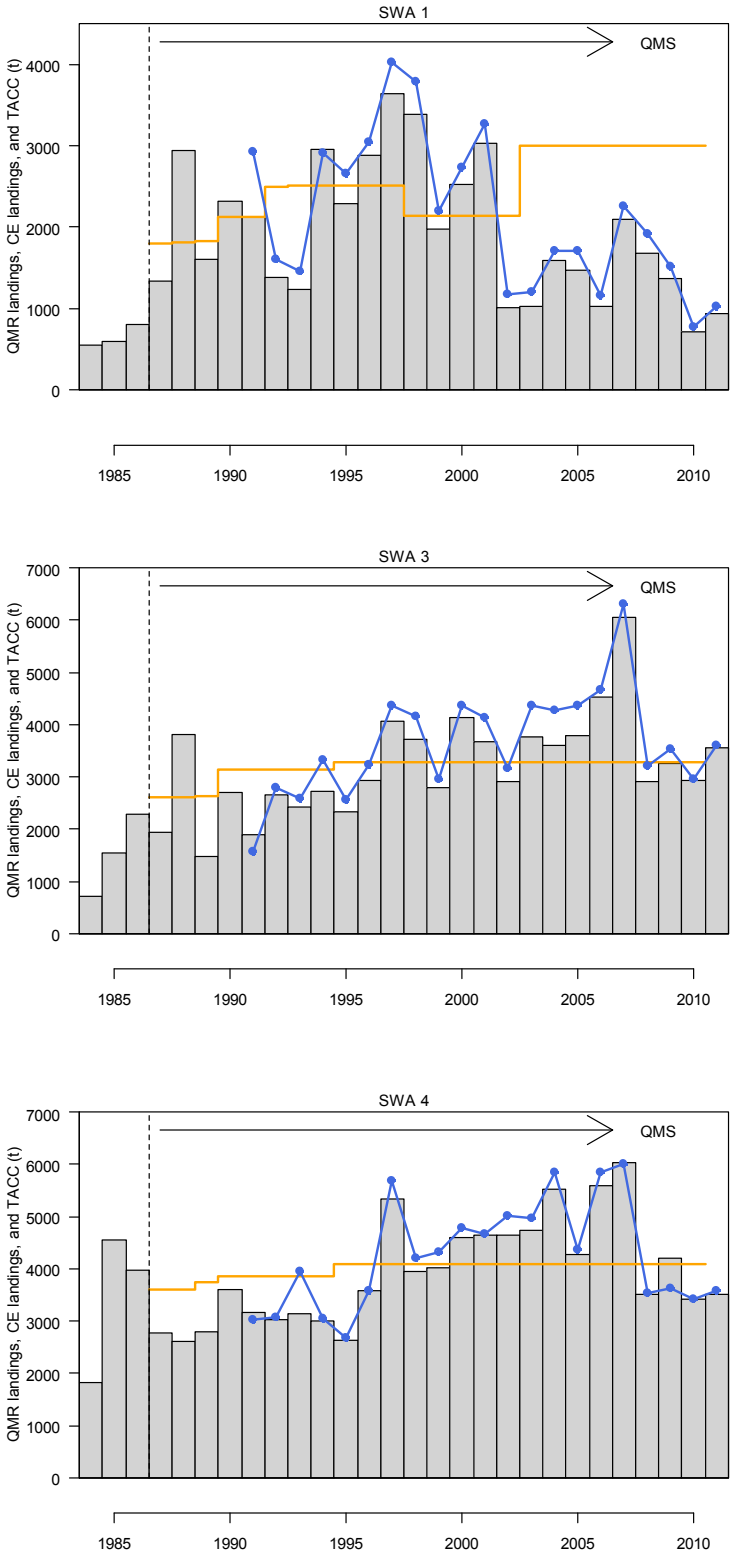


Figure C1: The QMR/MHR landings (grey bars), un-groomed catch effort landings (dotted blue line), and TACC (gold line) for SWA 1, 3 and 4 from 1984 to 2011.

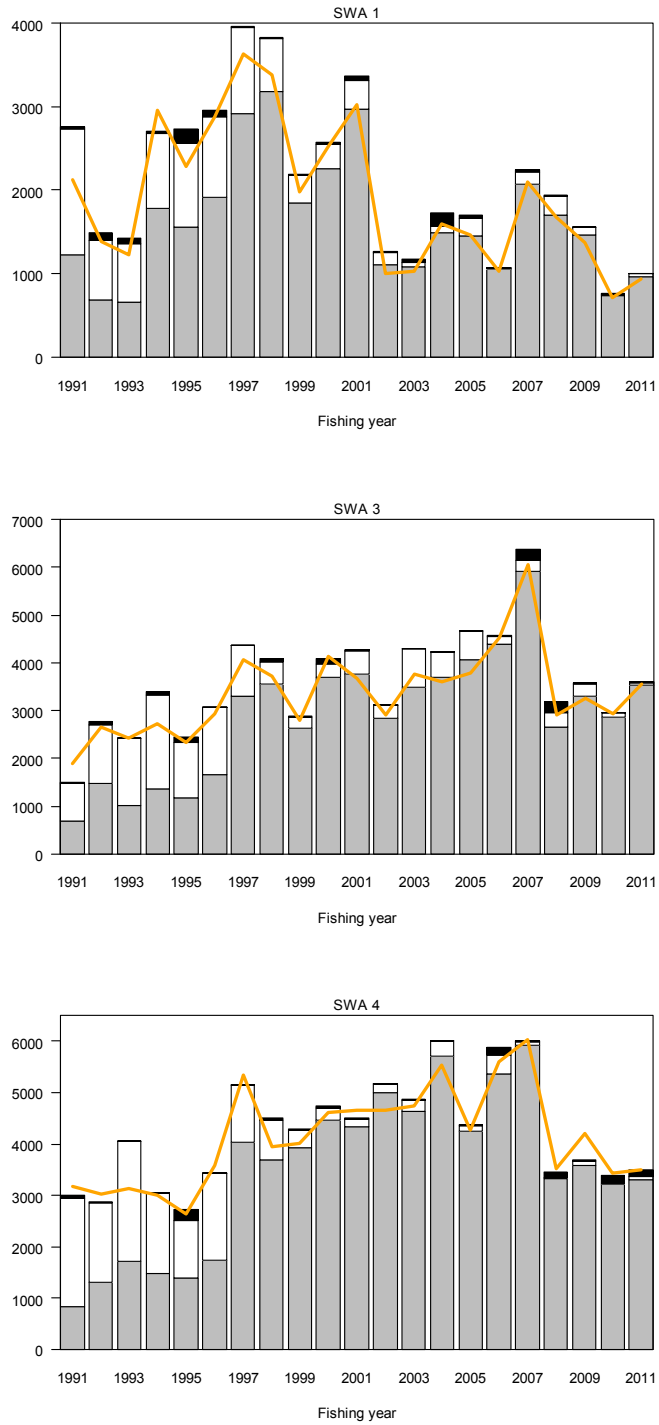


Figure C2: The retained landings (grey bars), interim landings (white bars), and landings dropped during data grooming (black bars), and MHR landings (gold line) for SWA1, 3 and 4 from the 1991 to 2011 fishing year.

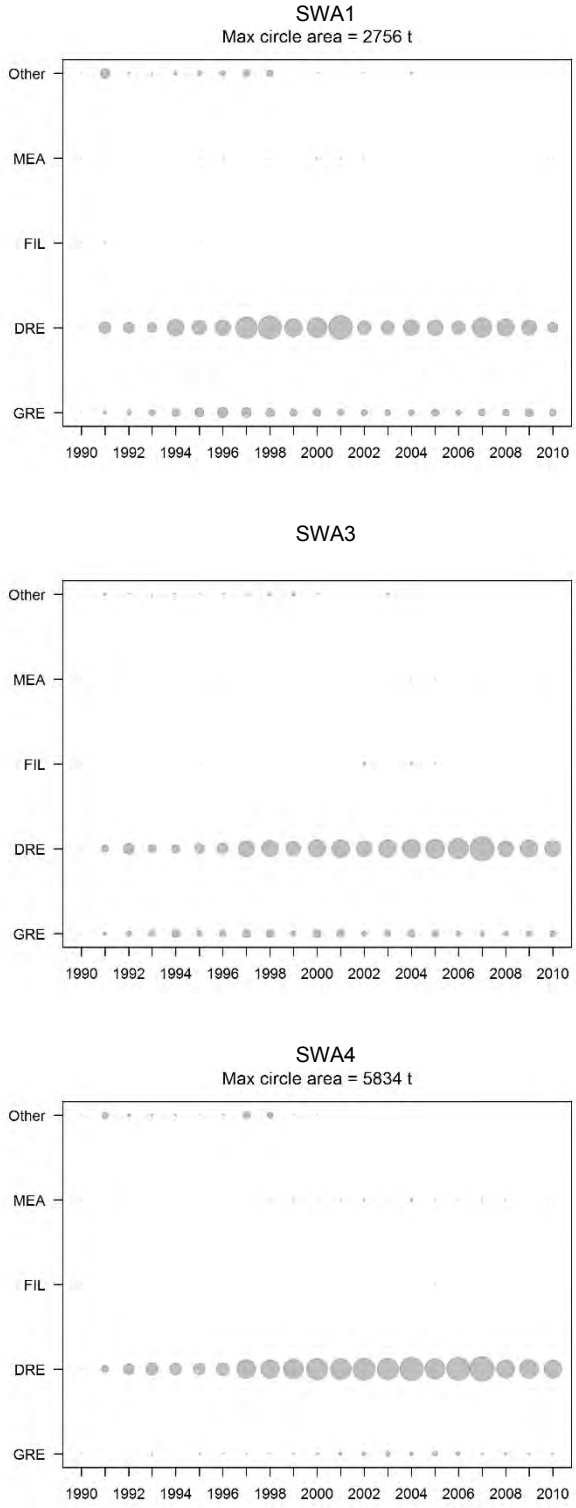


Figure C3: The proportion of retained landings (greenweight) by processed state for SWA 1, 3 and 4 from the 1991 to 2011 fishing year in the groomed and unmerged dataset. "DRE" includes "Dressed", "Headed, gutted and tailed", "Headed and gutted" and "Trunked"; "GRE" refers to "Whole or Green"; "MEA" refers to "Mealed" and "FIL" refers to "Filleted".

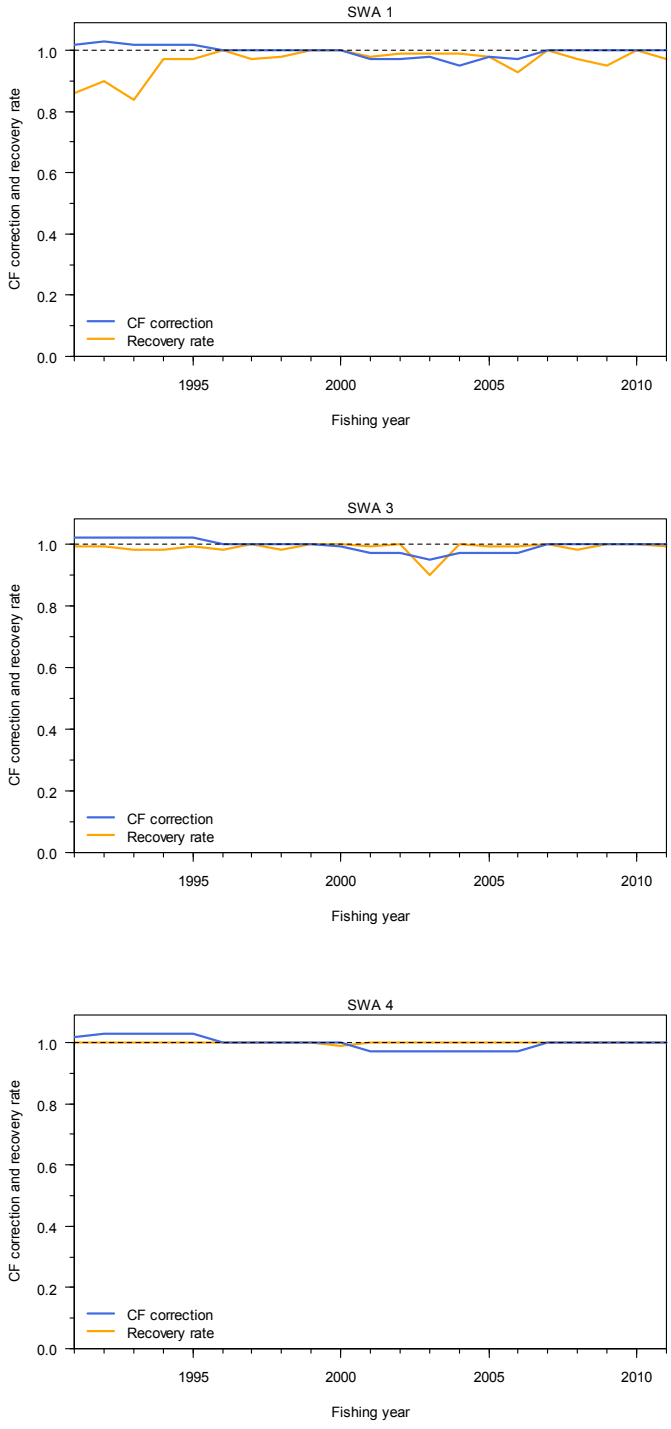


Figure C4: Conversion factor (CF) corrections (by the centroid method), defined as the ratio of annual green weight recalculated using the most recent correction factors for each processed state to the reported green weight, and the recovery rate, defined as the ratio of annual landings in the groomed and merged dataset to those in the groomed and unmerged dataset, for SWA 1, 3 and 4 from the 1991 to 2011 fishing year.

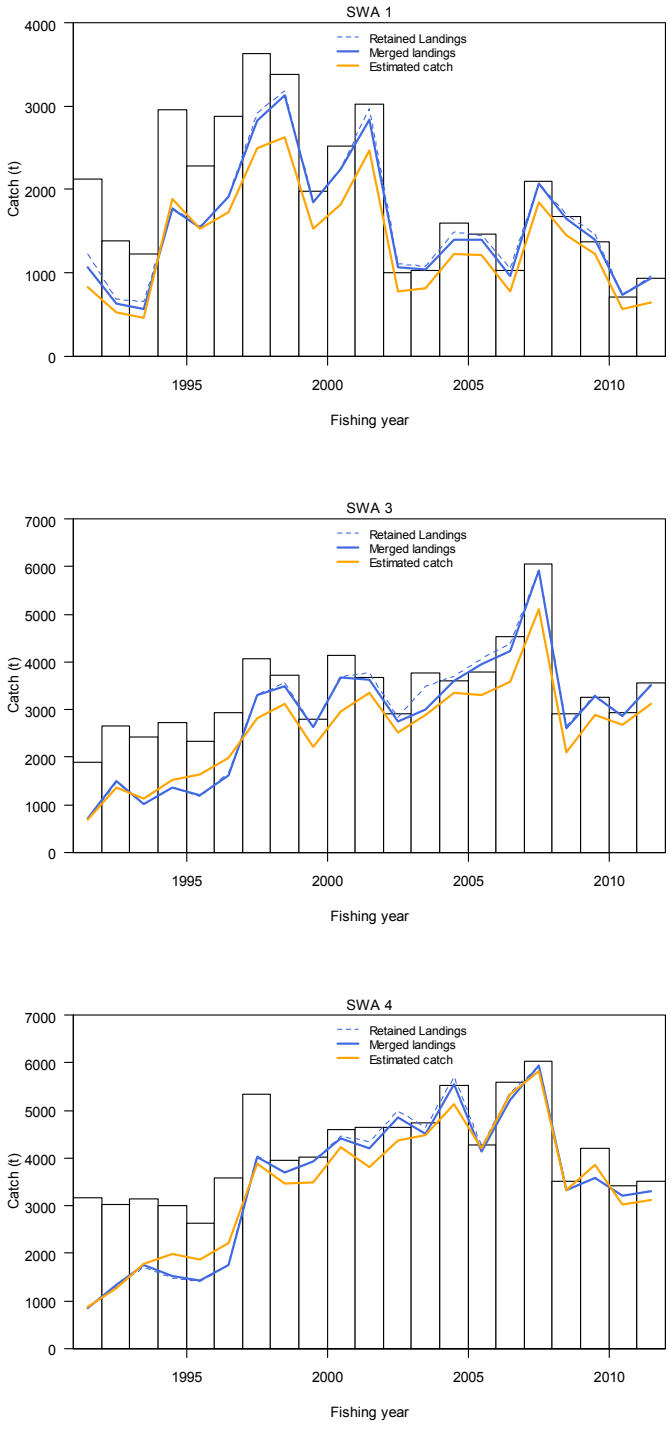


Figure C5: The QMR/MHR landings (white bars), retained landings in the groomed and unmerged dataset (blue dashed line), retained landings in groomed and merged dataset (blue solid line), and daily processed catch in the groomed and merged dataset (gold solid line), using the centroid method, for SWA 1, 3 and 4 from the 1991 to 2011 fishing year.

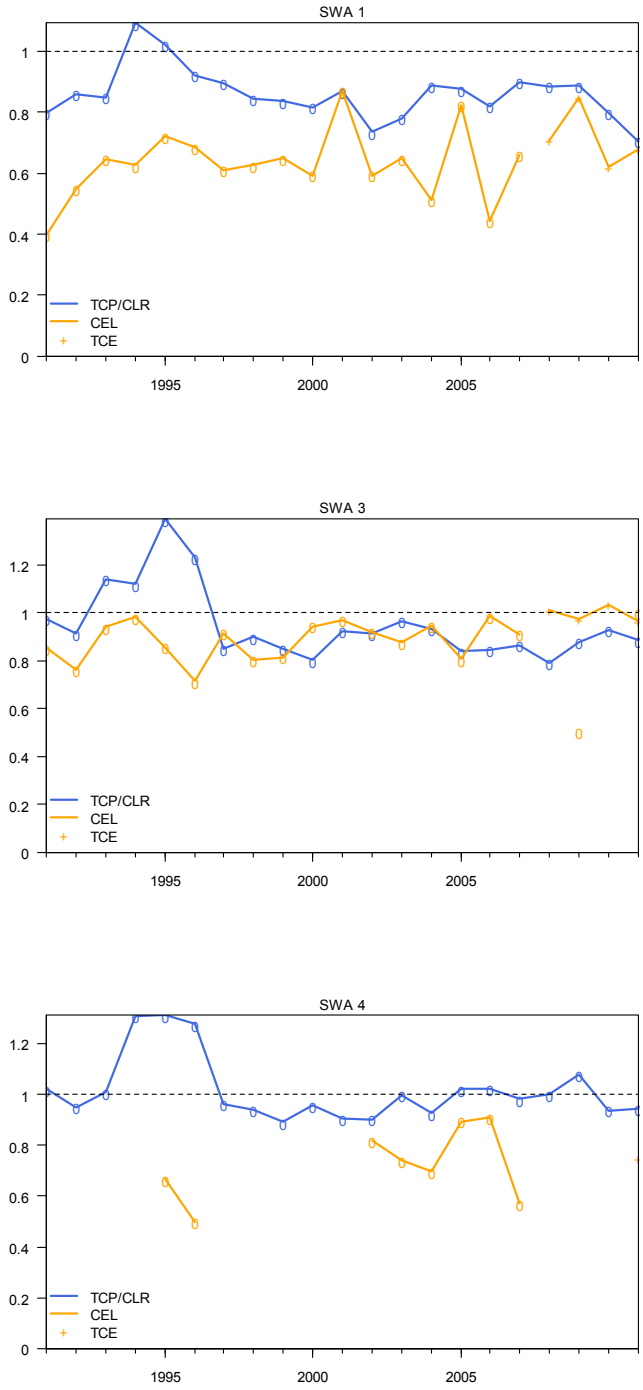


Figure C6: The reporting rate, defined as the ratio of greenweight calculated from annual processed catch as a proportion of retained landings in the groomed and merged dataset, for SWA 1, 3 and 4 from the 1991 to 2011 fishing year.

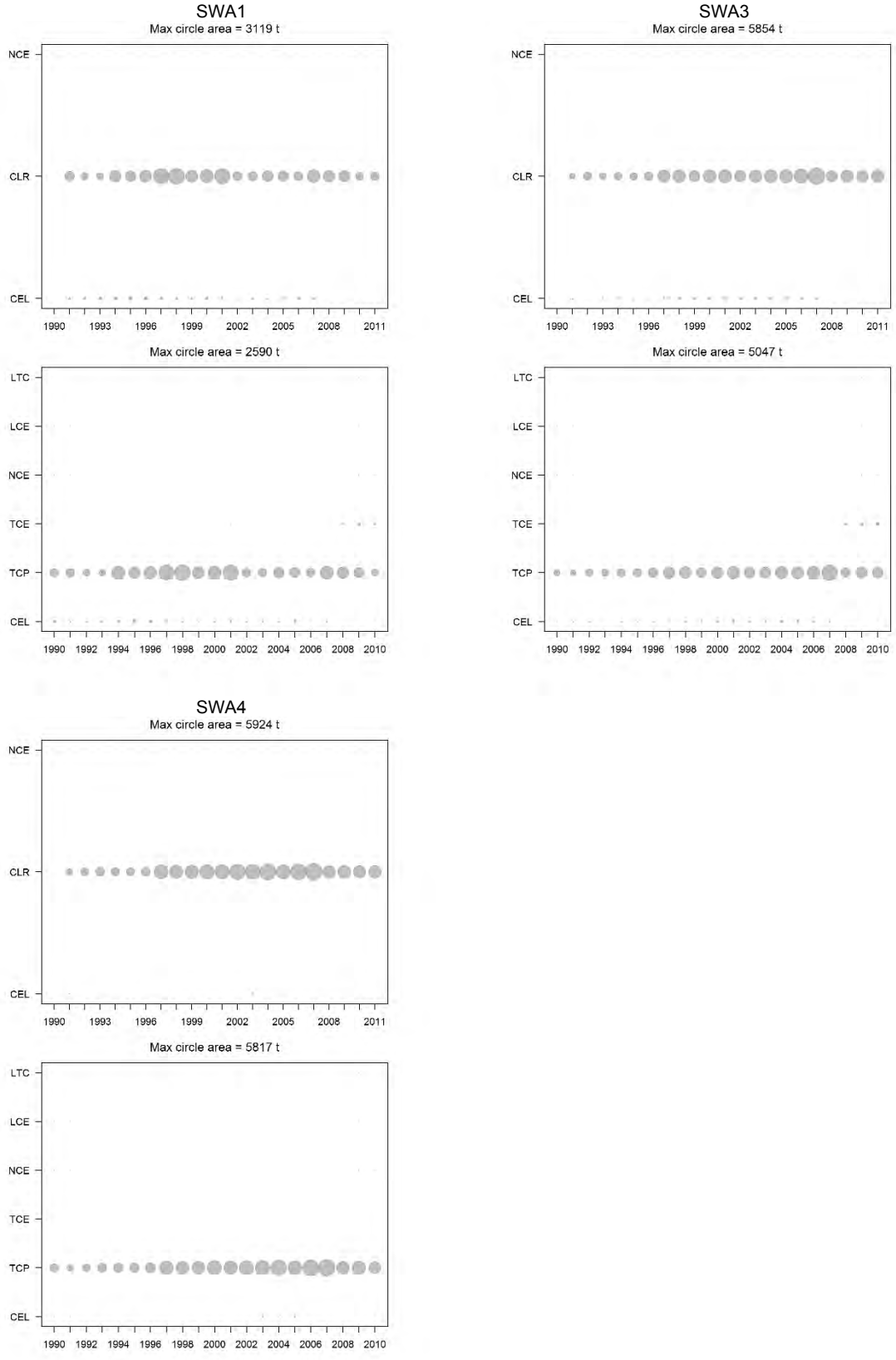


Figure C7: Proportion of landings by form type (top panels) in the groomed and unmerged dataset, and proportion of processed catches by form type (bottom panels) in the groomed and merged dataset, for SWA 1, 3 and 4 from the 1991 to 2011 fishing year.

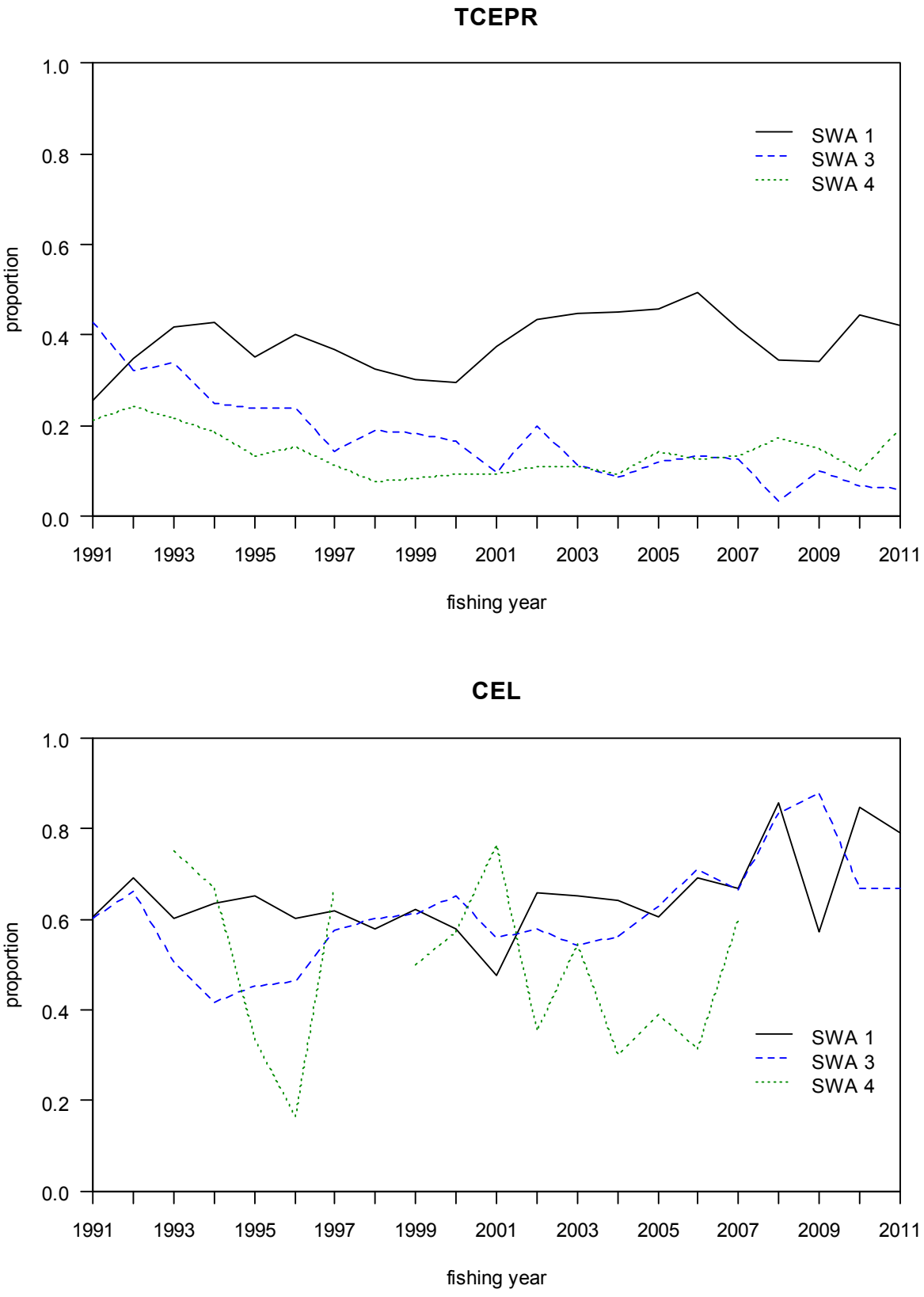


Figure C8: Proportion of trips with zero estimated catch, for TCEPR and CEL forms for SWA 1, 3 and 4 from 1991 to 2011.

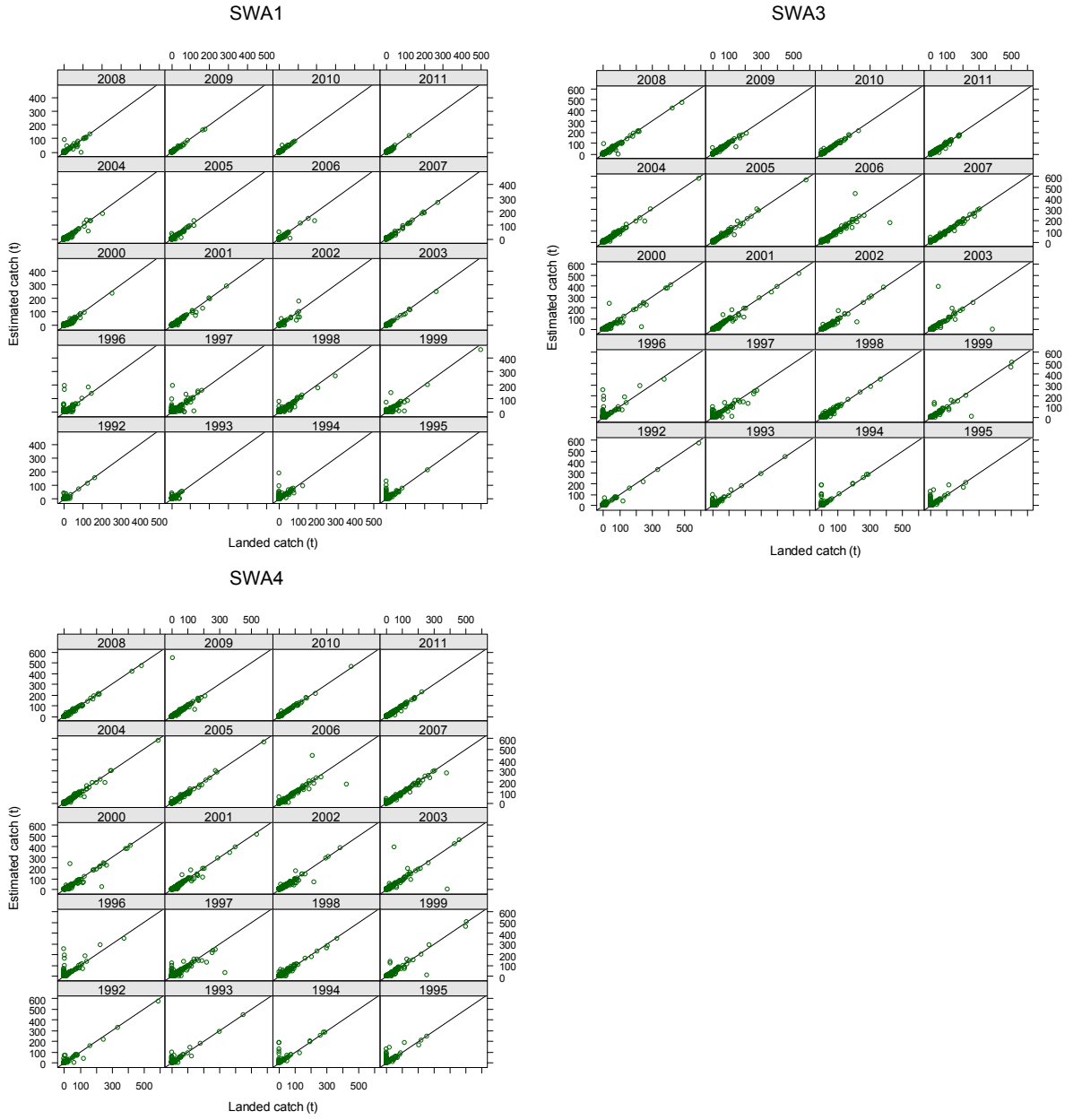


Figure C9: Estimated catch versus reported landings on a trip basis in the groomed and merged dataset, for SWA 1, 3 and 4 from the 1991 to 2011 fishing year.

APPENDIX D: SUMMARIES OF CATCH AND EFFORT DATA

Table D1: Total catch (t) for each region from groomed and merged data for fishing years 1998–2011.

	Chatham Rise	ECNI	ECSI	Southland	WCNI	WCSI	Total
1998	218.93	192.86	3 229.29	3 838.89	41.59	2 781.65	10 303.21
1999	123.77	179.57	2 026.34	4 439.67	47.63	1 576.16	8 393.13
2000	302.17	209.45	2 473.01	5 404.69	9.41	1 951.74	10 350.46
2001	385.43	123.81	3 031.17	4 454.05	13.27	2 669.38	10 677.12
2002	389.44	121.39	2 244.11	4 989.32	45.74	884.20	8 674.21
2003	496.26	85.65	2 830.03	4 209.71	52.69	882.67	8 557.01
2004	358.88	68.11	3 286.70	5 566.07	12.84	1 240.16	10 532.76
2005	898.01	114.71	3 412.83	3 848.48	14.70	1 179.33	9 468.07
2006	545.90	41.12	3 595.02	5 348.34	46.59	821.12	10 398.08
2007	391.30	98.27	5 472.81	6 073.35	26.95	1 859.87	13 922.55
2008	505.31	104.69	2 287.72	3 221.78	9.02	1 467.61	7 596.13
2009	582.20	175.08	3 168.04	3 202.90	4.61	1 120.20	8 253.04
2010	241.48	125.75	2 629.53	3 278.39	2.83	554.48	6 832.47
2011	337.24	223.97	3 524.77	3 016.07	2.91	630.21	7 735.19
Total	5 776.35	1 864.43	43 211.39	60 891.71	330.78	19 618.78	131 693.44

Table D2: Total catch (t) by vessel nationality from groomed and merged data for fishing year 1998–2011.

	KOREA	NZ	JAPAN	UKRAINE	MALTA	PANAMA	VANUATU	DOMINICA	CYPRUS	BELIZE	Other	Total
1998	2 396.54	3 400.50	1 630.48	1 033.47	170.66	195.36	332.33	454.88	97.14	230.69	361.16	10 303.21
1999	2 850.80	2 139.24	1 699.46	544.68	120.96	102.03	213.41	238.93	97.17	325.48	60.98	8 393.13
2000	3 095.13	3 453.67	1 902.53	908.43	137.55	239.18	127.52	197.54	161.11	102.79	25.01	10 350.46
2001	3 671.64	3 202.08	2 096.57	571.94	287.95	305.07	133.15	242.95	145.70	-	20.07	10 677.12
2002	2 923.55	2 382.58	1 606.30	669.02	627.74	163.05	53.81	121.77	126.38	-	-	8 674.21
2003	3 021.83	2 352.71	1 430.70	613.26	524.96	208.70	162.50	112.01	130.34	-	0.00	8 557.01
2004	2 555.01	3 899.06	1 575.89	583.55	1 236.38	366.87	81.38	117.02	117.43	-	0.17	10 532.76
2005	3 514.69	4 327.42	893.02	105.26	448.30	162.19	8.49	8.70	-	-	-	9 468.07
2006	4 208.22	3 516.20	1 173.21	380.31	318.49	535.44	132.78	107.65	-	-	25.77	10 398.08
2007	7 201.73	3 787.22	1 412.07	323.79	494.60	-	217.05	16.23	-	-	469.87	13 922.55
2008	4 027.53	2 074.83	913.38	258.76	202.84	-	86.13	32.66	-	-	0.00	7 596.13
2009	5 039.21	2 303.52	224.87	468.93	1.59	-	166.59	48.33	-	-	0.00	8 253.04
2010	4 419.21	1 406.56	619.67	179.27	-	-	154.05	53.20	-	-	0.52	6 832.47
2011	4 199.31	2 370.50	448.67	408.37	-	-	186.55	65.65	-	-	56.13	7 735.19
Total	53 124.40	40 616.10	17 626.82	7 049.06	4 572.03	2 277.87	2 055.73	1 817.52	875.26	658.96	1 019.68	131 693.44

Table D3a: Proportion of catch reported each month from the Chatham Rise region for fishing years 1998–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1998	0.08	0.48	0.12	0.02	-	-	0.01	0.04	0.09	0.07	-	0.08	219
1999	0.05	0.11	0.02	0.06	0.02	0.07	0.52	0.02	-	-	-	0.12	124
2000	0.07	0.02	0.40	0.24	0.03	0.06	0.14	0.03	0.01	-	-	-	302
2001	0.06	0.11	0.22	0.12	0.01	0.15	0.27	-	-	-	-	0.05	385
2002	0.06	0.12	0.19	0.13	0.16	0.01	0.02	0.12	-	0.01	0.03	0.16	389
2003	0.08	0.11	0.17	0.09	0.09	0.12	0.30	0.02	-	0.01	-	0.02	496
2004	0.03	0.16	0.36	0.10	0.09	0.03	0.10	0.05	0.03	0.05	-	0.02	359
2005	0.06	0.24	0.11	0.20	0.03	0.03	0.01	0.20	0.03	-	0.05	0.05	898
2006	0.09	0.19	0.05	0.13	0.03	0.07	0.01	0.01	0.43	-	0.01	0.01	546
2007	0.02	0.10	0.13	0.34	0.06	0.04	0.06	0.06	0.03	0.06	-	0.08	391
2008	0.03	0.13	0.09	0.12	0.04	0.01	0.03	0.19	-	0.03	0.28	0.06	505
2009	0.03	-	0.08	0.23	-	0.01	0.01	0.44	0.08	-	-	0.13	582
2010	0.04	0.06	0.06	0.09	0.21	0.09	0.06	0.03	-	-	0.32	0.04	241
2011	0.01	0.40	0.35	0.04	0.03	0.04	0.05	-	-	-	-	0.08	337
Total	0.05	0.16	0.16	0.15	0.05	0.05	0.08	0.11	0.06	0.01	0.05	0.06	5 776

Table D3b: Proportion of catch reported for each statistical area from the Chatham Rise region for fishing years 1998–2011.

	049	050	051	052	403	404	409	410	Other	Total
1998	0.04	0.05	0.01	0.20	0.02	0.31	0.01	0.37	-	219
1999	0.55	0.01	0.09	0.02	0.01	0.20	0.03	0.09	0.01	124
2000	0.54	0.07	0.06	0.19	0.07	0.05	0.01	0.01	-	302
2001	0.25	0.16	0.03	0.35	0.01	0.14	0.04	0.03	-	385
2002	0.14	0.10	0.03	0.12	-	0.21	0.03	0.37	-	389
2003	0.47	0.10	0.14	0.17	0.02	0.08	-	0.02	-	496
2004	0.23	0.12	0.11	0.14	0.03	0.04	0.24	0.10	-	359
2005	0.08	0.05	0.07	0.27	0.02	0.13	0.04	0.34	-	898
2006	0.22	0.11	0.05	0.45	0.01	0.05	0.03	0.08	-	546
2007	0.07	0.05	0.04	0.07	0.07	0.13	0.31	0.26	-	391
2008	0.26	0.11	-	0.09	0.03	0.37	0.07	0.06	-	505
2009	0.29	0.07	0.33	0.08	-	0.06	0.02	0.15	-	582
2010	0.32	0.04	0.05	0.09	0.03	0.09	0.07	0.30	-	241
2011	0.09	0.02	0.06	0.03	0.08	0.07	0.33	0.33	-	337
Total	0.23	0.08	0.08	0.18	0.03	0.13	0.08	0.18	-	5 776

Table D3c: Proportion of catch reported by gear type from the Chatham Rise region for fishing years 1998–2011. BT=Bottom trawl, MB=Mid-bottom trawl, MW=Mid-water trawl.

	BT	MB	MW	Other	Total
1998	1	-	-	-	219
1999	0.46	0.54	-	-	124
2000	0.40	0.49	0.11	-	302
2001	0.79	0.17	0.04	-	385
2002	1	-	-	-	389
2003	0.58	0.42	-	-	496
2004	0.83	0.17	-	-	359
2005	0.98	0.02	-	-	898
2006	0.93	0.07	-	-	546
2007	1	-	-	-	391
2008	1	-	-	-	505
2009	0.98	0.01	-	-	582
2010	0.94	0.03	0.03	-	241
2011	0.97	0.02	0.01	-	337
Total	0.88	0.11	0.01	-	5 776

Table D3d: Proportion of catch reported by target species from the Chatham Rise region for fishing years 1998–2011.

	BAR	BYX	HAK	HOK	JMA	LIN	SWA	TAR	Other	Total
1998	0.11	-	0.15	0.56	0.03	-	0.05	-	0.11	219
1999	0.51	0.08	0.09	0.20	-	0.05	0.03	-	0.05	124
2000	0.30	0.05	0.06	0.23	0.26	0.01	-	-	0.10	302
2001	0.16	0.03	0.09	0.19	0.08	0.02	0.09	0.11	0.24	385
2002	0.07	0.01	0.12	0.19	0.12	0.07	0.18	0.03	0.21	389
2003	0.36	0.11	0.06	0.09	0.10	0.02	0.05	0.12	0.09	496
2004	0.17	0.04	0.05	0.49	-	-	0.04	0.15	0.05	359
2005	0.01	0.02	0.14	0.40	-	0.01	0.25	0.07	0.11	898
2006	0.09	0.02	0.02	0.11	0.01	0.10	0.42	0.15	0.08	546
2007	0.01	0.04	0.05	0.61	-	0.12	0.13	0.03	0.01	391
2008	0.04	0.01	0.12	0.17	0.01	0.36	0.21	0.09	0.01	505
2009	0.18	0.01	0.02	0.10	0.01	0.10	0.58	0.01	-	582
2010	0.02	0.07	0.02	0.22	-	0.11	0.48	0.07	0.01	241
2011	0.01	0.06	-	0.71	-	-	0.14	0.08	0.01	337
Total	0.12	0.03	0.07	0.29	0.04	0.07	0.22	0.07	0.08	5 776

Table D4a: Proportion of catch reported each month from the ECSI region for fishing years 1998–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1998	0.14	0.05	0.02	0.06	0.11	0.06	0.13	0.13	0.06	-	-	0.25	3 229
1999	0.18	0.13	0.06	0.04	0.09	0.08	0.14	0.12	0.01	0.01	0.03	0.11	2 026
2000	0.15	0.07	0.06	0.10	0.07	0.10	0.12	0.19	0.02	-	-	0.11	2 473
2001	0.13	0.04	0.05	0.02	0.06	0.17	0.11	0.10	0.04	0.02	-	0.26	3 031
2002	0.19	0.05	0.03	0.02	0.02	0.04	0.18	0.09	-	-	-	0.37	2 244
2003	0.19	0.04	0.03	0.05	0.06	0.04	0.11	0.13	0.04	-	0.03	0.31	2 830
2004	0.15	0.01	0.08	0.04	0.02	0.05	0.17	0.09	0.07	0.10	0.04	0.18	3 287
2005	0.05	0.01	0.03	0.06	0.06	0.02	0.28	0.17	0.07	0.01	0.06	0.19	3 413
2006	0.07	0.03	0.03	0.08	0.03	0.08	0.28	0.25	0.09	0.02	-	0.03	3 595
2007	0.14	0.12	0.02	0.06	0.05	0.04	0.22	0.18	0.10	-	0.01	0.04	5 473
2008	0.09	0.03	0.07	0.08	0.03	0.02	0.30	0.17	0.07	0.09	0.02	0.05	2 288
2009	0.20	0.12	0.06	0.08	0.04	0.08	0.13	0.07	0.03	0.04	0.02	0.12	3 168
2010	0.31	0.06	0.23	0.09	0.03	0.05	0.03	0.07	0.04	0.03	0.01	0.03	2 630
2011	0.16	0.13	0.39	0.04	0.11	0.04	0.05	0.05	0.02	0.01	-	0.01	3 525
Total	0.15	0.07	0.08	0.06	0.05	0.06	0.16	0.13	0.05	0.02	0.02	0.14	43 211

Table D4b: Proportion of catch reported for each statistical area from the ECSI region for fishing years 1998–2011.

	018	020	021	022	023	401	407	408	Other	Total
1998	0.05	0.42	0.15	0.21	0.04	0.04	0.01	-	0.09	3 229
1999	0.03	0.41	0.13	0.19	0.04	0.09	0.01	0.01	0.09	2 026
2000	0.08	0.41	0.09	0.20	0.09	0.05	0.03	-	0.06	2 473
2001	0.02	0.36	0.12	0.22	0.15	0.04	0.06	-	0.04	3 031
2002	0.01	0.51	0.23	0.11	0.04	0.03	0.01	0.01	0.05	2 244
2003	0.02	0.46	0.10	0.22	0.04	0.10	0.01	-	0.06	2 830
2004	0.02	0.40	0.08	0.24	0.10	0.06	0.02	0.03	0.05	3 287
2005	0.01	0.29	0.05	0.48	0.05	0.03	0.02	0.01	0.06	3 413
2006	0.02	0.21	0.05	0.43	0.13	0.02	0.04	0.04	0.06	3 595
2007	-	0.23	0.02	0.52	0.10	0.02	0.04	0.03	0.04	5 473
2008	0.01	0.25	0.07	0.39	0.10	0.04	0.07	0.02	0.05	2 288
2009	0.01	0.21	0.01	0.62	0.05	0.01	0.01	0.04	0.05	3 168
2010	0.01	0.26	0.02	0.48	0.11	0.02	0.03	0.02	0.05	2 630
2011	0.01	0.14	0.01	0.49	0.13	0.04	0.07	0.04	0.08	3 525
Total	0.02	0.31	0.07	0.36	0.08	0.04	0.03	0.02	0.06	43 211

Table D4c: Proportion of catch reported by gear type from the ECSI region for fishing years 1998–2011.

	BT	DS	MB	MW	RLP	SN	Other	Total
1998	0.85	-	0.10	0.04	-	-	0.01	3 229
1999	0.89	-	0.08	0.02	-	-	-	2 026
2000	0.94	-	0.04	0.02	-	-	-	2 473
2001	0.97	-	0.02	0.01	-	-	-	3 031
2002	0.97	-	0.01	0.02	-	-	-	2 244
2003	0.94	-	0.04	0.02	-	-	-	2 830
2004	0.95	-	0.03	0.01	-	-	-	3 287
2005	0.91	-	0.08	0.01	-	-	-	3 413
2006	0.91	-	0.07	0.01	-	-	-	3 595
2007	0.95	-	0.05	-	-	-	-	5 473
2008	0.94	-	0.06	-	-	-	-	2 288
2009	0.90	-	0.09	0.01	-	-	-	3 168
2010	0.92	-	0.08	-	-	-	-	2 630
2011	0.91	-	0.08	0.01	-	-	-	3 525
Total	0.92	-	0.06	0.01	-	-	-	43 211

Table D4d: Proportion of catch reported by target species from the ECSI region for fishing years 1998–2011.

	BAR	HOK	JMA	RCO	SPE	SQU	SWA	TAR	Other	Total
1998	0.05	0.63	0.02	0.10	-	0.12	0.06	-	0.02	3 229
1999	0.04	0.62	-	0.08	-	0.15	0.08	-	0.03	2 026
2000	0.02	0.73	-	0.06	-	0.16	-	0.01	0.02	2 473
2001	0.04	0.60	-	0.02	-	0.26	0.06	-	0.02	3 031
2002	0.02	0.61	0.01	0.04	-	0.23	0.06	-	0.03	2 244
2003	0.02	0.58	0.02	0.04	0.02	0.21	0.06	-	0.04	2 830
2004	0.01	0.78	-	0.06	0.01	0.13	0.01	-	0.01	3 287
2005	0.01	0.46	-	0.03	-	0.35	0.13	0.01	0.02	3 413
2006	0.01	0.53	0.05	0.01	-	0.21	0.18	-	0.01	3 595
2007	0.05	0.35	0.02	0.01	0.06	0.27	0.22	-	0.03	5 473
2008	0.07	0.41	0.02	0.02	-	0.17	0.28	0.01	0.02	2 288
2009	0.12	0.25	-	0.03	-	0.02	0.49	0.02	0.06	3 168
2010	0.05	0.31	0.02	0.03	0.01	0.09	0.40	0.02	0.07	2 630
2011	0.06	0.39	0.05	0.02	0.02	0.07	0.37	0.02	0.01	3 525
Total	0.04	0.50	0.02	0.04	0.01	0.18	0.18	0.01	0.03	43 211

Table D5a: Proportion of catch reported each month from the Southland region for fishing years 1998–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1998	0.03	0.01	0.15	0.09	0.08	0.07	0.13	0.27	0.06	0.01	0.01	0.08	3 839
1999	0.03	0.02	0.08	0.11	0.15	0.39	0.13	0.03	0.01	0.01	-	0.04	4 440
2000	0.02	0.06	0.15	0.12	0.25	0.16	0.11	0.05	0.03	-	-	0.04	5 405
2001	0.11	0.03	0.10	0.13	0.07	0.12	0.16	0.17	0.06	-	-	0.05	4 454
2002	0.04	0.05	0.07	0.17	0.07	0.16	0.14	0.14	0.07	-	-	0.10	4 989
2003	0.03	0.02	0.04	0.20	0.07	0.30	0.20	0.08	0.05	-	-	0.02	4 210
2004	0.02	0.02	0.04	0.26	0.05	0.25	0.19	0.11	0.03	-	0.01	0.03	5 566
2005	0.01	0.08	0.14	0.08	0.05	0.08	0.33	0.14	0.05	0.03	-	-	3 848
2006	0.05	0.19	0.04	0.06	0.05	0.14	0.17	0.27	0.02	-	-	-	5 348
2007	0.04	0.08	0.25	0.25	0.07	0.09	0.17	0.02	0.01	0.01	-	-	6 073
2008	0.03	0.02	0.18	0.11	0.02	0.09	0.47	0.04	0.03	-	-	0.01	3 222
2009	-	0.08	0.09	0.14	0.28	0.07	0.10	0.12	0.11	0.01	-	-	3 203
2010	0.01	0.01	0.17	0.26	0.06	0.10	0.02	0.30	0.05	0.02	-	-	3 278
2011	0.02	0.02	0.03	0.35	0.22	0.18	0.07	0.05	0.04	0.03	-	-	3 016
Total	0.03	0.05	0.11	0.16	0.10	0.16	0.17	0.13	0.04	0.01	-	0.03	60 892

Table D5b: Proportion of catch reported for each statistical area from the Southland region for fishing years 1998–2011.

	026	027	028	029	030	031	504	602	Other	Total
1998	0.15	0.15	0.25	0.02	0.25	0.03	0.11	0.01	0.03	3 839
1999	0.20	0.09	0.55	-	0.12	0.01	0.02	-	-	4 440
2000	0.28	0.17	0.33	-	0.12	-	0.06	0.04	-	5 405
2001	0.22	0.13	0.35	0.02	0.22	0.02	0.04	-	-	4 454
2002	0.13	0.11	0.42	0.02	0.18	0.05	0.07	0.01	0.01	4 989
2003	0.13	0.19	0.45	-	0.08	0.01	0.12	0.02	-	4 210
2004	0.14	0.12	0.49	-	0.04	0.02	0.10	0.07	-	5 566
2005	0.23	0.27	0.25	-	0.07	-	0.11	0.05	0.02	3 848
2006	0.21	0.28	0.23	-	0.07	-	0.15	0.06	-	5 348
2007	0.19	0.28	0.31	0.01	0.01	-	0.16	0.03	-	6 073
2008	0.22	0.28	0.38	-	0.01	-	0.09	0.02	0.01	3 222
2009	0.13	0.32	0.32	-	0.01	-	0.16	0.05	-	3 203
2010	0.17	0.22	0.39	-	0.03	-	0.10	0.09	-	3 278
2011	0.24	0.25	0.22	-	0.01	-	0.20	0.06	-	3 016
Total	0.19	0.20	0.36	0.01	0.09	0.01	0.10	0.04	0.01	60 892

Table D5c: Proportion of catch reported by gear type from the Southland region for fishing years 1998–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1998	0.03	0.01	0.15	0.09	0.08	0.07	0.13	0.27	0.06	0.01	0.01	0.08	3 839
1999	0.03	0.02	0.08	0.11	0.15	0.39	0.13	0.03	0.01	0.01	-	0.04	4 440
2000	0.02	0.06	0.15	0.12	0.25	0.16	0.11	0.05	0.03	-	-	0.04	5 405
2001	0.11	0.03	0.10	0.13	0.07	0.12	0.16	0.17	0.06	-	-	0.05	4 454
2002	0.04	0.05	0.07	0.17	0.07	0.16	0.14	0.14	0.07	-	-	0.10	4 989
2003	0.03	0.02	0.04	0.20	0.07	0.30	0.20	0.08	0.05	-	-	0.02	4 210
2004	0.02	0.02	0.04	0.26	0.05	0.25	0.19	0.11	0.03	-	0.01	0.03	5 566
2005	0.01	0.08	0.14	0.08	0.05	0.08	0.33	0.14	0.05	0.03	-	-	3 848
2006	0.05	0.19	0.04	0.06	0.05	0.14	0.17	0.27	0.02	-	-	-	5 348
2007	0.04	0.08	0.25	0.25	0.07	0.09	0.17	0.02	0.01	0.01	-	-	6 073
2008	0.03	0.02	0.18	0.11	0.02	0.09	0.47	0.04	0.03	-	-	0.01	3 222
2009	-	0.08	0.09	0.14	0.28	0.07	0.10	0.12	0.11	0.01	-	-	3 203
2010	0.01	0.01	0.17	0.26	0.06	0.10	0.02	0.30	0.05	0.02	-	-	3 278
2011	0.02	0.02	0.03	0.35	0.22	0.18	0.07	0.05	0.04	0.03	-	-	3 016
Total	0.03	0.05	0.11	0.16	0.10	0.16	0.17	0.13	0.04	0.01	-	0.03	60 892

Table D5d: Proportion of catch reported by target species from the Southland region for fishing years 1998–2011.

	BAR	HAK	HOK	JMA	LIN	SQU	SWA	WWA	Other	Total
1998	0.04	-	0.19	0.08	0.01	0.38	0.30	-	0.01	3 839
1999	0.01	0.01	0.12	0.06	0.01	0.50	0.28	0.01	-	4 440
2000	0.05	-	0.31	0.03	0.01	0.26	0.33	0.01	-	5 405
2001	0.01	0.01	0.24	0.01	-	0.29	0.39	0.05	-	4 454
2002	0.01	-	0.21	0.02	-	0.44	0.30	0.01	0.01	4 989
2003	0.01	-	0.10	0.01	-	0.52	0.29	0.06	0.01	4 210
2004	0.01	-	0.13	-	-	0.59	0.21	0.05	-	5 566
2005	-	0.01	0.10	-	0.02	0.48	0.35	0.03	0.02	3 848
2006	0.01	-	0.06	-	0.02	0.54	0.29	0.07	0.01	5 348
2007	0.01	0.01	0.12	-	0.02	0.53	0.30	0.01	0.01	6 073
2008	0.01	-	0.02	-	0.02	0.24	0.70	0.01	-	3 222
2009	0.01	0.01	0.09	-	0.01	0.45	0.39	0.03	-	3 203
2010	0.01	0.01	0.02	-	0.02	0.49	0.42	0.01	0.01	3 278
2011	0.01	-	0.06	0.01	0.02	0.63	0.26	0.01	0.01	3 016
Total	0.01	-	0.14	0.02	0.01	0.46	0.33	0.03	0.01	60 892

Table D6a: Proportion of catch reported each month from the WCSI region for fishing years 1998–2011.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1998	-	-	-	-	-	-	-	0.01	0.06	0.52	0.38	0.03	2 782
1999	-	-	-	-	-	-	-	0.11	0.13	0.38	0.25	0.13	1 576
2000	0.01	-	-	-	-	-	-	0.01	0.07	0.40	0.47	0.04	1 952
2001	-	-	-	-	-	-	0.03	0.09	0.19	0.20	0.41	0.07	2 669
2002	-	-	-	-	-	-	-	-	0.20	0.19	0.54	0.06	884
2003	-	-	-	-	-	-	-	0.02	0.48	0.20	0.21	0.09	883
2004	0.01	-	-	-	-	-	-	0.01	0.13	0.41	0.34	0.11	1 240
2005	0.01	-	-	-	-	-	-	0.01	0.07	0.47	0.27	0.17	1 179
2006	0.01	-	-	-	-	-	-	0.13	0.18	0.40	0.20	0.07	821
2007	-	-	-	-	-	-	-	0.01	0.07	0.12	0.72	0.07	1 860
2008	0.01	-	-	-	-	-	-	0.01	0.15	0.29	0.48	0.05	1 468
2009	-	-	-	-	-	-	-	0.02	0.06	0.34	0.53	0.05	1 120
2010	0.01	-	-	-	-	-	-	0.01	0.17	0.31	0.40	0.08	554
2011	-	0.01	-	-	-	-	-	-	0.31	0.23	0.37	0.07	630
Total	-	-	-	-	-	-	-	0.03	0.14	0.33	0.41	0.07	19 619

Table D6b: Proportion of catch reported for each statistical area from the WCSI region for fishing years 1998–2011.

	033	034	035	036	703	Other	Total
1998	-	0.52	0.47	0.01	-	-	2 782
1999	0.01	0.43	0.49	0.05	0.03	-	1 576
2000	-	0.58	0.41	0.01	-	-	1 952
2001	0.01	0.63	0.36	0.01	-	-	2 669
2002	0.01	0.48	0.50	0.01	-	-	884
2003	0.02	0.49	0.46	0.03	-	-	883
2004	0.01	0.41	0.50	0.08	-	-	1 240
2005	0.01	0.36	0.56	0.06	0.01	-	1 179
2006	0.01	0.47	0.42	0.10	-	-	821
2007	-	0.15	0.84	0.01	-	-	1 860
2008	0.01	0.25	0.73	0.01	-	-	1 468
2009	0.01	0.31	0.67	0.01	-	-	1 120
2010	0.03	0.49	0.44	0.04	-	-	554
2011	-	0.41	0.56	0.03	-	-	630
Total	0.01	0.44	0.52	0.03	-	-	19 619

Table D6c: Proportion of catch reported by gear type from the WCSI region for fishing years 1998–2011.

	BT	MB	MW	Other	Total
1998	0.13	0.55	0.32	-	2 782
1999	0.48	0.30	0.22	-	1 576
2000	0.42	0.32	0.26	-	1 952
2001	0.51	0.30	0.19	-	2 669
2002	0.78	0.16	0.06	-	884
2003	0.80	0.14	0.06	-	883
2004	0.73	0.23	0.05	-	1 240
2005	0.91	0.08	0.01	-	1 179
2006	0.93	0.05	0.03	-	821
2007	0.91	0.07	0.03	-	1 860
2008	0.92	0.07	0.02	-	1 468
2009	0.90	0.09	0.01	-	1 120
2010	0.83	0.14	0.03	-	554
2011	0.82	0.12	0.06	-	630
Total	0.63	0.23	0.13	-	19 619

Table D6d: Proportion of catch reports by target species from the WCSI region for fishing years 1998–2011.

	BAR	HAK	HOK	JMA	LIN	SQU	SWA	TAR	Other	Total
1998	0.01	0.02	0.97	0.01	-	-	-	-	-	2 782
1999	0.02	0.03	0.84	0.03	-	-	0.06	-	0.02	1 576
2000	0.02	0.02	0.94	0.01	-	-	0.01	-	-	1 952
2001	0.04	0.04	0.73	0.01	-	0.03	0.15	-	0.01	2 669
2002	0.05	0.03	0.74	0.01	-	-	0.16	-	-	884
2003	0.05	0.04	0.71	0.01	-	0.05	0.13	-	0.01	883
2004	0.04	0.04	0.83	-	0.01	0.02	0.06	-	-	1 240
2005	0.15	0.09	0.46	0.01	-	0.08	0.20	-	0.01	1 179
2006	0.02	0.08	0.62	-	0.01	-	0.25	0.01	0.01	821
2007	0.13	0.06	0.27	0.04	0.01	-	0.49	-	-	1 860
2008	0.18	0.11	0.27	0.01	0.01	-	0.42	-	0.01	1 468
2009	0.14	0.15	0.26	0.02	0.01	-	0.41	0.01	0.01	1 120
2010	0.20	0.20	0.35	-	0.01	-	0.19	0.01	0.03	554
2011	-	0.26	0.68	-	-	-	0.03	0.01	0.01	630
Total	0.07	0.06	0.66	0.01	-	0.01	0.17	-	0.01	19 619

Table D7: Species codes used in this report.

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
BIG	Big eye tuna	*Thunnas obesus*
BNS	Blue nose	*Hyperoglyphe antarctica*
BOE	Black dory	*Allocyttus niger*
BYX	Alfonsino	*Beryx splendens, B. decadactylus*
CDL	Black cardinal	*Epigonus telescopus*
HAK	Hake	*Merluccius australis*
HOK	Hoki	*Macruronus novaezelandiae*
HPB	Groper	*Polyprion oxygeneios, P. americanus*
JMA	Jack mackerels	*Trachurus declivis*, *T. novaezelandiae*, *T. symmetricus murphyi*
KAH	Kahawai	*Arripis trutta, A. xylabion*
LDO	Lookdown dory	*Cyttus traversi*
LIN	Ling	*Genypterus blacodes*
OEO	Oreos	*Allocyttus niger, Neocyttus rhomboidalis, Pseudocyttus maculatus*
ORH	Orange roughy	*Hoplostethus atlanticus*
PTO	Patagonian Toothfish	*Dissostichus eleginoides*
RCO	Red cod	*Pseudophycis bachus*
RIB	Ribaldo	*Mora moro*
SBW	Southern blue whiting	*Micromesistius australis*
SCH	School shark	*Galeorhinus galeus*
SCI	Scampi	*Metanephrops challengeri*
SKI	Gemfish	*Rexea solandri*
SNA	Snapper	*Pagrus auratus*
SPE	Sea perch	*Helicolenus percoides*
SPO	Rig	*Mustelus lenticulatus*
SQU	Arrow squid	*Nototodarus gouldi*, *N. sloanni*
SSO	Smooth oreo	*Pseudocyttus maculatus*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
TRE	Trevally	*Pseudocaranx dentex*
WAR	Blue warehou	*Seriolella brama*
WWA	White warehou	*Seriolella caerulea*

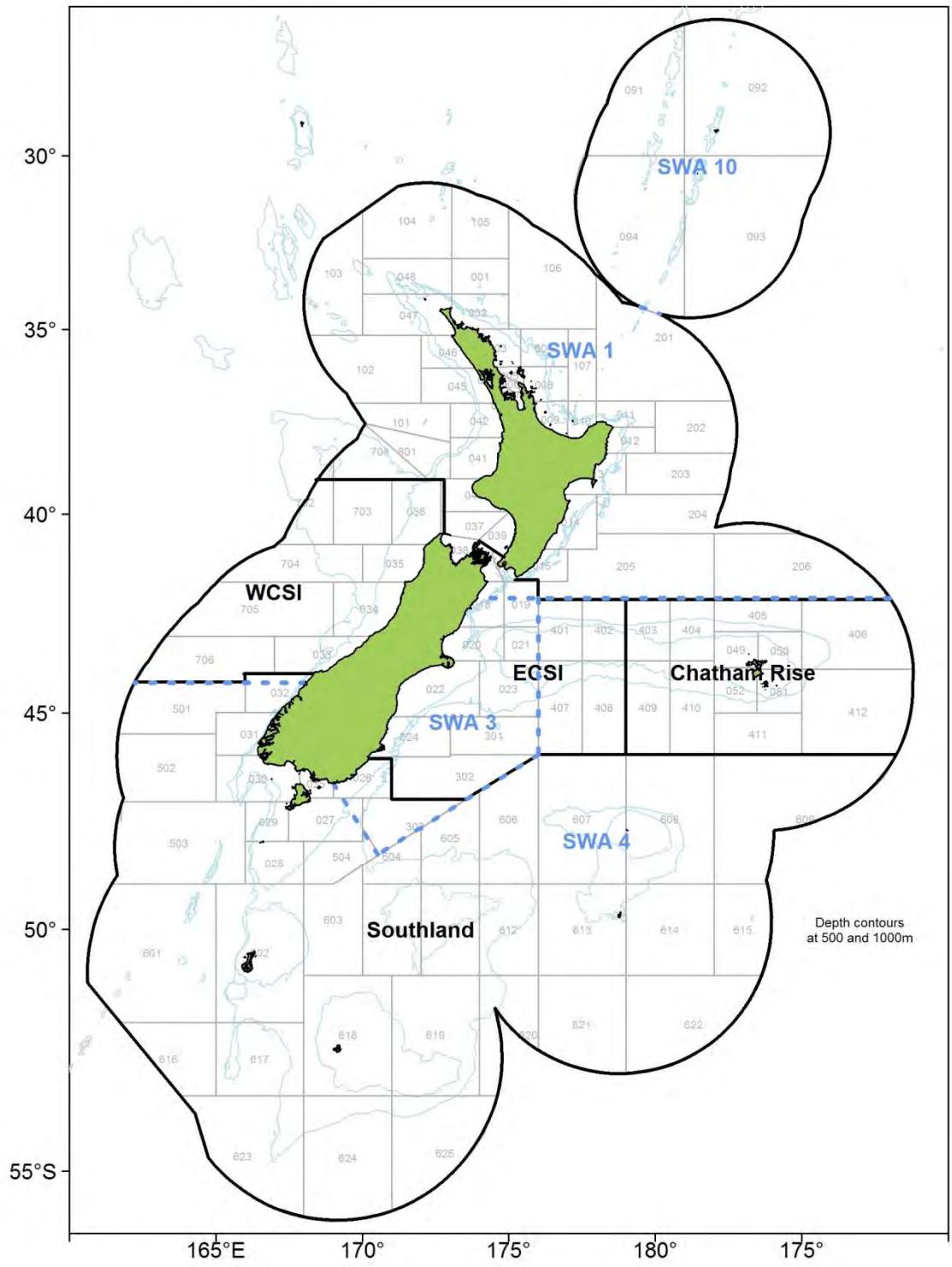


Figure D0: Map showing the Sub-area boundaries (black lines) used in this analysis and the administrative fishstock boundaries (blue dashed lines) for SWA 1, SWA 3, SWA 4, and SWA 10, including statistical areas, and the 200 m, 500 m, and 1000 m depth contours.

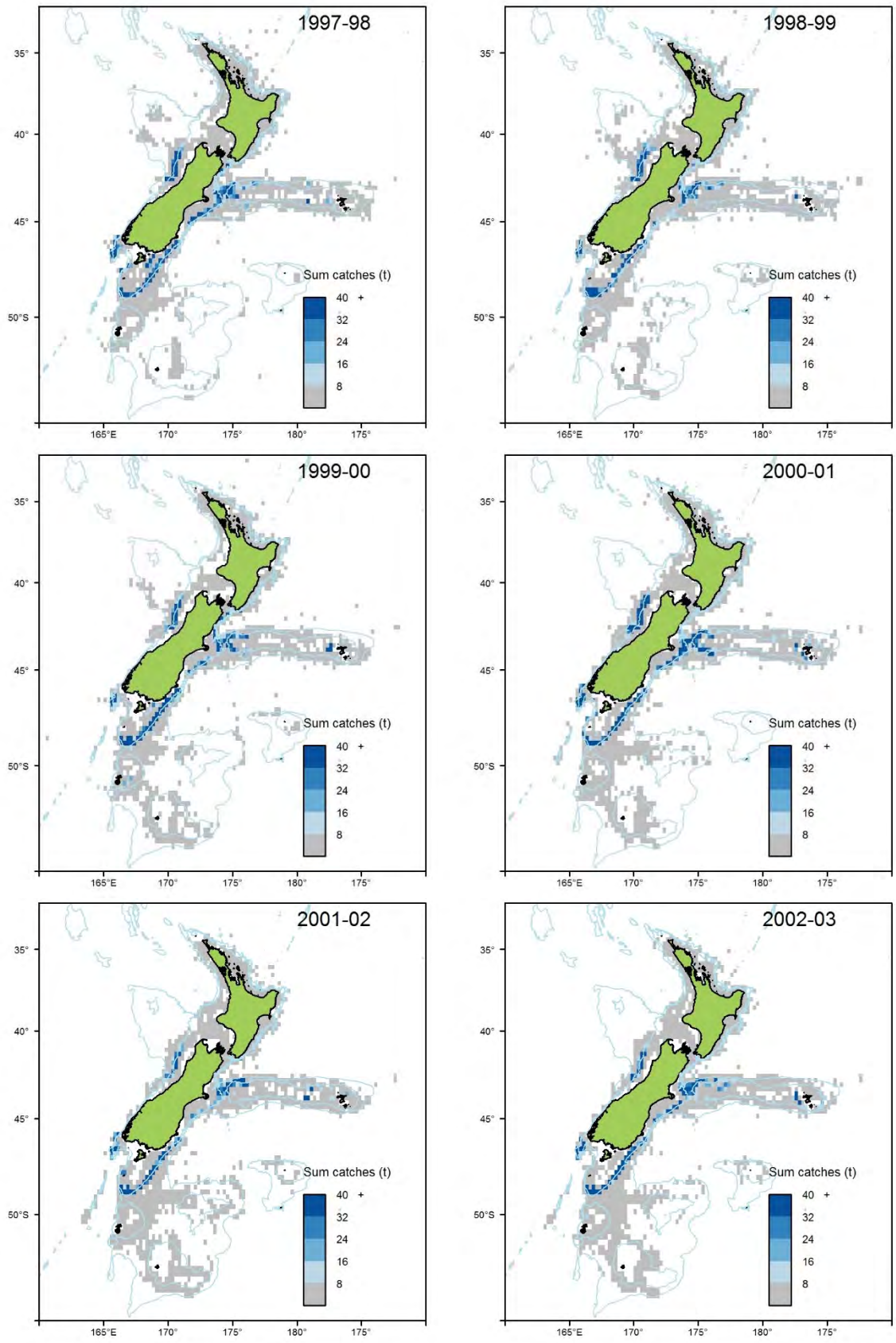


Figure D1: Annual catch (in tonnes) of all commercial silver warehou catches from all form types by fishing year (1 October to 30 September) 1998 to 2011.

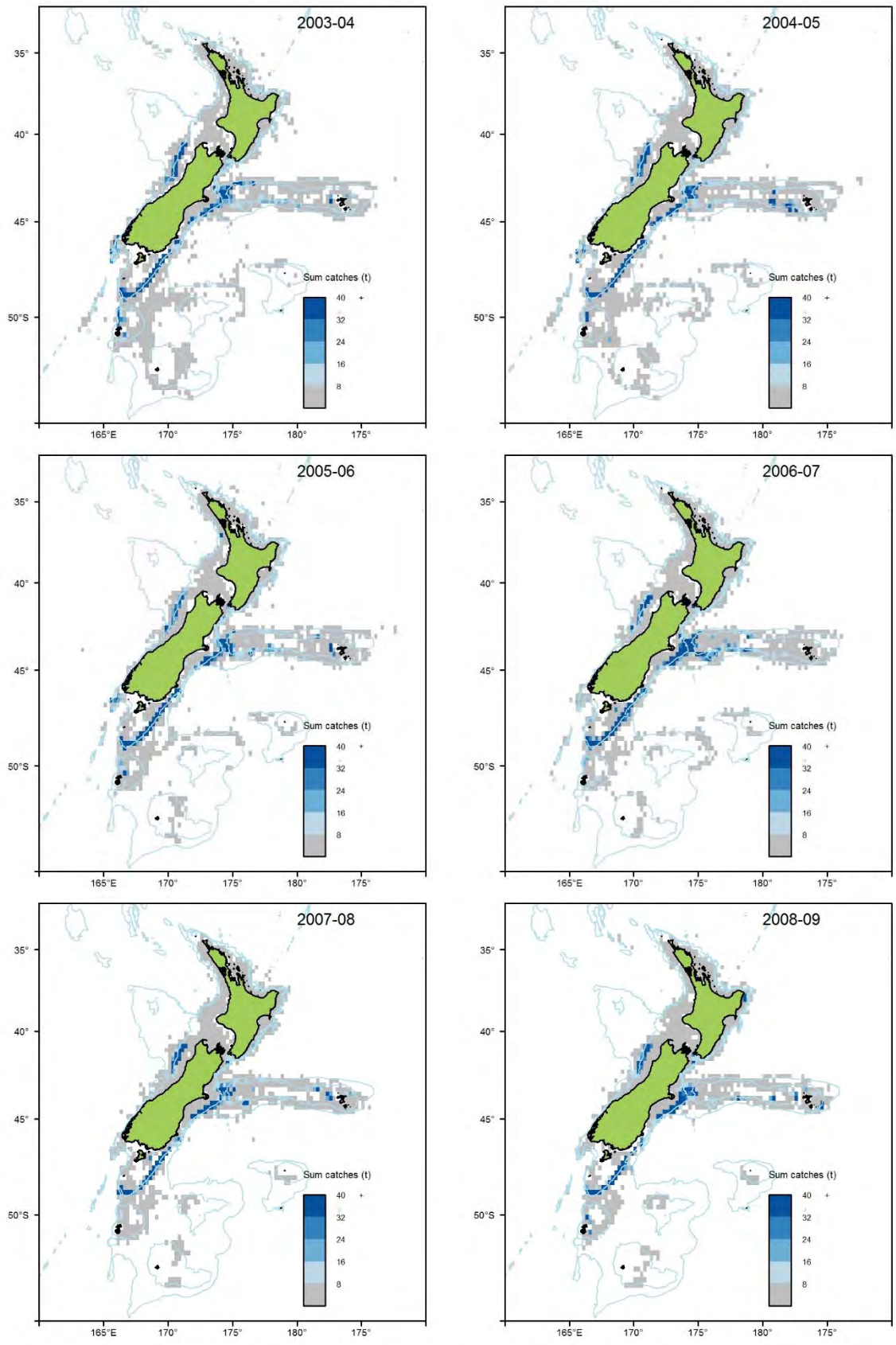


Figure D1: (Continued).

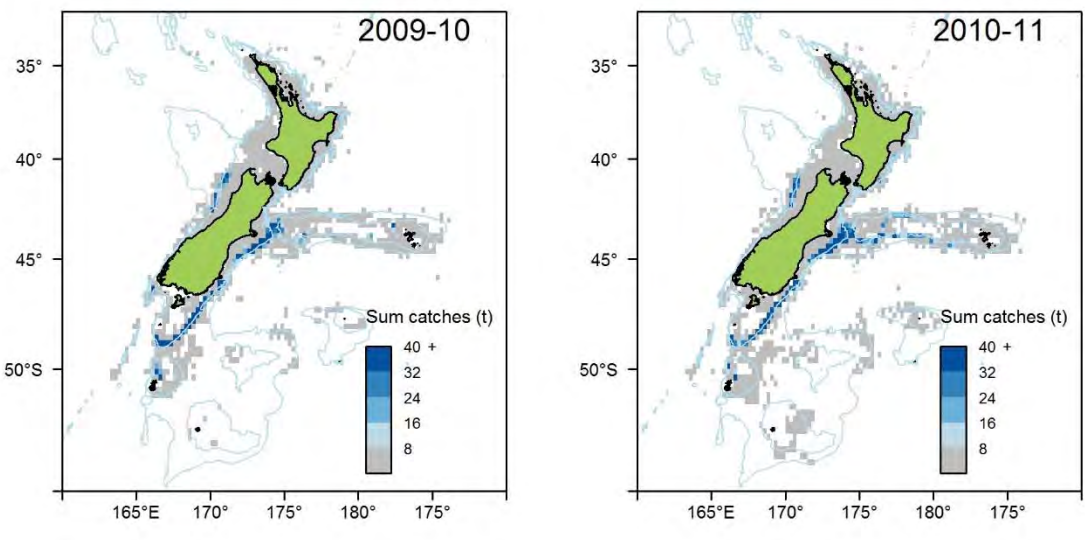


Figure D1: (Continued).

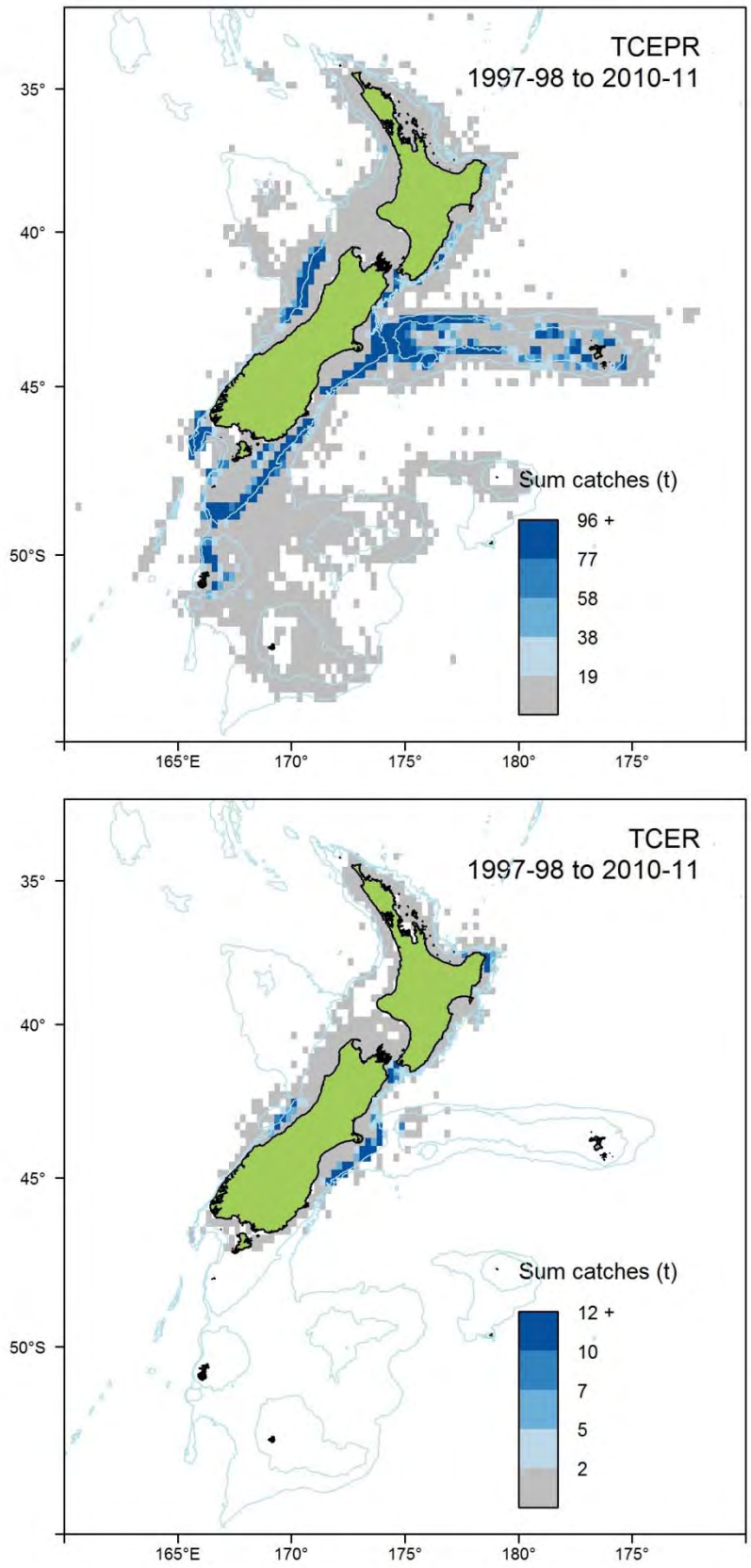


Figure D1b: Catch (in tonnes) of all commercial silver warehou catches from TCEPR (top) and TCER (bottom) for fishing years 1998 to 2011.

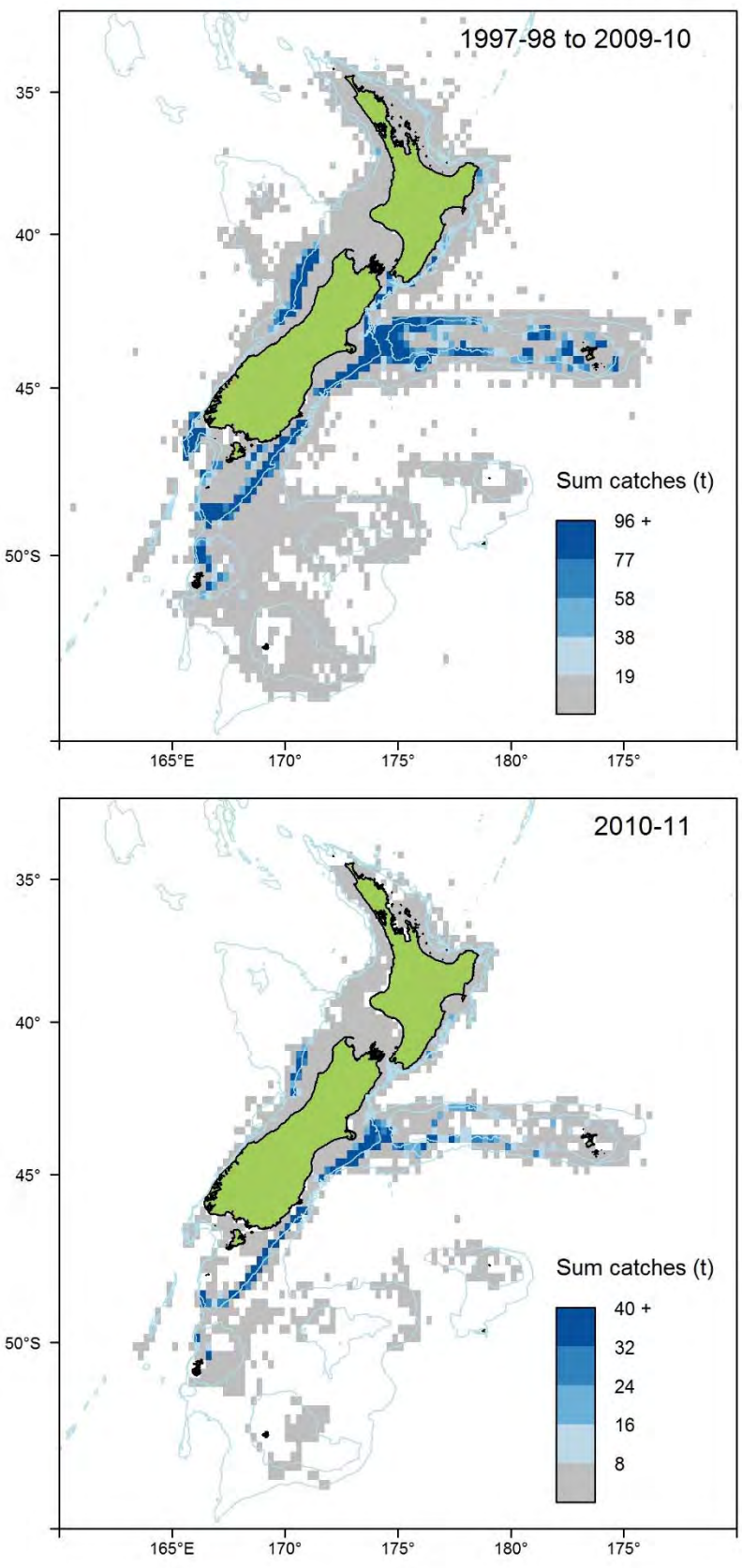


Figure D1c: Catch (in tonnes) of all commercial silver warehou catches for fishing years 1998–2010 (top) and 2011 (bottom).

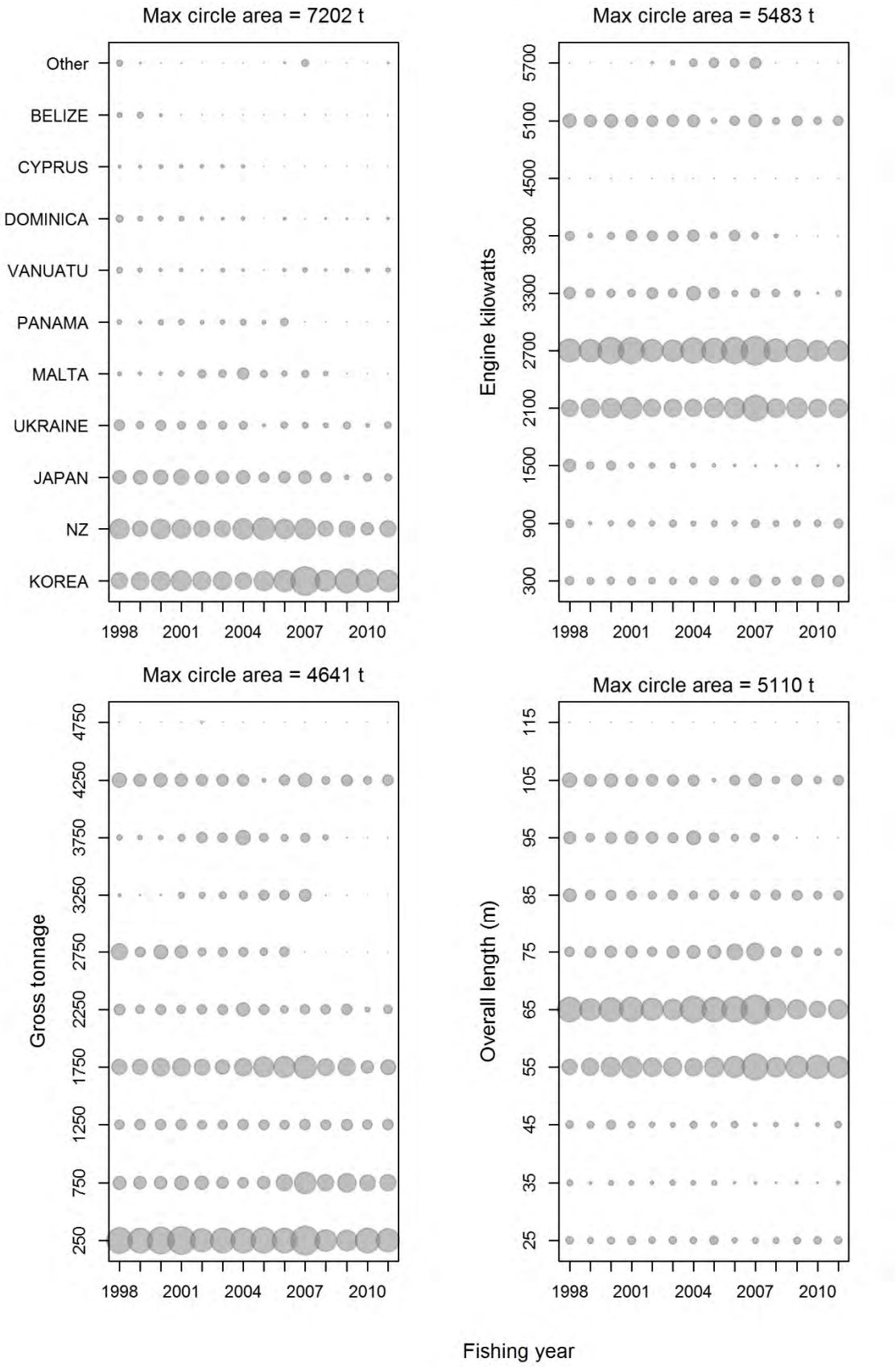


Figure D2a: Distribution of annual catch by nationality, vessel power, gross tonnage, and length (m) for all merged data.

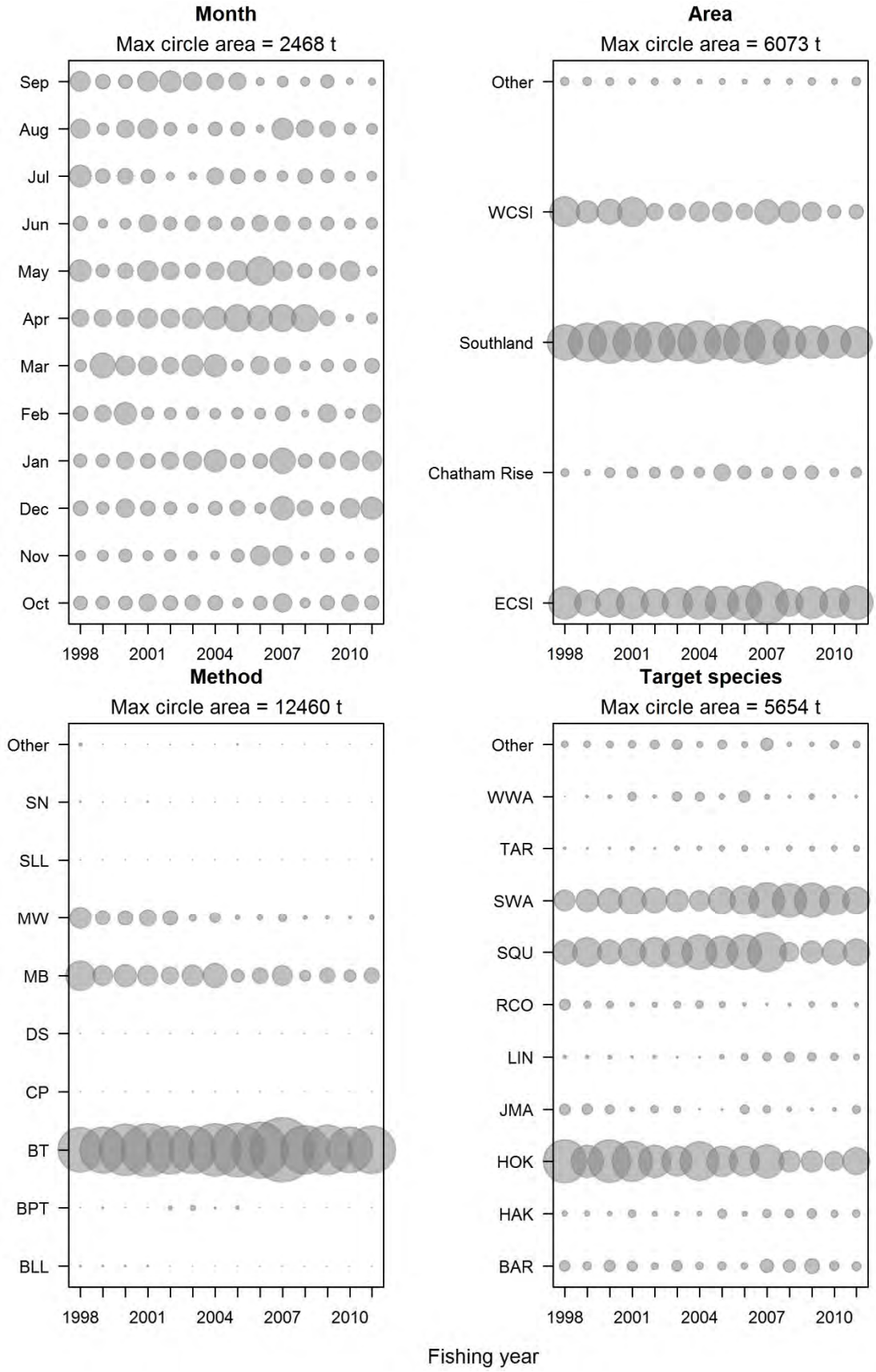


Figure D2b: Distribution of annual catch by month, area, method, and target species for all merged data.

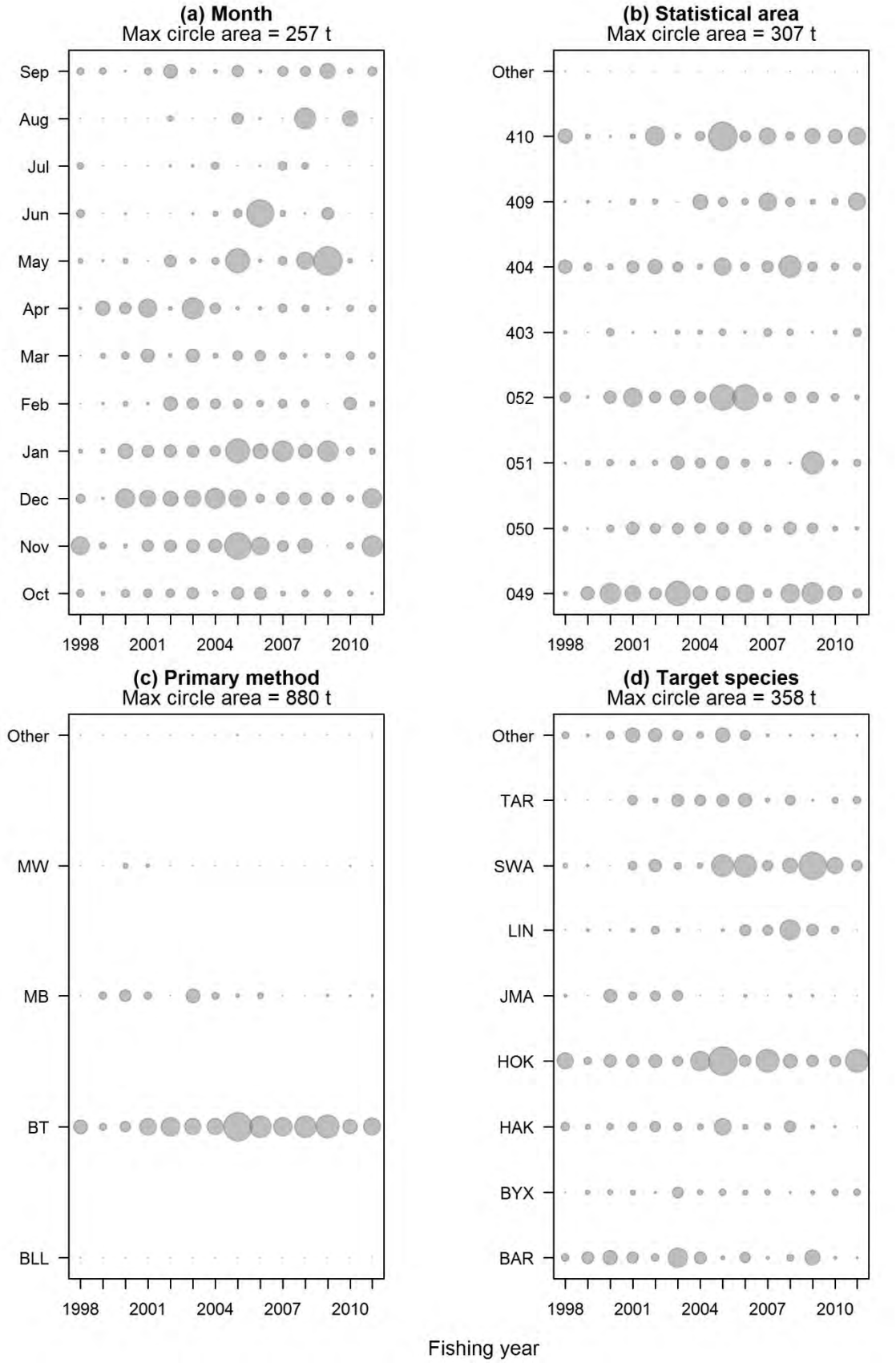


Figure D3a: Distribution of silver warehou catch in the Chatham Rise region for 1991–2011 fishing years in relation to a) month, b) statistical area, c) fishing method, and d) target species.

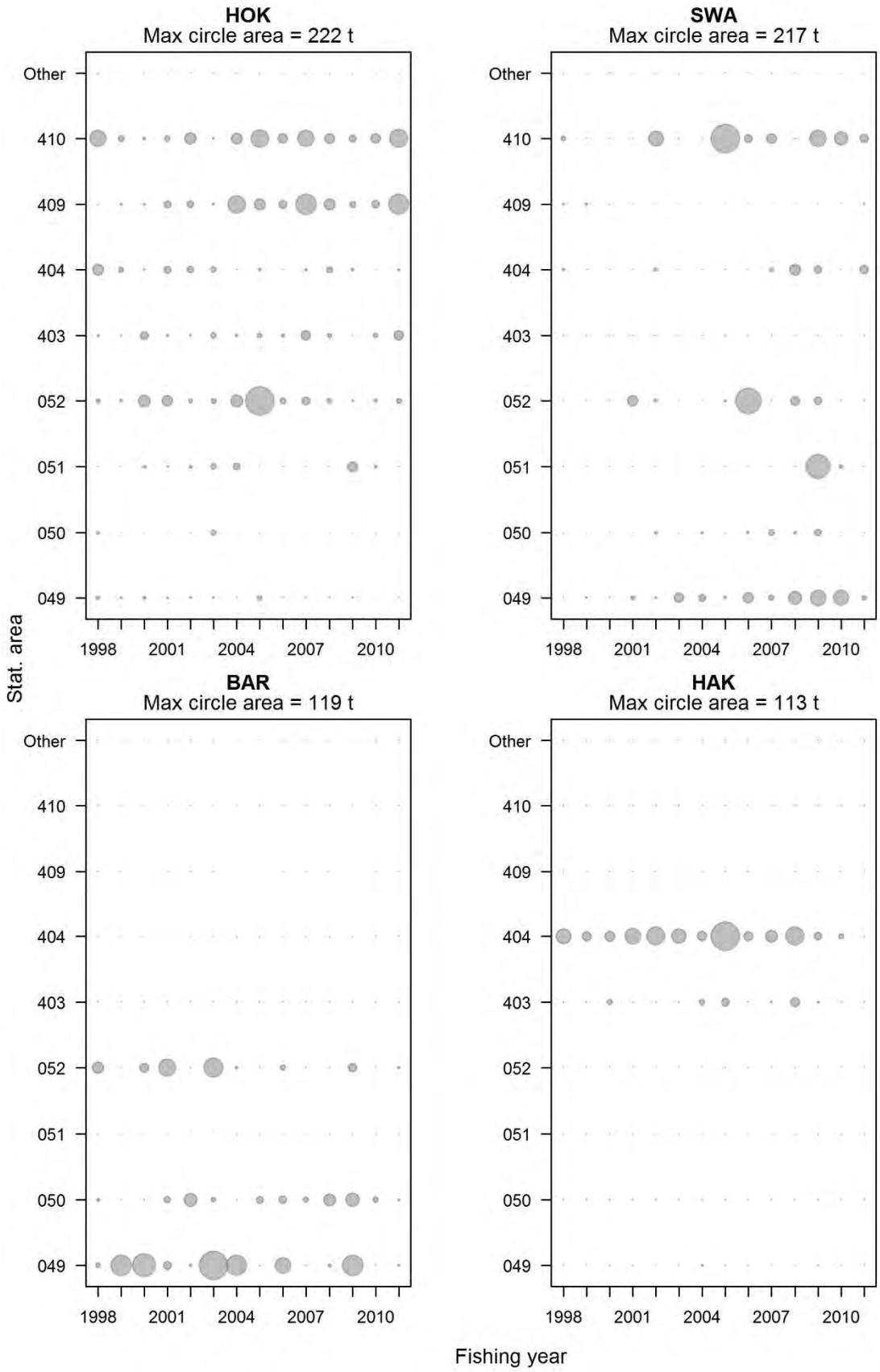


Figure D3b: Distribution of silver warehou catch in the Chatham Rise region for 1991–2011 fishing years in relation to statistical area for the top four target species.

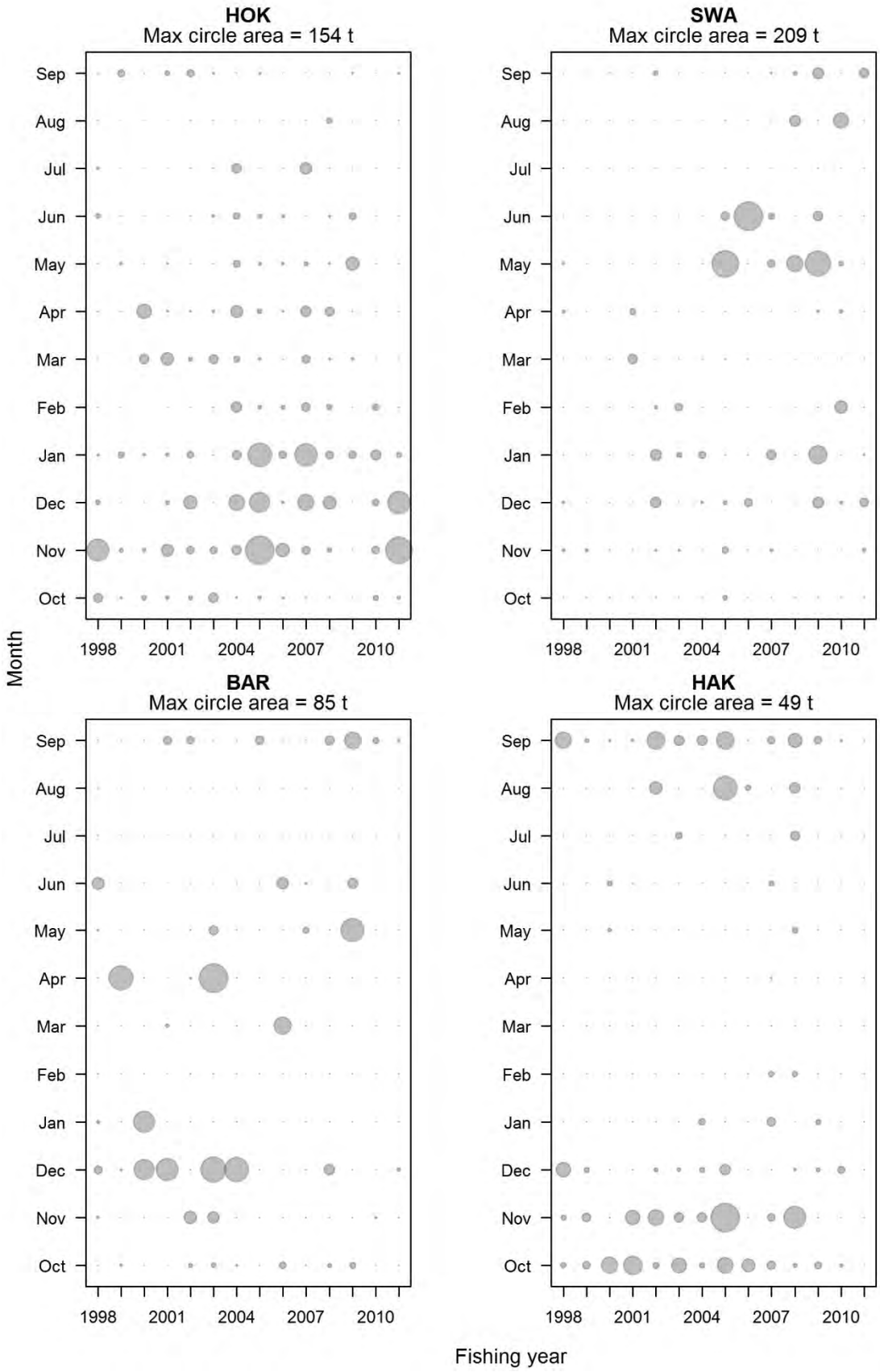


Figure D3c: Distribution of silver warehou catch in the Chatham Rise region for 1991–2011 fishing years in relation to month for the top four target species.

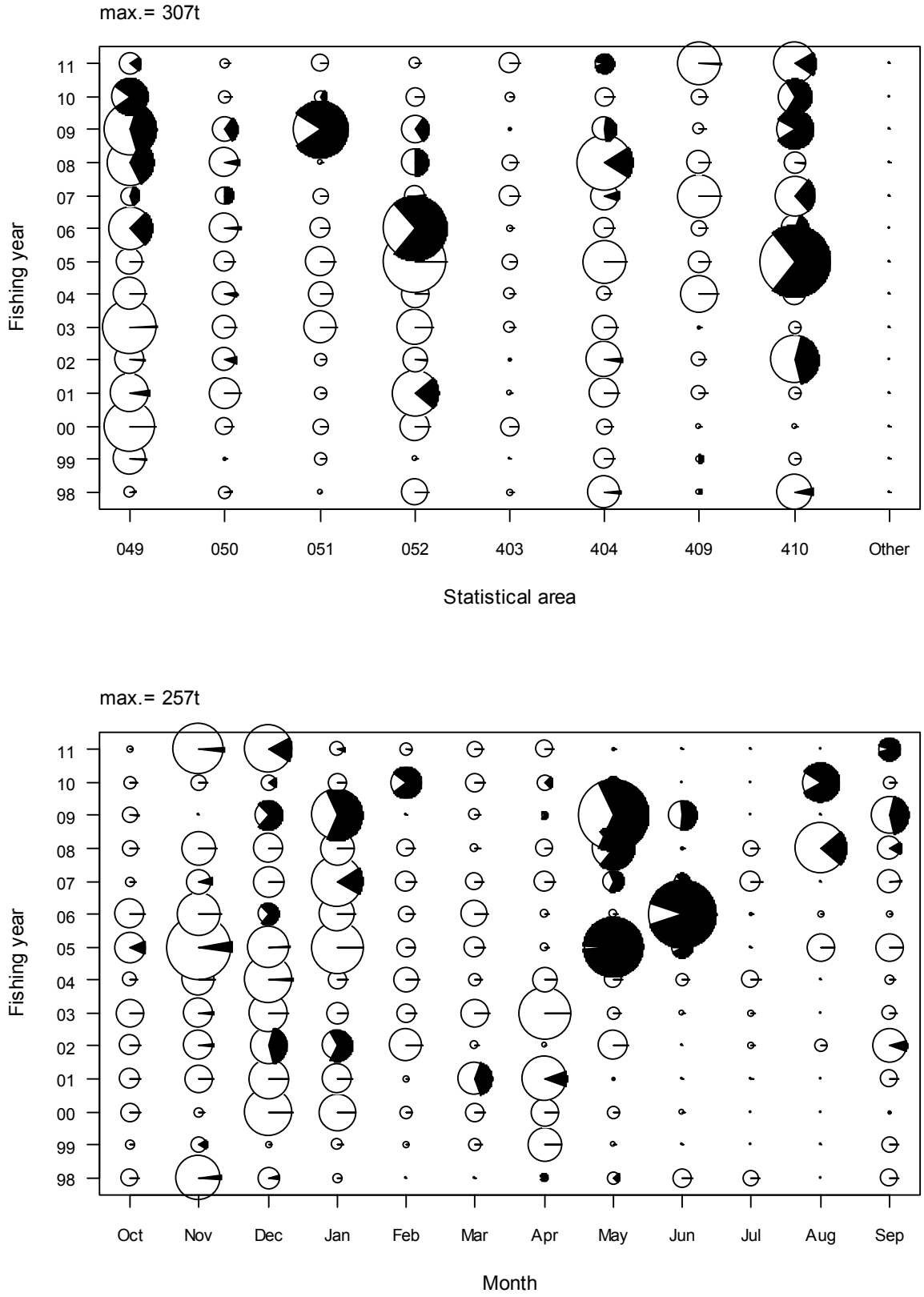


Figure D4: Distribution of SWA catch by fishing year with circle size proportional to the total catch and black portion of the pie indicating proportion of the catch as targeted SWA by a) statistical area, and b) month for the Chatham Rise region.

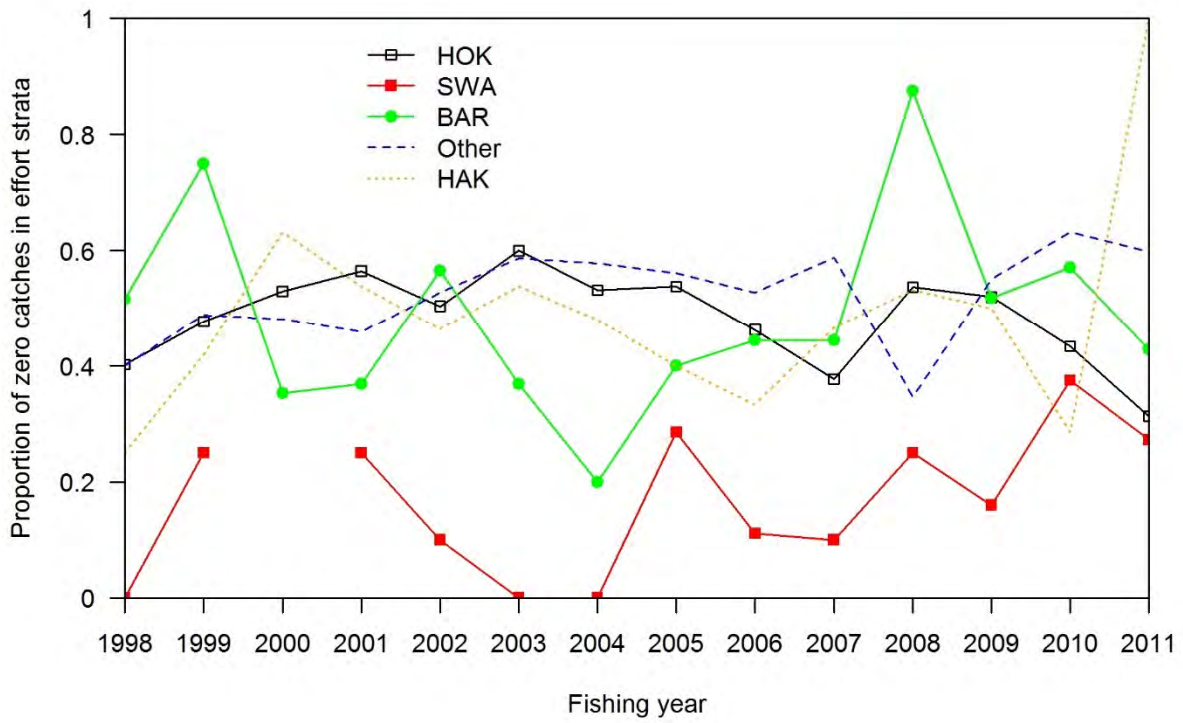


Figure D5: Proportion of tows with zero reported SWA catch for major target species for the Chatham Rise region.

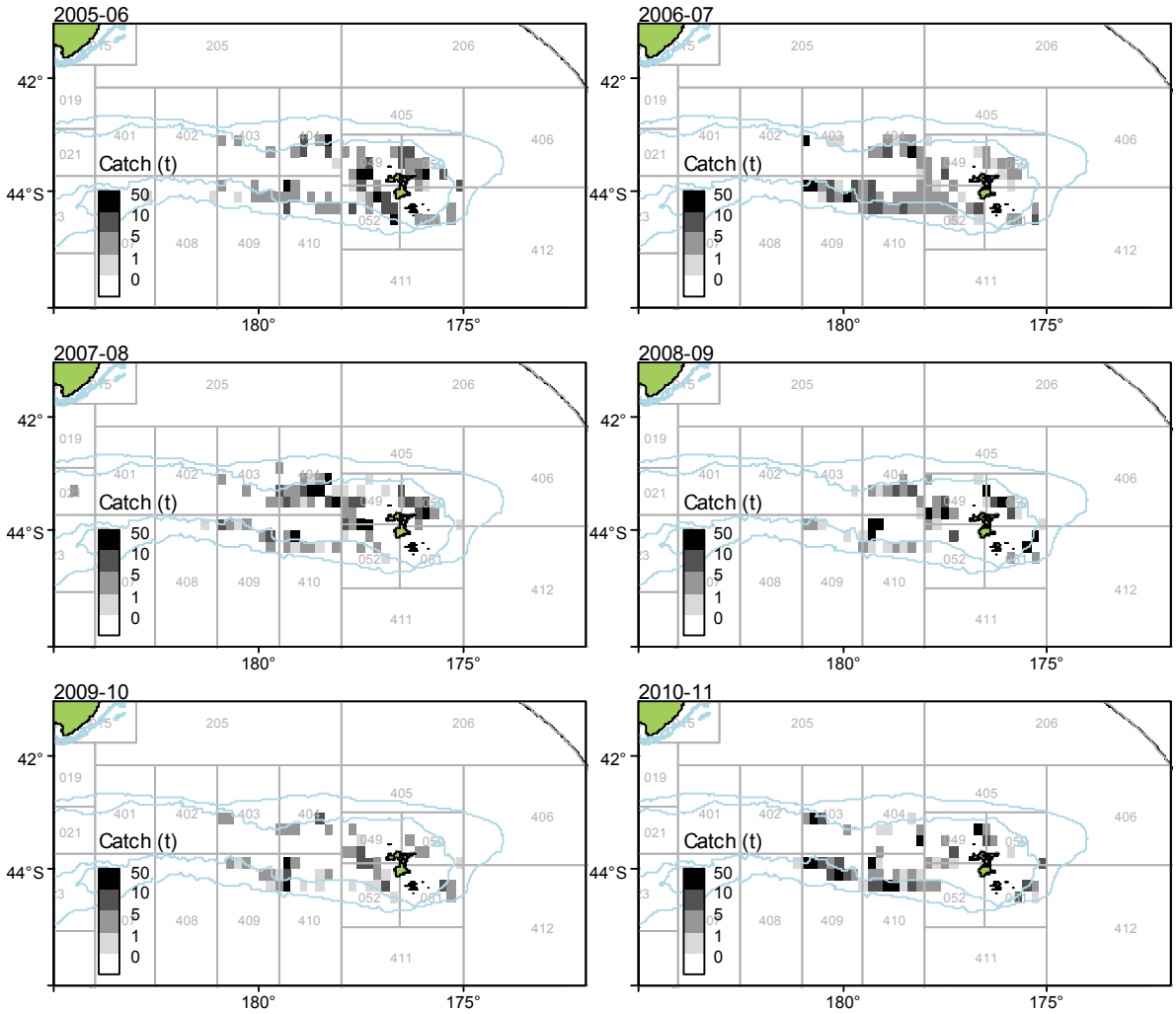


Figure D6: Distribution of silver warehou catch within the Chatham Rise region aggregated into 0.2 degree spatial blocks for fishing years 2006–2011.

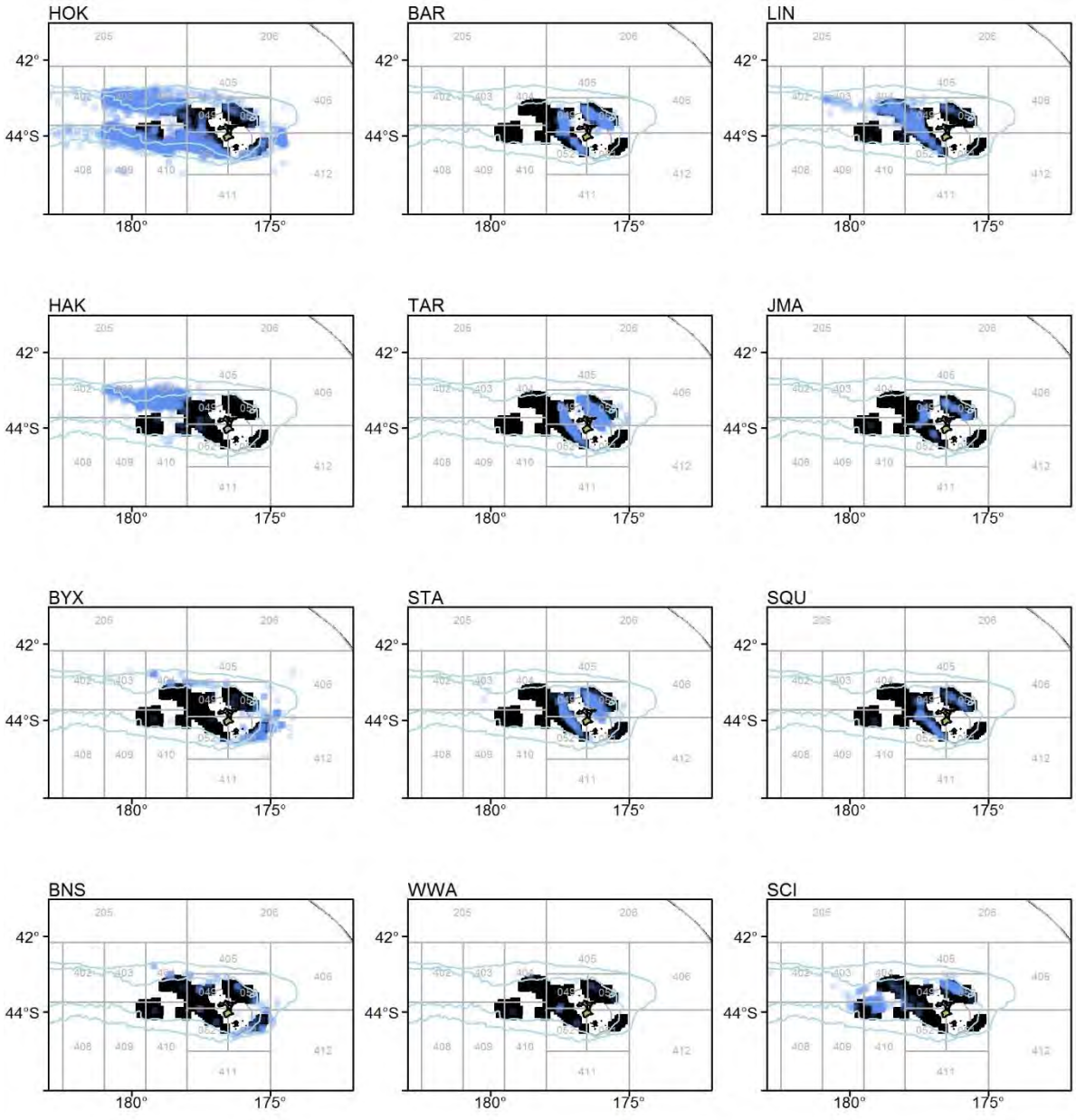


Figure D7: Chatham Rise statistical areas and bathymetry showing the distribution of trawls by target species for the main target species (blue cells) compared to the distribution of SWA target effort distribution (black cells) for all years combined.

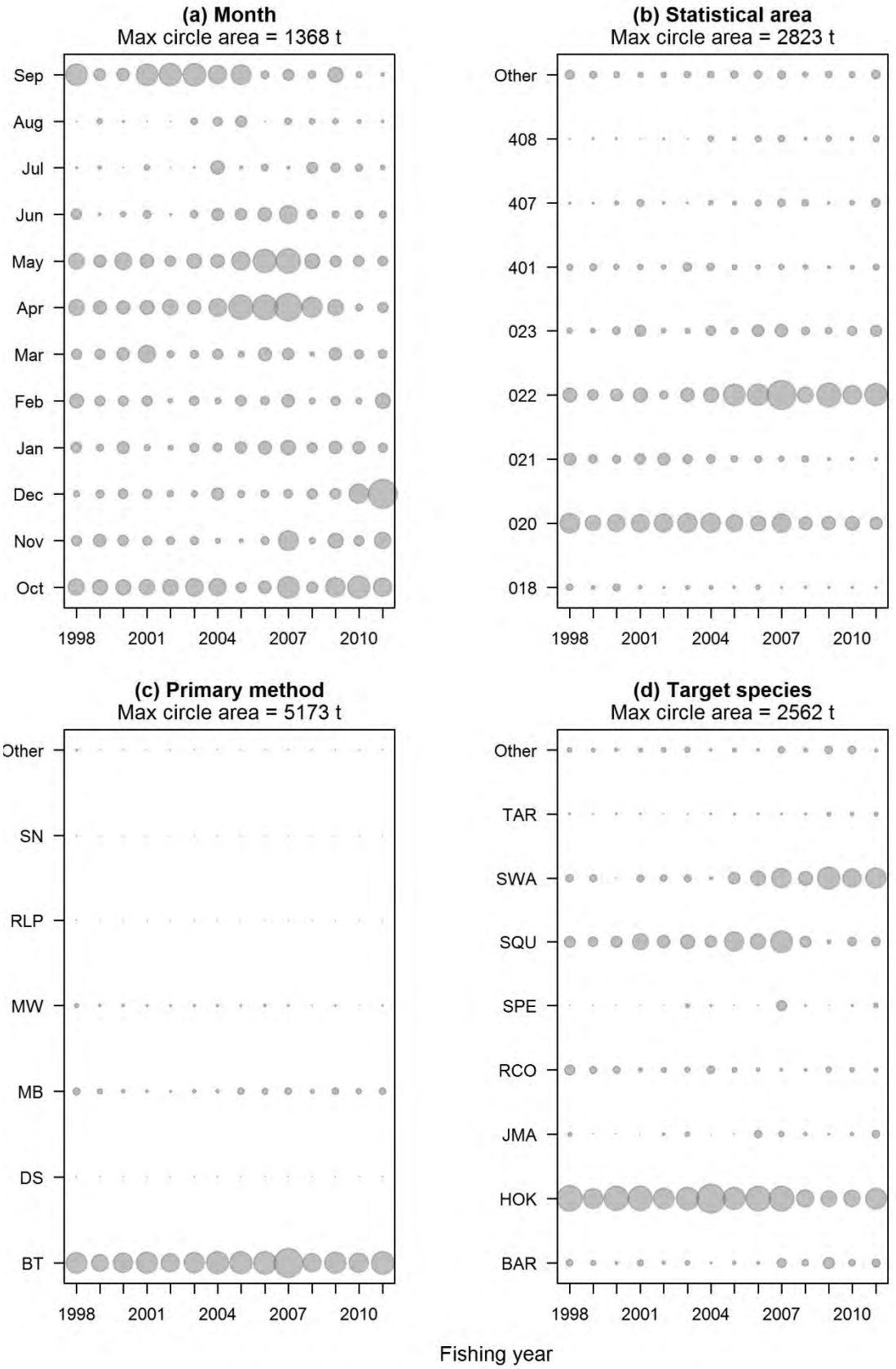


Figure D8a: Distribution of silver warehou catch in the East Coast South Island region for 1991–2011 fishing years in relation to a) month, b) statistical area, c) fishing method, and d) target species.

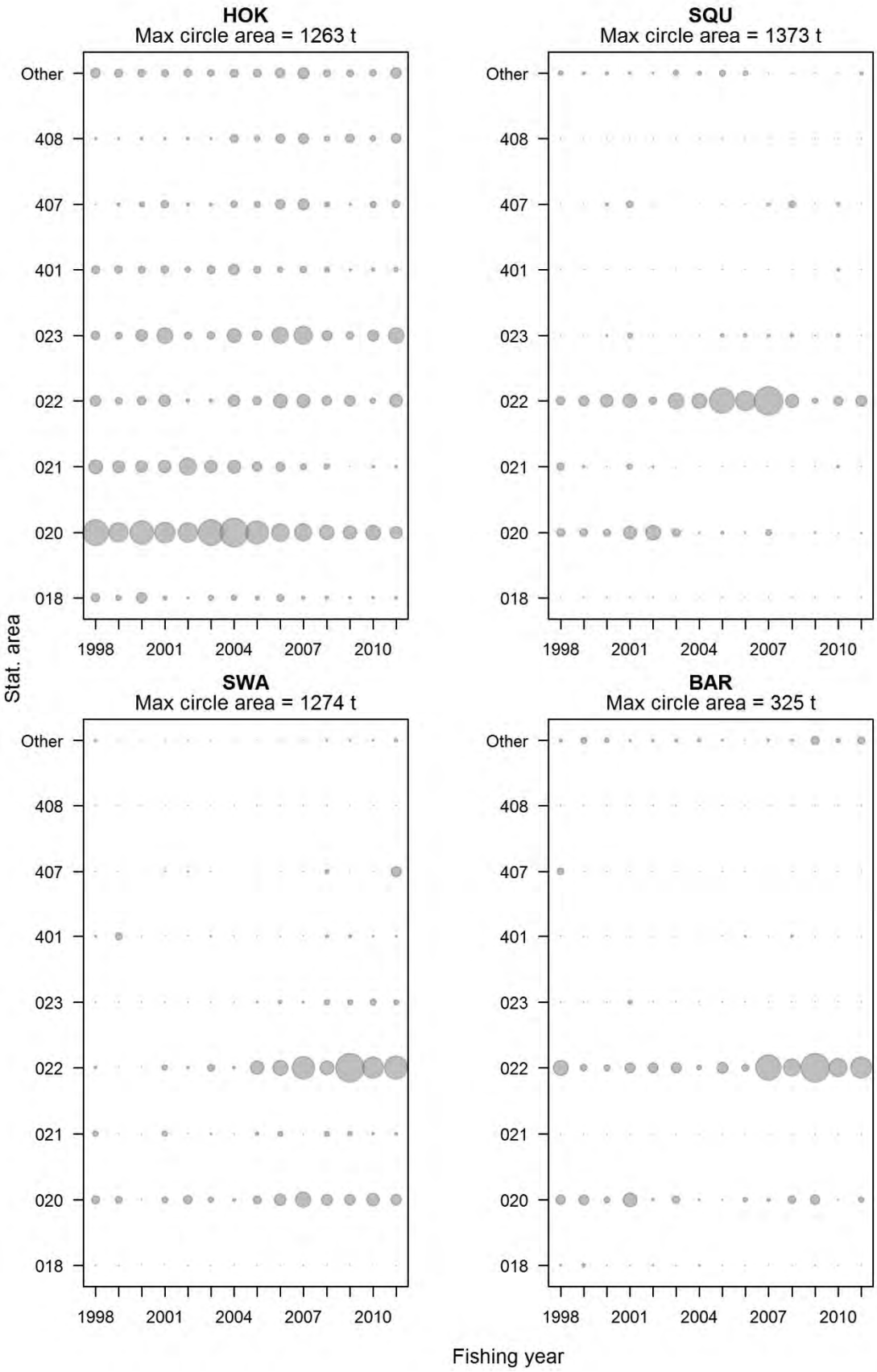


Figure D8b: Distribution of silver warehou catch in the East Coast South Island region for 1991–2011 fishing years in relation to statistical area for the top four target species.

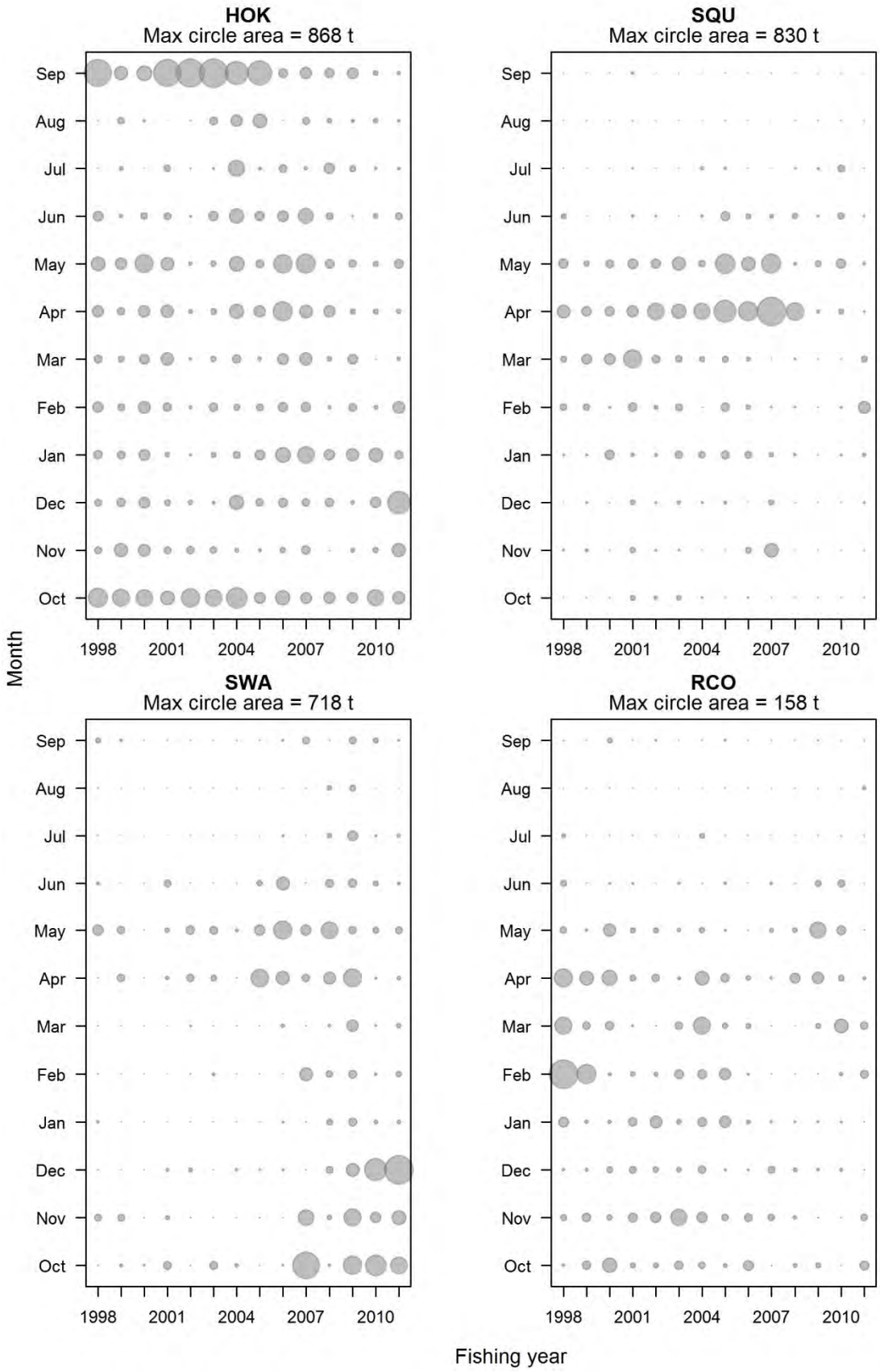


Figure D8c: Distribution of silver warehou catch in the East Coast South Island region for 1991–2011 fishing years in relation to month for the top four target species.

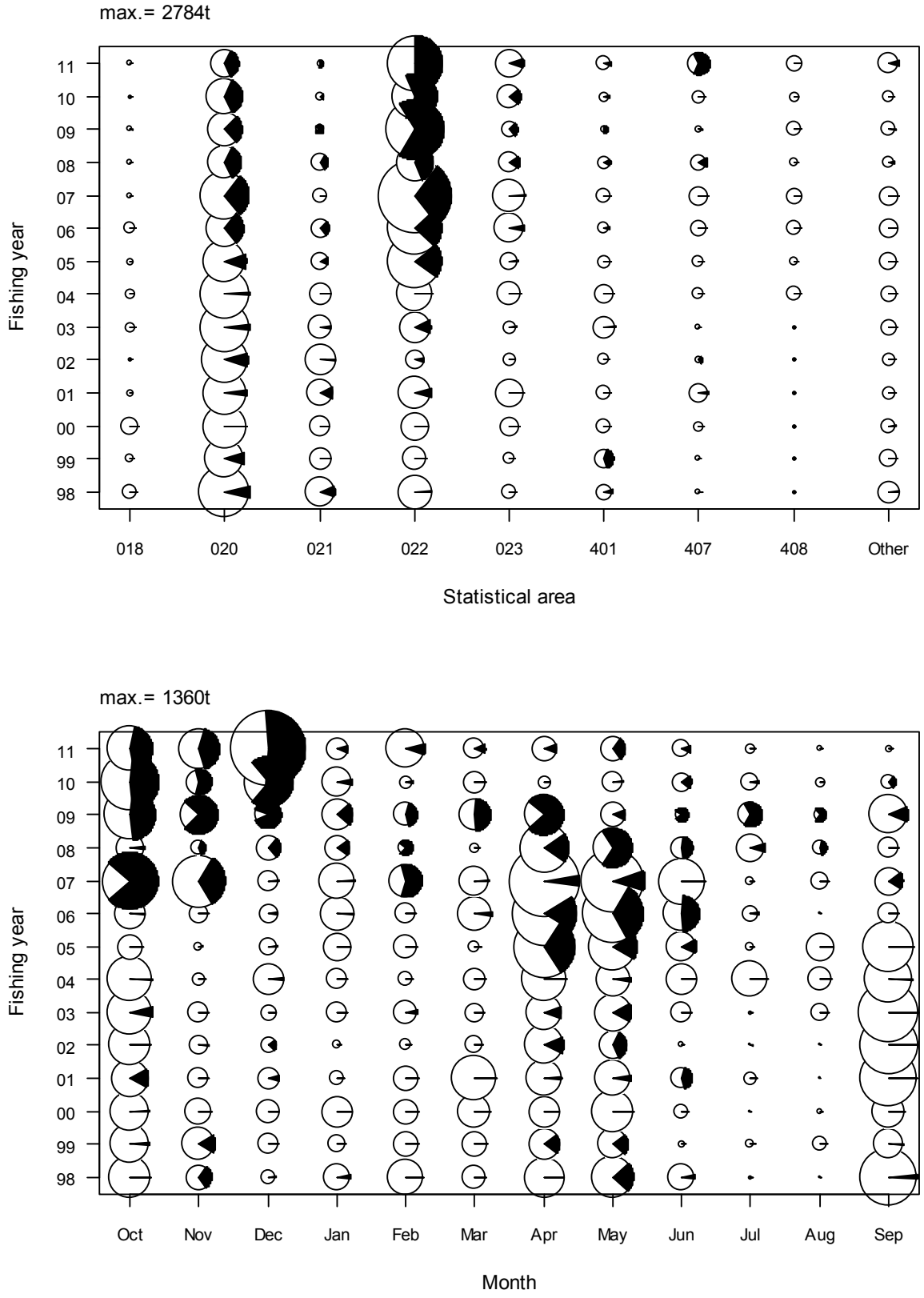


Figure D9: Distribution of SWA catch by fishing year with circle size proportional to the total catch and black portion of the pie indicating proportion of the catch as targeted SWA by a) statistical area, and b) month for the East Coast South Island region.

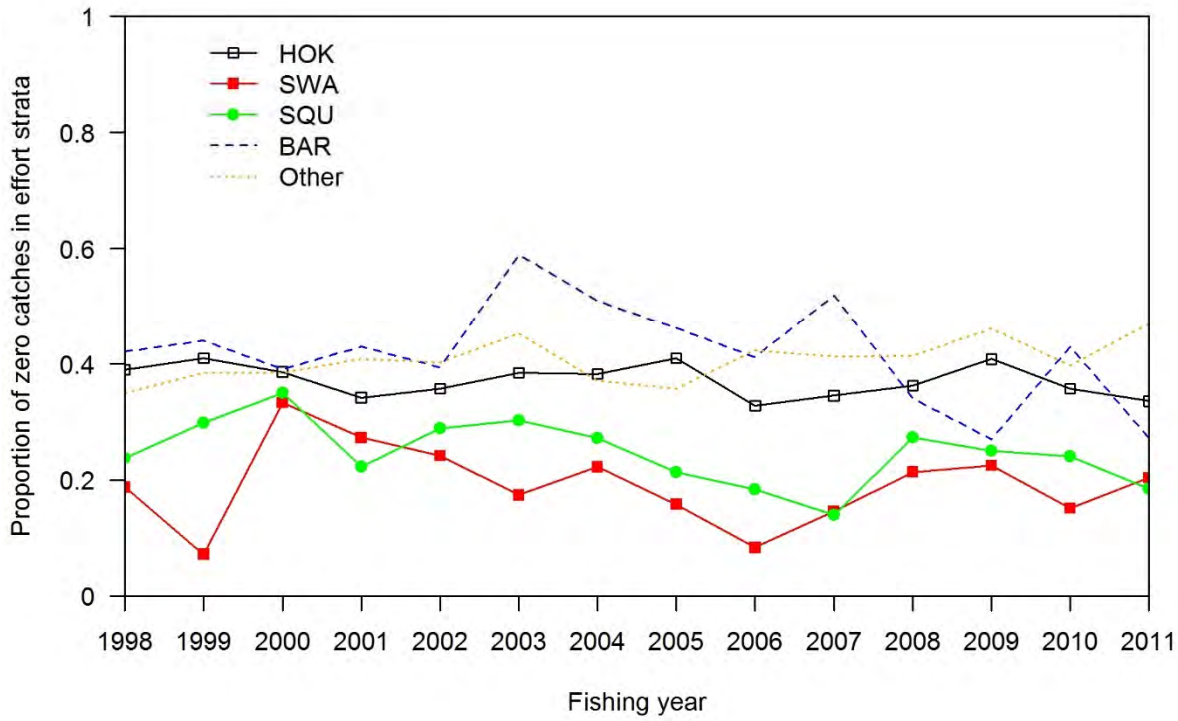


Figure D10: Proportion of tows with zero reported SWA catch for major target species for the East Coast South Island region.

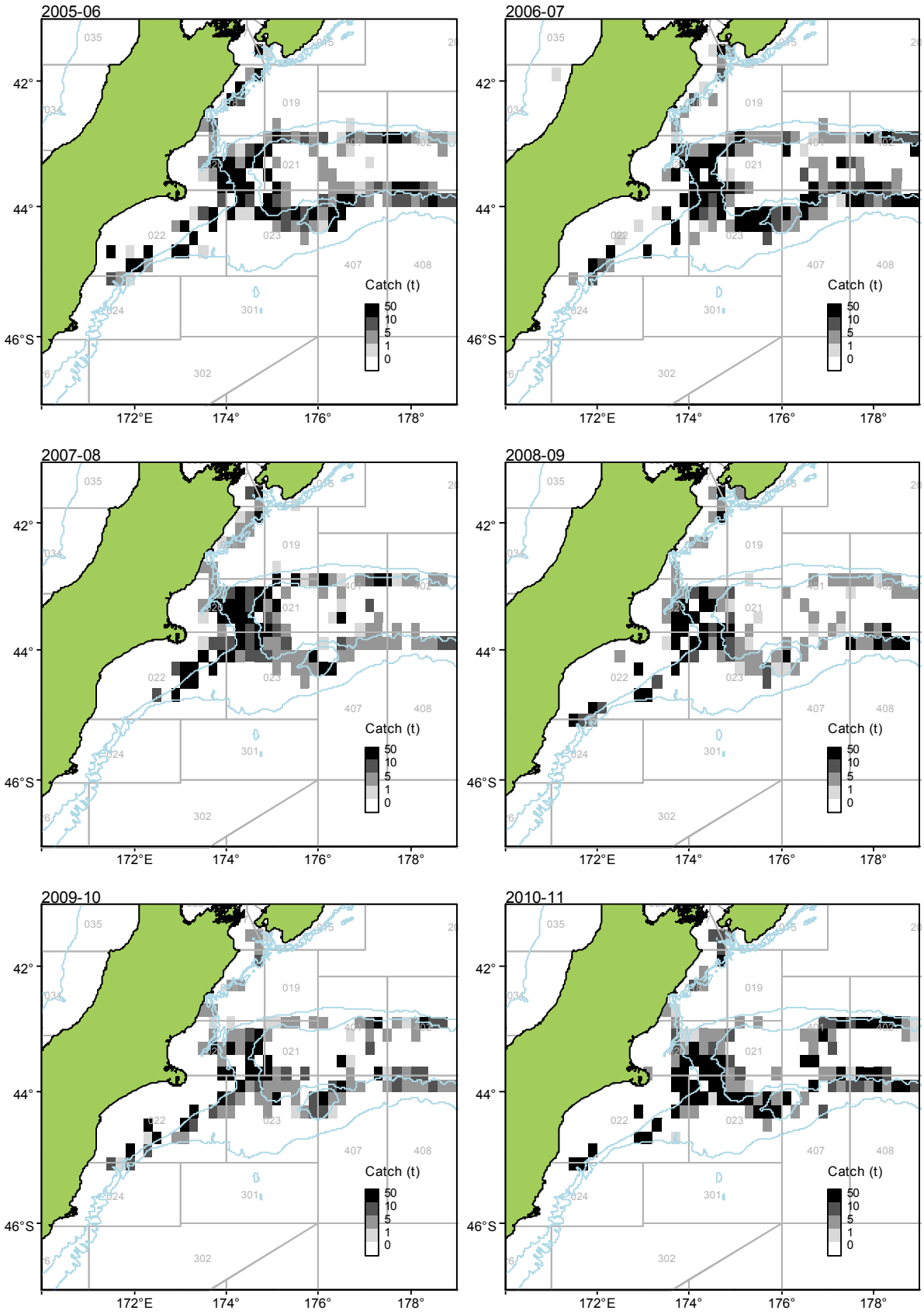


Figure D11: Distribution of silver warehou catch within the East Coast South Island region aggregated into 0.2 degree spatial blocks for fishing years 2006–2011.

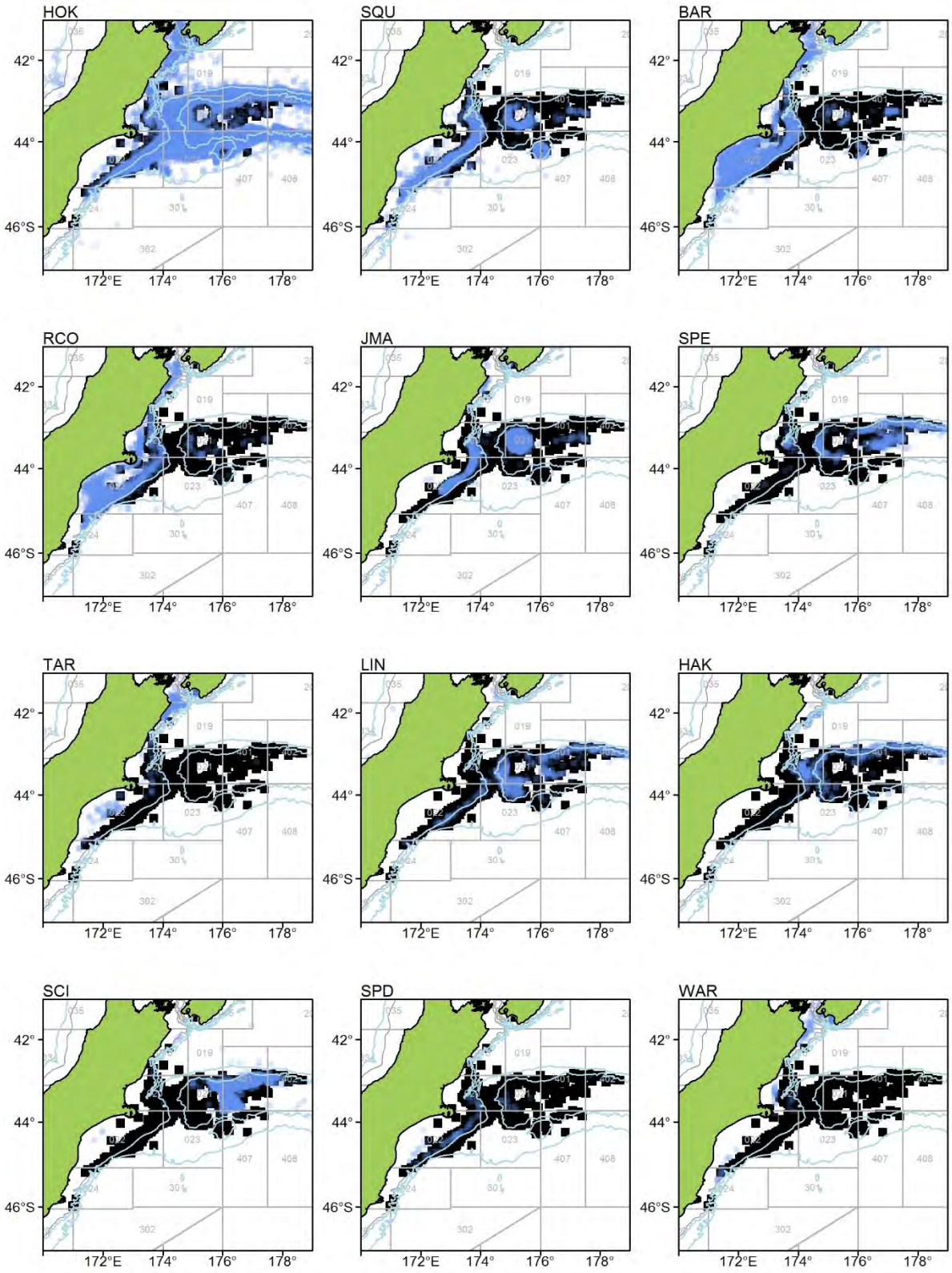


Figure D12: East Coast South Island statistical areas and bathymetry showing the distribution of trawls by target species for the main target species (blue cells) compared to the distribution of SWA target effort distribution (black cells) for all years combined.

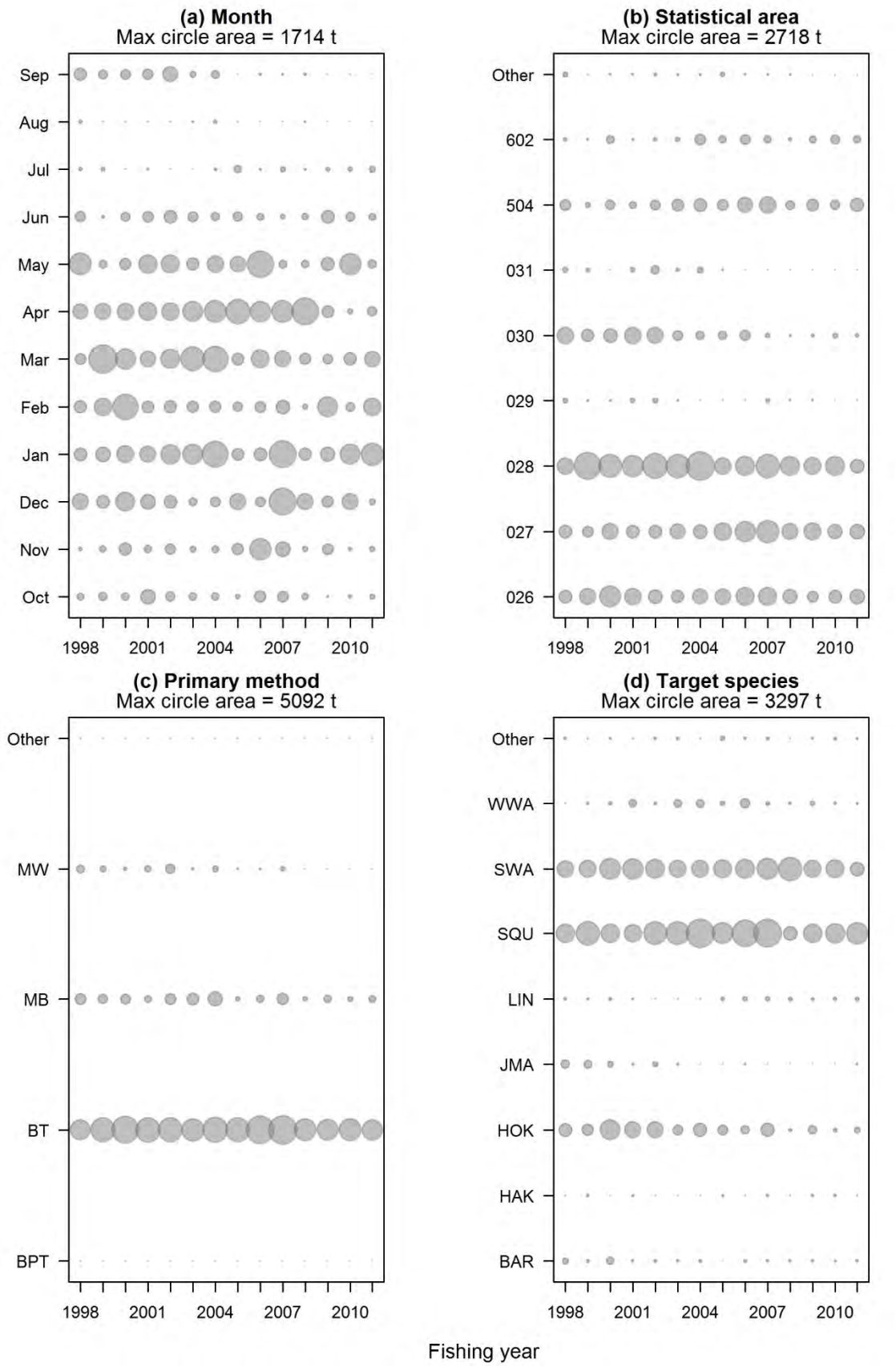


Figure D13a: Distribution of silver warehou catch in the Southland region for 1991–2011 fishing years in relation to a) month, b) statistical area, c) fishing method, and d) target species.

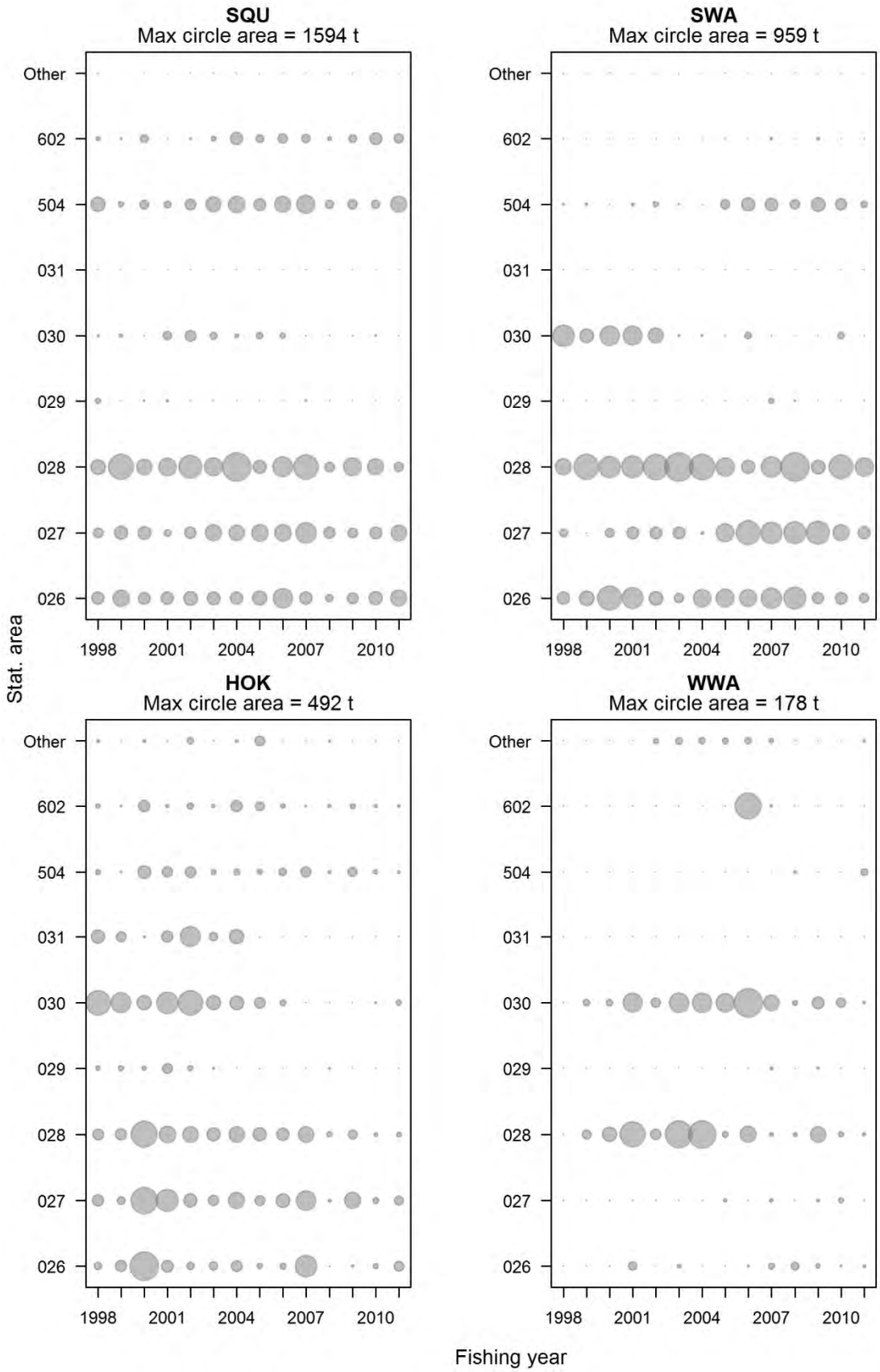


Figure D13b: Distribution of silver warehou catch in the Southland region for 1991–2011 fishing years in relation to statistical area for the top four target species.

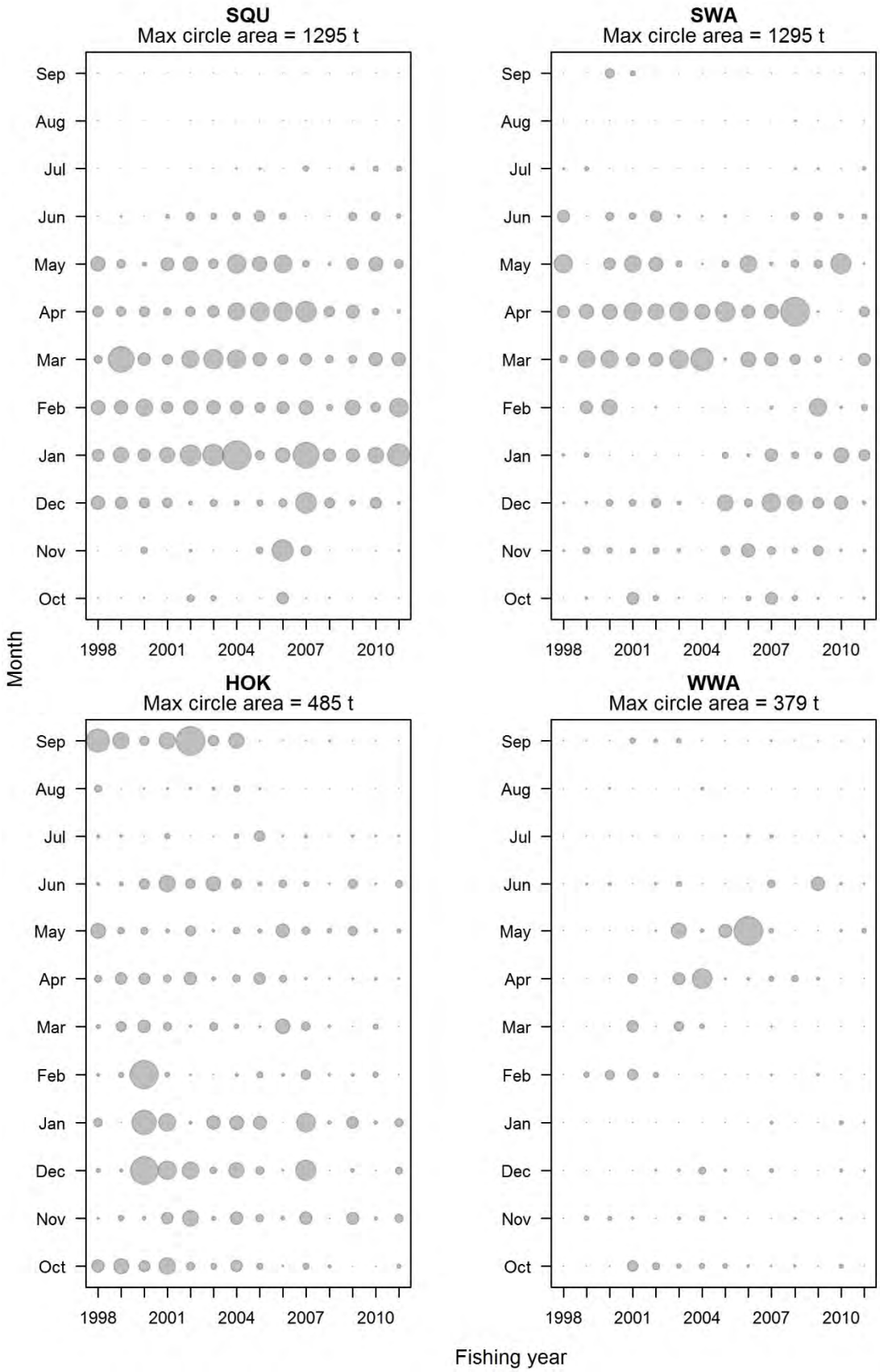


Figure D13c: Distribution of silver warehou catch in the Southland region for 1991–2011 fishing years in relation to month for the top four target species.

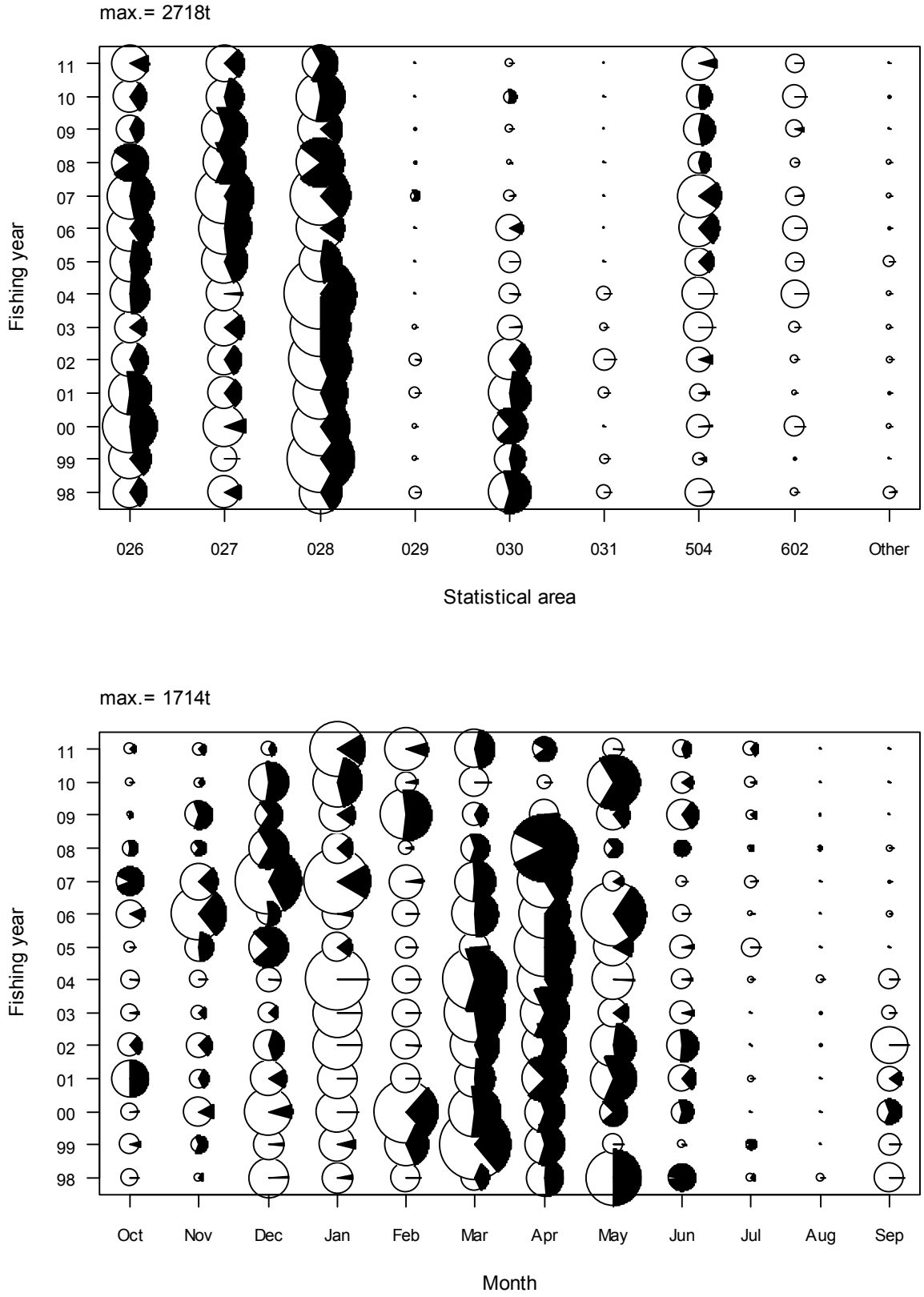


Figure D14: Distribution of SWA catch by fishing year with circle size proportional to the total catch and black portion of the pie indicating proportion of the catch as targeted SWA by a) statistical area, and b) month for the Southland region.

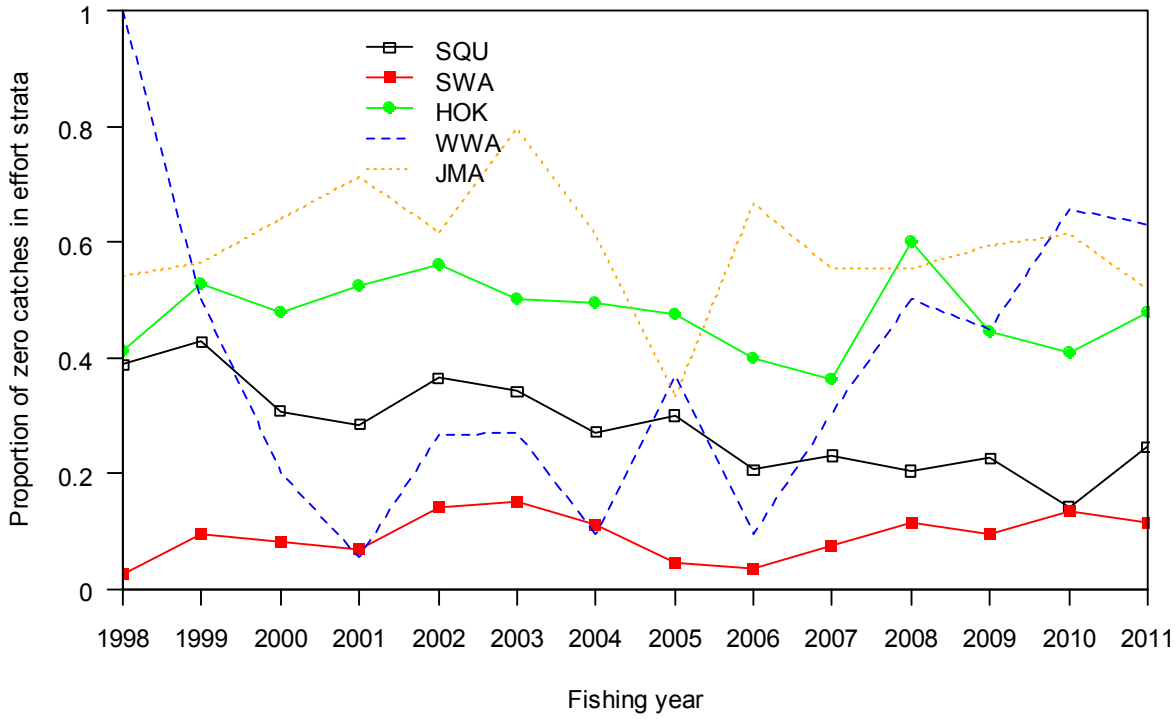


Figure D15: Proportion of tows with zero reported SWA catch for major target species for the Southland region.

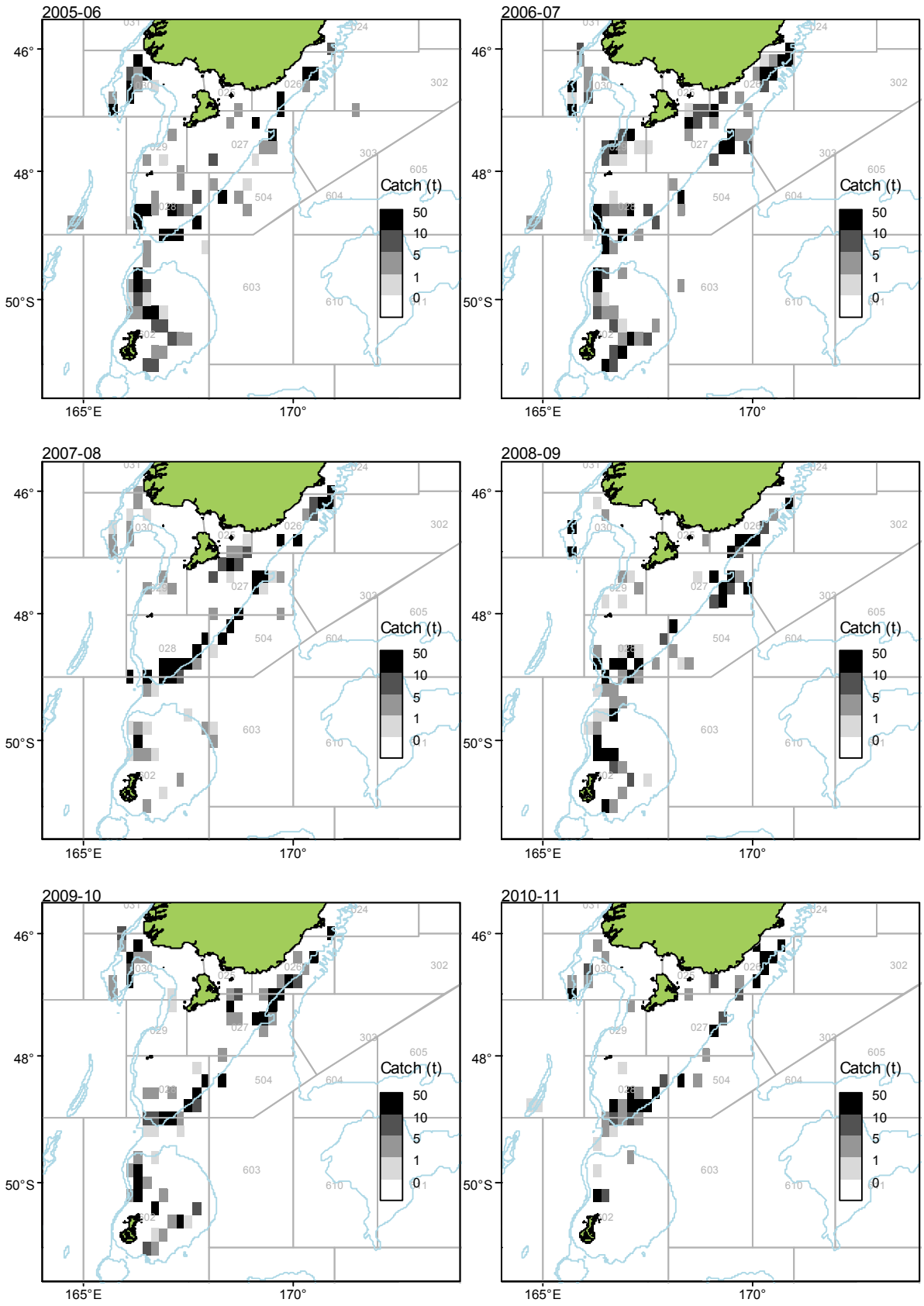


Figure D16: Distribution of silver warehou catch within the Southland region aggregated into 0.2 degree spatial blocks for fishing years 2006–2011.

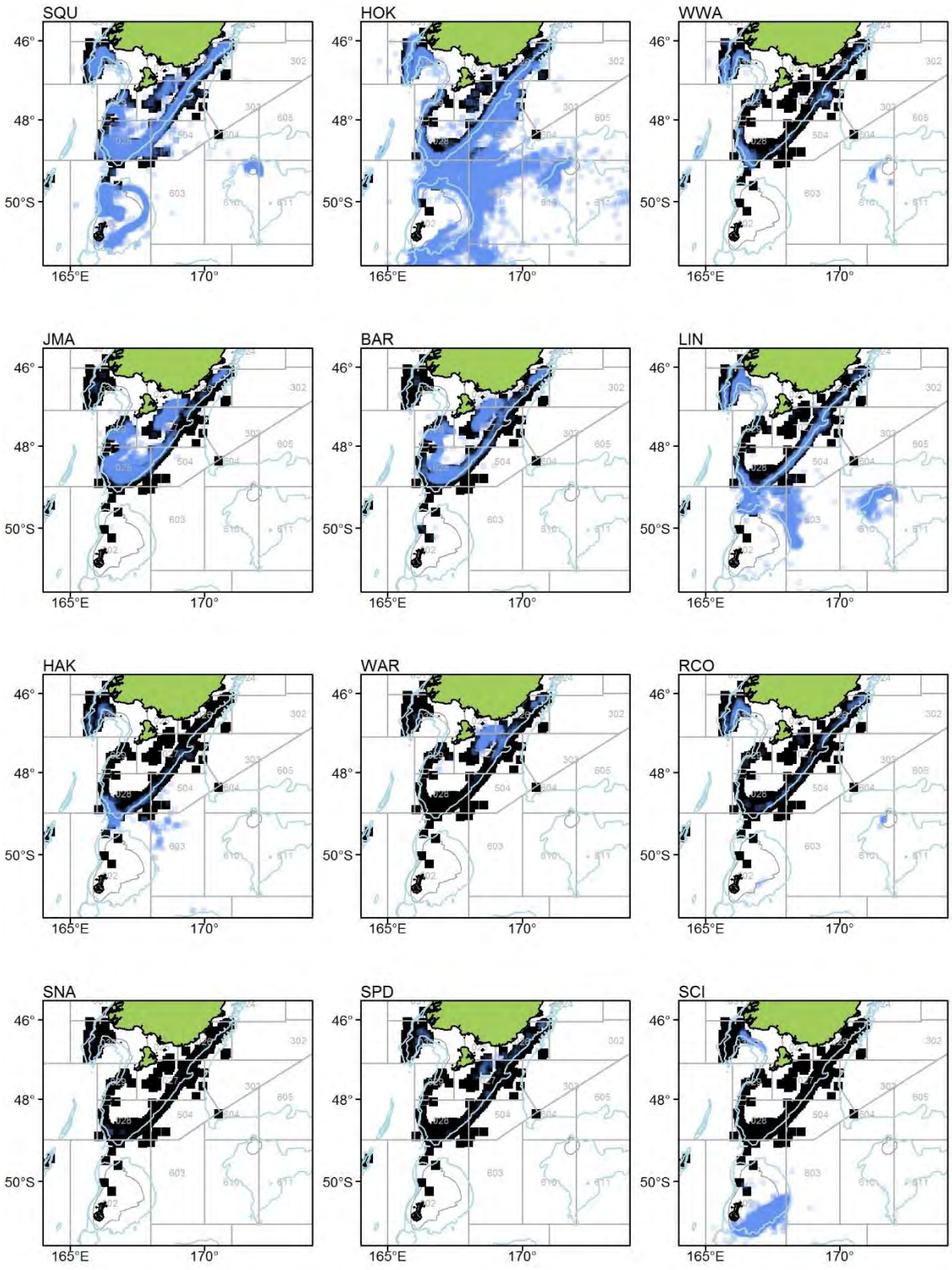


Figure D17: Southland statistical areas and bathymetry showing the distribution of trawls by target species for the main target species (blue cells) compared to the distribution of SWA target effort distribution (black cells) for all years combined.

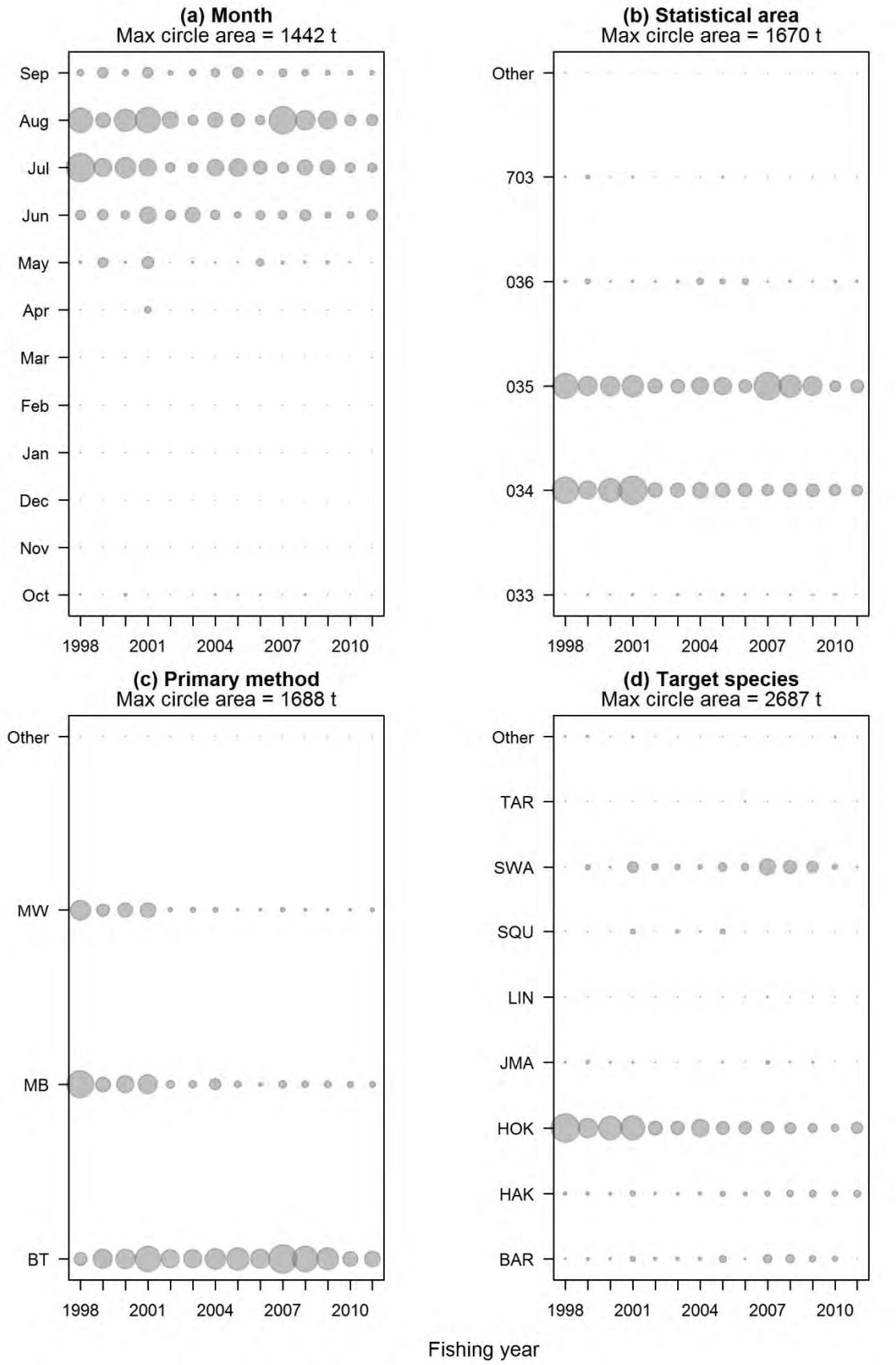


Figure D18a: Distribution of silver warehou catch in the West Coast South Island region for 1991–2011 fishing years in relation to a) month, b) statistical area, c) fishing method, and d) target species.

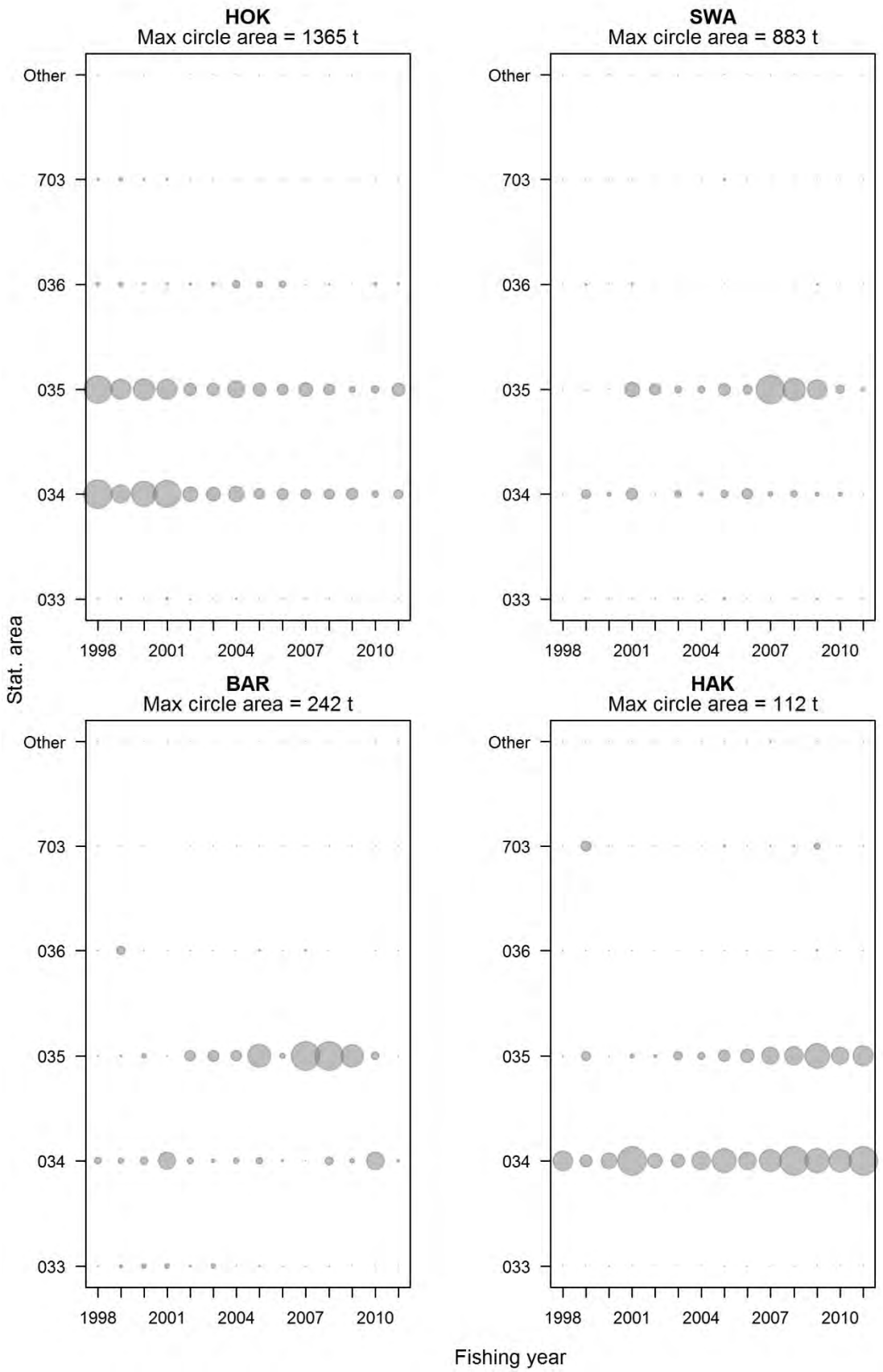


Figure D18b: Distribution of silver warehou catch in the West Coast South Island region for 1991–2011 fishing years in relation to statistical area for the top four target species.

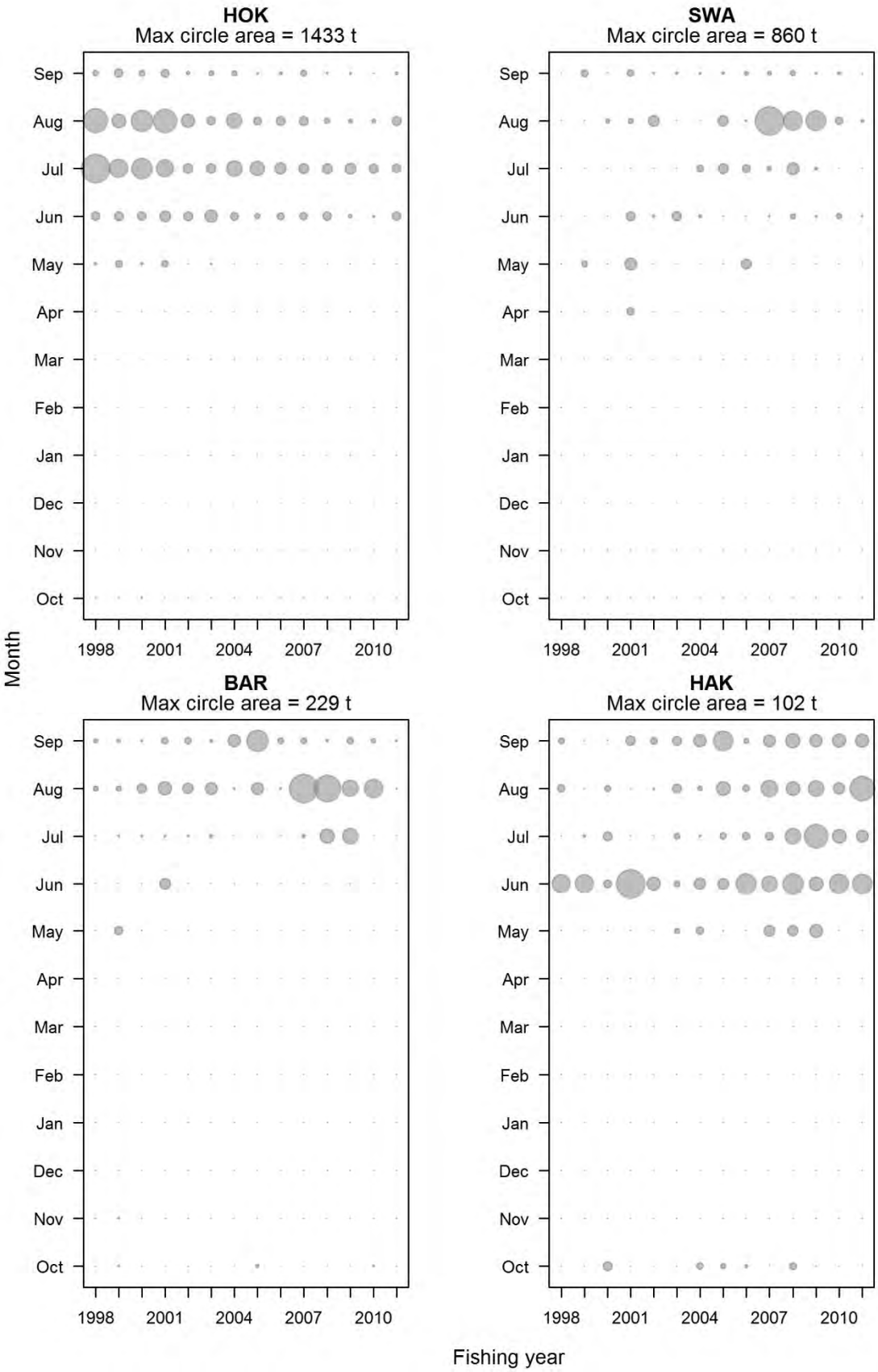


Figure D18c: Distribution of silver warehou catch in the West Coast South Island region for 1991–2011 fishing years in relation to month for the top four target species.

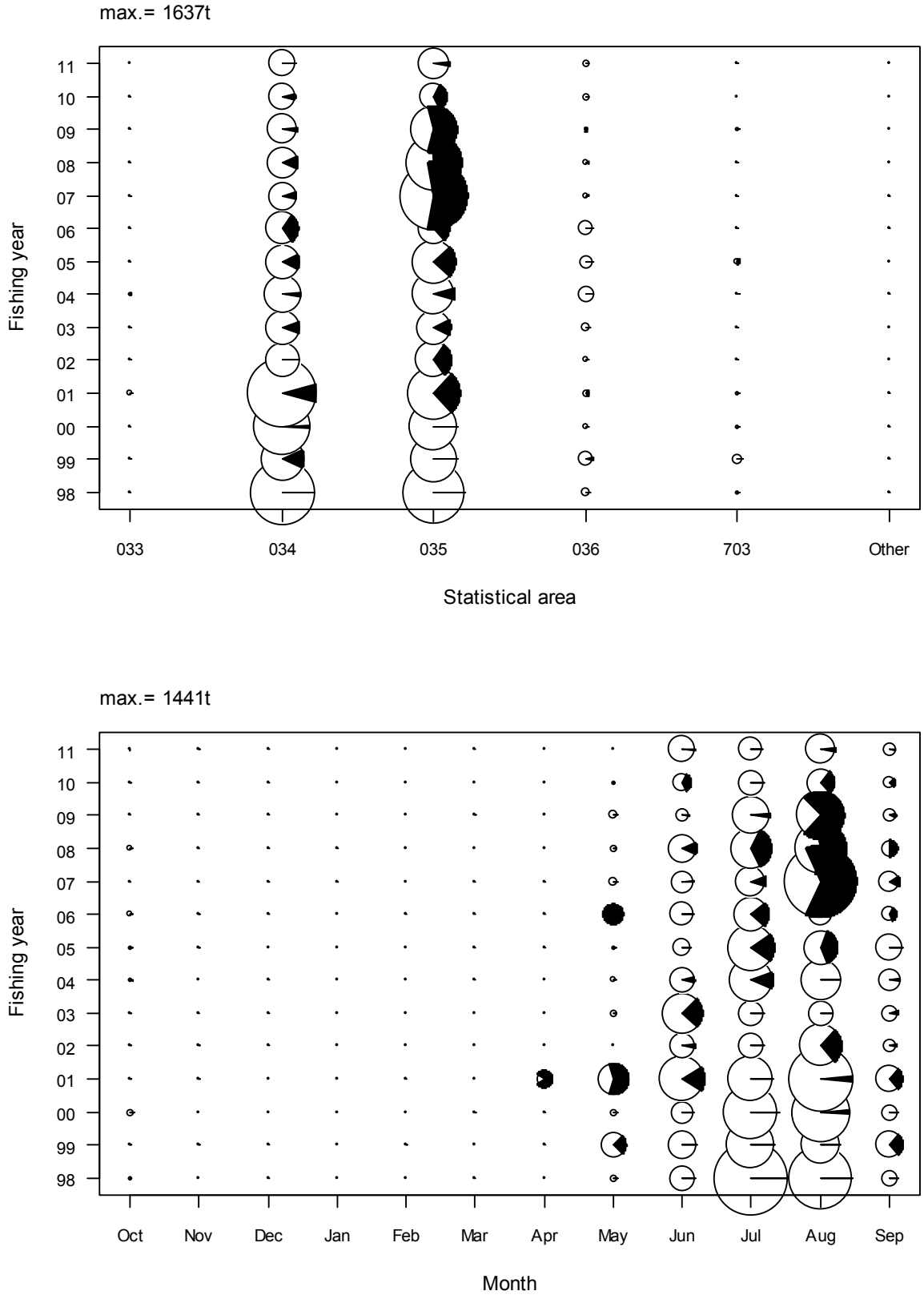


Figure D19: Distribution of SWA catch by fishing year with circle size proportional to the total catch and black portion of the pie indicating proportion of the catch as targeted SWA by a) statistical area, and b) month for the West Coast South Island region.

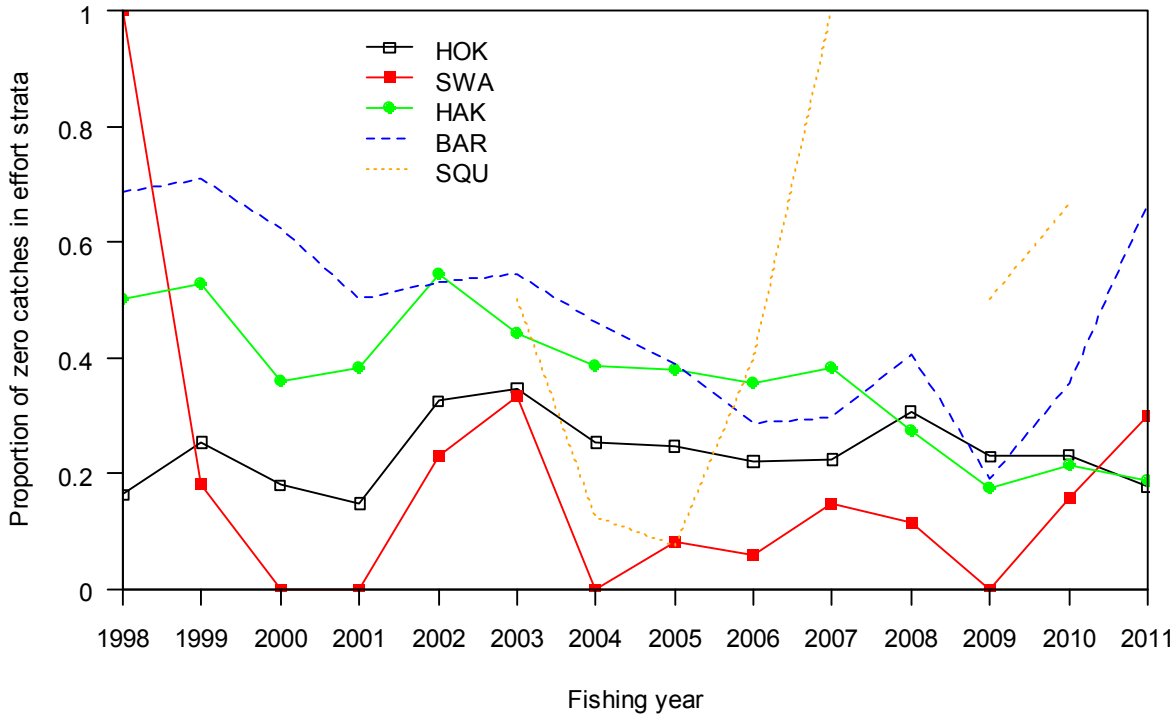


Figure D20: Proportion of tows with zero reported SWA catch for major target species for the West Coast South Island region.

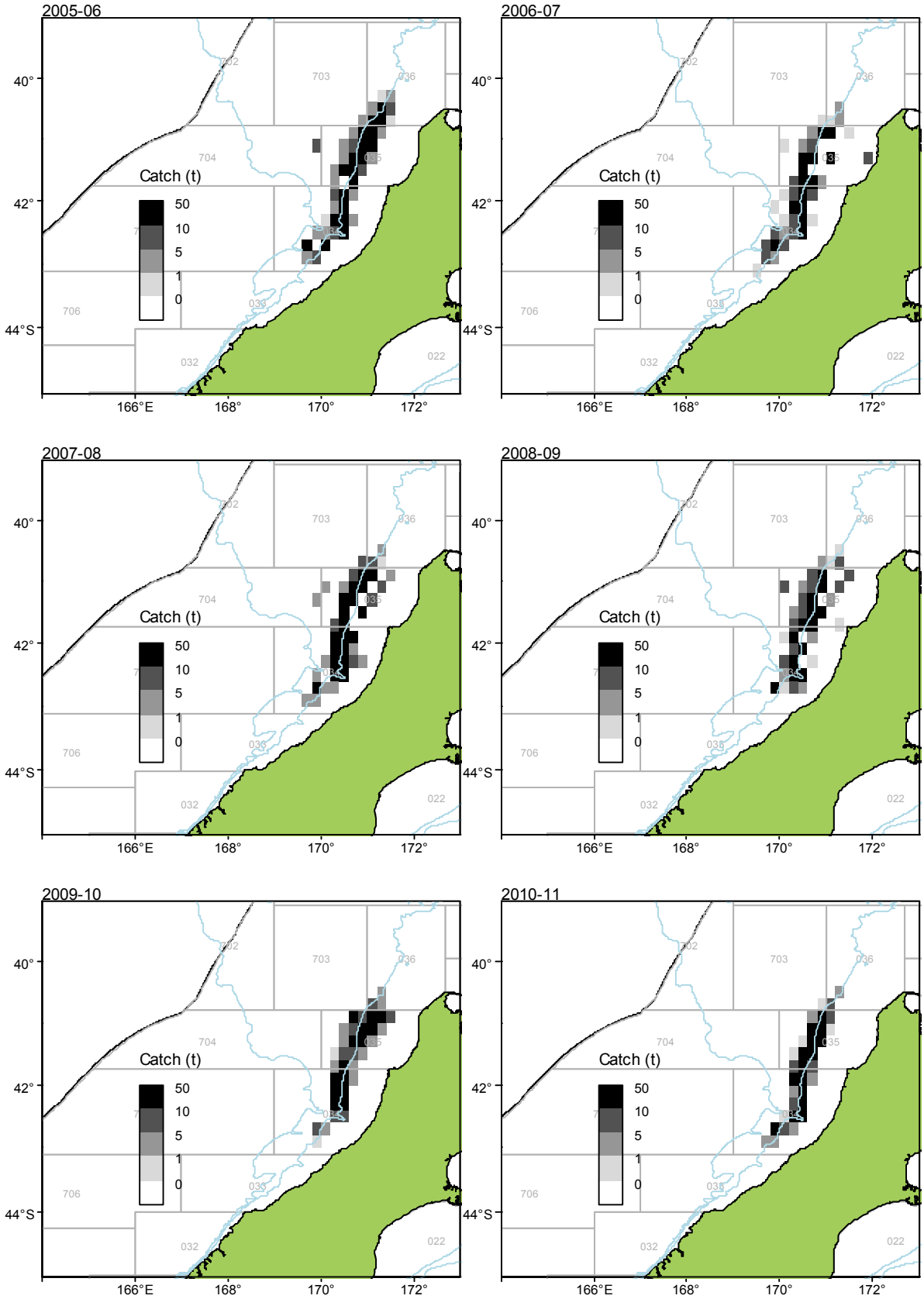


Figure D21: Distribution of silver warehou catch within the West Coast South Island region aggregated into 0.2 degree spatial blocks for fishing years 2006–2011.

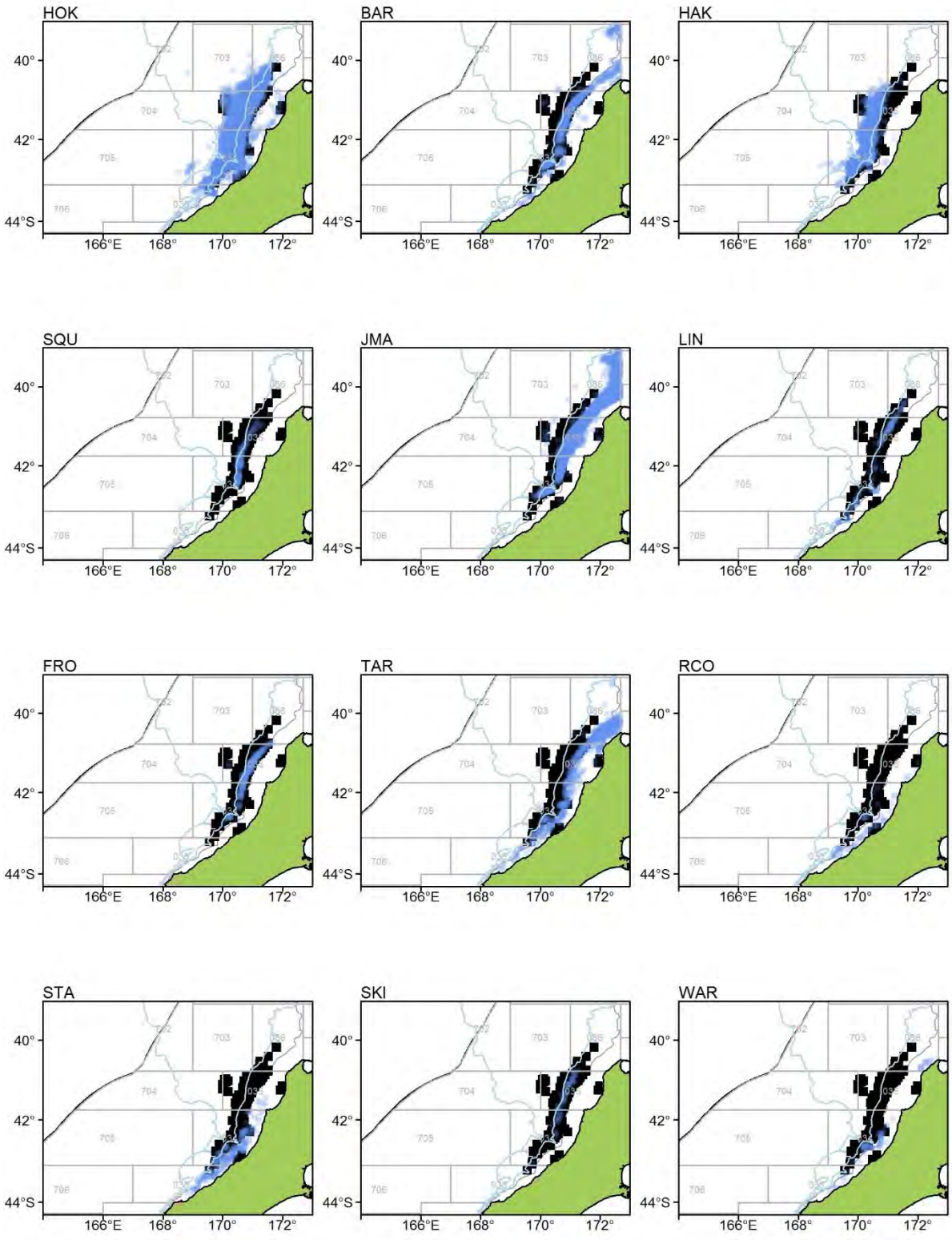


Figure D22: West Coast South Island statistical areas and bathymetry showing the distribution of trawls by target species for the main target species (blue cells) compared to the distribution of SWA target effort distribution (black cells) for all years combined.

APPENDIX E: CATCH PER UNIT EFFORT

CPUE Model 1a (Chatham Rise)

Table E1a.1: Criteria used for defining the data used for CPUE Model 1a (Chatham Rise).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP	No
primary_method	BT	No
target_species	HOK, SWA, HAK, BAR	Yes
start_stats_area_code	049, 052, 404, 410, 050, 051, 409	Yes
fishing_duration	All	Yes
vessel_key	All core non-twin	Yes
fish_month	All	Yes
twin	All	Yes

Table E1a.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 1a (Chatham Rise). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	29	153	0.38	186.30	95	1.96
1999	24	140	0.51	39.10	68	0.58
2000	24	115	0.56	53.60	51	1.05
2001	27	150	0.52	146.60	72	2.04
2002	29	146	0.41	214.50	86	2.49
2003	21	116	0.54	85.70	53	1.62
2004	24	116	0.42	191.10	67	2.85
2005	17	105	0.40	690.10	63	10.95
2006	18	64	0.34	313.20	42	7.46
2007	19	90	0.29	289.30	64	4.52
2008	18	102	0.52	254	49	5.18
2009	15	83	0.27	499.90	61	8.20
2010	16	56	0.39	167.70	34	4.93
2011	10	60	0.32	262.80	41	6.41

Table E1a.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 1a (Chatham Rise). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	9	53	0.43	72	30	2.40
1999	10	56	0.61	24.30	22	1.10
2000	11	40	0.57	44.70	17	2.63
2001	11	52	0.44	68.50	29	2.36
2002	10	57	0.47	78	30	2.60
2003	5	22	0.41	16.60	13	1.28
2004	10	29	0.38	59.60	18	3.31
2005	7	28	0.25	194.90	21	9.28
2006	6	13	0.31	221.90	9	24.66
2007	8	27	0.22	32.40	21	1.54
2008	8	50	0.58	159.10	21	7.58
2009	7	40	0.30	199.90	28	7.14
2010	7	12	0.58	67	5	13.40
2011	3	17	0.59	26.50	7	3.79

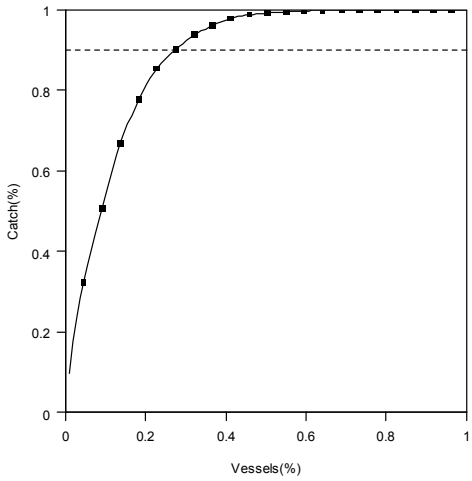
Table E1a.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 1a (Chatham Rise) and the corresponding total R^2 value.

	R-squared
fish_year	17.17
target_species	30.11
fish_month	39.17
vessel_key	43.86
poly(fishing_duration, 3)	46.67
start_stats_area_code	48.88

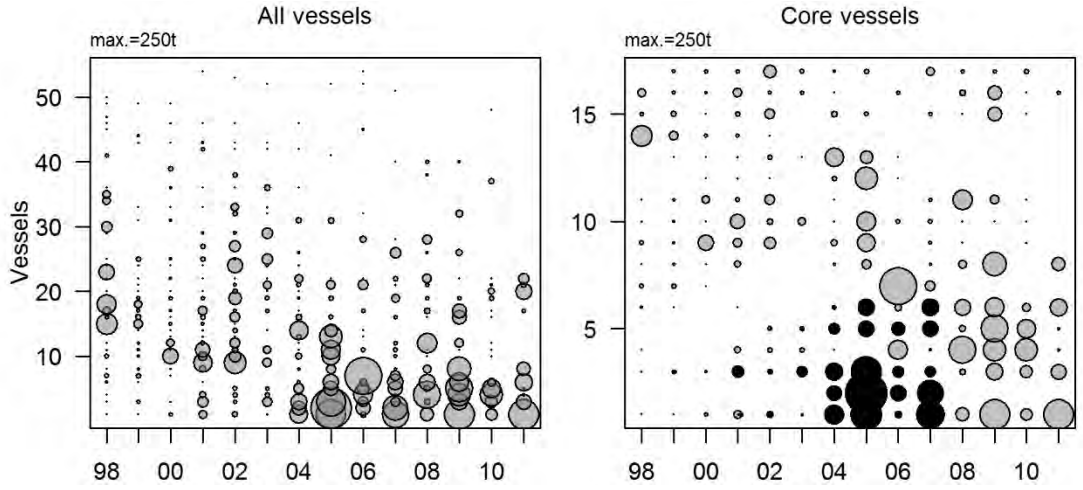
Table E1a.5: Chatham Rise CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 1a (Chatham Rise).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	0.16	0.11	0.26	0.22	0.23
1999	0.43	0.27	0.69	0.24	0.24
2000	0.68	0.39	1.19	0.28	0.28
2001	0.69	0.45	1.05	0.21	0.21
2002	1.48	0.98	2.23	0.20	0.21
2003	0.39	0.21	0.70	0.30	0.30
2004	0.76	0.44	1.31	0.27	0.28
2005	5.57	3.31	9.40	0.26	0.27
2006	4.14	1.91	8.97	0.39	0.40
2007	1.19	0.71	1.98	0.26	0.26
2008	1.46	0.87	2.46	0.26	0.27
2009	2.56	1.66	3.97	0.22	0.22
2010	1.17	0.48	2.85	0.44	0.47
2011	0.57	0.26	1.27	0.40	0.42

a)



b)



c)

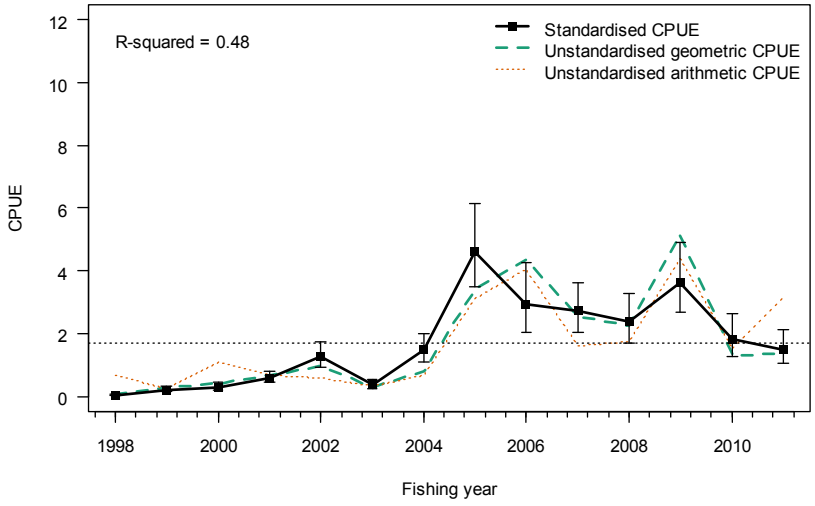


Figure E1a.1: Chatham Rise CPUE Model 1a (stratified dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel for All vessels (left), and Core vessels with catch from twin vessels shown in black (right) for each fishing year. c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

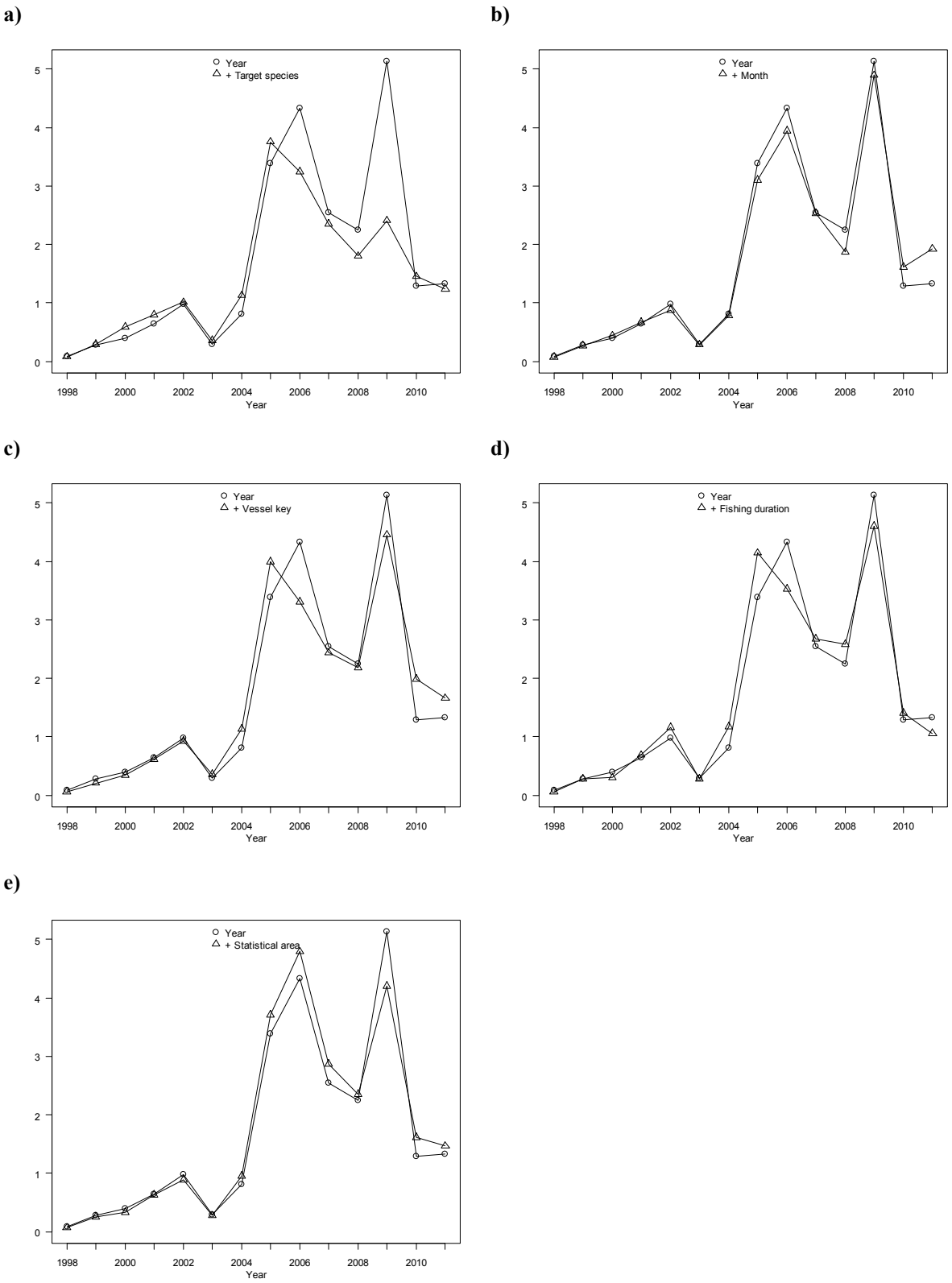


Figure E1a.2: Influence of a) Year + target species, b) Year + month, c) Year + vessel, d) Year + fishing duration, and e) Year + statistical area on CPUE Model 1a (Chatham Rise).

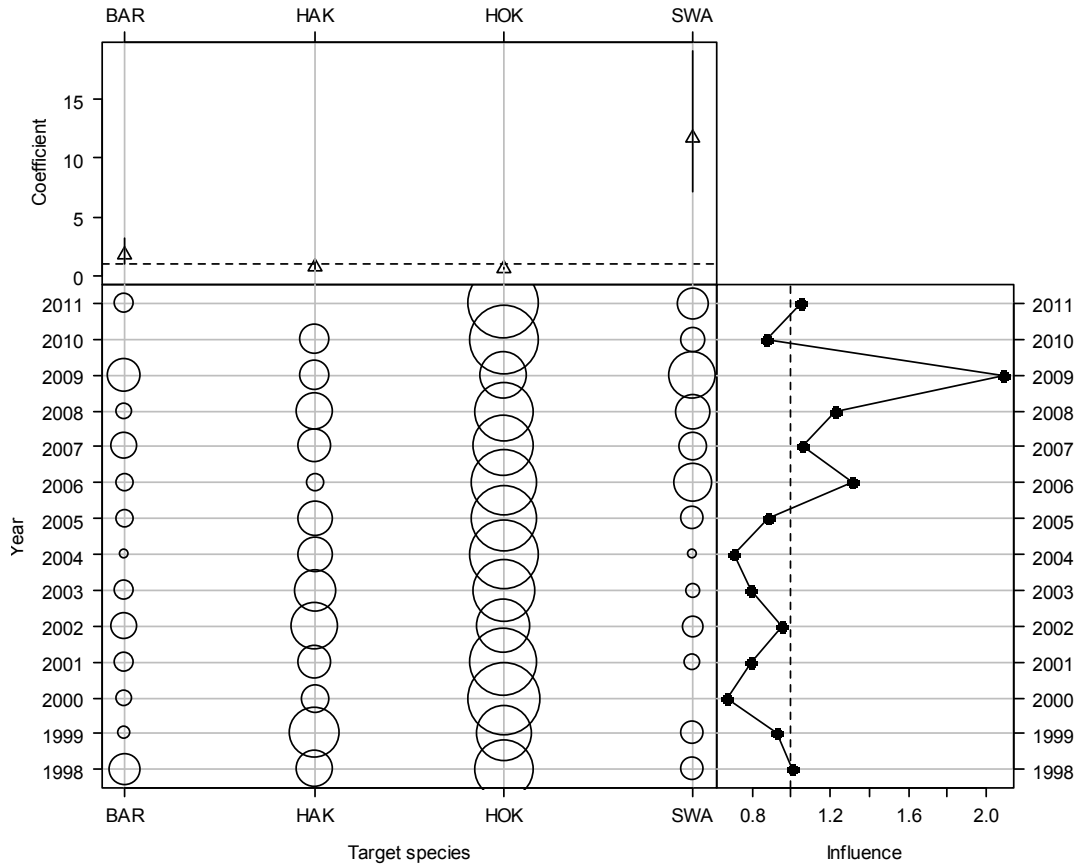


Figure E1a.3a: Influence of target species on CPUE Model 1a (Chatham Rise).

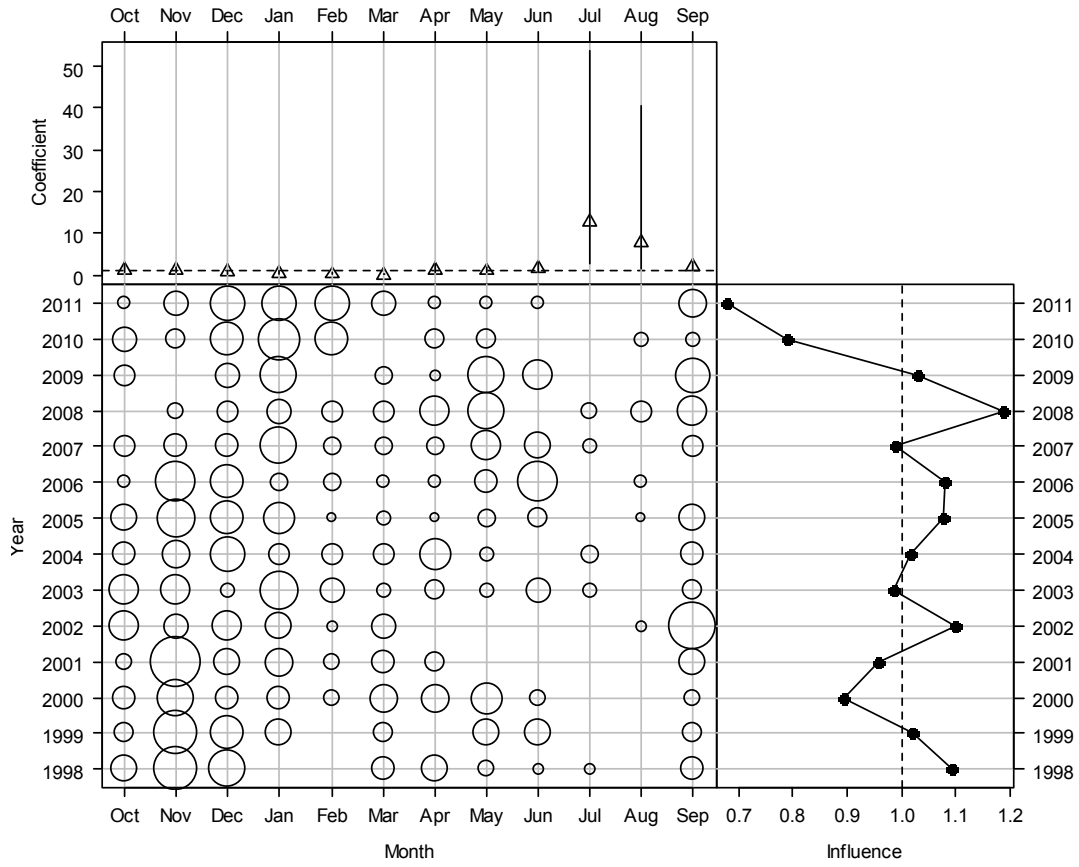


Figure E1a.3b: Influence of fishing month on CPUE Model 1a (Chatham Rise).

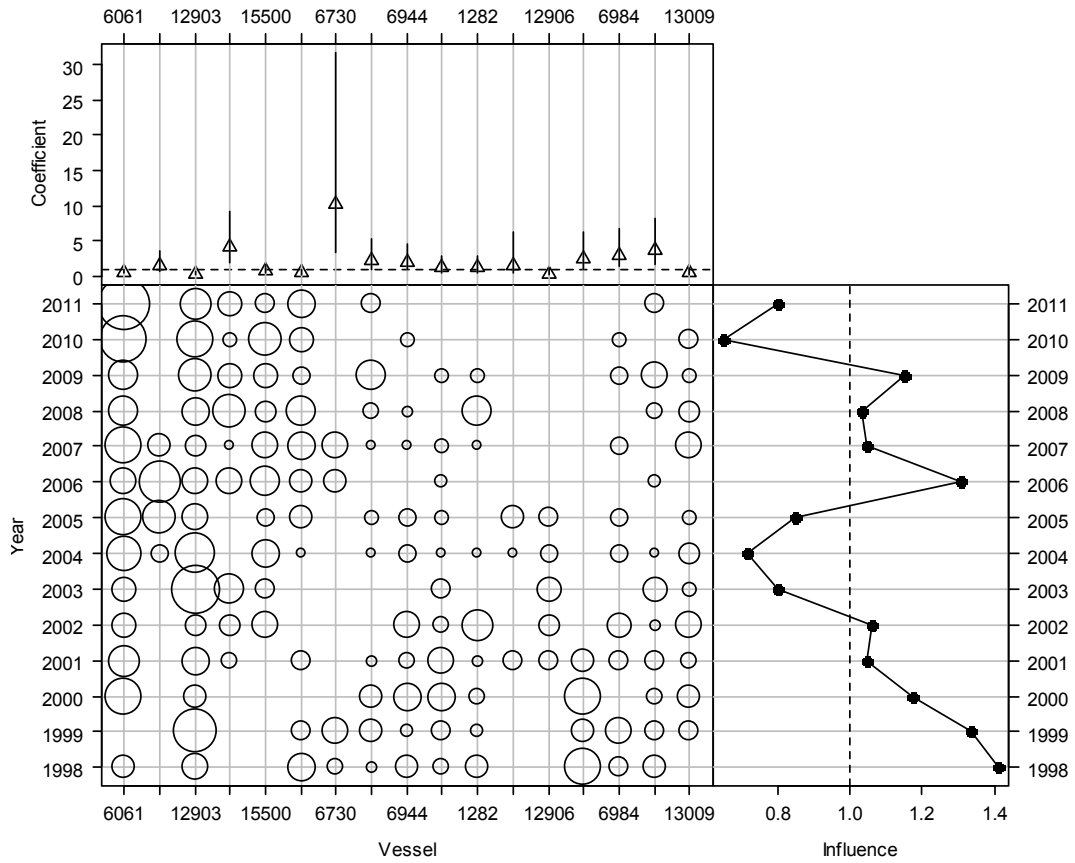


Figure E1a.3c: Influence of vessel on CPUE Model 1a (Chatham Rise).

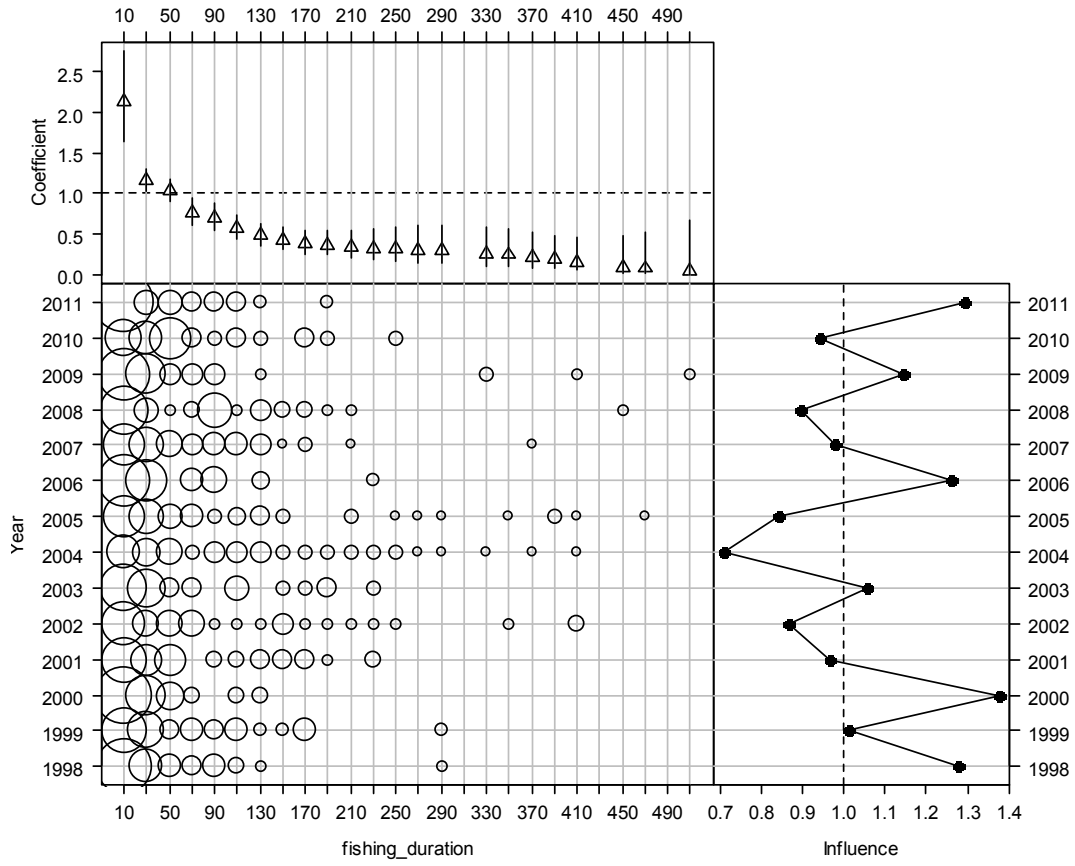


Figure E1a.3d: Influence of fishing duration on CPUE Model 1a (Chatham Rise).

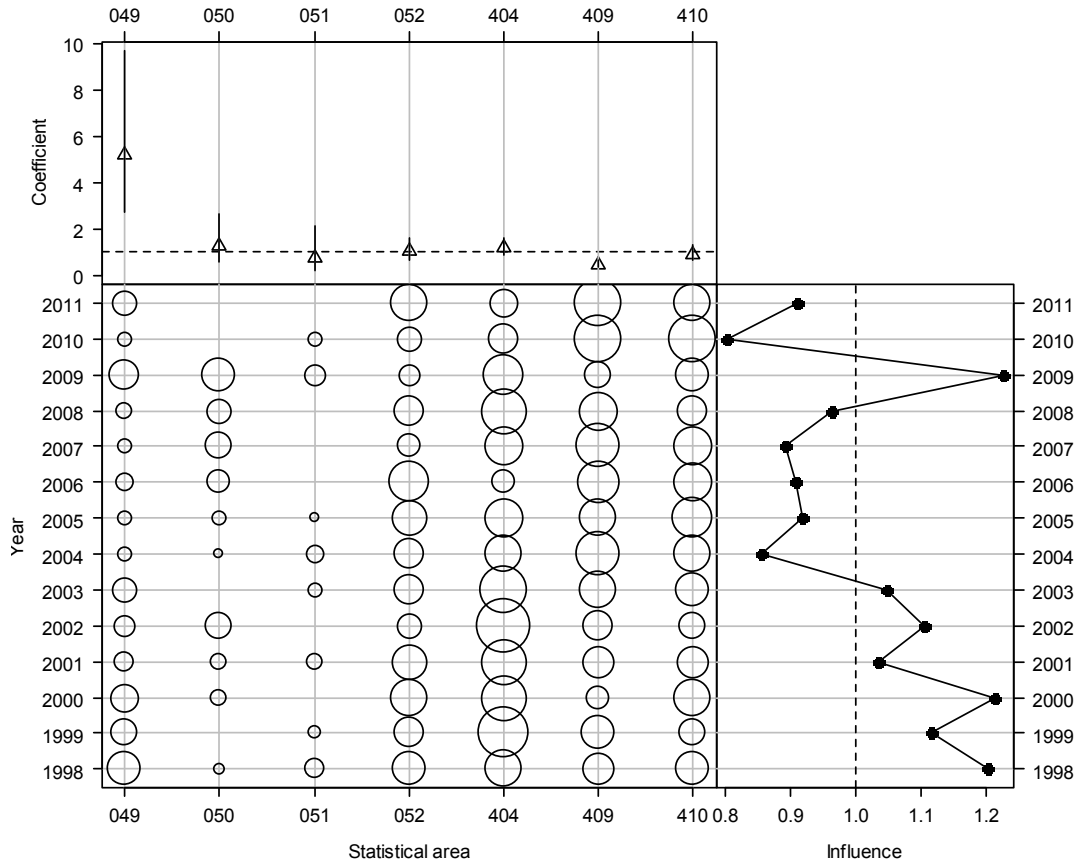


Figure E1a.3e: Influence of statistical area on CPUE Model 1a (Chatham Rise).

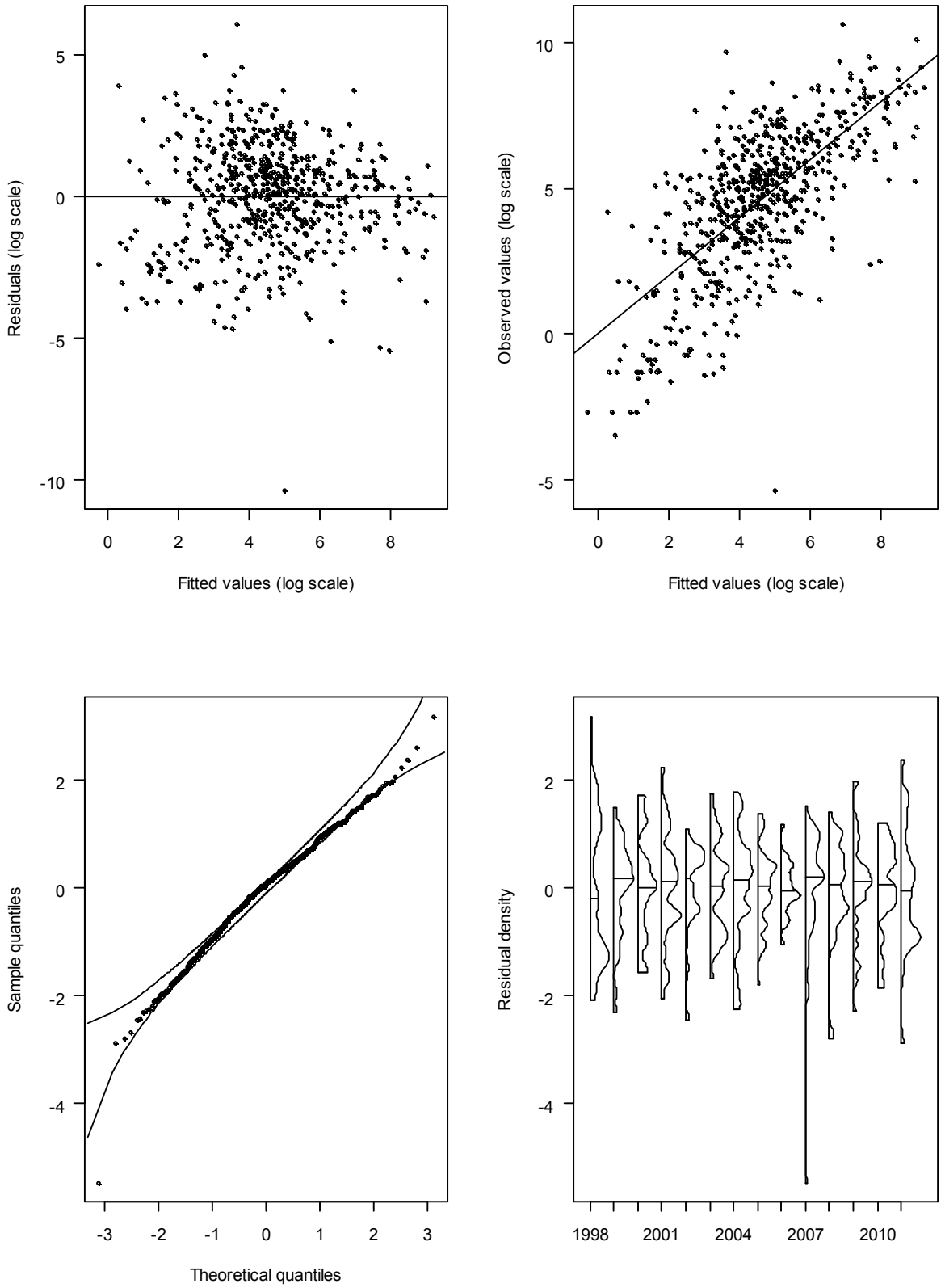


Figure E1a.4: Residual diagnostic plots describing the fit of CPUE Model 1a (Chatham Rise) to the data.

CPUE Model 1b (Chatham Rise, un-merged tow level dataset)

Table E1b.1: Criteria used for defining the data used for CPUE Model 1b (Chatham Rise, tow level).

Variable	Values	Offered
fish_year	1998:2011	Yes
form_type	TCP	No
primary_method	BT	No
target_species	HOK, SWA, HAK, BAR	Yes
start_stats_area_code	049, 052, 404, 410, 050, 051, 409	Yes
fishing_duration	All	Yes
vessel_key	All core	Yes
fish_month	All	Yes
effort_depth	All	Yes
effort_height	All	Yes
effort_width	All	Yes
tow	True, False	Yes

Table E1b.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 1b (Chatham Rise). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	30	1 451	0.91	197.10	125	1.58
1999	28	2 468	0.97	26.30	71	0.37
2000	27	1 207	0.96	47.50	51	0.93
2001	27	1 346	0.88	126.10	158	0.80
2002	29	1 508	0.86	231	211	1.09
2003	21	1 339	0.93	64.90	96	0.68
2004	24	1 624	0.88	147.20	201	0.73
2005	17	1 328	0.72	623.30	367	1.70
2006	18	458	0.72	261.80	129	2.03
2007	19	885	0.68	226.50	284	0.80
2008	18	1 085	0.83	219.90	181	1.21
2009	15	671	0.79	485.70	143	3.40
2010	16	616	0.83	145.30	104	1.40
2011	10	456	0.67	238.20	149	1.60

Table E1b.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 1b (Chatham Rise). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	13	804	0.92	93.10	61	1.53
1999	14	1 384	0.96	21.60	57	0.38
2000	13	702	0.94	42.50	39	1.09
2001	14	976	0.87	73.70	128	0.58
2002	14	908	0.83	103.50	157	0.66
2003	9	814	0.93	26.30	57	0.46
2004	16	1 430	0.88	137.30	178	0.77
2005	13	1 296	0.73	618.50	348	1.78
2006	12	427	0.70	255.90	126	2.03
2007	14	798	0.66	209.80	274	0.77
2008	13	1 021	0.83	201.50	171	1.18
2009	11	572	0.77	476	133	3.58
2010	12	596	0.83	139.60	99	1.41
2011	8	394	0.74	199.90	101	1.98

Table E1b.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 1b (Chatham Rise) and the corresponding total R^2 value.

	R-squared
fish_year	13.03
target_species	23.49
vessel_key	28.02
start_stats_area_code	30.29
fish_month	32.72
poly(effort_depth, 3)	34.53
poly(fishing_duration, 3)	35.74
poly(effort_width, 3)	36.78

Table E1b.5: Chatham Rise CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 1b (Chatham Rise).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	0.95	0.68	1.31	0.16	0.16
1999	0.60	0.44	0.83	0.16	0.16
2000	1.03	0.65	1.62	0.23	0.23
2001	1.06	0.82	1.37	0.13	0.13
2002	0.71	0.58	0.88	0.10	0.10
2003	0.66	0.47	0.94	0.17	0.17
2004	1.41	0.90	2.19	0.22	0.22
2005	1.38	1.10	1.73	0.11	0.11
2006	1.39	0.89	2.15	0.22	0.22
2007	0.99	0.72	1.35	0.16	0.16
2008	0.98	0.73	1.32	0.15	0.15
2009	1.24	0.90	1.70	0.16	0.16
2010	0.97	0.64	1.50	0.21	0.22
2011	1.08	0.63	1.85	0.27	0.27

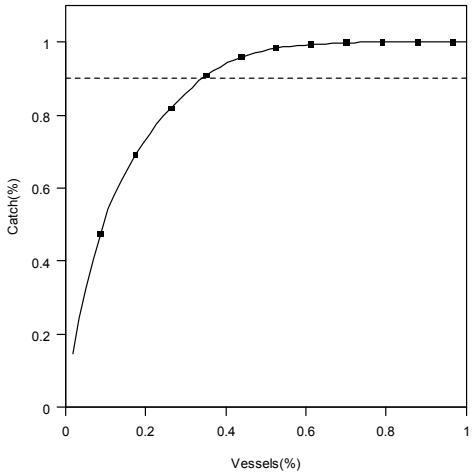
Table E1b.6: Variables retained in order of decreasing explanatory value for binomial Model 1b (Chatham Rise) and the corresponding total R^2 value.

	R-squared
fish_year	4.73
fish_month	11.31
poly(effort_depth, 3)	16.06
vessel_key	20.33
target_species	22.79

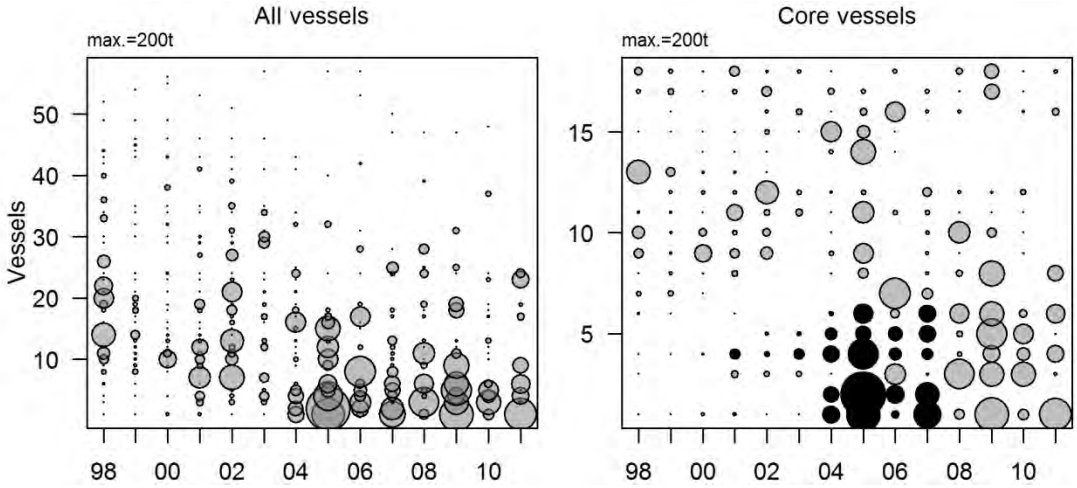
Table E1b.7: Estimated values for probability of a non-zero tow (binomial model), CPUE (log-normal model), and CPUE (delta log-normal model) for CPUE Model 1b (Chatham Rise).

	Binomial	Log-normal	Delta log-normal
1998	0.22	0.95	0.22
1999	0.09	0.60	0.09
2000	0.07	1.03	0.07
2001	0.21	1.06	0.21
2002	0.23	0.71	0.23
2003	0.17	0.66	0.17
2004	0.05	1.41	0.05
2005	0.21	1.38	0.21
2006	0.53	1.39	0.53
2007	0.38	0.99	0.38
2008	0.17	0.98	0.17
2009	0.24	1.24	0.24
2010	0.31	0.97	0.31
2011	0.13	1.08	0.13

a)



b)



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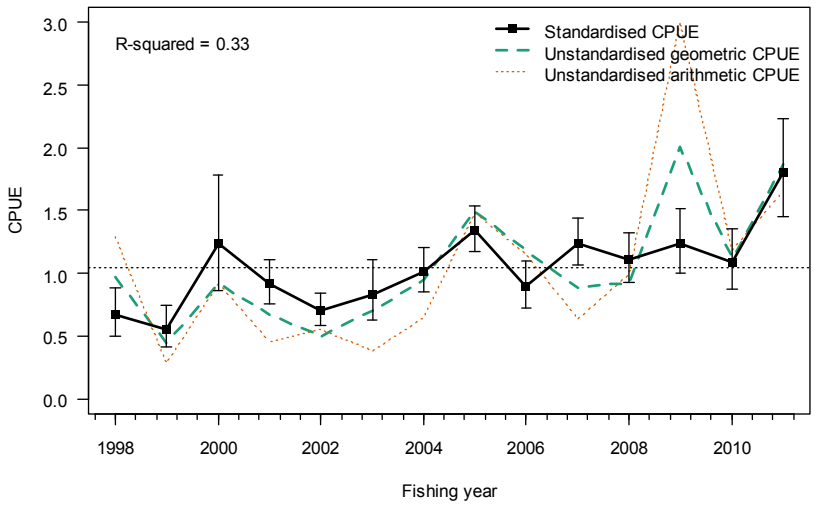


Figure E1b.1: Chatham Rise CPUE Model 1b (unmerged, tow-level dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel. Black shaded portions of symbols indicate the proportion of catch using twin trawl gear. c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

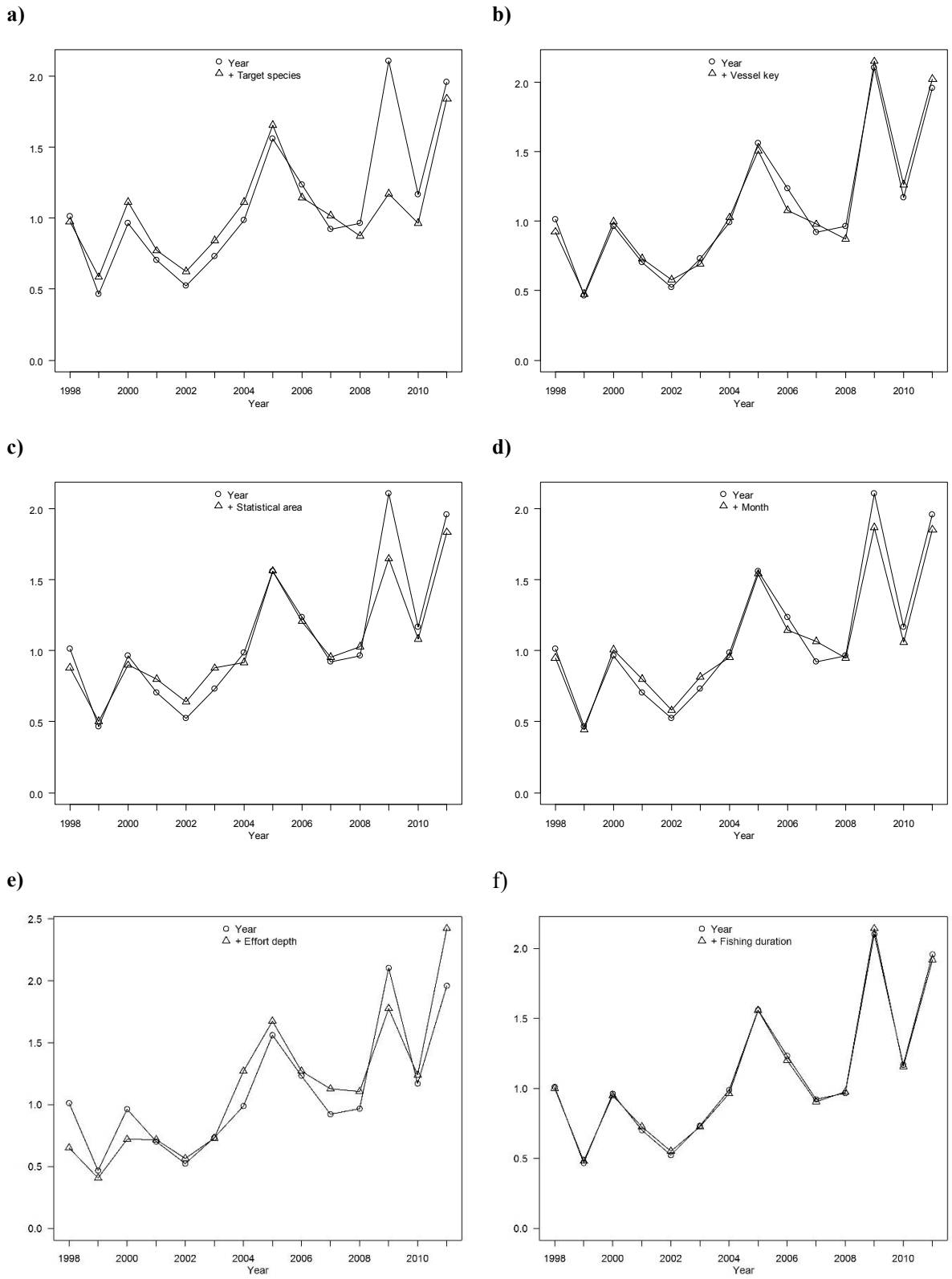


Figure E1b.2: Influence of a) Year + target species, b) Year + vessel, c) Year + statistical area, d) Year + month, e) Year + fishing duration, and f) Year + effort width on CPUE Model 1b (Chatham Rise).

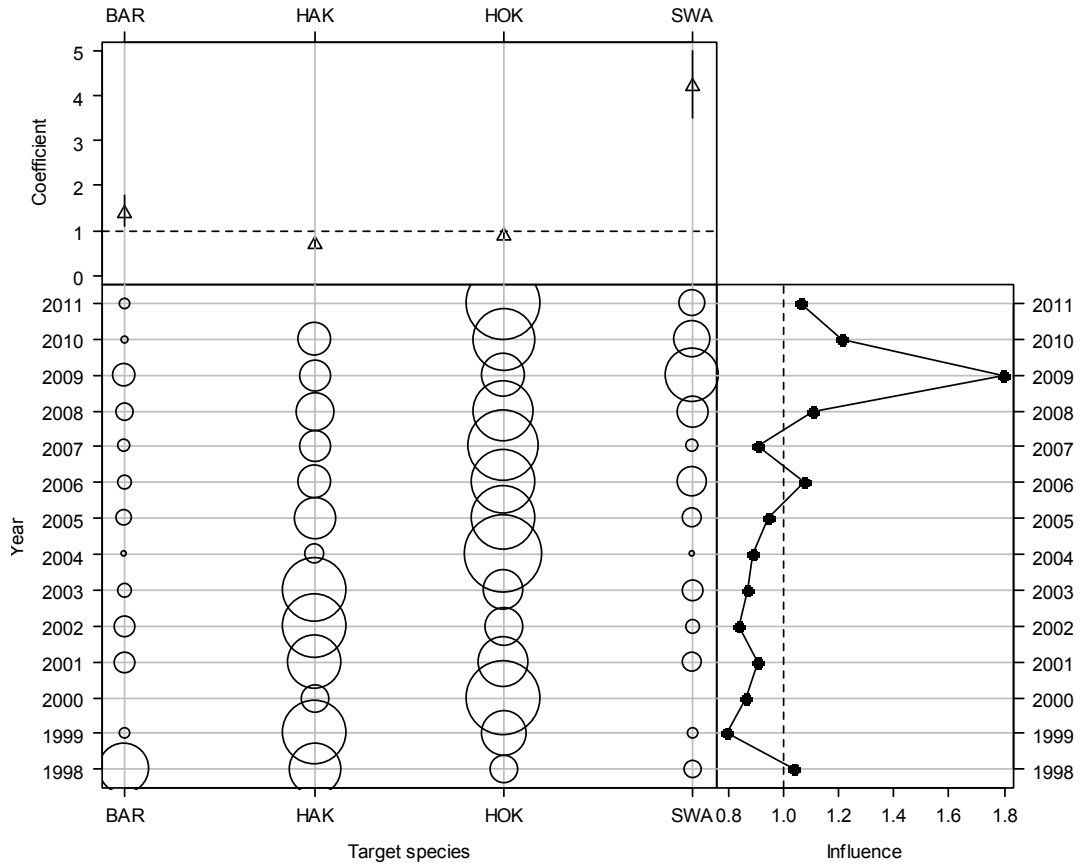


Figure E1b.3a: Influence of target species on CPUE Model 1b (Chatham Rise).

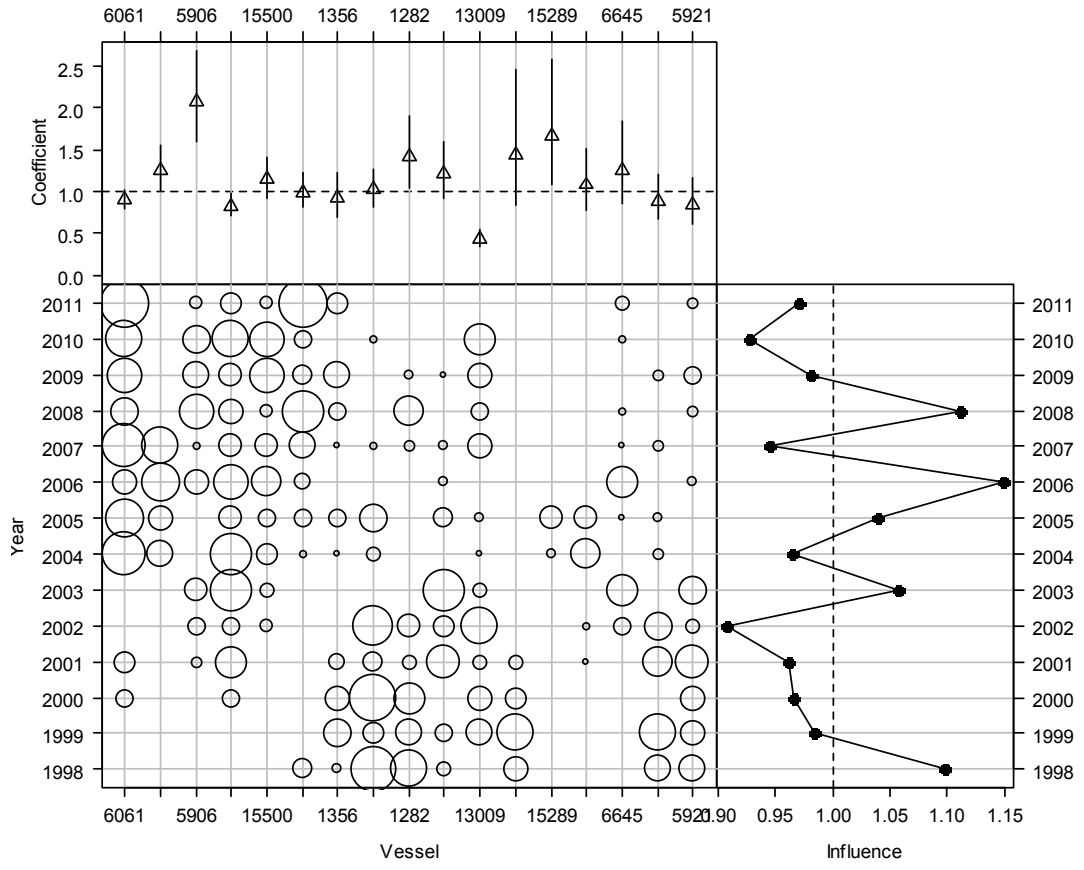


Figure E1b.3b: Influence of vessel on CPUE Model 1b (Chatham Rise).

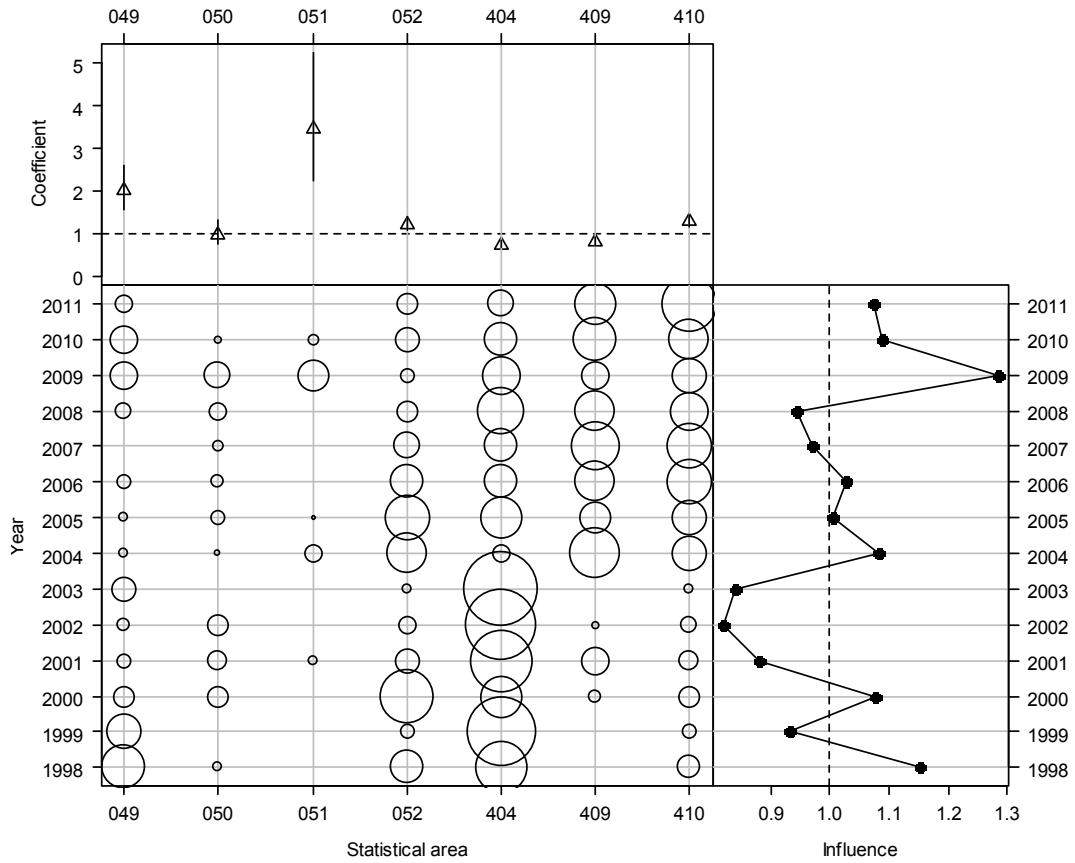


Figure E1b.3c: Influence of statistical area on CPUE Model 1b (Chatham Rise).

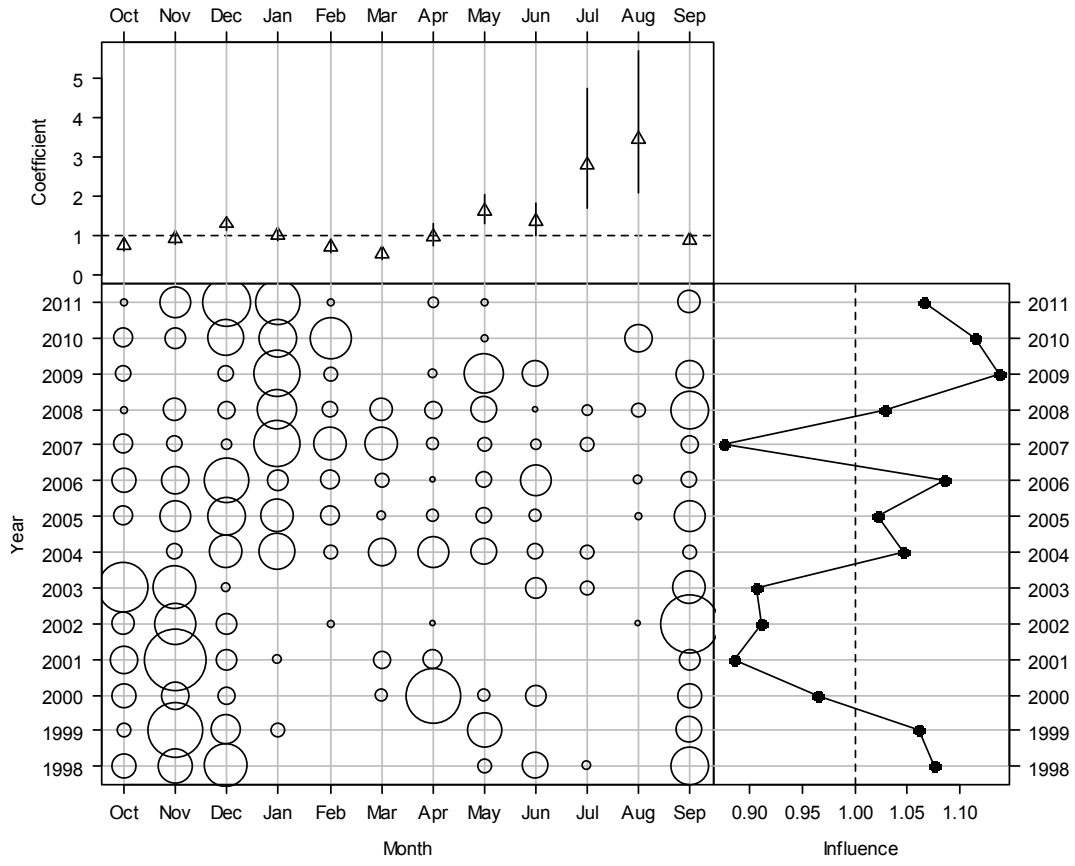


Figure E1b.3d: Influence of month on CPUE Model 1b (Chatham Rise).

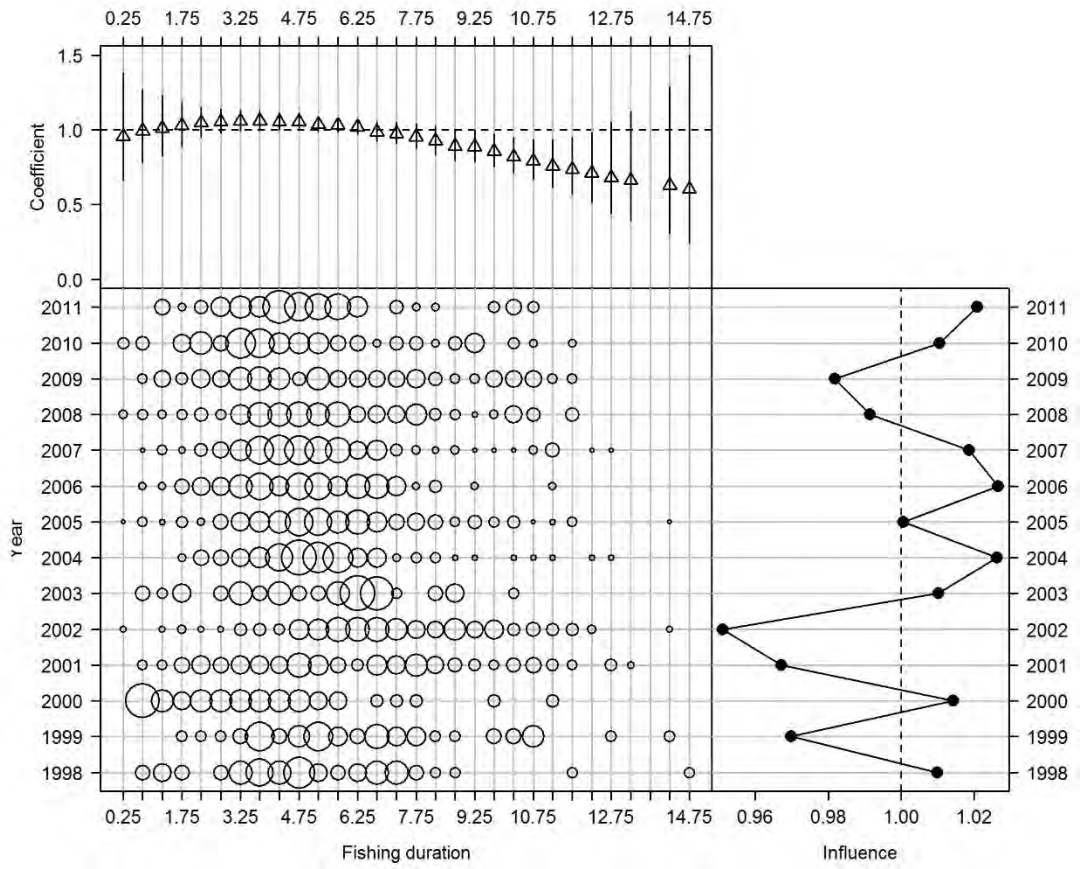


Figure E1b.3e: Influence of fishing duration on CPUE Model 1b (Chatham Rise).

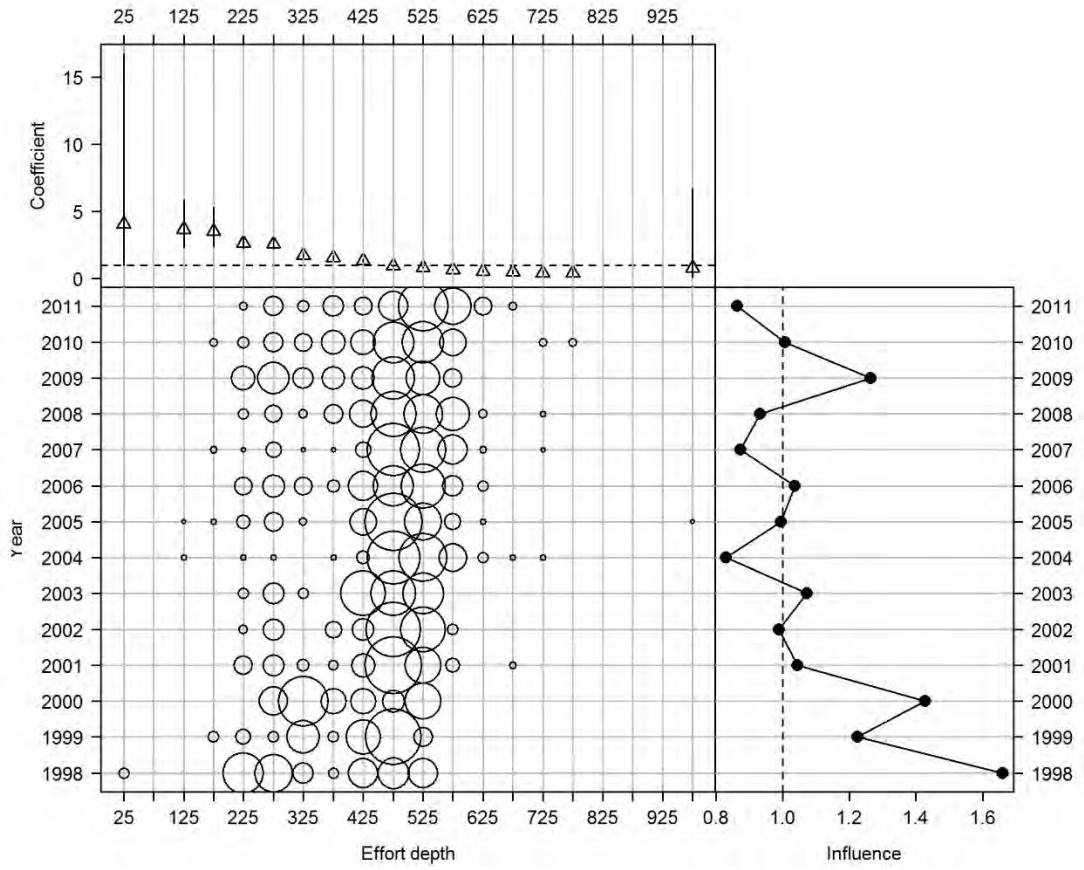


Figure E1b.3f: Influence of effort depth area on CPUE Model 1b (Chatham Rise).

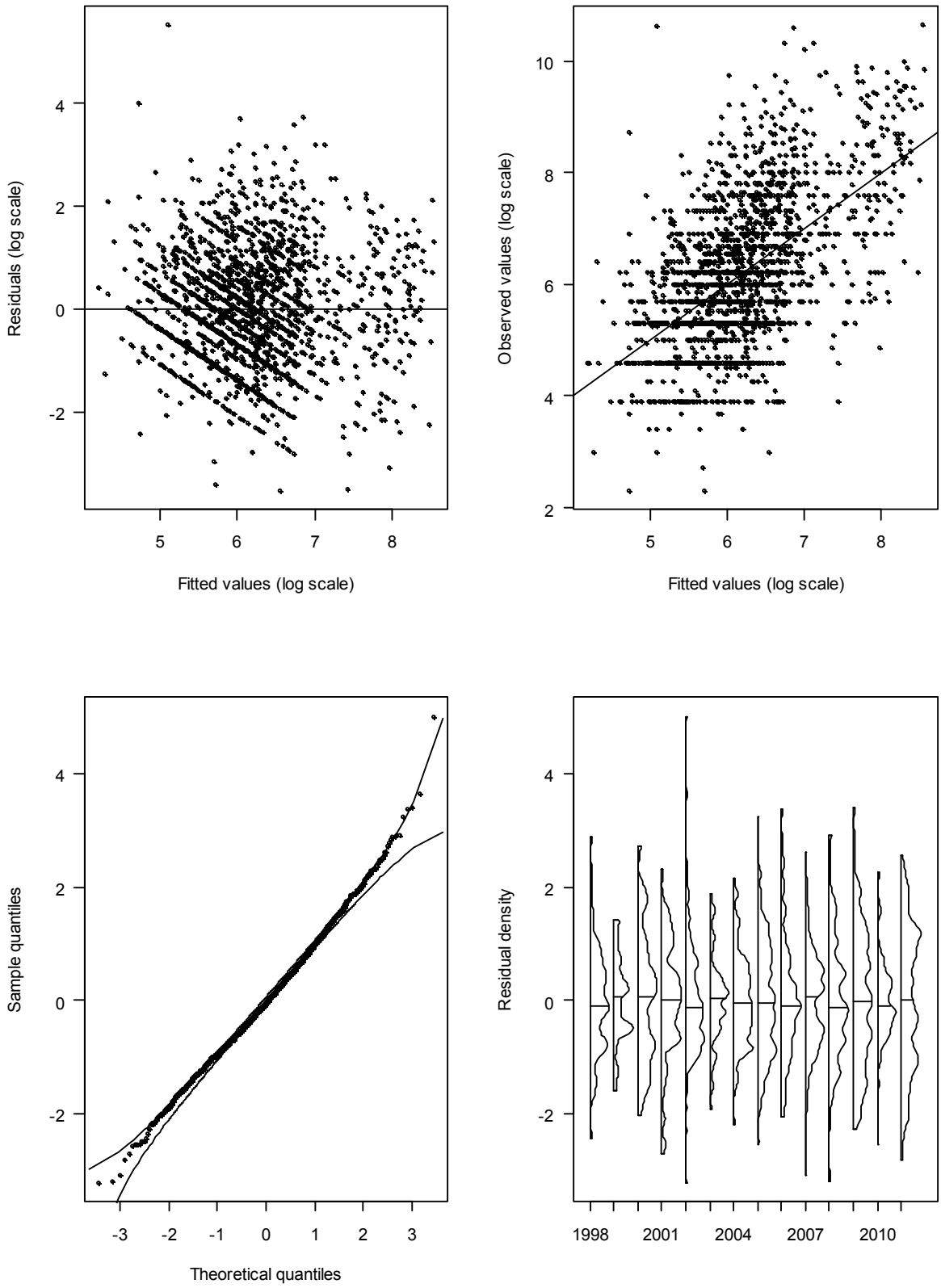


Figure E1b.4: Residual diagnostic plots describing the fit of CPUE Model 1b (Chatham Rise) to the data.

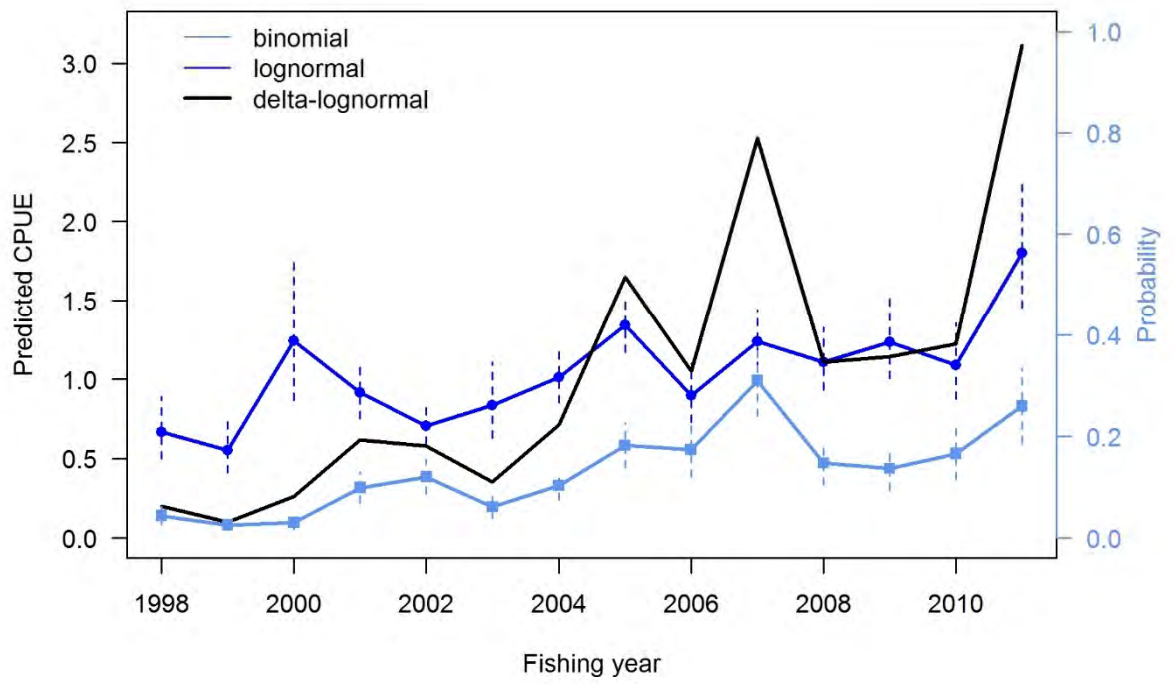


Figure E1b.5: Binomial, log-normal, and resulting delta-lognormal models for CPUE Model 1b (Chatham Rise).

CPUE Model 2a (East Coast South Island)

Table E2a.1: Criteria used for defining the data used for CPUE Model 2a (ECSI).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP, CEL, TCE	Yes
primary_method	BT, MB	Yes
target_species	HOK, SWA, SQU, BAR, RCO	Yes
start_stats_area_code	408, 407, 401, 401, 023, 022, 021, 020, 018	Yes
fish_month	All	Yes
vessel_key	All	Yes
fishing_duration	All	Yes
twin	True, False	Yes

Table E2a.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 2a (ECSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	88	1 220	0.27	2 736.50	890	3.07
1999	73	1 174	0.29	1 773	833	2.13
2000	69	1 198	0.27	2 252.40	877	2.57
2001	72	1 394	0.25	2 827.30	1 050	2.69
2002	60	1 005	0.30	2 015.40	706	2.85
2003	63	1 172	0.33	2 391.10	789	3.03
2004	52	861	0.28	3 063.80	616	4.97
2005	55	824	0.28	3 151.40	592	5.32
2006	51	767	0.21	3 127.80	605	5.17
2007	48	674	0.23	4 671.40	518	9.02
2008	41	707	0.30	2 055.90	495	4.15
2009	39	695	0.34	2 774.20	462	6
2010	44	798	0.32	2 219.20	539	4.12
2011	45	771	0.28	2 915.40	553	5.27

Table E2a.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 2a (ECSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	31	673	0.30	1 426.20	474	3.01
1999	31	782	0.34	1 359.40	514	2.64
2000	32	897	0.31	2 085.90	620	3.36
2001	35	1 011	0.29	2 477.40	717	3.46
2002	34	773	0.33	1 805.50	520	3.47
2003	35	869	0.37	2 031.60	549	3.70
2004	31	699	0.32	2 890.40	475	6.09
2005	32	670	0.31	2 863.40	462	6.20
2006	32	618	0.24	3 032.10	470	6.45
2007	28	586	0.25	4 601.50	438	10.51
2008	25	563	0.29	1 975.60	400	4.94
2009	25	508	0.33	2 529	340	7.44
2010	24	507	0.33	2 018.30	342	5.90
2011	24	536	0.27	2 587	392	6.60

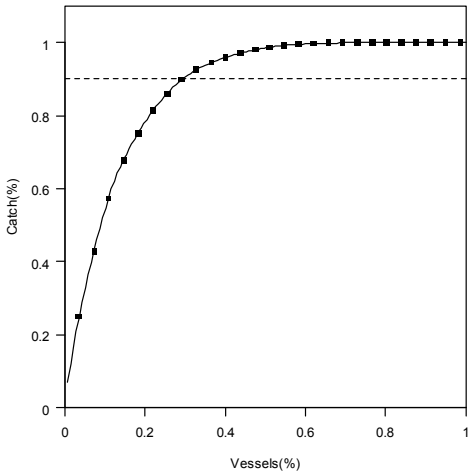
Table E2a.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 2a (ECSI) and the corresponding total R^2 value.

	R-squared
fish_year	6.76
vessel_key	19.11
target_species	23.47
fish_month	26.41
start_stats_area_code	28.71

Table E2a.5: ECSI CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 2a (ECSI).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	0.69	0.63	0.75	0.05	0.05
1999	0.57	0.52	0.63	0.04	0.04
2000	0.79	0.73	0.86	0.04	0.04
2001	0.84	0.78	0.91	0.04	0.04
2002	0.43	0.40	0.47	0.04	0.04
2003	0.57	0.52	0.62	0.04	0.04
2004	1.79	1.63	1.96	0.05	0.05
2005	1.08	0.99	1.19	0.05	0.05
2006	1.70	1.55	1.86	0.05	0.05
2007	1.92	1.75	2.12	0.05	0.05
2008	1.35	1.22	1.49	0.05	0.05
2009	0.97	0.87	1.08	0.05	0.05
2010	1.04	0.93	1.15	0.05	0.05
2011	1.82	1.65	2.02	0.05	0.05

a)



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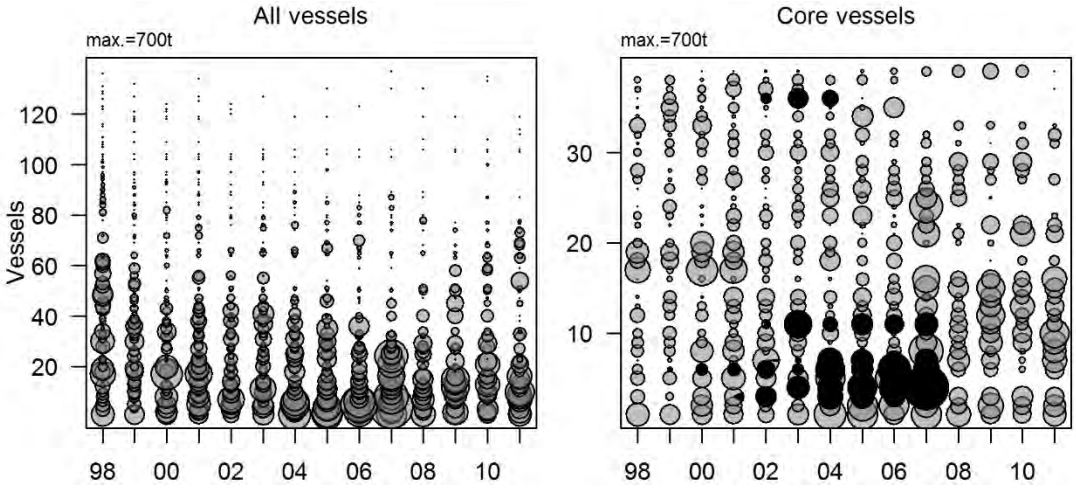

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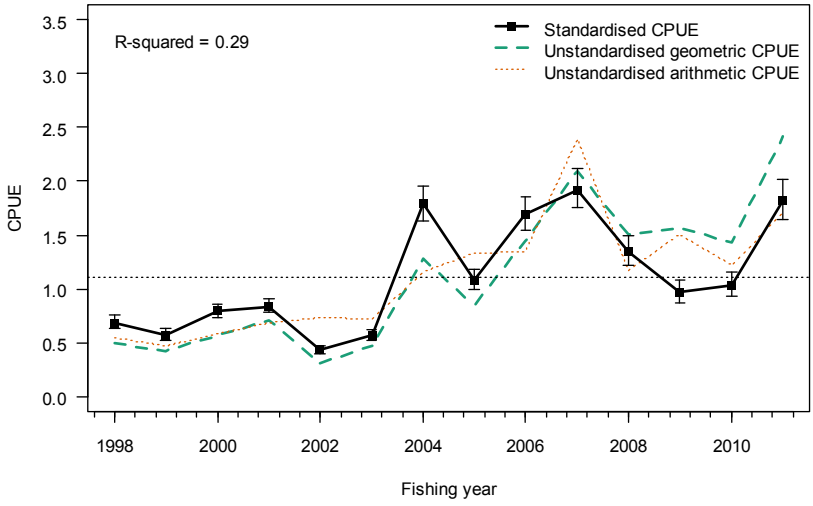


Figure E2a.1: ECSI CPUE Model 2a (stratified dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel for All vessels (left) and Core vessels with catch from twin vessels shown in black (right). c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

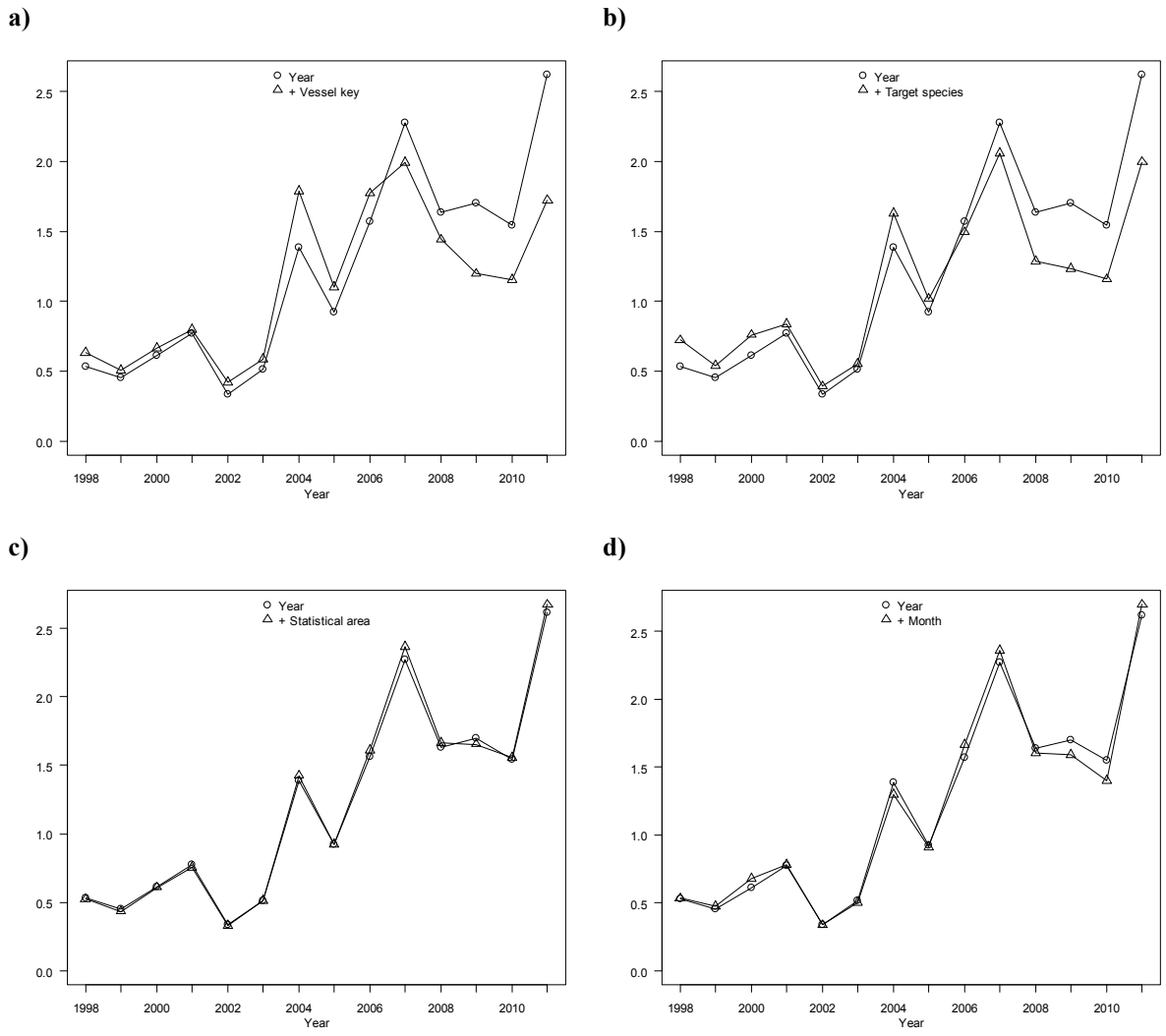


Figure E2a.2: Influence of a) Year + vessel, b) Year + target species, c) Year + statistical area, and d) Year + month on CPUE Model 2a (ECSI).

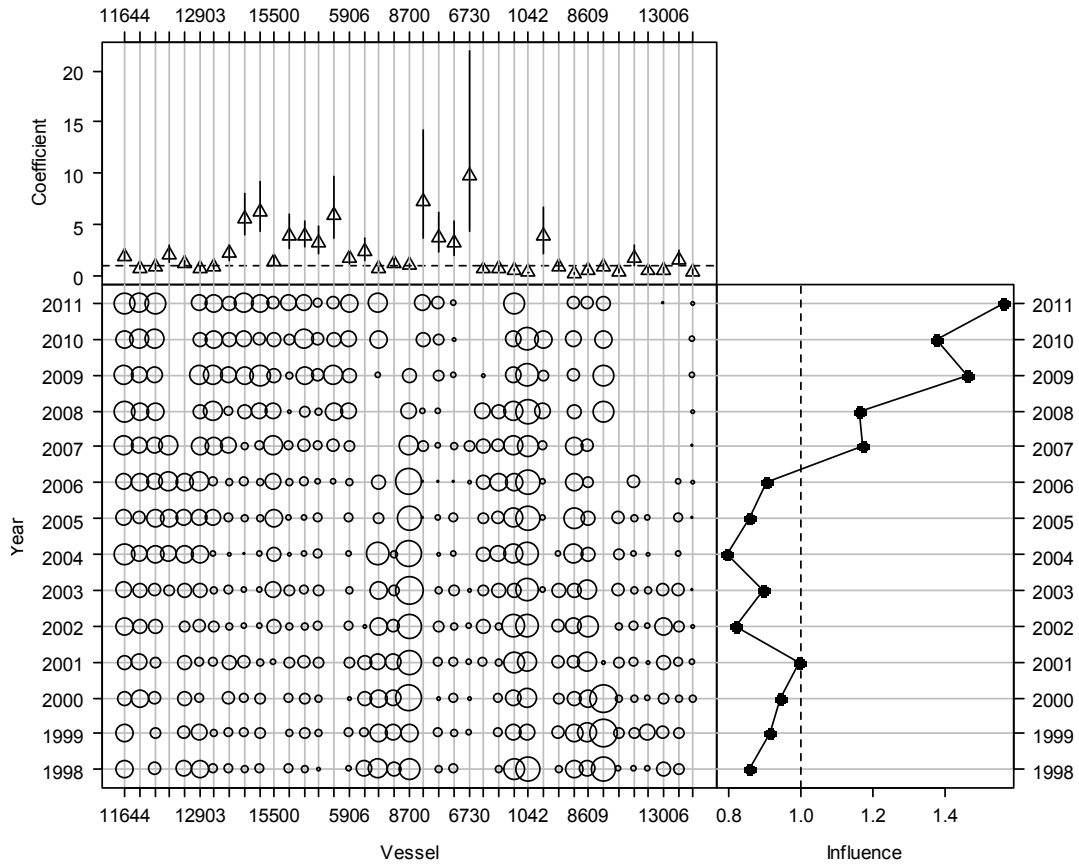


Figure E2a.3a: Influence of vessel on CPUE Model 2a (ECSI).

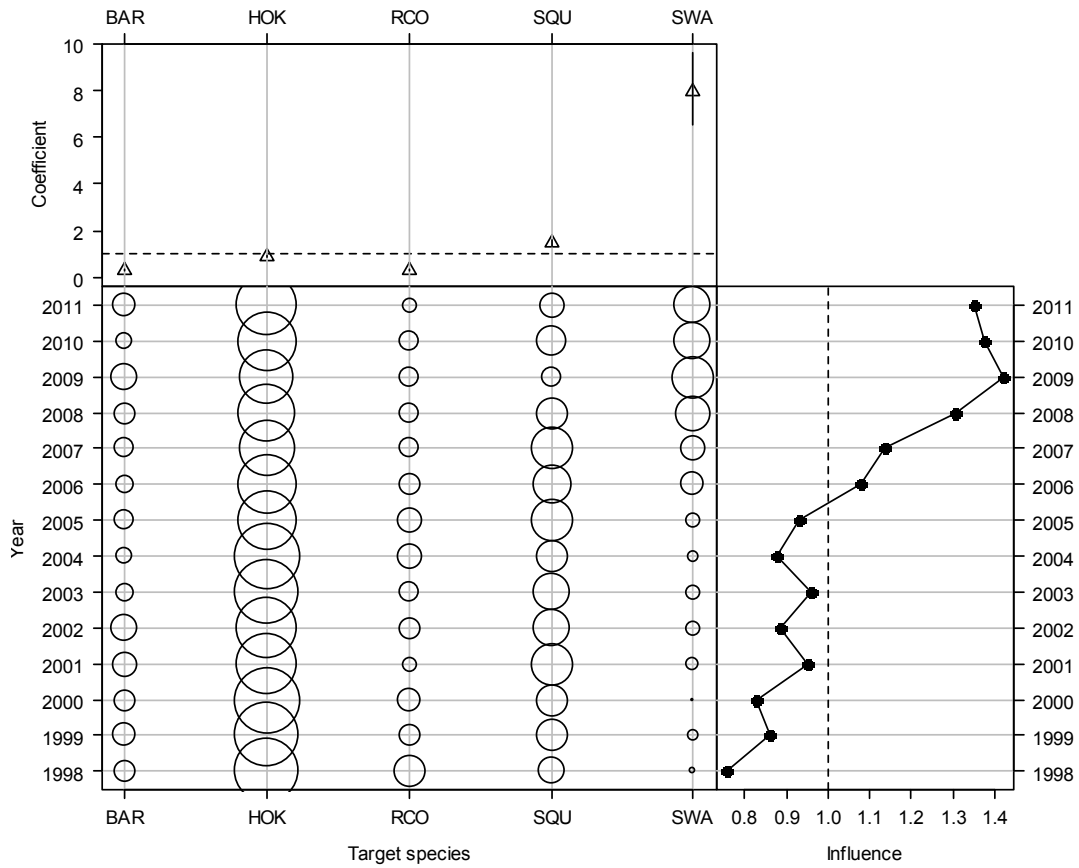


Figure E2a.3b: Influence of target species on CPUE Model 2a (ECSI).

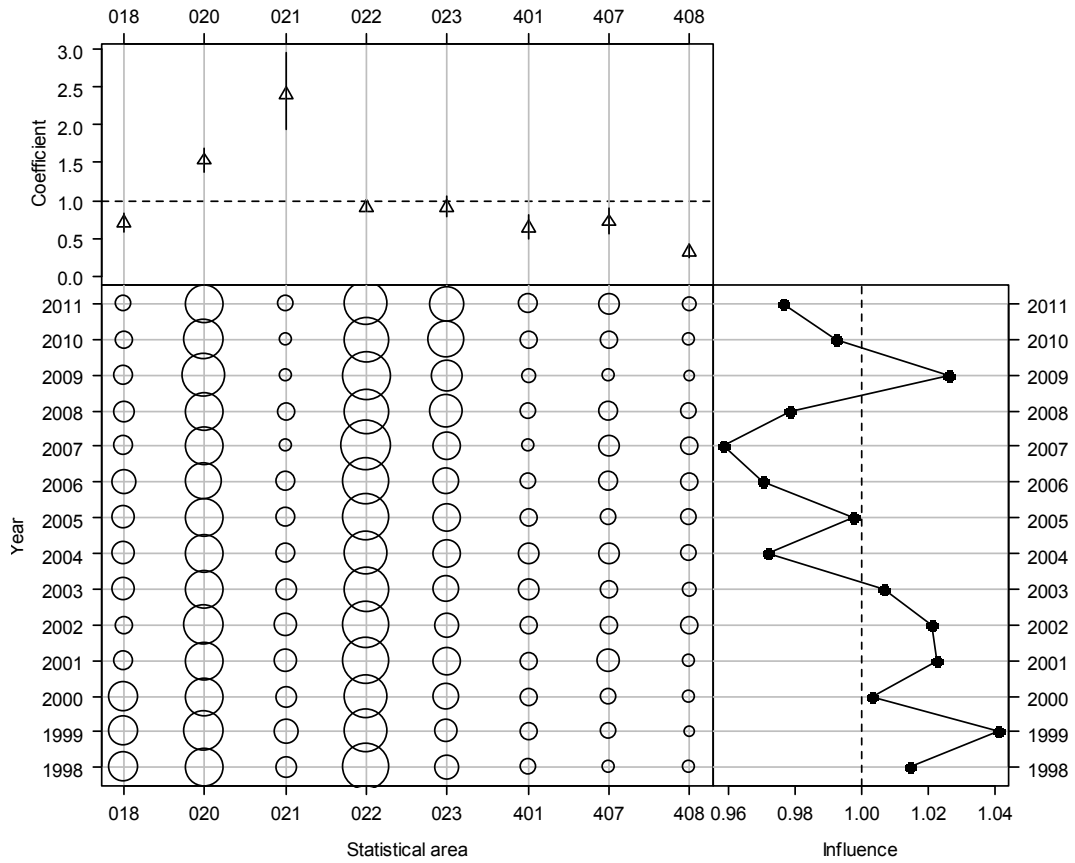


Figure E2a.3c: Influence of statistical area on CPUE Model 2a (ECSI).

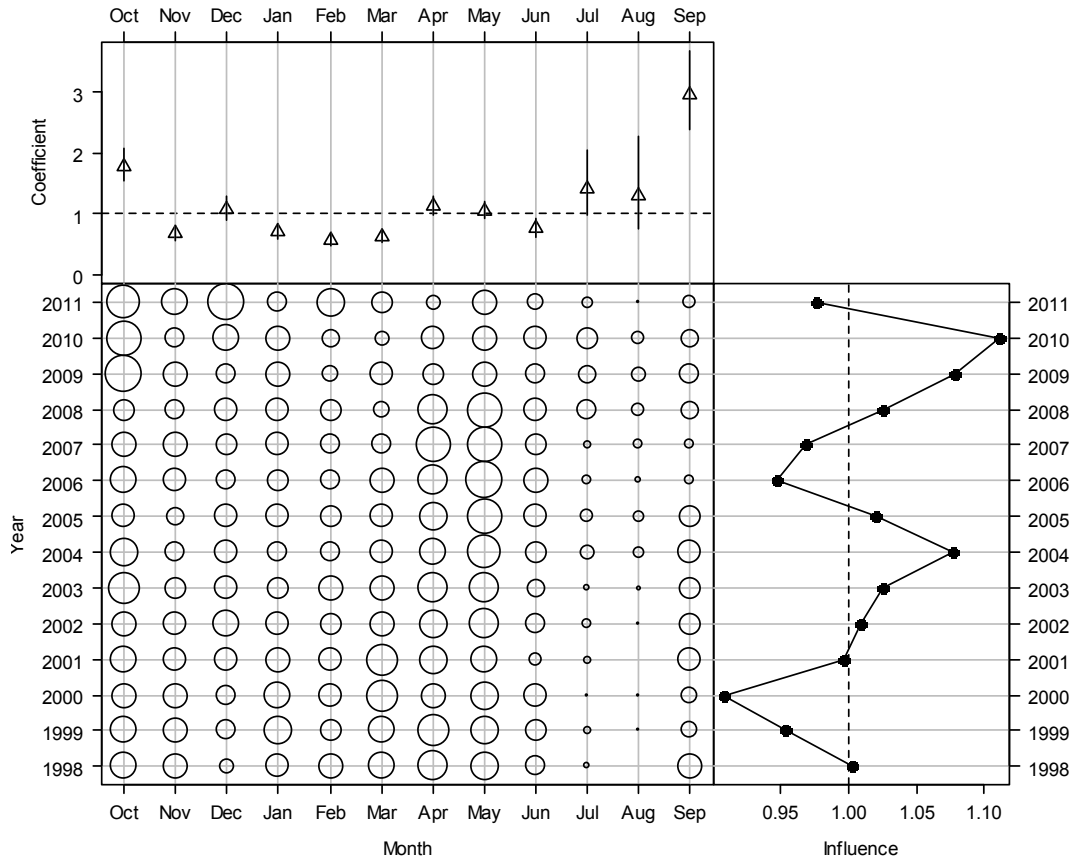


Figure E2a.3d: Influence of month on CPUE Model 2a (ECSI).

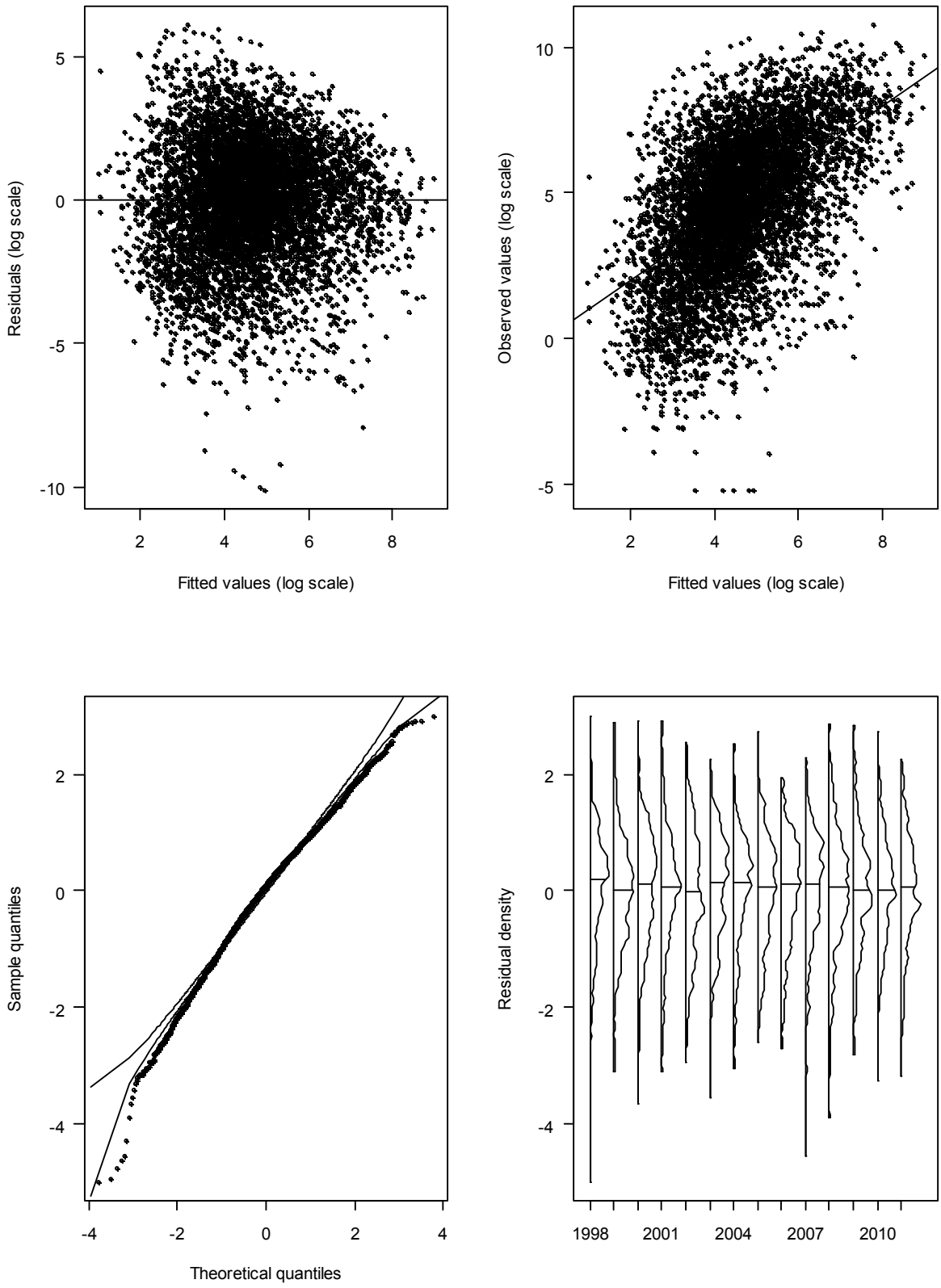


Figure E2a.4: Residual diagnostic plots describing the fit of CPUE Model 2a (ECSI) to the data.

CPUE Model 2b (East Coast South Island, un-merged tow level dataset)

Table E2b.1: Criteria used for defining the data used for CPUE Model 2b (ECSI, tow level).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP, CEL, TCE	Yes
primary_method	BT, MB	Yes
target_species	HOK, SWA, SQU, BAR, RCO	Yes
start_stats_area_code	408, 407, 401, 401, 023, 022, 021, 020, 018	Yes
fish_month	All	Yes
vessel_key	All core vessels	Yes
fishing_duration	All	Yes
effort_depth	All	Yes
effort_height	All	Yes
effort_width	All	Yes
twin	True, False	Yes

Table E2b.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 2b (ECSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	103	12 752	0.78	2 501.60	2 763	0.91
1999	83	11 721	0.83	1 466.60	1 962	0.75
2000	77	12 451	0.78	1 891.10	2 718	0.70
2001	80	11 680	0.74	2 545.10	2 980	0.85
2002	65	8 512	0.82	1 830.90	1 571	1.17
2003	70	10 022	0.81	2 142.60	1 923	1.11
2004	64	7 222	0.62	2 807.20	2 723	1.03
2005	65	6 043	0.64	2 741.50	2 163	1.27
2006	60	5 890	0.59	2 867.60	2 396	1.20
2007	53	4 987	0.50	4 079.60	2 483	1.64
2008	46	4 895	0.65	1 813.30	1 690	1.07
2009	42	5 019	0.70	2 392.80	1 511	1.58
2010	49	5 339	0.74	2 054.20	1 367	1.50
2011	50	4 788	0.64	2 648.40	1 746	1.52

Table E2b.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 2b (ECSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	32	7 125	0.76	1 361.60	1 693	0.80
1999	31	8 493	0.83	1 027	1 469	0.70
2000	33	9 797	0.75	1 704.70	2 426	0.70
2001	35	9 365	0.74	2 250.70	2 429	0.93
2002	34	6 795	0.81	1 631.50	1 281	1.27
2003	35	8 119	0.80	1 950.70	1 584	1.23
2004	33	6 535	0.61	2 673.10	2 553	1.05
2005	31	5 244	0.64	2 461	1 892	1.30
2006	32	5 416	0.58	2 759.50	2 293	1.20
2007	28	4 745	0.49	4 026	2 436	1.65
2008	25	4 450	0.65	1 728.90	1 570	1.10
2009	25	4 466	0.71	2 154.20	1 314	1.64
2010	24	4 396	0.74	1 869.10	1 147	1.63
2011	24	3 925	0.62	2 351.10	1 509	1.56

Table E2b.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 2b (ECSI) and the corresponding total R^2 value.

	R-squared
fish_year	3.32
vessel_key	11.75
fish_month	14.98
target_species	18
poly(effort_depth, 3)	19.06

Table E2b.5: ECSI CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 2b (ECSI).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	0.82	0.78	0.86	0.03	0.03
1999	0.65	0.62	0.69	0.03	0.03
2000	0.86	0.82	0.90	0.02	0.02
2001	0.75	0.72	0.79	0.02	0.02
2002	0.95	0.90	1	0.03	0.03
2003	0.98	0.93	1.03	0.03	0.03
2004	1.26	1.21	1.32	0.02	0.02
2005	1.17	1.12	1.23	0.02	0.02
2006	1.29	1.23	1.35	0.02	0.02
2007	1.37	1.31	1.43	0.02	0.02
2008	0.93	0.88	0.98	0.03	0.03
2009	0.99	0.93	1.04	0.03	0.03
2010	1.05	0.99	1.11	0.03	0.03
2011	1.23	1.16	1.30	0.03	0.03

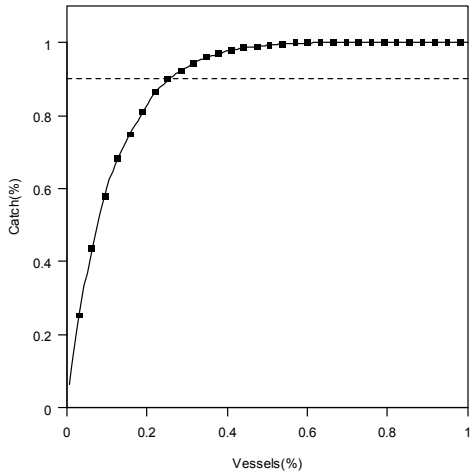
Table E2b.6: Variables retained in order of decreasing explanatory value for binomial Model 2b (ECSI) and the corresponding total R^2 value.

	R-squared
fish_year	3.50
fish_month	7.72
poly(effort_depth, 3)	12.19
start_stats_area_code	14.65
vessel_key	16.17

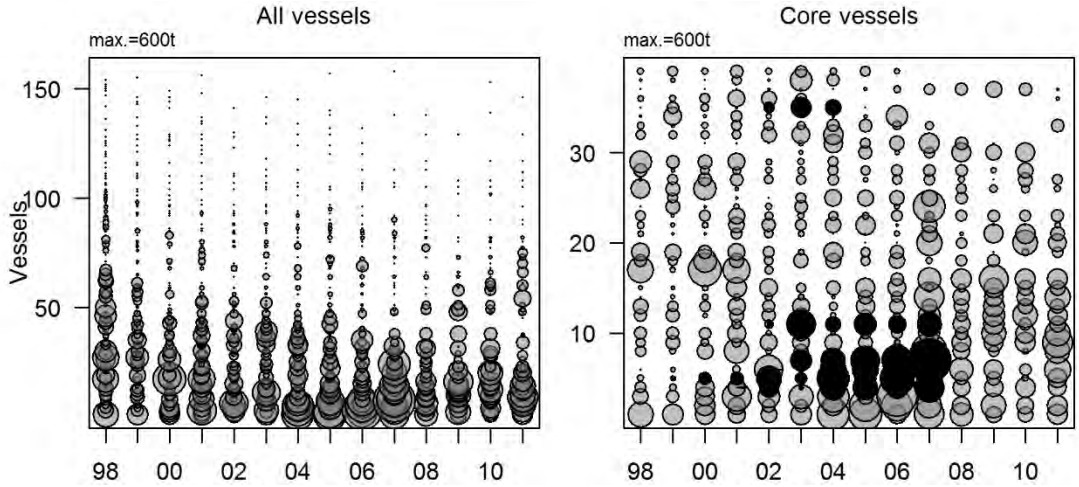
Table E2b.7: Estimated values for probability of a non-zero tow (binomial model), CPUE (log-normal model), and CPUE (delta log-normal model) for CPUE Model 2b (ECSI).

	Binomial	Log-normal	Delta log-normal
1998	0.18	0.82	0.18
1999	0.15	0.65	0.15
2000	0.20	0.86	0.20
2001	0.21	0.75	0.21
2002	0.15	0.95	0.15
2003	0.15	0.98	0.15
2004	0.35	1.26	0.35
2005	0.31	1.17	0.31
2006	0.39	1.29	0.39
2007	0.49	1.37	0.49
2008	0.30	0.93	0.30
2009	0.21	0.99	0.21
2010	0.22	1.05	0.22
2011	0.36	1.23	0.36

a)



b)



c)

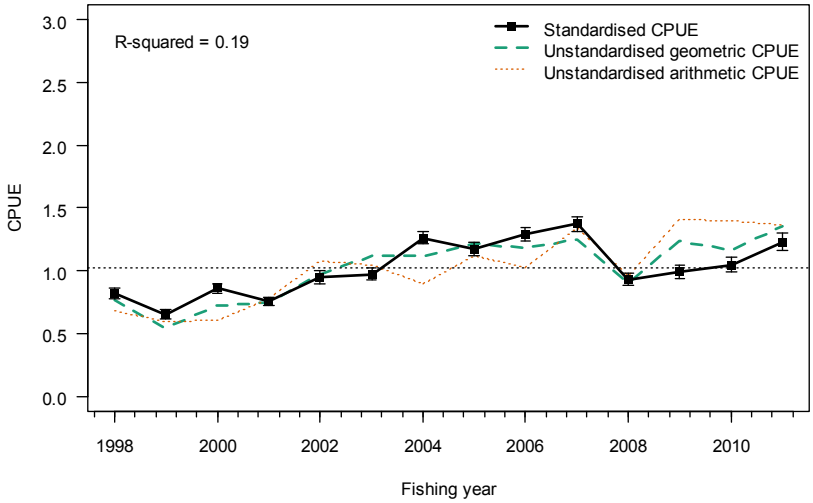


Figure E2b.1: ECSI CPUE Model 2b (unmerged, tow-level dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel. Black shaded portions of symbols indicate the proportion of catch using twin trawl gear. c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

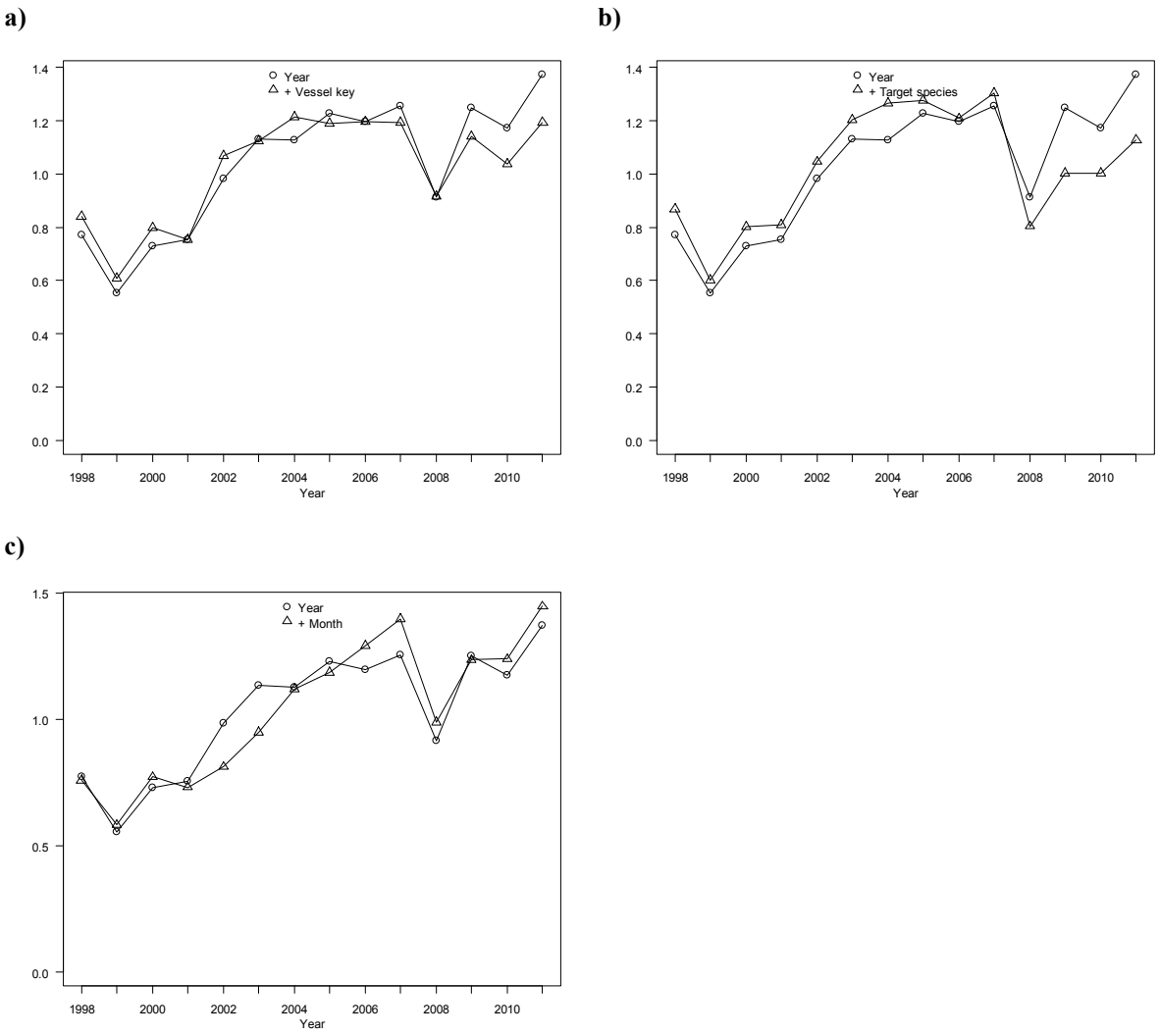


Figure E2b.2: Influence of a) Year + vessel, b) Year + target species, and c) Year + month on CPUE Model 2b (ECSI).

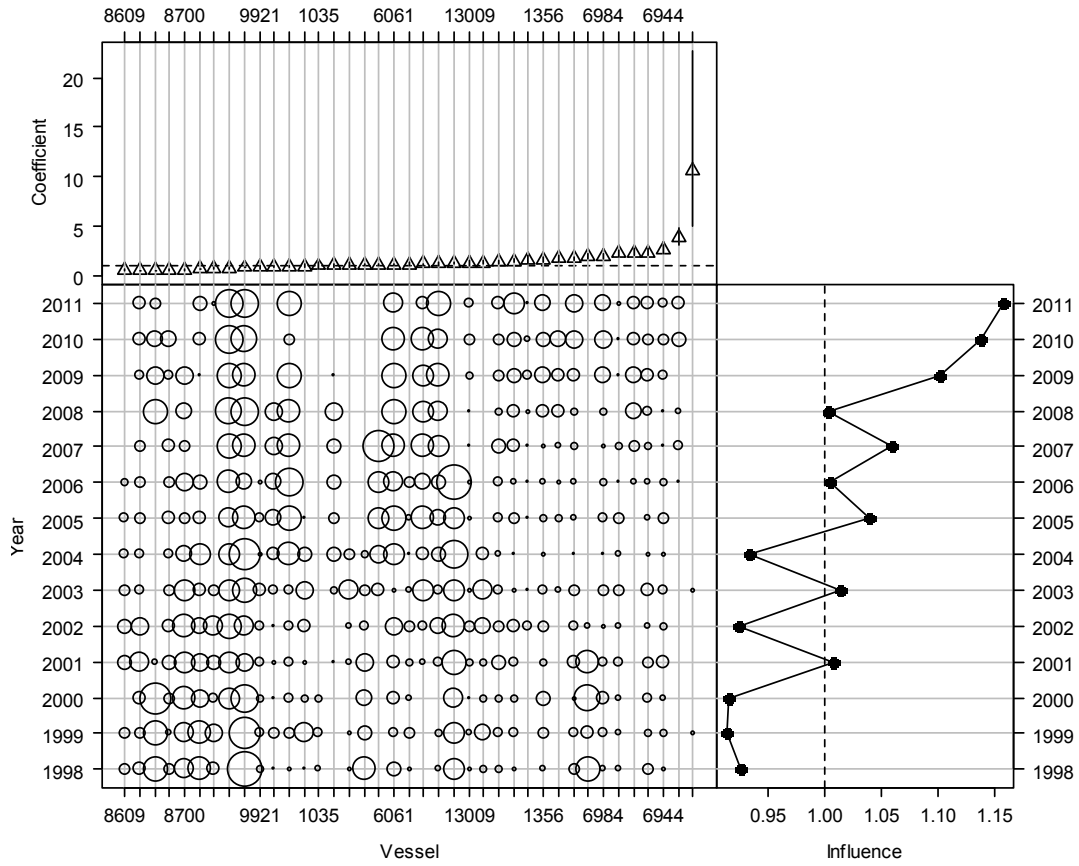


Figure E2b.3a: Influence of vessel on CPUE Model 2b (ECSI).

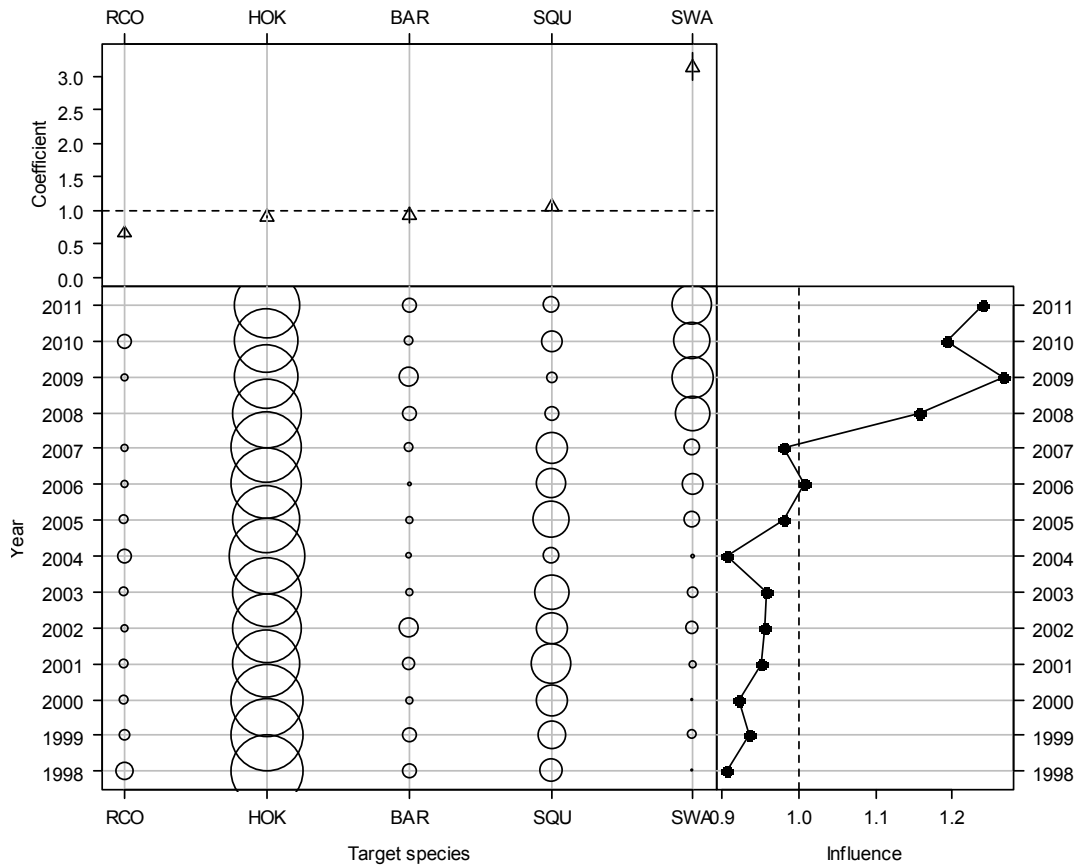


Figure E2b.3b: Influence of target species on CPUE Model 2b (ECSI).

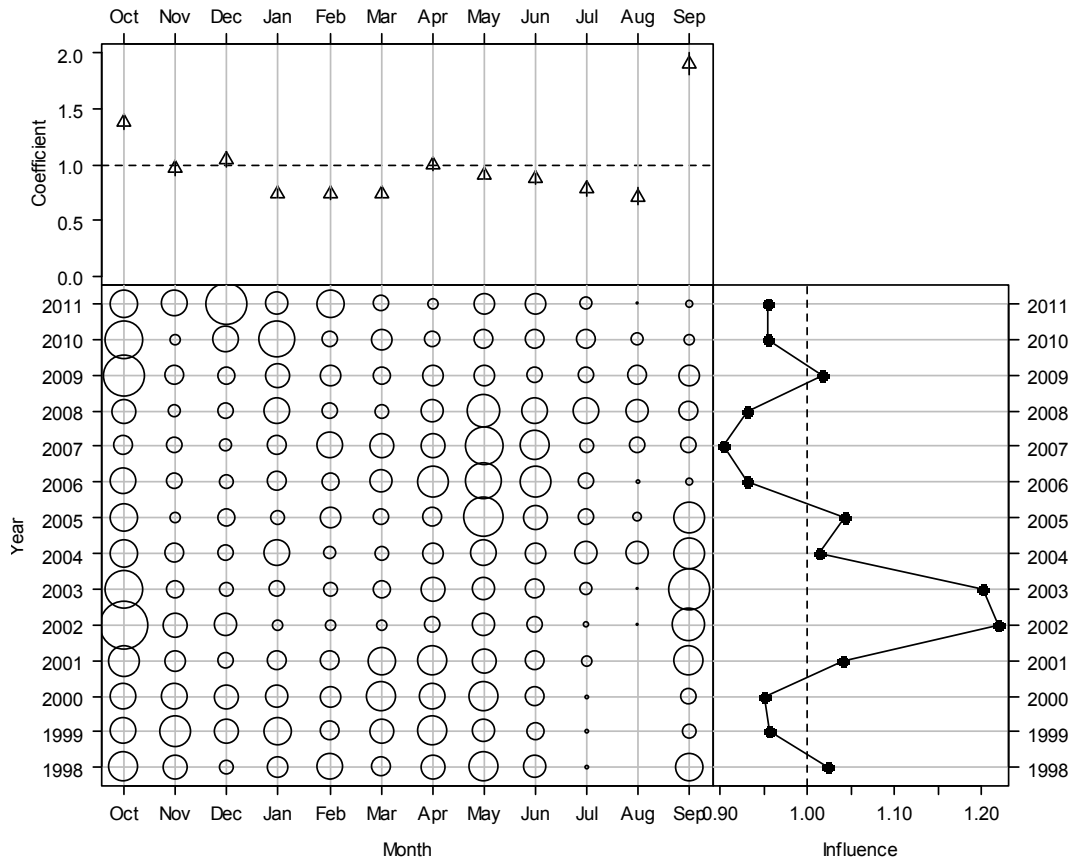


Figure E2b.3c: Influence of month on CPUE Model 2b (ECSI).

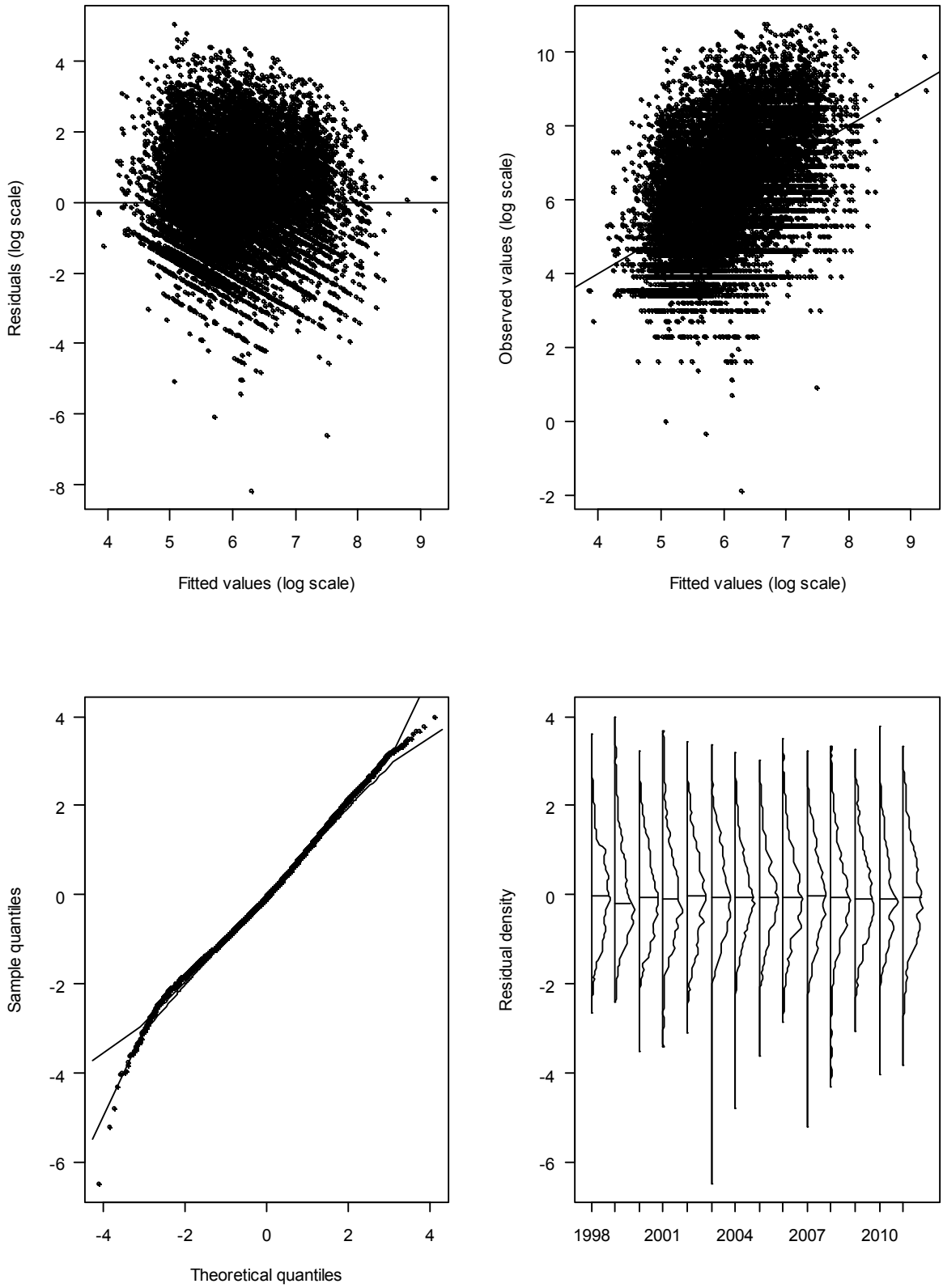


Figure E2b.4: Residual diagnostic plots describing the fit of CPUE Model 2b (ECSI) to the data.

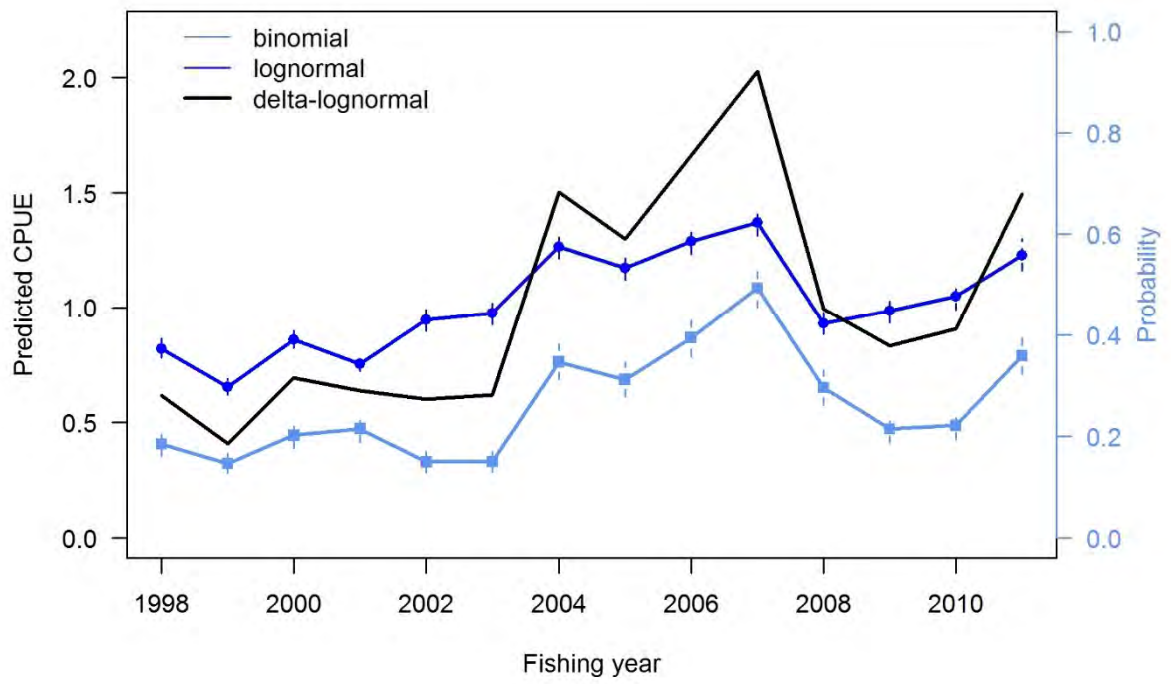


Figure E2b.5: Binomial, log-normal, and resulting delta-lognormal models for CPUE Model 2b (ECSI).

CPUE Model 3a (Southland)

Table E3a.1: Criteria used for defining the data used for CPUE Model 3a (Southland).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP	No
primary_method	BT, MB	No
target_species	HOK, SWA, SQU, WWA	Yes
start_stats_area_code	602, 504, 030, 028, 027, 028	Yes
fishing_duration	All	Yes
vessel_key	All core	Yes
fish_month	All	Yes
twin	All	Yes

Table E3a.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 3a (Southland). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	58	599	0.36	2 808.90	382	7.35
1999	50	610	0.42	3 808.60	351	10.85
2000	43	647	0.34	4 824.10	424	11.38
2001	43	739	0.36	4 016.10	476	8.44
2002	43	768	0.36	4 211.80	490	8.60
2003	43	741	0.34	4 002.70	490	8.17
2004	39	689	0.26	5 244	513	10.22
2005	41	725	0.26	3 569.50	537	6.65
2006	40	638	0.16	5 112.30	534	9.57
2007	32	652	0.18	5 662.30	533	10.62
2008	30	447	0.23	3 079.40	342	9
2009	26	498	0.21	3 053	392	7.79
2010	27	500	0.18	3 100.50	409	7.58
2011	27	580	0.27	2 862.80	426	6.72

Table E3a.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 3a (Southland). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	20	242	0.36	1 944.50	155	12.55
1999	22	370	0.40	3 443.50	222	15.51
2000	22	445	0.32	4 370	304	14.38
2001	24	495	0.32	3 641.70	336	10.84
2002	24	542	0.30	3 623.90	380	9.54
2003	24	513	0.32	3 611	351	10.29
2004	25	469	0.22	4 222.20	365	11.57
2005	25	526	0.24	3 072	402	7.64
2006	26	512	0.14	4 662	438	10.64
2007	25	582	0.15	5 189	495	10.48
2008	24	391	0.21	3 006.50	310	9.70
2009	21	441	0.19	2 824.20	356	7.93
2010	21	445	0.17	3 037.50	371	8.19
2011	19	498	0.26	2 767.30	371	7.46

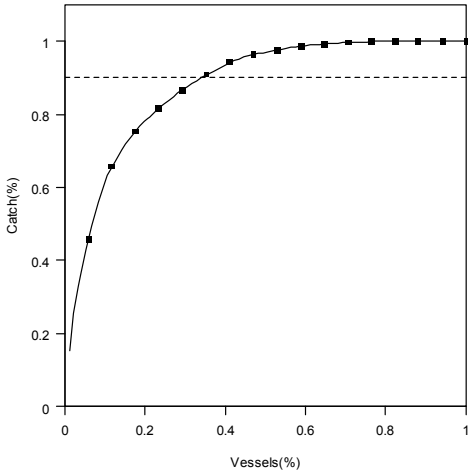
Table E3a.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 3a (Chatham Rise) and the corresponding total R^2 value.

	R-squared
fish_year	2.16
start_stats_area_code	19.28
target_species	27.38
vessel_key	30.10
fish_month	32.25

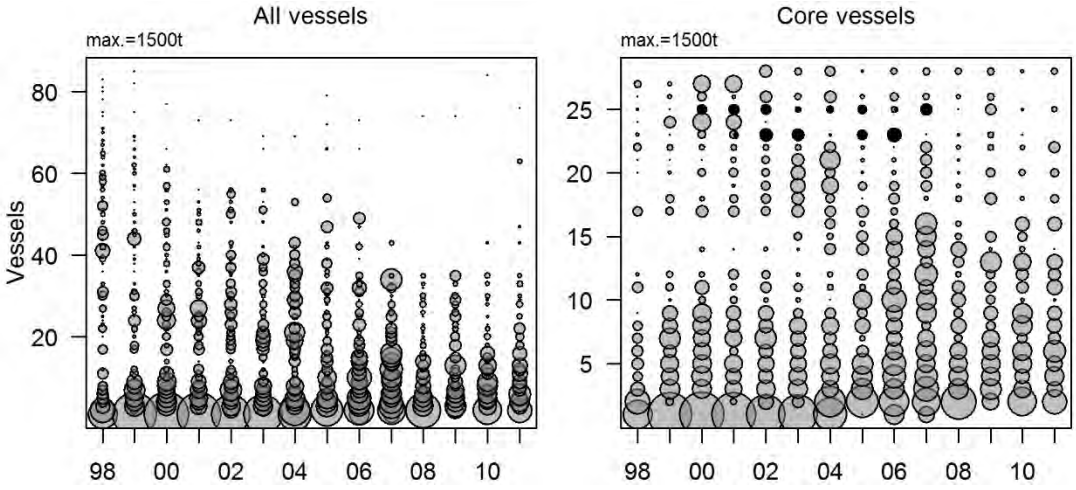
Table E3a.5: Chatham Rise CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 3a (Chatham Rise).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	0.74	0.63	0.86	0.08	0.08
1999	0.81	0.71	0.93	0.07	0.07
2000	1.38	1.23	1.55	0.06	0.06
2001	1.14	1.03	1.27	0.05	0.05
2002	0.65	0.59	0.72	0.05	0.05
2003	0.90	0.81	1	0.05	0.05
2004	1.39	1.26	1.55	0.05	0.05
2005	0.69	0.63	0.77	0.05	0.05
2006	1.29	1.17	1.42	0.05	0.05
2007	1.77	1.62	1.94	0.05	0.05
2008	0.81	0.72	0.90	0.06	0.06
2009	1.24	1.11	1.38	0.05	0.05
2010	1.23	1.11	1.36	0.05	0.05
2011	0.66	0.60	0.74	0.05	0.05

a)



b)



c)

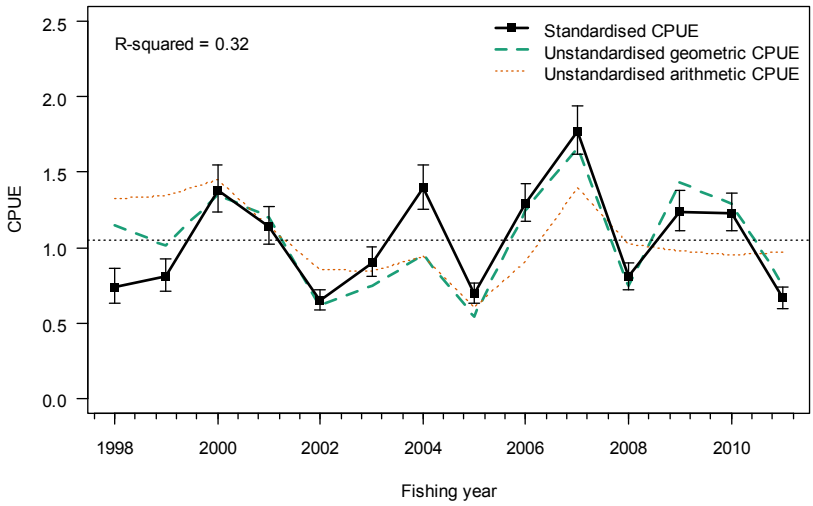


Figure E3a.1: Chatham Rise CPUE Model 3a (stratified dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel for All vessels (left), and Core vessels with catch from twin vessels shown in black (right). c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

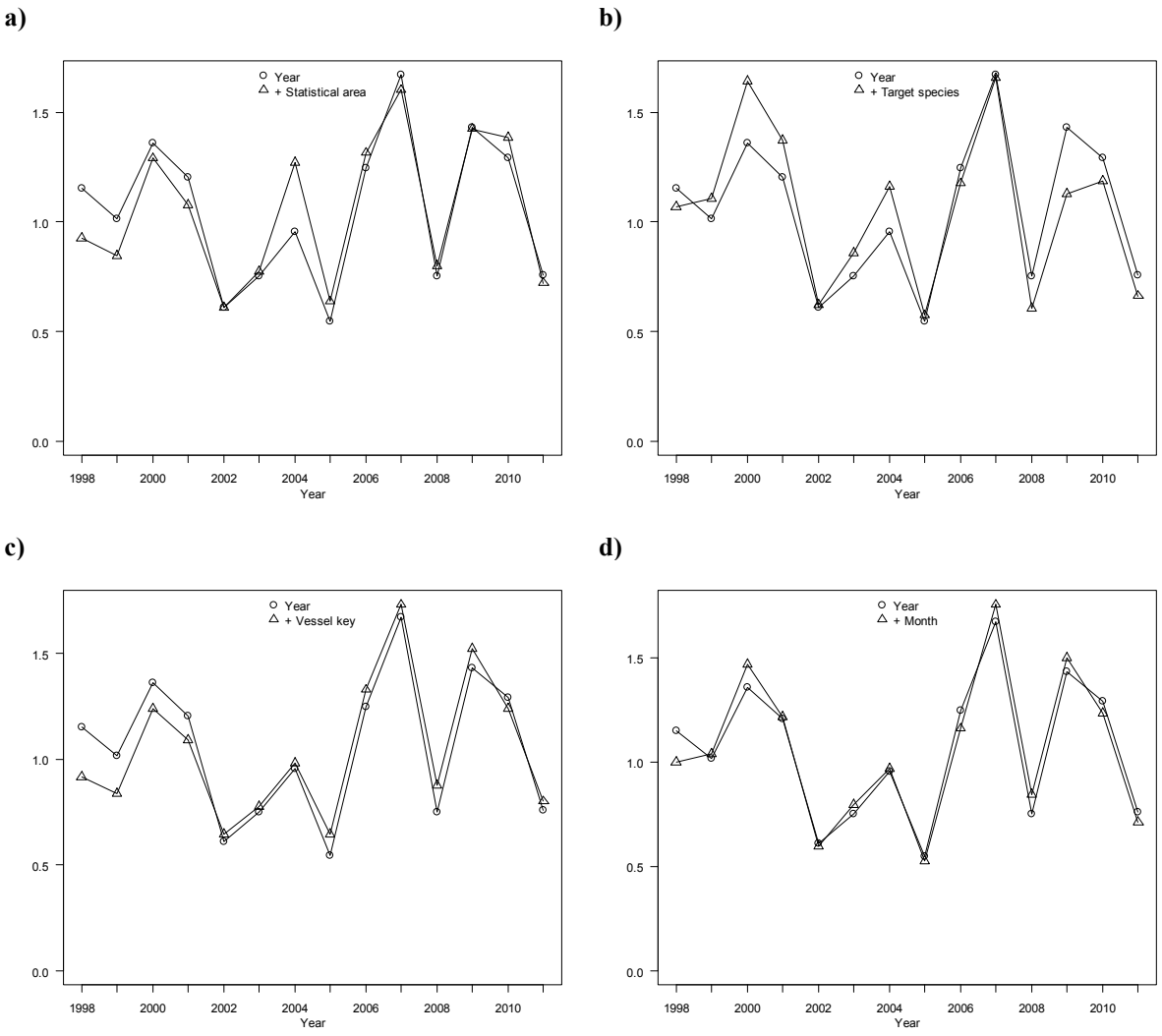


Figure E3a.2: Influence of a) Year + statistical area, b) Year + target species, c) Year + vessel, and d) Year + month on CPUE Model 3a (Southland).

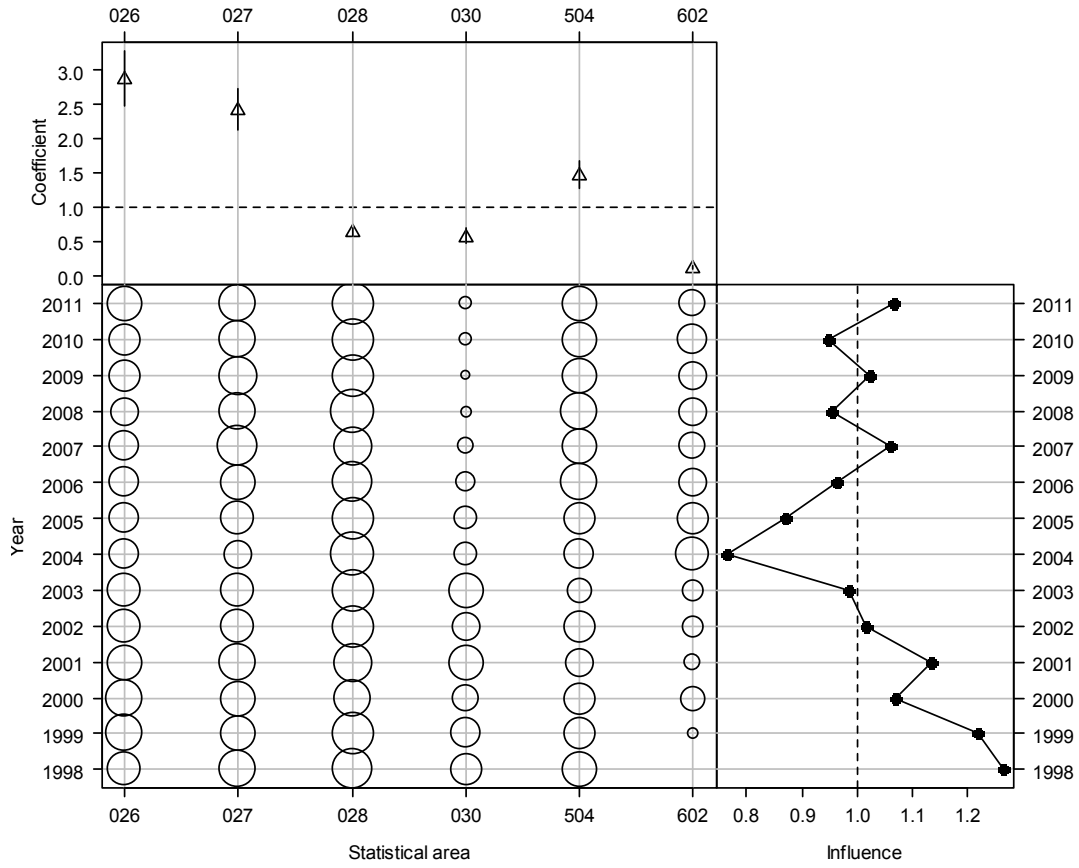


Figure E3a.3a: Influence of statistical area on CPUE Model 3a (Southland).

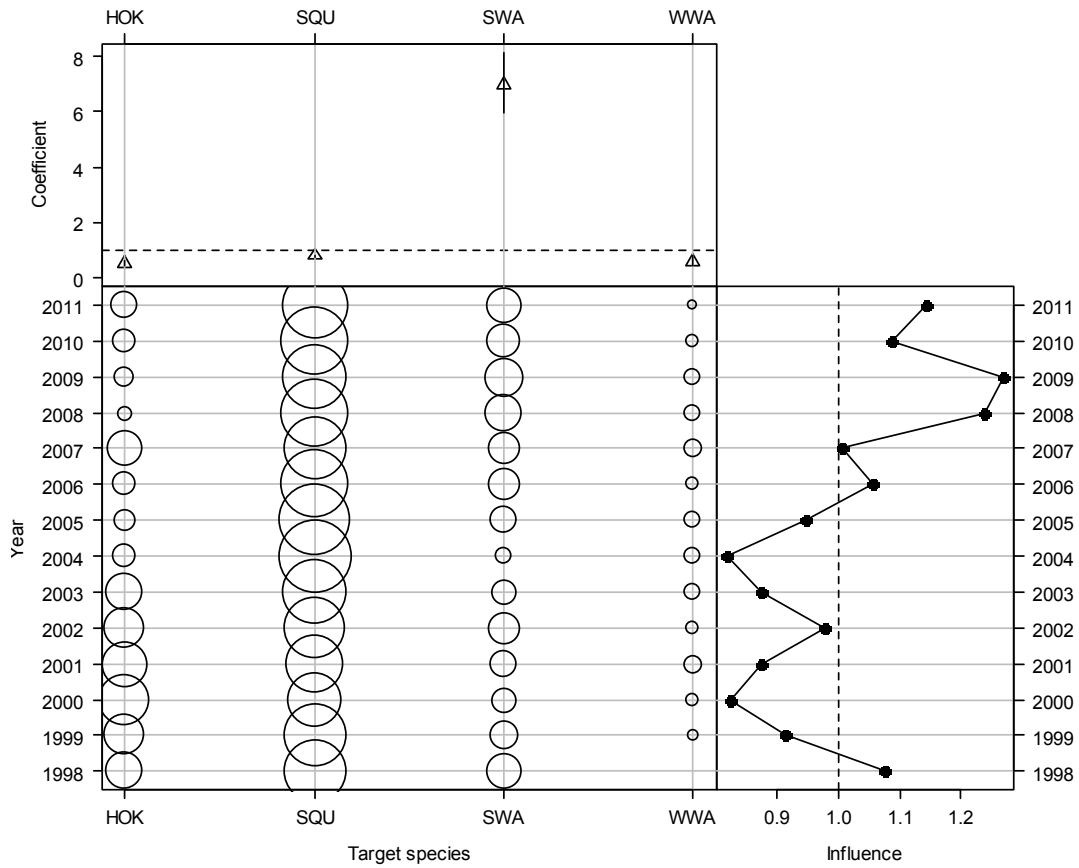


Figure E3a.3b: Influence of target species on CPUE Model 3a (Southland)

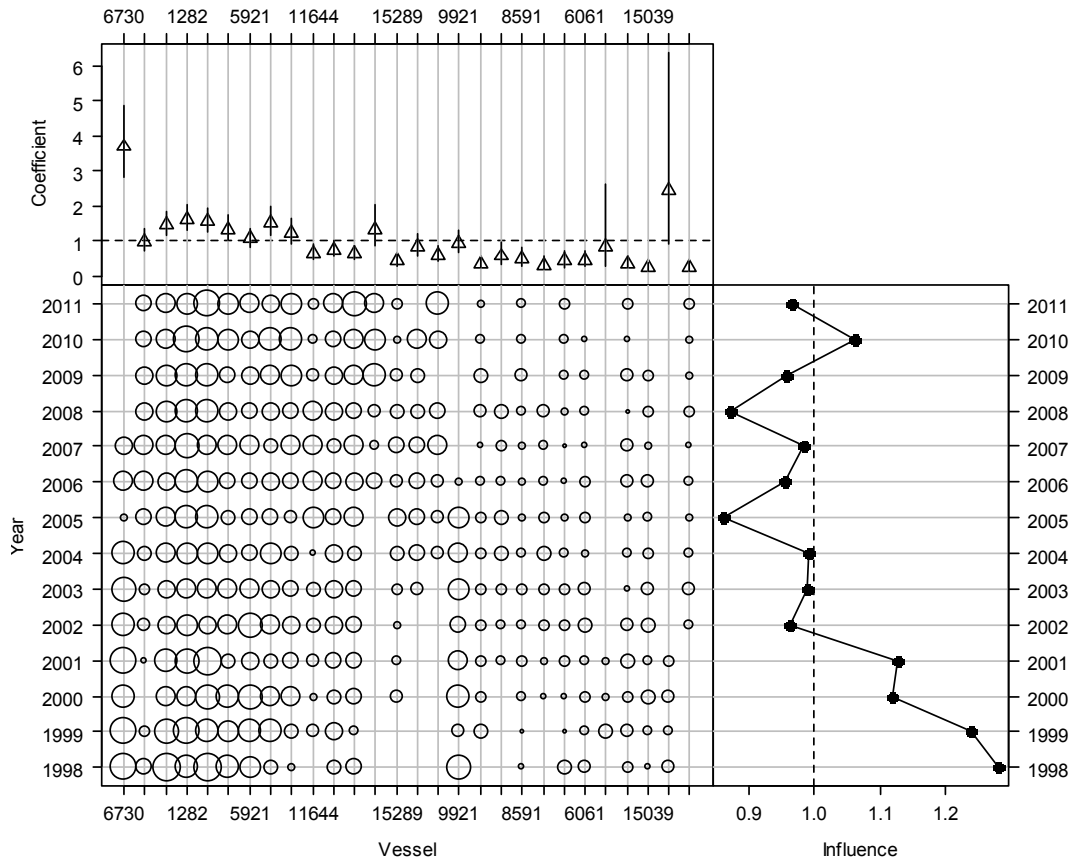


Figure E3a.3c: Influence of vessel on CPUE Model 3a (Southland).

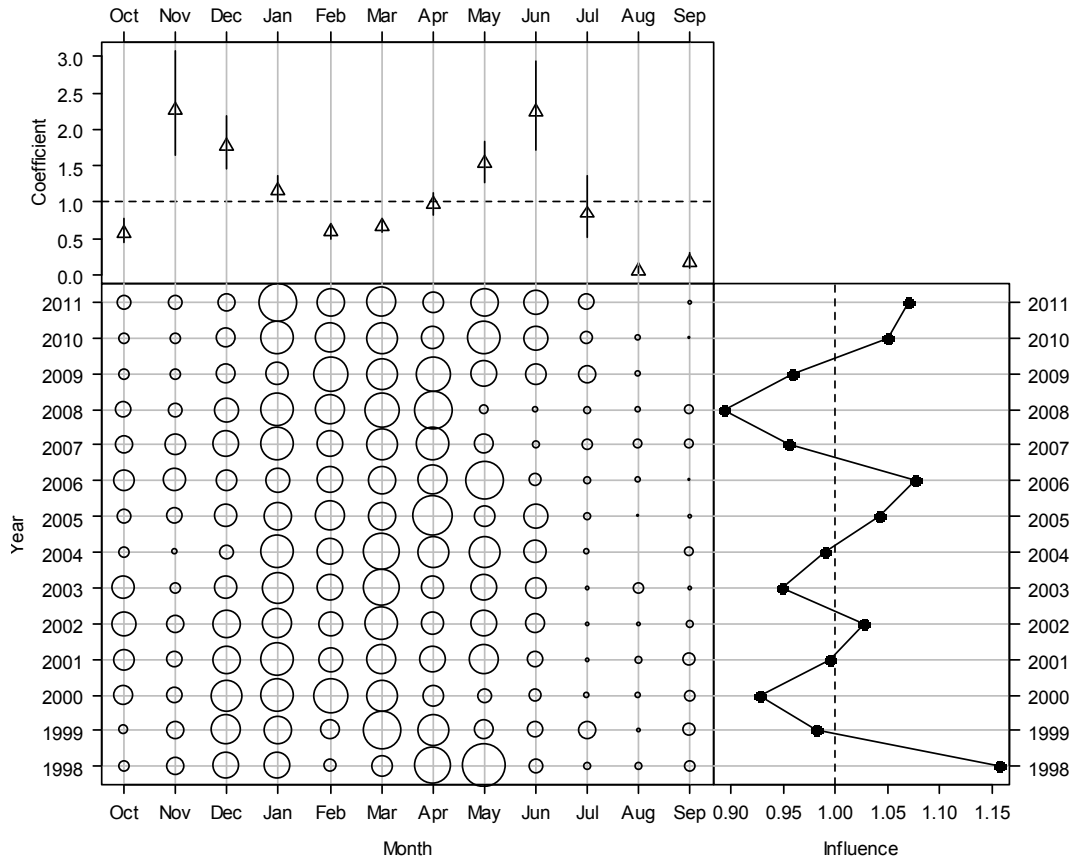


Figure E3a.3d: Influence of month on CPUE Model 3a (Southland).

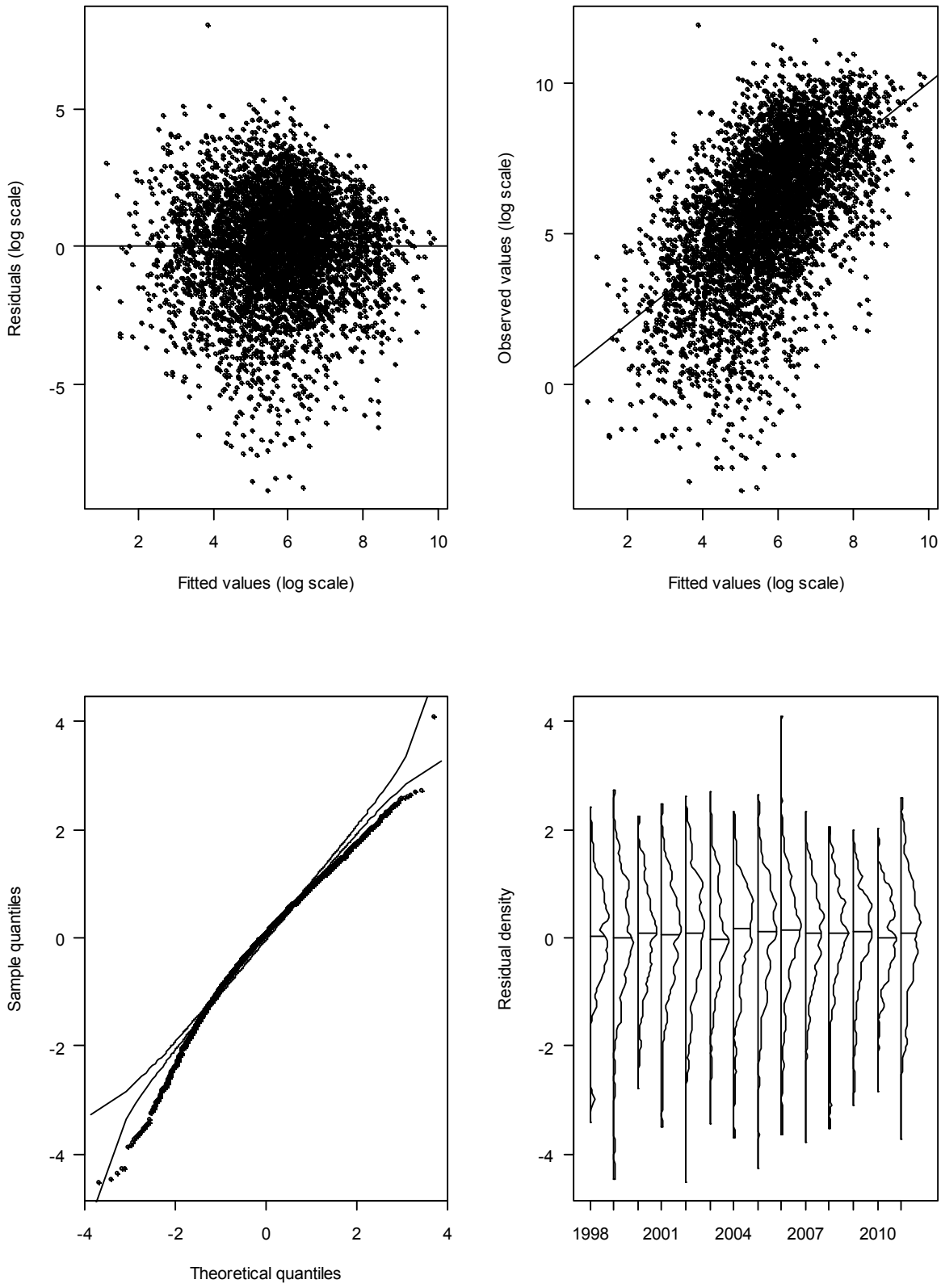


Figure E3a.4: Residual diagnostic plots describing the fit of CPUE Model 3a (Southland) to the data.

CPUE Model 3b (Southland, un-merged tow level dataset)

Table E3b.1: Criteria used for defining the data used for CPUE Model 3b (Southland, tow level).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP	No
primary_method	BT, MB	No
target_species	HOK, SWA, SQU, WWA	Yes
start_stats_area_code	602, 504, 030, 028, 027, 028	Yes
fishing_duration	All	Yes
vessel_key	All core	Yes
fish_month	All	Yes
effort_depth	All	Yes
effort_height	All	Yes
effort_width	All	Yes
twin	True, False	Yes

Table E3b.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 3b (Southland). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	59	8 391	0.84	2 774.90	1 328	2.09
1999	52	7 679	0.79	3 181.70	1 643	1.94
2000	43	8 049	0.79	4 126.70	1 667	2.48
2001	43	8 454	0.76	3 622.20	1 993	1.82
2002	43	9 429	0.78	3 570.60	2 052	1.74
2003	44	8 966	0.79	3 733.90	1 895	1.97
2004	39	8 824	0.68	4 314.40	2 856	1.51
2005	41	9 512	0.74	3 259.30	2 504	1.30
2006	40	7 679	0.61	4 927	2 973	1.66
2007	32	5 507	0.54	5 291.50	2 548	2.08
2008	30	4 574	0.67	2 802.10	1 498	1.87
2009	26	4 668	0.70	3 194.90	1 408	2.27
2010	27	4 626	0.54	2 642.90	2 127	1.24
2011	27	4 983	0.76	2 442.30	1 173	2.08

Table E3b.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 3b (Southland). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	21	2 684	0.74	1 949.90	694	2.81
1999	23	3 573	0.70	2 787.60	1 080	2.58
2000	23	4 746	0.72	3 768.90	1 334	2.83
2001	25	5 036	0.67	3 192.30	1 656	1.93
2002	24	5 902	0.72	3 053.50	1 633	1.87
2003	25	5 910	0.73	3 368.10	1 585	2.12
2004	26	5 902	0.65	3 565.40	2 087	1.71
2005	26	6 550	0.69	2 888.20	1 998	1.45
2006	27	5 886	0.59	4 496.30	2 412	1.86
2007	26	4 570	0.49	4 908	2 337	2.10
2008	25	3 861	0.62	2 760.30	1 450	1.90
2009	22	3 910	0.66	3 082.70	1 324	2.33
2010	22	3 953	0.48	2 605.20	2 036	1.28
2011	20	3 999	0.73	2 369.40	1 092	2.17

Table E3b.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 3b (Southland) and the corresponding total R^2 value.

	R-squared
fish_year	2.76
start_stats_area_code	19.38
target_species	26.65
vessel_key	30.44

Table E3b.5: Chatham Rise CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 3b (Southland).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	1.08	0.99	1.17	0.04	0.04
1999	1.16	1.09	1.23	0.03	0.03
2000	1.34	1.26	1.42	0.03	0.03
2001	0.86	0.82	0.91	0.03	0.03
2002	0.96	0.91	1.01	0.03	0.03
2003	0.97	0.92	1.02	0.03	0.03
2004	1.52	1.46	1.59	0.02	0.02
2005	0.76	0.73	0.80	0.02	0.02
2006	0.87	0.84	0.91	0.02	0.02
2007	1.11	1.06	1.16	0.02	0.02
2008	0.72	0.68	0.76	0.03	0.03
2009	1.20	1.14	1.27	0.03	0.03
2010	0.91	0.87	0.96	0.02	0.02
2011	0.85	0.80	0.90	0.03	0.03

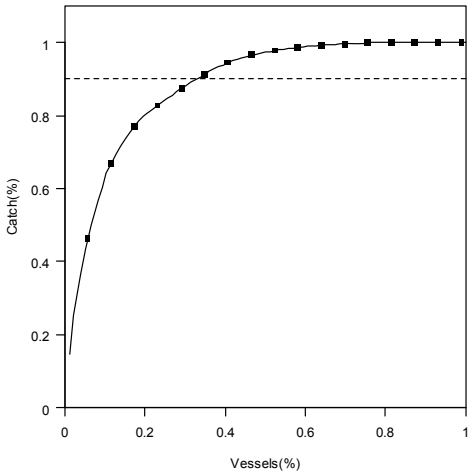
Table E3b.6: Variables retained in order of decreasing explanatory value for binomial Model 3b (Southland) and the corresponding total R^2 value.

	R-squared
fish_year	2.29
vessel_key	9.17
start_stats_area_code	14.24
target_species	17.04
poly(effort_depth, 3)	18.18

Table E3b.7: Estimated values for probability of a non-zero tow (binomial model), CPUE (log-normal model), and CPUE (delta log-normal model) for CPUE Model 3b (Southland).

	Binomial	Log-normal	Delta log-normal
1998	0.18	1.08	0.18
1999	0.22	1.16	0.22
2000	0.32	1.34	0.32
2001	0.34	0.86	0.34
2002	0.26	0.96	0.26
2003	0.24	0.97	0.24
2004	0.36	1.52	0.36
2005	0.30	0.76	0.30
2006	0.39	0.87	0.39
2007	0.51	1.11	0.51
2008	0.36	0.72	0.36
2009	0.37	1.20	0.37
2010	0.51	0.91	0.51
2011	0.25	0.85	0.25

a)



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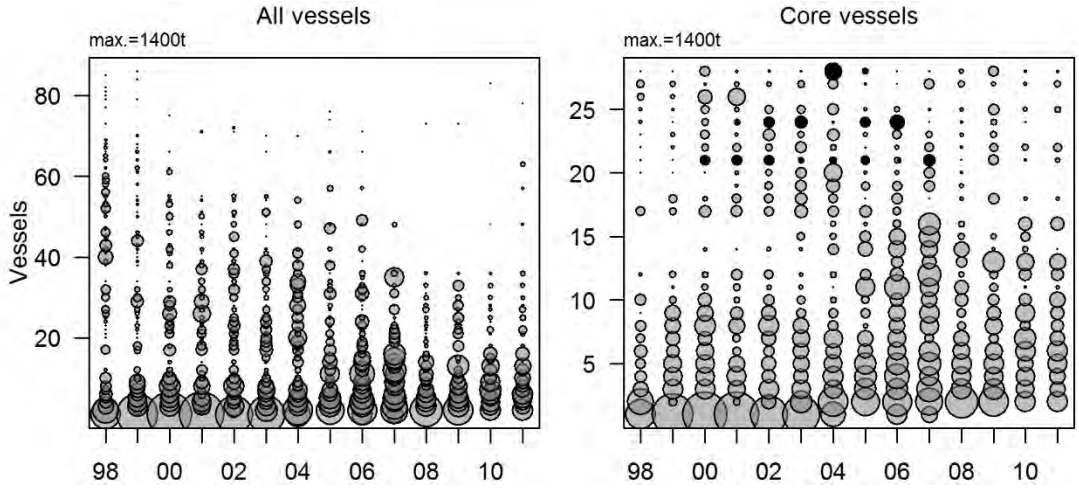


c)

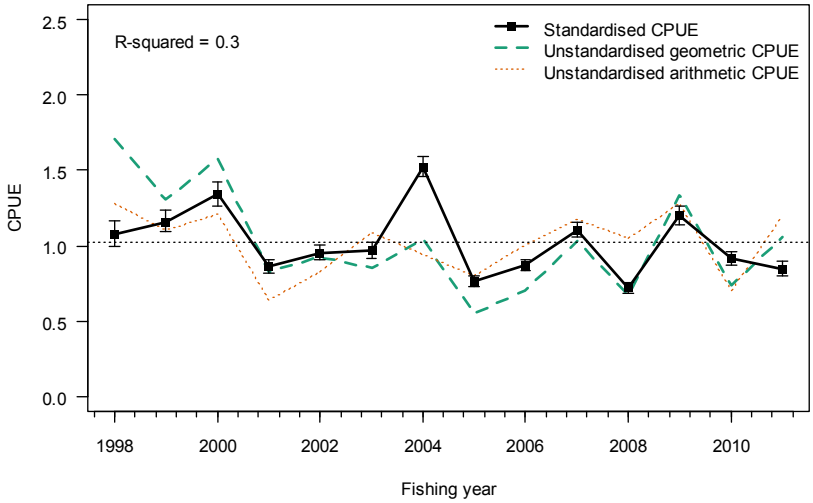
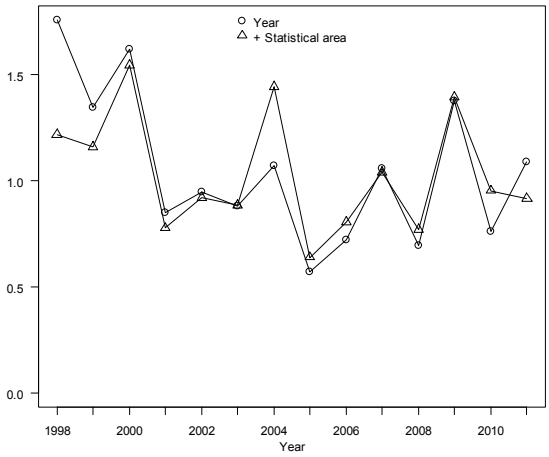
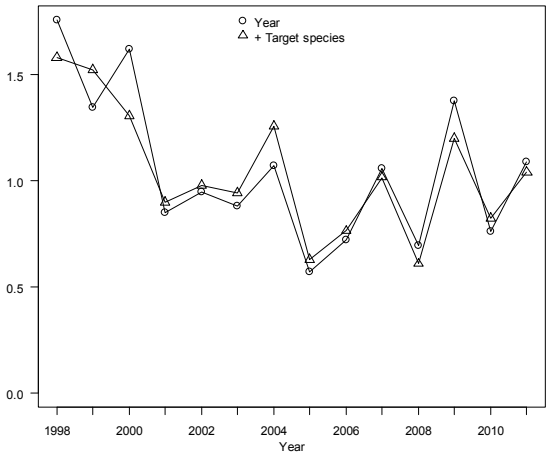


Figure E3b.1: Southland CPUE Model 3b (unmerged, tow-level dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel. Black shaded portions of symbols indicate the proportion of catch using twin trawl gear. c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

a)



b)



c)

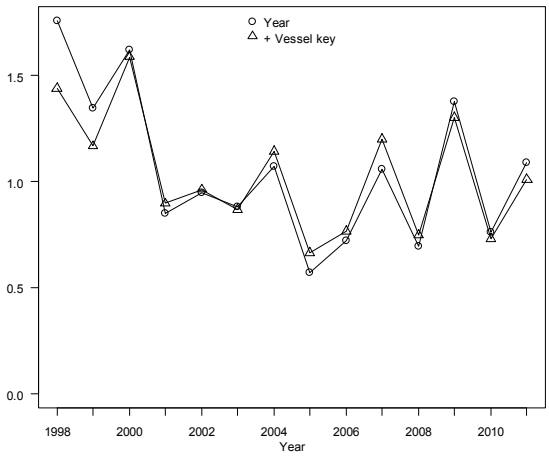


Figure E3b.2: Influence of a) Year + statistical area, b) Year + target species, and c) Year + vessel on CPUE Model 3b (Southland).

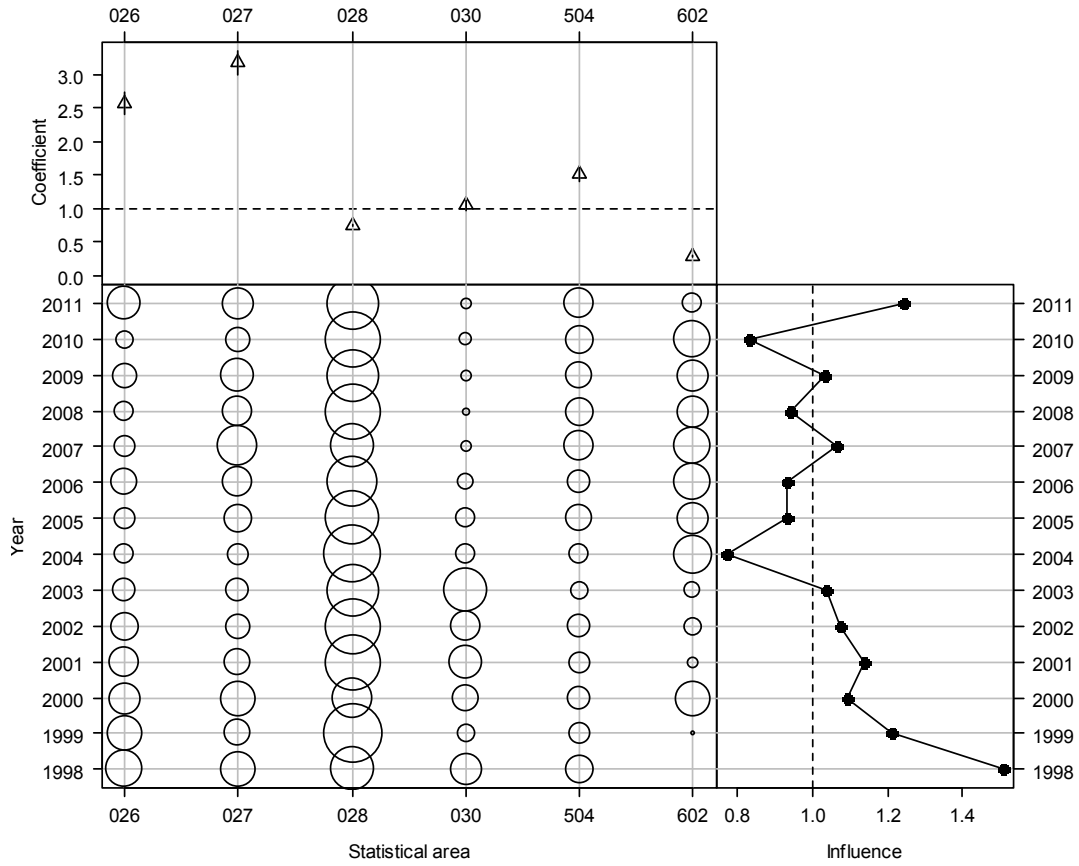


Figure E3b.3a: Influence of statistical area on CPUE Model 3b (Southland).

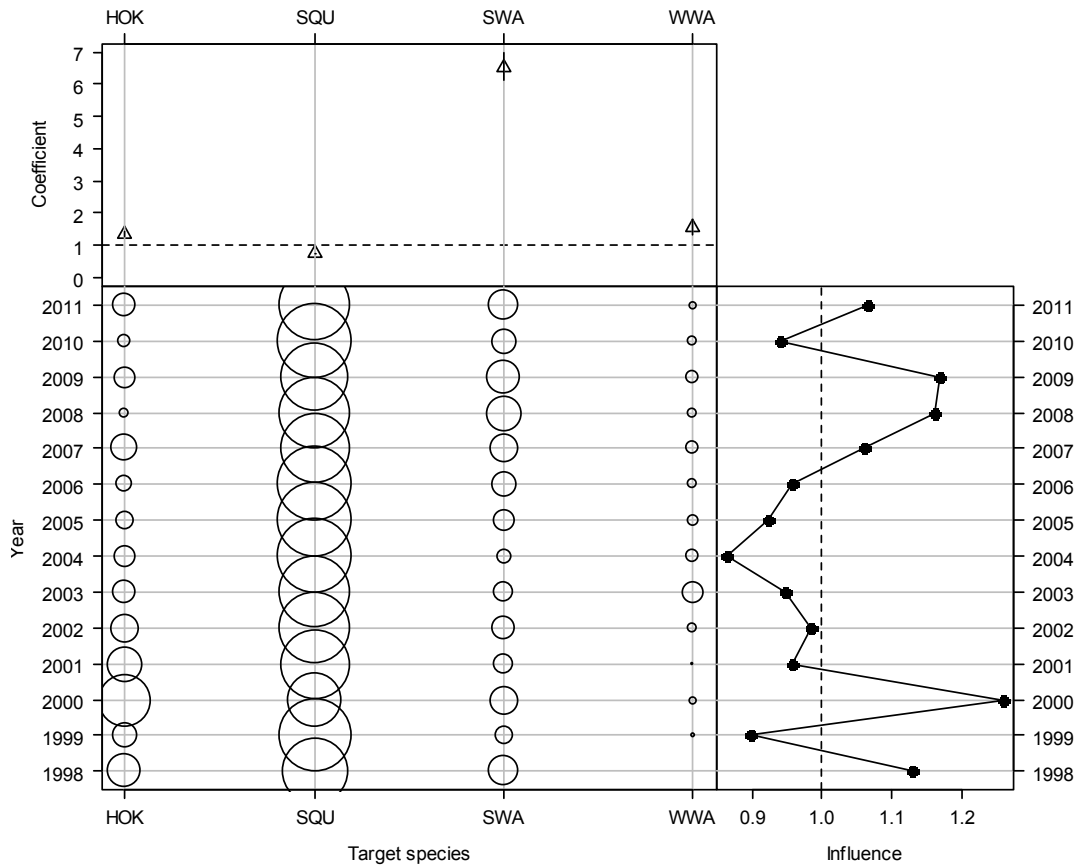


Figure E3b.3b: Influence of target species on CPUE Model 3b (Southland).

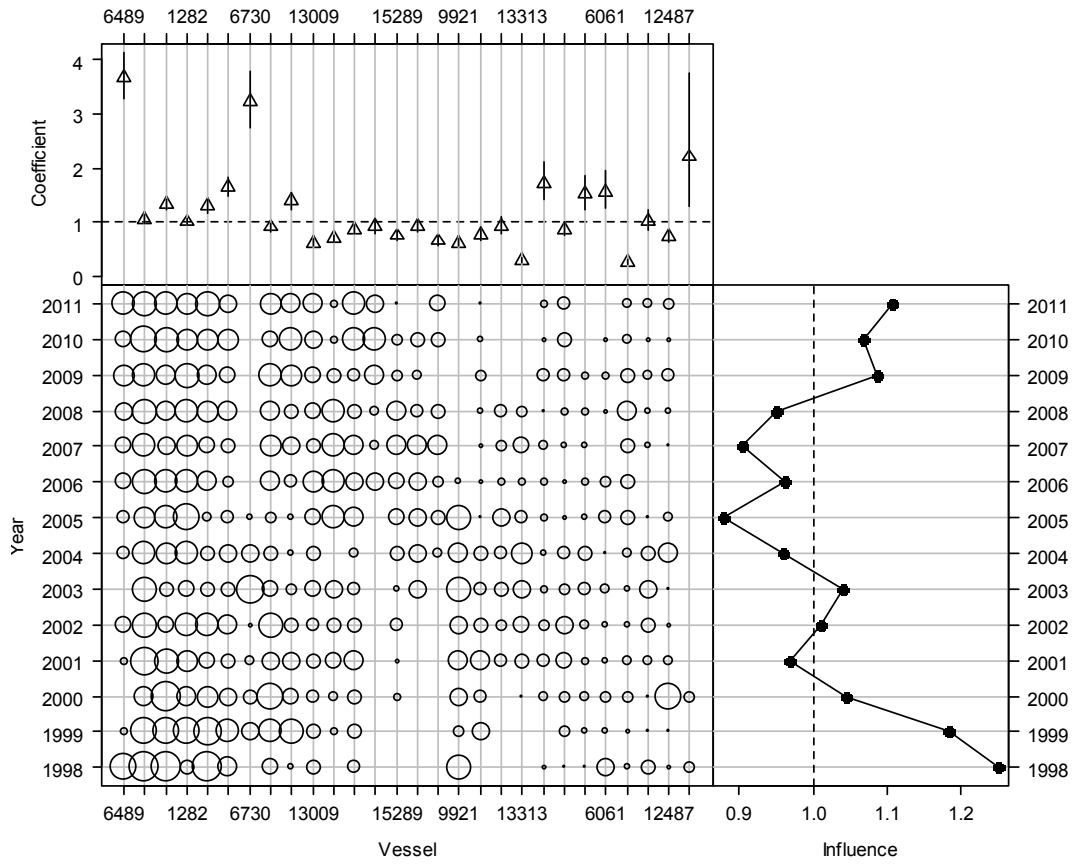


Figure E3b.3c: Influence of vessel on CPUE Model 3b (Southland).

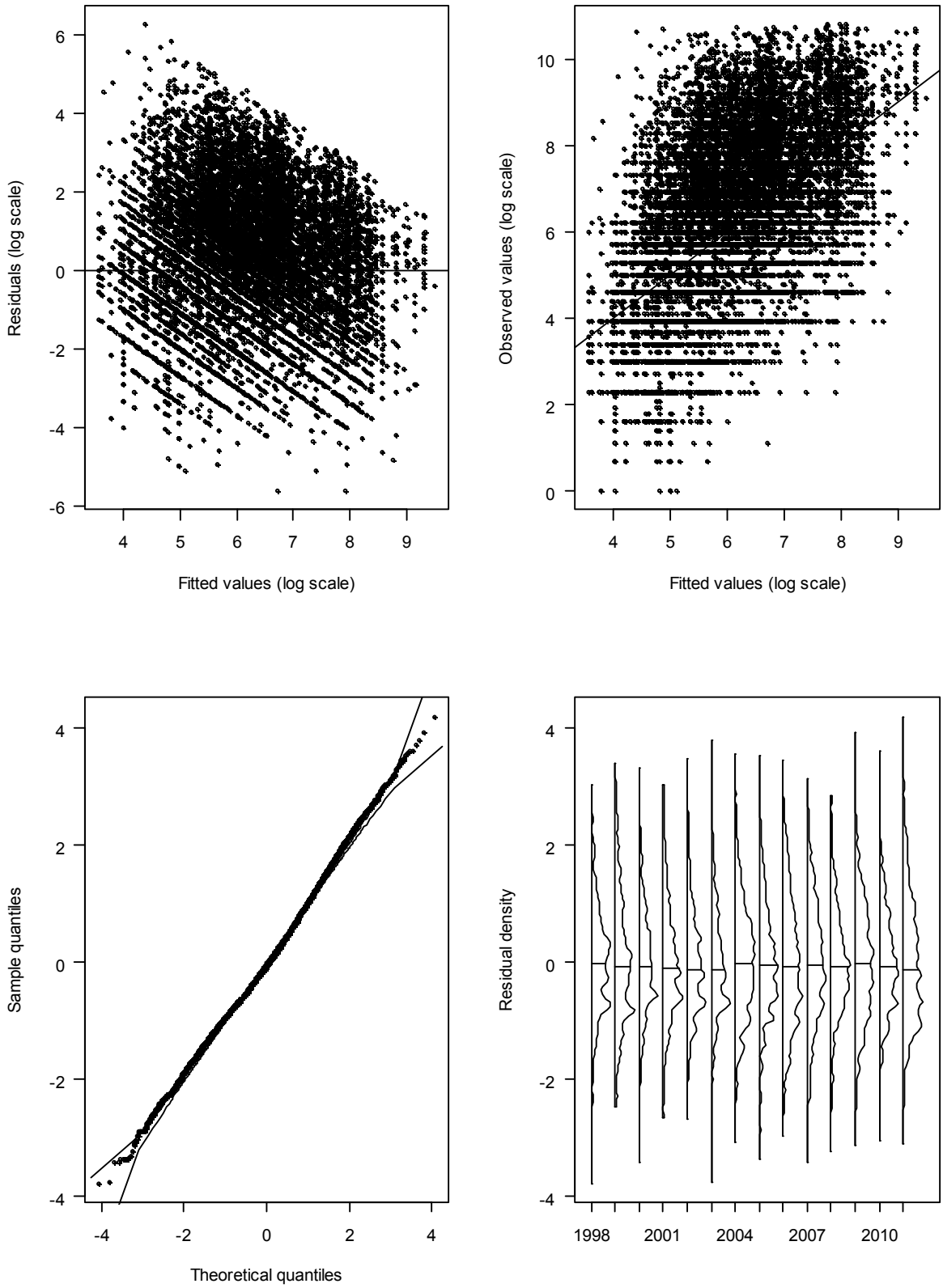


Figure E3b.4: Residual diagnostic plots describing the fit of (Southland) to the data.

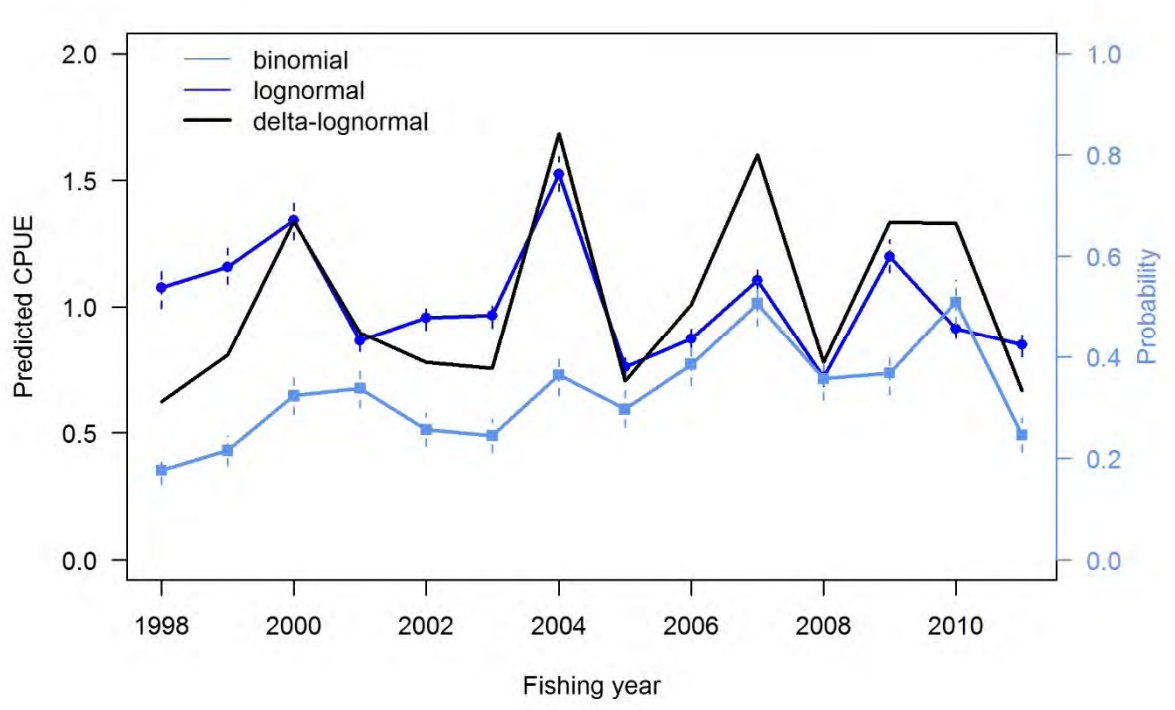


Figure E3b.5: Binomial, log-normal, and resulting delta-lognormal models for CPUE Model 3b (Southland).

CPUE Model 4a (West Coast South Island)

Table E4a.1: Criteria used for defining the data used for CPUE Model 4a (WCSI).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP	No
primary_method	BT, MW, MB	Yes
target_species	HOK, SWA, HAK, BAR	Yes
start_stats_area_code	034, 035, 036	Yes
fish_month	May, Jun, Jul, Aug, Sep, Oct	Yes
fishing_duration	All	Yes
twin	True, False	Yes

Table E4a.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 4a (WCSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	61	551	0.20	2 745.80	442	6.21
1999	60	492	0.28	1 444.90	354	4.08
2000	58	514	0.19	1 909	418	4.57
2001	67	641	0.16	2 451.80	537	4.57
2002	63	670	0.31	866.20	459	1.89
2003	52	631	0.34	805.70	418	1.93
2004	58	513	0.26	1 193.10	382	3.12
2005	44	422	0.27	1 036.10	308	3.36
2006	41	374	0.24	790.50	283	2.79
2007	39	481	0.28	1 764.40	348	5.07
2008	33	325	0.29	1 430.30	231	6.19
2009	32	273	0.20	1 070.90	219	4.89
2010	33	377	0.24	522.60	285	1.83
2011	35	357	0.24	614	273	2.25

Table E4a.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 4a (WCSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	31	329	0.21	1 867.50	261	7.16
1999	32	376	0.29	1 222.30	268	4.56
2000	34	412	0.20	1 723.20	331	5.21
2001	35	462	0.20	2 226.70	371	6
2002	36	468	0.38	816.40	292	2.80
2003	35	521	0.38	787.60	324	2.43
2004	32	398	0.27	1 145.50	291	3.94
2005	31	357	0.27	1 003.30	260	3.86
2006	28	314	0.27	642.10	230	2.79
2007	26	415	0.28	1 728.90	298	5.80
2008	21	264	0.27	1 418	193	7.35
2009	23	220	0.18	1 043.40	181	5.76
2010	21	295	0.22	487.20	230	2.12
2011	21	257	0.21	585	203	2.88

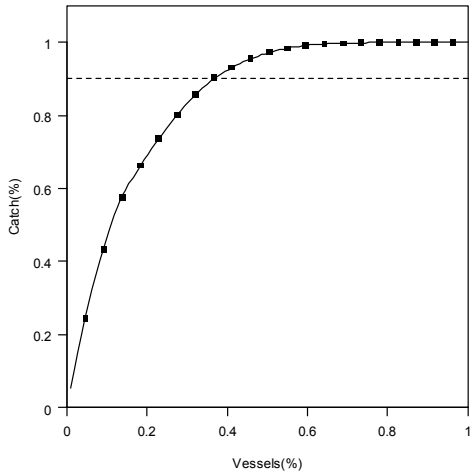
Table E4a.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 4a (WCSI) and the corresponding total R^2 value.

	R-squared
fish_year	4.32
vessel_key	17.89
target_species	26.19
primary_method	30.54
fish_month	32.63
start_stats_area_code	34.16

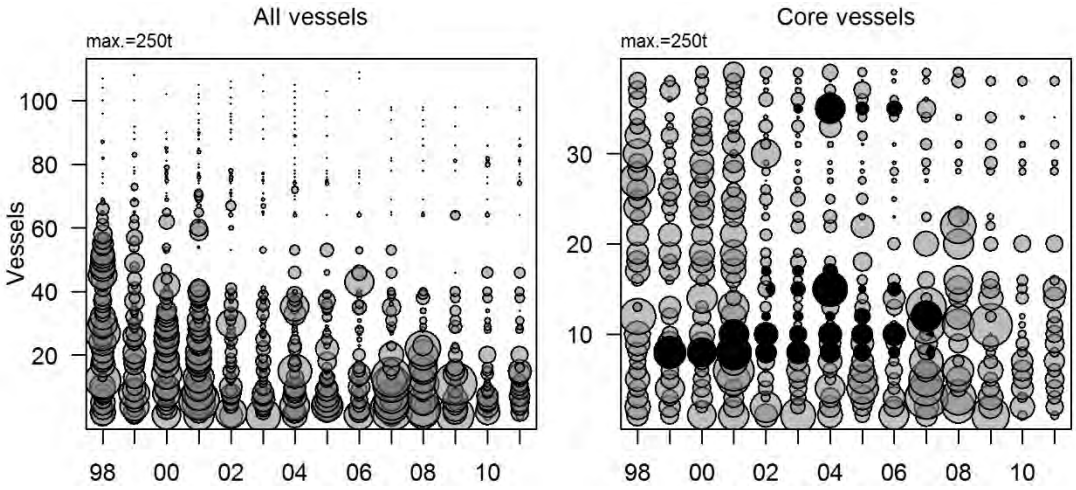
Table E4a.5: WCSI CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 4a (WCSI).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	1.83	1.61	2.08	0.06	0.06
1999	0.98	0.86	1.11	0.06	0.06
2000	1.92	1.72	2.15	0.06	0.06
2001	1.74	1.57	1.94	0.05	0.05
2002	0.38	0.34	0.43	0.06	0.06
2003	0.42	0.38	0.47	0.06	0.06
2004	1.06	0.95	1.20	0.06	0.06
2005	0.76	0.67	0.86	0.06	0.06
2006	0.65	0.57	0.74	0.07	0.07
2007	1.14	1.02	1.28	0.06	0.06
2008	1.27	1.09	1.47	0.07	0.07
2009	1.20	1.04	1.40	0.07	0.07
2010	0.96	0.84	1.09	0.07	0.07
2011	1.18	1.02	1.35	0.07	0.07

a)



b)



c)

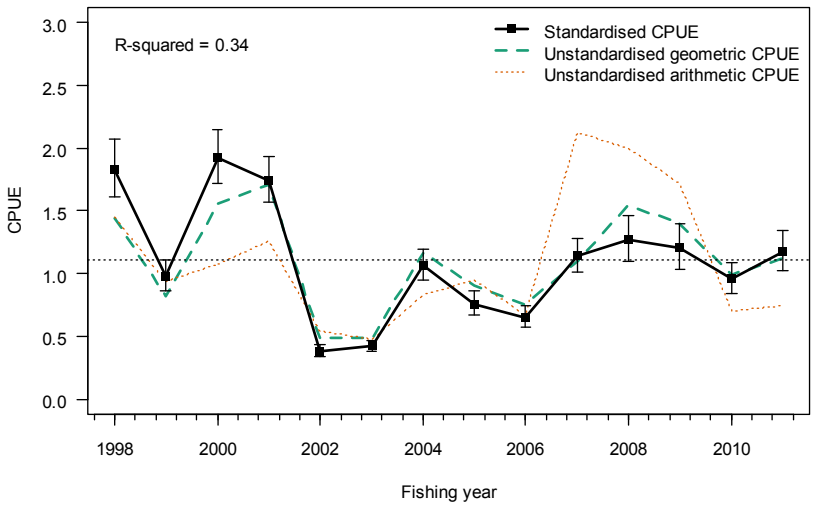


Figure E4a.1: WCSI CPUE Model 4a (stratified dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel for All vessels (left), and Core vessels with catch from twin vessels shown in black (right). c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

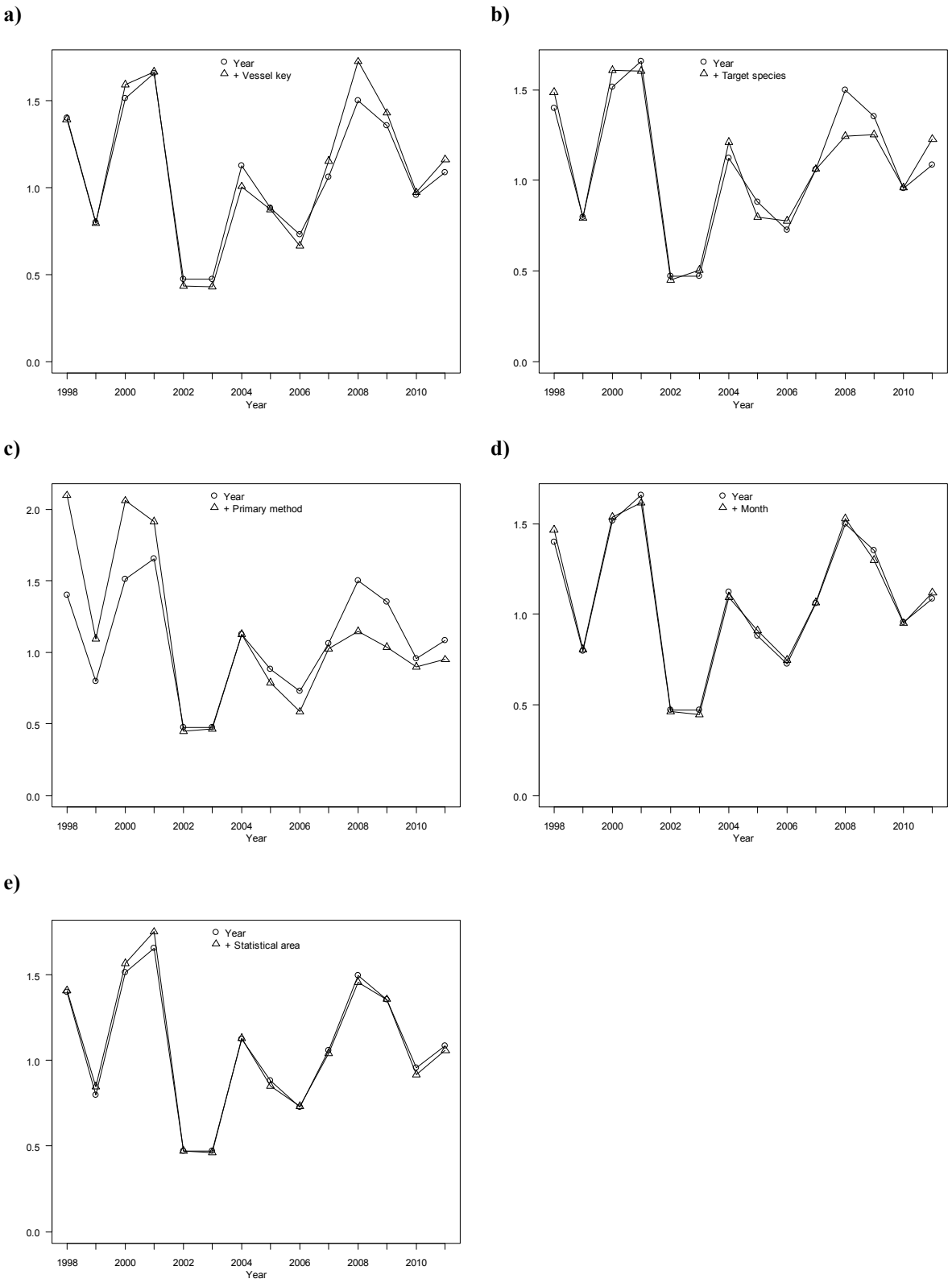


Figure E4a.2: Influence of a) Year + vessel, b) Year + target species, c) Year + method, d) Year + month, and e) Year + statistical area on CPUE Model 4a (WCSI).

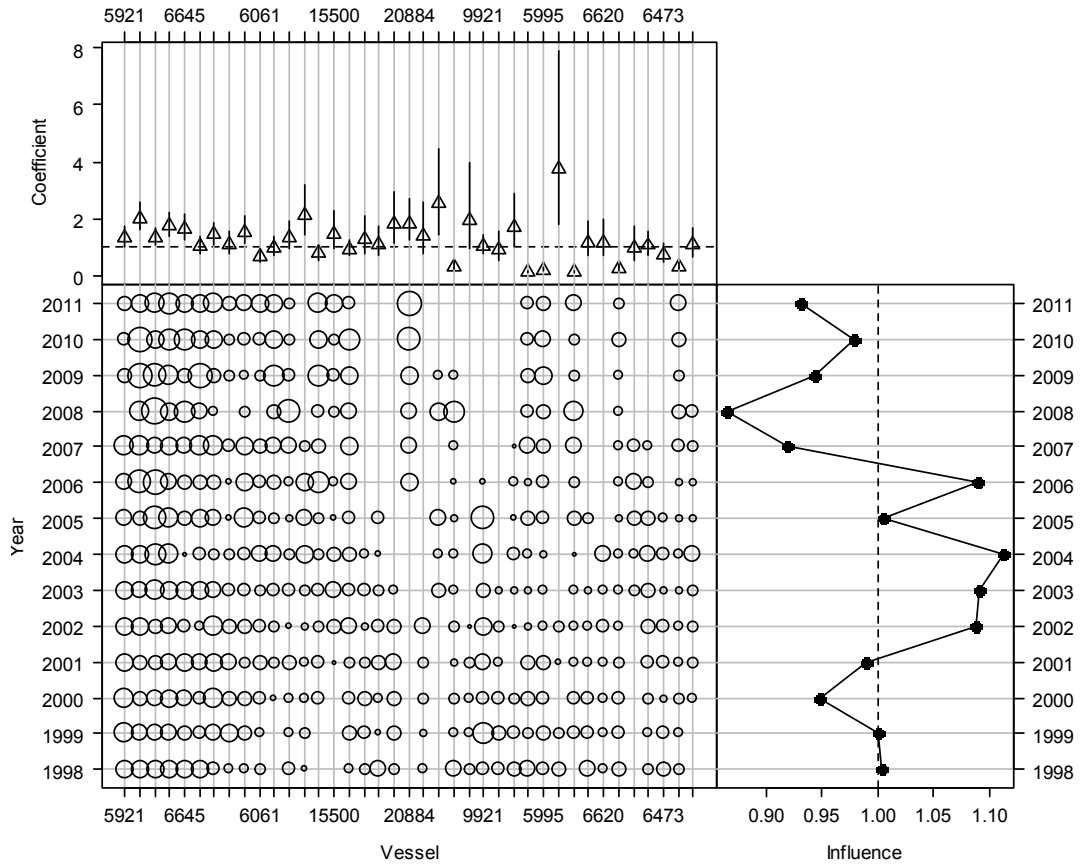


Figure E4a.3a: Influence of vessel on CPUE Model 4a (WCSI).

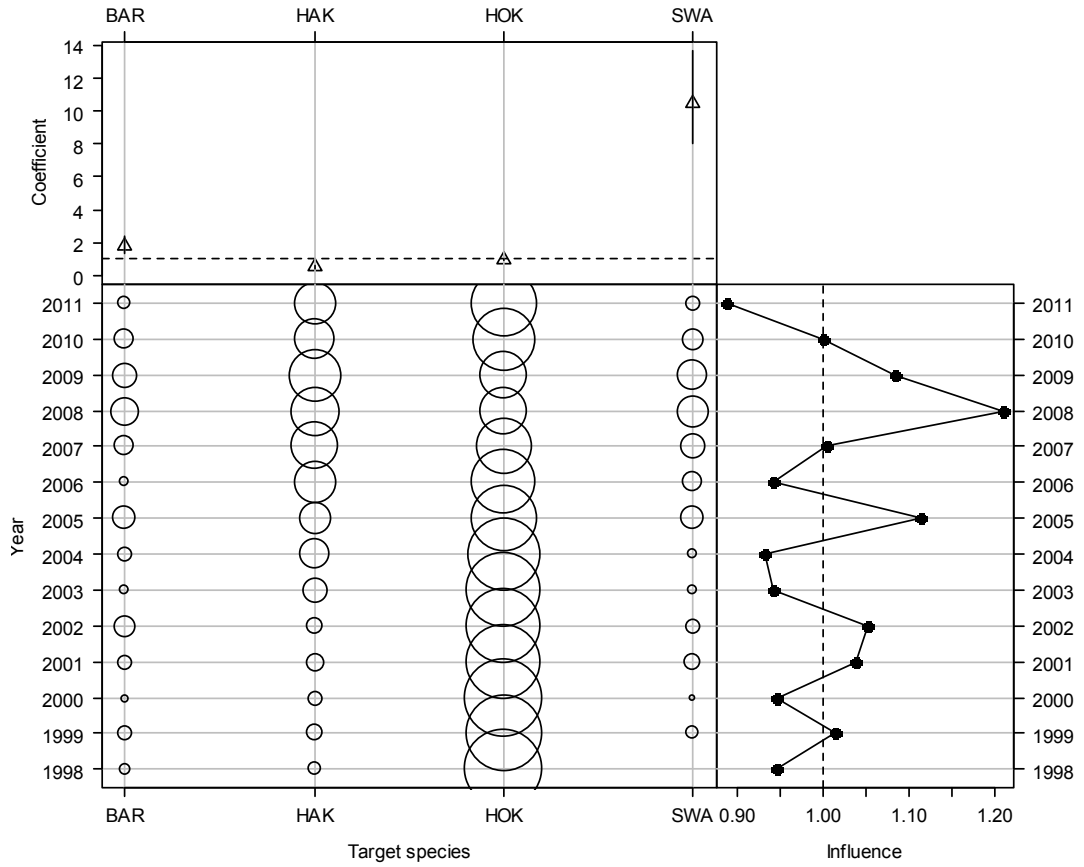


Figure E4a.3b: Influence of target species on CPUE Model 4a (WCSI).

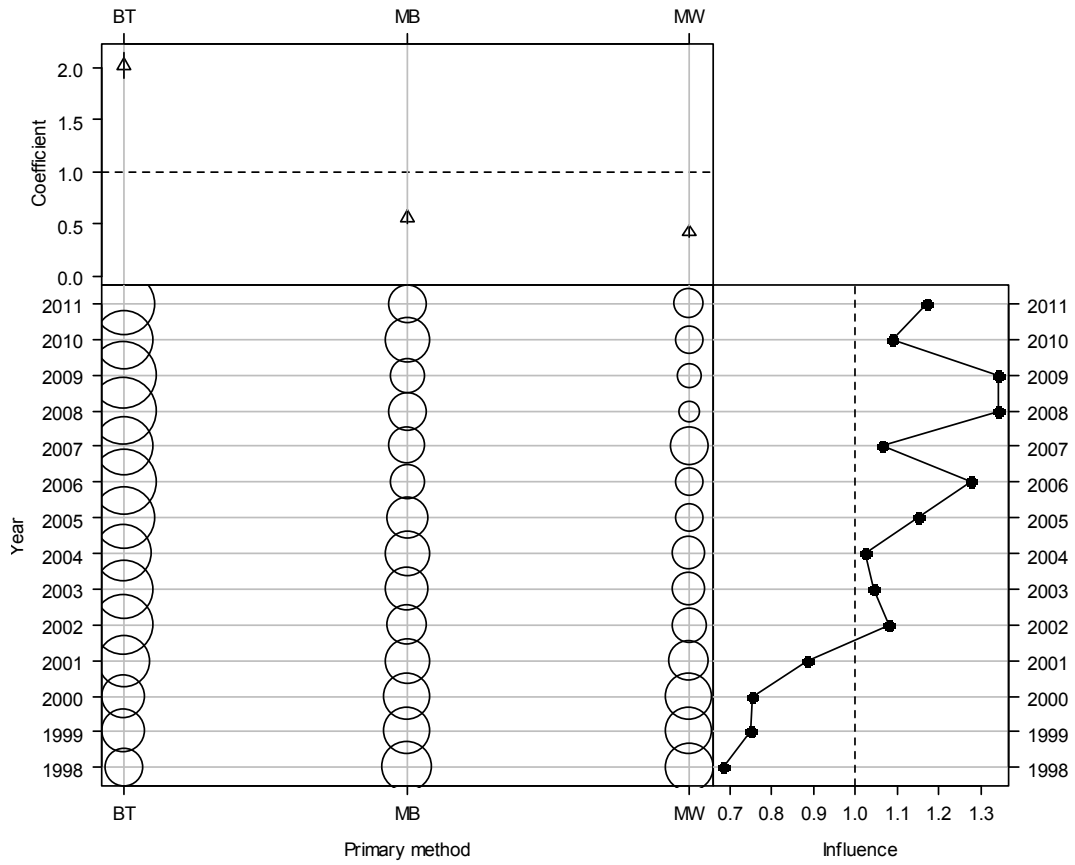


Figure E4a.3c: Influence of method on CPUE Model 4a (WCSI).

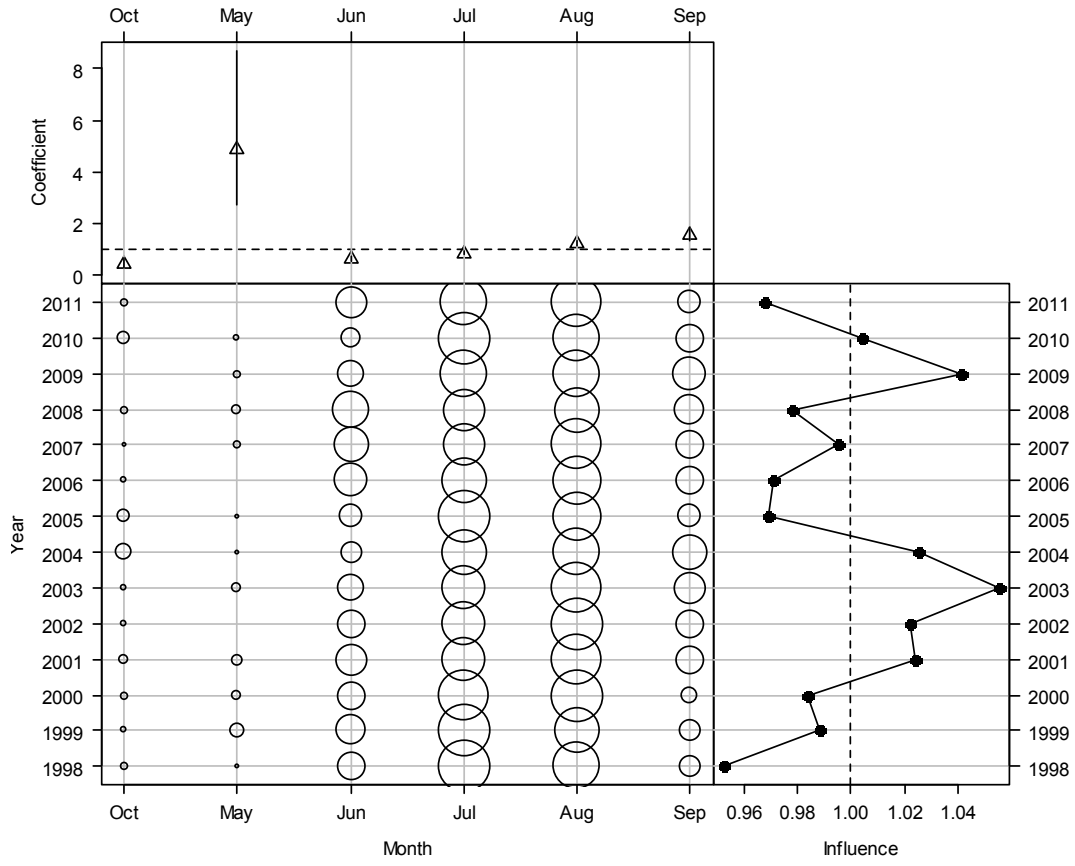


Figure E4a.3d: Influence of month on CPUE Model 4a (WCSI).

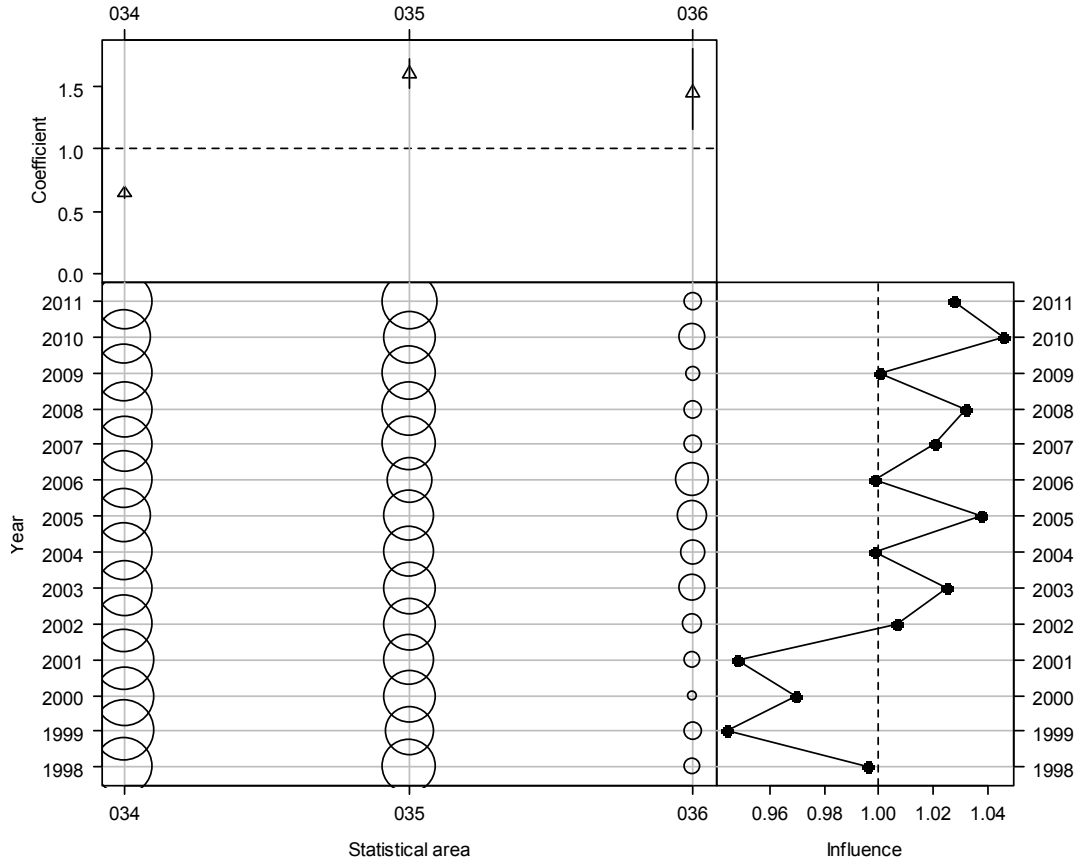


Figure E4a.3e: Influence of statistical area on CPUE Model 4a (WCSI).

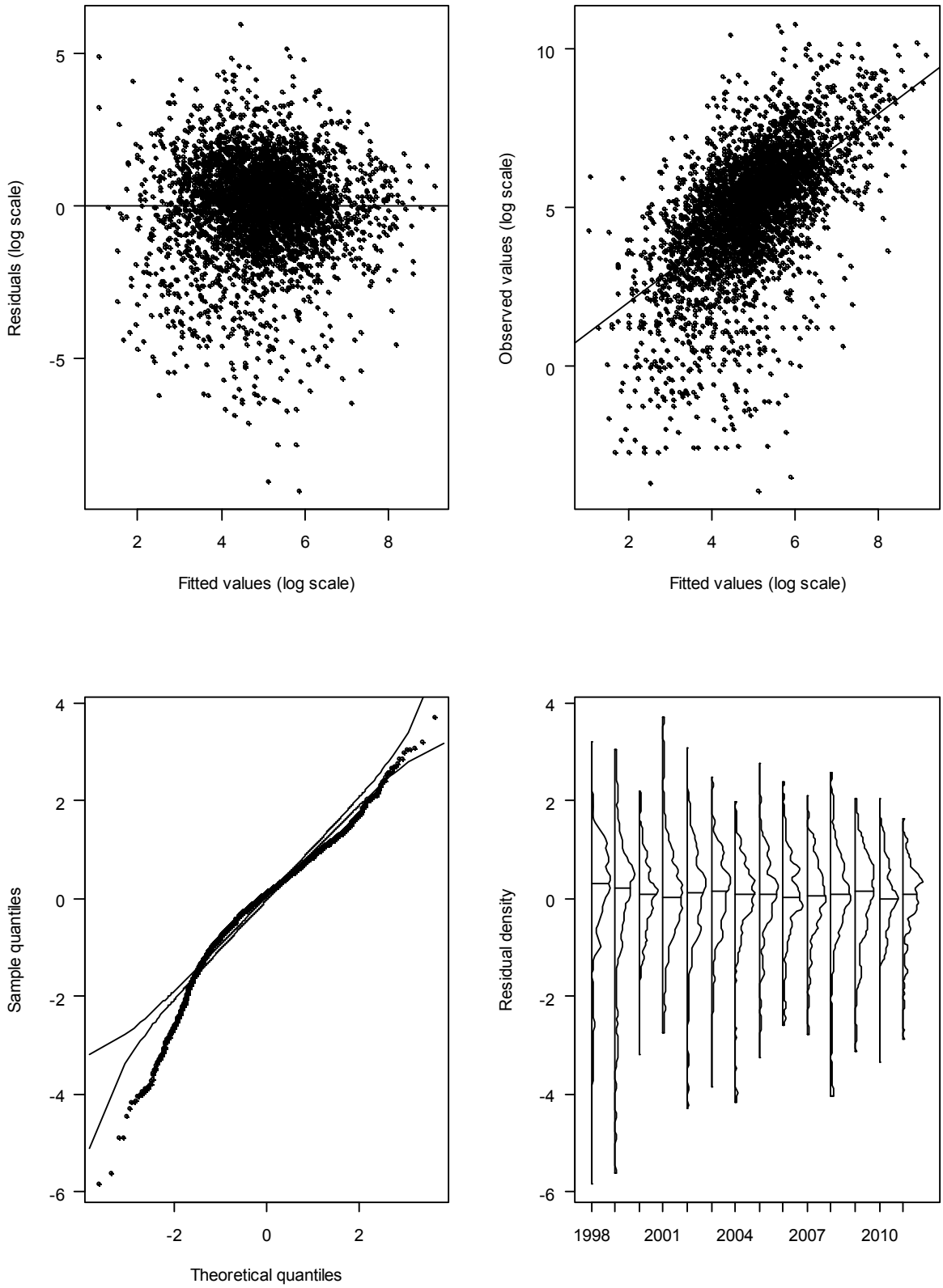


Figure E4a.4: Residual diagnostic plots describing the fit of CPUE Model 4a (WCSI) to the data.

CPUE Model 4b (West Coast South Island, un-merged tow level dataset)

Table E4b.1: Criteria used for defining the data used for CPUE Model 4b (WCSI, tow level).

Variable	Values	Offered
fish_year	1998:2011	Yes (forced)
form_type	TCP	No
primary_method	BT, MW, MB	Yes
target_species	HOK, SWA, HAK, BAR	Yes
start_stats_area_code	034, 035, 036	Yes
fish_month	May, Jun, Jul, Aug, Sep, Oct	Yes
fishing_duration	All	Yes
vessel_key	All core	Yes
effort_depth	All	Yes
effort_height	All	Yes
twin	All	Yes

Table E4b.2: CPUE datasets for all vessels for each year (1998–2011) for CPUE Model 4b (WCSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	64	7 573	0.63	2 439.80	2 777	0.88
1999	61	6 409	0.72	1 179.10	1 780	0.66
2000	58	6 601	0.61	1 600.30	2 584	0.62
2001	67	7 811	0.63	2 094.80	2 886	0.73
2002	65	7 260	0.81	677.50	1 398	0.48
2003	53	7 184	0.76	676.40	1 751	0.39
2004	58	5 762	0.69	1 109.30	1 813	0.61
2005	45	4 491	0.68	961.70	1 456	0.66
2006	41	3 932	0.68	668.70	1 246	0.54
2007	39	3 321	0.62	1 560.40	1 273	1.23
2008	33	2 676	0.60	1 321.40	1 076	1.23
2009	32	2 351	0.58	991.80	976	1.02
2010	34	2 656	0.61	421	1 038	0.41
2011	35	3 274	0.60	426.80	1 324	0.32

Table E4b.3: CPUE datasets for core vessels for each year (1998–2011) for CPUE Model 4b (WCSI). CPUE is unstandardised catch per non-zero tow.

	No. vessels	No. records	Zeros	Catch (t)	Effort	CPUE
1998	29	4 361	0.60	1 611.90	1 726	0.93
1999	30	4 592	0.70	1 008.20	1 364	0.74
2000	32	5 211	0.59	1 367.10	2 151	0.64
2001	34	5 805	0.59	1 902.80	2 399	0.79
2002	35	5 536	0.79	616.10	1 144	0.54
2003	35	6 193	0.73	664.20	1 669	0.40
2004	32	4 934	0.67	1 054.50	1 644	0.64
2005	32	3 948	0.65	934.20	1 385	0.67
2006	29	3 531	0.68	530.40	1 127	0.47
2007	27	3 124	0.60	1 540	1 239	1.24
2008	22	2 543	0.59	1 319	1 045	1.26
2009	24	2 201	0.57	978.20	936	1.05
2010	22	2 461	0.60	400.90	986	0.41
2011	22	2 758	0.54	416.10	1 269	0.33

Table E4b.4: Variables retained in order of decreasing explanatory value for lognormal CPUE Model 4b (WCSI) and the corresponding total R^2 value.

	R-squared
fish_year	5.74
target_species	14.52
vessel_key	18
primary_method	21.86
poly(fishing_duration, 3)	22.90

Table E4b.5: WCSI CPUE estimated values, upper and lower confidence intervals and CVs by year for lognormal CPUE Model 4b (WCSI).

Year	CPUE	Lower CI	Upper CI	Standard error	CV
1998	2.14	2.03	2.25	0.03	0.03
1999	1.23	1.16	1.30	0.03	0.03
2000	1.50	1.43	1.57	0.02	0.02
2001	1.27	1.22	1.33	0.02	0.02
2002	0.69	0.65	0.73	0.03	0.03
2003	0.63	0.60	0.66	0.02	0.02
2004	1.05	1	1.10	0.03	0.03
2005	0.92	0.87	0.97	0.03	0.03
2006	0.79	0.74	0.84	0.03	0.03
2007	0.96	0.90	1.01	0.03	0.03
2008	1.19	1.12	1.27	0.03	0.03
2009	1.07	1.01	1.15	0.03	0.03
2010	0.68	0.64	0.72	0.03	0.03
2011	0.73	0.69	0.78	0.03	0.03

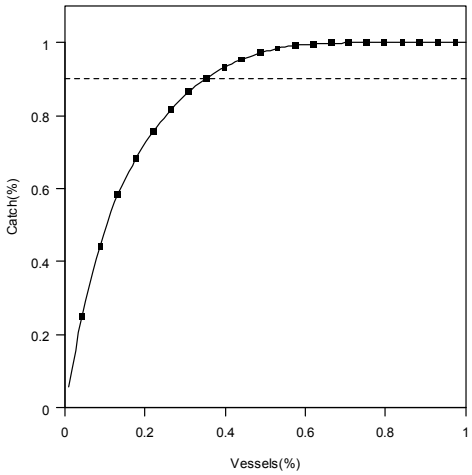
Table E4b.6: Variables retained in order of decreasing explanatory value for binomial Model 4b (WCSI) and the corresponding total R^2 value.

	R-squared
fish_year	1.81
vessel_key	12.33
poly(effort_depth, 3)	15.14
primary_method	16.33

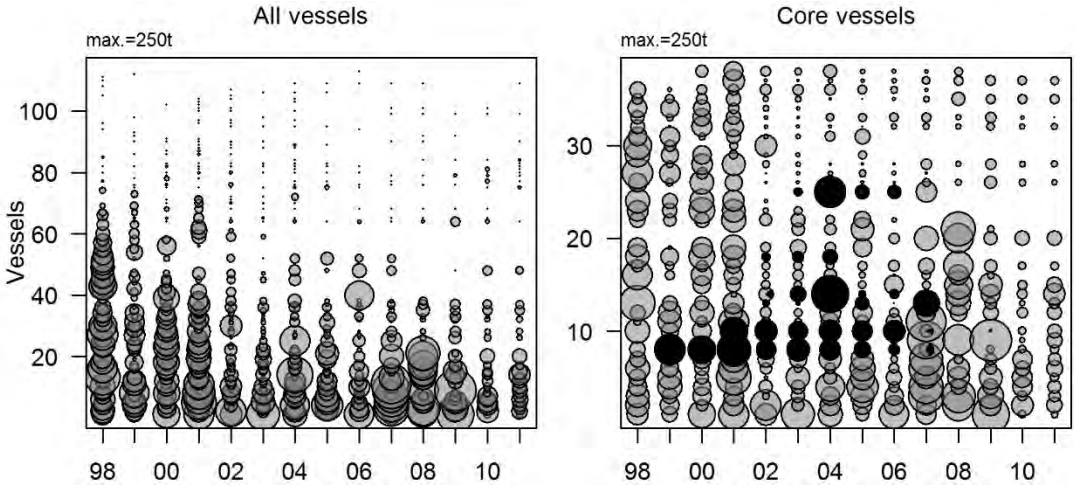
Table E4b.7: Estimated values for probability of a non-zero tow (binomial model), CPUE (log-normal model), and CPUE (delta log-normal model) for CPUE Model 4b (WCSI).

	Binomial	Log-normal	Delta log-normal
1998	0.37	2.14	0.37
1999	0.26	1.23	0.26
2000	0.39	1.50	0.39
2001	0.39	1.27	0.39
2002	0.16	0.69	0.16
2003	0.20	0.63	0.20
2004	0.30	1.05	0.30
2005	0.33	0.92	0.33
2006	0.27	0.79	0.27
2007	0.44	0.96	0.44
2008	0.41	1.19	0.41
2009	0.43	1.07	0.43
2010	0.37	0.68	0.37
2011	0.40	0.73	0.40

a)



b)



c)

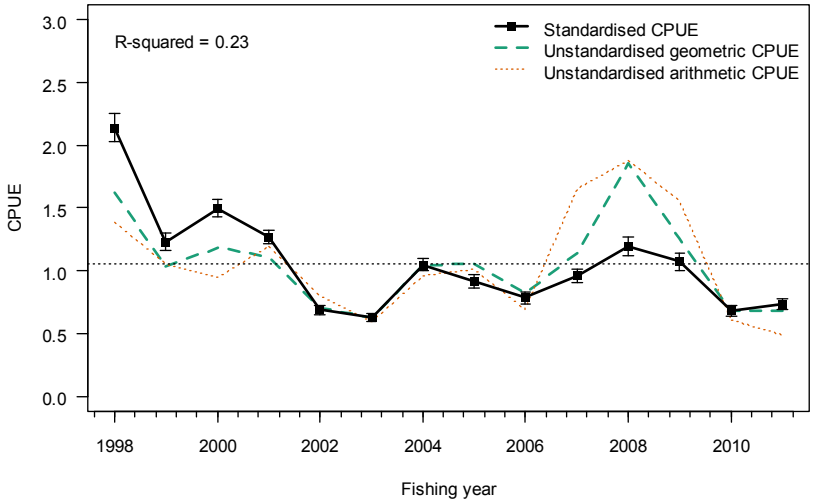
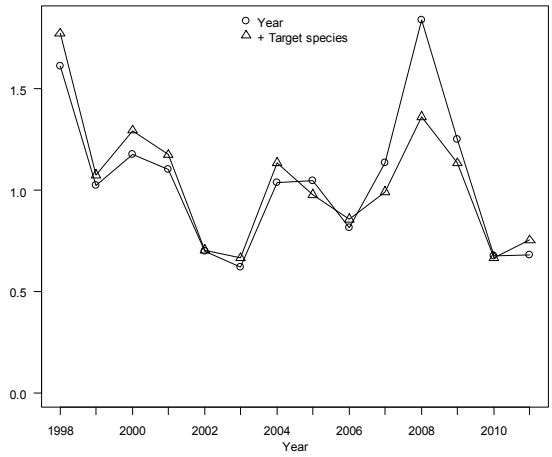
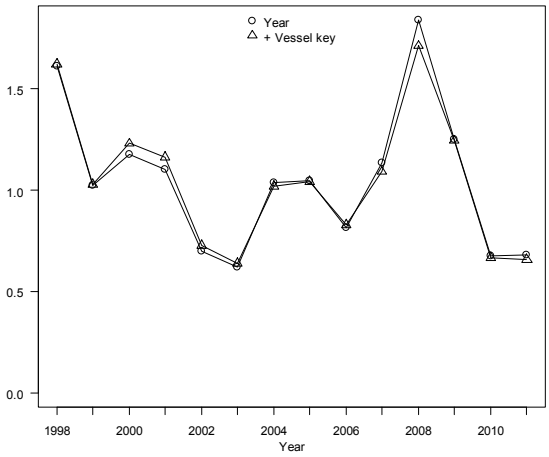


Figure E4b.1: WCSI CPUE Model 4b (unmerged, tow-level dataset): a) Cumulative proportion of SWA catch ranked by vessel. b) Scaled annual catch by vessel. Black shaded portions of symbols indicate the proportion of catch using twin trawl gear. c) Arithmetic, geometric, and standardised CPUE indices for SWA 1998–2011.

a)



b)



c)

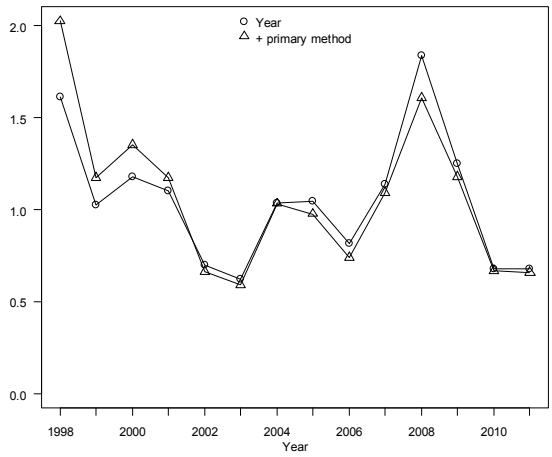


Figure E4b.2: Influence of a) Year + target species, b) Year + vessel, and c) Year + method on CPUE Model 4b (WCSI).

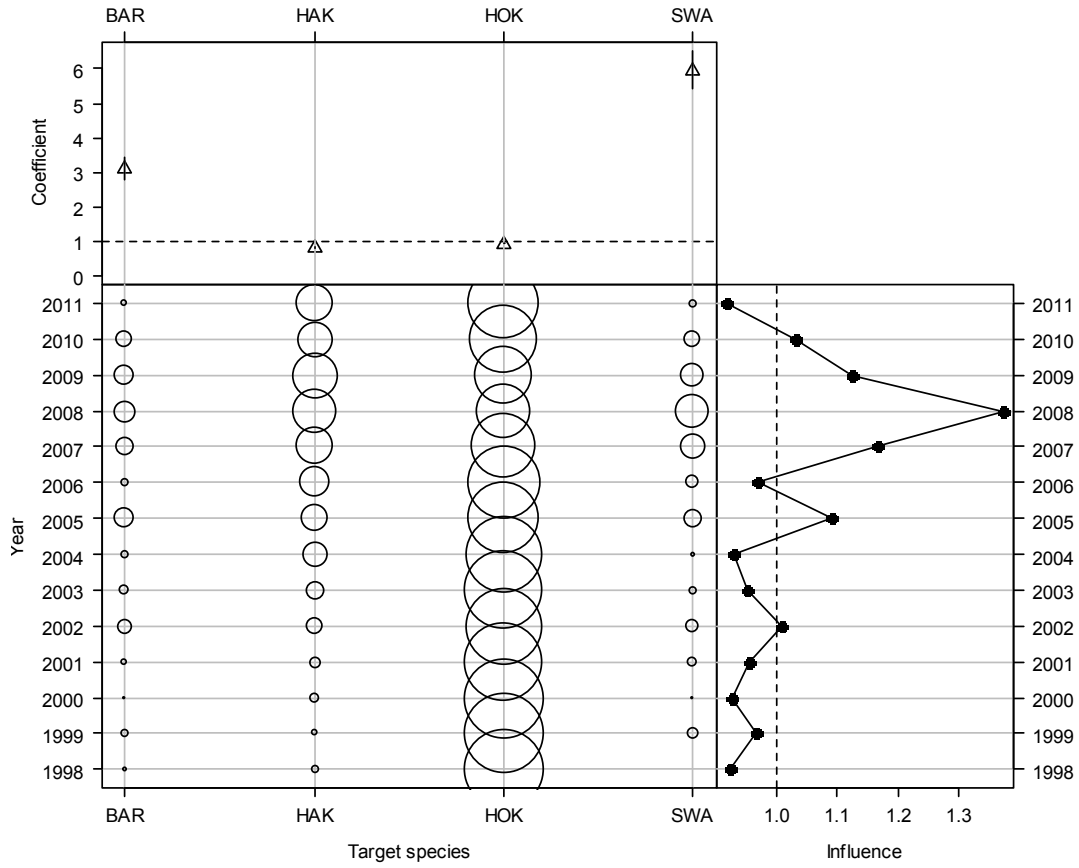


Figure E4b.3a: Influence of target species on CPUE Model 4b (WCSI).

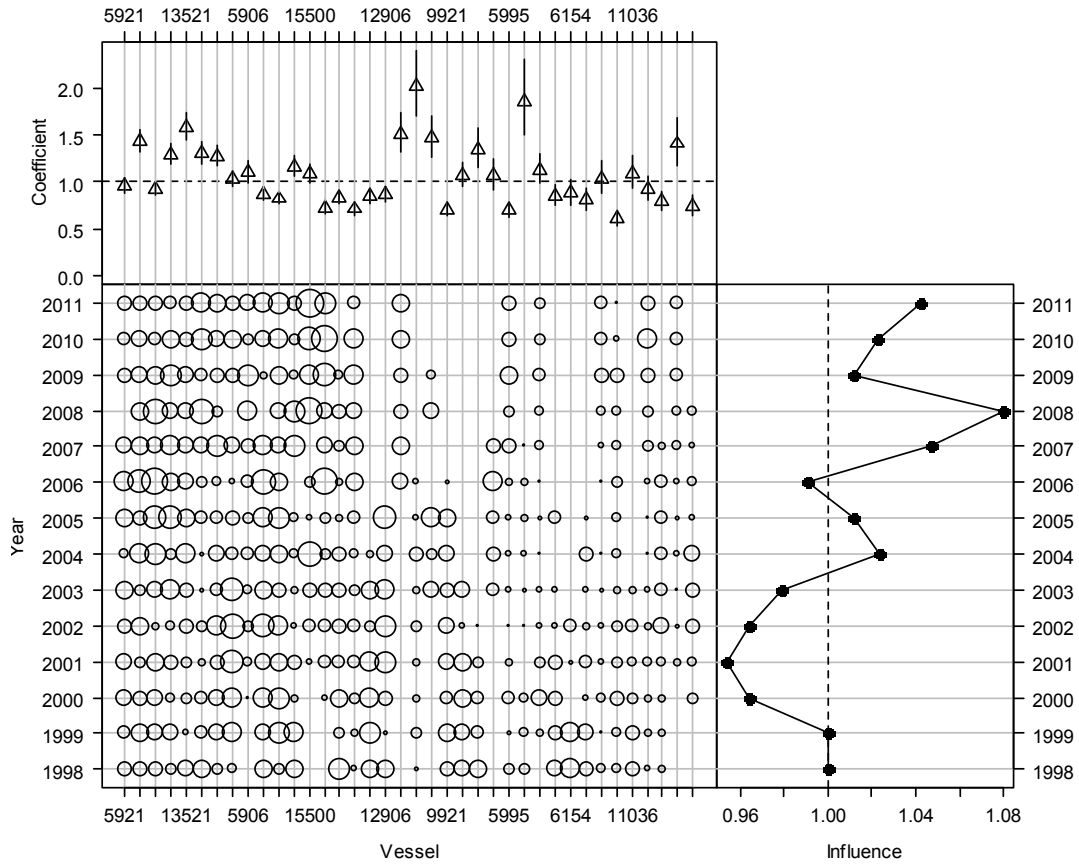


Figure E4b.3b: Influence of vessel on CPUE Model 4b (WCSI).

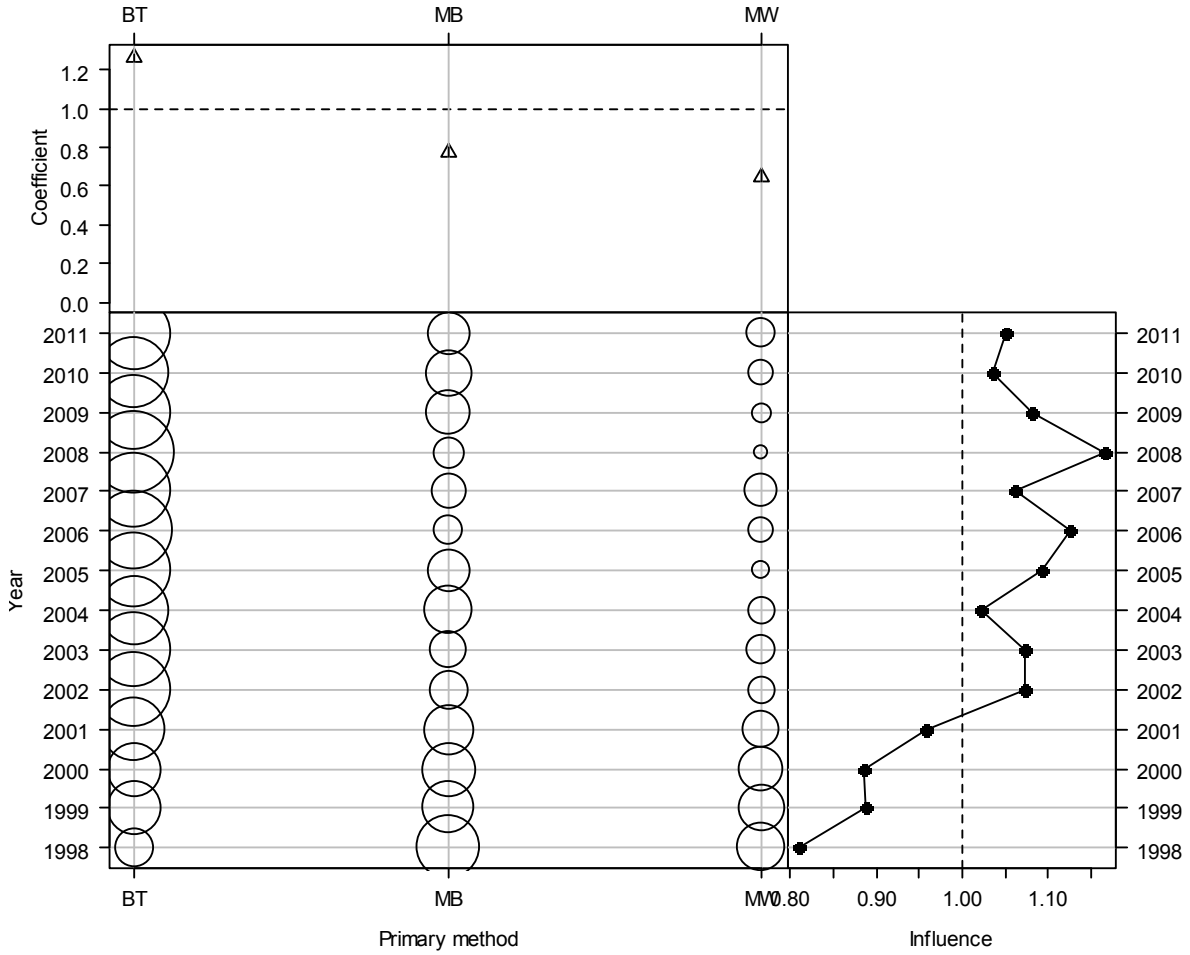


Figure E4b.3c: Influence of method on CPUE Model 4b (WCSI).

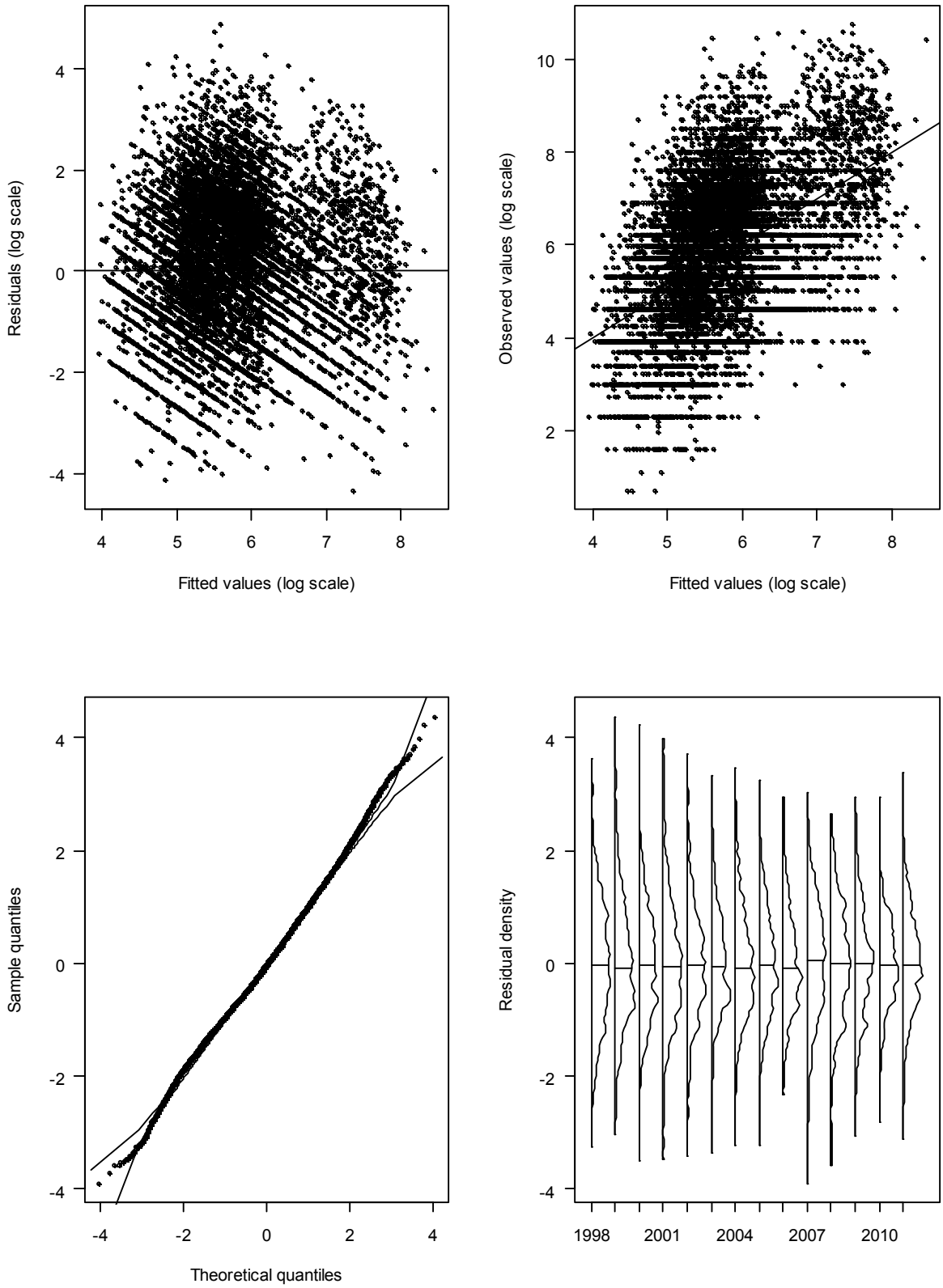


Figure E4b.4: Residual diagnostic plots describing the fit of CPUE Model 4b (WCSI) to the data.

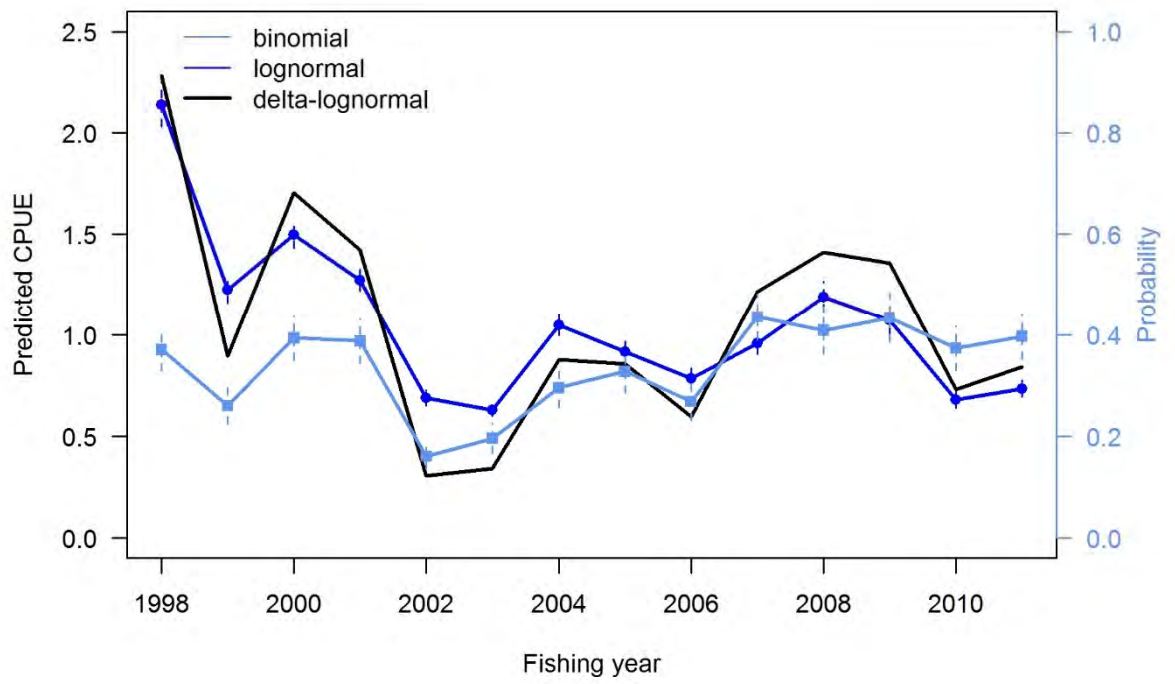
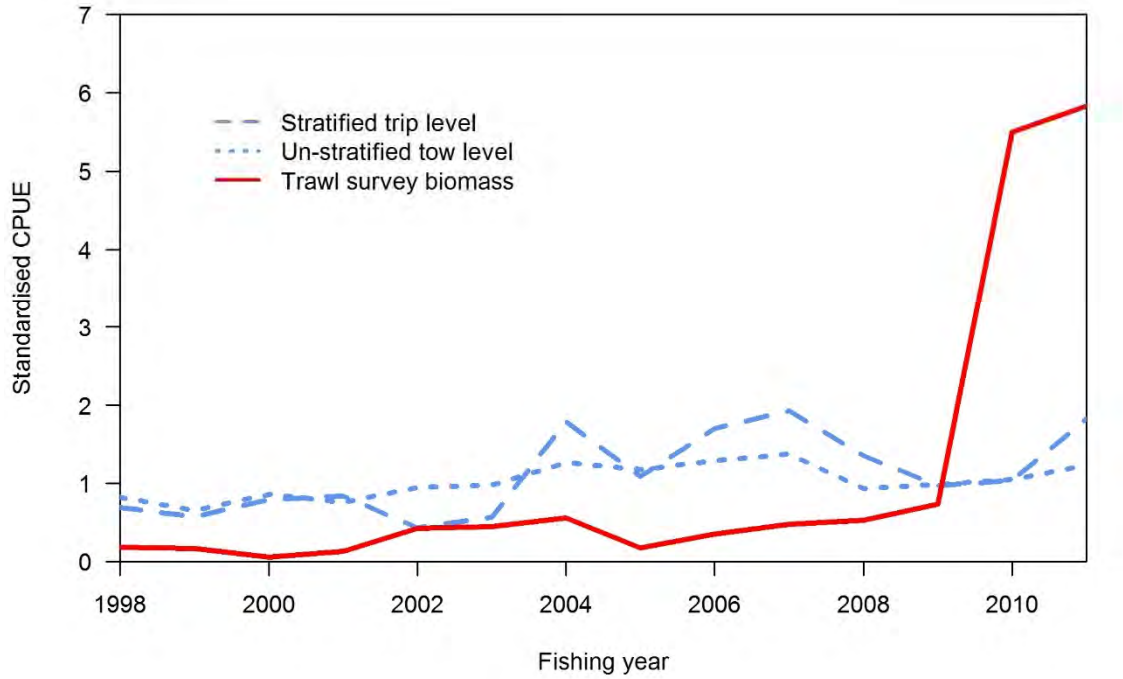


Figure E4b.5: Binomial, log-normal, and resulting delta-lognormal models for CPUE Model 4b (WCSI).

CPUE Comparisons

a)



b)

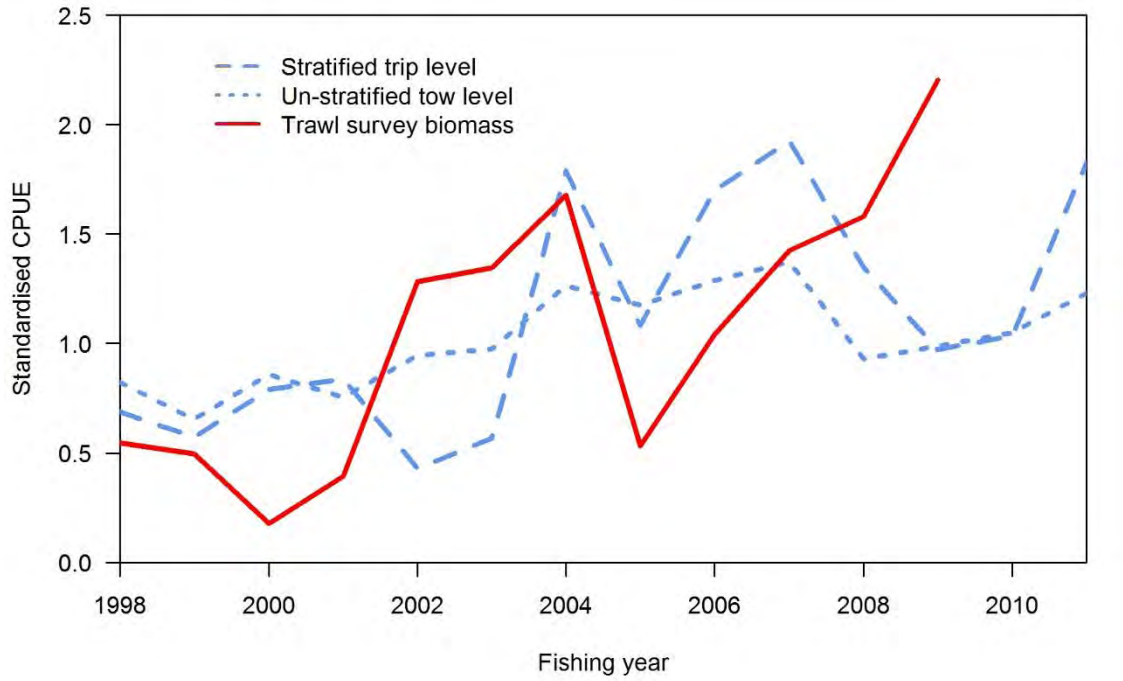
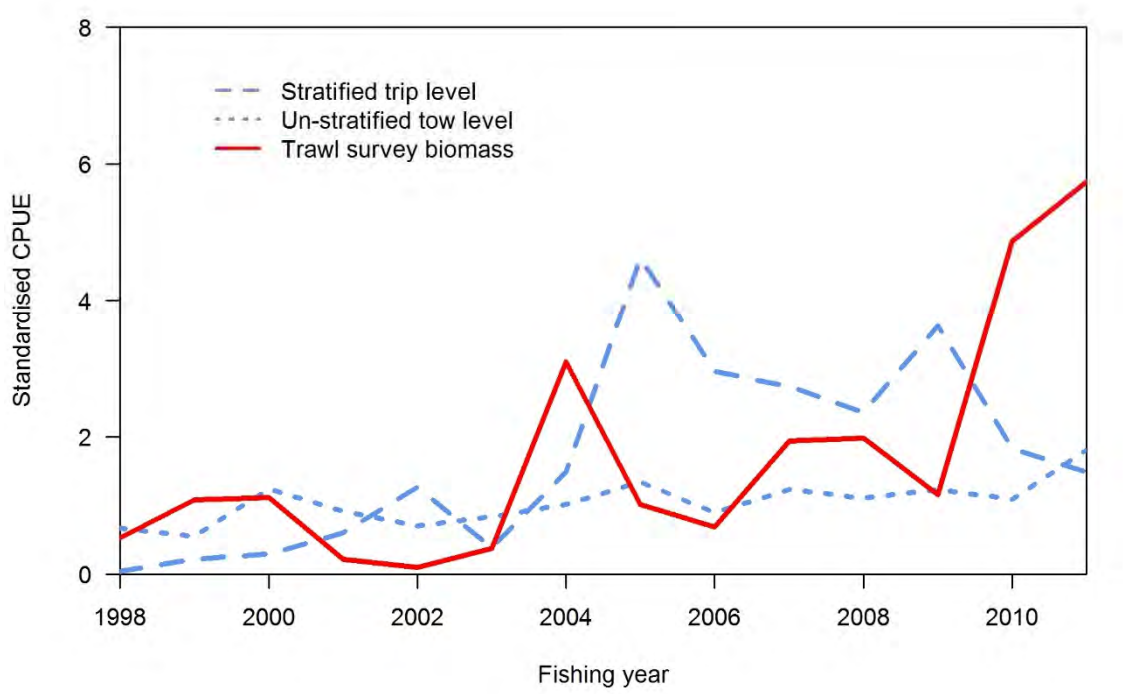


Figure E5.1: ECSI standardised CPUE for merged (stratified, trip level) and unmerged (un-stratified, tow level) and biomass estimates from Chatham Rise East trawl surveys a) 1998–2011 and b) restricted biomass estimate to 1998–2009.



b)

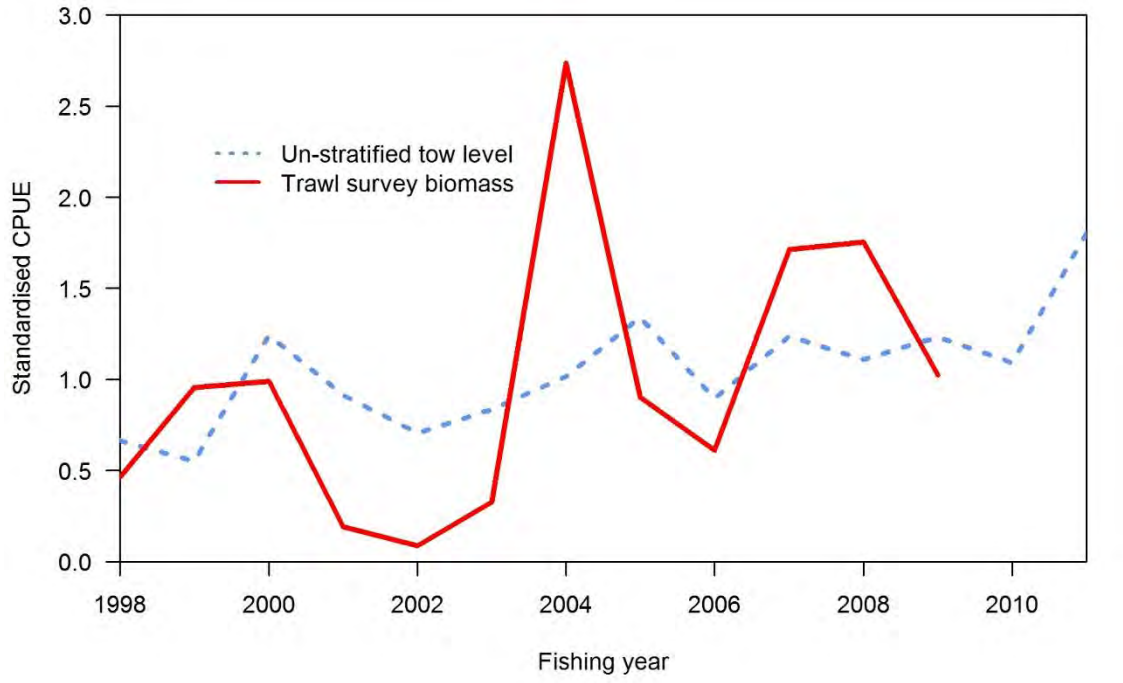


Figure E5.2: Chatham Rise standardised CPUE for merged (stratified, trip level) and unmerged (un-stratified, tow level) and biomass estimates from Chatham Rise East trawl surveys a) 1998–2011 and b) restricted biomass estimate to 1998–2009 and omitted stratified trip level CPUE.

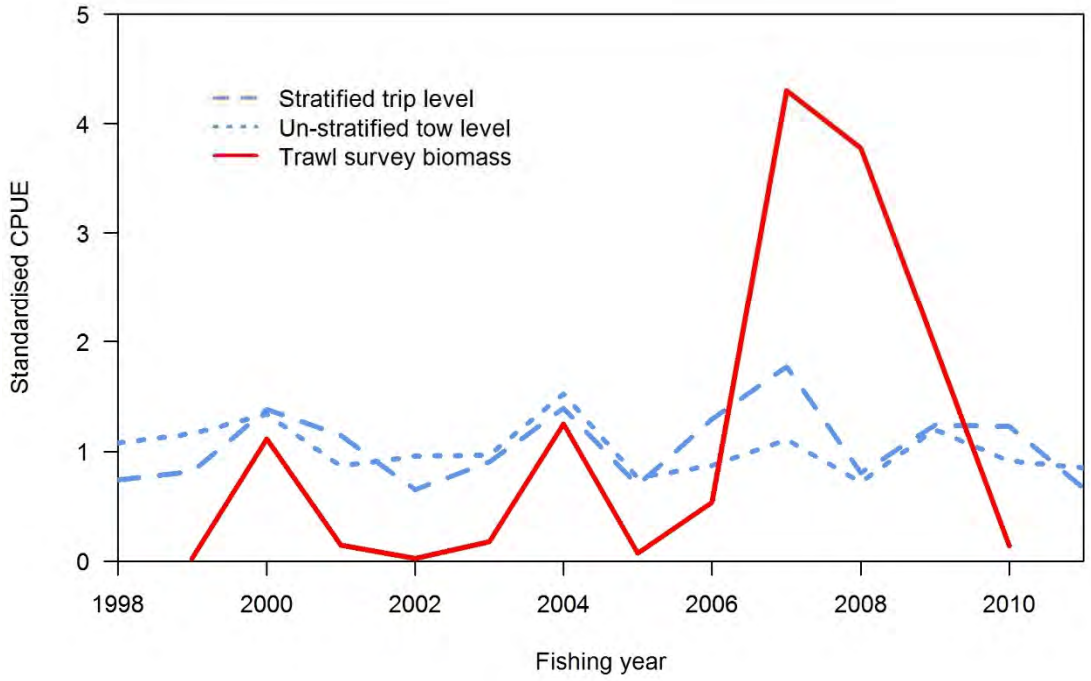


Figure E5.3: Southland standardised CPUE for merged (stratified, trip level) and unmerged (un-stratified, tow level) and biomass estimates from sub-Antarctic summer trawl surveys.

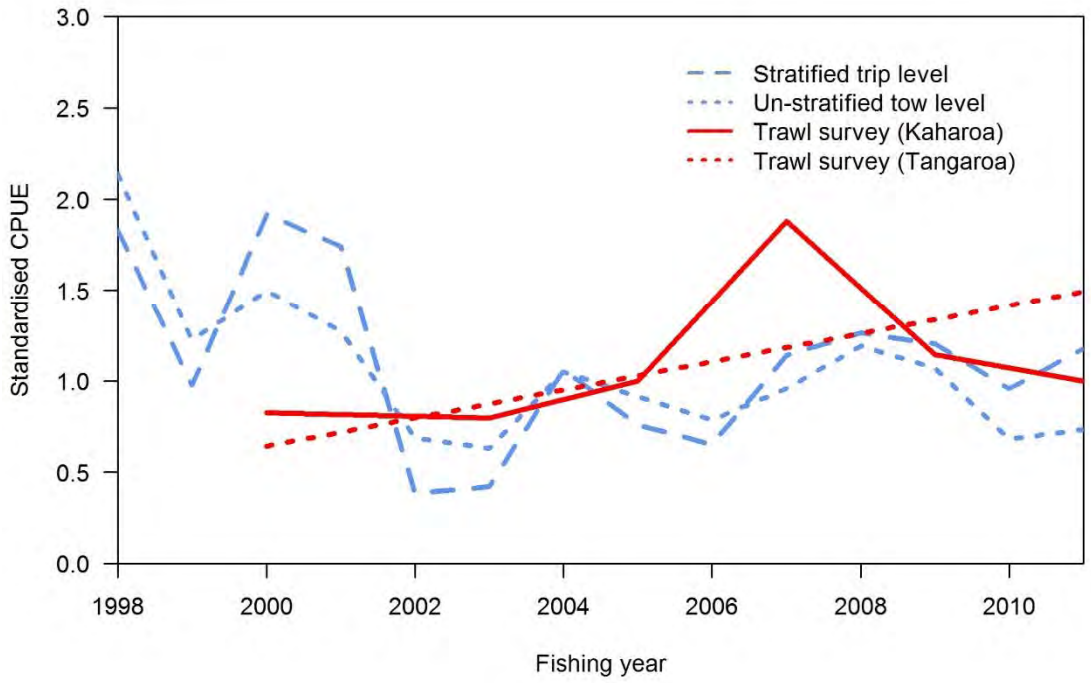


Figure E5.4: WCSI standardised CPUE for merged (stratified, trip level) and unmerged (un-stratified, tow level) and biomass estimates from WCSI *Kaharoa* and *Tangaroa* surveys.

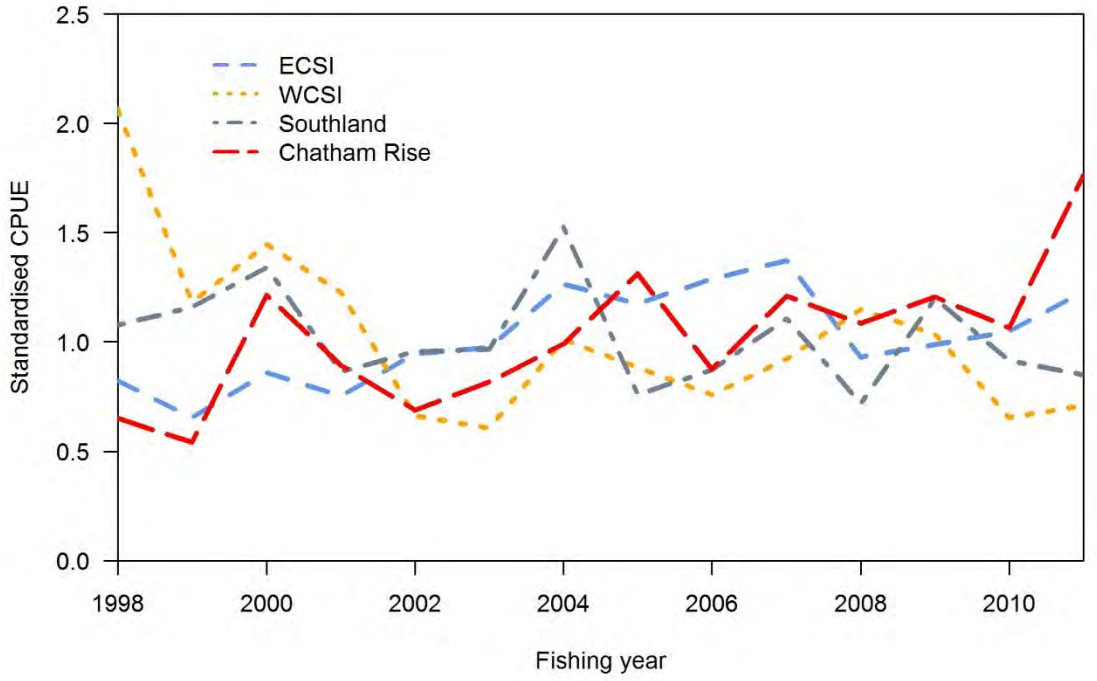


Figure E5.5: Standardised CPUE for unmerged (tow level) datasets for ECSI, WCSI, Southland and Chatham Rise in 1998–2011.