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Fishery characterisation and standardised CPUE analyses for white warehou, *Seriolella caerulea*, 1989–90 to 2013–14

New Zealand Fisheries Assessment Report 2015/66

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This report is part of a series of middle depth fishery characterisations for species or stocks for which no robust stock assessment has been developed. It follows the standardised format used in previous reports, with additional information and analyses where appropriate. This report is an update of the most recent characterisation of white warehou fisheries that was carried out with data from 1989–90 to 2009–10.

Reliable records of white warehou (*Seriolella caerulea*) catches are available annually since the 1989–90 fishing year. Although there was some misreporting of silver warehou and white warehou catch before that, this has not been quantified, and data since 1989–90 are assumed to be accurate for the species recorded. White warehou entered the Quota Management System on 1 October 1998, with an initial Total Allowable Commercial Catch (TACC) of 3374 t. This was increased to 3735 t in 2006, but the TACC was not caught in any fishing year, and landings from 2013–14 represented 51% of the current TACC. White warehou were almost entirely caught by bottom trawl, with a smaller amount by midwater trawl, and most catch was recorded on Trawl Catch Effort and Processing Returns. In 2013 and 2014, about 20% of the west coast South Island (WCSI) white warehou catch was reported on the TCER form. From 1990 to 2014, 52 238 t of white warehou catch was reported: 70% from the Sub-Antarctic area, 24% from off the east coast South Island (ECSI) and across the Chatham Rise, and 4% from off the WCSI. In the Sub-Antarctic, 36% of catches were from white warehou target tows, although since 2003 this has been over 50% in most years; the remainder was primarily from tows targeting ling (*Genypterus blacodes*), hoki (*Macruronus novaezelandiae*), and silver warehou. The greatest catches in this area were from waters off the Stewart-Snares shelf, near the Puysegur Bank, and off the Auckland Islands Shelf. About 63% of the catch from off the ECSI and the Chatham Rise was from hoki target tows, with only 1% from white warehou targeted tows. The highest catches were from the east coast statistical areas. There appeared to be no definite season for white warehou catches in those areas. Catches off the WCSI were from bottom and mid-water hoki and hake tows, and were restricted to the months in which those target fisheries operated (June–September).

Random trawl surveys of the Chatham Rise, Sub-Antarctic, and WCSI areas by R.V. *Tangaroa* have been conducted since 1991 with core strata in depths of 200–800 m, 300–800 m, and 200–800m respectively, to survey primarily hoki, hake, and ling. These surveys may be useful to monitor relative abundance for white warehou, though the coefficients of variation (CV) for the annual estimates are variable (20–54% for the Chatham Rise, 24–61% for the Sub-Antarctic, and 27–51% for the WCSI), and are influenced markedly by the occasional large catch. The Chatham Rise series showed a slight overall increase in biomass to 2004, with a subsequent decline. Biomass for the Sub-Antarctic shows no clear trend since the start of the time series, and large estimates of biomass are associated with larger CVs. The WCSI biomass estimates are much lower than estimates from the Chatham Rise and Sub-Antarctic surveys.

Standardised CPUE analyses of the main fishery areas are presented for Chatham Rise, Sub-Antarctic, and WCSI although none appeared to reliable track relative abundance. Trends differed between areas, i.e., an increase then a decrease on the Chatham Rise, a large increase then decrease in the early 1990s followed by a flat trend in the Sub-Antarctic region, and an overall decrease in the WCSI region. All three areas exhibited lower indices with a flattening trend in recent years.

Observer sampling of the commercial catch of white warehou was not optimised for white warehou, but was driven by the location and timing of the main target fisheries being observed. This led to little data

being collected during the spawning season (August–October) from the Chatham Rise and Sub-Antarctic. More data are required to better describe spawning seasons and biological characteristics of the catch in the commercial fishery. Improved observer coverage could also potentially allow for further development of observer CPUE. A more intensive collection of length and gonad data on the Chatham Rise and Sub-Antarctic by observers during the spawning season could provide a better indication of spawning areas and stock boundaries. Ageing using otoliths was partially validated in the late 1990s, but no catch-at-age series have been developed. Reading and analysis of the otoliths collected since 1998 from the observer programme are available for analysis and interpretation.

1. INTRODUCTION

White warehou is one of the many species caught in middle depth and inshore fisheries within New Zealand's EEZ for which the catch is not regularly assessed. This project is designed to ensure that data available for monitoring important middle depth species are routinely summarised and assessed under a three to four year rotating schedule as described in the 10 year Research Programme for Deepwater Fisheries (Ministry of Fisheries 2010). Currently, white warehou (*Seriolella caerulea* Guichenot, 1848) is included as one of five bycatch species to be managed under the Hoki Fisheries Plan. The primary management focus for this species is to ensure that by 2015 "there is sufficient information available to assess the performance of the stock against agreed management targets" (Ministry of Fisheries 2010).

White warehou is generally caught by bottom trawling in depths of 150 to 800 m mainly as bycatch in the hoki, hake, ling and silver warehou fisheries, but also in a variety of other target fisheries such as squid, ling, and white warehou (Ballara & Baird, 2012). Target fishing on white warehou has been reported from around Mernoo Bank, the Stewart-Snares shelf, Puysegur Bank and on the west coast of the South Island, with the best catch rates recorded in the southern areas. The main areas of fishing are the Sub-Antarctic, and Chatham Rise.

Middle depth research trawl surveys, designed principally to estimate hoki, hake, and ling abundance, have been carried out on a regular basis on the Chatham Rise and Sub-Antarctic by *Tangaroa* in most years since 1991 (there were no Sub-Antarctic surveys in 1995–1999, 2010, and 2013, and no Chatham Rise survey in 2015), and provide biomass estimates for these main fishing areas identified in this study. White warehou biomass is usually in the top 15 species for the Chatham Rise series, the survey samples their depth distribution well although coefficients of variation (CV) vary widely (median CV 28%, range 20–46%, O'Driscoll et al. (2011)) and the biomass estimates are not consistent from year to year. White warehou are less abundant in the Sub-Antarctic, and biomass estimates have higher CVs than on the Chatham Rise (for example, see Bagley & O'Driscoll 2012). A winter WCSI trawl and acoustic survey also enables biomass to be estimated for white warehou in this area.

This report is an update of the most recent characterisation of white warehou fisheries that was carried out with data from 1989–90 to 2009–10 (Ballara & Baird 2012). That study found that there were information gaps – such as spawning season timings and biological characteristics of the catch in the commercial fishery. Improved coverage of all fishing areas by the observer programme was suggested, which would involve collection of all key aspects of biology including length, weight, sex, gonad development, and possibly the collection of otoliths. In particular, increased observer coverage across the Chatham Rise and the Sub-Antarctic during the spawning season was suggested to provide a better indication of spawning area and stock. Also, analysis of the otoliths collected since 1998 from the observer programme could be used to determine the potential to develop catch-at-age and length-at-age series. It was also identified that the combined hoki trawl and acoustic survey for the WCSI could provide an opportunity for monitoring biomass and collecting biological information for the WCSI white warehou stock. These recommendations were accepted by the Middle Depth Species Working Group.

Under the 10 year National Fisheries Plan for Deepwater and Middle-depth Fisheries (Ministry of Fisheries 2010) the white warehou fishery is to be characterised every 4 years in 2009–10, 2013–14 and 2017–18. This report summarises the analyses carried out for the Ministry for Primary Industries under project DEE201007WWAD "Characterisation and fishery monitoring of deepwater and middle depth species" which, for white warehou, includes the following objectives:

- To characterise the fisheries by analysis of commercial catch and effort data up to 2013–14;
- To carry out standardised CPUE analyses for the major fisheries (Fishstocks) where appropriate;
- To review the indices from CPUE analyses, all relevant research trawl surveys and observer logbooks to determine any trends in biomass, size frequency distributions or catch rates;
- To review stock structure using data accessed above and any other relevant biological or fishery information;

- 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.
- To make recommendations on future data requirements (including recommendations for annual levels of observer sampling) and methods for monitoring the stocks.

The report contains sections of text and tables that can be transferred to the MPI Plenary report as appropriate. Some topics present in plenary reports were not reported on in this report but the headings are listed in the appropriate place in grey. Tables and figures are provided in four Appendices: A, Survey data; B, Observer data; C. Fishery Characterisation; and D, Catch-per-unit-effort analyses.

2. FISHERY SUMMARY

2.1 Commercial fisheries

White warehou is generally caught over the continental shelf and slope in depths of 150 to 800 m by large deepwater trawlers bottom trawling (Bagley & Hurst 1997) mainly as bycatch in the hoki, hake, ling and silver warehou fisheries, and to a lesser extent, squid, ling, and white warehou (Ballara & Baird, 2012). The main areas of fishing are the Stewart-Snares shelf area, with some extension into the Sub-Antarctic area since 1990–91, and the Chatham Rise. The annual catch from other fisheries has been relatively small; the WCSI catch is usually less than 100 t and the North Island catch rarely exceeds 50 t. Target fishing on white warehou has been reported from around Mernoo Bank, the Stewart-Snares shelf, Puysegur Bank and on the west coast of the South Island (WCSI), with the best catch rates recorded in the southern areas. Target fishing for white warehou is market-driven, with higher prices fetched by high fat content fish on the Japanese market (C. Hufflett, Solander Marine Ltd., pers. comm.; Ministry of Fisheries 2007). Since 2000, annual catches from the targeted white warehou fishery have generally been similar or greater than those caught as bycatch in hoki fisheries, though this varies by area (see Section 7 of this report).

White warehou fisheries developed during the 1970s and were estimated to be between 1500 and 2000 t (Bagley & Hurst 1997). Before the 200 n. mile Exclusive Economic Zone (EEZ) was established on 1 March 1978, white warehou landings (by foreign fishing nations) were combined with both silver warehou (*S. punctate*) and blue (or common) warehou (*S. brama*) as 'warehous'. Estimated catches of white warehou for 1970–1977 calendar years are given in Table 1 (up to 2000 t annually). From 1978–79 to 1982–83, annual catches of up to 900 t were reported, mainly from the Sub-Antarctic and the Chatham Rise (Table 2).

Landings data are available from the 1989–90 fishing year after the introduction of the Catch Landing Return (CLR) and Catch Effort Landing Return (CELR) forms (Table 3). In most years CLR forms correspond well with records of annual landings from Licensed Fish Receiver Returns (Ministry for Primary Industries, 2014). Catch Effort Landing Returns (CELRs) collected daily catch-effort and landings data from trawl vessels under 28 m and vessels operating in various other fisheries (such as those using longline methods and setnets) up to 1 October 2007. The Trawl Catch Effort Returns (TCERs) introduced on 1 October 2007 for small (6–28 m) trawl vessels, and Trawl Catch Effort Processing Returns (TCEPRs) introduced in 1989 for vessels over 28 m long, collect tow-by-tow catch-effort data and have associated landings data reported on Catch Landing Returns (CLRs). The CELR form was replaced by specific fishery catch-effort-landing method forms for some fishing methods in 2008.

White warehou was introduced into the Quota Management System (QMS) on 1 October 1998 with a Total Allowable Commercial Catch (TACC) of 3374 t. Fishstock areas for white warehou were initially based on the 10 Quota Management Areas (QMAs), but at the start of the 2007–08 fishing year, WWA 5 and 6 were combined into WWA 5B because the fishery straddles the boundary between the two areas (Ministry of Fisheries 2007). The current fishery is managed as the eight stocks shown in Figure 1a. The Kermadec region (WWA 10) has an administrative TACC of 1 t, but no catch of white warehou has

been reported from this area. Note that FMA 10 (WWA 10) has been closed to bottom trawling (and dredging) since November 2007 under the Fisheries (Benthic Protection Areas) Regulations 2007. A nominal catch allowance of 1 t exists for both recreational and customary catch in each of the fishstocks WWA 2–7.

Although eight administrative stocks exist, for the purpose of this report, WWA stocks have been divided into five main fisheries (Figure 1b). These regions are East Coast North Island ("ECNI", FMAs 1 and 2); East Coast South Island and Chatham Rise ("CHAT", most of FMA 3 and all of FMA 4); Sub-Antarctic ("SUBA", the lower part of FMA 3 just south of Dunedin and FMA 5B); West Coast South Island ("WCSI", FMA 7); and West Coast North Island ("WCNI", FMAs 8 and 9).

Landings have increased from 1438 t in 1989–90 to a high of 3694 t in 1996–97 (Table 3, Figure 2). On 1 October 2006, a new total TACC of 3935 t was established through increases in the TACCs for WWA 3, 4, and 7 (to 583 t, 330 t, and 127 t respectively). For these stocks, landings had been above the TACC for a number of years and the increased TACCs represent the average of the previous seven years plus an additional 10%. Despite this change, the catch in WWA 3 in 2006–07 was 25% more than the new TACC, but has been about 40% less than the TACC since 2007–08. The largest fisheries have been in WWA 5 and 6 (WWA 5B), at about 1000–2000 t; and in WWA 3 and 4 (mainly Chatham Rise), at about 400–1250 t (Table 3). Other area catches were small; the largest in WWA 7 occasionally exceeded 100 t. In the last 10 years, landings have ranged between about 1324 t and 3215 t, and was 1908 t in 2013–14, an increase of about 500 t over the previous 3 years.

Hoki catch has varied over the period since 1988, when 255 000 t was caught. The TACC reduced over time to 90 000 t (in 2008) but has increased since to 150 000 t (in 2014). It is believed that changes in hoki catch and effort have affected the landings of white warehou in most areas.

Table 1: Estimated catch (t) of white warehou for years 1970 to 1977. [Source: Bagley & Hurst (1997).]

Vessel nationality	1970*	1971*	1972	1973	1974	1975	1976	1977
Japanese	17	25	222	447	234	1 453	1 558	334
Russian	na	na	1 300	1 200	1 480	40	440	1 260
Korean	–	–	–	–	–	–	–	400
Total	17	25	1 522	1 647	1 714	1 493	1 998	1 994

* Japanese data only.

Table 2: Reported landings (t) of white warehou by fishing year and area, by foreign licensed and joint venture vessels, 1978–79 to 1983–83. The EEZ areas (*see* figure 2 of Baird & McKoy 1988) correspond approximately to the Quota management Areas (QMAs) as indicated. Fishing years are from 1 April to 31 March apart from 1983–83 which is a six month transitional period from 1 April to 30 September. No data are available for the 1980–81 fishing year. [Source: Bagley & Hurst (1997).]

EEZ area	B	C(M)	C(1)	D	E(B)	E(P)	E(C)	E(A)	F(E)	F(W)	G	H	
QMA area	1 & 2		3	4				6		5	7	8 & 9	Total
1978–79	1	20	10	1	0	5	0	141	86	26	20	6	315
1979–80	2	8	5	230	57	5	4	312	34	97	42	0	795
1980–81	–	–	–	–	–	–	–	–	–	–	–	–	–
1981–82	0	41	2	53	0	2	5	153	27	248	10	1	542
1982–83	0	375	1	88	0	11	0	198	39	137	33	0	882
1983–83	0	167	5	49	0	0	0	12	9	34	24	0	300

Note: The EEZ area E (A) also included part of QMA 5, south of 48°30' S.

Table 3: Reported landings (rounded to nearest tonne) of white warehou by FMA and fishing year 1982–83 to 2013–14. Data since 1997–98 are based on catch and effort returns. No landings were reported from WWA 10. (Source: Ministry for Primary Industries (2014)).

Year	WWA 1	WWA 2	WWA 3	WWA 4	WWA 5(5B)*	WWA 6	WWA 7	WWA 8	WWA 9	Total
1982–83	0	35	179	69	248	7	24	< 1	0	562
1983–84	0	28	111	33	282	24	29	< 1	0	510
1984–85	0	2	123	39	150	12	15	< 1	0	342
1985–86	0	5	589	61	277	43	81	< 1	0	1 058
1986–87	0	10	239	29	167	144	15	< 1	0	573
1987–88	< 1	9	431	26	113	20	28	< 1	0	629
1988–89	6	1	118	43	843	16	10	0	0	1 040
1989–90	1	9	484	16	555	291	83	0	0	1 438
1990–91	2	12	695	88	568	278	69	1	0	1 713
1991–92	6	22	589	113	833	1 028	45	0	0	2 636
1992–93	2	13	281	106	560	645	125	2	0	1 734
1993–94	6	34	197	23	1 235	592	69	0	0	2 156
1994–95	4	41	327	243	1 936	185	80	0	0	2 816
1995–96	2	68	566	137	1 555	50	62	0	0	2 440
1996–97	3	89	508	220	2 309	494	71	0	0	3 694
1997–98	2	31	516	153	1 217	126	98	< 1	< 1	2 155
1998–99	< 1	34	398	120	1 269	412	73	< 1	0	2 306
1999–00	< 1	48	559	277	1 112	211	153	< 1	0	2 351
2000–01	< 1	21	661	303	703	119	90	< 1	0	1 897
2001–02	0	8	446	262	921	219	85	< 1	< 1	1 941
2002–03	< 1	20	852	397	1 462	457	158	0	0	3 346
2003–04	< 1	47	458	365	1 141	211	135	0	0	2 357
2004–05	< 1	24	347	365	1 568	436	123	< 1	0	2 863
2005–06	< 1	35	589	312	1 176	250	133	0	0	2 495
2006–07	< 1	10	733	304	1 484	563	121	0	0	3 215
2007–08	< 1	43	345	207	*1 431	N/A	90	0	< 1	2 116
2008–09	< 1	22	302	85	*1 644	N/A	110	< 1	< 1	2 164
2009–10	< 1	7	355	179	*1 106	N/A	44	< 1	0	1 691
2010–11	< 1	12	391	81	* 787	N/A	52	< 1	0	1 324
2011–12	< 1	3	204	112	* 978	N/A	77	< 1	0	1 375
2012–13	< 1	6	174	117	*1 037	N/A	118	< 1	0	1 452
2013–14	< 1	8	302	110	*1 373	N/A	115	< 1	0	1 908

* In 2007–08 WWA 5 was merged with WWA 6 to create WWA 5B. The landings and TACC for WWA 5B are presented after 2007–08 in the WWA 5(5B)* column.

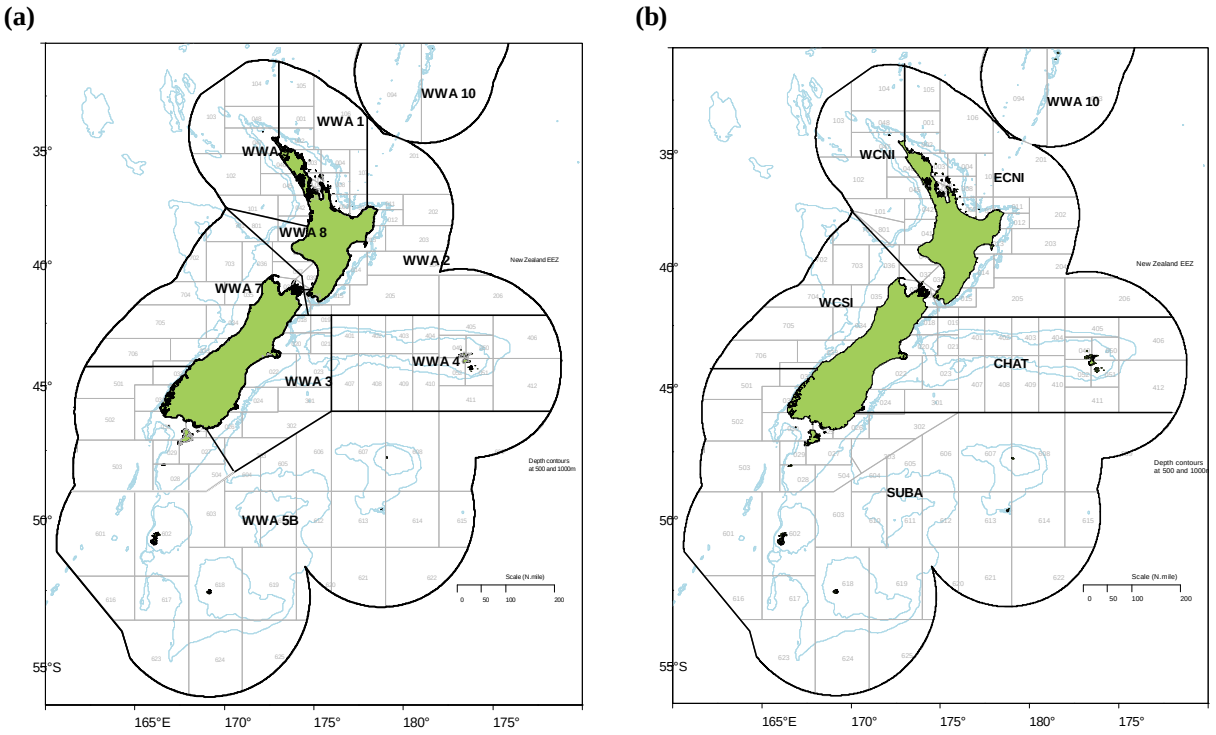

Figure 1: Maps showing (a) administrative fishstock boundaries for WWA 1, 2, 3, 4, 5B, 7, 8, 9 and 10, including statistical areas, and the 500 m and 1000 m depth contours, and (b) areas used in this analysis, including statistical areas, and the 500 m and 1000 m depth contours. ECNI, east coast North Island; CHAT, east coast South Island and the Chatham Rise; WCSI, west coast South Island; WCNI, west coast North Island; and SUBA, Sub-Antarctic. WCNI and WWA 10 are not used in the analysis as there was little catch in these areas.

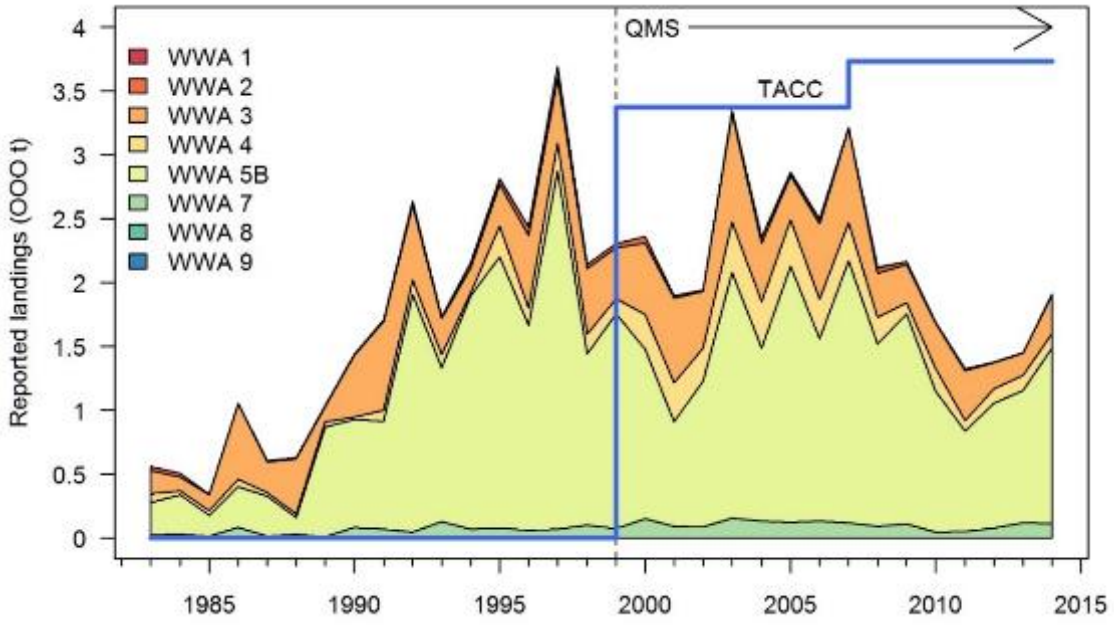

Figure 2: Total reported landings by QMA, and the total TACC, for 1989–90 (1990) to 2013–14 (2014).

2.2 Recreational fisheries

There is no available information on the recreational harvest of white warehou, but given the mainly offshore nature of the catch, recreational take is likely to be negligible.

2.3 Māori customary fisheries

There is no available information on Māori customary harvest of white warehou, but given the mainly offshore and deeper water nature of the catch, customary take is likely to be negligible.

2.4 Illegal and misreported catch

There is no quantitative information available on the illegal or misreported catch of white warehou. In 1988 it was shown that substantial amounts of silver warehou were misreported as white warehou, however, the extent of misreporting is unknown and the catch records remain unaltered (Bagley & Hurst 1997).

2.5 Other sources of mortality

Some mortality may occur with escapement from nets and fish may have been caught and discarded from very small catches (Horn 1999). However, there is no quantitative information available on these sources of mortality.

2.6 Regulations affecting the fishery

Current and historical limits on catch for white warehou are described in Section 2.1. Minimum codend mesh-size regulations that currently apply to the trawl fisheries specify 60 mm for Sub-Antarctic (FMA 6) fisheries and FMA 5 south of 48°S; and 100 mm elsewhere. Previously, the codend mesh-size change took effect at the boundary between the Snares and Auckland Islands fisheries (the old EEZ area F/E boundary), which was at 48° 30'S. However, since 1 October 1983 the codend mesh size change takes effect at latitude 48°S to allow for targeting of squid around the Snares Islands (Hurst 1988).

Protection of bycatch species in multi-species fisheries (particularly relevant in trawl fisheries such as white warehou) is mainly through the QMS, with quotas currently set for 628 fishstocks. Catches of protected species such as corals, seabirds, and marine mammals are monitored through the government observer programme and all trawl vessels over 28 m have been required to deploy seabird mitigation devices to minimise interactions with trawl warps since April 2006 (Ministry of Fisheries 2011).

3. BIOLOGY

3. 1 Distribution

White warehou is one of four species of *Seriolella* in New Zealand waters (McDowell 1982), three of which are commercially fished. This species is widely distributed throughout the New Zealand EEZ, and also occurs off southern Australia, Chile, and Argentina (Gavrilov & Markina 1979, McDowell 1980, see Bagley & Hurst 1997). White warehou occur in fish assemblages in depths of about 100–900 m (Anderson et al. 1998, Horn et al. 2011).

Most catches are from the edge of the continental shelf and the upper slope, especially on the Chatham Rise and Campbell Plateau, as well as off the west coast South Island and east coast North Island (Bagley &

Hurst 1997, O'Driscoll et al. 2003). Catches of adult white warehou (more than 40 cm fork length) from observer and trawl survey data were distributed between 36° off the east coast North Island (ECNI) and 54° S southeast of Campbell Rise and 168° E on the Challenger Plateau to 174.5° W, east of the Chatham Islands. The main adult white warehou distribution is in depths of about 250–750 m, and immature fish have a shallower distribution, usually in less than 500 m, mainly in 200–400 m (Bagley & Hurst 1997, O'Driscoll et al. 2003).

Juvenile white warehou are likely to be pelagic and thus not readily captured by bottom trawl surveys (see Bagley & Hurst 1997, Horn 2001). However, catches of juveniles (i.e., younger than 3 years) during middle depth and deepwater trawl surveys were from across the Chatham Rise, off the eastern edge of the Stewart-Snares shelf, sporadically across the Campbell Plateau, and off the WCSI (O'Driscoll et al. 2003). Immature fish (less than 40 cm) were also reported by observers from off the ECNI. Catch rates were consistently small, except for one tow near the Veryan Bank on the southern Chatham Rise with a catch rate of 4.9 $t.km^{-2}$. Catches of juveniles from inshore surveys were mainly off the edge of the continental shelf in about 200 m, and catch rates were very low (maximum off the ECSI of 350 $kg.km^{-2}$) (O'Driscoll et al. 2003). Pre-recruit fish (25–35 cm) were recorded on the Chatham Rise and Sub-Antarctic (Hurst & Bagley 1997, Horn 1999). This pattern is evident in the trawl survey length distribution which shows that small fish have a preference for shallow waters on the Chatham Rise, Sub-Antarctic, and off the WCSI, and fish over 50 cm are more likely to be caught in depths over 500 m (Figure A2 in Appendix A). Similar patterns are shown in the observer data for areas and depths where white warehou have been sampled from the commercial catch (Figure B3 of Appendix B).

Gavrilov & Markina (1979) indicated that white warehou caught in the Sub-Antarctic in winter and Chatham Rise in summer preferred water temperatures between 6 and 10 °C — a temperature range similar to that given by Bagley & Hurst (1997). In a study to determine climate effects Dunn et al. (2009) found no clear correlations between white warehou biomass indices from the Sub-Antarctic trawl surveys and climate indices.

In commercial fisheries, white warehou is most often caught in the target fishery in the Sub-Antarctic (off the Stewart-Snares shelf, Auckland Islands Shelf, and at Puysegur), and as bycatch, mainly in the hoki fishery, particularly on the western Chatham Rise (including the ECSI), but also to a lesser extent in the Sub-Antarctic and WCSI (see Section 7 of this report).

Biomass trends and length frequency distributions for research survey series that cover appropriate depth ranges for white warehou are summarised in Appendix A and Section 5. These are the summer Chatham Rise surveys, summer and autumn Sub-Antarctic surveys, and winter WCSI surveys on R.V. *Tangaroa*. The main conclusions from these surveys are that:

- most surveys are characterised by small catches and occasional large catches
- biomass on the Chatham Rise is consistently greater than on the Sub-Antarctic
- Chatham Rise biomass has been reasonably stable, apart from a couple of peaks in the early 2000s, though the estimate for 2010 is the lowest since 1999, and has remained low since then
- most of the Chatham Rise biomass is west of 180°
- male biomass in these regions is slightly higher than female biomass in most years and this difference is more pronounced in the Sub-Antarctic
- WCSI biomass is much lower than on the Chatham Rise and Sub-Antarctic
- WCSI fish tend to be larger than in the other areas, and the female biomass is higher than the male biomass.

The MPI observer sampling programme has collected length frequency, weight and gonad stage information for white warehou. These data have been summarised by year and are presented in Appendix B. Scaled length frequencies show that larger white warehou were caught off the WCSI and in Sub-Antarctic waters than on the Chatham Rise. This is not so evident in the trawl survey data which is restricted to January (Chatham Rise) and December (Sub-Antarctic).

3.2 Spawning

Surveys undertaken in 1968–77 in New Zealand waters indicated that white warehou spawn in midwater in autumn and winter on the western slopes of the Chatham Rise (Gavrilov & Markina 1979). Bagley & Hurst (1997) proposed three areas as important spawning areas for white warehou during late winter-early spring (peaking in August-September): around the Mernoo Bank, off the WCSI, and off the continental shelf south of New Zealand (described as "Southland"). White warehou eggs were reported from plankton sampling nets off the WCSI (see Bagley & Hurst 1997) and larval white warehou were caught off the ECSI south of Banks Peninsula, but the month of sampling is not clear (Hickford & Schiel 2003).

Ripe and running ripe fish have been recorded from the ECNI, Chatham Rise, WCSI, off Puysegur, and in the Sub-Antarctic, especially off the Stewart-Snares shelf (O'Driscoll et al. 2003). These trawl survey and observer data are updated in this report (Sections 5 and 6). Most ripe and running ripe females were seen in waters off the WCSI in July–October, in the Sub-Antarctic (off Puysegur and between the Stewart-Snares shelf and the Auckland Islands Shelf) in March–December, and the western Chatham Rise from May–October) (Figures A16, A17, B8 and B9). These data suggest that the spawning season may extend from winter to late spring, or that there are multiple stocks with differences in the timing of their spawning seasons. Immature/resting and maturing fish were present throughout the year for the Chatham Rise and Sub-Antarctic in the observer data (Figures B8 and B9). Ripe fish on the Chatham Rise were present during May–October, running ripe in June–September, and spent fish in August–December. Most ripening fish in the Sub-Antarctic were seen in March–October, ripe fish in June–September, and spent fish from January–April, and September–November. Maturing/ripe, running ripe, and spent fish were present off the WCSI, where sampling (and fishing) was generally restricted to June–September. Although limited to certain months and areas, the trawl survey records are generally consistent with these results (see Table A2, Figures A16 and A17). There is minimal evidence of spawning outside these areas.

3.3 Stocks and spatial distribution

Gavrilov (1979) described spawning on the Mernoo Bank area of the Chatham Rise, and Gavrilov & Markina (1979) defined a size range of 30–64 cm for sexually mature fish. Bagley & Hurst (1997) described the size range for adult fish as 35–62 cm, and from a summary of fishery and research data suggested that there were three spawning areas: Chatham Rise, the Sub-Antarctic, and off the WCSI.

Evidence presented in Ballara & Baird (2012) and in this report is in agreement with the delineation of three stocks based on the main spawning areas. Catches of adult fish were made in all areas for all months throughout the year (see Sections 5 and 6 of this report). Overall the size ranges for fish from the Chatham Rise and the Sub-Antarctic were similar in the observer data in most years (see Sections 5 and 6 of this report), the larger mode (at or over 50 cm) was seen in the Sub-Antarctic data (Figures B4 and B6), and most fish from the WCSI were over 50 cm (Figure B7).

3.4 Ageing

No new information on ageing is available since the previous characterisation (Ballara & Baird 2012). Initial work on ageing white warehou assumed a birthdate of 1 August and maturity at age 3 or 4 years, with age 1 fish at about 23–24 cm, age 2 at 31–32 cm, age 3 at 38–39 cm and age 4 at 47 cm (Gavrilov 1979, Bagley & Hurst 1997).

Ageing of white warehou was partially validated by Horn (1999, 2001), based on a dataset of otoliths, covering all months of the year, collected during 1992–98 from 895 fish caught during observed commercial tows and trawl survey tows in the Chatham Rise and Sub-Antarctic. Females grow faster than males and maximum ages are 18 years for males and 21 years for females (Horn 1999). Fish grow rapidly until they spawn (at about 3 or 4 years), and growth is much slower after 6–8 years (Horn 2001).

Modes from length frequencies of Chatham Rise fish were considered to represent consecutive year classes by Horn (2001): at 18–21 cm, 30–32 cm, 36–39 cm, and 41–44 cm. Fish from the Sub-Antarctic area were considered to show similar distributions. Data collected subsequently during trawl surveys and by observers indicate the presence of all these year classes, except the age 1+ fish (see Sections 5 and 6).

3.5 Growth curves

No new information on growth parameters is available since the previous characterisation (Ballara & Baird 2012). Von Bertalanffy growth parameters presented in Table 4 are based on work by Horn (1999, 2001). Growth is initially rapid up to first spawning (3–4 years) and is negligible after about age 10. Growth of females is significantly faster than that of males and thus females are significantly larger at age than males (Horn 2001). Females also attain larger maximum size than males. There were no significant differences in von Bertalanffy growth curves between areas (Horn 2001).

Table 4: Summary of von Bertalanffy growth parameters for white warehou from the Chatham Rise (WWA 3 & WWA 4) and Sub-Antarctic (WWA 5B). [Source : Horn 2001.] NB : Ageing in this study used partially validated methods.

Sex	*n*	L_∞ (95% CI)	*k* (95% CI)	t_0 (95% CI)	*P* (95% CI)
Chatham Rise					
Male	346	57.1 (55.5–58.8)	0.153 (0.114–0.192)	0.19 (0.10–0.29)	0.328 (0.283–0.372)
Female	279	61.0 (58.9–63.0)	0.131 (0.096–0.166)	0.14 (0.10–0.26)	0.350 (0.303–0.398)
Sub-Antarctic					
Male	149	62.4 (56.7–68.2)	0.098 (0.038–0.158)	0.14 (-0.10–0.30)	0.297 (0.238–0.355)
Female	109	70.2 (59.1–81.4)	0.058 (0.002–0.113)	0.22 (0.05–0.39)	0.281 (0.224–0.339)
All data combined					
Male	495	58.2 (56.5–60.0)	0.136 (0.102–0.170)	0.16 (0.07–0.25)	0.316 (0.278–0.353)
Female	388	63.5 (60.9–66.1)	0.103 (0.072–0.132)	0.15 (0.04–0.25)	0.325 (0.287–0.362)

3.6 Natural mortality

No new information on natural mortality is available since the previous characterisation (Ballara & Baird 2012). Instantaneous natural mortality (*M*) was estimated by Horn (1999), based on the method of Hoenig (1983) where $M = -\log_e(p)/A$ where *p* is the proportion of the population that reaches A or older, with a value of $p = 0.05$ producing an *M* of 0.25 for males and 0.20 for females. Two other estimates were derived using data (sexes combined) from the largest available trawl survey sample (January 1998 Chatham Rise): Chapman & Robson (1960) where $M = \log_e[(1+a)/a]$ where *a* is the mean age of fish above recruitment age ($M = 0.26$); and the slope of the right hand limb of the catch curve using the regression model defined as R1 by Dunn et al. (1999) ($M = 0.28$). With their longer life span, the *M* value should be lower for females. The latter two methods were considered by Horn (1999) to be more reliable, but to allow for fishing mortality, the estimates should be slightly reduced to: *M* of 0.25 for males and 0.20 for females, as given above. However, the Middle Depths Species Fisheries Assessment Working Group considered the data inadequate for establishing a difference in *M* by sex. The final decision was to use 0.25 for both sexes in stock assessment modelling with sensitivity tests of plus or minus 0.05.

3.7 Length-weight relationship

No new information on length weight parameters is available since the previous characterisation (Ballara & Baird 2012). Length weight parameters for Chatham Rise and Sub-Antarctic white warehou were estimated by Bagley & Hurst (1997) and updated by Horn (1999) and the latter are given in Table 5.

Table 5: Length-weight parameters for white warehou, where weight (g) = αL^{β} and L is fork length (cm). Source : Horn (1999). Note: few data were available for WWA 7.

Area	Sex	*a*	*B*	*n*	Range
WWA 1–4, 10	Male	0.0247	2.981	459	18–59
(combined)	Female	0.0177	3.069	360	19–62
	All	0.0200	3.037	829	16–62
WWA 5B	Male	0.0138	3.132	231	20–60
	Female	0.0106	3.197	131	20–62
	All	0.0111	3.188	406	20–62
WWA 7	All	0.0200	3.037	–	–

3.8 Feeding and trophic status

No new information on feeding studies of white warehou are available since the previous characterisation (Ballara & Baird 2012). Initial dietary studies by Gavrilov & Markina (1979) found that salps were the primary prey source for white warehou (98% by weight for 30–64 cm white warehou), with amphipods also present, and very small white warehou fed mainly on amphipods and chaetognatha. Stomachs were from white warehou sampled in the winter from the western Chatham Rise, in summer and autumn from Pukaki Rise, and in autumn from the Stewart-Snares shelf. A wider variety of tunicates were present in white warehou off Stewart-Snares shelf (Gavrilov & Markina 1979), whereas white warehou at Pukaki Rise fed on salps. Gavrilov & Markina (1979) related their findings to white warehou distribution and proposed that white warehou at about 24–31 cm long move to deeper water and feed on zooplankton, mainly salps; white warehou over 30 cm are usually on the slope of the shelf; and that in winter, white warehou migrate to the western Chatham Rise to spawn, after which they feed on tunicates and salps.

Recent studies report similar dietary components. In a literature review and summary of research trawl data (1960–2000), Stevens et al. (2011a) reported 96% occurrence for salps in stomach contents analysed from 262 white warehou, 20–60 cm. Fish were sampled during trawl surveys on the Chatham Rise and in Sub-Antarctic waters (particularly around the Stewart-Snares shelf). This study also found 6% occurrence for crustaceans, mostly amphipods and euphausiids, and a smaller amount of unidentified teleosts. Overall, the identified prey items represented at least three main invertebrate groups in two phyla and one teleost species.

Similar results were reported by Horn et al. (2011) in an analysis of stomach data from 291 fish (17–60 cm) collected from three consecutive middle depth December–January Chatham Rise trawl surveys on *Tangaroa* (2004–05 to 2006–07). Additional analyses indicated that year, latitude, longitude, and moon phase may influence the white warehou diet. Tunicates were relatively less important and amphipods, copepods, and euphausiids relatively more important in the diet on the northern Chatham Rise. Several distinctions between this diet and the diet of silver warehou (a species with a similar spatial and vertical distribution) were suggested by Horn et al. (2011): white warehou consumed mainly salps, whereas a wider variety of tunicates were present in the silver warehou diet, and crustaceans appeared to be more important to the white warehou diet, though these data could be confounded because of a commensal relationship some amphipods have with salps.

No evidence of white warehou in the diet of any demersal fish on the Chatham Rise has been found to date (see Horn et al. 2011). However, Hurst & Bagley (1992) reported occurrence of small white warehou in jack mackerel stomachs from fish caught near the Chatham Islands.

4. CURRENT AND ASSOCIATED RESEARCH PROGRAMMES

4.1 Ministry for Primary Industries

White warehou is one of 18 species included on a list to be regularly characterised under the Ministry of Fisheries 'Deepwater 10-year Plan'. There are no specific research programmes for white warehou. Research trawl surveys on *Tangaroa* on the Chatham Rise and Sub-Antarctic in summer, and on the WCSI in winter are the only ongoing time series in which white warehou catches and length frequencies are regularly recorded (see Section 5). Note that there were also four autumn Sub-Antarctic trawl surveys, and one spring Sub-Antarctic survey, and four Southland surveys. Numbers of white warehou measured totalled 18 325 for the Chatham Rise time series (range of 162–1699 fish per survey); 4142 for the summer Sub-Antarctic time series (range 42–603); 425 for the autumn surveys range (29–238); 209 for the Southland surveys range (4–93); and 80 for the WCSI surveys range (16–45).

Biomass estimates on the Chatham Rise time series range from 533–7932 t, 211–2433 t on the summer Sub-Antarctic time series, and 12–65 t for the WCSI winter time series. Biomass of this species is considered to be moderately well estimated in the core survey area (Bagley et al. 2013a, O'Driscoll et al. 2011) with CVs generally ranging from 20 to 50%.

5. FISHERY INDEPENDENT OBSERVATIONS

5.1 Research surveys

5.1.1 Biomass indices, length frequencies, and gonad stage data, length and age frequencies

Bottom trawl surveys in waters within the depth range of white warehou are summarised in this section. The surveys are part of standardised time series with potential use to monitor white warehou abundance. The relevant trawl survey outputs are summarised in Table 6 and Appendix A. Note that years referred to in the research survey section are calendar years. The following trawl survey series were analysed using NIWA's research trawl survey analysis program "SurvCalc" (Francis & Fu 2012): *Tangaroa* surveys on the Chatham Rise (core strata of 200–800 m), in Sub-Antarctic waters summer, autumn, and spring (core strata of 300–800 m), a short series in Southland waters (30–600 m), and a WCSI winter series (2000 survey: 300–650 m, 2012–2013 surveys: 200–800 m). *Kaharoa* surveys in inshore shallower waters during winter and summer off the east and WCSI were not used as they did not cover the entire depth range appropriate for this species.

This section mainly considers the continuing time series potentially suitable for monitoring white warehou abundance; that is, *Tangaroa* surveys in waters 200–800 m deep. There have been no surveys designed specifically to estimate white warehou abundance. The Chatham Rise (1992–2014) and Sub-Antarctic (1991–1993, 2010–2009, 2011–2012, 2014) *Tangaroa* random bottom trawl survey time series, were primarily aimed at surveying hoki, hake, and ling (O'Driscoll et al. 2011).

The core strata of these surveys cover the appropriate depth range, although they do not provide precise biomass indices (Chatham Rise CVs 24–54%, Sub-Antarctic summer survey CVs 24–61%) (Figure A1, Table 6). The Sub-Antarctic *Tangaroa* autumn (1992–93, 1996, 1998) and spring (1992) surveys also cover the range well. The *Tangaroa* Southland (1993–1996) and WCSI winter series (2000, 2012–2013) also cover the depth range, although most white warehou are caught in depths more than 300 m and station density is more limited in strata less than 300 m depth (Figure A1).

The distribution of white warehou length data extracted from the trawl database for surveys between 1979 and 2014 represent a mix of years, areas, vessels, and gear. The largest fish were generally found

off WCSI, with smaller white warehou generally found on the Chatham Rise and Sub-Antarctic in shallower waters (Figure A2).

Length frequency distributions were determined using SurvCalc which involves scaling by percentage sampled and area trawled to estimate the population in the survey area available to the trawl. The length–weight coefficients used to determine the frequencies are from the reports of each trawl survey listed in Table 6.

Table 6: Biomass indices (t) and coefficients of variation (CV) for white warehou from *Tangaroa* trawl surveys (Assumptions: areal availability, vertical availability and vulnerability = 1).

Trip code	Date	Reference	Biomass (t)	% CV
Chatham Rise*				
TAN9106	Dec 1991–Feb 1992	Horn (1994a)	2 227	30
TAN9212	Dec 1992–Feb 1993	Horn (1994b)	2 939	46
TAN9401	Jan 1994	Schofield & Horn (1994)	1 606	27
TAN9501	Jan–Feb 1995	Schofield & Livingston (1995)	734	25
TAN9601	Dec 1995–Jan 1996	Schofield & Livingston (1996)	533	24
TAN9701	Jan 1997	Schofield & Livingston (1997)	2 287	20
TAN9801	Jan 1998	Bagley & Hurst (1998)	1 009	24
TAN9901	Jan 1999	Bagley & Livingston (2000)	3 136	41
TAN0001	Dec 1999–Jan 2000	Stevens et al. (2001)	2 385	24
TAN0101	Dec 2000–Jan 2001	Stevens & Livingston (2002)	4 262	25
TAN0201	Dec 2001–Jan 2002	Stevens & Livingston (2003)	6 881	45
TAN0301	Dec 2002–Jan 2003	Livingston et al. (2004)	3 685	34
TAN0401	Dec 2003–Jan 2004	Livingston & Stevens (2005)	7 932	44
TAN0501	Dec 2004–Jan 2005	Stevens & O'Driscoll (2006)	4 542	25
TAN0601	Dec 2005–Jan 2006	Stevens & O'Driscoll (2007)	2 929	29
TAN0701	Dec 2006–Jan 2007	Stevens et al. (2008)	2 853	21
TAN0801	Dec 2007–Jan 2008	Stevens et al. (2009a)	1 899	28
TAN0901	Dec 2008–Jan 2009	Stevens et al. (2009b)	3 667	33
TAN1001	Jan 2010	Stevens et al. (2011b)	983	21
TAN1101	Jan 2011	Stevens et al. (2012)	1 861	54
TAN1201	Jan 2012	Stevens et al. (2013)	1 925	32
TAN1301	Jan 2013	Stevens et al. (2014)	2 030	33
TAN1401	Jan 2014	Stevens et al. (2015)	1 299	34
Sub-Antarctic (summer) ǂ				
TAN9105	Nov–Dec 1991	Chatterton & Hanchet (1994)	1 605	58
TAN9211	Nov–Dec 1992	Ingerson et al. (1995)	243	26
TAN9310	Nov–Dec 1993	Ingerson & Hanchet (1995)	293	28
TAN0012	Nov–Dec 2000	O'Driscoll et al. (2001)	266	39
TAN0118	Nov–Dec 2001	O'Driscoll & Bagley (2003a)	2 433	54
TAN0219	Nov–Dec 2002	O'Driscoll & Bagley (2003b)	853	24
TAN0317	Nov–Dec 2003	O'Driscoll & Bagley (2004)	709	58
TAN0414	Nov–Dec 2004	O'Driscoll & Bagley (2006a)	1 061	31
TAN0515	Nov–Dec 2005	O'Driscoll & Bagley (2006b)	538	38
TAN0617	Nov–Dec 2006	O'Driscoll & Bagley (2008)	646	26
TAN0714	Nov–Dec 2007	Bagley et al. (2009)	1 707	61
TAN0813	Nov–Dec 2008	O'Driscoll & Bagley (2009)	2 283	40
TAN0911	Nov-Dec 2009	Bagley & O'Driscoll (2012)	2 093	35
TAN1117	Nov–Dec 2011	Bagley et al. 2013b	390	27
TAN1215	Nov–Dec 2012	Bagley et al. 2014	1 259	29
TAN1412	Nov–Dec 2014	Bagley et al. (in prep)	211	40
Sub-Antarctic (autumn)				
TAN9204	Apr–May 1992	Schofield & Livingston (1994a)	256	30
TAN9304	May–Jun 1993	Schofield & Livingston (1994c)	907	24
TAN9605	Mar–Apr 1996	Colman (1996)	239	31
TAN9805	Apr–May 1998	Bagley & MacMillan (1999)	2 887	68

Trip code	Date	Reference	Biomass (t)	% CV
Sub-Antarctic (spring)				
TAN9209	Sep–Oct 1992	Schofield & Livingston (1994b)	350	55
Southland				
TAN9301	Feb–Mar 1993	Hurst & Bagley (1994)	18	34
TAN9402	Feb–Mar 1994	Bagley & Hurst (1995)	46	49
TAN9502	Feb–Mar 1995	Bagley & Hurst (1996a)	2	76
TAN9604	Feb–Mar 1996	Bagley & Hurst (1996b)	102	87
WCSI#				
TAN0007	Jul–Aug 2000	O'Driscoll et al. (2004)	12	51
TAN1210	Jul–Aug 2012	O'Driscoll et al. (2014)	65	34
TAN1310	Aug 2013	O'Driscoll et al. (2015)	26	27

* A summary of the Chatham Rise *Tangaroa* trawl survey time series is given by O'Driscoll et al. (2011.

ǂ A summary of the summer *Tangaroa* Sub-Antarctic trawl survey series is given by Bagley et al. (2013a).

WCSI 2000 survey depth range 300–650 m; 2012 and 2013 survey depth range 200–800m.

Chatham Rise summer trawl survey series

The Chatham Rise January *Tangaroa* trawl survey analysis presented here covers surveys from 1992 to 2014 in the core strata depths of 200–800 m (Table 6). White warehou were recorded in between 28 and 62% of all core strata tows in each year (Table A1), with tows catching white warehou located across most of the survey area (see Figure A1). White warehou catches were generally small (mean catches per survey ranged from 3–35 kg), with maximum catches generally under 1000 kg; the largest catch of 2685 kg was caught in 2001. The Chatham Rise core survey area and depth range is appropriate for monitoring white warehou, and the biomass was often in the top 12 species. The biomass of white warehou was in the top 18 of the commercial species biomass in all surveys before 2001. In most surveys since then, white warehou has been in the top 12 (for example, see Stevens et al. 2009a), although it dropped to 19th highest commercial species biomass in 2010 (Stevens et al. 2011b) and 16th in 2014 (Stevens et al. 2015).

Biomass for white warehou shows a slight overall increase in biomass to 2004, with a subsequent decline, and higher estimates of biomass usually have higher CVs (Table 6, Figure A3). Over the first nine years of the time series, the biomass fluctuated between 533 t and 3136 t. A steep increase to 6881 t in 2002 and almost 8000 t in 2004 was followed by a decrease and the estimate for 2010 was one of the lowest in the series. From 2011 to 2014 the biomass fluctuated between levels of 1299–2030 t. The CVs for white warehou show a wide range for the core survey (20–54%), although only half are less than 30%, and hence the biomass is poorly estimated (Table 6, Figure A3).

The male biomass was generally slightly higher that of the females, and both the male and female biomass trend was aligned closely with the overall biomass trend (Figure A3). Males are usually more numerous than females with a mean ratio for the time series of 0.84 females to every male (range 0.64–1.04). Biomass estimates west of 180° were generally higher than for east of 180° (Figure A3). The biomass from the 200–400 m depth strata follows the overall trend in most years (Figure A3). The biomass from the 600–800 m strata is low (Figure A3).

Other Chatham Rise trawl surveys were undertaken before the *Tangaroa* surveys in various months during 1983–89. (Ballara & Baird 2012). Catches had a much narrower range than that for the summer *Tangaroa* surveys, with maximum catches per survey between 152 and 174 kg.

The number of white warehou measured annually from Chatham Rise *Tangaroa* surveys ranged from 162 to 1387, but was over 300 in all but four years (Figure A4). Fish length was generally between 20 and 69 cm, with few fish less than 30 cm, and with males usually more numerous than females (Figure A4). Smaller fish are likely to be in waters shallower than those sampled by this survey series

(see Figure A2), and the trawl gear used may not adequately sample the smaller fish which are likely to be higher in the water column (Horn 2001). Few fish longer than 60 cm were sampled.

White warehou showed multiple modes in the length frequency data in some years suggesting that recruitment is variable (Figure A4), and this may be useful to track changes in year-class strength (O'Driscoll et al. 2011). Length frequency distributions for Chatham Rise white warehou show four distinct modes, at about 28–32 cm, 36–40 cm, 42–48 cm, and 52–56 cm, though not all modes are apparent in all surveys. Length distributions of males and females are similar within a survey.

There appears to be variation in the strength of year classes from year to year, with distinct modes in most years, with some evidence of year class progression: for example (after Horn 2001) from the 2+ fish in 2003 through to 2014 at about 48–52 cm. Few adult fish were evident in some years, e.g., in 2000–2002 when the distributions were unimodal. Also, from 2004–2010, fish at 40–50 cm were abundant, especially in 2009, with relatively few fish over 50 cm until after 2010. From 2010–2014, distinct modes were again present with small fish also seen in the 2011 and 2013 surveys. The 1983, 1984, and 1986 *Shinkai Maru* surveys caught mainly small fish (about 20 cm) in March, a wider range of sizes in November of the same year (but few small fish), and the full size range in July (Ballara & Baird 2012). Generally, when a strongly recruiting year class is present, it appears as a distinct mode in the length frequency distribution, sometimes the distribution has multiple modes where there are several strong year classes.

Mean length has decreased and then increased since the start of the time series, for both males and females. The mean length ranged from 38–44 cm from 1992–1999, and then decreased to 31–35 cm from 2000–2003 when the length frequencies were unimodal, and from 2004 increased back to a similar level to that of the early 1990s. Gonad stage data showed that most fish were immature, resting, or maturing (see Figure A16).

Ageing of white warehou was partially validated by Horn (1999, 2001), and modes from length frequencies of Chatham Rise fish were considered to represent consecutive year classes by Horn (2001): at 18–21 cm, 30–32 cm, 36–39 cm, and 41–44 cm (Section 3.5). Few otoliths have been collected since 1998 (Table A3), and no catch-at-age history has been developed for white warehou from trawl surveys.

Sub-Antarctic summer, spring, and autumn trawl survey series

The Sub-Antarctic *Tangaroa* trawl survey analyses presented here cover summer surveys (1991–1993, 2001–2009, 2011–2012, 2014), autumn surveys (1992–1993, 1996, 1998) and a spring (1992) survey in the core strata depths of 300–800 m (Table 6). The Sub-Antarctic core survey area and depth range is appropriate for white warehou as this species is only occasionally found deeper than 800 m (Bagley et al. 2013a). White warehou were caught in 13–38% of the summer core strata survey stations, 15–48% of the autumn survey stations, and 19% of the spring survey stations (Table A1). Most catches were small (mean catches per survey ranged between 0.5 and 21 kg) and maximum catches ranged from 8–1195 kg per survey. A similar pattern to that seen in the Chatham Rise survey data of a few larger catches but mainly small catches was observed here, although the catches were generally smaller, especially in the autumn surveys. White warehou was usually in the top 10–15 commercial species by biomass in these surveys (see for example, Bagley & O'Driscoll 2012).

Biomass indices for the summer Sub-Antarctic surveys are consistently lower than those estimated for the Chatham Rise (Table 6), and males again are more numerous than females with a mean ratio for the time series of 0.8 females for every male (range 0.4–2.2). Biomass shows no clear trend since the start of the time series, large estimates of biomass are associated with large CVs (range 24–61%), and hence the biomass is poorly estimated (Figure A5, Table 6). Male biomass was usually higher than that of the females and the male biomass trend was more variable and reflected the overall biomass trend (Figure A5). The biomass from the 300–600 m depth strata follows the overall trend in all years, and the biomass from the 600–800m strata is low, although more variable for females (Figure A5).

Estimates for the four autumn surveys are lower than the summer survey estimates and show substantial between-survey differences (Table 6, Figure A6). The larger catches in the 1998 survey resulted in a biomass estimate more similar to that seen in the summer surveys, but the large CV suggests that this is not well estimated. Where there are comparable years with the summer series (1992 and 1993), 1992 shows similar biomass (summer = 243 t CV = 26%, autumn = 256 t CV = 30%), but the 1993 autumn survey has a substantially higher biomass (summer = 293 t CV = 28%, autumn = 907 t CV = 24%) (Table 6, Figures A6, A7, and A8). Few differences are seen in male and female biomass estimates for the autumn survey, except in 1998 when the male biomass was about twice the female biomass. Biomass for the Sub-Antarctic *Amaltal Explorer* surveys in October-November 1989 and July-August 1990 were within the range of the Sub-Antarctic *Tangaroa* surveys, despite differences in the two vessels and gear, although the biomass and CV from the November-December 1990 survey was much higher. The CVs for the autumn Sub-Antarctic series were also high (24–68%) (Ballara & Baird, 2012).

Fewer fish were measured from the Sub-Antarctic summer surveys than on Chatham Rise surveys, with 42–600 per survey (Figure A9). Length frequency distributions from the summer Sub-Antarctic series (Figure A9) have multiple modes although there is no clear year class progression, and the distributions are variable from year to year. In the 2007–2012 surveys the distribution is centred about 44–50 cm fish, with smaller numbers of fish 50–60 cm and few fish under 30 cm. Overall, scaled population numbers are lower for both sexes than on the Chatham Rise, and males are more numerous than females. The same modes seen on the Chatham Rise are present in the Sub-Antarctic summer survey data. Females grow to a larger size than males but both sexes appear to grow to a larger size in the Sub-Antarctic than on the Chatham Rise. This difference in maximum size between areas may be indicative of separate biological stocks. For the Sub-Antarctic summer surveys, mean length for both males and females decreased from the 1991–93 levels to a low in 2001–2003 but has generally increased since then.

The length frequency distributions from the four autumn Sub-Antarctic series (Figure A10) are based on widely differing numbers of measured fish, and although the scaled population numbers indicate that, overall, males are more numerous, this is heavily weighted by the 1998 data. The female to male ratio was about 0.7 (range 0.4–1.1). Few fish were measured from most of the autumn surveys, but these surveys indicate the presence of all size classes in this season. Length frequency distributions from the spring Sub-Antarctic survey show a similar length range (Figure A12), and there was a ratio of 1.5 females to every male.

Gonad stage data in Sub-Antarctic summer surveys indicate that most fish are resting or maturing, although spent fish were found in October (Table A2).

Southland late summer *Tangaroa* trawl survey series

The *Tangaroa* trawl surveys carried out in waters around the Stewart-Snares shelf and off Puysegur (known as the "Southland" series) during February–March of years 1993–96 were conducted in depths of 30–600 m. This survey series was optimised for 10 species, which did not include white warehou (Hurst & Bagley 1994), and had little success in catching white warehou, with most catches taken in waters deeper than 300 m (Table A1, Figure A1). Catches of white warehou were recorded from between 2 and 9% of stations per survey (Table A1). Catch rates were low with maximum catches ranging from 3–159 kg per survey. The Southland biomass estimates are much lower than estimates from other *Tangaroa* surveys except for the WCSI (Table 6, Figure A12). Biomass estimates varied over the four surveys, but are not well estimated, with CVs ranging from 34–87%.

The length frequency distributions shown in Figure A13 are not informative. Length frequencies are broad but spiky, although males show a peak at 35 and 50 cm in 1994 and 1996 respectively, and there are more males than females caught with an overall ratio of 0.4 females to every male caught (range 0.4–0.5) , and females and males are a similar size (Figure A13).

WCSI winter *Tangaroa* trawl survey series

Trawl surveys were carried out on the WCSI during July–August in 2000 and 2012–2013. The 2000 survey was part of a series of acoustic surveys of WCSI hoki spawning areas and covered the 300–650 m depth range. The 2012 and 2013 surveys were carried out as part of a WCSI combined trawl and acoustic survey series of the WCSI hoki spawning areas (O'Driscoll et al. 2015). The trawl survey design was changed in 2012 by adding strata in the north to cover the depth range of other key species, and increasing the depth range to 200–800 m (O'Driscoll et al. 2014). To enable comparisons of the 2000 survey with the 2012 and 2013 surveys, biomass and scaled length frequencies from the daytime random trawl component of the 2000 survey were run using the revised 2012 stratum areas (O'Driscoll et al. 2015). The WCSI survey series was optimised for various middle depth species north of Hokitika Canyon, which did not include white warehou, and the total survey area is appropriate for white warehou, although this species is also found south of the Hokitika Canyon (see Figure C43). The depth range of 200–800 m for the core strata in the 2012 and 2013 surveys is appropriate for white warehou, however depths from the 2000 survey do not cover the depth range for white warehou (Figure A1), and results for this survey should be treated with caution.

Catches of white warehou were recorded in 15–16% of all stations per survey (Table A1). Mean catches per survey were about 1–2 kg, with maximum catches ranging from 11–34 kg per survey. The WCSI biomass estimates are much lower than estimates from the Chatham Rise and Sub-Antarctic *Tangaroa* surveys (Table 6, Figure A14). Total biomass estimates for core strata were similar in the 2000 and 2013 surveys, but higher in the 2012 survey, but are not well estimated, with CVs ranging from 27–51%, suggesting that this survey is not suitable for monitoring white warehou. Biomass estimates for 200–800 m strata showed a decrease from 2012 to 2013, with CVs of 34 and 27% (Table 6).

Length frequency distributions exhibited little variation in the relative size of the modes from survey to survey, and hence no tracking of cohorts is possible (Figure A15). Females are more numerous, with a mean ratio of 6.5 females to every male (range 2–11.7), and females had a larger size range than males (Figure A15). Length frequency distributions for the WCSI surveys may not be informative due to the small catches of white warehou.

Most females on the WCSI are ripening in July and August, although in August, 30% are ripe or running ripe and 8% spent, and males were mostly ripe, but sample sizes were small (Table A2, Figure A16) .

5.1.2 Female maturity

The female maturity data were summarised here using the observer five stage reproductive scale: immature and resting, maturing, ripe, running ripe, and spent. The relative proportions of the reproductive stage data are shown in Figure A16 by area, and the numbers of fish sampled are given in Table A2. Immature, resting, or maturing fish were found on the Chatham Rise and Sub-Antarctic in summer, although there were a few spent fish (Table A2, Figure A16). On the WCSI a few running ripe fish were found in winter, although most were ripening, spawning probably takes place in winter. Spent fish were reported from the Chatham Rise, Stewart-Snares shelf and Auckland Islands Shelf in December and January, and off the WCSI in August.

6. FISHERY DEPENDENT OBSERVATIONS

6.1 Observer data

Length and age sampling

All tables and figures relating to observer data collected from white warehou fisheries are contained in Appendix B (Tables B1–B8, Figures B1–B9). The main fishery areas used in this section are those given in Figure 2. These data have been collected since 1990–91 (Tables B1–B4); most observer samples in 1992–2014 came from the Sub-Antarctic, Chatham Rise, and WCSI areas (Table B1). On average, about

13% of the Chatham Rise white warehou estimated catch was observed (annual range 1–68%), compared with 20% for Sub-Antarctic (range 0.4–93%), 25% for WCSI (1–89%), and 3.9% (0–156%) for ECNI (where some years observed catches have been greater than estimated catches).

The representativeness of observer sampling of white warehou was evaluated by plotting the proportion of landed catch for each year by area and by month, statistical area, depth range, and vessel length as circles, and overlaying this with the proportion of the observed catch for those same circles as crosses (Figures B1–B2). If the proportions are the same, the plots align; if over- or under-sampling has occurred, the crosses are either larger or smaller than the circles. Observed catches by area are representative of catches from the Chatham Rise, Sub-Antarctic, and the WCSI, so CPUE series were produced for these areas (Figure B1, see Section 8, Appendix D). Length frequency samples from Sub-Antarctic appear to be representative of the catch, but the Chatham Rise and WCSI were under-sampled, especially for the Chatham Rise in the last seven out of nine years (Figure B1).

This observer effort generally represents the timing of the main fisheries for middle depth and deepwater fisheries, which is particularly evident off WCSI where much of the data collection occurred during the hoki spawning season between June and September (Figure B2a). WCSI coverage by month was good during the hoki spawning season, although June and August were under-sampled in some years (Figure B2a). Coverage by statistical area on the WCSI was good although there was no coverage in Statistical Area 033 in 2013 and 2014, and the area 035 coverage was light in 2011 and 2012. Sampling has occurred in most months for the Chatham Rise and Sub-Antarctic areas, and from October–December for the ECNI, but has been variable from year to year (Figure B2). There was more coverage in Chatham Rise from the ECSI areas, but coverage across the Chatham Rise was patchy (Figure B2b). The Sub-Antarctic region has the most samples (Table B1–B4), although sampling in the Auckland Islands, Snares Shelf and Puysegur fisheries are highly variable (Figure B2c). ECNI catches are patchy and not representatively sampled by month, or statistical area (Figure B2d). On the Chatham Rise and Sub-Antarctic vessel size range was well covered by observers, but on the WCSI, with a large vessel size range, small vessels under 40 m were under-sampled, and larger vessels greater than 70 m were under-sampled in earlier years. Observer coverage by depth was good for all main areas except for the ECNI (Figure B2).

The length distributions of observed white warehou for all years combined show that smaller (under 40 cm) white warehou are more likely to be found in the Chatham Rise and Sub-Antarctic regions – especially in shallower waters and at the shelf edge (e.g., off the ECSI, southern Chatham Rise, off the Stewart-Snares shelf, Auckland Islands Shelf, and the Bounty Platform). Large white warehou (greater than 50 cm) were caught mainly in the WCSI region, as well as ECNI, Puysegur, and northern Chatham Rise (Figure B3).

The numbers of white warehou measured per tow by observers varied markedly. Between 1 and 216 fish were sampled from 11% of tows with white warehou catches, with 84% of sampled tows having a sample size of 1 to 20 white warehou, and 16% having a sample size of only one fish. Over 47 825 fish were measured and sexed (Table B5), and 75% of these were caught from the Sub-Antarctic throughout the year, but this was variable by month and year (Table B6). More males than females were caught in this area in most years. The Chatham Rise observer coverage accounted for 20% of the measured white warehou, with sampling intensity variable throughout the year, and again generally more males were caught than females (Table B6). The WCSI observer coverage accounted for 3% of the measured white warehou. These were sampled mainly from June–September, and generally more females were caught than males (Table B6). White warehou from the ECNI fishery areas each made up about 0.7% of the total sampled numbers, and annual and monthly numbers varied markedly, with more females than males measured (Tables B5 and B6).

Very few individual white warehou were weighed by observers (24 in 2008, 40 in 2009, 2 in 2011, and 3 in 2013 and 2014).

A total of 10 859 pairs of otoliths from white warehou were collected by observers, with 416–1149 collected each year since 1998 (Table B7). These otoliths are from all areas except WWA 8, WWA 9, WWA 1, and WWA 10. Most are from the Sub-Antarctic (56.5%) and Chatham Rise (33.7%), with the remainder from the WCSI (6.9%), and ECNI (2.6%). In recent years samples may be adequate from the Sub-Antarctic area to produce catch at age data.

Length and age frequencies

Scaled length frequency distributions were determined using the 'catch.at.age' software (Bull & Dunn 2002) which scales the length frequency from each catch up to the tow catch, sums over catches in each stratum, scales up to the total stratum catch, and then sums across the strata, to yield overall length frequencies. Numbers of white warehou were estimated from catch weights using an overall length-weight relationship for trawl surveys on the Chatham Rise (a = 0.0220, b = 3.006) and Sub-Antarctic (a = 0.0263, b = 2.9506), and the length-weight relationship calculated by Horn (1999) for the WCSI region (a = 0.0200, b = 3.037). Length data from tows with more than three white warehou measured were used to create the length frequency distributions by area.

Length frequency distributions are presented for the Chatham Rise, ECNI, Sub-Antarctic, and WCSI in Figures B4–B7, respectively. Sample sizes in the Chatham Rise and Sub-Antarctic regions are larger (Figures B4 and B5), and fish measured in these areas are from effort throughout the year. Fish from Chatham Rise are generally smaller (range 30–60 cm) than those on the ECNI and WCSI, with modes at about 32–36 cm, 39–44 cm, and about 50 cm. There does appear to be a size progression from about 1999–2000 to 2008. Based on the 2000 and 2001 distributions (Figure B4) the progressing mode probably comprises at least two strong year classes. The distribution from 2009 appears relatively uniform, and shows little information on year class.

Sample sizes on the ECNI are small and there is no clear picture of cohorts moving through the fishery (Figure B5). Fish are generally large, with more males than females (Figure B5).

A broad size distribution (25–69 cm) is evident in the Sub-Antarctic fish (Figure B6). In the earlier years, the distributions show a distinct mode at 30–36 cm, with the remaining fish between 45 and 60 cm. These smaller fish are absent or rare in the following years. The mode at about 40 cm seen in the early-2000s does not appear in later years, when most fish were 48–58 cm. The last five years show very similar distributions, although there are also small modes at about 30–35 cm in 2012 and 2013. The progression of a relatively strong year class observed in the trawl survey (length mode at about 30 cm in 1999, probably aged 2+ years) is apparent throughout much of the series. This year class has a mode at 42 cm in 2003, and then a progressive mode from 47 cm in 2006 through to 50 cm in 2010. These lengths and ages match well with the growth curve produced by Horn (2001). As seen in the trawl survey data, the 1+ year class appears to be largely absent from all areas and presumably these small fish are in shallower waters or higher in the water column and thus not available to commercial and research trawls (Figure A9).

Sample sizes on the WCSI are small and there is no clear picture of cohorts moving through the fishery (Figure B7). However, the largest fish are encountered on the WCSI, when observer coverage is mainly in June–September, with fish generally ranging from 50–70 cm. Females appeared to be larger than males in this region, although males appear to be more numerous. The few trawl survey data from this area, in similar depths, also included larger fish (see Figure A15).

Female maturity

Observer data on female white warehou maturity using a 5-stage gonad scale (immature/resting, maturing, ripe, running ripe, spent) are summarised in Table B8 and Figures B8 and B9. Data are available throughout the year for the Chatham Rise, with both immature/resting and maturing fish being present at all times. Where there were reasonable samples (more than 40 per month), ripe fish were present mainly from May–October, running ripe fish were present in June and August–November, and

spent fish were present from August–December, peaking in September. This suggests an extended spawning season from at least May–November. Ripe and running ripe fish occurred mainly on the ECSI and the western Chatham Rise

Data were also available from all months for the Sub-Antarctic region, with both immature/resting and maturing fish being present throughout the year. Ripe fish are present mainly from March–November, running ripe fish from May–October, and spent fish are present from January–April, and September–November, also suggesting an extended spawning season from at least March–November. Spawning in the Sub-Antarctic probably occurs at Puysegur, the Auckland Islands, and the Snares Shelf (Figure B9).

WCSI data are available from June to November, though most are collected during the June–September hoki spawning season. The proportion of immature/resting stage fish is lower, and the proportion of spent fish is higher, than for the same period for the Chatham Rise. Maturing, ripe and running ripe fish were present in all six sampled months, and it was likely that spawning occurred at least from June–September, with the proportion of maturing fish decreasing and the proportion of running ripe and spent fish increasing over that period in Statistical Areas 033–036

There are few data for the ECNI, with most fish immature/resting or maturing, ripe fish found in October and November, and spent fish in January, October, and December.

6.2 Catch and effort data sources

Catch-effort, daily processed, and landed data were requested from the MPI catch-effort database "warehou" as extract 9843 (Table C1). The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of white warehou in WWA fish stock areas (see Figure 1) between 1 October 1989 and 30 September 2014. Data are analysed by fishing year (1 October to 30 September), referred to as, for example, 1990 for the 1989–1990 fishing year. The fields from the database tables requested are listed in Table C1.

TCEPR and TCER forms record tow-by-tow data with the estimated catch (by weight) of the top five species (TCEPRs) or the top eight species (TCERs) in each individual tow. CELR forms record estimated daily catches for the top five species, which are further stratified by statistical area, method of capture, and target species. Greenweight data associated with landing events are reported on the bottom part of the CELR forms, or on CLR forms for fishing reported on TCEPRs and TCERs. Information on total harvest levels are provided via the Quota Management Report/Monthly Harvest Return (QMR/MHR) system, but only at the resolution of Quota Management Area.

The data were groomed and restratified to derive the datasets required for the characterisation and CPUE analyses using a variation of the method developed by Starr (2007) as implemented by Manning et al. (2004), with refinements by Blackwell et al. (2005) and Manning (2007), and further modifications 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 overcomes 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 was developed for monitoring bycatch species in the Adaptive Management Programme. The major steps are as follows.

Step 1: The fishing effort, estimated catch, and landings data are 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 restratified 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 data. 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 and trip ID.

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, but 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: Data for many species are reported using a combination of form types, although some species such as white warehou are reported on TCEPR forms almost exclusively. The original intent of the merging process was to allow trip level landings data to be mapped to CELR effort strata. The grooming and merging process also allows an evaluation of the amount of catch and effort that is not captured using TCEPR and TCER forms at the fishing event level. If this is substantial, 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.

7 DESCRIPTIVE ANALYSIS OF CATCH

7.1 Summary of catches

All tables and figures relating to characterisation of white warehou fisheries are contained in Appendix C (Tables C1–12, Figures C1–53). Table C1 provides a summary of the data requested from MPI for this characterisation, and Table C12 contains a list of species codes used.

The reported QMR/MHR landings, ungroomed catch-effort landings, and TACCs for all WWA fish stocks (except WWA 10) from 1990–2014 are shown in Figure C1. MHR landings and TACCs are also presented earlier in Tables 1 to 3. For all Fishstocks, the ungroomed catch-effort landings are fairly close to the reported MHR landings, except for WWA 3 and 5B in 1998 (Figure C1). During the early- to mid-2000s, the reported MHR landings consistently exceeded the TACCs in WWA 3, 4, and 7, and from 1 October 2006 the TACCs for these areas were increased to 583 t, 330 t, and 127 t, respectively. The catch in WWA 3 in 2006–07 was well above the new TACC, but has been under the TACC since 2007–08 (Figure C1).

The landings data provide a verified 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, as well as interim landing events, where catch is transferred or retained, and may therefore appear subsequently as a final landing event (SeaFIC 2007). The procedure of Starr (2007) separates final and interim landings based on the landing destination code, and only landings with destination codes that 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. The majority of landing events on CELR forms were recorded as “L” (Landed). The proportion of landing events recorded with “T” (transferred to another vessel) and “R” (retained on board) destination codes (both defined as interim landing events by Starr (2007)) for stocks is relatively high for CLR forms from the 1990s to around the early 2000s. From then on there are few “T” events, “R” events decrease (as a proportion of the total) and the majority of landing events are “L” (landed to NZ). It is unclear how the catches from “T” trips are recorded, as the transferred catches could have been landed by foreign vessels to ports outside New Zealand. Other interim landing events (retained as bait, in holding receptacles, or on board) were also dropped (after Starr 2007, Parker & Fu 2011). The conversion factor “J” (observer authorised discard) was introduced in 2013 which will better quantify discarding of white warehou in the future. Destination code “A” may have in the past at least partially accounted for observer authorised

discards (Tiffany Bock, MPI, pers. comm.). A small amount of observer authorised discard landings was recorded in 2014 for WWA 3, WWA 5B, and WWA 7.

The weight, number of records, and description of each potential landed state is given in Table C3. The grooming process excluded a small number of trips with invalid codes in fishing method, target species, statistical area, and trip date which could not be fixed using the median imputation method. The estimated catch and landings removed from the dataset in this process were generally insignificant over the time series. The retained landings, interim landings, and total landings dropped during data grooming are shown in Figure C2. The reported QMR/MHR landings do not match well with the retained landings for a number of fishing years, particularly in the 1990s (Table C4). This improved somewhat after interim destination codes were used less often and the majority of white warehou was landed in New Zealand, though there were still large discrepancies for WWA 5B and 7 in the 2000s.

The main processed state for retained landings of white warehou in WWA 3, 4, 5B, and 7 was "DRE" (includes "dressed", "headed and gutted", and "trunked") with smaller amounts landed green or made into fishmeal (Figure C3). WWA 1, 2, 8, and 9 generally had a mixture of white warehou landed as green or dressed. The "DRE" code use is likely to reflect the presence of larger vessels operating more offshore. For some QMS species conversion factors have changed over time since entering the QMS. This means that for those species different amounts of greenweight catch are associated with the same amount of processed catch for particular product forms. In such cases, the greenweights can be 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, rather than real changes in processing methodology across the fleet. However, other than a minor adjustment of 5.56 to 5.6 for fishmeal on 1 October 1990, and 1.8 to 1.75 for dressed fish on 1 October 2000, white warehou conversion factors have been static and adjustments have not been necessary in this study (Figure C4). The "OAD" ("observer authorised discard") code introduced on 1 October 2013 with a conversion factor of 1 did not appear in this data.

The retained landings adjusted for the changes in conversion factors were allocated to the effort strata based on the statistical areas within each fish stock. For this study, the "centroid method" was used in which the midpoint of each statistical area is used to allocate it to the larger fish stock area, for example, Statistical Areas 018 and 019 were allocated to WWA 3, and Statistical Area 032 was allocated to WWA 5B. This resulted in a closer relationship between QMR/MHR landings, merged landings, and estimated catch for most stocks. Details of the retained landings in unmerged and merged datasets and estimated catches in the groomed and merged datasets are given in Table C4.

Estimated catch, QMR, retained, and merged landings are plotted in Figure C5 and summarised in Table C4. In most WWA stocks the retained landings were usually lower than the QMR/MHR landings, particularly during the early 1990s, and in WWA 5B and 7. There was an improvement in the match between retained landings and QMR/MHR landings from 1998 on. Estimated catches followed the same trend as merged landings, but were consistently lower than the QMR/MHR landings with an improvement from 1998 on (as seen with the retained landings).

The reporting rate, defined to be the ratio of the annual estimated catch to the retained landings in the groomed and merged dataset, is shown in Figure C5. The TCEPR/CLR reporting rate was quite variable in WWA stocks and usually less than 1. Why this is so is uncertain, although for all stocks the annual estimated catches consistently fell short of the reported catches, and there was no apparent change in the level of reporting through the time series (Figure C5). In WWA 2 the reporting rate for TCEPRs decreased to nearly 0%. In WWA 3, the annual TCEPR and CELR estimated catches fluctuated in a similar way as the reported landings for both CELRs and TCEPRs. In WWA 4, which was dominated by vessels using TCEPR forms, the reporting rate was lower, fluctuating between 40–90%. In WWA 5B, also dominated by vessels using TCEPR forms, the reporting rate was higher, fluctuating at about 80–95%, and increasing in recent years. WWA 7 had lower fluctuating reporting rates. WWA 1, 8, and 9 showed no trend due to few data.

The estimated catches and retained landings by form type for each fish stock are shown in Figure C6. For most stocks, most of the estimated catch is reported on the TCEPR form with landings recorded on the CLR form, and there was a small but consistent proportion of catch recorded on CELR forms, presumably by smaller vessels fishing in inshore areas. In the 2008 fishing year, all vessels that previously reported on CELR forms appeared to have switched to TCER forms, however little or no WWA was recorded on the TCER form, except in WWA 7 in 2013 and 2014. In WWA 4, there has been little catch recorded on CELR forms, except in 2006. Most trips that reported landings of white warehou reported estimated catches too. Those that did not tended to be trips with small catches on vessels using CELR forms, generally in WWA 1, 2, 8, and 9 (Table C5). Although estimated catches tend not to be recorded when catches are small (because vessels only report the top five (or eight) species caught), overall the estimated catches represented approximately 80% of the harvest reported via the MHR/QMR system. There also appears to be a reasonably close match between estimated catch and reported landings at trip level (Table C4, Figure C6).

The percentage of TCEPR forms recording a zero estimated catch in the tow-by-tow data ranged from about 9–100%, although this was much lower in stocks with higher catch: 14–40%, 11–45%, 11–49%, and 9–53% for stocks WWA 3, WWA 4, WWA 5B, and WWA 7 respectively (Table C5). On CELR/TCER recorded trips, the percentage is generally higher with 4–100% of trips recording no estimated catch on CELR/TCER forms. Figure C7 also shows that on a trip by trip basis for each fishing year, there appears to be a reasonably close match, where there are larger catches, between estimated catch and reported landings at trip level. However, some trips that recorded no estimated catch reported a small amount of landings (Figure C7).

7.2 Fishery Summary

White warehou is caught as bycatch in a variety of target fisheries around mainland New Zealand, mainly on the ECSI and Chatham Rise, in the Sub-Antarctic, the WCNI, and the WCSI. White warehou was caught in only small amounts on the WCNI so this area was not analysed in detail.

The spatial distribution of the total commercial catch is shown in Figure C8. The highest catches were from the Sub-Antarctic and Chatham Rise regions (Table C6, Figure C9). Within the Chatham Rise region, inshore statistical areas (in particular 020 and 023) had higher catches, with lower catches across most of the Chatham Rise (Figures C8 and C11). Catches in the Sub-Antarctic were highest in 028 (southern part of the Stewart-Snares shelf), 030 (Puysegur Bank, and 602 (Auckland Islands) (Figures C8 and C23). For WCSI, catches were almost entirely from Statistical Areas 034 and 035 (Figures C8 and C34) where much of the effort in the hoki winter spawning fishery is concentrated, with low steady reported catches since the early 1990s. Small catches from the ECNI have consistently been from Statistical Area 014 (southern Hawke Bay), 015 (Wairarapa Coast), and 016 (Cook Strait) (Figures C8 and C45).

Total estimated catch for each region from the groomed and merged dataset are shown in Table C6 and Figure C9. The Sub-Antarctic and Chatham Rise regions were the dominant areas with yearly catches regularly in excess of 300 t in Chatham Rise and 700 t in Sub-Antarctic, compared with the 20–150 t catches reported from WCSI. The ECNI and WCNI catches are minor in comparison, with annual estimated catches ranging from just 4 to 85 t for the ECNI and less than 1 t for the WCNI, totalling 639 and 5 t respectively. Since 1990, total estimated catches for Chatham Rise, Sub-Antarctic, and WCSI were 12 695, 36 778, and 2120 t, respectively.

Across all areas white warehou are caught primarily by bottom trawling, with a small amount also taken by midwater trawling and midwater trawling on the bottom (Figure C9). A variety of other fishing methods are also reported to catch white warehou but catch is negligible.

White warehou was caught as bycatch in a variety of target fisheries around mainland New Zealand throughout the year, mostly in the hoki, hake and ling fisheries, but also in tows targeting squid and silver warehou (Figure C9). White warehou has been a reported target fishery since 1998, when the

species was introduced into the QMS. Most of the targeted catch was taken in the Sub-Antarctic, and since 2000. The annual white warehou catch from the white warehou target fishery has been similar to or greater than that from the hoki target fishery (Figure C10, C23).

Across all fisheries there is no distinct season in which white warehou catches peak, although before 2000 the larger monthly catches were taken in August-September and since 2000 the largest monthly catches were mainly from fishing in October (Figure C9). For the three main regions, catches were reported throughout the year, with the exception of the WCSI where nearly all of the catch was taken between June and September (Figure C34), when the hoki and hake fisheries operated.

Most white warehou catch was from Japanese vessels, with a large proportion of the remainder from Korean and New Zealand vessels (Table C7, Figure C10). All vessel sizes caught white warehou, but the majority of vessels are 50–70 m metres in length and are over 2000 kilowatts in power, and 1700 gross tonnes; a minor amount of white warehou is taken by much smaller inshore vessels (Figure C10).

In this characterisation section, finer scale areas are used to review the hypothesised stock structure as a prelude to developing CPUE analyses that might be useful for monitoring the major fisheries. The fisheries summarised in more detail include CHAT (the east coast South Island and Chatham Rise), the WCSI, SUBA (Sub-Antarctic), and the ECNI (see Figure 1).

7.2.1 East Coast South Island and Chatham Rise (CHAT)

The CHAT region had the second largest proportion of the total white warehou catch for the study period (Table C6, Figure C9). White warehou catches were mainly reported on TCEPR forms with only slightly more of the data captured by the TCEPR processed form (see Figure D1). White warehou were caught mainly by trawlers that fished with bottom trawls and targeted a variety of species, with highest catches as bycatch in hoki trawls (Figure C11). Annual estimated white warehou catches were generally smaller during 1990–95, then increased over time with catches at 413–1058 t during 1995–2008 (Table C8). Since 2009, catches have decreased and varied from 249–404 t, with the 2012–2014 catches the lowest since 1994 (Table C8). No distinct season is apparent for the region, although catches may decrease slightly from June to August when the hoki fleet (which takes the majority of the white warehou catch) moves away from the CHAT area to target hoki spawning fisheries (Table C8a, Figure C11).

Statistical Areas on the ECSI (018, 020–023) produce relatively high catches and account for 64% of the total CHAT estimated catch (Table C8b, Figure C11). The spread of catch across the statistical areas on the Chatham Rise was lower and more even, although Statistical Areas 402, 407, and 408 produced a high proportion of estimated catch in some years. Overall, almost 95% of the white warehou estimated catch in the CHAT region was taken by bottom trawling, with the remainder from midwater trawls (Table C8c, Figure C11). Setnets produced 23% of the reported white warehou catch in 1994 and 1998; it may be that these catches were of blue warehou and misreported as white warehou.

Hoki was the key target species and accounted for 63% of the white warehou catch; only 1% of the white warehou catch was targeted (Table C8d, Figure C11). The catches in hoki trawls were highest in Statistical Areas 018, 020–023 in most years, and 401–402, 407–410 in some years, and in depths of 200–700 m (Figures C12, C13 and C14). Although catches in hoki trawls occurred throughout the year, those in July–September were minimal. Other main target species included alfonsino, ling, squid, and silver warehou, and to a lesser extent bluenose, hake, red cod, sea perch, and white warehou (Table C8d, Figures C11).

The largest white warehou catches in hake fisheries were in Statistical Areas 021, 022, 401, and 404, generally from September–December and in depths of 300–600 m (Figures C12–C14). Ling target catches were taken mainly on the ECSI and western Chatham Rise in some years from August–January and from 300–500 m depths (Figures C12–C14). White warehou catches from silver warehou tows were mainly reported in Statistical Areas 020–023 in most months and from 200–600 m. The largest white warehou catches in alfonsino fisheries were in Statistical Areas 049, 051 and 404 from August–May in depths of 200–400 m. Bluenose had larger catches in Statistical Areas 052 and 404 in most months in

depths of 200–400 m, squid had largest catches in 020–022 from September–June in depths of 100–500m, and white warehou targeting had largest catches in Statistical Areas 020–023 and 401 in most months in depths of 200–600 m (Figures C12–C14).

For the hoki trawl target fishery the proportion of zero estimated tows is over 80%, as is the proportion of zero tows for hake and ling except in 1991 for hake, and ling in 2003 and 2004 (Figure C15). The proportions of zero tows for other species are generally more variable (Figure C15).

Unstandardised catch rates (kg per tow) of white warehou show that for most target species, the white warehou catch rate was variable with little trend (Figure C16). For the main target fishery of hoki, the catch rates were variable and decreased to 2002, and then increased sharply to 2006, and subsequently decreased in the following years. Throughout the time series, catch rates in the hoki fishery ranged from about 20–650 kg per tow. Catch rates from ling targeting were variable at about 30–500 kg per tow, although catch per tow was very high in September 1991, with some large catches of white warehou (20–89 t by one vessel). This may be due to mis-reporting of silver and white warehou, but cannot be verified from the data. Target hake catch rates showed no trend, although were higher in 1997 and 2007, and ranged from 100–1900 kg per tow. Target silver warehou catch rates also showed no trend, although they were very high in 1997. Target white warehou catch rates showed no trend, and were very low from 2012–2014. In other main target fisheries where the effort is much less than for hoki, annual catch rates ranged up to almost 500 kg per tow, and were variable, although they decreased for the alfonsino fishery in recent years.

Fishing duration for bottom tows targeting hoki with reported white warehou catch was generally in the range 3–5 hours per tow with an increasing trend over the time series (Figure C17). Daily bottom tow duration for target hake increased from the early 1990s to peak at about 10 hours per day in 2009, but has decreased. Daily bottom tow durations for targets white warehou, silver warehou, ling and squid showed more variable and sometimes longer durations to hoki with no overall trend. Tow duration was lower during tows that targeted bluenose, or alfonsino.

Median effort depth for bottom trawls with white warehou catch has been constant from the late 1990s for tows targeting hoki, at about 500–600 m (Figure C18). Effort depth for hake is similar to hoki but with a slightly narrower range, except in 2011 where fishing was much deeper. Generally other target fisheries caught white warehou in shallower waters: under 500 m for white warehou, silver warehou and ling; 200–300 m for squid; and under 400 m, but variable, for alfonsino and bluenose and red cod.

The distributions for data describing bottom trawl gear width (wingspread), gear height, distance towed, and vessel speed, tonnage, and length by target species (when white warehou catches were reported) are shown in Figure C19. Effort widths were generally about 30–45 m, except for bluenose and alfonsino with width at 15–30 m, and white warehou with a narrow range between 20–30 m. Generally, the tows targeted at middle depth species had headline heights of under 4 m, apart from bluenose and alfonsino which was about 4.5–5.5 m. Effort speed was similar for most middle depth target species, at between 3.5 and 4.5 kt, although bluenose and alfonsino tows had a speed generally below 3.5 kt. Most fishing distances were 10–50 km per tow, though alfonsino and bluenose targeting resulted in very short distances. Vessels that caught white warehou on hoki target tows were generally about twice the tonnage of vessels catching other target species. Smaller vessels targeted bluenose, alfonsino, and larger vessels (most 50–70 m long) targeted other species. The full range of vessel sizes shown in Figure C19 reflects the spread of smaller inshore vessels fishing at Mernoo Bank and inshore waters of the Chatham Islands and the larger vessels fishing a range of depths across the Chatham Rise.

The distribution of white warehou catch by vessels reporting on TCEPR forms has not changed since 1990, although in some years they are more widespread (Figure C20). Highest catches for this time period are from the ECSI, the Mernoo Gap area, and in some years along the north and south Chatham Rise and around the Chatham Islands (Figure C20).

White warehou was caught in some target tows for target hoki, hake, ling and silver warehou (Figure C21), especially in shallower depths. Other species showed some tows with no white warehou caught, especially in deeper waters. White warehou was generally caught when it was targeted.

7.2.2 Sub-Antarctic (SUBA)

The Sub-Antarctic region contributes by far the greatest proportion of the country's white warehou catch (Table C6, Figure C9). White warehou catches from Sub-Antarctic were mainly reported on TCEPR forms, with similar amounts of the data captured by the TCEPR processed form (see Figure D1). White warehou are caught mainly by bottom trawls targeting a variety of species, with highest catches as bycatch in target white warehou, hoki, hake, ling, and silver warehou trawls (Table C9, Figure C22). Estimated annual white warehou catches ranged from 878–2647 t, with most over 1000 t (Table C9a). There does not appear to be a distinct season, with white warehou caught in all months, although in earlier years there were higher catches in September and in the 2000s there were higher catches in October. In the last eight years, there were higher catches for September–December (Table C9a, Figure C22).

Most white warehou is caught in Statistical Areas 028 (Snares Shelf), 030 (Puysegur Bank), and 602 (Auckland Islands); these areas account for 77% of the total Sub-Antarctic estimated catch (Table C9b, Figure C22). Overall, more than 99% of the white warehou estimated catch in Sub-Antarctic was taken by bottom trawling, with the remainder from midwater trawls (Table C9c, Figure C22).

Unlike the Chatham Rise region, more of the Sub-Antarctic white warehou catch was taken in tows that targeted white warehou than any other target species (i.e., 36% overall). White warehou targeting accounted for over 50% of the catch in most years from 2003 (Table C9d, Figure C22). Ling, hoki, and silver warehou were other dominant target fisheries, with 22%, 18%, and 15% of the overall catch respectively, with other minor target fisheries including hake, scampi, squid, and barracouta (Table C9d, Figure 22). Silver warehou was a dominant target in the 1990s, and white warehou has been a dominant target since 1999, which is likely to be due to the introduction of white warehou into QMS from 1 October 1998. The catches in white warehou target trawls were mainly on the Snares Shelf (area 028), at Puysegur (030), and in the last seven years north east of the Auckland Islands (610), in depths of 300–700 m, in most months of the year (Figures C23–C25). Catches from silver warehou tows were mainly reported in Statistical Areas 028 and 030 in most months, and in depths of 300–700 m (Figure C25).

White warehou catches in ling and hoki tows were high in some years, especially during ling tows in September in some years (Figure C24). The catches in hoki trawls were mainly on the Snares Shelf (areas 026–028), at Puysegur (030), and around the Auckland Islands (602), in depths of 300–700 m (Figures C23–C25). Although catches in hoki trawls occurred throughout the year, catches in July and August were minimal in the last five years. Ling target catches were taken mainly in Statistical Areas 028, 030, and 602 from September–January, and in 400–700 m depths (Figures C23–C25). Squid fisheries had largest catches in areas 026–028, 030, 504 and 602, from October to June, in depths of 100–500 m; scampi fisheries had largest catches in the Auckland Islands (602) year-round in depths of 400–500 m; hake fisheries had larger white warehou catches in Statistical Areas 028 and 602, generally from October–March and in depths of 400–700 m; and barracouta fisheries had catches mainly in the 1990s in 026, 028 and 029 in December–May in depths of 100–400 m (Figures C23–C25).

When white warehou was the reported target, the proportion of tows with zero catches of white warehou in the estimated tow-by-tow data was generally below 20%, whereas silver warehou target trawls had from 40–95% of zero tows with higher proportions from 2004 (Figure C26). For target hoki trawls, the proportion of tows with zero white warehou catches was high at about 90% until 2004, but has been generally lower since then (Figure C26). The proportions of zero catch tows for target ling and hake trawls varied between 40–90%, and 15–90% respectively, and for other species is high (over 95%) (Figure C26).

Unstandardised catch rates (kg per tow) of white warehou varied markedly for most target species (Figure C27). Target white warehou catch rates were variable in the 1990s when there were few target tows, and since 2000 catch rates have been fairly stable, at about 400–600 kg per tow. The hoki, scampi,

and squid target fisheries have also showed a fairly stable catch rate, whereas catch rates in other target fisheries such as ling, silver warehou, and hake decreased in later years.

Fishing duration for bottom tows with reported white warehou catch in the white warehou, scampi, ling, and hoki fisheries remained relatively constant throughout the time period whereas fishing duration showed an increasing trend in the silver warehou, and squid fisheries since 2005 (Figure C28). Other less important target fisheries had more variable tow durations for bottom trawls.

Median effort depth for bottom tows in the Sub-Antarctic is similar to many of the same target species in the Chatham Rise region, with most tows being in 400–600 m for most species and ranging from 200–800 m (Figure C29). There were some clear distinctions in depth ranges of TCEPR bottom tows that caught white warehou: targets included squid in waters at about 200–350m m; silver warehou in 300–500 m; white warehou and scampi in 400–500 m; ling in 400–700 m; and hoki mainly in 500–700 m.

The distributions for data describing bottom trawl gear width (wingspread), gear height, distance towed, and vessel speed, tonnage, and length by target species (when white warehou catches were reported) are shown in Figure C30. Effort widths were generally about 30–45 m, except for white warehou and hake target trawls with effort widths of 10–30 m, and twin-net scampi trawls at 50–60 m. Scampi headline heights were the lowest, at about 1 m. Generally, the tows targeted at middle depth species had headline heights of under 4 m, apart from white warehou and hake target tows which were up to 7 m. Effort speed was similar for most middle depth target species, at between 3.5 and 4.5 kts, except for scampi tows at about 2.5 kts. Most tow fishing distances were between 10–40 km per tow, except for white warehou and hake target tows which were at 10–20 km per tow. Vessel tonnage ranged from around 100–4500 t with most being between 500 and 2500 t. Vessels that caught white warehou on hoki target tows had higher vessel tonnage compared with other target fisheries, and scampi vessels had a much lower tonnage. Vessel length for most species is around 50–70 m, with scampi vessels being noticeably smaller at 20–40 m.

The distribution of white warehou catch reported on TCEPR forms was similar each year, with most of the catch taken around the Snares Shelf, Puysegur Bank, and Auckland Islands (Figure C31). In some years reasonable catches are taken from the Pukaki Rise. Vessels targeting the main middle depth target species in the Sub-Antarctic generally caught white warehou (Figure C32). Hoki target tows caught white warehou in a wider area including on the Campbell Plateau, and tows in shallower (targeting squid, scampi, silver warehou, and barracouta) or deeper waters (targeting hoki or ling) often caught no white warehou.

7.2.3 West coast south Island (WCSI)

The WCSI region contributed an estimated 2120 t of white warehou, about 4% of the total white warehou catch for 1990–2014 (Table C6, Figure C33a). White warehou catches from WCSI were mainly reported on TCEPR forms, with only slightly more of the data captured by the TCEPR processed form; 20% of the WCSI catch was reported on the TCER form in 2013 and 2014 (see Figure D1).

White warehou are caught predominantly by bottom trawling for a variety of target species, with highest catches as bycatch in hoki and hake trawls (Table C10, Figure C33a). Annual white warehou catches from this area were relatively small during 1990–2002 at 19–99 t, but increased from 2003–2009 to levels ranging from 102–143 t (Table C10a). Catches decreased from 2010–2012 to 53–62 t, and increased slightly to 132 and 106 t respectively in 2013 and 2014. The WCSI is the only region to have a distinct season with nearly all of the catch taken during June to October (Table C10a, Figure C33a) which coincides with the hoki and hake spawning fisheries.

On the WCSI, Statistical Areas 033–035 have the highest catches, with 034 accounting for 80% of the overall catch (Table C10b, Figure C33a). The white warehou catch increased in area 034 from about 1998 and remained fairly constant since then despite cuts in the hoki quota (which started in 2002). Overall, 88%

of the white warehou estimated catch on the WCSI was taken by bottom trawling, with the remainder from midwater trawls (Table C10c, Figure C33a), and the bottom trawl component of the catch has increased to over 97% since 2002 (Table C10d). Midwater trawl gear is the predominant gear type in the WCSI hoki and hake spawning fisheries, though bottom trawling has accounted for about a third of the hoki catch since 2004 (Ballara & O'Driscoll 2015). Often in the hoki target fishery, midwater trawls are fished on or near the seafloor and this probably accounts for the greater importance of midwater trawling for white warehou in the WCSI region (Ballara & O'Driscoll 2015).

Hoki and hake were the key target species on the WCSI and accounted for 50% and 46% of the total estimated white warehou catch, respectively (Table C10d). Hoki was the dominant target species from 1999 until 2005. The proportion of the catch from the hake fishery increased from 2003 and since 2005 the hake fishery has become the dominant target fishery catching white warehou in this region. The other main target species produced only 4% of the estimated white warehou catch, with small quantities from barracouta, jack mackerel, lookdown dory, ling, orange roughy, gemfish, white warehou and silver warehou target fishing (Table C10d).

In 2013 and 2014, about 20% of the WCSI white warehou was reported on the TCER form in Statistical Areas 033 and 034 by bottom trawling from May–September, targeting hake, and white warehou in depths of 400–750 m by small vessels (Figure C33b).

White warehou catches from the hoki and hake target fisheries were largest in Statistical Areas 034 and 035 from June–September, and mainly in depths of 400–800 m and 500–800 m respectively (Figures C34–C36). Other target species had variable white warehou catches generally in Statistical Area 034, in October–December in depths of 300–700 m (Figures C34–C36).

When bottom trawling for hoki or hake, the proportion of tows with zero white warehou catch in the estimated data has generally been high (i.e., hoki generally over 90% and hake between 40–100%), as have proportions for other target species (Figure C37).

Unstandardised catch rates (kg per tow) of white warehou for bottom trawling show that for the hoki target fishery, effort in bottom tows increased until 2003, and then decreased and catch rates were variable with about 300–500 kg per tow (Figure 38). In the hake fishery there was a corresponding expansion in effort of bottom tows from 2003 with the catch of white warehou per tow variable, but decreasing over time, and around 300–600 kg per tow during the last few years.

Fishing duration for bottom tows with reported white warehou catch in the hoki target fishery had an overall range of around 4–8 h per tow, and showed an increasing trend with increased variability (Figure C39). Bottom tow duration for target hake trawls has varied between 5 and 10 hours a day, although it has primarily been near the upper end of this range in the last few years. Bottom tow durations for other target species generally had shorter durations than hoki, with more variation. Tow duration for silver warehou target tows appears to have increased in a similar way.

Median effort depth for bottom trawls with white warehou catch for hoki and hake target fishing is relatively constant at between 400–600 m for hoki, and 500–700 m for hake, with depth ranges of around 200–800 m in most fishing years (Figure C40).

The distributions for data describing bottom trawl gear width (wingspread), gear height, distance towed, and vessel speed, tonnage, and length by target species (when white warehou catches were reported) are shown in Figure C41. Effort widths for bottom trawls for hoki and hake target species trawls were generally about 35–45 m, and had headline heights under 5 m. Effort speed was similar, at between 3.5 and 4.5 kts, and most fishing distances were 20–40 km per tow, although hake target tows were often 70 km, and hake and hoki targeting distances were often as low as 10 km per tow. Most vessels catching white warehou tended to be longer than 50 m. Target species, effort variables and vessel characteristics for vessels catching white warehou off WCSI are similar to those for the Sub-Antarctic and CHAT

regions, most likely because many of the vessels that fish in those areas also fish on the WCSI during the hoki spawning season.

The distribution of white warehou catch by vessels reporting on TCEPR forms from the WCSI has not changed since 1990, with the white warehou catches taken on the hoki and hake spawning grounds (Statistical Areas 034 and 035) mainly along the 500 m contour (Figure C42a). In some years catches are more widespread, being further north on the WCSI (Statistical Area 036). The distribution of white warehou catch by vessels reporting on TCER forms was almost entirely in Statistical Areas 033 and 034 also along the 500 m contour (Figure C42b).

For both TCEPR and TCER forms vessels targeting hoki and hake on the WCSI generally caught white warehou, and other target species fisheries did not catch white warehou (Figure C43).

7.2.4 East Coast North Island (ECNI)

Of the four main areas identified in this study, ECNI contributes by far the least amount of the country's white warehou catch, ranging from 4–85 t each year and just 639 t of estimated catch for the study period (Table C6, Figure C9), or 1.2% of the total catch. White warehou catches from this area were reported on TCEPR, TCER, and CELR forms, with most TCEPR estimated catch from 1993–1999, and CELR data mainly from 1990–1993, with very little TCER catch (Figure C44).

There does not appear to be a distinct season, with white warehou caught in all months except July and August (Table 11a, Figure C44). Higher catches were in Statistical Areas 014 and 015 (southern Hawke Bay and Wairarapa Coast), and 016 (Cook Strait), in all years (Table C11b, Figure C44). White warehou are caught by bottom and midwater trawls, with 58% of the catch taken by bottom trawling (Table 11c, Figure C44). A variety of species were targeted with 77% of the catch taken as bycatch in hoki trawls (Table 11d, Figure C44). There is no targeted fishing for white warehou in the ECNI region.

Hoki was the most common target species producing white warehou catch on ECNI. Hoki bottom target white warehou catch was mainly in Statistical Areas 014–015 from October–June in depths of 300–600 m, and midwater trawls from Statistical Areas 015–016 from October–June in depths of 100–600 m (Figures C45–C47). For all target fisheries the proportion of tows with zero white warehou catch has been more that 90% for both bottom and midwater trawls (Figure C48).

Unstandardised catch rates (kg per tow) of white warehou show that for most target species, the white warehou catch rate was variable with little trend (Figure C49). For bottom trawls in the hoki fishery, unstandardised catch rates of white warehou decreased until 2002, and then increased, but were variable (ranging10–140 kg per tow) (Figure C49).Unstandardised catch rates for midwater trawls were variable but higher from 2006, and ranged between 10–200 kg per tow (Figure C49). Data were variable and patchy in other target fisheries.

Tow duration in bottom and midwater tows for hoki was usually around 2–4 h per tow.

Most white warehou caught in the hoki bottom trawl target fishery was caught at depths of between 200–400 m, although midwater trawls fished shallower depths of 150–400 m (Figure C51). Effort depth was consistent for scampi with most tows being between 350–400 m, and white warehou caught in the cardinalfish target fishery was mainly at depths between 500–700 m, and for alfonsino between 400–600 m (Figure C51).

The distributions for data describing bottom and midwater trawl gear width (wingspread), gear height, distance towed, and vessel speed, tonnage, and length by target (when white warehou catches were reported) are shown in Figure C52. Effort widths for bottom trawls for hoki were generally about 20–35 m, widths for alfonsino and cardinalfish were less than 20 m, and vessels targeting scampi reported wider widths (about 40–60 m) that reflect the number of nets used (Figure C52a). Generally, the bottom tows targeting hoki had headline heights less than 4 m, and those for target alfonsino and cardinalfish

were higher at about 6 m, and for scampi were about 1 m, although the range for scampi tows was wide. Effort speeds for bottom trawls were slightly slower than those seen in most fisheries in other areas, generally ranging 3–3.5 kts, although hoki target tows ranged 4–4.5 kts, and scampi tows were about 2.5 kts. Most bottom trawl fishing distances were between 5 and 30 km per tow, although alfonsino and cardinalfish had much shorter distances of less than 10 km per tow. Vessels targeting hoki with midwater gear mainly reported effort widths of about 60–90 m, and vessels targeting alfonsino were mainly between 30–80 m (Figure C52b). For both hoki and alfonsino midwater tows, headline heights were less than 5 m, effort speed was 3.5–4 kts, and distances towed were generally less than 10 km, although there were some longer distances (Figure C52b). Vessels that caught white warehou in ECNI were generally small with most being less than 750 GRT and 40 m in length (Figures C52a and C52b).

The distribution of white warehou catches for the region was variable during the study period for bottom and midwater trawl vessels reporting on TCEPRs (Figure C53). The catch was mainly taken from Statistical Areas 014–016 off the lower east coast and in Cook Strait although this distribution was patchy, especially in later years (Figures C53 and C54). Hoki bottom target white warehou catch was mainly in Statistical Areas 014–016, and midwater trawls from Statistical Areas 015–016 (Figure C54). White warehou was caught in alfonsino target trawls in Statistical Areas 014–015 for bottom trawls, and Statistical Area 015 for midwater trawls, whereas white warehou catches from target cardinalfish and scampi tows were mainly in Statistical Areas 014 and 015 (Figure C54).

7.2.5 West Coast North Island (WCNI)

Of the five main areas identified in this study, the WCNI contributed the least amount of the total white warehou catch, with annual catches ranging from 0–1.1 t for 1990–2014 and an overall total catch of 3.9 t. No further analysis of this area was undertaken.

7.2.6 Summary

A summary of the characterisations by fishery areas is given in Table 7. White warehou was sometimes targeted and was often recorded in the top five species on TCEPR forms; hence the estimated tow-by-tow data were used in the characterisations.

The Chatham Rise region contributes 24% of the country's white warehou catch, with catches mainly reported on the TCEPR form by bottom trawlers targeting a variety of species, and with highest catches as bycatch in hoki trawls (63%). Annual estimated white warehou catches from this area were generally smaller during 1990–95, then increased over time with catches at 413–1058 t during 1995–2008. Since 2009, catches have decreased and varied from 249–404 t, with the 2012–2014 catches the lowest since 1994. No distinct season is apparent for the region, although it appears that catches may decrease slightly from July–August when vessels move away to target hoki spawning fisheries. Highest catches are from the ECSI, the Mernoo Gap area, and sometimes along the north and south Chatham Rise and around the Chatham Islands.

The Sub-Antarctic region contributes the greatest proportion of the country's white warehou. White warehou catches were mainly reported on TCEPR forms by bottom trawlers targeting a variety of species, with highest catches in the white warehou target fishery and as bycatch in hoki, hake, ling, and silver warehou target trawls. In this area, white warehou target catch accounted for over 50% of the catch in most years from 2003. Most annual white warehou catches were over 1000 t. No distinct season is apparent for the region, although catches tend to be higher in September–December, and lower in January–April. Most white warehou is caught around the Auckland Islands, Snares Shelf, and Puysegur Bank. In some years reasonable catches are taken on the Pukaki Rise, the south western Bounty Plateau, and around the Campbell Rise.

The WCSI region contributed 4% of the country's white warehou estimated catch, with catches mainly reported on TCEPR forms (although 20% was reported on the TCER form in 2013 and 2014). About 88% of the white warehou catch was taken by bottom trawling, with the remainder from midwater trawls, although the bottom trawl component increased to over 97% since 2002. White warehou are caught in a variety of target fisheries, with highest catches as bycatch in hoki and hake target tows. White warehou catch in the hake fishery increased on the WCSI since 2003 and has been greater than bycatch from the hoki fishery since 2005. White warehou catch occurs primarily in Statistical Areas 033–035 along the 500 m contour, and in Statistical Areas 033–034 for TCER vessels in 2013 and 2014. The WCSI was the only region with a distinct time of year in which white warehou was caught — a reflection of the timing of the winter hoki spawning fishery in that area.

The ECNI contributes the least amount of the country's white warehou catch, with 639 t of estimated catch (1.2% of the total catch). White warehou catches were mainly reported on TCEPR and CELR forms, with catches mainly by bottom trawlers targeting a variety of species, particularly hoki. No distinct season is apparent for ECNI. The catch is mainly taken from Statistical Areas 014 and 015 (southern Hawke Bay and Wairarapa Coast), and 016 (Cook Strait).

Fishing effort variables, target species and vessel characteristics are similar between the Chatham Rise, Sub-Antarctic, and WCSI regions. It is likely that many of the vessels that catch white warehou are active in all three areas at different times of the year.

On the basis of this characterisation, the Chatham Rise and Sub-Antarctic regions have large enough and stable enough white warehou catches over time to be used in a standardised CPUE analysis. A standardised CPUE analysis for the WCSI is also investigated, although catches and numbers of records are small.

Table 7: Summary of features of the main white warehou fisheries. BT, bottom trawl; MW, midwater trawl. Fish stock and area definitions are shown in Figures 1 and 3 species codes are defined in Table C12.

Area WWA	ECNI 1 and 2	CHAT Upper 3, all of 4	SUBA Lower 3, all of 5B	WCSI 7	WCNI 8 and 9
General characteristics					
Key fishery areas	Cook Strait, Wairarapa Coast South Hawkes Bay	East coast South Island/Chatham Rise	Snares Shelf/ Auckland Islands	West coast South Island	West coast North Island
Key statistical areas	014, 015, 016	018, 020, 022, 023	028, 030	034, 035	-
Secondary statistical areas		401–402, 404, 407–408	602		
Season	Year round, slight decline in Jul–Aug	Year round, slight decline in Jul–Aug	Year round	Jun–Oct	-
Gear type	BT/MW	BT	BT	BT/MW	- -
Target species					
Key target species	HOK	HOK	WWA, LIN, HOK, SWA	HOK, HAK	
Secondary target species	SCI, BYX	LIN, SWA, BYX, SQU,	HAK, SQU	NA	-
Target WWA as a % of total catch	1%	1 %	36 %, > 50% from 2003	1 %	-
Target WWA catch trends	-	-	Stable	-	-
Target WWA catch rate trends	-	-	Flat	-	-

8. CPUE ANALYSES

The focus of this analysis is on the three fishery areas Chatham Rise, Sub-Antarctic, and WCSI, where deepwater vessels operate using bottom trawl. All tables and figures relating to CPUE analyses for white warehou are contained in Appendix D (Tables D1–D6, Figures D1–D33). For standardised CPUE analyses of trawl catches, the use of 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). As almost all white warehou catch is recorded on the top five species estimated tow-by-tow part of the TCEPR form (Figure D1), and previous CPUE analyses also found the overall trend for estimated tow-by-tow and daily processed CPUE indices to be similar (Ballara & Baird 2012), this study did not use daily processed catch for CPUE analyses. Observer tow-by-tow catch was also analysed for the Chatham Rise, Sub-Antarctic, and WCSI areas, as there were consistent sets of data from these areas (Figure D1).

Annual unstandardised (raw) CPUE indices were calculated as the mean of the catch per tow (in kilograms) for TCEPR estimated and observed tow-by-tow data. Estimates of relative year effects were obtained from a stepwise multiple regression method, where the data were fitted using a lognormal model using log transformed non-zero catch-effort data. A forward stepwise multiple-regression fitting algorithm (Chambers & Hastie 1991) implemented in the R statistical programming language (R Development Core Team 2013) was used to fit all models. The algorithm generates a final regression model iteratively and used the year term as the initial or base model in all cases. The reduction in residual deviance (denoted R^2) was calculated for each single term added to the base model. The term that resulted in the greatest reduction in the residual deviance was then added to the base model, where the change was at least 1%. The algorithm was then repeated, updating the base model, until no more terms were added. Interaction terms were ignored as only bottom tows were used. A stopping rule of 1% change in residual deviance was used because this results in a relatively parsimonious model with moderate explanatory power. Alternative stopping rules or error structures were not investigated.

The variable year was treated as a categorical value so that the regression coefficients of each year could vary independently within the model. The relative year effects calculated from the regression coefficients represent the change in CPUE through time, all other effects having been taken into account, and represents a possible index of abundance. Year was standardised to the first year. Year indices were standardised to the mean and were presented in canonical form (Francis 1999).

Categorical and continuous variables offered to the model are listed in Table D1. Fits to continuous variables were modelled as third-order polynomials, though a fourth-order polynomial was also offered to the models for duration. In each analysis, statistical area and latitude or longitude were not allowed to enter the same model at the same time because they were correlated. Twin trawl vessels for the years 1996–2007 were defined as in Hurst (2009), data from 2008 was identified as a possible twin trawl tow using vessels identified in Hurst (2009), and from 2009–2014 were identified from the catch effort primary method code (Table D2).

Vessel was incorporated into the CPUE standardisation to allow for differences in fishing power between vessels. Vessels not involved in the fishery for at least three consecutive years should be excluded because they provided little information for the standardisations, which could result in model over-fitting (Francis 2001). Thus, CPUE analyses were undertaken for "core" vessels that were determined for each area analysis using gear- and area-specific criteria based on approximately 80% of positive white warehou catch, the number of years of vessel participation, and the number of tows per vessel-year (Table D3, Figure D2).

The influence of each variable accepted into the lognormal models was described by coefficient–distribution–influence (CDI) plots (Bentley et al. 2012). These plots show the combined effect of (a) the expected log catch for each level of the variable (model coefficients) and (b) the distribution of the levels

of the variable in each year, and therefore describe the influence that the variable has on the unstandardised CPUE and that is accounted for by the standardisation.

Model fits to the lognormal component of the combined model were investigated using standard residual diagnostics. For each model, a plot of residuals against fitted values and a plot of residuals against quantiles of the standard normal distribution were produced to check for departures from the regression assumptions of homoscedasticity and normality of errors in log-space (i.e., log-normal errors). For the binomial component, model fits were investigated visually using randomised quantile residuals (Dunn & Smyth 1996). Randomised quantile residuals are based on the idea of inverting the estimated distribution function for each observation to obtain exactly standard normal residuals. For discrete distributions, such as the binomial, some randomisation was introduced to produce continuous normal residuals.

The data constraints applied to each of the lognormal, binomial, and delta-lognormal models presented here are given in Table D3. The following models for bottom trawl fisheries were run: the Chatham Rise 1994–2014 data for main target species; the Sub-Antarctic 1992–2014 TCEPR data and 1998–2014 observer data for main target species; and the WCSI 1993–2014 TCEPR data and 1998–2014 observer data for hoki or hake target species. For each of the models, the number of vessels, amount of effort, proportion of zeros, and amount of white warehou catch, and the unstandardised CPUE are listed in Table D4, for all vessels and core vessels. The variables retained in each model are given in Table D5 and the CPUE indices (calculated as the mean of catch per tow (kg)) by fishing year are given for each model in Table D6.

The Chatham Rise and Sub-Antarctic regions were considered for standardised CPUE analyses because they were the regions in which there was a reasonable level of white warehou catch (over 200 t per annum) for at least 10 years (1990–2014 fishing years). A standardised CPUE analysis of the WCSI region was also carried out; however, as catches ranged from 19 to 143 t per year, results may not be reliable as indices of abundance.

8.1 Chatham Rise (CHAT)

TCEPR model

White warehou catches from the Chatham Rise were mainly reported on TCEPR forms with only slightly more of the data captured by the TCEPR processed form (see Figure D1), hence the estimated tow-by-tow dataset is an appropriate dataset to analyse. A Chatham Rise tow-by-tow model used data from bottom trawl for main target fisheries from fishing years 1994 to 2014 (Table D3).

A total of 119 unique vessels (range 21–60 vessels each year) using bottom tows caught 7001 t of white warehou since 1994, from 154 745 tows (Table D4). The percentage of zero tows was high, ranging from 82 to 95%. Core vessels for the tow-by-tow estimated index were defined as those participating in the fishery for six or more years, and reporting all tows per vessel-year (Table D3, Figures D2 and D3). Forty-seven core vessels (range 12–39 per year) caught 6141.6 t of white warehou, representing 87% of the total catch during 1994–2014 with catches for core vessels ranging from 35.3–636.9 t annually (Table D4). The number of all vessels has declined steadily since its peak in the mid-1990s (Table D4).

Four variables were selected into the lognormal model, resulting in a total R^2 of 26.4%, with *vessel* explaining 23.6% of the residual deviance (Table D5). The other variables selected were *Statistical Area*, and *start time*. In contrast for the binomial model, 13.4% of the residual deviance was explained by four retained variables, with *depth of bottom* included and *start time* excluded.

Overall the estimated tow-by-tow lognormal standardised catch indices showed an increasing trend with minor fluctuations from 1990 to 2006, followed by a decrease to 2009, and then a flattening off (Table D6 Figure D4). Confidence intervals are small, probably due to the small nature of most white warehou

catches. This catch index matches the unstandardised index reasonably well except for the first two and last few years. The low binomial probability results in some differences between the lognormal and the delta-lognormal indices (Figure D5).There is little effect in the addition of retained variables in the lognormal model (Figure D6), except for the first two and last few years. The overall trend of the standardised biomass indices from the Chatham Rise trawl survey series shows an increase, and then a decrease while the CPUE lognormal indices are relatively flat (Figure D7).

The effects of the selected variables on the expected catch rates of white warehou in the lognormal catch models are shown in the CDI plots in Figure D8. Generally, the changes in the influence of the main variables was small. For vessel – the variable with the most explanatory power – changes are related to the movement of vessels out of the fishery, especially the negative influence in 2012–2014; for statistical area – changes are largely related to fishing area, with relatively higher catches for statistical areas closer to the ECSI or the Chatham Islands. Predicted CPUE by statistical area generally followed the overall lognormal CPUE trend for most statistical areas, although there were some exceptions in individual years (Figure D9). Higher coefficients were estimated when start times were in the late morning (Figure D8). Non-zero catches are more likely in ECSI statistical areas, and in depths between 300–500 m (Figure D10a).

The lognormal diagnostics were reasonably satisfied and the quantile–quantile plot for the lognormal model indicated balanced residuals and no significant deviations from normality (Figure D11). The diagnostics for the binomial model indicated a reasonable pattern in the residuals and the quantile-quantile plot appeared adequate (Figure D12).

Observer model

Data collected by observers from the Chatham Rise main target species trawl fisheries was also analysed to produce a CPUE series, using the combined model from fishing years 1994 to 2014 (Table D3). The total data set included 74 observed vessels, while the final data set had 46 vessels that had been observed for at least two years (Table D3 and D4). There were 7621 tows in the core data set, and 31–70% of tows reported no white warehou catch per year (Table D4).

Five variables were selected into the lognormal model, resulting in a total R^2 of 24%, with *vessel* explaining 19% of the residual deviance (Table D5). The other variables selected included *depth of bottom*, *latitude*, and *longitude*. The binomial model explained 12.6% of the residual deviance with four retained variables, all the same as the lognormal model variables.

The lognormal standardised catch index shows an overall flat trend, although there is an increasing trend from 1999 to 2007, with a subsequent decrease to 2010, and then a flattening off of indices, and it matches the unstandardised index reasonably well in most years (Table D6, Figure D4). The binomial series has no trend, although indices are a bit lower in 1996 and 1997, and the delta-lognormal indices are generally similar to the lognormal model, although they are affected by years when the binomial indices are lower, especially in 2006 (Figure D5). The addition of retained variables in the lognormal model have an effect of increasing the index in 1994 and lowering the index in 2005 and 2006, with the addition of vessel having the largest impact on the model (Figure D6). The observer series seems to follow the overall trend of the TCEPR tow-by-tow indices except early years when there is much less data (Figure D7). Standardised lognormal TCEPR and observer CPUE indices are relatively flat, and biomass indices from the Chatham Rise trawl survey series show an increase, and then a decrease, although all indices indicate a decline from 2005 to 2010, with a subsequent levelling off (Figure D7).

Generally, the changes in the influence of the main variables was small (Figure D8b). For vessel, higher catch rates are related to change in vessels, and the negative influence in 1994 and 1995 affected by effort from a few vessels in these years. For latitude and longitude, the changes are related to fishing area, with higher catch rates in areas closer to the ECSI or near Chatham Islands, and higher coefficients were also estimated when effort occurred in shallower water. Non-zero catches are more likely to the

south, between longitudes 174–177° and to the far-east, and in depths of greater than 300–500 m (Figure D10b).

The model assumptions were well satisfied, with very balanced residuals and no significant deviations from normality (Figure D11 and D12).

8.2 Sub-Antarctic (SUBA)

TCEPR model

White warehou catches from the Sub-Antarctic were mainly reported on TCEPR forms with only slightly more of the data captured by the TCEPR processed form (see Figure D1), hence the estimated tow-by-tow dataset is an appropriate dataset to analyse. A Sub-Antarctic model used data from bottom trawl for the main target fisheries in fishing years 1992 to 2014 (Table D3).

A total of 100 unique vessels (range 17–40 vessels each year) targeting hake, hoki, ling, silver warehou, white warehou, or squid in bottom tows caught an estimated 26 752 t of white warehou since 1992, from 120 636 tows (Table D4). The percentage of zero tows for core vessels was high, ranging between 68–91%. Core vessels were defined as those participating in the fishery for four or more years, and reporting more than 20 tows per vessel-year (Table D3, Figures D13 and D14). Twenty four core vessels (range 3–13 per year) caught an estimated 18 590 t of white warehou, representing 69% of the total estimated catch for these target species (Table D4). As for the Chatham Rise, the number of all vessels has declined steadily since its peak in the mid-1990s (Table D4).

Four variables were selected into the lognormal model, resulting in a total R^2 of 35.6%, with *target species* explaining 24.7% of the residual deviance (Table D5). The other variables selected included *vessel*, *statistical area*, and *start time*. In contrast for the binomial model, 28.6% of the residual deviance was explained by five retained variables, with *depth of bottom* included and *start time* excluded.

The estimated tow-by-tow lognormal standardised catch index increased up to 1996, decreased sharply to 1997 and then stabilised, with minor fluctuations through to 2014 (Table D6, Figure D15), and the index matches the unstandardised index reasonably well from 2006. The low binomial probability results in some differences between the lognormal and the delta-lognormal indices (Figure D16).There is some effect in the addition of retained variables in the lognormal model in the earlier years (Figure D17). When plotted together, the standardised biomass indices from the Sub-Antarctic trawl survey series poorly match the CPUE series (Figure D18).

The effects of the selected variables on the expected catch rates of white warehou in the lognormal catch model are shown in the CDI plots in Figure D19. Catch rates were highest for target white warehou tows, for tow start times in late morning, and in Statistical Areas 503 and 610 (Figure D19). The changes are largely related to the movement of vessels out of the fishery, and the positive influence reflects effort by vessels with higher coefficients, and hence suggests that fleet dynamics and behaviour have changed over time, with periods when several vessels ceased to operate and new ones entered the fleet (Figure D19). This will in part be a reflection of the changes in fleet structure and targeting practices as hoki catches decreased and then increased, reflecting the decrease then increase in hoki TACCs (Ballara & O'Driscoll 2015), plus to a smaller degree, reflect the success or not of the squid fishery (Ballara & Baird 2012). Changes in the overall fleet have shown a negative influence in CPUE for target species until 2002, and then a positive influence. The core fleet shows a negative influence on target species, and then positive influence on CPUE in later years. The changes in the influence of statistical area and start time of tow were small (Figure D19). Predicted CPUE by statistical area generally followed the overall lognormal CPUE trend for most statistical areas, although there were some exceptions in individual years (Figure D20).

The diagnostics were good and the quantile-quantile plots indicated little deviation from the normal distribution of the residuals at both the lower and upper ends, i.e., very small and very large catch rates were well modelled (Figure D22). The diagnostics for the binomial model indicated a reasonable pattern in the residuals and the quantile-quantile plot appeared adequate (Figure D23).

Observer model

Data collected by observers from the Sub-Antarctic target hoki, hake, ling, white warehou, silver warehou, and squid trawl fisheries were also analysed to produce a CPUE series, using the combined model for fishing years 1998 to 2014 (Table D3). The total data set included 52 observed vessels, while the core data set had 22 vessels that had been observed for at least five years (Table D3 and D4). There were 7536 tows in the core data set, and 39–84% of tows reported no white warehou catch per year (Table D4).

Six variables were selected into the lognormal model, resulting in a total R^2 of 35.7%, with target species explaining 24.7% of the residual deviance (Table D5). The other variables selected were the same as the TCEPR daily processed model, but with the addition of *month*. The binomial model explained 34.3% of the residual deviance with four retained variables (*target species*, *vessel*, and *depth of bottom*).

The lognormal standardised catch index shows an overall flat trend, although there is a slight increasing trend from 2000 to 2006, with a subsequent decrease to 2011, and a slight increase to 2014 (Table D6, Figure D15). The observer standardised index does not match the unstandardised index well with the latter being lower in earlier years and higher in later years (Figure D15). The binomial series has no trend, and the delta-lognormal indices are generally similar to the lognormal model, although they are affected by years when the binomial indices are lower (Figure D16). The addition of retained variables in the lognormal model have an effect of flattening out the indices, with the addition of target species having the largest impact on the model (Figure D17). The observer series seems to follow the overall trend of the TCEPR estimated tow-by-tow indices data, but poorly matches the standardised biomass indices from the Sub-Antarctic trawl survey (Figure D18).

Generally, the changes in the influence of the main variables was small (Figure D19b). For *target species*, *vessel*, *depth of bottom*, and *statistical area*, influence moved from negative to positive again reflecting changes in fleet structure and targeting behaviour. Non-zero catches are more likely for all target species except squid, and in depths of 400–550 m (Figure D21b).

The model assumptions were well satisfied, with very balanced residuals and no significant deviations from normality (Figure D22 and D23).

8.3 WCSI

TCEPR models

White warehou catches from the WCSI were mainly reported on TCEPR forms with only slightly more of the data captured by the TCEPR processed form (see Figure D1), hence the estimated tow-by-tow dataset is an appropriate dataset to analyse. A WCSI model used data from bottom trawl for target hoki and hake fisheries in fishing years 1993 to 2014 (June–September) (Table D3).

A total of 79 unique vessels (range 15–35 vessels each year) using bottom tows caught 1036 t of white warehou since 1993, from 30 800 tows (Table D4). The percentage of zero tows was high, ranging from 82 to 95%. Core vessels were defined as those participating in the fishery for five or more years, and reporting more than twenty tows per vessel-year (Table D3, Figures D24 and D25). Twenty-six core vessels (range 4–22 per year) caught 913 t of white warehou, representing 88% of the total catch during 1993–2014, with estimated white warehou catches ranging from 5–100 t annually (Table D4).

Six variables were selected into the lognormal model, resulting in a total R^2 of 18.9%, with *vessel* explaining 10.4% of the residual deviance (Table D5). The other variables selected were *month*, *latitude*, *duration*, and *mid time of tow*. In contrast for the binomial model, 25.8% of the residual deviance was explained by five retained variables, with *depth of bottom* and *day of year* included and *month*, *duration*, and *mid time of tow* excluded.

The estimated tow-by-tow lognormal standardised catch indices fluctuated with no trend to 1998, increased sharply in 1999, declined to 2005, and has been relatively flat since then (Table D6, Figure D26). Confidence intervals are largest in the first seven years for this index (Figure D26). The indices match the unstandardised indices reasonably well, although the unstandardised indices are lower until about 2000, then are slightly above the indices (Figure D26). The low binomial probability for the estimated tow-by-tow model results in some differences between the lognormal and the delta-lognormal indices (Figure D27). The addition of retained variables in either lognormal model caused the indices to increase in the 1990s and decrease slightly after that (Figure D28). The standardised biomass indices from the WCSI trawl survey series poorly match the CPUE indices (Figure D29).

The effects of the selected variables on the expected catch rates in the lognormal catch model are shown in the CDI plots in Figure D30. Generally, the change due to the influence of the main variables was small. Catch rates were highest in May and September, at more southerly latitudes, for longer tows, and for tows with a mid-tow time of midday. Influence plots also show that fleet dynamics have changed over time as the vessel and fishing duration influence on CPUE has moved from negative to positive, the mid time of tow influence on CPUE generally moved from positive to negative, and the month influence on CPUE moved from negative to positive (apart from 1996, 2006, and 2012). Thus these variables have a large overall influence on observed CPUE from year to year. There were small shifts in latitude, so this variable has little influence on observed CPUE from year to year, and the influence overall is neutral. Non-zero catches are more likely in particularly deep tows, later in the time period (August–September), in more southerly or westerly tows, and with shorter fishing durations (Figure D31a).

The diagnostics were poor and the quantile–quantile plot for the lognormal model indicated small deviations from the normal distribution of the residuals at both the lower and upper ends, i.e., very small and very large catch rates were not well modelled (Figure D32). This suggests that the lognormal models can be improved, and there may be violations of model assumptions (i.e., the assumption of normally distributed constant variance residual errors). The diagnostics for the binomial model indicated a reasonable pattern in the residuals and the quantile-quantile plot appeared adequate (Figure D33). However this may be deceptive as for the estimated tow-by-tow core data there were ten years with fewer than 100 tows with non-zero catches.

TCER model

TCER data is available from 2008–2014, although there is very little data until 2013 and 2014, when 20% of the WCSI white warehou was reported on the TCER. A TCER analysis may be feasible in the future if there is enough data.

Observer model

Data collected by observers from the target trawl fishery for bottom trawl for hoki or hake off WCSI were also analysed to produce a CPUE series using the combined model from the fishing years 1998 to 2014 (Table D3). The total data set included 44 observed vessels, while the core data set had 24 vessels that had been observed for at least two years (Table D3 and D4). There were 1748 tows in the core data set, and 5–78% of tows reported no white warehou catch per year (Table D4). In the core dataset, all years had fewer than 100 tows with non-zero catches per year (Table D4).

Six variables were selected into the lognormal model, resulting in a total R^2 of 36.7%, with *vessel* explaining 17.5% of the residual deviance (Table D5). The other variables selected included *depth of*

bottom, *longitude*, *month*, and *duration*. The binomial model explained 27.2% of the residual deviance with six retained variables, with similar variables except without *month*, and *day of year* instead (Table D5).

The lognormal standardised catch index is spiky with little trend, and has a high index in 1999, and lower indices from 2008 (Table D6, Figure D26). The binomial series has no trend, although indices are high in 2009, and the delta-lognormal indices are generally similar to the lognormal model, although they are affected by years when the binomial indices are high, especially in 2009 (Figure D27). The addition of retained variables in the lognormal model have an effect of increasing the index in 1999 and lowering the index in 2008 and 2009, with the addition of vessel having the largest impact on the model (Figure D28). The observer series seems to follow the overall trend of the TCEPR tow-by-tow indices although is spiky in comparison, and 1999, 2005–2007 show higher indices (Figure D29). The three years of comparable data from the WCSI trawl survey series poorly match the observer CPUE indices (Figure D29).

The effects of the selected variables on the expected catch rates of white warehou in the lognormal observed catch model suggest that fleet dynamics and behaviour have changed as duration, longitude and month show a changing pattern of influence in earlier and later years (Figure D30b). Other variables show no trend. Non-zero catches are more likely in particularly deep waters, for longer tows, in more westerly tows, and later in the time period (August–September) (Figure D31b).

The model assumptions were well satisfied, with very balanced residuals and no significant deviations from normality (Figure D32 and D33), however, this may be deceptive as all years had fewer than 100 tows with non-zero catches.

8.4 CPUE summary

Standardised CPUE of white warehou was attempted for the Chatham Rise and Sub-Antarctic regions, and also for the WCSI although catches were low in this area. The white warehou catches from fisheries in all three areas are a consequence of bycatch, although there is some effort targeting of white warehou in the Sub-Antarctic region. The Chatham Rise bycatch of white warehou is concentrated off the ECSI and mainly taken in the hoki fishery. The Sub-Antarctic catch is concentrated off the south and west of the Snares Shelf with some targeting of white warehou, but also as a result of targeting of hoki, hake, ling, silver warehou, and squid. The WCSI fishery is of short duration (June–September), with white warehou mainly a bycatch of hoki and hake effort.

For all white warehou models, the diagnostic plots for the CPUE analyses showed that the lognormal model was able to capture most extremes in catch rates. The trends between areas are different with an increase and decrease in the Chatham Rise; a large increase then decrease in the early 1990s, then a flat trend after that in the Sub-Antarctic region; and a slight decreasing trend in the WCSI region. All three areas have lower indices with a flattening trend in recent years.

The overall R^2 values for each region and CPUE lognormal model varied for core models (18–43%) and was higher for the Chatham Rise TCEPR tow-by-tow model, and for Sub-Antarctic and WCSI observer models. Although fishing year was forced into every CPUE model, it rarely explained more than a few percent of the null model deviance. Some explanatory variables were consistent for all models, i.e., vessel and area fished (as statistical area or latitude and/or longitude) entered every model. Depth of bottom was important in all observer data models. Target species was clearly important in the Sub-Antarctic region as this variable entered both models. Time of season (as month) and length of tow (as duration) were important in the WCSI region. The residual deviance explained by the binomial models was slightly lower than the lognormal models (range 12–34%), and for each dataset was generally lower than its lognormal counterpart, with the main predictors being similar to the lognormal models. A large proportion of the underlying variability was not explained. Although this is not unusual for CPUE

analyses (e.g., Vignaux 1994, Punt et al. 2000), it may be a reflection of a lack of explanatory information available to the models.

Vessel was important in all models and the indices reflect the fleet movements of the hoki fishery in particular, on an annual basis as well as a longer period as a response to changes in the TACC (lower hoki TACC during the early 2000s). There may have been changes in fleet dynamics as influence plots show a changing trend throughout the middle of the series for all areas especially for such variables as vessel, start or mid time of tow, depth of bottom, fishing duration, statistical area or longitude, and in the Sub-Antarctic for target species. A decrease in the last few years in the CPUE from the hoki bottom trawl fishery for all three areas may be related to the increased proportions of effort by vessels with lower catch rates of white warehou. Reporting of target species may have changed. On the WCSI there has been relatively less white warehou caught recently by hoki target vessels and increased white warehou catches by hake target vessels. Increases in white warehou targeting in the Sub-Antarctic since 2000 may be related to reporting changes relating to TACC constraints on various target species. Given the changes in fleet structure and behaviour in recent years it is possible that the last few years of the white warehou CPUE series may not be representative of abundance.

CPUE indices are not believed to provide reliable estimates of hoki abundance and are not currently included in the hoki stock assessment (McKenzie 2015). As a lot of the white warehou CPUE data includes tows from the hoki target fishery, changes in fishing practice in this fishery will also be problematic for the white warehou analyses. These changes include use of twin trawls, use of escapement panels on nets of smaller boats, incorrect recording of tow duration as some vessels leave the catch in the water until ready to process, changes in target bag size to reflect the processing capacity of the vessel and quality of fish product desired, precision seafood harvesting (PSH) and the reliability of gear parameters recorded on the fishing returns (Ballara & O'Driscoll 2015). There are also other effects on catching ability that cannot be quantified, such as improvements or changes in net and bottom rig design and electronic equipment.

A proportional relationship between CPUE and abundance is assumed. The amplitude of annual deviations in some CPUE models is also large, meaning that even if CPUE did track abundance, a very large change in biomass would be needed to observe a trend in the CPUE.

The Chatham Rise model did not correlate well with the Chatham Rise trawl survey time series. This fishery showed reasonably consistent catch rates throughout the time series. Bottom depth was important in the Chatham Rise hoki fishery and most white warehou catches were from tows in 300–600 m, although catches in the trawl survey were from throughout the 200–800 m depth range. Either of the Chatham Rise lognormal models could potentially be used to complement the Chatham Rise trawl survey time series.

Sub-Antarctic CPUE indices do not correlate well with the Sub-Antarctic research survey biomass index, although the survey index is not believed to track white warehou abundance. There was no trend for either the CPUE or trawl survey indices for the Sub-Antarctic. Vessel, depth of bottom, and area fished (statistical area or longitude) were important in this area and most likely relate to the effect of the main target trawl fisheries there.

For the WCSI, there are no extended fishery independent indices (only three comparable survey indices are available from 2000, 2012 and 2013). For the WCSI, CPUE models show consistent trends; however, the catches were low, and the results may not be reliable.

The lognormal diagnostic plots for the CPUE analyses show that model assumptions were generally well satisfied. Diagnostics for the binomial models were good, however, there is little published documentation on the success of using randomised quantile residuals as diagnostics for discrete response variable models, so the interpretation of diagnostics should be treated with caution. Use of the delta-lognormal model generally had small effect on the indices.

12. SUMMARY AND RECOMMENDATIONS

12.1 Biology

White warehou are considered to consist of three separate biological stocks: Sub-Antarctic, Chatham Rise, and WCSI (Bagley & Hurst 1997). The data presented here suggest that there is no reason to revise this. The observer data indicate that the spawning season is in winter months, from June–October, in all three areas. The difference in maximum size distributions from trawl surveys of Chatham Rise and Sub-Antarctic, suggests that there may be stock differences between the two areas (Ballara & Baird 2012). Gavrilov & Markina (1979) suggested from diet studies that white warehou move to the Chatham Rise from the Sub-Antarctic area to spawn, but there is no evidence of any movement in the data presented here, largely because of the lack of data from both areas during the spawning season.

Comparable trawl surveys of middle depth species on the Chatham Rise and Sub-Antarctic areas conducted since 1991, and the WCSI trawl survey series which commenced in 2012, may be appropriate to monitor relative abundance for white warehou for these areas. The surveys cover most of the white warehou depth range, although the CVs for the annual estimates are variable and are influenced markedly by occasional large catches. The indices for the Sub-Antarctic, where 70% of the commercial catch was caught, are not well estimated and the areas surveyed do not fully encompass the main catch areas (such as off the Stewart-Snares shelf) (Ballara & Baird 2012). Length frequency distributions in both areas are difficult to interpret and there may be some influence in the fish distribution and schooling pattern that means that not all fish size classes are available to the net or are present in an area at the time of sampling (Ballara & Baird 2012). The Chatham Rise recorded the second lowest biomass indices in 2010, and the Sub-Antarctic the lowest in 2014. The WCSI biomass estimates are much lower than estimates from the Chatham Rise and Sub-Antarctic surveys, but the WCSI trawl survey does not cover the entire distribution of white warehou in that area.

Collection of length, weight, and gonad data on the Chatham Rise and Sub-Antarctic by observers during winter (June–September) could increase knowledge of length-weight relationships, spawning biology and areas, and potential stock relationships.

Otolith sampling and development of catch-at-age for Chatham Rise and Sub-Antarctic would increase its usefulness for monitoring and aid in interpretation of trends; numbers of fish sampled from the WCSI are too low to do this. Better optimised observer sampling of the main fisheries is required to adequately

monitor catch-at-length (and potentially catch-at-age) and spawning times and areas. Ageing has been partially validated (Horn 2001) and otoliths collected since Horn (2001) was completed are available for analysis and interpretation.

12.2 Status of the stocks

No estimates of biomass or stock status are available for any white warehou fishstock. Catches in the three main fishery areas largely result from fishing for other target species, though in recent years, a larger proportion of the white warehou catch from the Sub-Antarctic has come from target tows. Whether this is a trend, or a result of changes in effort for other target species due to management of TACCs is unknown.

Estimates of biomass on the Chatham Rise (most of WWA 3 and all of WWA 4) are available for Chatham Rise surveys since 1991. Relative biomass indices on the Chatham Rise show a slight overall increase in biomass to 2004, with a subsequent decline. The biomass index in 2010 was the lowest in the series. The CPUE analyses of the trawl fishery using data from the main target species on the Chatham Rise do not correlate well with trawl survey indices. Length frequency plots from the Chatham Rise trawl survey time series indicate that it may be possible to track year classes, although ageing would need to occur to confirm the actual ages of these cohorts.

Estimates of biomass in the Sub-Antarctic (WWA 3 south of the Otago Peninsula and WWA 5B) are available from the Sub-Antarctic trawl surveys since 1991. Estimates from Sub-Antarctic showed a large increase followed by a decrease in the early 1990s, then a relatively flat trend after that. The Sub-Antarctic CPUE indices are even less reliable than the Chatham Rise indices, and do not correlate well with the Sub-Antarctic research survey biomass index. Length frequency plots from the Sub-Antarctic trawl survey time series also indicate that it may be possible to track year classes.

Estimates of white warehou biomass are available for the WCSI (WWA 7) from three comparable WCSI survey indices in 2000, 2012 and 2013. Nearly all of the white warehou catch is taken during the hoki spawning season and increasingly in the hake fishery. The WCSI CPUE index complements the trawl survey indices and the observer CPUE series should be relatively free of biases.

Standardised CPUE analyses were not attempted for the fishing area ECNI (WWA 1 and 2) or WCNI (WWA 8 and 9) as catches are patchy and small.

White warehou sampling by observers would benefit from optimisation in key fishery areas. Observer data for this study were found to be minimal for the WCSI and ECNI regions, and not representative of all months and statistical areas for Sub-Antarctic and especially the Chatham Rise in some years. More directed coverage may also allow more accurate recording of catch per tow that might allow for better CPUE analyses based on Observer data.

Targeted otolith sampling would enable the development of series of catch-at-age. Some otoliths have been taken in the past by observers but not in large numbers. Collection of length frequency and gonad stage information is also important to help determine stock structure and reproductive biology, as outlined above.

12.2 Observer Programme sampling

White warehou sampling by observers would benefit from optimisation in the key fishery areas, particularly to achieve better coverage throughout the year, where possible. The 2002 version of the observer manual requires observers to collect otoliths from five fish per tow and to measure, sex, and stage gonads (females only) for 80–100 fish from a white warehou target tow or 100–150 every 2–3 days if white warehou are caught when another species is targeted. Timely collection of length

frequency, fish weight, and gonad stage information is important for better determination of stock structure.

12.3 Future data needs and research requirements

Gaps exist in data collection required to better describe the biological characteristics and the spawning and stock definitions. Summer trawl surveys of the Chatham Rise and Sub-Antarctic, and the recent winter trawl survey on the WCSI, provide biomass estimates for the three main fishing areas identified in this study. Biological information from observer sampling could be enhanced, with the goal of developing appropriate monitoring tools, as follows:

1. Improved coverage of all fishery areas by the observer programme. This would involve collection of all key aspects of biology including length, weight, sex, gonad data, and otoliths. Improved observer coverage could also potentially allow for further development of observer CPUE. Collection of length and gonad data on the Chatham Rise and Sub-Antarctic by observers during the spawning season to potentially provide a better indication of spawning area and stock. Collection of length and gonad data on the Chatham Rise by observers all year around to fill gaps in knowledge for this stock.

2. Analysis of the otoliths collected since 1998 from the observer programme to provide a larger sample for ageing and potentially to develop catch-at-age and length-at-age series.

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14. REFERENCES

Anderson, O.F.; Bagley, N.W.; Hurst, R.J.; Francis, M.P.; Clark, M.R.; McMillan, P.J. (1998). Atlas of New Zealand fish and squid distributions from research bottom trawls. *NIWA Technical Report 42*. 303 p.

Bagley, N.W.; Hurst, R.J. (1995). Trawl survey of middle depth and inshore bottom species off Southland, February–March 1994 (TAN9402). *New Zealand Fisheries Data Report No. 73.* 47 p.

Bagley, N.W.; Hurst, R.J. (1996a). Trawl survey of middle depth and inshore bottom species off Southland, February–March 1995(TAN9502). *New Zealand Fisheries Data Report No. 77.* 51 p.

Bagley, N.W.; Hurst, R.J. (1996b). Trawl survey of middle depth and inshore bottom species off Southland, February–March 1996 (TAN9604). *New Zealand Fisheries Data Report No. 52.* 58 p.

Bagley, N.W.; Hurst, R.J. (1997). A summary of the biology and commercial landings and a stock assessment of white warehou *Seriolella caerulea* Guichenot, 1848 (Stromateoidei: Centrolophidae) in New Zealand waters. New Zealand Fisheries Assessment Research Document 1997/13. (Unpublished document held by NIWA library, Wellington). 34 p.

Bagley, N.W.; Hurst, R.J. (1998). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1998 (TAN9801). *NIWA Technical Report 44.* 54 p

Bagley, N.W.; Livingston, M.E. (2000). Trawl survey of hoki and middle depth species on the Chatham

Rise, January 1999 (TAN9901). *NIWA Technical Report 81*. 52 p.

Bagley, N.W.; McMillan, P. J. (1999). Trawl survey of hake and middle depth species in the Southland and Sub-Antarctic areas April-May 1998 (TAN9805). *NIWA Technical Report 52*. 48 p.

Bagley, N.W.; O'Driscoll, R.L. (2012). Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, November–December 2009 (TAN0911). *New Zealand Fisheries Assessment Report 2012/05*. 70 p.

Bagley, N.W.; O'Driscoll, R.L.; Francis, R.I.C.C.; Ballara, S.L. (2009). Trawl survey of middle-depth species in the Southland and Sub-Antarctic areas, November–December 2007 (TAN0714). *New Zealand Fisheries Assessment Report 2009/9.* 63 p

Bagley N. W.; Ballara S. L.; O'Driscoll, R. L.; D.; Fu, D.; Lyon W. (2013a). A review of hoki and middle depth summer trawl surveys of the Sub-Antarctic, November December 1991–1993 and 2000–2009. *New Zealand Fisheries Assessment Report 2013/41*. 63 p + supplements.

Bagley, N.W.; O'Driscoll, R.L.; Oeffner, J. (2013b). Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2011 (TAN1117). *New Zealand Fisheries Assessment Report 2013/23.* 70 p.

Bagley, N.W.; O'Driscoll, R.L.; Oeffner, J. (2014). Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2012 (TAN1215). *New Zealand Fisheries Assessment Report 2014/12.*

Bagley et al. 2015 (in prep). Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2014 (TAN1412). *New Zealand Fisheries Assessment Report 2015/nn.* Xx p.

Baird, G.G.; McKoy, J.L. (Comps. & Eds.) (1988). Papers from the workshop to review fish stock assessments for the 1987–88 New Zealand fishing year. (Unpublished paper held at NIWA, Greta Point library, Wellington.) 300 p.

Ballara S.L.; Baird, S.J. (2012). Fishery characterisation and standardised CPUE analyses for white warehou, *Seriolella caerulea*, 1989–90 to 2009–10. *New Zealand Fisheries Assessment Report 2012/49*. 265 p.

Ballara, S.L.; O'Driscoll, R.L. (2015) Catches, size, and age structure of the 2013–14 hoki fishery, and a summary of input data used for the 2015 stock assessment. *New Zealand Fisheries Assessment Report 2015/57.* 123 p.

Bentley, N.; Kendrick, T.H.; Starr, P.J.; Breen, P.A. (2012). Influence plots and metrics: tools for better understanding fisheries catch-per-unit-effort standardizations. *ICES Journal of Marine Science 69(1)*: 84–88.

Blackwell, R.G.; Manning, M.J.; Gilbert, D.J. (2005). Standardised CPUE analysis of the target rig (*Mustelus lenticulatus*) set net fishery in northern New Zealand (SPO 1 and SPO 8). Final Research Report for Ministry of Fisheries Project SPO2004-01, Objective 1. 37 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Bull, B.; Dunn, A. (2002). Catch-at-age user manual v1.06.2002/09/12. NIWA Internal Report 114. 23 p. (Unpublished report held in NIWA library, Wellington.)

Chambers, J.M.; Hastie, T.J. (1991). Statistical models in S. Wadsworth & Brooks-Cole, Pacific Grove, CA. 608 p.

Chapman, D.G.; Robson, D.S. (1960). The analysis of a catch curve. *Biometrics 16*: 354–368.

Chatterton, T.D.; Hanchet, S.M. (1994). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, November–December 1991 (TAN9105). *New Zealand Fisheries Data Report 41*. 55 p.

Colman, J.A. (1996). Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, March-April 1996 (TAN9605). *New Zealand Fisheries Technical Report 83*. 40 p.

Dunn, A.; Francis, R.I.C.C.; Doonan, I.J. (1999). The sensitivity of some catch curve estimators of mortality to stochastic noise, error, and selectivity. New Zealand Fisheries Assessment Research Document 99/5. (Unpublished document held by NIWA library, Wellington). 23 p.

Dunn, M.R.; Hurst, R.J.; Renwick J.; Francis, R.I.C.C.; Devine, J.; McKenzie, A. (2009). Fish abundance and climate trends in New Zealand. *New Zealand Aquatic Environment and Biodiversity Report No. 31*. 73 p.

Dunn, P.K.; Smyth, G.K. (1996). Randomized quantile residuals. *Journal of Computational and Graphical Statistics 5*: 1–10.

Francis, R.I.C.C. (1999). The impact of correlation in standardised CPUE indices. New Zealand Fisheries Assessment Research Document 99/42. 30 p. (Unpublished report held in NIWA library, Wellington.)

Francis, R.I.C.C. (2001). Orange roughy CPUE on the South and East Chatham Rise. *New Zealand Fisheries Assessment Report 2001/26.*30 p.

Francis, R.I.C.C.; Fu, D. (2012). SurvCalc User Manual v1.2-2011-09-28. *NIWA Technical Report 134*. 54 p.

Gavrilov, G.M. (1979). *Seriolella* of the New Zealand plateau. Report of the Pacific Ocean Scientific Research Institute of Fisheries and Oceanography (TRINO). (In Russian, English translation held in NIWA, Wellington.)

Gavrilov, G.M.; Markina, N.P. (1979). The feeding ecology of fishes of the genus *Seriolella* (fam. Nomeidae) on the New Zealand plateau. *Journal of Ichthyology 19(6)*: 128–135.

Hickford, M.J.H.; Schiel, D.R. (2003). Comparative dispersal of larvae from demersal versus pelagic spawning fishes. *Marine Ecology Progress Series 252*: 255–71.

Hoenig, J.M. (1983). Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin 82*: 898–902.

Horn, P.L. (1994a). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1991-January 1992 (TAN9106). *New Zealand Fisheries Data Report 43.* 38 p.

Horn, P.L. (1994b). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1992-February 1993 (TAN9219). 43 p.

Horn, P.L. (1999). A validated ageing method and updated stock assessment for white warehou (*Seriolella caerulea*) in New Zealand waters. New Zealand Fisheries Assessment Research Document. 1999/44. (Unpublished report held by NIWA library, Wellington). 24 p.

Horn, P.L. (2001). Validated ageing methods for blue warehou (*Seriolella brama*) and white warehou (*S. caerulea*) in New Zealand waters. *Marine and Freshwater Research 52*: 297–309.

Horn, P.L.; Burrell, T.; Connell, A.; Dunn, M.R. (2011). A comparison of the diets of silver (*Seriolella punctata*) and white (*Seriolella caerulea*) warehou. *Marine Biology Research 7(6)*: 576–591.

Hurst, R.J. (1988). The barracouta, *Thyrsites atun*, fishery around New Zealand: historical trends to 1984. *New Zealand Fisheries Technical Report: 5*. 43 p.

Hurst, R.J. (2009). Determination of commercial fishing gear and changes in commercial fishing gear in all middle depths fisheries. Final Research Report for Ministry of Fisheries Research Project MID2006-04 Objectives 1&2. 85 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Hurst, R.J.; Bagley, N.W. (1992). Trawl survey of barracouta and associated finfish near the Chatham Islands, New Zealand, December 1985. *New Zealand Fisheries Technical Report No. 30.* 36 p.

Hurst, R.J.; Bagley, N.W. (1994). Trawl survey of middle depth and inshore bottom species off Southland, February–March 1993 (TAN9301). *New Zealand Fisheries Data Report 52*. 58 p.

Ingerson, J.K.V.; Hanchet, S.M. (1995). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, November-December 1993 (TAN9310). *New Zealand Fisheries Data Report 67*. 44 p.

Ingerson, J.K.V.; Hanchet, S.M.; Chatterton, T.D. (1995). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, November-December 1992 (TAN9211). *New Zealand Fisheries Data Report 66*. 43 p.

Livingston, M.E.; Stevens, D.W (2005). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2004 (TAN0401). *New Zealand Fisheries Assessment Report 2005/21*. 62 p.

Livingston, M.E.; Stevens, D.W.; O'Driscoll, R.L.; Francis, R.I.C.C. (2004). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2003 (TAN0301). *New Zealand Fisheries Assessment Report 2004/16*. 71 p.

McDowall, R.M. (1980). *Seriolella caerulea* Guichenot, 1884 in New Zealand waters (Stromateoidei: Centrolophidae). *Journal of the Royal Society of New Zealand 10(1)*: 65–74.

McDowell, R.M. (1982). The centrolophid fishes of New Zealand (Pisces: Stromateoidei). *Journal of the Royal Society of New Zealand 12*: 103–142.

McKenzie, A (2015). Initial assessment results for hoki in 2015. DWWG2015-17 (Unpublished report held by the Ministry for Primary Industries, Wellington).

Manning, M.J. (2007). Relative abundance of giant stargazer (*Kathetostoma giganteum*) in STA 5 based on commercial catch-per-unit-effort data. *New Zealand Fisheries Assessment Report 2007/14*. 42 p.

Manning, M.J.; Hanchet, S.M.; Stevenson, M.L. (2004). A description and analysis of New Zealand's spiny dogfish (*Squalus acanthias*) fisheries and recommendations on appropriate methods to monitor the status of the stocks. *New Zealand Fisheries Assessment Report 2004/61*. 135 p.

Ministry of Fisheries (2007). Initial Position Paper (2005).White warehou: proposed amalgamation of WWA5 and WWA6. Accessed June 2012 at http://www.fish.govt.nz/NR/rdonlyres/BEB11446-54A9-44F4-81BB-567D6F224AAB/0/consultation_WWA_5_6_amalgamation_07.pdf.

Ministry of Fisheries (2010). National Fisheries Plan for Deepwater and Middle-depth Fisheries, Part 1B, Hoki Fisheries Plan. 51 p. Accessed March 2012 online at http://www.fish.govt.nz/NR/rdonlyres/1BF0E4A9-A3D6-45CC-9A7D-49978E09161E/0/NFP_Deepwater_and_Middledepth_Fisheries_Part_1B_HOKI.pdf

Ministry of Fisheries (2011). May 2011 Plenary Report. Ministry of Fisheries, Wellington, New Zealand pp. 1147–1152. (Unpublished document held by Ministry for Primary Industries, Wellington).

Ministry for Primary Industries (2014). Fisheries Assessment Plenary, May 2014: stock assessments and stock status. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand.1381 p.

O'Driscoll, R.L.; Bagley, N.W. (2003a). Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, November–December 2001 (TAN0118). *New Zealand Fisheries Assessment Report 2003/1*. 53 p.

O'Driscoll, R.L.; Bagley, N.W. (2003b). Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, November–December 2002 (TAN0219). *New Zealand Fisheries Assessment Report 2003/46*. 57 p.

O'Driscoll, R.L.; Bagley, N.W. (2004). Trawl survey results of hoki hake and ling in Southland and Sub-Antarctic areas Nov–Dec 2003 (TAN0317). *New Zealand Fisheries Assessment Report 2004/49.* 58 p.

O'Driscoll, R.L.; Bagley, N. W. (2006a). Trawl survey of hoki, hake, and ling in the Southland and Sub-Antarctic areas, November–December 2004 (TAN0414). *New Zealand Fisheries Assessment Report* 2006/2. 60 p.

O'Driscoll, R.L.; Bagley, N.W. (2006b). Trawl survey of middle-depth species in the Southland and Sub-Antarctic areas, November–December 2005 (TAN0515). *New Zealand Fisheries Assessment Report* 2006/45. 64 p.

O'Driscoll, R.L.; Bagley, N.W. (2008). Trawl survey of middle-depth species in the Southland and Sub-Antarctic areas, November–December 2006 (TAN0617). *New Zealand Fisheries Assessment Report* 2008/30. 61 p.

O'Driscoll, R.L.; Bagley, N.W. (2009). Trawl survey of middle-depth species in the Southland and Sub-Antarctic areas, November–December 2008 (TAN0813). *New Zealand Fisheries Assessment Report* 2009/56. 67 p.

O'Driscoll, R.L.; Bagley, N.W.; Ballara, S.L.; Ladroit, Y. (2015). Trawl and acoustic survey of hoki and middle depth fish abundance on the west coast South Island, July–August 2013 (TAN1308). *New Zealand Fisheries Assessment Report 2015/20*. 104 p.

O'Driscoll, R.L.; Bagley, N.W.; Ballara, S.L.; Oeffner, J. (2014). Trawl and acoustic survey of hoki and middle depth fish abundance on the west coast South Island, July–August 2012 (TAN1210). *New Zealand Fisheries Assessment Report 2014/09*.

O'Driscoll, R.L.; Bagley, N.W.; Bull, B. (2001). Trawl survey of middle depth species in Southland and Sub-Antarctic areas Nov–Dec 2000 (TAN0012). *NIWA Technical Report 110*. 78 p.

O'Driscoll, R.L.; Bagley, N.W.; Dunn, A. (2004). Further analysis of an acoustic survey of spawning hoki off the west coast South Island in winter 2000. *New Zealand Fisheries Assessment Report 2004/2*. 53 p.

O'Driscoll, R.L.; Booth, J.D.; Bagley, N.W.; Anderson, O.F.; Griggs, L.H.; Stevenson, M.L.; Francis, M.P. (2003). Areas of importance for spawning, pupping or egg-laying, and juveniles of New Zealand deepwater fish, pelagic fish, and invertebrates. *NIWA Technical Report 119*. 377 p.

O'Driscoll, R.L.; MacGibbon, D.; Fu, D.; Lyon, W.; Stevens, D.W. (2011). A review of hoki and middle depth trawl surveys of the Chatham Rise, January 1992–2010. *New Zealand Fisheries Assessment Report 2011/47*. 72 p.

Parker, S., Fu, D. (2011). Fishery characterisation and standardised CPUE analyses for silver warehou (*Seriolella punctata*) in SWA 3 and 4, 1989–90 to 2007–08. *New Zealand Fisheries Assessment 2011/1*.

Punt, A.E.; Walker, T.I.; Taylor, B.L.; Pribac, F. (2000). Standardization of catch and effort data in a spatially-structured shark fishery. *Fisheries Research 45*: 129–145.

R Development Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. http://www.R-project.org.

Schofield, K.A.; Horn, P.L. 1994). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1994 (TAN9401). *New Zealand Fisheries Data Report 53*. 55 p.

Schofield, K.A.; Livingston, M.E. (1994a). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, April-May 1992 (TAN9204). *New Zealand Fisheries Data Report 45*. 38 p.

Schofield, K.A.; Livingston, M.E. (1994b). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, September-October 1992 (TAN9209). *New Zealand Fisheries Data Report 46*. 43 p.

Schofield, K.A.; Livingston, M.E. (1994c). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, May-June 1992 (TAN9304). *New Zealand Fisheries Data Report 47*.

Schofield, K.A.; Livingston, M.E. (1995). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1995 (TAN9501). *New Zealand Fisheries Data Report 59*. 53 p.

Schofield, K.A.; Livingston, M.E. (1996). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1996 (TAN9601). *New Zealand Fisheries Data Report 71*. 50 p.

Schofield, K.A.; Livingston, M.E. (1997). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1997 (TAN9701). *NIWA Technical Report 6*. 52 p.

SeaFIC (Seafood Industry Council) (2007). Silver warehou: SWA 1 Adaptive Management Programme Full-term Review Report. AMPWG-2007/22. (Unpublished report held by the Ministry for Primary Industries, Wellington).

Starr, P.J. (2007). Procedure for merging MFish landing and effort data, V2.0. Document AMPWG/07/04. (Unpublished report held by Ministry for Primary Industries, Wellington).

Stevens, D.W.; Hurst, R.J.; Bagley, N.W. (2011a). Feeding habits of New Zealand fishes: a literature review and summary of research trawl database records 1960 to 2000. *New Zealand Aquatic Environment and Biodiversity Report No. 85*. 218 p.

Stevens, D.W.; Livingston, M.E. (2002). Trawl survey of hoki and middle depth species on the Chatham

Rise, January 2001 (TAN0101). *NIWA Technical Report 116*. 61 p.

Stevens, D.W.; Livingston, M.E. (2003). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2002 (TAN0201). *New Zealand Fisheries Assessment Report 2003/19*. 57 p.

Stevens, D.W.; Livingston, M.E.; Bagley, N.W. (2001). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2000 (TAN0001). *NIWA Technical Report 104*. 55 p.

Stevens, D.W.; O'Driscoll, R.L. (2006). Trawl survey of hoki and middle-depth species on the Chatham Rise, January 2005 (TAN0501) *New Zealand Fisheries Assessment Report 2006/13*. 73 p.

Stevens, D.W.; O'Driscoll, R.L. (2007). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2006 (TAN0601). *New Zealand Fisheries Assessment Report 2007/5*. 73 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; Ballara, S.L.; Horn, P.L. (2012). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2011 (TAN1101). *New Zealand Fisheries Assessment Report 2012/10*. 98 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; Ballara, S.L.; Horn, P.L. (2013). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2012 (TAN1201). *New Zealand Fisheries Assessment Report 2013/34*. 103 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; MacGibbon, D.; Horn, P.L.; Gauthier, S. (2011b). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2010 (TAN1001). *New Zealand Fisheries Assessment Report 2011/10*. 112 p.

Stevens, D.W.; O'Driscoll, R.L.; Gauthier, S. (2008). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2007 (TAN0701). *New Zealand Fisheries Assessment Report 2008/52*. 81 p.

Stevens, D.W.; O'Driscoll, R.L.; Horn, P.L. (2009a). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2008 (TAN0801). *New Zealand Fisheries Assessment Report 2009/18*. 86 p.

Stevens, D.W.; O'Driscoll, R.L.; Horn, P.L. (2009b). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2009 (TAN0901). *New Zealand Fisheries Assessment Report 2009/66*. 91 p.

Stevens, D.W.; O'Driscoll, R.L.; Ladroit, Y.; Ballara, S.L.; MacGibbon, D.J.; Horn, P.L. (2015).Trawl survey of hoki and middle depth species on the Chatham Rise, January 2014 (TAN1401). *New Zealand Fisheries Assessment Report 2015/19*. 119 p.

Stevens, D.W.; O'Driscoll, R.L.; Oeffner, J.; Ballara, S.L.; Horn, P.L. (2014). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2013 (TAN1301). *New Zealand Fisheries Assessment Report 2014/02*. 110 p.

Vignaux, M. (1994). Catch per unit effort (CPUE) analysis of west coast South Island and Cook Strait spawning hoki fisheries, 1987–93. New Zealand Fisheries Assessment Research Document 94/11. 29 p. (Unpublished report held in NIWA library, Wellington.)

APPENDIX A: TRAWL SURVEY SUMMARIES

Table A1: Summary of non-zero white warehou catches for each *Tangaroa* survey and percent of stations with white warehou catches.

(a) Chatham Rise

	Catch (kg) summary				Core strata stations	
Survey	**Min**	**Median**	**Mean**	**Max**	**Total**	**Percent with WWA**
tan9106	0	0	11.5	456.5	184	36.4
tan9212	0	0	10.6	555.9	194	37.6
tan9401	0	1.3	8.7	308.3	165	54.5
tan9501	0	0	4.3	90.6	122	27.9
tan9601	0	0	3	27	89	36
tan9701	0	0	13.6	226.8	103	47.6
tan9801	0	0	6	90.8	87	49.4
tan9901	0	0.6	14.9	554.9	100	55
TAN0001	0	0.1	12.1	186.9	128	52.3
TAN0101	0	2.8	35.6	2685	119	58.8
TAN0201	0	0.1	26.4	952.4	107	50.5
TAN0301	0	0.9	23.8	577.1	115	51.3
TAN0401	0	3	30.3	1394.6	110	59.1
TAN0501	0	1.4	22.6	373.3	106	51.9
TAN0601	0	0	15.9	509.4	96	42.7
TAN0701	0	2.8	13.9	210.7	101	62.4
TAN0801	0	0	19.3	1131.6	101	42.6
TAN0901	0	0	23	1057	108	46.3
TAN1001	0	0	4.5	49.6	91	44
TAN1101	0	0	10.2	513.2	90	46.7
TAN1201	0	0	8.9	179.5	100	38
TAN1301	0	1.2	12	457.4	91	54.9
TAN1401	0	0	5.2	87.5	87	37.9
All	0	0	14.6	2685	2594	46.8

(b) Sub Antarctic summer

	Catch (kg) summary				Core strata stations	
Survey	**Min**	**Median**	**Mean**	**Max**	**Total**	**Percent with WWA**
tan9105	0	0	7.5	838.9	154	34.4
tan9211	0	0	0.6	17.9	155	14.2
tan9310	0	0	0.8	29.2	134	19.4
TAN0012	0	0	0.9	29.2	84	13.1
TAN0118	0	0	21.1	1195.8	85	29.4
TAN0219	0	0	10.8	445.7	85	35.3
TAN0317	0	0	2	56.7	69	20.3
TAN0414	0	0	13.3	509.8	78	28.2
TAN0515	0	0	3.5	106.2	77	23.4
TAN0617	0	0	5.6	219.3	75	38.7
TAN0714	0	0	18.1	1188.9	80	33.8
TAN0813	0	0	12.4	421.8	75	32
TAN0911	0	0	14.1	518.9	74	36.5
TAN1117	0	0	5.4	104.2	80	33.8
TAN1215	0	0	11.2	275.4	80	35
TAN1412	0	0	0.9	16	76	21.1
All	0	0	7.4	1195.8	1461	27.3

Table A1: continued.

(c) Sub-Antarctic autumn

	Catch (kg) summary				Core strata stations	
Survey	**Min**	**Median**	**Mean**	**Max**	**Total**	**Percent with WWA**
tan9204	0	0	0.5	8.2	90	15.6
tan9304	0	0	2	35.4	100	48
tan9605	0	0	0.6	10	79	21.5
tan9805	0	0	13.1	576	58	34.5
All	0	0	3.2	576	327	30.3

(d) Sub-Antarctic spring

	Catch (kg) summary				Core strata stations	
Survey	**Min**	**Median**	**Mean**	**Max**	**Total**	**Percent with WWA**
tan9209	0	0	0.9	40.2	101	18.8
All	0	0	0.9	40.2	101	18.8

(e) Southland

	Catch (kg) summary				Core strata stations	
Survey	**Min**	**Median**	**Mean**	**Max**	**Total**	**Percent with WWA**
tan9301	0	0	0.7	28.8	113	8.8
tan9402	0	0	0.6	24.6	129	8.5
tan9502	0	0	0	3	150	2
tan9604	0	0	1.4	159	124	3.2
All	0	0	0.7	159	516	5.4

(f) WCSI

	Catch (kg) summary				Core strata stations	
Survey	**Min**	**Median**	**Mean**	**Max**	**Total**	**Percent with WWA**
TAN1210	0	0	2	34	63	15.9
TAN1308	0	0	1.1	11	65	15.4
All	0	0	1.3	34	175	14.9

Table A2: Numbers of female white warehou at each reproductive stage, from trawl survey data, by month and area. 1, immature or resting; 2, maturing; 3, ripe; 4 running ripe; 5 spent.

	Month											
Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ECNI												
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	1	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
Chatham Rise												
1	388	-	-	-	-	1	-	-	-	-	-	63
2	77	-	-	-	-	-	9	-	-	-	-	5
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	10	-	-	-	-	-	1	-	-	-	-	-
Sub-Antarctic												
1	-	23	3	34	-	-	-	1	3	-	103	474
2	-	5	10	22	-	-	-	-	3	-	7	73
3	-	1	-	-	-	-	-	-	-	-	-	1
4	-	-	-	-	-	-	-	-	-	-	-	0
5	-	-	-	1	-	-	-	-	-	-	-	12
WCSI												
1	-	-	-	-	-	-	-	1	-	-	-	-
2	-	-	-	-	-	-	4	20	-	-	-	-
3	-	-	-	-	-	-	-	8	-	-	-	-
4	-	-	-	-	-	-	-	3	-	-	-	-
5	-	-	-	-	-	-	-	3	-	-	-	-
Total												
1	388	23	3	34	-	1	-	2	3	-	103	537
2	77	5	10	23	-	-	13	20	3	-	7	78
3	-	1	-	-	-	-	-	8	-	-	-	1
4	-	-	-	-	-	-	-	3	-	-	-	-
5	10	-	-	1	-	-	1	3	-	1	-	12

Table A2: ctd. Numbers of male white warehou at each reproductive stage, from trawl survey data, by month and area.

	Month											
Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ECNI												
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
Chatham Rise												
1	542	-	-	-	-	-	-	-	-	-	-	125
2	6	-	-	-	-	-	-	-	-	-	-	2
3	-	-	-	-	-	1	-	-	-	-	-	-
4	-	-	-	-	-	-	10	-	-	-	-	-
5	43	-	-	-	-	-	-	-	-	-	-	-
Sub-Antarctic												
1	-	55	40	73	-	-	-	1	16	-	291	1000
2	-	-	3	31	-	-	-	-	1	-	-	70
3	-	-	-	-	-	-	-	7	1	-	-	3
4	-	-	-	-	-	-	-	-	2	-	-	-
5	-	4	-	-	-	-	-	-	-	-	1	49
WCSI												
1	-	-	-	-	-	-	-	1	-	-	-	-
2	-	-	-	-	-	-	2	-	-	-	-	-
3	-	-	-	-	-	-	5	13	-	-	-	-
4	-	-	-	-	-	-	-	8	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
Total												
1	542	55	40	73	-	-	-	2	16	-	291	1125
2	6	-	3	31	-	-	2	-	1	-	-	72
3	-	-	-	-	-	1	5	20	1	-	-	3
4	-	-	-	-	-	-	10	8	2	-	-	-
5	43	4	-	-	-	-	-	-	-	-	1	49

Table A3: Number of otolith pairs collected from trawl surveys by area and survey for calendar years 1992–2014.

Year and survey	CHAT	SUBA	WCSI	Total
1993 tan9301	46	-	-	46
1994 tan9401	47	-	-	47
1996 tan9601 (CHAT), tan9604 (SUBA)	90	29	-	119
1997 tan9701	116	-	-	116
1998 tan9801 (CHAT); tan9805 (SUBA)	230	117	-	347
2010 TAN1001	1	-	-	-
2013 TAN1308	-	-	2	2
Total	530	146	2	678

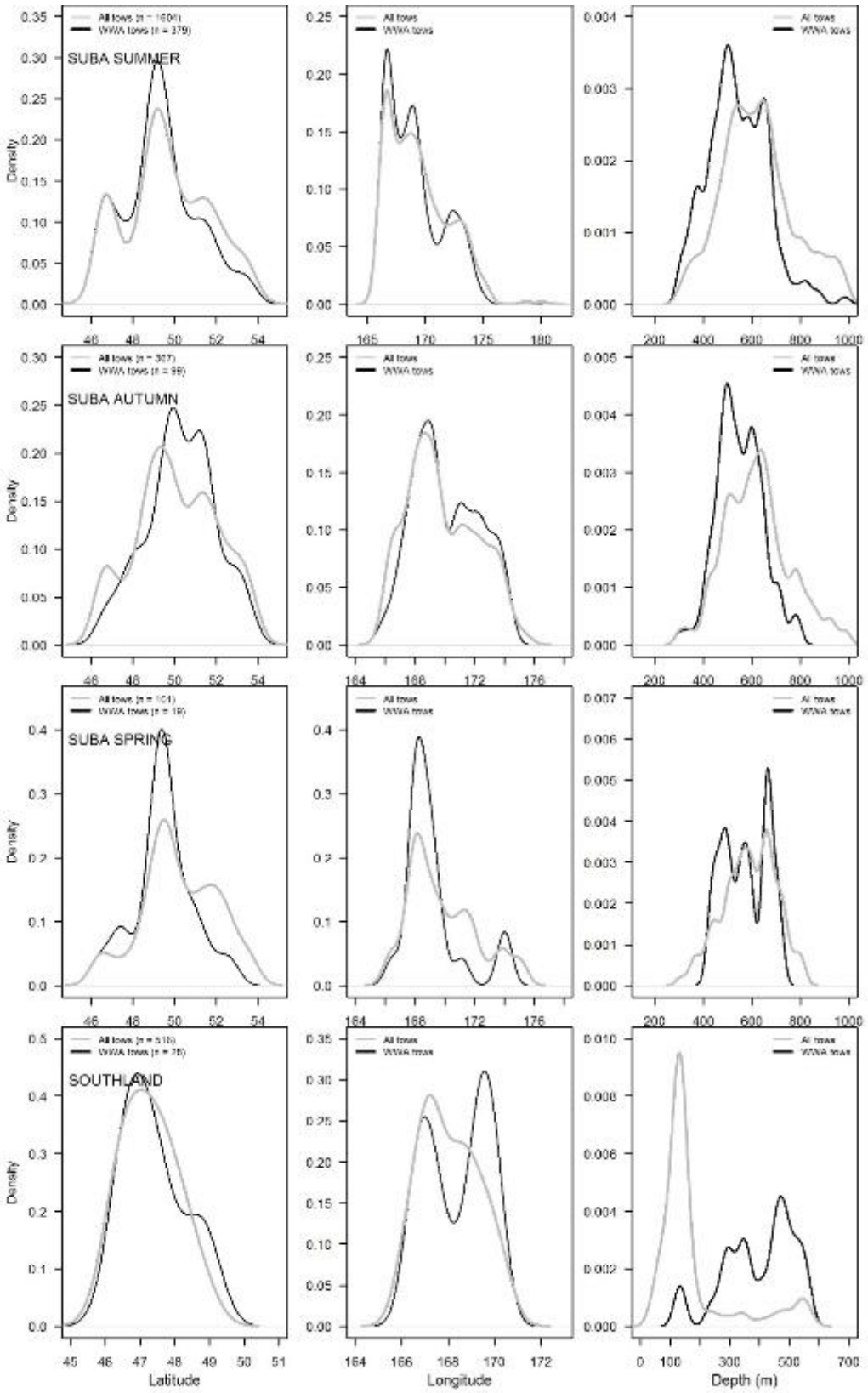


Figure A1: Distribution of *Tangaroa* trawl survey tows with catches of white warehou, for the Sub-Antarctic summer surveys (SUBA), and Southland (SOUTHLAND) late summer surveys, by latitude, longitude, and maximum depth of tow.

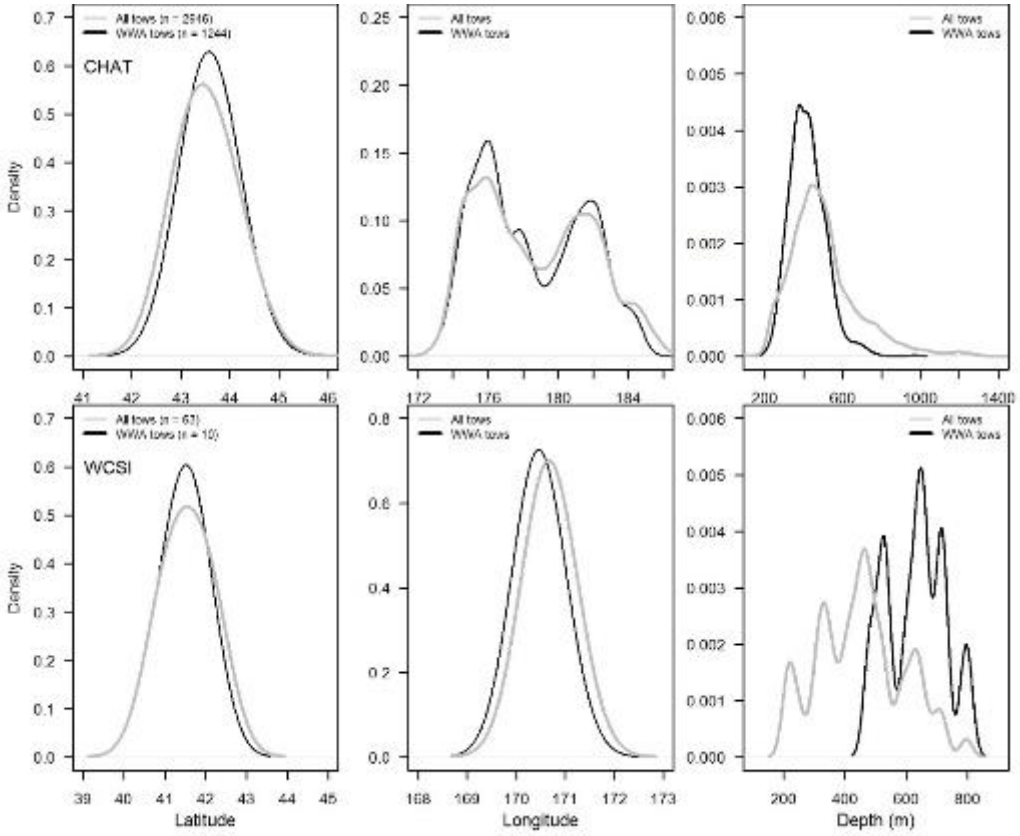


Figure A1 ctd.: Distribution of *Tangaroa* trawl survey tows with catches of white warehou, for the Chatham Rise summer surveys (CHAT), and WCSI (WCSI) surveys, by latitude, longitude, and maximum depth of tow.

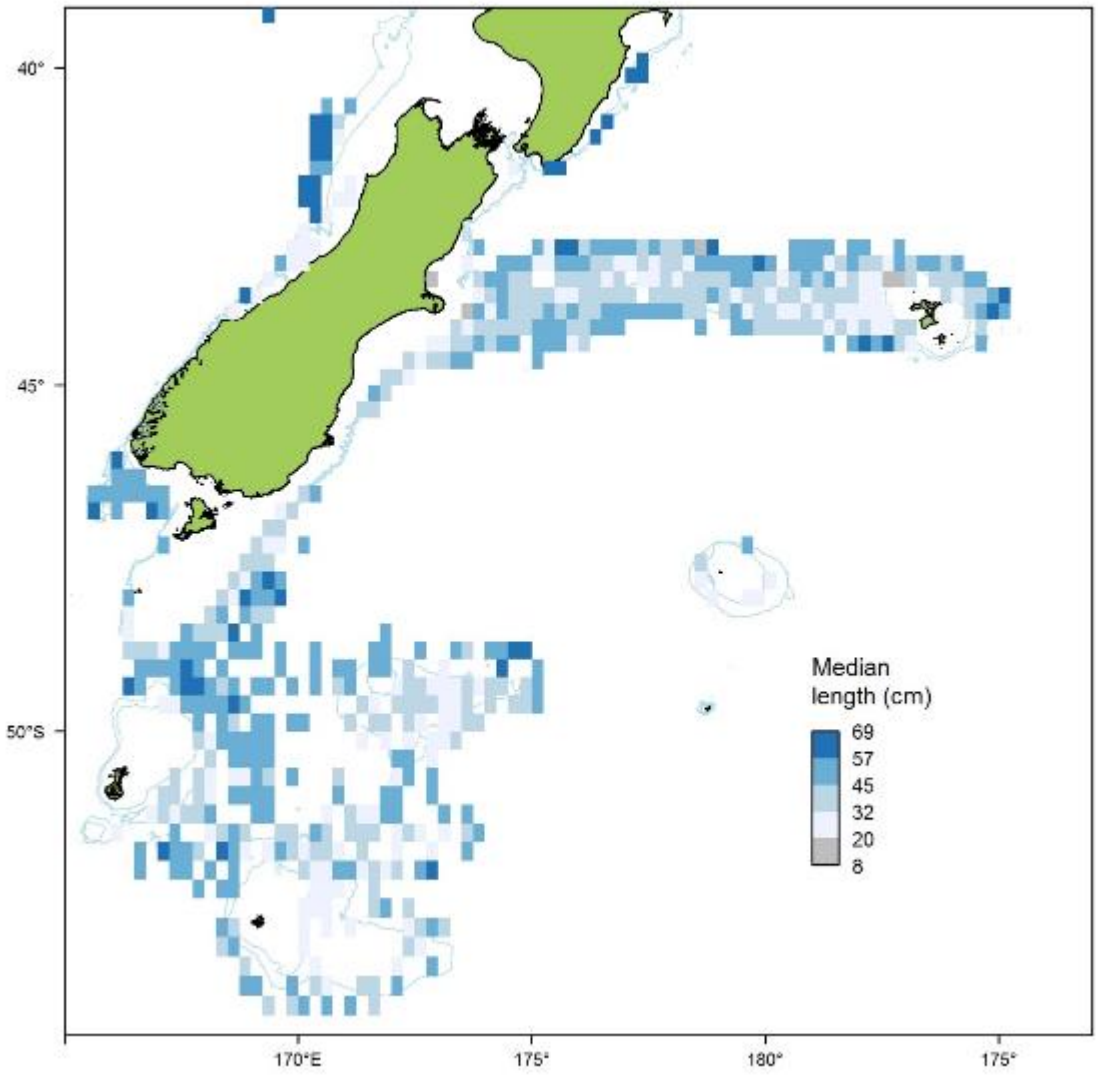


Figure A2: Distribution of lengths (median per 0.25° latitude × longitude cell) from 29 626 white warehou caught during trawl surveys completed between 1979 and 2014.

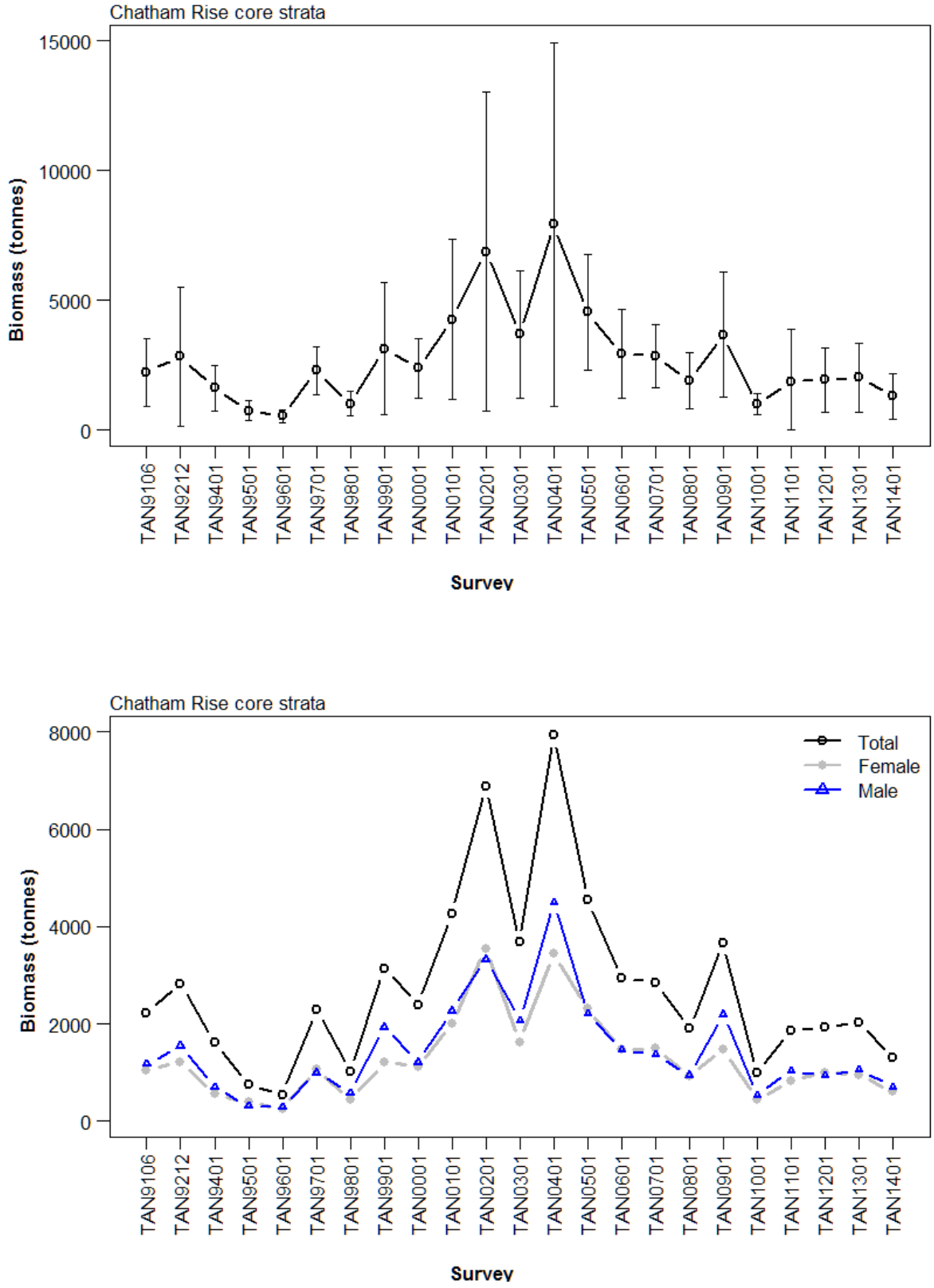
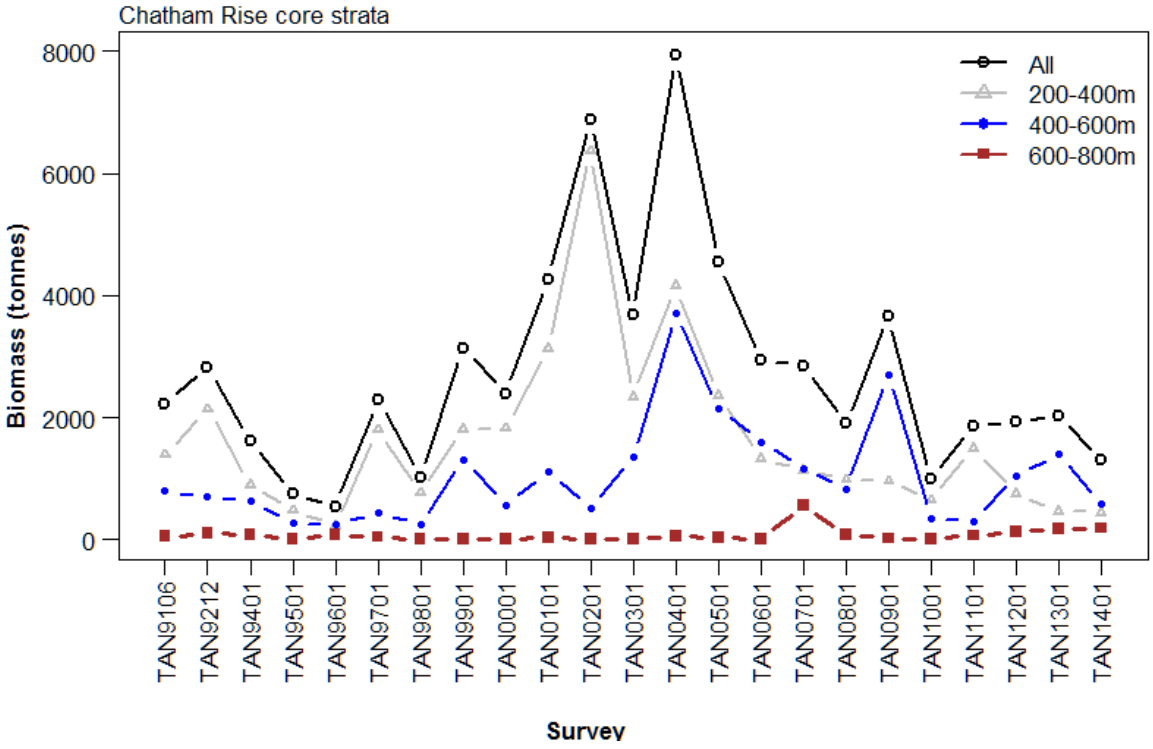


Figure A3. Doorspread biomass estimates, for all white warehou (± CV, top panel) and by sex (bottom panel), from the Chatham Rise *Tangaroa* surveys from 1991 to 2014.



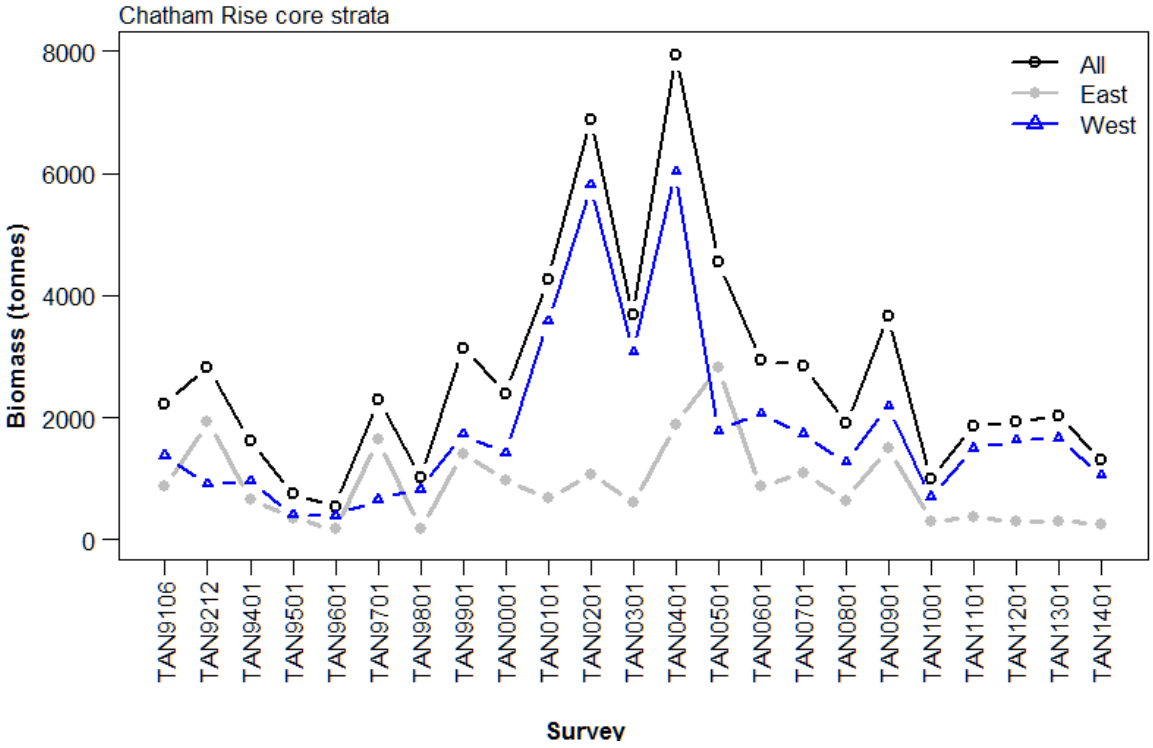


Figure A3 ctd.: Doorspread biomass estimates, for white warehou from the summer Chatham Rise *Tangaroa* surveys (200–800 m) and for those catches by depth range, and from east and west of 180° from 1991 to 2014.

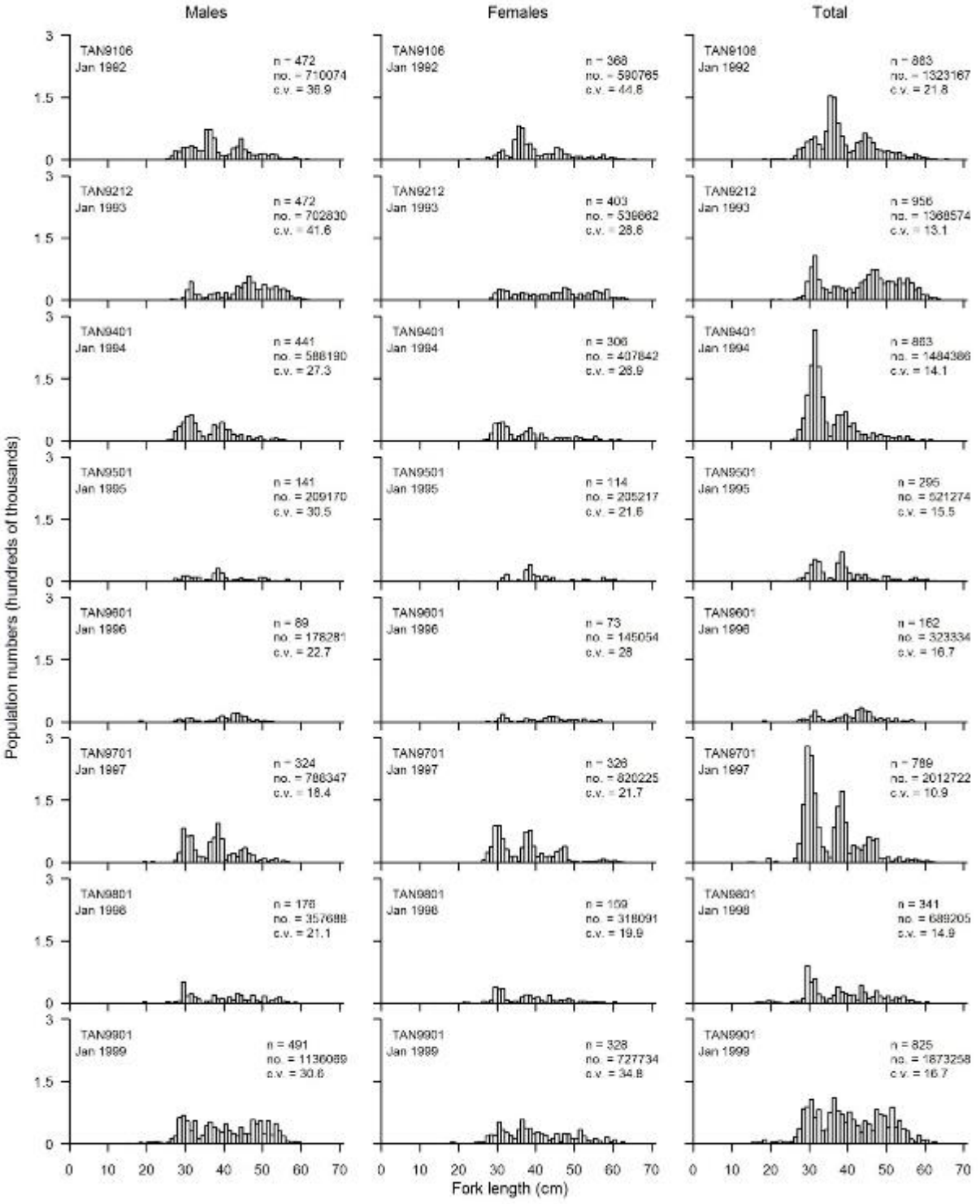


Figure A4: Scaled population length frequencies of white warehou from the Chatham Rise January *Tangaroa* (TAN) surveys, 1991 to 1999. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

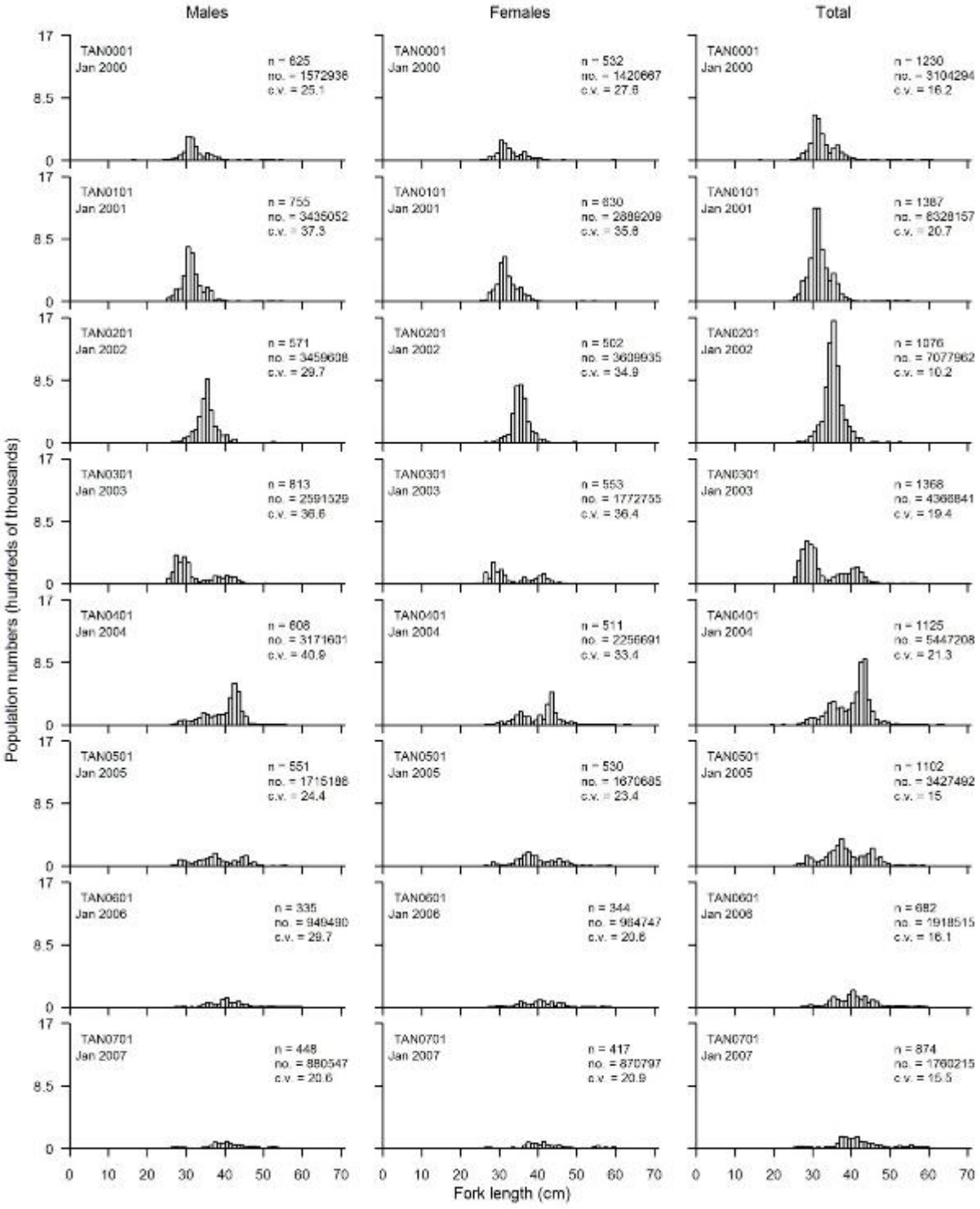


Figure A4 ctd.: Scaled population length frequencies of white warehou from the Chatham Rise January *Tangaroa* (TAN) surveys, 2000 to 2007. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

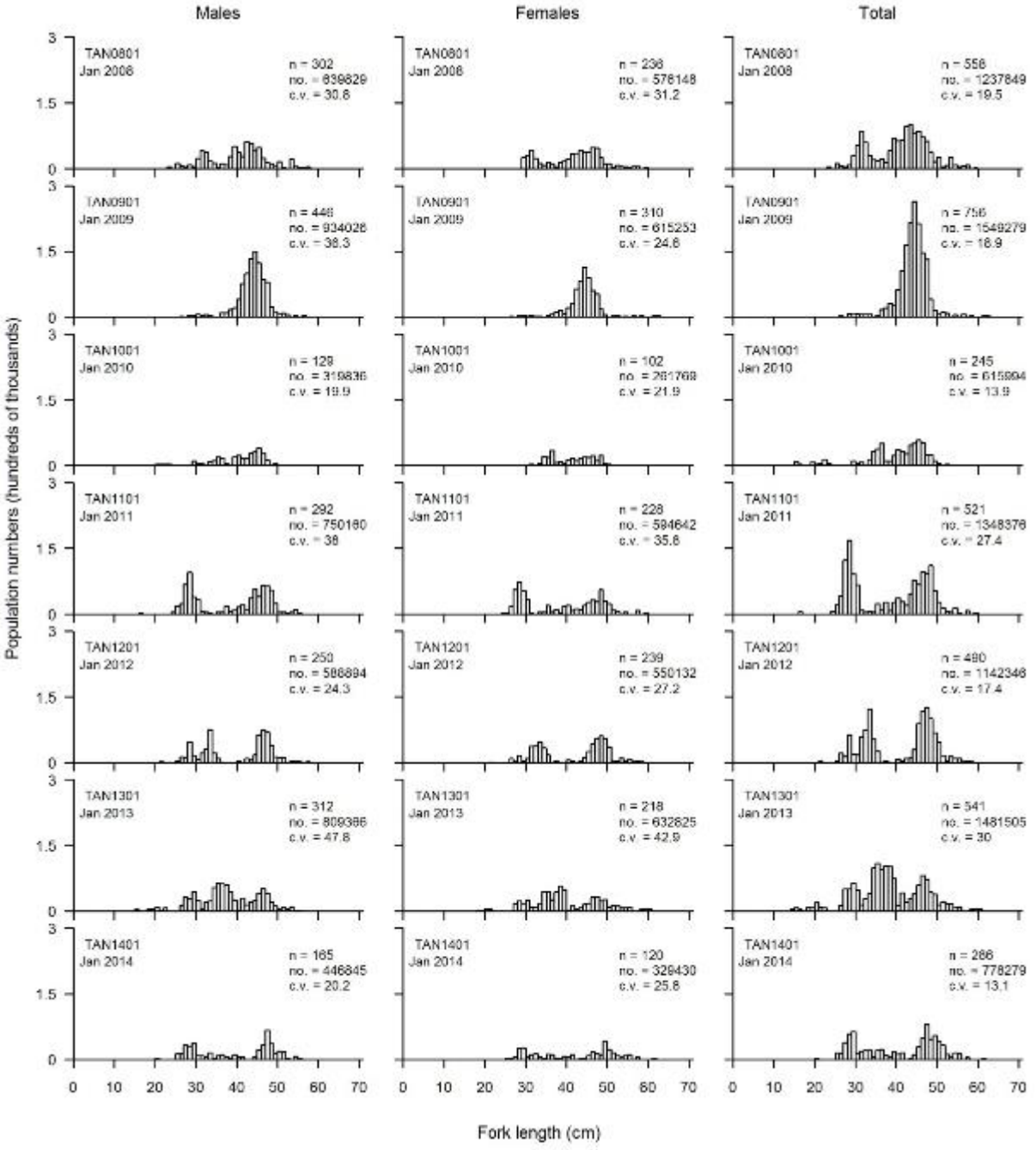


Figure A4 ctd.: Scaled population length frequencies of white warehou from the Chatham Rise January *Tangaroa* (TAN) surveys, 2008 to 2014. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

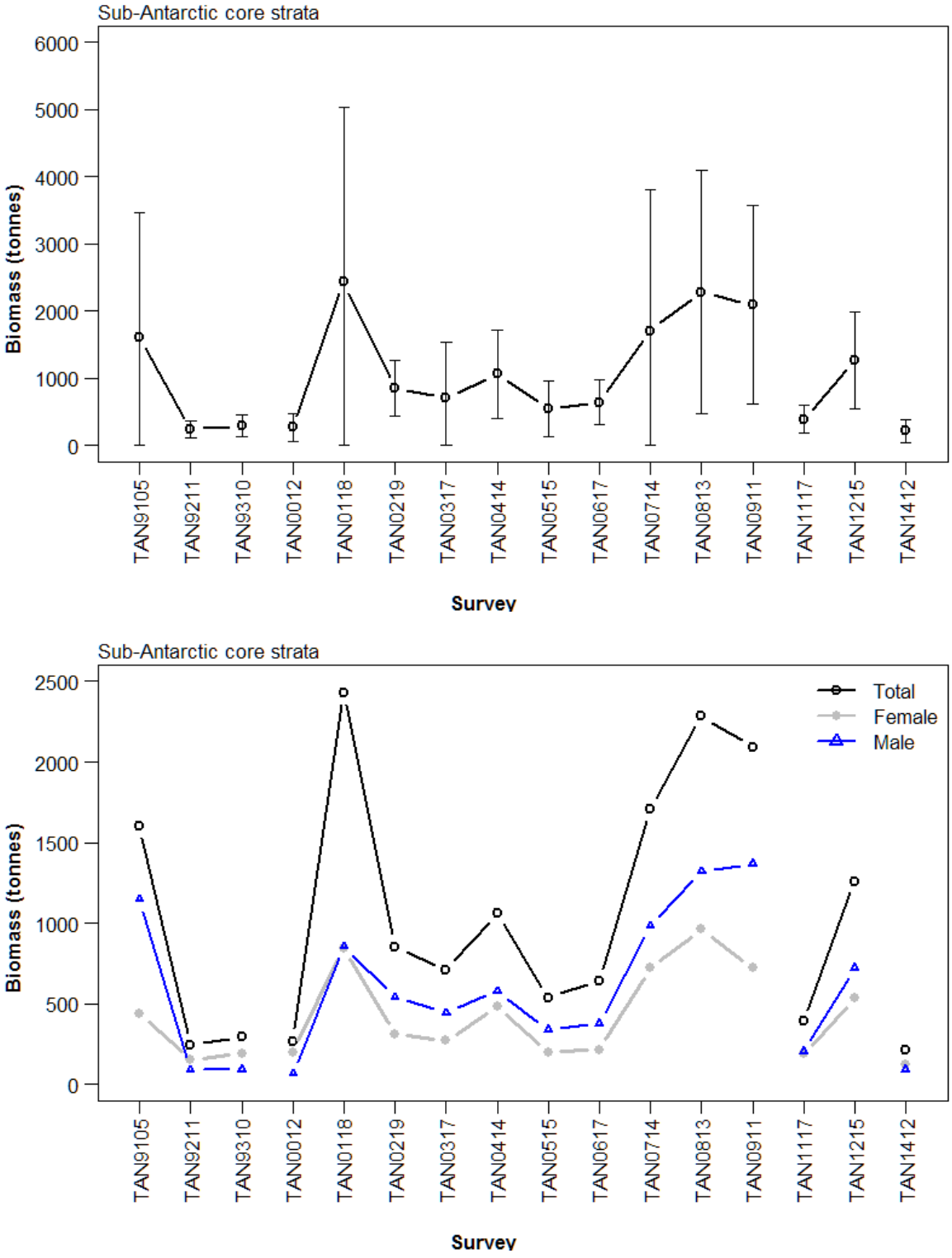


Figure A5: Doorspread biomass estimates, for all white warehou (± CV, top panel) and by sex (bottom panel), from summer *Tangaroa* surveys of Sub-Antarctic 1991–1993, 2000–2009, 2011–2012, and 2014.

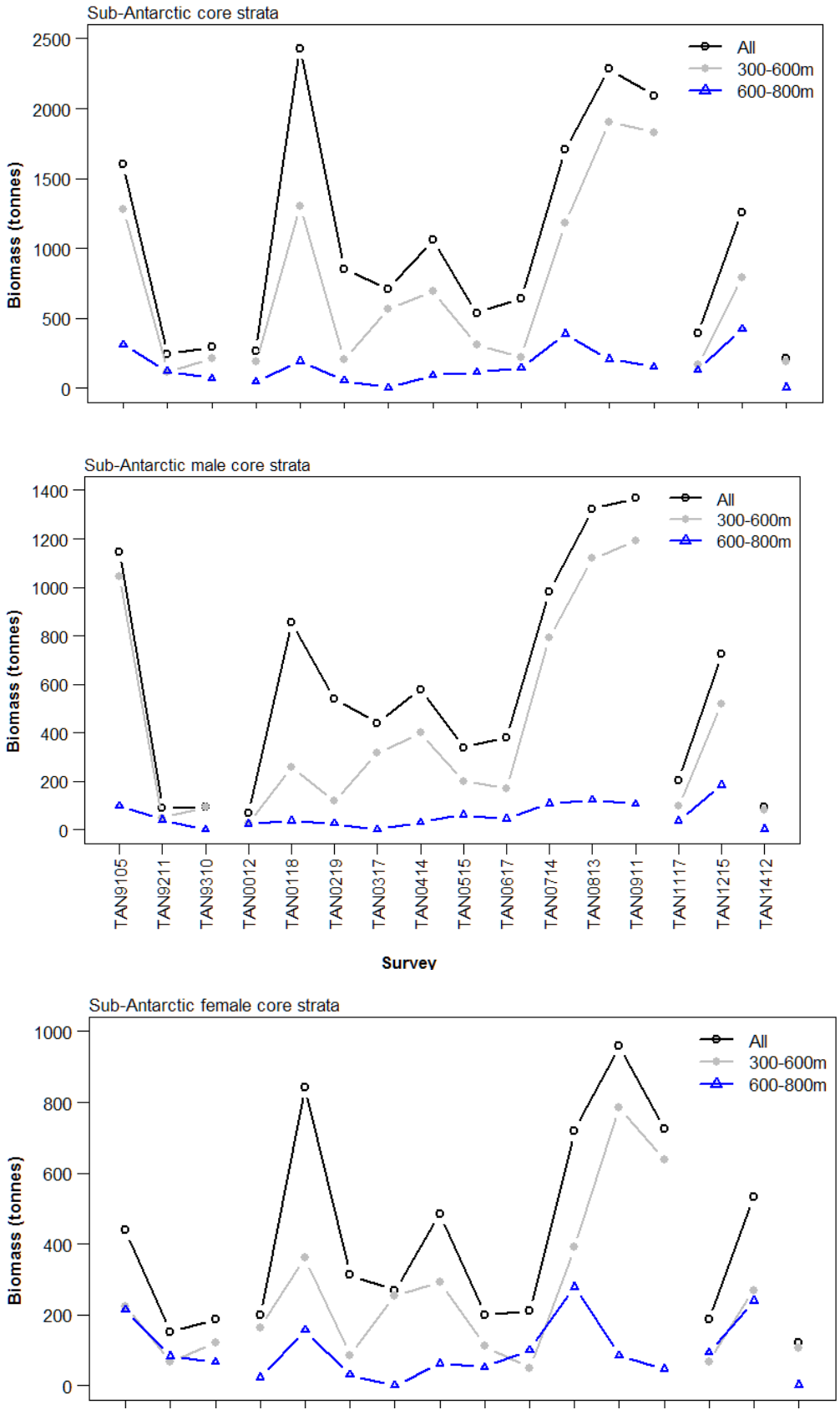


Figure A5 ctd.: Doorspread biomass estimates, for all, female, and male white warehou from summer Sub-Antarctic *Tangaroa* surveys (300–800 m) and for those catches from 300–600 m and 600–800 m, from 1991–1993, 2000–2009, 2011–2012, and 2014.

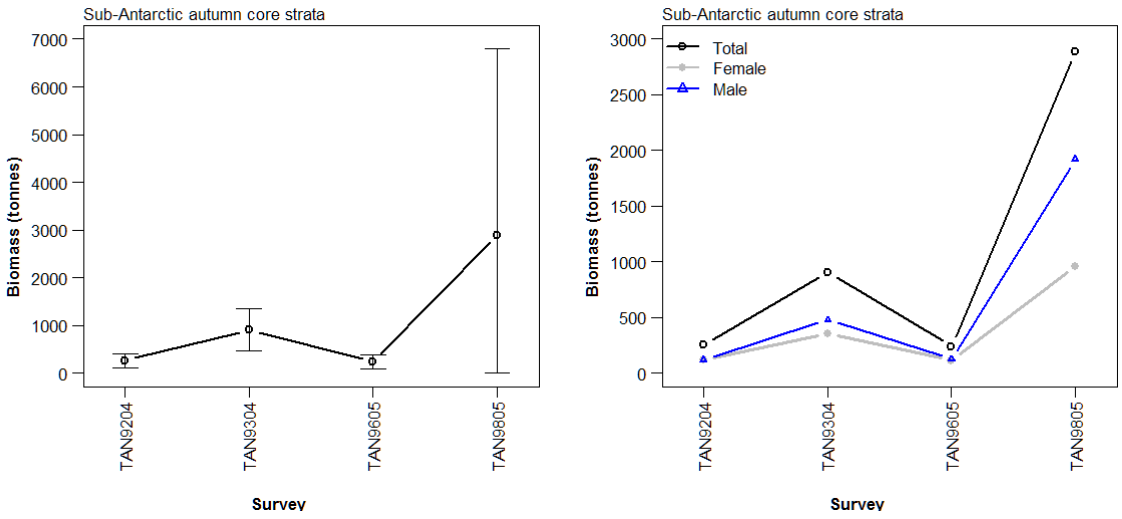


Figure A6: Doorspread biomass estimates, for all white warehou (± CV, above) and by sex, from autumn *Tangaroa* surveys of Sub-Antarctic from 1992–1993, 1996, and 1998.

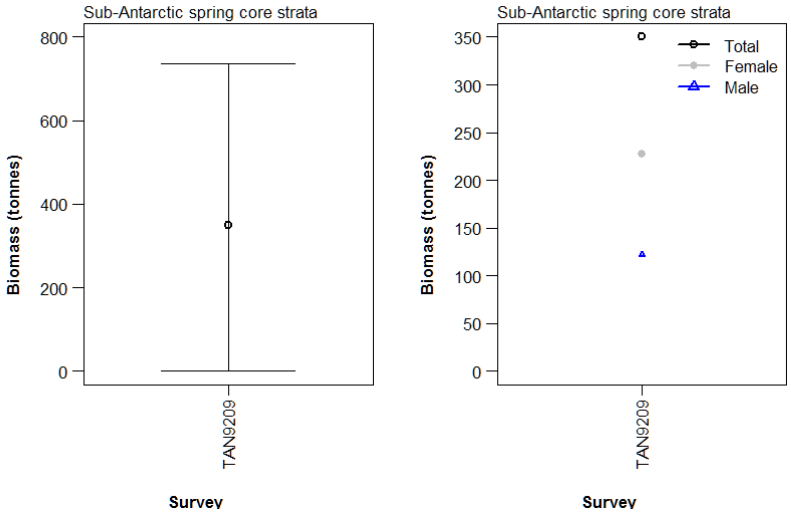


Figure A7: Doorspread biomass estimates, for all white warehou (± CV, above) and by sex (below), from the spring Sub-Antarctic *Tangaroa* survey from 1998.

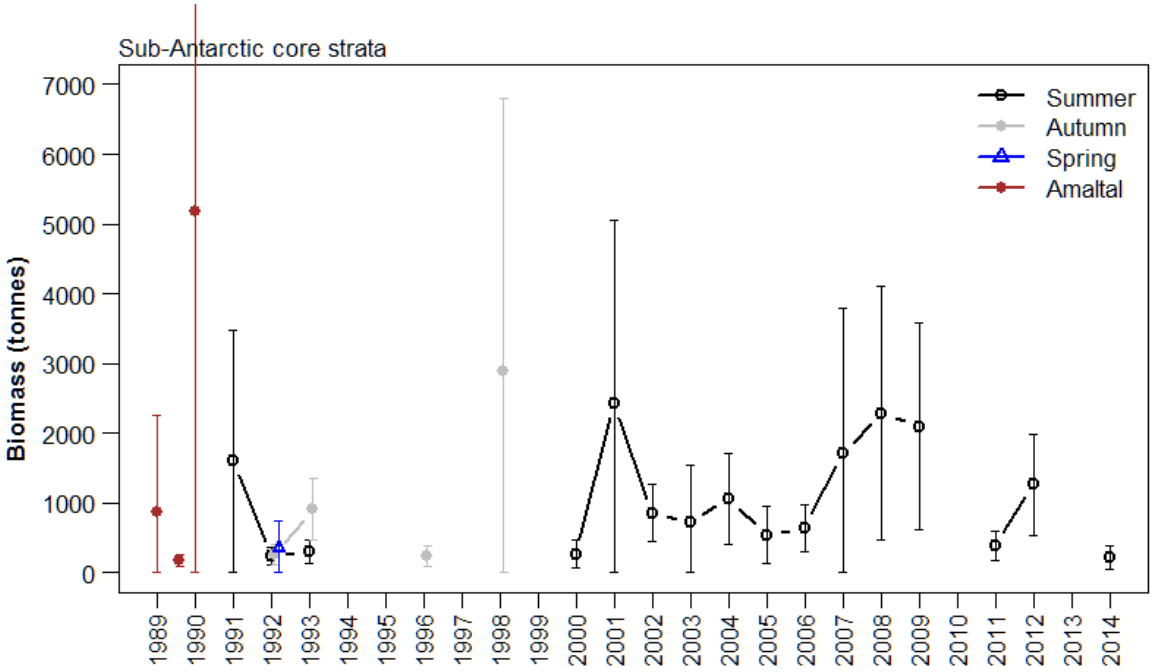


Figure A8: Doorspread biomass estimates of white warehou from the *Tangaroa* Sub-Antarctic November-December summer surveys, 2005-2009, and 2011-2012 (Summer); *Tangaroa* Sub-Antarctic autumn surveys from 1992-1993, 1996, and 1998 (Autumn); *Tangaroa* Sub-Antarctic spring survey from 1998 (Spring); and *Amaltal Explorer* Sub-Antarctic surveys in Oct-Nov 1989 and Jul-Aug and Nov-Dec 1990 (Amaltal).

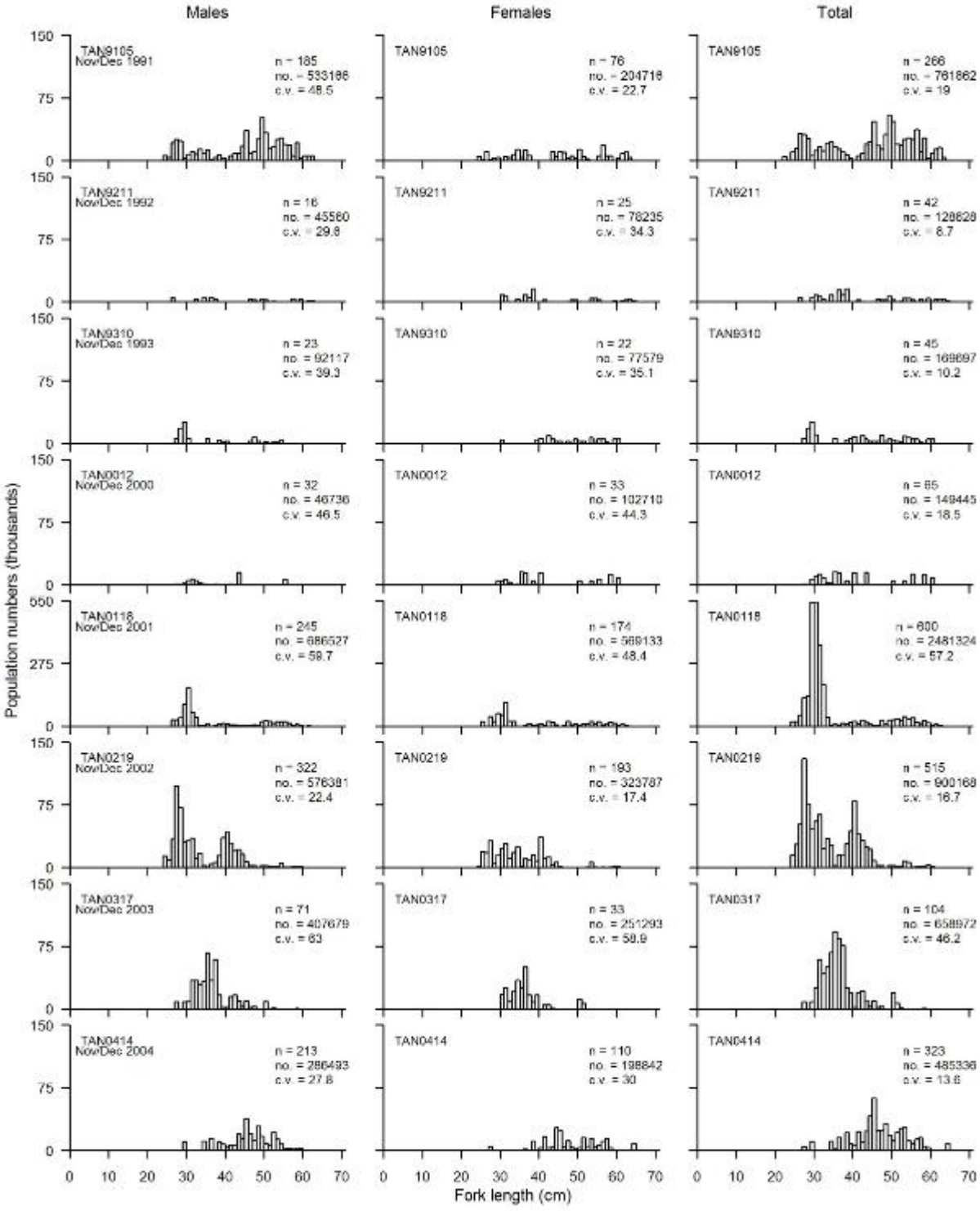


Figure A9: Scaled population length frequencies of white warehou from the Sub-Antarctic November–December *Tangaroa* (TAN) surveys, 1991–93 and 2000–04. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

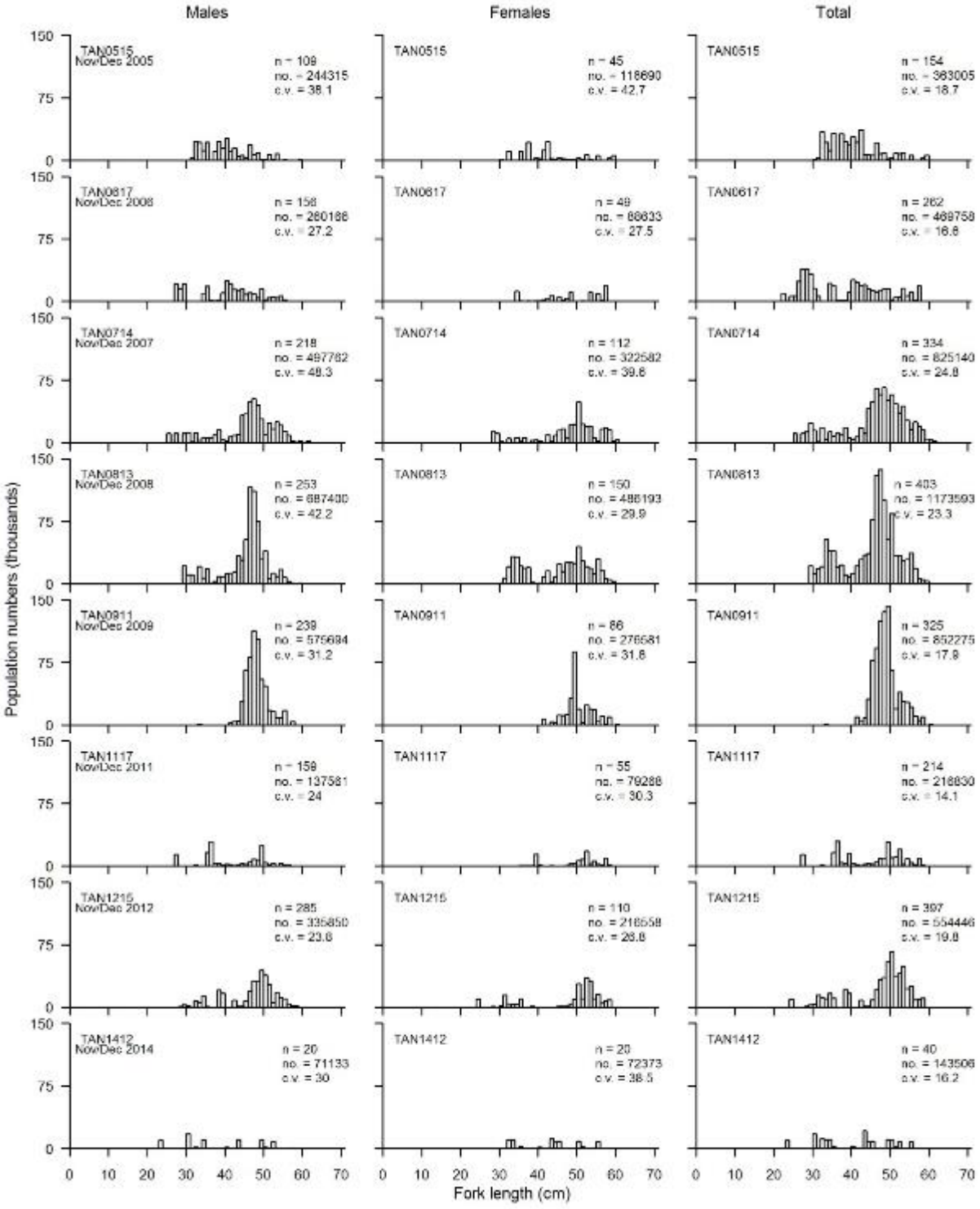


Figure A9 ctd.: Scaled population length frequencies of white warehou from the Sub-Antarctic November–December *Tangaroa* (TAN) surveys, 2005–2009, 2011–2012, and 2014. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

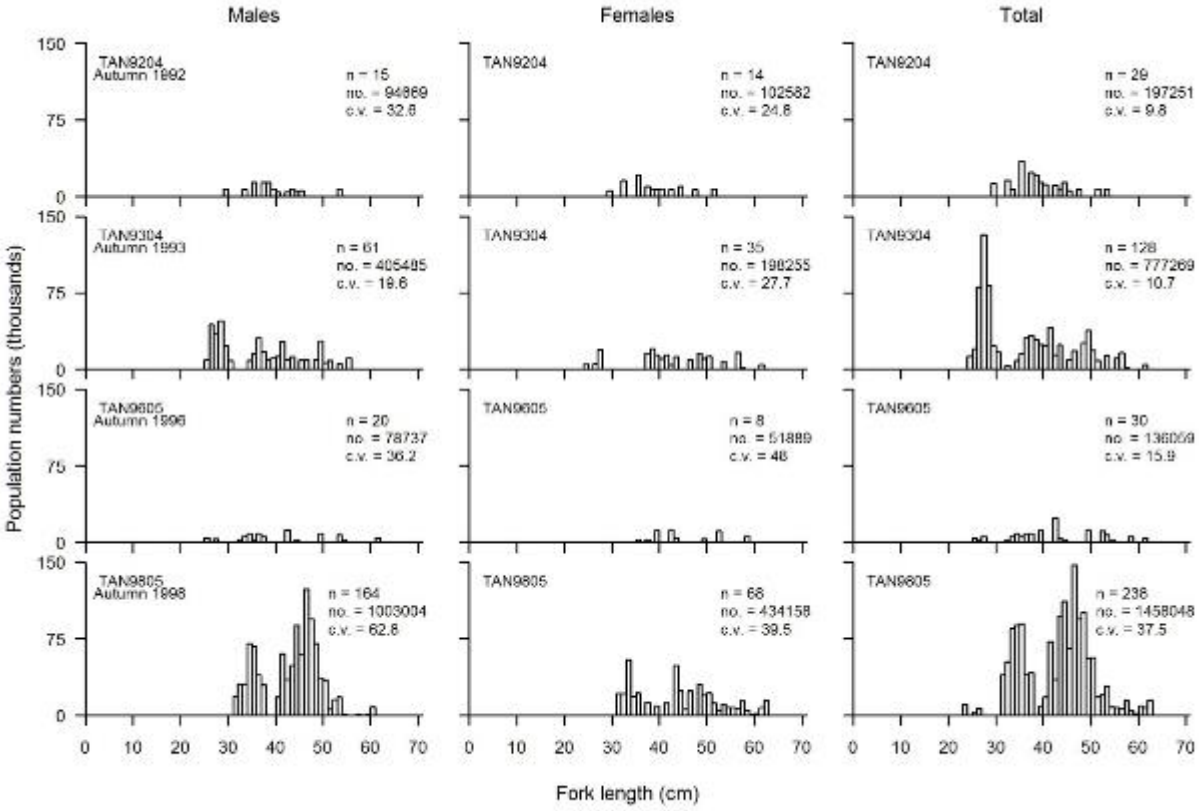


Figure A10: Scaled population length frequencies of white warehou from the Sub-Antarctic Autumn *Tangaroa* (TAN) surveys, 1992–1993, 1996, and 1998. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

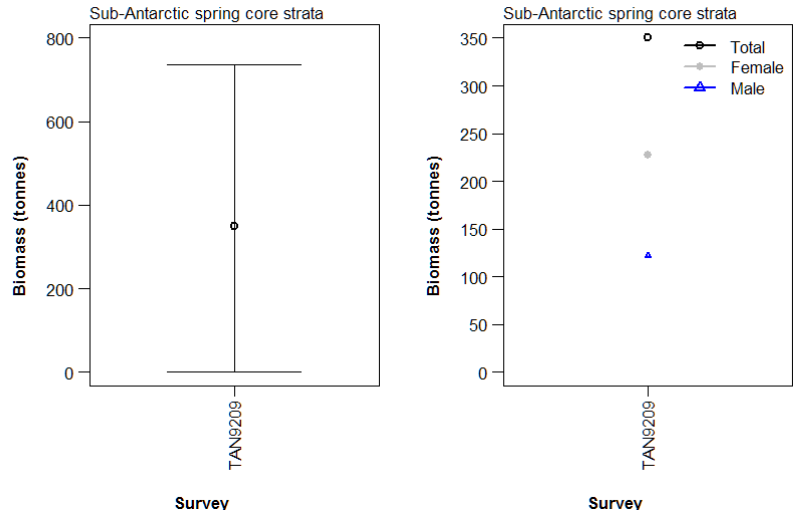


Figure A11: Doorspread biomass estimates, for all white warehou (± CV, left panel) and by sex (right panel), from the Sub-Antarctic Spring *Tangaroa* 1992 survey.

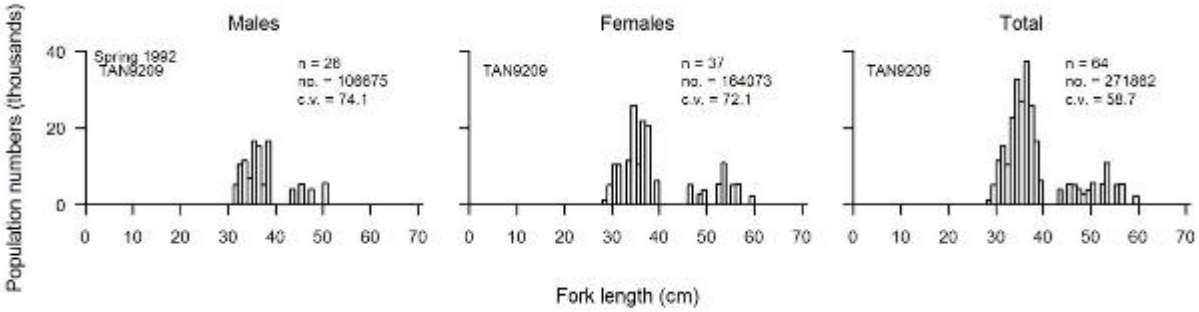


Figure A12: Scaled population length frequencies of white warehou from the Sub-Antarctic Spring *Tangaroa* (TAN) survey, 1998. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

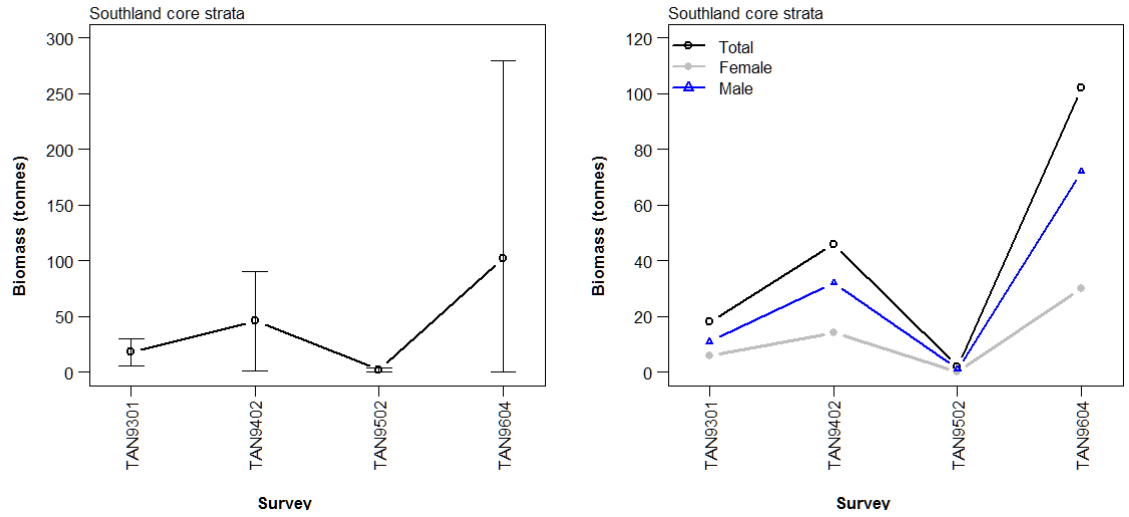


Figure A12: Doorspread biomass estimates, for all white warehou (± CV, left panel) and by sex (right panel), from the February–March Southland *Tangaroa* surveys 1993–96.

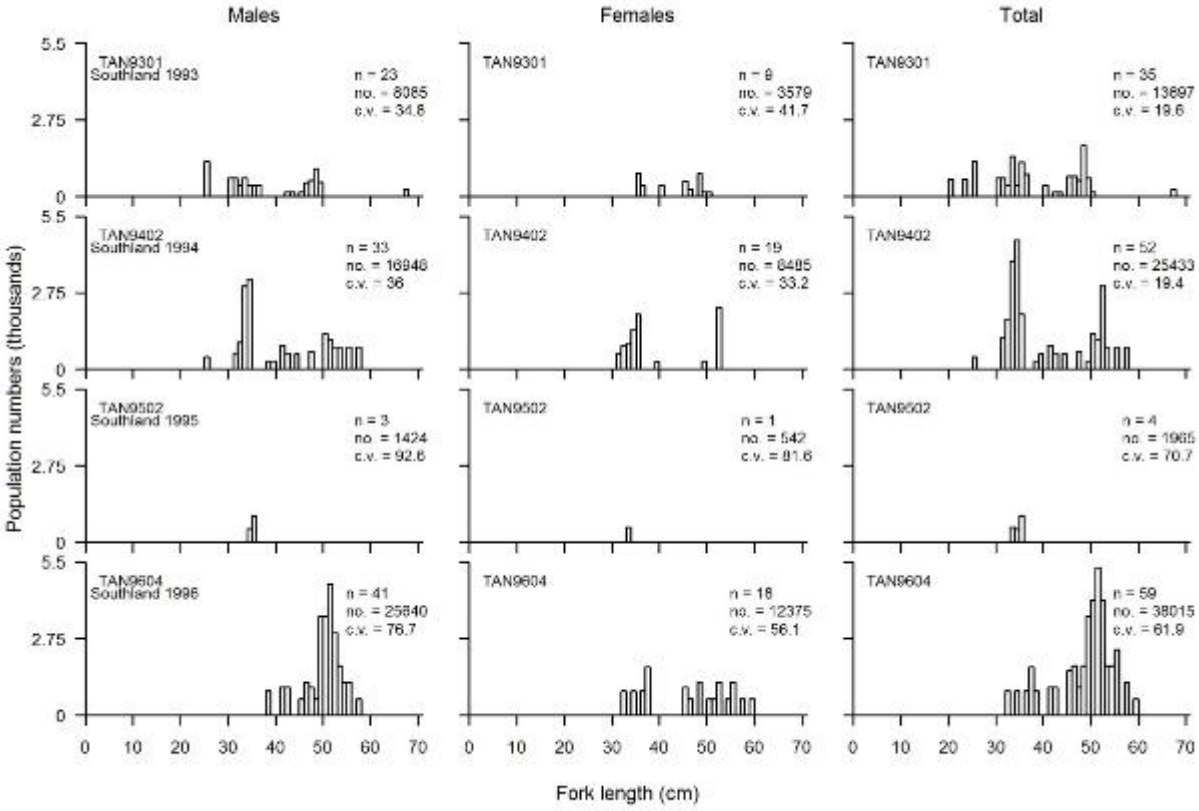


Figure A13: Scaled population length frequencies of white warehou from the Southland February–March *Tangaroa* (TAN) surveys, 1993–96. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

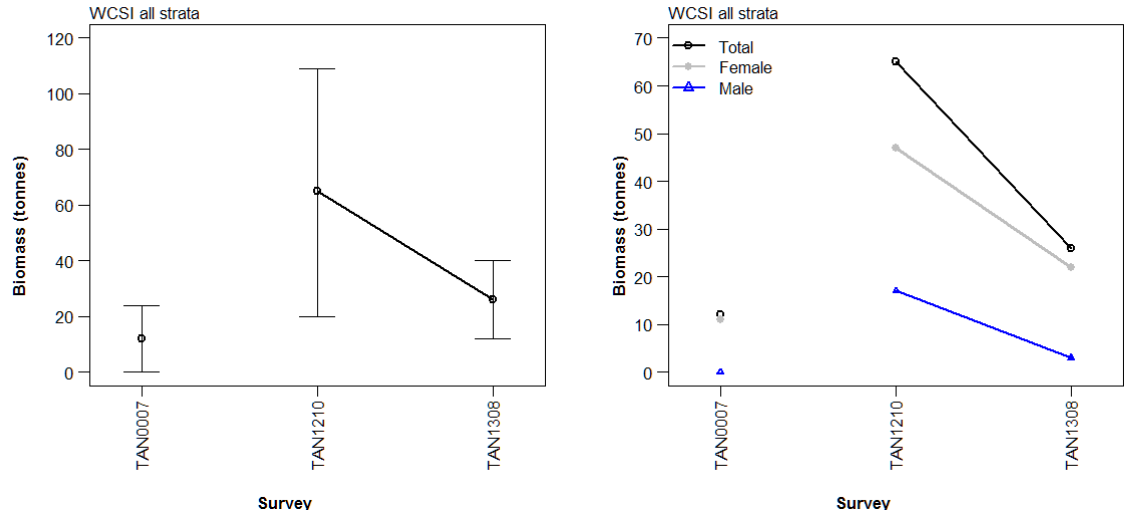


Figure A14: Doorspread biomass estimates, for all white warehou (± CV, left panel) and by sex (right panel), from the winter WCSI *Tangaroa* surveys 2000, and 2012–2013. (Note TAN0007 has 300–650 m core strata, and TAN1210 and TAN1308 have 200–800 m core strata).

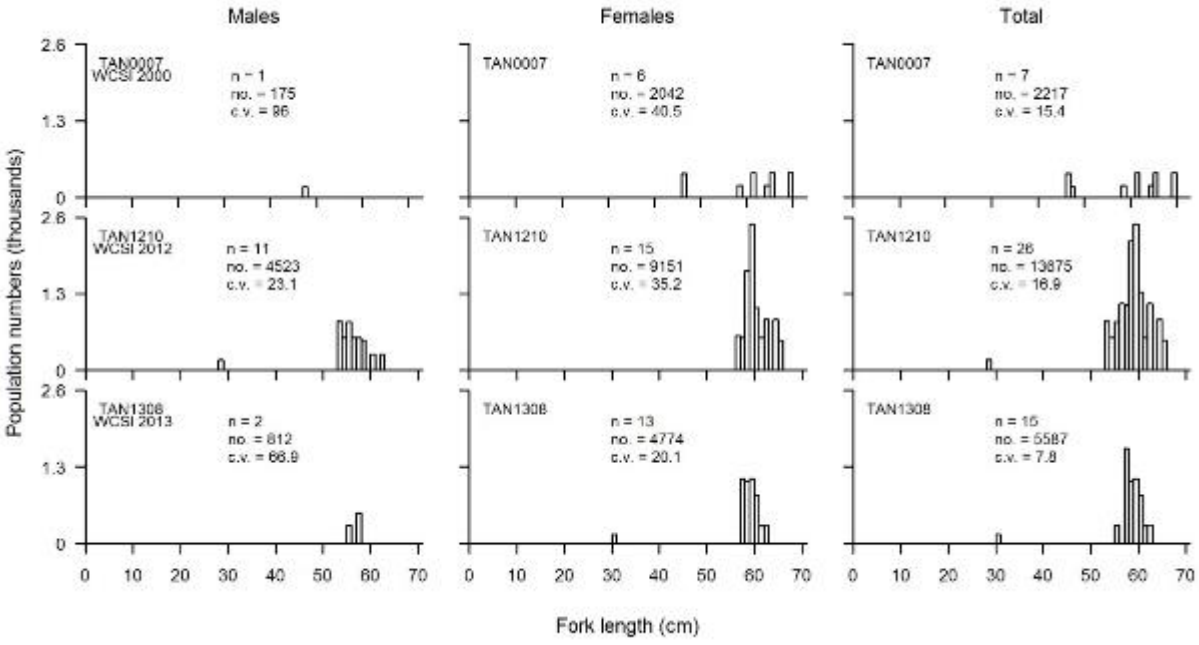


Figure A15: Scaled population length frequencies of white warehou from the winter WCSI *Tangaroa* (TAN) surveys, 2000, and 2012–2013. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.] (Note TAN0007 has 300–650 m core strata, and TAN1210 and TAN1308 have 200–800 m core strata).

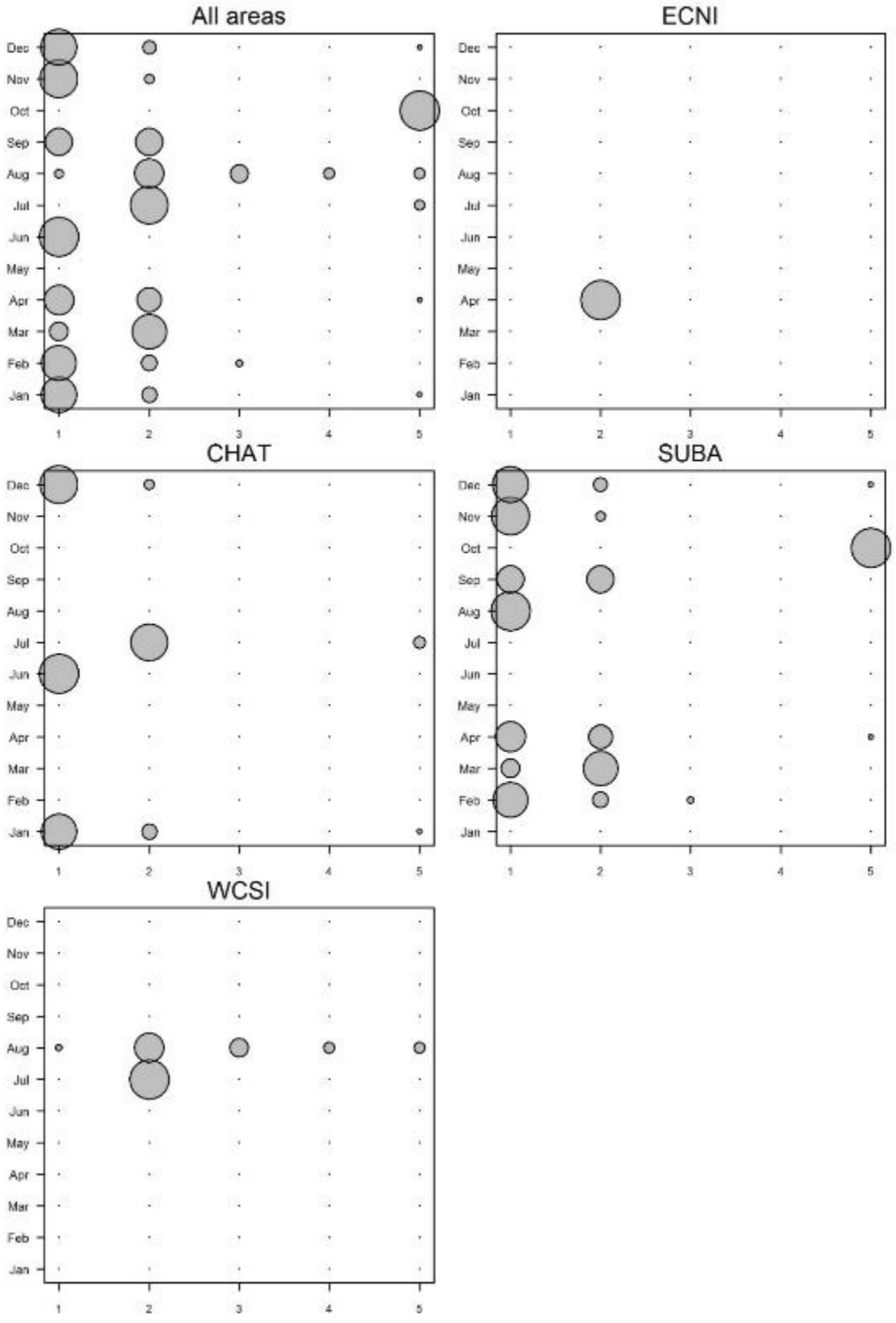


Figure A16: Relative proportions of female white warehou reproductive stage data from trawl surveys, by month, for each area. 1: immature or resting; 2: ripening; 3: ripe; 4: running ripe and partially spent; 5: spent.

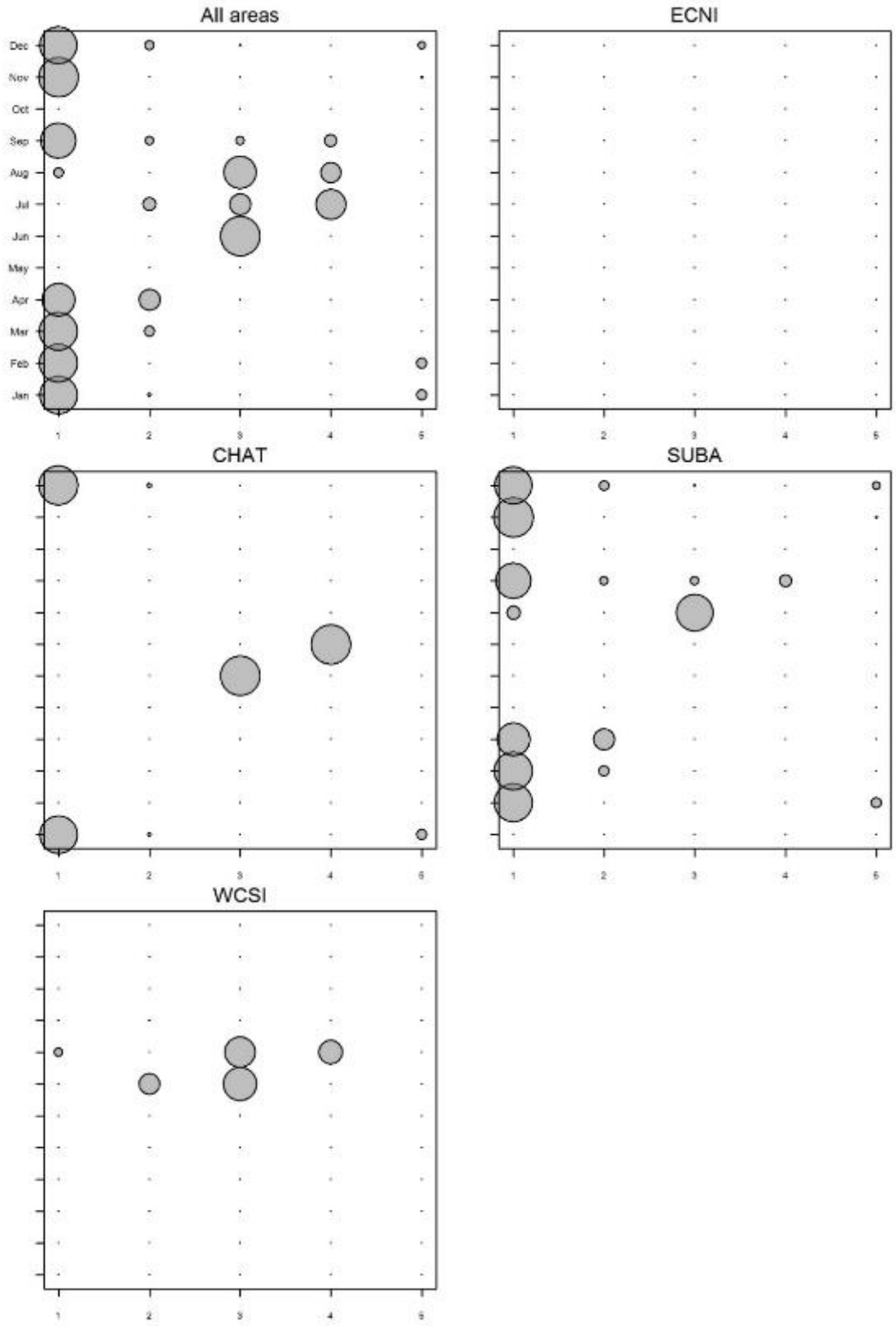


Figure A16: ctd. Relative proportions of male white warehou reproductive stage data from trawl surveys, by month, for each area. 1: immature or resting; 2: ripening; 3: ripe; 4: running ripe and partially spent; 5: spent.

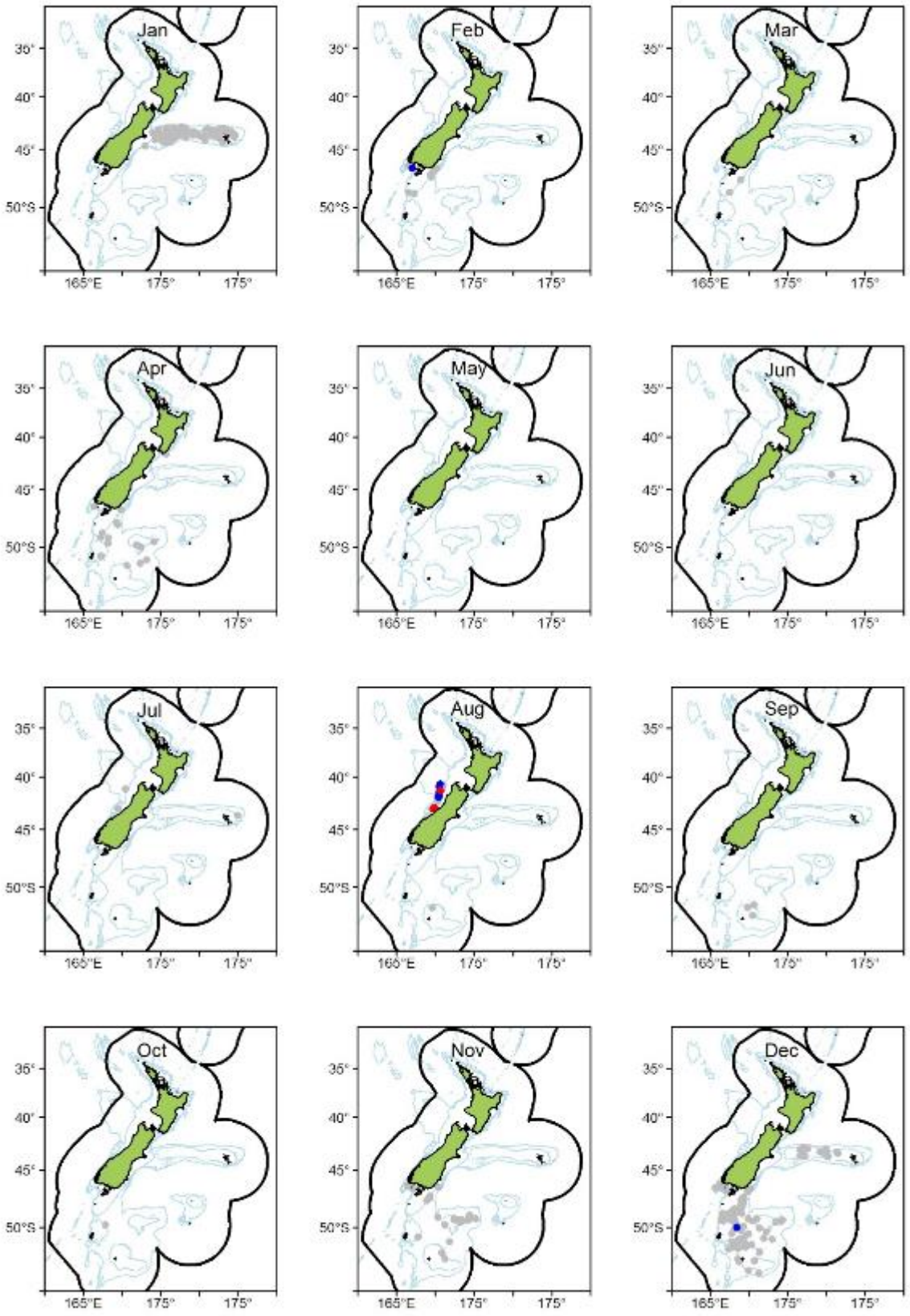


Figure A17: Distribution of female white warehou reproductive stage data from trawl surveys, by month. [Grey = immature, resting, maturing or spent; Blue = ripe; and Red = running ripe.

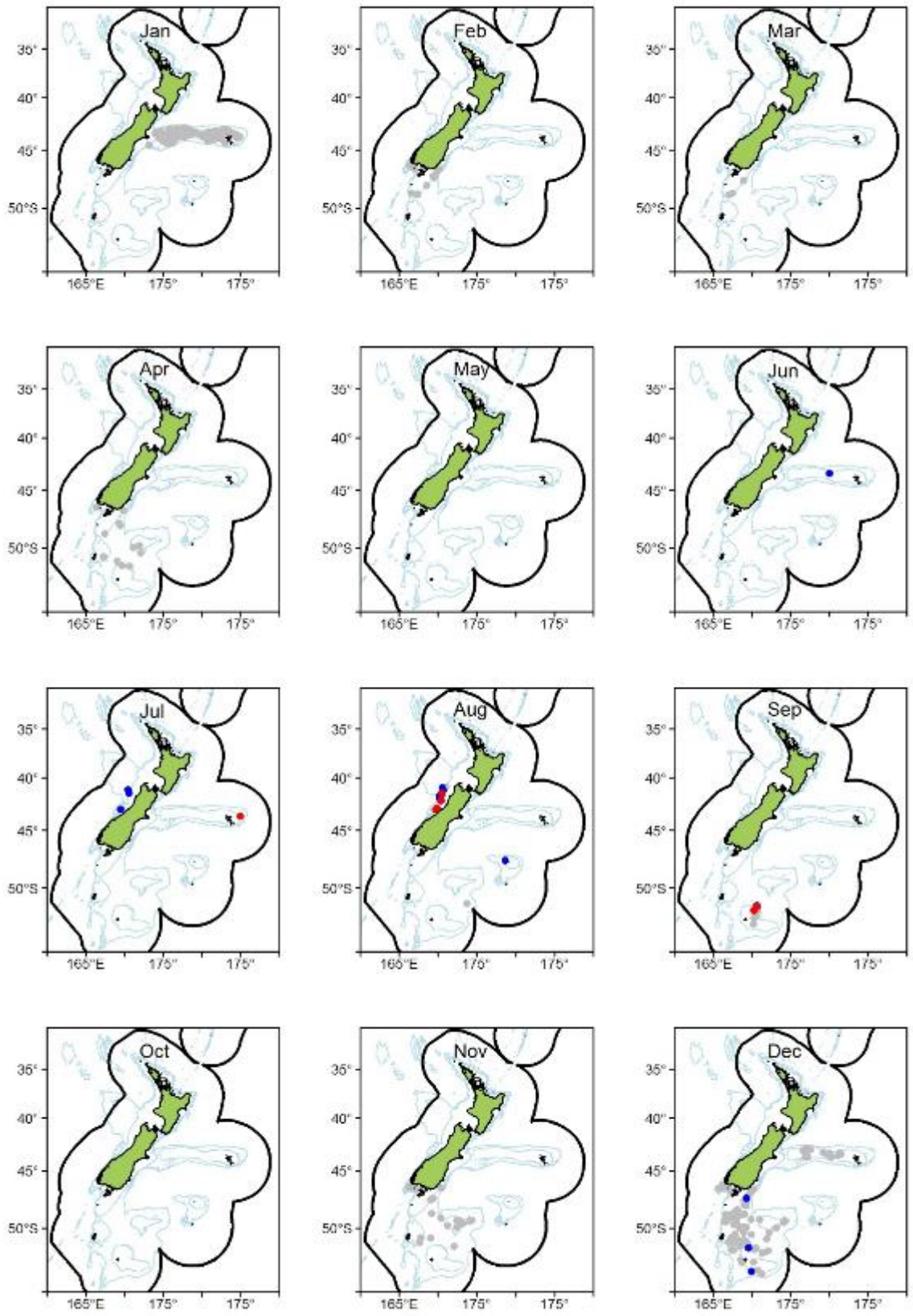


Figure A17: continued. Distribution of male white warehou reproductive stage data from trawl surveys, by month. [Grey = immature, resting, maturing or spent; Blue = ripe; and Red = running ripe.]

APPENDIX B: OBSERVER DATA

Table B1: Total number of observed trawl catches and tows sampled for white warehou, by area for fishing years 1990–91 to 2013–14. Areas are defined in Figure 1.

(a) Tows

Fishing year	CHAT	ECNI	SUBA	WCSI	Other	Total
1990–91	261	-	266	39	-	566
1991–92	267	44	767	62	-	1 140
1992–93	117	17	292	139	-	565
1993–94	254	-	291	81	31	657
1994–95	169	-	118	15	-	302
1995–96	183	7	111	63	1	365
1996–97	107	14	101	11	-	233
1997–98	449	19	278	51	-	797
1998–99	597	78	348	90	-	1 113
1999–00	411	16	487	108	11	1 033
2000–01	563	18	488	33	-	1 102
2001–02	636	15	448	239	2	1 340
2002–03	544	9	591	147	5	1 296
2003–04	440	-	314	186	-	940
2004–05	557	1	244	77	-	879
2005–06	533	-	376	253	3	1 165
2006–07	558	6	493	69	1	1 127
2007–08	511	9	587	253	4	1 364
2008–09	404	4	628	102	-	1 138
2009–10	431	45	760	140	7	1 383
2010–11	438	16	618	119	4	1 195
2011–12	436	7	743	100	6	1 292
2012–13	792	12	1 305	439	-	2 548
2013–14	696	2	1 086	449	5	2 238
Total	10 354	339	11 740	3 265	80	25 778

(b) Catches

Fishing year	CHAT	ECNI	SUBA	WCSI	Other	Total
1990–91	29	-	4	5	-	38
1991–92	21	1	65	5	-	92
1992–93	3	0	30	25	-	58
1993–94	8	-	17	9	5	39
1994–95	6	-	9	0	-	15
1995–96	22	0	24	5	2	52
1996–97	4	0	8	1	-	13
1997–98	46	1	31	4	-	81
1998–99	29	2	22	9	-	61
1999–00	30	0	140	30	1	202
2000–01	62	1	70	1	-	133
2001–02	36	0	208	26	0	270
2002–03	55	0	301	16	0	372
2003–04	61	-	171	12	-	244
2004–05	98	0	60	9	-	167
2005–06	110	-	175	27	0	313
2006–07	83	1	566	10	0	659
2007–08	43	0	247	30	0	321
2008–09	38	0	587	13	-	639
2009–10	105	1	521	8	0	635
2010–11	53	0	623	6	0	682
2011–12	45	0	544	16	0	605
2012–13	79	1	900	44	-	1 023
2013–14	113	0	1 268	57	0	1 438
Total	1 180	8	6 590	368	9	8 155

Table B2: Total number of observed trawl tows sampled for white warehou, by area, for fishing years 1991–92 to 2013–14. Note: Numbers of tows sampled are higher than values on the length frequency plots as this table includes tows where fewer than three fish were sampled. Areas defined in Figure 1.

Fishing year	CHAT	ECNI	SUBA	WCSI	Other	Total
1991–92	-	-	1	-	-	1
1992–93	-	-	2	-	-	2
1993–94	-	-	-	-	-	-
1994–95	-	-	1	-	-	1
1995–96	7	1	1	1	-	10
1996–97	7	-	3	-	-	10
1997–98	55	2	87	6	-	150
1998–99	197	61	82	44	-	384
1999–00	73	15	118	22	3	231
2000–01	114	13	86	12	-	225
2001–02	71	5	123	32	2	233
2002–03	57	3	124	13	1	198
2003–04	71	-	68	17	-	156
2004–05	106	-	37	20	-	163
2005–06	55	-	48	44	-	147
2006–07	46	-	98	4	-	148
2007–08	42	-	65	9	-	116
2008–09	18	-	64	11	-	93
2009–10	40	-	57	5	-	102
2010–11	27	-	69	1	-	97
2011–12	12	-	110	1	-	123
2012–13	19	2	108	9	-	138
2013–14	16	-	114	7	-	137
Total	1 033	102	1 466	258	6	2 865

Table B3: Number of observed tows sampled for white warehou, by month, for fishing years 1991–92 to 2013–14 where data exist.

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1991–92	-	-	-	-	-	-	-	-	-	-	-	1	1
1992–93	-	-	-	-	1	1	-	-	-	-	-	-	2
1993–94	-	-	-	-	-	-	-	-	-	-	-	-	-
1994–95	-	-	-	-	1	-	-	-	-	-	-	-	1
1995–96	3	-	-	-	-	1	-	-	1	-	1	4	10
1996–97	7	-	-	-	2	-	-	-	-	-	-	1	10
1997–98	5	-	2	2	5	31	68	10	1	4	3	19	150
1998–99	75	55	41	32	28	11	14	64	12	35	9	8	384
1999–00	4	30	5	17	17	4	10	79	21	22	1	21	231
2000–01	23	43	42	25	49	4	3	11	8	9	5	3	225
2001–02	21	33	19	5	11	19	35	23	9	33	13	12	233
2002–03	10	32	19	15	15	13	11	11	28	7	10	27	198
2003–04	8	30	13	8	3	9	12	-	3	14	31	25	156
2004–05	8	19	16	29	13	19	-	3	17	12	17	10	163
2005–06	26	10	11	-	8	6	1	10	16	19	34	6	147
2006–07	14	9	12	9	18	6	6	16	5	14	22	17	148
2007–08	15	32	6	1	2	9	-	28	2	-	5	16	116
2008–09	3	1	14	2	1	16	-	3	14	16	3	20	93
2009–10	21	8	12	9	1	12	2	10	7	13	6	1	102
2010–11	27	13	9	8	9	9	2	3	4	8	4	1	97
2011–12	13	17	14	6	13	15	1	4	1	16	4	19	123
2012–13	20	19	23	9	6	1	2	10	3	35	-	10	138
2013–14	15	20	24	28	4	-	1	3	9	12	2	19	137
Total	318	371	282	205	207	186	168	288	161	269	170	240	2 865

Table B4: Number of observed tows sampled for white warehou, by month, for fishing years 1991–92 to 2013–14 where data exist. Areas defined in Figure 1.

(a) CHAT

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	3	-	-	-	-	-	-	-	-	-	-	4	7
1996–97	7	-	-	-	-	-	-	-	-	-	-	-	7
1997–98	5	-	1	-	-	4	34	10	-	-	-	1	55
1998–99	38	25	39	30	22	3	3	27	4	6	-	-	197
1999–00	1	11	5	1	1	-	1	34	8	-	-	11	73
2000–01	19	31	37	4	14	2	3	1	1	2	-	-	114
2001–02	11	14	6	4	2	-	16	17	-	1	-	-	71
2002–03	9	10	10	2	-	-	2	2	1	-	-	21	57
2003–04	3	5	2	1	-	6	12	-	-	8	19	15	71
2004–05	3	6	12	27	13	19	-	3	17	1	4	1	106
2005–06	24	2	2	-	7	2	1	-	9	8	-	-	55
2006–07	2	4	7	6	2	3	1	16	4	1	-	-	46
2007–08	-	4	2	1	2	-	-	28	2	-	-	3	42
2008–09	1	1	-	-	-	11	-	1	1	-	-	3	18
2009–10	6	-	10	9	-	9	1	4	-	-	1	-	40
2010–11	2	1	1	-	6	9	1	3	-	-	3	1	27
2011–12	-	3	2	-	2	1	-	3	1	-	-	-	12
2012–13	-	5	3	2	1	-	-	5	1	-	-	2	19
2013–14	-	9	4	1	-	-	-	-	-	-	-	2	16
Total	134	131	143	88	72	69	75	154	49	27	27	64	1 033

(b) ECNI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	1	-	-	-	1
1997–98	-	-	-	2	-	-	-	-	-	-	-	-	2
1998–99	29	30	-	-	-	-	-	-	-	-	-	2	61
1999–00	-	14	-	-	1	-	-	-	-	-	-	-	15
2000–01	-	8	5	-	-	-	-	-	-	-	-	-	13
2001–02	-	3	2	-	-	-	-	-	-	-	-	-	5
2002–03	-	-	3	-	-	-	-	-	-	-	-	-	3
2012–13	-	-	-	-	-	-	1	1	-	-	-	-	2
Total	29	55	10	2	1	-	1	1	1	-	-	2	102

Table B4: continued.

(c) SUBA

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1991–92	-	-	-	-	-	-	-	-	-	-	-	1	1
1992–93	-	-	-	-	1	1	-	-	-	-	-	-	2
1993–94	-	-	-	-	-	-	-	-	-	-	-	-	-
1994–95	-	-	-	-	1	-	-	-	-	-	-	-	1
1995–96	-	-	-	-	-	1	-	-	-	-	-	-	1
1996–97	-	-	-	-	2	-	-	-	-	-	-	1	3
1997–98	-	-	1	-	5	27	34	-	1	-	1	18	87
1998–99	8	-	2	2	6	8	11	37	-	-	2	6	82
1999–00	3	5	-	16	14	3	8	45	12	3	1	8	118
2000–01	1	4	-	21	35	2	-	10	7	-	3	3	86
2001–02	10	16	11	1	8	19	19	6	6	4	11	12	123
2002–03	1	22	6	13	15	12	9	9	27	-	9	1	124
2003–04	5	25	11	7	3	3	-	-	3	-	7	4	68
2004–05	5	13	4	2	-	-	-	-	-	-	8	5	37
2005–06	2	6	9	-	1	4	-	10	7	5	4	-	48
2006–07	12	5	5	3	16	3	5	-	-	12	22	15	98
2007–08	15	28	4	-	-	9	-	-	-	-	4	5	65
2008–09	1	-	14	2	1	5	-	2	13	16	3	7	64
2009–10	15	8	2	-	1	3	1	6	7	12	2	-	57
2010–11	25	12	8	8	3	-	1	-	3	8	1	-	69
2011–12	13	14	12	6	11	14	1	1	-	16	4	18	110
2012–13	20	14	20	7	5	1	1	4	2	32	-	2	108
2013–14	15	11	20	27	4	-	1	3	7	8	2	16	114
Total	151	183	129	115	132	115	91	133	95	116	84	122	1 466

(d) WCSI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	-	-	1	-	1
1997–98	-	-	-	-	-	-	-	-	-	4	2	-	6
1998–99	-	-	-	-	-	-	-	-	8	29	7	-	44
1999–00	-	-	-	-	-	-	-	-	1	19	-	2	22
2000–01	3	-	-	-	-	-	-	-	-	7	2	-	12
2001–02	-	-	-	-	-	-	-	-	2	28	2	-	32
2002–03	-	-	-	-	-	-	-	-	-	7	1	5	13
2003–04	-	-	-	-	-	-	-	-	-	6	5	6	17
2004–05	-	-	-	-	-	-	-	-	-	11	5	4	20
2005–06	-	2	-	-	-	-	-	-	-	6	30	6	44
2006–07	-	-	-	-	-	-	-	-	1	1	-	2	4
2007–08	-	-	-	-	-	-	-	-	-	-	1	8	9
2008–09	1	-	-	-	-	-	-	-	-	-	-	10	11
2009–10	-	-	-	-	-	-	-	-	-	1	3	1	5
2010–11	-	-	-	-	-	-	-	-	1	-	-	-	1
2011–12	-	-	-	-	-	-	-	-	-	-	-	1	1
2012–13	-	-	-	-	-	-	-	-	-	3	-	6	9
2013–14	-	-	-	-	-	-	-	-	2	4	-	1	7
Total	4	2	-	-	-	-	-	-	15	126	59	52	258

Table B5: Total number of white warehou measured by fishing year and area sampled from each tow by the observer programme, for fishing years 1991–92 to 2013–14 where data exist. Note: Numbers measured differ from those on Figures B4, B5 and B6 for some years as scaled length frequencies plots only include tows where more than three individual fish are measured. Areas defined in Figure 1.

Fishing year	CHAT	ECNI	SUBA	WCSI	Other	Total
1991–92	-	-	104	-	-	104
1992–93	-	-	3	-	-	3
1993–94	-	-	-	-	-	-
1994–95	-	-	42	-	-	42
1995–96	41	1	48	2	-	92
1996–97	66	-	15	-	-	81
1997–98	409	4	647	38	-	1 098
1998–99	1 532	230	546	101	-	2 409
1999–00	706	22	1 036	187	23	1 974
2000–01	877	22	719	52	-	1 670
2001–02	351	16	1 583	154	2	2 106
2002–03	797	17	1 508	58	12	2 392
2003–04	635	-	1 007	63	-	1 705
2004–05	830	-	486	105	-	1 421
2005–06	505	-	845	293	-	1 643
2006–07	447	-	2 484	29	-	2 960
2007–08	511	-	1 334	117	-	1 962
2008–09	234	-	2 111	148	-	2 493
2009–10	700	-	2 362	82	-	3 144
2010–11	507	-	2 848	1	-	3 356
2011–12	272	-	4 559	5	-	4 836
2012–13	312	40	5 242	105	-	5 699
2013–14	254	-	6 306	75	-	6 635
Total	9 986	352	35 835	1 615	37	47 825

Table B6: Total number of white warehou measured, by area, for fishing years 1991–92 to 2013–14 where data exist. Note: Numbers measured differ from those given in Figures B4–B6 for some years because scaled length frequencies plots only include tows where more than three individual fish are measured. Areas defined in Figure 1.

(a) CHAT
Total numbers:

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	14	-	-	-	-	-	-	-	-	-	-	27	41
1996–97	66	-	-	-	-	-	-	-	-	-	-	-	66
1997–98	9	-	30	-	-	9	235	72	-	-	-	54	409
1998–99	429	113	141	133	159	12	15	400	120	10	-	-	1 532
1999–00	2	32	8	1	3	-	5	543	74	-	-	38	706
2000–01	72	146	300	95	58	2	131	11	56	6	-	-	877
2001–02	43	59	25	12	6	-	85	120	-	1	-	-	351
2002–03	117	413	42	12	-	-	10	13	7	-	-	183	797
2003–04	35	12	14	16	-	67	149	-	-	58	182	102	635
2004–05	22	86	149	208	153	96	-	26	63	2	20	5	830
2005–06	113	10	2	-	94	35	15	-	118	118	-	-	505
2006–07	8	25	57	100	12	6	20	189	23	7	-	-	447
2007–08	-	55	32	10	31	-	-	324	23	-	-	36	511
2008–09	10	10	-	-	-	121	-	20	20	-	-	53	234
2009–10	89	-	25	13	-	383	20	70	-	-	100	-	700
2010–11	57	20	20	-	85	166	30	49	-	-	60	20	507
2011–12	-	67	2	-	40	40	-	70	53	-	-	-	272
2012–13	-	91	27	35	20	-	-	92	20	-	-	27	312
2013–14	-	108	86	20	-	-	-	-	-	-	-	40	254
Total	1 086	1 247	960	655	661	937	715	1 999	577	202	362	585	9 986

Females (%)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	21.4	-	-	-	-	-	-	-	-	-	-	18.5	19.5
1996–97	37.9	-	-	-	-	-	-	-	-	-	-	-	37.9
1997–98	44.4	-	30.0	-	-	33.3	22.1	27.8	-	-	-	29.6	25.4
1998–99	33.3	47.8	34.0	60.2	28.3	75.0	40.0	30.8	23.3	20.0	-	-	35.1
1999–00	50.0	68.8	12.5	100.0	100.0	-	-	39.6	45.9	-	-	50.0	41.9
2000–01	44.4	44.5	45.0	47.4	48.3	100.0	79.4	27.3	46.4	16.7	-	-	50.3
2001–02	32.6	59.3	48.0	33.3	66.7	-	42.4	35.0	-	100.0	-	-	42.2
2002–03	32.5	55.0	54.8	58.3	-	-	70.0	69.2	57.1	-	-	20.2	44.2
2003–04	40.0	66.7	50.0	43.8	-	37.3	41.6	-	-	34.5	35.2	31.4	37.6
2004–05	63.6	55.8	54.4	56.7	51.6	36.5	-	26.9	41.3	100.0	15.0	40.0	50.0
2005–06	55.8	30.0	50.0	-	43.6	51.4	66.7	-	39.0	44.9	-	-	46.5
2006–07	100.0	48.0	54.4	44.0	58.3	83.3	65.0	46.6	52.2	57.1	-	-	50.1
2007–08	-	45.5	31.2	30.0	71.0	-	-	58.3	47.8	-	-	75.0	56.2
2008–09	20.0	30.0	-	-	-	45.5	-	55.0	25.0	-	-	49.1	43.6
2009–10	38.2	-	52.0	23.1	-	51.4	60.0	57.1	-	-	21.0	-	45.7
2010–11	38.6	25.0	30.0	-	42.4	57.8	70.0	38.8	-	-	61.7	10.0	48.1
2011–12	-	98.5	100.0	-	42.5	47.5	-	45.7	49.1	-	-	-	59.6
2012–13	-	49.5	40.7	48.6	30.0	-	-	54.3	75.0	-	-	74.1	52.6
2013–14	-	55.6	41.9	50.0	-	-	-	-	-	-	-	20.0	44.9
Total	38.4	54.4	44.4	51.8	43.6	49.5	45.2	42.4	40.4	41.1	34.5	33.2	44.2

Table B6: continued.

(b) ECNI
Total numbers:

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	1	-	-	-	1
1996–97	-	-	-	-	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	4	-	-	-	-	-	-	-	-	4
1998–99	77	146	-	-	-	-	-	-	-	-	-	7	230
1999–00	-	21	-	-	1	-	-	-	-	-	-	-	22
2000–01	-	16	6	-	-	-	-	-	-	-	-	-	22
2001–02	-	13	3	-	-	-	-	-	-	-	-	-	16
2002–03	-	-	17	-	-	-	-	-	-	-	-	-	17
2012–13	-	-	-	-	-	-	20	20	-	-	-	-	40
Total	77	196	26	4	1	-	20	20	1	-	-	7	352

Females (%)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	100.0	-	-	-	100.0
1996–97	-	-	-	-	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	50.0	-	-	-	-	-	-	-	-	50.0
1998–99	79.2	80.1	-	-	-	-	-	-	-	-	-	-	77.4
1999–00	-	85.7	-	-	100.0	-	-	-	-	-	-	-	86.4
2000–01	-	68.8	50.0	-	-	-	-	-	-	-	-	-	63.6
2001–02	-	69.2	100.0	-	-	-	-	-	-	-	-	-	75.0
2002–03	-	-	94.1	-	-	-	-	-	-	-	-	-	94.1
2012–13	-	-	-	-	-	-	65.0	70.0	-	-	-	-	67.5
Total	79.2	79.1	84.6	50.0	100.0	-	65.0	70.0	100.0	-	-	-	76.4

Table B6: continued.

(c) SUBA

Total numbers:

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1991–92	-	-	-	-	-	-	-	-	-	-	-	104	104
1992–93	-	-	-	-	2	1	-	-	-	-	-	-	3
1994–95	-	-	-	-	42	-	-	-	-	-	-	-	42
1995–96	-	-	-	-	-	48	-	-	-	-	-	-	48
1996–97	-	-	-	-	12	-	-	-	-	-	-	3	15
1997–98	-	-	20	-	157	209	190	-	1	-	8	62	647
1998–99	11	-	30	3	10	37	54	140	-	-	2	259	546
1999–00	31	494	-	78	59	140	22	116	35	9	29	23	1 036
2000–01	1	7	-	222	338	9	-	65	56	-	18	3	719
2001–02	308	492	28	10	69	313	81	25	10	7	43	197	1 583
2002–03	5	255	26	87	214	410	270	39	143	-	54	5	1 508
2003–04	54	243	466	62	52	55	-	-	7	-	32	36	1 007
2004–05	75	157	80	36	-	-	-	-	-	-	117	21	486
2005–06	21	15	162	-	1	30	-	194	105	283	34	-	845
2006–07	246	101	37	24	230	6	40	-	-	1 199	411	190	2 484
2007–08	217	538	240	-	-	180	-	-	-	-	6	153	1 334
2008–09	19	-	210	14	14	100	-	26	380	1 020	187	141	2 111
2009–10	754	250	117	-	20	22	8	363	325	430	73	-	2 362
2010–11	1 862	243	63	127	49	-	5	-	117	367	15	-	2 848
2011–12	631	693	582	302	322	381	4	80	-	1 418	20	126	4 559
2012–13	1 163	786	823	384	102	21	20	72	21	1 810	-	40	5 242
2013–14	1 084	315	1 203	1 544	63	-	20	110	58	709	160	1 040	6 306
Total	6 482	4 589	4 087	2 893	1 756	1 962	714	1 230	1 258	7 252	1 209	2 403	35 835

Females (%)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1991–92	-	-	-	-	-	-	-	-	-	-	-	30.8	30.8
1992–93	-	-	-	-	50.0	-	-	-	-	-	-	-	33.3
1994–95	-	-	-	-	38.1	-	-	-	-	-	-	-	38.1
1995–96	-	-	-	-	-	62.5	-	-	-	-	-	-	62.5
1996–97	-	-	-	-	8.3	-	-	-	-	-	-	100.0	26.7
1997–98	-	-	30.0	-	45.9	50.2	36.8	-	100.0	-	-	62.9	45.3
1998–99	72.7	-	36.7	33.3	40.0	48.6	48.1	62.1	-	-	100.0	11.2	34.1
1999–00	-	37.2	-	26.9	49.2	66.4	45.5	54.3	48.6	88.9	44.8	34.8	43.1
2000–01	-	71.4	-	46.8	37.0	33.3	-	32.3	23.2	-	27.8	33.3	38.5
2001–02	34.7	28.0	78.6	50.0	47.8	44.7	42.0	48.0	80.0	28.6	37.2	24.4	35.7
2002–03	-	38.0	53.8	36.8	38.8	72.0	55.9	66.7	58.7	-	9.3	60.0	52.4
2003–04	46.3	48.6	51.1	43.5	50.0	49.1	-	-	42.9	-	6.2	11.1	46.7
2004–05	72.0	45.9	41.2	36.1	-	-	-	-	-	-	65.0	71.4	54.1
2005–06	14.3	20.0	35.8	-	100.0	46.7	-	30.9	38.1	33.6	41.2	-	34.1
2006–07	51.6	46.5	54.1	45.8	31.3	16.7	27.5	-	-	44.8	38.4	69.5	44.9
2007–08	54.4	34.0	67.9	-	-	22.2	-	-	-	-	33.3	52.3	43.9
2008–09	63.2	-	53.8	50.0	71.4	44.0	-	34.6	44.5	48.4	59.4	62.4	50.1
2009–10	41.0	27.6	45.3	-	15.0	59.1	62.5	50.7	42.8	55.8	35.6	-	44.1
2010–11	37.4	47.3	34.9	32.3	42.9	-	20.0	-	41.9	56.4	60.0	-	40.8
2011–12	39.1	41.4	38.3	51.3	37.3	29.4	50.0	60.0	-	60.6	55.0	50.0	46.7
2012–13	52.6	48.7	56.7	34.6	17.6	76.2	5.0	55.6	42.9	50.1	-	60.0	49.8
2013–14	38.5	38.4	44.1	35.6	36.5	-	65.0	39.1	32.8	58.3	57.5	44.2	42.5
Total	42.2	39.7	48.3	38.0	37.5	48.5	45.4	48.2	43.8	51.9	44.8	42.8	44.8

Table B6: continued.

(d) WCSI
Total numbers:

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	-	-	2	-	2
1997–98	-	-	-	-	-	-	-	-	-	35	3	-	38
1998–99	-	-	-	-	-	-	-	-	15	75	11	-	101
1999–00	-	-	-	-	-	-	-	-	6	178	-	3	187
2000–01	3	-	-	-	-	-	-	-	-	37	12	-	52
2001–02	-	-	-	-	-	-	-	-	8	144	2	-	154
2002–03	-	-	-	-	-	-	-	-	-	24	1	33	58
2003–04	-	-	-	-	-	-	-	-	-	10	20	33	63
2004–05	-	-	-	-	-	-	-	-	-	58	20	27	105
2005–06	-	5	-	-	-	-	-	-	-	51	203	34	293
2006–07	-	-	-	-	-	-	-	-	1	12	-	16	29
2007–08	-	-	-	-	-	-	-	-	-	-	12	105	117
2008–09	10	-	-	-	-	-	-	-	-	-	-	138	148
2009–10	-	-	-	-	-	-	-	-	-	14	48	20	82
2010–11	-	-	-	-	-	-	-	-	1	-	-	-	1
2011–12	-	-	-	-	-	-	-	-	-	-	-	5	5
2012–13	-	-	-	-	-	-	-	-	-	36	-	69	105
2013–14	-	-	-	-	-	-	-	-	10	48	-	17	75
Total	13	5	-	-	-	-	-	-	41	722	334	500	1 615

Females (%)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	-	-	-	-	-
1997–98	-	-	-	-	-	-	-	-	-	51.4	-	-	47.4
1998–99	-	-	-	-	-	-	-	-	80.0	65.3	45.5	-	65.3
1999–00	-	-	-	-	-	-	-	-	16.7	47.2	-	100.0	47.1
2000–01	-	-	-	-	-	-	-	-	-	45.9	91.7	-	53.8
2001–02	-	-	-	-	-	-	-	-	25.0	57.6	50.0	-	55.8
2002–03	-	-	-	-	-	-	-	-	-	54.2	100.0	45.5	50.0
2003–04	-	-	-	-	-	-	-	-	-	60.0	30.0	69.7	55.6
2004–05	-	-	-	-	-	-	-	-	-	67.2	35.0	14.8	47.6
2005–06	-	100.0	-	-	-	-	-	-	-	51.0	36.5	64.7	43.3
2006–07	-	-	-	-	-	-	-	-	100.0	58.3	-	81.2	72.4
2007–08	-	-	-	-	-	-	-	-	-	-	16.7	52.4	48.7
2008–09	60.0	-	-	-	-	-	-	-	-	-	-	51.4	52.0
2009–10	-	-	-	-	-	-	-	-	-	57.1	56.2	15.0	46.3
2010–11	-	-	-	-	-	-	-	-	100.0	-	-	-	100.0
2011–12	-	-	-	-	-	-	-	-	-	-	-	60.0	60.0
2012–13	-	-	-	-	-	-	-	-	-	77.8	-	30.4	46.7
2013–14	-	-	-	-	-	-	-	-	80.0	60.4	-	82.4	68.0
Total	46.2	100.0	-	-	-	-	-	-	61.0	56.4	40.1	49.4	51.0

Table B7: Number of otolith pairs collected by observers by area for calendar years 1992–2014.

Year	CHAT	ECNI	SUBA	WCSI	Other	Total
1992	-	-	5	-	-	5
1993	-	-	2	4	-	6
1994	-	-	-	-	-	-
1995	-	-	5	-	-	5
1996	-	1	-	-	-	1
1997	24	0	4	-	-	28
1998	538	112	481	18	-	1 149
1999	334	95	217	79	-	725
2000	247	21	313	46	18	645
2001	328	22	206	35	-	591
2002	172	13	374	113	2	674
2003	240	10	450	53	-	753
2004	360	-	281	33	-	674
2005	393	-	166	67	-	626
2006	188	-	268	114	-	570
2007	187	-	432	18	-	637
2008	176	-	270	30	-	476
2009	73	-	353	49	-	475
2010	87	-	304	25	-	416
2011	106	-	426	0	-	532
2012	51	-	652	5	-	708
2013	87	10	410	36	-	543
2014	71	0	521	28	-	620
Total	3 662	284	6 140	753	20	10 859

Table B8: Number of female white warehou gonads staged by fishing year and month sampled from each area by the observer programme for fishing years 1991–92 to 2013–14 where data exist. Areas defined in Figure 1.

(a) CHAT

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	3	-	-	-	-	-	-	-	-	-	-	5	8
1996–97	25	-	-	-	-	-	-	-	-	-	-	-	25
1997–98	4	-	9	-	-	3	52	20	-	-	-	16	104
1998–99	143	54	48	80	45	9	6	123	28	2	-	-	538
1999–00	1	22	1	1	3	-	-	215	34	-	-	19	296
2000–01	32	65	135	45	28	2	104	3	26	1	-	-	441
2001–02	14	35	12	4	4	-	36	42	-	1	-	-	148
2002–03	38	226	23	7	-	-	7	9	4	-	-	37	351
2003–04	14	8	7	7	-	25	62	-	-	20	63	32	238
2004–05	14	48	81	118	77	33	-	7	26	2	3	2	411
2005–06	63	3	1	-	41	18	10	-	46	53	-	-	235
2006–07	8	12	31	44	7	5	13	88	12	4	-	-	224
2007–08	-	25	10	3	22	-	-	189	11	-	-	27	287
2008–09	2	3	-	-	-	55	-	11	5	-	-	26	102
2009–10	34	-	13	3	-	197	12	40	-	-	21	-	320
2010–11	22	5	6	-	35	96	21	19	-	-	37	2	243
2011–12	-	66	2	-	17	19	-	32	26	-	-	-	162
2012–13	-	45	11	17	6	-	-	50	15	-	-	20	164
2013–14	-	60	36	10	-	-	-	-	-	-	-	8	114
Total	417	677	426	339	285	462	323	848	233	83	124	194	4 411

(b) ECNI

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1995–96	-	-	-	-	-	-	-	-	1	-	-	-	1
1997–98	-	-	-	2	-	-	-	-	-	-	-	-	2
1998–99	61	117	-	-	-	-	-	-	-	-	-	-	178
1999–00	-	18	-	-	1	-	-	-	-	-	-	-	19
2000–01	-	11	3	-	-	-	-	-	-	-	-	-	14
2001–02	-	9	3	-	-	-	-	-	-	-	-	-	12
2002–03	-	-	16	-	-	-	-	-	-	-	-	-	16
2012–13	-	-	-	-	-	-	13	14	-	-	-	-	27
Total	61	155	22	2	1	-	13	14	1	-	-	-	269

Table B8: continued.

(c) SUBA

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1991–92	-	-	-	-	-	-	-	-	-	-	-	32	32
1992–93	-	-	-	-	1	-	-	-	-	-	-	-	1
1993–94	-	-	-	-	-	-	-	-	-	-	-	-	-
1994–95	-	-	-	-	16	-	-	-	-	-	-	-	16
1995–96	-	-	-	-	-	30	-	-	-	-	-	-	30
1996–97	-	-	-	-	1	-	-	-	-	-	-	3	4
1997–98	-	-	6	-	72	105	70	-	1	-	-	39	293
1998–99	8	-	11	1	4	18	26	87	-	-	2	29	186
1999–00	-	184	-	21	29	93	10	63	17	8	13	8	446
2000–01	-	5	-	104	125	3	-	21	13	-	5	1	277
2001–02	107	138	22	5	33	140	34	12	8	2	16	48	565
2002–03	-	97	14	32	82	295	151	26	84	-	5	3	789
2003–04	25	118	238	27	26	27	-	-	2	-	2	4	469
2004–05	54	72	33	13	-	-	-	-	-	-	76	15	263
2005–06	3	3	58	-	1	14	-	60	40	95	14	-	288
2006–07	127	46	20	11	72	1	11	-	-	537	158	132	1 115
2007–08	118	183	164	-	-	40	-	-	-	-	2	80	587
2008–09	12	-	113	7	10	44	-	9	169	493	111	88	1 056
2009–10	309	69	53	-	3	13	5	184	139	240	26	-	1 041
2010–11	697	115	22	41	21	-	1	-	49	207	9	-	1 162
2011–12	247	287	223	155	120	112	2	48	-	859	11	63	2 127
2012–13	612	383	467	133	18	16	1	40	9	907	-	24	2 610
2013–14	417	121	530	550	23	-	13	43	19	413	92	460	2 681
Total	2 736	1 821	1 974	1 100	657	951	324	593	550	3 761	542	1 029	16 038

(d) WCSI

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1997–98	-	-	-	-	-	-	-	-	-	18	-	-	18
1998–99	-	-	-	-	-	-	-	-	12	49	5	-	66
1999–00	-	-	-	-	-	-	-	-	1	84	-	3	88
2000–01	-	-	-	-	-	-	-	-	-	17	11	-	28
2001–02	-	-	-	-	-	-	-	-	2	83	1	-	86
2002–03	-	-	-	-	-	-	-	-	-	13	1	15	29
2003–04	-	-	-	-	-	-	-	-	-	6	6	23	35
2004–05	-	-	-	-	-	-	-	-	-	39	7	4	50
2005–06	-	5	-	-	-	-	-	-	-	26	74	22	127
2006–07	-	-	-	-	-	-	-	-	1	7	-	13	21
2007–08	-	-	-	-	-	-	-	-	-	-	2	55	57
2008–09	6	-	-	-	-	-	-	-	-	-	-	71	77
2009–10	-	-	-	-	-	-	-	-	-	8	27	3	38
2010–11	-	-	-	-	-	-	-	-	1	-	-	-	1
2011–12	-	-	-	-	-	-	-	-	-	-	-	3	3
2012–13	-	-	-	-	-	-	-	-	-	28	-	21	49
2013–14	-	-	-	-	-	-	-	-	8	29	-	14	51
Total	6	5	-	-	-	-	-	-	25	407	134	247	824

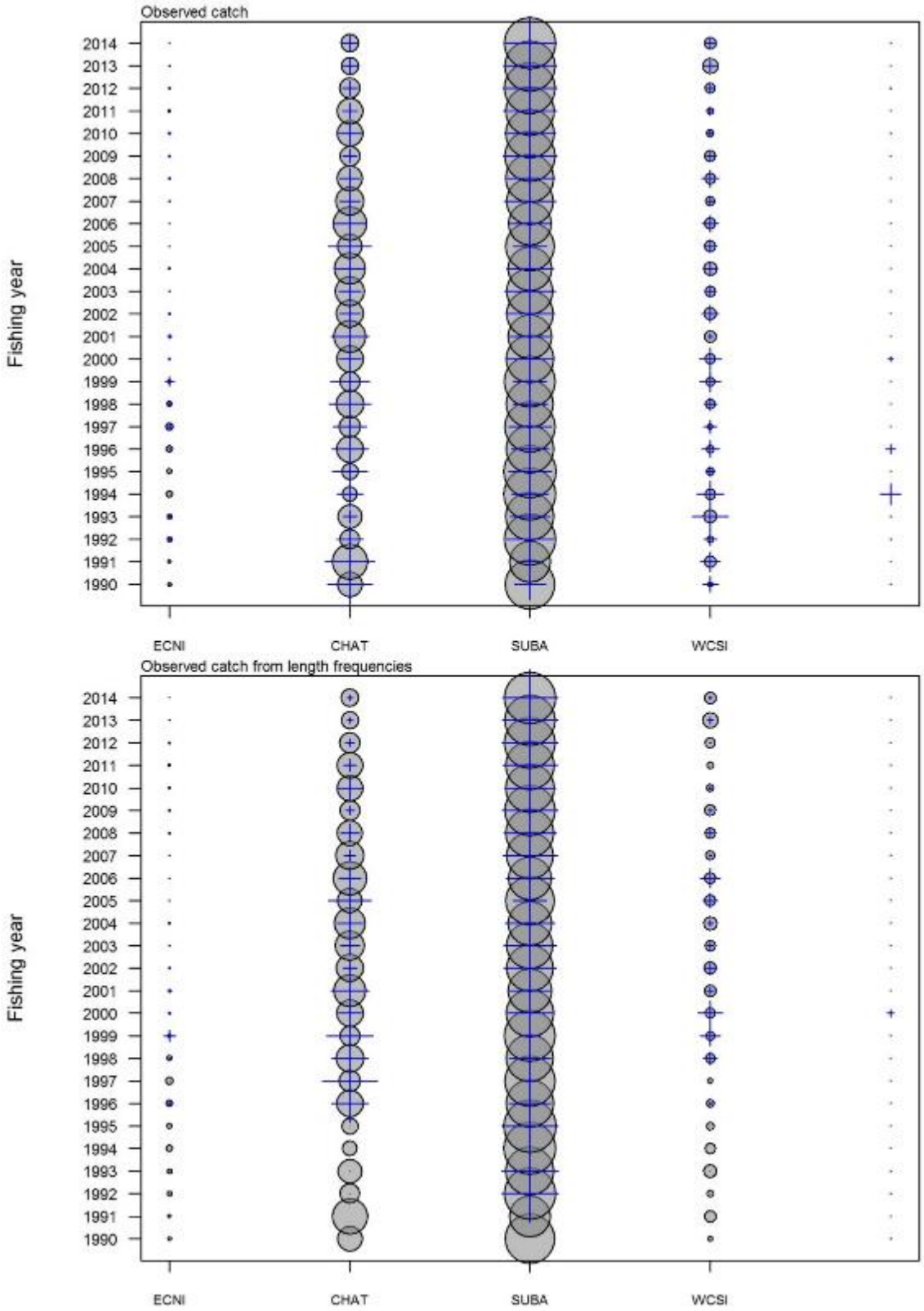


Figure B1: Representativeness of observer sampling of white warehou catch by fishing year and area. Circles show the proportion of processed white warehou catch by area within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter. Top panel is observed white warehou catch from all tows, and bottom panel is observed catch from tows where white warehou length frequency samples were taken.

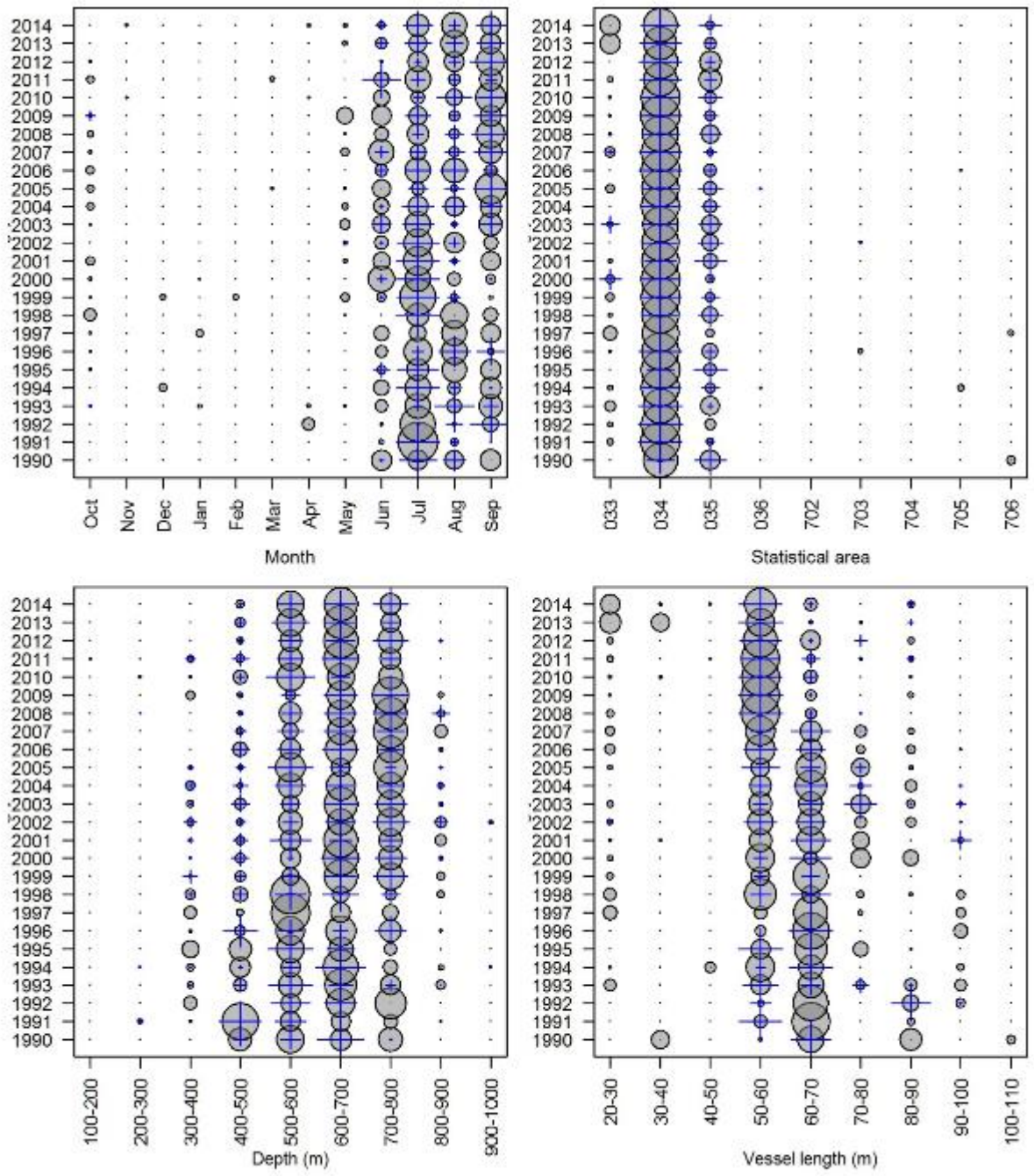


Figure B2a: Representativeness of observer sampling of white warehou WCSI catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

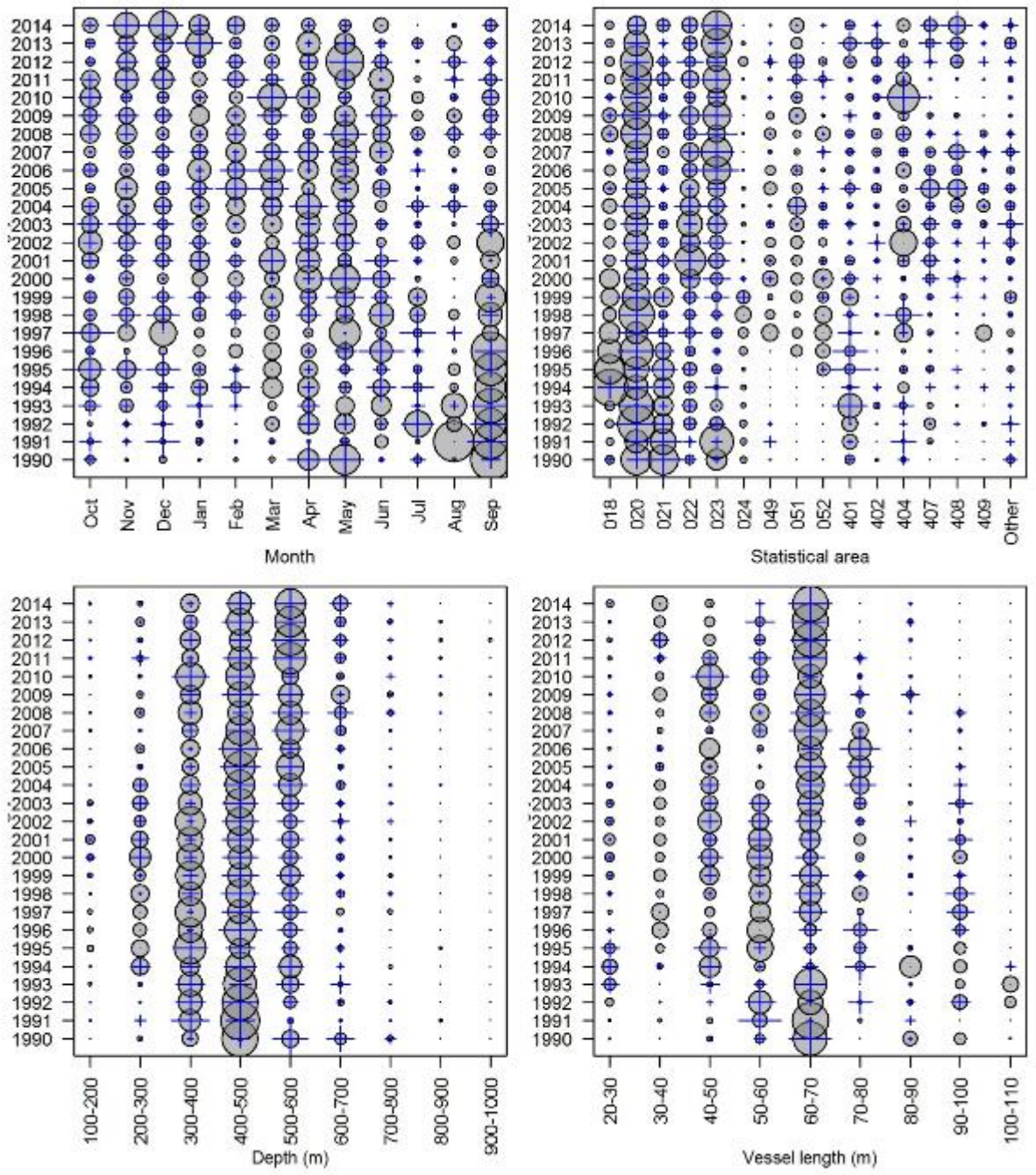


Figure B2b: Representativeness of observer sampling of white warehou CHAT catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

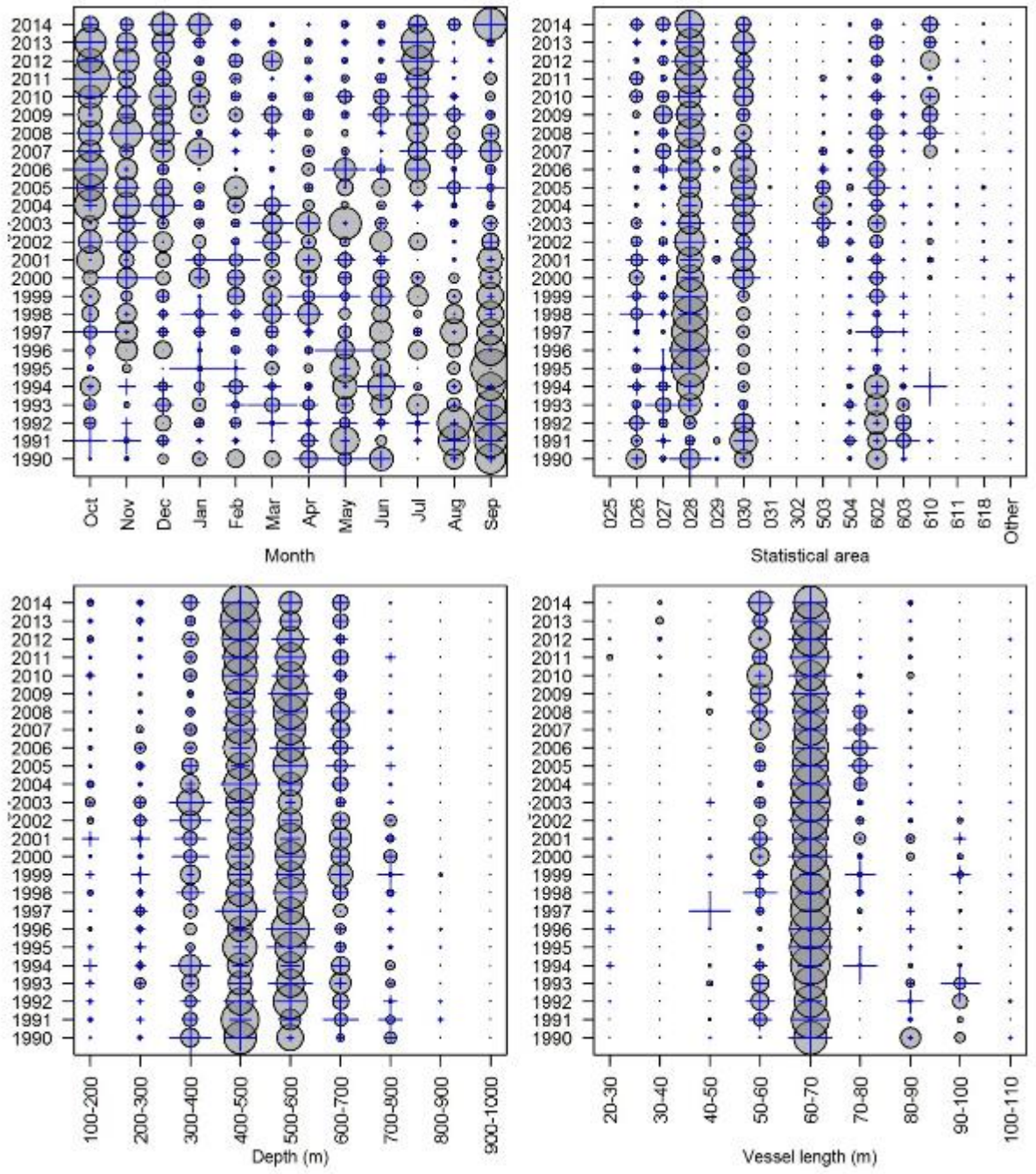


Figure B2c: Representativeness of observer sampling of white warehou SUBA catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

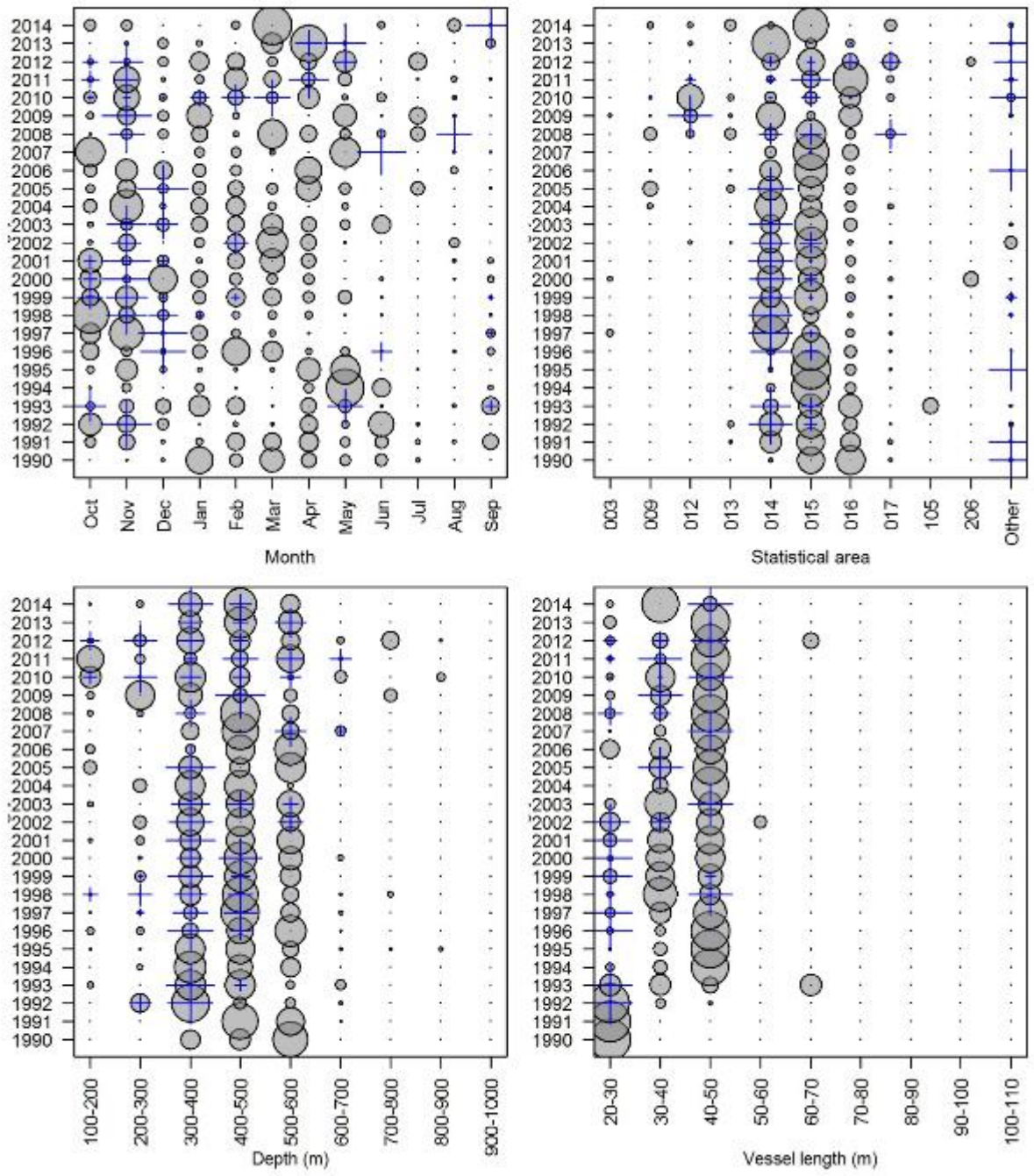


Figure B2d: Representativeness of observer sampling of white warehou ECNI catch by fishing year and month, statistical area, depth (m), and vessel size (m). Circles show the proportion of catch by month within a year; crosses show the proportion of observed catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

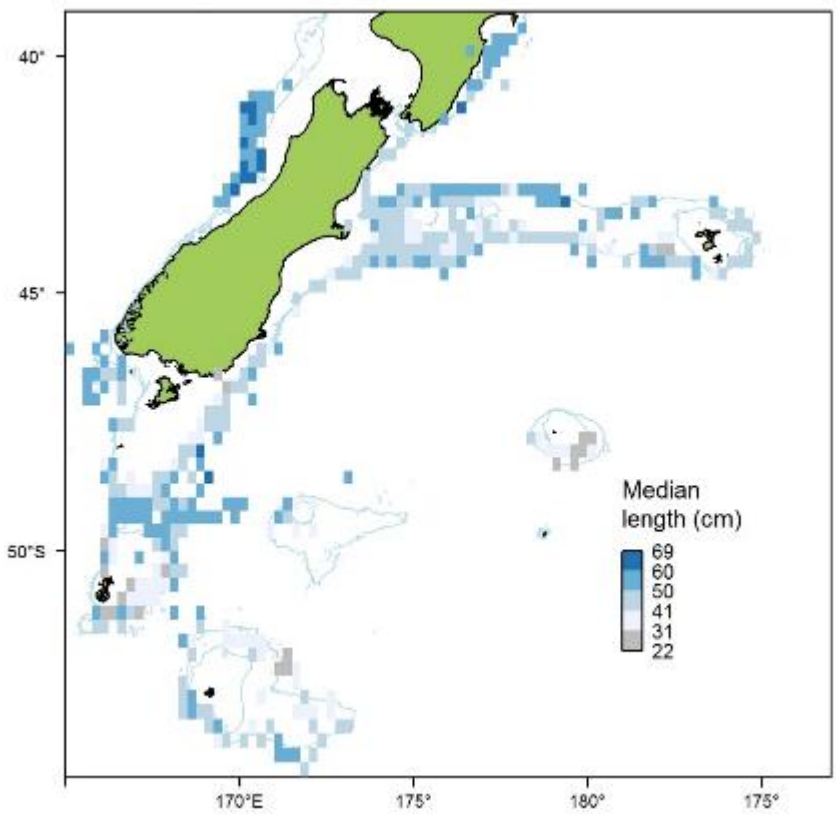


Figure B3: Median length of observed white warehou (n = 47 825) for 0.25° cells (all years combined).

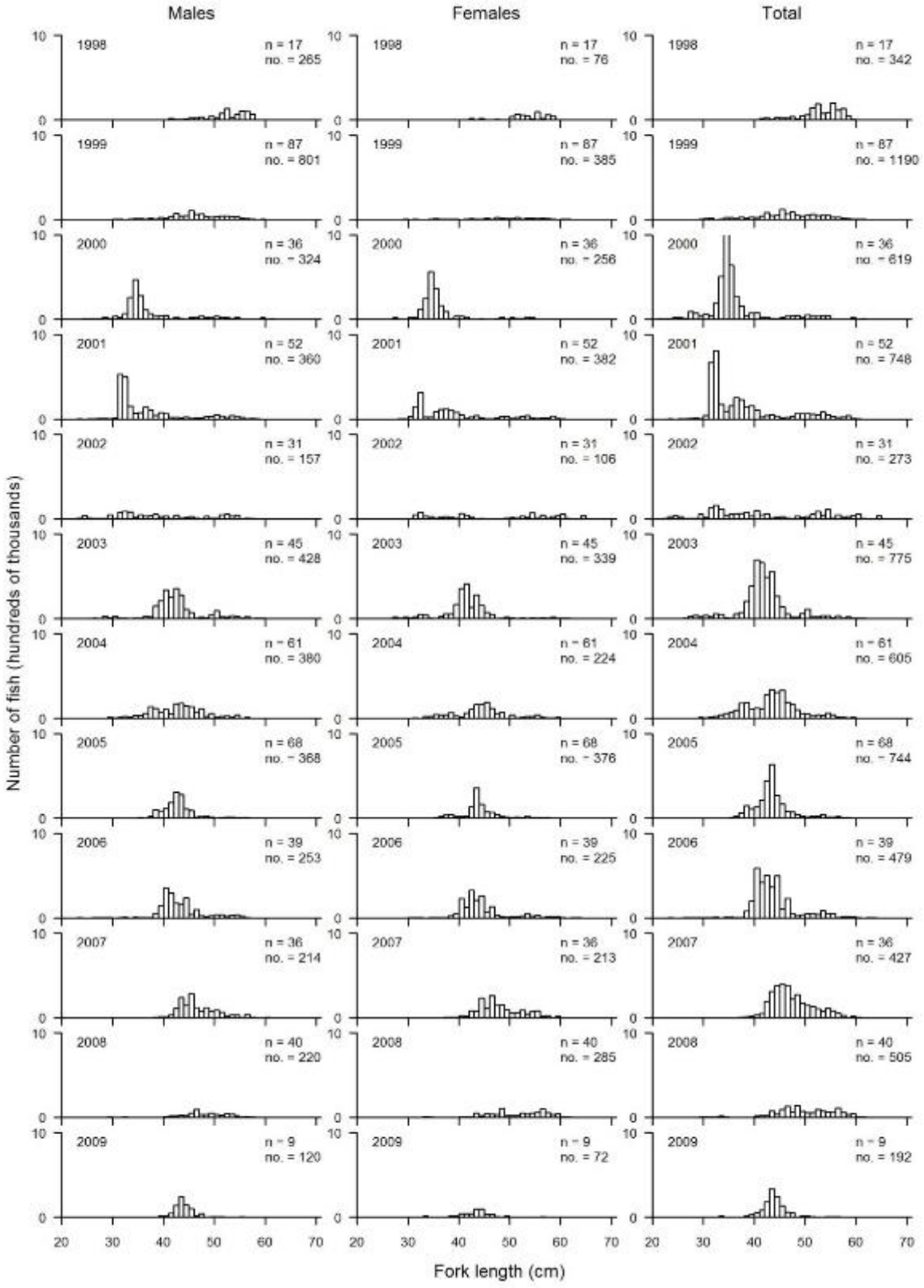


Figure B4: Scaled length frequency of white warehou sampled by observers from commercial catches from the CHAT area, where there were more than three white warehou per tow, for fishing years 1997–98 (1998) to 2013–14 (2014). n, number of tows sampled with more than three individual white warehou per tow; no., number of white warehou sampled.

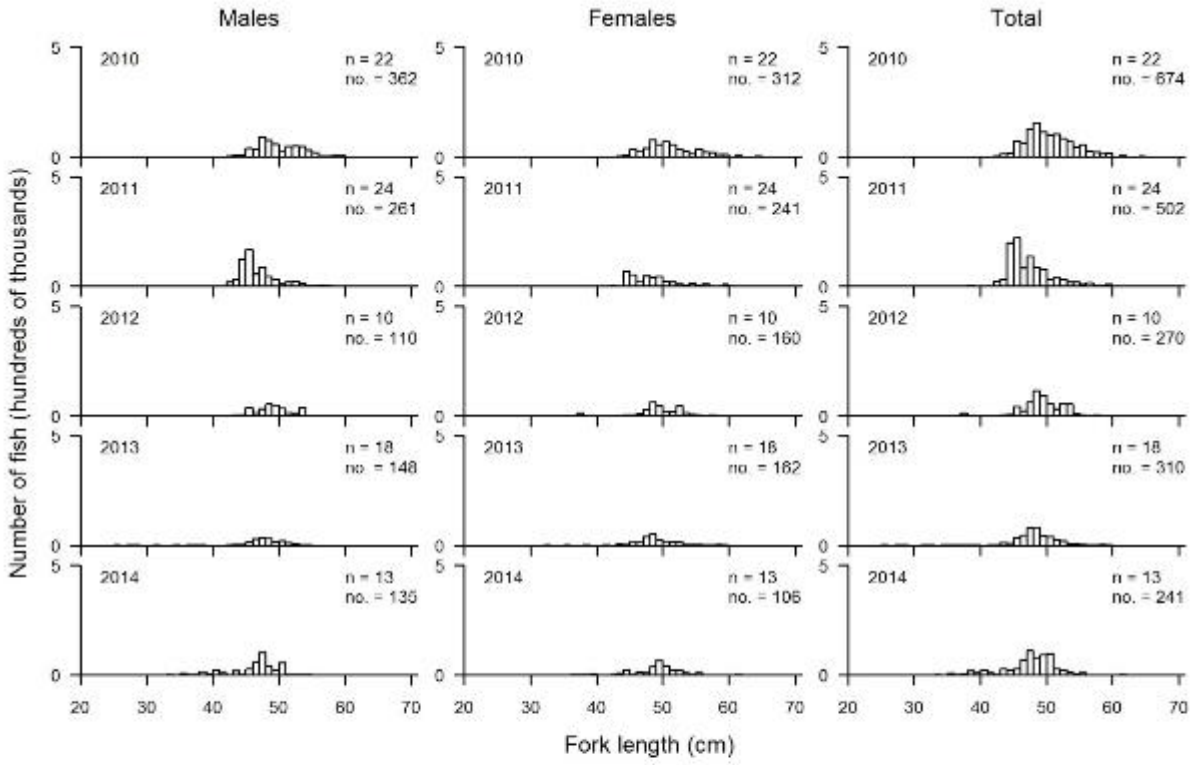


Figure B4: continued

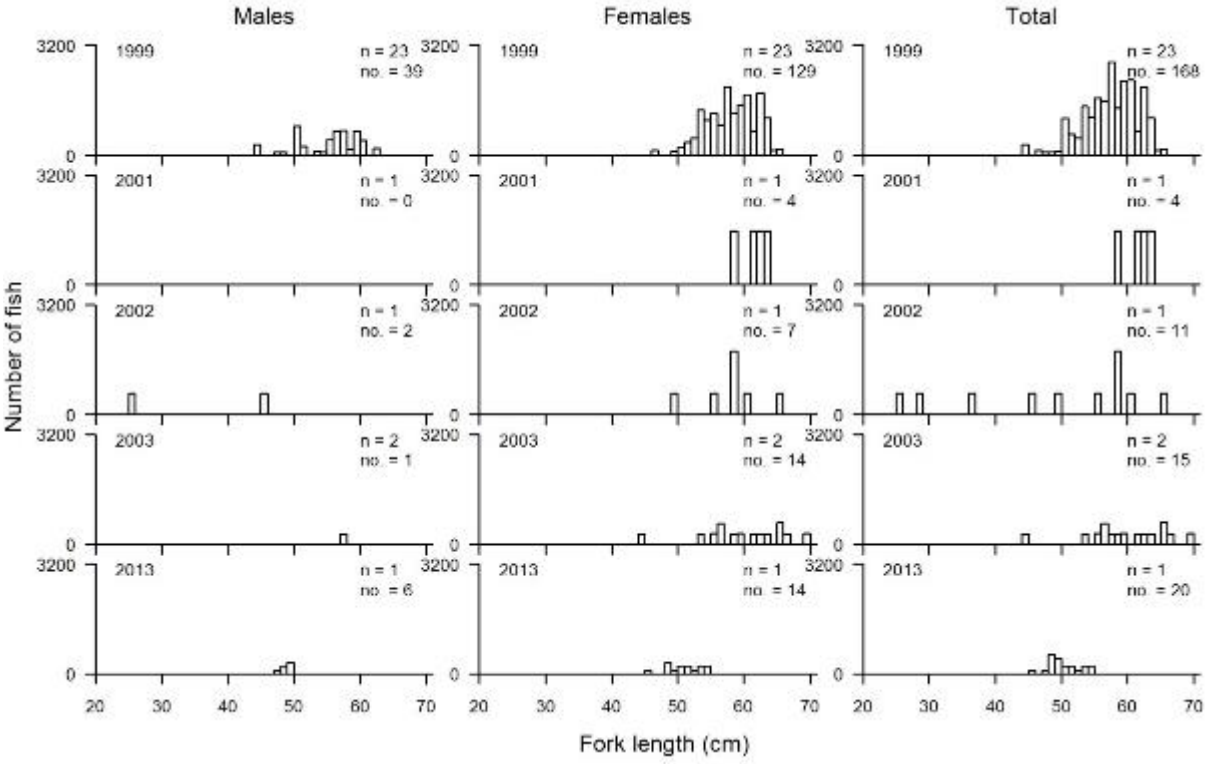


Figure B5: Scaled length frequency of white warehou sampled by observers from commercial catches from the ECNI area, where there were more than three white warehou per tow, for fishing years 1998–99, (1999), 2000–01 to 2002–03 (2001–2003), and 2012–13 (2013). n, number of tows sampled with more than three individual white warehou per tow; no., number of white warehou sampled.

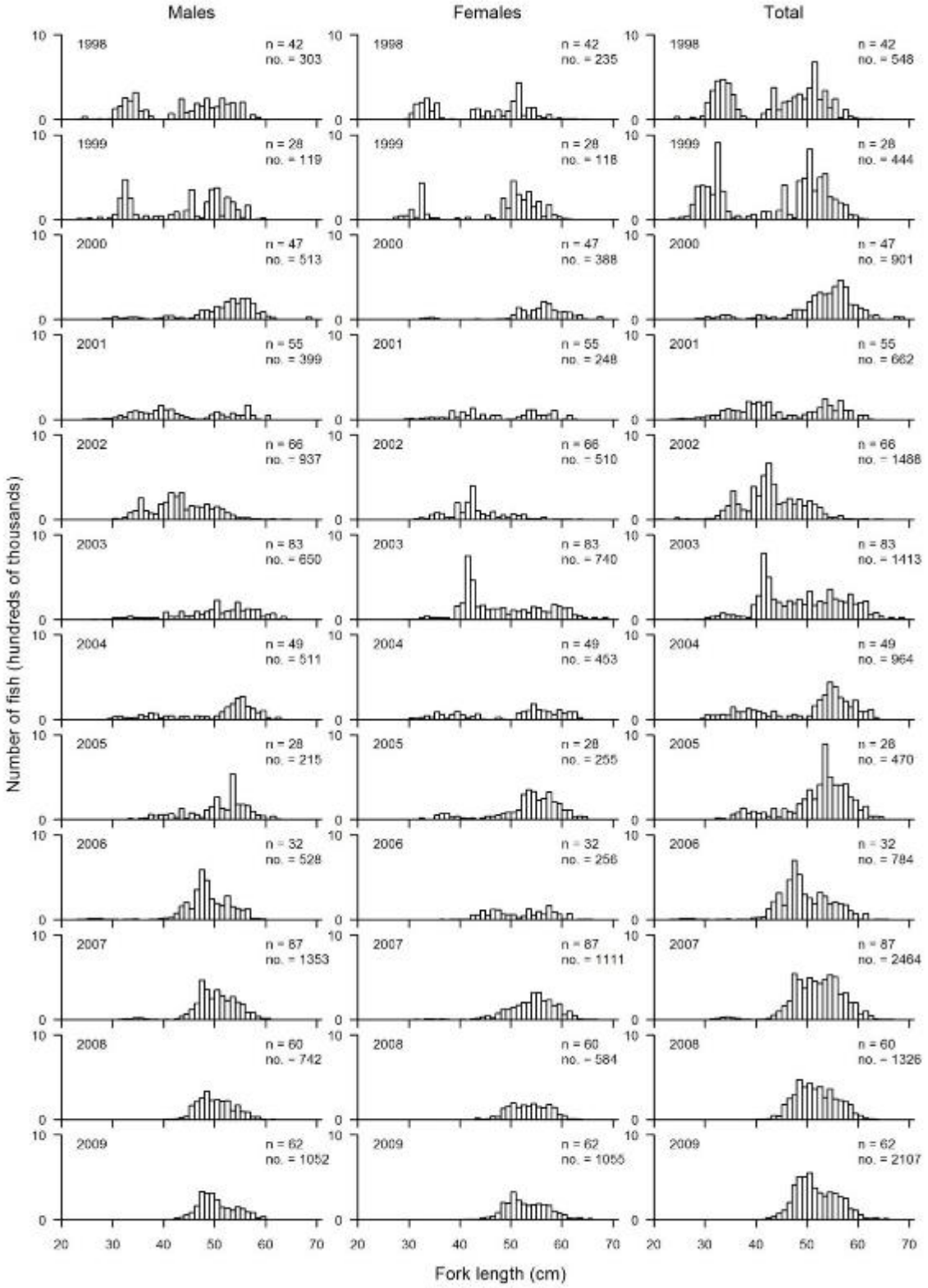


Figure B6: Scaled length frequency of white warehou sampled by observers from commercial catches from the SUBA area, where there were more than three white warehou per tow, for fishing years 1997–98 (1998) to 2013–14 (2014). n, number of tows sampled with more than three individual white warehou per tow; no., number of white warehou sampled.

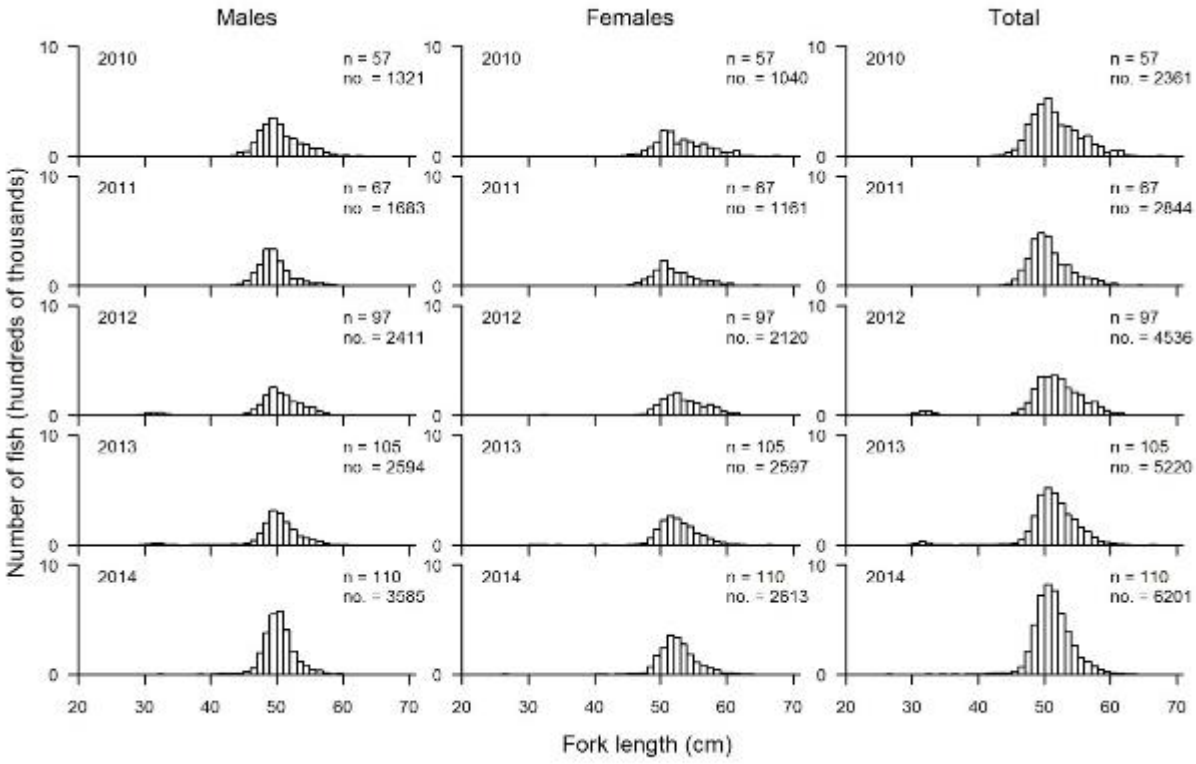


Figure B6: continued.

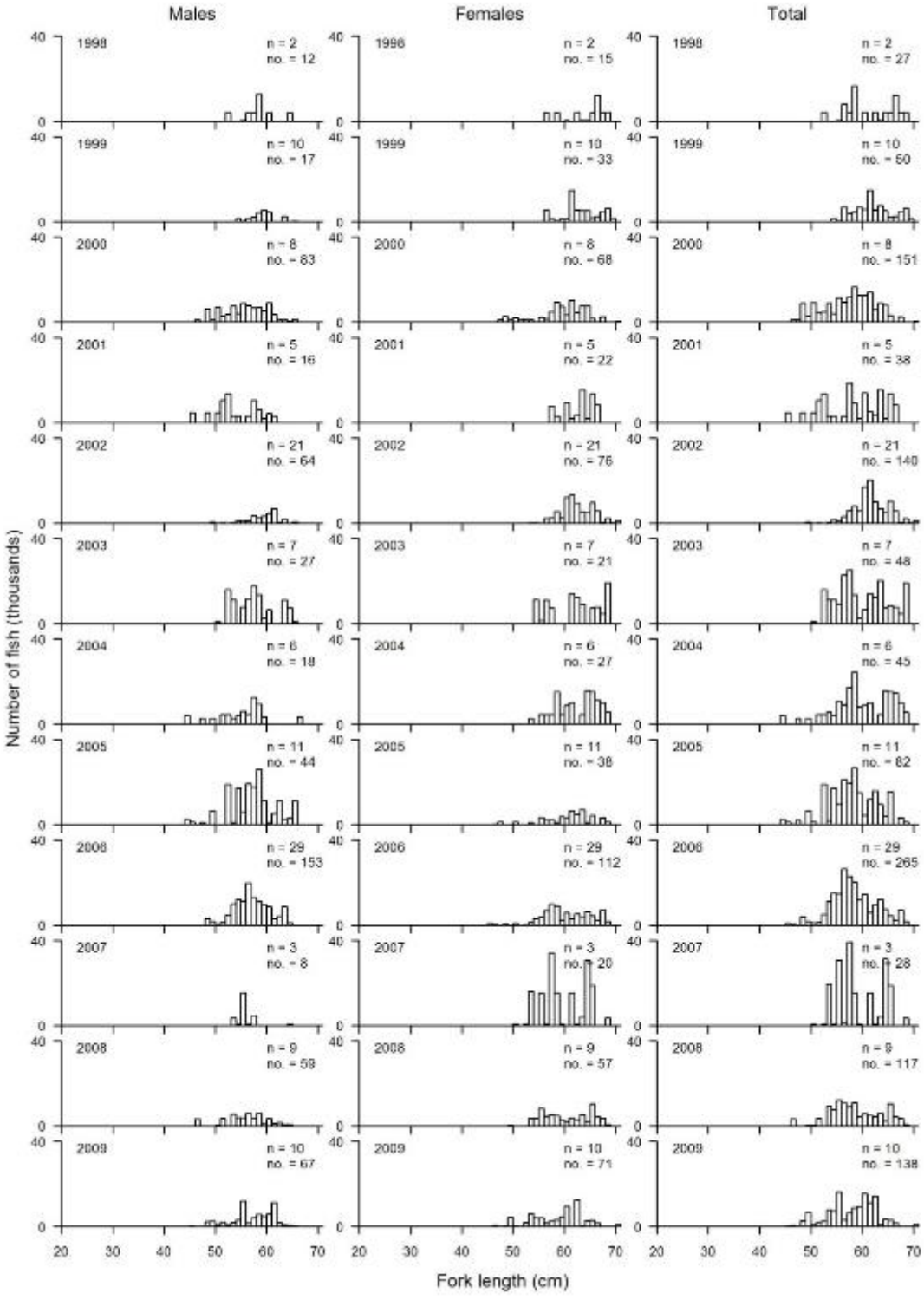


Figure B7: Scaled length frequency of white warehou sampled by observers from commercial catches from the WCSI area, where there were more than three white warehou per tow, for fishing years 1997–98 (1998) to 2013–14 (2014). n, number of tows sampled with more than three individual white warehou per tow; no., number of white warehou sampled.

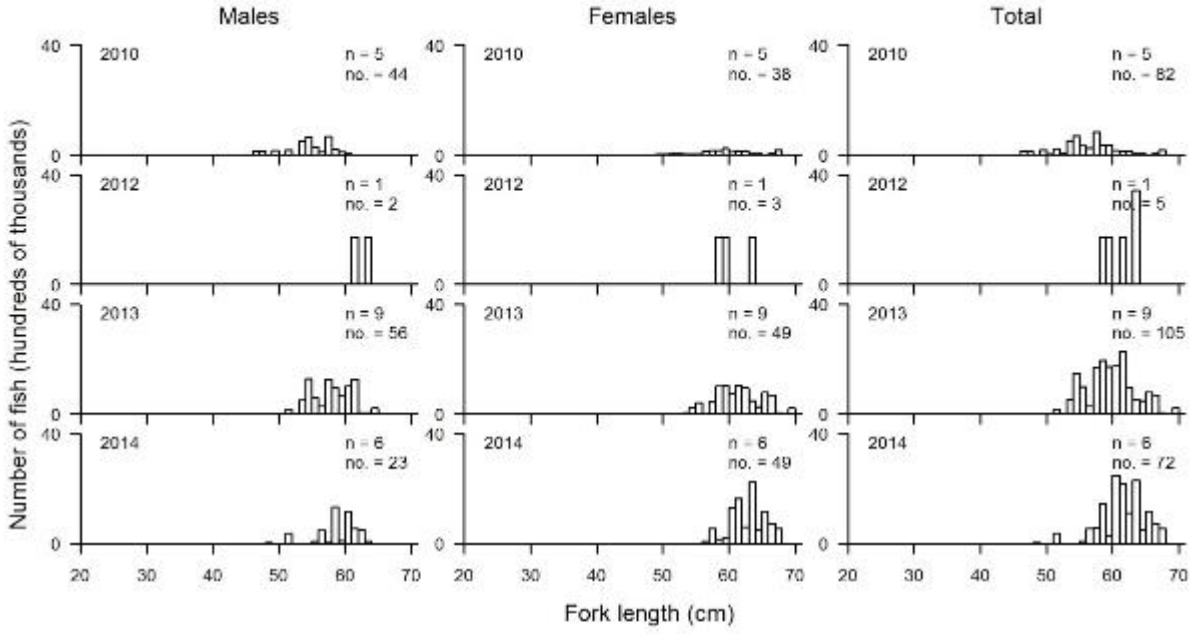


Figure B7: continued

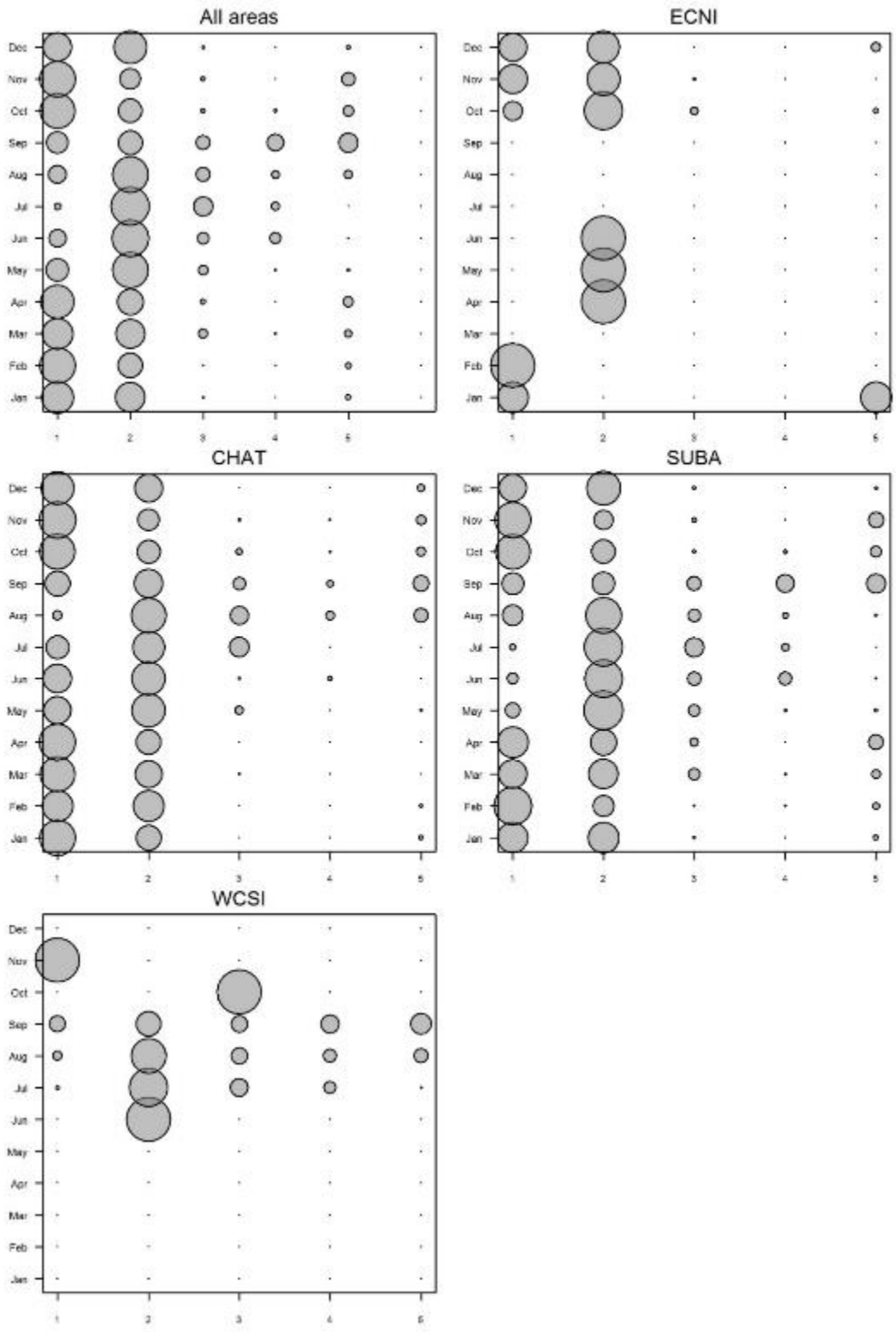


Figure B8: Gonad stages of female white warehou sampled by observers from commercial catches, by month and area. Stages are: 1, resting/immature; 2, maturing; 3, ripe; 4, running ripe; 5, spent.

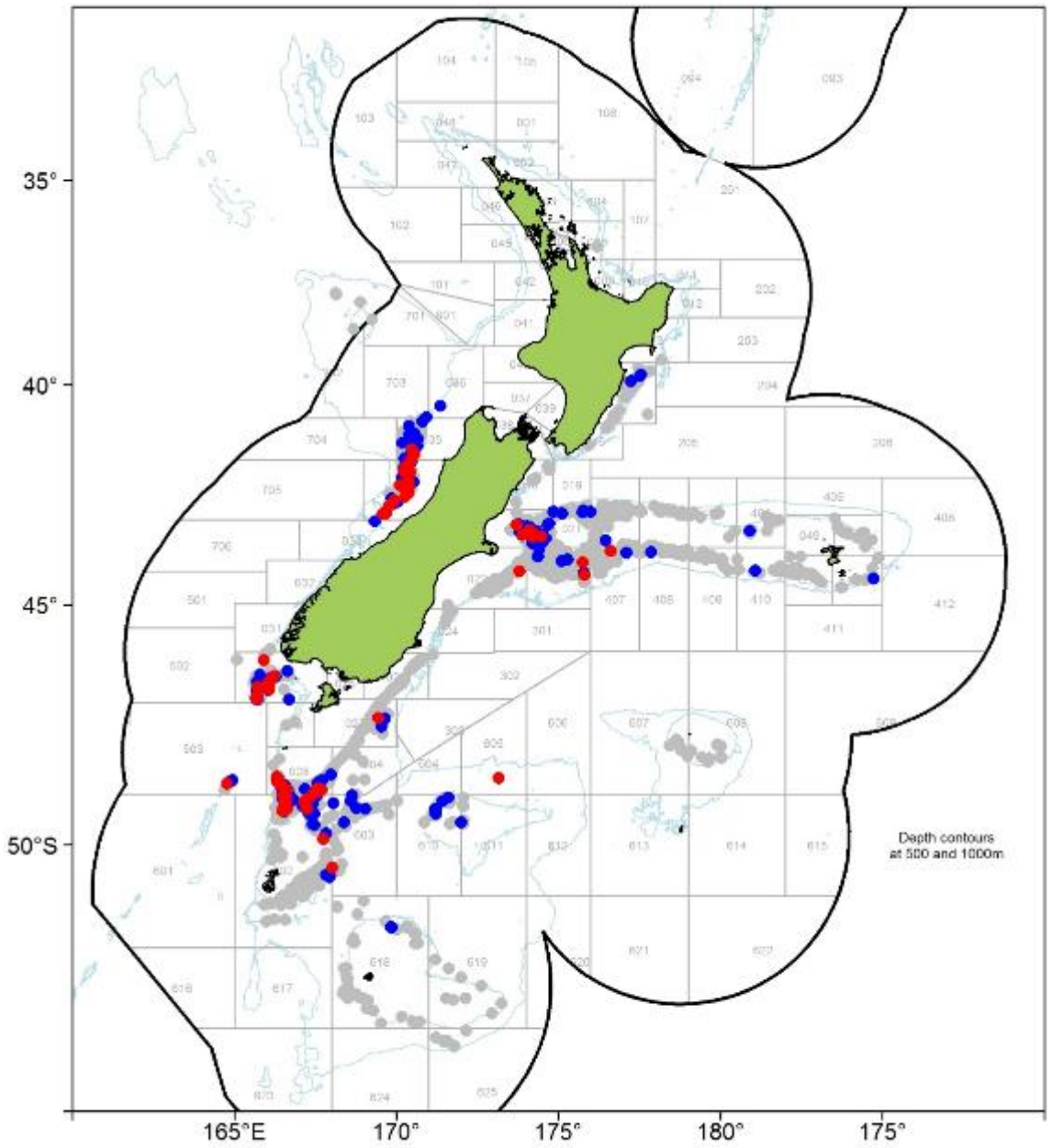


Figure B9a: Location of female white warehou gonad stages sampled by the Observer Programme. Grey = stage 1 (immature), stage 2 (maturing), and stage 5 (spent); blue = stage 3 (ripe), red = stage 4 (running ripe).

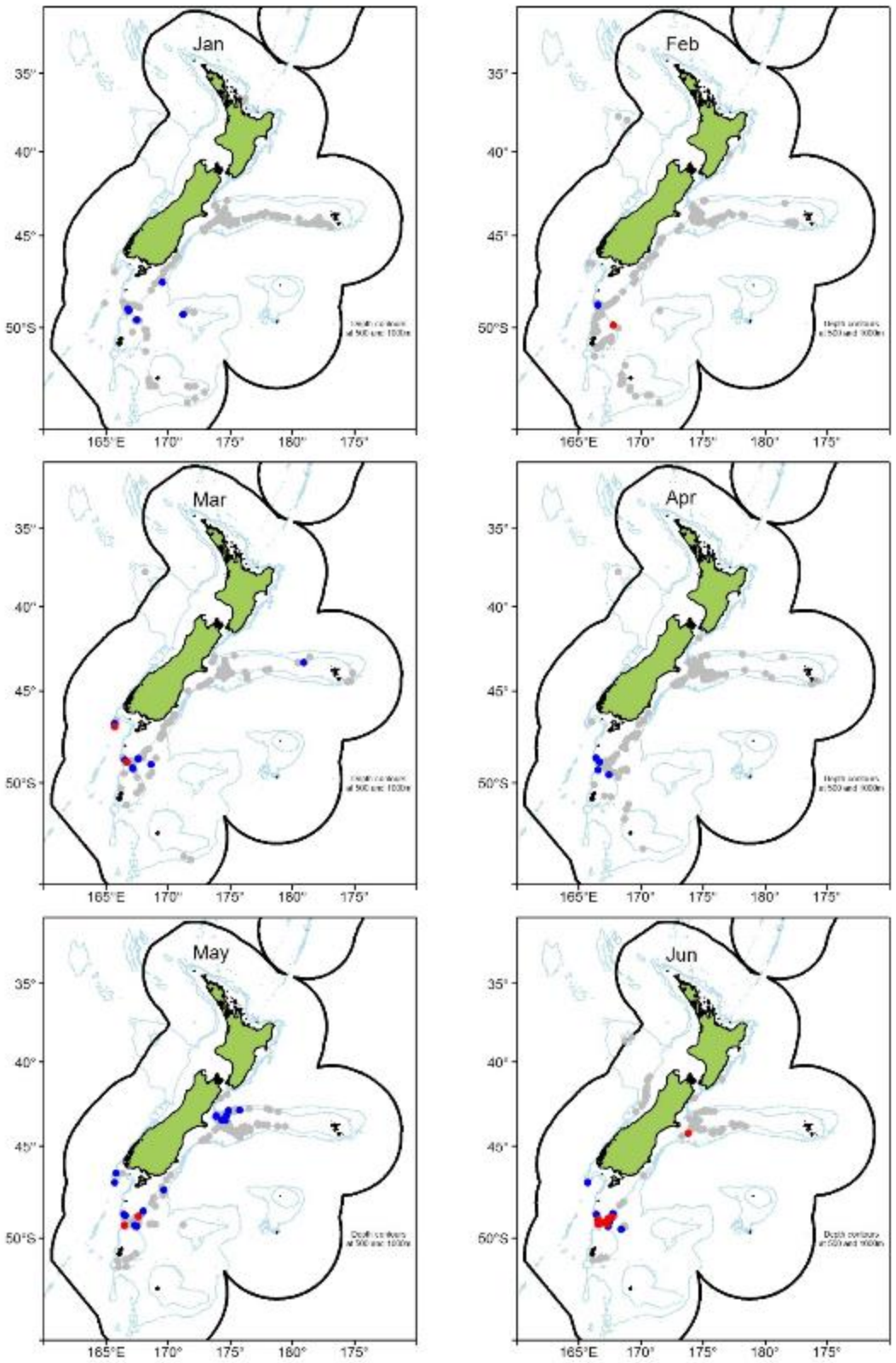


Figure B9b: Location of female white warehou gonad stages sampled by observers, by month. Grey: stage 1 (immature), stage 2 (maturing), or stage 5 (spent); blue = stage 3 (ripe), red = stage 4 (running ripe).

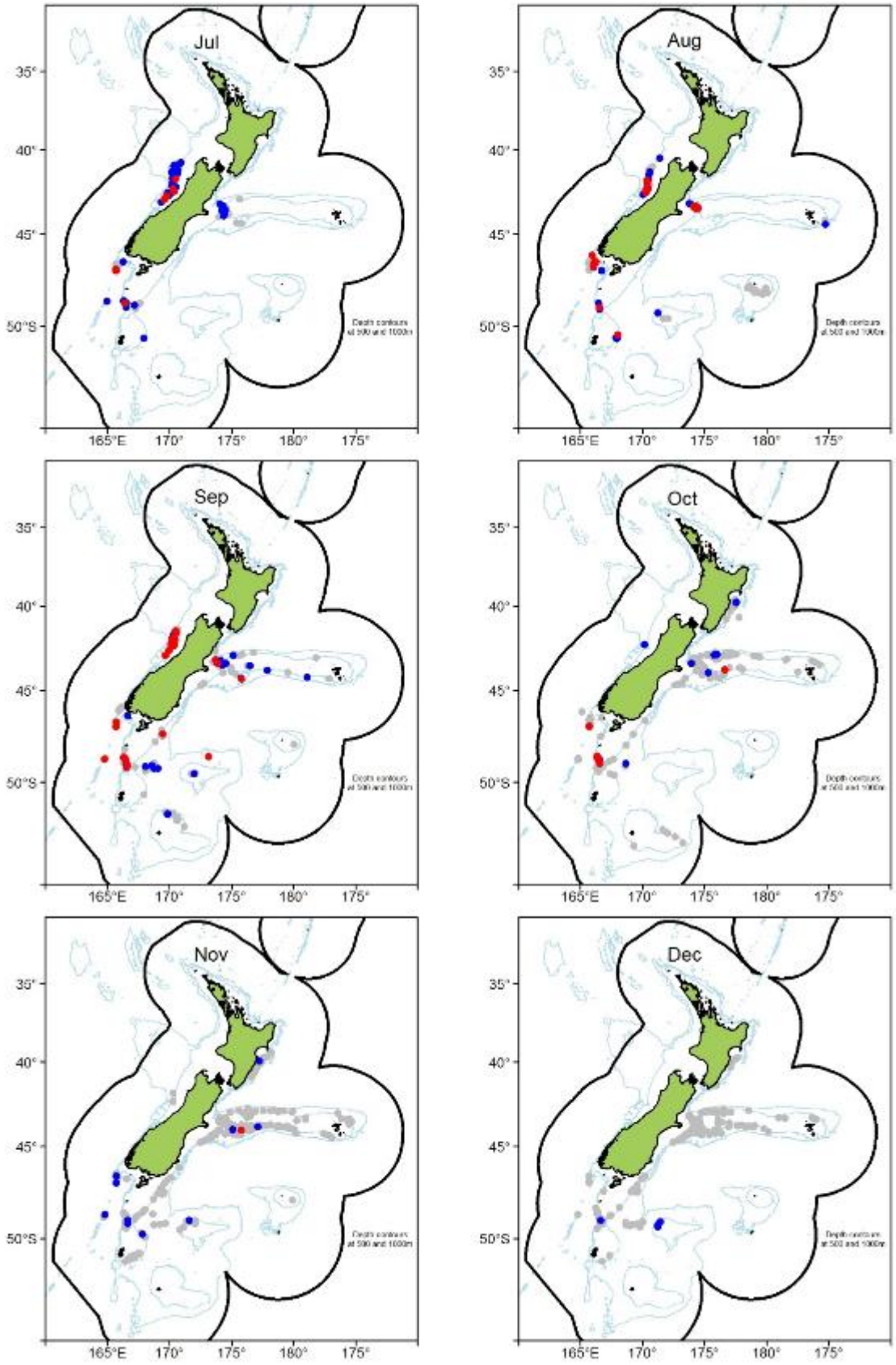


Figure B9b: continued.

APPENDIX C: CHARACTERISATION

Table C1: List of tables and fields requested in the Ministry for Primary Industries extract 9843.

Fishing_events table

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

Landing_events table

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

Estimated subcatch table

Event_Key	Species_code (ALL species	Literal_yn
Version_seqno	for each 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 WWA stocks for fishing years 1990 to 2014. CLR is Catch Landing Return; CELR is Catch Effort Landing Return; L: landed to NZ; E: eaten; T: transferred to another vessel; R: retained on board; O: Conveyed outside New Zealand; D: discarded; J: Observer authorised discard. Note: the Total column includes counts of destination codes other than L, E, R, T, O, D, J.

WWA 1

	CLR form								CELR and NCELR form					
	L	**E**	**R**	**T**	**O**	**D**	**J**	**Total**	**L**	**E**	**R**	**T**	**Total**	**Total**
1990	1	-	-	-	-	-	-	1	21	-	-	-	21	22
1991	1	-	-	1	-	-	-	2	6	-	-	-	6	8
1992	7	-	-	-	-	-	-	7	15	-	-	-	15	22
1993	3	-	1	-	-	-	-	4	26	-	-	-	26	30
1994	11	-	-	-	-	-	-	11	4	-	-	-	4	15
1995	3	-	-	1	-	-	-	4	13	-	-	-	13	17
1996	2	-	1	-	-	-	-	3	6	-	-	-	6	9
1997	6	-	1	-	-	-	-	7	1	-	-	-	1	8
1998	7	-	-	-	-	-	-	7	2	-	-	-	2	9
1999	4	-	1	-	-	-	-	5	3	1	-	-	4	9
2000	3	-	-	-	-	-	-	3	3	-	-	-	3	6
2001	4	-	-	-	-	-	-	4	3	-	-	-	3	7
2002	2	-	-	-	-	-	-	2	-	-	-	-	-	2
2003	2	-	-	-	-	-	-	2	5	-	-	-	5	7
2004	2	1	-	-	-	-	-	3	4	1	-	-	5	8
2005	-	-	-	-	-	-	-	-	7	-	-	-	7	7
2006	4	-	-	-	-	-	-	4	4	-	-	-	4	8
2007	2	-	-	-	-	-	-	2	5	-	-	-	5	7
2008	5	-	-	-	-	-	-	5	3	-	-	-	3	8
2009	11	-	-	-	-	-	-	11	3	-	-	-	3	14
2010	11	1	-	-	-	-	-	12	1	-	-	-	1	13
2011	9	-	-	-	-	-	-	9	3	-	-	-	3	12
2012	10	-	-	-	-	-	-	10	1	-	-	-	1	11
2013	9	-	-	-	-	-	-	9	-	-	-	-	-	9
2014	9	-	-	-	-	-	-	9	-	-	-	-	-	9
Total	128	2	4	2	-	-	-	136	139	2	-	-	141	277

WWA 2

	CLR form								CELR and NCELR form					
	L	**E**	**R**	**T**	**O**	**D**	**J**	**Total**	**L**	**E**	**R**	**T**	**Total**	**Total**
1990	8	-	-	-	-	-	-	8	34	-	-	-	34	42
1991	9	-	-	-	-	-	-	9	46	-	-	-	46	55
1992	18	-	1	-	-	-	-	19	60	-	-	-	60	79
1993	50	-	-	-	-	-	-	50	49	-	-	-	49	99
1994	36	-	-	-	-	-	-	36	22	-	-	-	22	58
1995	54	-	-	-	-	-	-	54	10	-	-	-	10	64
1996	96	1	1	-	-	-	-	98	9	-	-	-	9	107
1997	160	-	2	-	-	-	-	162	7	-	-	-	7	169
1998	94	-	4	-	-	-	-	98	3	-	-	-	3	101
1999	112	-	1	-	-	-	-	113	8	-	-	-	8	121
2000	101	9	1	-	-	-	-	111	3	-	-	-	3	114
2001	79	2	-	-	-	-	-	81	4	-	-	-	4	85
2002	75	3	-	-	-	1	-	79	1	-	-	-	1	80
2003	86	1	-	-	-	-	-	87	6	-	-	-	6	93
2004	64	1	-	-	-	-	-	65	7	-	-	-	7	72
2005	62	1	1	-	-	-	-	64	6	-	-	-	6	70
2006	56	3	-	-	-	-	-	59	15	-	-	-	15	74
2007	55	7	-	-	-	-	-	62	13	-	-	-	13	75
2008	81	3	1	-	-	-	-	85	11	-	-	-	11	96
2009	65	1	-	-	-	-	-	66	10	-	-	-	10	76
2010	49	9	3	-	-	-	-	61	4	-	-	-	4	65
2011	62	17	1	-	-	-	-	80	1	-	-	-	1	81
2012	54	15	1	-	-	-	-	70	2	-	-	-	2	72
2013	52	15	1	-	-	-	-	68	8	-	-	-	8	76
2014	59	15	1	-	-	-	-	75	-	-	-	-	-	75
Total	1 637	103	19	-	-	1	-	1 760	339	-	-	-	339	2 099

Table C2: continued.

WWA 3

	CLR form								CELR and NCELR form					
	L	E	R	T	O	D	J	Total	L	E	R	T	Total	Total
1990	48	-	13	47	8	-	-	116	337	-	-	-	337	453
1991	58	-	8	24	6	-	-	96	433	-	-	-	433	529
1992	90	-	20	49	12	-	-	171	256	-	-	-	256	427
1993	124	-	19	39	5	-	-	187	361	-	-	-	361	548
1994	103	8	20	22	2	1	-	156	370	-	-	-	370	526
1995	116	11	16	40	2	2	-	187	448	-	-	-	448	635
1996	196	16	15	41	2	-	-	270	439	-	-	-	439	709
1997	217	14	31	15	4	-	-	281	331	-	-	-	331	612
1998	294	33	23	12	4	3	-	369	559	-	-	-	559	928
1999	312	45	22	1	1	-	-	381	302	-	-	-	302	683
2000	365	83	31	-	-	-	-	479	232	-	-	-	232	711
2001	451	90	25	-	1	-	-	567	397	-	-	-	397	964
2002	386	90	25	-	-	3	-	504	213	-	-	-	213	717
2003	476	118	45	-	1	1	-	641	299	-	-	-	299	940
2004	322	81	42	2	2	-	-	449	211	-	1	-	212	661
2005	229	77	22	-	-	1	-	329	163	-	-	-	163	492
2006	217	76	19	-	-	-	-	312	104	-	-	-	104	416
2007	247	97	26	-	-	-	-	370	79	-	-	-	79	449
2008	246	90	29	-	-	-	-	365	101	-	1	-	102	467
2009	196	97	21	-	-	-	-	314	77	-	4	-	81	395
2010	210	101	15	-	-	-	-	326	81	-	1	-	82	408
2011	214	122	11	-	-	-	-	347	38	-	-	-	38	385
2012	209	108	15	-	-	-	-	332	62	-	-	-	62	394
2013	176	93	8	-	-	-	-	277	35	-	1	-	36	313
2014	198	105	6	-	-	-	15	324	38	-	-	-	38	362
Total	5 700	1 555	527	292	50	11	15	8 150	5 966	-	8	-	5 974	14 124

WWA 4

	CLR form								CELR and NCELR form					
	L	E	R	T	O	D	J	Total	L	E	R	T	Total	Total
1990	9	-	4	14	-	-	-	27	-	-	-	-	-	27
1991	28	-	9	13	2	-	-	52	-	-	-	-	-	52
1992	49	-	13	16	4	-	-	82	-	-	-	-	-	82
1993	49	2	19	30	4	-	-	104	2	-	-	-	2	106
1994	23	-	9	19	1	-	-	52	-	-	-	-	-	52
1995	51	11	10	19	1	1	-	93	-	-	-	-	-	93
1996	47	7	3	20	2	-	-	79	1	-	-	-	1	80
1997	64	13	11	13	1	-	-	102	-	-	-	-	-	102
1998	114	33	18	9	2	-	-	176	2	-	-	-	2	178
1999	139	55	16	-	-	-	-	210	6	-	-	-	6	216
2000	147	50	17	-	1	-	-	215	8	-	-	-	8	223
2001	198	60	12	-	1	1	-	272	19	-	-	-	19	291
2002	182	52	11	-	-	3	-	248	32	-	-	-	32	280
2003	223	52	18	-	-	2	-	295	17	-	-	-	17	312
2004	180	56	15	-	-	1	-	252	25	-	-	-	25	277
2005	196	55	8	-	-	-	-	259	5	-	-	-	5	264
2006	159	37	5	-	-	1	-	202	7	-	-	-	7	209
2007	141	54	7	-	-	-	-	202	18	-	-	-	18	220
2008	164	62	7	-	-	-	-	233	-	-	-	-	-	233
2009	107	55	5	-	-	-	-	167	-	-	-	-	-	167
2010	133	55	5	-	-	-	-	193	-	-	-	-	-	193
2011	142	62	10	-	-	-	-	214	-	-	-	-	-	214
2012	120	52	4	-	-	-	-	176	-	-	-	-	-	176
2013	125	63	7	-	-	-	-	195	-	-	-	-	-	195
2014	126	53	19	-	-	-	-	198	-	-	-	-	-	198
Total	2 916	939	262	153	19	9	-	4 298	142	-	-	-	142	4 440

Table C2: continued.

WWA 5B

	CLR form								CELR and NCELR form					
	L	E	R	T	O	D	J	Total	L	E	R	T	Total	Total
1990	36	-	9	38	9	-	-	92	-	-	-	-	-	92
1991	75	-	23	28	13	-	-	139	1	-	-	-	1	140
1992	130	3	33	37	20	-	-	223	-	-	-	-	-	223
1993	87	4	15	33	4	-	-	143	2	-	-	-	2	145
1994	61	8	21	29	8	1	-	128	2	-	-	-	2	130
1995	82	18	8	29	8	-	-	145	-	-	-	-	-	145
1996	95	18	24	31	3	-	-	171	2	-	-	-	2	173
1997	126	37	32	29	6	1	-	231	2	-	-	-	2	233
1998	175	46	22	4	7	6	-	260	2	-	-	-	2	262
1999	211	57	36	-	-	1	-	305	2	-	-	-	2	307
2000	276	75	26	-	-	3	-	380	2	-	-	-	2	382
2001	289	115	25	-	9	2	-	440	3	-	-	-	3	443
2002	304	130	23	-	-	-	-	457	-	-	-	-	-	457
2003	370	133	24	-	5	2	-	534	5	1	-	-	6	540
2004	245	130	23	-	4	1	-	403	19	1	-	-	20	423
2005	240	137	38	-	5	2	-	422	23	-	-	-	23	445
2006	233	139	47	-	-	1	-	420	26	-	-	-	26	446
2007	250	163	36	-	2	-	-	451	13	-	-	-	13	464
2008	163	103	11	-	-	-	-	277	1	-	-	-	1	278
2009	141	106	13	-	-	-	-	260	-	-	-	-	-	260
2010	148	101	11	-	-	-	-	260	-	-	-	-	-	260
2011	171	119	9	-	-	-	-	299	-	-	-	-	-	299
2012	200	129	12	-	-	-	-	341	-	-	-	-	-	341
2013	182	126	19	-	-	-	-	327	-	-	-	-	-	327
2014	196	113	11	-	-	-	31	351	-	-	-	-	-	351
Total	4 486	2 010	551	258	103	20	31	7 459	105	2	-	-	107	7 566

WWA 7

	CLR form								CELR and NCELR form					
	L	E	R	T	O	D	J	Total	L	E	R	T	Total	Total
1990	10	-	49	14	12	-	-	85	11	-	-	-	11	96
1991	29	-	13	11	6	1	-	60	18	-	-	-	18	78
1992	21	1	13	7	5	1	-	48	21	-	-	1	22	70
1993	35	2	26	26	4	-	-	93	36	-	-	-	36	129
1994	29	9	20	14	2	1	-	75	19	-	-	-	19	94
1995	27	3	5	32	2	-	-	69	13	-	-	-	13	82
1996	35	4	7	21	-	-	-	67	16	-	-	-	16	83
1997	57	9	23	12	1	-	-	102	16	-	-	-	16	118
1998	76	21	7	10	1	-	-	115	11	-	-	-	11	126
1999	73	22	17	6	-	1	-	119	23	-	-	-	23	142
2000	76	32	14	-	-	-	-	122	17	-	-	-	17	139
2001	90	39	10	4	1	-	-	144	14	-	-	-	14	158
2002	132	37	13	-	-	1	-	183	11	-	-	-	11	194
2003	126	44	17	-	-	2	-	189	11	-	-	-	11	200
2004	114	48	9	-	-	-	-	171	16	-	-	-	16	187
2005	73	37	8	-	-	2	-	120	12	-	-	-	12	132
2006	83	47	9	-	-	-	-	139	16	-	-	-	16	155
2007	72	43	12	-	-	-	-	127	14	-	-	-	14	141
2008	79	35	10	-	-	-	-	124	-	-	-	-	-	124
2009	78	36	8	-	-	-	-	122	1	-	-	-	1	123
2010	77	40	4	-	-	-	-	121	-	-	-	-	-	121
2011	100	41	1	-	-	-	-	142	-	-	-	-	-	142
2012	85	52	7	-	-	-	-	144	1	-	-	-	1	145
2013	93	45	6	-	-	-	-	144	-	-	-	-	-	144
2014	124	46	2	-	-	-	9	181	-	-	-	-	-	181
Total	1 794	693	310	157	34	9	9	3 006	297	-	-	1	298	3 304

Table C2: continued.

WWA 8

	CLR form								CELR and NCELR form					
	L	E	R	T	O	D	J	Total	L	E	R	T	Total	Total
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	6	-	-	-	6	6
1992	-	-	-	-	-	-	-	-	1	-	-	-	1	1
1993	1	-	-	-	-	-	-	1	32	-	-	-	32	33
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-	2	-	-	-	2	2
1996	-	-	-	-	-	-	-	-	4	-	-	-	4	4
1997	1	-	-	-	-	-	-	1	-	-	-	-	-	1
1998	-	1	-	-	-	-	-	1	2	-	-	-	2	3
1999	-	-	-	-	-	-	-	-	1	-	-	-	1	1
2000	-	-	-	-	-	-	-	-	1	-	-	-	1	1
2001	1	-	-	-	-	-	-	1	-	-	-	-	-	1
2002	1	-	-	-	-	-	-	1	-	-	-	-	-	1
2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	1	-	-	-	-	-	-	1	-	-	-	-	-	1
2005	1	-	-	-	-	-	-	1	1	-	-	-	1	2
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	1	-	-	-	-	-	-	1	-	-	-	-	-	1
2009	2	-	-	-	-	-	-	2	-	-	-	-	-	2
2010	-	1	-	-	-	-	-	1	-	-	-	-	-	1
2011	-	1	-	-	-	-	-	1	-	-	-	-	-	1
2012	2	-	-	-	-	-	-	2	-	-	-	-	-	2
2013	1	1	-	-	-	-	-	2	-	-	-	-	-	2
2014	3	-	-	-	-	-	-	3	-	-	-	-	-	3
Total	15	4	-	-	-	-	-	19	50	-	-	-	50	69

WWA 9

	CLR form								CELR and NCELR form					
	L	E	R	T	O	D	J	Total	L	E	R	T	Total	Total
1990	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	1	-	-	-	1	-	-	-	-	-	1
1996	-	-	-	-	-	-	-	-	1	-	-	-	1	1
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	1	-	-	-	-	-	-	1	-	-	-	-	-	1
1999	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	2	-	-	-	-	-	-	2	-	-	-	-	-	2
2004	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	2	1	-	-	-	-	-	3	-	-	-	-	-	3
2009	1	-	-	-	-	-	-	1	-	-	-	-	-	1
2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	1	-	-	-	-	-	-	1	-	-	-	-	-	1
2013	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2014	1	-	-	-	-	-	-	1	-	-	-	-	-	1
Total	8	1	-	1	-	-	-	10	1	-	-	-	1	11

Table C3: Destination codes, total landing weight, number of landings, and whether the records were kept or dropped, for all white warehou catch reported for 1990–2014, by WWA stock.

WWA 1

Destination code	Greenweight (t)	No. records	Description	Action
L	32.16	267	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	0.08	2	Transferred to another vessel	Keep
F	0.02	7	Recreational catch	Keep
E	0.02	4	Eaten	Keep
W	0.02	2	Sold at wharf	Keep
R	1.05	4	Retained on board	Drop

WWA 2

Destination code	Greenweight (t)	No. records	Description	Action
L	660.98	1 976	Landed in New Zealand to a Licensed Fish Receiver	Keep
E	1.40	103	Eaten	Keep
W	0.01	3	Sold at wharf	Keep
A	0.00	1	Accidental loss	Keep
F	0.00	1	Recreational catch	Keep
D	0.00	1	Discarded	Keep
U	0.00	1	Used as bait	Keep
R	3.49	19	Retained on board	Drop
Q	0.41	6	Holding receptacle on land	Drop

WWA 3

Destination code	Greenweight (t)	No. records	Description	Action
L	9 029.91	11 666	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	1 007.96	292	Transferred to another vessel	Keep
O	953.31	50	Conveyed outside New Zealand	Keep
E	94.18	1 555	Eaten	Keep
A	1.14	39	Accidental loss	Keep
D	0.45	11	Discarded	Keep
J	0.31	15	Observer authorised discard	Keep
W	0.02	4	Sold at wharf	Keep
S	0.01	3	Seized by the Crown	Keep
F	0.01	3	Recreational catch	Keep
R	918.81	535	Retained on board	Drop
Null	4.24	13	Missing destination type code	Drop
Q	2.52	124	Holding receptacle on land	Drop
B	0.01	1	Stored as bait	Drop

WWA 4

Destination code	Greenweight (t)	No. records	Description	Action
L	4 298.30	3 058	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	180.27	153	Transferred to another vessel	Keep
O	69.64	19	Conveyed outside New Zealand	Keep
E	47.92	939	Eaten	Keep
A	0.61	17	Accidental loss	Keep
S	0.38	1	Seized by the Crown	Keep
C	0.35	1	Disposed to the Crown	Keep
D	0.18	9	Discarded	Keep
F	0.08	4	Recreational catch	Keep
W	0.04	12	Sold at wharf	Keep
R	252.92	262	Retained on board	Drop
Null	2.18	4	Missing destination type code	Drop

Table C3: continued.

WWA 5B

Destination code	Greenweight (t)	No. records	Description	Action
L	30 507.57	4 591	Landed in New Zealand to a Licensed Fish Receiver	Keep
O	3 997.54	103	Conveyed outside New Zealand	Keep
T	654.58	258	Transferred to another vessel	Keep
D	118.11	20	Discarded	Keep
E	111.06	2 012	Eaten	Keep
A	6.96	104	Accidental loss	Keep
J	1.51	31	Observer authorised discard	Keep
W	0.03	2	Sold at wharf	Keep
F	0.00	1	Recreational catch	Keep
R	4 890.27	551	Retained on board	Drop
Q	0.40	1	Holding receptacle on land	Drop
Null	0.00	4	Missing destination type code	Drop

WWA 7

Destination code	Greenweight (t)	No. records	Description	Action
L	2 037.72	2 091	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	134.67	158	Transferred to another vessel	Keep
E	37.05	693	Eaten	Keep
O	29.08	34	Conveyed outside New Zealand	Keep
S	0.60	3	Seized by the Crown	Keep
A	0.16	17	Accidental loss	Keep
D	0.14	9	Discarded	Keep
J	0.13	9	Observer authorised discard	Keep
R	312.63	310	Retained on board	Drop
Null	0.02	1	Missing destination type code	Drop

WWA 8

Destination code	Greenweight (t)	No. records	Description	Action
L	2.82	65	Landed in New Zealand to a Licensed Fish Receiver	Keep
E	0.03	4	Eaten	Keep
W	0.01	1	Sold at wharf	Keep
Q	0.04	1	Holding receptacle on land	Drop

WWA 9

Destination code	Greenweight (t)	No. records	Description	Action
L	0.23	9	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	0.04	1	Transferred to another vessel	Keep
E	0.01	1	Eaten	Keep

Table C4: The reported Quota Management Report (QMR) or Monthly Harvest Return (MHR) catch, 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 WWA stocks from 1990 to 2014. All catch and landings data are in tonnes.

WWA 1

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	1	1	-	-	-
1991	2	2	-	-	-
1992	6	6	1	-	-
1993	2	1	1	-	-
1994	6	6	-	-	-
1995	4	4	-	-	-
1996	2	1	-	-	-
1997	3	2	-	-	-
1998	2	2	1	-	-
1999	1	1	-	-	-
2000	1	1	-	-	-
2001	1	-	-	-	-
2002	-	-	-	-	-
2003	1	-	-	-	-
2004	1	-	-	-	-
2005	1	-	-	-	-
2006	1	2	-	-	-
2007	1	-	-	-	-
2008	1	1	1	-	-
2009	1	1	-	-	-
2010	1	1	1	-	-
2011	1	-	-	-	-
2012	1	-	-	-	-
2013	1	-	-	-	-
2014	1	-	-	-	-

WWA 2

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	9	9	8	6	67
1991	12	11	10	5	42
1992	22	21	21	13	59
1993	13	13	11	7	54
1994	34	31	26	19	56
1995	41	40	40	24	59
1996	68	68	65	27	40
1997	89	86	83	41	46
1998	31	32	31	19	61
1999	34	34	33	9	26
2000	48	49	39	3	6
2001	21	23	20	3	14
2002	8	7	7	2	25
2003	20	19	19	2	10
2004	47	47	46	2	4
2005	24	24	24	1	4
2006	35	33	33	2	6
2007	10	10	10	2	20
2008	43	39	39	3	7
2009	22	21	21	2	9
2010	7	5	5	1	14
2011	12	12	11	2	17
2012	3	3	3	1	33
2013	6	6	6	1	17
2014	8	8	8	1	12

Table C4: continued.

WWA 3

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	484	479	482	385	80
1991	695	677	658	581	84
1992	589	524	508	449	76
1993	281	250	240	184	65
1994	197	163	153	135	69
1995	327	308	301	270	83
1996	566	350	337	349	62
1997	508	470	437	206	41
1998	516	641	610	405	78
1999	398	402	391	248	62
2000	559	558	542	416	74
2001	661	649	643	437	66
2002	446	440	438	243	54
2003	852	808	800	579	68
2004	458	494	489	356	78
2005	347	349	349	251	72
2006	589	578	577	466	79
2007	733	694	693	565	77
2008	345	313	306	243	70
2009	302	310	306	218	72
2010	355	349	349	278	78
2011	391	398	395	297	76
2012	204	190	190	113	55
2013	174	177	177	91	52
2014	302	298	298	210	70

WWA 4

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	16	15	12	12	75
1991	88	79	71	61	69
1992	113	70	60	43	38
1993	106	91	87	58	55
1994	23	15	13	6	26
1995	243	206	88	35	14
1996	137	135	128	77	56
1997	220	219	211	188	85
1998	153	154	150	110	72
1999	120	119	115	78	65
2000	277	252	245	167	60
2001	303	308	306	146	48
2002	262	264	259	157	60
2003	397	393	388	257	65
2004	365	364	363	256	70
2005	365	392	373	245	67
2006	312	304	304	217	70
2007	304	299	299	205	67
2008	207	195	195	136	66
2009	85	84	84	52	61
2010	179	175	175	145	81
2011	81	81	81	49	60
2012	112	90	89	50	45
2013	117	107	105	37	32
2014	110	107	107	63	57

Table C4: continued.

WWA 5B

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	846	715	708	649	77
1991	846	777	754	737	87
1992	1 861	1 677	1 628	1 563	84
1993	1 205	919	893	807	67
1994	1 827	1 202	1 169	1 144	63
1995	2 121	2 120	2 059	2 151	101
1996	1 605	1 668	1 625	1 384	86
1997	2 803	2 618	2 546	1 981	71
1998	1 343	1 353	1 311	1 135	85
1999	1 681	1 736	1 686	1 587	94
2000	1 323	1 222	1 189	1 154	87
2001	822	991	991	856	104
2002	1 140	1 100	1 100	906	79
2003	1 919	1 849	1 849	1 668	87
2004	1 352	1 353	1 353	1 201	89
2005	2 004	1 934	1 934	1 869	93
2006	1 426	1 184	1 184	1 051	74
2007	2 047	2 172	2 172	2 017	99
2008	1 431	1 508	1 508	1 398	98
2009	1 644	1 575	1 575	1 436	87
2010	1 106	1 059	1 059	1 008	91
2011	787	827	827	775	98
2012	978	962	962	881	90
2013	1 037	1 034	1 034	957	92
2014	1 373	1 385	1 385	1 289	94

WWA 7

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	83	19	19	9	11
1991	69	72	66	62	90
1992	45	40	39	33	73
1993	125	100	97	65	52
1994	69	62	60	49	71
1995	80	73	69	50	62
1996	62	58	56	37	60
1997	71	58	56	24	34
1998	98	105	100	54	55
1999	73	67	65	49	67
2000	153	94	90	66	43
2001	90	88	88	69	77
2002	85	94	91	64	75
2003	158	135	134	99	63
2004	135	149	143	114	84
2005	123	123	123	100	81
2006	133	107	107	75	56
2007	121	112	112	86	71
2008	90	103	102	71	79
2009	110	114	114	72	65
2010	44	53	53	28	64
2011	52	53	50	19	37
2012	77	63	63	37	48
2013	118	132	132	93	79
2014	115	107	106	71	62

Table C4: continued.

WWA 8

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	-	-	-	-	-
1991	1	1	1	-	-
1992	-	-	-	-	-
1993	2	2	1	1	50
1994	-	-	-	-	-
1995	-	-	-	-	-
1996	-	-	-	-	-
1997	-	-	-	-	-
1998	1	-	-	-	-
1999	1	-	-	-	-
2000	1	-	-	-	-
2001	1	-	-	-	-
2002	1	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	1	-	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	1	-	-	-	-
2010	1	-	-	-	-
2011	1	-	-	-	-
2012	1	-	-	-	-
2013	1	-	-	-	-
2014	1	-	-	-	-

WWA 9

Year	MHR	Unmerged landings	Merged landings	Estimated catch	Percent MHR
1990	-	-	-	-	-
1991	-	-	-	-	-
1992	-	-	-	-	-
1993	-	-	-	-	-
1994	-	-	-	-	-
1995	-	-	-	-	-
1996	-	-	-	-	-
1997	-	-	-	-	-
1998	1	-	-	-	-
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	1	-	-	-	-
2003	-	-	-	-	-
2004	-	-	-	-	-
2005	-	-	-	-	-
2006	-	-	-	-	-
2007	-	-	-	-	-
2008	1	-	-	-	-
2009	1	-	-	-	-
2010	-	-	-	-	-
2011	-	-	-	-	-
2012	1	-	-	-	-
2013	-	-	-	-	-
2014	1	-	-	-	-

Table C5: Total number of trips, number of trips with zero estimated catch, and proportion of trips with zero estimated catch, by form type for WWA 1–9 from 1990 to 2014. Areas are shown in Figure 1.

WWA 1

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	21	12	0.57	1	-	-
1991	7	3	0.43	2	1	0.50
1992	15	9	0.60	6	1	0.17
1993	26	20	0.77	4	1	0.25
1994	4	1	0.25	10	6	0.60
1995	12	4	0.33	4	1	0.25
1996	6	4	0.67	2	1	0.50
1997	1	1	1	5	2	0.40
1998	2	-	-	6	3	0.50
1999	4	3	0.75	5	4	0.80
2000	3	1	0.33	3	2	0.67
2001	3	1	0.33	4	3	0.75
2002	1	1	1	2	1	0.50
2003	5	4	0.80	2	2	1
2004	5	2	0.40	3	2	0.67
2005	8	1	0.12	-	-	-
2006	4	2	0.50	4	3	0.75
2007	4	4	1	2	2	1
2008	1	-	-	1	1	1
2009	2	-	-	1	1	1
2010	-	-	-	1	1	1
2011	1	1	1	-	-	-
2012	3	2	0.67	2	1	0.50
2013	3	2	0.67	1	1	1
2014	1	-	-	1	1	1

WWA 2

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	34	15	0.44	8	5	0.62
1991	38	11	0.29	9	6	0.67
1992	56	26	0.46	17	4	0.24
1993	49	30	0.61	45	20	0.44
1994	23	15	0.65	31	17	0.55
1995	10	3	0.30	51	13	0.25
1996	10	8	0.80	95	28	0.29
1997	7	3	0.43	146	47	0.32
1998	3	1	0.33	95	31	0.33
1999	9	4	0.44	106	31	0.29
2000	4	4	1	97	35	0.36
2001	4	3	0.75	73	30	0.41
2002	1	-	-	72	32	0.44
2003	6	5	0.83	74	21	0.28
2004	7	7	1	61	21	0.34
2005	6	4	0.67	62	24	0.39
2006	12	10	0.83	53	19	0.36
2007	13	11	0.85	52	25	0.48
2008	5	3	0.60	59	16	0.27
2009	-	-	-	46	5	0.11
2010	-	-	-	34	13	0.38
2011	2	-	-	44	16	0.36
2012	1	1	1	37	18	0.49
2013	2	2	1	39	30	0.77
2014	2	2	1	41	27	0.66

Table C5: continued.

WWA 3

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	334	164	0.49	87	35	0.40
1991	431	241	0.56	79	23	0.29
1992	253	140	0.55	124	53	0.43
1993	359	167	0.47	152	65	0.43
1994	367	154	0.42	122	53	0.43
1995	446	122	0.27	133	54	0.41
1996	424	160	0.38	206	64	0.31
1997	324	184	0.57	209	71	0.34
1998	490	227	0.46	287	104	0.36
1999	294	167	0.57	279	96	0.34
2000	230	158	0.69	270	68	0.25
2001	395	263	0.67	331	76	0.23
2002	211	143	0.68	283	65	0.23
2003	298	172	0.58	330	59	0.18
2004	211	162	0.77	234	66	0.28
2005	163	99	0.61	164	48	0.29
2006	102	75	0.74	147	41	0.28
2007	28	17	0.61	151	28	0.19
2008	69	29	0.42	107	15	0.14
2009	35	22	0.63	122	23	0.19
2010	58	27	0.47	118	24	0.20
2011	36	14	0.39	135	29	0.21
2012	66	26	0.39	111	36	0.32
2013	21	14	0.67	110	38	0.35
2014	36	20	0.56	118	43	0.36

WWA 4

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	-	-	-	19	3	0.16
1991	-	-	-	36	8	0.22
1992	-	-	-	59	23	0.39
1993	1	-	-	69	21	0.30
1994	-	-	-	38	17	0.45
1995	-	-	-	61	24	0.39
1996	1	1	1	66	13	0.20
1997	-	-	-	72	13	0.18
1998	2	2	1	111	19	0.17
1999	6	5	0.83	116	27	0.23
2000	8	7	0.88	108	25	0.23
2001	19	15	0.79	136	20	0.15
2002	32	16	0.50	125	18	0.14
2003	17	9	0.53	131	15	0.11
2004	25	9	0.36	122	21	0.17
2005	5	1	0.20	128	30	0.23
2006	7	1	0.14	106	24	0.23
2007	18	9	0.50	108	28	0.26
2008	-	-	-	101	31	0.31
2009	-	-	-	84	25	0.30
2010	-	-	-	73	15	0.21
2011	-	-	-	83	22	0.27
2012	2	-	-	78	32	0.41
2013	6	4	0.67	79	29	0.37
2014	8	7	0.88	71	28	0.39

Table C5: continued.

WWA 5

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	-	-	-	63	20	0.32
1991	1	-	-	71	17	0.24
1992	-	-	-	112	34	0.30
1993	2	2	1	77	15	0.19
1994	2	2	1	67	18	0.27
1995	-	-	-	82	27	0.33
1996	2	-	-	87	20	0.23
1997	2	-	-	99	12	0.12
1998	2	2	1	111	12	0.11
1999	2	1	0.50	121	33	0.27
2000	2	2	1	126	23	0.18
2001	3	3	1	155	34	0.22
2002	-	-	-	157	36	0.23
2003	6	4	0.67	172	26	0.15
2004	20	5	0.25	135	36	0.27
2005	23	4	0.17	136	41	0.30
2006	26	2	0.08	131	36	0.27
2007	13	3	0.23	144	40	0.28
2008	3	-	-	99	25	0.25
2009	7	2	0.29	104	20	0.19
2010	12	1	0.08	105	30	0.29
2011	25	1	0.04	133	56	0.42
2012	23	-	-	139	52	0.37
2013	16	1	0.06	154	76	0.49
2014	23	1	0.04	128	54	0.42

WWA 7

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	11	8	0.73	24	8	0.33
1991	18	14	0.78	39	13	0.33
1992	21	18	0.86	28	7	0.25
1993	35	26	0.74	54	19	0.35
1994	19	14	0.74	49	22	0.45
1995	13	9	0.69	50	18	0.36
1996	16	14	0.88	49	14	0.29
1997	14	10	0.71	62	32	0.52
1998	11	11	1	71	17	0.24
1999	22	16	0.73	69	29	0.42
2000	15	11	0.73	62	23	0.37
2001	14	9	0.64	77	26	0.34
2002	11	8	0.73	73	19	0.26
2003	11	8	0.73	77	19	0.25
2004	16	13	0.81	84	21	0.25
2005	12	8	0.67	56	22	0.39
2006	16	13	0.81	57	5	0.09
2007	14	9	0.64	52	11	0.21
2008	14	6	0.43	41	10	0.24
2009	18	11	0.61	42	5	0.12
2010	17	11	0.65	48	14	0.29
2011	34	28	0.82	47	17	0.36
2012	15	13	0.87	59	31	0.53
2013	34	11	0.32	52	27	0.52
2014	45	14	0.31	61	28	0.46

Table C5: continued.

WWA 8

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	-	-	-	-	-	-
1991	6	-	-	-	-	-
1992	1	-	-	-	-	-
1993	32	11	0.34	1	-	-
1994	-	-	-	-	-	-
1995	2	-	-	-	-	-
1996	4	-	-	-	-	-
1997	-	-	-	1	-	-
1998	3	1	0.33	1	-	-
1999	1	-	-	-	-	-
2000	1	-	-	-	-	-
2001	-	-	-	1	1	1
2002	-	-	-	1	1	1
2003	-	-	-	-	-	-
2004	-	-	-	-	-	-
2005	1	1	1	1	1	1
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	1	1	1
2009	-	-	-	-	-	-
2010	-	-	-	1	1	1
2011	-	-	-	1	-	-
2012	-	-	-	2	1	0.50
2013	-	-	-	2	1	0.50
2014	-	-	-	1	1	1

WWA 9

	CELR/TCE estimated catch			TCEPR estimated catch		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	-	-	-	-	-	-
1991	-	-	-	-	-	-
1992	-	-	-	-	-	-
1993	-	-	-	-	-	-
1994	-	-	-	-	-	-
1995	-	-	-	1	1	1
1996	1	1	1	-	-	-
1997	-	-	-	-	-	-
1998	-	-	-	1	-	-
1999	-	-	-	-	-	-
2000	-	-	-	-	-	-
2001	-	-	-	-	-	-
2002	-	-	-	-	-	-
2003	-	-	-	1	1	1
2004	-	-	-	-	-	-
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	3	3	1
2009	-	-	-	1	1	1
2010	-	-	-	-	-	-
2011	-	-	-	-	-	-
2012	-	-	-	1	1	1
2013	-	-	-	-	-	-
2014	-	-	-	1	1	1

Table C6: Total catch (t) for each area from groomed and merged data, 1989–90 (1990) to 2013–14 (2014). Areas are shown in Figure 1b.

Year	CHAT	ECNI	SUBA	WCSI	Other	Total
1990	277	9	925	19	-	1 230
1991	605	11	878	65	1	1 559
1992	325	23	1 871	38	-	2 257
1993	276	12	943	96	2	1 328
1994	119	29	1 216	57	-	1 422
1995	298	42	2 149	68	-	2 557
1996	451	65	1 639	56	-	2 212
1997	547	85	2 647	53	1	3 332
1998	628	32	1 443	99	-	2 203
1999	413	34	1 780	65	-	2 292
2000	593	42	1 383	88	-	2 106
2001	843	20	1 096	88	-	2 047
2002	558	7	1 238	91	-	1 895
2003	1 058	19	1 979	134	-	3 189
2004	831	47	1 373	143	-	2 394
2005	699	24	1 958	123	-	2 803
2006	841	33	1 225	106	-	2 205
2007	951	10	2 212	112	-	3 285
2008	486	39	1 523	102	-	2 150
2009	333	21	1 631	114	-	2 100
2010	403	6	1 180	53	-	1 642
2011	374	11	929	50	-	1 364
2012	249	4	992	62	-	1 307
2013	258	6	1 057	132	-	1 453
2014	280	8	1 510	106	-	1 904
Total	12 695	639	36 778	2 120	6	52 238

Table C7: Total catch (t) by vessel nationality from groomed and merged data, 1989–90 (1990) to 2013–14 (2014).

Year	NZ	Korea	Japan	Panama	Norway	Russian	Cyprus	Other	Total
1990	1 126	25	9	-	61	8	-	0	1 230
1991	1 343	31	49	-	127	5	-	4	1 559
1992	2 046	50	28	-	128	3	-	3	2 257
1993	1 013	73	104	-	118	9	-	11	1 328
1994	1 114	106	77	-	120	3	-	1	1 422
1995	2 181	217	93	-	62	2	-	3	2 557
1996	1 695	316	138	-	35	9	-	19	2 212
1997	2 640	351	238	9	81	7	-	5	3 332
1998	1 297	305	216	154	62	127	37	5	2 203
1999	1 564	322	297	70	4	4	28	4	2 292
2000	908	433	630	104	9	1	20	1	2 106
2001	684	672	513	76	58	3	39	4	2 047
2002	673	659	426	64	33	2	29	10	1 895
2003	1 346	1 052	532	83	78	3	57	37	3 189
2004	811	1 075	183	282	-	9	13	22	2 394
2005	1 089	1 210	271	196	-	15	-	22	2 803
2006	661	992	285	251	-	4	-	11	2 205
2007	733	1 583	932	-	-	1	-	36	3 285
2008	701	857	569	-	-	1	-	22	2 150
2009	755	535	806	-	-	3	-	0	2 100
2010	399	508	726	-	-	5	-	3	1 642
2011	507	510	307	-	-	40	-	0	1 364
2012	527	390	372	-	-	16	-	2	1 307
2013	669	498	282	-	-	3	-	1	1 453
2014	785	565	550	-	-	4	-	0	1 904
Total	27 268	13 336	8 633	1 290	976	288	223	225	52 238

Table C8: Proportion of white warehou catch reported from the CHAT area, by month, statistical area, method, and target species for 1990 to 2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	0.01	-	0.02	-	0.01	0.05	0.29	0.09	0.01	0.02	0.04	0.45	277
1991	0.02	0.01	0.02	0.02	-	0.01	-	0.02	0.04	0.01	0.79	0.05	605
1992	0.02	0.02	0.02	-	-	0.09	0.16	0.09	0.06	0.18	0.10	0.26	325
1993	0.06	0.05	0.02	0.02	0.01	0.09	0.05	0.15	0.05	0.01	0.31	0.19	276
1994	0.12	0.04	0.04	0.12	0.07	0.08	0.08	0.04	0.10	0.02	0.02	0.28	119
1995	0.20	0.07	0.03	0.10	0.01	0.13	0.04	0.02	0.04	0.02	0.12	0.23	298
1996	0.04	0.01	0.05	0.03	0.05	0.09	0.12	0.26	0.16	-	0.01	0.18	451
1997	0.11	0.12	0.07	0.02	0.05	0.04	0.06	0.23	0.03	0.03	0.01	0.24	547
1998	0.05	0.05	0.07	0.05	0.07	0.22	0.08	0.14	0.11	0.01	0.01	0.15	628
1999	0.04	0.09	0.05	0.05	0.04	0.13	0.11	0.17	0.05	0.08	-	0.20	413
2000	0.06	0.07	0.05	0.07	0.07	0.09	0.21	0.27	0.02	-	-	0.08	593
2001	0.09	0.09	0.07	0.09	0.10	0.18	0.12	0.07	0.02	0.02	0.01	0.13	843
2002	0.17	0.08	0.10	0.05	0.05	0.08	0.11	0.08	0.02	0.04	0.03	0.21	558
2003	0.11	0.09	0.04	0.07	0.14	0.13	0.17	0.12	0.03	0.01	0.01	0.10	1 058
2004	0.09	0.07	0.16	0.06	0.10	0.08	0.17	0.04	0.06	0.08	0.03	0.07	831
2005	0.08	0.12	0.07	0.13	0.09	0.07	0.16	0.13	0.06	0.01	0.03	0.07	699
2006	0.09	0.06	0.11	0.11	0.15	0.05	0.25	0.12	0.02	0.01	0.01	0.02	841
2007	0.04	0.08	0.05	0.16	0.05	0.07	0.15	0.19	0.12	-	0.03	0.04	951
2008	0.17	0.05	0.08	0.10	0.09	0.01	0.08	0.21	0.05	0.06	0.05	0.05	486
2009	0.17	0.09	0.05	0.17	0.05	0.05	0.05	0.18	0.03	0.07	0.02	0.06	333
2010	0.17	0.02	0.08	0.09	0.06	0.22	0.12	0.06	0.08	0.02	0.02	0.08	403
2011	0.12	0.15	0.16	0.07	0.06	0.05	0.05	0.21	0.06	-	0.01	0.05	374
2012	0.08	0.10	0.05	0.06	0.06	0.09	0.18	0.29	0.04	0.01	0.03	0.02	249
2013	0.04	0.08	0.20	0.20	0.08	0.07	0.11	0.05	0.10	-	0.04	0.02	258
2014	0.11	0.27	0.13	0.09	0.07	0.08	0.06	0.04	0.10	-	0.01	0.04	280
Total	0.09	0.07	0.07	0.08	0.07	0.09	0.13	0.13	0.06	0.03	0.07	0.11	12 695

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	018	020	021	022	023	049	051	052	401	402	404	407	408	Other	Total
1990	0.03	0.37	0.32	0.04	0.16	-	-	-	0.03	0.01	0.01	-	-	0.04	277
1991	0.02	0.20	0.25	0.01	0.39	-	-	-	0.08	-	0.02	0.01	-	0.02	605
1992	0.02	0.50	0.13	0.08	0.07	-	-	-	0.09	0.01	-	0.06	-	0.04	325
1993	0.03	0.36	0.11	0.10	0.07	-	-	-	0.20	0.03	0.06	0.01	-	0.02	276
1994	0.41	0.20	0.14	0.07	0.04	-	-	-	0.02	0.01	0.07	-	-	0.03	119
1995	0.21	0.20	0.17	0.07	0.03	-	-	0.14	0.06	0.01	0.05	0.02	-	0.03	298
1996	0.18	0.30	0.12	0.06	0.02	-	0.04	0.12	0.04	-	0.02	0.03	-	0.05	451
1997	0.09	0.33	0.06	0.04	0.05	0.08	0.02	0.07	0.03	-	0.08	0.03	-	0.12	547
1998	0.05	0.37	0.03	0.06	0.03	0.03	0.01	0.08	0.02	0.01	0.07	-	-	0.23	628
1999	0.06	0.29	0.10	0.14	0.07	0.01	0.04	0.04	0.09	0.01	0.02	0.02	0.01	0.10	413
2000	0.05	0.25	0.05	0.16	0.07	0.07	0.05	0.12	0.04	0.01	0.01	0.05	0.03	0.03	593
2001	0.03	0.17	0.06	0.26	0.11	0.03	0.04	0.02	0.04	0.02	0.05	0.08	0.03	0.06	843
2002	0.04	0.23	0.04	0.12	0.12	0.03	0.06	0.02	0.02	0.02	0.18	0.06	0.03	0.06	558
2003	0.03	0.21	0.03	0.21	0.15	0.02	0.06	0.02	0.02	0.01	0.06	0.08	0.04	0.05	1 058
2004	0.02	0.28	0.03	0.12	0.11	-	0.10	0.02	0.02	0.01	0.05	0.04	0.09	0.10	831
2005	0.02	0.18	0.02	0.13	0.12	0.05	0.03	0.01	0.04	0.04	0.04	0.13	0.13	0.08	699
2006	0.01	0.24	0.04	0.08	0.26	0.04	0.04	0.01	0.03	0.02	0.07	0.05	0.07	0.04	841
2007	0.01	0.19	0.05	0.12	0.31	0.01	0.01	0.01	0.03	0.03	0.03	0.05	0.10	0.05	951
2008	0.02	0.30	0.07	0.06	0.15	0.06	0.02	0.09	0.03	0.04	0.08	0.02	0.01	0.05	486
2009	0.02	0.28	0.03	0.15	0.27	0.02	0.08	0.01	0.02	0.03	0.04	0.02	0.01	0.01	333
2010	0.02	0.30	0.02	0.06	0.16	-	0.04	-	0.03	0.02	0.30	0.02	-	0.02	403
2011	0.02	0.32	0.07	0.11	0.27	0.01	0.03	0.02	0.02	0.04	0.06	0.01	0.02	0.02	374
2012	0.03	0.34	0.05	0.05	0.15	0.01	0.05	0.04	0.05	0.05	0.04	0.02	0.08	0.04	249
2013	0.04	0.22	-	0.05	0.28	-	0.02	-	0.11	0.07	0.02	0.06	0.08	0.04	258
2014	0.03	0.15	0.08	0.08	0.29	-	0.05	-	0.03	0.01	0.04	0.07	0.11	0.06	280
Total	0.04	0.26	0.07	0.11	0.16	0.02	0.04	0.03	0.04	0.02	0.06	0.05	0.04	0.06	12 695

Table C8: continued.

(c) Method. BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl; SN is setnet.

Year	BT	MB	MW	SN	Total
1990	0.96	-	-	0.04	277
1991	0.98	-	-	0.02	605
1992	0.97	-	-	0.03	325
1993	0.96	-	-	0.04	276
1994	0.75	-	-	0.23	119
1995	0.90	-	0.01	0.09	298
1996	0.91	-	0.03	0.06	451
1997	0.96	-	-	0.04	547
1998	0.76	-	-	0.23	628
1999	0.96	0.01	-	0.03	413
2000	0.99	-	-	0.01	593
2001	0.99	-	-	0.01	843
2002	0.99	-	-	0.01	558
2003	0.99	-	0.01	-	1 058
2004	0.99	-	-	-	831
2005	0.98	0.01	-	-	699
2006	0.99	-	-	-	841
2007	0.98	0.01	-	-	951
2008	0.94	0.04	0.02	-	486
2009	0.97	0.01	0.01	-	333
2010	0.71	0.09	0.19	-	403
2011	0.92	0.04	0.02	-	374
2012	0.96	0.01	0.01	0.02	249
2013	0.92	0.02	0.06	-	258
2014	0.94	0.04	0.02	-	280
Total	0.95	0.01	0.01	0.03	12 695

(d) Target species. (Target species codes are defined in Table C12).

Year	BNS	BYX	HAK	HOK	LIN	RCO	SPE	SQU	SWA	WWA	Other	Total
1990	0.01	-	0.01	0.47	0.03	0.01	-	-	0.34	0.11	0.03	277
1991	-	-	0.01	0.09	0.74	-	-	-	0.13	0.01	0.02	605
1992	-	-	0.01	0.62	0.07	0.01	-	0.01	0.23	-	0.04	325
1993	0.01	-	0.06	0.78	0.04	0.03	-	-	0.03	-	0.05	276
1994	0.04	-	0.07	0.57	0.19	-	-	0.04	0.02	-	0.08	119
1995	0.02	-	0.05	0.68	0.06	0.02	-	0.02	0.09	-	0.06	298
1996	0.02	0.04	0.02	0.74	0.03	0.02	-	0.01	0.08	-	0.03	451
1997	-	0.02	0.08	0.73	0.03	0.01	-	0.03	0.07	-	0.02	547
1998	0.01	0.01	0.06	0.54	0.22	0.03	-	0.06	0.01	-	0.06	628
1999	0.01	0.07	0.12	0.65	0.02	0.01	-	0.08	-	0.02	0.03	413
2000	-	0.06	0.03	0.66	0.02	0.02	-	0.18	-	-	0.02	593
2001	-	0.05	0.04	0.66	0.01	0.01	-	0.18	0.03	-	0.02	843
2002	0.15	0.03	0.03	0.54	0.06	0.01	0.01	0.09	0.02	0.05	0.01	558
2003	0.05	0.07	0.01	0.64	0.02	0.02	0.01	0.12	0.02	0.03	0.01	1 058
2004	0.04	0.10	0.01	0.77	-	0.02	0.01	0.04	-	0.01	0.01	831
2005	0.02	0.07	0.02	0.79	0.01	0.01	-	0.01	0.04	-	0.02	699
2006	0.03	0.11	-	0.67	0.02	-	-	0.02	0.12	0.01	0.02	841
2007	-	0.04	0.04	0.68	0.09	-	0.09	0.02	0.02	-	0.01	951
2008	-	0.08	0.02	0.45	0.16	-	0.06	0.01	0.18	0.01	0.01	486
2009	0.01	0.09	0.04	0.53	0.09	-	-	-	0.21	0.02	0.02	333
2010	0.01	0.31	0.01	0.32	0.11	-	0.05	-	0.14	0.04	0.01	403
2011	0.01	0.09	-	0.67	0.01	-	0.01	-	0.16	0.03	0.01	374
2012	0.01	0.09	-	0.79	0.02	-	-	-	0.04	0.02	0.02	249
2013	-	0.05	-	0.84	-	-	0.03	-	0.05	-	0.02	258
2014	-	0.09	-	0.84	0.01	-	-	-	0.02	0.01	0.01	280
Total	0.02	0.06	0.03	0.63	0.08	0.01	0.01	0.05	0.07	0.01	0.02	12 695

Table C9: Proportion of white warehou catch reported from the SUBA area, by month, statistical area, method, and target species for 1990 to 2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	-	0.01	-	-	0.14	0.14	0.06	0.11	0.16	-	0.07	0.31	925
1991	-	0.01	0.01	-	0.01	-	0.17	0.21	0.04	0.01	0.15	0.41	878
1992	0.07	-	0.09	0.02	0.02	0.02	0.02	0.03	0.01	0.01	0.33	0.36	1 871
1993	0.03	0.02	0.09	0.02	0.02	0.08	0.04	0.08	0.23	0.14	0.05	0.20	943
1994	-	0.01	0.03	0.06	0.01	0.01	0.07	0.13	0.23	0.07	0.26	0.10	1 216
1995	0.01	0.02	-	0.01	0.03	0.04	0.02	0.35	-	-	-	0.49	2 149
1996	0.02	0.13	0.08	0.01	0.03	0.02	0.09	0.02	0.09	0.15	-	0.35	1 639
1997	0.06	0.11	0.02	0.02	0.05	0.02	0.02	0.03	0.15	0.07	0.09	0.36	2 647
1998	0.08	0.06	0.02	0.04	0.02	0.21	0.05	0.03	0.09	0.01	0.18	0.22	1 443
1999	0.01	0.09	0.05	-	0.11	0.03	0.06	0.02	0.18	0.07	0.08	0.30	1 780
2000	0.06	0.12	0.14	0.06	0.10	0.09	0.09	0.04	0.09	0.03	0.10	0.08	1 383
2001	0.30	0.04	0.08	0.05	0.05	0.14	0.14	0.04	0.03	-	-	0.12	1 096
2002	0.22	0.11	0.13	0.04	0.02	0.09	0.03	0.08	0.17	0.01	-	0.10	1 238
2003	0.10	0.06	0.04	0.04	0.01	0.13	0.15	0.35	0.01	-	0.02	0.09	1 979
2004	0.33	0.22	0.11	0.03	0.09	0.08	0.04	0.03	0.02	-	0.03	0.02	1 373
2005	0.29	0.10	0.07	0.02	0.15	-	0.03	0.08	0.11	0.07	0.06	0.01	1 958
2006	0.40	0.09	0.04	-	0.01	0.02	0.03	0.17	0.01	0.18	0.02	0.03	1 225
2007	0.18	0.10	0.16	0.16	-	-	0.04	0.02	0.02	0.12	0.05	0.15	2 212
2008	0.24	0.22	0.14	0.01	0.03	0.01	0.01	0.01	0.01	0.18	0.01	0.12	1 523
2009	0.18	0.10	0.13	0.12	0.05	0.08	0.04	0.02	0.19	0.02	0.05	0.02	1 631
2010	0.23	0.06	0.19	0.12	0.03	0.04	0.02	0.10	0.10	0.04	0.01	0.05	1 180
2011	0.46	0.12	0.05	0.06	0.04	-	0.01	0.03	0.03	0.13	-	0.07	929
2012	0.21	0.16	0.08	0.05	0.05	0.13	0.02	0.03	-	0.26	-	0.01	992
2013	0.24	0.14	0.13	0.04	0.02	0.02	0.02	0.02	0.01	0.29	-	0.07	1 057
2014	0.09	0.06	0.25	0.07	0.03	0.01	0.01	0.04	0.01	0.13	-	0.30	1 510
Total	0.14	0.09	0.08	0.04	0.05	0.05	0.05	0.09	0.08	0.08	0.07	0.19	36 778

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	026	027	028	029	030	503	504	602	603	610	611	618	Other	Total
1990	0.24	0.04	0.24	0.01	0.09	-	0.03	0.35	-	-	-	-	-	925
1991	0.14	0.02	0.04	0.03	0.31	-	0.05	0.24	0.17	-	-	-	-	878
1992	0.13	0.05	0.09	-	0.22	-	0.01	0.33	0.16	-	-	-	0.01	1 871
1993	0.05	0.15	0.34	-	0.06	-	0.03	0.28	0.08	-	-	-	-	943
1994	0.04	0.04	0.44	-	0.08	-	0.02	0.35	0.03	0.01	-	-	-	1 216
1995	0.04	0.02	0.83	-	0.05	-	-	0.04	-	-	-	-	-	2 149
1996	0.01	0.01	0.89	-	0.08	-	-	0.01	-	-	-	-	-	1 639
1997	0.04	0.01	0.79	-	0.09	-	0.01	0.07	-	-	-	-	-	2 647
1998	0.09	0.02	0.69	-	0.13	-	0.01	0.04	0.02	-	-	-	-	1 443
1999	0.05	0.03	0.64	-	0.13	-	-	0.14	-	-	-	-	-	1 780
2000	0.14	0.02	0.43	-	0.26	-	0.01	0.12	-	0.01	-	-	-	1 383
2001	0.10	0.05	0.38	0.02	0.32	-	0.03	0.07	-	0.02	-	0.01	-	1 096
2002	0.11	0.05	0.48	-	0.11	0.08	0.02	0.11	-	0.03	-	-	-	1 238
2003	0.07	0.01	0.30	-	0.28	0.10	0.01	0.20	0.01	0.01	-	-	-	1 979
2004	0.02	0.01	0.36	-	0.28	0.21	0.01	0.09	0.01	0.01	0.01	-	-	1 373
2005	0.01	0.02	0.27	-	0.35	0.11	0.03	0.19	-	-	-	0.01	0.01	1 958
2006	0.03	0.05	0.30	0.02	0.40	0.02	0.01	0.15	-	-	-	-	-	1 225
2007	0.02	0.14	0.38	0.03	0.16	0.03	0.01	0.10	0.01	0.10	-	-	-	2 212
2008	0.01	0.05	0.51	-	0.17	0.01	-	0.13	0.01	0.10	-	-	-	1 523
2009	0.03	0.20	0.42	-	0.10	-	-	0.07	0.01	0.15	-	-	-	1 631
2010	0.10	0.09	0.32	-	0.22	0.01	-	0.06	-	0.19	-	-	-	1 180
2011	0.11	0.04	0.52	-	0.22	0.02	0.01	0.04	-	0.01	-	-	0.01	929
2012	0.03	0.07	0.47	-	0.12	-	0.01	0.08	-	0.22	-	-	-	992
2013	0.02	0.03	0.44	-	0.28	-	-	0.13	-	0.09	-	-	-	1 057
2014	0.08	0.12	0.44	-	0.12	-	0.01	0.08	-	0.14	-	-	-	1 510
Total	0.06	0.05	0.46	0.01	0.18	0.03	0.01	0.13	0.02	0.04	-	-	-	36 778

Table C9: continued.

(c) Method. BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl.

Year	BT	MB	MW	Other	Total
1990	1	-	-	-	925
1991	1	-	-	-	878
1992	1	-	-	-	1 871
1993	1	-	-	-	943
1994	1	-	-	-	1 216
1995	1	-	-	-	2 149
1996	0.99	0.01	-	-	1 639
1997	1	-	-	-	2 647
1998	0.99	-	0.01	-	1 443
1999	1	-	-	-	1 780
2000	1	-	-	-	1 383
2001	0.99	-	-	-	1 096
2002	0.99	-	-	-	1 238
2003	0.98	0.01	0.01	-	1 979
2004	1	-	-	-	1 373
2005	0.99	-	0.01	-	1 958
2006	1	-	-	-	1 225
2007	1	-	-	-	2 212
2008	1	-	-	-	1 523
2009	1	-	-	-	1 631
2010	1	-	-	-	1 180
2011	0.99	0.01	-	-	929
2012	1	-	-	-	992
2013	1	-	-	-	1 057
2014	1	-	-	-	1 510
Total	1	-	-	-	36 778

(d) Target species. (Target species codes are defined in Table C12).

Year	BAR	HAK	HOK	LIN	SBW	SCI	SQU	SWA	WAR	WWA	Other	Total
1990	0.01	0.06	0.13	0.14	-	-	0.04	0.16	-	0.45	0.02	925
1991	-	0.01	0.24	0.13	-	-	0.01	0.26	-	0.35	-	878
1992	-	0.11	0.14	0.46	-	-	0.01	0.17	-	0.11	-	1 871
1993	-	0.03	0.27	0.31	-	-	0.03	0.36	-	-	0.01	943
1994	-	0.09	0.15	0.32	0.01	-	0.16	0.28	-	-	-	1 216
1995	-	0.05	0.25	0.24	-	-	0.01	0.45	-	-	-	2 149
1996	-	0.18	0.05	0.44	-	-	0.01	0.32	-	-	-	1 639
1997	-	0.09	0.07	0.64	-	-	0.02	0.18	-	-	-	2 647
1998	-	0.10	0.36	0.09	-	-	0.02	0.32	-	0.11	-	1 443
1999	-	0.03	0.15	0.34	-	-	0.02	0.21	-	0.24	-	1 780
2000	-	0.04	0.37	0.11	-	-	0.03	0.20	-	0.25	-	1 383
2001	-	0.04	0.40	0.04	-	0.01	0.05	0.09	-	0.37	-	1 096
2002	-	0.01	0.26	0.02	-	-	0.09	0.16	-	0.45	-	1 238
2003	-	0.01	0.12	0.01	-	0.01	0.11	0.08	-	0.66	-	1 979
2004	-	0.05	0.20	0.04	-	-	0.04	0.01	-	0.65	-	1 373
2005	-	0.01	0.16	0.06	-	-	0.05	0.03	-	0.67	-	1 958
2006	-	0.01	0.16	0.19	-	-	0.08	0.04	-	0.50	-	1 225
2007	-	0.01	0.19	0.35	-	-	0.03	0.05	-	0.36	-	2 212
2008	-	0.02	0.13	0.26	-	-	0.01	0.02	-	0.55	-	1 523
2009	-	0.06	0.14	0.07	-	-	0.01	0.01	-	0.71	-	1 631
2010	-	0.06	0.15	0.18	-	-	0.02	0.05	-	0.54	-	1 180
2011	-	0.01	0.20	0.24	-	-	0.02	0.03	0.01	0.49	-	929
2012	-	0.06	0.11	0.11	-	-	0.05	0.01	-	0.66	-	992
2013	-	0.06	0.09	0.13	-	-	0.04	0.02	-	0.66	0.01	1 057
2014	-	0.03	0.14	0.06	-	-	0.01	0.04	-	0.72	-	1 510
Total	-	0.05	0.18	0.22	-	-	0.04	0.15	-	0.36	-	36 778

Table C10: Proportion of white warehou catch reported from the WCSI area, by month, statistical area, method, and target species for 1990 to 2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	-	-	-	-	-	-	-	-	0.19	0.13	0.59	0.09	19
1991	-	-	-	-	-	-	-	-	0.02	0.91	0.04	0.03	65
1992	0.01	0.03	-	-	-	-	-	-	0.06	0.75	0.04	0.12	38
1993	-	0.02	-	-	-	-	0.01	-	0.27	0.17	0.24	0.29	96
1994	-	-	-	-	-	-	-	-	0.32	0.35	0.19	0.13	57
1995	-	-	-	-	-	-	-	-	0.14	0.54	0.15	0.17	68
1996	0.01	-	-	-	-	-	-	0.03	0.23	0.31	0.26	0.16	56
1997	-	-	-	-	-	-	-	0.08	0.05	0.55	0.24	0.08	53
1998	0.03	-	-	-	-	-	-	-	0.12	0.19	0.49	0.17	99
1999	0.02	0.02	-	-	0.02	-	-	0.11	0.11	0.62	0.04	0.05	65
2000	0.01	-	-	-	-	-	-	-	0.67	0.15	0.14	0.03	88
2001	0.02	-	-	-	-	-	-	0.06	0.39	0.23	0.05	0.24	88
2002	-	-	-	-	-	-	-	0.01	0.41	0.30	0.18	0.11	91
2003	0.01	-	-	-	-	-	-	0.12	0.36	0.20	0.10	0.22	134
2004	0.03	-	-	-	-	-	-	0.04	0.32	0.16	0.27	0.17	143
2005	0.03	-	-	-	-	0.01	-	0.01	0.24	0.12	0.16	0.44	123
2006	0.05	-	-	-	-	-	-	-	0.28	0.41	0.22	0.05	106
2007	-	-	-	-	-	-	-	0.04	0.40	0.12	0.17	0.26	112
2008	0.04	-	-	-	-	-	-	0.11	0.23	0.17	0.11	0.34	102
2009	-	-	-	-	-	-	-	0.28	0.10	0.29	0.17	0.16	114
2010	0.01	-	-	-	-	-	-	-	0.14	0.24	0.22	0.38	53
2011	-	-	-	-	-	0.01	-	-	0.22	0.30	0.20	0.27	50
2012	-	-	-	-	-	-	-	-	0.10	0.24	0.25	0.41	62
2013	-	-	-	-	-	-	-	0.02	0.10	0.20	0.40	0.28	132
2014	-	-	-	-	-	-	0.01	0.03	0.15	0.25	0.41	0.15	106
Total	0.01	-	-	-	-	-	-	0.05	0.24	0.28	0.21	0.20	2 120

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	033	034	035	Other	Total
1990	-	0.78	0.21	-	19
1991	0.03	0.90	0.07	-	65
1992	0.05	0.83	0.12	-	38
1993	0.02	0.80	0.15	0.02	96
1994	0.12	0.76	0.12	0.01	57
1995	-	0.90	0.09	0.01	68
1996	0.01	0.84	0.13	0.02	56
1997	0.08	0.85	0.07	-	53
1998	-	0.55	0.45	-	99
1999	0.03	0.82	0.13	0.01	65
2000	0.04	0.83	0.13	-	88
2001	0.02	0.84	0.14	-	88
2002	-	0.76	0.23	0.01	91
2003	0.02	0.77	0.20	0.01	134
2004	-	0.86	0.13	-	143
2005	0.04	0.80	0.15	-	123
2006	-	0.90	0.09	-	106
2007	0.07	0.89	0.04	-	112
2008	0.01	0.76	0.23	-	102
2009	-	0.90	0.10	-	114
2010	0.01	0.84	0.15	-	53
2011	0.01	0.61	0.38	-	50
2012	-	0.68	0.32	-	62
2013	0.19	0.70	0.11	-	132
2014	0.21	0.72	0.07	-	106
Total	0.04	0.80	0.16	-	2 120

Table C10: continued.

(c) Method. BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl.

Year	BT	MB	MW	Other	Total
1990	0.40	0.19	0.41	-	19
1991	0.93	0.03	0.04	-	65
1992	0.95	0.02	0.04	-	38
1993	0.63	0.26	0.11	-	96
1994	0.89	0.04	0.07	-	57
1995	0.85	0.05	0.10	-	68
1996	0.60	0.09	0.31	-	56
1997	0.51	0.08	0.41	-	53
1998	0.32	0.10	0.57	-	99
1999	0.81	0.04	0.15	-	65
2000	0.71	0.15	0.14	-	88
2001	0.85	0.03	0.12	-	88
2002	0.97	0.01	0.01	-	91
2003	0.98	0.01	0.01	-	134
2004	0.98	0.01	0.01	-	143
2005	0.99	0.01	-	-	123
2006	0.99	-	0.01	-	106
2007	0.95	0.03	0.02	-	112
2008	1	-	-	-	102
2009	0.99	-	-	-	114
2010	0.98	0.01	0.01	-	53
2011	0.98	0.01	0.01	-	50
2012	1	-	-	-	62
2013	1	-	-	-	132
2014	0.99	0.01	0.01	-	106
Total	0.88	0.04	0.08	-	2 120

(d) Target species. (Target species codes are defined in Table C12).

Year	BAR	HAK	HOK	JMA	LDO	LIN	ORH	SKI	SWA	WWA	Other	Total
1990	-	-	0.90	0.06	-	-	-	-	-	0.03	0.01	19
1991	0.03	-	0.96	-	-	-	-	-	-	-	-	65
1992	0.05	0.08	0.82	0.01	-	0.02	-	-	-	-	-	38
1993	0.01	0.22	0.67	0.02	-	-	-	0.03	-	0.04	0.01	96
1994	0.03	0.20	0.75	-	-	-	-	-	0.01	-	0.01	57
1995	0.01	0.07	0.83	-	-	-	-	-	0.08	-	-	68
1996	-	0.13	0.86	-	-	-	-	-	-	-	-	56
1997	-	0.24	0.75	-	-	-	-	-	-	-	-	53
1998	-	0.01	0.94	-	-	-	-	0.02	-	-	0.02	99
1999	-	0.04	0.92	-	-	-	0.02	-	-	-	0.01	65
2000	-	0.13	0.86	-	-	-	-	-	-	-	-	88
2001	-	0.13	0.86	-	-	-	0.01	-	-	-	-	88
2002	-	0.17	0.82	-	-	-	0.01	-	-	-	-	91
2003	-	0.45	0.55	-	-	-	-	-	-	-	-	134
2004	-	0.39	0.60	-	-	-	-	-	-	-	-	143
2005	-	0.79	0.19	-	0.01	-	0.01	-	-	-	-	123
2006	-	0.56	0.43	-	-	-	-	-	-	-	0.01	106
2007	-	0.80	0.15	-	0.02	-	0.02	-	-	-	-	112
2008	-	0.86	0.12	-	-	-	-	-	0.01	-	-	102
2009	-	0.96	0.03	-	-	-	-	-	-	-	-	114
2010	-	0.82	0.17	-	-	-	-	-	-	-	0.01	53
2011	0.03	0.83	0.13	-	-	0.01	-	-	-	-	-	50
2012	-	0.72	0.25	-	0.01	-	-	-	0.01	-	-	62
2013	-	0.82	0.07	-	-	-	-	-	0.02	0.09	-	132
2014	-	0.71	0.20	-	-	0.02	-	-	-	0.06	-	106
Total	0.01	0.46	0.50	-	-	-	-	-	0.01	0.01	-	2 120

Table C11: Proportion of white warehou catch reported from the ECNI area, by month, statistical area, method, and target species for 1990 to 2014.

(a) Month

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	-	0.01	0.01	0.31	0.09	0.27	0.14	0.11	0.03	0.01	0.02	0.01	9
1991	0.13	0.02	0.01	0.02	0.12	0.33	0.14	0.08	0.04	0.01	0.01	0.10	11
1992	0.24	0.06	0.03	0.04	0.03	0.06	0.08	0.13	0.29	0.01	0.03	-	23
1993	0.08	0.11	0.14	0.28	0.14	0.02	0.11	0.09	-	0.01	0.01	-	12
1994	-	0.05	0.02	0.02	-	0.02	0.27	0.44	0.16	-	-	0.01	29
1995	0.02	0.15	0.08	0.02	0.02	0.03	0.33	0.35	-	-	-	-	42
1996	0.11	0.04	0.12	0.13	0.34	0.14	0.03	0.02	0.01	-	-	0.05	65
1997	0.19	0.33	0.08	0.07	0.08	0.05	0.05	0.07	0.06	-	-	0.03	85
1998	0.49	0.09	0.04	0.04	0.02	0.12	0.11	0.02	0.06	0.01	-	0.01	32
1999	0.08	0.14	0.03	0.12	0.10	0.17	0.22	0.08	0.03	-	-	0.03	34
2000	0.06	0.19	0.08	0.10	0.19	0.07	0.06	-	0.12	-	-	0.11	42
2001	0.11	0.10	0.04	0.15	0.20	0.11	0.05	0.06	0.05	-	-	0.11	20
2002	0.02	0.09	0.05	0.07	0.25	0.31	0.09	0.01	0.07	-	0.02	0.01	7
2003	0.08	0.07	0.05	0.17	0.09	0.25	0.19	0.07	0.04	-	-	-	19
2004	0.03	0.13	0.04	0.04	0.21	0.31	0.13	0.09	-	-	-	0.01	47
2005	0.04	0.10	0.14	0.13	0.21	0.16	0.17	0.04	0.01	0.01	-	-	24
2006	0.13	0.07	0.07	0.12	0.10	0.44	0.04	0.01	0.01	-	0.01	0.01	33
2007	0.03	0.18	0.02	0.08	0.07	0.16	0.13	0.24	0.08	-	-	-	10
2008	0.03	0.03	0.01	0.06	0.18	0.33	0.28	0.05	0.03	0.01	-	-	39
2009	0.08	0.07	0.10	0.17	0.10	0.27	0.06	0.08	0.02	0.03	0.01	-	21
2010	0.04	0.14	0.03	0.07	0.21	0.12	0.12	0.17	0.09	-	-	-	6
2011	0.01	0.12	0.03	0.31	0.21	0.11	0.17	-	0.02	-	0.01	-	11
2012	0.02	0.04	0.07	0.25	0.19	0.35	0.02	0.04	-	-	-	0.01	4
2013	0.06	0.18	0.10	0.15	0.09	0.05	0.25	0.10	-	-	-	-	6
2014	0.22	0.08	0.03	0.06	0.06	0.11	0.31	0.11	-	-	0.01	0.01	8
Total	0.11	0.13	0.06	0.10	0.14	0.16	0.13	0.10	0.05	-	-	0.03	639

(b) Statistical area (Statistical areas are shown in Figure 1).

Year	005	009	010	011	012	013	014	015	016	017	204	205	Other	Total
1990	-	-	0.02	-	-	0.03	0.07	0.44	0.41	0.01	-	-	0.02	9
1991	-	-	-	-	-	0.01	0.23	0.59	0.14	0.01	0.02	-	-	11
1992	-	0.01	0.04	-	-	0.04	0.20	0.43	0.25	0.01	0.01	-	0.02	23
1993	-	-	0.03	-	-	0.04	0.17	0.44	0.27	0.01	0.02	-	0.03	12
1994	-	-	-	-	-	-	0.06	0.63	0.20	0.09	0.01	-	-	29
1995	-	-	-	-	-	-	0.02	0.70	0.21	0.03	0.03	-	-	42
1996	-	-	-	0.01	0.01	-	0.03	0.52	0.43	-	-	-	-	65
1997	-	-	-	-	-	-	0.41	0.13	0.41	0.03	-	0.01	-	85
1998	0.03	-	-	-	-	-	0.56	0.17	0.21	0.01	-	-	-	32
1999	-	-	-	-	-	-	0.18	0.35	0.45	-	-	0.01	-	34
2000	-	-	-	-	-	-	0.06	0.11	0.77	0.05	-	-	-	42
2001	-	-	-	-	-	0.01	0.26	0.29	0.44	-	-	0.01	-	20
2002	-	-	-	-	-	0.01	0.33	0.40	0.25	-	0.01	-	-	7
2003	-	-	-	-	-	0.01	0.11	0.32	0.56	-	-	-	-	19
2004	-	-	-	-	-	-	0.07	0.15	0.76	0.01	-	-	-	47
2005	-	0.01	-	-	-	-	0.07	0.43	0.49	-	-	-	-	24
2006	-	-	-	-	-	0.03	0.03	0.24	0.68	0.01	-	-	-	33
2007	-	-	-	-	-	0.01	0.06	0.26	0.65	0.01	0.01	-	-	10
2008	-	0.01	-	-	-	0.01	0.02	0.42	0.51	-	-	0.02	-	39
2009	-	-	-	-	0.02	-	0.04	0.21	0.72	-	-	-	-	21
2010	-	0.01	0.03	0.01	0.13	0.01	0.05	0.20	0.47	0.01	0.01	-	0.07	6
2011	-	-	-	-	0.01	-	0.05	0.32	0.60	0.01	-	-	0.01	11
2012	-	-	-	-	-	-	0.09	0.36	0.44	0.06	0.03	-	0.01	4
2013	-	-	-	0.01	0.02	0.03	0.06	0.19	0.60	0.06	0.03	-	-	6
2014	-	-	-	-	0.02	0.01	0.04	0.31	0.60	0.01	-	-	-	8
Total	-	-	-	-	-	0.01	0.15	0.34	0.47	0.02	0.01	-	-	639

Table C11: continued.

(c) Method. BT: bottom trawl; MB: midwater trawl within 5 m of the seabed; MW: midwater trawl; SN is setnet.

Year	BT	MB	MW	SN	Other	Total
1990	0.35	0.21	-	0.20	0.24	9
1991	0.27	0.06	-	0.67	-	11
1992	0.52	0.16	0.04	0.09	0.18	23
1993	0.49	0.21	0.01	0.27	0.01	12
1994	0.81	0.02	0.12	0.05	-	29
1995	0.89	0.01	0.09	0.01	-	42
1996	0.77	0.20	0.03	-	-	65
1997	0.85	0.04	0.11	-	-	85
1998	0.81	0.07	0.13	-	-	32
1999	0.57	0.22	0.21	-	-	34
2000	0.51	0.24	0.25	-	-	42
2001	0.54	0.17	0.29	-	-	20
2002	0.62	0.21	0.16	-	-	7
2003	0.47	0.31	0.22	-	-	19
2004	0.26	0.45	0.28	-	-	47
2005	0.47	0.41	0.10	0.01	0.01	24
2006	0.30	0.62	0.08	-	-	33
2007	0.41	0.44	0.11	-	0.04	10
2008	0.34	0.45	0.16	0.03	0.01	39
2009	0.29	0.42	0.24	0.02	0.03	21
2010	0.50	0.30	0.17	0.01	0.02	6
2011	0.36	0.04	0.59	-	0.02	11
2012	0.39	0.23	0.34	-	0.04	4
2013	0.28	0.45	0.20	0.06	0.01	6
2014	0.49	0.35	0.14	-	0.02	8
Total	0.58	0.23	0.15	0.03	0.02	639

d) Target species. (Target species codes are defined in Table C12).

Year	BNS	BYX	CDL	HOK	ORH	SCI	SKI	TAR	WAR	WWA	Other	Total
1990	0.18	0.45	-	0.01	-	-	0.16	0.15	-	-	0.04	9
1991	0.29	0.01	-	0.03	0.01	0.03	0.01	0.01	0.13	0.29	0.20	11
1992	0.21	0.03	-	0.17	0.01	0.20	0.16	0.03	0.09	-	0.09	23
1993	0.05	0.11	0.01	0.12	0.08	0.09	0.18	0.17	0.10	0.01	0.07	12
1994	0.04	0.05	0.03	0.78	0.02	0.04	0.02	-	-	-	0.01	29
1995	0.01	0.08	-	0.79	0.08	0.01	-	-	-	-	0.03	42
1996	-	0.05	0.01	0.84	0.06	0.03	0.01	-	-	-	-	65
1997	-	-	0.01	0.92	0.01	0.03	0.02	-	-	-	-	85
1998	-	0.08	-	0.82	-	0.03	0.03	-	-	-	0.04	32
1999	-	0.01	0.02	0.80	-	0.06	-	0.01	-	0.08	-	34
2000	-	0.01	-	0.96	-	0.01	-	-	0.01	-	-	42
2001	0.01	-	0.02	0.90	-	0.05	-	-	-	-	0.01	20
2002	-	0.03	0.06	0.56	0.01	0.33	-	-	-	-	0.01	7
2003	-	0.04	0.03	0.82	-	0.12	-	-	-	-	-	19
2004	-	0.06	-	0.91	0.01	0.01	-	-	-	-	-	47
2005	0.01	0.07	0.01	0.78	0.08	0.04	-	-	-	-	0.01	24
2006	0.03	0.10	0.01	0.81	0.02	-	-	0.01	-	-	0.02	33
2007	0.03	0.04	0.02	0.86	0.01	0.01	-	0.02	-	-	0.01	10
2008	0.02	0.28	-	0.67	-	-	-	-	0.01	0.01	0.01	39
2009	0.04	0.09	-	0.83	0.03	-	-	-	-	-	-	21
2010	0.04	0.18	0.05	0.64	0.05	0.01	-	-	-	-	0.02	6
2011	0.01	0.06	0.01	0.89	-	-	-	-	-	-	0.02	11
2012	0.03	0.15	0.01	0.76	0.02	0.02	-	-	-	-	0.02	4
2013	0.05	0.08	0.06	0.75	0.03	-	-	-	-	-	0.03	6
2014	0.02	0.08	0.04	0.84	0.01	-	0.01	-	-	-	0.01	8
Total	0.03	0.07	0.01	0.77	0.02	0.04	0.02	0.01	0.01	0.01	0.02	639

Table C12: Species codes used in the report.

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
BNS	Bluenose	*Hyperoglyphe antarctica*
BYX	Alfonsino	*Beryx splendens, B. decadactylus*
CDL	Cardinalfish	*Epigonus lenimen & E. robustus*
HAK	Hake	*Merluccius australis*
HOK	Hoki	*Macruronus novaezelandiae*
JMA	Jack mackerels	*Trachurus declivis, T. novaezelandiae, T. symmetricus murphyi*
LIN	Ling	*Genypterus blacodes*
LDO	Lookdown dory	*Cyttus traversi*
ORH	Orange roughy	*Hoplostethus atlanticus*
RCO	Red cod	*Pseudophycis bachus*
SBW	Southern blue whiting	*Micromesistius australis*
SCI	Scampi	*Metanephrops challengeri*
SKI	Gemfish	*Rexea solandri*
SPE	Sea perch	*Helicolenus percoides*
SQU	Arrow squid	*Nototodarus gouldi, N. sloanni*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
WAR	Blue warehou	*Seriolella brama*
WWA	White warehou	*Seriolella caerulea*

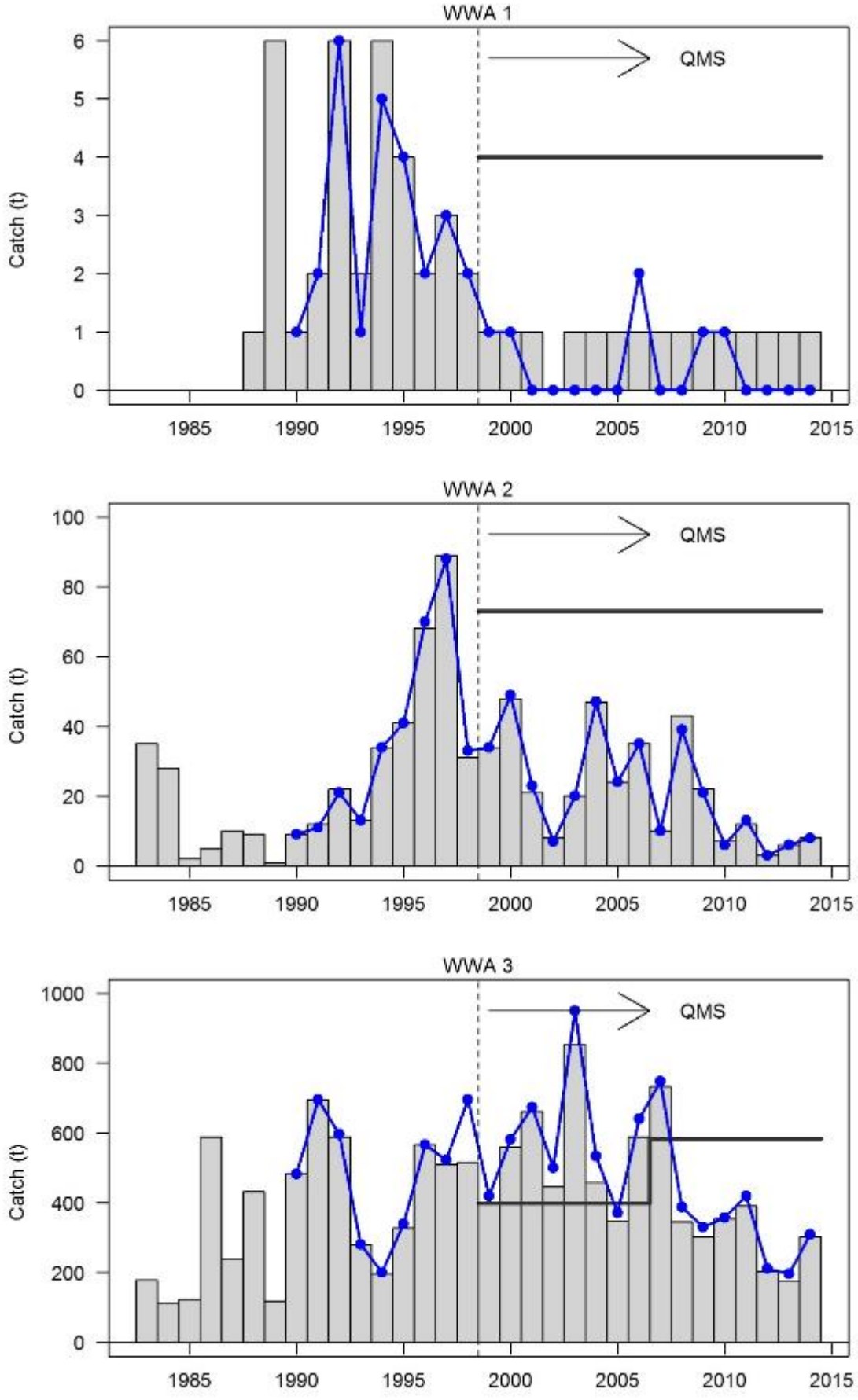
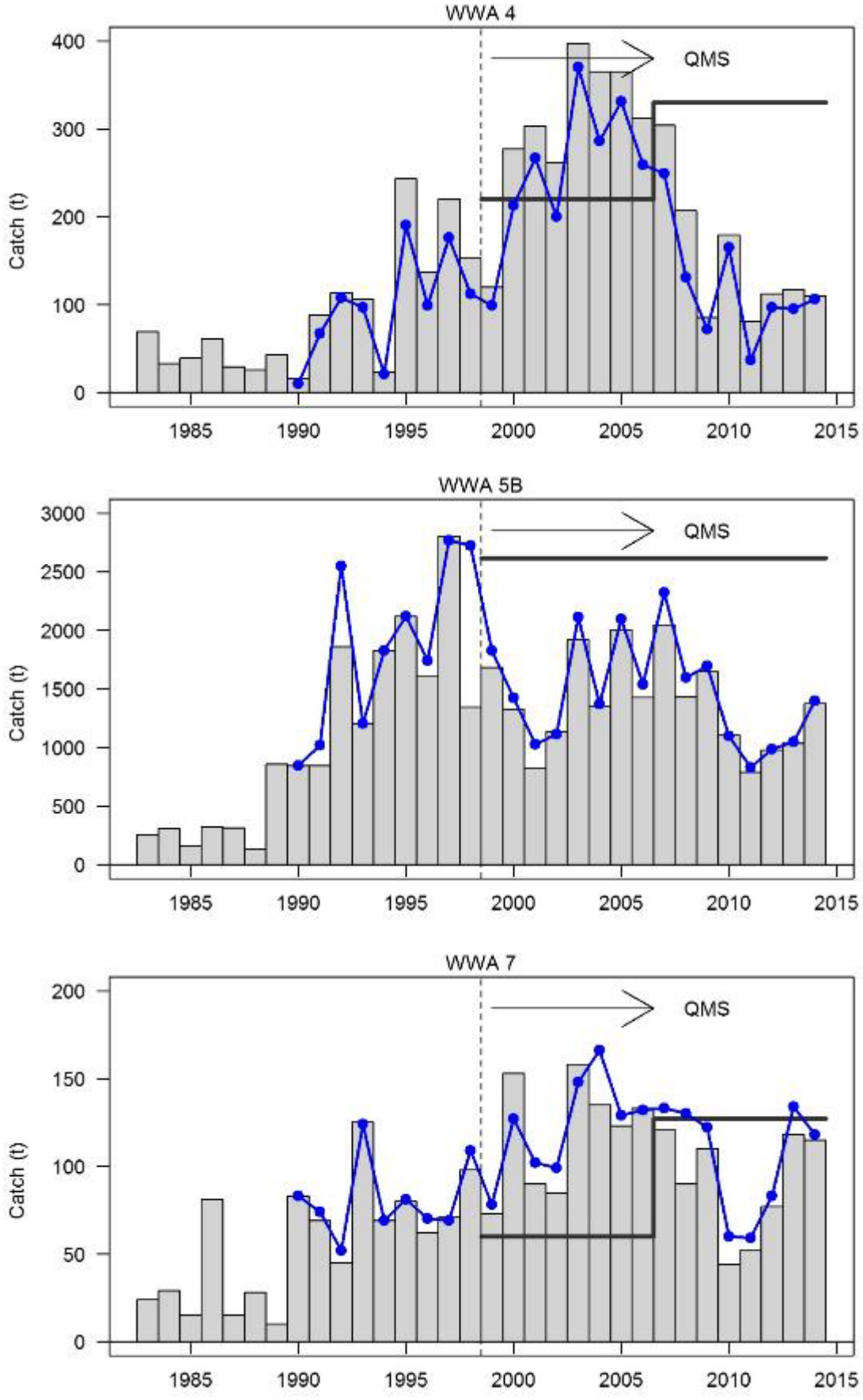


Figure C1: The QMR/MHR landings (grey bars), ungroomed catch effort landings (blue line), and TACC (black line) in tonnes for WWA stocks for 1990 to 2014.



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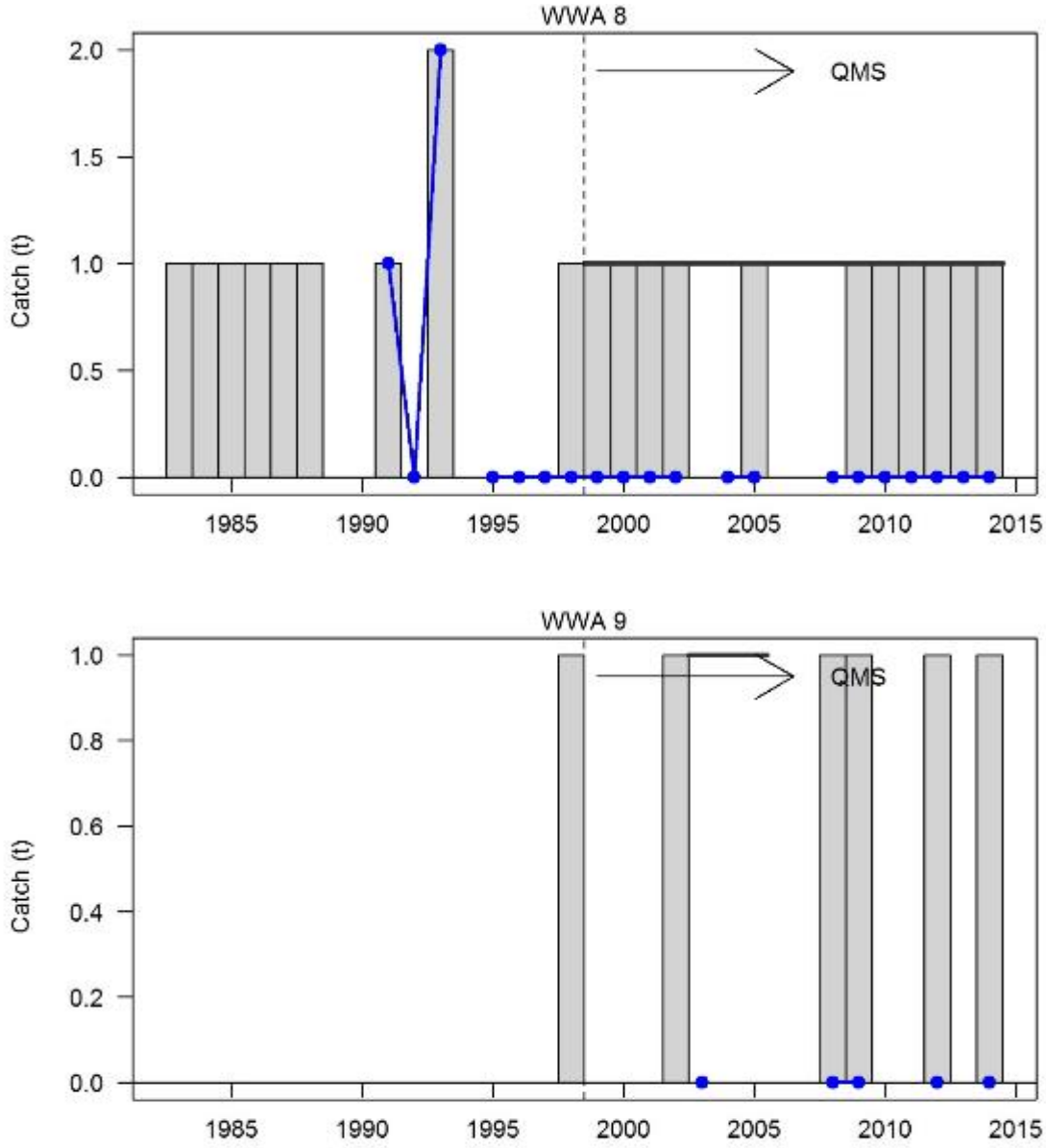

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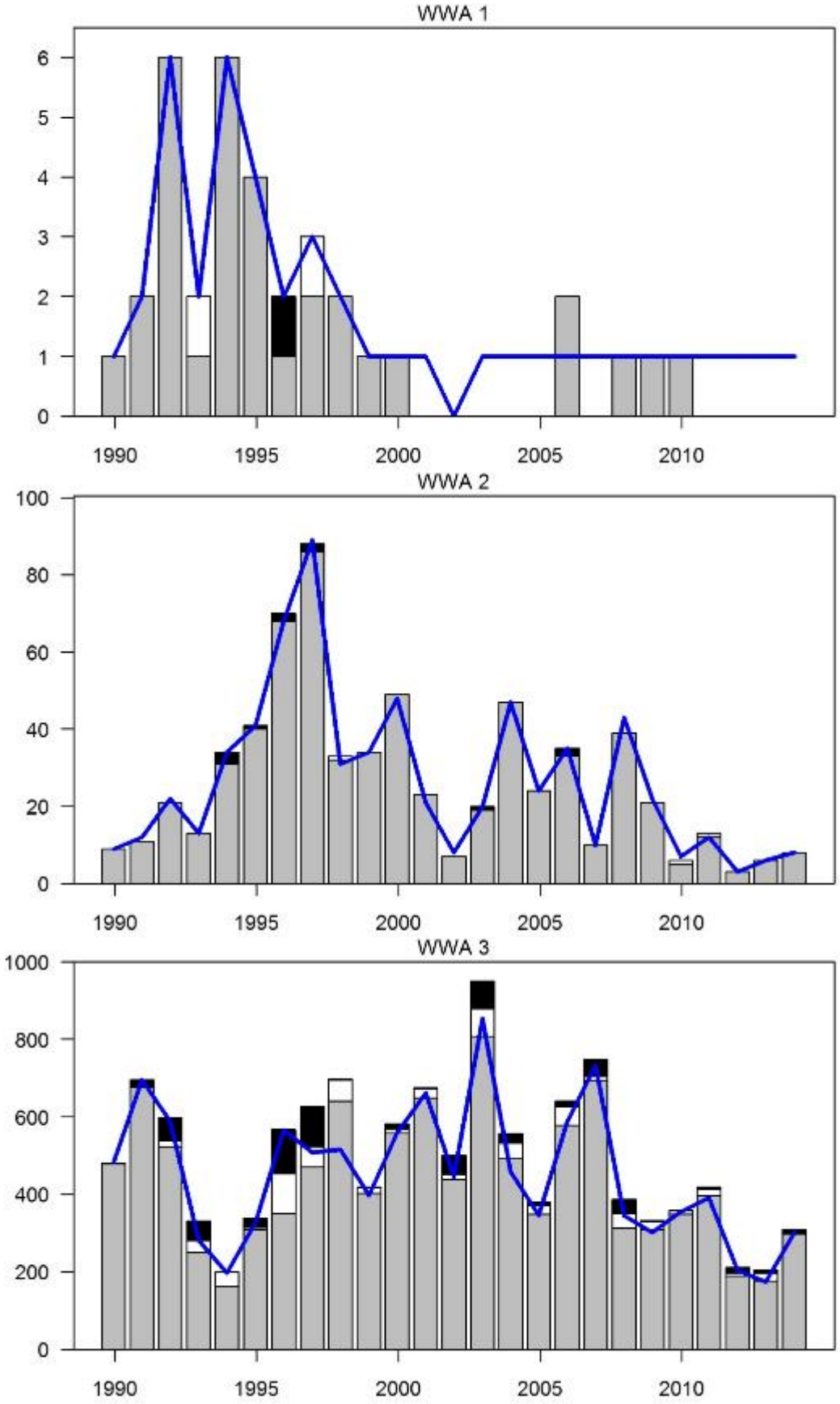
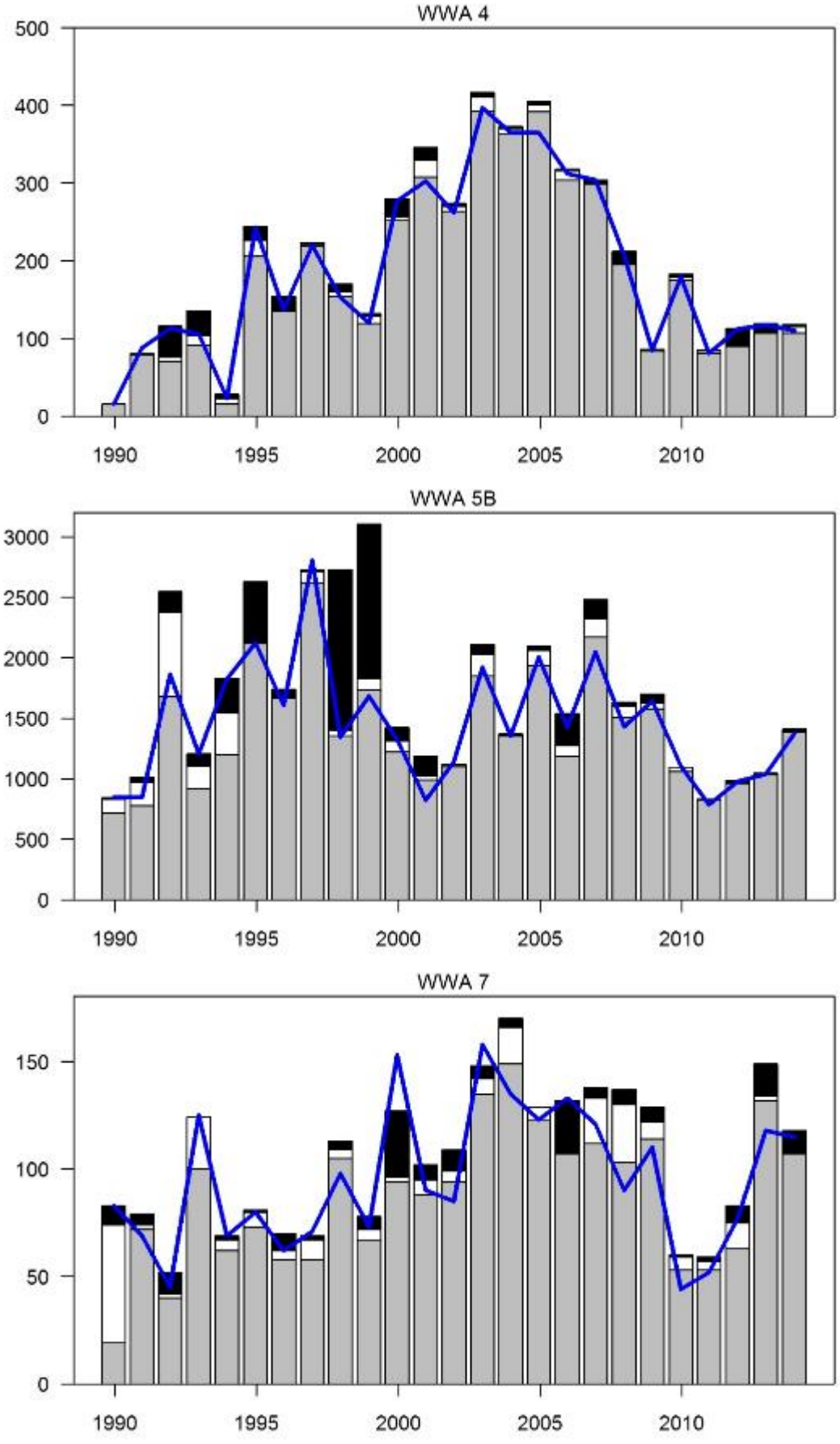


Figure C2: The retained landings (grey bars), interim landings (white bars), and landings dropped during data grooming (black bars), and MHR landings (blue line) in tonnes for WWA stocks from the 1990 to 2014 fishing year.



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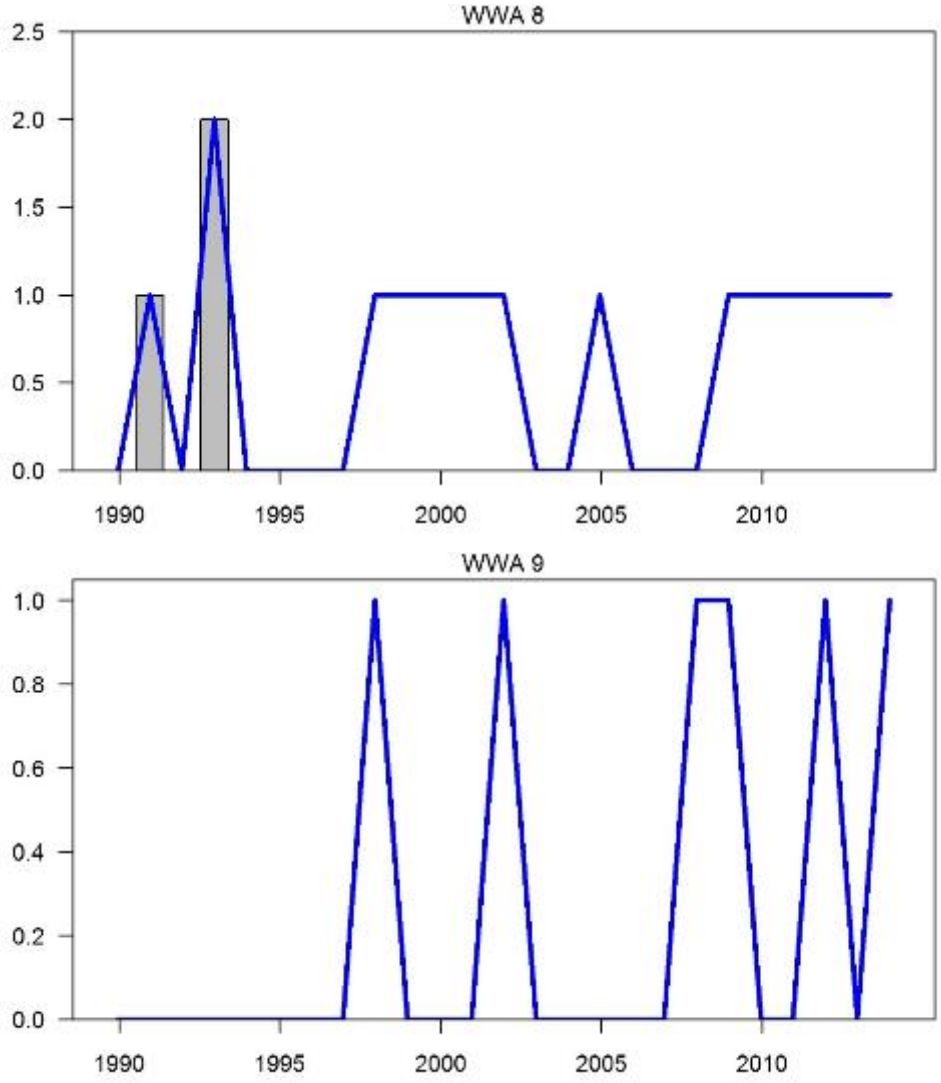

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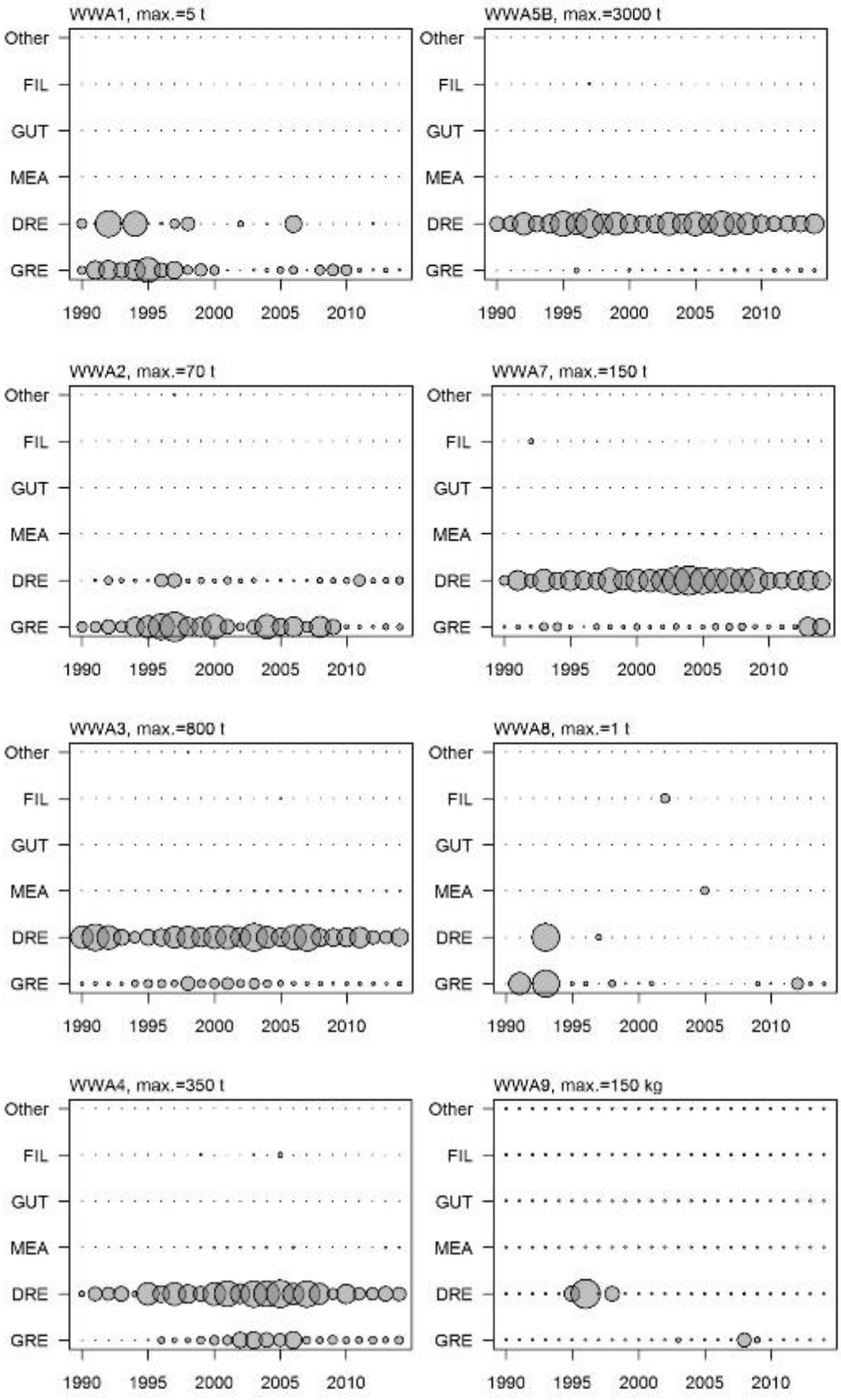


Figure C3: Retained landings (greenweight in tonnes) by processed state for WWA stocks for 1990 to 2014 in the groomed and unmerged dataset. GRE, Green; DRE, dressed or headed, gutted, and tailed; GUT, gutted; FIL, filleted or skin off filleted, and MEA, mealed.

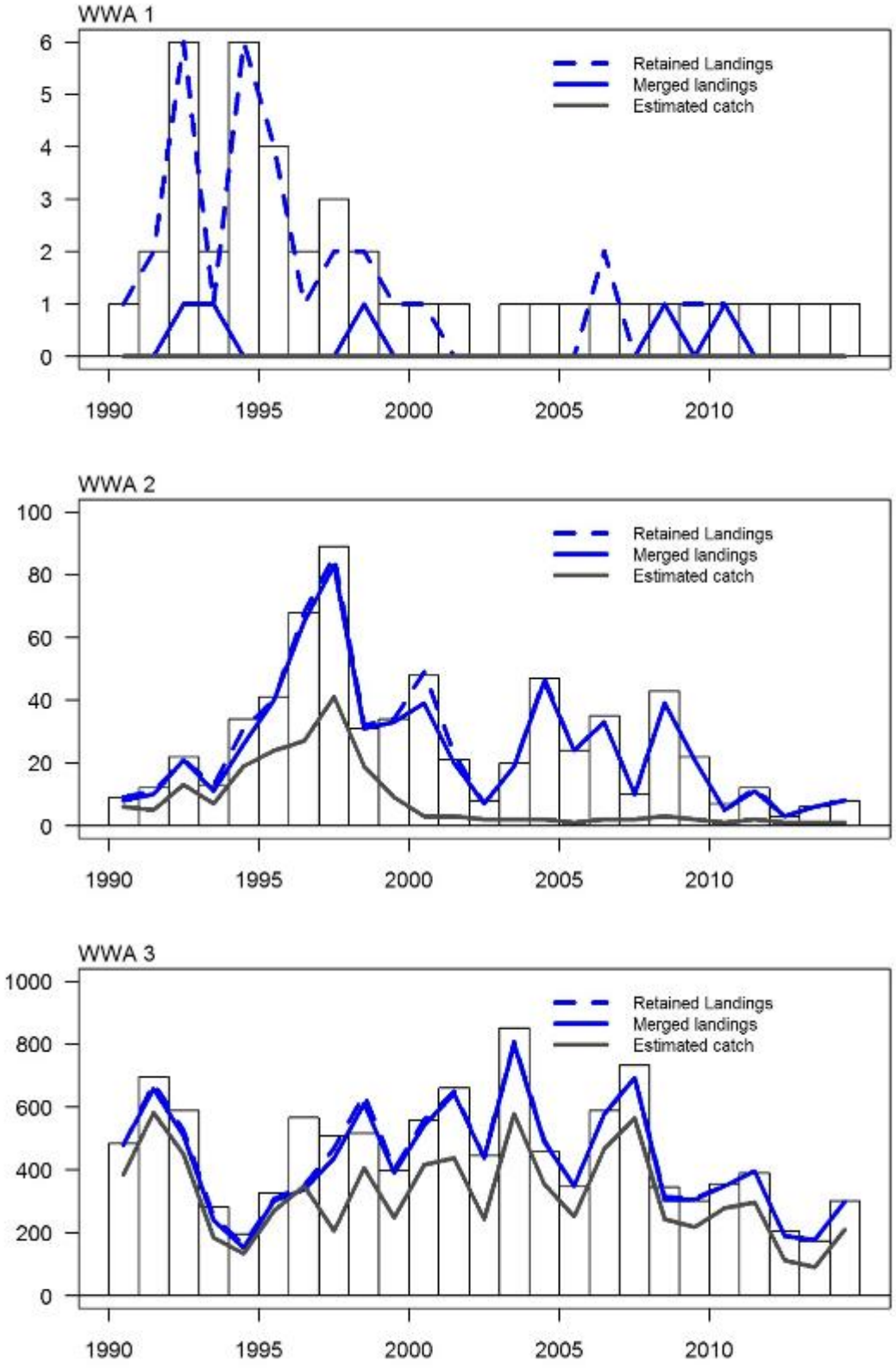


Figure C4: The QMR/MHR landings (white bars), retained landings in the groomed and unmerged dataset (blue dashed line), retained landings in groomed and merged dataset (blue solid line), and estimated catch in the groomed and merged dataset (grey solid line), using the centroid method, for WWA stocks from the 1990 to 2014 fishing year. All landings and catch data are in tonnes.

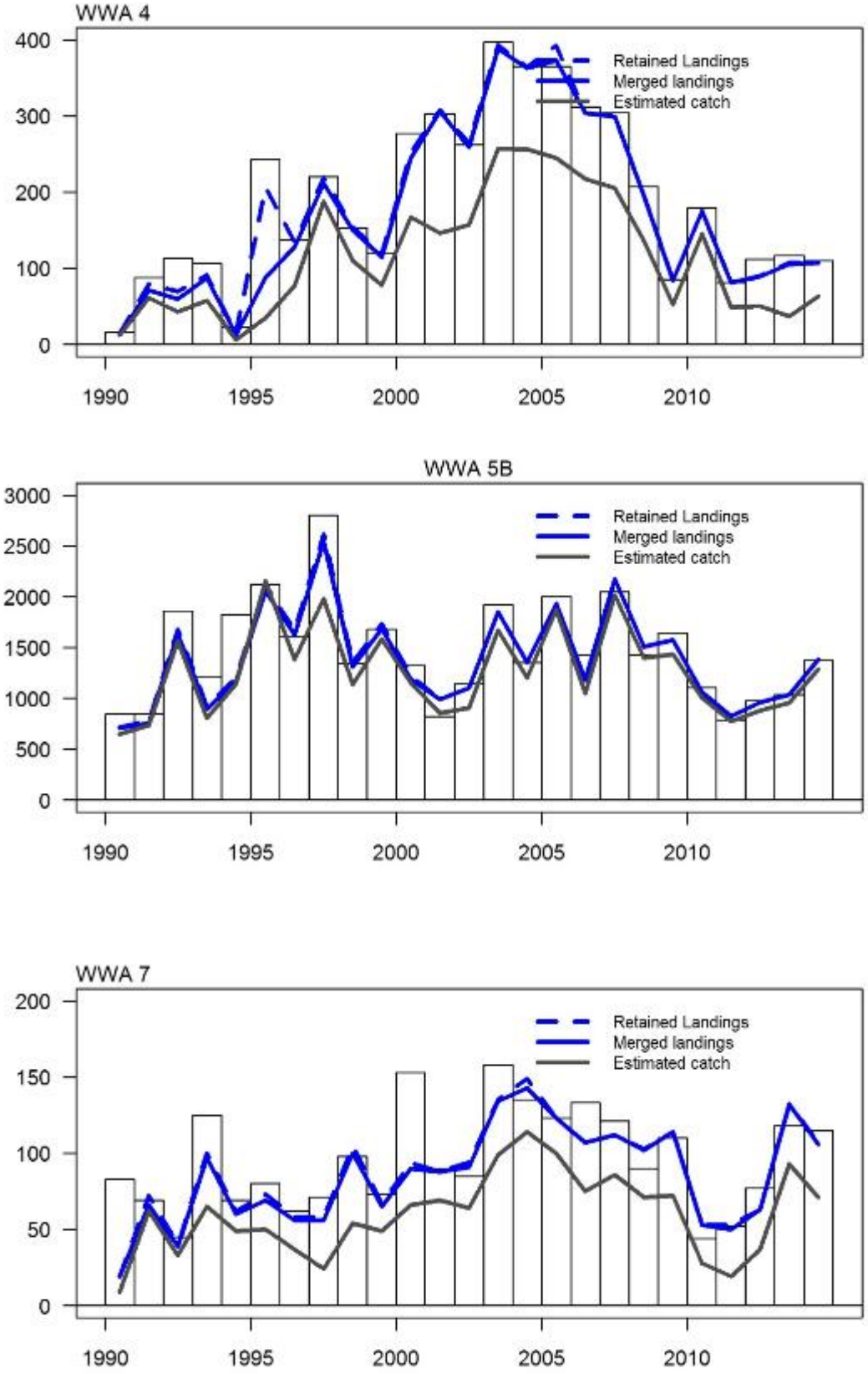


Figure C4: ctd.

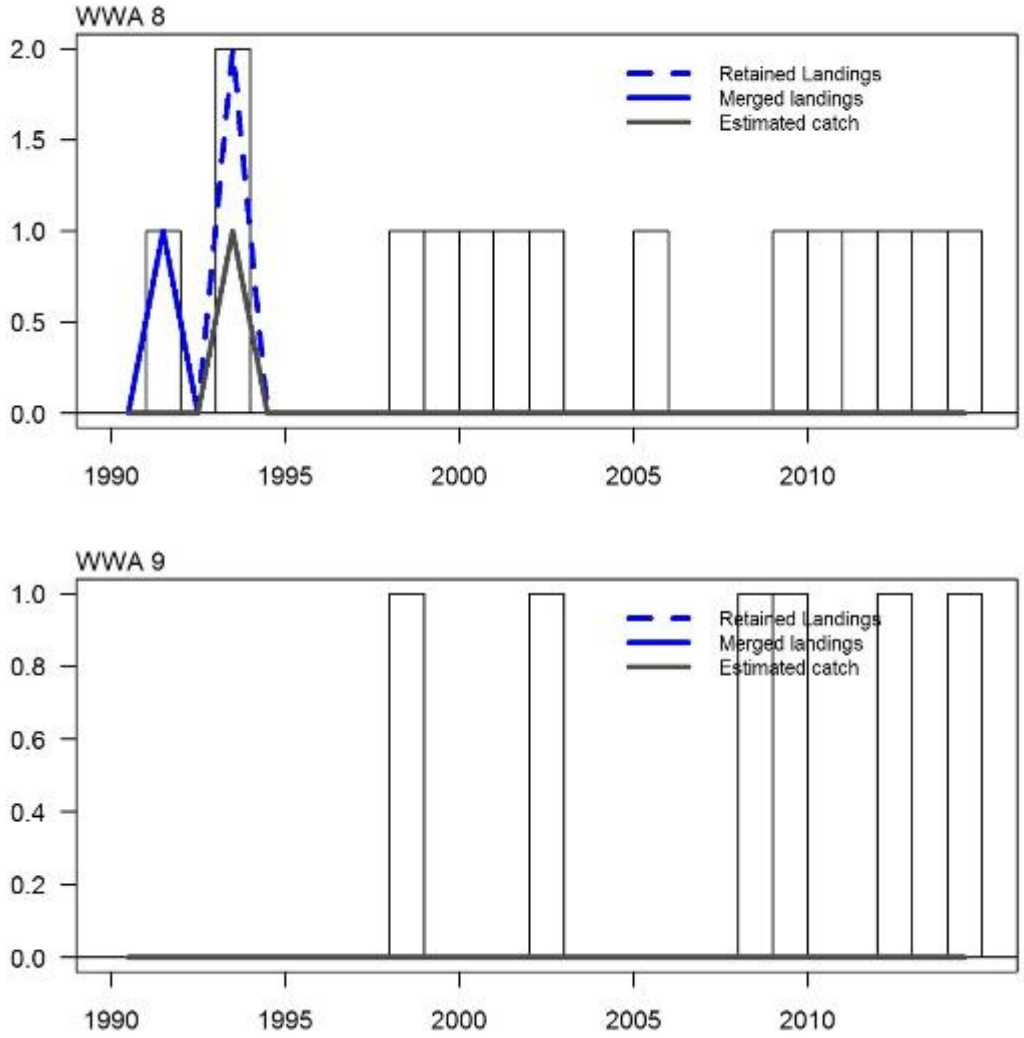


Figure C4: ctd.

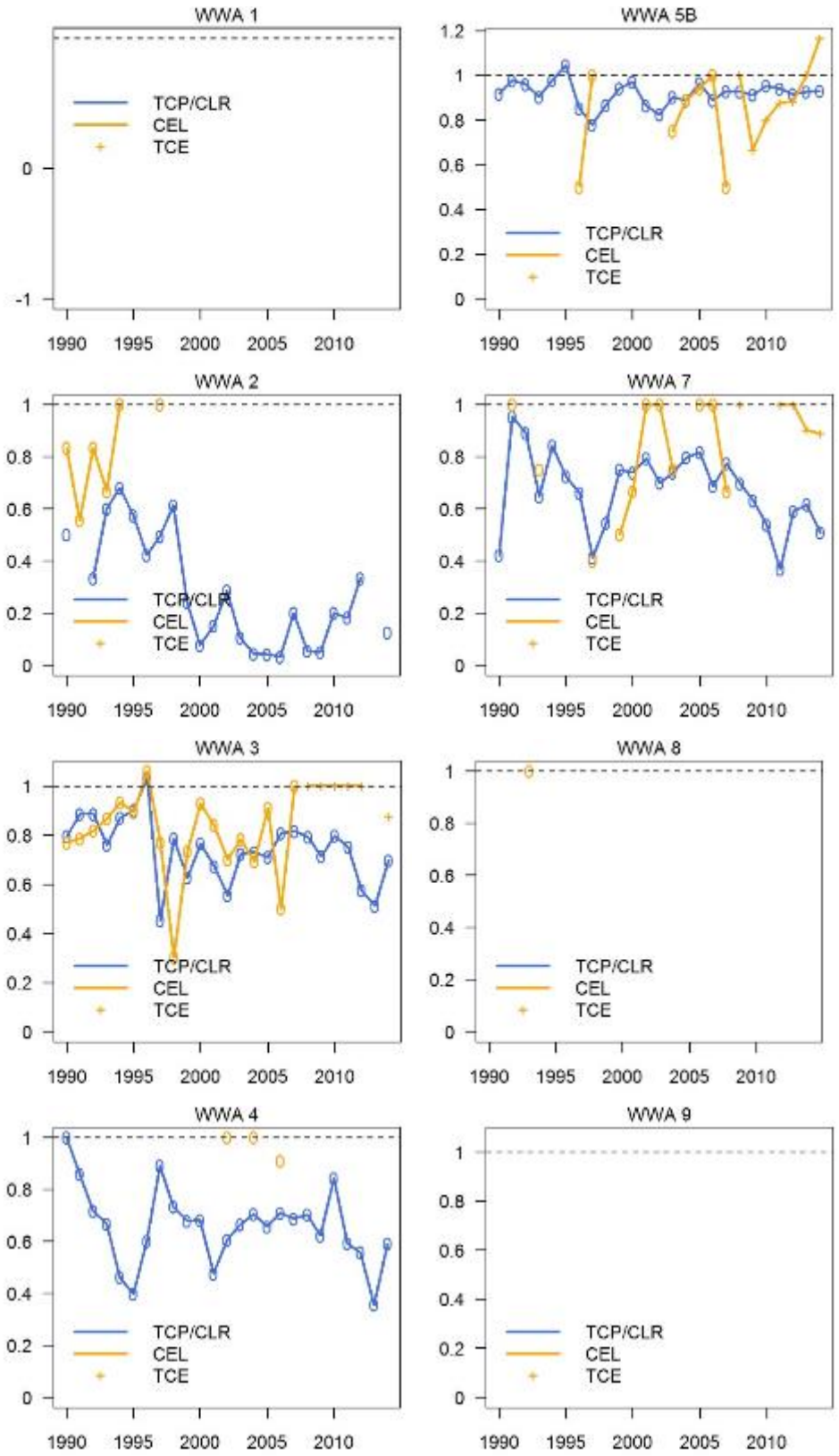


Figure C5: The reporting rate, defined as the ratio of the estimated catch as a proportion of retained landings in the groomed and merged dataset, for WWA stocks for 1990 to 2014. The reporting rates for each stock were calculated by form type, where TCP is Trawl Catch Effort Processing Return; CLR is Catch Landing Return; CEL is Catch Effort Landing Return; and TCE is Trawl Catch Effort Return.

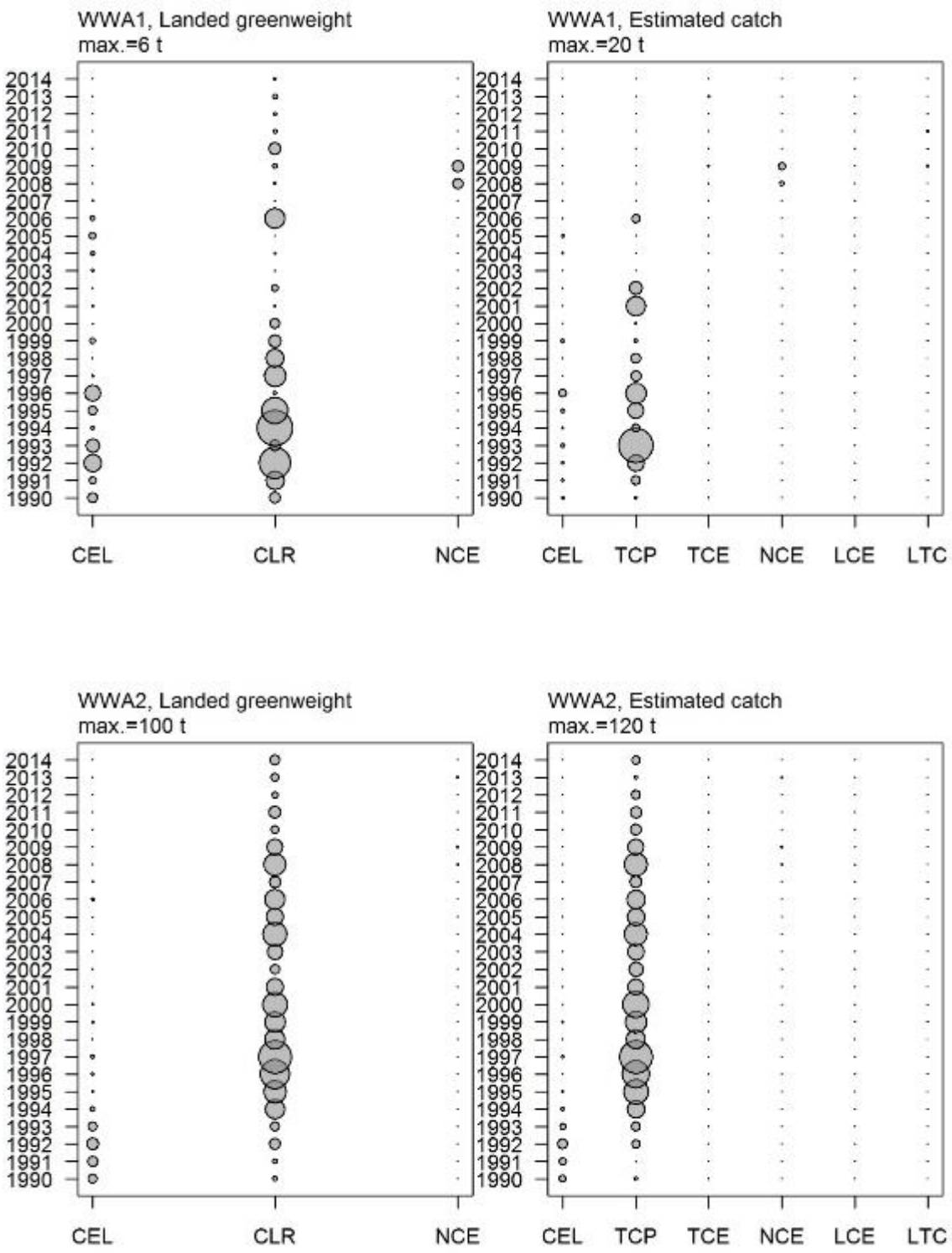


Figure C6: Proportion of landings by form type in the groomed and unmerged dataset, and proportion of estimated catches by form type in the groomed and merged dataset, for WWA stocks from 1990 to 2014, where CEL is Catch, Effort, Landing Return; CLR is Catch Landing Return; TCP is Trawl, Catch, Effort, and Processing Return; TCE is Trawl, Catch, Effort Return; NCE is Net Catch Effort Return; LCE is Line Catch Effort return; and LTC is Lining Trip Catch, Effort return. The area of the circle is proportional to the annual catches (only comparable within each panel).

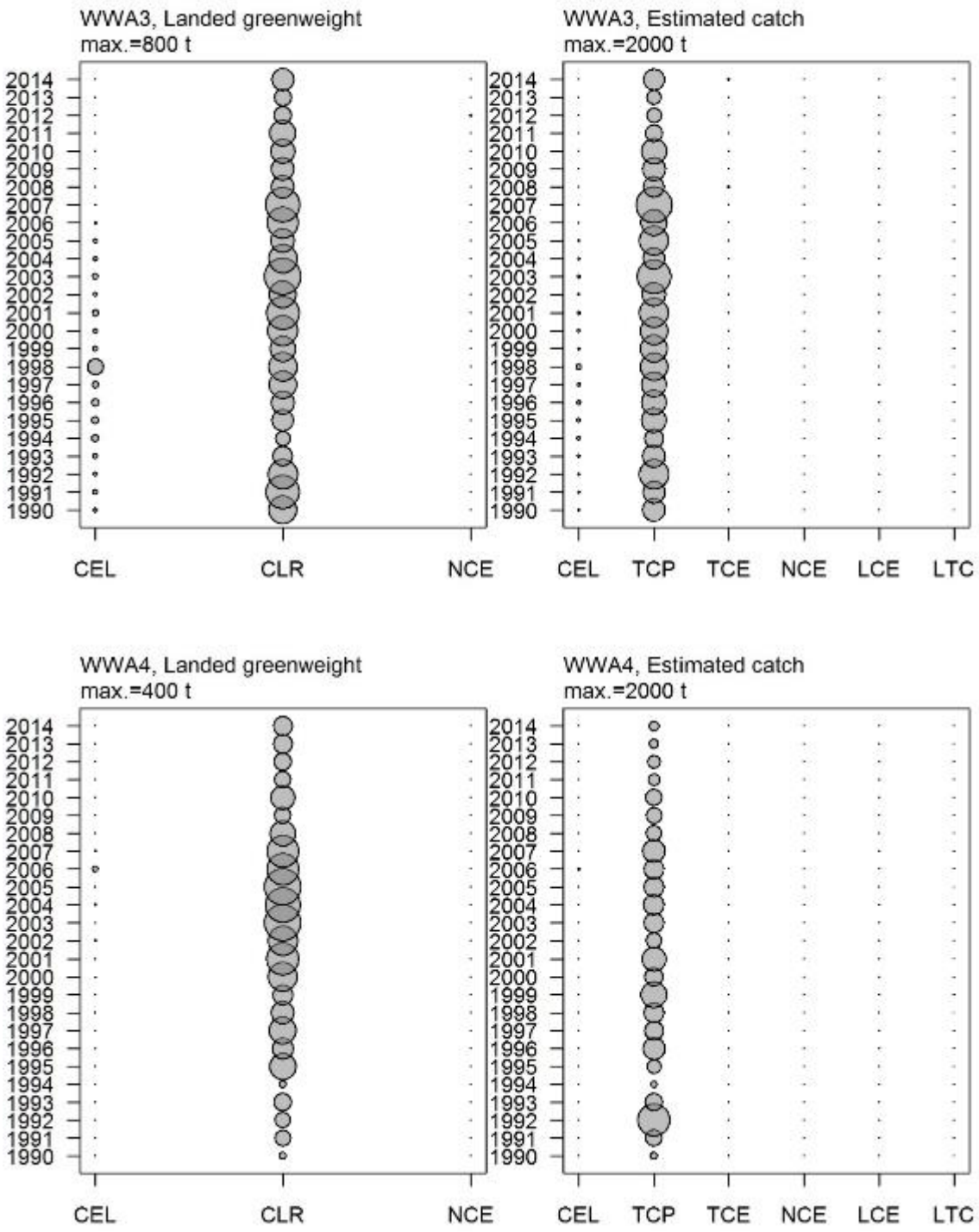


Figure C6: ctd.

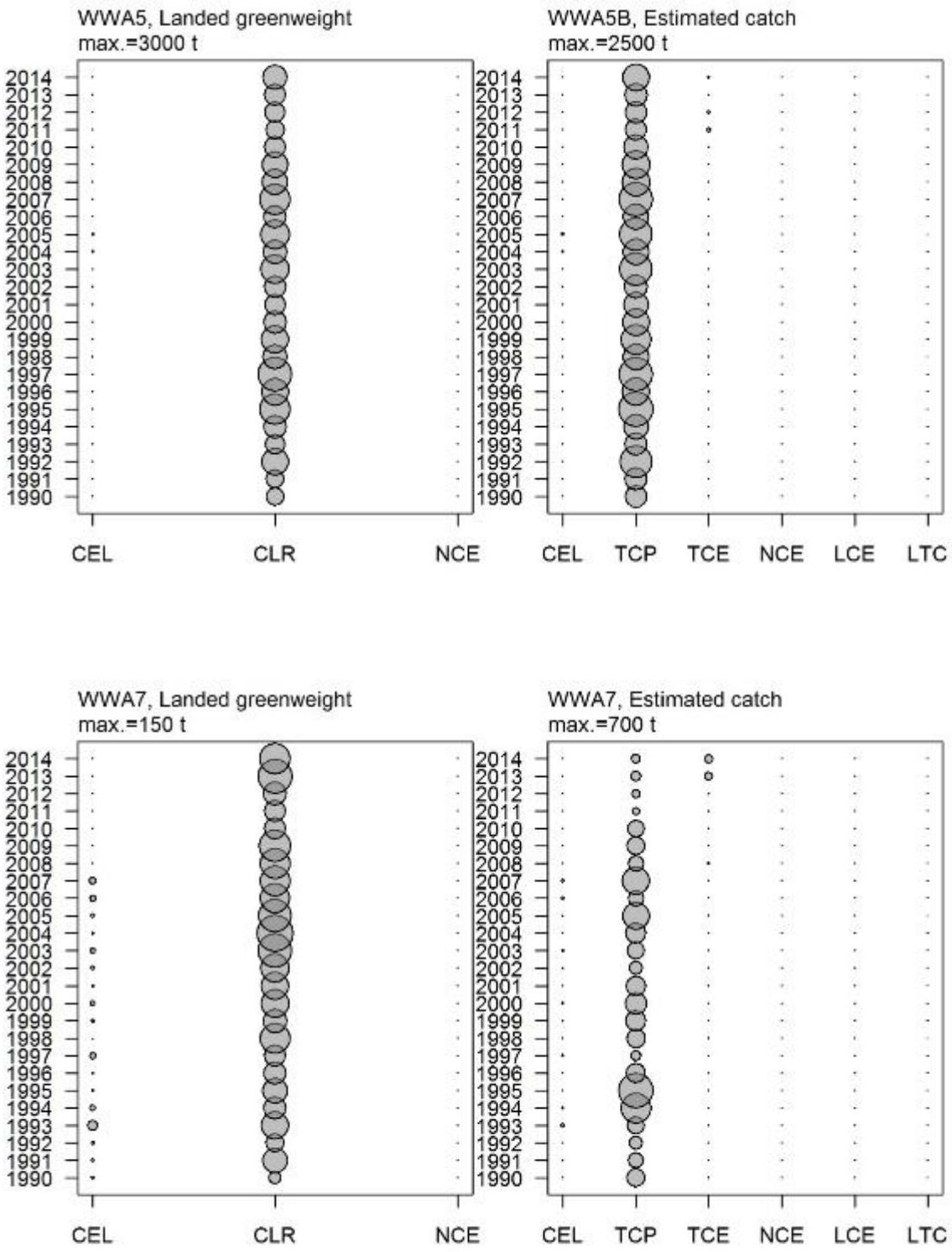


Figure C6: ctd.

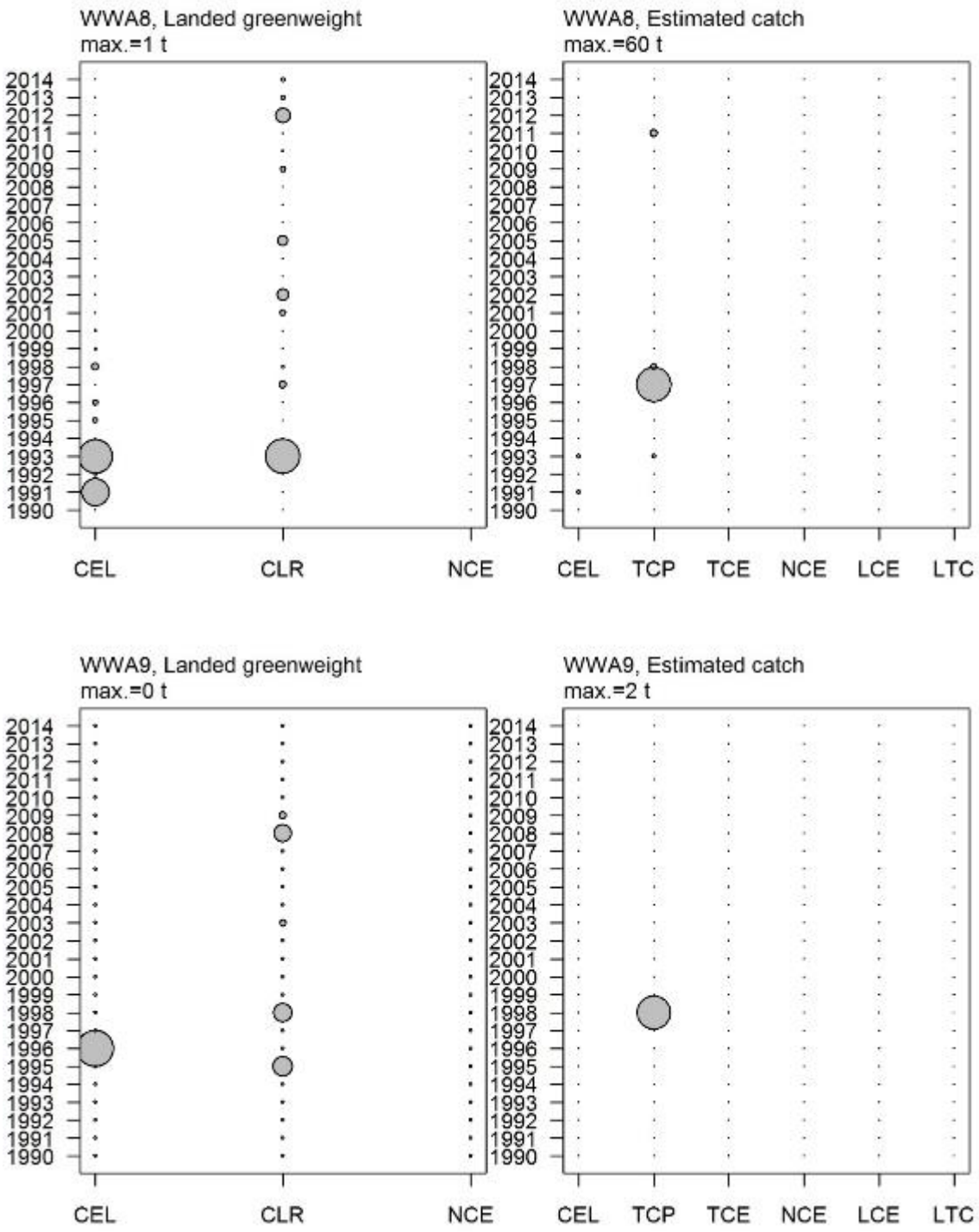


Figure C6: ctd.

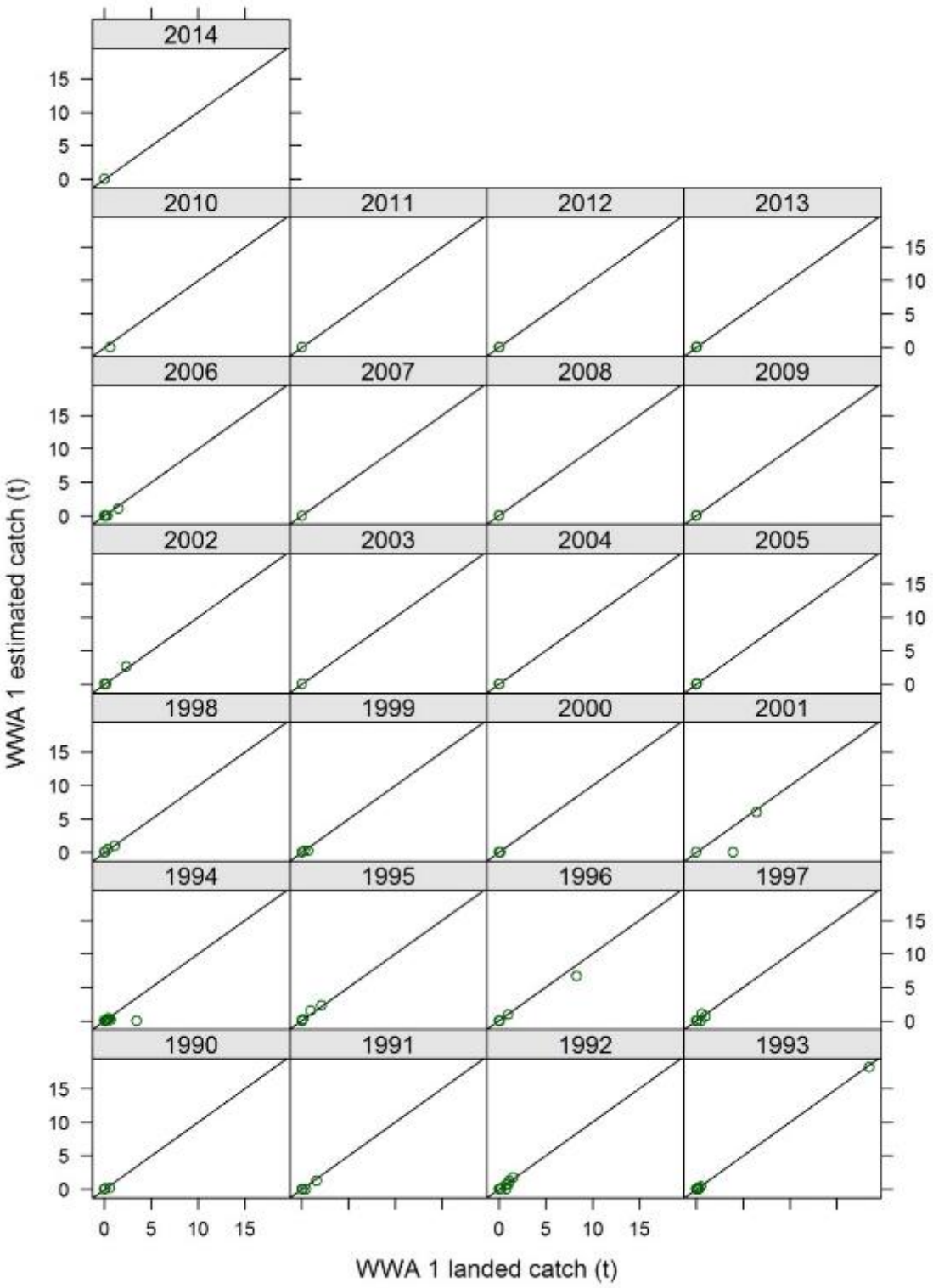
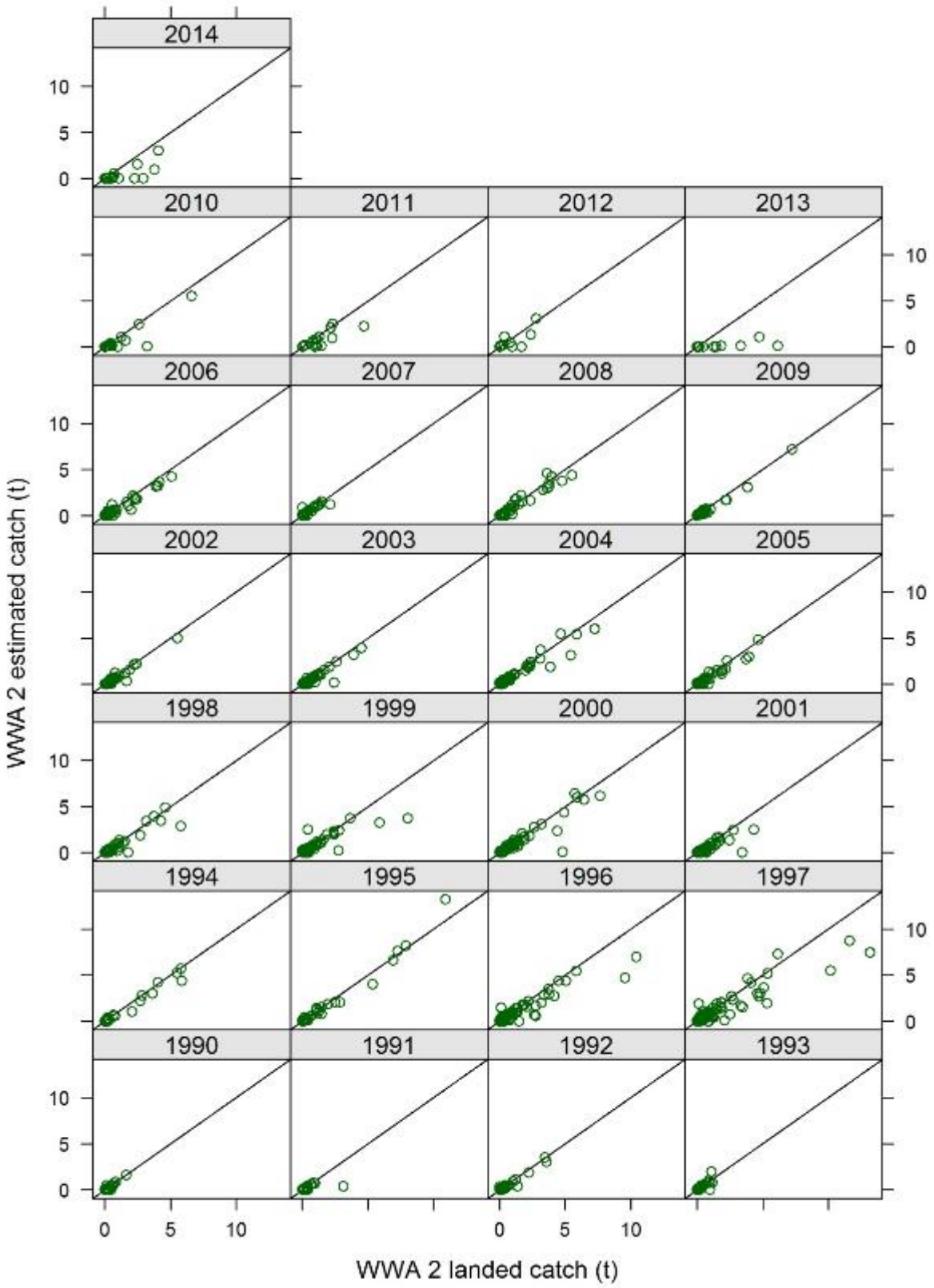


Figure C7: Estimated TCEPR, TCER, and CELR catch versus reported CLR and CELR landings on a trip basis in the groomed and merged dataset, for WWA stocks, by form type for 1990 to 2014. CELR: Catch, Effort, Landing Return; TCEPR is Trawl Catch, Effort, and Processing Return; TCER: Trawl Catch, Effort, Return; CLR: Catch Landing Return.



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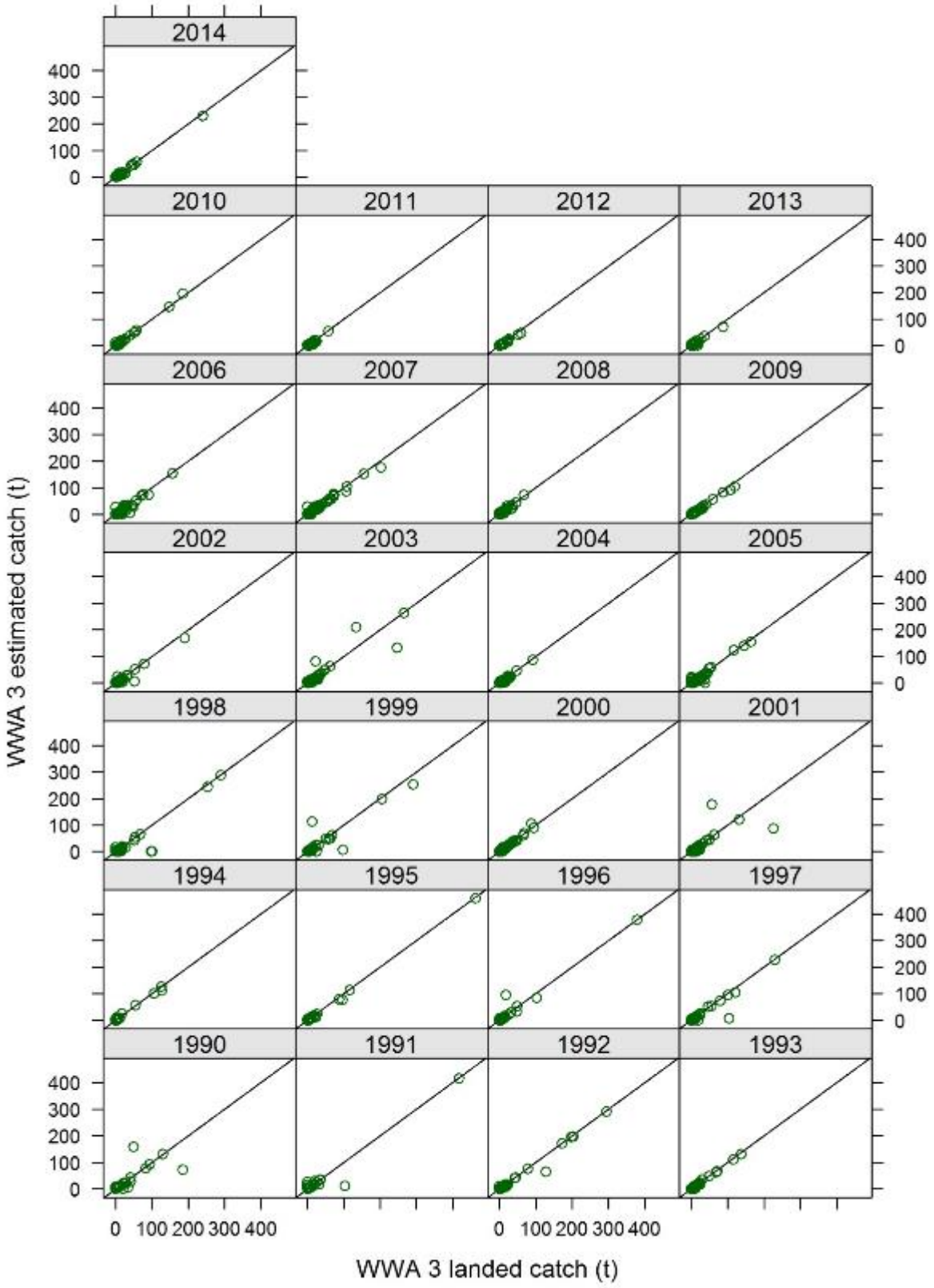

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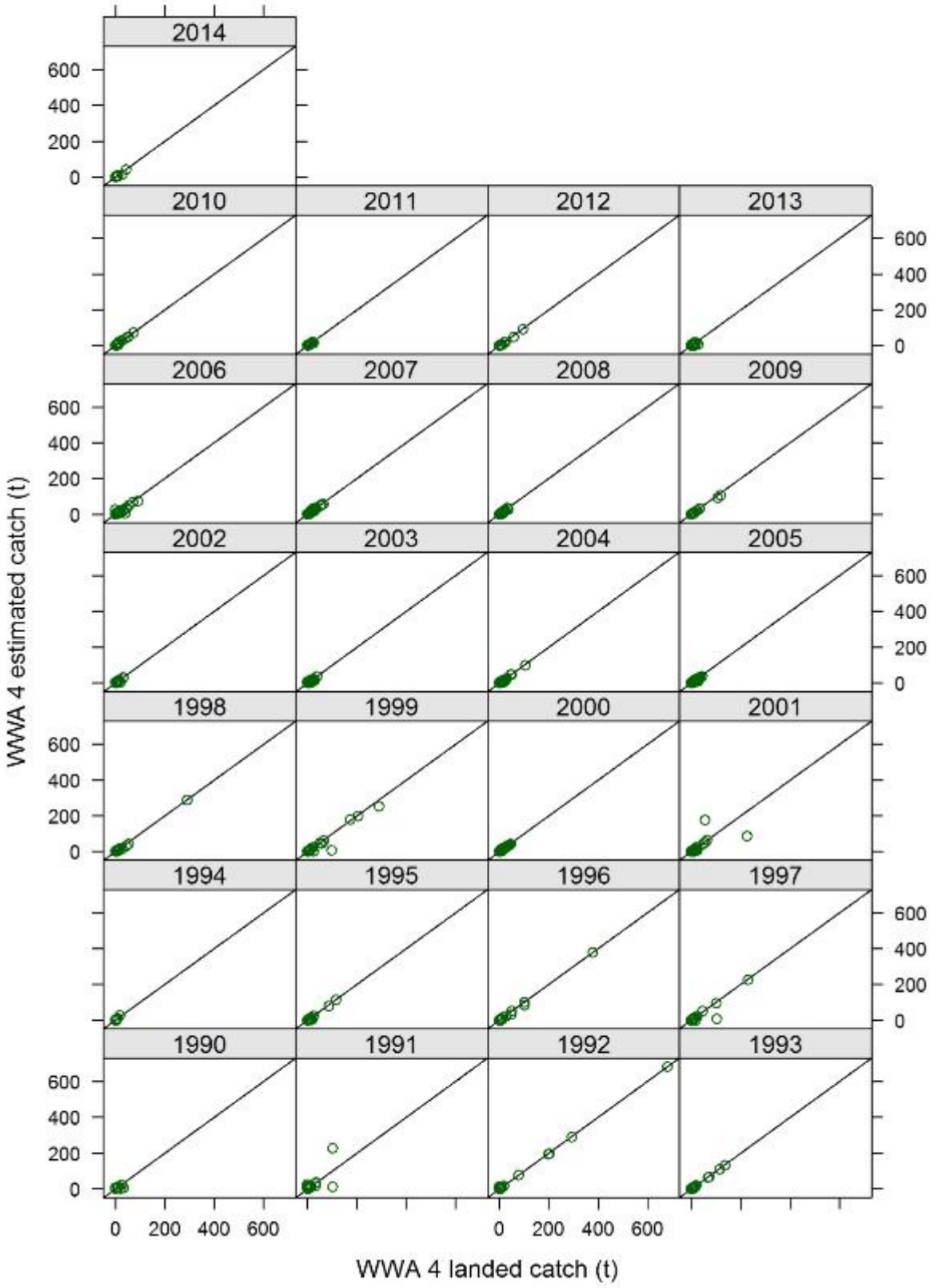

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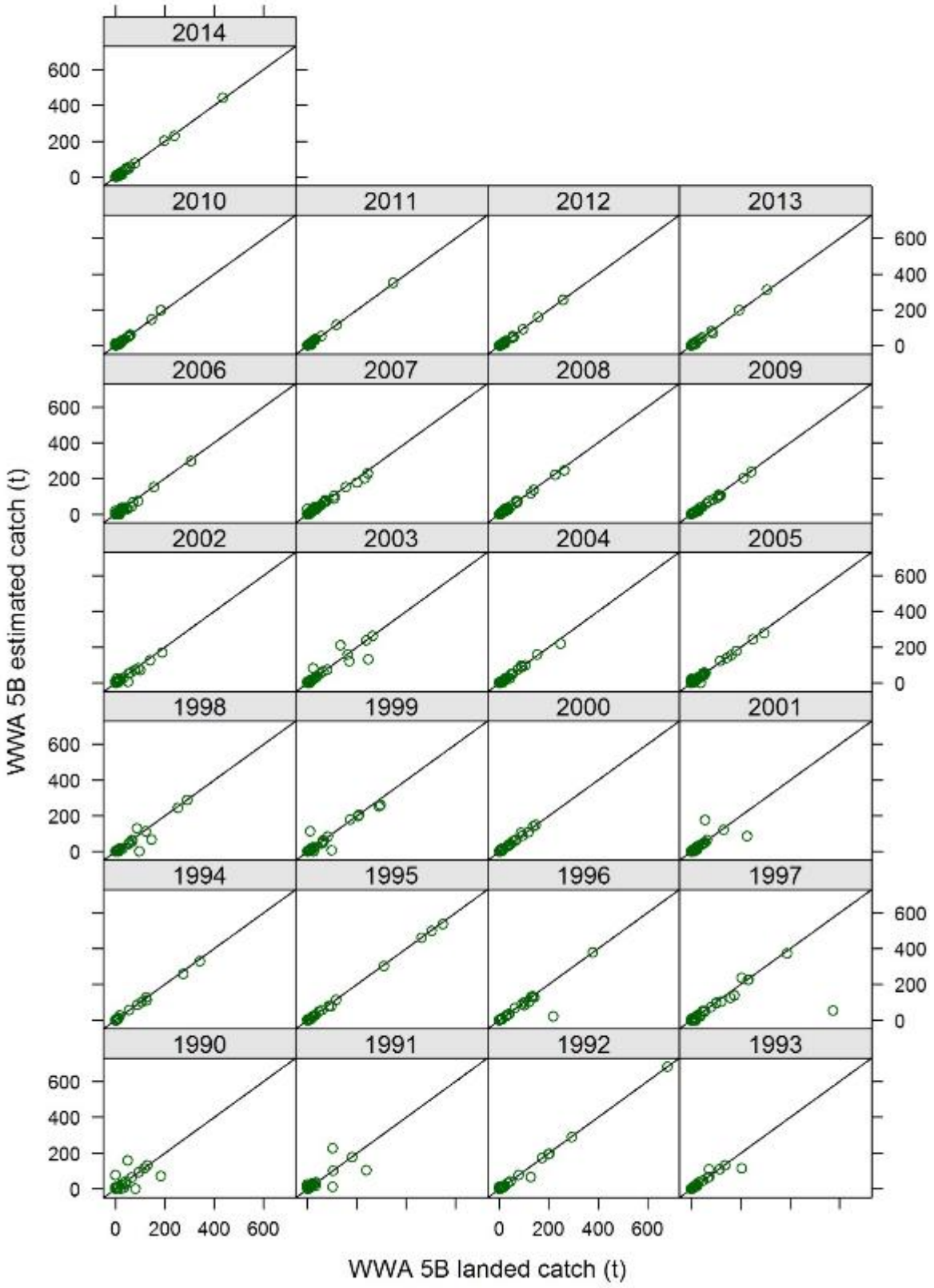

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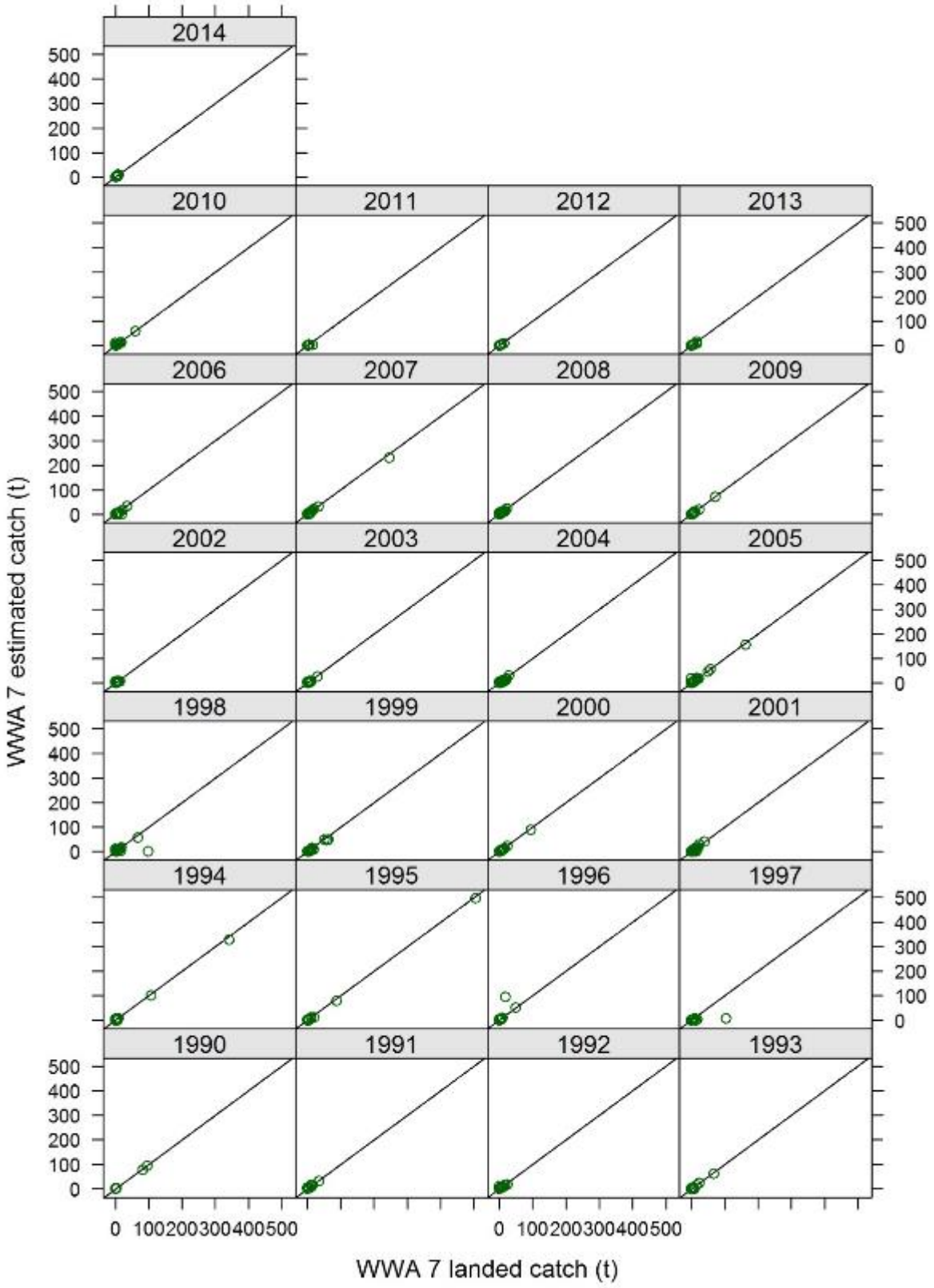
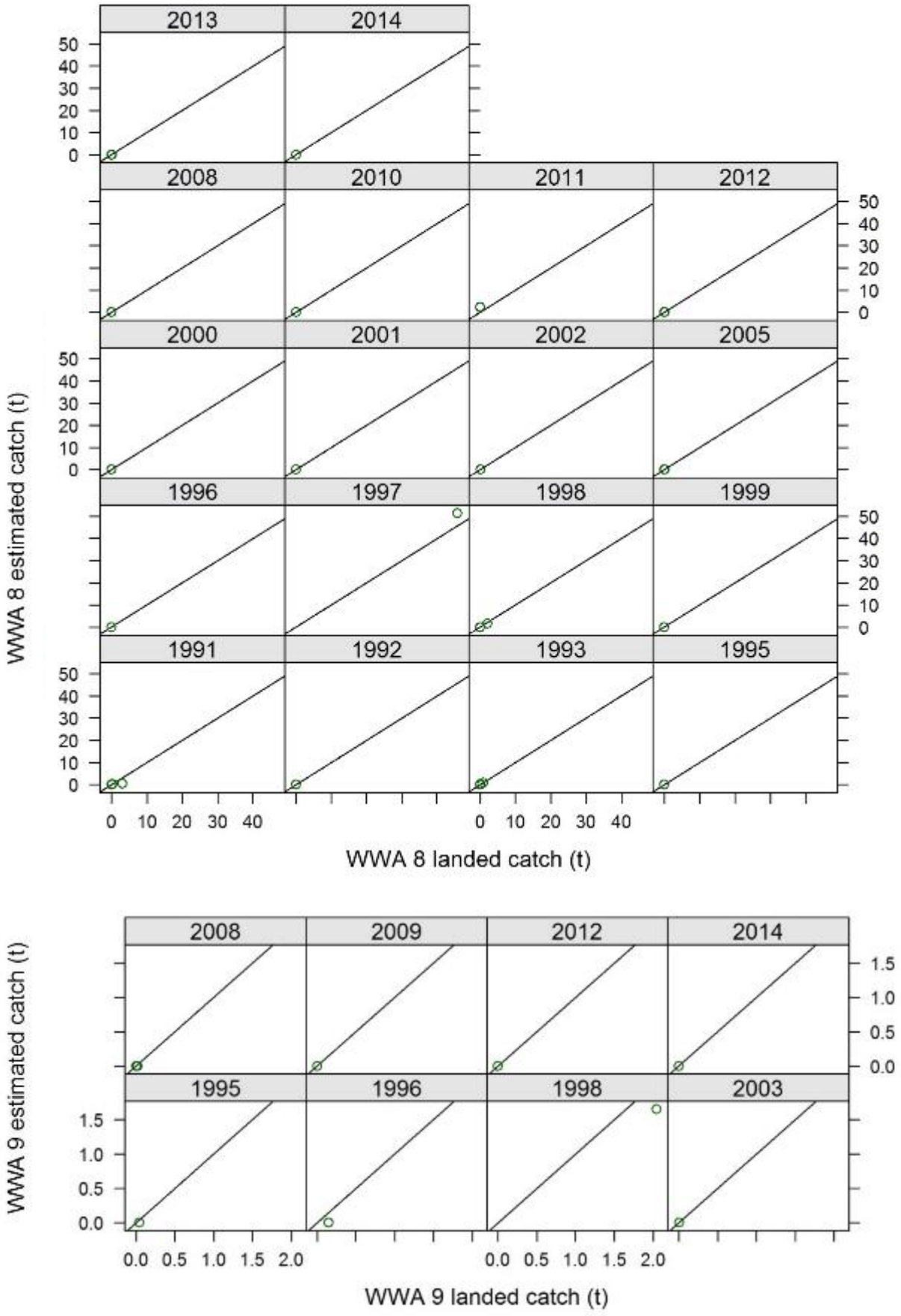


Figure C7: ctd.



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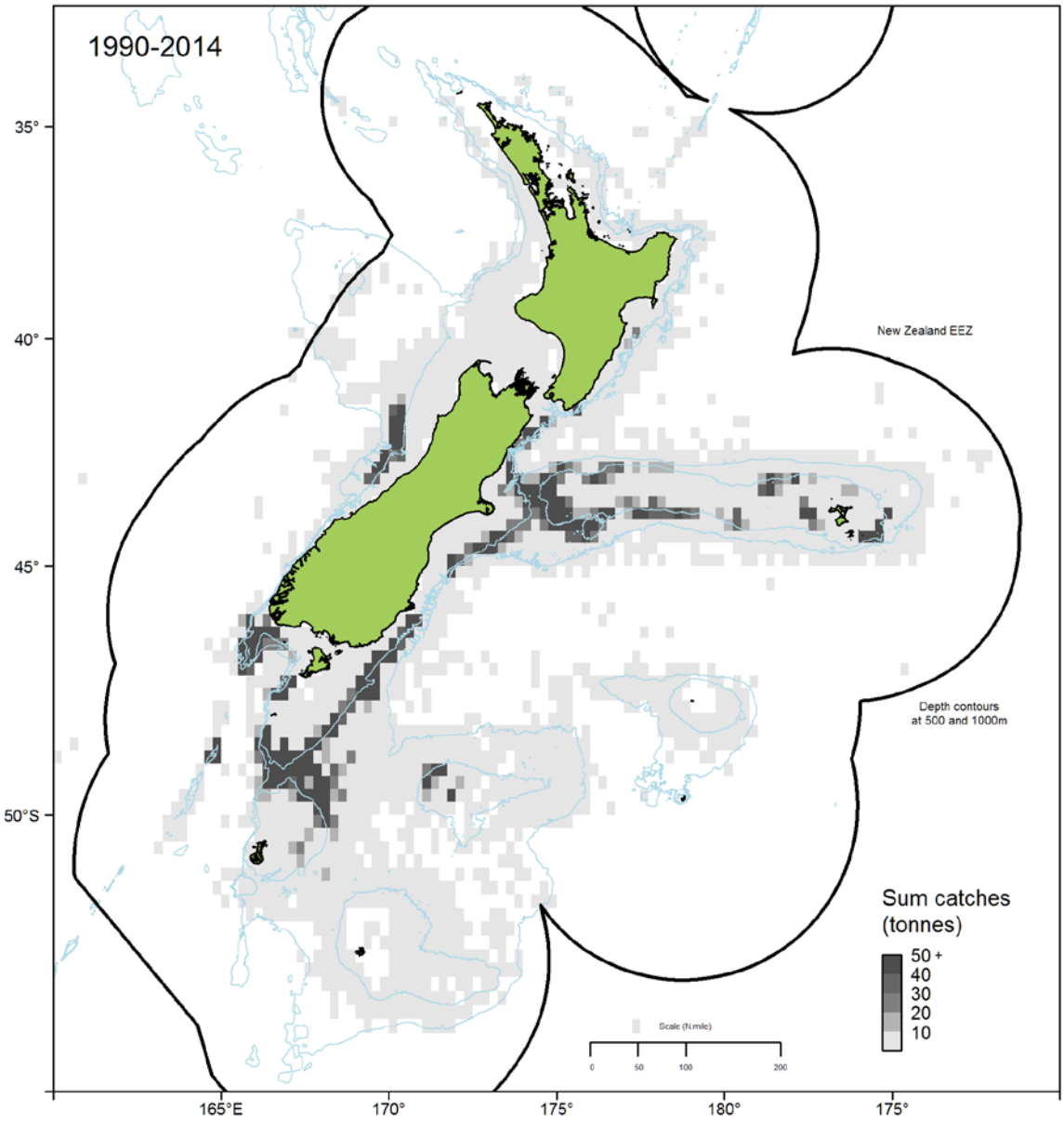


Figure C8a: Annual catch (t) of all commercial white warehou catches from Trawl Catch, Effort, and Processing Return (TCEPR) records for all years combined (1990 to 2014).

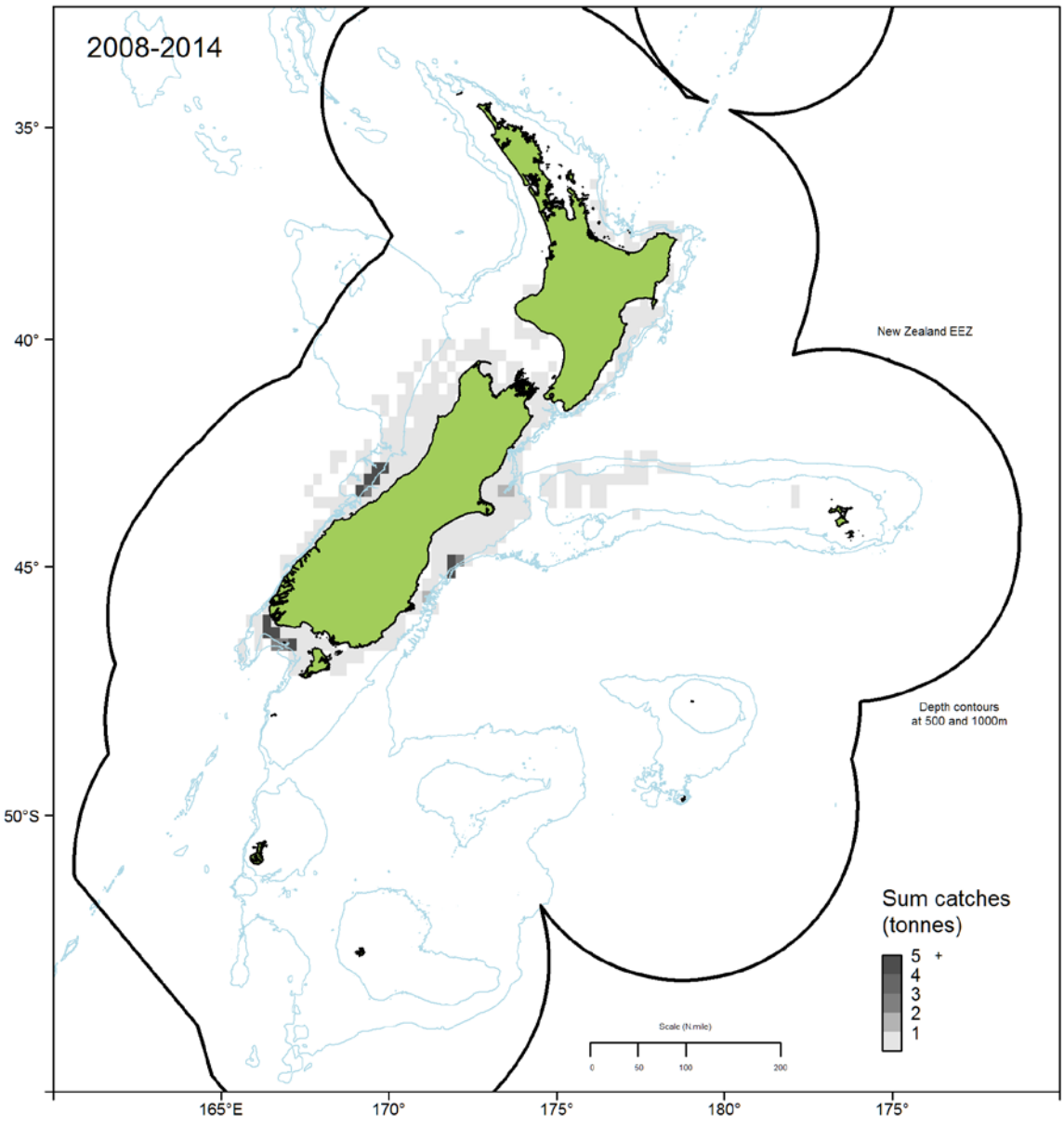


Figure C8b: Annual catch (t) of all commercial white warehou catches from Trawl Catch, Effort, and Return (TCER) records for all years combined (2008 to 2014).

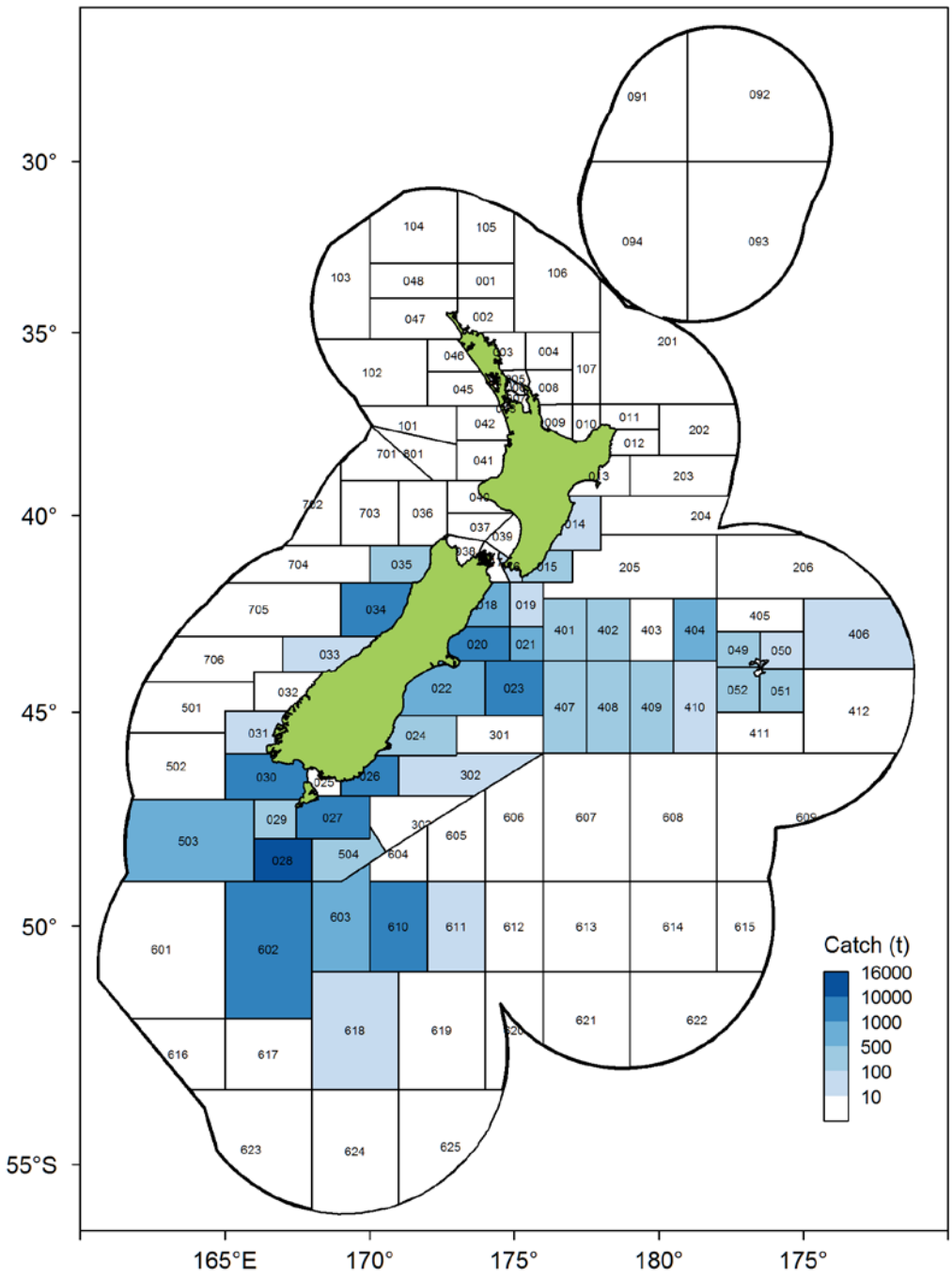


Figure C8c: Annual catch (in tonnes) of all commercial white warehou catches by statistical area for all forms and methods over all fishing years, 1989–90 to 2013–14.

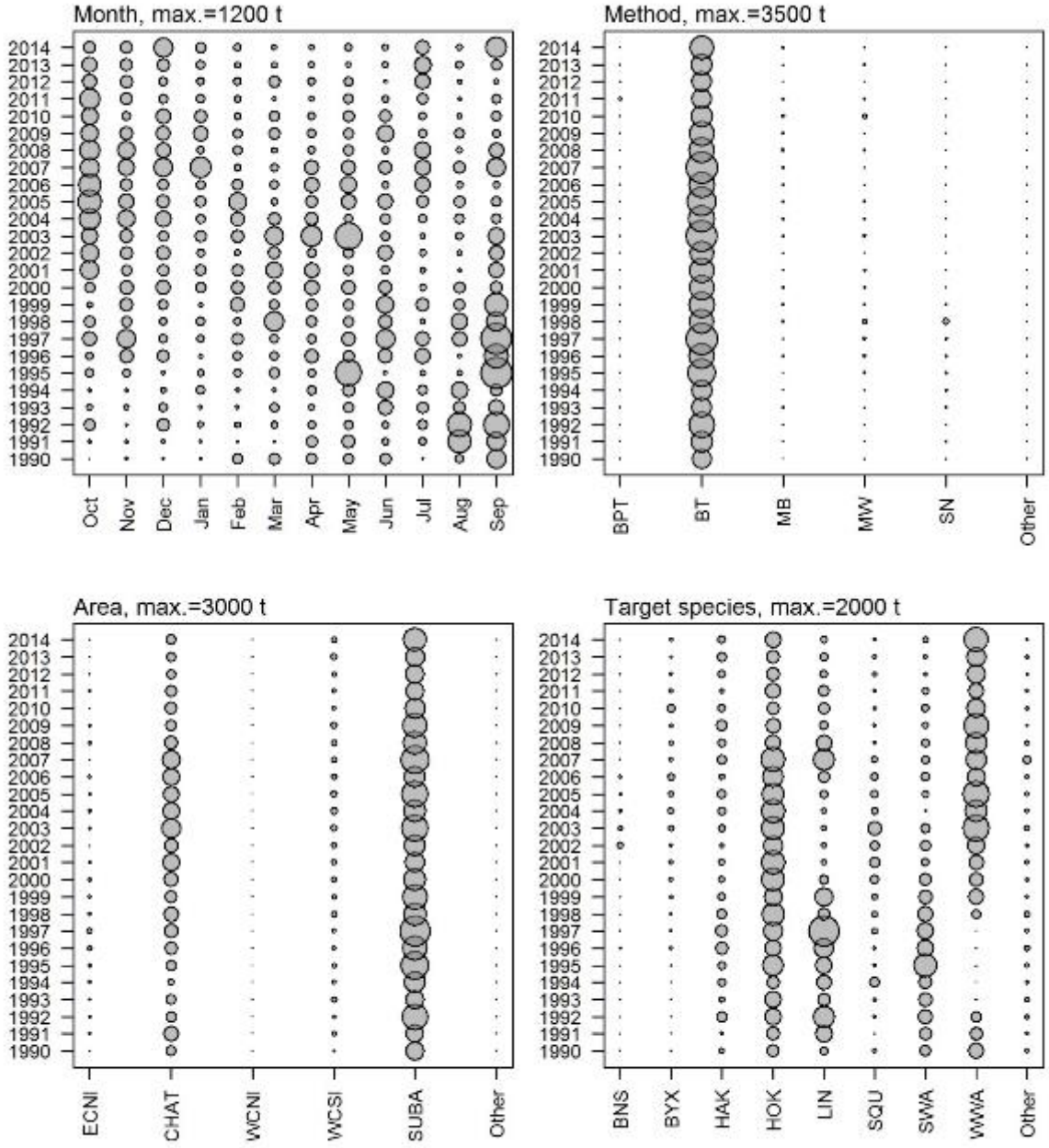


Figure C9: Distribution of annual catch (t) by month, area, method, and target species for all merged data. Circle size is proportional to catch; maximum circle size is indicated on each plot. Statistical areas are shown in Figure 1. BPT is bottom pair trawl; BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; SN is setnet. Target species codes are defined in Table C12.

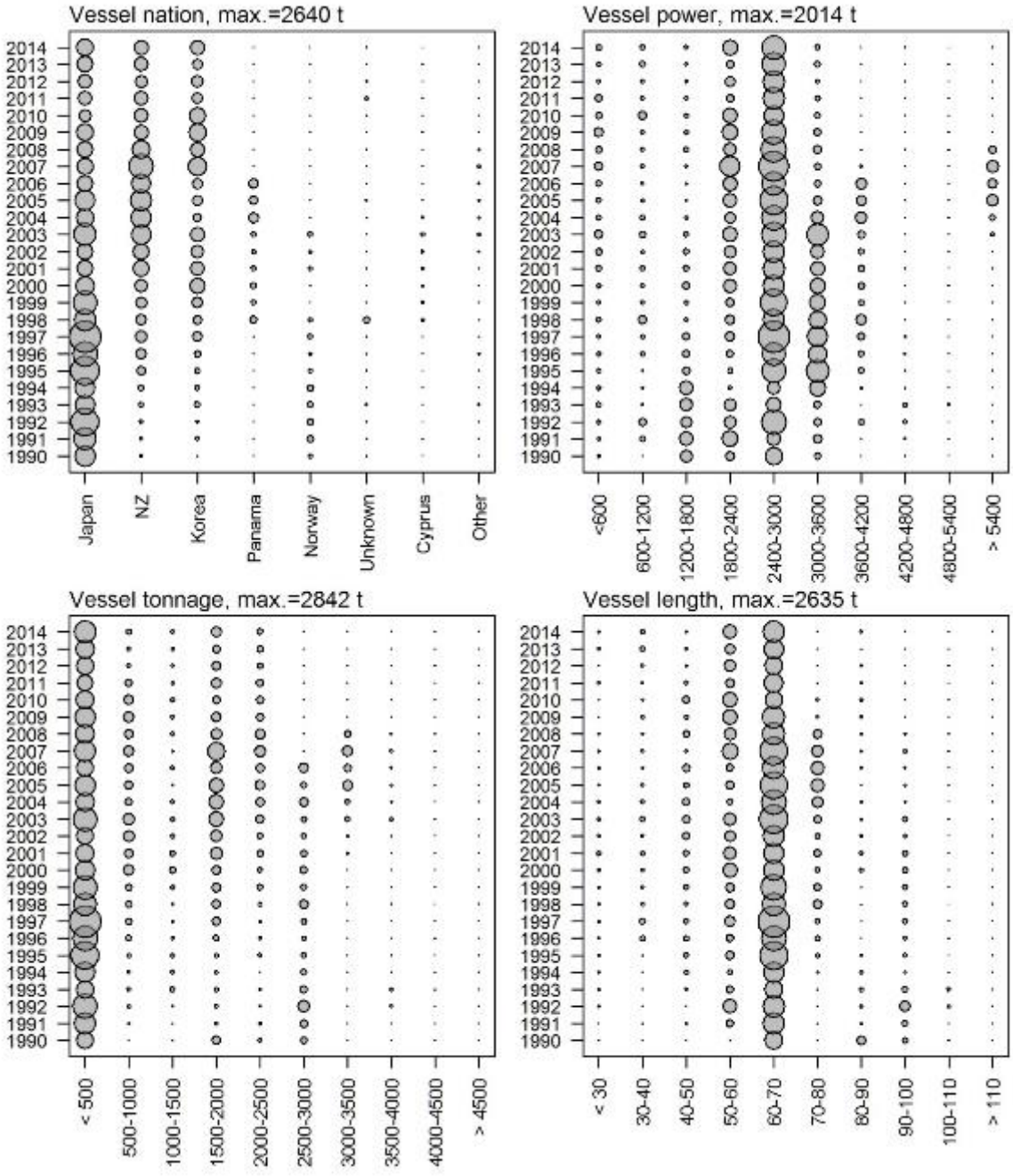


Figure C10: Distribution of annual catch (t) by nationality, vessel power (kW), vessel gross tonnage, and vessel length (m) for all estimated merged data. Circle size is proportional to catch; maximum circle size is indicated on each plot.

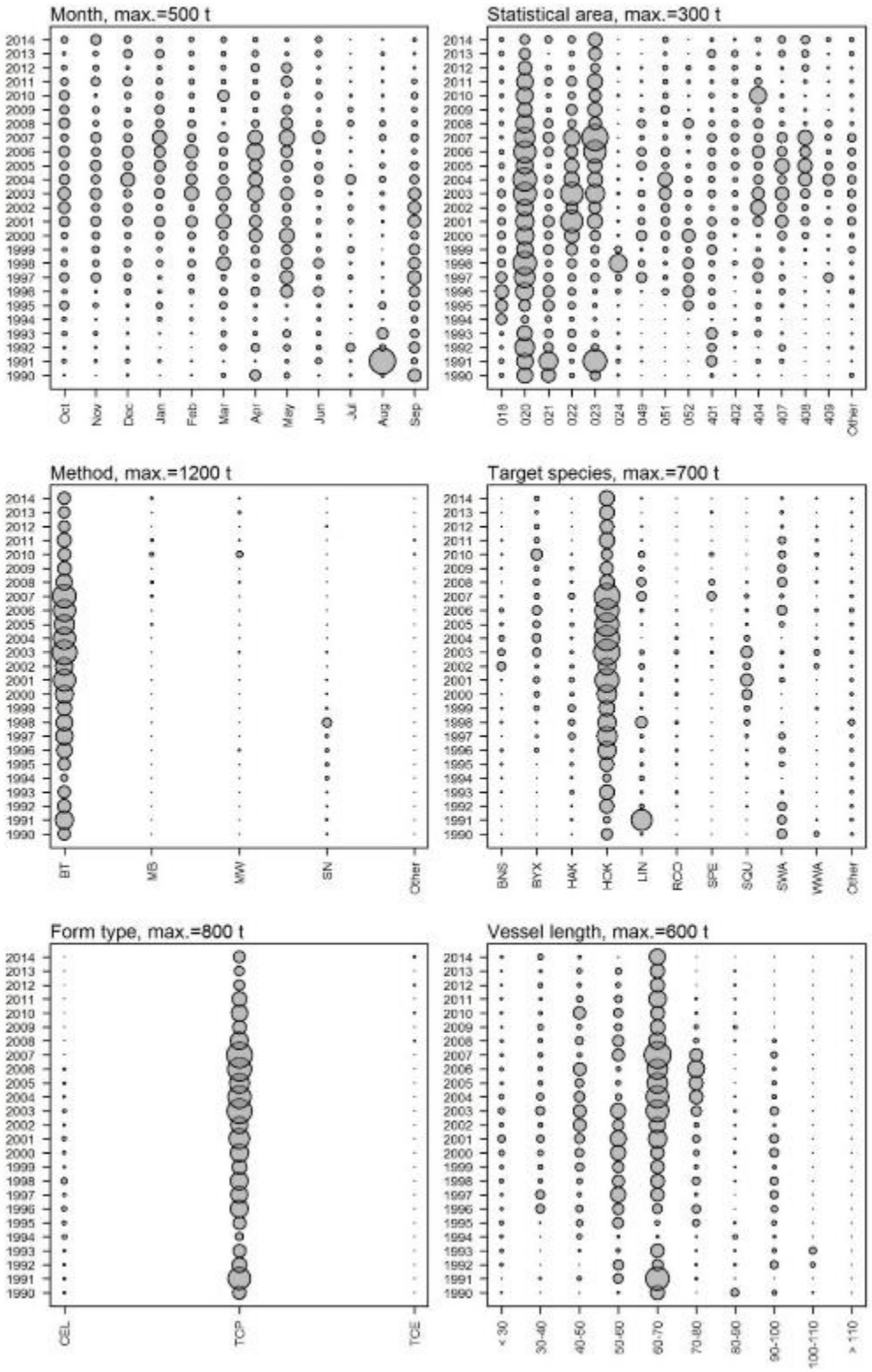


Figure C11: Distribution of annual estimated catch (t) by month, statistical area, method, target species, form type, and vessel length for CHAT merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Method codes are given in Figure C10; target species codes are given in Table C12; and form types are defined in Figure C7.

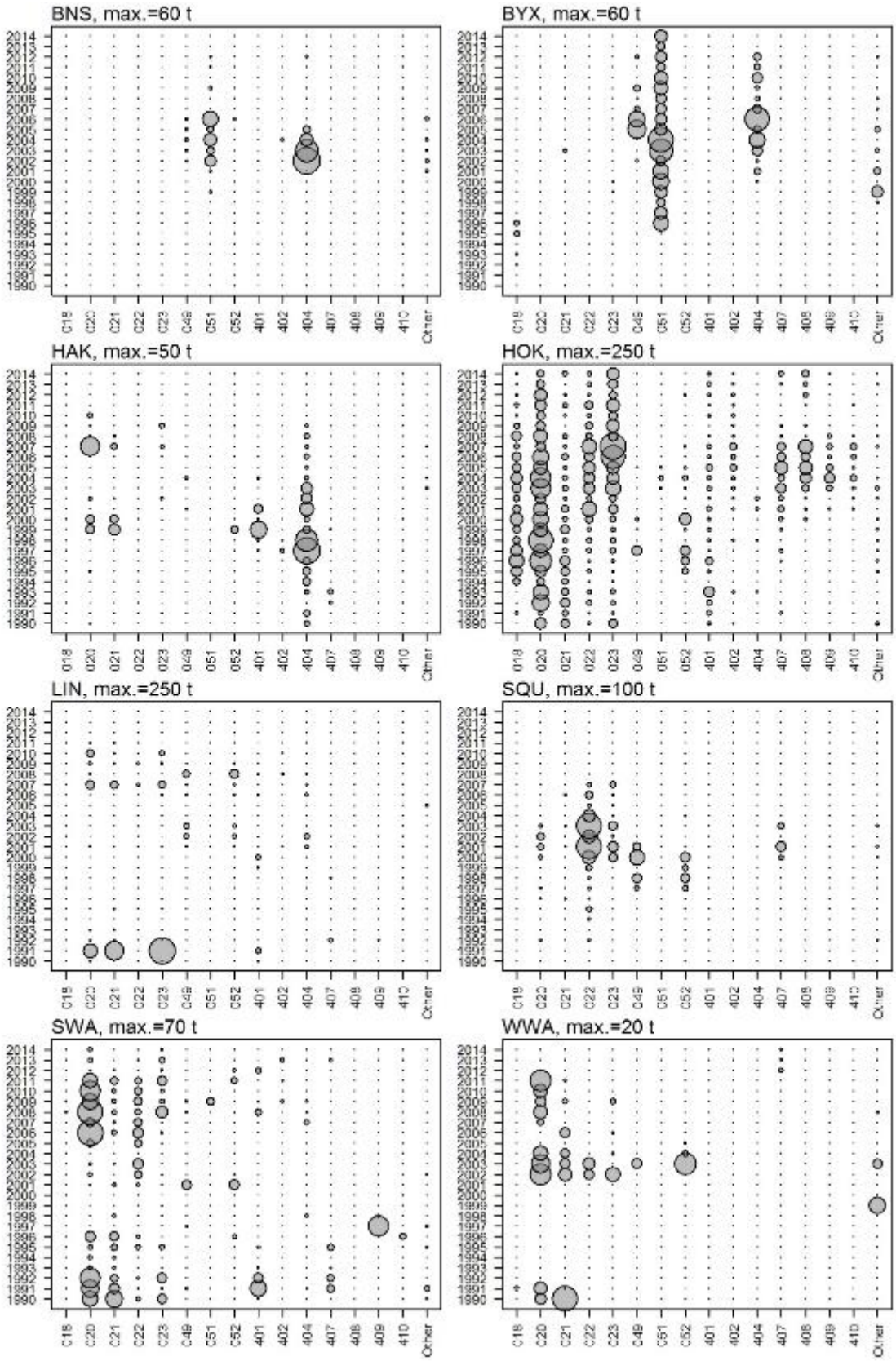


Figure C12: Distribution of white warehou annual catch (t) by statistical area for CHAT unmerged estimated data by main target species for all TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1 and Target species codes are defined in Table C12.

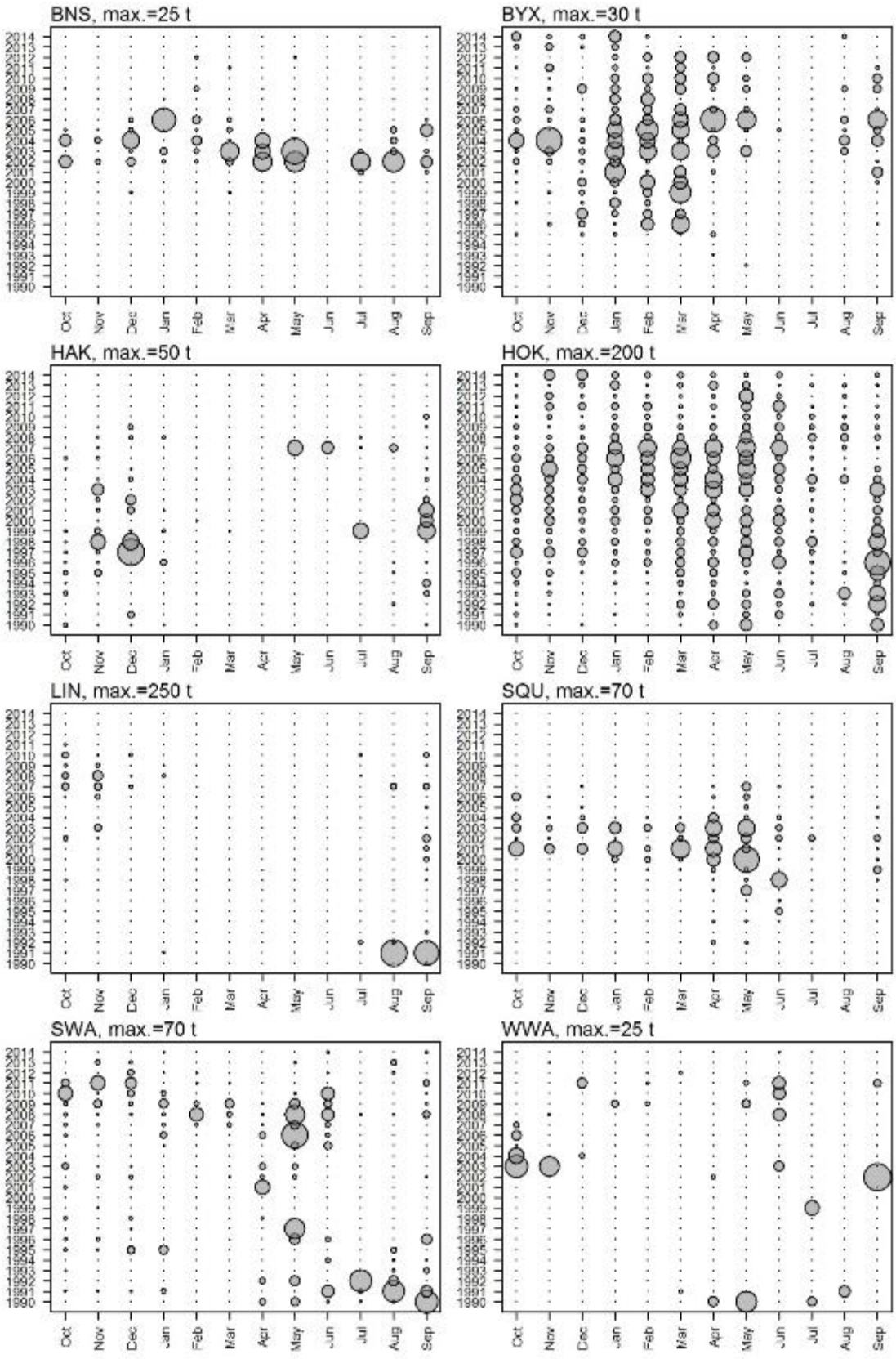


Figure C13: Distribution of white warehou annual catch (t) by month for CHAT unmerged estimated data by main target species for TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12

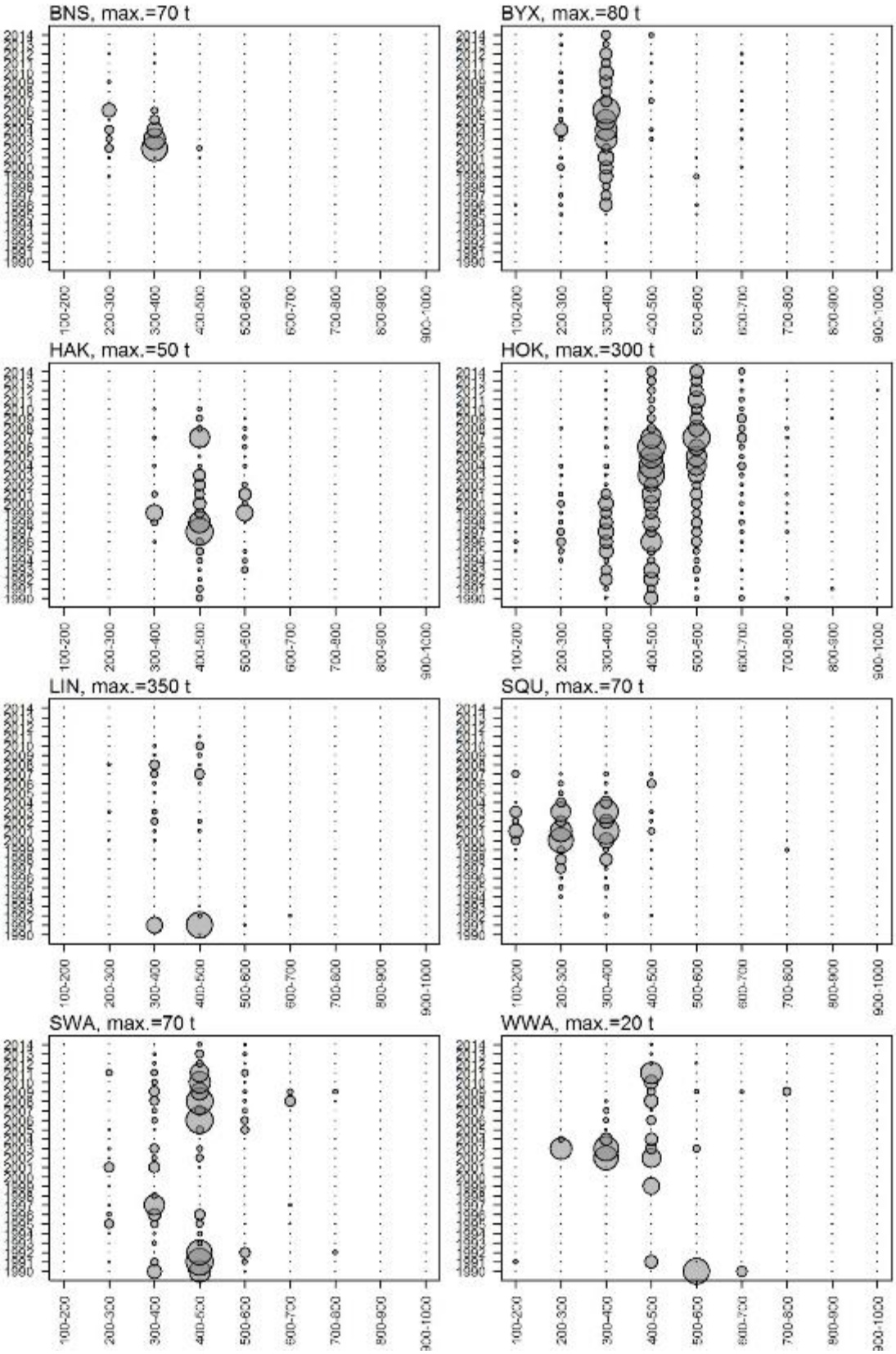


Figure C14: Distribution of white warehou annual catch (t) by bottom depth for CHAT unmerged estimated data by main target species for TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

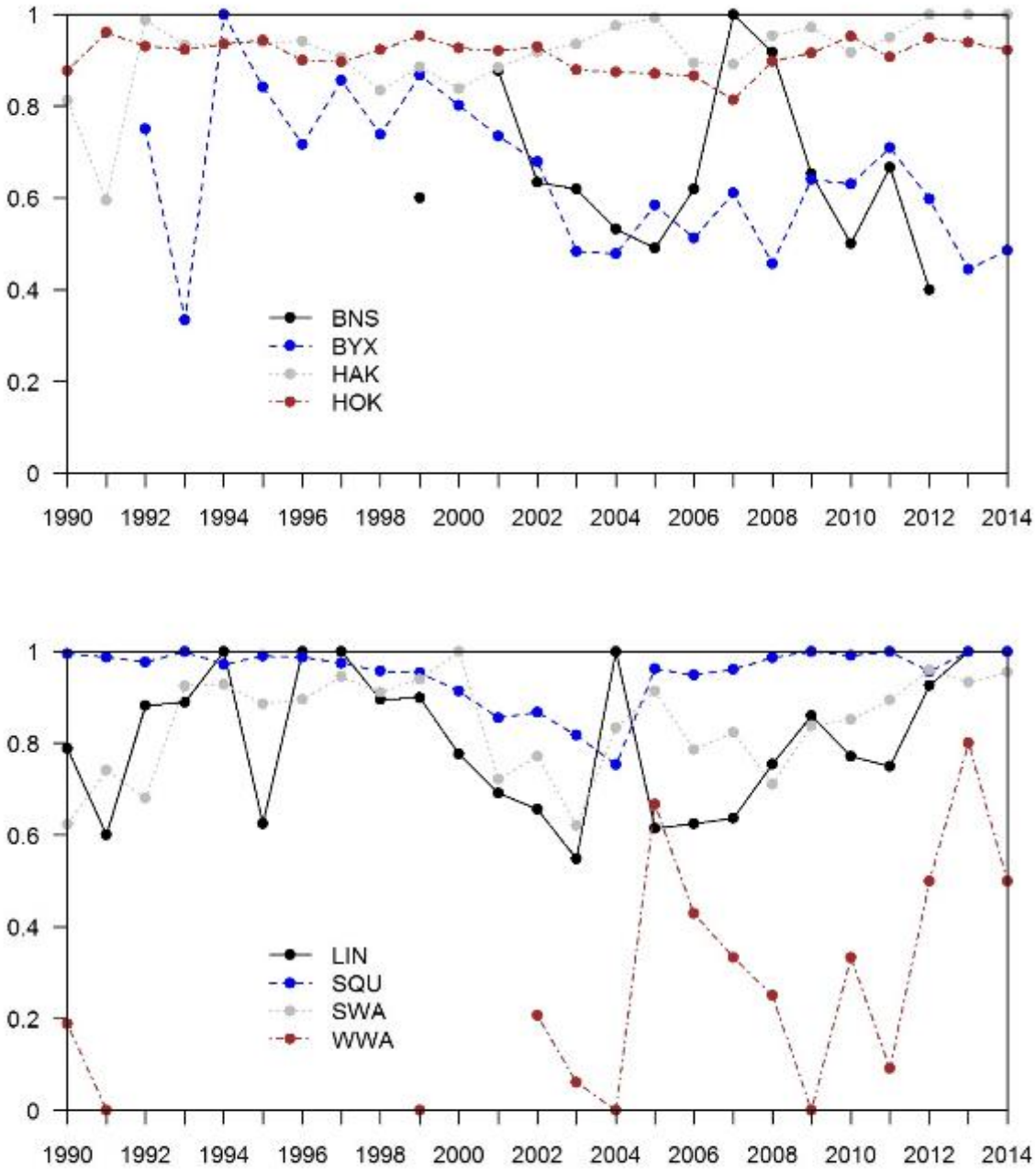


Figure C15: Proportion of zeros in unmerged estimated data by main target species in the CHAT region for TCEPR bottom tows for fishing years 1990 to 2014. Target species codes are defined in Table C12.

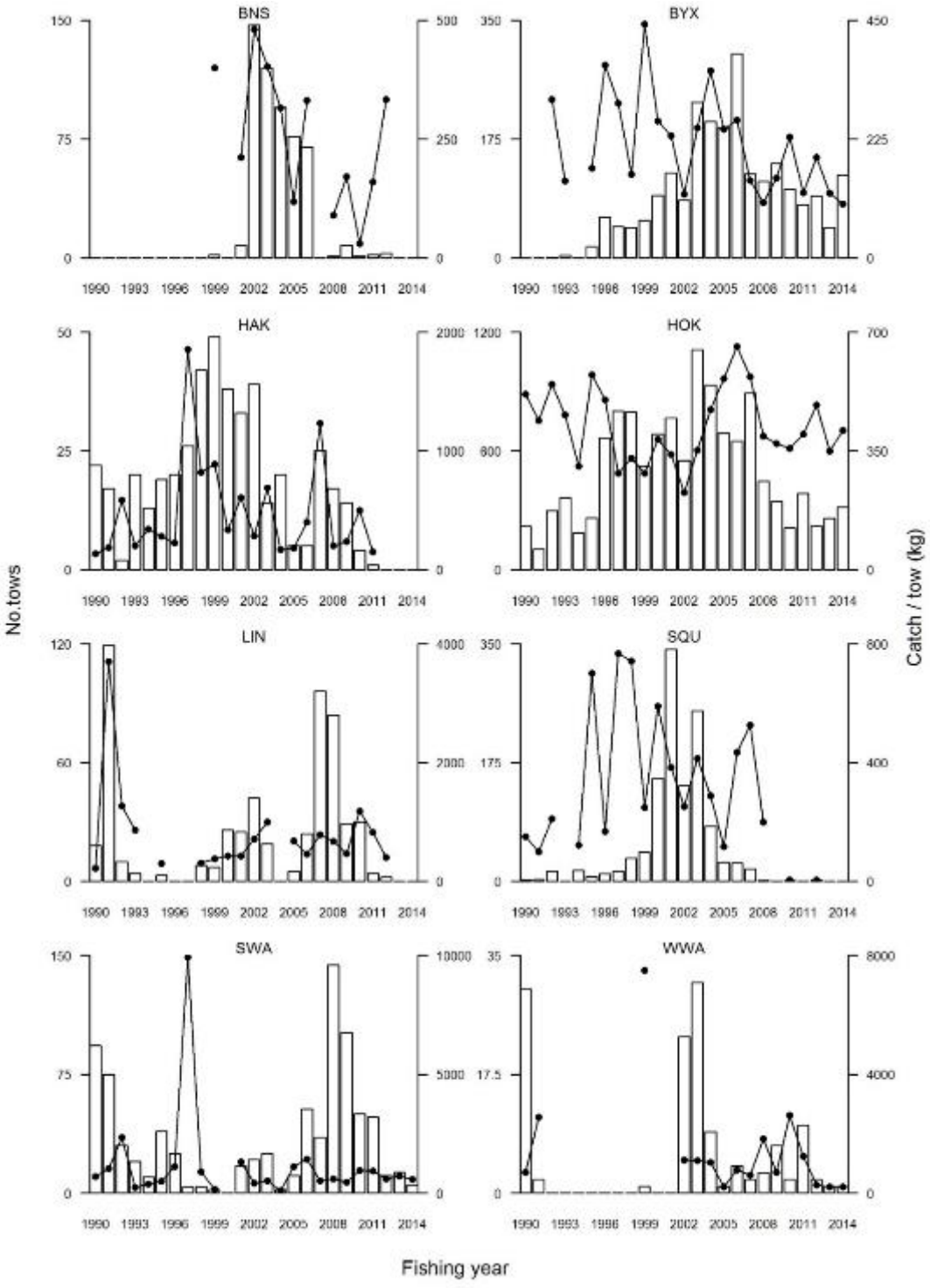


Figure C16: Unstandardised catch rate (kg/tow) of white warehou (lines), and the number of tows (bars) for the CHAT area, by main target species for unmerged estimated TCEPR bottom trawl data. Target species codes are given in Table C12.

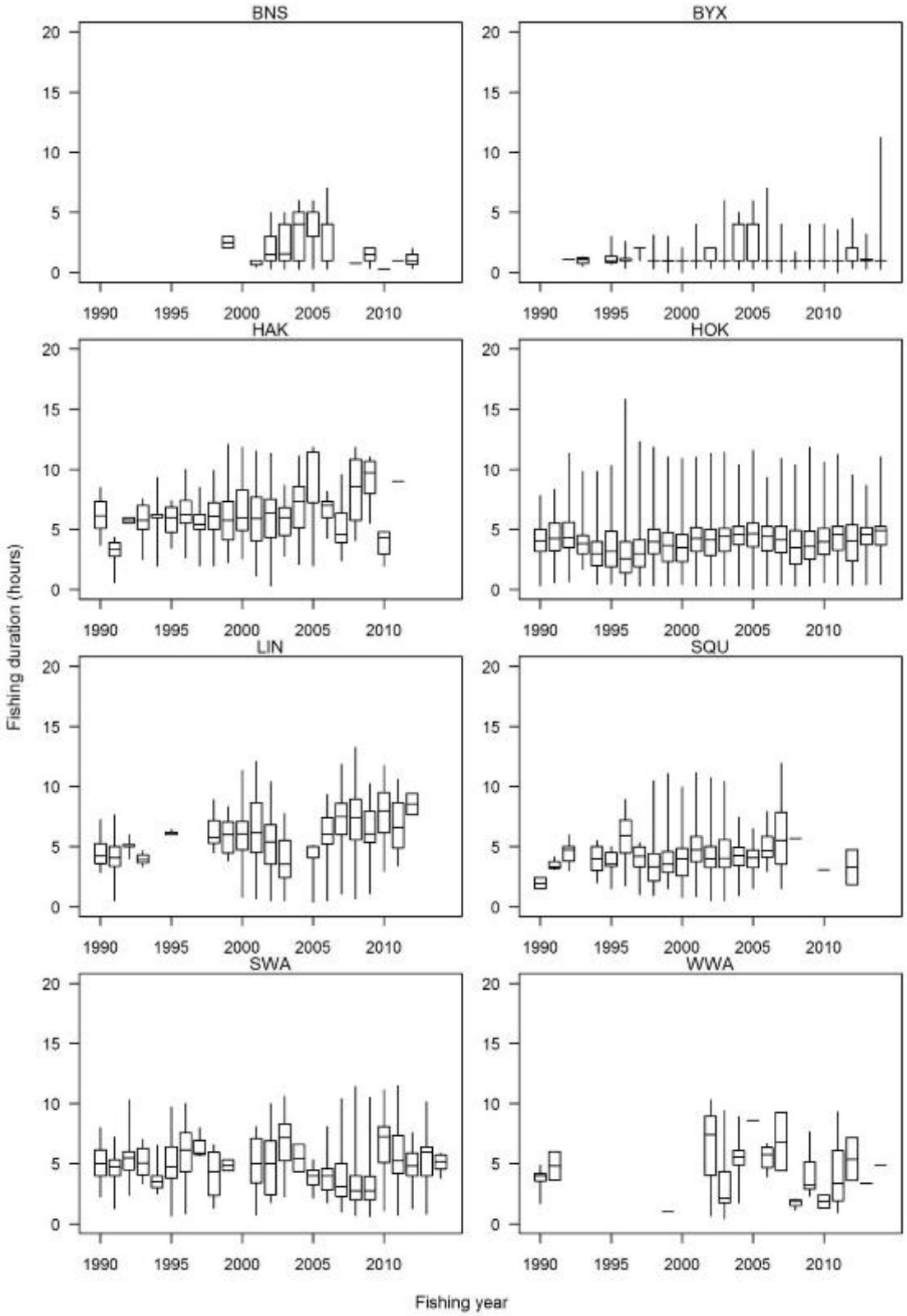


Figure C17: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during unmerged estimated TCEPR bottom trawls that caught white warehou in the CHAT area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

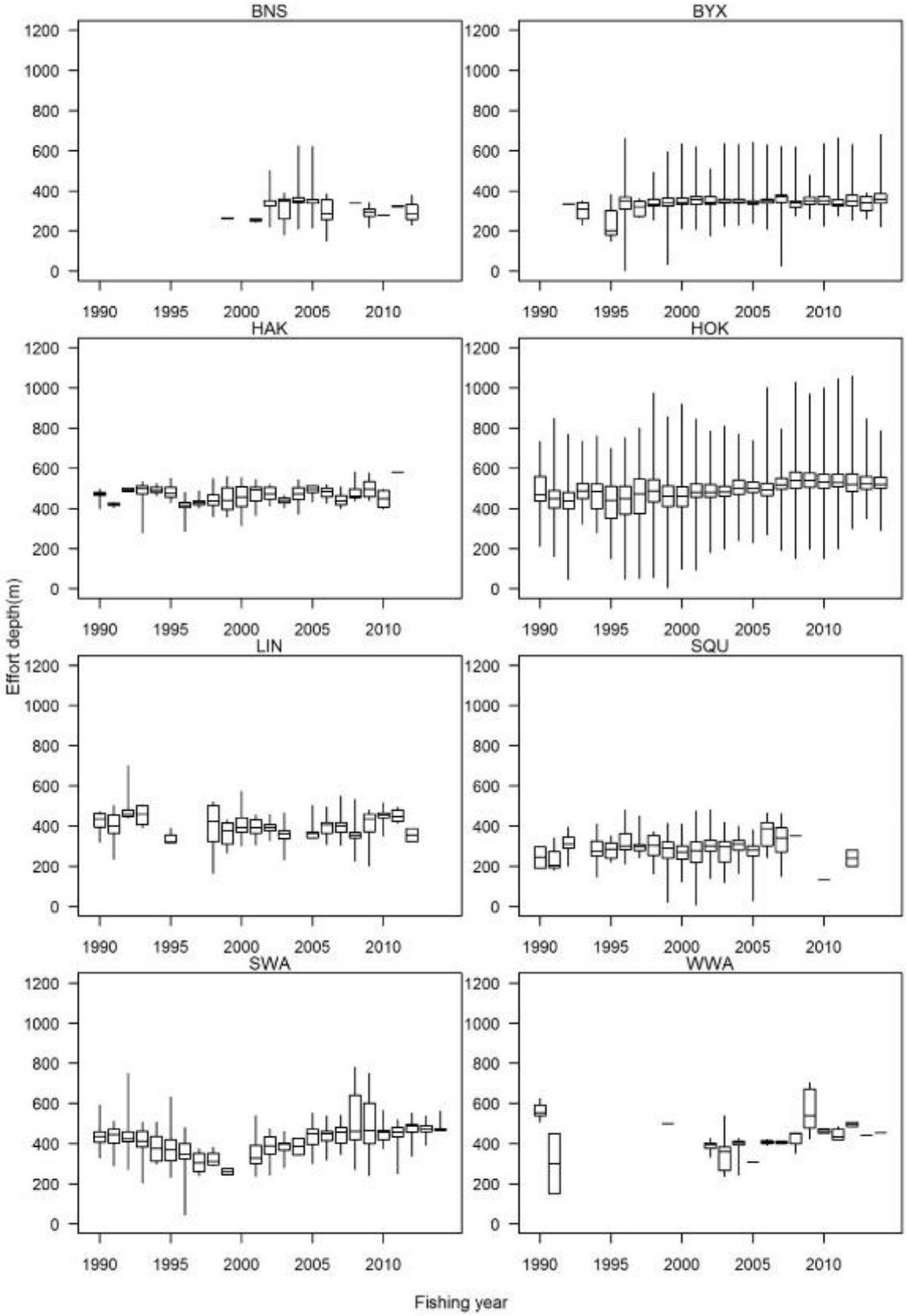


Figure C18: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished during unmerged estimated TCEPR bottom trawls that caught white warehou in the CHAT area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

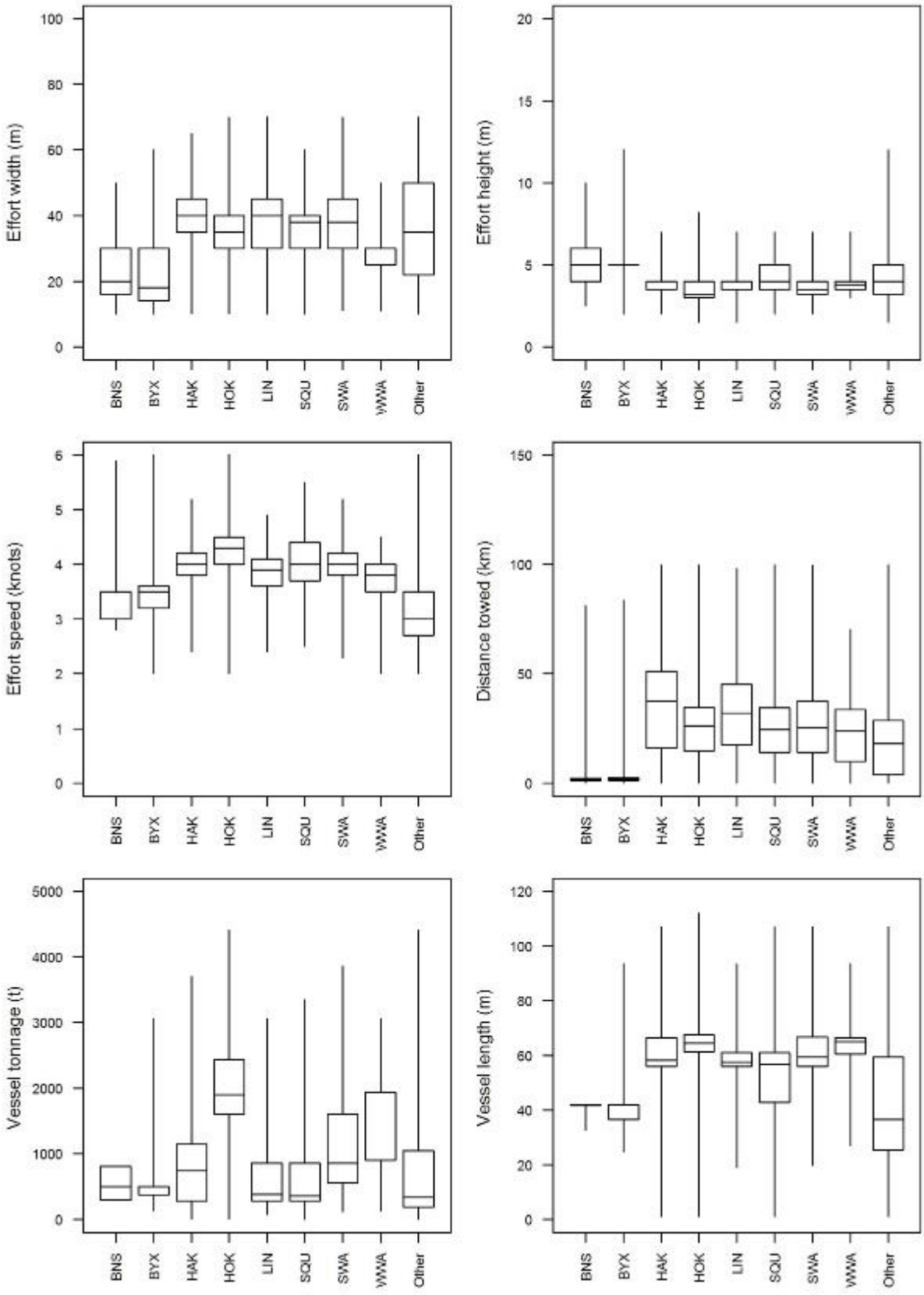


Figure C19: Distribution of fishing effort variables and vessel characteristics for the CHAT area for main target species that caught white warehou for unmerged estimated TCEPR bottom trawls for 1990 to 2014. Target species codes are given in Table C12.

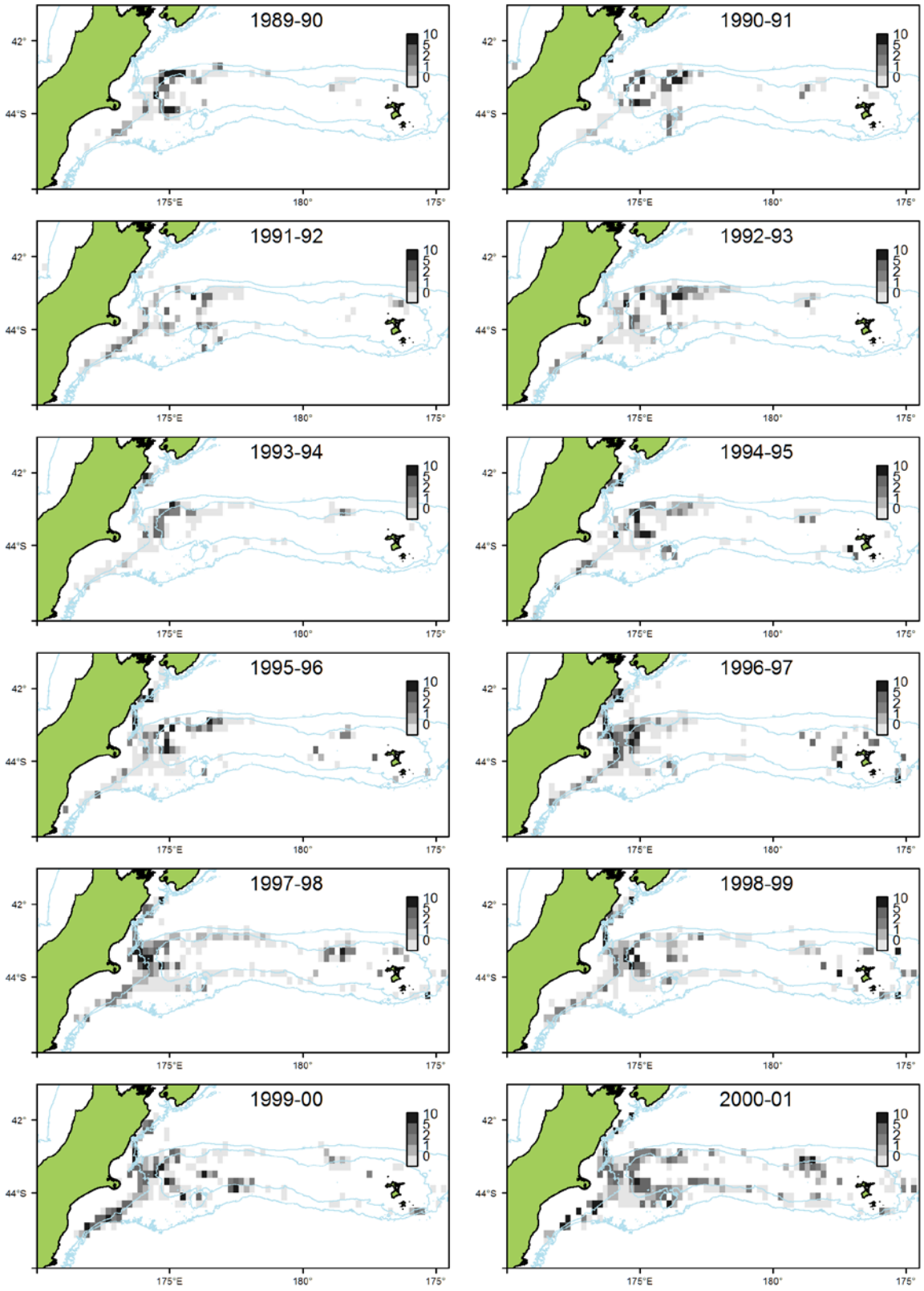


Figure C20: Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 1989–90 to 2000–01.

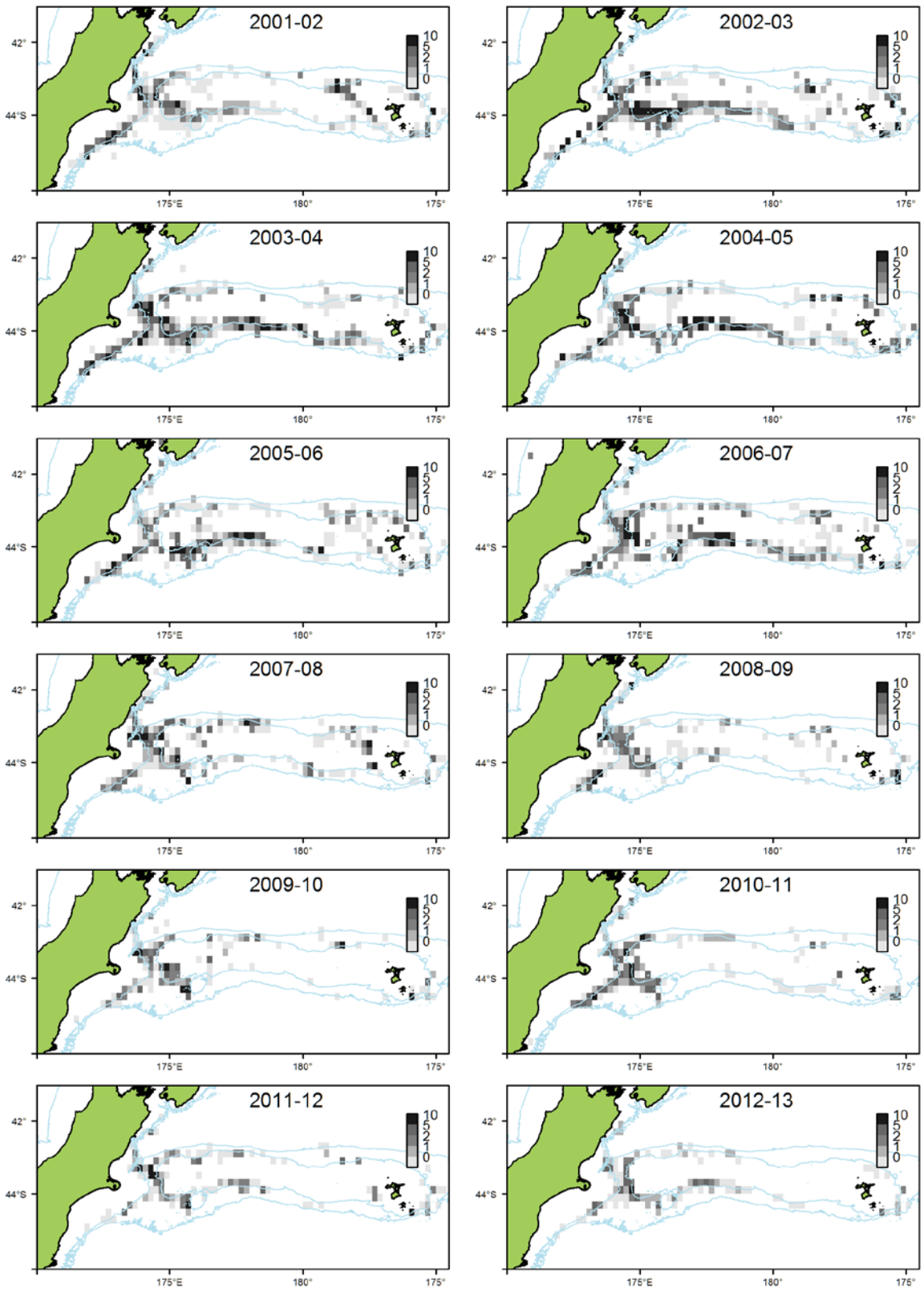


Figure C20: continued. Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 2001–02 to 2012–13.

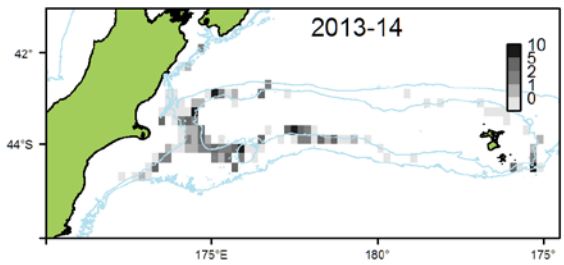


Figure C20: continued. Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 2013–14.

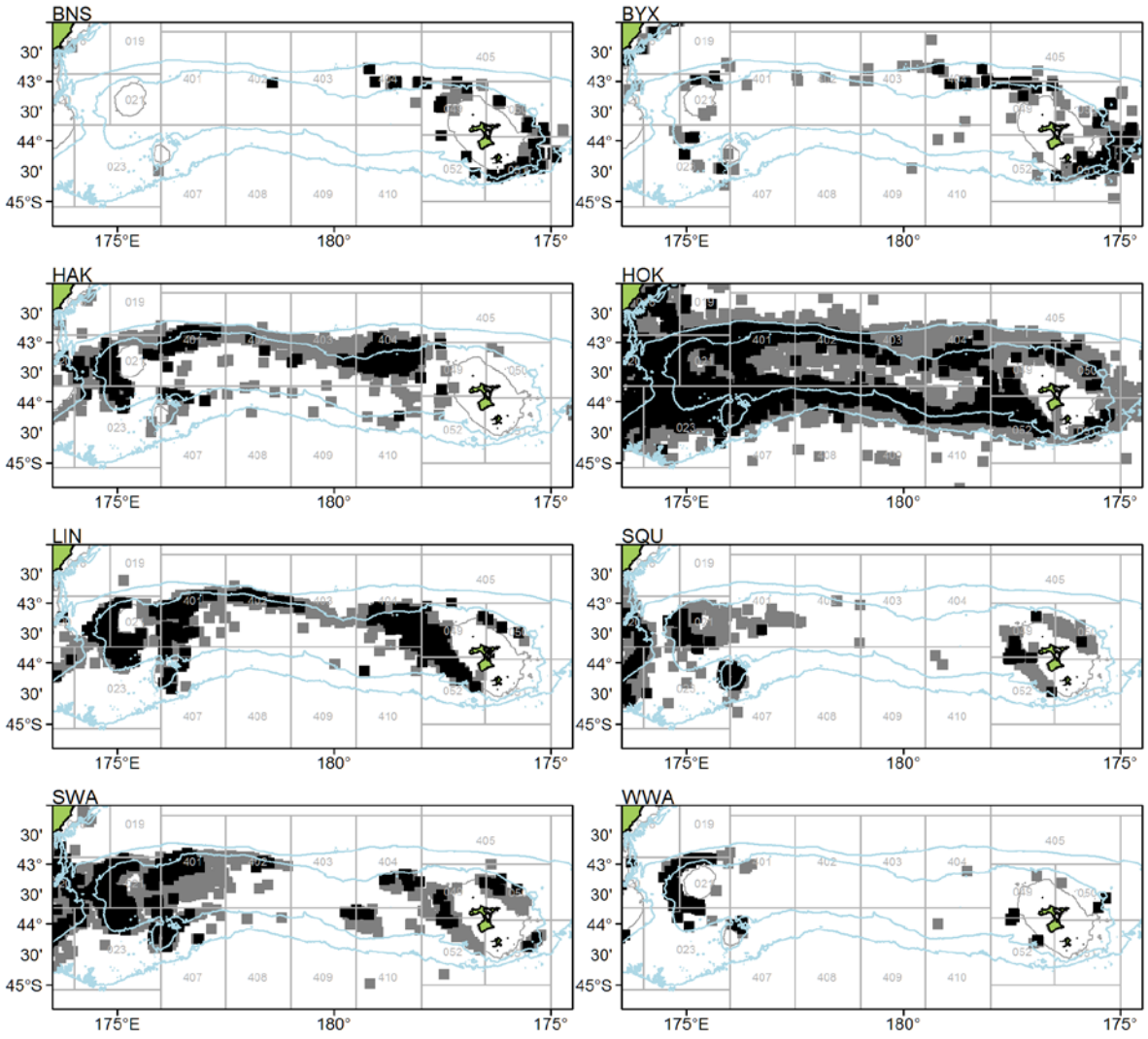


Figure C21: CHAT statistical areas and bathymetry showing the distribution of estimated TCEPR bottom trawls by target species (grey) in the merged processed data and bottom trawls by target species where white warehou was caught (black) for the main target species for all years combined. Target species are defined in Table C12.

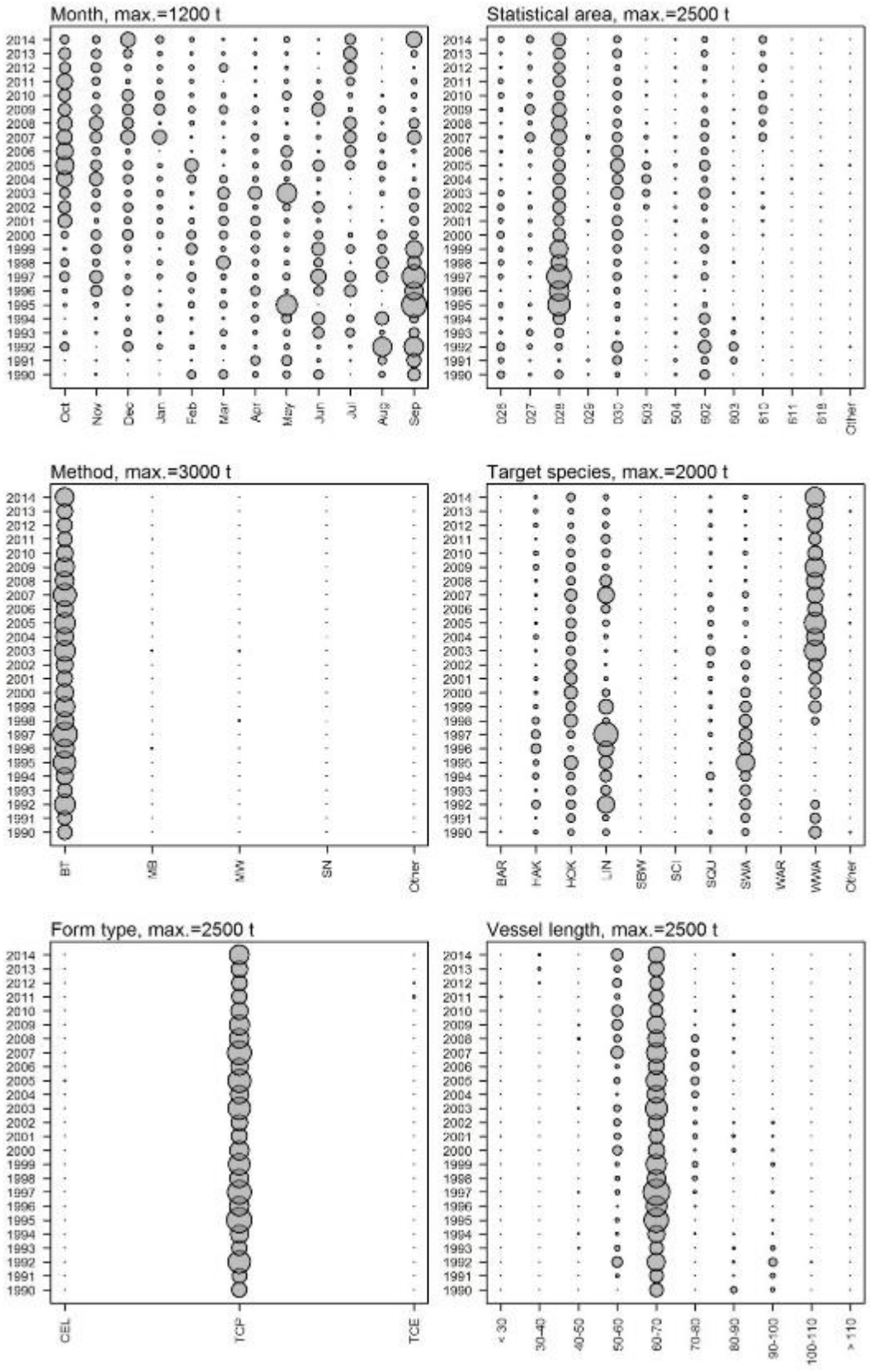


Figure C22: Distribution of annual catch (t) by month, statistical area, method, target species, form type, and vessel length for SUBA estimated merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Method codes are given in Figure C10; target species codes are given in Table C12; and form types are defined in Figure C7.

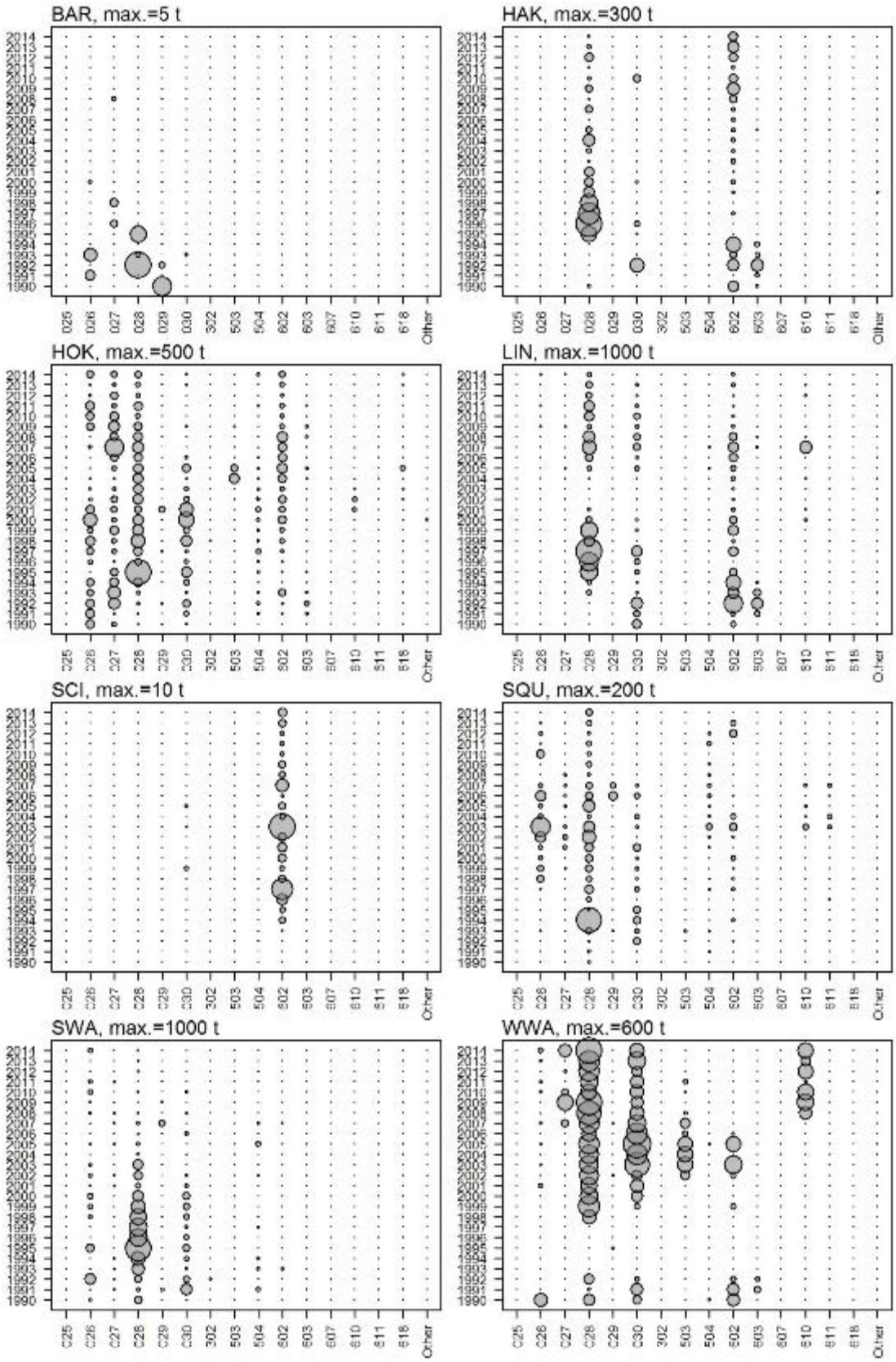


Figure C23: Distribution of white warehou annual catch (t) by statistical area for SUBA unmerged estimated data by main target species for all TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1 and Target species codes are defined in Table C12.

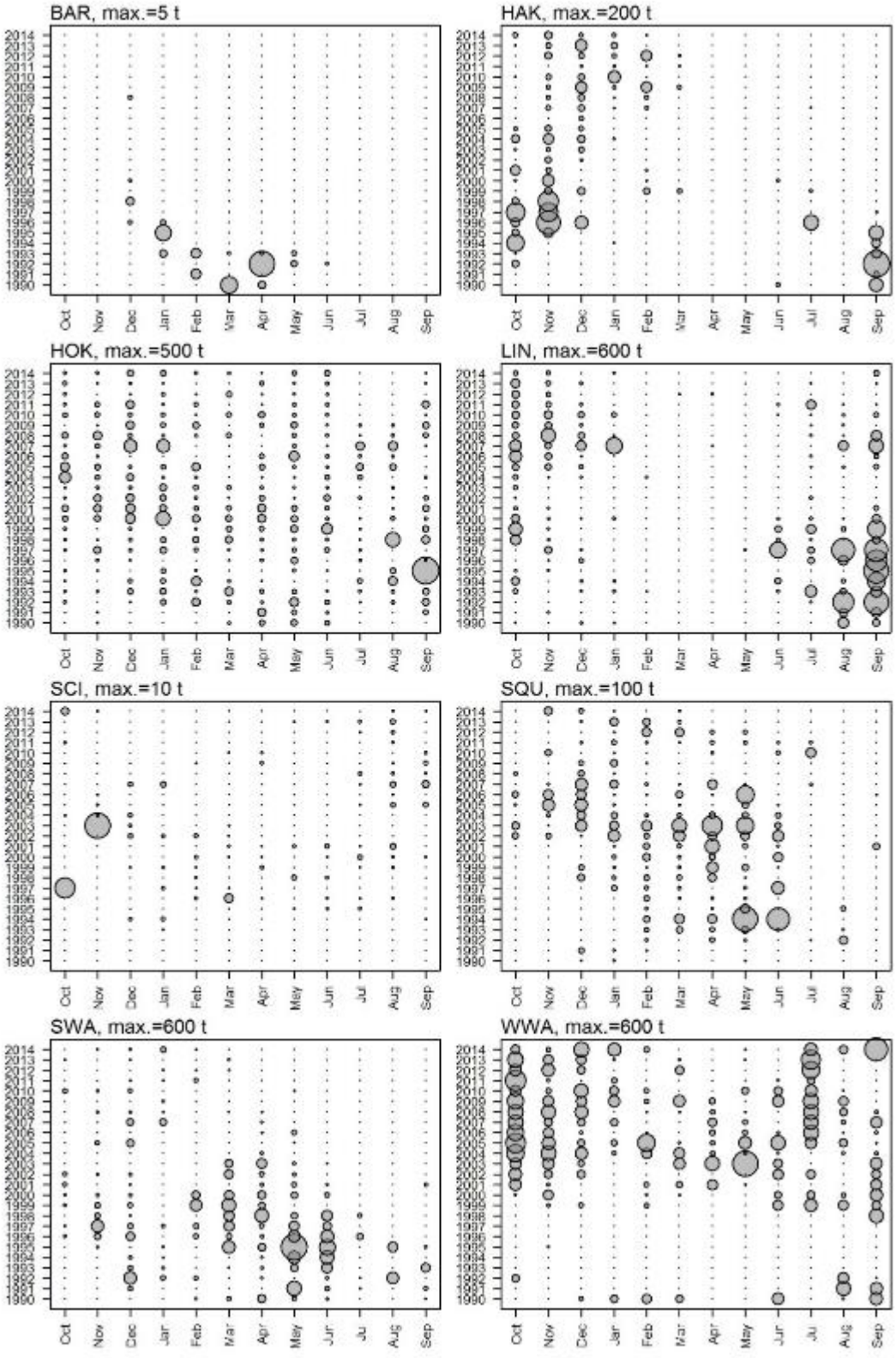


Figure C24: Distribution of white warehou annual catch (t) by month for SUBA unmerged estimated data by main target species for TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

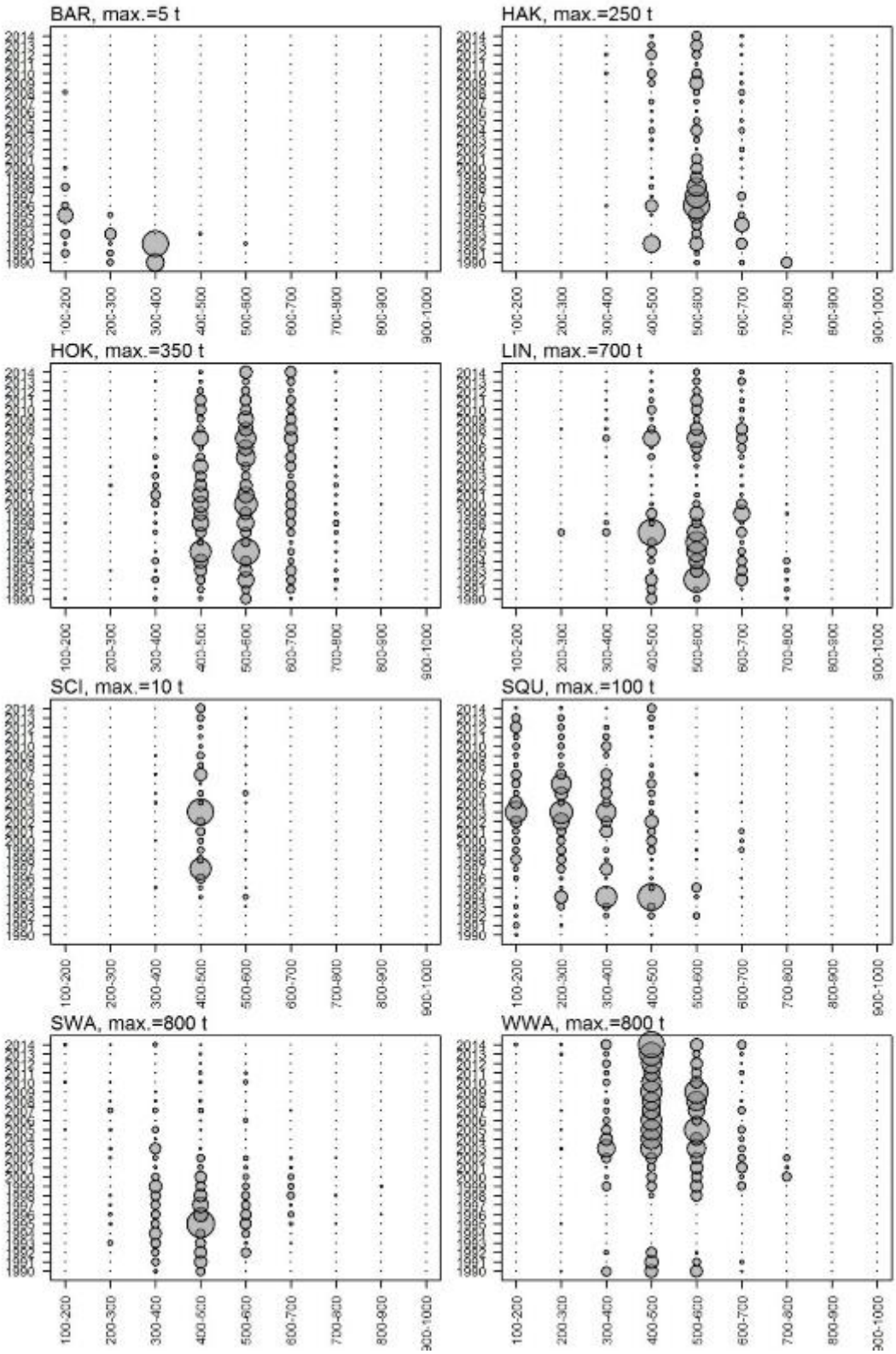


Figure C25: Distribution of white warehou annual catch (t) by bottom depth for SUBA unmerged estimated data by main target species for TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

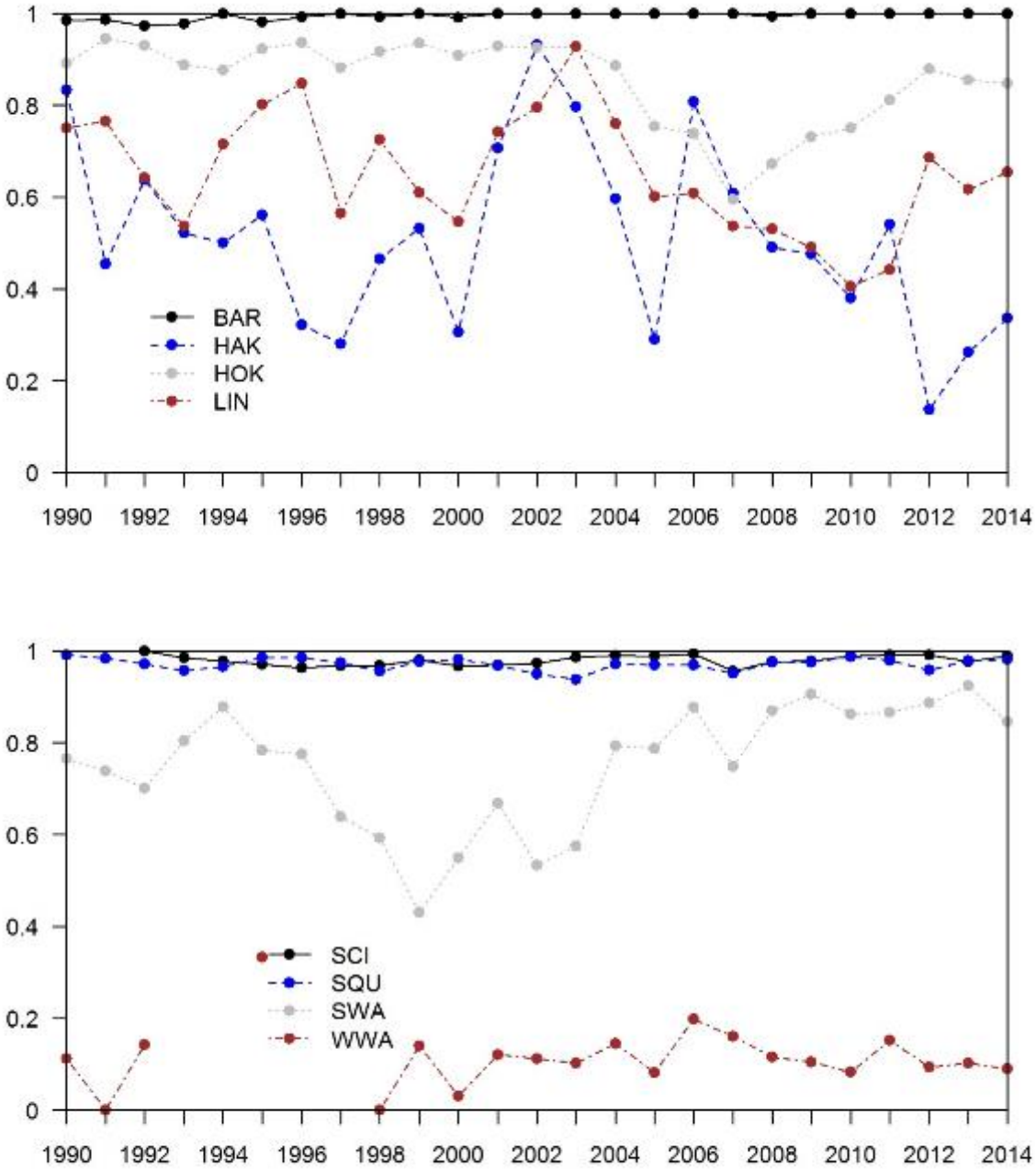


Figure C26: Proportion of zeros in unmerged estimated data by main target species in the SUBA region for TCEPR bottom tows for fishing years 1990 to 2014. Target species codes are defined in Table C12.

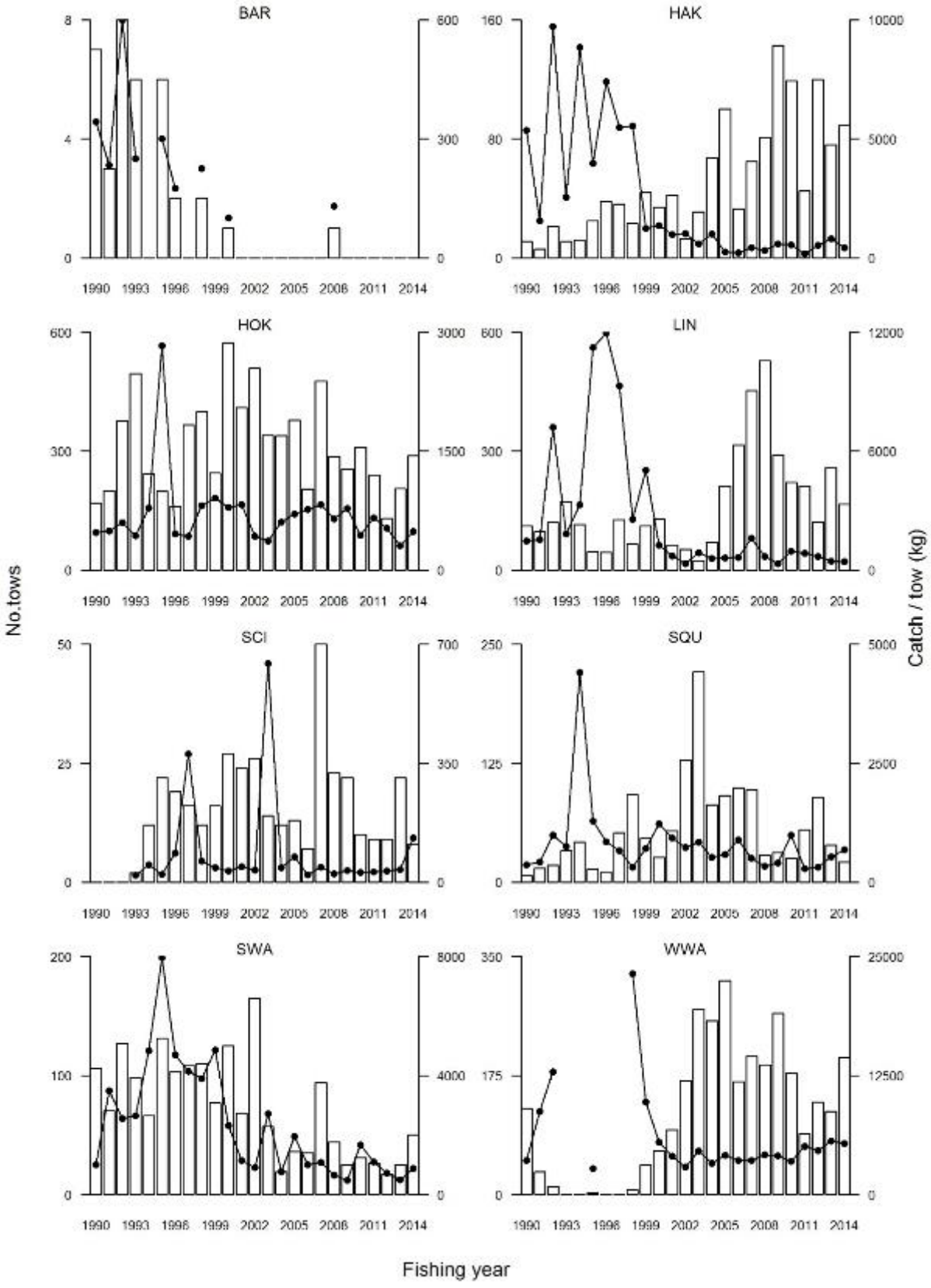


Figure C27: Unstandardised catch rate (kg/tow) of white warehou (lines), and the number of tows (bars) for the SUBA area, by main target species for unmerged estimated TCEPR bottom trawl data. Target species codes are given in Table C12.

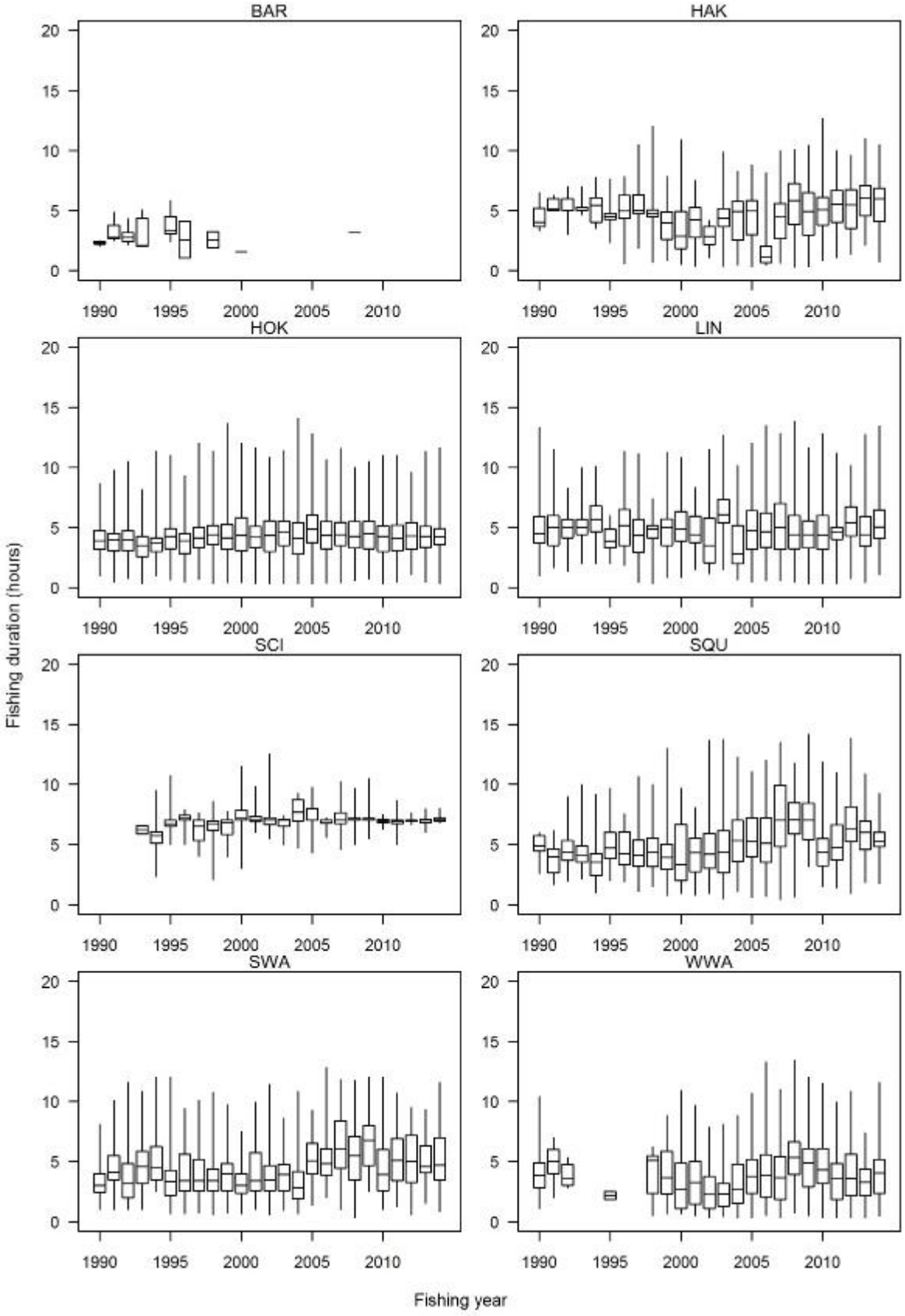


Figure C28: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during unmerged estimated TCEPR bottom trawls that caught white warehou in the SUBA area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

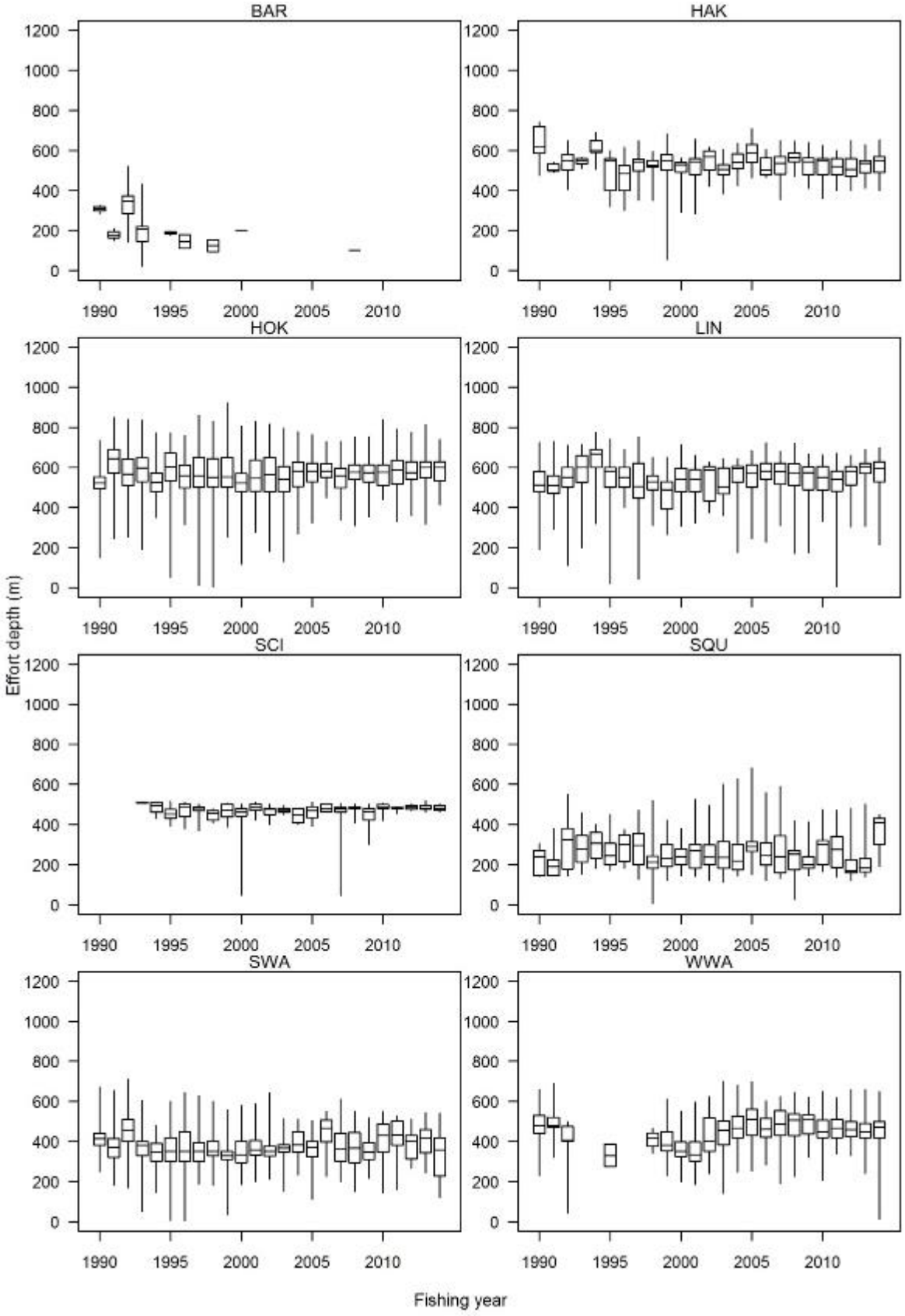


Figure C29: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished during unmerged estimated TCEPR bottom trawls that caught white warehou in the SUBA area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

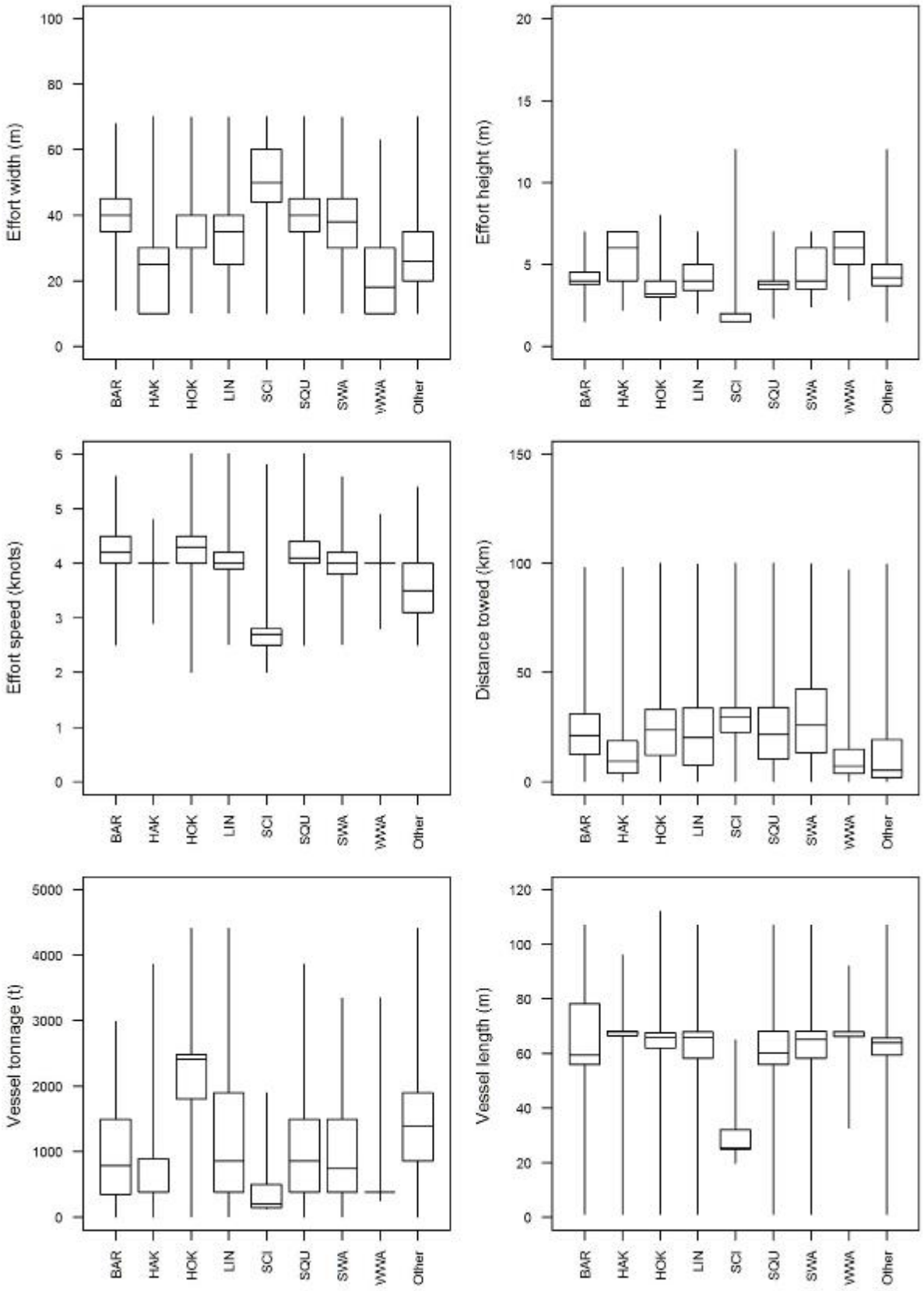


Figure C30: Distribution of fishing effort variables and vessel characteristics for the SUBA area for main target species that caught white warehou for unmerged estimated TCEPR bottom trawls for 1990 to 2014. Target species codes are given in Table C12.

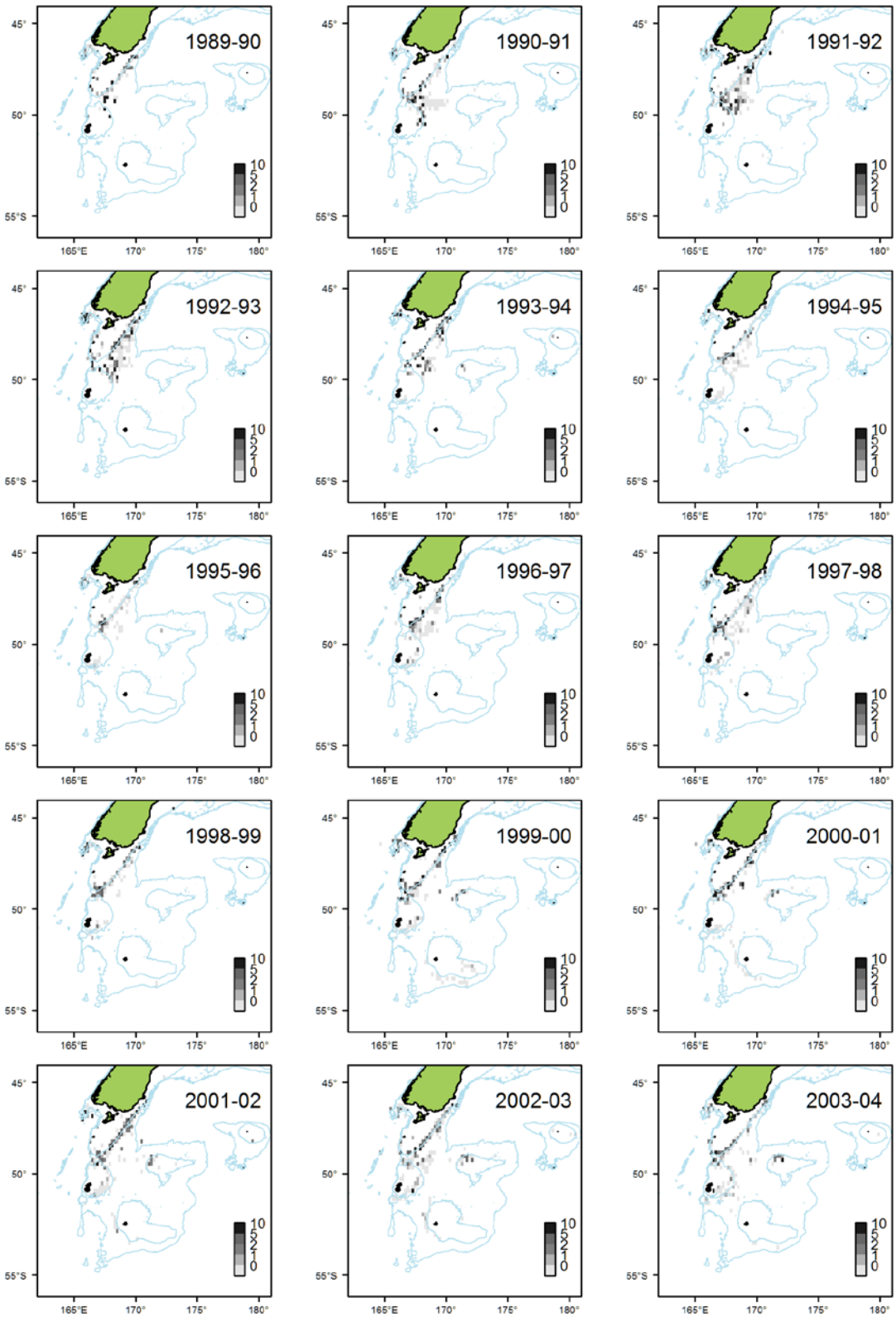


Figure C31: Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 1989–90 to 2003–04.

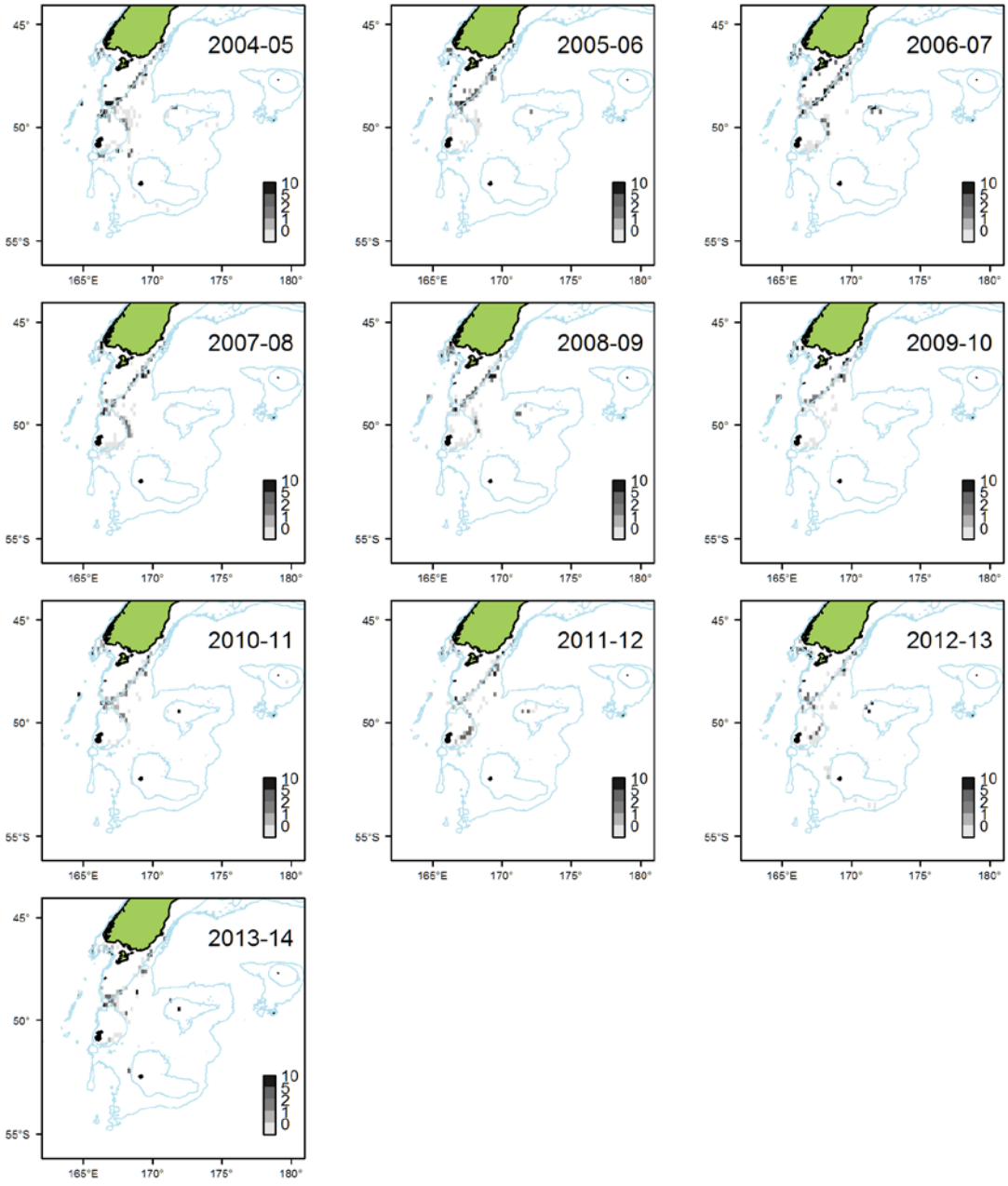


Figure C31: continued. Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 2004–05 to 2013–14.

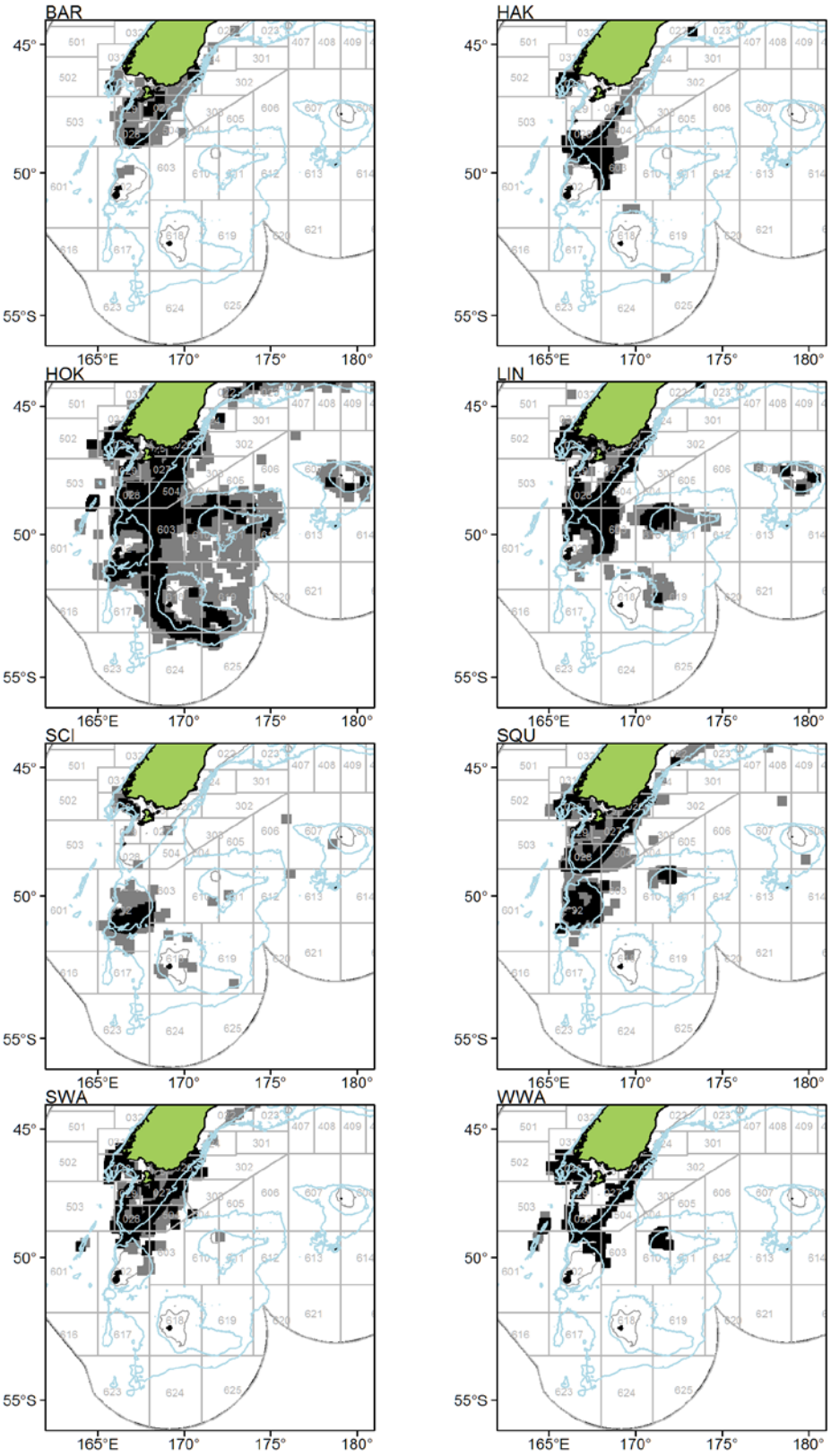


Figure C32: SUBA statistical areas and bathymetry showing the distribution of TCEPR bottom trawls by target species (grey) in the merged estimated data and bottom trawls by target species where white warehou was caught (black) for the main target species for all years combined. Target species are defined in Table C12.

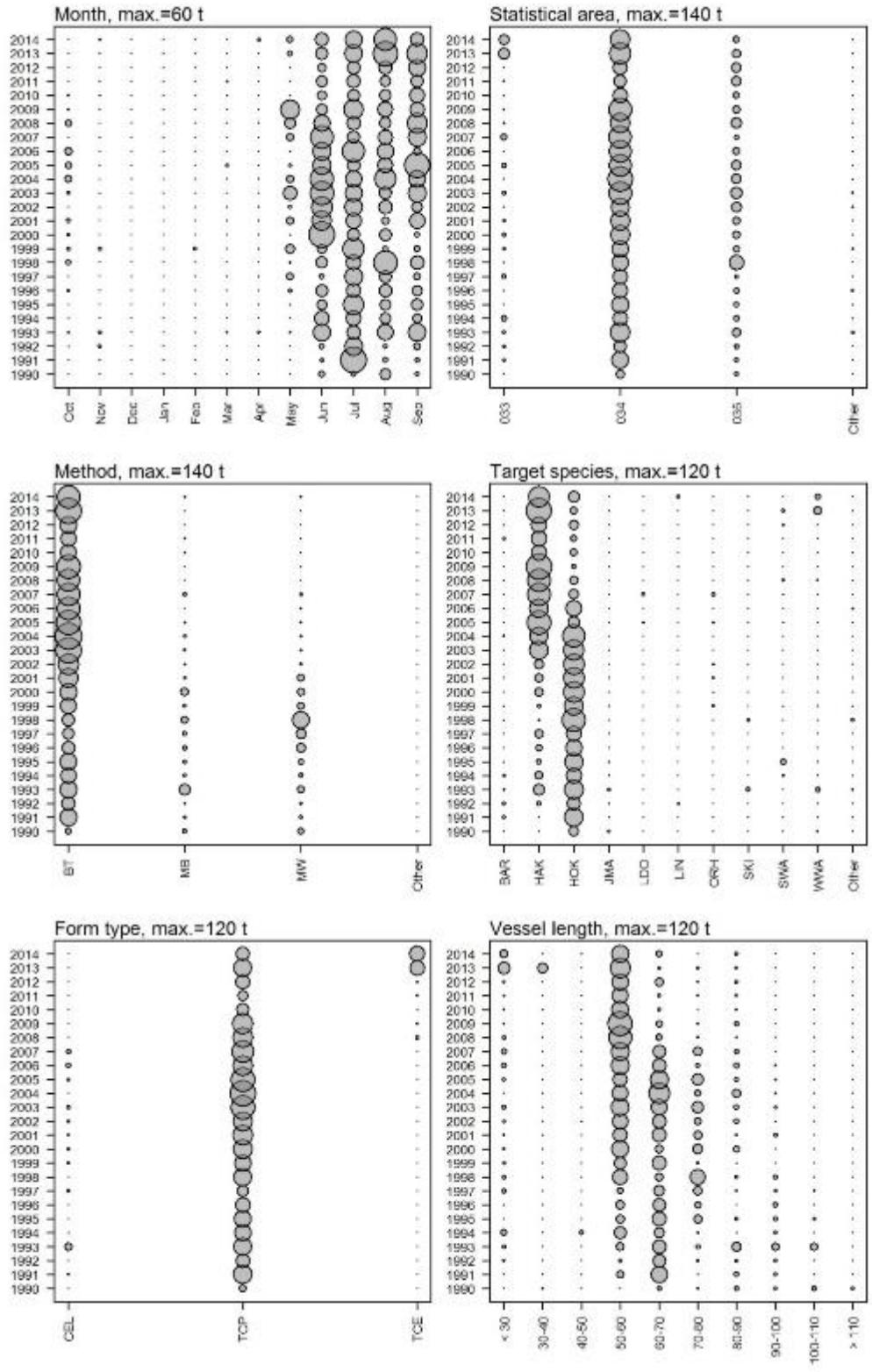


Figure C33a: Distribution of annual catch (t) by month, statistical area, method, target species, form type, and vessel length for WCSI TCEPR, CELR, and TCER estimated merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Method codes are given in Figure C10; target species codes are given in Table C12; and form types are defined in Figure C7.

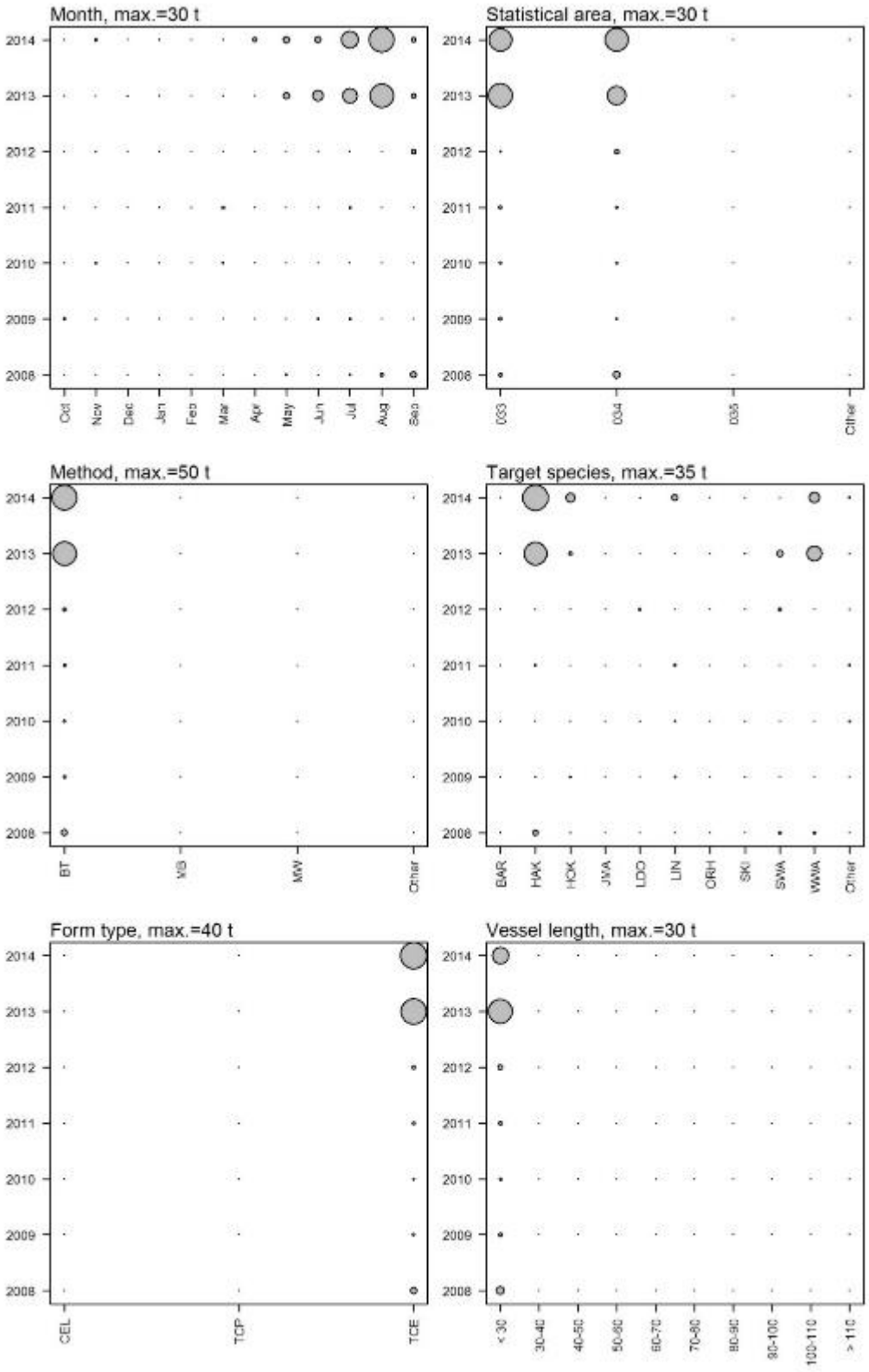


Figure C33b: Distribution of annual catch (t) by month, statistical area, method, target species, form type, and vessel length for WCSI TCER estimated merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Method codes are given in Figure C10; target species codes are given in Table C12; and form types are defined in Figure C7.

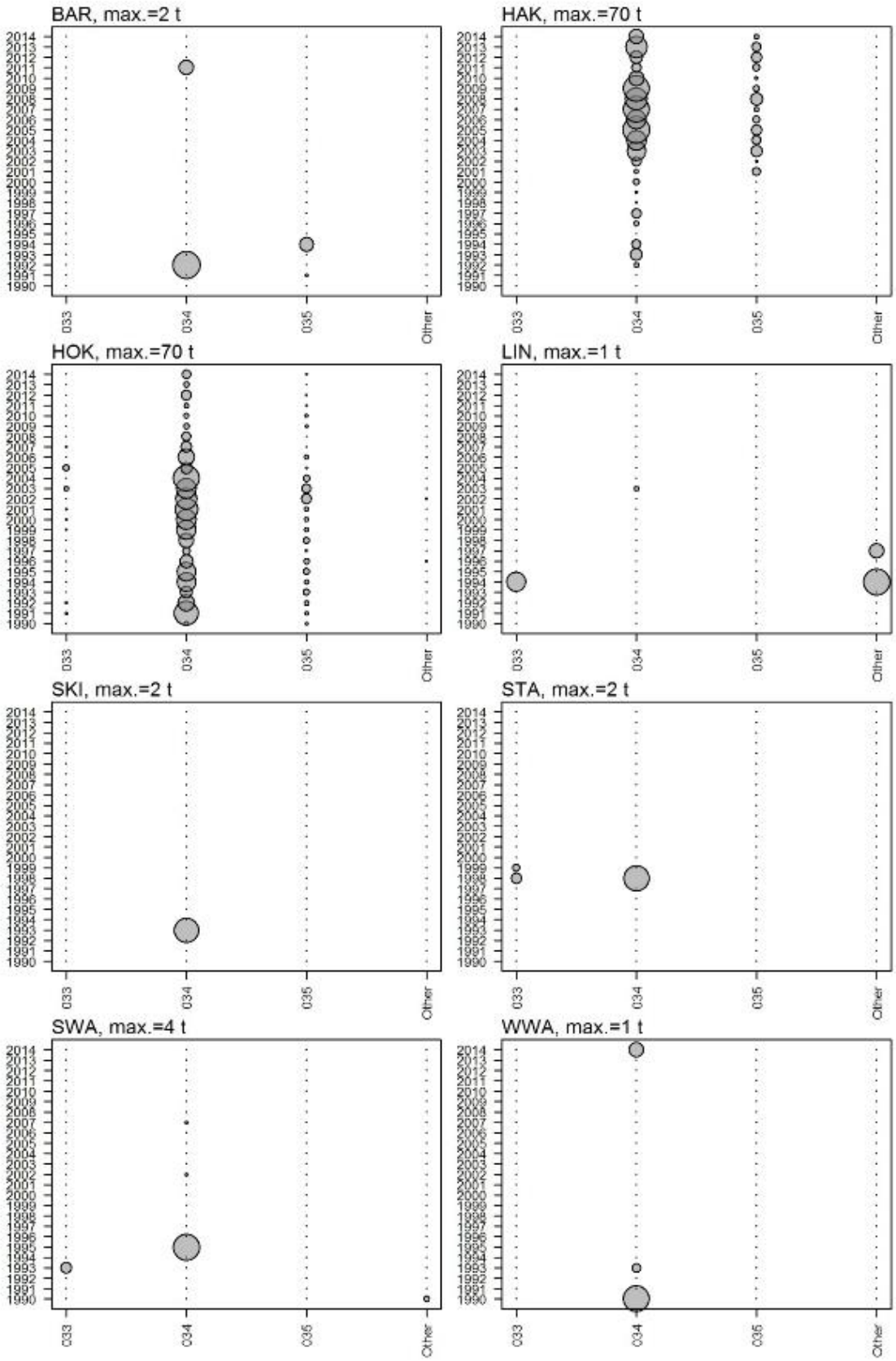


Figure C34: Distribution of white warehou annual catch (t) by statistical area for WCSI unmerged estimated data by main target species for all TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1 and Target species codes are defined in Table C12.

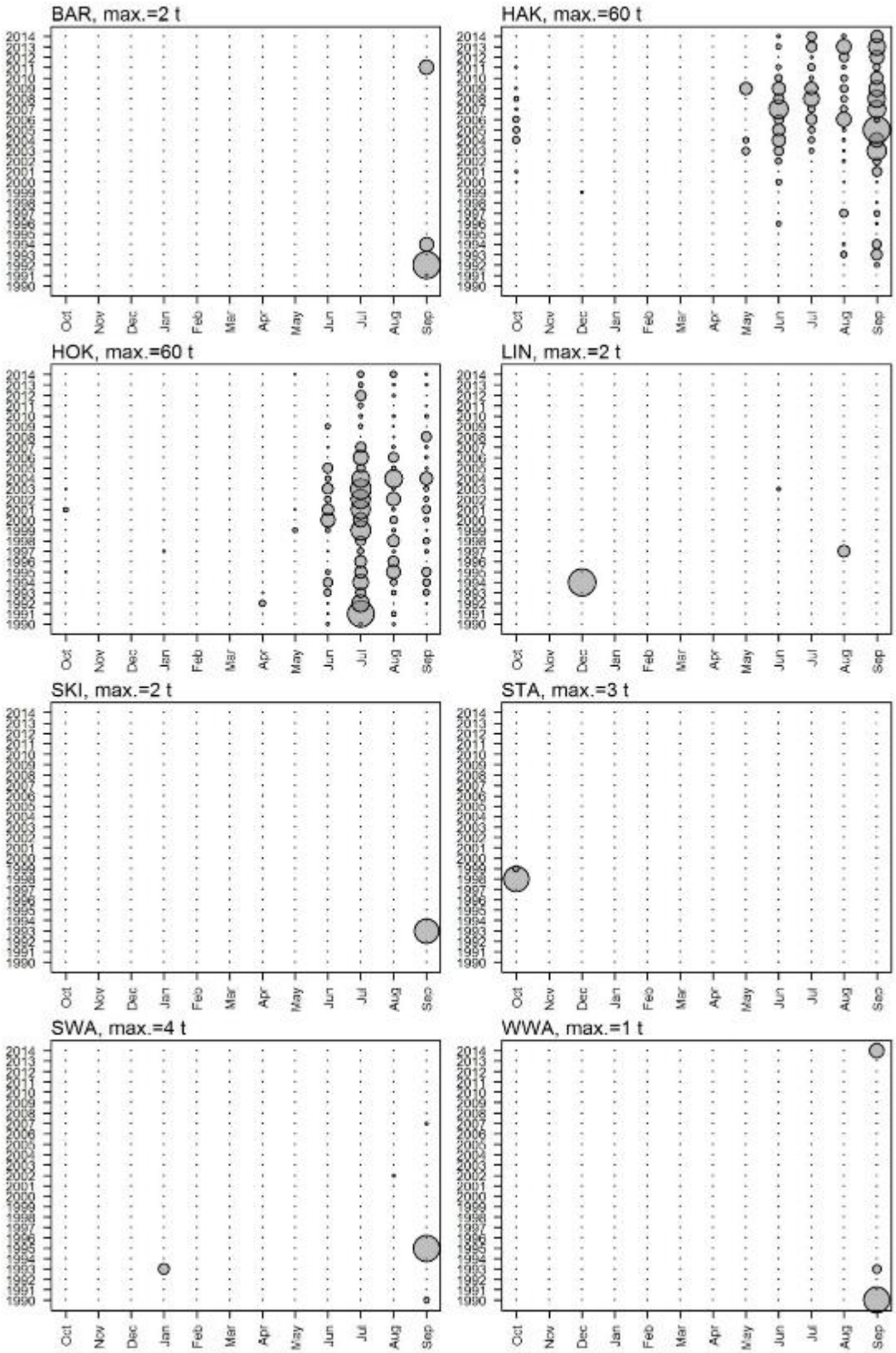


Figure C35: Distribution of white warehou annual catch (t) by month for WCSI unmerged estimated data by main target species for TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

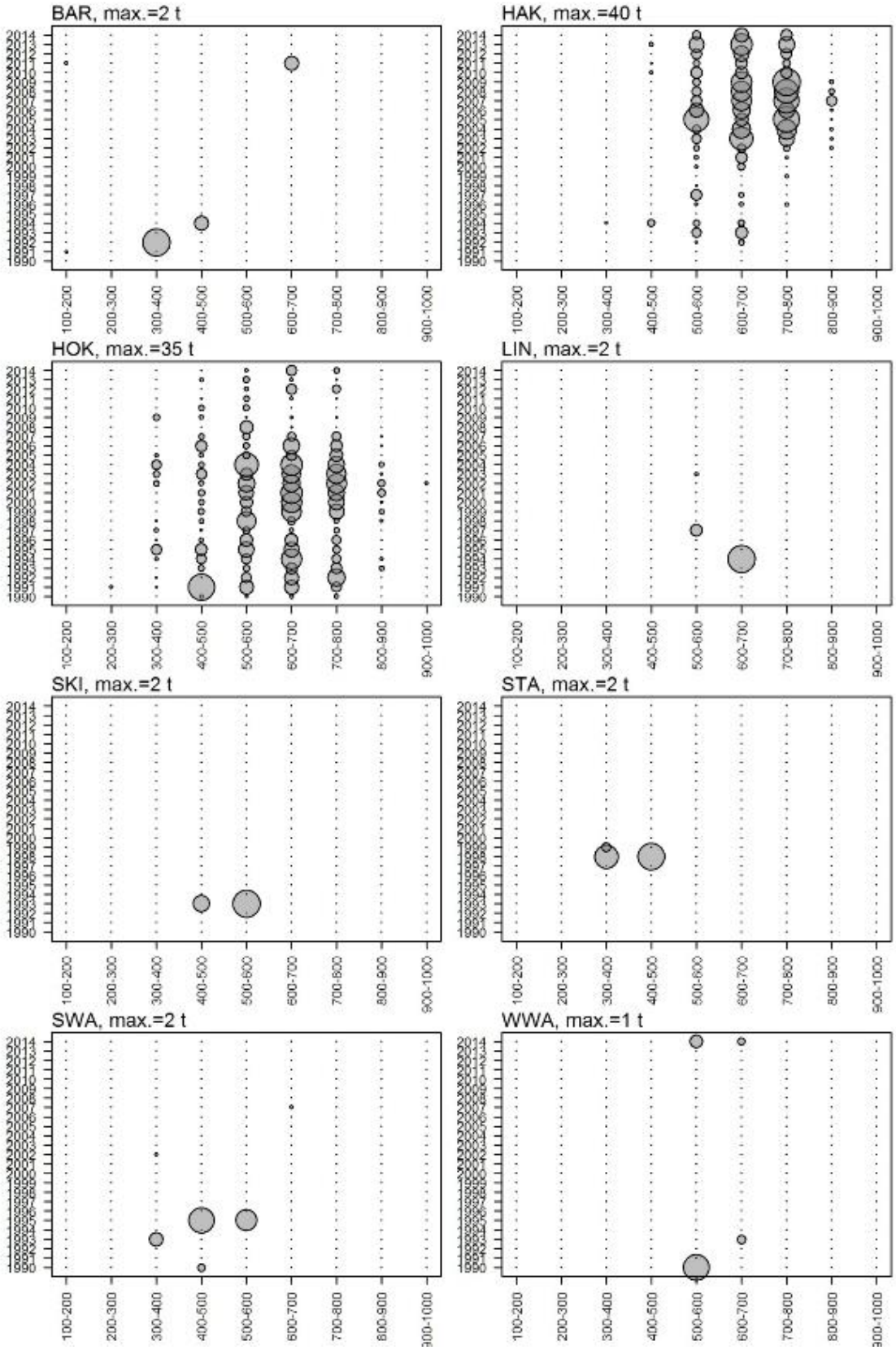


Figure C36: Distribution of white warehou annual catch (t) by bottom depth for WCSI unmerged estimated data by main target species for TCEPR bottom trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

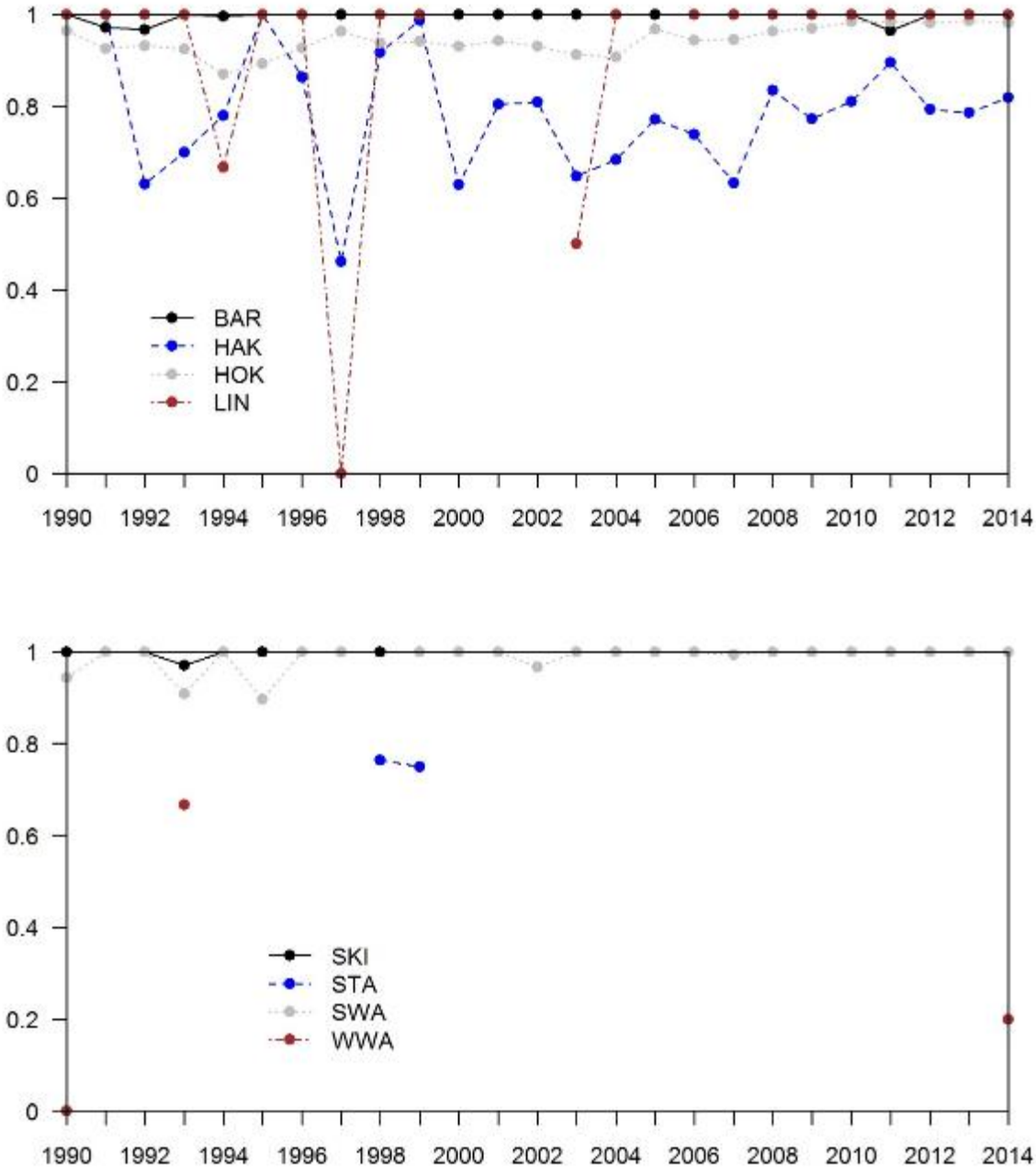


Figure C37: Proportion of zeros in unmerged estimated data by main target species in the WCSI region for estimated TCEPR bottom tows for fishing years 1990 to 2014. Target species codes are defined in Table C12.

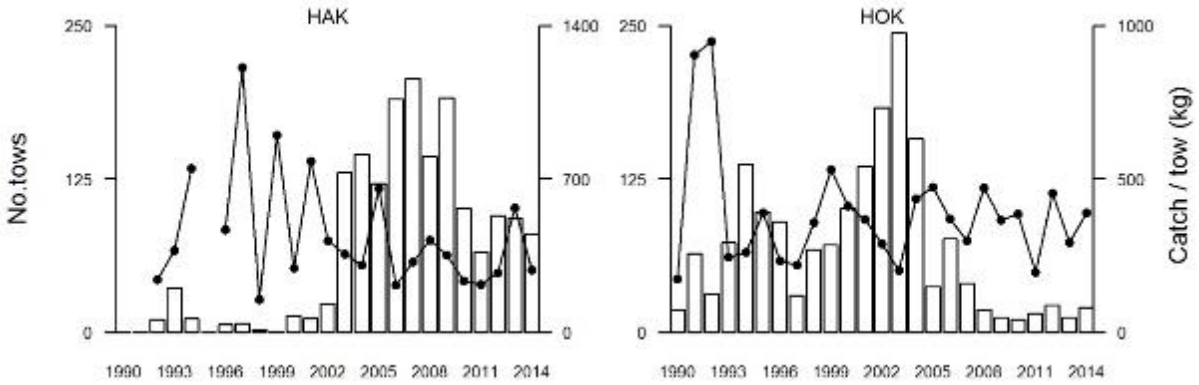


Figure C38: Unstandardised catch rate (kg/tow) of white warehou (lines), and the number of tows (bars) for the WCSI area, by main target species for unmerged estimated TCEPR bottom trawl data. Target species codes are given in Table C12.

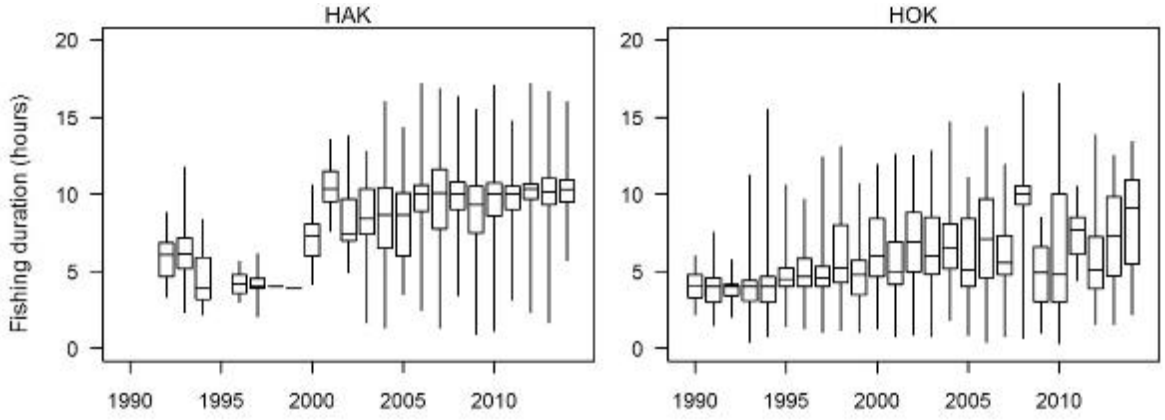


Figure C39: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during unmerged estimated TCEPR bottom trawls that caught white warehou in the WCSI area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

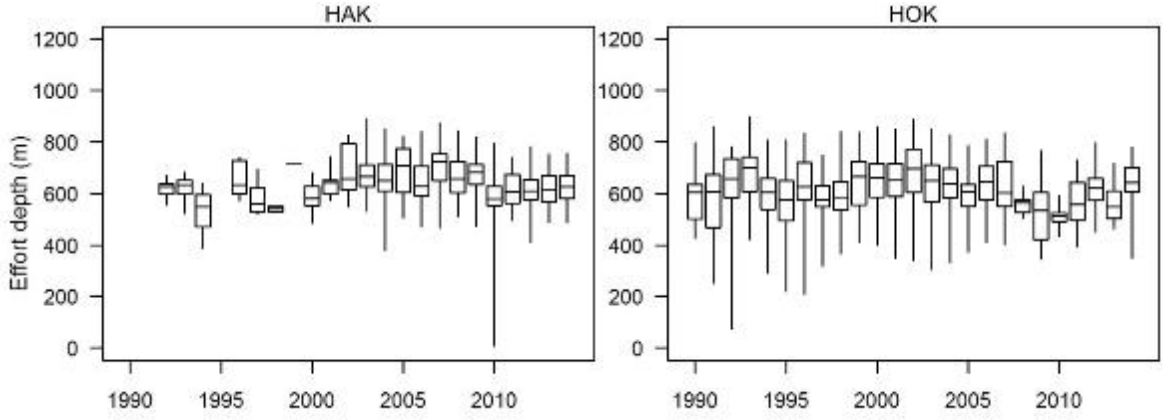


Figure C40: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished during unmerged estimated TCEPR bottom trawls that caught white warehou in the WCSI area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

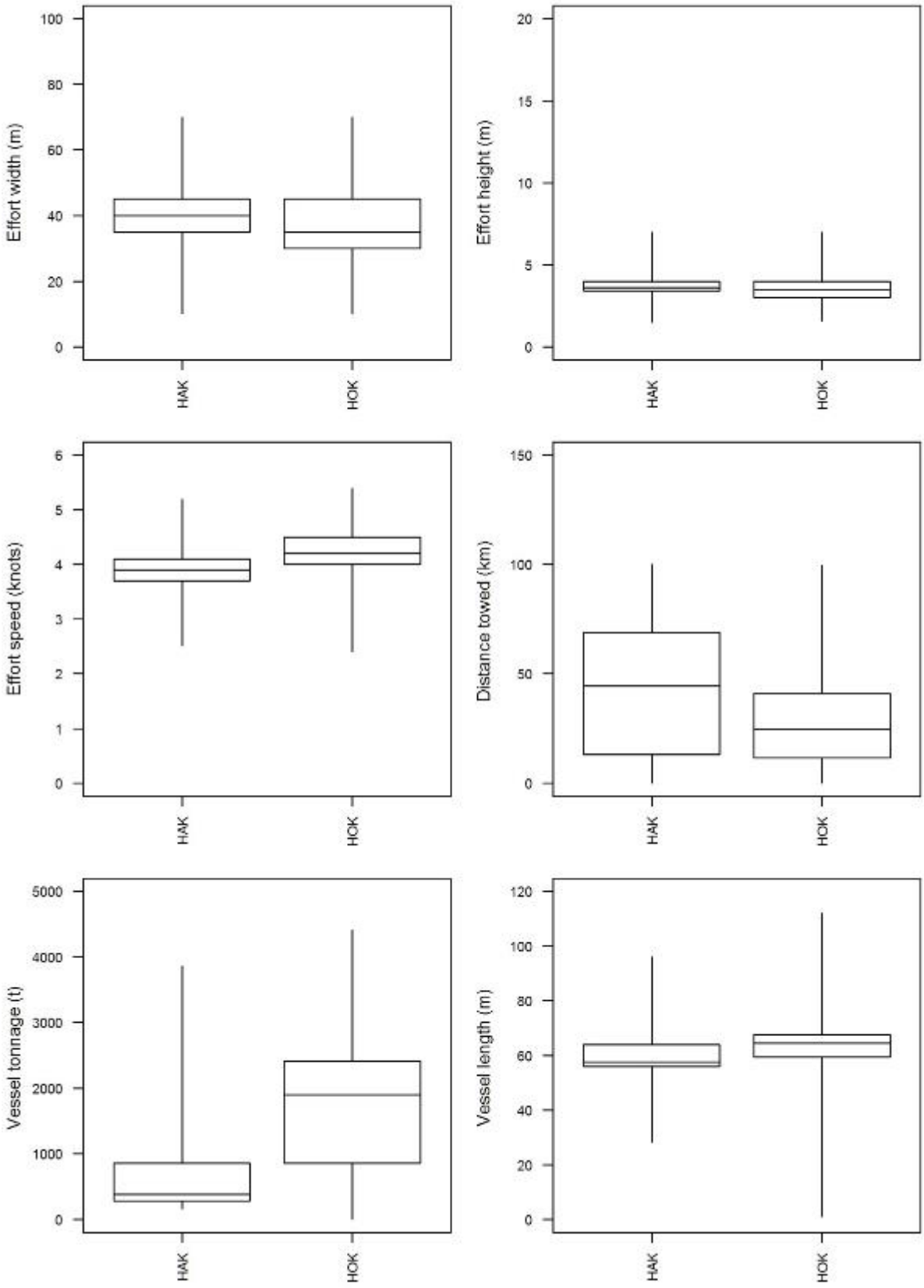


Figure C41: Distribution of fishing effort variables and vessel characteristics for the WCSI area or main target species that caught white warehou for unmerged estimated TCEPR bottom trawls for 1990 to 2014. Target species codes are given in Table C12.

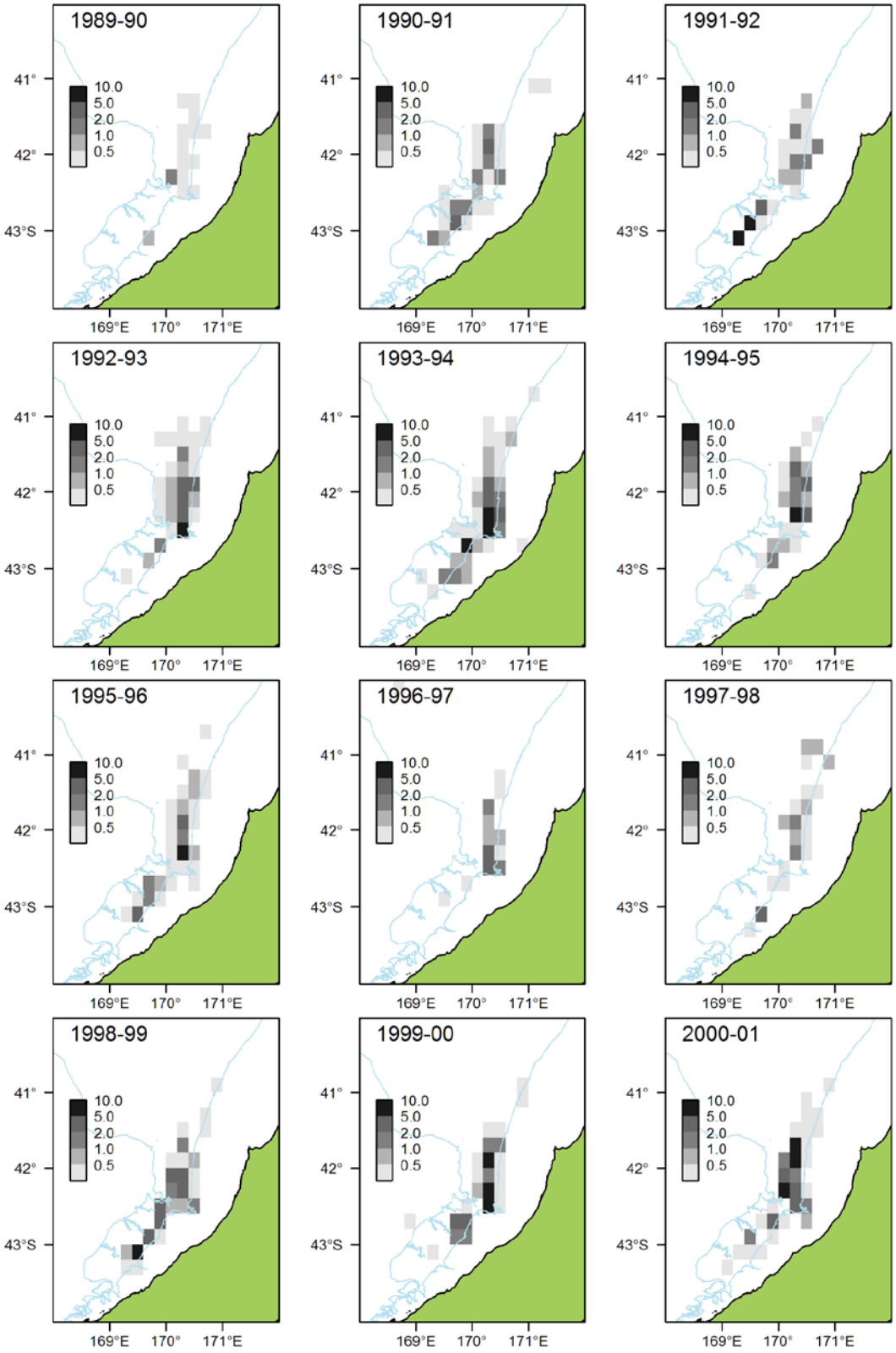


Figure C42a: Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the WCSI area, for 1989–90 to 2000–01.

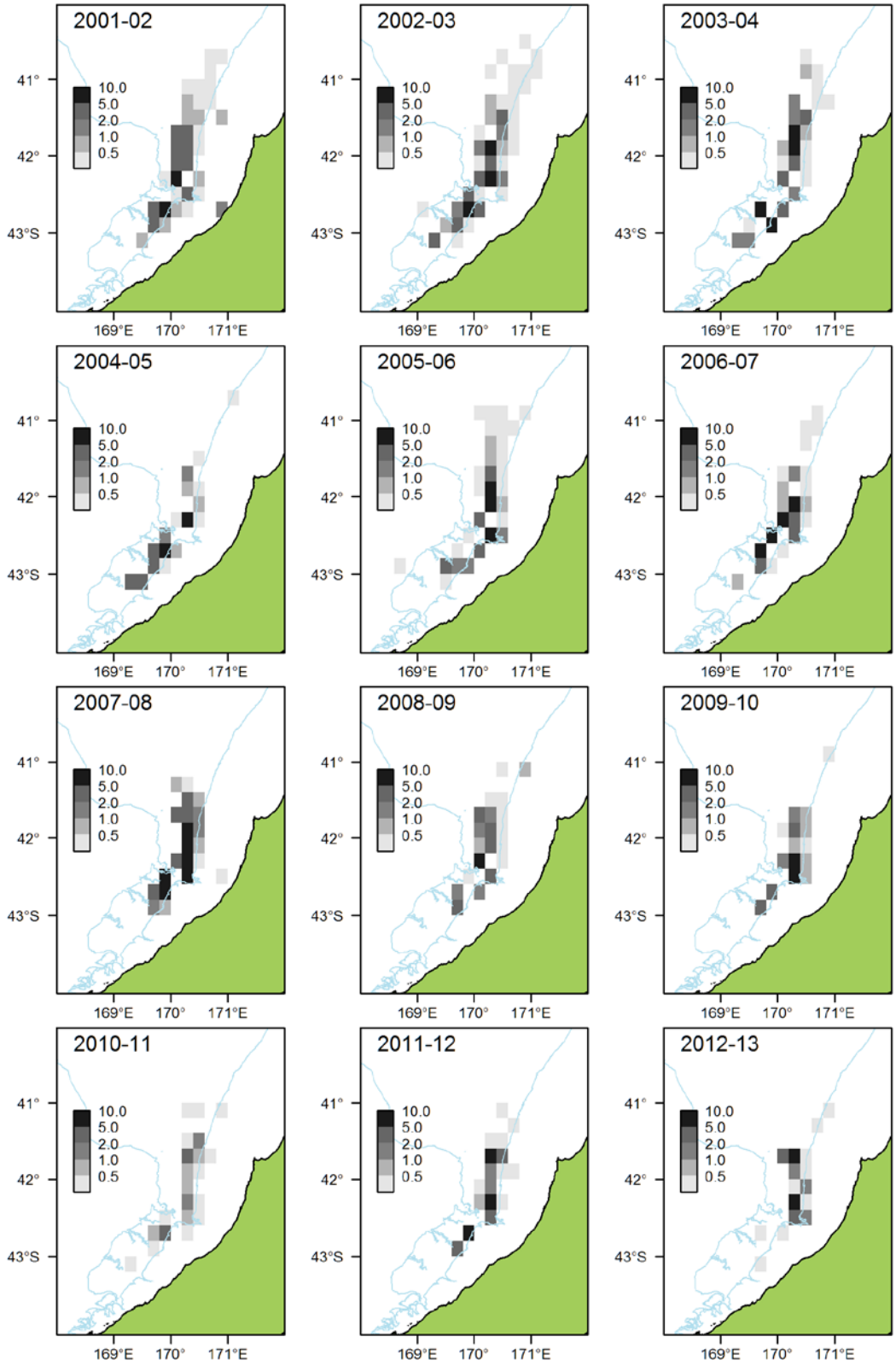


Figure C42a: ctd. Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the WCSI area, for 2001–02 to 2012–13.

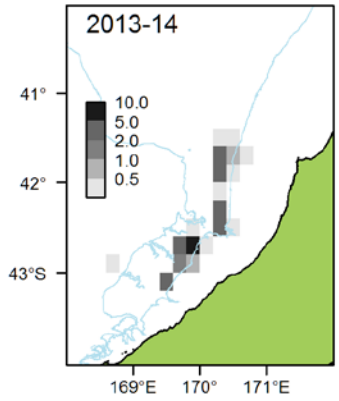


Figure C42a: ctd. Distribution of estimated TCEPR bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the WCSI area, for 2013–14.

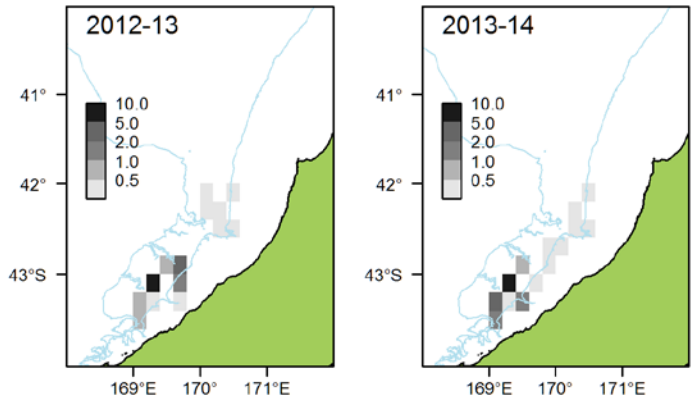


Figure C42b: Distribution of TCER bottom trawl white warehou catch (t) aggregated into 0.2° spatial blocks within the WCSI area, for 2012–13 and 2013–14

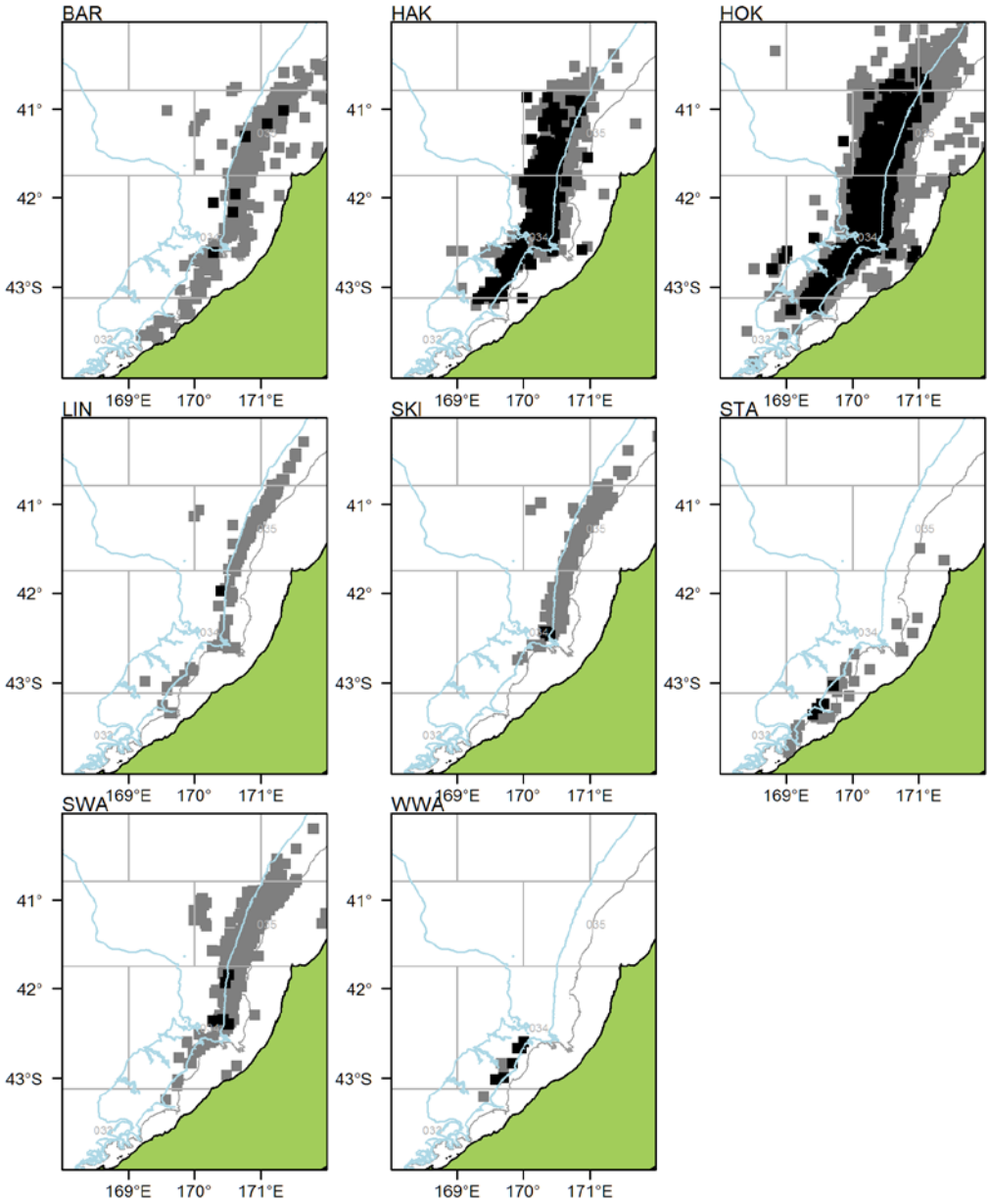


Figure C43a: WCSI statistical areas and bathymetry showing the distribution of TCEPR bottom trawls by target species (grey) in the merged estimated data and bottom trawls by target species where white warehou was caught (black) for the main target species for all years combined. Target species are defined in Table C12.

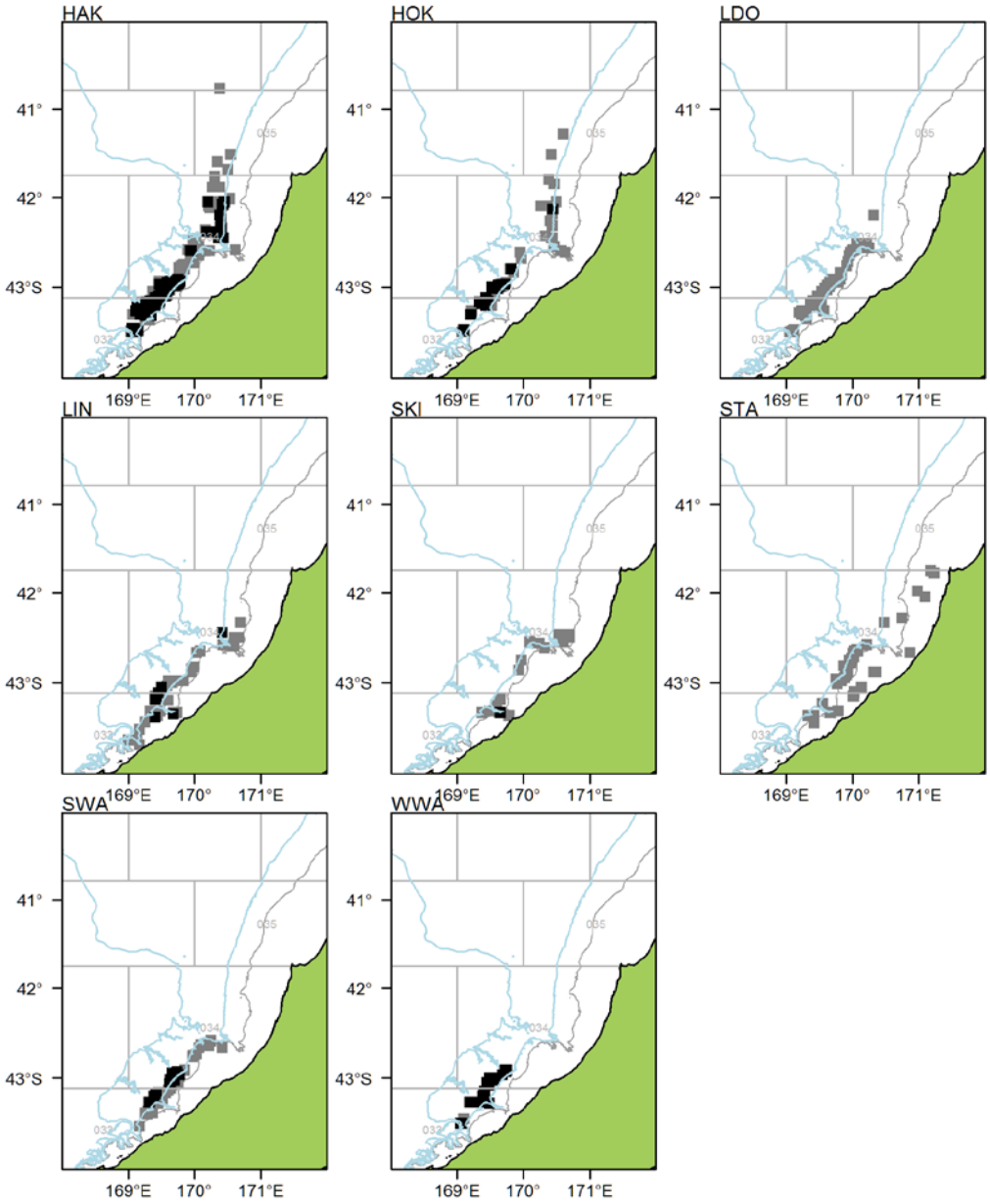


Figure C43b: WCSI statistical areas and bathymetry showing the distribution of TCER bottom trawls by target species (grey) in the merged estimated data and bottom trawls by target species where white warehou was caught (black) for the main target species for all years combined. Target species are defined in Table C12.

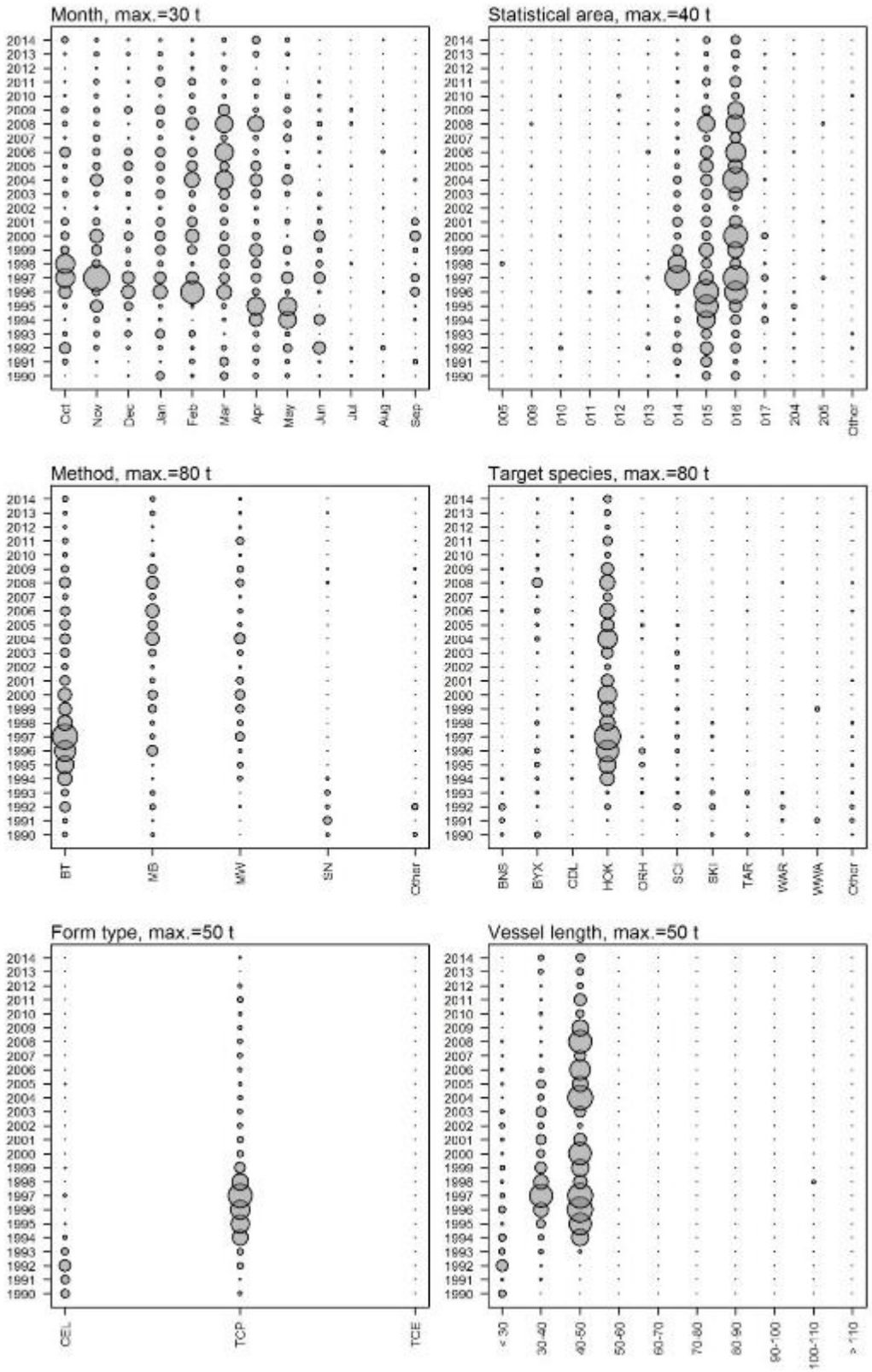
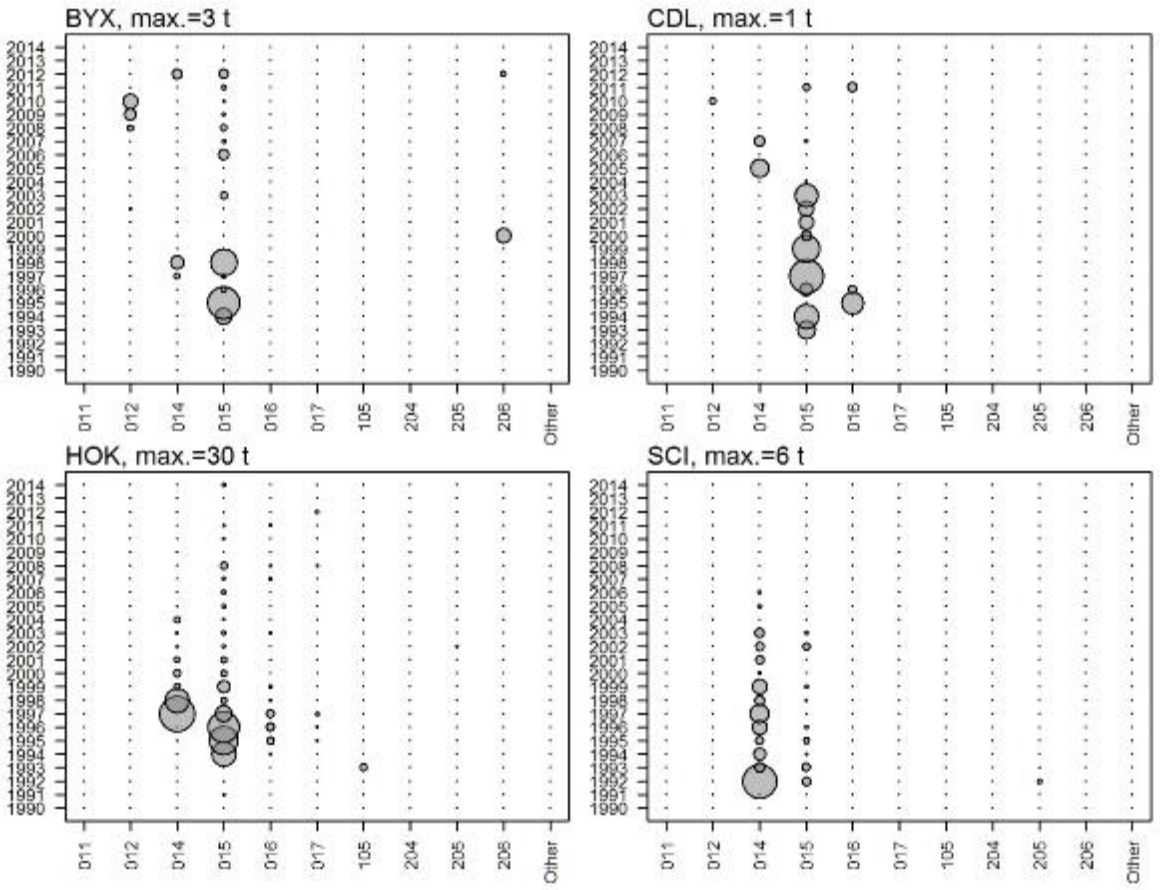


Figure C44: Distribution of annual catch (t) by month, statistical area, method, target species, form type, and vessel length for ECNI estimated merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Method codes are given in Figure C10; target species codes are given in Table C12; and form types are defined in Figure C7.

(a) Bottom trawls



(b) Midwater trawls

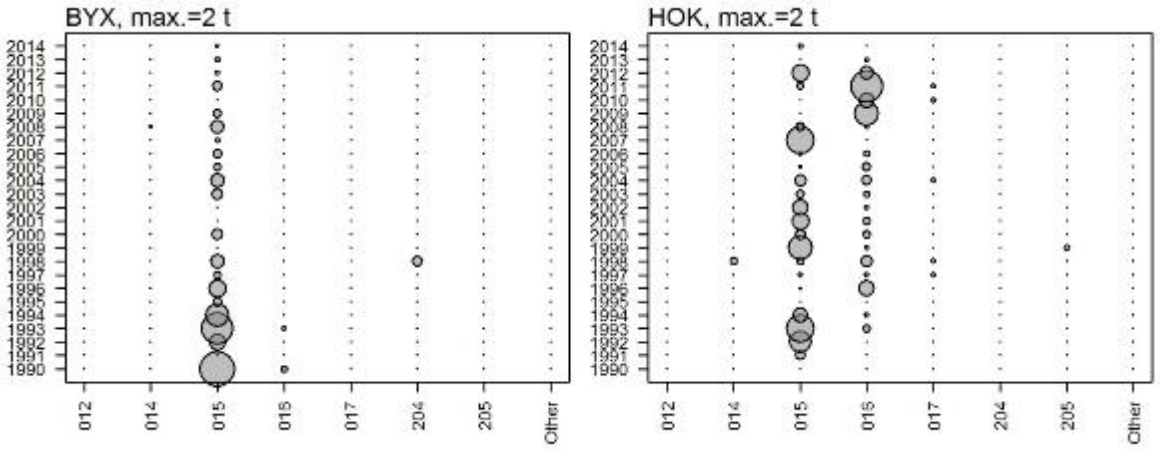
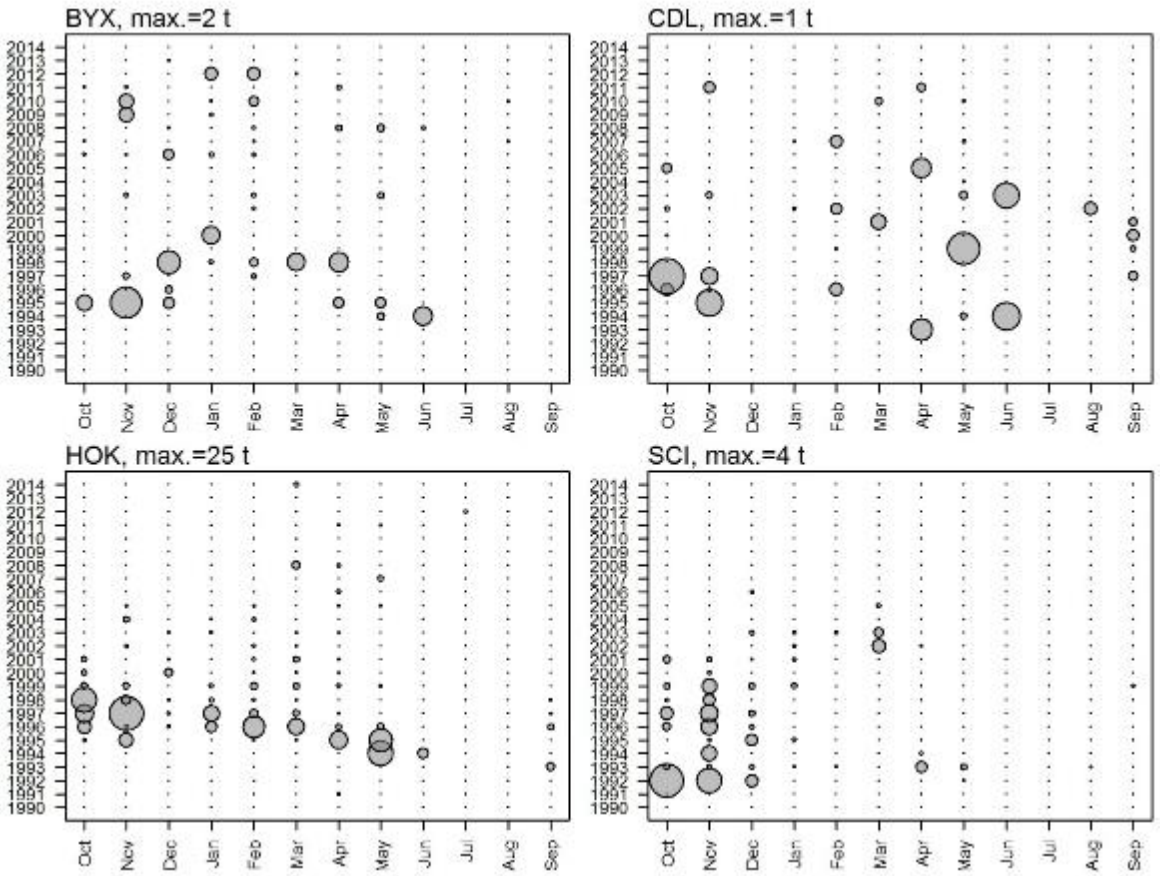


Figure C45: Distribution of white warehou annual catch (t) by statistical area for ECNI unmerged estimated data trawls by main target species for all TCEPR bottom and midwater trawls trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1 and Target species codes are defined in Table C12.

(a) Bottom trawls



(b) Midwater trawls

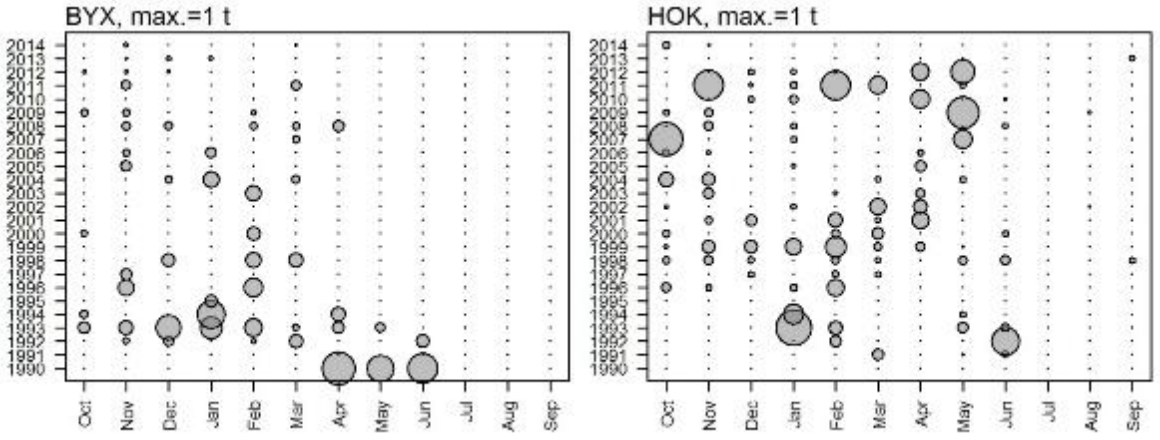
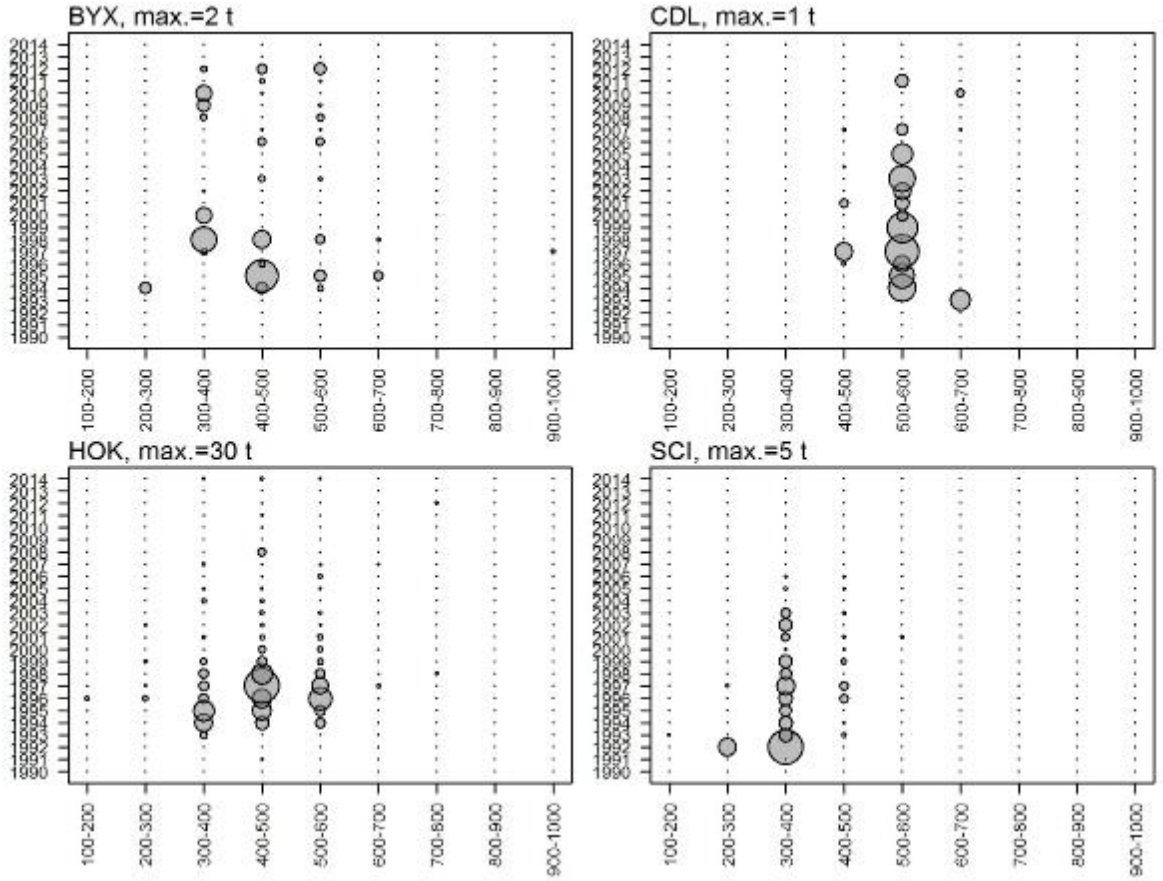


Figure C46: Distribution of white warehou annual catch (t) by month for ECNI unmerged estimated data trawls by main target species for TCEPR bottom and midwater trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

(a) Bottom trawls



(b) Midwater trawls

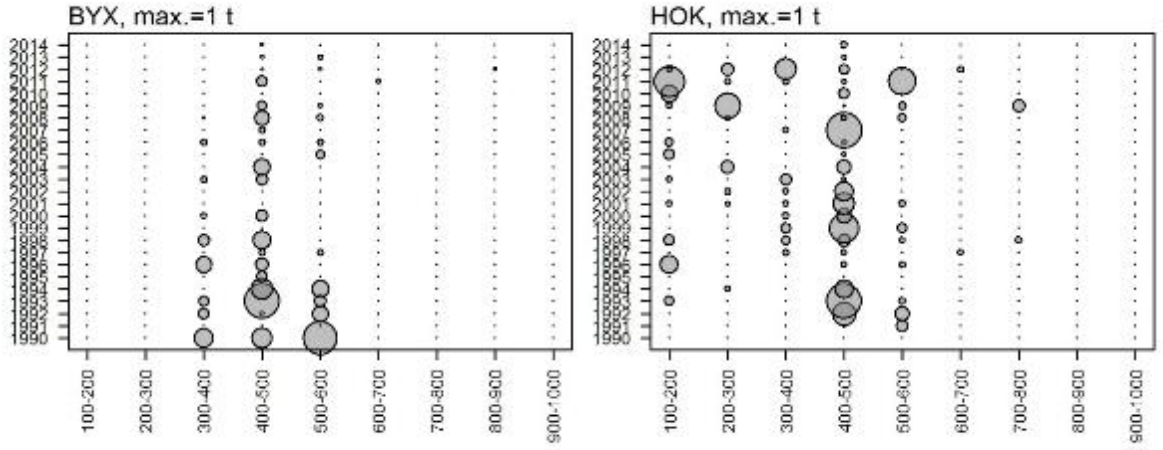
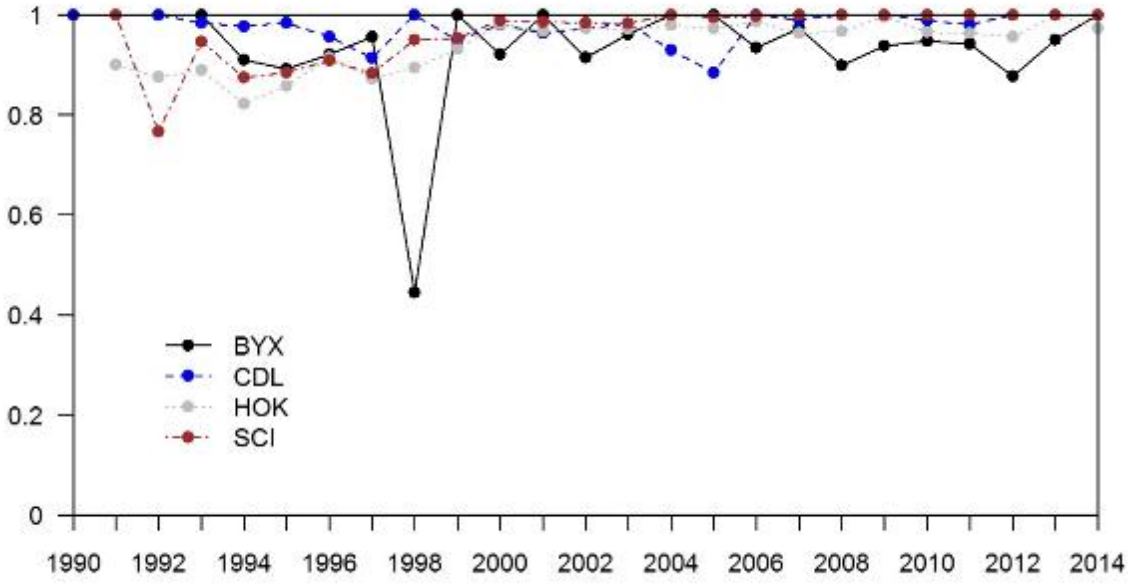


Figure C47: Distribution of white warehou annual catch (t) by bottom depth for ECNI unmerged estimated data by main target species for TCEPR for bottom and midwater trawl tows for fishing years 1990 to 2014. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are defined in Table C12.

(a) Bottom trawls



(b) Midwater trawls

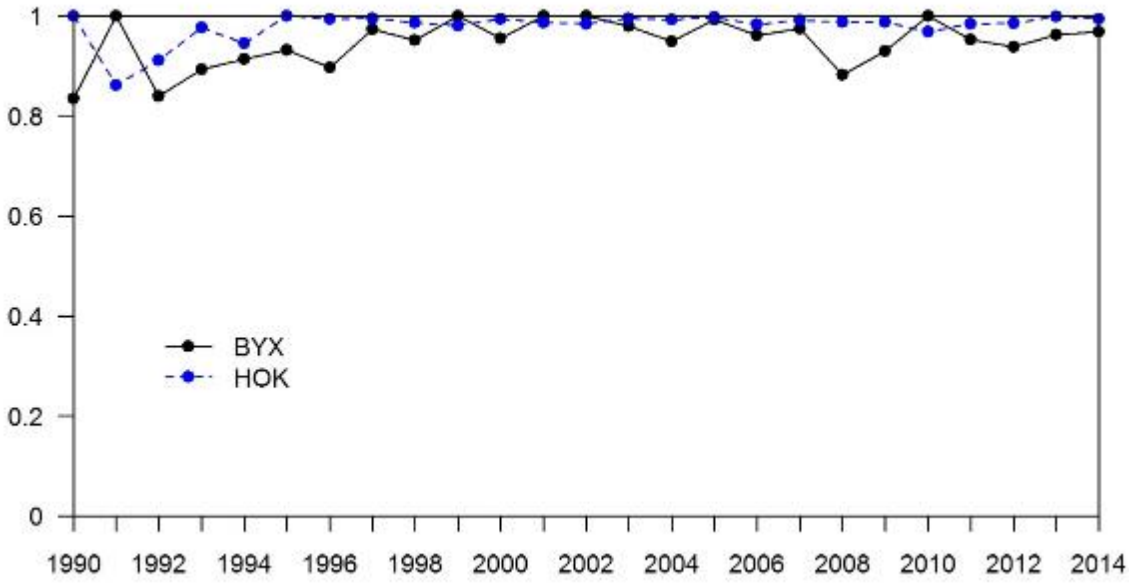
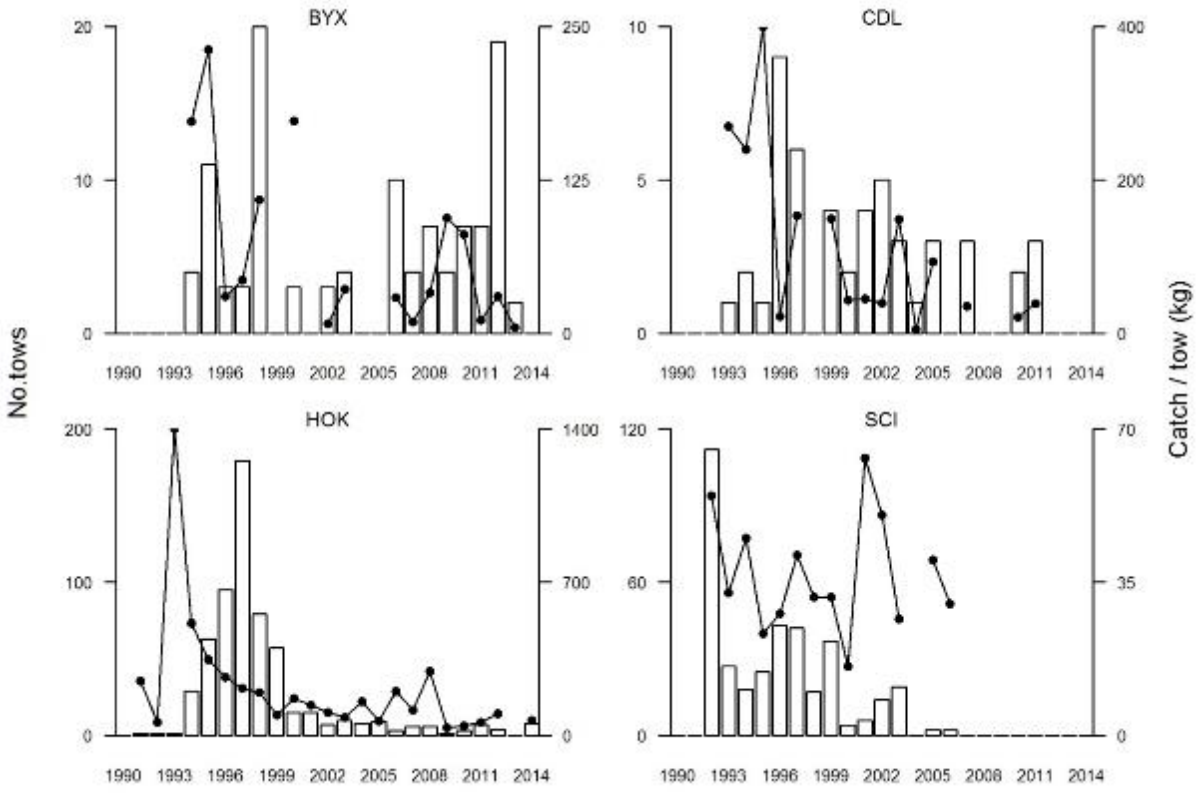


Figure C48: Proportion of zeros in unmerged estimated data by main target species in the ECNI region for TCEPR bottom and midwater trawls for fishing years 1990 to 2014. Target species codes are defined in Table C12.

(a) Bottom trawls



(b) Midwater trawls

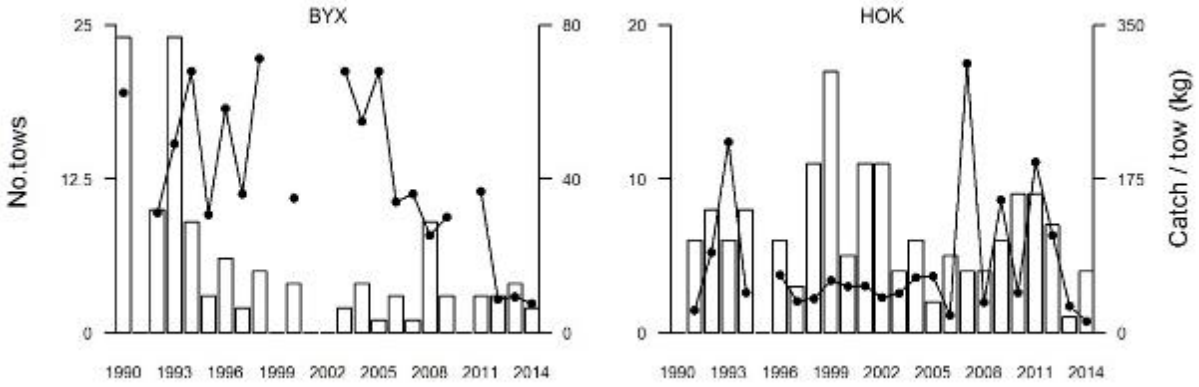
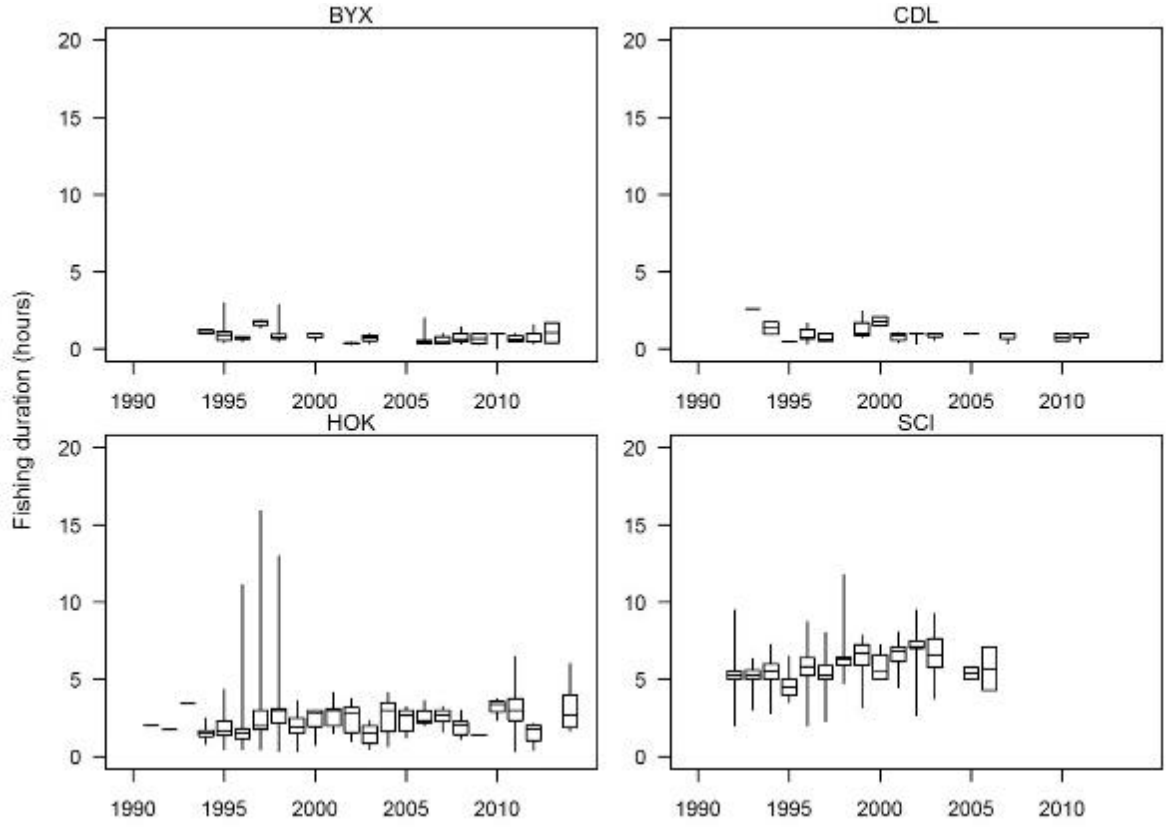


Figure C49: Unstandardised catch rate (kg/tow) of white warehou (lines), and the number of tows (bars) for the ECNI area, by main target species for unmerged estimated TCEPR bottom and midwater trawl data. Target species codes are given in Table C12.

(a) Bottom trawls



(b) Midwater trawls

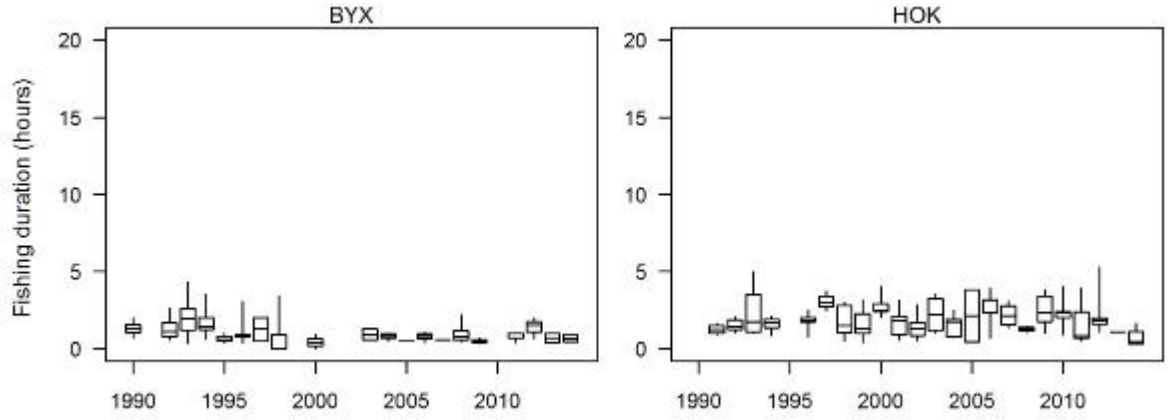
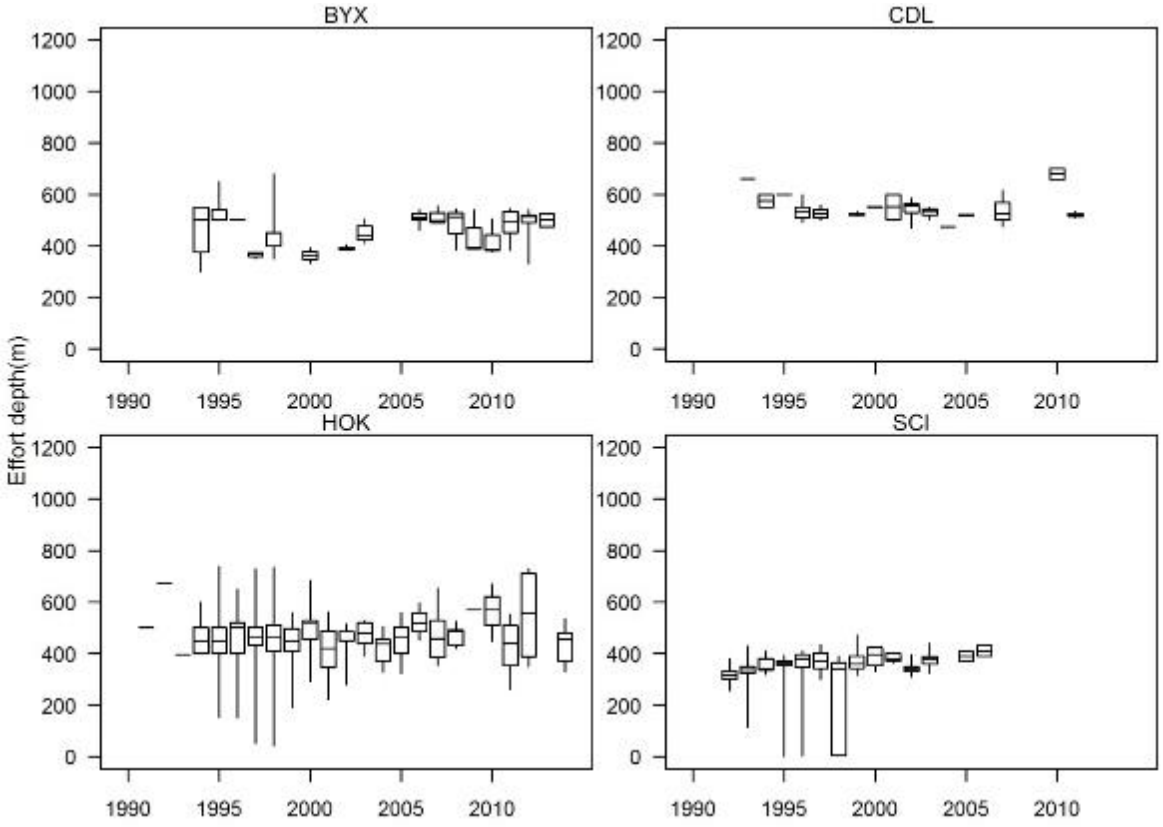


Figure C50: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during unmerged estimated TCEPR bottom and midwater trawls that caught white warehou in the ECNI area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

(a) Bottom trawls



(b) Midwater trawls

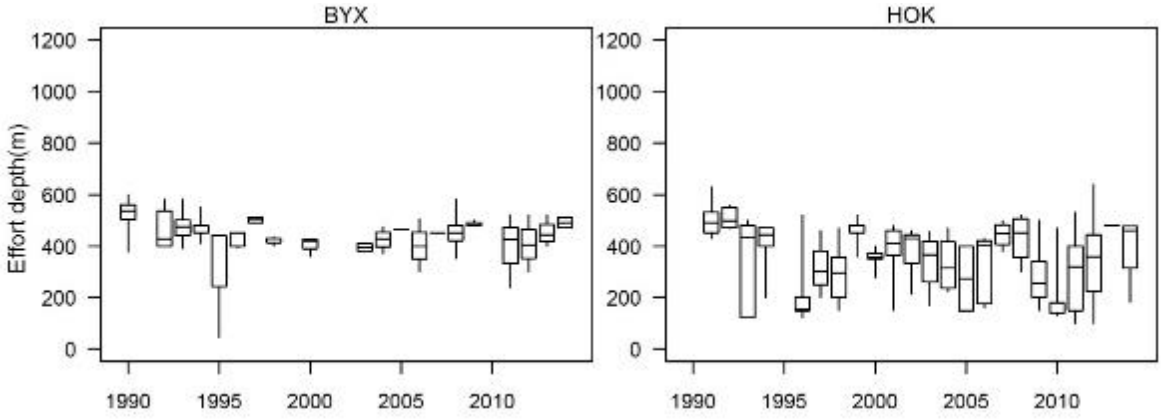


Figure C51: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished during unmerged estimated TCEPR bottom and midwater trawls that caught white warehou in the ECNI area, by main target species and fishing year for 1990 to 2014. Target species codes are given in Table C12.

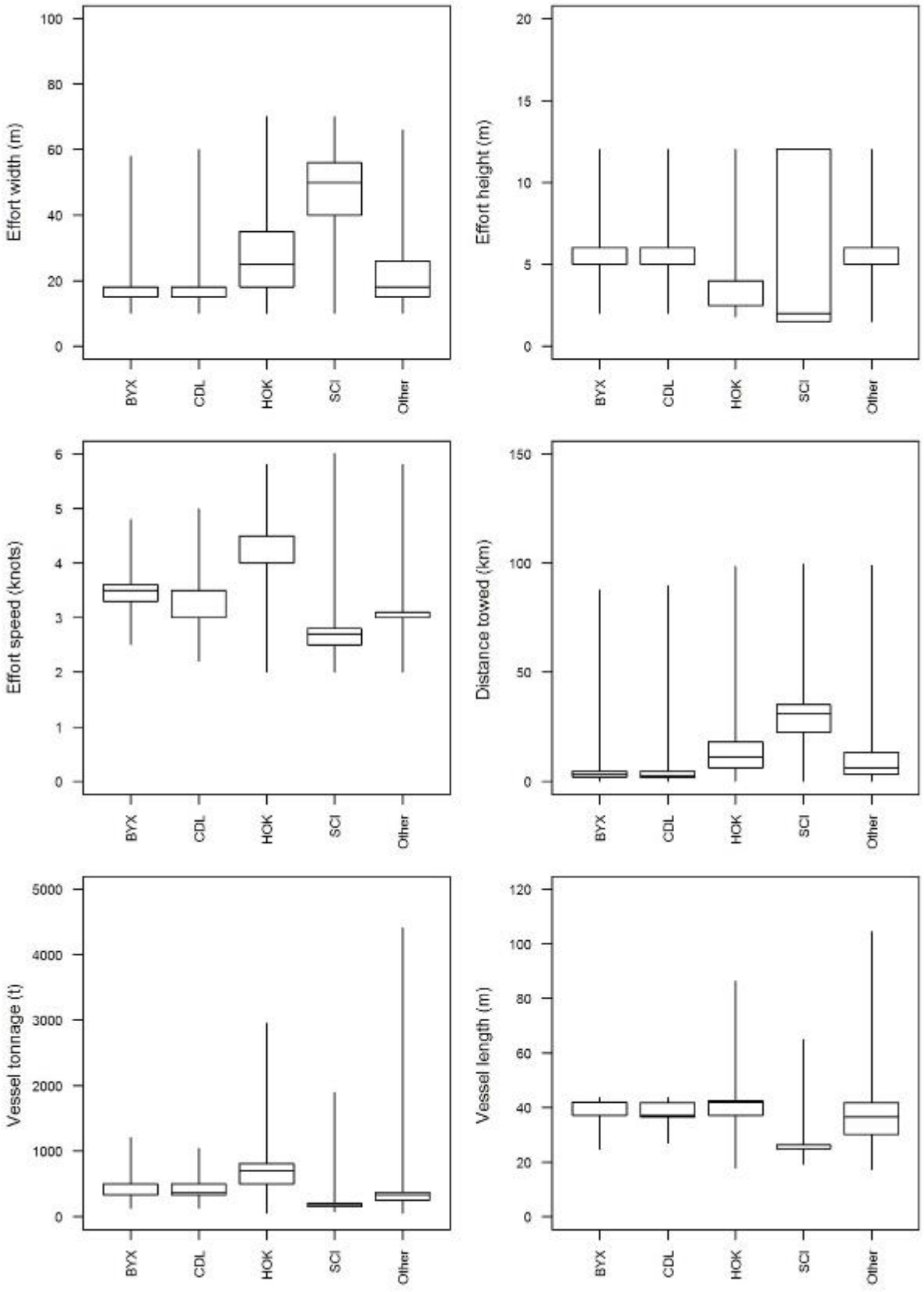


Figure C52a: Distribution of fishing effort variables and vessel characteristics for the ECNI area for main target species that caught white warehou for unmerged estimated TCEPR bottom trawls for 1990 to 2014. Target species codes are given in Table C12.

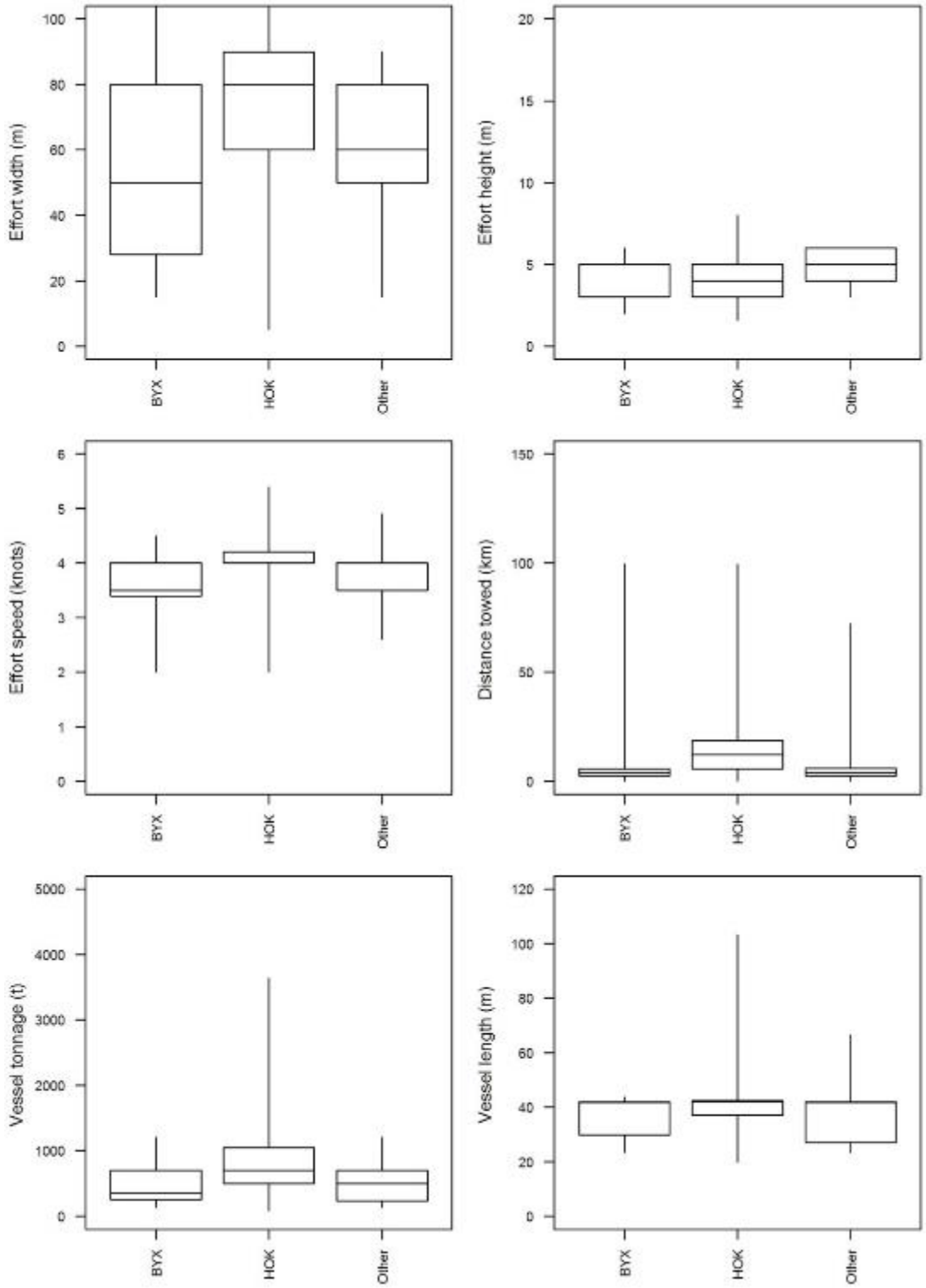


Figure C52b: Distribution of fishing effort variables and vessel characteristics for the ECNI area for main target species that caught white warehou for unmerged estimated TCEPR midwater trawls for 1990 to 2014. Target species codes are given in Table C12.

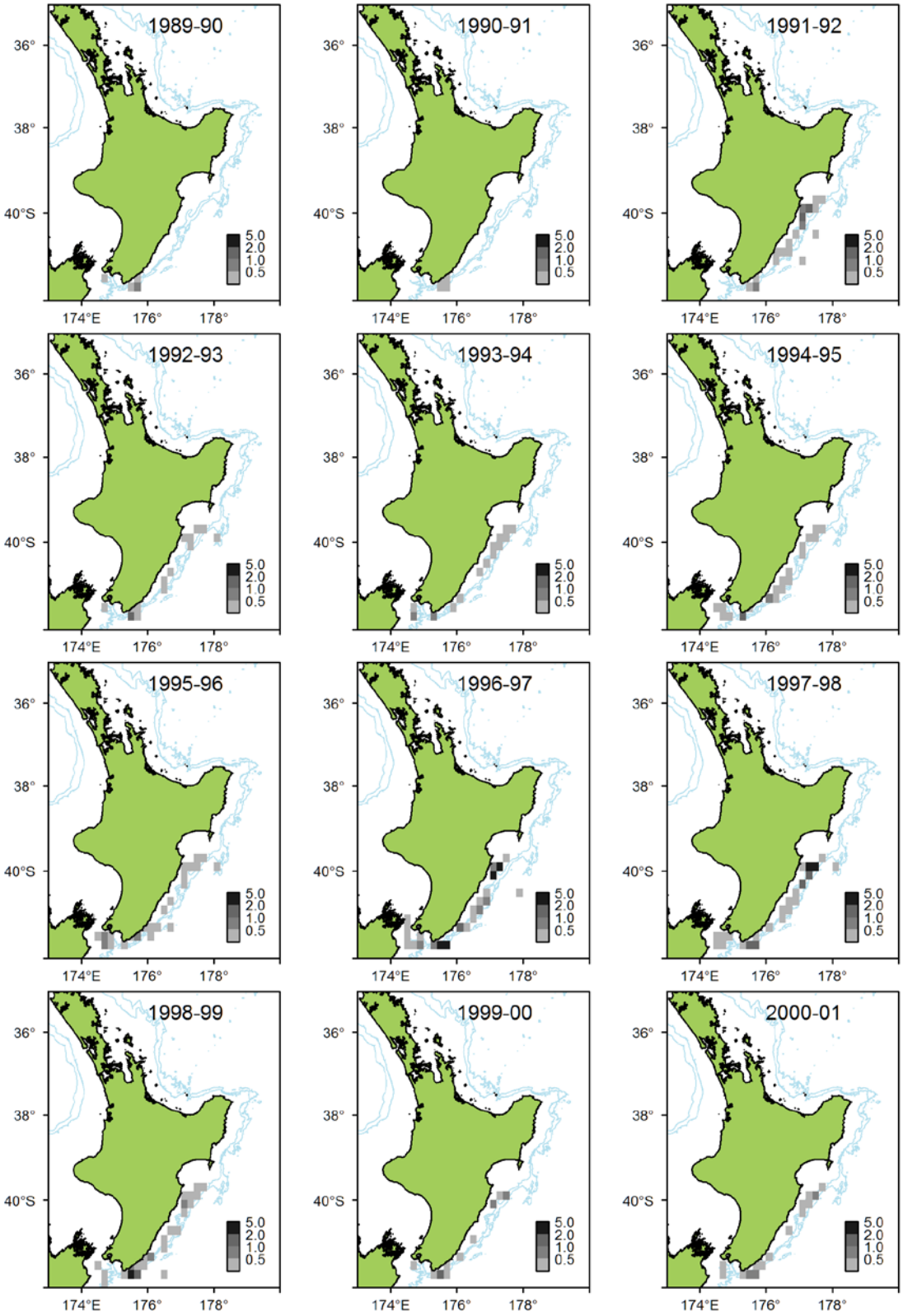


Figure C53: Distribution of estimated TCEPR bottom and midwater trawls for white warehou catch (t) aggregated into 0.2° spatial blocks within the ECNI area, for 1989–90 to 2000–01.

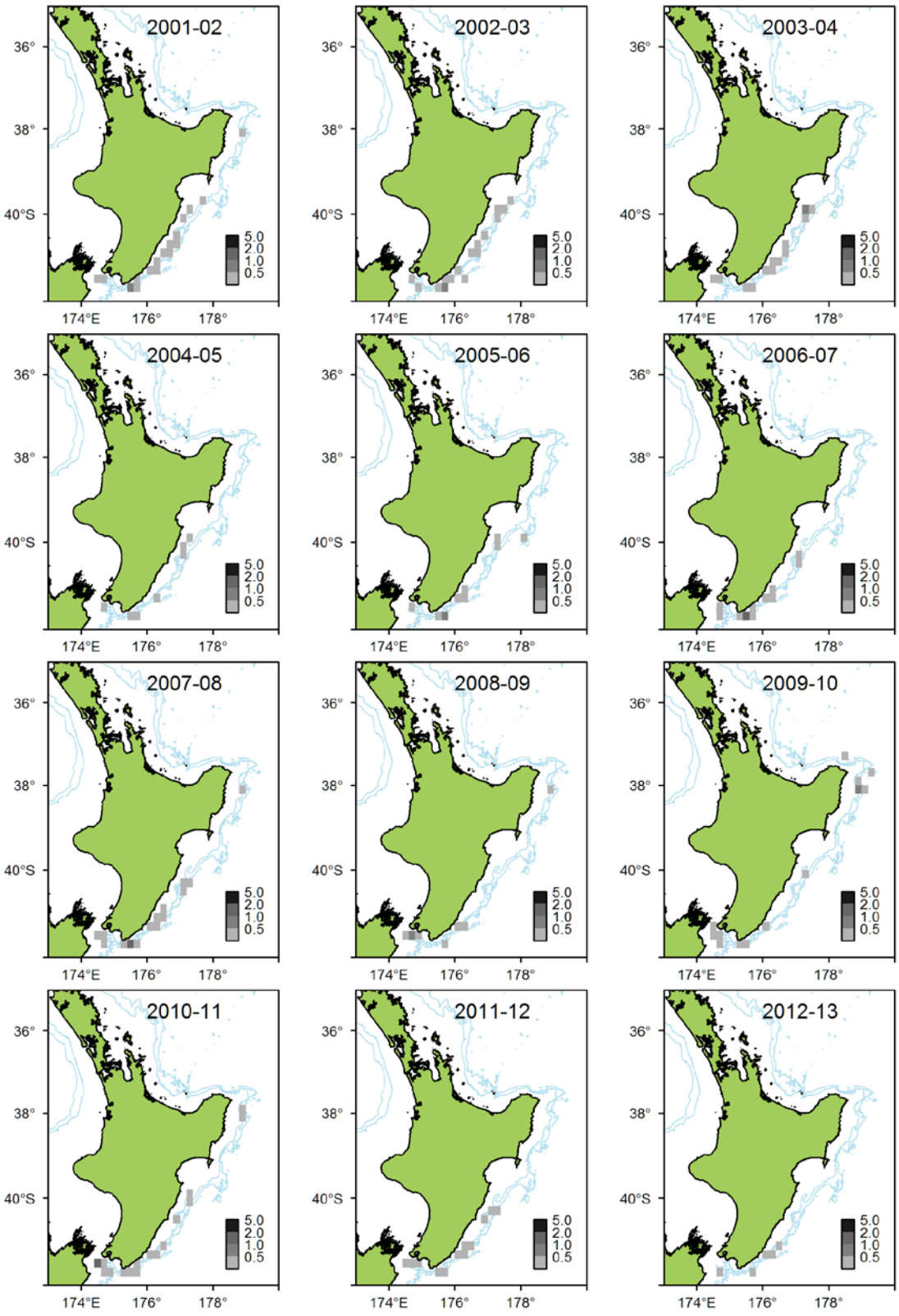


Figure C53: ctd. Distribution of estimated TCEPR bottom and midwater trawls for white warehou catch (t) aggregated into 0.2° spatial blocks within the ECNI area, for 2001–02 to 2012–13.

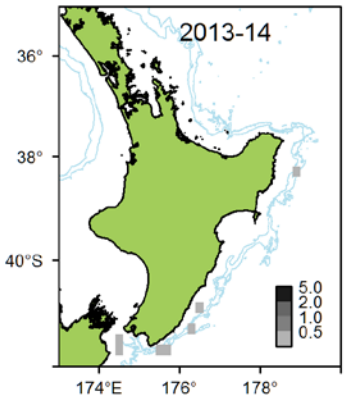
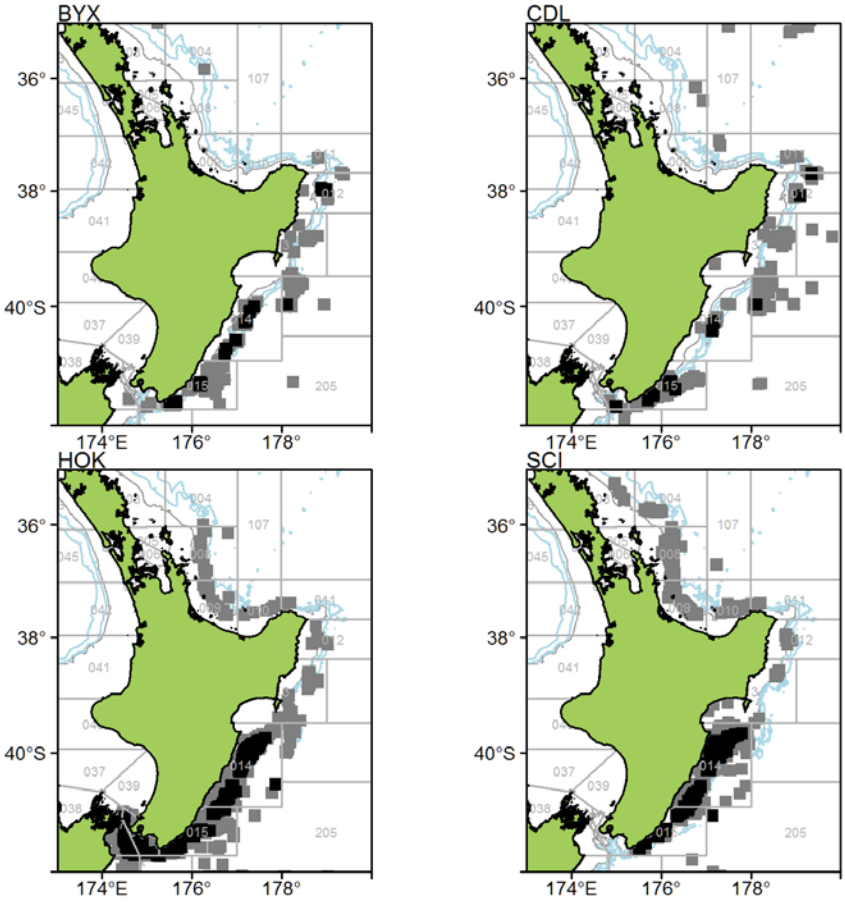


Figure C53: ctd. Distribution of estimated TCEPR bottom and midwater trawls for white warehou catch (t) aggregated into 0.2° spatial blocks within the ECNI area, for 2013–14.

(a) Bottom trawls



(b) Midwater trawls

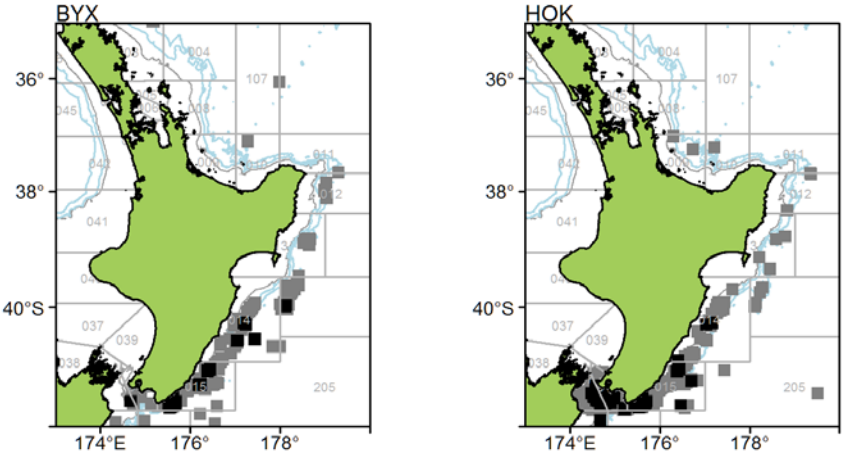


Figure C54: ECNI statistical areas and bathymetry showing the distribution of TCEPR bottom and midwater trawls by target species (grey) in the merged estimated data and bottom trawls by target species where white warehou was caught (black) for the main target species for all years combined. Target species are defined in Table C12.

APPENDIX D: CATCH-PER-UNIT-EFFORT ANALYSIS

Table D1: Description of variables and their type used in the CPUE analysis for the TCEPR data and Observer tow-by-tow data. Continuous variables were fitted as third order polynomials except for tow duration which was offered as both third and fourth order polynomials.

Variable	Type	Description
Year	Categorical	Fishing year (Oct–Sep); or Year (Jun–Sep)
Vessel	Categorical	Unique (encrypted) vessel identification number
Statistical area	Categorical	Statistical area
Tow duration	Continuous	Duration of a tow (hrs)
Catch	Continuous	Estimated green weight of white warehou (t) caught from a tow
Target species	Categorical	Target species of tow
Date	Continuous	Start date of tow
Month	Categorical	Month of the year
Fday	Continuous	Day of the year
Time start	Continuous	Start time of tow
Time mid	Continuous	Mid time of tow
Tow distance	Continuous	Distance of tow (kt)
Distance2	Continuous	Distance (as speed*duration) of tow (kt)
Headline height	Continuous	Headline height (m) of the net for a tow
Bottom depth	Continuous	Seabed depth (m) for a tow
Net depth	Continuous	Net depth (m) for a tow
Speed	Continuous	Vessel speed (knots) for a tow
Vessel experience	Continuous	Number of years the vessel has been involved in the fishery
Twin tow	Categorical	T/F variable for a vessel that used twin trawl for a tow
Longitude	Continuous	Longitude of the vessel for a tow
Latitude	Continuous	Latitude of the vessel for a tow
Number of nets	Categorical	Number of nets a vessel has used in a tow (observer data only)

Table D2: Definition of twin trawlers.

Fishing years	Data source	Twin trawl
1996–2007	Hurst (2009)	Twin trawl code 1:3
2008	No data	Vessel twin vessel 1996–2007 identified, so possible identification, but call these vessels twin trawlers
2009–2014	Primary_method recorded on TCEPR as effort_total_num ; fishing method; and effort_width eg 2MW100	Positive identification from effort_total_num as number of nets used

Table D3: CPUE data constraints for TCEPR and observer core tow-by-tow data.

CHAT: TCEPR tow-by-tow

Data source	TCEPR estimated tow-by-tow data
Year range	1994–2014 (October–September)
Statareas	≥ 50 tows: 018, 020–023, 049, 051, 052, 401, 402, 404 ,406, 407–410, 412
Method	BT
Target species	BNS, BYX, HAK, HOK, LIN, SPE, SQU, SWA, WWA
Core vessel selection	≥ 6 years vessel participation, all tows per vessel-year
Catch	< 30 t
Other	200–800 m; 0.2–15 hours; PSH tows removed

CHAT: Observed tow-by-tow

Data source	Observer data
Year range	1994–2014 (October–September)
Statareas	≥ 50 tows: 020–023, 050, 052,401–402, 407–409
Method	BT
Target species	BYS, HAK, HOK, LIN, SCI, SPE, SQU, SWA
Core vessel selection	≥ 2 years vessel participation, all tows per vessel-year
Catch	< 30 t
Other	200–800 m; 0.2–15 hours

SUBA: TCEPR tow-by-tow

Data source	TCEPR estimated tow-by-tow data
Year range	1992–2014 (October–September)
Statareas	≥ 50 tows: 026–028, 030, 503, 504, 602, 603, 610, 618
Method	BT
Target species	HAK, HOK, LIN, SQU, SWA, WWA
Core vessel selection	≥ 4 years vessel participation, ≥ 20 tows per vessel-year
Catch	< 30 t
Other	200–800 m; 0.2–15 hours; PSH tows removed

SUBA: Observed tow-by-tow

Data source	Observer data
Year range	1998–2014 (October–September)
Statareas	≥ 50 tows: 026–028, 030, 504, 602, 603, 610, 618
Method	BT
Target species	HAK, HOK, LIN, SQU, SWA, WWA
Core vessel selection	≥ 5 years vessel participation, all tows per vessel-year
Catch	< 30 t
Other	200–800 m; 0.2–15 hours

WCSI: TCEPR tow-by-tow

Data source	TCEPR estimated tow-by-tow data
Year range	1993–2014 (June–September)
Statareas	≥ 50 tows: 034, 035
Method	BT
Target species	HAK, HOK
Core vessel selection	≥ 5 years vessel participation, ≥ 20 tows per vessel-year
Catch	< 30 t
Other	200–800 m; 0.2–15 hours; PSH tows removed; latitude 168°–171.5°

WCSI: Observed tow-by-tow

Data source	Observer data
Year range	1998–2014 (June–September)
Statareas	≥ 50 tows: 034, 035
Method	BT
Target species	HAK, HOK
Core vessel selection	≥ 2 years vessel participation, all tows per vessel-year
Catch	< 30 t
Other	200–800 m; 0.2–15 hours

Table D4: Summary of CHAT data used in the analyses of estimated CPUE for all vessels and core vessels for each fishing year, where 1993–94 is 1994. Vessels, number of unique vessels fishing; Effort, number of tow records fished with a non-zero catch; Zeros, proportion of tows that caught zero catch; Catch, estimated catch; CPUE, unstandardised CPUE from the non-zero tow-by-tow data.

CHAT: TCEPR tow-by-tow

	All vessels					Core vessels				
Fishing year	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**
1994	37	66.2	219	0.94	0.30	12	35.3	109	0.95	0.32
1995	50	178.6	337	0.94	0.53	19	90.1	229	0.93	0.39
1996	56	309.5	765	0.91	0.40	24	130.1	417	0.92	0.31
1997	60	298.4	869	0.90	0.34	30	219.5	540	0.90	0.41
1998	60	331.5	919	0.92	0.36	37	202.1	720	0.92	0.28
1999	53	217.3	661	0.95	0.33	35	183.2	578	0.94	0.32
2000	43	393.6	969	0.91	0.41	33	391.4	965	0.91	0.41
2001	48	467.5	1 283	0.89	0.36	35	445.3	1 218	0.89	0.37
2002	44	314.9	1 050	0.89	0.30	37	309.1	1 025	0.89	0.30
2003	45	664.2	1 766	0.84	0.38	39	636.9	1 672	0.84	0.38
2004	40	579.1	1 334	0.84	0.43	31	553.4	1 298	0.83	0.43
2005	37	458.8	998	0.86	0.46	27	396.5	910	0.85	0.44
2006	34	628.5	1 119	0.82	0.56	24	608.2	1 063	0.81	0.57
2007	30	719.1	1 222	0.80	0.59	25	593.9	1 009	0.80	0.59
2008	25	355.8	835	0.85	0.43	23	337.1	814	0.85	0.41
2009	24	216.1	635	0.89	0.34	21	211.6	626	0.88	0.34
2010	24	200.7	406	0.92	0.49	21	199.9	401	0.92	0.50
2011	26	222.6	523	0.89	0.43	22	221.4	521	0.89	0.42
2012	25	130.3	317	0.93	0.41	19	127.8	310	0.93	0.41
2013	24	104.5	314	0.93	0.33	14	104.5	314	0.92	0.33
2014	21	144.2	440	0.89	0.33	15	144.2	439	0.89	0.33

CHAT: Observer tow-by-tow

	All vessels					Core vessels				
Fishing year	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**
1994	14	3.3	114	0.71	0.03	6	2.5	79	0.62	0.03
1995	6	2.8	72	0.68	0.04	5	2.7	70	0.68	0.04
1996	9	16.2	75	0.71	0.22	7	16.2	70	0.70	0.23
1997	7	2.1	42	0.59	0.05	3	2.1	41	0.53	0.05
1998	18	10.0	193	0.61	0.05	14	10.0	193	0.61	0.05
1999	19	9.8	266	0.55	0.04	14	9.0	249	0.53	0.04
2000	14	12.4	178	0.51	0.07	11	12.3	175	0.50	0.07
2001	20	30.6	239	0.51	0.13	13	30.6	239	0.43	0.13
2002	16	14.2	281	0.42	0.05	14	14.1	278	0.42	0.05
2003	19	25.0	227	0.57	0.11	15	25.0	227	0.47	0.11
2004	15	21.6	171	0.53	0.13	10	14.1	106	0.60	0.13
2005	12	48.6	229	0.41	0.21	11	48.6	229	0.40	0.21
2006	12	46.2	216	0.38	0.21	8	46.2	216	0.31	0.21
2007	15	41.4	223	0.48	0.19	13	40.8	215	0.48	0.19
2008	13	20.0	201	0.51	0.10	12	20.0	201	0.50	0.10
2009	16	13.1	145	0.59	0.09	16	13.1	145	0.59	0.09
2010	15	11.4	122	0.62	0.09	13	11.4	122	0.61	0.09
2011	15	20.2	138	0.51	0.15	11	20.0	135	0.49	0.15
2012	11	11.6	121	0.69	0.10	10	11.6	121	0.68	0.10
2013	17	31.1	265	0.58	0.12	17	31.1	265	0.58	0.12
2014	16	20.9	243	0.50	0.09	12	20.8	231	0.49	0.09

Table D4: continued.

SUBA: TCEPR tow-by-tow

	All vessels					Core vessels				
Fishing year	No. vessels	Catch	Effort	Prop. zeros	CPUE	No. vessels	Catch	Effort	Prop. zeros	CPUE
1992	40	1 417.1	648	0.90	2.19	4	940.6	297	0.75	3.17
1993	33	832.8	790	0.86	1.05	6	259.2	293	0.80	0.88
1994	29	1 012.6	473	0.88	2.14	6	609.4	241	0.86	2.53
1995	30	1 274.4	388	0.91	3.28	4	1 210.8	252	0.84	4.80
1996	27	1 059.7	343	0.91	3.09	5	1 011.9	221	0.81	4.58
1997	37	1 292.7	664	0.88	1.95	8	634.5	345	0.81	1.84
1998	34	988.2	671	0.90	1.47	8	165.5	320	0.87	0.52
1999	33	1 498.8	549	0.90	2.73	6	306.1	172	0.88	1.78
2000	29	1 240.2	891	0.88	1.39	12	388.1	468	0.89	0.83
2001	33	902.1	715	0.91	1.26	5	124.9	210	0.91	0.59
2002	36	908.4	1 012	0.89	0.90	13	471.6	531	0.89	0.89
2003	37	1 519.1	901	0.90	1.69	8	1 008.3	465	0.86	2.17
2004	33	1 151.3	814	0.87	1.41	9	1 099.4	692	0.81	1.59
2005	30	1 769.7	1 120	0.79	1.58	10	1 597.7	913	0.71	1.75
2006	27	937.6	830	0.83	1.13	8	854.6	680	0.70	1.26
2007	23	1 757.3	1 315	0.70	1.34	13	1 675.5	1 176	0.60	1.42
2008	23	1 397.5	1 145	0.68	1.22	10	1 145.1	958	0.61	1.20
2009	19	1 290.8	999	0.71	1.29	9	1 187.1	846	0.62	1.40
2010	21	1 107.7	881	0.77	1.26	8	891.9	747	0.68	1.19
2011	21	708.2	654	0.83	1.08	6	618.2	549	0.72	1.13
2012	23	615.8	598	0.83	1.03	6	526.1	431	0.71	1.22
2013	24	851.1	710	0.82	1.20	6	741.9	573	0.70	1.29
2014	17	1 219.3	809	0.79	1.51	8	1 121.9	685	0.73	1.64

SUBA: Observer tow-by-tow

	All vessels					Core vessels				
Fishing year	No. vessels	Catch	Effort	Prop. zeros	CPUE	No. vessels	Catch	Effort	Prop. zeros	CPUE
1998	11	18.9	92	0.67	0.21	4	0.9	20	0.84	0.04
1999	15	11.7	142	0.68	0.08	9	6.9	107	0.65	0.06
2000	14	73.3	214	0.60	0.34	9	70.8	195	0.57	0.36
2001	22	39.3	198	0.71	0.20	10	32.8	134	0.65	0.24
2002	12	92.5	162	0.75	0.57	8	92.3	155	0.71	0.60
2003	17	109.3	218	0.73	0.50	11	104.1	162	0.67	0.64
2004	19	73.1	105	0.79	0.70	8	72.5	97	0.61	0.75
2005	18	21.6	85	0.87	0.25	7	21.5	84	0.70	0.26
2006	16	69.2	161	0.70	0.43	12	69.1	158	0.65	0.44
2007	19	239.5	198	0.61	1.21	12	239.5	197	0.53	1.22
2008	17	109.1	221	0.62	0.49	11	109.0	218	0.51	0.50
2009	19	221.9	253	0.60	0.88	10	221.9	253	0.39	0.88
2010	16	163.6	294	0.49	0.56	10	163.6	294	0.42	0.56
2011	18	210.2	226	0.56	0.93	11	210.1	222	0.50	0.95
2012	15	155.1	273	0.49	0.57	8	148.6	234	0.41	0.64
2013	18	477.7	446	0.61	1.07	14	471.7	341	0.60	1.38
2014	15	556.2	399	0.56	1.39	10	549.2	361	0.54	1.52

Table D4: continued.

WCSI: TCEPR tow-by-tow

	All vessels					Core vessels				
Fishing year	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**
1993	23	29.2	97	0.89	0.30	6	11.3	55	0.85	0.21
1994	24	42.7	142	0.86	0.30	7	23.1	79	0.83	0.29
1995	19	37.8	94	0.88	0.40	7	29.6	69	0.85	0.43
1996	25	22.9	90	0.92	0.25	4	11.3	31	0.86	0.36
1997	27	14.1	33	0.95	0.43	8	5.2	22	0.91	0.24
1998	28	23.3	65	0.93	0.36	12	20.5	36	0.93	0.57
1999	25	31.9	63	0.94	0.51	9	20.5	40	0.93	0.51
2000	27	43.7	100	0.93	0.44	11	43.2	99	0.86	0.44
2001	33	51.8	127	0.94	0.41	17	50.3	116	0.93	0.43
2002	31	54.9	167	0.93	0.33	17	54.0	159	0.91	0.34
2003	35	82.4	357	0.87	0.23	20	70.7	310	0.85	0.23
2004	32	100.9	261	0.86	0.39	22	100.4	257	0.85	0.39
2005	27	88.7	138	0.91	0.64	11	81.2	110	0.88	0.74
2006	23	64.6	249	0.86	0.26	18	63.3	243	0.85	0.26
2007	21	66.6	210	0.82	0.32	17	64.9	201	0.82	0.32
2008	15	63.3	141	0.89	0.45	11	63.1	140	0.86	0.45
2009	18	56.7	183	0.83	0.31	14	56.7	183	0.82	0.31
2010	19	26.1	106	0.90	0.25	11	25.9	100	0.87	0.26
2011	18	16.5	77	0.95	0.21	13	16.4	76	0.93	0.22
2012	20	34.6	112	0.93	0.31	13	34.6	111	0.90	0.31
2013	19	53.8	98	0.92	0.55	10	37.2	93	0.89	0.40
2014	15	29.5	96	0.94	0.31	9	29.5	94	0.91	0.31

WCSI: Observer tow-by-tow

	All vessels					Core vessels				
Fishing year	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**	**No. vessels**	**Catch**	**Effort**	**Prop. zeros**	**CPUE**
1998	4	1.7	19	0.70	0.09	4	1.7	19	0.70	0.09
1999	8	4.8	35	0.80	0.14	4	4.7	28	0.72	0.17
2000	9	12.0	36	0.67	0.33	5	12.0	36	0.64	0.33
2001	7	0.4	11	0.82	0.04	4	0.4	11	0.78	0.04
2002	10	9.7	73	0.72	0.13	9	9.4	69	0.73	0.14
2003	12	2.4	43	0.73	0.06	9	2.2	36	0.72	0.06
2004	11	4.3	58	0.61	0.07	6	3.7	52	0.58	0.07
2005	9	2.4	21	0.75	0.11	3	2.0	17	0.72	0.12
2006	9	8.1	62	0.61	0.13	8	8.1	62	0.61	0.13
2007	8	3.0	21	0.71	0.14	7	3.0	21	0.71	0.14
2008	7	2.1	27	0.64	0.08	7	2.1	27	0.64	0.08
2009	5	1.9	18	0.14	0.11	4	1.9	18	0.05	0.11
2010	8	1.6	26	0.77	0.06	8	1.6	26	0.77	0.06
2011	9	1.1	24	0.77	0.05	5	1.1	24	0.68	0.05
2012	11	2.5	17	0.90	0.15	5	2.5	16	0.71	0.16
2013	10	8.0	77	0.60	0.10	8	8.0	77	0.43	0.10
2014	9	4.9	63	0.62	0.08	7	4.9	63	0.62	0.08

Table D5: Variables retained in order of decreasing explanatory value by each lognormal and binomial model and the corresponding total r^2 values.

CHAT: TCEPR tow-by-tow

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	2.26	Year	2.19
Vessel	23.58	Vessel	9.47
Statistical area	25.12	Depth of bottom	11.63
Start time	26.37	Statistical area	13.42

CHAT: Observer tow-by-tow

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	6.23	Year	2.59
Vessel	19.28	Vessel	6.57
Depth of bottom	21.64	Latitude	9.68
Longitude	22.66	Depth of bottom	11.08
Latitude	23.96	Longitude	12.59

SUBA: TCEPR tow-by-tow

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	5.20	Year	5.44
Target species	24.73	Target species	21.01
Vessel	32.47	Statistical area	25.33
Statistical area	34.25	Depth of bottom	27.22
Start time	35.55	Vessel	28.60

SUBA: Observer tow-by-tow

Lognormal		Binomial	
Variable	**R-squared**		
Year	5.89	**Variable**	**R-squared**
Target species	33.95	Year	3.19
Vessel	38.75	Target species	29.43
Month	40.42	Vessel	32.92
Depth of bottom	42	Depth of bottom	34.26
Statistical area	43.21		

WCSI: TCEPR tow-by-tow

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	2.93	Year	1.66
Vessel	10.40	Depth of bottom	15.28
Month	14.01	Day of year	23.22
Latitude	16.54	Latitude	24.49
Duration	17.90	Vessel	25.81
Mid time of tow	18.95		

WCSI: Observer tow-by-tow

Lognormal		Binomial	
Variable	**R-squared**	**Variable**	**R-squared**
Year	4.81	Year	4.05
Vessel	17.55	Depth of bottom	18.67
Longitude	27.06	Duration	22.30
Month	32.16	Day of year	24.16
Duration	35.36	Longitude	25.88
Depth of bottom	36.69	Vessel	27.16

Table D6: CHAT lognormal CPUE core indices by fishing year, where 1993–94 is 1994, with 95% confidence intervals.

CHAT: TCEPR tow-by-tow

	Lognormal		Binomial		Delta lognormal
Year	Index	CI	Index	CI	Index
1994	0.67	0.55–0.81	0.03	0.01–0.04	0.22
1995	0.79	0.69–0.91	0.05	0.03–0.07	0.55
1996	0.71	0.64–0.78	0.05	0.03–0.06	0.42
1997	0.75	0.69–0.82	0.06	0.04–0.09	0.62
1998	0.75	0.69–0.81	0.06	0.04–0.08	0.58
1999	0.73	0.67–0.80	0.04	0.03–0.06	0.38
2000	0.82	0.77–0.88	0.06	0.04–0.08	0.62
2001	0.95	0.89–1.01	0.08	0.05–0.11	0.97
2002	0.87	0.82–0.93	0.07	0.05–0.10	0.82
2003	1.23	1.16–1.29	0.12	0.08–0.16	1.95
2004	1.34	1.26–1.42	0.12	0.08–0.15	2.01
2005	1.14	1.07–1.23	0.09	0.06–0.12	1.30
2006	1.45	1.36–1.55	0.10	0.07–0.14	1.94
2007	1.39	1.30–1.49	0.14	0.10–0.19	2.51
2008	1.10	1.03–1.19	0.09	0.06–0.12	1.30
2009	1.04	0.96–1.13	0.06	0.04–0.08	0.79
2010	1.22	1.11–1.35	0.05	0.03–0.07	0.77
2011	1.11	1.02–1.21	0.07	0.05–0.10	1.06
2012	1.16	1.04–1.30	0.05	0.03–0.07	0.75
2013	1.15	1.03–1.28	0.06	0.04–0.08	0.88
2014	1.20	1.09–1.32	0.07	0.05–0.10	1.12

CHAT: Observer tow-by-tow

	Lognormal		Binomial		Delta lognormal
Year	Index	CI	Index	CI	Index
1994	1.10	0.86–1.42	0.73	0.60–0.86	1.24
1995	0.99	0.73–1.36	0.59	0.42–0.75	0.90
1996	1.79	1.34–2.38	0.35	0.19–0.51	0.98
1997	1.18	0.83–1.68	0.42	0.22–0.62	0.76
1998	0.76	0.65–0.89	0.63	0.49–0.77	0.75
1999	0.54	0.46–0.63	0.66	0.52–0.80	0.55
2000	0.81	0.68–0.97	0.76	0.64–0.87	0.95
2001	1.16	0.98–1.37	0.73	0.61–0.85	1.31
2002	0.71	0.62–0.81	0.75	0.64–0.87	0.83
2003	1.08	0.92–1.26	0.70	0.57–0.83	1.18
2004	1.25	0.98–1.60	0.60	0.44–0.75	1.16
2005	1.46	1.24–1.72	0.77	0.67–0.87	1.75
2006	1.15	0.98–1.36	0.78	0.67–0.88	1.39
2007	1.54	1.33–1.79	0.75	0.64–0.86	1.80
2008	0.96	0.82–1.13	0.73	0.61–0.85	1.09
2009	1.00	0.83–1.19	0.58	0.43–0.73	0.90
2010	0.82	0.67–1.00	0.54	0.39–0.70	0.69
2011	0.95	0.80–1.15	0.66	0.52–0.80	0.98
2012	0.80	0.66–0.97	0.53	0.38–0.69	0.66
2013	0.86	0.74–0.99	0.65	0.51–0.79	0.87
2014	0.88	0.76–1.03	0.77	0.66–0.88	1.05

Table D6: continued.

SUBA: TCEPR tow-by-tow

	Lognormal		Binomial		Delta lognormal
Year	**Index**	**CI**	**Index**	**CI**	**Index**
1992	1.73	1.49–2.00	0.32	0.27–0.38	2.11
1993	1.26	1.10–1.45	0.34	0.28–0.39	1.59
1994	2.00	1.74–2.30	0.20	0.16–0.25	1.53
1995	2.57	2.23–2.96	0.19	0.15–0.23	1.79
1996	2.69	2.33–3.10	0.19	0.15–0.24	1.96
1997	1.03	0.91–1.16	0.34	0.28–0.40	1.32
1998	0.80	0.71–0.91	0.24	0.20–0.28	0.72
1999	1.24	1.06–1.46	0.18	0.14–0.22	0.82
2000	0.93	0.84–1.04	0.18	0.15–0.22	0.64
2001	0.79	0.69–0.92	0.16	0.12–0.19	0.46
2002	0.67	0.61–0.74	0.21	0.18–0.25	0.53
2003	0.75	0.67–0.83	0.22	0.18–0.26	0.61
2004	0.75	0.69–0.81	0.20	0.16–0.23	0.55
2005	0.82	0.76–0.89	0.34	0.30–0.39	1.06
2006	0.87	0.80–0.95	0.31	0.27–0.36	1.02
2007	0.94	0.88–1.01	0.42	0.37–0.47	1.48
2008	0.93	0.87–1.01	0.40	0.35–0.45	1.39
2009	0.78	0.72–0.85	0.37	0.32–0.42	1.08
2010	0.79	0.72–0.86	0.38	0.33–0.43	1.11
2011	0.71	0.65–0.78	0.33	0.29–0.38	0.89
2012	0.63	0.57–0.70	0.31	0.26–0.36	0.73
2013	0.80	0.73–0.88	0.31	0.26–0.35	0.93
2014	0.83	0.76–0.91	0.32	0.28–0.37	1.01

SUBA: Observer tow-by-tow

	Lognormal		Binomial		Delta lognormal
Year	**Index**	**CI**	**Index**	**CI**	**Index**
1998	0.74	0.47–1.17	0.59	0.40–0.77	0.68
1999	1.59	1.25–2.02	0.68	0.56–0.81	1.69
2000	0.77	0.66–0.91	0.51	0.37–0.65	0.61
2001	0.89	0.72–1.11	0.70	0.57–0.83	0.97
2002	0.85	0.71–1.03	0.50	0.35–0.64	0.66
2003	1.05	0.88–1.24	0.70	0.58–0.82	1.14
2004	0.83	0.67–1.03	0.51	0.35–0.66	0.66
2005	1.00	0.80–1.26	0.65	0.50–0.79	1.01
2006	1.44	1.20–1.73	0.64	0.50–0.77	1.43
2007	1.42	1.18–1.69	0.74	0.63–0.85	1.64
2008	1.25	1.07–1.47	0.71	0.59–0.82	1.38
2009	1.10	0.95–1.28	0.66	0.53–0.79	1.13
2010	1.10	0.95–1.27	0.61	0.47–0.74	1.04
2011	0.65	0.56–0.76	0.69	0.57–0.82	0.70
2012	0.86	0.74–1.00	0.67	0.54–0.80	0.90
2013	0.84	0.74–0.95	0.65	0.52–0.77	0.85
2014	1.13	0.99–1.28	0.58	0.45–0.71	1.02

Table D6: continued.

WCSI: TCEPR tow-by-tow

	Lognormal		Binomial		Delta lognormal
Year	**Index**	**CI**	**Index**	**CI**	**Index**
1993	1.04	0.77–1.40	0.05	0.02–0.08	0.76
1994	1.12	0.84–1.49	0.10	0.05–0.14	1.44
1995	1.34	1.02–1.78	0.12	0.07–0.18	2.23
1996	1.29	0.88–1.90	0.07	0.03–0.12	1.25
1997	1.16	0.75–1.79	0.05	0.02–0.08	0.71
1998	1.22	0.87–1.72	0.08	0.04–0.13	1.33
1999	1.88	1.36–2.62	0.08	0.04–0.13	2.05
2000	1.26	1.02–1.55	0.12	0.07–0.18	2.05
2001	1.07	0.88–1.31	0.06	0.03–0.09	0.84
2002	1.07	0.90–1.26	0.07	0.04–0.11	1.05
2003	0.77	0.67–0.88	0.13	0.07–0.18	1.32
2004	0.95	0.82–1.10	0.09	0.05–0.13	1.17
2005	0.67	0.55–0.82	0.07	0.04–0.11	0.64
2006	0.81	0.70–0.94	0.09	0.05–0.13	1.00
2007	0.77	0.65–0.90	0.09	0.05–0.14	0.95
2008	1.14	0.95–1.37	0.05	0.02–0.07	0.75
2009	0.93	0.79–1.10	0.05	0.03–0.08	0.67
2010	0.75	0.60–0.92	0.04	0.02–0.06	0.42
2011	0.71	0.56–0.90	0.04	0.02–0.06	0.40
2012	0.99	0.81–1.21	0.05	0.03–0.08	0.70
2013	0.84	0.68–1.05	0.05	0.02–0.07	0.52
2014	0.90	0.72–1.12	0.04	0.02–0.05	0.43

WCSI: Observer tow-by-tow

	Lognormal		Binomial		Delta lognormal
Year	**Index**	**CI**	**Index**	**CI**	**Index**
1998	0.90	0.50–1.60	0.18	0–0.37	0.69
1999	3.12	1.85–5.24	0.18	-0.01–0.37	2.43
2000	1.15	0.76–1.75	0.27	0.04–0.51	1.35
2001	0.64	0.33–1.25	0.23	0.03–0.44	0.64
2002	1.11	0.83–1.49	0.20	0.03–0.36	0.93
2003	0.80	0.52–1.23	0.29	0.04–0.54	0.98
2004	1.13	0.76–1.67	0.34	0.08–0.60	1.63
2005	1.52	0.88–2.60	0.18	-0.02–0.37	1.16
2006	1.42	0.99–2.03	0.26	0.03–0.49	1.59
2007	1.68	1.05–2.69	0.26	0.02–0.51	1.87
2008	0.71	0.46–1.08	0.13	-0.01–0.27	0.40
2009	0.70	0.42–1.17	0.58	0.01–1.16	1.74
2010	0.84	0.55–1.29	0.22	0.01–0.42	0.78
2011	0.64	0.40–1.00	0.23	0–0.45	0.62
2012	0.88	0.52–1.50	0.19	-0.05–0.43	0.72
2013	0.81	0.58–1.13	0.21	0.01–0.42	0.74
2014	0.71	0.51–0.99	0.16	0–0.32	0.48

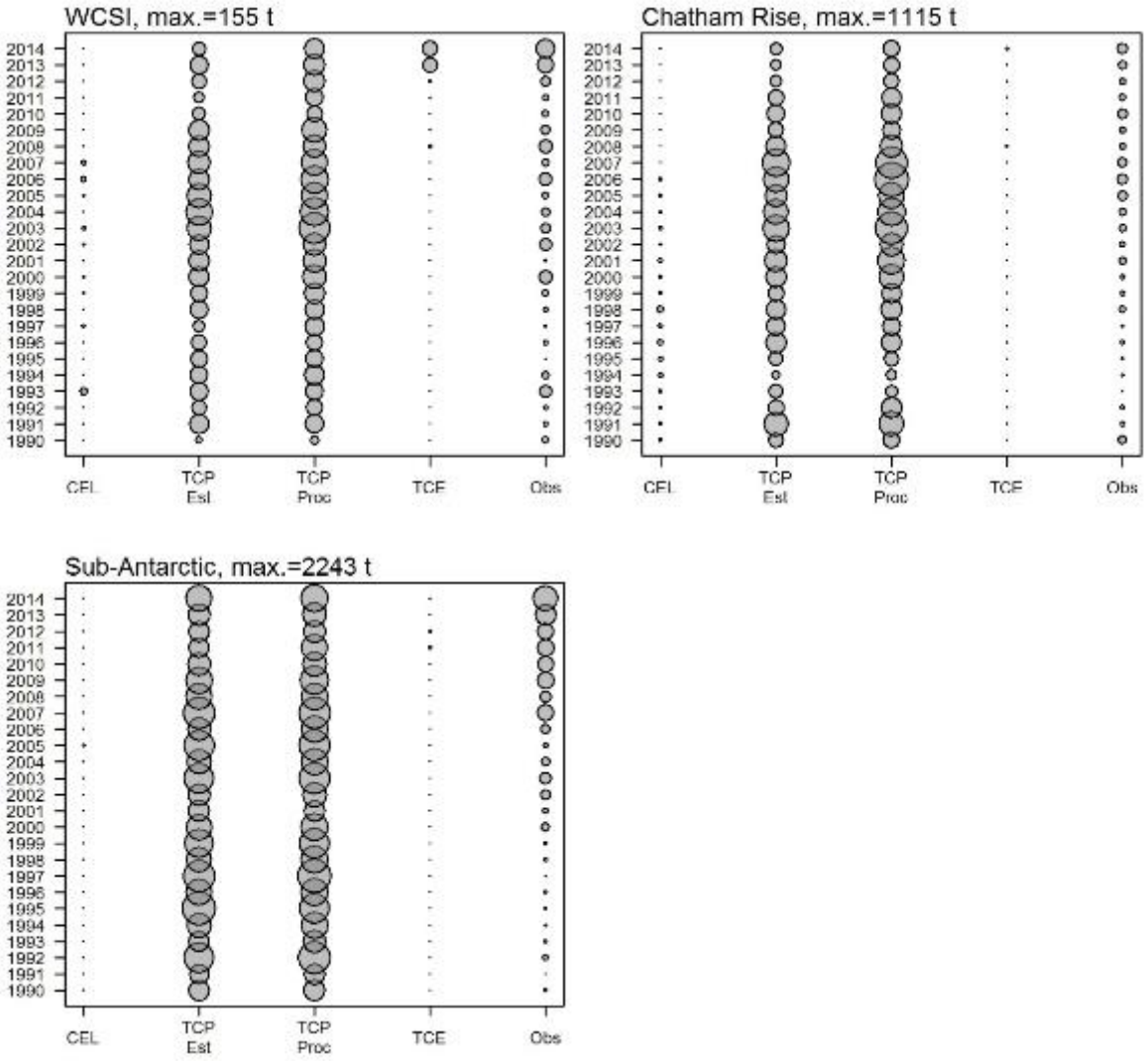


Figure D1: Distribution of annual white warehou catch by form type for estimated, merged daily processed data, and observer data. Circle size is proportional to catch; maximum circle size is indicated on each plot. TCP Est is estimated data from the Trawl, Catch, Effort, and Processing Return; TCP Proc is daily processed data from the Trawl, Catch, Effort, and Processing Return; TCE is Trawl, Catch, Effort Return; Obs is observer data. Areas are shown in Figure 1.

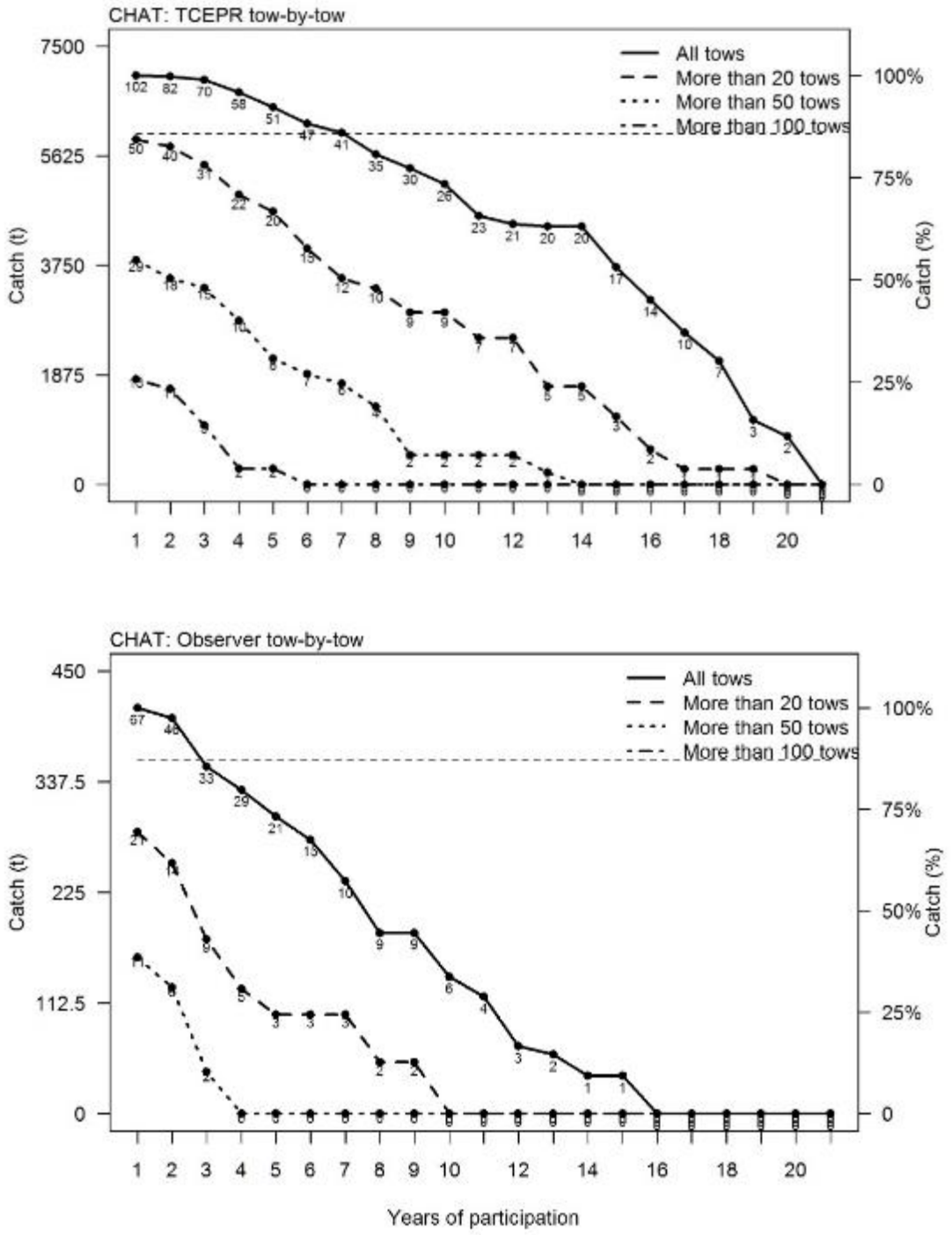
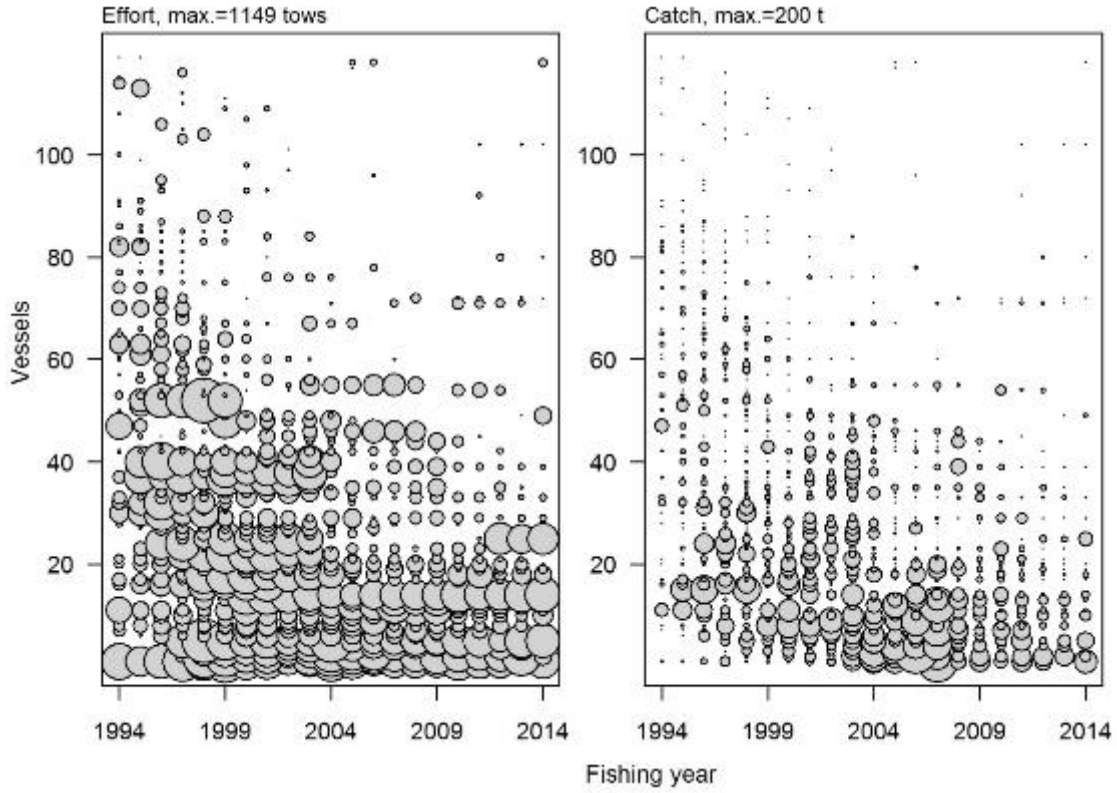


Figure D2: Relationship between years of vessel participation and total white warehou CHAT catch by dataset. The number under each circle indicates the number of vessels with the corresponding years of participation. Dotted horizontal line represents 80% of catch.

(a) All vessels



(b) Core vessels

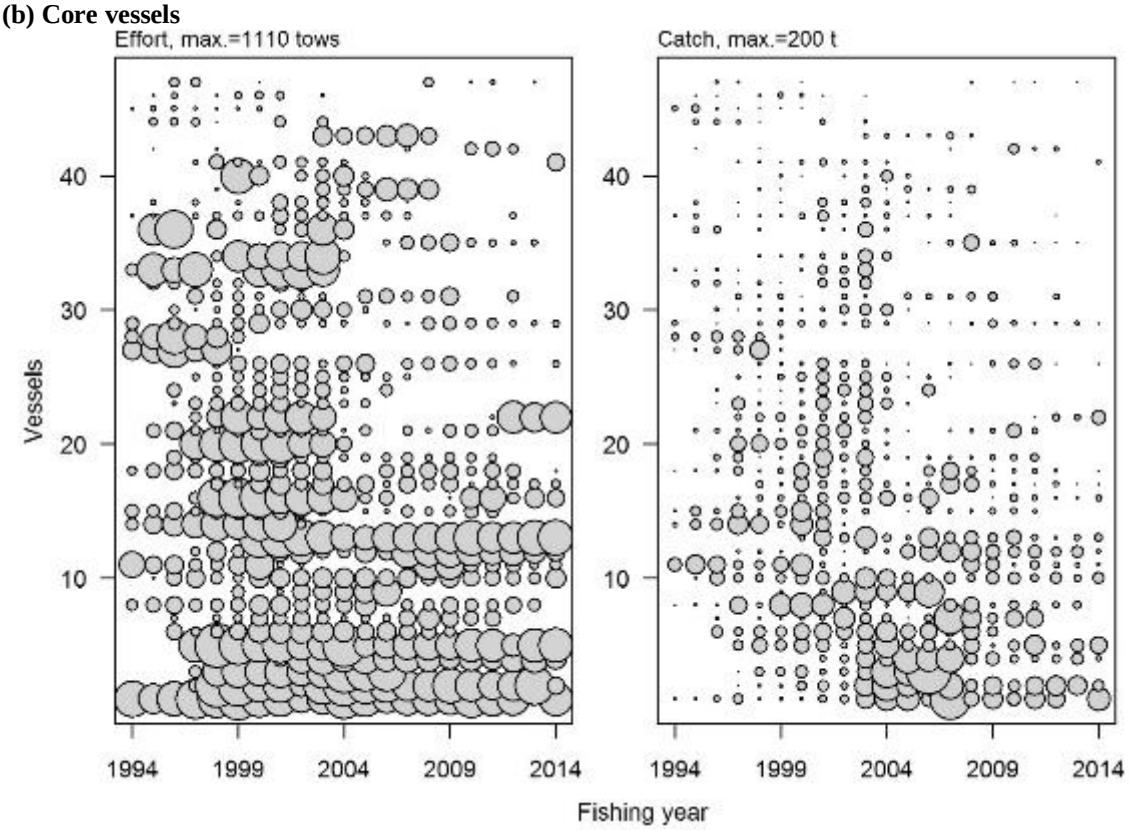
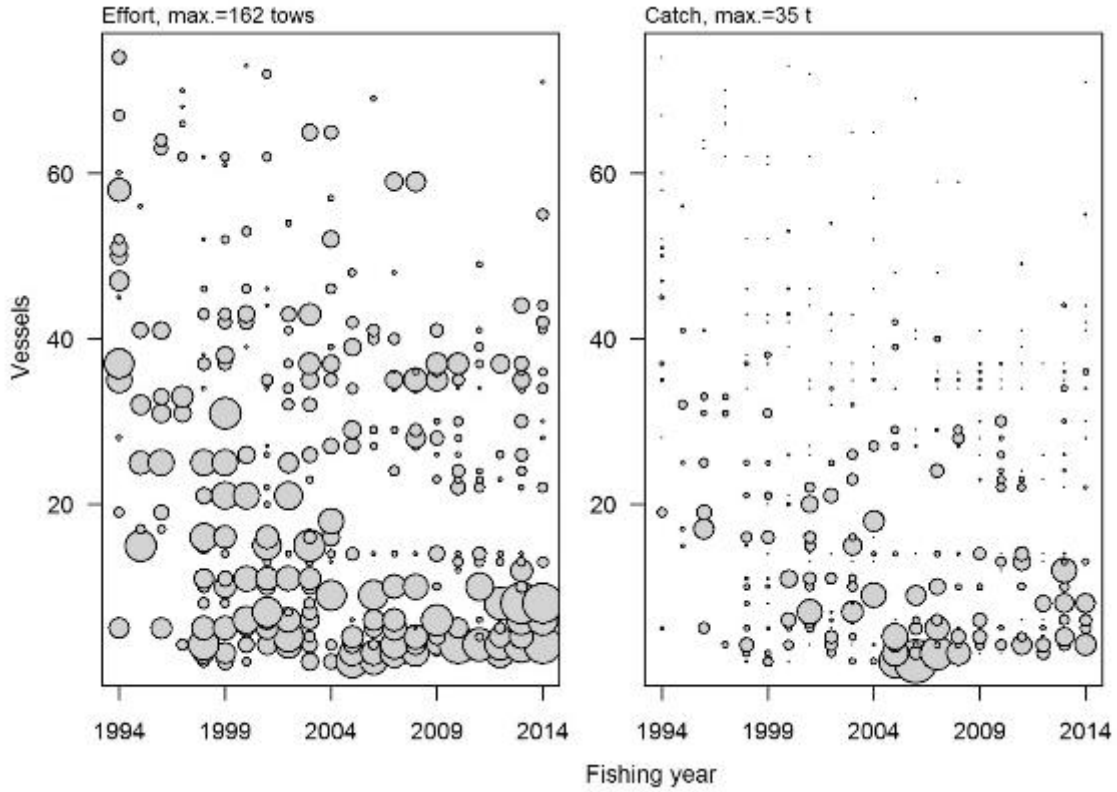


Figure D3a: CHAT TCEPR tow-by-tow analysis. Summary of effort (number of tows) and estimated white warehou catch by fishing year 1994 to 2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

(a) All vessels



(b) Core vessels

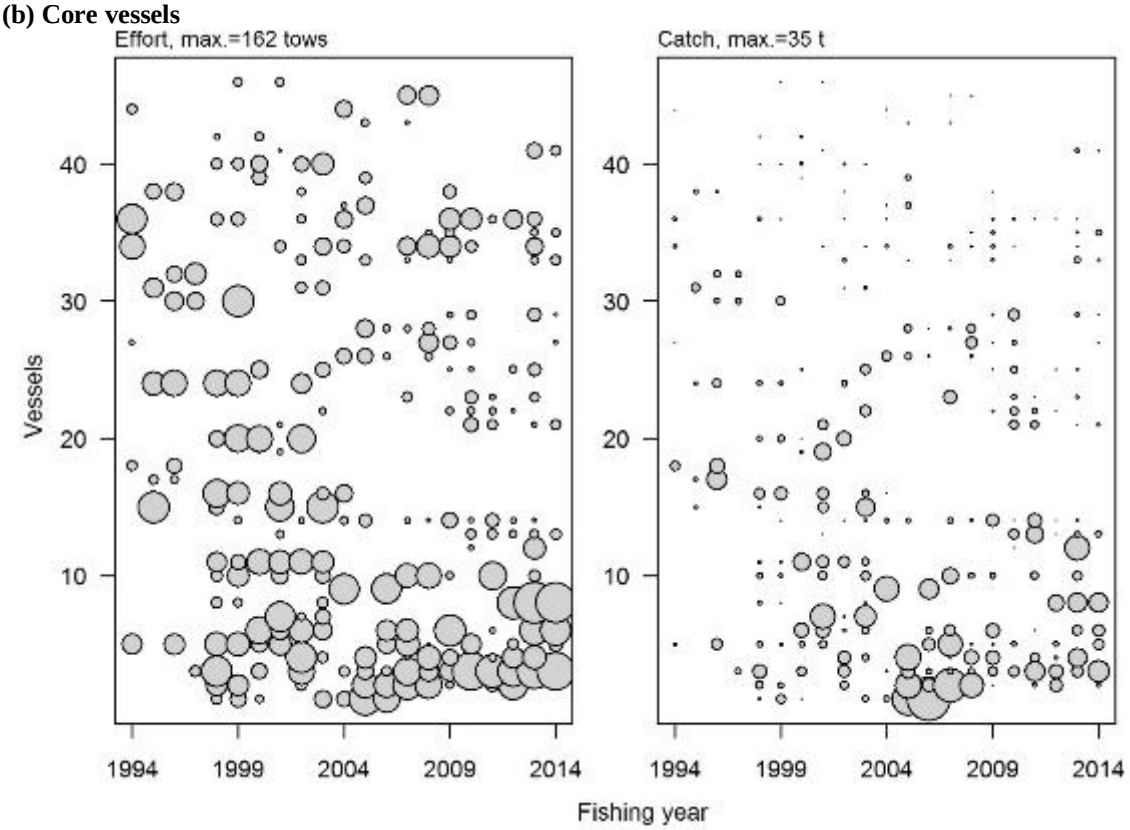


Figure D3b: CHAT Observer tow-by-tow analysis. Summary of effort (number of tows) and estimated white warehou catch by fishing year 1994 to 2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

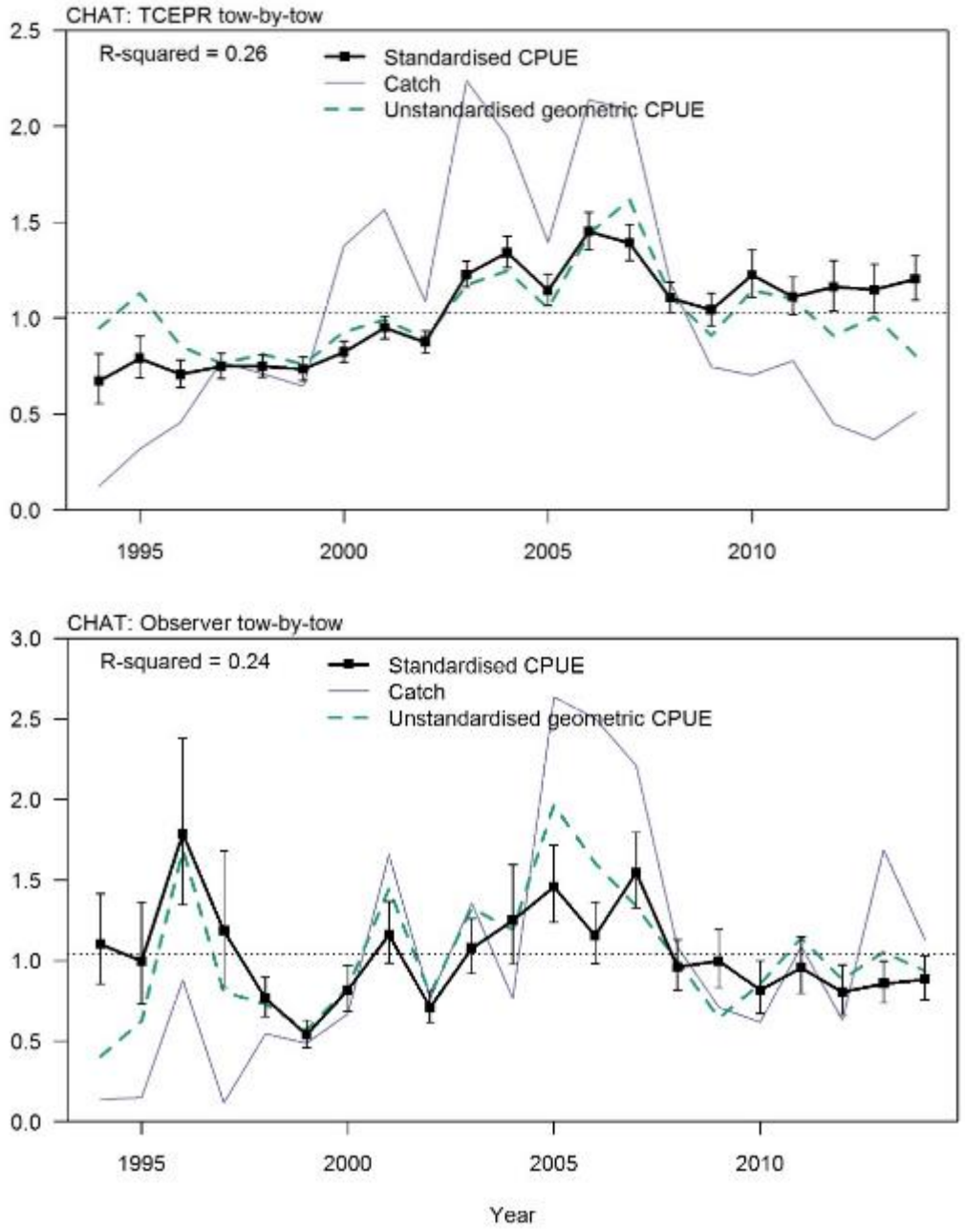


Figure D4: CHAT CPUE lognormal indices showing catches (scaled to same mean as indices), and lognormal standardised and un-standardised indices. Bars indicate 95% confidence intervals. Year defined as October–September.

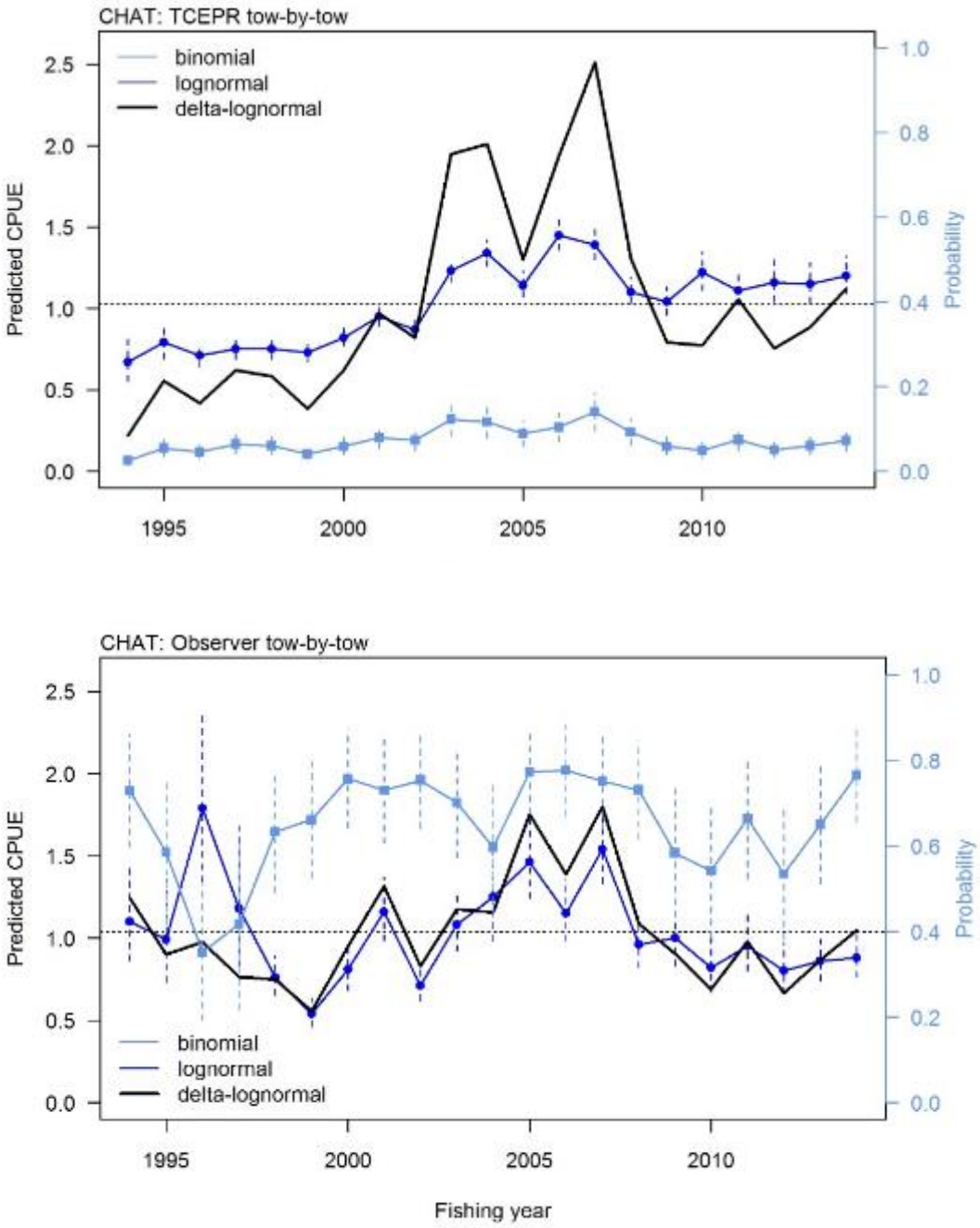


Figure D5: CHAT CPUE from the lognormal, binomial and combined models. Bars indicate 95% confidence intervals. Year defined as October–September.

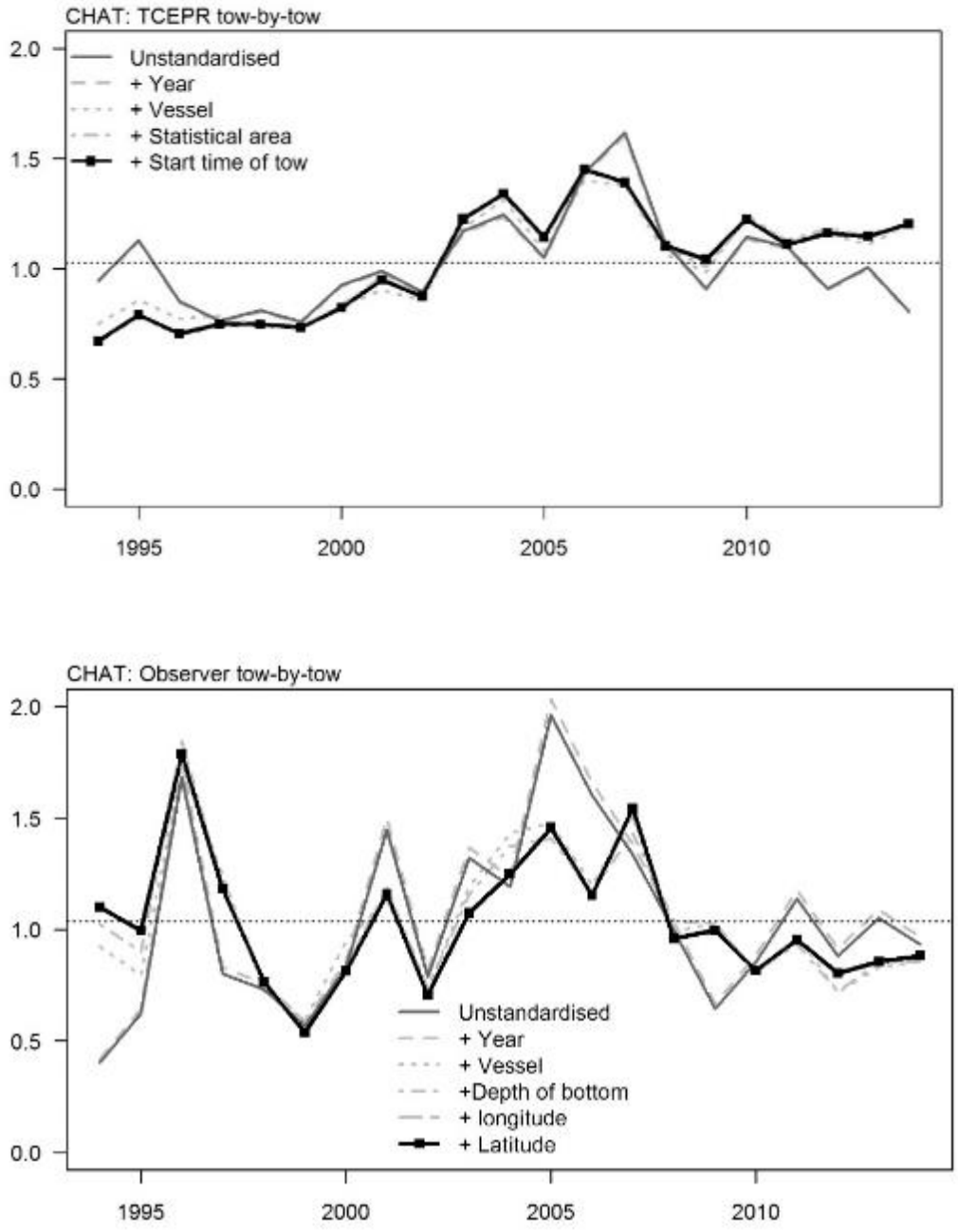


Figure D6: Addition of variables into the CHAT CPUE lognormal CPUE model for each fishery by fishing year. Year defined as October–September.

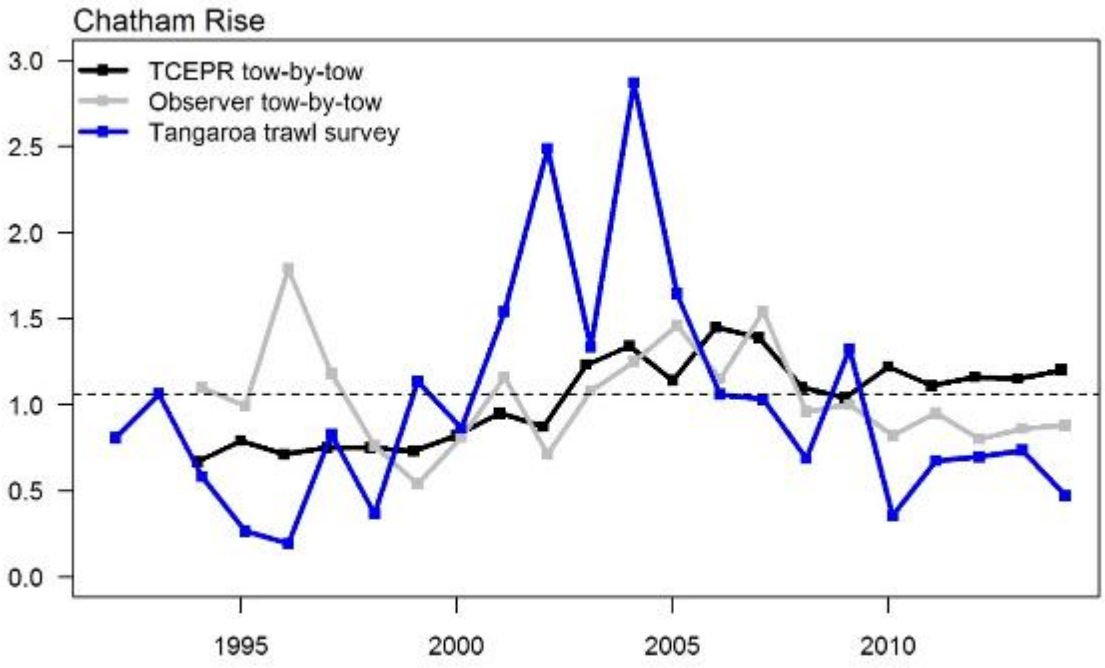


Figure D7: Comparison of CHAT indices for the TCEPR tow-by-tow, and Observer tow-by-tow datasets for fishing years 1994 to 2014, and the Chatham Rise January trawl survey for white warehou biomass indices 1992–2014. Indices have been standardised to have a mean of one.

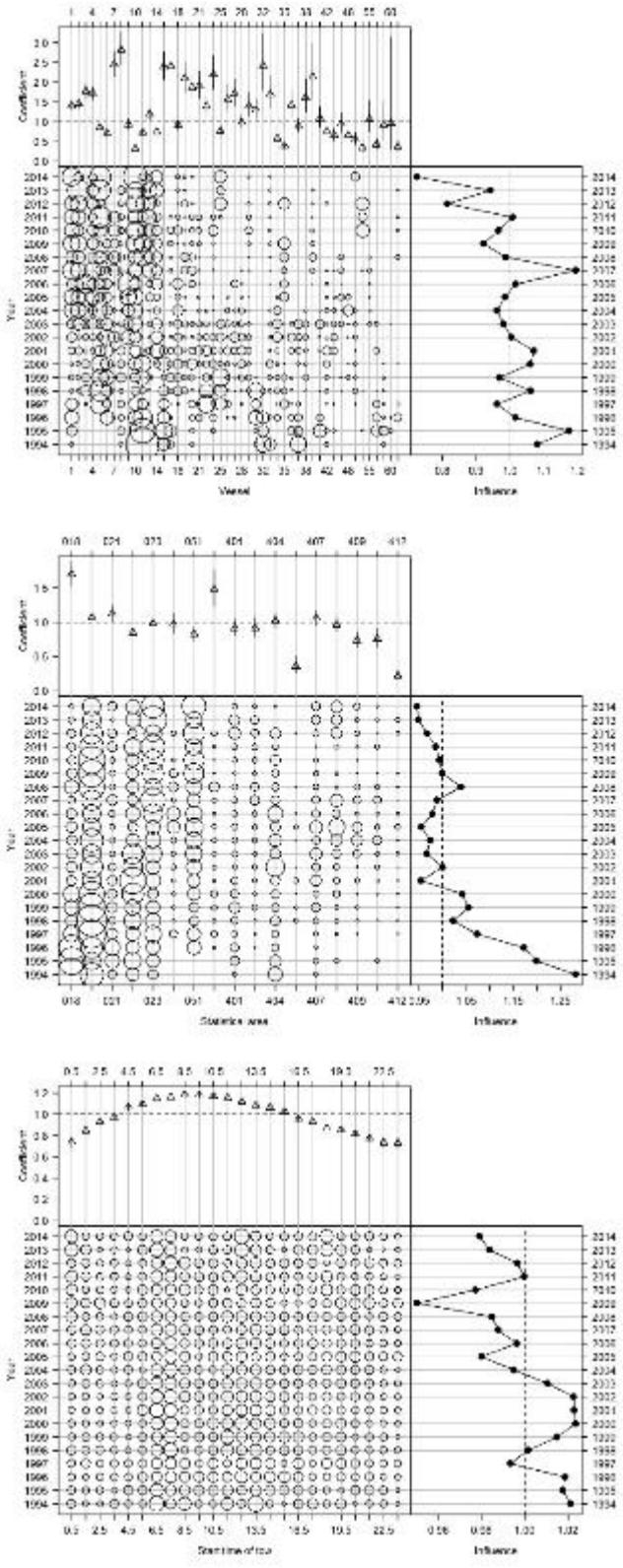


Figure D8a: CHAT TCEPR tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

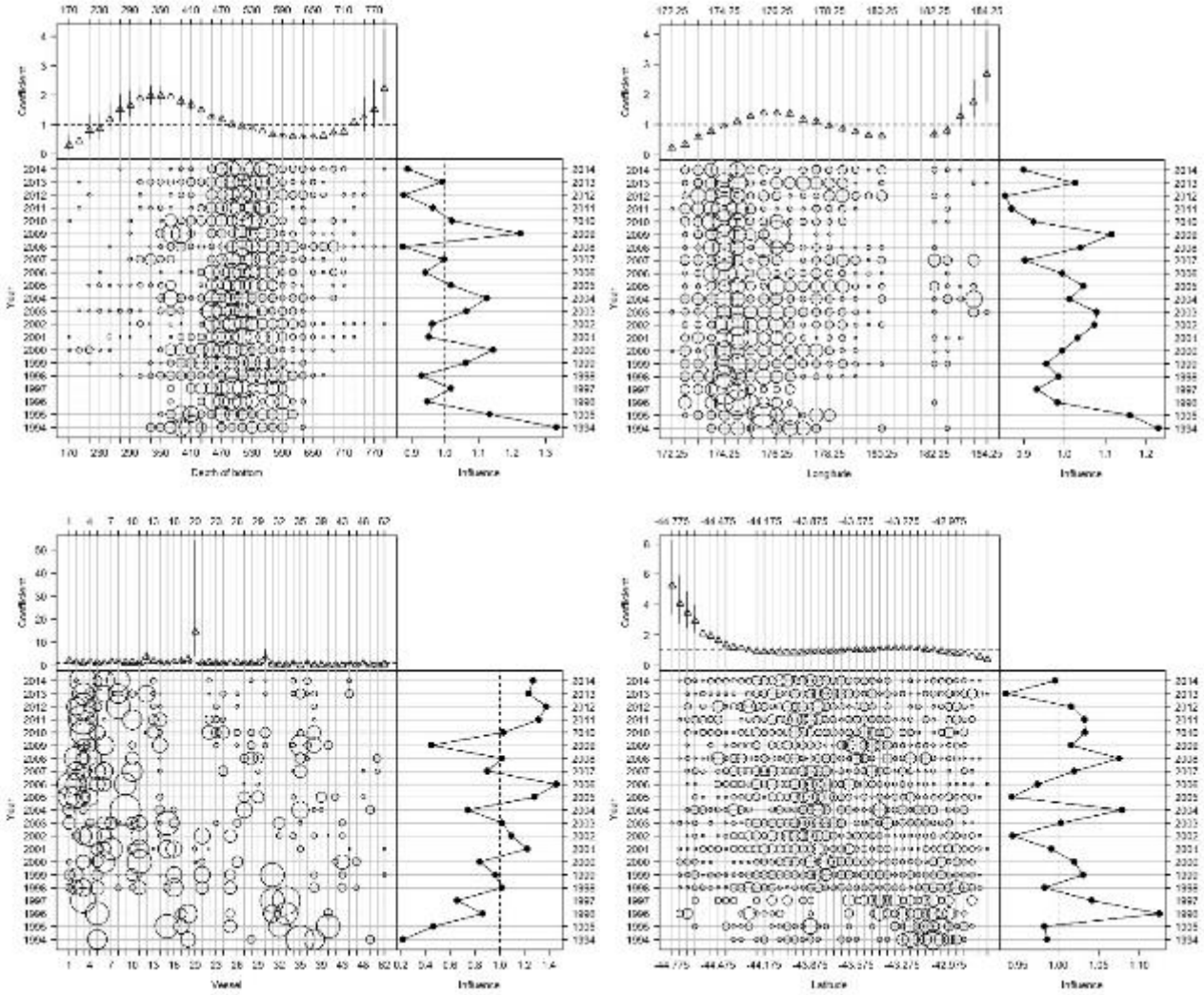


Figure D8b: CHAT Observer tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

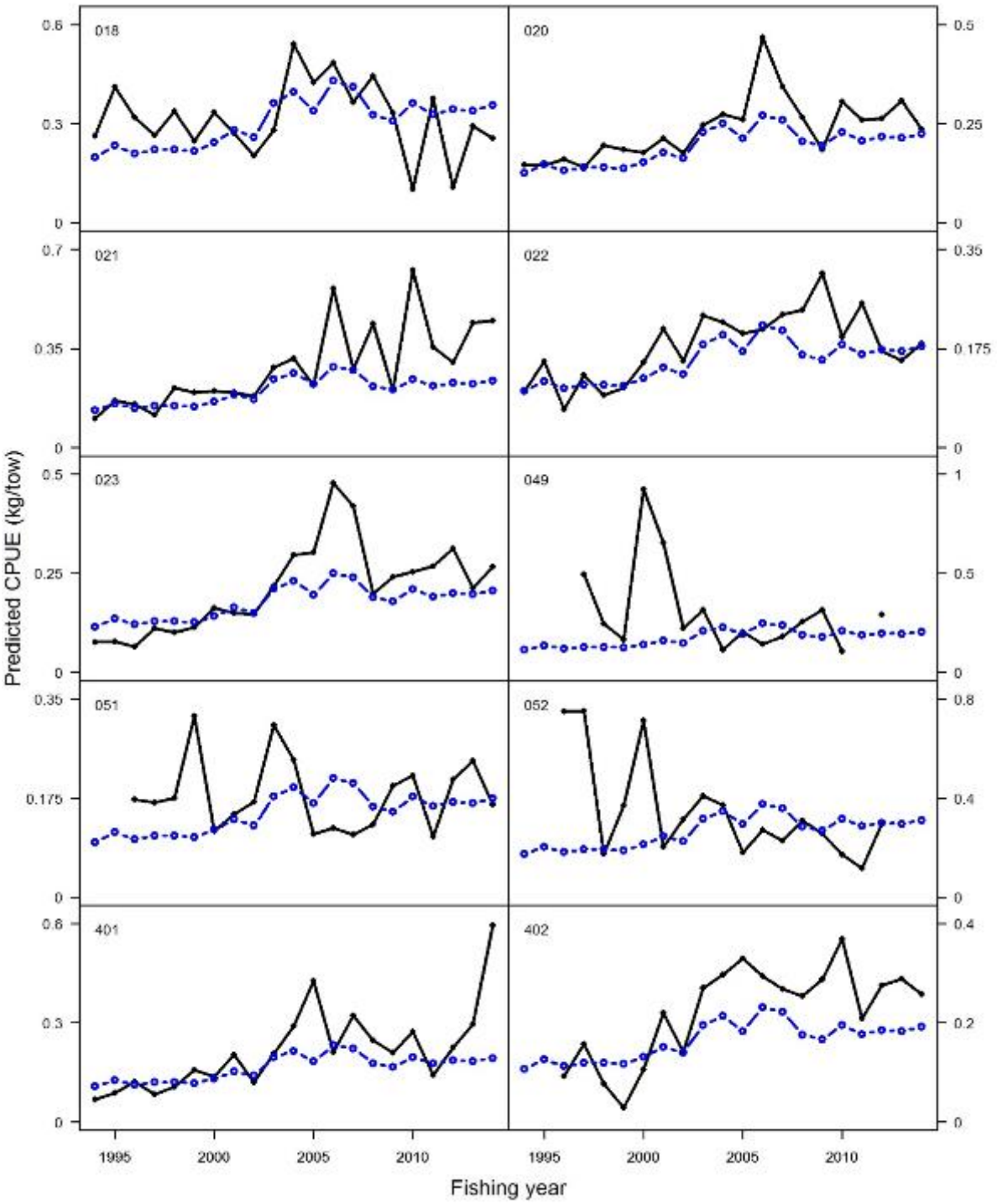


Figure D9: Predicted CPUE by statistical area for the CHAT TCEPR tow-by-tow lognormal model showing model with year-statistical area interaction (black) and without year-statistical area interaction (blue).

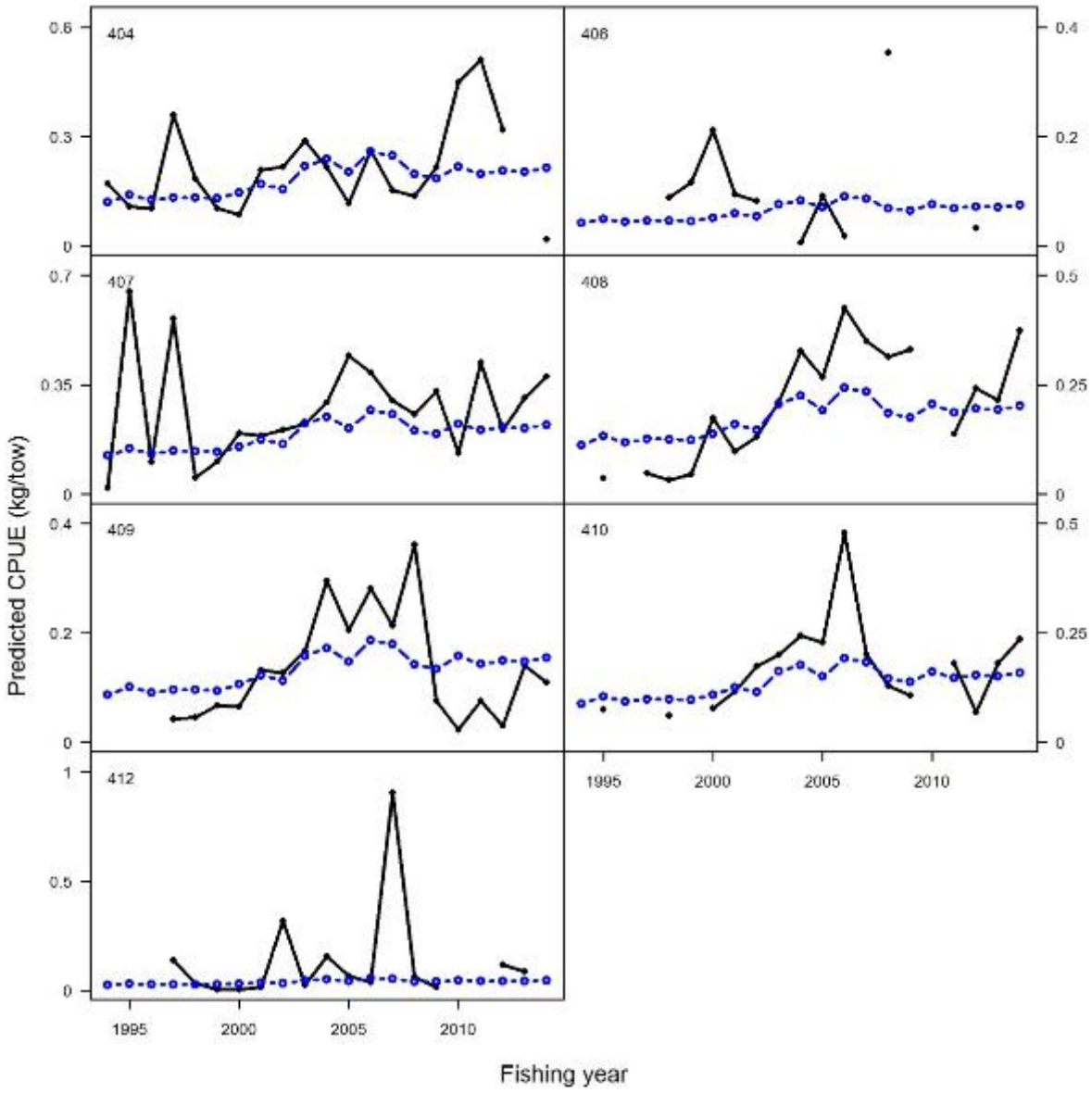


Figure D9: continued.

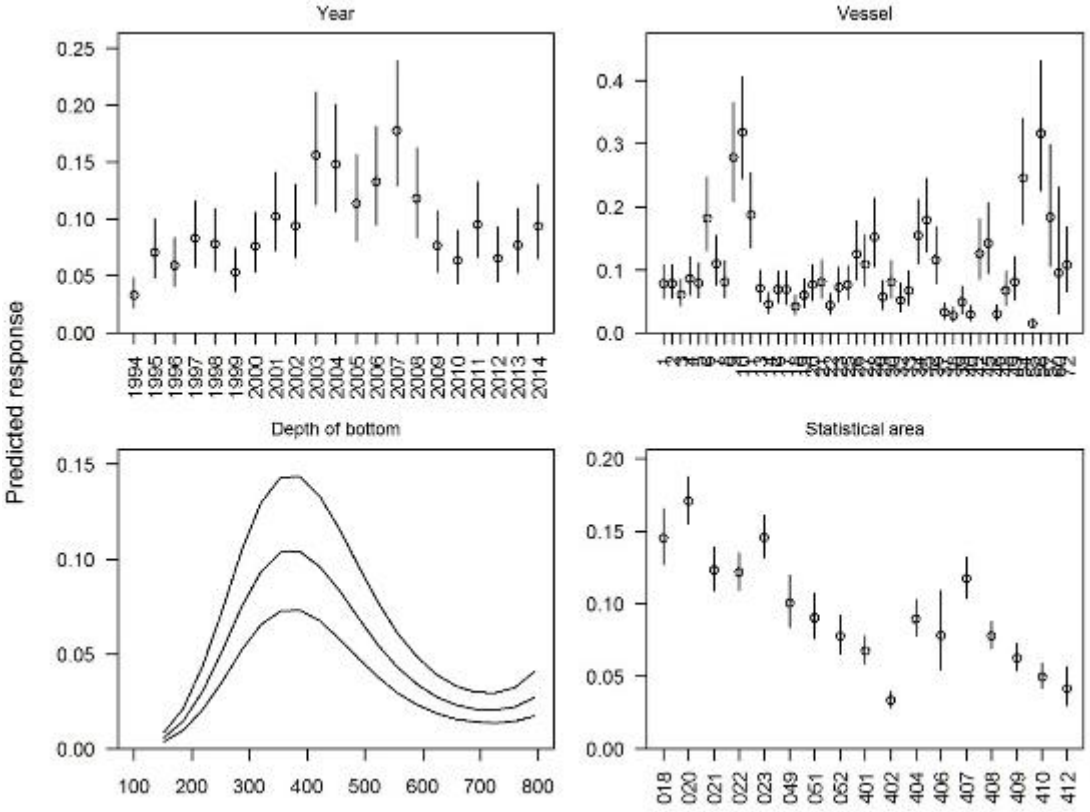


Figure D10a: Binomial effects of selected variables in the binomial model for the CHAT TCEPR tow-by-tow catch. Bars indicate 95% confidence interval.

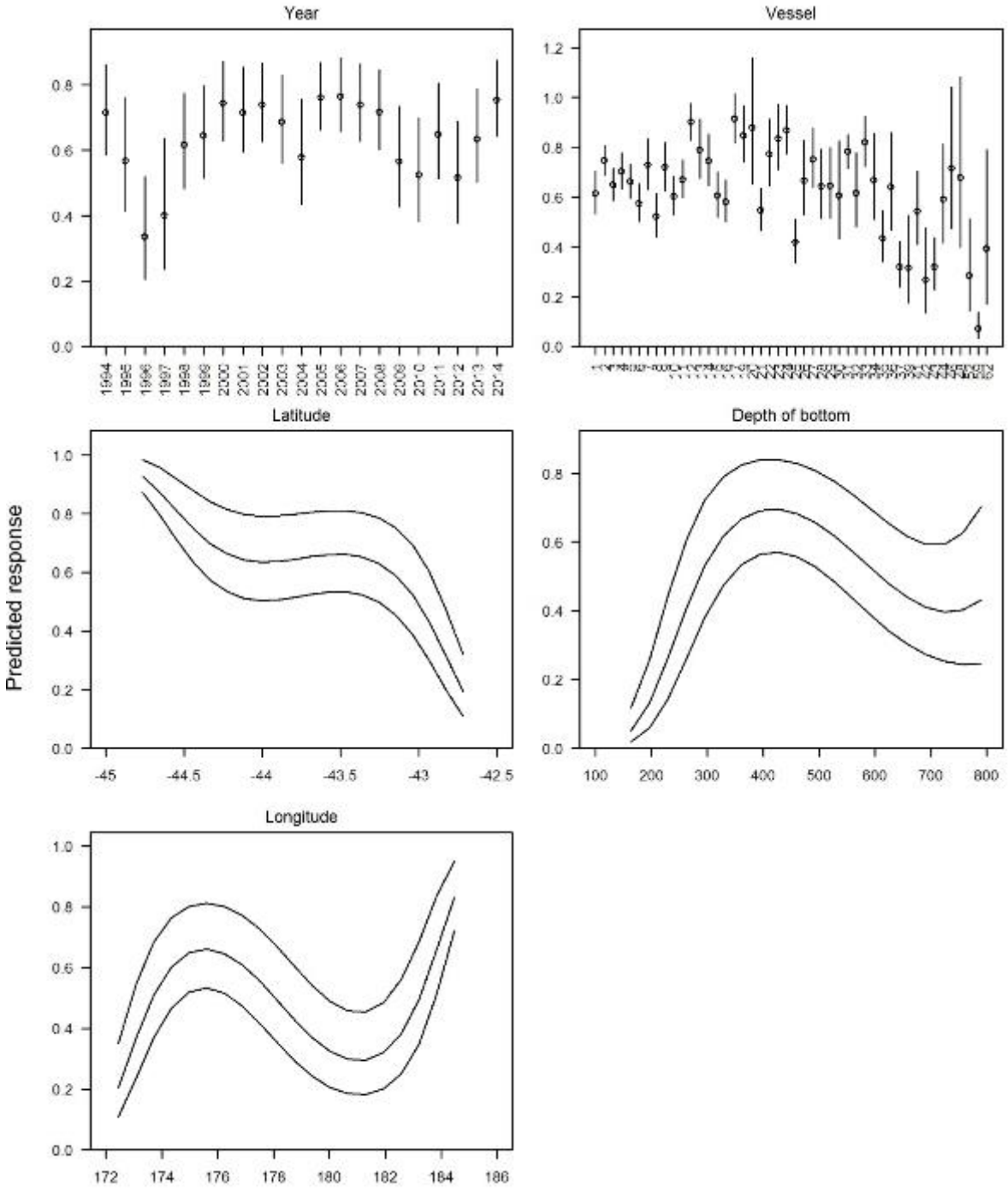


Figure D10b: Binomial effects of selected variables in the binomial model for the CHAT observer tow-by-tow catch. Bars indicate 95% confidence interval.

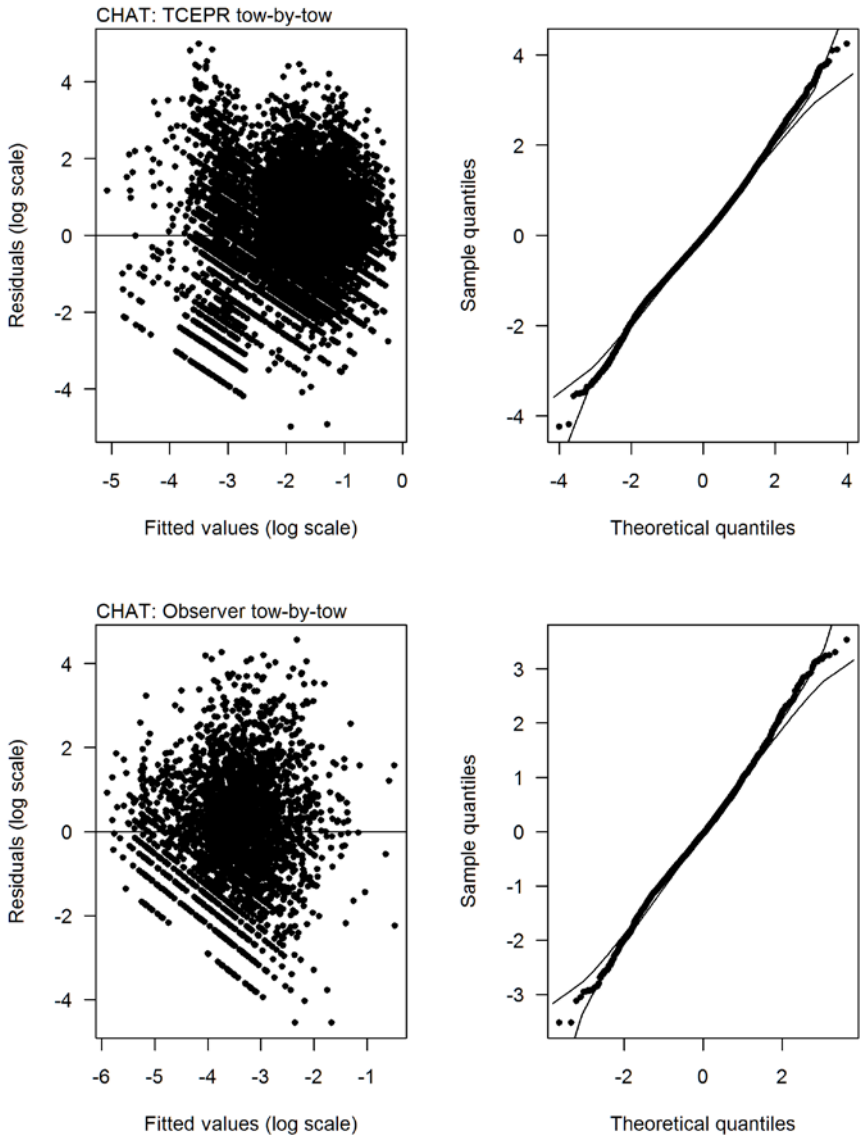


Figure D11: Distribution of the standardised residuals against fitted values (left) and quantile-quantile plot of the residuals (right) for CHAT lognormal models.

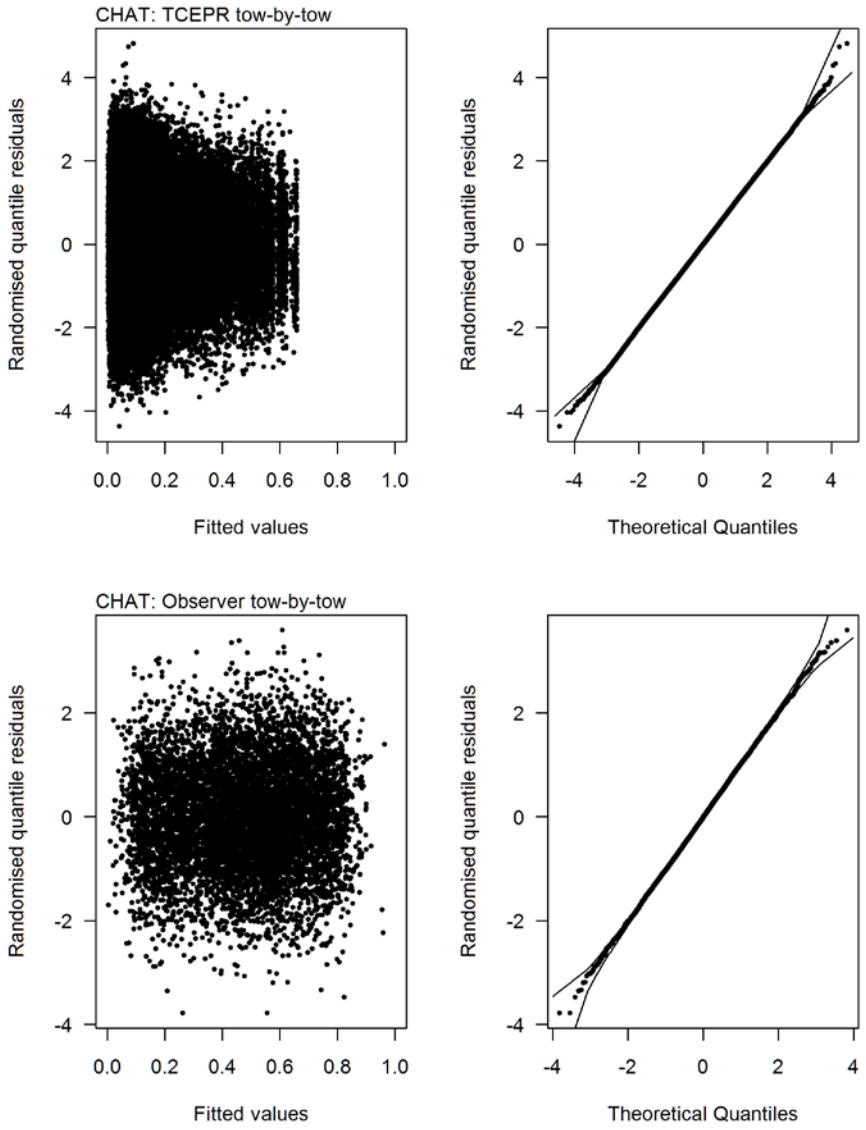


Figure D12: Distribution of the randomised quantile residuals against fitted values (left) and quantile-quantile plot of the randomised quantile residuals (right) for CHAT binomial models.

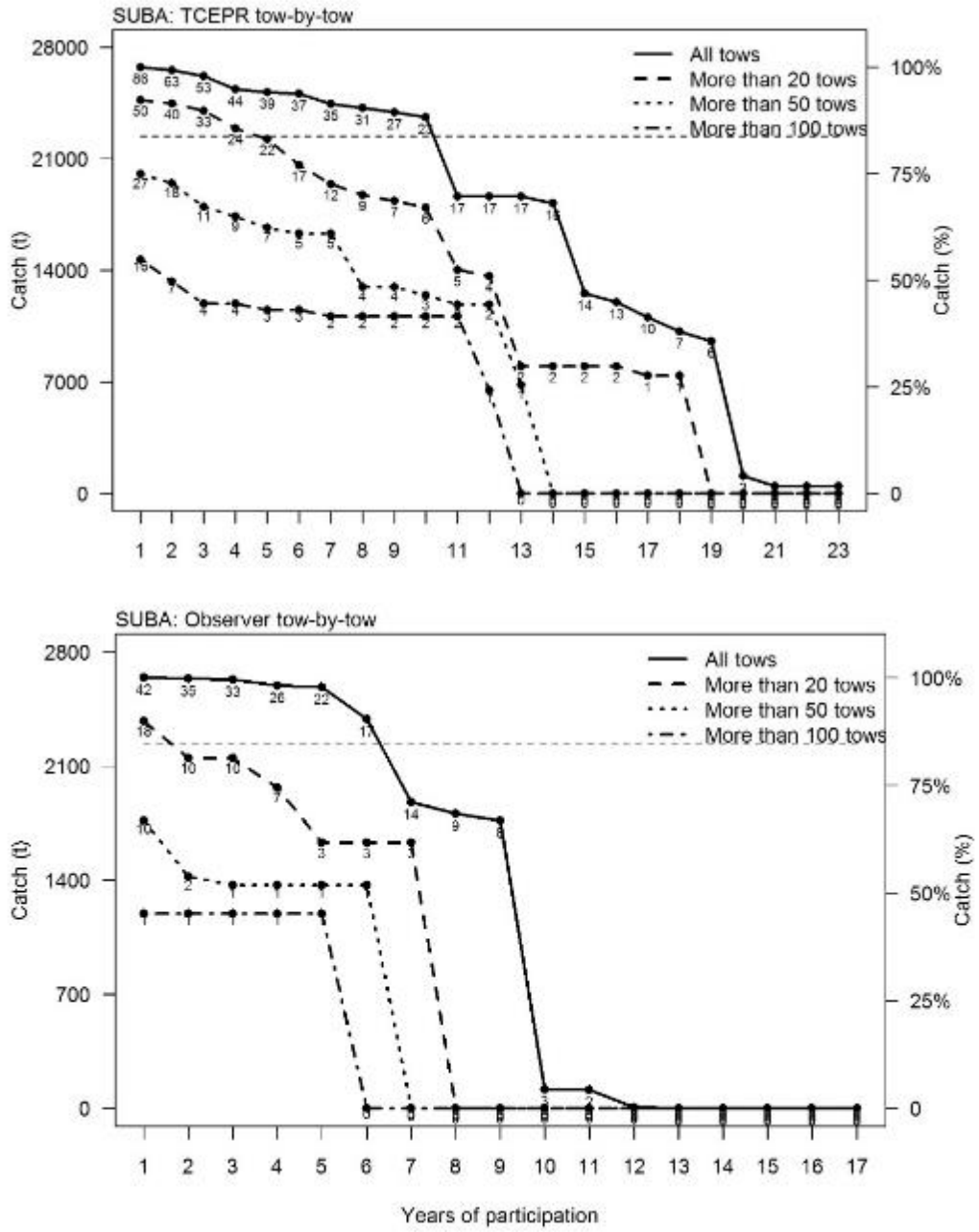
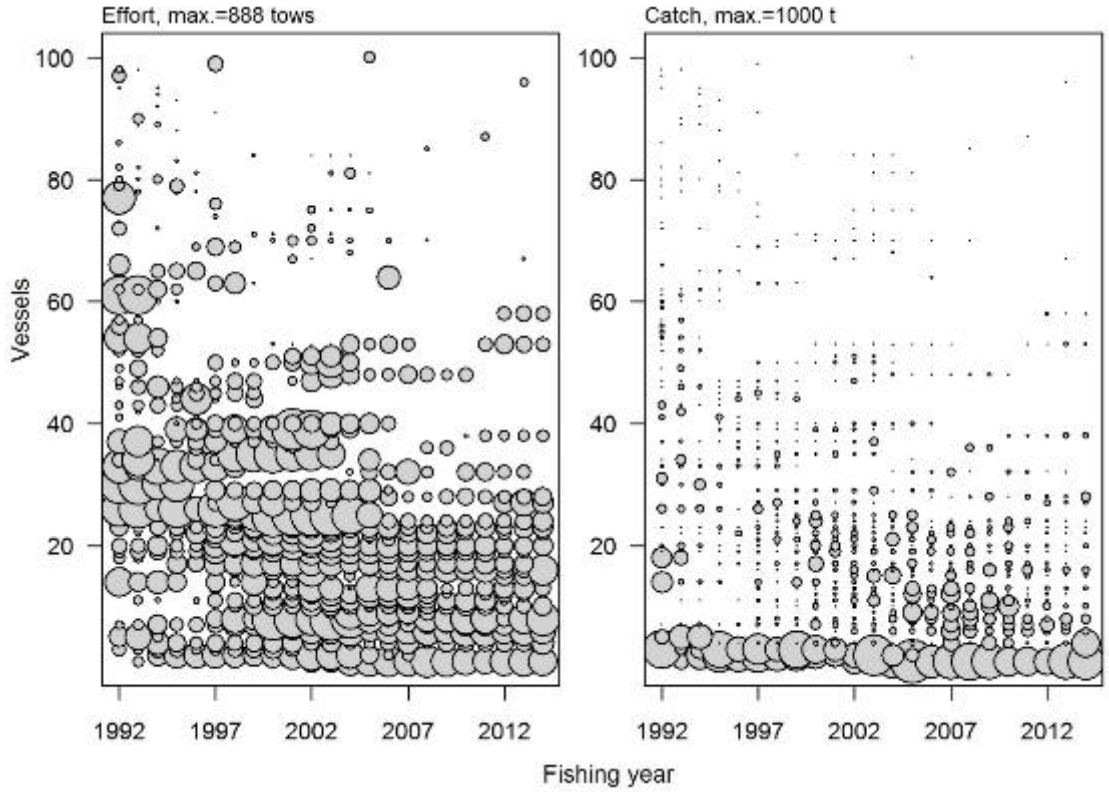


Figure D13: Relationship between years of vessel participation and total white warehou SUBA catch by area. The number under each circle indicates the number of vessels with the corresponding years of participation. Dotted horizontal line represents 80% of catch.

(a) All vessels



(b) Core vessels

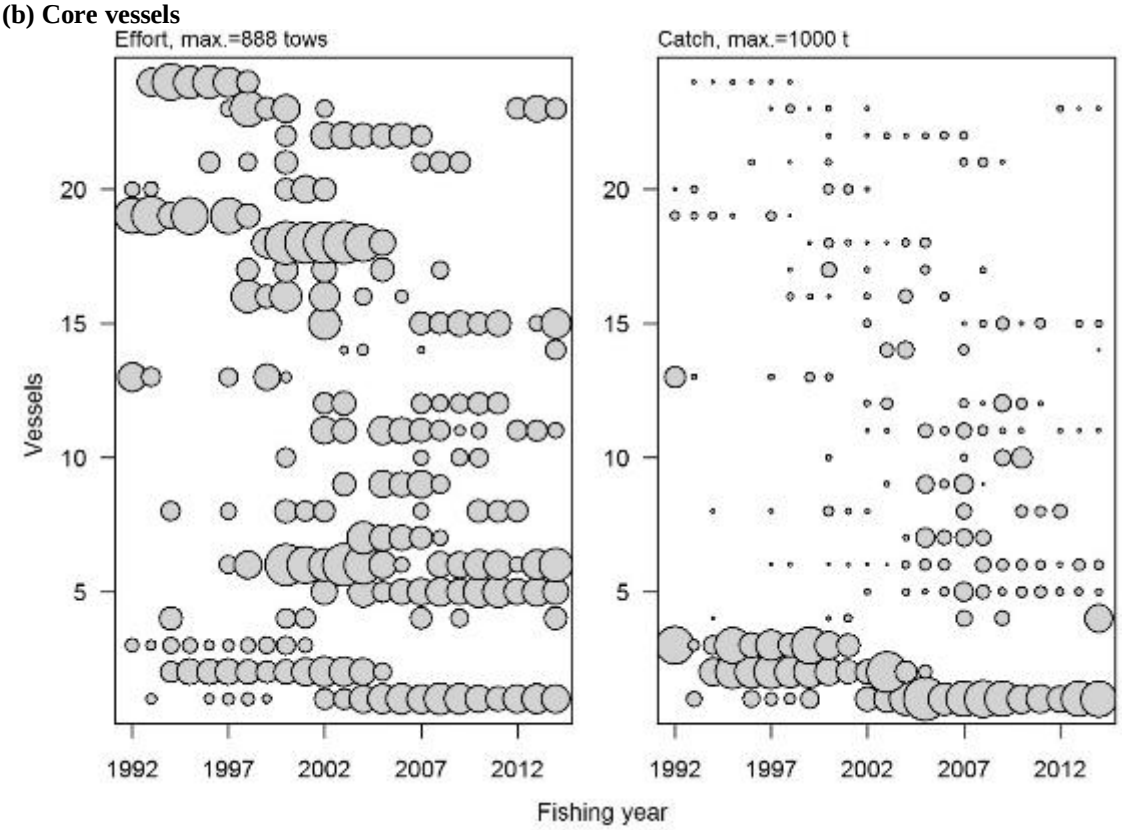
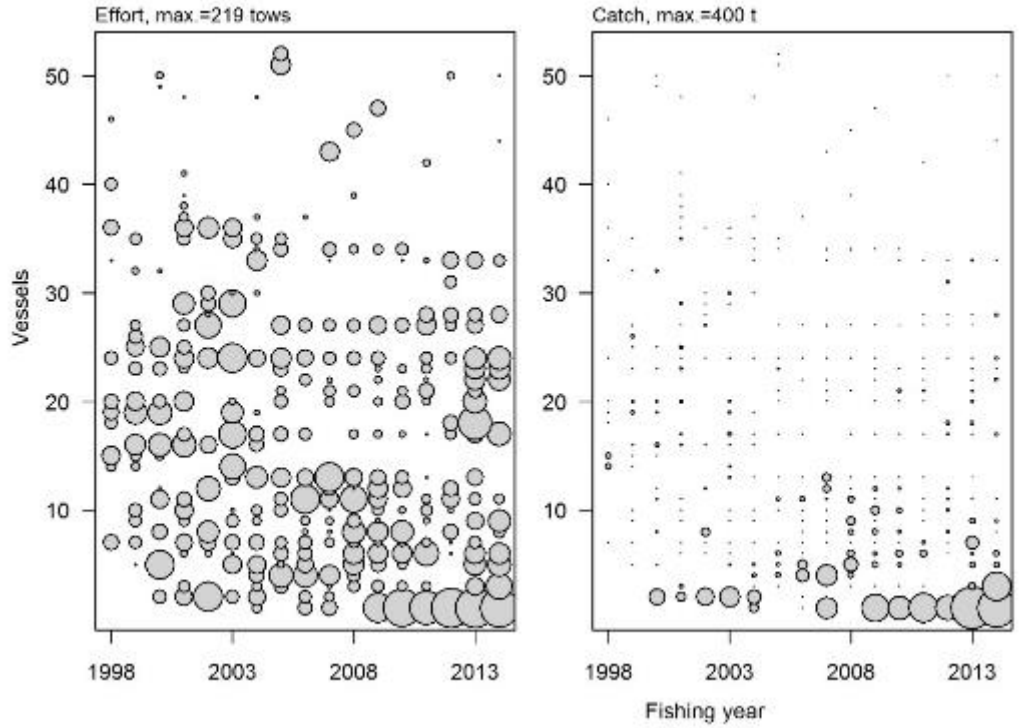


Figure D14a: SUBA TCEPR tow-by-tow analysis. Summary of effort (number of tows) and estimated white warehou catch by fishing year 1992 to 2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

(a) All vessels



(b) Core vessels

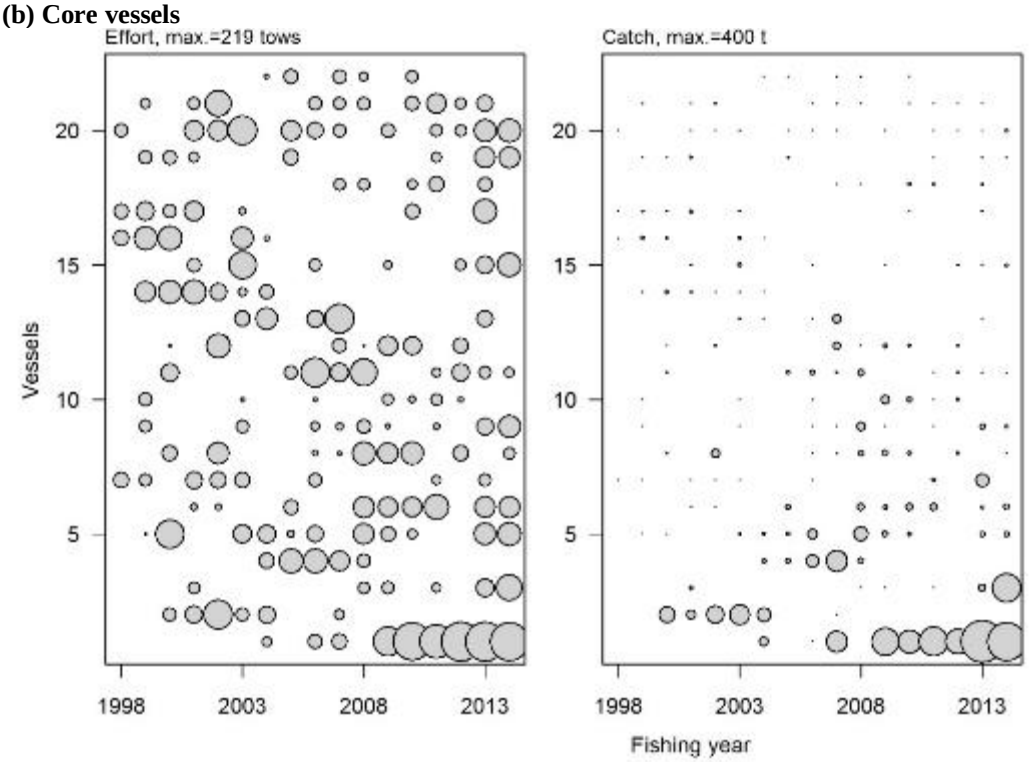


Figure D14b: SUBA Observer tow-by-tow analysis. Summary of effort (number of tows) and estimated white warehou catch by fishing year 1992 to 2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

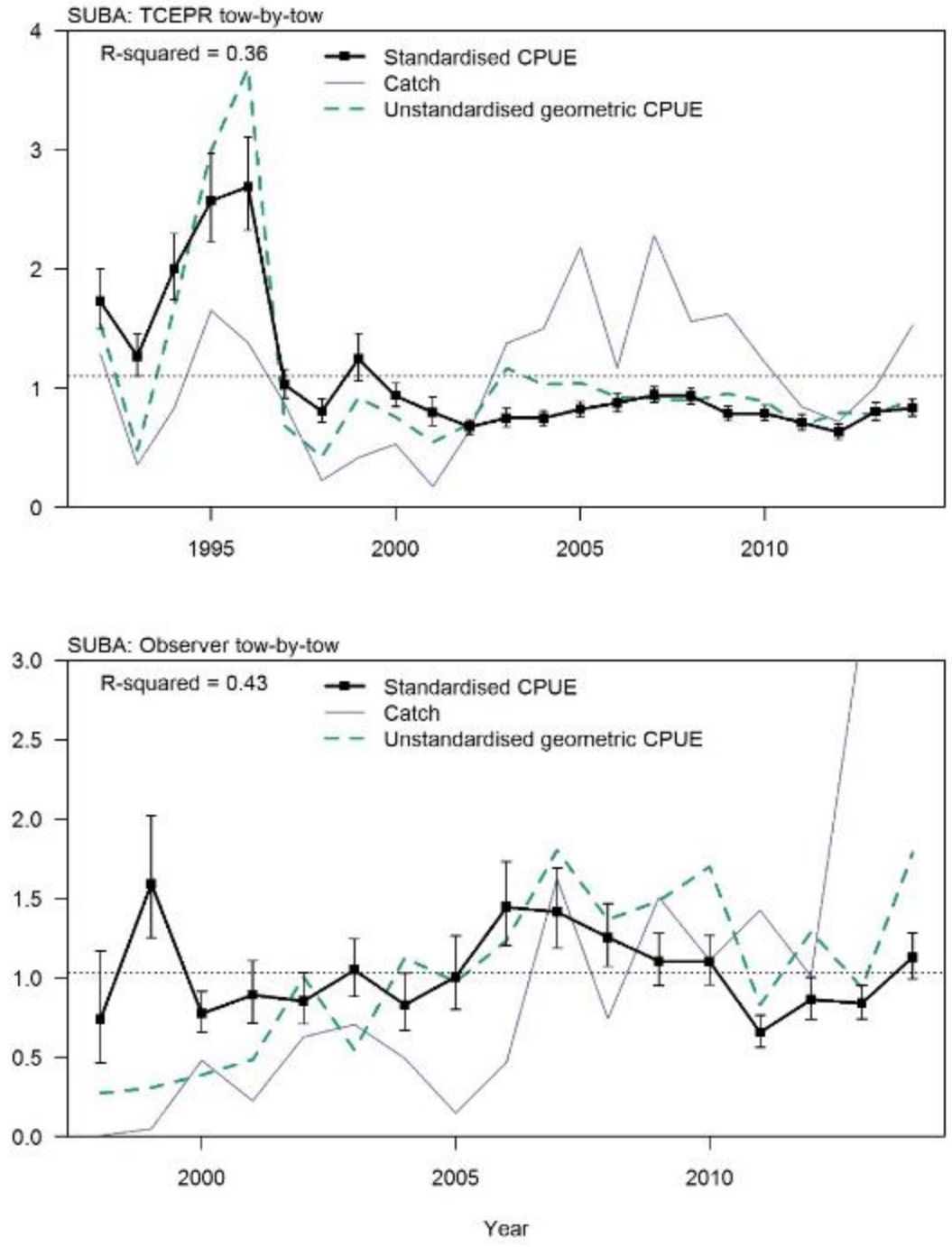


Figure D15: SUBA CPUE lognormal indices showing catches (scaled to same mean as indices), and lognormal standardised and un-standardised indices. Bars indicate 95% confidence intervals. Year defined as October–September.

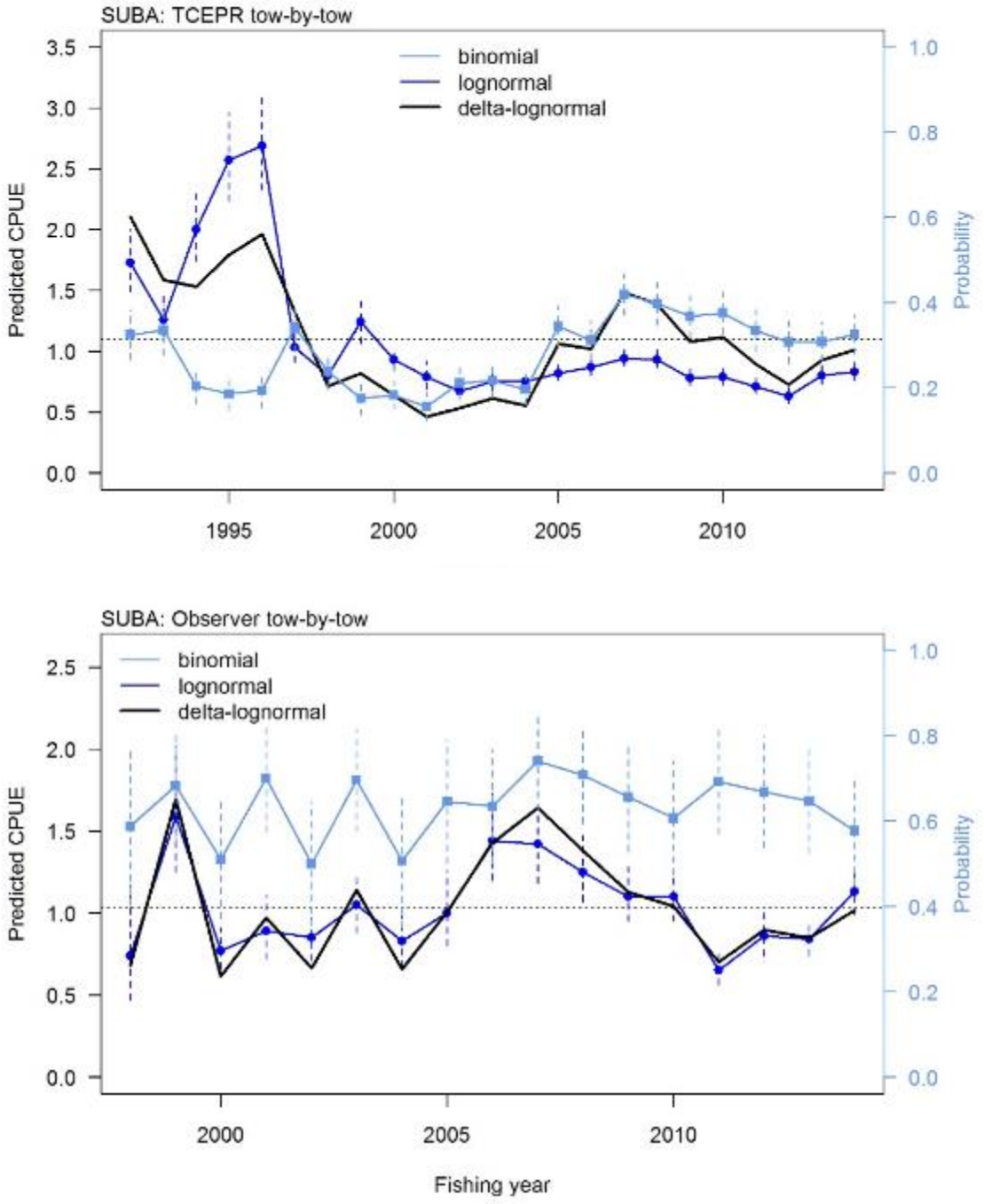


Figure D16: SUBA CPUE from the lognormal, binomial and combined models. Bars indicate 95% confidence intervals. Year defined as October–September.

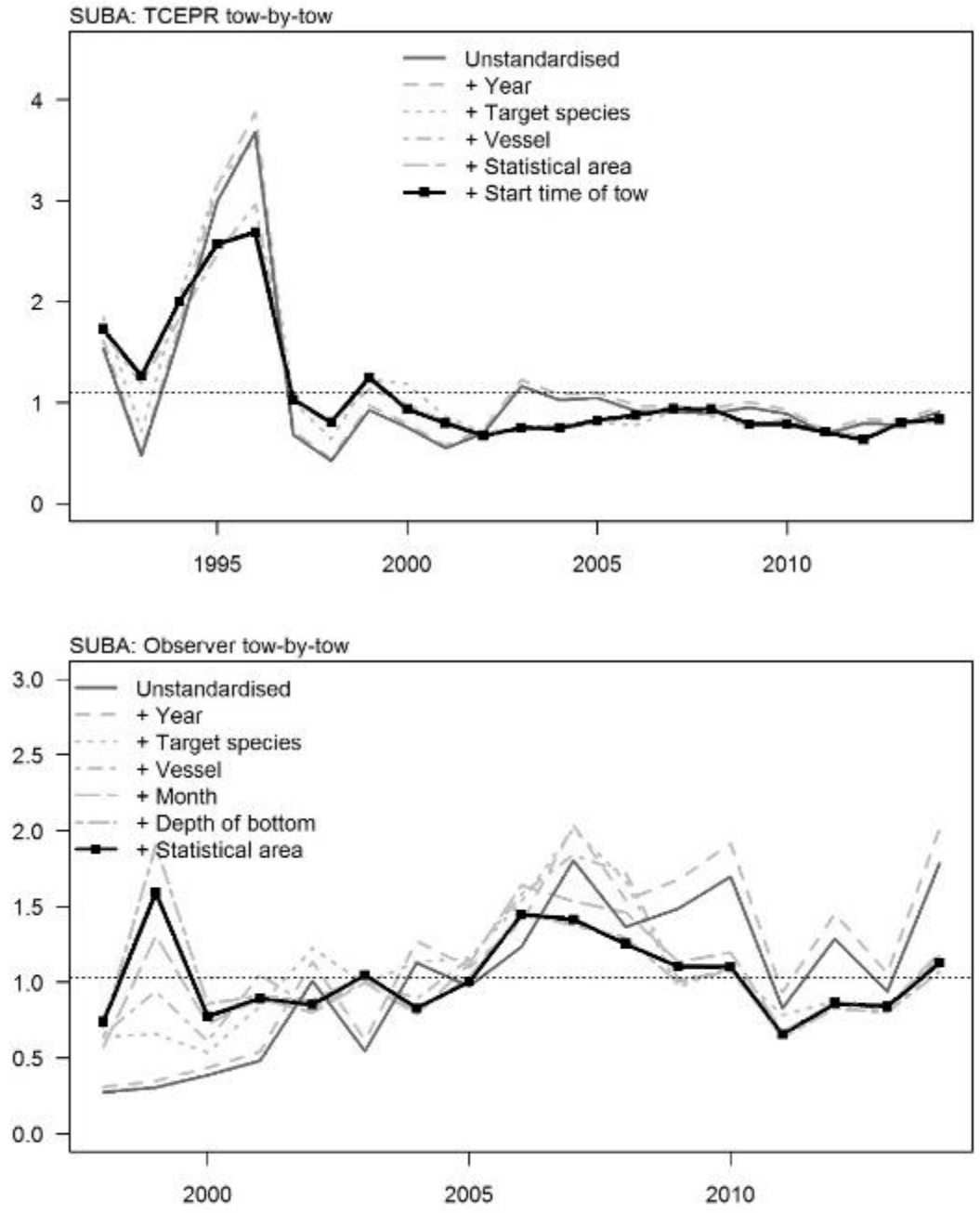


Figure D17: Addition of variables into the SUBA CPUE lognormal CPUE model for each fishery by fishing year. Year defined as October‑September.

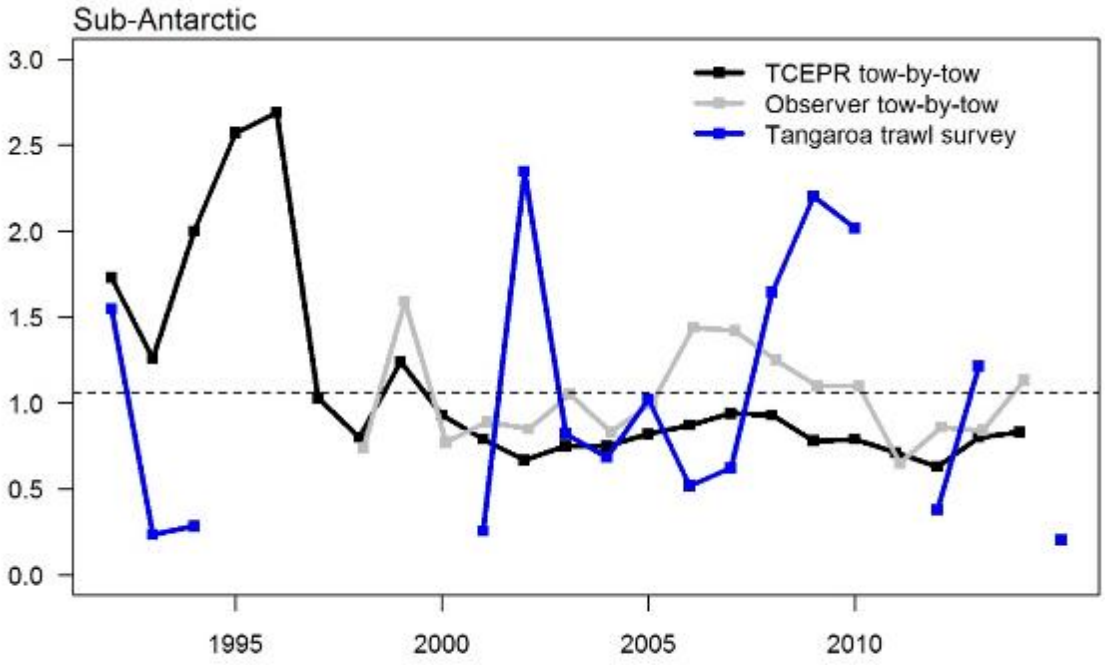


Figure D18: Comparison of SUBA indices for the TCEPR tow-by-tow, and Observer tow-by-tow datasets by fishing year, and the Sub-Antarctic November–December trawl survey for white warehou biomass 1991–1993; 2000–2009, 2011–2012, 2014 indices (one year has been added to biomass indices so matches correct fishing year, e.g. November–December 1991 is plotted as 1992 fishing year). Indices have been standardised to have a mean of one.

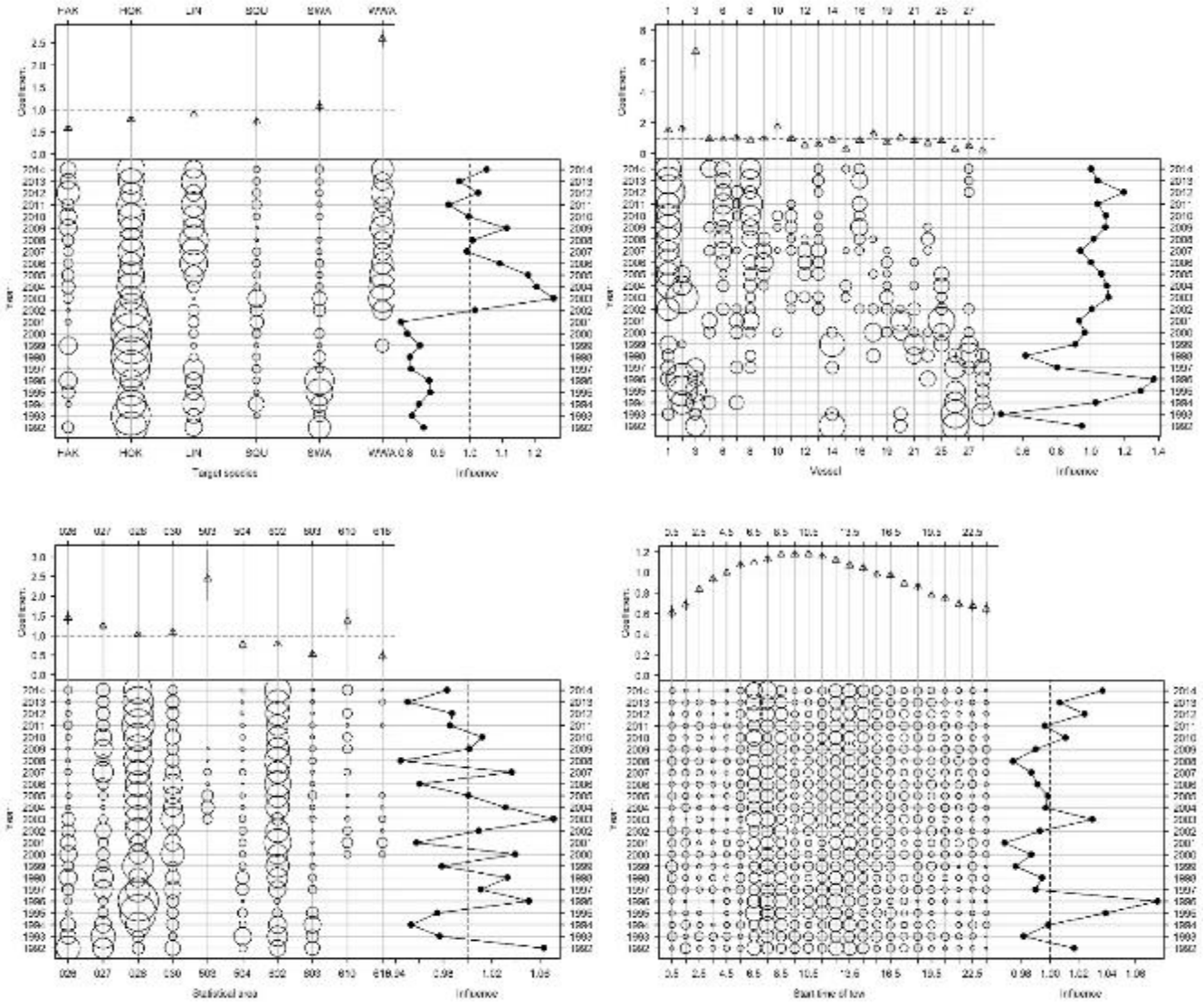


Figure D19a: SUBA TCEPR tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

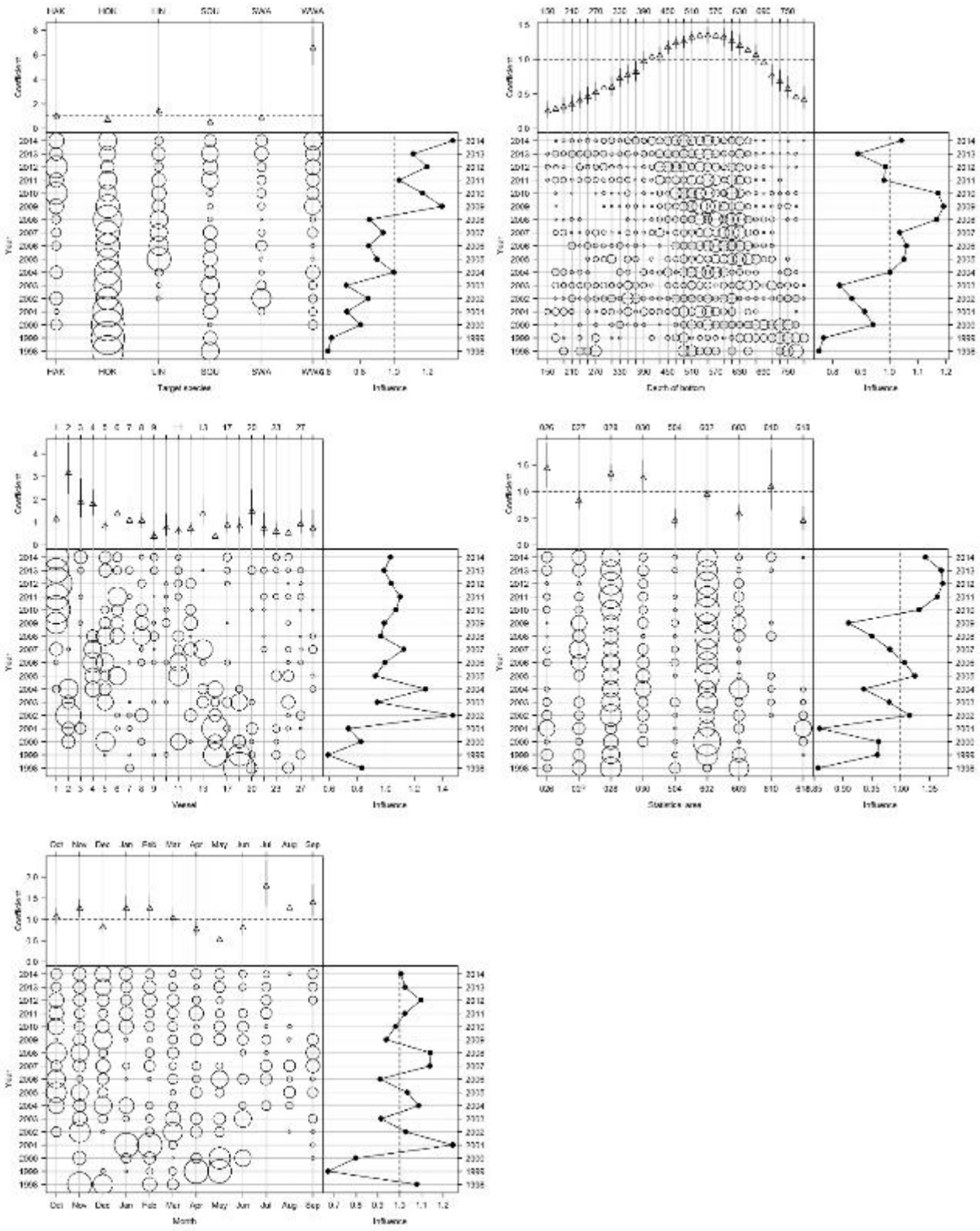


Figure D19b: SUBA Observer tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

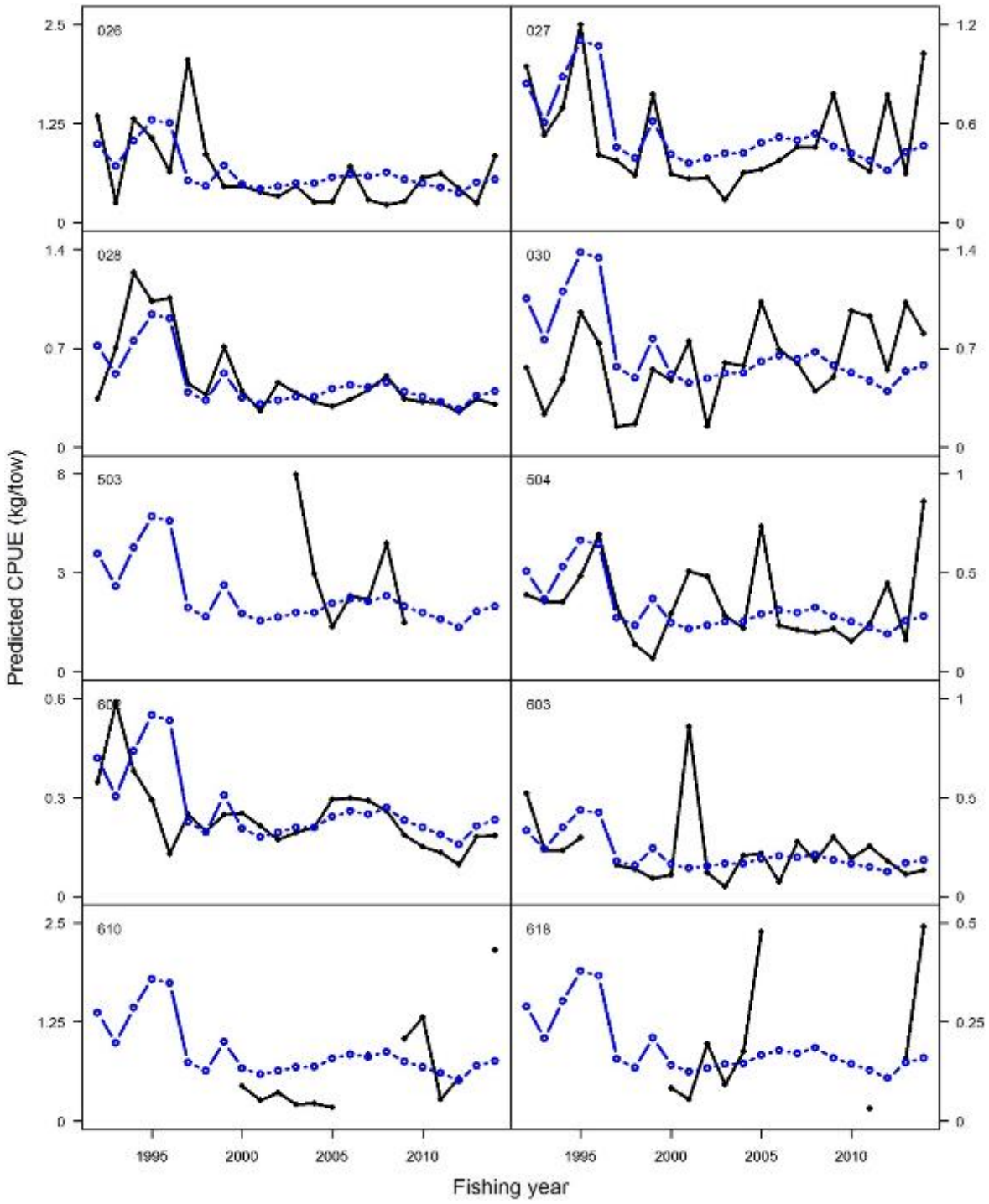


Figure D20: Predicted CPUE by statistical area for the SUBA TCEPR tow-by-tow lognormal model showing model with year-statistical area interaction (black) and without year-statistical area interaction (blue).

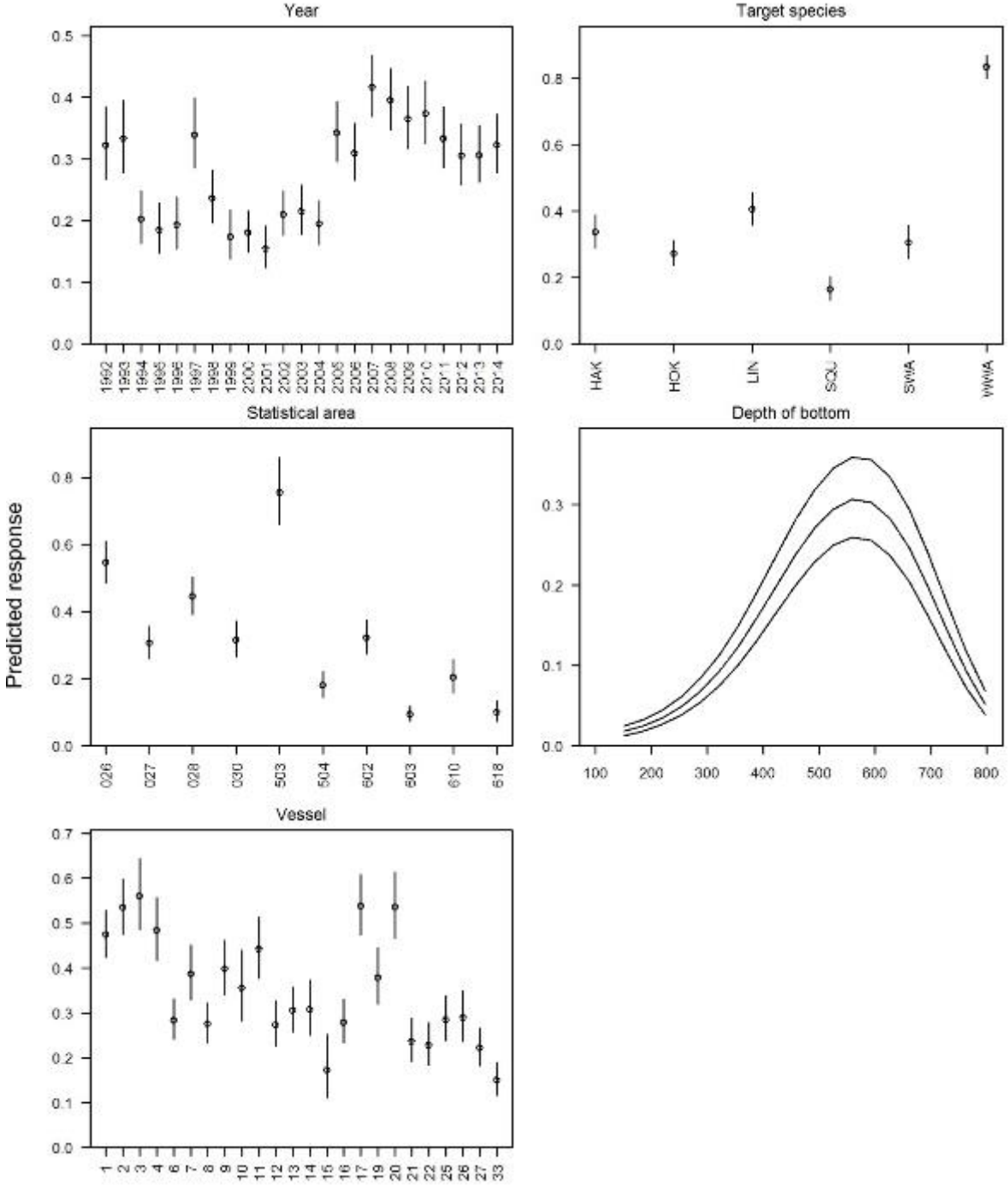


Figure D21a: Binomial effects of selected variables in the binomial model for the SUBA TCEPR tow-by-tow catch. Bars indicate 95% confidence interval.

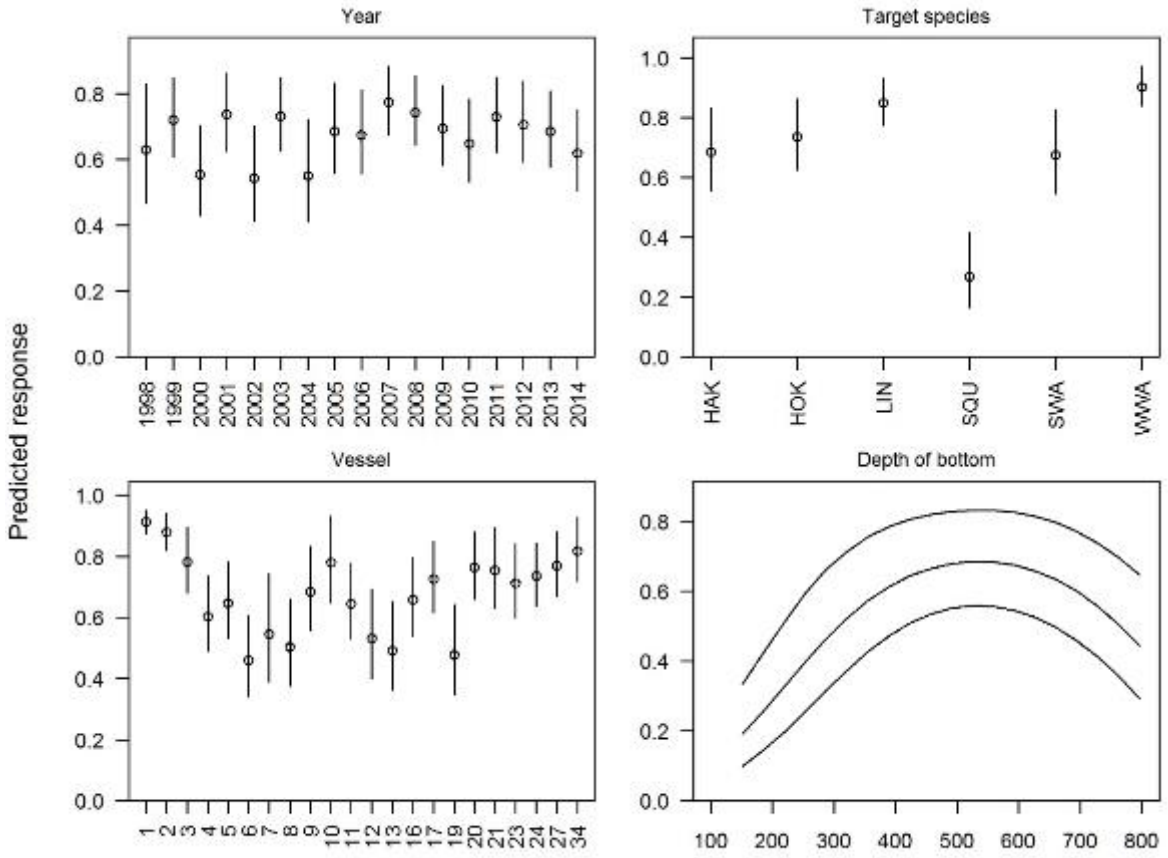


Figure D21b: Binomial effects of selected variables in the binomial model for the SUBA observer tow-by-tow catch. Bars indicate 95% confidence interval.

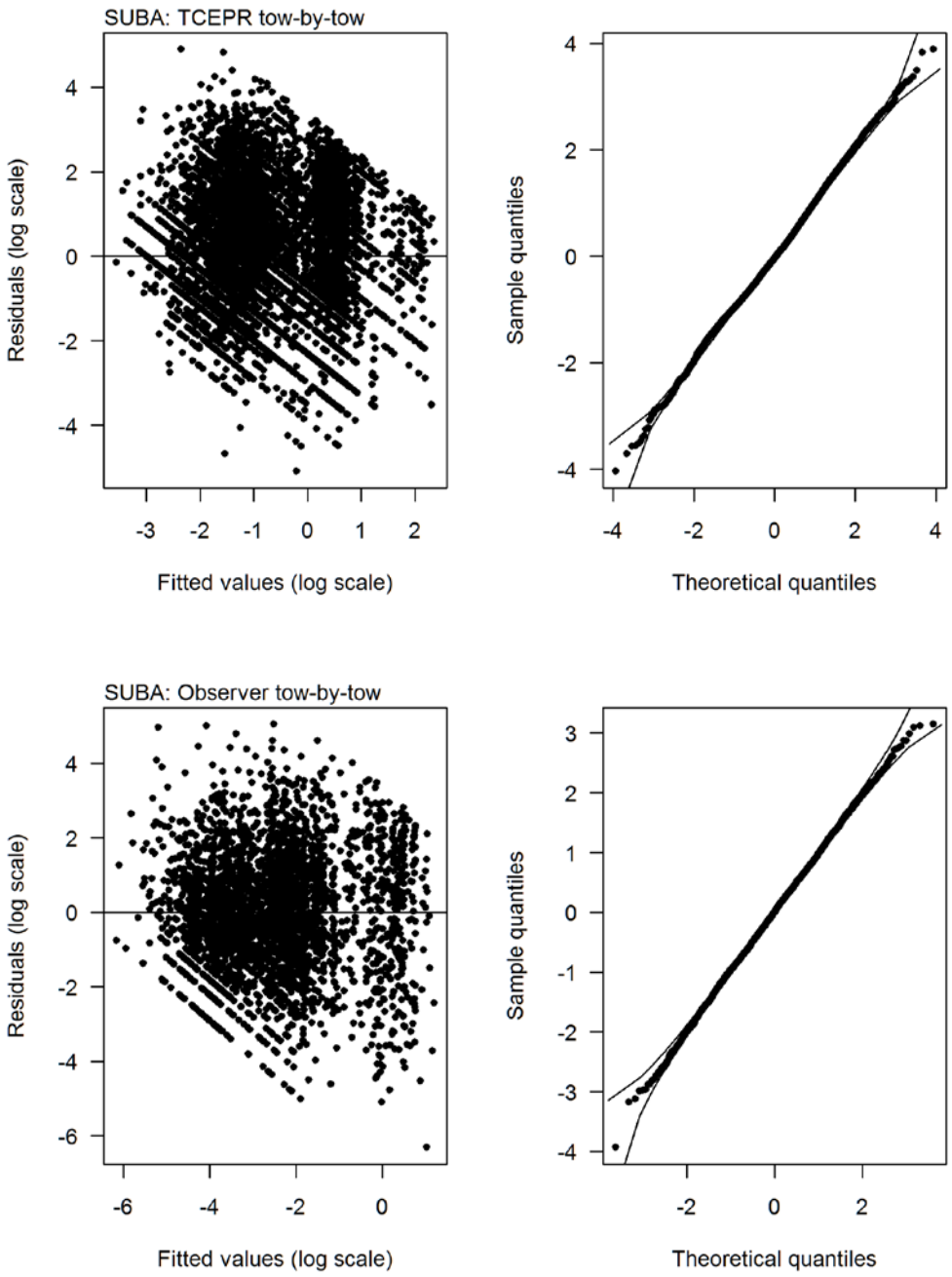


Figure D22: Distribution of the standardised residuals against fitted values (left) and quantile-quantile plot of the residuals (right) for SUBA lognormal models.

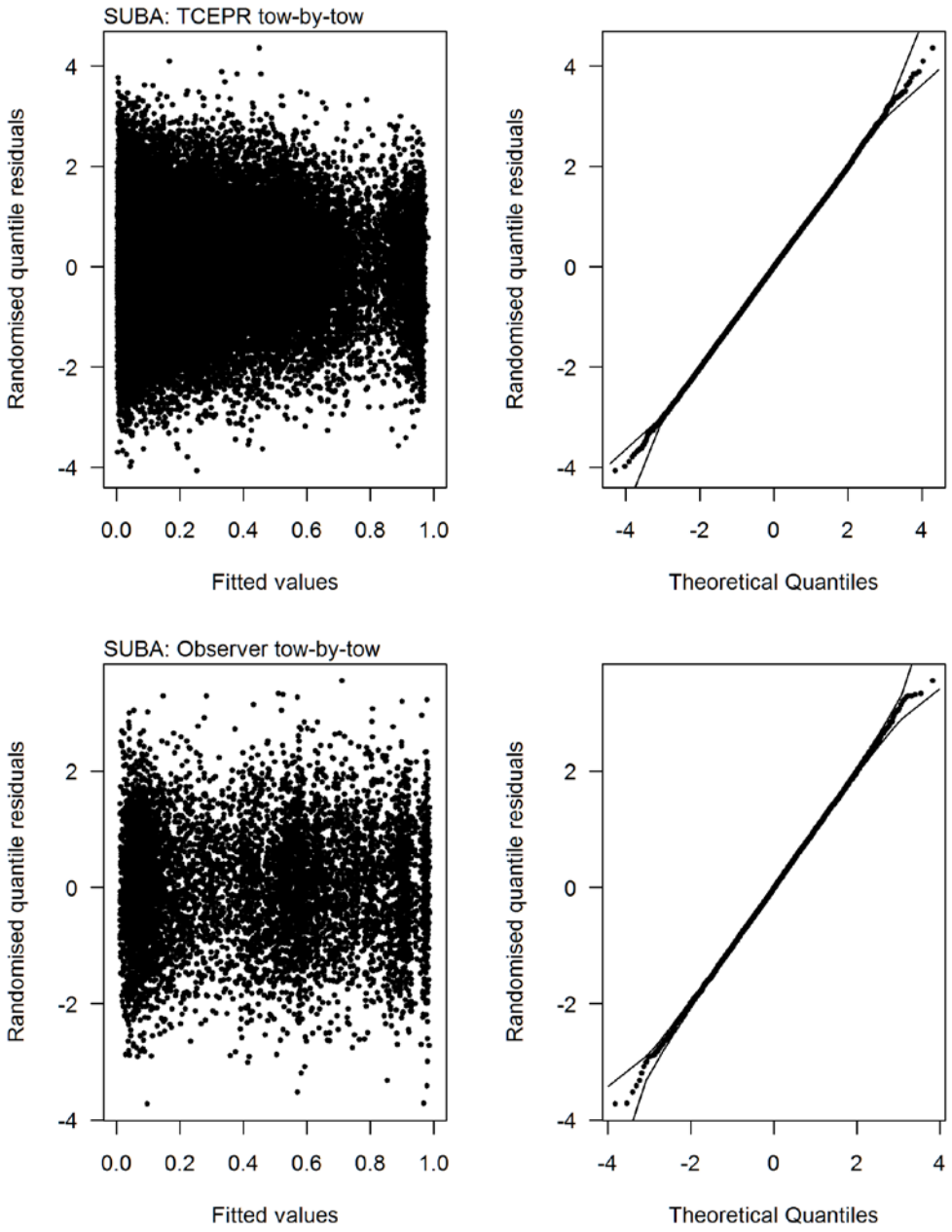


Figure D23: Distribution of the randomised quantile residuals against fitted values (left) and quantile-quantile plot of the randomised quantile residuals (right) for SUBA binomial models.

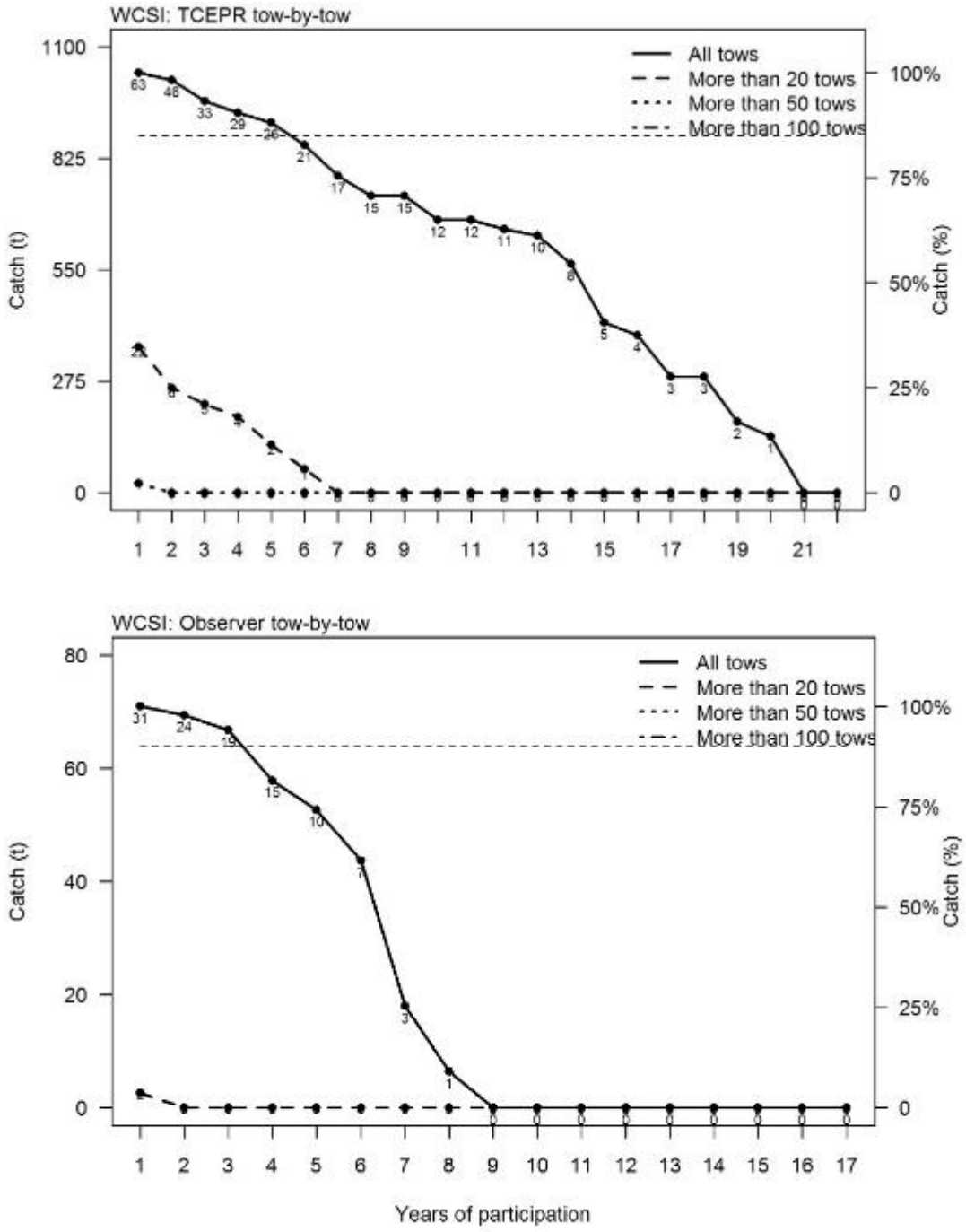
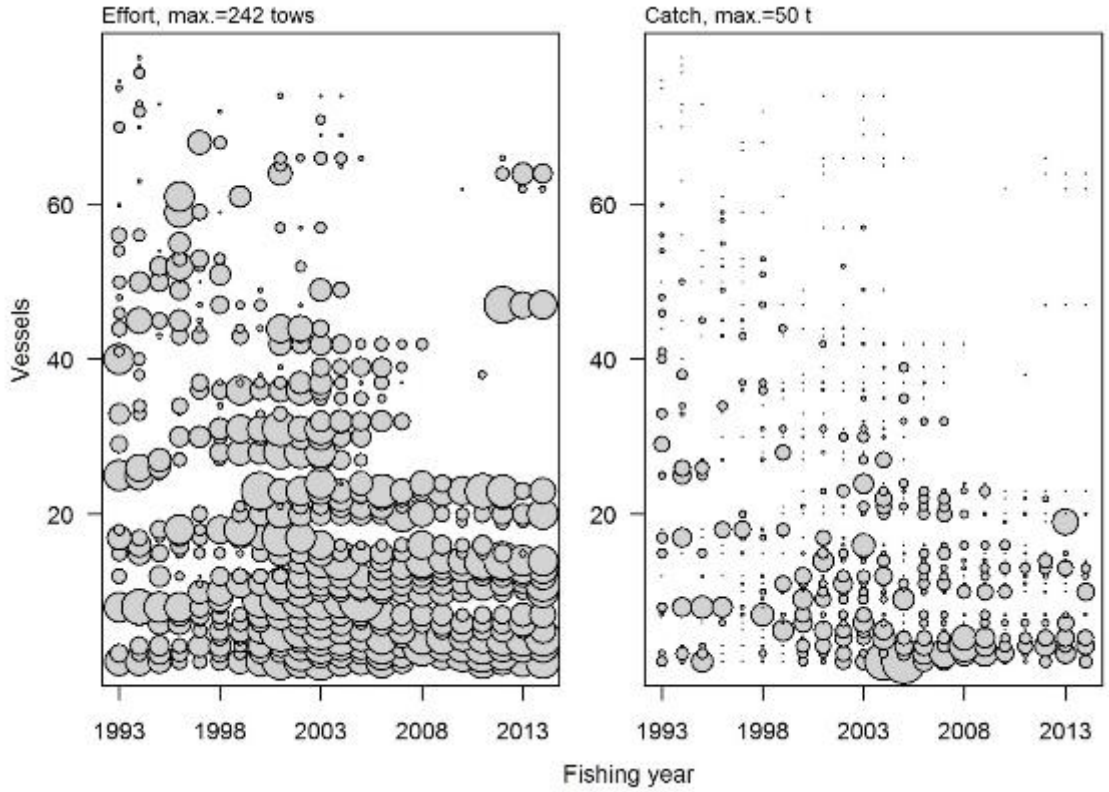


Figure D24: Relationship between years of vessel participation and total white warehou WCSI catch by dataset. The number under each circle indicates the number of vessels with the corresponding years of participation. Dotted horizontal line represents 80% of catch.

(a) All vessels



(b) Core vessels

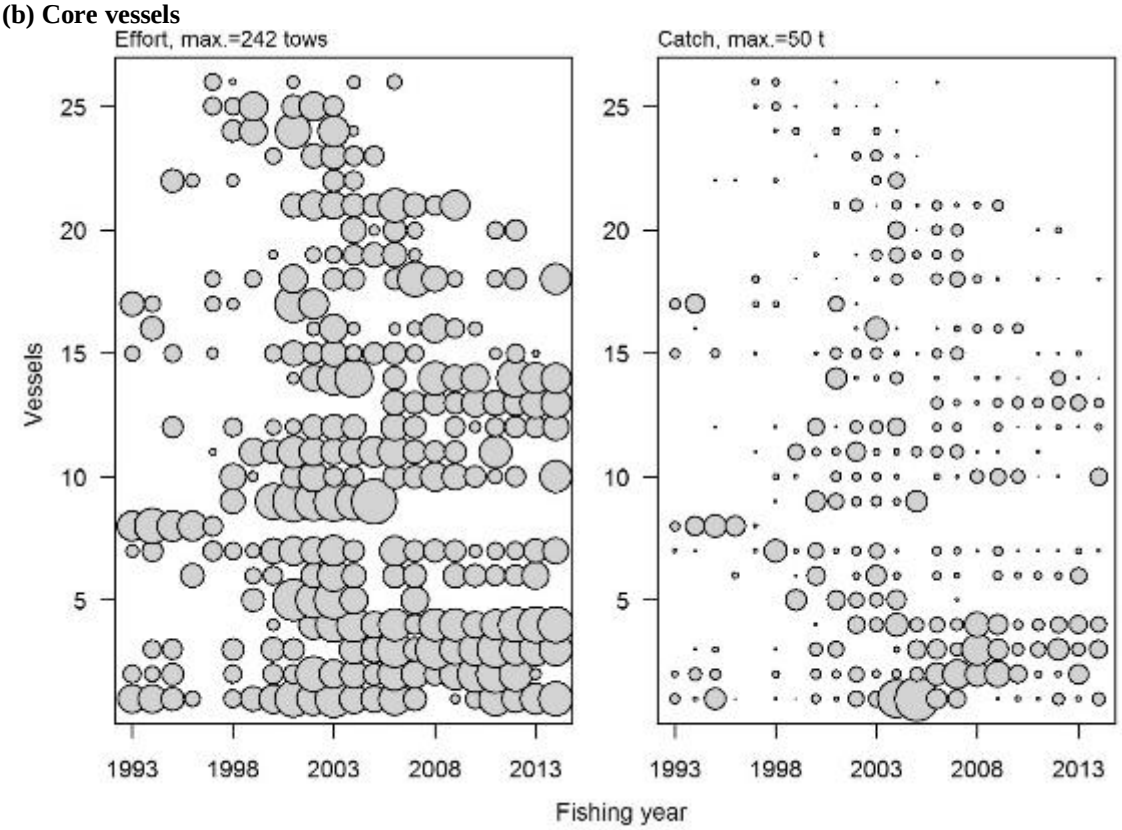
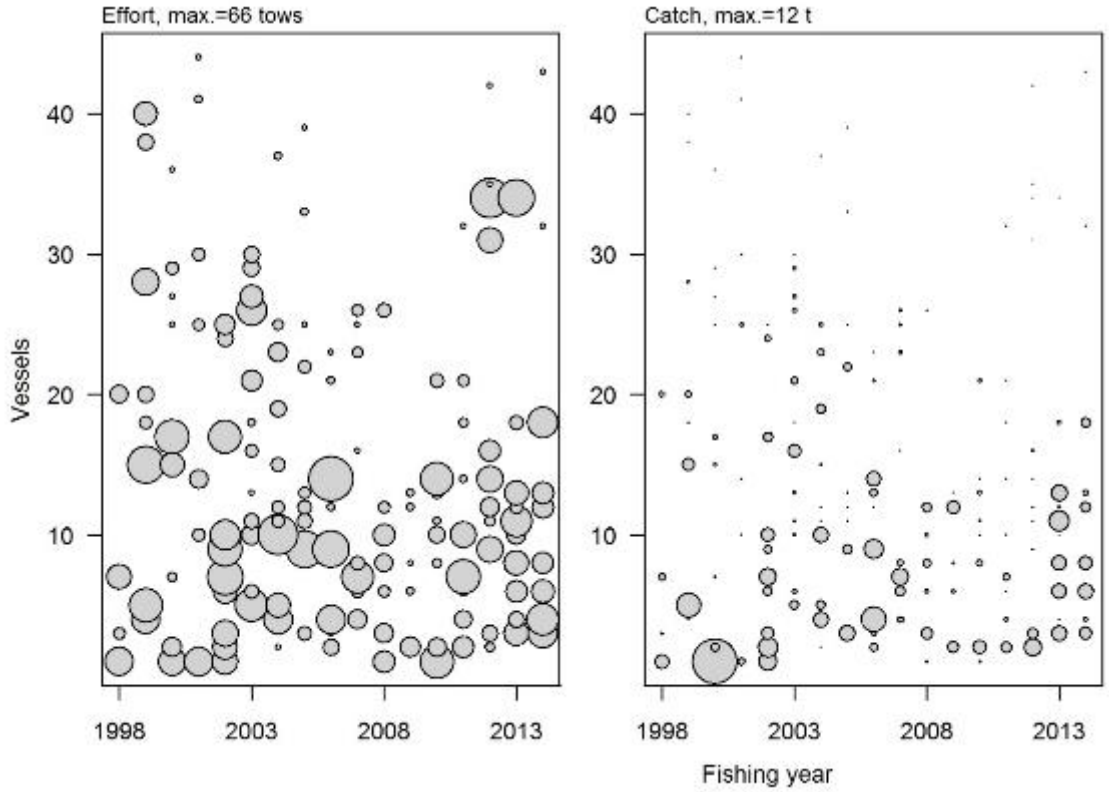


Figure D25a: WCSI TCEPR tow-by-tow analysis. Summary of effort (number of tows) and estimated white warehou catch by fishing year 1993 to 2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

(a) All vessels



(b) Core vessels

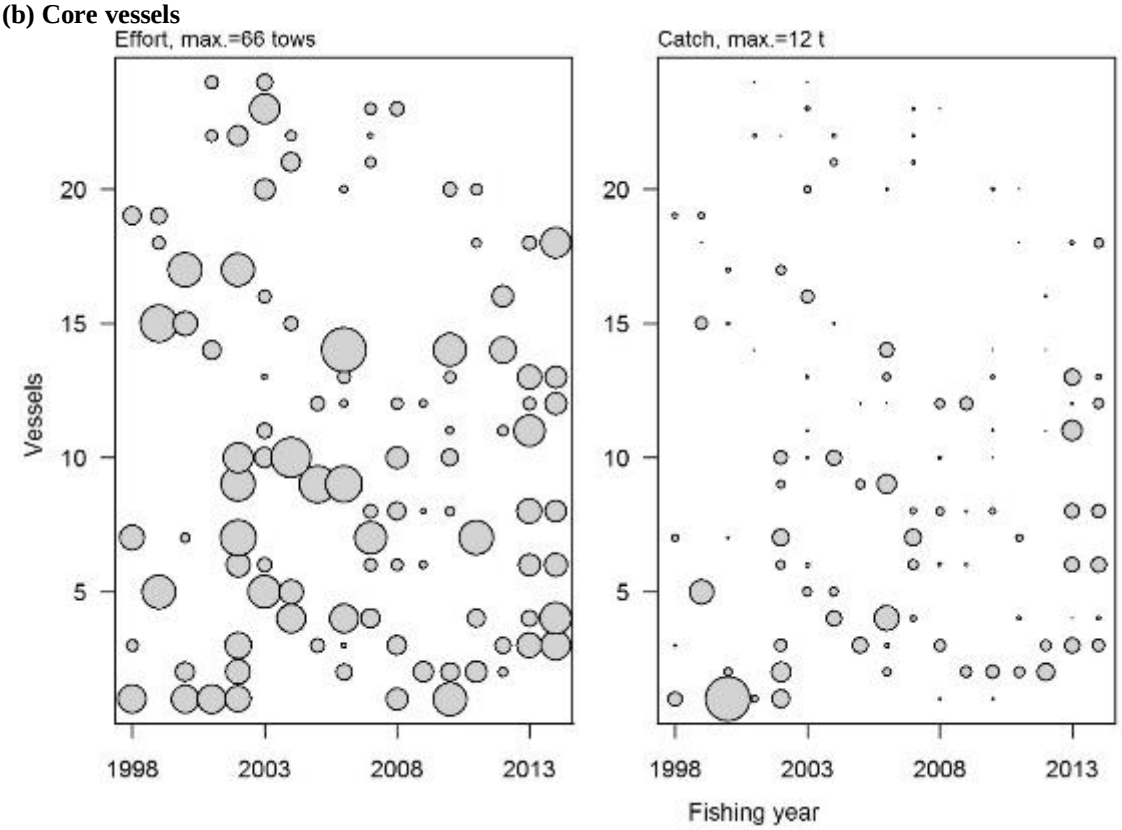


Figure D25b: WCSI Observer tow-by-tow analysis. Summary of effort (number of tows) and estimated white warehou catch by fishing year 1993 to 2014 from (a) all TCEPR BT tows and (b) TCEPR BT core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

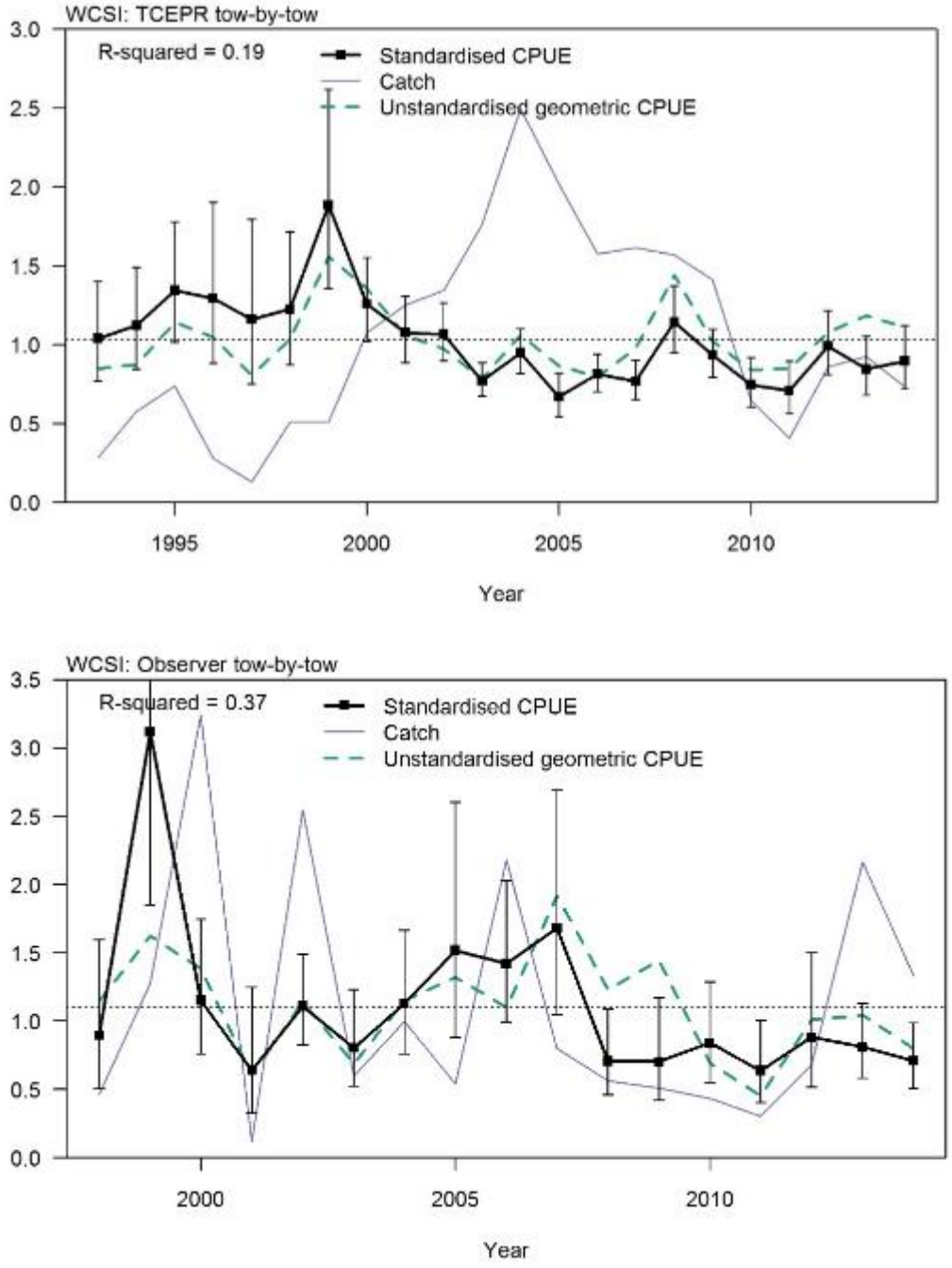


Figure D26: WCSI CPUE lognormal indices showing catches (scaled to same mean as indices), and lognormal standardised and un-standardised indices. Bars indicate 95% confidence intervals. Year defined as October–September.

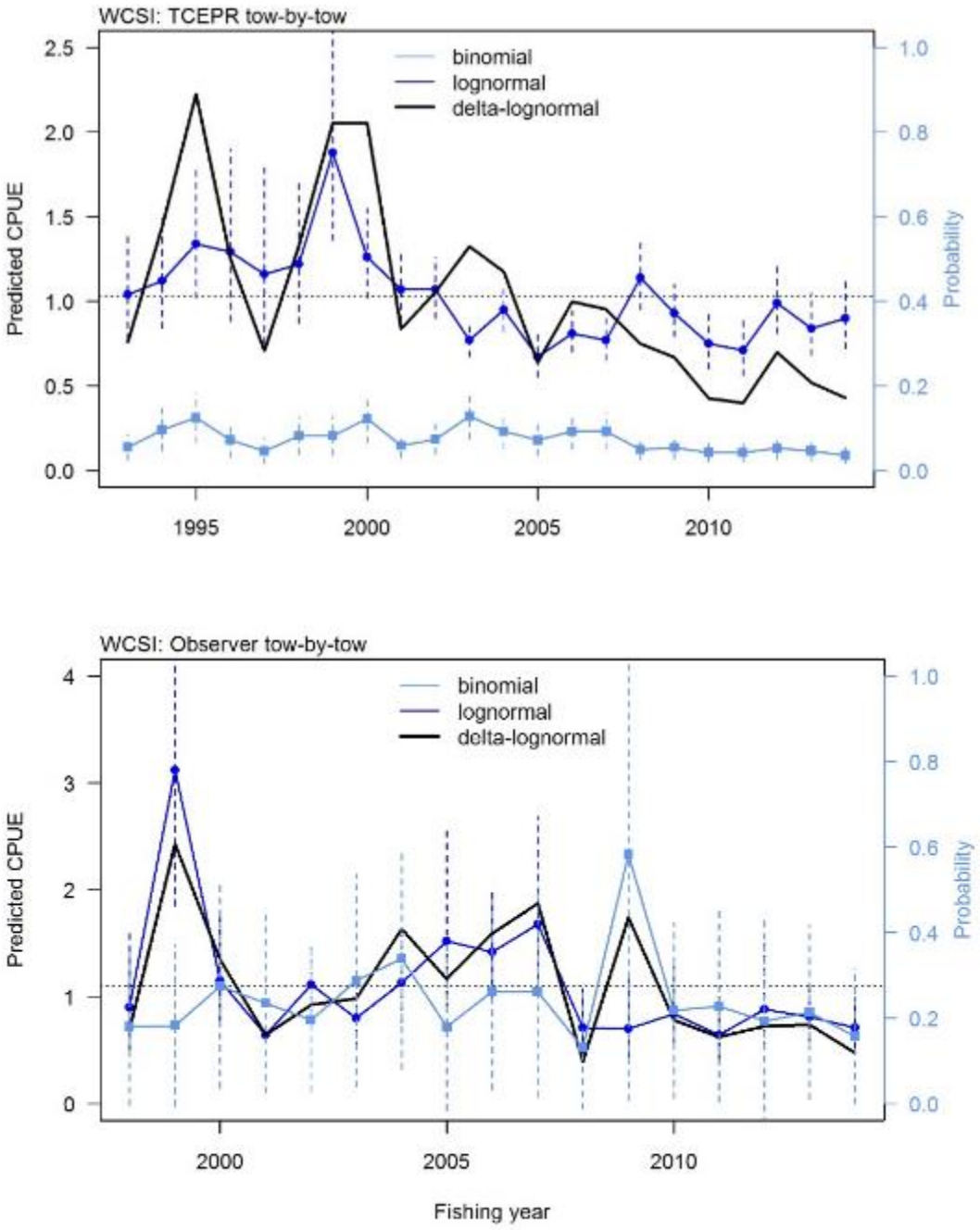


Figure D27: WCSI CPUE from the lognormal, binomial and combined models. Bars indicate 95% confidence intervals. Year defined as October–September.

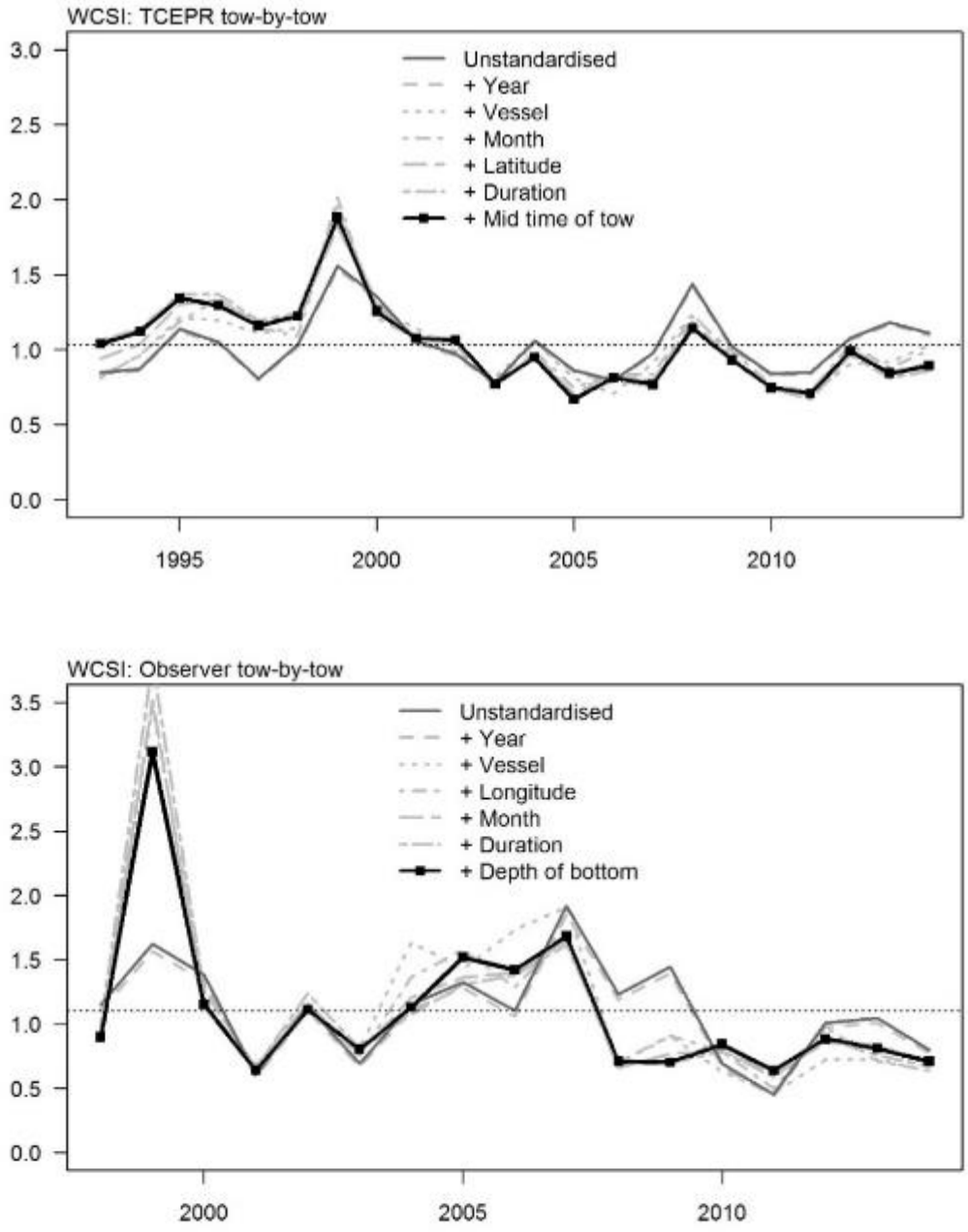


Figure D28: Addition of variables into the WCSI CPUE lognormal CPUE model for each fishery by fishing year. Year defined as October–September.

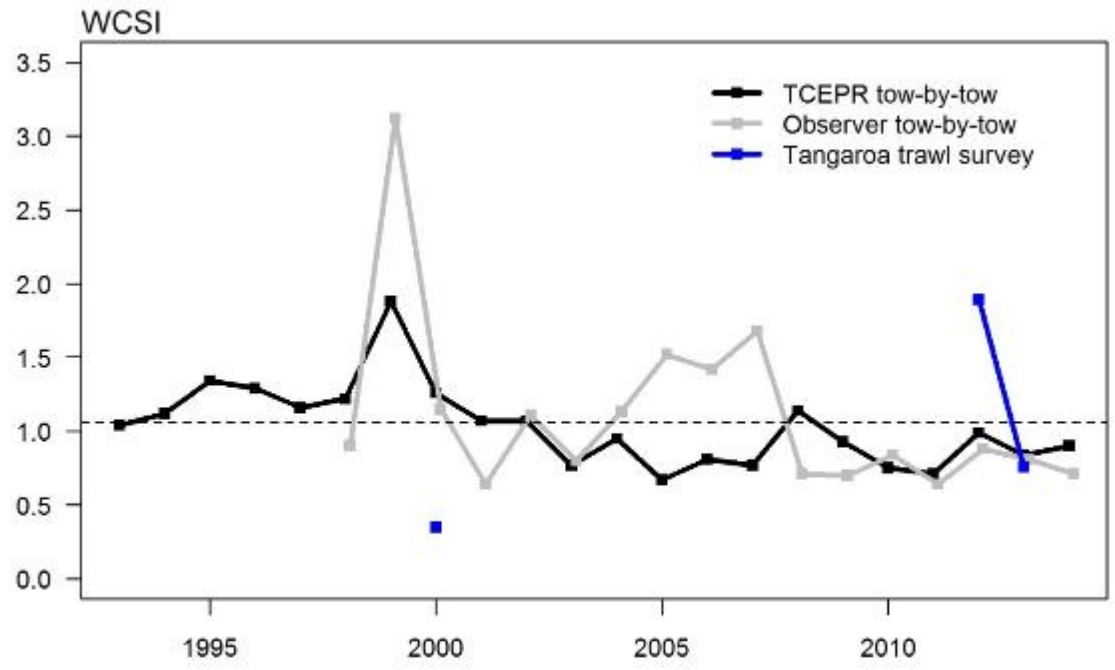


Figure D29: Comparison of WCSI indices for the TCEPR tow-by-tow, and Observer tow-by-tow datasets for fishing years 1993 to 2014, and the WCSI July trawl survey for white warehou biomass indices 1992. 2012–2013. Indices have been standardised to have a mean of one.

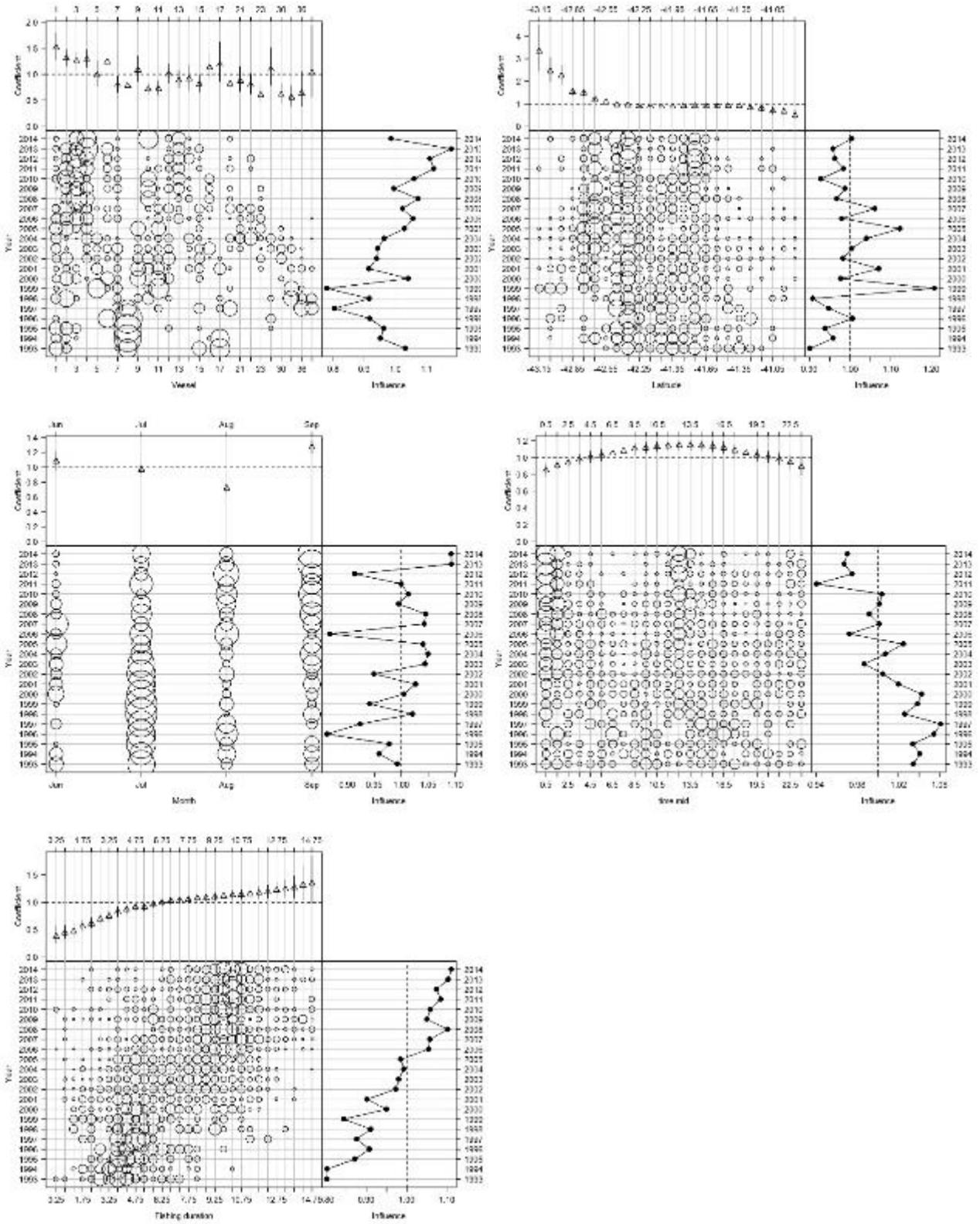


Figure D30a: WCSI TCEPR tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

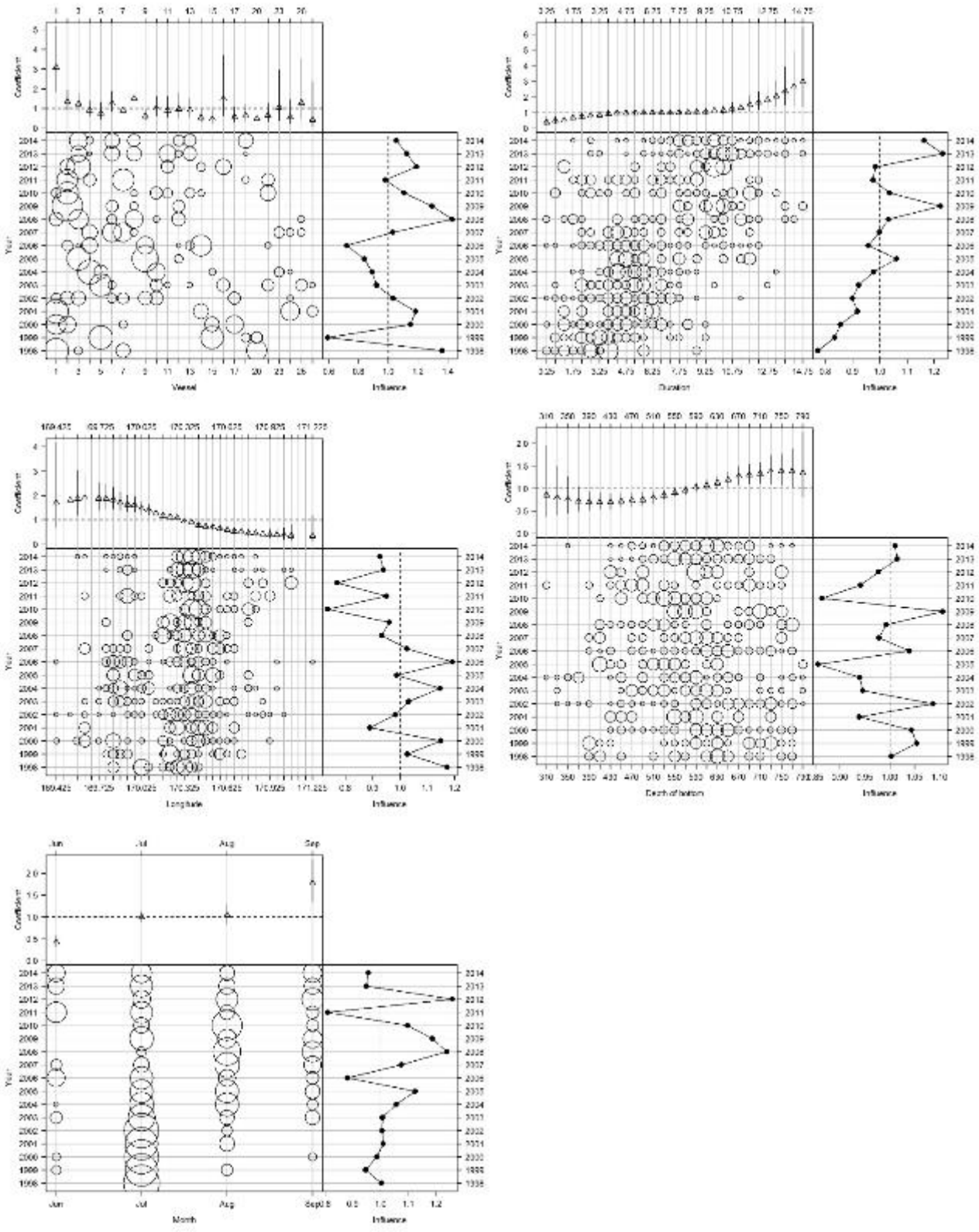


Figure D30b: WCSI Observer tow-by-tow analysis. Effect and influence of variable in the lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

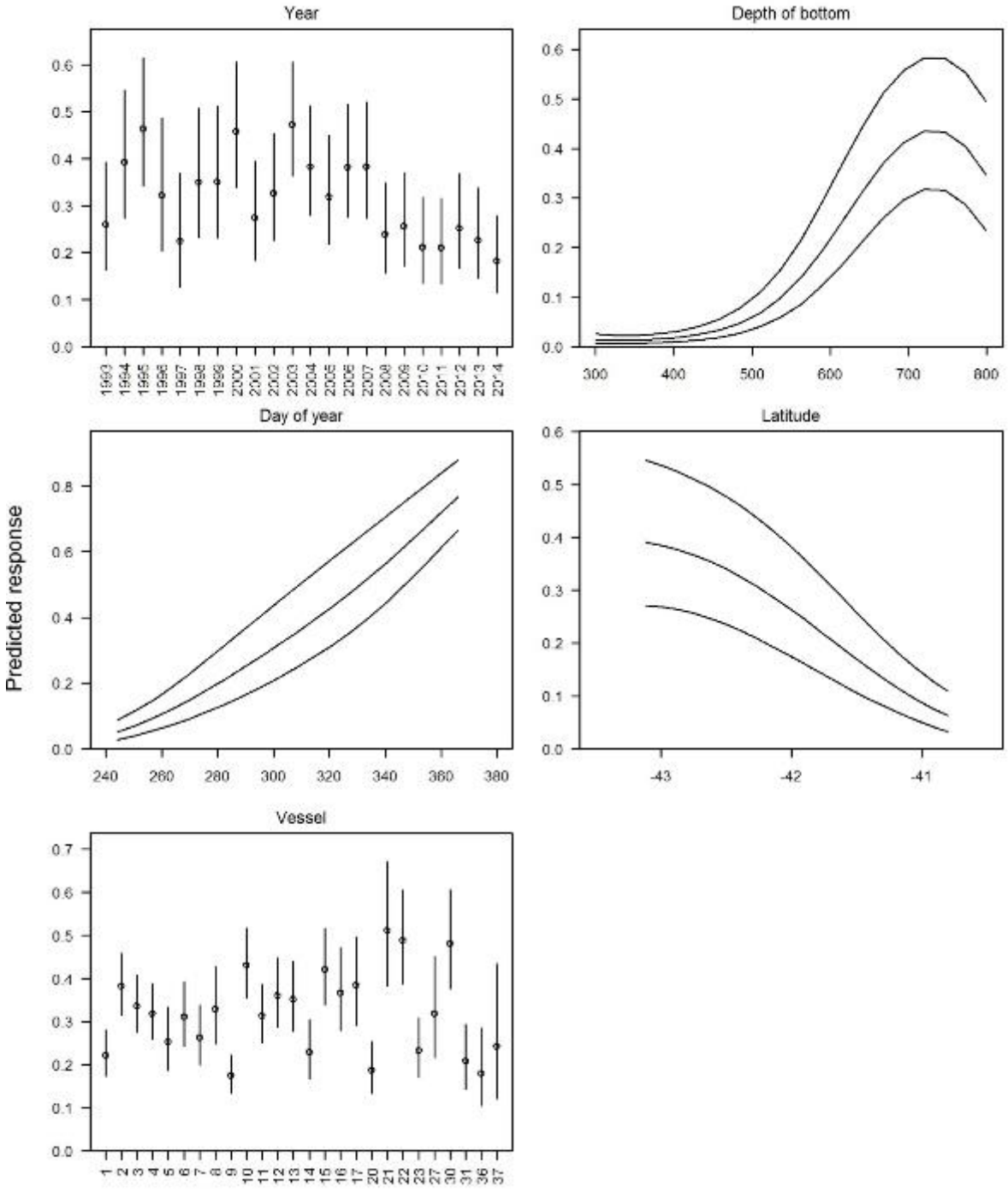


Figure D31a: Binomial effects of selected variables in the binomial model for the WCSI TCEPR tow-by-tow catch. Bars indicate 95% confidence interval.

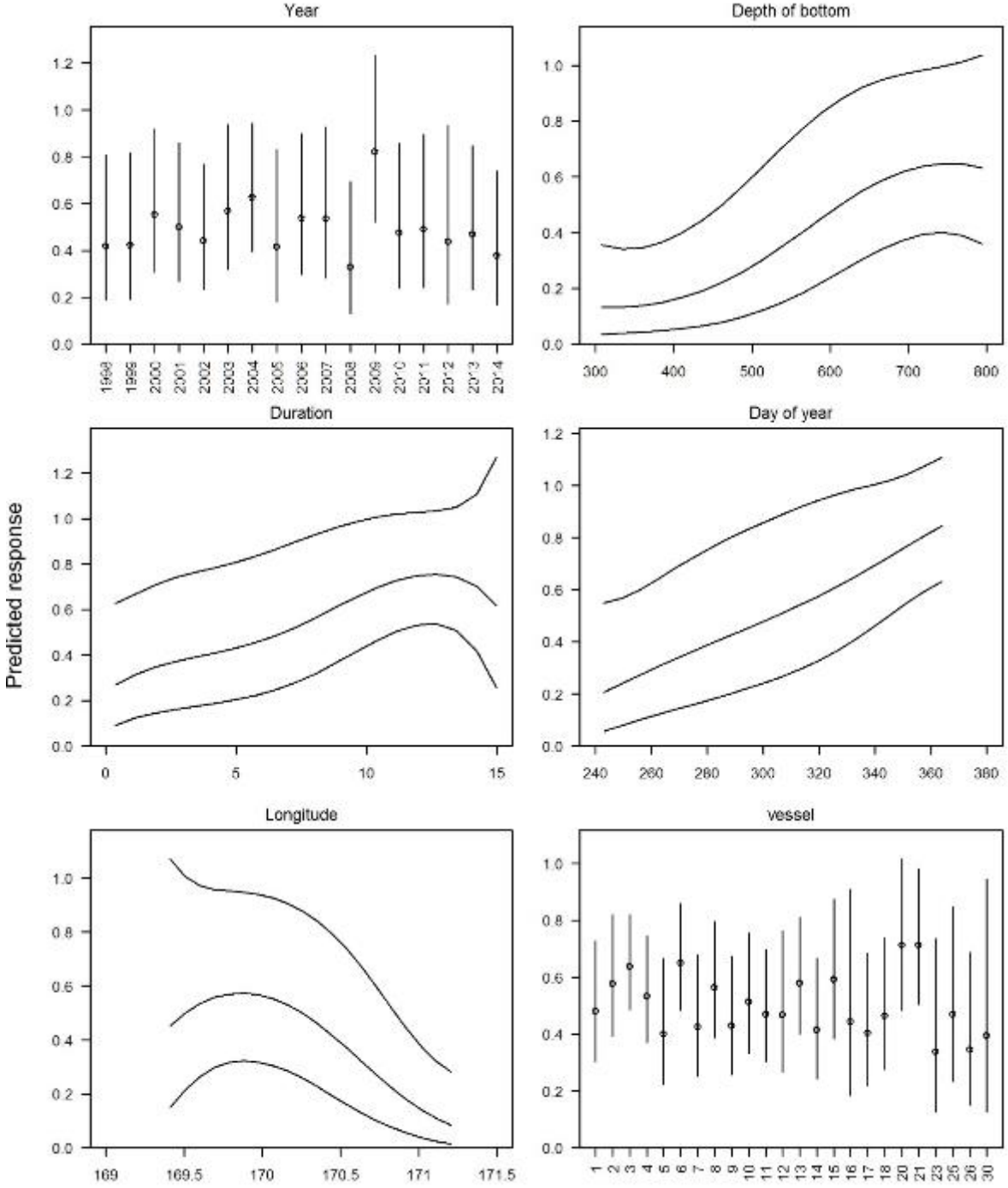


Figure D31b: Binomial effects of selected variables in the binomial model for the WCSI observer tow-by-tow catch. Bars indicate 95% confidence interval.

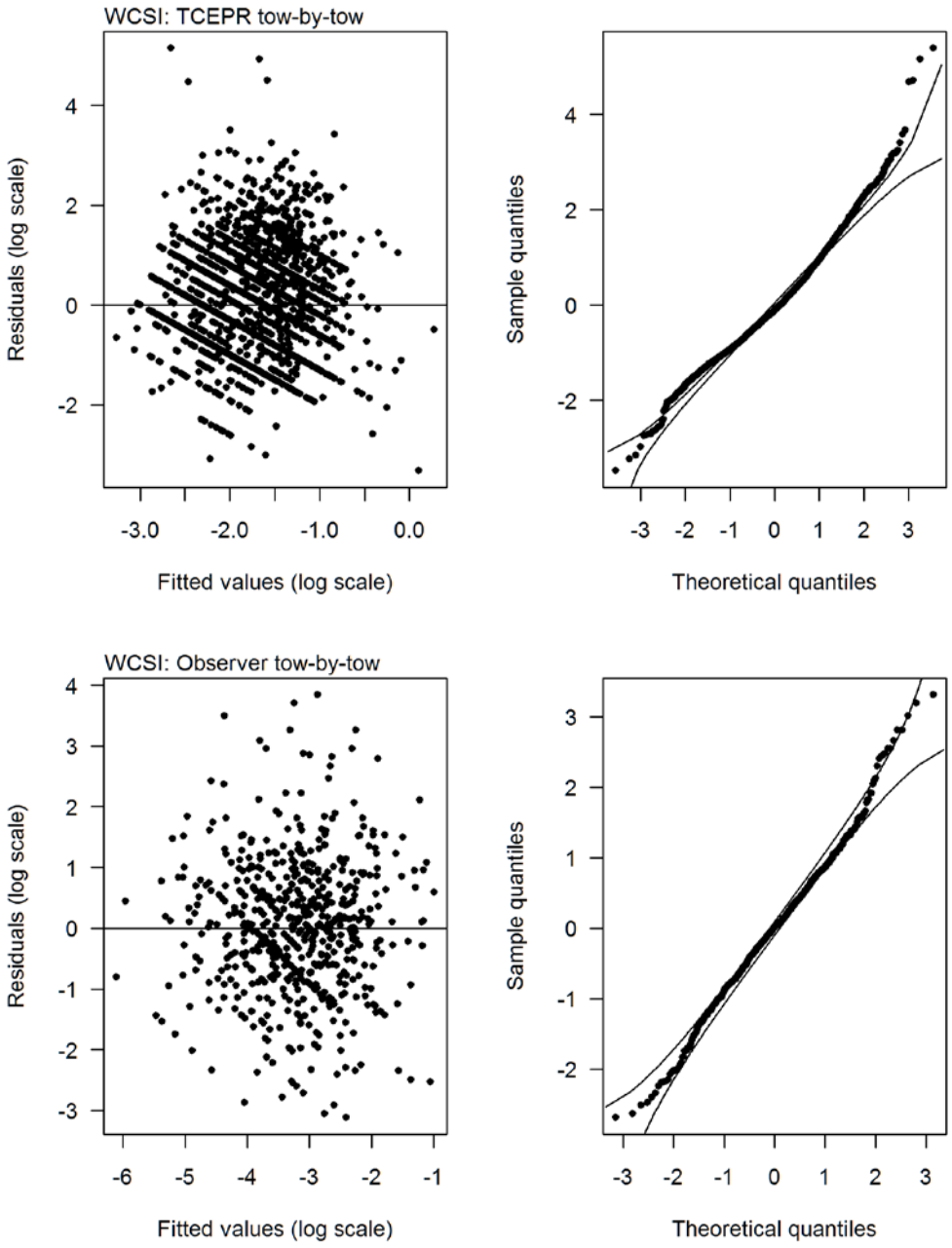


Figure D32: Distribution of the standardised residuals against fitted values (left) and quantile-quantile plot of the residuals (right) for WCSI lognormal models.

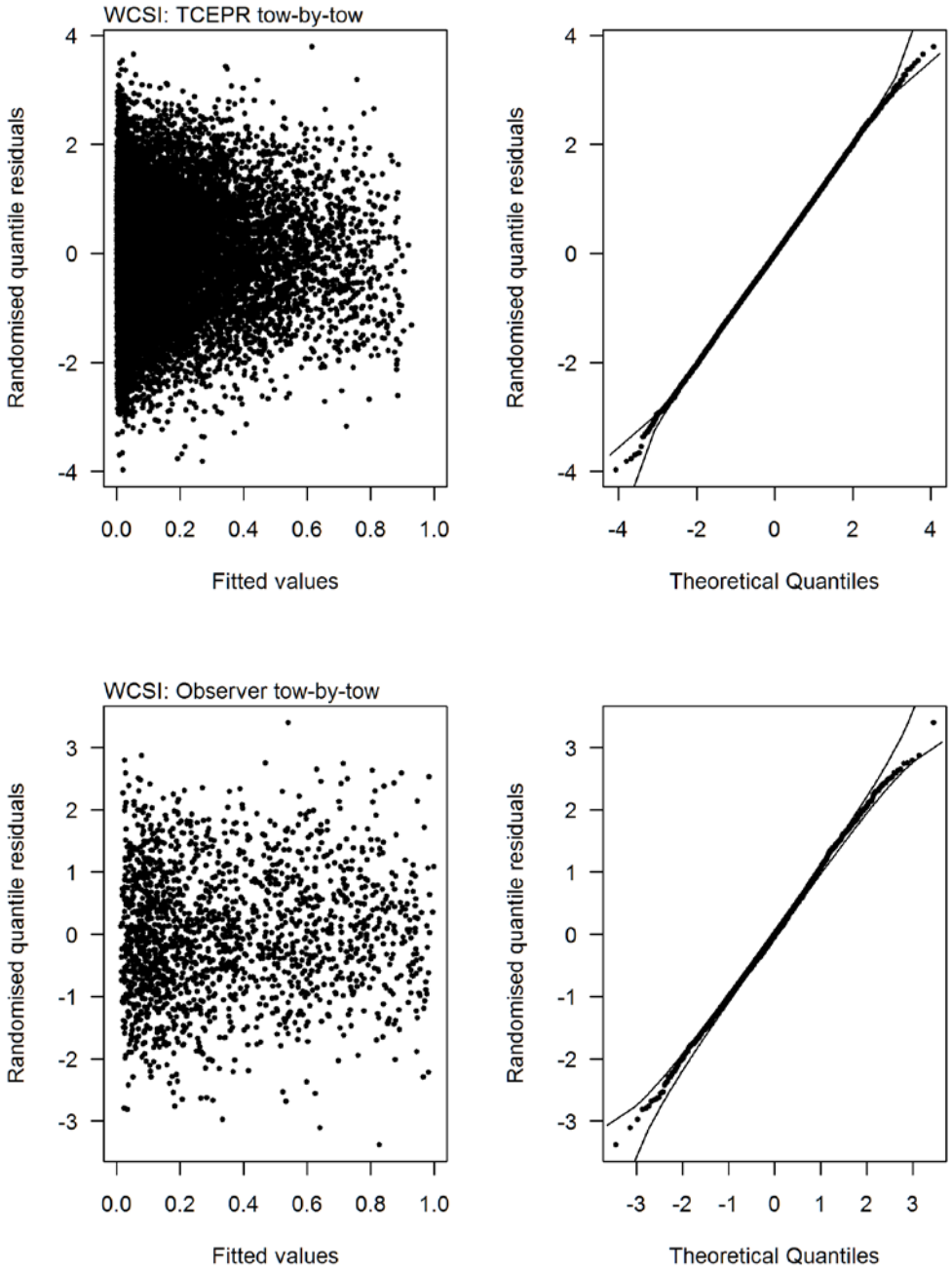


Figure D33: Distribution of the randomised quantile residuals against fitted values (left) and quantile-quantile plot of the randomised quantile residuals (right) for WCSI binomial models.