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Updated BAR 1 barracouta (*Thyrsites atun*) characterisation, with standardised CPUE for the east coast South Island fishery, 1990 to 2017

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S J Baird

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Ministry for Primary Industries
PO Box 2526
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EXECUTIVE SUMMARY

Baird, S.J. (2019). Updated BAR 1 barracouta (*Thyrsites atun*) characterisation, with standardised CPUE for the east coast South Island fishery, 1990 to 2017.

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This report updates the fishery characterisation for the barracouta BAR 1 fishstock to cover all fishing years from 1990 to 2017 and presents updated standardised annual catch per unit effort (CPUE) indices for the small vessel fishery off the east coast of the South Island (ECSI) part of BAR 1.

In BAR 1, most of the barracouta catch was from bottom trawl fisheries, mainly in waters shallower than 250 m. Barracouta were caught as targeted catch and as bycatch from other targets such as tarakihi (*Nemadactylus macropterus*) and red gurnard (*Chelidonichthys kumu*) in the waters off the east coast of the North Island (ECNI), and red cod (*Pseudophycis bachus*) and arrow squid (*Nototodarus sloanii*, *N. gouldi*) in waters off the east coast of the South Island (ECSI). Barracouta were also caught during midwater trawls targeted at barracouta and jack mackerels (*Trachurus* spp.) near the shelf edge in the ECSI area.

The ECSI data accounted for 87% of the total landed catch of 233 485 t for BAR 1 during 1990–2017, with 53% of the total catch from barracouta target tows, 21% from red cod, and 10% from arrow squid tows. Annual catches peaked in the late 1990s at about 9200 t and in 2010–14 at close to the BAR 1 Total Allowable Commercial Catch limit of 11 000 t. Catches dropped to 5000–6000 t in 2015–16 and increased to almost 9000 t in 2017. Most of the ECSI catch was from Statistical Area 022 (68%), 020 (16%), and 024 (9%), at depths of 50–140 m. Fishing in January-May produced 65% of the catch, and 21% was from October–December. Bottom trawl gear was the primary method with barracouta catch, although since 2008, large catches have been reported from midwater gear targeted at barracouta and jack mackerels. About 68% of the ECSI area barracouta catch was reported on TCEPRs, and in the years in which the TCER data were available (2008–17), 33% of was from TCERs.

Three final standardised CPUE models are presented. The Southern Inshore Working Group in 2016 considered the effort and catches of the large vessel fleets (fishing with bottom or midwater trawl nets) to be unrepresentative of most of the vessels catching barracouta in the ECSI area over the time series. The working group in 2016 accepted the combined index (delta-lognormal catch-per-unit-effort model) based on the day-level landed catch data from bottom trawl effort reported on Catch Effort Landing Returns (CELR) and Trawl Catch Effort Returns (TCER) as an index of abundance for BAR 1. This model restricted the analysis to small (under 28 m) vessels. In the 2018 analysis, the dataset was extended to include the catch and effort from Trawl Catch Effort Processing Returns (TCEPR) for small vessels. A core vessel subset of the data provided a total catch of 73 000 t for 1990–2017, which was 83% of the total landed catch from these vessels. *Vessel*, *target species*, *month*, and *fishing duration* were the main explanatory variables in the final lognormal model, with a r^2 of 46%. After a peak during 1997 and 1998, there was a period of relatively lower CPUE from 1999 to 2009, followed by an increase up to 2013, to a level similar to the earlier peak. In the following two years, the indices dropped to about the series mean. Subsequently, there was an increase and in 2017 the index was similar to that seen in 2014. The TCEPR (second) and TCER (third) CPUE models run in 2016 were also updated and the results are presented in this report.

Biomass indices from the latter years of the ECSI research random trawl survey series (2009, 2012, 2014, and 2016) conducted during May-June followed a similar trajectory to that for the ECSI fishing fleet CPUE indices and appear to provide a useful comparison for the index of abundance for this part of BAR 1. The observer coverage of this ECSI area was directed at larger trawlers, mainly during October and February-April, and there is no observed information from the small vessel fleet. This lack of observer coverage limits the data availability to better inform the characterisation of the commercial catch by small vessels.

The ECNI barracouta catch for 1990–2017 totalled almost 30 000 t and annual catches from barracouta-targeted effort decreased over the time series to less than 80 t per year during 2005–17. Most ECNI catches were from bottom trawl target fishing for species such as tarakihi and red gurnard by small (under 28 m) New Zealand vessels in coastal waters. Small catches of barracouta were made throughout the year, but more consistent catches were made during July-September and from waters in Statistical Areas 013 and 014, as well as 015–17. For all years, 42% of the catch was from TCEPR forms, and for the 2008–17 period, 60% was from TCERs. The lack of targeting and the low rate of catch rates from tarakihi and other inshore species, relative to when barracouta was the target, limit the usefulness of these data to determine the status of barracouta in these northern waters of BAR 1. No further data are available for analysis in this area: trawling in ECNI receives little observer coverage and no appropriate or recent research trawl survey data exist.

1. INTRODUCTION

The fishstock area of BAR 1 encompasses the east coasts of the North Island and the South Island, New Zealand (Figure 1) and is considered to contain a single biological stock of barracouta (*Thyrsites atun*). Under the Inshore Finfish Fisheries Draft National Plan (Ministry of Fisheries 2011), as a Group 4 stock, the management objective for barracouta in BAR 1 is to maintain relative stock abundance at or above a target level accepted as a proxy for *Bmsy*. The primary indices for abundance used to monitor BAR 1 are based on the standardised catch-per-unit-effort (CPUE) series for bottom trawl catches from the east coast South Island small vessel domestic fleet, and the most recent report by Baird (2016) indicated that CPUE indices declined during the 2000s then recovered after 2005.

1.1 Overview

Barracouta fisheries developed in the late-1960s when Japanese vessels commenced fishing in New Zealand waters. The fisheries came under quota management under the Deepwater Policy on 1 October 1983 and the Quota Management System in 1986, with an annual TACC set for the combined barracouta fishstocks (Figure 1) at 31 000 t. Since the 2001–02 fishing year (1 October–30 September), this was set at 32 672 t.

Previous characterisations of New Zealand barracouta fisheries were carried out for 1936–37 to 1983–84 by Hurst (1988a, 1988b), 1989–90 to 2007–08 by Hurst et al. (2012), and 1989–90 to 2013–14 by Baird (2016). Specific area analyses were carried out for BAR 1 for 1989–90 to 1999–2000 by Langley & Walker (2002a, 2002b), and for BAR 5 for 1989–90 to 1997–98 by Harley et al. (1999). Stock structure was reviewed by Hurst (1988a, 1988b), Hurst & Bagley (1989), and Langley & Bentley (2002). Age determination using otoliths was validated by Horn (2002).

Barracouta in BAR 1 is mainly caught by bottom trawl in target fisheries and as bycatch in several alternative target fisheries, primarily off the east coast South Island (ECSI), the part of BAR 1 with adequate data for CPUE analyses (see Hurst et al. 2012, Baird 2016). In recent years, market demand has led to an increase in barracouta target fishing near the South Island shelf edge by a small number of large midwater trawlers. The localised (in time and space) nature of this fishery was considered by the Southern Inshore Working Group to be of limited use as a measure of relative abundance, so CPUE analyses were restricted to the small vessel domestic fleet. This domestic fleet has had little or no observer coverage. However, it operates in inshore waters surveyed biennially by *RV Kaharoa*, and the trends in these winter ECSI inshore trawl surveys (Beentjes et al. 2016) are potentially useful for monitoring recruitment (Hurst et al. 2012, Baird 2016). Previous tagging research showed that this species can exhibit large seasonal migrations associated with spawning movements and is known to migrate north from the east coast of the South Island during late autumn/winter to spawn off the east coast of the North Island up to Bay of Plenty in late winter/spring (Hurst & Bagley 1989). The Hurst et al. (2012) review indicated that stock structure remained unclear, with some potential movement or mixing of summer/autumn feeding schools between Southland (BAR 5) and ECSI (BAR 1).

This report fulfils the specific objectives of project BAR201701: Objective 1 *to characterise the BAR 1 fishery*; and Objective 2 *to analyse existing commercial catch and effort data and update the accepted standardised CPUE index of abundance for BAR1 to the end of the 2016/2017 fishing year*. Much of the information presented in section 2 is repeated from Baird (2016), with updated information provided where it exists. The TCEPR and TCER CPUE indices from 2016 were updated to include data from the most recent three fishing years (2014–15 to 2016–17).

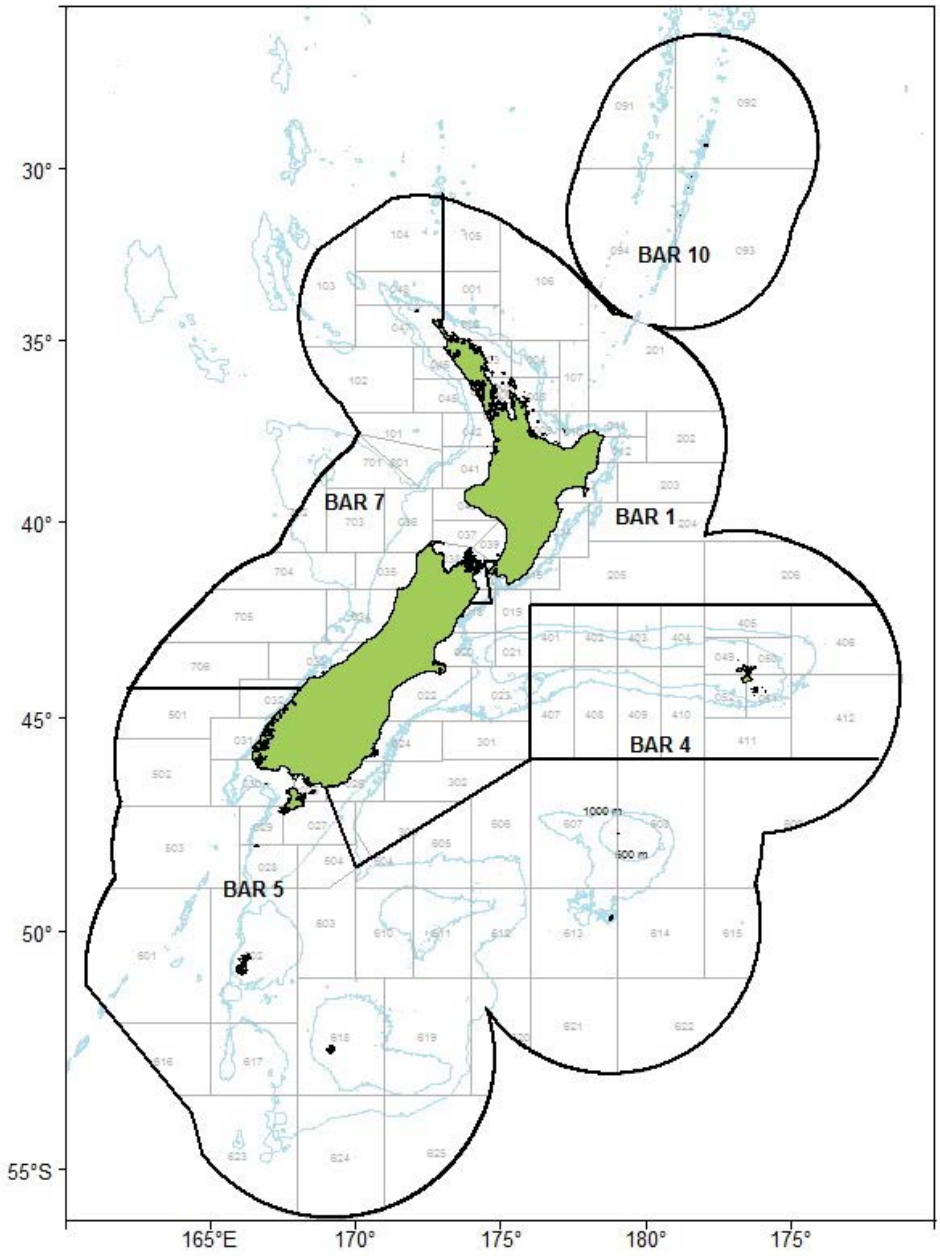

Figure 1: Map showing the administrative fish stock boundaries for BAR 1, 4, 5, 7, and 10, including statistical areas, and the 500 m and 1000 m depth contours.

2. REVIEW OF THE BAR 1 FISHERIES

2.1 Commercial fisheries

This report updates the summarised commercial catch and landings reported for BAR 1 for the 1990–2014 fishing years by Baird (2016). This report presents information for fishing years (1 October–30 September) and each fishing year is referred to as the most recent year, for example, 1990 is the 1989–90 fishing year.

The annual TACC for BAR 1 increased steadily from 8510 t in 1987 to 9969 t in 1993, and to 11 000 t in 1997 where it has remained (Table 1). Between 1995 and 1998, reported annual landings overran

the TACC, before dropping to about 50% of the TACC in the mid-2000s. Between 2009 and 2014, landings were close to the TACC, with small overruns in 2011 and 2014. Landings dropped in 2015 and 2016 to levels similar to those reported during the mid-2000s, but rose again in 2017 to close to 90% of the annual TACC.

New Zealand annual barracouta landings from all fishstocks were 20 000–30 000 t from 1990–2017 (Ministry for Primary Industries 2018). Until 2003, 30–47% of the New Zealand barracouta landings were reported from BAR 1, with 40–47% during 1995 to 2000 (Figure 2). The BAR 1 landings dropped to less than 25% from 2005 to 2008 when total barracouta landings were 27 000–29 600 t. From 2009 on, landings in most years were over 25 000 t, with over 30% from BAR 1.

Table 1: Landings (t) and TACC (t) for barracouta in BAR 1 from 1984 to 2017. From Ministry for Primary Industries (2018). Data marked with an asterisk are Fisheries Statistics Unit data. NA, not applicable.

Fishing year	Landings	TACC	Fishing year	Landings	TACC
1984*	7 805	NA	2000–01	7 118	11 000
1985*	5 442	NA	2001–02	6 900	11 000
1986*	5 395	NA	2002–03	7 595	11 000
1987	8 877	8 510	2003–04	5 949	11 000
1988	9 256	8 837	2004–05	6 085	11 000
1989	5 838	9 426	2005–06	7 030	11 000
1990	9 209	9 841	2006–07	5 351	11 000
1991	9 401	9 957	2007–08	5 987	11 000
1992	6 733	9 957	2008–09	8 861	11 000
1993	9 032	9 969	2009–10	10 635	11 000
1994	7 299	9 969	2010–11	11 420	11 000
1995	10 023	9 969	2011–12	9 305	11 000
1996	11 252	9 969	2012–13	9 740	11 000
1997	11 873	11 000	2013–14	11 309	11 000
1998	11 543	11 000	2014–15	6 902	11 000
1999	9 229	11 000	2015–16	5 568	11 000
2000	10 032	11 000	2016–17	9 520	11 000

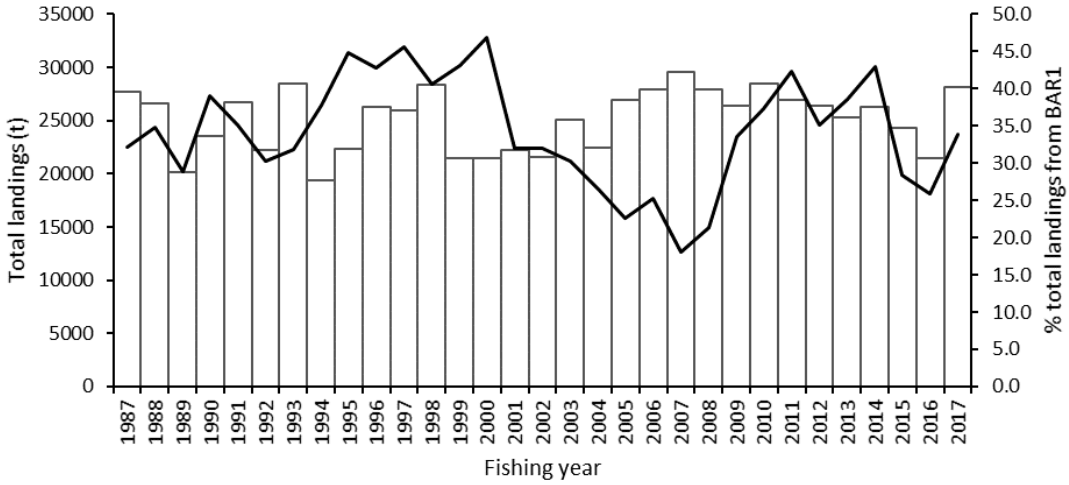

Figure 2: New Zealand annual barracouta landings (bars) from all fishstocks and percentage that were reported from BAR 1 (line), for 1987–2017 fishing years (data from Ministry for Primary Industries 2018).

3. BIOLOGY AND DISTRIBUTION

Hurst et al. (2012) provided a comprehensive summary of barracouta biology, reproduction, and ageing information. Information particularly relevant for the BAR 1 stock is included here and largely repeats that given by Baird (2016).

3.1 Distribution and spawning

Barracouta occupy waters from shallow depths out to about 670 m, with catches indicating a peak distribution between 30–350 m, particularly in 100–200 m (Anderson et al. 1998, Bagley et al. 2000). Mature-sized fish (from 50–60 cm fork length: 2–3 yr old) are found throughout this depth range; juveniles are mainly caught in waters shallower than 150 m (Hurst et al. 2000a, 2000b).

Barracouta distribution varies seasonally, with extensive spawning migrations (Hurst & Bagley 1989). Mature fish from the ECSI waters are thought to migrate northwards after June to spawn in the ECNI area during August–September, based on tagging experiments (Hurst & Bagley 1989); however, Observer data from the shelf edge waters indicate spawning activity off ECSI in October–December (see Section 5.0). There is no evidence of spawning within Canterbury Bight waters, but data from these waters are sparse; fish caught during the ECSI trawl surveys are not staged and there are no Observer data from the commercial barracouta catch in these waters.

3.2 Stock structure

The most recent stock review was completed by Hurst et al. (2012). The separation of the EEZ waters into four main management stocks is based on observation of spawning locations and movement (from tagging data) from trawl surveys. Hurst et al. (2012) suggested that there may be mixing between the summer/autumn feeding schools in the ECSI area and fish in the Stewart-Snares shelf area (in BAR 5). Further work is required to understand this relationship. Biological data that represent good annual coverage and the spatial distribution of barracouta in eastern and southern waters are lacking. The tagging evidence that showed movements from ECSI to ECNI to spawn in northern waters (Hurst 1988a) receives some further validity in the higher bycatch of barracouta in the tarakihi/red gurnard target fisheries in ECNI during July-September, but the lack of data for ECNI restricts any further clarification, and the presence of ripe and running ripe fish off the ECSI during October–December suggests a broader spawning time and area.

3.3 Age and growth

Age and growth information for barracouta relies on data collected from the Southland trawl series on the Stewart-Snares shelf in the mid-1990s (Horn 2002) and from Observer coverage of commercial effort on Stewart-Snares shelf (Horn et al. 2012). Fish that measured about 38 cm fork length were aged at 1 year; about 52 cm at 2 years; about 60 cm at 3 years; 64–65 cm at 4 years; 69 cm at 5 years; 71–73 cm at 6 years; 74–77 cm at 7 years; 79–82 cm at 8 years; 79–85 cm at 9 years; 81–86 cm at 10 years; and 88 cm at 11 years (larger fish were mostly females) (Horn 2002). These mean length-at-age values were similar to those calculated for Chatham Island fish by Hurst & Bagley (1987) (see Horn 2002). Fish are considered mature at about 50–60 cm (aged 2–3 years).

The main mode for commercially-caught barracouta on the Stewart-Snares shelf in October–April was at 60–65 cm in 2005 and about 65 cm in 2010. There was a moderately strong year class at 1+ age (30–35 cm) apparent in 2005. The catch sampled by observers in these areas was dominated by 3 and 4 year old fish.

Von Bertalanffy growth parameters derived for Southland (Stewart-Snares shelf) barracouta males and females were given by Harley et al. (1999) and Hurst et al. (table 5, 2012). No new information is available for age and growth of barracouta.

3.4 Natural mortality

No new information is available for natural mortality *M* for New Zealand barracouta since the information provided by Hurst et al. (table 5, 2012).

3.5 Length-weight relationship

No new information is available on length-weight parameters since the characterisation by Hurst et al. (table 5, 2012).

3.6 Feeding and trophic status

No new information is available for feeding and trophic status for barracouta. The most recent data, analysed by Stevens et al. (2011) were summarised by Baird (2016) and indicated that crustaceans were the most important dietary component.

4. FISHERY INDEPENDENT OBSERVATIONS

4.1 Research surveys

Hurst et al. (2012) summarised historical trawl survey catch and biological data relating to barracouta throughout the EEZ up to 2009. The information for the winter trawl survey of the ECSI component presented here was given by Baird (2016), based on the trawl survey reports from this series (Table 2), with some preliminary results from the 2018 survey (MacGibbon et al. 2019).

ECSI winter research survey series
The relevant research survey series for BAR 1 is the winter series undertaken off the east coast of the South Island by *RV Kaharoa*. This series consists of several parts, based on the timing and frequency of surveys and the depth ranges surveyed. The core survey sampled depths of 30–400 m in the Canterbury Bight area (within Statistical Area 022) and Pegasus Bay (020). The first part was in May–June for consecutive years from 1991 to 1994 inclusive, then again in 1996. The second part was from 2007 to 2009 on an annual basis, when stations were added in the 10–30 m depth range; but this stratum was sampled only if time and resources allowed (Beentjes & MacGibbon 2013). The series was started again in 2012 (April–June), on a biennial basis, and the addition of the 10–30 m stratum was formally instigated.

Barracouta was generally in the top 3 of species caught (by weight) during these surveys in the core depth range, and the species occurred in 82–95% of tows within a survey, accounting for 15–37% of the survey catch (see references listed in Table 2 for individual survey information). The species targeted on these winter trawl surveys were: dark ghost shark, elephant fish, giant stargazer, red cod, red gurnard, sea perch, spiny dogfish, and tarakihi. Barracouta was not a target species so the biological data collected were limited to length and sex measurements.

4.2 Biomass indices, length frequencies, and gonad stage data for relevant surveys

The biomass indices from the core strata of the winter ECSI trawl survey series indicated a marked increase in barracouta in the second part of the series, from 2007 on until 2014, when the CVs were under 20% (Table 2). The 2014 survey resulted in a biomass estimate substantially larger than the 2007 survey, but within the error bounds of the 2009 and 2012 surveys (Figure A1, see Beentjes & MacGibbon 2013). The 2016 survey had the lowest biomass estimate since 2007, at less than 20 000 t (Beentjes et al. 2016), and preliminary data indicated an increase in biomass in 2018 to about 30 000 t (MacGibbon et al. 2019). Larger catch rates were evident in the 2007–14 series, particularly in the Canterbury Bight area from 30 m out to the shelf edge (see Beentjes & MacGibbon 2013 and Beentjes et al. 2015). In 2016, larger catch rates were from the 10–100 m waters (Beentjes et al. 2016). The inclusion of the shallow stratum of 10–30 m in 2007, 2012, 2014, and 2016 resulted in increases in the estimated biomass for 30–400 m by 16%, 6%, 1%, and 17% respectively (see Beentjes & MacGibbon 2013, Beentjes et al. 2015, Beentjes et al. 2016).

Length frequency distributions were determined using SurvCalc (Francis & Fu 2012) which involves scaling by the proportion sampled and area trawled to estimate the population size structure in the survey area available to the trawl (for example, see Beentjes et al. 2016). The length-weight coefficients used to determine the frequencies were $a = 0.0055$ and $b = 2.9812$ for all surveys.

Fish sampled were 8–114 cm (Figure A2). Strong modes were present in most years, and in the plots of total fish there are three clear pre-recruit modes representing 0+, 1+, and 2+, fish at around 15–25 cm, 35 cm, and 50 cm (see Harley et al. 1999, Horn 2002). In the first part of the series (1991–96) and for the 2007–09 data, it is possible to see movement of the younger cohorts through to the large fish modes at 60–80 cm. Similar modes were evident in the 2014 data (see Beentjes et al. 2015). These data appear to represent strong year classes for 1989, 1990, 1995, 2003 to 2005, and 2007 (see Hurst et al. 2012), and 2011. Horn (2002) noted the importance of the strong 1989 year class, negligible recruitment evident in the 1990–94 commercial data, with 1+ and 2+ fish from the 1995 year class appearing in the commercial catch from 1997.

Table 2: Relative biomass indices (t) and coefficients of variation (CV) for barracouta from the winter east coast South Island *Kaharoa* (KAH) trawl survey series* (with assumptions: areal availability, vertical availability, and vulnerability = 1), in core strata depths of 30–400 m. The estimates were produced using NIWA's research trawl survey analysis program "SurvCalc" (Francis & Fu 2012).

Trip code	Date	Reference	Biomass (t)	% CV
KAH9105	May-Jun 1991	Beentjes & Wass (1994)	8 361	29
KAH9205	May-Jun 1992	Beentjes (1995a)	11 672	23
KAH9306	May-Jun 1993	Beentjes (1995b)	18 197	22
KAH9406	May-Jun 1994	Beentjes (1998a)	6 965	34
KAH9606	May-Jun 1996	Beentjes (1998b)	16 848	19
KAH0705	May-Jun 2007	Beentjes & Stevenson (2008)	21 132	17
KAH0806	May-Jun 2008	Beentjes & Stevenson (2009)	25 544	16
KAH0905	May-Jun 2009	Beentjes et al. (2010)	33 360	16
KAH1207	Apr-Jun 2012	Beentjes et al. (2013)	34 325	17
KAH1402	Apr-Jun 2014	Beentjes et al. (2015)	46 563	19
KAH1605	Apr-Jun 2016	Beentjes et al. (2016)	19 708	27
KAH1803	Apr-Jun 2018	MacGibbon et al. (2019)	29 926	23

* Summary reviews of this trawl survey time series are given by Beentjes & Stevenson (2000) for 1991–96 and by Beentjes & MacGibbon (2013) for all years in the table above, except 2014, 2016, and 2018.

5. FISHERY DEPENDENT OBSERVATIONS

5.1 Observer data

The observer data were collected from the larger vessels (over 28 m) that fished mainly in offshore waters and completed Trawl Catch Effort Processing Returns (TCEPR). All tables and figures relating to MPI observer data collected from BAR 1 barracouta fisheries are provided in Appendix B (Tables B1–B8, Figures B1–B6). Table B1 provides the definition of species codes used in tables and figures throughout the report. The number of observed trips and tows, including those with barracouta catches, are given by fishing year for ECNI and ECSI in Table B2. The distribution of this observed effort is shown in Figure B1.

A total of 2019 trips and 50 232 tows were observed in BAR 1 during the 1990–2017 fishing years, resulting in a total observed catch of 31 372.5 t (Table B2). Observations in ECSI accounted for 73% of observed trips, 62% of observed tows, and 99.5% of the observed barracouta catch. About 44% of ECSI observed trips and 20% of ECSI observed tows caught barracouta; however, in the last five years, when over 1000 tows per year were observed in ECSI, at least 32% caught barracouta. About 60% of the ECSI observed catch total of 31 210 t, was from 2013–17. In contrast, 40% of 551 observed trips and 15% of 19 112 observed tows in ECNI had barracouta catch, but the catches were small and totalled 162.9 t for 1990–2017.

Biological data were reported from 19% of ECSI observed trips and 22% of observed tows with barracouta catch. In the last 5 years, the barracouta catch was sampled from at least 44% of trips (annual maximum of 74%) and 20–33% of observed tows. Over 86 500 fish from ECSI (including about 42 800 females) were sampled for length and sex; 63% were sampled from 2013 to 2017 and 63% of these fish were females. In ECNI waters, 18 trips and 38 tows were sampled, to yield a total of 565 measured fish – less than 1% of the total number of sampled barracouta for BAR 1.

The primary target species for the all observed tows in the ECSI area was hoki, which accounted for 62% of the observed tows, with at least 500 tows observed in most years (Table B3c). Another 14% targeted deepwater species including orange roughy, black oreo and smooth oreo. About 8% of tows targeted barracouta and another 13.5% were jack mackerel, arrow squid, or silver warehou tows, with more than 100 tows observed for each of these species in the last few years combined (Table B3c). In the last 5 years, barracouta-targeted tows accounted for 43% of observed tows with barracouta catch, and 77% of the observed barracouta catch. Arrow squid and jack mackerel tows produced 38% of the barracouta catch (Table B3d). The month with the greatest observed catch was February, followed by October, March and April (Table B4b). The median catch rate observed from ECSI tows was 1105 kg (range 1–65 000 kg, mean of 5013 kg).

Most observed tows in the ECNI area targeted hoki, scampi, and orange roughy, with increased numbers of observed snapper, tarakihi, and trevally tows between 2014 and 2017 (Table B3a). The target species with the greatest number of tows with barracouta catch were snapper, tarakihi, hoki, and trevally (see Table B3b). The observed catch was small, totalling 42 t from snapper target tows, with most of the remainder from tarakihi and hoki tows throughout the year in most months (Table B4a. The median catch rate of barracouta observed from ECNI tows was 10 kg (range 1–8988 kg, mean of 57.3 kg).

For both areas, the annual number of tows observed and the number of tows with barracouta varied throughout the time series. In particular, the ECSI data had higher numbers of observed tows during 1998–2004 and in 2013–17, with differences in the numbers of tows with barracouta catches between these two time periods (Table B2). From 2013, there was increased observer coverage of the offshore fleet (Ministry of Agriculture and Forestry 2012, Abraham & Richard 2018), and, in the most recent years, the ECSI observations came mainly from the increased number of tows that targeted barracouta, jack mackerels, arrow squid, and silver warehou (see Table B3c and d). There was more observer

coverage of recent tows in ECNI, with increased coverage of John dory, snapper, tarakihi, and trevally during 2014–17 (Table B3a and b).

The spread of the observed catch relative to the commercial catch, for each area, is shown in Figure B2 by month for each fishing year. If the proportions are the same, the plotting symbols align; if over- or under-sampling has occurred, the crosses are either larger or smaller than the circles. For the larger BAR 1 catch represented in the ECSI data, the relative amounts of catch for commercial and observed data are reasonably well matched in most years, particularly from 2013 onwards. This catch, was mostly taken by vessels that targeted barracouta, jack mackerels, and arrow squid during February-April. The smaller BAR 1 catch from ECNI was mainly caught in July-September, but observer coverage of these months was inconsistent.

Observers measured, sexed, and staged a proportion of the observed barracouta catch (Tables B5–B8). This sampling was dependent on the size of the catch and varied greatly between years in each area. Overall, 565 fish were sampled from 38 tows in ECNI, with 46% of fish from 2014. In ECSI, 86 542 barracouta were sampled from 1393 observed tows. The months with the most tows sampled in ECSI were October (mainly since 2010), and February–April (with most sampling from the early 2000s and from 2010 onwards). Overall, 62% of observed ECSI tows and 63% of the sampled ECSI fish were from 2013–17. Since 2010, most ECSI barracouta sampling (including the recording of reproductive stage for females) occurred in October and February-June, with relatively few tows observed and fish sampled (including female staging) during July-September, other than in 2008 and 2012 (Tables B6 and B8). For months with the greatest amount of sampling in ECSI, the proportion of females to males was about 45% in October compared with about 50–51% during February–April (see Table B7).

5.1.1 Length frequencies

The distribution of barracouta length data from BAR 1 largely represents the distribution for all observed barracouta catches throughout New Zealand waters (Figure B3a). Male and female barracouta length distributions were similar; males were 27–107 cm, females 17–115 cm. Most barracouta were between 50 and 80 cm in length (Figures B3a and B3b). Overall, barracouta from BAR 1 showed several peaks, with the main one at about 70 cm, a second one at about 55 cm, and a relatively small one at about 40 cm. Most of these fish were from ECSI. The small number from ECNI were generally between 60 and 80 cm, with a minimum length of 55 cm.

For months in which there were more data, the ECSI barracouta caught in October peaked at about 50–65 cm; whereas in February-April, most fish were 60–75 cm long. In other months, the numbers sampled were less, and the length data are likely to rely more on a small number of years of data (as for the July-September months) and potentially a small number of vessels that may not be representative of the fleet. The distribution of lengths by month for each sex was very similar to that shown for all fish.

Scaled length frequencies 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 barracouta were estimated from catch weights using an overall length-weight relationship provided by Beentjes & Stevenson (2000) where $a = 0.0091$ and $b = 2.88$. Length data from tows with more than 5 measured barracouta were used to generate the length frequency plots shown in Figure B4 for ECSI. This resulted in some fishing years having too few data to plot (for example, 1991, 1992, 1996, 1998, and 2008), and relatively few data for other years until 2010. For 2010–14, the data indicate movement of a cohort identified at about 50 cm in 2010 (but not present in the 2009 data) through to about 70 cm. It is evident that the tows observed in ECSI generally caught fish smaller than 80 cm, although there is some evidence of smaller fish in 2010, 2014, and 2017. All the observed data from this area were from large vessels between about 55 and 104 m in length, with most effort targeting barracouta, arrow squid, and jack mackerels in February–April, and barracouta and silver warehou in October.

Data from the observer programme indicated that the larger vessel commercial ECSI fishery primarily caught larger fish (60–80 cm), though with greater observer sampling after 2009, fish as small as about 30 cm were recorded by observers in some years. Few fish larger than 80 cm were present in either the observer data or the trawl survey data. The fish from the observed catch were likely to be caught deeper than those from the trawl surveys; most of the barracouta catch from trawl surveys was from stations in 50–200 m (Beentjes & MacGibbon 2013) and therefore west of the main observer effort on larger vessels targeting species in waters 200 m or deeper, at or near the shelf edge.

5.1.2 Reproductive stages

Ripe and running ripe females were sampled in ECSI during January-February and September-December (stages 3 and 4) (Figures B5, B6a, and B6b).

6. DESCRIPTIVE ANALYSIS OF CATCH

6.1 Catch and effort data sources

Catch-effort, daily processed, and landed data were requested from the Ministry for Primary Industries catch-effort database "warehou" as extract 11521 (Table C1 in Appendix C). The dataset consists of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of barracouta in BAR fish stock areas (see Figure 1) between 1 October 1989 and 30 September 2017.

The estimated catches associated with the fishing events were reported on the Ministry for Primary Industries Catch Effort Landing Returns (CELR), Trawl Catch Effort Returns (TCER), Trawl Catch Effort and Processing Return (TCEPR), and Netting Catch Effort Returns (NCER). The green weight associated with landing events was reported on the bottom part of the CELRs, and the back of NCERs, or where fishing was reported on the two other forms it was recorded on the associated Catch Landing Return (CLR).

TCEPR and TCER forms record tow-by-tow data and summarise the estimated catch for the top five species and eight species, respectively (by weight), for individual tows, together with latitude and longitude of the tow. CELR forms summarise daily fishing effort and catch, which are further stratified by statistical area, method of capture, target species, and catch estimates of the top five species. NCER forms record set-by-set data and summarise the estimated catch for the top eight species (by weight) for individual sets, together with latitude and longitude. Trawl vessels less than 28 m in length could use either CELR or TCEPR forms, whereas trawl vessels over 28 m must use TCEPR forms. From 1 October 2007, TCER forms were used by vessels over 6 m and under 28 m (if under 6 m the CELR is still used). NCER forms were introduced on 1 October 2006 for set net vessels over 6 m (if less than 6 m the CELR is still used).

Information on total harvest levels was provided via the Quota Management Report/Monthly Harvest Return (QMR/MHR) system, but only at the resolution of Quota Management Area. Concerns were expressed (e.g. Phillips 2001) that bycatch species, such as barracouta, may not be well reported at the fishing event level on TCEPRs. The daily processed part of the TCEPR contains information on the catch of all quota species caught and processed that day, and these data may provide a more accurate account of low and zero catch observations. However, it is not possible to assign processed catch to a specific day or amount of effort because catch is not always processed on the day it is caught and can be split among days.

The extracted data were groomed and restratified to derive the datasets required for the characterisation and CPUE analyses using a variation of the data processing method developed by Starr (2007) and further developed by Langley (2014). The method allowed catch-effort and landings data collected using different form types that record data with different spatial and temporal resolutions to be combined. It also overcame the main limitation of the CELR, TCER, and TCEPR reporting systems, i.e., frequent non-reporting of species that make up only a minor component of the catch. The major steps were as follows.

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

Step 2: The groomed fishing effort data for each valid trip reported on form types TCER and TCEPR were restratified by vessel, date, and method into a daily dataset in a format equivalent to the CELR data. The groomed estimated catch data for TCEPR and TCER were assigned to the associated fishing effort data as daily sum of estimated catch, based on the top 5 catch species per day. For TCER catch data (for which the top 8 species per tow are recorded), where the day has no barracouta in the top 5 species, zero was assigned to the estimated catch in the daily record. The groomed estimated catch data were assigned to the CELR effort data. Lastly, the CELR data were combined with the newly created daily effort and catch data from the TCER and TCEPR forms.

Step 3: The groomed greenweight landings data were allocated to the daily 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 were not recorded for the trip, but a landing was recorded for the trip, the total fishing effort in each effort stratum, as a proportion of the total fishing effort for the trip, was used to allocate the greenweight landings.

Data for many species are reported using a combination of form types. 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. 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.

Processed product weights were converted to greenweight catches using species and product-form-specific conversion factors. Some product form conversion factors for barracouta have changed since the full implementation of the QMS (even though fish processing has not); with the result that different amounts of greenweight catch are associated with the same amount of processed catch for particular product forms throughout the database. During the grooming process, these changes were standardised relative to the latest conversion factor defined for each product state, based on the assumption that the changes in conversion factors reflected improved estimates of the actual conversion when processing, rather than real changes in processing methodology across the fleet. The catch-consistency checking algorithm designed by Blackwell et al. (2005) was used to systematically compare the different catch weights recorded for a particular fishing trip against one another, and this returns the single most consistent catch type for each trip. The following adjustments were made for several conversion factors, apart from the minor adjustment of 5.556 to 5.6 for fishmeal on 1 October 1990. From 1 October 1996, the value for "HGU -headed and gutted" was changed from 1.5 to 1.45. The value for "DRE - dressed" was changed from 1.5 to 1.55 from 1 October 1997, then this change was reversed from 1 April 2008.

The landings data retained in the dataset, and adjusted for any changes in conversion factors, were allocated using the 'centroid' method to the effort strata, based on the statistical areas within each fish stock. Thus, the midpoint of each statistical area was used to allocate the data to the larger fish stock area. These landings data provide a verified green weight landed for a fish stock on a trip basis. However, landings data include all final landing events where a vessel offloads catch to a Licensed Fish Receiver, and interim landing events where catch is transferred or retained and may therefore appear subsequently as a final landing event (SeaFIC 2007). Starr's procedure separates final and interim landings based on the landing destination code, and only landings with destination codes that indicate a final landing are generally retained (see table 2 in Starr (2007)).

6.2 Summary of catches

All tables and figures for the characterisation of barracouta fisheries are in Appendix C (Tables C1–C7, Figures C1–C26). Table C1 provides a summary of the data requested from MPI for this characterisation for BAR 1.

The reported QMR/MHR landings, ungroomed catch-effort landings, and TACCs for fish stocks in BAR 1 are shown in Figure C1. The ungroomed catch-effort landings were similar to the reported QMR/MHR landings in most years, and both sets of landings data were generally under the TACC, except for 1996–98, 2011, and 2014. Both data sources indicated that landings in 2010–14 were closer to the TACC limit than data from 2001–08 and 2015–16 when annual landings were between 6000 and 8000 t and the TACC was at 11 000 t. Landings from 2017 increased again to close to 10 000 t.

Landings of catch-effort data reported on TCEPRs and TCERs are recorded on CLRs. Overall, the numbers of landings events peaked in the mid-late 1990s (about 5500–7000 events per year), steadily decreased to about 3000–3400 events in 2008–11 and remained fairly stable at 3500–3600 events from 2012–17, apart from a peak at 3800 events in 2014 (Table C2). The increase in landing events recorded on CLR from 2008 onwards reflects the change in form type used by 6–28 m trawl vessels (from CELR to TCER). Landing events on both CELRs and CLRs were primarily coded as "L" (landed to New Zealand). Small numbers of events were coded as "R" (retained on board) throughout the time series, "T" (transferred to another vessel) up until the end of the 1998 fishing year on CLRs, and "C" on CELRs between 1990 and 1993. For all years combined, 96% of landings (in terms of weight) were coded as "L" (Table C3). Landings with destination codes of "B", "Q", and "R", or where the code was missing, were ignored for the final landings dataset: these represented about 1.5% of the landings by weight and 2.0% of the landing events. These codes are described as "interim" codes by Starr (2007), and though landings coded as "T" are often considered as "interim", they were retained in the dataset. The retained landings, interim landings, and total landings dropped during data grooming are shown in Figure C2.

The main processed state for retained landings of barracouta in BAR 1 was "GRE" (green weight), with a lesser amount reported as "DRE" (dressed weight) (Figure C3); for 2009–11 and 2014, more barracouta catch was reported as "DRE" than "GRE". The "DRE" code use reflects the catch of larger vessels that operate more offshore and process fish on board. The recovery rates, defined as the groomed and merged landings as a proportion of the groomed and unmerged landings (after Manning et al. 2004), are plotted in Figure C4. The recovery rates were close to 100% in most years, indicating a consistent match between the recorded statistical areas on the catch forms and the stocks reported on landings forms on a trip basis.

Annual QMR/MHR landings, groomed retained landings, merged landings, and merged estimated catches are plotted in Figure C5. The merged estimated catches generally followed the same trend as merged landings and the groomed retained landings but were lower than landings for some fishing years. Estimated catches tend not to be recorded when catches are small (because vessels only report the top five species caught on TCEPRs and top eight on TCERs). Some inconsistencies may result from catch being allocated to the wrong fishing year for trips that straddle fishing years.

The reporting rate (the ratio of the annual estimated catch to the retained landings in the groomed and merged dataset) is shown in Figure C6 for the main form types. The TCEPR/CLR reporting rate for BAR 1 was reasonably steady at between about 0.9 and 1.0. Any barracouta catches reported from TCER and TCEPR vessels not in the top 8 species by estimated catchweight per tow (for TCER) or top 5 (for TCEPR) will be in the merged landings data, but not in the merged estimated data. The value of this ratio also depends on how well the statistical areas recorded on the TCEPRs and TCERs are matched to the stocks reported on the CLR on a trip basis. The reporting rates for the TCER/CLR data were close to 1.0, whereas the rates reported from CEL/CLR data suggested consistently higher estimated catch data relative to landings data for 1996 to 2003. A comparison of the annual estimated and landed catches is shown in Figure C7.

Annual landings reported on CLRs were generally larger than those from CELRs (Figure C8), and from 2008, when TCERs were introduced (and thus landings from this form were reported on CLRs), effectively all trawl landings were from CLRs. The annual estimated catches reported on TCEPRs were higher than those from TCERs during 2008–15 and 2017; there was little difference between them in 2016.

Over the time series, the total number of trips reported each year on CELRs decreased from about 4560–5240 trips per year during 1992–98 to 2200–2910 trips during 2001–07 (Table C4). For those years, about 60–70% of the trips reported barracouta catches. After 2007, following the introduction of the TCER, there were 216–430 trips a year on CELRs and 1745–2212 trips reported on TCERs, with over 2000 trips with barracouta catches each year during 2014–17. About 88% of TCER trips each year had estimated barracouta catches. For years when 950–1420 trips were reported (1995–2004) on TCEPRs, 76–84% of trips had estimated barracouta catch compared with about 80–90% for years 2008–14 when about 400–500 trips were reported each year. During the 2015–17 fishing years, when the annual number of trips was less than 500, the percentage of TCEPR trips that reported barracouta dropped from 77% to 72%.

6.3 Barracouta BAR 1 trawl fishery

Barracouta catches in BAR 1 were from inshore-shelf waters off the east coasts of the North Island and the South Island, and as shown in Figure C9 and Table C5, two subareas were defined as "ECNI" and "ECSI" based on the boundaries of Statistical Areas (see Figure B1). The density of barracouta catches where data were reported on TCEPRs (1990–2017 combined) was greatest off the South Island, particularly near the shelf edge off Banks Peninsula and in the inshore waters of the Canterbury Bight. For the TCER catches (2008–17 combined), the density was also highest off the South Island east coast, but generally more inshore than the TCEPR catches.

Off the North Island east coast, catches from TCERs were evident in waters south of East Cape (particularly in Statistical Areas 013–014), whereas catches reported on TCEPRs were from the entire coastline.

Landed catches of barracouta in BAR 1 totalled about 233 500 t (Figure 3, Table C5), with 87% of the catch from the ECSI area. Annual catches peaked in the mid-late 1990s and 2010–14. From 2008 onwards, about 90% of the annual catch was from ECSI fishing. Catches from ECSI also peaked in the mid-late 1990s, at about 7500–9700 t per year before dropping to a low of 3800 t in 2007, then increased to peaks of over 9000–10 800 t in 2010–14. Catches dropped to 5000–6000 t in 2015–16, then increased again in 2017 to a similar amount reported for 2012 and 2013.

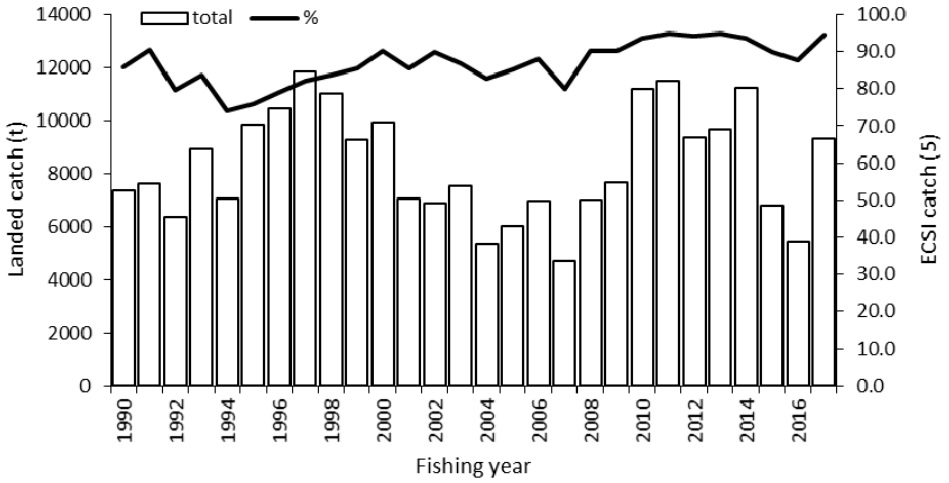

Figure 3: Annual BAR 1 landed catch (bars) and percentage (line) reported from ECSI, 1990–2017.

6.3.1 ECNI fishery

There were few differences in patterns of the ECNI barracouta catch in the three years since the last summary of catch and effort (see Baird 2016). The patterns indicated that most barracouta catch continued to be as bycatch from other target fisheries. The main points are given below, based on Figures C10–C15c.

Barracouta landed catches totalled almost 30 000 t for 1990–2017 (Table C6). Annual catches peaked in 1994–98 with over 1500 t per fishing year, were 700–1000 t up to 2010 and were generally less than 700 t for 2011–17. Small New Zealand trawl vessels, using bottom trawl gear, consistently reported almost 100% of the annual ECNI catch and from 2014, more catch was reported from TCER effort than on TCEPRs (Figure C10).

The main months that contributed consistently to the annual catches were July, August, and September (see Figure C10); about 46% of the total catch was from these months (median of 42% for 2008–17). Statistical Areas 013 and 014 consistently accounted for higher annual catches throughout the time series relative to other areas (see Figure C10) and these two areas contributed 39% of the total catch, with over 40% per year for 2008–17 — a period in which most of the barracouta catch came from areas 012–017 (East Cape south to Cook Strait).

The main target species were tarakihi and barracouta; across all years since 1990 these two targets accounted for 30% and 27% of the total ECNI barracouta catch, respectively (see Figure C10). The combined red gurnard, common warehou, snapper, gemfish, and hoki effort contributed to 31% of the total catch; though annual catches were variable throughout the time series. The catch from tarakihi effort accounted for 46–56% of the annual catch during 2005–12, but in recent years, less catch came from this target fishery with 36–44% from tarakihi effort in 2015–17, when there were increased catches of barracouta from red gurnard-targeted effort. Over the time series, the catch from barracouta-targeted effort decreased from over 40% of the annual barracouta catch in the early 1990s to generally less than 10% in the last 14 years.

The distributions of catches by month and Statistical Areas are shown in Figures C11a and C11b. Catches from tarakihi and red gurnard effort were from throughout the year, with higher catches mainly from July-September. Distinct differences were evident in the catches by area for the main target species over the time series. Barracouta-targeted effort yielded catches mainly from 009 and 013–016 in the 1990s. Areas

011–015 were important for catches during effort targeted at tarakihi, as were areas 013 and 014 for red gurnard, whereas the more northern areas 002–010 were important for snapper.

Barracouta catches were generally reported from throughout the range of the effort targeted at other species (Figures C12a and C12b). This effort was widespread for most species, but more constrained geographically when compared to the effort distribution for barracouta (e.g., hoki and common warehou) or by depth for others (e.g., gemfish). The patchiness, annual variation, and low level of the catches is evident in annual catch distribution plots based on TCEPR and TCER data (Figures C13a and C13b).

The distribution of effort variables that describe the TCEPR vessels for the main target species are shown in Figure C14a. These characteristics can be summarised as follows: wingspread values of about 20–30 m; headline heights of 4–6 m for barracouta, 3–5 m for red gurnard, snapper, tarakihi, trevally, and hoki, and 5–8 m for gemfish and common warehou. Tow speed was fairly uniform across the targets, as was the distance towed, although median values for barracouta, gemfish, and tarakihi tows were higher than for other targets, especially John dory and snapper. Small vessels (under 28 m) made up most of the effort for all targets other than hoki.

Figures C14b and C14c summarise the data distribution of the fishing duration and depth variables for the main TCEPR target species across the time series. Fishing duration values appeared to be more stable after the mid-1990s for all target species except for some with fewer data, as indicated by the larger intervals around the medians for gemfish, common warehou, and silver warehou. Tarakihi tows were consistently longer in duration than other tows, with median values of about 4–5 h. Median values for red gurnard tows since 2000 were substantially lower than those for the mid-late 1990s. Snapper and other inshore target species had median values of generally less than 3 h.

Distinct differences were evident in the depths fished, as expected from the range of target species with barracouta catch reported on TCEPRs (see Figure C14c). Tarakihi and barracouta targeting was in similar depths (100–200 m), the main inshore species were generally in depths of 50–100 m, and hoki, gemfish, and silver warehou target fishing was in depths of over 200 m.

Similar ranges were evident in the TCER tow-by-tow data (Figures C15a–C15c), although values for headline height and vessel size for these smaller vessels were slightly lower than those for TCEPR vessels. The reported fishing duration data suggest that tows for tarakihi and red gurnard were generally longer than for the other main targets, especially red cod, dark ghost shark, and snapper and were stable across the time series. TCER vessels generally fished in less than 150 m depths.

6.3.2 ECSI fishery area

The total landed catch was 203 568 t for 1990–2017, with peak annual catches close to or just over 10 000 t in 1997, 2010, 2011, and 2014 (see Table C5). Catches for 2015 and 2016 dropped to about 6100 t and 4780 t, respectively, then increased to 8819 t in 2017.

Throughout the time series, between 50% and 80% of the annual catch was reported on TCEPRs, with TCEPR catches of 2345–8372 t a year (Table C6a). Catches reported on TCEPRs were generally more than twice those reported on TCERs for 2008–14 and 2017, whereas the catches reported during 2015 and 2016 were similar (Figure C16). In the early years of the time series, the catch was largely from bottom trawl effort, but between 2008 and 2014 and in 2017, the increased annual catches came mainly from midwater TCEPR vessels that targeted mainly barracouta in Statistical Area 022 (Table C6b, Figure C16). Higher catches were reported from bottom trawl effort compared with midwater effort during 2015–16.

The catch from CELR and TCER forms was from small domestic vessels, but vessels that completed TCEPRs included a number of nationalities. New Zealand vessels reported at least 60% of the annual

ECSI catch in most years 1990–2007 (Figure C17a). From 2008, New Zealand vessels generally accounted for less than 50% of the catch in most years, despite reporting higher catches. This resulted from occasional larger catches from Korean bottom trawl vessels and large, though variable, catches from the Ukrainian and Russian midwater trawlers.

Throughout the series, barracouta was caught mainly during October to June, with 65% of the total catch caught during January–May (see Table C6c, Figure C16). In the period when TCER and TCEPR forms can be compared (2008–17), the season was broader for the TCER data (Figures C17b and C17c). July, August, and September had consistently small catches, relative to other months and together accounted for 7.5% of the total catch.

The main target species for the ECSI catch was barracouta. From 2008–17, barracouta-targeted catch accounted for 60–80% of the annual catch, as it did in the early 1990s. During 1994–2007, 30–50% of the catch was from barracouta tows, with the rest of the annual catch mainly from red cod, arrow squid, and jack mackerel effort (Figure C16, Table C6d). Over the last 10 years, the TCEPR and TCER catches were mainly from barracouta tows, with relatively small catches from mainly jack mackerel, arrow squid, and silver warehou effort in the TCEPR data, and from red cod, tarakihi, and common warehou in the TCER data (Figures C17b and C17c).

Where barracouta was the target, the proportion of tows with zero catches was low relative to other targets for the TCEPR and TCER forms (Figures C18a and C18b): at no more than 10% for TCEPR and close to 1% for TCER. For 2009–17, about 20–30% of red cod and arrow squid tows reported on TCEPRs, and 10–20% of TCER red cod tows and 20–30% of TCER tarakihi tows, caught no barracouta. The distribution of bottom trawl catches by month and target were similar for both form types, with catches from barracouta and red cod targeting mainly between October and June, whereas catches from arrow squid targeting were from January to May and catches from tarakihi targeting on TCERs were mainly January–June but also from July-September, and from October in recent years (Figures C19a–C19b). The monthly catch distributions of the daily data (vessels under 28 m), based on the three forms, are shown by main target species in Figure C19c. Figure C19d shows the monthly distribution of midwater catches.

Statistical Area 022 consistently accounted for 60–78% of the annual catch, relative to other areas, and overall contributed 68% of the total catch, with most of the remainder from 020 and 024 (Table C6e, Figures C20a–C20c). The catch from bottom trawl effort targeted at barracouta and red cod was primarily from Statistical Area 022 for all forms, with lesser catches from 018, 020, and 024. Statistical Area 022 was also the most important area for catch from arrow squid effort until 2009, after which the catches were small. The secondary areas for squid effort were 020, 024, and 026. Since the mid-2000s, the catch from tarakihi effort was primarily from 022, 020, and 018. The bycatch of barracouta in Statistical Area 022 was also important in the last 10 years, coming from effort that targeted silver warehou, red gurnard, and elephantfish. Common warehou targeted tows caught barracouta in 020, mostly during 2009–17. Catches from midwater trawl were predominantly from barracouta and jack mackerel tows in area 022 (Figure C20d).

The location of effort reported on TCEPRs and TCERs by target species is shown in Figures C21a and C21b. Barracouta catches were generally reported from throughout the range of the effort targeted at other main species, except for some deeper effort targeted at hoki and silver warehou, representing the overlap of targeting with the waters preferred by barracouta. Barracouta catches were reported from TCER effort targeted at a variety of species across the shelf off the east coast South Island, with distinct differences in distribution depending on the target. However, the primary targets for barracouta catch and bycatch (barracouta, tarakihi, and red cod) have very similar distributions.

For TCEPRs, the distribution of bottom trawl catches by year is variable, but higher catches were reported from close to the shelf edge and closer inshore between about 44° and 45° S where barracouta and red cod were targeted (compare Figures C21a and C22a). Catches were more constrained in distribution in the 2000s, especially from 2008–17, and the higher catches were restricted mainly to the shelf edge, with low catches inshore. This reflected the geographic difference in the spread of the larger and smaller vessels

that reported on TCEPRs and the change in the relative importance of the target fisheries in terms of barracouta catch. For the TCER catch distribution, the effect of target species is evident in some years (compare Figures C21b and C22b) with a reasonably even spread of catches across the shelf, from year to year. Areas of higher catches in most years are evident around the border of Statistical Areas 020 and 022 and in the southern part of 022.

The distribution of effort variables that describe the TCEPR bottom trawl vessels for the main target species are shown in Figures C23a–C23c. These distributions identify the different species targeted by different vessel sizes, with larger variable values generally corresponding to effort by the larger New Zealand and foreign vessels that targeted species such as barracouta, arrow squid, hoki, and silver warehou. The main variables are summarised as: wingspread values of about 20–40 m; headline heights of 3–5 m; tow speed of 3–4.5 kn., with slower speeds for barracouta, red cod, tarakihi, and elephant fish targets; and tow lengths of 10–30 km, with median values around 20 km. Smaller vessels (under 46 m) accounted for most of the effort for barracouta, red cod, tarakihi, common warehou, and elephant fish, as well as a proportion of the arrow squid effort.

Figures C23b and C23c summarise the data distribution of the fishing duration and depth variables for the main TCEPR target species across the time series. Fishing duration values were constant across the time series for barracouta except the higher values seen in 2008 when a small group of vessels had longer tow durations and fished in slightly deeper water than usual. For most other main target species with consistent data, tow durations were steady across the time series, at less than about 5 h. Tow duration for arrow squid and silver warehou increased towards the end of the series. The constrained error bars seen in the red cod data for 2008–17, for fishing duration and effort depth, reflect the smaller number of vessels present relative to earlier years.

Distinct differences were evident in the depths fished, based on target species reported on TCEPRs (see Figure C23c). Red cod and barracouta targeting was at similar depths (60–150 m), with tarakihi having a tighter distribution at around 60–115 m and arrow squid at 150–275 m. Hoki targeting was generally in the deepest water, over 400 m, and silver warehou at 200–400 m.

The midwater TCEPR explanatory variable data are shown in Figures C23d–C23f. There are few differences between the main variables for the target species barracouta, jack mackerel, and arrow squid which were mainly targeted by large vessels (over 80 m). Wingspreads were about 100 m and headline heights were 20–50 m, except when hoki was targeted (headline height of about 60 m). The tow speed for hoki, at 4 kn, was generally slower than for the other targets, but target had no effect on the distance towed for midwater nets. Fishing duration for barracouta and jack mackerel midwater effort increased over the time series, though were relatively stable after 2008, whereas hoki effort duration values were also relatively stable after 2008, but at a lower level than before 2008 (Figure C23e). The depths fished varied by the midwater target species, with barracouta and jack mackerel effort consistent over the time series at about 100–150 m, arrow squid generally at 100–200 m, and hoki mainly at 300–500 m (Figure C23f).

The tow-by-tow data reported on TCERs represent the smaller trawl vessels operating bottom trawl gear, with most vessels less than about 20 m, except for the 20–26 m vessels targeting arrow squid (Figure C24a). Wingspread values ranged from 20–40 m, except where the target was tarakihi or flatfish, where most values were around 20 m. Tows for the main species with barracouta catch (barracouta, red cod, and tarakihi) used nets with headline heights of 3–4 m, towed at about 3 kt, for about 3–4 h, although tarakihi tows were slightly longer in duration. There were few differences in the distribution of fishing duration values by target species across years (Figure C24b) and slight differences in the depths fished, although for the three targets with the most barracouta catch tarakihi effort was slightly deeper than that for barracouta and red cod (Figure C24c).

6.4 Trawl fishery summary

A summary of the features of each trawl fishery area is given in Table 3, and the catch information summarises the groomed merged landed catch. The ECSI area accounted for 87% of the total landed catch from trawl fishing, for 1990–2017, with 53% of the total catch from barracouta-targeted effort, 21% from red cod tows and 10% from arrow squid effort. Other target fishing that caught barracouta included effort targeted at red gurnard, gemfish, snapper, and common warehou in the ECNI fishery area, and jack mackerels, tarakihi, and common warehou in the ECSI fishery area. The increases in catches seen after 2008 resulted from an increase in targeting barracouta in ECSI by New Zealand and Korean bottom trawls and Ukrainian/Russian midwater trawls; with catches from barracouta-targeted tows increasing from about 2000–4000 t during 1995–2007 to 5000–8000 t during 2008–14. Industry sources indicated that the development of at least one new market for barracouta was responsible for the increase in targeting this species in ECSI. The decrease in 2015–16, at a time when foreign vessels were being assimilated into joint-venture fleets, was followed by an increase back to about 6500 t in 2017.

Most of the ECSI catch was from Statistical Area 022 (68%), 020 (16%), and 024 (9%), at depths of about 50–140 m. Fishing in January-May account for 65% of the catch, with another 21% from October–December. Bottom trawl gear was the primary method to catch barracouta, though post-2008, large catches were reported from midwater gear targeted at barracouta and jack mackerels. About 68% of the ECSI area barracouta catch was reported on TCEPRs and in the years in which the TCER data were available (2008–17), 33% of the catch was from TCERs.

The ECNI barracouta catch was small and annual catches decreased over the time series to less than 80 t a year during 2005–17. The ECNI catches were from a wider variety of species targeted by bottom trawls operated by New Zealand vessels in coastal waters. About 30% of the catch was from tarakihi tows and 27% from barracouta tows. Small catches of barracouta were made throughout the year, but more consistent catches were made during July–September and from waters in Statistical Areas 013 and 014, as well as 015–17. For all years, 42% of the catch was from TCEPR forms, and for the 2008–17 period, 60% was from TCERs.

Prior to development of the CPUE datasets, the ECSI tow-by-tow data were allocated to the trawl regions shown in Figure C25 (TCER data) and Figure C26 (TCEPR data) in recognition of the catch pattern. This variable was added to the datasets as *trawl region*.

Table 3: Summary of features of the ECNI and ECSI subareas of the BAR 1 barracouta fishery, based on the merged landed catch data, where TCEPR is Trawl Catch Effort Processing Return, TCER is Trawl Catch Effort Return, 1990–2017. Area definitions are shown in Figure 1 and Figure C9.

QMA area	ECNI	ECSI
General characteristics		
Key fishery areas	East Coast North Island	East Coast South Island
Key statistical areas (ranked, high to low)	013, 014, 015–017, 009	022, 020, 024
Secondary statistical areas (ranked)	002, 003, 010–012	018, 026, 021
Season	July–September	January-May; October–December
Gear type (% catch)	96% bottom trawl	71% bottom trawl; 29% midwater trawl
Target species		
Key target species (% catch)	Tarakihi (30%), barracouta (27%)	Barracouta (53%); red cod (21%); arrow squid (10%)
Secondary target species	Red gurnard, gemfish, snapper, common warehou	Jack mackerels, tarakihi, common warehou
Target barracouta catch trends	Decreased: ~ 200–640 t in 1990–2004; 9–77 t in 2005–17.	Increased: ~ 2000–4600 t in 1990–2008; 5000–8000 t in 2009–14; 2900–3700 t in 2015–16; 6500 t in 2017
Barracouta catch		
Landed catch (t)	29 917 t	203 568 t
Landed catch (% total BAR 1 catch)	13%	87%
Annual catch	~ 1000–2400 t in 1990–2004; 520–920 t in 2002–17	5000–7500 t in 1990–95; ~ 8000–9200 t in 1996–2000; 4000–7000 t in 2001–09; 8000–11000 t in 2010–14; 5000–6000 t in 2015–16; 8900 t in 2017.
Total area catch (% total from barracouta target effort)	22%	55%
Total area catch (% total by TCEPR)	42%	68%
Total area catch (% total by TCER for 2008–17)	60%	33%
Start depths of tows with barracouta	Median:85 m 25–75%: 54–120 m	Median: 90 m. 25–75%: 50–140 m
Vessel nationality	100% New Zealand	60% New Zealand; 16% Korea; 24% Ukraine/Russia

7. CPUE ANALYSES

This project had the objective to update the previous CPUE for the ECSI part of BAR 1 (Baird 2016). Thus, the main CPUE analysis is based on daily bottom trawl data from small trawl vessels that do not process fish at sea and report their data on CELRs (1990–2007) and TCERs (2008–17), with an adjustment to the input data. It was apparent in the data that some of these small vessels used a mixture of forms and so the input dataset was adjusted to include data from TCEPRs completed by vessels under 28 m. Two further analyses were run using the estimated catches reported on TCEPRs and TCERs. The similarity between the trends shown by the groomed estimated catch data and the groomed landings data indicated that the estimated catch data could be used to calculate a representative CPUE index. The tow-by-tow data included a range of descriptive variables that may influence a CPUE model (such as target species, tow distance, or bottom depth) and any trends in catch rates can be modelled at smaller spatial and temporal scales. When the tow-by-tow data were merged to daily data, the variables available for CPUE analyses required summing over the day or converting to a daily mean. However, in fishery areas where consistent amounts of annual data were recorded on CELR forms prior to 2006–07, the merging of data from all form types was necessary.

The CPUE method was unchanged from the previous assessment. Annual unstandardised (raw) CPUE indices were calculated as the mean of the catch-per-tow (kg) for 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 2017) was used to fit all models. The algorithm generated a final regression model iteratively and used the year term as the initial or base model in all cases. The reduction in residual deviance (denoted r^2) was calculated for each single term added to the base model. The term that resulted in the greatest reduction in the residual deviance was then added to the base model, where the change was at least 1%. The algorithm was then repeated, updating the base model, until no more terms were added. A stopping rule of 1% change in residual deviance was used as 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 considered. Hence, it represents a possible index of abundance. Year indices were standardised to the mean and were presented in canonical form (Francis 1999).

Categorical and continuous variables offered to the models are listed in Table D1 in Appendix D. Fits to continuous variables were modelled as third-order polynomials, although a fourth-order polynomial was also offered to the models for *duration*. In each analysis *trawl region* and *start latitude* or *start longitude* were not allowed to enter the same model at the same time as they were correlated. For the estimated catch runs all variables were included.

A vessel variable was incorporated into the CPUE standardisation to allow for differences in fishing power between vessels. A core set of vessels was determined for each model in an attempt to restrict any model over-fitting by the inclusion of vessels that had limited participation in each defined fishery (Francis 2001). Thus, CPUE analyses were undertaken for the "core" vessels that reported at least 80% of the barracouta catch and had steady involvement in the fishery.

The 10 years of TCER data were modelled separately because they represented the inshore fleet of smaller vessels and included records for the top 8 catch species. These data provided tow level information on target species, location, and tow parameters in generally shallower waters than fished by the larger vessels.

Model fits 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., lognormal errors). Binomial and a combination of the lognormal and binomial (delta-lognormal models) were also run, but only the indices are provided in this report.

The final ECSI CPUE models, listed in Table D2, were:

1. a day-level merged CELR/TCER/TCEPR mixed target, bottom trawl, landed catch dataset for October–September to incorporate the main target species in the barracouta catch data for the small vessels, 1990–2017;
2. a tow level TCER mixed target, bottom trawl, estimated catch dataset defined by trawl regions for October-September 2008–17; and
3. a tow level TCEPR mixed target, bottom trawl, estimated catch dataset defined by trawl regions for October–June to incorporate the main target species in the barracouta catch data, 1990–2017.

7.1 ECSI standardised CPUE models

(a) CELR/TCER/TCEPR mixed target bottom trawl (barracouta, red cod, and tarakihi)

In 2016, the SINSWG accepted the combined index (delta lognormal model) series based on the 1990–2014 daily data from CELR and TCER forms (targeting barracouta, red cod, and tarakihi) as an index of abundance for BAR 1, with most of the explanatory power coming from the *vessel*, *target species*, *month*, *and fishing duration* variable (see Baird 2016). This report presents the updated version of that CPUE series, with an additional three fishing years of data and the inclusion of the small vessel TCEPR data.

The number of daily records, proportion of zeros, catch, and unstandardised CPUE for the merged day-level CELR/TCER/TCEPR data are listed in Table D3. Standardised model results are shown in Tables D4–D5 and Figures D1–D10.

A total of 193 unique vessels (35–76 vessels each year) landed 87 373 t of barracouta during 1990–2017 from 47 773 daily records (Table D3). The number of daily records was 1083–3328 per year, and the landed catch was 1444–4770 t annually for all vessels. The distribution of the daily catch and effort data is shown in Figure D1. A total of 29 core vessels accounted for 70% of the total daily records and 83% of the landed catch (Figure D2, Table D3); annually 8–23 core vessels accounted for 600–2490 daily records and 1394–4186 t. From 2008, when data were from TCERs and TCEPRs, 8–11 core vessels each year landed 1650–3445 t. The core vessel catch and effort data included vessels no longer in the time series, vessels that entered the time series in the 2000s, and those with consistent presence (Figure D3). The percentage of zero days for all vessels and core vessels diverged slightly from 2010 onwards, and core vessels had a decreasing trend for 2010–17 (Figure D4).

Four variables were selected into the lognormal model, and resulted in a total r^2 of 45.7%, with *vessel* explaining 38.5% of the residual deviance (Table D4). The other variables selected were *target species*, *month*, and *fishing duration*.

A slightly increasing trend was indicated by the lognormal indices, particularly from the early 2000s (Table D5, Figure D5). The higher indices from 1996–98 are similar to those for 2010–14; however, the earlier period represents more vessels with smaller catches than in the later period (see Figure D3); many of these vessels were not present in the data after 2005. The addition of the TCEPR data had no real effect on the CPUE. The annual indices from the binomial model were relatively constant and had a negligible effect as shown by the trajectory of the combined indices (Figure D6). Stepwise analysis revealed that the effect of the addition of the selected variables increased the indices in the earlier years up to 2000 and lowered the indices from 2008 onwards (Figure D7).

Figure D8 and the influence plots (after Bentley et al. 2012) in Figures D9a–D9d show the expected distributions and effects of the selected variables. The expected catch rates by vessel varied: five vessels had substantially higher catch rates, and sixteen vessels had low catch rates relative to others. Figure D9a indicates the substantial influence of individual vessels, largely driven by the decrease in effort (or departure from the area) by vessels that fished before the 2000s and that generally had lower catch coefficients than vessels that fished throughout the series or arrived in the area in subsequent years. The vessels with higher catch rates maintained their levels of effort, resulting in a continuing positive influence overall.

The catch rate from barracouta-targeted tows was about twice the rate when red cod and tarakihi were targeted, and there was a positive influence in years where there was increased barracouta-targeted effort and a negative effect when more effort was expended for red cod and tarakihi (Figure D9b). A positive influence was evident after 2010 as the target effort exceeded tarakihi effort, concurrent with a relatively large decrease in red cod effort.

Generally, higher rates were evident from December to June compared with the low rates during August and September in particular. The relative evenness of the effort expended by month throughout the time series resulted in small and variable influences (Figure D9c). Catch rates increased as the number of hours fished per day increased; and the relative evenness of effort, with higher amounts of effort generally of 4.5–13.5 h duration when the catch coefficient was close to 1, resulted in small influences overall (Figure D9d).

The lognormal model diagnostics are shown in Figure D10.

(b) TCER mixed target bottom trawl (barracouta, red cod, and tarakihi)

The number of tows, proportion of zero catches, estimated catch, and unstandardised CPUE for the TCER data are listed in Table D3. Standardised model results are shown in Tables D4–D5 and Figures D11–D19. The catch data used in this analysis included the reported catch of the top eight species, as required on the form.

A total of 71 unique vessels (35–45 vessels each year) caught an estimated 22 352 t of barracouta during 2008–2017 from 33 406 bottom trawl tows (Table D3, Figure D11). The percentage of zero tows was consistent each year, 22–32%. Estimated barracouta catches were 1750–3140 t annually, and the numbers of annual tows were 2617–3894. Thirteen vessels were chosen as core vessels (Figure D12) and the distributions of the effort and catch data are shown in Figure D13. Core vessels (9–11 per year) accounted for 80% of the bottom tows made by all vessels and caught an estimated 20 310 t of barracouta, representing 91% of the total catch for 2008–17. The proportions of zero tows for all vessels and core vessels showed no real trend over the time series (Figure D14).

Four variables were selected into the lognormal model, and resulted in a total r^2 of 31.2%, with *vessel* explaining 20.0% of the residual deviance (see Table D4). The other variables selected were *mid tow time*, *target species*, and *tow depth*.

A slightly increasing trend is shown by the lognormal indices for the 10 years of available data (Table D5, Figure D15). The consistent trend in the proportion of non-zero tows is reflected in a lack of influence of the binomial on the lognormal seen in the delta-lognormal series (Figure D16). The effect of the addition of the selected variables is shown in Figure D17, with the overall effect of increasing the indices before 2011, no effect for 2012–15, then lowering the indices during 2016–17 (Figure D17). The influence plots in Figures D18a–D18d show the expected distributions and the relatively small influences of the retained variables. The vessel effect reflects the relative amounts of annual effort by three vessels with a lower catch coefficient than other vessels. Small increases in the effort by another three vessels with higher catch coefficients had a positive effect during 2016 and 2017. The catch coefficient from barracouta-targeted tows is substantially higher than that for red cod and tarakihi. Increased effort for barracouta in 2015–17 combined with a drop in red cod targeting, had a small positive effect. Higher catch coefficients were likely for tows where the mid tow time was 0630–

1530 h, and at 50–150 m, in the middle of the day; the influences of these variables was relatively small.

Model diagnostics are shown in Figure D19.

(c) TCEPR mixed target bottom trawl (barracouta, red cod, and arrow squid)

The number of tows, proportion of zero catches, estimated catch, and unstandardised CPUE are listed in Table D3. Standardised model results are shown in Tables D4–D5 and Figures D20–D28.

A total of 115 unique vessels (9–34 vessels each year) caught an estimated 70 446 t of barracouta during 1990–2017 from 58 471 bottom trawl tows (Table D3, Figure D20). The percentage of zero tows decreased over the time series, from 21–49% for 1990–2007 to 10–21% of tows during 2011–17. Estimated barracouta catches were 600 (2008)–4858 t (1996) annually, and the number of annual tows were 168 (2008)–4799 (1996). Twenty-seven vessels were chosen as core vessels (Figure D21) and 7–22 were present per year, with 7–8 vessels per year in 2014–17. Core vessels accounted for 82% of the bottom tows made by all TCEPR vessels and caught an estimated 61 873 t of barracouta, representing 87% of the total catch for 1990–2017. About 7 vessels reported reasonably consistent catches when they were present in the fishery, and one vessel had substantially more effort and catch than others during 2010–17 (see Figure D22). The proportion of zero tows deceased over the time series (Figure D23).

For the tow-by-tow estimated core data analysis, six variables were selected into the lognormal model, and resulted in a total r^2 of 23%, with *effort depth* explaining 12.4% of the residual deviance (Table D4). The other variables selected were *vessel*, *tow depth*, *start time of tow*, *trawl region*, and *month*.

The CPUE series from the lognormal models is presented in Table D5 and Figure D24. The tow-by-tow estimated catch index decreased during the early to mid-2000s then increased after 2007 to a level slightly higher than seen in the indices for the mid to late-1990s, though the larger confidence intervals indicate less stability in this trend. The influence of the non-zero catches seen in the binomial model was reflected in the lower indices at the beginning of the time series by the delta-lognormal model and, similarly, by the higher indices represented for 2010–15 (Figure D25).

The effects of the addition of the selected variables on the unstandardised catch rate are shown in Figure D26 and the influence plots in Figures D27a–D27f. Catch coefficients were higher when the effort was in waters shallower than about 155 m as was evident in the positive effect in recent years when there was increased effort in these depths. The increase in barracouta-targeted effort after 2007 had a positive influence and was tempered only by occasional years when the squid effort increased (Figure D27b). A large positive effect in 2008 resulted from the absence of a number of vessels (with low catch rates) and the increased effort of at least 7 vessels, all with relatively high catch rates (Figure D27c). Smaller influences were evident for the remaining retained variables (Figures D27d-D27f), although there was a negative effect in 2008 when the effort was almost exclusively in the DEEP area, and in 2015 when there was an increase in effort in SOUTH – both areas had the lowest catch coefficients.

Model diagnostics are shown in Figure D28.

8. SUMMARY AND RECOMMENDATIONS

Barracouta occur on the continental shelf mainly in depths of 50–250 m. The understanding of the distribution of barracouta stocks in New Zealand waters is based on tagging work, research trawl surveys, observer and commercial fisheries data, including length frequency data (Hurst 1988a, Hurst & Bagley 1989, Langley & Bentley 2002, Hurst et al. 2012). For the fish in BAR 1, barracouta from east coast South Island are thought to migrate north to the east coast North Island to spawn, and

Langley & Bentley 2002 presented some evidence that the barracouta in the Southland area (on the Stewart-Snares shelf) may be part of this stock as well. However, Hurst et al. (2012), with a longer time series, found that the similarities between strong and weak year classes were not always consistent between the areas and these authors concluded that the current stock boundaries should remain in place.

The updated CPUE presented in this report extends the earlier model with the addition of three years of data as well as the addition of TCEPR data from small vessels (under 28 m). This was accepted by the SINS Working Group in 2018 as the most consistent time series for barracouta in the ECSI part of BAR 1, both as targeted catch as well as bycatch. A comparison of the ECSI trawl survey indices (for the recruited biomass, from Beentjes et al. 2016) and the small vessel day-level indices revealed similar trends (Figure 4), reaffirming the value of the trawl survey in monitoring the ECSI small vessel catch. Although the survey is not optimised for barracouta, it covers all the depth ranges seen in the small vessel commercial fishery, and barracouta remains one of the top three catch species in each survey (MacGibbon et al. 2019).

There are compromises with the use of merged day level data in terms of the available variables. The location of effort is restricted to one Statistical Area and one target species for a fishing day for each vessel trip, and the fishing duration is the sum of hours fished during the day. This day-level model accounted for about 73 000 t barracouta caught during 1990–2017, representing about 83% of the day-level landed catch.

Fishing year (as represented by the season within each fishing year) was forced into each CPUE model. In the main small vessel CPUE it explained about 10% of the null model deviance. The three models showed broadly the same trend, and the r^2 values varied from low to moderate, with 23% for the TCEPR model, 31% for the TCER model over 10 years, and 46% for the merged CELR/TCER /TCEPR data. Some explanatory variables were consistent for all models, with *vessel* and *target* entering each model: *vessel* the primary influence for the small vessel models and *effort depth* for the TCEPR model. The other variables retained in the models included *target species, month*, and *fishing duration* (CELR/TCER/TCEPR); *mid tow time*, *target species*, and *effort depth* (TCER); and *depth*, *tow start time*, *trawl region*, and *month* (TCEPR). Generally, these variables had small influence.

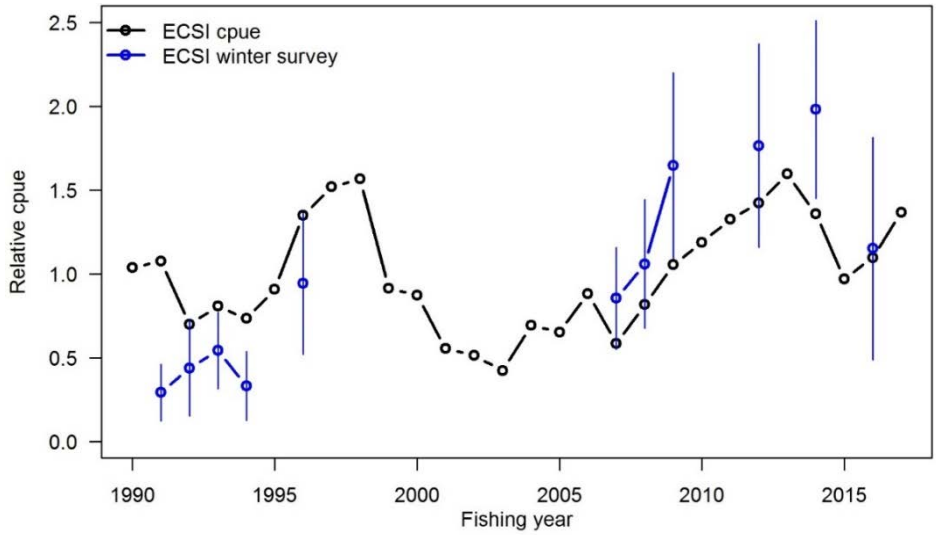

Figure 4: Comparison of the BAR 1 ECSI delta-lognormal indices for 1990–2017 and the recruited biomass (and associated variance) from the ECSI winter trawl survey series (after Beentjes et al. 2016). The recruited biomass is based on fish over 60 cm fork length. Each series was standardised to the mean for concurrent years.

8.1 Future data and research requirements

8.1.1 Trawl survey information

Gaps in the data available to increase understanding of the distribution of barracouta, spatially and temporally, continue to limit any further clarification of the spawning and stock definitions. The ECSI trawl survey in core depths of 30–400 m provides a comparable dataset for the inshore barracouta catch, with surveys run every two years during May-June — at a time when reasonable commercial catches have been reported from barracouta, red cod, and tarakihi effort. Additional collection of barracouta biological data (similar to that collected for the survey target species, including otoliths) could be useful in further describing this fishery/stock. The survey samples a wide range of size classes, but there are no otolith data to create a complementary dataset to that used for ageing work based on the Southland (Stewart-Snares shelf) survey data from the mid-1990s.

The Southland trawl survey series in the mid-late 1990s provided a wealth of information on a variety of species, including barracouta, and re-commencement of this survey series could greatly increase understanding of the barracouta stock in southern and south-eastern waters.

8.1.2 Observer information

Collection of length, weight, and gonad data by observers is required at appropriate spatial and temporal scales for the commercial effort by both the smaller and large vessel fleets. Currently the observer information is limited by the location and timing of fisheries in which barracouta is targeted or is a bycatch species by larger trawl vessels. Improved observer coverage of both fleets in both the ECSI and ECNI areas would potentially provide biological information through the collection of length, weight, sex, gonad data, and otoliths. This information would directly relate to the commercial catch and potentially increase the understanding of the stock structure within BAR 1. Length and reproductive stage data from fish caught throughout the year in BAR 1 could be combined with that collected from BAR 5, to enable a combined analysis to better understand any stock structure relationships that may exist between the two areas.

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11. APPENDIX A: RELEVANT TRAWL SURVEY DATA SUMMARIES

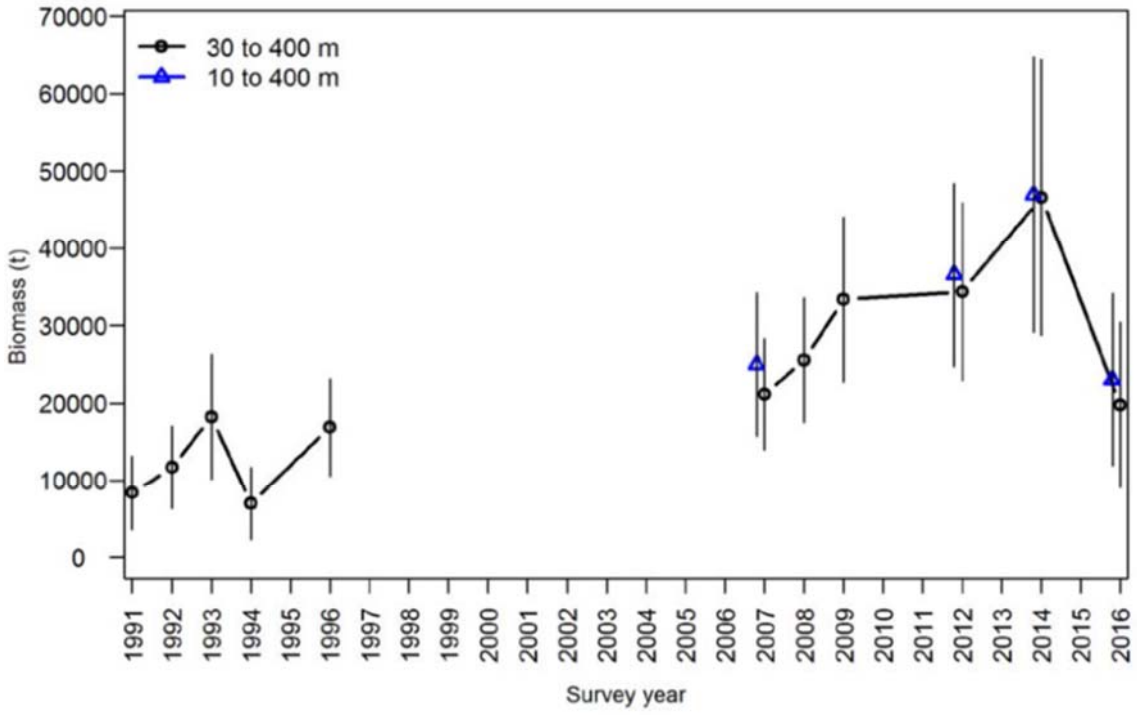


Figure A1: Total estimated biomass and 95% confidence intervals for barracouta caught during the ECSI winter trawl survey, core strata (30–400 m), and for all depth strata (10–400 m) where possible (2007, 2012, 2014, and 2016). This plot is figure 15 from Beentjes et al. (2016).

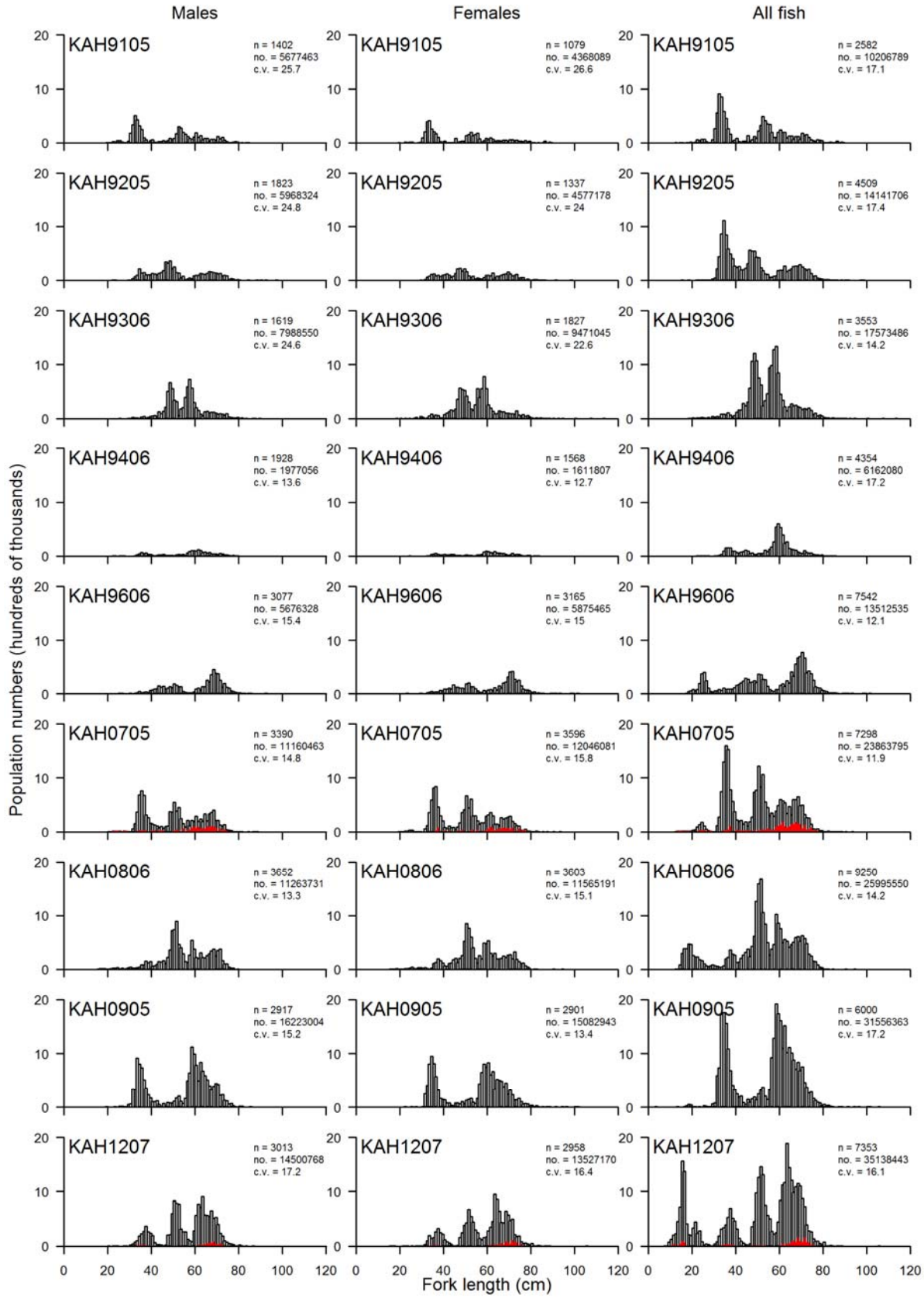


Figure A2: Scaled length frequency distributions for barracouta in core strata (30–400 m) for the ECSI winter surveys listed in Table 2, except for KAH1402. Where possible, data from the 10–30 m stratum were also included and are shown in red for 2007 and 2012. n, number of fish measured; no., core strata population estimates; c.v., coefficient of variation. This plot is from figure 4 from Beentjes & MacGibbon (2013) (see continuation on next page for KAH1402 and KAH1605).

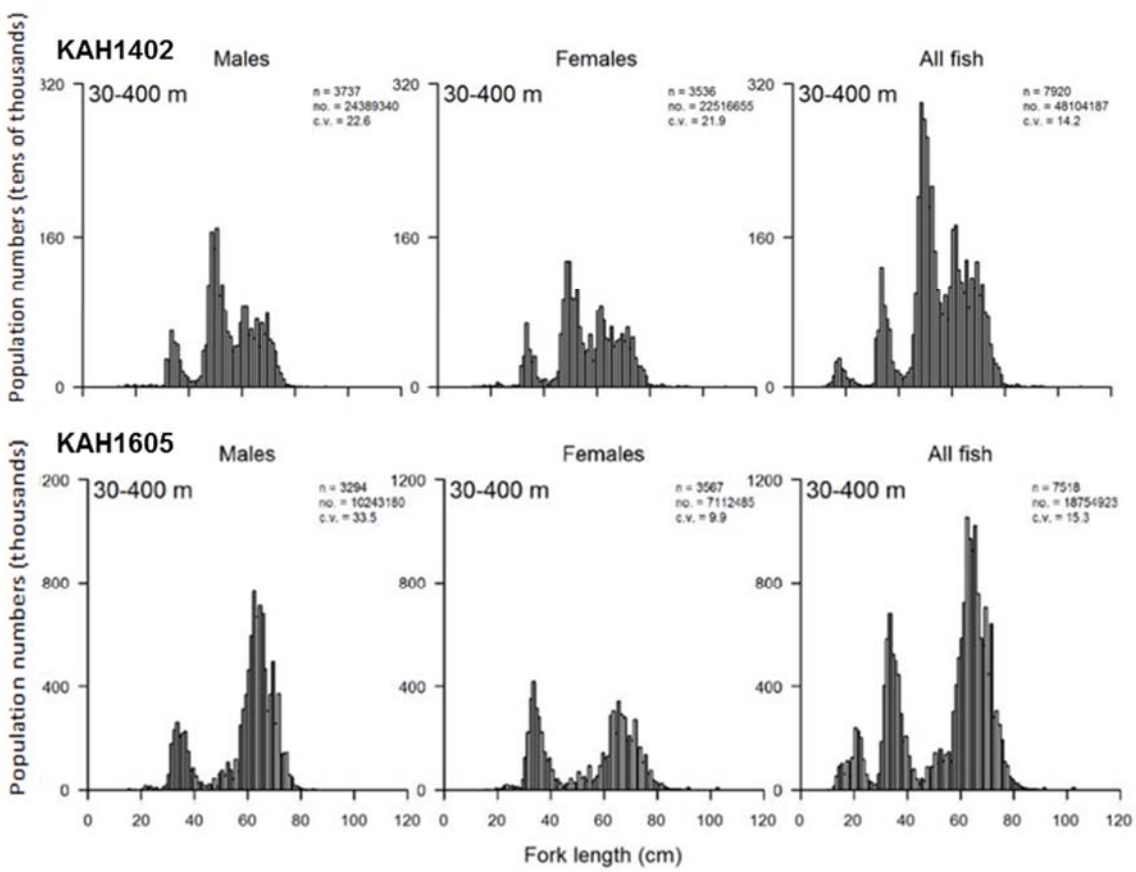


Figure A2: *continued.* Scaled length frequency distributions showing population numbers of barracouta in core strata (30–400 m) for the 2014 and 2016 ECSI winter surveys (from figure 6 in Beentjes et al. 2015 and figure 6 in Beentjes et al. 2016). Note the different scales on the y-axes above.

12. APPENDIX B: OBSERVER DATA SUMMARIES FOR BAR 1, 1990–2017

Table B1: Species codes used in the report.

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
BYX	Alfonsino	*Beryx splendens & B. decadactylus*
CDL	Deepsea cardinalfish	*Epigonus telescopus*
ELE	Elephant fish	*Callorhynchus milii*
FLA	Flatfish species	*Rhombosolea leporina, R. plebeia, R. retiaria, R. tapirina, Pelotretis flavilatus, Peltorhamphus novaezeelandiae, Colistium guntheri, C. nudipinnis*
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*
GUR	Red gurnard	*Chelidonichthys kumu*
HOK	Hoki	*Macruronus novaezelandiae*
JMA	Jack mackerels	*Trachurus declivis*, *T. novaezelandiae*, *T. murphyi*
JDO	John dory	*Zeus faber*
LIN	Ling	*Genypterus blacodes*
OEO	Oreos	*Pseudocyttus maculatus, Allocyttus niger, Neocyttus rhomboidalis and Allocyttus verucosus*
ORH	Orange roughy	*Hoplostethus atlanticus*
RBT	Redbait	*Emmelichthys nitidus*
RBY	Rubyfish	*Plagiogeneion rubiginosum*
RCO	Red cod	*Pseudophycis bachus*
SCI	Scampi	*Metanephrops challengeri*
SKI	Gemfish	*Rexea solandri*
SNA	Snapper	*Pagrus auratus*
SQU	Arrow squid	*Nototodarus gouldi*, *N. sloanii*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
TRE	Trevally	*Pseudocaranx georgianus*
WAR	Common warehou	*Seriolella brama*

Table B2: Number of observed trips and observed tows in BAR 1 (ECNI and ECSI), including the number where barracouta catch was observed and sampled for barracouta length and sex, for fishing years 1990–2017. –, no data.

(a) BAR 1 ECNI

Fishing year	Total observed trips	Trips with BAR	Total observed tows	Tows with BAR	Observed BAR catch (t)	Trips with LF data	Tows with LF data	Total BAR sampled	No. females sampled
1990	8	3	122	4	0.3	0	–	–	–
1991	8	0	402	0	–	0	–	–	–
1992	4	1	150	4	<0.1	0	–	–	–
1993	8	1	145	1	<0.1	0	–	–	–
1994	17	2	317	6	0.1	0	–	–	–
1995	12	1	452	1	<0.1	0	–	–	–
1996	19	2	496	2	<0.1	0	–	–	–
1997	12	0	343	0	–	0	–	–	–
1998	20	8	504	36	4.6	1	1	20	15
1999	30	9	1 021	59	12.4	1	1	1	1
2000	27	7	1 050	44	2.8	1	1	1	1
2001	20	7	537	51	2.2	3	8	94	56
2002	20	4	611	7	<0.1	0	–	–	–
2003	18	6	496	35	1.5	0	–	–	–
2004	16	3	312	10	0.1	0	–	–	–
2005	20	5	287	42	5.6	2	9	47	23
2006	15	4	453	18	3.0	1	1	1	0
2007	26	8	738	65	1.1	2	3	30	18
2008	23	6	913	33	0.6	2	4	24	16
2009	13	6	527	29	0.5	1	2	27	14
2010	22	7	674	32	2.7	0	–	–	–
2011	18	4	774	13	0.1	0	–	–	–
2012	17	7	693	55	2.1	0	–	–	–
2013	12	5	239	44	2.5	0	–	–	–
2014	35	30	1 580	455	34.4	1	4	260	0
2015	45	34	2 198	782	36.8	2	4	60	36
2016	26	20	1 174	373	18.5	0	–	–	–
2017	40	31	1 904	640	31.1	0	–	–	–
All	551	221	19 112	2 845	162.9	18	38	565	179

(b) BAR 1 ECSI

Fishing year	Total observed trips	Trips with BAR	Total observed tows	Tows with BAR	Observed BAR catch (t)	Trips with LF data	Tows with LF data	Total BAR sampled	No. females
1990	18	10	564	77	365.6	0	–	–	–
1991	17	9	833	164	282.2	1	1	77	51
1992	20	10	351	48	35.7	1	1	102	53
1993	18	8	384	194	236.8	3	14	497	235
1994	33	11	981	254	170.2	2	12	214	114
1995	23	6	459	71	198.6	1	7	757	364
1996	24	8	929	80	53.2	2	5	24	13
1997	25	9	455	52	171.1	2	3	326	161
1998	35	13	1 185	52	65.3	1	2	22	12
1999	47	16	1 046	180	518.1	5	19	1 101	534
2000	90	13	1 943	145	402.7	5	22	1 067	583
2001	137	33	2 759	325	1 027.0	15	71	3 818	1 700
2002	120	13	2 525	163	567.0	6	33	1 639	810
2003	107	21	1 661	143	338.8	10	33	1 311	679
2004	56	12	1 231	41	56.0	4	8	173	91
2005	48	12	943	63	24.2	3	18	184	83
2006	27	12	762	88	337.8	7	19	1 480	807
2007	37	23	693	109	558.3	4	14	1 298	669
2008	37	15	818	125	1 357.0	3	38	3 346	1 793
2009	38	17	907	44	305.3	6	11	974	416
2010	32	15	895	173	2 232.8	6	44	3 286	1 811
2011	41	27	973	219	1 386.8	12	53	3 610	1 775
2012	50	31	718	224	2 015.8	17	95	6 348	3 238
2013	87	63	1 698	647	4 010.9	28	214	12 060	5 705
2014	92	73	1 633	867	6 340.7	44	237	15 961	7 870
2015	78	63	1 250	666	2 135.2	25	133	7 985	4 060
2016	53	42	1 097	352	1 626.9	27	89	5 695	2 481
2017	78	61	1 427	660	4 389.8	45	197	13 247	6 658
All	1 468	646	31 120	6 226	31 209.6	281	1 393	86 542	42 766

Table B3: Number of observed tows and the number of observed tows with barracouta catch, by main target species for fishing years 1990 to 2017, for BAR 1 ECNI and ECSI. Codes of target species are defined in Table B1.

(a) BAR 1 ECNI: All observed tows

Fishing year	BYX	CDL	GSH	GUR	HOK	JDO	ORH	RBY	SCI	SKI	SNA	TAR	TRE	Other	All
1990	0	0	0	0	6	0	93	0	0	4	0	0	0	19	122
1991	1	0	0	0	0	0	45	0	350	0	0	0	0	6	402
1992	0	0	0	0	0	0	0	0	149	0	0	0	0	1	150
1993	0	0	0	0	14	0	21	0	110	0	0	0	0	0	145
1994	0	10	0	0	39	0	69	0	199	0	0	0	0	0	317
1995	3	8	0	0	0	0	188	1	197	55	0	0	0	0	452
1996	0	110	0	0	46	0	187	0	149	0	0	0	0	4	496
1997	1	4	0	0	6	0	225	2	95	3	0	0	0	7	343
1998	0	0	0	0	270	0	150	1	60	20	0	0	0	3	504
1999	9	11	0	0	297	0	235	3	363	82	0	7	6	8	1 021
2000	32	69	0	4	177	0	463	0	254	38	0	10	0	3	1 050
2001	6	6	0	0	281	0	21	6	146	29	0	41	0	1	537
2002	8	25	0	0	147	0	128	0	299	0	0	1	1	2	611
2003	1	81	0	0	154	0	199	0	32	15	0	1	0	13	496
2004	40	64	0	0	132	1	68	0	5	0	0	0	1	1	312
2005	20	9	0	3	141	0	33	0	66	0	0	13	0	2	287
2006	88	35	0	0	66	0	126	1	114	0	4	14	0	5	453
2007	21	45	0	2	227	63	179	2	136	0	8	21	29	5	738
2008	33	145	2	0	203	0	234	3	247	0	24	7	13	2	913
2009	46	43	0	0	172	0	90	25	130	0	21	0	0	0	527
2010	96	17	0	0	321	0	89	0	150	0	0	0	0	1	674
2011	128	89	0	5	93	0	195	18	213	0	5	24	0	4	774
2012	24	28	0	4	193	2	98	45	239	1	23	20	14	2	693
2013	0	5	0	0	182	0	19	0	16	1	16	0	0	0	239
2014	1	2	0	30	254	207	21	14	106	5	388	330	194	28	1 580
2015	56	25	0	103	455	232	161	17	0	0	537	343	213	56	2 198
2016	9	0	0	41	173	70	100	15	72	1	428	121	127	17	1 174
2017	50	14	0	37	142	58	184	12	0	29	584	434	301	59	1 904
All	673	845	2	229	4 191	633	3 621	165	3 897	283	2 038	1 387	899	249	19 112

(b) ECNI observed tows with barracouta catch

Fishing year	BYX	GSH	GUR	HOK	JDO	ORH	RBY	SCI	SKI	SNA	TAR	TRE	Other	All
1990	0	0	0	0	0	1	0	0	1	0	0	0	2	4
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	4	0	0	0	0	0	4
1993	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1994	0	0	0	6	0	0	0	0	0	0	0	0	0	6
1995	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1996	0	0	0	0	0	0	0	2	0	0	0	0	0	2
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	28	0	0	0	1	7	0	0	0	0	36
1999	0	0	0	18	0	0	0	0	31	0	5	4	1	59
2000	0	0	4	15	0	0	0	2	14	0	9	0	0	44
2001	0	0	0	8	0	0	1	0	8	0	34	0	0	51
2002	0	0	0	3	0	0	0	2	0	0	1	1	0	7
2003	0	0	0	22	0	0	0	0	12	0	0	0	1	35
2004	0	0	0	7	1	0	0	0	0	0	0	1	1	10
2005	0	0	3	27	0	0	0	0	0	0	11	0	1	42
2006	5	0	0	0	0	0	0	0	0	2	11	0	0	18
2007	0	0	0	41	10	0	0	0	0	2	7	5	0	65
2008	0	1	0	16	0	0	0	0	0	9	4	3	0	33
2009	0	0	0	16	0	0	0	2	0	11	0	0	0	29
2010	1	0	0	33	0	0	0	2	0	0	0	0	0	36
2011	2	0	2	2	0	2	0	0	0	4	1	0	0	13
2012	0	0	0	34	0	0	0	2	0	7	9	3	0	55
2013	0	0	0	38	0	0	0	0	0	6	0	0	0	44
2014	0	0	16	28	93	0	3	0	0	86	161	56	12	455
2015	4	0	31	80	101	0	0	0	0	299	153	107	7	782
2016	0	0	15	2	22	0	0	0	0	219	39	73	3	373
2017	6	0	29	11	20	0	0	0	7	201	210	149	7	640
All	18	1	100	435	247	3	4	19	80	846	655	402	35	2 845

(c) BAR 1 ECSI: All observed tows

Fishing year	BAR	HOK	JMA	LIN	OEO	ORH	RBT	SCI	SQU	SWA	Other	All
1990	44	302	0	7	86	56	0	0	0	27	42	564
1991	82	278	2	133	255	31	0	3	0	14	35	833
1992	25	259	0	1	17	7	0	8	7	15	12	351
1993	38	108	161	0	0	1	0	1	30	13	32	384
1994	0	362	39	0	47	129	0	133	267	4	0	981
1995	41	217	5	0	123	4	0	60	3	6	0	459
1996	0	695	94	0	53	28	0	47	12	0	0	929
1997	37	269	5	0	80	53	0	0	7	1	3	455
1998	11	998	15	0	106	20	0	29	6	0	0	1 185
1999	41	756	24	0	59	38	0	51	72	1	4	1 046
2000	60	1 293	11	0	488	32	0	21	23	2	13	1 943
2001	65	1 842	36	0	474	63	0	18	232	12	17	2 759
2002	27	1 904	68	0	314	32	0	83	64	11	22	2 525
2003	20	1 347	32	0	89	8	0	72	78	12	3	1 661
2004	7	1 010	0	0	105	0	0	64	34	7	4	1 231
2005	5	757	4	0	88	2	0	0	68	8	11	943
2006	17	548	56	1	81	4	0	0	16	35	4	762
2007	37	397	16	0	140	0	0	0	38	26	39	693
2008	93	543	15	2	118	4	0	4	2	17	20	818
2009	22	508	4	16	199	17	0	1	9	71	60	907
2010	102	590	14	13	110	3	0	0	5	43	15	895
2011	64	572	23	4	112	23	0	1	63	104	7	973
2012	146	382	52	1	56	0	3	0	18	31	29	718
2013	291	897	209	12	46	15	23	0	48	150	7	1 698
2014	353	576	263	7	61	0	81	0	70	205	17	1 633
2015	214	398	115	3	105	38	23	6	158	171	19	1 250
2016	180	575	37	1	37	32	5	0	120	95	15	1 097
2017	351	619	39	0	75	33	20	0	146	128	16	1 427
All	2 373	19 002	1 339	201	3 524	673	155	602	1 596	1 209	446	31 120

(d) ECSI observed tows with barracouta catch

Fishing year	BAR	HOK	JMA	LIN	OEO	RBT	SQU	SWA	Other	All
1990	43	13	0	0	0	0	0	13	8	77
1991	73	46	2	5	1	0	0	7	30	164
1992	23	7	0	0	0	0	1	7	10	48
1993	37	2	96	0	0	0	26	6	27	194
1994	0	10	30	0	0	0	213	1	0	254
1995	39	23	2	0	0	0	3	4	0	71
1996	0	11	58	0	0	0	11	0	0	80
1997	37	1	5	0	0	0	6	0	3	52
1998	9	22	15	0	0	0	6	0	0	52
1999	39	59	17	0	0	0	63	0	2	180
2000	60	47	11	0	0	0	15	0	12	145
2001	64	19	36	0	0	0	190	2	14	325
2002	27	2	58	0	0	0	57	5	14	163
2003	18	30	31	0	0	0	55	9	0	143
2004	7	5	0	0	0	0	24	1	4	41
2005	4	5	2	0	0	0	50	2	0	63
2006	17	9	49	0	0	0	10	2	1	88
2007	36	3	13	0	0	0	22	8	27	109
2008	90	8	10	0	0	0	1	4	12	125
2009	21	6	4	0	0	0	8	5	0	44
2010	101	27	10	0	0	0	2	24	9	173
2011	63	12	23	1	0	0	55	65	0	219
2012	143	9	39	0	0	0	17	14	2	224
2013	283	28	188	0	0	9	43	95	1	647
2014	350	18	244	0	0	68	60	115	12	867
2015	212	49	104	0	0	14	136	133	18	666
2016	180	11	27	0	0	4	63	59	8	352
2017	348	28	36	0	0	17	129	92	10	660
All	2 324	510	1 110	6	1	112	1 266	673	224	6 226

Table B4: Total observed barracouta catch (t), by main target species and month, for ECNI and ECSI, for the fishing years 1990–2017 combined. Codes of target species are defined in Table B1.

(a) BAR 1 ECNI. Catches of barracouta from observed tows, catch weight per tow was 1–8988 kg (median of 10 kg, mean of 57.3 kg, 1st quartile of 4 kg, 3rd quartile of 40 kg).

Target	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
BYX	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.89
CDL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GSH	0.06	–	–	–	–	–	–	–	–	–	–	–	0.06
GUR	0.01	0.68	0.31	1.08	0.28	0.02	0.52	0.00	0.30	0.06	–	0.15	3.41
HOK	0.33	0.72	3.34	2.65	4.30	1.79	0.28	2.31	0.63	0.41	0.62	3.82	21.20
JDO	0.64	1.07	3.68	0.39	0.71	0.02	0.61	0.04	0.57	0.11	0.00	0.26	8.09
ORH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02
RBY	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.07
SCI	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.01	0.00	0.01	0.10
SKI	0.38	7.00	0.78	0.07	1.79	0.02	0.74	0.06	0.00	0.00	0.00	0.00	10.83
SNA	4.13	12.36	3.47	0.38	0.30	0.21	0.26	4.55	3.18	8.53	1.78	2.49	41.62
TAR	2.58	2.73	3.50	4.74	3.60	3.03	3.42	3.32	1.20	4.04	4.89	2.05	39.10
TRE	2.11	3.83	0.77	1.27	1.02	0.15	0.44	0.92	0.54	2.67	0.41	0.55	14.66
Other*	0.01	1.84	2.65	0.11	0.41	0.25	0.00	1.11	0.00	0.26	10.78	5.46	22.88
All	10.30	30.29	18.50	10.68	12.41	5.48	6.28	12.30	6.54	16.08	18.48	15.60	162.93

* The observed catches in August and September were from tows that targeted silver warehou in 2014.

(b) BAR 1 ECSI. Catches of barracouta from observed tows, catch weight per tow was 1–65000 kg (median of 1105 kg, mean of 5013 kg, 1st quartile of 80 kg, 3rd quartile of 6701 kg).

Target	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
BAR	5 109.8	159.8	156.0	944.3	6 858.3	3 890.0	2 209.6	375.1	988.8	874.7	883.1	1435.2	23 884.6
HOK	2.8	1.0	11.7	10.5	18.9	5.0	12.4	45.6	5.1	0.0	0.2	18.8	132.0
JMA	168.0	2.7	12.4	21.8	1 089.6	1 179.4	1 536.0	128.5	14.0	–	18.6	25.8	4 196.9
LIN	1.1	0.0	0.2	0.1	–	–	–	–	–	–	–	0.0	1.4
OEO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ORH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RBT	172.1	–	–	–	1.0	0.2	0.2	–	–	–	–	1.1	174.5
SCI	0.0	0.0	0.0	0.0	0.0	–	–	–	0.0	–	0.0	0.0	0.0
SQU	0.0	1.7	8.5	164.8	469.1	243.9	230.6	137.5	141.9	0.0	0.0	0.4	1 398.5
SWA	758.9	129.5	115.4	102.5	41.9	13.9	3.4	1.3	15.2	0.0	17.9	23.3	1 223.3
Other	74.1	4.2	32.7	6.2	12.9	14.1	23.7	8.4	2.8	2.3	6.8	10.1	198.4
All	6 286.9	299.0	336.9	1 250.2	8 491.7	5 346.4	4 015.9	696.5	1 167.8	877.0	926.7	1 514.7	31 209.6

Table B5: Number of observer tows sampled for length and sex measurements by month for each fishing year, 1991–2017, for BAR 1 ECNI and ECSI. Note: no sampling occurred in ECNI for fishing years 1990–97, 2002–04, 2010–13, or 2016–17; and in ECSI in 1990.

(a) BAR 1 ECNI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
1998	0	0	1	0	0	0	0	0	0	0	0	0	1
1999	0	0	0	0	0	0	0	0	0	0	0	1	1
2000	0	0	0	0	0	0	0	0	0	0	1	0	1
2001	5	0	0	0	0	0	0	0	0	0	1	2	8
2005	0	0	0	0	0	0	0	0	0	0	1	8	9
2006	0	0	0	0	0	0	0	0	0	0	1	0	1
2007	0	0	2	0	0	0	0	0	0	0	1	0	3
2008	0	0	0	0	0	0	0	0	0	0	1	3	4
2009	0	0	0	0	0	0	0	0	0	2	0	0	2
2014	0	0	0	0	0	0	0	0	0	0	3	1	4
2015	0	0	0	0	2	2	0	0	0	0	0	0	4
All	5	0	3	0	2	2	0	0	0	2	9	15	38

(b) BAR 1 ECSI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
1991	0	0	1	0	0	0	0	0	0	0	0	0	1
1992	0	0	0	0	0	0	0	0	0	1	0	0	1
1993	0	0	0	0	0	0	9	0	0	5	0	0	14
1994	0	0	0	0	0	0	4	8	0	0	0	0	12
1995	0	0	0	0	0	0	7	0	0	0	0	0	7
1996	0	0	4	0	0	0	0	1	0	0	0	0	5
1997	0	0	0	0	0	0	1	2	0	0	0	0	3
1998	0	2	0	0	0	0	0	0	0	0	0	0	2
1999	0	0	6	1	0	1	11	0	0	0	0	0	19
2000	0	0	0	4	0	12	0	6	0	0	0	0	22
2001	8	0	0	0	39	13	7	3	0	0	0	1	71
2002	9	0	0	0	0	3	19	2	0	0	0	0	33
2003	0	0	0	1	0	2	18	6	0	0	0	6	33
2004	1	0	0	0	1	1	5	0	0	0	0	0	8
2005	0	0	0	0	0	0	0	15	1	0	1	1	18
2006	0	0	0	0	0	6	0	3	0	0	9	1	19
2007	1	0	1	0	0	0	2	0	4	6	0	0	14
2008	0	0	0	0	0	0	0	0	3	10	11	14	38
2009	0	0	0	0	0	6	3	0	0	0	1	1	11
2010	6	1	0	0	14	21	2	0	0	0	0	0	44
2011	5	2	5	0	30	0	10	0	1	0	0	0	53
2012	10	0	0	0	10	13	23	10	15	6	2	6	95
2013	36	5	2	0	89	49	27	0	4	0	0	2	214
2014	70	2	4	14	74	55	5	7	2	0	0	4	237
2015	5	0	2	6	43	34	28	15	0	0	0	0	133
2016	33	7	4	11	5	5	12	3	7	0	0	2	89
2017	43	4	8	20	35	25	27	1	28	0	0	6	197
All	227	23	37	57	340	246	220	82	65	28	24	44	1393

Table B6: Number of barracouta sampled for length and sex measurements by month for each fishing year, 1991–2017, for BAR 1 ECNI and ECSI. Note: no sampling occurred in ECNI for fishing years 1990–97, 2002–04, 2010–13, or 2016–17; and in ECSI in 1990.

(a) BAR 1 ECNI

Fishing	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
1998	0	0	20	0	0	0	0	0	0	0	0	0	20
1999	0	0	0	0	0	0	0	0	0	0	0	1	1
2000	0	0	0	0	0	0	0	0	0	0	1	0	1
2001	84	0	0	0	0	0	0	0	0	0	1	9	94
2005	0	0	0	0	0	0	0	0	0	0	2	45	47
2006	0	0	0	0	0	0	0	0	0	0	1	0	1
2007	0	0	10	0	0	0	0	0	0	0	20	0	30
2008	0	0	0	0	0	0	0	0	0	0	20	4	24
2009	0	0	0	0	0	0	0	0	0	27	0	0	27
2014	0	0	0	0	0	0	0	0	0	0	180	80	260
2015	0	0	0	0	20	40	0	0	0	0	0	0	60
All	84	0	30	0	20	40	0	0	0	27	225	139	565

(b) BAR 1 ECSI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
1991	0	0	77	0	0	0	0	0	0	0	0	0	77
1992	0	0	0	0	0	0	0	0	0	102	0	0	102
1993	0	0	0	0	0	0	44	0	0	453	0	0	497
1994	0	0	0	0	0	0	104	110	0	0	0	0	214
1995	0	0	0	0	0	0	757	0	0	0	0	0	757
1996	0	0	22	0	0	0	0	2	0	0	0	0	24
1997	0	0	0	0	0	0	110	216	0	0	0	0	326
1998	0	22	0	0	0	0	0	0	0	0	0	0	22
1999	0	0	28	1	0	27	1 045	0	0	0	0	0	1 101
2000	0	0	0	172	0	547	0	348	0	0	0	0	1 067
2001	832	0	0	0	1 956	530	188	305	0	0	0	7	3 818
2002	929	0	0	0	0	135	402	173	0	0	0	0	1 639
2003	0	0	0	98	0	132	795	52	0	0	0	234	1 311
2004	10	0	0	0	8	5	150	0	0	0	0	0	173
2005	0	0	0	0	0	0	0	180	2	0	1	1	184
2006	0	0	0	0	0	315	0	206	0	0	869	90	1 480
2007	100	0	10	0	0	0	191	0	416	581	0	0	1 298
2008	0	0	0	0	0	0	0	0	250	819	977	1300	3 346
2009	0	0	0	0	0	480	285	0	0	0	110	99	974
2010	386	20	0	0	1 098	1 604	178	0	0	0	0	0	3 286
2011	440	203	132	0	2 073	0	670	0	92	0	0	0	3 610
2012	747	0	0	0	834	783	815	776	1 323	448	161	461	6 348
2013	2 614	320	105	0	4 592	2 670	1 220	0	320	0	0	160	12 001
2014	5 012	90	209	1 017	4 675	3 829	300	320	160	0	0	348	15 960
2015	203	0	40	180	2 879	2 042	1 677	964	0	0	0	0	7 985
2016	2 054	664	241	1 114	230	235	654	43	350	0	0	110	5 695
2017	2 801	244	534	1 154	2 625	1 423	2 117	20	1 838	0	0	491	13 247
All	16 128	1 563	1 398	3 736	20 970	14 757	11 702	3 715	4 751	2 403	2 118	3 301	86 542

Table B7: Total numbers of sampled barracouta and percentage of sampled barracouta that were females, by month for each fishing year, 1991–2017, for BAR 1 ECSI. Note there were no observer data for the 1990 fishing year.

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All	Total numbers
1991	–	–	66.2	–	–	–	–	–	–	–	–	–	66.2	77
1992	–	–	–	–	–	–	–	–	–	52.0	–	–	52.0	102
1993	–	–	–	–	–	–	36.4	–	–	48.3	–	–	47.3	497
1994	–	–	–	–	–	–	59.6	47.3	–	–	–	–	53.3	214
1995	–	–	–	–	–	–	48.1	–	–	–	–	–	48.1	757
1996	–	–	50.0	–	–	–	–	100.0	–	–	–	–	54.2	24
1997	–	–	–	–	–	–	51.8	48.1	–	–	–	–	49.4	326
1998	–	54.5	–	–	–	–	–	–	–	–	–	–	54.5	22
1999	–	–	25	0	–	51.8	49.1	–	–	–	–	–	48.5	1 101
2000	–	–	–	59.3	–	51.2	–	57.8	–	–	–	–	54.6	1 067
2001	18.3	–	–	–	53.4	51.3	61.2	38.0	–	–	–	14.3	44.5	3 818
2002	46.7	–	–	–	–	51.1	55.2	49.1	–	–	–	–	49.4	1 639
2003	–	–	–	58.2	–	31.1	52.6	73.1	–	–	–	53.4	51.8	1 311
2004	70.0	–	–	–	37.5	20.0	53.3	–	–	–	–	–	52.6	173
2005	–	–	–	–	–	–	–	45.0	50.0	–	0.0	100.0	45.1	184
2006	–	–	–	–	–	51.7	–	52.9	–	–	56.7	46.7	54.5	1 480
2007	50.0	–	40	–	–	–	44.0	–	54.6	52.3	–	–	51.5	1 298
2008	–	–	–	–	–	–	–	–	37.6	53.6	56.8	54.2	53.6	3 346
2009	–	–	–	–	–	46.9	44.9	–	–	–	18.2	43.4	42.7	974
2010	35.2	25.0	–	–	61.1	55.0	65.2	–	–	–	–	–	55.1	3 286
2011	54.1	27.6	59.8	–	48.6	–	50.7	–	58.7	–	–	–	49.2	3 610
2012	38.8	–	–	–	57.1	52.1	50.9	56.7	55.0	43.1	49.7	45.1	51.0	6 348
2013	40.9	35.6	52.4	–	50.4	50.4	46.1	–	49.7	–	–	53.1	47.5	12 001
2014	50.4	48.9	30.1	60.3	51.4	45.8	53.3	41.9	33.1	–	–	34.8	49.3	15 960
2015	30.5	–	57.5	61.7	46.7	52.3	55.2	54.3	–	–	–	–	50.8	7 985
2016	45.2	47.0	51.5	23.9	52.6	71.9	46.5	74.4	48.3	–	–	50.9	43.6	5 695
2017	49.4	29.9	52.2	56.6	52.2	46.7	49.9	55.0	50.7	–	–	47.5	50.3	13 247
All	45.1	39.4	49.8	48.2	51.3	49.8	50.7	51.9	50.9	50.3	54.2	49.1	49.4	86 542
Total numbers	16 128	1 563	1 398	3 736	20 970	14 757	11 702	3 715	4 751	2 403	2 118	3 301	86 542	

Table B8: Number of female barracouta that were staged, by month for each fishing year, 1991–2017, for BAR 1 ECSI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
1991	0	0	51	0	0	0	0	0	0	0	0	0	51
1992	0	0	0	0	0	0	0	0	0	53	0	0	53
1993	0	0	0	0	0	0	16	0	0	219	0	0	235
1994	0	0	0	0	0	0	62	52	0	0	0	0	114
1995	0	0	0	0	0	0	364	0	0	0	0	0	364
1996	0	0	11	0	0	0	0	2	0	0	0	0	13
1997	0	0	0	0	0	0	57	104	0	0	0	0	161
1998	0	12	0	0	0	0	0	0	0	0	0	0	12
1999	0	0	7	0	0	14	513	0	0	0	0	0	534
2000	0	0	0	102	0	279	0	201	0	0	0	0	582
2001	152	0	0	0	1 044	272	115	116	0	0	0	1	1 700
2002	434	0	0	0	0	69	221	85	0	0	0	0	809
2003	0	0	0	57	0	41	418	38	0	0	0	125	679
2004	7	0	0	0	3	1	80	0	0	0	0	0	91
2005	0	0	0	0	0	0	0	81	1	0	0	1	83
2006	0	0	0	0	0	163	0	109	0	0	493	42	807
2007	50	0	4	0	0	0	84	0	227	242	0	0	607
2008	0	0	0	0	0	0	0	0	94	437	555	705	1 791
2009	0	0	0	0	0	225	128	0	0	0	20	43	416
2010	136	5	0	0	671	883	116	0	0	0	0	0	1 811
2011	238	56	79	0	1 008	0	340	0	54	0	0	0	1 775
2012	290	0	0	0	476	408	415	440	685	193	80	208	3 195
2013	1 068	114	55	0	2 316	1 345	563	0	159	0	0	85	5 705
2014	2 524	44	63	613	2 405	1 753	160	134	53	0	0	121	7 870
2015	62	0	23	111	1 346	1 069	926	523	0	0	0	0	4 060
2016	896	312	124	266	121	169	304	32	169	0	0	56	2 449
2017	1 385	73	279	652	1 371	663	1 056	11	932	0	0	233	6 655
All	7 242	616	696	1 801	10 761	7 354	5 938	1 928	2 374	1 144	1 148	1 620	42 622

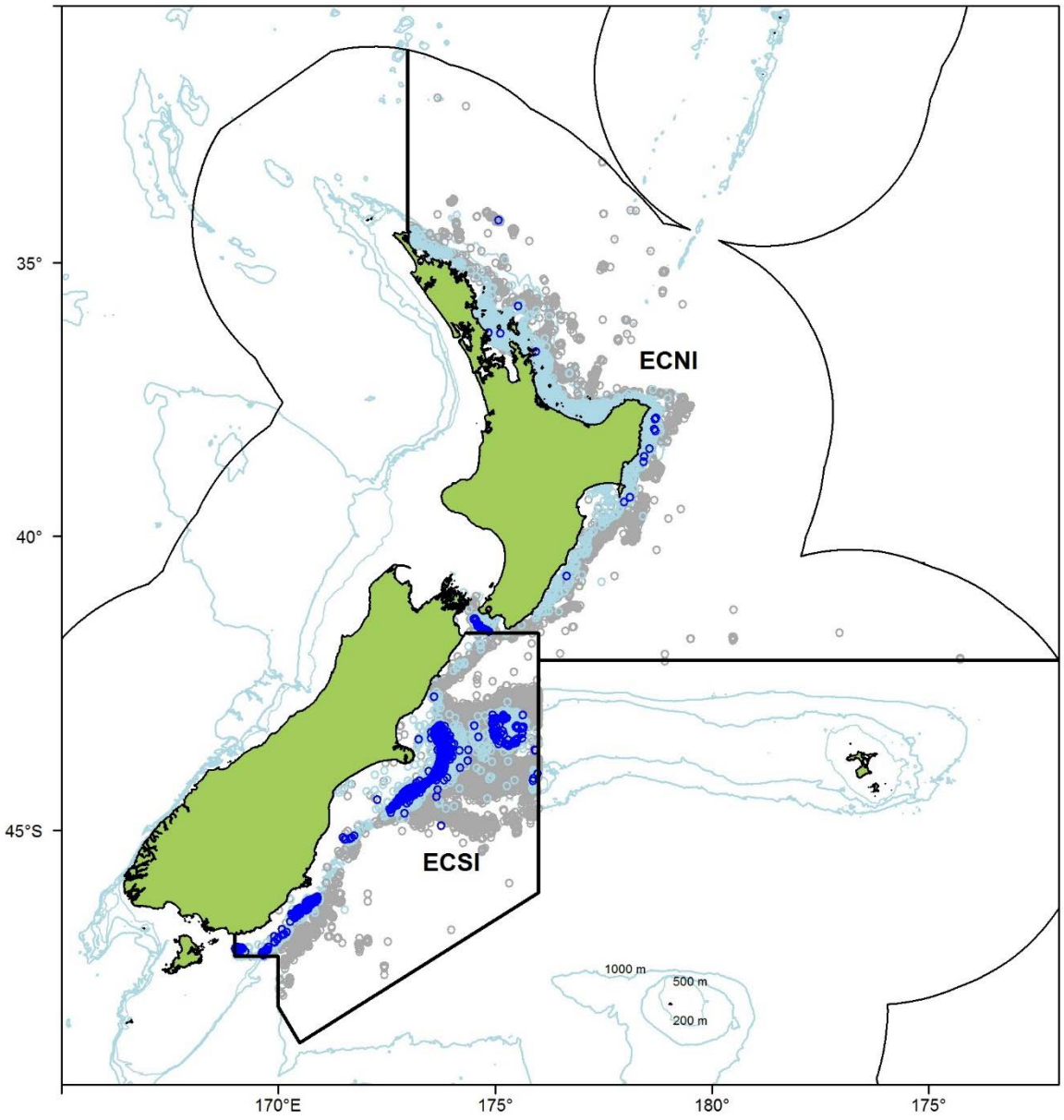
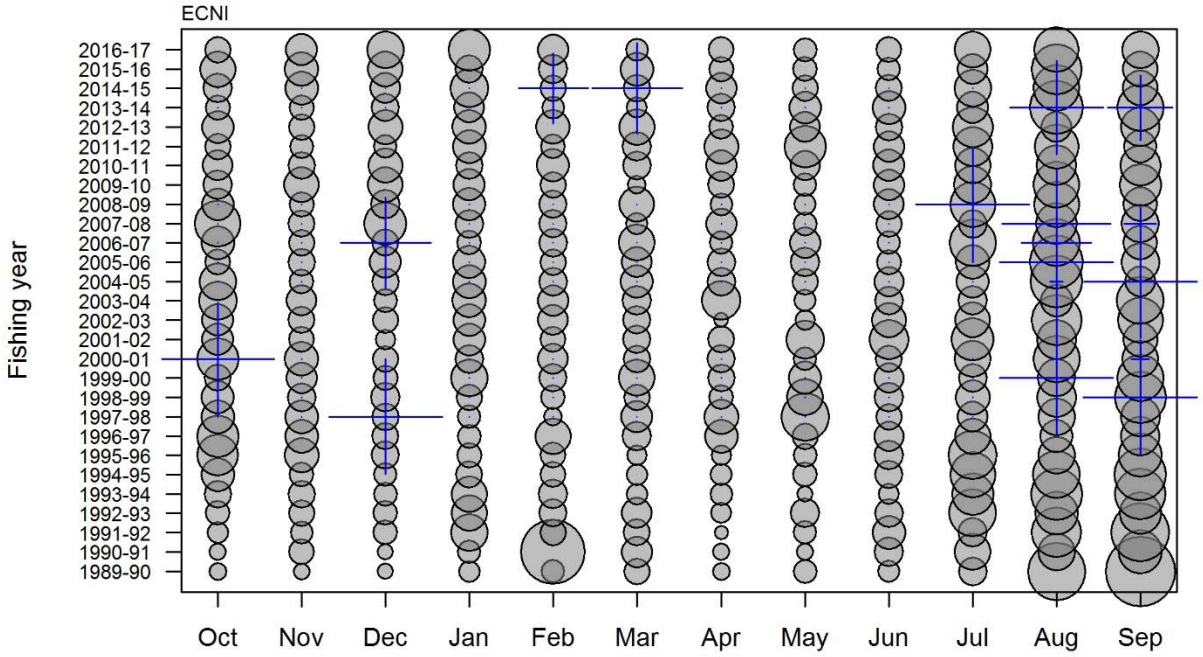


Figure B1: Distribution of observed tows, where grey circles represent observed tows in the ECNI and ECSI subareas of BAR 1, light blue circles indicate observed tows with barracouta catch, and blue circles are observed tows for which the barracouta catch was sampled for length and sex data, for 1991–2017.

a. BAR 1 ECNI



b. BAR 1 ECSI

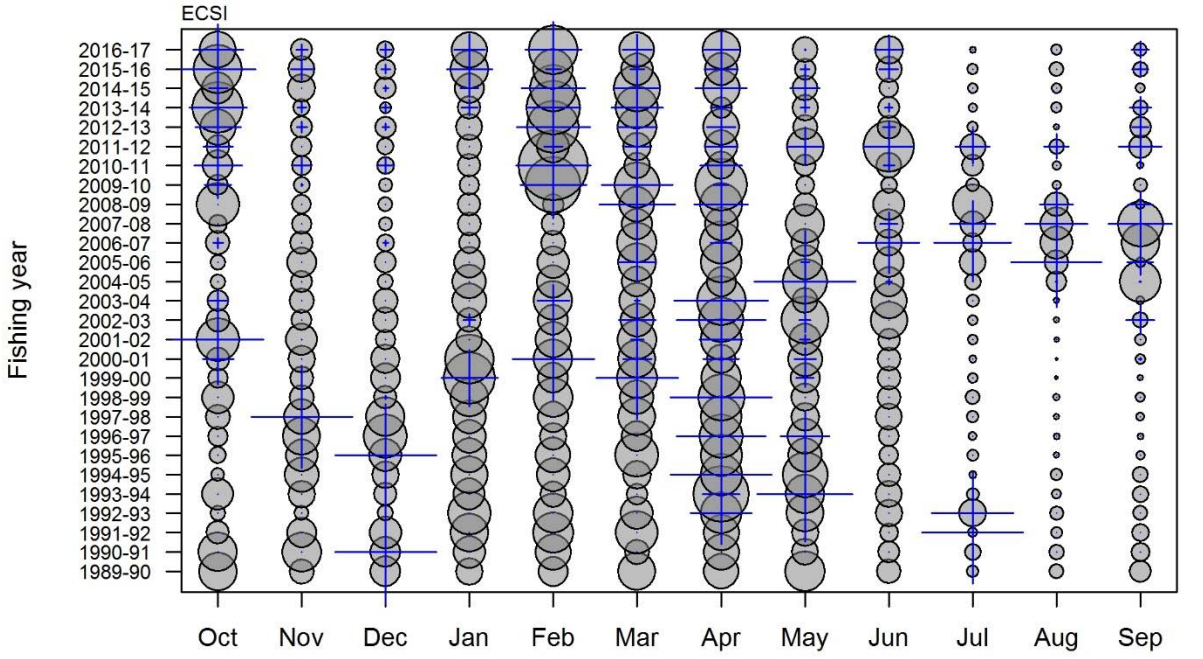


Figure B2: Proportions of the annual commercial barracouta catch (○) and the observed barracouta catch (+) in each month, for the ENCI and ECSI areas of BAR 1.

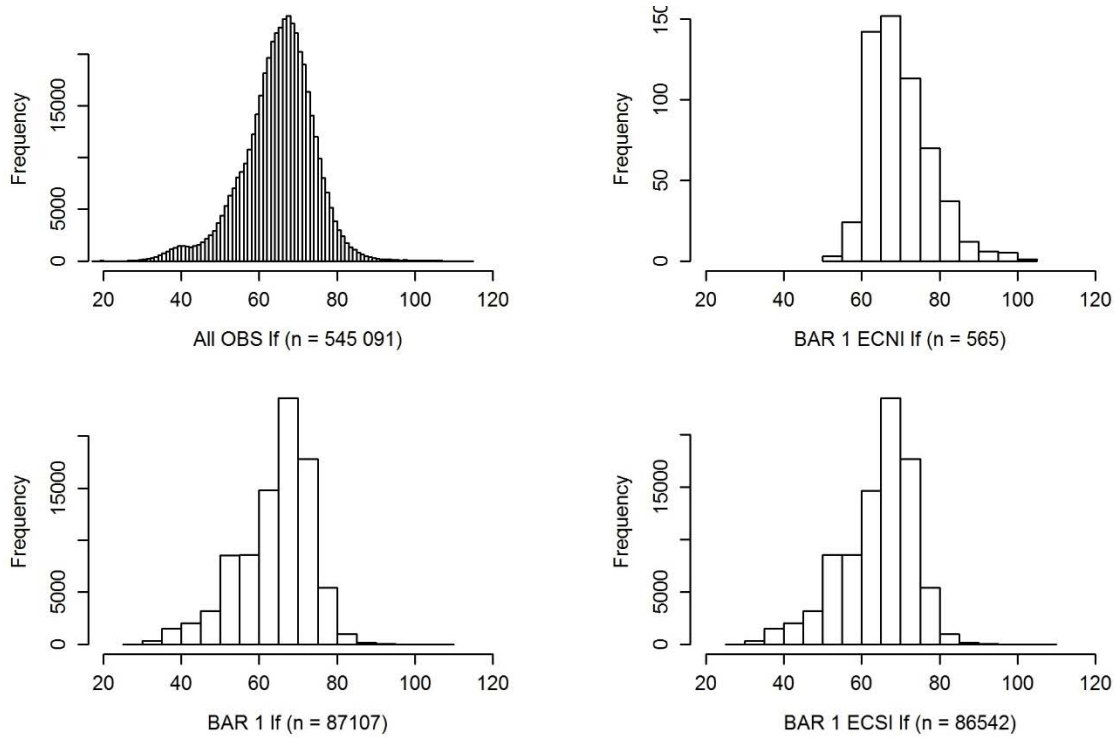


Figure B3a: Distribution of barracouta length data for all barracouta measured by observers (upper left), for BAR 1 barracouta (lower left), for ECNI (upper right), and for ECSI (lower right), for 1991–2017.

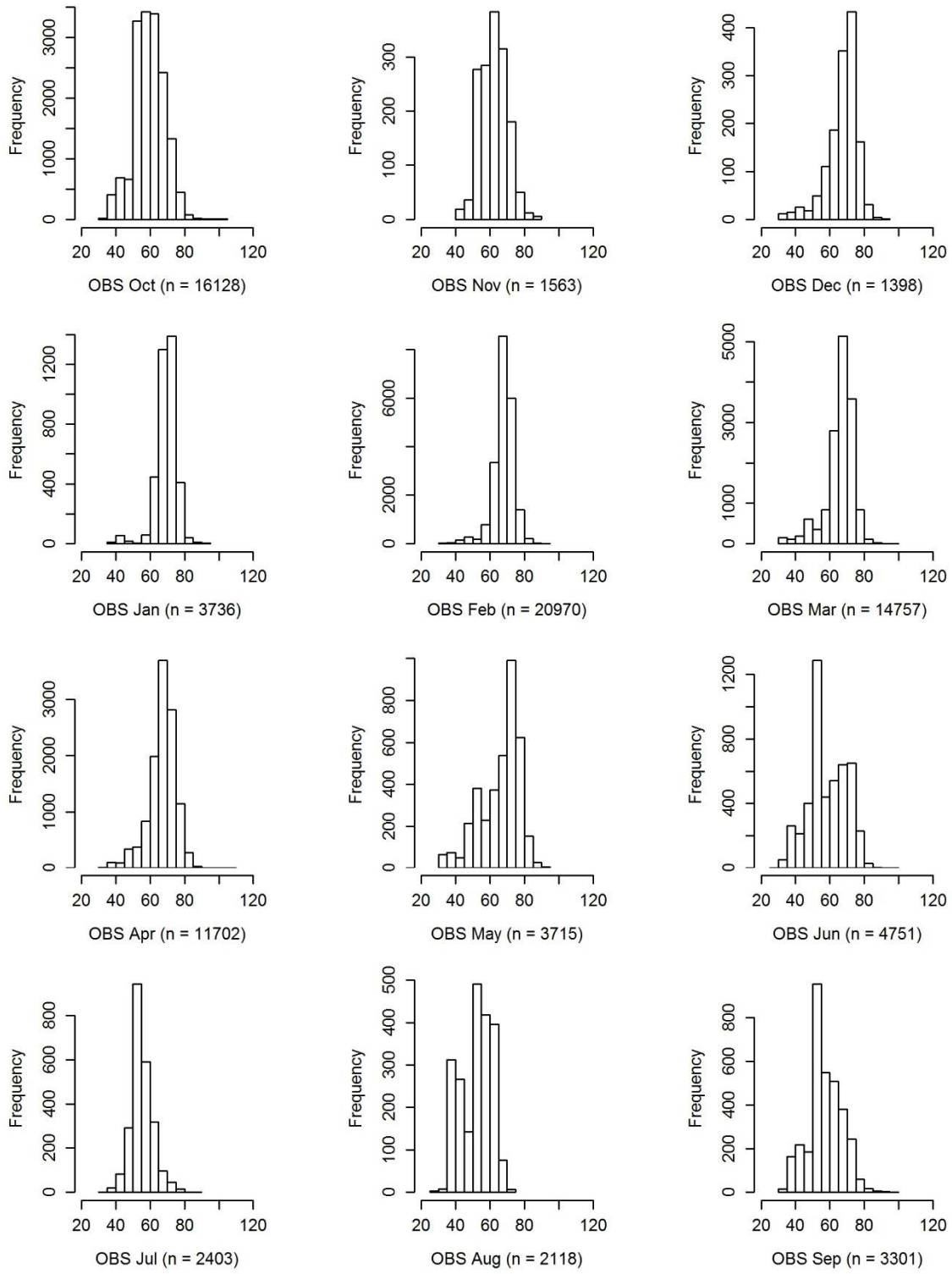


Figure B3b: Distribution of barracouta length data for all ECSI barracouta measured by observers, by month (October-September), for 1991–2017.

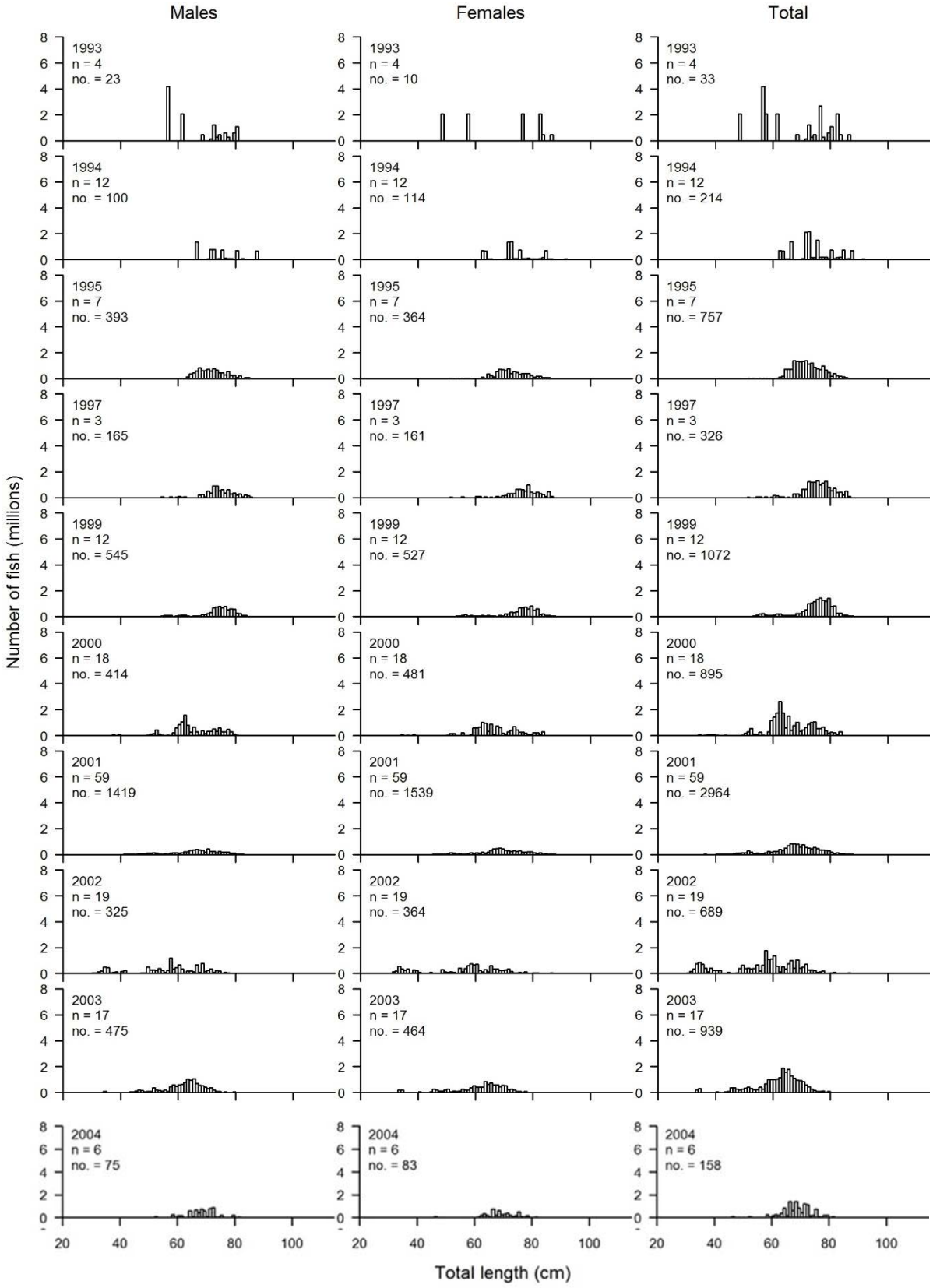


Figure B4: Scaled length frequency of barracouta sampled by observers from commercial catches from the ECSI area, where there were more than 5 barracouta per tow, for the main months of observer coverage (February-May) for fishing years 1993–95, 1997, 1999–2007, 2009–17. n, number of tows sampled with more than 5 barracouta; no., number of barracouta sampled.

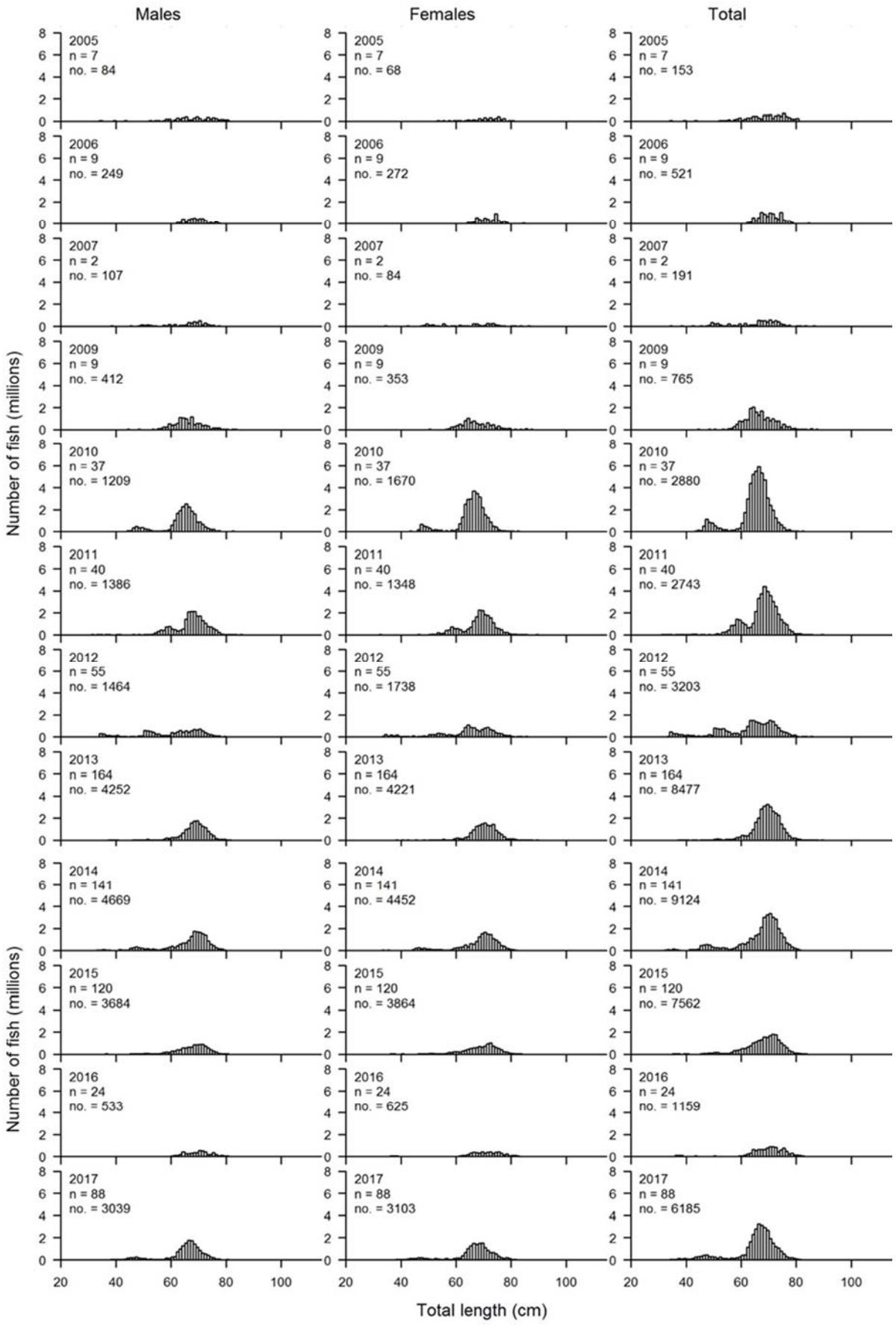


Figure B4: ***continued*.**

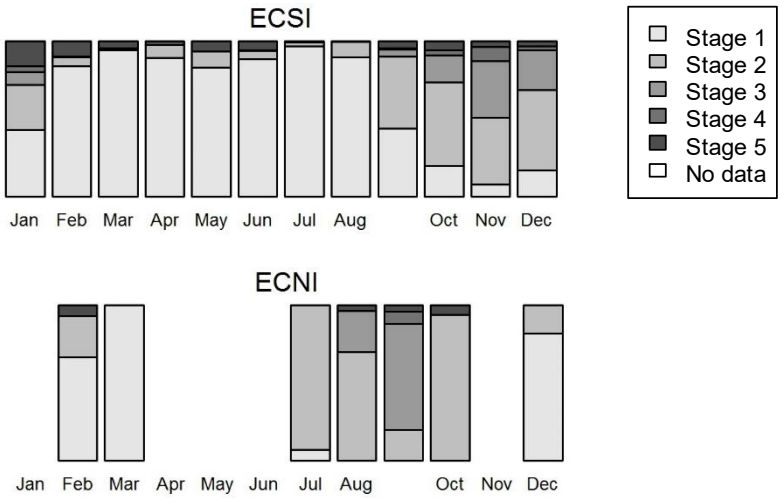


Figure B5: Percent of female reproductive stage by month, where the lightest grey indicates stage 1 and black is stage 5, for each BAR 1 area, from 1990–2017. Female reproductive stage 1 is immature/resting, stage 2 ripening, stage 3 ripe, stage 4 running ripe, and stage 5 spent.

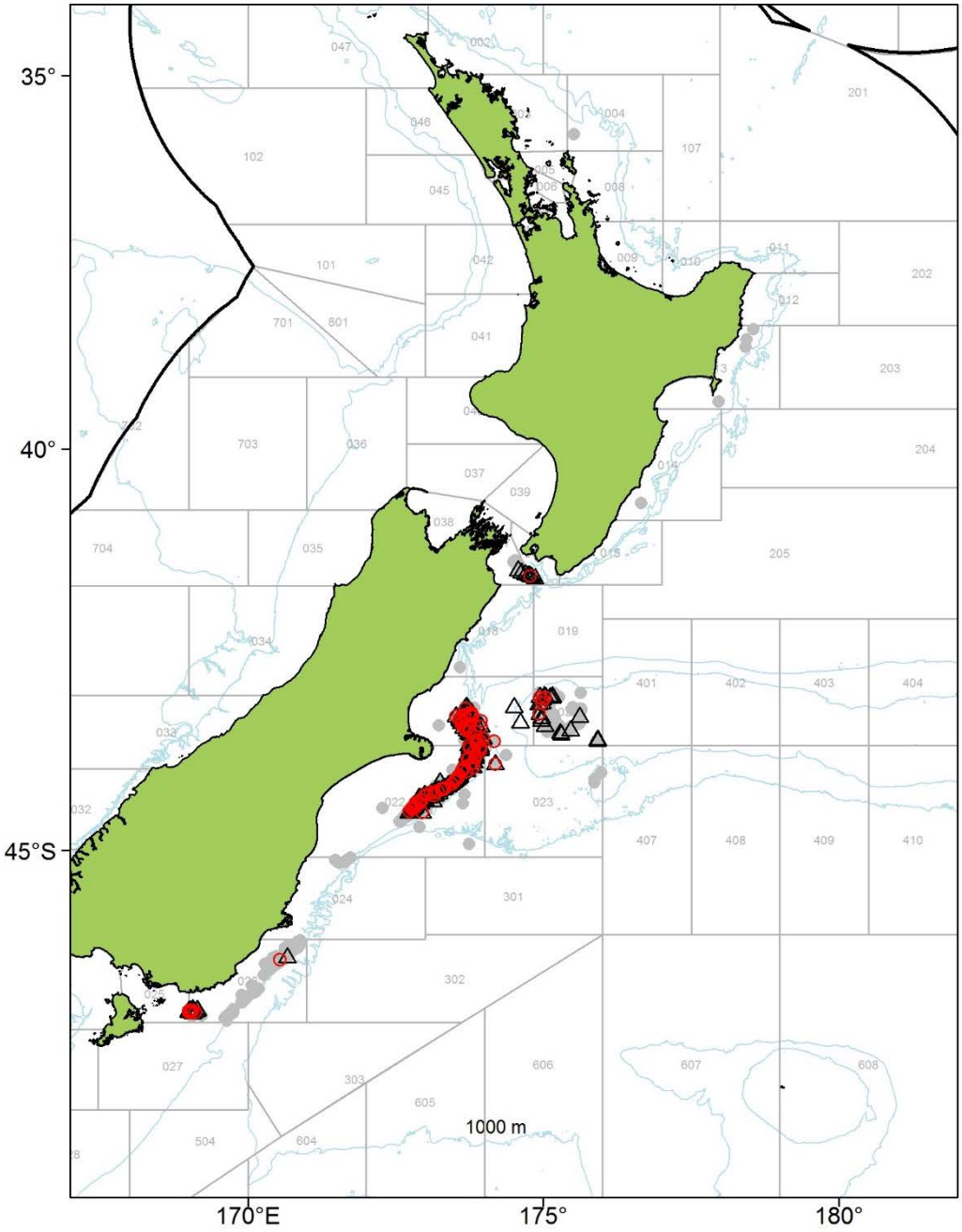


Figure B6a: Distribution of BAR 1 female barracouta reproductive stage samples collected by observers where grey circles represent immature females, △ are ripe, and ○ are running ripe, 1991–2017.

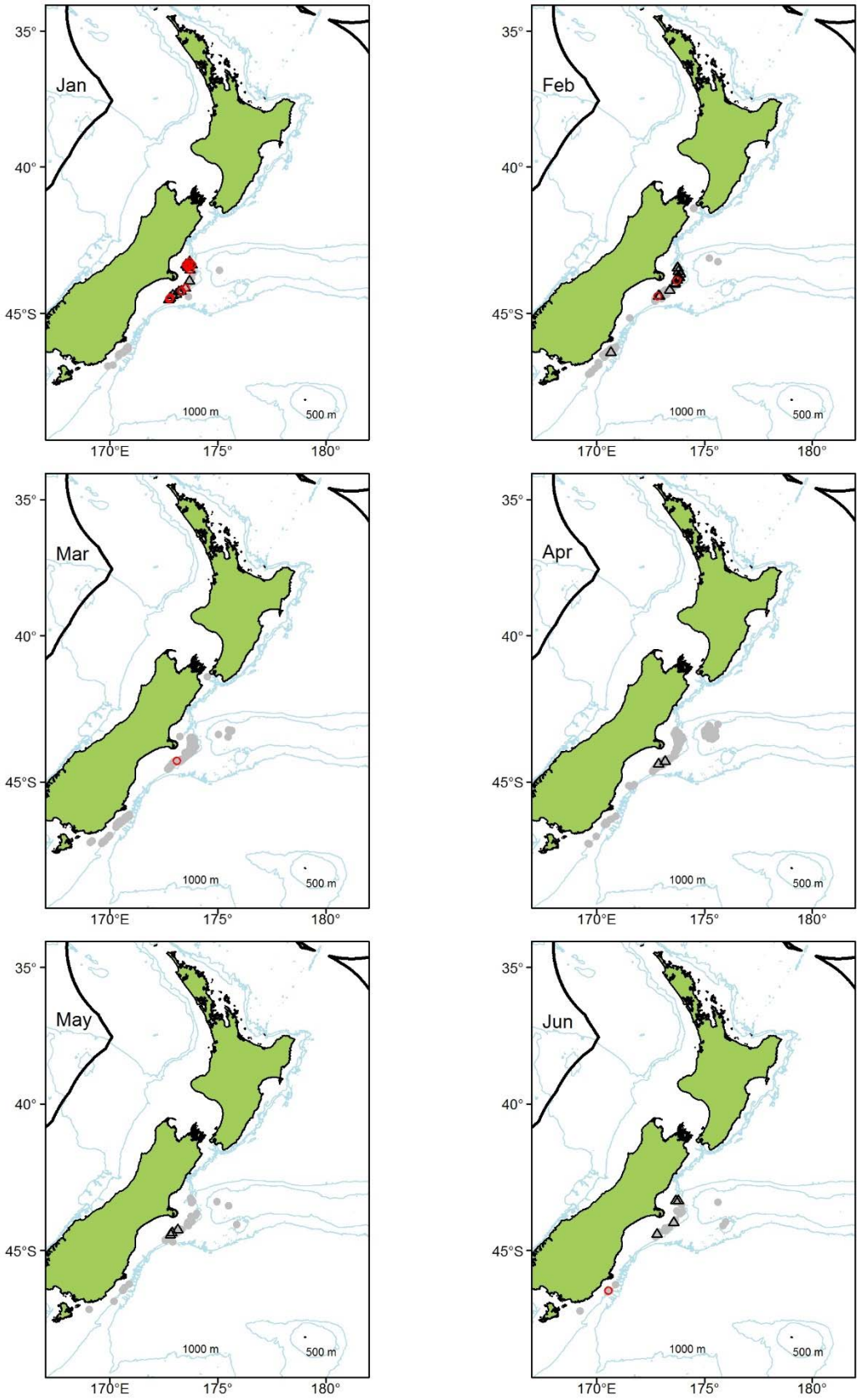


Figure B6b: Distribution of female barracouta reproductive stage data from observer data, by month, where grey circles represent immature females, △ are ripe, and ○ are running ripe, 1991–2017. Ripe and running ripe females totalled *n* = 4 in ECNI and *n* = 1755 in ECSI.

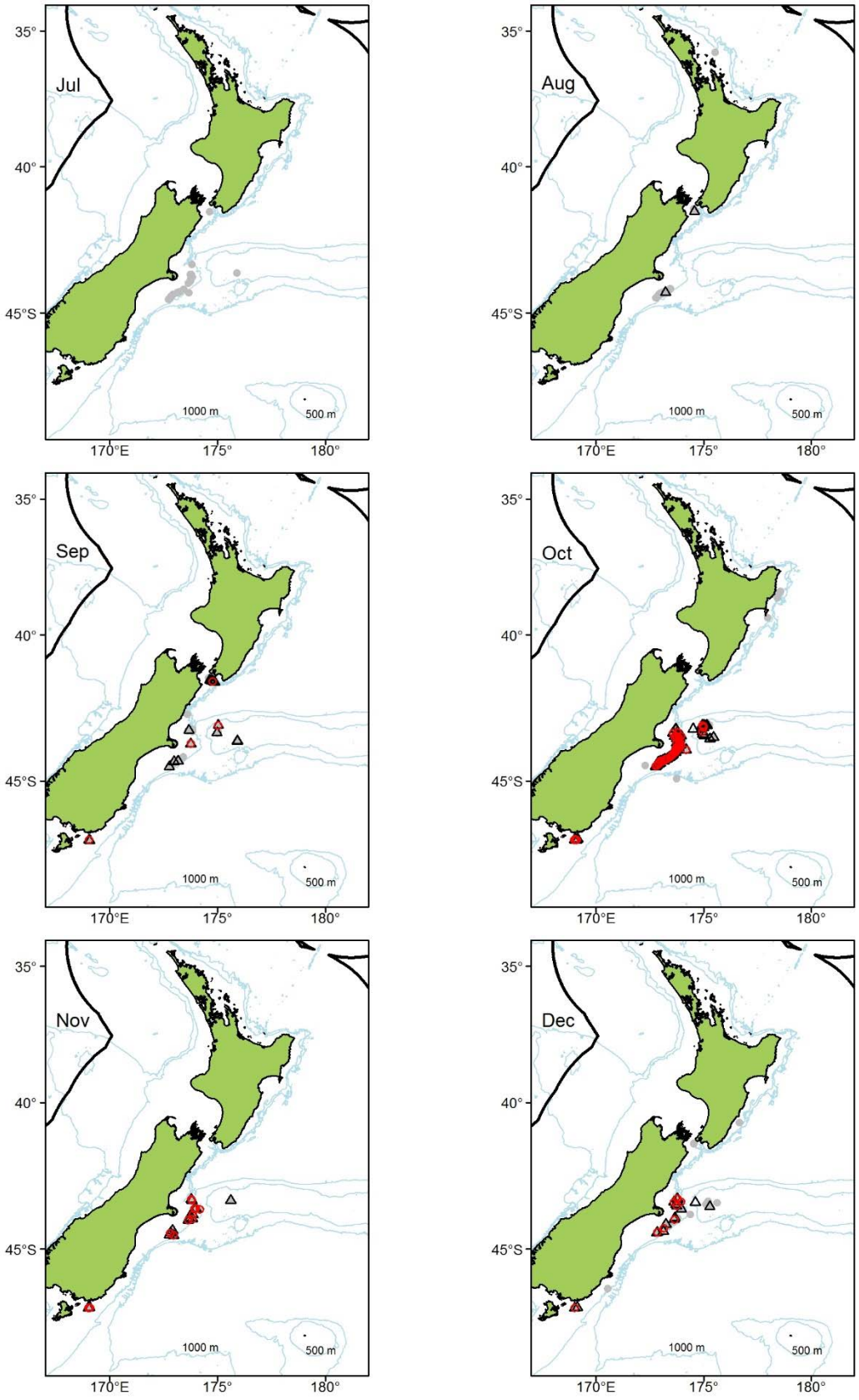


Figure B6b – ***continued.***

13. APPENDIX C: CHARACTERISATION

Table C1: List of tables and fields requested in the Ministry for Primary Industries extract 11521.

Fishing_events table

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

Landing_events table

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

Estimated subcatch table

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

Process data table

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

Vessel_history table

Vessel_key
Flag_nationality_code
Built_year
Engine_kilowatts
Gross_tonnes
Overall_length_metres
History_start_datetime
History_end_datetime

Table C2: Number of landing events by major destination code and form type for BAR 1 for 1990–2017. CELR is Catch Effort Landing Return; NCELR is Netting Catch Effort Landing Return; CLR is Catch Landing Return. Destination codes are defined in Table C3.

Fishing	CELR/NCELR			CLR				All				
year	L	R	Total	L	T	R	Total	L	T	R	A	Total
1990	3 194	18	3 349	526	62	14	610	3 720	62	32	2	3 959
1991	4 170	23	4 246	456	72	17	552	4 626	72	40	3	4 798
1992	4 614	14	4 727	614	49	31	704	5 228	49	45	4	5 431
1993	5 354	25	5 446	718	72	9	802	6 072	73	34	–	6 248
1994	4 868	28	4 948	889	42	23	964	5 757	42	51	2	5 912
1995	5 363	27	5 479	1 003	80	34	1 125	6 366	80	61	4	6 604
1996	5 272	21	5 415	1 528	90	19	1 641	6 800	93	40	2	7 056
1997	4 875	18	4 955	1 496	35	15	1 555	6 371	35	33	1	6 510
1998	4 726	33	4 812	1513	9	27	1 556	6 239	9	60	–	6 368
1999	4 072	23	4 150	1 387	–	20	1 414	5 459	3	43	3	5 564
2000	3 628	10	3 667	1 188	–	17	1 209	4 816	–	27	5	4 876
2001	2 957	7	2 990	1 114	–	12	1 143	4 071	–	19	10	4 133
2002	2 525	26	2 565	1 087	–	11	1 105	3 612	–	37	2	3 670
2003	2 445	5	2 472	1 155	–	23	1 183	3 600	–	28	3	3 655
2004	2 651	15	2 716	1 121	–	23	1 153	3 772	–	38	3	3 869
2005	2 877	18	2 940	956	–	28	1 006	3 833	–	46	10	3 946
2006	2 903	6	2 997	891	–	14	922	3 794	–	20	8	3 919
2007	2 335	4	2 440	862	–	11	891	3 197	8	15	10	3 331
2008	329	5	383	2 507	–	41	2 608	2836	–	46	13	2 991
2009	389	6	464	2 635	–	35	2 736	3 024	–	41	17	3 200
2010	434	5	516	2 784	–	37	2 896	3 218	–	42	14	3 412
2011	463	1	548	2 615	–	25	2 778	3 078	–	26	16	3 326
2012	555	NA	677	2 738	–	15	2 853	3 293	–	15	13	3 530
2013	563	5	712	2 724	–	28	2 927	3 287	–	35	33	3 639
2014	513	2	620	2 976	–	18	3 200	3 489	–	20	39	3 820
2015	517	2	649	2 728	–	27	2 865	3 245	–	29	9	3 514
2016	433	4	500	2 870	1	20	3 015	3 303	1	24	13	3 515
2017	407	2	482	2 982	–	13	3 144	3 389	–	15	25	3 626
Total	73 432	353	75 865	46 063	511	609	48 557	119 495	527	962	264	124 422

Table C3: Destination codes, total landing weight, number of landings, and whether the records were kept or dropped, for all barracouta catch reported for 1990–2017, for BAR 1.

Destination code	Greenweight (t)	No. records	Description	Action
L	231 632.5	119 495	Landed in New Zealand to a Licensed Fish Receiver	Keep
T	7 037.1	527	Transferred to another vessel	Keep
A	266.4	264	Accidental loss	Keep
O	157.9	20	Conveyed outside New Zealand	Keep
C	102.8	129	Disposed to the Crown	Keep
U	47.9	844	Used as bait	Keep
D	7.1	36	Discarded	Keep
E	3.7	207	Eaten	Keep
F	1.4	184	Recreational catch	Keep
W	1.3	152	Sold at wharf	Keep
S	0.4	6	Seized by the Crown	Keep
H	0.3	3	Loss from holding pot	Keep
R	3 466.3	962	Retained on board	Drop
Invalid	168.3	148	Invalid destination type code recorded	Drop
Q	52.7	754	Holding receptacle on land	Drop
Null	41.7	71	Missing destination type code	Drop
B	21.2	620	Stored as bait	Drop

Table C4: Total number of trips and proportion of trips with zero estimated catch, by form type for BAR 1 for 1990–2017. CELR is Catch Effort Landing Return; TCER is Trawl Catch Effort Return, and TCEPR is Trawl Catch Effort Processing Return.

	CELR		TCEPR		TCER	
Fishing year	Total trips	Proportion zero trips	Total trips	Proportion zero trips	Total trips	Proportion zero trips
1990	3 196	0.32	402	0.04	–	–
1991	4 076	0.33	390	0.07	–	–
1992	4 559	0.40	567	0.11	–	–
1993	5 239	0.37	705	0.12	–	–
1994	4 740	0.38	816	0.15	–	–
1995	5 139	0.36	965	0.16	–	–
1996	4 998	0.31	1 332	0.17	–	–
1997	4 703	0.30	1 359	0.19	–	–
1998	4 509	0.28	1 414	0.17	–	–
1999	3 946	0.29	1 232	0.18	–	–
2000	3 511	0.30	1 026	0.24	–	–
2001	2 911	0.29	967	0.23	–	–
2002	2 480	0.30	972	0.24	–	–
2003	2 396	0.30	990	0.23	–	–
2004	2 646	0.31	966	0.20	–	–
2005	2 862	0.35	846	0.17	–	–
2006	2 890	0.35	745	0.14	–	–
2007	2 215	0.34	683	0.13	–	–
2008	216	0.36	434	0.18	1 745	0.10
2009	240	0.37	500	0.07	1 878	0.10
2010	345	0.36	458	0.13	2 049	0.11
2011	378	0.44	474	0.09	1 760	0.14
2012	411	0.48	466	0.13	1 944	0.11
2013	430	0.48	376	0.18	2 090	0.12
2014	402	0.44	467	0.20	2 212	0.15
2015	348	0.36	456	0.23	2 017	0.13
2016	317	0.36	414	0.24	2 058	0.12
2017	288	0.40	469	0.28	2 114	0.15

Table C5: Total landed catch (t) for BAR 1 subareas ECNI and ECSI and all BAR 1, from the groomed and merged data, for 1990–2017.

Fishing year	ECNI	ECSI	Total catch (t)
1990	1 041	6 334	7 375
1991	715	6 913	7 628
1992	1 299	5 083	6 382
1993	1 466	7 479	8 945
1994	1 819	5 224	7 043
1995	2 372	7 466	9 838
1996	2 206	8 237	10 443
1997	2 112	9 714	11 826
1998	1 817	9 205	11 022
1999	1 344	7 949	9 293
2000	973	8 950	9 923
2001	1 026	6 046	7 072
2002	700	6 170	6 870
2003	1 004	6 516	7 520
2004	919	4 429	5 348
2005	892	5 131	6 023
2006	834	6 141	6 975
2007	948	3 779	4 727
2008	690	6 339	7 029
2009	761	6 901	7 662
2010	720	10 489	11 209
2011	606	10 870	11 476
2012	553	8 802	9 355
2013	495	9 193	9 688
2014	728	10 517	11 245
2015	692	6 092	6 784
2016	669	4 781	5 450
2017	516	8 819	9 335
Total catch (t)	29 917	203 568	233 485

Table C6a: Total barracouta catch (t) reported from the ECSI of BAR 1, by main form type, for 1990–2017. CEL is Catch Effort Landing Return; TCER is Trawl Catch Effort Return; TCEPR is Trawl Catch Effort Processing Return. Of the total 3 t were reported on NCE forms.

Fishing year	CELR	TCER	TCEPR	Total catch (t)
1990	1 657	–	4 677	6 334
1991	2 869	–	4 045	6 913
1992	1 249	–	3 834	5 083
1993	1 336	–	6 143	7 479
1994	1 080	–	4 145	5 224
1995	1 898	–	5 568	7 466
1996	2 032	–	6 204	8 237
1997	2 936	–	6 778	9 714
1998	3 221	–	5 984	9 205
1999	2 227	–	5 722	7 949
2000	2 188	–	6 762	8 950
2001	2 043	–	4 003	6 046
2002	1 880	–	4 289	6 170
2003	2 196	–	4 320	6 516
2004	1 969	–	2 460	4 429
2005	2 047	–	3 084	5 131
2006	2 864	–	3 277	6 141
2007	1 434	–	2 345	3 779
2008	30	2 221	4 088	6 339
2009	75	2 085	4 740	6 901
2010	69	2 114	8 306	10 489
2011	34	2 463	8 372	10 870
2012	72	3 218	5 511	8 802
2013	92	3 812	5 289	9 193
2014	69	2 989	7 459	10 517
2015	92	2 788	3 211	6 092
2016	79	2 333	2 368	4 781
2017	55	3 124	5 640	8 819
Total catch (t)	37 794	27 147	138 624	203 568

Table C6b: Total barracouta catch (t) and percentage reported from the ECSI of BAR 1, by primary method, for 1990–2017. BT is bottom trawl; DS is Danish seine; MW is midwater trawl; PS is purse seine.

	BT	DS	MW	PS	Other	Total
1990	6 220	0	0	114	0	6 334
1991	6 798	0	69	45	1	6 913
1992	5 042	0	2	37	1	5 083
1993	6 403	0	1 004	71	1	7 479
1994	3 090	0	2 028	85	21	5 224
1995	5 823	0	1 548	94	1	7 466
1996	6 965	0	1 228	41	3	8 237
1997	8 394	0	1 298	21	1	9 714
1998	8 059	0	1 026	118	3	9 205
1999	6 777	0	1 159	11	2	7 949
2000	6 758	0	2 146	46	0	8 950
2001	5 300	0	660	86	1	6 046
2002	4 663	0	1 471	36	0	6 170
2003	5 020	0	1 393	102	1	6 516
2004	4 328	3	97	0	0	4 429
2005	3 400	1	1 731	0	0	5 131
2006	4 688	1	1 444	2	7	6 141
2007	2 220	17	1 538	0	4	3 779
2008	3 088	19	3 221	0	10	6 339
2009	3 918	63	2 907	0	12	6 901
2010	3 057	55	7 364	0	13	10 489
2011	5 217	24	5 618	0	10	10 870
2012	6 876	62	1 854	0	10	8 802
2013	5 443	80	3 659	1	11	9 193
2014	4 082	57	6 365	0	12	10 517
2015	3 726	81	2 274	0	11	6 092
2016	3 561	69	1 140	0	11	4 781
2017	4 814	39	3 950	0	16	8 819
Total	143 728	572	58 193	910	165	203 568

Table C6c: Total barracouta landed catch (t) and catch reported from the ECSI of BAR 1, by month, for 1990–2014.

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
1990	634	695	219	580	631	820	782	958	382	103	76	453	6 334
1991	815	1 042	653	738	863	444	1 023	524	326	171	148	167	6 913
1992	298	525	482	749	773	901	675	379	122	53	83	42	5 083
1993	166	160	186	1 459	1 042	992	1 400	809	788	237	132	107	7 479
1994	474	318	362	497	369	266	1 623	869	253	82	44	69	5 224
1995	219	750	564	903	993	451	1 154	1 735	335	48	106	207	7 466
1996	266	853	761	1 036	1 036	1 534	1 406	898	255	107	39	47	8 237
1997	371	1 917	1 341	994	712	1 075	1 645	1 140	386	65	42	26	9 714
1998	556	1 015	1 292	1 046	909	1 384	1 418	817	578	118	37	34	9 205
1999	626	504	396	1 358	1 356	804	1 742	443	462	134	45	80	7 949
2000	323	678	759	2 120	750	2 034	1 148	528	472	97	16	26	8 950
2001	306	546	1 096	1 291	520	873	354	712	285	21	8	34	6 046
2002	904	620	250	406	938	902	1 204	580	245	37	11	71	6 170
2003	271	271	394	386	559	1 007	1 196	1 357	846	45	24	158	6 516
2004	188	236	243	627	377	740	920	318	644	75	19	41	4 429
2005	103	203	87	585	572	447	695	817	464	143	193	823	5 131
2006	142	487	280	494	661	900	1 057	862	445	410	360	42	6 141
2007	223	150	96	164	228	638	663	249	275	127	402	564	3 779
2008	161	192	105	316	296	472	596	781	529	733	28	2 131	6 339
2009	375	230	137	417	352	1 050	1 430	377	812	1 312	335	74	6 901
2010	402	203	188	355	4 016	2 680	1 647	336	255	166	92	151	10 489
2011	982	438	331	584	5 250	707	862	486	833	273	87	38	10 870
2012	471	361	237	515	908	694	895	1 250	2 245	398	205	620	8 802
2013	932	461	343	661	2 471	1 484	1 035	589	472	121	39	585	9 193
2014	2 600	281	145	813	3 434	1 159	455	746	465	98	78	243	10 517
2015	549	504	310	903	1 273	965	791	372	217	79	79	50	6 092
2016	1 078	344	193	700	743	527	420	211	331	62	112	61	4 781
2017	1 159	428	251	1 219	2 058	1 362	853	535	689	39	101	126	8 819
All	15 596	14 413	11 700	21 917	34 088	27 313	29 090	19 677	14 409	5 355	2 939	7 071	203 568

Table C6d: Total barracouta catch reported from ECSI of BAR 1, by main target species, for 1990–2017. Target species code definitions are given in Table B1.

Fishing year	BAR	ELE	FLA	GUR	HOK	JMA	RCO	SPD	SPE	SQU	SWA	TAR	WAR	Other	Total
1990	4 202	24	57	12	47	23	1 496	10	3	149	40	64	32	175	6 334
1991	4 739	15	61	89	105	133	1 361	24	3	143	12	55	58	115	6 913
1992	3 197	6	54	2	30	25	1 213	14	10	387	48	28	27	42	5 083
1993	4 402	6	112	6	53	181	2 116	130	9	278	52	17	5	113	7 479
1994	1 470	6	46	14	126	183	1 342	1	14	1 854	52	47	20	50	5 224
1995	3 131	13	40	15	88	637	2 275	19	5	1 139	27	33	5	39	7 466
1996	2 914	3	125	11	75	305	3 216	13	24	1 357	39	72	7	77	8 237
1997	3 525	7	132	4	81	344	4 630	3	7	806	53	55	9	57	9 714
1998	2 577	0	232	6	98	713	4 290	12	56	1 089	6	20	18	88	9 205
1999	3 211	3	261	4	55	841	2 149	4	15	1 275	16	58	41	18	7 949
2000	3 432	3	103	0	65	869	2 333	4	7	1 996	7	22	61	49	8 950
2001	2 110	4	118	2	14	402	1 144	0	5	2 188	2	14	19	25	6 046
2002	3 079	7	47	12	27	670	1 242	2	4	988	17	24	29	22	6 170
2003	3 431	40	19	23	148	825	1 168	0	7	732	5	28	34	54	6 516
2004	2 325	163	47	8	11	7	1 310	0	10	464	0	41	33	9	4 429
2005	2 661	54	35	11	60	54	1 617	8	8	300	5	189	91	38	5 131
2006	2 054	118	18	70	5	1 017	1 747	74	3	668	6	254	101	6	6 141
2007	2 047	35	28	19	3	234	624	29	0	434	58	204	53	12	3 779
2008	4 625	65	33	18	5	291	574	5	1	250	224	184	49	14	6 339
2009	5 035	68	32	23	8	299	703	30	2	189	44	395	53	19	6 901
2010	8 429	37	46	50	7	431	605	45	7	79	44	423	250	37	10 489
2011	7 628	37	22	46	3	749	851	11	40	650	184	392	193	64	10 870
2012	6 311	134	44	31	3	409	840	13	19	133	147	318	361	39	8 802
2013	5 972	60	106	129	2	503	1 105	0	20	102	332	501	241	120	9 193
2014	6 399	52	73	114	5	1 849	960	0	42	95	204	537	66	121	10 517
2015	3 660	116	81	81	26	426	418	2	73	204	156	470	315	64	6 092
2016	2 887	79	69	135	2	76	478	0	37	173	73	403	252	116	4 781
2017	6 486	39	52	38	19	132	449	0	18	243	283	712	230	118	8 819
Total	111 942	1 195	2 094	977	1 170	12 625	42 256	454	447	18 363	2 136	5 558	2 651	1 701	203 568

Table C6e: Total barracouta landed catch (t) and annual catch reported from the ECSI of BAR 1, by Statistical Area, for fishing years 1990–2017.

Fishing year	018	020	021	022	023	024	026	Other	All
1990	500	1 155	51	4 482	1	84	53	8	6 334
1991	531	952	163	4 080	107	859	217	6	6 913
1992	223	876	13	2 721	4	1 121	123	2	5 083
1993	363	567	205	4784	16	1 042	493	9	7 479
1994	388	859	223	3 330	2	318	106	0	5 224
1995	283	1 086	403	4 806	13	816	49	9	7 466
1996	363	1 288	50	5 664	34	488	348	1	8 237
1997	336	1 386	85	7 099	28	608	172	0	9 714
1998	345	2 266	59	5 682	17	487	347	2	9 205
1999	406	1 231	9	5 238	5	890	166	4	7 949
2000	230	1 113	17	6 781	17	672	120	0	8 950
2001	421	876	24	3 837	52	382	455	0	6 046
2002	292	1 137	10	3 916	6	731	79	0	6 170
2003	241	681	123	5 004	0	332	135	0	6 516
2004	59	591	2	2 273	0	1 333	169	0	4 429
2005	61	1 038	5	3 779	0	191	57	0	5 131
2006	48	691	158	4 555	25	529	135	0	6 141
2007	39	639	80	2 587	0	420	14	0	3 779
2008	95	699	124	4 450	2	872	97	0	6 339
2009	45	607	50	4 762	11	1 249	166	10	6 901
2010	70	1 573	26	7 894	2	749	176	0	10 489
2011	101	2 391	9	6 849	1	1 164	352	3	10 870
2012	110	1 065	26	6 891	0	536	173	0	8 802
2013	276	946	151	7 009	0	599	212	0	9 193
2014	184	1 858	170	7 717	0	389	198	0	10 517
2015	135	1 539	105	3 172	1	573	567	0	6 092
2016	156	969	17	2 990	4	492	152	0	4 781
2017	123	2 177	60	5 574	0	633	252	0	8 819
All	6 423	32 256	2 416	137 923	349	18 559	5 584	58	203 568

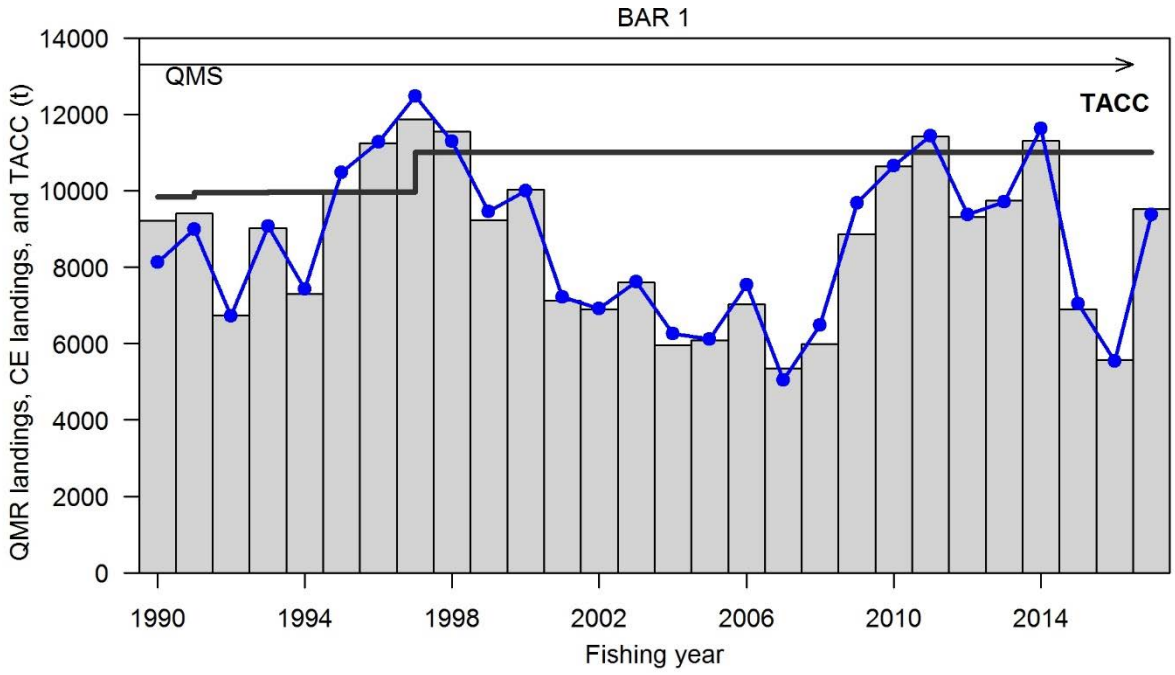


Figure C1: The QMR/MHR landings (grey bars), un-groomed catch effort landings (blue line), and TACC (black line) in tonnes for BAR 1 for the fishing years 1990 to 2017.

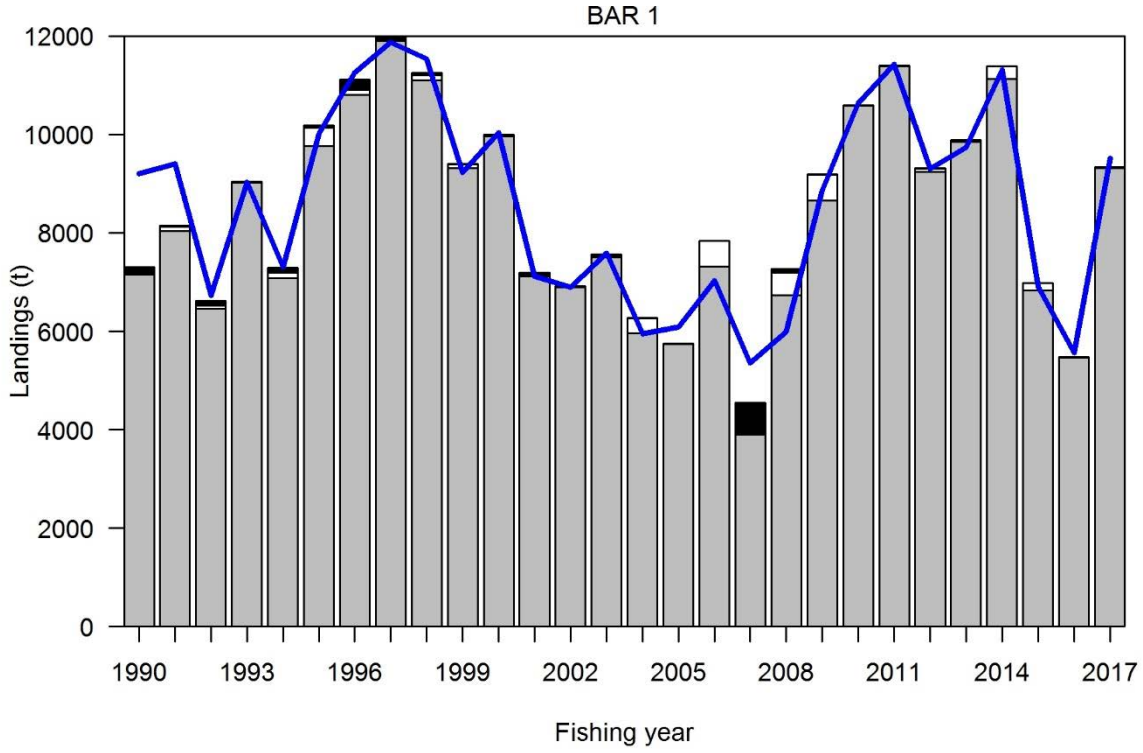


Figure C2: The retained landings (grey bars), interim landings (white bars), and landings dropped during data grooming (black bars), and MHR landings (blue line) in tonnes for BAR 1 for the fishing years 1990 to 2017.

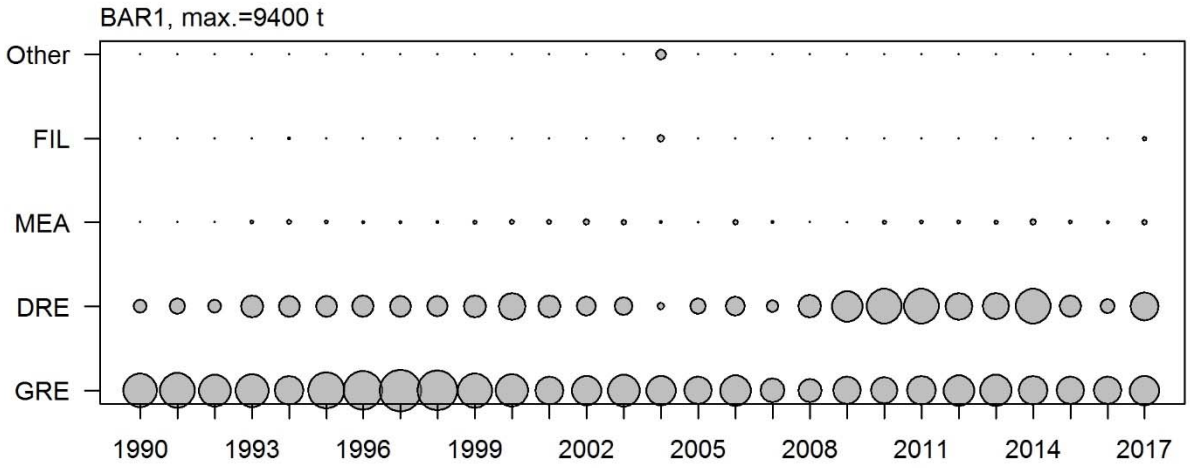


Figure C3: Retained landings (greenweight) by processed state for the BAR 1 stock for fishing years 1990–2017. GRE is Green; DRE is dressed; MEA is mealed; and FIL is filleted or skin off filleted.

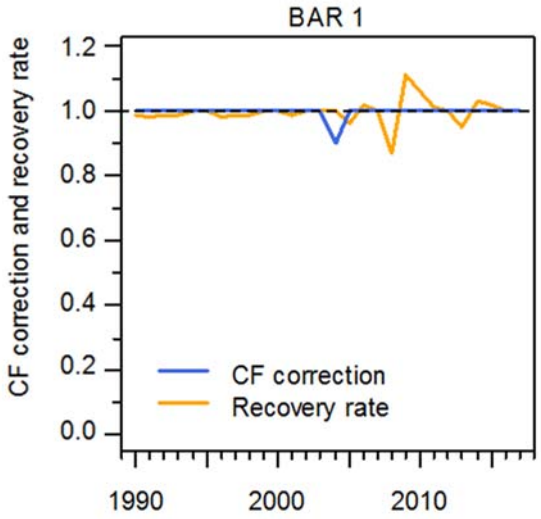


Figure C4: Conversion factor (CF) corrections (by the centroid method), defined as the ratio of annual green weight recalculated using the most recent correction factors for each processed state to the reported green weight, and the recovery rate, defined as the ratio of annual landings in the groomed and merged dataset to those in the groomed and unmerged dataset, for BAR 1, for the fishing years 1990–2017.

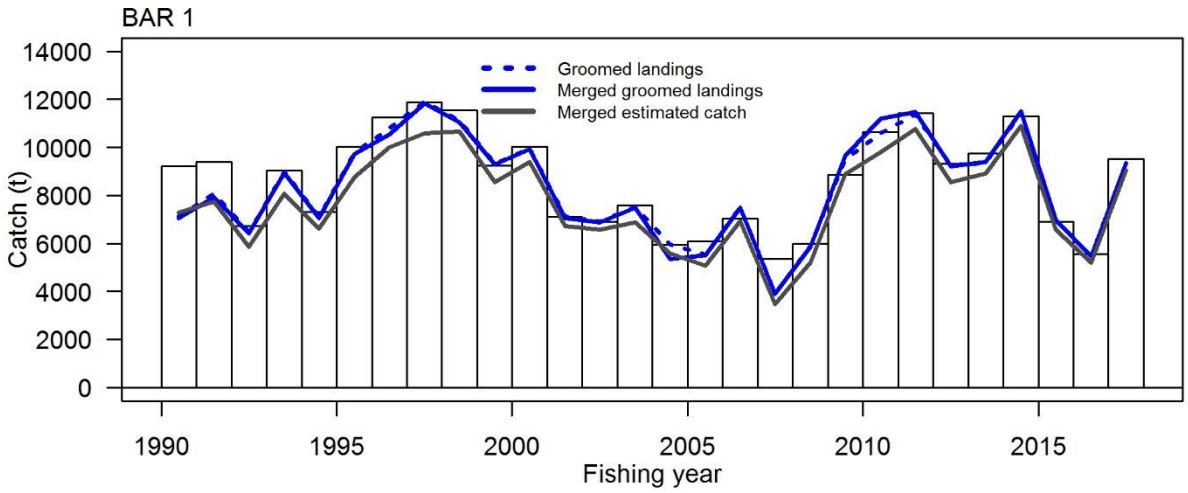


Figure C5: The QMR/MHR landings (white bars), retained landings in the groomed and unmerged dataset (blue dashed line), retained landings in groomed and merged dataset (blue solid line), and estimated catch in the groomed and merged dataset (grey solid line), for BAR 1, for the fishing years 1990–2017.

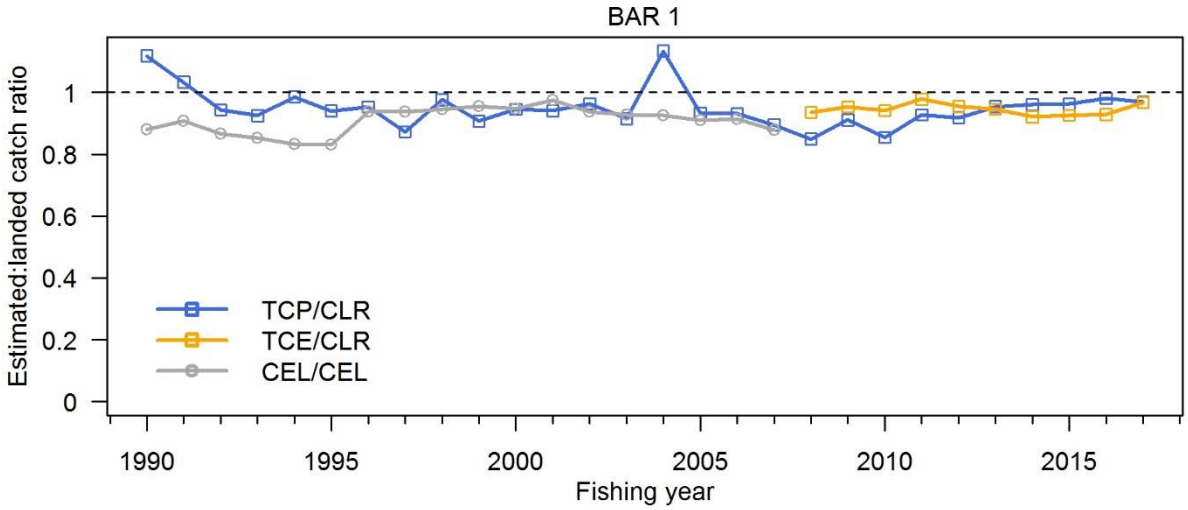


Figure C6: The reporting rate, defined as the ratio of the estimated catch as a proportion of retained landings in the groomed and merged BAR 1 dataset, by form type, for the fishing years 1990–2017.

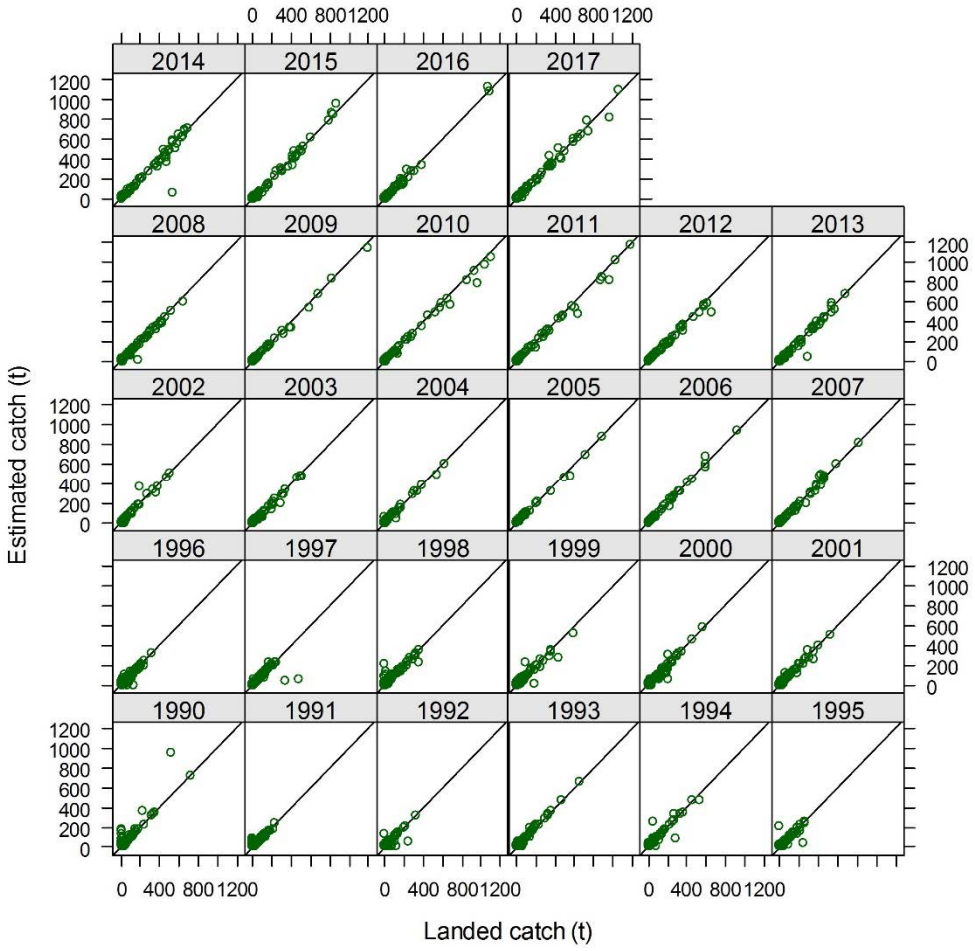


Figure C7: Comparison of estimated and landed catches in the groomed and merged BAR 1 dataset, for the fishing years 1990–2017.

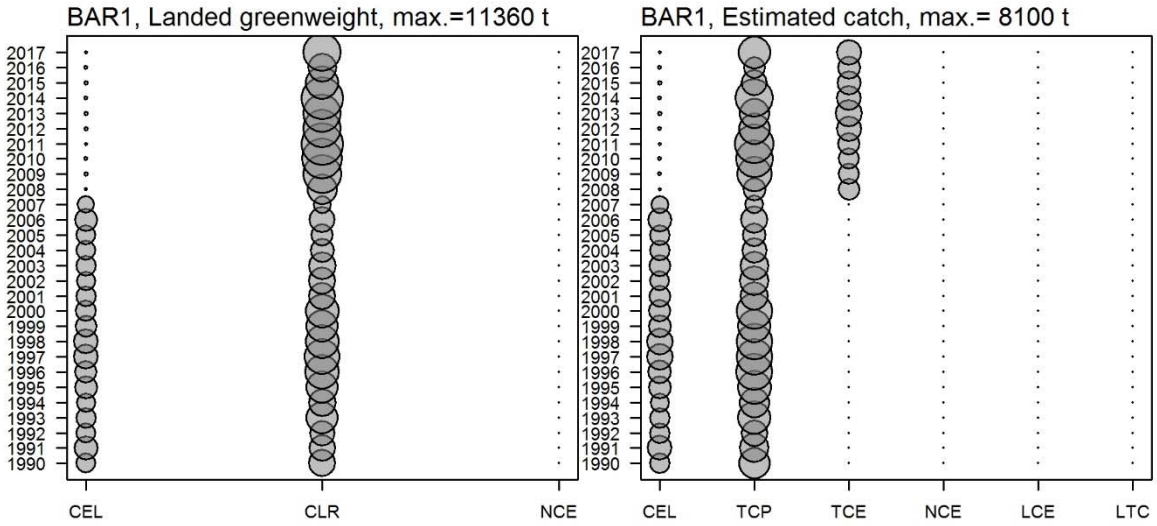


Figure C8: Proportion of landings and estimated catch by form type in the groomed and unmerged dataset, for BAR 1, for the fishing years 1990–2017. The area of the circle is proportional to the annual catches (only comparable within each panel). CEL is Catch Effort Landing Return, CLR is Catch Landing Return, NCE is Netting Catch Effort Return, TCP is Trawl Catch Effort Processing Return, TCE is Trawl Catch Effort Return, LCE is Line Catch Effort Return, and LTC is Lining Trip Catch Effort Return.

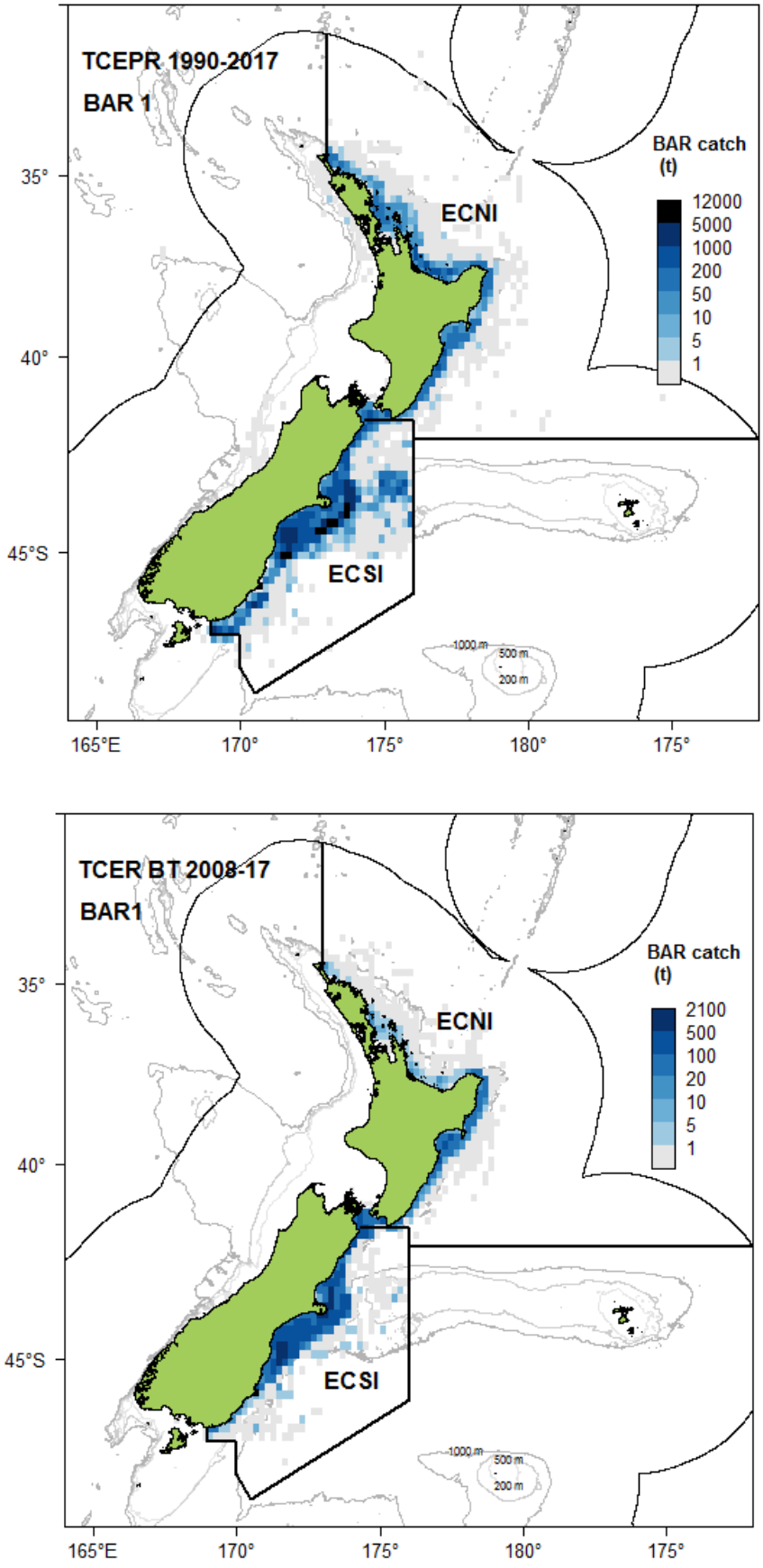


Figure C9: Total estimated barracouta catch (t) from Trawl Catch Effort and Processing Return (TCEPR) records (upper) and from Trawl Catch Effort Return (TCER) (lower), for ECNI and ECSI of BAR 1.

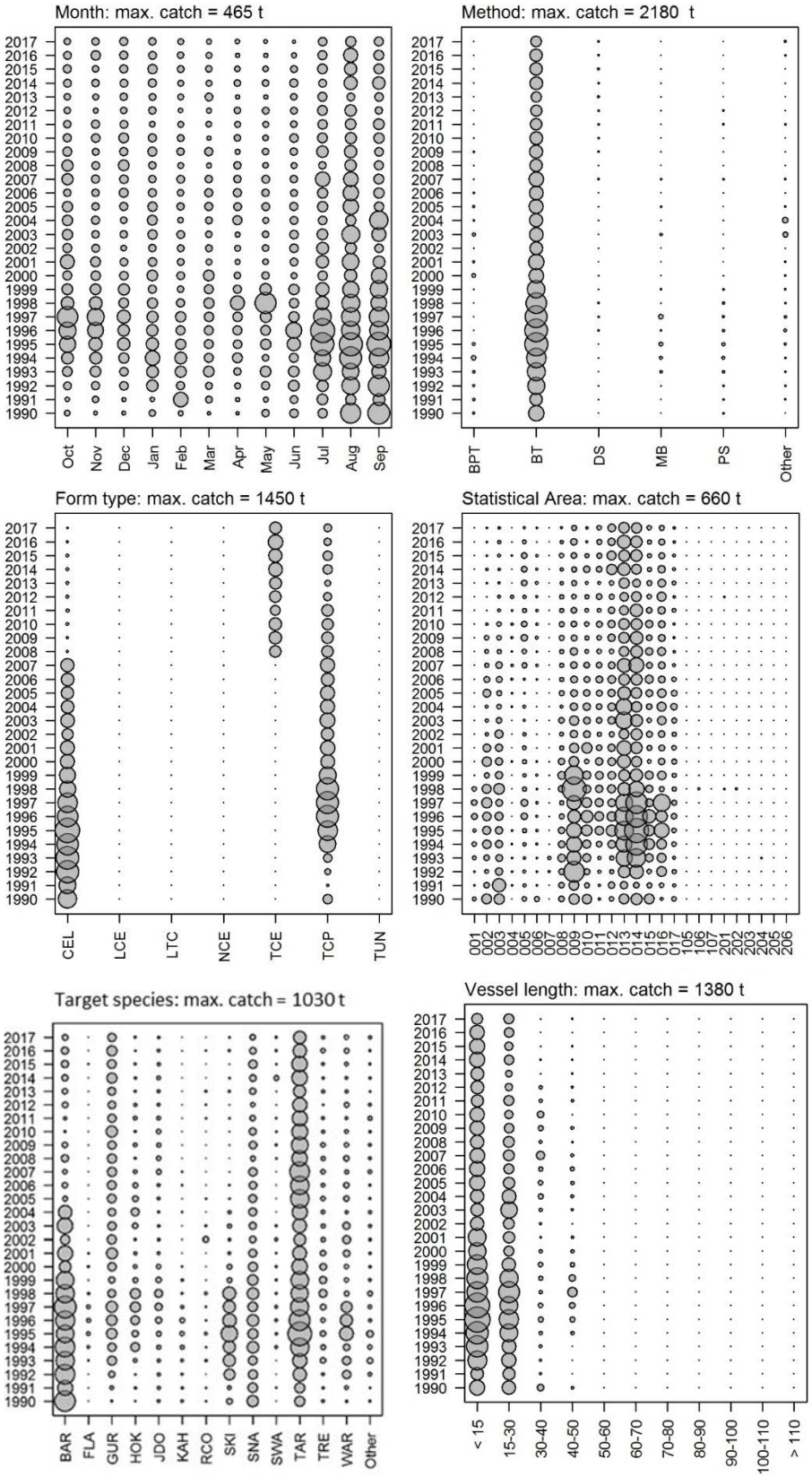


Figure C10: Distribution of annual catch (t) by month, method, form type, statistical area, target species, and vessel length for ECNI merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left-hand corner of each plot. BT is bottom trawl, BPT is bottom paired trawl, MW is midwater trawl, and DS is Danish seine. Form types are defined in Figure C8. Target species codes are given in Table B1. Statistical Areas are shown in Figure 1.

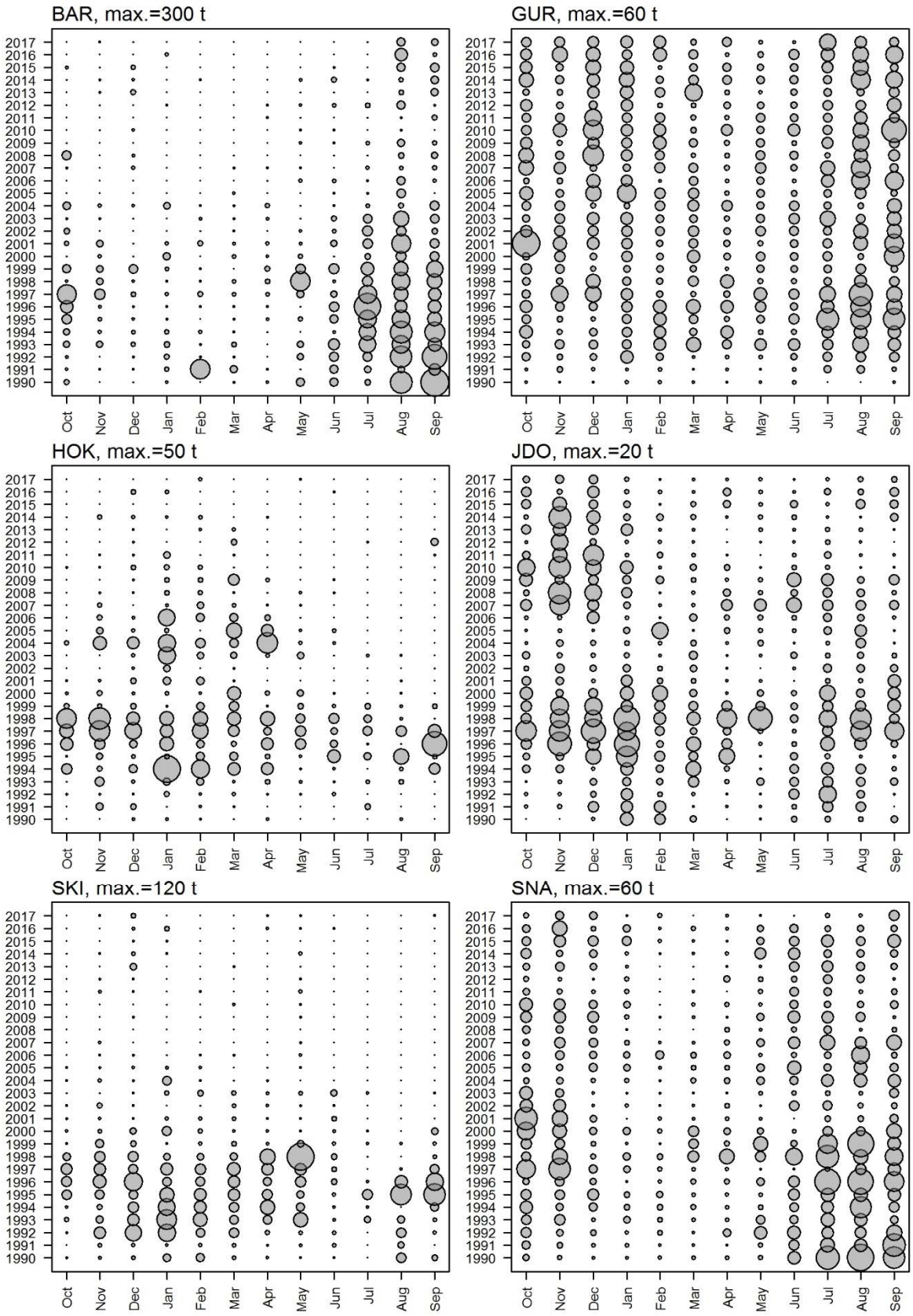


Figure C11a: Distribution of annual catch (t) by month and target species for ECNI merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left-hand corner of each plot. See Table B1 for definition of target species codes.

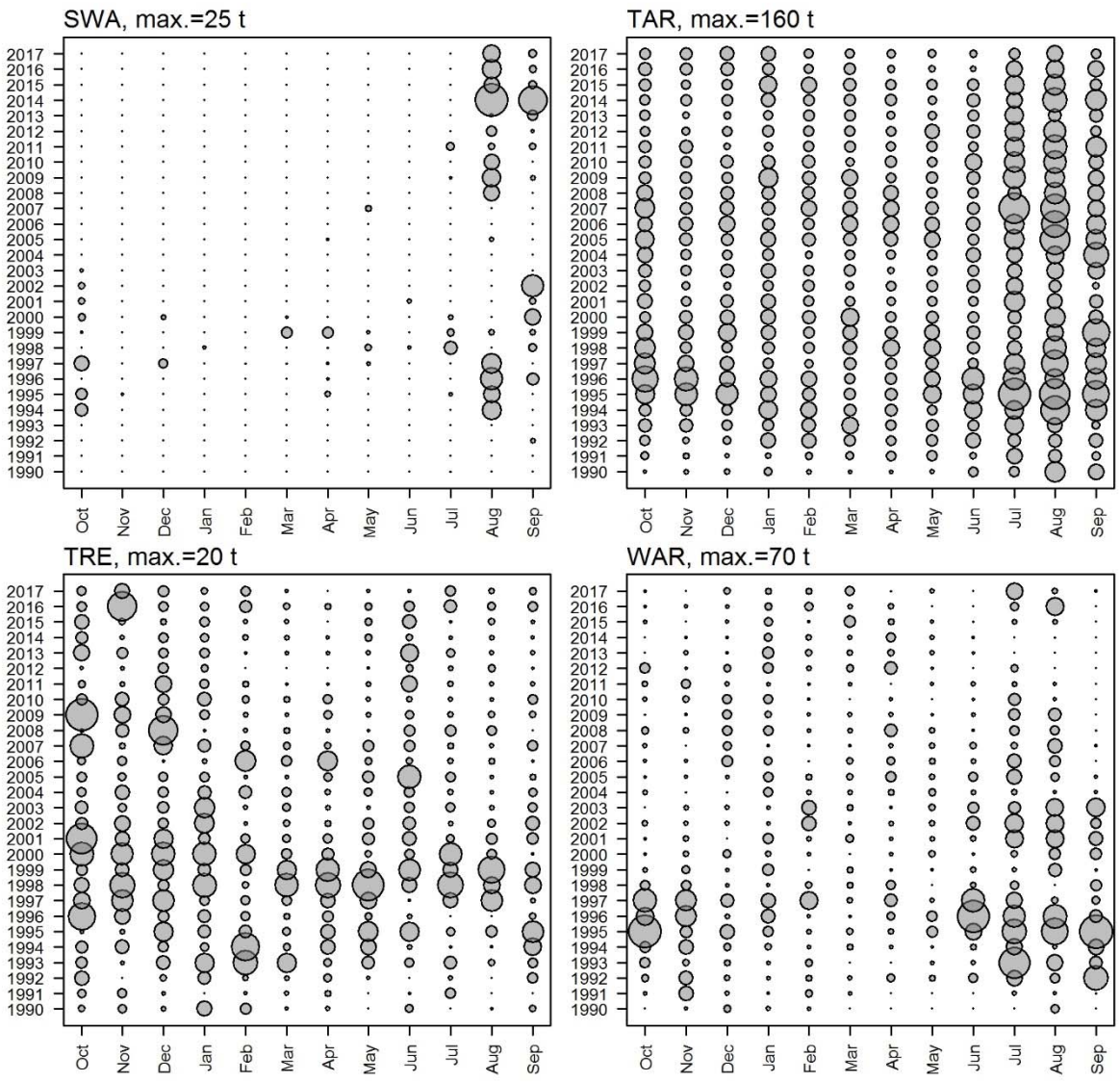


Figure C11a *continued.*

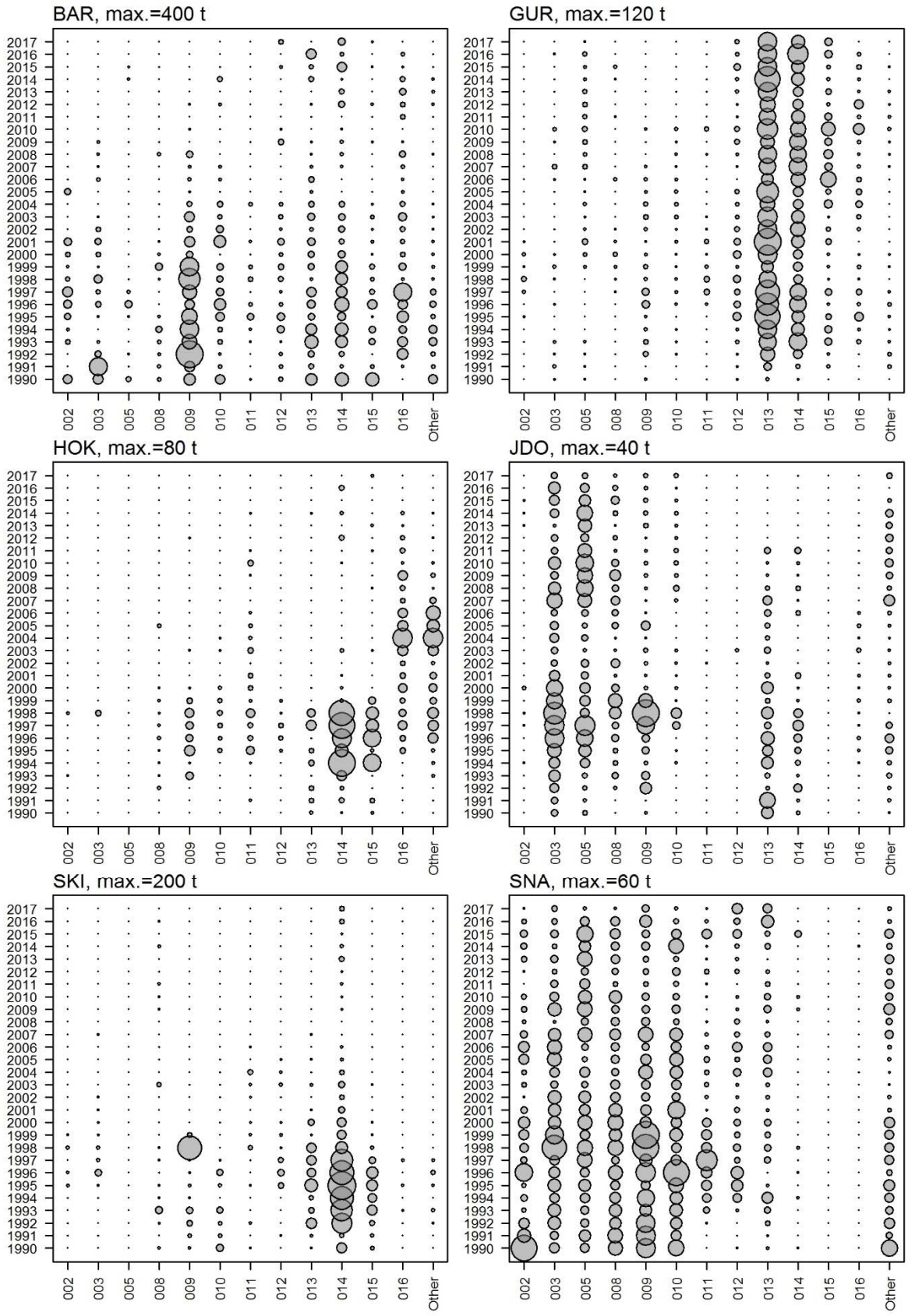


Figure C11b: Distribution of annual catch (t) by statistical area for the main target species for ECNI merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left-hand corner of each plot. See Table B1 for definition of target species codes and Figure 1 for statistical areas.

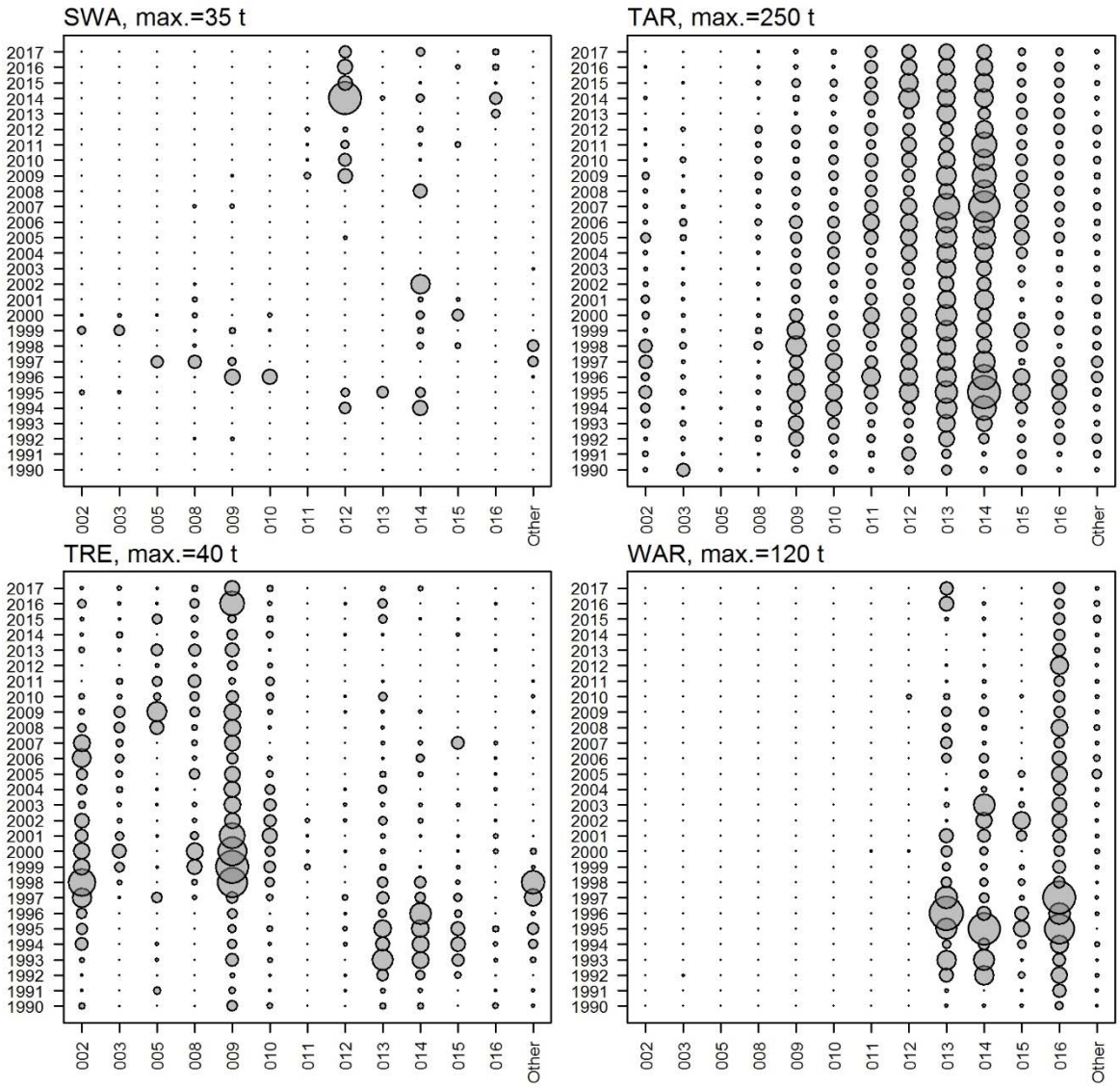


Figure C11b *continued.*

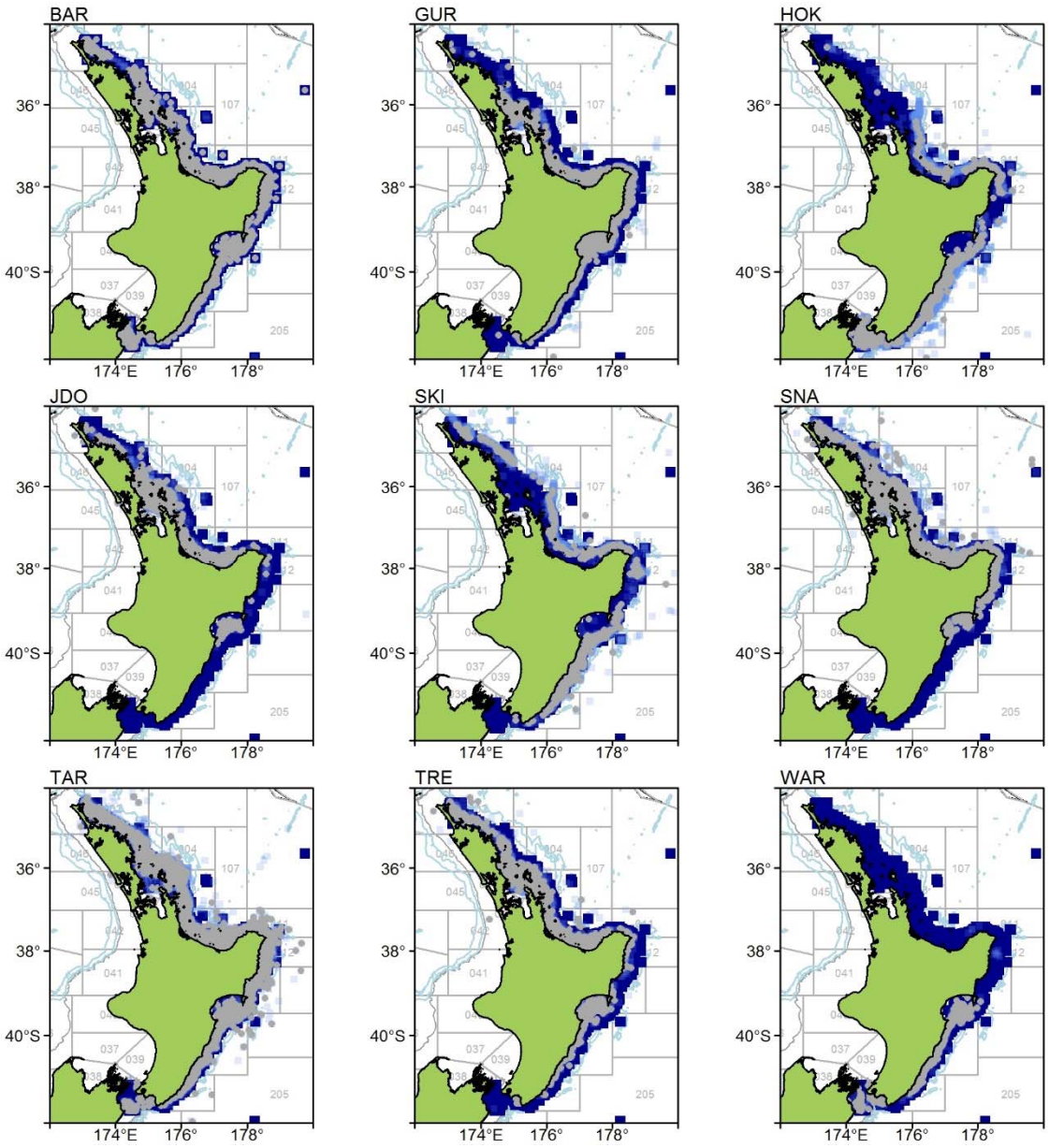


Figure C12a: Distribution of TCEPR effort for barracouta (■), for the main target species (■), and for the main target species where barracouta was caught (●), for the BAR 1 ECNI fishery, 1990–2017. Target species codes are defined in Table B1.

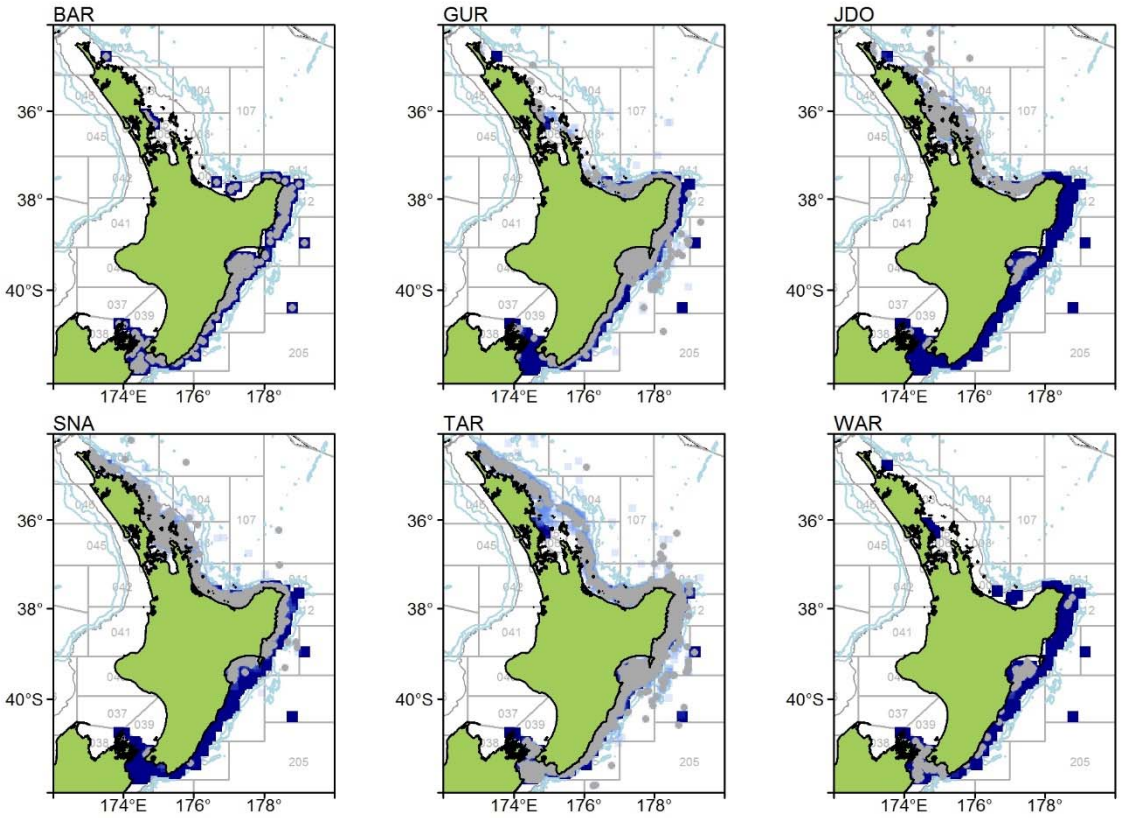


Figure C12b: Distribution of TCER effort for barracouta (■), for the main target species (■), and for the main target species where barracouta was caught (●), for the BAR 1 ECNI fishery, 2008–17. Target species codes are defined in Table B1.

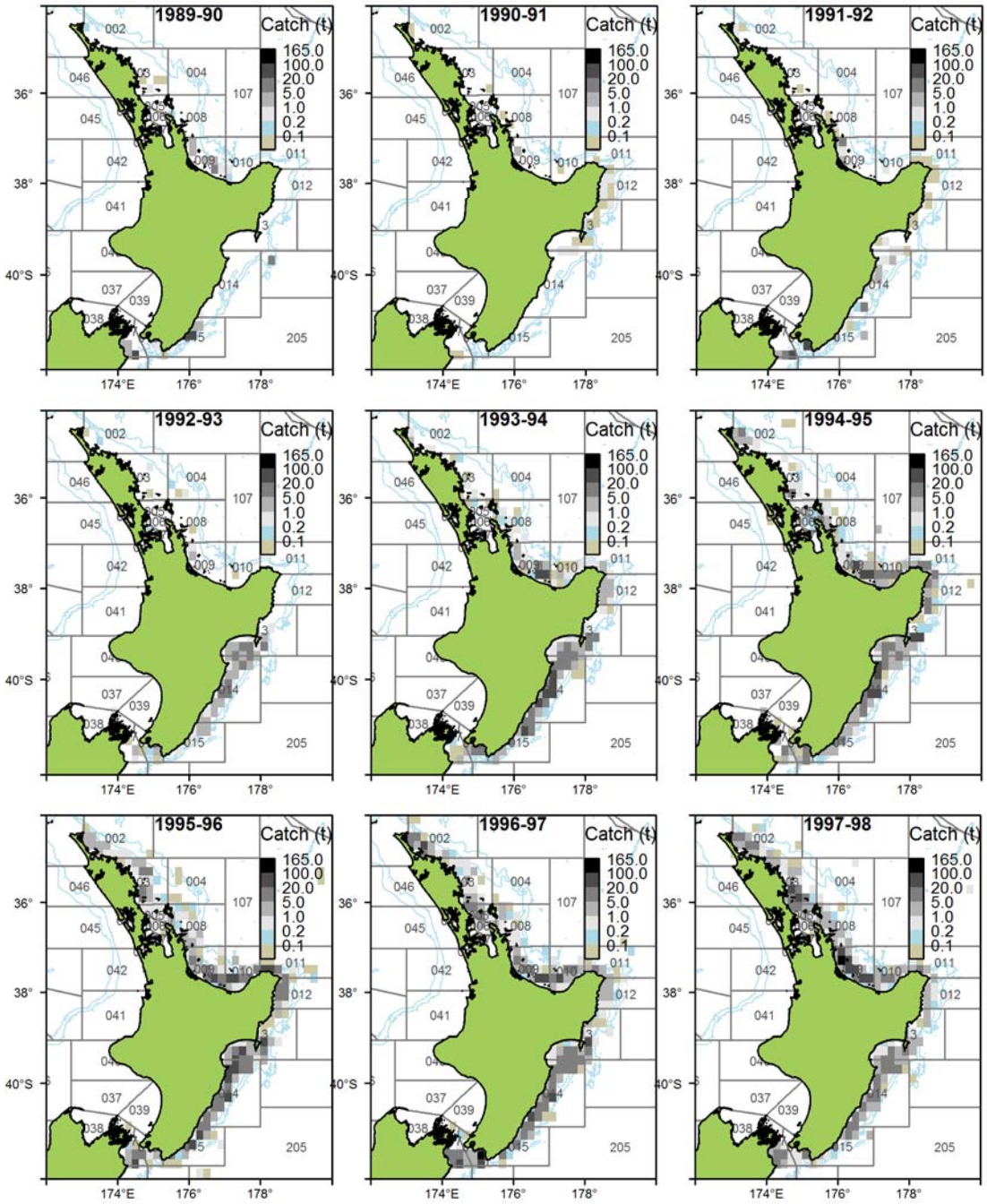


Figure C13a: Distribution of TCEPR bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECNI area, 1989–90 to 2016–17. Blue lines show the 500 m and 1000 m depth contours.

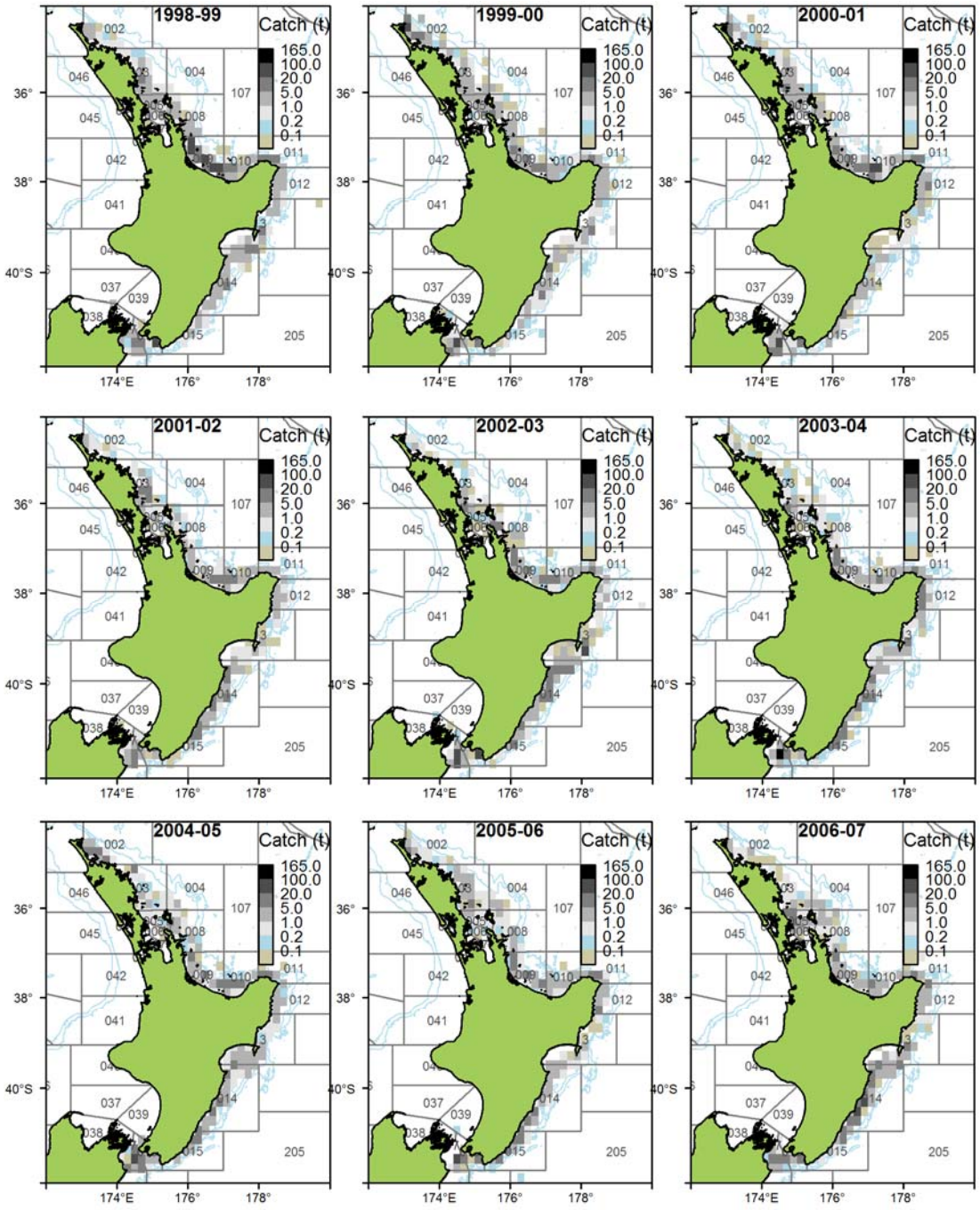


Figure C13a *continued.*

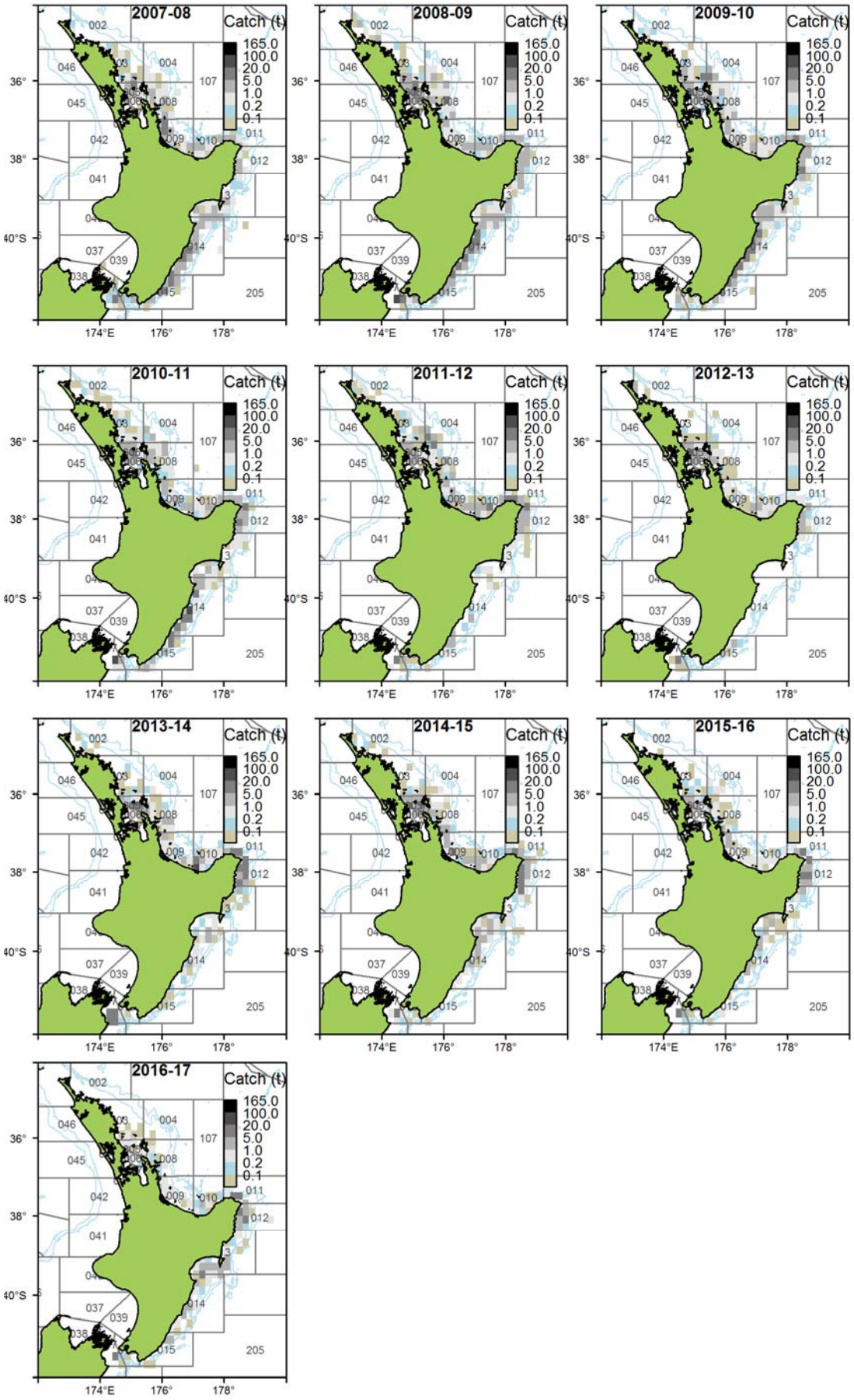


Figure C13a *continued.*

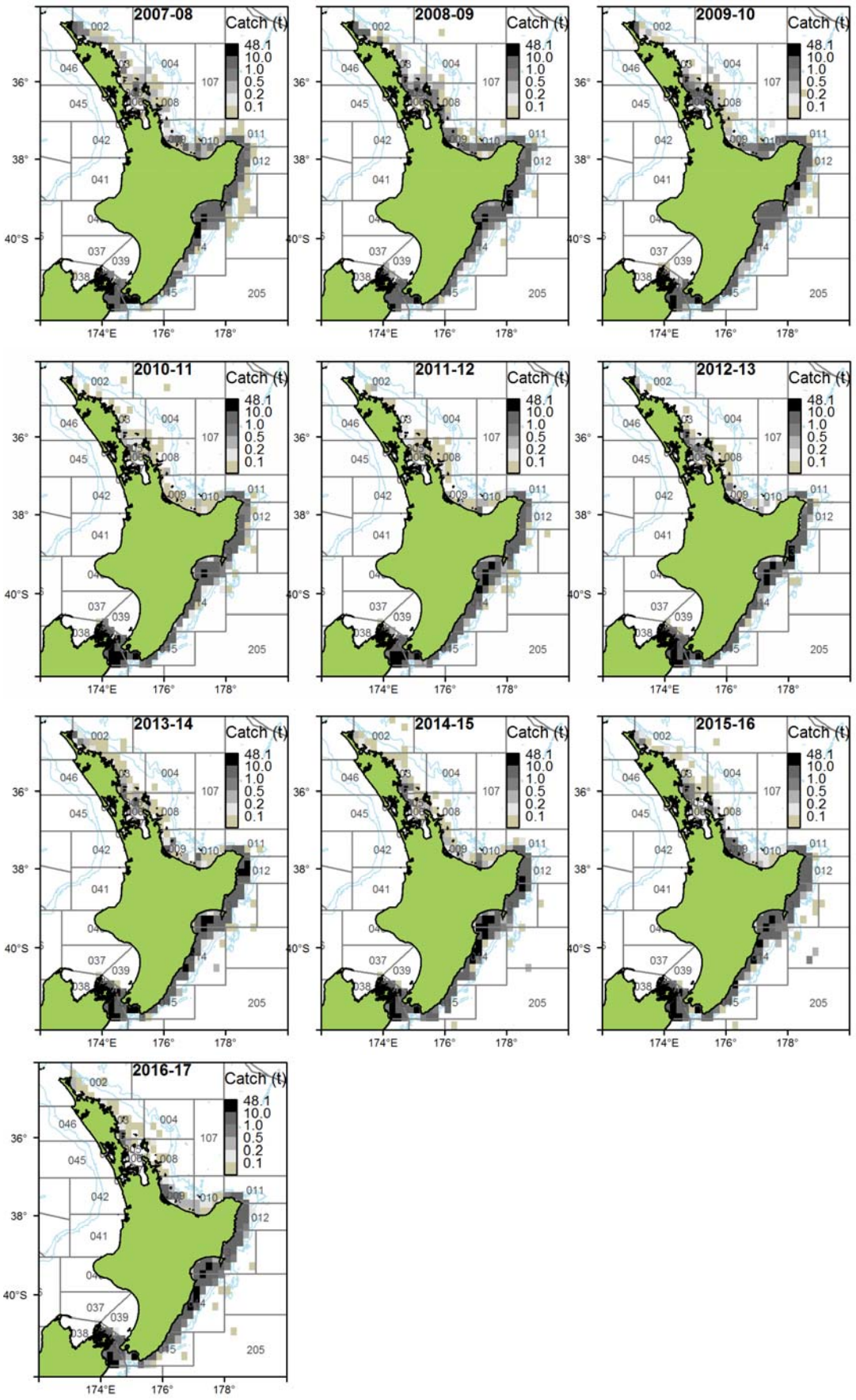


Figure C13b: Distribution of TCER bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECNI area, 2007–08 to 2016–17. Blue lines show the 500 m and 1000 m depth contours.

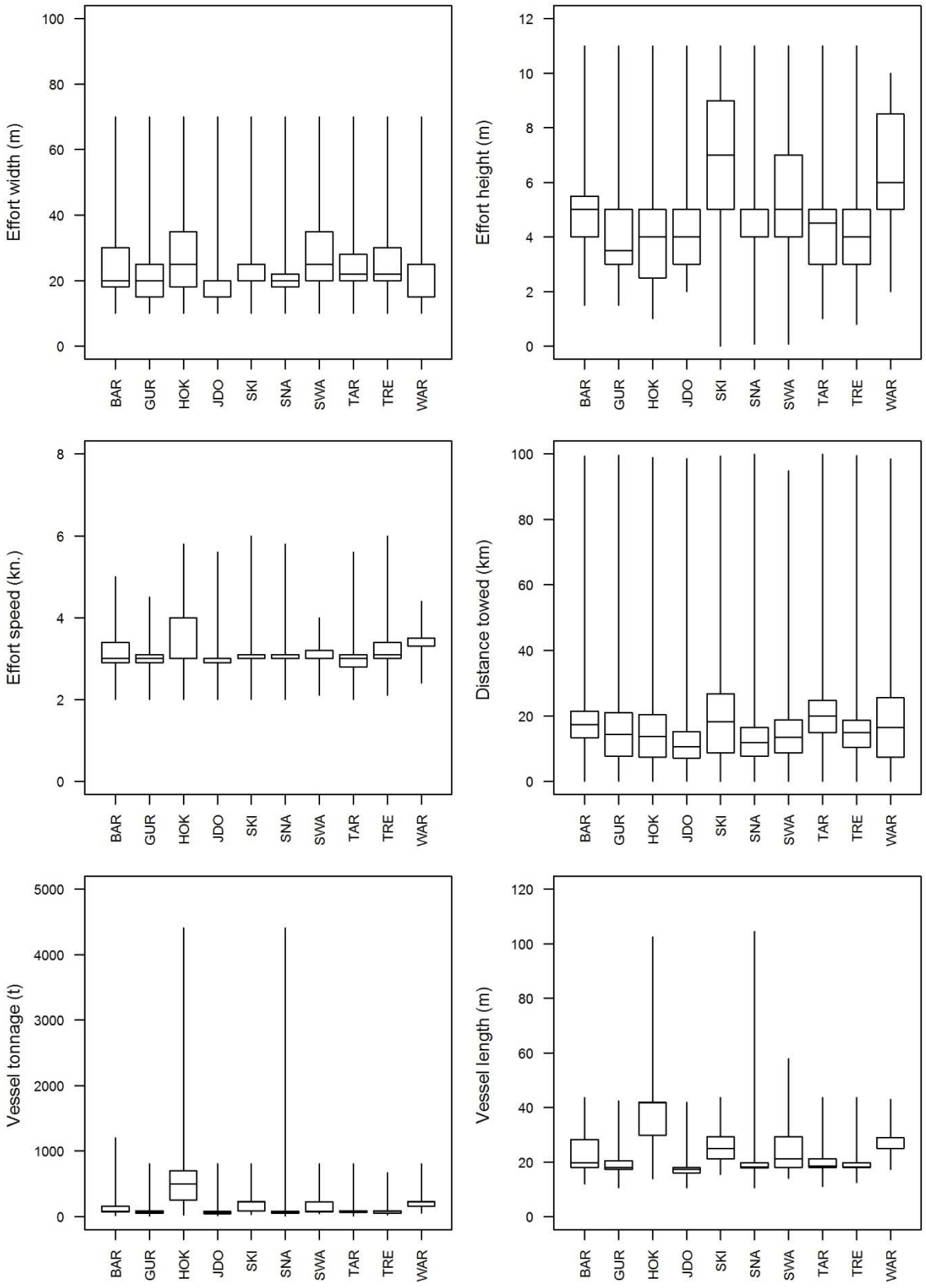


Figure C14a: Annual median (horizontal line), inter-quartile range (box), and range (vertical lines) of TCEPR bottom trawl variables reported for major target species fisheries catching barracouta in the BAR 1 ECNI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

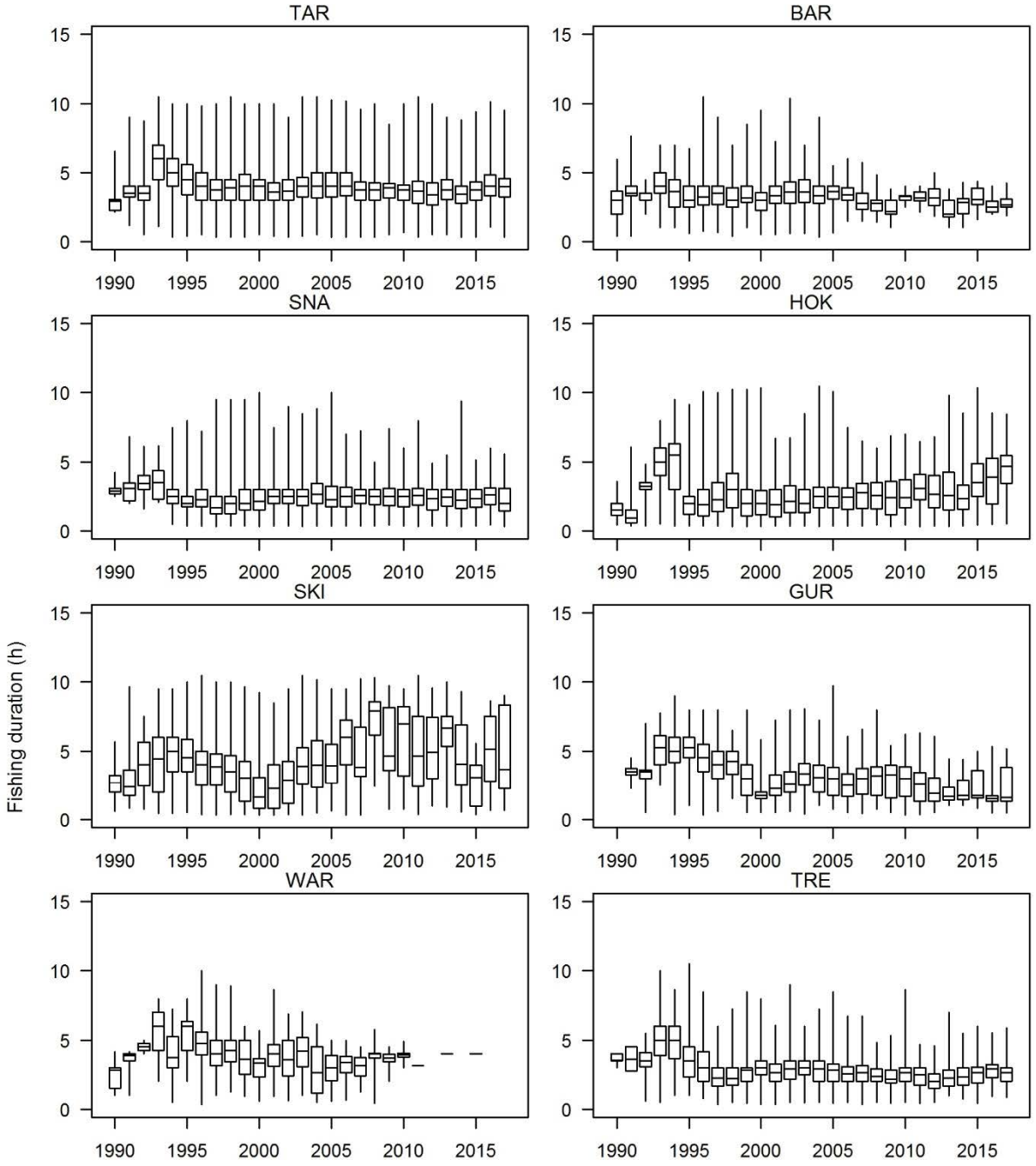


Figure C14b: Annual median (horizontal line), inter-quartile range (box), and range (vertical lines) of TCEPR bottom trawl tow durations reported for major target species fisheries catching barracouta in the BAR 1 ECNI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

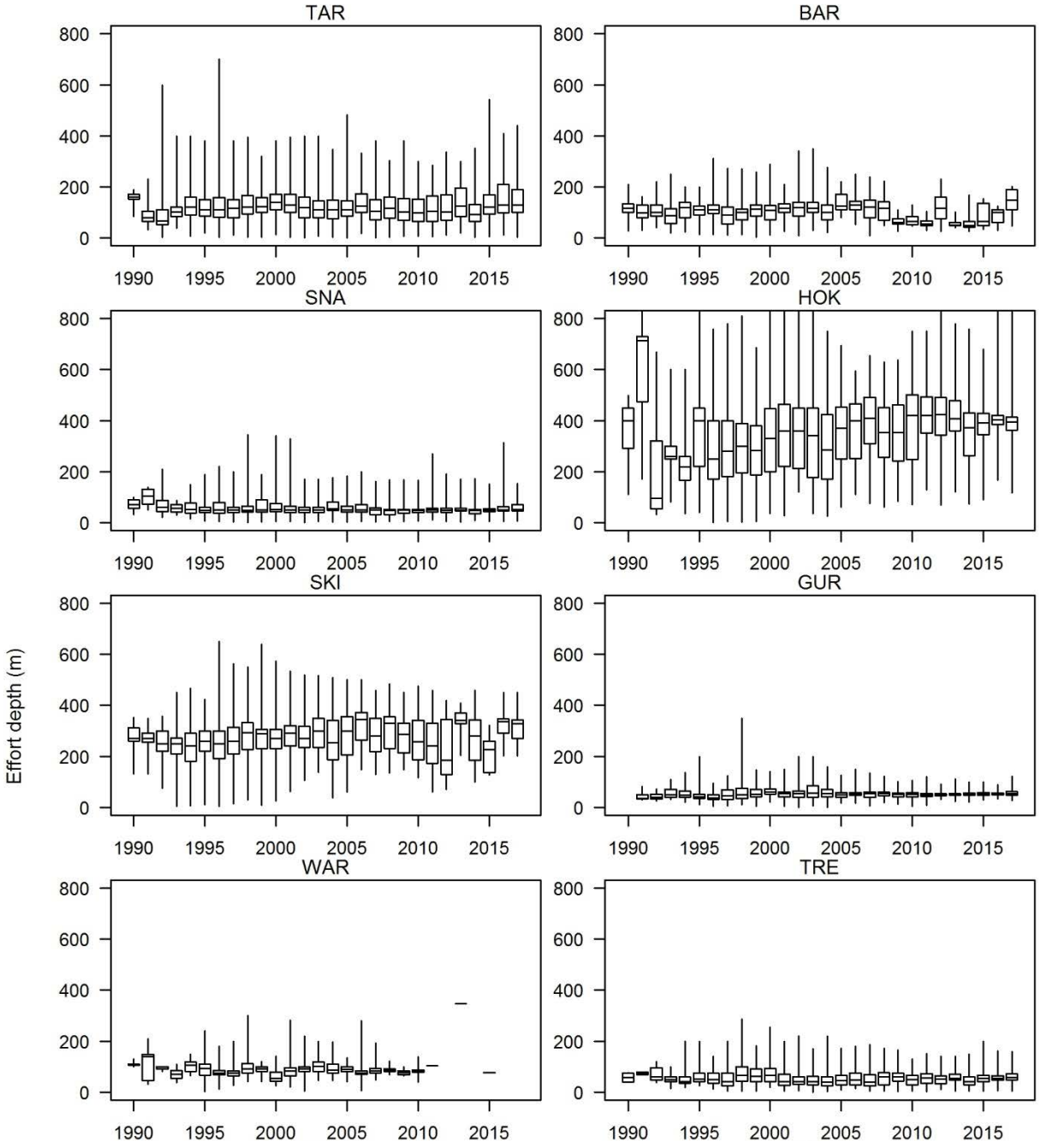


Figure C14c: Annual median (horizontal line), inter-quartile range (box), and range (vertical lines) of TCEPR bottom trawl effort depths reported for major target species fisheries catching barracouta in the BAR 1 ECNI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

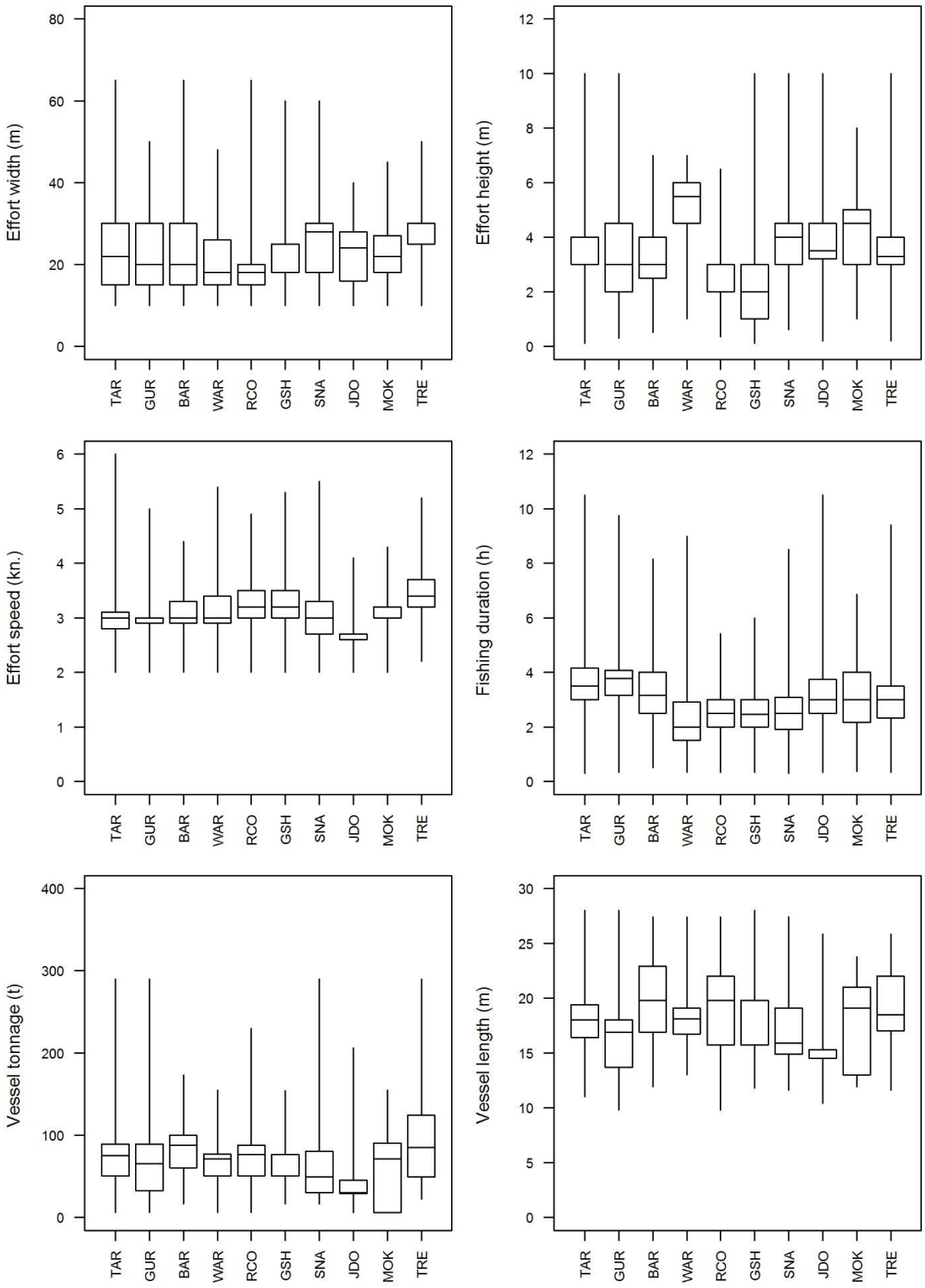


Figure C15a: Annual median (horizontal line), inter-quartile range (box), and range (vertical lines) of TCER bottom trawl variables reported for major target species fisheries catching barracouta in the BAR 1 ECNI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

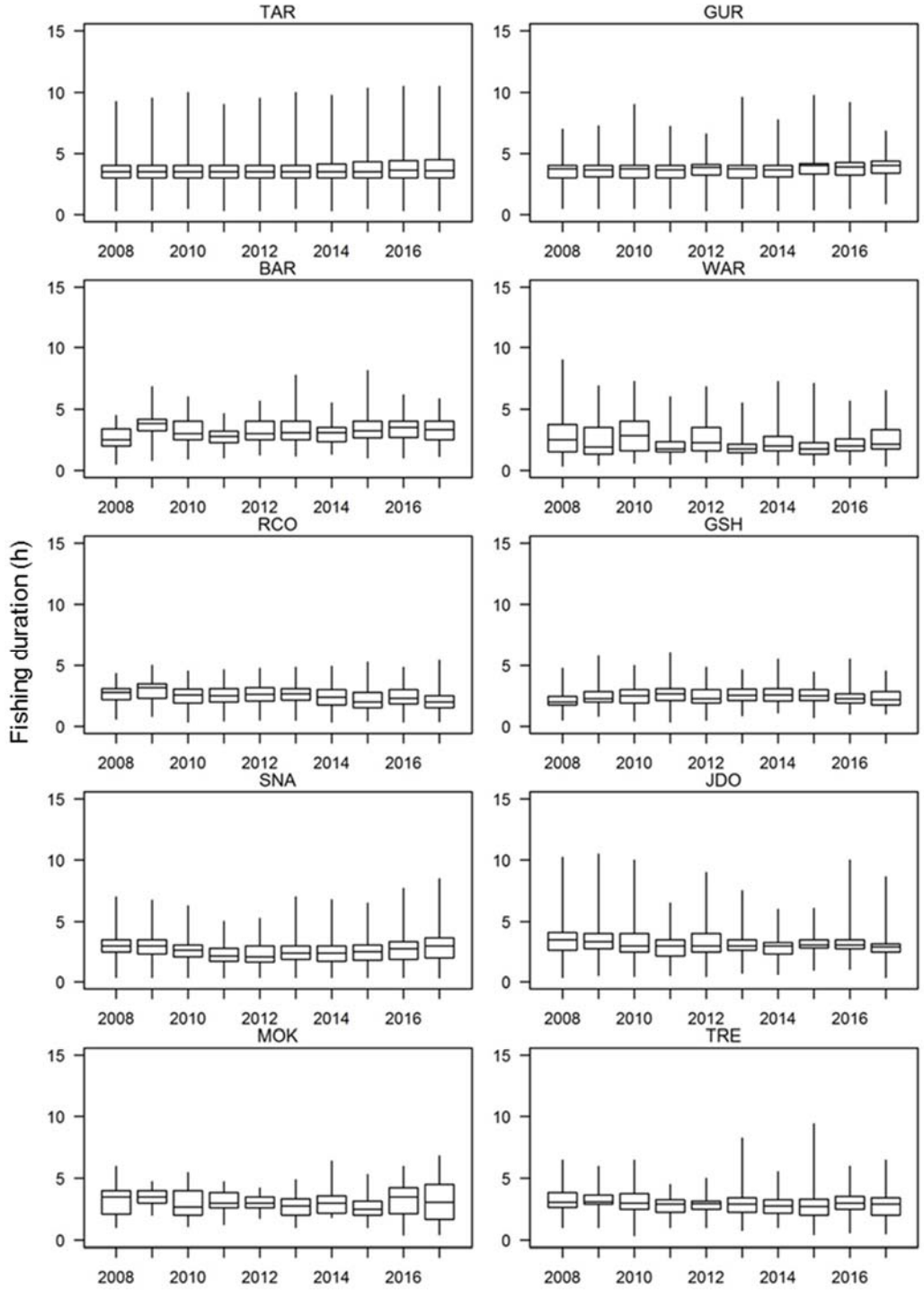


Figure C15b: Annual median (horizontal line), inter-quartile range (box), and range (vertical lines) of TCER bottom trawl tow durations reported for major target species fisheries catching barracouta in the BAR 1 ECNI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

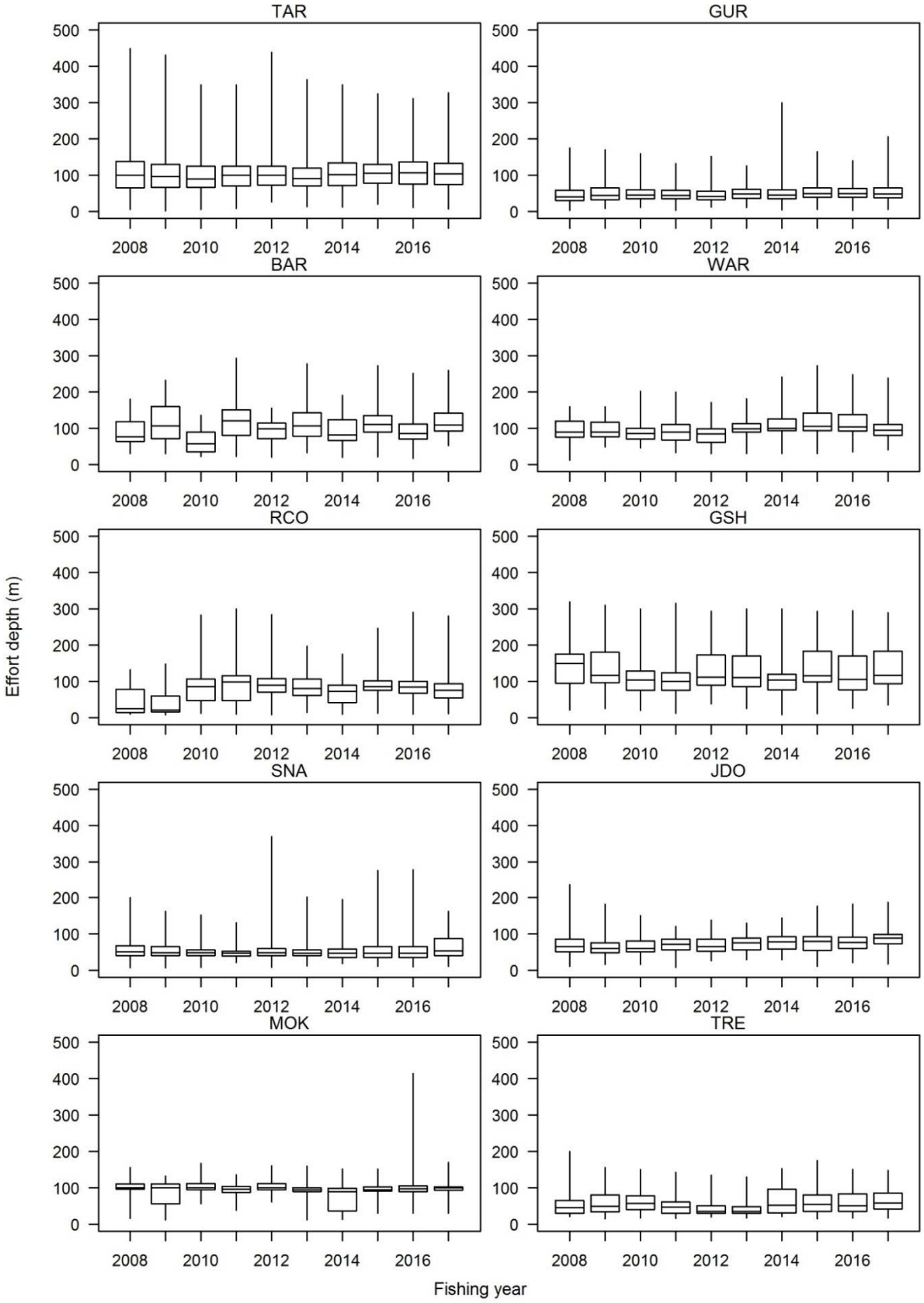


Figure C15c: Annual median (horizontal line), inter-quartile range (box), and range (vertical lines) of TCER bottom trawl effort depths reported for major target species fisheries catching barracouta in the BAR 1 ECNI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

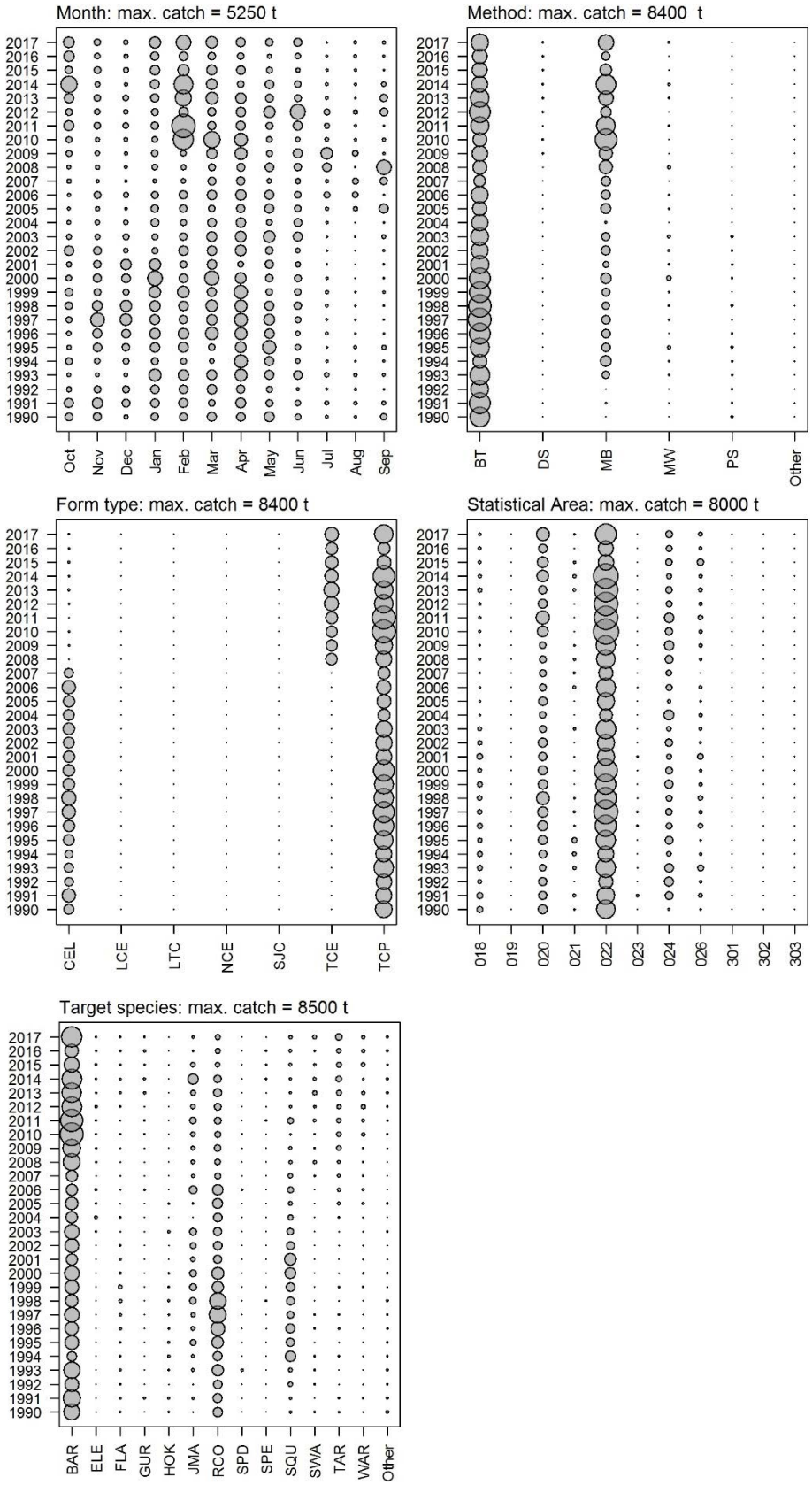


Figure C16: Distribution of annual catch (t) by month, method, form type, statistical area, and target species for ECSI merged trawl data. Circle size is proportional to catch; maximum circle size is indicated on the top left-hand corner of each plot. Statistical areas are shown in Figure 1. Primary form types are CELR (CEL), TCER (TCE), and TCEPR (TCP). Primary fishing methods are bottom trawl (BT), midwater near the bottom (MB), and midwater trawl (MW). Target species codes are given in Table B1.

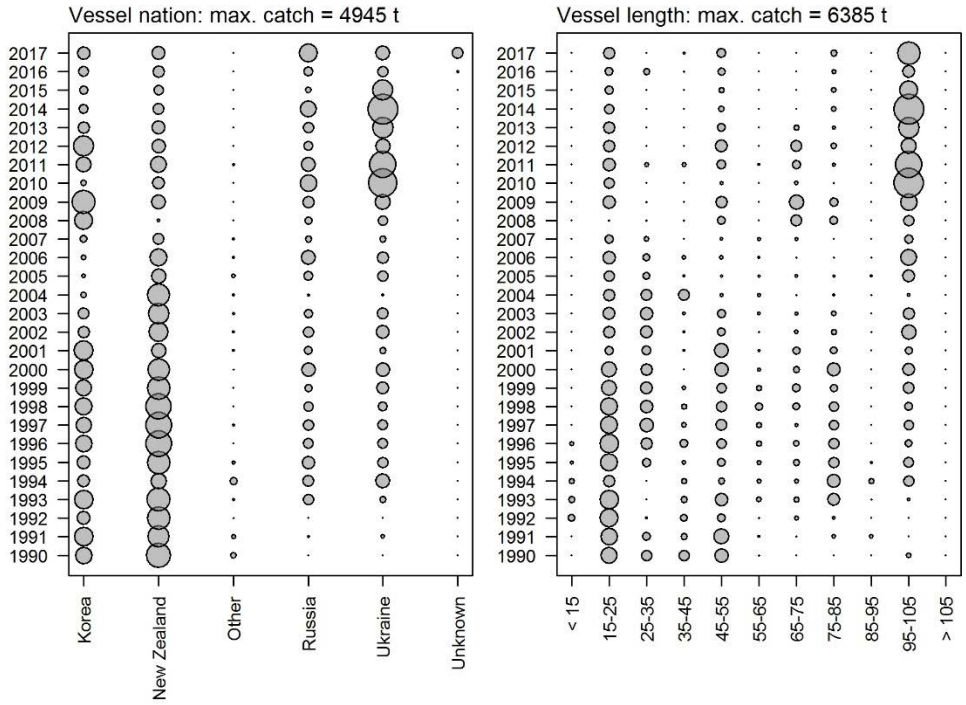


Figure C17a: Distribution of annual estimated catch (t) by vessel flag nationality (left) and vessel overall length (m) (right) for ECSI BAR 1 unmerged TCEPR data. Circle size is proportional to catch; maximum circle size is indicated on the top left-hand corner of each plot.

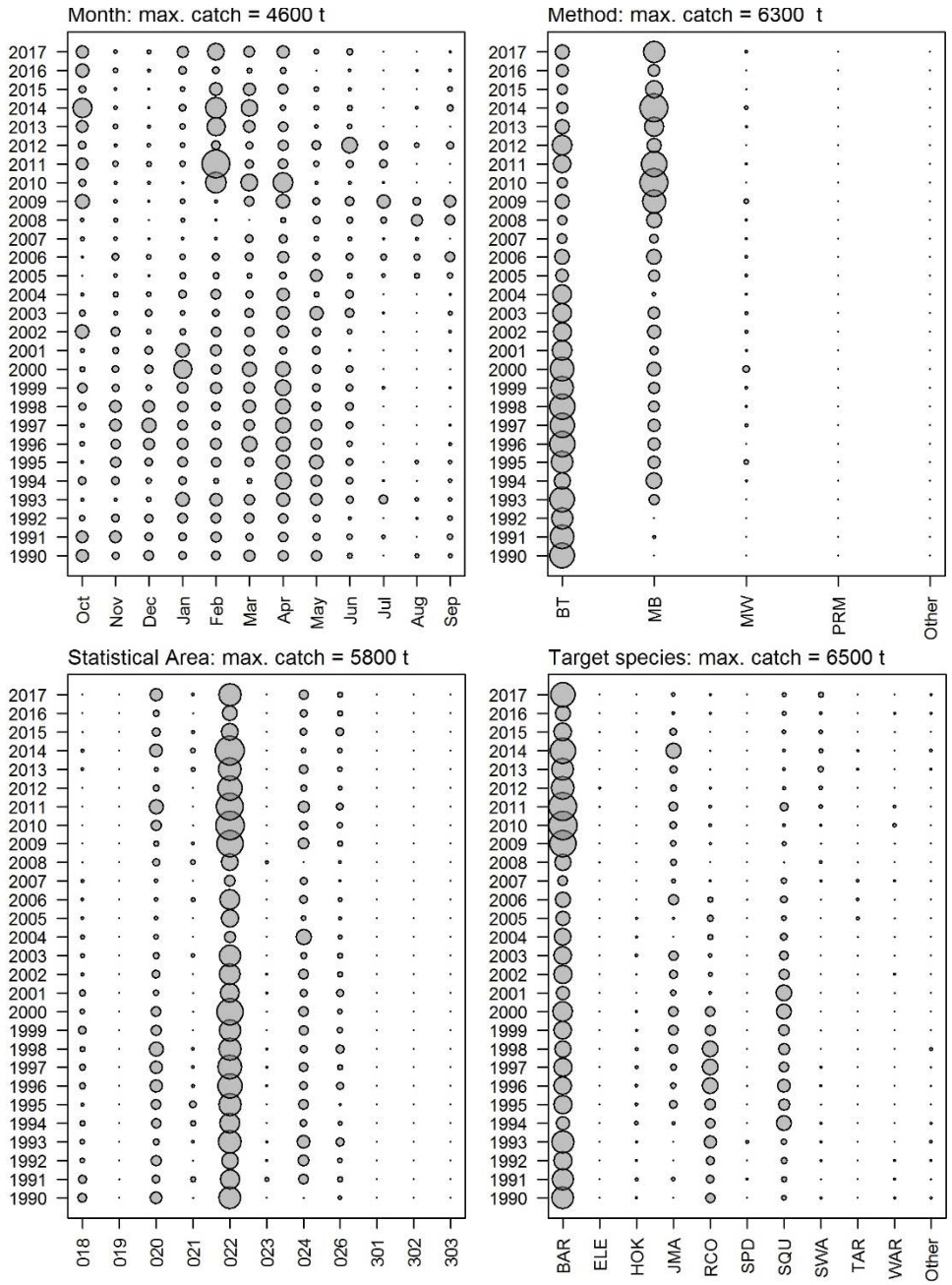


Figure C17b: Distribution of annual estimated catch (t) by month, method, Statistical Area (see Figure 1), and target species for ECSI BAR 1 unmerged TCEPR data. Circle size is proportional to catch; maximum circle size is indicated on the top left-hand corner of each plot. Statistical areas are shown in Figure 1. Fishing methods are BT for bottom trawl and MW for midwater trawl. Target species codes are given in Table B1.

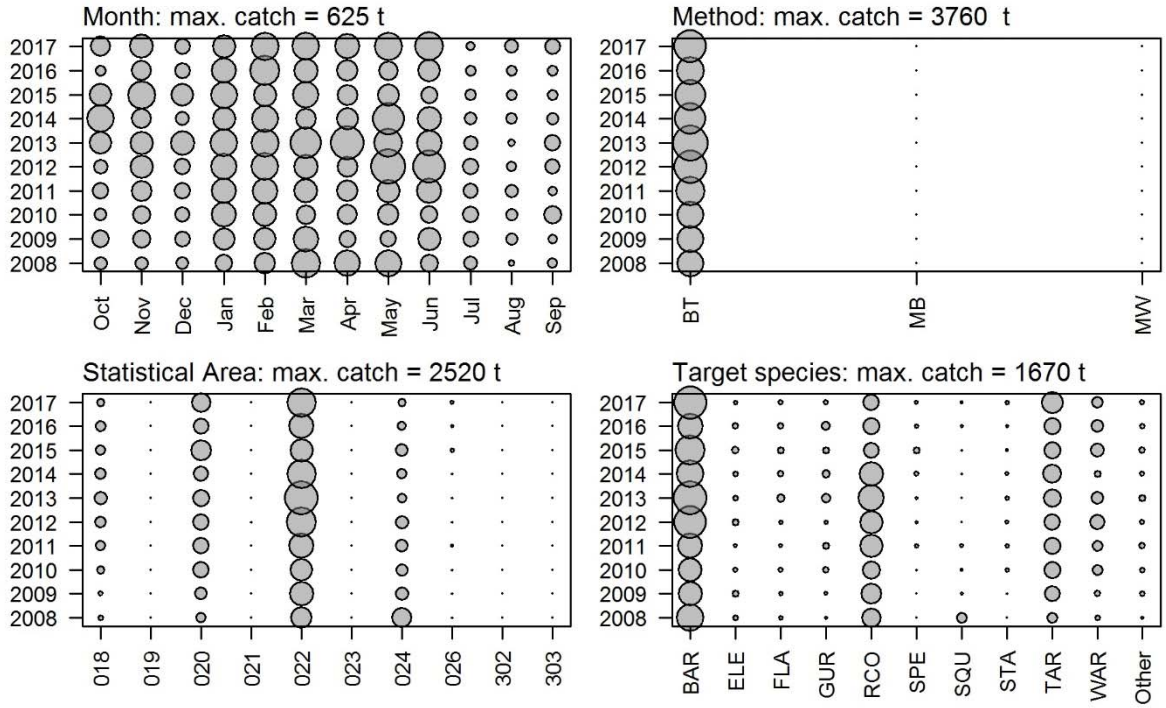


Figure C17c: Distribution of annual estimated catch (t) by month, method, statistical area, and target species for ECSI BAR 1 unmerged TCER data. See Figure C17b caption for code descriptions.

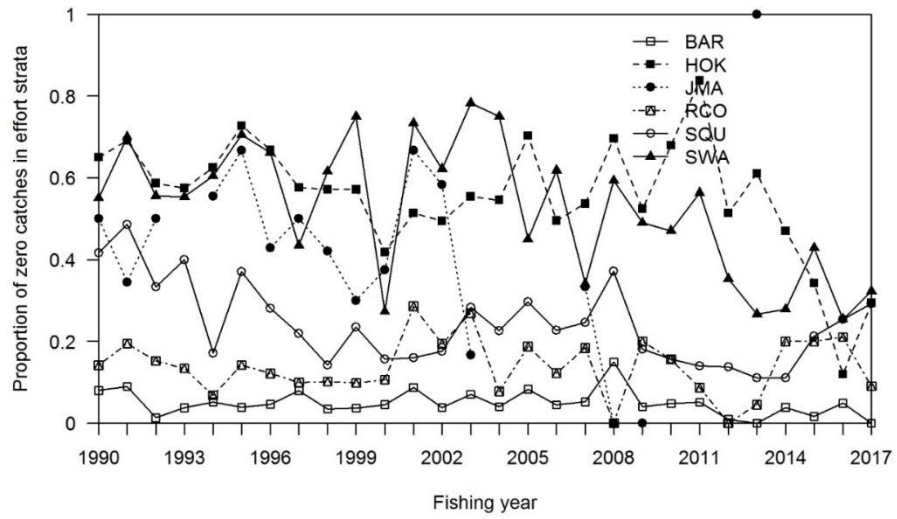


Figure C18a: Proportion of zero catches by main target species for the ECSI subarea of BAR 1 for TCEPR bottom trawl unmerged estimated catch data, 1990–2017 fishing years.

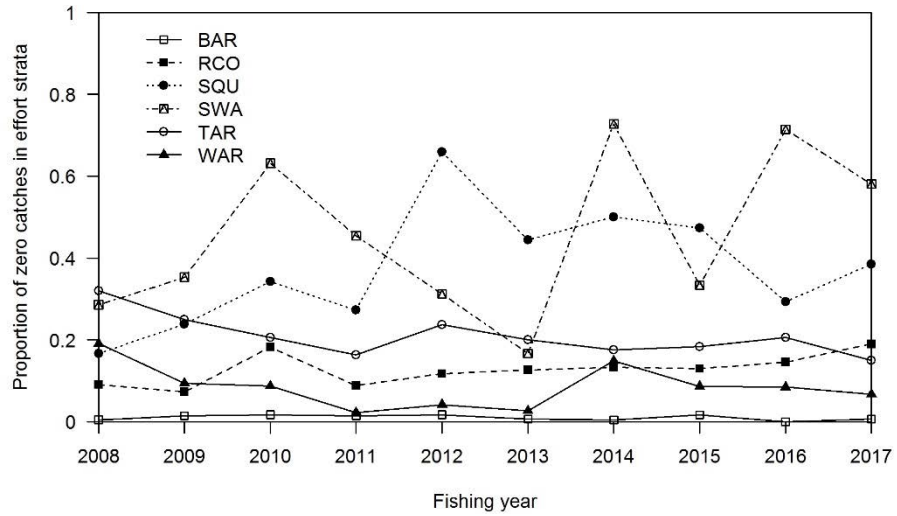


Figure C18b: Proportion of zeros by main target species for the ECSI subarea of BAR 1 for TCER bottom trawl unmerged estimated catch data, 2008–17 fishing years.

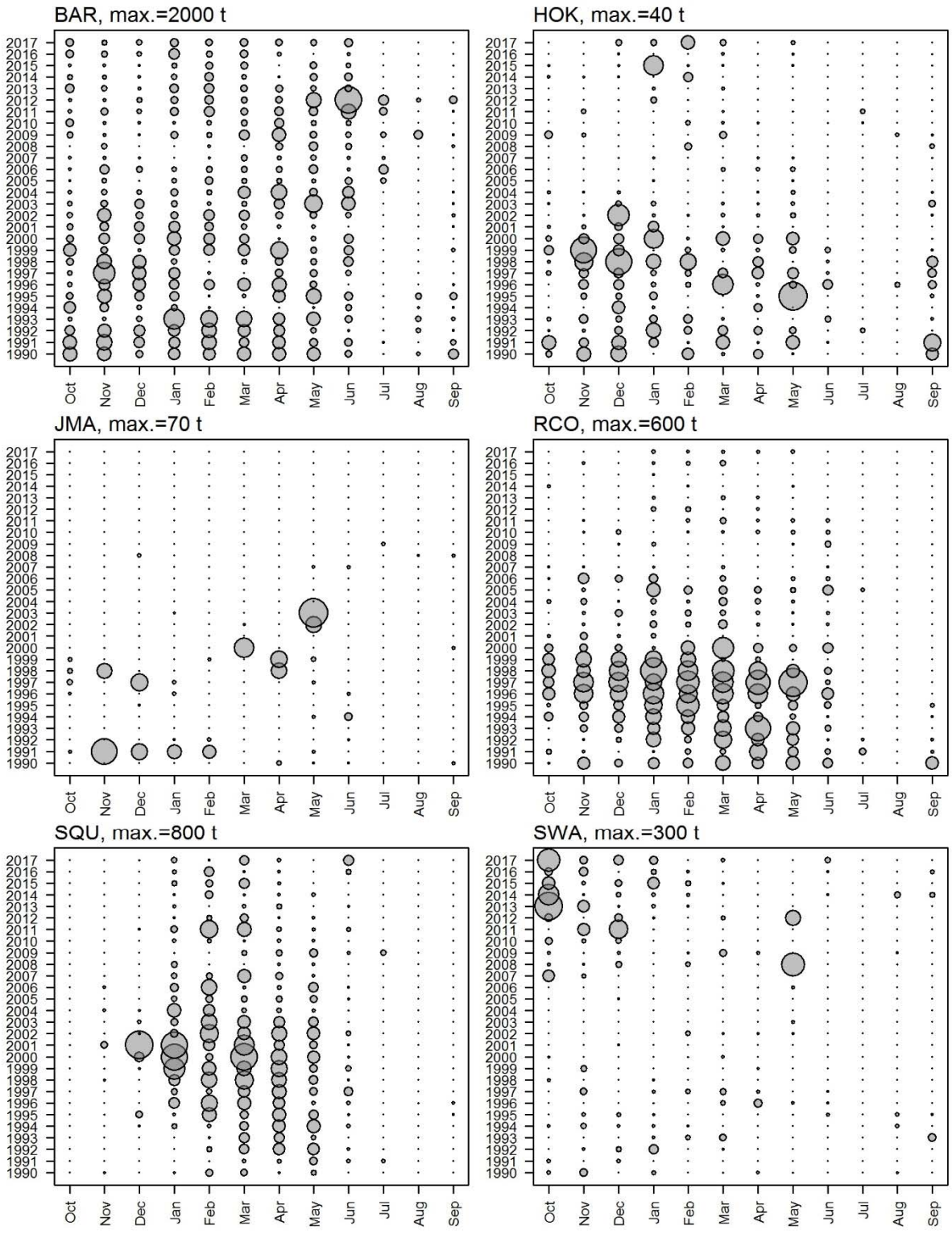


Figure C19a: Distribution of annual estimated catch (t) from the unmerged TCEPR data for the ECSI fishery area by month and fishing year for the main bottom trawl target species fisheries reported on TCEPRs. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

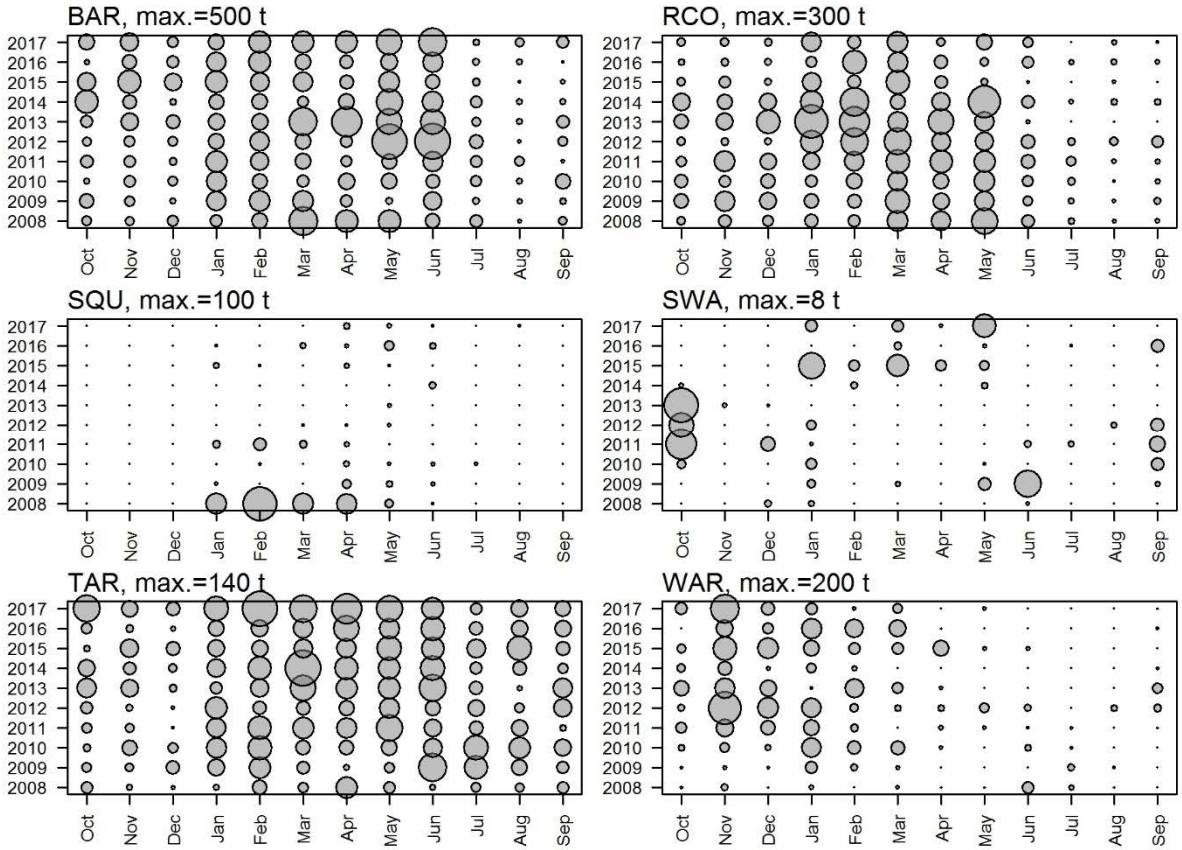


Figure C19b: Distribution of annual estimated catch (t) from the unmerged TCER data for the ECSI fishery area by month and fishing year for the main bottom trawl target species fisheries reported on TCERs. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

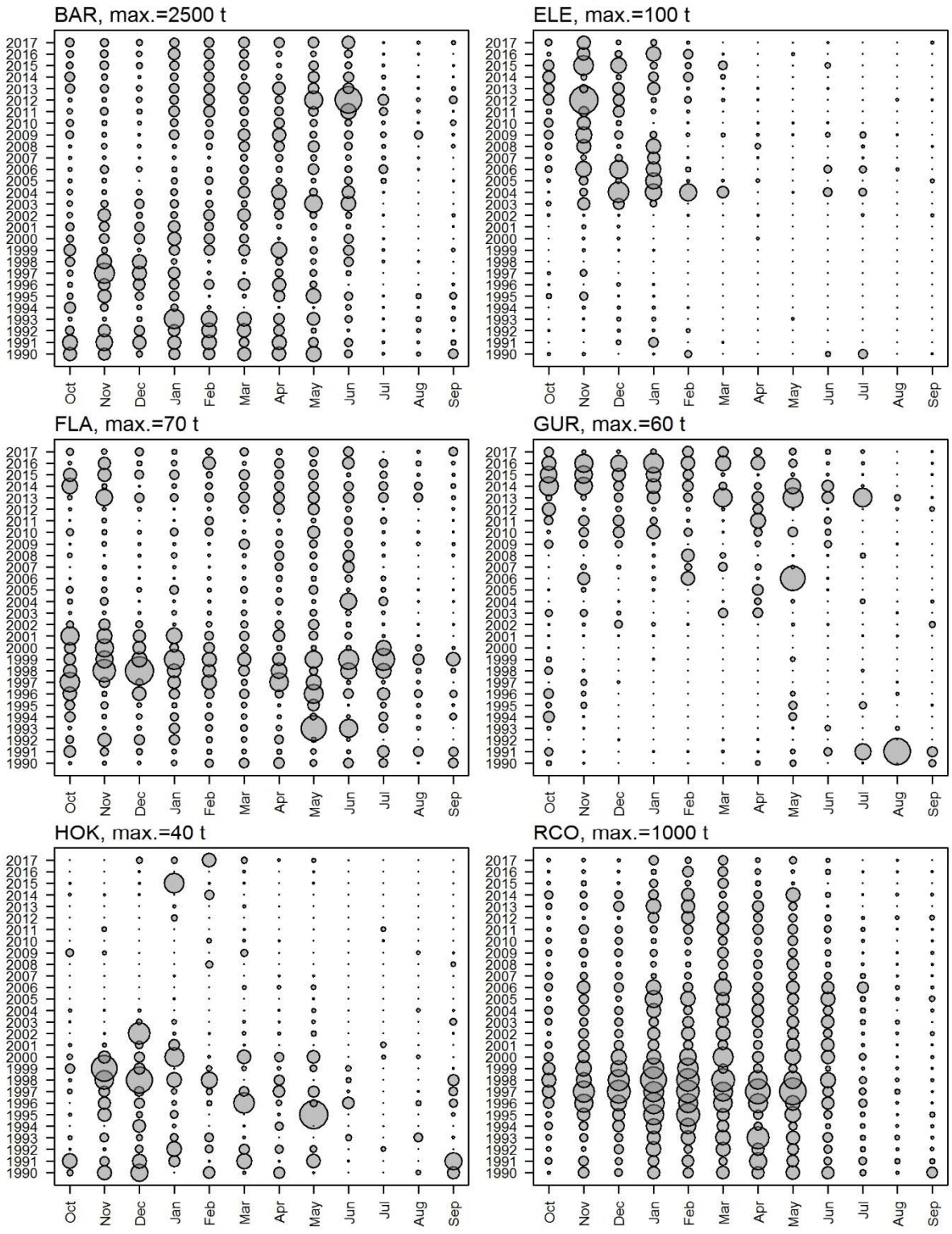


Figure C19c: Distribution of annual landed catch (t) from the merged CELR (1990–2007), TCER (2008–17), and TCEPR (1990–2017) data for the ECSI fishery area by month and fishing year for the main bottom trawl target species fisheries. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

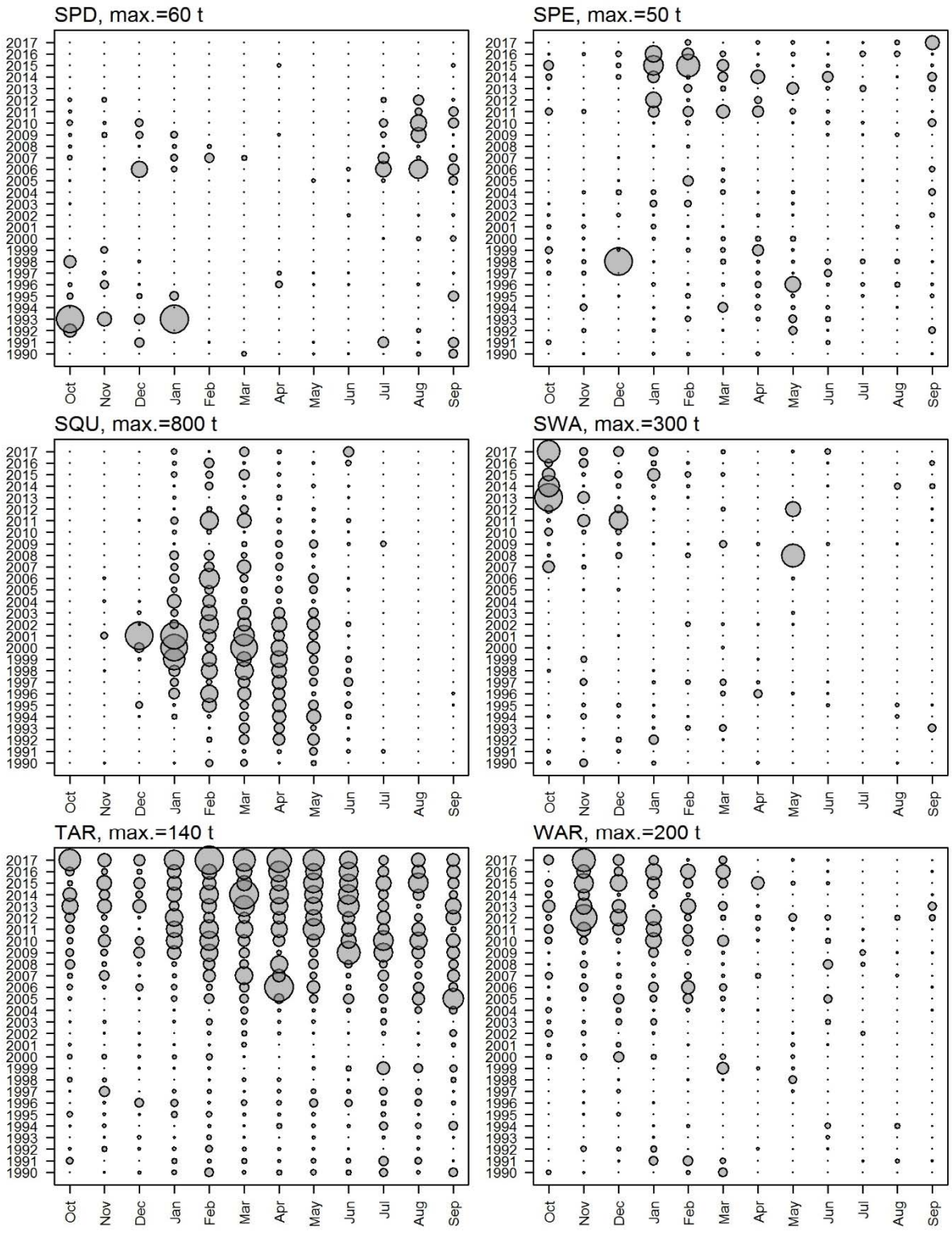


Figure C19c: — *continued*.

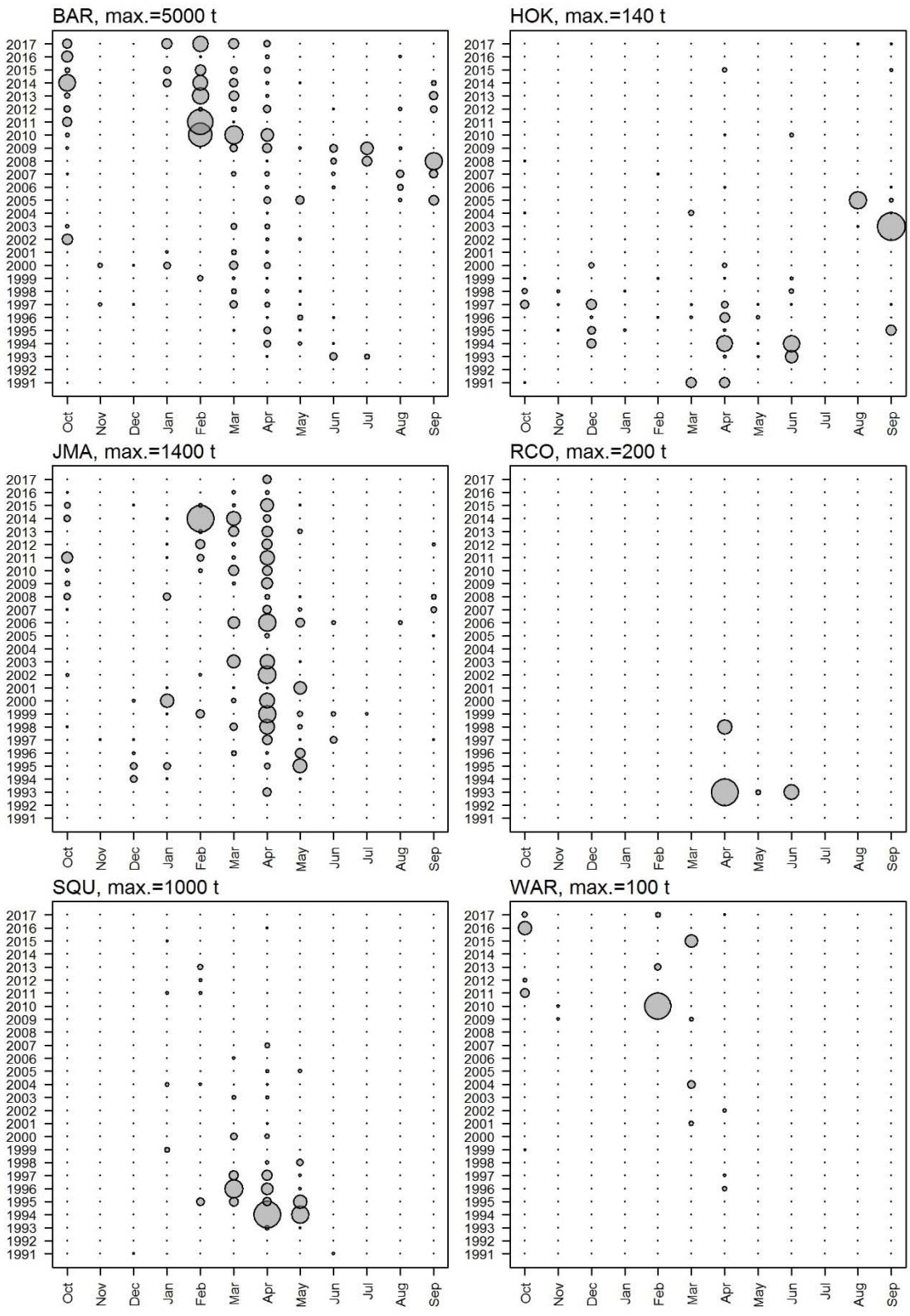


Figure C19d: Distribution of annual estimated catch (t) from the unmerged TCEPR MW data for the ECSI fishery area by month and fishing year for the main target species fisheries. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

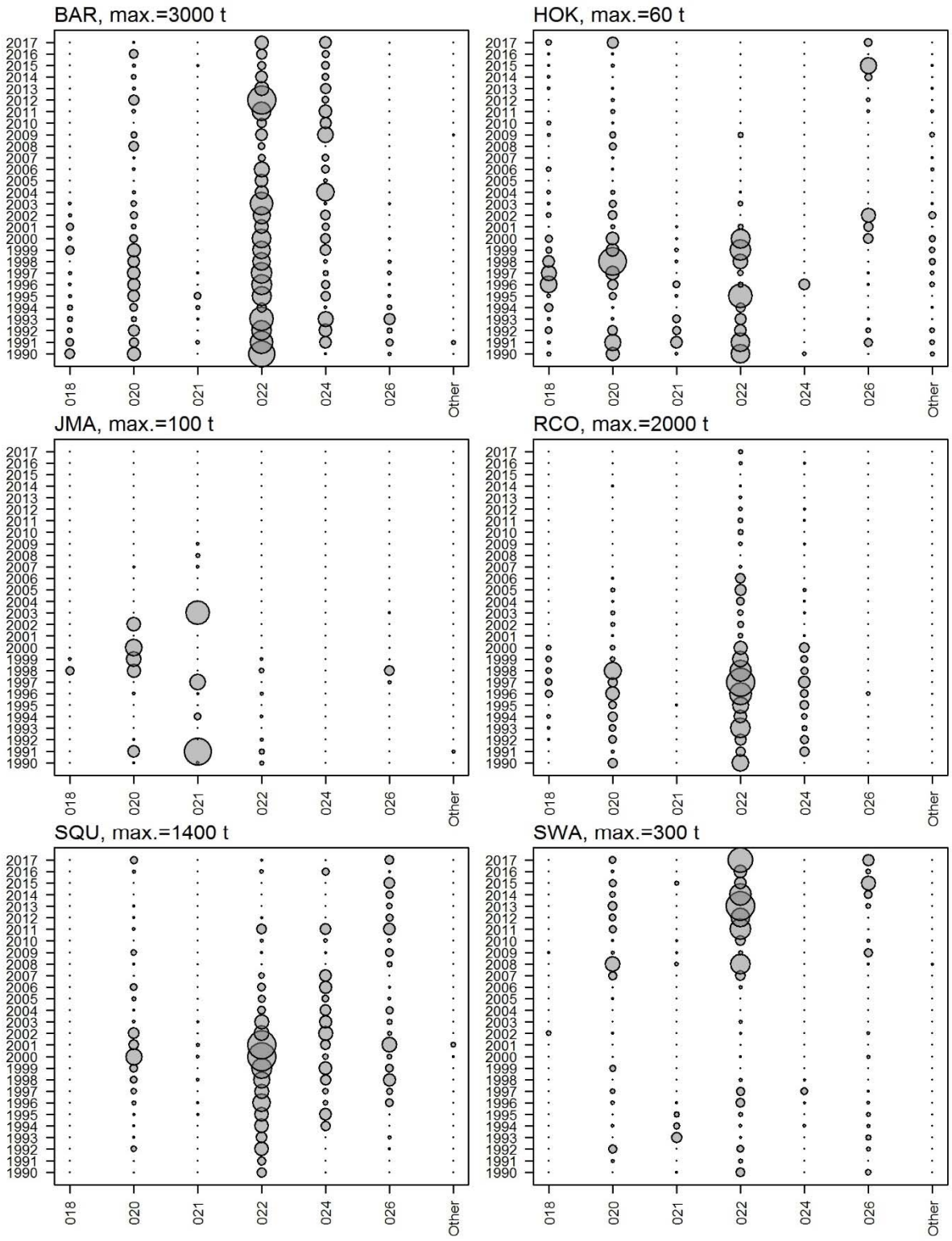


Figure C20a: Distribution of annual estimated catch (t) from the unmerged TCEPR data for the ECSI fishery area by Statistical Area and fishing year for the main bottom trawl target species fisheries. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

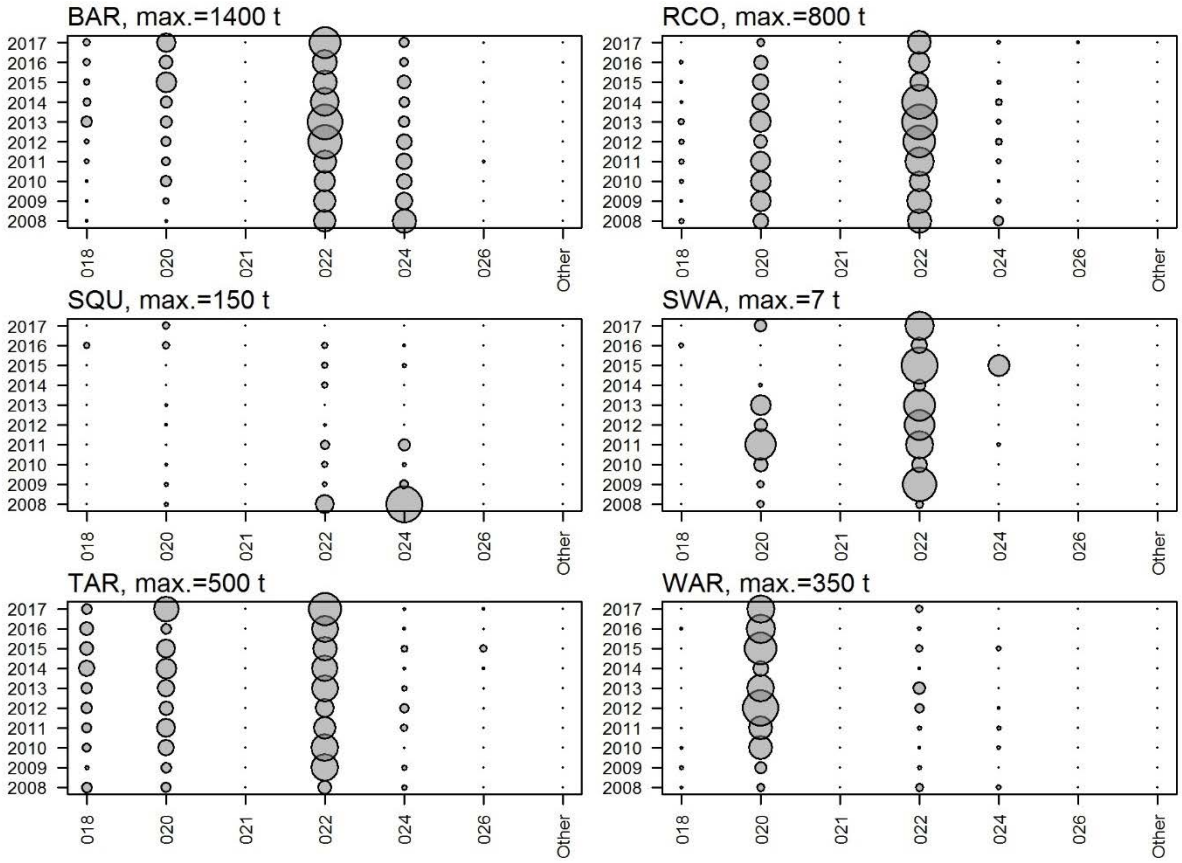


Figure C20b: Distribution of annual estimated catch (t) from the unmerged TCER data for the ECSI fishery area by Statistical Area and fishing year for the main bottom trawl target species fisheries reported on TCERs. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

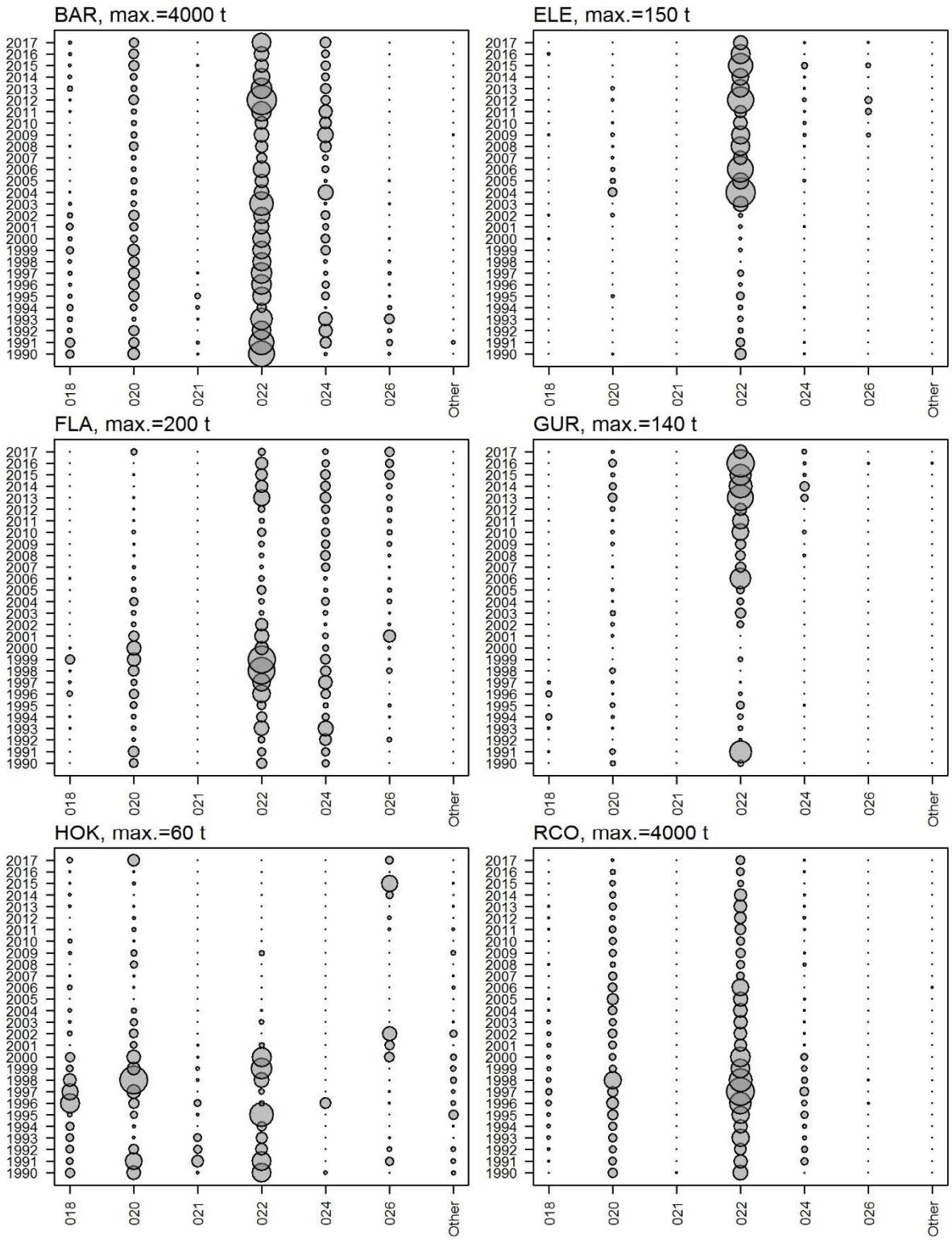


Figure C20c: Distribution of annual landed catch (t) from the merged CELR, TCER, and TCEPR data for the ECSI fishery area by Statistical Area and fishing year for the main bottom trawl target species fisheries. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

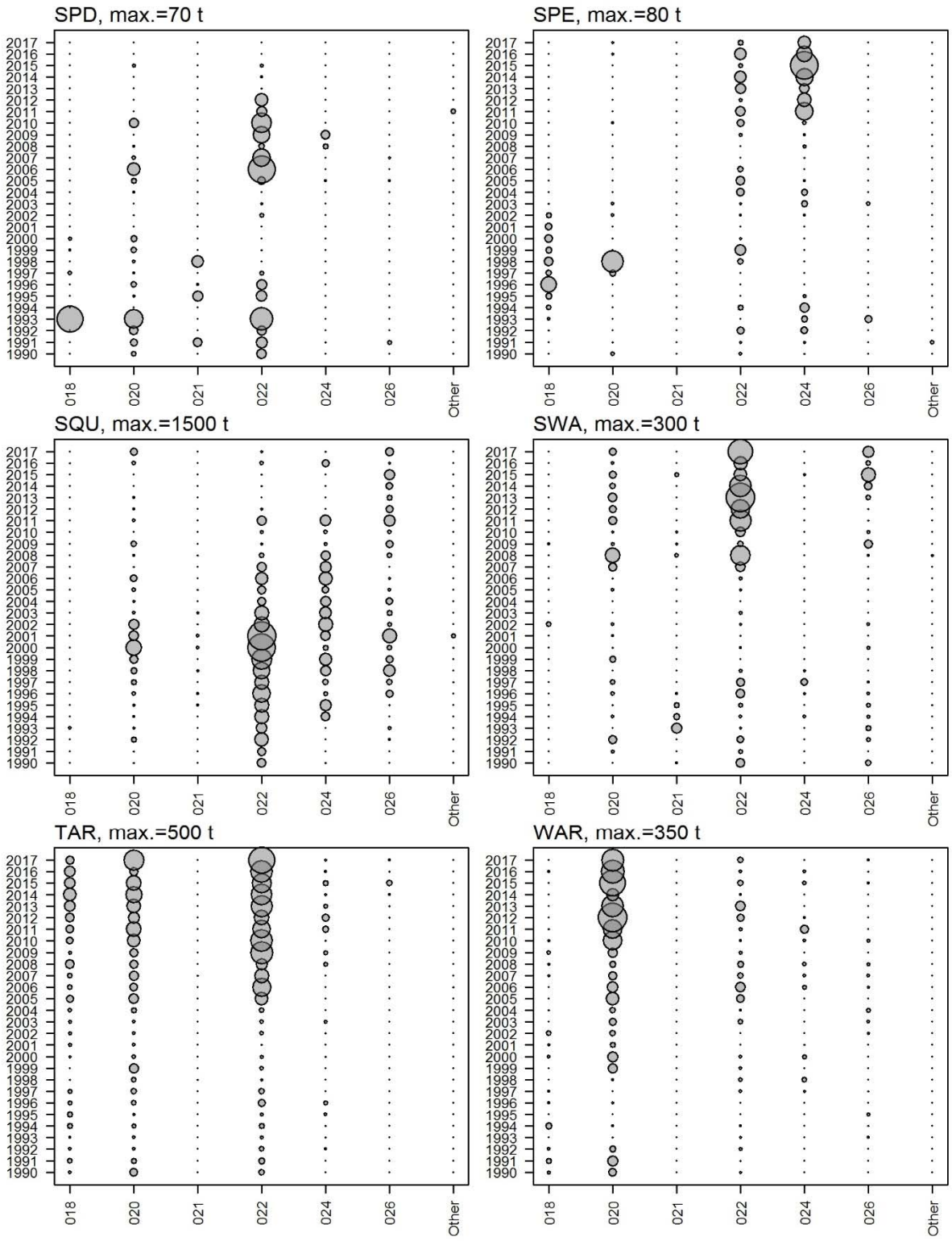


Figure C20c: — *continued*.

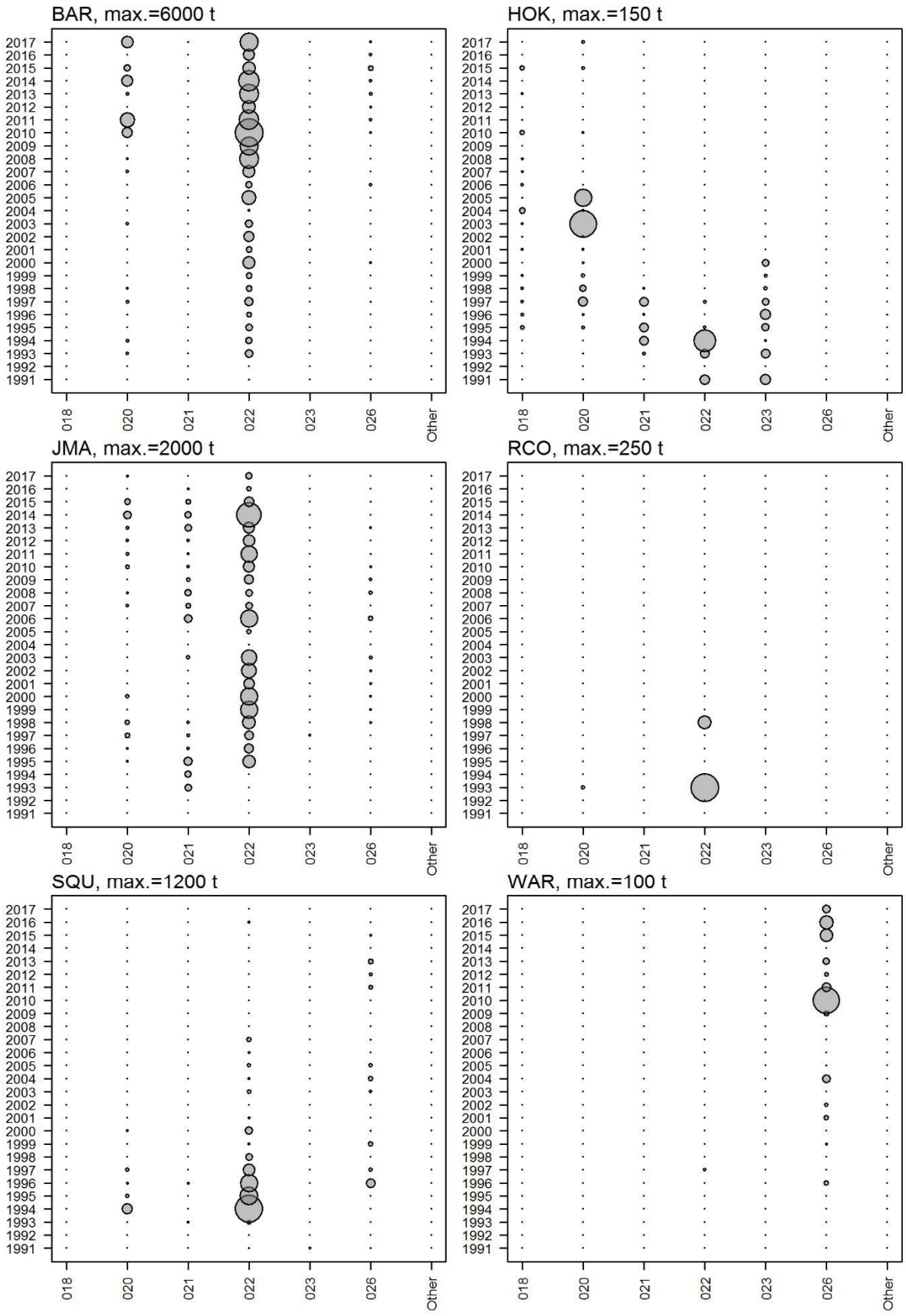


Figure C20d: Distribution of estimated catch (t) from the unmerged TCEPR MW data for the ECSI fishery area by Statistical Area and fishing year for the main target species fisheries. Circle size is proportional to the catch for each species stratum; maximum circle size is indicated on the top left-hand corner of each plot.

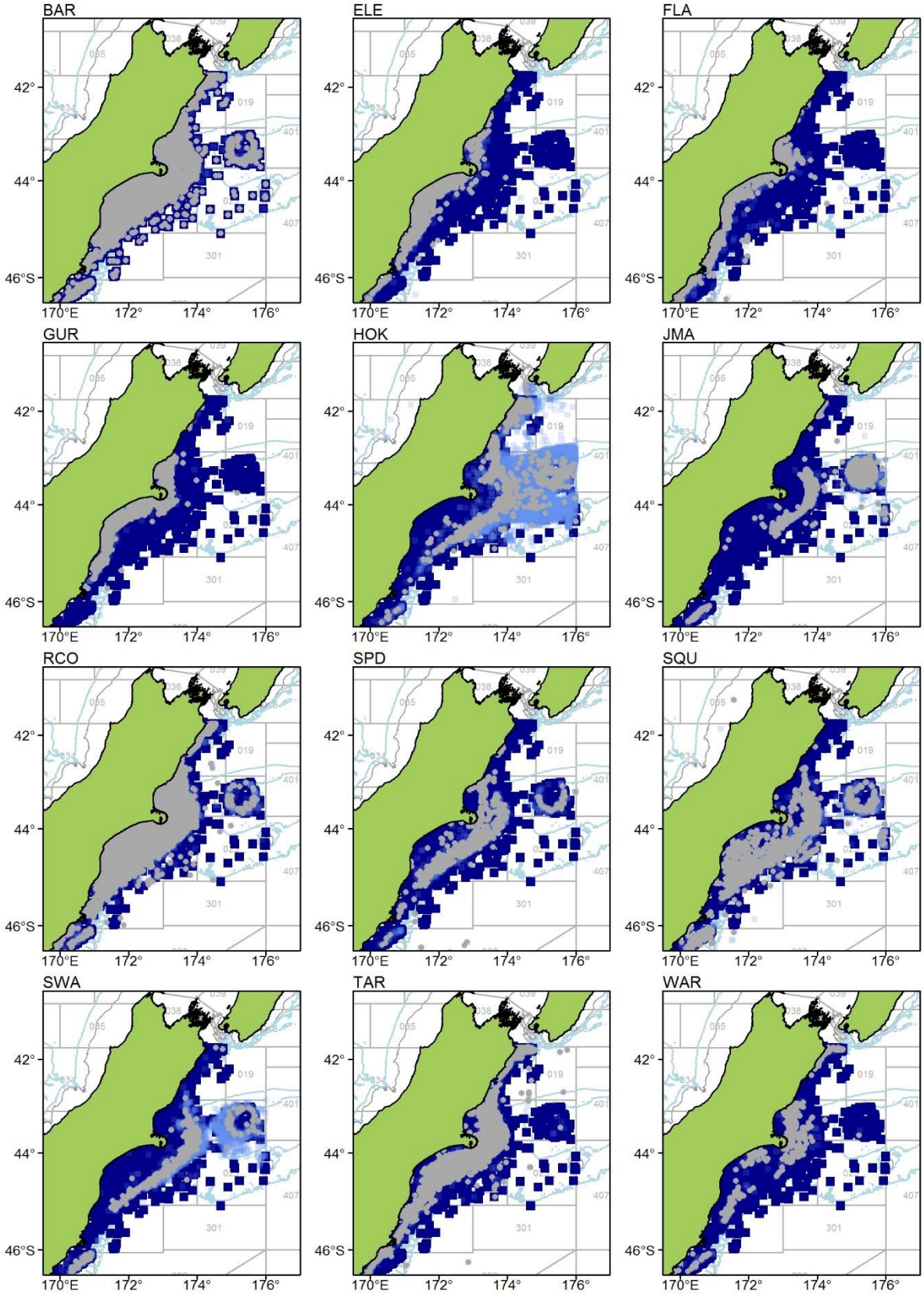


Figure C21a: Distribution of TCEPR effort for barracouta (■), for the main target species (■), and for the main target species where barracouta was caught (●), for the BAR 1 ECSI fishery, 1990–2017. Target species codes are defined in Table B1.

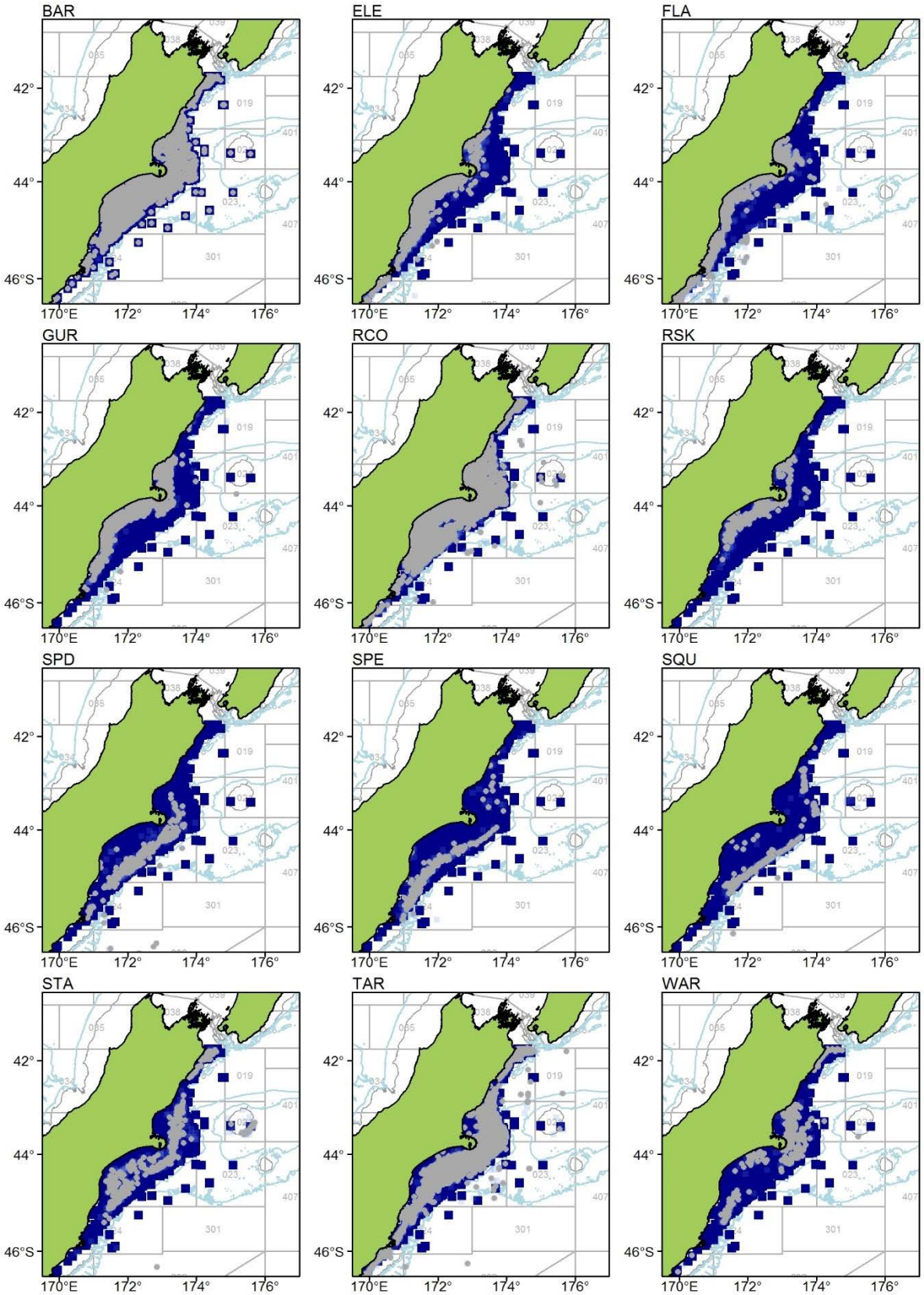


Figure C21b: Distribution of TCER effort for barracouta (■), for the main target species (■), and for the main target species where barracouta was caught (●), for the BAR 1 ECSI fishery area, fishing years 2008–17 combined. Target species codes are defined in Table B1.

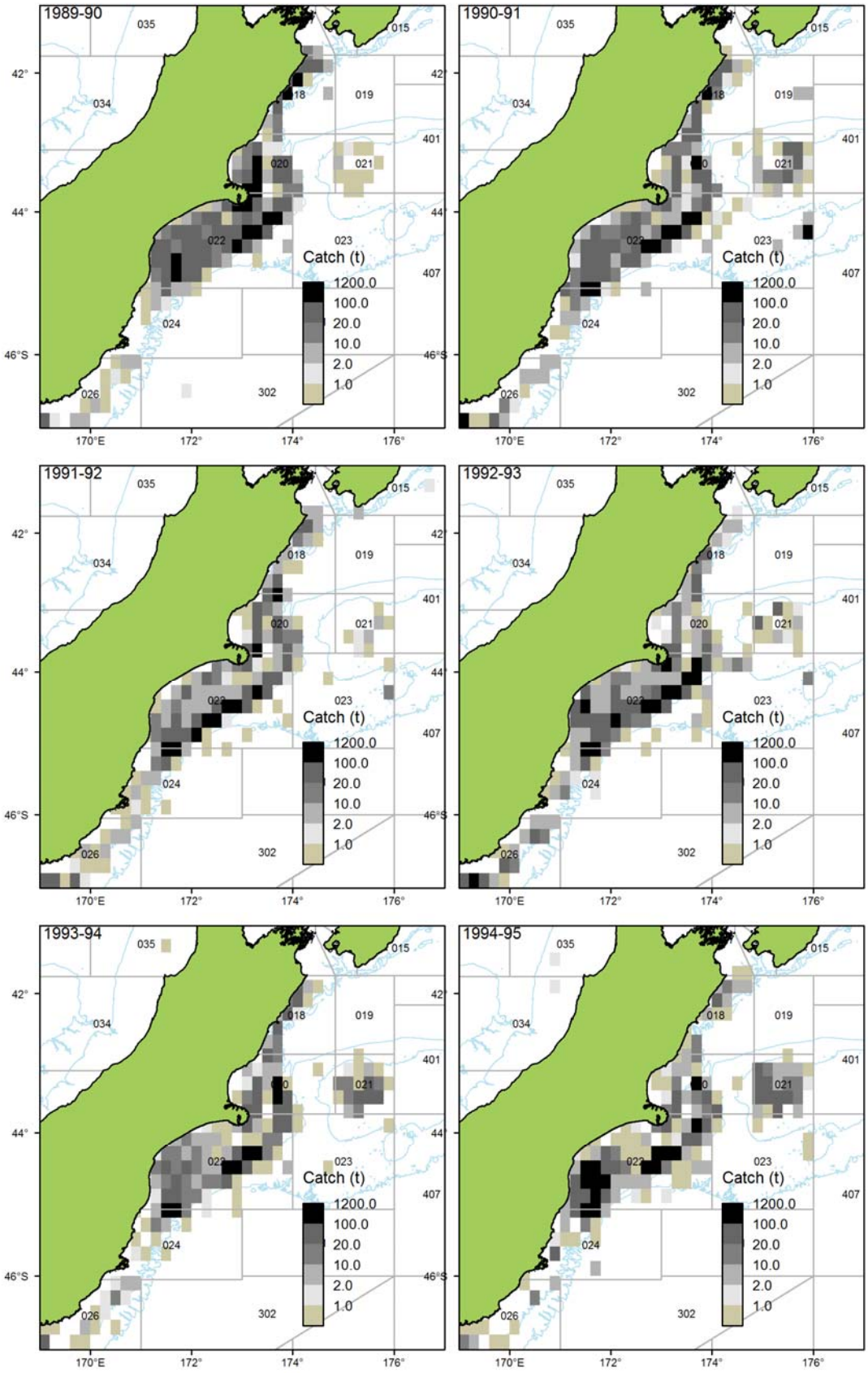


Figure C22a: Distribution of TCEPR bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 1989–90 to 1994–95. Blue lines show the 500 m and 1000 m depth contours.

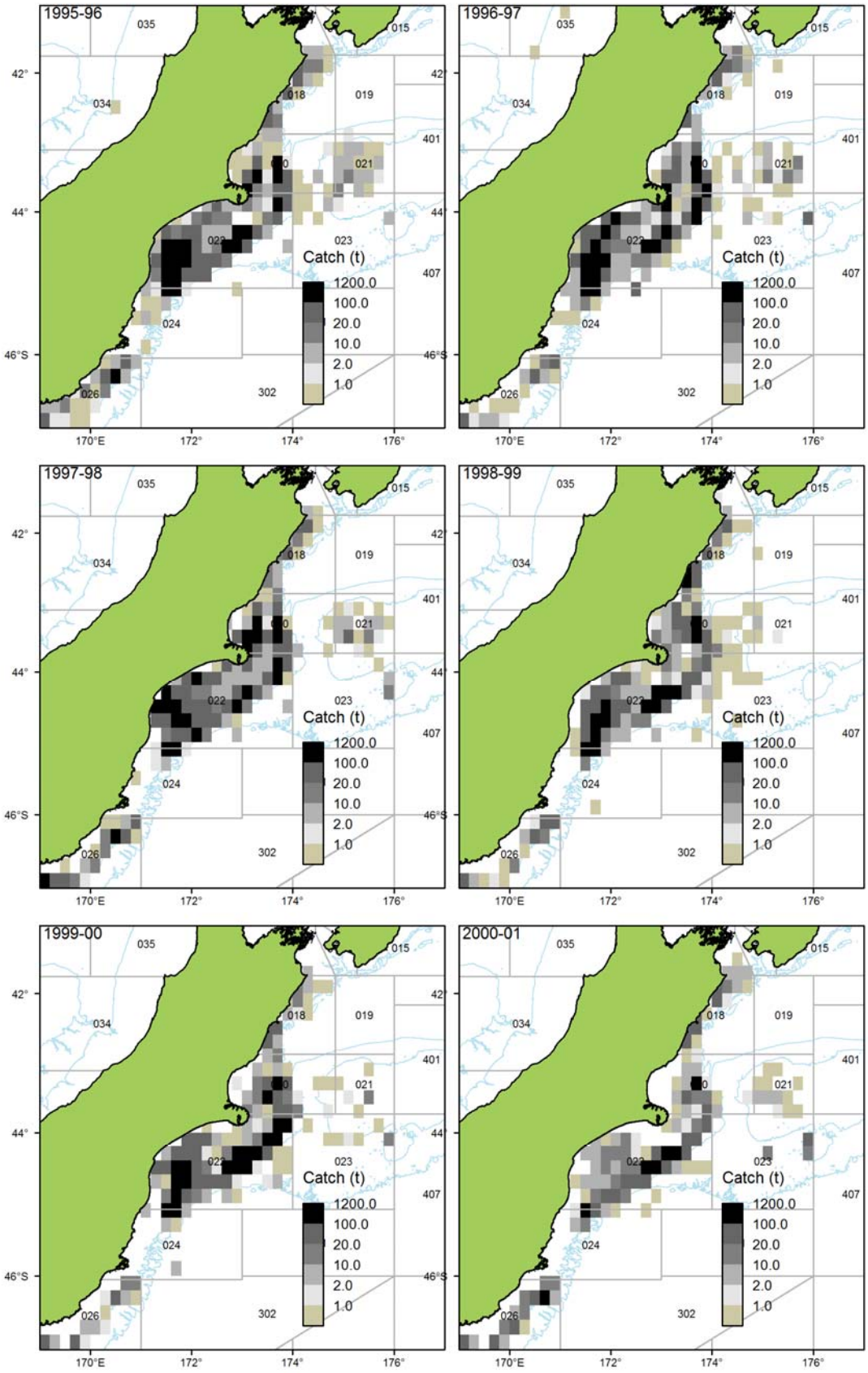


Figure C22a *continued*: Distribution of TCEPR bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 1995–96 to 2000–01. Blue lines show the 500 m and 1000 m depth contours.

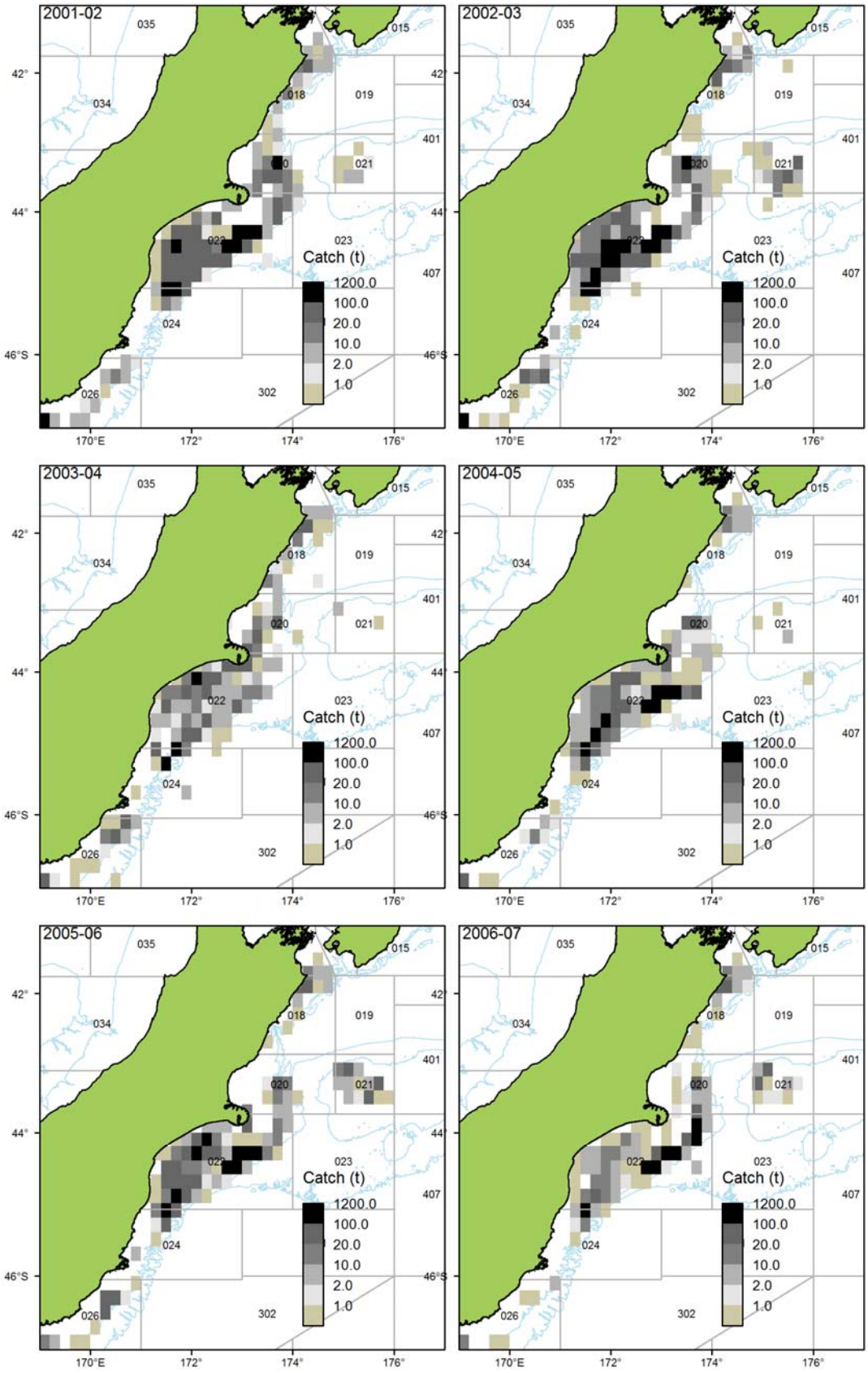


Figure C22a *continued*: Distribution of TCEPR bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 2001–02 to 2006–07. Blue lines show the 500 m and 1000 m depth contours.

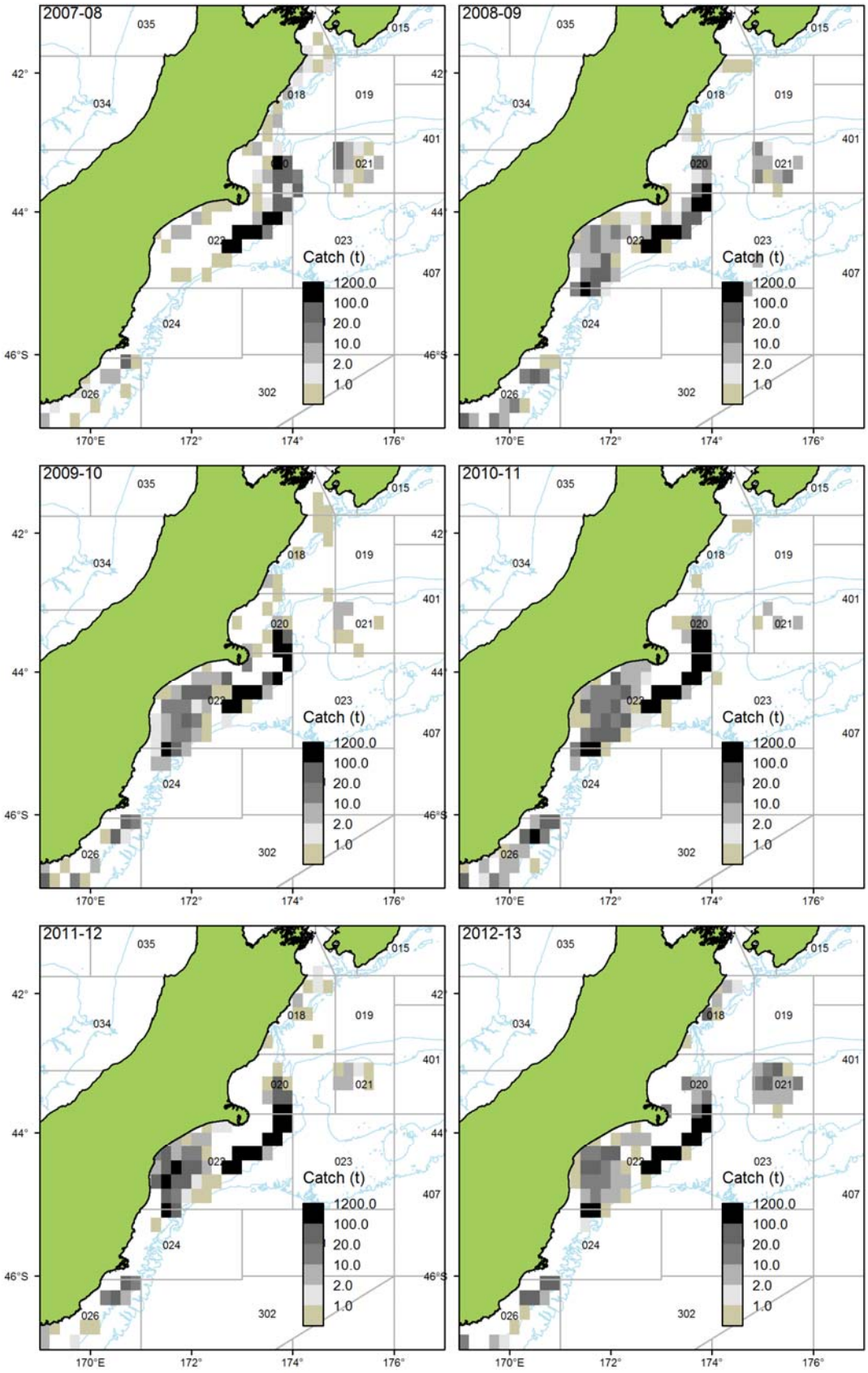


Figure C22a *continued*: Distribution of TCEPR bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 2007–08 to 2012–13. Blue lines show the 500 m and 1000 m depth contours.

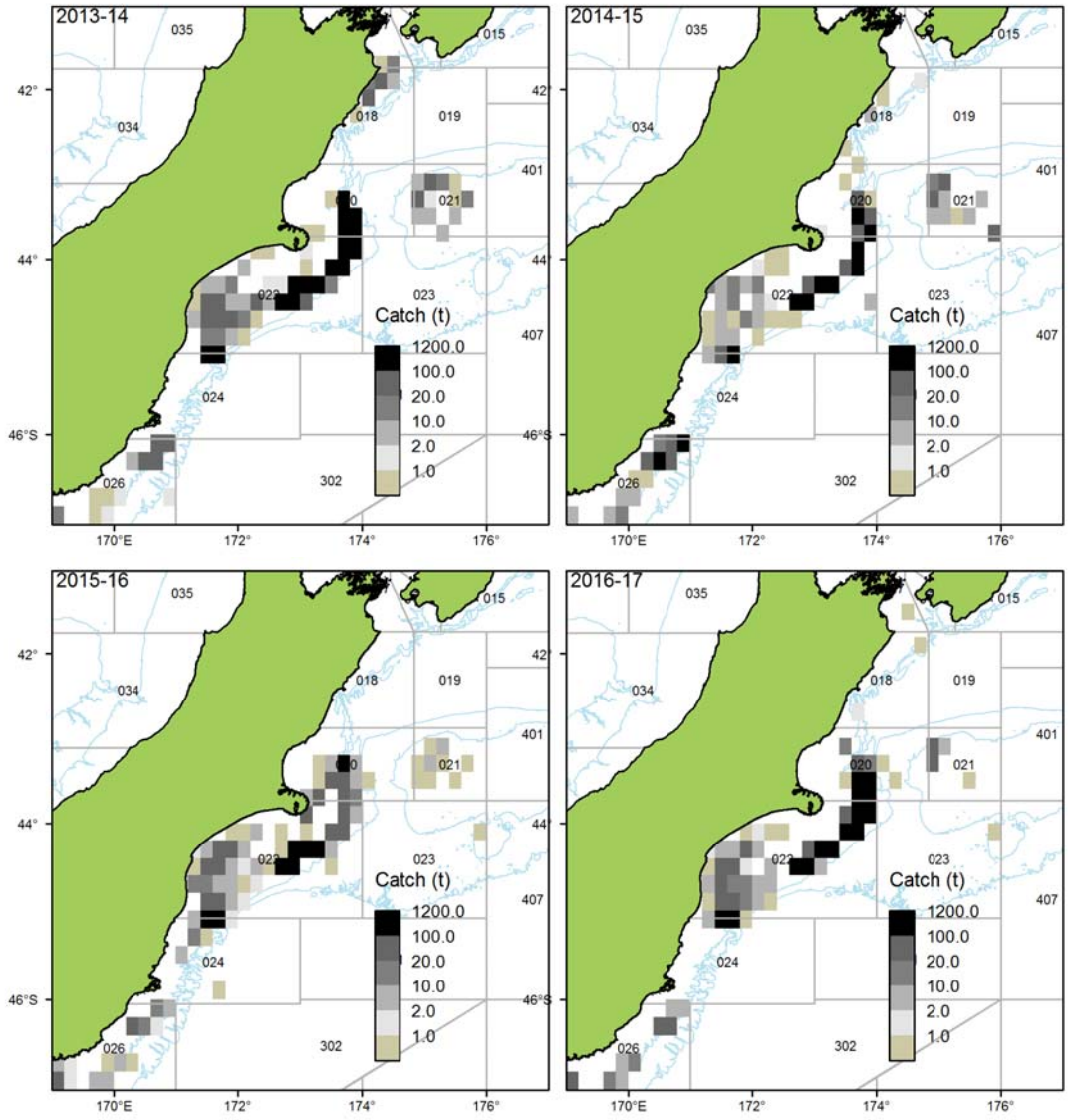


Figure C22a *continued*: Distribution of TCEPR bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 2013–14 to 2016–17. Blue lines show the 500 m and 1000 m depth contours.

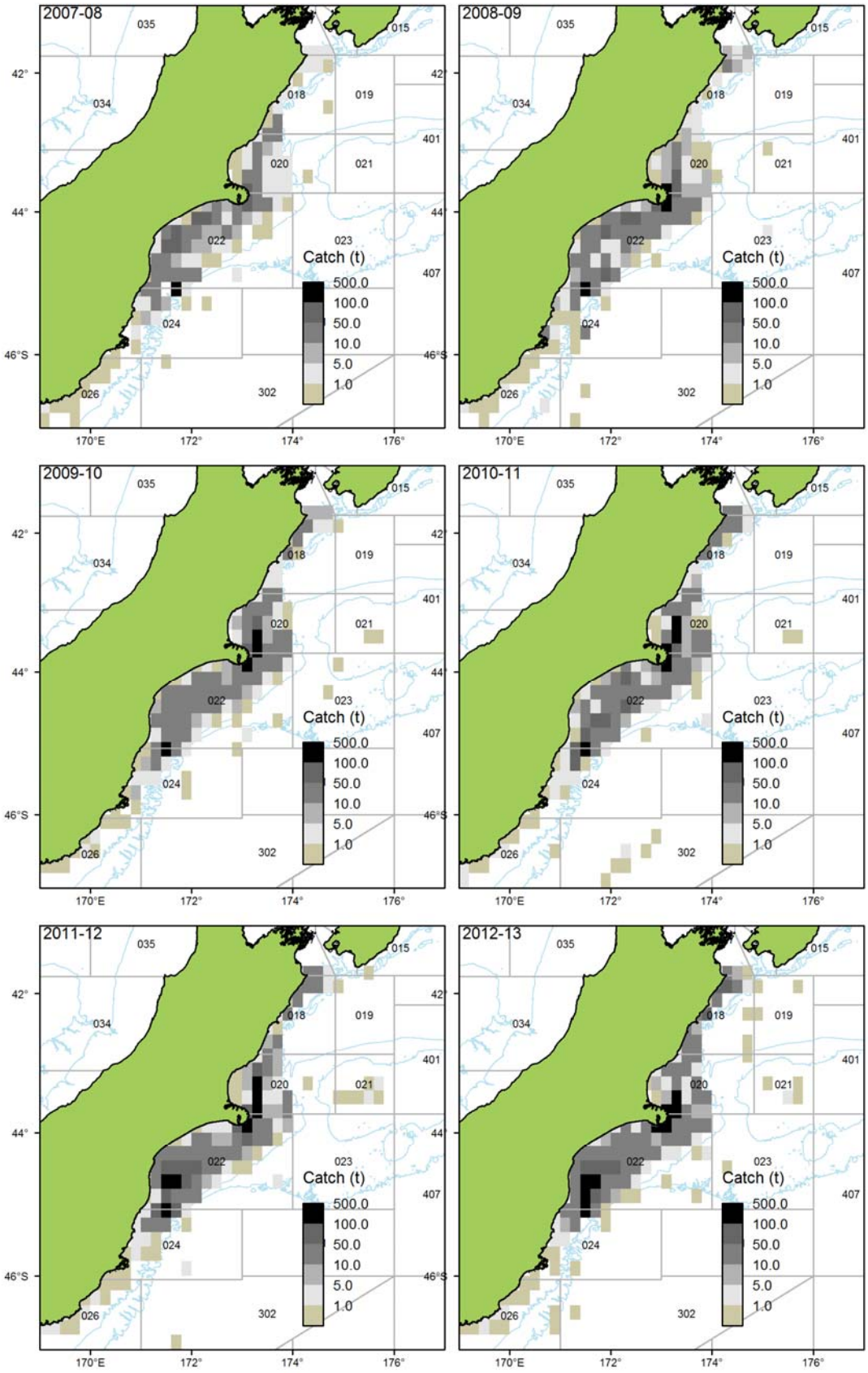


Figure C22b: Distribution of TCER bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 2007–08 to 2012–13. Blue lines show the 500 m and 1000 m depth contours.

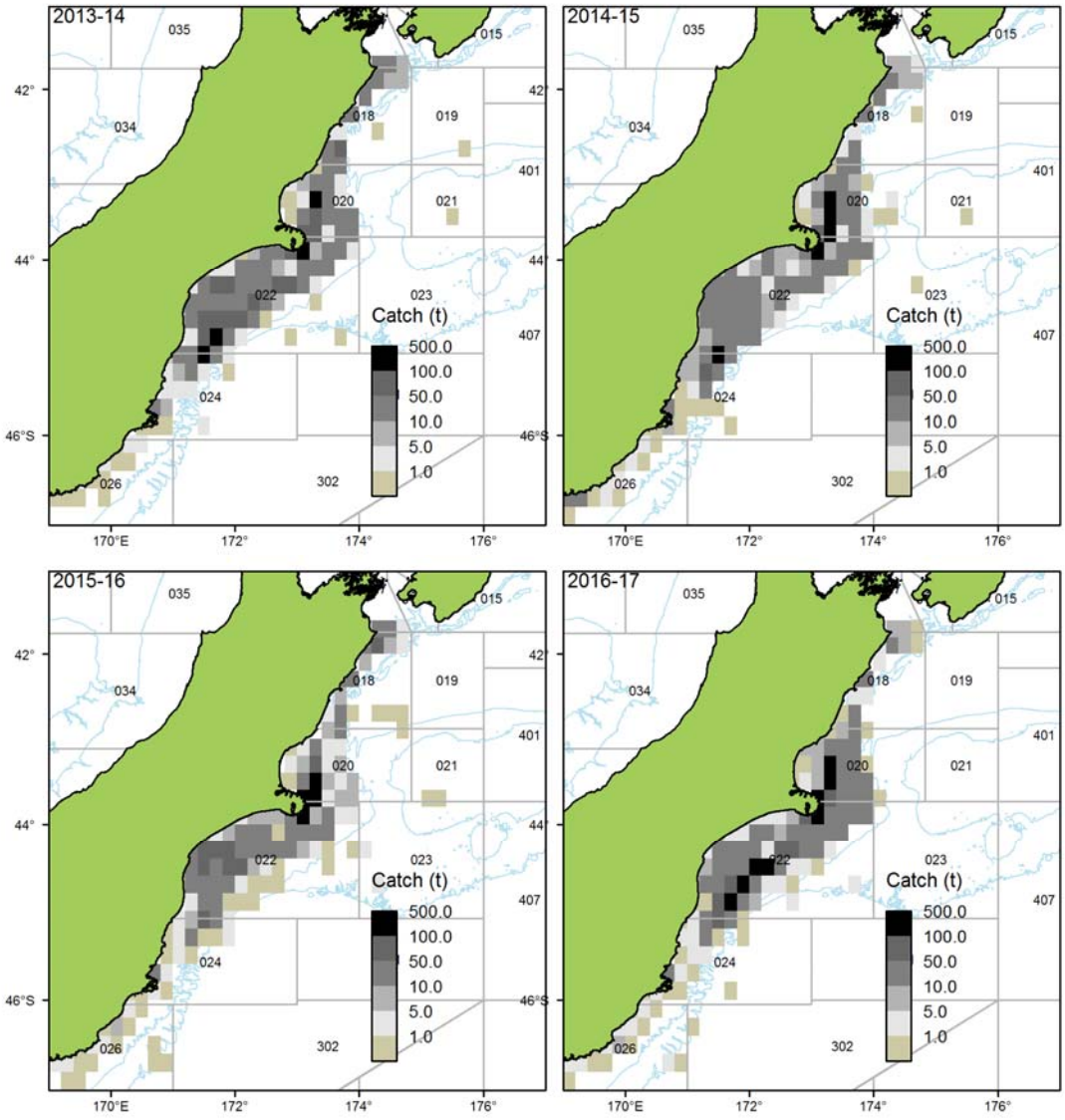


Figure C22b *continued*: Distribution of TCER bottom trawl barracouta catch aggregated into 0.2° cells within the BAR 1 ECSI area, 2013–14 to 2016–17. Blue lines show the 500 m and 1000 m depth contours.

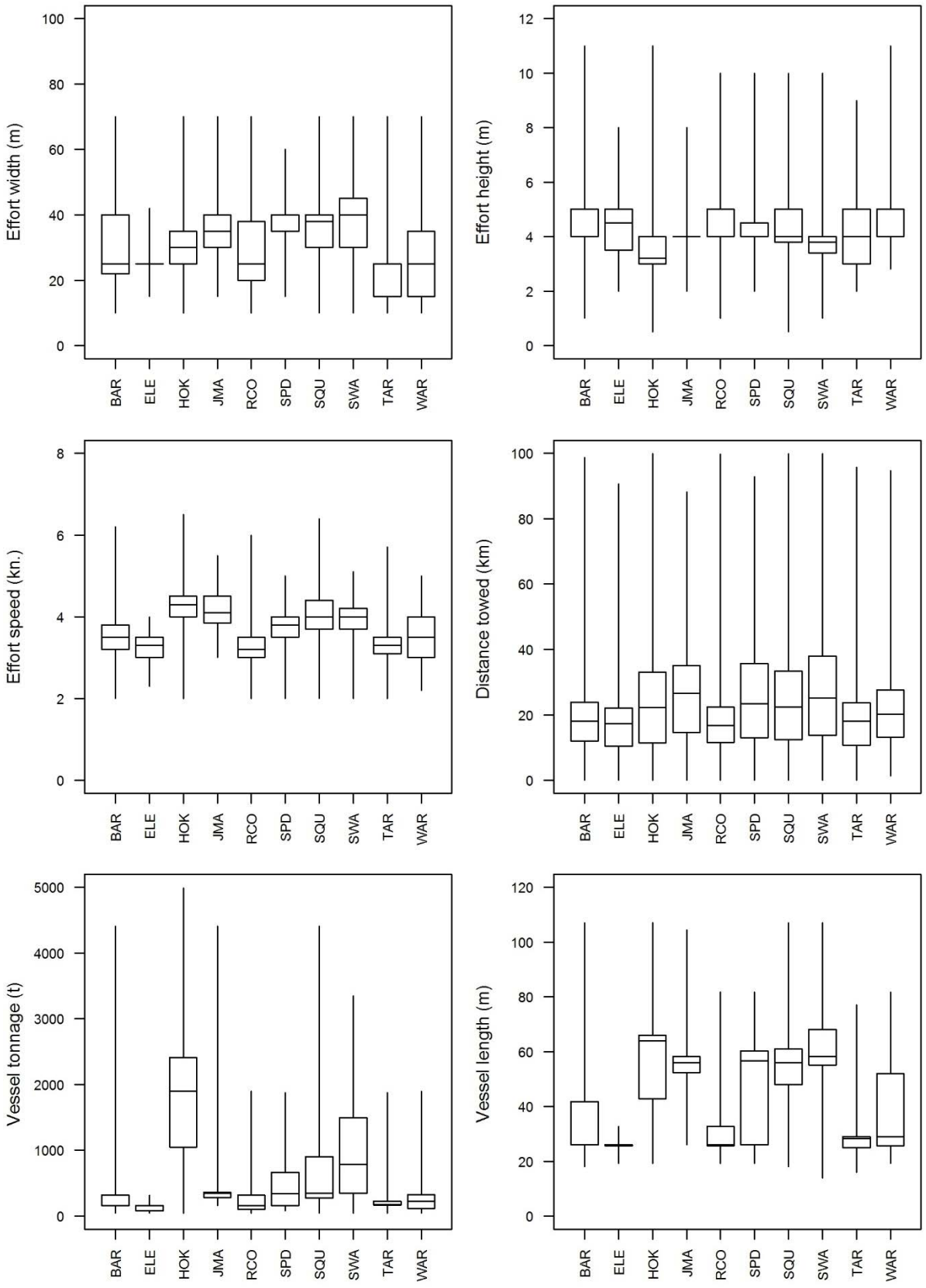


Figure C23a: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCEPR bottom trawl tow variables reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are given in Table B1.

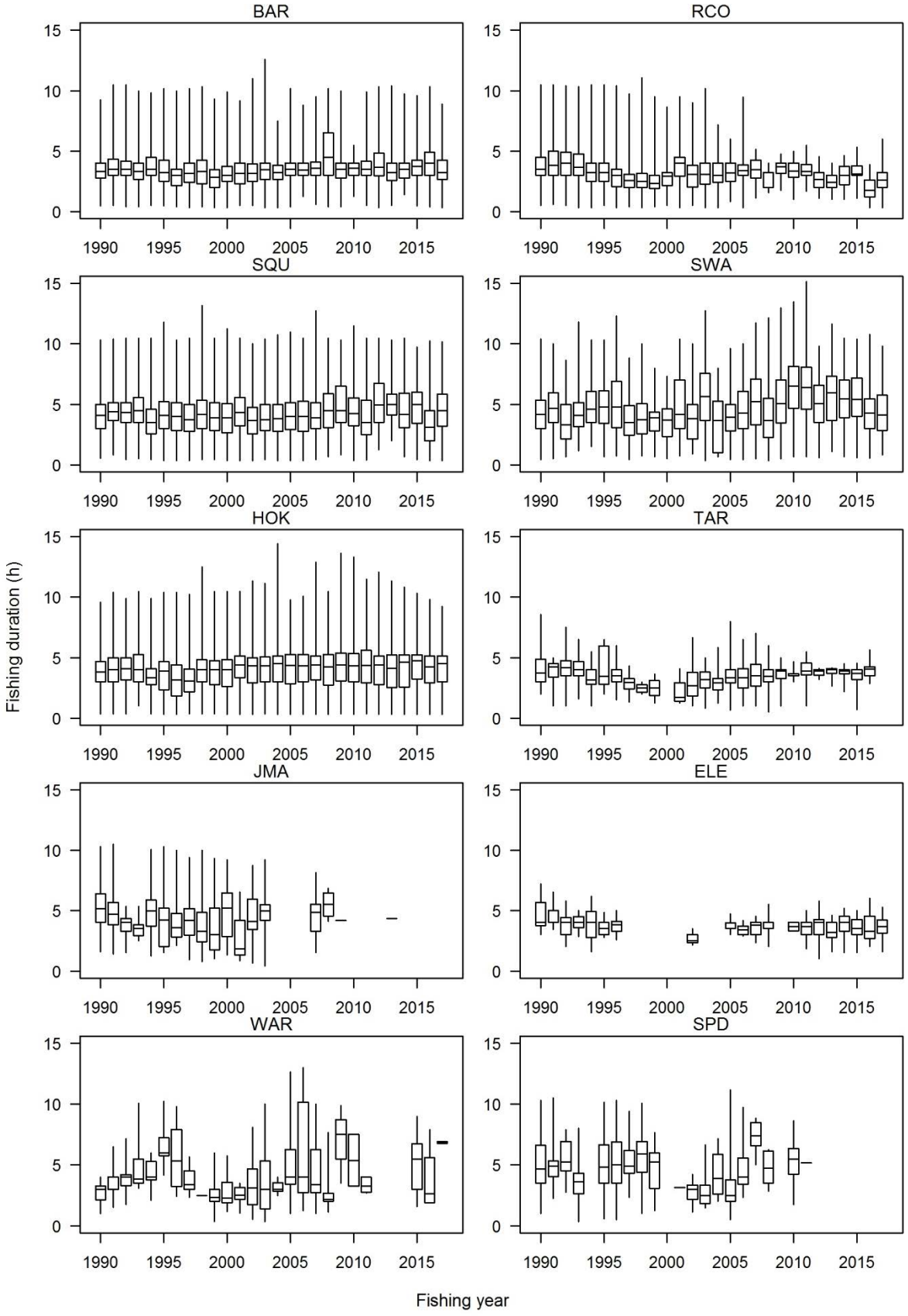


Figure C23b: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCEPR bottom trawl tow durations reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are given in Table B1.

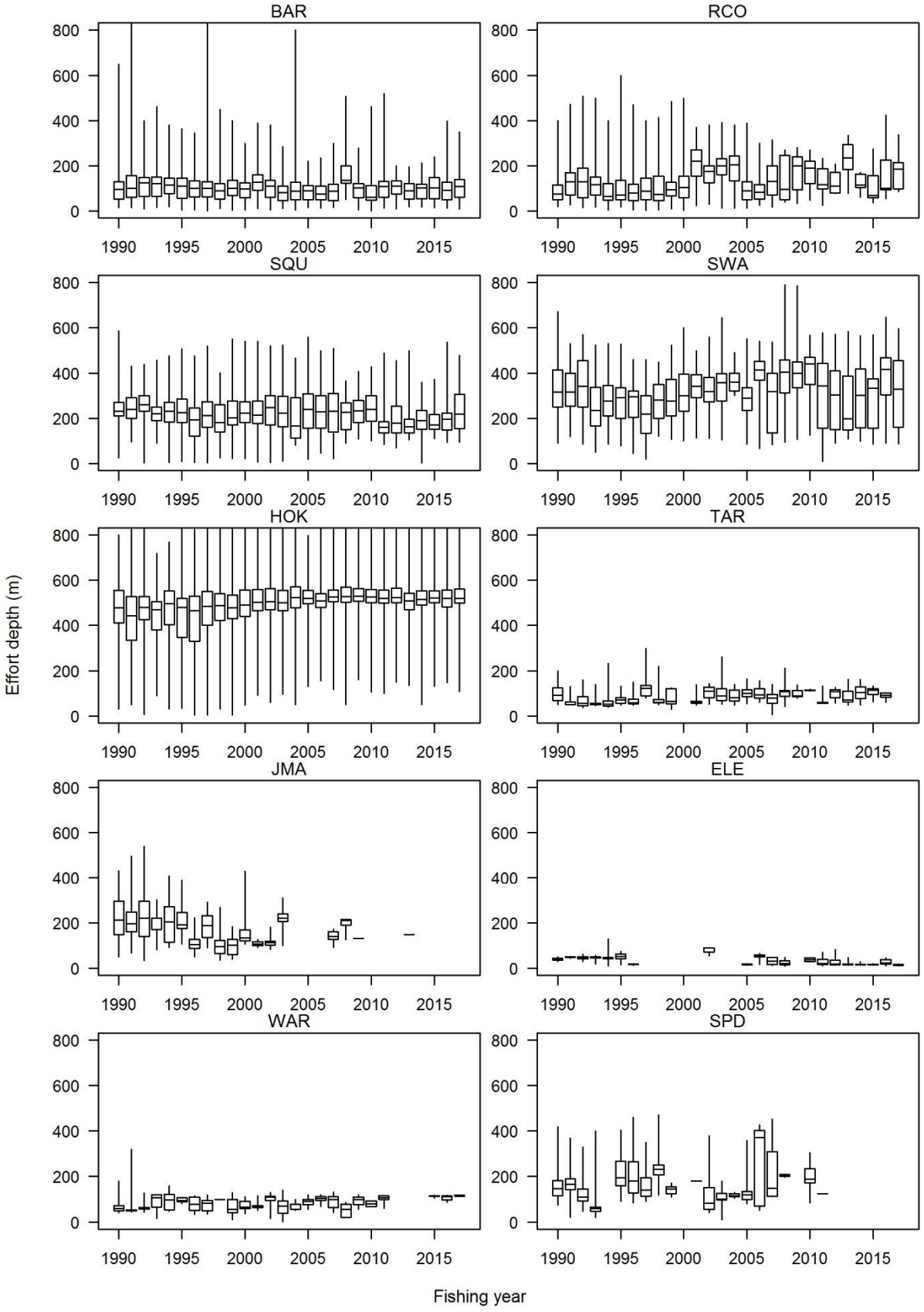


Figure C23c: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCEPR bottom trawl tow durations reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are given in Table B1.

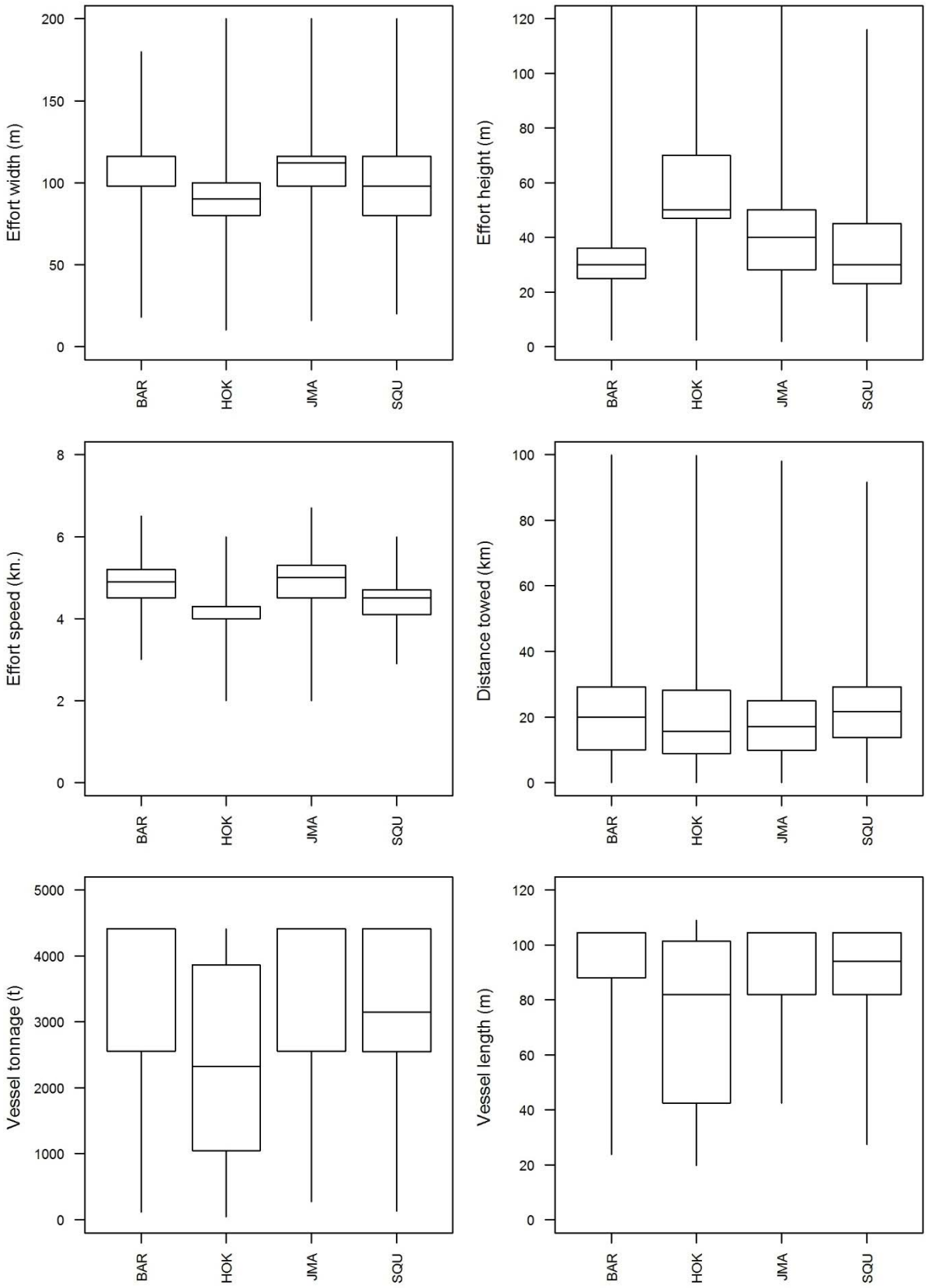


Figure C23d: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCEPR midwater trawl tow variables reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are given in Table B1.

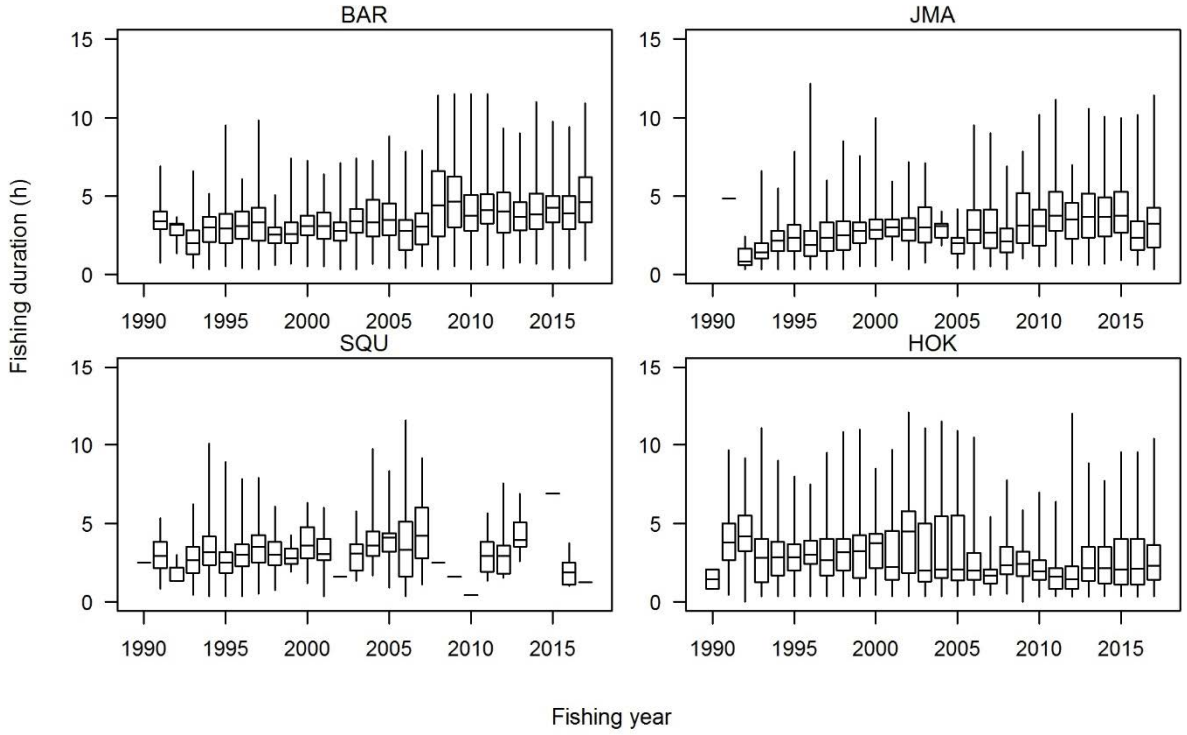


Figure C23e: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCEPR midwater trawl tow durations reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are given in Table B1.

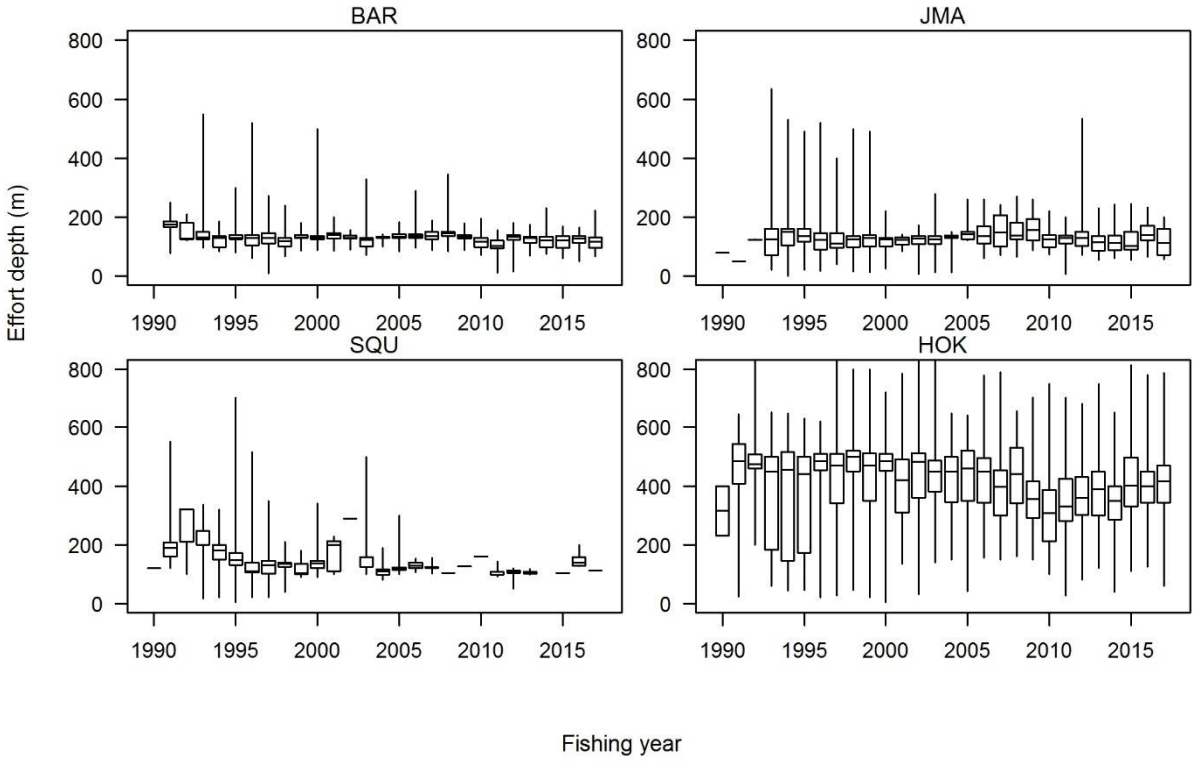


Figure C23f: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCEPR midwater trawl fishing depth reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are given in Table B1.

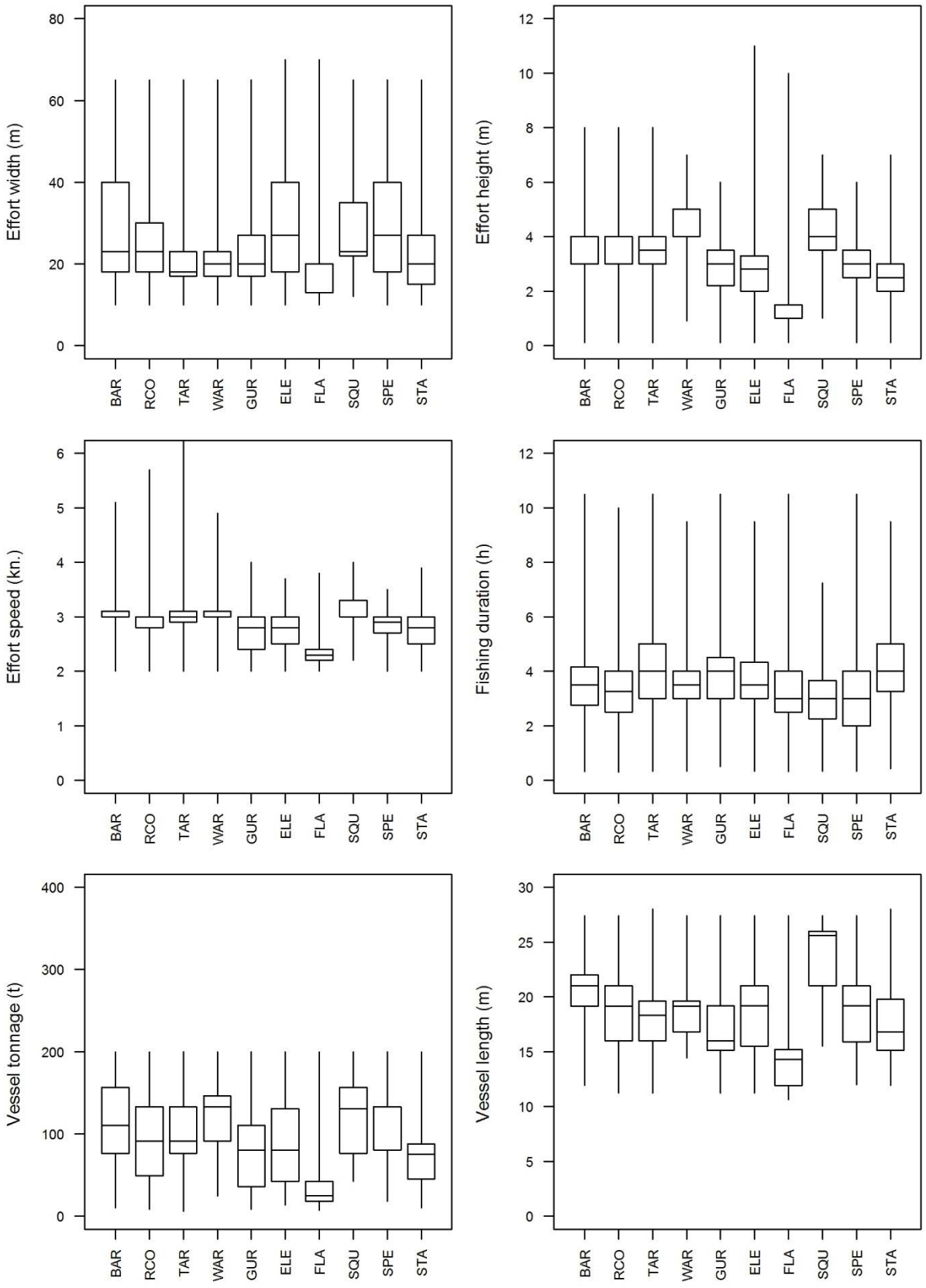


Figure C24a: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCER bottom trawl variables reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

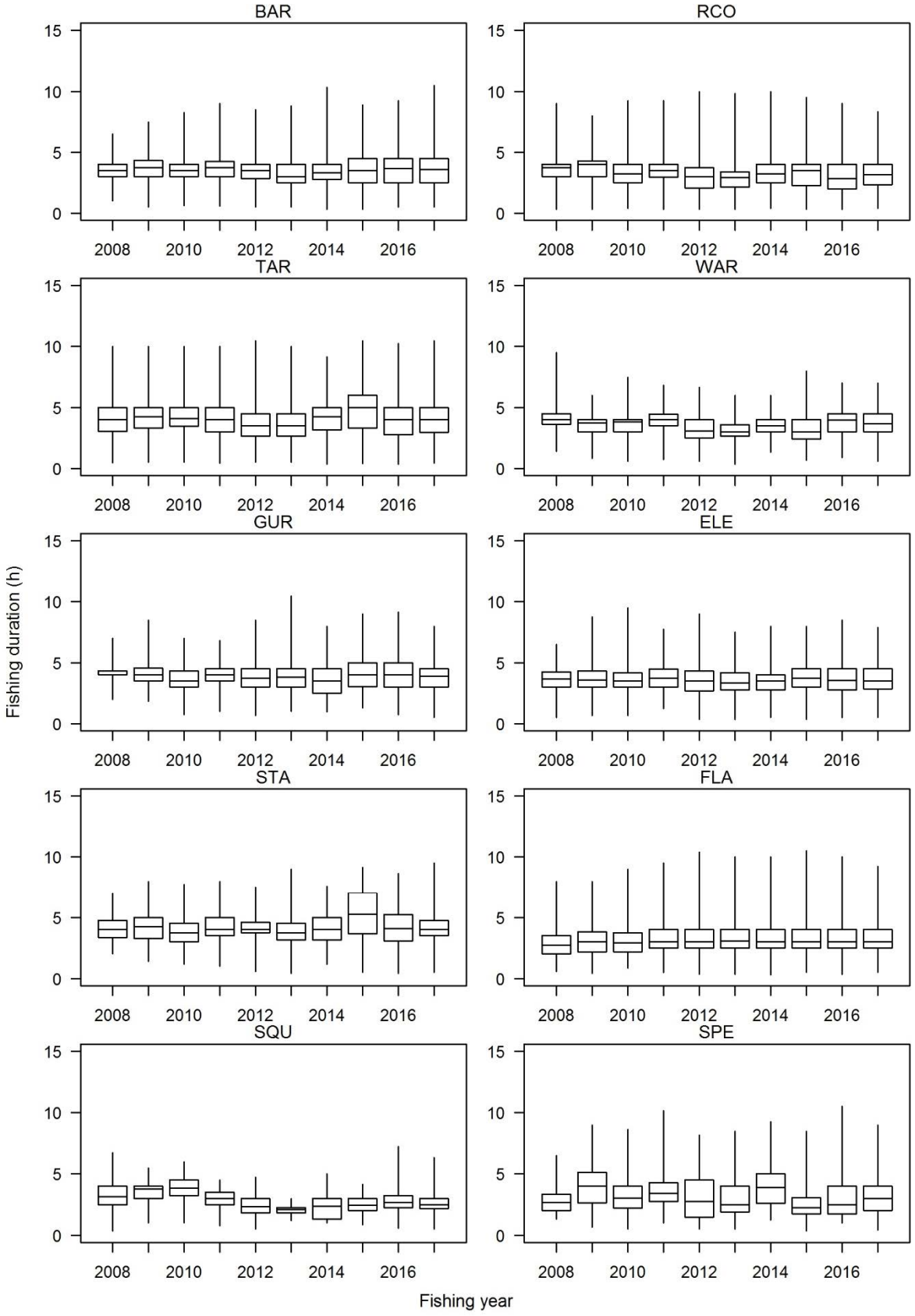


Figure C24b: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCER bottom trawl fishing duration reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

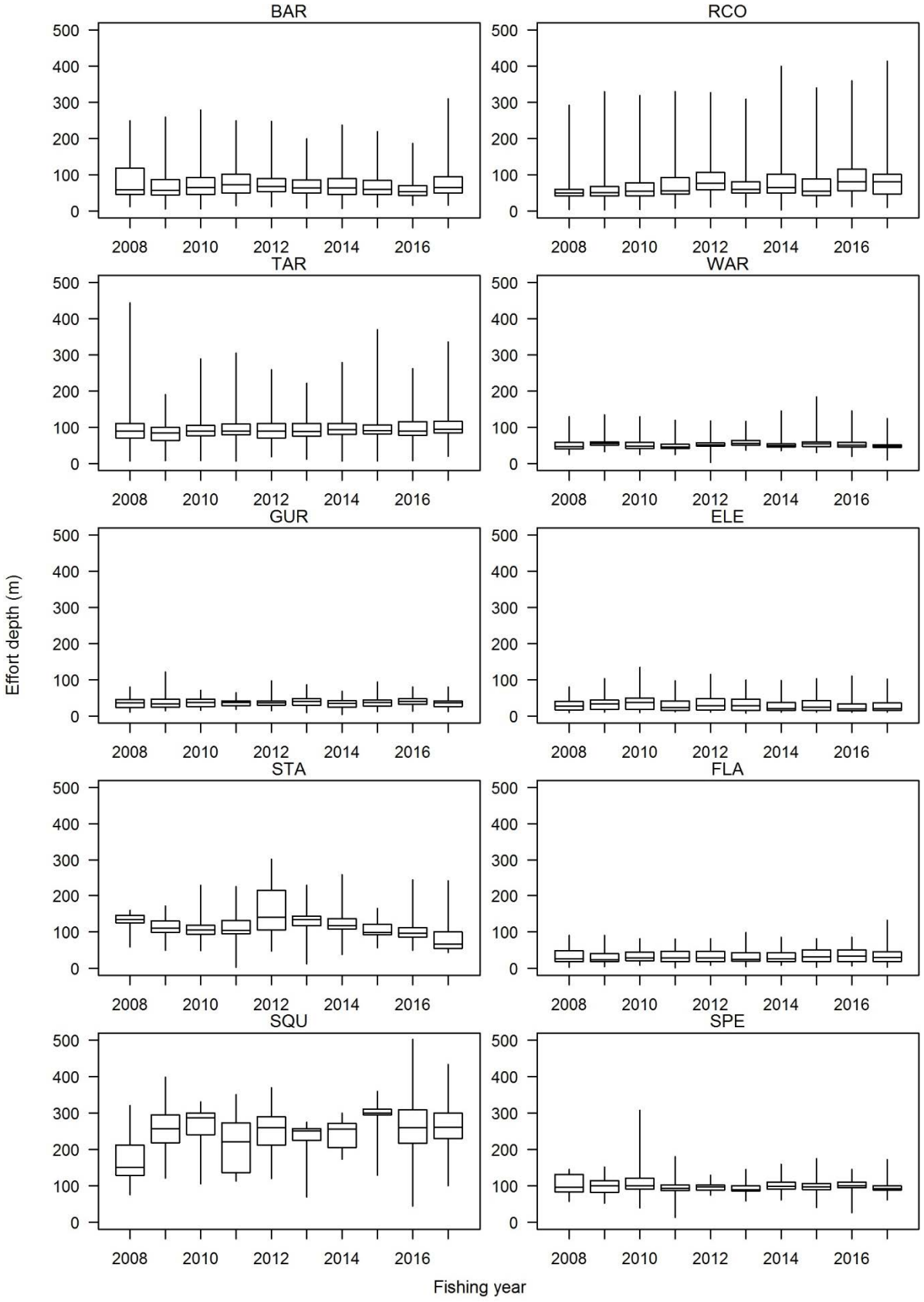


Figure C24c: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) of TCER bottom trawl fishing depth reported for major target species fisheries catching barracouta in the BAR 1 ECSI fishery area, based on the groomed unmerged data. Target species codes are defined in Table B1.

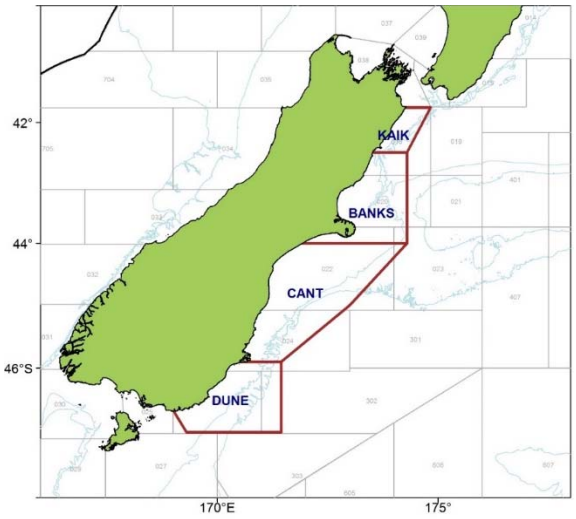


Figure C25: Areas used to analyse the barracouta catch from tow-by-tow TCER records, for 2008–17.

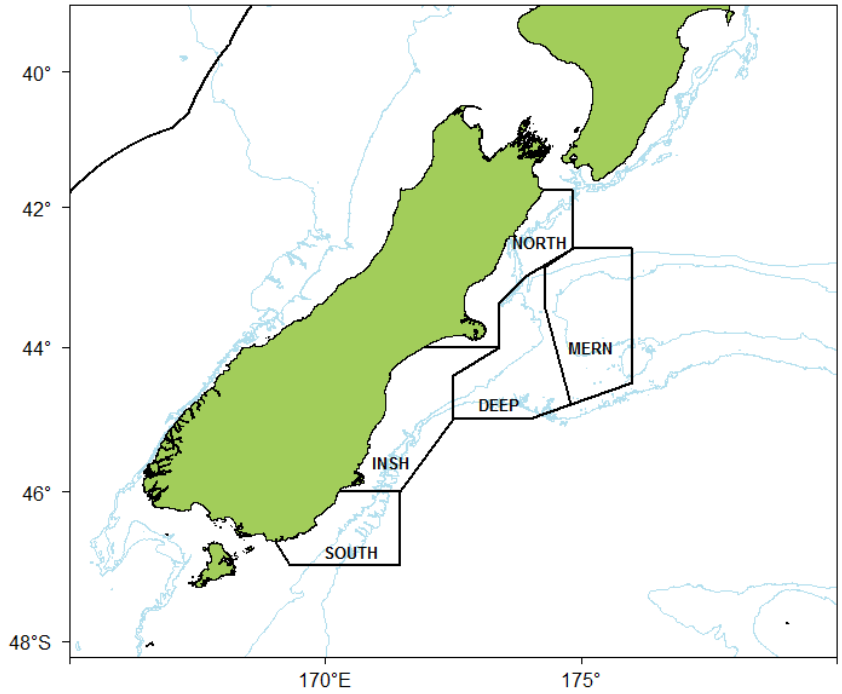


Figure C26: Areas used to analyse the barracouta catch from tow-by-tow TCEPR records. The areas here denote activity by different fleets: catch from New Zealand vessels was generally in less than 250 m and primarily from the INSH area; catch from joint-venture vessels was mainly from the edge of the shelf in the DEEP area and in the SOUTH area. Data from the MERN area were not included.

14. APPENDIX D: CATCH-PER-UNIT-EFFORT ANALYSIS

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

(a) BAR 1 ECSI CELR/TCER/TCEPR bottom trawl day-by-day landed catch data

Variable	Type	Description
Year	Categorical	Fishing year (1 Oct–30 Sep)
Vessel	Categorical	Unique (encrypted) vessel identification
Statistical area	Categorical	Statistical area
Target species	Categorical	Main daily target species
Month	Categorical	Month of fishing year
Fishing duration	Continuous	Duration of daily effort (h)
Headline height	Continuous	Headline height (m) of the net for a tow
Bottom depth	Continuous	Seabed depth (m) for a tow
Effort depth	Continuous	Depth of trawl gear (m)
Speed	Continuous	Vessel speed (kn.) for a tow
Wingspread	Continuous	Wingspread (m) of the net for a tow
Vessel experience	Continuous	Number of years the vessel has been
Catch	Continuous	Estimated greenweight (t) of barracouta
Fday	Continuous	Day of the year

(b) BAR 1 ECSI TCEPR and TCER bottom trawl tow-by-tow data

Variable	Type	Description
Year	Categorical	Fishing year (1 Oct–30 Sep)
Vessel	Categorical	Unique (encrypted) vessel identification
Statistical area	Categorical	Statistical area
Trawl region	Categorical	Allocated trawl region based on catch
Tow duration	Continuous	Duration of tow (h)
Tow distance	Continuous	Distance of tow (km) (TCEPR only)
Distance2	Continuous	Distance (as speed * duration) of tow (km)
Headline height	Continuous	Headline height (m) of the net for a tow
Bottom depth	Continuous	Seabed depth (m) for a tow
Effort depth	Continuous	Depth of trawl gear (m)
Speed	Continuous	Vessel speed (kn.) for a tow
Wingspread	Continuous	Wingspread (m) of the net for a tow
Vessel experience	Continuous	Number of years the vessel has been
Catch	Continuous	Estimated greenweight (t) of barracouta
Longitude	Continuous	Start longitude of the vessel for a tow
Latitude	Continuous	Start latitude of the vessel for a tow
Target species	Categorical	Target species of tow
Date	Continuous	Date of the tow
Month	Categorical	Month of the fishing year
Fday	Continuous	Day of the year
Time start	Continuous	Start time of tow
Time mid	Continuous	Mid time of tow

Table D2: CPUE data constraints for core datasets in the BAR 1 ECSI area. Trawl regions for (2) and (3) are shown in Figures C25 and C26.

(1) BAR 1 ECSI: CELR/TCER/TCEPR daily data mixed target bottom tows – landed catch

Data source	CELR, TCER, TCEPR data merged to day level
Vessel type	Vessels < 28 m in overall length
Year range	1990–2017
Season definition	October–September
Method	BT
Target species	BAR, RCO, TAR
Statistical areas	018, 020, 022, 024
Core vessel selection	≥ 8 years vessel participation and 20 days and ≥ 80% catch
Total core vessel landed catch	73 000 t

(2) BAR 1 ECSI: TCER bottom trawl tow-by-tow data mixed target tows – estimated catch

Data source	TCER tow-by-tow
Fishing year range	2008–2017
Season definition	October-September
Method	BT
Target species	BAR, RCO, TAR
Trawl region	KAIK, BANKS, CANT, DUNE
Depth	20–250 m
Core vessel selection	90% of catch, ≥ 6 years vessel participation, all tows per vessel-year
Total core vessel estimated catch	20 310 t

(3) BAR1 ECSI: TCEPR bottom trawl tow-by-tow data mixed target tows – estimated catch

Data source	TCEPR tow-by-tow
Fishing year range	1990–2017
Season definition	October-June
Method	BT
Target species	BAR, RCO, SQU
Trawl region	NORTH, INSH, DEEP, SOUTH
Depth	20–350 m
Core vessel selection	> 80% of catch, ≥ 7 years vessel participation, all tows per vessel-year
Total core vessel estimated catch	61 875 t

Table D3: Summary of BAR 1 ECSI TCEPR data used in the analyses of estimated catch for all vessels and for core vessels. Zero records/tows are those with no barracouta catch; CPUE, unstandardised CPUE.

(1) Barracouta landed catch data from BAR 1 ECSI merged daily CELR, TCER, and TCEPR data where barracouta, red cod, and tarakihi were targeted using bottom trawl gear, October-September in Statistical Areas 018, 020, 022, and 024, for all vessels and core vessels, by fishing years 1990 to 2017.

	All vessels						Core vessels					
Fish year	No. vessels	No. daily records	Prop. zero records	Catch (t)	No. non-zero records	CPUE	No. vessels	No. daily records	Prop. zero records	Catch (t)	No. non-zero records	CPUE
1990	62	2 448	0.14	3 609.6	2 107	1.71	15	1 173	0.11	1 896.8	1 041	1.82
1991	76	2 846	0.13	4 602.7	2 478	1.86	19	1 530	0.1	2 607.3	1 370	1.90
1992	71	3 089	0.16	3 887.8	2 608	1.49	21	2 002	0.14	2 656.6	1 722	1.54
1993	68	3 100	0.14	3 816.1	2 677	1.43	21	2 011	0.11	2 988.5	1 794	1.67
1994	71	2 615	0.14	1 822.7	2 259	0.81	21	1 794	0.11	1 459.5	1 593	0.92
1995	69	3 328	0.14	3 688.1	2 866	1.29	22	2 093	0.11	2 773.7	1 854	1.50
1996	67	3 069	0.13	4 100.7	2 658	1.54	22	2 164	0.09	3 404.4	1 960	1.74
1997	60	3 080	0.13	4 741.6	2 679	1.77	23	2 204	0.10	3 739.7	1 975	1.89
1998	53	3 161	0.13	4 770.5	2 765	1.73	23	2 490	0.10	4 185.8	2 237	1.87
1999	47	2 446	0.15	3 335.6	2 078	1.61	18	1 926	0.13	2 974.1	1 684	1.77
2000	53	2 250	0.14	3 322.7	1 925	1.73	20	1 851	0.11	2 881.6	1 651	1.75
2001	48	2 244	0.23	2 097.9	1 721	1.22	19	1 705	0.16	1 787.9	1 433	1.25
2002	45	1 987	0.23	2 265.3	1 523	1.49	15	1 520	0.17	2 038.8	1 265	1.61
2003	37	2 021	0.21	2 875.7	1 598	1.8	18	1 724	0.16	2 757.5	1 442	1.91
2004	49	1 930	0.20	2 480.4	1 551	1.6	19	1 541	0.14	2 370.3	1 331	1.78
2005	44	1 983	0.22	2 444.2	1 538	1.59	18	1 536	0.18	2 280.3	1 252	1.82
2006	43	1 967	0.19	3 071.4	1 592	1.93	16	1 500	0.14	2 871.7	1 283	2.24
2007	37	1 383	0.19	1 443.7	1 114	1.3	14	1 134	0.16	1 393.7	953	1.46
2008	37	1 173	0.28	1 762.4	850	2.07	10	899	0.21	1 666.1	713	2.34
2009	34	1 412	0.24	2 945.9	1 073	2.75	11	1 166	0.17	2 876.5	969	2.97
2010	41	1 430	0.29	2 486.7	1 016	2.45	10	965	0.14	2 359.7	828	2.85
2011	46	1 408	0.24	3 230.5	1 065	3.03	10	1 088	0.16	3 098.4	918	3.38
2012	40	1 324	0.27	3 549.8	972	3.65	10	900	0.17	3 298.7	750	4.40
2013	40	1 451	0.21	4 034.3	1 146	3.52	10	912	0.09	3 445.1	833	4.14
2014	40	1 442	0.21	3 155.6	1 141	2.77	10	961	0.13	2 710.7	839	3.23
2015	39	1 185	0.23	2 453.3	913	2.69	9	773	0.17	2 088.9	640	3.26
2016	34	1 083	0.28	2 022.6	781	2.59	8	597	0.15	1 648.7	505	3.26
2017	35	1 399	0.23	3 354.6	1 079	3.11	8	737	0.10	2 743.0	664	4.13
Total	193	58 254		87 372.8	47 773		29	40 986		73 003.7	35 499	

(2) Barracouta estimated catch data (tow-by-tow) from bottom trawl TCERs, October–September, in Statistical Areas 018, 020, 022, and 024, for barracouta, red cod, and tarakihi, for fishing years 2008–17.

	All vessels						Core vessels					
Fish year	No. vessels	No. tows	Prop. zero tows	Catch (t)	No. non-zero tows	CPUE	No. vessels	No. tows	Prop. zero tows	Catch (t)	No. non-zero tows	CPUE
2008	36	3 111	0.29	1 828.1	2 201	0.83	9	2 340	0.29	1 326.0	1 652	0.80
2009	34	3 419	0.28	1 857.5	2 458	0.76	10	2 821	0.24	1 769.0	2 148	0.82
2010	43	3 497	0.32	1 752.0	2 388	0.73	10	2 773	0.27	1 611.9	2 032	0.79
2011	45	3 439	0.28	2 091.1	2 493	0.84	11	2 894	0.23	2 017.1	2 219	0.91
2012	43	3 314	0.28	2 685.9	2 382	1.13	12	2 695	0.25	2 535.4	2 018	1.26
2013	42	3 657	0.22	3 139.7	2 846	1.10	13	3 055	0.19	2 992.2	2 489	1.20
2014	40	3 894	0.27	2 481.2	2 828	0.88	12	3 197	0.24	2 341.9	2 437	0.96
2015	39	3 083	0.25	2 063.7	2 300	0.90	12	2 635	0.22	1 984.8	2 048	0.97
2016	35	2 617	0.24	1 759.6	1 981	0.89	11	1 996	0.23	1 546.0	1 538	1.01
2017	38	3 375	0.26	2 693.4	2 499	1.08	11	2 156	0.23	2 185.8	1 664	1.31
Total	71	33 406		22 352.3	24 376		13	26 562		20 310.1	20 245	

(3) Barracouta estimated bottom trawl catch data (tow-by-tow) from bottom trawl TCEPRs, October–June, for barracouta, red cod, and arrow squid, for fishing years 1990–2017.

	All vessels						Core vessels					
Fish year	No. vessels	No. tows	Prop. zero tows	Catch (t)	No. non-zero tows	CPUE	No. vessels	No. tows	Prop. zero tows	Catch (t)	No. non-zero tows	CPUE
1990	31	3 333	0.32	4 533.5	2 272	2.00	9	1627	0.24	2 157.8	1 240	1.74
1991	30	2 471	0.21	3 763.4	1 942	1.94	10	1406	0.15	2 163.0	1 200	1.80
1992	30	3 647	0.37	3 332.7	2 312	1.44	14	2082	0.39	2 230.7	1 270	1.76
1993	29	3 774	0.31	4 397.8	2 593	1.70	15	2484	0.33	3 612.8	1 667	2.17
1994	26	3 043	0.45	1 816.5	1 671	1.09	15	2299	0.46	1 474.5	1 248	1.18
1995	28	2 851	0.38	3 534.4	1 764	2.00	18	2391	0.36	3 380.6	1 519	2.23
1996	31	4 799	0.42	4 858.4	2 794	1.74	20	3709	0.43	3 989.3	2 114	1.89
1997	34	4 157	0.42	4 396.5	2 403	1.83	22	3477	0.38	4 181.4	2 144	1.95
1998	30	4 500	0.4	4 741.3	2 680	1.77	21	3966	0.37	4 434.5	2 485	1.78
1999	27	3 136	0.32	3 954.8	2 119	1.87	22	3043	0.32	3 887.9	2 077	1.87
2000	25	2 999	0.24	4 303.2	2 271	1.89	19	2957	0.24	4 280.4	2 241	1.91
2001	27	3 115	0.32	3 059.5	2 111	1.45	19	2969	0.32	3 021.6	2 023	1.49
2002	23	2 524	0.32	2 525.4	1 713	1.47	18	2486	0.32	2 502.1	1 686	1.48
2003	23	2 805	0.43	2 564.4	1 589	1.61	18	2605	0.44	2 480.6	1 465	1.69
2004	23	2 229	0.34	2 868.0	1 460	1.96	18	2194	0.35	2 853.8	1 433	1.99
2005	27	1 756	0.53	1 067.5	819	1.30	15	1490	0.49	942.1	756	1.25
2006	26	1 616	0.43	1 475.1	920	1.60	15	1376	0.36	1 386.6	880	1.58
2007	19	1 063	0.49	612.6	547	1.12	15	997	0.47	600.9	530	1.13
2008	16	168	0.25	600.3	126	4.76	11	144	0.27	568.5	105	5.41
2009	13	468	0.17	1 271.7	387	3.29	12	464	0.17	1 264.6	383	3.30
2010	16	487	0.28	834.8	353	2.36	10	468	0.25	822.8	351	2.34
2011	20	863	0.14	1 952.5	741	2.63	13	696	0.12	1 762.9	613	2.88
2012	15	613	0.15	2 624.7	518	5.07	12	597	0.16	2 613.7	504	5.19
2013	16	426	0.14	1 343.0	368	3.65	10	412	0.13	1 326.2	358	3.70
2014	9	304	0.1	823.5	275	2.99	7	293	0.09	819.5	267	3.07
2015	11	265	0.17	702.1	219	3.21	7	248	0.16	695.9	208	3.35
2016	13	539	0.21	1 062.6	425	2.50	8	503	0.18	1 042.6	410	2.54
2017	12	520	0.12	1 426.1	459	3.11	7	491	0.1	1 375.9	443	3.11
All	115	58 471		70 446.1	37 851		27	47 874		61 873.2	31 620	

Table D4: Variables retained in order of decreasing explanatory value by each BAR 1 ECSI lognormal model and the corresponding total r^2 value.

Dataset	Variable	r^2
CELR, TCER, TCEPR daily bottom trawl data for BAR, RCO, and TAR		
Lognormal	Fishing year	10.2
For 1990–2017 fishing years	Vessel	38.5
	Target species	41.9
	Month	44.2
	Fishing duration	45.7
TCER tow-by-tow estimated bottom trawl catch for BAR, RCO, and TAR		
Lognormal	Year	2.1
For 2008–17 fishing years	Vessel	20.0
	Mid tow time	25.2
	Target species	28.9
	Effort depth	31.2
TCEPR tow-by-tow estimated bottom tow catch for BAR, RCO, and SQU		
Lognormal	Year	4.0
For 1990–17 fishing years	Effort depth	12.4
	Target	15.7
	Vessel	19.2
	Start time of tow	20.8
	Trawl region	22.1
	Month	23.2

Table D5: ECSI lognormal CPUE core indices by fishing year, with 95% confidence intervals and CVs.

(a) CELR/ TCER/ TCEPR

Core vessels: BT target BAR, RCO, TAR

Fishing year	Index	95% CI	CV	Fishing year	Index	95% CI	CV
1990	1.04	0.98–1.11	0.03	2004	0.74	0.70–0.78	0.03
1991	1.09	1.03–1.15	0.03	2005	0.75	0.71–0.80	0.03
1992	0.72	0.68–0.75	0.03	2006	0.94	0.89–0.99	0.03
1993	0.79	0.75–0.83	0.02	2007	0.65	0.61–0.70	0.03
1994	0.72	0.69–0.76	0.03	2008	0.99	0.91–1.06	0.04
1995	0.89	0.85–0.94	0.02	2009	1.17	1.10–1.25	0.03
1996	1.30	1.24–1.36	0.02	2010	1.26	1.18–1.35	0.04
1997	1.49	1.42–1.56	0.02	2011	1.41	1.32–1.51	0.03
1998	1.54	1.47–1.61	0.02	2012	1.58	1.47–1.70	0.04
1999	0.95	0.90–1.00	0.03	2013	1.57	1.47–1.69	0.04
2000	0.90	0.86–0.95	0.03	2014	1.42	1.32–1.52	0.03
2001	0.65	0.62–0.69	0.03	2015	1.10	1.02–1.19	0.04
2002	0.61	0.58–0.65	0.03	2016	1.23	1.12–1.34	0.04
2003	0.50	0.48–0.53	0.03	2017	1.43	1.32–1.55	0.04

(b)TCER

Core vessels: BT target

Fishing year	Index	95% CI	CV
2008	0.69	0.66–0.73	0.02
2009	0.88	0.84–0.92	0.02
2010	1.01	0.97–1.06	0.02
2011	1.08	1.03–1.12	0.02
2012	1.14	1.09–1.19	0.02
2013	1.25	1.20–1.30	0.02
2014	0.99	0.95–1.03	0.02
2015	0.93	0.89–0.97	0.02
2016	0.99	0.94–1.04	0.02
2017	1.18	1.12–1.23	0.02

(c)TCEPR

Core vessels: BT target BAR, RCO, SQU

Fishing year	Index	95% CI	CV	Fishing year	Index	95% CI	CV
1990	0.87	0.82–0.92	0.03	2004	0.73	0.69–0.77	0.03
1991	0.96	0.90–1.02	0.03	2005	0.49	0.45–0.52	0.04
1992	0.92	0.86–0.97	0.03	2006	0.80	0.75–0.86	0.03
1993	0.97	0.92–1.02	0.03	2007	0.48	0.44–0.52	0.04
1994	0.88	0.83–0.93	0.03	2008	1.40	1.16–1.70	0.10
1995	1.11	1.05–1.17	0.03	2009	1.11	1.00–1.22	0.05
1996	1.14	1.09–1.19	0.02	2010	0.82	0.74–0.92	0.05
1997	1.26	1.20–1.32	0.02	2011	1.25	1.15–1.36	0.04
1998	1.22	1.16–1.27	0.02	2012	1.26	1.15–1.38	0.05
1999	1.12	1.07–1.17	0.02	2013	1.27	1.14–1.41	0.05
2000	1.29	1.23–1.35	0.02	2014	1.46	1.30–1.65	0.06
2001	0.92	0.88–0.97	0.02	2015	1.51	1.31–1.73	0.07
2002	0.85	0.80–0.89	0.03	2016	0.92	0.84–1.02	0.05
2003	0.75	0.71–0.79	0.03	2017	1.35	1.23–1.49	0.05

Figure D1: BAR 1 ECSI summary of effort (number of CELR, TCER, and TCEPR daily records) and landed barracouta catch (t) by fishing year for 1990–2017, for all vessels. The symbol area is proportional to either the number of records or the annual catch, and the maximum circle size is shown in the label on the plot.

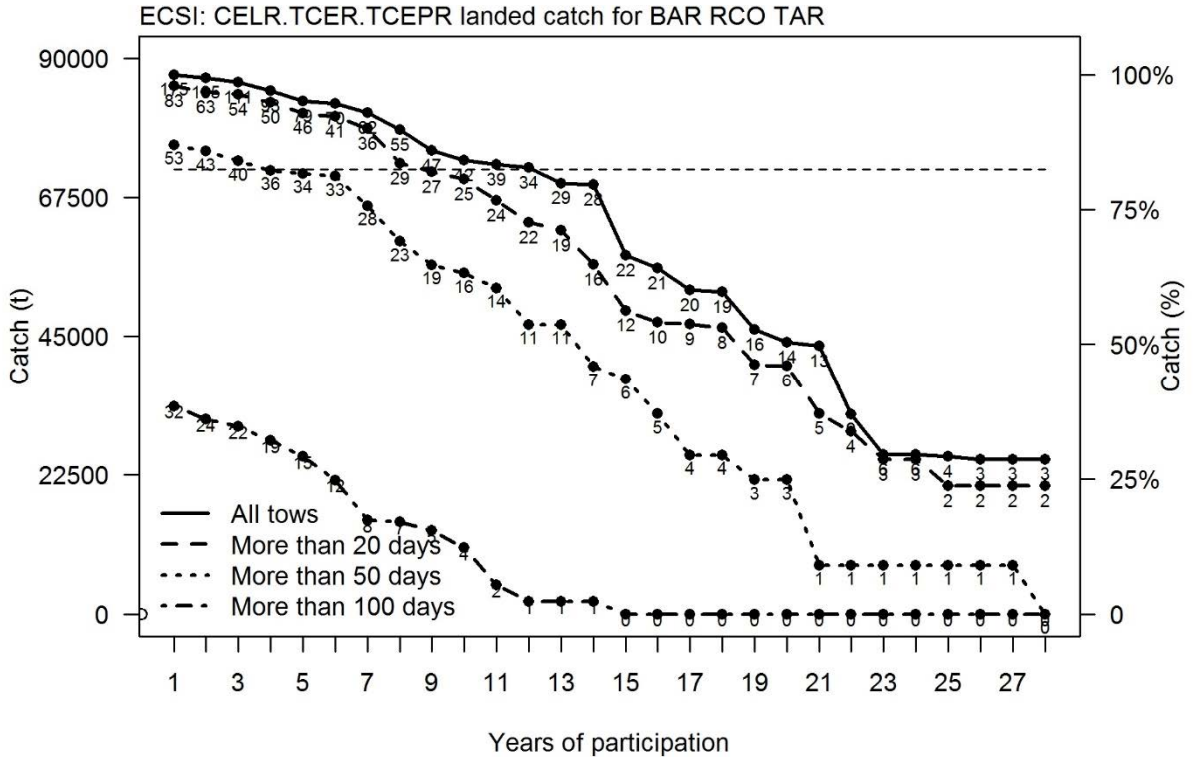


Figure D2: Vessel participation plot showing number of years in the fishery for core vessel choice for ECSI BT CELR/TCER/TCEPR mixed target CPUE.

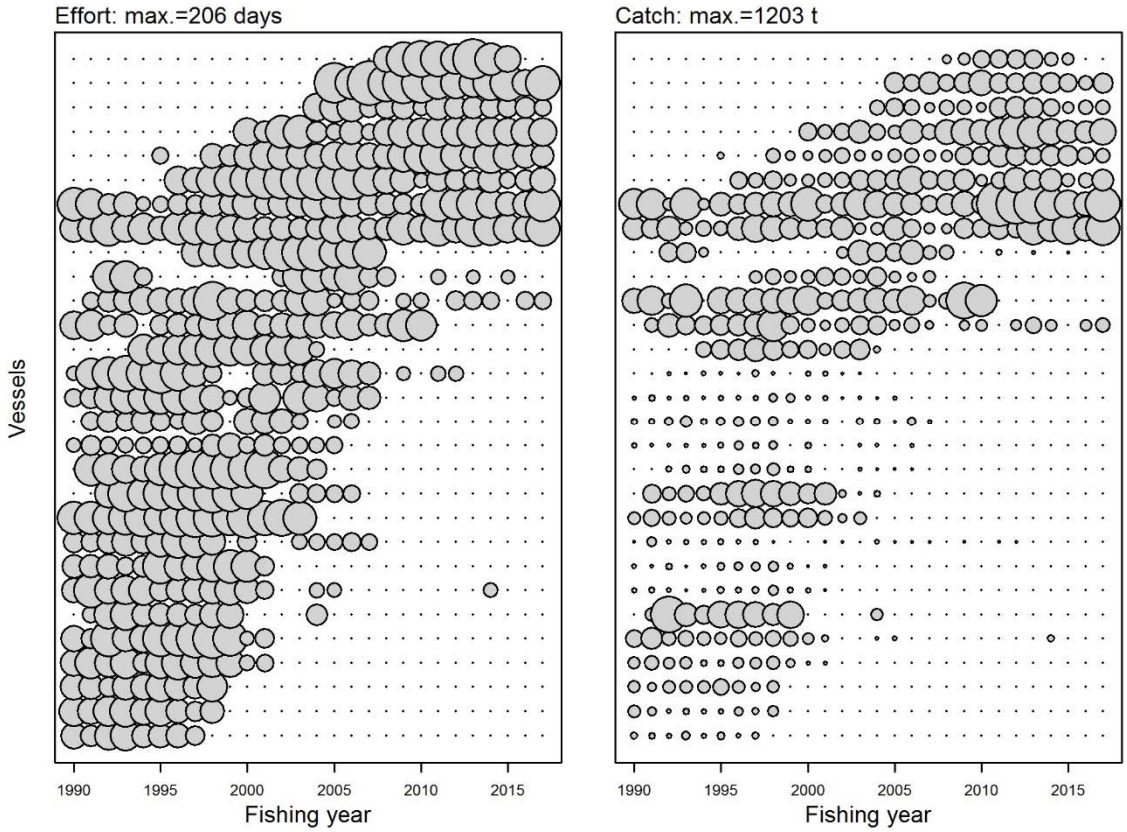


Figure D3: BAR 1 ECSI summary of effort (number of CELR, TCER, and TCEPR daily records) and landed barracouta catch (t) by fishing year for 1990–2017, for core vessels. The symbol area is proportional to either the number of records or the annual catch, and the maximum circle size is shown in the label on the plot.

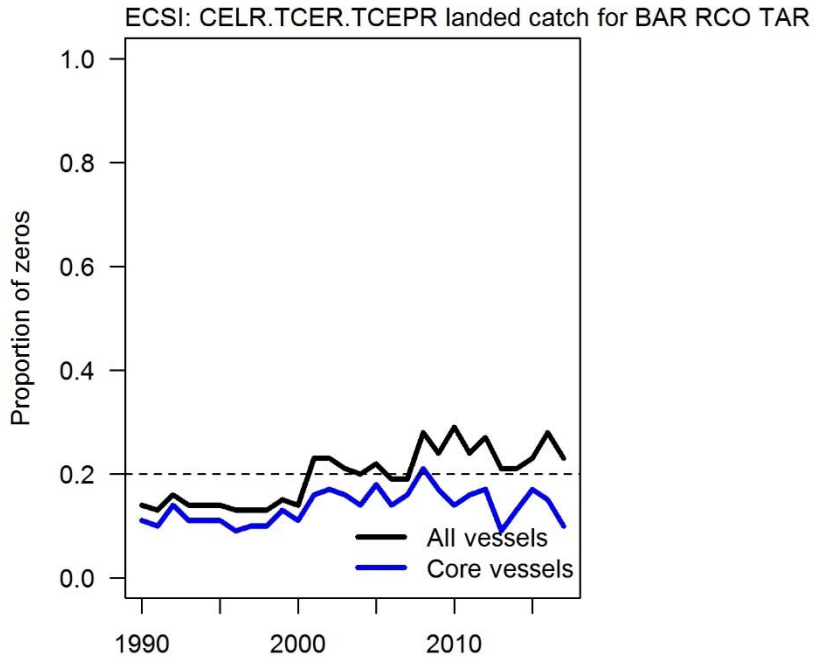


Figure D4: Proportion of zero barracouta catches in the ECSI CELR/TCER/TCEPR daily bottom trawl records, for all vessels and for core vessels, 1990–2017.

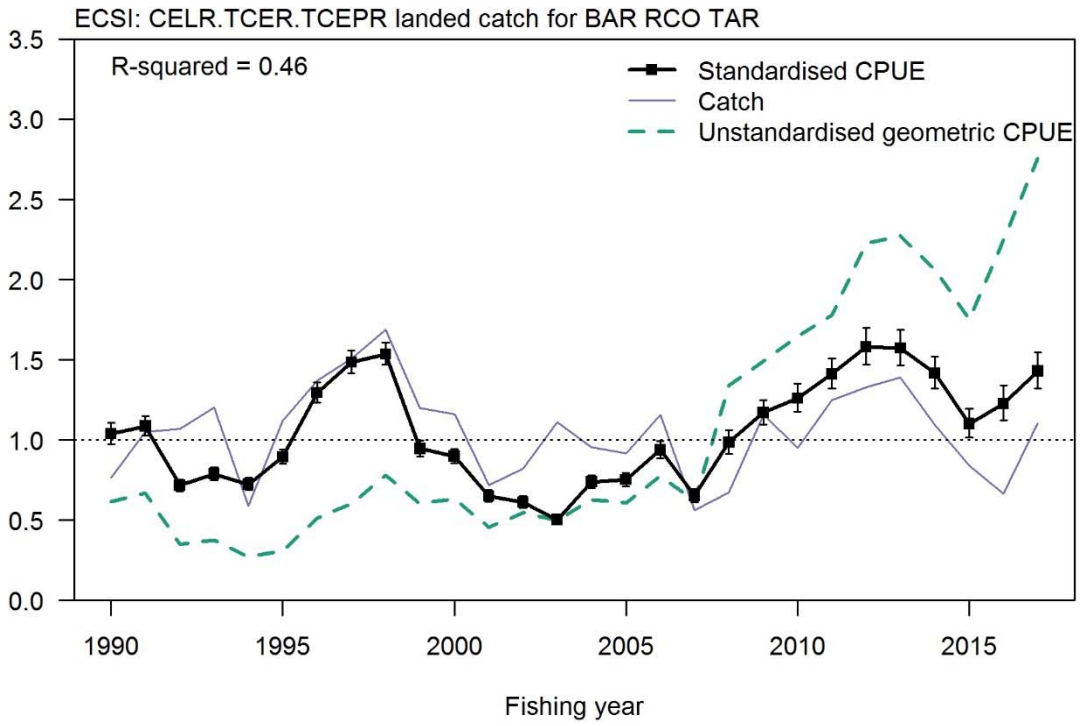


Figure D5: CPUE lognormal indices for ECSI, based on the CELR/TCER/TCEPR bottom trawl mixed target dataset, showing catches (scaled to same mean as indices), and lognormal standardised and unstandardised indices. Bars indicate 95% confidence intervals.

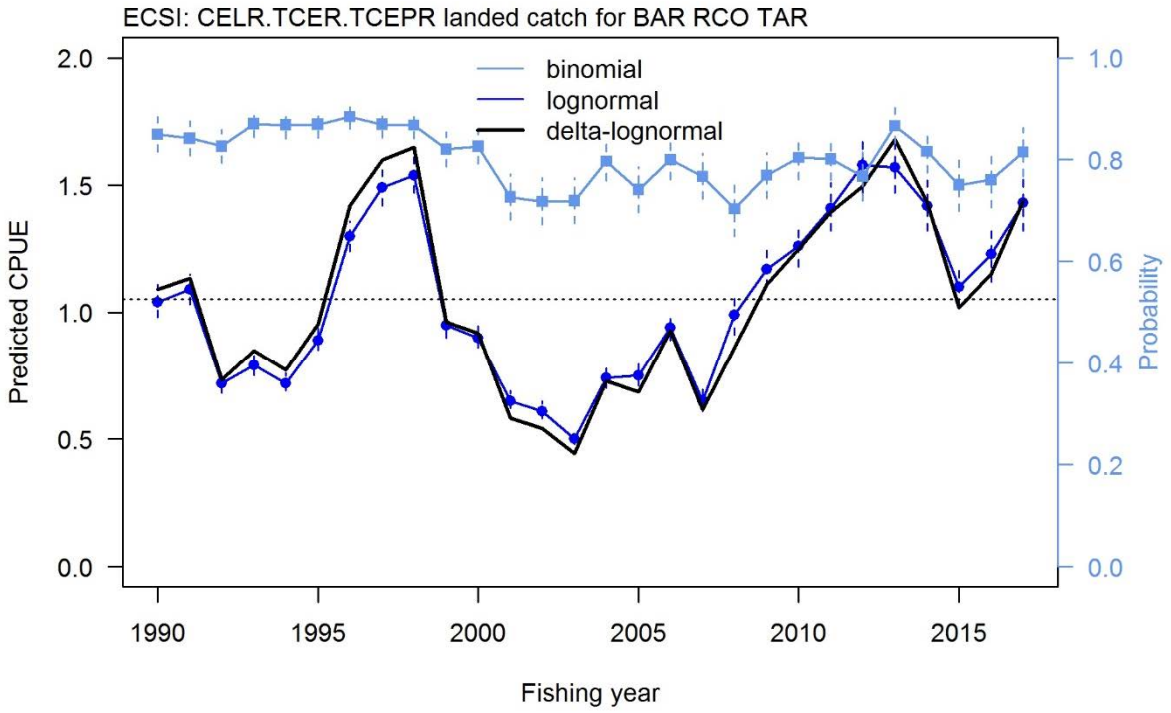


Figure D6: ECSI CELR/TCER/TCEPR CPUE from the lognormal, binomial, and delta–lognormal (combined) core vessel mixed target, bottom trawl landed catch model, for October-September, 1990–2017. Bars indicate 95% confidence intervals.

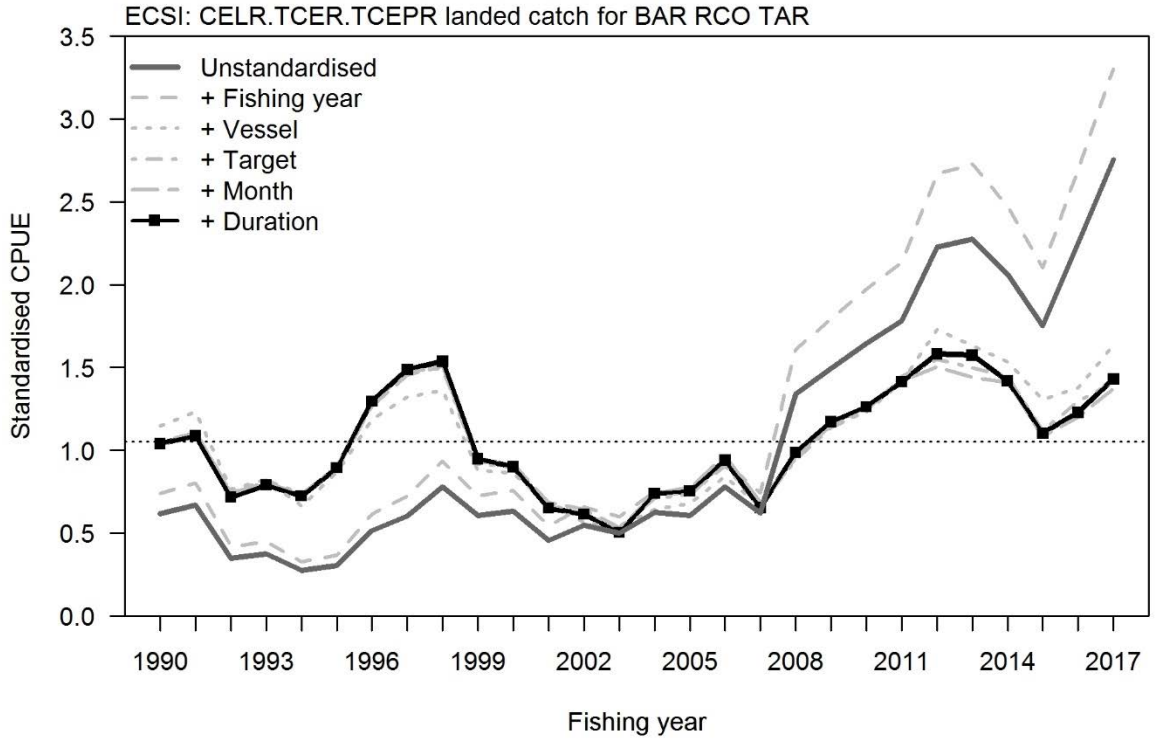


Figure D7: Addition of variables into the lognormal CPUE from the lognormal model for the ECSI CELR/TCER/TCEPR trawl fishery using bottom trawls to target barracouta, red cod, and tarakihi in Statistical Areas 018, 020, 022, and 024, during October-September of each fishing year, 1990–2017.

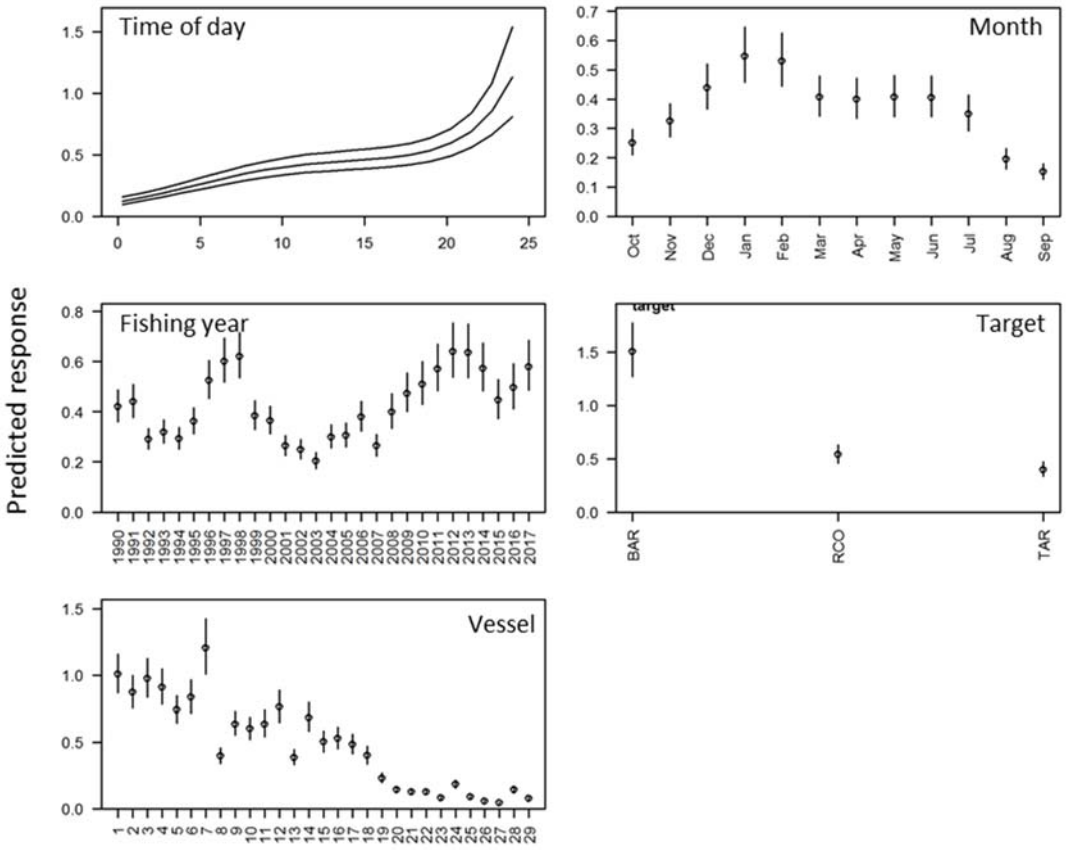


Figure D8: Effects of selected variables in the lognormal model for the ECSI CELR/TCER/TCEPR bottom trawl landed catch for core mixed target vessels, 1990–2017. Bars indicate 95% confidence intervals.

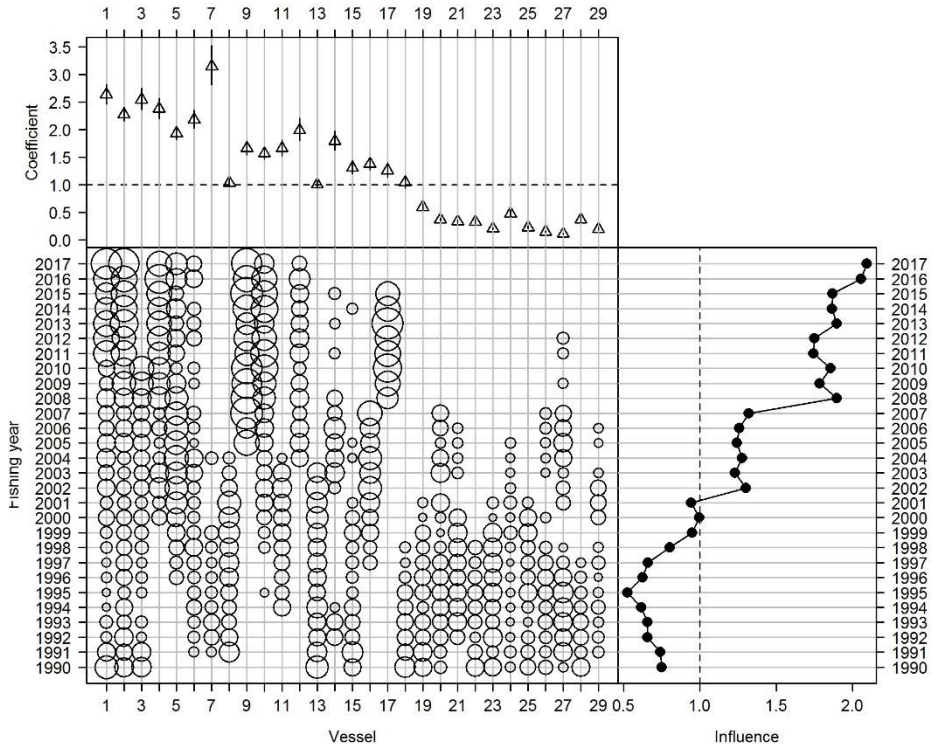


Figure D9a: Effect and influence of vessel in the ECSI CELR/TCER/TCEPR daily core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

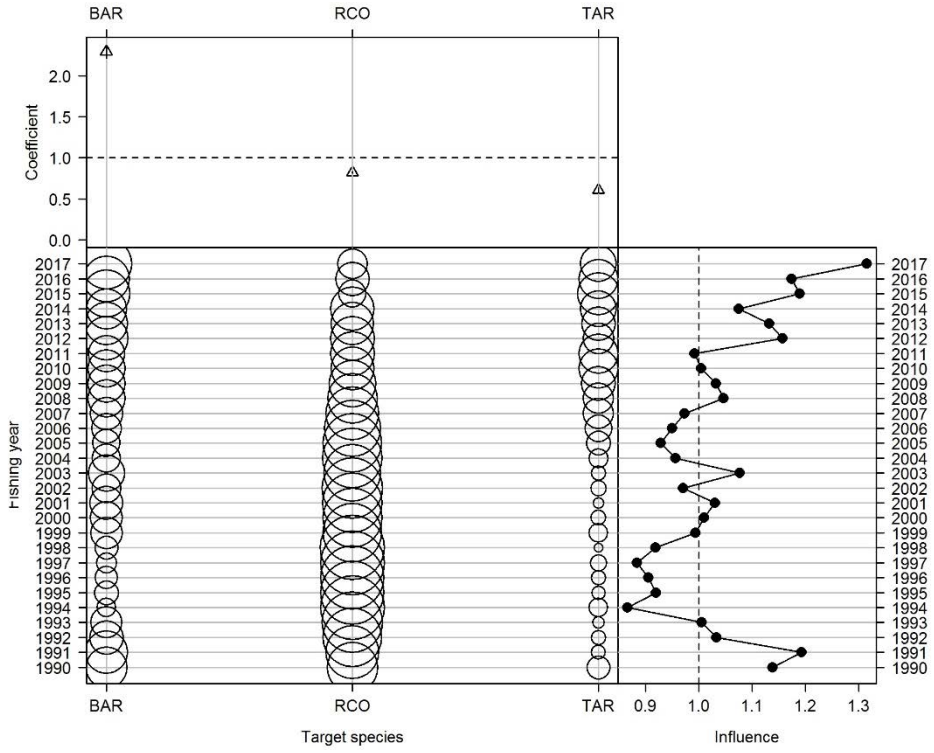


Figure D9b: Effect and influence of target species in the ECSI CELR/TCER/TCEPR daily core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

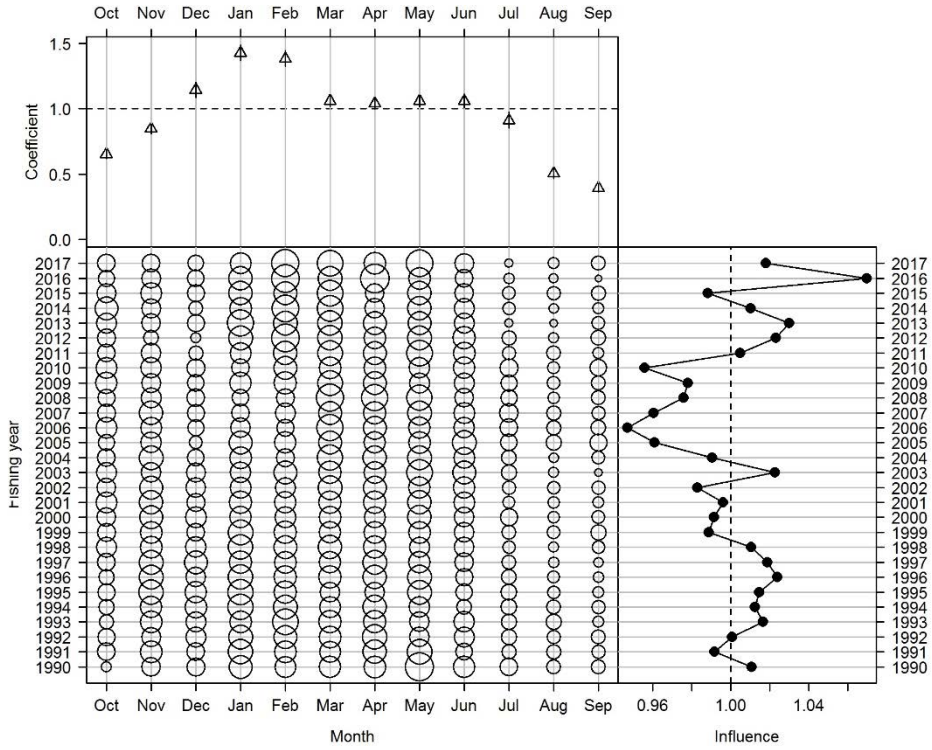


Figure D9c: Effect and influence of month in the BAR 1 ECSI CELR/TCER/TCEPR daily core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

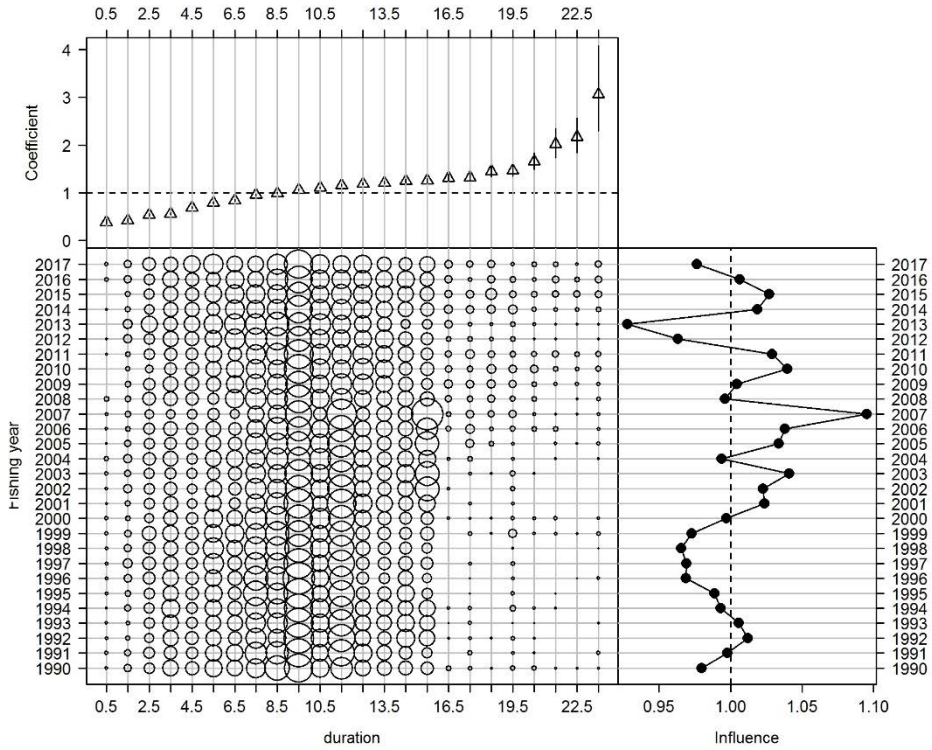


Figure D9d: Effect and influence of fishing duration in the ECSI CELR/TCER/TCEPR daily core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

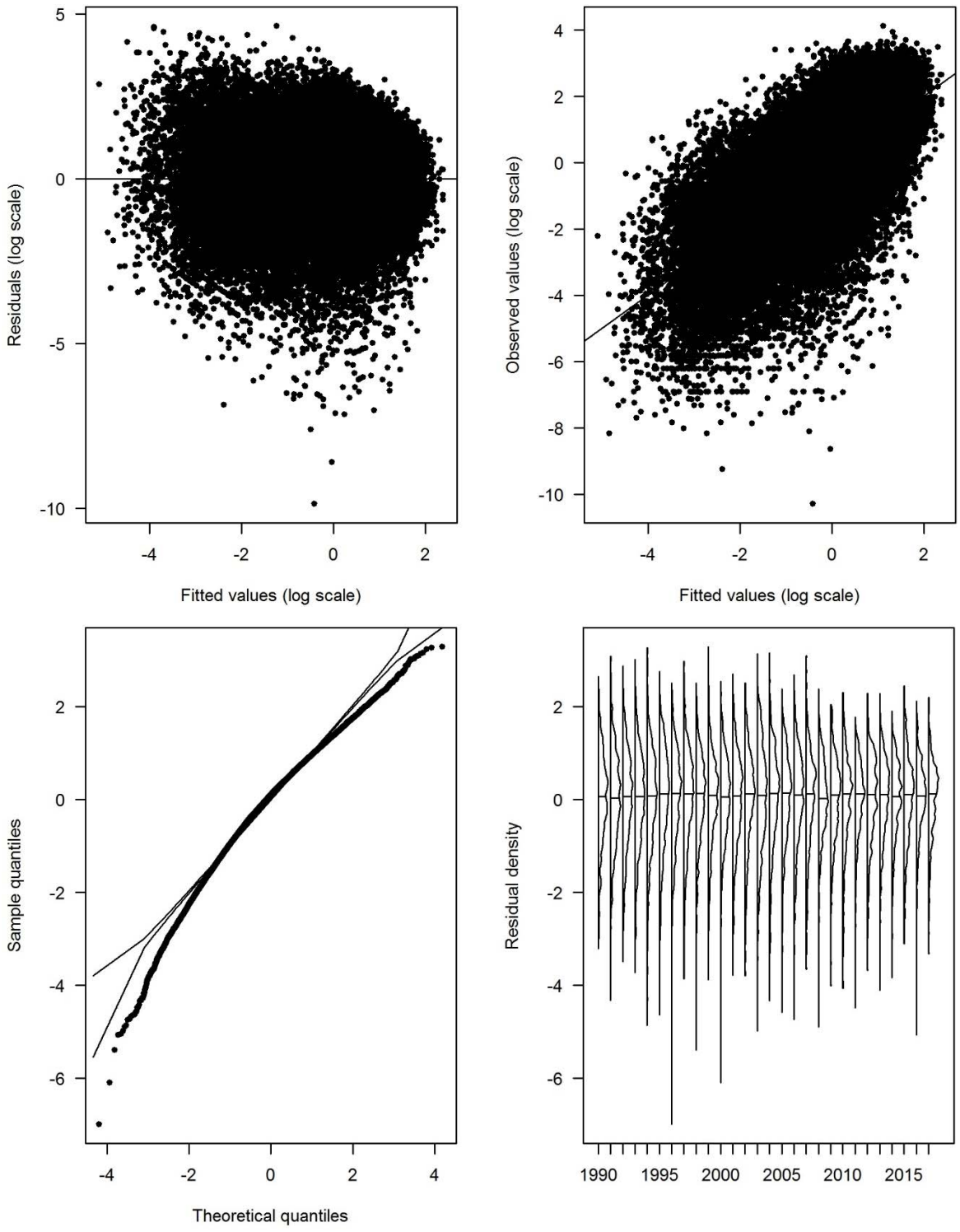


Figure D10: ECSI CELR/TCER/TCEPR daily BT lognormal model: distribution of the standardised and observed residuals against fitted values (upper), the quantile–quantile plot of the residuals and density plot of the residuals (lower).

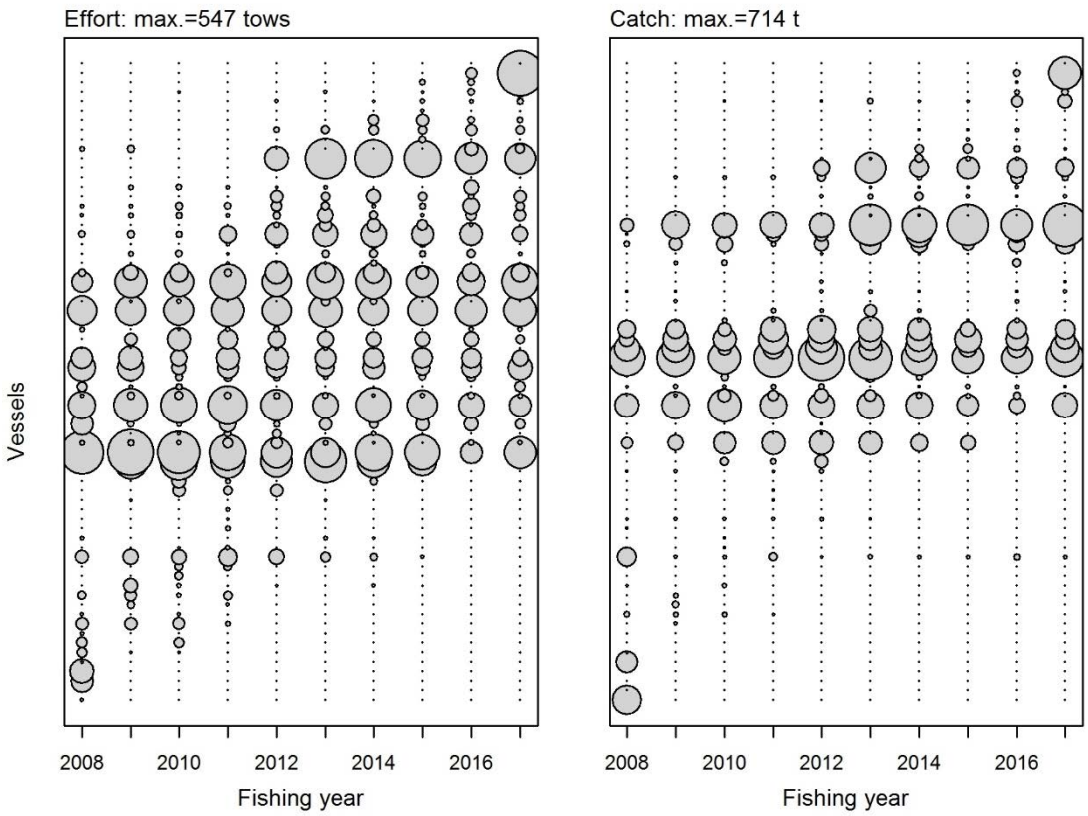


Figure D11: ECSI BT TCER summary of effort (number of TCER tows) and estimated barracouta catch (t) by fishing year for 2008–17, for all vessels. The symbol area is proportional to either the number of records or the annual catch, and the maximum circle size is shown in the label on the plot.

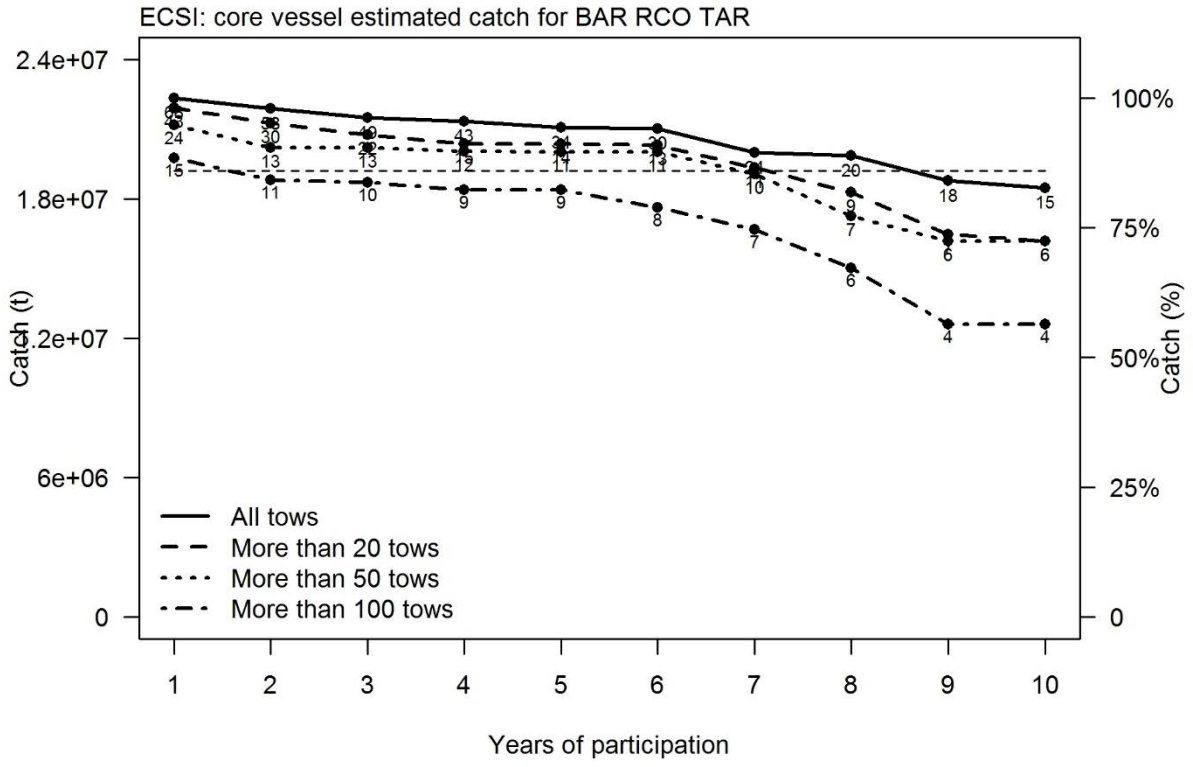


Figure D12: Vessel participation plot showing number of years in the fishery for core vessel choice for ECSI BT TCER mixed target CPUE. The dashed line represents 80% of the catch.

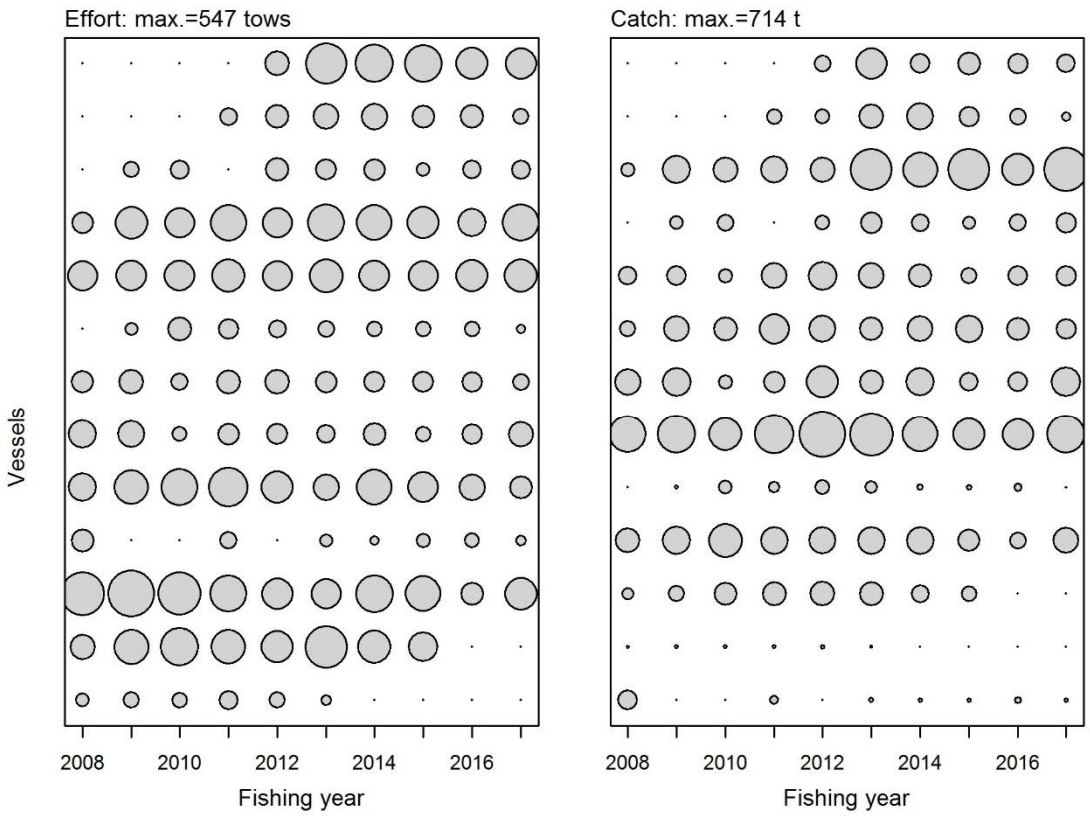


Figure D13: ECSI BT TCER summary of effort (number of TCER tows) and estimated barracouta catch (t) by fishing year for 2008–17, for core vessels. The symbol area is proportional to either the number of records or the annual catch, and the maximum circle size is shown in the label on the plot.

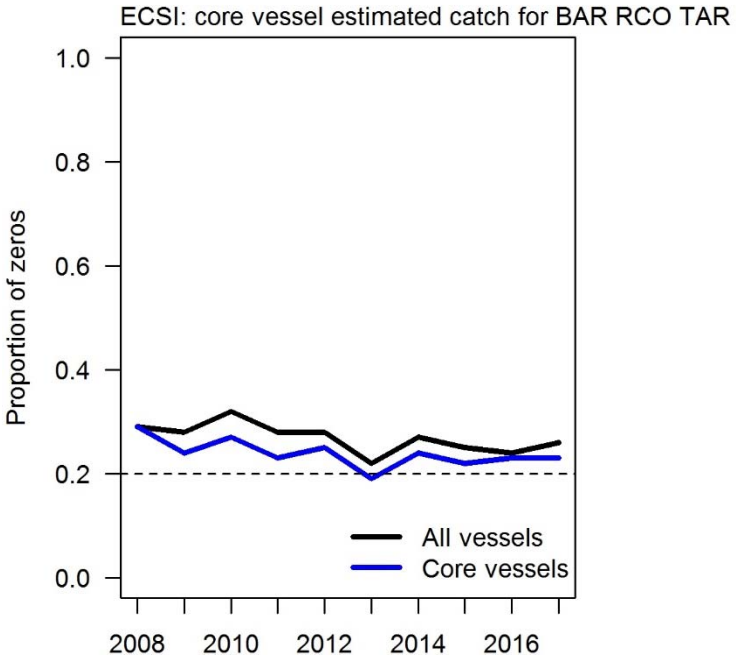


Figure D14: Proportion of zero barracouta catches in the ECSI TCER bottom trawl records, for all vessels and for core vessels, 2008–17.

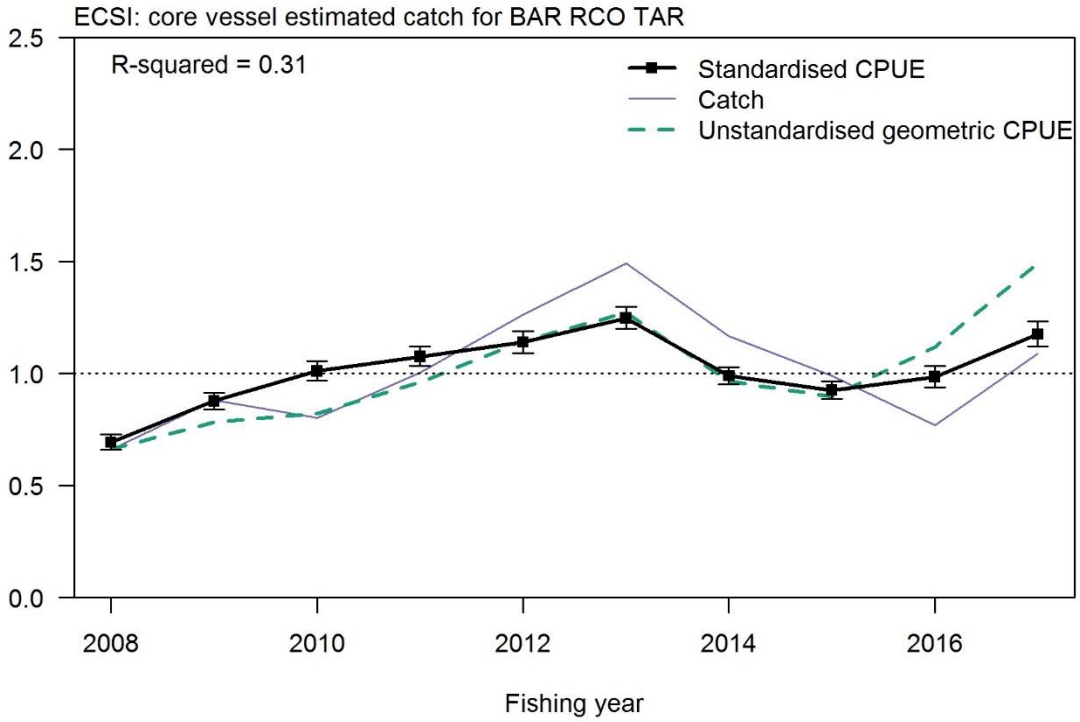


Figure D15: CPUE lognormal indices for ECSI, based on the core vessel TCER tow-by-tow, bottom trawl, mixed target dataset, showing catches (scaled to same mean as indices), and lognormal standardised and unstandardised indices. Bars indicate 95% confidence intervals.

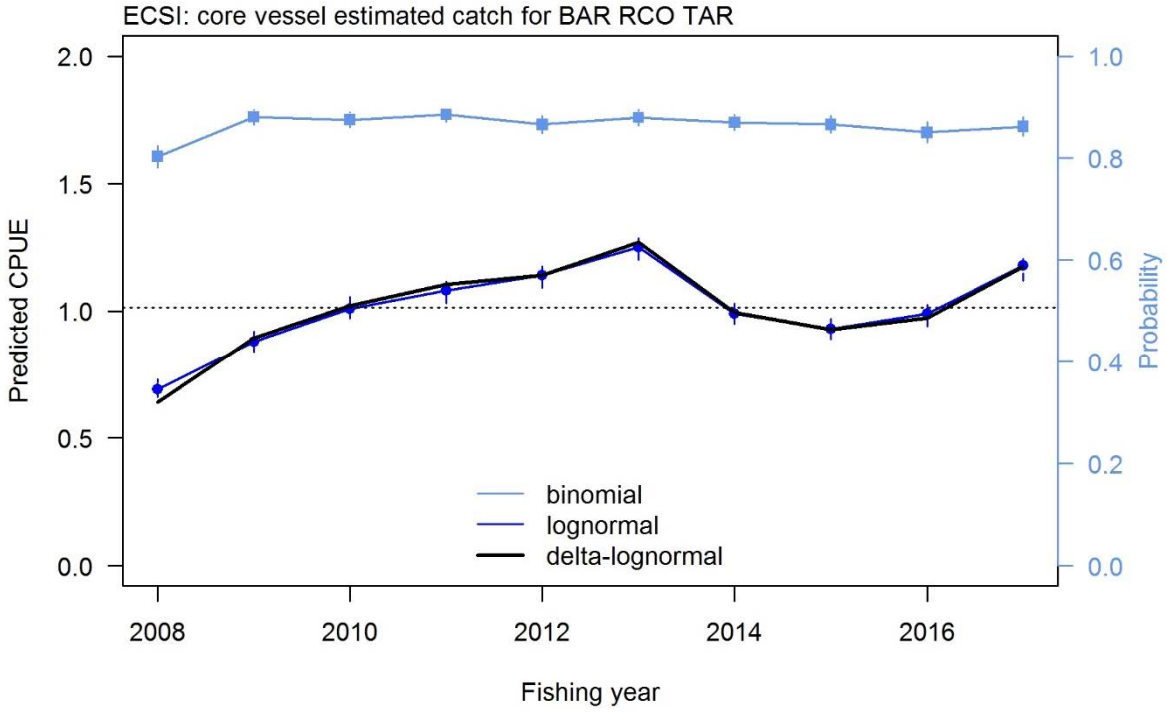


Figure D16: ECSI TCER CPUE from the lognormal, binomial, and delta–lognormal (combined) core vessel mixed target, bottom trawl landed catch model, for October-September, 2008–17. Bars indicate 95% confidence intervals.

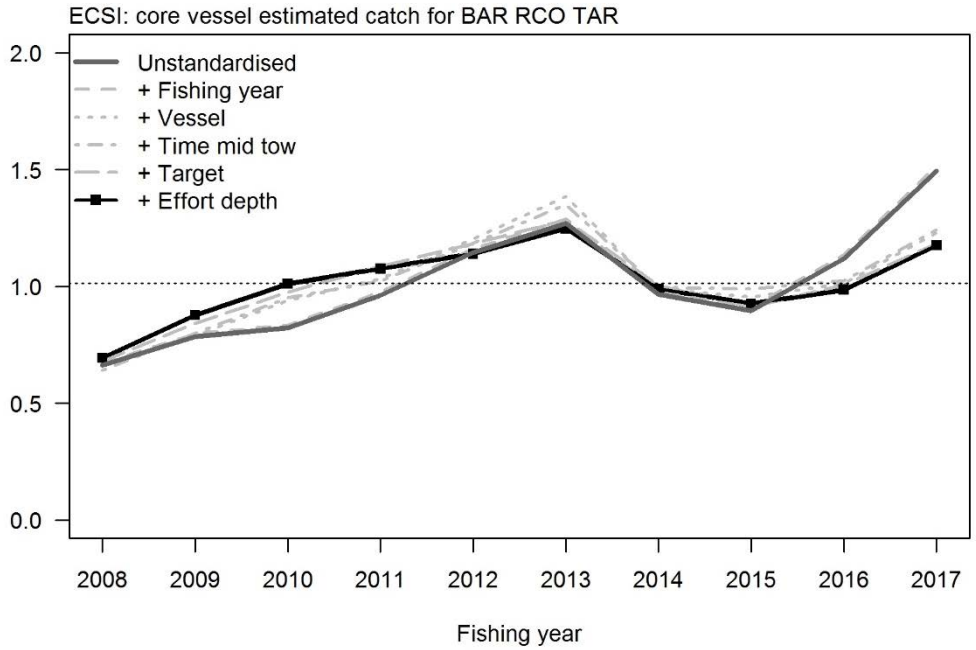


Figure D17: Addition of variables into the lognormal CPUE model for the ECSI TCER trawl fishery using bottom trawls to target barracouta, red cod, and tarakihi in Statistical Areas 018, 020, 022, and 024, during October-September of each fishing year, 2008–17.

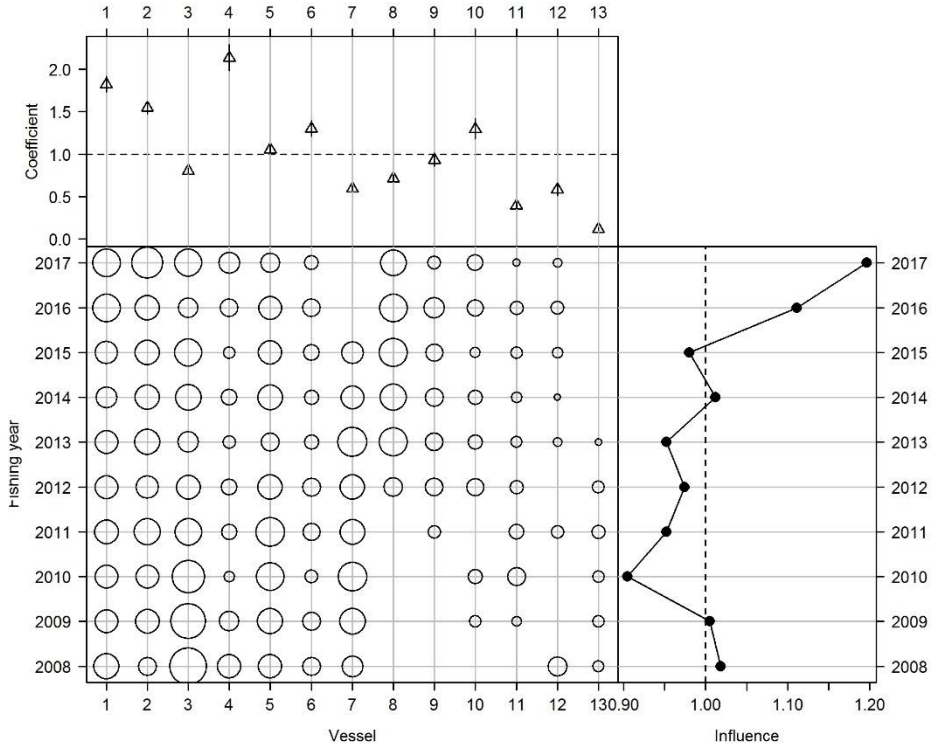


Figure D18a: Effect and influence of vessel in the ECSI TCER tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

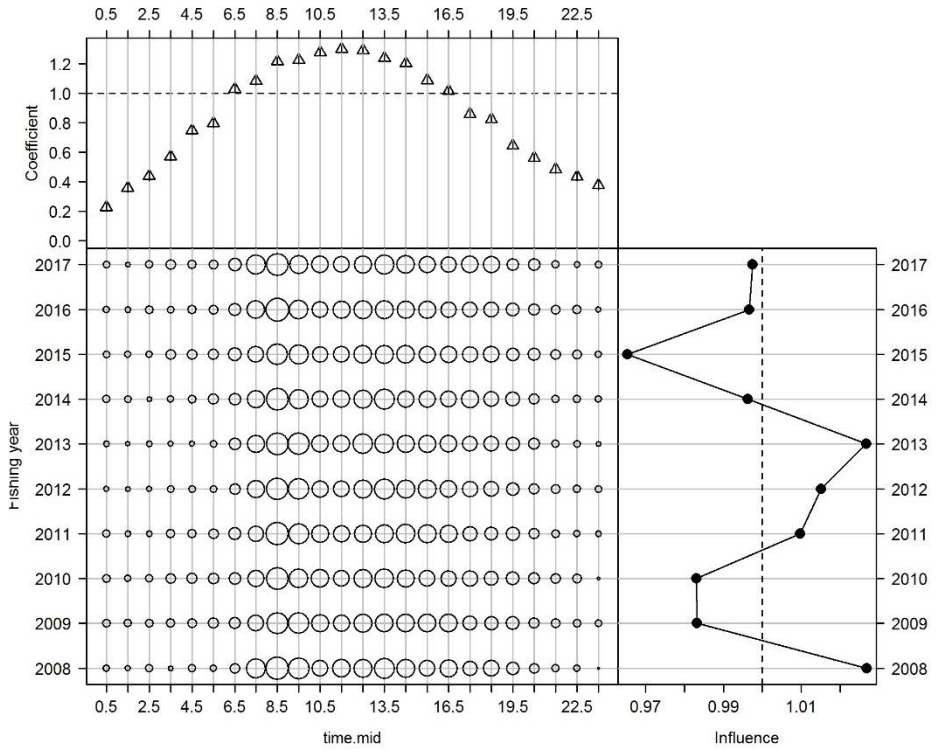


Figure D18b: Effect and influence of mid tow time in the ECSI TCER tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

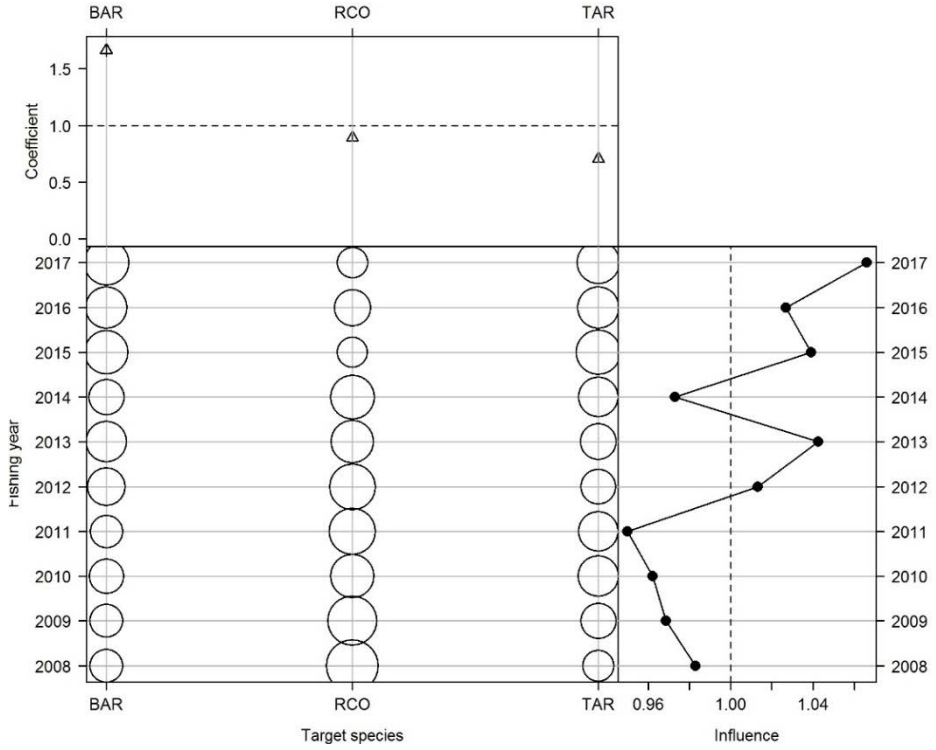


Figure D18c: Effect and influence of target species in the ECSI TCER tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

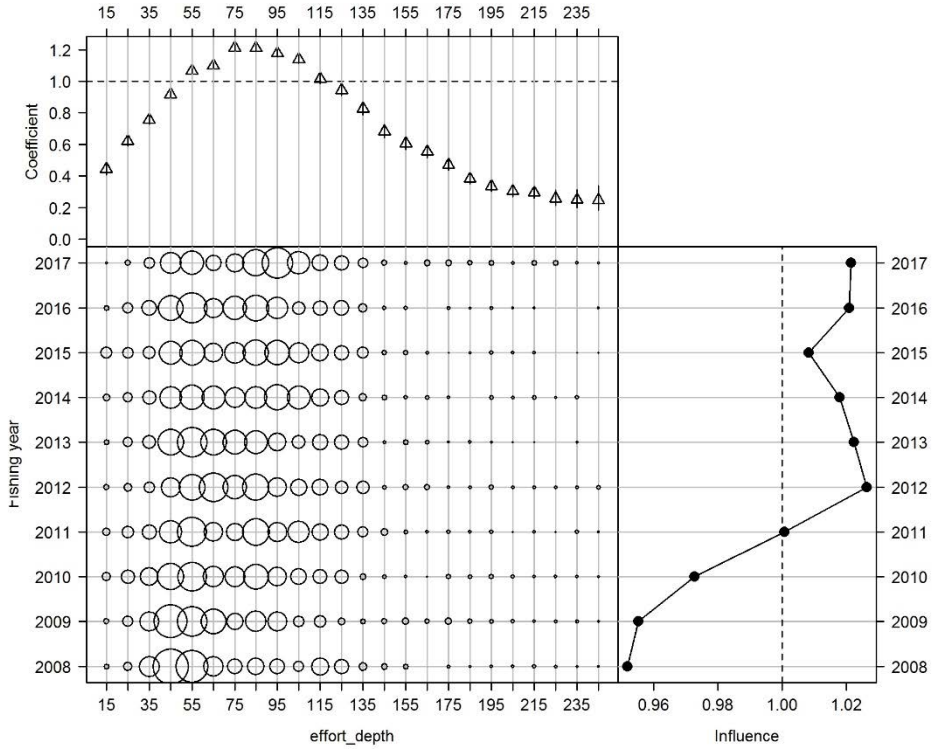


Figure D18d: Effect and influence of effort depth in the ECSI TCER tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

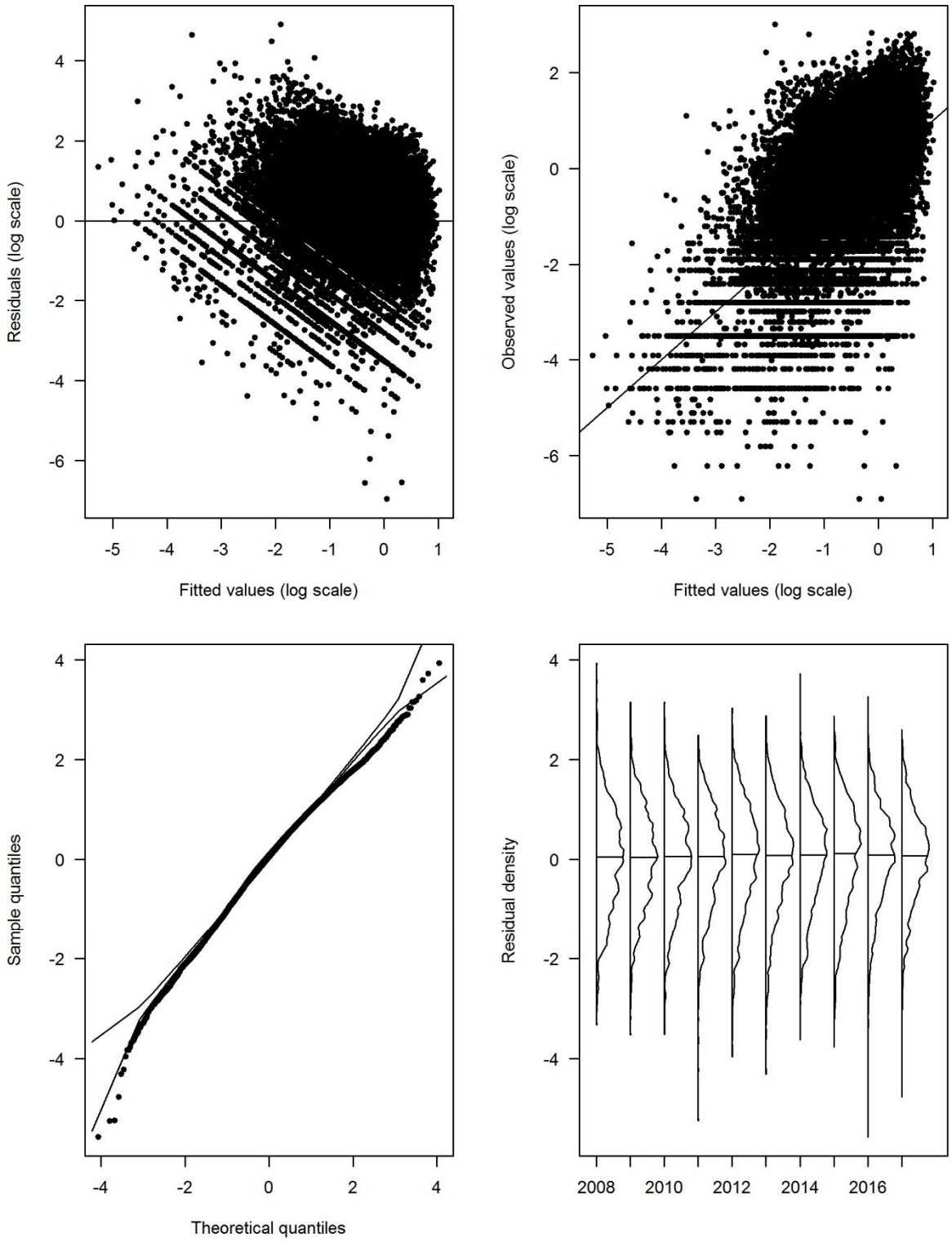


Figure D19: ECSI TCER tow-by-tow BT lognormal model: distribution of the standardised and observed residuals against fitted values (upper), the quantile-quantile plot of the residuals, and density plot of the residuals (lower).

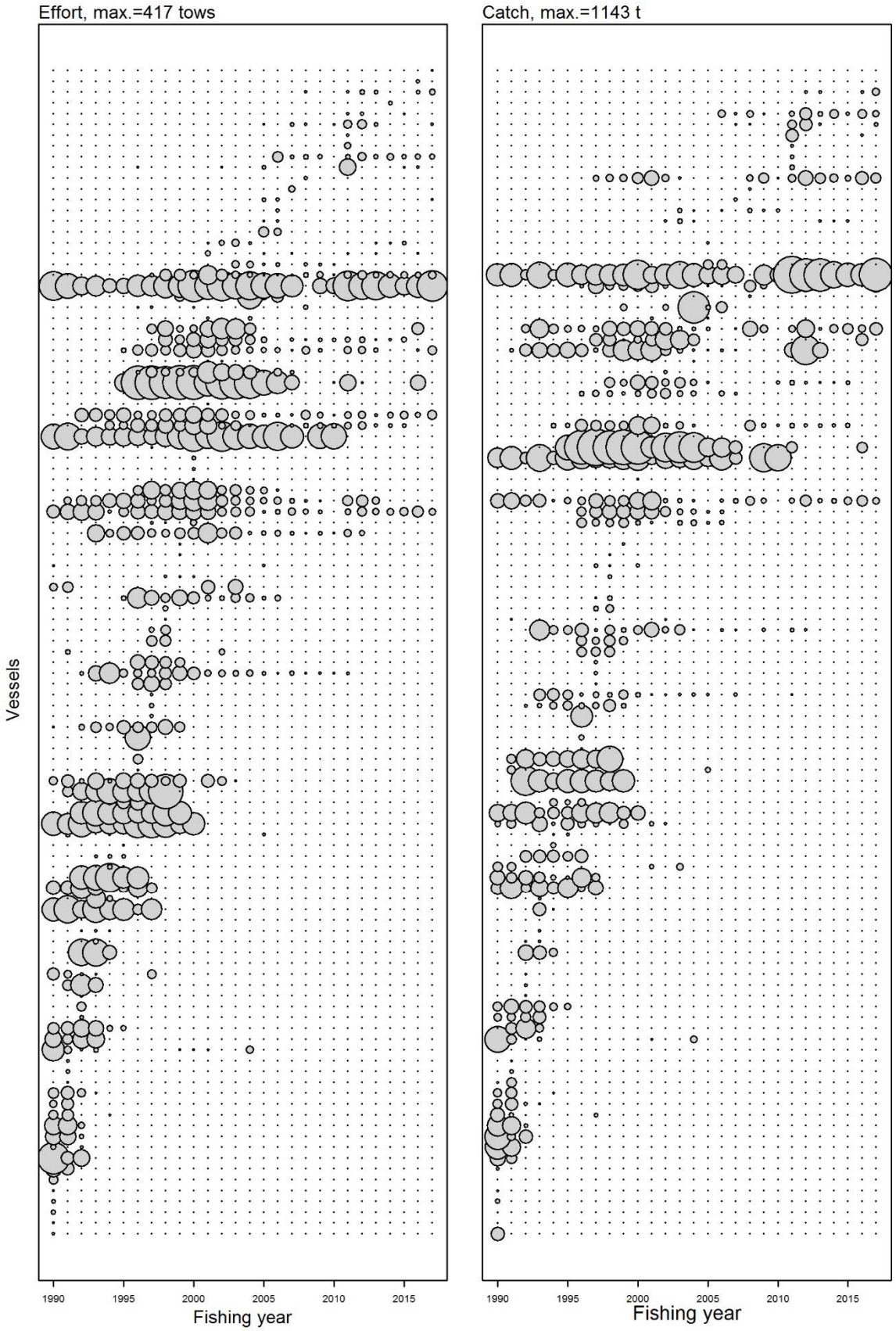


Figure D20: ECSI BT TCEPR summary of effort (number of TCEPR tows) and estimated barracouta catch (t) by fishing year for 1990–2017, for all vessels. The symbol area is proportional to either the number of records or the annual catch, and the maximum circle size is shown in the label on the plot.

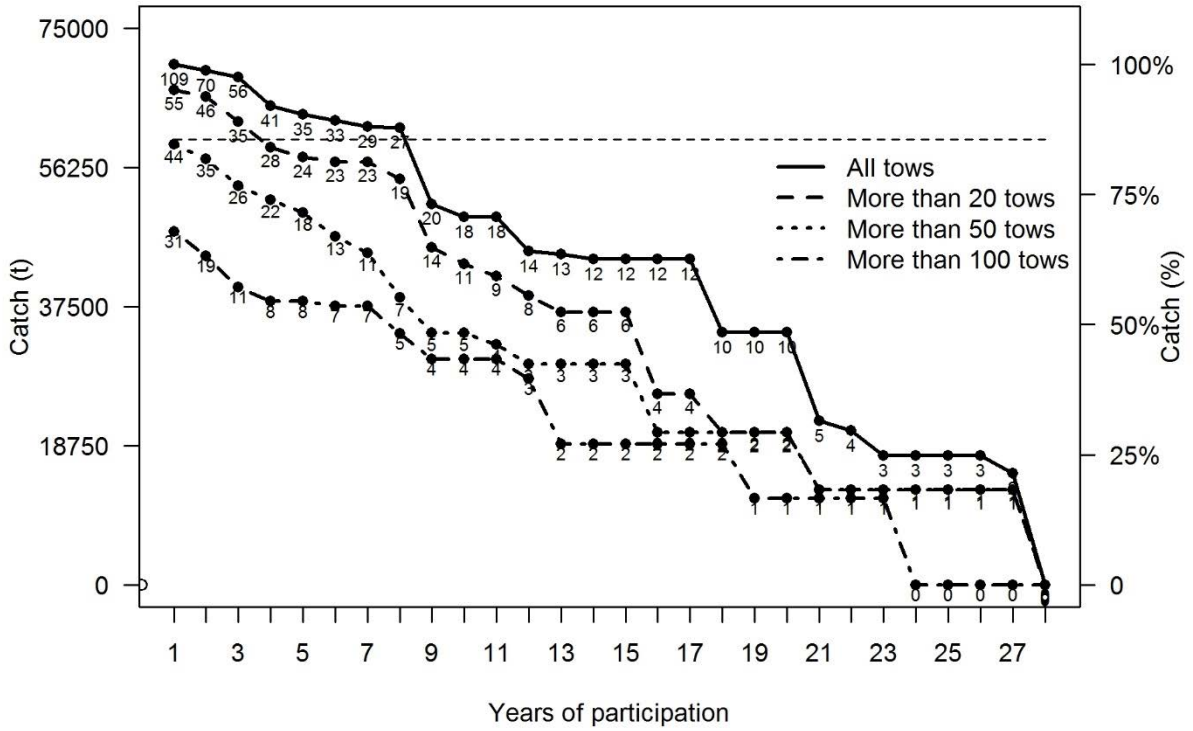


Figure D21: Vessel participation plot showing number of years in the fishery for core vessel choice for ECSI BT TCEPR mixed target CPUE. The dashed line represents 80% of the catch.

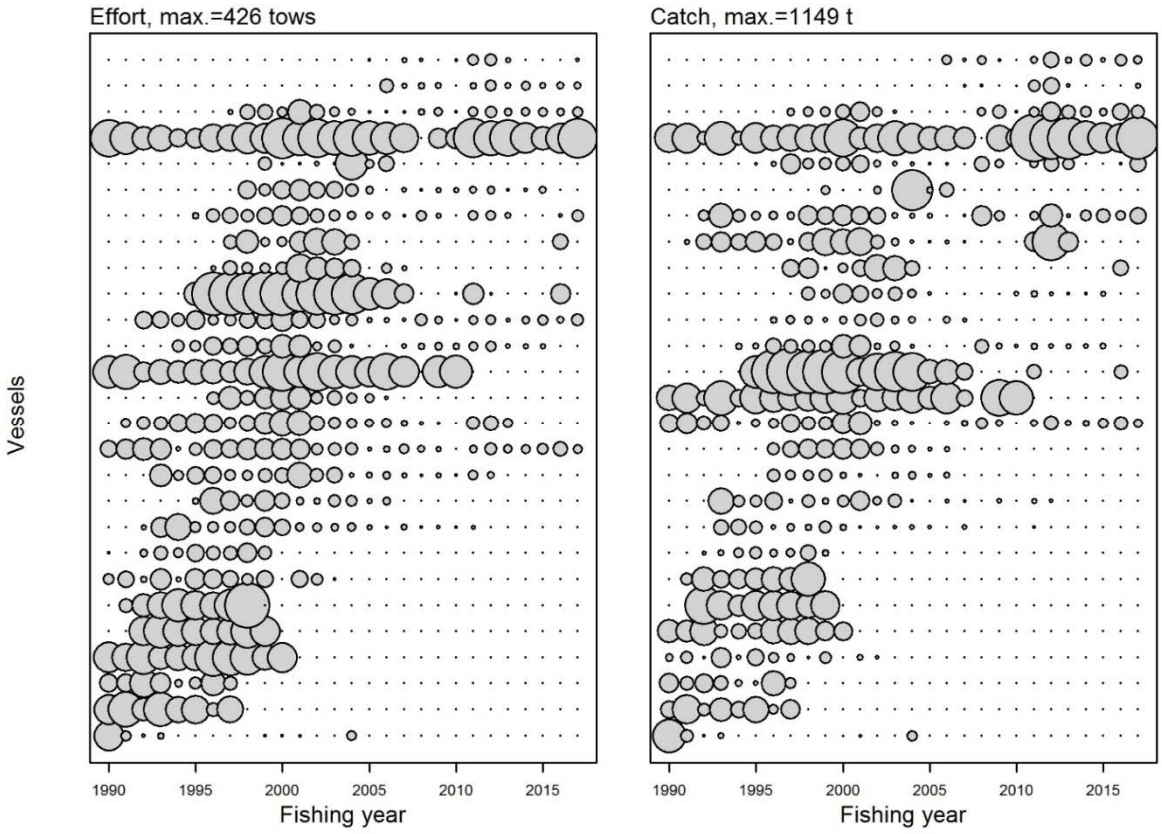


Figure D22: ECSI BT TCEPR summary of effort (number of TCEPR tows) and estimated barracouta catch (t) by fishing year for 1990–2017, for core vessels. The symbol area is proportional to either the number of records or the annual catch, and the maximum circle size is shown in the label on the plot.

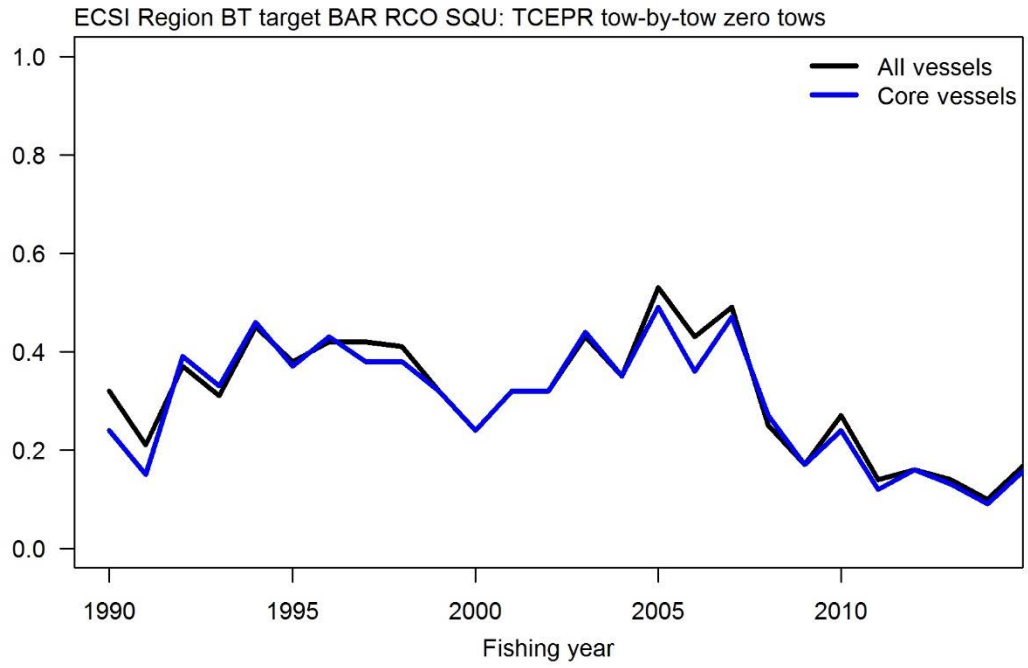


Figure D23: Proportion of zero barracouta catches in the ECSI TCEPR tow-by-tow bottom trawl records, for all vessels and for core vessels, 1990–2017.

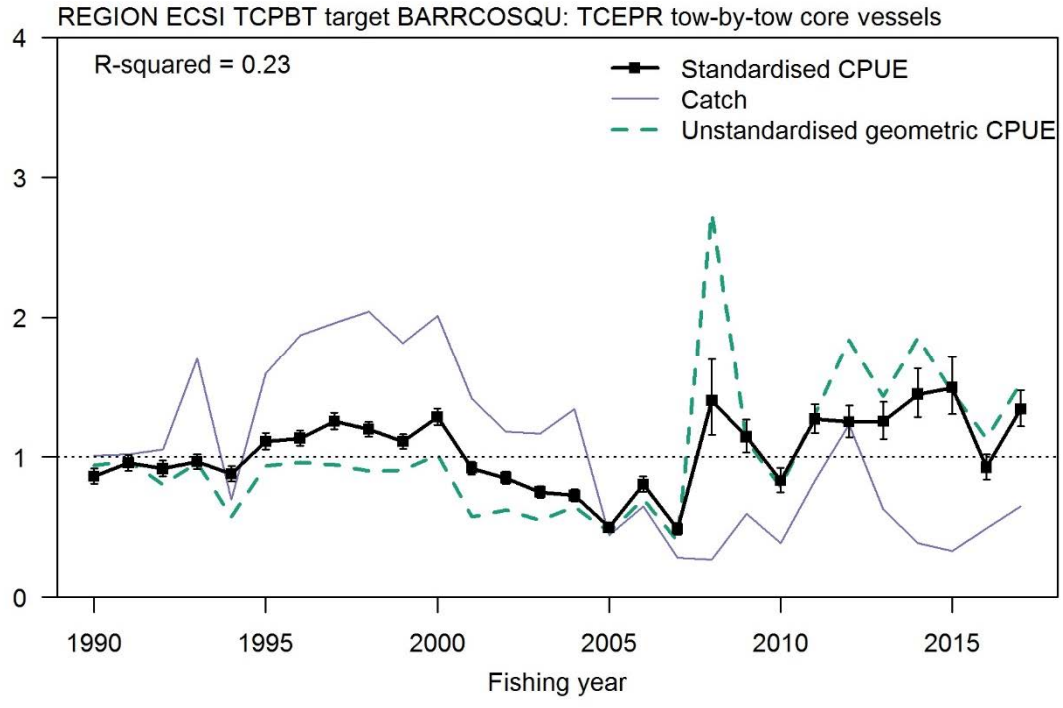


Figure D24: CPUE lognormal indices for ECSI, based on the core vessel TCEPR tow-by-tow, bottom trawl, mixed target dataset, showing catches (scaled to same mean as indices), and lognormal standardised and unstandardised indices. Bars indicate 95% confidence intervals.

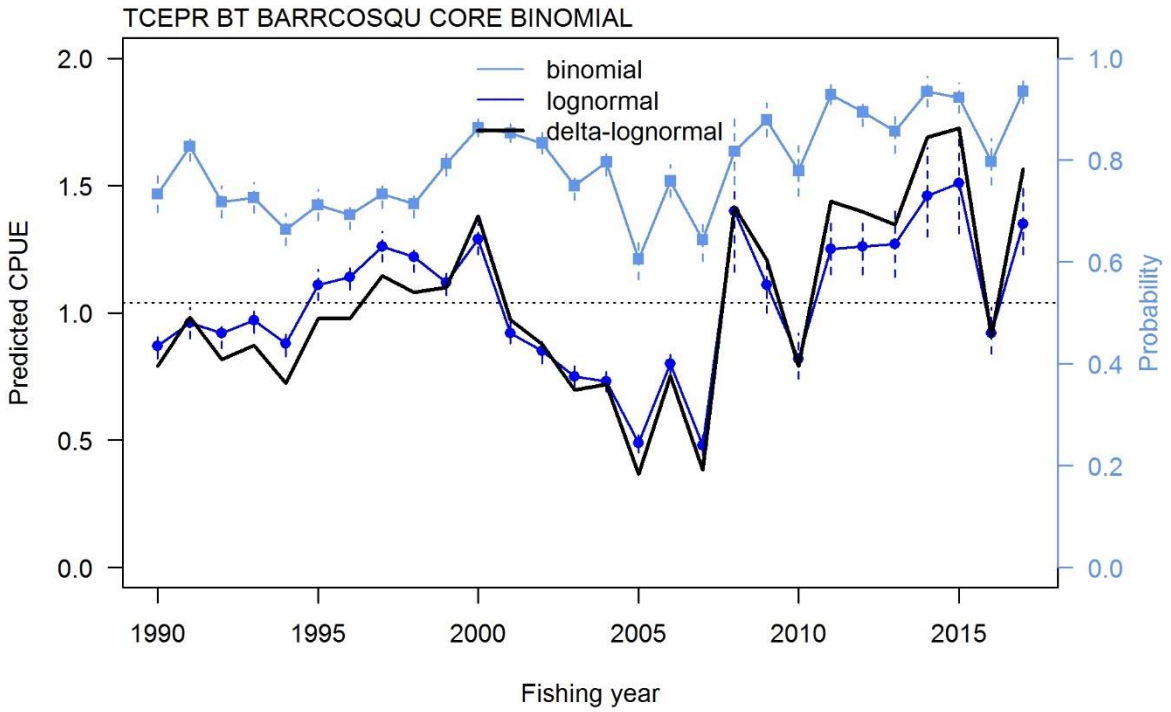


Figure D25: ECSI TCEPR CPUE from the lognormal, binomial, and delta–lognormal (combined) core vessel mixed target, bottom trawl landed catch model, for October-June, 1990–2017. Bars indicate 95% confidence intervals.

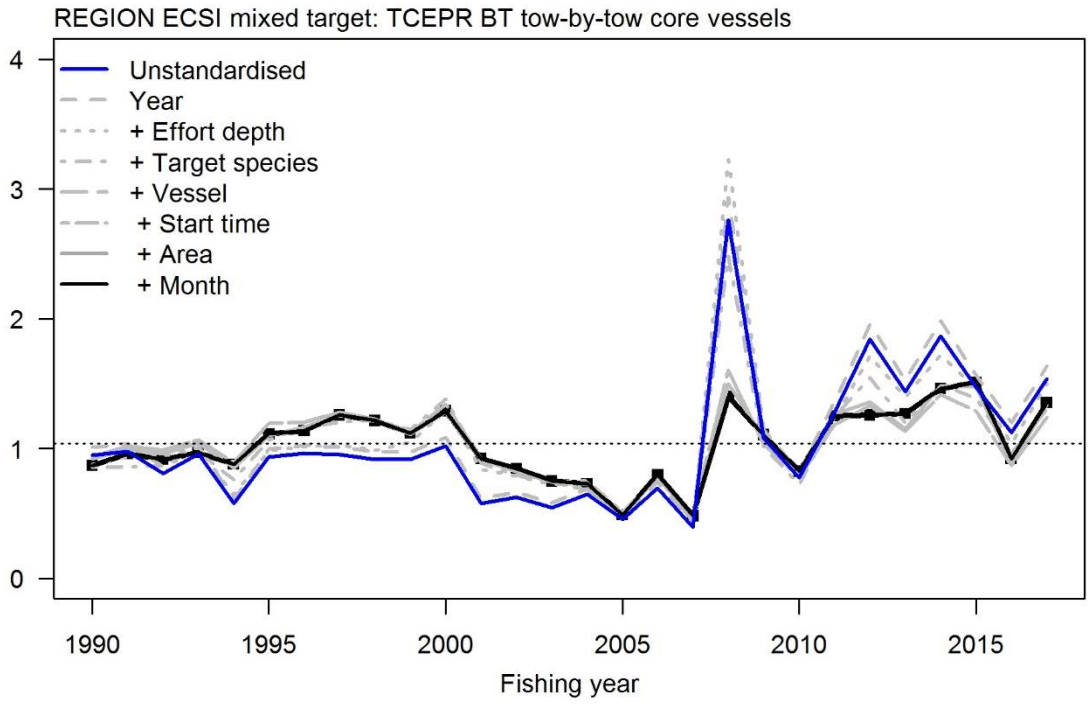


Figure D26: Addition of variables into the lognormal CPUE from the lognormal model for the ECSI TCEPR trawl fishery using bottom trawls to target barracouta, red cod, and squid during October-June of each fishing year, 1990–2017.

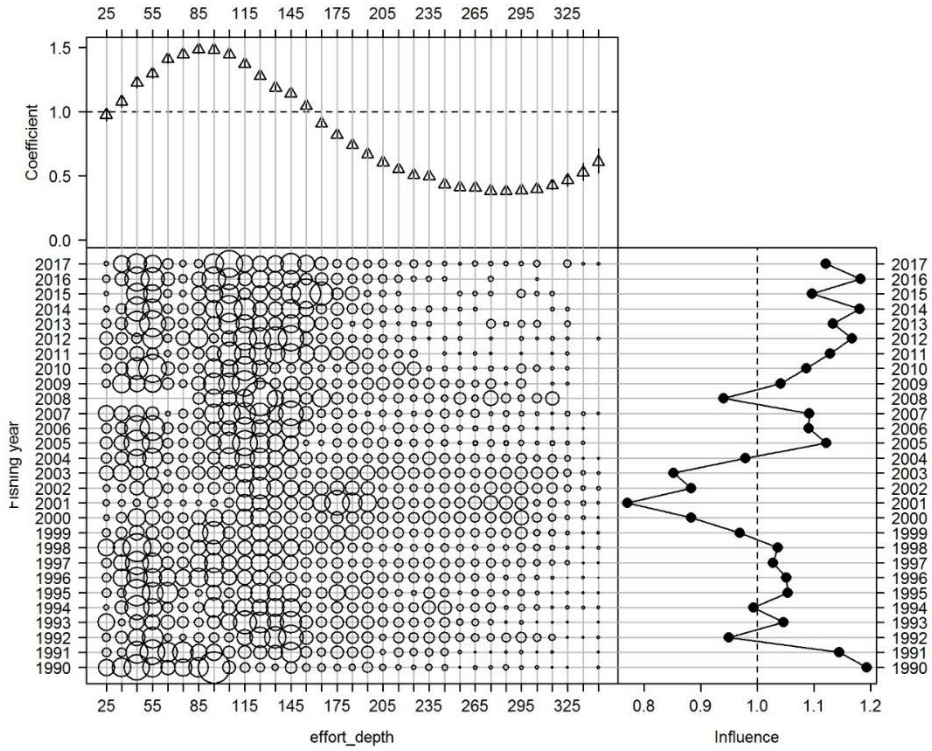


Figure D27a: Effect and influence of depth of effort in the ECSI TCEPR tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

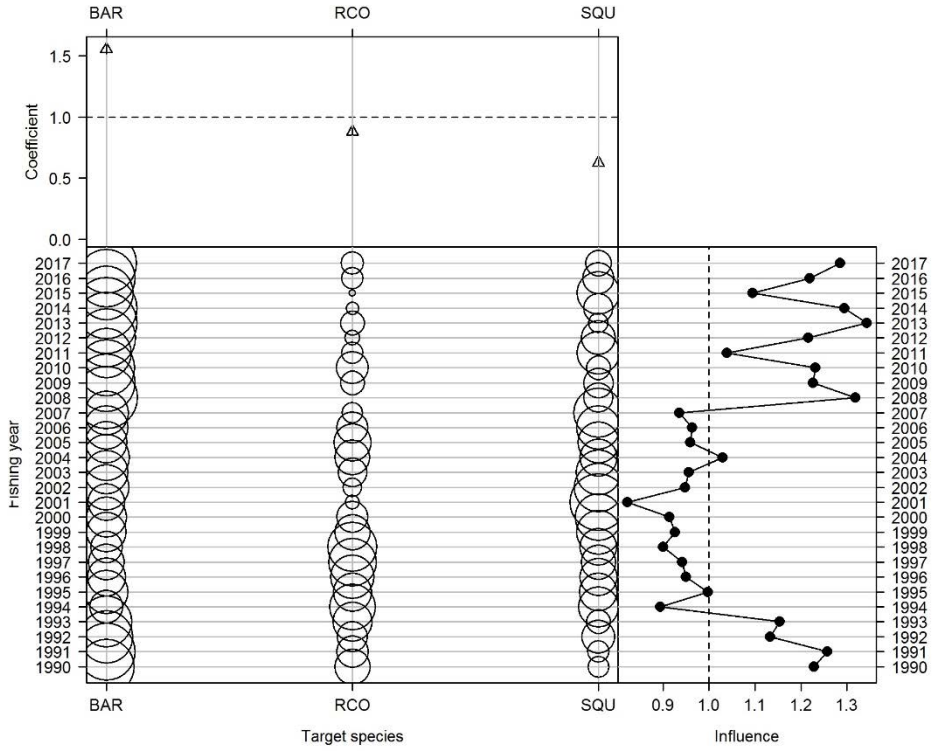


Figure D27b: Effect and influence of target species in the ECSI TCEPR tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

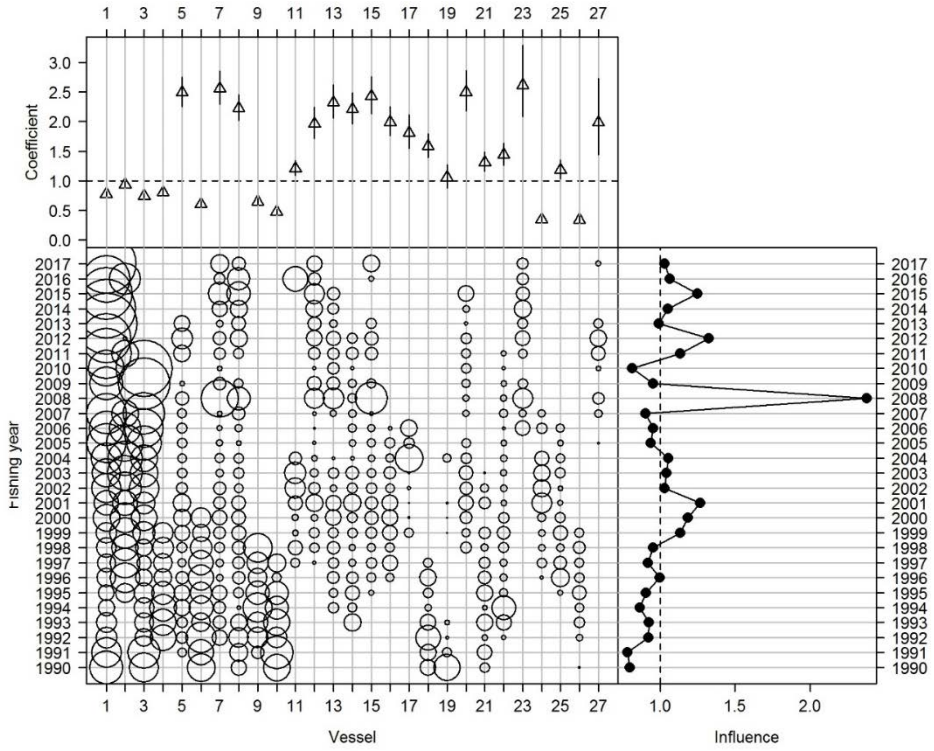


Figure D27c: Effect and influence of vessel in the ECSI TCEPR tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

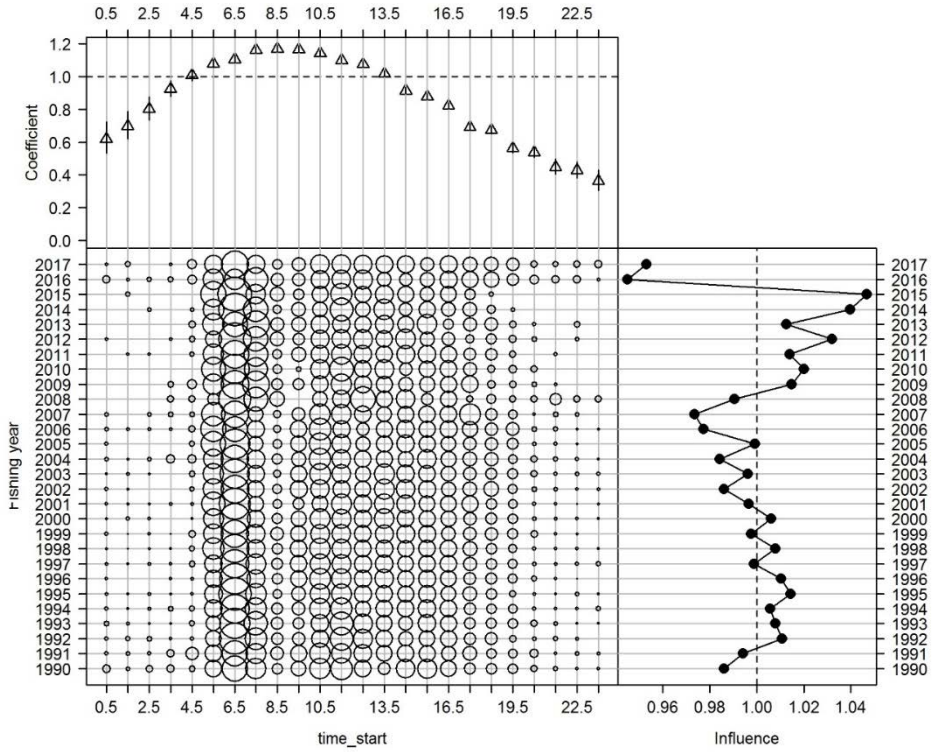


Figure D27d: Effect and influence of tow start time in the ECSI TCEPR tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

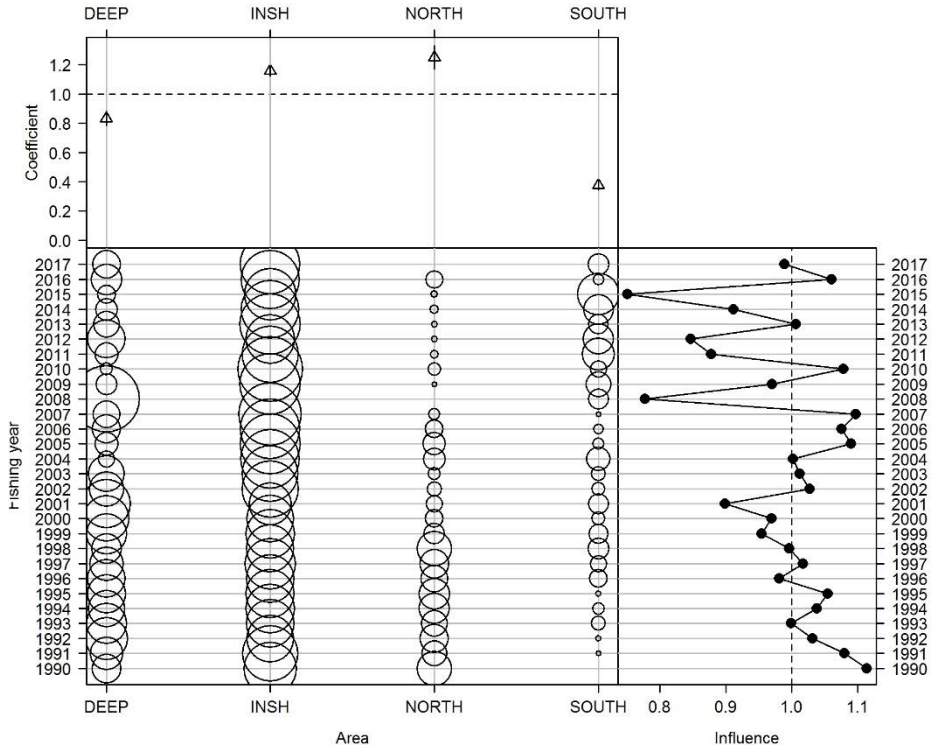


Figure D27e: Effect and influence of area in the ECSI TCEPR tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

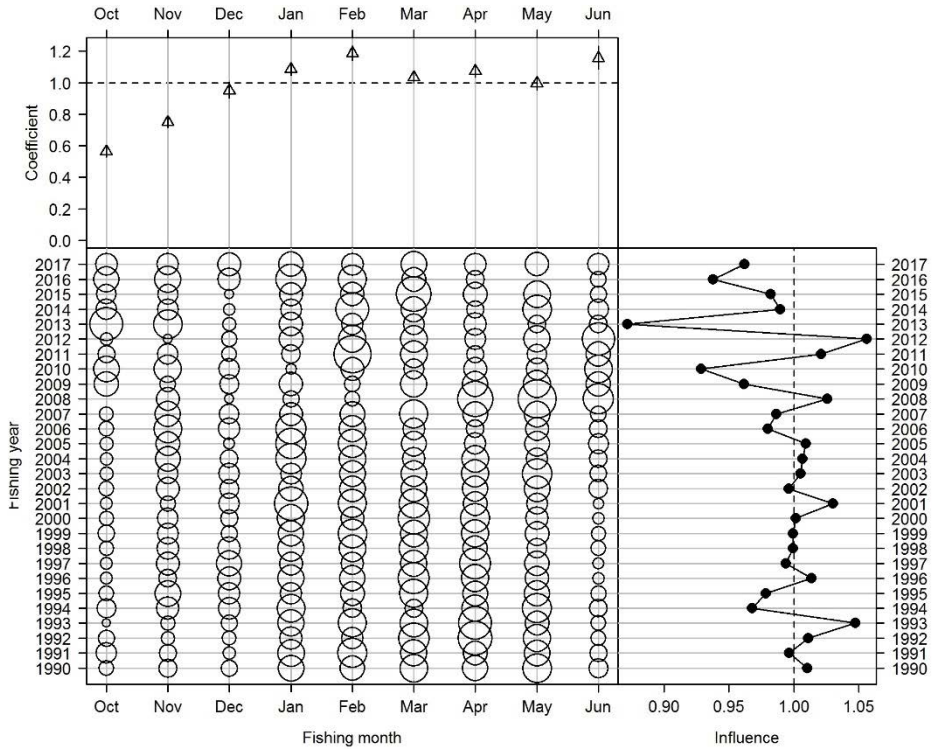


Figure D27f: Effect and influence of month in the ECSI TCEPR tow-by-tow core vessel mixed target BT lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of the effort by variable and fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

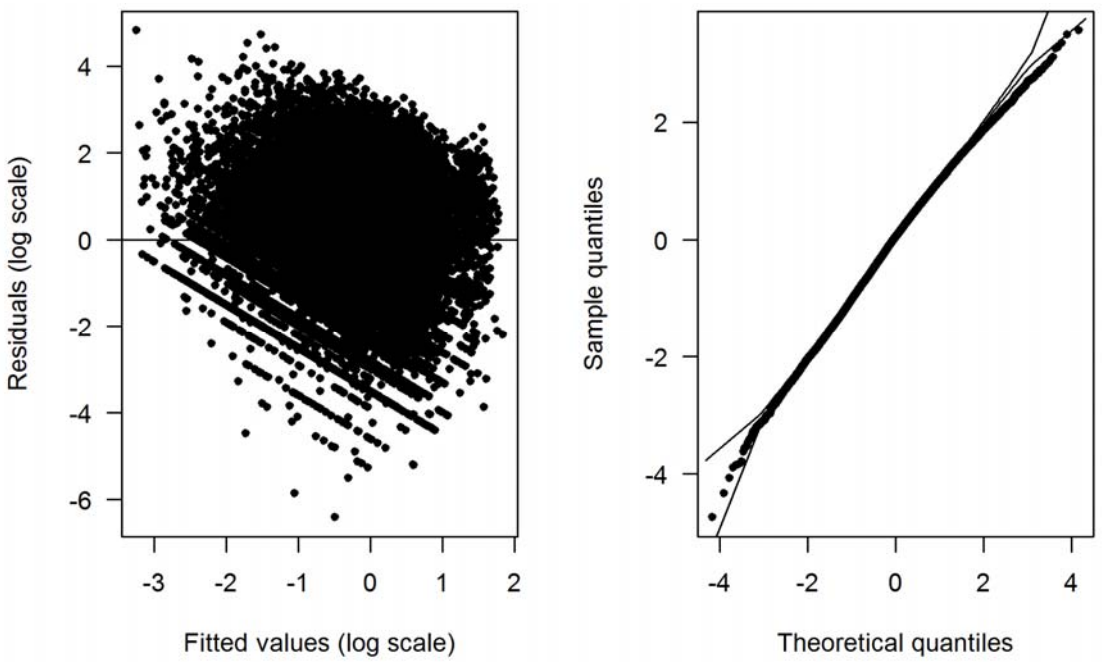


Figure D28: ECSI TCEPR tow-by-tow BT lognormal model: distribution of the standardised residuals against fitted values (left), and the quantile-quantile plot of the residuals (right).