Fisheries New Zealand

Tini a Tangaroa

Fishery characterisation and standardised CPUE for spiny dogfish, *Squalus acanthias*, in SPD 3, SPD 4, and SPD 5, 1989–90 to 2010–11

New Zealand Fisheries Assessment Report 2021/21

S.J. Baird,
S.L. Ballara

ISSN 1179-5352 (online)
ISBN 978-1-99-100373-7 (online)

April 2021

New Zealand Government

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-and-resources/publications
http://fs.fish.govt.nz go to Document library/Research reports

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Baird, S.J.; Ballara S.L. (2021). Fishery characterisation and standardised CPUE for spiny dogfish, *Squalus acanthias*, in SPD 3, SPD 4, and SPD 5, 1989–90 to 2010–11.

***New Zealand Fisheries Assessment Report 2021/21*. 196 p.**

This report is part of a series of middle depth fishery characterisations for species or stocks that are not regularly assessed. The focus is spiny dogfish catch in three Quota Management Areas in waters to the east and south of the South Island: CHAT, a Chatham Rise area defined by SPD 4 and the eastern area of SPD 3, and SUBA, the sub-Antarctic area that is SPD 5. This study analysed the spiny dogfish commercial catch which was mostly taken by vessels considered part of the New Zealand 'deepwater' fleet that operate mainly at depths of 200–1000 m.

Spiny dogfish entered the Quota Management System (QMS) on 1 October 2004, with a Total Allowable Commercial Catch (TACC) of 12 660 t. This TACC has remained unchanged. From 2008 to 2011, the total annual landings were about 50% of the TACC. Spiny dogfish was primarily caught during fishing activities for other target species, and it is likely that the commercial catch records from October 2004 onwards are the most reliable for describing the catch. From 1989–90 to 2010–11, 113 420 t were reported: 50% from SPD 3, 30% from SPD 5, and 20% from SPD 4.

The catch from the CHAT fishery was primarily from the hoki (*Macruronus novaezelandiae*) bottom trawl fishery during October to June, mainly west of 180° and from the ling (*Genypterus blacodes*) bottom longline fishery during July to September, mainly west of the Chatham Islands. In the SUBA area, catches were primarily reported from bottom trawl effort targeted at arrow squid (*Nototodarus sloanii*, *N. gouldi*), hoki, and barracouta (*Thyrsites atun*) during October to April off the Stewart-Snares shelf. As a bycatch species, any seasonal effect is likely to be related to the timing of the target fisheries in which the species was caught.

Random trawl surveys of the Chatham Rise and sub-Antarctic areas by R.V. *Tangaroa* in summer have been conducted since 1991 with core strata at depths of 200–800 m and 300–800 m, respectively, to survey primarily hoki, hake (*Merluccius australis*), and ling. These time series provide relative biomass indices of spiny dogfish for the Chatham Rise, with annual coefficients of variation (CV) generally between 10% and 20%, and for the sub-Antarctic (CV 12–34% from 2000). Both survey series had occasional years of high relative biomass estimates (and high CV). The Chatham Rise series showed a slight increase overall, and a generally flat trajectory from 2000. Females accounted for most of the relative biomass each year. In contrast, the reasonably flat sub-Antarctic survey series was characterised by higher female relative biomass in the earlier part of the time series, but similar estimates for males and females since 2007.

Standardised CPUE analyses using lognormal models were developed at the tow level for the hoki bottom trawl fishery; at the day level for the ling longline fishery in CHAT; at the tow level for mixed targets; and at the day level for bottom trawl fisheries in SUBA. Analyses covered time periods that represented consecutive fishing years with reasonably consistent catch. The R^2 values ranged between 21% and 50%. The CHAT hoki bottom trawl index increased after the species was introduced into the QMS, then decreased slightly after 2009, whereas the ling longline index appeared to increase slightly over the time series, especially after 2007. Over the full time series the trends in the two SUBA indices were similar, with a suggestion of some stability or a small decrease towards the end of the time series.

The similarity of the CHAT hoki bottom trawl index to that from the trawl survey suggests that the Chatham Rise trawl survey should continue to be used to monitor spiny dogfish, at least in depths over 200 m. The depth sampling distribution of the sub-Antarctic trawl survey appears to be less useful, and

reinstatement of the Southland trawl survey (mainly on Stewart-Snares shelf) may provide better information about this species.

Observer sampling of commercial catches of spiny dogfish was driven by the location and timing of the main target fisheries being observed. The observer data from these areas are not representative of the full range of depths in which spiny dogfish are distributed. Sampling from smaller vessels operating on the Stewart-Snares shelf would provide a more representative set of data from the SUBA area.

1. INTRODUCTION

Spiny dogfish (*Squalus acanthias*) is one of the many species not regularly monitored or assessed. This project is part of a series designed to ensure that species caught in middle depth and inshore fisheries within New Zealand's EEZ are routinely summarised and assessed.

Within New Zealand waters, spiny dogfish are generally found at depths of less than 500 m in waters south of about 37° S from Manukau Harbour on the west and East Cape on the east coast of the North Island to 53.5° S, southeast of Campbell Rise (Anderson et al. 1998). Two other *Squalus* species are found in more northern waters. *Squalus griffini* (previously *S. mitsukuirii*) is mainly restricted to North Island waters, although its southern distribution overlaps with *S. acanthias* off the central west coast and near the Chatham Islands. Its northern distribution extends up to Raoul Island in the Kermadec group, where it overlaps that of the newly-described *S. raoulensis* (Duffy & Last 2007a, 2007b). *Squalus griffini*, known as northern spiny dogfish, has a different species code for reporting purposes to that of *S. acanthias*, but it is likely that an unknown amount of misidentification and misreporting has occured, particularly in Fishery Management Areas (FMAs) 1, 8, and 9.

Most of the New Zealand spiny dogfish catch is taken as bycatch by the deepwater fleet in the jack mackerel (*Trachurus* spp.), barracouta (*Thyrsites atun*), hoki (*Macruronus novaezelandiae*), red cod (*Pseudophycis bachus*), and arrow squid (*Nototodarus sloanii*, *N. gouldi*) fisheries, at depths of 100–500 m, and by the inshore trawlers targeting flatfish (*Rhombosolea* spp., *Pelotretis flavilatus*, *Peltorhamphus novaezeelandiae*, *Colistium* spp.), snapper (*Pagrus auratus)*, tarakihi (*Nemadactylus macropterus*), and red gurnard (*Chelidonichthys kumu*) (Manning et al. 2004). Setnets and bottom longlines account for the remainder of the catch. Most of the landed catch is trunked and sent to Asian and European markets. Discarding was a practice of fishers unable to avoid catching the species, mainly because of the low economic value and the handling and processing difficulties of spiny dogfish . Since 1 October 2004, when the species was introduced into the Quota Management System (QMS), fishers have been allowed to discard unwanted catch at sea legally, on the provision that the total catch is reported (Ministry of Fisheries 2011). Since then, catches have ranged from 7200 to 8300 t of which between 55 and 70% are reported as discarded at sea.

Hanchet (1986, 1988) studied the distribution and abundance, reproductive biology and growth, and life history characteristics of spiny dogfish off the east coast of the South Island. Hanchet & Ingerson (1997) presented a summary of biology and relevant data from trawl surveys and commercial fisheries, including the first stock assessment. A second assessment was undertaken by Walker et al. (1999), but according to Manning et al. (2004) the authors were not able to relate the catch-per-unit analysis to relative abundance. Phillips (2004) summarised the length frequency distributions from observed commercial catches and research trawl surveys off the west coast South Island, on the Chatham Rise, and in sub-Antarctic waters, and noted that the coverage of the commercial catch by observers was uneven.

In a study of fish communities on the Chatham Rise, Bull et al. (2001) described the preferred depths of spiny dogfish as shallower than 350 m and similar to a variety of other species, including barracouta, red cod, jack mackerels, arrow squid, silver warehou (*Seriolella punctata*), orange perch (*Lepidoperca aurantia*), giant stargazer (*Kathetostoma giganteum*), and dark ghost shark (*Hydrolagus novaezealandiae*). Based on trawl survey data from 1992–99, catch rates of spiny dogfish were slightly greater on the southern rise than the northern rise. Spiny dogfish was caught along with hoki, silver warehou, and dark ghost shark in depths of 200–350 m. Off the Otago coast, spiny dogfish was a dominant species in the shallow water community (Jacob et al. 1998).

The most recent characterisation of spiny dogfish fisheries throughout the EEZ by Manning et al. (2004) indicated four major fisheries for which the following recommendations were made: the east coast South Island fishery be monitored with commercial setnet CPUE; the Chatham Rise fishery with research trawl survey and commercial catch and length distributions; the Southland fishery with commercial bottom trawl CPUE and commercial catch size distribution; and the west coast

South Island with inshore research trawl survey and commercial catch size distribution. These recommendations were accepted by the Inshore Fishery Assessment Working Group (Manning 2009).

Updated relative abundance indices and catch-at-length estimates for the east coast South Island and Stewart-Snares shelf fisheries were presented by Manning (2009) for 1989–90 to 2005–06. He noted that the dominance of the target setnet catch in the total catch (mainly setnet and bottom trawl) from SPD 3 dropped markedly, from 54% in 1989–90 to 5% in 2005–06. The main catch method in SPD 5, mostly from December to April was bottom trawl but also midwater trawl targeting squid and jack mackerel. In SPD 5, male lengths from observed fisheries were unimodal (range 45–90 cm) and the female distributions were bimodal (peaks at 55–60 cm and 85 cm).

An analysis of catch rates in the mixed target hoki-hake-ling fisheries indicated that spiny dogfish accounted for 16% of the commercial species bycatch from 2000–01 to 2006–07, 95% of the observed discards of commercial species, and was present in 50% of observed tows (Ballara et al. 2010). The highest bycatch ratios for spiny dogfish were from Cook Strait.

Middle depth research trawl surveys designed principally to estimate hoki, hake, and ling abundance (and other species) have been carried out annually using *Tangaroa* on the Chatham Rise and Sub-Antarctic since 1991 (with a hiatus on the sub-Antarctic from 1995 to 1999). Spiny dogfish biomass was usually in the top 10 species for the Chatham Rise series. The survey sampled depth distribution well and coefficients of variation (CV) indicate that the biomass was moderately well estimated (median 28%, range 20–46%, O'Driscoll et al. (2011)). Spiny dogfish were less abundant in the sub-Antarctic, and biomass estimates had higher CVs than on the Chatham Rise (e.g., see Bagley & O'Driscoll 2012). Inshore trawl survey series are also available to potentially provide measures of population status.

The Ministry for Primary Industries (MPI) project DEE201007SPD to characterise the New Zealand spiny dogfish fisheries by analysis of commercial catch and effort data up to 2010–11 had the following objectives:

- to carry out standardised CPUE analyses for the major fisheries (Fishstocks) where appropriate;
- to review the indices from CPUE analyses, all relevant research trawl surveys and Observer logbooks to determine any trends in biomass, size frequency distributions or catch rates;
- to review stock structure using data accessed above and any other relevant biological or fishery information;
- to assess the availability and utility of developing a series of age frequency distributions from trawl survey and Observer collected data; and
- to make recommendations on future data requirements (including recommendations for annual levels of Observer sampling) and methods for monitoring the stocks.

MPI (now Fisheries New Zealand) requested that this work be restricted to the Chatham Rise fishstock areas analysed by Manning et al. (2004) (SPD 4 and the eastern part of SPD 3), and the sub-Antarctic area (SPD 5), up to 2010–11.

2. FISHERY SUMMARY

2.1 Commercial fisheries

Commercial catch-effort and landings reporting returns from 1989–90 to the 2010–11 fishing year (1 October to 30 September), provide the basis for the data used in this report. Tow-by-tow catch-effort data from trawling were reported on Trawl Catch Effort and Processing Returns (TCEPRs) by vessels over 28 m throughout this time period. Starting on 1 October 2007 tow-by-tow catch-effort data were also reported on Trawl Catch Effort Returns (TCERs) by small (6–28 m) trawl vessels. For both of these form types associated landings data are reported on Catch Landing Returns (CLRs).

Before 1 October 2007 trawl vessels under 28 m and vessels operating in various other fisheries including longline and setnet used Catch Effort Landing Returns (CELRs) to collect daily catch-effort and landings data by statistical area. The CELR form was replaced by the Lining Catch Effort Return (LCER) for bottom longline vessels over 28 m, (a daily form introduced in January 2004), and the Lining Trip Catch Effort Return (LTCER) for smaller bottom longline vessels (introduced on 1 October 2007). The landings data for both these form types are reported on CLRs. Setnet data were reported on CELRs until 1 October 2007 when the Netting Catch Effort Landing Return (NCELR) was introduced.

Competitive quotas for spiny dogfish were introduced in 1992–93 for landings in SPD 3 (4075 t) and SPD 5 (3600 t) in an effort to slow targeting of non-ITQ species (Francis 1998). At the same time, targeting of spiny dogfish was prohibited in SPD 4 (Francis & Shallard 1999) A decade later, on 1 October 2004, spiny dogfish was introduced into the Quota Management System (QMS) with a Total Allowable Commercial Catch (TACC) of 12 660 t, split between the six fishstock areas shown in Figure 1. These fishstock areas equate to Fishery Management Areas (FMAs), except for SPD 1 (FMAs 1 & 2), SPD 5 (FMAs 5 & 6), and SPD 8 (FMAs 8 & 9). SPD 10 essentially has no catch.

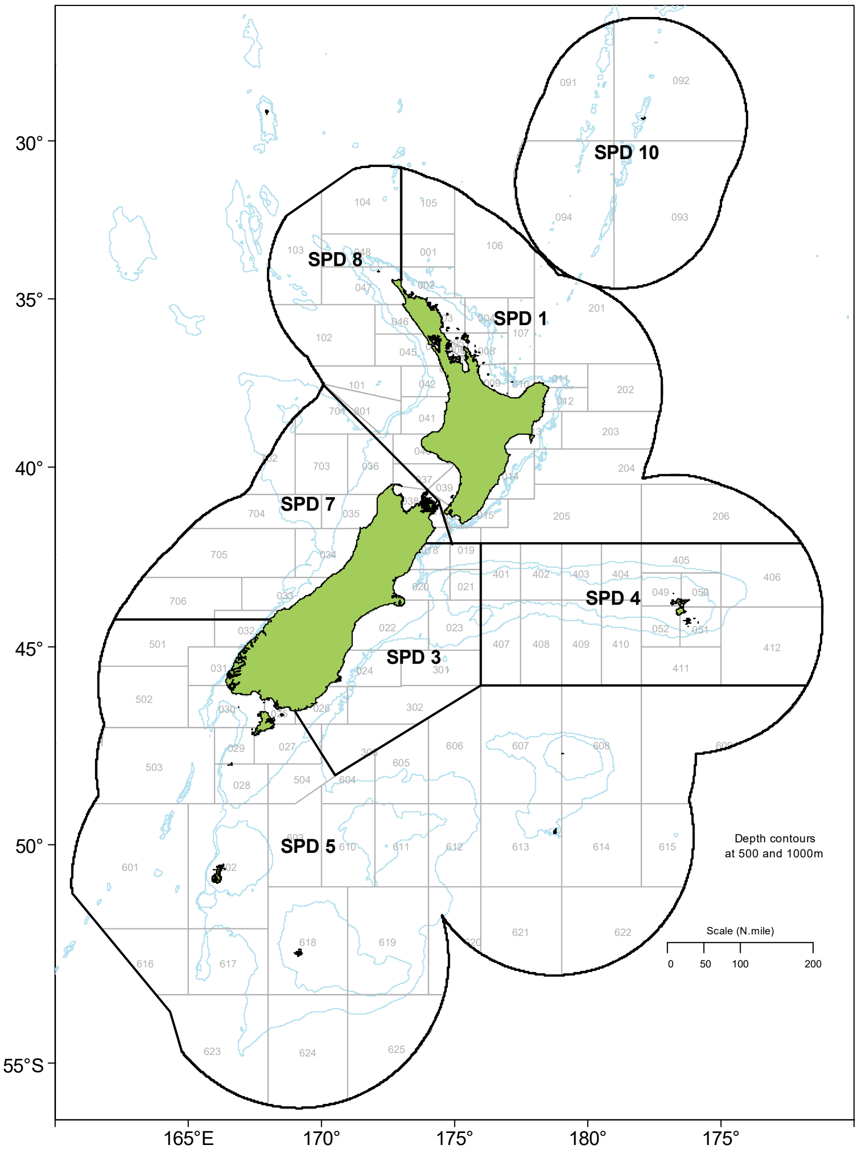


Figure 1: Map showing the administrative fish stock boundaries for SPD 1, 3, 4, 5, 7, 8, and 10, including statistical areas, and the 500 m and 1000 m depth contours.

Estimates of total landings of the species before introduction to the QMS are likely to be underestimates of the actual catch because of discarding with no requirement to report the catch (Table 1). Total landings by FMA and QMS fishstock areas are given in Table 2 and Table 3, respectively.

Table 1: Reported catches of spiny dogfish (t) by fishing year. FSU (Fisheries Statistics Unit), LFRR (Licensed Fish Receiver Return). Discards reported from CELR (Catch Effort Landing Return), and CLR (Catch Landing Return). Numbers in brackets are probably underestimates. Best estimate is considered the best available. (– no data). From Ministry for Primary Industries (2013).

	FSU data				Best
	Inshore	Deepwater	LFRR	Discards	estimate
1980–81	–	(196)	–	–	196
1981–82	–	1 881	–	–	1 881
1982–83	(107)	2 568	–	–	2 675
1983–84	309	2 949	–	–	3 258
1984–85	303	3 266	–	–	3 569
1985–86	311	2 802	–	–	3 113
1986–87	870	2 277	2 608	–	3 147
1987–88	834	3 877	4 823	–	4 823
1988–89	(351)	(500)	3 573	(16)	3 589
1989–90	(14)	0	2 952	321	3 273
1990–91	–	–	5 983	333	6 316
1991–92	–	–	3 274	521	3 795
1992–93	–	–	4 157	616	4 773
1993–94	–	–	6 150	1 063	7 213
1994–95	–	–	4 793	628	5 421
1995–96	–	–	6 230	1 920	8 150
1996–97	–	–	4 887	2 572	7 459

Table 2: Reported landings (t) of spiny dogfish by Fishery Management Area (FMA). Proportions by area were taken from CELR and CLR and pro-rated to the best estimate from Table 1. Competitive quotas of 4075 t for FMA 3, and of 3600 t for FMAs 5 and 6, were introduced in 1992–93. (– no data). From Ministry for Primary Industries (2013).

Fishing										FMA		
Year	1	2	3	4	5	6	7	8	9	10	Other	Total
1982–83	4	0	151	131	2 089	81	145	66	7	–	–	2 675
1983–84	22	18	409	347	565	1 700	119	63	16	–	–	3 258
1984–85	21	12	557	481	451	1 899	90	48	10	–	–	3 569
1985–86	13	11	892	411	537	1 017	120	92	20	–	–	3 113
1986–87	64	18	1 048	162	1 002	29	501	296	27	–	–	3 147
1987–88	50	9	1 664	172	642	16	1 402	841	27	–	–	4 823
1988–89	341	16	1 510	168	771	7	633	132	11	–	–	3 589
1989–90	36	14	2 243	136	241	2	521	80	0	–	–	3 273
1990–91	129	14	2 987	513	1 708	14	883	67	0	–	–	6 316
1991–92	54	23	1 801	66	538	33	1 031	249	0	–	–	3 795
1992–93	50	9	2 128	218	817	22	1 163	366	0	–	–	4 773
1993–94	51	34	3 165	358	1 158	21	2 212	214	0	–	–	7 213
1994–95	84	47	2 883	363	606	37	1 205	196	0	–	–	5 421
1995–96	68	177	2 558	969	1 147	152	1 205	186	15	–	–	7 052
1996–97	30	159	2 428	1 287	764	120	1 517	235	7	1	1	6 555
1997–98	52	165	5 042	917	428	223	2 389	1 172	34	0	11	10 433
1998–99	45	488	3 148	1 048	1 996	154	1 902	74	< 1	0	< 1	8 424
1999–00	15	328	3 309	994	1 163	189	1 505	25	7	0	5	7 540
2000–01	38	336	4 355	1 075	1 389	212	1 310	54	16	0	28	8 811
2001–02	12	222	4 249	1 788	3 734	487	961	71	12	0	–	11 530
2002–03	10	245	3 553	1 010	2 621	413	772	85	19	0	0	8 727
2003–04	12	91	2 077	516	1 032	302	423	20	5	0	0	4 477

Table 3: Reported domestic landings (t) of spiny dogfish by fishstock and TACC from 2004–05 to 2010–11. From Ministry for Primary Industries (2013).

Fishstock	SPD 1		SPD 3		SPD 4		SPD 5		SPD 7	
FMA	1 & 2		3		4		5 & 6		7	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
2004–05	234	331	2 707	4 794	839	1 626	2 479	3 700	842	1 902
2005–06	186	331	3 831	4 794	1 055	1 626	2 298	3 700	832	1 902
2006–07	239	331	2 712	4 794	822	1 626	2 165	3 700	1 125	1 902
2007–08	156	331	2 082	4 794	1 397	1 626	1 501	3 700	928	1 902
2008–09	229	331	1 981	4 794	866	1 626	2 071	3 700	929	1 902
2009–10	128	331	1 855	4 794	667	1 626	2 205	3 700	1 116	1 902
2010–11	149	331	1 976	4 794	825	1 626	1 443	3 700	1 413	1 902

Fishstock	SPD 8		Total	
FMA	8 & 9		All	
	Landings	TACC	Landings	TACC
2004–05	121	307	7 222	12 660
2005–06	108	307	8 311	12 660
2006–07	118	307	7 181	12 660
2007–08	124	307	6 188	12 660
2008–09	150	307	6 226	12 660
2009–10	194	307	6 166	12 660
2010–11	219	307	6 026	12 660

Reported landings steadily increased over the years since the 1990–91 fishing year, with peaks in 1997–98 (10 433 t) and 2001–02 (11 530 t). After 2001–02, reported landings decreased sharply to reach a new low in 2003–04 (4477 t), the fishing year prior to the introduction of the species into the QMS when a total TACC of 12 660 t was set. Of the TACC, 67% was allocated to two fishstocks (SPD 3 and SPD 5). Annual reported landings subsequently increased to a peak in 2005–06 (8311 t), and remained relatively stable at about 6000 t, about 2000 t under the totals reported in the late 1990s, and about 50% of the total TACC. The reported landings did not reach the individual TACCs set for any of the fishstocks (see Table 3, Figure 2). Highest annual reported landings were from SPD 3 and SPD 5, then SPD 7 and SPD 4. Reported landings in SPD 3 and SPD 5 decreased slightly, whereas those in SPD 7 increased, from 2004–05 to 2010–11.

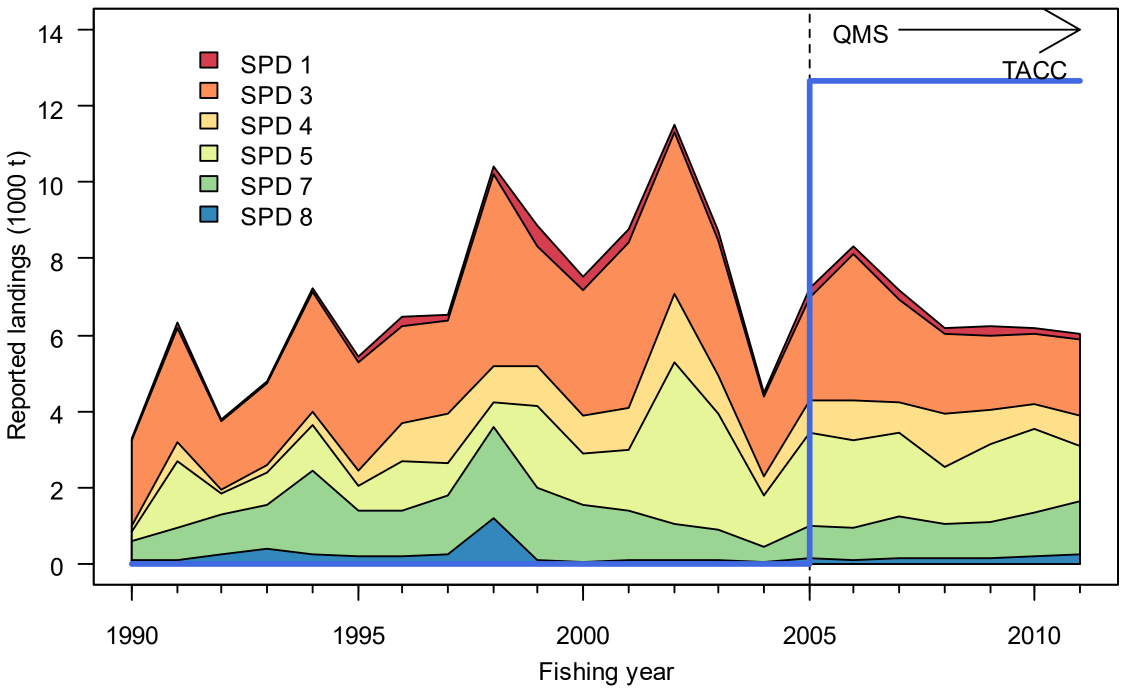


Figure 2: Total reported landings by QMA, and the total TACC, for 1989–90 (1990) to 2010–11 (2011).

For the analyses required for this report, the SPD fishstock areas were divided into fishery areas shown in Figure 3, where CHAT combines SPD 4 and the eastern part of SPD 3 (after Manning et al. 2004), ECSI is the remainder of SPD 3, and SUBA is equivalent to SPD 5.

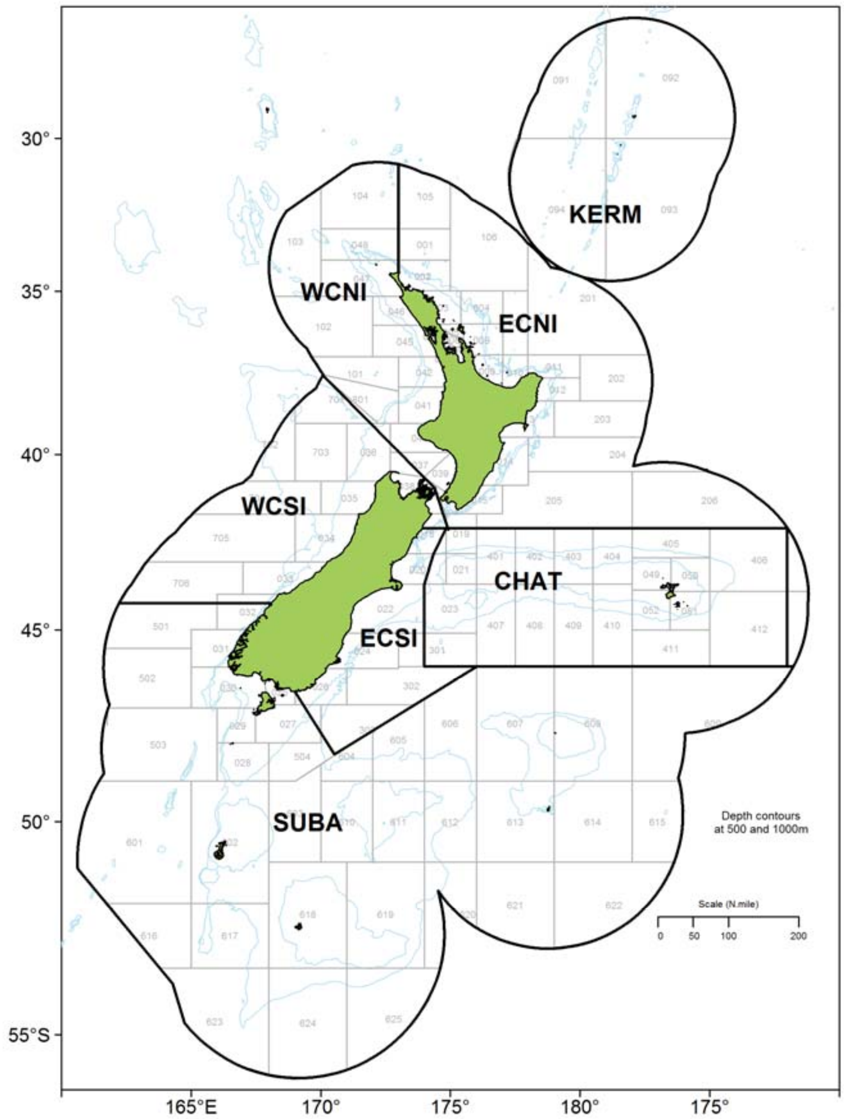


Figure 3: Map showing the areas used in this analysis, including statistical areas, and the 500 m and 1000 m depth contours. CHAT covers SPD 4 and the eastern part of SPD 3. ECNI, east coast North Island (SPD 1); ECSI, east coast South Island area of SPD 3; WCSI, west coast South Island (SPD 7); WCNI, west coast North Island (SPD 8); and SUBA, Sub-Antarctic (SPD 5).

2.2 Recreational fisheries

Spiny dogfish are caught by recreational fishers throughout their geographical range in New Zealand. They are mainly taken by rod and line and setnet as bycatch during target fishing for more valued species (see Francis 1998). There is a total recreational catch allowance of 245 t per year (Ministry of Fisheries 2011). Recreational fishers in southern New Zealand are limited to a bag limit of 15 spiny dogfish per day by amateur fishing regulations (Fisheries (South-East Area Amateur Fishing Regulations) and Fisheries (Southland and Sub-Antarctic Areas Amateur Fishing) Regulations 1991).

2.3 Māori customary fisheries

Māori traditionally harvested spiny dogfish (see Francis 1998), including the northern spiny dogfish, but the catch of 'dogfish' included other shark species such as rig and school shark. The level of customary allowance is set at 245 t per year (Ministry of Fisheries 2011); however, there is no available quantitative information on the current level of customary non-commercial catch of spiny dogfish.

2.4 Illegal and misreported catch

It is unlikely that there is an illegal catch of spiny dogfish because the quota has never been reached and this species has low commercial value. Before the introduction of the Schedule 6 legislation (see Section 2.6), there may have been some under-reporting of discarded catch (see Francis 1998). There may also have been some mis-coding and mis-reporting through identification issues with northern spiny dogfish.

2.5 Other sources of mortality

Before the species entered the QMS in October 2004, it was likely that a large amount of spiny dogfish was discarded by fishers and not reported on the catch returns. Under the current management regime, there is provision for fishers to catch then discard spiny dogfish alive or dead as long as the catch is recorded (see below). The proportion and the survival rate of live discarded dogfish is unknown.

2.6 Regulations affecting the fishery

Under Schedule 6 of the Fisheries Act 1996, spiny dogfish can be returned (whether alive or dead) to the waters from which it was taken. This recognises the unwanted bycatch of spiny dogfish from trawl fisheries, the limited likelihood of survival on release, the low (economic) value of the species, and the expectation that fishers will accurately record the discarded catch (Ministry of Fisheries 2008). Fishers use a special reporting code when completing forms to ensure that the discarded catch goes against the quota, and they are required to balance the catch with ACE or pay the SPD deemed value, whether the catch is landed or discarded (Ministry of Fisheries 2008).

Protection of spiny dogfish taken as bycatch in multi-species fisheries is mainly through the Quota Management System. There is no specific protection for spiny dogfish under the New Zealand National Plan of Action for the Conservation and Management of Sharks (Ministry of Fisheries 2008). The NPOA includes the management of spiny dogfish for the Challenger finfish, east coast North Island finfish, hoki, and Kermadec fisheries.

Codend minimum mesh-size regulations for trawl fisheries that catch spiny dogfish are 60 mm for sub-Antarctic (FMA 6) fisheries and FMA 5 south of 48°S; and 100 mm elsewhere. From 1 October 1977, the codend mesh-size change took effect at the boundary between the Snares Islands and Auckland Islands fisheries (the old EEZ area F/E boundary), which was at 48° 30' S. The management area boundary was changed on 1 October 1983 to 49° S (now the FMA5/6 boundary), but the codend mesh size change takes effect at 48° S to allow for targeting of squid around the Snares Islands (Hurst 1988).

3. BIOLOGY

Spiny dogfish are long-lived and slow-growing squaliform (dogfish sharks) sharks that occupy coastal temperate waters in both the northern and southern hemispheres (Campana et al. 2006). This species is well studied in northern hemisphere waters and subject to protective management regimes in the North Pacific and North Atlantic fisheries. The fish form large schools segregated by size, sex, and maturity status (Ketchen 1972, with resident and migratory components, both along the coast as well as between shallower and deeper waters (McFarlane & King 2003, Campana et al. 2009, Tribuzio et al. 2009). The species distribution is strongly linked to water temperatures of about 6–15 °C (Shepherd et al. 2002, Compagno et al. 2005). Although some differences are seen between populations off the northern Atlantic and Pacific coasts, the spiny dogfish are considered as one species, and in both populations, fishing pressure was considered a major cause for the decrease in maximum size and size at maturity for female spiny dogfish and a large increase in the ratio of mature males to mature females (Sosebee 2005). North Atlantic spiny dogfish recruit to the fishery at about 36 cm total length and mature females are generally over 80 cm in total length and mature males are over 60 cm (Rago & Sosebee 2010). Below is a summary of the knowledge of this species in New Zealand waters.

3.1 Distribution

Within the New Zealand EEZ, spiny dogfish are widely distributed, particularly south of 38° S in waters shallower than 500 m (Anderson et al. 1998). Small juvenile spiny dogfish (at 0+, under 45 cm) are generally found in waters shallower than 100 m off the east coast South Island and have also been recorded off Southland and the west coast South Island (see Hurst et al. 2000). Larger juveniles have a similar geographic distribution, to depths of 150 m, and are often in mixed schools with mature males and sub-adult females. Immature spiny dogfish have a wider distribution that includes waters off the west coast North Island, the sub-Antarctic, and the Chatham Rise (see Hurst et al. 2000).

The length distribution of spiny dogfish caught during trawl surveys (see Section 5 and Appendix A) and observed during commercial fishing effort (Section 6 and Appendix B) shows that the distribution of smaller fish is mainly in shallow inshore areas, out to the edge of the continental shelf. Spiny dogfish large enough to be captured and retained by commercial or research trawl nets in deeper waters were generally at least 50 cm total length. The offshore trawl survey data indicate that in sub-Antarctic waters, males were more likely to be further offshore and that along the Chatham Rise, east of 174°, females were dominant in the catch compared with males.

Pregnant females off Otago coast spend the first year of pregnancy inshore before moving to deeper waters (200–300 m) near the continental shelf edge where they give birth during the second year (Hanchet 1988). Pupping is known to occur along the east coast South Island from Kaikoura south to Foveaux Strait in March-September (peak in July-August) and in more localised shallow waters around Otago (see Hurst et al. 2000).

Hanchet (1986) reported the north-south movement of spiny dogfish along the east coast of the South Island, particularly of mature males and sub-adult females, with spiny dogfish more abundant in the waters of the Canterbury Bight during winter. Most spiny dogfish were in water temperatures of 9–13 °C, and as temperatures increased the dogfish moved south to cooler waters (Hanchet 1986).

In commercial fisheries, spiny dogfish is most often caught as bycatch in trawl fisheries off the east and west coasts of the South Island, Chatham Rise, and Stewart-Snares shelf and in bottom longline fisheries on the Chatham Rise and in sub-Antarctic waters (Section 6 and Appendix C).

3.2 Maturity and reproduction

Unlike the northern hemisphere spiny dogfish populations, little work has been undertaken on the reproductive characteristics of spiny dogfish in New Zealand waters. Hanchet (1986, 1988) used samples from east coast South Island trawl surveys, some commercial catches, and university research vessel surveys during the early 1980s to describe the main traits of spiny dogfish reproduction, presented below.

Overall, the species has low fecundity, a gestation period of about 24 months, and late maturity. On average, the length at maturity was 57.5 cm (total length) for males and 73 cm for females – a smaller size than for northern hemisphere spiny dogfish. However, length ranges of mature and immature spiny dogfish in Patagonian waters show considerable overlap (Alonso et al. 2002). Males are mostly mature by 6 y and females by 10 y (Table 4).

Parturition, mating, and ovulation occur mainly between April and September at depths of 200–300 m. Males move offshore to these waters during May to August for mating. Soon after ovulation, once the embryos reached about 2 cm, females move to shallow waters (under 50 m) for about 9 months, then return to 200–300 m depths for the remainder of the cycle. Hanchet (1988) suggested that parturition may occur off the bottom, in midwater. Mean length at birth was calculated at 24 cm (range 18–30 cm), and the mean number of pups was 5 (range 1–16 pups). The size of the litter increases linearly with the parent length.

There appeared to be latitudinal differences in the season of the cycle, as reported from other spiny dogfish studies (see Hanchet 1988) and in length at maturity; although the northern area (the southern boundary of which was defined at Timaru, at 44.4° S) had only one-third of the data collected from the southern area. In the northern area, 50% of females were mature at 74 cm (compared with 71.5 cm), and 50% of females had given birth and ovulated by mid-July compared with mid-August in the southern area. Females from the Tasman Bay area (about 41°S) matured at about 76.5 cm (see Hanchet 1988).

The trawl survey data suggest that mature females were present from trawl catches at depths of 30–800 m south of about 40° S (see Section 5). There is a lack ofdata available on the reproductive state of female spiny dogfish from observed commercial fishing (Section 6).

Table 4: Maturity age ogive based on Hanchet (1986).

Age (years)	3	4	5	6	7	8	9	10	11	12
Males	0.00	0.02	0.21	0.68	1.00	1.00	1.00	1.00	1.00	1.00
Females	0.00	0.00	0.00	0.00	0.04	0.04	0.23	0.52	0.75	1.00

3.3 Stocks and spatial distribution

There are no data such as genetic analysis of tissue samples or analysis of spatial distribution from tagging studies to inform the delineation of the stock structure of spiny dogfish in New Zealand waters. Most of the data that has been used to describe spiny dogfish stocks in New Zealand waters are from inshore and deepwater trawl surveys and from commercial fisheries data. Hanchet & Ingerson (1997) summarised early trawl survey data which suggested seasonal migrations along the east coast South Island, with abundance higher in the southern waters during October-April and higher in more northern waters in May-September. Off the west coast South Island, seasonal migrations were evident with catches highest in summer and autumn, with fish likely to be moving north in winter as far as north and south Taranaki Bights – waters where there is also evidence of a resident summer population (see Hanchet & Ingerson 1997).

Hanchet & Ingerson (1997) recommended the use of five fish stocks within the EEZ: SPD 1, SPD 3, SPD 4, SPD 5, and SPD 7. Manning et al. (2004) developed this further to delineate between the fishing activity of smaller vessels operating along the east coast South Island and the main Chatham Rise activity and this separation is continued in this study.

3.4 Age and growth

The main ageing technique used for spiny dogfish involves counts of zones observed in cross sections of the second dorsal fin spine, validated using oxytetracycline and bomb-radiocarbon dating (Campana et al. 2006, see Bubley et al. 2012). Campana et al. (2006) determined ages of up to about 45 y based on spine enamel growth, concurring with other studies that showed that North Pacific spiny dogfish live longer than those from the North Atlantic. Bubley et al. (2012) developed a method to use assumed annual band deposition in vertebrae sections, which appears to be more reliable than the spine ageing, particularly for older and larger individuals. Male and female spiny dogfish have similar growth patterns until they reach the age and size of maturity for males, after which growth for males slows (Campana et al. 2009).

Hanchet (1986) used dorsal fin spines, length frequency data, eye lens-weight frequency data, and reproductive data in a New Zealand ageing study and validated the ages of young fish (under 4 years old) to derive the von Bertalanffy growth curves for males and females presented in Table 5 and the age-at-maturity table in Section 3.2. Hanchet (1986) considered that the values were also reliable for older fish (see Hanchet & Ingerson 1997). Growth was similar to that of North Atlantic spiny dogfish, but the New Zealand spiny dogfish were faster growing and shorter lived compared with North Pacific dogfish. Females attained larger maximum size than males, 111 cm for females (age 26 y) and 90 cm for males (21 y) Hanchet (1988).

Spines are routinely collected from a range of spiny dogfish male and female lengths during the winter inshore trawl surveys off the east coast South Island: 423 in 2007 (Beentjes & Stevenson 2008), 417 in 2008 (Beentjes & Stevenson 2009), 768 in 2009 (Beentjes et al. 2010), and 387 in 2012 (Beentjes et al. 2013). The 2013 west coast South Island inshore survey collected 775 spines (Dan MacGibbon, NIWA, pers. comm.).

Table 5: Summary of von Bertalanffy growth parameters for spiny dogfish sampled from the Otago coast (inshore SPD 3). Source: Hanchet (1986), Hanchet & Ingerson (1997).

Sex	n	L_∞	k	t_0	Age at maturity	Maximum age
Otago						
Male	441	89.5	0.116	-2.88	6 y	21 y
Female	497	120.1	0.069	-3.45	10 y	26 y

3.5 Natural mortality

Total instantaneous natural mortality (M) was estimated by Hanchet (1986) as 0.2 y^{-1}, based on the survivorship table method of Holden (1977).

3.6 Length-weight relationship

Length-weight parameters for east coast South Island spiny dogfish were estimated by Hanchet (1986) (Table 6).

Table 6: Length-weight parameters for spiny dogfish, where weight (g) = αL^{β}, L is total length (cm), and n is the number of dogfish. Source : Hanchet (1986).

Area	Sex	a	b	n
SPD 3	Male	0.00275	3.05	542
(east coast South Island)	Female	0.00139	3.25	742

3.7 Feeding and trophic status

Spiny dogfish diets change as individuals grow and mature, with a general shift from a pelagic to a more demersal diet, and to larger prey items and more fish (Jones & Green 1977, Beamish & Sweeting 2009, Tribuzio et al. 2010). Alonso et al. (2002) found dietary differences between immature individuals, and mature males and mature females in a study of spiny dogfish off the Patagonian coast (Alonso et al. 2002), with main prey species including squid, merluccid fish, and salps.

The major dietary components, by occurrence, based on analysis of stomach contents from over 5000 spiny dogfish caught off the east coast of the South Island were post-larval squat lobsters, euphausids, and other crustaceans (totalling 60%) and fish species (15%) (Hanchet 1991).

A recent study of 11 squaliform shark species caught during three Chatham Rise summer trawl surveys at depths of 200–1200 m assigned the sharks to four trophic groups, with spiny dogfish at the lowest weighted mean trophic level, in a group on its own (Dunn et al. 2013). This study described the diet of spiny dogfish as ‘adaptive’ and concurred with Hanchet (1991) and international studies that show the wide range of benthic and pelagic fish and invertebrate prey in spiny dogfish diets, including scavenged fish. Dunn et al. (2013) identified important predictors of dietary variation for spiny dogfish (median length 74.4 cm, range 55.2–105.7 cm) as year, area, fish weight, and bottom water temperature. At least 24 species of prey fishes from benthic through to pelagic environments were identified. The most important fish prey were scavenged jack mackerel, hoki, and macrourids; salps and euphausids were most numerous; and by prey weight, squids were most important, then unidentified fish, scavenged fish, hoki, and octopods.

Hanchet (1986) reported that young dogfish (0+ and 1+ fish) were prey for adult spiny dogfish and blue shark (*Prionace glauca*). Other shark species such as school shark (*Galeorhinus galeus*), mako (*Isurus oxyrinchus*), porbeagle (*Lamna nasus*), and great white (*Carcharodon carcharias*) predated on larger spiny dogfish.

4. CURRENT AND ASSOCIATED RESEARCH PROGRAMMES

4.1 Fisheries New Zealand

Spiny dogfish is one of 18 species included on a list to be characterised once every three years under the Ministry of Fisheries (now Fisheries New Zealand) ‘Deepwater 10–year Plan’. There are no specific research programmes for spiny dogfish. Annual (or alternate years) research trawl surveys using *Tangaroa* on the Chatham Rise and sub-Antarctic in summer regularly sample catches and collect length frequency data for spiny dogfish. Surveys using *Kaharoa* off the west and east coasts of the South Island collected similar data from inshore waters during winter, and although these surveys were less regular, they have recently operated on alternate years. The *Kaharoa* trawl survey summer series off the east coast South Island was discontinued.

5. FISHERY INDEPENDENT OBSERVATIONS

5.1 Research surveys

This section provides biomass estimates and length frequency summaries from the main time series of inshore and deeper water trawl surveys. Hanchet & Ingerson (1997) provided a summary of earlier surveys that indicated significantly higher catch rates in summer south of Timaru on the east coast South Island and in winter, north of Timaru; and that lower catch rates were obtained on the Stewart-Snares shelf during October-December than in January-April. Catch rates were low during sub-Antarctic surveys. Catches off the west coast South Island were highest in summer and winter and fish most likely migrate north during winter to around the Taranaki Bight. Biomass estimates from west coast North Island were low with low precision during two October surveys.

Biomass indices, length frequencies, and gonad stage data

This section summarises bottom trawl surveys in waters within the depth range of spiny dogfish in the SPD 3, SPD 4, and SPD 5 fishery areas. The surveys are part of standardised time series with potential use to monitor spiny dogfish abundance. The relevant trawl survey outputs were obtained using NIWA’s research trawl survey analysis program “SurvCalc” (Francis & Fu 2012) and are summarised in Table 7 and Appendix A. They update the trawl series summaries of biomass indices and length frequency distributions provided by Manning et al. (2004) and Manning (2009). The trawl survey series include *Tangaroa* surveys on the Chatham Rise (core strata of 200–800 m), in Sub-Antarctic waters (core strata of 300–800 m), and a short series in Southland waters (30–600 m); and *Kaharoa* surveys in inshore shallower waters during winter and summer off the east coast of the South Island (core strata 30–400 m).

Little biological data were collected for spiny dogfish from the sub-Antarctic autumn series, except the last survey (see Bagley & McMillan 1999), and therefore this survey series is not included here.

None of these surveys was designed specifically to estimate spiny dogfish abundance. The Chatham Rise and sub-Antarctic *Tangaroa* random bottom trawl survey time series, started in 1991, were primarily aimed at surveying hoki, hake, and ling (see for example, O'Driscoll et al. 2011) and only covered part of the depth range (10–700 m) and geographical distribution of the species (see Anderson et al. 1998). The Sub-Antarctic series also has no summer surveys during the years 1994–99. The *Kaharoa* east coast South Island surveys were optimised for dark ghost shark, giant stargazer, red cod, sea perch (*Helicolenus* spp.), spiny dogfish, and tarakihi for the winter series (for example, see Beentjes & Stevenson 2009) and, for the discontinued summer series, the target species included elephant fish (*Callorhinchus milii*), red gurnard, giant stargazer, and juvenile red cod (for example, see Stevenson & Beentjes 1999). The core strata of all these surveys include the geographic areas where spiny dogfish are available for capture in the seasons surveyed but cover only part of the depth range appropriate for this species (Figure A1). Tows with spiny dogfish catch generally had a shallower distribution on the Chatham Rise (200–600 m) compared with in sub-Antarctic waters (300–800 m). Tows throughout the depth range of the Southland trawl series caught spiny dogfish, as did the shallower tows off the east coast South Island in the *Kaharoa* summer and winter surveys.

The distribution of spiny dogfish length data extracted from the *trawl* database for surveys between 1979 and 2011 and shown in Figure A2 represents a mix of years, areas, vessels, and gear. Fish greater than 60 cm were recorded from depths greater than 500 m off the west coast South Island, off the Stewart-Snares shelf, on the northern Chatham Rise slope, and off the east coast North Island. Fish of 40–60 cm were distributed in shallower depths across the top of the Chatham Rise and inshore waters off the east and west coasts of the South Island, as well as in deeper waters across the Southern Plateau. However, this size range was not caught in inshore waters off the southern South Island east coast. The smallest dogfish were from shallow waters close to the coast, mainly in north Canterbury Bight waters.

Length frequency distributions were determined using SurvCalc which involves scaling by percentage sampled and area trawled to estimate the population in the survey area available to the trawl. The length-weight coefficients used to determine the frequencies are from the reports of each trawl survey listed in Table 7.

Table 7: Relative biomass indices (t) and coefficients of variation (CV) for spiny dogfish from *Tangaroa* (TAN) and *Kaharoa* (KAH) trawl surveys (with assumptions: areal availability, vertical availability, and vulnerability = 1), for the time period covered by the characterisation.

Trip code	Date	Reference	Biomass (t)	% CV
Chatham Rise*				
TAN9106	Dec 1991–Feb 1992	Horn (1994a)	2 396	14
TAN9212	Dec 1992–Feb 1993	Horn (1994b)	2 088	12
TAN9401	Jan 1994	Schofield & Horn (1994)	3 454	13
TAN9501	Jan–Feb 1995	Schofield & Livingston (1995)	2 841	20
TAN9601	Dec 1995–Jan 1996	Schofield & Livingston (1996)	4 969	10
TAN9701	Jan 1997	Schofield & Livingston (1997)	9 570	14
TAN9801	Jan 1998	Bagley & Hurst (1998)	5 608	17
TAN9901	Jan 1999	Bagley & Livingston (2000)	8 551	13
TAN0001	Dec 1999–Jan 2000	Stevens et al. (2001)	8 906	9
TAN0101	Dec 2000–Jan 2001	Stevens & Livingston (2002)	9 586	9
TAN0201	Dec 2001–Jan 2002	Stevens & Livingston (2003)	6 600	8
TAN0301	Dec 2002–Jan 2003	Livingston et al. (2004)	6 191	17
TAN0401	Dec 2003–Jan 2004	Livingston & Stevens (2005)	12 289	18
TAN0501	Dec 2004–Jan 2005	Stevens & O'Driscoll (2006)	7 227	15
TAN0601	Dec 2005–Jan 2006	Stevens & O'Driscoll (2007)	5 650	14
TAN0701	Dec 2006–Jan 2007	Stevens et al. (2008)	5 922	10
TAN0801	Dec 2007–Jan 2008	Stevens et al. (2009a)	15 674	38
TAN0901	Dec 2008–Jan 2009	Stevens et al. (2009b)	5 548	11
TAN1001	Jan 2010	Stevens et al. (2011)	6 698	17
TAN1101	Jan 2011	Stevens et al. (2012)	7 794	14
Sub-Antarctic (summer)ǂ				
TAN9105	Nov–Dec 1991	Chatterton & Hanchet (1994)	8 908	54
TAN9211	Nov–Dec 1992	Ingerson et al. (1995)	815	20
TAN9310	Nov–Dec 1993	Ingerson & Hanchet (1995)	1 649	22
TAN0012	Nov–Dec 2000	O'Driscoll et al. (2002)	4 173	12
TAN0118	Nov–Dec 2001	O'Driscoll & Bagley (2003a)	8 528	31
TAN0219	Nov–Dec 2002	O'Driscoll & Bagley (2003b)	3 505	19
TAN0317	Nov–Dec 2003	O'Driscoll & Bagley (2004)	2 317	17
TAN0414	Nov–Dec 2004	O'Driscoll & Bagley (2006a)	3 378	27
TAN0515	Nov–Dec 2005	O'Driscoll & Bagley (2006b)	4 344	19
TAN0617	Nov–Dec 2006	O'Driscoll & Bagley (2008)	3 039	19
TAN0714	Nov–Dec 2007	Bagley et al. (2009)	3 589	17
TAN0813	Nov–Dec 2008	O'Driscoll & Bagley (2009)	3 080	19
TAN0911	Nov–Dec 2009	Bagley & O'Driscoll (2012)	4 296	34
Sub-Antarctic (autumn)				
TAN9204	Apr–May 1992	Schofield & Livingston (1994a)	926	30
TAN9304	May–Jun 1993	Schofield & Livingston (1994b)	493	38
TAN9605	Mar–Apr 1996	Colman (1996)	242	54
TAN9805	Apr–May 1998	Bagley & McMillan (1999)	2 125	48
Southland (late summer)				
TAN9301	Feb–Mar 1993	Hurst & Bagley (1994))	36 023	13
TAN9402	Feb–Mar 1994	Bagley & Hurst (1995)	36 328	17
TAN9502	Feb–Mar 1995	Bagley & Hurst (1996a)	91 364	29
TAN9604	Feb–Mar 1996	Bagley & Hurst (1996b)	89 818	29

* A summary of this trawl survey time series is given by O'Driscoll et al. (2011).

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

Table 7 *continued*: Biomass indices (t) and coefficients of variation (CV) for spiny dogfish from *Tangaroa* (TAN) and *Kaharoa* (KAH) trawl surveys (with assumptions: areal availability, vertical availability, and vulnerability = 1).

Trip code	Date	Reference	Biomass (t)	% CV
East coast South Island Winter 30–400 m †				
KAH9105	May–Jun 1991	Beentjes & Wass (1994)	12 340	22
KAH9205	May–Jun 1992	Beentjes (1995a)	10 787	26
KAH9306	May–Jun 1993	Beentjes (1995b)	13 949	17
KAH9406	May–Jun 1994	Beentjes (1998a)	14 530	10
KAH9606	May–Jun 1996	Beentjes (1998b)	35 169	15
KAH0705	May–Jun 2007	Beentjes & Stevenson (2008)	35 386	27
KAH0806	May–Jun 2008	Beentjes & Stevenson (2009)	28 476	22
KAH0905	May–Jun 2009	Beentjes et al. (2010)	25 311	31
East coast South Island Summer‡				
KAH9618	Dec 1996–Jan 1997	Stevenson (1997)	35 776	28
KAH9704	Dec 2001–Jan 2002	Stevenson & Hurst (1998)	29 765	25
KAH9809	Dec 1998–Jan 1999	Stevenson & Beentjes (1999)	22 842	16
KAH9917	Dec 1999–Jan 2000	Stevenson & Beentjes (2001)	49 970	37
KAH0014	Dec 2004–Jan 2005	Stevenson & Beentjes (2002)	30 508	34

† A summary of the winter series from 1991 to 1996 is given by Beentjes & Stevenson (2000). The biomass indices given here are for 30–400 m.

‡ A summary of the summer series is given by Beentjes & Stevenson (2001).

5.1.1 *Tangaroa* trawl survey time series

Chatham Rise summer trawl survey series

The Chatham Rise *Tangaroa* trawl survey analysis presented here covers surveys conducted primarily during January, from 1992 (TAN9106) to 2011 (TAN1101) in the core strata depths of 200–800 m (Table 7). Spiny dogfish were recorded from 63% of all core strata tows from the time series (Table A1). Most spiny dogfish catches were located across the centre of the Chatham Rise, i.e., generally in shallower waters (see Figure A1). Spiny dogfish catches were recorded from over 70% of the stations from 1997–2002 and 60–70% of stations in 2003–11. The spiny dogfish catch per station was small (median catches per station were under15 kg, though up to 28 kg from 1997–2002). Maximum catch per station was mostly under 500 kg, and the largest catch of 2952 kg was in 2008. Annual trawl survey reports show that the biomass of spiny dogfish was in the top 10 of the commercial species core strata biomass for each survey, with the highest ranking of 3rd in 1997 and 2008 (Schofield & Livingston 1997, Stevens et al. 2009a).

The biomass indices for the Chatham Rise summer (January) survey appear to be well estimated with CVs ranging from 8 to 20% (Table 7, Figure A3), other than in 2008 (CV = 38%), when the largest catch of the time series was caught (Table A1). Biomass appeared to increase from 1991 to 1997 and then stay flat. (Figure A3). The January 2012 and 2013 survey biomass indices of 5438 t, CV=14% (Stevens et al. 2013) and 6864 t, CV=15% (Stevens et al. 2014) were similar to those for the 2009 and 2010 surveys. Most of the biomass was made up from females, with a very small proportion being males (Figure A3).

Survey biomass estimates were similar west and east of 180° (Figure A3), though estimates were generally larger from the western area in the first half of the series.The influence of larger biomass from the 200–400 m depths is strong in some years.

The median number of spiny dogfish measured from Chatham Rise *Tangaroa* surveys was 1576 and fish were 50–110 cm TL over the time series. Females predominated in scaled population numbers, with a ratio of females:males of 3.0–5.0 for most surveys (series range 2.5–11.0). Length frequency distributions indicate that this survey catches females of 55–110 cm and males of 50–80 cm

(Figure A4). In most surveys, modes were at about 60–64 cm (for males and females) and also at 82–84 cm for females, though relatively fewer larger females were present in the last four surveys. Length frequencies were investigated for catches west or east of 180° and for catches in 200–400 m and in 400–600 m depth ranges. For both these strata there appeared to be no real differences in the length frequencies when compared with the full survey data, so the area and depth frequencies are not included in this report.

Sub-Antarctic summer and autumn trawl survey series

During the sub-Antarctic *Tangaroa* surveys, spiny dogfish were caught on 50% of the summer core strata stations (28–76%) and 22% of the autumn survey stations (9–34%) (Table A2). Most catches were very small, with median catch per station 0–6 kg and maximum catches during summer surveys similar in size to that from the Chatham Rise surveys. Spiny dogfish was usually in the top eight commercial species by biomass in the summer surveys (see for example, Bagley & O'Driscoll 2012).

Biomass indices for the summer sub-Antarctic surveys from 2000 onwards show a reasonably consistent flat pattern around 3000–4400 t (apart from the large estimate in 2001) (Figure A5, Table 7). The CVs for the 2000–09 series of surveys are generally slightly higher (12–34%) than for the Chatham Rise and lower than the autumn sub-Antarctic series (30–54%). There was no survey in 2010, and the survey indices for the following, most recent surveys were the lowest since 1993, at 1941 t, CV=19%, for 2011 (Bagley et al. 2013) and 843 t, CV=12%, for 2012 (Bagley et al. 2013).

Biomass estimates for females were greater than for males in the early years of the series, but the last four surveys had more similar male and female biomass estimates, with the male biomass exceeding the female biomass in 2007 and in 2009 (Figure A5). This pattern is very different from that seen on the Chatham Rise.

Fewer fish were measured from the sub-Antarctic summer surveys, with 574–1097 per survey since 2000 (Figure A6). The length distribution of males is tighter than that of females with a peak around 68–74 cm in most years and few fish outside the range 58–80 cm. Females showed a similar distribution to that seen on the Chatham Rise surveys, and although modes were evident in most years, there was more variation in the relative size of the modes from survey to survey. Fewer larger females were present in the last four years of this series.

Overall, scaled population numbers were lower than on the Chatham Rise, although there were more males than females, with the ratio of females:males 0.7:2.9 for surveys from 2000–09. Length frequency distributions from this survey time series showed similar modal patterns to the Chatham Rise survey series, although there were relatively fewer larger females and the primary mode at about 64–68 cm was mainly influenced by the abundance of males.

Southland late summer *Tangaroa* trawl survey series

The *Tangaroa* trawl surveys carried out in waters around the Stewart-Snares shelf and off Puysegur (known as the "Southland" series) during February-March of years 1993–96 were conducted at depths of 30–600 m. This survey series was optimised for 10 species, including the monitoring of spiny dogfish (Hurst & Bagley 1994). Catches of spiny dogfish were recorded from 86–92% of stations per survey (Table A3). Median catches per survey were 34–133.5 kg and the maximum catches were substantially larger than those recorded on the Chatham Rise surveys, with the largest catch at 25 150 kg. The Southland biomass estimates are substantially greater than estimates from other *Tangaroa* surveys (Table 7, Figure A7), with most catches taken in waters shallower than 200 m, the lower depth limit of the Chatham Rise surveys. Biomass estimates were very similar for the first two surveys with the female biomass double the male biomass; however the increase in survey biomass in the last two surveys was mainly from a large increase in male biomass (Figure A7). The biomass indices were moderately well estimated, with CVs of 17–29%.

The Southland series conducted in the mid-late 1990s provided information on depths outside the ranges covered by the other, longer *Tangaroa* time series. The number of fish measured per survey was 5444–

7070. The female: male ratio changed from about 1.5 for the first two years to about 0.4 for the last two surveys. The length frequency distributions shown in Figure A8 indicate a tight distribution for males (55–80 cm) centred on a clear mode at around 70 cm. The female distribution is relatively flat with evidence in some years of slight modes at about 60 cm and 80 cm. Females were 50–100 cm long.

5.1.2 *Kaharoa* east coast South Island trawl survey time series

Kaharoa surveys off the east coast South Island were conducted in summer (1996–2000) and in winter (1991–94, 1996, 2007–09) at depths of 30–400 m (with added depth strata at 10–30 m for the 2007–09 surveys). For these surveys, nearly all tows caught spiny dogfish (Table A4). There was only one survey year in which both summer and winter surveys were conducted (1996). The summer series was discontinued because of concerns about changes in catchability over the series (R. Hurst, NIWA, pers. comm.). Median catch per summer survey was 45–69.5 kg, with maximum catches of 1827–7588 kg (Table A4). The biomass indices appear to be reasonably flat and were moderately well estimated although CVs for 1999 and 2004 were 37 and 34% (Table 7, Figure A9). The male biomass was slightly higher than the female biomass on all surveys.

There were 6783–9463 spiny dogfish measured per summer survey, with similar numbers of males and females in all surveys except in 1997 and 1998 (Figure A10). The ratio of females:males, based on scaled population numbers was always under 1 (0.6–0.9 per survey). Fish length ranges were 20–109 cm for females and 20–99 cm for males. Modes were distinct at about 30 cm and 50 cm for both sexes, although for the surveys with higher biomass estimates, the smaller mode was present in 1999 but not in 2000.

Median catches from the winter surveys were generally larger than the summer series (71–246.5 kg), but the maximum catches showed a similar range (2391–7319 kg) (Table A4). The winter core survey biomass estimates shown in Figure A11 do not include the 10–30 m strata tows for the last three survey years, which slightly raised the biomass indices by under 5% per survey for those years. The winter indices showed a relatively flat trend for the first four years before a substantial increase in biomass in the 1996 survey. High biomass was also obtained in the first year of the second part of the series (2007), but estimates decreased in 2008 and 2009. The 2012 survey biomass was similar to 2007 (Beentjes et al. 2013). The precision of the biomass indices for the earlier years is better than that for the later years (Table 7, Figure A11).

In contrast to the surveys in the deeper more offshore waters of the Chatham Rise, the male biomass was generally much greater than the females estimates, with the biomass of females contributing most to the apparent decline in total biomass from 2007 to 2009.

In the winter survey series 2247–12 183 fish were measured per survey and the female:male ratio was close to 0.5 for all surveys except the 1994 survey (0.3) and the 2007 survey (0.7). The winter-caught dogfish were 26–107 cm for 30–400 m depths but fish as small as 22 cm were caught when the 10–30 m strata were added to the 2007–09 surveys. Length frequency data suggest that modes were 28–32 cm, 58–64 cm, and 64–70 cm for males, depending on the survey year and female modes were 48–54 cm, and 56–60 cm for the 2007–09 surveys (Figures A12). Few females over 80 cm were represented in the east coast South Island summer or winter data.

5.1.3 Female maturity

The female maturity data are represented here as three reproductive stages: immature, maturing, and mature. The relative proportions of the reproductive stage data are shown in Figure A13 by area, throughout the EEZ, and the monthly distribution is displayed in Figure A14. The numbers of sampled females is given in Table A5. There was a high degree of overlap in the distribution of the three reproductive stages, with all stages reported from the same areas in many months. For areas where there were more than 100 females staged in a month, the Chatham Rise summary for January is about 50% mature females, 25% maturing, and 25% immature. For the ECSI sampling in April-June, there was an increasing proportion of mature females to 50% or more for May and June (although the numbers sampled in May were more than 10 times those sampled in the other months). The proportion of maturing females stayed fairly constant between those months. Most females sampled from the Stewart-Snares shelf and the sub-Antarctic in December were maturing.

6. FISHERY DEPENDENT OBSERVATIONS

6.1 Observer data

Length and age sampling

All tables and figures relating to observer data collected from spiny dogfish fisheries are provided in Appendix B (Tables B1–B7, Figures B1–B6). The main fishery areas used in this section are those given in Figure 3. Although this section covers observed fisheries in all the spiny dogfish QMAs, the focus is on SPD 3, SPD 4, and SPD 5. The number of observed tows with spiny dogfish catch and the reported catch for those tows, by area and fishing year, are given in Tables B1 and B2.

The MPI Observer Programme manual states that observers are required to collect a length frequency sample of 100 sexed spiny dogfish per tow (or set) for 10 tows (or sets) per trip. Data have been collected since 1996–97, although the number of fishing events sampled was low (1538), especially since 2004–05 (Tables B3–B5). Most observer sampling was from the SUBA fisheries, during January-April. On average, across all 15 years, about 50% of the SUBA spiny dogfish catch was observed (annual range 6–87%), compared with 14% for CHAT (range 0–56%) and WCSI (0–52%), and 10% (0–34%) for ECSI.

The proportion of the observer coverage of the spiny dogfish trawl catch by area, relative to the commercial catch, is presented in Figures B1 and B2. For the areas of interest to this study, a higher proportion of the observed catch each year was from SUBA (generally over 50% of annual catch), with most of the remainder from CHAT and ECSI. The commercial catch is more evenly distributed in most years across SUBA, CHAT, and ECSI. The placement of observers has targetted coverage of the main fisheries for middle depth and deepwater species; this is particularly evident in SUBA, where much of the data collection occurred in the middle depths and squid fisheries that operate between January and April. Sampling occurred in most months for the CHAT and ECSI areas, but was variable from year to year.

The numbers measured per tow/set by observers when spiny dogfish was caught varied, with 1–20 dogfish in 39% of tows with spiny dogfish catches, 17% with 21–80 dogfish per tow, 38% with 81–120 dogfish, and 6% with between 121 and the maximum of 247 dogfish per tow. The distribution of observer length data for all years combined show little size discrimination by geographical region (Figure B3). Lengths of observed spiny dogfish were all over 50 cm, and the smallest in this range were generally in shallower shelf waters.

Over 83 250 fish were measured and sexed (Table B6), and 48% were sampled from SUBA, mainly during January-April (83%), from 1996–97 to 2004–05 inclusive (90%). More males than females were caught in this area in most years. The ECSI observer coverage accounted for 21% of the measured dogfish. Sampling occurred throughout the year with 71% collected from January-June and 89% from 1996–97 to 2003–04 inclusive. More female dogfish (65%) were sampled than males in this area, although the monthly data show a wide variation even in years where large numbers were measured. Samples measured from the CHAT fishery area made up 7% of the total numbers and annual and monthly numbers were very variable. More females (77%) than males were sampled, but there was wide variation between months.

No individual spiny dogfish weight data were collected by observers. Although observers are not required to collect female reproductive stage data, a very small amount of these data exist (Table B7), but no breakdown is given here. No spiny dogfish spines or vertebrae samples(for ageing) were collected by observers.

Length frequency distributions

Scaled length frequency distributions were determined using the ‘catch.at.age’ software (Bull & Dunn 2002) which scales the length frequency measurements 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 frequency distributions. Numbers of spiny dogfish were estimated from catch weights using an overall length-weight relationship for trawl surveys on the Chatham Rise (a = 0.001608, b = 3.229126, O’Driscoll et al. 2011) and sub-Antarctic (a = 0.001009174, b = 3.335599, Bagley et al. 2013), for the CHAT data and the SUBA data, respectively. The length-weight relationship calculated by Beentjes & Stevenson (2009) from the 2008 inshore east coast South Island trawl survey (a = 0.0017, b = 3.1941) was used for the ECSI region. Length data from tows with more than 5 spiny dogfish measured were used to create the length frequency distributions by area.

Length frequency distributions are presented for CHAT, ECSI, and SUBA in Figures B4–B6, respectively. The ranges of spiny dogfish lengths were similar in all areas. All three areas had a wide range of sampled tows per year: 2–19 tows for CHAT, 4–47 for ECSI, and 6–106 tows for SUBA. The length frequency distributions based on the CHAT data are similar to those from the Chatham Rise trawl surveys for males, but more variable for females (see Figures A4 and B4). However, the sample numbers are low.

For the ECSI, this observer coverage represents effort in deeper more offshore waters to the eastern extent of the summer and winter *Kaharoa* ECSI trawl surveys. The observed males were 50–80 cm, with most at 60–70 cm (Figure B5). The females were 50–103 cm, with peaks at around 54–58 cm and 80 cm. These distributions, although based on small sample sizes, show no evidence of the small males and females evident in the ECSI trawl survey length frequency distributions (see Figures A10 and A12) and include larger fish of both sexes. However, the peak around 50 cm for females appears in the ECSI trawl survey female length frequency distributions (Figures A10, A12, and B5).

The SUBA area spiny dogfish length frequency distributions generally followed a similar pattern as that described above, the main exception being in 2001–02 when there were larger numbers of both sexes in the 50–60 cm range (Figure B6). These observed length frequency distributions are similar in range and modes to those from the Southland and sub-Antarctic *Tangaroa* trawl series (see Figures A6 and A8). The commercial catch of spiny dogfish is mainly from effort during January-April, whereas the trawl survey data are for April-May for the Southland series and November-December for the summer sub-Antarctic series.

These observer data represent commercial effort on larger vessels that generally operate offshore and in waters over 200 m and are thus less likely to encounter the smaller juvenile spiny dogfish.

6.2 Catch and effort data sources

Catch-effort, daily processed, and landed data were requested from the Ministry for Primary Industry catch-effort database “warehou” as extract 8527 (Table C1). The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of spiny dogfish in SPD fish stock areas (see Figure 1) between 1 October 1989 and 30 September 2011. Data were analysed by fishing year (1 October to 30 September), referred to as, for example, 1990 for the 1989–1990 fishing year.

The estimated catches associated with the fishing days were reported on the more general CELRs and catches by tow were reported on the more detailed TCEPRs. The greenweight data associated with landing events were reported on the bottom part of the CELR forms, or on the CLR for fishing reported on the TCEPR and TCER. TCEPR and TCER forms record tow-by-tow data and summarise the estimated catch (by weight) for the top five species (TCEPRs) or the top eight species (TCERs) for individual tows. CELR forms summarise daily catches, which are further stratified by statistical area, method of capture, and target species.

Information on total harvest levels were 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 spiny dogfish, may not be well reported at the fishing event level on TCEPRs (and, since 2007, TCERs). The daily processed part of the TCEPR contains information regarding 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 was caught and can be split among days. The daily processed catch was not examined in this study, except as comparisons for CPUE analyses.

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). The method allows catch-effort and landings data collected using different form types that record data with different spatial and temporal resolutions to be combined. It also overcomes the main limitation of the CELR and TCEPR reporting systems, i.e., frequent non-reporting of species that make up only a minor component of the catch. The procedure was developed for monitoring bycatch species in the Adaptive Management Programme. The major steps are as follows.

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

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

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

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

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. But if the amount of lost catch and effort is predictable, minor, and stable over time and area, the estimated catch at the level of the fishing event provides a much more detailed dataset for characterisation and CPUE analysis.

7. DESCRIPTIVE ANALYSIS OF CATCH

7.1 Summary of catches

All tables and figures for the characterisation of spiny dogfish fisheries are in Appendix C (Tables C1–C13, Figures C1–C32). Table C1 provides a summary of the data requested from MPI for this characterisation which focusses on SPD 3, SPD 4, and SPD 5, in particular the CHAT and SUBA areas shown in Figure 3.

The reported QMR/MHR landings, ungroomed catch-effort landings, and TACCs for fish stocks SPD 3, SPD 4, and SPD 5 are shown in Figure C1. For the three fish stocks, the ungroomed catch-effort landings were similar to the reported QMR/MHR landings in most years, except for some inconsistencies in the early 2000s. In particular, SPD 3 catch-effort landings were consistently higher during fishing years 2002–04, with 2004 catch-effort landings twice the reported QMR/MHR landings. Catch-effort landings also exceeded the QMR/MHR landings in 2003, 2004, and 2010 in SPD 4 and in 2004 in SPD 5. The QMR/MHR landings exceeded catch-effort landings in several years in SPD 4 and SPD 5. Since October 2004, when spiny dogfish was brought into the QMS, the QMR/MHR landings were lower than the TACCs for each of these fish stocks, and annual reported landings generally represented about 60% or less of each TACC.

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

Table C2 summarises the number of landing events for the major destination codes, for the three fishstocks. Several changes in fishery catch reporting are evident in these data: the inclusion of spiny dogfish in Schedule 6A of the Fisheries Act on introduction into the QMS in October 2004, and the introduction of the TCER form for small trawl vessels from October 2007. Landings of catch-effort data reported on TCEPRs and TCERs are reported on CLRs. Before 1999, in the three fish stocks, landing events on CLRs were coded as "L" (landed to New Zealand), "T" (transferred to another vessel), "R" (retained on board), or "D" (discarded non-ITQ). All but "T" of these codes were used on CELRs before 1999.

In SPD 3, the majority of landing events were recorded as "L" on CELRs. From 2005, with the introduction of the code "M" (QMS returned to sea – Part 6A), most landing events on both forms were coded as "L" or "M". Generally a small percentage of events was recorded as "R". Since 1998, virtually no events were coded as "T" (transferred to another vessel). The latter two destination codes are defined as interim landing events by Starr (2007).

In SPD 4, the majority of landing records were from CLRs, with most events coded as "D" between 1998 and 2004, then predominantly coded as "M" or "L" from 2005 onwards, with the number of "M" events generally twice those coded as "L". In SPD 5, landings events on CELRs were mainly coded as "L" and "D", but from 2000 most were "L". On CLRs, events were more commonly coded as "D" between 1998 and 2004, and from 2005 as "M" and "L". Overall, with the reporting form change in 2007, over 50% of events were "L", with the remainder coded as "M" and a small percentage as "R".

The weight, number of records, and description of each potential landed state are given in Table C3. Details of the data corrections by imputation and removal of invalid records during the grooming process are given in Table C4. The grooming process excluded a small number of trips with invalid codes in fishing method, target species, statistical area, or trip date which could not be fixed using the median imputation method. The estimated catch and landings removed from the dataset in this process were generally insignificant over the time series. The retained landings, interim landings, and total landings dropped during data grooming are shown in Figure C2. The reported MHR landings do not match well with the retained landings for a number of fishing years, particularly from 2002 to 2004, with the most obvious inconsistencies in SPD 3. There was less inconsistency once spiny dogfish was part of the QMS and "L" and "M" were the primary codes used.

The main processed state for retained landings of spiny dogfish in the three fish stocks was "GRE" (greenweight), though there were differences between areas (Figure C3). In SPD 3, similar amounts were "GRE" and "DRE" (includes "dressed", "headed and gutted", and "trunked") until 1999, after which time most fish were "GRE", with a small amount recorded as "MEA" (meal). The "DRE" and "MEA" code use is likely to reflect the presence of larger vessels operating more offshore. In SPD 4, small amounts were recorded as "FIN" (finned) between 1994 and 2004 and as "MEA" from 2004 onwards. In SPD 5, relatively small amounts were coded to states other than "GRE", and there was a slight increase in the amount reported as "MEA" after 2005.

For some QMS species, conversion factors changed over time since entering the QMS. This means that for those species different amounts of greenweight catch are associated with the same amount of processed catch for particular product forms. In such cases, the greenweights can be standardised using the most recent conversion factor for each processed state, based on the assumption that the changes in conversion factors reflect improving estimates of the actual conversion factor when processing, rather than real changes in processing methodology across the fleet. 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 1993, "FIN" was assigned a conversion factor of 30, the values for "DRE" and "HGU" (head and gutted) changed from 2.0 to 2.7, and the value for "FIL" (filleted) increased from 2.7 to 4.1 (see Manning 2009 for a full list of spiny dogfish conversion factors). These adjustments are evident in the beginning of the series shown in Figure C4.

The retained landings adjusted for the changes in conversion factors were allocated to the effort strata based on the statistical areas within each fish stock. For this study, the "centroid method" was used in which the midpoint of each statistical area is used to allocate it to the larger fish stock area, for example, statistical areas 018 and 019 were allocated to SPD 3. This resulted in a closer relationship between QMR/MHR landings, merged landings, and processed catch for SPD 3 and SPD 5. Details of the retained landings in unmerged and merged datasets and processed catches in the groomed and merged datasets are given in Table C5. 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 for the three fish stocks, indicating a consistent match between the recorded statistical areas on the catch forms (CELR, TCEPR, TCER, LCER, LTCER, and NLCER) and the stocks reported on the CELR/CLR/NCLER forms on a trip basis.

Estimated catch, QMR/MHR landings, retained landings, merged landings and estimated catch are plotted in Figure C5 and summarised in Table C5. In SPD 3, the retained landings were similar or lower than the QMR/MHR landings, particularly in the mid-1990s and in 1998; however, the retained landings were higher than the QMR/MHR landings for 2002–04. For the remainder of the time series, there were few differences. In SPD 4, the retained landings and QMR/MHR were similar, apart from 1997, 2002, 2006, and 2008 when the QMR/MHR landings were higher, and in 2003, 2004, 2007, and 2011 when retained landings were higher. In SPD 5, the retained and QMR/MHR landings were similar, with the main differences in 2002 and 2003 when the QMR/MHR landings were higher and in 2004, when the retained landings were higher than the QMR/MHR landings. Overall, there was an improvement in the match between retained landings and QMR landings from 2005 on. Estimated catches generally followed the same trend as merged landings and were lower than the QMR landings, other than in 2004 in SPD 3 and SPD 5.

The reporting rate, defined to be the ratio of the annual estimated catch to the retained landings in the groomed and merged dataset is shown in Figure C6 for the main form types. The TCEPR/CLR reporting rate for SPD 3 was variable in the years before 1998, after which it levelled out and was consistently about 70–80%. This indicates a fairly consistent match between the recorded statistical areas on the TCEPR and the stocks reported on the CLR on a trip basis. The CELR and TCER/CLR rates were generally higher, with rates above 80% since 2004. The trend in the TCEPR/CLR reporting rate for SPD 5 was similar to that seen for SPD 3 in the latter half of the time series, apart from 2004, when the percentage was greater than 100. The CELR and TCER/CLR rates for SPD 5 were similar to that seen in SPD 3, except for the years before 1996 when the estimated catch was 1.5–3.5 times greater than the retained landings. In SPD 4, the reporting rates were the most variable, though generally 50–80%. With the introduction of the separate longline form in 2004, most of the CELR records were transferred to LCERs, with the remainder being captured on LTCERs from 1 October 2007. Although 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), the estimated catches were 77% of the harvest reported via the MHR/QMR system for SPD 3, 73% for SPD 4, and 85% for SPD 5 (see Table C5).

The proportions of estimated catches and retained landings by form type for each fish stock are shown in Figure C7. The three stocks show quite different patterns. For SPD 3, the proportions for TCEPR and CELR forms, and subsequently the TCER forms which replaced CELRs, were similar, with CELRs showing a slightly larger proportion in the earlier years and larger proportion on TCEPRs from 2000 (with the landings recorded on the corresponding CLR forms). A small component of the catch came from NCELRs, LCERs, and LTCERs. For SPD 4, estimated catches from CELR and TCEPR dominate up to 2003, after which the catches are predominantly from TCEPRs and LCERs. In SPD 5, TCEPRs contribute the greatest to the total estimated annual catch, with minor amounts from CELRs throughout the time series and from TCER, NCELR, and LCER forms in the latter years.

Most trips that reported landings of spiny dogfish reported estimated catches. The percentage of zero estimated catch (when spiny dogfish is landed) on CELR reported trips were between 9 and 69% with means of 23–30% for the three areas, and the more extreme values were more likely from SPD 4 (Table C6). On TCEPR recorded trips, the range was 2–44% with means of 16–21% for the three areas. There was a reasonably close match between estimated catch and reported landings at trip level, in most years, although some trips that recorded no estimated catch reported a small amount of landings (for example, in 2002 in all areas) (Figure C8).

7.2 Fishery summary

The spatial distribution of the total commercial catch is shown in Figures C9a, C9b, and C9c. Highest catches were from east coast South Island inshore Statistical Areas 020 and 022. Other areas with high catches include the other statistical areas of the South Island east and south coasts (018, 021, 023, 024–028, 030, and 504) and west of the Chatham Islands (Statistical Areas 404, 410, 049, 050, and 052), Cook Strait (017), and west coast North Island (034, 035, 037, 038). The addition of position data reported by smaller vessels with the introduction of the TCER form in 2007 shows an added level of detail not previously available for the inshore fishing catch-effort data (Figure C9b).

Spiny dogfish was caught as bycatch in a variety of target fisheries around mainland New Zealand throughout the year, predominantly by bottom trawling, but also by bottom longline, midwater trawls, and set nets (Figure C10). The highest catches were from the Chatham Rise and the sub-Antarctic (Table C7), with the remainder from the west coast South Island and smaller amounts from Cook Strait and the east and west coasts of the North Island.

Key target species were barracouta, hoki, ling, red cod, and squid. For most target fisheries, the reported spiny dogfish catch was greatest between 1999 and 2004. Since 2005, the reported annual spiny dogfish catch for tows that targeted silver warehou and tarakihi increased and those targeting red cod decreased. The largest catches when spiny dogfish was targeted were generally pre-1997. Since then, for these groomed and merged data, the annual catches when spiny dogfish was targeted were lower than the catches as bycatch of other fisheries.

Most spiny dogfish catch was from New Zealand vessels, with a large proportion of the remainder from Korean vessels (Figure C11, Table C8). All vessel sizes caught spiny dogfish. The largest catches were from New Zealand vessels that fished inshore waters (generally less than 28 m long) and those that are part of the 'deepwater fleet' in the 43–70 m length range.

In this characterisation section, the areas defined in Figure 3 are used to review the hypothesised stock structure and to develop CPUE analyses that might be useful to monitor the major fisheries. The main areas of spiny dogfish catches are: CHAT – the Chatham Rise west of about 174° E (the eastern part of SPD 3, combined with SPD 4 (after Manning et al. 2004)) and SUBA – sub-Antarctic waters (SPD 5).

7.2.1 CHAT (SPD 4 and eastern part of SPD 3)

Spiny dogfish catches from this area were mainly reported from CELRs and Longline Catch Effort Returns (LCERs) by bottom longline vessels targeting ling and from TCEPRs by trawlers that fished predominantly with bottom trawls and targeted a variety of species, with highest catches of spiny dogfish as bycatch in hoki trawls (Figures C12 and C13a). Annual spiny dogfish catches from this area were relatively small from 1990–95, then increased (Table C9a). Catches increased to about 1000 t during 1996–2000, to 1500–1900 in 2001–03, and dropped to under 1000 t in 2004. Since becoming a QMS species at the beginning of the 2005 fishing year, catches have varied between about 1000 and 1300 t. No distinct season was apparent for the region, though larger catches were more common during July–September when the ling longline fleet was more active (Table C9a, Figure C12).

Before 1996, Statistical Area 021 accounted for 21–43% of the annual spiny dogfish catch (Figure C12, Table C9b). During 1991–93, the catch from the neighbouring area (401) contributed 13–37%. These two areas include the Mernoo Bank waters. From1996 on, the spread of catch across the statistical areas of CHAT was more even, although areas around Veryan Bank (023 and 407) and west and north of the Chatham Islands (404, 049, and 050) frequently contributed more than 12%. The latter catch was primarily from ling longline sets and provided the maximum catch of about 450 t from Statistical Area 404 in 2002. Since 2005, the bottom trawl catches from Statistical Area 023 and the bottom trawl and longline catches combined from Statistical Area 049 were consistently larger than other areas (Figure C12).

Almost 60% of the spiny dogfish catch in CHAT was taken by bottom trawl and another 40% came from bottom longline, with the remainder from midwater trawls (Table C9c, Figure C12). In the early 1990s, the bottom trawl catch was small, but from 1994 to 2004, the catch was more evenly distributed between the two main gear types. From 2005 to 2009, a higher percentage of the catch was from bottom trawl. In 2010–11, slightly more catch came from bottom longline than from bottom trawl.

Most bottom trawl catches were made in October-June inclusive (Figure C13a), with less catch in the July–September period when larger vessels moved away from the Chatham Rise to hoki spawning grounds. Bottom trawl catches were from all statistical areas, in particular 021 pre–2004, 023 since 1998, and 049 and 050 since 2005. Hoki was the key bottom trawl target species and accounted for 29% of the total spiny dogfish catch. The catches in hoki tows were from across CHAT and highest in Statistical Area 023 (Figure C13b). Although catches in hoki tows occurred throughout the year, catches in July-September were minimal (Figure C13c).

Other main trawl target species were barracouta, squid, silver warehou, tarakihi, and hake. Barracouta and tarakihi fisheries had the largest catches in 049 and 050, squid in 021, and ling in 021, 049, and 052 (Figure C13b). Small catches from silver warehou tows were reported from 021, 023, 049, 050, 052, 401, and 410. Catches from barracouta tows were mainly in May-June, tarakihi mainly January-May, silver warehou throughout the year; squid in April-June; and ling in August-February (Figure C13c).

Ling was the key target species in CHAT, accounting for 40% followed by hoki with 29% of the spiny dogfish catch overall (Table C9d, Figure C12). The catch from ling targeted effort was predominantly by bottom longline. Very small catches were made by bottom longline when bluenose, hapuku, and bass were targeted. Ling bottom longline catches of spiny dogfish were made throughout the CHAT area (Figure C14a) with high catches from 049, 404, and 410. The maximum annual catch was 500 t from 404 in 2003. Catches from other target species were very small and generally occurred after 2005 (Figures C14b, C14c). Catches were made throughout the year, though most came from July-September.

A comparison of annual catch and the proportion of the catch that was from targeted effort is shown for bottom trawl and bottom longline in Figure C15a by statistical area and in Figure C15b by month. The catch proportion from targeted trawl effort was very small throughout the time series and particularly since spiny dogfish became a QMS species, when the target catch was reported from around the Chatham Islands in June 2006. Before 2005, some target spiny dogfish catch was taken in months throughout the year in some years and statistical areas close to the Chatham Islands and the Mernoo Bank (021), except in fishing years 1992–94, i.e., about the time competitive quotas were brought in for spiny dogfish catches in SPD 3 and SPD 5.

In most years, the merged data indicated that zero catches of spiny dogfish were reported from under 50% of the main target trawl data and under 30% of the bottom longline data compared with higher and more variable proportions of zero catches obtained from the unmerged (TCEPR) data (Figure C16a and C16b). For the main trawl target, hoki, the proportion of zero catches in the unmerged data was about twice that in the merged data at about 80% in the last 10 years. The proportion of zero catches reported in the unmerged ling longline data decreased markedly over the series to about 15–20% in recent years.

For most target species, the spiny dogfish catch rate was variable with little trend (Figures C17a and C17b). For the main target fishery of hoki, the trend was pretty flat throughout the years of expansion of effort (to about 4000–6000 tows per year) in the early 2000s and slightly higher in the following years when the hoki fishery TACC was lower with about 2000 tows made per year, with rates of about 150–200 kg per tow. In other main target fisheries where the effort was much less than for hoki, annual catch rates ranged from over 500 kg per tow to almost 2000 kg per tow, with rising catch rates evident from 2005 onwards from barracouta tows, and higher but variable rates from silver warehou and ling tows. Catch rates from squid tows decreased sharply in recent years and scampi trawls had a steady low catch of spiny dogfish. Occasional large annual catch rates were recorded from giant stargazer tows. The relatively very small, inconsistent amount of targeted effort for spiny dogfish resulted in variable, but relatively high catch rates, with the highest rate at about 5000 kg per tow in 2006.

Unstandardised catch rates from ling bottom longline fisheries increased over the time series to almost 800 kg per set in 2001 and 2003, dropped steadily to about 100 kg per set in 2008 and rose to over 400 kg per set in 2011. In most years since 1994, 1200–1800 sets per year were reported.

Fishing duration for bottom tows with reported spiny dogfish catch increased slightly over the time series for the hoki target fishery at around 3–5 h for most tows (Figure C18). Although tow durations for other targets were variable, most increased after about 2005, and showed more variation within a year. The largest increase was seen in the squid tows in 2010, with 4–10 h tows. Similar tow durations were reported for ling and silver warehou target trawls in recent years. Scampi tow durations increased to about 7.5 h over the time series.

Median effort depth for bottom trawls with spiny dogfish catch from hoki tows were constant from the late 1990s, at 500–600 m (Figure C19). Generally other targets caught spiny dogfish in shallower waters: under 300 m for barracouta except in 2011, under 500 m for silver warehou and ling, 200–300 m for squid, slightly shallower for jack mackerel, about 400 m for scampi.

The distributions for data describing bottom trawl gear width (wingspread), gear height, distance towed, and vessel speed, tonnage, and length by target (when spiny dogfish catches were reported) are shown in Figure C20. Wingspread was generally about 30–45 m, except for the twin-net scampi trawls at 50–60 m and the smaller tarakihi trawls. Scampi headline heights were the lowest, at about 1 m. Generally, the tows targeted at middle depth species had headline heights of under 4 m, whereas the shallower targets appeared to have slightly higher headline heights and showed more variation. Towing speed was similar for most middle depth target species, at 3.5–4.5 kn. Scampi towing speed was about 2.5 kn. and stargazer and tarakihi were slightly higher at 3.0–3.5 kn. Most tows lengths were 20–40 km, though barracouta and squid tows were generally 10–30 km long. Vessels that caught spiny dogfish on hoki target tows were twice the tonnage of vessels with catch from other target species. Smaller vessels targeted scampi, stargazer, and tarakihi and larger vessels (most 46–65 m long) targeted other species. The full range of vessel size shown in Figure C20 reflects the spread of smaller inshore vessels fishing at Mernoo Bank and inshore waters of the Chatham Islands and the larger vessels fishing a range of depths across the Chatham Rise.

The distribution of spiny dogfish catches by vessels reporting on TCEPRs shows that the highest catches were from around the Mernoo Bank and the Chatham Islands before 1996–97 (Figure C21). In the following years, the distribution of catches was wider and the highest catches were also made near the Reserve Bank northeast of Mernoo Bank, the Veryan Bank to the southeast, and in waters less than 500 m particularly along the southern Chatham Rise. The spatial catch distribution showed a reasonable amount of variation from year to year. In comparison, the distribution of spiny dogfish catch from bottom longline sets was more localised in most years in the main ling target fishery area, with the highest catches east of 180° and west of the Chatham Islands on the top of the Rise (Figure C22).

7.2.2 SUBA (SPD 5)

The SUBA region is equivalent to SPD 5 and the total catch from 1989–90 to 2010–11 was 30% greater than the total catch from CHAT (compare Tables C9a and C10a). Most of the spiny dogfish catch from this area was caught during October-June, with peak months in December-March (Figure C23), and most was reported from statistical areas on the Stewart-Snares shelf (025, 027, 028) throughout the time series and from 030 (Puysegur Trench) and 504 (southeast of 027) since 2000 (Figure C23, Table C10b). The majority of the catch was taken by bottom trawl targeting squid, hoki, barracouta, and silver warehou and reported on TCEPRs (Table C10c, Figures C24a–C24c). Squid target catches were important throughout the time series, and were larger and more consistent from 1999 on and mainly came from Statistical Area 028 during January to March. The main catch period for hoki fisheries was from 1999 on, with most spiny dogfish caught during October to June, and the largest annual catches from Statistical Area 027.

The annual spiny dogfish catch from bottom longline effort increased from 2005, with catches in most months, but concentrated in February to June (Figure C25a). Small annual catches of spiny dogfish were consistently reported from bottom longline sets in Statistical Area 030 from 1994 onwards. Other catches were reported mainly from near the Auckland Islands Shelf, Pukaki Rise, Campbell Rise, and Bounty Platform (602, 604, 605, 610, 618, and 608) after 2004. The primary target was ling, although catches were smaller than from the trawl fisheries, and there were very small catches from other targets. The distribution of spiny dogfish catches by statistical area and month for each of the bottom longline target fisheries are shown in Figures C25b and C25c.

From 2007, setnet catches accounted for 11–15% of the total annual spiny dogfish catch in SUBA (Table C10c). After 2001, catches were reported from setnet throughout the year, particularly during January-June (Figure C26a). These catches mainly came from Statistical Area 025 (Foveaux Strait), 030 (Puysegur Trench), and 027 (east of Stewart Island). The main target species was school shark (in 025, 027, and 030 during January-August), but some targeting of spiny dogfish and rig also caught spiny dogfish (Figures C26b and C26c). Catches from spiny dogfish target were mainly from 025 and made during May-July and catches from rig were also from 025, but concentrated during October-February.

The proportion of the annual spiny dogfish catch for the main fishing methods, by statistical area and month is shown in Figures C27a and C27b. The small amount of catch taken on targeted tows occurred during summer in 025, 027, and 030 where the main spiny dogfish setnet fishery occurs throughout the year, but predominantly in May-August. There was overlap of methods and areas, but the majority of the catch in any area where bottom trawls were used was caught by that method. The setnet catch in 030 was likely to be from depths much shallower than where the bottom longliners and trawlers operate.

In most years, the merged data indicated that zero catches of spiny dogfish were reported from under 50% of the main target tows and under 30% of the bottom longline sets compared with higher and more variable proportions of zero catches obtained from the unmerged data (Figure C28a and C28b). The merged setnet data showed a decreasing trend of zero catch in the first half of the time series and about 10% zero catch after 2001 (Figure C28a).

Catch rates were very variable for most trawl target species, except for squid targeted (100–250 kg per tow) and an increasing catch rate from hoki target tows since 2002 (Figures C29a–C29c). Catch rates for most other trawl targets, for which there was much less effort, show the effect of occasional large catches of spiny dogfish every few years. The spiny dogfish catch rate in ling bottom longline sets increased over the time series. The catch rates for other longline targets and setnet were very variable. Setnet targeting spiny dogfish resulted in the highest catch rate for this method.

Fishing duration for most bottom tows with spiny dogfish catch showed an increasing trend for squid and silver warehou fisheries since 2005, with most 4–8 h per tow (Figure C30a). Barracouta tows showed a similar range, but the median duration decreased over the last five years. Tow duration for hoki and ling fisheries were constant over the time series with median duration of about 5 h. Other less important target fisheries had more variable tow durations for bottom trawls. Fishing duration for midwater tows was lower in the hoki and barracouta fisheries than for bottom tows and were similar in duration to the southern blue whiting midwater tows that caught spiny dogfish after the mid-1990s (Figure C30b).

There were some clear distinctions in depth ranges of TCEPR bottom tows that caught spiny dogfish (Figure C30c): shallow targets included squid, barracouta, common warehou, and jack mackerel at depths under 200 m; silver warehou, red cod, and spiny dogfish tows caught spiny dogfish at 200–400 m; white warehou targets were at 400–500 m; and hoki targets mainly at 600–700 m. Midwater tows showed similar trends, except that the hoki tows were slightly shallower than the bottom tows (Figure C30d). Southern blue whiting tows were mainly at 300–500 m.

For TCEPR bottom tows, most species were targeted with wingspreads of 30–50 m and headline heights of 3.5–4.4 m, with nets towed at about 4 kn. (Figure C30e). The median distance towed was similar for most target species (at about 20 km) except for red cod and silver warehou, which had longer tows, and white warehou target tows which behaved differently for all parameters. Median vessel lengths for hoki, ling, silver warehou, and white warehou were about 65 m and others were around 60 m. There were differences in tonnage values, in particular for hoki target vessels at twice those of other vessels. Midwater net wingspreads were usually about 50–100 m (Figure C30f), and these nets were towed at about 4.0–4.5 kn. Vessels towing midwater nets were almost all more than 1000 t in weight and 50 m in length.

The distribution of spiny dogfish catches reported on TCEPRs was similar each year (Figure C31). Most of the catch was taken around the Stewart-Snares shelf, the Auckland Islands, and east of the Puysegur Trench. Since 2005 the spatial extent of the spiny dogfish catches by trawl gear was constrained mainly to the edge of the Stewart-Snares shelf. The small catches from longline were very patchy in their distribution, with the larger catches from along the top of the Pukaki Rise (Figure C32).

7.2.3 Overview

A summary of the characterisations by the CHAT and SUBA fishery areas is given in Table 8. Over all years, 40% of the CHAT catch was from ling bottom longline effort mainly during July-September. Bottom trawl effort accounted for 58% of the overall CHAT catch, primarily as bycatch from effort targeted at hoki and various other trawl fisheries, mainly during October to March. Between 2005 and 2009, bottom trawl accounted for more of the annual TCEPR catch spiny dogfish in CHAT than did bottom longline, but this was reversed in the 2010 and 2011 fishing years. Over the CHAT time series, annual catches increased from about 1000 t in the mid-1990s until the early 2000s when almost 2000 t were reported in 2002, then decreased again. Since 2005, annual catches have been between 1000 and 1300 t. Most spiny dogfish catches from hoki bottom trawls were in 500–600 m, deeper than for all other targets. Overall, the trawl bycatch was characterised by many small catches with an occasional large catch, resulting in fluctuating catch rates for most trawl fisheries other than hoki.

Catch rates in the CHAT ling longline fishery peaked in the late 1990s and early 2000s, dropped sharply during 2004–09, then increased in the last few years. Catches from trawling were more widespread than for bottom longline, and both small and larger factory trawlers contributed to the catch.

The spiny dogfish catch estimated from SUBA was 30% greater than the CHAT catch, with bottom trawls taking over 80% over the time series. The Stewart-Snares shelf and associated slope was the most important area for spiny dogfish catches from mainly squid during January-March and hoki during October-June. Since 2005 there was a small increase in percentage of spiny dogfish catch from spiny dogfish target tows. There was an increase in spiny dogfish catches during bottom longline fishing after 2005, with catches located in main areas of ling longline fishing.

The annual catch reported from all methods in SUBA was 40–50% greater than in CHAT in all years but one since 2005, but the two areas had similar catches for 2011 (about 1200–1300 t). Fishing effort variables and vessel characteristics were similar between the CHAT and SUBA, though there was a wider range of species targeted by bottom trawl gear in the SUBA area. It is likely that the larger trawl vessels that caught spiny dogfish were active in both areas at some stage of the year. There appeared to be no distinct season for spiny dogfish catches; rather the timing of catches reflects the timing of the main target fishery effort.

Table 8: Summary of features of the main spiny dogfish fisheries. BT is bottom trawl; BLL is bottom longline. Fish stock and area definitions are shown in Figures 1 and 3. Target species codes are defined in Table C11.

Area	CHAT	SUBA
SPD	Eastern SPD 3, all of SPD 4	SPD 5
Key fishery areas	For BT: Mernoo Bank, Veryan Bank, south Chatham Rise, Chatham Islands For BLL: west and south of Chatham Islands	Stewart-Snares shelf, Auckland Islands Shelf, Puysegur
Key statistical areas	For BT: 023, 049, 050 For BLL: 049, 404, 410	025, 027, 028, 030
Secondary statistical areas	For BT: 052, 401–402, 404, 407–410 For BLL: 021, 051, 052, 401	504
Season	Year round, slight decline in Jul–Aug	October–May
Gear type	BT, BLL	BT
Key target species	For BT: HOK For BLL: LIN	For BT: SQU, HOK
Secondary target species	For BT: BAR, LIN, SWA, SQU For BLL: BNS, HPB	BAR, SWA

8. CPUE ANALYSES

8.1 CHAT and SUBA CPUE

This analysis is on the two fishery areas CHAT and SUBA, where deepwater vessels operate using bottom trawl and bottom longline fishing. For standardised CPUE analyses of trawl catches, the use of TCEPR tow-by-tow data allows for the trend in catch rates to be modelled using smaller spatial and temporal scales, and also enables additional factors influencing CPUE to be included (such as tow distance or bottom depth). This approach was taken for CHAT and SUBA bottom trawl fisheries using the estimated catch and daily processed catch. However, only the results for the estimated catch are shown here because the trends were similar. For the SUBA area, a second model that used TCEPR, TCER, and CELR data merged by trip-vessel-statistical area-target species was also run. An analysis of the bottom longline fisheries was completed for CHAT using CELRs and LCERs merged to vessel-day-statistical area; however, the lack of bottom longline data in SUBA precluded any analysis of longline in that area. All tables and figures relating to CPUE analyses for spiny dogfish are contained in Appendix D (Tables D1–D5, Figures D1–D21).

Annual unstandardised (raw) CPUE indices were calculated as the mean of the catch per tow (in kilograms) for tow by tow data, or catch per vessel-day for daily processed 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 2011), was used to fit all models. The algorithm generates a final regression model iteratively and used the year term as the initial or base model in all cases. The reduction in residual deviance (denoted R^2) was calculated for each single term added to the base model. The term that resulted in the greatest reduction in the residual deviance was then added to the base model if the change was at least 1%. The algorithm was then repeated, updating the base model, until no more terms were added. A stopping rule of 1% change in residual deviance was used because this results in a relatively parsimonious model with moderate explanatory power. Alternative stopping rules or error structures were not investigated.

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 model are listed in Table D1. 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 *statistical area* and *start latitude* or *start longitude* were not allowed to enter the same model at the same time because they were correlated.

A vessel variable was incorporated into the CPUE standardisation to allow for differences in fishing power between vessels. Vessels not regularly involved in the fishery were excluded because they provided little information for the standardisations, which could result in model over-fitting (Francis 2001). Thus, CPUE analyses were undertaken for "core" vessels that were determined for each area analysis using gear-area-specific criteria based on the spiny dogfish catch, the number of years of vessel participation, and the number of tows per year (Table D2, Figure D1).

The influence of each variable accepted into the lognormal models was described by coefficient-distribution-influence (CDI) plots (Bentley et al. 2012). These plots show the combined effect of (a) the expected log catch for each level of the variable (model coefficients) and (b) the distribution of the levels of the variable in each year, and therefore describes the influence that the variable has on the unstandardised CPUE and that is accounted for by the standardisation.

Fits to the model were investigated using standard residual diagnostics. For each model, a plot of residuals against fitted values and a plot of residuals against quantiles of the standard normal distribution were produced to check for departures from the regression assumptions of homoscedasticity and normality of errors in log-space (i.e., log-normal errors).

The data constraints applied to each of the four models presented here are given in Table D2. The following models were run:

a. lognormal, binomial, and delta-lognormal for the CHAT TCEPR hoki bottom trawl fishery during 1999–2011 (on estimated catch);
b. lognormal CHAT ling bottom longline fishery during 1996–2011;
c. lognormal, binomial, and delta-lognormal for the SUBA TCEPR main bottom trawl fisheries during 2000–2011 (on estimated catch);
d. lognormal SUBA bottom trawl fisheries for main targets, based on the merged data from TCEPR, CELR, and TCER forms for 2000–2011.

For the tow-by-tow estimated data, tows with no spiny dogfish catch (zero tows) were excluded. For each of the models listed above, the number of vessels, amount of effort, proportion of zeros, amount of spiny dogfish catch, and the unstandardised CPUE are listed in Table D3, for all vessels and for core vessels, where appropriate. The variables retained in each model are given in Table D4 and the CPUE indices by fishing year are given for each model in Table D5.

8.1.1 Chatham Rise standardised CPUE TCEPR hoki BT Model

A total of 50 unique vessels (14–34 vessels each year) using bottom tows have caught an estimated 3224 t of spiny dogfish since fishing year 1999, from 53 131 tows (Table D3). The percentage of zero tows was high, 72–91%. Thirteen core vessels (6–8per year) caught an estimated 2890 t of spiny dogfish, 90% of the total catch during 1999–2011. Estimated spiny dogfish catches for core vessels were 123–297 t annually, and the largest catch by vessel for a year was 150 t (Figure D2).

Five variables were selected into the lognormal model, resulting in a total R^2 of 27%, with *vessel* explaining 16% of the residual deviance (Table D4). The other variables selected were *duration*, *mid time of tow*, *month*, and *depth of bottom*. For the binomial model, 14% of the residual deviance was explained by five retained variables, with *latitude* retained and *duration* excluded.

Indices from the models are presented in Table D5 and Figures D2b and D2c. The lognormal standardised catch index showed an increasing trend from 1999 to 2007–09, after which it decreased to the mean level for the period. This catch index matches the unstandardised index reasonably well. The steady decrease in the binomial probability from 2004 to 2009 results in the main anomaly between the lognormal and the delta-lognormal indices. The effect of the addition of retained variables in the lognormal model is most apparent during fishing years 2004–09 (Figure D3).

The effects of the selected variables on the expected catch rates of spiny dogfish in the lognormal tow-by-tow estimated catch models are shown in the CDI plots in Figures D4. Generally, the changes in the influence of the main variables were small. For *vessel* – the variable with the most explanatory power – the changes are largely related to the movement out of the fishery of vessels with relatively low catch rates. The peak of the influence for 2004–09 represents the greater proportion of effort by vessels with highest coefficients. Higher coefficients were estimated when tows were between 4 and 10 h long, the *mid tow time* between 0830 and 1630 h, and the effort was mainly in June-August. These variables had a small positive effect when the years of greater effort corresponded with the higher catch coefficients. Depth of bottom showed a very small change from positive to negative after 2006 when there was relatively greater proportion of effort in middle depths where catch rates were relatively lower.

The diagnostics were good and the quantile-quantile plot for the lognormal model indicated a small deviation from the normal distribution of the residuals at both the lower and upper ends (Figure D5). The effects of variables selected into the binomial model and the model diagnostics are shown in Figures D6a and D6b.

For the fishing years 1999–2011, a comparison of the estimated catch with the processed catch for the core vessels in each data set is shown in Figure D6c; there appear to be few differences post 2003.

8.1.2 CHAT bottom longline standardised CPUE model

The data constraints for the CHAT bottom longline merged vessel-day-statistical-area model are given in Table D2. The CHAT bottom longline data for effort targeting ling included 31 vessels during 1996–2011 (4–9 vessels per year) (Table D3). About 6300 t of spiny dogfish were caught during this period from a total of 6756 fishing days. For all vessels the annual percentage of days with zero catch was 4–54%, though since 2002, under 15% of days had zero catch. Eleven core vessels fished during 1996–2011 (3–6 annually) for a total of 5006 days which represented 74% of the total data. All core vessel fishing days had some catch of spiny dogfish, and the total catch by core vessels represented 92% of total catch. The core vessels averaged about 312 fishing days a year, but the number of fishing days reported by individual vessels was very variable for some and consistent over a number of years for others (Figure D7a). Generally a larger number of days fishing by a vessel in a year corresponded with a larger catch of spiny dogfish.

The four variables selected and retained in the model resulted in a total R^2 of 42.6%, with 30% of the residual deviance explained by *log(totalhooks)* (Table D4). The other variables selected were *month*, *vessel*, and *statistical area*.

The standardised year effects show an initial increase from 1996 to 1999, followed by a variable but relatively flat time series until 2007 after which there appeared to be an increasing trend (Figure D7b). This pattern indicates an increase when the bottom trawl lognormal shows a decrease, and vice versa, between 2001 and 2011 (compare Figures D2c and D7b).The effects of the addition of the selected variables are shown in Figure D8, and the addition of *vessel* has the largest effect and generally flattens the unstandardised trajectory by dropping the high points up to 2004 and raising the low points in the second half of the series.

The CDI plots (Figure D9) reflect the changes in fleet dynamics over time, with only two core vessels operating in all 11 years and most of the rest operating either before, or after, 2004. The effect of these vessel activities was to cause a decreasing trend in the influence from positive in the years up to 2003 to a (smaller) negative influence from 2004 onwards. Three vessels had similar coefficients that were significantly lower than the other eight vessels – a reflection of the varied fleet which includes autoline vessels which set a greater number of hooks per set than the smaller non–autoline vessels. Similar trends (positive, then negative) in influence are shown by the other selected variables, but the changes are smaller. Catch coefficients increased steadily as hook numbers set increased. Before 2004, more days with larger number of hooks had a positive influence; the vessels that set more hooks and had higher coefficients appeared to drop out of the fishery after 2003. Highest coefficients were obtained during August–October. Very small changes were evident due to influence by the area fished, with the influence changing to negative a year later than for the other variables. In general, expected catch rates were slightly higher in statistical areas across the southern Chatham Rise, and lowest in areas across the northern ChathamRise except for 404 and 049.

The model assumptions were mainly satisfied with only a small deviation from normality (Figure D10).

8.1.3 Sub-Antarctic standardised TCEPR CPUE Model

The two bottom trawl SUBA models used data from fishing years (October–September) 2000–2011, fishing years for which steady annual catches were reported. The data constraints used for the tow-by-tow estimated model are given in Table D2. For this model, 57 unique vessels (19–37 vessels per year) using bottom trawl gear to target barracouta, blue warehou, hoki, ling, jack mackerel, silver warehou, spiny dogfish, squid, or white warehou caught an estimated 13 431 t of spiny dogfish, from 77 592 tows (Table D3). The 20 core vessels identified for 2000–2011 (see Figure D1) accounted for 68% of the total tows and 86% of the total spiny dogfish catch. There was little difference between the annual proportion of zeros in all data and that in core vessels' data which had 56–78% zero tows. Annual catch estimates from core vessels peaked at 1896 t in 2002 from 16 vessels. The summary of catch and effort for these vessels is shown in Figure D11a.

Five variables were selected into the lognormal TCEPR SUBA model, resulting in a total R^2 of 20.6%, with *statistical area* explaining 12.3% of the residual deviance (Table D4). The other variables selected were *target species*, *fishing duration*, *vessel*, and *month*.

The standardised year effects show a flat or slightly decreasing trend after a small peak in the years immediately before the species was introduced to the QMS (Figure D11b); the different catch rate indices were generally similar (Figure D11c). Throughout the trajectory, the effect of *statistical area* is evident in Figure D12.

Influence plots for the main variables are shown in Figure D13. Positive effects were achieved when effort was in statistical areas on the Stewart-Snares shelf, where the catch coefficients were highest, especially for effort targeted at barracouta, silver warehou, hoki, ling, and blue warehou. In contrast, effort targeted at squid had a negative influence. The influence of *fishing duration*, *target species*, and *month* was small overall, with some positive influence from tows over 6 h long and from vessels that consistently fished in this area post-QMS.

The diagnostics were good and the quantile–quantile plot for the lognormal model indicated a small deviation from the normal distribution of the residuals at both the lower and upper ends (Figure D14). The effects of variables selected into the binomial model and the model diagnostics are shown in Figures D15a and D15b. A comparison of these two TCEPR models and the delta-lognormal model is shown in Figure D16. The addition of zeros has the greatest effect on the lognormal model in the early 2000s before the species was introduced into the QMS.

For the fishing years 2000–2011, a comparison of the estimated catch with the processed catch for the core vessels in each data set indicates that more catch is available for analysis in the estimated data (Figure D17).

8.1.4 Sub-Antarctic standardised merged CPUE Models

For the merged data SUBA bottom trawl model based on data from TCEPR, CELR, and TCER forms merged together, the data constraints are given in Table D2. A wider range of target species was included in this dataset reflecting the greater presence of smaller vessels targeting inshore species. Thus, the merged dataset includes the target species listed above for the TCEPR model, as well as flatfish species, red gurnard, and stargazer. From 130 vessels, 75 were included as core vessels (37–59 per year) accounted for 50% of all records and 79% of the total spiny dogfish catch (see Table D3). Tows with zero catches by core vessels ranged between 25 and 50%, and there was a wide range of catches — fewer than 20 vessels took most of the catch (Figure D18a).

For the merged trip SUBA bottom trawl lognormal model, four variables were selected, resulting in a total R^2 of 50.3%, with *vessel* explaining 42.2% of the residual deviance (Table D4). The other variables selected were *fishing duration*, *target species*, and *month*.

The standardised year effects show a similar trend to that for the TCEPR model, with a small increase before 2005 after which there appears to be some stability or the suggestion of a decrease (Figure D18b, see also Figure D11b). Catch per hour and catch per tow were very similar throughout the time series. The effect of the addition of variables into the model is shown in Figure D19. *Target species* appears to have the most effect in 2000, with *vessel* having more influence after 2001 (Figure D20). After 2005, the influence of *vessel* was moderated mainly by *fishing duration* and *target species*, with relatively small effects.

The diagnostics were good and the quantile–quantile plots indicated small deviation from the normal distribution of the residuals at both the lower and upper ends (Figure D21).

8.2 CPUE summary

An underlying assumption of the models presented here is that the catch of spiny dogfish was reported consistently over the time series. This is known to be incorrect, but it is assumed that better reporting of this primarily bycatch species occurred in the late 1990s when market demands were greater following the collapse of northern hemisphere spiny dogfish fisheries. Competitive catches were introduced in 1992–93 for SPD 3 and SPD 5, and target trawling was banned in SPD 4 at this time. With the introduction into the QMS, the species could be readily discarded, alive or dead, on the provision that the catch was recorded.

The spiny dogfish catches from the CHAT and SUBA areas were primarily bycatch from other target fishery effort. The Chatham Rise bycatch of spiny dogfish in the hoki trawl fishery was concentrated mainly in Statistical Areas 023, 407–410 (see Figure C13b), whereas the bottom longline catch mainly came from 049, 404 and 410 (see Figure C14a). The main effort with spiny dogfish bycatch from these two fisheries was almost complementary in terms of month of the year, with hoki vessels taking most of the trawl catch of spiny dogfish during October–June and ling longline vessels taking catch during July–September. The spiny dogfish catch from these two fisheries had a moderate amount of spatial overlap, but not generally in the areas where catches were greatest (compare Figures C21 and C22).

The overall R^2 values for the CHAT and SUBA area CPUE lognormal core vessel models varied (27–50%) and tended to be higher for merged trip-level models, with 43% for the CHAT longline and 50% for the SUBA model. Some explanatory variables were consistent for all models, with *vessel* and *month* entering every model, and *fishing duration* entering the trawl fishery models. *Target species* entered both tow-by-tow and merged mixed species SUBA models. *Time of tow* and *bottom depth* entered only the CHAT hoki BT model and *statistical area* was important in the SUBA estimated model as well as the CHAT longline model. A large proportion of the underlying variability was not explained. Although this is not unusual for CPUE analyses (e.g., Vignaux 1994, Punt et al. 2000), it may be a reflection of a lack of explanatory information available to the models.

Chatham Rise

Vessel was important in this area, and the indices for both the hoki bottom trawl fishery and the ling longline fishery reflect the fleet movements during the time periods analysed. For the hoki fishery, these movements were in response to changes in the TACC – in particular to the lowered TACC during the early 2000s. In the longline fishery, different longline vessels entered and left the fishery over the time series, with fewer larger vessels operating on the Chatham Rise during the second half of time series. Towards the end of the ling longline fishery time series there was relatively more effort (vessel days and total hooks) in the main months and in statistical areas where catch rates were generally higher, particularly to the west of Chatham Islands, and led to an increase in the CPUE. A decrease in the last few years in the CPUE from the hoki bottom trawl fishery appears to be related to the increased proportions of effort by vessels with low catch rates and of effort with shorter tow duration. The opposing trends indicated by the hoki bottom trawl and the ling longline trends may indicate that in certain years, spiny dogfish were more likely to be caught during winter months than during other seasons, and vice versa.

The Chatham Rise research trawl survey relative biomass time series shows a generally flat trend since 2000 (see Figure A3), with the data from 2012 and 2013 indicating no change (see Section 5.1.1). The trend shown by the CHAT hoki lognormal model (see Figure D2c) is similar, though it appears to decrease slightly at the end of the time series. It appears that this survey is useful to monitor spiny dogfish on the Chatham Rise, though it does primarily catch females.

The commercial hoki fishery showed reasonably consistent catch rates throughout the time series (see Figure C17a). *Bottom depth* was important and most of the spiny dogfish catches were from tows in 450–550 m, whereas catches in the trawl survey were from throughout the 200–800 m depth range. *Month* was also important and the higher proportion of hoki effort in January, when the trawl surveys operate, appeared to have a positive influence after 2004.

Sub-Antarctic fishery area

The Sub-Antarctic trawl catch was concentrated off the south and east of the Stewart-Snares shelf with a very small amount of target catch, but most spiny dogfish catch from a mix of middle depths and inshore target species. For the trawl fisheries, the lognormal model that used the tow-by-tow data was considered to be more useful than the merged data, despite the fact that there were a large number of zero catch tows. However, the indices generally showed similar trends, with a decreasing trajectory after the early 2000s followed by a prolonged period of more stable indices at a lower level than estimated for the preceding years (see Figures D16 and D18b). This pattern is the opposite of that seen for the same years on the Chatham Rise hoki fishery. *Target species*, *vessel*, and *statistical area* were important in this area and most likely primarily relate to the effect of the two main trawl fisheries here – the hoki and squid fisheries.

The sub-Antarctic research survey biomass indices (see Figure A5) could be described as showing little trend; though in the most recent two surveys, 2012 and 2013, the biomass indices were lower than previous surveys, especially in 2013 (see section 5.1.1) This survey does not cover the depth range of this species, and although the CVs were moderate, the survey indices are not likely to be very useful in monitoring biomass because of the sampling effort strata. However, as seen in Section 5, these surveys suggest that the population of spiny dogfish available to the net in the sub-Antarctic waters is different from that on the Chatham Rise.

9. SUMMARY AND RECOMMENDATIONS

9.1 Biology

Spiny dogfish are widespread on shallower (200–700 m) parts of the Chatham Rise and the sub-Antarctic area. Research trawl surveys of middle depth species in Chatham Rise waters appear to be useful to monitor relative biomass of larger (over 50 cm TL) spiny dogfish, though the CVs for the annual estimates suggest that some years are influenced markedly by the occasional large catch. Hanchet & Ingerson (1997) suggested that occasional large relative biomass estimates may reflect changes in their vertical or areal availability possibly due to environmental conditions. There is, however, a large difference in the sex ratios of samples from the two main survey areas considered here. Females are dominant in the Chatham Rise survey biomass estimates, whereas the biomass estimates of males and females are more similar from the sub-Antarctic surveys, particularly in the most recent years. The short late-summer time series of four surveys from Southland showed a distinct difference between the male and female estimates, with females dominant in the first two surveys and males in the last two surveys when the total biomass estimates were double that of the first two surveys. The east coast South Island winter trawl surveys sample a shallower (30–400 m) coastal part of the spiny dogfish distribution and do not overlap with the area defined in this study as CHAT. However, in the winter surveys the male biomass is consistently greater than the female biomass suggesting that the smaller males may favour shallower inshore waters in winter and the larger females favour deeper offshore waters in early summer.

Trawl surveys in these areas continue to collect data on length, weight, and reproductive stage, and the inshore east coast South Island trawl survey also collects the dorsal fin spines for potential age estimates. There is limited biological data collection on spiny dogfish caught during observed fisheries. Currently the length and sex are collected, but the weight and reproductive stage information is not collected from commercial fisheries.

Spiny dogfish are known to move seasonally to areas with preferred water temperatures, as well as between inshore and offshore waters, depending on their life stage and reproductive state. Little information is available on these seasonal patterns in New Zealand waters, other than that presented by Hanchet (1986) for the east coast of the South Island.

About 70% of the commercial catch during 1989–90 to 2010–11 was caught in the Sub-Antarctic area, but the biomass indices in this area may not reflect the catch because it is likely that the areas surveyed in the Sub-Antarctic do not represent the main catch areas (such as off the Stewart-Snares shelf). Length frequency distributions in this area show a decrease in the number of large females in recent years, relative to earlier surveys, whereas the male distributions appear similar from one survey to another. Large females were also less prevalent in the 2009–11 Chatham Rise trawl surveys and in the observer data for CHAT.

It is likely that there are dogfish size classes that are not available to the net or the hook. Certainly the observer data only have records of dogfish over 50 cm. However, this is unlikely to be a reason for a lower proportion of larger females in the catch. The spatial distribution of female dogfish relative to the 2 year gestation period may provide some differences in the availability of fish to the net, but this may vary by year rather than show a similar pattern from one year to another. The schooling nature of spiny dogfish results in occasional large catches, and it may be that in some years these large schools are not present at the time the area was sampled. For example, newly-recruited dogfish may be less likely to be caught because they may be more pelagic in their behaviour.

9.2 Status of the stocks

There are no estimates of absolute biomass available for any spiny dogfish fish stock. The stocks identified in the CHAT and SUBA areas in this analysis are represented by SPD 3 (in part), and SPD 4, and SPD 5. The TACCs in these areas have never been reached. For all these areas, it is not known whether the current levels of take are sustainable, and it is difficult to interpret CPUE indices from years before more stringent reporting was required (pre fishing year 2005) when the species joined the QMS.

Since 2005, the CHAT hoki bottom trawl lognormal indices have increased slightly then decreased so that the index for 2011 is similar to that in 2005. Although the ling longline index is considered to be unreliable because of the sporadic nature of the vessel activity over the time series, longline catches indicate the presence of spiny dogfish in the months outside the time when most of the trawl catch is reported.

For the sub-Antarctic stock there is thought to be some movement from the east coast South Island down to the Stewart-Snares shelf. The sub-Antarctic trawl surveys indicate that the spiny dogfish available to the net in more southern waters represent a more even split of male and female than seen on the Chatham Rise, though it appears there may be differences in the sex ratio in the immediate Stewart-Snares shelf waters compared with the wider area sampled by the November-December sub-Antarctic trawl survey.

This work primarily addresses the bycatch of spiny dogfish from commercial fisheries operated in areas mainly fished by vessels that form the 'deepwater fleet'. Thus the resulting CPUE indices are strongly and indirectly influenced by the way in which the other target fisheries operate. Factors that may influence this may be known or unknown and work at the level of the target fishery, the fishing company, and the vessel skipper. These may include the target fishery management (TACCs), any codes of practice, individual vessel quota allowance, individual fishing behaviour or strategy for a vessel, and individual catch reporting. Thus, for all the models it is difficult to know whether the resulting indices represent a trend, or whether they are influenced by some of the above factors. The migratory and schooling behaviour of spiny dogfish may also confound the indices indirectly. Catches of spiny dogfish caught in inshore fisheries may affect the catch in offshore areas and different life stages may be available to one fishing method more than another or to one or more target fisheries at different times of the year.

9.3 Observer Programme sampling

Spiny dogfish sampling by observers would benefit from optimisation in the key fishery areas, particularly to achieve better coverage of all months of the year and of all methods given that this species is caught by setnet, trawl gear, and longline. Collection of spines for ageing would also provide an indication of the age and size of the spiny dogfish that are caught by the different commercial fisheries. It is important to understand what is occurring in the inshore fisheries because of the offshore movement of the species by different life stages as well as by mature breeding females. Timely collection of length frequency, weight, and reproduction stage information is important for better determination of stock structure.

9.4 Future data needs and research requirements

Gaps exist in the collection of data required to describe the biological characteristics and define the stocks for spiny dogfish. These gaps could be filled and other knowledge augmented, with the goal of developing appropriate monitoring tools, as follows:

1. Increased coverage of all fishery areas and methods by the observer programme, in particular increasing the observer coverage across the entire Chatham Rise and the sub-Antarctic throughout the year, as well as including coverage of the east coast South Island inshore areas where mating and pupping is known or thought to occur (see Section 9.3). This coverage should collect length, weight, sex, and maturity data as well as spines for ageing.
2. Analysis of the spiny dogfish spines (1995 in total) collected from the east coast South Island trawl surveys since 2007 (four surveys) to update the catch-at-age and length-at-age series of Hanchet (1986, 1988). These samples represent a wide range of length sizes for each sex and were collected from the surveys that are conducted every two years – the most recent being in 2012 (Beentjes et al.

2013). Work in the northern hemisphere (Bubley et al. 2012) suggested that the use of vertebrae for ageing may also be worth investigating for spiny dogfish in New Zealand waters.
3. Collection of spines from the Chatham Rise and sub-Antarctic trawl surveys would be valuable in determining the composition of the trawl survey spiny dogfish catch. Length frequency data suggests that the catch may contain many age classes.
4. A tagging programme as part of the Chatham Rise trawl survey could provide information on the spatial distribution of spiny dogfish.

10. ACKNOWLEDGMENTS

Thanks to NIWA colleagues Neil Bagley, Malcolm Francis, Peter Horn, Emma Jones, and Alistair Dunn for helpful discussions during this study. Thanks also to Peter McMillan (NIWA) for a comprehensive review of this report and to Marianne Vignaux (Fisheries New Zealand) for editorial comments. This work was completed under funding from the Ministry for Primary Industries (Project DEE201007).

11. REFERENCES

Alonso, M.K.; Crespo, E.A.; Garcia, N.A.; Pedraza, S.N.;Mariotti, P.A.; Mora, N.J. (2002). Fishery and ontogenetic driven changes in the diet of the spiny dogfish, *Squalus acanthias*, in Patagonaian waters, Argentina. *Environmental Biology of Fishes 63*: 193–202.

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

Bagley, N.W.; Ballara, S.L.; O'Driscoll, R.L.; Fu, D.; Lyon, W. (2013). A review of hoki and middle depth summer trawl surveys of the Sub-Antarctic, November–December 1991–93 and 2000–09. *New Zealand Fisheries Assessment Report 2013/41*. 63 p plus supplements.

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

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

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

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

Bagley, N.W.; Livingston, M.E. (2000). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1999 (TAN9901). *NIWA Technical Report 81*. 52 p.

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

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

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

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

Ballara, S.L.; O'Driscoll, R.L. (2012). Catches, size, and age structure of the 2009–10 hoki fishery, and a summary of input data used for the 2011 stock assessment. *New Zealand Fisheries Assessment Report 2012/19*. 109 p.

Ballara, S.L.; O'Driscoll, R.L.; Anderson, O.F. (2010). Fish discards and non-target fish catch in the trawl fisheries for hoki, hake, and ling. *New Zealand Fisheries Assessment Report 2010/48*. 100 p.

Beamish, R.J.; Sweeting, R.W. (2009). Spiny dogfish in the pelagic waters of the Strait of Georgia and Puget Sound, pp. 195–208. *In* Galluci, V.F.; McFarlane, G.A.; Bargmann, G.G. (Eds.), *Biology & management of dogfish sharks*. American Fisheries Society, Bethesda, Maryland. 435 p.

Beentjes, M.P. (1995a). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, May–June 1992 (KAH9205). *New Zealand Fisheries Data Report No. 55*. 58 p.

Beentjes, M.P. (1995b). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, May–June 1993 (KAH9306). *New Zealand Fisheries Data Report No. 56*. 78 p.

Beentjes, M.P. (1998a). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, May–June 1994 (KAH9406). *NIWA Technical Report 20.* 65 p.

Beentjes, M.P. (1998b). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, May–June 1996 (KAH9606). *NIWA Technical Report 21*. 66 p.

Beentjes, M.P.; MacGibbon, D.J.; Lyon, W.S. (2013). Inshore trawl survey of Canterbury Bight and Pegasus Bay, April–June 2012 (KAH1207). *New Zealand Fisheries Assessment Report 2013/36.*135 p.

Beentjes, M.P.; Lyon, W.S.; Stevenson, M.L. (2010). Inshore trawl survey of Canterbury Bight and Pegasus Bay, May–June 2009 (KAH0905). *New Zealand Fisheries Assessment Report 2010/29.*102 p.

Beentjes, M.P.; Stevenson, M.L. (2000). Review of the east coast South Island winter trawl survey time series, 1991–96. *NIWA Technical Report 86*. 64 p.

Beentjes, M.P.; Stevenson, M.L. (2001). Review of the east coast South Island trawl survey time series, 1996–97 to 1999–2000. *NIWA Technical Report 108*. 92 p.

Beentjes, M.P.; Stevenson, M.L. (2008). Inshore trawl survey of Canterbury Bight and Pegasus Bay, May–June 2007 (KAH0705). *New Zealand Fisheries Assessment Report 2008/38.* 95 p.

Beentjes, M.P.; Stevenson, M.L. (2009). Inshore trawl survey of Canterbury Bight and Pegasus Bay, May–June 2008 (KAH0806). *New Zealand Fisheries Assessment Report 2009/57.*105 p.

Beentjes, M.P.; Wass, R. (1994). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, May–June 1991 (KAH9105). *New Zealand Fisheries Data Report No. 48*. 49 p.

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

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

Bull, B.; Livingston, M.E.; Hurst, R.; Bagley, N. (2001). Upper-slope fish communities on the Chatham Rise, New Zealand, 1992–99. *New Zealand Journal of Marine and Freshwater Research 35(4)*: 795–815.

Bubley, W.J.; Kneebone, J.; Sulikowski, J.A.; Tsang, P.C.W. (2012). Reassessment of spiny dogfish *Squalus acanthias* age and growth using vertebrae and dorsal-fin spines. *Journal of Fish Biology 80*: 1300–1319.

Campana, S.E.; Jones, C.; McFarlane, G.A.; Myklevoll, S. (2006). Bomb dating and age validation using the spines of spiny dogfish (*Squalus acanthias*). *Environmental Biology of Fishes 77*: 327–336.

Campana, S.E.; Joyce, W.; Kulka, D.W. (2009). Growth and reproduction of spiny dogfish off the eastern coast of Canada, including inferences on stock structure, pp. 195–208. *In* Galluci, V.F.; McFarlane, G.A.; Bargmann, G.G. (Eds), *Biology and management of dogfish shark*s. American Fisheries Society, Bethesda, Maryland. 435 p.

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

Chatterton, T.D.; Hanchet, S.M. (1994). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, November–December 1991 (TAN9105). *New Zealand Fisheries Data Report No. 41*. 55 p.

Colman, J.A. (1996). Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, March–April 1996 (TAN9605). *New Zealand Fisheries Data Report No. 83*. 40 p.

Compagno, L.; Dando, M.; Fowler, S. (2005). Sharks of the World. Princeton University Press. 480 p.

Duffy, C.A.J.; Last, P.R. (2007a). Part 9— Redescription of the Spiny Dogfish *Squalus griffini* Phillipps, 1931 from New Zealand, pp. 91–100. *In*: Last, P.R.; White, W.T.; Pogonoski, J.J. (Eds), Descriptions of new dogfishes of the genus *Squalus* (Squaloidea: Squalidae). *CSIRO Marine and Atmospheric Research Paper 014*. 130 p.

Duffy, C.A.J.; Last, P.R. (2007b). Part 4—*Squalus raoulensis* sp. nov., a new spurdog of the 'megalopscubensis group' from the Kermadec Ridge, pp. 31–38. *In*: Last, P.R.; White, W.T.; Pogonoski, J.J. (Eds), Descriptions of new dogfishes of the genus *Squalus* (Squaloidea: Squalidae. *CSIRO Marine and Atmospheric Research Paper 014*. 130 p.

Dunn, M.R.; Stevens, D.W.; Forman, J.S.; Connell, A. (2013). Trophic interactions and distribution of some squaliforme sharks, including new diet descriptions for *Deania calcea* and *Squalus acanthias*. *PLoS ONE 8(3)*: e59938. doi:10.1371/journal.pone.0059938.

Francis, M.P. (1998). New Zealand shark fisheries: development, size and management. *Marine and Freshwater Research 49*: 579–591.

Francis, M.P.; Shallard, B. (1999). New Zealand shark fishery management. Pp. 515–551, *in* Shotton, R. (Ed.), Case studies of the management of elasmobranch fisheries. *FAO Fisheries Technical Paper No. 378*. FAO, Rome (Italy).

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

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

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

Hanchet, S.M. (1986). The distribution and abundance, reproduction, growth, and life history characteristics of spiny dogfish, *Squalus acanthias* (Linneaus), in New Zealand. (Unpublished PhD thesis, University of Otago, New Zealand held by the NIWA library, Wellington.) 314 p.

Hanchet, S. (1988). Reproductive biology of *Squalus acanthias* from the coast, South Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 22*: 537–549.

Hanchet, S. (1991). Diet of the spiny dogfish, *Squalus acanthias* Linnaeus, on the east coast, South Island, New Zealand. *Journal of Fish Biology 39(3)*: 313–323.

Hanchet, S.M.; Ingerson, J.K.V. (1997). A summary of biology and commercial landings, and a stock assessment of spiny dogfish (*Squalus acanthias*). New Zealand Fisheries Assessment Research Document 97/06.46 p. (Unpublished report held by the NIWA library, Wellington.)

Holden, M.J. (1977). Elasmobranchs, pp. 187–215. *In* Gulland, J.A. (Ed.), *Fish population dynamics*. Wiley & Sons, London. 372 p.

Horn, P.L. (1994a). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1991–January 1992 (TAN9106). *New Zealand Fisheries Data Report No. 43.* 38 p.

Horn, P.L. (1994b). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1992–February 1993 (TAN9219). *New Zealand Fisheries Data Report No. 44*. 43 p.

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

Hurst, R.J.; Bagley, N.W. (1994). Trawl survey of middle depth and inshore bottom species off Southland, February–March 1993 (TAN9301). *New Zealand Fisheries Data Report No. 52.* 58 p.

Hurst, R.J.; Stevenson, M.L.; Bagley, N.W.; Griggs, L.H.; Morrison, M.A.; Francis, M.P. (2000). Areas of importance for spawning, pupping or egg-laying, and juveniles of New Zealand coastal fish. *NIWA Technical Report 119*. 377 p.

Ingerson, J.K.V.; Hanchet, S.M. (1995). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, November–December 1993 (TAN9310). *New Zealand Fisheries Data Report No. 67*. 44 p.

Ingerson, J.K.V.; Hanchet, S.M.; Chatterton, T.D. (1995). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, November–December 1992 (TAN9211). *New Zealand Fisheries Data Report No. 66*. 43 p.

Jacob, W.; McClatchie, S.; Probert, P.K.; Hurst, R.J. (1998). Demersal fish assembalges off southern New Zealand in relation to depth and temperature. *Deep-Sea Research I 45*: 2119–2155.

Jones, B.C.; Green, G.H. (1977). Food and feeding of spiny dogfish (*Squalus acanthias*) in British Columbia waters. *Journal of the Fisheries Research Board of Canada 34 (11)*: 2067–2078.

Ketchen, K.S. (1972). Size at maturity, fecundity, and embryonic growth of the spiny dogfish (*Squalus acanthias*) in British Columbia waters. *Jounral of Fisheries Research Board Canada 29(12)*: 1717-1723.

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

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

Manning, M.J. (2009). Updated relative abundance indices and catch-at-length estimates for spiny dogfish (*Squalus acanthias*) in SPD 3 and 5 to the end of the 2005–06 fishing year. *New Zealand Fisheries Assessment Report 2009/61*. 90 p.

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

McFarlane, G.A.; King, J. (2003). Migration patterns of spiny dogfish (*Squalus acanthias*) in the North Pacific Ocean. *Fishery Bulletin 101(2)*: 358–367.

Ministry of Fisheries (2008). National Plan of Action for the conservation and management of sharks. October 2008. Ministry of Fisheries, Wellington, New Zealand. 90 p.

Ministry of Fisheries (2011). May 2011 Plenary Report, pp. 1147–1152. Ministry of Fisheries, Wellington, New Zealand.

Ministry for Primary Industries (2013). Fisheries Assessment Plenary: Stock Assessments and Yield Estimates May 2013. Volume 3: Red Snapper to Yellow-eyed Mullet. (Unpublished report held by Fisheries New Zealand, Wellington.)

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

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

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

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

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

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

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

O'Driscoll, R.L.; Bagley, N.W.; Bull, B. (2002). Trawl survey of middle depth species in Southland and Sub-Antarctic areas Nov–Dec 2000 (TAN0012). *NIWA Technical Report 110*. 78 p.

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

Phillips, N.L. (2001). Analysis of silver warehou (Seriolella punctata) catch-per-unit-effort (CPUE) data. *New Zealand Fisheries Assessment Report 2001/73*. 48 p.
Phillips, N.L. (2004). Length frequency distributions of spiny dogfish from the Chatham Rise, Sub-Antarctic, and the west coast South Island fisheries. *New Zealand Fisheries Assessment Report 2004/53*. 36 p.
Punt, A.E.; Walker, T.I.; Taylor, B.L.; Pribac, F. (2000). Standardization of catch and effort data in a spatially-structured shark fishery. *Fisheries Research 45*: 129–145.
R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. http://www.R–project.org.
Rago, P.J.; Sosebee, K.A. (2010). Biological Reference Points for Spiny Dogfish. Northeast Fisheries Science Center Reference Document 10-06. (Unpublished report from the NOAA National Marine Fisheries Service, Woods Hole, Massachusetts.)52 p.
Schofield, K.A.; Horn, P.L. (1994). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1994 (TAN9401). *New Zealand Fisheries Data Report No. 53*. 55 p.
Schofield, K.A.; Livingston, M.E. (1994a). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, April–May 1992 (TAN9204). *New Zealand Fisheries Data Report No. 45*. 38 p.
Schofield, K.A.; Livingston, M.E. (1994b). Trawl survey of hoki and associated species in the Southland and Sub-Antarctic areas, September–October 1992 (TAN9209). *New Zealand Fisheries Data Report No. 46*. 43 p.
Schofield, K.A.; Livingston, M.E. (1995). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1995 (TAN9501). *New Zealand Fisheries Data Report No. 59*. 53 p.
Schofield, K.A.; Livingston, M.E. (1996). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1996 (TAN9601). *New Zealand Fisheries Data Report No. 71*. 50 p.
Schofield, K.A.; Livingston, M.E. (1997). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1997 (TAN9701). *NIWA Technical Report 6.* 52 p.
SeaFIC (Seafood Industry Council) (2007). Silver warehou: SWA 1 Adaptive Management Programme Full-term Review Report. AMPWG-2007/22. (Unpublished report held by Fisheries New Zealand, Wellington).
Shepherd, T.; Page, F.; Macdonald, B. (2002). Length and sex-specific associations between spiny dogfish (*Squalus acanthias*) and hydrographic variables in the bay of Fundy and Scotian Shelf. *Fisheries Oceanography 11*: 78–89.
Sosebee, K.A. (2005). Are Density-dependent Effects on Elasmobranch Maturity Possible? *Journal of Northwest Atlantic Fishery Science 35*: 115–124.
Starr, P.J. (2007). Procedure for merging MFish landing and effort data, V2.0. *Document AMPWG/07/04*. (Unpublished report held by Fisheries New Zealand, Wellington).
Stevens, D.W.; Livingston, M.E. (2002). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2001 (TAN0101). *NIWA Technical Report 116*. 61 p.
Stevens, D.W.; Livingston, M.E. (2003). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2002 (TAN0201). *NIWA Fisheries Assessment Report 2003/19*. 57 p.
Stevens, D.W.; Livingston, M.E.; Bagley, N.W. (2001). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2000 (TAN0001). *NIWA Technical Report 104*. 55 p.
Stevens, D.W.; O’Driscoll, R.L. (2006): Trawl survey of hoki and middle–depth species on the Chatham Rise, January 2005 (TAN0501) *New Zealand Fisheries Assessment Report 2006/13*. 73 p.
Stevens, D.W.; O’Driscoll, R.L. (2007). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2006 (TAN0601). *New Zealand Fisheries Assessment Report 2007/5*. 73 p.
Stevens, D.W.; O'Driscoll, R.L.; Gauthier, S. (2008). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2007 (TAN0701). *New Zealand Fisheries Assessment Report 2008/52.* 81 p.
Stevens, D.W.; O'Driscoll, R.L.; Horn, P.L. (2009a). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2008 (TAN0801). *New Zealand Fisheries Assessment Report 2009/18.* 86 p.
Stevens, D.W.; O'Driscoll, R.L.; Horn, P.L. (2009b). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2009 (TAN0901). *New Zealand Fisheries Assessment Report 2009/66.* 91 p.

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

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; Ballara, S.L.; Horn, P.L. (2012). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2011 (TAN1101). *New Zealand Fisheries Assessment Report 2012/10*. 103 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; Ballara, S.L.; Horn, P.L. (2013). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2012 (TAN1201). *New Zealand Fisheries Assessment Report 2013/34*. 98 p.

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

Stevenson, M.L. (1997). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1996–January 1997 (KAH9618). *NIWA Technical Report 7*. 67 p.

Stevenson, M.L.; Hurst, R.J. (1998). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1997–January 1998 (KAH9704). *NIWA Technical Report 32*. 74 p.

Stevenson, M.L.; Beentjes, M.P. (1999). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1998–January 1999 (KAH9809). *NIWA Technical Report 63*. 66 p.

Stevenson, M.L.; Beentjes, M.P. (2001). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1999–January 2000 (KAH9917 & CMP9901). *NIWA Technical Report 99*. 94 p.

Stevenson, M.L.; Beentjes, M.P. (2002). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 2000–January 2001 (KAH0014, CMP0001). *NIWA Technical Report 112*. 97 p.

Tribuzio, C.A.; Gallucci, V.F.; Bargmann, G.G. (2009). A survey of demographics and reproductive biology of spiny dogfish (*Squalus acanthias*) in Puget Sound, WA, pp. 181–194. *In* Galluci, V.F.; McFarlane, G.A.; Bargmann, G.G. (Eds.), *Biology & management of dogfish sharks*. American Fisheries Society, Bethesda, Maryland. 435 p.

Tribuzio,C.A.; Kruser, C.A.; Fujioka, J.T. (2010). Age and growth of spiny dogfish (*Squalus acanthias*) in the Gulf of Alaska: analysis of alternative growth models. *Fishery Bulletin 108*: 119–135.

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

Walker, T.L; Taylor, B.L.; Bridge, N.F.; Brown, L. (1999). Spiny dogfish assessment project. Draft report prepared for New Zealand Ministry of Fisheries for research project SPD9701. 120 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

APPENDIX A: TRAWL SURVEY SUMMARIES

Table A1: Summary of spiny dogfish catches for each *Tangaroa* Chatham Rise survey and percent of stations with spiny dogfish catches.

						Catch (kg) summary	Core strata stations	
Survey	Min.	1st	Median	Mean	3rd	Max.	Total	% with SPD
TAN9106	0.0	0.0	0.0	13.6	9.5	274.2	184	41.3
TAN9212	0.0	0.0	1.6	17.2	16.8	172.9	194	54.6
TAN9401	0.0	0.0	2.1	24.6	19.3	529.6	165	55.8
TAN9501	0.0	0.0	0.0	12.4	11.1	233.1	122	45.9
TAN9601	0.0	0.0	4.9	30.0	40.9	265.5	89	60.7
TAN9701	0.0	0.5	27.2	56.4	52.2	818.1	103	74.8
TAN9801	0.0	0.0	14.2	34.0	42.7	510.4	87	72.4
TAN9901	0.0	0.0	26.9	47.8	69.6	539.8	100	74.0
TAN0001	0.0	2.9	27.5	49.4	59.9	747.9	128	76.6
TAN0101	0.0	0.0	22.1	45.9	60.6	248.6	119	72.3
TAN0201	0.0	0.3	22.2	34.6	54.1	221.0	107	74.8
TAN0301	0.0	0.0	11.9	29.7	35.9	409.0	115	66.1
TAN0401	0.0	0.0	10.3	46.2	43.8	756.3	110	64.5
TAN0501	0.0	0.0	8.5	40.2	56.3	264.3	106	63.2
TAN0601	0.0	0.0	12.9	27.2	44.7	177.9	96	68.8
TAN0701	0.0	0.0	8.5	27.3	37.6	229.8	101	64.4
TAN0801	0.0	0.0	9.2	67.5	38.7	2 952.0	101	66.3
TAN0901	0.0	0.0	9.2	26.6	35.8	241.1	108	62.0
TAN1001	0.0	0.0	5.1	31.6	38.9	374.6	91	59.3
TAN1101	0.0	0.0	13.1	36.6	46.0	279.1	90	63.3
All	0.0	0.0	7.9	33.3	40.9	2 952.0	2 316	62.7

Table A2: Summary of spiny dogfish catches for each *Tangaroa* summer Sub-Antarctic survey and percent of stations with spiny dogfish catches.

						Catch (kg) summary	Core strata stations	
Survey	Min.	1st	Median	Mean	3rd	Max.	Total	% with SPD
Summer series								
TAN9105	0.0	0.0	0.0	24.3	1.3	1 251.0	154	27.9
TAN9211	0.0	0.0	0.0	3.6	1.4	60.6	155	27.7
TAN9310	0.0	0.0	0.0	6.2	3.1	272.3	134	40.3
TAN0012	0.0	1.5	5.9	11.5	14.1	84.5	84	76.2
TAN0118	0.0	0.0	0.0	26.6	7.4	419.1	85	44.7
TAN0219	0.0	0.0	2.6	22.2	9.4	748.6	85	63.5
TAN0317	0.0	0.0	1.5	18.2	7.5	225.1	69	55.1
TAN0414	0.0	0.0	1.2	23.4	8.3	397.5	78	51.3
TAN0515	0.0	0.0	3.0	23.9	14.2	365.8	77	57.1
TAN0617	0.0	0.0	2.9	14.2	10.3	148.5	75	64.0
TAN0714	0.0	0.0	1.9	19.9	18.6	349.6	80	57.5
TAN0813	0.0	0.0	2.7	16.1	7.0	357.6	75	68.0
TAN0911	0.0	0.0	2.4	24.8	8.1	708.4	74	60.8
All	0.0	0.0	0.0	17.0	7.4	1 251.0	1 225	49.6
Autumn series								
TAN9204	0.0	0.0	0.0	2.9	1.4	55.3	90	32.0
TAN9304	0.0	0.0	0.0	2.2	0.0	47.8	100	17.0
TAN9605	0.0	0.0	0.0	0.9	0.0	42.6	89	9.0
TAN9805	0.0	0.0	0.0	10.5	1.2	456.6	58	34.0
All	0.0	0.0	0.0	3.5	0.0	456.6	337	22.0

Table A3: Summary of spiny dogfish catches for each *Tangaroa* February–March Southland survey and percent of stations with spiny dogfish catches.

	Catch (kg) summary						Core strata stations	
Survey	Min.	1st	Median	Mean	3rd	Max.	Total	% with SPD
TAN9301	0.0	32.9	133.5	435.0	388.8	5 631.0	113	92.9
TAN9402	0.0	31.0	114.2	394.4	335.4	6 756.0	129	96.1
TAN9502	0.0	6.2	34.0	818.3	311.0	25 150.0	150	89.3
TAN9604	0.0	8.8	75.3	614.6	275.7	8 652.0	124	86.3
All	0.0	14.7	82.7	579.4	336.5	25 150.0	516	91.1

Table A4: Summary of spiny dogfish catches for each *Kaharoa* summer and winter surveys and percent of stations with spiny dogfish catches.

	Catch (kg) summary						Core strata stations	
Survey	Min.	1st	Median	Mean	3rd	Max.	Total	% with SPD
Summer 30–400 m								
kah9618	0	19	47	155.4	130	1827	113	96
kah9704	0	7.25	45	222.1	112.5	5584	138	90
kah9809	0	18.75	69.5	199.6	193.2	2703	120	97
kah9917	0	27.75	66.5	378.7	263	7588	120	97
kah0014	0	9.5	42	301	133.5	6882	123	98
All	0	18	55	251.8	171	7588	614	95
Winter 10–400 m								
kah9105	0	59	134	294.3	231	2391	55	96
kah9205	0	46.25	115	219	189	4001	80	99
kah9306	0	57.75	115	292.1	352.2	2377	74	99
kah9406	0	114.8	246.5	350.1	403	2578	100	96
kah9606	0	71.25	164	506.5	487.8	4245	118	98
kah0705	2	29	71	403.8	217	6705	105	100
kah0806	3	45.5	96	419.1	330	6312	99	100
kah0905	1	25	77	336.4	230	7319	93	100
All	0	47	123	366.4	318	7319	427	99
Winter 30–400 m								
kah9105	0	59	134	294.3	231	2391	55	96
kah9205	0	46.25	115	219	189	4001	80	99
kah9306	0	57.75	115	292.1	352.2	2377	74	99
kah9406	0	114.8	246.5	350.1	403	2578	100	96
kah9606	0	71.25	164	506.5	487.8	4245	118	98
kah0705	2	29.75	70	434.4	216.5	6705	94	100
kah0806	3	44	94	421.4	312.5	6312	96	100
kah0905	1	23.5	77	352.4	234	7319	87	100
All		47.0	123	372	320	7319	704	99

Table A5: Length data (total length in cm) summaries for the Chatham Rise and sub-Antarctic (2922 males and 4864 females) trawl surveys.

(a) Chatham Rise (total numbers: 4977 males and 25 123 females)

	Mean length		Median length		No. measured	
Trip	Males	Females	Males	Females	Males	Females
tan9212	66.9	71.0	65.0	68.0	128	965
tan9401	69.1	75.6	69.0	73.0	94	758
tan9501	64.4	72.0	64.0	70.0	213	543
tan9601	65.4	78.1	64.5	79.0	190	904
tan9701	65.9	72.8	66.0	70.0	482	1667
tan9801	66.3	74.6	67.0	75.0	210	960
tan9901	67.4	76.3	67.0	77.0	285	1615
tan0001	67.0	77.4	67.0	79.0	162	2163
tan0101	66.5	76.9	66.0	79.0	197	2278
tan0201	65.1	76.4	65.0	79.0	292	1776
tan0301	67.6	76.9	68.0	80.0	203	1158
tan0401	67.4	74.4	68.0	74.0	240	1471
tan0501	66.4	70.0	66.0	67.0	365	1716
tan0601	65.4	71.0	65.0	67.0	327	1140
tan0701	66.2	74.5	65.0	73.0	204	938
tan0801	66.5	76.7	65.5	78.0	178	1196
tan0901	62.9	69.4	62.0	65.0	392	1183
tan1001	64.2	68.8	64.0	67.0	420	1222
tan1101	64.0	70.3	63.0	69.0	395	1470

(b) Sub-Antarctic (total numbers: 2922 males and 4864 females)

	Mean length		Median length		No. measured	
Trip	Males	Females	Males	Females	Males	Females
tan9105	73.3	77.2	70.0	78.0	108	184
tan9211	68.6	77.4	69.0	78.0	13	63
tan9310	66.1	79.3	66.0	80.0	93	189
tan0012	69.6	83.2	70.0	85.0	110	290
tan0118	66.7	78.6	67.0	82.0	438	659
tan0219	63.7	77.5	64.0	81.0	179	492
tan0317	66.2	79.1	66.0	80.0	132	441
tan0414	67.2	76.3	68.0	78.0	324	455
tan0515	65.6	75.7	66.0	78.0	303	493
tan0617	65.7	76.4	66.0	79.0	179	385
tan0714	66.9	72.7	67.0	72.0	496	471
tan0813	66.5	77.1	67.0	80.0	160	416
tan0911	64.8	65.9	65.0	62.0	387	326

Table A6: Numbers of females at each reproductive stage, from trawl survey data, by month and area relevant to SPD 3, SPD 4, and SPD 5.

	Month												
Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All
CHAT													
Immature	706	0	0	0	1	0	0	0	0	0	0	1	708
Maturing	749	0	0	0	40	0	0	0	0	0	0	1	790
Mature	1370	0	0	0	29	11	0	0	0	0	0	23	1 433
Total	2825	0	0	0	70	11	0	0	0	0	0	25	2 931
ECSI													
Immature	9	0	0	50	308	19	0	0	0	0	0	0	386
Maturing	0	0	0	43	485	44	0	0	0	0	0	0	572
Mature	2	0	0	44	718	66	0	0	0	0	0	0	830
Total	11	0	0	137	1511	129	0	0	0	0	0	0	1 788
PUYS													
Immature	0	0	0	0	0	0	0	0	0	0	1	0	1
Maturing	0	0	0	0	0	0	0	0	0	0	0	3	3
Mature	0	0	0	0	0	0	0	0	0	0	23	47	70
Total	0	0	0	0	0	0	0	0	0	0	24	50	74
STEW													
Immature	0	0	0	0	0	0	0	0	0	0	1	48	49
Maturing	0	0	0	0	0	0	0	0	0	0	23	206	229
Mature	0	0	0	0	0	0	0	0	0	0	37	148	185
Total	0	0	0	0	0	0	0	0	0	0	61	402	463
SUBA													
Immature	0	0	0	0	0	0	0	0	0	0	10	33	43
Maturing	0	0	0	0	0	0	0	0	1	0	7	91	99
Mature	0	0	0	0	0	0	0	0	0	0	4	44	48
Total	0	0	0	0	0	0	0	0	1	0	21	168	190

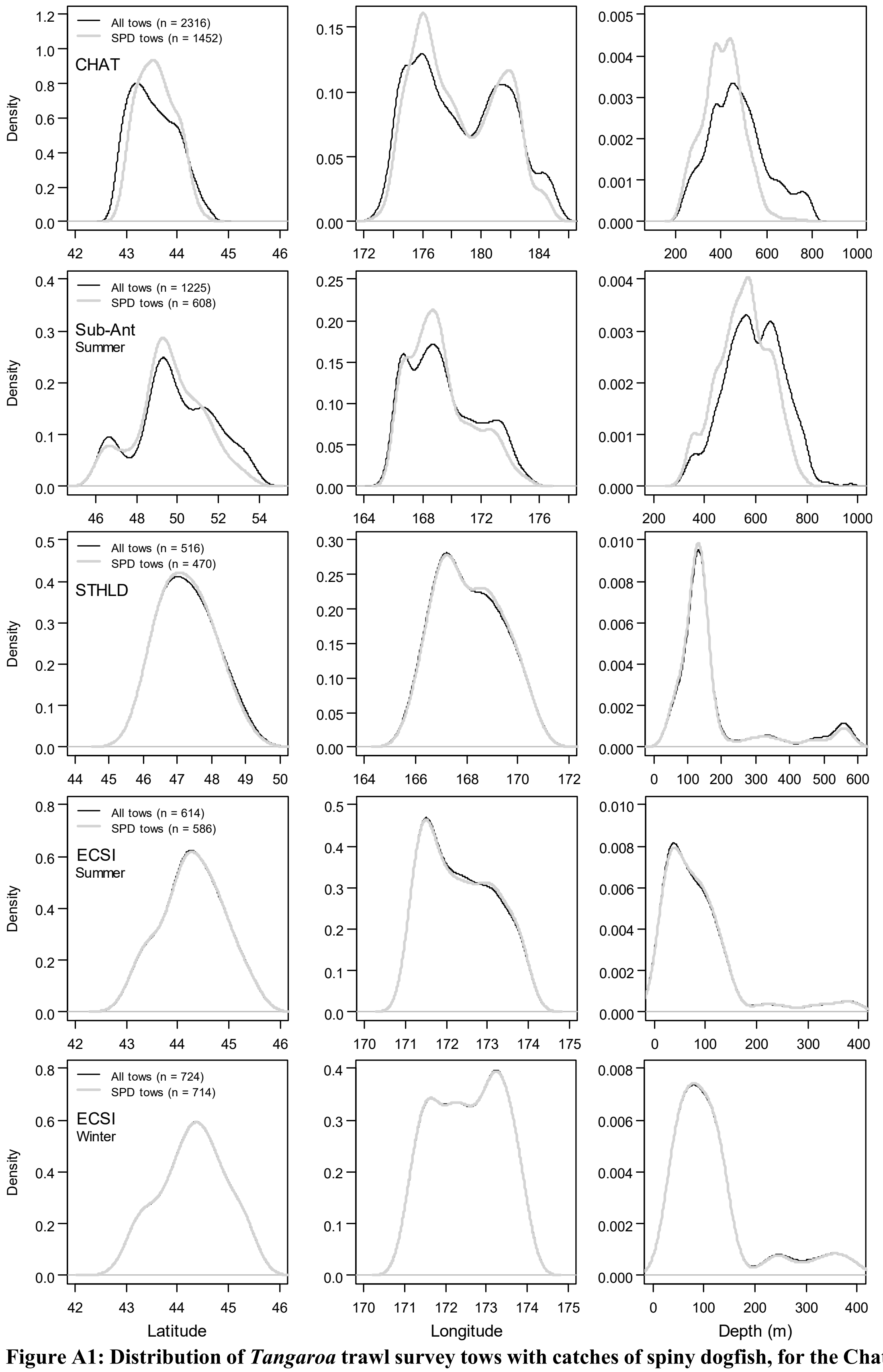


Figure A1: Distribution of *Tangaroa* trawl survey tows with catches of spiny dogfish, for the Chatham Rise summer surveys (CHAT), Sub-Antarctic summer surveys (Sub-Ant), and Southland (STHLD) late summer surveys, and for *Kaharoa* surveys of east coast South Island (ECSI) in summer and winter, by latitude, longitude, and maximum depth of tow.

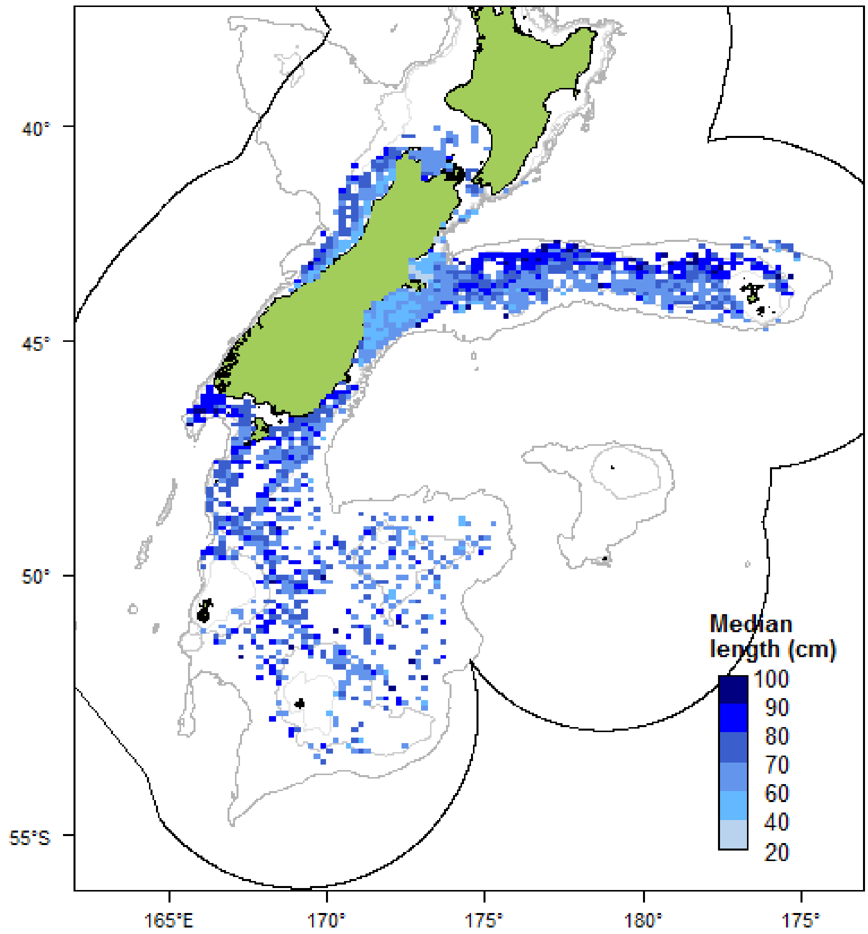
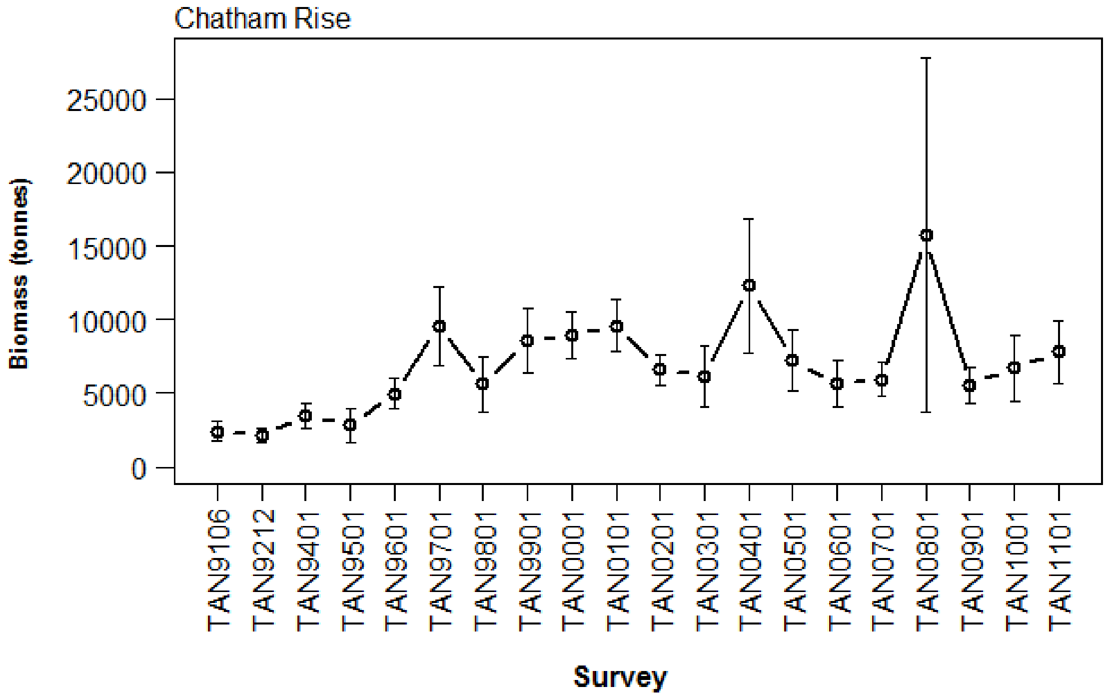


Figure A2: Distribution of lengths (median per 0.2° latitude × longitude cell) from 204 288 spiny dogfish caught during trawl surveys completed between 1979 and 2011.



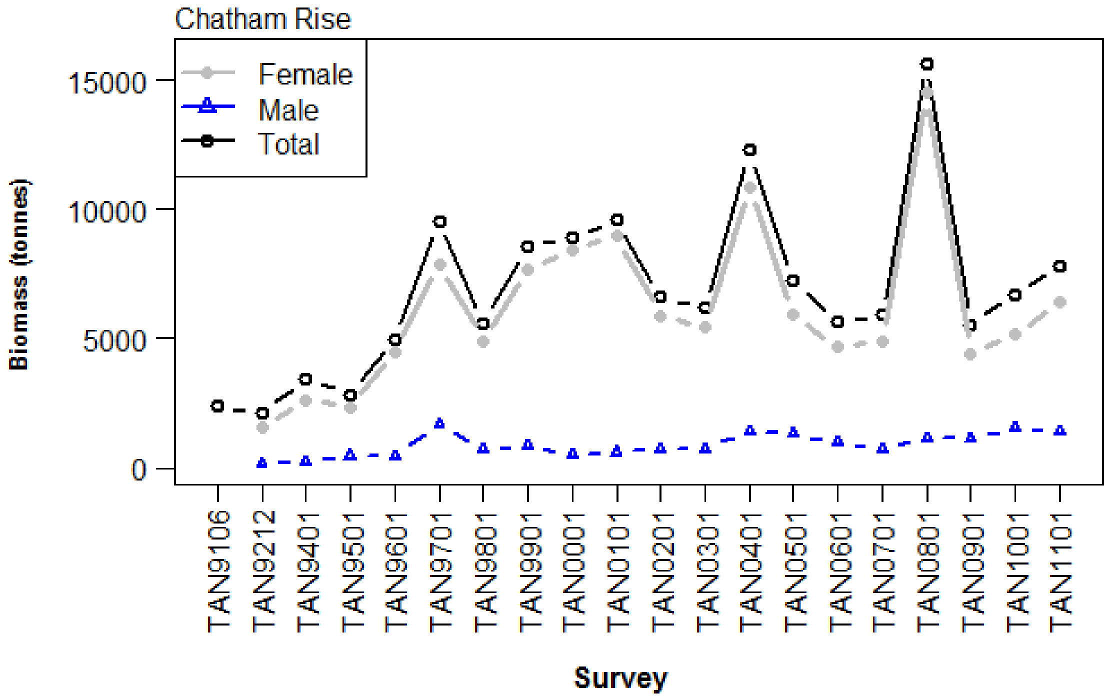


Figure A3: Doorspread biomass estimates, for all spiny dogfish (± CV, above) and by sex (below), from the summer *Tangaroa* surveys on the Chatham Rise, 1991–2011.

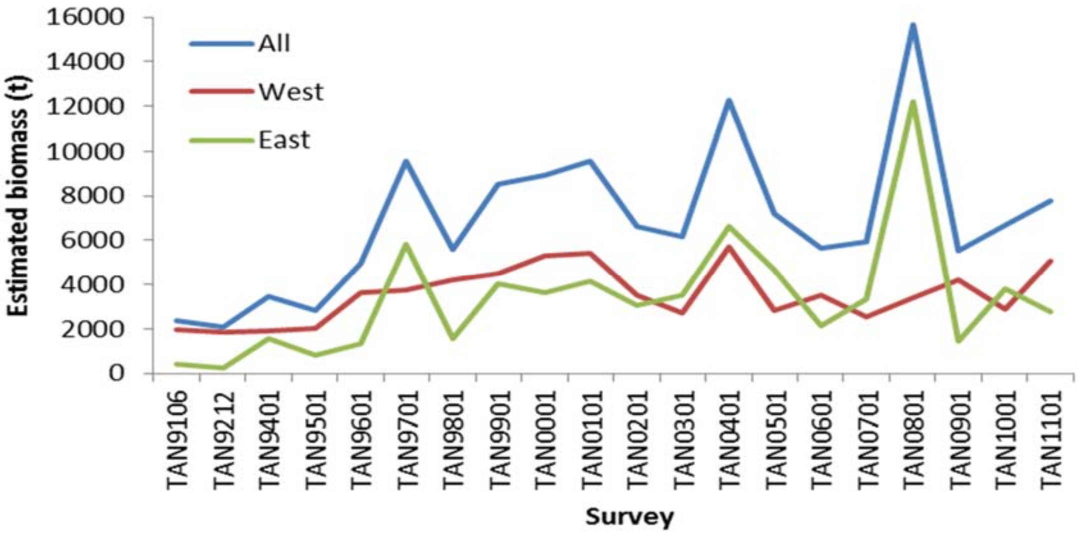


Figure A3 *continued*: Doorspread biomass estimates, for spiny dogfish from the summer Chatham Rise *Tangaroa* and for those catches from west or east of 180°, 1991–92 to 2011.

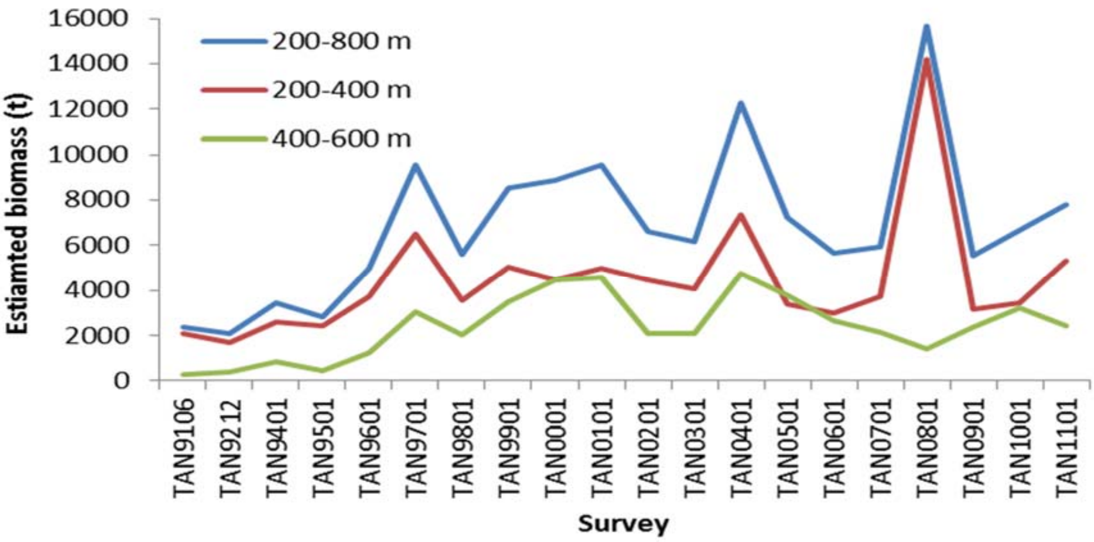


Figure A3 *continued*: Doorspread biomass estimates, for spiny dogfish from the summer Chatham Rise *Tangaroa* (200–800m) and for those catches from 200–400 m and 400–600 m, 1991–92 to 2011.

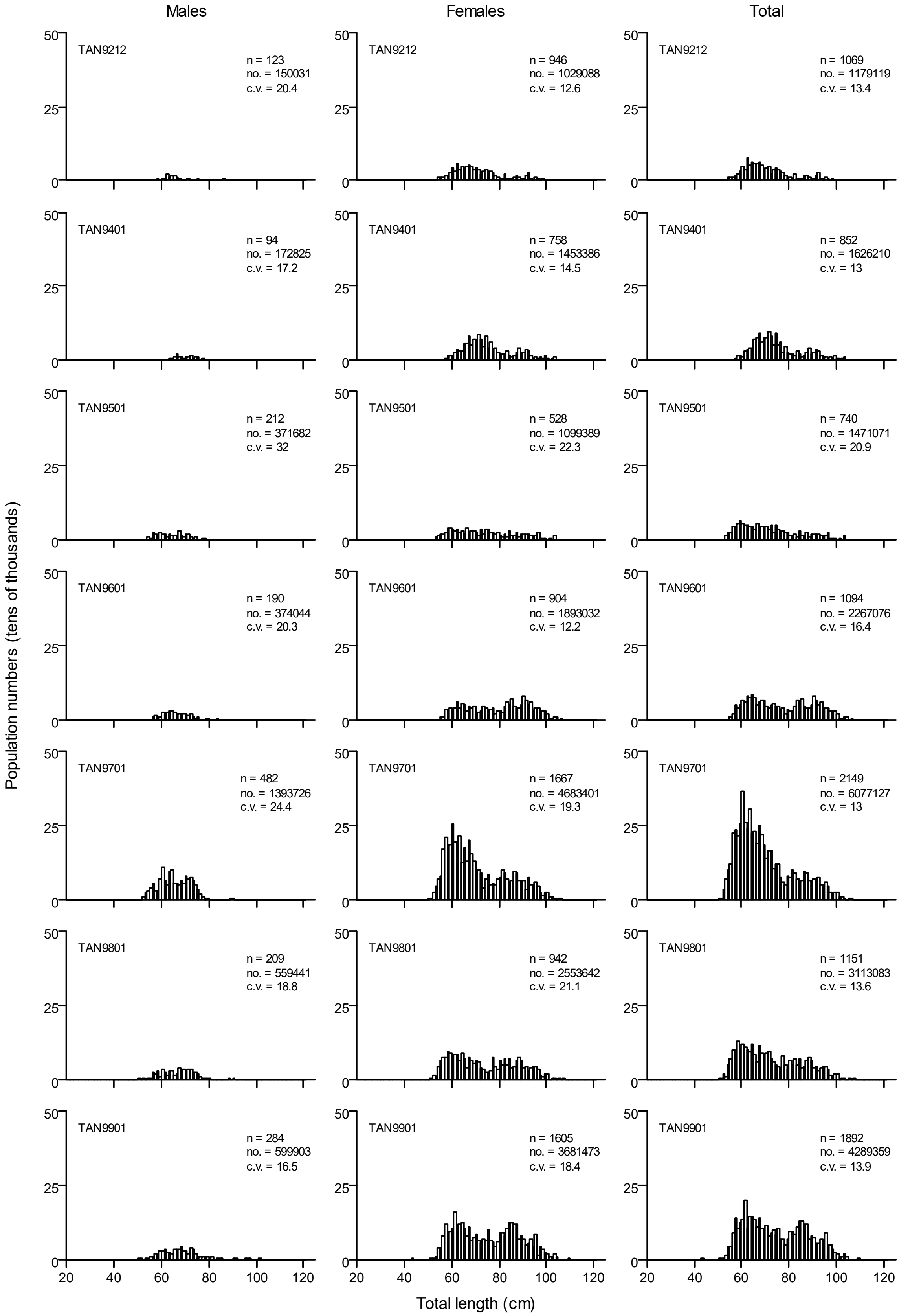


Figure A4: Scaled population length frequency distributions of spiny dogfish from the Chatham Rise January *Tangaroa* (TAN) surveys, 1992 to 1999. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

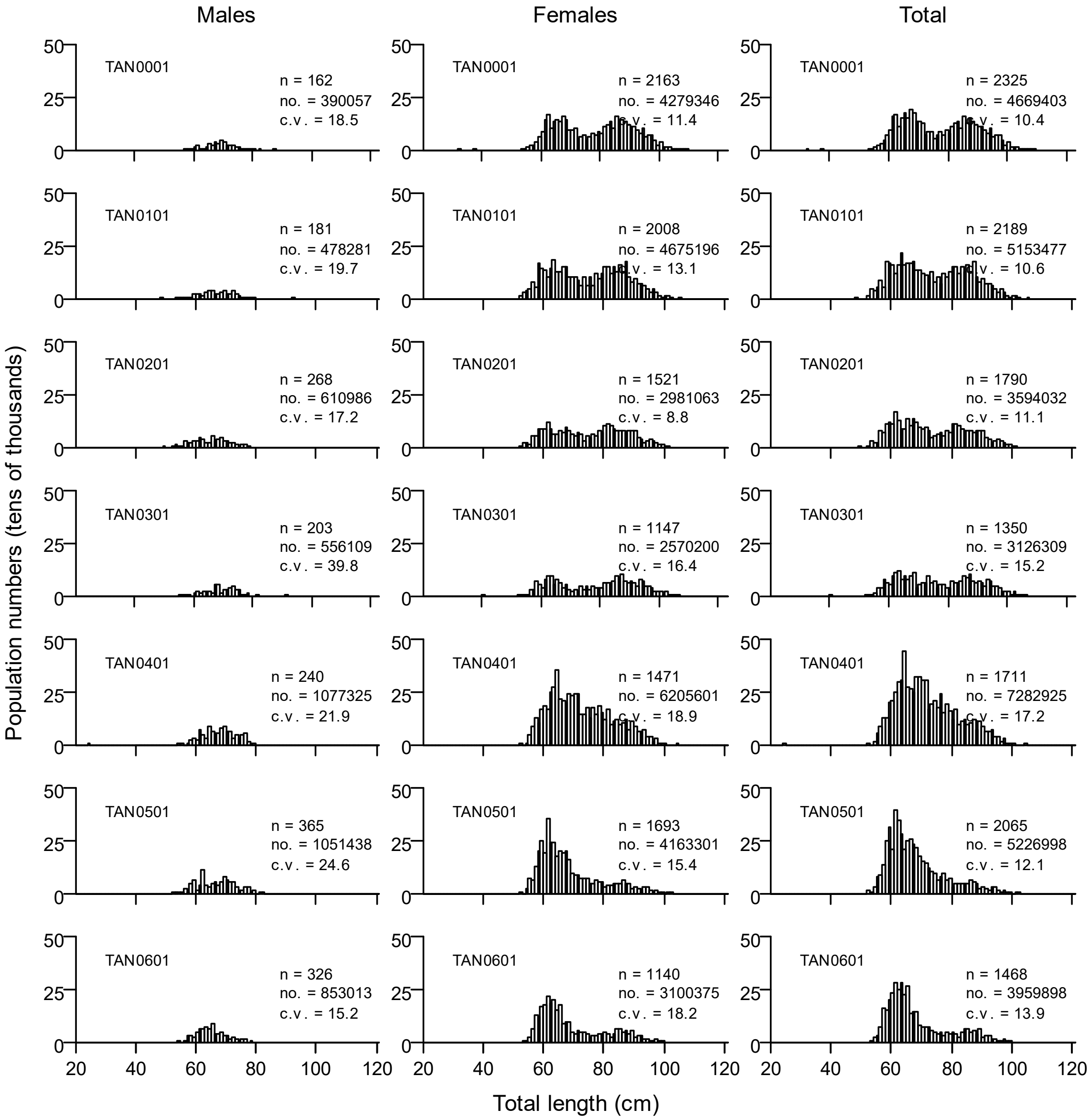


Figure A4 *continued*: Scaled population length frequency distributions of spiny dogfish from the Chatham Rise January *Tangaroa* (TAN) surveys, 2000 to 2006. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

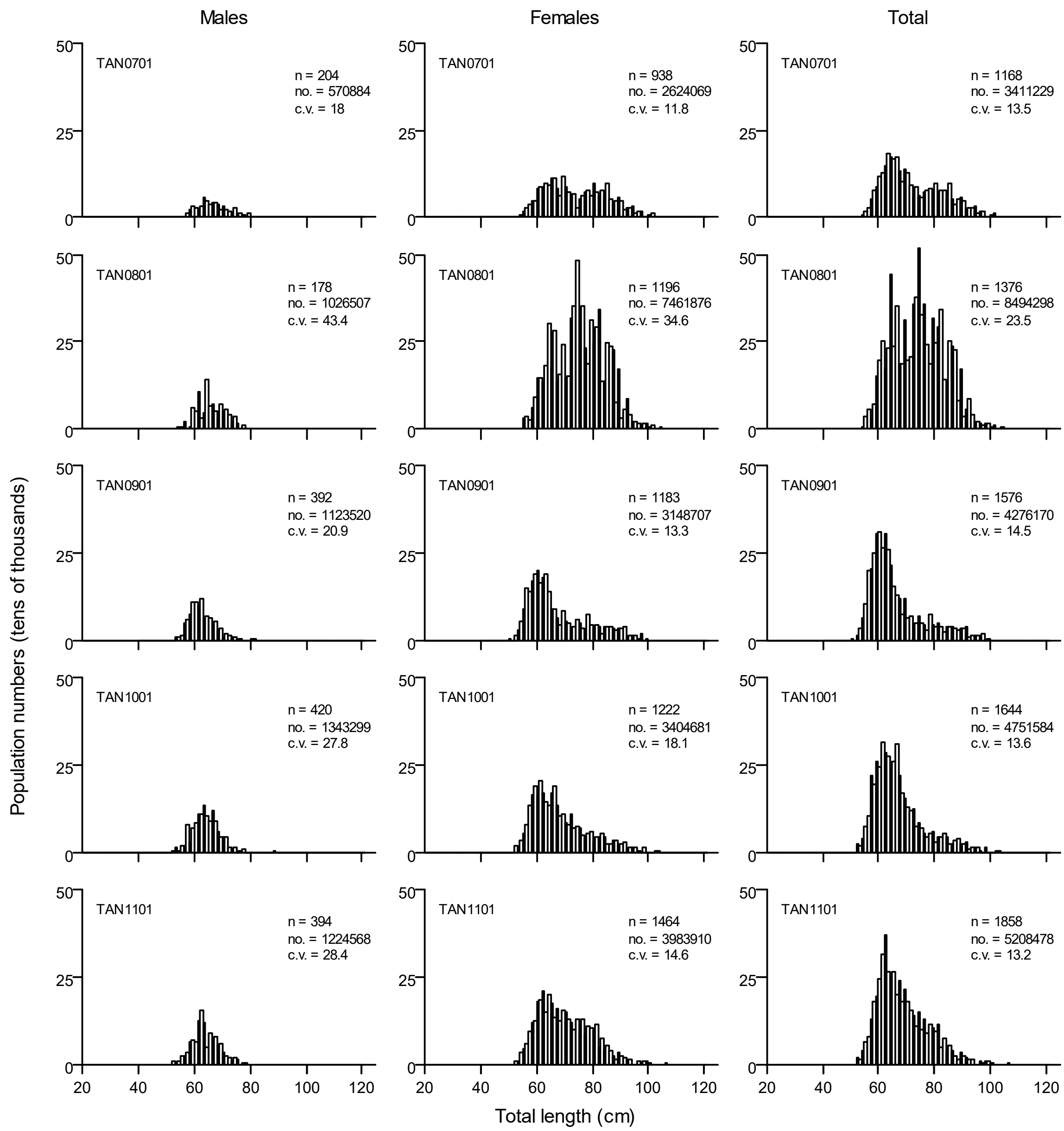


Figure A4 *continued*: Scaled population length frequency distributions of spiny dogfish from the Chatham Rise January *Tangaroa* (TAN) surveys, 2007 to 2011. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

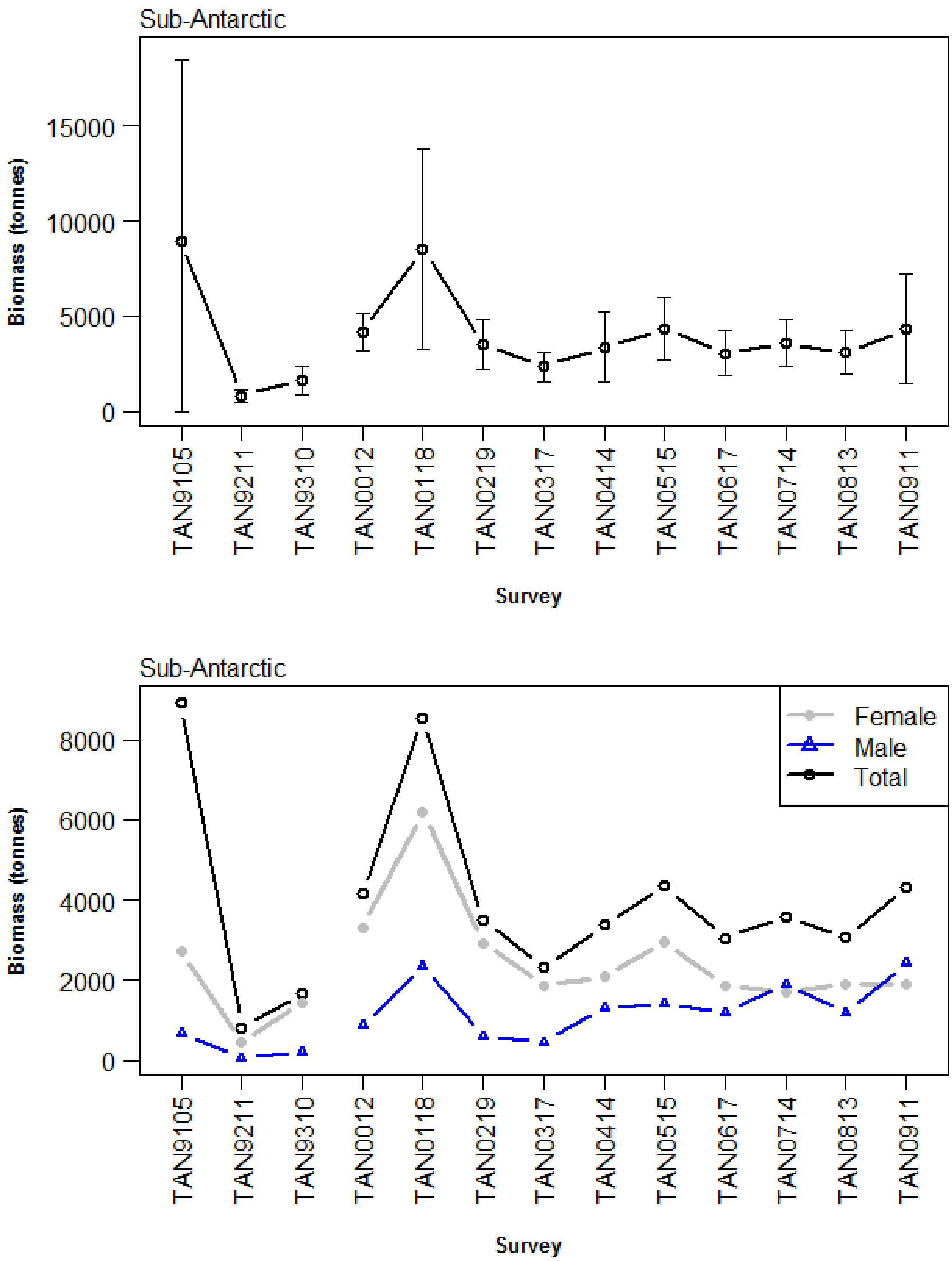


Figure A5: Doorspread biomass estimates, for all spiny dogfish (± CV, above) and by sex (below), from the summer Sub-Antarctic *Tangaroa* surveys 1991–2009.

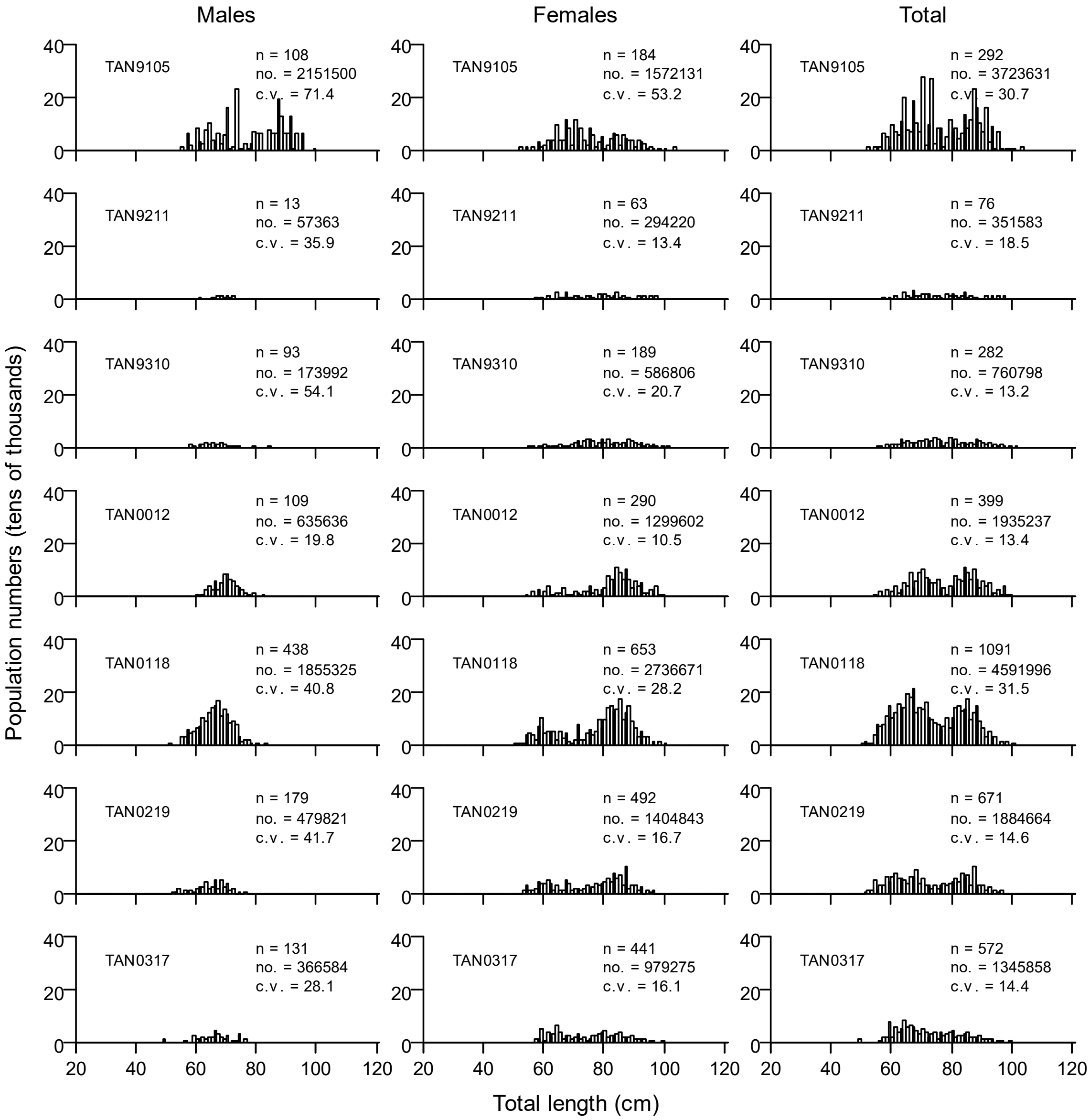


Figure A6: Scaled population length frequency distributions of spiny dogfish from the Sub-Antarctic November–December *Tangaroa* (TAN) surveys, 1991–93 and 2000–03. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

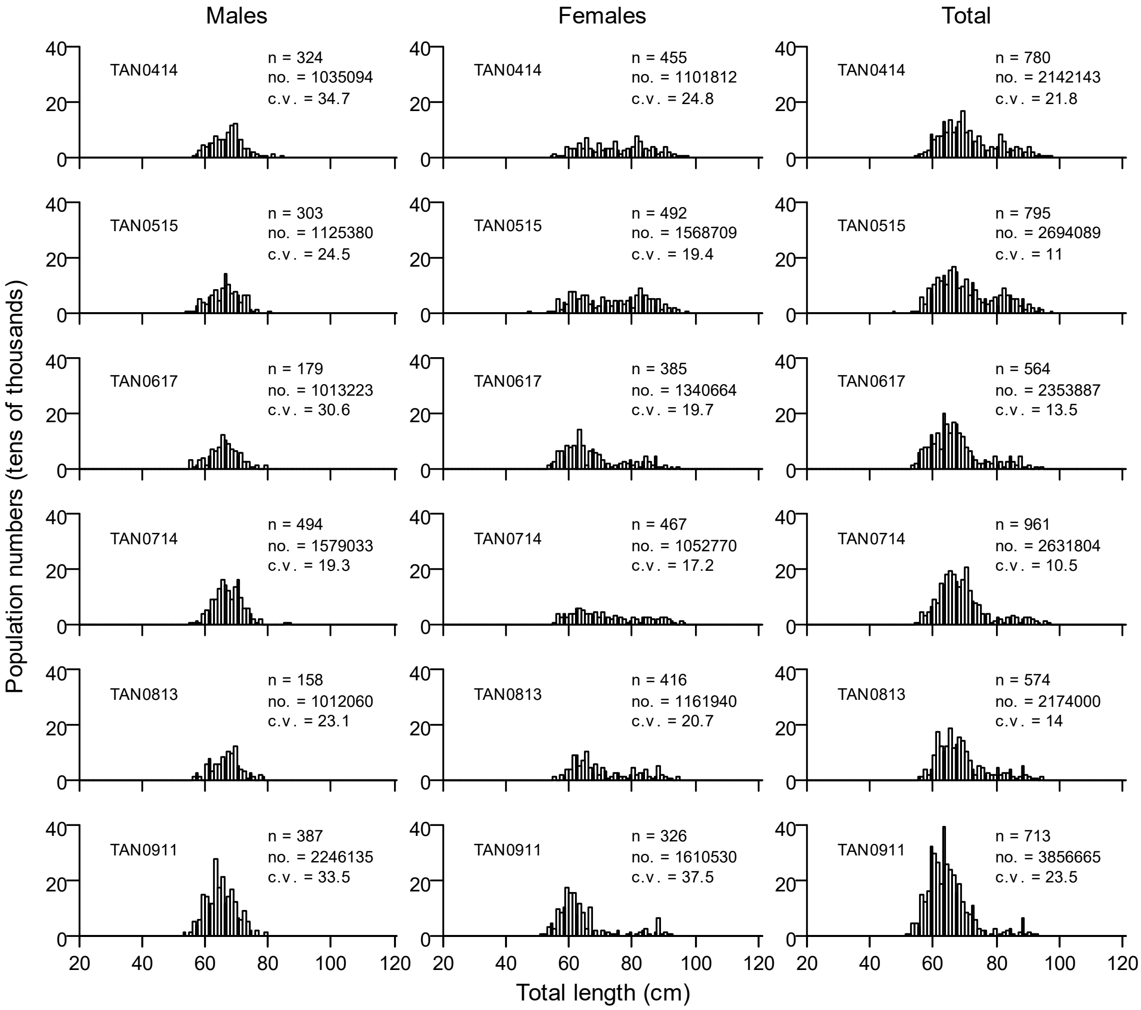


Figure A6 *continued*: Scaled population length frequency distributions of spiny dogfish from the Sub-Antarctic November–December *Tangaroa* (TAN) surveys, 2004–2009. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

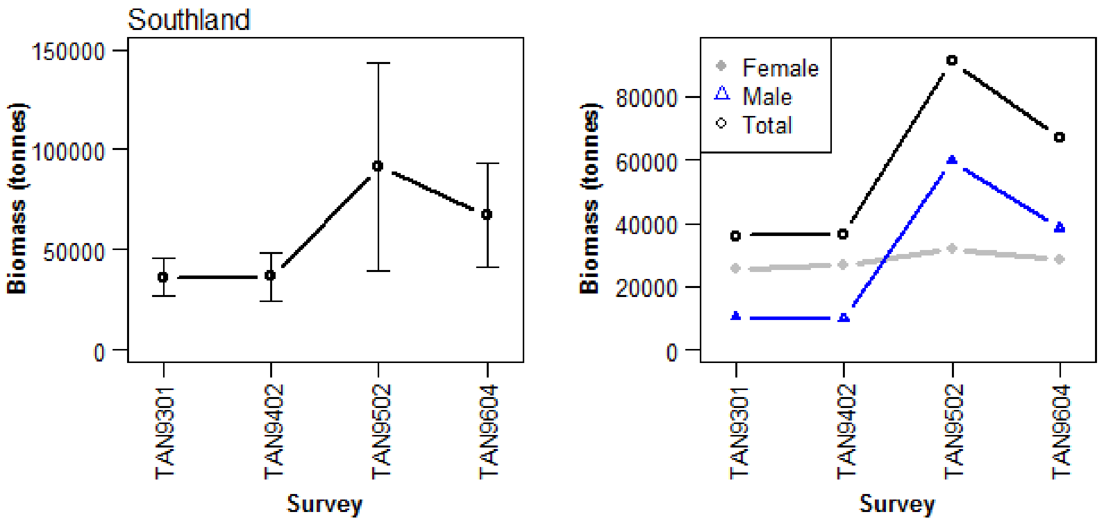


Figure A7: Doorspread biomass estimates, for all spiny dogfish (± CV, above) and by sex (below), from the February–March Southland *Tangaroa* surveys 1993–96.

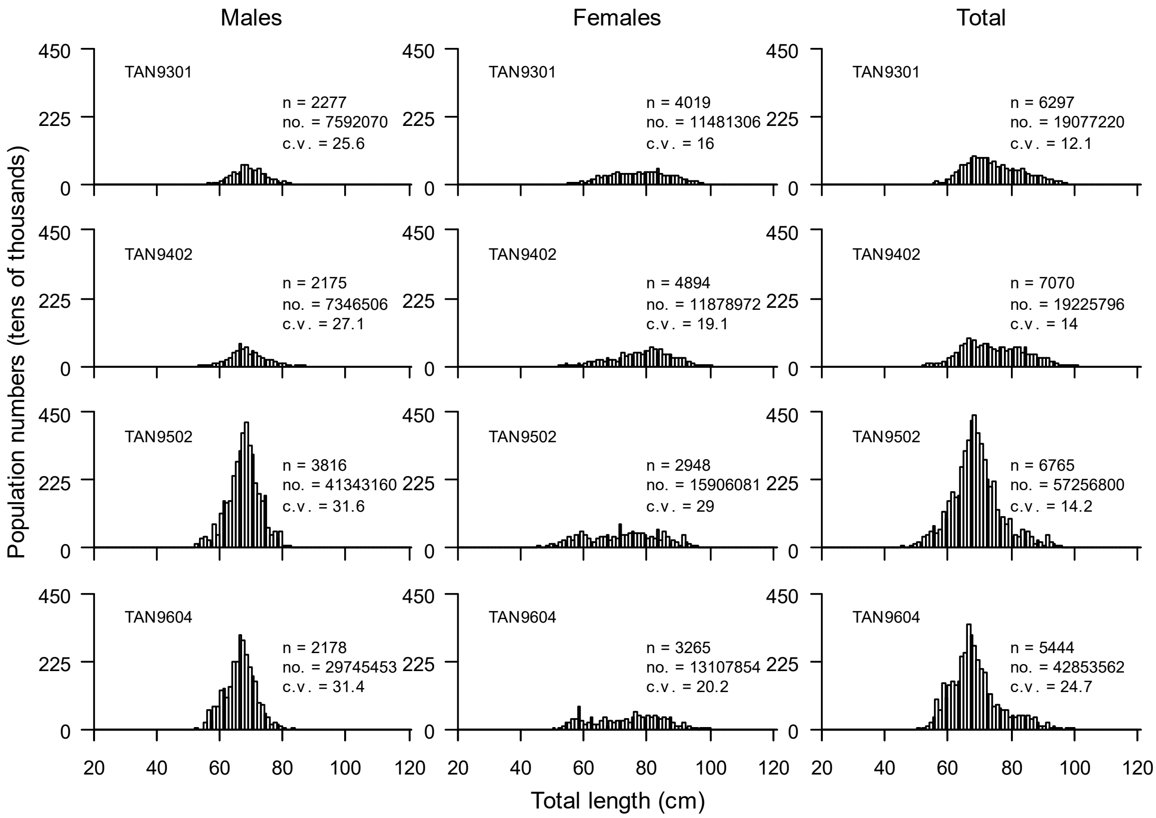


Figure A8: Scaled population length frequency distributions of spiny dogfish from the Southland February–March *Tangaroa* (TAN) surveys, 1993–96. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

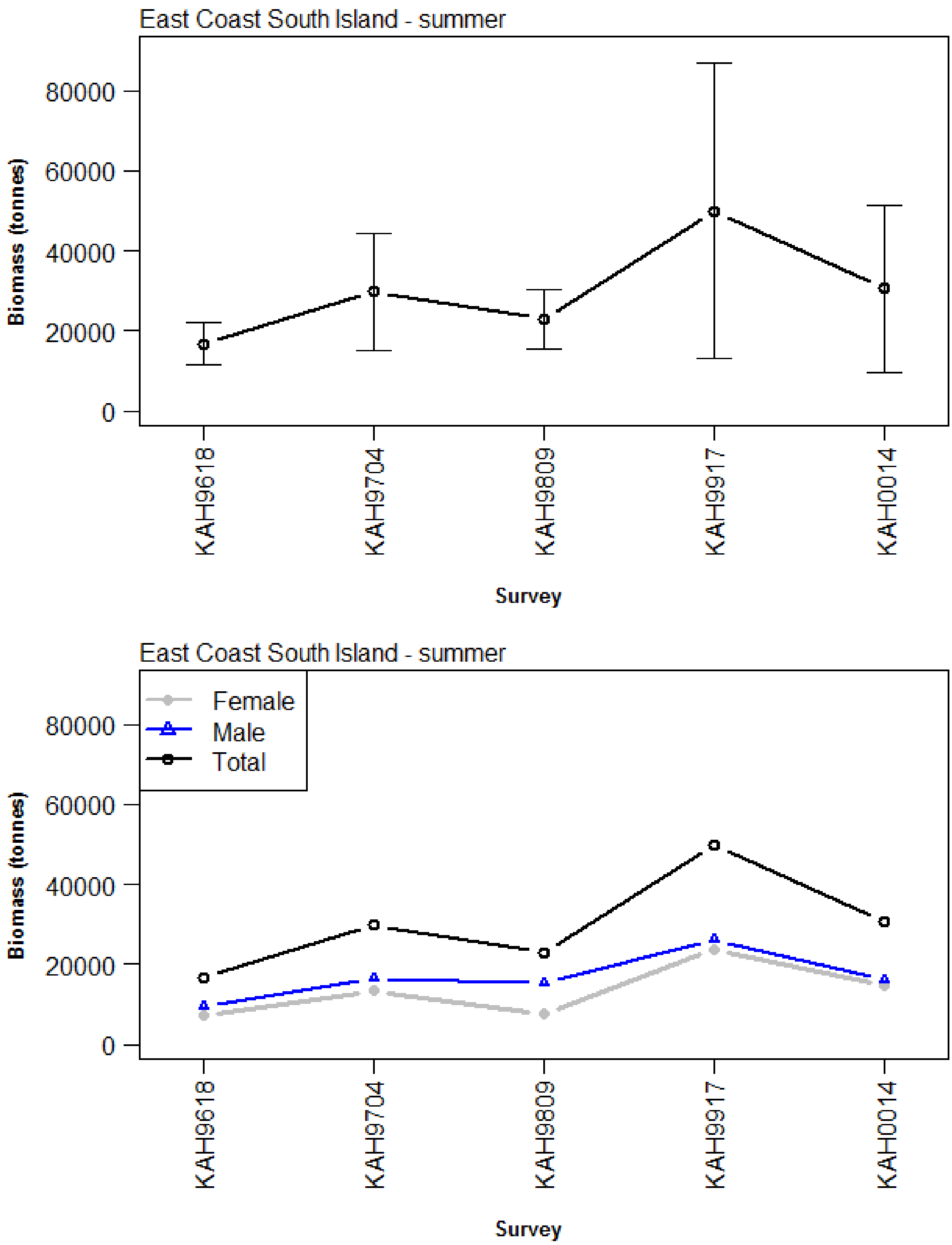


Figure A9: Doorspread biomass estimates, for all spiny dogfish (± CV, above) and by sex (below), from the summer East Coast South Island *Kaharoa* surveys 1996–2000.

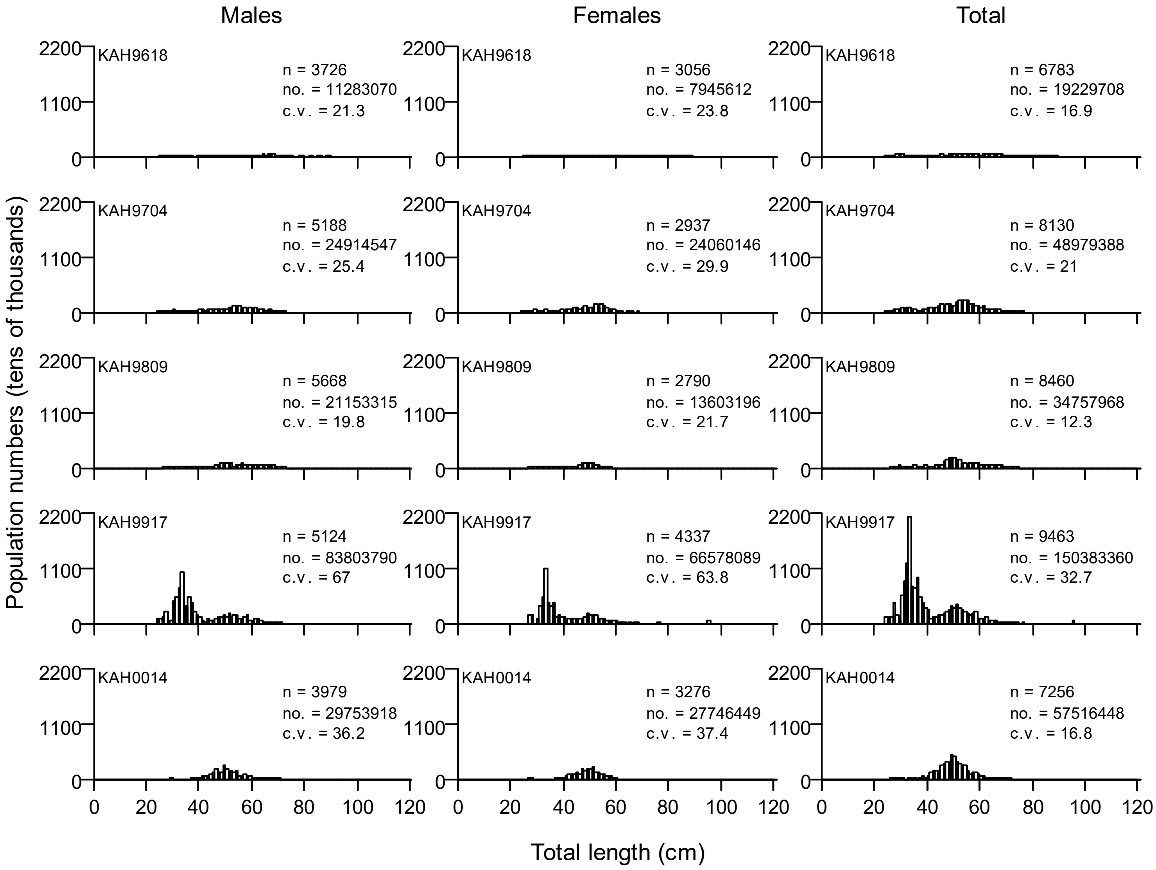


Figure A10: Scaled population length frequency distributions of spiny dogfish from the summer East Coast South Island *Kaharoa* (KAH) surveys, 1996–2000. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

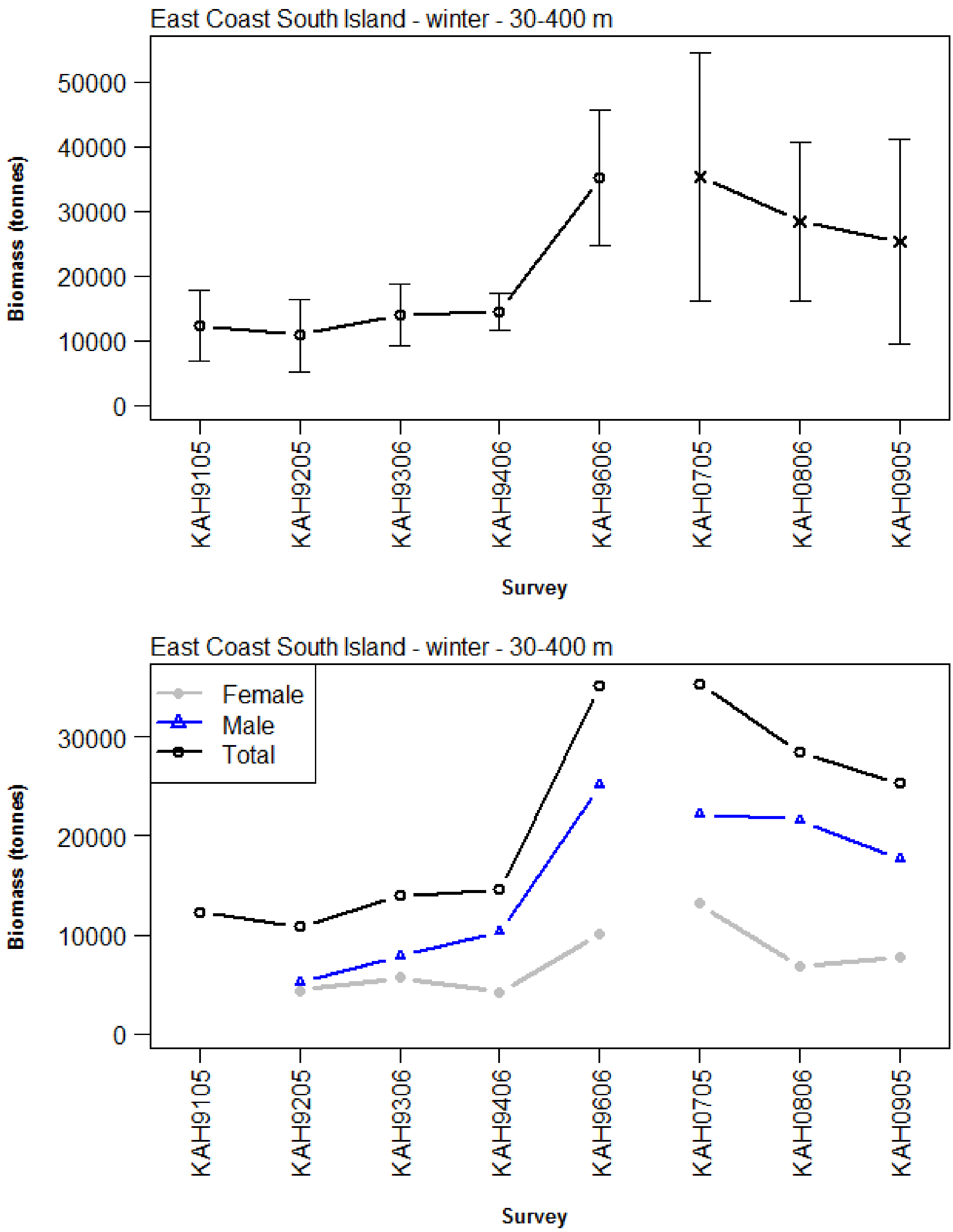


Figure A11: Doorspread biomass estimates, for all spiny dogfish (± CV, above) and by sex (below), from the winter East Coast South Island *Kaharoa* surveys 1991–96 and 2007–09, in depths of 30–400 m.

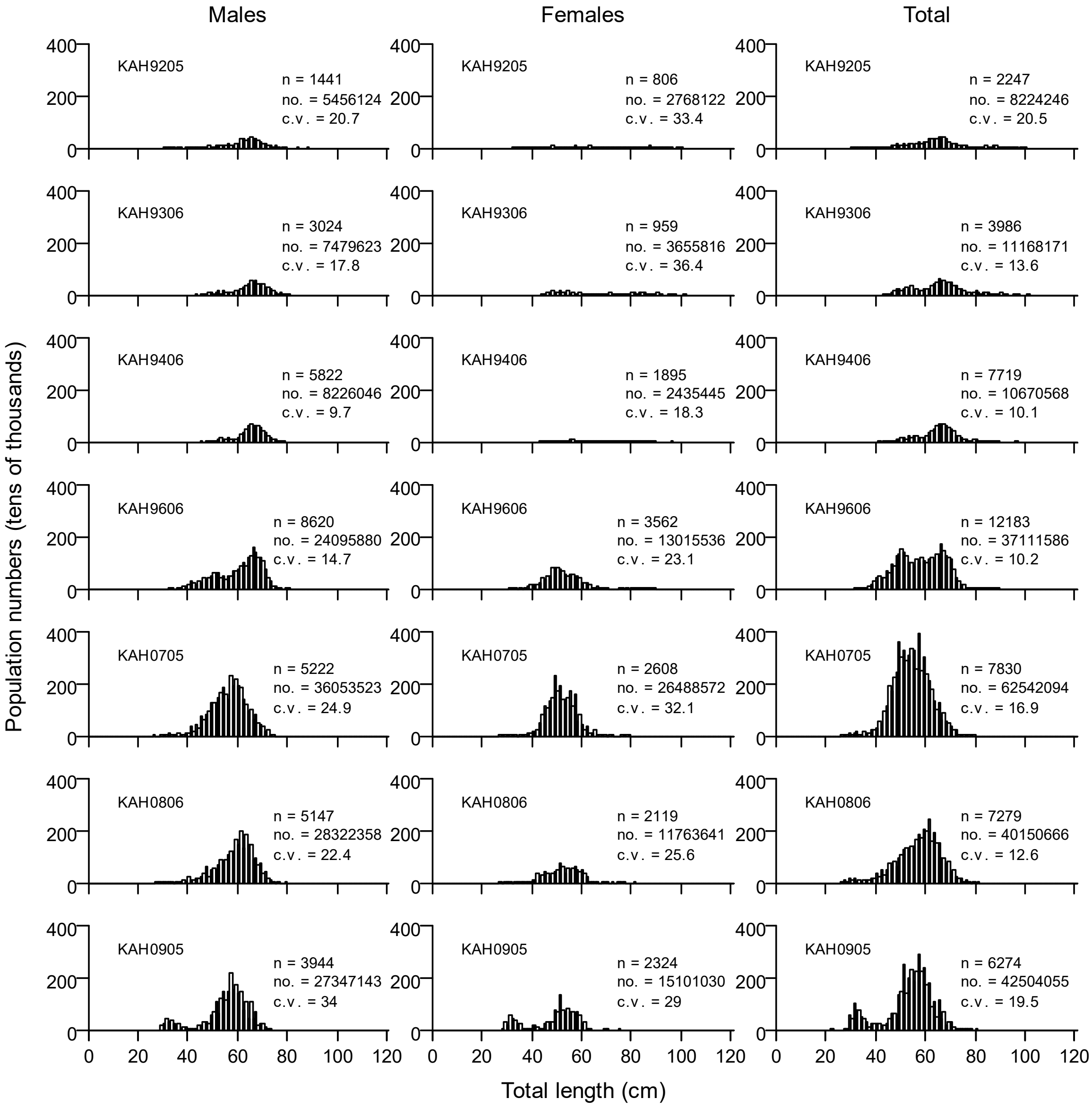


Figure A12: Scaled population length frequency distributions of spiny dogfish from the winter East Coast South Island *Kaharoa* (KAH) surveys, 1992–94, 1996, and 2007–09. [n = number of fish measured, no. = population number, c.v. = coefficient of variation.]

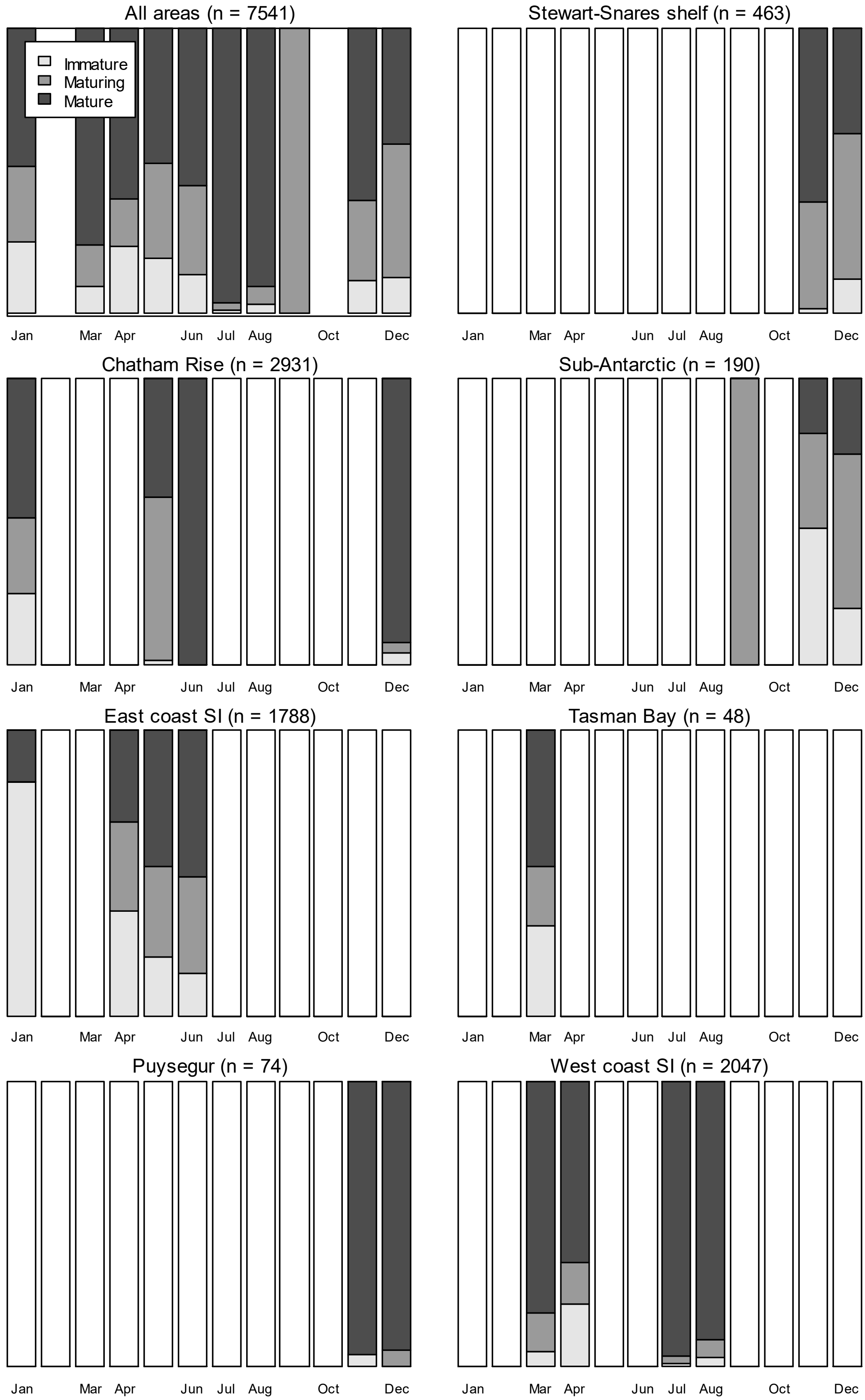


Figure A13: Relative proportions of female spiny dogfish reproductive stage data from trawl surveys (data up to December 2012), by month for each area. Numbers of females measured from each area are given in parentheses.

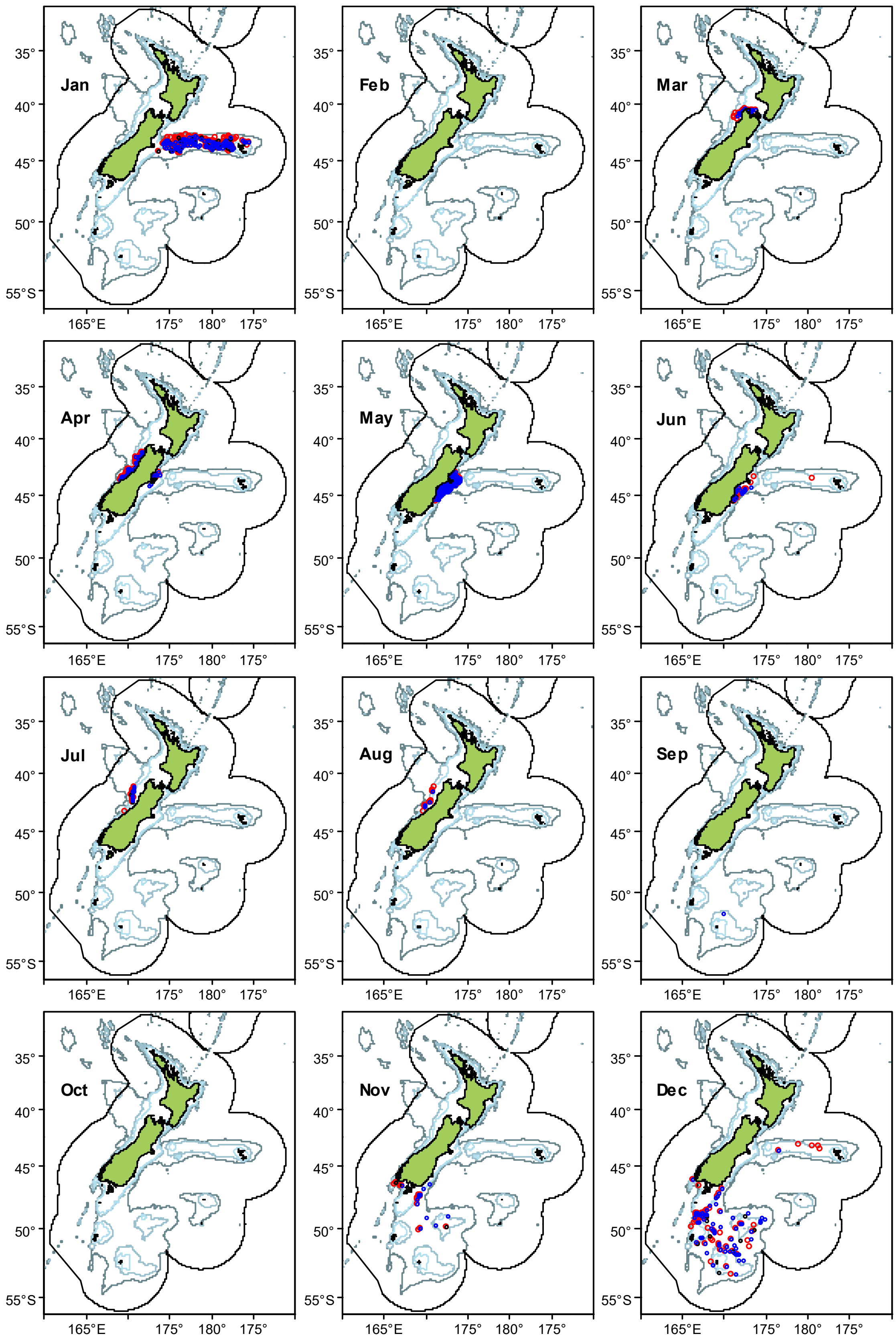


Figure A14: Distribution of female spiny dogfish reproductive stage data from trawl surveys, by month. [o = immature; o = maturing; and o = mature.]

APPENDIX B: OBSERVER DATA

Table B1: Total number of observed trawl tows with reported catch of spiny dogfish, by area for fishing years 1996–97 to 2010–11. Note: The annual totals include some tows not allocated to an area (0.9% of total tows). Areas are defined in Figure 3.

Fishing								Fishery areas
year	chat	cook	ecni	ecsi	suba	wcni	wcsi	Total
1996–97	154	0	1	52	446	155	421	1 229
1997–98	617	143	11	140	802	210	545	2 475
1998–99	572	207	41	166	957	21	691	2 666
1999–00	494	147	54	159	918	49	535	2 380
2000–01	644	200	6	219	2 335	78	497	3 992
2001–02	607	103	37	130	1 318	53	715	3 011
2002–03	681	117	14	200	1 497	179	438	3 163
2003–04	469	119	1	116	1 076	31	651	2 487
2004–05	522	93	16	92	1 159	223	548	2 666
2005–06	539	59	37	156	1 146	435	505	2 922
2006–07	604	146	4	164	1 228	447	452	3 118
2007–08	635	177	26	144	1 310	385	501	3 216
2008–09	434	140	0	115	1 261	317	374	2 656
2009–10	425	214	9	236	1 677	432	450	3 456
2010–11	489	85	26	214	1 229	265	421	2 770
Total	7 886	1 950	283	2 303	18 359	3 280	7 744	42 207

Table B2: Annual observed trawl catch (t) of spiny dogfish, by area for fishing years 1996–97 to 2010–11. Areas are defined in Figure 3.

Fishing								Fishery areas
year	chat	cook	ecni	ecsi	suba	wcni	wcsi	Total
1996–97	8.84		0.00	12.41	146.67	113.94	88.71	370.57
1997–98	53.87	55.01	1.03	38.24	238.43	74.10	249.14	709.82
1998–99	115.97	97.13	4.30	78.28	380.50	9.31	225.05	910.53
1999–00	141.64	109.15	2.21	64.32	232.46	0.87	110.43	661.08
2000–01	106.86	86.54	0.13	113.38	636.94	2.20	82.26	1 028.32
2001–02	129.41	45.20	0.29	56.04	848.99	1.18	121.70	1 202.80
2002–03	71.85	104.25	0.92	44.59	634.23	10.40	40.68	906.92
2003–04	60.26	38.52	0.01	32.35	382.06	1.10	51.87	566.18
2004–05	102.21	38.05	4.68	68.36	274.75	13.66	43.90	545.62
2005–06	98.01	15.12	0.83	105.60	292.03	18.14	73.16	602.89
2006–07	146.75	84.61	0.54	119.95	283.34	39.07	48.68	722.94
2007–08	176.24	64.68	0.18	183.27	336.62	12.02	66.68	839.69
2008–09	83.22	26.76		113.75	536.22	27.42	44.28	831.65
2009–10	79.77	32.15	0.19	134.98	499.84	31.05	107.97	885.94
2010–11	75.74	13.10	0.20	261.64	467.46	28.40	69.15	915.69
Total	1 450.62	810.28	15.51	1 427.15	6190.55	382.87	1 423.66	11 700.63

Table B3: Total number of observed trawl tows sampled for spiny dogfish, by area for fishing years 1996–97 to 2010–11. Note: Numbers of tows sampled are greater than values on the length frequency plots because this table includes tows where fewer than five fish were sampled. Areas are defined in Figure 3.

Fishing	Fishery areas					
year	CHAT	ECSI	Other	SUBA	WCSI	Total
1996–97	0	6	0	21	36	63
1997–98	23	58	28	74	51	234
1998–99	7	37	5	95	42	186
1999–00	10	27	12	47	45	141
2000–01	7	42	18	124	41	232
2001–02	7	16	0	54	22	99
2002–03	3	20	18	64	24	129
2003–04	0	10	16	42	26	94
2004–05	19	7	11	69	5	111
2005–06	0	4	4	13	19	40
2006–07	12	6	9	22	0	49
2007–08	8	7	15	16	3	49
2008–09	2	0	17	10	2	31
2009–10	0	25	0	18	7	50
2010–11	8	6	2	7	7	30
Total	106	271	155	676	330	1 538

Table B4: Number of observed tows sampled for spiny dogfish length, by month for fishing years 1996–97 to 2010–11 where data exist. Areas are defined in Figure 3.

Fishing	Month of fishing year												
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1996–97	0	0	0	0	0	14	4	4	2	13	17	9	63
1997–98	0	15	37	47	18	31	30	1	0	27	24	4	234
1998–99	5	3	8	11	31	47	12	6	1	32	23	7	186
1999–00	1	9	0	3	6	27	8	20	8	26	26	7	141
2000–01	5	2	4	12	71	40	23	1	10	18	33	13	232
2001–02	2	5	0	8	10	18	15	12	0	13	10	6	99
2002–03	9	10	0	11	21	2	3	9	6	9	23	26	129
2003–04	4	0	6	20	9	2	3	0	0	14	31	5	94
2004–05	1	2	5	29	19	9	32	4	2	2	4	2	111
2005–06	0	0	4	5	0	4	1	2	6	2	16	0	40
2006–07	1	0	4	5	9	5	7	8	0	2	8	0	49
2007–08	1	4	11	1	6	5	0	10	2	8	1	0	49
2008–09	0	0	2	0	0	3	1	1	3	15	5	1	31
2009–10	0	2	5	12	4	8	8	2	0	0	7	2	50
2010–11	3	0	1	2	3	3	8	3	0	0	6	1	30
Total	32	52	87	166	207	218	155	83	40	181	234	83	1 538

Table B5: Number of observed tows sampled for spiny dogfish length from each area, by month for fishing years 1996–97 to 2010–11, where more than five individual fish were measured per tow. Areas are defined in Figure 3.

(a) CHAT

Fishing	Month of fishing year												
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1996–97	0	0	0	0	0	0	0	0	0	0	0	0	0
1997–98	0	6	3	14	0	0	0	0	0	0	0	0	23
1998–99	0	3	1	0	3	0	0	0	0	0	0	0	7
1999–00	0	2	0	0	0	0	0	3	2	0	0	3	10
2000–01	0	0	2	0	3	0	0	0	0	0	0	2	7
2001–02	0	2	0	0	0	0	0	5	0	0	0	0	7
2002–03	1	0	0	0	1	0	0	0	0	0	0	1	3
2003–04	0	0	0	0	0	0	0	0	0	0	0	0	0
2004–05	0	0	0	16	3	0	0	0	0	0	0	0	19
2006–07	0	0	0	0	0	0	0	0	0	0	0	0	0
2006–07	0	0	3	1	0	0	0	8	0	0	0	0	12
2007–08	0	2	0	0	0	0	0	6	0	0	0	0	8
2008–09	0	0	0	0	0	0	0	0	0	0	1	1	2
2009–10	0	0	0	0	0	0	0	0	0	0	0	0	0
2010–11	0	0	0	0	0	0	6	1	0	0	0	1	8
Total	1	15	9	31	10	0	6	23	2	0	1	8	106

(b) ECSI

Fishing	Month of fishing year												
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1996–97	0	0	0	0	0	0	1	3	2	0	0	0	6
1997–98	0	5	21	6	5	5	14	1	0	0	0	1	58
1998–99	1	0	3	9	1	2	6	6	1	8	0	0	37
1999–00	1	2	0	0	0	4	1	17	2	0	0	0	27
2000–01	2	2	2	5	10	2	7	0	10	0	0	2	42
2001–02	1	0	0	7	0	0	1	6	0	1	0	0	16
2002–03	0	0	0	1	0	0	2	4	1	0	0	12	20
2003–04	0	0	1	0	0	0	0	0	0	3	6	0	10
2004–05	1	1	0	0	3	0	1	0	1	0	0	0	7
2005–06	0	0	0	0	0	0	0	0	0	0	4	0	4
2006–07	0	0	1	0	0	0	3	0	0	2	0	0	6
2007–08	0	1	0	0	0	0	0	1	2	2	1	0	7
2008–09	0	0	0	0	0	0	0	0	0	0	0	0	0
2009–10	0	2	5	12	2	3	0	0	0	0	0	1	25
2010–11	0	0	1	0	1	0	2	2	0	0	0	0	6
Total	6	13	34	40	22	16	38	40	19	16	11	16	271

Table B5 *continued*

(c) SUBA

Fishing year	Month of fishing year												Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1996–97	0	0	0	0	0	14	3	1	0	0	0	3	21
1997–98	0	0	3	14	12	26	16	0	0	0	0	3	74
1998–99	4	0	4	2	27	45	6	0	0	0	0	7	95
1999–00	0	2	0	2	5	23	7	0	3	4	0	1	47
2000–01	3	0	0	7	58	38	16	1	0	0	0	1	124
2001–02	1	3	0	1	10	18	14	1	0	0	0	6	54
2002–03	2	10	0	10	20	2	0	5	5	0	0	10	64
2003–04	3	0	5	20	9	2	3	0	0	0	0	0	42
2004–05	0	0	5	13	13	9	24	4	1	0	0	0	69
2005–06	0	0	0	5	0	4	1	2	1	0	0	0	13
2006–07	1	0	0	3	9	5	4	0	0	0	0	0	22
2007–08	1	1	2	1	6	5	0	0	0	0	0	0	16
2008–09	0	0	2	0	0	3	1	1	3	0	0	0	10
2009–10	0	0	0	0	2	5	8	2	0	0	0	1	18
2010–11	0	0	0	2	2	3	0	0	0	0	0	0	7
Total	15	16	21	80	173	202	103	17	13	4	0	32	676

(d) WCSI

Fishing year	Month of fishing year												Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1996–97	0	0	0	0	0	0	0	0	0	13	17	6	36
1997–98	0	0	0	0	0	0	0	0	0	27	24	0	51
1998–99	0	0	0	0	0	0	0	0	0	24	18	0	42
1999–00	0	0	0	0	0	0	0	0	1	19	23	2	45
2000–01	0	0	0	0	0	0	0	0	0	17	23	1	41
2001–02	0	0	0	0	0	0	0	0	0	12	10	0	22
2002–03	1	0	0	0	0	0	0	0	0	7	14	2	24
2003–04	0	0	0	0	0	0	0	0	0	5	18	3	26
2004–05	0	0	0	0	0	0	0	0	0	2	1	2	5
2005–06	0	0	0	0	0	0	0	0	5	2	12	0	19
2006–07	0	0	0	0	0	0	0	0	0	0	0	0	0
2007–08	0	0	0	0	0	0	0	0	0	3	0	0	3
2008–09	0	0	0	0	0	0	0	0	0	0	2	0	2
2009–10	0	0	0	0	0	0	0	0	0	0	7	0	7
2010–11	1	0	0	0	0	0	0	0	0	0	6	0	7
Total	2	0	0	0	0	0	0	0	6	131	175	16	330

Table B6: Total number of spiny dogfish measured, by area for fishing years 1991–92 to 2010–11. Note: Numbers measured differ from those given in Figures B4–B6 for some years because scaled length frequency plots only include tows with more than five individual fish measurements. –, no data.

(a) CHAT

Fishing	Month of fishing year												
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Total numbers													
1996–97	0	0	0	0	0	0	0	0	0	0	0	0	0
1997–98	0	332	170	60	0	0	0	0	0	0	0	0	562
1998–99	0	140	93	0	300	0	0	0	0	0	0	0	533
1999–00	0	194	0	0	0	0	0	236	245	0	0	295	970
2000–01	0	0	200	0	50	0	0	0	0	0	0	121	371
2001–02	0	193	0	0	0	0	0	530	0	0	0	0	723
2002–03	52	0	0	0	120	0	0	0	0	0	0	89	261
2003–04	0	0	0	0	0	0	0	0	0	0	0	0	0
2004–05	0	0	0	1067	192	0	0	0	0	0	0	0	1 259
2005–06	0	0	0	0	0	0	0	0	0	0	0	0	0
2006–07	0	0	30	20	0	0	0	517	0	0	0	0	567
2007–08	0	124	0	0	0	0	0	86	0	0	0	0	210
2008–09	0	0	0	0	0	0	0	0	0	0	11	10	21
2010–11	0	0	0	0	0	0	285	10	0	0	0	105	400
Total	52	983	493	1147	662	0	285	1379	245	0	11	620	5 877
Females (%)													
1996–97	–	–	–	–	–	–	–	–	–	–	–	–	–
1997–98	–	91.3	91.2	80.0	–	–	–	–	–	–	–	–	90.0
1998–99	–	71.4	95.7	–	75.3	–	–	–	–	–	–	–	77.9
1999–00	–	86.6	–	–	–	–	–	58.9	63.3	–	–	74.6	70.3
2000–01	–	–	100.0	–	80.0	–	–	–	–	–	–	97.5	96.5
2001–02	–	92.7	–	–	–	–	–	57.0	–	–	–	–	66.5
2002–03	96.2	–	–	–	98.3	–	–	–	–	–	–	92.1	95.8
2003–04	–	–	–	–	–	–	–	–	–	–	–	–	–
2004–05	–	–	–	74.4	64.6	–	–	–	–	–	–	–	72.9
2005–06	–	–	–	–	–	–	–	–	–	–	–	–	–
2006–07	–	–	86.7	90.0	–	–	–	86.1	–	–	–	–	86.2
2007–08	–	98.4	–	–	–	–	–	81.4	–	–	–	–	91.4
2008–09	–	–	–	–	–	–	–	–	–	–	100.0	90.0	95.2
2010–11	–	–	–	–	–	–	46.0	60.0	–	–	–	98.1	60.0
Total	96.2	88.7	95.3	75.0	76.7	–	46.0	69.8	63.3	–	100.0	85.8	77.4

Table B6 *continued*

(b) ECSI

Fishing year	Month of fishing year												Total
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Total numbers													
1996–97	0	0	0	0	0	0	103	278	90	0	0	0	471
1997–98	0	485	240	321	355	302	426	101	0	0	0	62	2 292
1998–99	39	0	284	993	100	225	629	663	89	133	0	0	3 155
1999–00	20	121	0	0	0	355	100	1438	193	0	0	0	2 227
2000–01	184	199	198	266	592	193	506	0	997	0	0	209	3 344
2001–02	100	0	0	718	0	0	22	573	0	160	0	0	1 573
2002–03	0	0	0	106	0	0	205	314	114	0	0	776	1 515
2003–04	0	0	8	0	0	0	0	0	0	351	618	0	977
2004–05	100	48	0	0	130	0	79	0	110	0	0	0	467
2005–06	0	0	0	0	0	0	0	0	0	0	85	0	85
2006–07	0	0	9	0	0	0	225	0	0	222	0	0	456
2007–08	0	20	0	0	0	0	0	14	39	30	20	0	123
2008–09	0	0	0	0	0	0	0	0	0	0	0	0	0
2009–10	0	40	153	139	37	49	0	0	0	0	0	20	438
2010–11	0	0	103	0	100	0	40	64	0	0	0	0	307
Total	443	913	995	2 543	1 314	1 124	2 335	3 445	1 632	896	723	1 067	17 430
Females (%)													
1996–97	–	–	–	–	–	–	35.9	54.0	55.6	–	–	–	50.3
1997–98	–	87.4	98.8	96.3	98.3	68.9	80.5	100.0	–	–	–	67.7	87.8
1998–99	56.4	–	99.3	68.9	39.0	47.1	36.7	51.4	41.6	43.6	–	–	57.1
1999–00	35.0	57.9	–	–	–	32.1	55.0	40.8	50.3	–	–	–	41.8
2000–01	96.2	100.0	81.3	98.1	64.4	46.6	85.6	–	69.3	–	–	71.8	76.0
2001–02	84.0	–	–	89.8	–	–	36.4	46.8	–	47.5	–	–	68.7
2002–03	–	–	–	41.5	–	–	15.1	36.9	49.1	–	–	88.1	61.5
2003–04	–	–	100.0	–	–	–	–	–	–	70.1	72.2	–	71.6
2004–05	90.0	79.2	–	–	56.9	–	64.6	–	35.5	–	–	–	62.5
2005–06	–	–	–	–	–	–	–	–	–	–	44.7	–	44.7
2006–07	–	–	100.0	–	–	–	68.9	–	–	65.8		–	68.0
2007–08	–	50.0	–	–	–	–	–	85.7	46.2	23.3	85.0	–	52.0
2008–09	–	–	–	–	–	–	–	–	–	–	–	–	–
2009–10	–	92.5	87.6	56.8	8.1	20.4	–	–	–	–	–	100.0	64.6
2010–11	–	–	54.4	–	9.0	–	12.5	84.4	–	–	–	–	40.4
All	85.8	85.2	89.1	79.5	65.1	47.0	57.8	47.3	60.5	59.5	69.3	84.0	65.1

Table B6 *continued*

(c) SUBA

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	Month of fishing year												
Total numbers													
1996–97	0	0	0	0	0	1 379	306	68	0	0	0	42	1 795
1997–98	0	0	362	1201	972	888	166	0	0	0	0	39	3 628
1998–99	143	0	404	203	886	1 393	694	0	0	0	0	54	3 777
1999–00	0	200	0	149	331	2 059	763	0	323	425	0	1	4 251
2000–01	217	0	0	427	4 140	1 753	1 299	103	0	0	0	90	8 029
2001–02	27	328	0	102	939	1 774	1 105	24	0	0	0	11	4 310
2002–03	164	1 056	0	487	1 954	112	0	468	380	0	0	31	4 652
2003–04	43	0	285	1230	441	200	165	0	0	0	0	0	2 364
2004–05	0	0	557	732	744	293	706	392	92	0	0	0	3 516
2005–06	0	0	0	521	0	398	100	35	84	0	0	0	1 138
2006–07	8	0	0	66	611	149	33	0	0	0	0	0	867
2007–08	100	1	33	17	26	74	0	0	0	0	0	0	251
2008–09	0	0	202	0	0	320	100	20	60	0	0	0	702
2009–10	0	0	0	0	25	156	476	200	0	0	0	5	862
2010–11	0	0	0	26	120	33	0	0	0	0	0	0	179
Total	702	1 585	1 843	5 161	11 189	10 981	5 913	1 310	939	425	0	273	40 321
Females (%)													
1996–97	–	–	–	–	–	16.3	7.5	95.6	–	–	–	92.9	19.6
1997–98	–	–	30.9	33.2	53.5	22.0	22.9	–	–	–	–	92.3	35.8
1998–99	94.4	–	61.6	31.0	51.0	27.1	16.0	–	–	–	–	96.3	38.1
1999–00	–	86.0	–	89.9	13.9	30.3	9.8	–	42.1	33.6	–	100.0	31.3
2000–01	88.9	–	–	68.6	41.7	38.6	13.9	94.2	–	–	–	92.2	40.5
2001–02	92.6	48.2	–	50.0	29.5	18.7	21.1	41.7	–	–	–	81.8	25.4
2002–03	66.5	41.3	–	25.1	83.9	41.1	–	48.7	47.1	–	–	83.9	59.9
2003–04	100.0	–	67.4	38.5	42.6	67.5	9.7	–	–	–	–	–	44.3
2004–05	–	–	76.7	54.4	26.5	59.0	42.4	48.0	20.7	–	–	–	48.4
2005–06	–	–	–	42.2	–	80.7	31.0	25.7	15.5	–	–	–	52.2
2006–07	87.5	–	–	63.6	68.2	51.7	39.4		–	–	–	–	64.1
2007–08	86.0	100.0	100.0	76.5	92.3	68.9	–		–	–	–	–	82.9
2008–09	–	–	30.2	–	–	9.4	51.0	35.0	33.3	–	–	–	24.1
2009–10	–	–	–	–	44.0	61.5	56.5	23.5	–	–	–	60.0	49.4
2010–11	–	–	–	30.8	5.8	39.4	–	–	–	–	–	–	15.6
Total	85.2	48.4	58.3	43.0	49.2	30.7	22.6	49.7	39.1	33.6	–	91.2	40.4

Table B6 *continued*

(d) WCSI

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	Month of fishing year												
Total number													
1996–97	0	0	0	0	0	0	0	0	0	1 322	766	593	2 681
1997–98	0	0	0	0	0	0	0	0	0	853	656	0	1 509
1998–99	0	0	0	0	0	0	0	0	0	1 440	1 392	0	2 832
1999–00	0	0	0	0	0	0	0	0	104	1 992	2 353	26	4 475
2000–01	0	0	0	0	0	0	0	0	0	1 060	1 377	76	2 513
2001–02	0	0	0	0	0	0	0	0	0	625	325	0	950
2002–03	10	0	0	0	0	0	0	0	0	555	1 180	6	1 751
2003–04	0	0	0	0	0	0	0	0	0	379	778	87	1 244
2004–05	0	0	0	0	0	0	0	0	0	22	20	105	147
2005–06	0	0	0	0	0	0	0	0	497	25	159	0	681
2007–08	0	0	0	0	0	0	0	0	0	218	0	0	218
2008–09	0	0	0	0	0	0	0	0	0	0	28	0	28
2009–10	0	0	0	0	0	0	0	0	0	0	142	0	142
2010–11	104	0	0	0	0	0	0	0	0	0	355	0	459
Total	114	0	0	0	0	0	0	0	601	8 491	9 531	893	19 630
Females (%)													
1996–97	–	–	–	–	–	–	–	–	–	70.2	80.4	96.1	78.9
1997–98	–	–	–	–	–	–	–	–	–	49.9	83.7	–	64.6
1998–99	–	–	–	–	–	–	–	–	–	59.5	74.6	–	66.9
1999–00	–	–	–	–	–	–	–	–	86.5	68.6	64.6	69.2	66.9
2000–01	–	–	–	–	–	–	–	–	–	85.8	71.5	86.8	78.0
2001–02	–	–	–	–	–	–	–	–	–	71.2	40.3	–	60.6
2002–03	80.0	–	–	–	–	–	–	–	–	83.8	73.9	100.0	77.2
2003–04	–	–	–	–	–	–	–	–	–	66.2	92.4	96.6	84.7
2004–05	–	–	–	–	–	–	–	–	–	72.7	75.0	93.3	87.8
2005–06	–	–	–	–	–	–	–	–	53.9	92.0	81.8	–	61.8
2007–08	–	–	–	–	–	–	–	–	–	90.8	–	–	90.8
2008–09	–	–	–	–	–	–	–	–	–	–	82.1	–	82.1
2009–10	–	–	–	–	–	–	–	–	–	–	88.7	–	88.7
2010–11	84.6	–	–	–	–	–	–	–	–	–	85.6	–	85.4
Total	84.2	–	–	–	–	–	–	–	59.6	69.3	73.7	94.3	72.4

Table B7: Number of female spiny dogfish with reproductive stage data recorded by observers in each area, by month and fishing year. No reproductive stage data were collected from the Chatham Rise east of 174° E or from the west coast South Island.

(a) ECSI

Fishing	Month of fishing year												
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1996–97	0	0	0	0	0	0	0	0	0	0	0	0	0
1997–98	0	0	0	138	0	66	0	0	0	0	0	0	204
1998–99	0	0	0	73	0	0	0	0	0	0	0	0	73
1999–00	0	0	0	0	0	0	0	0	0	0	0	0	0
2000–01	0	0	0	0	0	0	0	0	0	0	0	0	0
2001–02	0	0	0	0	0	0	0	0	0	0	0	0	0
2002–03	0	0	0	0	0	0	0	0	0	0	0	0	0
2003–04	0	0	0	0	0	0	0	0	0	0	0	0	0
2004–05	0	0	0	0	0	0	0	0	0	0	0	0	0
2005–06	0	0	0	0	0	0	0	0	0	0	0	0	0
2006–07	0	0	0	0	0	0	0	0	0	0	0	0	0
2007–08	0	0	0	0	0	0	0	0	0	0	0	0	0
2009–10	0	0	0	0	0	0	0	0	0	0	0	0	0
2010–11	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	211	0	66	0	0	0	0	0	0	277

(b) SUBA

Fishing	Month of fishing year												
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1996–97	0	0	0	0	0	0	0	0	0	0	0	0	0
1997–98	0	0	0	33	0	0	0	0	0	0	0	0	33
1998–99	0	0	0	0	0	0	0	0	0	0	0	0	0
1999–00	0	0	0	0	0	0	0	0	0	0	0	0	0
2000–01	0	0	0	14	13	1	0	0	0	0	0	0	28
2001–02	0	0	0	0	0	0	0	0	0	0	0	0	0
2002–03	0	0	0	0	0	0	0	0	0	0	0	0	0
2003–04	0	0	0	0	0	0	0	0	0	0	0	0	0
2004–05	0	0	0	0	0	0	0	0	0	0	0	0	0
2005–06	0	0	0	0	0	0	31	0	0	0	0	0	31
2006–07	0	0	0	0	0	0	0	0	0	0	0	0	0
2007–08	0	0	0	0	0	23	0	0	0	0	0	0	23
2008–09	0	0	0	0	0	0	0	0	0	0	0	0	0
2009–10	0	0	0	0	0	0	0	0	0	0	0	0	0
2010–11	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	47	13	24	31	0	0	0	0	0	115

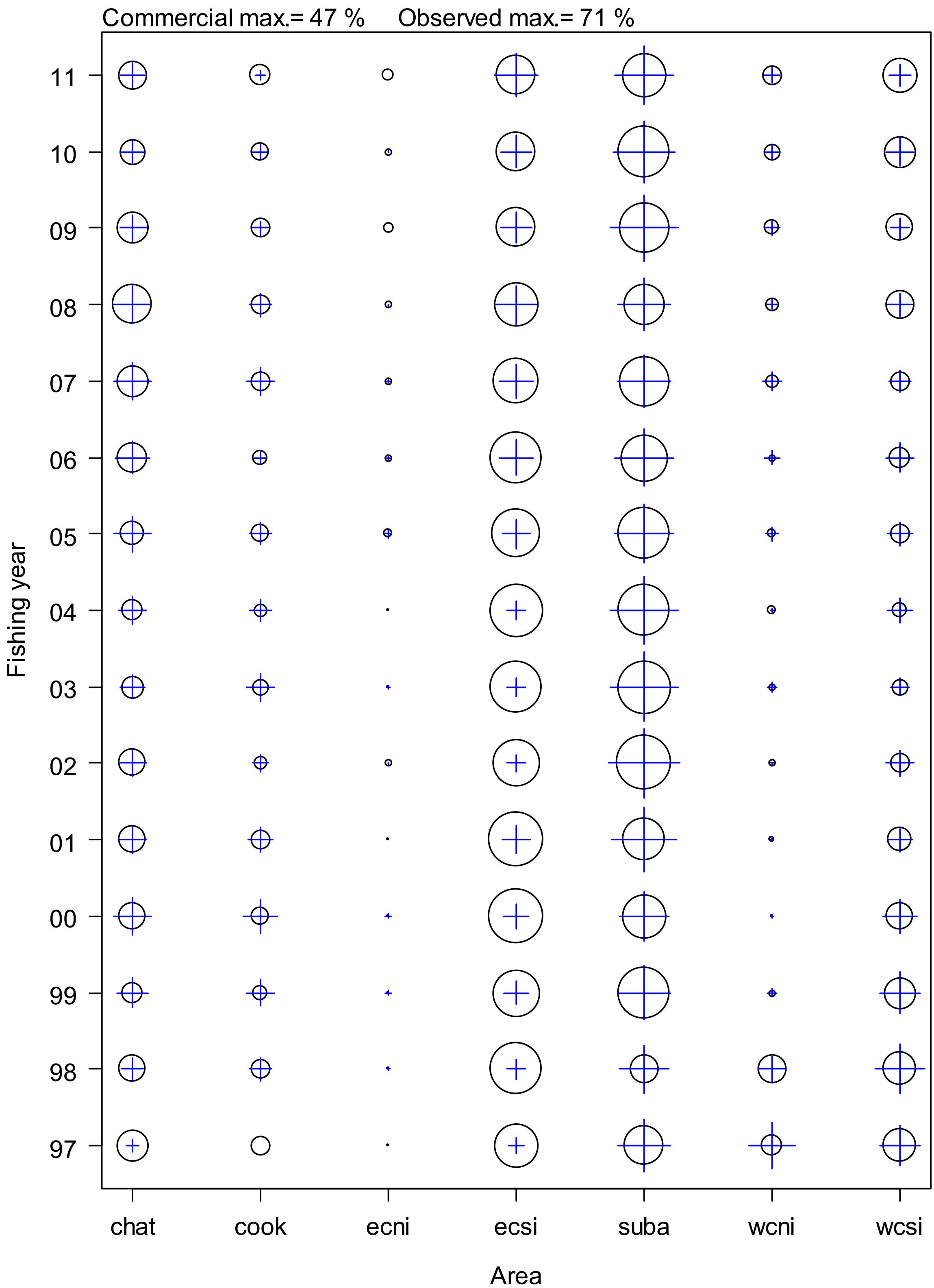


Figure B1: Proportion of spiny dogfish commercial trawl catch (○) and observer catch (+) each fishing year by area, where 97 represents fishing year 1996–97. Areas: chat is Chatham Rise east of 174° E; cook is Cook Strait; ecni is east coast North Island; ecsi is east coast South Island and Chatham Rise west of 174° E; suba is Sub-Antarctic; wcni is west coast North Island; wcsi is west coast South Island.

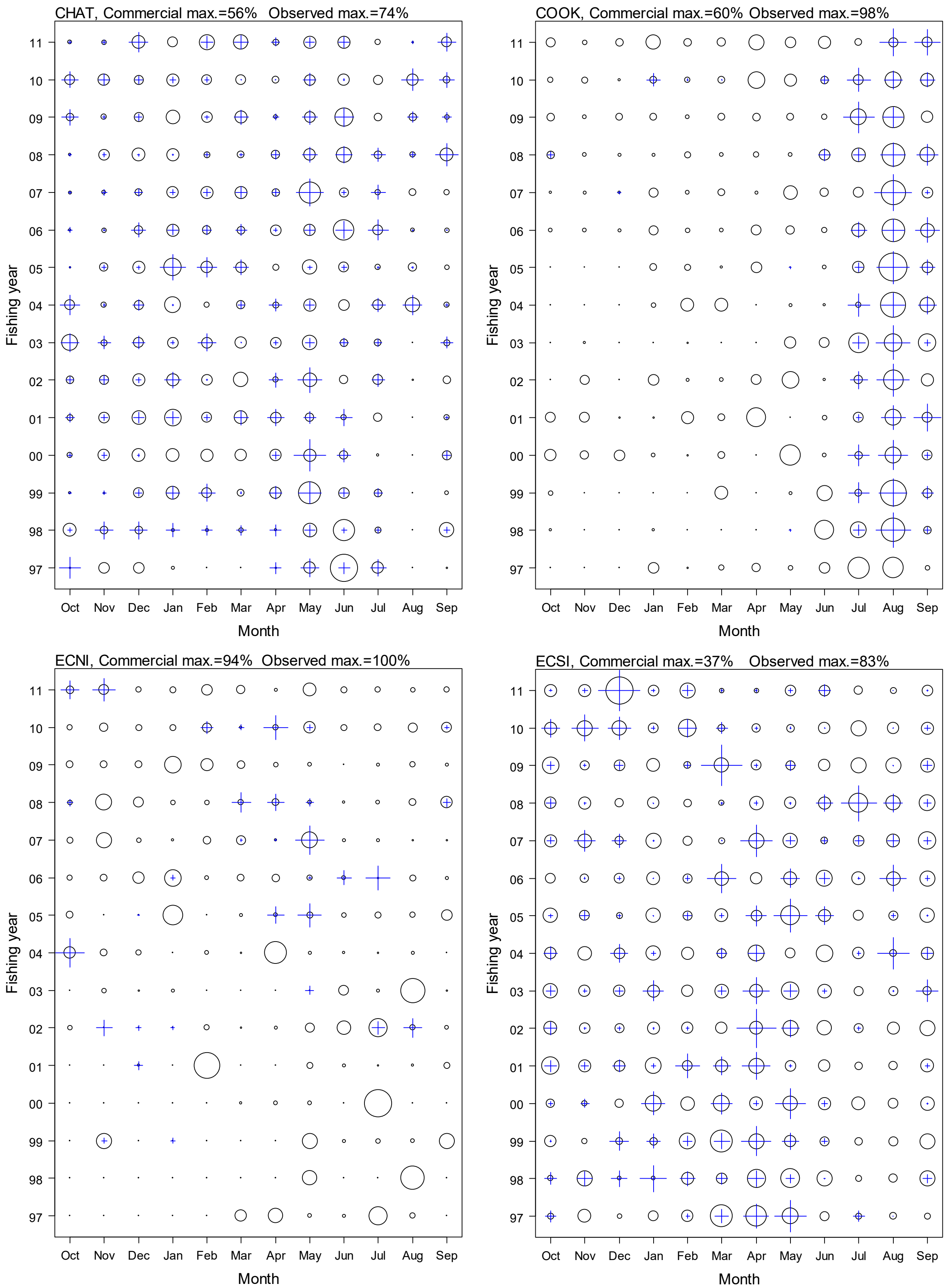


Figure B2: Proportion of spiny dogfish commercial trawl catch (○) and observer catch (+) for each area, by fishing year, where 97 represents fishing year 1996–97, and by month. Areas are: Chatham Rise east of 174° E (CHAT), Cook Strait (COOK), east coast North Island (ECNI), and east coast South Island (ECSI).

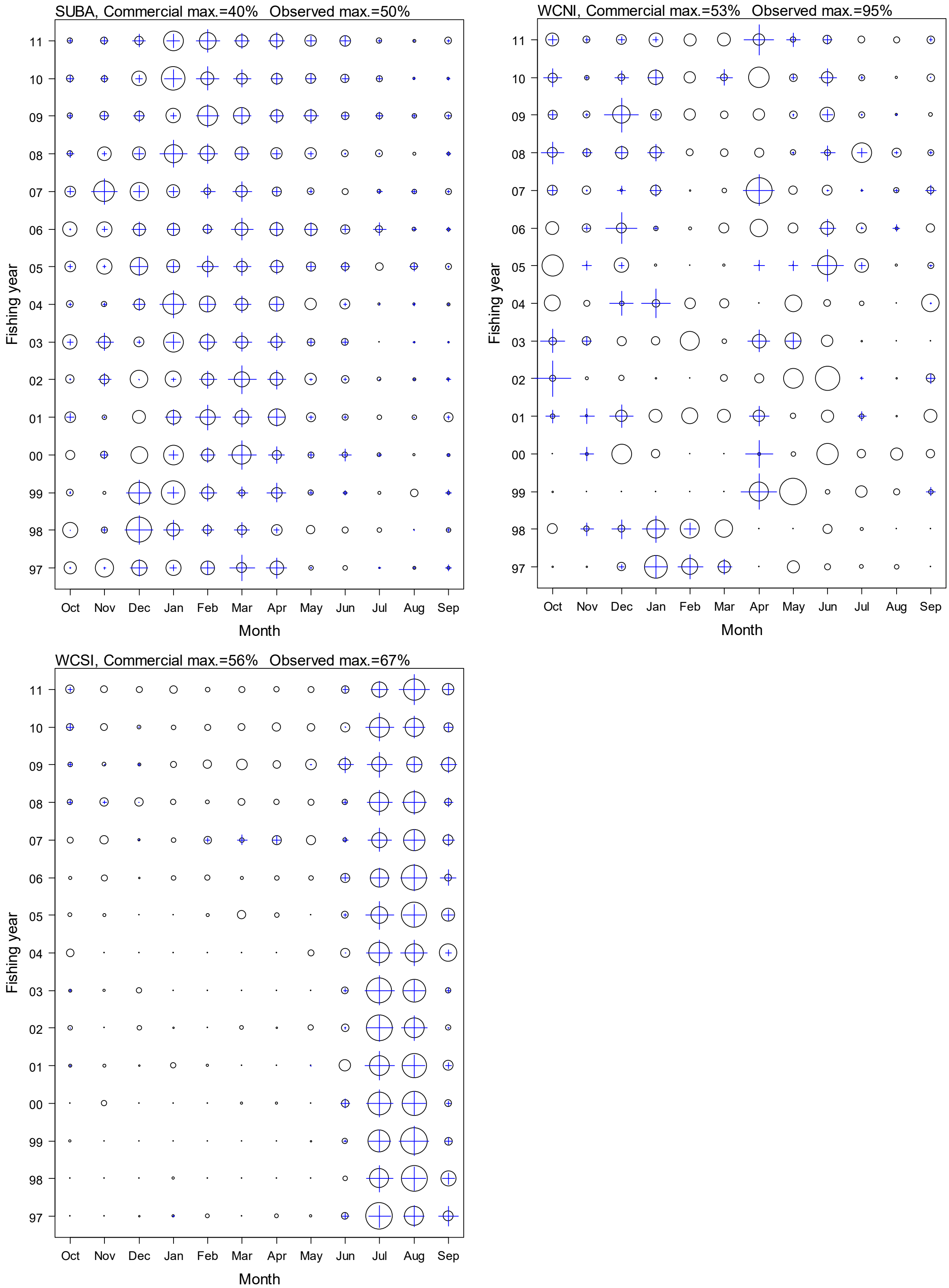


Figure B2 *continued*: Proportion of spiny dogfish commercial trawl catch (○) and observer catch (+) for each area, by fishing year, where 97 represents fishing year 1996–97, and by month. Areas are: Sub-Antarctic (SUBA), west coast North Island (WCNI), and west coast South Island (WCSI).

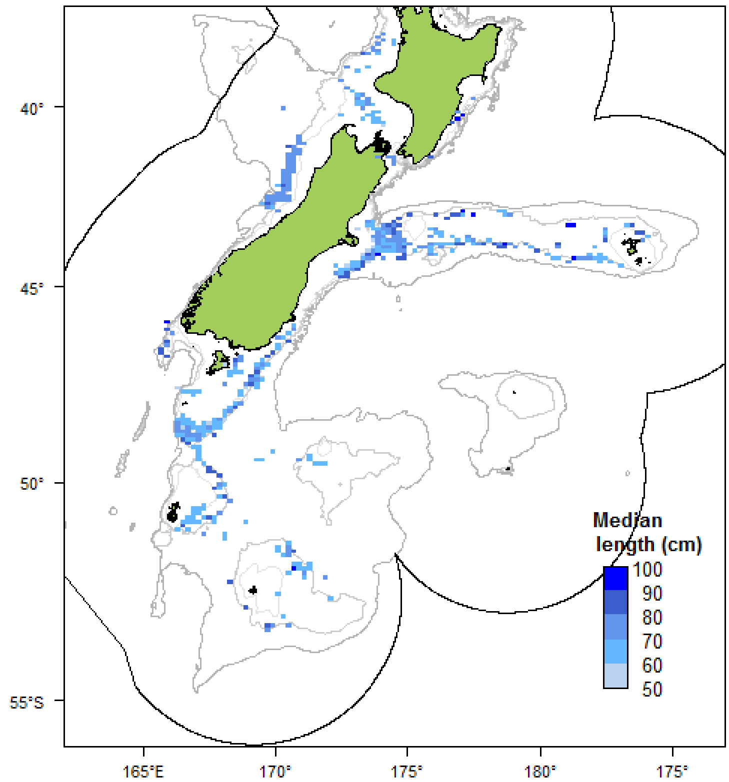


Figure B3: Median length of observed spiny dogfish (n = 92 180) for 0.2° cells (all years combined).

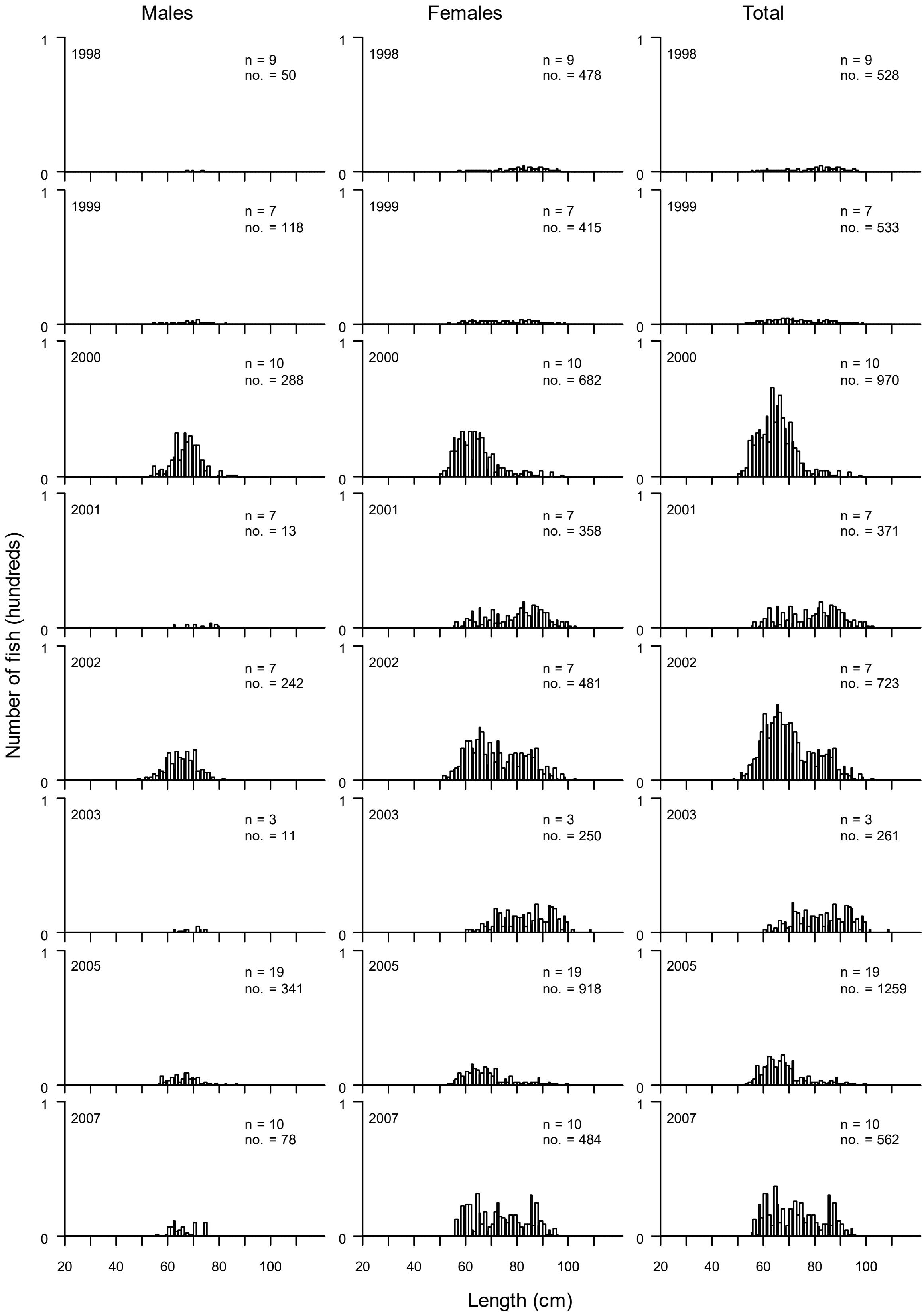


Figure B4: Scaled length frequency distributions of spiny dogfish sampled by observers from commercial catches from the CHAT area, where there were more than 5 spiny dogfish per tow, for fishing years 1997–98 (1998) to 2002–03, 2004–05, and 2006–07 (2007). n, number of tows sampled with more than 5 individual spiny dogfish per tow; no., number of spiny dogfish sampled.

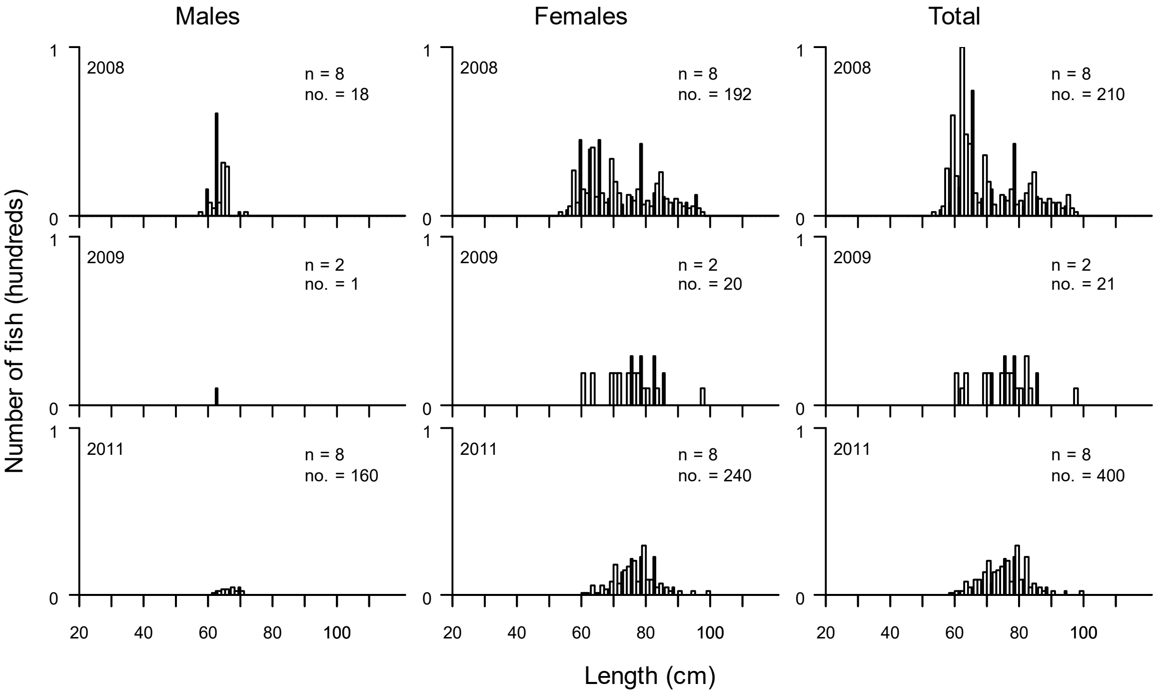


Figure B4 *continued*: Scaled length frequency distributions of spiny dogfish sampled by observers from commercial catches from the CHAT area, where there were more than 5 spiny dogfish per tow, for fishing years 2007–08 (2008), 2008–09 (2009), and 2010–11 (2011). n, number of tows sampled with more than 5 individual spiny dogfish per tow; no., number of spiny dogfish sampled.

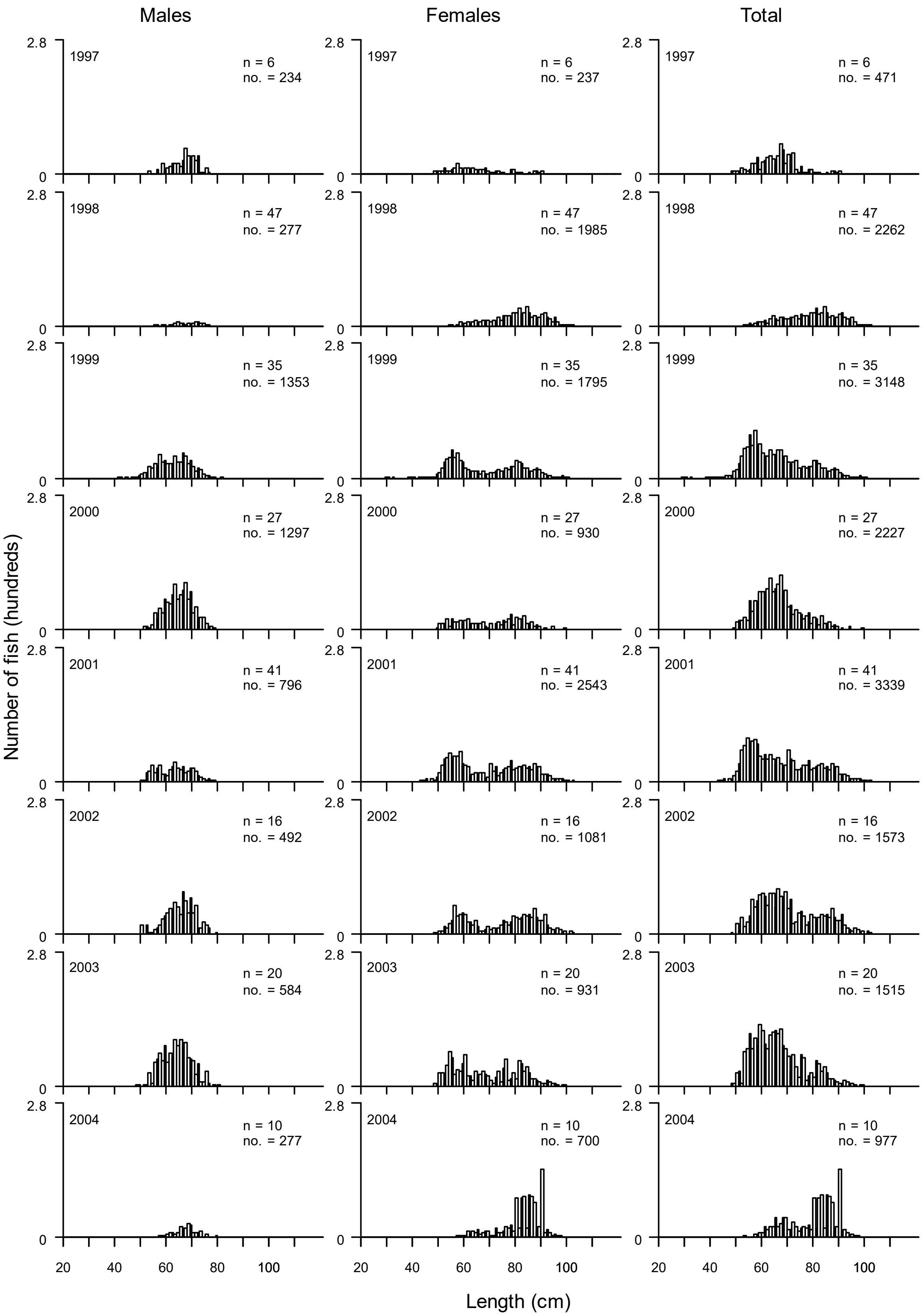


Figure B5: Scaled length frequency distributions of spiny dogfish sampled by observers from commercial catches from the ESCI, where there were more than 5 spiny dogfish per tow, for fishing years 1996–97 (1997) to 2003–04 (2004). n, number of tows sampled with more than 5 individual spiny dogfish per tow; no., number of spiny dogfish sampled.

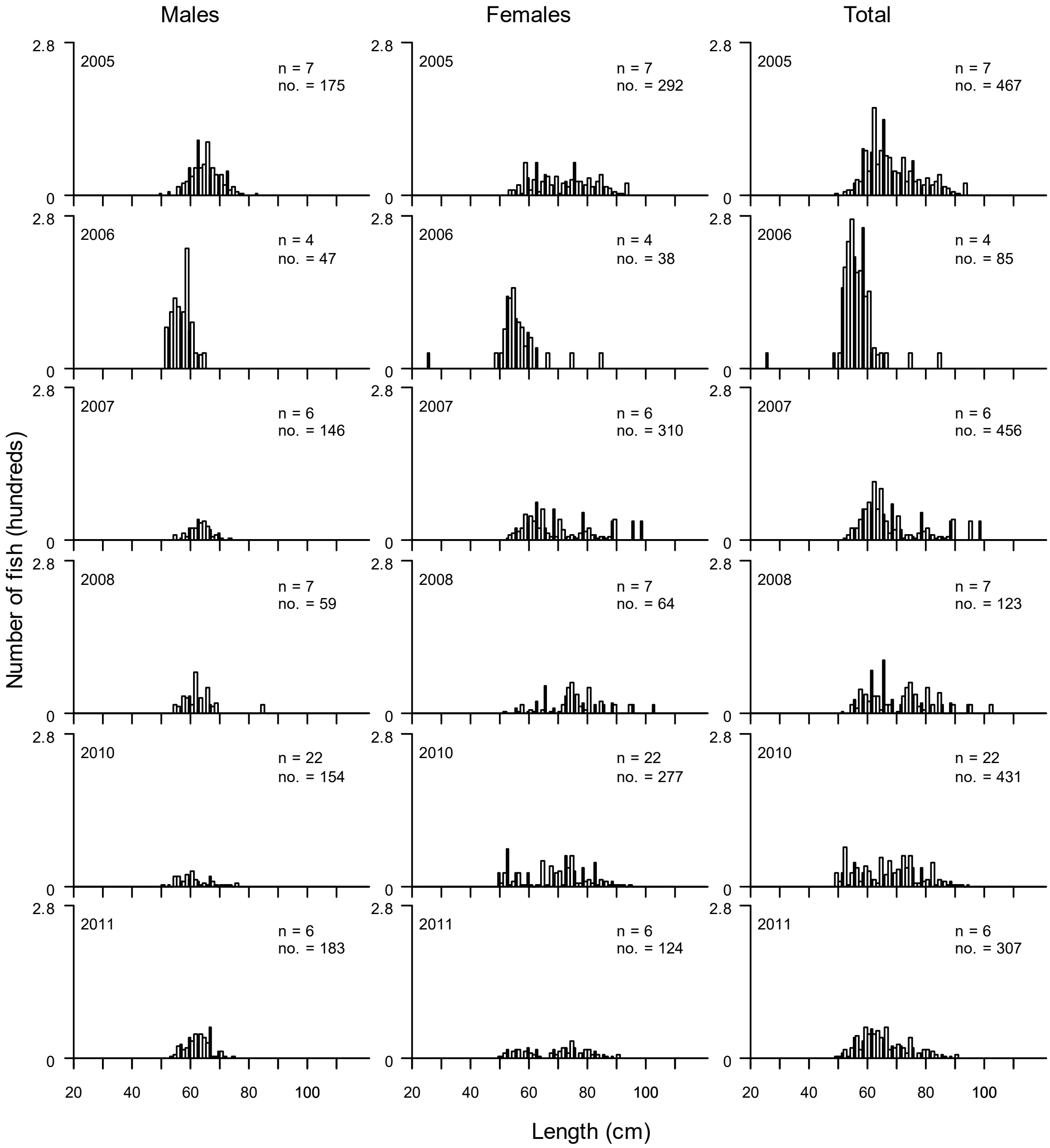


Figure B5 *continued*: Scaled length frequency distributions of spiny dogfish sampled by observers from commercial catches from the ESCI, where there were more than 5 spiny dogfish per tow, for fishing years 2004–05 (2005) to 2007–08, and 2009–10 to 2010–11 (2011). n, number of tows sampled with more than 5 individual spiny dogfish per tow; no., number of spiny dogfish sampled.

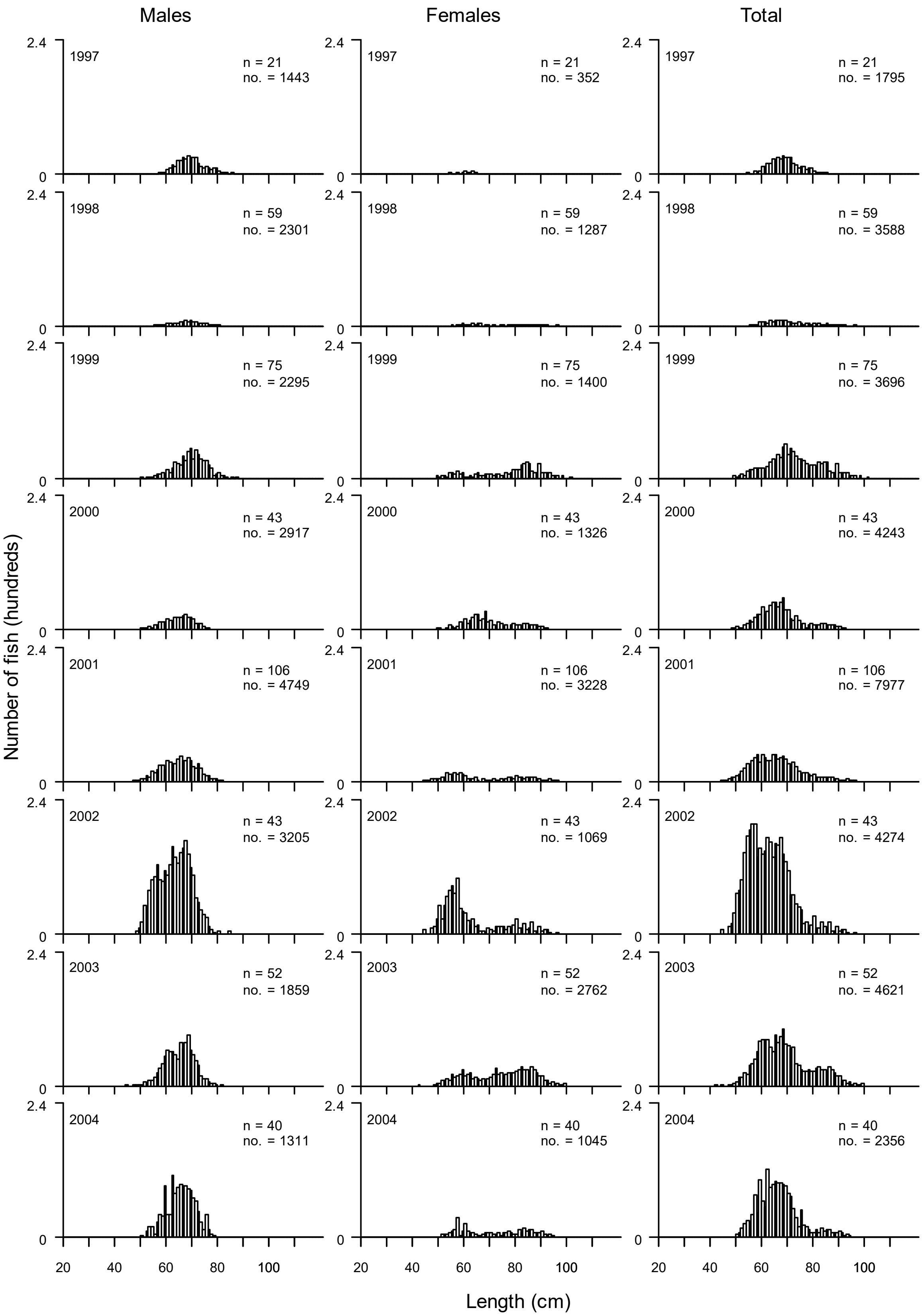


Figure B6: Scaled length frequency distributions of spiny dogfish sampled by observers from commercial catches from the SUBA area, where there were more than 5 spiny dogfish per tow, for fishing years 1996–97 (1997) to 2003–04 (2004). n, number of tows sampled with more than 5 individual spiny dogfish per tow; no., number of spiny dogfish sampled.

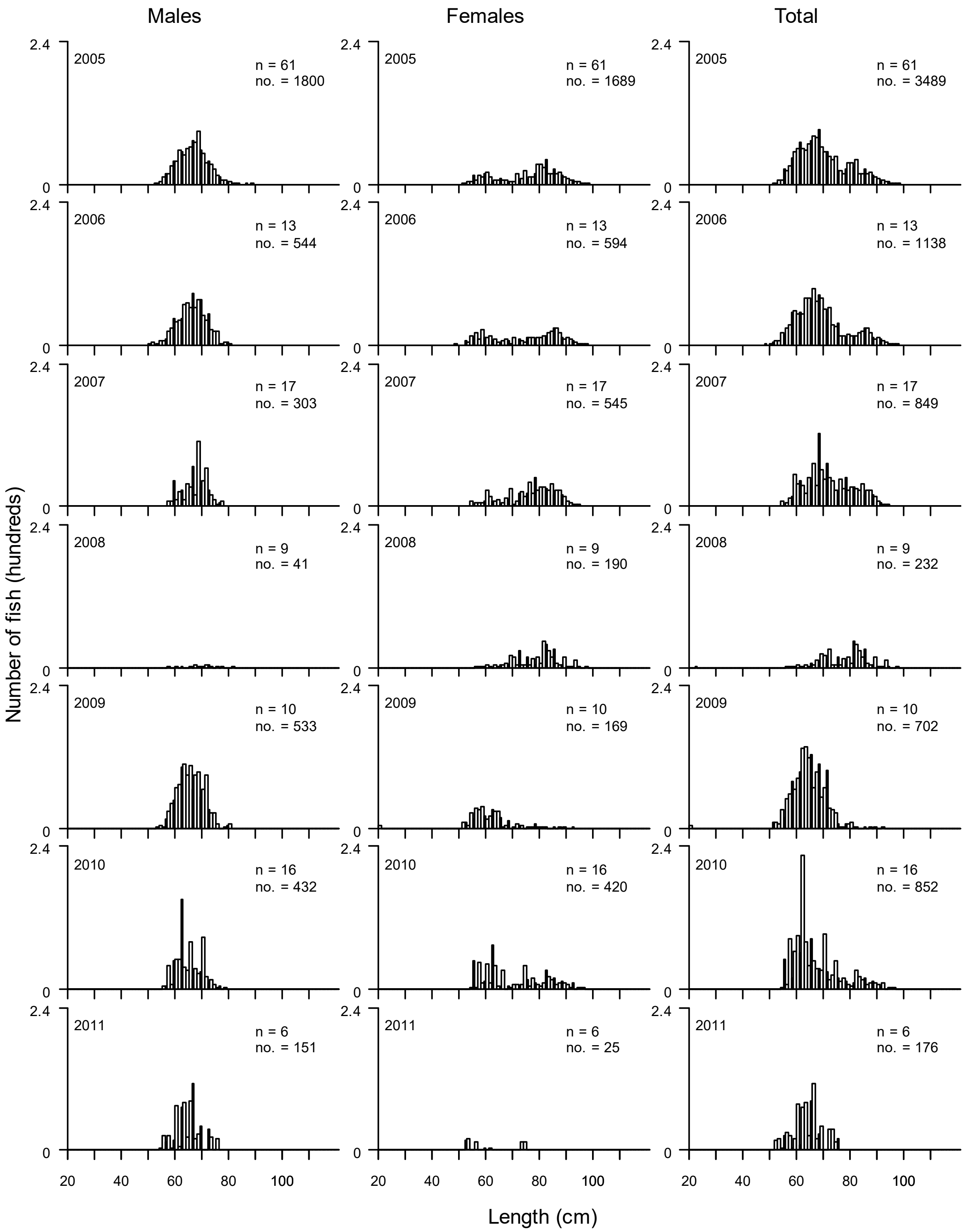


Figure B6 *continued*: Scaled length frequency distributions of spiny dogfish sampled by observers from commercial catches from the SUBA area, where there were more than 5 spiny dogfish per tow, for fishing years 2004–05 (2005) to 2010–11 (2011). n, number of tows sampled with more than 5 individual spiny dogfish per tow; no., number of spiny dogfish sampled

APPENDIX C: CHARACTERISATION

Table C1: List of tables and fields requested in the Ministry for Primary Industries extract 8527.

Fishing_events table

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

Landing_events table

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

Estimated subcatch table

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

Process data table

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

Vessel_history table

Vessel_key	Engine_kilowatts	History_start_datetime
Flag_nationality_code	Gross_tonnes	History_end_datetime
Built_year	Overall_length_metres	

Table C2: Number of landing events by major destination code and form type for SPD stocks for fishing years 1989–90 (1990) to 2010–11 (2011). CLR is Catch Landing Return; CELR is Catch Effort Landing Return. NCELR is Netting Catch Effort Landing Return. Destination codes are defined in Table C3. Note: the last Total column includes counts of all reported destination codes.

SPD 3

						CLR						CELR/NCELR*	
Year	L	T	R	D	M	Total	L	T	R	D	M	Total	Total
1990	44	53	9	42	0	151	2 150	0	17	333	0	2 643	2 794
1991	62	60	15	19	0	160	3 762	0	34	141	0	4 020	4 180
1992	200	48	25	16	0	293	4 075	1	35	210	0	4 364	4 657
1993	129	64	7	13	0	214	3 945	0	21	288	0	4 304	4 518
1994	128	39	13	32	0	213	4 387	0	21	258	0	4 684	4 897
1995	104	65	27	31	0	231	3 804	0	11	218	0	4 077	4 308
1996	140	74	12	54	0	281	3 882	0	14	197	0	4 189	4 470
1997	122	34	13	66	0	239	3 472	0	13	258	0	3 808	4 047
1998	53	6	5	143	0	210	2 450	0	24	158	0	2 657	2 867
1999	119	0	6	229	0	356	2 695	0	25	156	0	2 889	3 245
2000	161	0	4	261	0	427	2 594	0	64	169	0	2 832	3 259
2001	205	0	3	322	0	534	3 122	0	297	303	0	3 751	4 285
2002	320	0	6	314	0	642	2 675	0	82	342	0	3 342	3 984
2003	261	0	12	335	0	608	2 504	0	10	246	0	2 880	3 488
2004	217	2	13	331	0	565	2 060	0	29	326	0	2 566	3 131
2005	203	0	5	29	247	486	2 165	0	46	64	445	2 770	3 256
2006	212	0	7	0	275	496	2 667	1	16	3	801	3 505	4 001
2007	243	0	12	0	263	522	2 410	0	3	0	789	3 254	3 776
2008	1 011	0	25	0	604	1 646	1 224	0	6	0	636	1 926	3 572
2009	1 138	0	44	0	630	1 814	1 012	0	47	0	443	1 774	3 588
2010	1 229	0	17	0	669	1 920	972	0	34	0	368	1 764	3 684
2011	679	0	14	0	543	1 239	530	0	2	0	597	1 482	2 721
All	6 980	445	294	2 237	3 231	13 247	58 557	2	851	3 670	4 079	69 481	82 728

* The NCELR was introduced in October 2007 to replace the CELR where setnet was the fishery method.

Table C2: *continued.*

SPD 4

	CLR						CELR/NCELR						
	L	**T**	**R**	**D**	**M**	**Total**	**L**	**T**	**R**	**D**	**M**	**Total**	**Total**
1990	19	13	3	4	–	39	39	–	–	1	–	41	80
1991	21	35	5	5	–	69	15	–	–	1	–	16	85
1992	17	16	4	–	–	39	13	–	–	1	–	14	53
1993	14	27	8	3	–	52	13	–	–	9	–	22	74
1994	8	11	6	3	–	28	46	–	–	12	–	58	86
1995	6	9	1	10	–	26	26	–	2	13	–	41	67
1996	17	27	2	13	–	60	31	–	–	13	–	45	105
1997	27	16	6	24	–	73	29	–	5	10	–	45	118
1998	25	3	4	73	–	108	21	–	3	8	–	32	140
1999	34	–	8	77	–	120	19	–	3	7	–	29	149
2000	37	–	3	90	–	132	15	–	3	8	–	26	158
2001	39	–	2	125	–	167	15	–	40	37	–	96	263
2002	95	–	–	104	–	199	30	–	2	7	–	39	238
2003	61	–	3	116	–	180	24	–	5	9	–	38	218
2004	56	–	4	122	–	184	4	–	–	8	–	12	196
2005	76	–	2	9	127	216	3	–	–	1	4	8	224
2006	44	–	5	–	129	179	11	–	–	–	1	12	191
2007	90	–	7	–	125	224	3	–	–	–	15	18	242
2008	73	–	6	–	181	265	–	–	–	–	–	1	266
2009	42	–	–	–	104	146	–	–	–	–	–	–	146
2010	55	–	2	–	110	167	–	–	–	–	–	–	167
2011	59	–	4	–	121	184	1	–	–	–	–	1	185
Total	915	157	85	778	897	2 857	358	–	63	145	20	594	3 451

Table C2: ***continued.***

SPD 5

	CLR						CELR/NCELR						
	L	**T**	**R**	**D**	**M**	**Total**	**L**	**T**	**R**	**D**	**M**	**Total**	**Total**
1990	10	37	2	6	–	60	43	–	6	10	–	60	117
1991	25	52	12	18	–	111	69	–	9	42	–	128	239
1992	40	43	23	14	–	123	53	–	14	49	–	117	240
1993	28	42	12	25	–	108	109	–	14	28	–	151	259
1994	18	35	9	22	–	85	125	–	5	39	–	172	257
1995	17	36	7	29	–	91	71	–	2	57	–	131	222
1996	27	49	21	38	–	135	37	–	2	48	–	99	234
1997	44	33	14	53	–	148	42	–	2	65	–	126	274
1998	26	1	3	82	–	114	30	–	3	36	–	74	188
1999	74	–	6	128	–	211	38	–	–	67	–	106	317
2000	63	–	2	115	–	183	114	–	13	61	–	188	371
2001	64	–	3	165	–	236	460	–	42	25	–	542	778
2002	124	–	1	182	–	312	503	–	37	38	–	602	914
2003	109	–	3	176	–	289	361	–	51	68	–	498	787
2004	90	–	12	194	–	297	189	–	8	57	–	292	589
2005	138	–	15	5	234	397	483	4	8	2	24	543	940
2006	135	–	11	1	238	389	473	–	10	–	9	492	881
2007	126	–	13	–	205	352	562	–	10	–	15	588	940
2008	364	–	8	–	191	566	243	–	–	–	6	257	823
2009	347	–	12	–	206	566	149	–	–	–	14	168	734
2010	436	–	12	–	183	637	197	–	–	–	–	202	839
2011	432	–	11	–	187	632	–	–	–	–	–	161	793
Total	2 737	328	212	1 253	1 444	6 039	4 500	4	255	696	72	5 397	11 736

Table C3: Destination codes, total landing weight, number of landings, and whether the records were kept or dropped, for all spiny dogfish catch reported for 1990–2011, by SPD stock.

SPD 3

Destination code	Greenweight (t)	No. records	Description	Action
L	35 241.65	65 537	Landed in New Zealand to a Licensed Fish Receiver	Keep
D	18 897.23	5 909	Discarded	Keep
M	7 690.02	7 310	Schedule 6 species able to be returned to the water	Keep
T	4 183.20	447	Transferred to another vessel	Keep
O	107.24	19	Conveyed outside New Zealand	Keep
A	75.92	71	Accidental loss	Keep
E	66.68	23	Eaten	Keep
H	7.34	1	Loss from holding pot	Keep
U	6.94	493	Used as bait	Keep
W	1.45	40	Sold at wharf	Keep
C	1.24	9	Disposed to the Crown	Keep
F	0.19	39	Recreational catch	Keep
S	0.01	3	Seized by the Crown	Keep
R	640.14	1 145	Retained on board	Drop
Q	399.08	1 594	Holding receptacle on land	Drop
Null	6.89	54	Missing destination type code	Drop
B	1.47	34	Stored as bait	Drop

SPD 4

Destination code	Greenweight (t)	No. records	Description	Action
L	7 089.84	1 274	Landed in New Zealand to a Licensed Fish Receiver	Keep
D	5 952.89	923	Discarded	Keep
M	3 924.19	917	Schedule 6 species able to be returned to the water	Keep
T	845.35	157	Transferred to another vessel	Keep
A	19.5	7	Accidental loss	Keep
O	17.78	6	Conveyed outside New Zealand	Keep
E	15.71	7	Eaten	Keep
C	13.85	1	Disposed to the Crown	Keep
H	0.22	1	Loss from holding pot	Keep
S	0.01	2	Seized by the Crown	Keep
U	-	1	Used as bait	Keep
R	817.1	148	Retained on board	Drop
Null	38.13	2	Missing destination type code	Drop
B	12.48	5	Stored as bait	Drop

Table C3: ***continued.***

SPD 5

Destination code	**Greenweight (t)**	**No. records**	**Description**	**Action**
L	15 511.89	7237	Landed in New Zealand to a Licensed Fish Receiver	Keep
D	8 203.36	1949	Discarded	Keep
M	5 839.55	1516	Schedule 6 species able to be returned to the water	Keep
T	4 293.89	332	Transferred to another vessel	Keep
A	153.21	32	Accidental loss	Keep
E	112.01	29	Eaten	Keep
O	108.96	11	Conveyed outside New Zealand	Keep
H	3.63	1	Loss from holding pot	Keep
U	2.22	37	Used as bait	Keep
S	0.01	2	Seized by the Crown	Keep
R	488.15	467	Retained on board	Drop
Q	4.86	98	Holding receptacle on land	Drop
P	1.00	1	Holding receptacle in the water	Drop
Invalid	0.70	2	Invalid destination type code recorded	Drop
B	0.00	9	Stored as bait	Drop
Null	0.00	13	Missing destination type code	Drop

Table C4: Details of data corrections by imputation and invalid record removal during the grooming process for each QMA. 'Records' is the number of unique records; 'Trips' is the number of unique trips; and 'Catch' is the total greenweight of spiny dogfish remaining in the effort and landings datasets after each step in the grooming process.

SPD 3

	Effort			Landings		
Records removed	**Records**	**Trips**	**Catch**	**Records**	**Trips**	**Catch**
Original extract	435 616	71 826	77 063	90 755	71 708	67 624
Remove missing keys	435 611	71 824	77 063	90 753	71 706	67 623
Remove unmatched trip number	435 611	71 824	77 063	90 451	71 462	67 452
Remove duplicate form number	428 189	70 054	76 618	87 634	69 694	66 760
Remove invalid start date	427 272	69 631	76 540	87 555	69 631	66 737
Remove invalid primary method	427 272	69 631	76 540	87 555	69 631	66 737
Remove invalid stats area	421 945	69 114	75 876	86 825	69 114	66 247
Restratify effort	122 619	69 114	75 876	86 825	69 114	66 247
Remove BPQRT destination types	121 314	68 320	75 649	84 246	68 320	65 407
Remove multiple states	121 314	68 320	75 649	83 061	68 319	65 404
Remove invalid green weight	121 045	68 160	75 307	82 856	68 159	65 386
Fix extreme weight	121 045	68 160	75 307	82 856	68 159	62 626
DQSS	121 045	68 160	75 307	82 856	68 159	62 626

SPD 4

	Effort			Landings		
Records removed	**Records**	**Trips**	**Catch**	**Records**	**Trips**	**Catch**
Original extract	195 542	2 797	27 351	7 496	2 620	19 055
Remove missing keys	195 542	2 797	27 351	7 496	2 620	19 055
Remove unmatched trip number	195 542	2 797	27 351	7 478	2 613	19 037
Remove duplicate form number	194 708	2 775	27 065	7 439	2 592	18 722
Remove invalid start date	194 100	2 587	26 998	7 422	2 587	18 717
Remove invalid primary method	194 100	2 587	26 998	7 422	2 587	18 717
Remove invalid stats area	190 796	2 540	26 654	7 264	2 540	18 448
Restratify effort	21 903	2 540	26 654	7 264	2 540	18 448
Remove BPQRT destination types	21 829	2 527	26 635	6 956	2 527	17 610
Remove multiple states	21 829	2 527	26 635	6 908	2 527	17 610
Remove invalid green weight	21 790	2 522	26 529	6 896	2 522	17 496
DQSS	21 790	2 522	26 529	6 896	2 522	17 496

Table C4: *continued.*

SPD 5

	Effort			Landings		
Records removed	**Records**	**Trips**	**Catch**	**Records**	**Trips**	**Catch**
Original extract	435 616	71 826	77 063	90 755	71 708	67 624
Remove missing keys	435 611	71 824	77 063	90 753	71 706	67 623
Remove unmatched trip number	435 611	71 824	77 063	90 451	71 462	67 452
Remove duplicate form number	428 189	70 054	76 618	87 634	69 694	66 760
Remove invalid start date	427 272	69 631	76 540	87 555	69 631	66 737
Remove invalid primary method	427 272	69 631	76 540	87 555	69 631	66 737
Remove invalid stats area	421 945	69 114	75 876	86 825	69 114	66 247
Restratify effort	122 619	69 114	75 876	86 825	69 114	66 247
Remove BPQRT destination types	121 314	68 320	75 649	84 246	68 320	65 407
Remove multiple states	121 314	68 320	75 649	83 061	68 319	65 404
Remove invalid green weight	121 045	68 160	75 307	82 856	68 159	65 386
Fix extreme weight	121 045	68 160	75 307	82 856	68 159	62 626
DQSS	121 045	68 160	75 307	82 856	68 159	62 626

Table C5: The reported Quota Management Report (QMR) or Monthly Harvest Return (MHR) catch, annual retained landings in the groomed and unmerged dataset, and retained landings in the groomed and merged dataset, and estimated catches in the groomed and merged dataset for SPD stocks from 1989–90 (1990) to 2010–11 (2011). All catch and landings data are in tonnes.

				SPD 3	
				Merged estimated	
Fishing year	MHR	Unmerged landings	Merged landings	Catch	% of MHR
1990	2 243	1 841	2 116	1 960	87
1991	2 987	2 588	2 973	2 437	82
1992	1 801	1 727	2 109	1 442	80
1993	2 128	2 053	2 052	1 811	85
1994	3 165	2 859	2 859	2 093	66
1995	2 883	2 271	2 271	1 775	62
1996	2 558	2 547	2 457	1 813	71
1997	2 428	2 374	2 367	1 782	73
1998	5 042	2 307	2 297	1 701	34
1999	3 148	3 133	3 122	2 352	75
2000	3 309	3 341	3 339	2 496	75
2001	4 355	4 368	4 368	2 923	67
2002	4 249	5 205	5 205	3 845	90
2003	3 553	4 782	4 782	3 390	95
2004	2 077	4 084	4 084	3 107	150
2005	2 707	2 839	2 839	2 314	85
2006	3 831	3 761	3 761	3 019	79
2007	2 712	2 728	2 728	2 206	81
2008	2 082	1 911	1 911	1 664	80
2009	1 981	1 990	1 990	1 615	82
2010	1 855	1 713	1 713	1 364	74
2011	1 976	1 921	1 921	1 499	76

				SPD 4	
				Merged estimated	
Fishing year	MHR	Unmerged landings	Merged landings	Catch	% of MHR
1990	136	107	109	116	85
1991	513	445	446	387	75
1992	66	61	66	33	50
1993	218	208	208	167	77
1994	358	327	327	284	79
1995	363	254	254	194	53
1996	969	875	875	628	65
1997	1 287	1 050	1 048	713	55
1998	917	814	813	396	43
1999	1 048	1 101	1 097	735	70
2000	994	921	921	584	59
2001	1 075	1 132	1 132	753	70
2002	1 788	1 587	1 587	1 128	63
2003	1 010	1 248	1 248	1 027	102
2004	516	736	736	491	95
2005	839	905	905	816	97
2006	1 055	873	873	747	71
2007	822	1 040	1 040	905	110
2008	1 397	1 175	1 175	813	58
2009	866	706	706	566	65
2010	667	805	805	715	107
2011	825	805	805	749	91

Table C5: ***continued.***

				SPD 5	
				Merged estimated	
Fishing year	MHR	Unmerged landings	Merged landings	Catch	% of MHR
1990	243	196	203	227	93
1991	1 722	1 513	1 525	1 495	87
1992	571	488	517	514	90
1993	839	773	773	638	76
1994	1 179	1 044	1 044	853	72
1995	643	419	419	352	55
1996	1 299	1 270	1 270	992	76
1997	884	776	766	613	69
1998	651	417	417	297	46
1999	2 150	2 040	2 037	1 571	73
2000	1 352	1 234	1 234	959	272
2001	1 601	1 391	1 391	1 111	69
2002	4 221	3 864	3 864	3 251	77
2003	3 034	2 712	2 712	2 521	83
2004	1 334	1 821	1 821	2 106	158
2005	2 479	2 421	2 421	2 123	86
2006	2 298	2 261	2 261	2 049	89
2007	2 165	2 156	2 156	1 957	90
2008	1 501	1 439	1 439	1 178	78
2009	2 071	1 949	1 949	1 605	77
2010	2 205	2 186	2 186	1 826	83
2011	1 443	1 353	1 353	1 258	87

Table C6: Total number of trips, number of trips with zero estimated catch, and proportion of trips with zero estimated catch, by form type for SPD 3, SPD 4, and SPD 5 from 1989–90 (1990) to 2010–11 (2011). Fishstock areas are shown in Figure 1. CELR is Catch Effort Landing Return; TCER is Trawl Catch Effort Return, and TCEPR is Trawl Catch Effort Processing Return.

SPD 3

	CELR/TCER			TCEPR		
	Total	Zero	Proportion	Total	Zero	Proportion
1990	2 409	393	0.16	105	12	0.11
1991	3 721	782	0.21	109	15	0.14
1992	4 120	1 108	0.27	232	70	0.30
1993	4 037	961	0.24	188	63	0.34
1994	4 378	1 157	0.26	178	74	0.42
1995	3 801	1 242	0.33	152	36	0.24
1996	3 823	1 180	0.31	196	61	0.31
1997	3 344	1 066	0.32	174	51	0.29
1998	2 264	786	0.35	173	76	0.44
1999	2 523	836	0.33	235	73	0.31
2000	2 418	955	0.39	301	77	0.26
2001	2 895	1 101	0.38	362	63	0.17
2002	2 553	815	0.32	379	45	0.12
2003	2 335	707	0.30	382	49	0.13
2004	2 208	688	0.31	350	56	0.16
2005	2 404	787	0.33	304	54	0.18
2006	2 908	962	0.33	297	27	0.09
2007	1 493	763	0.51	270	14	0.05
2008	1 445	334	0.23	149	14	0.09
2009	1 465	383	0.26	217	40	0.18
2010	1 531	351	0.23	210	30	0.14
2011	927	274	0.30	236	54	0.23

SPD 4

	CELR/TCE			TCEPR		
	Total	Zero	Proportion	Total	Zero	Proportion
1990	39	5	0.13	27	1	0.04
1991	14	9	0.64	54	1	0.02
1992	11	3	0.27	33	3	0.09
1993	21	2	0.10	42	4	0.10
1994	40	7	0.18	20	3	0.15
1995	24	9	0.38	21	3	0.14
1996	27	10	0.37	46	4	0.09
1997	26	5	0.19	48	6	0.12
1998	19	5	0.26	84	33	0.39
1999	18	4	0.22	92	29	0.32
2000	11	1	0.09	98	17	0.17
2001	35	24	0.69	127	23	0.18
2002	27	6	0.22	128	26	0.20
2003	21	11	0.52	121	15	0.12
2004	8	1	0.12	109	20	0.18
2005	7	1	0.14	125	27	0.22
2006	12	2	0.17	104	9	0.09
2007	16	–	–	111	16	0.14
2008	–	–	–	107	21	0.20
2009	–	–	–	72	11	0.15
2010	–	–	–	81	16	0.20
2011	–	–	–	92	13	0.14

Table C6: *continued*.

SPD 5

	CELR/TCE			TCEPR		
	Total	**Zero**	**Proportion**	**Total**	**Zero**	**Proportion**
1990	47	4	0.09	45	4	0.09
1991	107	14	0.13	79	6	0.08
1992	87	12	0.14	77	16	0.21
1993	119	19	0.16	88	16	0.18
1994	149	25	0.17	64	9	0.14
1995	122	18	0.15	67	8	0.12
1996	85	13	0.15	85	8	0.09
1997	74	29	0.39	108	20	0.19
1998	47	15	0.32	86	35	0.41
1999	46	15	0.33	137	33	0.24
2000	101	46	0.46	124	24	0.19
2001	369	111	0.30	173	38	0.22
2002	410	140	0.34	186	26	0.14
2003	340	117	0.34	185	24	0.13
2004	204	48	0.24	195	46	0.24
2005	408	67	0.16	222	33	0.15
2006	418	76	0.18	204	28	0.14
2007	344	109	0.32	185	24	0.13
2008	290	45	0.16	157	36	0.23
2009	255	38	0.15	168	26	0.15
2010	313	60	0.19	162	22	0.14
2011	265	46	0.17	171	35	0.20

Table C7: Total catch (t) for each area from groomed and merged data, 1989–90 (1990) to 2010–11 (2011). Chatham Rise here combines SPD 3 and SPD 4 and Sub-Antarctic is SPD 5.

	Chatham Rise	Sub-Antarctic	Total
1990	2 045.04	202.87	2 247.91
1991	3 371.84	1 523.44	4 895.28
1992	2 151.15	499.95	2 651.10
1993	2 229.09	770.09	2 999.19
1994	3 153.06	1 039.03	4 192.09
1995	2 506.74	418.68	2 925.42
1996	3 248.28	1 269.16	4 517.43
1997	3 370.44	761.05	4 131.48
1998	3 099.16	414.96	3 514.12
1999	4 202.91	2 036.85	6 239.77
2000	4 241.44	1 233.66	5 475.10
2001	5 479.50	1 386.84	6 866.34
2002	6 718.65	3 862.61	10 581.25
2003	6 015.28	2 706.07	8 721.35
2004	4 768.42	1 818.42	6 586.84
2005	3 678.52	2 419.91	6 098.43
2006	4 608.48	2 255.35	6 863.83
2007	3 749.69	2 155.70	5 905.38
2008	3 050.84	1 436.35	4 487.19
2009	2 658.45	1 945.39	4 603.84
2010	2 505.83	2 185.53	4 691.36
2011	2 874.41	1 351.18	4 225.58
Total	79 727.19	33 693.11	113 420.30

Table C8: Total catch (t) by vessel nationality from groomed and merged data for the Chatham Rise (SPD 3 and SPD 4) and Sub-Antarctic (SPD 5) areas for 1989–90 (1990) to 2010–11 (2011).

	NZ	Korea	Unknown	Ukraine	Japan	Panama	Belize	Other	Total
990	956.32	191.62	1 099.97	–	–	–	–	–	2 247.91
1991	1 270.02	698.71	2 917.07	1.35	5.67	–	–	2.46	4 895.28
1992	1 277.97	612.25	759.78	–	1.10	–	–	–	2 651.10
1993	1 197.98	1 155.02	558.88	38.78	–	–	–	48.52	2 999.19
1994	1 877.75	1 596.69	559.16	90.29	16.49	–	–	51.72	4 192.09
1995	1 431.04	1 025.03	272.74	65.62	–	–	45.39	85.60	2 925.42
1996	1 995.12	2 018.16	210.47	83.40	11.69	–	149.53	49.06	4 517.43
1997	2 562.09	1 111.60	70.07	140.37	9.73	11.84	169.44	56.36	4 131.48
1998	2 582.42	540.88	4.09	76.36	13.59	46.68	96.10	154.00	3 514.12
1999	3 418.30	2 007.36	29.63	147.86	9.10	107.73	291.47	228.33	6 239.77
2000	3 323.64	1 574.18	13.98	241.62	17.16	82.66	0.70	221.16	5 475.10
2001	4 785.07	1 389.58	13.02	281.86	89.30	87.98	–	219.53	6 866.34
2002	5 769.72	4 020.14	1.15	189.64	330.45	45.33	–	224.81	10 581.25
2003	5 422.42	2 546.05	7.45	123.81	312.49	82.13	–	227	8 721.35
2004	5 102.75	1 024.40	25.82	137.97	87.21	98.89	–	109.81	6 586.84
2005	4 270.86	1 565.02	13.19	67.67	9.94	74.60	–	97.15	6 098.43
2006	4 421.87	1 860.34	5.67	131.16	124.67	221.41	–	98.71	6 863.83
2007	3 617.59	2 069.44	3.05	35.74	115.31	–	–	64.25	5 905.38
2008	2 649.40	1 743.91	3.42	45.82	12.38	–	–	32.26	4 487.19
2009	2 769.06	1 634.28	7.58	76.70	76.89	–	–	39.32	4 603.84
2010	2 788.80	1 684.70	0.09	45.57	69.20	–	–	103.00	4 691.36
2011	2 539.73	1 527.16	32.84	38.62	76.85	–	–	10.39	4 225.58
Total	66 029.91	33 596.53	6 609.11	2 060.20	1 389.21	859.26	752.63	2 123.45	113 420.30

Table C9a: Proportion of spiny dogfish catch reported from the CHAT area, by month, for 1989–90 (1990) to 2010–11 (2011). CHAT area is shown in Figure 3.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1990	–	–	0.02	0.04	–	0.23	0.09	0.13	0.15	0.06	0.04	0.24	147
1991	0.07	0.30	0.15	0.28	–	–	–	0.04	0.07	0.05	–	0.04	790
1992	0.04	0.35	0.16	0.05	0.01	0.01	0.12	0.06	0.10	0.01	0.07	0.04	112
1993	0.03	0.07	–	0.04	0.01	0.12	0.13	0.34	0.17	0.04	0.01	0.03	322
1994	0.01	0.03	0.01	0.09	0.02	0.04	0.02	0.25	0.26	0.03	0.12	0.11	465
1995	0.10	0.02	0.19	0.13	0.02	0.02	–	0.01	0.23	0.07	0.09	0.12	476
1996	0.07	0.03	0.08	0.05	–	0.03	0.02	0.18	0.13	0.14	0.11	0.16	1 059
1997	0.04	0.05	0.04	–	0.01	0.03	0.02	0.13	0.21	0.17	0.06	0.24	1 106
1998	0.19	0.04	0.14	0.03	0.02	0.02	0.02	0.14	0.08	0.09	0.08	0.15	961
1999	0.02	0.04	0.05	0.12	0.04	0.02	0.10	0.08	0.04	–	0.28	0.21	1 295
2000	0.08	0.11	0.09	0.10	0.05	0.06	0.06	0.11	0.02	0.13	0.02	0.18	1 187
2001	0.07	0.07	0.07	0.08	0.07	0.08	0.09	0.04	0.01	0.08	0.16	0.18	1 430
2002	0.06	0.06	0.08	0.08	0.06	0.09	0.05	0.06	0.05	0.22	0.13	0.06	1 907
2003	0.10	0.04	0.04	0.03	0.07	0.02	0.07	0.06	0.02	0.12	0.20	0.21	1 578
2004	0.08	0.03	0.08	0.10	0.05	0.05	0.05	0.08	0.10	0.13	0.14	0.11	886
2005	0.06	0.09	0.09	0.09	0.09	0.07	0.05	0.06	0.05	0.12	0.13	0.10	1 040
2006	0.03	0.07	0.04	0.12	0.06	0.06	0.16	0.07	0.22	0.07	0.05	0.04	1 197
2007	0.04	0.03	0.05	0.10	0.12	0.06	0.04	0.16	0.06	0.02	0.23	0.09	1 324
2008	0.10	0.12	0.07	0.14	0.05	0.05	0.09	0.17	0.06	0.03	0.06	0.08	1 369
2009	0.05	0.05	0.06	0.15	0.08	0.06	0.05	0.14	0.09	0.05	0.07	0.16	995
2010	0.10	0.06	0.05	0.10	0.08	0.04	0.05	0.06	0.05	0.01	0.26	0.13	1 006
2011	0.05	0.07	0.07	0.05	0.09	0.09	0.05	0.06	0.06	0.02	0.34	0.05	1 203
Total	0.07	0.07	0.07	0.09	0.05	0.05	0.06	0.10	0.08	0.09	0.14	0.13	21 852

Table C9b: Proportion of spiny dogfish catch reported from the CHAT area, by statistical area, for 1989–90 (1990) to 2010–11 (2011). CHAT area is shown in Figure 3. Statistical areas are shown in Figure 1.

	021	023	049	050	052	401	402	404	407	408	409	410	Other	Total
1990	0.21	0.08	0.12	0.20	0.15	0.03	–	–	0.13	–	–	–	0.08	147
1991	0.42	0.02	0.01	0.02	0.02	0.37	–	–	0.13	–	–	–	–	790
1992	0.41	0.05	0.08	0.08	0.04	0.23	0.01	0.01	0.04	–	–	0.04	–	112
1993	0.36	–	0.08	0.30	0.04	0.13	–	0.01	0.02	–	–	0.05	0.01	322
1994	0.28	0.03	0.08	0.07	0.09	0.05	0.11	0.03	0.04	0.01	–	0.19	0.02	465
1995	0.43	0.03	0.02	0.01	0.01	0.05	0.01	0.09	0.12	–	0.01	0.20	0.03	476
1996	0.15	0.03	0.14	0.14	0.08	0.04	0.04	0.15	–	0.03	0.04	0.14	0.03	1 059
1997	0.03	0.03	0.13	0.26	0.06	0.07	0.04	0.17	0.01	0.01	0.06	0.11	0.01	1 106
1998	0.09	0.08	0.09	0.04	0.06	0.13	0.10	0.17	0.03	0.06	0.02	0.10	0.03	961
1999	0.05	0.10	0.07	–	0.10	0.06	0.09	0.16	0.05	0.05	0.05	0.21	0.02	1 295
2000	0.06	0.15	0.02	0.01	0.07	0.07	0.08	0.10	0.06	0.11	0.06	0.12	0.09	1 187
2001	0.08	0.14	0.14	0.10	0.04	0.04	0.08	0.08	0.06	0.10	0.03	0.09	0.03	1 430
2002	0.06	0.10	0.13	0.12	0.07	0.04	0.04	0.19	0.04	0.03	0.02	0.09	0.08	1 907
2003	0.05	0.16	0.08	0.01	0.07	0.08	0.05	0.28	0.05	0.04	0.02	0.10	0.01	1 578
2004	0.02	0.16	0.07	0.01	0.12	0.09	0.07	0.08	0.04	0.05	0.05	0.17	0.08	886
2005	0.02	0.10	0.07	0.08	0.08	0.06	0.06	0.15	0.04	0.07	0.02	0.14	0.10	1 040
2006	0.06	0.21	0.13	0.13	0.05	0.07	0.05	0.03	0.05	0.11	0.02	0.06	0.03	1 197
2007	0.09	0.13	0.16	0.14	0.04	0.09	0.04	0.07	0.02	0.04	0.03	0.13	0.03	1 324
2008	0.04	0.11	0.18	0.17	0.14	0.05	0.03	0.06	0.02	0.08	0.03	0.05	0.03	1 369
2009	0.10	0.20	0.12	0.09	0.07	0.10	0.03	0.04	0.02	0.10	0.04	0.06	0.03	995
2010	0.03	0.17	0.17	0.03	0.05	0.09	0.02	0.21	0.03	0.05	0.02	0.07	0.05	1 006
2011	0.04	0.15	0.17	0.05	0.04	0.09	0.04	0.19	0.02	0.02	0.02	0.11	0.06	1 203
Total	0.09	0.11	0.11	0.09	0.07	0.08	0.05	0.13	0.04	0.05	0.03	0.11	0.04	21 852

Table C9c: Proportion of spiny dogfish catch reported from the CHAT area, by gear type, for 1989–90 (1990) to 2010–11 (2011). BLL is bottom longline; BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl.

	BLL	BT	MB	MW	Other	Total
1990	–	0.99	–	–	0.01	147
1991	–	0.99	–	–	–	790
1992	0.10	0.89	0.01	–	–	112
1993	0.12	0.82	–	0.06	–	322
1994	0.50	0.43	0.04	0.01	0.01	465
1995	0.41	0.47	0.01	0.11	–	476
1996	0.46	0.48	0.04	0.02	–	1 059
1997	0.53	0.44	0.03	–	–	1 106
1998	0.51	0.47	0.02	–	–	961
1999	0.57	0.42	0.01	–	–	1 295
2000	0.41	0.57	0.02	–	–	1 187
2001	0.40	0.57	0.01	–	0.01	1 430
2002	0.42	0.57	0.01	–	–	1 907
2003	0.50	0.50	–	–	–	1 578
2004	0.46	0.53	0.01	–	–	886
2005	0.37	0.62	0.01	–	–	1 040
2006	0.22	0.78	–	–	–	1 197
2007	0.37	0.62	–	0.01	–	1 324
2008	0.19	0.80	–	–	0.01	1 369
2009	0.27	0.72	0.01	–	–	995
2010	0.53	0.47	–	–	–	1 006
2011	0.57	0.43	–	–	–	1 203
Total	0.40	0.58	0.01	0.01	–	21 852

Table C9d: Proportion of spiny dogfish catch reported from the CHAT area, by target species, for 1989–90 (1990) to 2010–11 (2011). Target species codes are defined in Table C11.

	BAR	HAK	HOK	LIN	SCI	SQU	SWA	TAR	Other	Total
1990	0.29	–	0.11	0.04	–	0.08	0.07	0.04	0.37	147
1991	0.20	–	0.32	0.11	–	0.04	0.08	–	0.24	790
1992	0.17	0.01	0.52	0.20	0.01	0.01	0.06	–	0.02	112
1993	0.40	–	0.15	0.14	–	0.06	0.13	–	0.11	322
1994	0.11	0.01	0.02	0.49	–	0.22	0.03	–	0.12	465
1995	0.09	0.01	0.07	0.40	–	0.08	0.11	–	0.25	476
1996	0.17	0.04	0.13	0.45	–	0.04	0.06	0.02	0.09	1 059
1997	0.26	0.04	0.08	0.53	–	0.04	–	–	0.05	1 106
1998	0.07	0.08	0.24	0.51	–	0.04	–	–	0.05	961
1999	–	0.02	0.39	0.57	–	0.01	–	–	0.01	1 295
2000	0.01	0.01	0.50	0.42	–	0.06	–	–	0.01	1 187
2001	0.01	0.01	0.42	0.40	–	0.06	0.01	0.08	0.03	1 430
2002	0.01	0.01	0.24	0.43	0.01	0.02	0.01	0.06	0.20	1 907
2003	–	–	0.34	0.51	0.03	0.03	0.01	0.02	0.06	1 578
2004	–	0.02	0.44	0.43	0.03	0.01	0.01	0.01	0.06	886
2005	0.01	0.06	0.32	0.36	0.03	0.02	0.03	0.12	0.05	1 040
2006	0.06	–	0.40	0.20	0.04	0.02	0.10	0.09	0.09	1 197
2007	0.13	0.01	0.23	0.40	0.03	0.01	0.01	0.07	0.10	1 324
2008	0.15	0.02	0.29	0.30	0.03	0.01	0.03	0.07	0.10	1 369
2009	0.12	0.01	0.36	0.27	0.05	–	0.10	0.03	0.06	995
2010	0.03	–	0.27	0.49	0.04	–	0.06	0.03	0.08	1 006
2011	0.01	–	0.23	0.49	0.02	–	0.04	0.09	0.12	1 203
Total	0.07	0.02	0.29	0.40	0.02	0.03	0.03	0.04	0.09	21 852

Table C10a: Proportion of spiny dogfish catch reported from the SUBA area, by month, for 1990–91 (1991) to 2010–11 (2011). SUBA area is shown in Figure 3.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1991	0.02	–	0.07	0.19	0.55	0.05	0.03	0.04	0.02	0.01	0.02	0.01	1 523
1992	0.10	0.03	0.06	0.19	0.16	0.20	0.05	0.03	–	–	0.04	0.13	500
1993	0.04	0.01	0.15	0.17	0.29	0.21	0.03	0.01	0.06	–	0.01	0.02	770
1994	0.06	0.04	0.17	0.14	0.41	0.09	0.01	0.01	0.03	0.01	–	0.02	1 039
1995	0.04	0.30	0.18	0.29	0.09	0.02	0.01	–	0.05	–	0.01	0.02	419
1996	0.06	0.07	0.19	0.05	0.29	0.01	0.02	0.03	0.05	–	–	0.23	1 269
1997	0.13	0.22	0.17	0.09	0.09	0.13	0.10	0.03	0.02	–	–	0.02	761
1998	0.11	0.07	0.17	0.13	0.08	0.17	0.10	0.06	0.06	0.03	0.01	0.01	415
1999	0.05	0.01	0.44	0.28	0.04	0.05	0.06	0.01	0.01	0.01	0.04	0.01	2 037
2000	0.05	0.05	0.21	0.19	0.18	0.18	0.05	0.02	0.03	0.01	0.01	0.03	1 234
2001	0.07	0.02	0.12	0.13	0.17	0.15	0.14	0.05	0.04	0.02	0.04	0.06	1 387
2002	0.06	0.05	0.19	0.15	0.13	0.16	0.09	0.09	0.04	0.02	0.01	–	3 863
2003	0.20	0.08	0.06	0.27	0.08	0.16	0.05	0.04	0.03	0.01	0.01	–	2 706
2004	0.05	0.05	0.10	0.19	0.09	0.13	0.14	0.11	0.10	0.01	–	0.02	1 818
2005	0.08	0.15	0.15	0.14	0.08	0.09	0.10	0.06	0.04	0.05	0.03	0.03	2 420
2006	0.15	0.14	0.07	0.10	0.07	0.16	0.11	0.09	0.06	0.04	0.01	0.01	2 255
2007	0.11	0.23	0.14	0.10	0.09	0.08	0.06	0.06	0.04	0.03	0.02	0.04	2 156
2008	0.04	0.10	0.16	0.12	0.10	0.13	0.09	0.08	0.06	0.04	0.02	0.04	1 436
2009	0.03	0.08	0.09	0.16	0.17	0.14	0.13	0.09	0.05	0.02	0.02	0.01	1 945
2010	0.05	0.03	0.18	0.24	0.15	0.07	0.08	0.09	0.04	0.02	0.02	0.03	2 186
2011	0.05	0.04	0.03	0.23	0.13	0.09	0.14	0.11	0.09	0.04	0.03	0.02	1 351
Total	0.08	0.08	0.15	0.17	0.15	0.12	0.08	0.06	0.05	0.02	0.02	0.03	33 490

Table C10b: Proportion of spiny dogfish catch reported from the SUBA area, by statistical area, for 1990–91 (1991 to 2010–11 (2011). SUBA area is shown in Figure 3. Statistical areas are shown in Figure 1.

	025	027	028	029	030	031	504	602	603	604	610	618	Other	Total
1991	0.35	0.27	0.27	0.03	0.04	–	0.03	0.01	–	–	–	–	–	1 523
1992	0.13	0.31	0.37	0.04	0.04	–	0.04	0.03	0.01	–	–	0.01	0.01	500
1993	0.25	0.26	0.36	0.06	0.03	–	0.03	0.01	–	–	–	–	–	770
1994	0.09	0.37	0.32	0.01	0.08	–	0.10	0.01	0.01	–	–	–	–	1 039
1995	0.25	0.25	0.17	0.01	0.23	–	0.07	0.01	–	–	0.01	–	–	419
1996	0.19	0.63	0.06	0.02	0.04	–	0.04	0.01	–	–	–	–	0.01	1 269
1997	0.03	0.32	0.39	0.01	0.08	0.01	0.11	0.03	–	–	–	–	0.01	761
1998	0.10	0.31	0.23	0.01	0.13	0.01	0.12	0.04	0.02	–	–	0.03	–	415
1999	0.09	0.18	0.54	–	0.04	–	0.13	0.01	–	–	–	–	–	2 037
2000	0.03	0.28	0.48	0.02	0.04	–	0.10	0.03	–	–	–	–	–	1 234
2001	0.09	0.21	0.37	–	0.21	–	0.07	0.01	–	–	0.01	–	0.01	1 387
2002	0.06	0.33	0.28	0.01	0.14	–	0.15	0.02	0.01	–	–	–	–	3 863
2003	0.09	0.33	0.28	0.02	0.14	0.01	0.10	0.02	0.01	–	0.01	–	0.01	2 706
2004	0.10	0.12	0.48	0.01	0.15	–	0.05	0.05	0.02	–	0.01	–	–	1 818
2005	0.12	0.18	0.25	0.01	0.24	0.01	0.05	0.03	0.03	0.02	0.02	0.02	0.02	2 420
2006	0.17	0.28	0.30	0.01	0.14	–	0.06	0.01	–	0.01	0.02	0.01	–	2 255
2007	0.17	0.31	0.21	0.01	0.19	–	0.06	0.02	–	–	–	–	0.01	2 156
2008	0.23	0.25	0.25	0.01	0.16	–	0.02	0.03	0.01	–	0.01	–	0.02	1 436
2009	0.12	0.28	0.25	0.01	0.14	–	0.04	0.07	0.02	0.01	0.02	–	0.03	1 945
2010	0.21	0.22	0.34	0.01	0.08	0.01	0.07	0.02	0.01	–	0.01	0.02	0.01	2 186
2011	0.18	0.38	0.10	0.01	0.15	–	0.07	0.03	0.01	0.01	0.03	0.02	0.01	1 351
Total	0.14	0.28	0.30	0.01	0.13	–	0.08	0.03	0.01	–	0.01	0.01	0.01	33 490

Table C10c: Proportion of spiny dogfish catch reported from the SUBA area, by gear type, for 1990–91 (1991) to 2010–11 (2011). BT is bottom trawl; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; BLL is bottom longline; SN is setnet.

	BLL	BT	MB	MW	SN	Other	Total
1991	–	0.96	0.01	–	0.02	–	1 523
1992	0.02	0.81	0.11	0.03	0.04	–	500
1993	–	0.78	0.11	0.09	0.01	–	770
1994	0.02	0.93	–	0.02	0.03	–	1 039
1995	0.09	0.81	0.04	0.01	0.05	–	419
1996	–	0.89	0.04	0.05	0.01	–	1 269
1997	0.01	0.74	0.20	0.03	0.01	–	761
1998	0.07	0.57	0.29	0.03	0.03	–	415
1999	0.02	0.83	0.10	0.04	0.02	–	2 037
2000	0.01	0.79	0.17	0.03	–	–	1 234
2001	0.02	0.69	0.21	0.04	0.04	–	1 387
2002	0.01	0.91	0.05	0.01	0.03	–	3 863
2003	0.01	0.85	0.08	0.01	0.05	–	2 706
2004	0.02	0.80	0.08	0.02	0.08	–	1 818
2005	0.06	0.82	0.03	0.01	0.07	–	2 420
2006	0.03	0.87	0.02	–	0.06	–	2 255
2007	0.02	0.84	0.02	–	0.12	–	2 156
2008	0.05	0.76	0.02	0.01	0.15	–	1 436
2009	0.06	0.74	0.05	0.01	0.14	–	1 945
2010	0.04	0.79	0.04	0.02	0.11	–	2 186
2011	0.09	0.74	0.02	–	0.15	–	1 351
Total	0.03	0.82	0.07	0.02	0.06	–	33 490

Table C10d: Proportion of spiny dogfish catch reported from the SUBA area, by target species, for 1990–91 (1991) to 2010–11 (2011). Target species codes are defined in Table C11.

	BAR	HOK	JMA	LIN	SCH	SPD	SQU	SWA	WAR	Other	Total
1991	0.48	0.01	–	0.01	0.02	0.02	0.42	0.01	0.01	0.03	1 523
1992	0.27	0.03	0.02	0.03	0.03	0.02	0.34	0.07	0.12	0.07	500
1993	0.52	0.01	–	0.01	–	–	0.31	0.06	0.04	0.04	770
1994	0.23	0.05	0.01	0.03	0.03	–	0.30	0.20	0.08	0.06	1 039
1995	0.27	0.08	0.03	0.10	0.05	–	0.11	0.16	0.05	0.14	419
1996	0.25	0.06	0.16	0.01	0.01	–	0.02	0.18	0.10	0.22	1 269
1997	0.13	0.18	0.09	0.02	0.01	–	0.30	0.11	0.07	0.11	761
1998	0.17	0.12	0.29	0.09	0.03	–	0.20	0.01	–	0.10	415
1999	0.04	0.07	0.09	0.02	0.02	–	0.69	0.01	0.04	0.01	2 037
2000	0.06	0.28	0.13	0.01	–	–	0.42	0.05	0.01	0.04	1 234
2001	0.03	0.25	0.07	0.03	0.04	–	0.42	0.02	–	0.14	1 387
2002	0.05	0.20	0.08	0.01	0.02	–	0.42	0.10	0.01	0.10	3 863
2003	0.18	0.19	0.01	0.02	0.05	–	0.39	0.04	0.06	0.06	2 706
2004	0.04	0.24	0.01	0.04	0.07	–	0.45	0.01	0.01	0.13	1 818
2005	0.04	0.17	0.01	0.08	0.05	0.05	0.33	0.07	0.06	0.14	2 420
2006	0.02	0.10	0.01	0.08	0.05	0.12	0.38	0.07	0.09	0.07	2 255
2007	0.09	0.10	–	0.11	0.10	0.08	0.24	0.10	0.08	0.11	2 156
2008	0.17	0.06	–	0.11	0.09	0.15	0.24	0.07	0.02	0.10	1 436
2009	0.03	0.13	–	0.08	0.13	0.08	0.30	0.15	0.01	0.10	1 945
2010	0.10	0.10	0.02	0.09	0.09	0.08	0.37	0.04	0.01	0.09	2 186
2011	0.04	0.18	–	0.12	0.10	0.09	0.22	0.11	0.01	0.14	1 351
Total	0.12	0.14	0.04	0.05	0.05	0.04	0.36	0.07	0.04	0.09	33 490

Table C11: Species codes used in the report.

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
BCO	Blue cod	*Parapercis colias*
BNS	Bluenose	*Hyperoglyphe antarctica*
BUT	Butterfish	*Odax pullus*
ELE	Elephantfish	*Callorhinchus milii*
FLA	Flatfish species	*Rhombosolea leporina, R. plebeia, R. retiaria, R. tapirina, Pelotretis flavilatus, Peltorhamphus novaezeelandiae, Colistium guntheri, C. nudipinnis*
HAP	Hapuku	*Polyprion oxygeneios*
HPB	Hapuku and bass	*Polyprion oxygeneios*, *P. americanus*
HAK	Hake	*Merluccius australis*
HOK	Hoki	*Macruronus novaezelandiae*
JMA	Jack mackerels	*Trachurus declivis*, *T. novaezelandiae*, *T. murphyi*
LIN	Ling	*Genypterus blacodes*
MOK	Moki	*Latridopsis ciliaris*
RIB	Ribaldo	*Mora moro*
RCO	Red cod	*Pseudophycis bachus*
SCH	School shark	*Galeorhinus galeus*
SCI	Scampi	*Metanephrops challengeri*
SPD	Spiny dogfish	*Squalus acanthias*
SPO	Rig	*Mustelus lenticulatus*
SQU	Arrow squid	*Nototodarus gouldi*, *N. sloanii*
STA	Stargazers	*Kathetostoma giganteum*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
TRU	Trumpeter	*Latris lineata*
WAR	Blue warehou	*Seriolella brama*
WWA	White warehou	*Seriolella caerulea*

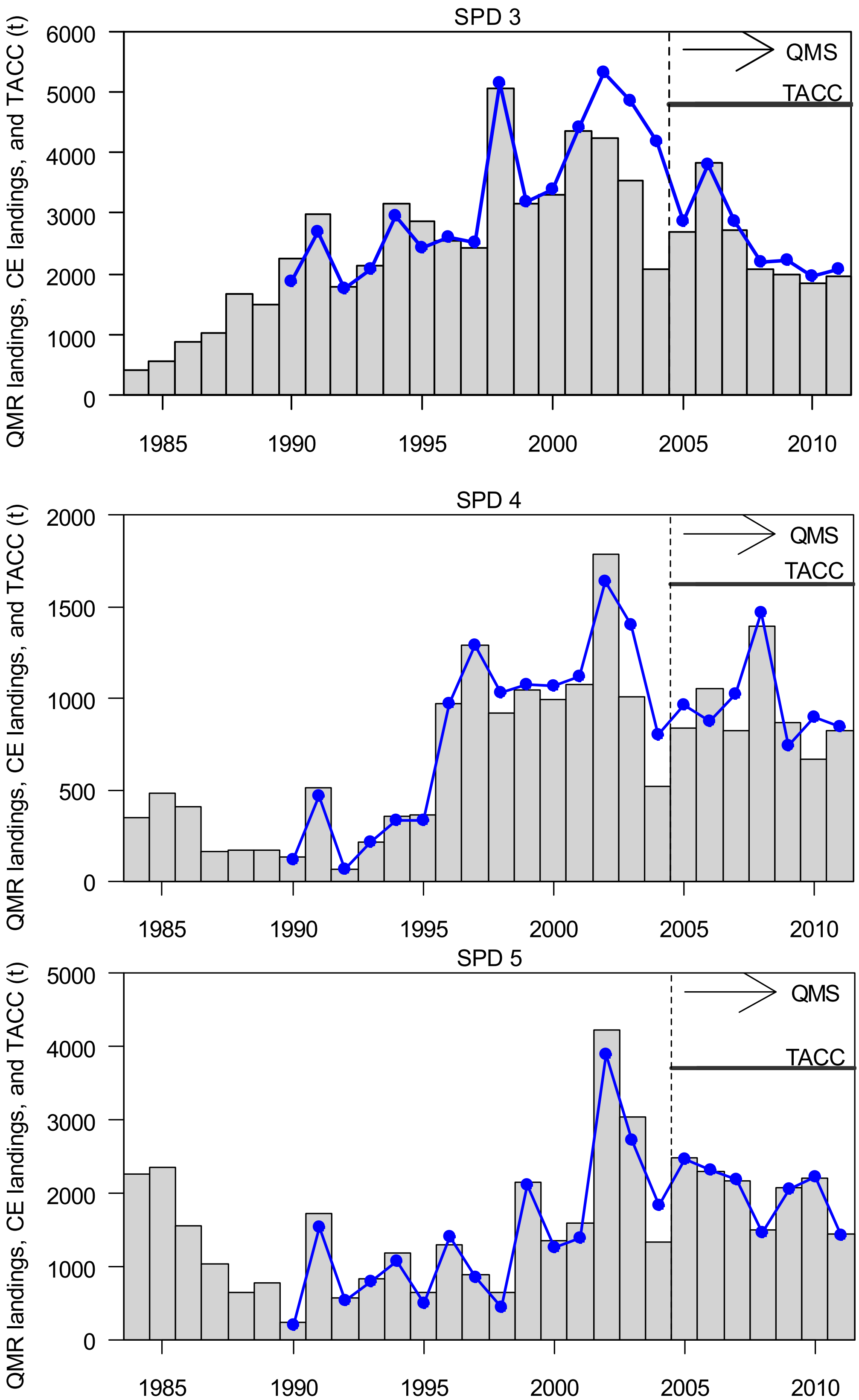


Figure C1:The QMR/MHR landings (grey bars), ungroomed catch effort landings (blue line), and TACC (black line) in tonnes for SPD stocks for 1984–95 (1985) to 2010–11 (2011).

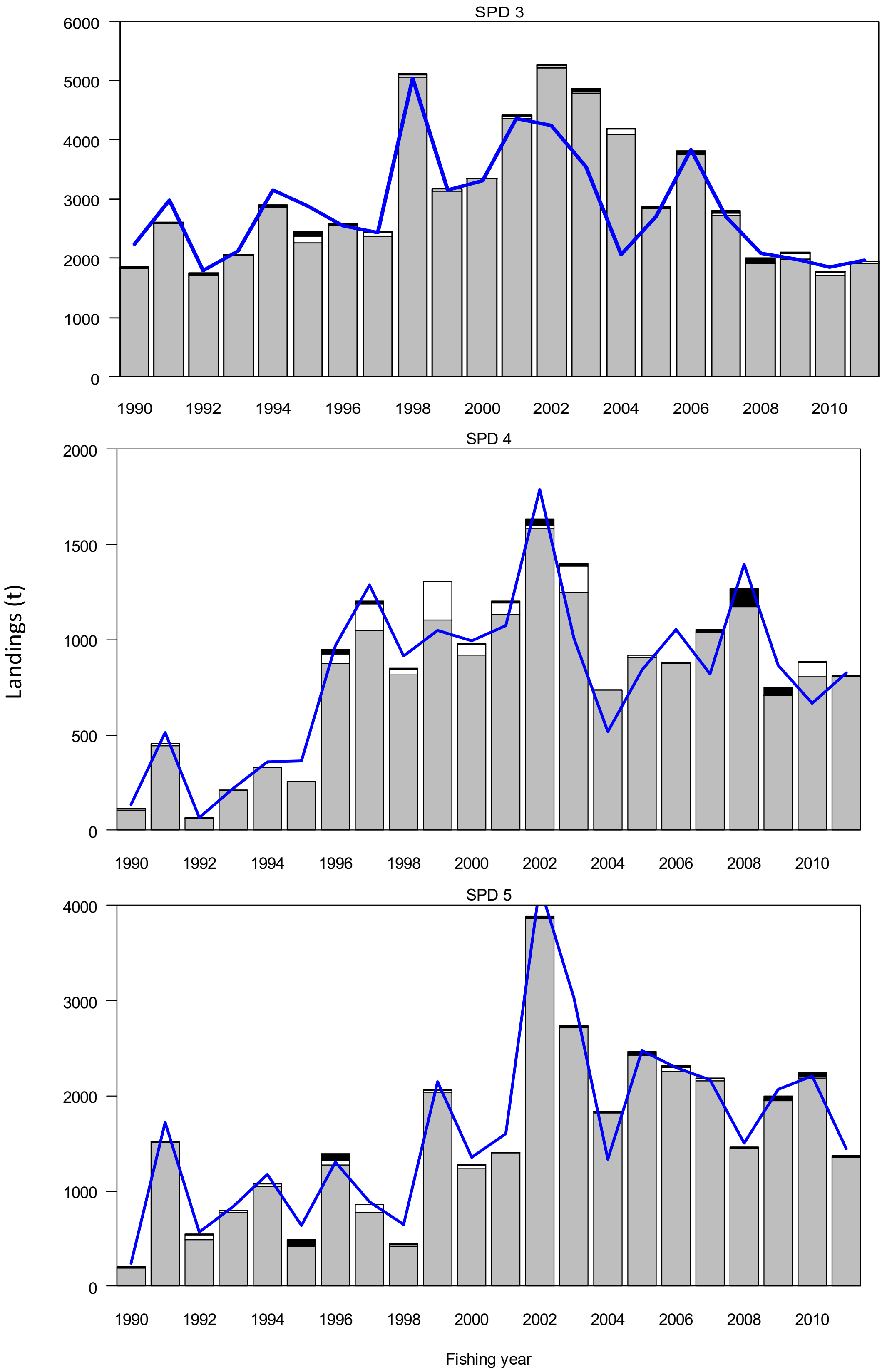
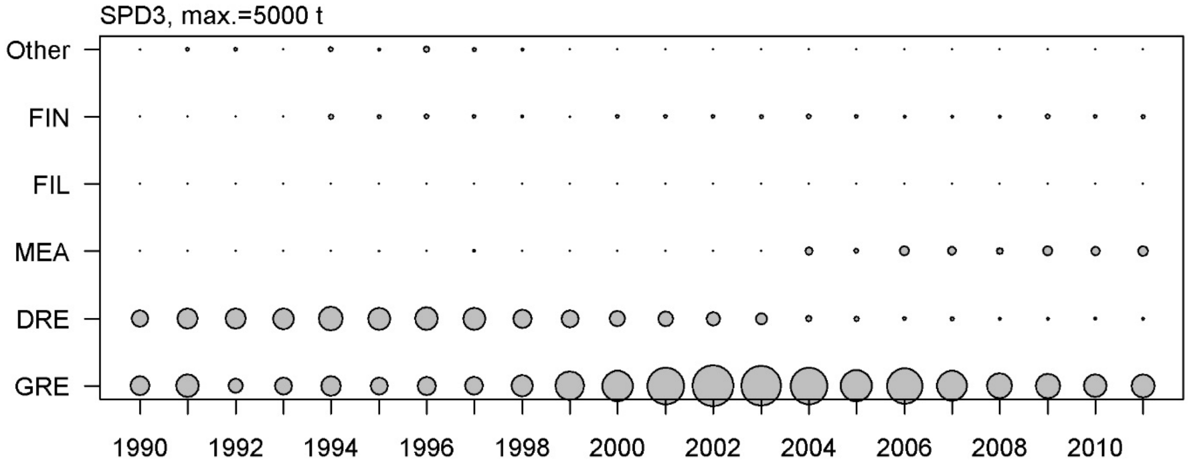
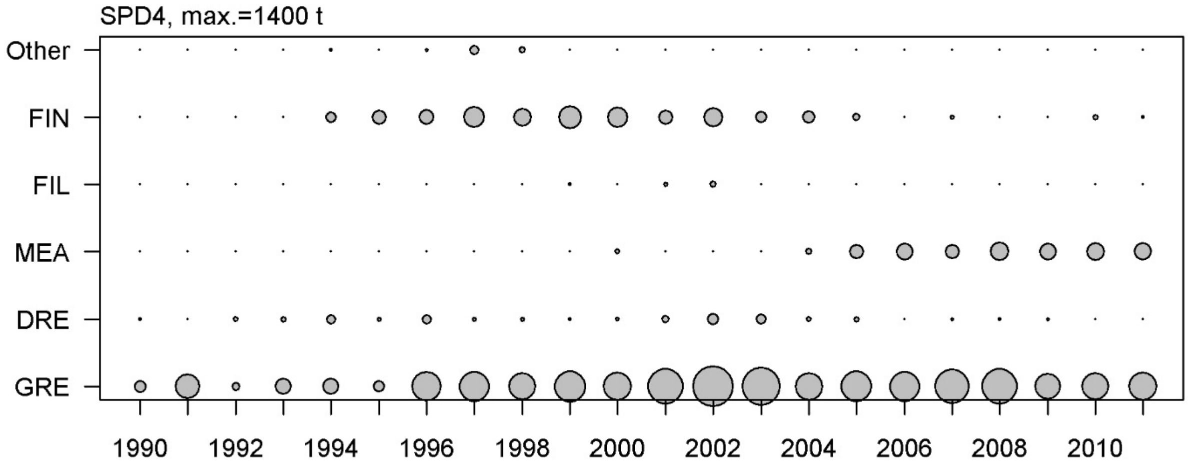


Figure C2: The retained landings (grey bars), interim landings (white bars), and landings dropped during data grooming (black bars), and MHR landings (blue line) in tonnes for SPD stocks for 1989–90 (1990) to 2010–11 (2011).





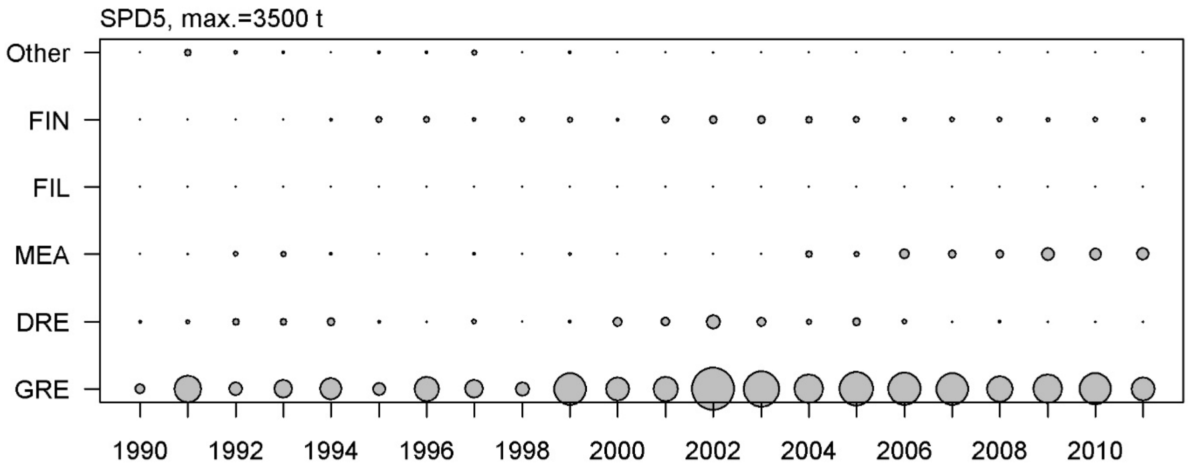


Figure C3: Retained landings (greenweight in tonnes) by processed state for SPD stocks for 1989–90 (1990) to 2010–11 (2011) in the groomed and unmerged dataset. GRE is Green; DRE is dressed or headed, gutted, and tailed; FIL is filleted or skin off filleted; MEA is mealed; FIN is fins removed.

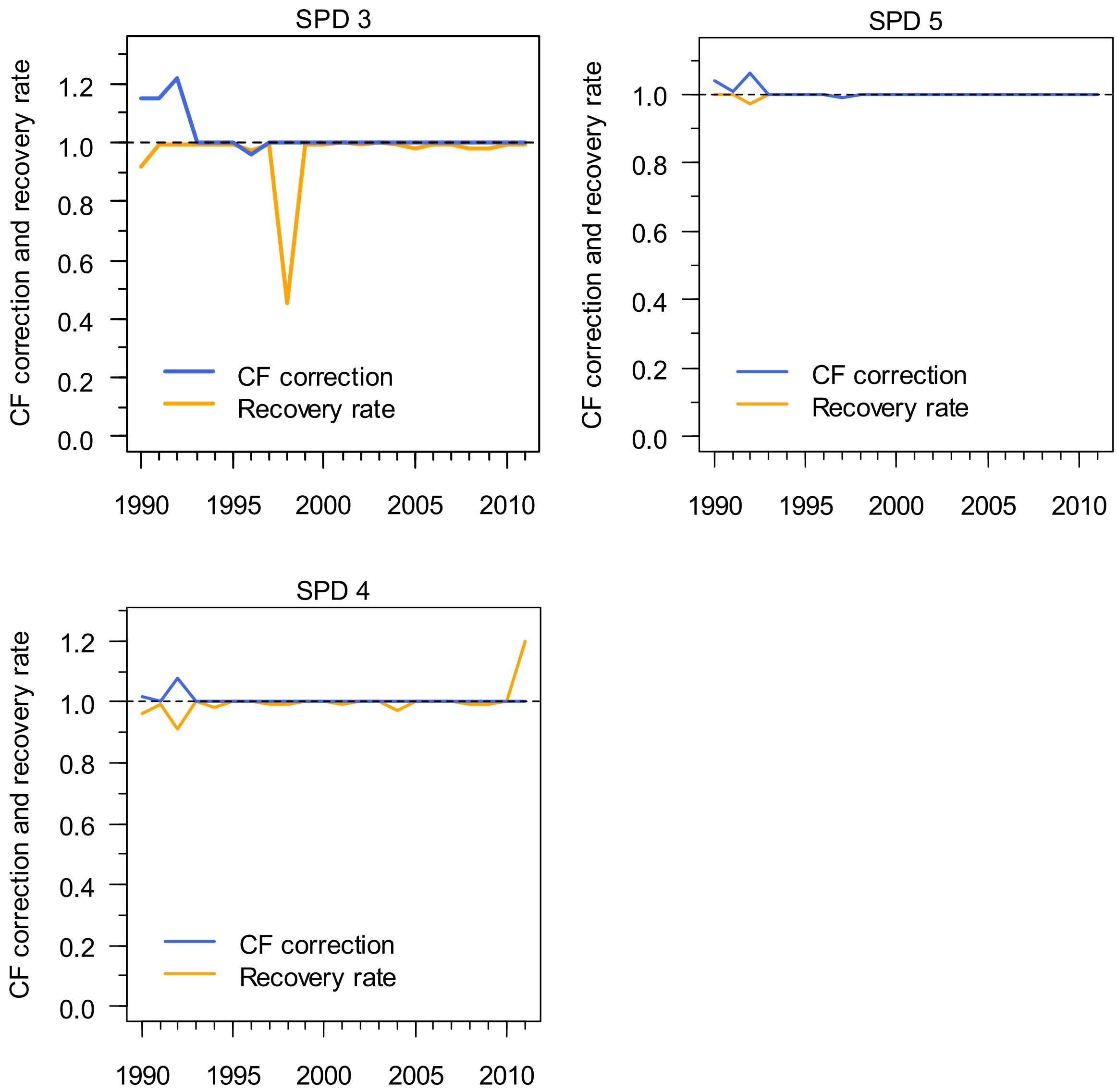


Figure C4: Conversion factor (CF) corrections (by the centroid method), defined as the ratio of annual greenweight recalculated using the most recent correction factors for each processed state to the reported greenweight; and the recovery rate, defined as the ratio of annual landings in the groomed and merged dataset to that in the groomed and unmerged dataset, for SPD 3, SPD 4, and SPD 5 stocks for 1989–90 (1990) to 2010–11 (2011).

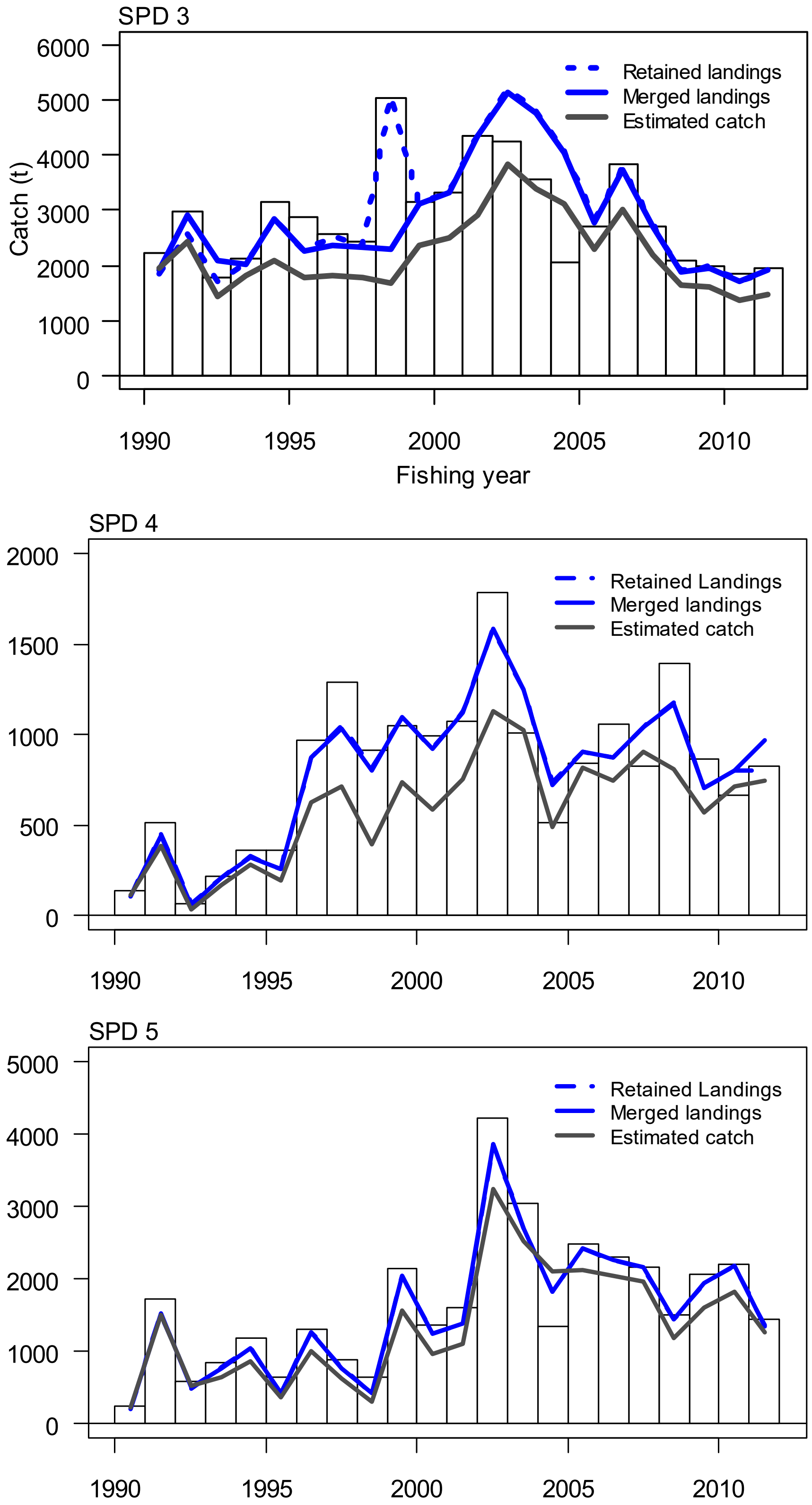


Figure C5: The QMR/MHR landings (white bars), retained landings in the groomed and unmerged dataset (blue dashed line), retained landings in groomed and merged dataset (blue solid line), and daily processed catch in the groomed and merged dataset (red solid line), using the centroid method, for SPD 3, SPD 4, and SPD 5 stocks for 1989–90 (1990) to 2010–11 (2011). All landings and catch data are in tonnes.

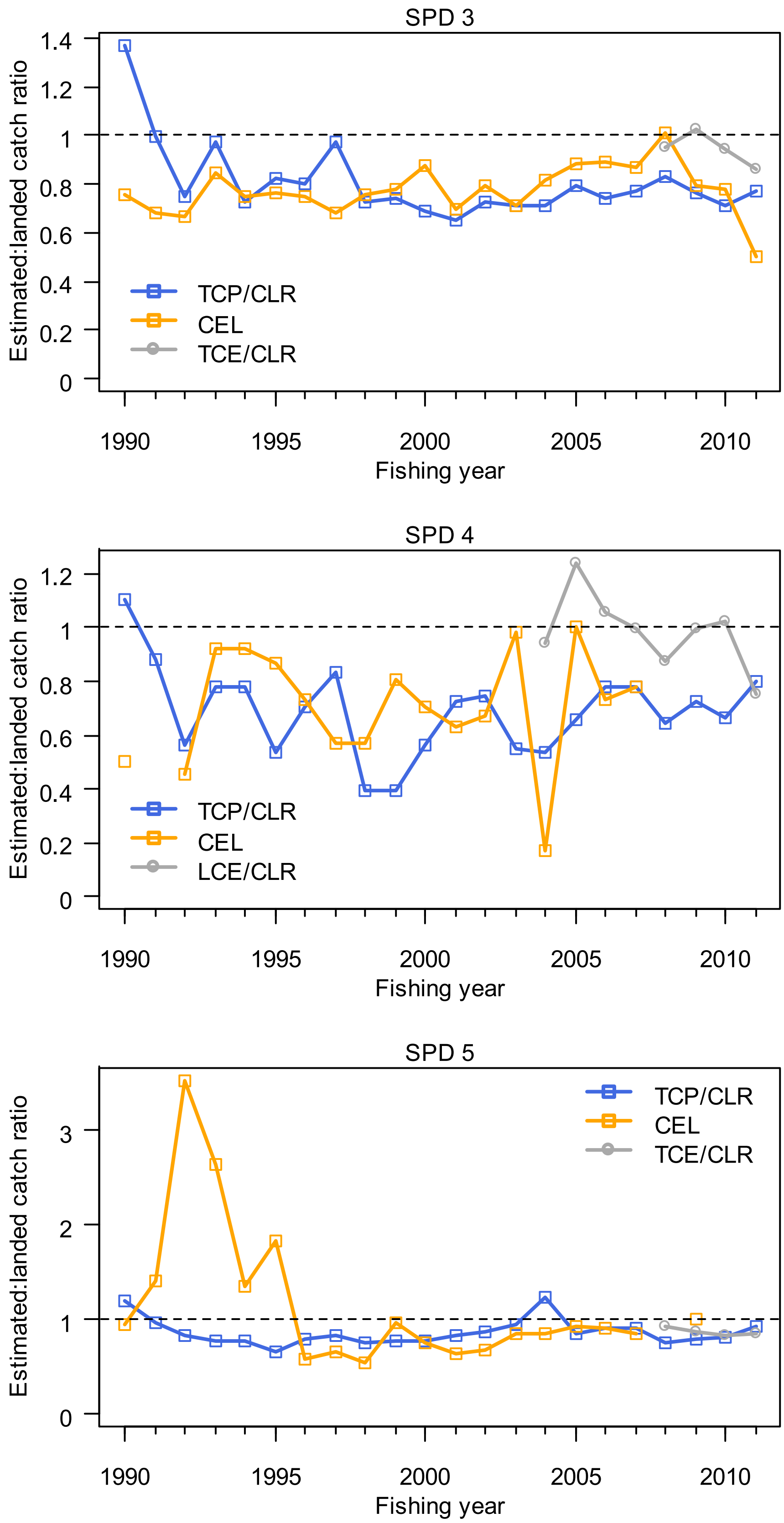


Figure C6: The reporting rate, defined as the ratio of the estimated catch as a proportion of retained landings in the groomed and merged dataset, for SPD 3, SPD 4, and SPD 5 stocks for 1989–90 (1990) to 2010–11 (2011). The reporting rates for each stock were calculated by form type, where TCP is Trawl Catch Effort Processing Return; CLR is Catch Landing Return; CEL is Catch Effort Landing Return; TCE is Trawl Catch Effort Return; and LCE is Lining Catch Effort Return.

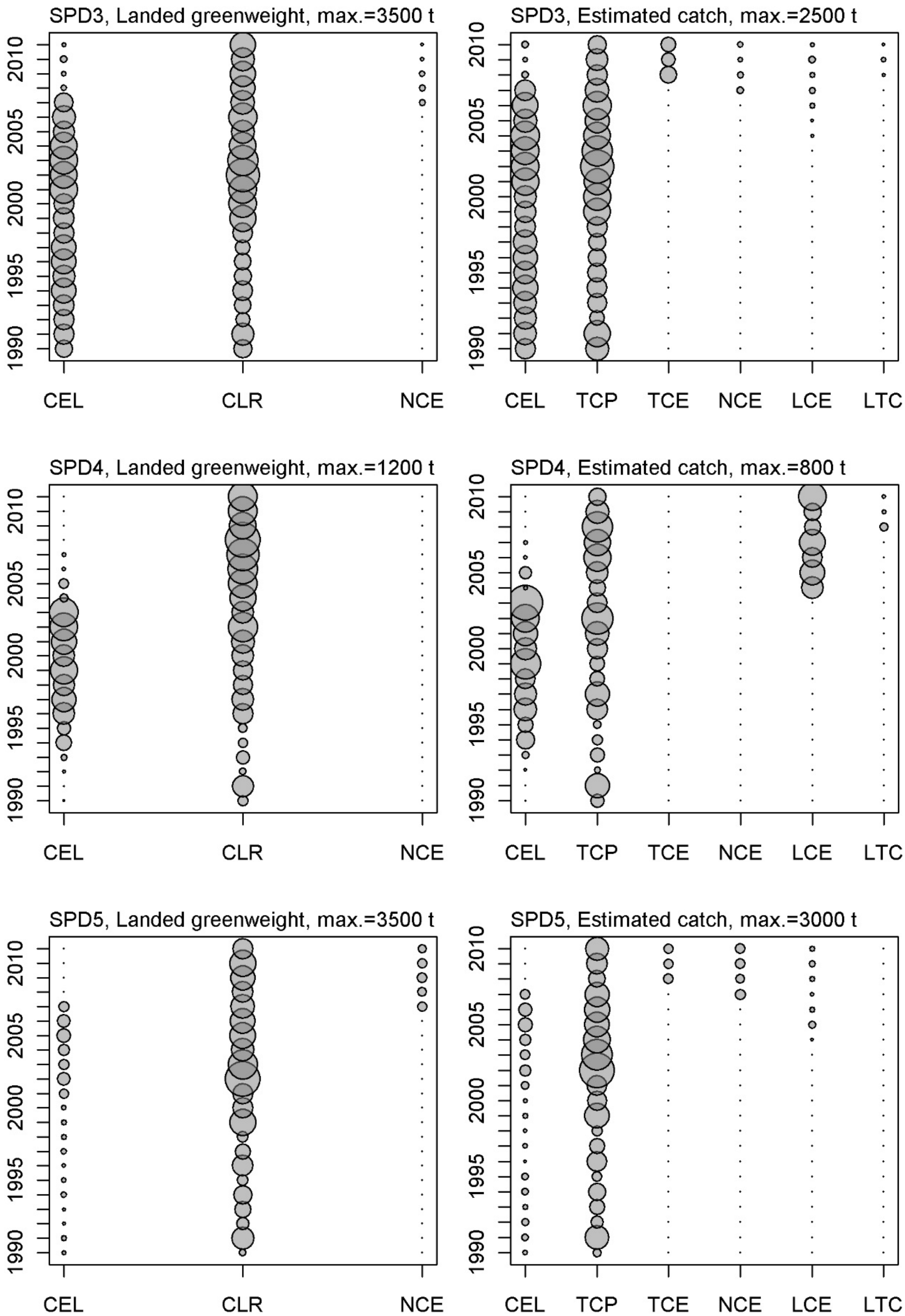


Figure C7: Proportion of landings by form type in the groomed and unmerged dataset (left), and proportion of estimated catches by form type in the groomed and merged dataset (right), for SPD 3, SPD 4, and SPD 5 stocks from 1989–90 (1990) to 2010–11 (2011). CEL is Catch, Effort, Landing Return; CLR is Catch Landing Return; TCP is Trawl Catch Effort and Processing Return; TCE is Trawl Catch Effort Return; NCE is Netting Catch Effort Return; LCE is Line Catch Effort Return; and LTC is Lining Trip Catch Effort Return. The area of the circle is proportional to the annual catches (only comparable within each panel).

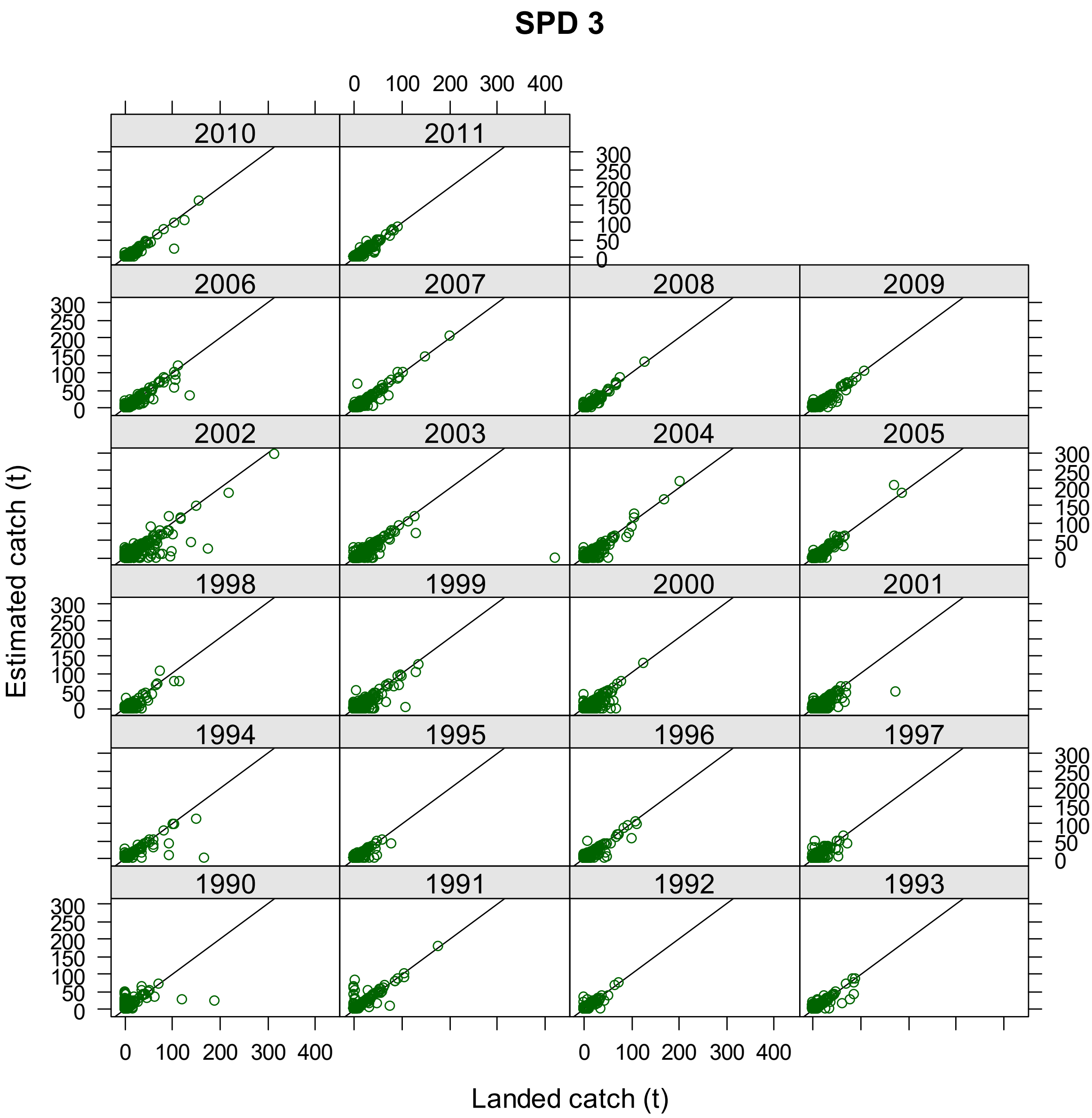


Figure C8: Estimated catch versus reported landings on a trip basis in the groomed and merged dataset, for SPD 3, SPD 4, and SPD 5 stocks for 1989–90 (1990) to 2010–11 (2011).

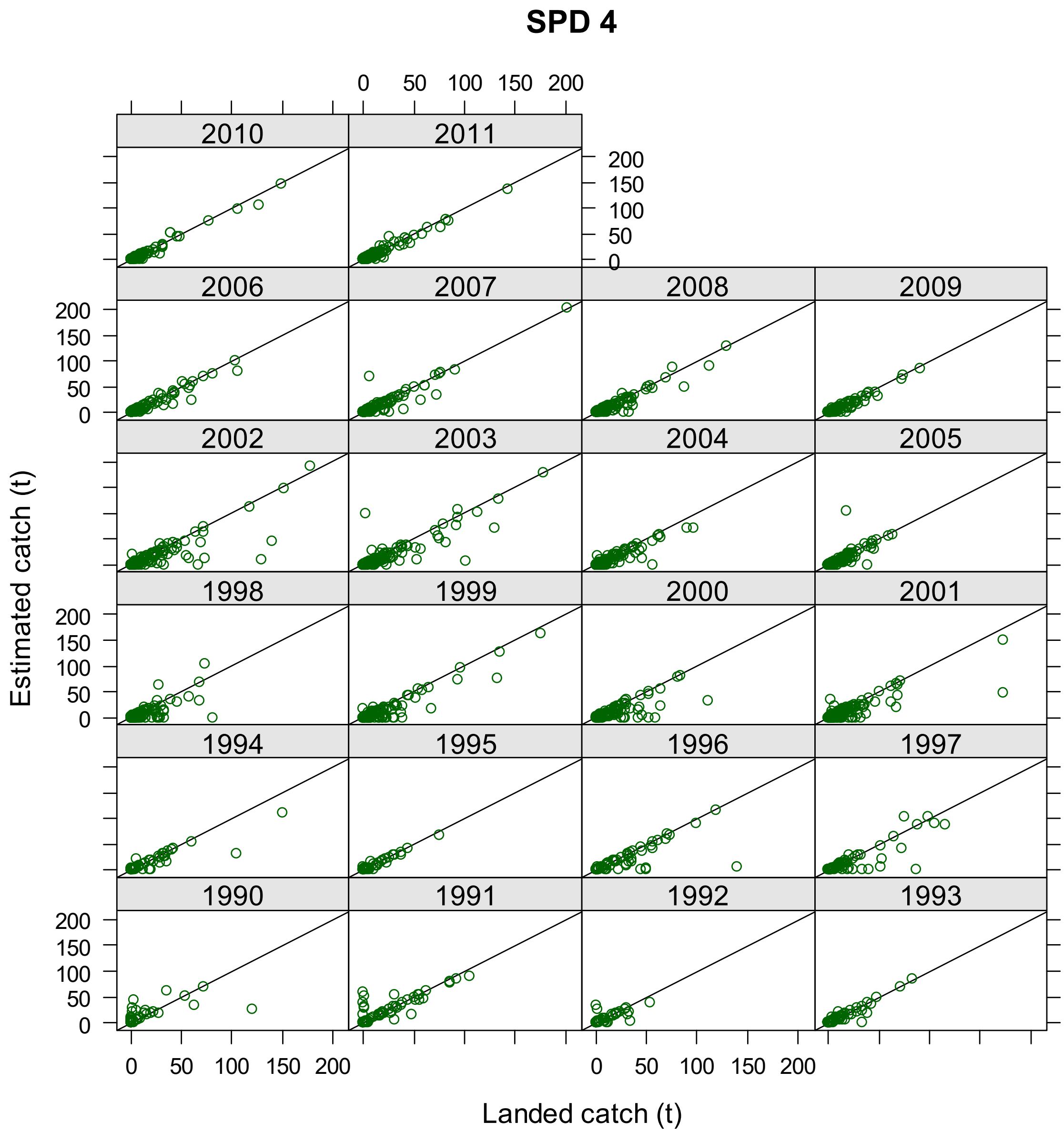


Figure C8: ***continued.***

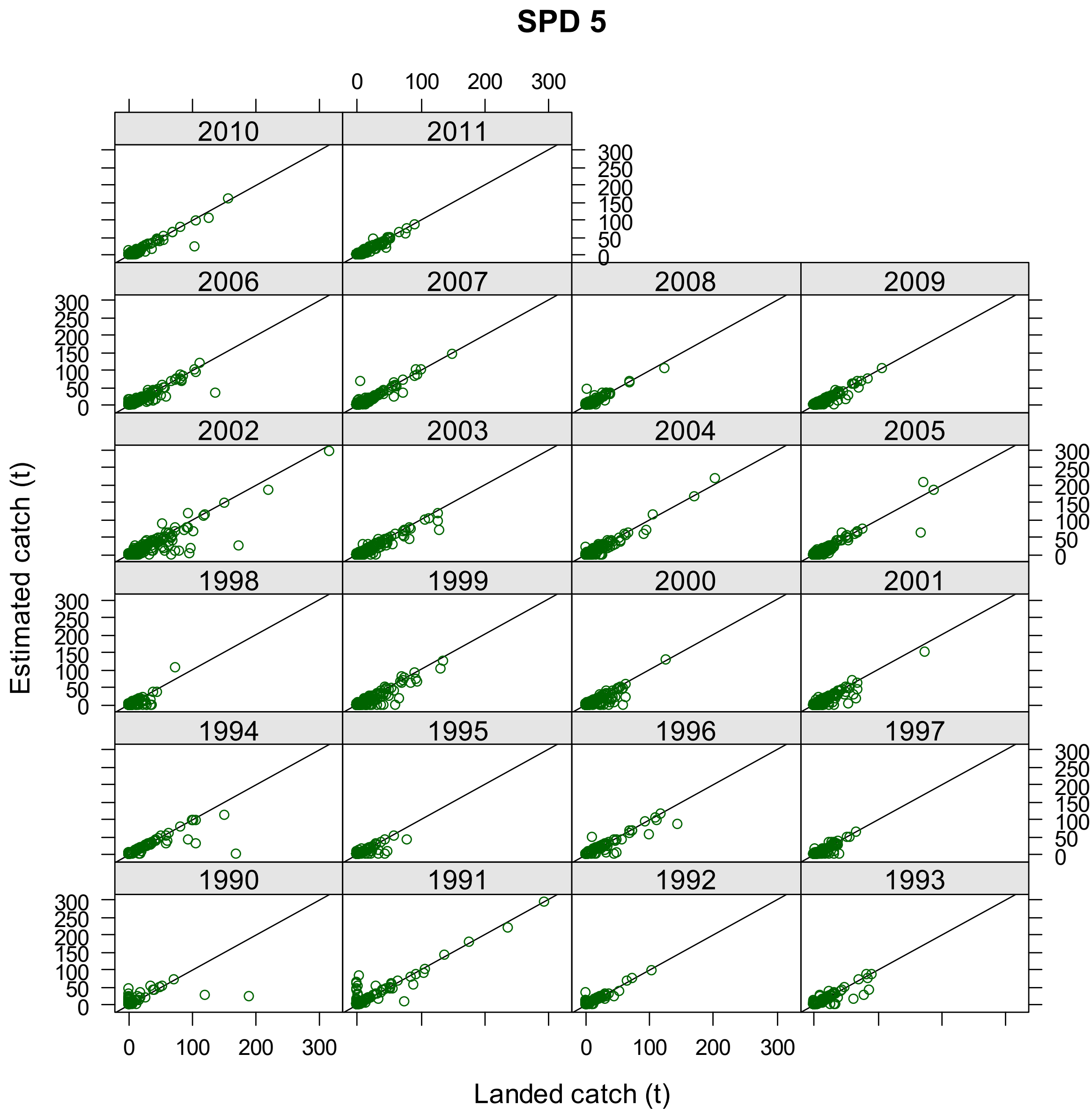


Figure C8: ***continued.***

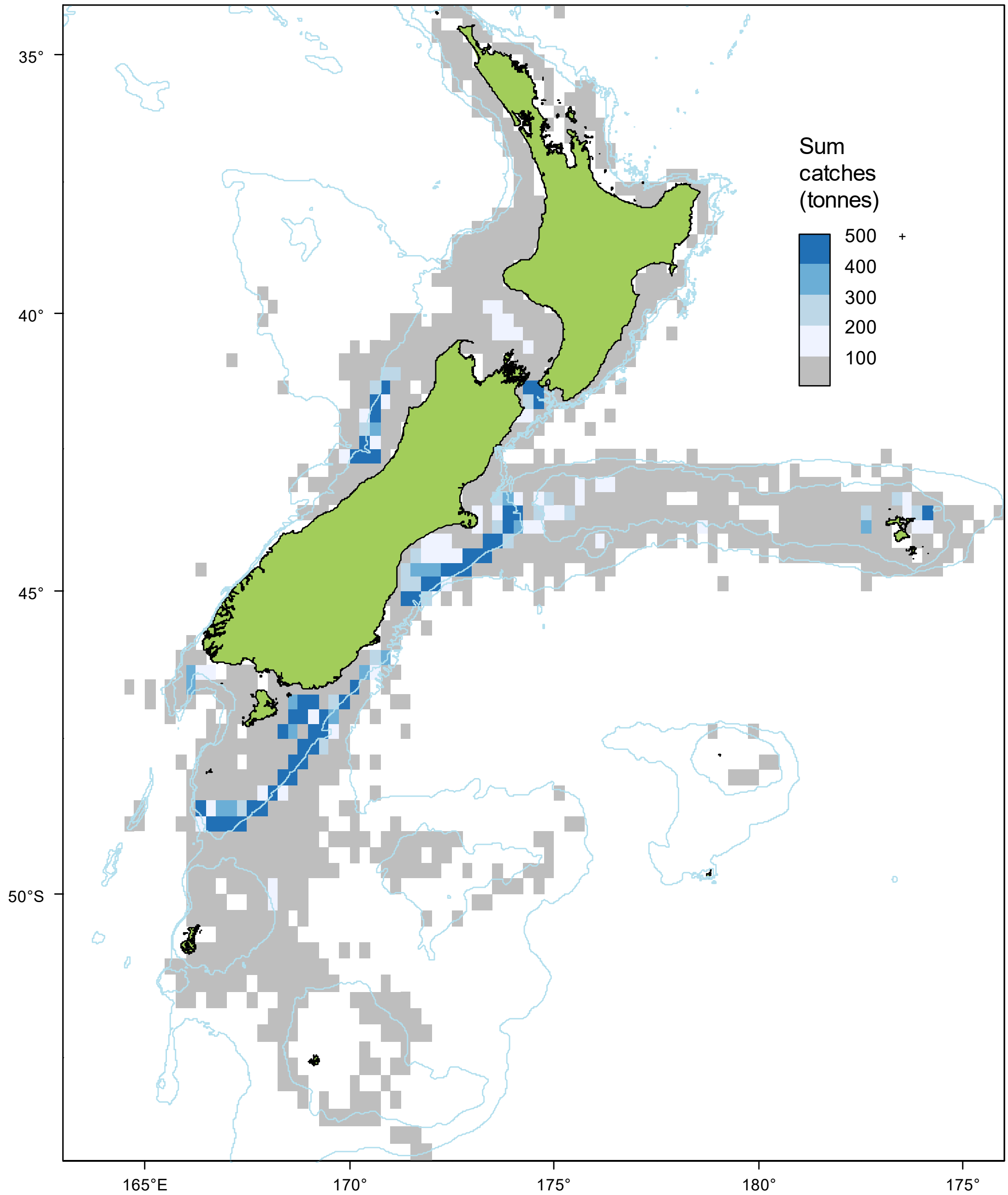


Figure C9a: Annual catch (t) of all commercial spiny dogfish catches from Trawl Catch Effort and Processing Return (TCEPR) records for 1989–90 to 2010–11 combined.

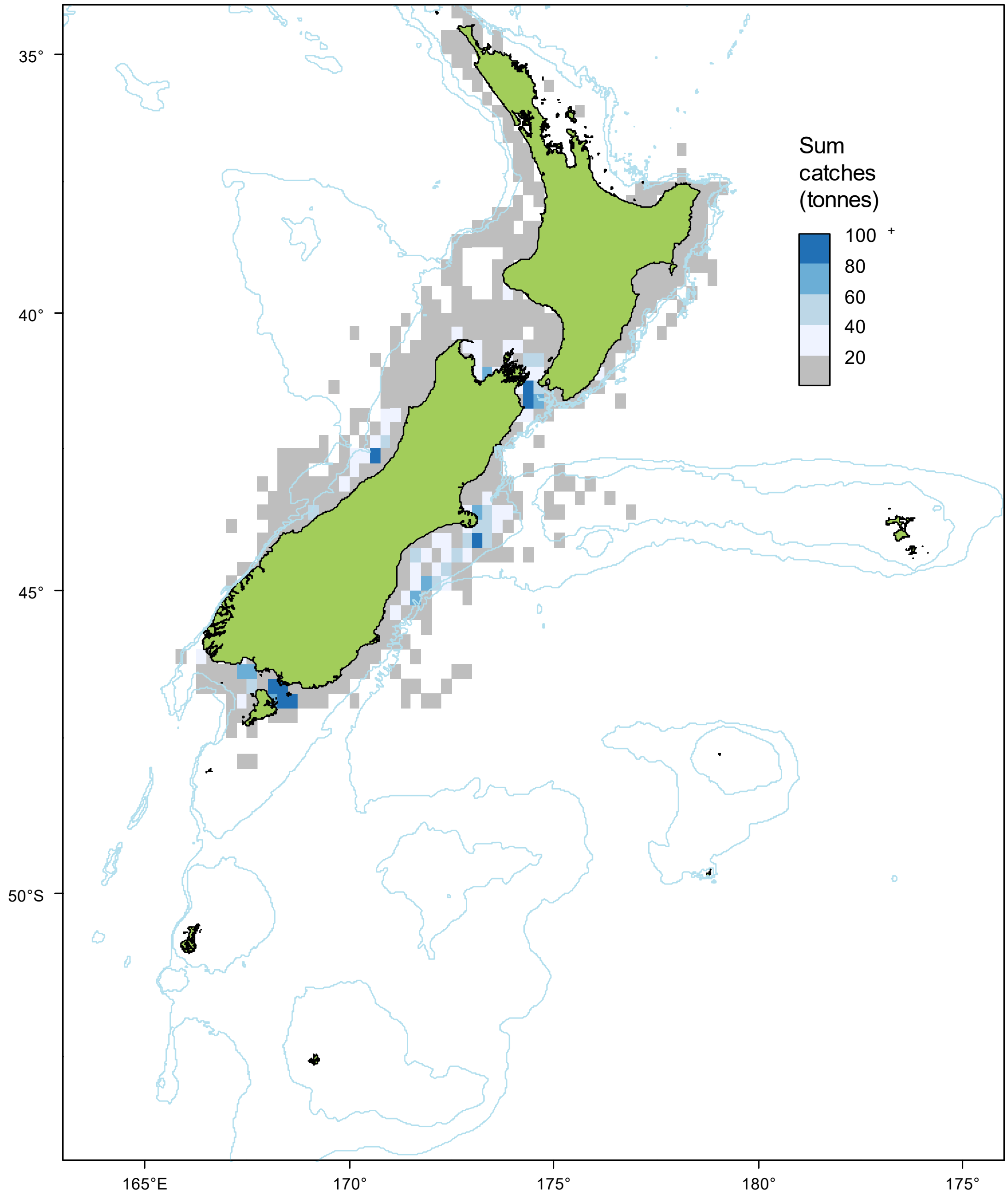


Figure C9b: Annual catch (t) of all commercial spiny dogfish catches from Trawl Catch and Effort Return (TCER) records 2007–08 to 2010–11 combined.

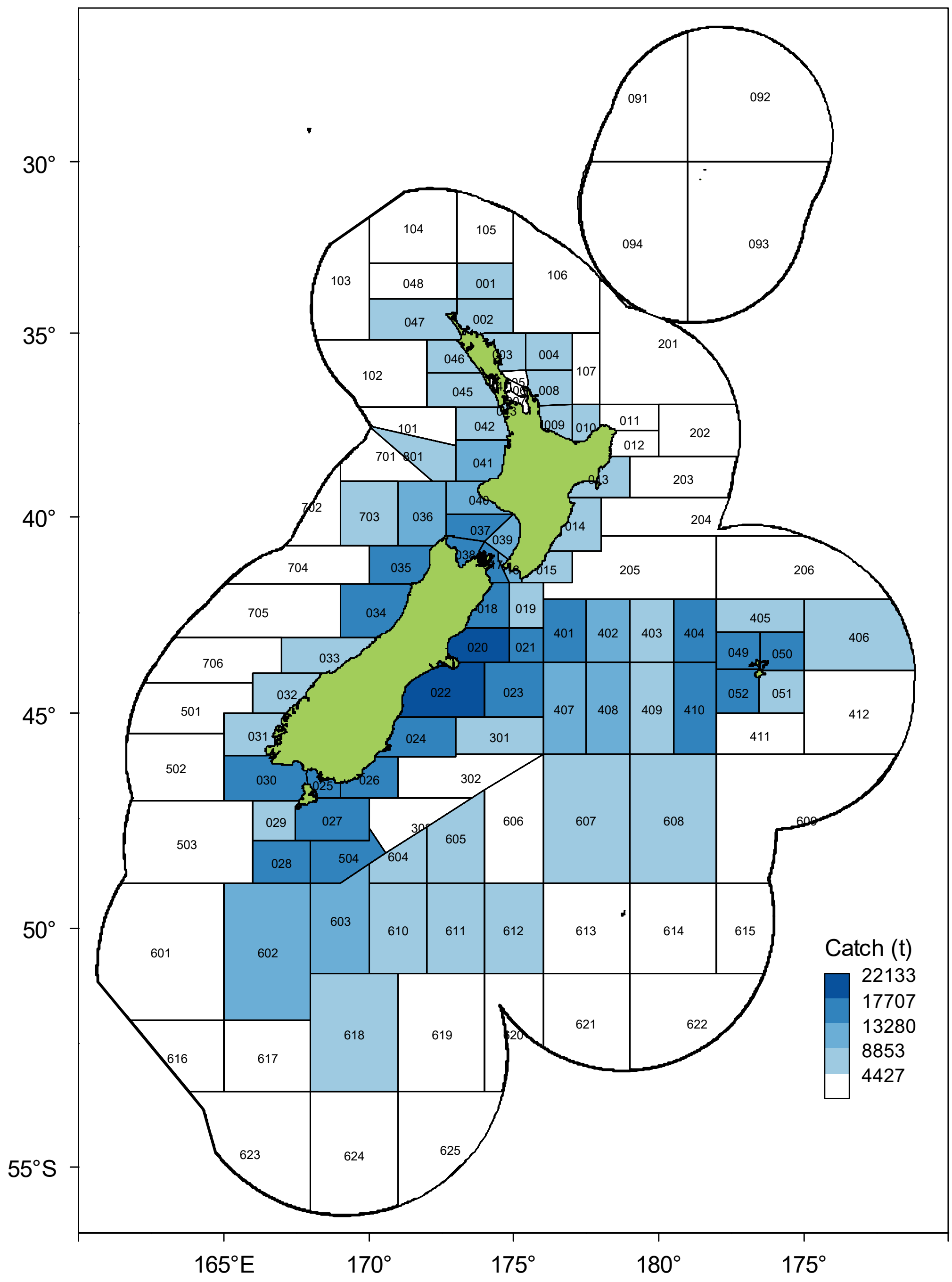


Figure C9c: Annual catch (in tonnes) of all commercial spiny dogfish catches by statistical area for all forms and methods over all fishing years, 1989–90 to 2010–11.

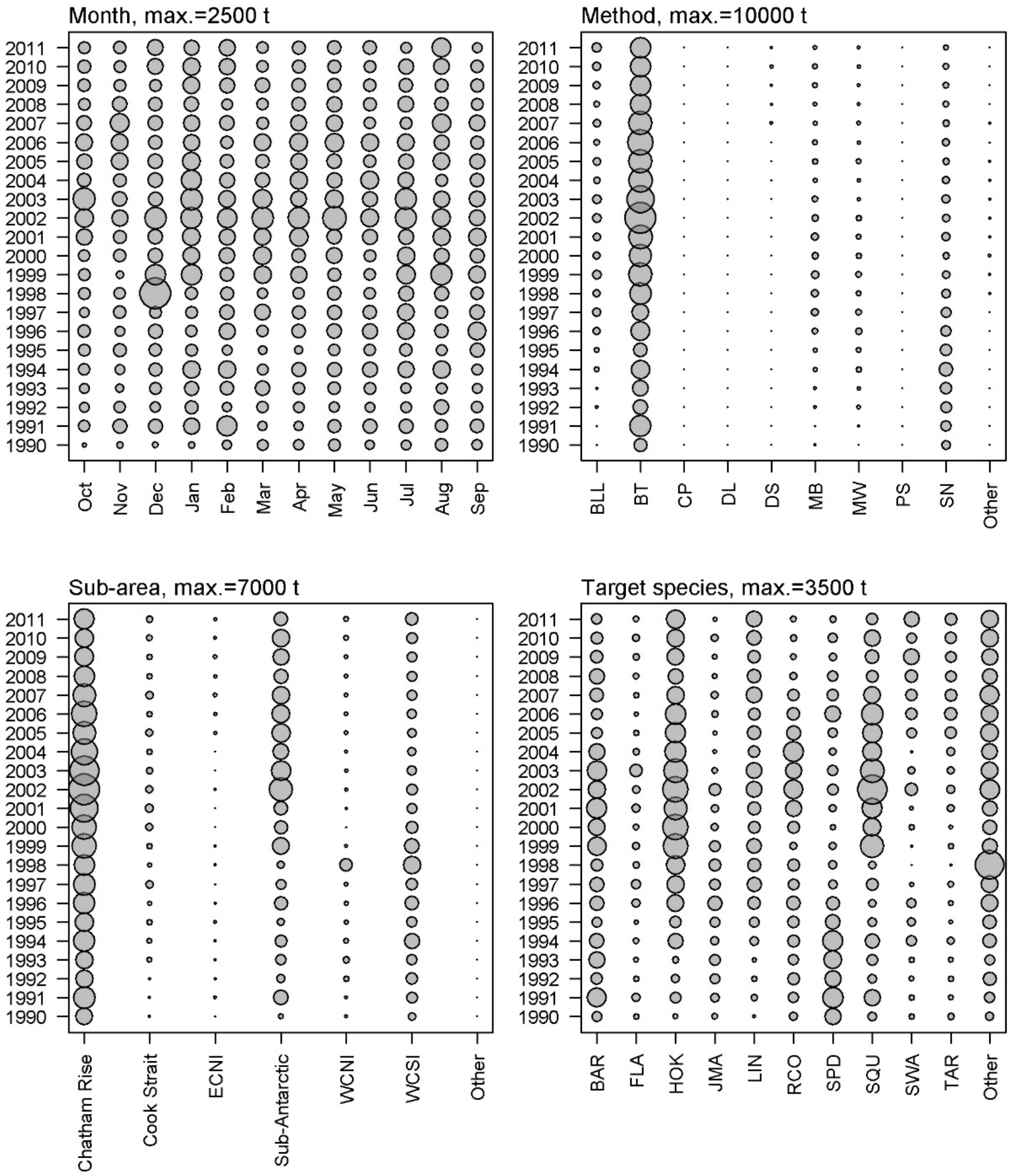


Figure C10: Distribution of annual catch (t) by month, method, area and target species for all merged data by fishing year from 1989–90 (1990) to 2010–11 (2011). Circle size is proportional to catch; maximum circle size for is indicated on top left hand corner of each plot. BLL is bottom longline; BT is bottom trawl; CP is cod potting; DL is dahn line; DS is Danish seine; MB is midwater trawl within 5 m of the seabed; MW is midwater trawl; PS is purse seine; SN is setnet. Statistical areas are shown in Figure 1. Target species codes are defined in Table C11.

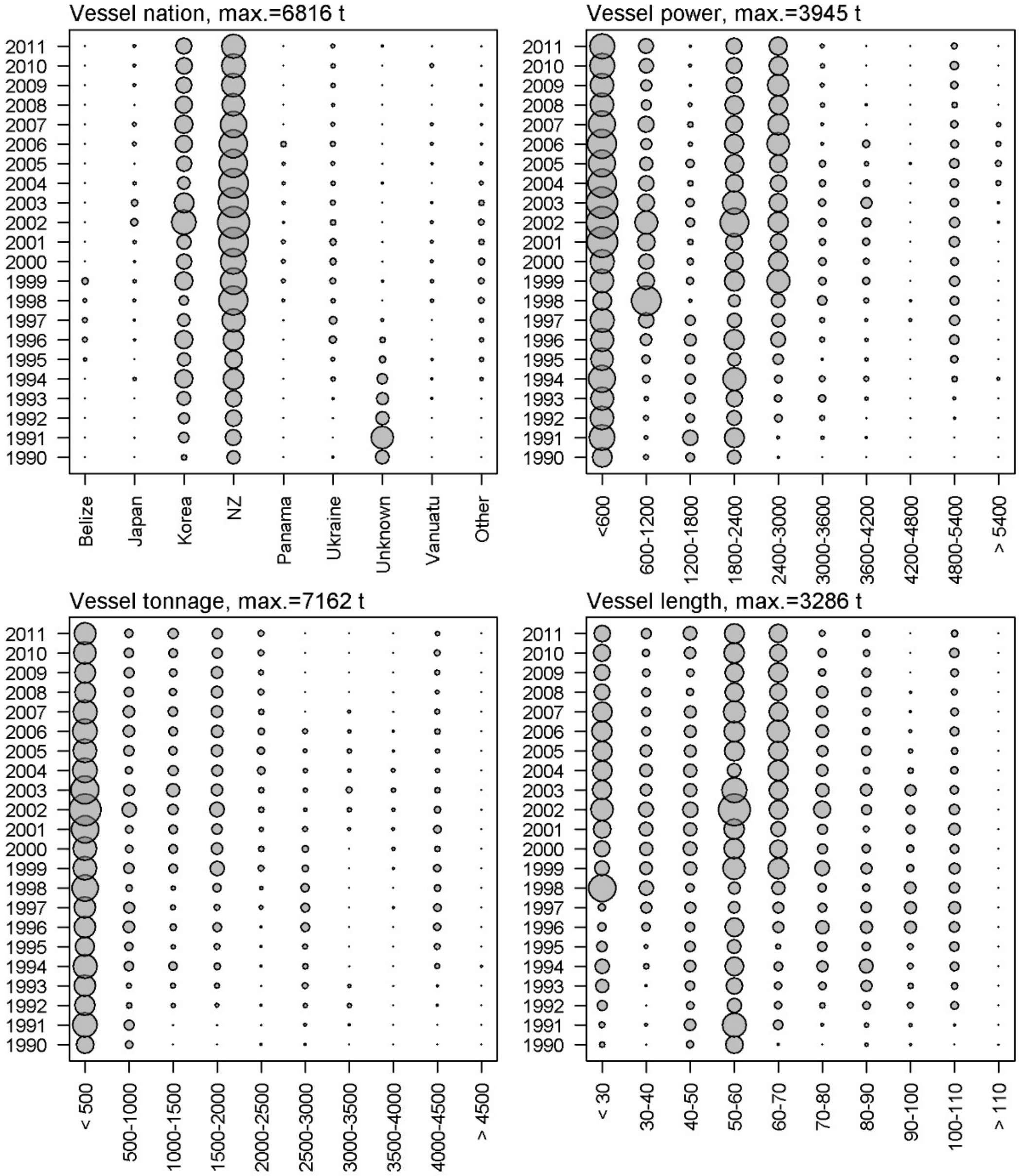


Figure C11: Distribution of annual catch (t) by nationality, vessel power (kW), vessel gross tonnage, and vessel length (m) for all merged data by fishing year from 1989–90 (1990) to 2010–11 (2011). Circle size is proportional to catch; maximum circle size is indicated on top left hand corner of each plot.

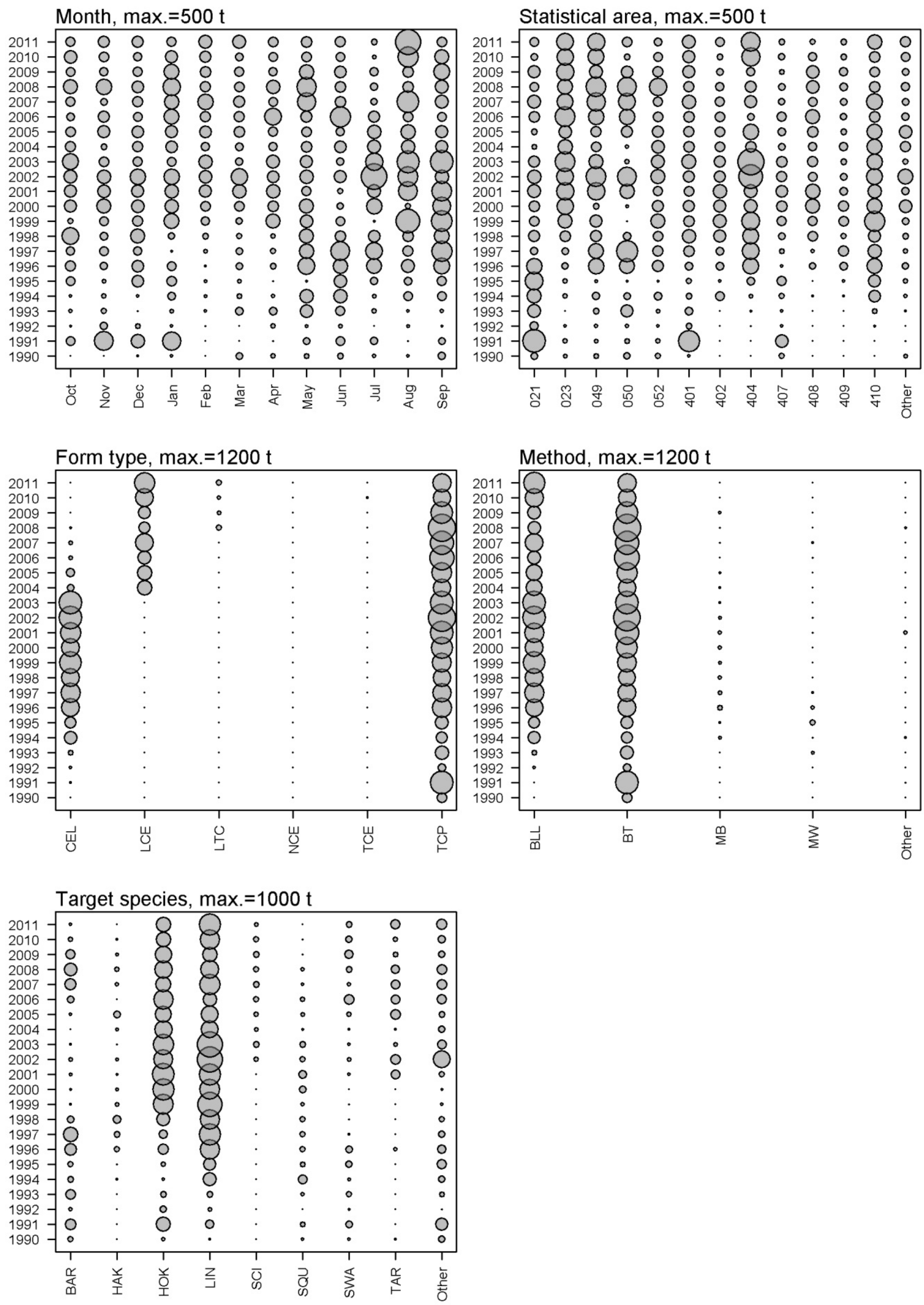


Figure C12: Distribution of annual catch (t) by month, statistical area, form type, method, and target species for CHAT merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1. Form types are defined on Figure C7 and fishing methods are defined in Figures C10. Target species codes are given in Table C11.

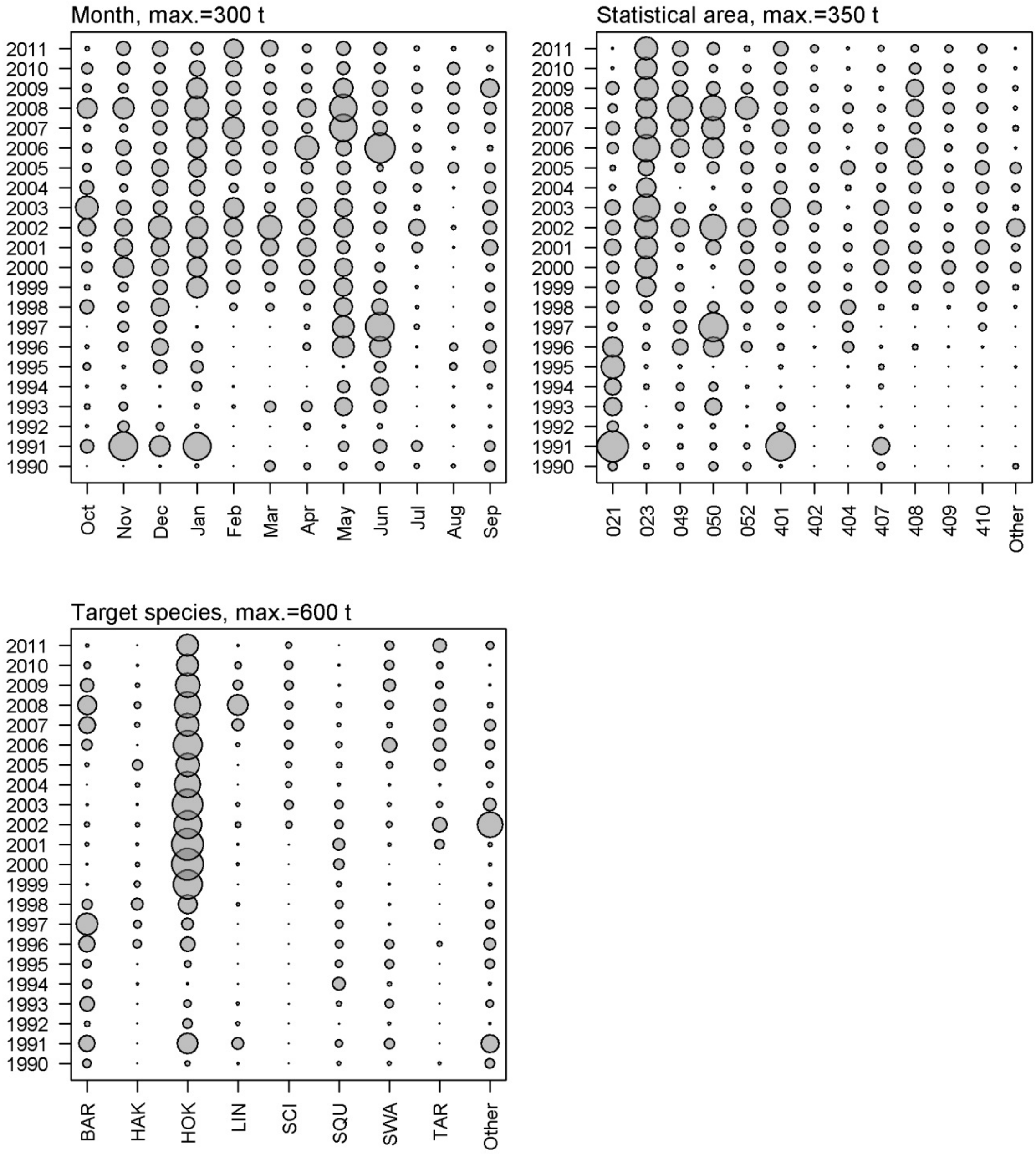


Figure C13a: Distribution of annual catch (t) by month, statistical area, and target species for CHAT merged data for TCEPR bottom tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1. Target species codes are given in Table C11.

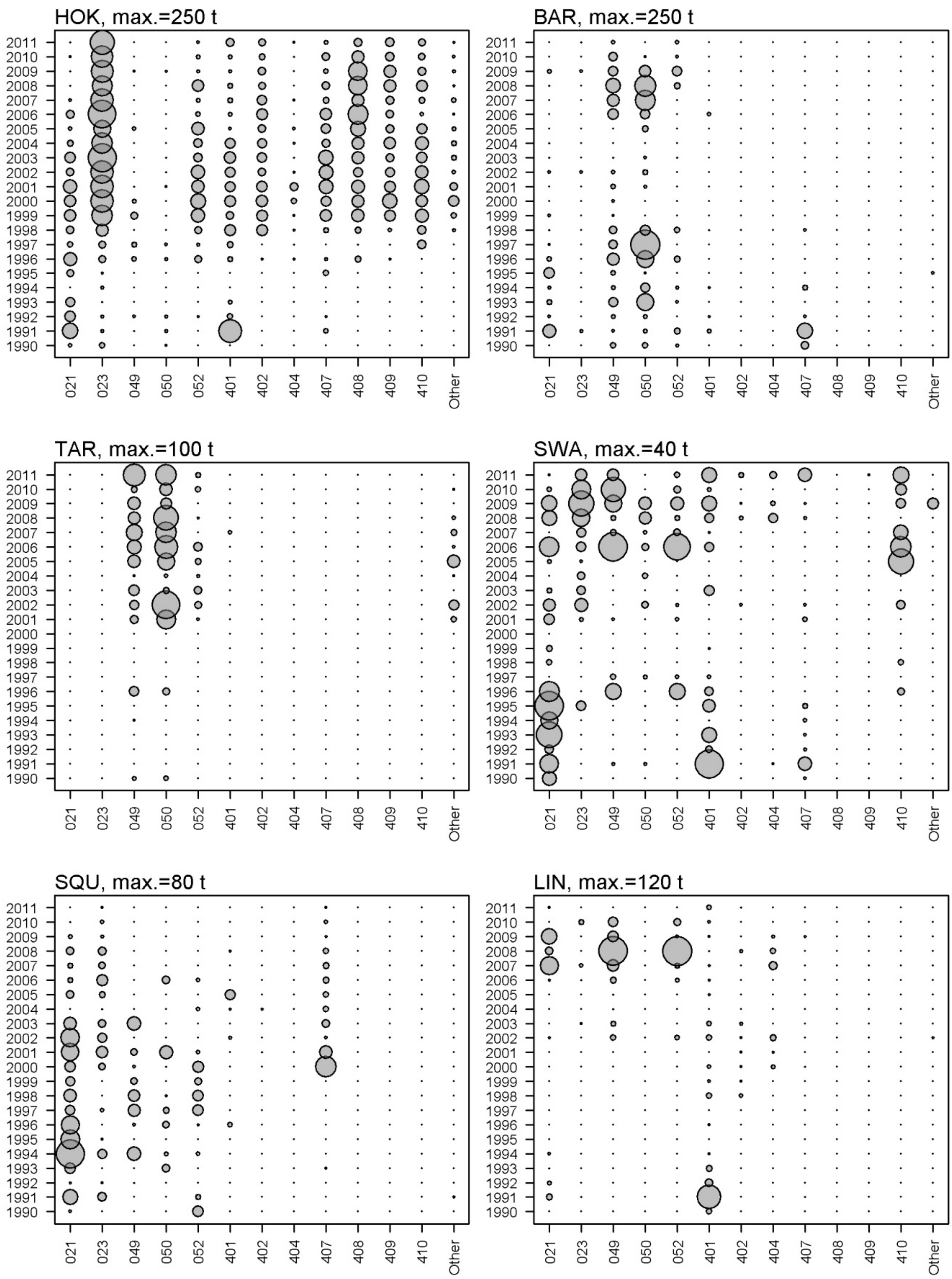


Figure C13b: Distribution of spiny dogfish annual catch (t) by statistical area for CHAT merged data for the top six target species for all TCEPR bottom trawl tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

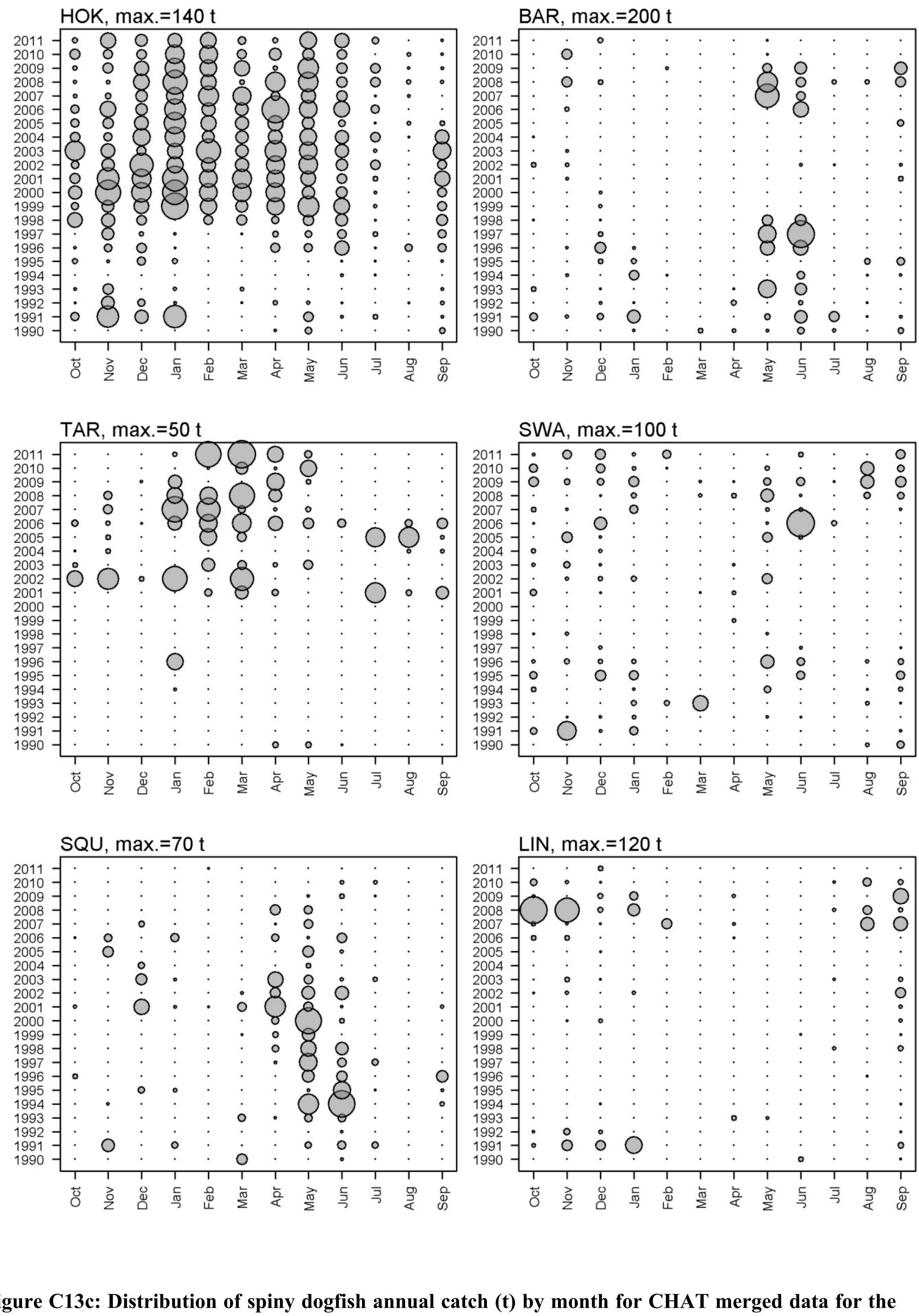


Figure C13c: Distribution of spiny dogfish annual catch (t) by month for CHAT merged data for the top six target species for all TCEPR bottom trawl tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

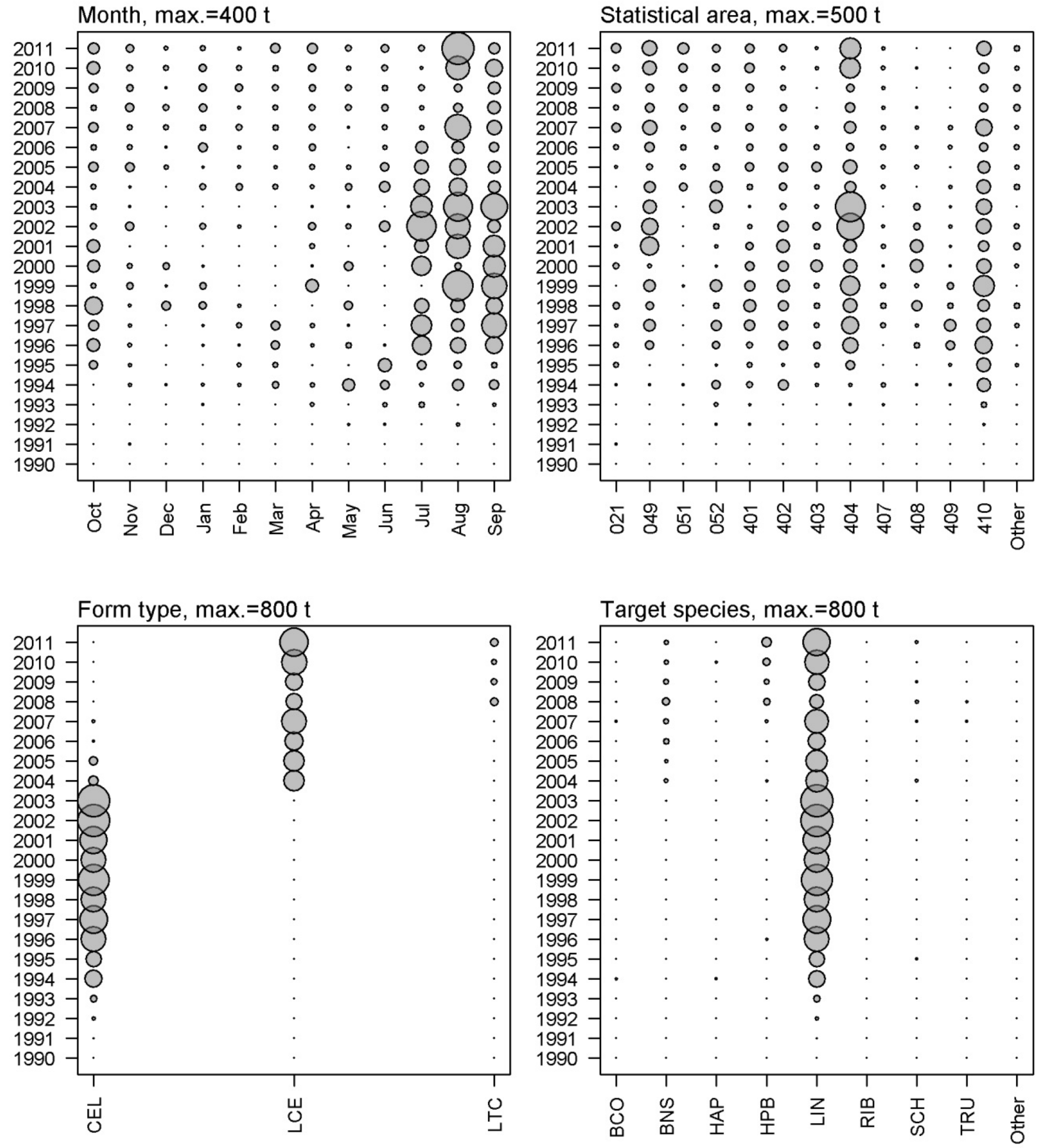


Figure C14a: Distribution of annual catch (t) by month, statistical area, form type, and target species for CHAT merged data for CELR, LCER, and LTCER bottom longline tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 1. Form type codes are given in Figure C10. Target species codes are given in Table C11.

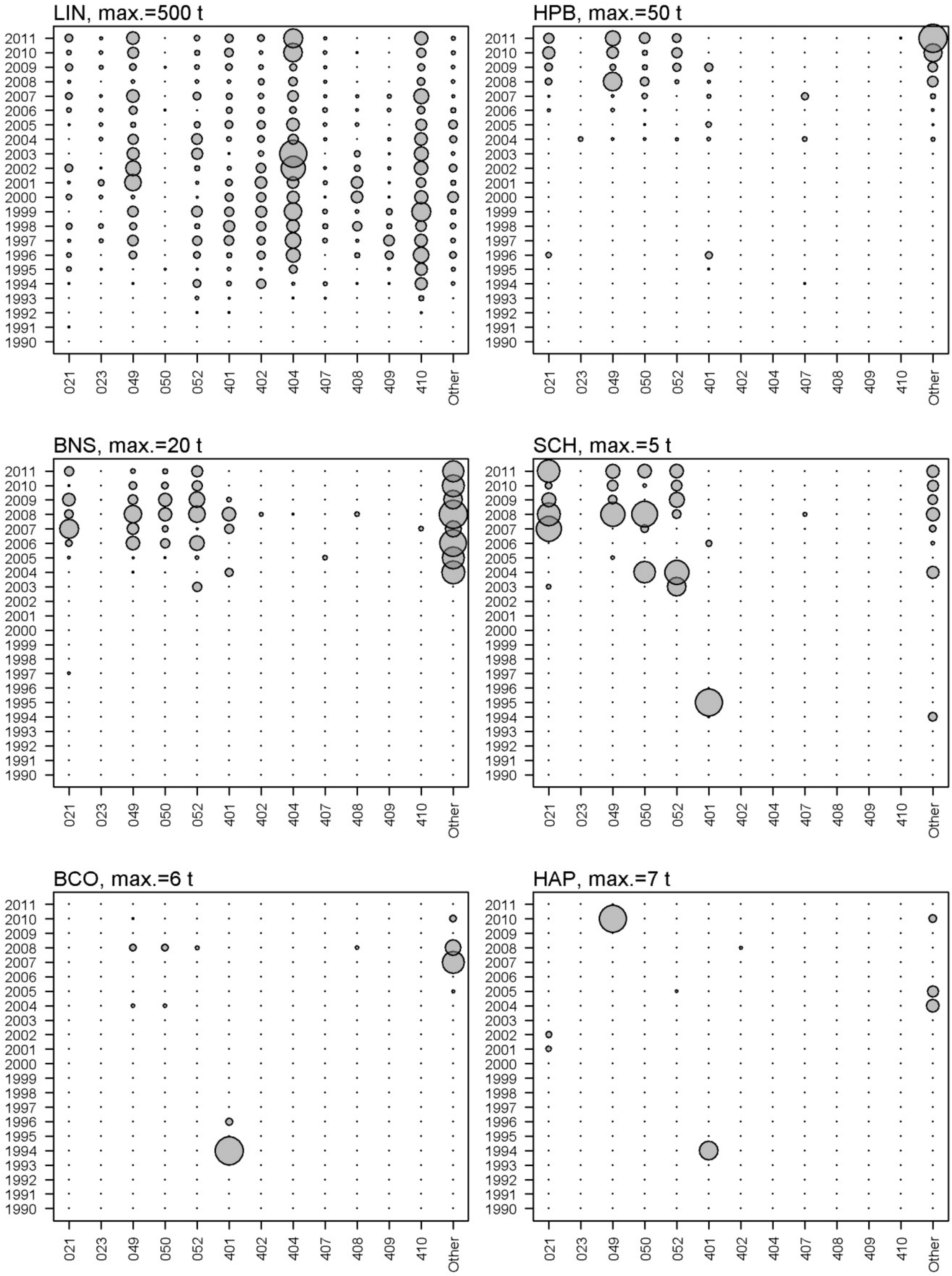


Figure C14b: Distribution of spiny dogfish annual catch (t) by statistical area for CHAT merged data for the top six target species for all CELR, LCER, and LTCER bottom longline events (method BLL). Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

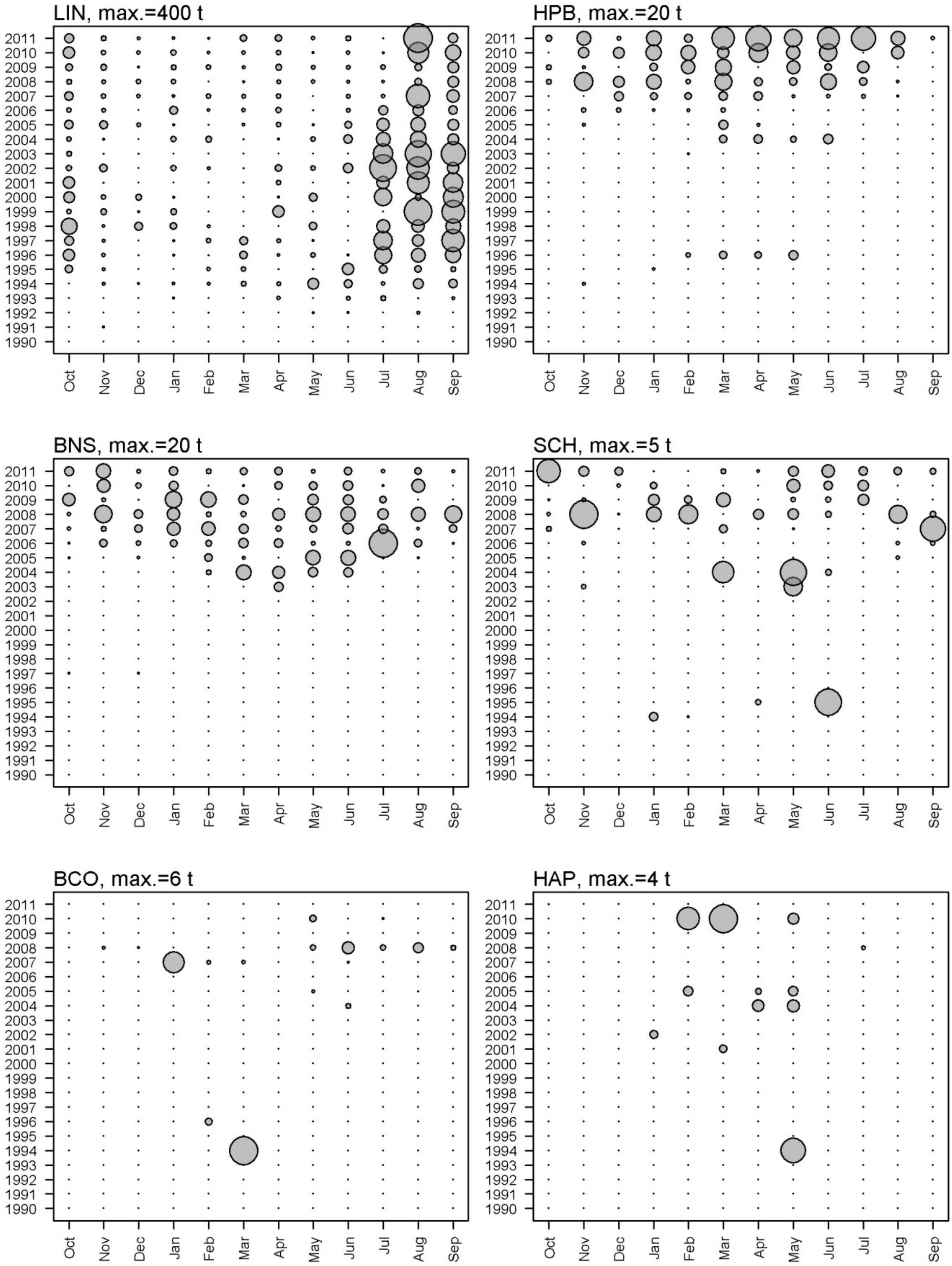


Figure C14c: Distribution of spiny dogfish annual catch (t) by month for CHAT merged data for the top six target species for all CELR, LCER, and LTCER bottom longline fishing events. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

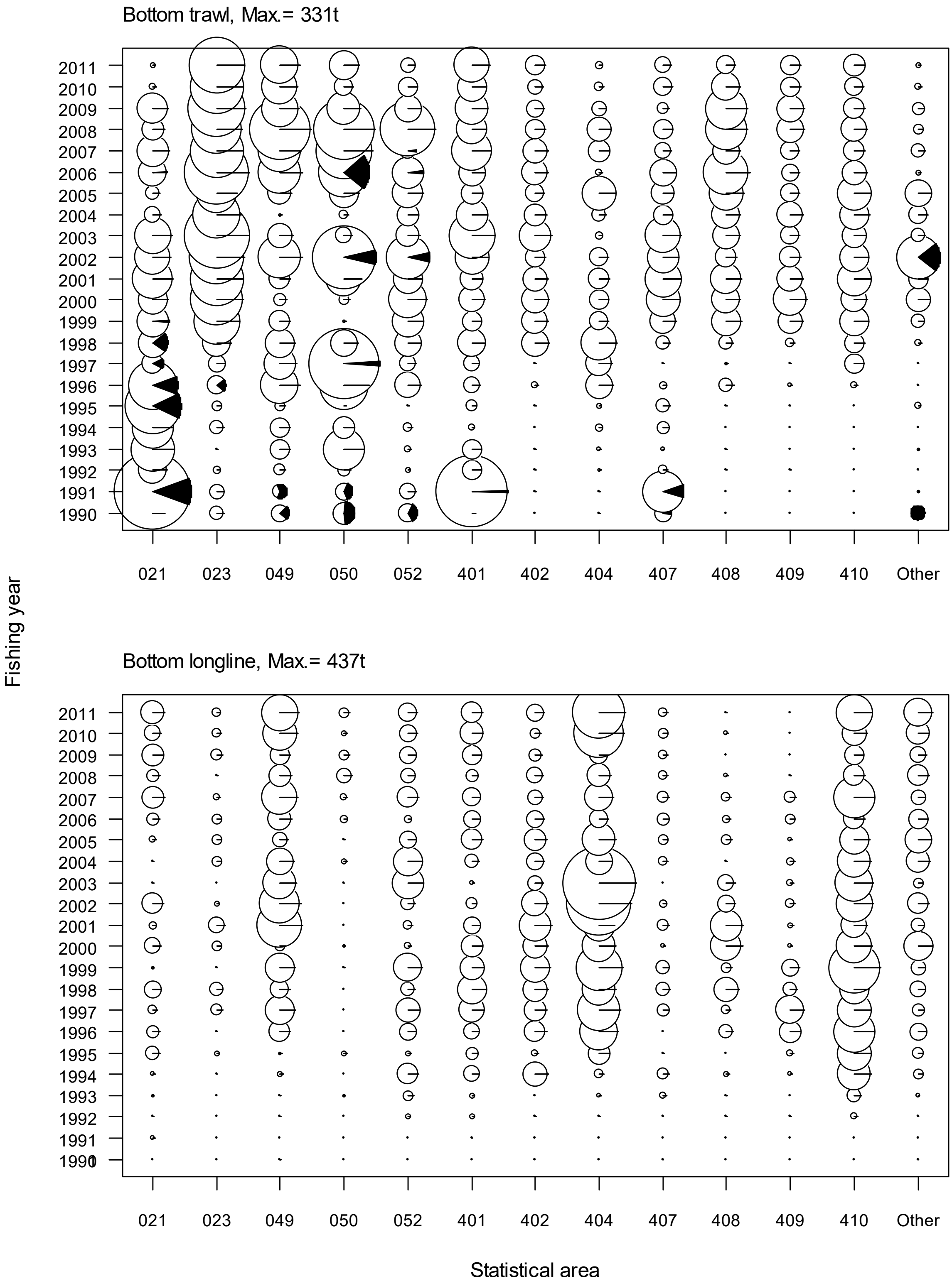


Figure C15a: Distribution of spiny dogfish catch by fishing year with circle size proportional to the total catch and black portion of the pie as proportion of the catch as targeted SPD by statistical area for the CHAT subarea for TCEPR bottom trawl and CELR, LCER, and LTCER bottom longline fishing methods. Statistical areas are shown in Figure 1.

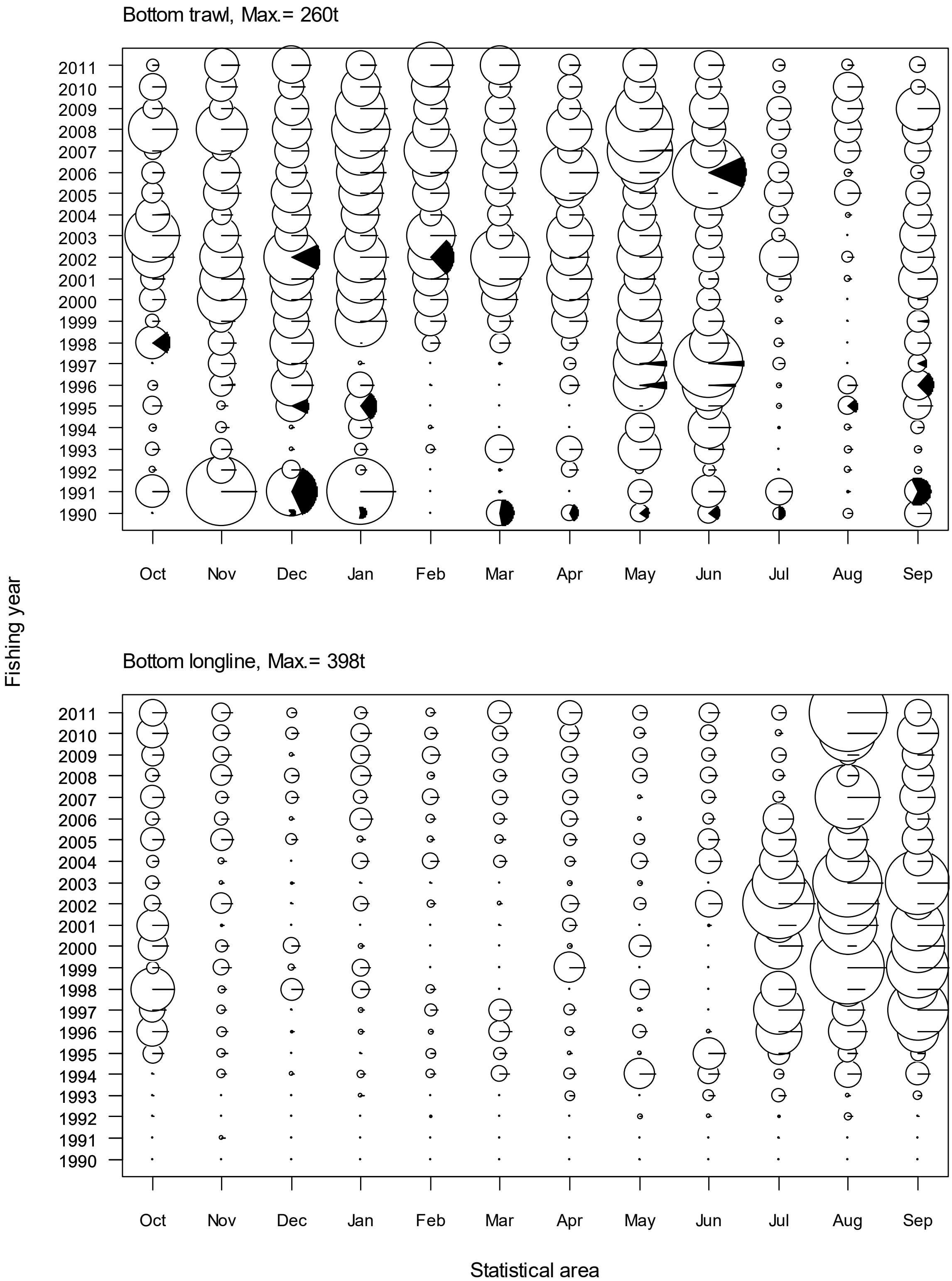


Figure C15b: Distribution of spiny dogfish catch by fishing year with circle size proportional to the total catch and black portion of the pie as proportion of the catch as targeted SPD by month for the CHAT subarea for TCEPR bottom trawl and CELR, LCER, and LTCER bottom longline fishing methods.

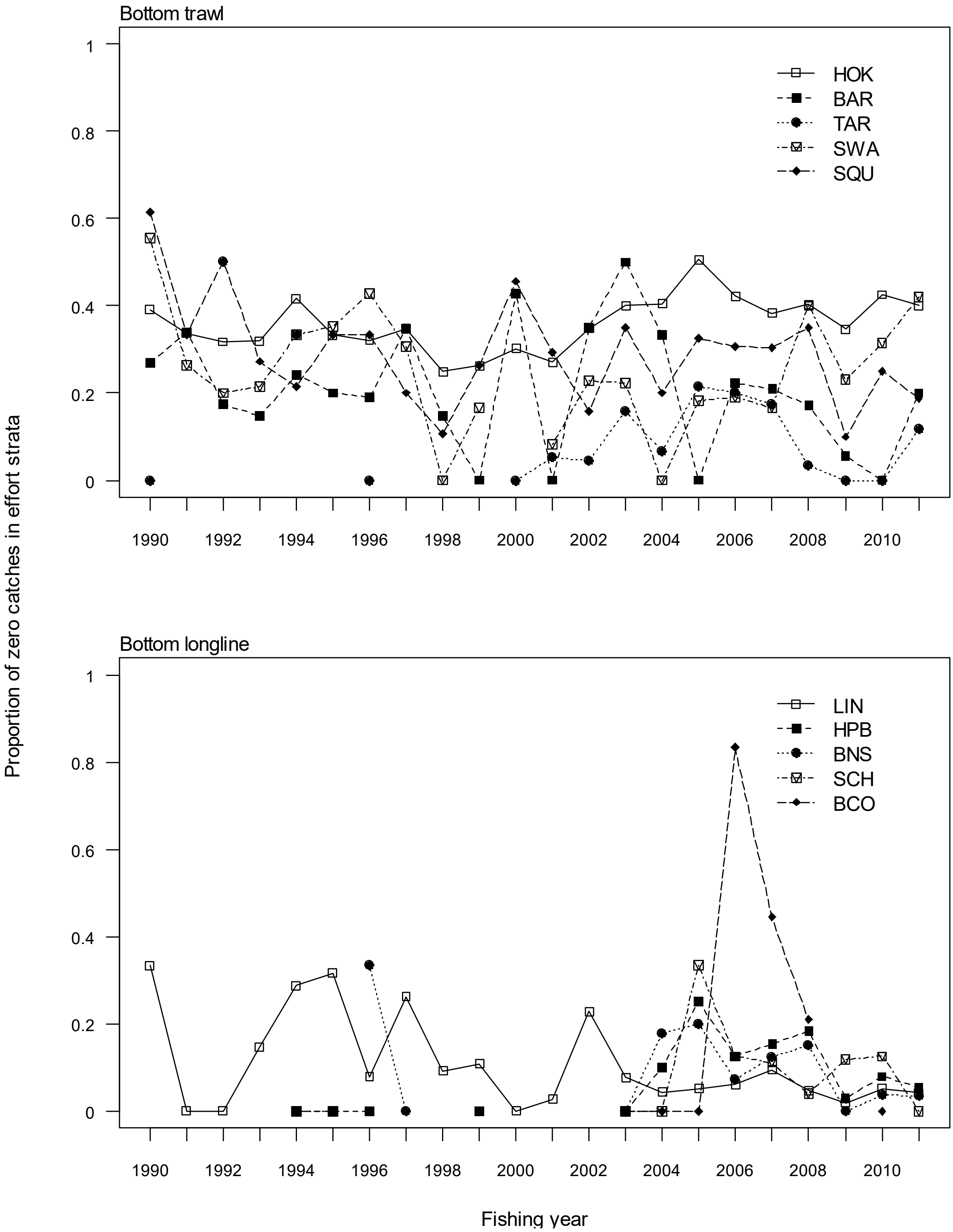
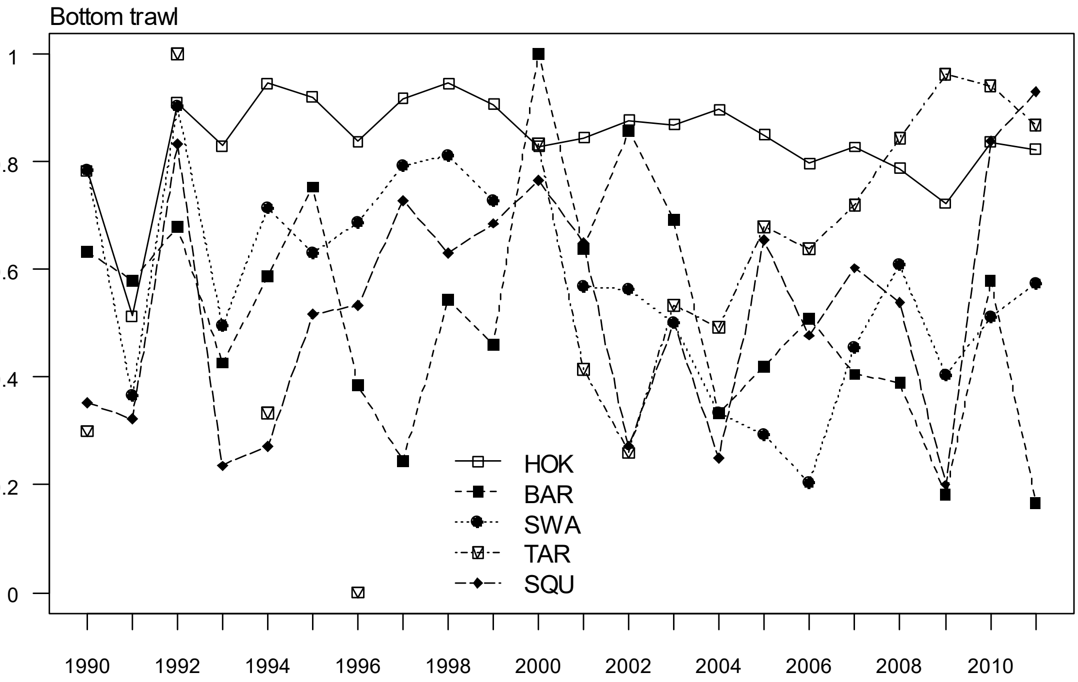


Figure C16a: Proportion of zeros by main target species for the CHAT subarea for TCEPR bottom trawl and CELR, LCER, and LTCER bottom longline fishing methods for merged data.



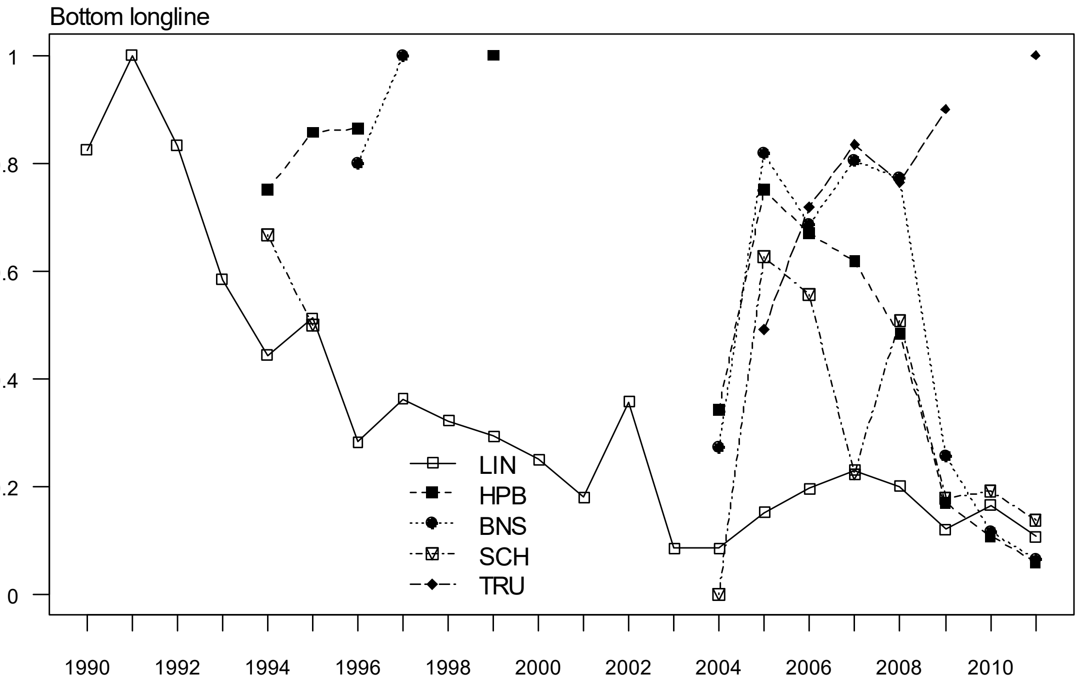


Figure C16b: Proportion of zeros by main target species for the CHAT subarea for TCEPR bottom trawl and CELR, LCER, and LTCER bottom longline fishing methods for unmerged data.

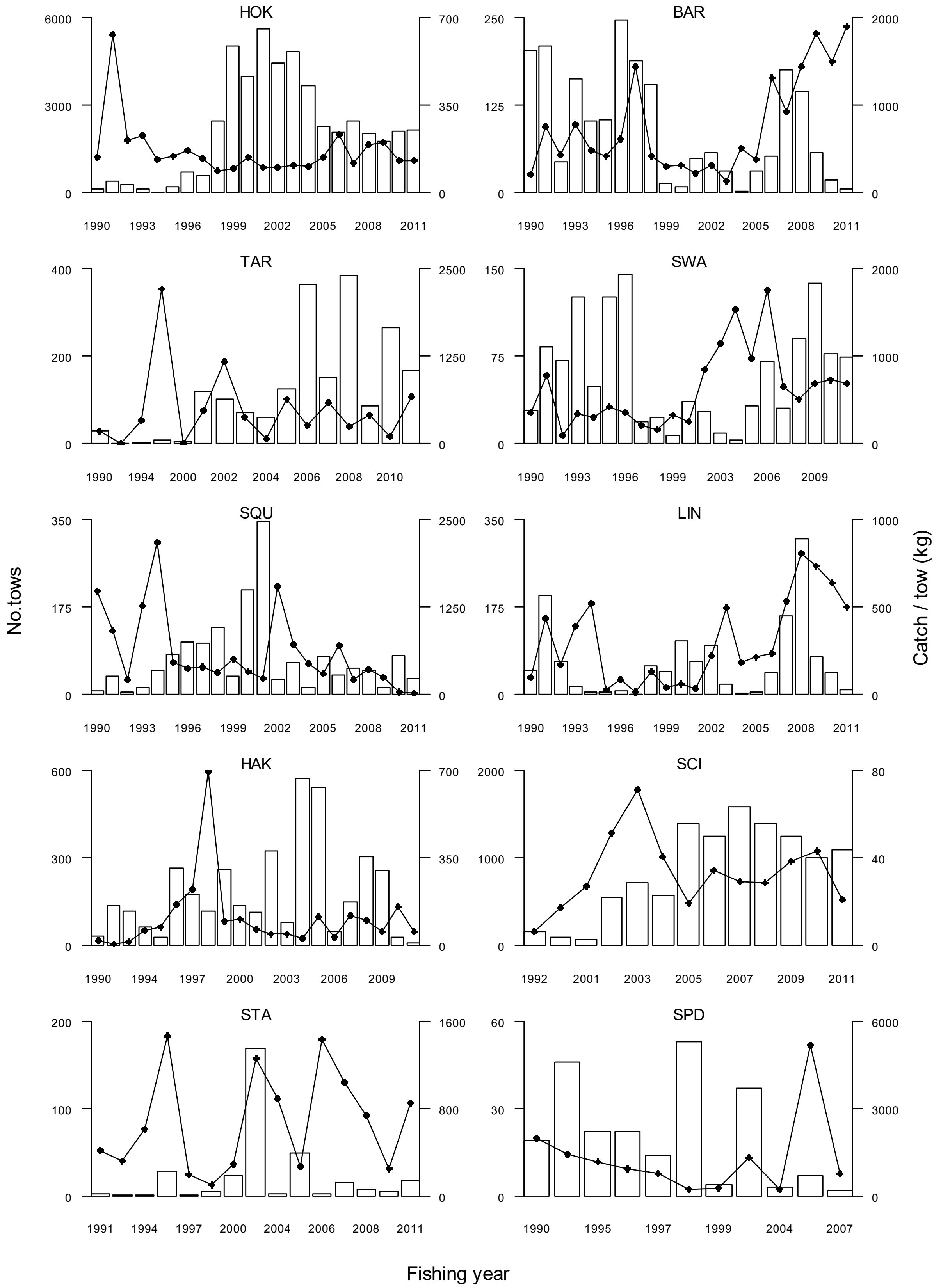


Figure C17a: Unstandardised catch rate (kg/tow) of spiny dogfish taken by TCEPR bottom trawl gear (lines), and the number of tows (bars) for the CHAT area, by target species for merged data. Target species codes are given in Table C11.

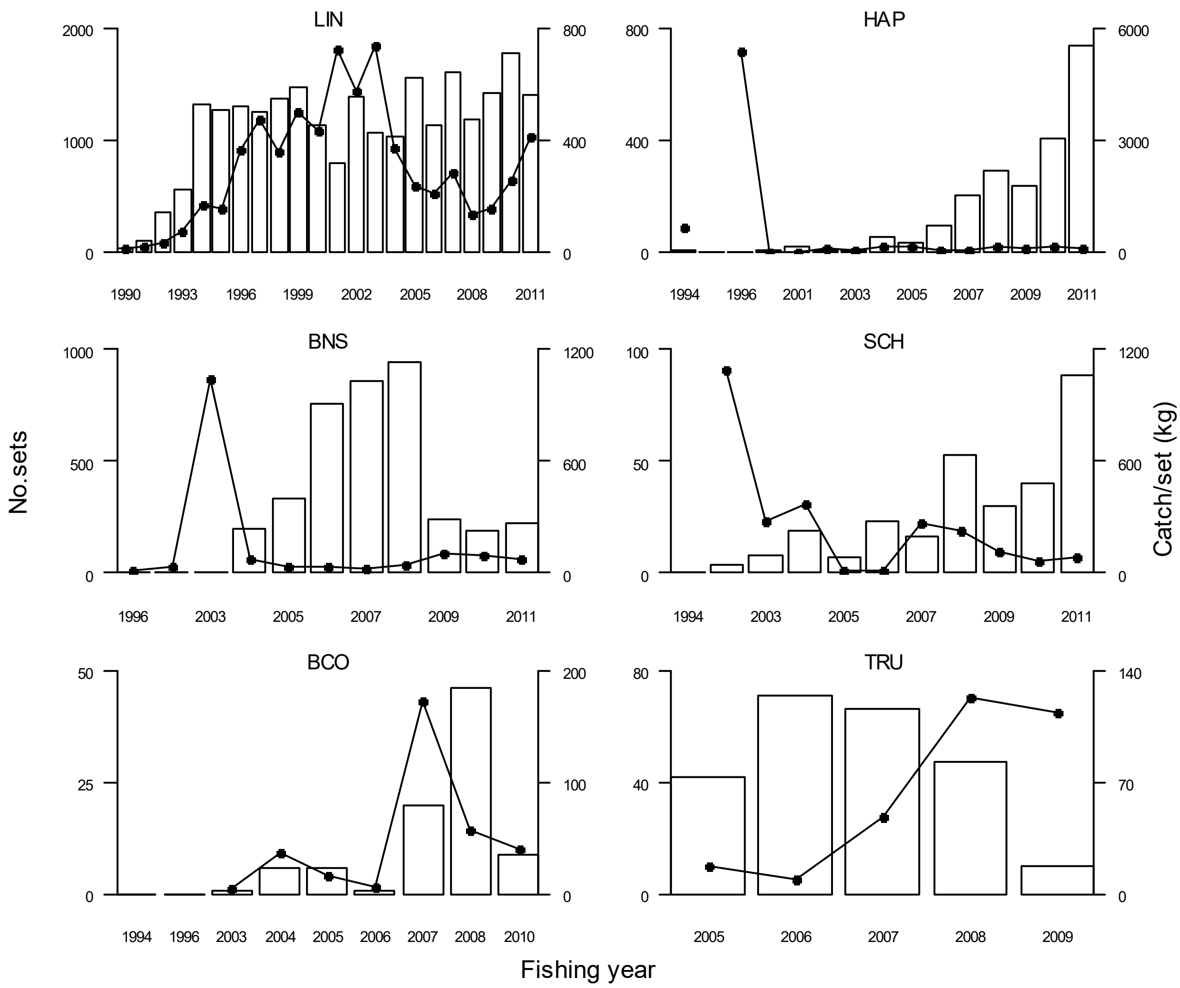


Figure C17b: Unstandardised catch rate (kg/set) of spiny dogfish taken by CELR, LCER, and LTCER bottom longline for gear (lines), and the number of tows (bars) for the CHAT area, by target species for merged data. Target species codes are given in Table C11.

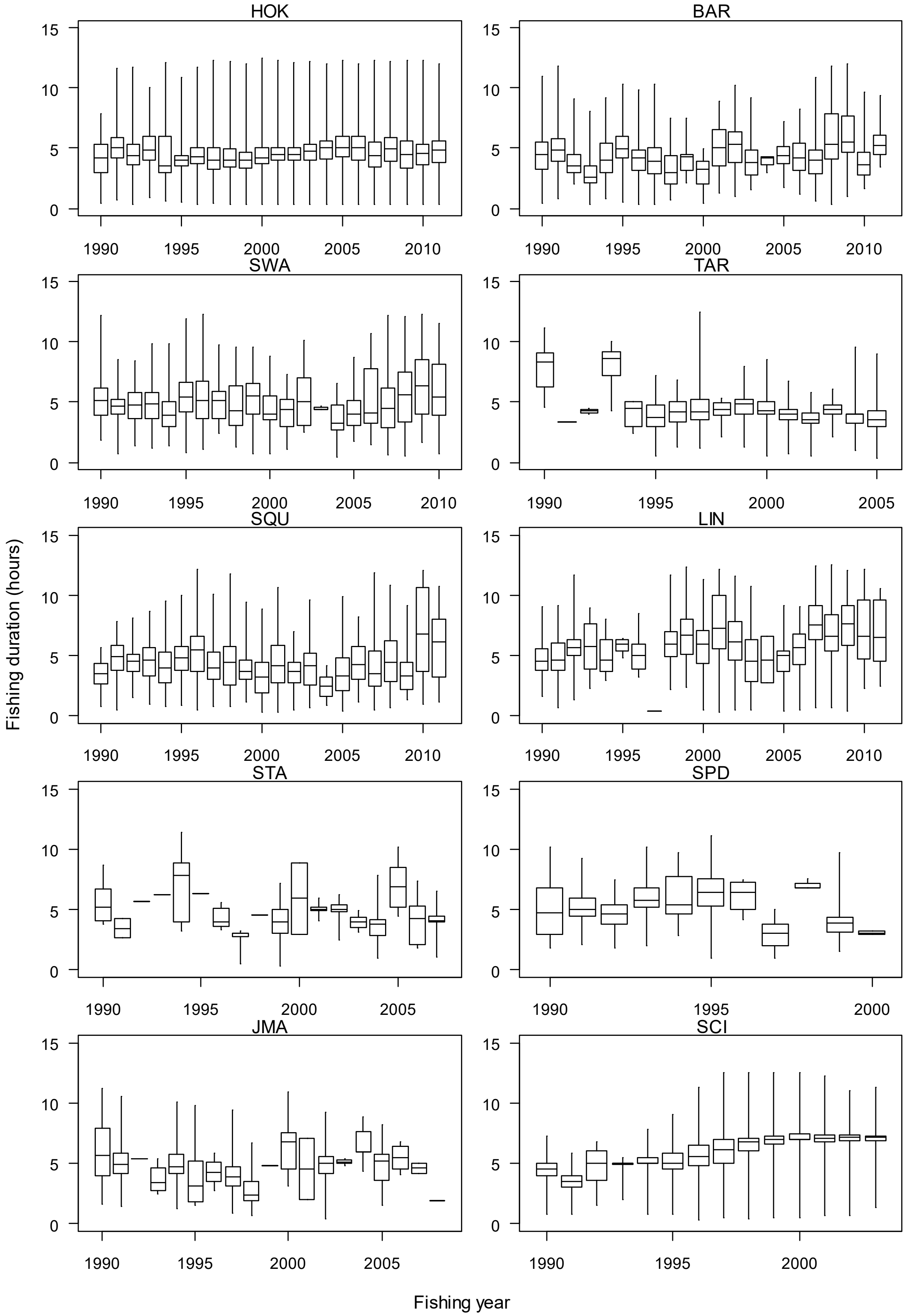


Figure C18: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during TCEPR bottom trawls that caught spiny dogfish in the CHAT area, by target species and fishing year where 1989–90 is 1990. Target species codes are given in Table C11.

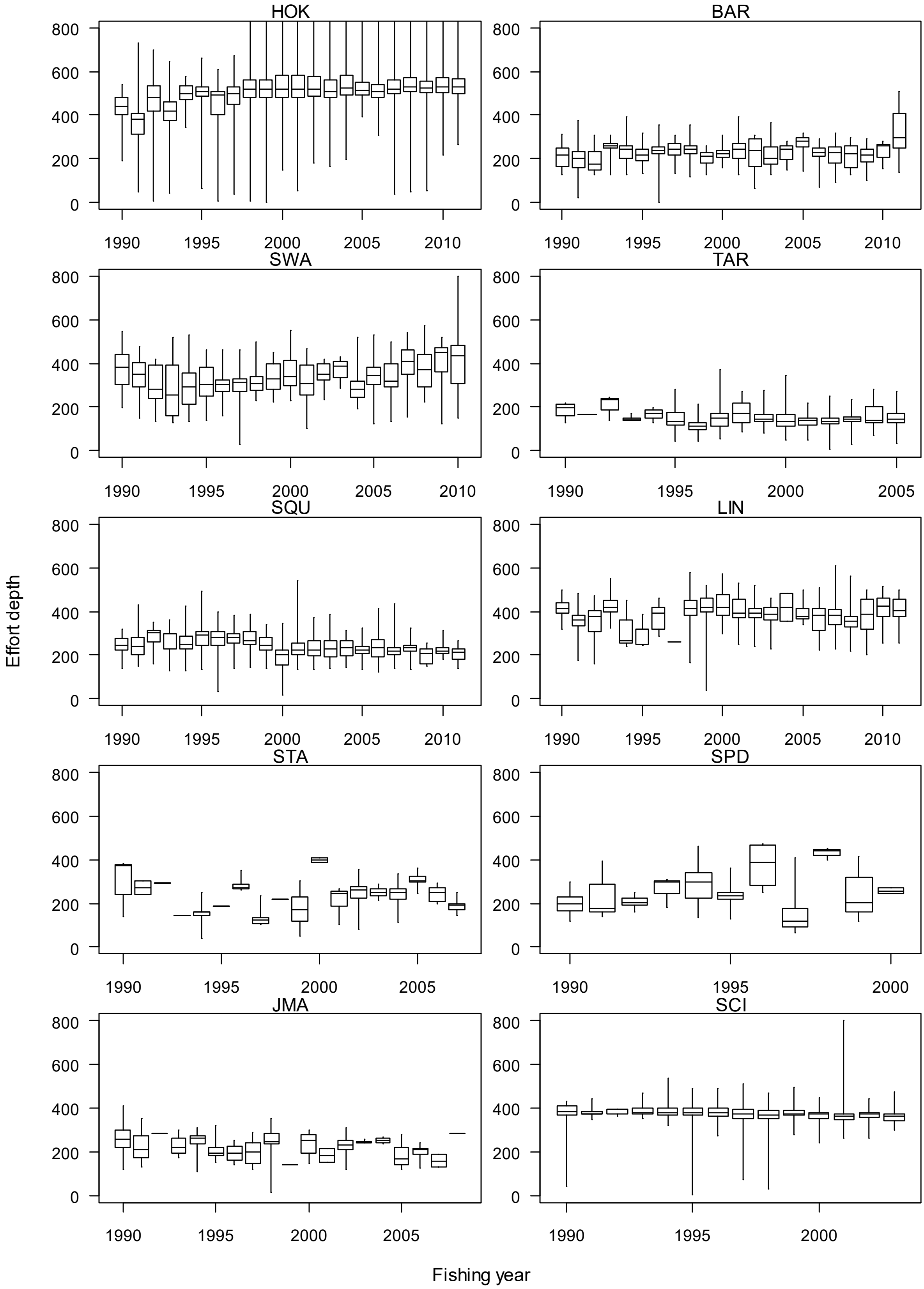


Figure C19: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished by TCEPR bottom trawls that caught spiny dogfish in the CHAT area by target species and fishing year where 1989–90 is 1990. Target species codes are defined in Table C11.

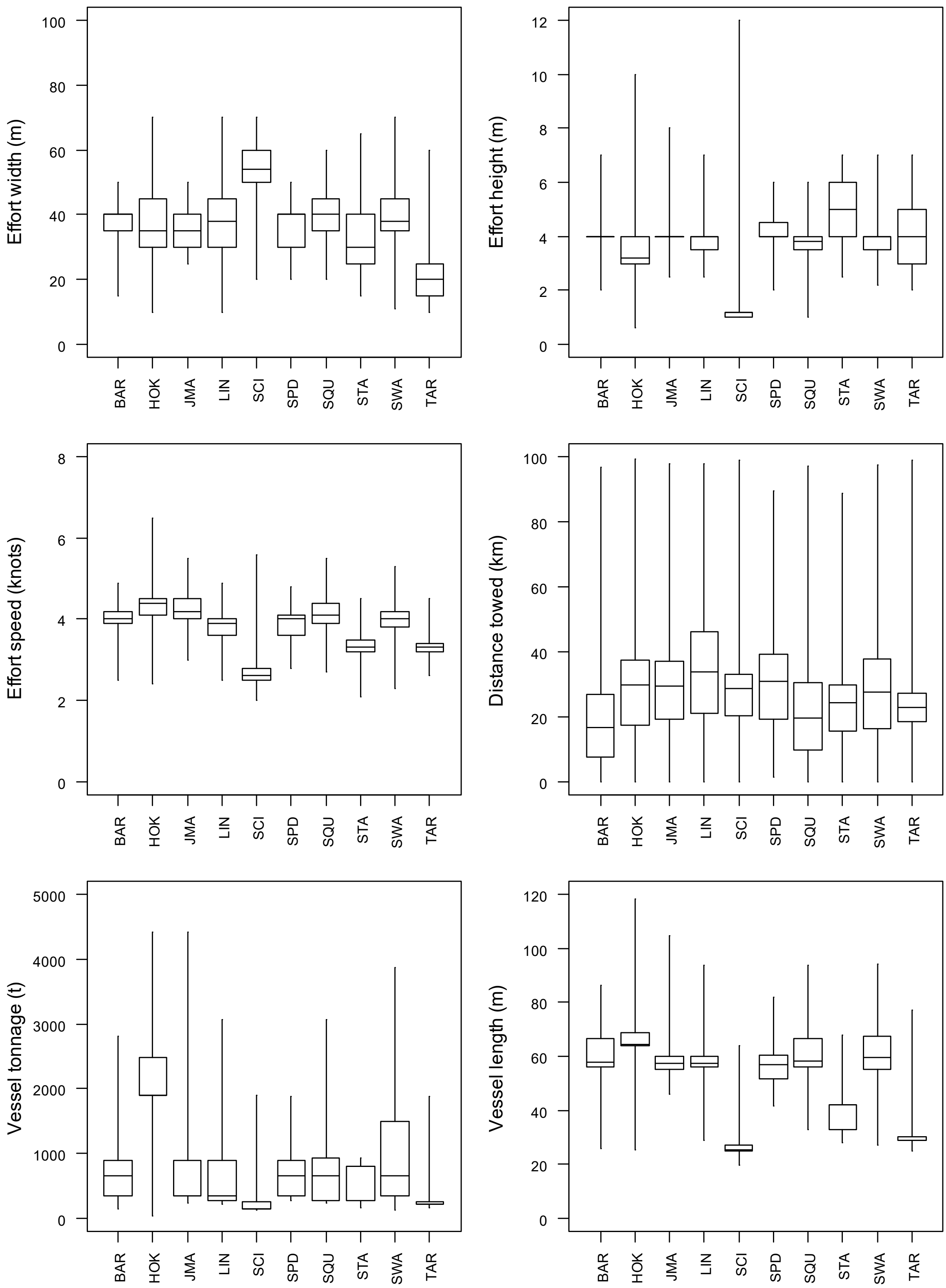


Figure C20: Distribution of fishing effort variables and vessel characteristics for the CHAT area during TCEPR bottom trawl effort for the major target species that caught spiny dogfish. Target species codes are given in Table C11.

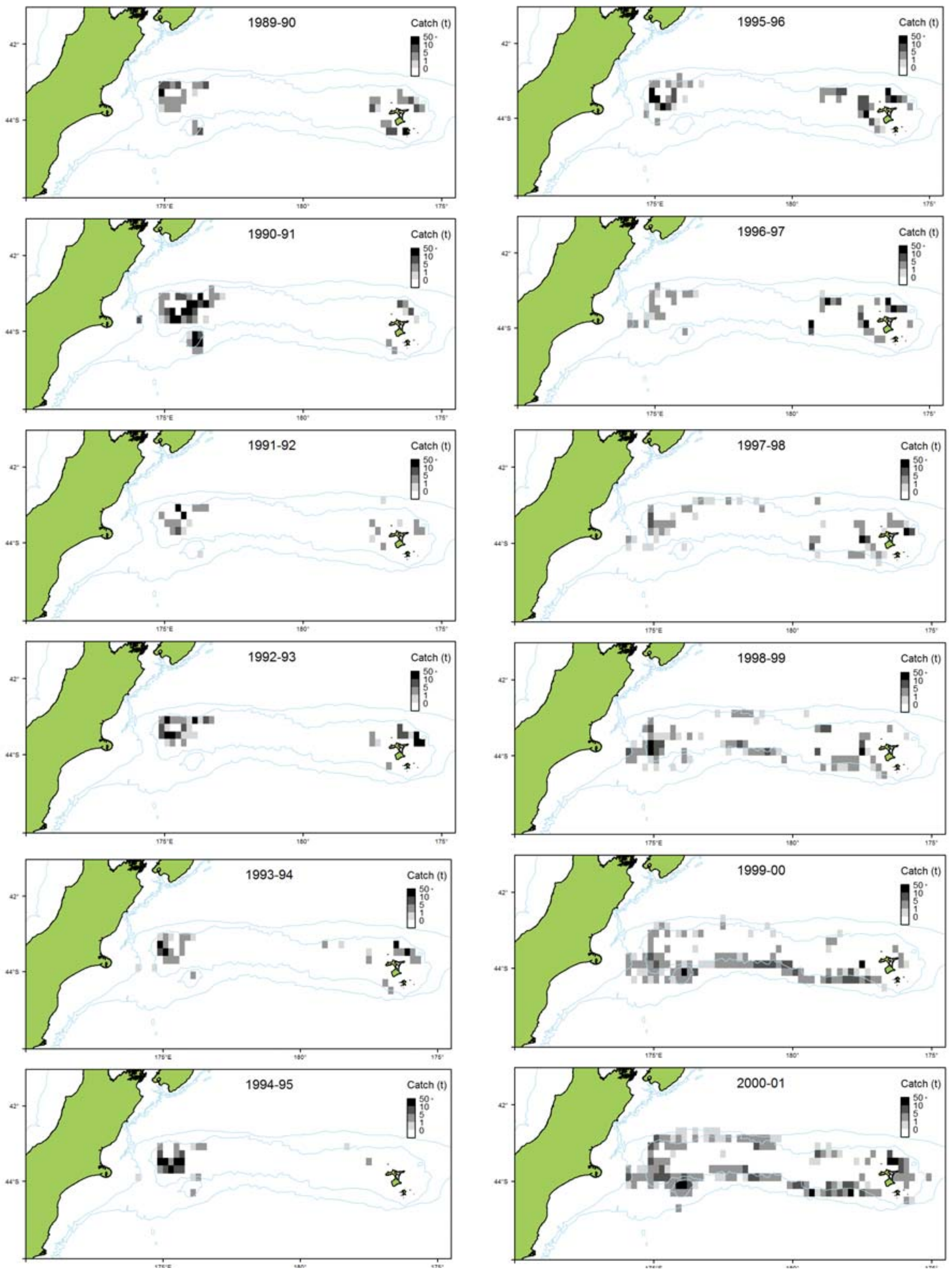


Figure C21: Distribution of TCEPR bottom trawl spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 1989–90 to 2000–01.

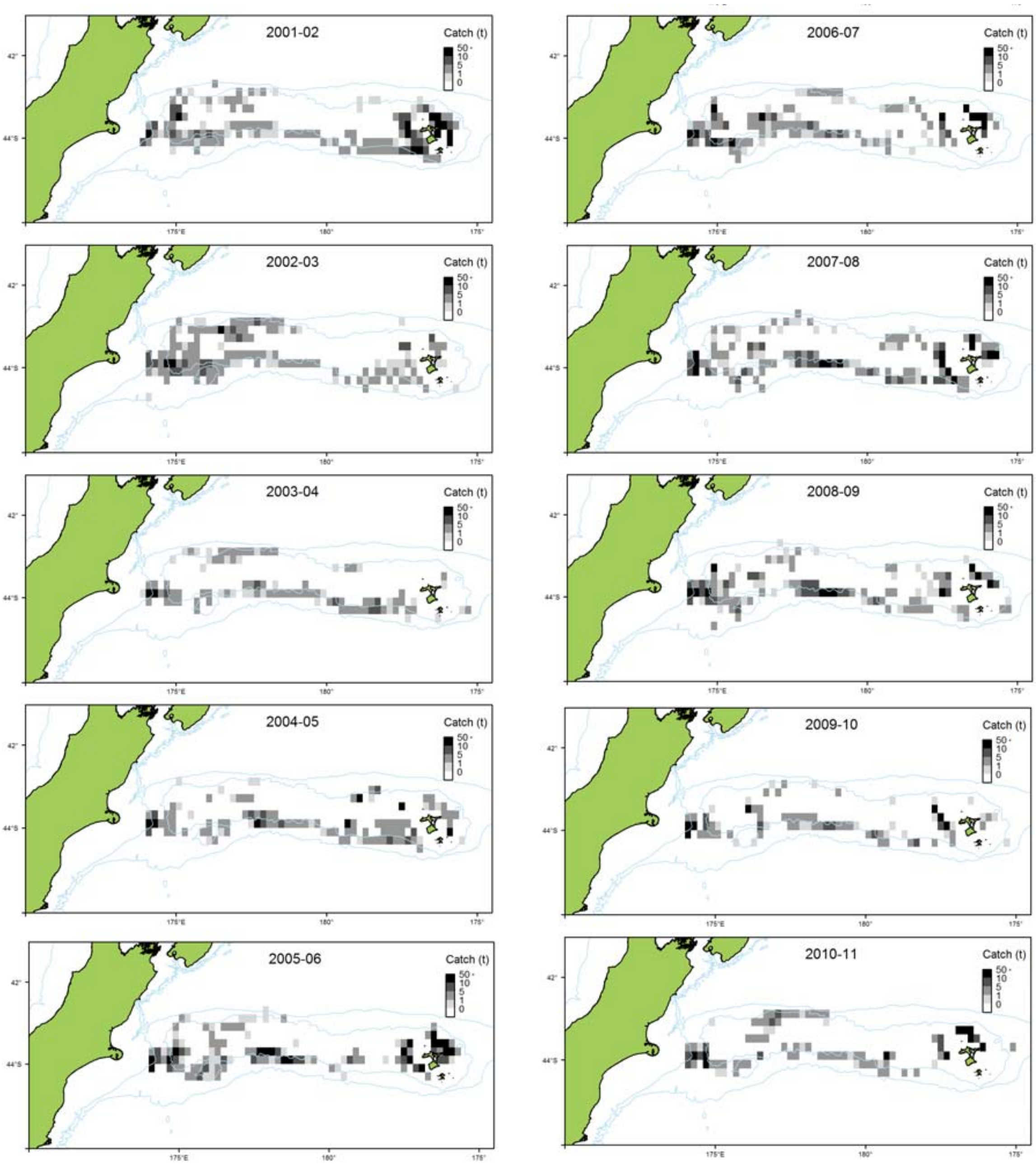


Figure C21 *continued*: Distribution of TCEPR bottom trawl spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 1997–98 to 2010–11.

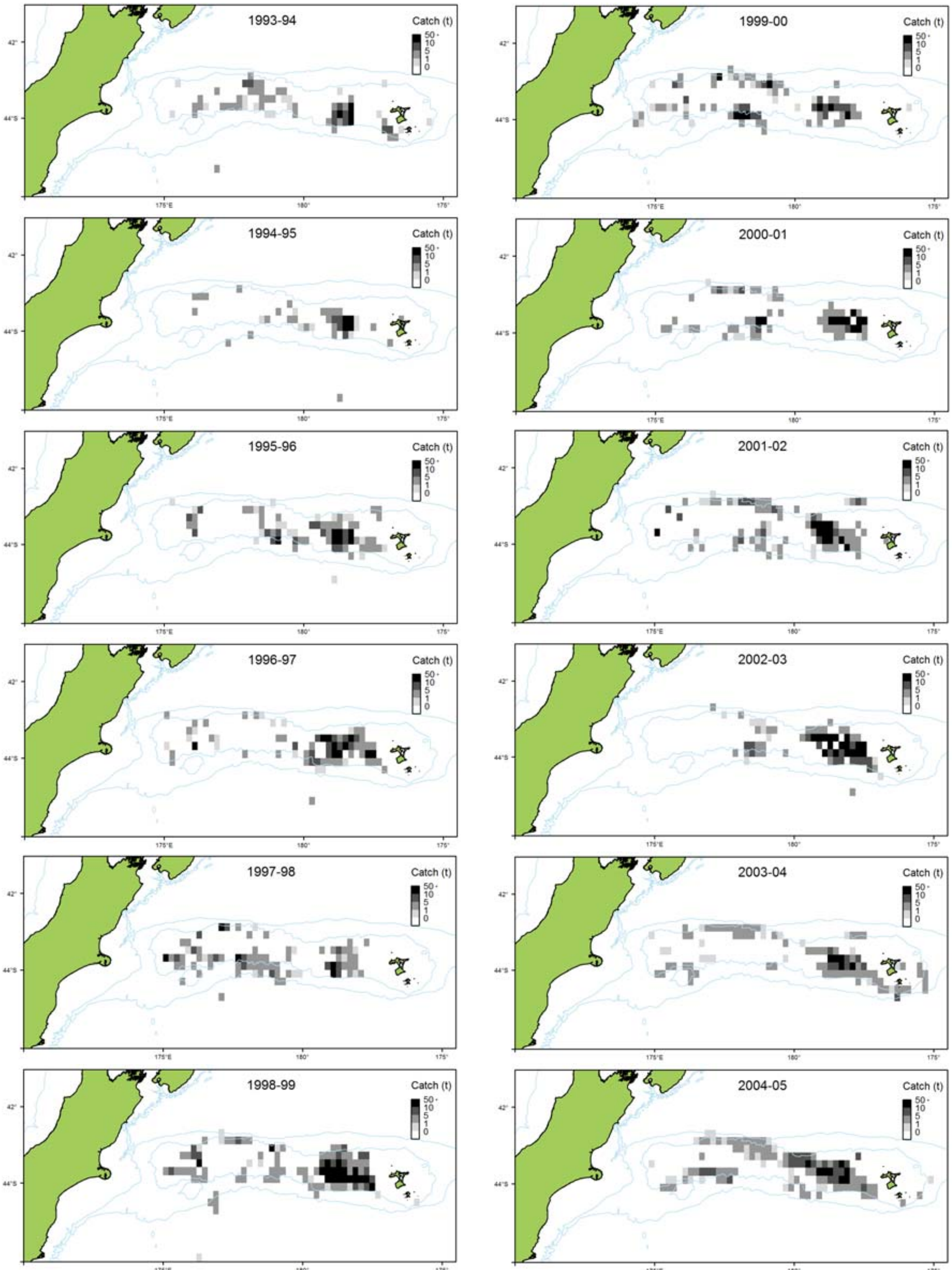


Figure C22: Distribution of CELR, LTCER, and LCER bottom longline spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 1993–94 to 2004–05.

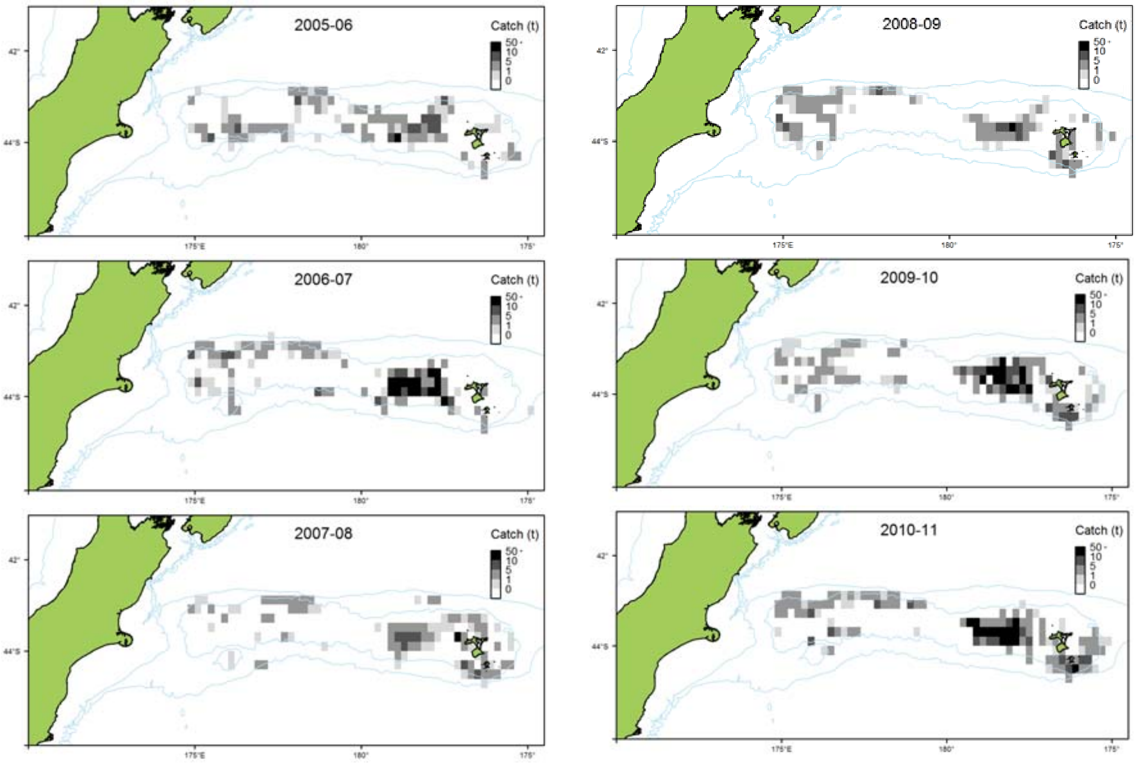


Figure C22 *continued*: Distribution of CELR, LTCER, and LCER bottom longline spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the CHAT area, for 2005–06 to 2010–11.

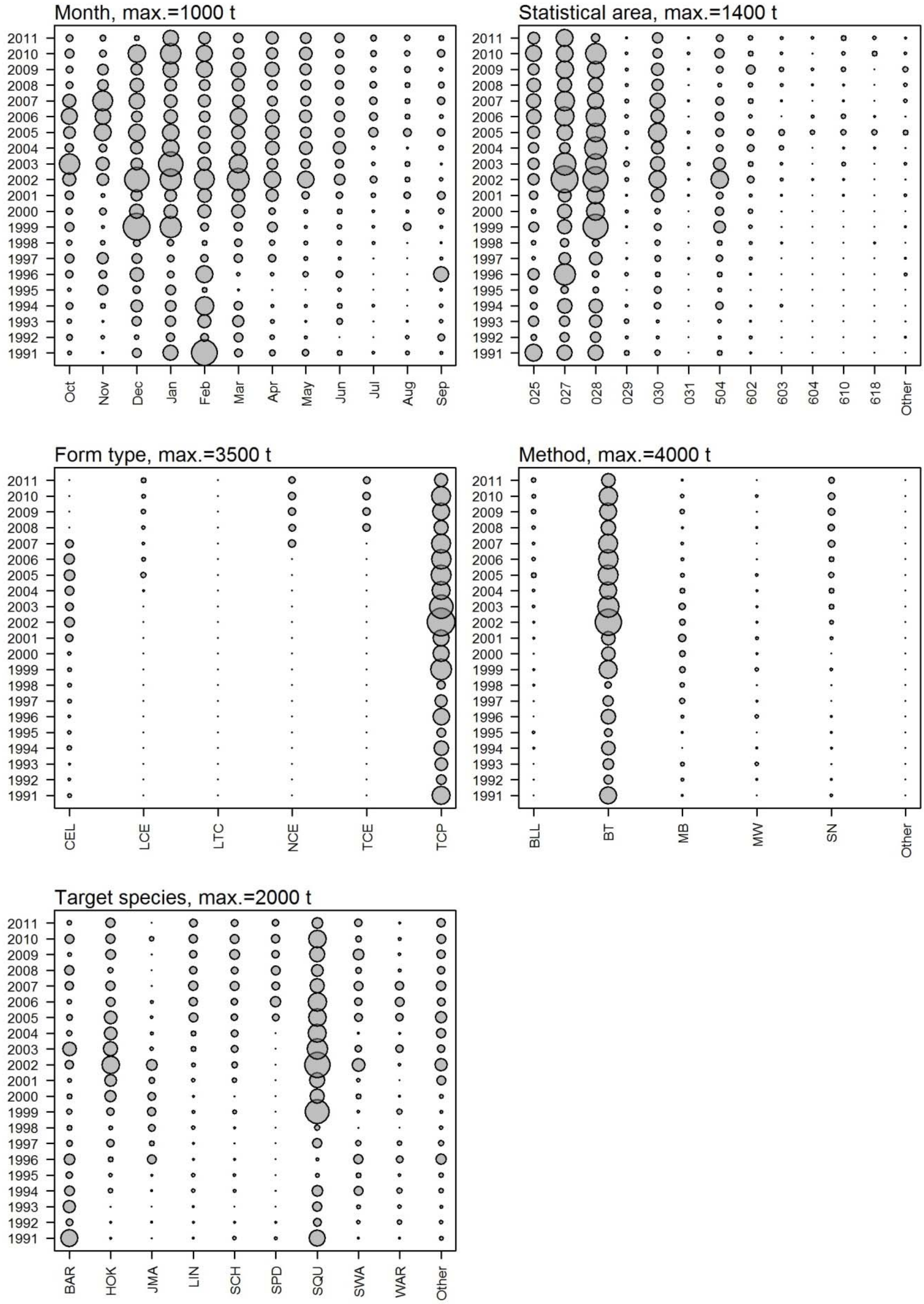


Figure C23: Distribution of annual catch (t) by month, statistical area, form type, method, and target species for SUBA merged data. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Method codes are given in Figure C10; target species codes are given in Table C11; and form types are defined in Figure C7.

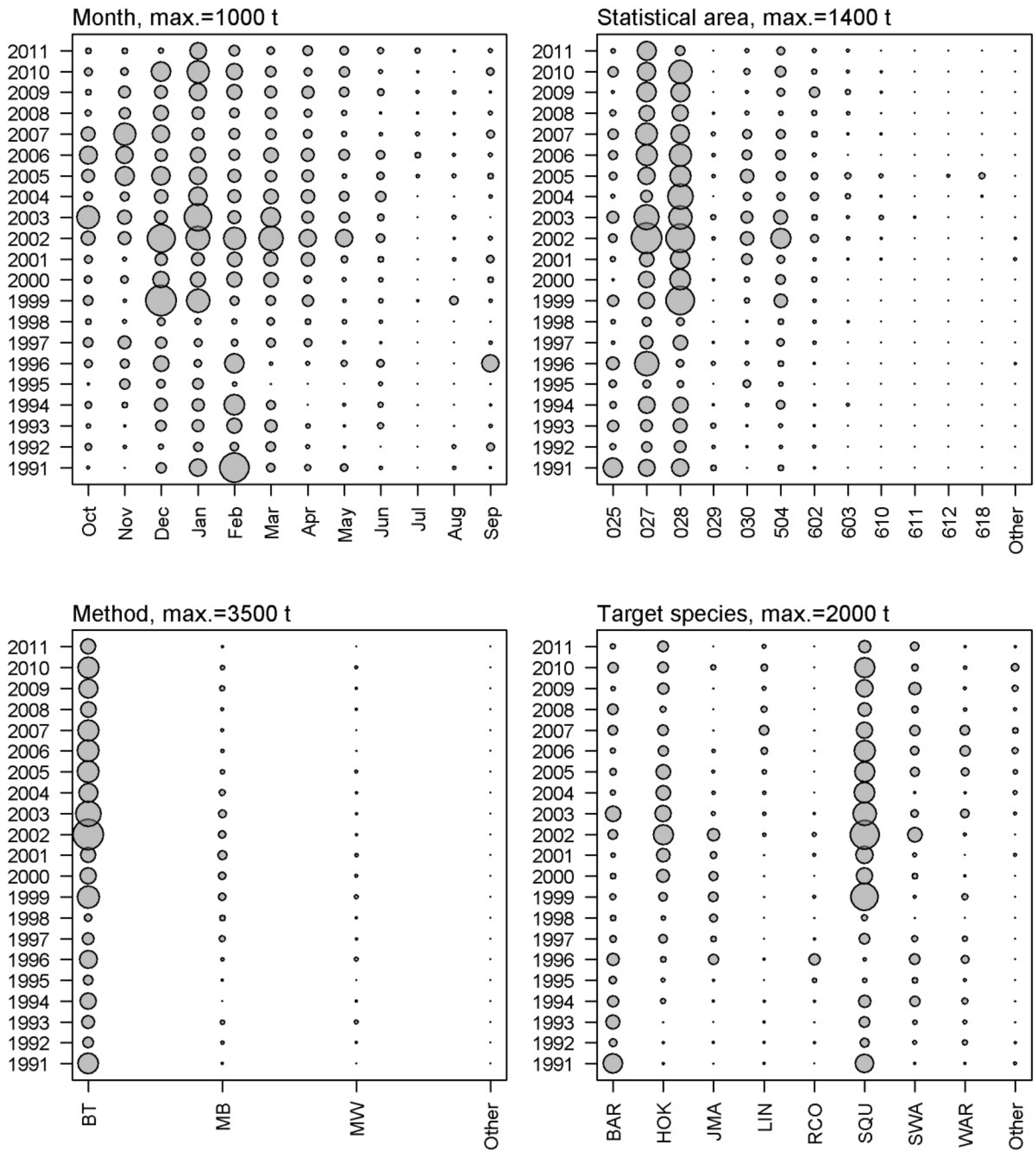


Figure C24a: Distribution of annual catch (t) by month, statistical area, method, and target species for SUBA merged data for TCEPR bottom tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are given in Table C11.

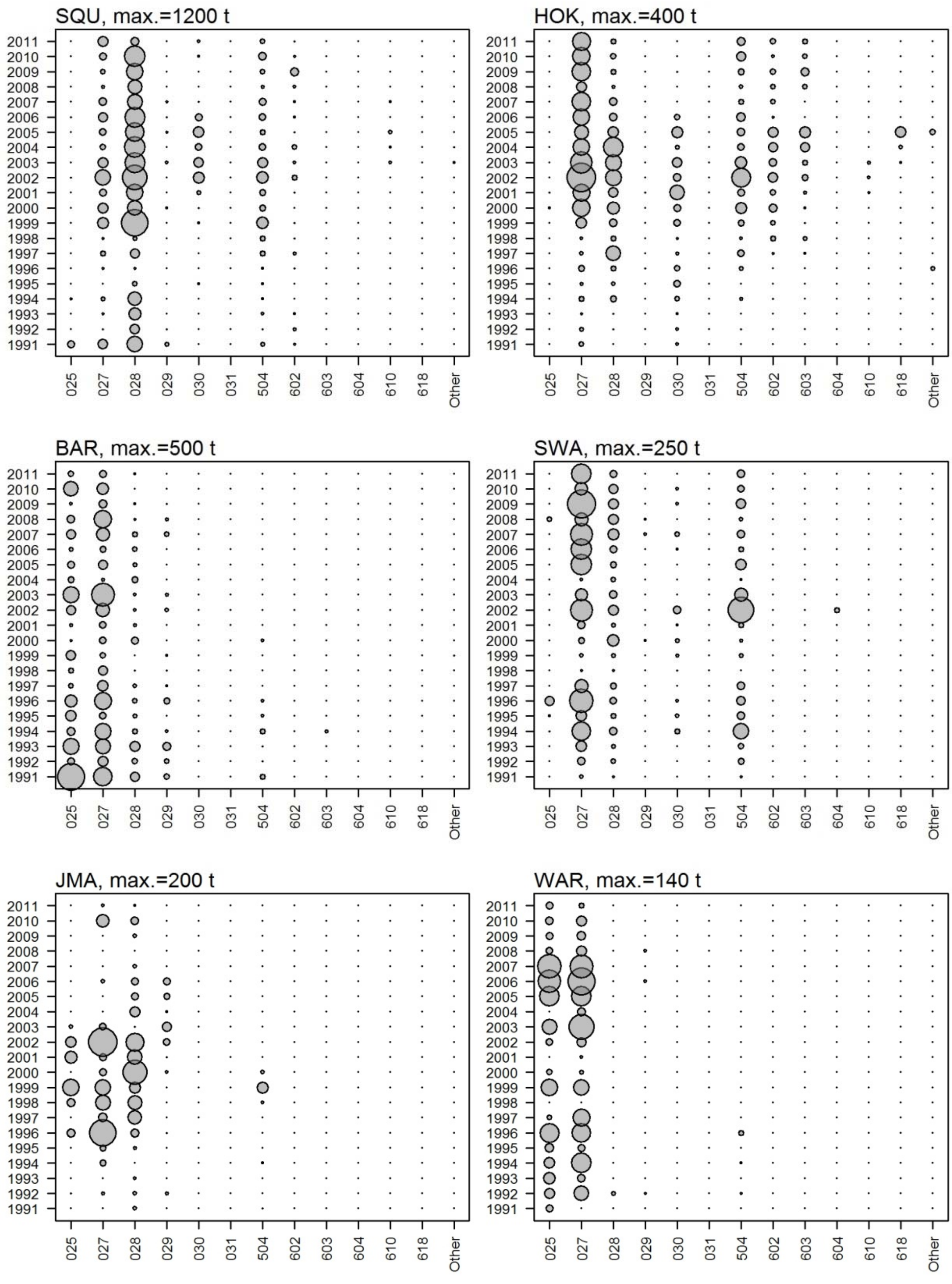


Figure C24b: Distribution of spiny dogfish annual catch (t) by statistical area for SUBA merged data for the top six target species for all TCEPR bottom and midwater trawl tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

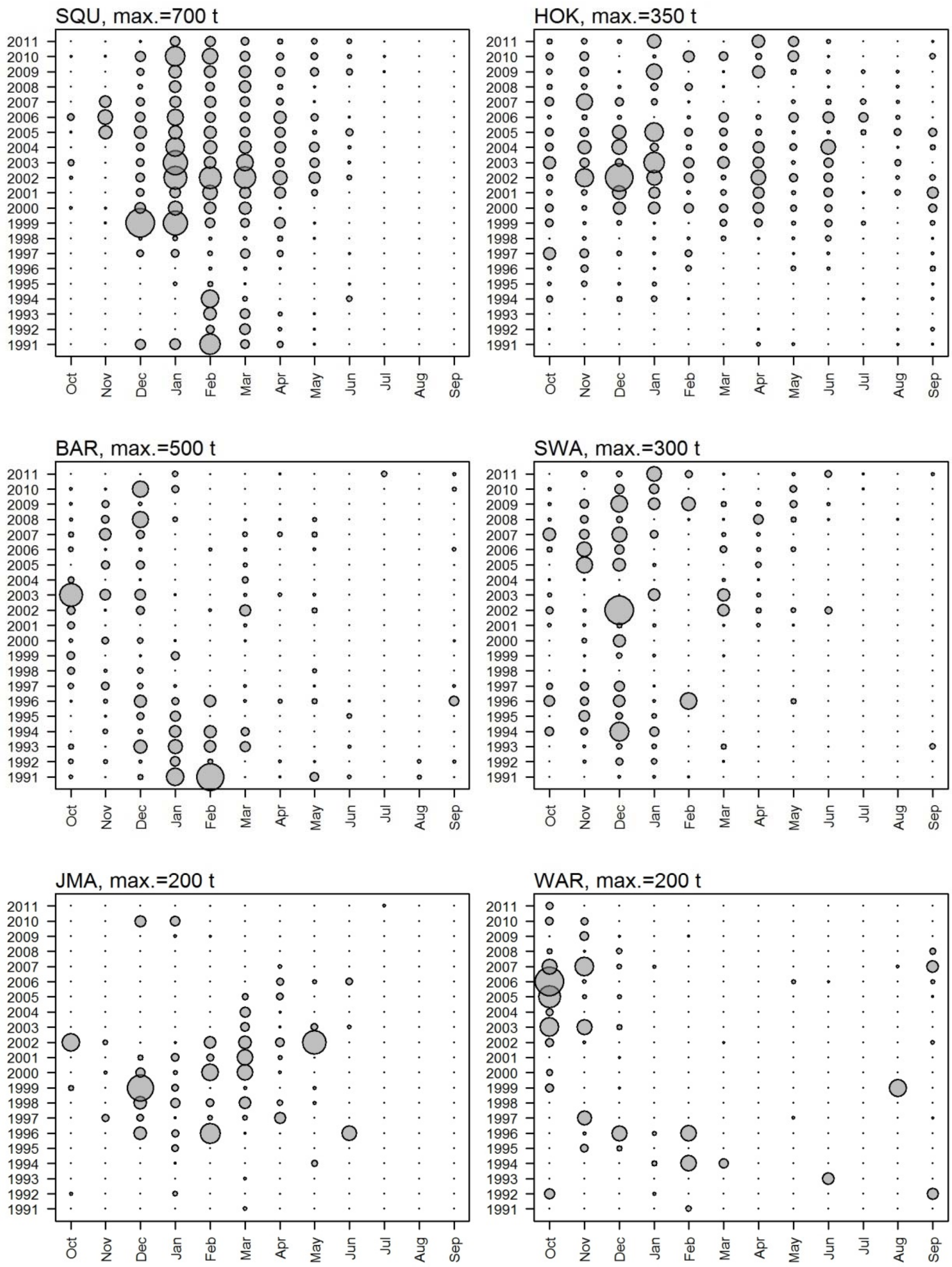


Figure C24c: Distribution of spiny dogfish annual catch (t) by month for SUBA merged data for the top six target species for all TCEPR bottom and midwater trawl tows. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot.

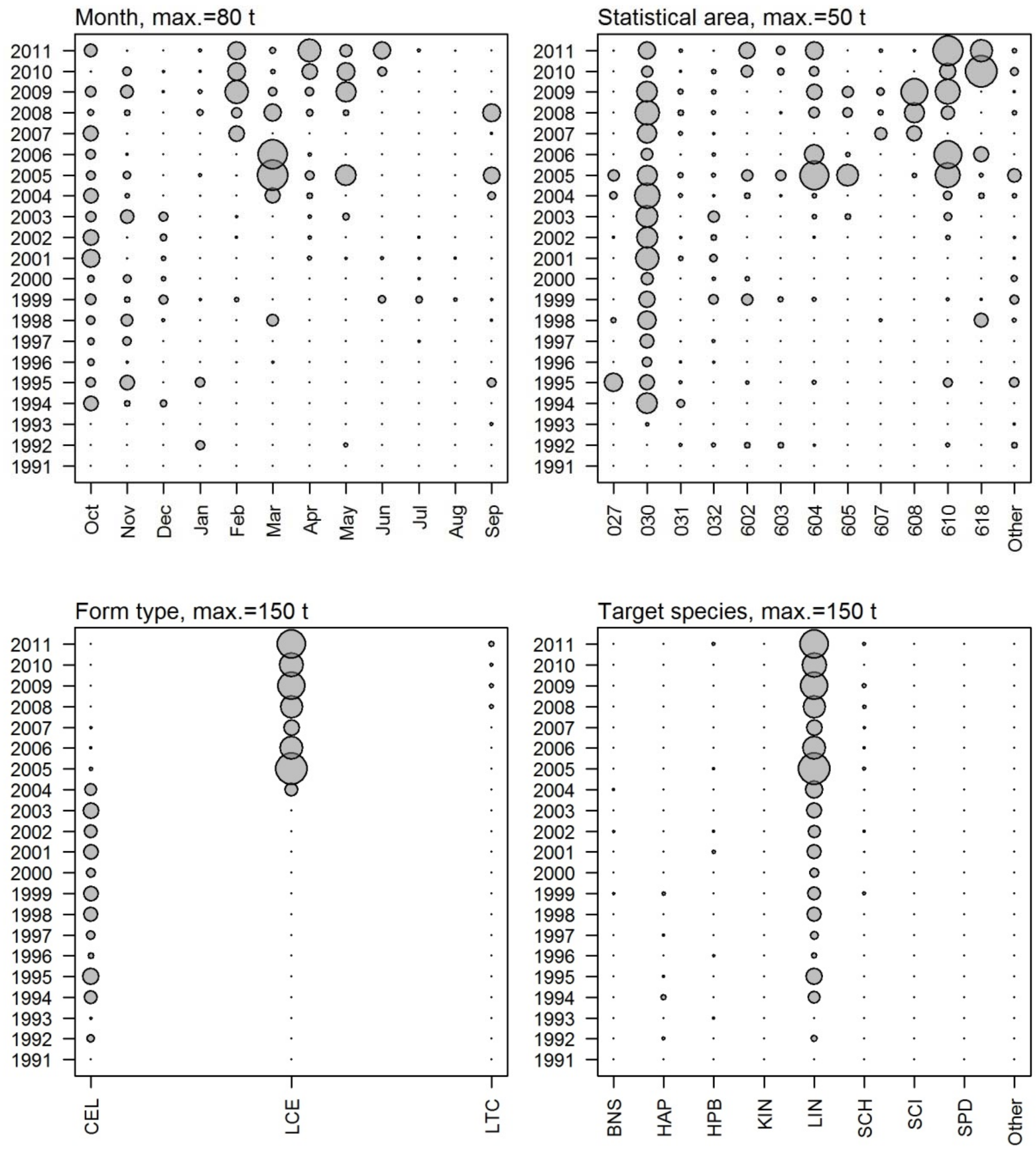


Figure C25a: Distribution of annual catch (t) by month, statistical area, form type, and target species for SUBA merged data for CELR, LCER, and LTCER bottom longline sets. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 3. Form type codes are given in Figure C10. Target species codes are given in Table C11.

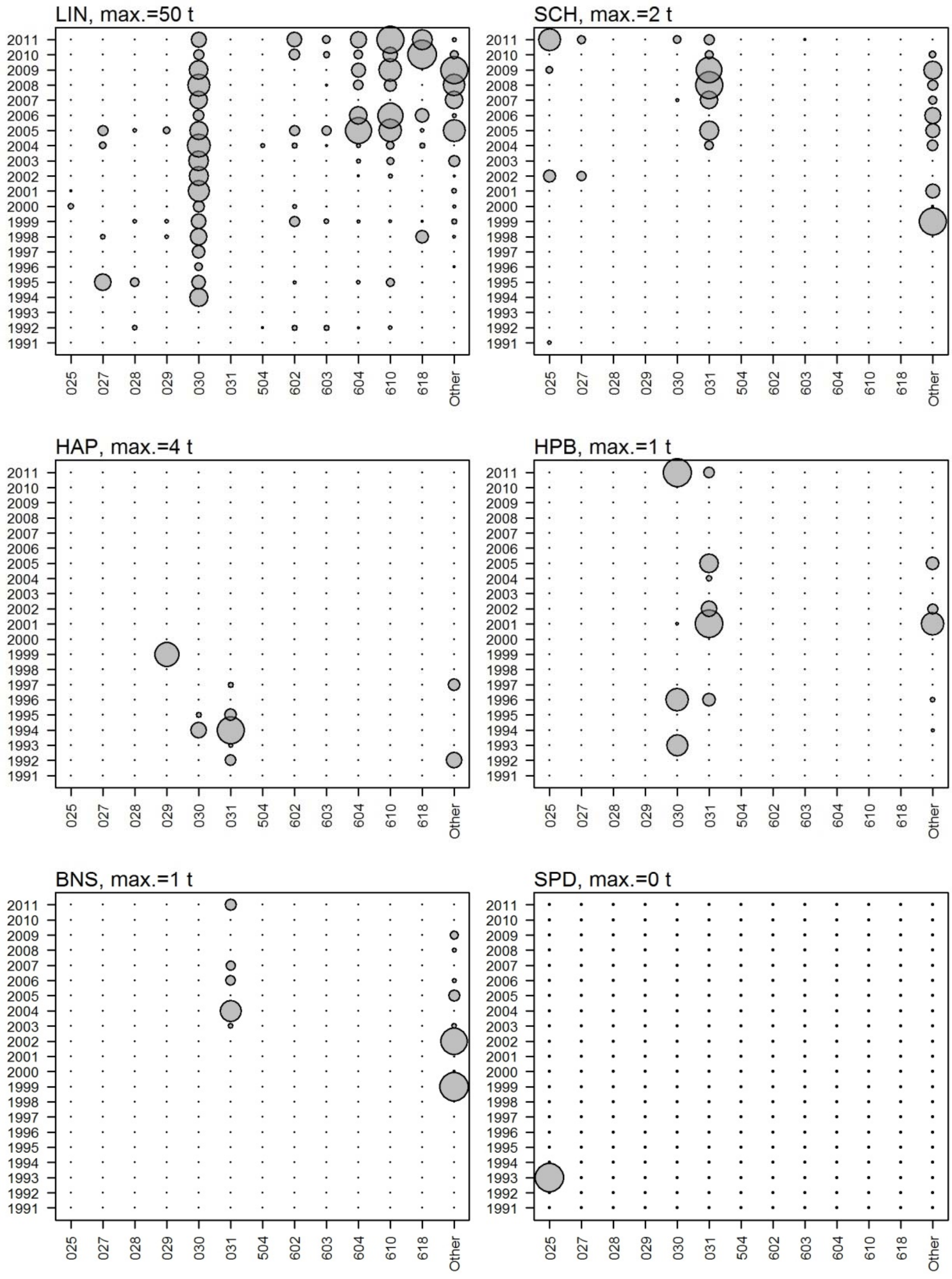


Figure C25b: Distribution of spiny dogfish annual catch (t) by statistical area for SUBA merged data for the top six target species for all CELR, LCER, and LTCER bottom longlines. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 3. Target species are given in Table C11.

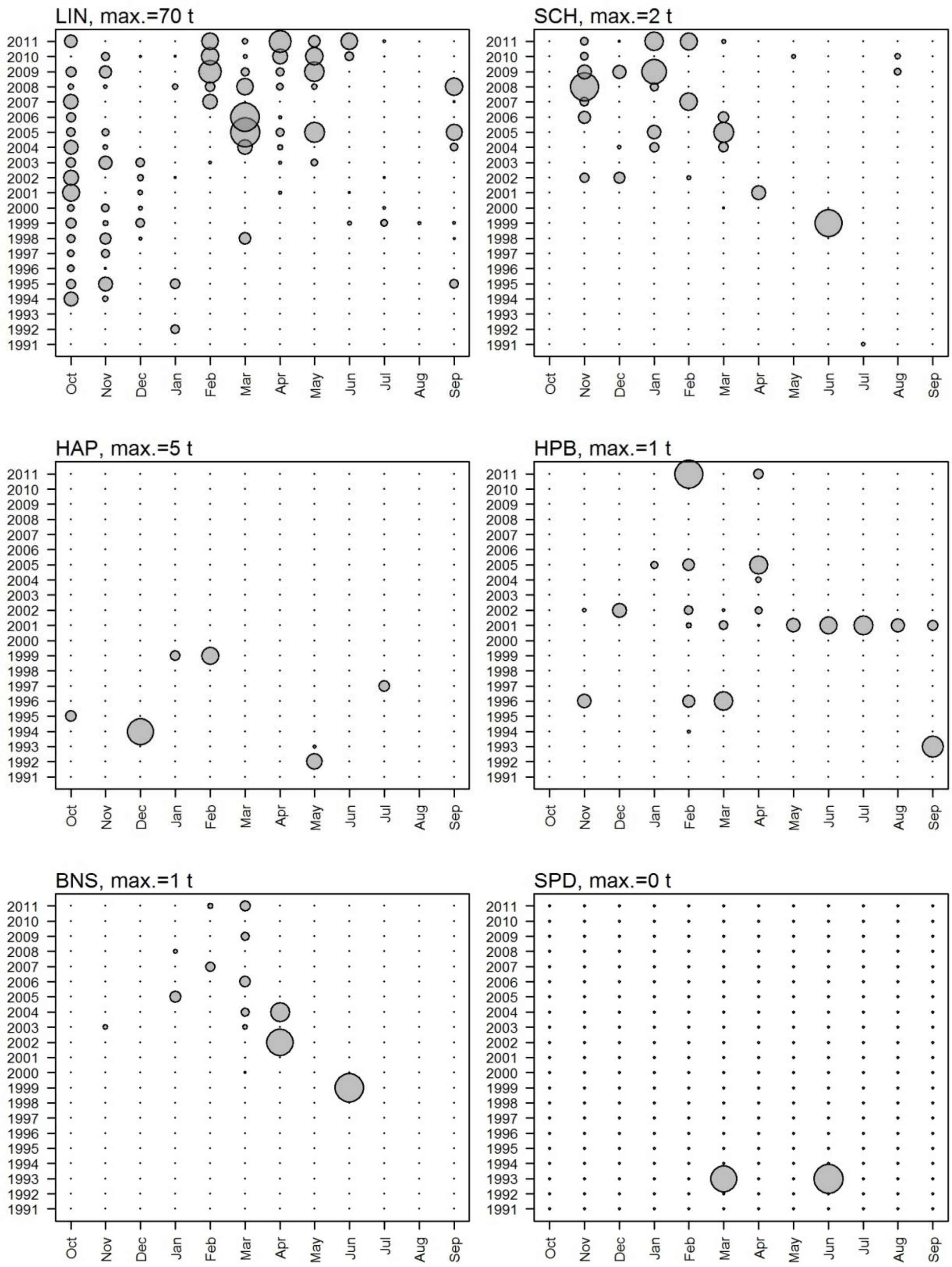


Figure C25c: Distribution of spiny dogfish annual catch (t) by month for SUBA merged data for the top six target species for all CELR, LCER, and LTCER bottom longline fishing events. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species are given in Table C11.

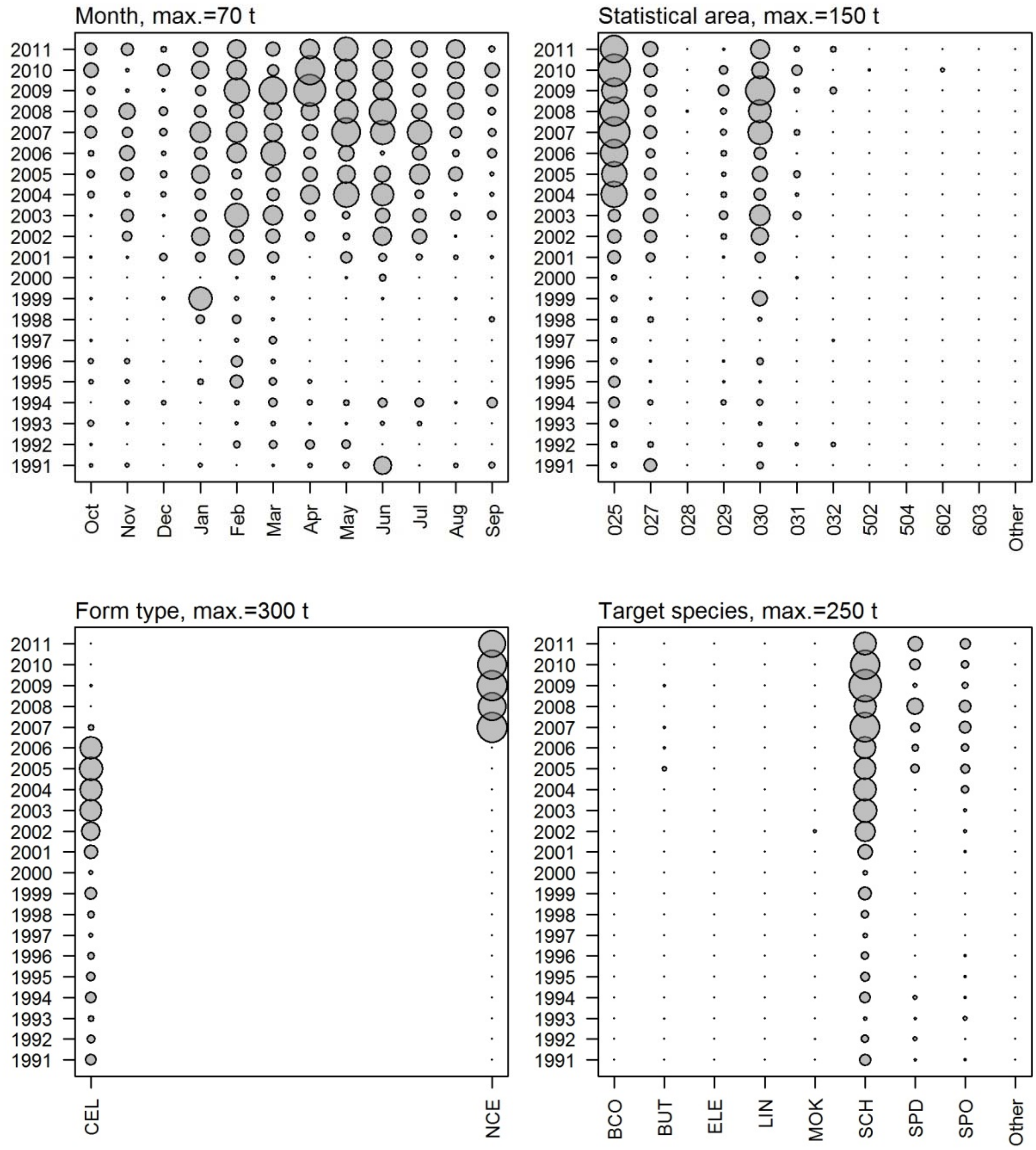


Figure C26a: Distribution of annual catch (t) by month, statistical area, form type, and target species for SUBA merged data for CELR and NCELR setnet sets. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Statistical areas are shown in Figure 3. Form type codes are given in Figure C10. Target species codes are given in Table C11.

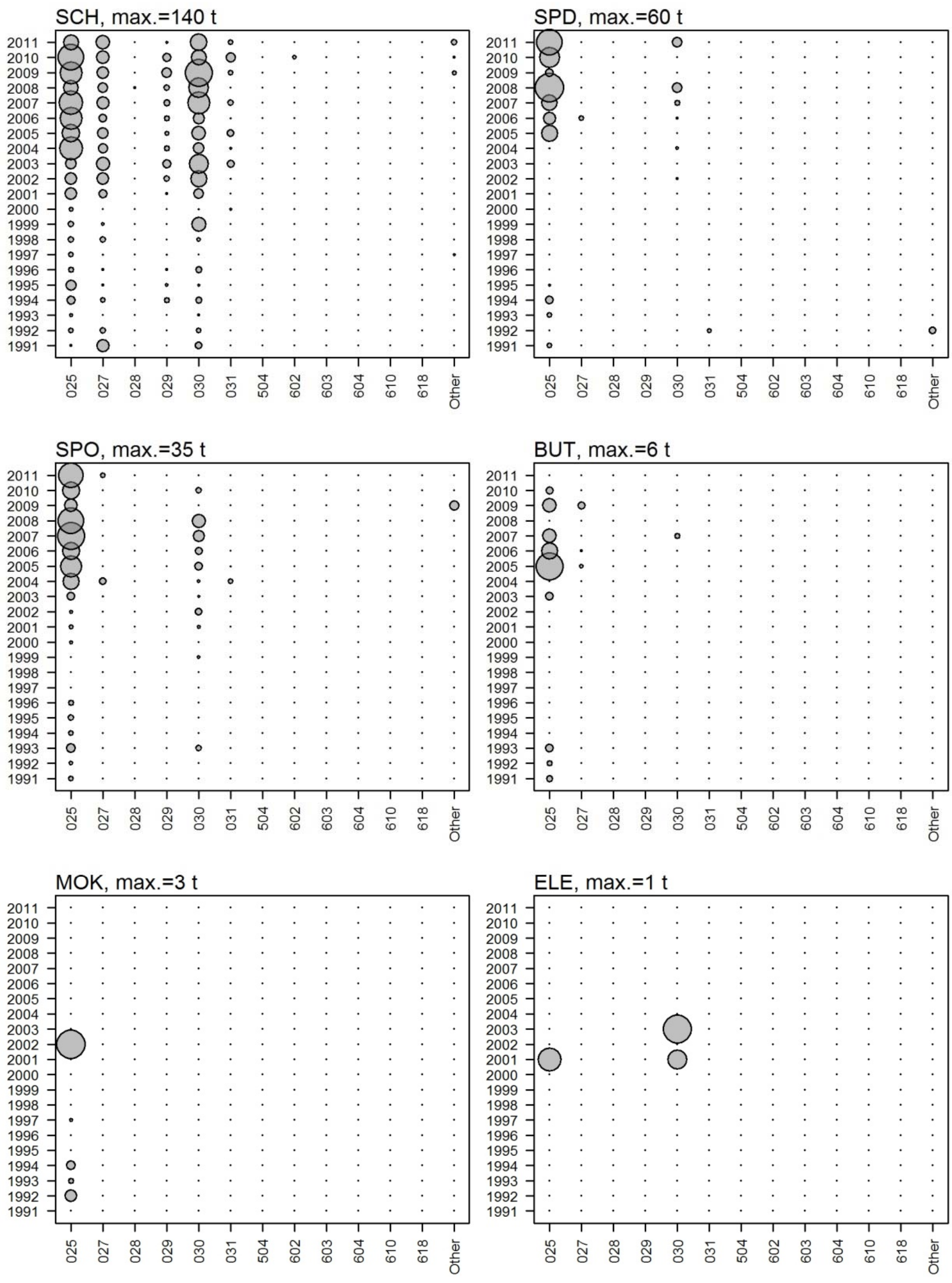


Figure C26b: Distribution of spiny dogfish annual catch (t) by statistical area for SUBA merged data for the top six target species for all CELR and NCELR setnets. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are given in Table C11.

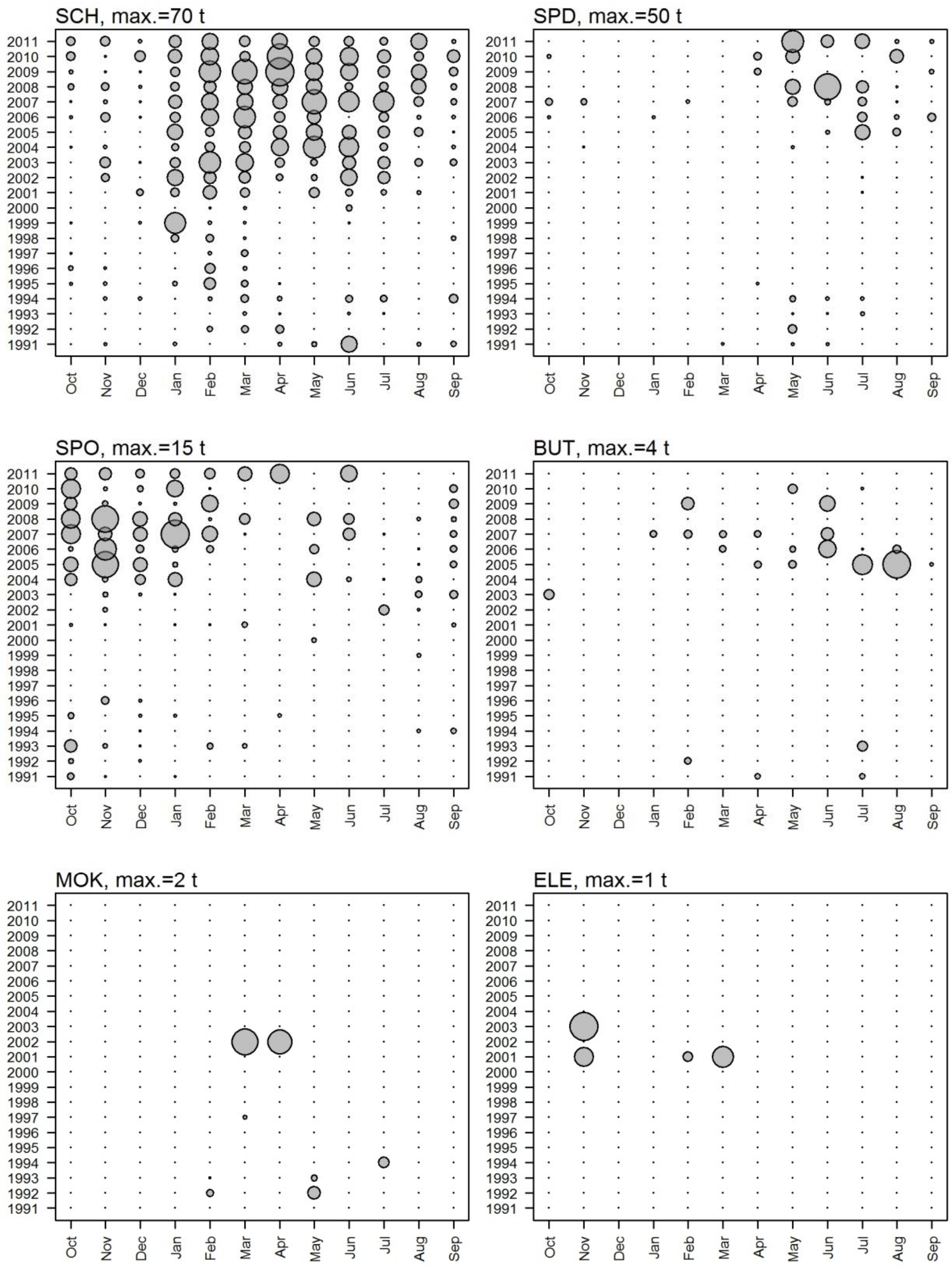


Figure C26c: Distribution of spiny dogfish annual catch (t) by month for SUBA merged data for the top six target species for all CELR and NCELR setnets. Circle size is proportional to catch; maximum circle size is indicated on the top left hand corner of each plot. Target species codes are given in Table C11.

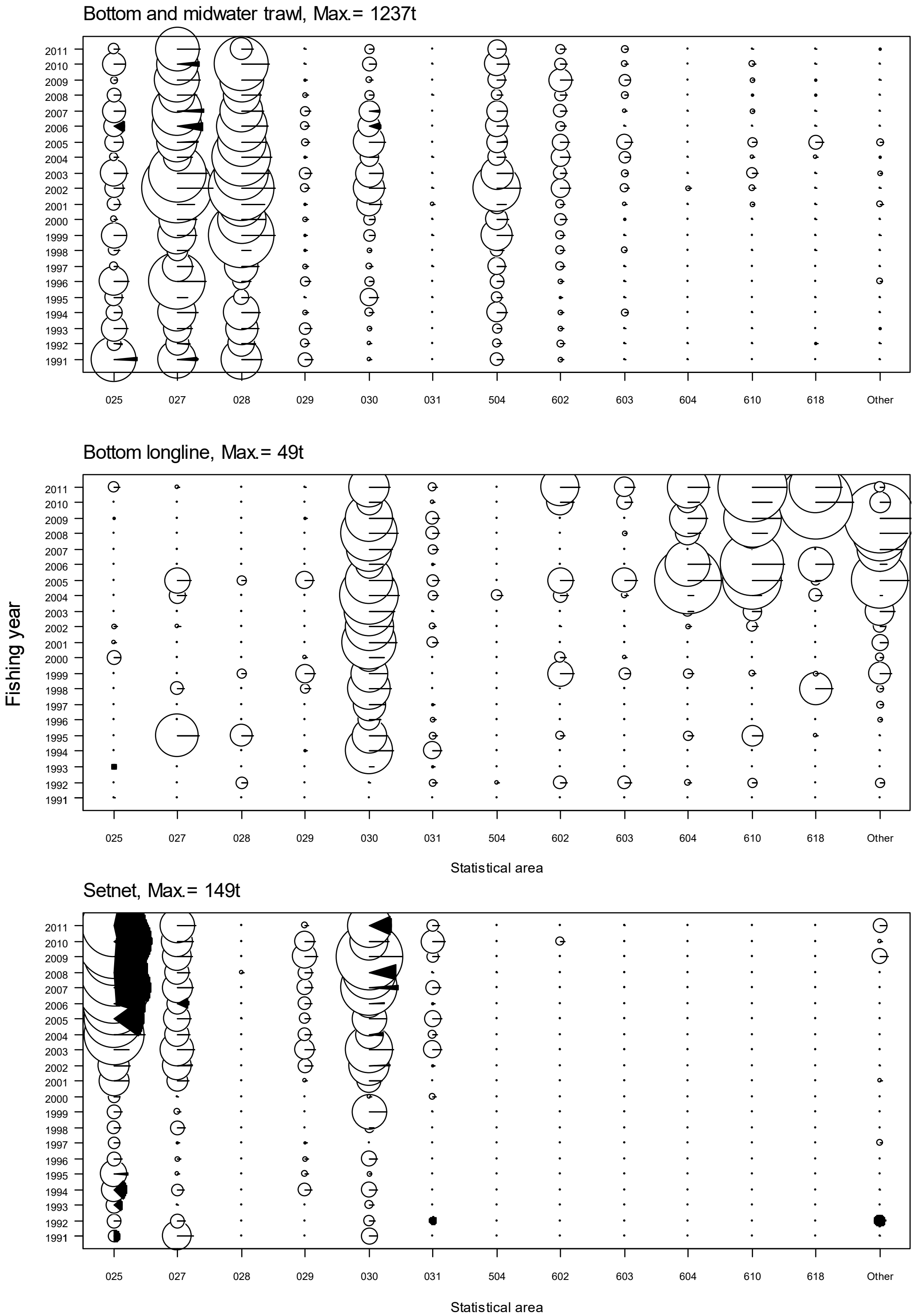


Figure C27a: Distribution of spiny dogfish catch by fishing year with circle size proportional to the total catch and black portion of the pie as the proportion of the catch as targeted SPD by statistical area for the SUBA subarea for TCEPR bottom and midwater trawl, CELR, LCER, and LTCER bottom longline and CELR and NCELR setnet fishing methods. Statistical areas are shown in Figure 3.

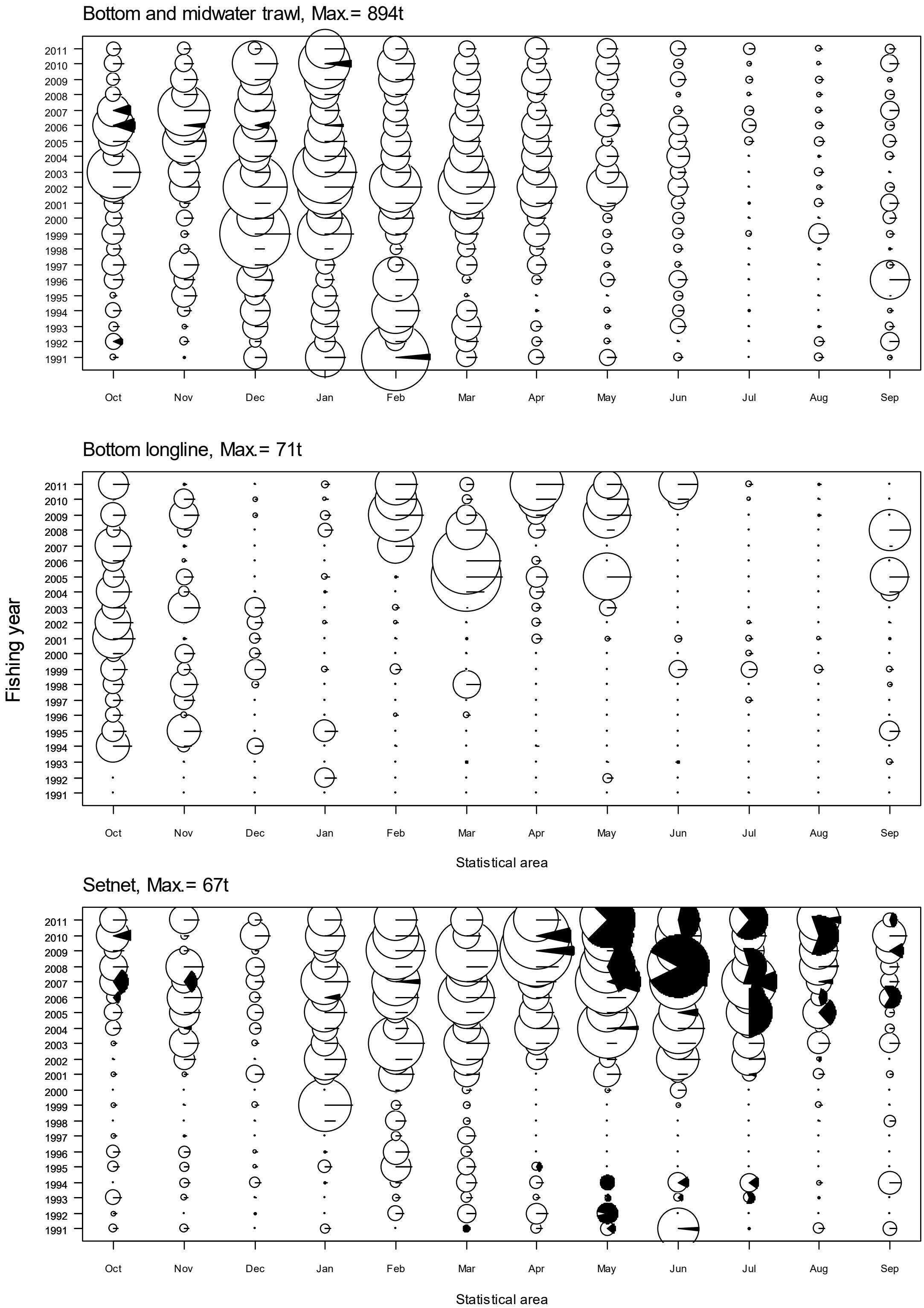


Figure C27b: Distribution of spiny dogfish catch by fishing year with circle size proportional to the total catch and black portion of the pie indicating proportion of the catch as targeted SPD, by month for the SUBA subarea for TCEPR bottom and midwater trawl, CELR, LCER, and LTCER bottom longline and CELR and NCELR setnet fishing methods. Statistical areas are shown in Figure 3.

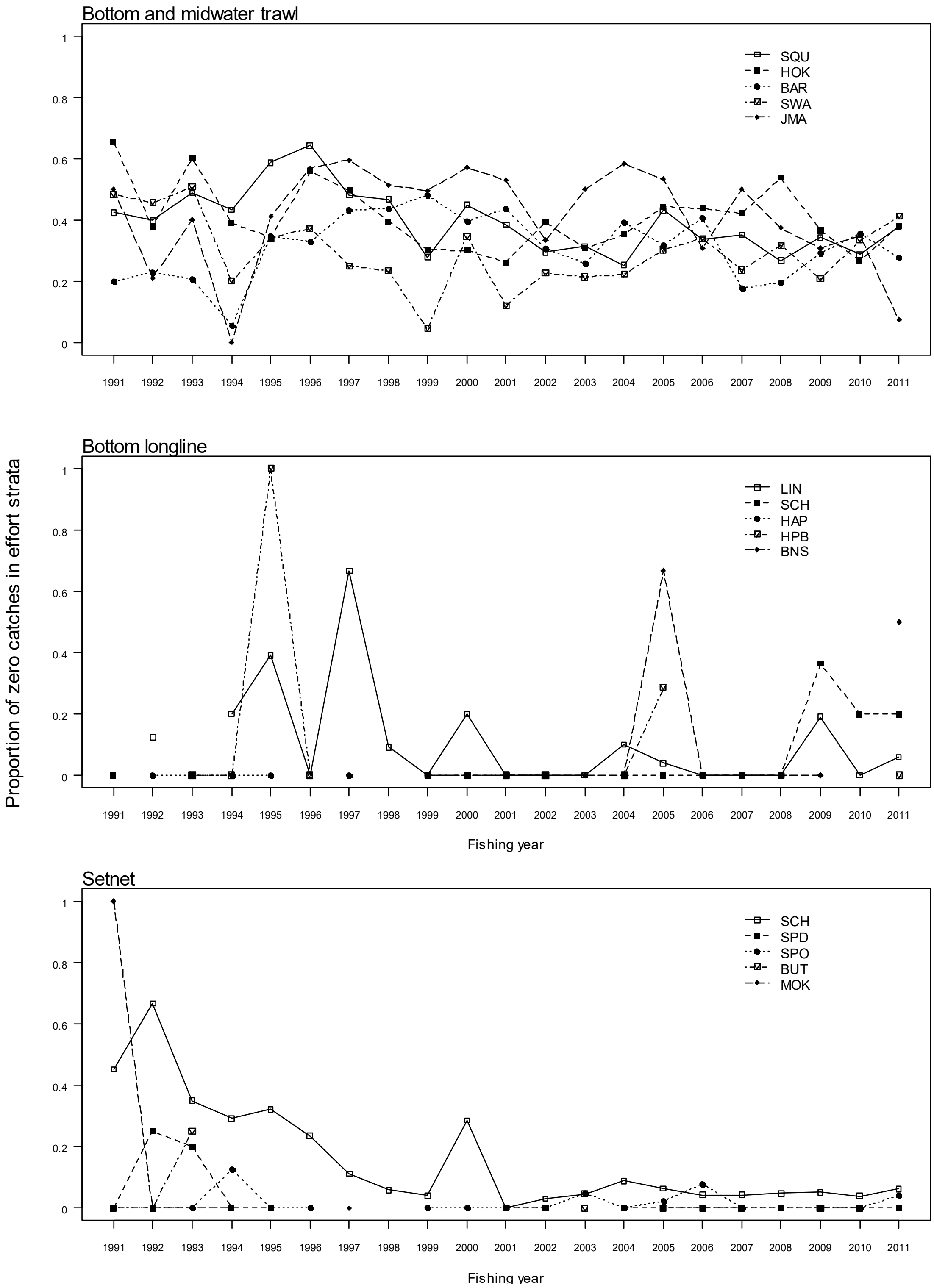


Figure C28a: Proportion of zeros by main target species for the SUBA subarea for TCEPR bottom and midwater trawl, CELR, LTCER, and LCER bottom longline and CELR and NCELR setnet fishing methods for merged data. Target species codes are given in Table C11.

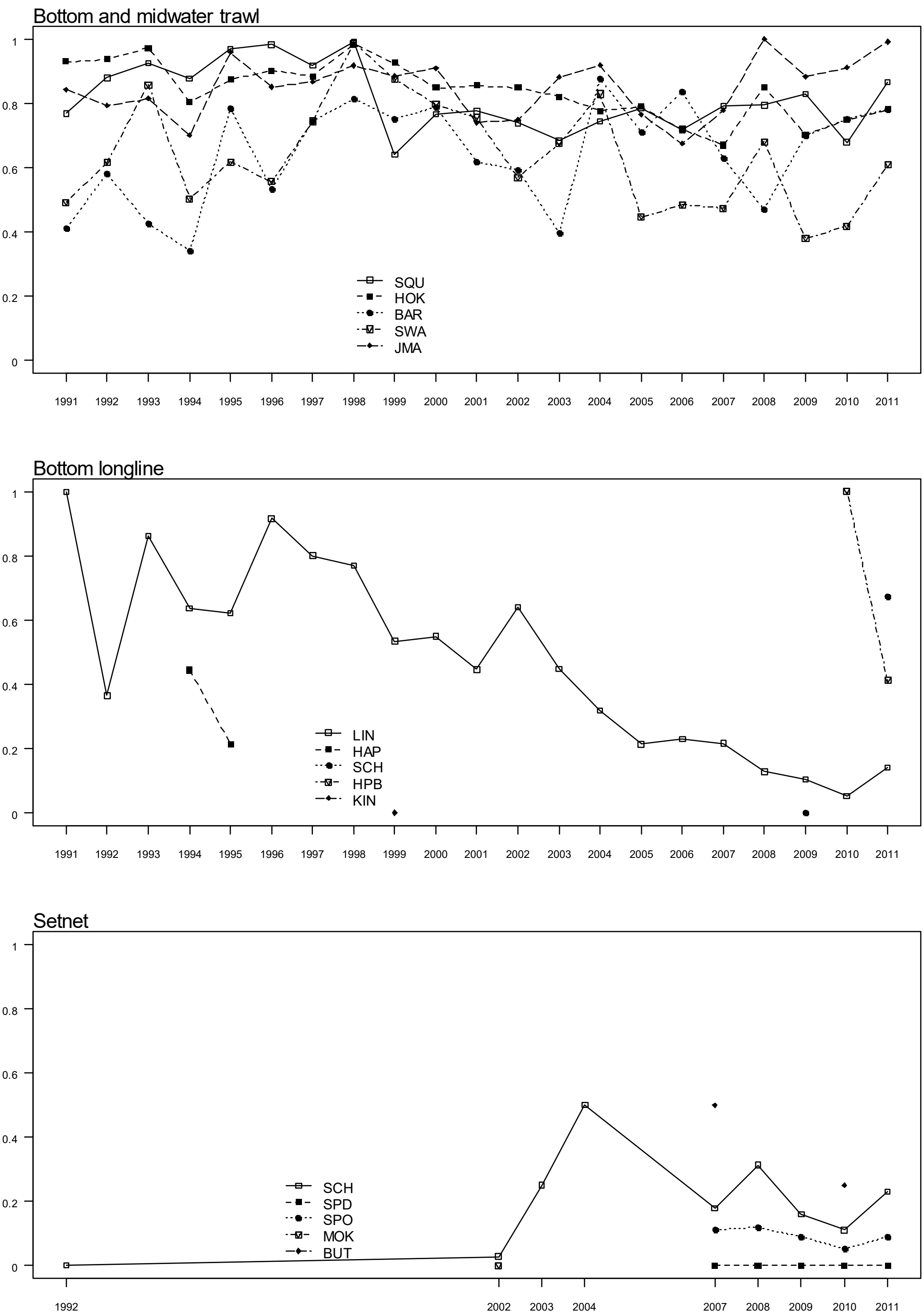


Figure C28b: Proportion of zeros by main target species for the SUBA subarea for TCEPR bottom and midwater trawl, CELR, LTCER, and LCER bottom longline and CELR and NCELR setnet fishing methods for unmerged data. Target species codes are given in Table C11.

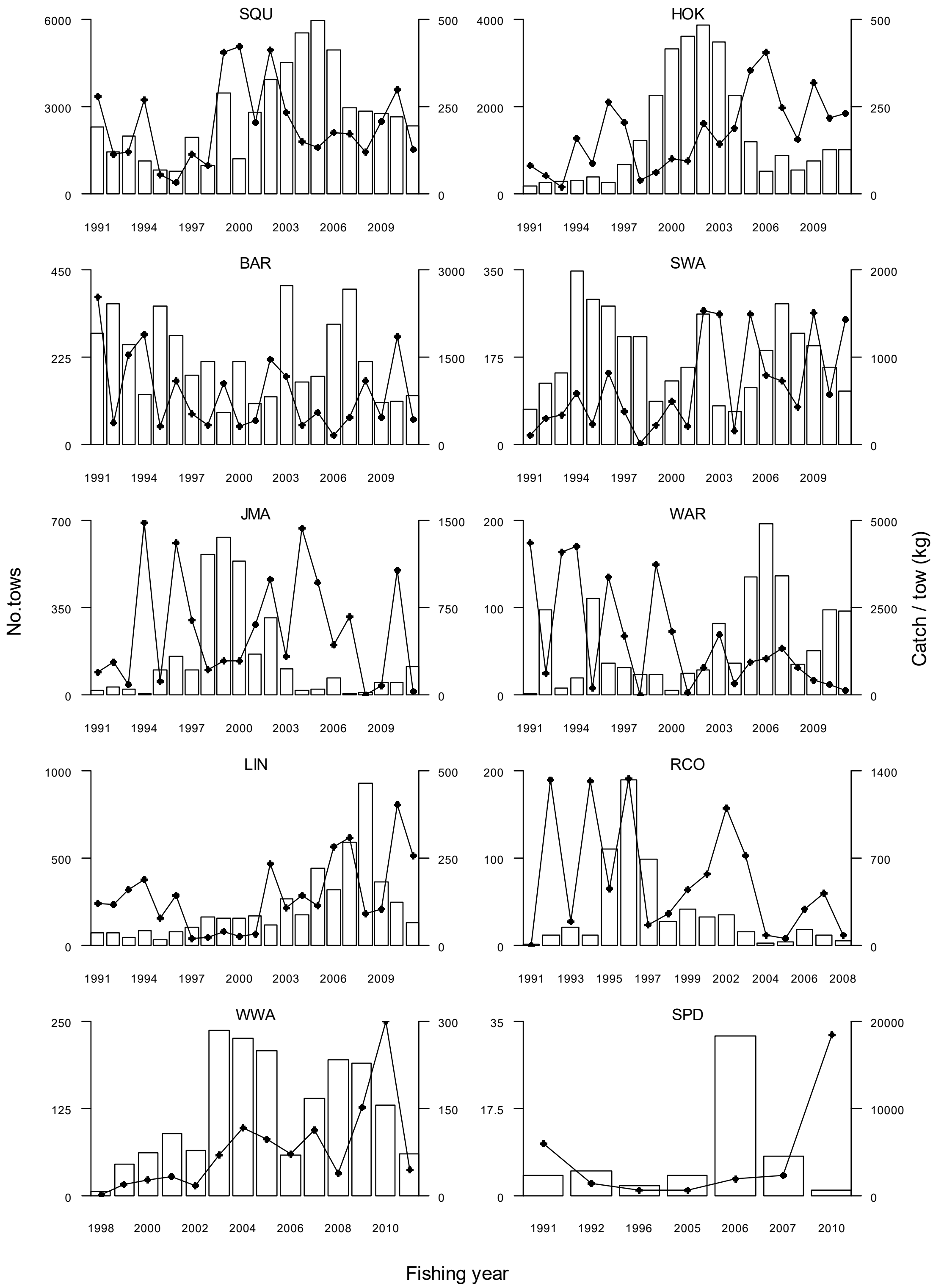


Figure C29a: Unstandardised catch rate (kg/tow) of spiny dogfish taken by TCEPR bottom and midwater trawl gear (lines), and the number of tows (bars) for the SUBA area, by target species for merged data. Target species codes are given in Table C11.]

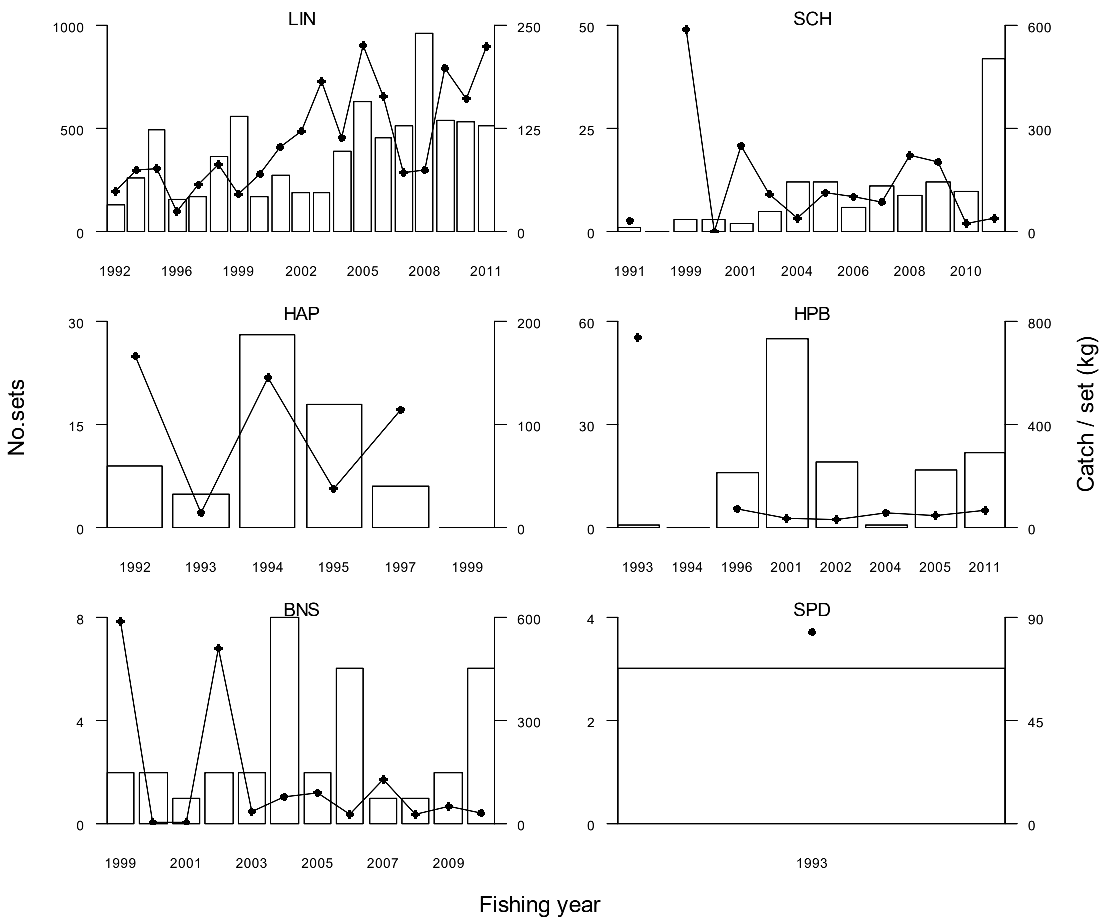


Figure C29b: Unstandardised catch rate (kg/tow) of spiny dogfish taken by CELR, LCER, and LTCER bottom longline for gear (lines), and the number of tows (bars) for the SUBA area, by target species for merged data. Target species codes are given in Table C11.

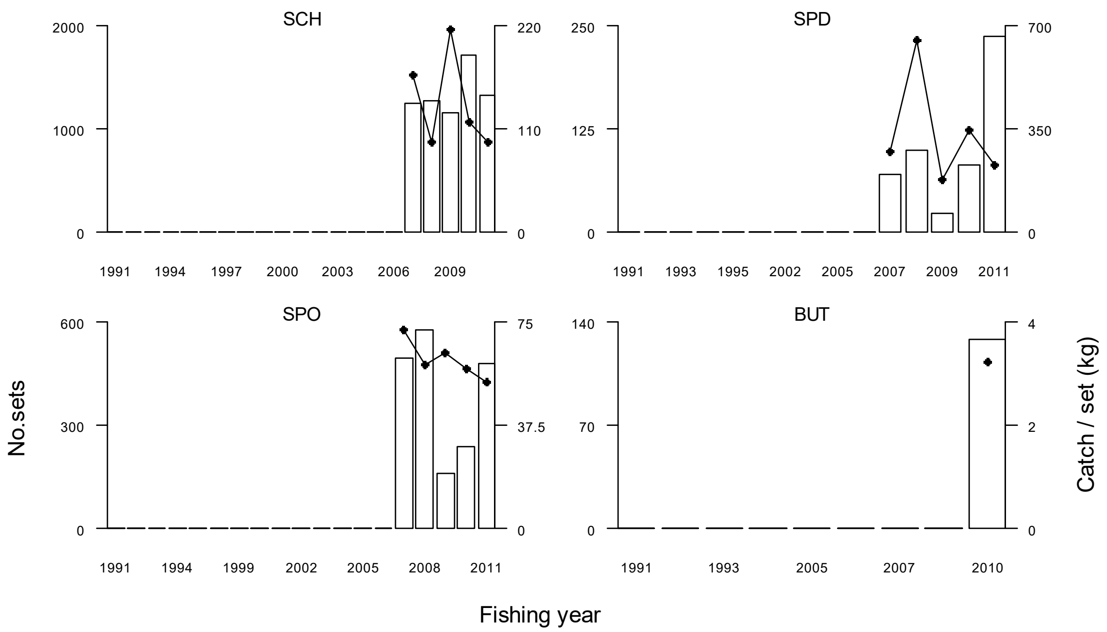


Figure C29c: Unstandardised catch rate (kg/tow) of spiny dogfish taken by CELR and NCELR setnet for gear (lines), and the number of tows (bars) for the SUBA area, by target species for merged data. Target species codes are given in Table C11.

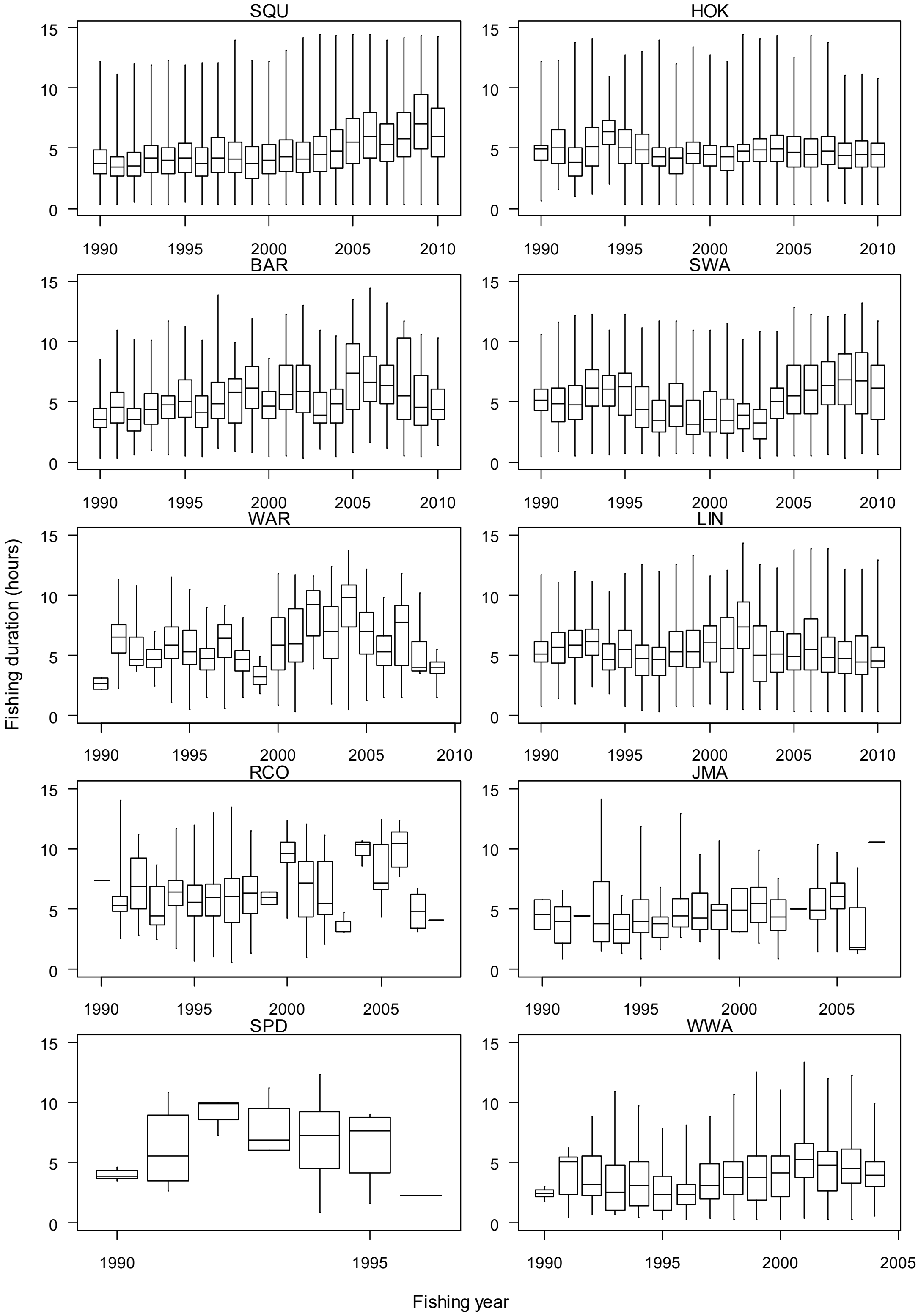


Figure C30a: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during TCEPR bottom trawls that caught spiny dogfish in the SUBA area, by target species and fishing year where 1989–90 is 1990. Target species codes are given in Table C11.

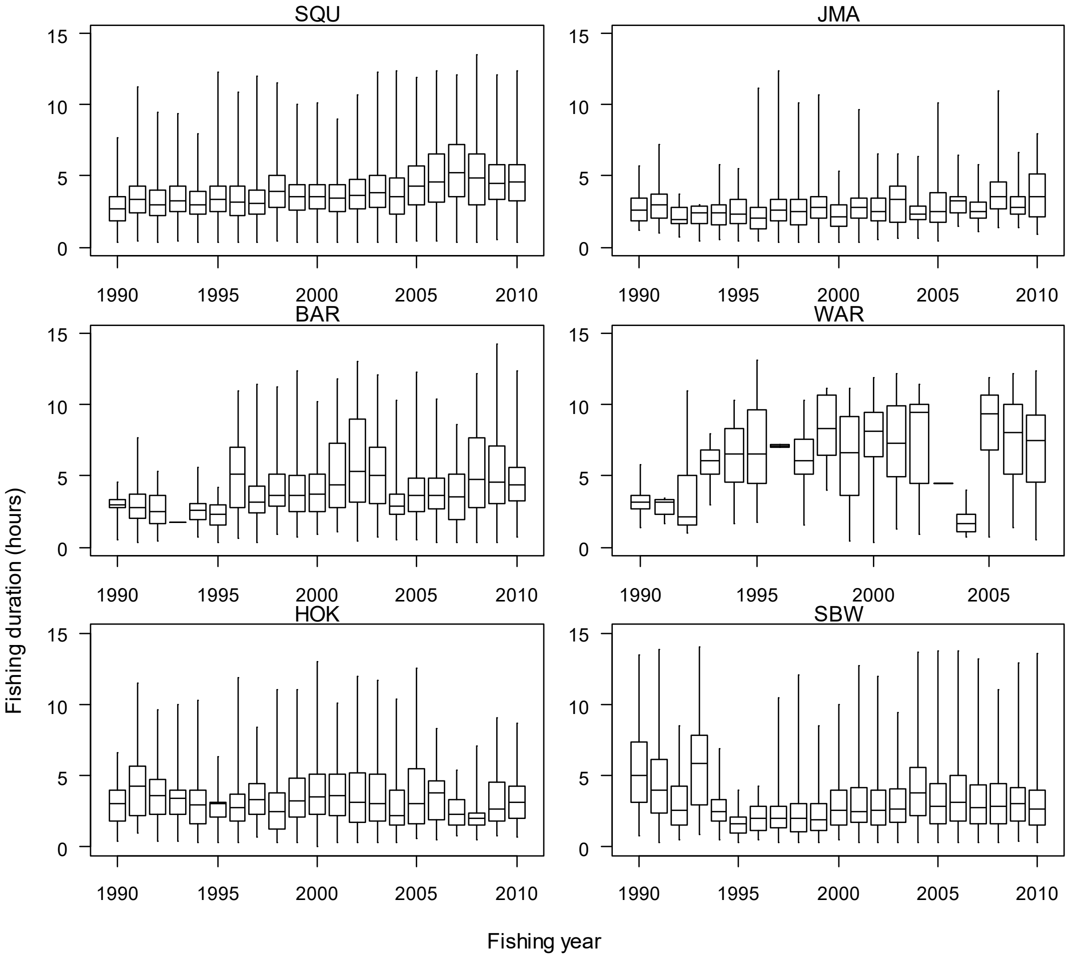


Figure C30b: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for fishing duration during TCEPR midwater trawls that caught spiny dogfish in the SUBA area, by target species and fishing year where 1989–90 is 1990. Target species codes are given in Table C11.

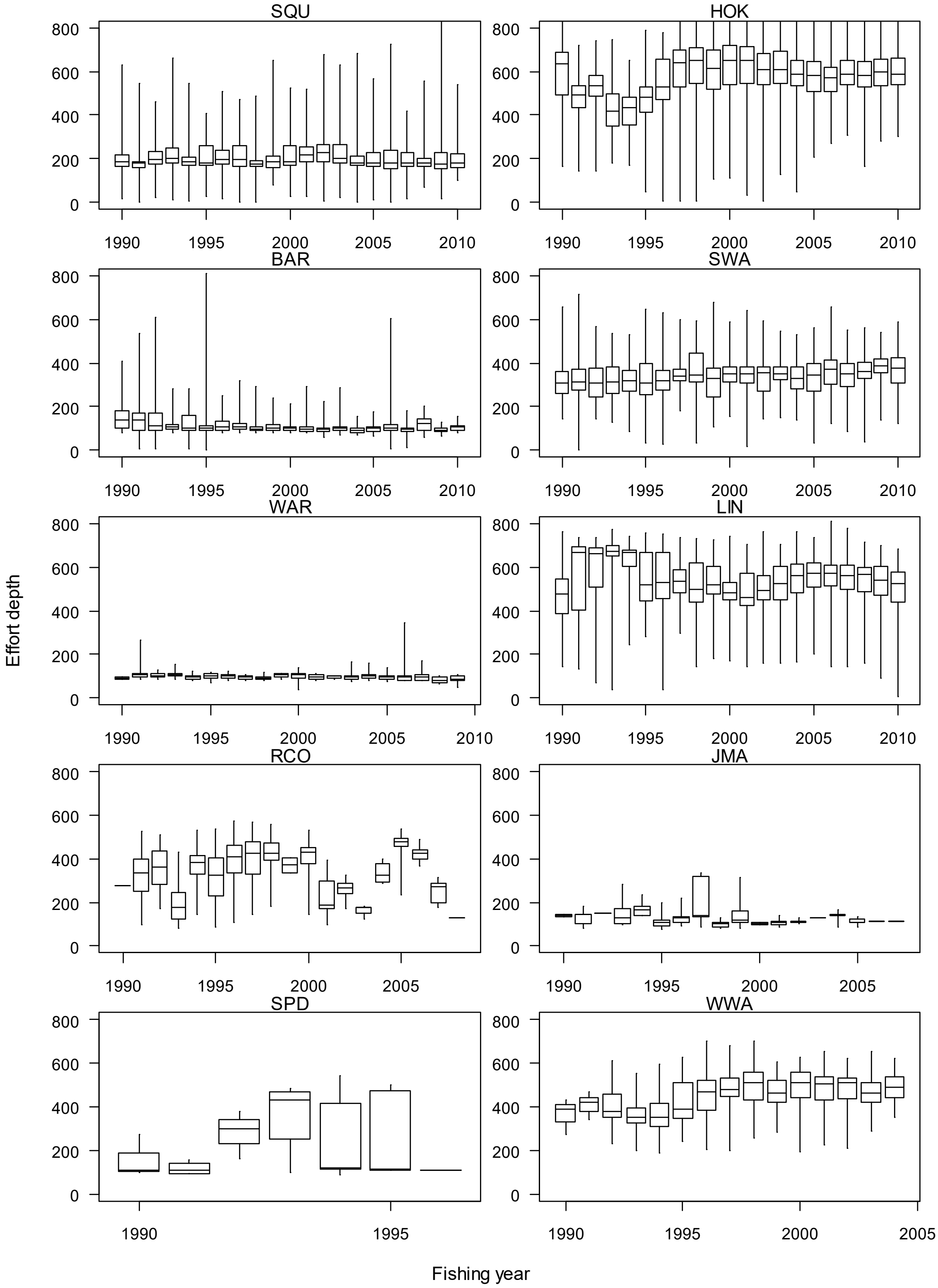


Figure C30c: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for depths (m) fished by TCEPR bottom trawls that caught spiny dogfish in the SUBA area by target species and fishing year where 1989–90 is 1990. Target species codes are defined in Table C11.

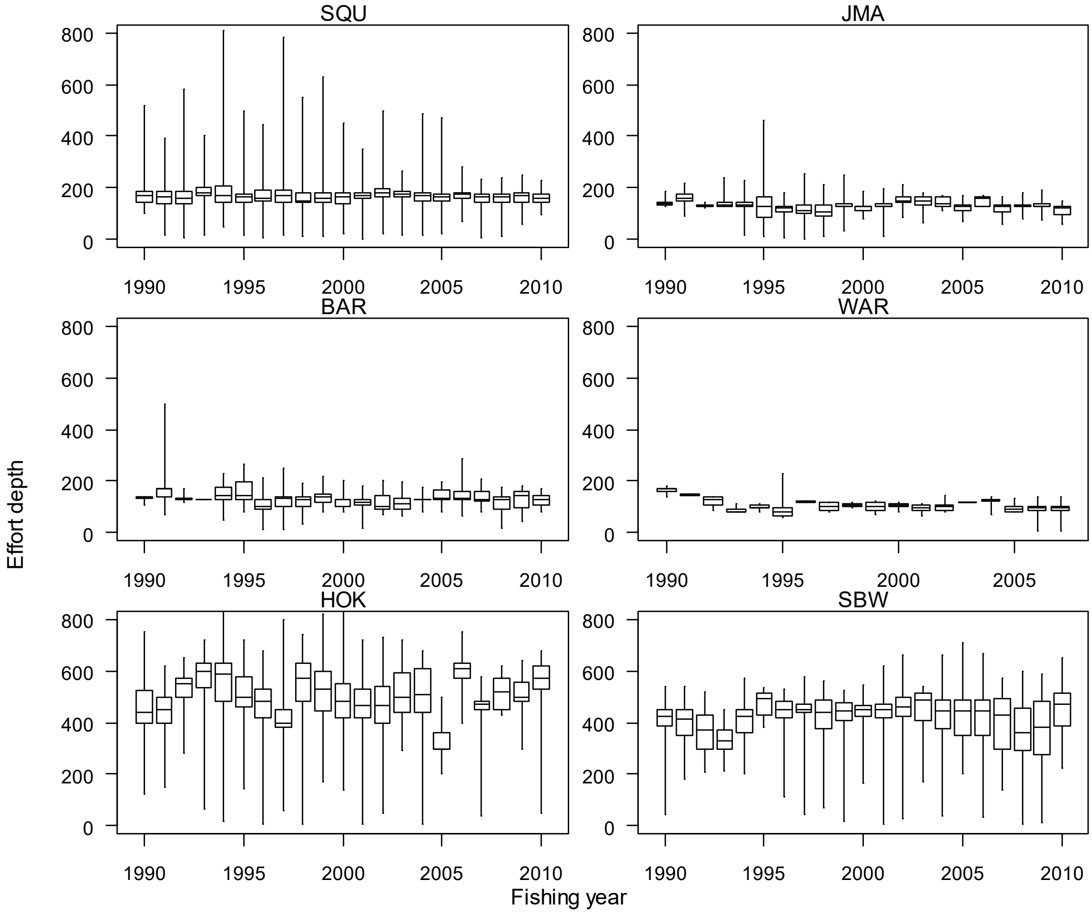


Figure C30d: Annual median (horizontal line), inter–quartile ranges (box), and range (vertical lines) for depths (m) fished by TCEPR midwater trawls that caught spiny dogfish in the SUBA area by target species and fishing year where 1989–90 is 1990. Target species codes are defined in Table C11.

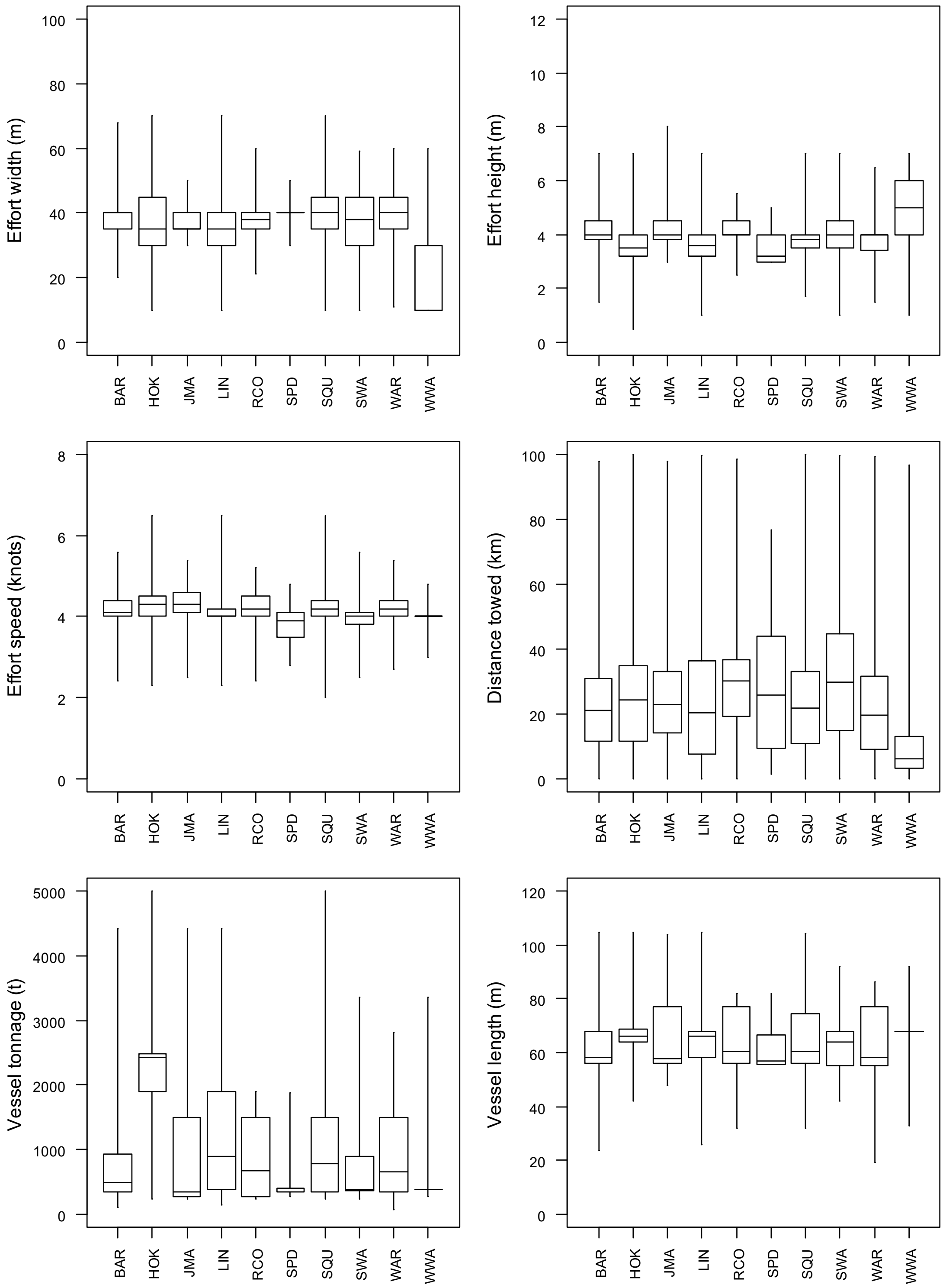


Figure C30e: Distribution of fishing effort variables and vessel characteristics for the SUBA area during TCEPR bottom trawl effort for the major target species that caught spiny dogfish. Target species codes are given in Table C11.

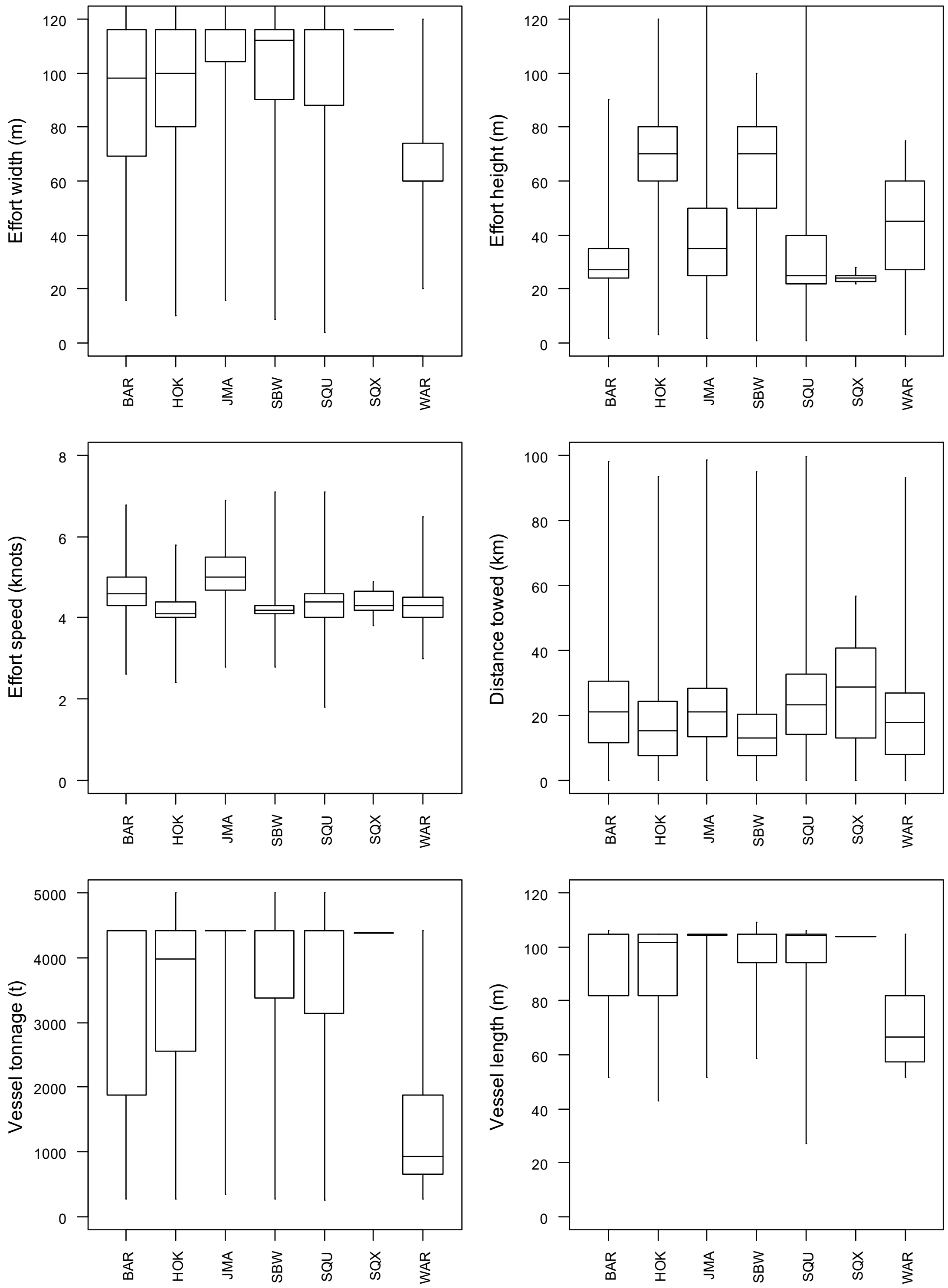


Figure C30f: Distribution of fishing effort variables and vessel characteristics for the SUBA area during TCEPR midwater trawl effort for the major target species that caught spiny dogfish. Target species codes are given in Table C11.

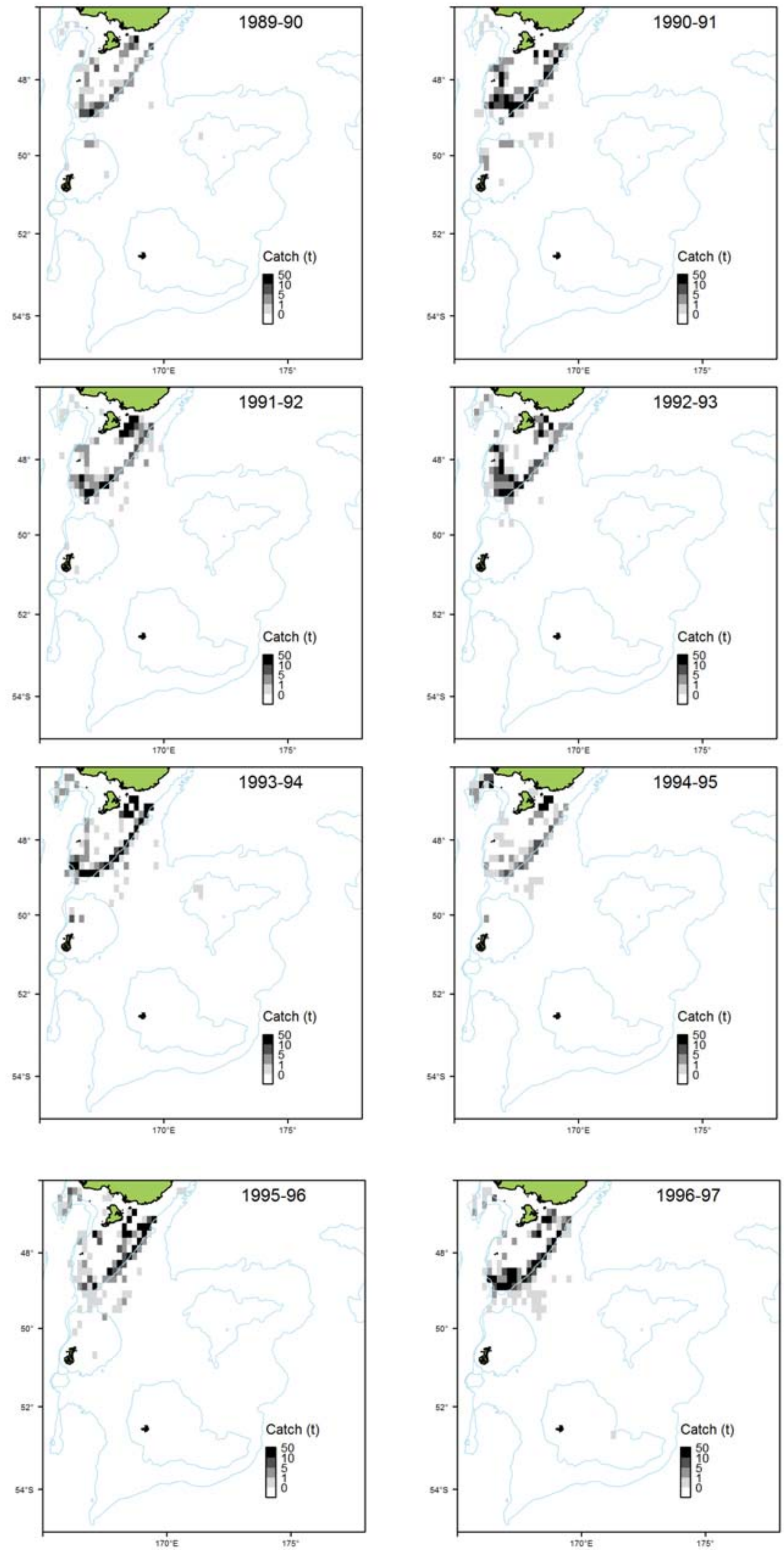


Figure C31: Distribution of TCEPR bottom and midwater trawl spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 1989–90 to 1996–97.

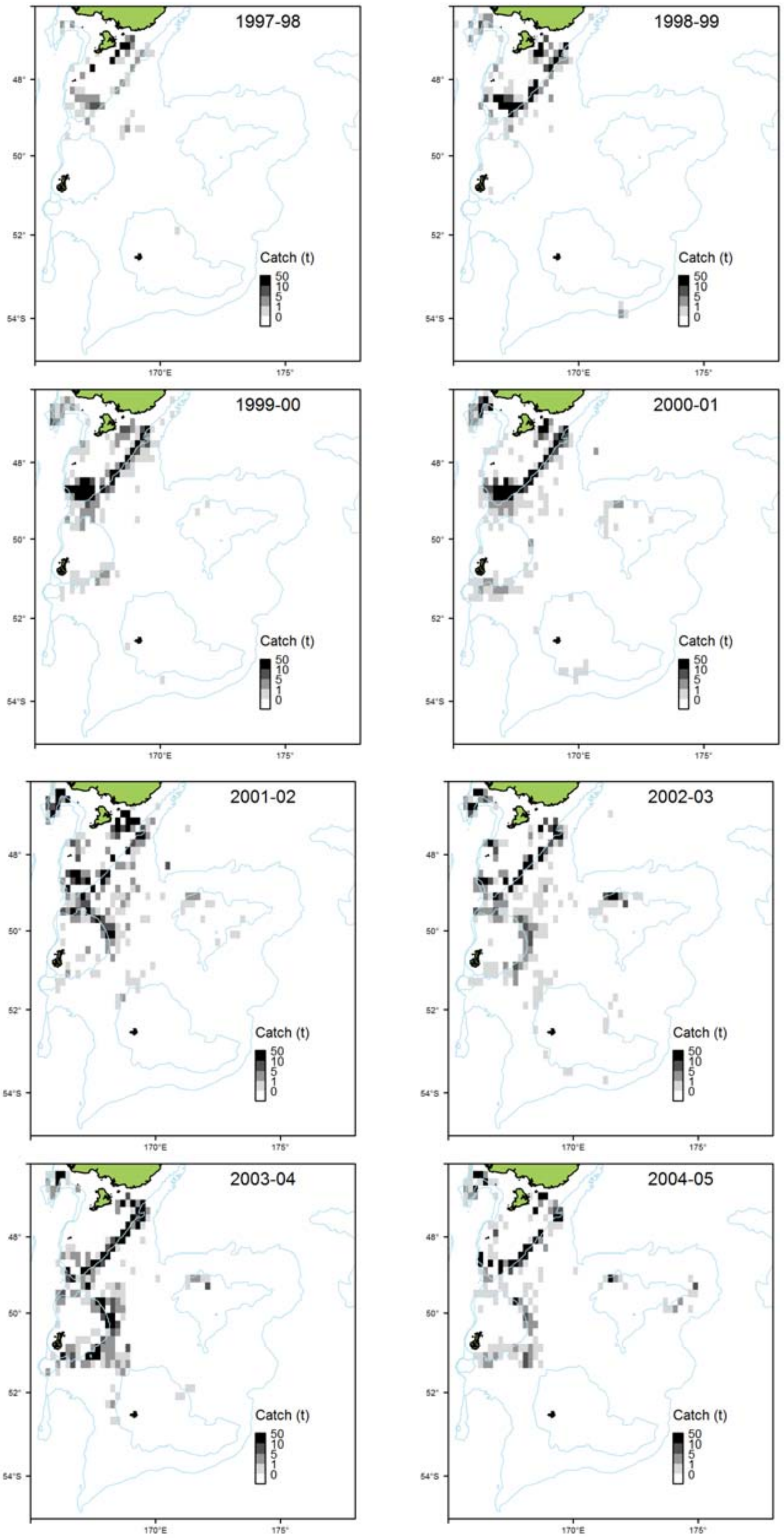


Figure C31 *continued*: Distribution of TCEPR bottom and midwater trawl spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 1997–98 to 2004–05.

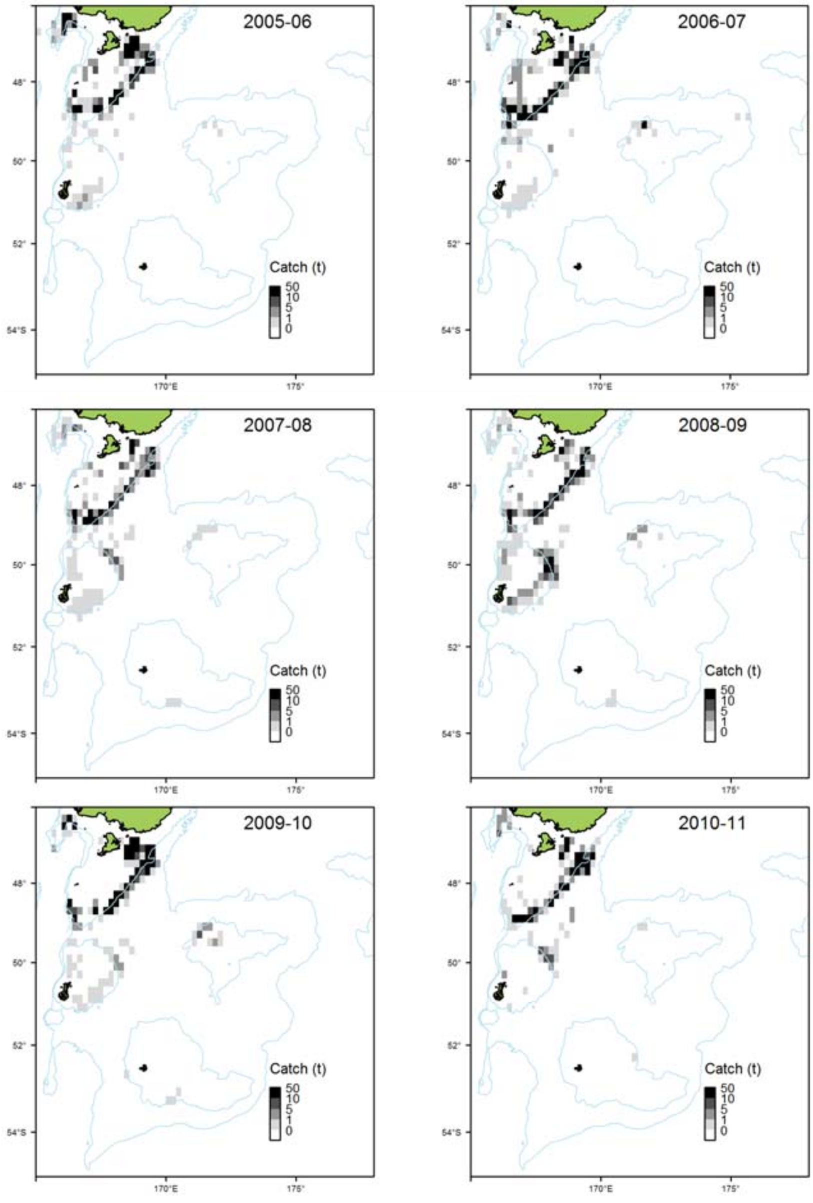


Figure C31 *continued*: Distribution of TCEPR bottom and midwater trawl spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 2005–06 to 2010–11.

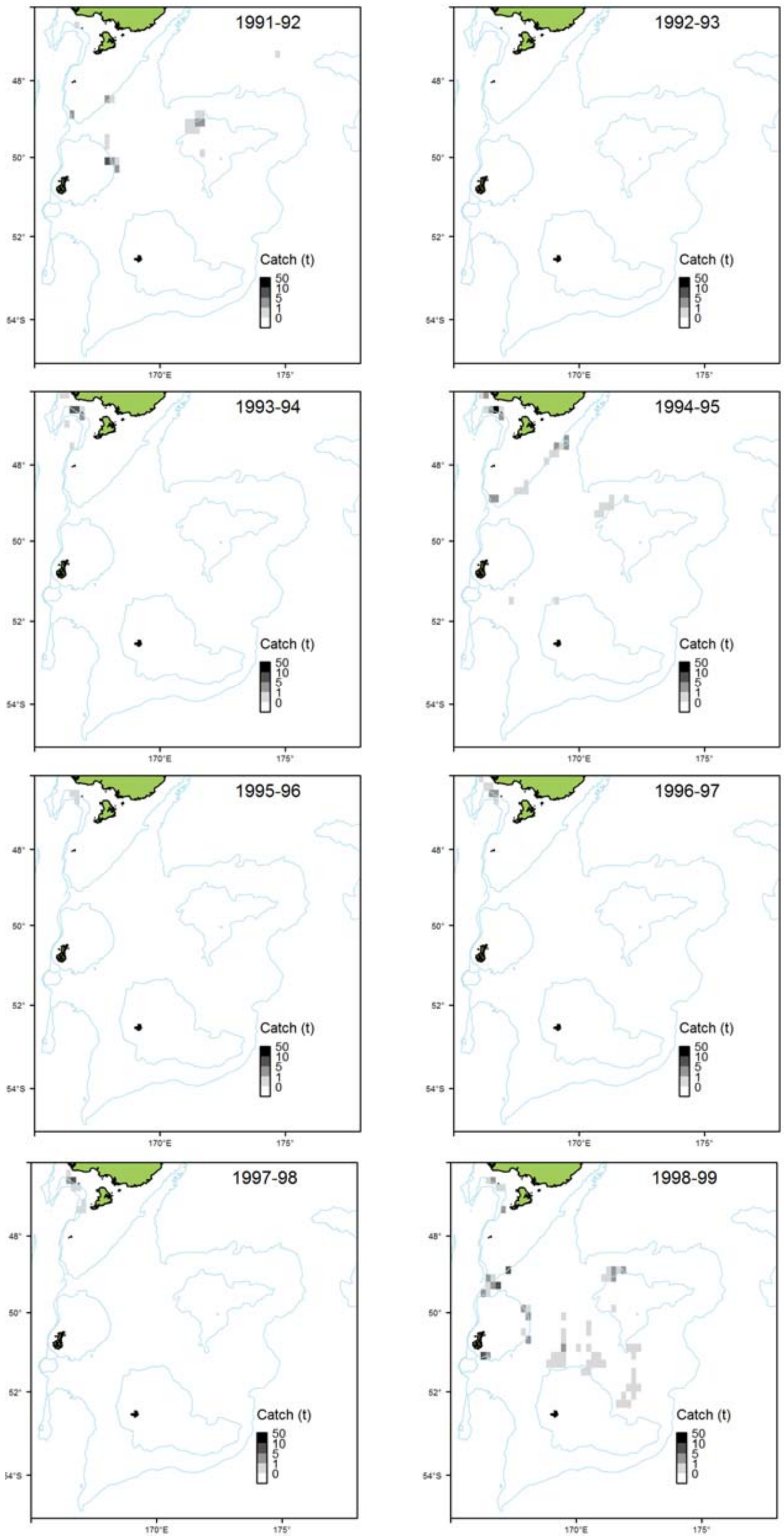


Figure C32: Distribution of CELR, LTCER, and LCER bottom longline spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 1991–92 to 1998–99.

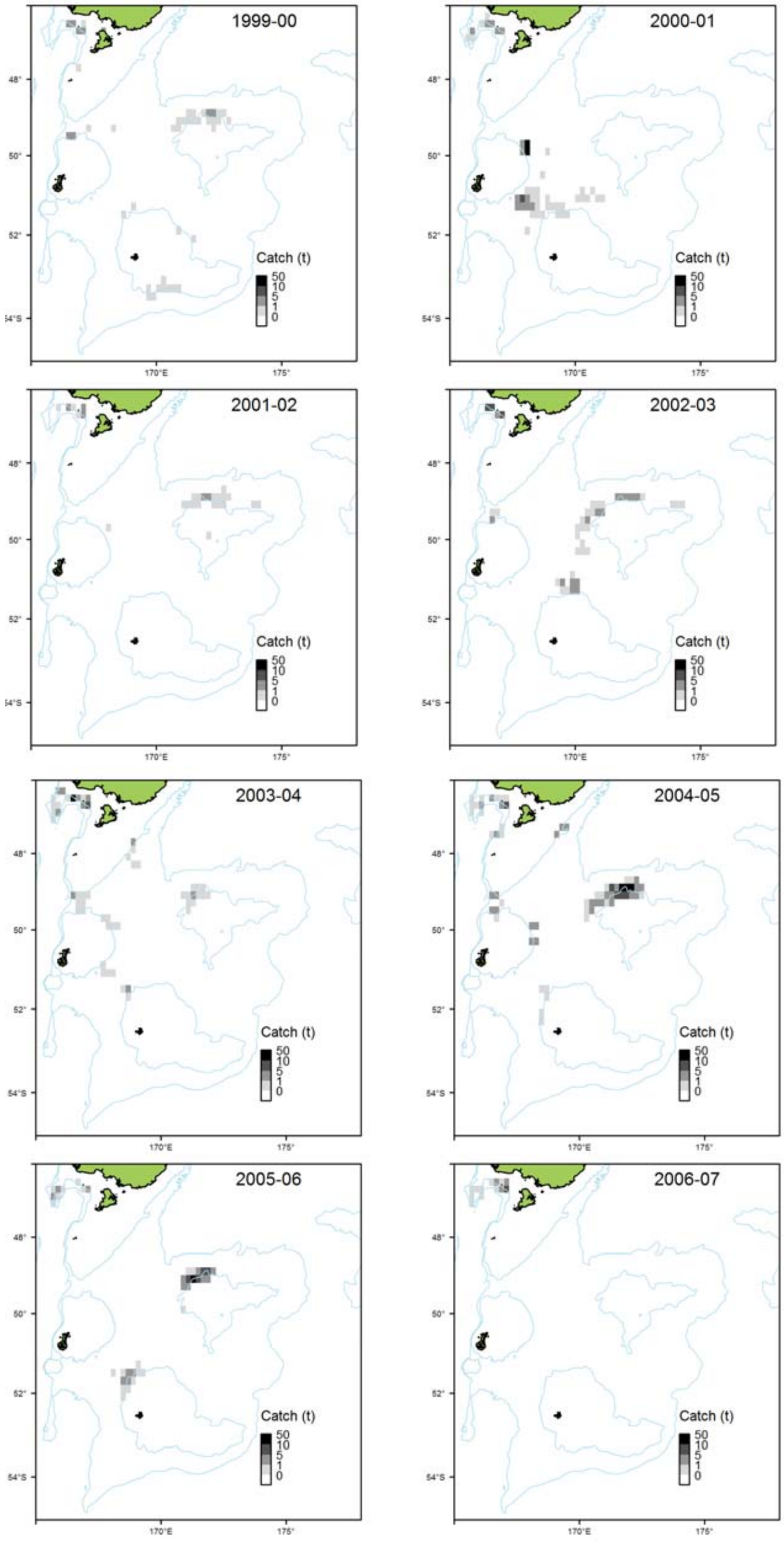


Figure C32 *continued*: Distribution of CELR, LTCER, and LCER bottom longline spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 1999–2000 to 2006–07.

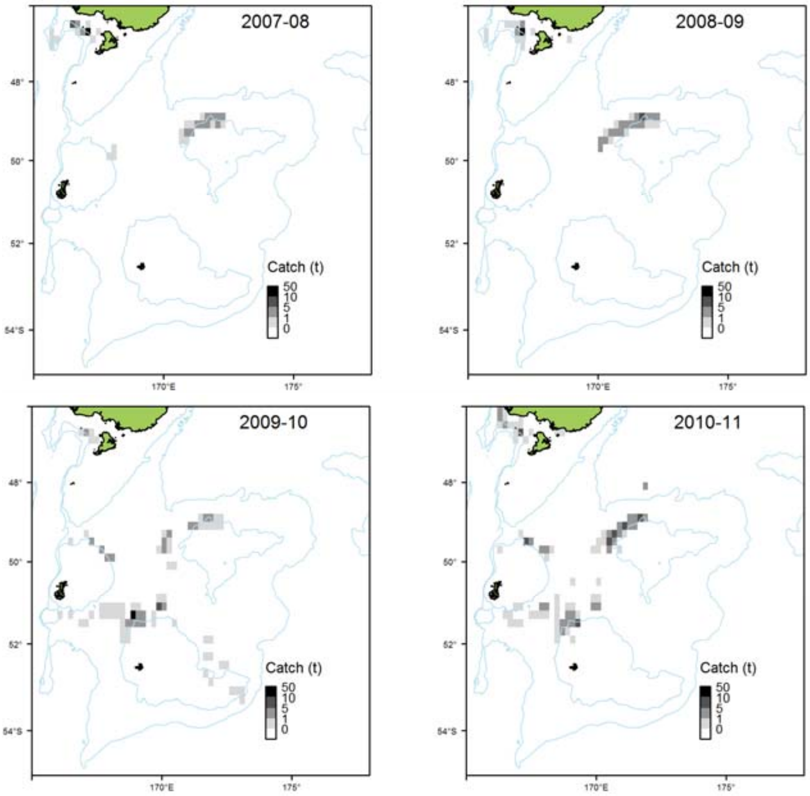


Figure C32 *continued*: Distribution of CELR, LTCER, and LCER bottom longline spiny dogfish catch (t) aggregated into 0.2° spatial blocks within the SUBA area, for 2007–08 to 2010–11.

APPENDIX D: CATCH-PER-UNIT-EFFORT ANALYSIS

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

(a) TCEPR BT tow-by-tow data

Variable	Type	Description
Year	Categorical	Fishing year (Oct–Sep)
Vessel	Categorical	Unique (encrypted) vessel identification number
Statistical area	Categorical	Statistical area
Tow duration	Continuous	Duration of tow (h)
Tow distance	Continuous	Distance of tow (km)
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
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 involved in the fishery
Twin trawl vessel	Categorical	T/F variable for a vessel that has used a twin trawl
Catch	Continuous	Estimated greenweight (t) of spiny dogfish caught from a tow
Longitude	Continuous	Longitude of the vessel for a tow
Latitude	Continuous	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 year
Fday	Continuous	Day of the year
Time start	Continuous	Start time of tow
Time mid	Continuous	Mid time of tow

(b) TCPER, TCER, CELR BT data merged by trip-vessel-statistical area-target species

Variable	Type	Description
Year	Categorical	Fishing year (Oct–Sep)
Vessel	Categorical	Unique (encrypted) vessel identification number
Form type	Categorical	Form type
Statarea	Categorical	Statistical area
Effort	Continuous	Number of tows for a given trip
Tow duration	Continuous	Duration of all tows (h) on a given trip
Catch	Continuous	Estimated greenweight (t) of spiny dogfish caught on a given trip
Target species	Categorical	Main target species on a given trip
Date	Continuous	First date of trip
Month	Categorical	Month of the year

(c) BLL data merged to vessel-day-statarea

Variable	Type	Description
Year	Categorical	Fishing year (Oct–Sep)
Vessel	Categorical	Unique (encrypted) vessel identification number
Statarea	Categorical	Statistical area
Effort	Continuous	Number of sets for a given day
Log(Effort)	Continuous	Log of number of sets for a given day
Total hooks	Continuous	Number of hooks for a given day
Log (Total hooks)	Continuous	Log of number of hooks for a given day
Catch	Continuous	Estimated greenweight (t) of spiny dogfish caught on a given day
Target species	Categorical	Main target species on a given day
Date	Continuous	Date the fish were processed
Month	Categorical	Month of the year
Fmonth	Categorical	Month of fishing year
Fday	Continuous	Day of the fishing year
Month: Total hooks	Categorical	Month of the year nested with total hooks
Month: Log(Total hooks)	Categorical	Month of the year nested with log of total hooks

Table D2: CPUE data constraints for core datasets.

(a) CHAT: TCEPR tow-by-tow BT data target hoki tows – estimated catch

Data source	TCEPR tow-by-tow
Year range	1999–2011
Year definition	October–September
Statistical areas	> 50 tows: 021, 023, 052, 401, 402, 407–410
Method	BT
Target species	HOK
Core vessel selection	80% of catch, ≥ 3 years vessel participation, ≥ 20 tows per vessel–year
Catch	< 10 t
Other	longitude >=174° E; 300–900 m; 0.2–12 h duration

(b) CHAT: Bottom longline for target ling lines merged to vessel–day–statistical area for target ling

Data source	CELR, LCER, and LTCER data merged to vessel–day–statistical area level
Year range	1996–2010
Year definition	October–September
Statistical areas	> 50 vessel–days: 021, 023, 052, 401–405, 407–410
Method	BLL
Target species	LIN
Core vessel selection	≥ 2 years vessel participation, ≥ 50 sets per vessel
Catch	< 10 t
Other	Longitude >=174° E; Total hooks 1000–50 000; CPUE > 1

(c) SUBA: TCEPR tow-by-tow BT data for main target species

Data source	TCEPR tow-by-tow
Year range	2000–2011
Year definition	October–September
Statistical areas	> 50 tows: 025–030, 504, 602–604, 610, 611, 618
Method	BT
Target species	SQU, HOK, BAR, SWA, WAR, LIN, JMA, SPD, WWA
Core vessel selection	80% of catch, ≥ 6 years vessel participation, ≥ 20 tows per vessel–year
Catch	< 10 t
Other	50–900 m; 0.2–12 h duration

(d) SUBA: Bottom tow TCEPR, TCER and CELR estimated data merged to trip level for main target species

Data source	TCEPR, TCER, CELR estimated data merged to trip level
Year range	2000–2011
Year definition	October–September
Statistical areas	025–030, 504
Method	BT
Target species	SQU, HOK, SWA, BAR, FLA, SPD, WAR, LIN, STA, GUR, JMA, WWA
Core vessel selection	≥ 3 years vessel participation, ≥ 3 non–zero tows per trip

Table D3: Summary of CHAT data used in the analyses of CPUE for all vessels and for core vessels for each fishing year, where 1998–99 is 1999. Vessels gives the number of unique vessels fishing; Tows gives the number of tow records; Zeros gives the proportion of tows (estimated) or days (line) that caught zero catch; Catch gives the estimated catch; CPUE gives the unstandardised CPUE from the tow-by-tow data (estimated) or daily catch non–zero records (line); Days gives the number of vessel days fished.

(a) CHAT: TCEPR estimated BT data for target hoki tows

	All vessels					Core vessels				
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	Zeros	Catch (t)	CPUE
1999	34	6 067	0.91	175.7	0.31	7	3 644	0.87	123.2	0.26
2000	25	4 812	0.83	288.7	0.35	6	2 736	0.73	255.6	0.35
2001	30	6 586	0.85	351.9	0.34	8	3 915	0.79	296.6	0.35
2002	26	5 645	0.88	256.2	0.37	8	3235	0.81	217.9	0.35
2003	27	6 277	0.87	248.8	0.30	8	3 939	0.83	211.9	0.32
2004	27	4 570	0.90	211.3	0.44	6	3 363	0.88	177.7	0.46
2005	19	3 366	0.85	239.2	0.47	7	2 630	0.82	225.1	0.47
2006	14	2 870	0.80	297.5	0.50	7	2 252	0.76	286.9	0.53
2007	17	3 019	0.83	233.7	0.44	6	2 299	0.79	227.6	0.46
2008	21	2 487	0.79	299.4	0.56	6	2 017	0.75	286.6	0.57
2009	19	2 075	0.72	281.2	0.48	6	1 735	0.68	278.6	0.49
2010	20	2 632	0.84	168.5	0.39	6	2 343	0.83	157.3	0.39
2011	19	2 725	0.82	171.6	0.35	7	2 353	0.82	144.5	0.34
Total	50	53 131		3 224.4		13	36 461		2 889.9	

(b) CHAT: bottom longline (BLL) target ling data merged to vessel–day–statistical area.

	All vessels					Final vessels				
Year	Vessels	Days	Zeros	Catch (t)	CPUE	Vessels	Days	Zeros	Catch (t)	CPUE
1996	7	419	0.30	349.2	1.19	3	261	–	288.3	1.10
1997	8	406	0.54	313.9	1.67	5	178	–	291.4	1.64
1998	8	390	0.43	297.2	1.33	5	210	–	263.9	1.26
1999	7	411	0.36	604.6	2.29	6	238	–	512.5	2.15
2000	4	275	0.32	315.0	1.69	4	184	–	298.8	1.62
2001	4	272	0.22	391.7	1.86	4	209	–	379.2	1.81
2002	6	489	0.46	530.3	2.01	4	261	–	486.9	1.87
2003	5	359	0.13	774.9	2.48	5	308	–	716.2	2.33
2004	7	382	0.11	305.4	0.90	6	339	–	305.4	0.90
2005	6	547	0.08	451.5	0.89	5	504	–	449.7	0.89
2006	7	369	0.09	247.4	0.74	5	331	–	236.0	0.71
2007	9	561	0.15	454.9	0.95	5	457	–	416.1	0.91
2008	9	415	0.14	154.0	0.43	2	297	–	128.2	0.43
2009	7	423	0.05	219.1	0.55	2	351	–	179.1	0.51
2010	5	571	0.10	476.2	0.92	3	498	–	463.0	0.93
2011	7	467	0.04	413.0	0.92	3	380	–	380.8	1.00
Total	31	6 756		6 298.1		11	5 006		5 795.3	

Table D3: *continued.*

(c) SUBA: TCEPR estimated BT data for main target species

	All vessels					Core vessels				
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	Zeros	Catch (t)	CPUE
2000	28	6 008	0.76	826.0	0.57	15	3 971	0.67	779.6	0.60
2001	35	6 654	0.75	756.5	0.46	15	3 964	0.65	673.8	0.49
2002	35	9 918	0.73	2 354.6	0.87	16	5 646	0.64	1 896.2	0.92
2003	37	9 047	0.67	1 773.4	0.59	17	6 280	0.59	1 525.3	0.59
2004	32	7 787	0.68	1 385.9	0.56	12	4 546	0.56	1 050.8	0.52
2005	33	8 042	0.71	1 056.7	0.45	17	5 296	0.66	866.4	0.48
2006	31	7 015	0.65	1 233.6	0.50	18	4 917	0.61	1 048.1	0.55
2007	23	5 304	0.66	1 146.3	0.64	15	3 900	0.63	1 045.7	0.73
2008	22	4 517	0.72	542.3	0.43	16	3 378	0.65	508.3	0.43
2009	19	4 010	0.71	788.4	0.67	14	3 148	0.67	699.6	0.68
2010	21	4 604	0.64	907.7	0.54	17	4 215	0.63	867.5	0.56
2011	22	4 686	0.80	658.8	0.69	14	3 812	0.78	590.3	0.70
All	57	77 592		13 430.6		20	53 073		11 551.7	

(d) SUBA: Bottom tow merged estimated data to trip level for main target species

	All vessels					Core vessels				
Year	Vessels	Tows	Zeros	Catch (t)	CPUE	Vessels	Tows	Zeros	Catch (t)	CPUE
2000	47	1320	0.62	1 242.4	2.45	37	658	0.50	1 039.2	3.13
2001	62	1963	0.58	1 207.7	1.48	48	1059	0.47	1 004.0	1.79
2002	69	2030	0.53	4 132.4	4.36	56	1088	0.41	3 231.1	5.03
2003	74	1860	0.54	3 006.2	3.55	59	995	0.40	1 975.0	3.33
2004	54	1325	0.53	1 636.1	2.65	46	714	0.39	1 389.8	3.22
2005	59	1763	0.55	1 974.9	2.47	50	898	0.35	1 534.1	2.61
2006	58	1736	0.49	2 166.9	2.45	51	977	0.30	1 768.1	2.57
2007	54	1987	0.54	2 031.8	2.21	42	1015	0.34	1 752.6	2.61
2008	49	1424	0.50	1 138.9	1.60	44	704	0.27	945.3	1.85
2009	44	1401	0.52	1 422.8	2.11	42	636	0.29	1 068.4	2.37
2010	53	1512	0.46	1 763.7	2.17	43	734	0.25	1 493.4	2.70
2011	47	1574	0.57	1 272.9	1.87	38	578	0.33	938.6	2.43
All	130	19 895		22 996.9		75	10 056		18 139.6	

Table D4: Variables retained in order of decreasing explanatory value by each CHAT or SUBA model and the corresponding total r^2 values.

Data set	Variable	R^2
CHAT: TCEPR tow-by-tow estimated BT target hoki tows. Lognormal	Year	5.3
	Vessel	15.9
	Duration	20.0
	Mid-time of tow	25.0
	Month	26.2
	Depth of bottom	27.3
CHAT: TCEPR tow-by-tow estimated BT target hoki tows. Binomial	Year	1.8
	Depth of bottom	6.9
	Vessel	9.2
	Month	11.1
	Latitude	12.8
	Mid-time of tow	14.4
CHAT: bottom longline target ling lines. Lognormal	Year	16.5
	Log(Total hooks)	29.6
	Month	36.8
	Vessel	40.8
	Statistical area	42.6
SUBA: TCEPR tow-by-tow BT main target species tows. Lognormal	Year	3.8
	Statistical area	12.3
	Target species	16.3
	Fishing duration	18.2
	Vessel	19.5
	Month	20.6
SUBA: TCEPR tow-by-tow BT main target species tows. Binomial	Year	1.1
	Statistical area	19.5
	Depth of bottom	21.5
	Vessel	23.6
	Month	25.0
SUBA: BT tows merged to trip level for main target species. Lognormal	Year	1.9
	Vessel	42.2
	Fishing duration	46.4
	Target species	48.8
	Month	50.3

Table D5: CPUE indices by fishing year, where 1998–99 is 1999, with 95% confidence intervals and CVs.

(a) CHAT: TCEPR tow-by-tow BT target hoki tows - estimated

	Lognormal			Binomial			Combined
Year	Index	95% CI	CV	Index	95% CI	CV	Index
1999	0.71	0.65–0.79	0.05	0.78	0.75–0.81	0.01	0.85
2000	0.94	0.87–1.02	0.04	0.56	0.52–0.60	0.02	0.81
2001	0.78	0.72–0.84	0.04	0.59	0.56–0.63	0.02	0.71
2002	0.81	0.74–0.89	0.04	0.70	0.66–0.73	0.02	0.87
2003	0.91	0.83–0.99	0.04	0.72	0.69–0.76	0.02	1.01
2004	0.97	0.88–1.08	0.05	0.80	0.77–0.83	0.01	1.19
2005	1.08	0.98–1.18	0.05	0.73	0.69–0.76	0.02	1.21
2006	1.18	1.09–1.29	0.04	0.67	0.63–0.71	0.02	1.22
2007	1.22	1.11–1.34	0.05	0.65	0.61–0.69	0.02	1.21
2008	1.24	1.13–1.36	0.05	0.57	0.52–0.61	0.02	1.08
2009	1.29	1.18–1.41	0.04	0.49	0.45–0.54	0.02	0.98
2010	1.07	0.97–1.19	0.05	0.68	0.65–0.72	0.02	1.12
2011	1.00	0.90–1.10	0.05	0.62	0.58–0.66	0.02	0.95

(b) CHAT: bottom longline target ling

	Lognormal		
Year	Index	95% CI	CV
1996	0.53	0.44–0.63	0.09
1997	0.72	0.60–0.88	0.10
1998	0.70	0.60–0.82	0.08
1999	1.32	1.14–1.52	0.07
2000	1.11	0.94–1.31	0.08
2001	0.95	0.81–1.11	0.08
2002	1.22	1.05–1.42	0.07
2003	1.27	1.11–1.46	0.07
2004	1.22	1.07–1.38	0.06
2005	0.91	0.81–1.02	0.06
2006	0.77	0.68–0.88	0.06
2007	0.78	0.70–0.87	0.06
2008	1.04	0.90–1.20	0.07
2009	1.35	1.18–1.54	0.07
2010	1.14	1.02–1.28	0.06
2011	1.61	1.43–1.83	0.06

Table D5: *continued*.

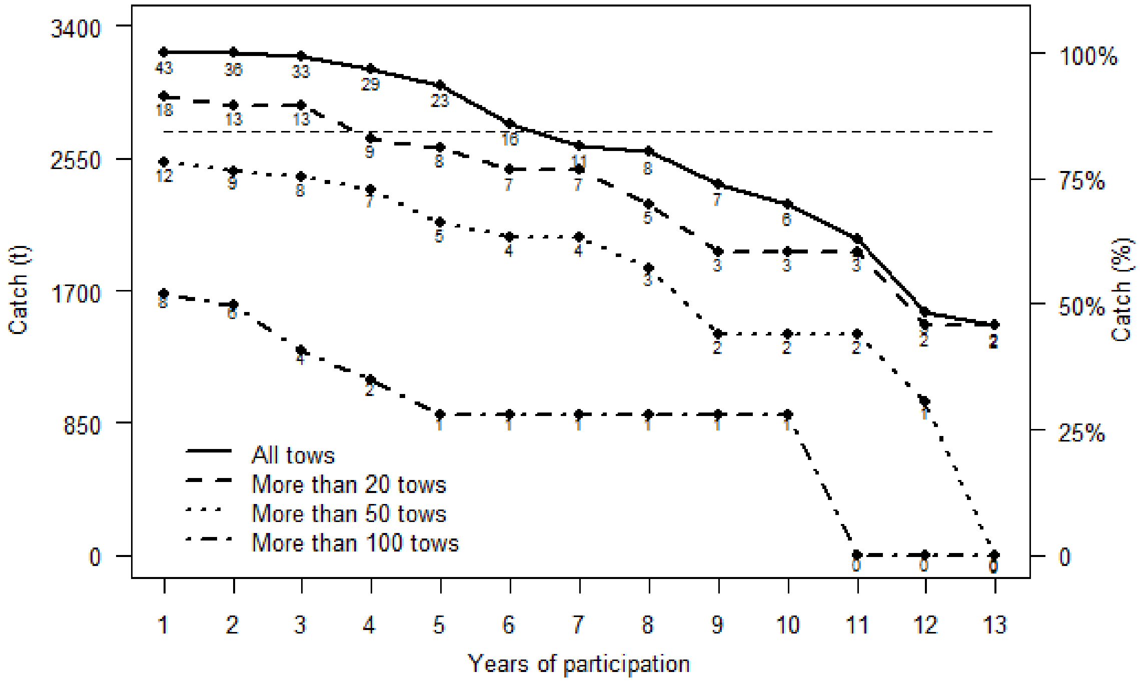
(c) SUBA TCEPR tow-by-tow BT main target species

	Lognormal			Binomial			Combined
Year	Index	95% CI	CV	index	95% CI	CV	index
2000	1.22	1.15–1.29	0.03	1.01	0.98–1.04	0.02	1.26
2001	1.03	0.98–1.09	0.03	0.98	0.95–1.01	0.02	1.01
2002	1.84	1.76–1.92	0.02	0.92	0.93–0.98	0.01	1.71
2003	1.33	1.27–1.39	0.02	0.92	0.89–0.94	0.01	1.15
2004	1.12	1.07–1.17	0.02	0.90	0.87–0.93	0.01	0.93
2005	0.79	0.75–0.83	0.02	1.07	1.04–1.10	0.01	0.91
2006	0.82	0.78–0.86	0.02	1.00	0.97–1.03	0.01	0.83
2007	0.84	0.80–0.89	0.03	1.02	0.99–1.05	0.02	0.89
2008	0.76	0.72–0.80	0.03	1.03	1.00–1.07	0.02	0.82
2009	1.06	0.99–1.12	0.03	1.01	0.97–1.04	0.02	1.10
2010	0.87	0.83–0.92	0.03	0.98	0.95–1.01	0.02	0.86
2011	0.77	0.72–0.82	0.03	1.15	1.12–1.19	0.02	0.99

(d) SUBA BT tows merged to trip level for main target species

	Lognormal		
Year	Index	95% CI	CV
2000	1.06	0.95–1.19	0.06
2001	1.01	0.92–1.10	0.04
2002	1.49	1.38–1.62	0.04
2003	1.34	1.24–1.46	0.04
2004	1.40	1.27–1.54	0.05
2005	0.99	0.91–1.08	0.04
2006	1.04	0.96–1.13	0.04
2007	0.86	0.79–0.93	0.04
2008	0.76	0.70–0.83	0.04
2009	0.79	0.72–0.87	0.05
2010	0.88	0.81–0.96	0.04
2011	0.70	0.64–0.78	0.05

(a) CHAT TCEPR tow-by-tow BT target hoki tows, 1998–99 (1999) to 2010–11 (2011)



(b) SUBA TCEPR tow-by-tow BT main target species tows, 1999–00 (2000) to 2010–11 (2011)

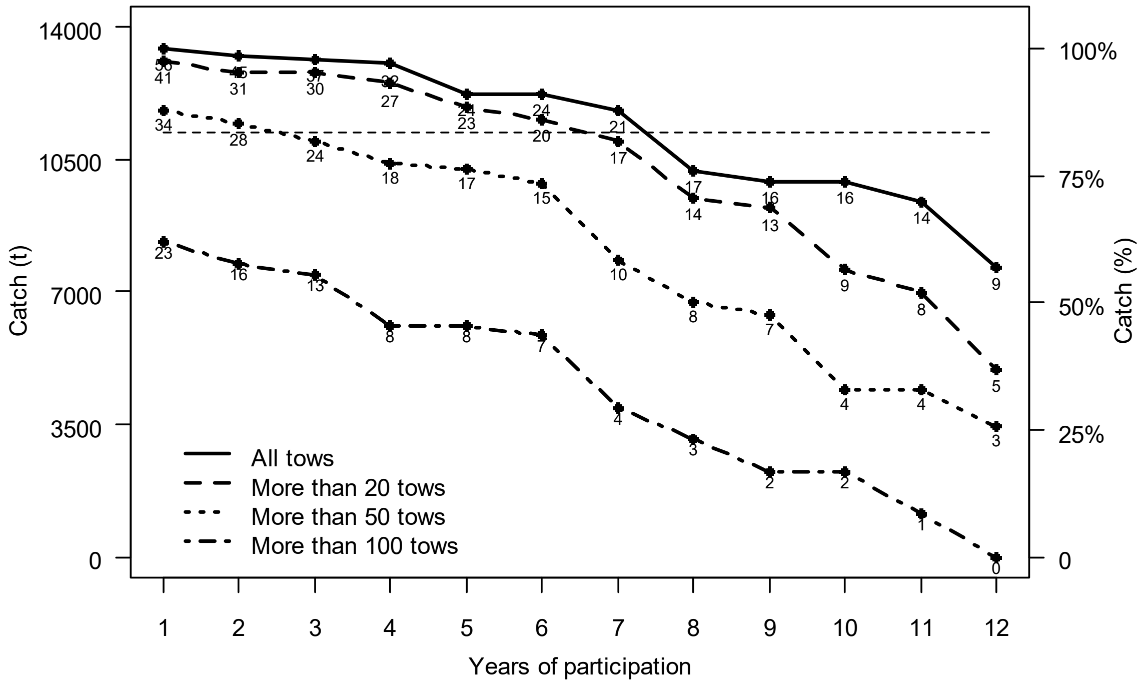


Figure D1: Relationship between years of vessel participation and total spiny dogfish catch for the (a) CHAT BT trawl hoki target fishery and (b) SUBA TCEPR BT main target fishery. The number under each circle indicates the number of vessels with the corresponding years of participation. Dotted horizontal line represents 80% of catch.

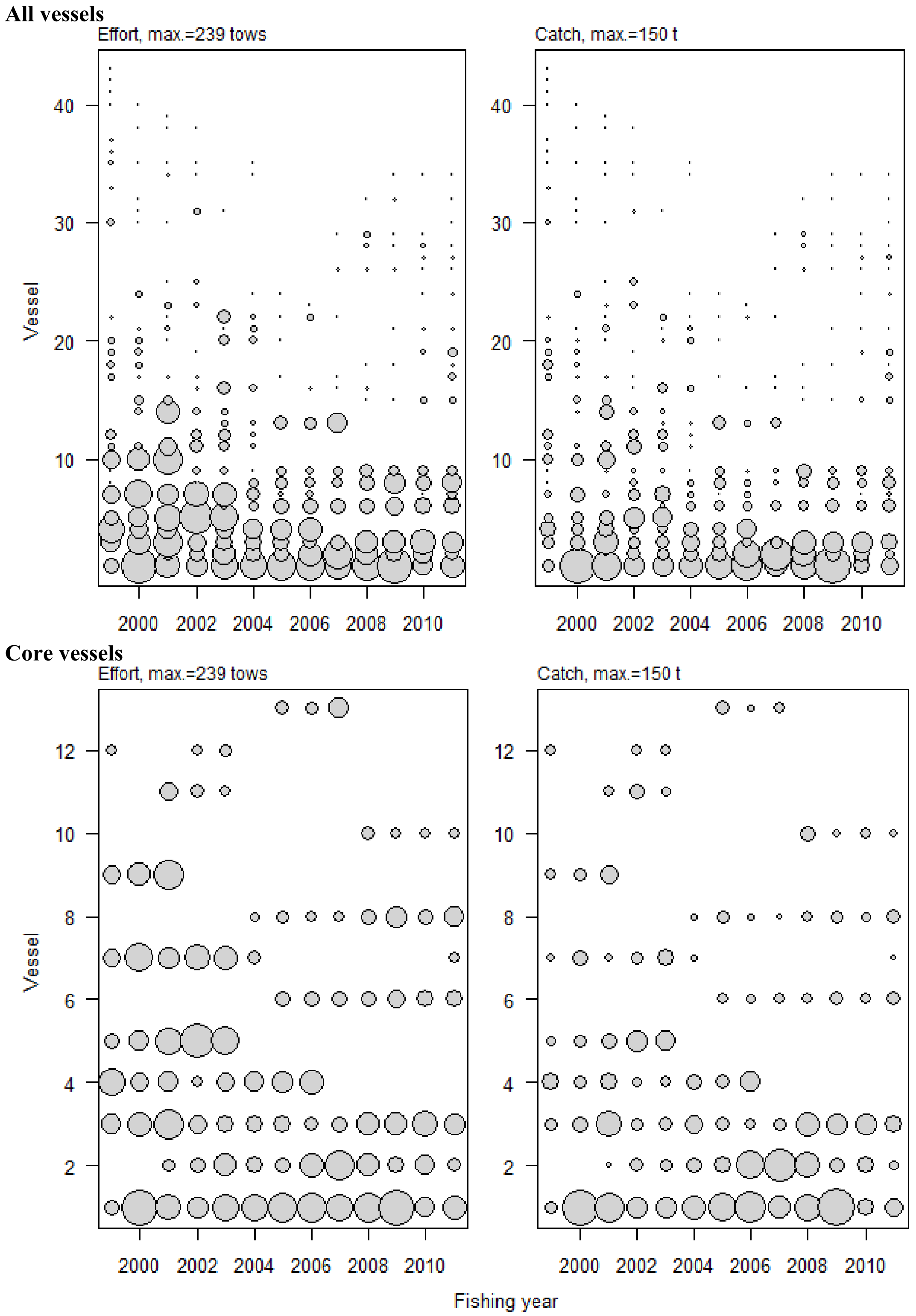


Figure D2a: CHAT summary of effort (number of tows) and estimated spiny dogfish catch by fishing year 1998–99 (1999) to 2010–11 (2011) from BT target hoki tows for all vessels and for core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

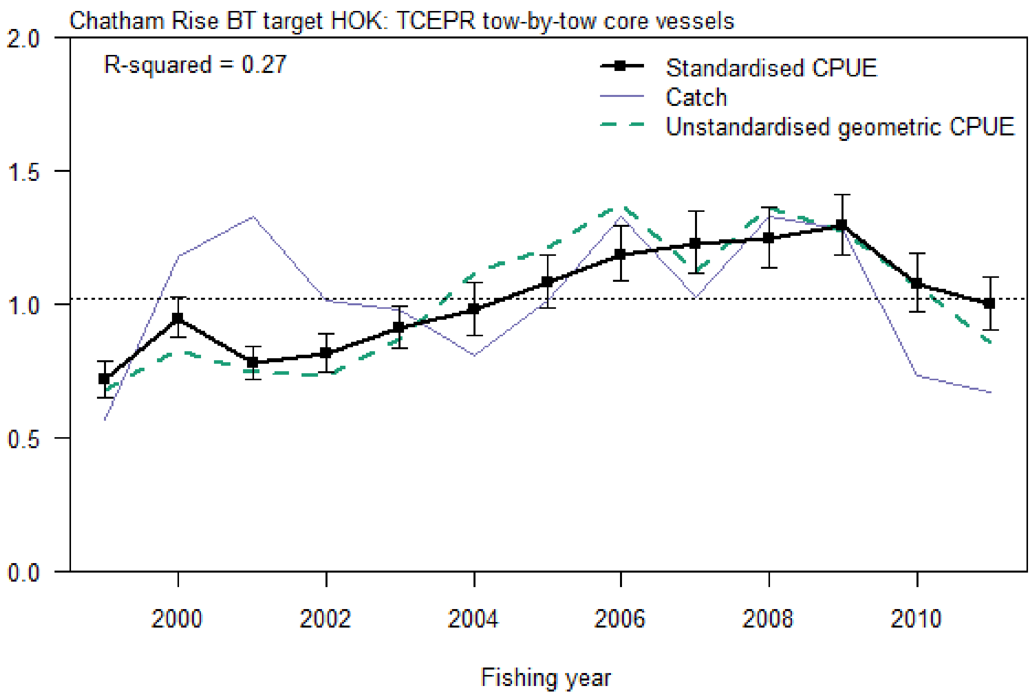


Figure D2b: CPUE lognormal indices for CHAT showing catches (scaled to same mean as indices), and lognormal standardised and un–standardised indices. Bars indicate 95% confidence intervals.

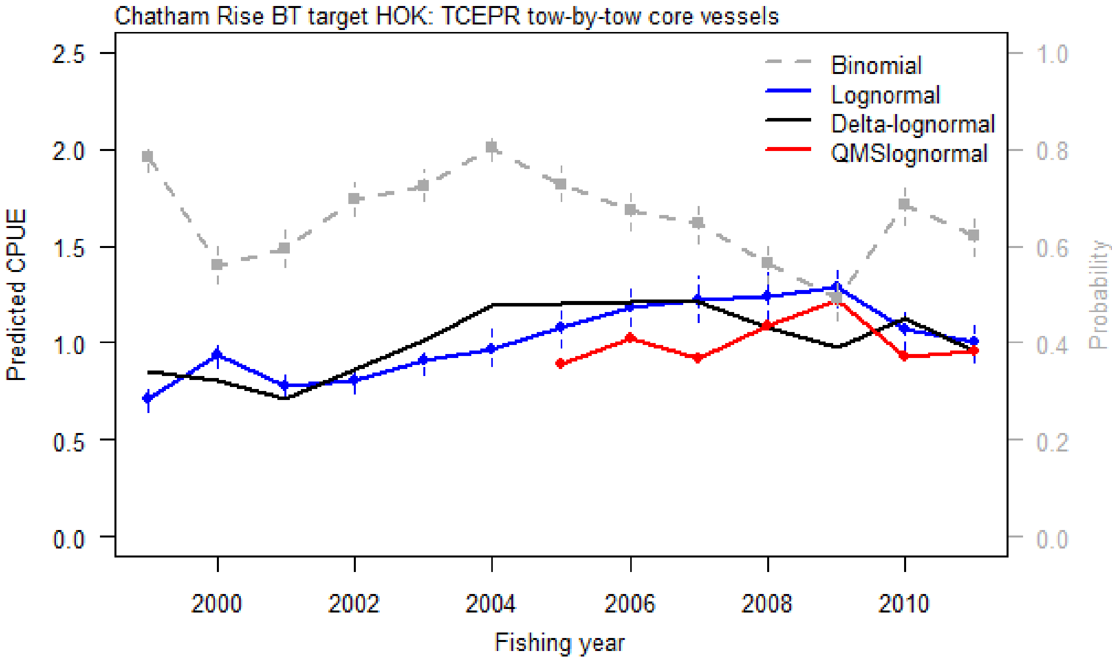


Figure D2c: CHAT CPUE from the lognormal, binomial, and delta-lognormal (combined) BT target hoki model, 1999–2011. A separate model was run for the post-QMS years, based on 5 core vessels, and this is plotted in red for comparison. Bars indicate 95% confidence intervals. Year is defined as October–September.

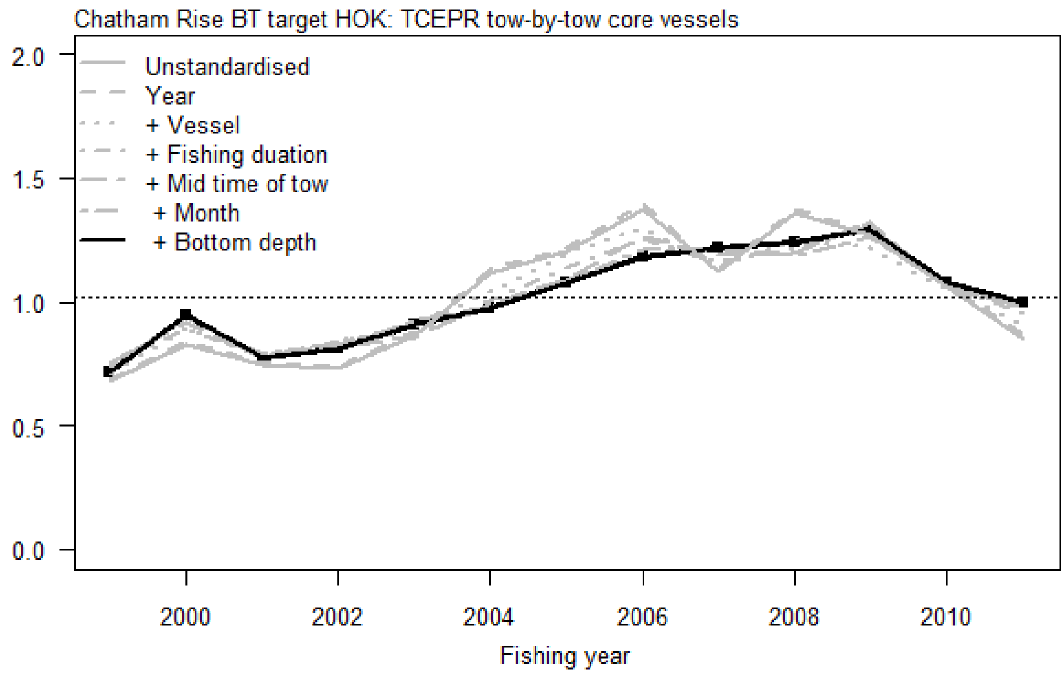


Figure D3: Addition of variables into the lognormal CPUE from the lognormal model for the CHAT fishery by fishing year. Year defined as October–September.

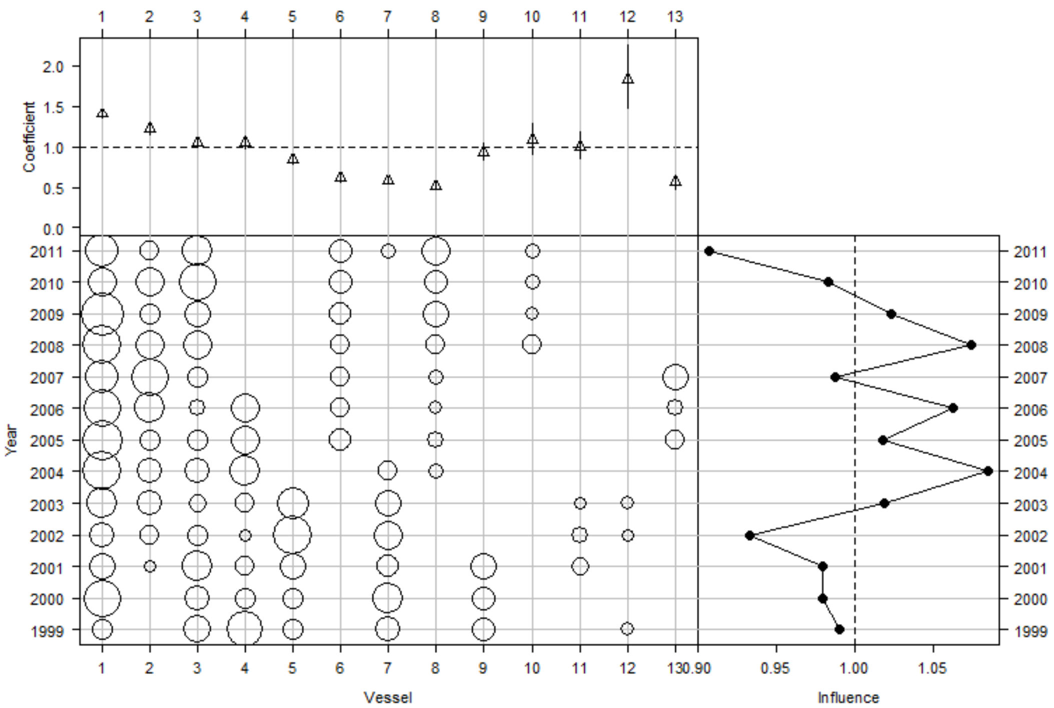


Figure D4: Effect and influence of vessel in the CHAT estimated core BT target hoki vessel lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable (vessel) by fishing year. Bottom right: influence of variable (vessel) on unstandardised CPUE by fishing year.

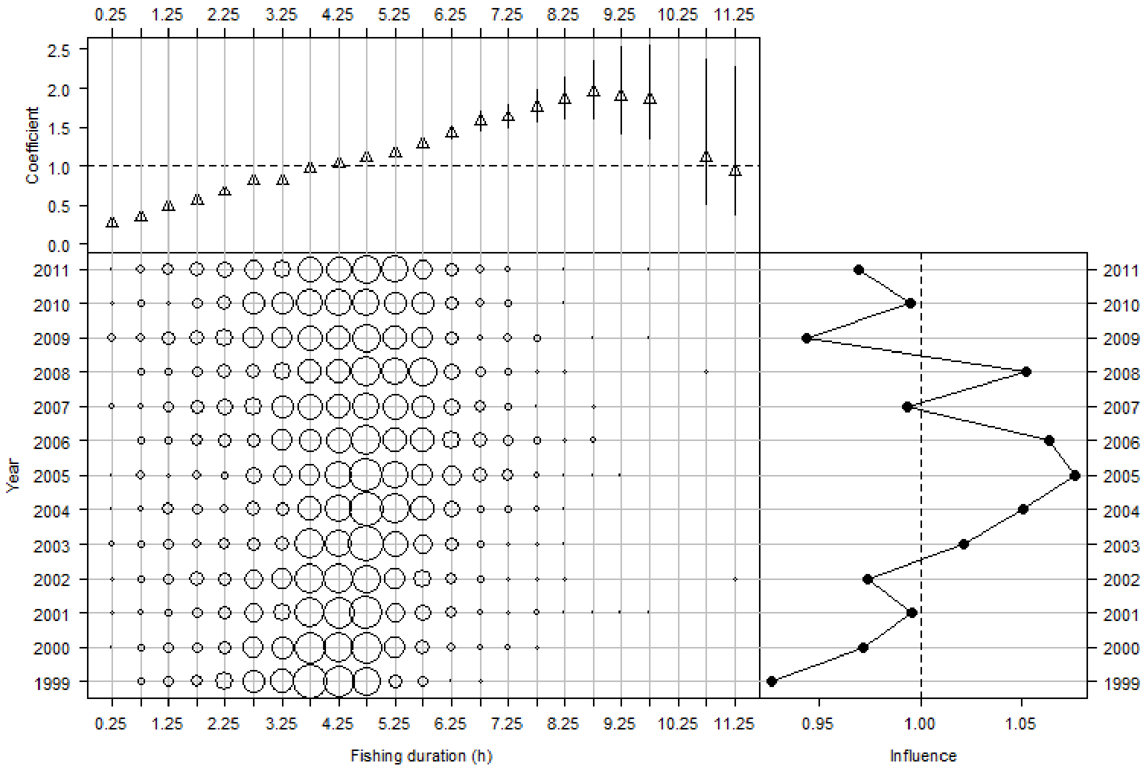


Figure D4 *continued*: Effect and influence of fishing duration of tow in the CHAT estimated core BT target hoki lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

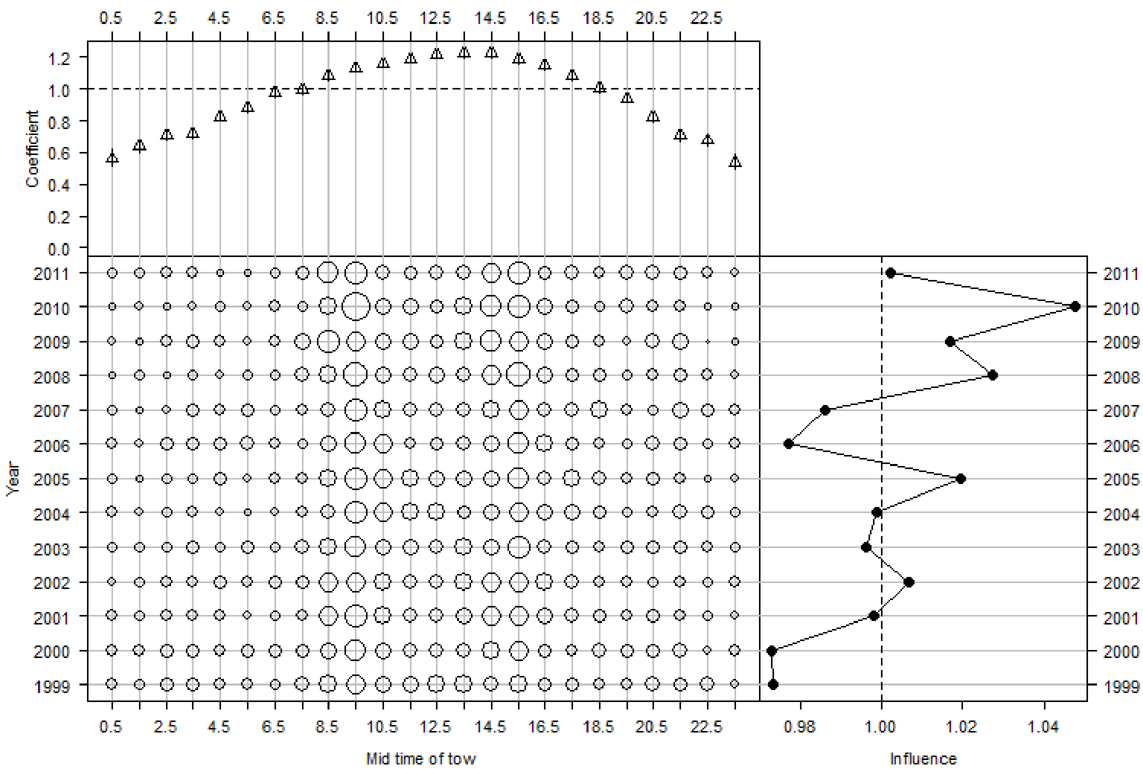


Figure D4 *continued*: Effect and influence of mid time of tow in the CHAT estimated BT target hoki core lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

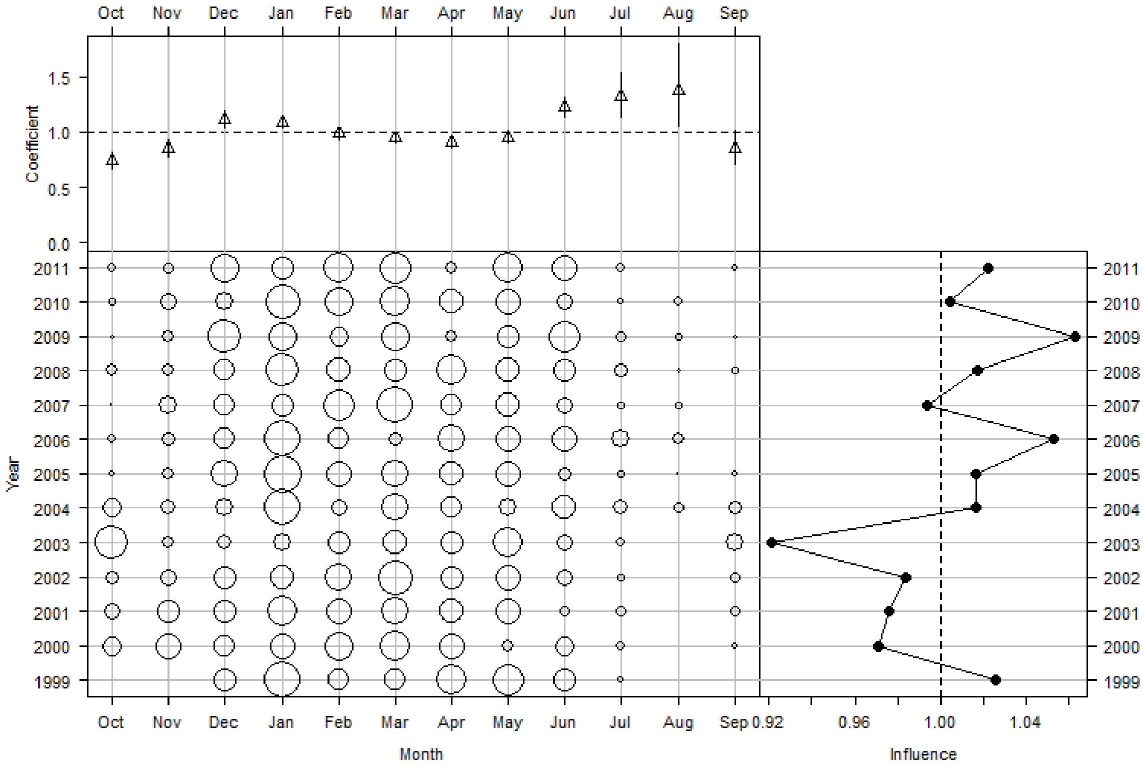


Figure D4 *continued*: Effect and influence of month in the CHAT estimated BT target hoki core lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

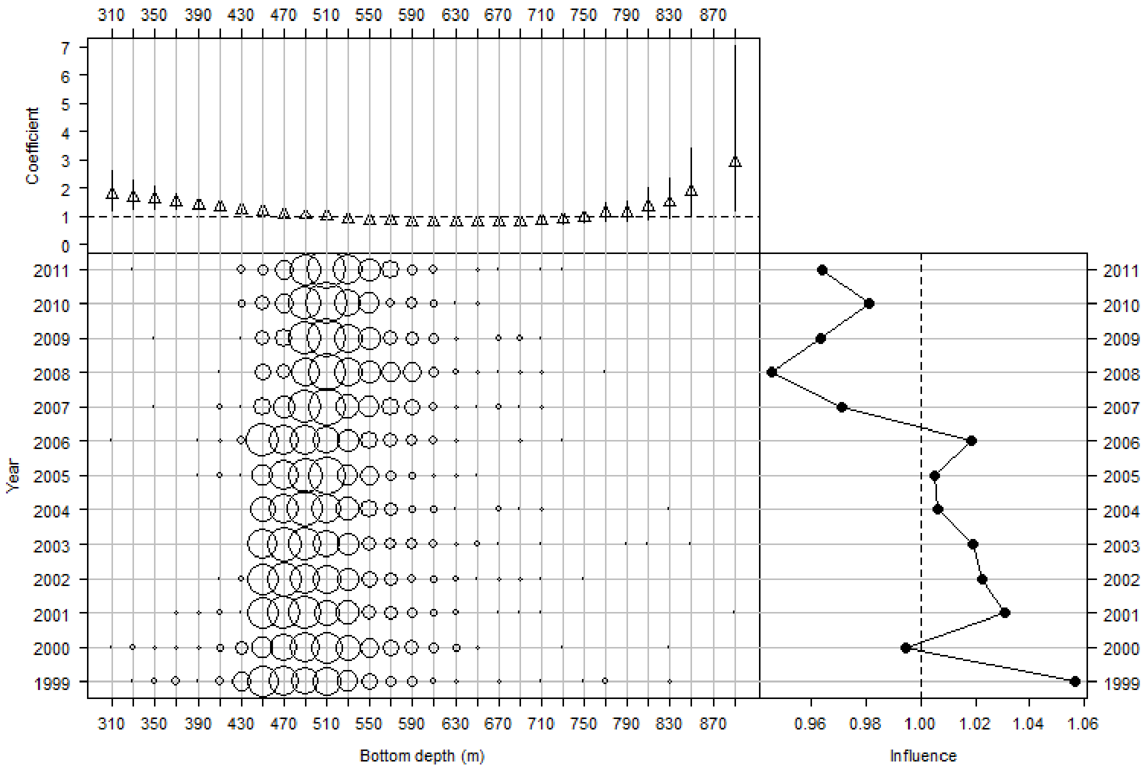


Figure D4 *continued*: Effect and influence of depth of bottom in the CHAT estimated BT target hoki core lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

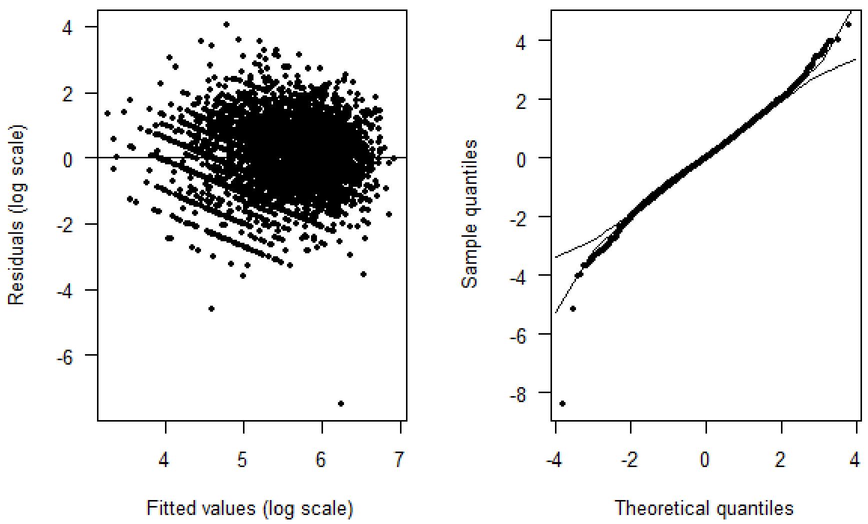


Figure D5: CHAT lognormal model (estimated tow-by-tow data for BT target hoki core vessels); distribution of the standardised residuals against fitted values (left) and quantile–quantile plot of the residuals (right).

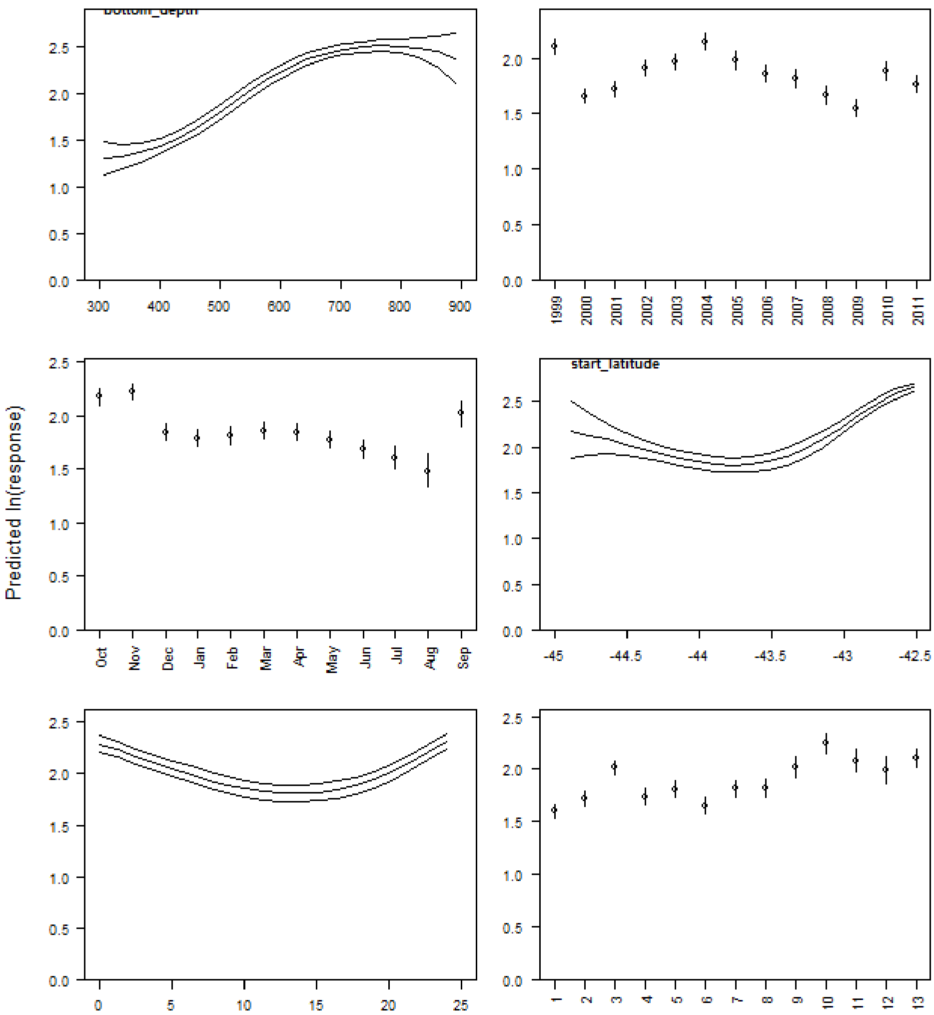


Figure D6a: Effects of selected variables in the binomial model for the CHAT estimated catch for core BT target hoki vessels, 1999–2011. Bars indicate 95% confidence interval. Left panel (from the top): bottom depth, month, mid-time of tow. Right panel (from the top): fishing year, start latitude, and vessel.

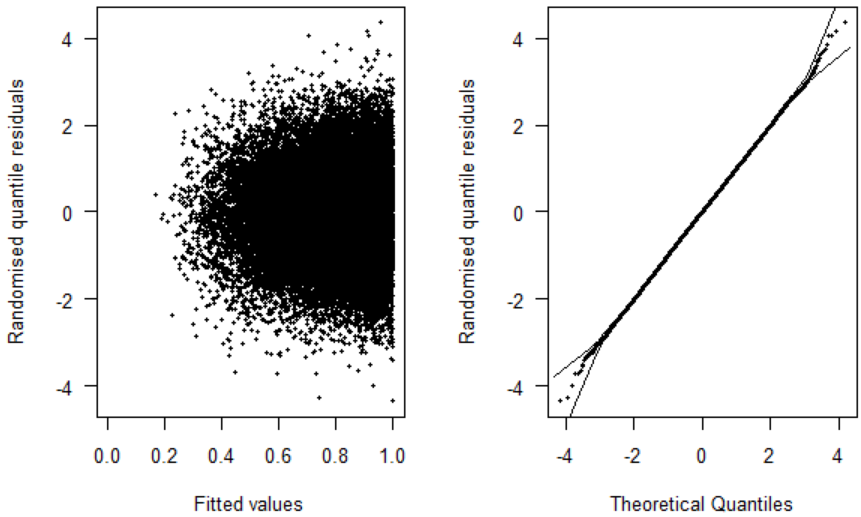


Figure D6b: CHAT binomial model (estimated tow-by-tow data for BT target hoki core vessels); distribution of the randomised quantile residuals against fitted values (left) and quantile–quantile plot of the randomised quantile residuals (right).

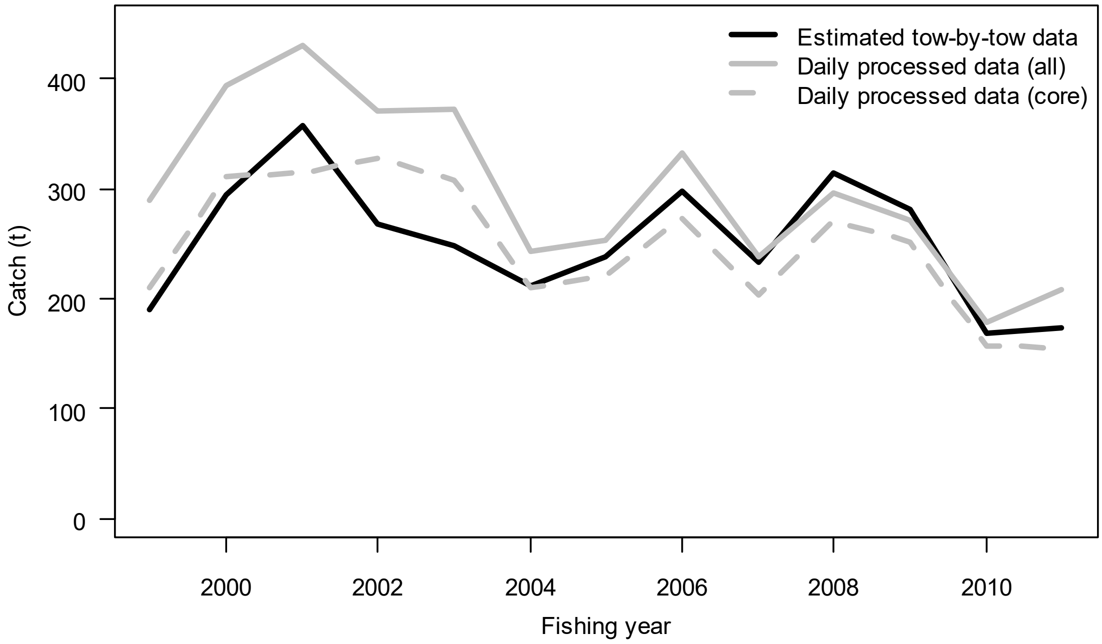
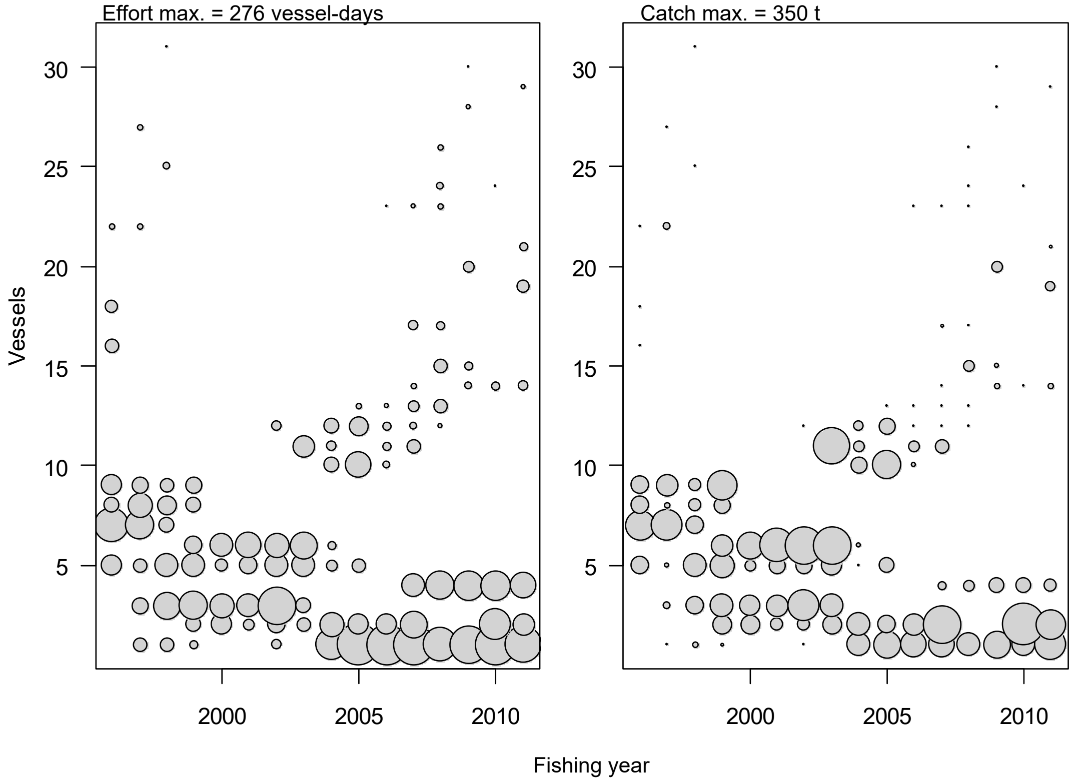


Figure D6c: Comparison between the catch from the estimated tow-by-tow core vessel data and the daily processed data for CHAT BT hoki vessels, 1998–99 (1999) to 2010–11 (2011).

All vessels



Core vessels

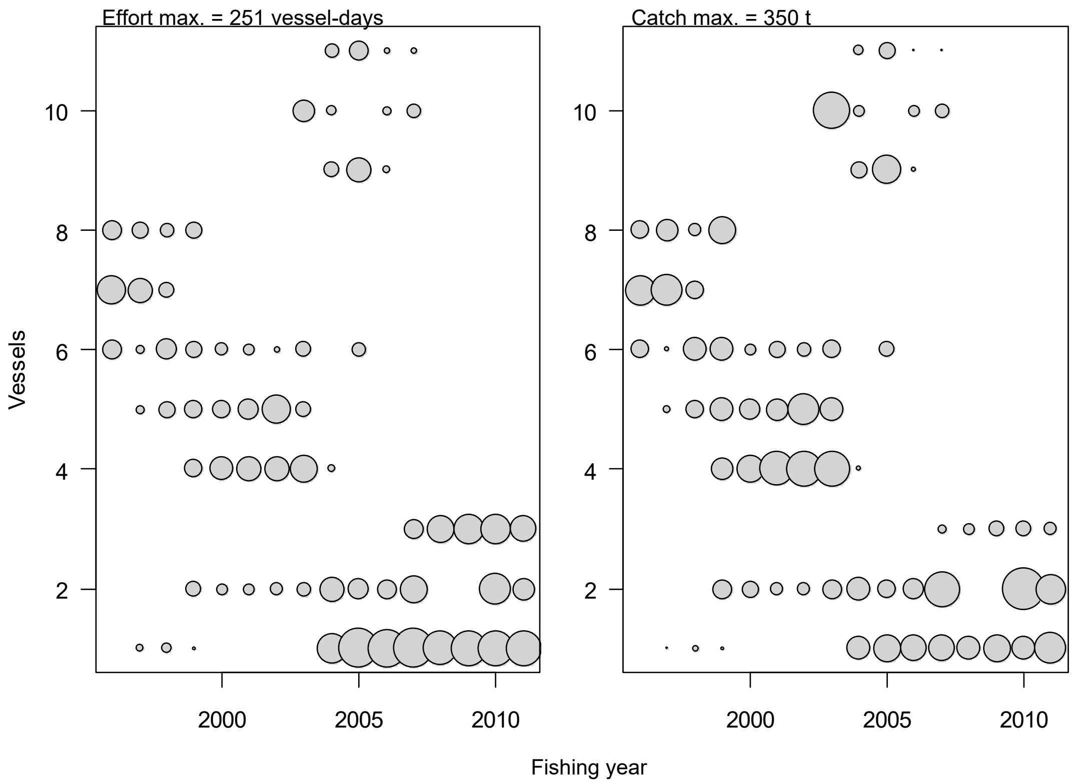


Figure D7a: CHAT summary of effort (number of days) and estimated spiny dogfish catch by fishing year 1997–98 (1998) to 2010–11 (2011) from BLL target ling sets, for all vessels and for core vessels. Symbol area is proportional to either number of vessel days or annual catch, and maximum circle size is shown in the label on the plot.

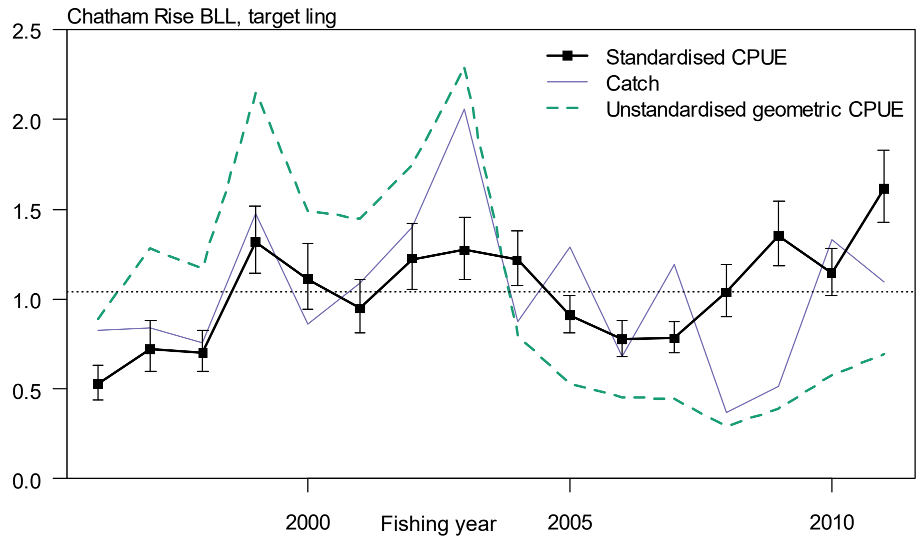


Figure D7b: CPUE lognormal indices for CHAT showing catches (scaled to same mean as indices), and lognormal standardised and unstandardised indices, by fishing year. Bars indicate 95% confidence intervals.

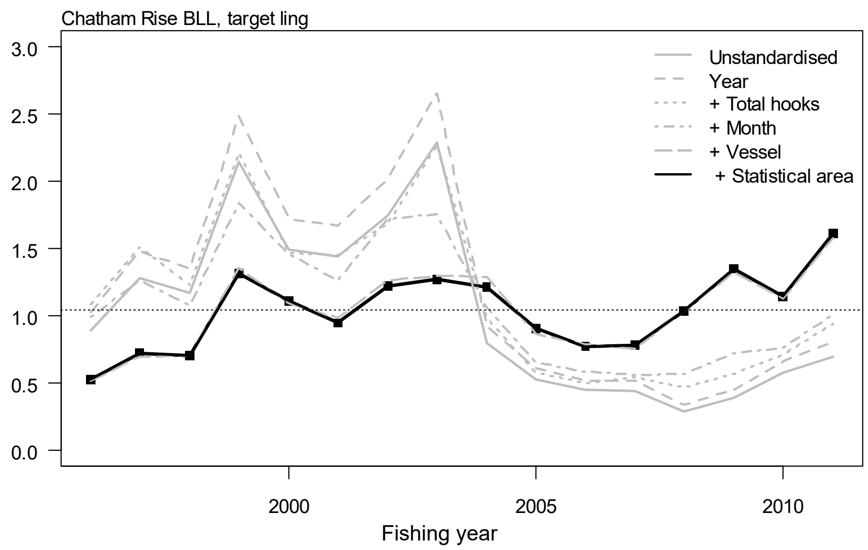


Figure D8: Addition of variables into the lognormal CPUE from the lognormal model for the CHAT fishery by fishing year.

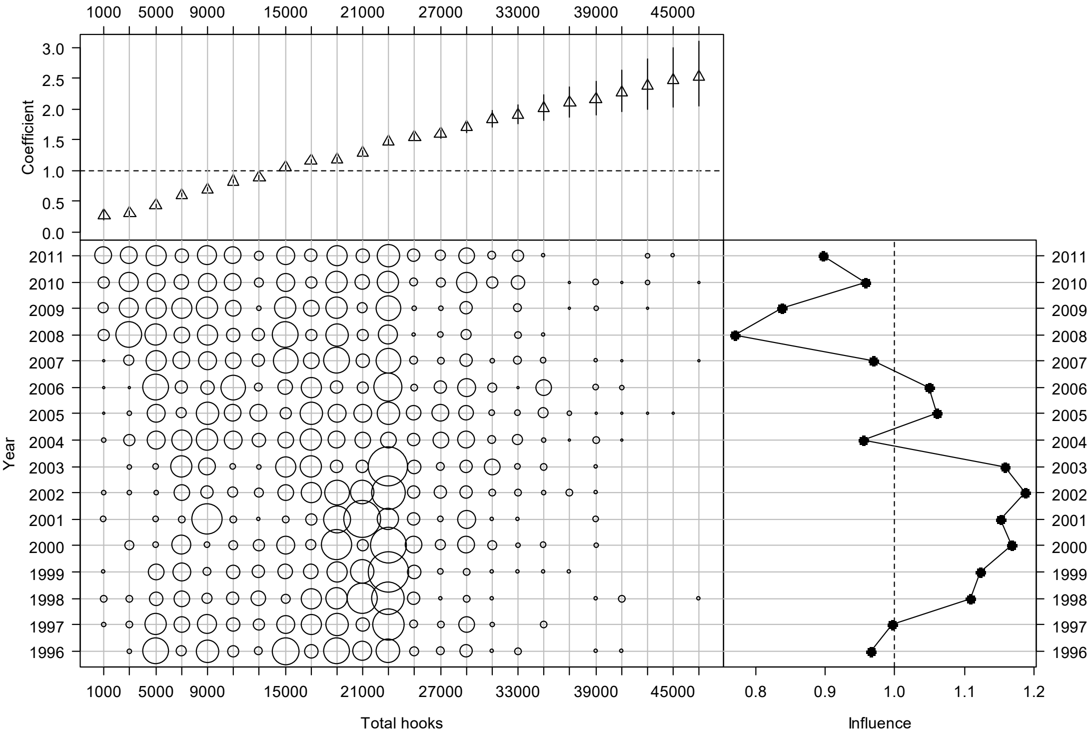


Figure D9: Effect and influence of total hooks in the CHAT processed core BLL target ling vessel lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable (number of hooks) by fishing year. Bottom right: influence of variable (vessel) on unstandardised CPUE by fishing year.

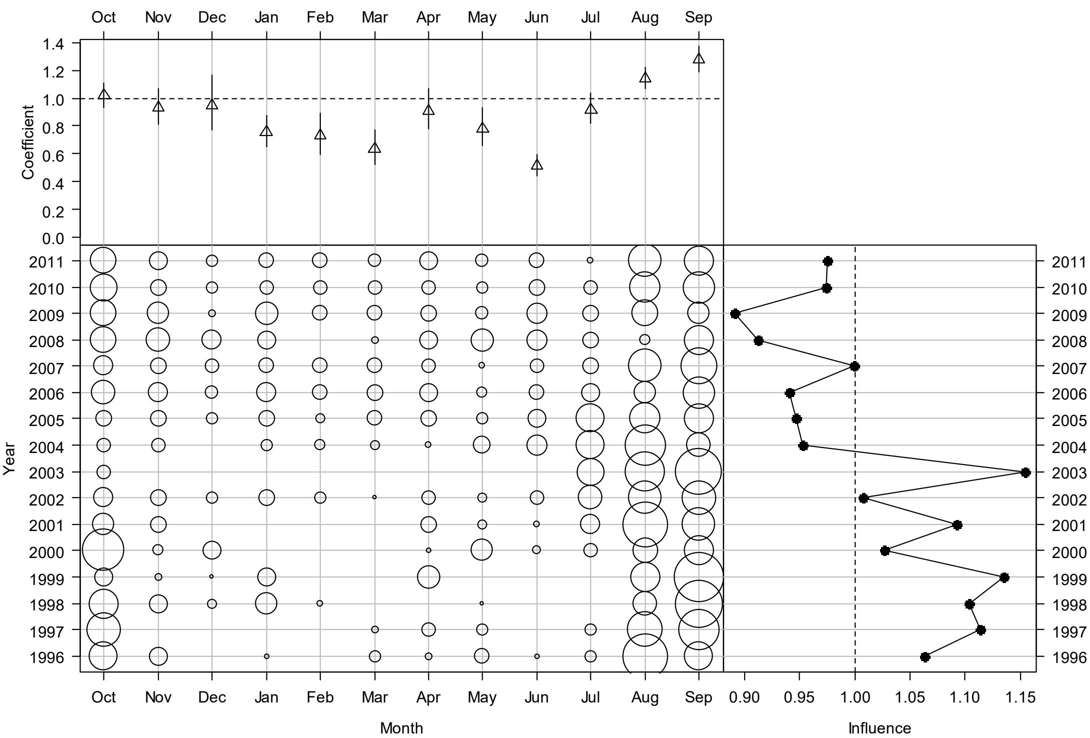


Figure D9 *continued*: Effect and influence of month in the CHAT processed core BLL target ling lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

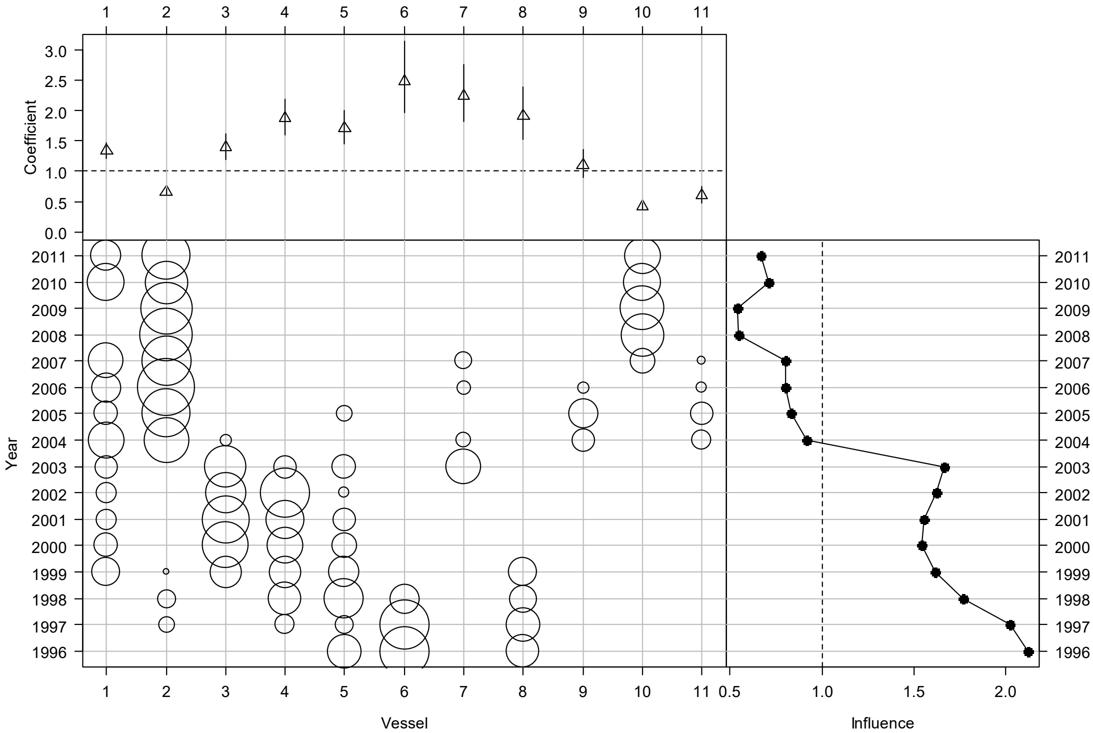


Figure D9 *continued*: Effect and influence of vessel in the CHAT processed core BLL target ling lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

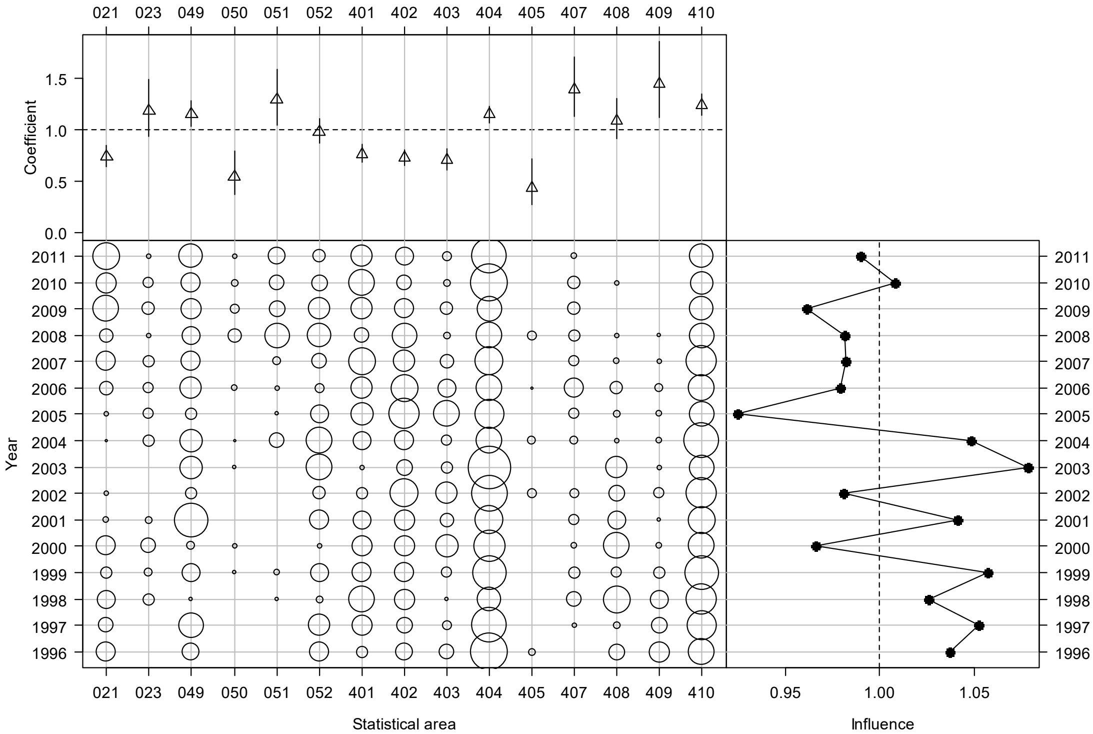


Figure D9 *continued*: Effect and influence of statistical area in the CHAT processed core BLL target ling lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

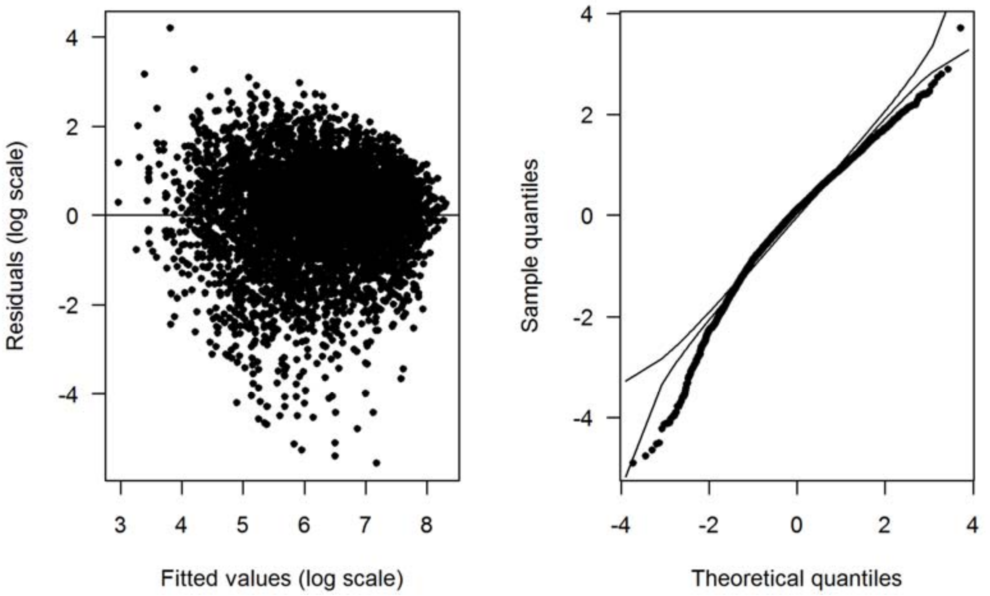


Figure D10: CHAT lognormal model (BLL target ling for core vessels); distribution of the standardised residuals against fitted values (left) and quantile–quantile plot of the residuals (right).

All vessels

Core vessels

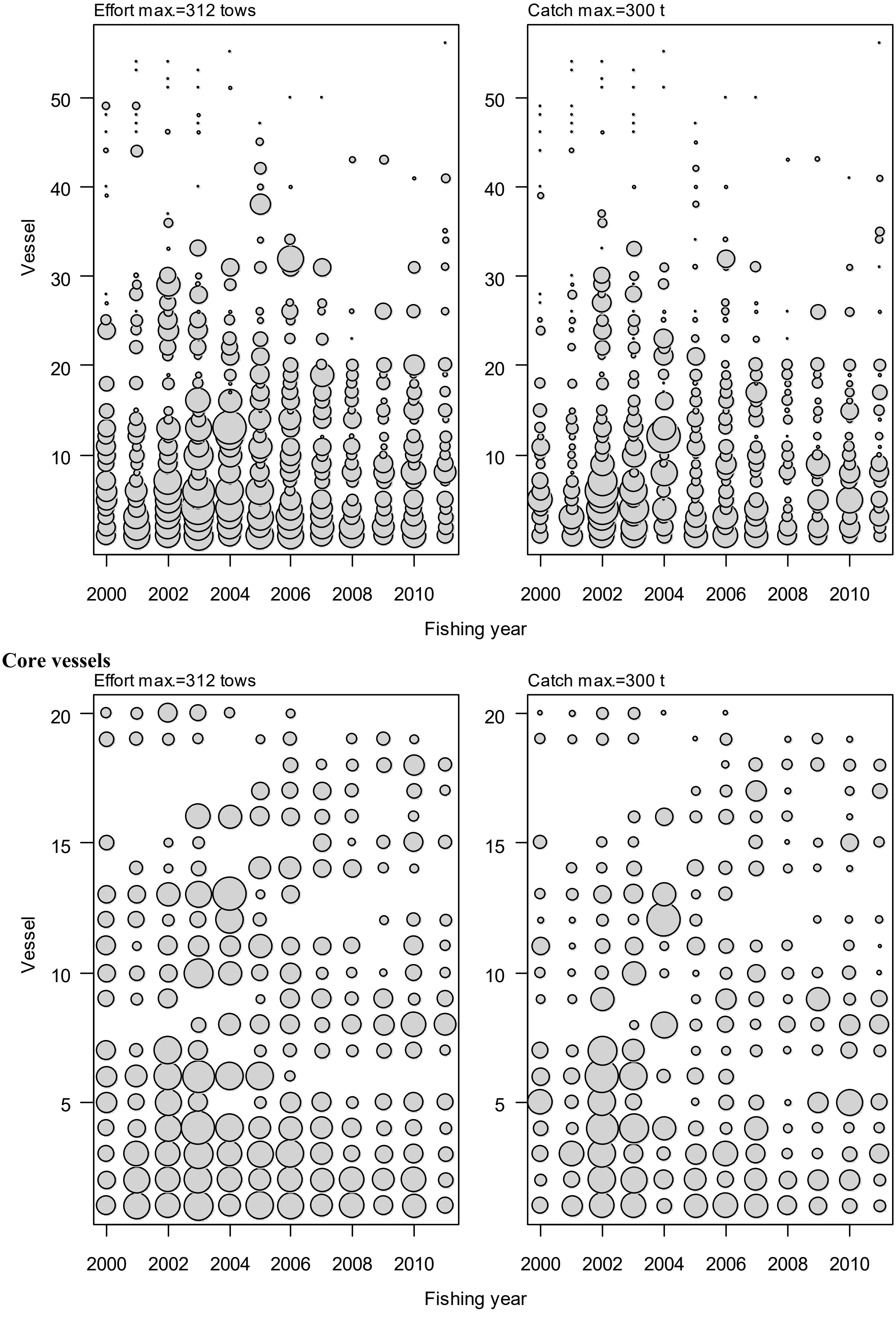


Figure D11a: SUBA summary of effort (number of tows) and estimated spiny dogfish catch by fishing year 1999–00 (2000) to 2010–11 (2011) from all TCEPR tow-by-tow BT for main target species tows, for all vessels and for core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

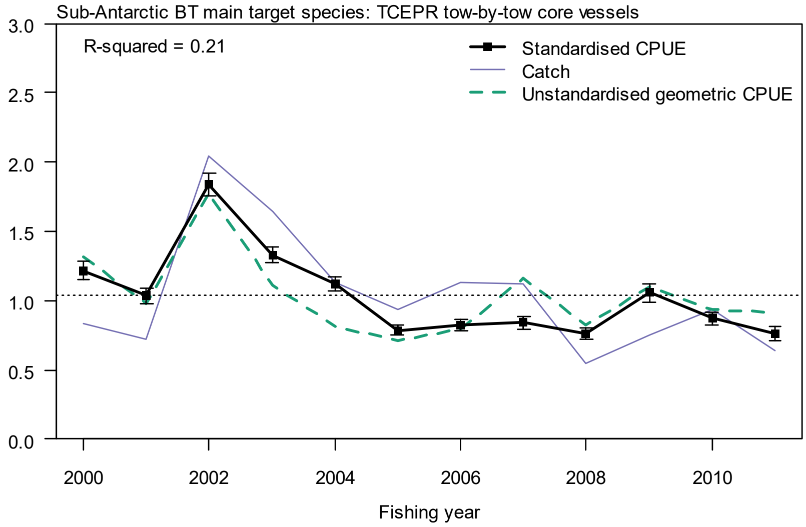


Figure D11b: CPUE lognormal indices for SUBA TCEPR catch showing catches (scaled to same mean as indices), and lognormal standardised and un–standardised indices. Bars indicate 95% confidence intervals.

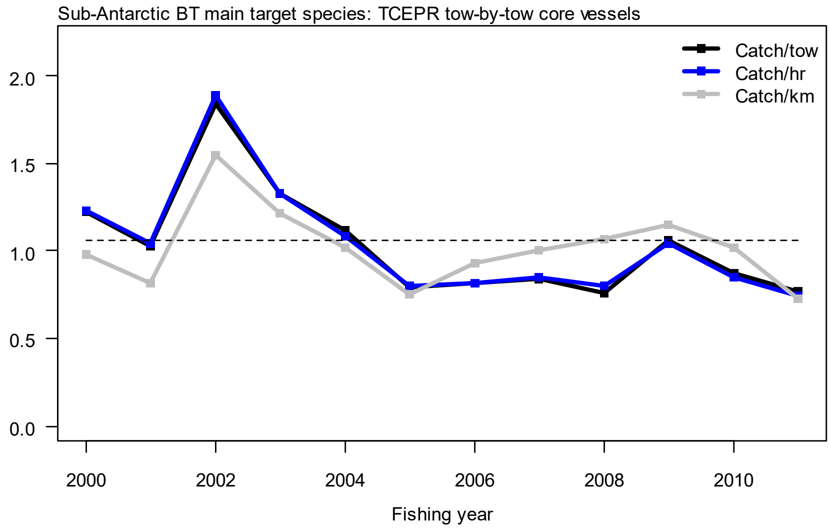


Figure D11c: Comparison of SUBA TCEPR indices for spiny dogfish datasets by fishing year.

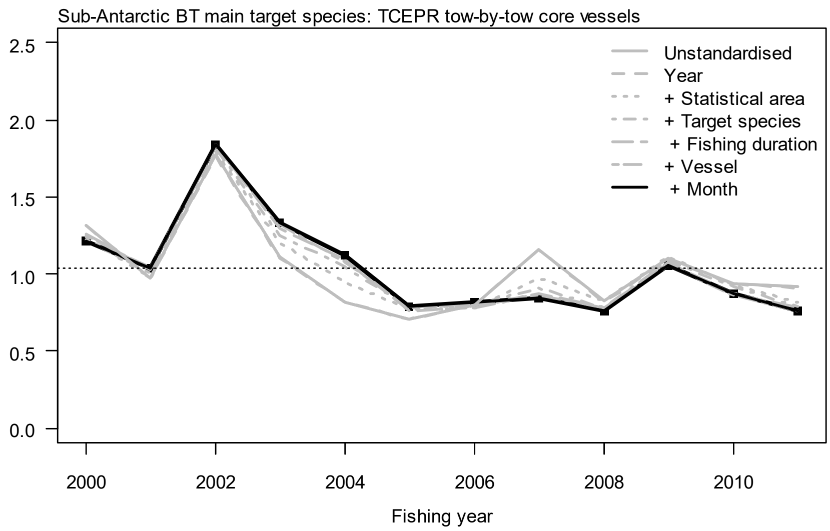


Figure D12: Addition of variables into the lognormal CPUE from the lognormal model for the SUBA fishery by fishing year.

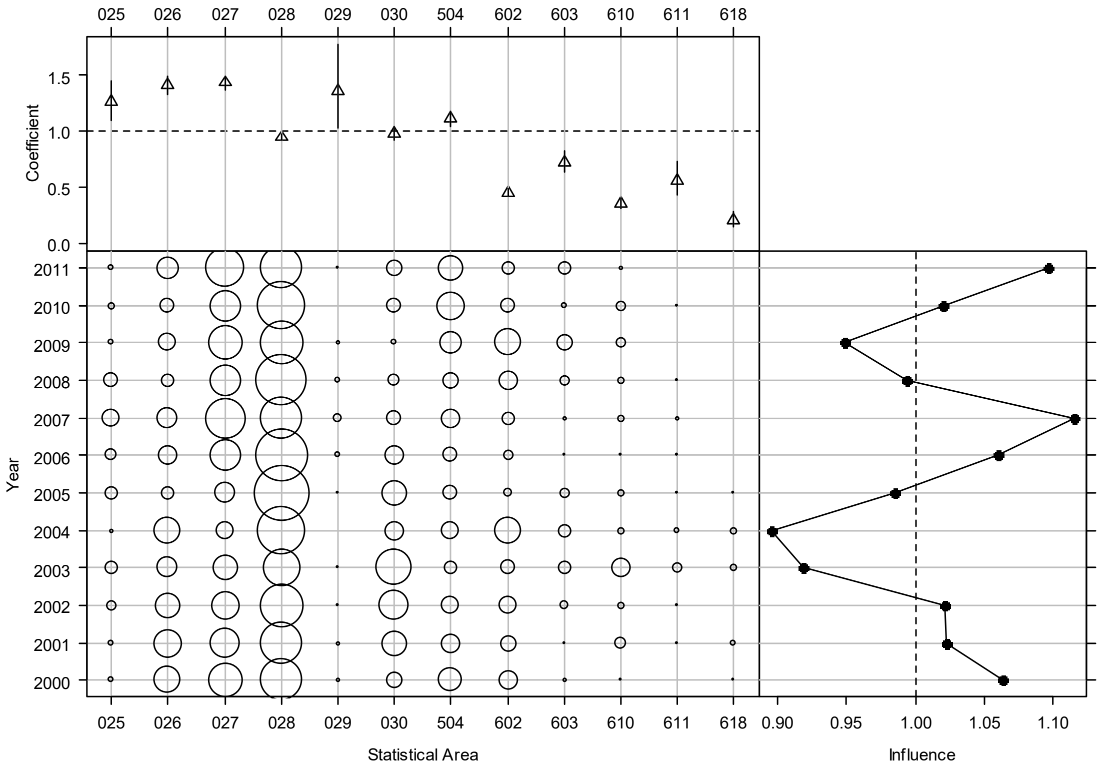


Figure D13: Effect and influence of statistical area in the SUBA estimated core BT tows for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable (statistical area) by fishing year. Bottom right: influence of variable (target) on unstandardised CPUE by fishing year.

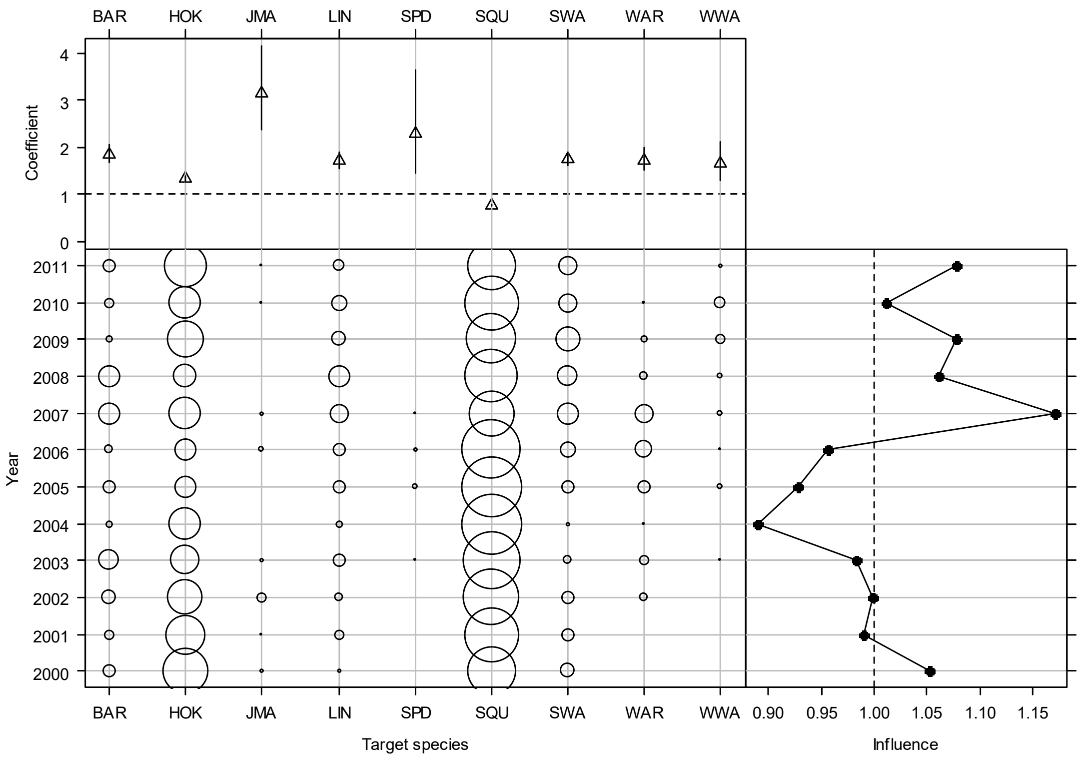


Figure D13 *continued*: Effect and influence of target species of tow in the SUBA estimated core BT tows for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

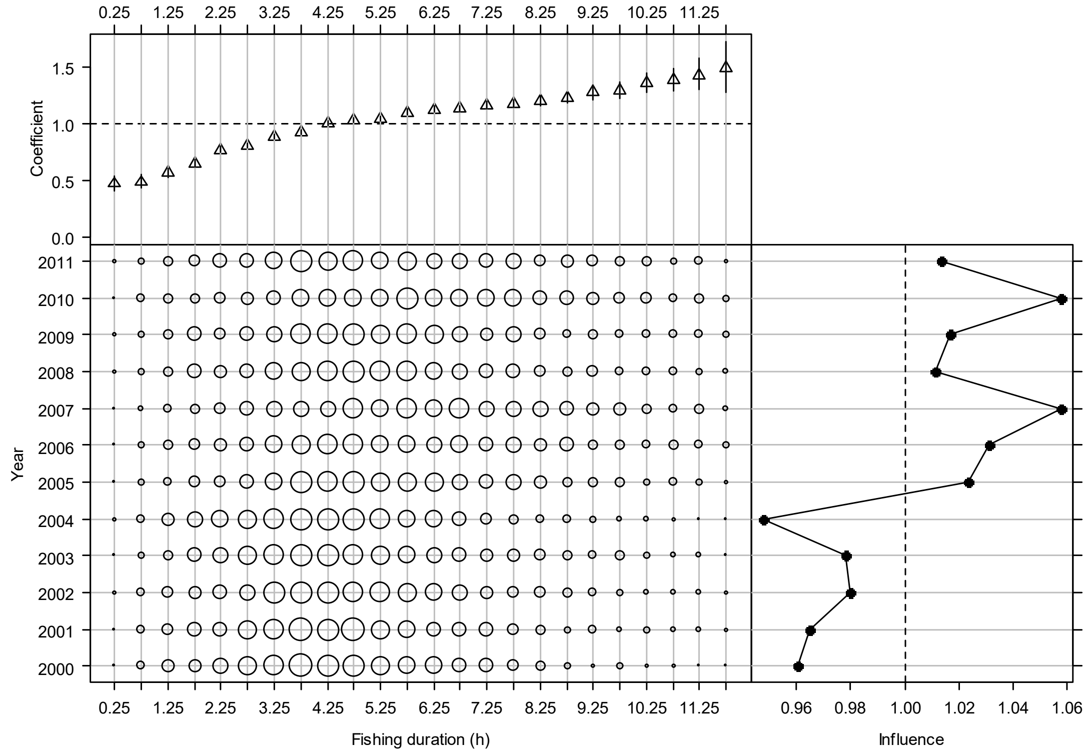


Figure D13 *continued*: Effect and influence of fishing duration of tow in the SUBA estimated core BT tows for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

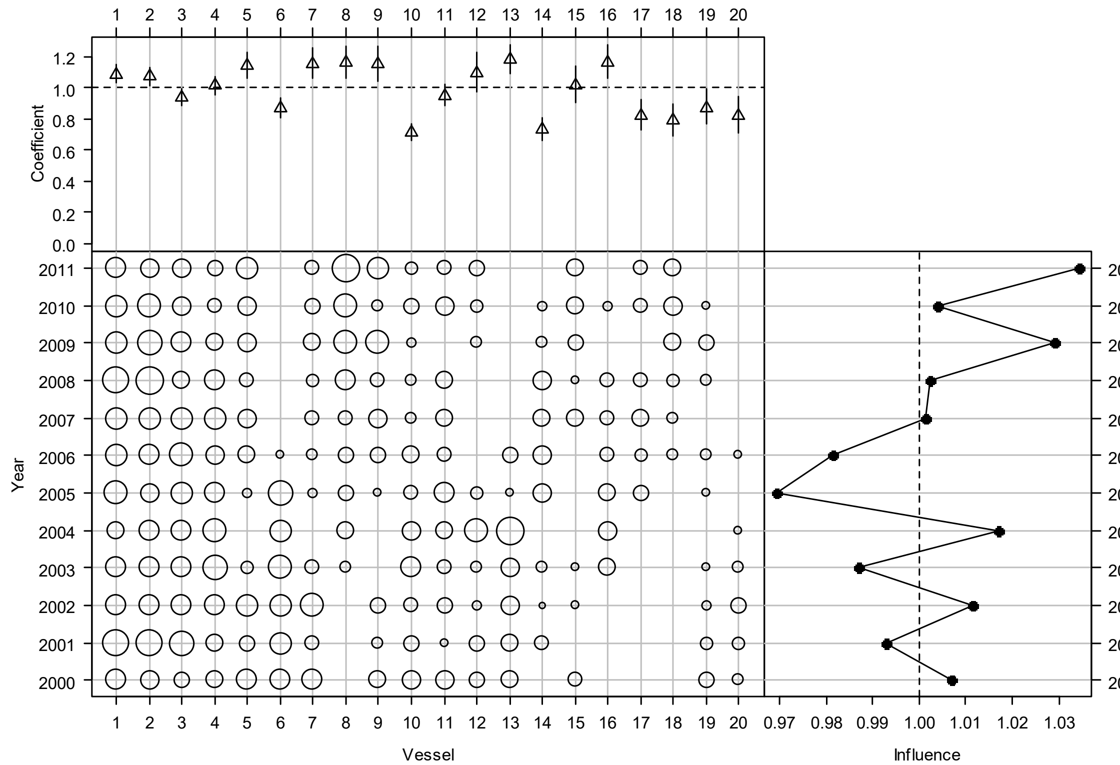


Figure D13 *continued*: Effect and influence of vessel in the SUBA estimated core BT tows for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

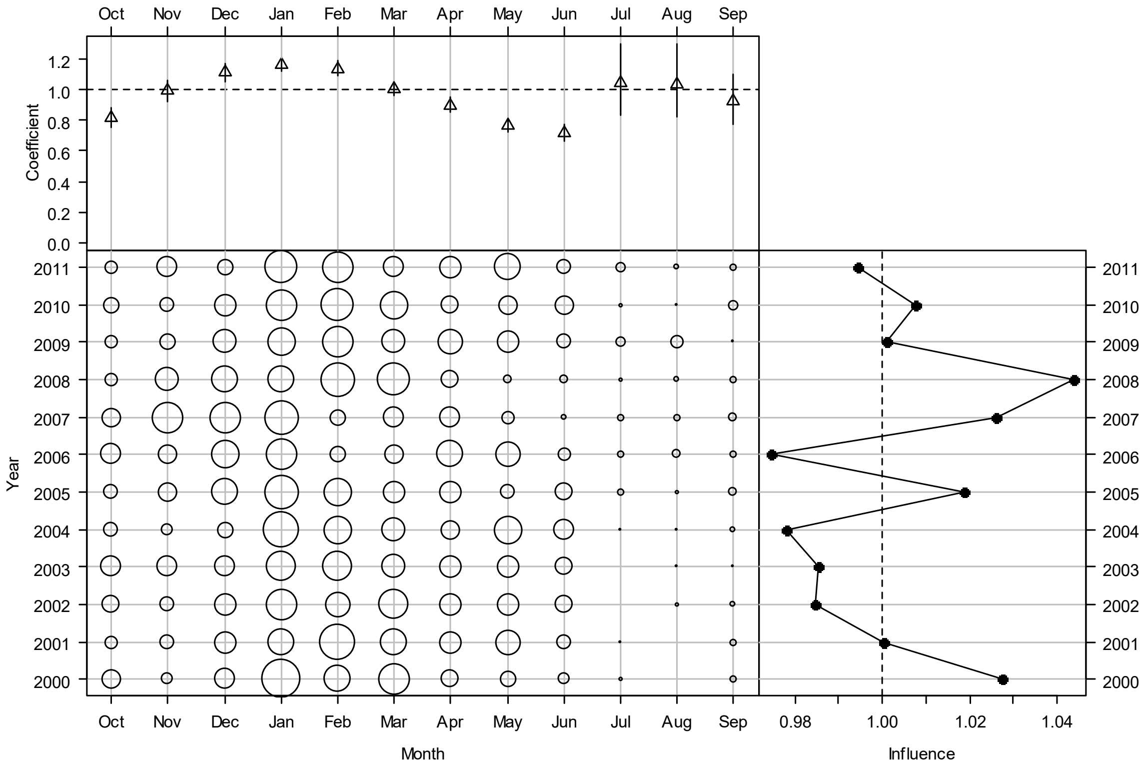


Figure D13 *continued*: Effect and influence of month of tow in the SUBA estimated core BT tows for main target species target vessels lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

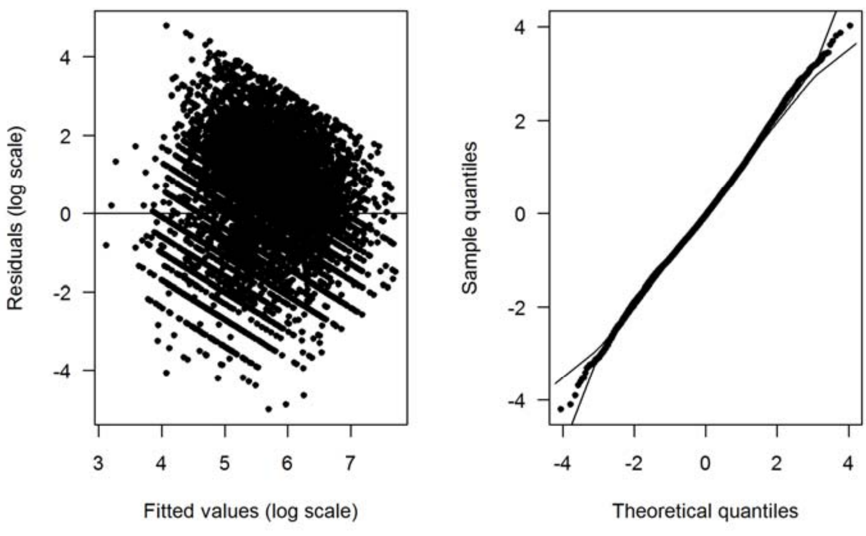


Figure D14: SUBA lognormal model (estimated tow-by-tow data for BT for main target species for core vessels); distribution of the standardised residuals against fitted values (left) and quantile–quantile plot of the residuals (right).

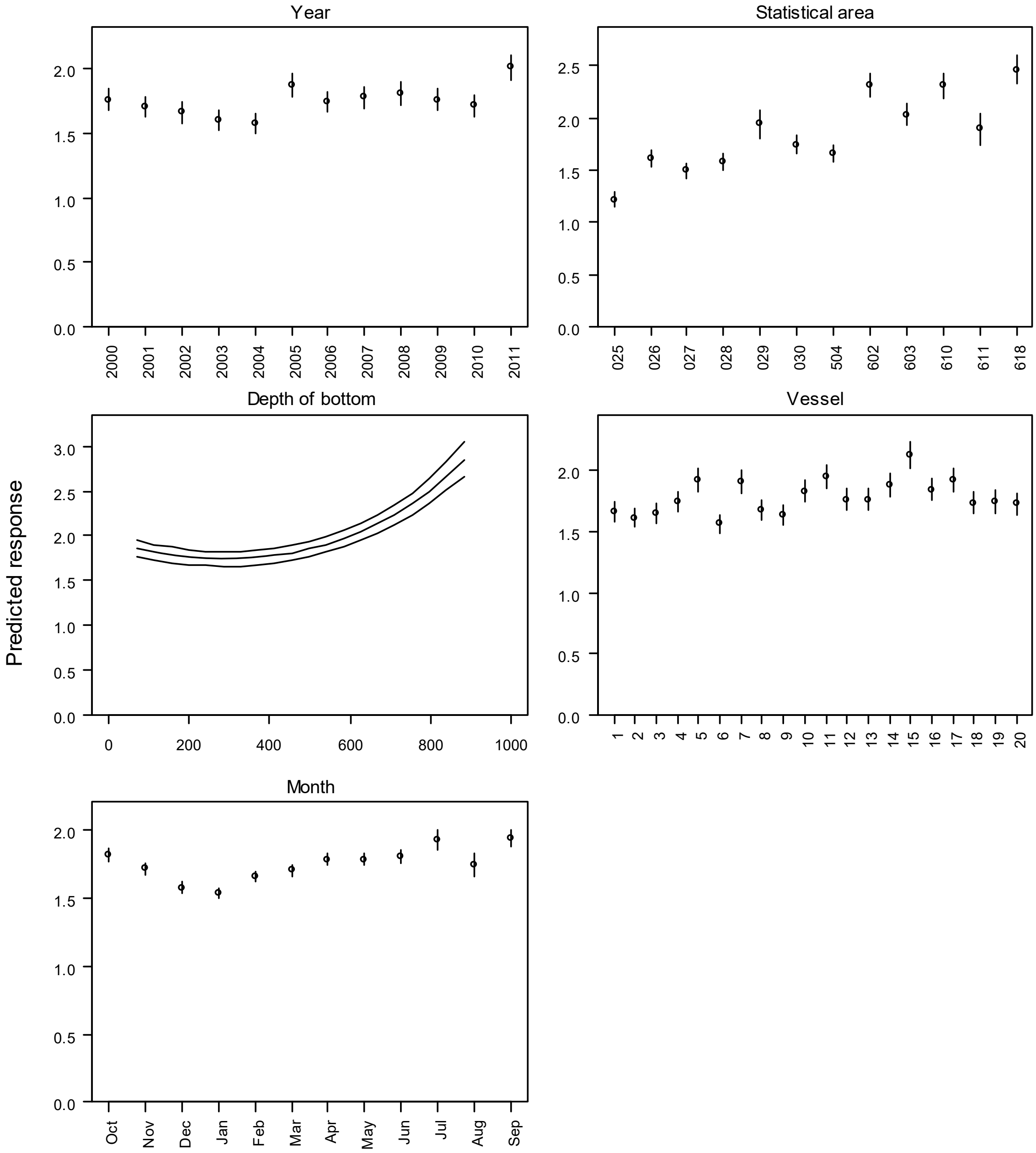


Figure D15a: Effects of selected variables in the binomial model for the SUBA estimated catch for core BT target main species vessels, 1999–00 (2000) to 2010–11 (2011). Bars indicate 95% confidence interval.

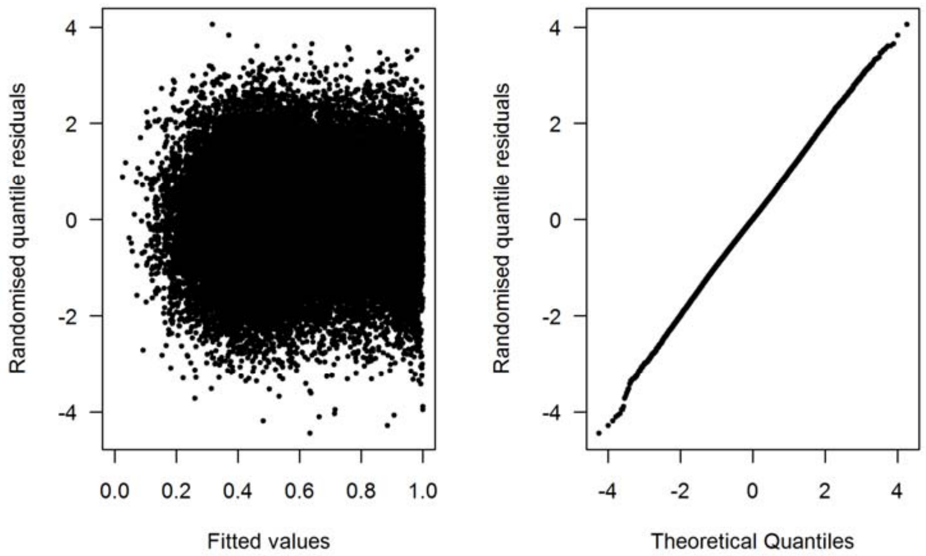


Figure D15b: SUBA binomial model (estimated tow-by-tow data for BT for main target species for core vessels); distribution of the standardised residuals against fitted values (left) and quantile–quantile plot of the residuals (right).

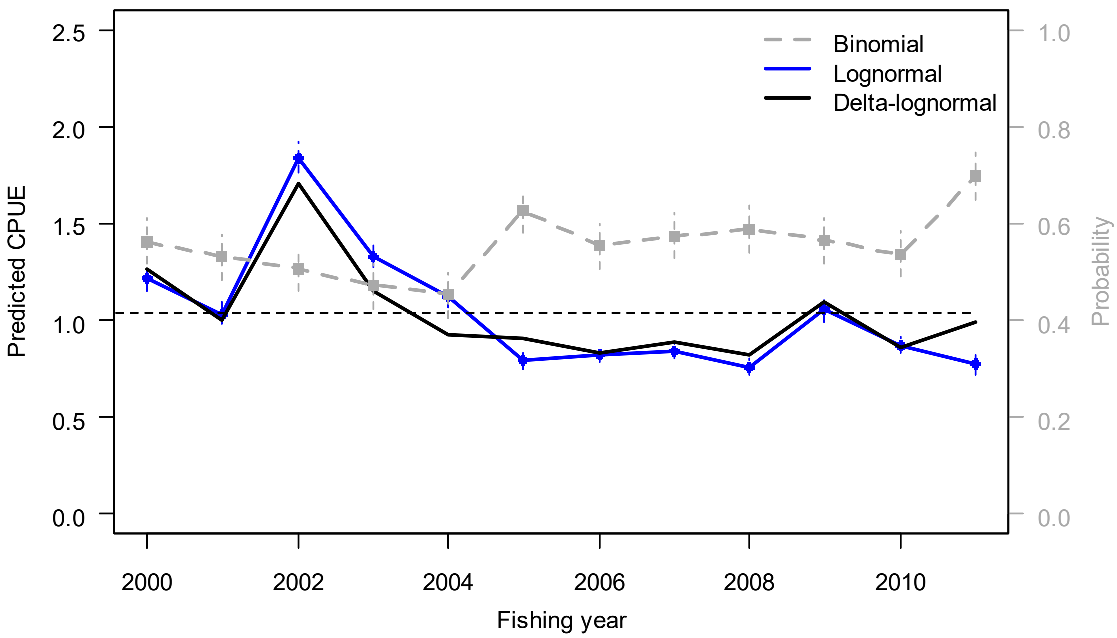


Figure D16: SUBA CPUE from the lognormal, binomial, and delta-lognormal TCEPR BT main target models, 1999–00 (2000) to 2010–11 (2011). Bars indicate 95% confidence intervals.

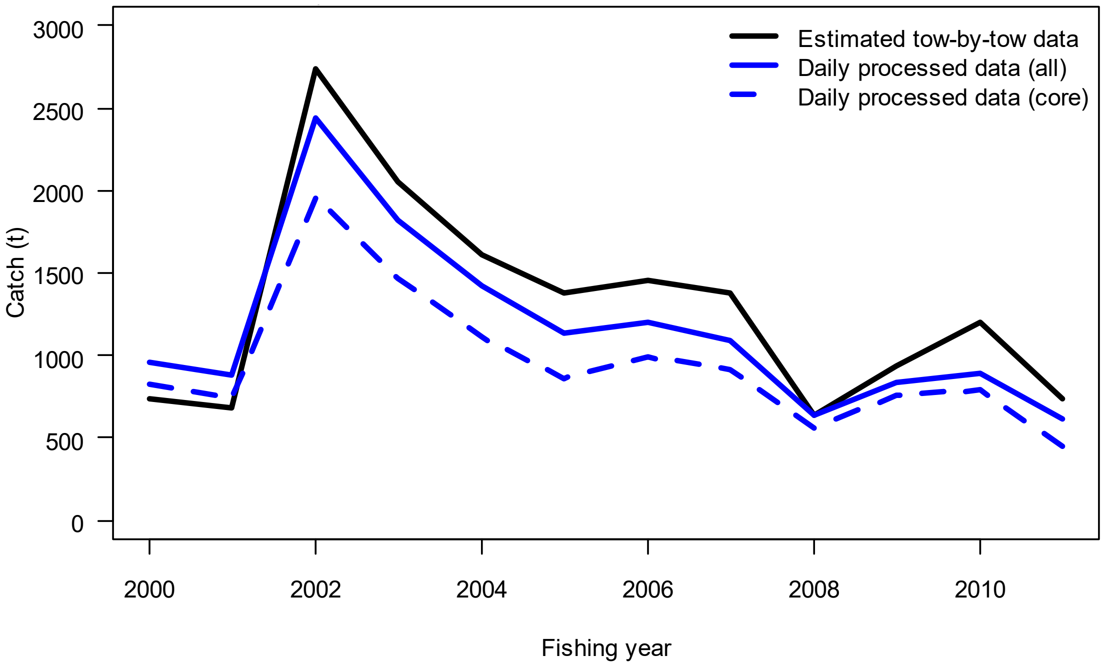
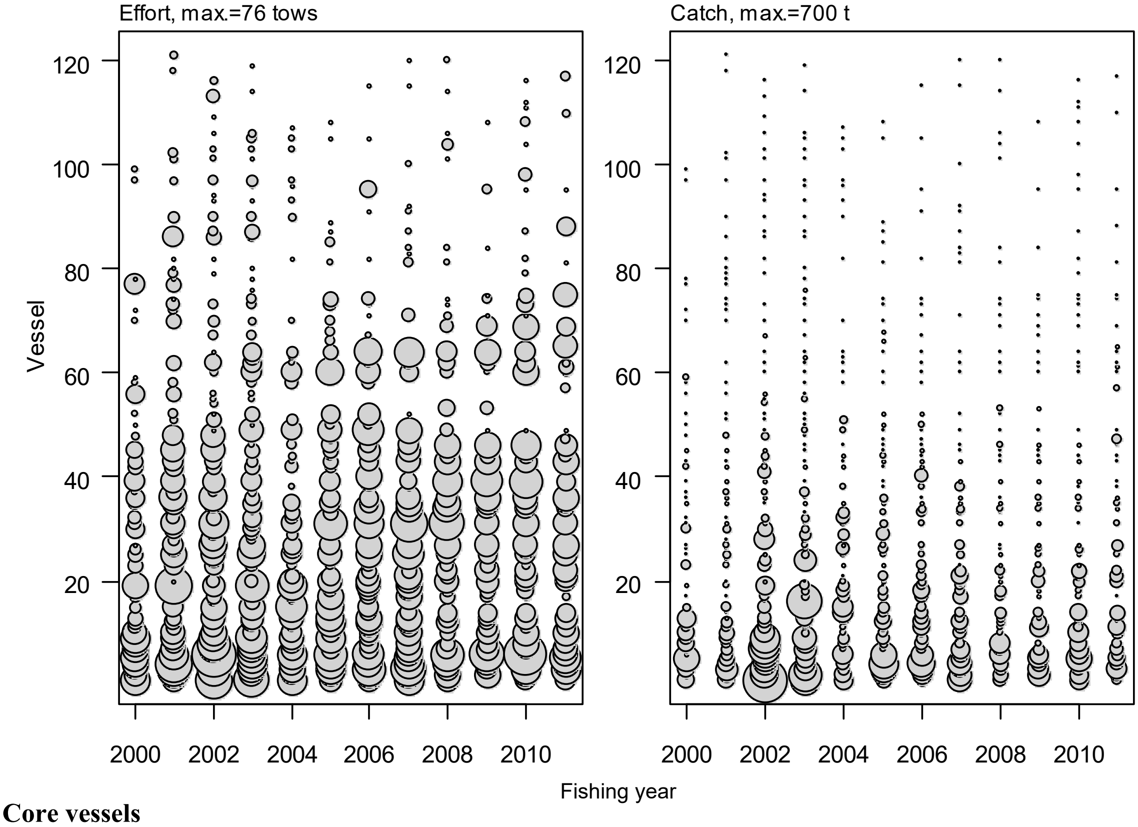


Figure D17: Comparison between the catch from the estimated tow-by-tow core vessel data and the daily processed data for SUBA BT main target vessels, 1999–00 (2000) to 2010–11 (2011).

All vessels



Core vessels

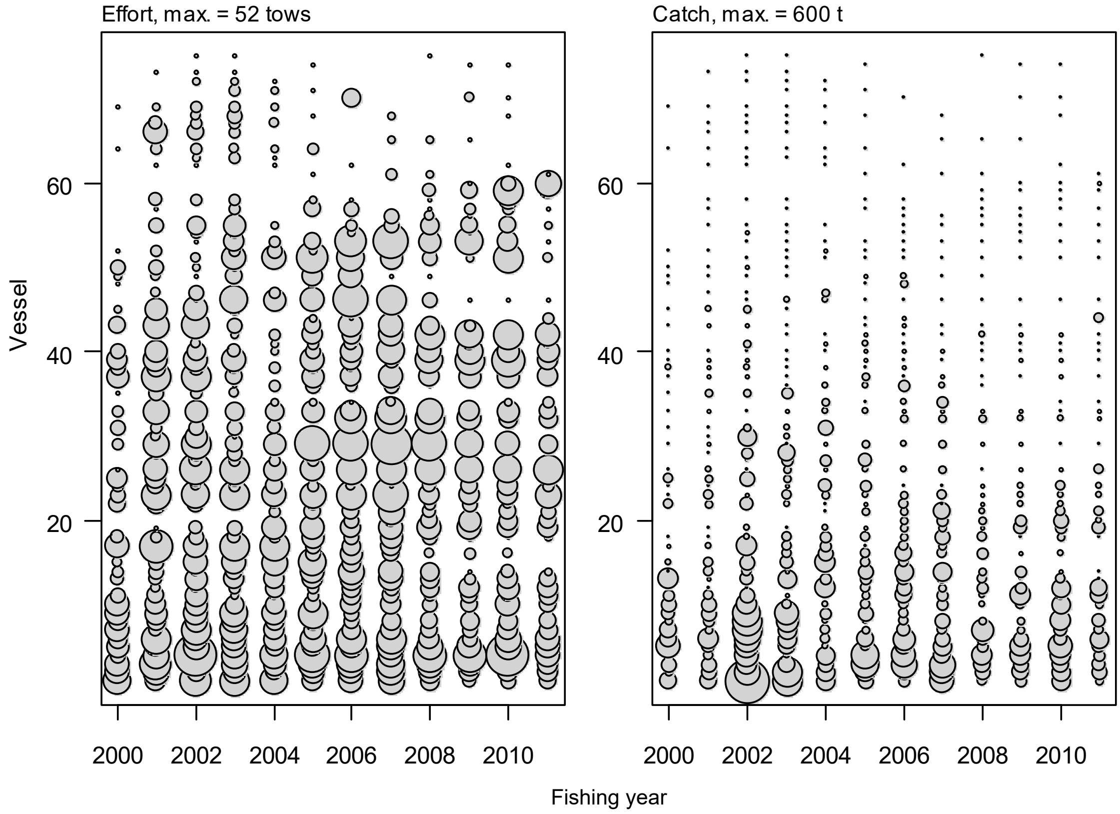


Figure D18a: SUBA summary of effort (number of tows) and estimated spiny dogfish catch by fishing year 1999–00 (2000) to 2010–11 (2011) from BT tows merged to trip level for main target species, for all vessels and for core vessels. Symbol area is proportional to either number of tows or annual catch, and maximum circle size is shown in the label on the plot.

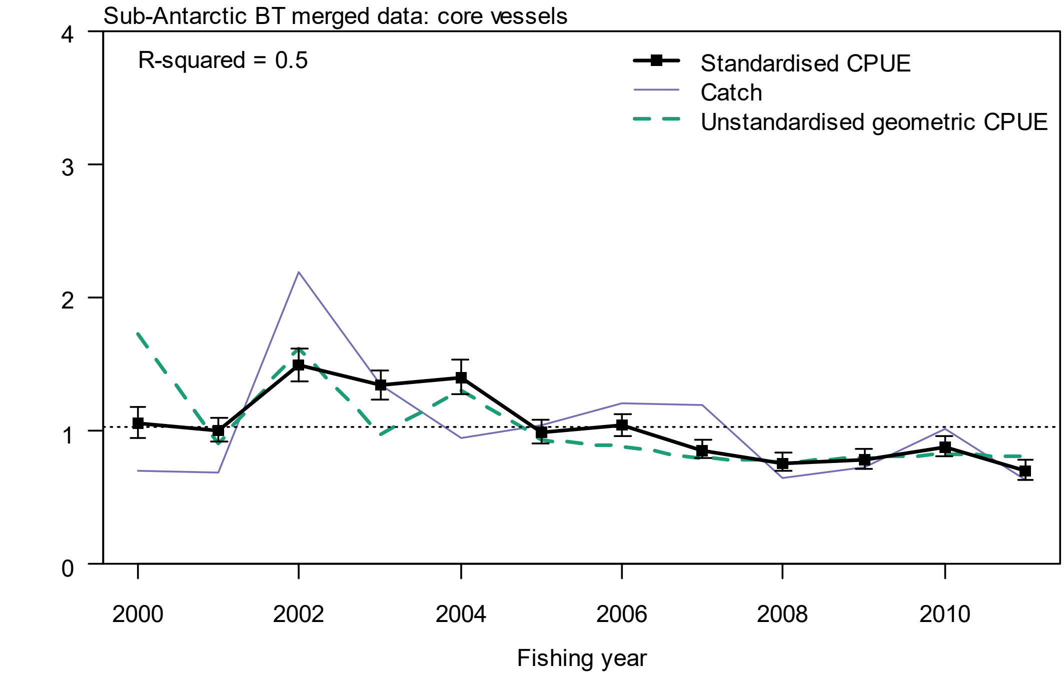


Figure D18b: CPUE lognormal indices for SUBA merged catch showing catches (scaled to same mean as indices), and lognormal standardised and un–standardised indices, with 95% confidence intervals.

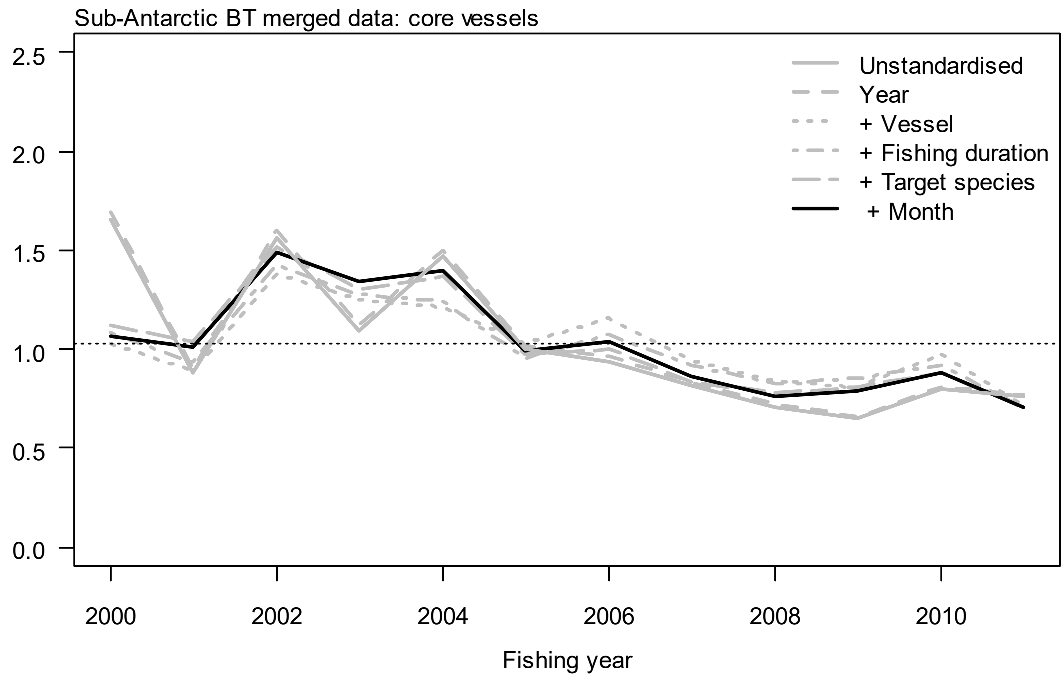


Figure D19: Addition of variables into the lognormal CPUE from the lognormal model for the SUBA fishery by fishing year.

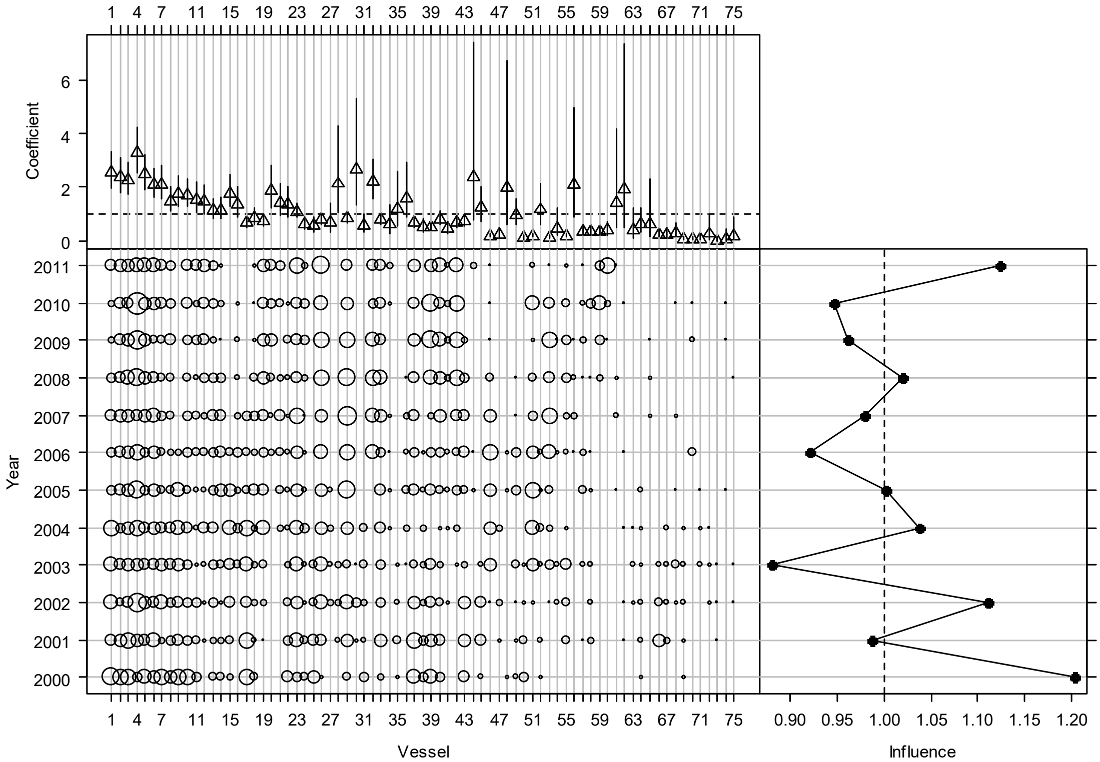


Figure D20: Effect and influence of vessel in the SUBA estimated BT tows merged to trip level for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable (vessel) by fishing year. Bottom right: influence of variable (vessel) on unstandardised CPUE by fishing year.

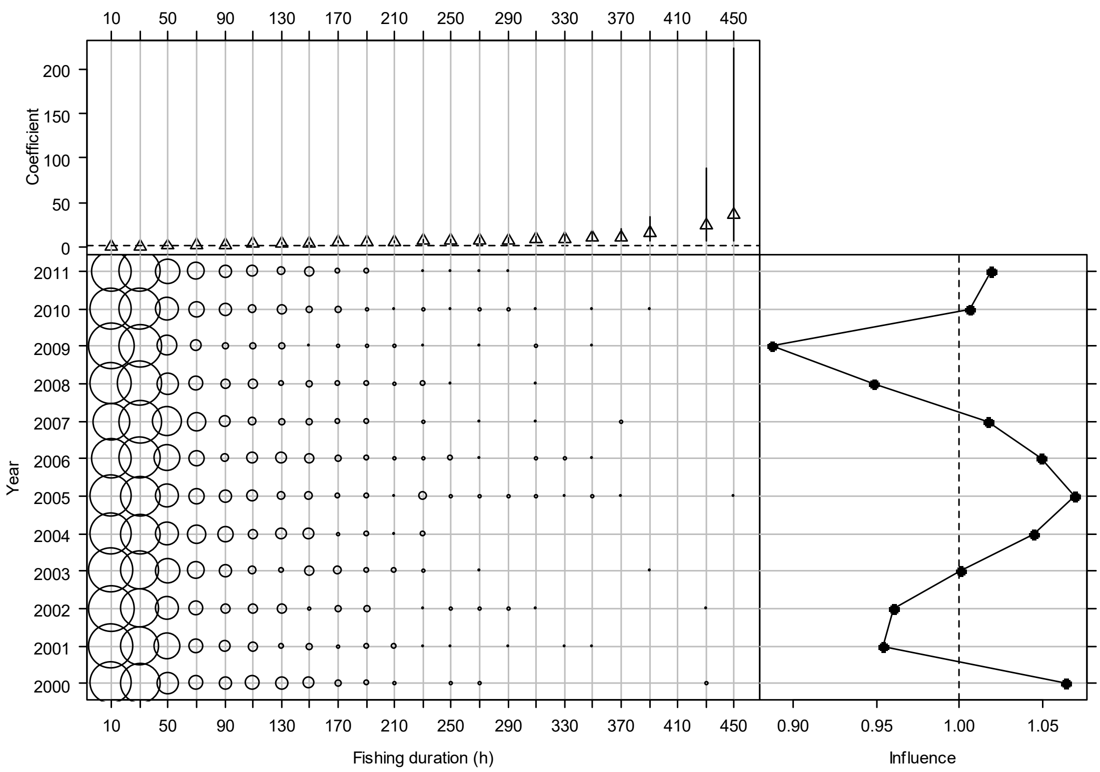


Figure D20 *continued*: Effect and influence of fishing duration of tow in the SUBA estimated BT tows merged to trip level for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

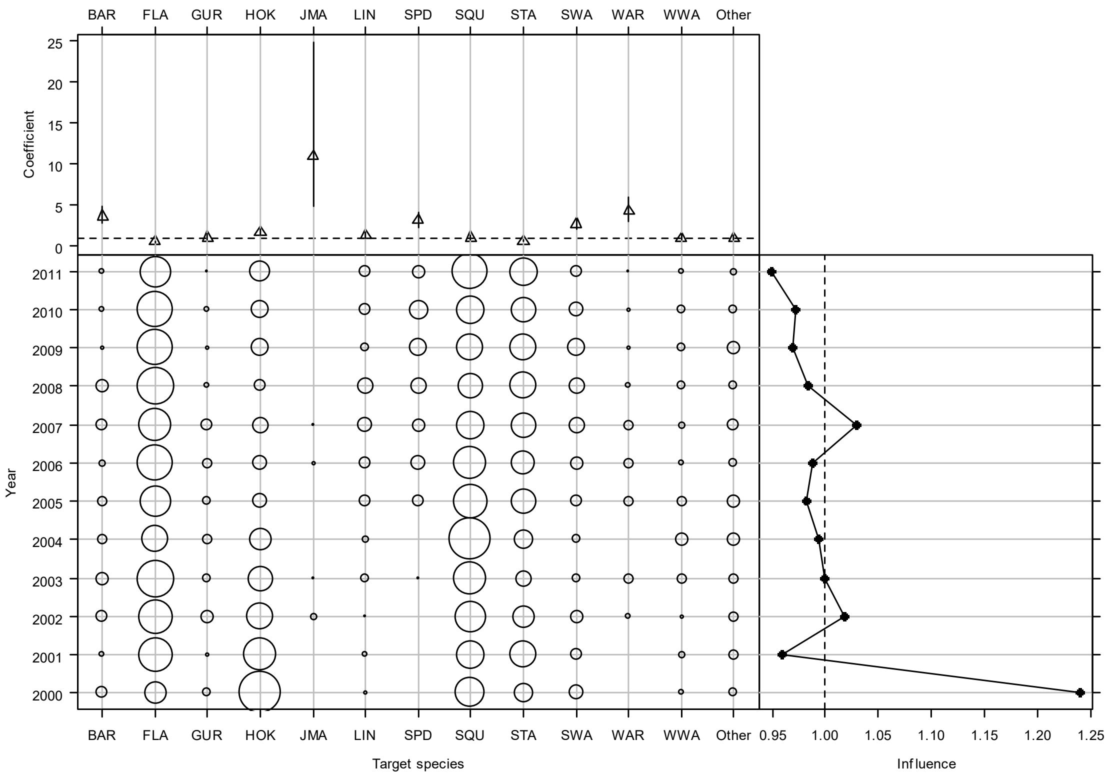


Figure D20 *continued*: Effect and influence of target species of tow in the SUBA estimated BT tows merged to trip level for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

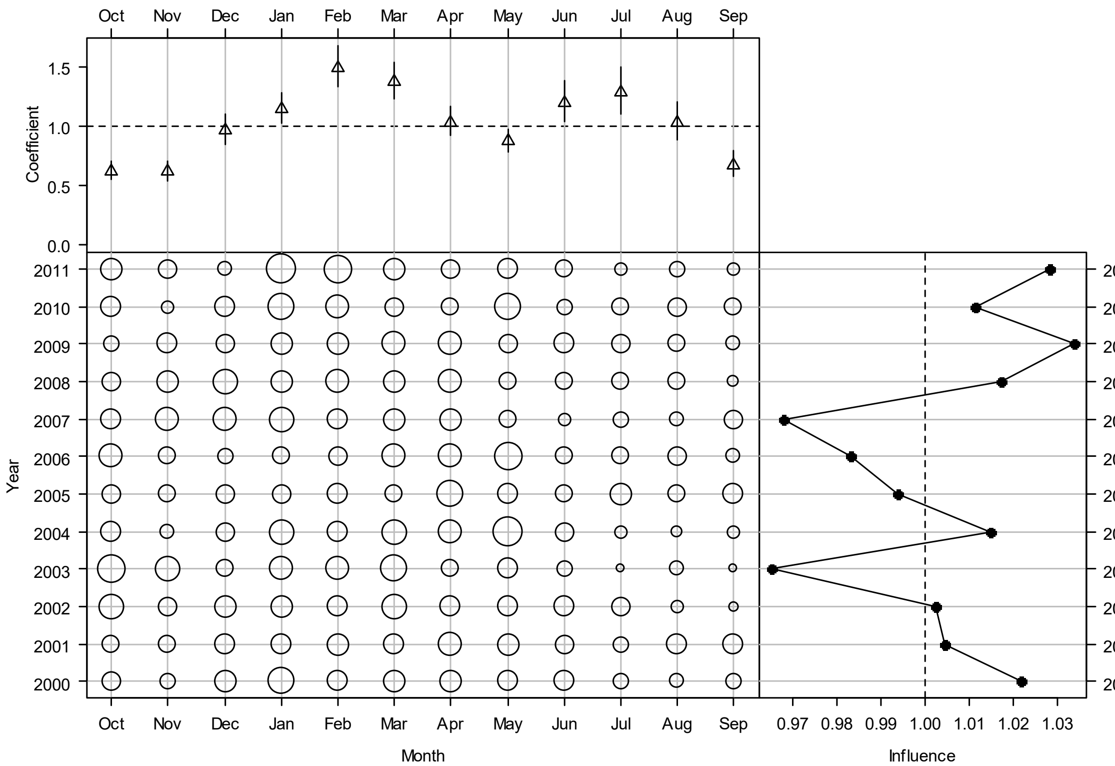


Figure D20 *continued*: Effect and influence of month of tow in the SUBA estimated BT tows merged to trip level for main target species lognormal model. Top: relative effect by level of variable. Bottom left: relative distribution of variable by fishing year. Bottom right: influence of variable on unstandardised CPUE by fishing year.

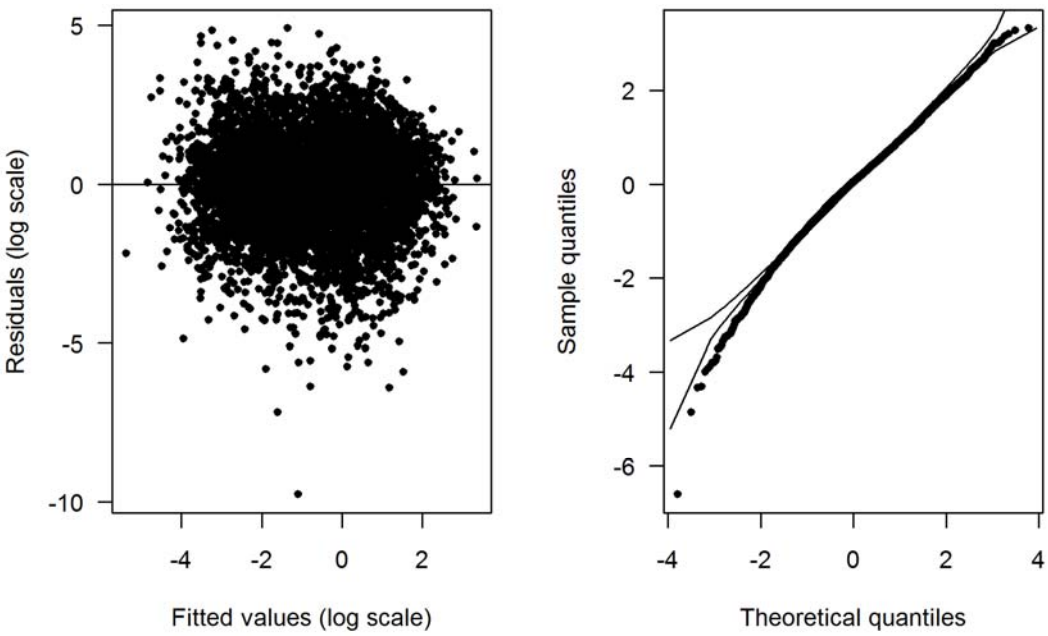


Figure D21: SUBA lognormal model (estimated tow-by-tow data merged to trip level for BT for main target species for core vessels); distribution of the standardised residuals against fitted values (left) and quantile-quantile plot of the residuals (right).