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Fishery characterisation and standardised CPUE analyses for arrow squid (*Nototodarus gouldi* and *N. sloanii*), 1989–90 to 2007–08, and potential management approaches for southern fisheries

New Zealand Fisheries Assessment Report 2012/47

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EXECUTIVE SUMMARY

Hurst R.J., Ballara, S.L., MacGibbon, D., Triantafillos, L. (2012). Fishery characterisation and standardised CPUE analyses for arrow squid (*Nototodarus gouldi* and *N. sloanii*), 1989–90 to 2007–08, and potential management approaches for southern fisheries.

***New Zealand Fisheries Assessment Report 2012/47*. 303 p.**

This report is the second in a series of middle depth fishery characterisations for species or stocks for which no robust stock assessments have been developed; the first being for silver warehou, *Seriolella punctata* (Parker & Fu 2011) and barracouta, *Thyrsites atun* (Hurst et al. 2012a). It follows the standardised reporting format used in that report, with additional information and analyses where appropriate.

Arrow squid have been exploited since the late-1960s, with significant landings developing in the mid-1970s. They were introduced into the Quota Management System (QMS) on 1 November 1987). Since then arrow squid have been primarily targeted by bottom trawls around the Auckland (SQU6T) and Snares Islands (part of SQU1T). The jig fishery around the South Island and off the west coast of the North Island (SQU1J) and bottom trawl fishery off the east coast of the South Island were important historically but have declined since the mid-1990s. There are also relatively small fisheries on the Chatham Rise. Fishing takes place over the continental shelf down to about 400m depth, with higher bottom trawl catch rates on the shelf edge in about 200–300 m. Catches are usually well within quota limits, however, in 2003–04 and 2005–06, in-season adjustments to catch limits were made to allow for higher catches.

Arrow squid live for about one year, spawn and die. The main spawning season is in winter but there is evidence of spawning throughout the year. The main fishing season is summer and autumn, based primarily on the winter-spawned cohort, although there is evidence of at least three separate main cohorts in the southern fisheries. There are two species in the fishery; *Nototodarus gouldi* and *N. sloanii*. *N. gouldi* occurs around the North Island and on the west coast of the South Island (WCSI), north of the Subtropical Convergence, whereas *N. sloanii* is found in and to the south of the convergence zone around the South Island, on the Chatham Rise and Sub-Antarctic plateau. Stock structure is undetermined but there are likely to be sub-populations based on spatial and temporal separation of fish (i.e., separately spawned cohorts). Based on research data and detailed analysis of observer length frequencies, there is probably mixing between Snares and Auckland Is. squid, which are currently managed as separate stocks.

Standardised annual catch per unit effort (CPUE) indices were developed from 1989–90 to 2007–08 for the main Auckland and Snares Islands fisheries (separately and combined). The models explained 20–26% of the null deviance and were similar to unstandardised indices, particularly after 1998. Standardised in-season indices were also developed for the Snares fishery 1989–90 to 2007–08 and show, on average, declining CPUE after week 11, although there is considerable seasonal variability in this pattern. These models explained 18–41% of the null deviance. Although the season tends to start later at the Auckland Is., in-season indices for 2008 (the only year analysed) showed a similar peak mid-season and a declining trend from week 13.

Observer collected length frequency data are available mainly from the Snares and Auckland Islands fisheries, from 1986–87 to 1999–00 and 2007–08 respectively (2009 data were not completely entered into in the database at the time of this analysis). Monthly (Snares) and weekly (selected Snares and Auckland Islands and east coast South Island) distributions were generated to determine cohort structure through the fishing season and potential stock relationships. There was considerable variability in the number and apparent relative strength of cohorts in each season; most seasons appeared to have at least three main cohorts, some seasons appeared to have several micro-cohorts within the main cohort. In some years, the Snares fishery appeared to lose larger squid at a time when

similar-sized squid appeared at the Auckland Island fishery, suggesting possible movement between the two areas. These two fisheries are currently assumed to be separate stocks.

Potential in-season management approaches were examined, with a view to allow for increased catch in good seasons. Unstandardised early in-season CPUE appears to have good potential to predict years of overall higher catch rates (r greater than or equal to 0.80 from week 8, up to 0.92 at week 8). There were not enough length frequency samples from years with high catch rates (only 2007–08) to determine their predictive capability. An in-season management approach based on early CPUE (such as used to allow an increase in 2003–04 and 2005–06) has definite potential but needs to be developed further to assess risks associated with timing of the decision and the amount of the increase. Preliminary analysis of potential pre-season prediction based on environmental variables suggested that ocean colour (Chlorophyll) may be useful (r in the range 0.6–0.7) but the analysis requires development of hypotheses on causal relationships, more spatially appropriate data, a longer ocean colour time series, and a more comprehensive and robust statistical analysis. Ocean colour correlations were highest (0.75–0.87) with in-season indices and these may have potential for inclusion in future CPUE analyses (annual or in-season). The feasibility of carrying out post-season assessment (e.g., using depletion modelling) was assessed and a preliminary cohort model was developed. There are adequate data available to enable this approach to be further developed and it is recommended that this be done in order to provide information on the level of impact of the fishery on stock size for individual fishing seasons and to inform in-season management approaches based on CPUE.

1. INTRODUCTION

Many of New Zealand's middle depth fisheries, other than gemfish, hoki, hake, ling, and southern blue whiting are not routinely monitored or assessed despite their moderate size and value. This project is designed to ensure that data available for monitoring important middle depth species are routinely summarised and assessed on a five-year rotating schedule as described in the Ministry of Fisheries medium-term research plan for Middle Depth species (Ministry of Fisheries 2008a). The first species to be characterised was silver warehou for Quota Management Areas (QMA) SWA3 and SWA4, in early 2009, under project MID200703 (Parker & Fu 2011). The next species, arrow squid (the subject of this report) and barracouta (*Thyrsites atun*) were analysed in late 2009 under project MID200801. Both of these fisheries have current management issues that can be informed by up-to-date fishery characterisation.

Previous characterisations (or partial characterisations) of New Zealand arrow squid fisheries have been carried from 1973–74 to 1986–87 by Mattlin & Colman (1988); for 1979–93 by Gibson (1995) and from 1989–90 to 1999–2000 by Langley (2001). Uozumi (1998) provided a comprehensive review of New Zealand arrow squid and the fisheries for them, including commercial data from Japanese commercial fishing in the New Zealand 200 n. mile Exclusive Economic Zone (EEZ) from 1969–70 to 1990–91 (including catch distribution, monthly and annual catch rates, and size frequencies). He also summarised Japanese research data from ten trawl surveys and two larval net surveys (including detailed information on growth, maturation, distribution, migration, and fluctuations in abundance).

This report summarises the analyses carried out for the Ministry of Fisheries under project MID200801, Objective 2: To characterise the New Zealand arrow squid fisheries by analysis of commercial catch and effort data up to 2007–08 including:

- To carry out CPUE analyses for the major fisheries (Fishstocks) where appropriate.
- To determine the feasibility of in season review of TACC levels using size frequency distributions and catch rates from the commercial fishery.
- To review stock structure using data accessed above and any other relevant biological or fishery information.
- To make recommendations on future data requirements (including recommendations for annual levels of Observer sampling) and methods for monitoring the stocks.

The report follows the standard format developed for the first report (Parker & Fu 2011), except where additional information and analyses have been included to meet the specific objectives of this project. The report contains sections of text and tables that can be transferred to the Ministry of Fisheries Plenary report as appropriate. Some topics present in plenary reports were not reported on in this report but the headings are listed in the appropriate place in grey. Tables and figures are provided in five Appendices: A, Survey and biological data; B, Observer data; C. Fishery Characterisation; D, Catch-per-unit-effort analyses; and E, Potential management approaches.

2. FISHERY SUMMARY

2.1 Commercial fisheries

The New Zealand arrow squid fishery is based on two related species. *Nototodarus gouldi* is found around the North Island and on the west coast of the South Island (WCSI), north of the Subtropical Convergence, whereas *N. sloanii* is found in and to the south of the convergence zone around the South Island, on the Chatham Rise and Sub-Antarctic plateau (Roper et al. 1984, Smith et al. 1987, Anderson et al. 1998). The fishery is presently managed as three separate fish stocks based on Quota Management Areas (QMAs, Figure 1): mainland and Chatham Rise jig fisheries (SQU 1J); Auckland and Campbell Islands trawl fisheries (SQU 6T); and mainland, Chatham Rise, and the rest of the Sub-Antarctic trawl fisheries (SQU 1T). An administrative stock has been established for the Kermadec area (SQU l0T), but no catch of arrow squid has been recorded from that area. Therefore, except for the Southern Islands SQU6T fishery, the two species are managed together in the main fishery areas. None of the QMS or Observer data and little of the research data have recorded the species separately.

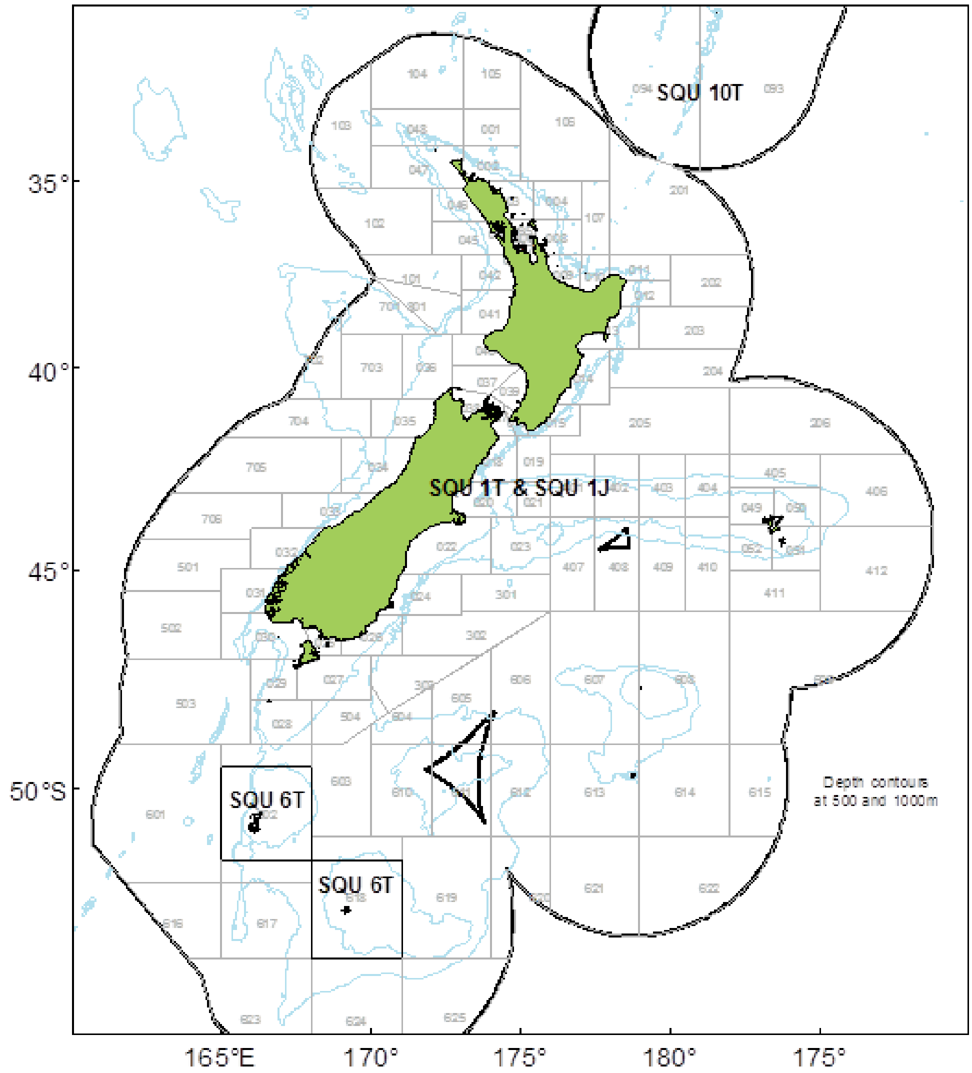

Figure 1: Map showing the administrative fishstock boundaries for SQU1J, SQU1T, SQU6T, and SQU10T including statistical areas, and the 500 m, and 1000 m depth contours.

Previous characterisations of New Zealand arrow squid fisheries include: from 1969–70 to 1990–91 (Japanese data only), Uozumi (1998); from 1973–74 to 1986–87, Mattlin & Colman (1988); from 1979 to 93, Gibson (1995); and from 1989–90 to 1999–2000, Langley (2001). Norris (1988, unpub.) documented catch limits from 1978–79 to 1986–87. Catch or effort restrictions and other management regulations prior to the introduction of the QMS are detailed in Section 2.6.

Research bottom trawls record that arrow squid occur in more than 25% of tows from 100–500m depth (Anderson et al. 1998). The main fisheries are in coastal waters (less than 300m depth) around mainland New Zealand, on the Chatham Rise and the Sub-Antarctic Plateau. The majority of the commercial catch is taken from the WCSI, lower west coast of the North Island, the east coast South Island (ECSI), the Stewart/Snares shelf (Snares) and the Auckland Islands (see Figure 2). Most arrow squid catch is targeted; all of the jig catch and 96% of trawl. The main target fisheries for other species where arrow squid is taken as bycatch are barracouta (*Thyrsites atun*), red cod (*Pseudophycis bachus*), hoki (*Macruronus novaezelandiae*), and jack mackerel (*Trachurus spp.*) trawl fisheries.

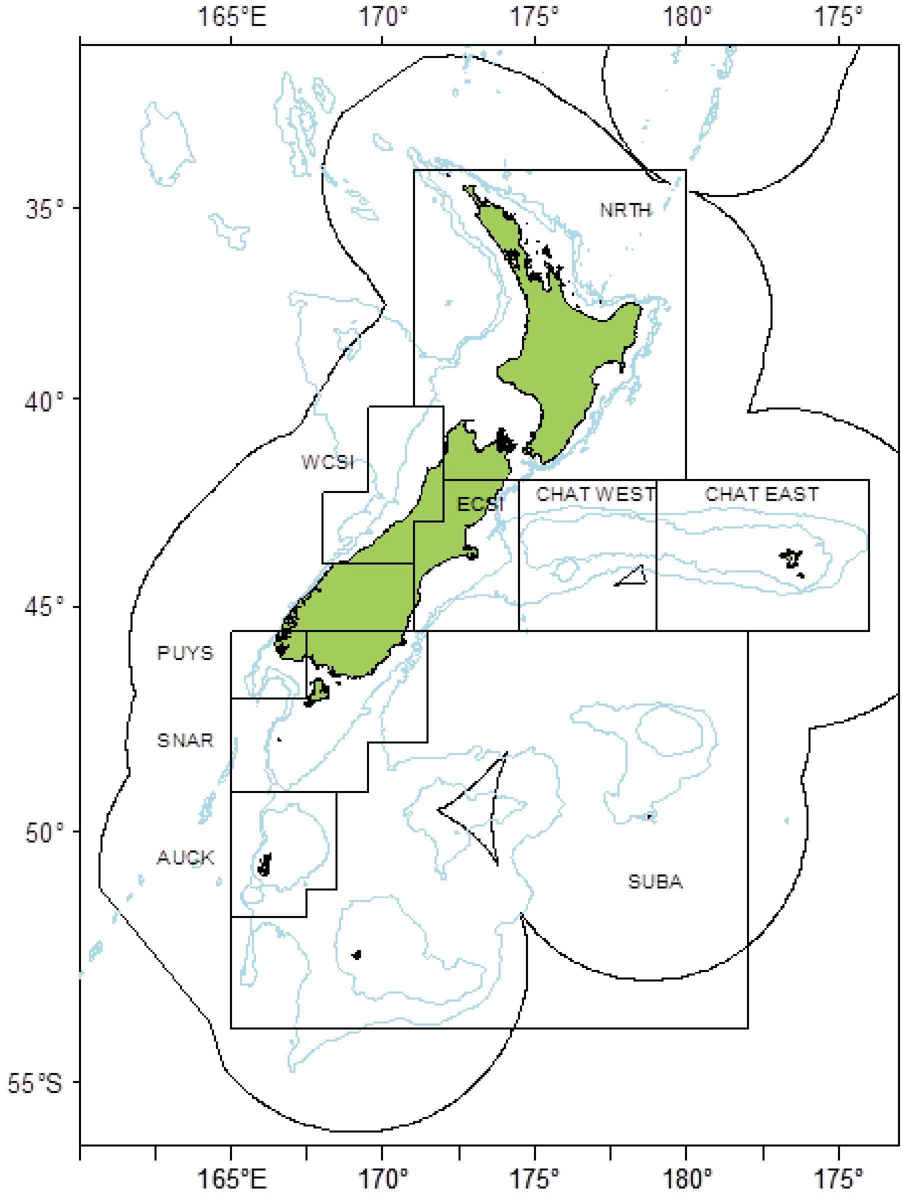

Figure 2: Map showing the regions used in this analysis, including the 500 m, and 1000 m depth contours. NRTH, North Island; WCSI, west coast South Island; ECSI, east coast South Island; CHAT WEST, western Chatham Rise; CHAT EAST, eastern Chatham Rise; PUYS, Puysegur Bank; SNAR, Stewart/Snares Is. shelf; AUCK, Auckland Is.; SUBA, Sub-Antractic plateau.

Commercial fishing for arrow squid developed in the late 1960s and early 1970s and was unregulated until the introduction of the 200 n. mile EEZ on 1 April 1978. Tables 1a–c provide details of the early history of the fishery prior to the introduction into the Quota Management System (QMS), based on Mattlin & Colman (1988) and an unpublished summary of the catch and effort limits allocated to foreign and joint venture vessels up to 1986–87 (Norris 1988 unpub.). Table 2 provides recent catch history from 1986–87. Note that the definition of fishing years has changed over time (see Table 1a). Since October 1983, fishing years have been 1 October to 30 September, and in this report, when fishing years are abbreviated, they are labelled as the most recent year (*e.g.,* 1998–99 becomes 1999).

In the 1978–79 fishing year foreign licensed fishing vessels were allocated a catch limit of 21 000 t and caught about 60% of this (Tables 1a, 1c). For 1979–80, foreign licensed trawlers were again allocated catch limits (30 000 t at the Auckland Is. and 2 700 t for the rest of the EEZ), but jiggers were controlled by effort limits on the number of vessels, based on average CPUE (2.20 t per vessel-day) and an average fishing season of 100 days. This equated to about 40 000 t jig catch per year and 90 000 t for all vessels per year, and represented about 15% of the original stock size estimate of 600 000 t (Mattlin & Colman 1988) that was derived using areal expansion of 1978–79 commercial catch data. This was more conservative than the 40% exploitation rate considered to be acceptable at the time (Caddy 1981, 1983) because of the uncertainty over the stock size estimate and the likely annual variability. The separate quota for the Auckland Is. was set to reduce the risk of overfishing this stock (Annala 1992).

On 1 April 1983, arrow squid were one of seven trawl caught species to be included under the Deepwater Policy that introduced individual quotas into deepwater trawl fisheries, allocating quota to NZ owned or chartered "deepwater" vessel (over 43 m in length) operators. Jig effort was still controlled by effort restrictions and increased to more than the 40 000 t originally allowed for, reaching a maximum of 69 500 t in 1983–84 (Table 1a, Mattlin & Colman 1988). This increase was probably due to increased effective effort (e.g., increases in the numbers of jig machines and lights per vessel) during the 1980s, as described by Gibson (1995). Total catch by all vessels in that year was about 107 900 t, with much of it (84 000 t) coming from the Snares and Auckland Islands fisheries (Table 1b).

Table 1a: Reported landings (t) by nationality from 1978–79 to 1985–86 (Source: FSU in Mattlin & Colman 1988, Gibson 1995 (in brackets). -, no data).

Fishing year	New Zealand trawl		Foreign trawl			Jig	Total
	Domestic	Chartered	Japan	USSR	Korea		
1978–79[a]	0	533	2 878	8 478	856	-	12 745+
1979–80	0	11 506	11 833	10 724	775	(26 431)	(34 838)
1980–81[b]	(0)	(9 027)	(3 129)	(5 989)	(0)	37 803	(55 949)
1981–82	0	25 893	7 284	7 391	1 221	44 649	86 438
1982–83	385	20 724	4 964	10 284	1 754	51 315	89 426
1983–83[c]	107	8 310	2 817	4 101	1 479		16 814
1983–84[d]	59	23 455	6 157	5 963	2 780	69 508	107 922
1984–85	632	33 037	6 719	8 414	2 296	38 237	89 335
1985–86	55	27 822	6 525	8 247	1 363	27 754	71 766

a 1 April – 31 March.
b Gibson (1995) figures for 1980–81 trawl are southern areas only and not available in Mattlin & Colman (1988).
c 1 April – 30 September.
d 1 October – 30 September.

Table 1b: Reported landings (t) by area and method from 1981–82 to 1985–86, for fishing years where complete data are available. Source: FSU in Mattlin & Colman 1988, Gibson 1995 (in brackets). Trawl areas are letters B-H; jig areas roman numerals I-VIII.

Area	Management area	1981–82	1982–83	1983–84	1984–85	1985–86
ECNI	B	0	0	0	0	0
	II, VIII	0	0	1	0	0
	Total	0	0	1	0	0
ECSI, Chat R	C, D	328	410	1 066	1 709	699
	IV, VI	21 243	8 222	16 337	14 412	4 217
	Total	21 571	8 632	17 403	16 121	4 916
Southland,	F[b]	2 499	3 624	14 750	19 807	16 528
Sub-Antarctic	E[b]	38 599	33 723	22 172	29 292	26 606
	VII	1261	4 376	47 045	18 127	15 839
	Total	42 359	41 723	83 967	67 226	58 973
WCSI	G	22	43	50	21	62
	III, V	16 498	28 750	4 431	5 099	7 521
	Total	16 520	28 793	4 481	5 120	7 583
WCNI	H	296	311	374	268	117
	I	5 608	9 962	1 637	591	122
	Total	5 904	10 273	2 011	859	239
Unidentified	Trawl	45	0	2	1	0
	Jig	39	5	57	8	0
	Total	84	5	59	9	0

a Fishing years as in Table 1a.

b The area boundary between E and F was changed from 48° 30′ S to 49° 00′ S on 1 October 1983; the minimum trawl codend mesh size, which had been 100 mm in all areas except for 60 mm in area E, was changed to 60 mm south of 48° 00′ S in area F as well.

Table 1c: Accepted tonnage (by jig or trawl) or number of jig vessels recruited, by nation, for fishing years[a] 1978–79 to 1985–86 (Source: Norris 1988, unpub.). DW, NZ vessels fishing under the deepwater policy allocation; JV, joint venture; Vess., vessels; t., tonnes.

Fishing year	Trawl					Jig				
	DW	Japan	Korea	USSR	Total	JV	Japan		Korea	
						Vess.	t.	Vess.	t.	Vess.
1978–79	0	4 000	2 000	15 000	21 000	59	29 000		1 000	
1979–80	0	14 400	500	17 800	32 700	82		98		4
1980–81	0	9 900	500	10 500	20 900	108		71		4
1981–82	0	9 900	1 600	10 000	21 500	55		78		6
1982–83	20 000	9 900	2 800	10 000	42 700	58		89		6
1983–84	27 300	9 900	2 800	10 000	50 000	63		92		6
1984–85	37 720	7 920	2 490	8 500	56 630	79		87		6
1985–86	52 359	7 920	2 240	8 700	71 219	63	24 000	79	1 500	6

a Fishing years 1 September to 31 August to 1981–82; 1 September to 30 September for 1982–83, then all 1 October to 30 September.

b Foreign and charter vessels were allocated catch limits after the introduction of the EEZ on 1 April 1978. Trawl caught squid were introduced under the Deepwater Trawl Policy on 1 April 1983.

On 1 November 1987, all squid catch came under the Quota Management System (QMS) and were managed by allocation of Individual Transferable Quotas (David Foster, Ministry of Fisheries, pers. comm.). The TACC was set at 121 010 t and increased to 166 250 t for 1989–90 through Quota Appeal Authority changes. This was reduced back to 118 571 t for 1990–91 through the shelving of quota (Table 2, Figure 3). There were in-season increases in 2003–04 and 2005–06 of 30% and 10% in area SQU1T based on estimated increased abundance (Ministry of Fisheries 2009). Note that the TACC level automatically reverts to the original value at the end of the fishing year.

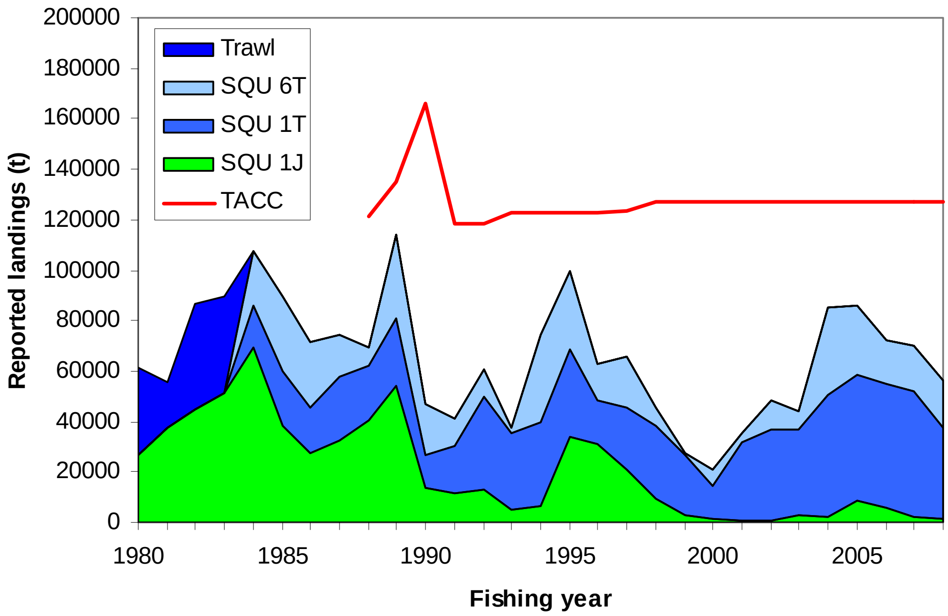

Figure 3: Reported landings of arrow squid by QMA (shaded regions) and the total TACC from fishing years 1979–80 to 2007–08 (see Table 1). Trawl catch cannot be assigned to SQU1T or SQU6T prior to 1983–84.

2.2 Recreational fisheries

The amount of arrow squid caught by recreational fishers is unknown.

2.3 Maori customary fisheries

No quantitative information is available on the current level of customary non-commercial take.

2.4 Illegal and misreported catch

No quantitative information is available on the current level of illegal and misreported catch.

2.5 Other sources of mortality

No information is available on other sources of mortality.

2.6 Regulations affecting the fishery

Current and historical limits on catch or effort in arrow squid fisheries are described in Section 2.1. Codend minimum mesh-size regulations that currently apply to the trawl fisheries 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 and Auckland Is. fisheries (the old EEZ area F/E boundary), which was at 48° 30’S. The management area boundary

Table 2: Reported landings (t) of arrow squid by Fishstock and TACCs (t) from 1986–87 to 2007–08 (QMS data from the plenary document).

Fish stock	SQU1J		SQU1T		SQU6T		SQU10 t			
FMA (s)	1–9		1–9		6		10		Total	
Fishing year	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1986–87	32 394	48 600[a]	25 621	26 400[a,b]	16 025	30 000[a]	0	10	74 040	105 000[a]
1987–88	40 312	57 705	21 983	30 962	7 021	32 333	0	10	69 316	121 010
1988–89	53 872	62 996	26 825	36 081	33 462	35 933	0	10	114 160	135 080
1989–90	13 895	76 136	13 161	47 986	19 859	42 118	0	10	46 915	166 250
1990–91	11 562	46 087	18 680	42 284	10 658	30 190	0	10	40 900	118 571
1991–92	12 985	45 766	36 653	42 284	10 861	30 190	0	10	60 509	118 571
1992–93	4 865	49 891	30 862	42 615	1 551	30 369	0	10	37 278	122 875
1993–94	6 524	49 891	33 434	42 615	34 534	30 369	0	10	74 492	122 875
1994–95	33 615	49 891	35 017	42 741	30 683	30 369	0	10	99 315	123 011
1995–96	30 805	49 891	17 823	42 741	14 041	30 369	0	10	62 668	123 011
1996–97	20 792	50 212	24 769	42 741	19 843	30 369	0	10	65 403	123 332
1997–98	9 329	50 212	28 687	44 741	7 344	32 369	0	10	45 362	127 332
1998–99	3 240	50 212	23 362	44 741	950	32 369	0	10	27 553	127 332
1999–00	1 457	50 212	13 049	44 741	6 241	32 369	0	10	20 747	127 332
2000–01	521	50 212	31 297	44 741	3 254	32 369	<1	10	35 071	127 332
2001–02	799	50 212	35 872	44 741	11 502	32 369	0	10	48 173	127 332
2002–03	2 896	50 212	33 936	44 741	6 887	32 369	0	10	43 720	127 332
2003–04	2 267	50 212	48 060	58 163[c]	34 635	32 369	0	10	84 962	127 332
2004–05	8 981	50 212	49 780	44 741	27 314	32 369	0	10	86 075	127 332
2005–06	5 844	50 212	49 149	49 215[c]	17 425	32 369	0	10	72 418	127 332
2006–07	2 278	50 212	49 495	44 741	18 479	32 369	0	10	70 253	127 332
2007–08	1 371	50 212	36 171	44 741	18 493	32 369	0	10	56 035	127 332

a. Mattlin & Colman (1988) figures cited here are less than those for 1986–87 as reported in the Plenary report (Ministry of Fisheries 2009).
b. Wording in Mattlin & Colman (1988) suggests that this TACC was for either jig or trawl in mainland fisheries.
c. In season increase of 30% for 2003–04 and 10% for 2005–06; note that the total TACC for the year remains unchanged.

was changed on 1 October 1983 to 49°S (now the FMA5/6 boundary) but the codend mesh size change takes effect at latitude 48°S to allow for targeting of squid around the Snares Islands (Hurst 1988).

Regulations to protect bycatch species apply in trawl fisheries. Catch of fish bycatch species is restricted through the QMS, with quotas set on 628 fishstocks. Catch of New Zealand sealions in the Auckland Islands fishery has been restricted by setting an annual Fishery-Related Mortality Limit (FRML) since 1992; vessels are required to cease fishing in the area when the limit is reached (Table 3). Sea Lion Exclusion (or escape) Devices (SLEDs) have been deployed from 2000–01. All trawl vessels have been required to deploy seabird mitigation devices to minimise interactions with trawl warps since April 2006 (Ministry of Fisheries 2009). There are no bycatch issues in jig fisheries.

Table 3. Date of closure of the SQU6T fishery when the fisheries-related mortality limit (FRML, introduced in 1992) on New Zealand sea lions was reached, or when voluntary closures took place. Source: Ministry of Fisheries 2009.

Fishing year	FRML	Date of closure	Fishing year	FRML	Date of closure
1991–92	32	No closure	2000–01	75	7 March 2001[a]
1992–93	63	No closure	2001–02	79	13 April 2002
1993–94	63	No closure	2002–03	70	29 March – 3 April 2003[b]
1994–95	69	No closure	2003–04	62	22 March – 4 April 2004[c]
1995–96	73	4 May 1996	2004–05	115	17 April 2005[d]
1996–97	79	28 March 1997	2005–06	150[e]	No closure
1997–98	63	27 March 1998	2006–07	93	No closure
1998–99	64	No closure	2007–08	81	No closure
1999–00	65	8 March 2000	2008–09	95[f]	

a No official closure. Industry voluntarily withdrew the majority of vessels on 7 March 2001.
b SQU6T fishery was closed on 29 March 2003. However, a High Court Ruling in April 2003 allowed fishing to continue.
c SQU6T fishery was closed on 22 March 2004. However, a Court of Appeal ruling in April 2004 allowed fishing to continue.
d No official closure. Industry voluntarily withdrew on 17 April 2005 upon reaching the 115 animal FRML on 17 April 2005.
e Initial limit of 97, increased mid-season to allow for extra squid catch.
f Initial limit of 113, reduced voluntarily in response to unexpectedly low pup numbers.

3. BIOLOGY

3.1 Distribution

Species distribution

Five species of the Subfamily Ommastrephidae are distributed in New Zealand waters (Uozumi 1998, Dunning 1998). Smith et al. (1981, 1987) reviewed the historical confusion over *Nototodarus* species in New Zealand waters and established that there were two species, through gel electrophoresis and detailed morphological studies, analysis of length frequency data and parasite loads. They are *N. gouldi* (McCoy 1888), or Gould's flying squid, and *N. sloanii* (Gray 1849), or Wellington flying squid. Uozumi (1998) found that young and adult (larger than 15cm) *N. gouldi* and *N. sloanii* can be distinguished by the number of suckers on Arm 1, and that squid 4–15 cm can be inferred from the relationship between dorsal mantle length and the number of suckers.

N. gouldi occurs in temperate to sub-tropical waters off Australia and on the west and northern coasts of New Zealand, north of the Subtropical Convergence. *N. sloanii* is limited to the New Zealand, predominantly coastal waters around the South Island, on the Chatham Rise and Sub-Antarctic plateau that are in, or south of, the Subtropical Convergence (Roper et al. 1984). Uozumi (1998) determined the distribution of the two species from Japanese commercial and research vessels between 1981–82 and 1991–92. *N. gouldi* was dominant (comprising more than 90% of arrow squid) off the west and south east coasts of the North Island (there was no fishing of the north east coast), dropping to about 60% off the west coast of the South Island (but with a highly variable mixing rate by year), and absent from the east and south coasts of the South Island, the Chatham Rise and the Sub-Antarctic (Uozumi 1998, Figure II-11). *N. sloanii* was found in all these areas, except for the north-west North Island, and reached 100% off the east and south coasts of the South Island, the Chatham Rise and the Sub-Antarctic. New Zealand research surveys carried out from Tasman Bay east through Cook Strait and down the east coast of the South Island by Mattlin et al. (1985) found a similar distribution of the two species. Anderson et al. (1998) plotted the distribution of the two species from New Zealand research surveys and found a similar distribution, but confirmed that *N. gouldi* is also present off the north-east coast of the North Island.

Size distribution

Squid spawn throughout the year and there are usually several cohorts present at any one time, but their abundance and distribution varies by season and size. Research surveys prior to 1990 and analysis of commercial size frequency data have established that small squid of both species are found in inshore waters (less than 200m) and appear to move offshore as they grow and mature (Mattlin et al. 1985; Gibson 1995, Uozumi 1998). For example, in February 1981 and April 1982 surveys of the Snares shelf and Auckland Islands, Uozumi (1998) found that small squid (10–12 months old) were more abundant on the Snares shelf, whereas large squid (4–6 months old) were more abundant at the Auckland Is. (Uozumi 1998, Figures VI-20–22). More extensive Sub-Antarctic surveys in March–April 1982 and October–November 1983 did not find evidence of larger squid in waters over about 300 m. None of these surveys sampled inside the 12 n. mile limit, so did not establish the size frequency of squid in more shallow coastal waters. However, a winter (June) survey of the Southland area sampled depths of 50–600 m and found no difference in the distribution of the various size groups across the shelf (Uozumi 1998). Mattlin et al. (1985) and Gibson (1995) also found evidence that the largest squid (over 30 cm) appear to migrate inshore: Mattlin et al. (1985) carried out seasonal surveys off the east coast of the South Island and found most large *N. sloanii* in May–June 1982 in depths of 50m; Gibson (1995) analysed commercial jig size frequencies and found that squid less than 200 g were predominant along the 200m contour, whereas large (greater than 500 g) squid were found later in the season in waters less than 100 m depth (Figure A1). Gibson (1995) also found that large *N. gouldi* were more frequent in shallow waters and in the northern part of west coast jig grounds. He also presented data for the 1986–87 season that showed a similar southward increase in size of *N. sloanii* to that described by Uozumi (1998), from the Snares Islands towards the southern limit of fishing at the Auckland Islands.

Research surveys since 1990 that cover appropriate depth ranges for arrow squid and have sampled lengths include the *R.V. Kaharoa* surveys of the east coast South Island (December-January “summer” and May-June “winter” series) and Tasman Bay/Golden Bay and the west coast of the South Island (March-April). Biomass trends and length frequencies for each survey series are shown in Figures A2–5. Two of the surveys from the coastal inshore Tasman Bay/Golden Bay area have greater numbers and proportions of squid in the 5–20 cm range than strata from the west coast South Island, and fewer squid over 22 cm. On the ECSI, winter surveys had more large squid than summer surveys. Plots of the winter distribution of large males (Figure A6) show that large females occur on the outer shelf edge as well as in shallower water, particularly off and to the north of Banks Peninsula. A comparison of 1986 Canterbury Bight length frequencies (Figure A4) with those from the Snares (Figure A7) shows a similar size range of squid in the same year and season, with large squid over 30 cm more prominent in June and small squid less than 15 cm more prominent in November (Snares) and December/January (Canterbury Bight). This is consistent with the winter spawned cohort being the dominant cohort in both areas.

The Ministry of Fisheries observer sampling programme has collected length frequencies from commercial fisheries mainly in the Snares and Auckland Is. areas. These data have been summarised by week for selected years (1990, 1991, 2008) for Snares shelf and Auckland Is. to compare the progression of cohorts through the fishery by area (see detailed description in Section 6.1). The one year of sufficient data for the Canterbury Bight (1994) has also been summarised. Weekly length frequencies presented in Appendix C are summarised in Figure A8. These data suggest a similar pattern to that described by Uozumi (1998) and Gibson (1985), with larger squid occurring around the Auckland Is. compared to the Snares at various times during the fishing season. However, like the early Japanese research surveys, these commercial vessels are restricted from fishing the more shallow coastal waters inside the 12 n. mile limit and other restricted areas such as the Solander corridor, and therefore movement of squid inshore as they mature to spawn cannot be discounted. Any relationship of the Snares to the ECSI was unclear because of the minimal overlap in time of the samples.

3.2 Stocks and spatial distribution

Potential substocks

The existence of up to eight subpopulations of arrow squid was suggested early in the history of the fisheries (Kawakami 1976, Kawakami & Okutani 1981), including evidence of two morphs of *N. sloanii* off the east coast of the South Island. Uozumi (1998) found that these two morphs were due to morphological changes with maturation (distinguished by the number of suckers on the hectocotylus). Subsequent evidence for the existence of subpopulations has been based primarily on the existence of more than one cohort, or differing size frequency distributions between areas sampled at the same time. From the nine New Zealand research surveys spanning 15 months, Mattlin et al. (1985) found evidence of two separate cohorts per annum for *N. gouldi* sampled in Tasman Bay, but were unable to distinguish cohort progression in polymodal distributions of *N. sloanii* off the east coast of the South Island.

Uozumi (1998) comprehensively reviewed existing studies (including tagging experiments) and presented Japanese commercial and research data including catch distribution, monthly catch rates, and size frequencies. This includes the distribution of adults, juveniles and paralarvae from ten research trawl surveys and two larval net surveys (Figures VI-20–22 Figures VI-4,5,7,8). He concluded that both species are mainly distributed on the shelf throughout their life span, with some inshore-offshore migration with age, but no evidence of migration on a large scale. He suggested a possible inshore migration of large mature squid to spawn based on his own and other available data (see Section 3.3). This supports the concept of possible subpopulations throughout the EEZ, particularly for *N. sloanii*.

Stock definitions for management

Mattlin & Colman (1988) provided the background to the fishstocks used for management. It was assumed that the stock of *N. gouldi* (the northern species) is a single stock and that the mainland stocks of *N. sloanii* comprise a single stock for management purposes. They noted that there was no genetic evidence from work by Smith et al. (1981) and little other evidence to support previous studies suggesting separate subpopulations, with the exception of the Auckland Islands. Mattlin & Colman (1988) presented monthly length frequency data from the Snares and Auckland Islands from observer sampling and suggested that the differences suggested some degree of isolation.

Analyses of more recent data presented in this characterisation are inconclusive as to the potential number of stocks for each of the arrow squid species. *N. gouldi* on the west coast of the South Island is possibly one main stock that migrates north to spawn off northern Taranaki, but at least one other spawning locality has been reported (see Section 3.3). *N. sloanii* has an extensive distribution from the west coast South Island and Chatham Rise down to the Southland and Sub-Antarctic and spawning may occur in all these areas (see Section 3.3).

The Auckland Is. squid fishery is managed as a separate stock but it is likely that some *N. sloanii* may migrate from the Snares to the Auckland Is. as they grow and mature (see Section 6.1, Uozumi 1998, Gibson 1995). Potential movement between the Snares and ECSI could not be determined due to lack of observer length frequency data in overlapping months (see Section 6.1). The relationship of squid hatched at different times of the year, in terms of possible sub-stocks, is also unknown.

3.3 Spawning

Arrow squid are short-lived and semelparous (spawn once and die). O'Dor (1998) suggests that they can only achieve genetic diversity and stabilise recruitment by spawning micro-cohorts throughout the year to take advantage of variable microhabitats. This type of behaviour links recruitment more tightly to environmental variability than for longer-lived species.

There is little direct evidence for spawning grounds of either species (Uozumi 1998). The only reported sighting of arrow squid egg masses has been for *N. gouldi* off the Poor Knights Islands (O'Shea et al. 2004).

Main spawning areas for *N. gouldi* are thought to be on the shelf in the North Taranaki Bight, based on the occurrence of large mature squid and/or very young paralarvae (Uozumi 1998 (Figures VI-20–22 Figures VI-4,5,7,8), Gibson 1995 (Figure A1)). Results of a tagging study also showed that some WCSI tagged squid migrated north (Sato 1985).

For *N. sloanii*, the occurrence of large mature squid and/or very young paralarve, as reported by Uozumi (1998), Gibson (1995), Mattlin et al. (1985) and here (Section 6.1), suggests possible spawning areas off the west coast South Island, at the Chatham Islands, on Mernoo and Veryan Banks, Canterbury Bight, Puysegur, Stewart and Snares Islands, and the Auckland Islands. The presence of all age classes at all times of year suggests spawning throughout the year (Uozumi 1998). Tagging studies on the Snares shelf and in Canterbury Bight found no evidence of movement between areas that might indicate spawning migrations (Sato 1985; Yamada & Kattoh 1987). Uozumi (1998) concluded that the available evidence, in conjunction with records of records of large squid in shallow water (Mattlin et al. 1985, Gibson 1995) suggested that spawning may occur in less than 50 m depth.

Timing

Surveys of eastern and southern New Zealand and patterns in commercial fisheries (Mattlin et al. 1985; Gibson 1995, Uozumi 1998) have found a wide range of sizes at all times indicating that both species spawn throughout the year. The largest aggregations form in late summer/autumn, resulting in the dominant winter (*N. gouldi*) or winter/early spring (*N. sloanii*) spawned cohorts (Uozumi 1998).

Maturation

From extensive surveys off central and southern New Zealand, Uozumi (1998) estimated maturation, copulation and gonadosomatic indices for both species of arrow squid. He found that maturation is related to both age and somatic growth and starts about two months earlier in males. Maturing males were found at 180–310 days old, with increasing proportions of mature males from 200 days. Males over 310 days were all mature. Maturing females were found at 200–310 days old, with increasing proportions of mature females from 230 days. Females over 320 days were all mature. The youngest age of copulation was 240 days for *N. gouldi* and 190 days for *N. sloanii*.

Squid in mature condition have been reported in waters less than 250 m. For *N. gouldi*, Uozumi (1998) found no mature males deeper than 250 m and no mature or copulated females with oviduct somatic indices (OSDI) greater than 4.0 deeper than 200 m, whereas females with OSDI greater than 4.0 were regularly found (up to 50%) in waters under 200 m. More fully matured squid were found in northern areas. For *N. sloanii*, Uozumi (1998) found fully mature squid in eastern and southern areas of New Zealand, but few from around the North Island or west coast South Island (WCSI). At the Snares and Auckland Is., he found no difference in the depth distribution of mature males, but the same reduction in high OSDI for females in deeper water as observed for *N. gouldi*. Uozumi concluded that maturity patterns suggested that females migrated into shallow water with maturation.

Observer records from 2008 recorded mature and spent arrow squid (*N. sloanii*) from both the Snares and Auckland Is. shelves and shelf edges (see Section 6.1)

3.4 Climate and recruitment

Environmental predictors are likely to be more useful for short-lived species because recent recruits comprise a large part of the stock. Exploited squid stocks are short-lived opportunists that generally have a life cycle of about one year, with little overlap between recruited cohorts, and generally high recruitment variability driven by the environment (Rodhouse 2001; Agnew et al. 2002).

Internationally, there are numerous studies that have attempted to link squid abundance to environmental conditions, both directly in relation to the time of spawning and the location of aggregations. Relationships include: SST and catch (Dow 1976: *Loligo pealei*); SST and abundance (Coehlo & Rosenburg 1984, and Caddy 1983: *Illex illecebrosus*; Chen et al. 2006: three *Loligo* species); SST in the spawning area (Waluda et al. 1999, 2001: *Illex argentinus*); SST for larval development (Sakurai et al. 2000: *Todarodes pacificus*); SST and El Niño events (Rodhouse 2001 and Yamashiro et al. 1998: *Dosidicus gigas*); SST 6 months prior to recruitment and abundance (Agnew et al. 2000: *L. gahi*)).

Hypotheses on how the ocean environment might cause inter-annual variability in ommastrephid squids of western boundary currents include: wind effects facilitating onshore transport of surface dwelling larvae and offshore migration of pre-adults in sub-pycnocline layers (i.e., below a layer of rapid density change); fluctuations in prey abundance; temperature effects; variations in predation pressure; and disease (Bakun & Csirke 1998).

Ommastrephid eggs are planktonic and subject to variable ocean current systems and research to predict the effects of environmental variability on abundance requires a full understanding of the early life history from egg to post-planktonic juvenile (Rodhouse 2001). Life cycles can be complex but hypotheses for poorly understood species can be developed from more well-known species (e.g., Anderson & Rodhouse 2001).

In New Zealand, the life cycle of arrow squid is not well known. Uozumi (1998) summarised knowledge of larval and post-larval juvenile distributions and spawning times (see Section 3.3). Uozumi (1998) suggested that there was no correlation between inter-annual variation in arrow squid CPUE and the Southern Oscillation Index (SOI), except for large increases in the CPUE indices for three cohorts (two on the Snares shelf and one in Canterbury Bight) in 1988–89. He noted that these were spawned in 1988 when a major La Nina event occurred. In Section 9.2, we report a preliminary analysis of environmental predictors of abundance for the Snares and Auckland Is. fisheries (correlating various factors with annual CPUE); highest correlations (r greater than 0.75) were found with ocean colour (chlorophyll).

3.5 Ageing

Maximum dorsal mantle lengths reached by arrow squid are about 40 cm (Mattlin et al. 1985; Uozumi 1998). Age determination using statoliths was conducted by Uozumi (1998). He found maximum ages of 373 and 374 days for *N. gouldi* and *N. sloanii*, respectively, at lengths of 37.6 and 40.6 cm. this indicates that the life span is about one year, for both species. Uozumi (1998) also reviewed literature on ommastrephid squids and found that a one-year life span has been reported in many species, especially those with a maximum size of about 40 cm.

3.6 Growth curves

Von Bertalanffy growth curve parameter estimates for the two species, cited in the 2009 plenary report (Ministry of Fisheries 2009), were estimated based on parasite loadings (Gibson & Jones 1993). More direct estimation of growth curves by examination of the relationship between dorsal mantle length and statolith radius was conducted by Uozumi (1998). He found that arrow squid growth differed by month class of hatching and sex. For example, squid hatched in August, that are 150–210 days old in the summer months are larger than squid hatched in February that reach this age in winter. Mean growth rates increased from about 1.3 mm/day in 90–150 days old squid, to about 1.9 mm/day in 150–210 day old squid. This implies a growth rate of about 4–6 cm per month (slightly greater than the 3.0–4.5 cm per month recorded by Mattlin et al. 1985). Male and female growth rates diverged after 200 days (by about 0.2 mm/day). At 300 days old, differences between the sexes ranged from 3.5–5.3 cm for *N. gouldi* and 2–4 cm for *N. sloanii*. Estimated growth parameters for arrow squid (by Uozumi 1998), by month of hatching are shown in Table 4).

3.7 Natural mortality

There are no estimates of natural mortality for New Zealand arrow squid. Caddy (1996) lists some published values for adult squid pre-spawning natural mortality, expressed on an annual basis, that fall in the range 0.35–1.8. He notes however that few are based on a specific estimation procedure. Pauly (1985) derived natural mortality estimates for squid of 0.53–2.13, based on an empirical relationship developed for fish.

Table 4: Estimated growth parameters for arrow squid, by month of hatching (after Uozumi 1998).

						N. gouldi
			Male			Female
Month	L_∞	K	T_0	L_∞	K	T_0
January	303.2	0.0224	185.3	395.8	0.0178	211.7
February	307.7	0.0216	188.6	389.5	0.0185	205.7
March	322.8	0.0202	196.7	390.8	0.0184	208.1
April	315.5	0.0207	196.3	376.4	0.0187	204.4
May	305.5	0.0227	190.0	374.2	0.0185	207.1
June	291.3	0.0254	181.8	352.1	0.0202	196.4
July	289.5	0.0271	178.5	349.2	0.0209	195.0
August	285.4	0.0272	175.2	342.0	0.0213	188.2
September	309.0	0.0232	178.6	289.9	0.0246	168.7
October	312.4	0.0221	180.4	312.1	0.0246	173.3
November	308.7	0.0214	180.0	321.6	0.0223	179.1
December	303.9	0.0223	184.9	355.7	0.0201	197.9

						N. sloanii
			Male			Female
Month	L_∞	K	T_0	L_∞	K	T_0
January	427.3	0.0212	230.0	438.5	0.0192	228.6
February	333.3	0.0267	202.4	419.7	0.0184	221.8
March	315.5	0.0242	200.1	434.8	0.0168	235.2
April	327.2	0.0205	206.6	468.7	0.0156	250.3
May	331.8	0.0204	205.3	444.7	0.0170	237.5
June	325.2	0.0219	190.4	407.8	0.0177	214.5
July	348.0	0.0196	188.8	434.2	0.0157	211.0
August	403.6	0.0167	202.0	420.9	0.0167	199.9
September	385.1	0.0184	191.4	393.5	0.0188	188.6
October	345.4	0.0223	176.1	400.8	0.0205	193.9
November	287.8	0.0313	158.9	383.8	0.0209	200.1
December	601.4	0.0123	279.7	446.2	0.0183	232.8

3.8 Length-weight relationships

Length-weight relationships for the two species of arrow squid are incorrectly reported from Mattlin et al. (1985) in the 2009 plenary document (Ministry of Fisheries 2009) and have been corrected in Table 5. These data came from year round surveys from outer Tasman Bay and down the ECSI. The length-weight relationship of *N. sloanii* from southern New Zealand for 2008 (Table B5) is also included.

Table 5: Length-weight relationships for the two species of arrow squid (weight = a (length)^b; weight in g, length in cm dorsal mantle length).

Species	Area, year	Size (cm)	a	b	Source
N. gouldi	Tasman Bay, north	≤ 12	0.07380	2.63	Mattlin et al. 1985
	ECSI, 1982–83	> 12	0.02900	3.00	
N. sloanii	ECSI, 1982–83	≤ 12	0.10970	2.43	
		> 12	0.01546	3.11	
	Snares shelf, 2008	9–41	0.0171	3.08	This report
	Auckland Is, 2008	10–40	0.0136	3.16	

3.9 Feeding and trophic status

Arrow squid are an important part of the diet for many species. From a summary of research surveys to 1999 (Stevens et al. 2012), squid (often unidentified to genus but including some records of arrow squid) were important (i.e., in more than 20% of stomachs containing food) in the diet of banded stargazer (*Kathestoma sp*., 59%), bluenose (*Hyperoglyphe antarctica*, 26%), giant stargazer (*Kathestoma giganteum*, 34%), gemfish (*Rexea solandri,* 43%), and hapuku (*Polyprion oxygeneios*, 21%). *Nototodarus* were also specifically recorded in the diets of alfonsino (*Beryx splendens*), barracouta (*Thyrsites atun*), hake (*Merluccius australis*), hoki (*Macruronus novaezelandiae*), ling (*Genypterus blacodes*), red cod (*Pseudophycis bachus*), red gurnard (*Cheilidonichtyes kumu*), sea perch (*Helicolenus percoides*), and southern blue whiting (*Micromesisteus australis*).

In a recent detailed trophic study on the Chatham Rise (Dunn et al. 2009a), cephalopods were identified as prey of almost all demersal fish species, and arrow squid (*N. sloanii*) was identified in the diet of hake, hoki, ling, Ray's bream (*Brama brama*), shovelnose spiny dogfish (*Deania calcea*), sea perch (*Helicolenus percoides*) smooth skate (*Raja innominata*), giant stargazer and silver warehou (*Seriolella punctata*), and was a significant component (more than 10% prey weight) of the diet of barracouta and spiny dogfish (*Squalus acanthias*).

Arrow squid have been recorded as important in the diet of marine mammals such as fur seals and NZ sealions, particularly during summer and autumn months (Fea et al. 1999, Harcourt et al. 2002, Chilvers 2008, Boren 2008) and in the diet of common dolphins (Meynier et al. 2008, Stockin 2008). They are also important in the diet of seabirds such as shy albatrosses (*Thalassarche cauta*) in Australia (Hedd & Gales 2001) and Buller's albatross (*Diomedea bulleri bulleri*) at the Snares and Solander Is. (James & Stahl 2000). Cephalopods in general are important in the diet of a wide range of Australasian albatrosses, petrels and penguins (Marchant & Higgins 2004).

Arrow squid in New Zealand waters have been recorded feeding on myctophids, sprats (*Sprattus antipodum*), pilchards (*Sardinops neopilchardus*), barracouta, euphausiids (commonly *Nyctiphanes australis)*, mysids, isopods and squid, probably other arrow squid (Yatsu 1986, Uozumi 1998). Uozumi found that the frequency of prey in stomachs of both species (by size) was: squid, 20–50%, increasing with size; fish, 20–40%, either increasing or no trend with size; crustaceans, 10–70%, decreasing with size and more important in *N. sloanii*. The relative importance of various food items changed between years. The percentage of empty stomachs was influenced by area, fishing method (higher for jig caught squid), month (higher in winter than summer months), size (decreasing with increasing size), maturation (increasing with increasing maturity), and time of day (highest at dusk for both species). In Australia, *N. gouldi* was found to feed mostly on pilchard, barracouta, and crustaceans (O'Sullivan & Cullen 1983). Cannibalism was also recorded.

4. CURRENT AND ASSOCIATED RESEARCH PROGRAMMES

4.1 Ministry of Fisheries

There are no specific ongoing research programmes on arrow squid. Ongoing research trawl surveys in four areas routinely catch and record catches of arrow squid. Arrow squid are taken in reasonable quantities on *Kaharoa* trawl surveys off the west and east coasts of the South Island, depth ranges are appropriate to sample squid, and these data probably monitor squid size frequencies in these areas and months reasonably well. Numbers of squid measured range from 727–2197 on winter surveys of the ECSI, (but measurements were discontinued from 2000); 2752–4330 on summer surveys of the ECSI (currently discontinued); and 802–5191 on autumn surveys of the WCSI (but measurements were discontinued from 2000). Arrow squid catches taken by *Tangaroa* on the Chatham Rise and in the Sub-Antarctic surveys are variable, probably because the minimum survey depths are at the deeper edge of the arrow squid distribution. Numbers of squid measured range from 194–1748 on summer surveys of the Chatham Rise, and 79–1143 from the Sub-Antarctic. It is not clear how well these data might monitor size frequencies in these areas and months.

4.2 FoRST

4.3 Other

5. FISHERY INDEPENDENT OBSERVATIONS

5.1 Research surveys

Biomass indices

Biomass indices from research surveys have limited use for management of squid stocks (because they live for only one year) unless they are designed to provide pre-season indices of recruitment. There are no surveys currently undertaken that do this. There are several potential uses of biomass indices from past or current research surveys for stock assessment: to provide information on relative distribution of species and cohorts or maturity stages (see Section 3); to provide pre-season estimates of recruitment; and to carry out post-season assessment perhaps in conjunction with other potential abundance indices such as CPUE (see Section 9.3).

Historically, bottom trawl and a few bongo and fine mesh midwater trawl surveys were conducted for arrow squid, or in arrow squid depths, in the 1980s by Japanese research vessels *Shinkai Maru, Tomi Maru* and *Kaiyo Maru*. Much of the data from these surveys is summarised by Uozumi (1998) and not included here (other than reproduction of a few of Uozumi's figures in Appendix A). Bottom trawl surveys by the *W.J.Scott* and *James Cook*, during the late 1970s and 1980s, were also aimed at arrow squid or in arrow squid depths. Some of these for Tasman Bay and/or ECSI have been published by Fenaughty & Bagley (1981) (ECSI) and Mattlin et al. (1985). A discontinued *Tangaroa* survey off Southland (1993–1996) also surveyed arrow squid depths and recorded catch rates, biomass and length frequencies (Hurst & Bagley 1997).

Currently, *Tangaroa* surveys on the Chatham Rise and in the Sub-Antarctic surveys do not provide adequate estimates of squid abundance because they start at the deeper edge of the arrow squid distribution (more than 200 or 300 m depth, respectively), so data are not reported here. Inshore *Kaharoa* surveys encompass the main depth range of arrow squid on the ECSI and WCSI and biomass indices are summarised here in Figures A4, 5, Table 6. The ECSI survey was first conducted as a winter (May–June) survey (1991–1996) then as a summer (December–January) survey (1996–

2000). It was then discontinued, but restarted as a winter survey in 2007. The winter series biomass shows no obvious trend, fluctuates about fourfold and has c.v.s of 17–32%. The WCSI and Tasman/Golden Bays survey takes place March–April and started in 1992. On the WCSI part of the survey the biomass fluctuates about sixfold and has c.v.s of 10–20% and for Tasman/Golden Bays the biomass fluctuates about thirteenfold with c.v.s of 17–38%. All surveys collect catch size information, but squid length frequency data have not been collected since 2000.

Table 6: Relative biomass indices (t) and coefficients of variation (c.v.) for arrow squid for east coast South Island (ECSI) – summer and winter, west coast South Island – WCSI and Tasman Bay/Golden Bay (TGB). Note that the ECSI summer series extended shallower and had a smaller cod-end mesh than the winter series.

Region	Fishstock	Year	Trip number	Biomass estimate	c.v. (%)
ECSI(winter)	SQU1	1991	KAH9105	333	22
		1992	KAH9205	1 303	32
		1993	KAH9306	1 062	17
		1994	KAH9406	1 421	25
		1996	KAH9606	1 204	30
		2007	KAH0705	1 242	23
		2008	KAH0806	998	19
		2009	KAH0904	867	25
ECSI(summer)	SQU1	1996–97	KAH9618	1 522	17
		1997–98	KAH9704	629	34
		1998–99	KAH9809	970	12
		1999–00	KAH9917	841	12
		2000–01	KAH0014	1 063	31
WCSI (WCSI)	SQU1	1992	KAH9204	2 780	20
		1994	KAH9404	1 002	10
		1995	KAH9504	3 021	14
		1997	KAH9701	904	14
		2000	KAH0004	473	12
		2003	KAH0304	2 050	13
		2005	KAH0503	712	11
		2007	KAH0704	1 097	10
		2009	KAH0904	368	17
WCSI (TBG)	SQU1	1992	KAH9204	181	21
		1994	KAH9404	190	24
		1995	KAH9504	429	58
		1997	KAH9701	63	14
		2000	KAH0004	50	38
		2003	KAH0304	205	17
		2005	KAH0503	177	18
		2007	KAH0704	130	18
		2009	KAH0904	34	18

Length and age frequencies

Length sampling from research surveys is most useful for determining the relative abundance and distribution of cohorts and, potentially, stock structure and movements. Historical survey data that have been useful for this purpose are described in Section 3. Uozumi (1998) aged statoliths collected from Japanese commercial and research vessels and developed age and growth relationships for squid month classes (see Section 3.6). No statoliths have been collected for routine ageing of squid from New Zealand research surveys.

Inshore *Kaharoa* surveys (described above) encompass the main depth range of arrow squid on the ECSI and WCSI and length frequency data (by numbers–at-length) are summarised here in Figures A6–8. Note that squid length frequency data have not been collected since 2000 due to other survey priorities. The ECSI winter series show the presence of at least three main size groups: 5–15, 15–25, and 25–40 cm; the larger squid are the dominant group in two of the three years in which adequate sampling took place. In contrast, the summer series shows squid up to about 30 cm and has a clearly dominant group at 5–15 cm, particularly in 1996 and 2000. This survey could potentially provide pre-season recruitment indices. The WCSI (WCSI) series shows up to four main size groups with no size group clearly dominant across years; the WCSI (Tasman/Golden Bay) series shows up to three main size groups, also with no size group clearly dominant across years. In some years (1992, 1994, 2000), corresponding modes smaller than 15 cm are more numerous in Tasman/Golden Bay compared to the WCSI itself, but numbers are similar in 1997. Modes from 15–30 cm are often similar in number, but the WCSI itself usually has more squid larger than 30 cm. There is possibly a relationship between squid in these two areas, but interpretation is complicated by the lack of species identification.

The value of these surveys for monitoring arrow squid stocks could be enhanced by identification of species (on the WCSI surveys), continuing length frequency measurements (for the identification of cohorts), and collecting maturity stage information for females (for the identification of spawning movements and areas). This would improve our ability to determine species distribution and stock identification.

6. FISHERY DEPENDENT OBSERVATIONS – OBSERVER DATA

6.1 Length sampling

The Ministry of Fisheries Observer Programme (OP) has collected squid sex and length data since 1986 (except from 2000–01 to 2006–07), mainly from the Auckland Islands and Snares Shelf trawl fishery (Table B1). Squid sex, length, weight, and female gonad stage data were collected in 2007–08 and 2008–09 (the most recent sampling year was not complete at the time of data extraction from the database and is not presented here). Squid were measured on 5524 tows from the trawl fishery, of which 2632 came from the Auckland Islands, 2686 from the Snares Shelf, and 206 from all other areas combined. The Auckland Islands fishery has had higher levels of observer coverage due to management measures in place for the protection of New Zealand sea lions. Most observed tows were from December to May, with the majority in February and March from the Snares and February to April from the Auckland Is. (Table B2). Up to about 17 000 squid were measured in peak months from the Snares and up to about 22 000 from the Auckland Is. (Table B3).

The representativeness of observer sampling of squid target trawls was evaluated by plotting the proportion of landed catch for each year by area and by month as circles, and overlaying this with the proportion of the observed catch for those same cells as crosses (Figure B1). If the proportions are the same, the plots align; if over- or under-sampling has occurred, the crosses are either larger or smaller than the circles. Sampling at the Auckland Is. and Snares has represented the catch well across years and months (although the Auckland Is. has been oversampled), but small catches in other areas have been poorly sampled. The observed catch, as a proportion of total target squid catch, has ranged from about 2–22% at the Auckland Is. and about 1–15% at the Snares (Table B4). Highest observer squid sampling was achieved in these areas in 2007–08 (22% and 15%, respectively). The weekly location of observer samples relative to higher densities of catch is shown for the two years that were analysed in detail (see below), 1990–91 and 2007–08, and shows that there is good sampling of the main areas fished in most weeks (Figure B2).

6.2 Length frequencies

The objectives of this project required estimation of length frequencies for the Snares, the Auckland Is., and ECSI. Length frequencies were estimated as the weighted average of individual length samples (by catch weight). Length frequency data for each year and area were post-stratified by weekly or monthly time strata. Length frequencies were determined using the 'catch.at.age' software (Bull & Dunn 2002) which scales the length frequency from each catch up to the tow catch, sums over catches in each stratum, scales up to the total stratum catch, and then sums across the strata, to yield overall length frequencies. Numbers of squid were estimated from catch weights using the length-weight relationship for observed squid in the Auckland Is. and Snares in 2008 (Table B5). No weight data were collected in earlier years.

Scaled length frequency distributions from the Snares and Auckland Is. fisheries were generated by month for the 12 years for which data were available (Figures B3,4). Both fisheries show evidence of between two and four main cohorts per season. The modes of these cohorts are between 3–15 cm apart, representing squid spawned several weeks to probably about 3 months apart. In general, squid appear to be smaller (several modal peaks between 10–20 cm) when they enter the Snares fishery than those entering the Auckland Is. fishery (more often 18–25 cm). This, combined with the lack of more than a few large squid (larger than 30 cm) at the Snares in most years, suggests that squid may move from the Snares to the Auckland Is. as they grow.

Weekly length frequency distributions (Figure B5) enabled possible movements to be better determined and were generated for the 1990, 1991 and 2008, and 1994 seasons to address stock structure issues (see Section 3.1).

In 1990, small-size (modal peak about 20 cm) squid were caught in high numbers at the Snares up to week 3. High numbers of similar sized squid were then caught at the Auckland Is. for weeks 4–7, suggesting possible movement, along with a larger cohort (peak about 30 cm). The next Snares samples, in weeks 11–13, were on a new cohort peaking at 19 cm in week 11 and there is no obvious correlation between this cohort and quite different sized cohorts for the rest of the Auckland Is. season.

In 1991, the Snares fishery was based on a cohort peaking at 15 cm in week 5 and caught in the largest numbers at 20 cm in week 12. The larger squid in this cohort (greater than 22 cm) appear to have gone by week 11. In contrast, the Auckland Is. fishery started fishing a cohort peaking at about 30 cm in week 4, but in low numbers up to week 8. By week 11, the fishery was catching a cohort peaking at 23 cm in large numbers, suggesting again that some may have moved in from the Snares. In week 14 at the Snares, the cohort peaking at 22 cm had gone and a smaller one at 17 cm was caught. In the same week, there was evidence of another cohort at 22 cm moving into the Auckland Is. and this and the slightly larger one sustained this fishery until week 19 when they were 27–35 cm long.

The pattern in 1994 was different. There was some suggestion of a mid-sized mode (about 25–26 cm) in both areas that occurred in both areas up to week 11, continued in catches at the Snares, but disappeared from the Auckland Is. A smaller mode in the low 20s then appeared in the Auckland Is. in week 12, but it is not clear if it was the same cohort at the Snares which appeared to decline there after week 13.

In 2008, cohorts again appeared to show movement between the two areas. By week 6 at the Snares, there were at least three main cohorts, peaking at about 13, 16, and 25 cm, whereas squid at the Auckland Is. were large (most larger than 26 cm) and caught in low numbers. The larger Snares cohort was caught in highest numbers in week 6 (at 26 cm) and, by week 9 at the Auckland Is., a cohort peaking at 30 cm was caught in its highest numbers. Similarly, the second Snares cohort, caught in highest numbers in week 6 (at about 18 cm), declined over subsequent weeks while a cohort peaking at 23–24 cm was caught in its highest numbers at the Auckland Is. in week 11. The third Snares cohort, caught in highest numbers in week 12 (at 21 cm) declined while a cohort peaking at a similar size was caught in highest numbers at the Auckland Is. in weeks 13 and 14.

Detailed analysis of weekly length frequencies suggests movement of Snares arrow squid to the Auckland Is. in three of the four years examined. Hence, data for these areas were treated both separately and combined in later sections of this report (Sections 8, 9).

6.3 Female maturity

Observers collected data on female maturity stage in 2008 using a 5-stage gonad scale (Table B6). Data for 2009 were also collected but were not completely entered into the database at the time of analysis and are not included here.

Data are presented separately and combined for the Snares and Auckland Is. fisheries (Table B7, Figures B6–B8). At the Snares, stage 1 females were most common in January and February and infrequent in May. The proportion of stage 2 females increased during the season and peaked in May. The pattern at the Auckland Is. was similar except that stage 1 females were less common, being in similar proportions to stage 2 from February to March. Stage 4 and 5 females were relatively rare but recorded in both areas in February and March (Observer Figures 6 and 7). They occurred on the southern Snares shelf edge and in the northern Auckland Is. area (Figure B6). The size of squid increased with gonad stage (Figure B8).

7 FISHERY DEPENDENT OBSERVATIONS – DESCRIPTIVE ANALYSIS OF CATCH

7.1 Catch and effort data sources

Catch and effort data were requested from the Ministry of Fisheries catch-effort database “warehou” as extract 7426. The data consist of all fishing and landing events associated with a set of fishing trips that reported a positive landing of arrow squid (species codes SQU, ASQ, NOS, NOG) between 1 October 1989 and 31 December 2008. The fields from the database tables requested are listed in Table C1a and a summary of variables available is given in Table C1b. Table C2 explains form type codes, species codes, method codes and processing codes and dates of usage.

The estimated arrow squid catch associated with the fishing events were reported on the Catch Effort Landing Returns (CELR), Trawl Catch Effort Return (TCER), Lining Trip Catch Effort Return (LTCER), and Trawl Catch Effort and Processing Return (TCEPR) (Tables C3–5). As there is no estimated arrow squid catch for the Squid Jigging Catch Effort Return (SJCER) and Tuna Long Lining Catch Effort Return (TLCER) forms, the greenweight from the processed part of the form was used. There was no arrow squid reported on the Net Catch Effort Landing Returns (NCELR) or Lining Catch Effort Return (LCER).

The green weight associated with landing events were reported on the bottom part of CELR forms, or where fishing was reported on TCEPR, TCER, TLCER, LTCER, or SJCER forms, on the associated Catch Landing Return (CLR) form. The CLR form also included high-seas (HS) landings from the HS TCEPR and HS CELR forms.

TCEPR forms record tow-by-tow data and summarise the estimated catch for the top five species for individual tows for trawl vessels greater than 28 m. CELR forms summarise daily catches, which are further stratified by statistical area, method of capture, and target species. Trawl vessels less than 28 m used either the TCEPR or CELR forms up until 1 October 2007. From 1 October 2007, the TCER form replaced the CELR form for trawl vessels less than 28 m, which includes tow-by-tow estimated catches up to the top eight species, although vessels less than 28 m also sometimes complete TCEPR forms.

The extracted data were groomed to derive the datasets required for the characterisation and CPUE analyses using a variation of Starr’s (2007) data processing method as implemented by Manning et al. (2004), with refinements by Blackwell et al. (2005), and Manning (2007) and further modified for this study. Although 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, this was not done as most (99%) catch was recorded on forms that recorded latitude and longitude. Outlier values in key variables that failed a range check were corrected using median imputation which involves replacing missing or outlier values with a median value calculated over some subset of the data.

7.2 Summary of catches

The history of squid fisheries since the introduction of the EEZ, in 1978, is summarised in Tables 1 and 2. The reported QMR/MHR landings, the catch-effort landings (un-groomed), and TACC for SQU 1T, 1J, and 6T from 1983–84 through to the 2007–08 fishing year are shown in Figure C1. For all three stocks, the catch-effort landings in the raw dataset are generally less than the reported MHR landings throughout the time series, and generally conform in trend. The MHR landings have been lower than the TACC in most years, although the TACC was exceeded in 2004–05 and 2006–07 for SQU1T, and for 1993–94, 1994–95, and 2003–04 for SQU6T.

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

Table C3 summarises squid estimated catches, and green weight associated with landing events, and reported catches. For landing events, a significant number recorded under "T" (transferred to another vessel) and "R" (retained on board) destination codes (both are defined as interim landing events by Starr (2007). The "T" events appear in the early part of the series through to the late 1990s (Figure C2, Table C4) and were recorded by vessels using TCEPR forms. It is unknown how the catches from those trips were recorded, as the transferred catches could be landed by foreign vessels to ports outside New Zealand.

The transferred landing events accounted for up to a third of the annual landings from 1989–90 to 1996–97 and excluding them from the dataset led to retained landings falling short of the MHR by 12–33%, although leaving them in would lead to overruns in landings for 1991–92 and 1996–97. The annual estimated catch exceeded retained landings by 25–40% in the mid-1990s (Table C3). Therefore the "T" landing events were excluded from the analysis, as were other interim landing events as defined by Starr (2007).

The retained landings and total landings dropped during data grooming are shown in Figure C2. The grooming process has excluded a small number of trips with invalid codes in fishing method, target species, statistical area, and date which cannot be fixed using the median imputation method. The estimated catch and landings removed from the dataset by this process were generally insignificant throughout the time series, although they were higher in the earlier part of the series in some years. For the three stocks, the retained landings fell short of the reported MHR in the early 1990s, but match closely for the later part of the time series.

The groomed landings are summarised by processed state in Figure C3. For all three stocks, the bulk of catches were landed green or processed to the dressed state. In 1989–90 and 1990–91 about half of the catch was processed as "HGU" (headed and gutted), and from 1991–92 to 1997–98 a small amount was processed as "TEN" (tentacles). Additional landed states such as ROE and HET do not have conversion factors as otherwise there would be double counting of landed catch.

The conversion factors for some processed states of arrow squid have been changed over time since the implementation of the QMS (Ministry of Fisheries 2008b, Table C2d), so greenweights were standardised using the most recent conversion factor for each processed state (based on the assumption that the changes in conversion factors reflect improving estimates of the actual conversion when processing arrow squid). This made little difference in the current analysis because most conversion factor changes occurred in 1990.

The MHR landings, and groomed retained landings and groomed estimated catches are plotted in Figure C4. For all three stocks, the estimated catches fell short of the retained landings in the 1990s, especially for SQU1J, and in all three stocks the estimated catches were closer to the MHR landings, and retained landings in the 2000s.

The proportions of estimated catches and retained landings by form type for each Fishstock are shown in Figure C5. For SQU1T and SQU6T the bulk of estimated catches are recorded on the TCEPR form, and for SQU1J the bulk of the processed catch is recorded on the SJCER form. For all three stocks the bulk of the landings are recorded on the CLR form. For SQU1T and SQU1J there has also been a small proportion of catch recorded on CELR forms, presumably by smaller vessels fishing in inshore areas. In the 2007–08 fishing year vessels previously recording on CELR forms in SQU1T appeared to have switched to TCER forms. In SQU6T, there has been little catch recorded on CELR forms.

7.3 Fishery Characterisation

The distribution of arrow squid catches is shown in Table C6. Catches over 10 000 t per annum are regularly recorded from the Auckland Is. and the Snares. Catches of this size were reported from the ECSI in the mid-1990s, partly because of jig effort which has since declined. The WCSI and Northern areas were relatively important in the early 1990s but have since declined for the same reason (Table C6c, Figure C7). Catches in other areas are highly variable. Overall, in the last 19 years, trawl catch has dominated (86%), mostly from the Snares (45%) and Auckland Is. (28%) fisheries. By individual fishing years, density of catches is highest in inshore and shelf edge areas from north Taranaki and WCSI to ECSI, the Snares and Auckland Is. (Figure C6), and occasionally at Puysegur Bank and on the Mernoo and Veryan banks on the western Chatham Rise.

All squid fisheries are highly seasonal (Tables C7–C9, Figure C7). Trawl fisheries have recorded catch throughout the year, but most is taken from January–April at the Snares, February–April at the Auckland Is., and February–May at Puysegur, the ECSI, and western Chatham Rise. Jig fisheries occur from December–May, with most catch taken from January–April. By area, catches peak in January–February in Puysegur and off the WCSI, February–March at the Snares and off the ECSI, and January–April off the northern North Island and on the western Chatham Rise.

Fishing vessels are primarily Korean and Ukrainian, with 900–5100 kilowatt engine power, 250–4 250 gross tonnage and 55–105 m overall length (Figure C7, Table C10). Jiggers (Figure C7e) tend to be smaller (250–1 250 gross tonnage and 25–75 m length) than trawlers and, where nationality is recorded, mainly from China and Japan (Figure C7c). Trawlers operating off the ECSI also tend to be smaller, mainly 250 t and 55 m length, and of Korean or New Zealand nationality (Figure C7k).

Squid is the only target species for jiggers and the dominant target species (96%) for trawlers across all areas (Table C11, Figures C7–9). The proportion target fished ranges from 99.8% at the Auckland Is. to 86% off the ECSI. The monthly pattern of catches in squid target and other species target fisheries is shown in Figure C8. As described above, squid are caught mainly from January–May in most areas. Most of the catch is targeted, except for the on the WCSI and in northern areas (Figure C9). For all the other main target species, the main seasons of capture are summer and autumn. Both bottom and midwater trawl gear are used in those areas where trawling predominates (Figure C8b), although midwater is used to a much lesser extent on the ECSI and at Puysegur.

Catches are predominantly recorded on SJCER (jig) and TCEPR (trawl) forms in areas other than the ECSI where trawl is recorded on CELR and, in the last year, TCER forms (Figure C8c, Table C12). Details of the form types, bottom trawl tows, midwater tows, and their respective gear and deployment parameters, and unstandardised CPUE indices for non-zero tows are given in Table C12, for the three main fisheries (Auckland Is., Snares, and ECSI). The proportion of zero tows by form type is generally over 60% for TCEPR, 80% for CELR and about 80% for the one year's data on TCER forms (Figure C10). The proportion of zero tows by target species (Figure C11) shows low values for squid target in key squid fisheries (Auckland Is., Snares, and ECSI) and slightly higher values in the other squid fisheries. The proportion of zero squid tows in other species target fisheries is mostly over 60%, the main exceptions being red cod and barracouta at the Snares, Puysegur, and on the western Chatham Rise and WCSI.

The number of vessels shows a decline at the Auckland Is. from the late 1990s, but is more stable in the other areas. Unstandardised CPUE at the Auckland Is. (bottom and midwater trawling) and Snares (bottom trawling only) shows an increase (catch/tow and catch per hour) after 2003, not mirrored in the ECSI (Table C12, Figure C12). Unstandardised catch rates of squid in other species target fisheries do not mirror squid target catch rates, with the possible exception of squid in the hoki fishery on the WCSI and the jack mackerel fishery in the North area.

Boxplots for key parameters for CPUE analyses are shown in Figures C13 and 14 and Table C12. Note that the tow duration at the Auckland Is. and Snares, as calculated by start and finish position, increases in recent years whilst tow distance decreases, particularly for bottom trawls (Figure C13a). This suggests that the tows may not be straight and therefore a second distance (distance 2) was offered for standardised CPUE analyses based on speed and duration of tow (Figure C13b). Other parameters were similar between the Auckland Is., Snares, and ECSI fisheries, except that vessels on the ECSI tend to be smaller and tow smaller midwater gear at a lower speed (Figure C14).

8 FISHERY DEPENDENT OBSERVATIONS – CPUE ANALYSES

The objectives of this project required estimation of standardised CPUE for the Snares fishery, for potential in-season management approaches, and the Auckland Is. fishery, because there is a strong likelihood squid migrate between the two areas (see Sections 3.1, 6.2). The Snares and Auckland Is. trawl fisheries are the largest arrow squid fisheries; there is minimal jig catch. Most of the catch is target fished from January–May and recorded on TCEPR forms (see Section 7). Therefore, the CPUE analysis was restricted to these data. Using tow-by-tow data allows for the trend in catch rates to be modelled using high resolution spatial and temporal scales, and also enables additional factors influencing CPUE to be included (such as start time, tow distance or depth).

CPUE analyses were conducted between seasons ('annual') for both areas, and within seasons ('in-season') for the Snares and the most recent year (2008) for the Auckland Is. and both areas combined (Table D1). The annual index has been developed here to describe how abundance has changed over time and to allow for the development of potential management approaches (both in-season management and pre-season forecast using environmental factors). However, as arrow squid live for only about one year, each season represents a new population, so in-season indices were also developed to potentially contribute to in-season management and post-season assessment approaches.

Estimates of relative week or year effects in each CPUE model were obtained from a stepwise multiple regression method in which the data were modelled using a lognormal generalised linear model following Dunn (2002). A forward stepwise multiple-regression fitting algorithm (Chambers & Hastie 1991) implemented in the R statistical programming language (R Development Core Team 2003) was used to fit all models. The algorithm generates a final regression model iteratively and used the *week* or *fishing year* term as the initial or base model in all cases. The reduction in residual deviance relative to the null deviance, R^2, is calculated for each single term added to the base model. The term that results in the greatest reduction in residual deviance is added to the base model if this would result in an improvement in the residual deviance of more than 1%. The algorithm then repeats this process, updating the model, until no new terms can be added. A stopping rule of 1% change in residual deviance was used as this results in a relatively parsimonious model with moderate explanatory power. Alternative stopping rules or error structures were not investigated.

For the in-season analyses, *week* was forced into the model as the first term, and the algorithm added variables based on changes in residual deviance. Variables were either categorical or continuous, with model fits to continuous variables being made as third-order polynomials. Categorical variables offered to the model included *week*, *vessel key*, and *primary method*; and continuous variables included *fishing duration*, *fishing distance* (calculated from positions at start and end of tow), *distance 2* (calculated as *fishing duration* x *speed*), *start latitude*, *start longitude*, *start time*, *effort depth (*depth of net*)*, *effort width (*wing spread*)*, and *effort height* (headline height). Although additional variables were available, they were not offered as explanatory variables as they were correlated with variables that were offered (e.g. statistical area and latitude, or vessel key and vessel power). *Fortnight* instead of *week* was also investigated for one year (the Snares area in 1991) but not pursued further.

For the annual analyses, similar variables were used, except that *fishing year* was forced into the model as the first term, and for the Snares and Auckland Is. combined dataset the model was also offered a categorical variable *area* (Auckland Is. or Snares). *Week* or *year* indices were standardised to the mean and were presented in canonical form (after Francis 1999).

Vessel effects were incorporated into the CPUE standardisations to allow for possible differences in fishing power between vessels. Vessels with minimal participation were excluded from the analyses. . “Core” vessels were defined as those vessels that were involved in the fishery for at least four years, and reported about 90% of the catch (after Phillips 2001). Most of Snares Shelf and Auckland Islands catch was target squid data in the months of January to May, so only these data were used. Trawl types included bottom and midwater trawls; no twin trawls (as identified by Hurst 2009) were present in the core vessel datasets.

The dependent variable was the log-transformed estimated catch per tow. Only the positive catches were retained, with zeros excluded, based on preliminary analyses including zero tows for the Snares 1991 dataset. The effect of excluding zero tows was examined by fitting a logistic model to the number of zeros and combining that time series with the log-normal time series following the method of Vignaux (1994). The effect of zero tows was also examined using the Tweedie model (Candy 2003) where zero catches were included within a single model structure and modelled at the same time and with appropriate weight as the other observed values. Model fits were investigated using standard regression diagnostic plots. For each model, a plot of residuals against fitted values and a plot of residuals against quantiles of the standard normal distribution were produced to check for departures from the regression assumptions of homoscedasticity and normality of errors in log-space (i.e., log-normal errors).

8.1 Snares, in-season indices, 1990 – 2008

Records of the number of tows, proportion of zero tows, catch, non-zero effort and unstandardised CPUE, for each week of each season for all vessels and core vessels only, are shown in Table D2. Plots describing the CPUE analysis results, for each season, are shown in Figures D1–20). These include: scaled annual catch by core vessels (Figures D1a–20a); cumulative proportion of squid catch ranked by vessel, to identify those catching 90% of the total (Figures D1b–20b); unstandardised and standardised CPUE (Figures D1c–20c); predictor variables (Figures D1d–20d); diagnostics (Figures D1e–20e); and comparison of weekly catch and standardised CPUE (Figures D1f–20f). Variables retained in the models and null-deviance explained (R^2) are given in Table D3 and standardised indices with co-efficients of variation are given in Table D4.

In model runs, variables *vessel*, *distance2, start time,* and one of *latitude* or *longitude* were often the most influential variables in the lognormal individual year models, although *fishing duration* or *effort depth* were sometimes important (Table D5). These models explained 18–41% of the null deviance, and this was higher in most of the 2000s datasets.

Week was forced into every CPUE model first, and explained 7–28% of the null model deviance, although this variable often explained more of the null deviance from 1998–99 (Table D3). The variable *vessel* entered all regressions (Table D3, Figures D1d–20d), generally in the top four variables. From 1989–90 to 1997–98 *vessel* was the most important variable after *week*.

D*istance2* was often important, with longer trawls producing more arrow squid catch per tow than shorter trawls, with *fishing distance* never entering any model (Table D3, Figures D1d–20d). *Distance2* (*speed* x *fishing duration*) captured the actual distance travelled better than *fishing distance* (calculated from start and end positions), indicating that longer tows may include curved trawl paths to stay within target locations. *Fishing duration* was important in four models (1995–96, 1996–97, 2005–06 and 2007–08), however these models did not use the variable *distance2*, indicating that *fishing duration* and *distance2* are rough proxies for each other. *Start time* was important in some models (Table D3, Figures D1d–20d), particularly in the 1990s, with higher arrow squid catch per tow between about 10am and 1pm. *Start latitude* and *start longitude* were also important in some models, especially in the 2000s. *Effort depth, effort width* and *effort height* were of lower importance in a few of the models, and *primary method* was of no importance in any model.

Standardised and unstandardised CPUE trends within seasons were often similar but variable between seasons (Figures D1c–20c). In some years (2000–03, 2007), standardised CPUE was higher at the end of the season than unstandardised indices. In most years, the standardised CPUE trend was flatter than the catch trend (Figures D1f–20f), reducing peaks at the start or middle of the season (weeks 3–12) and increasing indices at the end. The standardised index tracked the geometric mean closely, with the largest residuals for low CPUE values, tending to predict higher values than observed when CPUE was low (Figure D1e–D20e).

For the Snares 1991 dataset, all model runs included the variables *week* or *fortnight*, *vessel*, *start time*, and *latitude* and/or *longitude* (Table D3, Figures D2,3). The inclusion of all target species made very little difference to indices in the lognormal model (Figure D3g). Using *fortnight* instead of *week* in the lognormal model showed similar results, except that each fortnightly index appeared to be an average of the two weekly indices in which the fortnight occurred. The inclusion of zero tows using the combined (Vignaux) or Tweedie models also made very little difference to the indices.

A summary of all years standardised in-season CPUE for the Snares fishery is shown in Figure 4. The overall seasonal pattern is highly variable, sometimes with an increase during the first half of the season, but some years (e.g., 2000, 2001) also show relatively high catch rates towards the end of the season.

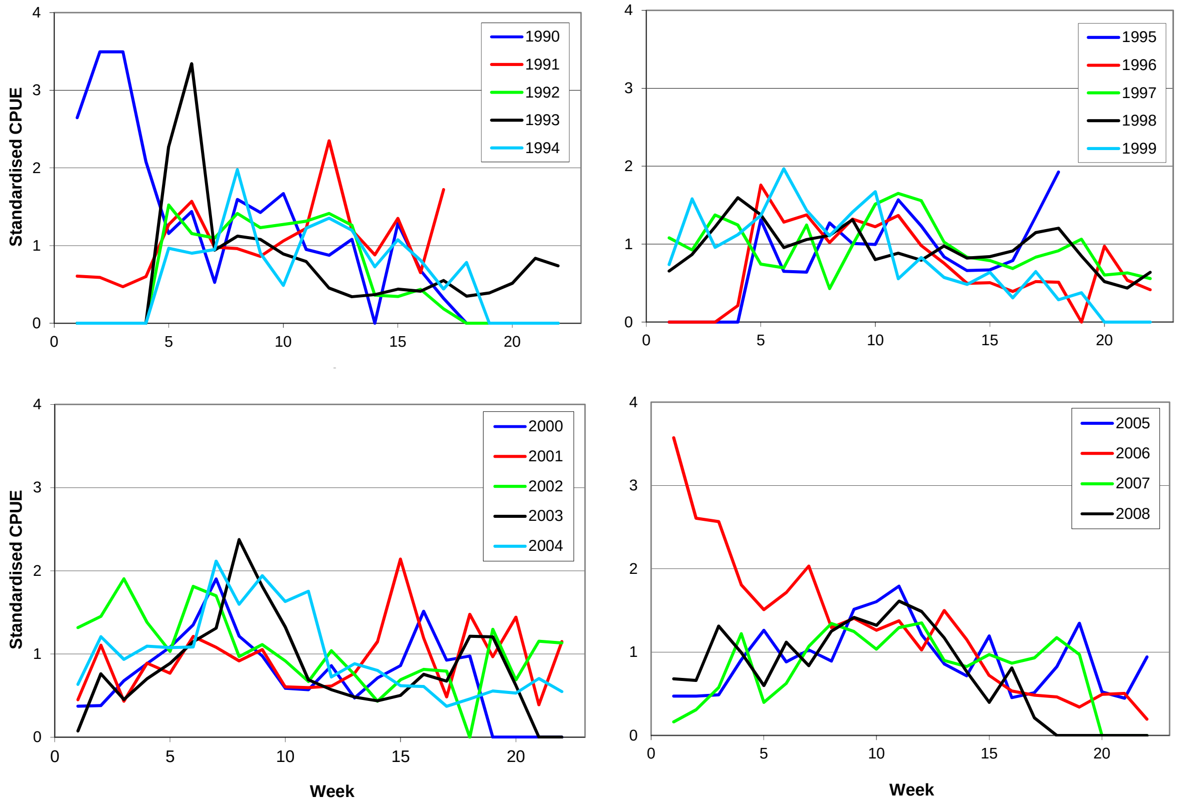

Figure 4: Summary of in-season CPUE indices from 1990–2008.

8.2 Auckland Islands 2008, in-season CPUE, 2008

A subset of vessels for each year was identified as a core set for each CPUE analysis to exclude vessels that contributed a minor amount of catch (and effort) to each time series (Table D2, Figure D21). The nominal arithmetic and geometric CPUE along with the standardised CPUE series for the lognormal model of individual years show a slightly decreasing trend in CPUE from week 8 to week 12, with an increase back up to the week 8 level, and then a decreasing trend again to week 17 (Figure D21c).

Week, fishing duration, start time, vessel, and *effort depth* (Table D3, Figure D21) entered the model and explained 32% of the null deviance. *Week* was forced into the CPUE model first, and explained 14% of the null model deviance. Expected arrow squid 2008 catch per tow tended to be higher for a fishing duration of 4–10 hours, between 100–300 m depth of net, and between 0500–1500 hrs. start time of fishing. Expected catch per tow decreased from about week 15. The standardised index tracked the geometric mean closely, with the largest residuals for low CPUE values, tending to predict higher values than observed when CPUE was low (Figure D21e). Standardised CPUE indices for each year generally flattened weekly variability seen in weekly catches but showed the same declining trend after week 15 (Figure D21f).

CPUE indices for 2008 were compared to those from the Snares fishery (Figure 5). Unstandardised and standardised indices tracked each other well within area. The main similarity in indices between the Auckland Is. and Snares fisheries was that they both peaked from week 8–13, then subsequently decreased to the season end at week 17. The main difference was that the Snares fishery started in week 1 whereas the Auckland Is. effort fishery started in week 8.

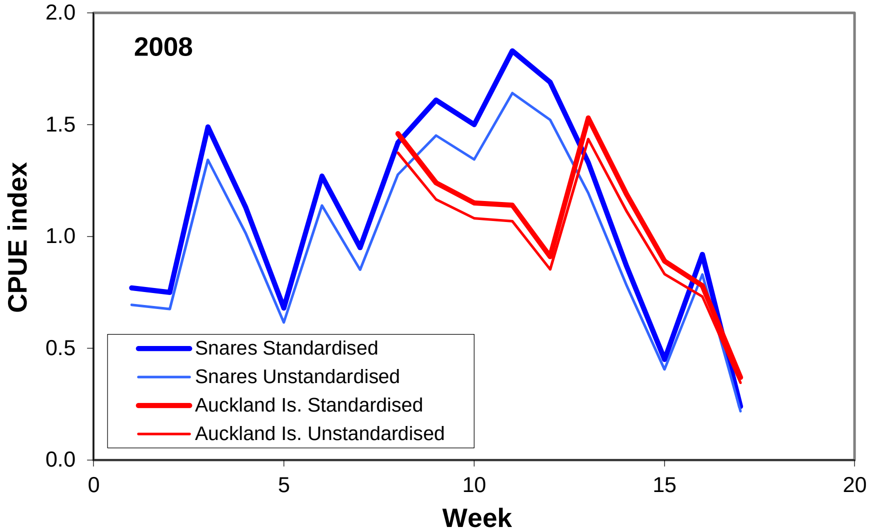

Figure 5: Standardised and unstandardised in-season CPUE indices for the Snares and Auckland Is. fisheries, 2008.

8.3 Snares Shelf and Auckland Islands, annual indices, 1990–2008

Records of the number of tows, proportion of zero tows, catch, non-zero effort and unstandardised CPUE, for each week of each season for all vessels and core vessels only, are shown in Table D2. Plots describing the CPUE analysis results are shown in Figures D22–24). Core vessels reporting 90% of the catch comprised about 40–50% of the vessels (Figures D22–24). The nominal arithmetic and geometric CPUE along with the standardised CPUE series for the lognormal model show a period of fluctuating but relatively flat CPUE from 1989–90 to 2002–03, with an increasing trend from 2003–04 (Figures D22b –24d).

In these model runs, variables *vessel*, *week*, *distance2, start time,* and one of *latitude* or *longitude* entered the models, and explained 20–26% of the null deviance (Table D3). *Fishing year* was forced into the CPUE model first, and explained 13–14% of the null model deviance.

For the Snares Shelf dataset, expected arrow squid catch rates were higher from *week* 4–12; and from 1500–1600 hrs. *start time*; were lower between the *latitudes* of 46° 30' and 47° 30'; showed an increasing trend from *year* 1999–00 to 2007–08; and with d*istance2* (Figure 22d). For the Auckland Islands dataset, expected arrow squid catch rates showed similar trends, although the *year* trend was more variable up to 1999–00 and *latitude* didn't enter the model (Figure 23d). For the combined Snares and Auckland Is. dataset, expected arrow squid catch rates showed similar trends to individual area models, except that *longitude* entered the model with higher expected catches for 165–167°E (Figures 24e). CPUE values overall fell in between values for the areas individually.

Standardised lognormal CPUE indices for each year generally tended to follow the trend of the standardised catches for that year (Figures D22–24f). Comparison of unstandardised and standardised annual CPUE indices (Figure 6) shows that trends are similar in the latter half of the series and that standardisation had most impact on the earlier half, up to 1998. This is when the core fleet structure appears to have changed considerably (Figures D22–24a,b).

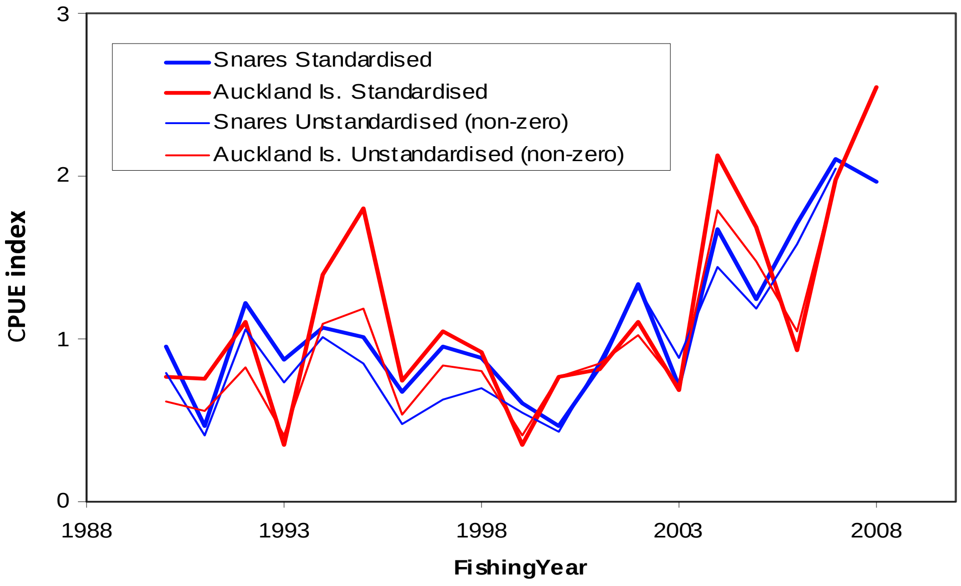

Figure 6: Standardised and unstandardised (arithmetic) in-season CPUE indices for the Snares and Auckland Is. fisheries, 1990–2008.

8.4 CPUE summary

In-season (weekly) standardised CPUE models developed for the Snares fishery for individual years 1990–2008 show considerable variability between years but a general trend of decreasing catch rates in the second half of the season (after about week 12). Key factors contributing to the model were *vessel*, *distance 2* or *duration*, *start time*, *latitude* and *depth*. Null deviance explained was 15–44%. *Week* was forced into the models and explained 7–28%.

An in-season (weekly) standardised CPUE model developed for the Auckland Is. fishery for 2008 shows relatively high CPUE from week 8 (season start) to week 15 and a declining trend for the last two weeks. Key factors contributing to the model were *vessel*, *duration*, *start time*, and *depth*. Null deviance explained was 32%. *Week* was forced into the model and explained 14%.

Annual standardised CPUE models developed for the Snares and Auckland Is. fisheries, independently and combined, for the years 1990–2008, show higher indices at the end of the series (2004, 2005, 2007 and 2008). Over all series, there appears to be a flattish trend up to about 2003 and an increasing trend subsequently, with all series showing a doubling in catch rate in the last five years. The Auckland Is. series shows the highest annual variability and one catch rate similar to the later years in 1995. Key factors contributing to the models were *week*, *vessel*, *distance 2*, *start time*, and *latitude* or *longitude*. Null deviance explained was 20–26%, lower on average than the in-season models. *Year* was forced into the models and explained 13–14% of the deviance.

9. PRINCIPLES FOR STOCK ASSESSMENT

Stock assessment and management of squid fisheries requires different approaches to most other fisheries because of their short life span. After one generation has spawned and died there is no information on which to base an assessment of potential recruitment strength and abundance of the next generation (Rodhouse 2001). For these reasons, Caddy (1983) recommended that the most appropriate way to manage squid stocks was by assessment and effort limitation in real time.

Early attempts to assess and manage squid stocks in New Zealand initially used an estimated biomass of 600 000 t for the NZ EEZ, calculated from the areal expansion method based on 1978–79 commercial catch data from both the jig and trawl fisheries variability (Mattlin & Colman 1988). It was recognised that this was not a satisfactory estimate of actual stock size, and that large biomass changes between years were possible. A conservative 15% was applied to generate an initial catch limit of 90 000 t, allocated as 30 000 t for the Auckland Is. trawl, 20 000 t for the remaining trawl areas, and about 40 000 t to jig (using a limit on the number of vessels and a catch per vessel estimate). Maximum Sustainable Yield (MSY) and Maximum Constant Yield (MCY) were also estimated but it was acknowledged that the concept of MSY is not realistic for squid as a new population is exploited each year with high inter-annual variability likely (Mattlin & Colman 1988). MSY was estimated to be 69 700 t for the mainland stocks (i.e., both species combined) and 41 800 t for the Auckland Is.; MCY was estimated at 32 400 t for the mainland stocks and 19 400 t for the Auckland Is.

Payne et al. (2005) reviewed various assessment methods that had been used for European squid stocks and elsewhere. In Europe these included depletion methods (Young et al. 2004), modified cohort analysis (Royer et al. 2002) and environmental predictors of recruitment (Robin & Denis 1999; Sims et al. 2001; Pierce & Boyle 2003; Zuur & Pierce 2004; Challier et al. 2005), and production models (FAO 1986). Outside Europe squid stocks assessed regularly include Falkland Island *Loligo gahi* and *Illex argentinus* (Agnew et al. 2005), South African *Loligo vulgaris reynaudi* (Roel & Butterworth 2000) and Japanese *Todarodes pacificus* (Suzuki 1990). The variety of methods used include: pre-season assessment based on fishing survey data; in-season assessment that uses data from the fishery as the season progresses to estimate the point at which fishing should cease, based on analysis of the influence of cumulative catch (Leslie & Davis 1939), or effort (DeLury 1947), on an abundance index such as CPUE (Royer et al. 2002), or refinements of these methods (Beddington et al. 1990; Rosenberg et al. 1990; Basson et al. 1996; Agnew et al. 2002, 2005); and post-season assessment using stock-recruitment relationships, surplus production models (FAO 1986), Virtual Population Analysis (Csirke 1987) and cohort analysis (Royer et al. 2002). Other developments in the assessment of squid fisheries have included better understanding the relationship between environmental conditions (e.g. sea surface temperature) and stock size (see Section 3.4) and the development of Bayesian assessments (McAllister et al. 2004).

One sub-objective of this project was to determine the feasibility of in-season review of TACC levels using size frequency distributions and catch rates from the commercial fishery. In this section we present results of analyses that address this approach, as well as two other possible management approaches for the Snares fishery: pre-season forecast using the relationship between annual CPUE and environmental conditions; and post-season assessment using weekly standardised CPUE and cohort depletion.

9.1 In-season review of TACC levels using size frequency distributions and catch rates

Fundamental to this approach is the need to use data that can be easily collected from the fishery at the start of the season and summarised in a timely manner for managers to make decisions that will still allow time for any additional quota to be taken. We have assumed that the main in-season adjustment that might be considered is an increase, but the technique does not necessarily need to apply just to increases.

9.1.1 In-season catch level review using catch rate information

This analysis addresses the question of how well early season unstandardised CPUE in the Snares squid target fishery predicts the total season catch and total season abundance (as measured by the annual standardised CPUE index described in Section 8.3).

The trends in the Snares fishery catch accumulating through each season, for individual years and for all years combined, are shown in Figure 7. "Early-season" is defined from this graph as the period when catches have reached about 10–50% of the total, on average, i.e., weeks 3–8. Note that the two decades of fishing are shown and that the most recent decade shows only a slight accelerating season increase (the Auckland Islands by comparison shown a more sharply increasing trend about 4–5 weeks later).

The weekly CPUE for all vessels targeting squid in the Snares area was calculated (from all squid target tows, Table D2). The unstandardised weekly CPUE, averaged across all years is shown in Figure 8. Note that it shows a similar trend to the standardised weekly CPUE, except for a slight divergence after week 14. The accumulated unstandardised CPUE for the early season, weeks 3–8, is also shown.

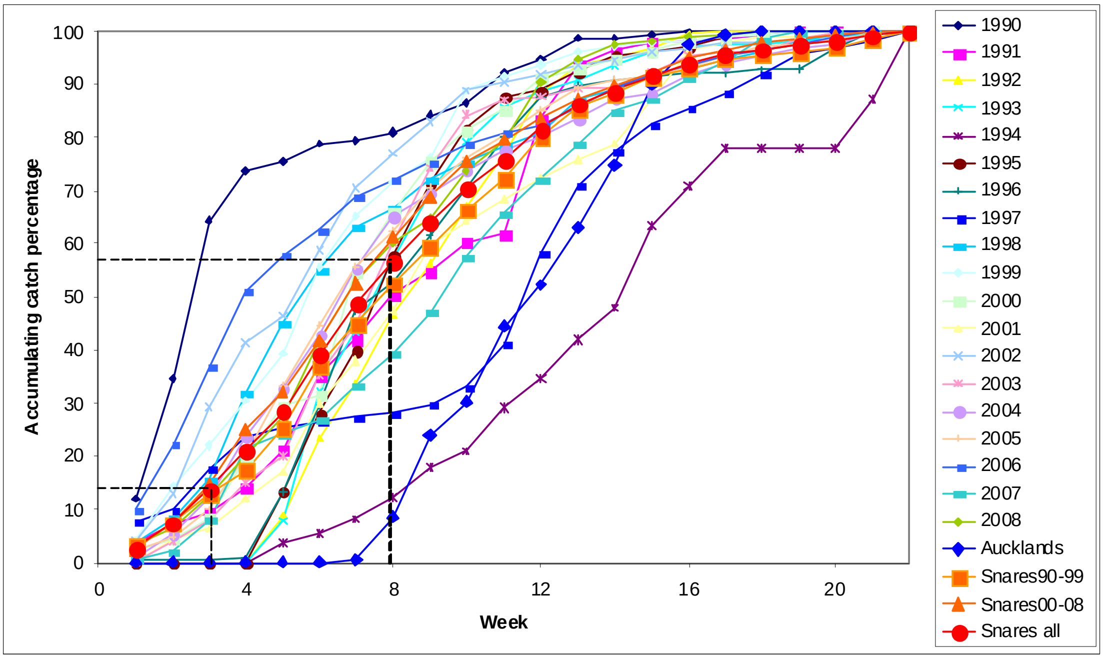

Figure 7: Trends in accumulative catch by week for each fishing season. Lines in bold show the average trends for the Snares (all years, 1990–1999, 2000–2008) and the Auckland Islands target bottom trawl fisheries. Dotted lines show the period defined as "early-season".

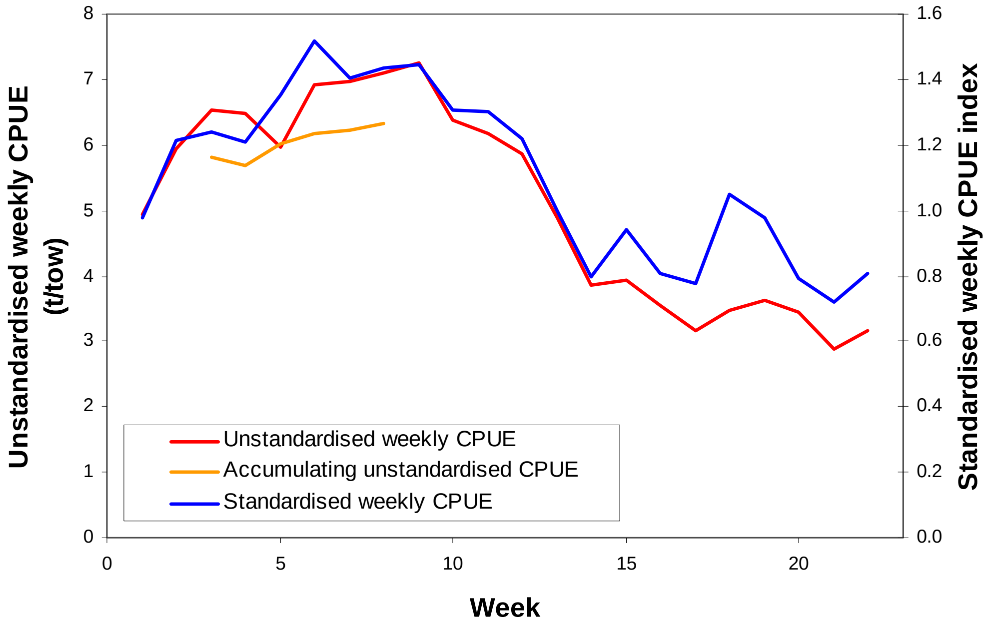

Figure 8: Average weekly CPUE (standardised and unstandardised, tonnes/tow) and accumulated unstandardised CPUE for weeks 3–8, for all vessels targeting squid in the Snares target bottom trawl fishery, 1989–90 to 2007–08.

Table 7: Accumulating unstandardised CPUE for all vessels targeting squid in the Snares target bottom trawl fishery, averaged by week for the period up to and including that week, 1989–90 to 2007–08. Correlation co-efficients are calculated for the early season unstandardised CPUE against the annual standardised (Std.) CPUE and target trawl catch.

Year	Year Std. CPUE	Catch (t)	Accumulating unstandardised CPUE by week (t/tow) 3	4	5	6	7	8
1990	0.96	7 142	6.84	6.21	5.92	5.37	4.79	4.46
1991	0.47	16 001	1.21	1.22	1.44	1.69	1.69	1.71
1992	1.22	26 970		3.93	6.38	6.55	6.56	6.81
1993	0.87	24 533			8.99	10.41	8.29	7.39
1994	1.07	13 532			4.68	4.98	5.28	5.98
1995	1.01	29 390			7.17	5.66	5.00	5.30
1996	0.67	18 812		1.75	2.81	2.66	2.64	2.52
1997	0.96	20 597	3.81	3.84	3.49	3.33	3.40	3.26
1998	0.89	21 509	3.44	4.14	4.34	4.37	4.31	4.25
1999	0.61	18 645	3.07	3.07	3.19	3.51	3.56	3.48
2000	0.47	4 779	1.20	1.48	1.70	2.09	2.59	2.78
2001	0.83	17 577	3.99	4.02	3.97	4.33	4.56	4.62
2002	1.34	26 571	11.77	11.07	10.30	10.60	10.55	10.08
2003	0.71	18 334	2.50	2.82	3.10	3.61	4.05	5.29
2004	1.67	41 702	5.83	6.94	7.52	7.88	9.07	9.54
2005	1.25	43 787	4.11	4.96	5.90	6.24	6.65	6.71
2006	1.71	43 930	16.58	15.37	14.19	13.58	13.40	12.56
2007	2.11	40 343	5.97	9.05	8.33	8.92	10.10	11.35
2008	1.96	33 093	11.00	11.26	10.95	11.62	11.64	12.24
Correlation v. annual CPUE			**0.70**	**0.83**	**0.80**	**0.80**	**0.88**	**0.92**
Correlation v. catch			**0.54**	**0.65**	**0.70**	**0.69**	**0.75**	**0.76**

The accumulated weekly unstandardised CPUE for weeks 3–8 was then correlated against the annual standardised CPUE and catch (Table 7, Figure 9) to see how well it might behave as a predictor. It was strongly positively correlated with annual standardised CPUE, with correlation co-efficients of at least 0.80 from week 4, up to 0.92 for week 8 (r^2 = 0.67 up to 0.85). Early season CPUE was less well correlated with annual catch, although correlation co-efficients reached at least 0.65 from week 4, up to 0.76 for week 8.

Characterisation and CPUE analysis of the Snares fishery (Sections 7, 8) suggested some changes in the fishing fleet between the 1990s and 2000s. This possibility was further examined here by performing the same analyses as above but split into the two time periods (1990–1999 and 2000–2008). Resulting trends in weekly CPUE (weeks 3–8) show relatively low and flat indices during the 1990s and more variability in trend and range of CPUE during the 2000s (Figure E1). Correlations for the later period are similar to the trend for the all years combined analysis above (Figures E2,3, Table E1). Correlations for the earlier period are lower and the trend is more variable, which is to be expected as the abundance indices are mostly average or low.

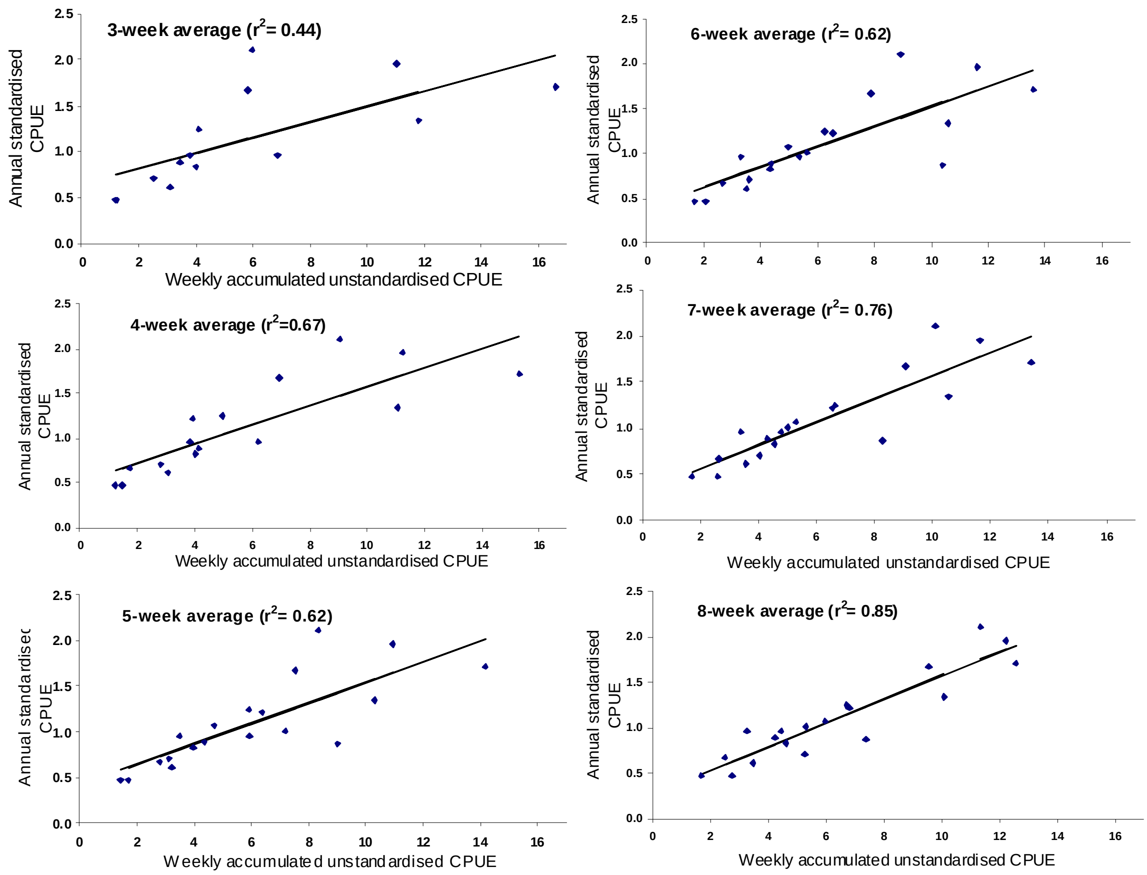

Figure 9: Correlations of weekly accumulated unstandardised CPUE and annual standardised CPUE indices for the Snares target bottom trawl fishery, 1989–90 to 2007–08.

9.1.2 In-season catch level review using size frequency information

There are two analyses presented here. The first examines the early season mean size data in the Snares squid target fishery as a potential predictor of total season abundance (as measured by the annual standardised CPUE index described in Section 8.3). The second uses numbers per tow as an indicator of early season abundance, in a similar manner to the analysis for catch per tow described above.

The mean size of squid was plotted by month for each season for which data were available from 1990 (Figure E4). “High”, “medium” and “low” abundance seasons were defined from the annual standardised CPUE series as greater than 1.2 (red), 0.8–1.2 (green) and less than 0.8 (blue), respectively. This suggested that, by February, there was likely to be considerable overlap in size frequencies. Therefore, size in January would be most useful but there was only one season (2008) with high abundance that was sampled by observers. However, the presence of a low abundance season (1996) with the highest average size suggests there is nothing in the early season size of squid that will predict a high or low abundance year. Actual size frequencies for January seasons are shown in Figure E5.

The second potential use of early season size frequency data is to develop early season unstandardised abundance indices using numbers per tow rather than tonnes per tow (as in Section 9.1.1). The method used is identical to that used for the tonnes per tow analysis, except that monthly size frequency data (scaled to monthly catch) were used for all years from 1990 where they were available.

The accumulated monthly CPUE (in numbers per tow) for months January to May, for each season sampled from 1990–2008 and correlations with annual unstandardised CPUE (in numbers per tow) are shown in Figure E6. January CPUE was weakly correlated with annual CPUE, but February and March had co-efficients of at least 0.95. Removal of the one strong abundance year (2008) reduces the strength of the correlations, but they are still at least 0.84 for February and March (Table E2). CPUE in numbers per tow showed a similar trend to CPUE in tonnes per tow (Figure E6).

9.1.3 In-season catch level review: Summary and Conclusions

In general, the weekly accumulated CPUE (in tonnes per tow) and the monthly accumulated CPUE (in numbers per tow) show potential to predict season abundance by at least the end of February. The utility of mean size during January was not able to be assessed due to the lack of length frequency data for the high abundance years from 2001–2007. In fact, all of the analyses using size frequency data would have been improved by sampling during this period and would have allowed for more confidence in them for a predictive management approach.

To effectively develop a management approach using early season CPUE (whether in tonnes or numbers per tow) to predict season abundance and allow for in-season catch increases requires:
1. Choice of the appropriate time to make an in-season adjustment
2. The ability to determine how much increase is appropriate (in relation to a defined level of minimal escapement)
3. Estimation of the probability of catching the increased TACC subsequent to the increase.

While this analysis has suggested some options for timing (e.g., the end of February), it provides no information on the last two requirements, except to suggest that obtaining the benefit from any increase after about week 12 (end of March) may be problematic. This is also likely to be further complicated by the potential movement of squid to the Auckland Is. area later in the season. This scenario is poorly understood as there are data for only one of the high abundance years (2008), which suggests some continuation of larger squid in the Snares fishery later in the season than in other years. All of these issues need to be properly assessed using a modelling approach, incorporating seasonal cohort depletion, natural mortality, catchability, and stock interactions with Auckland Islands. Robust decision making strategies can then be developed using a Management Procedure Evaluation (MPE) approach.

9.2 Pre-season forecast using the relationship between annual CPUE and environmental conditions

Nototodarus species are short-lived, living for up to a year before spawning and dying, and fluctuations in abundance are therefore likely to be driven by environmental conditions that affect survival, food supply, and growth. Globally, other studies have shown that abundance, distribution, growth, and movements are correlated with a range of environmental factors both prior to and during the fishing season (see Section 3.4). Key environmental correlates used in these studies include sea surface temperature (SST), winds, upwelling, onshore Ekman transport, frontal zones, chlorophyll (Chl) productivity (or ocean colour). Of these, SST, Chl, and wind and pressure indices were investigated in this project.

The analysis presented here was preliminary in nature in that it was examining possible linear relationships between potential pre-season environmental predictors and standardised indices of abundance (CPUE in tonnes/tow). Other types of relationships, finer scale environmental data and other abundance indices (e.g., numbers of squid) were not explored (although the latter is unlikely to be an issue as the CPUE in numbers per tow showed similar trends to catch). Correlations of environmental indices with in-season abundance indices were also calculated and the potential use of these for in-season management and incorporation into CPUE indices is considered in the discussion and recommendations.

9.2.1 CPUE indices and environmental data

Squid captured in Snares/Auckland Is. *N. sloanii* summer-autumn fisheries are predominantly the winter/early spring (May–September) spawned cohorts (Uozumi 1998). For this analysis the annual standardised indices (1990–2008) generated in this report (Section 8) were used, but we also developed a more extended times series of unstandardised CPUE indices (1982–2008) by incorporating data from Gibson (1995) and Langley (2001) that covered 1982–2000. These earlier indices were for target squid but included zero tows so similar indices from 1990–2008 were developed here to be consistent (from data in Table D2). There was a close match between indices given by Langley (2001) and those developed here for the overlapping period (1990–2000) and the series were normalised and combined by averaging across the overlapping period (Figure E7).

Environmental data were available over different temporal and spatial scales. Indices already available from previous studies (Dunn et al. 2009b; Hurst et al. 2012b) were used, but we extracted up-to-date indices for SST for the southern South Island and Auckland Is. areas from the National Center for Atmospheric Research (NCAR) database (Figures E8, 9). Details of the environmental data available and the period that the data cover are shown in Table E3.

9.2.2 Correlation analysis results

Most of the environmental indices examined in these preliminary analyses were not strongly correlated with squid fishery CPUE indices to be used as pre-season predictors of squid abundance (Tables E4–7). Only those correlations over 0.6 (highlighted in the tables) are described below. Given the number of correlations carried out, these results need to be treated with caution.

Note that the only annual series to show a correlation over 0.6 was the IPO with both pre- and in-season Snares unstandardised CPUE. As the IPO has not gone through a complete cycle during the span of the CPUE series, and shows an overall steady decline since 1985, any series that shows an overall increasing or decreasing trend is likely to be correlated with it and so this result is possibly spurious. This does not discount the possibility of a relationship over the longer term.

Pre-season analyses

Trenberth sea level pressure (Z2, November, westerlies over southern NZ) and Auckland Is. standardised CPUE showed a positive correlation (r = 0.61). Although there is reasonable correlation at either end of the series, there is a major diversion in the middle (Figure E10). It is also not clear why indices in this month might be more highly correlated than other pre-season months. The potential of this index as a pre-season predictor is unclear unless it can be associated with indices of upwelling or productivity.

Five of the six correlations of Chl indices from Puysegur (46°S 165°E) with Snares and Auckland Is CPUE were over 0.6 (range 0.44–0.68). There is evidence of Chl and CPUE indices tracking increases and declines in some years (Figure E11). However, the Chl time series is short (11 years) and there is a general overall increasing trend in both the Chl and CPUE indices that to some extent drives the correlation. A much longer time series is required. It is also not clear that indices generated for Puysegur will show the same level of spatial correlation as found for subareas of SST (Figure E11). Development of Chl by similar, or even smaller, subareas is highly desirable.

In-season analyses

Trenberth sea level pressure (M3, January, southerlies over western NZ) and Auckland Is. standardised CPUE showed a negative correlation (r = 0.63) (Figure E11). As for the in-season Trenberth relationship, the lack of correlation in subsequent months is a problem and any development of this relationship as a potential early in-season predictor would need to consider causal hypotheses.

The three correlations of Chl indices from Puysegur (46°S 165°E) with Snares and Auckland Is CPUE were all over 0.6 (range 0.76–0.85). The strongest correlations were for the Auckland Is and Snares and Auckland indices combined ($r \geq 0.85$). However, as cautioned above, the Chl time series is short (11 years) and there is a general overall increasing trend in both the Chl and CPUE indices that to some extent drives the correlation.

9.2.3 Pre-season forecast using environmental data: Summary and Conclusions

Most of the environmental indices examined in these preliminary analyses were not sufficiently strongly correlated with squid fishery CPUE indices to be used as pre-season predictors of squid abundance. Only one Trenberth index and the two sets of seasonal chlorophyll indices showed potential, with correlations reaching over 0.6. However, the chlorophyll time series spans only 11 years and a much longer time series is required to ensure that any relationship established is robust. Any future analysis should aim to develop hypotheses about causal relationships, develop indices for appropriate subareas within the Snares and Auckland Is. region, investigate non-linear relationships, and use a more rigorous statistical approach that includes predictor screening within cross-validations (Francis 2006) and possibly investigation of time series models (Pierce & Boyle 2003).

Note that there was some indication that one Trenberth index and chlorophyll indices correlated with annual CPUE (chlorophyll correlations were 0.75–0.87), suggesting that it may be appropriate to include them in future CPUE models, both annual or in-season. Indices available over finer spatial scales, such as chlorophyll or SST may also be useful to explain squid distribution and movements through the fishing season.

9.3 Post-season assessment modelling

The potential application of assessment modelling that we are proposing here would determine if the proportion of the stock remaining at the end of the fishing season is above a threshhold minimum spawning stock biomass (SSB_{min}), for example, 40% (Beddington et al. 1990). It is not being proposed as an in-season management tool as used in other squid fisheries to limit fishing effort during the season (e.g., Falklands: Beddington et al. 1990, Agnew et al. 1998).

Royer et al. (2002) combined depletion modelling (extended Leslie-DeLury model), cohort analysis (Pope 1972) and the Thompson and Bell model (Sparre & Venema 1998) to carry out assessment of English Channel loliginid squid. Development of depletion and cohort models was beyond the scope of this study. What we present here are the requirements for developing such a model, based on Royer et al. (2002), and an examination of the feasibility of identifying cohorts moving through the Snares/Auckland Is. Fisheries

9.3.1 Requirement for development of a depletion model

Requirements for developing a depletion model are summarised in Table 8.

Uncertainty about stock structure would require at least two scenarios to be modelled: Snares only and Snares and Auckland Is. combined. These fisheries are currently predominantly trawl fisheries but the jig fishery would need to be incorporated into the model if it started to increase in relative importance. Areas outside of the Snares fishery (e.g., Puysegur) may also need to be included if they increased.

The requirements of data and indices can be met from existing data and analyses. Most depletion models make assumptions about natural mortality, catchability and emigration/immigration and this would need to be done here.

Table 8: Status of data requirements to carry out depletion modelling for southern squid stocks (after Royer et al. 2002).

Requirement	Status
Stock definition	Several scenarios: Snares, Snares + Auckland Is
Abundance decline	Standardised CPUE indicates a major drop off in abundance from about week 12, on average
Total catch	Numbers-at-length available 1990–2000, 2008–09
Biological sampling	Continue length sampling, need individual weights (2008 only)
Age and growth	Initially could use assumption of similar growth between cohorts (potentially collect statoliths?)
In-season abundance index	Standardised (t/tow) 1990–2008; Unstandardised (no./tow) 1990–2000, 2008 (uses 2008 L-W relationship for other years)
Recruitment index	Estimate or use cohort analysis within model
Natural mortality (M) (weekly/monthly)	Need assumption (e.g. monthly: 0.05-0.25)
Catchability	Need assumption (e.g. constant, different north of 48°S?)?
Emigration/immigration	Need assumption (e.g. closed system)

9.3.2 Preliminary cohort identification

The aim of this analysis was not to provide a full cohort analysis (such as described by Royer et al. 2002), but to determine the feasibility of identifying cohorts for Snares and Auckland Is. fisheries. Inspection of length frequency distributions developed for four seasons (1990, 1991, 1994, 2008) suggested the existence of usually three distinctive multiple cohorts within each season; a large-sized group at the start of the season, a mid-sized group that formed the main cohort and a small-sized group at the end of the fishing season (see Section 6). We chose to analyse the 2008 season which was the most complex of the four.

The method developed to estimate the mean length and proportion of multiple cohorts within each week's data was as follows. Analysis of the length frequency data was done for one sex and one year at a time, so the description below omits year and sex indices. First, the catch length frequency for each week was normalised to give proportion-at-length, $p_{t,l}$:

$$p_{t,l} = \frac{N_{t,l}}{\sum_{l=lmin}^{l=lmax} N_{t,l}}$$

where $N_{t,l}$ is the number of squid at length l in week t, $lmin$ is the smallest and $lmax$ the largest length included in the sample. For each week, the analysis estimated the mean length of each assumed cohort, $\mu_{t,c}$, (where c indexes cohorts from 1 to as many as 4), the proportion of the cohort within the total catch sample, $P_{t,c}$, and the coefficient of variation (CV) of the distribution of lengths around the cohort mean. Values of $P_{t,c}$ were constrained to be between zero and unity. The standard deviation of the length distribution about its mean for each cohort was determined as:

$$\sigma_{t,c} = CV \mu_{t,c}$$

If n is the number of cohorts, the first n-1 values of $P_{t,c}$ were estimated and the value of $P_{t,n}$ was determined by subtraction. For each cohort in each week, the predicted length frequency $\hat{p}_{t,c,l}$ was the normal density function associated with each length, $\mu_{t,c}$ and $\sigma_{t,c}$, modified by the proportion $P_{t,c}$:

$$\hat{p}_{t,c,l} = f\left(l_{t,c}, \mu_{t,c}, \sigma_{t,c}\right) = P_{t,c} \frac{1}{\sqrt{2\pi}\sigma_{t,c}} \exp- \left(\frac{\left(l_{t,c} - \mu_{t,c}\right)^2}{2\left(\sigma_{t,c}\right)^2} \right)$$

(It would more technically correct to use the integral of the probability function between the lower and upper bounds of the length frequency bin, but the method described is adequate for the proof of concept work described here).

In any week, fewer cohorts than n could be estimated by setting the appropriate $P_{t,c}$ to zero. The predicted number at length in the whole weekly sample, $\hat{p}_{t,l}$ was then determined as the sum of the proportions in each cohort at that length, after renormalisation:

$$\hat{p}_{t,l} = \frac{\sum_{c=1}^{c=n} \hat{p}_{t,c,l}}{\sum_{l=lmin}^{l=lmax} \sum_{c=1}^{c=n} \hat{p}_{t,c,l}}$$

For each week, the parameters $\mu_{t,c}$, CV and $P_{t,c}$ (i.e. 2n parameters) were estimated by minimising the multinomial likelihood function:

$$-LL_t = \sum_{l=lmin}^{l=lmax} w_t \left(p_{t,c,l} + 0.01 \right) \left[\ln\left(p_{t,c,l} + 0.01 \right) - \ln\left(\hat{p}_{t,c}, l + 0.01 \right) \right]$$

where w_t is the weighted sample size. In the work reported here, this was set to 300, arbitrarily, and thus it did not affect the estimates. If the estimation were done simultaneously for all weeks, then w_t could be used to weight the samples from the various weeks differentially.

Minimisation required finding reasonable values for the parameters. In each year, one week was chosen, and initial values were chosen manually based on plots of resulting normal distributions compared with the observed pattern. After minimisation for this week, the estimated parameters could be used as initial values for the next week. After minimisation, the estimates for that week could be used as the initial values for the following week, and so on, and this procedure could also be used for weeks preceding the first minimised week. Minimisation was performed with the Excel™ Solver.

Initial attempts to fit the cohort model identified all micro-cohorts present in the 2008 fishery. The modal peaks of these micro-cohorts were about 3 cm apart and probably represented squid spawned approximately one month apart. The 2008 fishery had more of these micro-cohorts than earlier years examined and they were difficult to follow. Combining the data for the Snares and Auckland Is. enabled three main cohorts to be more easily identified that were 5 and 7 cm apart, possibly up to two months in age (Figure 10). The estimated growth of these cohorts of 3–5 cm per month (Figure 11) is consistent with growth rates determined by Uozumi (1998). The estimated proportion of the oldest cohort declined rapidly at the start of the fishery to low levels (less than 30%) but was present throughout the fishery. The second cohort dominated the fishery from week 5 and comprised over 50% at the end of the season, whereas the youngest cohort appeared mid-season and remained at 30% of the total to the end of the season.

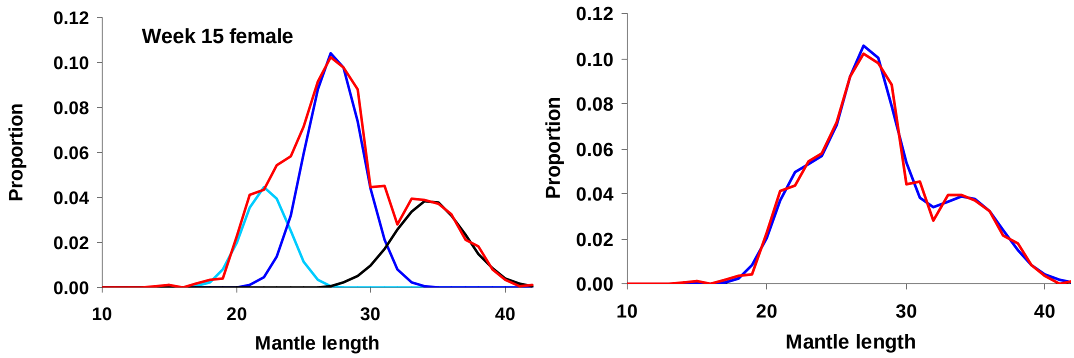

Figure 10: Example of fitting the cohort model based on three main cohorts (oldest in black to youngest in light blue) present in week 15, 2008 (Snares and Auckland Is. combined). Standard deviations of the length modes are 2.65, 2.10 and 1.17 cm (oldest to youngest).

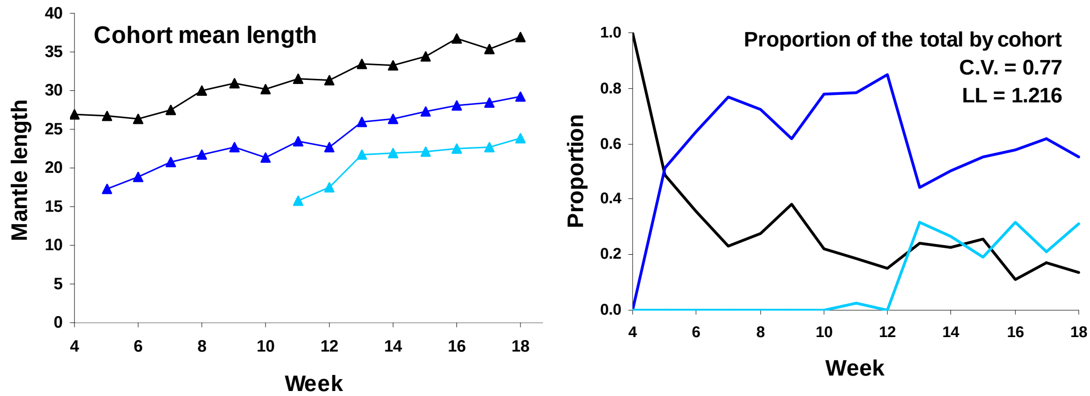

Figure 11: Estimated cohort growth (left) and cohort proportion of the weekly total numbers (right) for the Snares and Auckland Is. cohort model, C.V., co-efficient of variation; LL, log-likelihood fit.

9.3.3 Post-season assessment depletion modelling: Summary and Conclusions

Based on a review of the literature and the feasibility of conducting cohort analyses that are likely to show depletion through the season, our assessment is that development of a depletion model is feasible. It is worthy of further investigation without further data collection, and essential if in-season management is considered. Even without a move to an in-season approach, post-season depletion modelling would allow for annual assessment of the impact the fishery is having on the stock, which is currently unknown.

Depletion modelling of the fishery in the future will require continued biological sampling of length, weight and maturity stage. These data will also be essential to further understand the relationship between the Snares fishery and fisheries at the Auckland Is. and off the east coast of the South Island (if biological sampling data can be collected from the latter). Modelling may also be improved by collection of statoliths and ageing to confirm age and growth, cohort interpretation and possible migration of Snares squid to the Auckland Islands, but this should be assessed after the initial model is developed.

10. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

10.1 Benthic impact (sea-bed disturbance)
10.2 Incidental catch (fish and invertebrates)
10.3 Incidental catch (seabirds and mammals)
10.4 Community and trophic structure
10.5 Spawning disruption
10.6 Habitats of special significance
10.7 Biodiversity

11. AQUACULTURE AND ENHANCEMENT

12. SUMMARY AND RECOMMENDATIONS

12.1 Biology

Stock structure of arrow squid remains uncertain. Movements of squid between the Snares and Auckland Is. fishery appear likely but the proportion of squid migrating in each season might be quite variable. It is important to continue to collect size frequency (length and weight) and maturity data from these two fisheries to enable this to be monitored and better determined. Sampling from the east coast South Island is also highly desirable to determine if northward migrations are occurring.

Arrow squid have been found to live to about one year, spawn and then die. Multiple cohorts are present throughout the year, although peak spawning appears to be the winter months and the main summer–autumn fishery is based on the winter cohort.

Arrow squid are an important part of the food chain, feeding on zooplankton, small finfish and other arrow squid. They are in turn fed on by a wide variety of demersal and pelagic feeding inshore and middle depth finfish and elasmobranchs, as well as marine mammals.

12.2 Status of the stocks and potential management approaches

No estimates of reference, current, or absolute biomass are available for any squid fishery or stock. Biomass indices from inshore trawl surveys of the ECSI and WCSI by *Kaharoa* and annual CPUE indices may provide indices of abundance for the current season but are not useful for predicting future seasons as arrow squid only live for one year. *Tangaroa* trawl surveys do not cover the appropriate depth range for arrow squid. Maximum Constant Yield (MCY) and Current Annual Yield (CAY) cannot be determined. The sustainability of current TACCs and recent catch levels for these fish stocks is therefore not known.

Standardised annual abundance indices (in tonnes per tow) have been developed for the Snares and Auckland Is. fisheries, from 1989–90 to 2007–08. These indices are similar to unstandardised CPUE indices (in both tonnes per tow and numbers per tow). They show a flat trajectory up to 2001–02 and an increasing trend up to the highest point in 2007–08. Continuation of these series would be useful to establish whether this increasing trend continues.

Standardised in-season abundance indices (in tonnes per tow per week) have been developed for the Snares fishery, from 1989–90 to 2007–08. These indices show a similar in-season trend to unstandardised CPUE indices. Between seasons, there is considerable variation in the decline of abundance within the season, but on average, catch rates generally decline substantially after week 11.

In-season management appears to be feasible using early season catch rate and size frequency information. However, the appropriate timing and amount of any catch increase are best determined through development of a depletion modelling approach and Management Procedure Evaluation.

Preliminary assessment of pre-season predictors using environmental variables suggested that chlorophyll indices, in particular, showed potential, although the time series was short (11 years). Chlorophyll indices may also be useful for early-season prediction and better understanding of squid movement between the Snares and Auckland Is. areas. Future development of these analyses requires development of hypotheses on causal relationships, more appropriate indices to be developed by subareas, investigation of non-linear relationships and more rigorous statistical testing of any potential predictors.

Post-season assessment using a depletion modelling approach has the potential to provide estimates of the impact of the fishery on squid stocks (exploitation rates and status of the stocks annually) and enable more robust decision making ability for any in-season catch adjustments.

12.3 Future data requirements

Continuation of observer data collection of *N. sloanii* (SQU1T and 6T) length, weight, and maturity data are essential for better determination of stock structure, in-season management approaches and post-season assessment. The level of 2008 coverage (13% of Snares, 21% of Auckland Is. tows) provided representative temporal and spatial coverage and is probably adequate, but this will be better evaluated through assessment modelling.

Collection of length, weight, and maturity data from the east coast South Island fishery is also highly desirable for a few years to better determine stock relationships with Snares squid. Collection of these data on inshore trawl surveys by *Kaharoa* would also be highly desirable, particularly off the east coast South Island during winter.

Statolith collection to enable cohort identification (SQU1T and 6T, for stock structure and Snares fishery management approaches) is not proposed at this stage but should be reviewed after an initial depletion model is developed.

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15. APPENDIX A. SURVEY AND BIOLOGICAL DATA

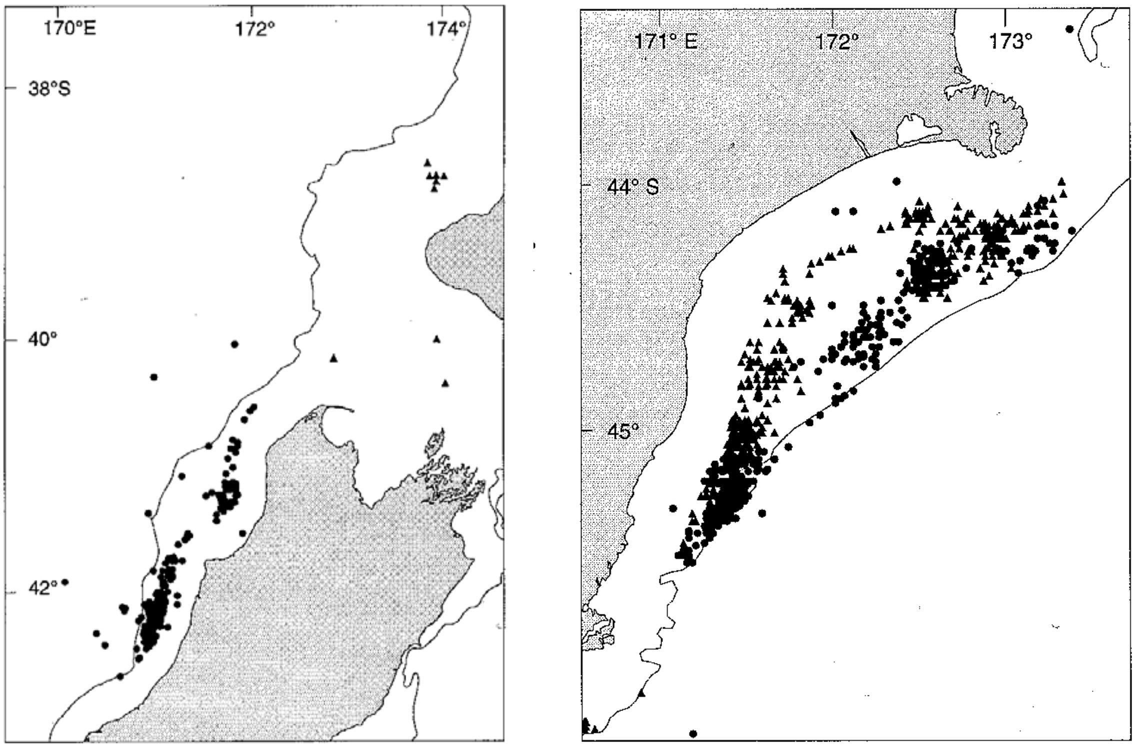


Figure A1: Distribution of large (more than 400 g, triangles) and small (less than 200 g, circles) *N. gouldi* (left) and *N. sloanii* (right) caught by jigging (from Gibson 1995, Figure 6).

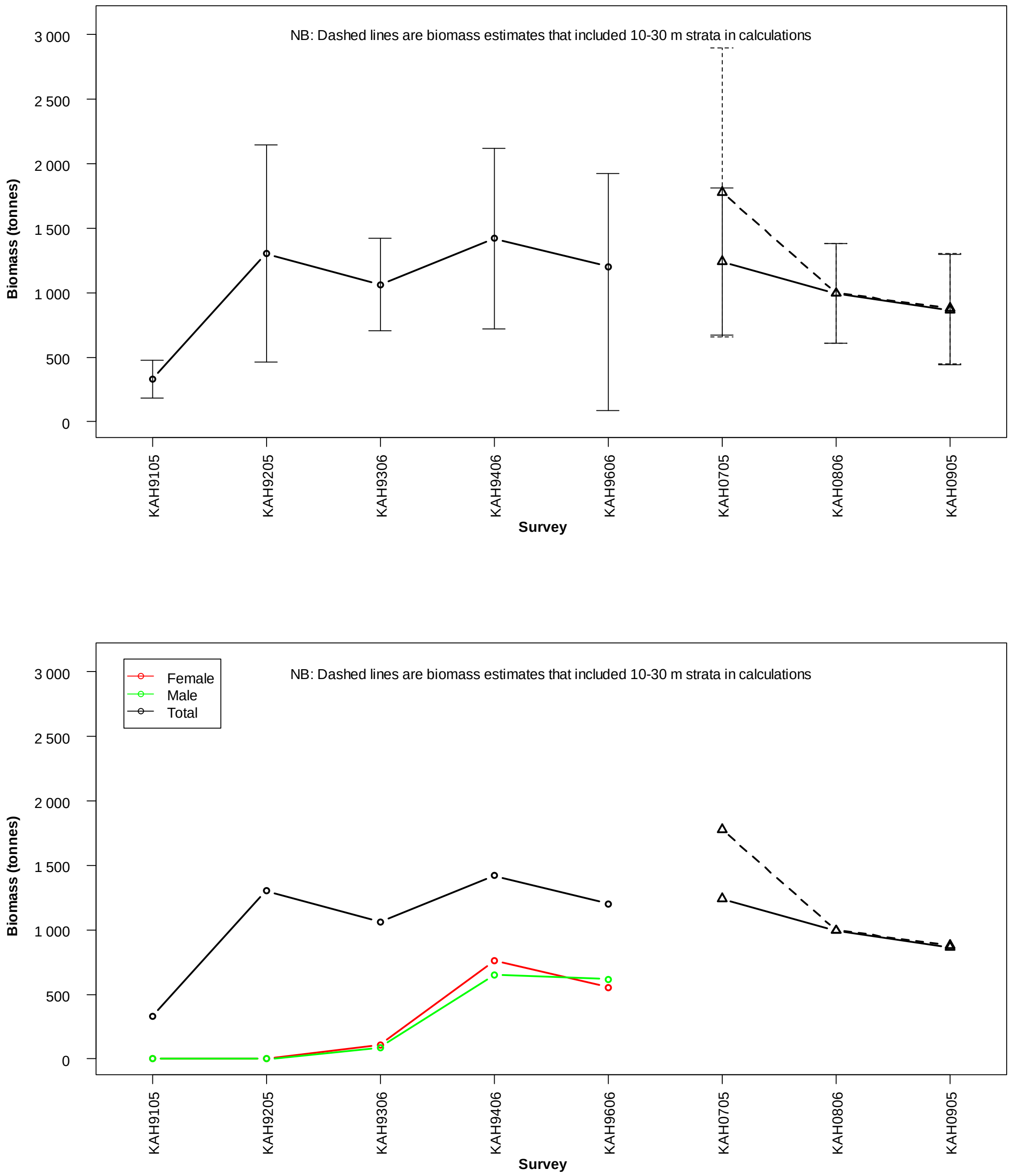


Figure A2a: Doorspread biomass estimates, for all arrow squid (above) and by sex (below), from the ECSI *Kaharoa* winter (May-June) surveys between 1991 and 2009 (note there were few fish measured in 1991 and 1992 and most fish measured in 1993 were unsexed).

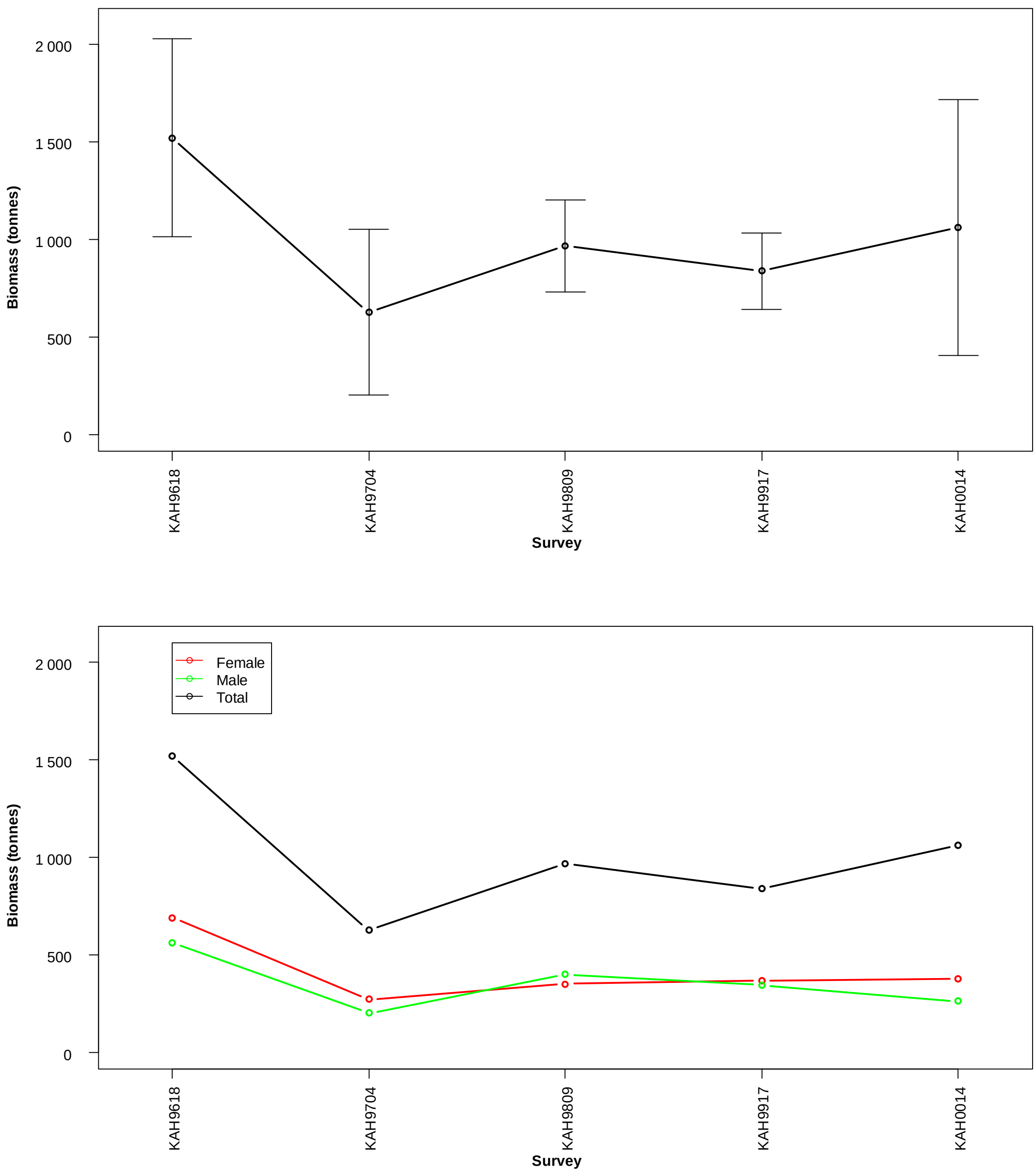


Figure A2b: Doorspread biomass estimates, for all arrow squid (above) and by sex (below), from ECSI *Kaharoa* summer (Dec-Jan) surveys between 1996 and 2001.

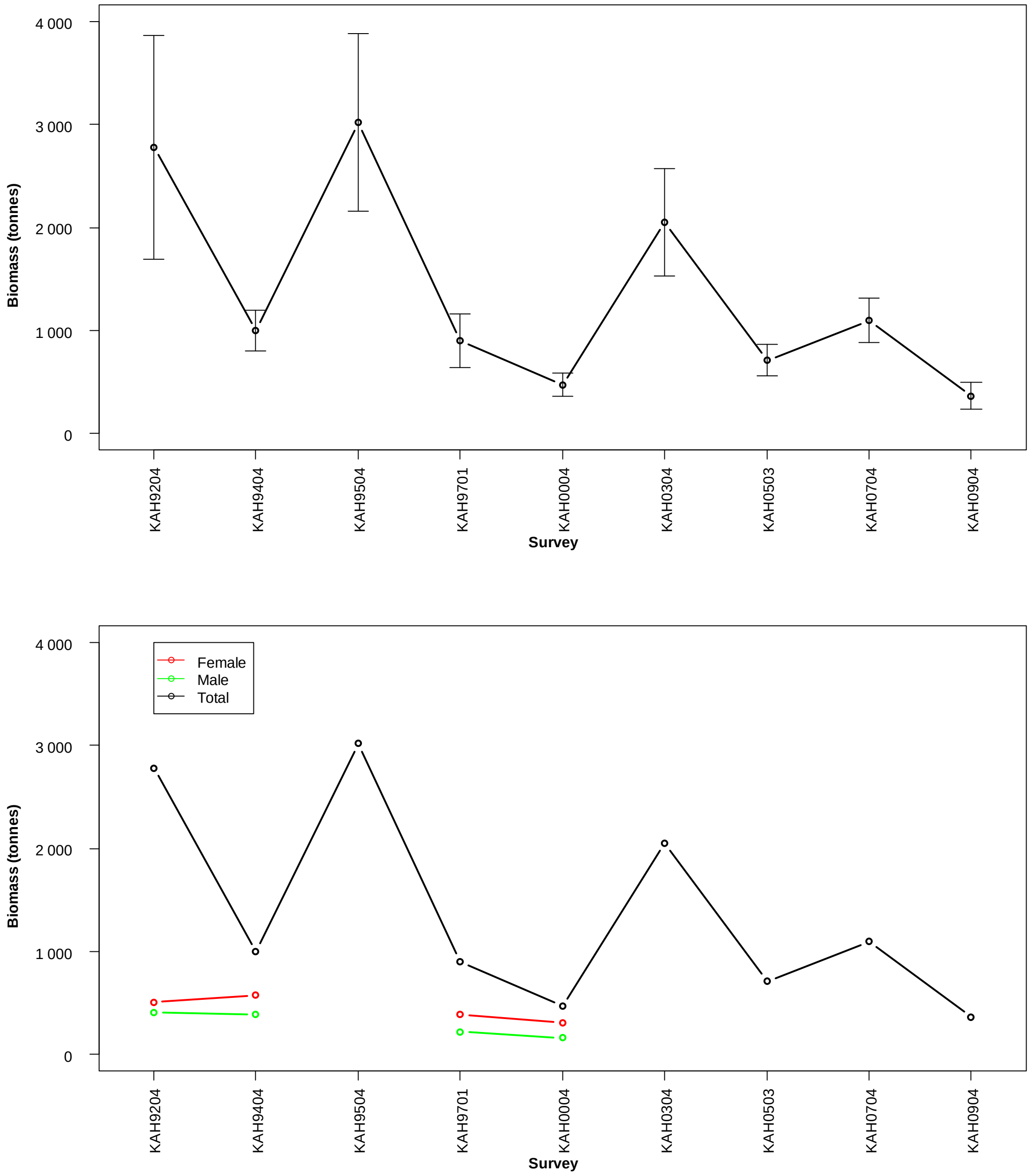
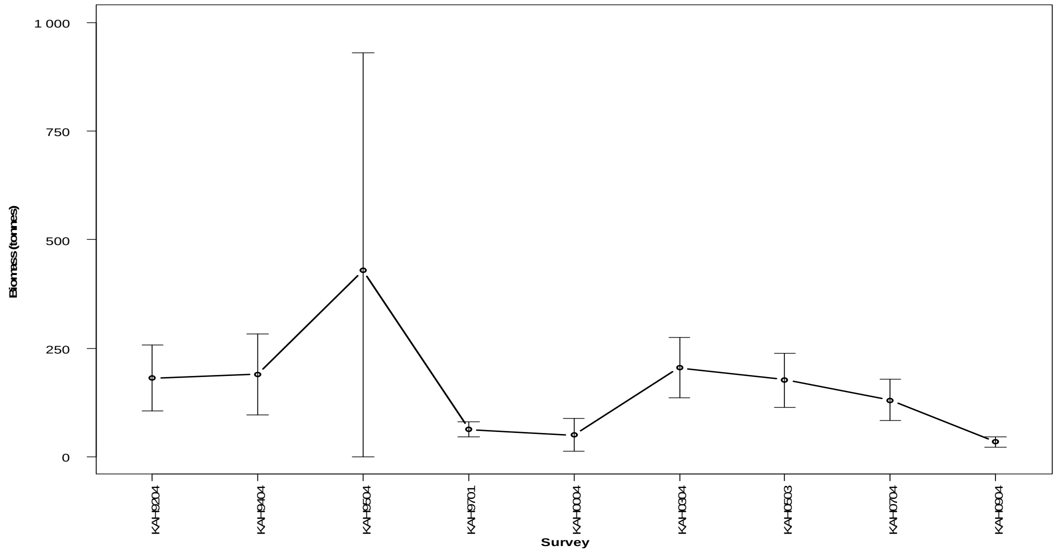


Figure A3a: Doorspread biomass estimates, for all arrow squid (above) and by sex (below), from WCSI (WCSI only) *Kaharoa* autumn surveys (Mar-Apr) between 1992 and 2009.



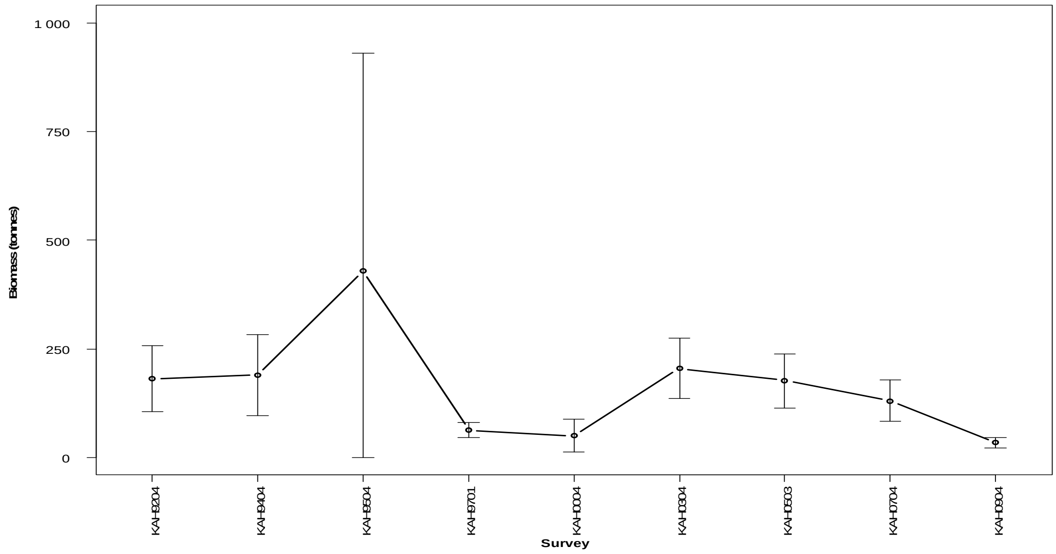


Figure A3b: Doorspread biomass estimates, for all arrow squid (above) and by sex (below), from WCSI (Tasman Bay Golden Bay) *Kaharoa* autumn surveys (Mar-Apr) between 1992 and 2009.

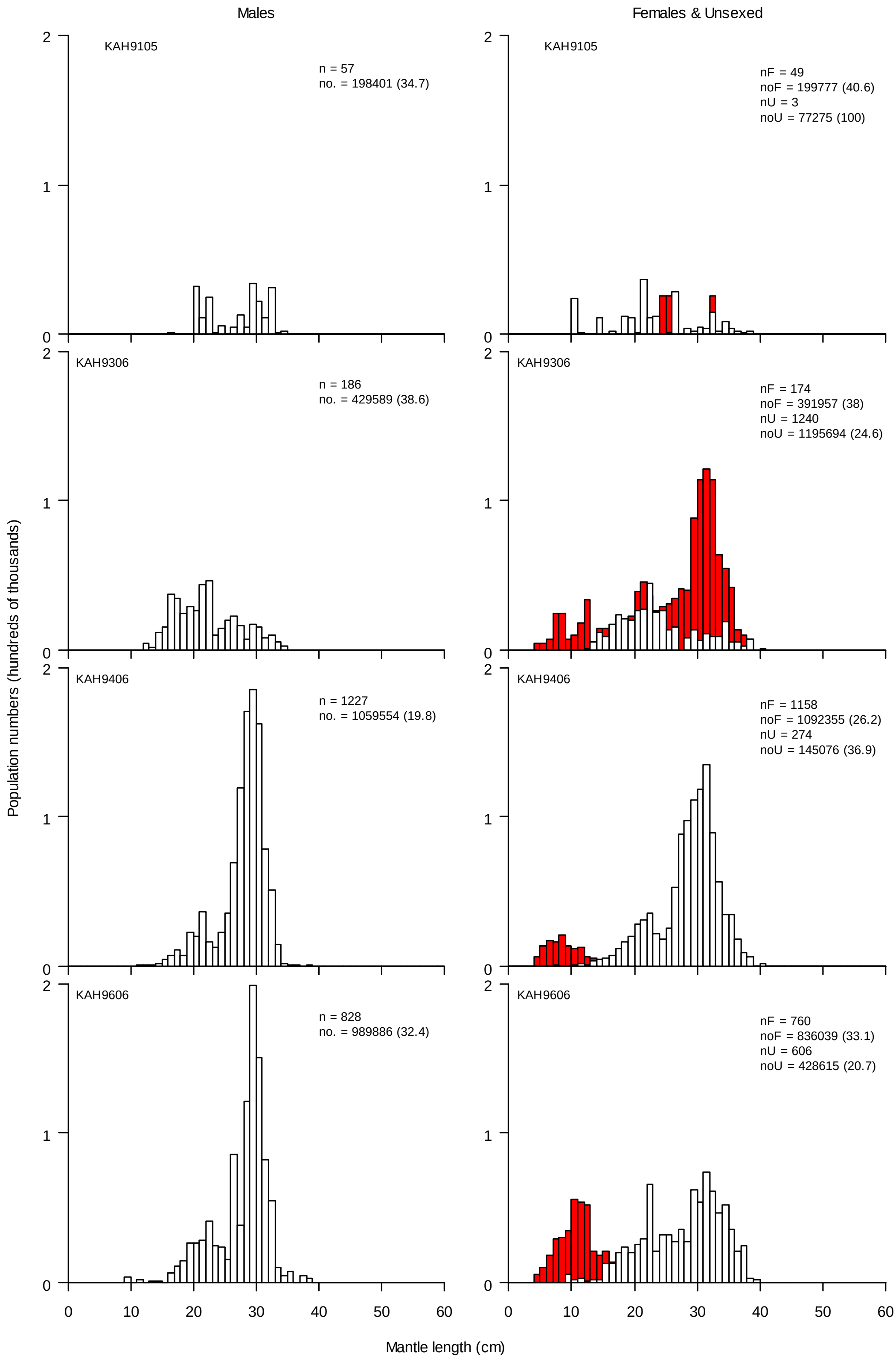


Figure A4a: Length frequencies of arrow squid from the ECSI *Kaharoa* (KAH) winter (May-June) surveys, 1991–1996. M, male; F, female; U, unsexed (shaded).

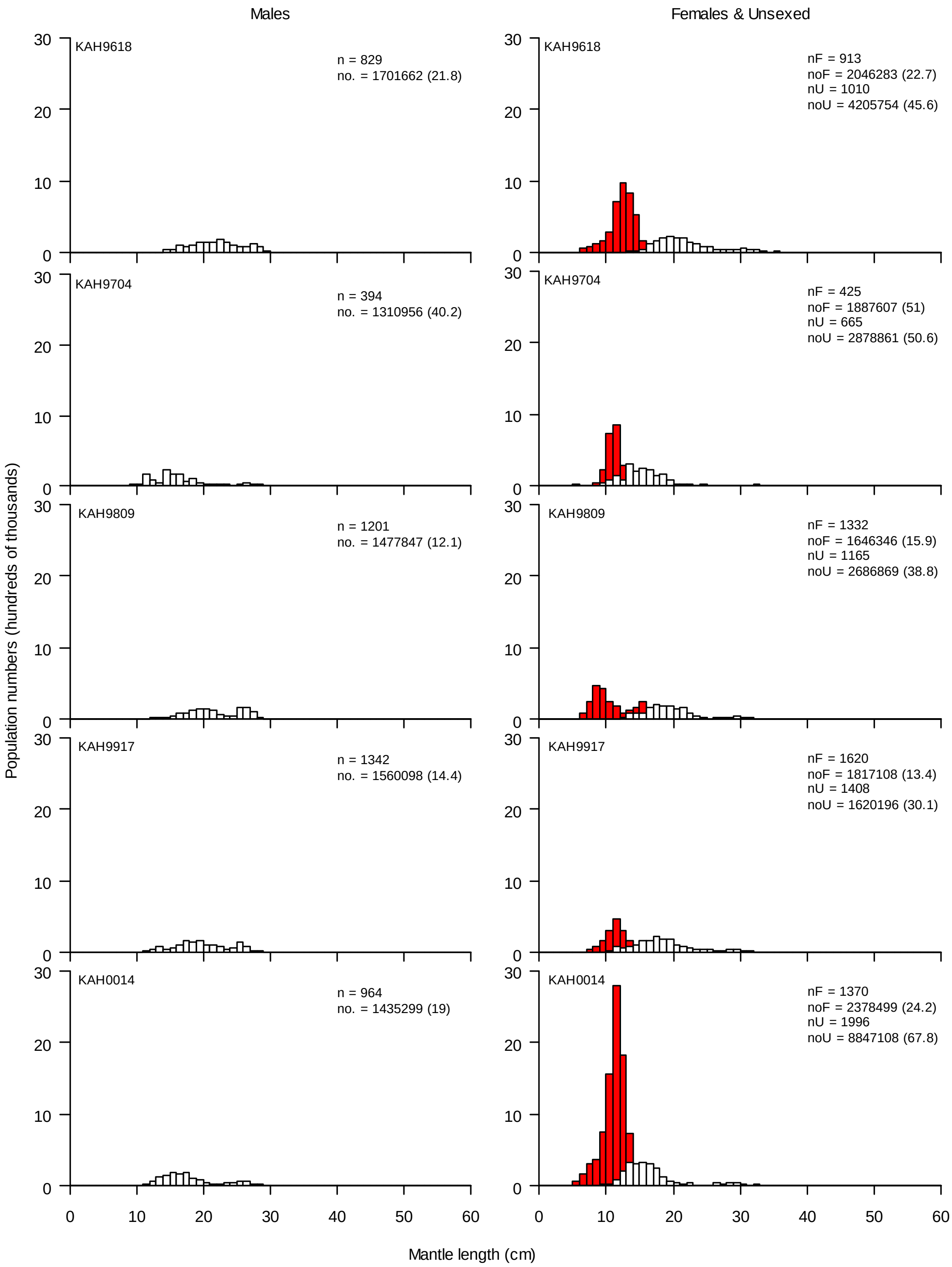


Figure A4b: Length frequencies of arrow squid from the ECSI, from *Kaharoa* (KAH) summer (Dec-Jan) surveys, 1996–2001. M, male; F, female; U, unsexed (shaded).

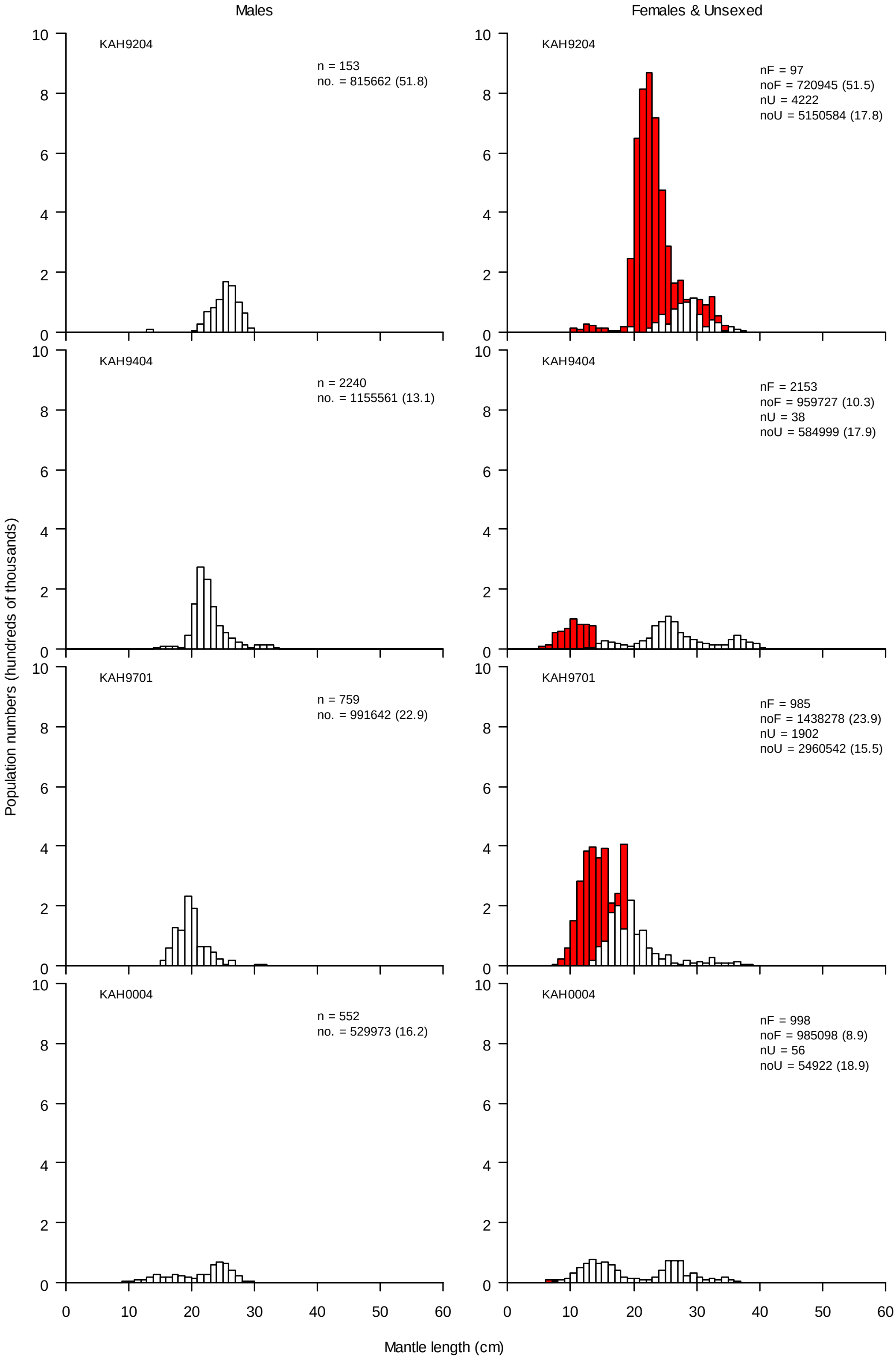


Figure A5a: Length frequencies of arrow squid from the WCSI (WCSI only) *Kaharoa* (KAH) autumn surveys (Mar-Apr), 1992–2000. M, male; F, female; U, unsexed (shaded).

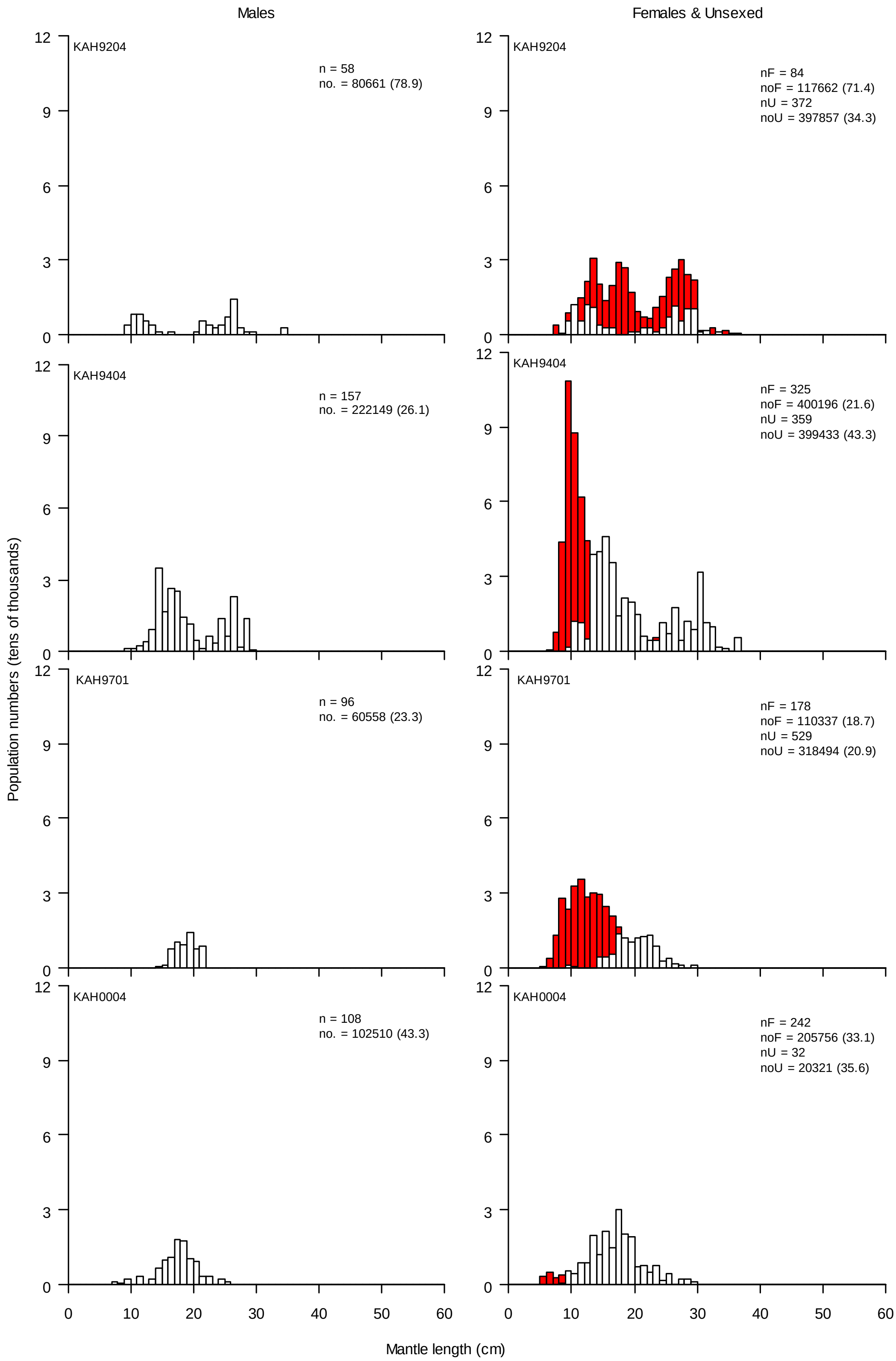


Figure A5b: Length frequencies of arrow squid from the WCSI (Tasman and Golden Bays) *Kaharoa* (KAH) surveys, 1992–2000. M, male; F, female; U, unsexed (shaded).

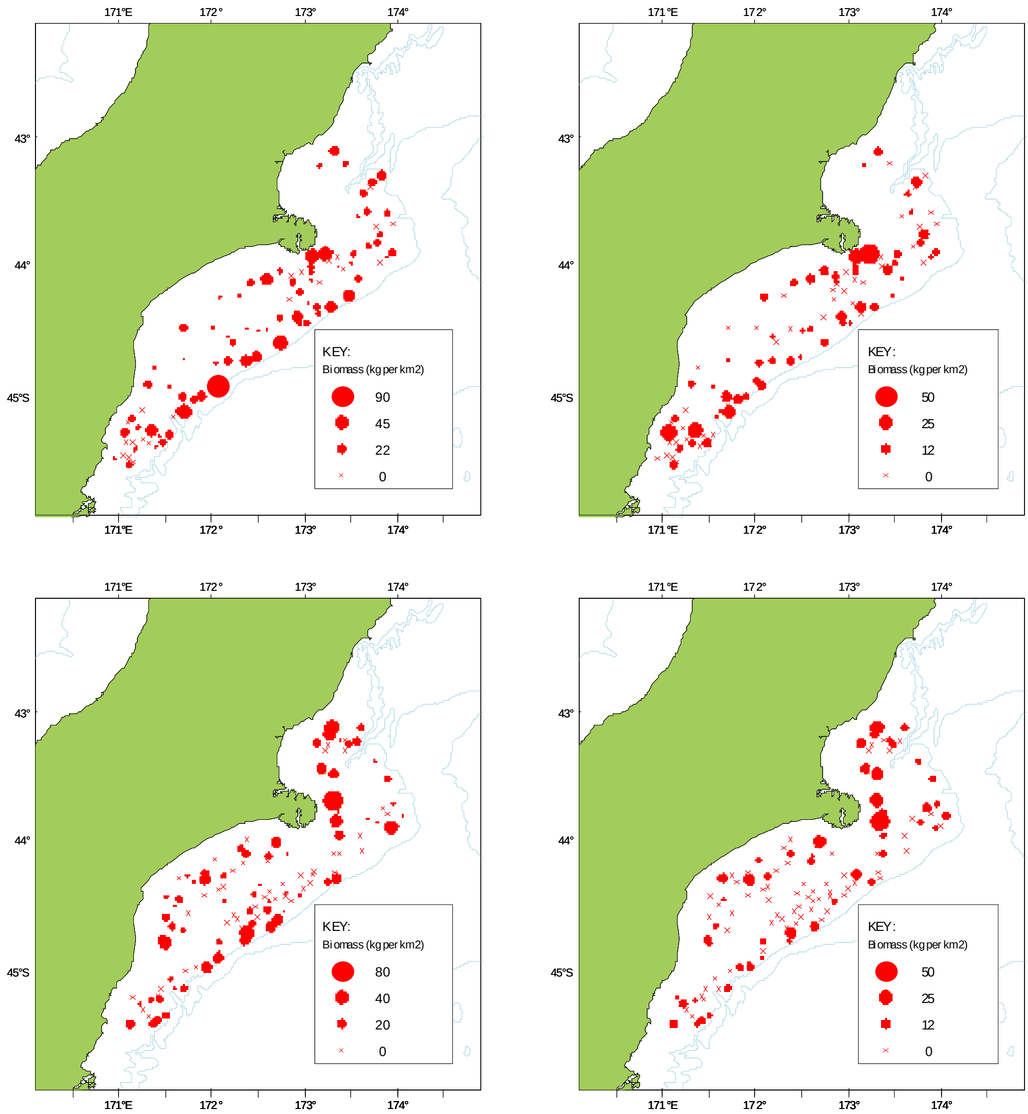


Figure A6: Catch rates (kg/km^2) of large arrow squid from *Kaharoa* surveys off the ECSI, winter 1994 (top) and 1996 (bottom), for males 30cm or greater (left) and females 35cm or greater (right).

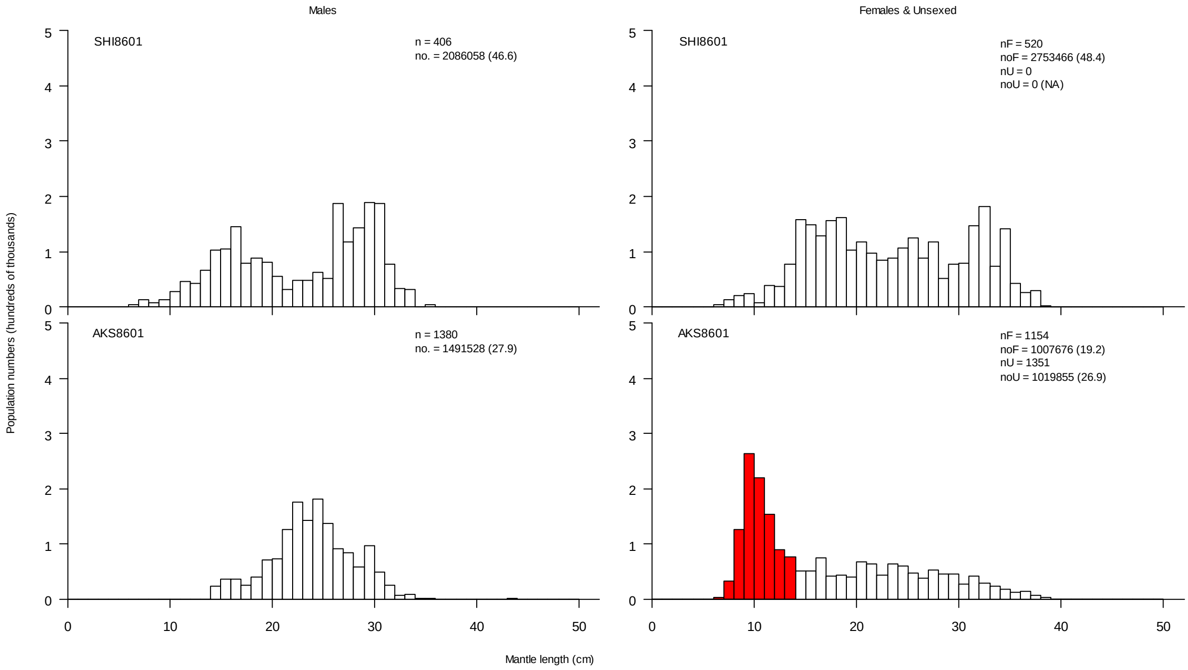


Figure A7: Length frequencies of arrow squid from Southland, from *Shinkai Maru* (SHI), *Akebono Maru* #3 (AKS) surveys in June and November 1986. M, male; F, female; U, unsexed (shaded).

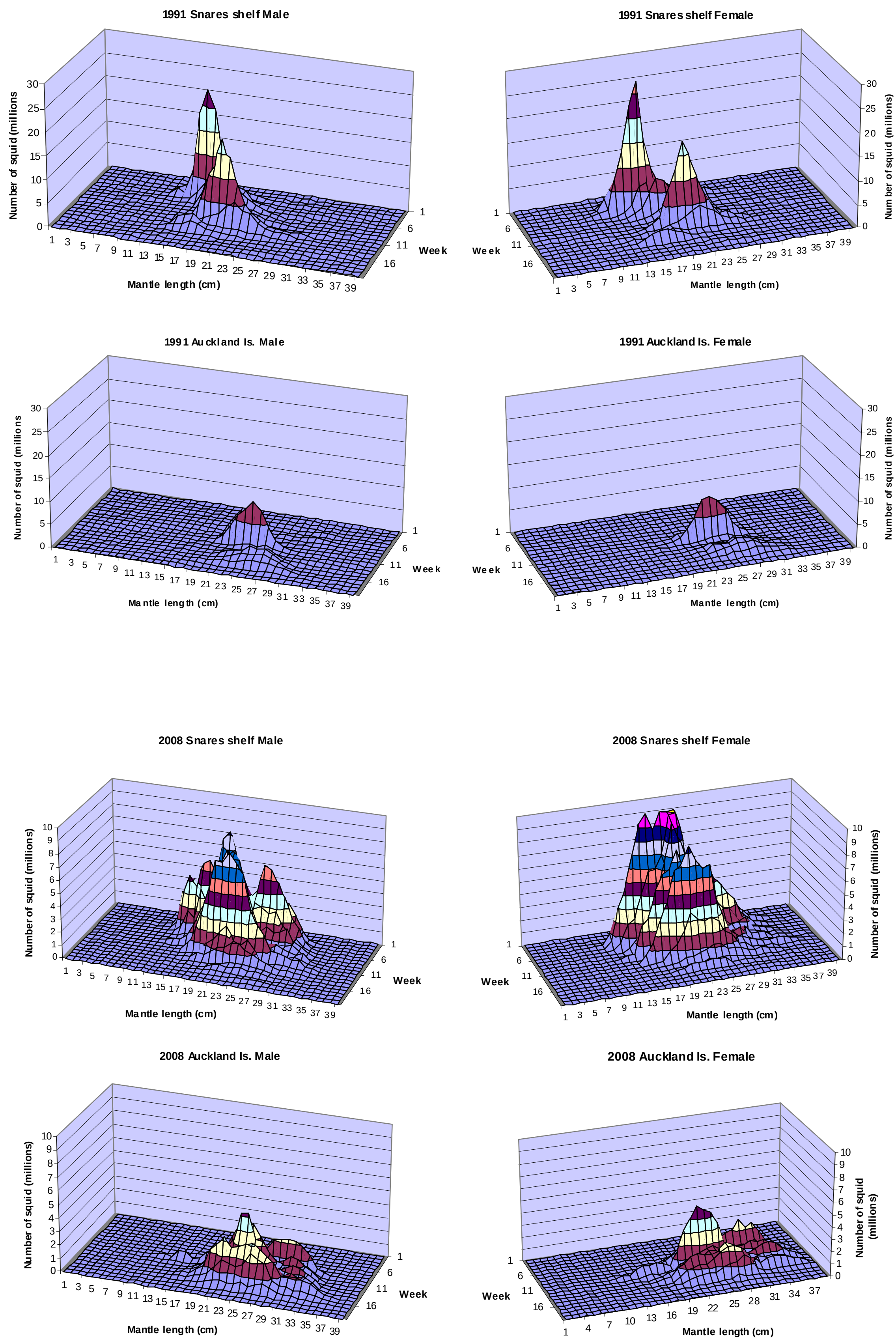


Figure A8a: Observer length frequencies (scaled to total catch) of arrow squid, by sex and week of the year, from the Snares and Auckland Is. fisheries, 1991 (top four panels) and 2008 (bottom four panels).

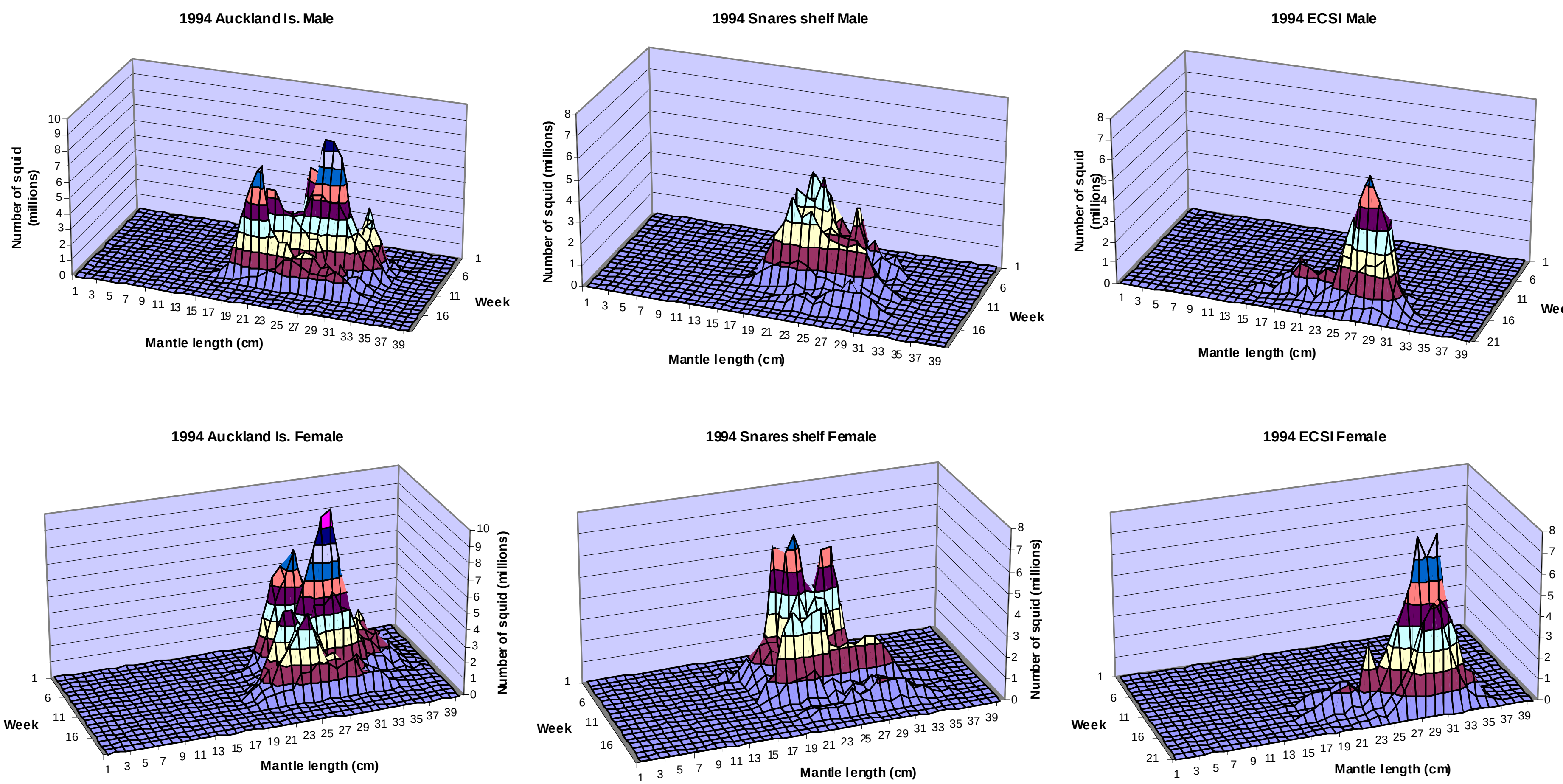


Figure A8b: Observer length frequencies (scaled to total catch) of arrow squid, by sex and week of the year, from the Auckland Is. (left two panels), Snares (mid two panels), and ECSI (right two panels) fisheries, 1994.

16. APPENDIX B. OBSERVER DATA

Table B1: Number of trawl tows and jigs by calendar year sampled for length from each arrow squid area by the observer programme, for fishing years 1986–7 to 2008–09. * Incomplete data.

(a) Trawl tows

Year	Auckland Islands	Snares Shelf	Puysegur	ECSI	West Chat	NRTH	WCSI	Null	Total
1986–87	500	250	-	7	-	9	-	-	766
1987–88	103	270	-	-	-	-	-	-	373
1988–89	220	96	-	-	-	-	-	-	316
1989–90	242	63	-	-	-	-	-	74	379
1990–91	131	334	-	-	-	-	-	-	465
1991–92	101	177	1	-	-	4	2	-	284
1992–93	54	500	-	23	3	-	-	-	581
1993–94	175	103	-	63	-	-	-	1	342
1994–95	112	136	-	1	-	2	-	-	251
1995–96	231	41	-	-	-	-	-	-	272
1996–97	153	93	-	-	-	-	-	-	246
1997–98	60	75	-	-	-	-	-	-	135
1998–99	26	74	-	2	-	-	-	-	102
1999–00	47	72	-	6	-	4	-	-	129
2001–01	-	-	-	-	-	-	-	-	-
2001–02	-	-	-	-	-	-	-	-	-
2002–03	-	-	-	-	-	-	-	-	-
2003–04	-	-	-	-	-	-	-	-	-
2004–05	-	-	-	-	-	-	-	-	-
2005–06	-	-	-	-	-	-	-	-	-
2006–07	-	-	-	-	-	-	-	-	-
2007–08	266	320	-	4	-	-	-	-	590
2008–09*	211	82	-	-	-	-	-	-	293
Total	2 632	2 686	2	106	3	19	2	75	5 524

(b) Jigs

Year	Auckland Islands	Snares Shelf	Puysegur	ECSI	West Chat	NRTH	WCSI	Null	Total
1991–92	-	-	1	1	-	57	-	-	59

Table B2: Number of target arrow squid tows by calendar year and month sampled for length from each arrow squid area overall by the observer programme, for fishing years 1986–87 to 2008–09. *Incomplete data.

(a) Snares Shelf, excluding Puysegur

Year	Dec	Jan	Feb	Mar	Apr	May	Total
1986–87	-	49	104	66	2	8	229
1987–88	-	23	134	86	6	10	259
1988–89	16	5	19	37	12	4	93
1989–90	-	54	-	8	-	-	62
1990–91	-	17	165	113	28	4	327
1991–92	-	-	71	58	31	-	160
1992–93	-	-	166	166	67	1	400
1993–94	-	-	17	62	21	-	100
1994–95	-	2	78	34	3	-	117
1995–96	-	2	13	17	9	-	41
1996–97	-	5	14	43	21	-	83
1997–98	-	6	65	4	-	-	75
1998–99	-	1	34	26	7	-	68
1999–00	-	6	21	28	-	1	56
2007–08	-	28	161	78	44	5	316
2008–09*	-	4	54	5	12	-	75
Total	16	202	1 116	831	263	33	2 461

(b) Auckland Islands

Year	Dec	Jan	Feb	Mar	Apr	May	Total
1986–87	5	43	121	163	112	56	500
1987–88	-	2	16	70	5	-	94
1988–89	1	15	26	96	71	10	219
1989–90	-	37	113	52	40	-	242
1990–91	-	8	11	73	31	8	131
1991–92	-	-	16	73	12	-	101
1992–93	-	-	2	3	12	-	17
1993–94	-	-	39	99	37	-	175
1994–95	-	-	1	39	52	-	92
1995–96	-	-	5	62	123	7	197
1996–97	-	12	80	58	-	-	150
1997–98	-	-	42	18	-	-	60
1998–99	-	-	-	12	14	-	26
1999–00	-	-	34	13	-	-	47
2007–08	-	-	34	118	110	4	266
2008–09*	-	-	23	49	124	5	201
Total	6	117	563	998	743	90	2 517

(c) ECSI

Year	Dec	Jan	Feb	Mar	Apr	May	Jun
1986–87	-	-	-	-	-	2	3
1992–93	-	-	-	-	5	-	-
1993–94	-	-	-	-	8	55	-
1998–99	-	-	-	-	2	-	-
1999–00	-	1	-	-	-	-	-
Total	-	1	-	-	15	57	3

Table B3: Number of arrow squid measured by calendar year and month sampled from each target arrow squid tow by area by the observer programme, for fishing years 1986–87 to 2008–09.
*** Incomplete data.**

(a) Snares Shelf

Year	Dec	Jan	Feb	Mar	Apr	May
1986–87	-	5 446	11 811	3 984	253	802
1987–88	-	2 322	16 592	9 380	669	1 005
1988–89	1 601	500	1 877	3 982	1 364	414
1989–90	-	5 782	-	973	-	-
1990–91	-	1 765	17 053	11 811	2 866	401
1991–92	-	-	7 050	6 276	3 201	-
1992–93	-	-	17 225	17 191	6 913	100
1993–94	-	-	1 705	6 483	2 166	-
1994–95	-	208	7 769	3 480	315	-
1995–96	-	207	1 338	1 726	922	-
1996–97	-	458	1 416	4 183	2 096	-
1997–98	-	454	6 154	412	-	-
1998–99	-	105	3 506	2 734	727	-
1999–00	-	621	2 154	2 898	-	100
2007–08	-	2 631	16 989	8 471	4 780	524
2008–09*	-	435	5 817	518	1 438	-

(b) Auckland Island

Year	Dec	Jan	Feb	Mar	Apr	May
1986–87	377	3 568	14 295	6 521	12 225	6 811
1987–88	-	211	1 556	8 442	500	-
1988–89	100	1 535	2 583	6 110	7 171	1 013
1989–90	-	3 810	11 571	7 400	5 043	-
1990–91	-	821	1 044	7 286	3 198	804
1991–92	-	-	1 526	299	1 220	-
1992–93	-	-	208	9 993	1 157	-
1993–94	-	-	3 978	4 038	3 769	-
1994–95	-	-	105	6 342	5 454	-
1995–96	-	-	516	5 556	12 447	703
1996–97	-	1198	7 968	1 727	-	-
1997–98	-	-	3 634	1 174	-	-
1998–99	-	-	-	1 343	1 557	-
1999–00	-	-	3 434	11 662	-	-
2007–08	-	-	3 343	5 288	12 130	414
2008–09*	-	-	2 480	21 787	13 177	529

(c) ECSI

Year	Dec	Jan	Feb	Mar	Apr	May	Jun
1986–87	-	-	-	-	-	130	120
1992–93	-	-	-	-	520	-	-
1993–94	-	-	-	-	852	5 589	-
1998–99	-	-	-	-	210	-	-
1999–00	-	100	-	-	-	-	-

Table B4: Proportion of observed target arrow squid catch to total observed target arrow squid catch (table columns), and proportion of observed target arrow squid catch to total catch (total columns).

(a) by area

	Observed catch/all observed catch						Obs/catch
Year	Auckland Is.	Snares	Puysegur	ECSI	NRTH	Null	Total
1989–90	65.5	28.3	-	-	-	6.2	8.1
1990–91	37.8	62.2	-	-	-	-	8.2
1991–92	40.8	59.2	-	-	0.3	-	4.7
1992–93	1.2	97.8	-	1.0	-	-	9.4
1993–94	53.2	23.6	-	23.2	-	-	5.2
1994–95	59.5	40.5	-	-	2	-	3.3
1995–96	90.6	9.4	-	-	-	-	4.4
1996–97	73.6	26.4	-	-	-	-	3.1
1997–98	44.3	55.7	-	-	-	-	2.6
1998–99	26.0	72.1	-	1.9	-	-	2.0
1999–00	62.3	37.4	-	0.2	4	-	3.8
2007–08	44.5	55.5	-	-	-	-	17.1

(b) Auckland Islands, by month

	Observed catch/all observed catch						Obs/catch
Year	Dec	Jan	Feb	Mar	Apr	May	Total
1989–90	-	28.4	47.4	14.9	9.3	0.0	8.1
1990–91	-	2.9	5.6	67.0	22.7	1.9	8.2
1991–92	-	0.0	24.4	67.4	8.2	0.0	7.9
1992–93	-	0.0	11.8	15.1	73.1	0.0	2.2
1993–94	-	0.0	19.4	61.9	18.8	0.0	5.3
1994–95	-	0.0	0.2	53.8	46.0	0.0	4.0
1995–96	-	0.0	2.9	30.8	62.5	3.9	7.7
1996–97	-	9.0	61.4	29.6	0.0	0.0	4.8
1997–98	-	0.0	65.2	34.8	0.0	0.0	5.1
1998–99	-	0.0	0.0	39.8	60.2	0.0	12.2
1999–00	-	0.0	81.4	18.6	0.0	0.0	6.9
2007–08	-	0.0	14.6	48.3	36.3	0.8	21.9

(c) Snares Shelf, excluding Puysegur, by month

	Observed catch/all observed catch						Obs/catch
Year	Dec	Jan	Feb	Mar	Apr	May	Total
1989–90	-	94.8	0.0	5.2	0.0	0.0	8.9
1990–91	-	1.7	42.0	43.4	11.8	1.1	8.6
1991–92	-	0.1	56.3	35.7	8.0	0.0	4.5
1992–93	-	0.0	57.6	31.9	9.9	0.5	10.9
1993–94	-	0.0	18.9	55.9	25.2	0.0	5.8
1994–95	-	0.8	63.6	32.8	2.9	0.0	3.5
1995–96	-	6.9	31.3	47.0	14.9	0.0	1.4
1996–97	-	4.0	19.9	63.1	13.0	0.0	2.0
1997–98	-	8.7	87.4	3.9	0.0	0.0	2.2
1998–99	-	1.2	59.8	33.1	5.8	0.0	1.7
1999–00	-	5.9	44.2	48.6	0.0	1.4	5.5
2007–08	-	4.2	58.7	28.8	7.2	1.0	15.3

Table B5: Arrow squid length weight parameters calculated from observer January to May 2008 data by area.

	LW parameters		R	Number	Length (cm)		Weight (Kg)	
Data set	a	b	squared	of fish	Min	Max	Min	Max
Auckland Is and and Snares	0. 0143	3.14	93.4	4 138	9	41	0.020	1.89
Snares	0. 0171	3.08	92.4	2 511	9	41	0.020	1.89
Auckland Is	0. 0136	3.16	94.8	1 627	10	40	0.035	1.69

Table B6: Five stage gonad scale used by observers in 2008 for female squid (after Lipinski, 1979)

Maturity Stage	Name	Description
1	Juvenile/Immature	Squid are small. The sexual organs may be hard to find. If visible, the ovary is translucent (see-through) or whitish and membranous. No eggs are observable. The nidamental glands may appear as small strips..
2	Preparatory	The sexual organs are not translucent. The nidamental glands are enlarged, covering some internal organs. Immature eggs in ovary are clearly visible.
3	Maturing	The nidamental glands are large. Many eggs can be seen in the ovary. Most of the eggs are not translucent (roughly 95%) and are pressed together.
4	Mature	As for maturing, but eggs are translucent (more than 60%). Cut open, the nidamental gland secretes a viscous substance.
5	Spent	There are almost no eggs or only degenerating ones. The nidamental glands are small, tissue slack and disintegrating. The condition of the animal is very poor. This is rarely observed.

Table B7: Number and proportion of Auckland Islands and Snares Shelf observed target arrow squid by gonad stage and month for the 2008 season.

		Stage (number of fish)					Stage (proportion)				
Area	Month	1	2	3	4	5	1	2	3	4	5
Snares and Auckland Is.	Jan	1 505	266	114	5	0	0.796	0.141	0.060	0.003	0.000
	Feb	7 666	2 661	569	66	5	0.699	0.243	0.052	0.006	0.000
	Mar	4 788	3 813	1561	214	71	0.458	0.365	0.149	0.020	0.007
	Apr	2 943	3 152	671	101	0	0.429	0.459	0.098	0.015	0.000
	May	21	407	17	5	0	0.047	0.904	0.038	0.011	0.000
Snares	Jan	1 505	266	114	5	0	0.796	0.141	0.060	0.003	0.000
	Feb	6 830	1 761	399	51	3	0.755	0.195	0.044	0.006	0.000
	Mar	2 252	1 257	622	76	16	0.533	0.298	0.147	0.018	0.004
	Apr	899	995	123	16	0	0.442	0.489	0.061	0.008	0.000
	May	5	241	10	4	0	0.019	0.927	0.038	0.015	0.000
Auckland Is.	Jan	0	0	0	0	0	0.000	0.000	0.000	0.000	0.000
	Feb	836	900	170	15	2	0.435	0.468	0.088	0.008	0.001
	Mar	2 536	2 556	939	138	55	0.407	0.411	0.151	0.022	0.009
	Apr	2 044	2 157	548	85	0	0.423	0.446	0.113	0.018	0.000
	May	16	166	7	1	0	0.084	0.874	0.037	0.005	0.000

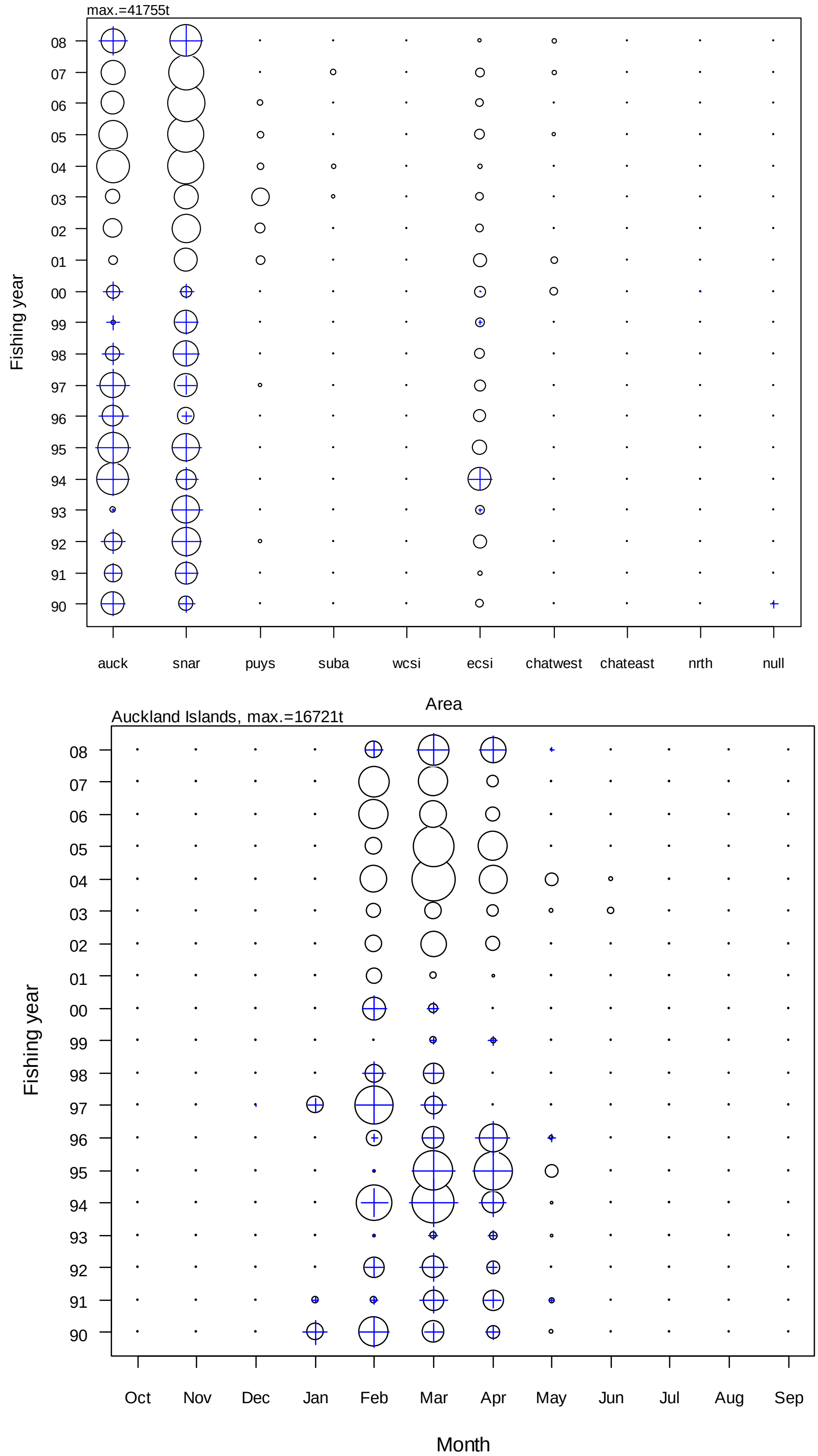


Figure B1: Representativeness of observer sampling of arrow squid target catch by fishing year and area (top panel) and by fishing year and month for the Auckland Islands, Snares Shelf, and ECSI. Circles show the proportion of target catch by month within a year, crosses show the proportion of observed target catch for the same cells. Representation is demonstrated by how closely the cross matches the circle diameter.

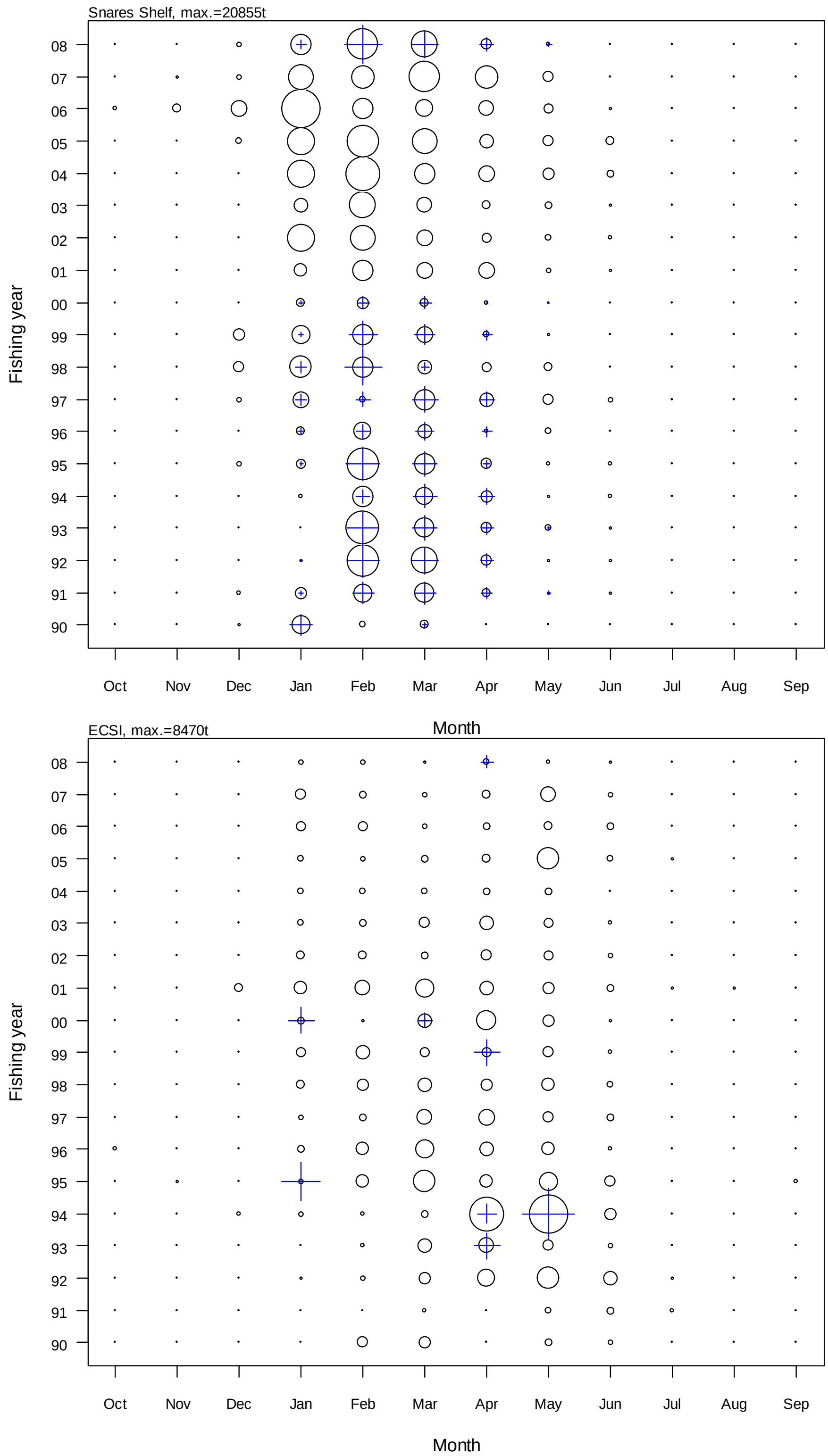


Figure B1: continued.

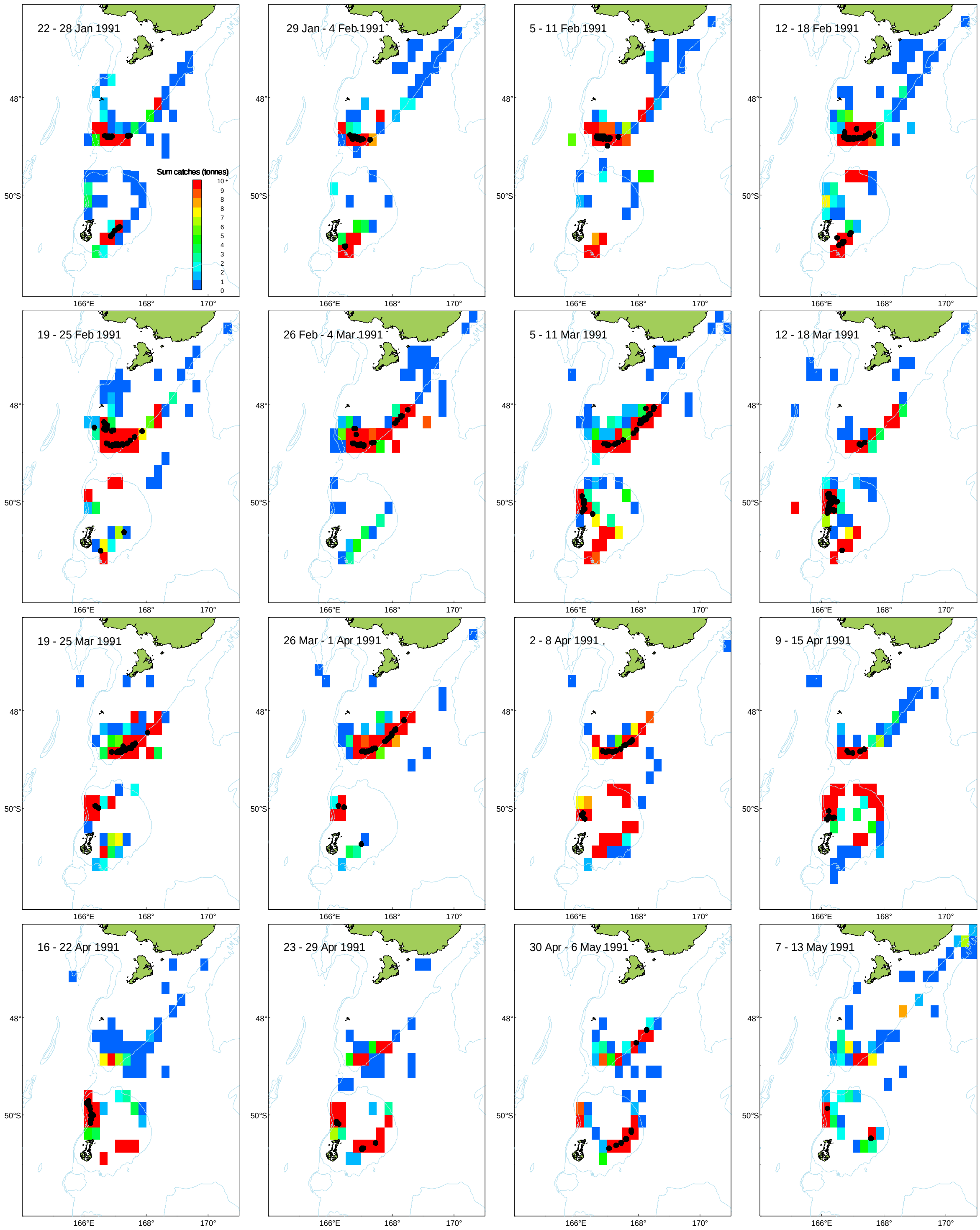


Figure B2a: Distribution of observed target arrow squid trawl tows (black dots), and density (in tonnes) of total target arrow squid catch, by week for 1991.

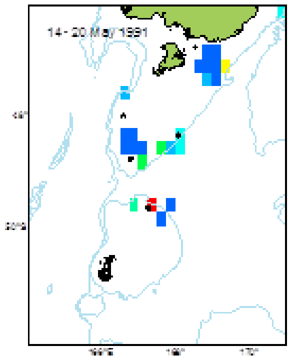


Figure B2a: continued.

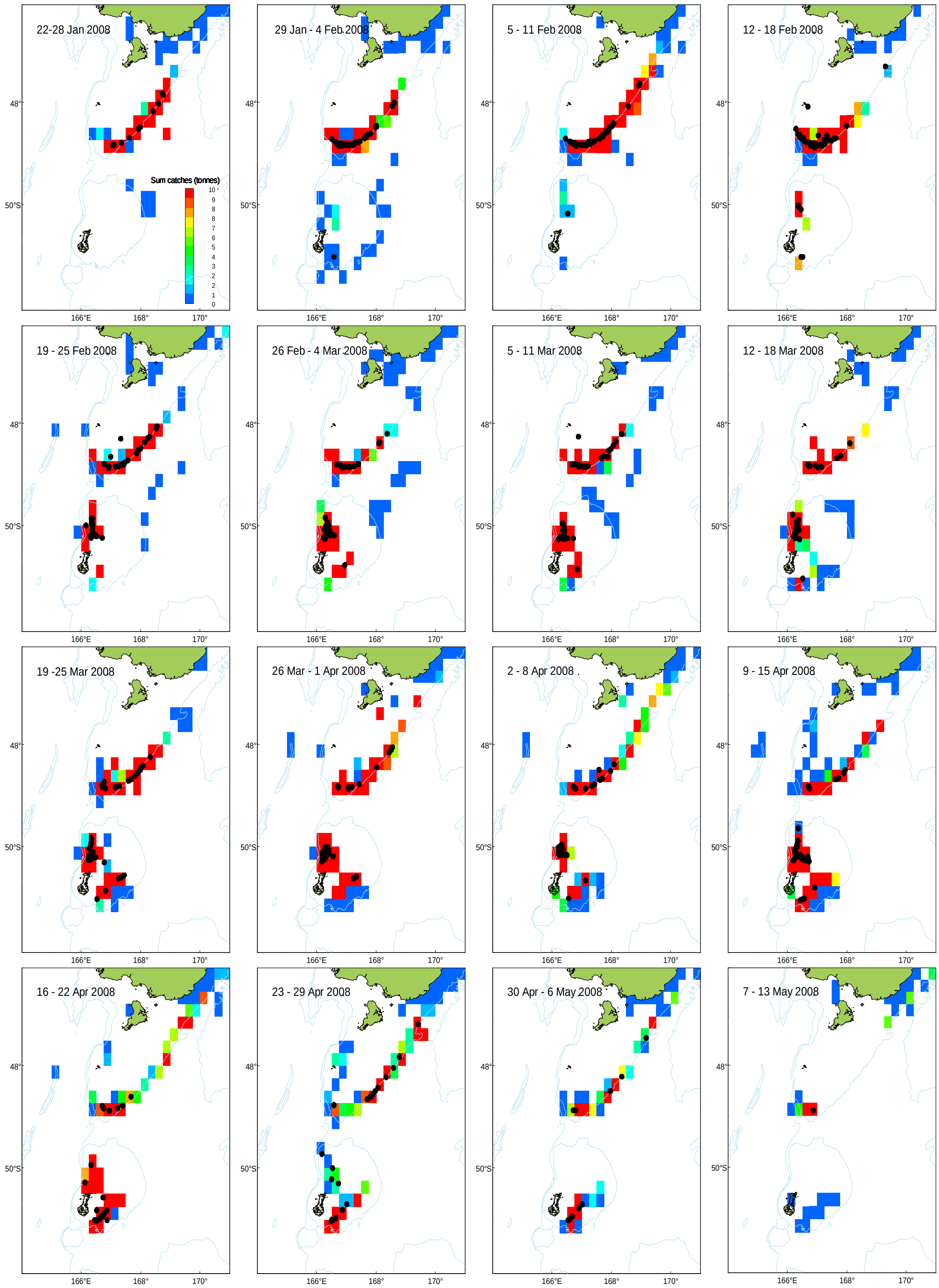


Figure B2b: Distribution of observed target arrow squid trawl tows (black dots), and density (in tonnes) of total target arrow squid catch (squares), by week for 2008.

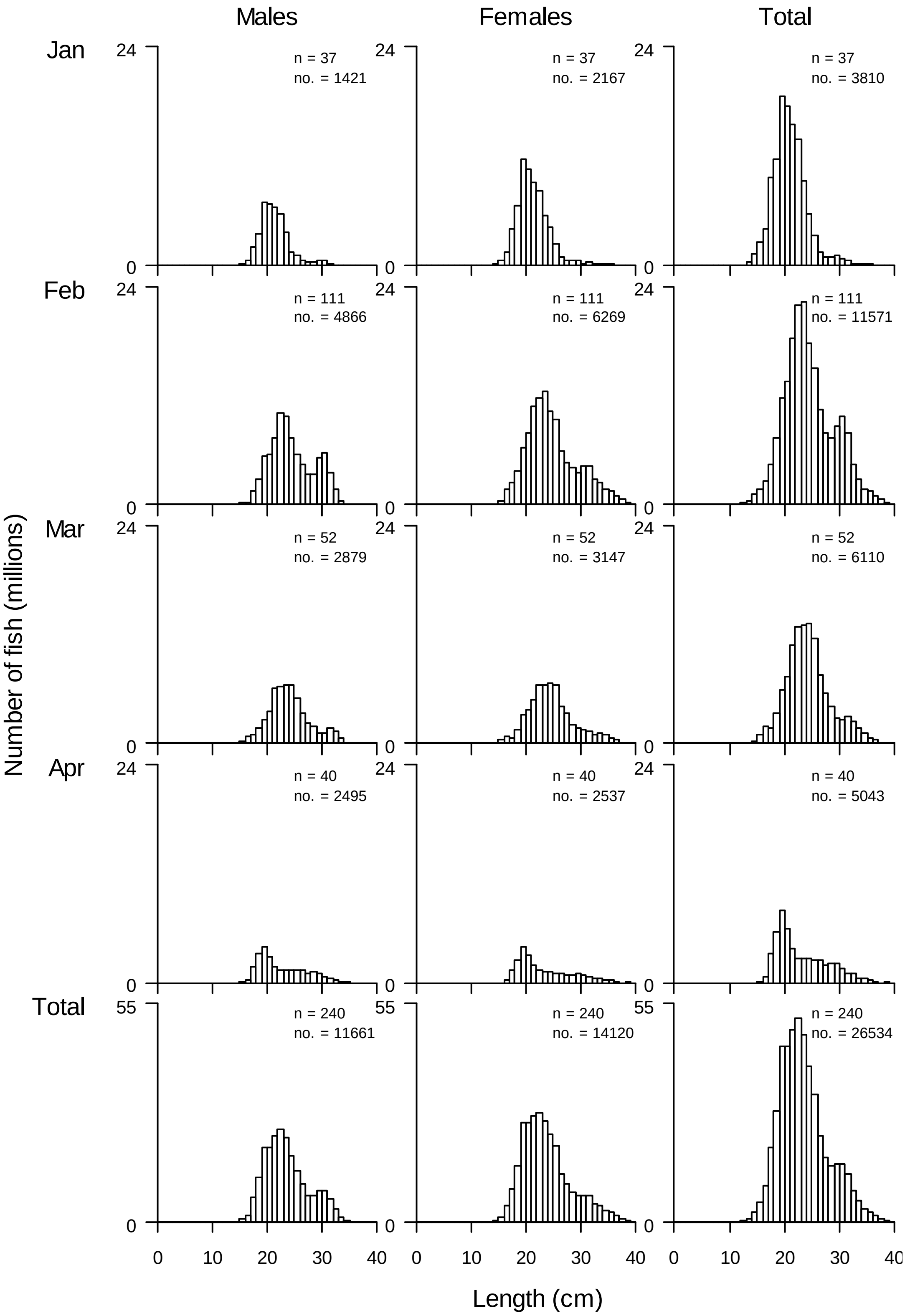


Figure B3a: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1990 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

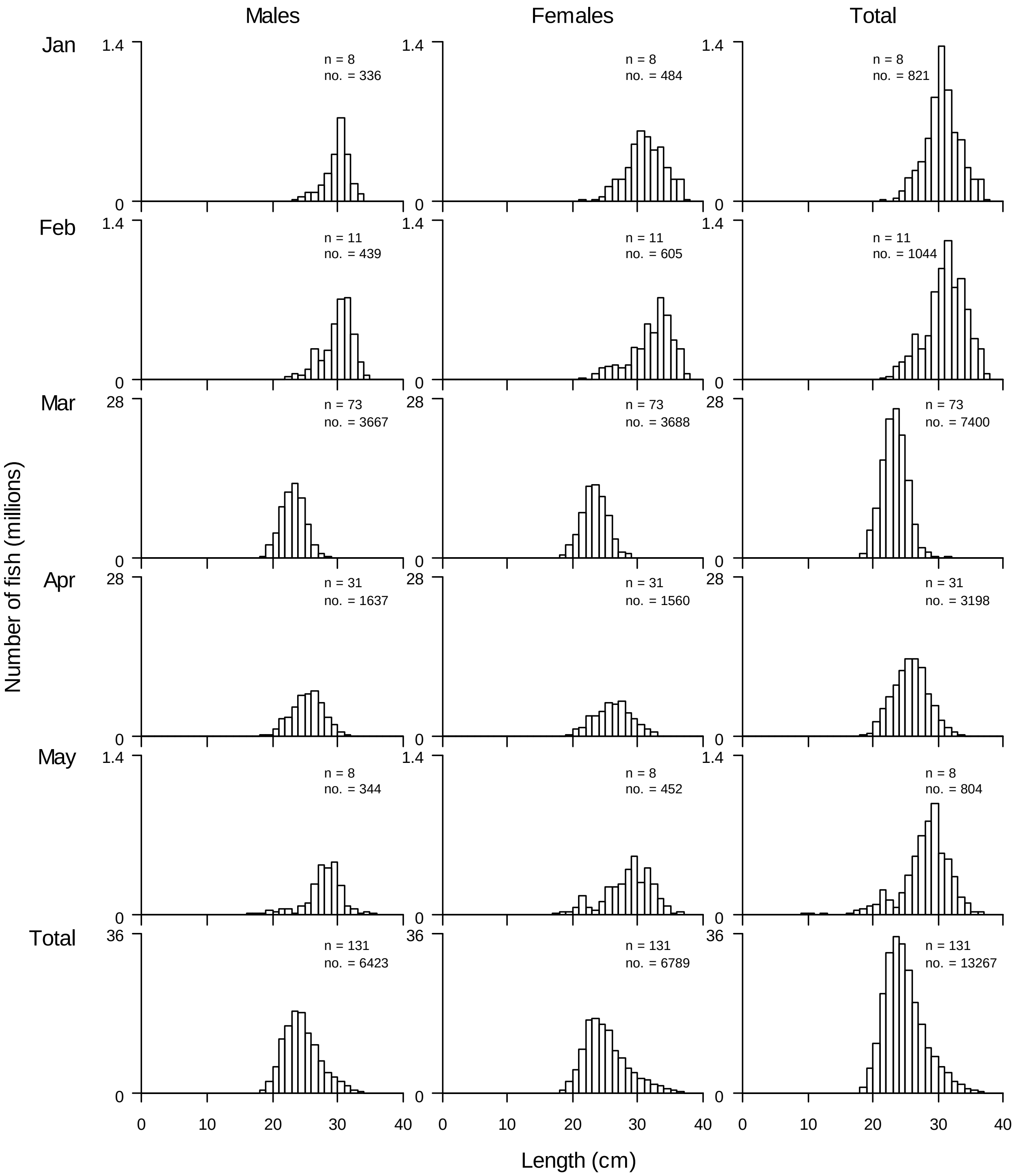


Figure B3b: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1991 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

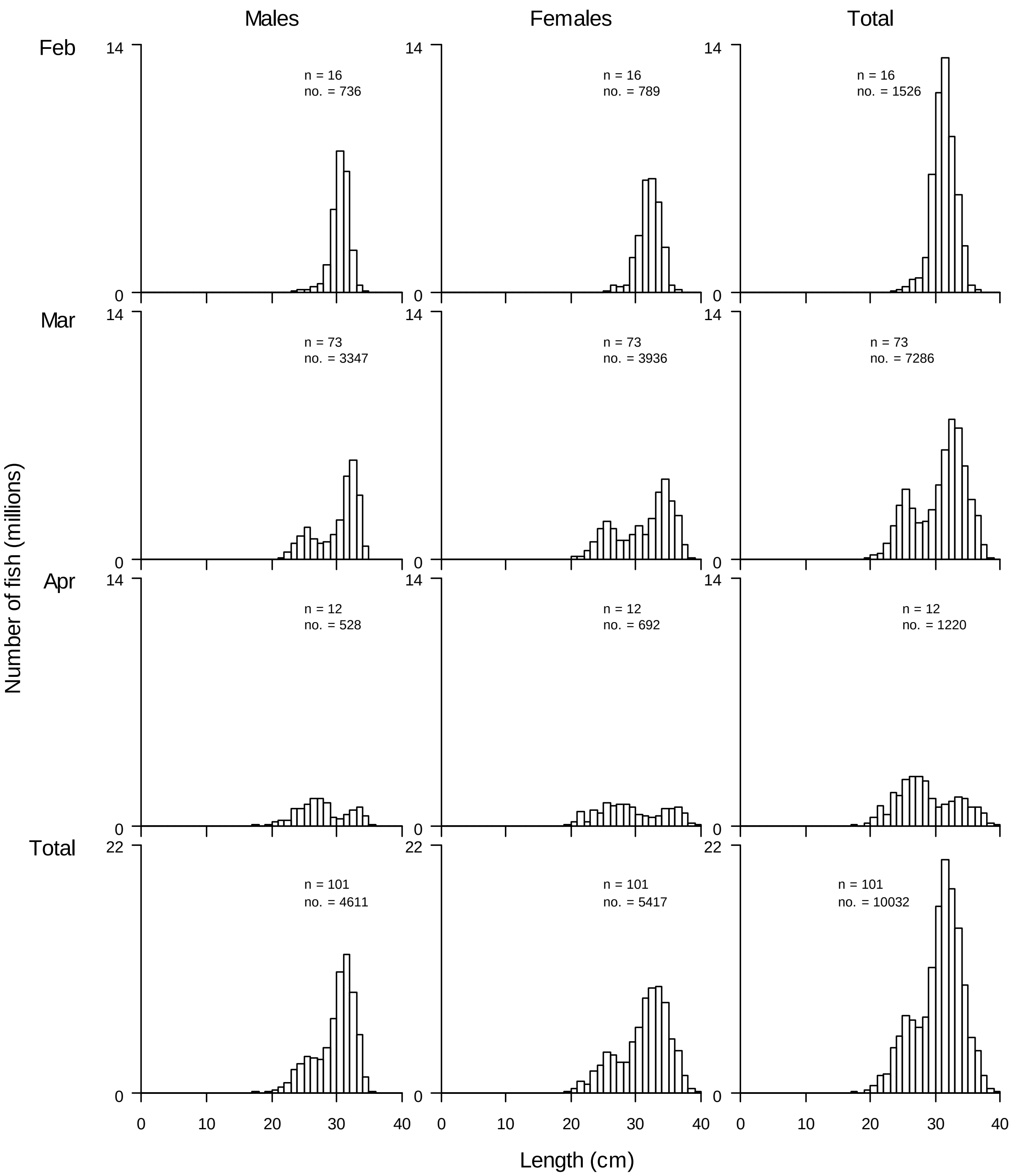


Figure B3c: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1992 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

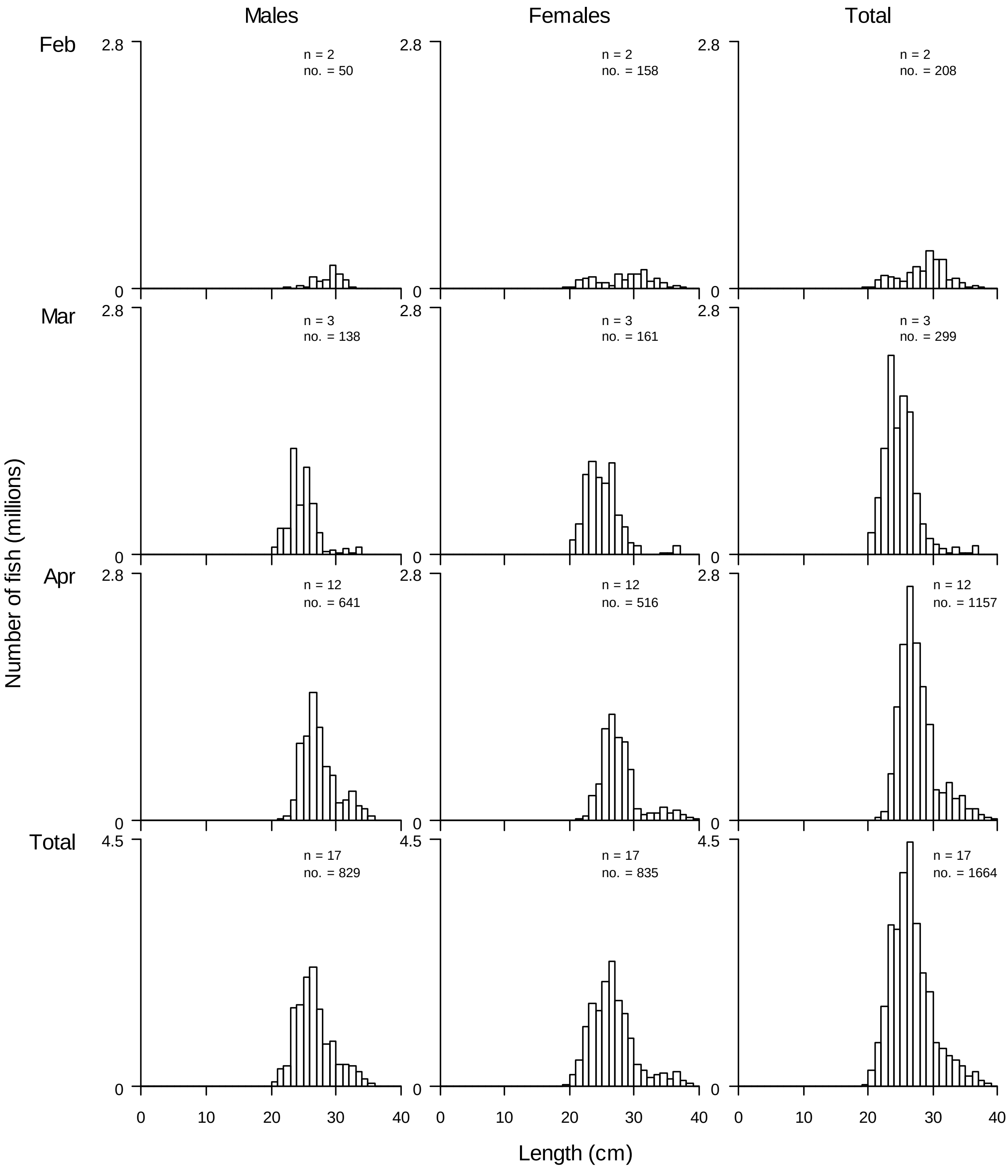


Figure B3d: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1993 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

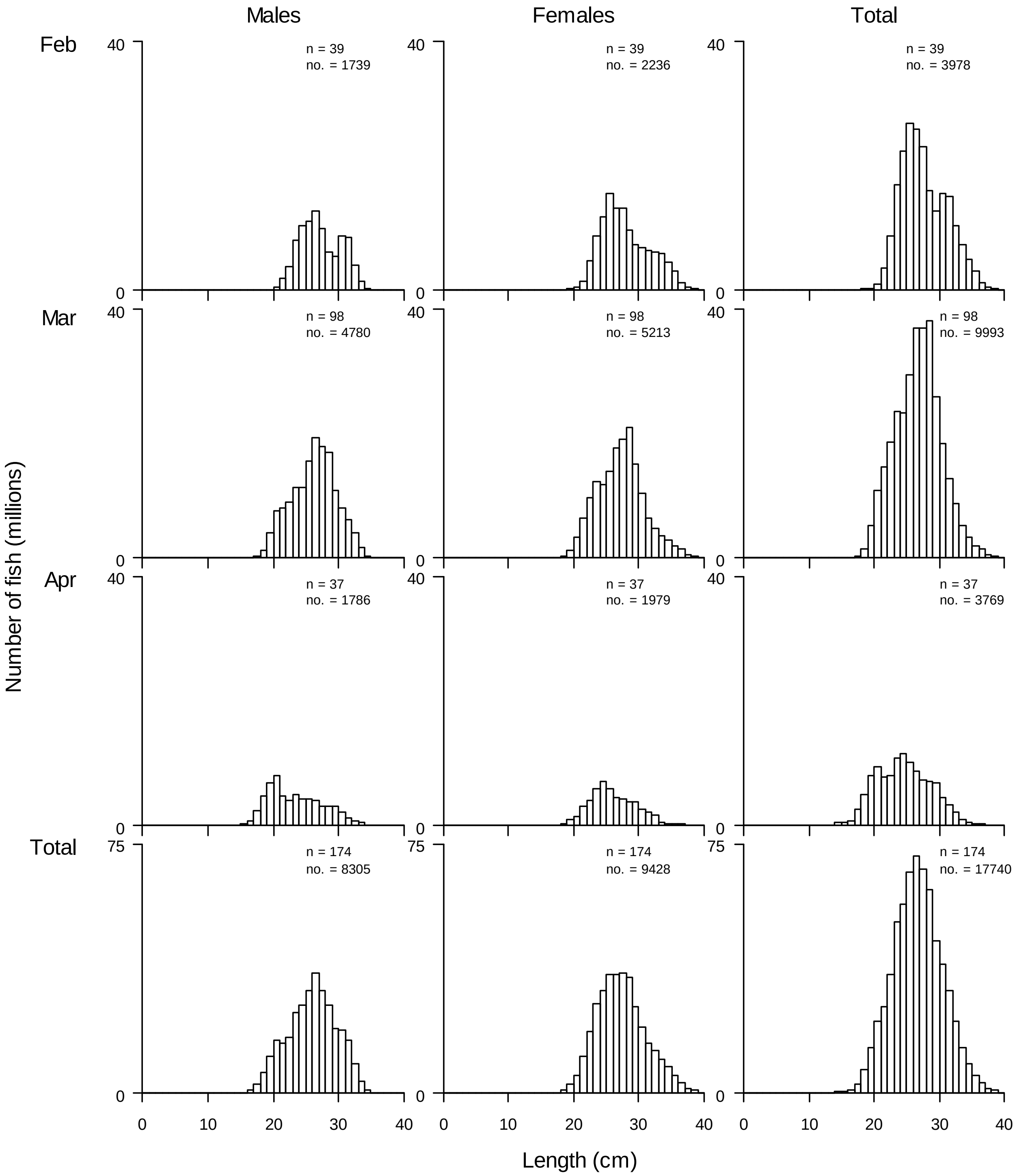


Figure B3e: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1994 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

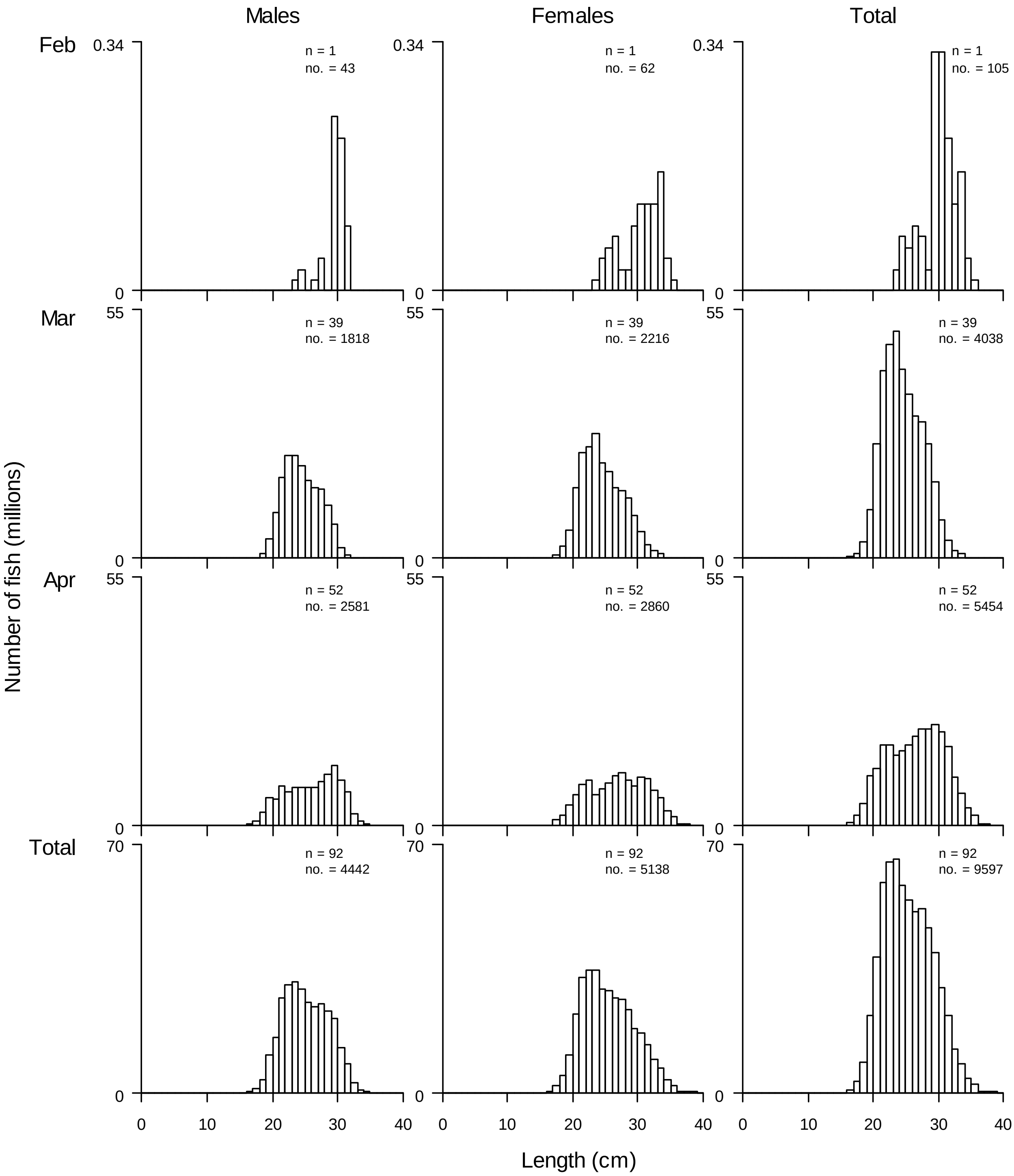


Figure B3f: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1995 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

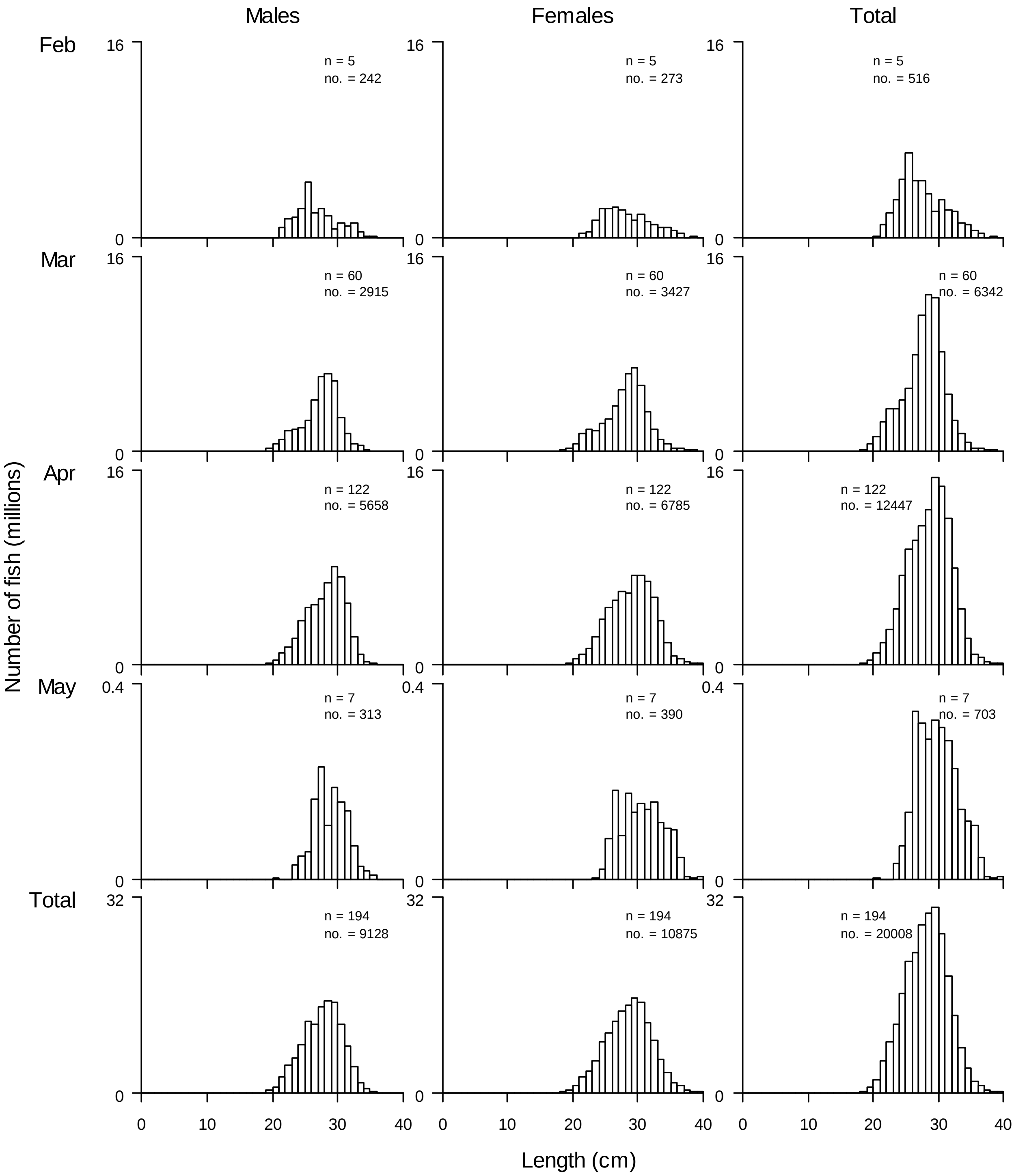


Figure B3g: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1996 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

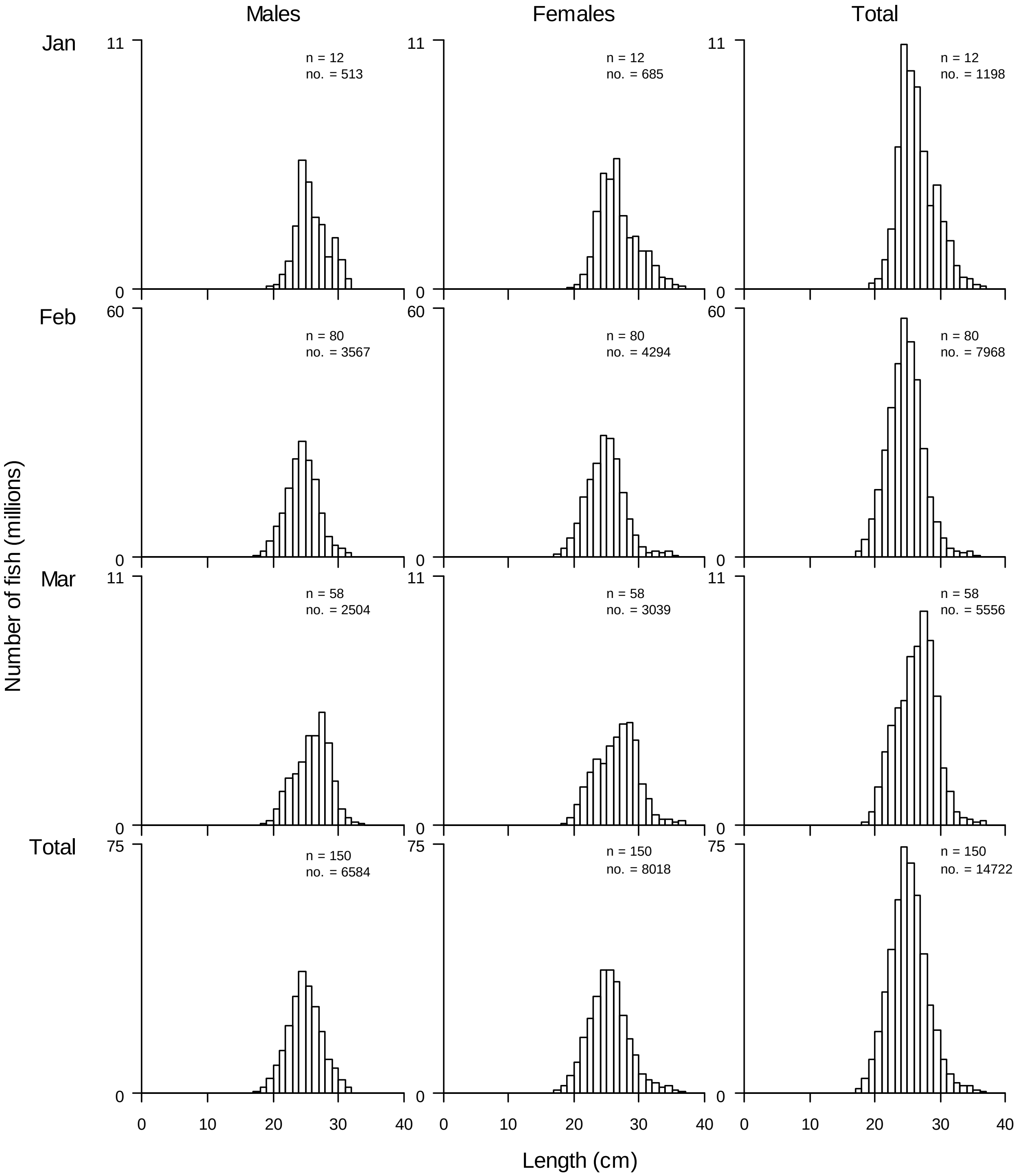


Figure B3h: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1997 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

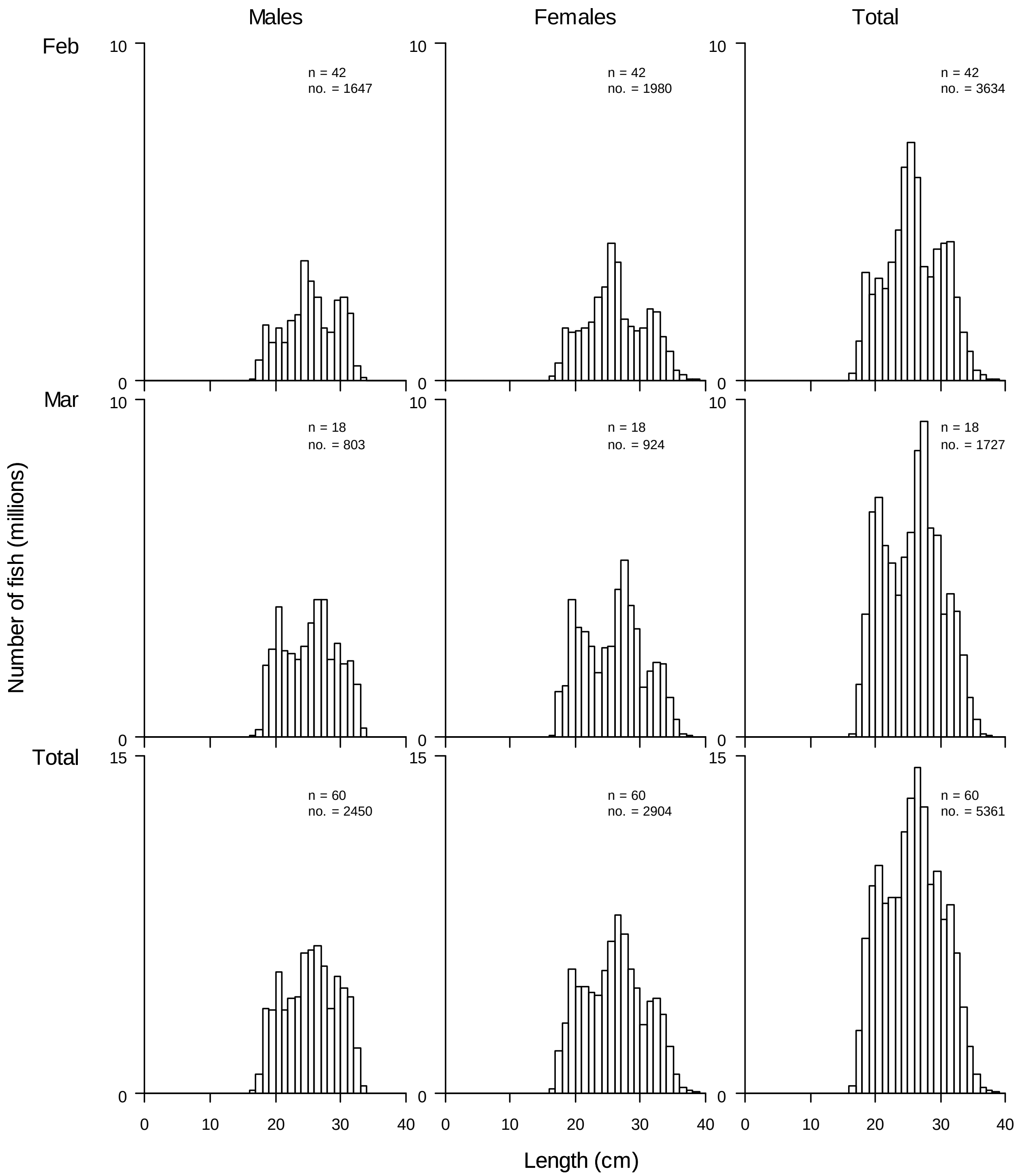


Figure B3i: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1998 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

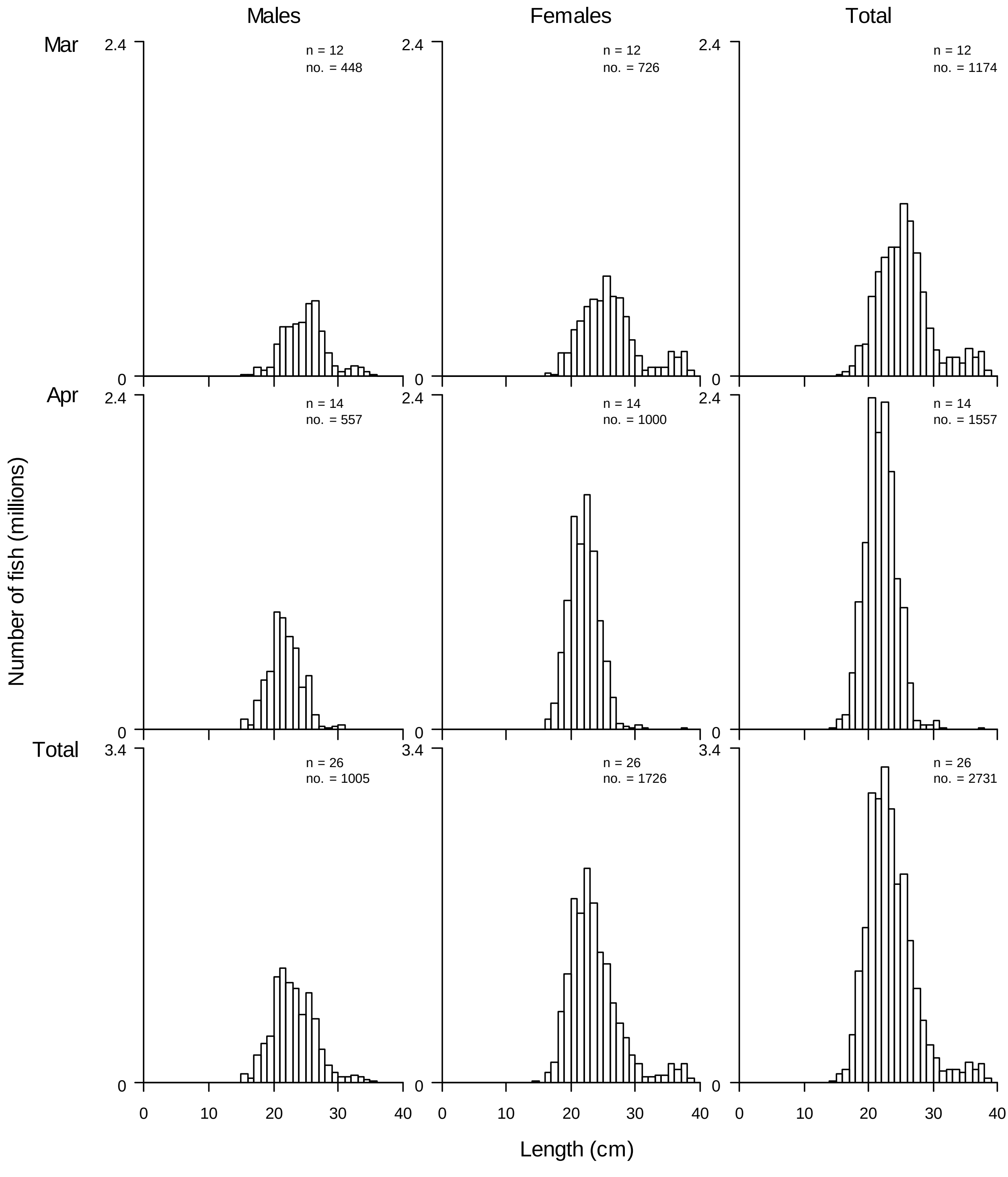


Figure B3j: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1999 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

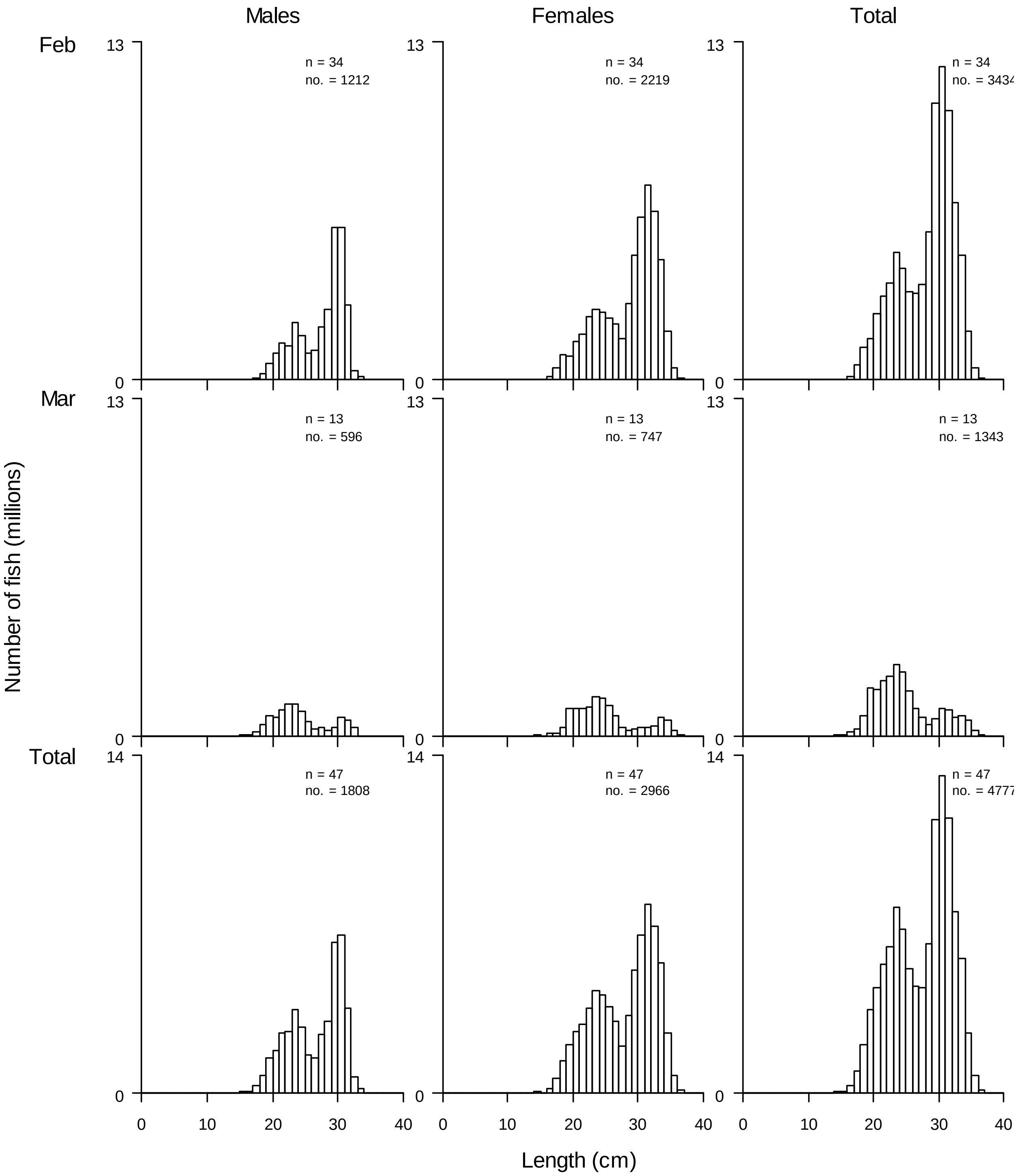


Figure B3k: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 2000 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

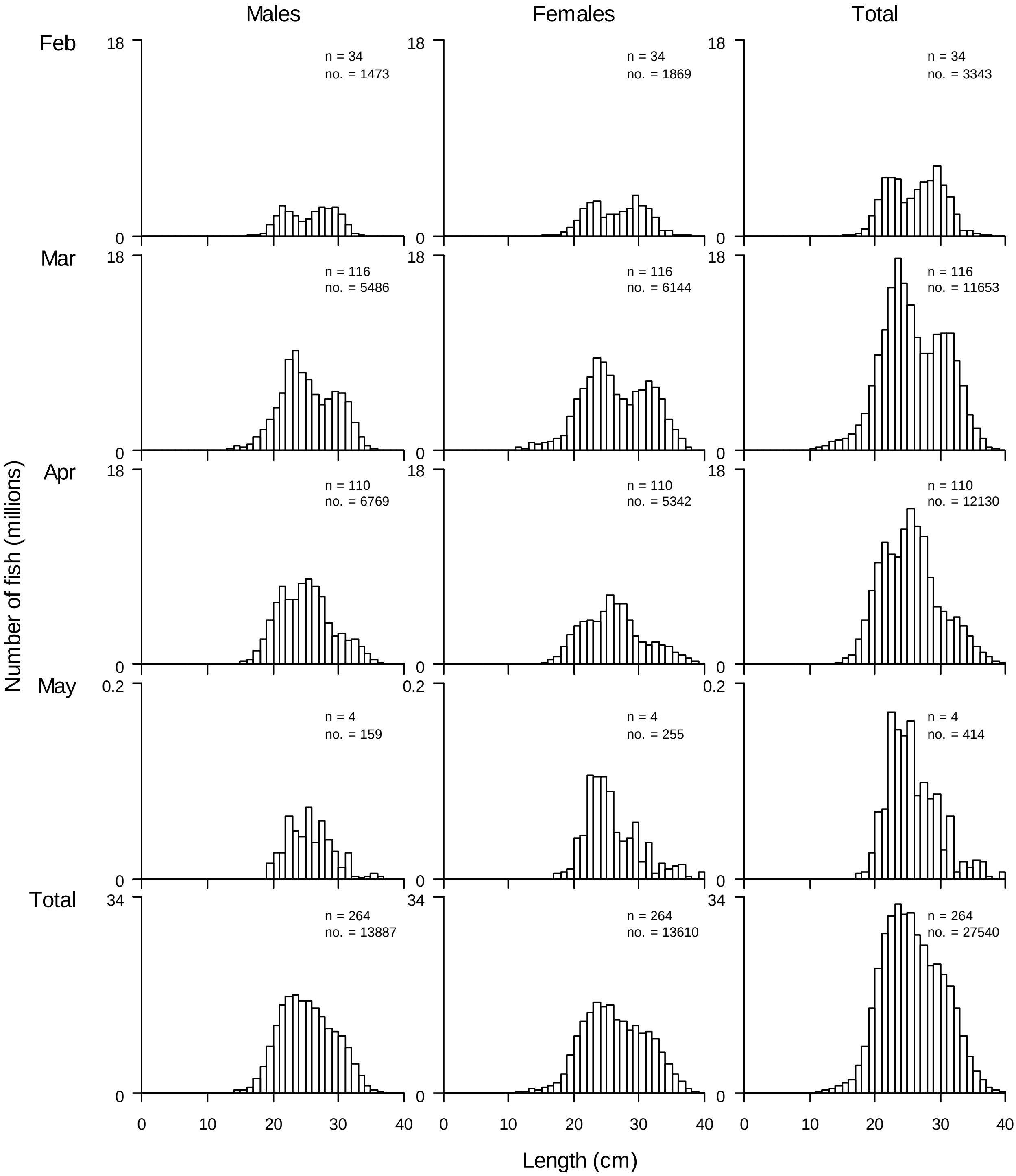


Figure B3l: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 2008 in the AUCKLAND ISLANDS region (n, number of tows sampled; no., number of fish sampled).

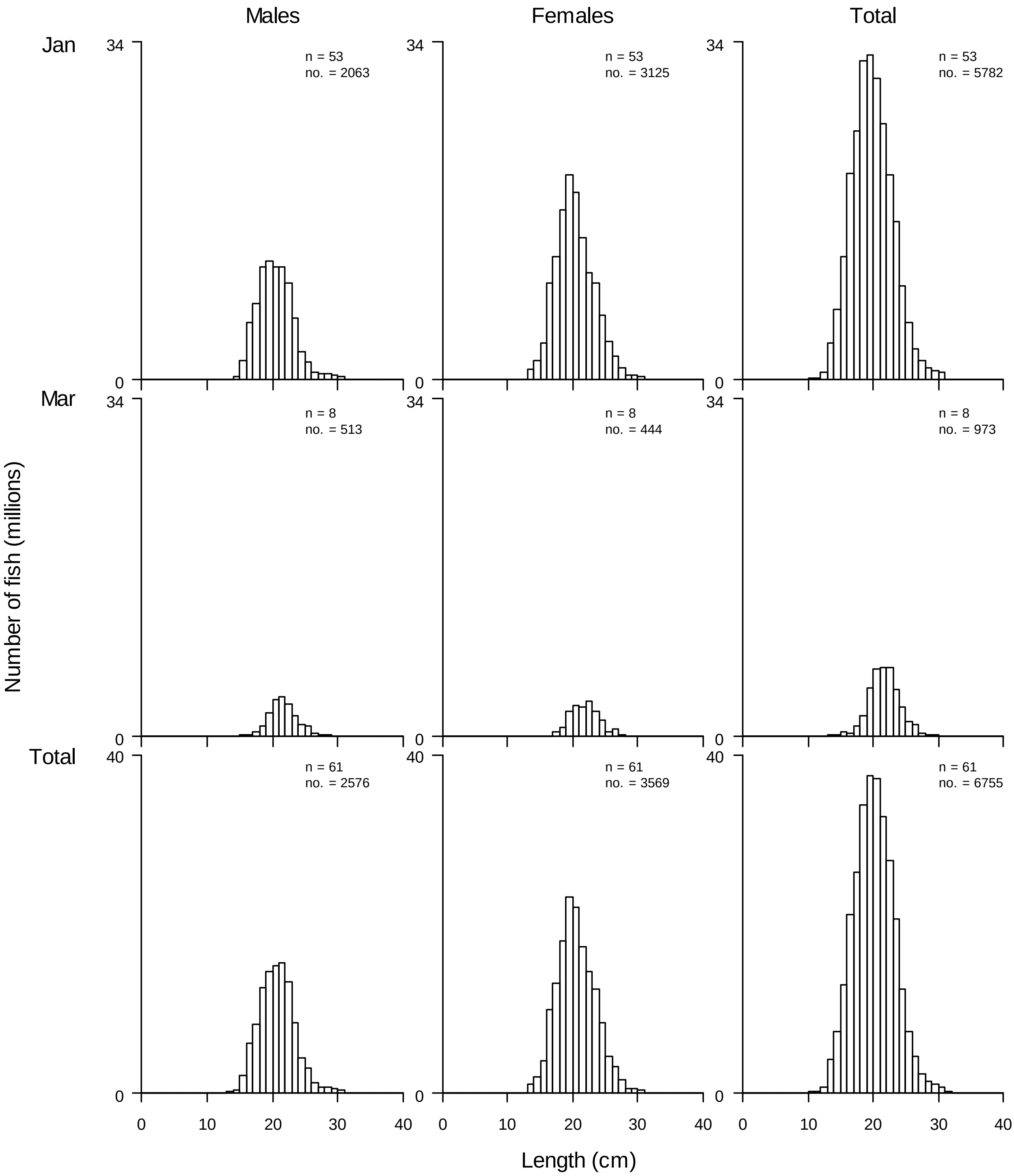


Figure B4a: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1990 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

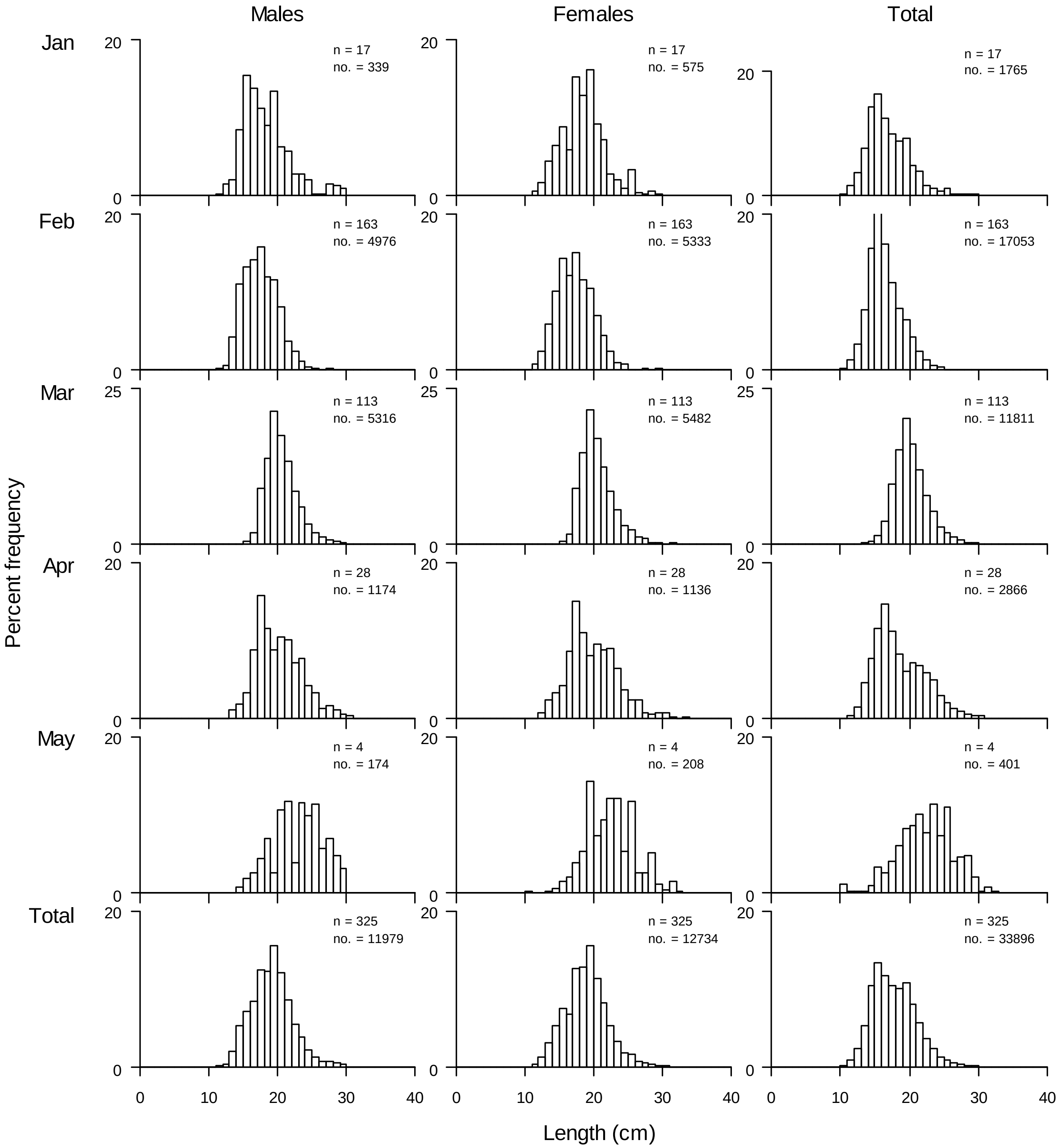


Figure B4b: Percent frequency distributions of arrow squid by month and overall sampled by the observer programme in 1991 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

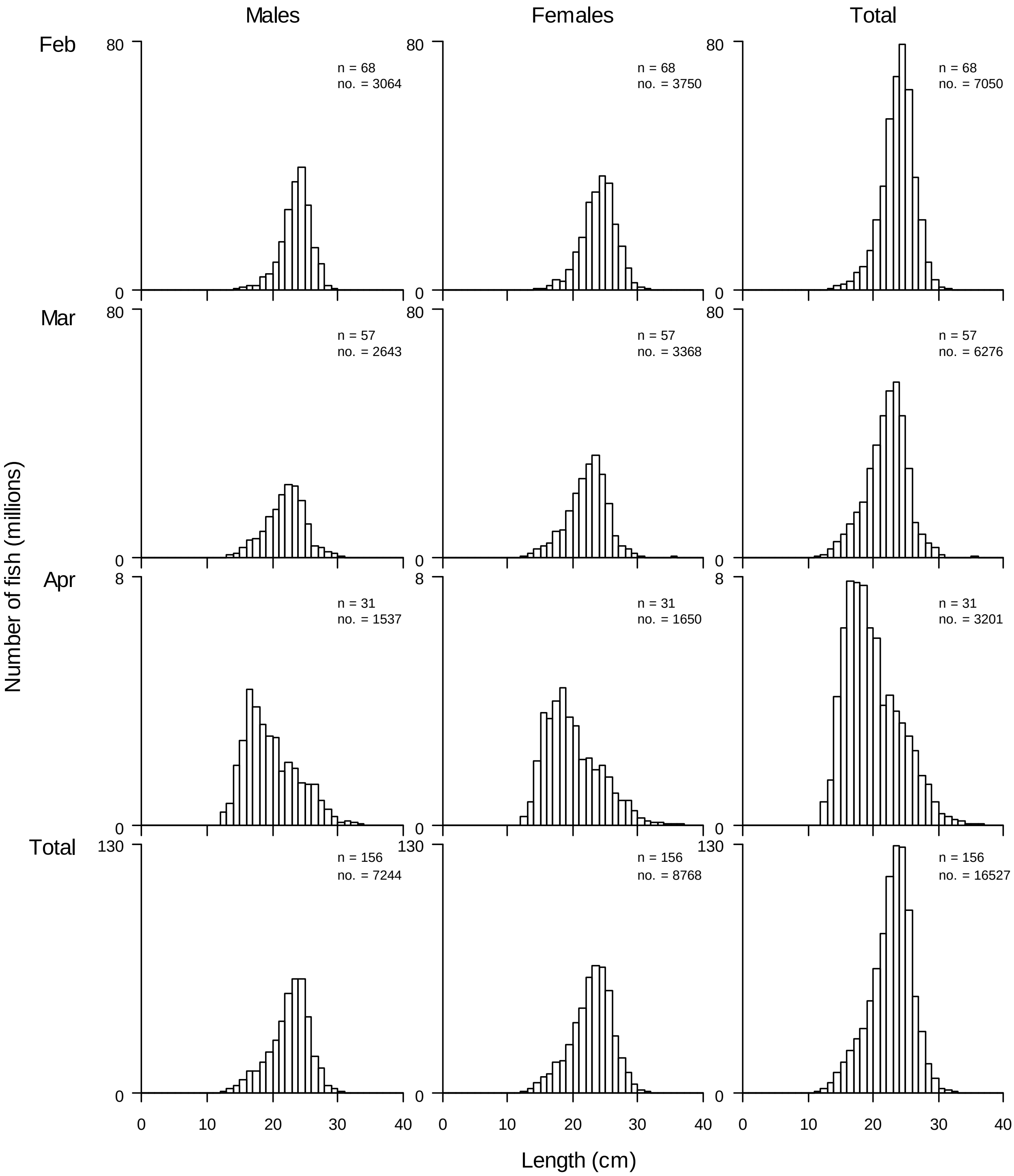


Figure B4c: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1992 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

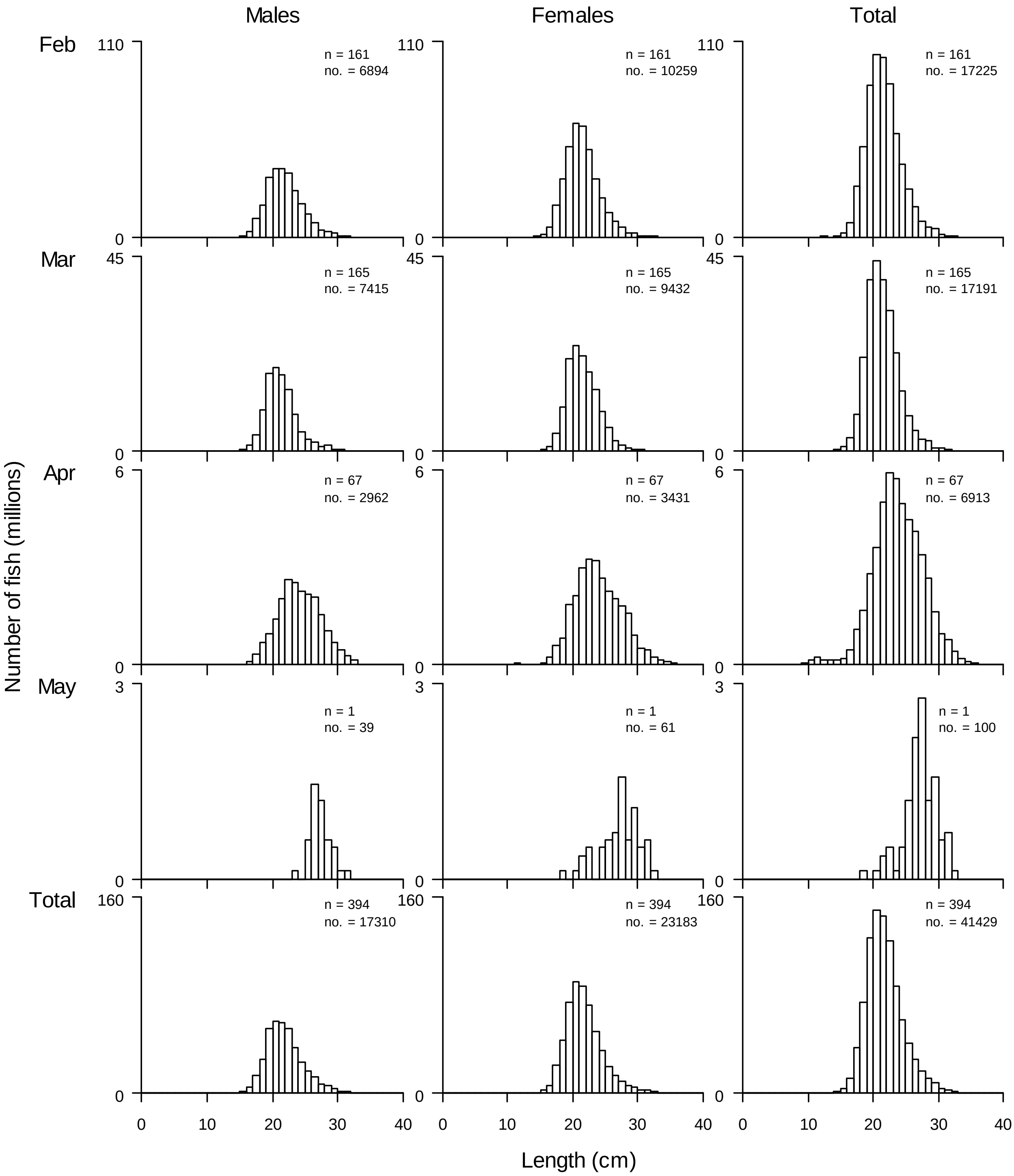


Figure B4d: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1993 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

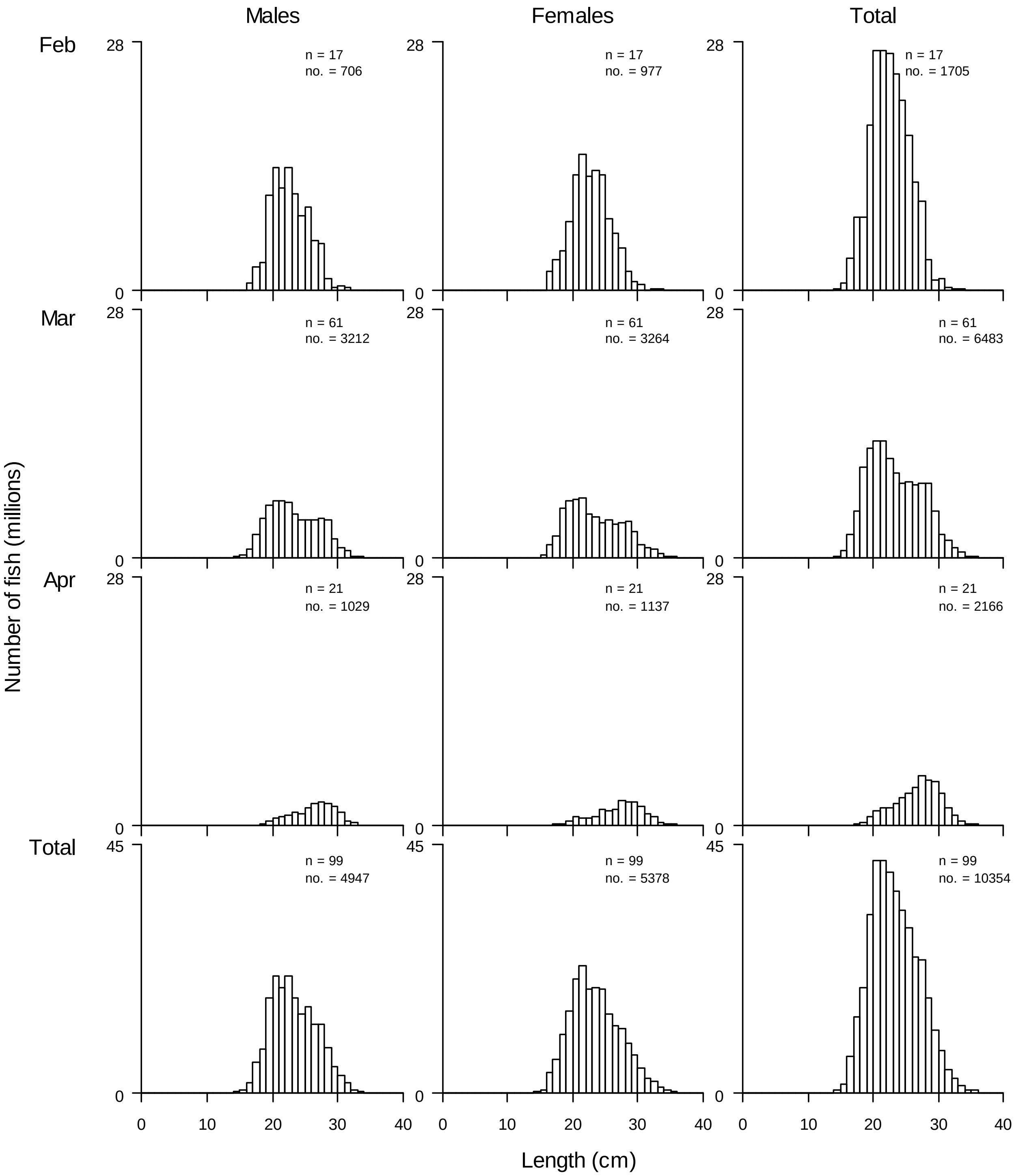


Figure B4e: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1994 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

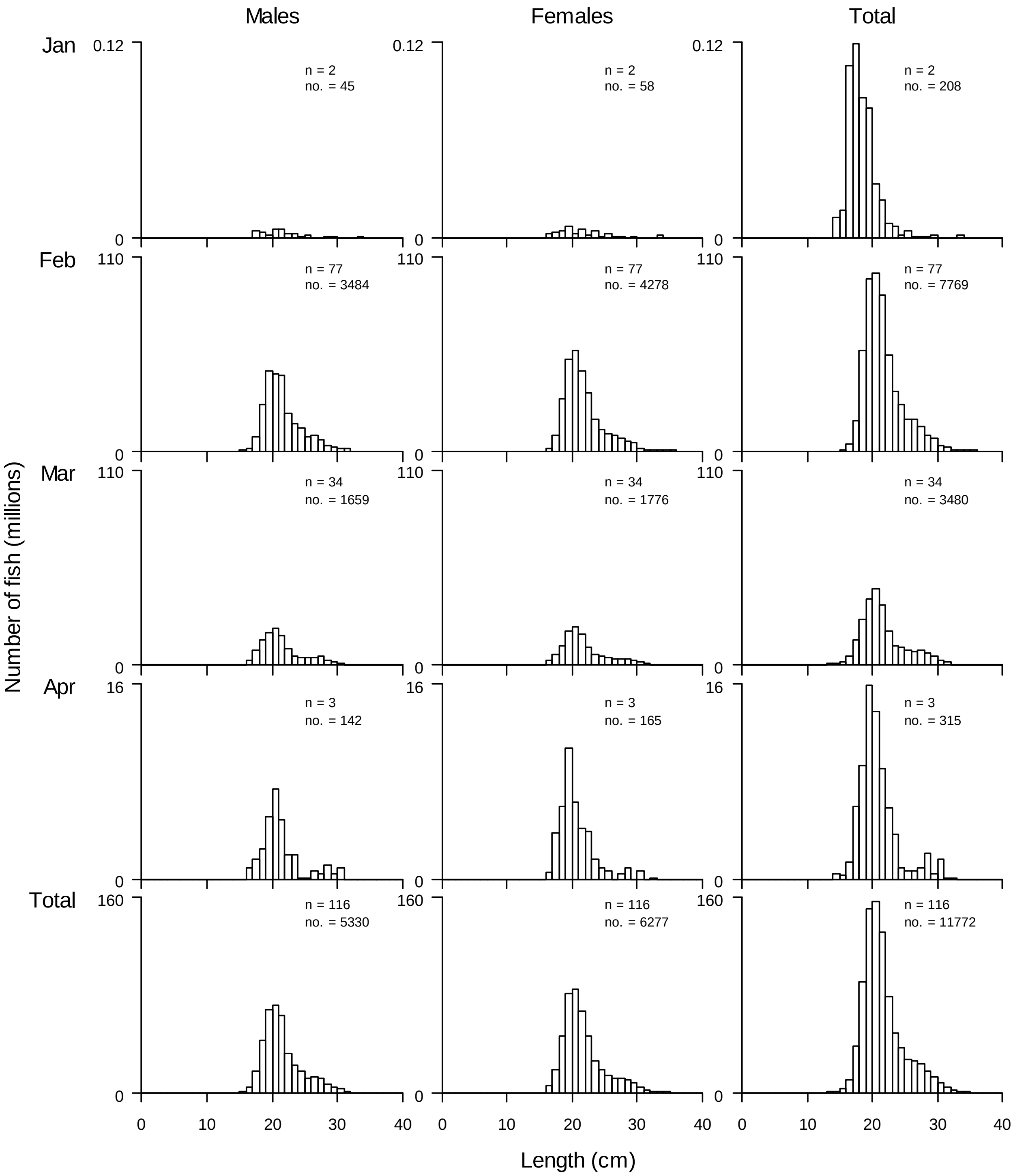


Figure B4f: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1995 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

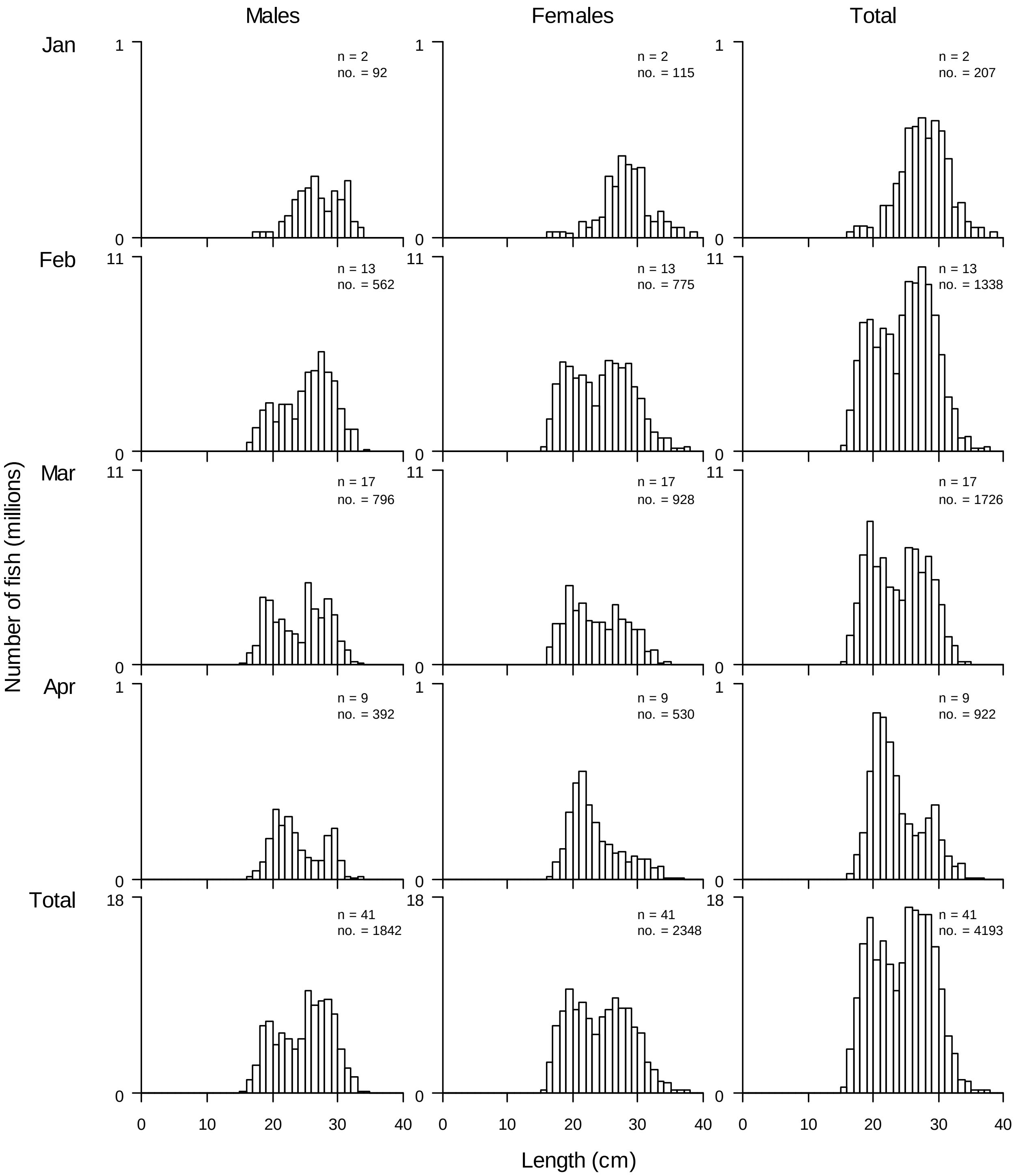


Figure B4g: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1996 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

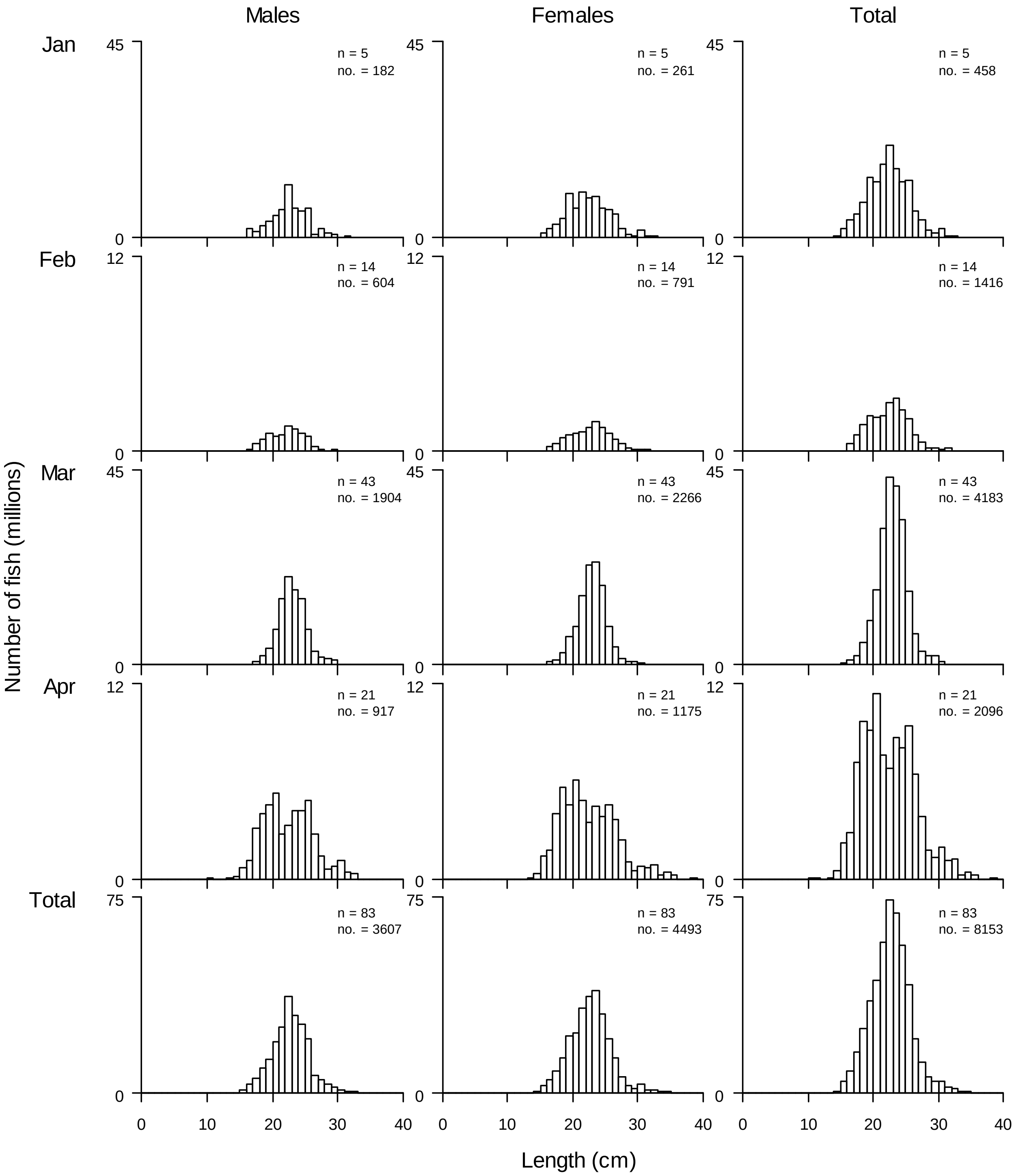


Figure B4h: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1997 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

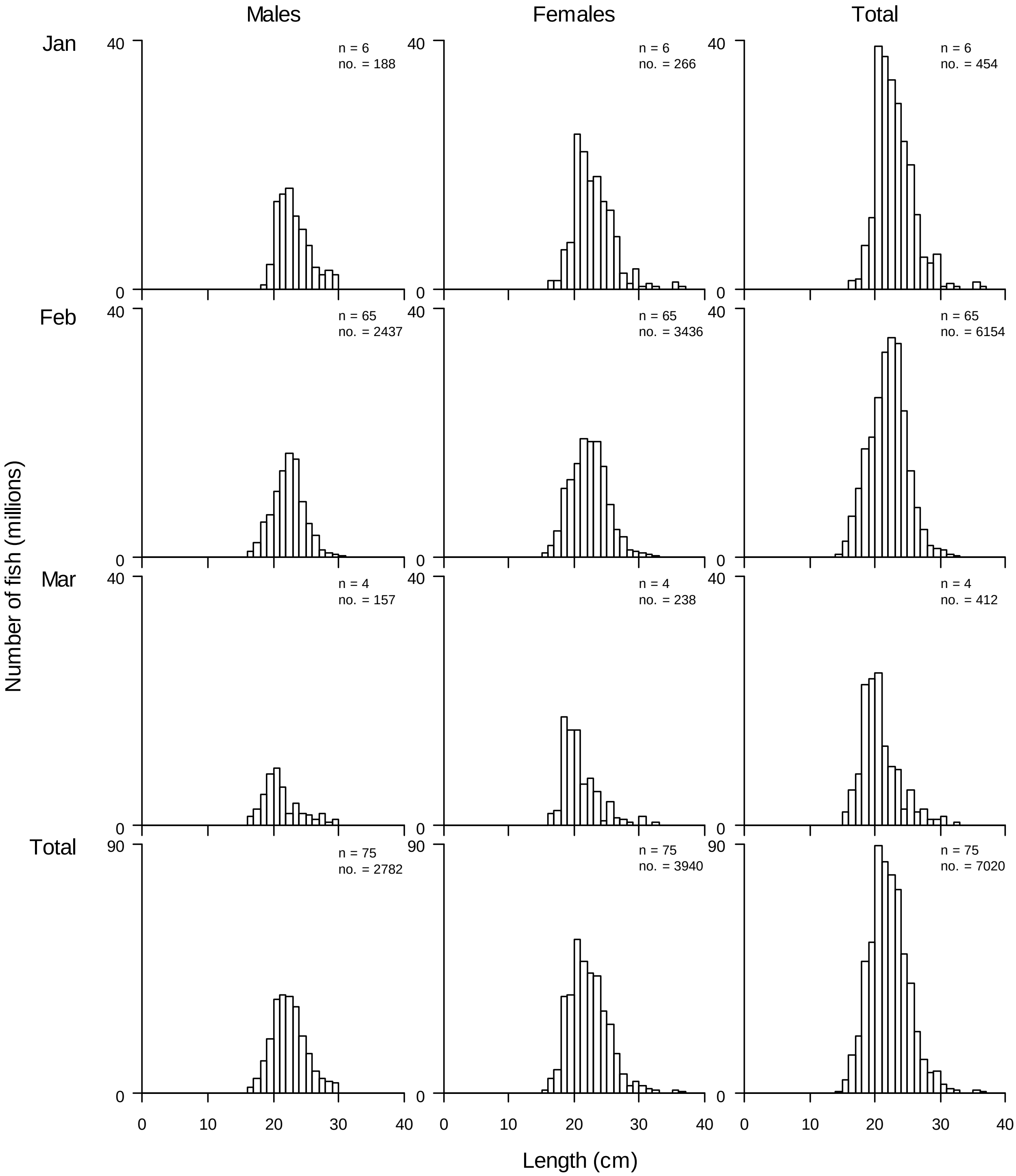


Figure B4i: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1998 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

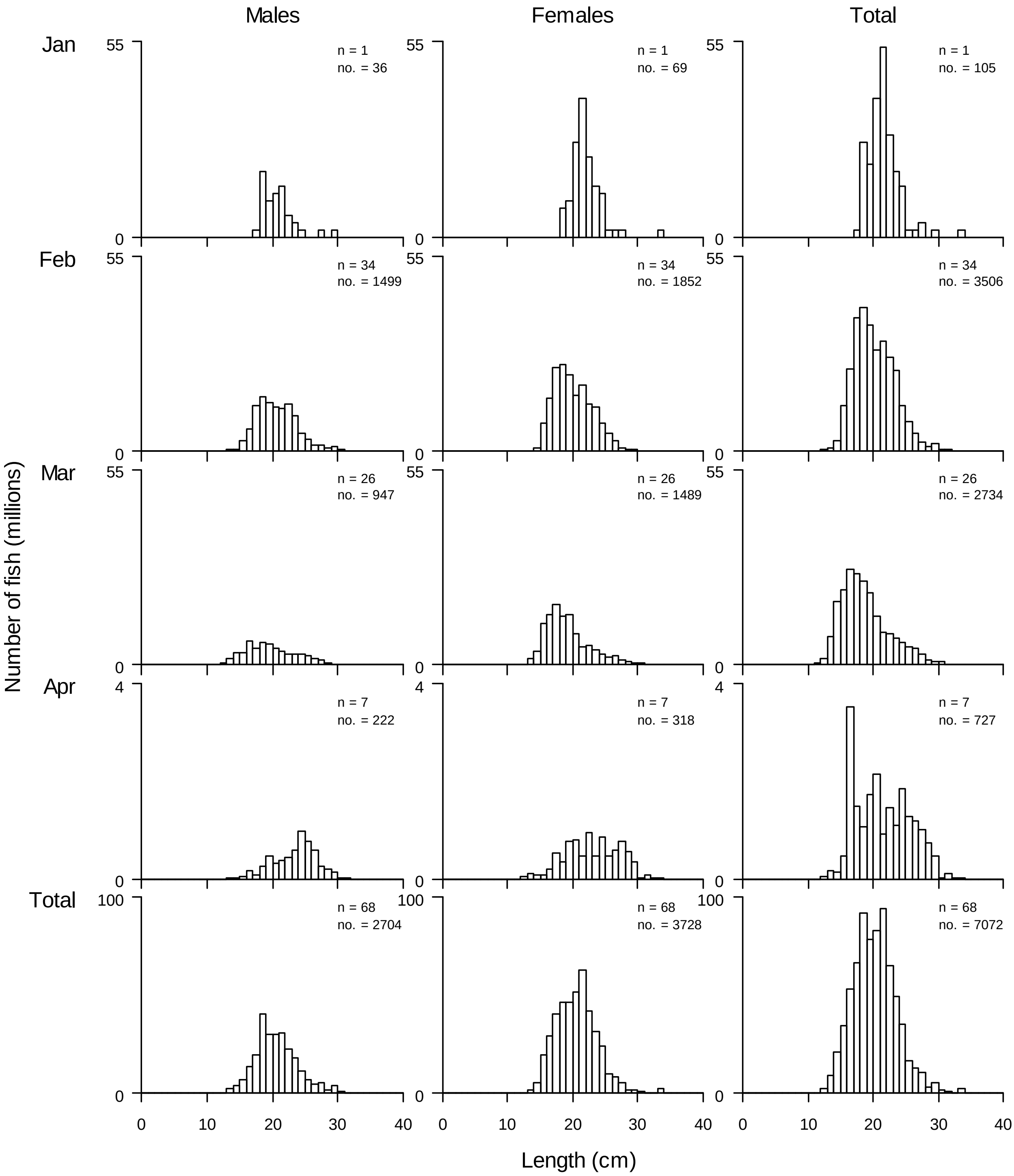


Figure B4j: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 1999 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

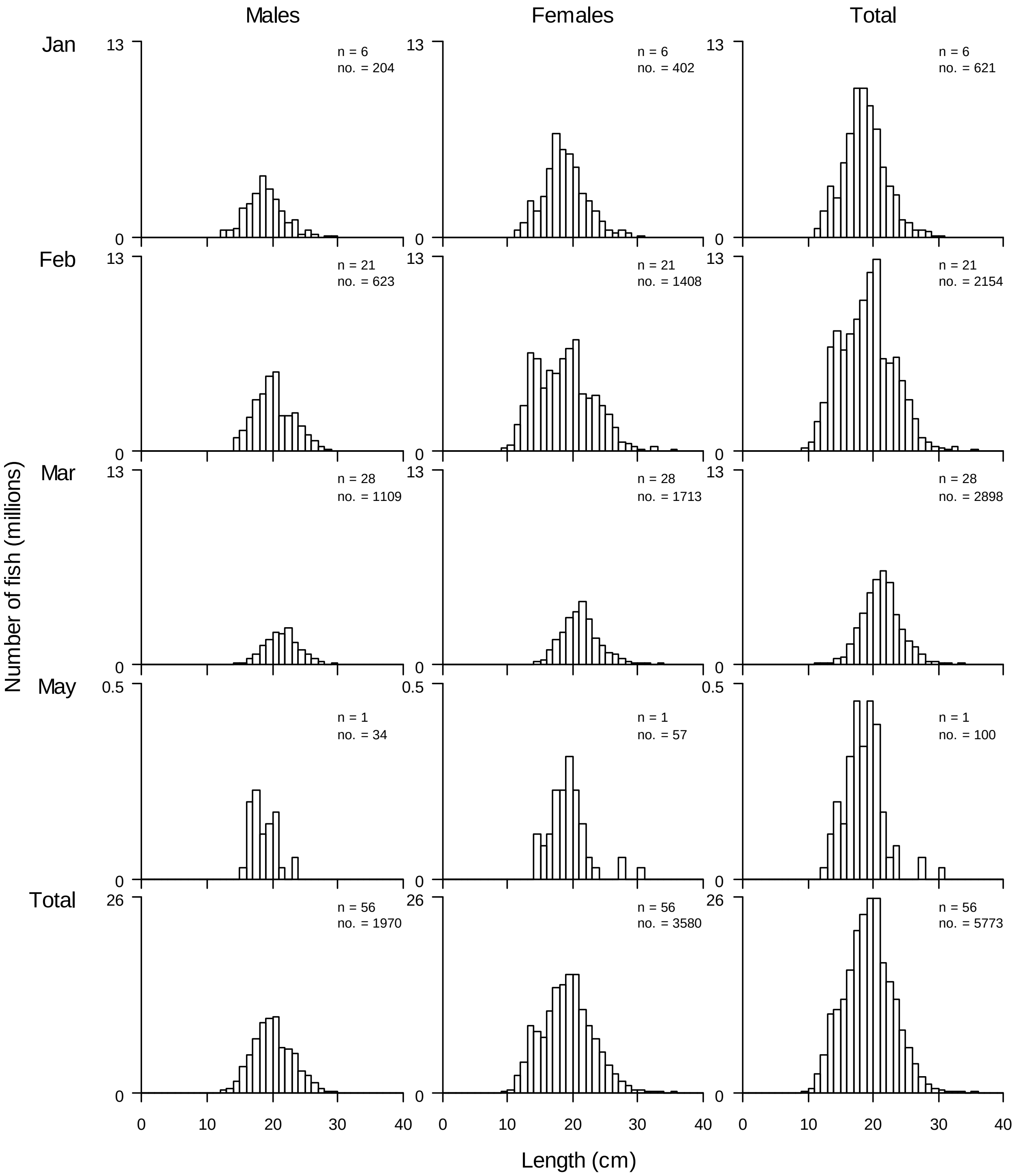


Figure B4k: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 2000 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

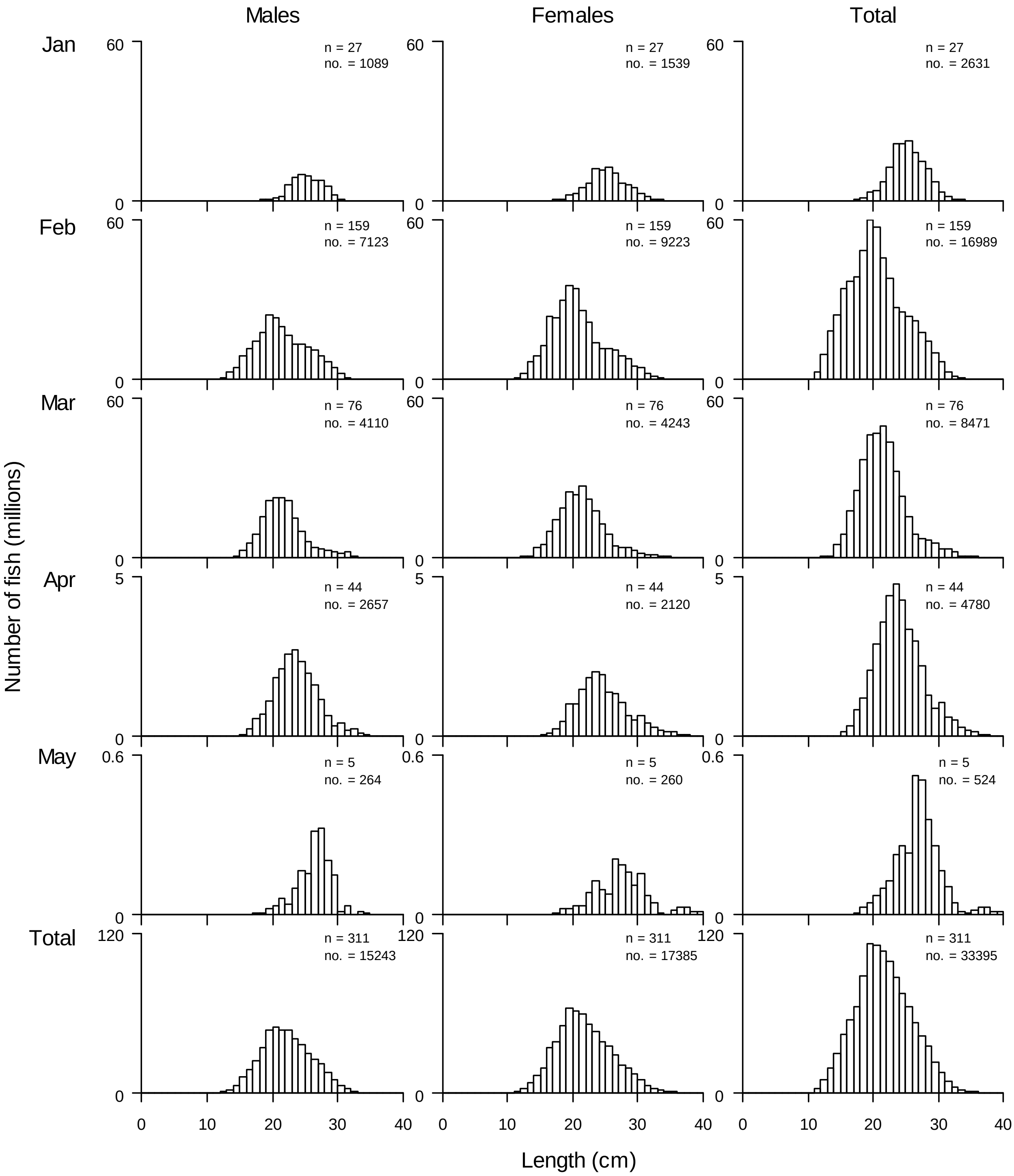


Figure B4l: Scaled length frequency distributions of arrow squid by month and overall sampled by the observer programme in 2008 in the SNARES SHELF region (n, number of tows sampled; no., number of fish sampled).

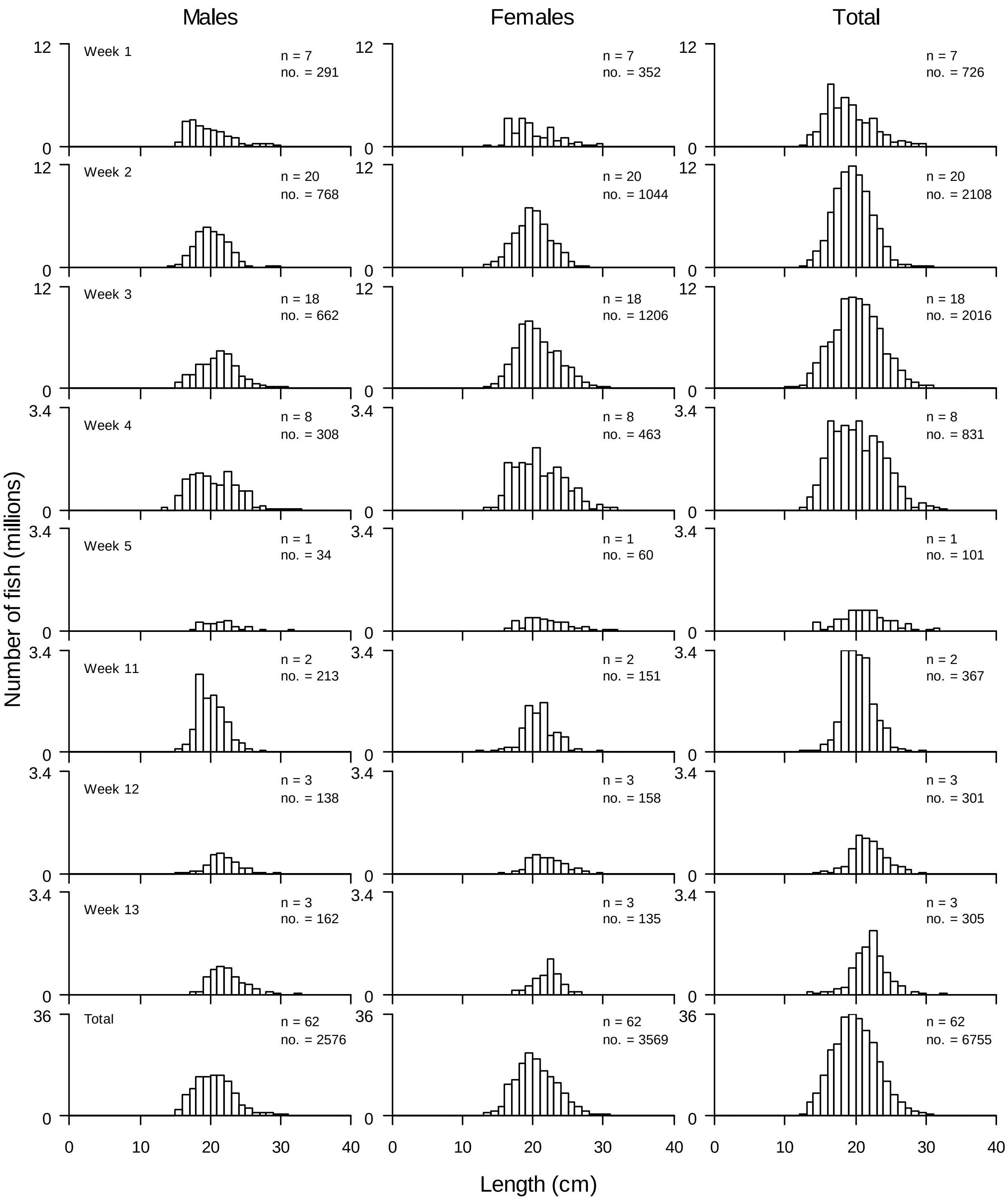


Figure B5a: Length frequency of arrow squid taken in target arrow squid commercial catches from the Snares Shelf trawl fishery 1990 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

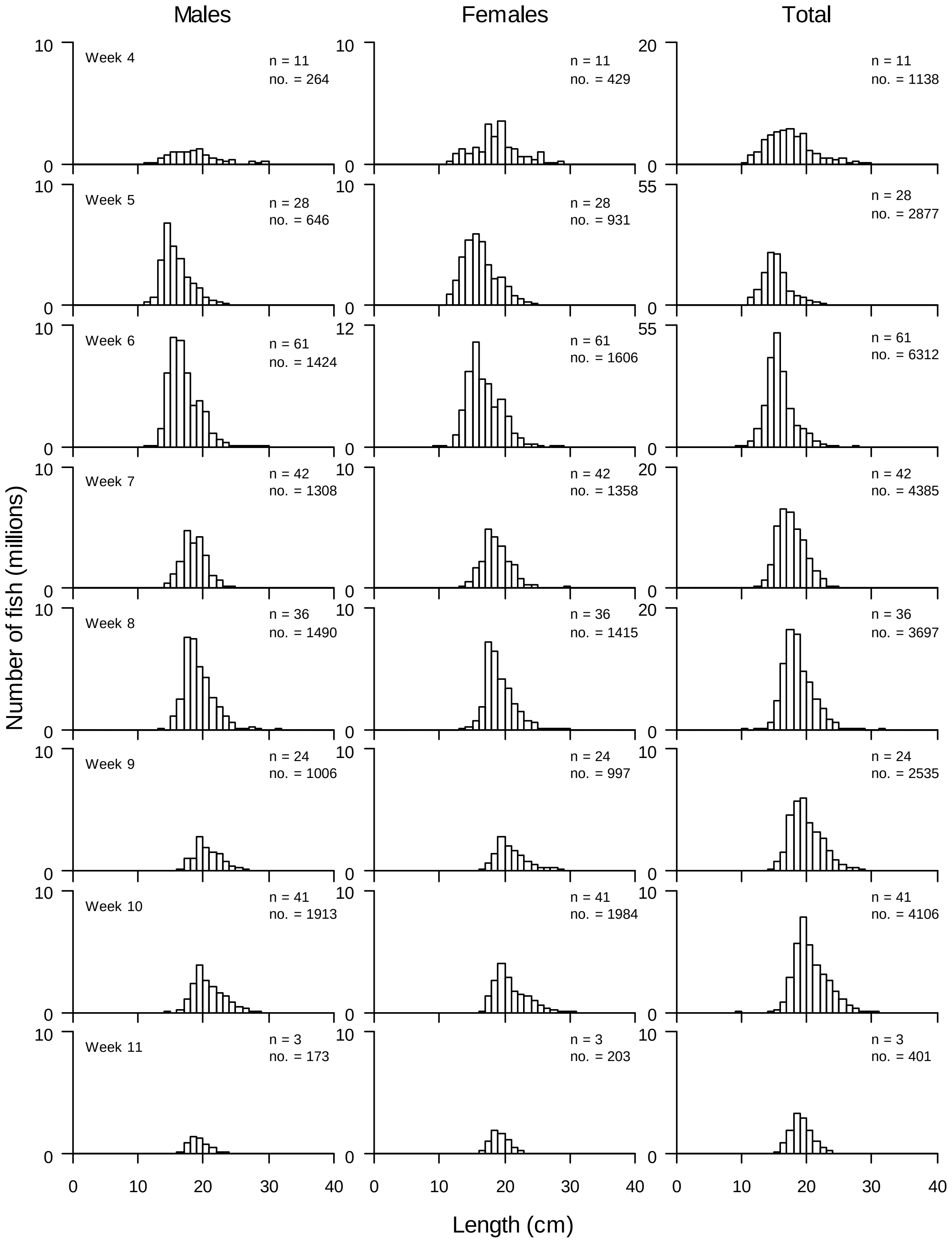


Figure B5b: Length frequency of arrow squid taken in target arrow squid commercial catches from the Snares Shelf trawl fishery 1991 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

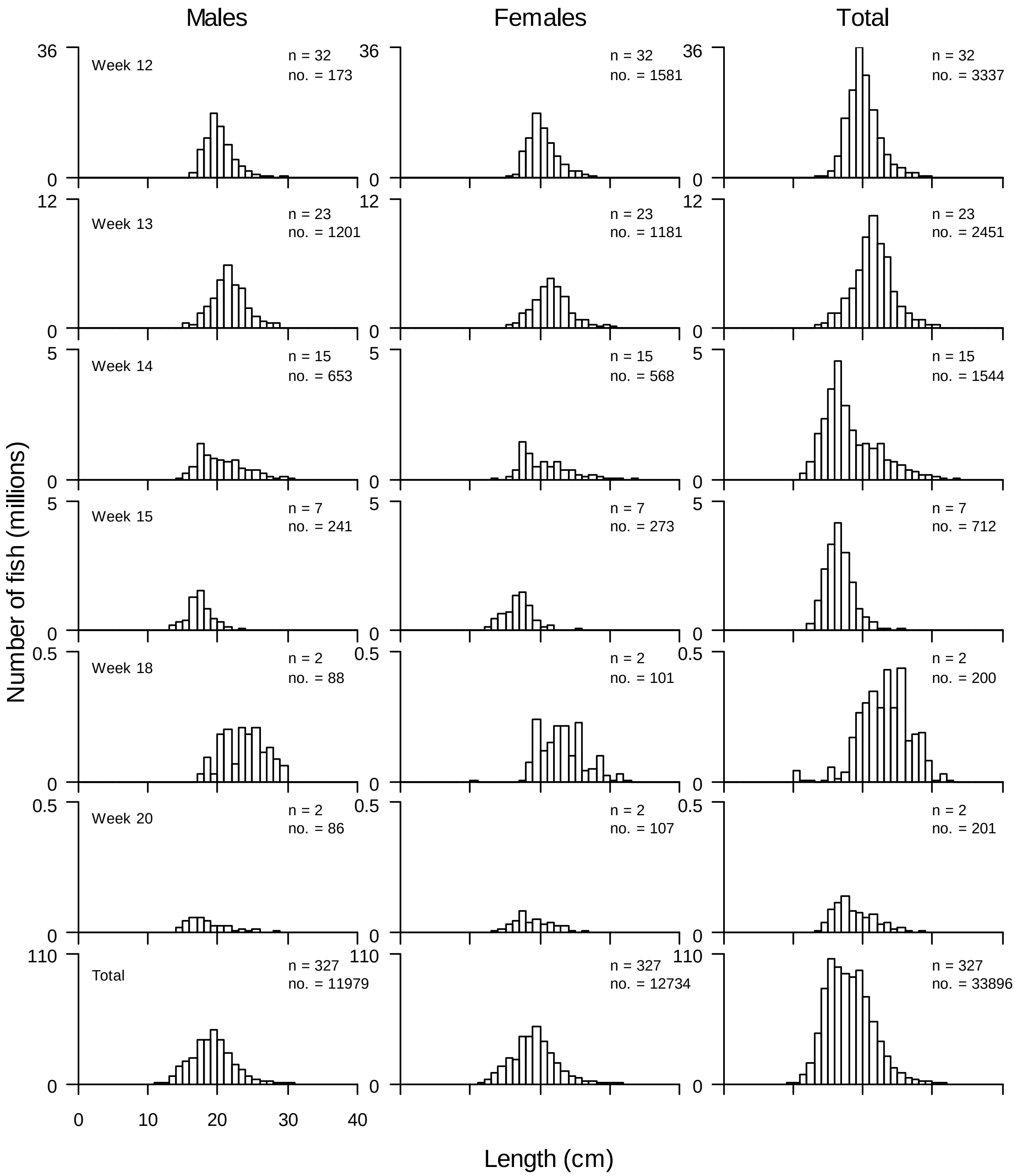


Figure B5b continued: Snares Shelf trawl fishery 1991 length frequencies.

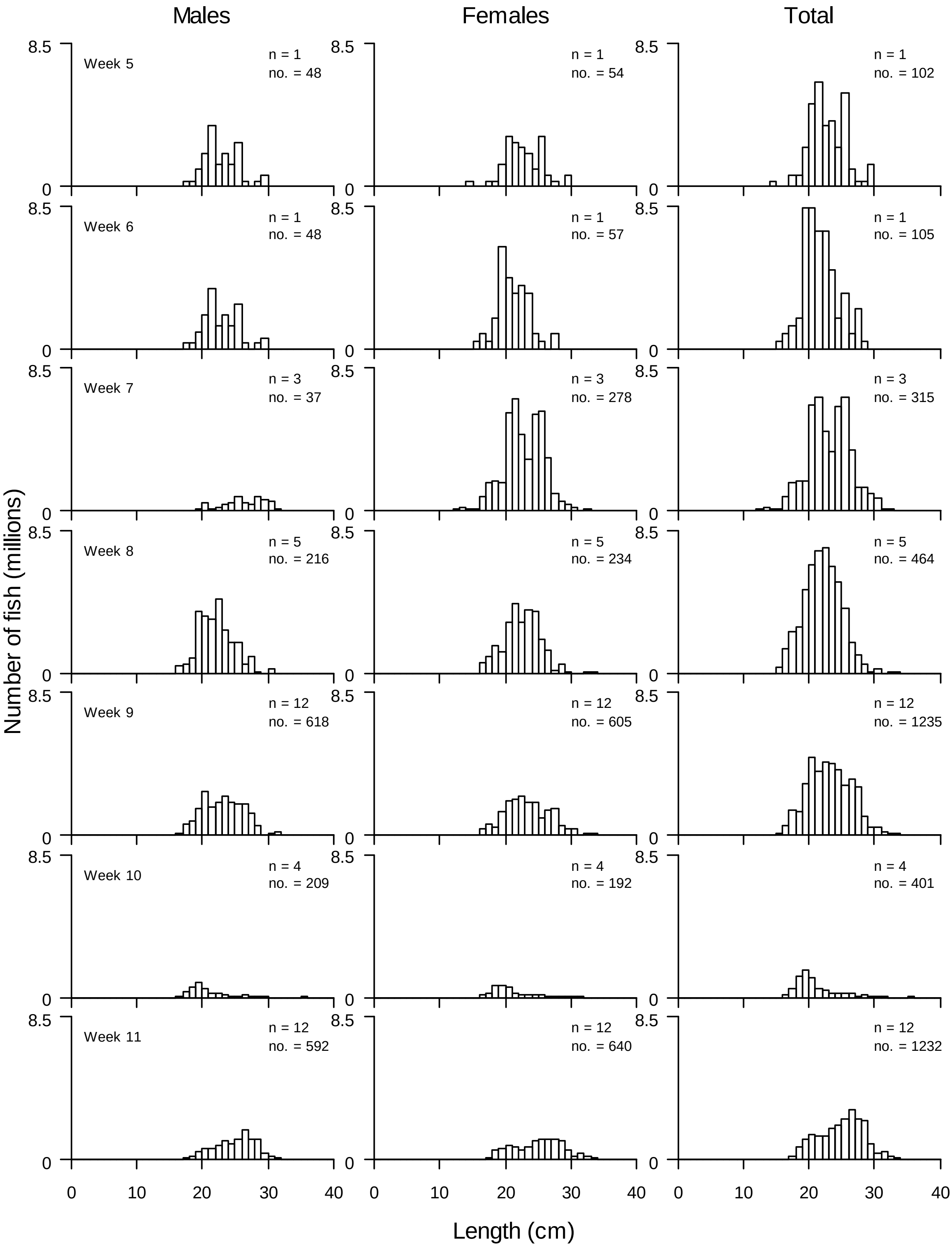


Figure B5c: Length frequency of arrow squid taken in target arrow squid commercial catches from the Snares Shelf trawl fishery 1994 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

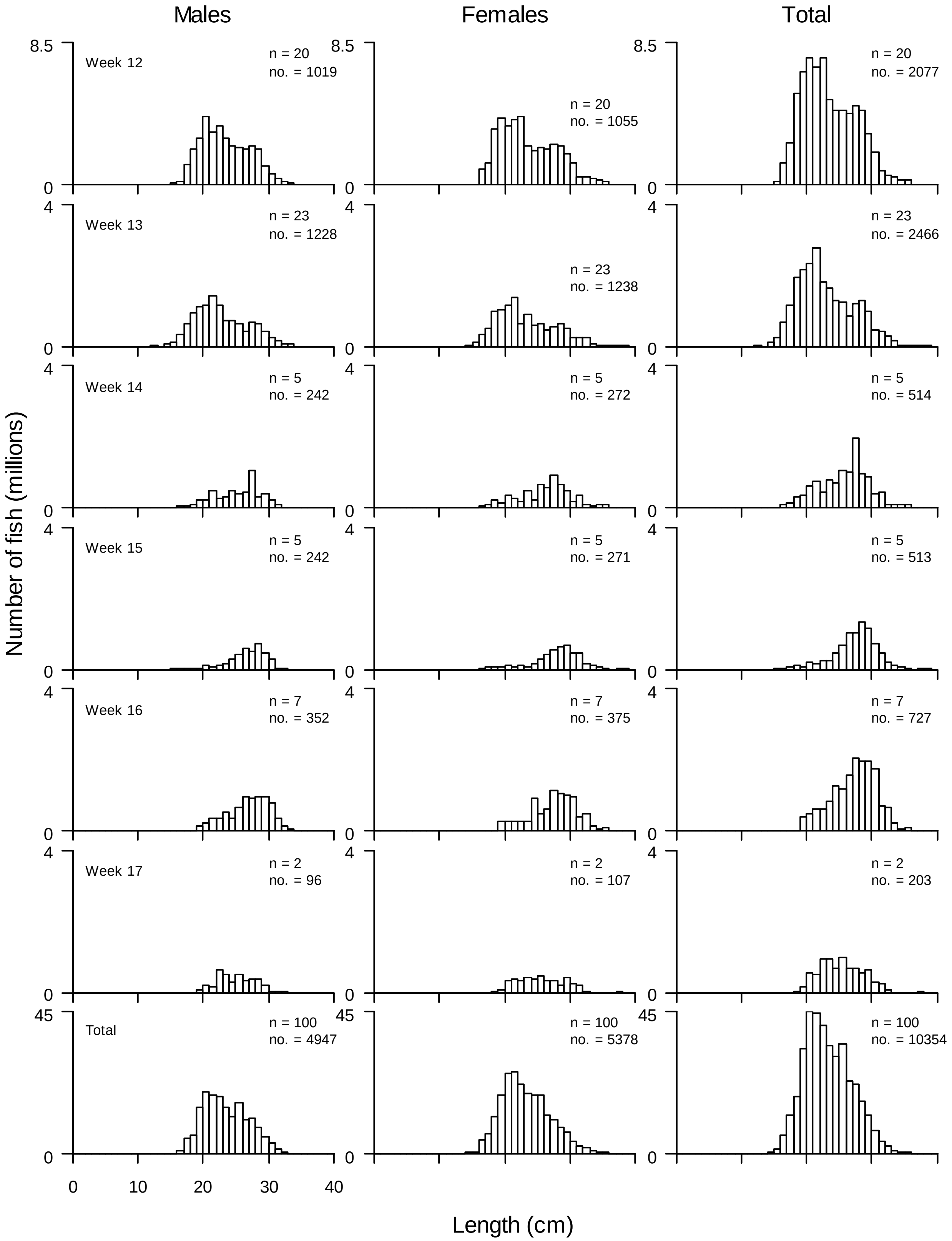


Figure B5c continued: Snares Shelf trawl fishery 1994 length frequency.

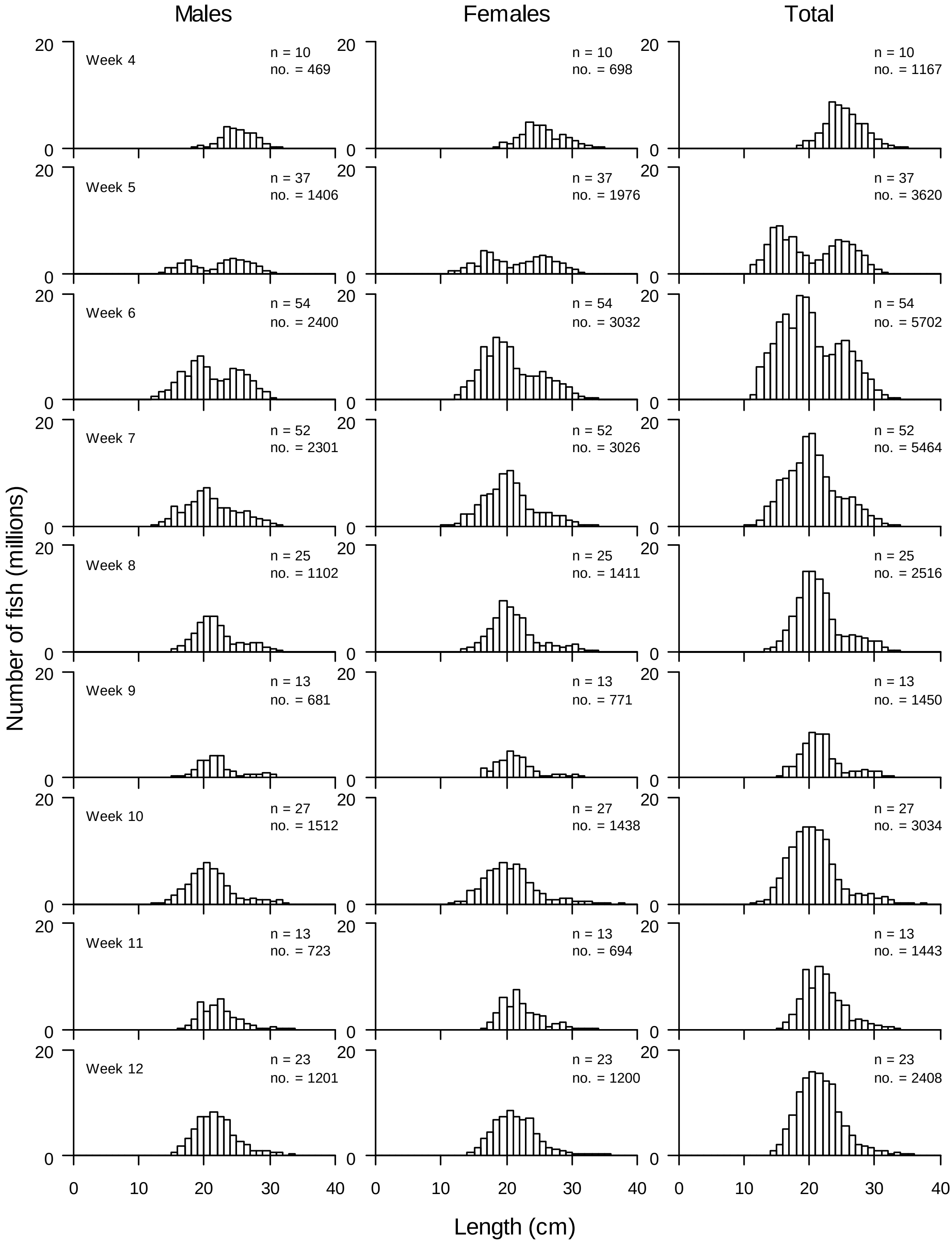


Figure B5d: Length frequency of arrow squid taken in target arrow squid commercial catches from the Snares Shelf trawl fishery 2008 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

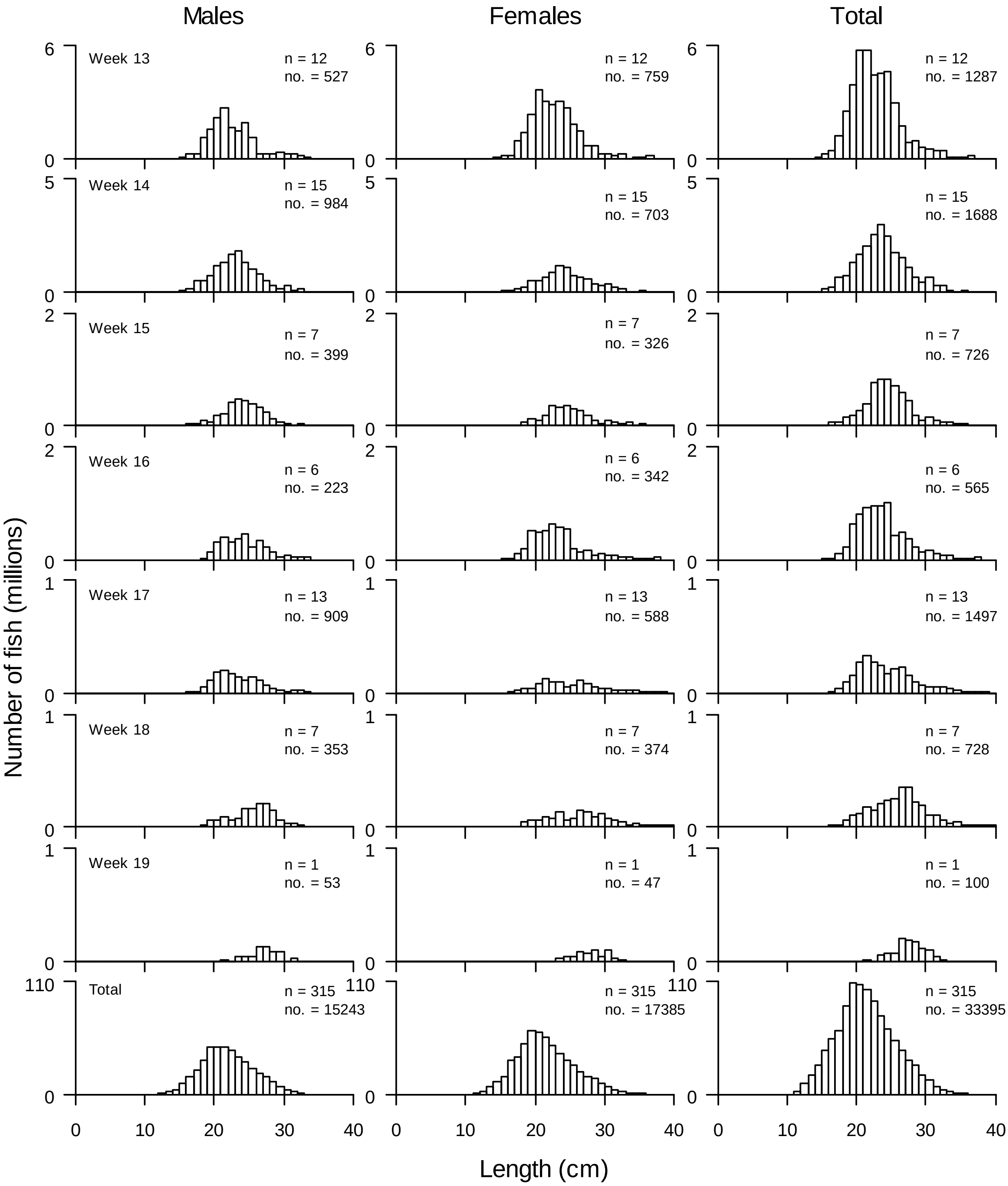


Figure B5d continued: Snares Shelf trawl fishery 2008 length frequency.

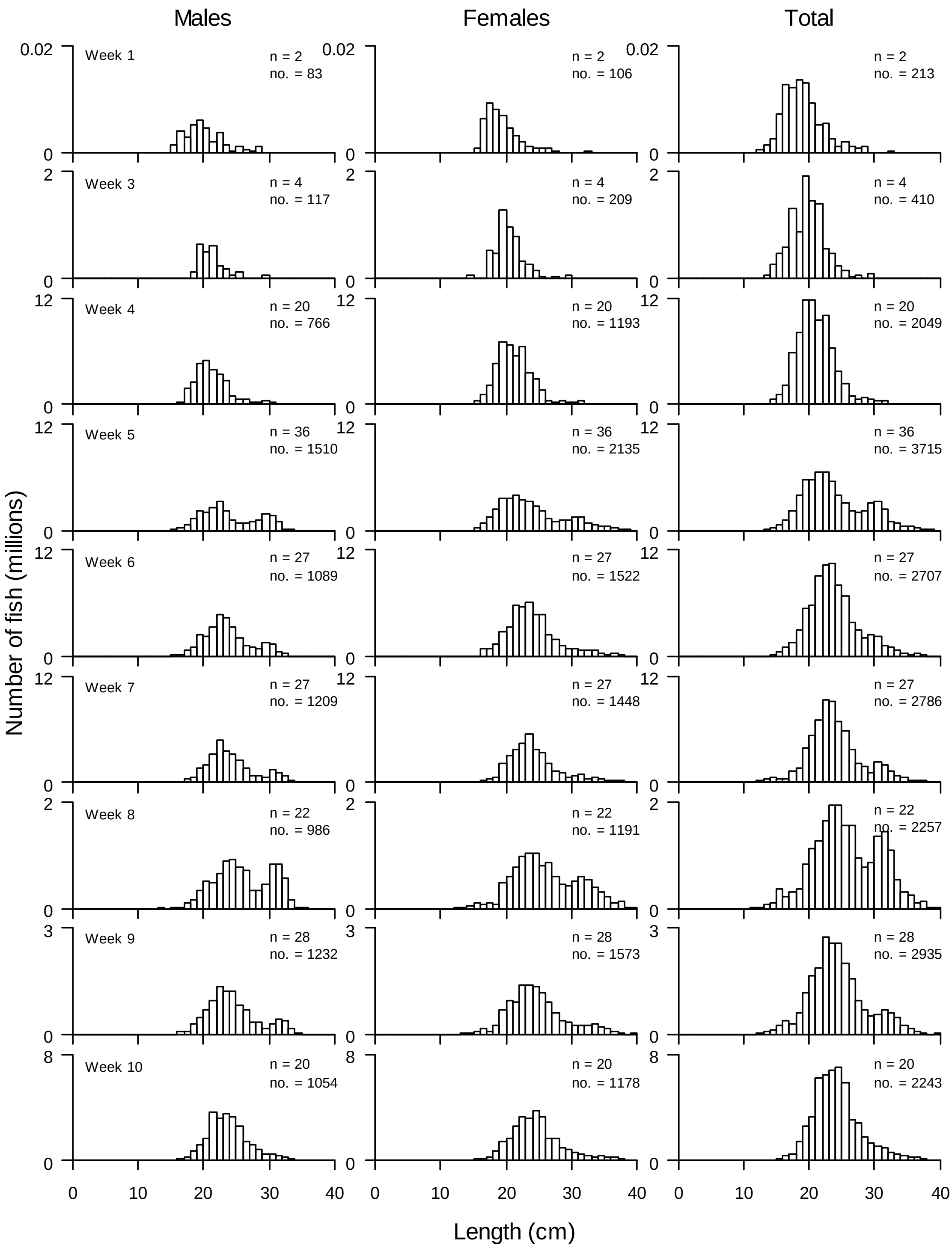


Figure B5e: Length frequency of arrow squid taken in target arrow squid commercial catches from the Auckland Islands trawl fishery 1990 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

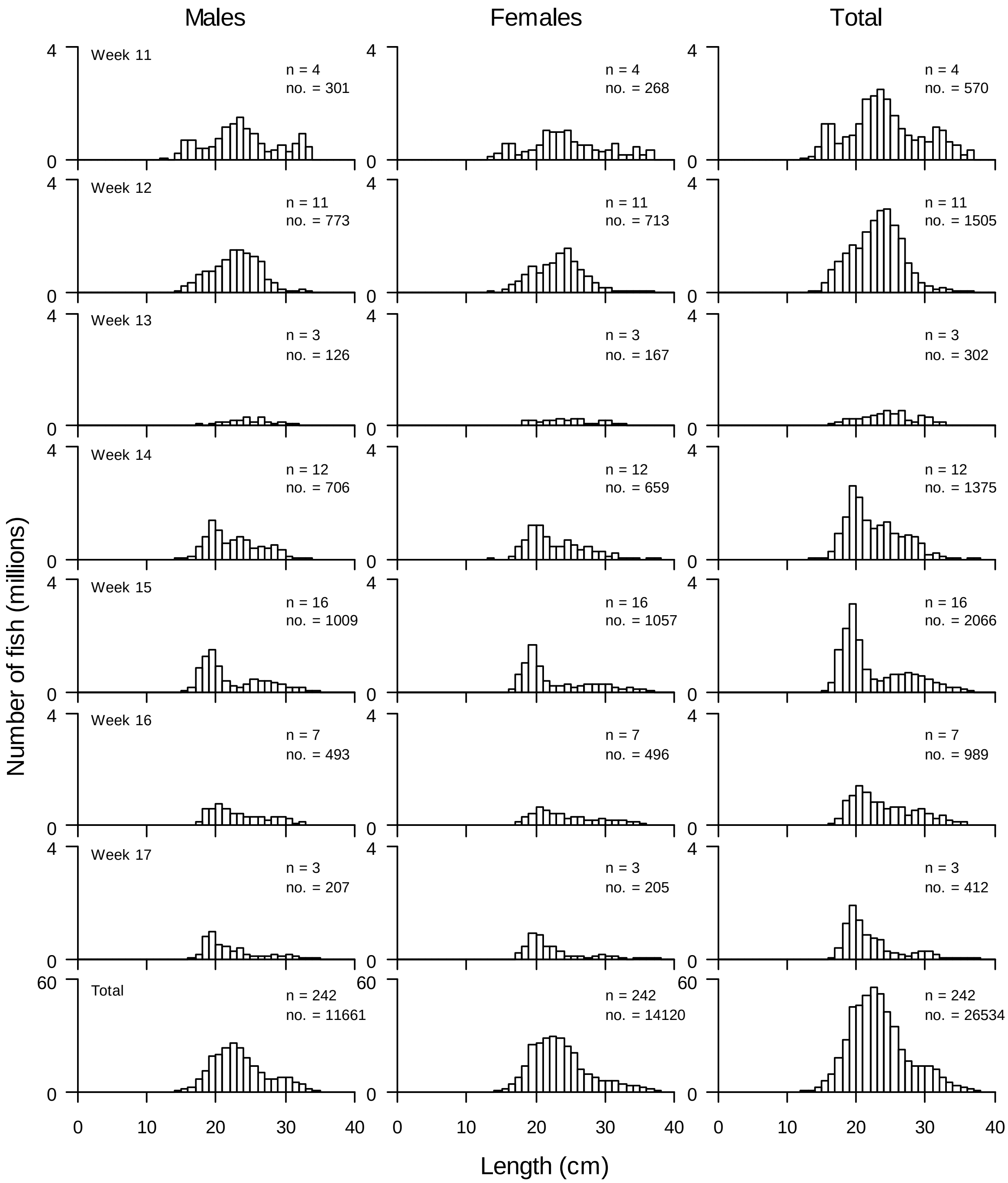


Figure B5e continued: Auckland Islands trawl fishery 1990 length frequency.

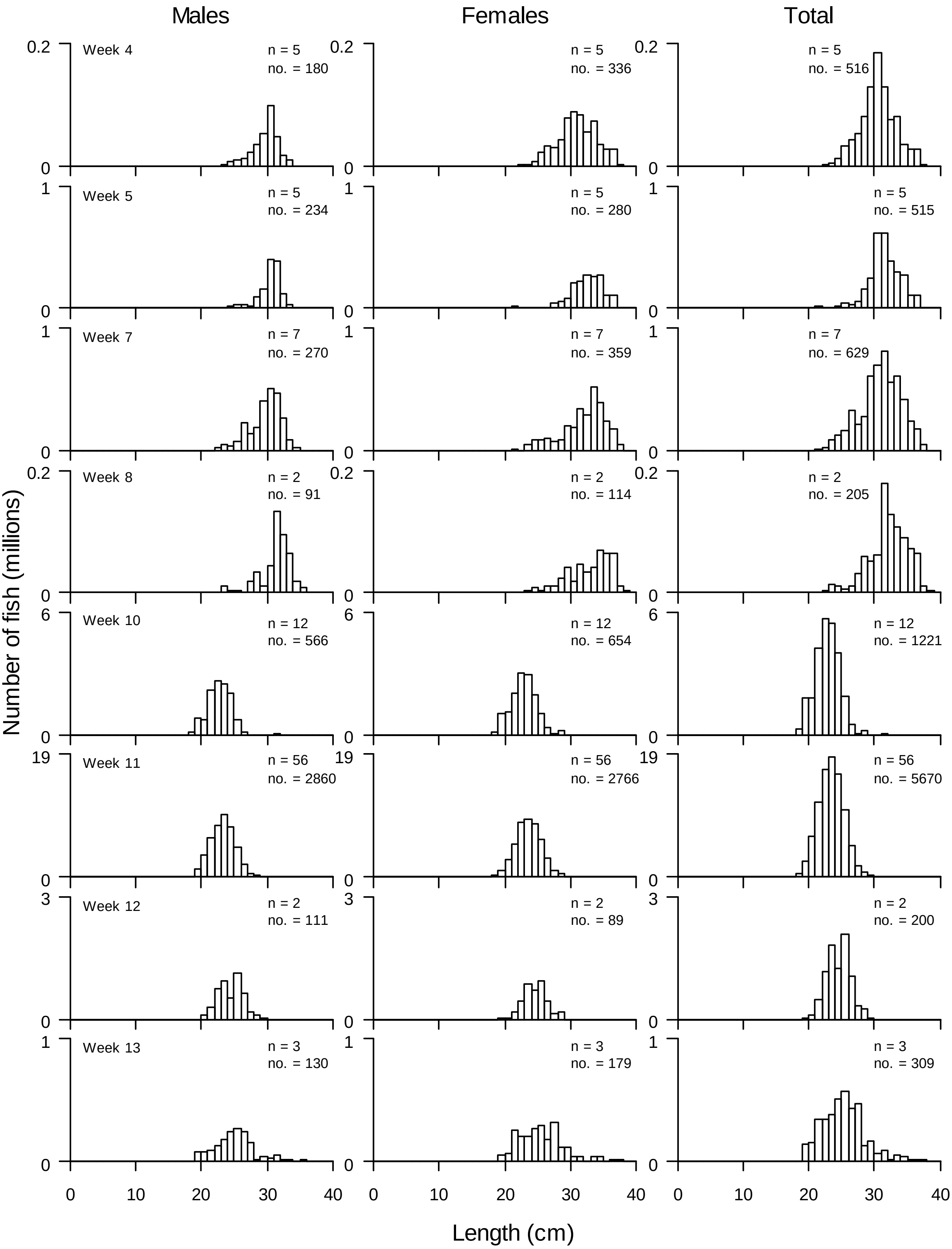


Figure B5f: Length frequency of arrow squid taken in target arrow squid commercial catches from the Auckland Islands trawl fishery 1991 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

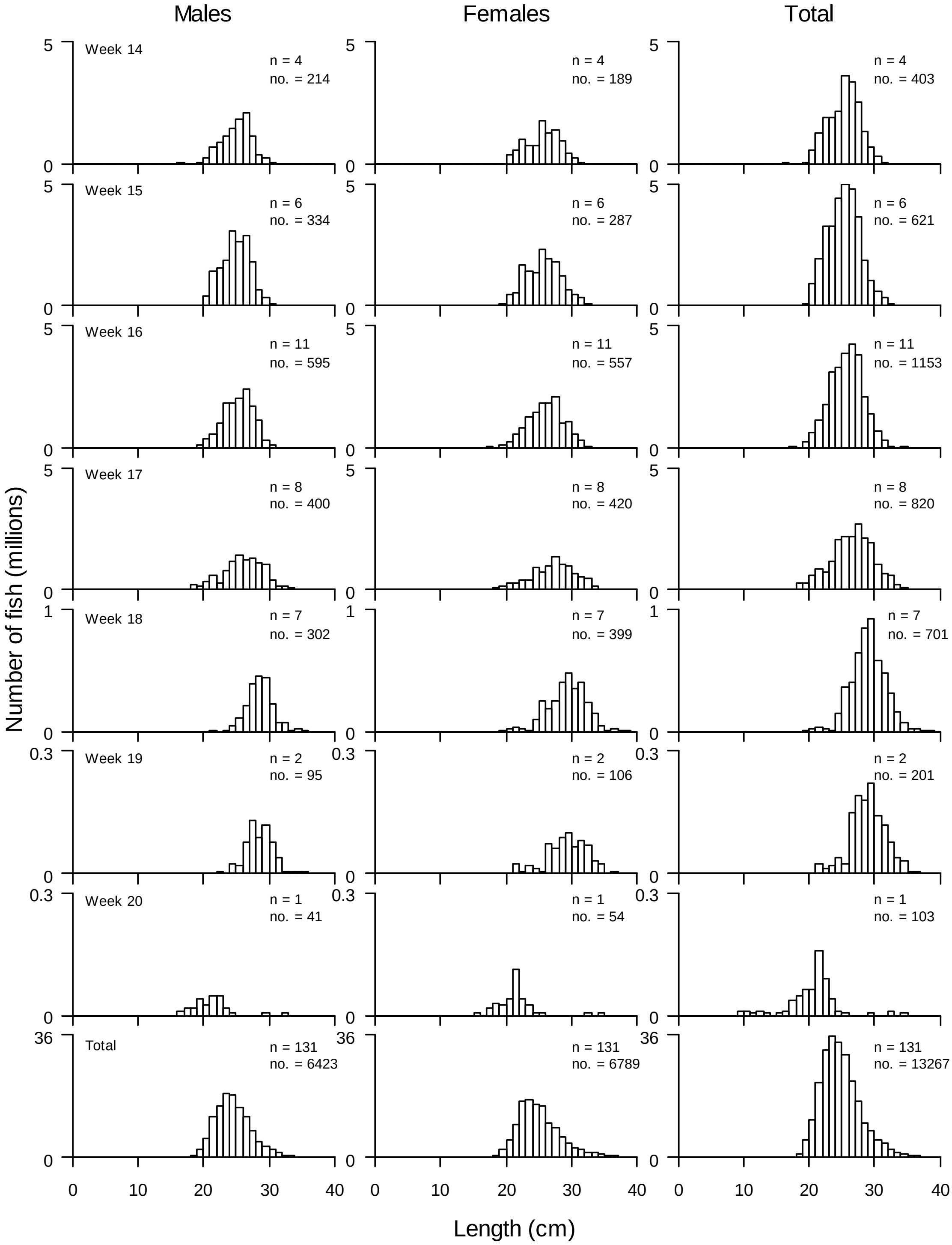


Figure B5f continued: Auckland Islands trawl fishery 1991 length frequency.

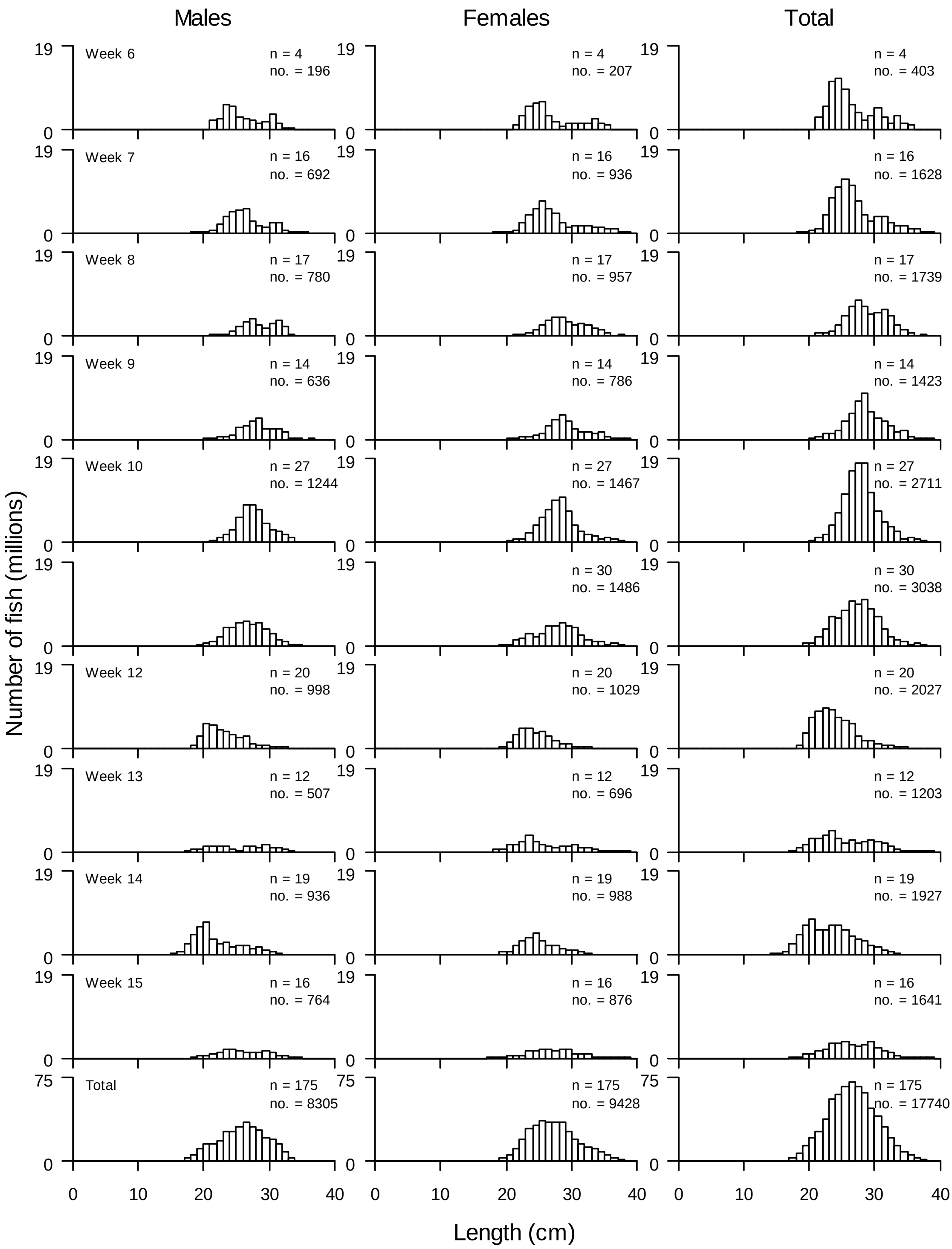


Figure B5g: Length frequency of arrow squid taken in target arrow squid commercial catches from the Auckland Islands trawl fishery 1994 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

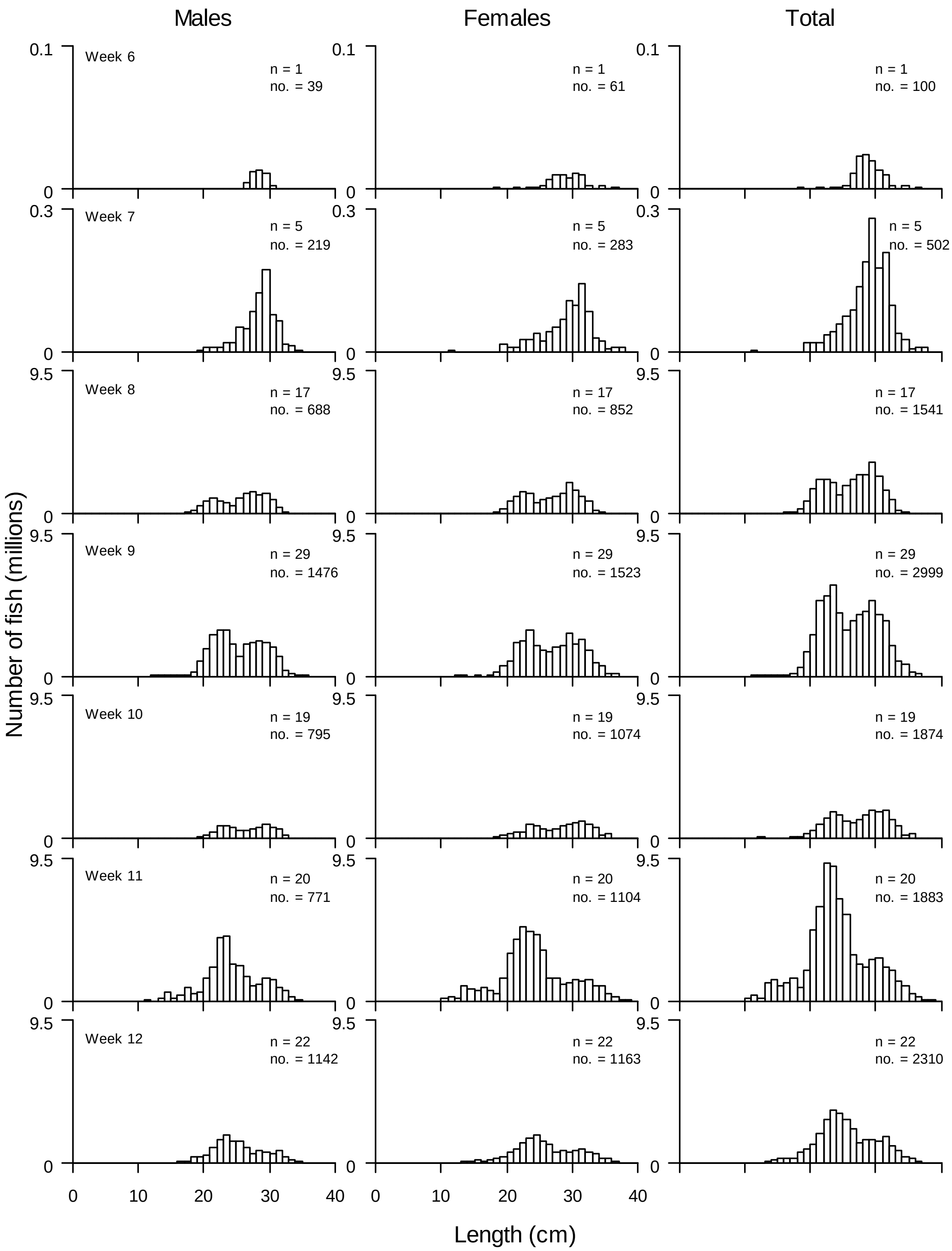


Figure B5h: Length frequency of arrow squid taken in target arrow squid commercial catches from the Auckland Islands trawl fishery 2008 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

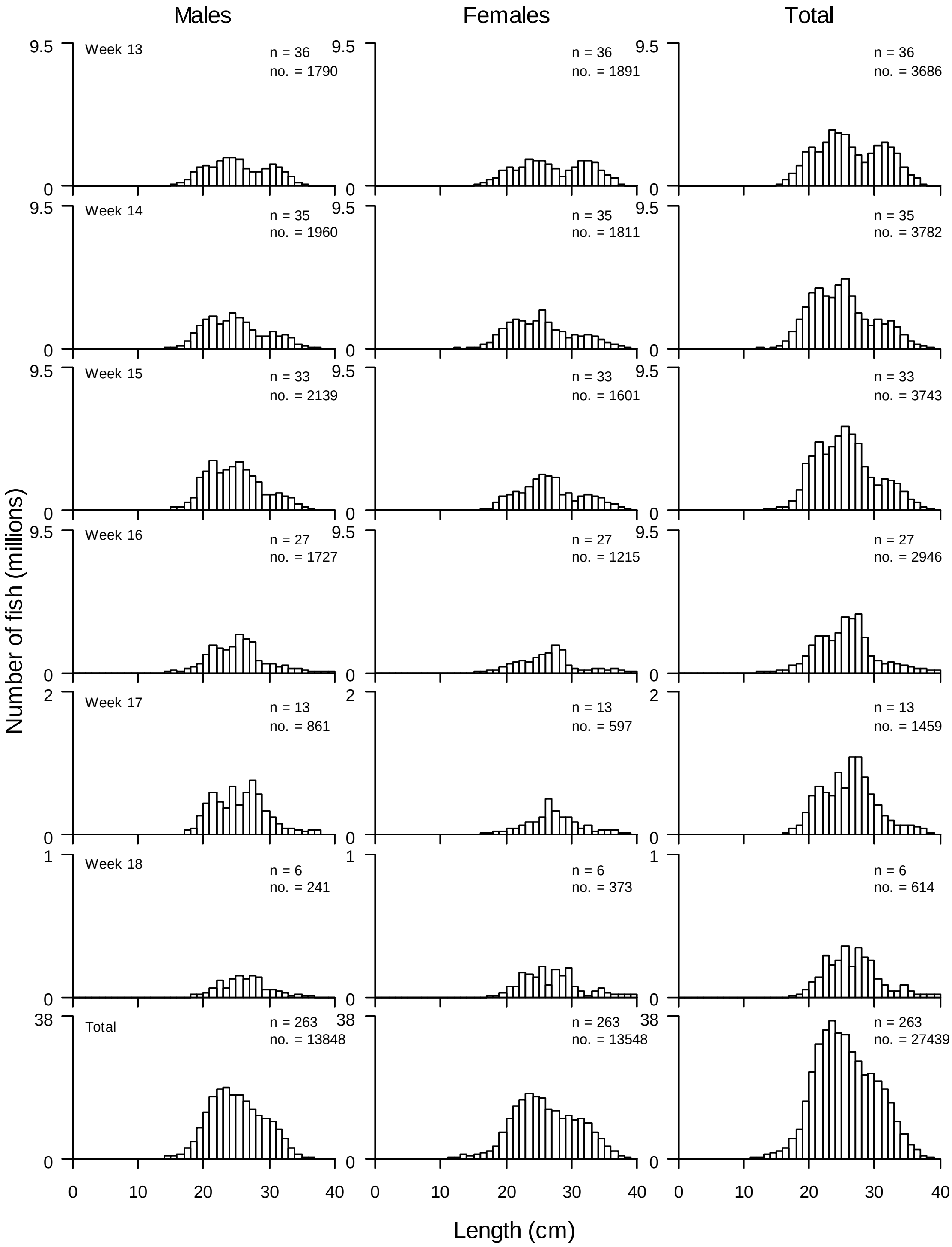


Figure B5h continued: Auckland Islands trawl fishery 2008 length frequency.

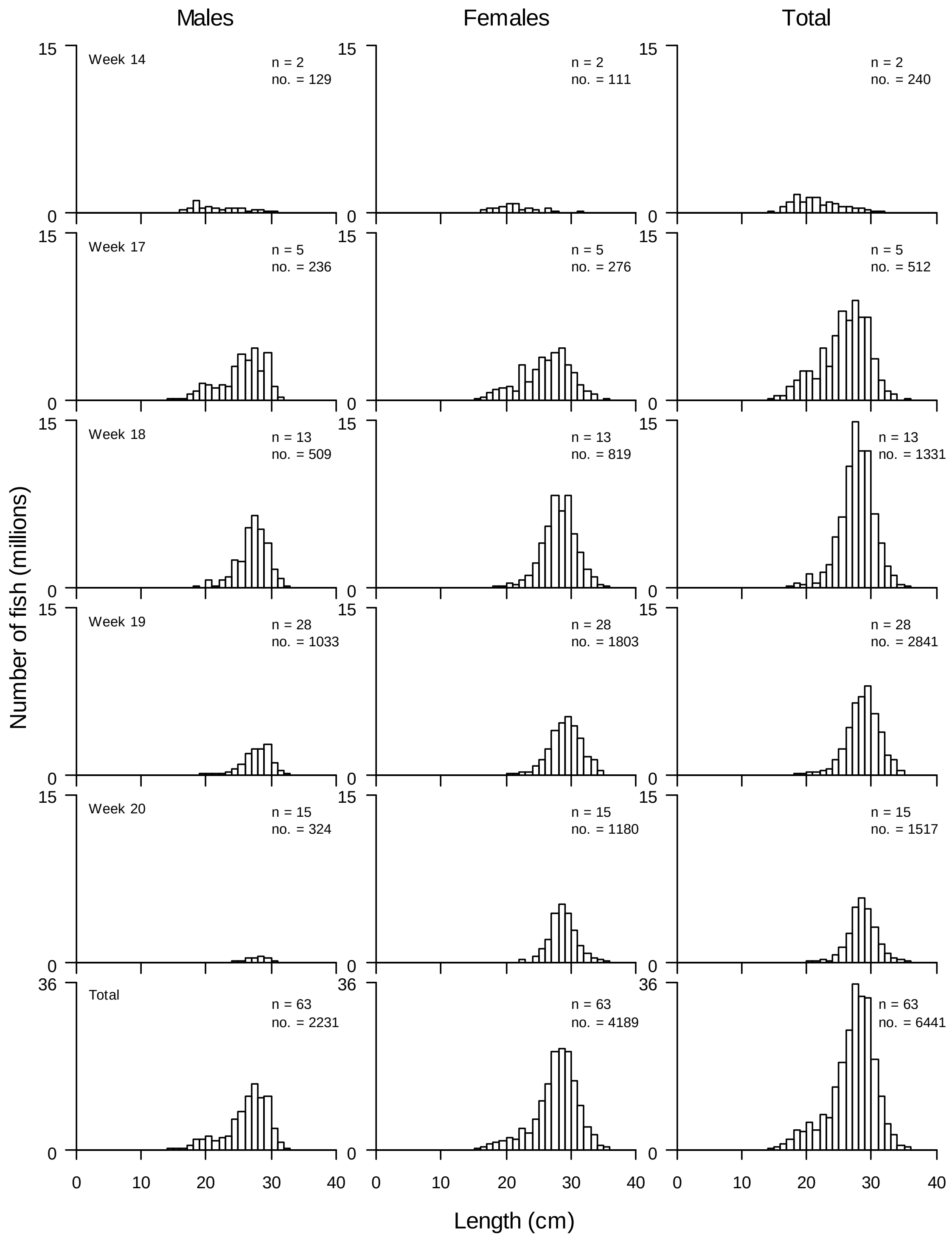


Figure B5i: Length frequency of arrow squid taken in target arrow squid commercial catches from the ECSI trawl fishery 1994 sampled by the Observer Programme (n, number of tows sampled; no., number of fish sampled).

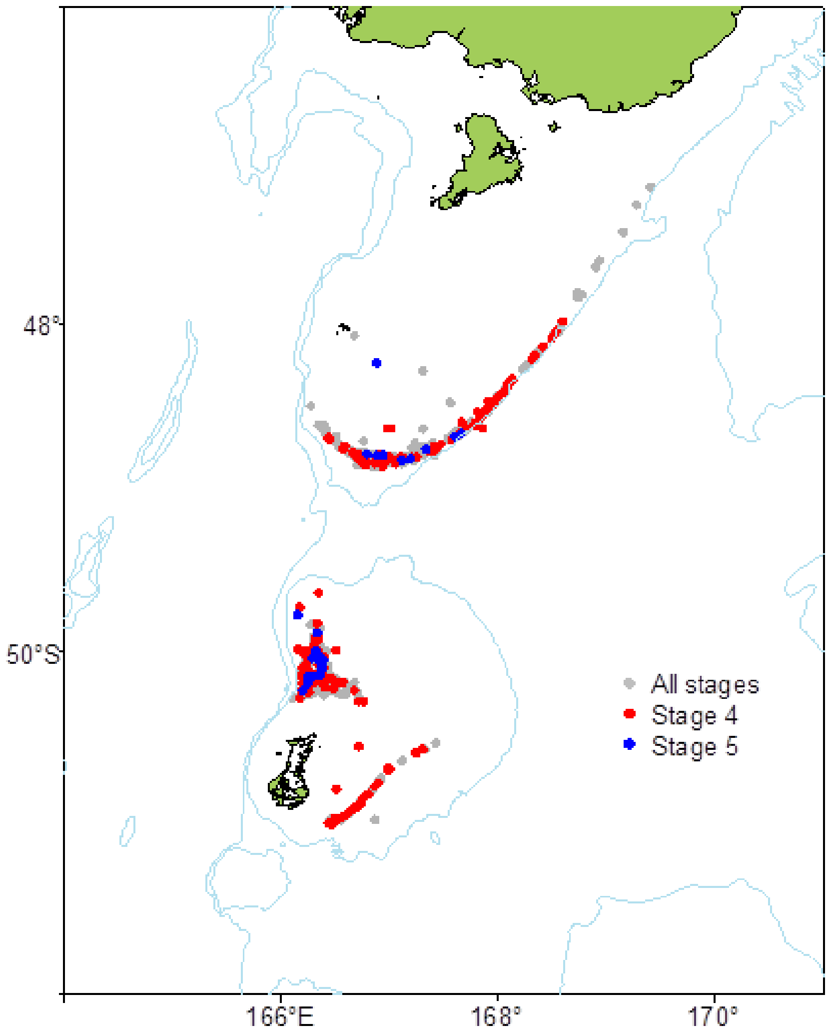


Figure B6: Location of observed squid by gonad stages

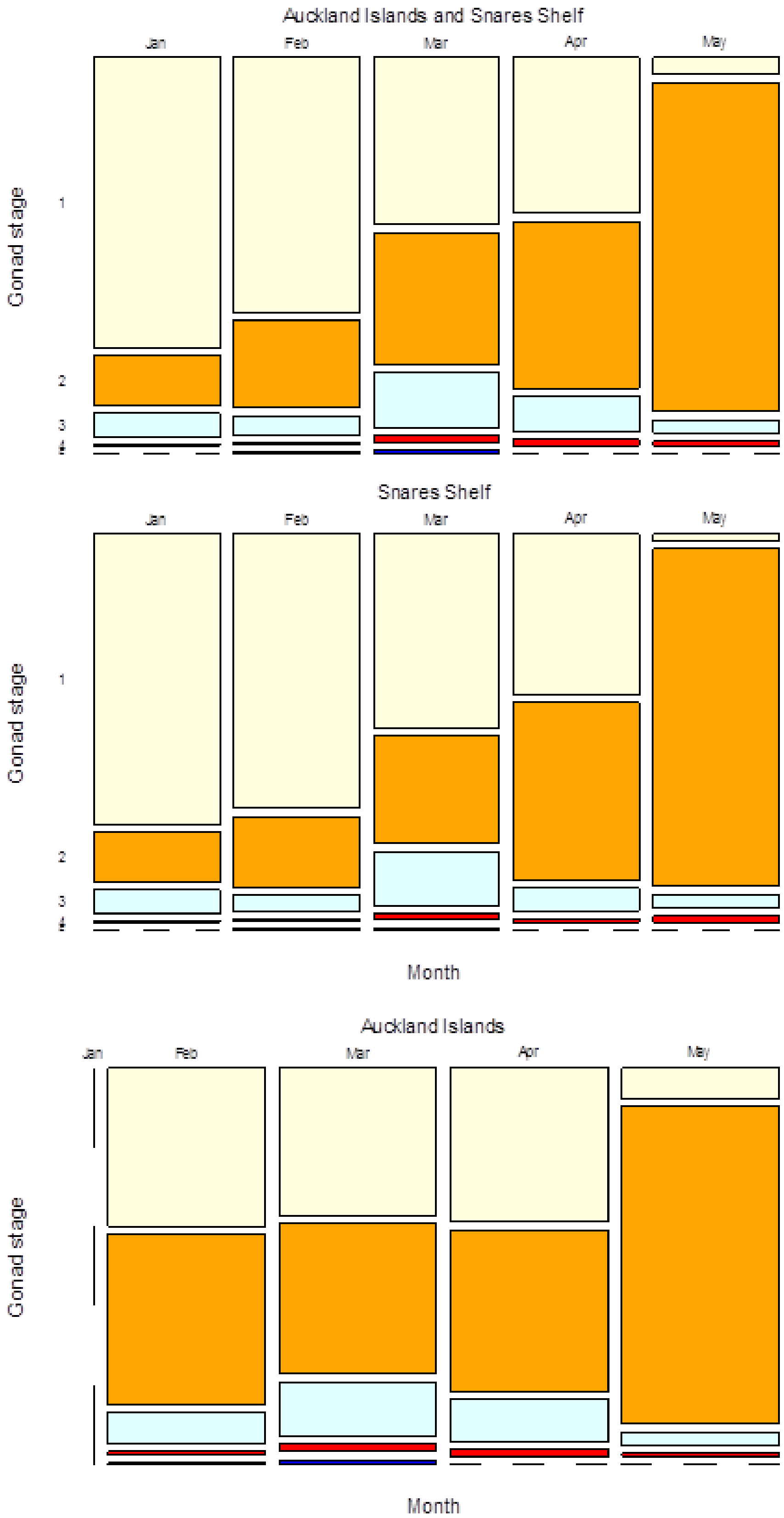


Figure B7: Proportion of observed 2008 squid gonad stages for target squid samples where female squid were staged by month and area. No data for January 2008 in the Auckland Islands area.

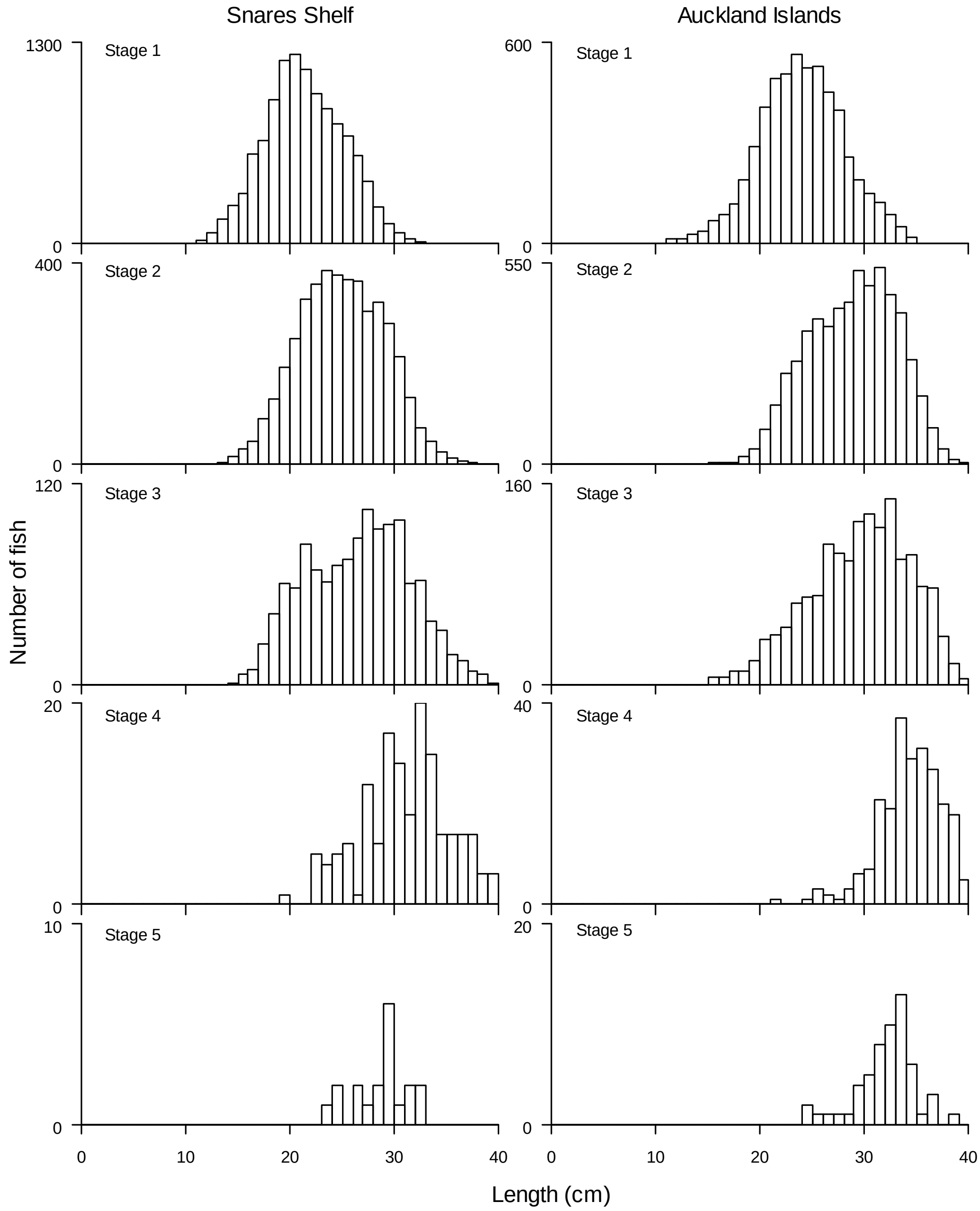


Figure B8: Unscaled length frequency of arrow squid taken in target arrow squid commercial catches by gonad stage from the Snares Shelf and Auckland Islands 2008 trawl fishery sampled by the Observer Programme.

17. APPENDIX C. FISHERY CHARACTERISATION

Table C1a: List of tables and fields requested in the Ministry of Fisheries extract 7426.

Fishing_events table

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

Landing_events table

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

Estimated subcatch table

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

Process data table

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

Vessel_history table

- Vessel_key
- Flag_nationality_code
- Built_year
- Engine_kilowatts
- Gross_tonnes
- Overall_length_metres
- History_start_datetime
- History_end_datetime

Table C1b: Summary of variables across three form types in Ministry of Fisheries extract 7426.

Variable	Data Form		
	TCEPR	CELR	SJCER
Vessel key	●	●	●
Flag nationality code	●	●	●
Year built	●	●	●
Engine kilowatts	●	●	●
Gross tonnes	●	●	●
Overall length (m)	●	●	●
Trip	●	●	●
Start date of trip	●	●	●
End date of trip	●	●	●
Start date of fishing	●	●	●
End date of fishing	●		●
Start time of fishing	●		●
End time of fishing	●		●
Start latitude (full accuracy)	●		●
Start longitude (full accuracy)	●		●
End latitude (full accuracy)	●		
End longitude (full accuracy)	●		
Start stats area code	●	●	●
Primary method (fishing method)	●	●	
Target species	●	●	●
Depth of bottom	●		●
Effort depth (TCEPR: Depth of net, SJCER: Depth deepest lure)	●		●
Pair trawl yn	●		
Effort height (Headline height)	●	●	
Effort width (Wingspread)	●	●	
Effort speed (Fishing speed)	●		
Fishing duration	●	●	●
Effort num (CELR: No tows; SJCER: No single jig reels used)		●	●
Effort num 2 (No double jig reels used)			●

Table C2: Characterisation Reference Tables

(a) Description of forms used and abbreviations used in this report if different from form type.

Form type	Abbreviation	Form name	
TCEPR	TCP	Trawl Catch Effort Processing Return	
CELR	CEL	Catch Effort Landing Return	**introduced in 1989–90** **30 different fishing methods**
LCER		Lining Catch Effort Return	**introduced in Jan 2004** **replaces CELR lining for vessels > 28 m**
SJCER	SJC	Squid Jigging catch effort Return	**introduced in August 1990**
NCELR	NCE	Netting Catch Effort and Landing Return	**introduced in Oct 2006** **Replaces setnet, driftnet, pair setnet for vessels ≥ 6 m reporting on CELR form**
TCER	TCE	Trawl Catch Effort Return	**introduced in Oct 2007** **replaces CELR for trawling vessels 6-28 m reporting on CELR form**
LTCER	LTC	Lining Trip Catch Effort Return	**introduced in Oct 2007** **replaces CELR for lining vessels 6-28 m reporting on CELR – trip based form**
TLCER	TUN	Tuna Long lining Catch Effort Return	**introduced in Oct 1990** surface lining targeting tuna
CLR	CLR	Catch Landing Return	**introduced in 1989–90** **includes landings from TCEPR, TCER, TCLER, LCER, LTCER** also includes high seas landings from HS TCEPR, HS TCER, HS TLCER, HS LCER

(b) Species codes

Species code	Species name	Scientific name
BAR	Barracouta	*Thyrsites atun*
HOK	Hoki	*Macruronus novaezelandiae*
JMA	Jack mackerel	*Trachurus declivis, T. s. murphyi, T. novaezelandiae*
LIN	Ling	*Genypterus blacodes*
RCO	Red cod	*Pseudophycis bachus*
SQU	Arrow squid	*Nototodarus sloanii, N. gouldi*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
WAR	Common warehou	*Seriolella brama*

(c) Method codes

Species code	Method description
BLL	Bottom longlining
BPT	Bottom pair trawl
BT	Bottom trawl
MW	Midwater trawl
DS	Danish seining single
PS	Purse seining
SJ	Squid jigging
T	Trolling

(d) Processed state codes and conversion factors and period of usage

State code	Description	Conversion factor	Start date	End date
TEN	Tentacles	4.300	1/10/1998	1/01/3000
GUT	Gutted	1.100	1/10/1986	30/09/1990
GUT	Gutted	1.350	1/10/1990	1/01/3000
HGU	Headed and gutted	2.000	1/10/1986	30/09/1990
HGU	Headed and gutted	1.900	1/10/1990	30/09/3000
TRU	Trunked	2.000	1/10/1986	30/09/1990
DRE	Dressed	1.900	1/10/1990	30/09/3000
FIL	Fillets skin-on	2.000	1/10/1986	30/10/1991
GGU	Gilled and gutted	1.100	1/10/1986	30/09/1990
HGT	Headed gutted and tailed	2.000	1/10/1986	30/09/1990
ACC	Accidental loss	1.000	1/10/1986	1/01/3000
DIS	Discarded	1.000	1/10/1990	1/01/3000
EAT	Eaten	1.000	1/10/1990	1/01/3000
GRE	Green or whole	1.000	1/10/1986	1/01/3000
MEA	Mealed	5.556	1/10/1986	30/09/1990
MEA	Mealed	5.600	1/10/1990	1/01/3000
HET	Head and tentacles	0.000	1/10/1986	1/01/3000
BEA	Beak and mouth	0.000	1/10/1986	1/01/3000
GBP	Gut by product	0.000	1/10/1986	1/01/3000
HDS	Heads	0.000	1/10/1986	1/01/3000
MEB	Fish meal by product	0.000	1/10/1986	1/01/3000
ROE	Roe	0.000	1/10/1986	1/01/3000
TNB	Tentacles by product	0.000	1/10/1986	1/01/3000
WIN	Squid wings	0.000	1/10/1986	1/01/3000

Table C3: Total arrow squid catches (tonnes) by fishing year, from 1989–90, using different data sources. Excludes data with no fish stock code. Estimated totals include estimated catch from TCEPR, HTC, TCER, CELR, and LTCER forms and processed catch from SJCER and TLCER forms. CLR and CELR landings include and exclude SQUET (ET) and transhipments (T). Reported landings are from the plenary document (Ministry of Fisheries 2009)..

		CLR and CELR landings				
Year	Estimated total	Exclude T Exclude ET	Include T Exclude ET	Exclude T Include ET	Include T Include ET	Reported landings
1989–90	26 806	25 868	31 589	25 868	31 589	46 915
1990–91	35 714	30 908	38 844	30 908	38 844	40 900
1991–92	56 805	53 030	64 608	53 030	64 608	60 509
1992–93	35 671	28 277	37 224	28 277	37 224	37 278
1993–94	69 408	51 386	71 241	51 387	71 241	74 492
1994–95	93 596	66 313	97 969	66 315	97 971	99 315
1995–96	55 862	43 302	59 840	43 302	59 840	62 668
1996–97	58 827	57 428	68 114	57 429	68 114	65 403
1997–98	41 747	40 745	41 776	40 745	41 776	45 362
1998–99	25 793	26 765	26 767	26 765	26 767	27 553
1999–00	19 936	20 912	20 912	20 912	20 912	20 747
2000–01	33 842	35 279	35 281	35 279	35 281	35 071
2001–02	45 261	48 632	48 635	48 677	48 680	48 173
2002–03	42 610	43 824	43 824	43 825	43 825	43 720
2003–04	80 854	84 077	84 077	84 077	84 077	84 962
2004–05	82 596	85 410	85 410	85 410	85 410	86 075
2005–06	69 163	72 298	72 298	72 299	72 299	72 418
2006–07	66 641	69 864	69 864	69 865	69 865	70 253
2007–08	53 330	55 502	55 502	55 503	55 503	56 035

Table C4: Total arrow squid CLR and CELR landings (tonnes) by stock and fishing year, from 1989–90, including and excluding transhipments (T).

(a) Exclude destination type T

Fishing year	SQU1T	SQU1J	SQU6T	NA	SQUET	Total
1989–90	7 061.3	1 683.2	17 123.7	-	-	25 868
1990–91	16 098.4	6 598.2	8 211.3	-	-	30 908
1991–92	35 698.9	7 636.8	9 694.4	-	-	53 030
1992–93	23 006.9	3 899.2	1 370.5	-	-	28 277
1993–94	20 976.3	3 745.0	26 664.5	-	0.7	51 387
1994–95	28 784.6	15 260.4	22 268.5	-	1.9	66 315
1995–96	15 893.9	14 174.2	13 233.7	734	-	44 036
1996–97	26 116.3	17 034.2	14 278.0	389	-	57 818
1997–98	26 937.9	6 640.4	7 166.9	99	-	40 844
1998–99	22 725.1	3 090.3	950.0	-	-	26 765
1999–00	13 094.3	1 492.1	6 325.4	-	0.2	20 912
2000–01	31 597.3	432.6	3 248.7	2	0.1	35 281
2001–02	36 576.8	597.6	11 457.6	-	45.4	48 677
2002–03	35 045.4	2 031.3	6 747.5	-	1.0	43 825
2003–04	48 150.8	2 198.0	33 728.2	-	0.4	84 077
2004–05	50 729.5	8 234.5	26 445.6	-	-	85 410
2005–06	49 750.6	5 671.2	16 876.7	-	0.1	72 299
2006–07	51 136.2	669.0	18 058.3	-	1.3	69 865
2007–08	36 572.6	834.9	18 094.9	-	0.1	55 503

(b) Include destination type T

Fishing year	SQU1T	SQU1J	SQU6T	NA	SQUET	Total
1989–90	10 608.6	2 417.8	18 562.4	-	-	31 588
1990–91	19 904.5	8 607.3	10 332.1	-	-	38 843
1991–92	42 075.6	11 876.3	10 656.6	-	-	64 608
1992–93	30 597.8	5 131.4	1 495.1	-	-	37 224
1993–94	33 674.3	5 853.3	31 713.2	-	0.7	71 241
1994–95	39 138.6	30 815.2	28 015.3	-	1.9	97 970
1995–96	22 450.3	22 618.5	14 771.0	734	-	60 573
1996–97	28 235.5	22 279.5	17 599.4	414	-	68 528
1997–98	27 453.4	6 640.4	7 681.8	99	-	41 874
1998–99	22 726.3	3 090.3	950.0	-	-	26 766
1999–00	13 094.3	1 492.1	6 325.4	-	0.2	20 911
2000–01	31 600.0	432.6	3 248.7	2	0.1	35 283
2001–02	36 579.5	597.6	11 457.6	-	45.4	48 680
2002–03	35 045.4	2 031.3	6 747.5	-	1.0	43 825
2003–04	48 150.8	2 198.0	33 728.2	-	0.4	84 077
2004–05	50 729.5	8 234.5	26 445.6	-	-	85 409
2005–06	49 750.6	5 671.2	16 876.7	-	0.1	72 299
2006–07	51 136.3	669.0	18 058.3	-	1.3	69 865
2007–08	36 572.6	834.9	18 094.9	-	0.1	55 503

Table C5: Squid groomed estimated catches by fishing year and form type. SJCER and TLCER catch data is greenweight from processed part of form. No arrow squid data for NCELR and LCER forms. SJCER introduced 27/8/1990.

								Catches (kg)
Year	TCEPR	HTC	TCER	CELR	SJCER	LTCER	TLCER	Total
1989–90	26 766 849	-	-	39 729	-	-	-	26 806 578
1990–91	25 967 116	-	-	91 328	9 656 014	-	-	35 714 458
1991–92	45 248 114	-	-	413 500	11 143 514	-	-	56 805 128
1992–93	29 840 337	-	-	273 768	5 557 200	-	-	35 671 305
1993–94	62 914 635	-	-	328 921	6 165 203	-	-	69 408 759
1994–95	62 935 823	-	-	428 370	30 232 012	-	-	93 596 206
1995–96	30 065 492	-	-	392 588	25 404 893	-	-	55 862 973
1996–97	41 998 196	-	-	365 736	16 464 029	-	-	58 827 962
1997–98	33 582 043	-	-	347 069	7 818 621	-	-	41 747 734
1998–99	22 280 153	-	-	359 172	3 154 647	-	-	25 793 973
1999–00	18 029 340	-	-	441 014	1 466 473	-	-	19 936 828
2000–01	31 787 339	-	-	1 543 109	511 984	-	-	33 842 433
2001–02	44 044 941	30	-	508 422	707 817	-	-	45 261 210
2002–03	38 649 213	90	-	603 119	3 357 952	-	-	42 610 375
2003–04	77 910 116	210	-	462 537	2 481 738	-	-	80 854 602
2004–05	73 768 616	-	-	766 441	8 061 370	-	1	82 596 429
2005–06	62 893 216	2	-	918 090	5 351 888	-	-	69 163 197
2006–07	63 190 278	490	-	1 221 058	2 229 389	-	-	66 641 215
2007–08	51 787 920	-	731 509	202	810 383	3	-	53 330 018
Total	843 659 738	822	731 509	9 504 177	140 575 134	3	1	994 471 384

Table C6: Estimated arrow squid catches (t) by area[1] for the fishing years 1989–90 to 2007–08.

(a) All fisheries, all fishing method catches (t)

Year	Auckland Is.	Snares	Puysegur	Sub Antarctic	ECSI	Chatham Rise West	Chatham Rise East	WCSI	North	Null	Total
1989–90	17 263	7 142	75	20	2 216	10	33	16	28	3	26 807
1990–91	9 552	16 001	4 410	49	890	91	31	2 632	2 055	4	35 714
1991–92	10 487	26 970	803	20	6 911	61	43	3 988	7 521	-	56 805
1992–93	1 444	24 533	247	2	7 939	38	121	706	642	-	35 671
1993–94	32 372	13 532	114	19	20 943	88	28	1 098	1 188	27	69 409
1994–95	29 240	29 390	379	79	19 859	330	105	7 047	7 129	38	93 596
1995–96	14 389	18 812	160	174	19 531	179	118	1 391	1 053	55	55 863
1996–97	19 399	20 597	897	162	15 745	76	291	738	813	111	58 828
1997–98	7 185	21 509	274	17	10 891	147	216	63	1 439	5	41 748
1998–99	914	18 645	70	9	5 973	46	37	17	59	22	25 794
1999–00	6 024	4 779	117	33	6 296	2 413	74	23	178	-	19 937
2000–01	3 112	17 577	3 058	13	7 703	1 661	90	177	452	-	33 842
2001–02	11 015	26 571	3 775	90	2 902	548	8	154	199	-	45 261
2002–03	6 842	18 334	10 160	652	3 203	57	16	1 882	1 466	-	42 610
2003–04	32 710	41 702	2 939	1 020	1 711	142	12	517	101	-	80 855
2004–05	26 051	43 787	1 740	111	7 301	1 608	29	1 618	351	-	82 596
2005–06	16 745	43 930	1 804	250	4 450	1 494	66	248	174	1	69 163
2006–07	17 831	40 343	211	1 160	4 412	1 606	22	403	654	-	66 641
2007–08	17 826	33 093	156	8	911	969	111	166	90	-	53 330
Total	280 402	467 247	31 388	3 890	149 787	11 563	1 450	22 886	25 593	266	994 471

1. See Figure 2 for area definitions

Table C6: continued.
(b) Trawl fishery catches (t)

Year	Auckland Is.	Snares	Puysegur	Sub Antarctic	ECSI	Chatham Rise West	Chatham Rise East	WCSI	North	Null	Total
1989–90	17 263	7 142	75	20	2 216	10	33	16	28	3	26 806
1990–91	9 552	15 322	17	15	864	85	31	56	117	-	26 058
1991–92	10 487	26 969	803	13	6 748	61	43	154	382	-	45 661
1992–93	1 444	24 478	246	2	3 584	38	121	108	91	-	30 112
1993–94	32 372	13 532	114	18	16 830	78	28	130	141	-	63 243
1994–95	29 240	24 884	379	3	7 967	290	66	160	252	-	63 242
1995–96	14 389	9 494	160	1	5 832	92	118	69	161	-	30 316
1996–97	19 343	17 051	832	2	4 509	48	279	77	212	-	42 353
1997–98	7 184	21 315	274	17	4 604	147	168	41	156	-	33 906
1998–99	910	17 970	70	8	3 588	35	15	15	28	-	22 639
1999–00	6 024	4 778	117	33	4 962	2 412	70	23	52	-	18 470
2000–01	3 112	17 577	3 057	12	7 507	1 659	90	177	139	-	33 330
2001–02	11 015	26 527	3 775	88	2 897	21	8	154	67	-	44 553
2002–03	6 842	18 209	9 812	651	3 196	51	16	382	93	-	39 252
2003–04	32 698	40 965	1 546	1 020	1 621	6	12	462	43	-	78 372
2004–05	26 051	41 459	1 636	94	4 294	699	29	179	92	-	74 534
2005–06	16 745	42 598	1 164	235	2 593	29	66	248	131	1	63 811
2006–07	17 831	40 286	125	1 160	3 386	975	22	360	265	-	64 409
2007–08	17 826	32 417	97	8	849	968	111	164	80	-	52 519
Total	280 328	442 973	24 299	3 402	88 047	7 703	1 325	2 975	2 529	5	853 586

Table C6: continued
(c) Jig fishery catches (t)

Year	Auckland Is.	Snares	Puysegur	Sub Antarctic	ECSI	Chatham Rise West	Chatham Rise East	WCSI	North	Null	Total
1989–90	-	-	-	-	-	-	-	-	-	-	-
1990–91	-	679	4 393	34	26	6	-	2 576	1 937	4	9 656
1991–92	-	1	-	7	163	-	-	3 835	7 139	-	11 144
1992–93	-	55	1	-	4 353	-	-	597	551	-	5 557
1993–94	-	-	-	-	4 113	10	-	969	1 047	27	6 165
1994–95	-	4 469	-	76	11 880	39	40	6 887	6 877	38	30 305
1995–96	-	9 318	-	173	13 677	87	-	1 322	890	55	25 522
1996–97	56	3 546	65	160	11 234	28	12	661	601	111	16 474
1997–98	-	190	-	-	6 279	-	48	22	1 283	5	7 827
1998–99	5	675	-	1	2 385	12	21	2	31	22	3 155
1999–00	-	1	-	-	1 334	1	4	-	126	-	1 466
2000–01	-	-	-	1	196	2	-	-	313	-	512
2001–02	-	44	-	1	4	526	-	-	132	-	708
2002–03	-	125	348	1	6	6	-	1 500	1 373	-	3 358
2003–04	12	737	1 393	-	90	137	-	56	58	-	2 482
2004–05	-	2 328	103	17	3 007	909	-	1 439	258	-	8 061
2005–06	-	1 332	640	15	1 857	1465	-	1	42	-	5 352
2006–07	-	57	86	-	1 025	631	-	43	388	-	2 229
2007–08	-	676	59	-	62	1	-	2	11	-	810
Total	73	24 232	7 088	487	61 691	3 860	125	19 911	23 057	260	140 784

Table C7: Estimated arrow squid catches (t) by month for the fishing years 1989–90 to 2007–08.

(a) All fishing method catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	10	45	196	7 964	9 421	6 346	1 897	597	263	11	30	26	26 807
1990–91	15	27	429	5 993	9 660	12 011	5 878	784	644	199	21	53	35 714
1991–92	10	25	1084	3 406	22 061	17 686	7 028	3 160	1 828	227	207	81	56 805
1992–93	50	26	232	1 053	18 761	8 492	4 880	1 519	467	115	63	14	35 671
1993–94	22	42	452	1 811	19 191	21 823	15 184	9 353	1 291	140	25	75	69 409
1994–95	40	104	731	7 441	26 909	31 841	20 596	4 564	1 004	91	42	235	93 596
1995–96	156	72	112	5 472	19 580	17 911	10 312	1 882	266	57	18	24	55 863
1996–97	56	90	1 095	11 534	20 793	15 161	6 093	2 853	1 006	89	8	50	58 828
1997–98	70	100	2 015	9 713	12 535	11 192	3 301	2 247	498	27	8	42	41 748
1998–99	23	28	2 046	7 019	8 267	5 756	1 684	824	111	14	5	16	25 794
1999–00	28	29	54	1 736	7 526	4 018	2 960	3 316	188	15	21	45	19 937
2000–01	84	102	703	3 735	10 073	7 133	7 069	3 989	664	153	82	54	33 842
2001–02	84	90	112	11 952	12 512	12 956	5 359	1 496	530	103	33	34	45 261
2002–03	74	107	386	4 767	16 792	11 036	5 302	2 898	1 106	130	7	4	42 610
2003–04	151	162	851	11 442	24 465	23 910	12 446	5 653	1 377	345	18	35	80 855
2004–05	73	72	664	12 806	20 190	26 572	13 953	5 933	1 937	217	65	115	82 596
2005–06	569	1 114	4 068	22 476	16 643	12 769	7 623	2 961	737	116	16	70	69 163
2006–07	87	238	1 042	11 415	17 053	22 177	10 116	3 999	333	119	19	44	66 641
2007–08	80	60	538	6 988	16 586	18 763	9 178	874	117	83	41	22	53 330
Total	1 682	2 535	16 809	148 724	309 020	287 552	150 859	58 904	14 368	2 251	728	1 040	994 471

Table C7: continued.

(b) Trawl fishery catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	10	45	196	7 964	9 421	6 346	1 897	597	263	11	30	26	26 806
1990–91	15	27	267	2 766	6 012	10 080	5 191	784	644	199	21	53	26 058
1991–92	10	25	67	389	18 739	15 779	5 417	2 890	1 828	227	207	81	45 661
1992–93	50	26	46	142	16 050	7 697	3 958	1 486	467	115	63	14	30 112
1993–94	22	42	159	470	18 172	20 524	13 542	8 789	1 283	140	25	75	63 243
1994–95	40	103	616	1 791	15 515	23 654	15 981	4 171	1 004	91	42	235	63 242
1995–96	156	72	74	1 550	7 852	9 582	8 783	1 881	266	57	18	24	30 316
1996–97	56	90	561	7 128	14 475	11 066	4 970	2 853	1 006	89	8	50	42 353
1997–98	70	100	1 968	7 698	10 380	8 360	2 510	2 247	498	27	8	41	33 906
1998–99	23	28	2 039	5 877	7 456	4 735	1 510	824	111	14	5	16	22 639
1999–00	28	29	51	1 645	7 164	3 321	2 657	3 306	188	15	21	45	18 470
2000–01	84	102	703	3 723	10 019	6 992	6 804	3 950	664	153	82	54	33 330
2001–02	84	90	112	11 784	12 316	12 718	5 254	1 496	530	103	33	34	44 553
2002–03	74	107	385	3 616	16 186	10 660	4 415	2 568	1 100	130	7	4	39 252
2003–04	151	162	804	10 823	23 801	23 568	12 060	5 228	1 377	345	18	35	78 372
2004–05	73	72	581	10 893	18 455	24 952	12 032	5 173	1 906	217	65	115	74 534
2005–06	569	1 114	3 952	21 458	15 200	11 472	6 356	2 751	737	116	16	70	63 811
2006–07	87	238	807	11 099	16 462	21 738	9 491	3 975	332	119	19	44	64 409
2007–08	80	60	497	6 695	16 421	18 661	8 969	874	117	83	41	22	52 519
Total	1 682	2 534	13 882	117 510	260 096	251 904	131 796	55 843	14 322	2 250	728	1 038	853 586

Table C7: continued.

(c) Jig fishery catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	-	-	-	-	-	-	-	-	-	-	-	-
1990–91	-	-	163	3 227	3 648	1 931	687	-	-	-	-	-	9 656
1991–92	-	-	1 017	3 017	3 322	1 907	1 611	269	-	-	-	-	11 144
1992–93	-	-	185	912	2 709	795	922	34	-	-	-	-	5 557
1993–94	-	-	293	1 340	1 019	1 299	1 642	564	8	-	-	-	6 165
1994–95	-	-	115	5 650	11 389	8 161	4 597	393	-	-	-	-	30 305
1995–96	-	-	38	3 922	11 714	8 325	1 522	-	-	-	-	-	25 522
1996–97	-	-	534	4 406	6 317	4 094	1 123	-	-	-	-	-	16 474
1997–98	-	-	47	2 011	2 147	2 832	790	-	-	-	-	-	7 827
1998–99	-	-	7	1 142	811	1 021	174	-	-	-	-	-	3 155
1999–00	-	-	3	91	362	696	303	10	-	-	-	-	1 466
2000–01	-	-	-	13	54	141	264	39	-	-	-	-	512
2001–02	-	-	-	168	196	238	106	0	-	-	-	-	708
2002–03	-	-	1	1 151	607	376	887	330	6	-	-	-	3 358
2003–04	-	-	47	619	664	341	385	426	-	-	-	-	2 482
2004–05	-	-	83	1 913	1 735	1 619	1 921	759	31	-	-	-	8 061
2005–06	-	-	116	1 018	1 443	1 297	1 267	210	-	-	-	-	5 352
2006–07	-	-	235	316	590	439	625	24	-	-	-	-	2 229
2007–08	-	-	41	292	165	102	209	-	-	-	-	-	810
Total	-	-	2 926	31 208	48 893	35 615	19 037	3 059	45	-	-	-	140 784

Table C8: Estimated arrow squid trawl catches (t) by month by area for the fishing years 1989–90 to 2007–08.

(a) Auckland Is. trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	-	39	2 791	8 006	4 421	1 766	230	3	-	0	6	17 263
1990–91	-	-	1	489	591	3 984	4 092	341	40	-	0	15	9 552
1991–92	-	-	-	44	4 104	4 434	1 828	1	44	-	29	3	10 487
1992–93	-	7	-	3	169	434	712	104	8	2	4	-	1 444
1993–94	-	-	1	4	11 839	15 755	4 658	94	20	-	-	2	32 372
1994–95	3	1	-	-	107	14 246	13 073	1 805	1	2	-	-	29 240
1995–96	2	-	-	1	2 324	4 581	7 292	186	-	-	-	-	14 389
1996–97	-	1	3	2 923	13 392	3 023	-	-	-	-	-	-	19 343
1997–98	-	2	-	-	2 978	4 132	66	3	1	-	-	-	7 184
1998–99	-	-	-	-	56	456	379	15	1	-	-	1	910
1999–00	-	-	-	10	5 008	1 000	2	-	1	1	-	2	6 024
2000–01	-	-	-	84	2 310	542	144	7	5	5	5	11	3 112
2001–02	1	4	5	24	2 613	6 435	1 925	1	2	1	1	4	11 015
2002–03	1	1	-	55	2 127	2 748	1 270	216	424	-	-	-	6 842
2003–04	1	1	-	-	6 743	16 721	7 302	1 703	199	27	-	-	32 698
2004–05	4	1	-	-	2 887	14 903	8 240	12	-	2	1	1	26 051
2005–06	3	1	-	-	8 104	6 473	2 150	13	-	-	-	-	16 745
2006–07	1	-	-	20	8 469	7 948	1 385	1	1	2	1	2	17 831
2007–08	2	-	-	-	2 892	8 450	6 414	62	1	1	2	1	17 826
Total	18	19	50	6 449	84 720	120 688	62 702	4 795	752	43	44	49	280 328

(b) Snares trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	7	144	5 169	605	1 043	96	20	44	-	11	2	7 142
1990–91	-	-	230	2 246	5 343	5 954	1 086	206	183	51	4	18	15 322
1991–92	1	11	10	164	14 365	10 458	1 622	120	142	36	32	9	26 969
1992–93	6	1	26	100	15 735	5 973	1 852	622	139	6	18	-	24 478
1993–94	-	17	38	227	6 146	4 396	2 134	135	331	64	-	42	13 532
1994–95	6	9	399	1 376	14 344	6 515	1 693	275	249	-	-	17	24 884
1995–96	24	8	25	1 097	4 482	2 848	240	704	59	2	1	4	9 494
1996–97	2	11	524	3 959	643	6 500	3 038	1 860	479	-	1	33	17 051
1997–98	8	4	1 907	7 226	6 432	3 043	1 566	1 050	65	-	-	14	21 315
1998–99	2	1	2 001	5 322	6 191	3 723	570	145	7	7	-	2	17 970
1999–00	7	5	37	1 220	2 064	1 042	289	70	21	-	1	21	4 778
2000–01	9	4	56	2 468	6 350	4 095	4 074	373	143	1	-	2	17 577
2001–02	65	24	56	11 220	9 189	3 816	1 299	589	261	6	-	2	26 527
2002–03	19	7	22	3 031	9 772	3 229	1 241	753	136	0	-	0	18 209
2003–04	13	4	11	10 516	16 775	6 562	4 168	2 101	796	13	-	6	40 965
2004–05	33	36	535	10 643	15 206	9 336	2 870	1 707	1 018	51	-	24	41 459
2005–06	323	1 029	3 891	20 855	6 444	4 650	3 622	1 568	207	-	-	8	42 598
2006–07	46	200	355	9 160	7 546	13 579	7 563	1 784	3	13	7	29	40 286
2007–08	32	21	465	6 529	13 283	10 114	1 687	229	23	3	20	10	32 417
Total	597	1 403	10 732	102 529	160 916	106 878	40 710	14 310	4 306	253	96	242	442 973

Table C8: continued.

(c) Puysegur trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	1	20	4	-	20	12	-	-	-	5	11	-	75
1990–91	4	5	-	-	-	-	-	1	2	-	1	6	17
1991–92	1	1	1	1	21	-	63	33	453	70	109	52	803
1992–93	28	9	1	-	21	4	13	57	95	5	5	7	246
1993–94	3	3	1	-	-	6	2	71	21	4	2	1	114
1994–95	15	32	81	7	1	0	110	54	48	-	18	13	379
1995–96	15	40	21	-	7	6	35	4	16	3	10	4	160
1996–97	34	34	4	4	2	198	412	62	74	-	-	8	832
1997–98	49	78	48	6	-	26	10	22	34	-	-	-	274
1998–99	6	17	22	1	-	10	9	3	-	-	1	2	70
1999–00	11	19	6	5	8	30	24	4	7	2	-	1	117
2000–01	32	46	20	1	4	191	27	2 654	76	1	1	3	3 057
2001–02	5	10	25	28	-	2 157	1 271	271	4	1	-	-	3 775
2002–03	9	1	1	3	3 783	3 967	764	984	300	-	-	1	9 812
2003–04	1	-	9	10	7	1	242	1 048	200	15	-	13	1 546
2004–05	7	6	23	6	162	302	504	50	562	2	-	11	1 636
2005–06	33	39	14	2	-	104	260	657	49	-	-	5	1 164
2006–07	17	11	35	8	1	-	44	3	-	1	1	3	125
2007–08	22	22	5	-	30	-	11	1	-	4	-	-	97
Total	296	392	321	83	4 066	7 013	3 801	5 980	1 941	114	159	130	24 299

(d) Sub-Antarctic (excluding Snares, Auckland Is., and Puysegur) trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	-	-	-	19	-	-	-	-	-	-	-	20
1990–91	-	-	-	1	10	-	-	-	-	-	-	4	15
1991–92	-	-	-	-	10	-	2	-	-	-	1	-	13
1992–93	-	-	-	-	-	2	-	-	-	-	-	-	2
1993–94	-	-	-	2	-	4	10	2	-	-	-	-	18
1994–95	-	-	-	-	-	-	2	-	-	-	-	-	3
1995–96	-	-	-	-	-	1	-	-	-	-	-	-	1
1996–97	-	-	1	-	-	-	-	-	-	-	-	1	2
1997–98	1	-	1	-	-	-	-	-	-	-	2	13	17
1998–99	-	-	-	1	2	-	-	-	-	-	-	3	8
1999–00	-	-	-	-	-	1	2	-	-	-	15	15	33
2000–01	-	-	-	9	-	2	-	-	-	-	-	-	12
2001–02	1	30	4	39	5	1	2	-	-	-	5	1	88
2002–03	8	89	329	213	10	-	1	-	-	-	-	-	651
2003–04	95	128	769	28	-	-	-	-	-	-	-	-	1 020
2004–05	19	12	16	-	-	-	-	-	-	-	-	47	94
2005–06	182	1	-	-	-	-	-	5	-	-	-	47	235
2006–07	2	-	143	1 015	-	-	-	-	-	-	-	-	1 160
2007–08	-	6	1	-	1	-	-	-	-	-	-	-	8
Total	307	267	1 264	1 310	59	13	19	8	1	-	23	131	3 402

Table C8: continued.

(e) ECSI trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	7	13	5	1	762	855	25	328	199	1	3	16	2 216
1990–91	8	6	17	16	25	91	9	218	375	96	3	2	864
1991–92	3	4	2	52	166	787	1 830	2 673	1 151	54	15	11	6 748
1992–93	9	4	8	8	103	1 248	1 360	639	143	44	18	-	3 584
1993–94	7	12	100	187	130	335	6 715	8 470	852	10	5	8	16 830
1994–95	10	54	38	145	1 005	2 858	1 072	2 017	636	5	5	123	7 967
1995–96	91	7	9	375	992	2 117	1 201	929	99	-	-	12	5 832
1996–97	17	38	10	192	384	1 288	1 486	767	317	6	-	4	4 509
1997–98	2	10	7	427	910	1 139	831	1 013	243	14	-	7	4 604
1998–99	13	6	14	546	1 199	540	534	632	98	1	1	2	3 588
1999–00	9	2	3	374	75	1 238	2 325	871	60	3	1	1	4 962
2000–01	38	24	493	1 008	1 338	1 997	1 242	843	376	69	62	16	7 507
2001–02	7	15	13	443	497	298	745	627	211	16	2	23	2 897
2002–03	34	7	9	283	387	691	1 102	582	97	3	-	1	3 196
2003–04	40	28	13	258	266	272	334	368	31	6	-	5	1 621
2004–05	4	-	1	229	175	390	398	2 699	292	46	41	20	4 294
2005–06	5	6	9	575	615	201	299	497	378	2	1	4	2 593
2006–07	17	22	8	738	384	159	425	1 453	171	1	1	7	3 386
2007–08	3	3	2	143	177	84	243	130	45	11	2	5	849
Total	324	260	762	6 001	9 589	16 588	22 176	25 755	5 771	389	160	271	88 047

(f) Chatham Rise West trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	-	2	-	-	-	1	4	2	-	-	1	10
1990–91	2	14	19	3	1	4	-	1	21	18	-	1	85
1991–92	-	2	7	3	-	1	17	19	10	-	1	-	61
1992–93	-	-	3	1	1	19	6	2	2	-	3	-	38
1993–94	-	4	7	12	-	-	10	6	25	-	-	13	78
1994–95	2	3	83	56	1	-	-	6	40	16	7	76	290
1995–96	22	15	2	2	5	-	7	17	16	-	2	3	92
1996–97	-	2	11	13	-	8	1	8	4	1	-	-	48
1997–98	6	1	-	1	-	1	16	114	6	-	-	1	147
1998–99	-	2	1	1	-	-	6	20	1	2	-	2	35
1999–00	-	1	-	-	-	1	4	2 324	81	-	-	-	2 412
2000–01	1	24	127	136	2	117	1 206	43	2	-	-	2	1 659
2001–02	-	-	-	14	-	2	1	3	1	-	-	-	21
2002–03	2	-	16	6	-	-	11	12	3	1	-	-	51
2003–04	-	-	1	-	-	-	3	2	-	-	-	-	6
2004–05	-	8	-	1	2	-	-	681	6	-	-	1	699
2005–06	1	9	-	-	1	1	2	4	8	-	-	2	29
2006–07	-	-	233	5	-	-	28	707	1	1	-	-	975
2007–08	15	-	1	-	-	-	603	348	-	-	-	-	968
Total	54	86	512	253	15	157	1 921	4 320	228	39	14	104	7 703

Table C8: continued.

(g) Chatham Rise East trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	-	-	-	1	3	1	13	14	-	-	-	33
1990–91	-	1	-	3	2	-	-	7	19	-	-	-	31
1991–92	-	-	1	9	2	1	28	-	1	-	-	-	43
1992–93	-	-	-	1	-	-	-	55	64	-	-	1	121
1993–94	1	-	-	5	1	-	2	2	17	-	-	-	28
1994–95	3	1	-	57	1	-	-	2	-	-	-	1	66
1995–96	-	-	1	15	-	-	-	33	68	-	-	-	118
1996–97	-	2	6	6	-	-	-	120	105	40	-	-	279
1997–98	-	1	1	-	-	-	-	35	126	2	2	-	168
1998–99	-	-	-	-	-	-	4	7	-	-	-	3	15
1999–00	-	-	1	26	-	-	5	28	7	-	-	2	70
2000–01	-	1	3	3	-	10	54	-	7	1	-	10	90
2001–02	2	1	1	1	-	-	-	-	-	-	-	2	8
2002–03	-	-	-	-	1	-	6	8	-	-	-	-	16
2003–04	-	-	1	1	-	-	-	-	-	-	-	10	12
2004–05	4	5	-	2	2	1	-	14	-	-	-	-	29
2005–06	3	14	8	7	1	1	-	-	30	-	-	-	66
2006–07	1	-	-	1	1	1	-	11	7	-	-	-	22
2007–08	-	-	-	4	2	1	-	93	10	1	-	-	111
Total	14	29	23	141	15	21	100	429	476	45	2	29	1 325

(h) WCSI trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	-	1	-	2	3	1	1	-	1	4	3	-	16
1990–91	-	-	-	4	1	3	1	1	1	32	9	4	56
1991–92	2	4	5	3	1	13	8	25	17	61	12	3	154
1992–93	2	2	1	2	5	7	9	1	10	52	14	2	108
1993–94	1	2	2	7	22	15	2	1	2	55	13	7	130
1994–95	1	1	5	7	27	14	8	1	19	66	9	3	160
1995–96	1	-	1	2	3	4	1	-	2	51	4	1	69
1996–97	-	1	-	5	12	5	3	2	4	40	4	2	77
1997–98	1	1	2	9	6	1	2	2	3	8	3	2	41
1998–99	-	1	-	2	2	-	1	1	1	3	2	-	15
1999–00	-	-	1	4	2	1	1	1	6	6	1	1	23
2000–01	-	1	1	7	5	13	34	6	33	68	5	4	177
2001–02	-	-	1	3	2	-	1	1	44	78	22	1	154
2002–03	-	-	1	18	87	8	1	3	134	125	5	1	382
2003–04	1	-	-	4	2	2	2	4	148	281	15	1	462
2004–05	1	1	-	2	16	9	1	1	20	106	16	8	179
2005–06	7	2	3	9	21	14	1	2	62	110	14	2	248
2006–07	1	2	3	20	42	19	12	8	146	98	8	1	360
2007–08	2	2	1	13	22	5	3	4	34	59	15	3	164
Total	20	22	26	122	280	135	91	64	690	1 304	175	47	2 975

Table C8: continued.

(i) North trawl catches (t)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1989–90	1	4	2	1	3	6	6	1	1	1	1	1	28
1990–91	1	1	1	5	39	43	3	11	4	3	3	4	117
1991–92	4	3	42	113	69	85	19	18	10	6	8	3	382
1992–93	3	3	8	27	15	9	5	6	6	5	2	2	91
1993–94	9	3	9	27	33	13	10	9	16	6	5	2	141
1994–95	1	3	8	142	30	20	23	10	10	2	3	1	252
1995–96	2	1	14	58	39	24	7	7	6	1	-	1	161
1996–97	2	1	2	26	43	44	32	34	21	3	3	2	212
1997–98	2	2	2	27	54	17	19	9	18	2	2	2	156
1998–99	1	1	1	4	4	4	6	1	3	1	1	1	28
1999–00	1	2	3	5	8	8	4	8	5	3	3	2	52
2000–01	2	3	3	6	11	24	22	23	23	7	9	5	139
2001–02	3	5	5	11	10	9	9	4	7	1	2	1	67
2002–03	1	1	7	7	19	17	21	10	7	1	1	-	93
2003–04	1	-	2	4	7	10	8	3	3	3	2	1	43
2004–05	2	3	5	10	7	11	18	10	7	10	6	2	92
2005–06	11	12	27	9	13	27	22	4	1	3	1	1	131
2006–07	2	3	30	131	19	31	33	7	3	3	1	2	265
2007–08	3	5	21	6	12	7	8	6	5	3	2	1	80
Total	51	56	191	622	436	408	274	181	157	64	54	35	2 529

Table C9: Estimated catches (t) each month from the arrow squid jig fishery by area for the fishing years 1989–90 to 2007–08.

(a) Auckland Is. jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1996–97	-	-	56	-	-	-	-	56
1998–99	-	-	5	-	-	-	-	5
Total	-	12	61	-	-	-	-	73

(b) Snares jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	-	19	630	30	-	-	-	679
1991–92	-	-	1	-	-	-	-	1
1992–93	-	-	7	47	-	-	-	55
1994–95	-	-	105	3 343	993	27	-	4 469
1995–96	-	575	4 930	3 776	37	-	-	9 318
1996–97	-	28	1 755	1 758	6	-	-	3 546
1997–98	1	133	46	11	-	-	-	190
1998–99	-	251	422	1	-	-	-	675
1999–00	-	-	1	-	-	-	-	1
2001–02	-	-	35	8	-	-	-	44
2002–03	-	-	1	92	32	-	-	125
2003–04	-	506	171	7	-	53	-	737
2004–05	-	334	1 358	633	3	-	-	2 328
2005–06	116	224	355	127	302	209	-	1 332
2006–07	-	54	3	-	-	-	-	57
2007–08	-	281	122	65	207	-	-	676
Total	116	2 406	9 941	9 899	1581	289	-	24 232

(c) Puysegur jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	-	2 160	2 233	-	-	-	-	4 393
1992–93	-	1	-	-	-	-	-	1
1996–97	-	-	37	28	-	-	-	65
2002–03	-	-	247	100	-	-	-	348
2003–04	-	28	339	313	354	357	-	1 393
2004–05	-	96	8	-	-	-	-	103
2005–06	-	-	640	-	-	-	-	640
2006–07	-	86	-	-	-	-	-	86
2007–08	-	-	30	29	-	-	-	59
Total	-	2 372	3 534	471	354	357	-	7 088

Table C9: continued.

(d) Sub-Antarctic (excluding Auckland Is., Snares, Puysegur areas) jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	31	-	3	-	-	-	-	34
1991–92	-	7	-	-	-	-	-	7
1994–95	-	-	23	53	-	-	-	76
1995–96	-	9	70	88	6	-	-	173
1996–97	-	112	38	11	-	-	-	160
1998–99	-	-	-	1	-	-	-	1
2000–01	-	1	-	-	-	-	-	1
2001–02	-	-	1	-	-	-	-	1
2002–03	-	1	-	-	-	-	-	1
2004–05	-	-	-	9	8	-	-	17
2005–06	-	-	15	0	-	-	-	15
Total	31	129	149	162	15	0	-	487

(e) ECSI jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	-	15	1	7	3	-	-	26
1991–92	10	8	140	3	1	-	-	163
1992–93	-	389	2 688	744	533	-	-	4 353
1993–94	10	128	819	1 186	1 414	548	8	4 113
1994–95	15	27	8 439	3 324	35	40	-	11 880
1995–96	-	1 946	6 682	4 428	621	-	-	13 677
1996–97	2	4 110	4 394	1 911	817	-	-	11 234
1997–98	7	1 838	1 953	2 458	22	-	-	6 279
1998–99	7	865	375	983	155	-	-	2 385
1999–00	2	78	361	693	200	-	-	1 334
2000–01	-	11	54	130	1	-	-	196
2001–02	-	1	1	2	-	-	-	4
2002–03	-	-	-	1	4	-	-	6
2003–04	-	57	28	2	-	3	-	90
2004–05	-	14	30	386	1 809	749	19	3 007
2005–06	-	19	401	582	854	1	-	1 857
2006–07	-	2	566	434	22	-	-	1 025
2007–08	28	12	14	8	2	-	-	62
Total	83	9 519	26 946	17 282	6 494	1 341	27	61 691

Table C9: continued.
(f) Chatham Rise West jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	-	5	-	1	-	-	-	6
1993–94	-	10	-	-	-	-	-	10
1994–95	-	-	28	-	3	8	-	39
1995–96	26	53	4	4	-	-	-	87
1996–97	-	13	1	12	1	-	-	28
1998–99	-	12	-	-	-	-	-	12
1999–00	-	-	1	-	-	-	-	1
2000–01	-	0	-	2	-	-	-	2
2001–02	-	155	158	209	3	-	-	526
2002–03	-	1	2	0	2	-	-	6
2003–04	-	2	126	2	6	-	-	137
2004–05	-	1	338	569	-	-	-	909
2005–06	-	774	33	546	111	-	-	1 465
2006–07	-	0	22	-	585	24	-	631
2007–08	1	-	-	-	-	-	-	1
Total	27	1 026	716	1347	712	32	-	3 860

(g) Chatham Rise East jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1994–95	-	-	38	-	-	1	-	40
1996–97	-	-	6	5	-	-	-	12
1997–98	-	22	20	6	-	-	-	48
1998–99	-	-	-	21	-	-	-	21
1999–00	-	-	-	4	-	-	-	4
Total	-	22	65	37	-	1	-	125

(h) WCSI jig catches (t)

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	68	1 012	701	579	216	-	-	2 576
1991–92	96	613	2 187	914	24	-	-	3 835
1992–93	180	417	-	-	-	-	-	597
1993–94	283	678	4	-	2	2	-	969
1994–95	100	4 515	2 250	22	-	1	-	6 887
1995–96	1	1 307	14	-	1	-	-	1 322
1996–97	530	121	5	6	-	-	-	661
1997–98	8	14	-	-	-	-	-	22
1998–99	-	-	2	-	-	-	-	2
2002–03	-	1 148	350	1	-	-	-	1 500
2003–04	46	10	-	-	-	-	-	56
2004–05	71	1 368	-	-	-	-	-	1 439
2005–06	-	1	-	-	-	-	-	1
2006–07	39	2	-	1	1	-	-	43
2007–08	2	-	-	-	-	-	-	2
Total	1 423	11 204	5 514	1 524	243	3	-	19 911

Table C9: continued.

(i) North jig catches (t) by month

Year	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1990–91	63	14	82	1 311	468	-	-	1 937
1991–92	910	2 390	994	989	1 586	269	-	7 139
1992–93	5	105	13	4	390	34	-	551
1993–94	-	525	196	103	209	14	-	1 047
1994–95	-	1 108	498	1 402	3 552	317	-	6 877
1995–96	12	17	-	28	834	-	-	890
1996–97	2	9	7	308	274	-	-	601
1997–98	32	4	128	357	763	-	-	1 283
1998–99	-	-	-	12	19	-	-	31
1999–00	-	13	-	-	103	10	-	126
2000–01	-	1	-	9	264	39	-	313
2001–02	-	12	-	18	103	-	-	132
2002–03	1	1	6	181	848	330	6	1 373
2003–04	1	4	-	18	24	11	-	58
2004–05	12	100	-	22	101	10	12	258
2005–06	-	1	-	42	-	-	-	42
2006–07	197	171	-	3	17	-	-	388
2007–08	11	-	-	-	-	-	-	11
Total	1 245	4 474	1 923	4 807	9 554	1 035	18	23 057

Table C10: Estimated arrow squid catches (t) by vessel nationality for the fishing years 1989–90 to 2007–08.

(a) Trawl fishery catch (t)

Year	Korea	Ukraine	Unknown	NZ	Vanuatu	Malta	Japan	Russian	Belize	Poland	Other	Total
1989–90	888	559	24 480	791	-	-	88	-	-	-	-	26 806
1990–91	2 980	1 526	20 888	155	-	-	40	470	-	-	-	26 058
1991–92	7 167	2 770	32 367	2 055	1 134	-	168	-	-	-	-	45 661
1992–93	5 456	4 411	16 871	2 405	679	250	40	-	-	-	-	30 112
1993–94	14 554	11 843	21 663	4 338	2 402	1 262	1 374	3 105	993	1 701	8	63 243
1994–95	15 765	10 485	16 195	3 585	6 870	730	1 135	2 556	4 218	1 337	366	63 242
1995–96	11 195	4 724	4 664	1 134	1 236	237	633	3 035	2 610	849	0	30 316
1996–97	18 313	9 883	56	1 550	1 596	733	1 119	4 473	1 901	2 081	647	42 353
1997–98	15 614	7 284	2	2 103	2 579	604	352	1 831	3 536	-	1	33 906
1998–99	11 037	3 529	-	1 290	1 528	331	75	1 445	3 403	-	-	22 639
1999–00	11 115	2 865	-	1 194	1 038	691	363	-	1 203	-	-	18 470
2000–01	14 113	8 766	-	3 865	3 502	2 283	801	-	-	-	1	33 330
2001–02	17 297	12 086	-	3 121	5 473	4 746	1 820	-	-	-	10	44 553
2002–03	18 930	8 410	-	3 242	3 111	3 356	2 194	-	-	-	8	39 252
2003–04	34 927	18 561	-	6 493	7 572	7 953	2 860	-	-	-	6	78 372
2004–05	30 043	16 867	-	13 082	6 369	6 606	1 554	-	-	-	14	74 534
2005–06	32 151	12 222	-	6 021	4 780	4 069	3 591	976	-	-	-	63 811
2006–07	24 940	14 496	-	5 955	6 568	4 904	3 993	3554	-	-	-	64 409
2007–08	20 262	15 788	-	3 602	6 742	5 182	943	-	-	-	-	52 519
Total	306 747	167 075	137 185	65 980	63 179	43 936	23 145	21 445	17 864	5 968	1 060	853 586

(b) Jig fishery catch (t)

Year	Japan	Unknown	China	USA	Korea	NZ	Total
1989–90	-	-	-	-	-	-	-
1990–91	1 151	8 280	-	-	225	0	9 656
1991–92	1 989	8 427	-	-	727	0	11 144
1992–93	1 937	3 306	-	-	309	5	5 557
1993–94	2 693	3 109	-	-	0	363	6 165
1994–95	11 068	12 265	5 634	-	825	512	30 305
1995–96	6 748	6 764	10 949	-	486	575	25 522
1996–97	4 138	-	12 001	-	110	225	16 474
1997–98	2 346	-	5 393	-	-	89	7 827
1998–99	1 691	-	1 464	-	-	-	3 155
1999–00	1 466	-	-	-	-	-	1 466
2000–01	512	-	-	-	-	-	512
2001–02	-	-	-	708	-	-	708
2002–03	1 491	-	-	1 867	-	-	3 358
2003–04	1 049	-	-	1 432	-	-	2 482
2004–05	3 316	-	3 412	518	815	-	8 061
2005–06	2 178	-	2 888	286	-	-	5 352
2006–07	2 229	-	-	-	-	-	2 229
2007–08	810	-	-	-	-	-	810
Total	46 815	42 152	41 740	4 811	3 497	1 769	140 784

Table C11: Estimated arrow squid trawl catches (t) by the nine target species with the largest arrow squid overall catches for the fishing years 1989–90 to 2007–08. Note that all squid jig data is target squid data.

(a) Overall trawl fishery catch (t)

Year	BAR	HOK	JMA	LIN	RCO	SQU	SWA	TAR	WAR	Other	Total
1989–90	328	61	53	54	19	26 159	76	7	-	49	26 806
1990–91	207	87	148	40	39	25 268	232	10	2	27	26 058
1991–92	779	337	313	112	505	43 214	198	73	14	115	45 661
1992–93	487	136	28	31	481	28 608	261	18	3	59	30 112
1993–94	429	173	84	44	350	61 696	306	49	17	95	63 243
1994–95	1 550	504	442	8	412	59 771	306	47	98	105	63 242
1995–96	609	154	674	11	720	27 847	188	34	4	74	30 316
1996–97	495	208	189	15	531	40 582	233	37	10	54	42 353
1997–98	425	266	299	11	993	31 612	142	26	6	125	33 906
1998–99	396	78	152	10	418	21 523	18	8	1	36	22 639
1999–00	206	145	98	5	482	17 381	54	15	1	84	18 470
2000–01	962	348	51	6	494	31 231	70	34	3	132	33 330
2001–02	381	289	435	46	454	42 690	166	16	4	71	44 553
2002–03	225	309	177	40	545	37 641	121	48	6	141	39 252
2003–04	353	432	31	124	540	76 660	84	27	2	119	78 372
2004–05	191	166	28	55	280	73 279	324	73	30	108	74 534
2005–06	698	127	70	69	144	62 158	205	107	73	160	63 811
2006–07	1 222	142	109	110	124	62 016	299	138	21	228	64 409
2007–08	399	55	30	169	103	51 010	558	83	12	101	52 519
Total	10 341	4 014	3 411	960	7 633	820 345	3 841	851	306	1 882	853 586

(b) Auckland Is. trawl fishery catch (t)

Year	BAR	HOK	JMA	LIN	RCO	SQU	SWA	TAR	WAR	Other	Total
1989–90	-	-	-	2	-	17 253	-	-	-	8	17 263
1990–91	-	2	6	13	-	9 531	-	-	-	1	9 552
1991–92	43	4	-	28	-	10 394	4	-	-	15	10 487
1992–93	-	1	-	10	-	1 427	2	-	-	4	1 444
1993–94	-	6	-	16	-	32 332	-	-	-	18	32 372
1994–95	-	1	3	-	-	29 225	-	-	-	10	29 240
1995–96	2	1	3	3	1	14 377	-	-	-	2	14 389
1996–97	-	1	-	-	-	19 340	-	-	-	2	19 343
1997–98	-	25	-	2	-	7 146	-	-	-	10	7 184
1998–99	-	1	-	-	-	905	-	-	-	4	910
1999–00	-	7	-	2	-	6 008	-	-	-	7	6 024
2000–01	-	5	-	-	-	3 077	-	-	-	30	3 112
2001–02	-	19	-	2	-	10 985	-	-	-	9	11 015
2002–03	4	23	-	-	16	6 784	-	-	-	15	6 842
2003–04	24	3	-	-	-	32 668	-	-	-	3	32 698
2004–05	-	43	-	1	-	25 993	-	-	-	14	26 051
2005–06	1	0	-	1	0	16 735	-	-	-	7	16 745
2006–07	-	1	-	1	-	17 807	-	-	-	21	17 831
2007–08	-	0	-	0	16	17 800	-	-	-	9	17 826
Total	74	141	12	82	34	279 788	6	-	-	192	280 328

Table C11: continued.
(c) Snares trawl fishery catch (t)

Year	BAR	HOK	JMA	LIN	RCO	SQU	SWA	TAR	WAR	Other	Total
1989–90	192	11	35	29	-	6 794	58	-	-	22	7 142
1990–91	65	15	58	15	1	14 941	224	-	1	2	15 322
1991–92	344	99	29	11	27	26 312	138	-	7	3	26 969
1992–93	101	25	4	3	10	24 119	205	-	-	11	24 478
1993–94	113	51	28	13	20	13 083	205	-	12	7	13 532
1994–95	1 091	341	227	2	25	22 861	236	-	94	6	24 884
1995–96	200	31	564	3	72	8 461	135	-	-	27	9 494
1996–97	115	46	144	9	43	16 518	170	-	5	1	17 051
1997–98	163	51	182	7	17	20 809	83	-	-	2	21 315
1998–99	186	32	143	7	8	17 583	9	-	-	3	17 970
1999–00	39	63	72	4	-	4 534	40	-	-	26	4 778
2000–01	159	90	38	-	-	17 222	46	-	-	21	17 577
2001–02	140	96	415	2	23	25 713	117	-	3	17	26 527
2002–03	48	30	158	1	10	17 841	69	-	1	52	18 209
2003–04	204	82	30	1	-	40 504	78	-	-	65	40 965
2004–05	37	32	22	32	13	41 231	67	-	2	23	41 459
2005–06	603	16	17	19	1	41 755	156	-	20	10	42 598
2006–07	1 025	30	11	49	-	39 000	150	-	2	21	40 286
2007–08	93	11	-	105	-	31 713	480	-	5	9	32 417
Total	4 922	1 149	2 179	311	271	430 995	2 664	1	152	330	442 973

(d) ECSI trawl fishery catch (t)

Year	BAR	HOK	JMA	LIN	RCO	SQU	SWA	TAR	WAR	Other	Total
1989–90	85	16	-	4	18	2 073	11	1	-	9	2 216
1990–91	56	9	3	2	34	751	2	1	-	4	864
1991–92	215	60	1	13	451	5 976	17	2	2	10	6 748
1992–93	220	24	-	3	446	2 860	20	1	-	9	3 584
1993–94	233	33	-	4	319	16 194	19	6	1	22	16 830
1994–95	243	23	21	3	259	7 359	27	5	1	27	7 967
1995–96	287	21	1	1	578	4 897	24	10	-	14	5 832
1996–97	135	23	-	-	442	3 881	10	9	2	7	4 509
1997–98	163	29	15	-	946	3 405	1	-	1	43	4 604
1998–99	199	14	8	-	399	2 958	-	-	-	8	3 588
1999–00	124	10	24	-	481	4 318	1	1	-	2	4 962
2000–01	730	31	1	-	470	6 264	2	1	-	8	7 507
2001–02	225	3	17	-	418	2 211	20	1	-	3	2 897
2002–03	127	8	4	1	512	2 498	39	-	-	7	3 196
2003–04	102	7	-	-	536	969	1	2	1	3	1 621
2004–05	121	-	-	-	255	3 648	226	11	25	7	4 294
2005–06	60	2	9	-	118	2 324	22	7	47	5	2 593
2006–07	97	3	22	1	90	3 005	132	14	7	14	3 386
2007–08	189	1	-	-	67	508	57	16	3	6	849
Total	3 611	316	128	33	6 840	76 097	633	88	91	208	88 047

Table C12a: Number of TCEPR, TCER and CELR tows, total catch, and number of vessels by fishing year for the AUCKLAND IS. region. Data source is groomed non-zero TCEPR, TCER, and CELR tows catching squid.

	Number of Vessels				Number of tows				Catch (t)			
Year	TCEPR	TCER	CELR	Total	TCEPR	TCER	CELR	Total	TCEPR	TCER	CELR	Total
1989–90	47	-	-	47	4 321	-	-	4 321	17 263	-	-	17 263
1990–91	52	-	-	52	2 661	-	-	2 661	9 552	-	-	9 552
1991–92	61	-	-	61	2 242	-	-	2 242	10 487	-	-	10 487
1992–93	41	-	-	41	646	-	-	646	1 444	-	-	1 444
1993–94	53	-	-	53	5 000	-	-	5 000	32 372	-	-	32 372
1994–95	57	-	-	57	4 029	-	-	4 029	29 240	-	-	29 240
1995–96	56	-	-	56	4 161	-	-	4 161	14 389	-	-	14 389
1996–97	51	-	-	51	3 629	-	-	3 629	19 343	-	-	19 343
1997–98	48	-	-	48	1 802	-	-	1 802	7 184	-	-	7 184
1998–99	43	-	-	43	520	-	-	520	910	-	-	910
1999–00	40	-	-	40	1 577	-	-	1 577	6 024	-	-	6 024
2000–01	36	-	-	36	1 218	-	-	1 218	3 112	-	-	3 112
2001–02	43	-	-	43	2 066	-	-	2 066	11 015	-	-	11 015
2002–03	40	-	-	40	1 595	-	-	1 595	6 842	-	-	6 842
2003–04	40	-	-	40	2 652	-	-	2 652	32 698	-	-	32 698
2004–05	44	-	-	44	2 957	-	-	2 957	26 051	-	-	26 051
2005–06	40	-	-	40	2 763	-	-	2 763	16 745	-	-	16 745
2006–07	37	-	-	37	1 720	-	-	1 720	17 831	-	-	17 831
2007–08	30	-	-	30	1 640	-	-	1 640	17 826	-	-	17 826
Total	194			194	47 199			47 199	280 328			280 328

Table C12b: Number of tows, vessels, catch, median tow effort variables, catch per tow, catch per hour, and catch per distance for the AUCKLAND IS. region by fishing year. Data source is groomed non-zero TCEPR bottom tows targeting arrow squid.

Year	Number of vessels	Total catch (t)	Number of tows	Median tow duration (h)	Median tow distance (km)	Median speed (knots)	Median net width (m)	Median headline height (m)	Median net depth (m)	Median catch per tow (t)	Median catch per hour (t/h)	Median catch per distance (t/km)
1989–90	25	2 931	702	3.58	20.01	4.0	35	4.0	210	2.70	0.75	0.14
1990–91	20	3 665	863	3.91	16.74	4.0	40	4.0	220	3.00	0.76	0.21
1991–92	16	2 508	438	3.54	22.74	4.4	35	4.6	175	4.00	1.02	0.18
1992–93	12	253	62	3.69	19.16	4.5	38	4.4	198	2.00	0.46	0.09
1993–94	18	8 982	1 428	4.00	16.78	4.0	40	4.0	184	4.50	1.13	0.29
1994–95	20	10 910	1 372	4.00	18.89	4.2	38	4.5	184	5.80	1.37	0.31
1995–96	18	3 154	692	3.75	19.04	4.4	40	4.0	170	3.00	0.83	0.17
1996–97	21	8 130	1 502	3.66	17.27	4.2	38	4.0	180	3.70	1.00	0.23
1997–98	16	1 786	215	3.76	18.21	4.3	40	4.0	175	6.00	1.50	0.31
1998–99	14	246	76	5.00	28.63	4.2	40	4.0	221	1.85	0.43	0.06
1999–00	13	2 426	439	2.83	21.81	4.2	40	4.0	190	4.00	1.17	0.16
2000–01	12	725	158	3.37	18.10	4.2	45	3.8	171	3.40	0.97	0.20
2001–02	17	2 280	488	4.25	25.84	4.1	40	4.0	187	3.00	0.64	0.13
2002–03	17	3 786	727	4.41	25.08	4.3	45	4.0	188	3.40	0.77	0.14
2003–04	21	16 751	1 430	5.08	21.25	4.2	45	3.8	200	8.50	1.58	0.39
2004–05	24	12 316	1 359	5.00	16.47	4.2	45	3.5	172	7.00	1.35	0.42
2005–06	23	13 034	1 879	5.83	13.23	4.1	45	3.5	168	5.00	0.86	0.38
2006–07	17	11 022	729	6.00	21.77	4.1	45	3.5	180	12.00	1.86	0.61
2007–08	14	8 249	630	5.83	13.08	4.1	45	3.4	170	12.00	2.00	1.02
All years	89	113 154	15 189	4.0	19.04	4.2	40	4.0	184	4.00	1.00	0.21

Table C12c: Number of tows, vessels, catch, median tow effort variables, catch per tow, catch per hour, and catch per distance for the AUCKLAND IS. region by fishing year. Data source is groomed non-zero TCEPR midwater tows targeting arrow squid.

Year	Number of vessels	Total catch (t)	Number of tows	Median tow duration (h)	Median tow distance (km)	Median speed (knots)	Median net width (m)	Median headline height (m)	Median net depth (m)	Median catch per tow (t)	Median catch per hour (t/h)	Median catch per distance (t/km)
1989–90	33	14 321	3 606	3.16	21.55	4.0	80	25	180	3.00	0.92	0.14
1990–91	31	5 866	1 782	2.83	17.74	4.2	80	20	180	2.00	0.73	0.12
1991–92	33	7 886	1 493	3.50	24.59	4.2	80	30	185	4.00	1.14	0.17
1992–93	24	1 174	483	3.00	22.04	4.5	90	25	184	1.00	0.40	0.05
1993–94	31	23 350	3 041	3.08	20.19	4.1	80	30	180	6.00	1.86	0.31
1994–95	31	18 315	2 345	3.08	20.01	4.2	90	40	175	5.00	1.85	0.30
1995–96	34	11 223	3 323	3.50	23.96	4.3	80	35	169	2.10	0.67	0.10
1996–97	28	11 210	1 974	3.25	21.24	4.2	98	35	165	3.21	1.04	0.16
1997–98	21	5 360	1 144	3.00	17.81	4.0	101	40	175	3.00	1.13	0.20
1998–99	19	659	263	2.91	19.84	4.2	104	20	185	1.50	0.55	0.09
1999–00	14	3 582	732	3.33	26.29	4.3	116	40	170	3.00	0.86	0.11
2000–01	11	2 351	390	3.16	26.28	4.5	116	23	165	4.00	1.25	0.15
2001–02	17	8 705	1 128	3.33	18.94	4.3	116	24	170	5.80	1.76	0.31
2002–03	14	2 998	704	3.50	20.14	4.4	116	23	170	2.65	0.79	0.14
2003–04	15	15 917	1 126	4.25	20.45	4.3	116	25	180	11.00	2.37	0.60
2004–05	18	13 677	1 293	3.80	12.57	4.3	95	25	173	8.00	2.19	0.66
2005–06	11	3 701	536	5.66	13.21	4.2	106	25	168	5.00	0.89	0.41
2006–07	10	6 785	583	6.08	16.05	4.4	116	25	174	10.00	1.60	0.71
2007–08	9	9 551	619	6.00	12.63	4.2	116	24	174	15.00	2.33	1.12
All years	130	166 631	26 565	3.33	20.14	4.2	101	25	174	4.00	1.13	0.17

Table C13a: Number of TCEPR, TCER and CELR tows, total catch, and number of vessels by fishing year for the SNARES region. Data source is groomed non-zero TCEPR, TCER, and CELR tows catching squid.

	Number of Vessels				Number of tows				Catch (t)			
Year	TCEPR	TCER	CELR	Total	TCEPR	TCER	CELR	Total	TCEPR	TCER	CELR	Total
1989–90	48	-	2	50	1 846	-	12	1 858	7 142	-	-	7 142
1990–91	61	-	1	62	6 087	-	6	6 093	15 322	-	-	15 322
1991–92	64	-	1	65	4 564	-	1	4 565	26 969	-	-	26 969
1992–93	55	-	5	60	5 668	-	38	5 706	24 478	-	-	24 478
1993–94	50	-	5	55	2 654	-	24	2 678	13 531	-	-	13 531
1994–95	59	-	3	62	5 376	-	9	5 385	24 884	-	-	24 884
1995–96	56	-	7	63	3 636	-	63	3 699	9 494	-	-	9 494
1996–97	58	-	4	62	4 716	-	74	4 790	17 051	-	-	17 051
1997–98	47	-	6	53	5 136	-	31	5 167	21 309	-	5	21 314
1998–99	43	-	1	44	5 710	-	12	5 722	17 961	-	9	17 970
1999–00	36	-	3	39	2 175	-	24	2 199	4 776	-	2	4 778
2000–01	37	-	4	41	3 529	-	24	3 553	17 576	-	-	17 576
2001–02	41	-	8	49	3 676	-	31	3 707	26 527	-	-	26 527
2002–03	41	-	7	48	3 537	-	48	3 585	18 206	-	2	18 208
2003–04	37	-	8	45	4 624	-	98	4 722	40 964	-	1	40 965
2004–05	41	-	5	46	6 159	-	19	6 178	41 459	-	-	41 459
2005–06	38	-	7	45	4 858	-	50	4 908	42 598	-	-	42 598
2006–07	33	-	5	38	3 601	-	22	3 623	40 286	-	-	40 286
2007–08	30	19	-	49	2 939	201	-	3 140	32 416	2	-	32 418
Total	204	19	34	239	80 491	201	586	81 278	442 949	2	19	442 970

Table C13b: Number of tows, vessels, catch, median tow effort variables, catch per tow, catch per hour, and catch per distance for the SNARES region by fishing year. Data source is groomed non-zero TCEPR bottom tows targeting arrow squid.

Year	Number of vessels	Total catch (t)	Number of tows	Median tow duration (h)	Median tow distance (km)	Median speed (knots)	Median net width (m)	Median headline height (m)	Median net depth (m)	Median catch per tow (t)	Median catch per hour (t/h)	Median catch per distance (t/km)
1989–90	23	2 194	595	3.33	22.68	4.2	35	4.0	190	2.50	0.74	0.11
1990–91	26	4 270	1 570	3.58	22.30	4.0	40	4.5	179	1.80	0.48	0.09
1991–92	24	4 517	875	3.25	24.48	4.3	35	4.9	174	3.50	1.08	0.15
1992–93	16	5 994	1 063	3.83	26.18	4.5	35	4.8	193	4.00	0.92	0.14
1993–94	18	6 016	1 125	4.00	24.85	4.3	35	4.5	226	3.50	0.94	0.16
1994–95	22	6 507	1 387	4.00	29.01	4.4	38	4.5	184	3.50	0.86	0.13
1995–96	16	4 681	1 126	4.08	19.63	4.4	35	4.0	120	3.00	0.75	0.16
1996–97	27	9 161	2 513	3.58	19.89	4.3	40	4.0	200	2.50	0.72	0.14
1997–98	21	11 926	2 815	4.00	22.39	4.3	40	4.0	185	3.00	0.75	0.14
1998–99	17	9 396	2 668	4.16	24.51	4.3	40	4.0	178	2.40	0.59	0.10
1999–00	16	2 573	897	4.16	29.17	4.2	40	4.0	180	2.00	0.44	0.07
2000–01	18	5 260	1 291	4.08	25.67	4.2	40	3.8	180	2.95	0.69	0.11
2001–02	19	12 182	1 853	4.33	26.22	4.1	45	3.5	207	5.00	1.15	0.19
2002–03	21	6 463	1 453	4.00	23.97	4.2	40	3.5	220	2.40	0.58	0.11
2003–04	22	22 228	2 632	4.00	21.79	4.2	45	3.8	194	5.90	1.41	0.27
2004–05	28	25 127	3 773	4.66	23.51	4.2	45	3.6	183	4.40	0.92	0.19
2005–06	27	24 181	2 943	5.25	18.32	4.1	45	3.5	198	5.00	0.97	0.32
2006–07	17	17 472	1 530	5.58	25.34	4.1	45	3.5	180	8.00	1.38	0.31
2007–08	15	13 668	1 175	5.16	17.93	4.0	45	3.4	204	9.00	1.69	0.53
All years	104	193 816	33 284	4.00	23.95	4.2	40	4.0	185	3.50	0.86	0.14

Table C13c: Number of tows, vessels, catch, median tow effort variables, catch per tow, catch per hour, and catch per distance for the SNARES region by fishing year. Data source is groomed non-zero TCEPR midwater tows targeting arrow squid.

Year	Number of vessels	Total catch (t)	Number of tows	Median tow duration (h)	Median tow distance (km)	Median speed (knots)	Median net width (m)	Median headline height (m)	Median net depth (m)	Median catch per tow (t)	Median catch per hour (t/h)	Median catch per distance (t/km)
1989–90	28	4 599	768	3.00	25.06	4.5	92	60.0	180	3.5	1.13	0.14
1990–91	31	10 672	4 241	3.25	24.52	4.2	90	25.0	175	1.5	0.46	0.06
1991–92	34	21 795	3 020	3.33	28.34	4.3	80	40.0	142	5.0	1.72	0.21
1992–93	34	18 125	4 179	3.16	25.78	4.5	84	25.0	170	2.0	0.71	0.09
1993–94	27	7 067	1 007	2.91	24.05	4.2	98	40.0	170	5.0	1.72	0.21
1994–95	33	16 354	2 863	3.33	27.88	4.4	90	40.0	150	4.0	1.29	0.16
1995–96	33	3 781	1 681	3.58	28.67	4.5	84	30.0	148	1.2	0.36	0.05
1996–97	31	7 357	1 774	3.58	26.71	4.2	98	30.0	180	3.0	0.78	0.11
1997–98	20	8 880	1 924	3.16	24.85	4.2	100	30.0	148	3.0	1.00	0.13
1998–99	18	8 178	2 589	4.00	31.45	4.2	104	24.0	150	2.0	0.59	0.07
1999–00	14	1 959	846	4.00	33.16	4.5	116	24.0	145	1.5	0.38	0.05
2000–01	13	11 962	1 872	3.58	29.60	4.5	116	22.0	165	4.5	1.24	0.16
2001–02	16	13 531	1 292	3.58	27.56	4.5	116	23.0	170	8.0	2.29	0.31
2002–03	14	11 377	1 662	3.91	26.94	4.5	116	24.0	185	4.5	1.20	0.18
2003–04	13	18 276	1 730	3.50	22.73	4.4	116	25.0	173	8.0	2.26	0.36
2004–05	16	16 104	1 914	3.58	23.29	4.5	95	25.0	168	6.0	1.62	0.25
2005–06	13	17 574	1 337	4.00	25.93	4.4	116	25.0	168	10.2	2.64	0.43
2006–07	10	21 528	1 270	4.25	21.46	4.5	116	25.0	173	15.0	3.19	0.74
2007–08	9	18 046	1 178	5.00	23.52	4.5	116	24.5	145	14.0	2.53	0.55
All years	128	237 165	37 147	3.58	25.93	4.5	100	25.0	168	4.5	1.24	0.16

Table C14a: Number of TCEPR, TCER and CELR tows, total catch, and number of vessels by fishing year for the ECSI region. Data source is groomed non-zero TCEPR, TCER, and CELR tows catching squid.

	Number of Vessels				Number of tows				Catch (t)			
Year	TCEPR	TCER	CELR	Total	TCEPR	TCER	CELR	Total	TCEPR	TCER	CELR	Total
1989–90	28	-	42	70	1 147	-	962	2 109	2 194	-	22	2 216
1990–91	30	-	44	74	795	-	1 097	1 892	827	-	37	864
1991–92	35	-	43	78	2 315	-	1 428	3 743	6 573	-	175	6 748
1992–93	37	-	51	88	1 941	-	1 876	3 817	3 397	-	187	3 584
1993–94	41	-	63	104	3 378	-	2 321	5 699	16 610	-	219	16 829
1994–95	47	-	59	106	2 649	-	2 486	5 135	7 771	-	197	7 968
1995–96	49	-	43	92	2 994	-	1 716	4 710	5 634	-	198	5 832
1996–97	49	-	46	95	2 170	-	1 776	3 946	4 295	-	214	4 509
1997–98	40	-	47	87	2 320	-	2 547	4 867	4 339	-	265	4 604
1998–99	40	-	36	76	1 785	-	1 341	3 126	3 259	-	329	3 588
1999–00	39	-	38	77	1 948	-	1 347	3 295	4 551	-	411	4 962
2000–01	34	-	44	78	2 576	-	2 572	5 148	6 072	-	1 436	7 508
2001–02	29	-	28	57	1 737	-	1 155	2 892	2 421	-	477	2 898
2002–03	32	-	31	63	1 859	-	1 385	3 244	2 713	-	484	3 197
2003–04	20	-	34	54	1 083	-	1 619	2 702	1 194	-	427	1 621
2004–05	33	-	45	78	1 227	-	2 096	3 323	3 592	-	702	4 294
2005–06	34	-	37	71	1 033	-	1 667	2 700	1 762	-	831	2 593
2006–07	30	-	33	63	936	-	1 801	2 737	2 323	-	1 063	3 386
2007–08	17	31	-	48	167	1811	-	1 978	226	622	-	848
Total	148	31	159	299	34 060	1811	31 192	67 063	79 753	622	7 674	88 049

Table C14b: Number of tows, vessels, catch, median tow effort variables, catch per tow, catch per hour, and catch per distance for the ECSI region by fishing year. Data source is groomed non-zero TCEPR bottom tows targeting arrow squid.

Year	Number of vessels	Total catch (t)	Number of tows	Median tow duration (h)	Median tow distance (km)	Median speed (knots)	Median net width (m))	Median headline height (m)	Median net depth (m)	Median catch per tow (t)	Median catch per hour (t/h)	Median catch per distance (t/km)
1989–90	15	2 072	682	4.00	23.15	4.00	35.0	4.0	230	2.00	0.54	0.10
1990–91	15	745	380	4.41	28.58	4.00	35.0	4.0	260	1.40	0.32	0.05
1991–92	19	5 969	1 304	4.33	27.29	4.10	38.0	4.0	260	4.00	0.91	0.16
1992–93	13	2 672	754	4.50	25.05	4.20	38.0	4.0	220	2.50	0.57	0.12
1993–94	22	9 970	1 765	3.50	20.50	4.00	35.0	4.5	225	4.00	1.17	0.20
1994–95	20	6 839	1 675	4.00	25.07	4.00	38.0	4.5	208	3.00	0.70	0.12
1995–96	24	4 796	1 644	4.00	22.77	4.20	38.0	4.0	220	2.00	0.51	0.09
1996–97	26	3 805	1 249	4.08	25.30	4.00	38.0	4.0	240	2.28	0.56	0.10
1997–98	25	3 361	1 213	4.23	25.90	4.20	38.0	4.0	212	1.80	0.43	0.07
1998–99	22	2 849	1 139	3.83	22.74	4.20	40.0	4.0	200	1.50	0.41	0.07
1999–00	24	4 112	1 398	4.00	25.87	4.10	40.0	4.0	232	2.08	0.53	0.08
2000–01	23	5 238	1 970	4.41	29.19	4.00	40.0	4.0	220	2.00	0.45	0.07
2001–02	19	2 054	1 224	3.66	21.64	3.80	28.0	5.0	250	0.90	0.26	0.04
2002–03	20	2 276	1 292	3.75	21.48	3.90	28.0	5.0	230	0.96	0.26	0.04
2003–04	15	778	424	3.50	21.47	3.50	28.0	5.0	263	0.90	0.27	0.05
2004–05	24	3 210	942	4.00	21.45	3.90	30.0	4.0	270	1.91	0.46	0.09
2005–06	26	1 673	764	3.91	20.45	3.50	28.0	5.0	240	1.26	0.34	0.06
2006–07	19	2 053	678	3.83	19.72	3.50	32.5	5.0	218	1.20	0.30	0.06
2007–08	8	82	26	4.20	23.01	4.15	45.0	3.2	288	2.00	0.56	0.17
All years	104	64 554	20 523	4.00	23.01	4.00	38.0	4.0	230	2.00	0.46	0.08

Table C14c: Number of tows, vessels, catch, median tow effort variables, catch per tow, catch per hour, and catch per distance for the ECSI region by fishing year. Data source is groomed non-zero TCEPR midwater tows targeting arrow squid.

Year	Number of vessels	Total catch (t)	Number of tows	Median tow duration (h)	Median tow distance (km)	Median speed (knots)	Median net width (m))	Median headline height (m)	Median net depth (m)	Median catch per tow (t)	Median catch per hour (t/h)	Median catch per distance (t/km)
1990–91	2	4	5	3.16	27.17	4.60	108.0	45.0	189.0	0.50	0.16	0.02
1992–93	4	145	50	2.83	21.31	4.50	98.0	25.0	200.0	1.50	0.49	0.07
1993–94	19	6127	905	3.16	21.59	4.30	98.0	35.0	180.0	5.00	1.35	0.24
1994–95	15	498	137	2.75	20.50	4.40	98.0	25.0	161.0	1.50	0.55	0.07
1995–96	15	65	62	3.00	23.76	4.35	96.5	23.0	166.5	0.50	0.18	0.02
1996–97	4	19	31	4.00	25.32	4.50	98.0	20.0	135.0	0.50	0.11	0.02
1997–98	2	5	7	4.16	34.52	4.40	98.0	22.0	125.0	0.30	0.08	0.01
1998–99	3	5	4	3.37	24.84	4.35	107.0	22.0	170.0	0.90	0.36	0.03
1999–00	5	7	10	4.00	31.33	4.50	101.0	22.5	145.0	0.50	0.13	0.02
2000–01	2	2	3	3.08	24.84	4.50	116.0	25.0	202.0	1.00	0.32	0.04
2002–03	2	2	6	3.70	15.69	4.30	98.0	20.0	143.0	0.10	0.03	0.03
2003–04	1	0	1	2.83	23.80	4.20	70.0	40.0	160.0	0.50	0.18	0.02
2004–05	1	3	2	3.33	14.32	4.20	98.0	18.0	133.0	1.50	0.47	0.12
2005–06	1	2	2	5.33	21.03	4.00	106.0	25.0	137.5	0.75	0.14	0.05
2006–07	1	0	1	2.25	20.54	4.70	70.0	40.0	155.0	0.50	0.22	0.02
All years	38	6884	1226	3.16	23.76	4.40	98.0	25.0	160.0	0.50	0.18	0.03

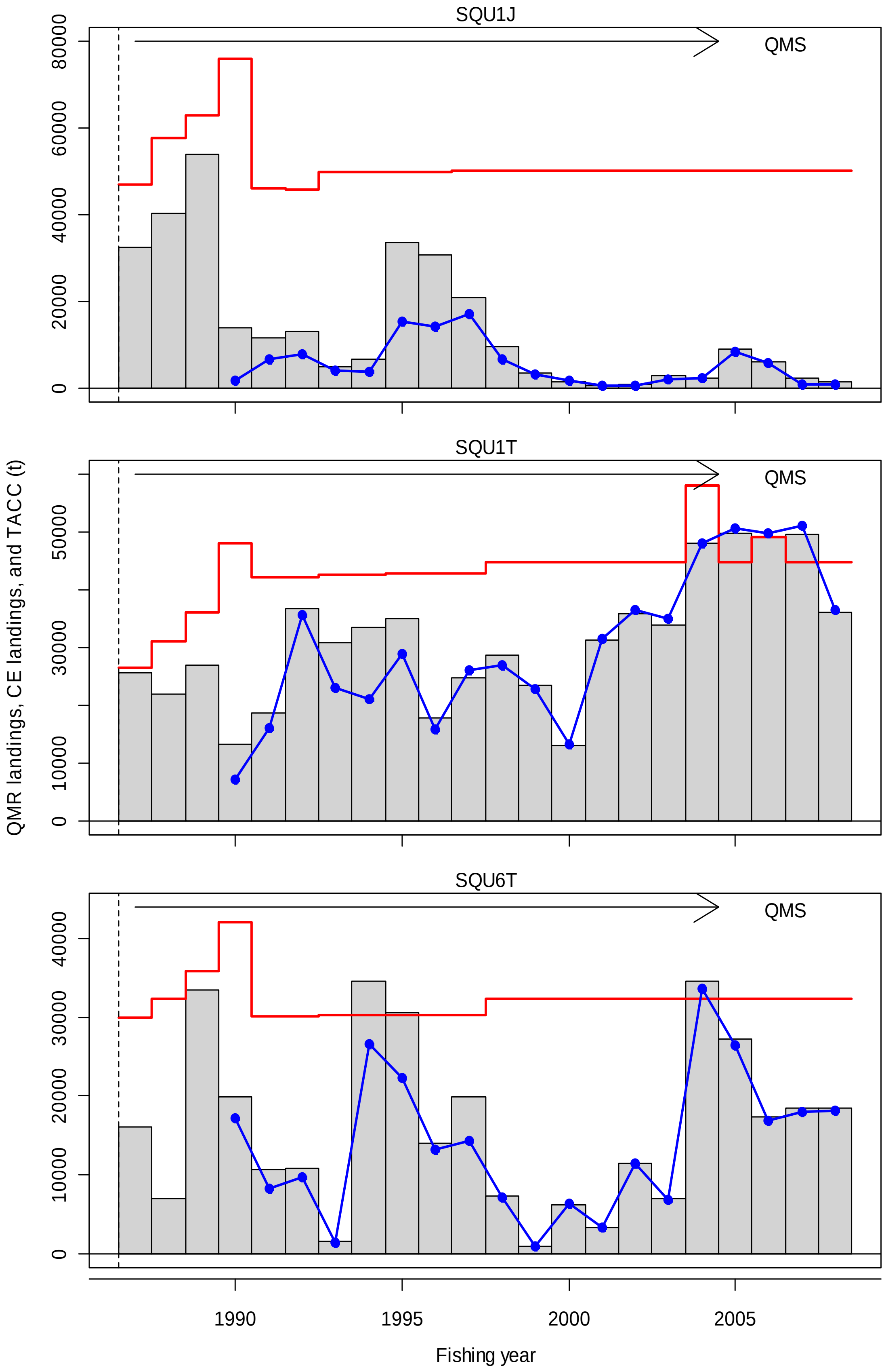


Figure C1: The QMR/MHR landings (gray bars), un-groomed catch effort landings (dotted blue line), and TACC (red line) for SQU 1T, 1J, and 6T for the fishing years 1983–84 to 2007–08.

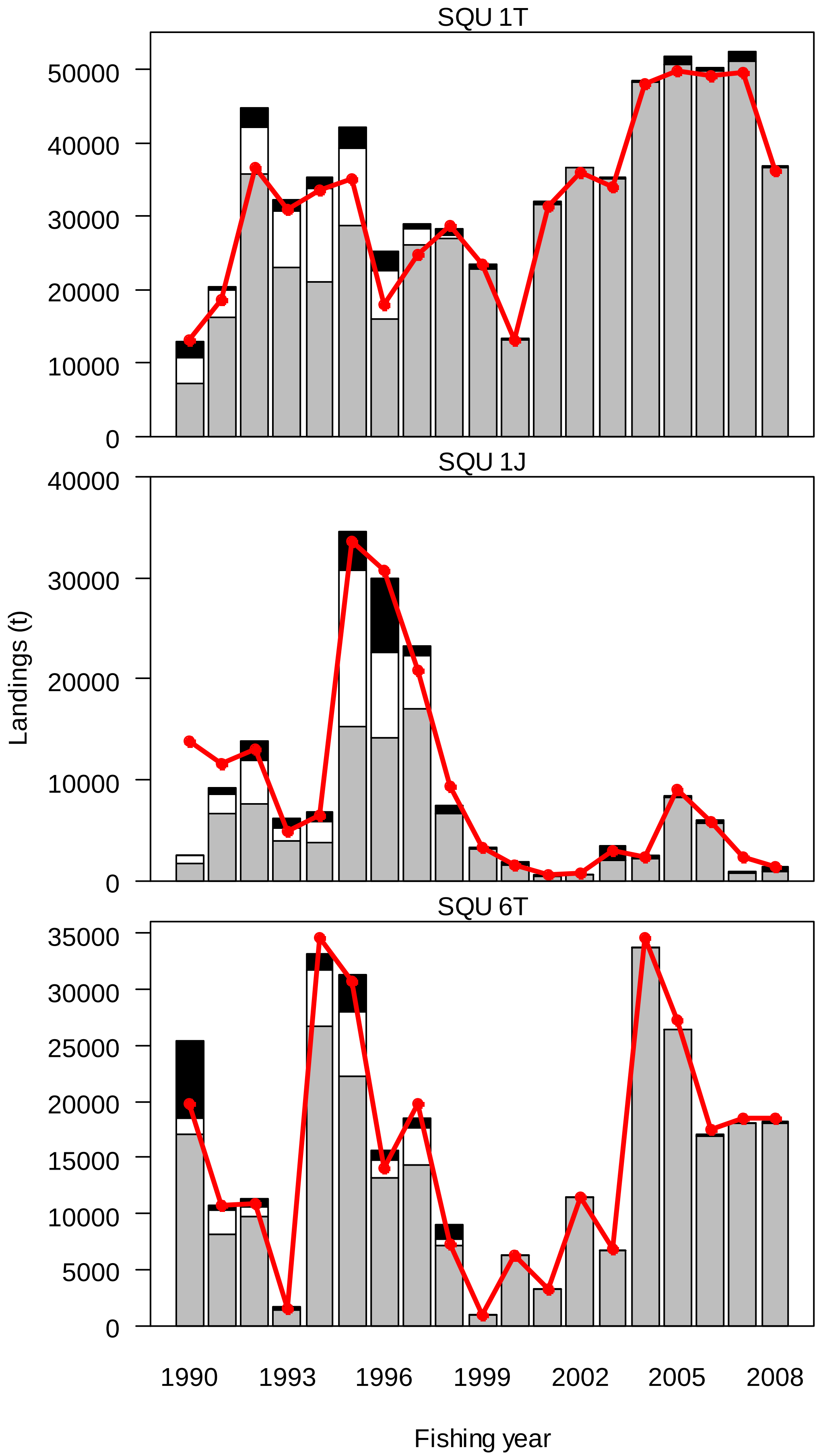


Figure C2: The retained landings (gray bars), transhipment landings (white bars), and landings dropped during data grooming (black bars), and MHR landings (red line) for SQU 1T, 1J, and 6T for the fishing years 1983–84 to 2007–08.

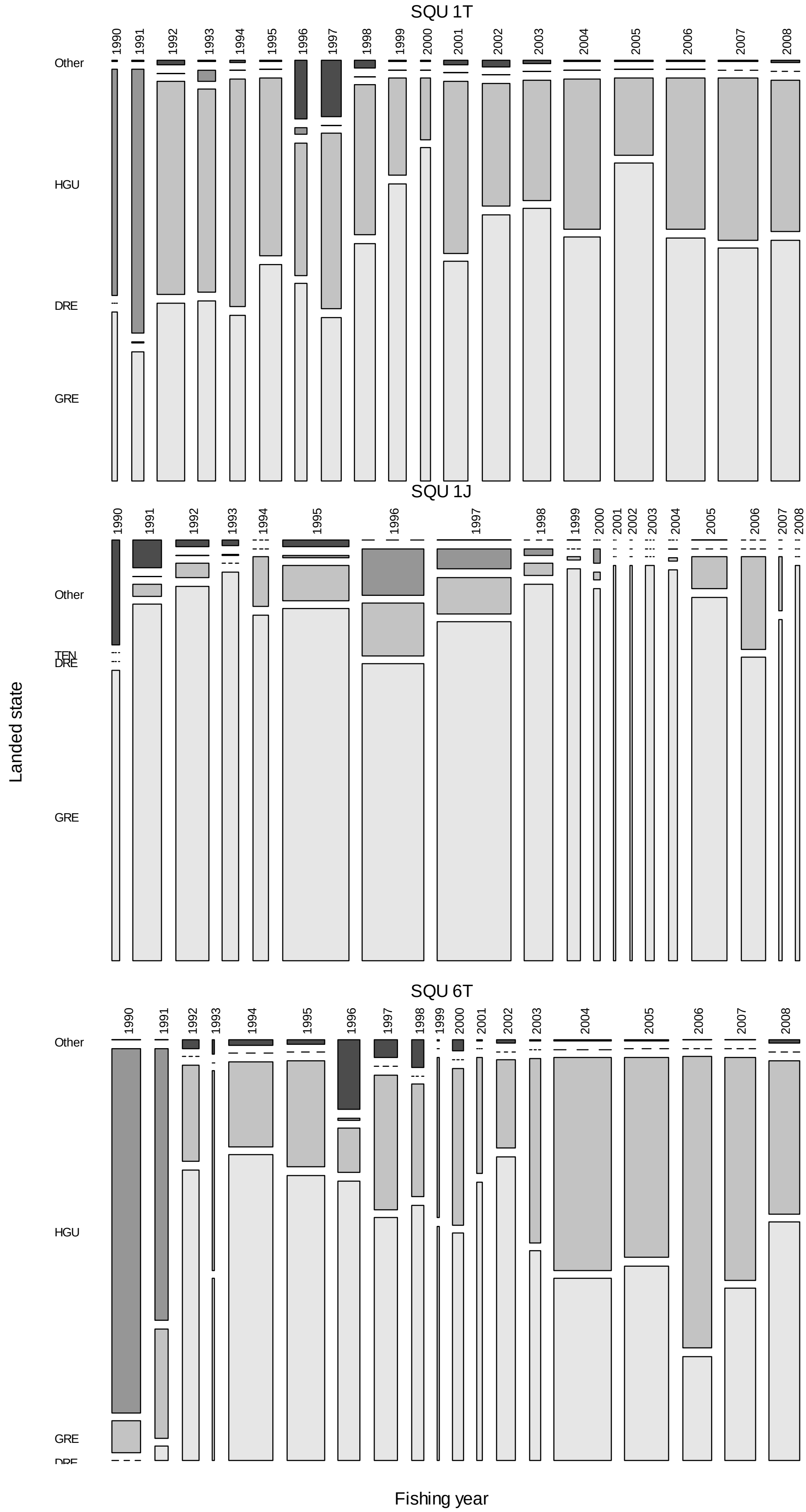


Figure C3: The proportion of retained landings (greenweight) by processed state for SQU 1T, 1J, and 6T for the fishing years 1989–90 to 2007–08 in the groomed dataset. "DRE" in this figure includes state codes "Dressed", "Headed, gutted, and tailed", and "trunked"; "GRE" refers to "Whole or Green"; "HGU" refers to "Headed and Gutted".

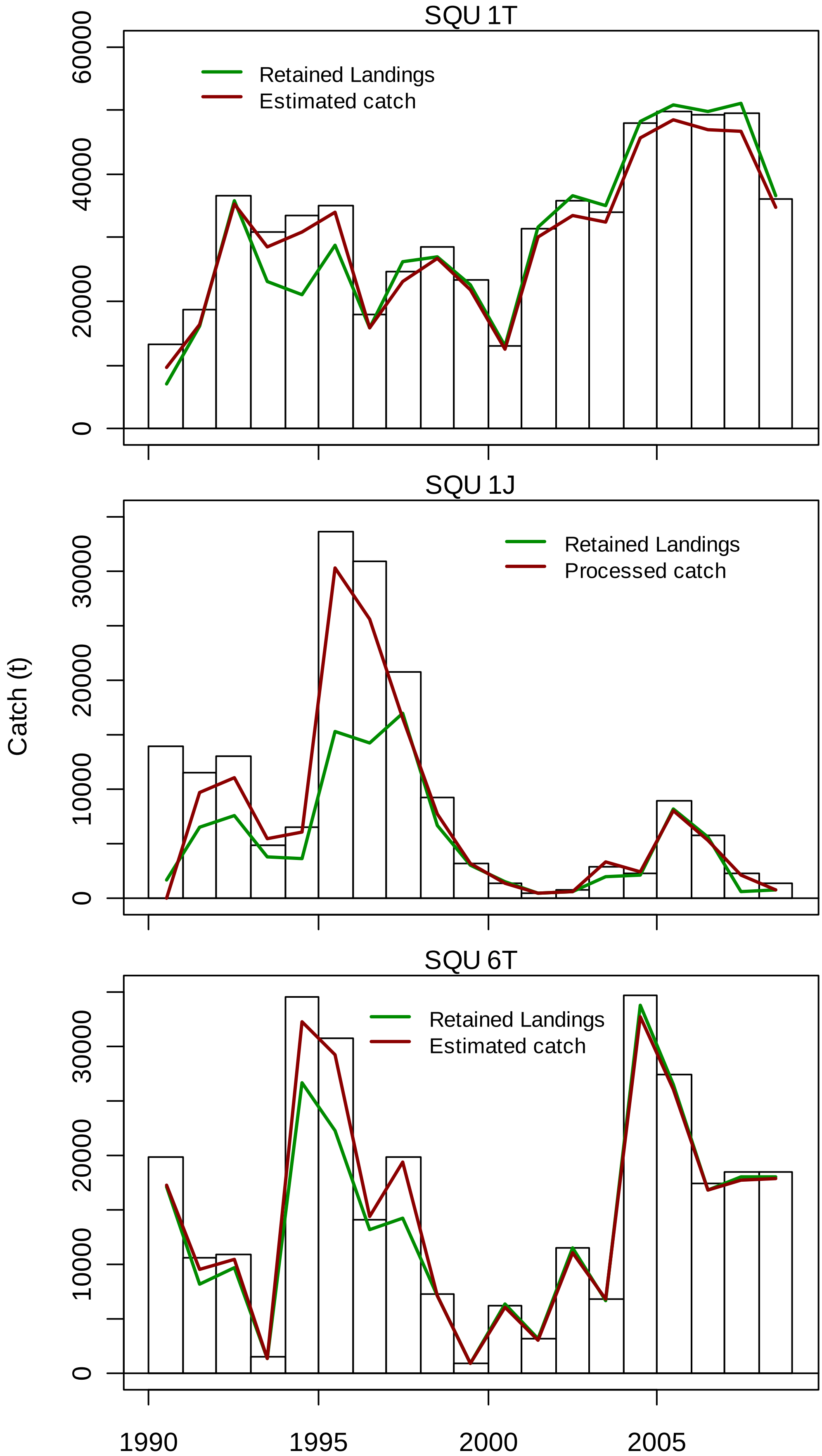


Figure C4: The QMR/MHR landings (white bars), retained landings (green solid line), and estimated or processed catch (red solid line) in the groomed dataset for SQU 1T, 1J, and 6T for the fishing years 1989–90 to 2007–08.

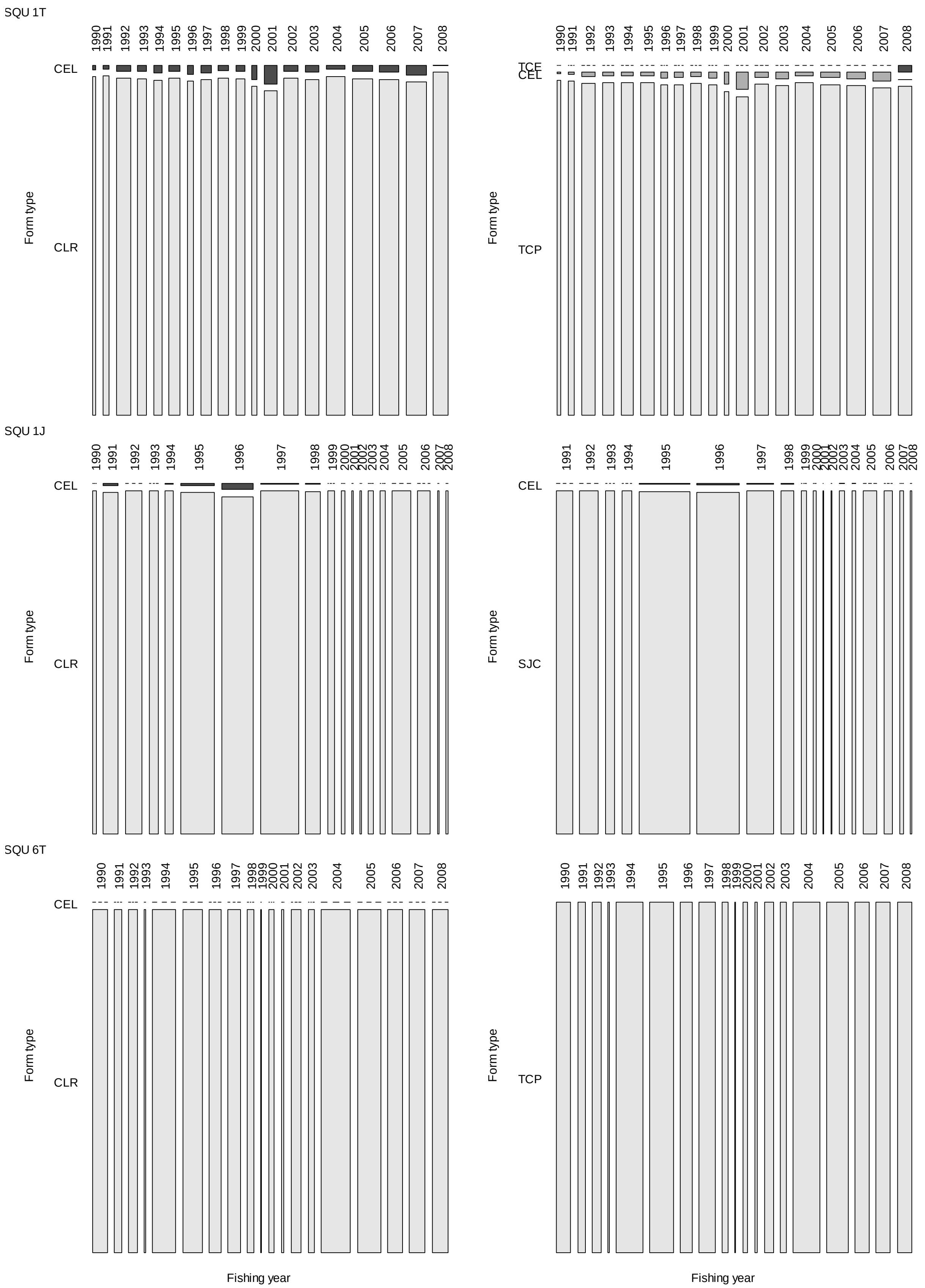


Figure C5: Proportion of landings by form type (left panel) in the groomed dataset, and proportion of estimated catches by form type (right panels) in the groomed dataset, SQU 1T, 1J, and 6T for the fishing years 1989–90 to 2007–08. The width of the bar is proportional to the annual catches (only comparable within each panel). Left panels: CEL, CELR landing return; CLR, Catch Landing Return; Right panels: TCP, TCEPR form; TCE, TCER form; CEL, CELR effort; SJC, SJCER form, see Table C2 for form type details.

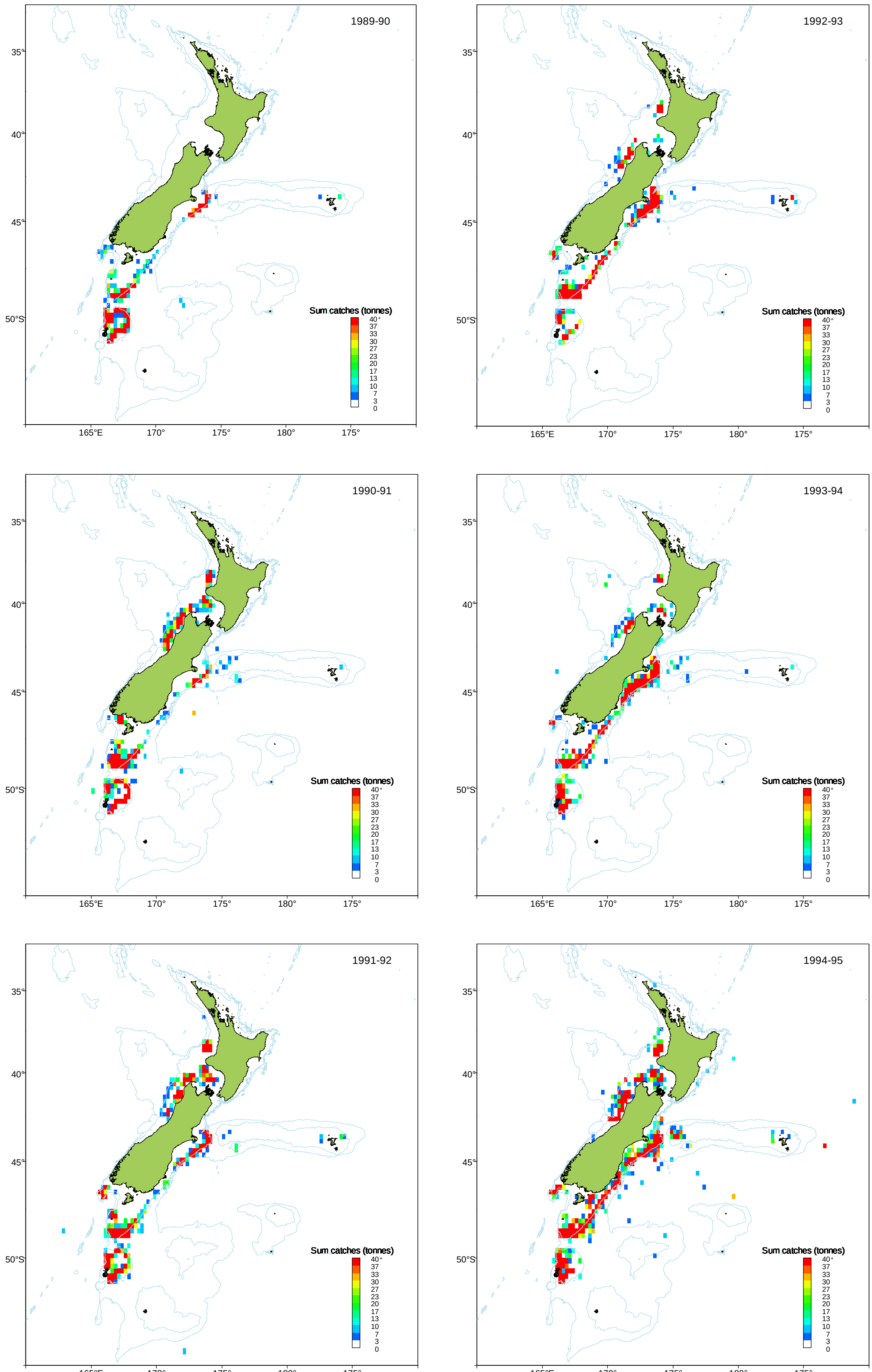


Figure C6: Density (in tonnes) of annual catch of all commercial squid catches from TCEPR, TCER, and SJCER records by fishing year (1 October to 30 September) 1989–90 to 2007–08.

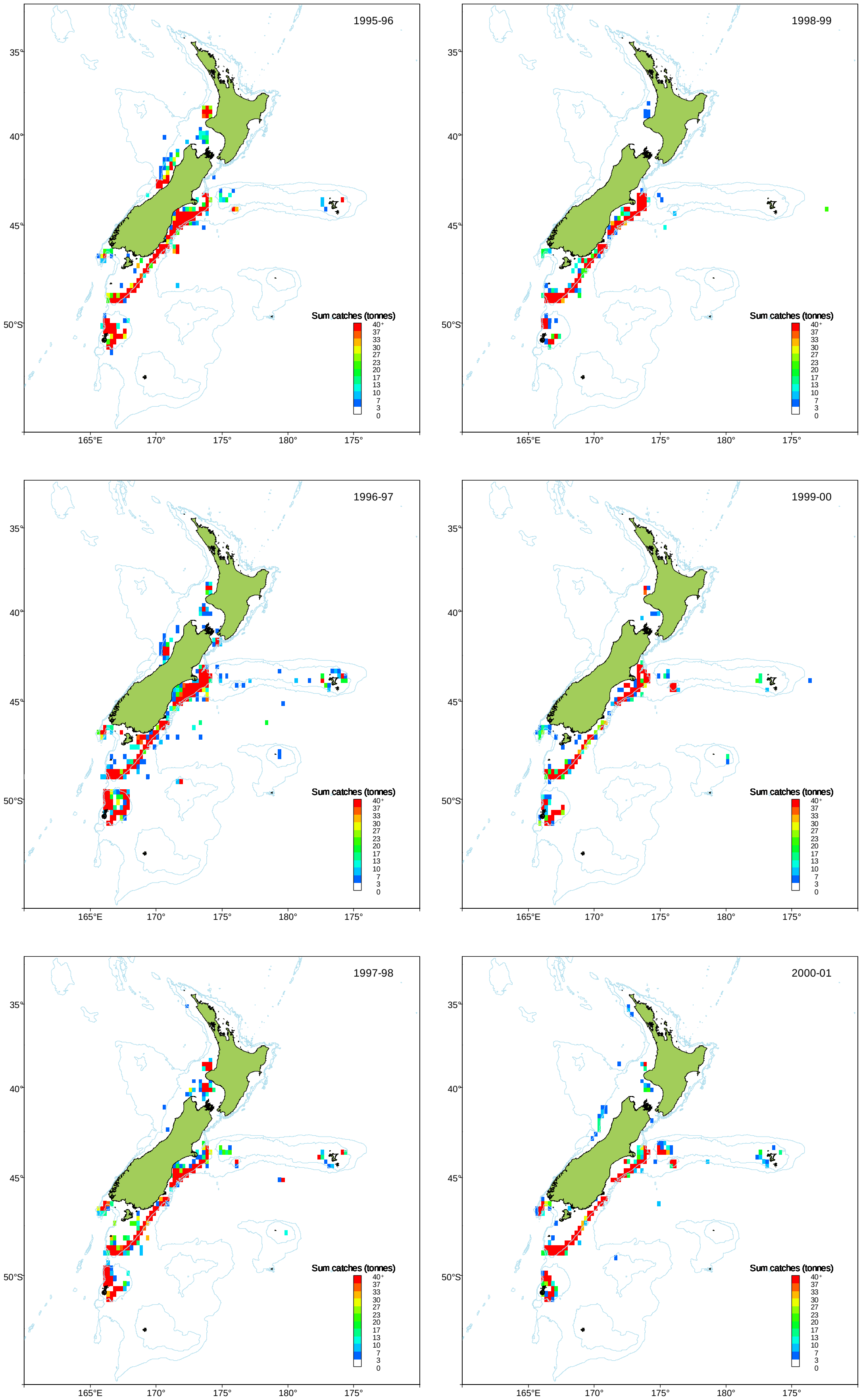


Figure C6: continued.

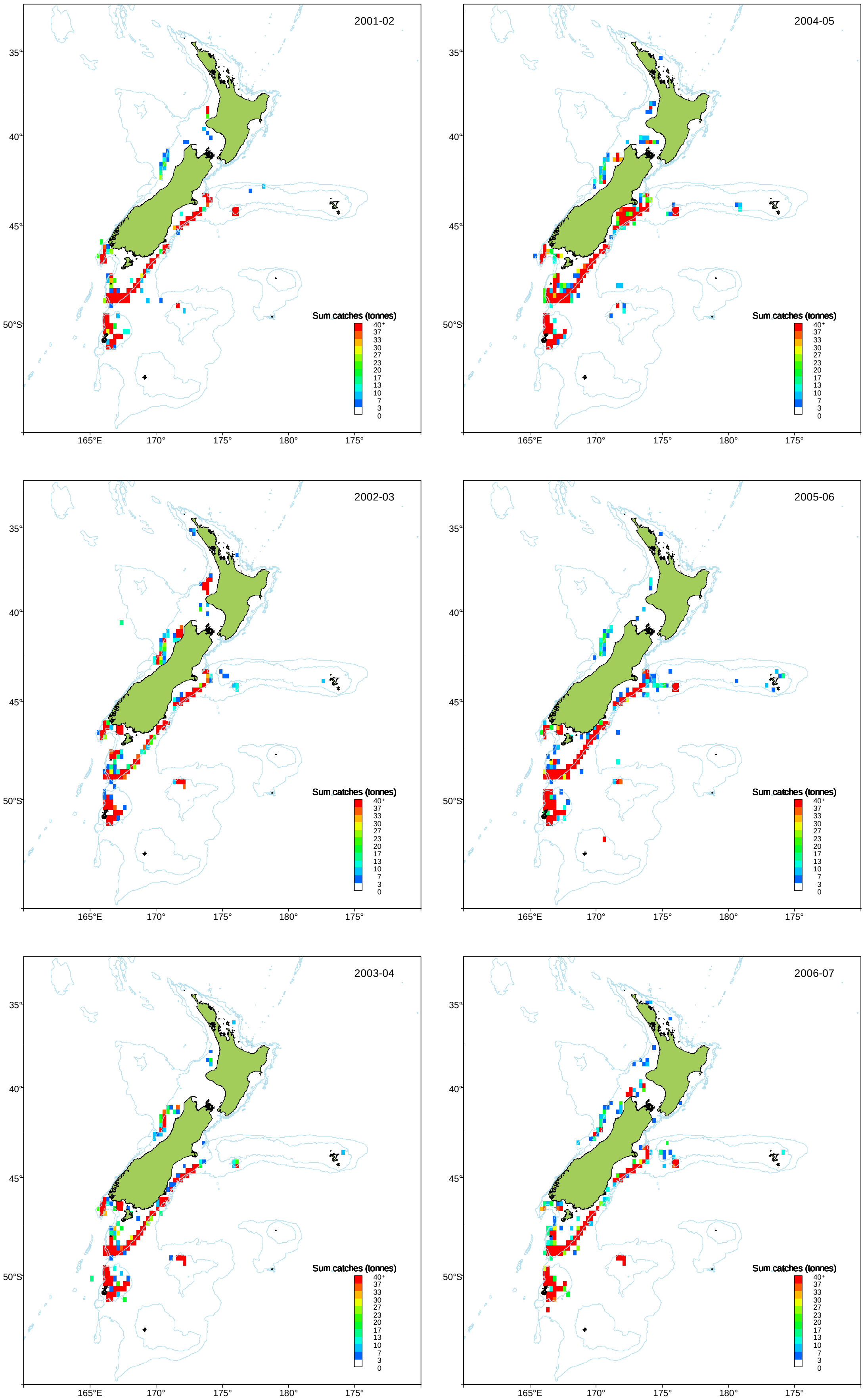


Figure C6: continued.

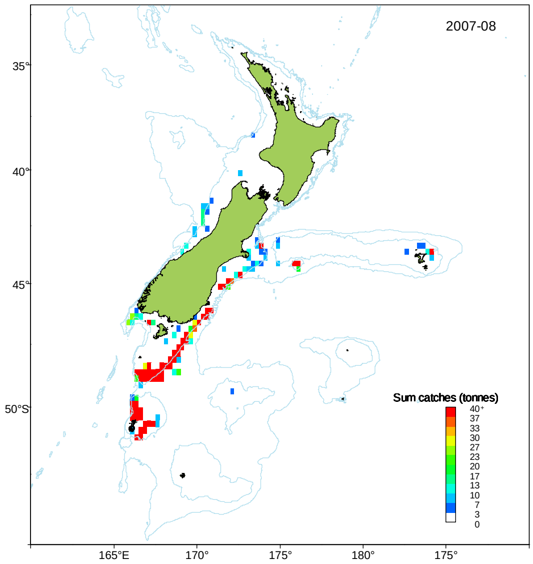


Figure C6: continued.

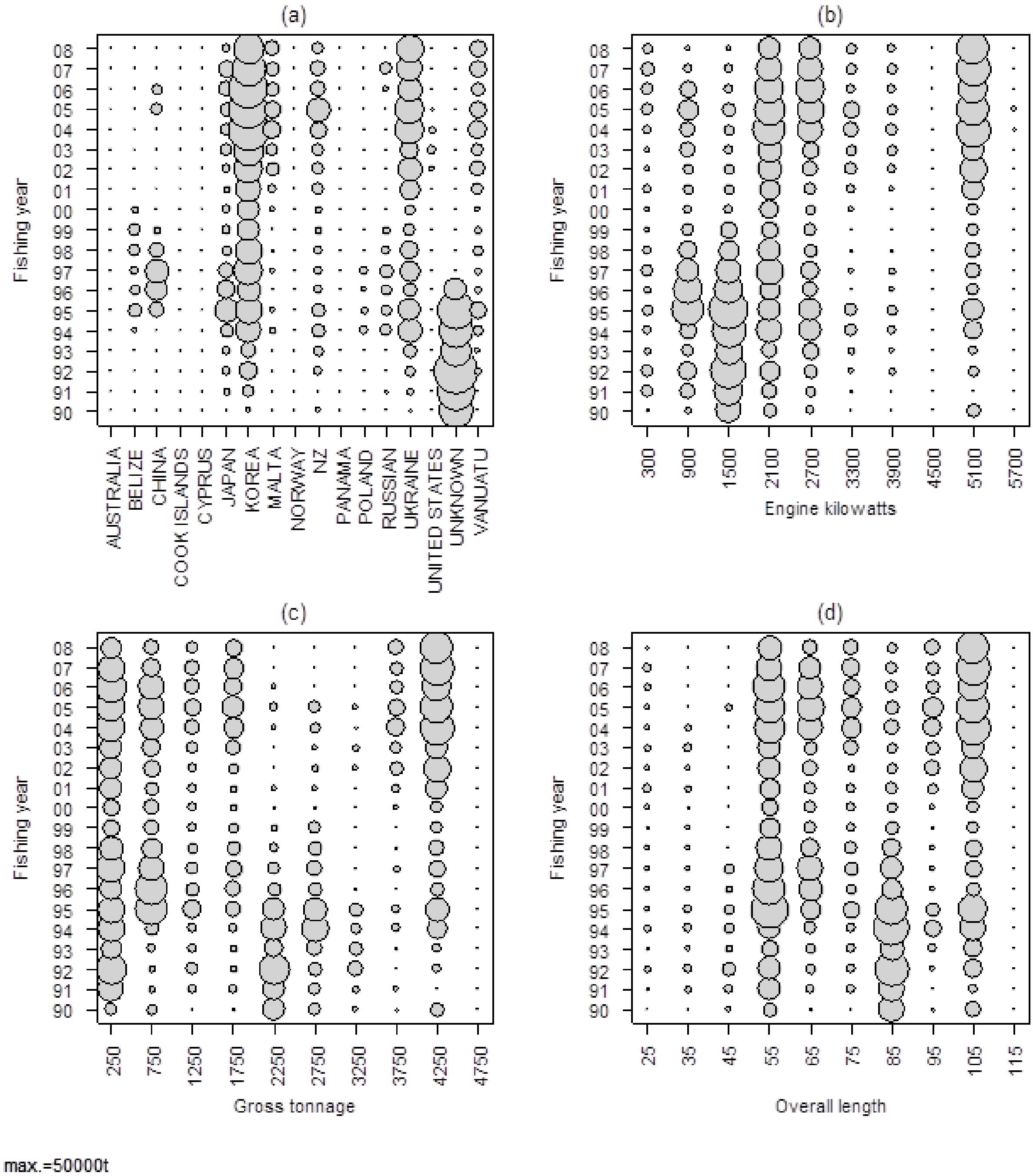


Figure C7a: Distribution of SQU catch for ALL DATA by nationality, vessel power, gross tonnage, and length (m) for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. 291 vessels with unknown nationalities.

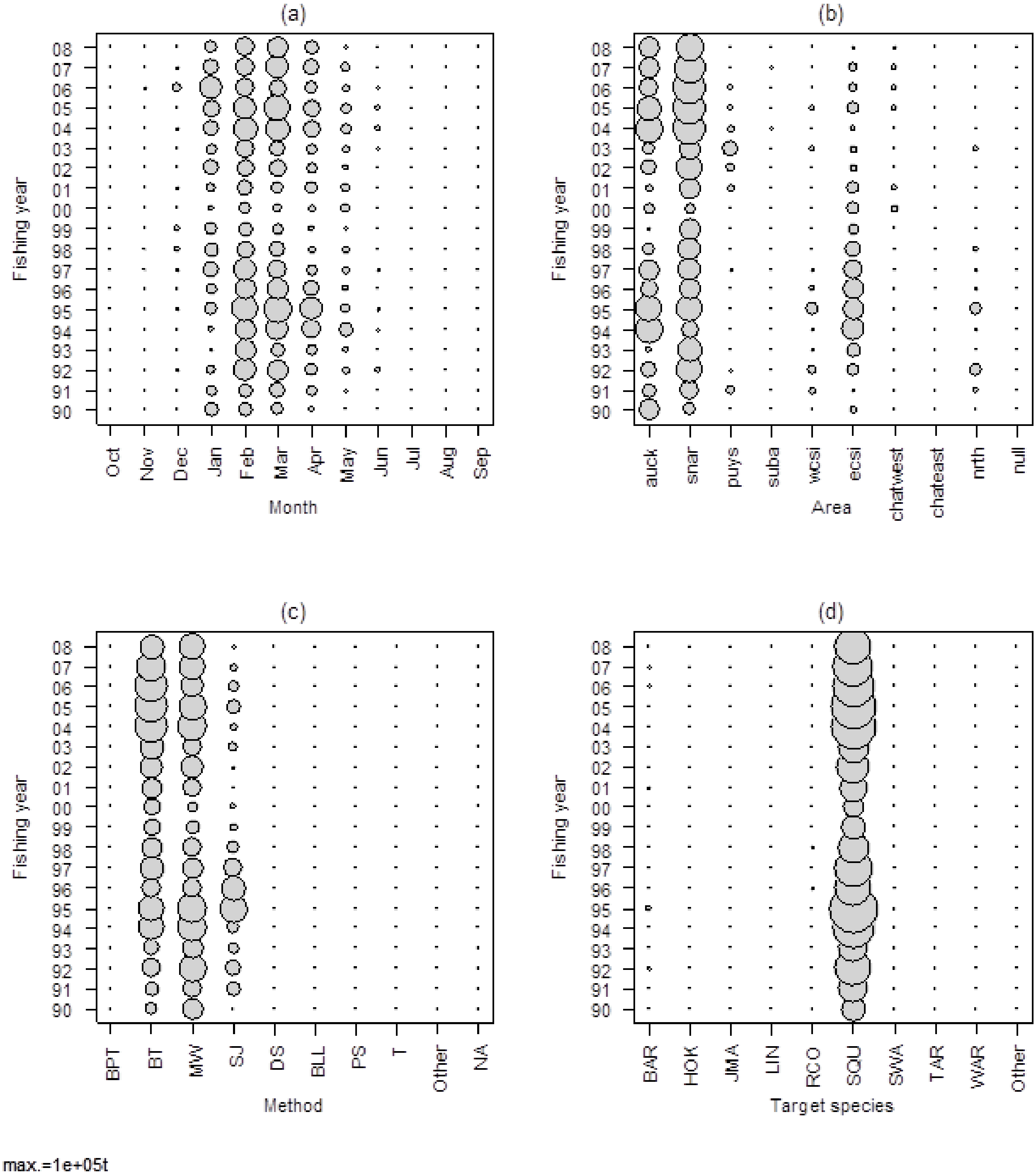


Figure C7b: Distribution of SQU catch for ALL DATA (circle size is proportional to catch for 1990–2008 fishing years in relation to a) month, b) area, c) fishing method, and d) target species for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. See Table C2 for methods and species codes definitions.

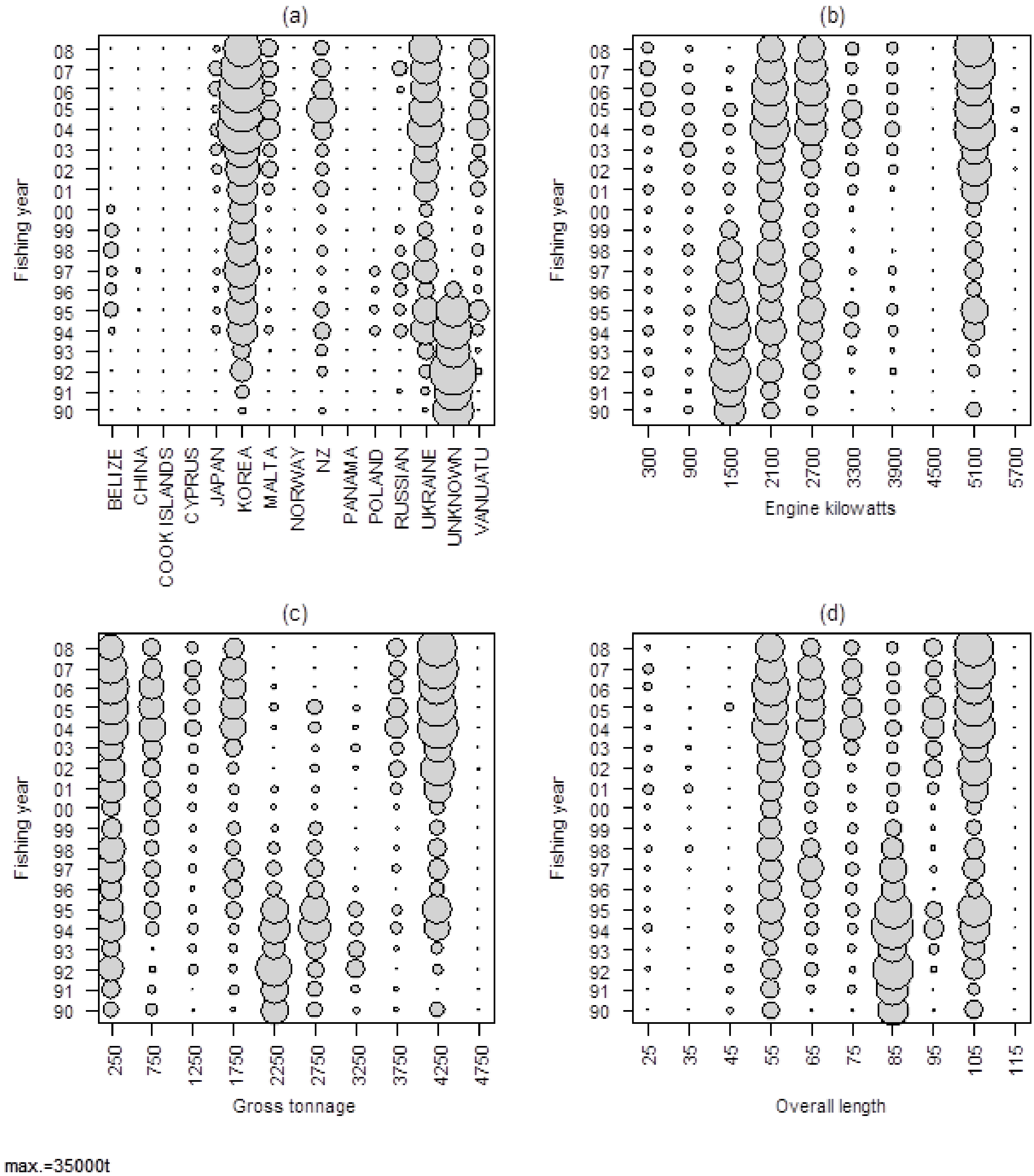


Figure C7c: Distribution of SQU catch for TRAWL DATA by nationality, vessel power, gross tonnage, and length (m) for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. 200 vessels with unknown nationalities.

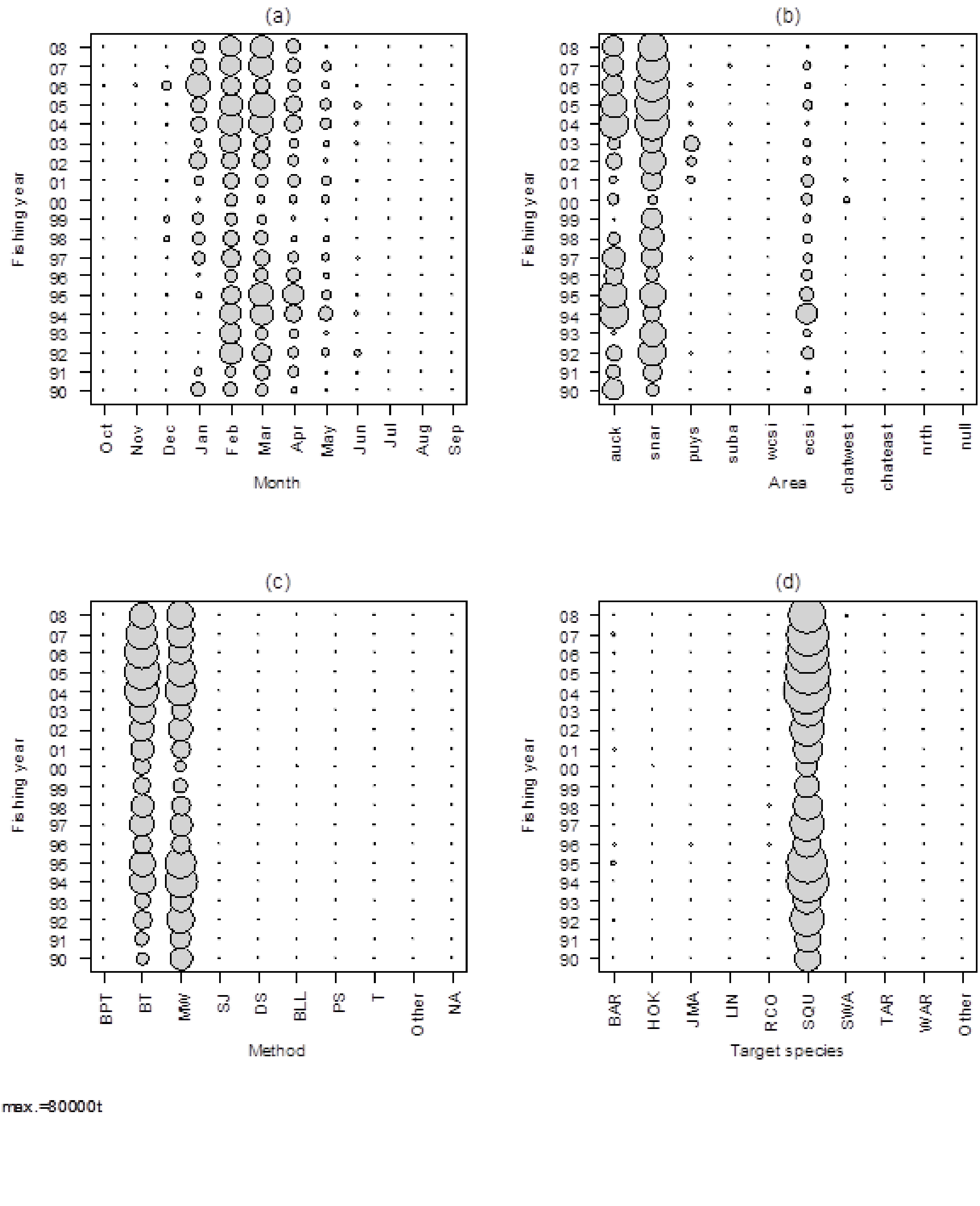


Figure C7d: Distribution of SQU catch for TRAWL DATA (circle size is proportional to catch for 1990–2008 fishing years in relation to a) month, b) area, c) fishing method, and d) target species for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. See Table C2 for methods and species codes definitions.

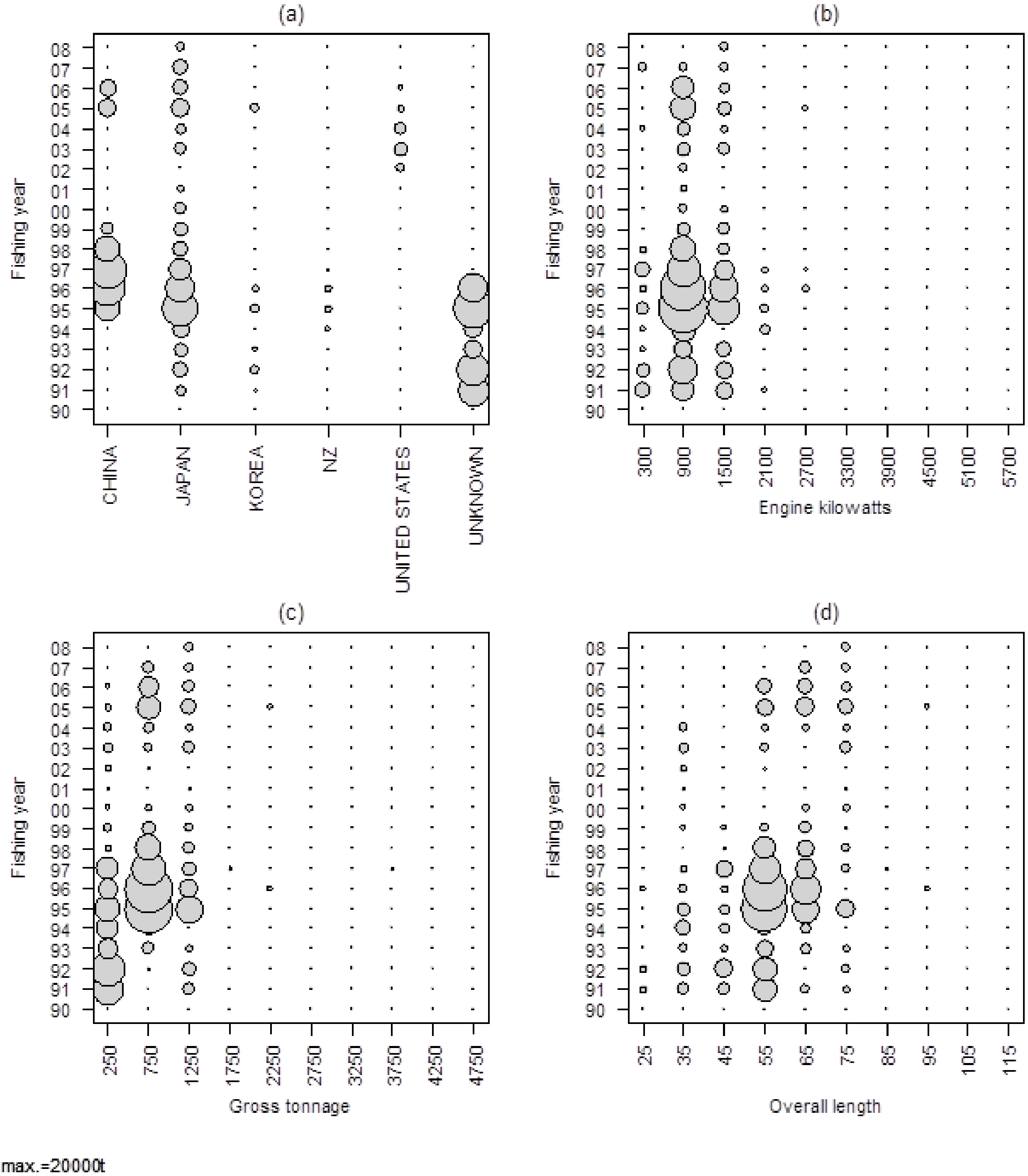


Figure C7e: Distribution of SQU catch for JIG DATA by nationality, vessel power, gross tonnage, and length (m) for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner.72 vessels with unknown nationalities.

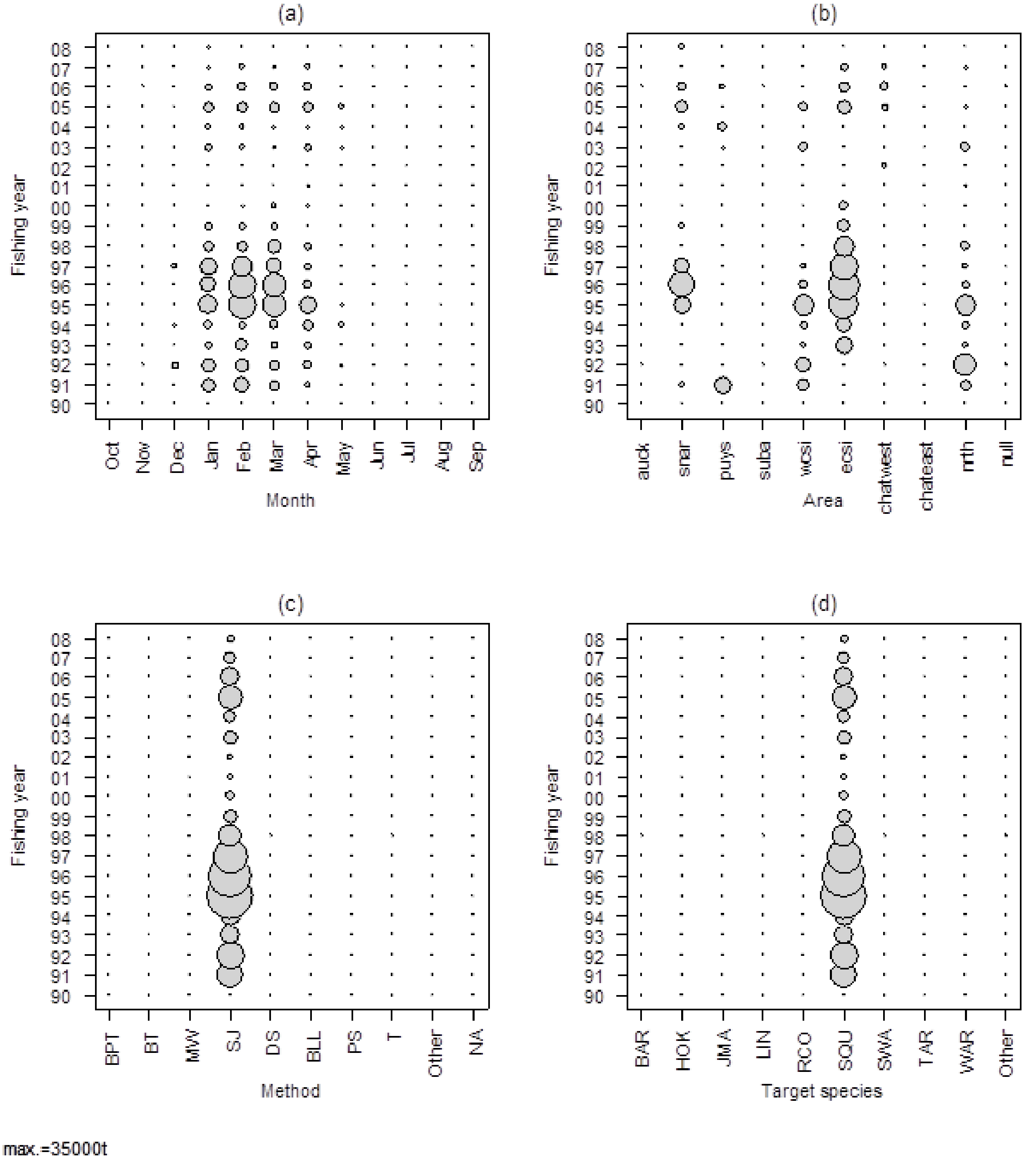


Figure C7f: Distribution of SQU catch for JIG DATA (circle size is proportional to catch for 1990–2008 fishing years in relation to a) month, b) area, c) fishing method, and d) target species for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. See Table C2 for methods and species codes definitions.

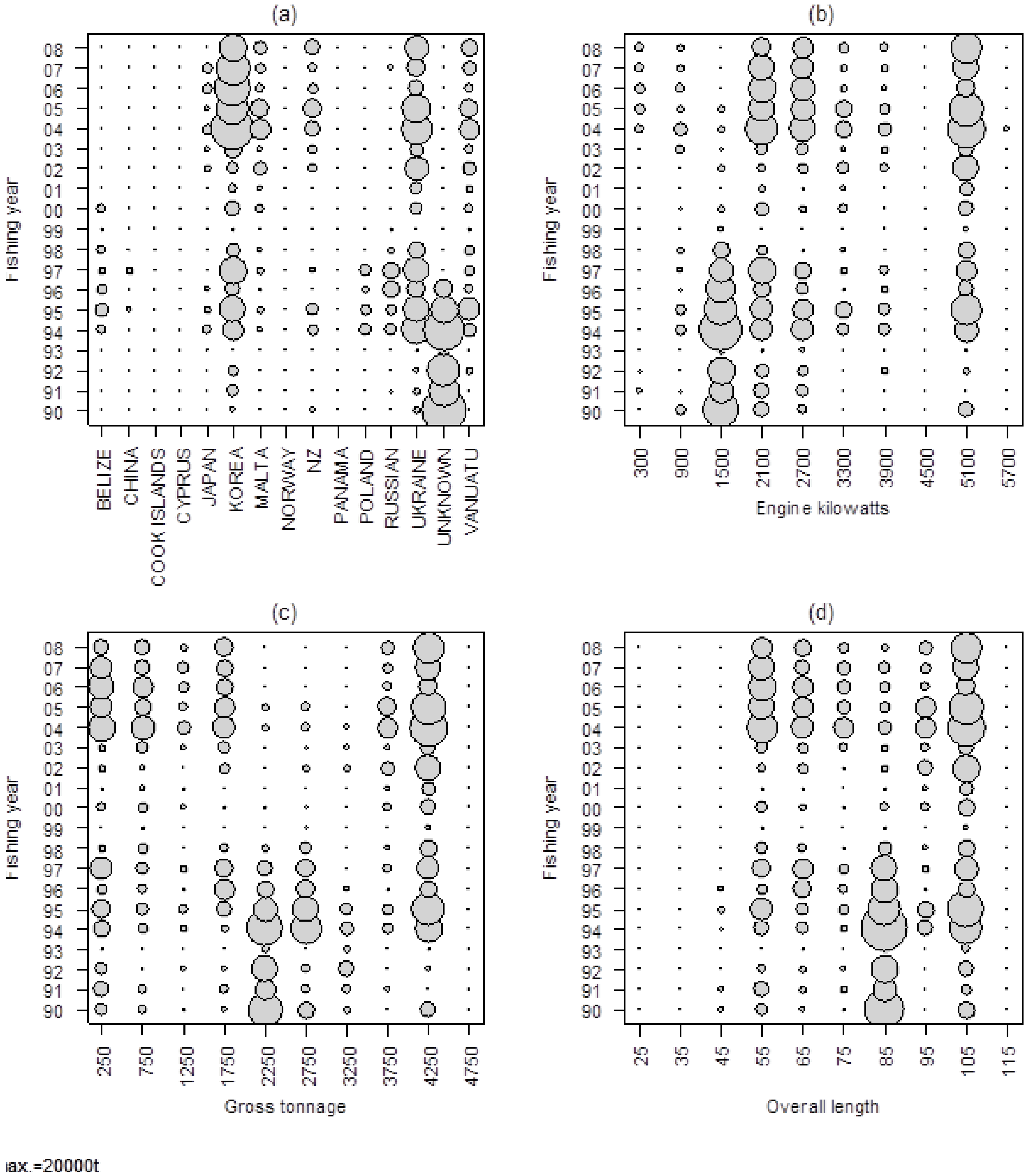


Figure C7g: Distribution of SQU catch for AUCKLAND IS. TRAWL DATA by nationality, vessel power, gross tonnage, and length (m) for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. 100 vessels with unknown nationalities.

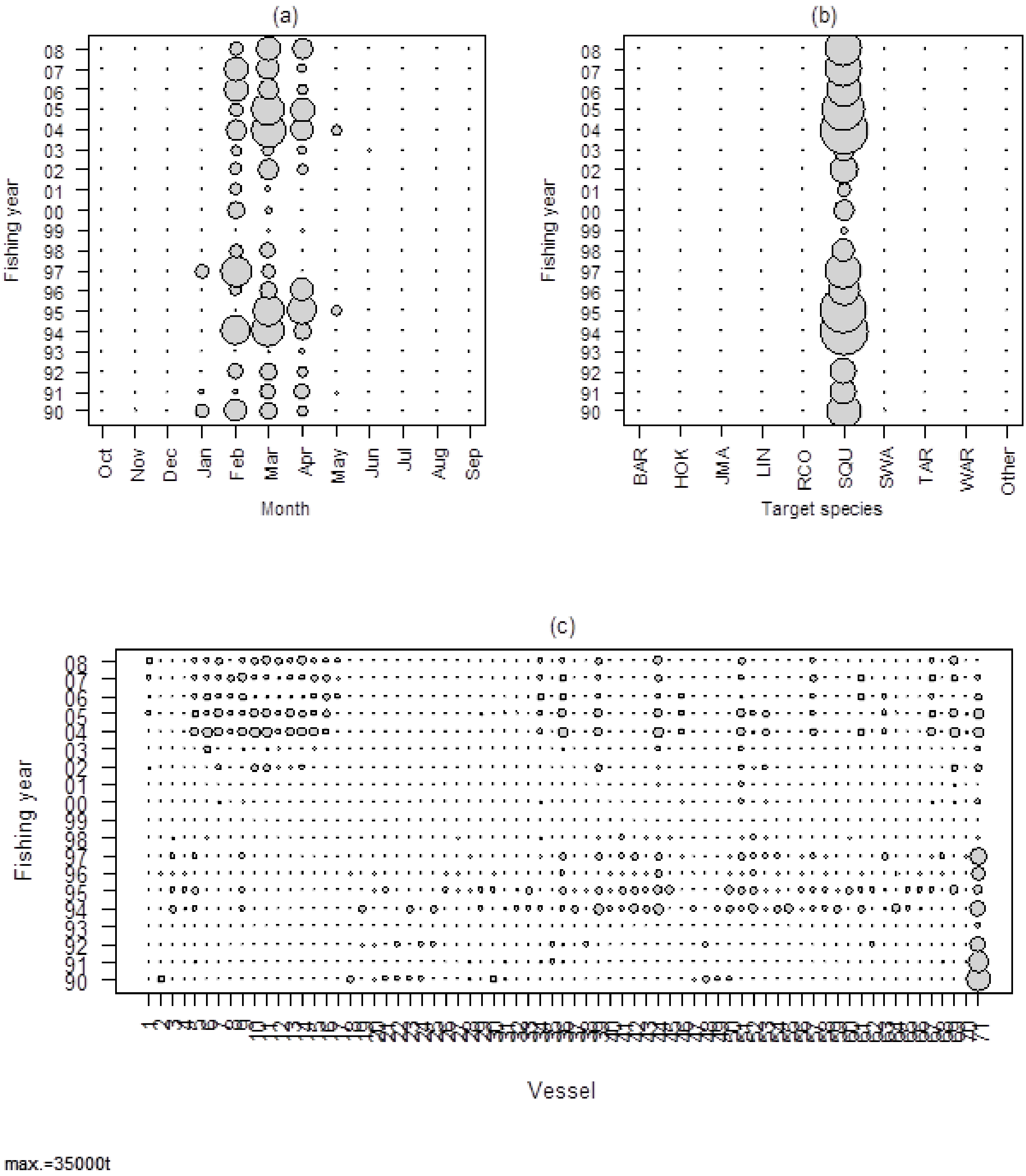


Figure C7h: Distribution of SQU catch for AUCKLAND IS. TRAWL DATA (circle size is proportional to catch for 1989–90 (90) to 2007–08 (08) fishing years by a) month, b) target species, and d) vessel (top 70 vessels, 206 vessels overall). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. See Table C2 for methods and species codes definitions.

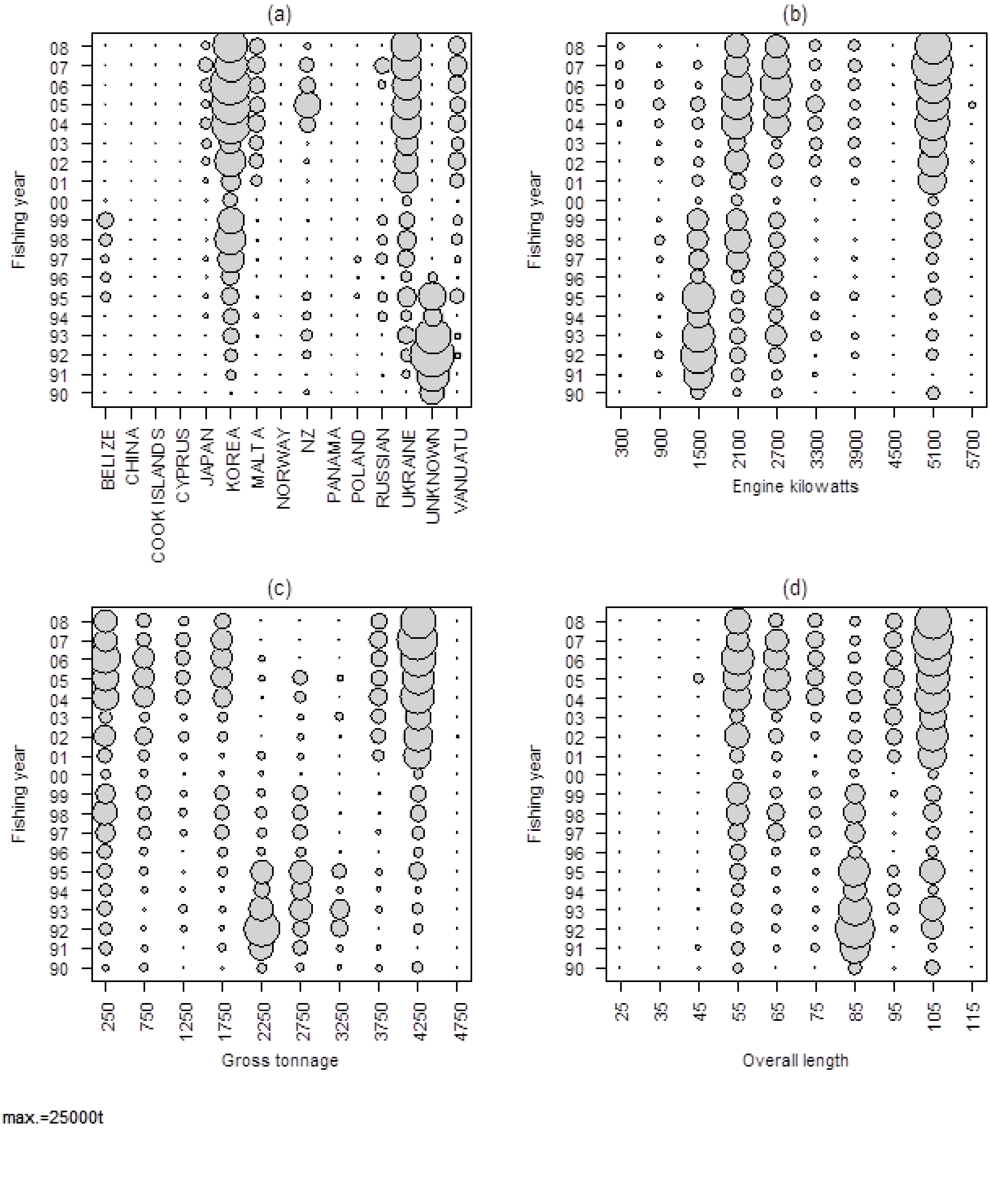


Figure C7i: Distribution of SQU catch for SNARES TRAWL DATA by nationality, vessel power, gross tonnage, and length (m) for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. 114 vessels with unknown nationalities.

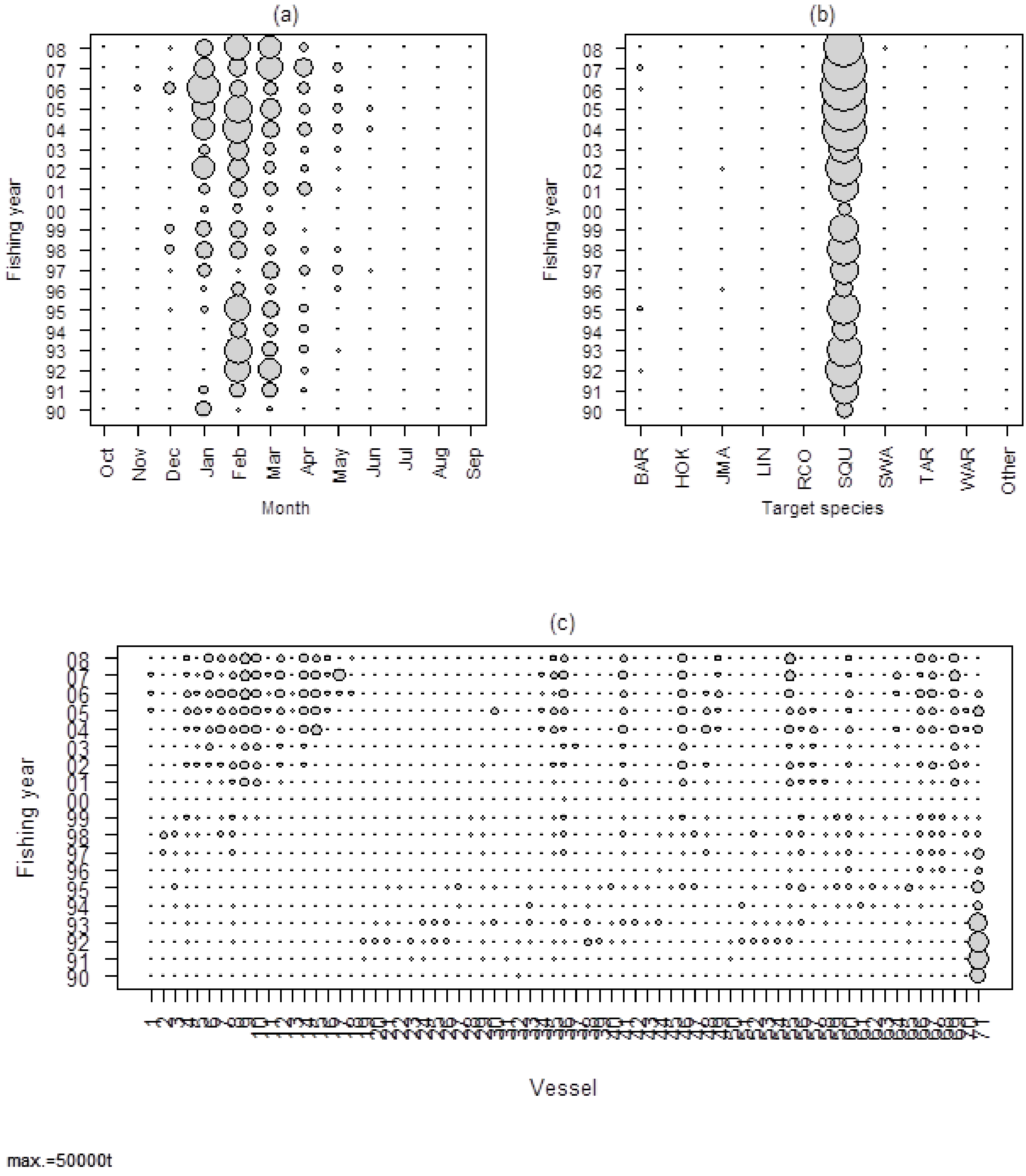


Figure C7j: Distribution of SQU catch for SNARES TRAWL DATA (circle size is proportional to catch for 1989–90 (90) to 2007–08 (08) fishing years by a) month, b) target species, and d) vessel (top 70 vessels, 314 vessels overall). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. See Table C2 for methods and species codes definitions.

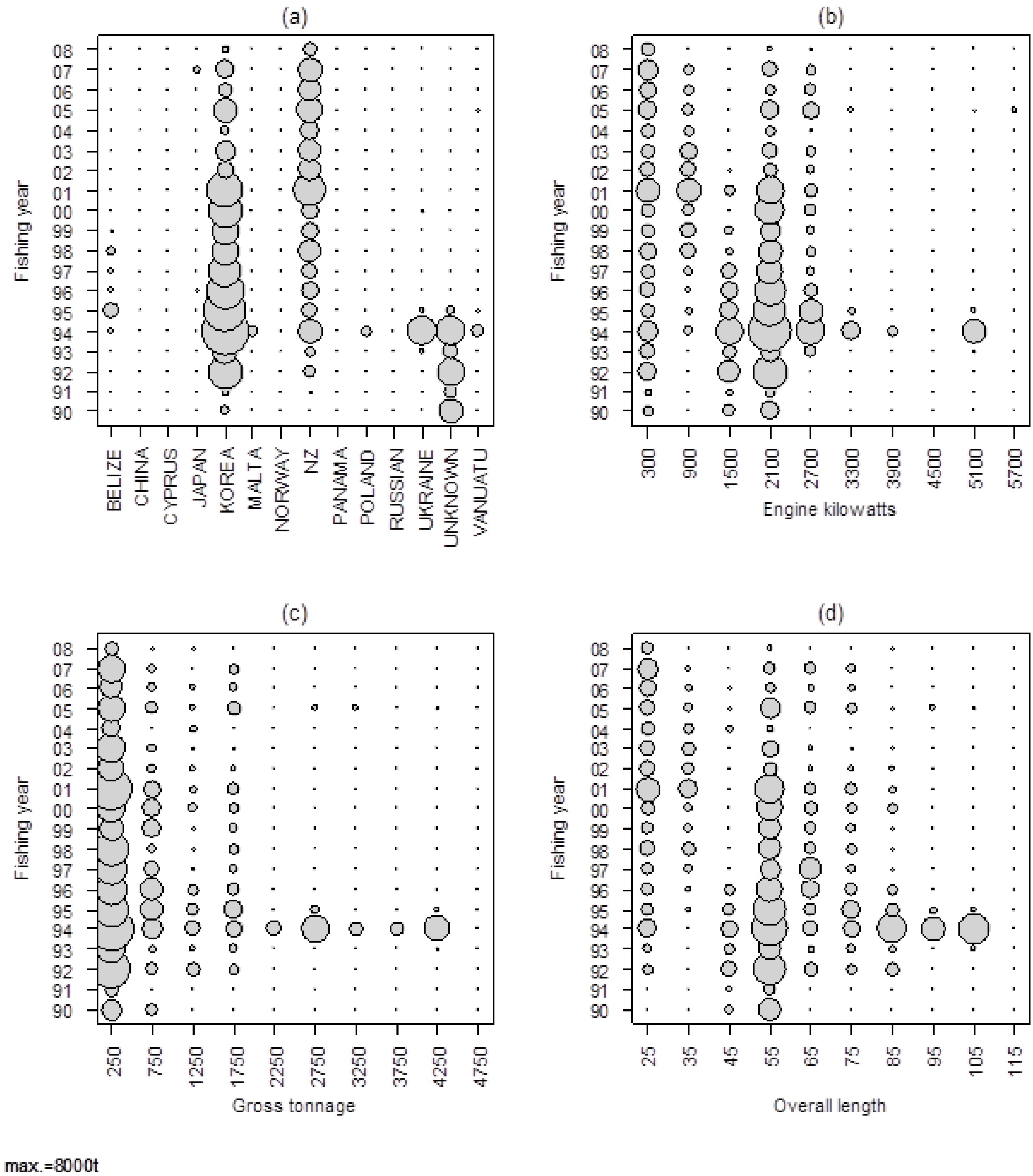


Figure C7k: Distribution of SQU catch for ECSI TRAWL DATA by nationality, vessel power, gross tonnage, and length (m) for fishing years 1989–90 (90) to 2007–08 (08). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. 79 vessels with unknown nationalities.

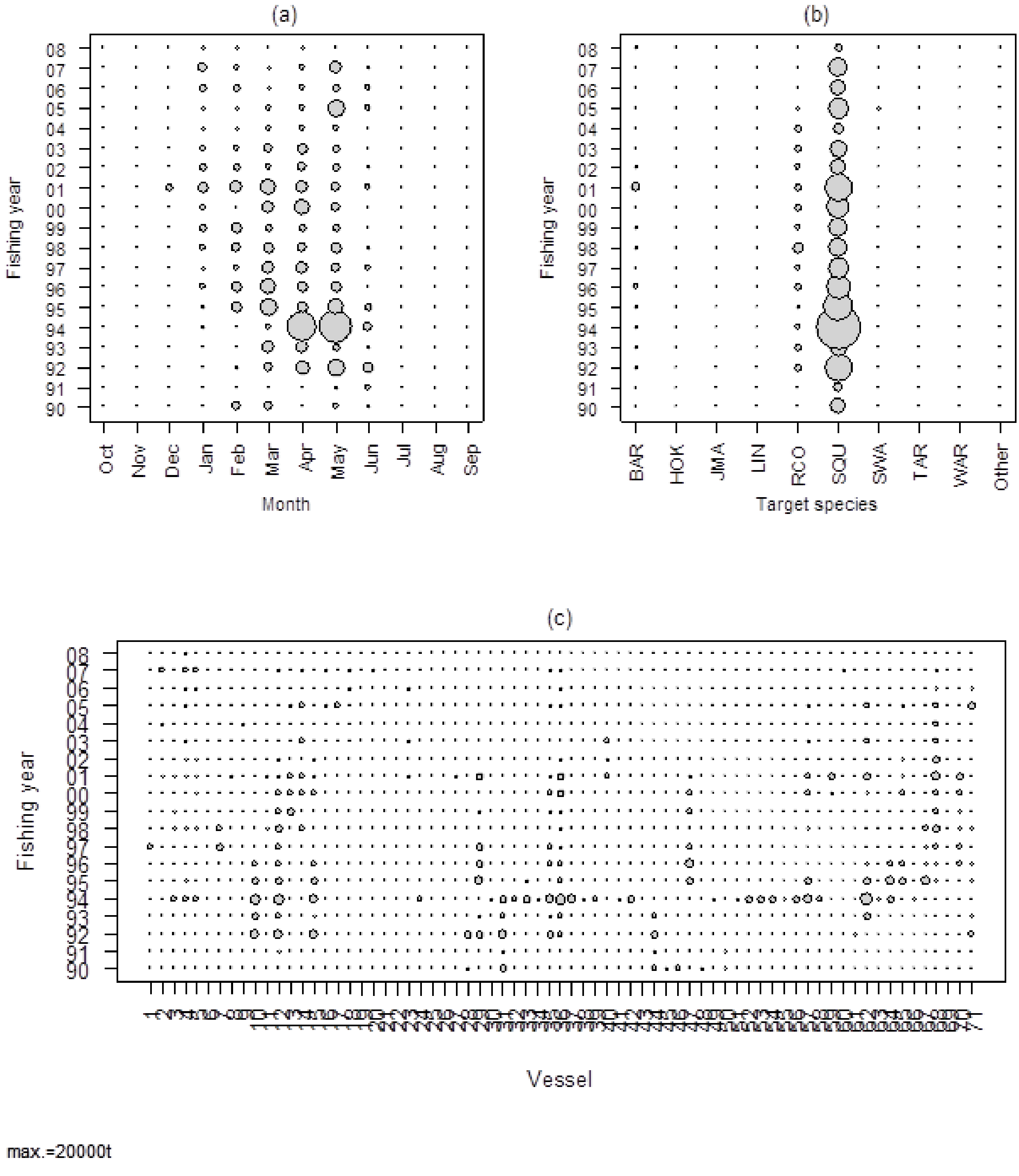


Figure C7l: Distribution of SQU catch for ECSI TRAWL DATA (circle size is proportional to catch for 1989–90 (90) to 2007–08 (08) fishing years by a) month, b) target species, and d) vessel (top 70 vessels, 396 vessels overall). Circle size is proportional to catch; maximum circle size is indicated in lower left hand corner. See Table C2 for methods and species codes definitions.

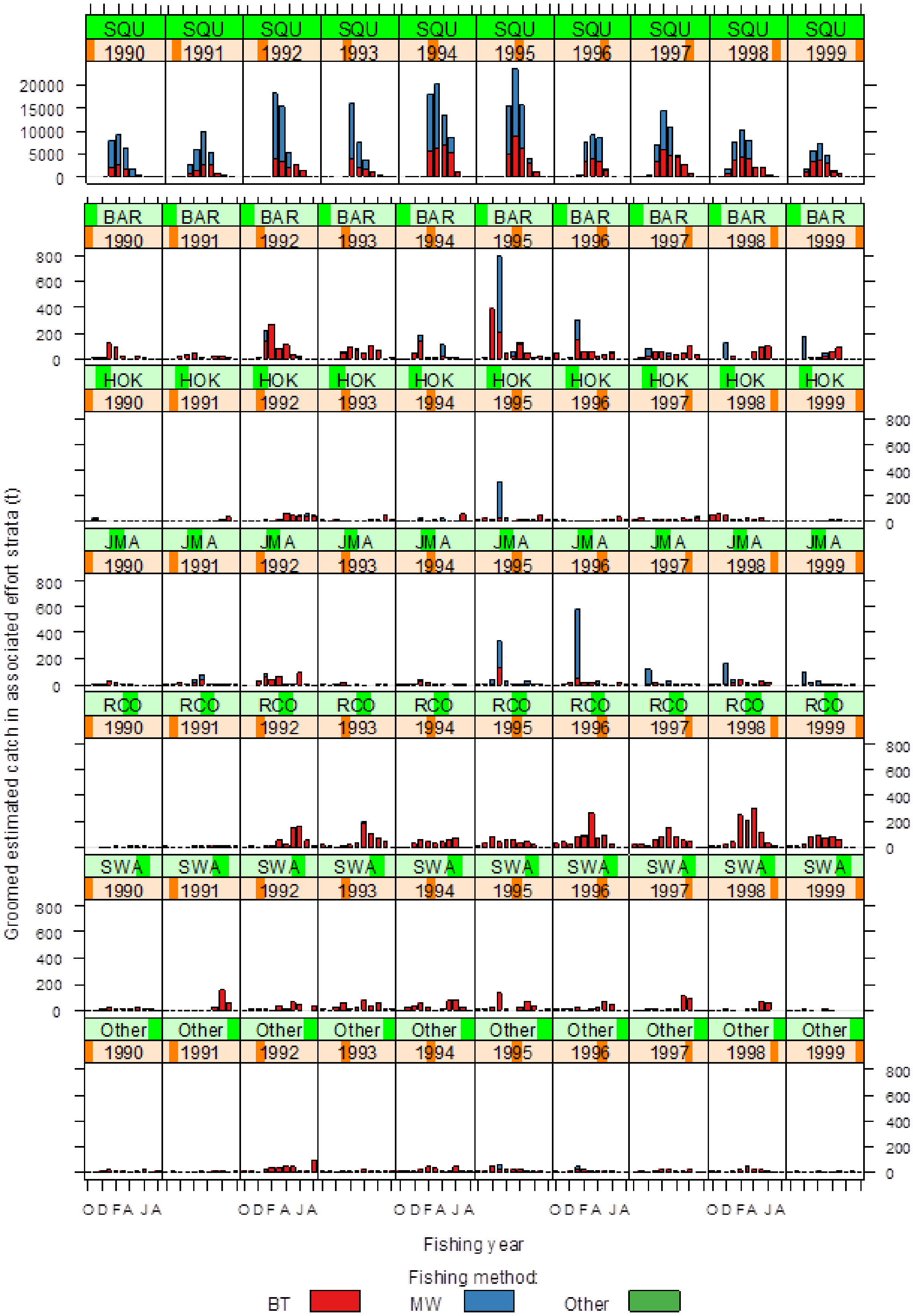


Figure C8a: Distribution of SQU trawl catch by target species (top five target species by squid catch) and by fishing method (MW and BT) for 1989–90 (90) to 2007–08 (08) fishing years. See Table C2 for method and species codes definitions.

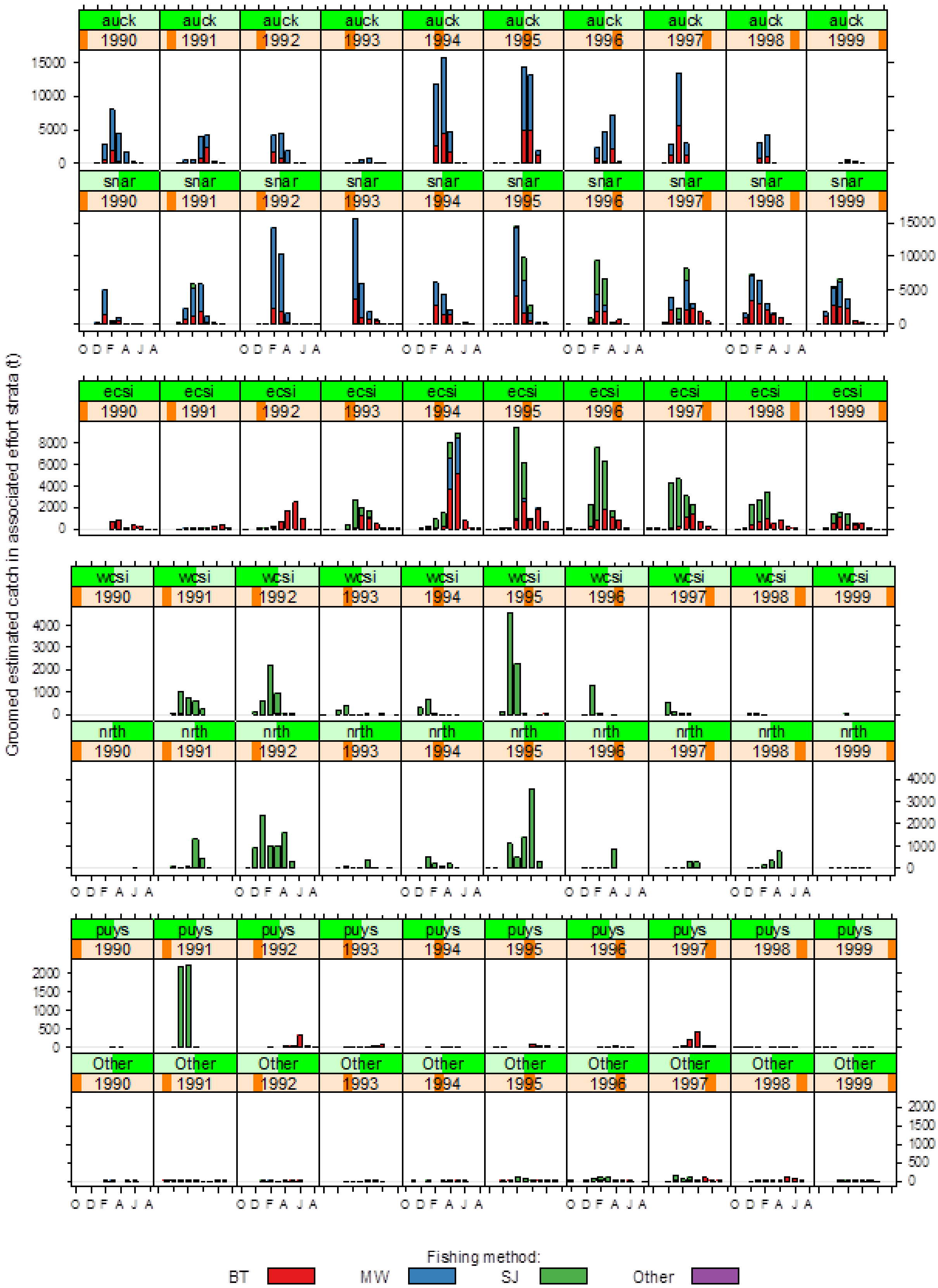


Figure C8b: Distribution of SQU catch by area and fishing method (MW, BT, SJ) for 1989–90 (90) to 2007–08 (08) fishing years. See Table C2 for method and species codes definitions.

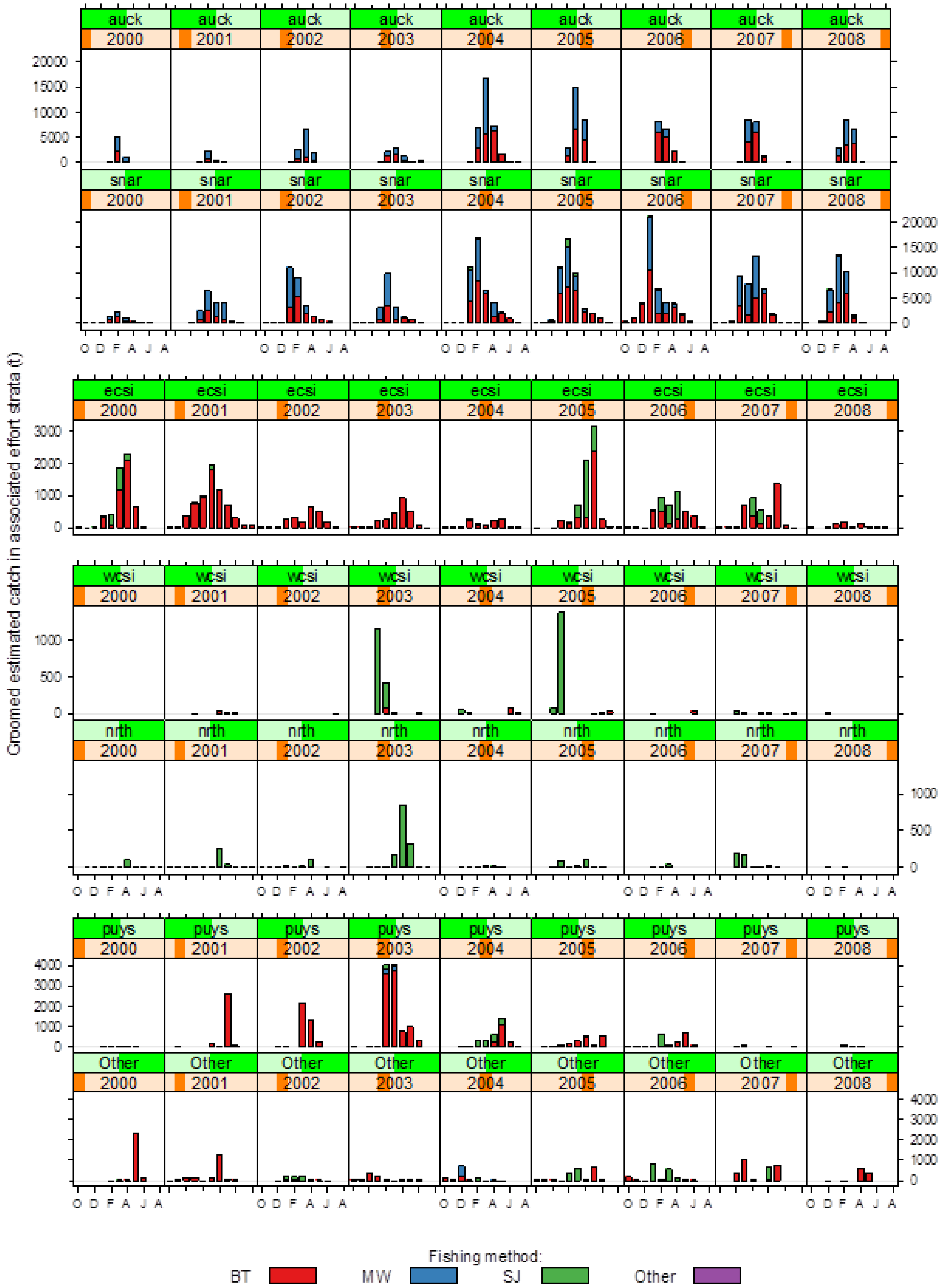


Figure C8b: continued.

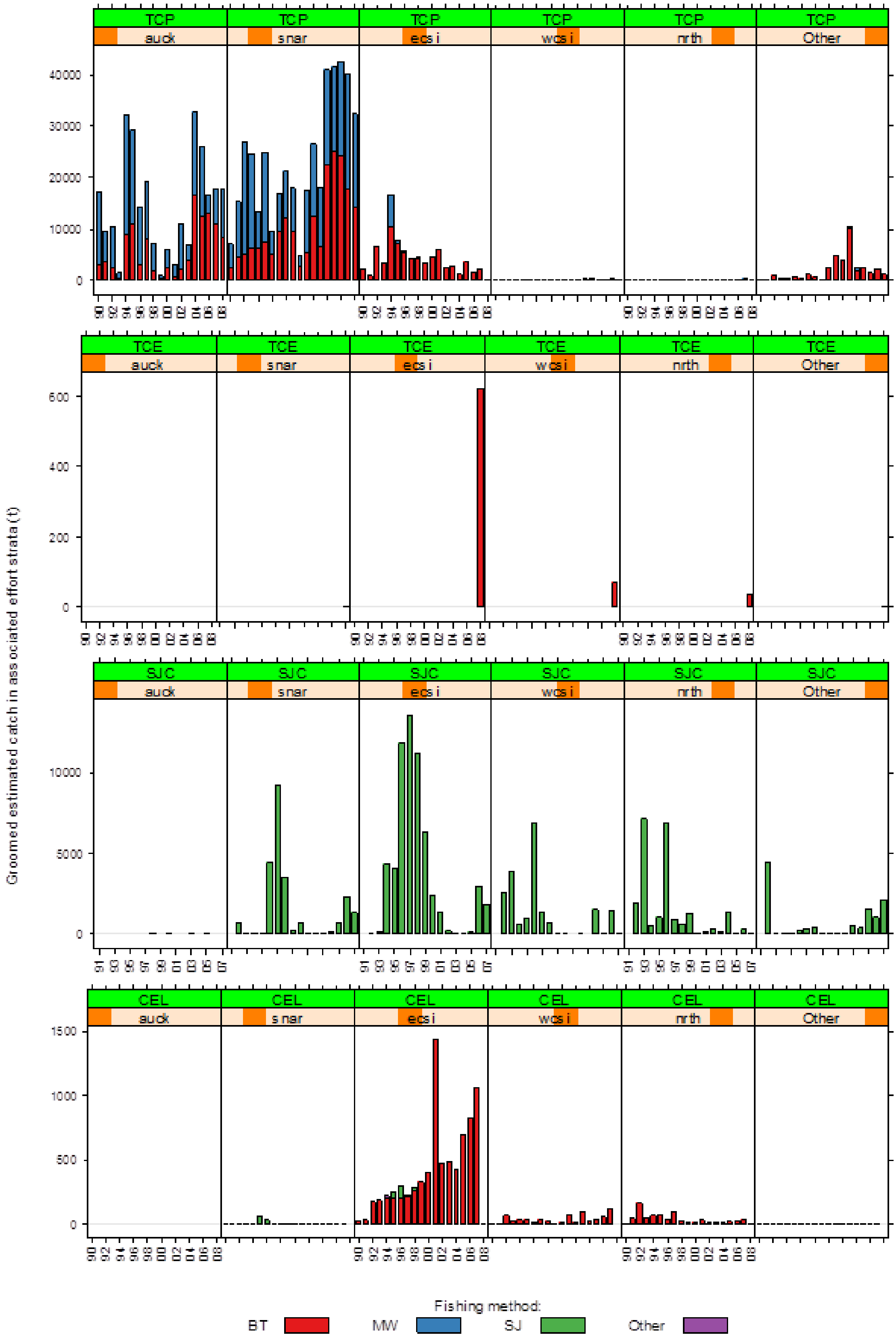


Figure C8c: Distribution of SQU catch by form type, area, and fishing method (MW, BT, SJ), for 1989–90 (90) to 2007–08 (08) fishing years. TCP, TCEPR form; TCE, TCER form; CEL, CELR effort; SJC, SJCER form, see Table C2 for form type and fishing method details.

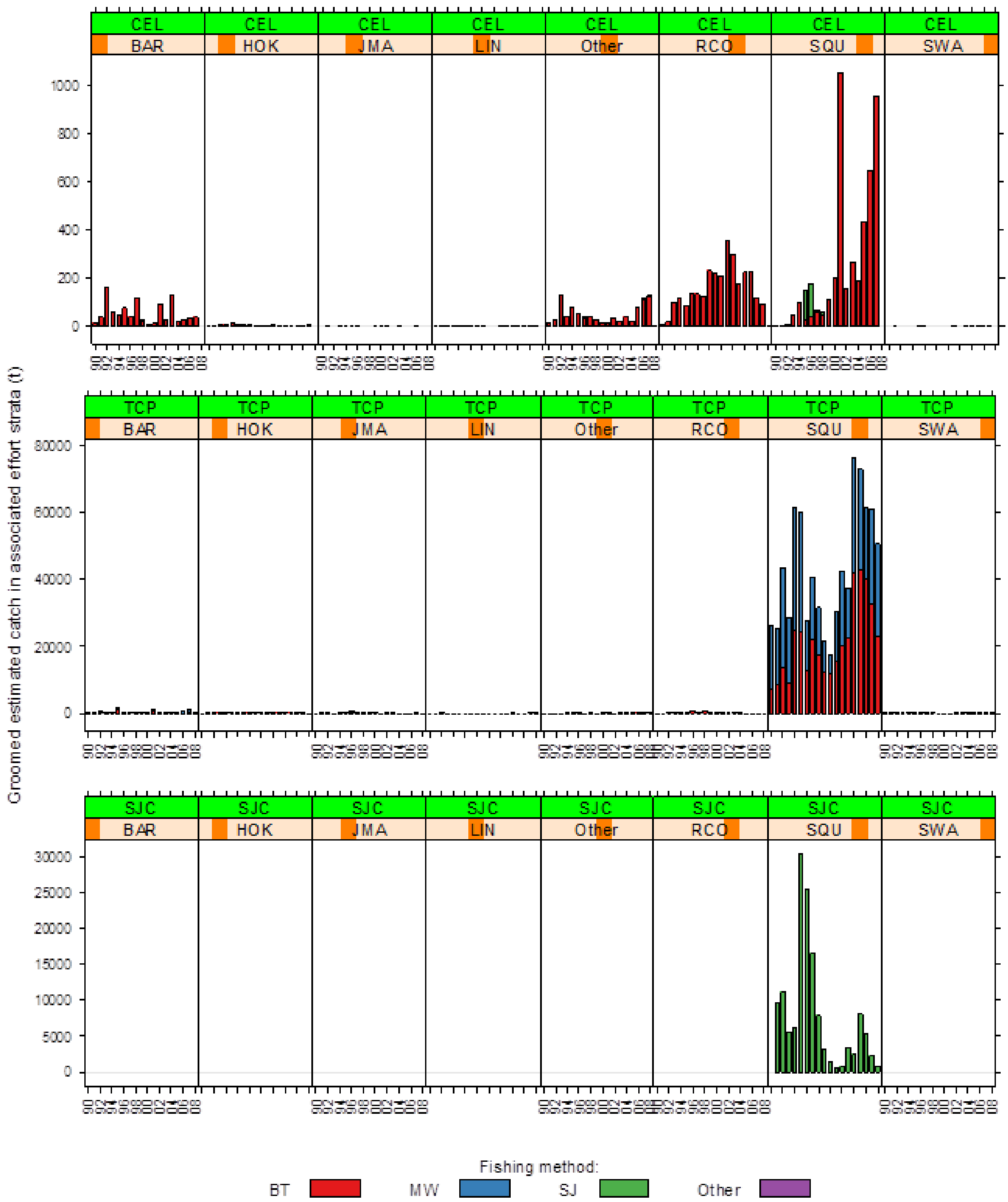


Figure C8d: Distribution of SQU catch by form type, target species, fishing method (MW, BT, SJ), and fishing year (1990–2008). TCP, TCEPR form; CEL, CELR effort; SJC, SJCER form, see Table C2 for form type and fishing method details.

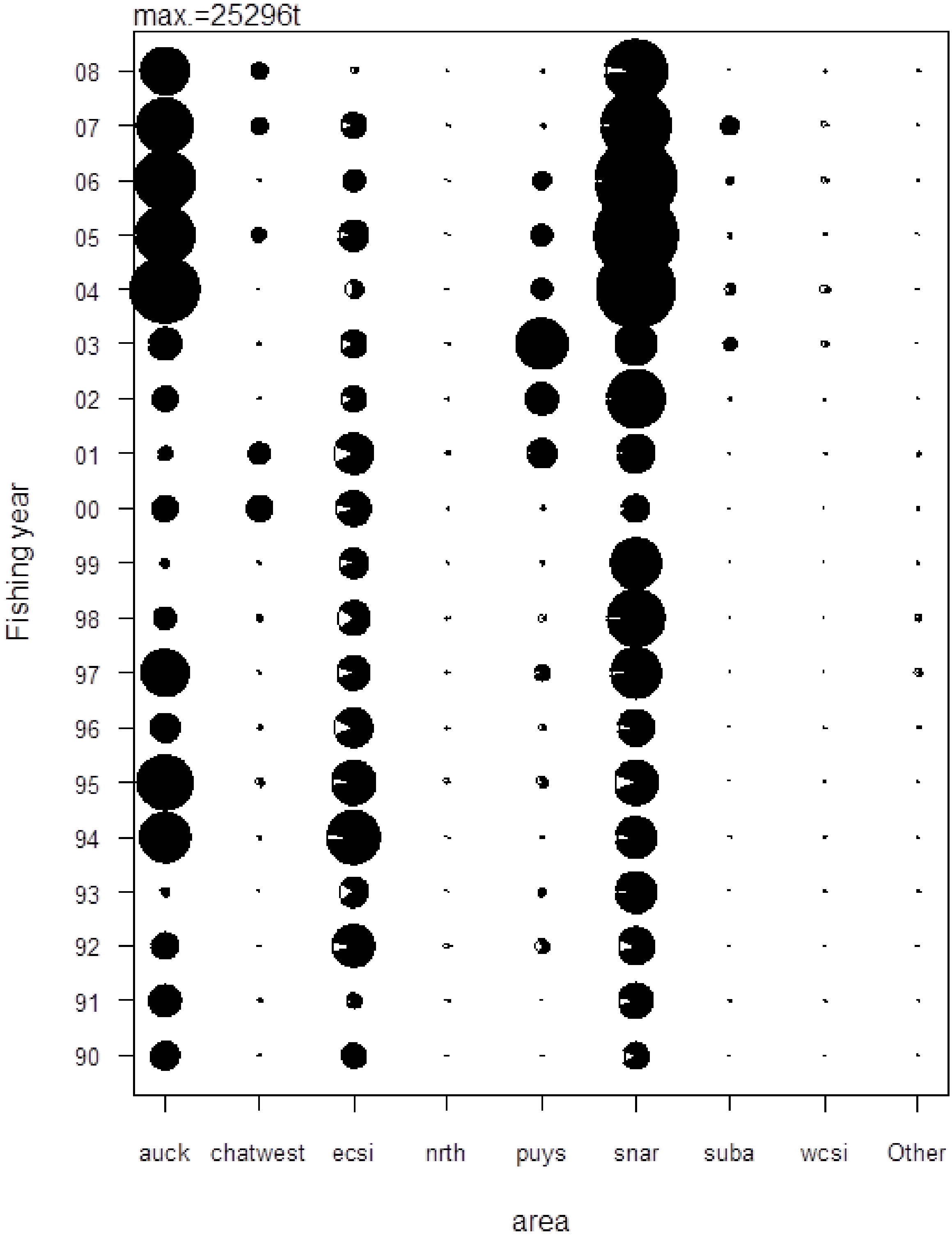


Figure C9a: Distribution of SQU catch by fishing year and area. Circle size is proportional to the total catch and the black portion of the pie indicates the proportion of the catch that was targeted.

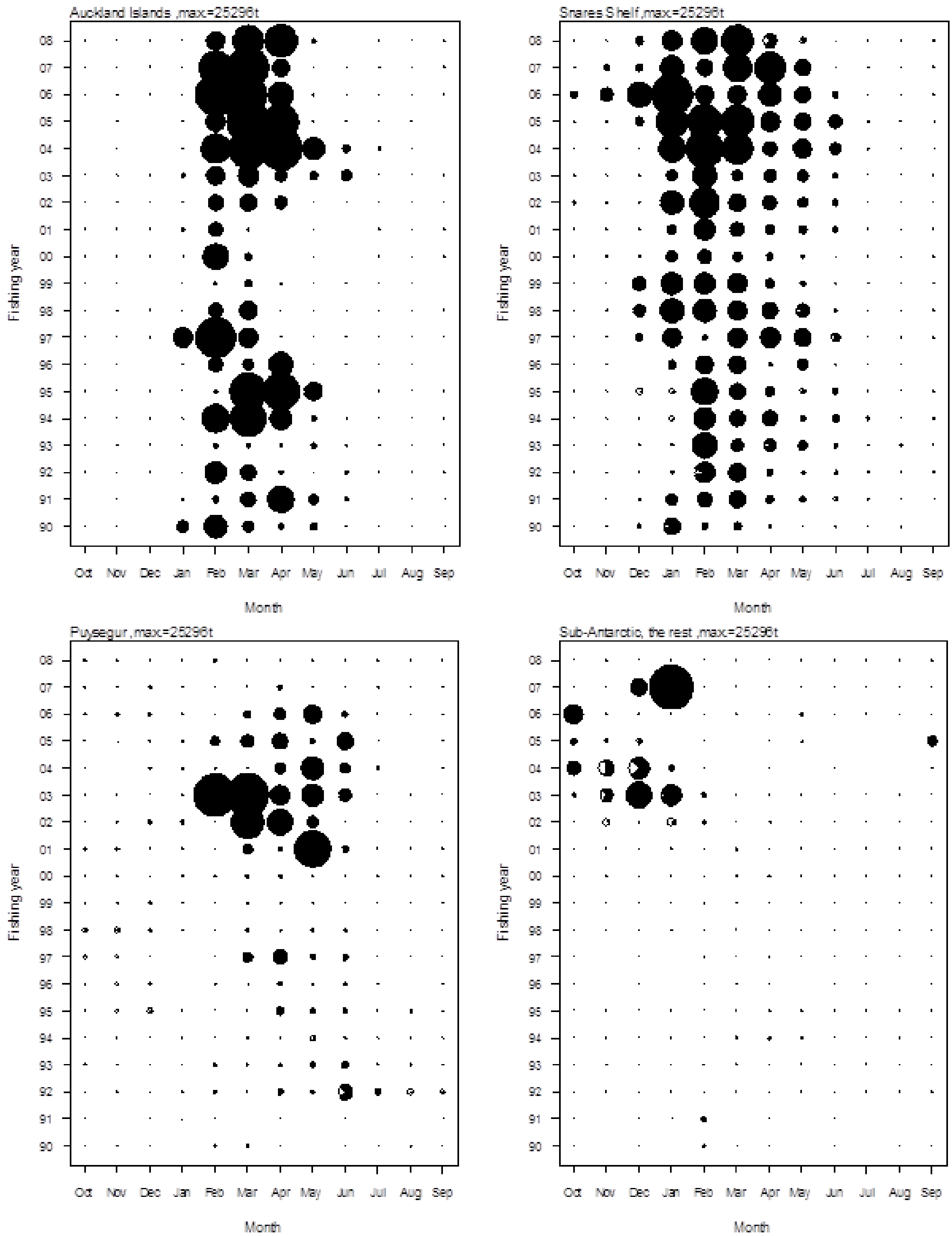


Figure C9b: Distribution of SQU catch by fishing year, area and month. Circle size is proportional to the total catch and the black portion of the pie indicates the proportion of the catch that was targeted.

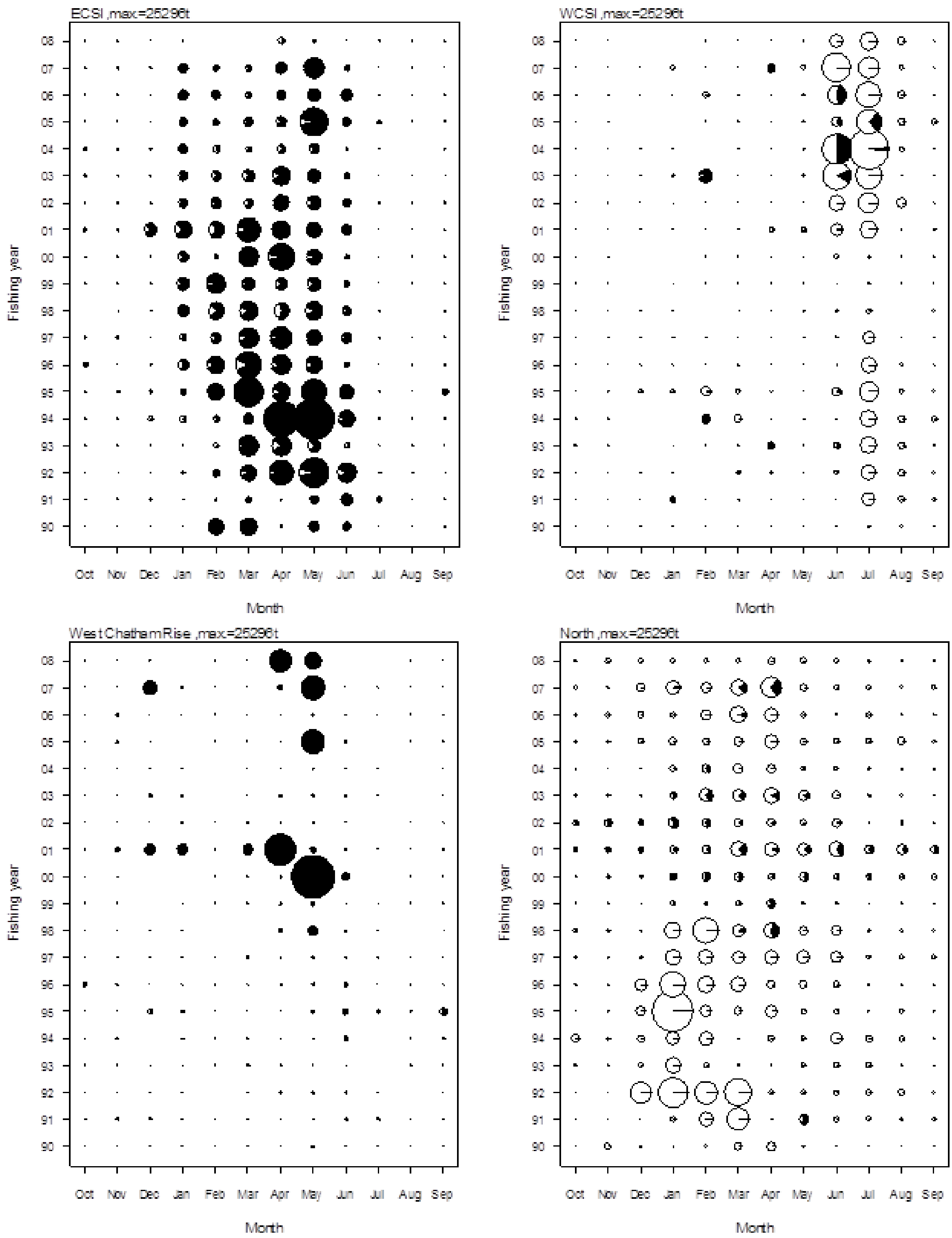


Figure C9b: continued. Distribution of SQU catch by fishing year, area and month. Circle size is proportional to the total catch and the black portion of the pie indicates the proportion of the catch that was targeted.

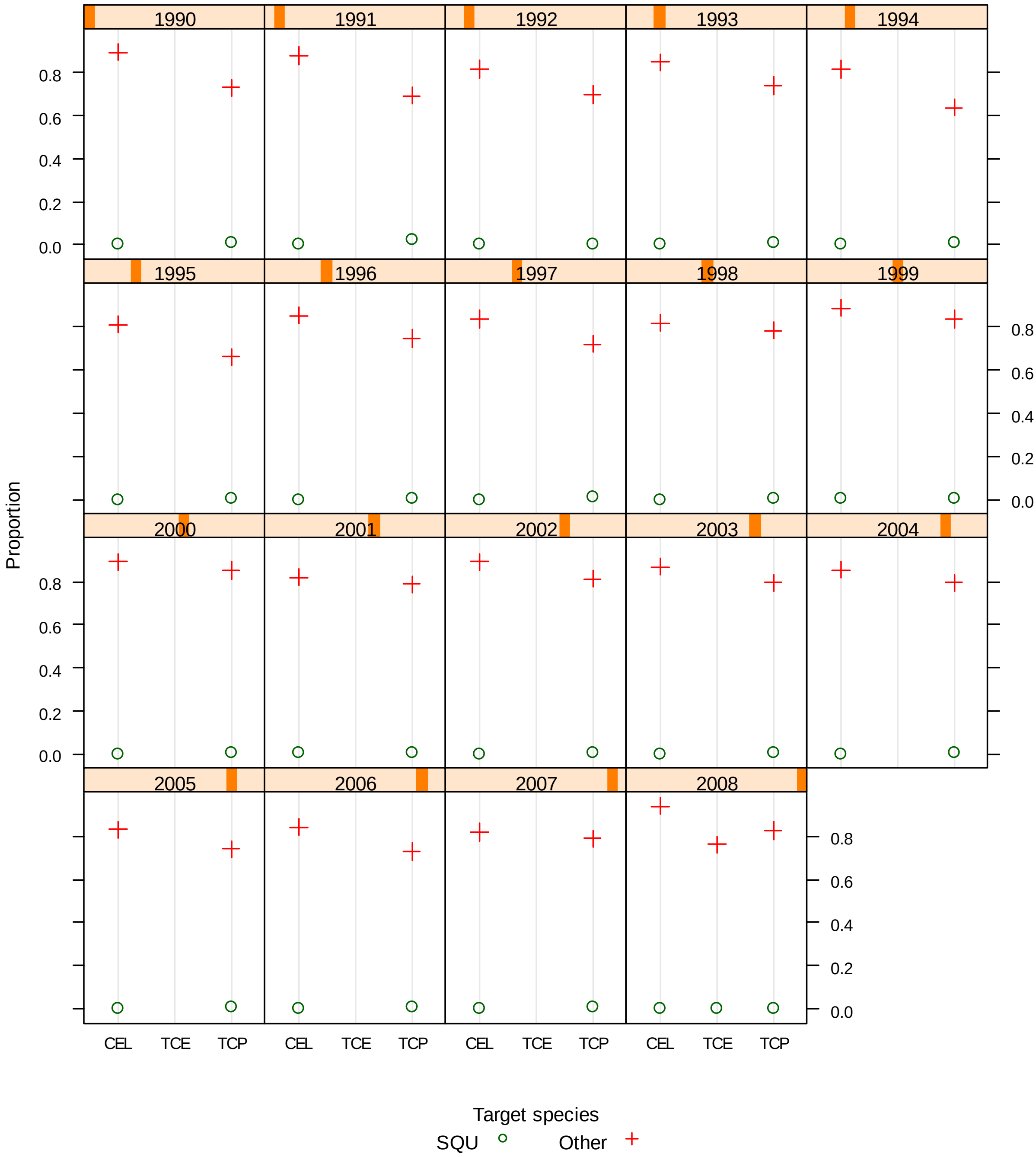


Figure C10: Proportion of SQU catch zero tows by form type and target species for fishing years 1990–2008. TCP, TCEPR form; TCE, TCER form; CEL, CELR effort. See Table C2 for form type details.

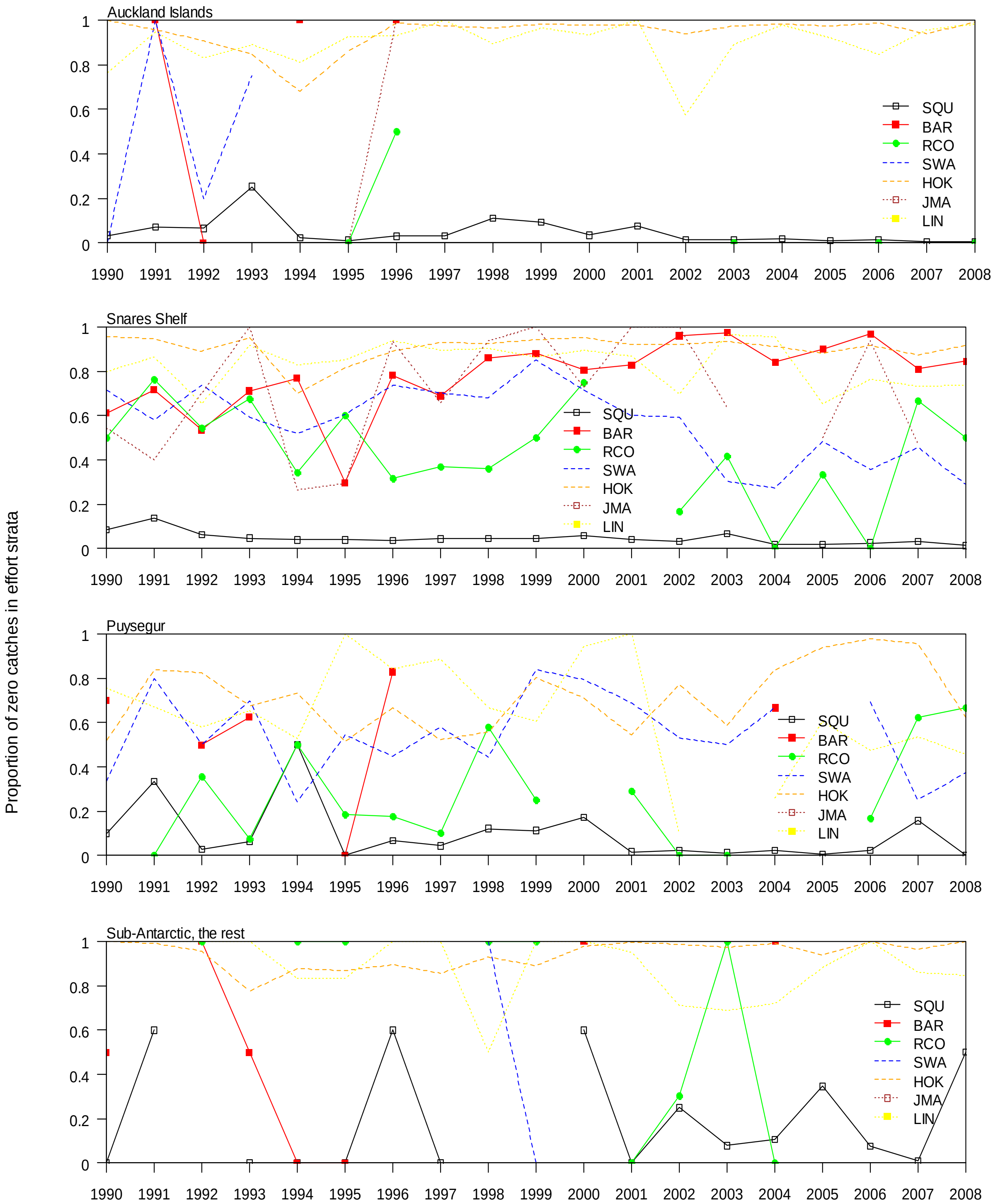


Figure C11: Proportion of BT trawl tows with zero SQU catch for major target species by area for fishing years 1989–90 (90) to 2007–08 (08). See Table C2 for species code definitions.

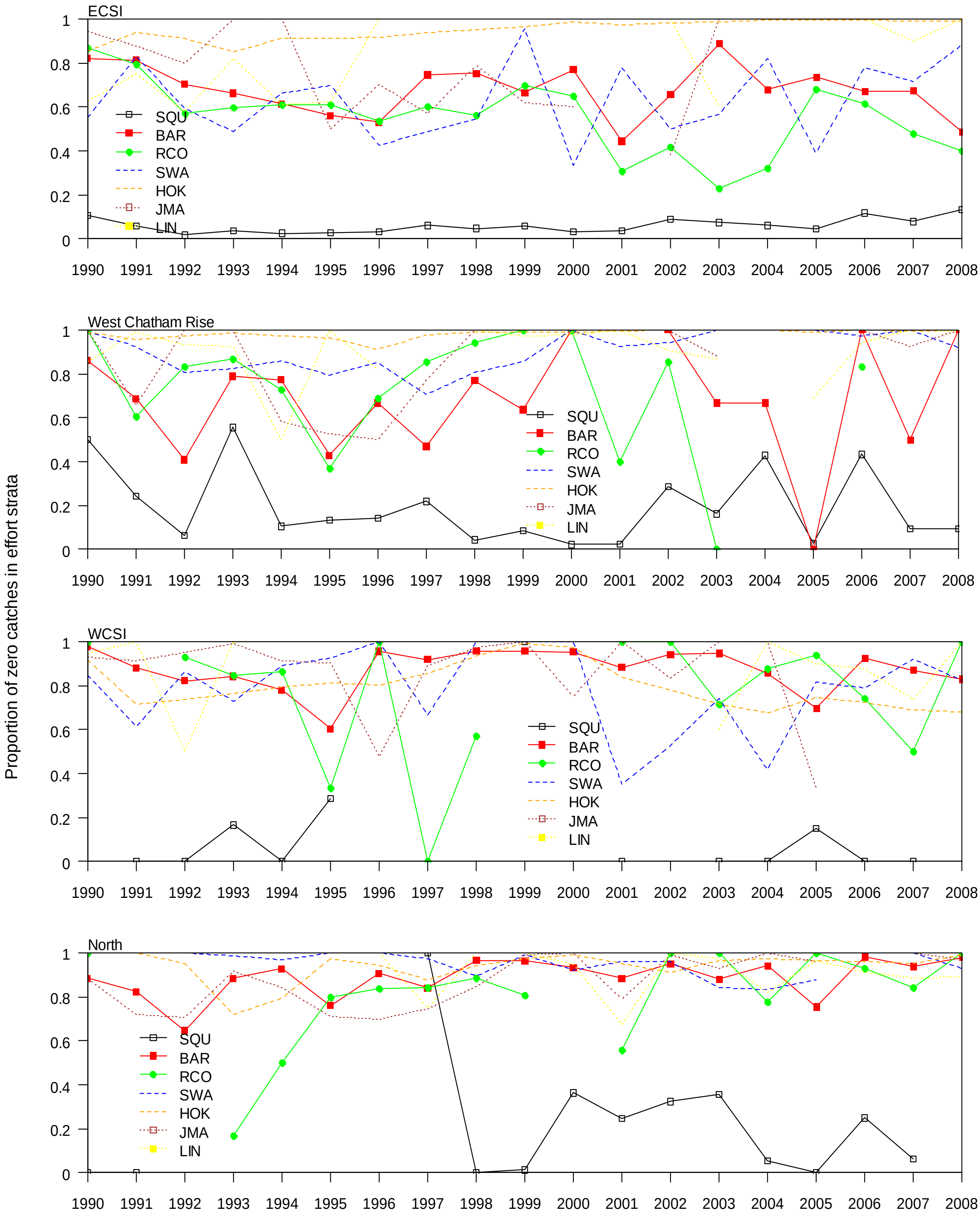


Figure C11 continued.

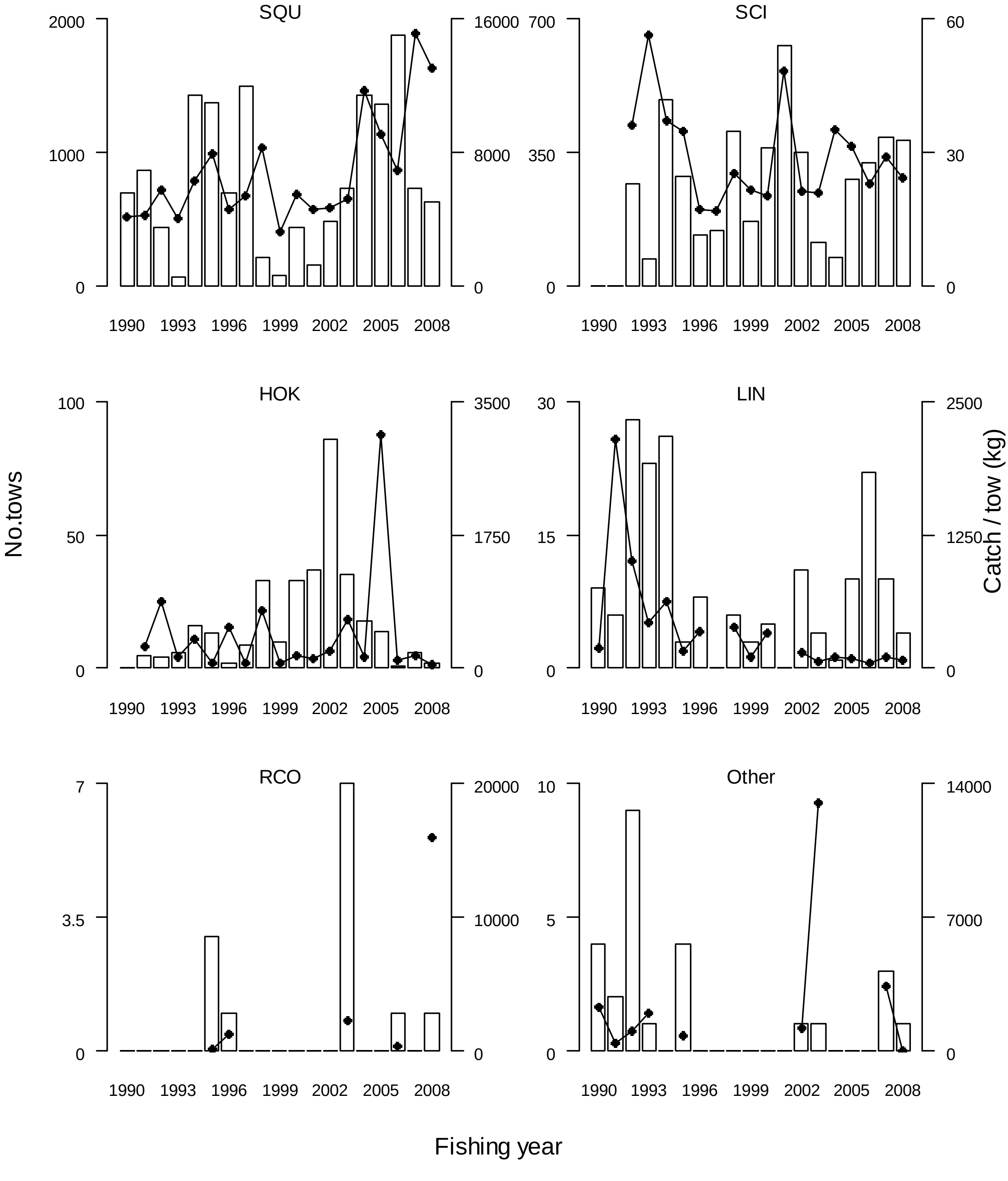


Figure C12a: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the AUCKLAND IS. region. Top five target species by squid catch are used. See Table C2 for species code definitions. Catch rates are total catch / total effort for each year. Bars, number of tows; lines, catch rates.

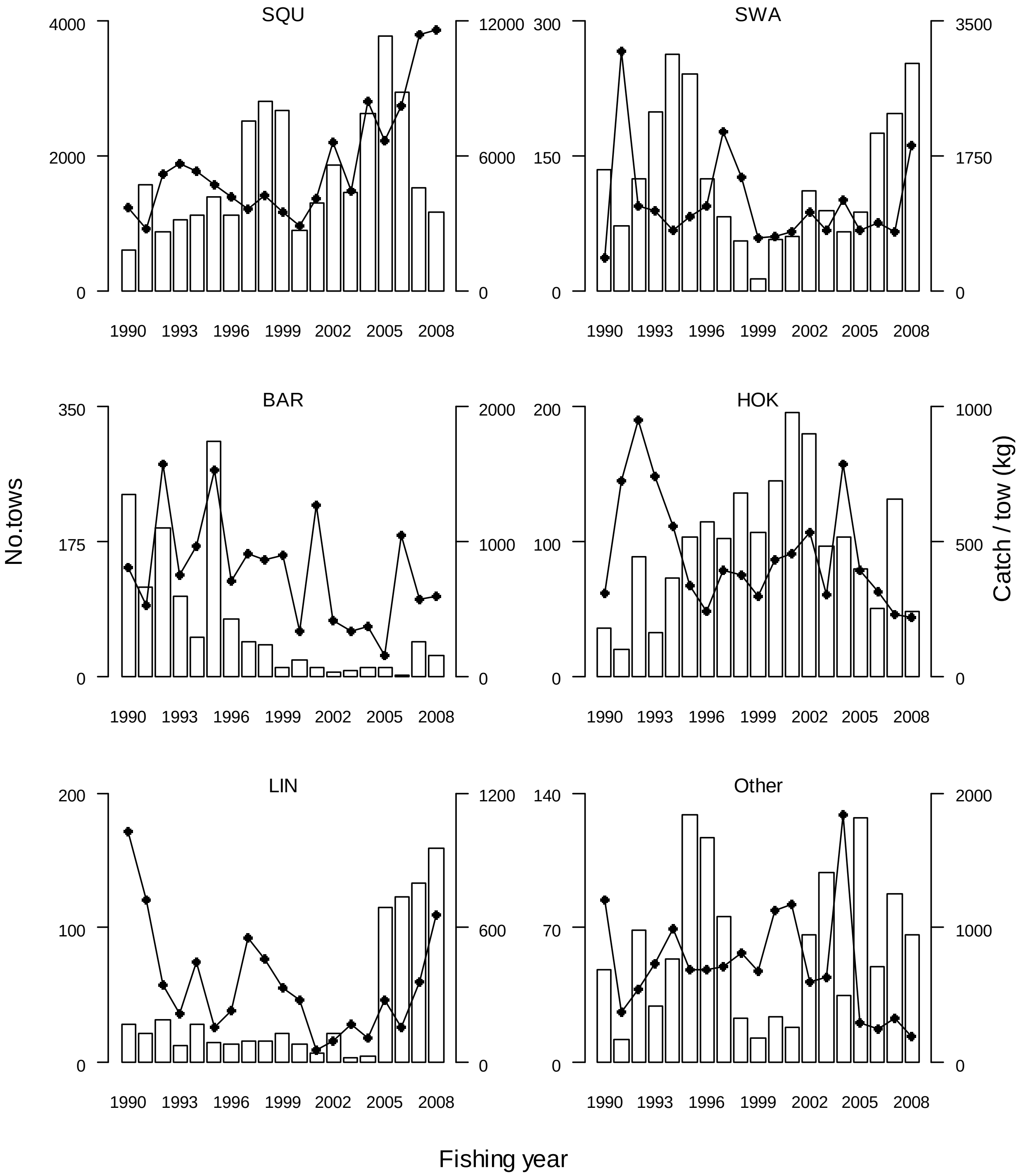


Figure C12b: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the SNARES region. Top five target species by squid catch are used. See Table C2 for species code definitions. Catch rates are total catch / total effort for each year. Bars, number of tows; lines, catch rates.

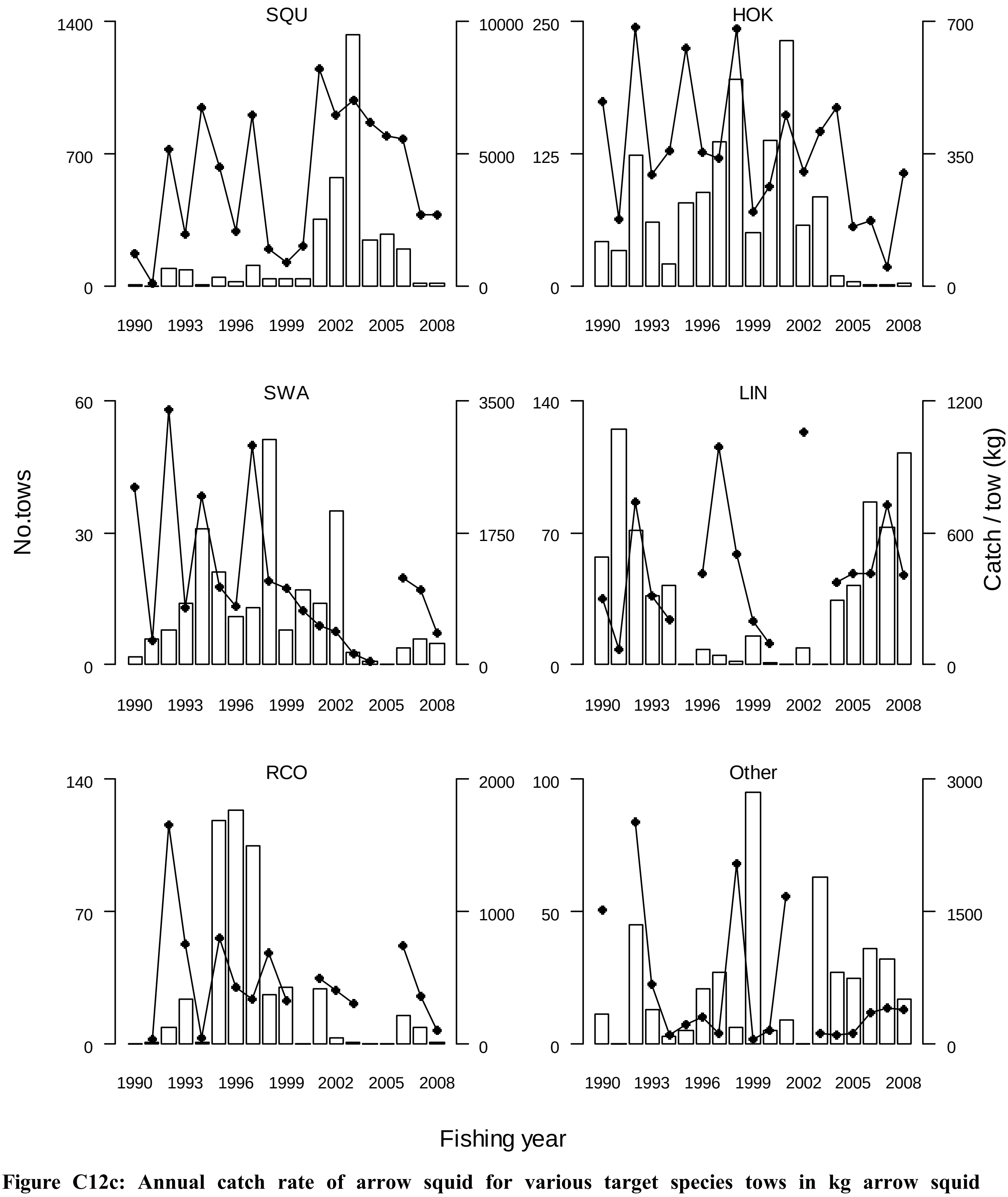


Figure C12c: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the PUYSEGUR region. Top five target species by squid catch are used. Catch rates are total catch / total effort for each year. See Table C2 for species code definitions. Bars, number of tows; lines, catch rates.

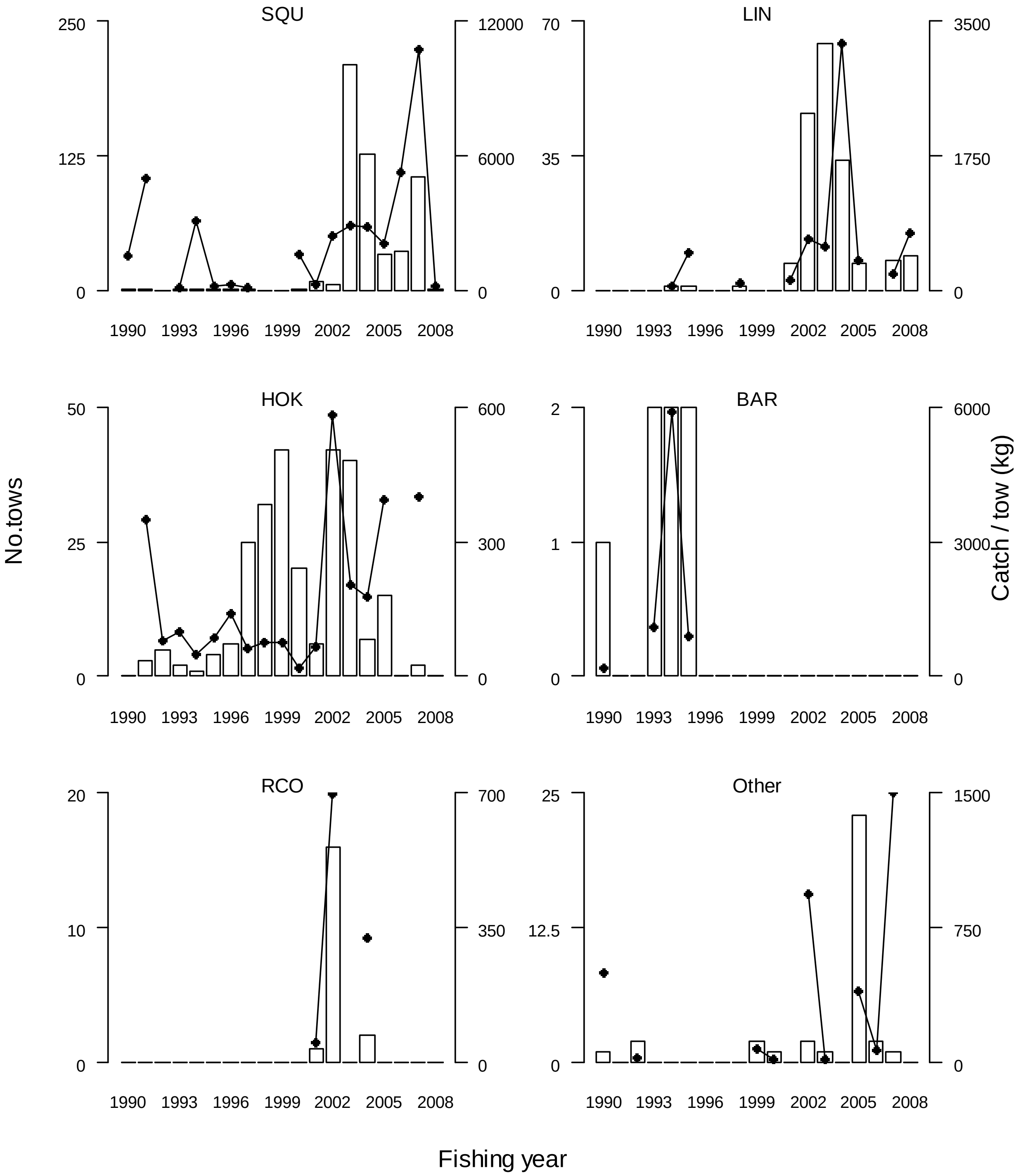


Figure C12d: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the REST OF THE SUB-ANTARCTIC region. Top five target species by squid catch are used. Catch rates are total catch / total effort for each year. See Table C2 for species code definitions. Bars, number of tows; lines, catch rates.

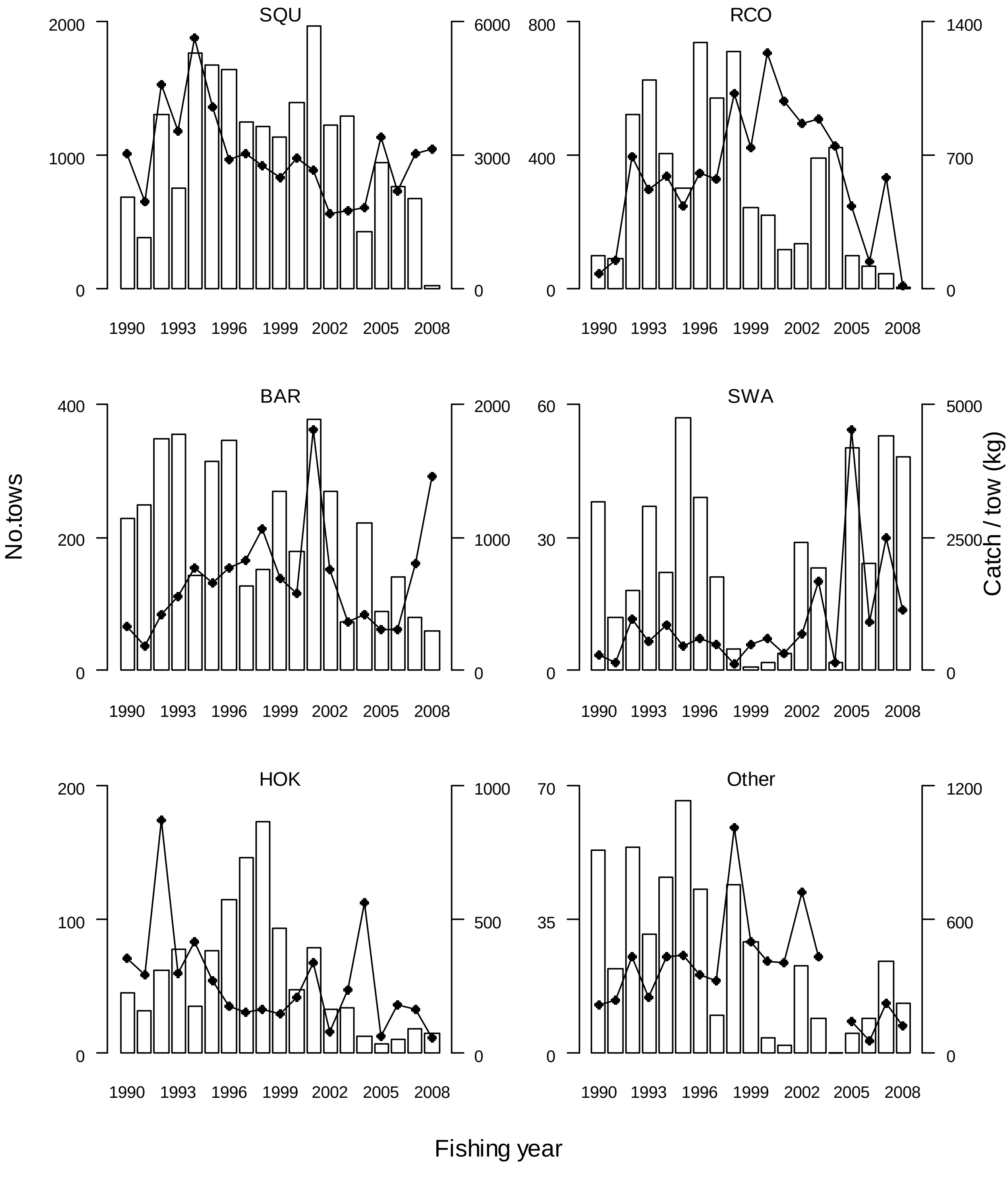


Figure C12e: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the ECSI region. Top five target species by squid catch are used. Catch rates are total catch / total effort for each year. See Table C2 for species code definitions. Bars, number of tows; lines, catch rates.

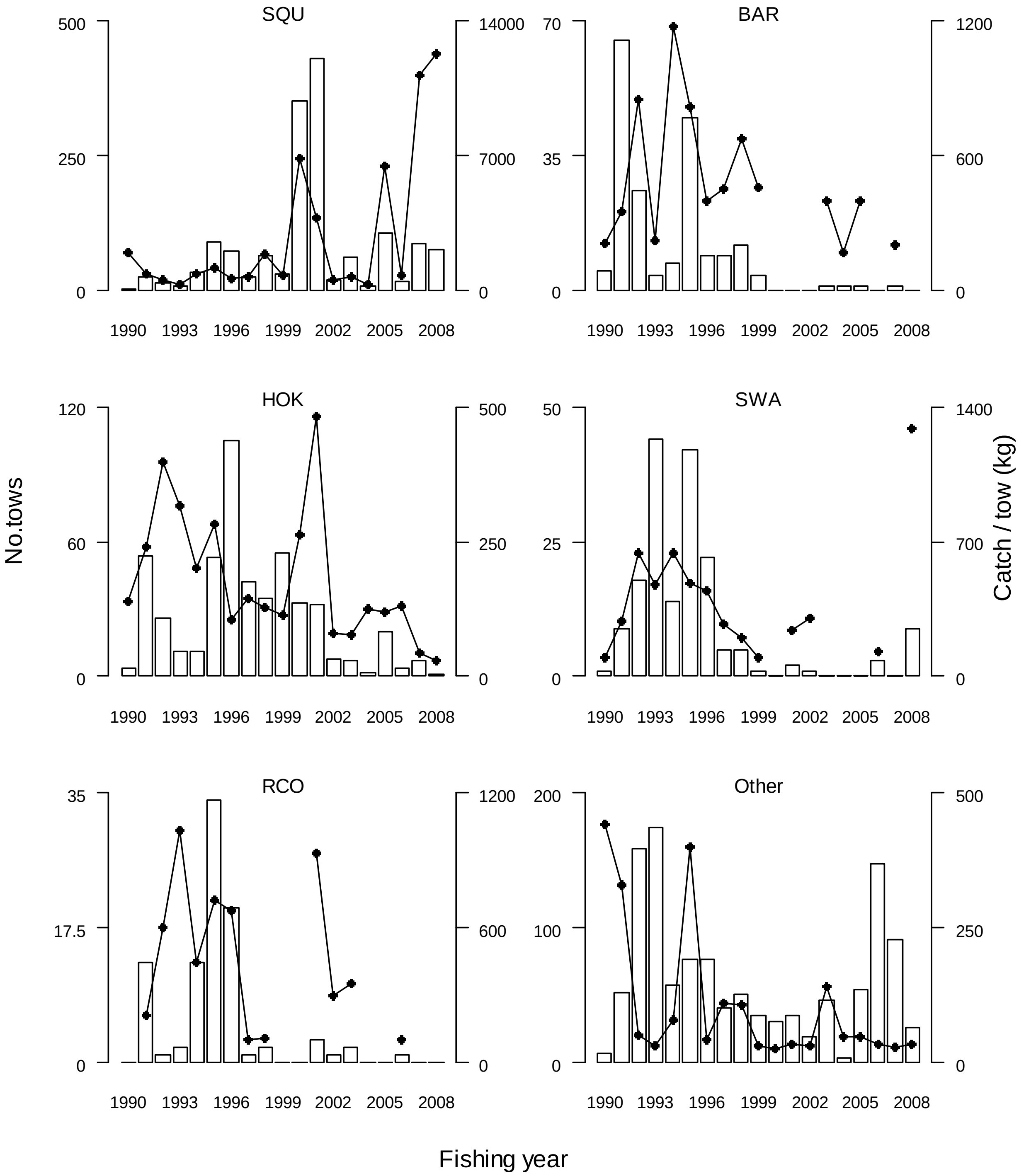


Figure C12f: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the WEST CHATHAM RISE region. Top five target species by squid catch are used. Catch rates are total catch / total effort for each year. See Table C2 for species code definitions. Bars, number of tows; lines, catch rates.

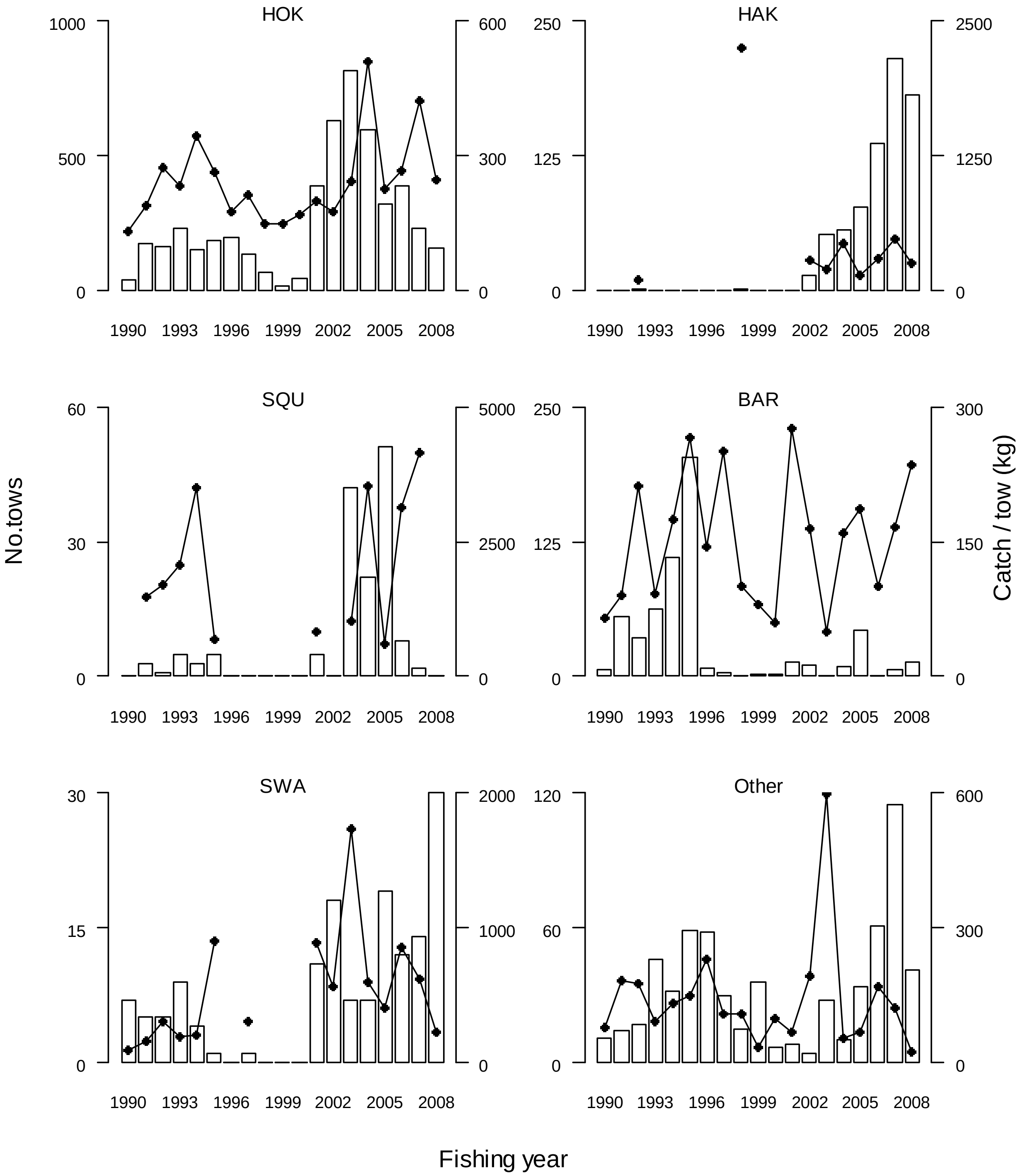


Figure C12g: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the WCSI region. Top five target species by squid catch are used. Catch rates are total catch / total effort for each year. See Table C2 for species code definitions. Bars, number of tows; lines, catch rates.

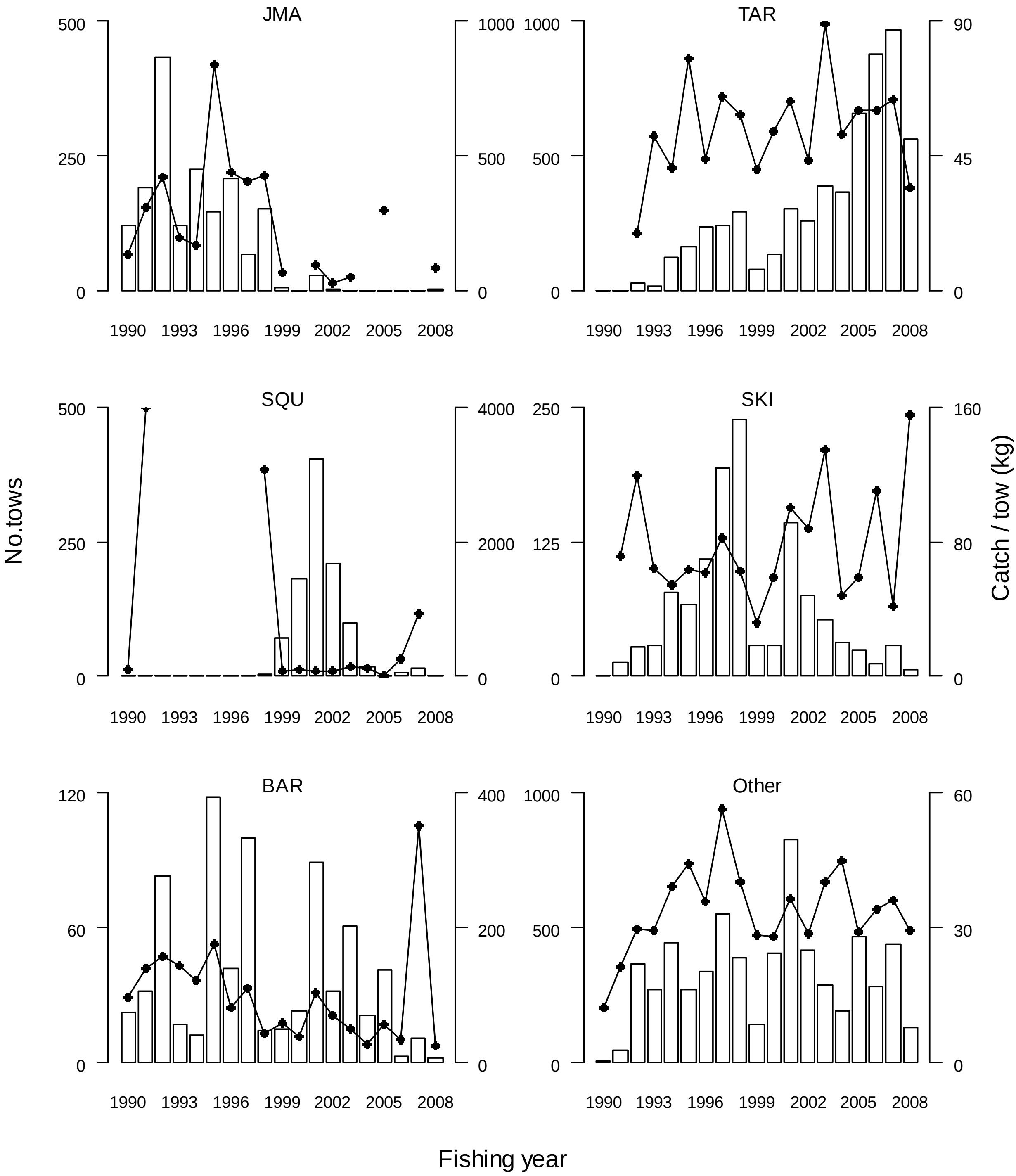


Figure C12h: Annual catch rate of arrow squid for various target species tows in kg arrow squid (catch/tow) and the number of tows for the NORTH region. Top five target species by squid catch are used. Catch rates are total catch / total effort for each year. See Table C2 for species code definitions. Bars, number of tows; lines, catch rates.

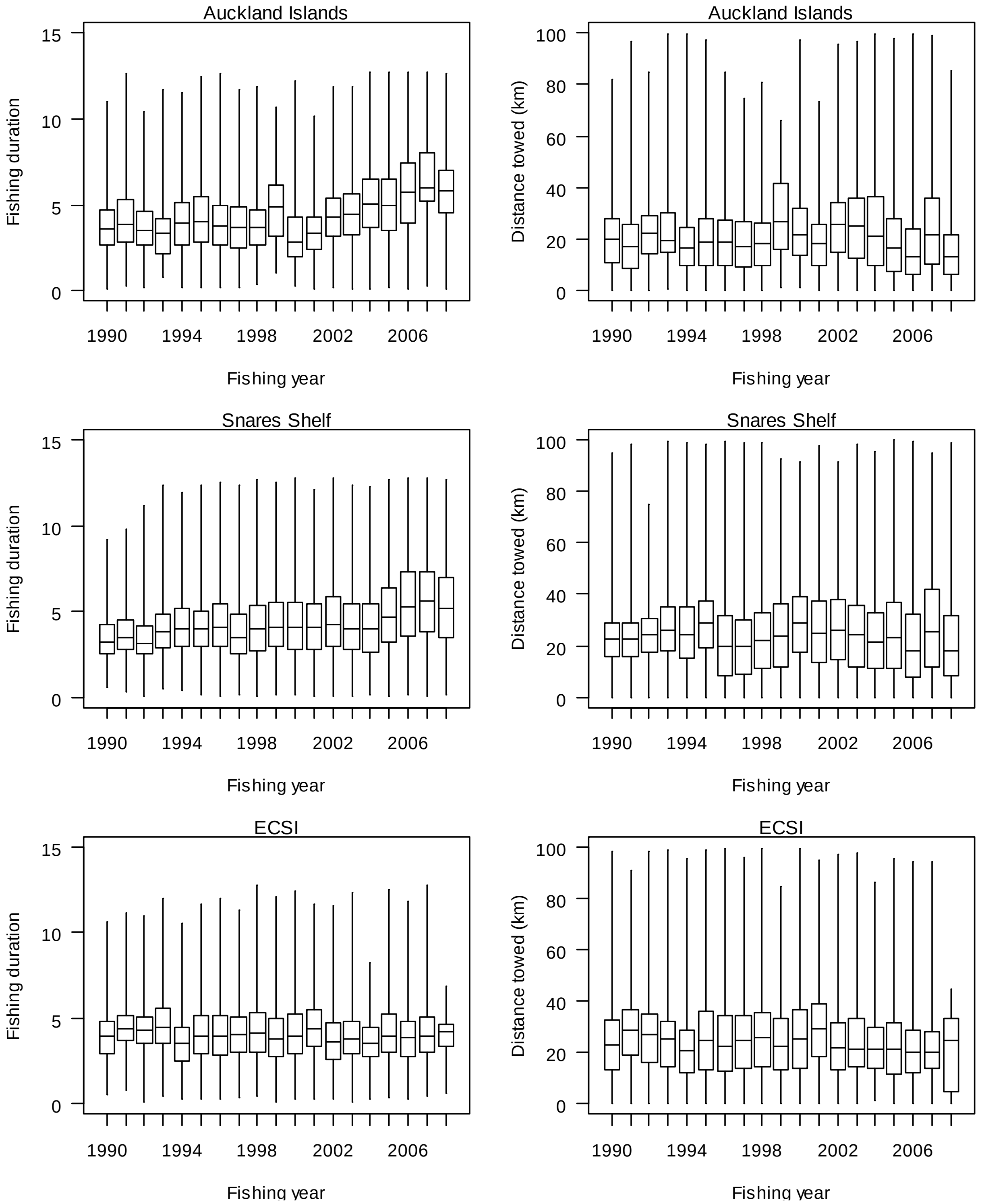


Figure C13a: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for tow durations and tow distance (start to finish position, km) for vessels targeting and catching arrow squid using bottom trawl gear in the Auckland Is., Snares, and ECSI regions.

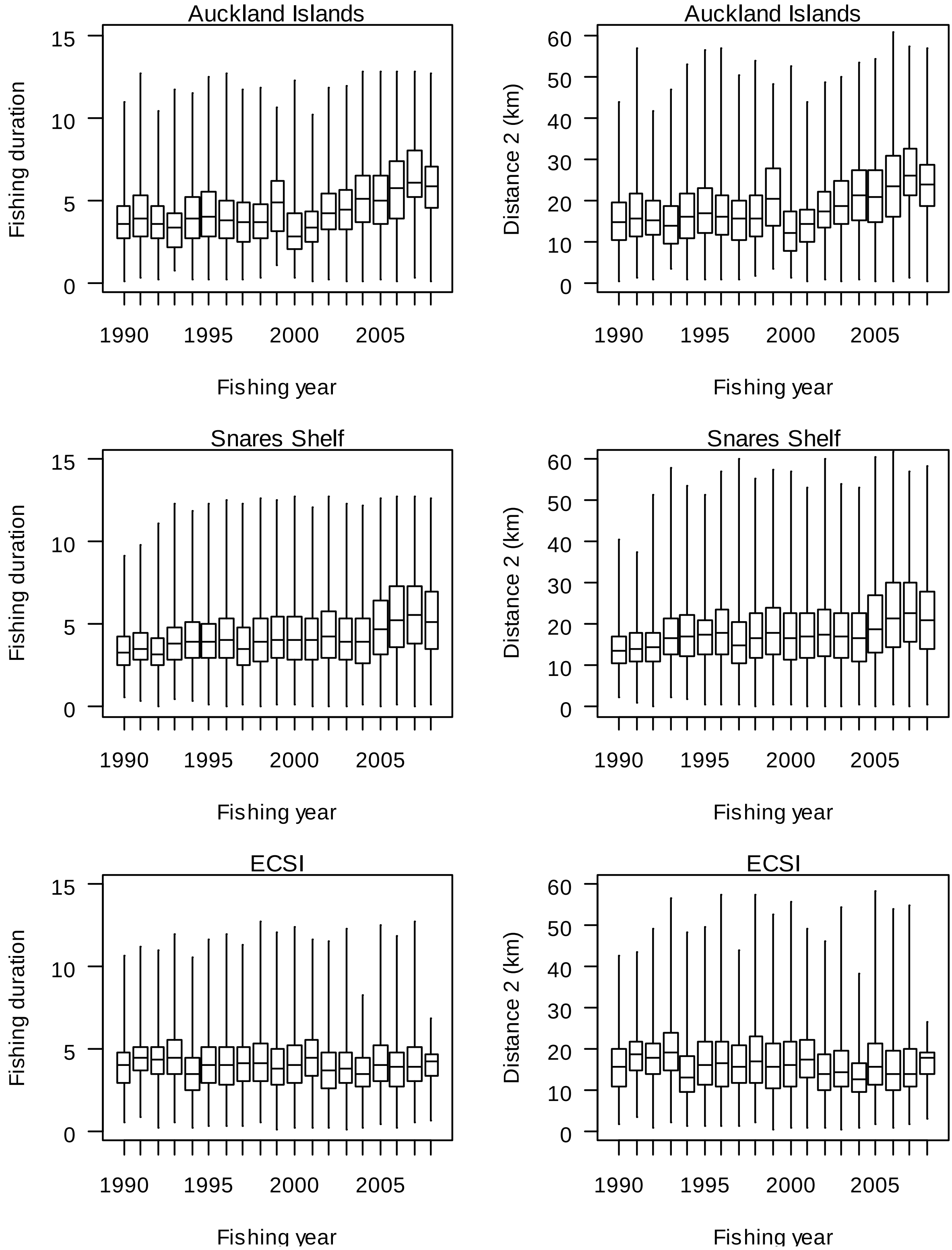


Figure C13b : Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for tow durations and distance 2 (tow speed x duration, km) for vessels targeting and catching arrow squid using bottom trawl gear in the Auckland Is., Snares, and ECSI regions.

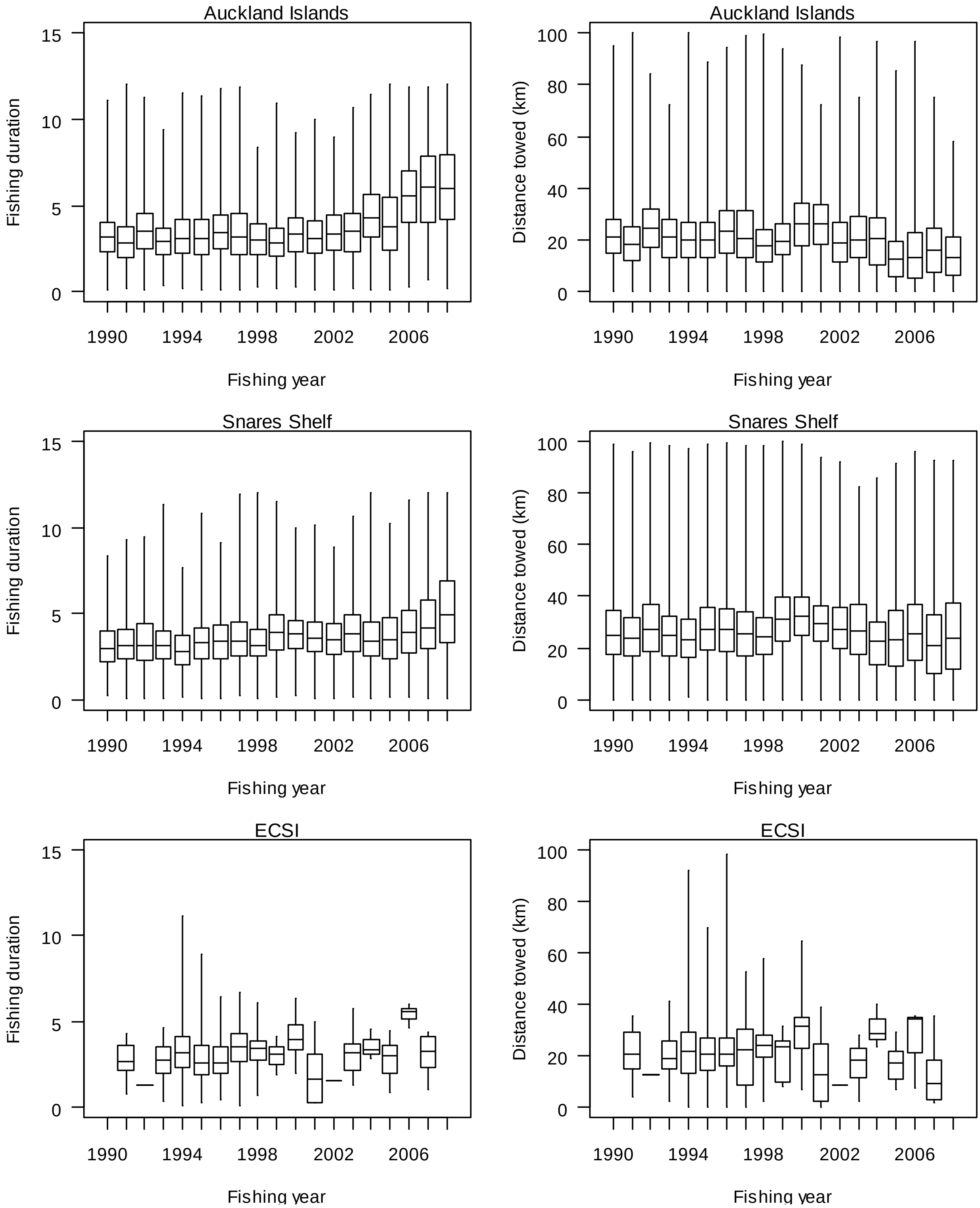


Figure C13c: Annual median (horizontal line), inter-quartile ranges (box), and range (vertical lines) for tow durations and tow distance (start to finish position, km) for vessels targeting and catching arrow squid using midwater trawl gear in the Auckland Is., Snares, and ECSI regions.

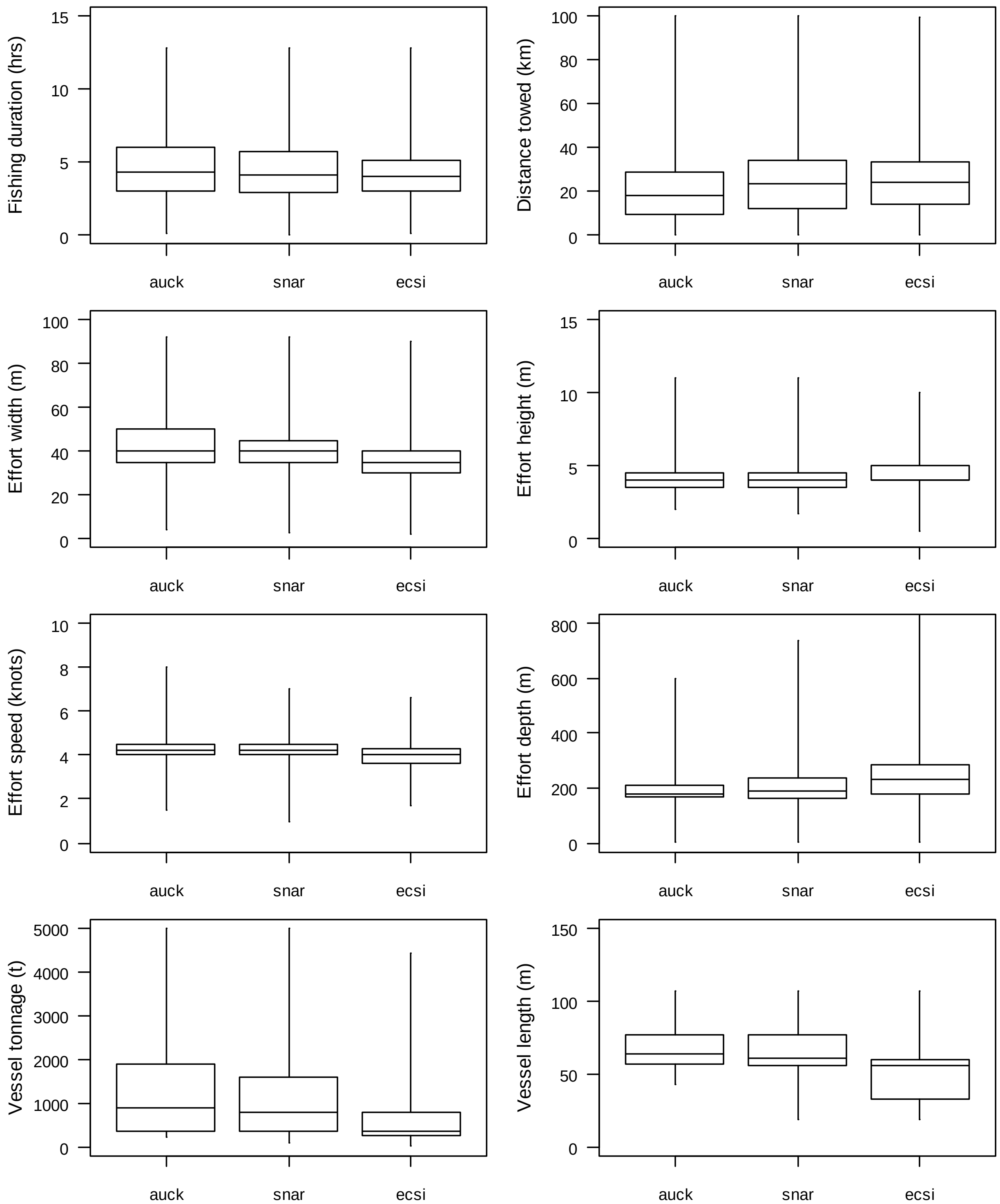


Figure C14a: Distribution of fishing effort variables and vessel characteristics for the Auckland Is., Snares, and ECSI regions taken by vessels targeting and catching arrow squid using bottom trawl gear (distance towed is from start to finish position).

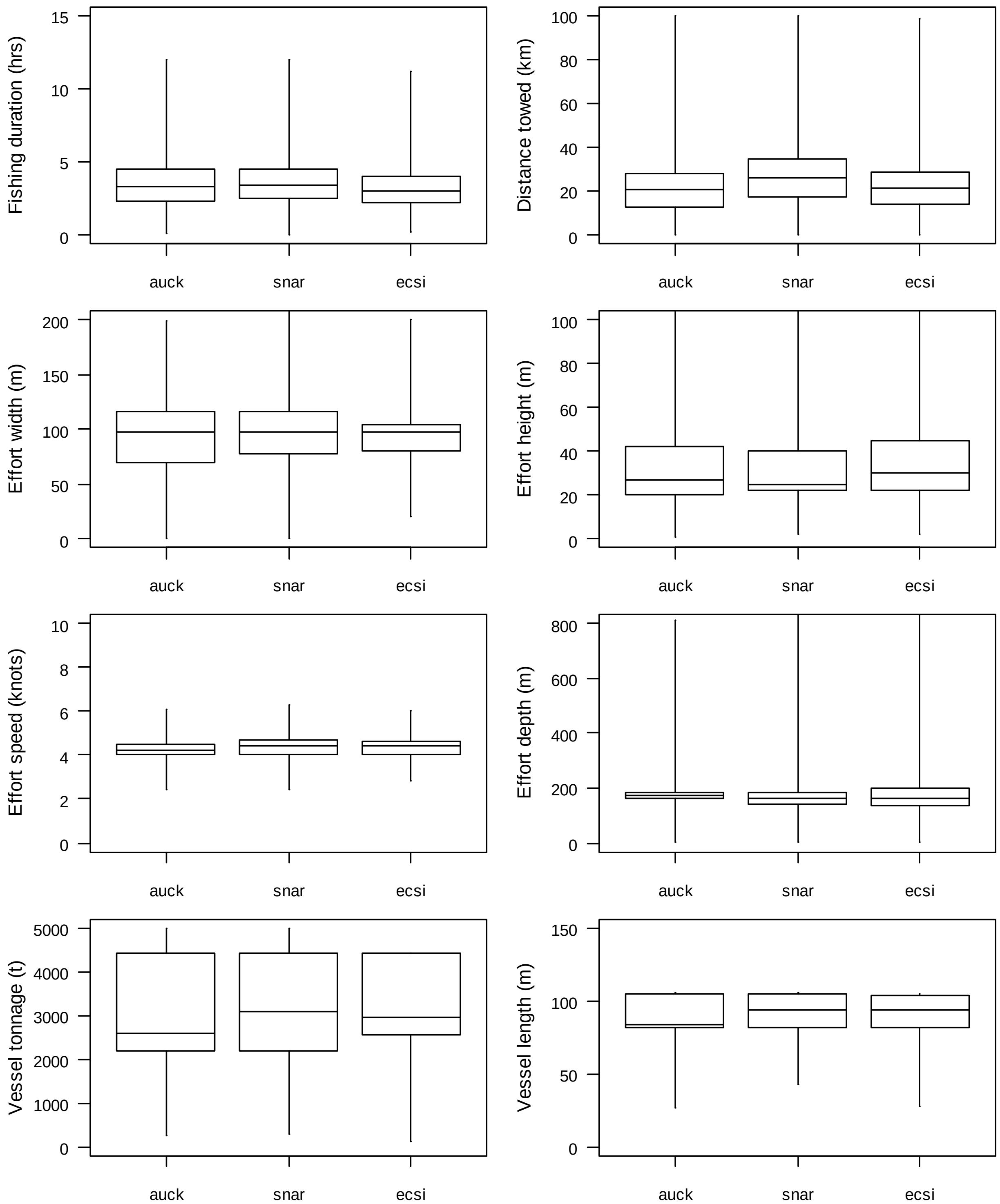


Figure C14b: Distribution of fishing effort variables and vessel characteristics for the Auckland Is., Snares, and ECSI regions taken by vessels targeting and catching arrow squid using midwater trawl gear (distance towed is from start to finish position.

18. APPENDIX D. CATCH-PER-UNIT-EFFORT ANALYSES

Table D1: CPUE indices developed for Snares and Auckland Is. fisheries

Model type					Fishery area
			Snares	Auckland Is.	Snares + Auckland Is.
Unstandardised	Annual	Log-normal	1990–2008	1990–2008	1990–2008
	In-season (weekly)	Log-normal	1990–2008	1990–2008	
Standardised	Annual	Log-normal	1990–2008	1990–2008	1990–2008
	In-season (weekly)	Log-normal	1990–2008	2008	2008
		Vignaux	1991		
		Tweedie	1991		
	In-season (fortnightly)	Log-normal	1991		

Table D2: CPUE datasets for all vessels and for core vessels for each week or month for each model. Zeros, proportion of zero tows; Effort, number of non-zero tows.

1990, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No. of records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	142	0.06	784.7	134	5.86	121	0.03	745.1	117	6.37
2	180	0.02	1 465.5	176	8.33	172	0.02	1 451.3	168	8.64
3	282	0.04	1 934.4	272	7.11	260	0.03	1 862.1	253	7.36
4	142	0.09	613.4	129	4.76	118	0.08	530.7	108	4.91
5	22	0.14	104.9	19	5.52	18	0.11	37.4	16	2.34
6	88	0.09	227.7	80	2.85	65	0.12	179.2	57	3.14
7	31	0.26	40.7	23	1.77	21	0.14	36.8	18	2.04
8	50	0.44	106.4	28	3.80	28	0.32	99.2	19	5.22
9	48	0.15	200.0	41	4.88	42	0.14	153.0	36	4.25
10	51	0.06	140.2	48	2.92	25	0.08	105.4	23	4.58
11	136	0.04	386.7	130	2.97	68	0.04	253.9	65	3.91
12	97	0.25	172.2	73	2.36	63	0.25	119.2	47	2.54
13	145	0.28	245.3	105	2.34	62	0.24	135.7	47	2.89
14	5	0.60	6.2	2	3.10	1	0.00	0.8	1	0.80
15	21	0.24	41.0	16	2.56	16	0.00	41.0	16	2.56
16	11	0.36	19.5	7	2.79	10	0.40	18.8	6	3.13
17	10	0.40	12.7	6	2.12	9	0.44	12.1	5	2.42
18	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-
21	3	0.00	4.2	3	1.40	-	-	-	-	-
22	3	0.00	3.6	3	1.20	-	-	-	-	-

Table D2: continued

1991, Snares, All target species by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	400	0.11	570.3	355	1.61	370	0.11	542.2	330	1.64
2	463	0.12	535.5	407	1.32	413	0.13	477.8	359	1.33
3	318	0.18	284.7	260	1.09	287	0.17	273.7	237	1.15
4	577	0.23	692.5	444	1.56	481	0.18	683.5	396	1.73
5	517	0.26	1 059.7	385	2.75	442	0.26	965.5	328	2.94
6	774	0.17	2 077.9	646	3.22	667	0.14	1 939.3	576	3.37
7	649	0.27	977.7	474	2.06	496	0.21	891.3	392	2.27
8	736	0.22	1 303.0	575	2.27	572	0.17	1 098.5	475	2.31
9	528	0.34	655.1	350	1.87	418	0.26	619.1	310	2.00
10	495	0.22	813.1	385	2.11	433	0.18	786.9	357	2.20
11	117	0.41	221.0	69	3.20	73	0.22	181.3	57	3.18
12	671	0.10	3 207.3	606	5.29	530	0.07	2 835.8	494	5.74
13	542	0.19	1 450.0	439	3.30	404	0.10	1 208.8	363	3.33
14	232	0.22	436.8	180	2.43	192	0.17	382.6	159	2.41
15	127	0.41	207.7	75	2.77	83	0.17	191.2	69	2.77
16	132	0.79	42.0	28	1.50	63	0.62	36.1	24	1.50
17	53	0.68	89.7	17	5.28	28	0.39	89.7	17	5.28
18	92	0.55	104.2	41	2.54	46	0.35	95.5	30	3.18
19	103	0.65	79.5	36	2.21	44	0.70	21.3	13	1.64
20	38	0.61	25.3	15	1.69	25	0.68	3.8	8	0.48
21	13	0.92	2.0	1	2.00	-	-	-	-	-
22	7	0.86	0.0	1	0.00	-	-	-	-	-

1991, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	377	0.10	555.0	338	1.64	347	0.10	526.9	313	1.68
2	456	0.11	535.4	406	1.32	406	0.12	477.6	358	1.33
3	283	0.11	277.7	251	1.11	258	0.12	266.7	228	1.17
4	558	0.21	689.0	440	1.57	477	0.18	680.0	392	1.73
5	450	0.18	1 056.8	371	2.85	375	0.16	962.6	314	3.07
6	714	0.10	2 074.6	640	3.24	614	0.07	1 936.5	572	3.39
7	571	0.20	967.5	458	2.11	444	0.15	882.6	379	2.33
8	683	0.19	1 278.0	551	2.32	540	0.15	1 075.5	458	2.35
9	467	0.29	647.2	332	1.95	393	0.24	612.2	297	2.06
10	435	0.14	793.7	372	2.13	396	0.13	768.8	345	2.23
11	85	0.20	220.8	68	3.25	69	0.19	181.1	56	3.23
12	648	0.08	3 195.7	599	5.34	524	0.06	2 825.4	490	5.77
13	511	0.14	1 450.0	439	3.30	400	0.09	1 208.8	363	3.33
14	212	0.16	433.3	179	2.42	188	0.16	379.1	158	2.40
15	99	0.24	207.7	75	2.77	83	0.17	191.2	69	2.77
16	81	0.69	41.5	25	1.66	57	0.61	35.7	22	1.62
17	25	0.32	89.7	17	5.28	25	0.32	89.7	17	5.28
18	66	0.38	104.2	41	2.54	-	-	-	-	-
19	43	0.35	70.8	28	2.53	-	-	-	-	-
20	14	0.57	15.0	6	2.50	-	-	-	-	-

Table D2: continued

1992, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	3	0.00	11.8	3	3.93	3	0.00	11.8	3	3.93
5	255	0.04	2 248.9	244	9.22	210	0.05	1 855.4	200	9.28
6	547	0.08	3 772.6	504	7.49	483	0.07	3 473.4	450	7.72
7	408	0.08	2 685.9	377	7.12	351	0.08	2 354.2	322	7.31
8	435	0.06	3 392.9	410	8.28	358	0.05	3 073.9	339	9.07
9	334	0.12	2 368.3	293	8.08	307	0.11	2 282.2	273	8.36
10	432	0.10	2 796.1	389	7.19	364	0.10	2 542.2	329	7.73
11	407	0.12	2 645.4	359	7.37	348	0.12	2 430.7	306	7.94
12	415	0.10	2 890.5	372	7.77	366	0.10	2 605.1	329	7.92
13	290	0.16	1 415.3	243	5.82	219	0.16	1 181.4	184	6.42
14	223	0.41	311.1	131	2.37	159	0.38	232.9	99	2.35
15	249	0.29	433.3	178	2.43	161	0.27	309.8	117	2.65
16	365	0.29	731.6	259	2.82	284	0.29	643.6	203	3.17
17	113	0.37	90.1	71	1.27	109	0.39	86.0	67	1.28
18	6	0.50	3.0	3	1.00	5	0.40	3.0	3	1.00
19	-	-	-	-	-	-	-	-	-	-
20	9	0.00	11.4	9	1.27	9	0.00	11.4	9	1.27
21	4	0.00	4.4	4	1.10	1	0.00	0.3	1	0.30
22	9	0.11	20.6	8	2.58	1	0.00	1.3	1	1.30

1993, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	212	0.04	1 906.5	203	9.39	197	0.05	1 781.2	188	9.47
6	490	0.03	5 798.5	477	12.16	435	0.03	5 305.7	423	12.54
7	664	0.13	2 681.9	577	4.65	580	0.13	2 440.0	506	4.82
8	697	0.14	3 272.1	596	5.49	595	0.15	2 789.3	508	5.49
9	735	0.13	3 105.2	637	4.87	615	0.13	2 733.6	538	5.08
10	575	0.11	2 171.4	510	4.26	487	0.10	2 001.5	436	4.59
11	583	0.15	1 542.6	498	3.10	491	0.13	1 395.2	428	3.26
12	546	0.24	741.2	415	1.79	467	0.24	649.3	356	1.82
13	502	0.32	485.5	341	1.42	442	0.33	422.5	294	1.44
14	572	0.38	745.9	355	2.10	494	0.38	670.1	307	2.18
15	312	0.17	551.0	258	2.14	262	0.18	433.8	215	2.02
16	158	0.25	299.2	118	2.54	123	0.24	243.6	93	2.62
17	40	0.50	63.5	20	3.17	35	0.49	63.1	18	3.51
18	44	0.75	13.7	11	1.25	26	0.69	11.2	8	1.40
19	73	0.25	114.6	55	2.08	42	0.38	73.2	26	2.82
20	47	0.11	118.0	42	2.81	40	0.10	112.5	36	3.12
21	52	0.12	264.8	46	5.76	45	0.11	247.1	40	6.18
22	20	0.00	79.9	20	4.00	19	0.00	78.9	19	4.15

Table D2: continued

1994, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	1	-	0.00	2.0	2.00	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	207	0.04	0.07	969.5	5.05	138	0.06	747.7	130	5.75
6	234	0.03	0.04	1 232.4	5.48	195	0.04	1 048.8	187	5.61
7	257	0.13	0.05	1 516.2	6.19	232	0.03	1 437.5	225	6.39
8	167	0.14	0.08	1 349.0	8.76	138	0.09	1 125.0	125	9.00
9	199	0.13	0.11	1 161.1	6.56	169	0.11	934.2	151	6.19
10	33	0.11	0.06	166.6	5.37	28	0.04	76.6	27	2.84
11	142	0.15	0.16	886.8	7.45	136	0.15	883.8	116	7.62
12	289	0.24	0.11	2 389.8	9.26	283	0.11	2 332.8	252	9.26
13	161	0.32	0.14	683.0	4.95	144	0.15	618.7	123	5.03
14	117	0.38	0.12	481.3	4.67	104	0.11	458.0	93	4.92
15	107	0.17	0.30	429.3	5.72	51	0.20	321.4	41	7.84
16	137	0.25	0.15	776.3	6.64	100	0.06	567.0	94	6.03
17	117	0.50	0.14	319.4	3.16	78	0.12	237.3	69	3.44
18	12	0.75	0.00	66.7	5.56	12	0.00	66.7	12	5.56
19	-	-	-	-	-	-	-	-	-	-
20	5	0.11	0.00	5.0	1.00	5	0.00	5.0	5	1.00
21	11	0.12	0.18	44.7	4.97	11	0.18	44.7	9	4.97
22	12	0.00	0.25	42.4	4.71	12	0.25	42.4	9	4.71

1995, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	417	0.06	2 991.8	393	7.61	332	0.05	2 511.5	314	8.00
6	805	0.10	3 338.6	727	4.59	666	0.11	2 705.3	593	4.56
7	729	0.07	2 675.6	677	3.95	627	0.07	2 397.0	584	4.10
8	645	0.03	3 992.3	624	6.40	570	0.03	3 747.7	553	6.78
9	636	0.07	3 082.2	593	5.20	543	0.07	2 842.3	507	5.61
10	449	0.09	2 286.6	409	5.59	353	0.10	2 088.8	318	6.57
11	200	0.10	1 381.9	180	7.68	177	0.11	1 253.5	158	7.93
12	39	0.10	219.5	35	6.27	39	0.10	219.5	35	6.27
13	204	0.15	839.4	173	4.85	186	0.15	751.8	159	4.73
14	198	0.24	613.3	150	4.09	164	0.27	500.7	120	4.17
15	63	0.16	224.8	53	4.24	56	0.14	210.7	48	4.39
16	70	0.27	233.3	51	4.57	61	0.28	217.3	44	4.94
17	70	0.23	393.6	54	7.29	64	0.25	360.1	48	7.50
18	31	0.52	100.9	15	6.73	24	0.67	61.4	8	7.67
19	22	0.41	67.6	13	5.20	22	0.41	67.6	13	5.20
20	1	0.00	4.5	1	4.50	-	-	-	-	-
21	2	0.50	3.0	1	3.00	-	-	-	-	-
22	16	0.00	62.0	16	3.88	-	-	-	-	-

Table D2: continued

1996, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	5	0.00	40.1	5	8.02	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	17	0.00	29.7	17	1.75	9	0.00	9.8	9	1.09
5	273	0.12	1 054.9	240	4.40	209	0.09	952.7	190	5.01
6	572	0.16	1 363.2	480	2.84	457	0.16	1 274.1	386	3.30
7	579	0.14	1 489.6	498	2.99	439	0.12	1 321.0	386	3.42
8	219	0.24	449.4	167	2.69	168	0.20	401.4	135	2.97
9	281	0.26	747.2	209	3.58	219	0.25	679.8	165	4.12
10	333	0.26	751.9	245	3.07	240	0.22	663.8	186	3.57
11	214	0.13	785.0	187	4.20	185	0.09	767.2	168	4.57
12	283	0.18	655.4	232	2.82	251	0.17	619.9	209	2.97
13	138	0.21	186.1	109	1.71	118	0.19	164.3	96	1.71
14	82	0.33	77.0	55	1.40	75	0.32	76.2	51	1.49
15	51	0.24	55.2	39	1.42	42	0.19	47.5	34	1.40
16	116	0.53	47.6	54	0.88	67	0.48	34.4	35	0.98
17	67	0.69	24.4	21	1.16	32	0.59	15.3	13	1.18
18	54	0.61	30.1	21	1.43	38	0.61	16.8	15	1.12
19	21	0.81	13.0	4	3.25	17	1.00	0.0	0	0.00
20	94	0.01	348.5	93	3.75	50	0.02	234.8	49	4.79
21	102	0.04	244.1	98	2.49	77	0.05	193.6	73	2.65
22	21	0.14	15.6	18	0.87	9	0.00	11.4	9	1.27

1997, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	300	0.04	1 218.8	289	4.22	297	0.04	1 216.8	286	4.25
2	117	0.05	356.8	111	3.21	109	0.06	350.9	103	3.41
3	281	0.08	1 212.7	258	4.70	213	0.04	1 118.0	205	5.45
4	247	0.05	973.1	235	4.14	223	0.05	927.3	212	4.37
5	133	0.11	278.5	119	2.34	106	0.08	258.5	98	2.64
6	64	0.08	159.3	59	2.70	53	0.08	106.3	49	2.17
7	32	0.19	122.3	26	4.70	27	0.19	101.3	22	4.60
8	55	0.05	124.9	52	2.40	44	0.05	102.0	42	2.43
9	51	0.08	219.7	47	4.67	42	0.05	193.5	40	4.84
10	117	0.04	557.7	112	4.98	87	0.02	452.9	85	5.33
11	222	0.06	1 280.5	209	6.13	187	0.05	1 070.4	177	6.05
12	577	0.07	2 689.6	537	5.01	458	0.08	2 251.2	422	5.33
13	632	0.11	2 004.5	562	3.57	478	0.11	1 608.7	426	3.78
14	392	0.09	1 006.1	356	2.83	303	0.06	907.8	285	3.19
15	369	0.18	815.4	301	2.71	280	0.16	737.2	235	3.14
16	227	0.19	450.5	184	2.45	189	0.15	430.9	160	2.69
17	190	0.24	487.7	144	3.39	166	0.22	461.2	129	3.58
18	165	0.16	552.7	139	3.98	163	0.15	552.7	139	3.98
19	121	0.02	617.0	119	5.18	118	0.02	563.0	116	4.85

20	39	0.03	154.5	38	4.07	39	0.03	154.5	38	4.07
21	59	0.03	246.3	57	4.32	58	0.03	225.3	56	4.02
22	45	0.04	268.4	43	6.24	44	0.05	261.4	42	6.22

Table D2: continued

1998, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	332	0.11	697.4	297	2.35	272	0.10	617.4	246	2.51
2	273	0.08	942.0	251	3.75	235	0.08	832.0	216	3.85
3	280	0.04	1337.3	270	4.95	235	0.04	1173.0	226	5.19
4	504	0.03	3145.2	488	6.45	448	0.03	2891.1	436	6.63
5	496	0.05	2548.2	472	5.40	397	0.04	2199.9	382	5.76
6	417	0.06	1889.6	390	4.85	330	0.07	1501.5	307	4.89
7	387	0.04	1521.1	373	4.08	301	0.03	1223.0	293	4.17
8	185	0.10	715.5	167	4.28	163	0.09	658.6	148	4.45
9	242	0.03	1042.9	234	4.46	205	0.02	952.5	201	4.74
10	214	0.06	586.2	202	2.90	165	0.04	522.2	158	3.31
11	194	0.04	557.2	186	3.00	144	0.05	467.1	137	3.41
12	193	0.13	494.2	167	2.96	174	0.12	469.9	153	3.07
13	293	0.08	1255.4	271	4.63	264	0.08	1175.2	243	4.84
14	114	0.06	311.9	107	2.91	109	0.06	305.4	102	2.99
15	129	0.23	569.1	99	5.75	129	0.23	569.1	99	5.75
16	38	0.32	134.5	26	5.17	38	0.32	134.5	26	5.17
17	82	0.07	406.3	76	5.35	81	0.07	406.0	75	5.41
18	60	0.02	253.3	59	4.29	48	0.02	193.3	47	4.11
19	94	0.11	396.4	84	4.72	85	0.09	345.4	77	4.49
20	80	0.07	185.4	74	2.51	78	0.08	179.4	72	2.49
21	66	0.00	140.7	66	2.13	62	0.00	130.7	62	2.11
22	12	0.08	31.6	11	2.87	11	0.09	27.6	10	2.76

1999, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	321	0.05	673.8	305	2.21	302	0.05	630.5	287	2.20
2	365	0.03	1 625.8	354	4.59	331	0.03	1 551.9	320	4.85
3	445	0.04	1 180.7	428	2.76	418	0.04	1 157.1	403	2.87
4	440	0.04	1 353.2	424	3.19	392	0.04	1 269.0	377	3.37
5	375	0.06	1 379.8	353	3.91	285	0.05	1 166.4	271	4.30
6	503	0.02	2 566.6	493	5.21	390	0.02	2 135.3	383	5.58
7	408	0.03	1 569.6	395	3.97	327	0.03	1 321.8	316	4.18
8	346	0.03	1 005.2	337	2.98	296	0.02	915.2	289	3.17
9	181	0.06	727.6	171	4.25	161	0.06	702.4	151	4.65
10	452	0.02	1 984.4	441	4.50	351	0.02	1 716.8	344	4.99
11	258	0.12	443.2	227	1.95	237	0.12	398.7	209	1.91
12	153	0.21	329.0	121	2.72	144	0.21	316.8	114	2.78
13	223	0.17	372.6	184	2.02	213	0.18	367.2	175	2.10
14	153	0.18	195.8	126	1.55	145	0.17	193.3	121	1.60
15	65	0.32	88.7	44	2.02	55	0.38	77.0	34	2.26
16	31	0.19	28.2	25	1.13	27	0.19	23.8	22	1.08
17	71	0.04	163.6	68	2.41	65	0.02	160.5	64	2.51
18	56	0.09	65.2	51	1.28	56	0.09	65.2	51	1.28
19	23	0.04	33.1	22	1.50	18	0.06	29.4	17	1.73
20	25	0.36	30.6	16	1.91	-	-	-	-	-
21	21	0.10	25.2	19	1.33	-	-	-	-	-

Table D2: continued

2000, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	98	0.14	95.0	84	1.13	87	0.09	92.8	79	1.17
2	127	0.10	110.8	114	0.97	122	0.10	106.2	110	0.97
3	101	0.14	177.5	87	2.04	101	0.14	177.5	87	2.04
4	222	0.05	515.3	210	2.45	215	0.06	505.5	203	2.49
5	171	0.02	436.9	167	2.62	134	0.02	372.1	131	2.84
6	21	0.24	84.8	16	5.30	14	0.14	66.0	12	5.50
7	189	0.05	1 056.8	180	5.87	150	0.03	909.5	146	6.23
8	121	0.09	495.7	110	4.51	98	0.09	431.1	89	4.84
9	132	0.02	424.9	129	3.29	102	0.03	361.1	99	3.65
10	166	0.08	276.7	152	1.82	134	0.07	241.2	124	1.95
11	113	0.19	169.4	92	1.84	90	0.17	112.8	75	1.50
12	130	0.19	269.3	105	2.56	103	0.22	207.8	80	2.60
13	99	0.31	84.1	68	1.24	88	0.33	72.3	59	1.23
14	70	0.51	74.2	34	2.18	70	0.51	74.2	34	2.18
15	39	0.26	71.9	29	2.48	39	0.26	71.9	29	2.48
16	26	0.00	79.5	26	3.06	26	0.00	79.5	26	3.06
17	21	0.05	39.0	20	1.95	19	0.00	34.1	19	1.79
18	16	0.06	27.8	15	1.85	16	0.06	27.8	15	1.85
19	3	0.00	11.5	3	3.83	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-
21	5	0.00	8.9	5	1.78	-	-	-	-	-

2001, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	9	0.00	20.9	9	2.32	7	0.00	20.2	7	2.89
2	103	0.09	719.8	94	7.66	100	0.09	715.1	91	7.86
3	125	0.05	333.4	119	2.80	125	0.05	333.4	119	2.80
4	233	0.04	959.5	224	4.28	215	0.03	891.8	209	4.27
5	217	0.03	809.5	211	3.84	164	0.03	691.8	159	4.35
6	353	0.02	2180.8	347	6.28	285	0.01	1966.8	283	6.95
7	226	0.01	1331.2	223	5.97	153	0.01	987.6	151	6.54
8	315	0.02	1590.4	309	5.15	262	0.02	1419.0	257	5.52
9	327	0.04	2083.0	315	6.61	269	0.03	1763.0	261	6.75
10	208	0.08	757.7	192	3.95	163	0.08	624.6	150	4.16
11	136	0.14	632.5	117	5.41	127	0.13	626.0	111	5.64
12	208	0.12	699.8	184	3.80	205	0.11	689.8	182	3.79
13	134	0.05	585.1	127	4.61	122	0.06	558.0	115	4.85
14	80	0.01	515.0	79	6.52	69	0.01	482.9	68	7.10
15	132	0.01	1426.8	131	10.89	126	0.00	1413.3	126	11.22
16	229	0.02	1512.8	224	6.75	204	0.02	1415.3	200	7.08
17	61	0.03	235.7	59	3.99	47	0.04	191.7	45	4.26
18	43	0.00	179.6	43	4.18	17	0.00	76.4	17	4.49
19	10	0.10	19.8	9	2.20	5	0.00	11.0	5	2.20
20	18	0.06	53.6	17	3.15	12	0.08	43.5	11	3.95
21	22	0.00	40.5	22	1.84	12	0.00	18.0	12	1.50
22	23	0.09	69.2	21	3.30	19	0.05	64.2	18	3.57

Table D2: continued

2002, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	85	0.02	1 009.0	83	12.16	83	0.01	1 008.5	82	12.30
2	207	0.02	2 237.6	203	11.02	198	0.02	2 192.4	194	11.30
3	325	0.01	4 107.6	322	12.76	301	0.01	3 756.6	298	12.61
4	340	0.01	3 043.2	335	9.08	304	0.02	2 783.4	299	9.31
5	170	0.03	1 230.7	165	7.46	146	0.03	1 082.7	142	7.62
6	254	0.01	3 071.8	251	12.24	207	0.00	2 685.0	206	13.03
7	288	0.03	2 957.7	280	10.56	219	0.01	2 423.7	216	11.22
8	246	0.05	1 655.9	233	7.11	188	0.05	1 294.1	179	7.23
9	186	0.02	1 420.5	183	7.76	148	0.02	1 193.0	145	8.23
10	232	0.02	1 481.2	227	6.53	178	0.02	1 169.4	174	6.72
11	100	0.07	348.2	93	3.74	84	0.06	323.1	79	4.09
12	67	0.10	413.2	60	6.89	57	0.09	330.3	52	6.35
13	89	0.02	410.1	87	4.71	57	0.04	249.1	55	4.53
14	72	0.11	239.7	64	3.75	40	0.15	124.2	34	3.65
15	113	0.04	441.5	109	4.05	101	0.03	409.5	98	4.18
16	76	0.11	199.4	68	2.93	68	0.12	189.7	60	3.16
17	51	0.02	206.9	50	4.14	48	0.02	202.7	47	4.31
18	4	0.00	3.8	4	0.95	-	-	-	-	-
19	60	0.07	159.8	56	2.85	52	0.06	148.1	49	3.02
20	88	0.05	251.6	84	3.00	76	0.05	215.6	72	2.99
21	18	0.28	49.6	13	3.82	15	0.33	44.6	10	4.46
22	22	0.05	77.0	21	3.67	17	0.06	73.9	16	4.62

2003, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	27	0.33	21.0	18	1.17	22	0.27	20.6	16	1.29
2	159	0.06	659.9	149	4.43	154	0.05	657.2	147	4.47
3	260	0.03	669.1	251	2.67	238	0.02	660.2	234	2.82
4	314	0.02	1 185.3	307	3.86	263	0.02	1 061.0	259	4.10
5	196	0.02	827.0	193	4.28	154	0.01	700.2	153	4.58
6	416	0.02	2 556.3	406	6.30	313	0.03	2 002.7	304	6.59
7	229	0.02	1 542.3	224	6.89	180	0.01	1 439.5	178	8.09
8	186	0.02	2 596.9	182	14.27	169	0.01	2 469.4	167	14.79
9	221	0.02	2 354.6	216	10.90	188	0.03	2 149.1	183	11.74
10	221	0.04	1 659.3	213	7.79	197	0.03	1 570.4	191	8.22
11	152	0.09	466.5	139	3.36	136	0.08	447.4	125	3.58
12	72	0.04	128.4	69	1.86	41	0.00	93.6	41	2.28
13	100	0.02	221.6	98	2.26	72	0.03	173.9	70	2.48
14	51	0.12	69.8	45	1.55	29	0.10	33.5	26	1.29
15	119	0.03	426.7	115	3.71	86	0.03	274.4	83	3.31
16	129	0.12	562.8	113	4.98	86	0.17	429.3	71	6.05
17	36	0.06	60.4	34	1.78	26	0.04	48.4	25	1.94
18	31	0.06	42.9	29	1.48	22	0.09	35.5	20	1.77
19	98	0.06	394.2	92	4.28	70	0.09	303.6	64	4.74
20	69	0.13	192.6	60	3.21	39	0.18	127.5	32	3.98
21	26	0.04	58.6	25	2.34	-	-	-	-	-
22	13	0.23	12.2	10	1.22	-	-	-	-	-

Table D2: continued

2004, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	77	0.03	317.7	75	4.24	53	0.04	294.2	51	5.77
2	260	0.02	1 741.1	256	6.80	226	0.02	1 520.3	222	6.85
3	381	0.01	2 535.2	377	6.72	341	0.01	2 380.8	337	7.06
4	410	0.02	4 213.6	400	10.53	369	0.02	4 006.1	362	11.07
5	342	0.01	3 360.9	339	9.91	273	0.00	2 915.1	272	10.72
6	390	0.01	3 776.0	387	9.76	338	0.01	3 474.7	335	10.37
7	281	0.01	4 563.8	279	16.36	249	0.00	4 202.7	249	16.88
8	285	0.02	3 659.2	280	13.07	225	0.01	3 109.2	222	14.01
9	122	0.00	1 637.5	122	13.42	67	0.00	1 136.7	67	16.97
10	131	0.02	1 542.5	128	12.05	98	0.02	1 200.5	96	12.51
11	108	0.03	1 352.0	105	12.88	96	0.03	1 247.5	93	13.41
12	153	0.10	956.2	138	6.93	123	0.09	855.8	112	7.64
13	170	0.04	1 327.2	163	8.14	141	0.04	1 165.5	136	8.57
14	182	0.03	1 359.1	176	7.72	166	0.04	1 282.5	160	8.02
15	54	0.09	301.8	49	6.16	48	0.10	291.7	43	6.78
16	196	0.10	1 378.8	177	7.79	179	0.11	1 277.5	160	7.98
17	217	0.15	826.7	184	4.49	202	0.15	770.1	171	4.50
18	121	0.08	547.5	111	4.93	96	0.10	436.9	86	5.08
19	86	0.14	425.8	74	5.75	68	0.16	296.2	57	5.20
20	76	0.05	361.4	72	5.02	60	0.05	259.6	57	4.55
21	123	0.02	681.5	120	5.68	82	0.02	484.5	80	6.06
22	42	0.02	188.0	41	4.59	36	0.03	160.0	35	4.57

2005, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	204	0.00	837.2	203	4.12	190	0.01	792.2	189	4.19
2	282	0.02	1 099.2	277	3.97	255	0.02	1 017.9	250	4.07
3	444	0.01	1 918.6	439	4.37	417	0.01	1 849.3	412	4.49
4	534	0.02	4 009.1	522	7.68	493	0.02	3 874.0	481	8.05
5	525	0.00	5 086.2	523	9.73	486	0.00	4 934.7	484	10.20
6	564	0.02	4 477.7	555	8.07	479	0.01	4 247.8	472	9.00
7	473	0.02	4 284.7	463	9.25	386	0.02	3 851.2	377	10.22
8	368	0.02	2 646.4	361	7.33	284	0.01	2 204.0	280	7.87
9	300	0.02	3 108.2	293	10.61	235	0.02	2 725.8	230	11.85
10	222	0.02	2 168.7	218	9.95	169	0.02	1 793.2	166	10.80
11	183	0.03	1 782.3	178	10.01	105	0.04	1 247.8	101	12.35
12	195	0.06	1 830.7	184	9.95	107	0.08	1 146.6	98	11.70
13	192	0.08	1 585.2	177	8.96	135	0.09	1 048.9	123	8.53
14	99	0.02	585.5	97	6.04	73	0.01	476.4	72	6.62
15	43	0.07	243.1	40	6.08	26	0.04	213.7	25	8.55
16	205	0.07	744.2	191	3.90	159	0.08	581.6	147	3.96
17	209	0.12	879.1	184	4.78	180	0.13	732.6	156	4.70
18	118	0.02	607.5	116	5.24	108	0.02	574.5	106	5.42
19	22	0.05	102.3	21	4.87	19	0.05	91.8	18	5.10
20	90	0.00	461.4	90	5.13	79	0.00	409.5	79	5.18
21	59	0.02	250.5	58	4.32	54	0.02	242.2	53	4.57
22	37	0.03	319.1	36	8.86	36	0.03	160.0	35	4.57

Table D2: continued

2006, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	186	0.01	3 350.1	185	18.11	171	0.01	3 272.2	170	19.25
2	265	0.02	4 196.7	260	16.14	236	0.02	3 821.9	231	16.55
3	310	0.01	4 928.8	308	16.00	260	0.01	4 284.5	258	16.61
4	412	0.01	4 826.6	409	11.80	346	0.01	4 246.3	343	12.38
5	251	0.02	2 380.2	247	9.64	213	0.01	2 209.4	210	10.52
6	153	0.04	1 609.1	147	10.95	125	0.03	1 516.5	121	12.53
7	162	0.03	2 002.2	157	12.75	112	0.04	1 554.2	107	14.53
8	168	0.03	1 115.6	163	6.84	91	0.02	815.7	89	9.17
9	140	0.01	1 164.3	138	8.44	72	0.01	706.9	71	9.96
10	166	0.04	1 159.8	160	7.25	100	0.03	891.3	97	9.19
11	111	0.05	792.6	106	7.48	92	0.02	771.5	90	8.57
12	56	0.02	403.7	55	7.34	54	0.02	391.7	53	7.39
13	112	0.00	1 070.5	112	9.56	92	0.00	1 029.2	92	11.19
14	148	0.01	1 315.8	146	9.01	118	0.00	1 162.0	118	9.85
15	154	0.13	814.3	134	6.08	128	0.15	725.6	109	6.66
16	185	0.17	621.4	153	4.06	154	0.19	572.1	125	4.58
17	156	0.12	633.6	137	4.62	130	0.12	590.0	115	5.13
18	78	0.03	353.2	76	4.65	71	0.03	316.4	69	4.59
19	103	0.09	376.4	94	4.00	93	0.06	323.9	87	3.72
20	104	0.05	444.9	99	4.49	97	0.04	433.6	93	4.66
21	92	0.07	337.6	86	3.93	85	0.07	319.6	79	4.05
22	30	0.13	43.4	26	1.67	30	0.13	43.4	26	1.67

2007, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	81	0.05	207.6	77	2.70	75	0.05	204.4	71	2.88
2	90	0.03	528.6	87	6.08	90	0.03	528.6	87	6.08
3	199	0.02	1 882.9	195	9.66	174	0.02	1 682.9	170	9.90
4	243	0.02	4 448.0	239	18.61	228	0.01	4 228.6	226	18.71
5	164	0.05	890.1	156	5.71	142	0.05	827.7	135	6.13
6	74	0.00	879.8	74	11.89	70	0.00	862.5	70	12.32
7	121	0.02	2 078.1	118	17.61	108	0.03	1 880.7	105	17.91
8	97	0.01	1 952.7	96	20.34	94	0.01	1 913.3	93	20.57
9	137	0.03	2 525.3	133	18.99	132	0.03	2 446.6	128	19.11
10	189	0.01	3 469.8	188	18.46	167	0.01	3 118.5	166	18.79
11	161	0.01	2 662.8	159	16.75	132	0.02	2 265.7	130	17.43
12	114	0.02	2 085.5	112	18.62	109	0.02	1 999.5	107	18.69
13	170	0.01	2 186.6	169	12.94	135	0.01	1 736.8	134	12.96
14	218	0.03	2 009.4	211	9.52	176	0.01	1 585.1	175	9.06
15	96	0.01	777.3	95	8.18	86	0.01	689.9	85	8.12
16	136	0.04	1 241.2	130	9.55	120	0.03	1 134.1	117	9.69
17	138	0.08	1 015.1	127	7.99	98	0.10	725.0	88	8.24
18	111	0.15	1 399.8	94	14.89	85	0.20	1 047.9	68	15.41
19	51	0.06	430.8	48	8.97	38	0.08	321.9	35	9.20
20	6	0.00	64.7	6	10.78	-	-	-	-	-
21	4	0.00	16.1	4	4.03	-	-	-	-	-
22	5	0.20	6.1	4	1.52	-	-	-	-	-

Table D2: continued

2008, Snares, Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	112	0.02	1 006.8	110	9.15	99	0.02	917.5	97	9.46
2	116	0.03	920.8	113	8.15	107	0.03	854.1	104	8.21
3	109	0.03	1 750.6	106	16.52	109	0.03	1 750.6	106	16.52
4	183	0.02	2 208.6	180	12.27	171	0.02	2 079.1	168	12.38
5	217	0.01	2 108.7	214	9.85	197	0.02	1 994.1	194	10.28
6	278	0.00	4 154.9	277	15.00	229	0.00	3 745.9	228	16.43
7	272	0.01	3 205.3	269	11.92	243	0.01	2 913.2	240	12.14
8	135	0.02	2 214.7	132	16.78	113	0.03	1 991.9	110	18.11
9	82	0.00	1 360.0	82	16.59	58	0.00	944.5	58	16.28
10	159	0.03	2 537.2	155	16.37	158	0.03	2 533.2	154	16.45
11	101	0.04	1 689.4	97	17.42	83	0.05	1 360.9	79	17.23
12	196	0.04	3 209.5	189	16.98	152	0.04	2 580.1	146	17.67
13	100	0.03	1 295.1	97	13.35	73	0.04	958.3	70	13.69
14	83	0.05	731.2	79	9.26	58	0.07	527.0	54	9.76
15	40	0.10	230.9	36	6.41	32	0.12	185.2	28	6.61
16	47	0.00	265.0	47	5.64	30	0.00	193.5	30	6.45
17	32	0.12	102.5	28	3.66	17	0.18	44.4	14	3.17
18	19	0.05	136.1	18	7.56	-	-	-	-	-
19	8	0.00	50.5	8	6.31	-	-	-	-	-

2008, Auckland Is., Target squid by week.

	All vessels					Core vessels				
Week	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	28	0.43	6.4	16	0.40	-	-	-	-	-
6	5	0.20	6.5	4	1.62	-	-	-	-	-
7	16	0.00	89.3	16	5.58	-	-	-	-	-
8	82	0.01	1 327.5	81	16.39	69	0.01	1 158.0	68	17.03
9	164	0.00	2 596.5	164	15.83	151	0.00	2 479.1	151	16.42
10	74	0.00	1 032.6	74	13.95	56	0.00	822.4	56	14.69
11	163	0.01	2 406.2	162	14.85	152	0.01	2 289.9	151	15.16
12	95	0.01	1 280.0	94	13.62	73	0.01	995.4	72	13.82
13	104	0.00	1 822.9	104	17.53	86	0.00	1 558.3	86	18.12
14	137	0.00	1 962.0	137	14.32	130	0.00	1 877.9	130	14.45
15	200	0.00	2 505.6	200	12.53	153	0.00	1 839.0	153	12.02
16	118	0.00	1 286.8	118	10.91	100	0.00	1 073.8	100	10.74
17	43	0.00	325.2	43	7.56	37	0.00	274.1	37	7.41
18	13	0.00	102.3	13	7.87	-	-	-	-	-

Table D2: continued

Snares, Target squid by year (January to May).

	All vessels					Core vessels				
Year	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1990	1 472	0.12	6 509.4	1 295	5.03	216	0.10	781.3	194	4.03
1991	6 779	0.17	14 703.8	5 636	2.61	1 752	0.13	4 264.6	1 528	2.79
1992	4 505	0.14	25 833.2	3 857	6.70	1 861	0.15	10 754.3	1 581	6.80
1993	6 322	0.18	23 955.5	5 179	4.63	2 834	0.17	12 877.5	2 364	5.45
1994	2 208	0.11	12 521.5	1 971	6.35	1 594	0.12	8 419.2	1 401	6.01
1995	4 597	0.09	22 511.0	4 165	5.40	3 062	0.10	14 856.9	2 753	5.40
1996	3 522	0.21	8 408.2	2 792	3.01	2 420	0.20	6 691.6	1 946	3.44
1997	4 435	0.10	15 797.1	3 997	3.95	3 252	0.10	12 103.8	2 922	4.14
1998	4 685	0.07	19 161.5	4 370	4.38	4 030	0.07	16 274.3	3 756	4.33
1999	4 915	0.06	15 841.9	4 604	3.44	4 803	0.06	15 370.6	4 495	3.42
2000	1 870	0.12	4 510.0	1 646	2.74	1 792	0.12	4 358.0	1 570	2.78
2001	3 212	0.04	16 756.7	3 076	5.45	3 183	0.04	16 607.9	3 049	5.45
2002	3 093	0.03	25 016.1	2 991	8.36	2 993	0.03	24 542.7	2 895	8.48
2003	3 125	0.04	16 708.6	2 988	5.59	3 003	0.04	15 744.9	2 873	5.48
2004	4 207	0.04	37 053.4	4 053	9.14	3 953	0.04	35 318.3	3 810	9.27
2005	5 368	0.03	39 026.7	5 226	7.47	4 757	0.03	35 872.9	4 634	7.74
2006	3 542	0.04	33 940.9	3 398	9.99	2 957	0.04	30 410.8	2 851	10.67
2007	2 605	0.03	32 758.3	2 522	12.99	2 300	0.02	29 615.9	2 253	13.15
2008	2 289	0.02	29 177.5	2 237	13.04	2 242	0.02	28 727.2	2 190	13.12

Auckland Is., Target squid by year (January to May).

	All vessels					Core vessels				
Year	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1990	4 528	0.05	17 208.5	4 286	4.02	1 069	0.04	3 826.1	1 022	3.74
1991	2 999	0.12	9 490.8	2 630	3.61	705	0.07	2 619.9	653	4.01
1992	2 100	0.08	10 217.0	1 923	5.31	737	0.08	3 728.0	681	5.47
1993	643	0.16	1 419.0	541	2.62	224	0.25	480.9	169	2.85
1994	4 622	0.04	31 682.6	4 453	7.11	3 124	0.03	21 414.6	3 023	7.08
1995	3 869	0.04	28 512.6	3 698	7.71	2 767	0.04	21 041.9	2 656	7.92
1996	4 442	0.10	14 129.9	4 010	3.52	2 628	0.10	9 063.8	2 374	3.82
1997	3 660	0.05	18 833.8	3 462	5.44	2 447	0.06	13 894.7	2 310	6.02
1998	1 442	0.06	7 060.3	1 357	5.20	1 328	0.05	6 554.1	1 255	5.22
1999	395	0.14	905.0	339	2.67	360	0.14	792.1	309	2.56
2000	1 205	0.03	5 872.9	1 168	5.03	1 101	0.03	5 223.1	1 064	4.91
2001	576	0.05	3 036.6	547	5.55	570	0.05	3 027.2	541	5.60
2002	1 638	0.02	10 769.1	1 611	6.68	1 507	0.02	9 940.6	1 481	6.71
2003	1 405	0.02	6 227.8	1 372	4.54	1 256	0.02	5 656.3	1 225	4.62
2004	2 454	0.02	28 103.1	2 408	11.67	2 274	0.02	26 701.7	2 235	11.95
2005	2 676	0.02	25 205.0	2 635	9.57	2 444	0.02	24 037.9	2 406	9.99
2006	2 446	0.02	16 321.0	2 407	6.78	2 158	0.02	14 724.0	2 124	6.93
2007	1 284	0.01	16 294.8	1 277	12.76	1 223	0.01	15 535.2	1 216	12.78
2008	1 242	0.01	16 749.7	1 226	13.66	1 218	0.01	16 348.2	1 202	13.60

Table D2: continued

Snares and Auckland Is., Target squid by year (January to May).

	All vessels					Core vessels threshold at catch 90%, 4 years				
Year	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1990	6 000	0.07	23 717.9	5 581	4.25	1 302	0.05	4 636.8	1 231	3.77
1991	9 778	0.15	24 194.6	8 266	2.93	2 459	0.11	6 884.5	2 181	3.16
1992	6 605	0.12	36 050.2	5 780	6.24	2 632	0.13	14 644.4	2 293	6.39
1993	6 965	0.18	25 374.5	5 720	4.44	3 106	0.17	13 665.7	2 581	5.29
1994	6 830	0.06	44 204.1	6 424	6.88	4 759	0.06	30 020.3	4 463	6.73
1995	8 466	0.07	51 023.6	7 863	6.49	5 968	0.07	36 311.0	5 532	6.56
1996	7 964	0.15	22 538.1	6 802	3.31	5 155	0.15	15 959.2	4 395	3.63
1997	8 095	0.08	34 630.9	7 459	4.64	5 764	0.08	26 371.3	5 295	4.98
1998	6 127	0.07	26 221.8	5 727	4.58	5 361	0.06	22 828.6	5 014	4.55
1999	5 310	0.07	16 746.9	4 943	3.39	5 163	0.07	16 162.7	4 804	3.36
2000	3 075	0.08	10 383.0	2 814	3.69	2 893	0.09	9 581.1	2 634	3.64
2001	3 788	0.04	19 793.4	3 623	5.46	3 753	0.04	19 635.2	3 590	5.47
2002	4 731	0.03	35 785.2	4 602	7.78	4 500	0.03	34 483.3	4 376	7.88
2003	4 530	0.04	22 936.4	4 360	5.26	4 259	0.04	21 401.2	4 098	5.22
2004	6 661	0.03	65 156.6	6 461	10.08	6 260	0.03	62 093.9	6 075	10.22
2005	8 044	0.02	64 231.7	7 861	8.17	7 206	0.02	59 927.5	7 045	8.51
2006	5 988	0.03	50 261.9	5 805	8.66	5 141	0.03	45 201.2	5 000	9.04
2007	3 889	0.02	49 053.1	3 799	12.91	3 537	0.02	45 208.8	3 483	12.98
2008	3 531	0.02	45 927.2	3 463	13.26	3 460	0.02	45 075.4	3 392	13.29

Snares and Auckland Is., Target squid by year (January to May).

	Core vessels threshold catch 100%, 4 years					Core vessels threshold catch 90%, 3 years				
Year	No records	Zeros	Catch (t)	Effort	CPUE	No records	Zeros	Catch (t)	Effort	CPUE
1990	1 339	0.05	4 713.8	1 266	3.72	1 942	0.06	7 137.9	1 819	3.92
1991	2 662	0.11	7 616.7	2 379	3.20	3 169	0.12	8 736.8	2 788	3.13
1992	2 672	0.13	14 985.4	2 332	6.43	3 594	0.13	20 653.8	3 112	6.64
1993	3 155	0.17	13 803.6	2 630	5.25	4 161	0.19	17 160.8	3 387	5.07
1994	4 759	0.06	30 020.3	4 463	6.73	6 183	0.06	39 470.6	5 808	6.80
1995	5 968	0.07	36 311.0	5 532	6.56	7 420	0.07	45 165.8	6 882	6.56
1996	5 155	0.15	15 959.2	4 395	3.63	6 076	0.15	18 010.5	5 185	3.47
1997	5 764	0.08	26 371.3	5 295	4.98	5 963	0.08	27 187.9	5 483	4.96
1998	5 361	0.06	22 828.6	5 014	4.55	5 361	0.06	22 828.6	5 014	4.55
1999	5 163	0.07	16 162.7	4 804	3.36	5 163	0.07	16 162.7	4 804	3.36
2000	2 893	0.09	9 581.1	2 634	3.64	2 893	0.09	9 581.1	2 634	3.64
2001	3 753	0.04	19 635.2	3 590	5.47	3 788	0.04	19 793.4	3 623	5.46
2002	4 500	0.03	34 483.3	4 376	7.88	4 576	0.03	35 094.4	4 451	7.88
2003	4 259	0.04	21 401.2	4 098	5.22	4 419	0.04	22 654.9	4 254	5.33
2004	6 260	0.03	62 093.9	6 075	10.22	6 260	0.03	62 093.9	6 075	10.22
2005	7 206	0.02	59 927.5	7 045	8.51	7 206	0.02	59 927.5	7 045	8.51
2006	5 141	0.03	45 201.2	5 000	9.04	5 324	0.03	46 582.1	5 178	9.00
2007	3 537	0.02	45 208.8	3 483	12.98	3 574	0.02	45 647.6	3 516	12.98
2008	3 460	0.02	45 075.4	3 392	13.29	3 531	0.02	45 927.2	3 463	13.26

Table D3: Variables retained in order of decreasing explanatory value model and the corresponding total R^2 value.

Dataset	Model	Variable	R^2 (%)
1990 Snares target squid core vessels	Lognormal, by week	Week	13.5
		Vessel	24.0
		Distance 2	28.1
		Longitude	29.4
		Effort width	30.4
		Effort height	32.1
1991 Snares All target species Core vessels	Lognormal, by week	Week	13.7
		Vessel	19.1
		Latitude	22.2
		Start time	24.9
		Longitude	26.9
1991 Snares target squid core vessels	Lognormal, by week	Week	14.1
		Vessel	19.8
		Start time	22.2
		Latitude	23.4
		Longitude	25.6
1991 Snares target squid core vessels	Binomial, by week	Week	4.3
		Vessel	14.3
		Time start	19.5
		Latitude	24.1
1991 Snares target squid core vessels	Tweedie, by week	Week	15.1
		Vessel	21.0
		Start time	23.4
		Latitude	25.0
		Longitude	27.5
1991 Snares target squid core vessels	Lognormal, by fortnight	Fortnight	13.02
		Vessel	18.69
		Start time	21.05
		Latitude	22.20
		Longitude	24.62
1992 Snares target squid core vessels	Lognormal, by week	Week	18.9
		Vessel	25.7
		Start time	28.2
		Distance 2	29.4
1993 Snares target squid core vessels	Lognormal, by week	Week	25.4
		Vessel	28.9
		Start time	31.7
1994 Snares target squid core vessels	Lognormal, by week	Week	8.2
		Vessel	21.3
		Distance 2	23.2
		Effort height	24.8
		Effort depth	25.9
1995 Snares target squid core vessels	Lognormal, by week	Week	7.3
		Vessel	16.5
		Time start	19.1
		Distance 2	21.4

Table D3: continued

Dataset	Model	Variable	R^2 (%)
1996 Snares target squid core vessels	Lognormal, by week	Week	7.9
		Vessel	26.8
		Duration	29.8
1997 Snares target squid core vessels	Lognormal, by week	Week	7.2
		Vessel	12.6
		Start time	15.5
		Effort depth	16.9
		Duration	17.9
1998 Snares target squid core vessels	Lognormal, by week	Week	7.3
		Vessel	11.2
		Latitude	13.0
		Distance 2	14.6
1999 Snares target squid core vessels	Lognormal, by week	Week	15.1
		Distance 2	18.1
		Vessel	20.1
		Effort depth	21.2
2000 Snares target squid core vessels	Lognormal, by week	Week	23.0
		Vessel	30.3
		Distance 2	36.1
		Longitude	39.1
		Start time	40.4
2001 Snares target squid core vessels	Lognormal, by week	Week	11.9
		Distance 2	20.9
		Vessel	27.2
		Latitude	31.4
2002 Snares target squid core vessels	Lognormal, by week	Week	20.0
		Distance 2	29.6
		Latitude	35.6
		Vessel	38.9
		Start time	41.1
2003 Snares target squid core vessels	Lognormal, by week	Week	25.4
		Latitude	35.6
		Distance 2	40.7
		Vessel	43.1
2004 Snares target squid core vessels	Lognormal, by week	Week	14.7
		Vessel	22.2
		Effort depth	26.2
		Distance 2	29.3
		Start time	31.1
		Latitude	32.5
2005 Snares target squid core vessels	Lognormal, by week	Week	11.4
		Distance 2	18.1
		Vessel	21.0
		Start time	23.2
		Longitude	25.0
		Effort height	26.5

Table D3: continued.

Dataset	Model	Variable	R^2 (%)
2006 Snares target squid core vessels	Lognormal, by week	Week	27.9
		Duration	35.5
		Effort depth	39.4
		Vessel	41.9
		Start time	43.9
2007 Snares target squid core vessels	Lognormal, by week	Week	20.7
		Latitude	28.4
		Vessel	32.6
		Start time	35.9
		Distance 2	37.5
2008 Snares target squid core vessels	Lognormal, by week	Week	12.4
		Longitude	19.2
		Distance 2	23.6
		Vessel	26.9
2008 Auckland Is. target squid core vessels		Week	13.8
		Duration	21.1
		Start time	26.2
		Vessel	30.7
		Effort depth	32.1
1990: 2008 Snares target squid core vessels	Lognormal, by year	Year	13.66
		Week	17.41
		Distance 2	20.31
		Vessel	22.84
		Latitude	24.86
		Start time	25.88
1990: 2008 Auckland Is. target squid core vessels	Lognormal, by year	Year	13.71
		Vessel	15.70
		Start time	17.58
		Distance 2	18.68
		Week	19.91
1990: 2008 Snares and Auckland Is. target squid core vessels	Lognormal, by year	Year	12.56
		Vessel	14.91
		Longitude	16.94
		Distance 2	18.96
		Week	20.30
1990: 2008 Snares and Auckland Is. target squid Threshold catch=100%	Lognormal, by year	Year	12.55
		Latitude	14.89
		Vessel	16.93
		Distance 2	18.95
		Week	20.27
		Start time	21.50
1990: 2008 Snares and Auckland Is. target squid Threshold catch=90% Threshold year=3	Lognormal, by year	Year	12.60
		Vessel	14.86
		Longitude	16.70
		Distance 2	18.61
		Week	20.01
		Start time	21.31

Table D4a: Snares 1991 CPUE estimated values and c.v.s.

	All target species Lognormal		Target squid Lognormal		Target squid Binomial		Target squid Combined	Target squid Tweedie	
	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	CPUE	c.v.
1	0.76	0.06	0.75	0.06	1.43	0.20	0.77	0.72	0.01
2	0.61	0.06	0.59	0.06	1.07	0.17	0.59	0.58	0.01
3	0.51	0.07	0.47	0.07	1.02	0.22	0.48	0.52	0.01
4	0.63	0.06	0.60	0.06	0.58	0.15	0.58	0.71	0.01
5	1.24	0.07	1.27	0.06	0.66	0.16	1.24	1.27	0.01
6	1.64	0.06	1.57	0.05	2.28	0.18	1.62	1.59	0.00
7	0.99	0.06	0.98	0.06	1.13	0.16	0.99	1.01	0.01
8	0.99	0.06	0.96	0.05	0.91	0.14	0.96	1.07	0.00
9	0.88	0.07	0.86	0.06	1.07	0.16	0.87	0.88	0.01
10	1.14	0.07	1.06	0.06	1.72	0.19	1.08	0.97	0.01
11	1.24	0.13	1.22	0.13	0.74	0.34	1.21	1.44	0.01
12	2.44	0.06	2.35	0.05	2.30	0.19	2.43	2.40	0.00
13	1.30	0.06	1.20	0.06	1.31	0.20	1.22	1.23	0.01
14	0.93	0.08	0.88	0.08	0.83	0.23	0.88	0.84	0.01
15	1.41	0.12	1.35	0.12	1.30	0.34	1.37	1.23	0.01
16	0.63	0.20	0.65	0.21	0.13	0.33	0.49	0.38	0.02
17	1.76	0.24	1.72	0.24	1.20	0.55	1.74	2.07	0.02
18	1.14	0.18	-	-	-	-	-		
19	0.86	0.29	-	-	-	-	-		
20	0.60	0.36	-	-	-	-	-		

	Target squid Lognormal	
Fortnight	CPUE	c.v.
1	0.63	0.05
2	0.52	0.05
3	1.39	0.04
4	0.92	0.04
5	0.90	0.05
6	2.09	0.05
7	1.03	0.05
8	1.06	0.10
9	1.16	0.14

Table D4b: Snares CPUE estimated values and c.v.s for the lognormal, target squid by week for fishing years 1990, 1992–2008.

	1990		1992		1993		1994		1995	
	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1	2.06	0.13	-	-	-	-	-	-	-	-
2	2.72	0.12	-	-	-	-	-	-	-	-
3	2.72	0.10	-	-	-	-	-	-	-	-
4	1.62	0.12	-	-	-	-	-	-	-	-
5	0.90	0.25	1.82	0.07	3.27	0.08	1.05	0.10	1.33	0.07
6	1.12	0.15	1.38	0.05	4.80	0.06	0.98	0.09	0.66	0.06
7	0.41	0.24	1.31	0.06	1.35	0.06	1.03	0.08	0.65	0.06
8	1.24	0.24	1.69	0.06	1.61	0.06	2.15	0.10	1.29	0.06
9	1.11	0.18	1.47	0.06	1.55	0.05	0.98	0.09	1.02	0.06
10	1.30	0.23	1.52	0.06	1.28	0.06	0.53	0.19	1.01	0.07
11	0.74	0.15	1.57	0.06	1.14	0.06	1.33	0.10	1.59	0.09
12	0.68	0.16	1.69	0.06	0.65	0.06	1.47	0.07	1.25	0.17
13	0.84	0.17	1.51	0.07	0.49	0.07	1.30	0.10	0.85	0.09
14	-	-	0.43	0.10	0.53	0.07	0.79	0.11	0.67	0.10
15	1.00	0.33	0.41	0.09	0.63	0.08	1.17	0.15	0.68	0.14
16	0.53	0.43	0.52	0.07	0.59	0.11	0.88	0.11	0.80	0.15
17	0.25	0.47	0.22	0.12	0.79	0.23	0.48	0.13	1.37	0.15
18	-	-	-	-	0.50	0.35	0.85	0.31	1.95	0.35
19	-	-	-	-	0.56	0.20	-	-		
20	-	-	-	-	0.74	0.17	-	-		
21	-	-	-	-	1.20	0.16	-	-		
22	-	-	-	-	1.06	0.23	-	-		

	1996		1997		1998		1999		2000	
	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1	-	-	1.18	0.07	0.72	0.07	0.90	0.06	0.45	0.12
2	-	-	1.01	0.10	0.95	0.07	1.93	0.06	0.46	0.11
3	-	-	1.50	0.07	1.34	0.07	1.17	0.06	0.82	0.11
4	0.28	0.33	1.36	0.08	1.75	0.06	1.37	0.06	1.07	0.09
5	2.33	0.08	0.81	0.10	1.51	0.06	1.67	0.07	1.31	0.10
6	1.70	0.07	0.76	0.14	1.05	0.06	2.40	0.06	1.63	0.29
7	1.82	0.07	1.36	0.22	1.16	0.06	1.75	0.06	2.30	0.09
8	1.35	0.09	0.47	0.15	1.22	0.09	1.35	0.06	1.47	0.12
9	1.75	0.09	1.08	0.16	1.44	0.08	1.72	0.08	1.18	0.11
10	1.62	0.08	1.65	0.11	0.88	0.08	2.04	0.06	0.71	0.10
11	1.81	0.09	1.80	0.08	0.97	0.09	0.68	0.07	0.69	0.12
12	1.30	0.08	1.70	0.06	0.87	0.08	1.01	0.09	1.04	0.12
13	1.00	0.11	1.12	0.05	1.07	0.07	0.70	0.08	0.57	0.14
14	0.66	0.15	0.91	0.06	0.90	0.10	0.59	0.09	0.86	0.18
15	0.67	0.18	0.86	0.07	0.92	0.10	0.78	0.17	1.04	0.19
16	0.52	0.17	0.75	0.08	1.00	0.19	0.38	0.21	1.83	0.21
17	0.69	0.28	0.91	0.09	1.26	0.12	0.79	0.13	1.12	0.24
18	0.68	0.25	1.00	0.09	1.32	0.15	0.35	0.14	1.18	0.26
19	-	-	1.16	0.10	0.93	0.12	0.46	0.24	-	-
20	1.29	0.15	0.66	0.17	0.57	0.12	-	-	-	-
21	0.71	0.12	0.69	0.14	0.48	0.13	-	-	-	-
22	0.55	0.36	0.61	0.18	0.70	0.31	-	-	-	-

Table D4b: continued.

	2001		2002		2003		2004		2005	
	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1	0.52	0.38	1.28	0.12	0.10	0.25	0.72	0.14	0.56	0.08
2	1.28	0.11	1.41	0.08	1.03	0.09	1.37	0.09	0.56	0.07
3	0.50	0.10	1.85	0.07	0.61	0.07	1.06	0.07	0.58	0.06
4	1.03	0.09	1.34	0.07	0.95	0.07	1.24	0.06	1.08	0.05
5	0.89	0.09	1.00	0.09	1.20	0.09	1.22	0.07	1.50	0.05
6	1.40	0.07	1.76	0.08	1.55	0.07	1.23	0.06	1.05	0.05
7	1.25	0.09	1.65	0.07	1.77	0.08	2.40	0.07	1.22	0.06
8	1.06	0.08	0.94	0.08	3.21	0.08	1.81	0.07	1.06	0.06
9	1.22	0.08	1.08	0.09	2.45	0.08	2.20	0.12	1.80	0.07
10	0.70	0.09	0.89	0.08	1.79	0.08	1.85	0.10	1.91	0.08
11	0.69	0.10	0.65	0.11	0.93	0.09	1.99	0.11	2.13	0.10
12	0.71	0.09	1.01	0.14	0.77	0.16	0.82	0.10	1.44	0.10
13	0.89	0.10	0.73	0.14	0.65	0.12	1.00	0.09	1.02	0.09
14	1.33	0.13	0.42	0.17	0.59	0.20	0.91	0.08	0.85	0.12
15	2.48	0.10	0.67	0.10	0.68	0.11	0.70	0.15	1.42	0.20
16	1.38	0.08	0.79	0.13	1.02	0.12	0.69	0.08	0.54	0.08
17	0.56	0.16	0.77	0.15	0.91	0.21	0.42	0.08	0.61	0.08
18	1.71	0.25	-	-	1.64	0.23	0.52	0.12	0.98	0.10
19	1.12	0.46	1.26	0.16	1.63	0.13	0.63	0.13	1.60	0.25
20	1.67	0.30	0.67	0.12	0.84	0.18	0.60	0.14	0.62	0.12
21	0.45	0.29	1.12	0.32	-	-	0.80	0.13	0.53	0.14
22	1.33	0.24	1.10	0.26	-	-	0.62	0.18	1.12	0.17

	2006		2007		2008	
	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1	3.48	0.08	0.20	0.12	0.77	0.11
2	2.54	0.07	0.38	0.11	0.75	0.10
3	2.50	0.07	0.71	0.08	1.49	0.10
4	1.76	0.06	1.51	0.07	1.13	0.08
5	1.47	0.08	0.49	0.09	0.68	0.08
6	1.67	0.10	0.77	0.12	1.27	0.07
7	1.98	0.10	1.32	0.10	0.95	0.07
8	1.26	0.11	1.66	0.11	1.42	0.10
9	1.37	0.12	1.54	0.09	1.61	0.13
10	1.23	0.11	1.28	0.08	1.50	0.09
11	1.34	0.11	1.60	0.09	1.83	0.12
12	1.00	0.14	1.67	0.10	1.69	0.09
13	1.46	0.11	1.11	0.09	1.33	0.12
14	1.12	0.09	1.02	0.08	0.87	0.13
15	0.70	0.10	1.20	0.11	0.45	0.18
16	0.52	0.09	1.07	0.10	0.92	0.18
17	0.47	0.10	1.15	0.11	0.24	0.26
18	0.45	0.13	1.45	0.12	-	-
19	0.33	0.12	1.20	0.17	-	-
20	0.48	0.11	-	-	-	-
21	0.49	0.12	-	-	-	-
22	0.19	0.20	-	-	-	-

Table D4c: Auckland Is. CPUE estimated values and c.v.s for the lognormal, target squid by week for the fishing year 2008.

	2008	
	CPUE	c.v.
1	-	-
2	-	-
3	-	-
4	-	-
5	-	-
6	-	-
7	-	-
8	1.46	0.12
9	1.24	0.09
10	1.15	0.13
11	1.14	0.08
12	0.91	0.11
13	1.53	0.11
14	1.19	0.09
15	0.89	0.08
16	0.78	0.11
17	0.37	0.16

Table D4d: Expected non-zero catch rate (kg/tow) from the lognormal CPUE models for the Snares and Auckland Is. target squid 2008 datasets standardised on the same fishing vessel.

	Predict CPUE output	
	Snares	Auckland Is.
1	8 670	-
2	8 441	-
3	16 758	-
4	12 651	-
5	7 682	-
6	14 211	-
7	10 621	-
8	15 945	20 699
9	18 118	17 551
10	16 777	16 284
11	20 480	16 104
12	18 989	12 841
13	14 897	21 635
14	9 769	16 776
15	5 058	12 514
16	10 359	11 010
17	2 733	5 213

Table D4e: Indices by year: (lognormal, target squid by year)

	Snares		Auckland Is.		Snares and Auckland Is.	
	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1990	0.96	0.07	0.76	0.04	0.75	0.03
1991	0.47	0.03	0.75	0.04	0.54	0.02
1992	1.22	0.03	1.10	0.04	1.22	0.02
1993	0.87	0.02	0.34	0.08	0.84	0.02
1994	1.07	0.03	1.40	0.02	1.23	0.02
1995	1.01	0.02	1.81	0.02	1.33	0.01
1996	0.67	0.02	0.74	0.02	0.70	0.02
1997	0.96	0.02	1.05	0.02	0.94	0.01
1998	0.89	0.02	0.92	0.03	0.87	0.01
1999	0.61	0.02	0.34	0.06	0.59	0.02
2000	0.47	0.03	0.77	0.03	0.54	0.02
2001	0.83	0.02	0.81	0.04	0.82	0.02
2002	1.34	0.02	1.10	0.03	1.22	0.02
2003	0.71	0.02	0.68	0.03	0.68	0.02
2004	1.67	0.02	2.13	0.02	1.71	0.01
2005	1.25	0.02	1.69	0.02	1.36	0.01
2006	1.71	0.02	0.93	0.02	1.25	0.02
2007	2.11	0.02	1.97	0.03	1.93	0.02
2008	1.96	0.02	2.55	0.03	2.14	0.02

	Snares and Auckland Is. Threshold=100%, threshold years=4		Snares and Auckland Is. Threshold=10%, threshold years=3	
	CPUE	c.v.	CPUE	c.v.
1990	0.73	0.03	0.75	0.03
1991	0.55	0.02	0.52	0.02
1992	1.22	0.02	1.28	0.02
1993	0.83	0.02	0.81	0.02
1994	1.23	0.02	1.26	0.01
1995	1.33	0.01	1.36	0.01
1996	0.70	0.02	0.67	0.01
1997	0.94	0.01	0.93	0.01
1998	0.87	0.01	0.86	0.01
1999	0.59	0.02	0.58	0.01
2000	0.55	0.02	0.54	0.02
2001	0.82	0.02	0.82	0.02
2002	1.22	0.02	1.22	0.02
2003	0.69	0.02	0.69	0.02
2004	1.71	0.01	1.71	0.01
2005	1.36	0.01	1.36	0.01
2006	1.25	0.02	1.25	0.01
2007	1.94	0.02	1.94	0.02
2008	2.14	0.02	2.15	0.02

Table D5: Summary of key factors in the Snares in-season standardised CPUE models (*n*=19), overall years and by decade: frequency of entering the models; average position entering the model; and average deviance explained (R^2).

	Frequency (%)			Average position		
Factor	1990–2008	1990–99	2000–08	1990–2008	1990–99	2000–08
Week	100	100	100	1.0	1.0	1.0
Vessel	100	100	100	2.6	2.1	3.2
Distance 2	63	50	78	3.1	3.2	3.0
Start time	63	50	78	3.9	3.2	4.4
Latitude	37	20	56	3.3	3.0	3.4
Effort depth	37	40	33	4.0	4.3	3.7
Longitude	21	20	22	4.5	4.5	4.5
Duration	21	20	22	3.0	4.0	2.0
Effort height	16	20	11	5.3	5.0	6.0
Effort width	11	10	11	5.5	5.0	6.0
R^2	30.2	25.1	35.9			

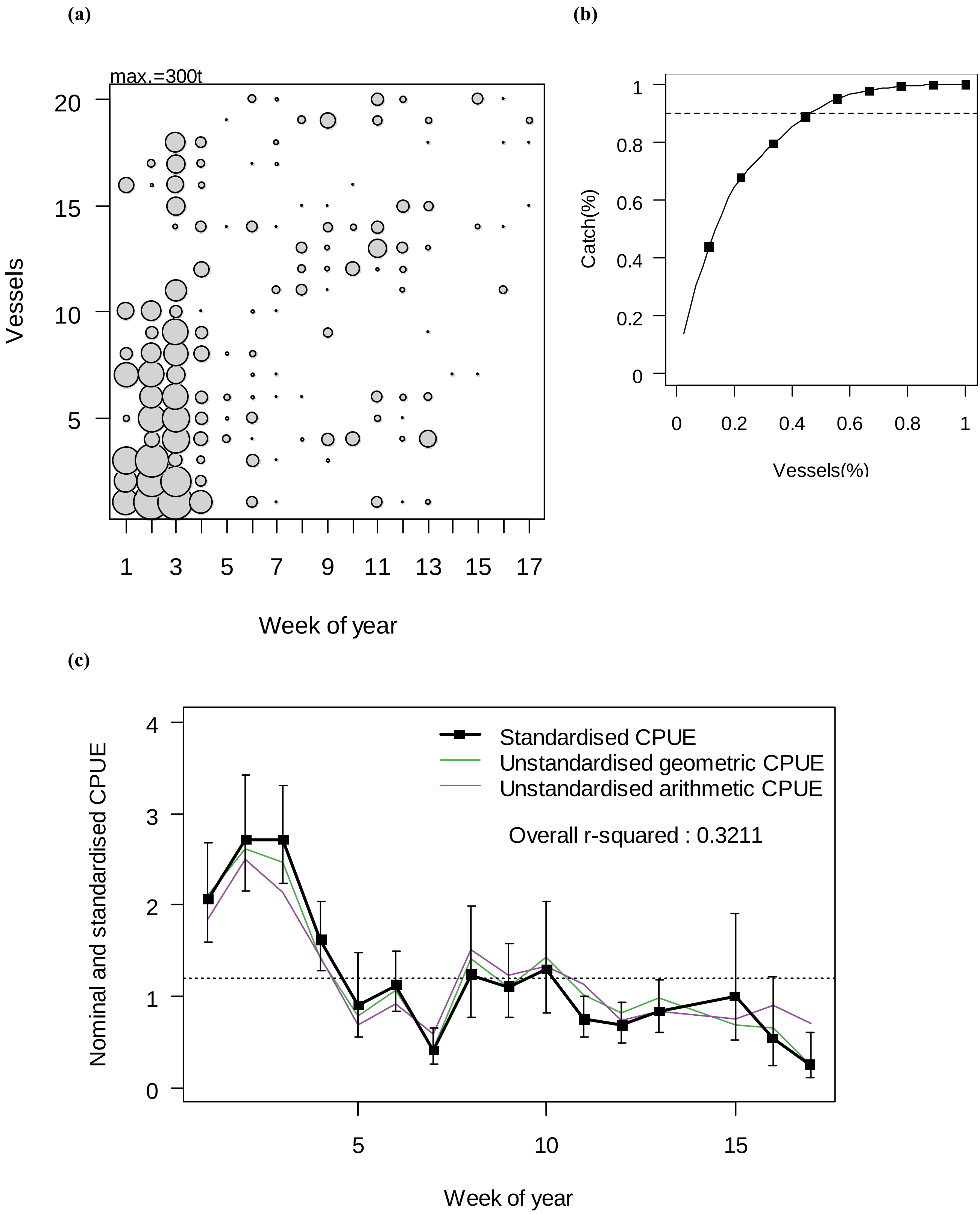


Figure D1: SNARES 1990 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

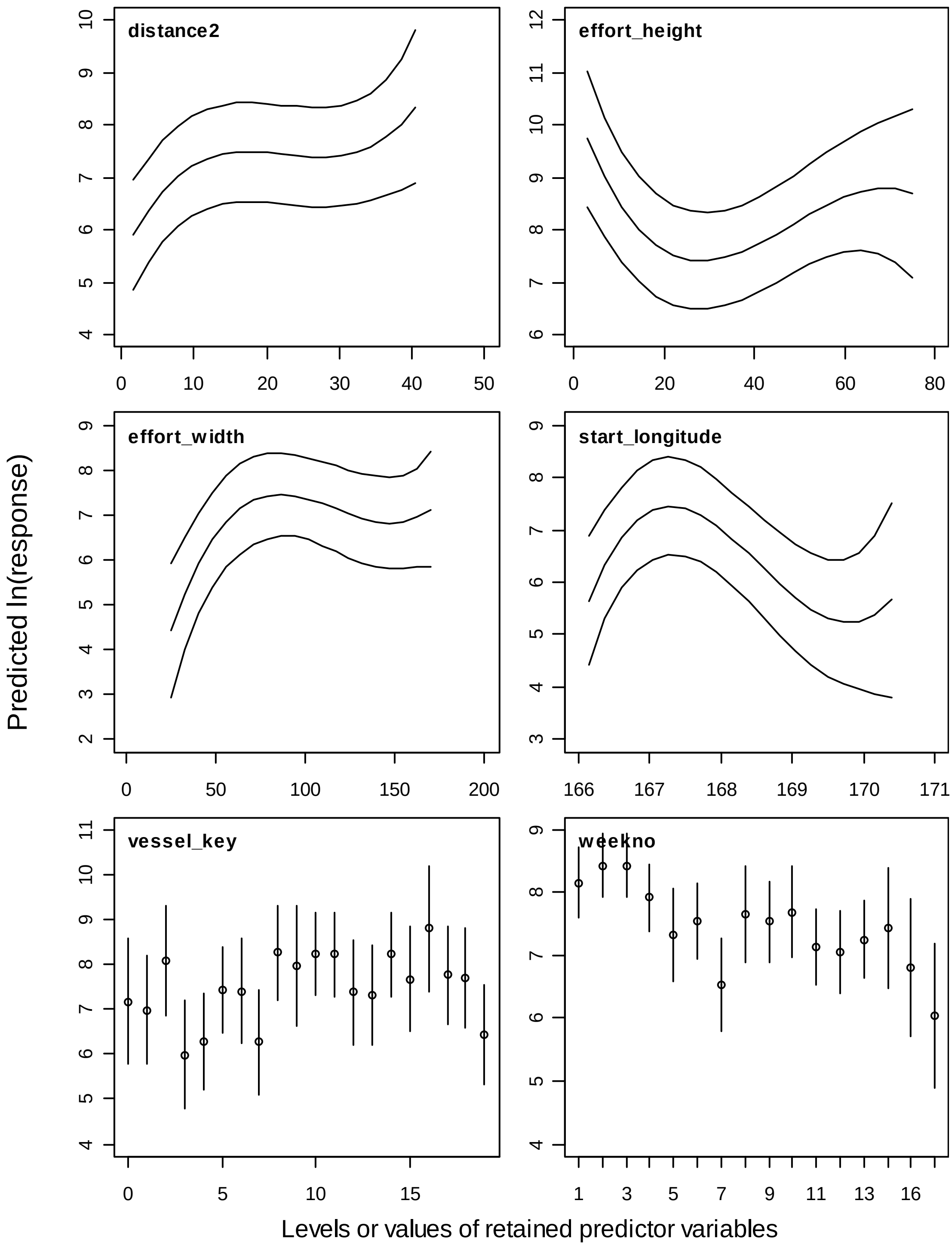
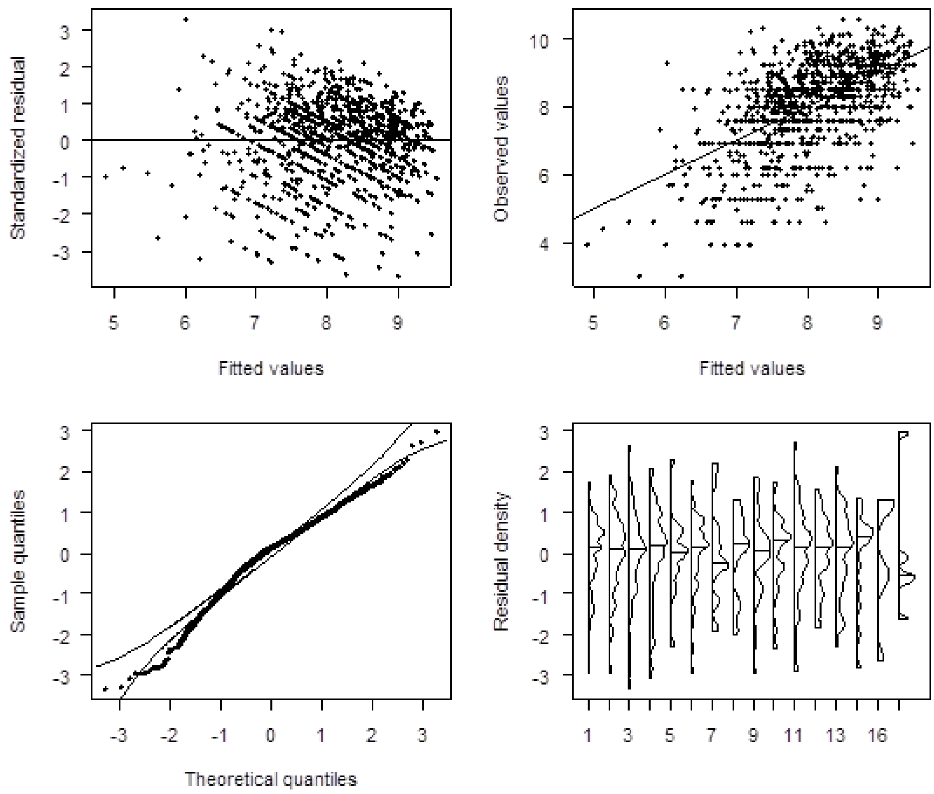


Figure D1d: SNARES 1990 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

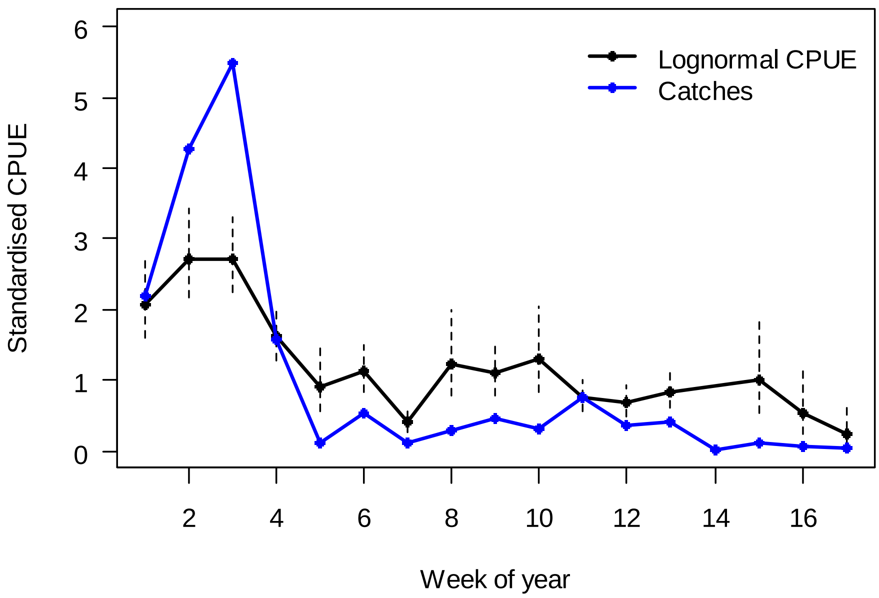
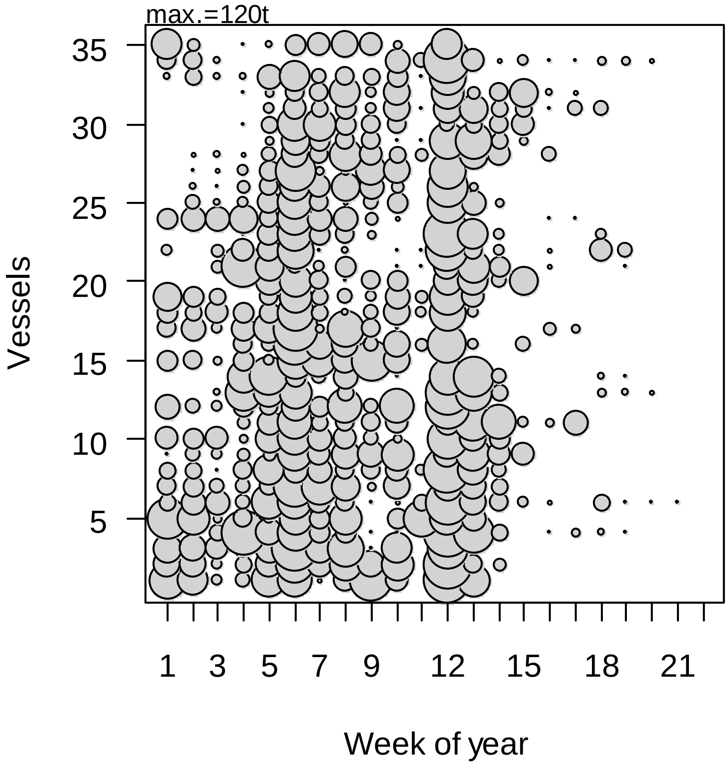
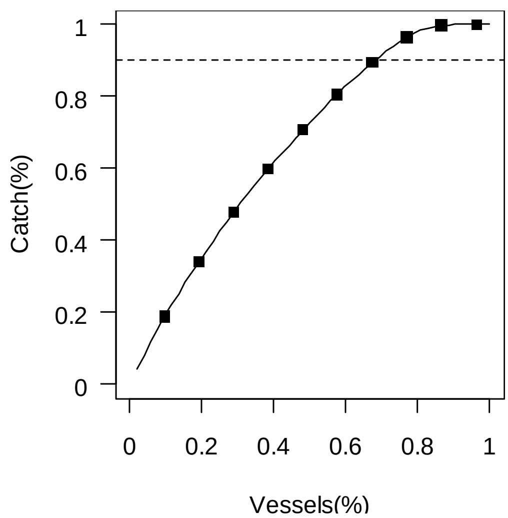


Figure D1: SNARES 1990 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

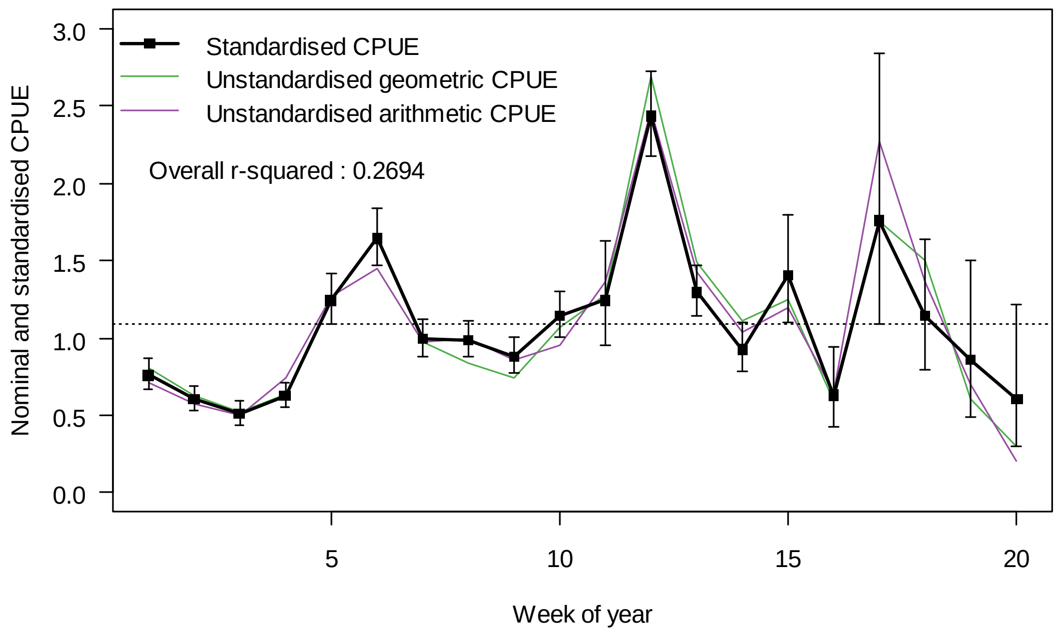


Figure D2: SNARES 1991 WEEKLY ALL TARGET SPECIES. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

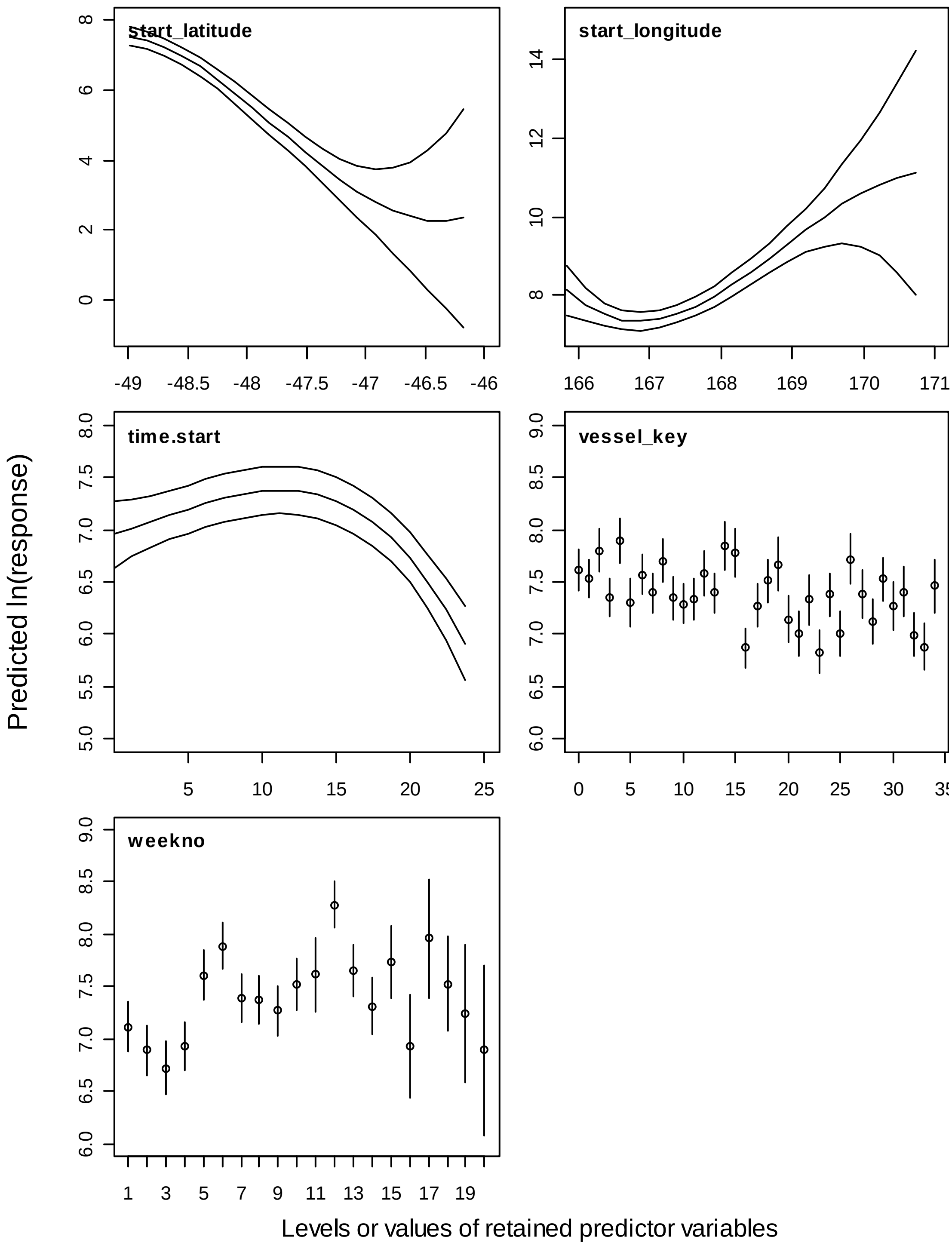
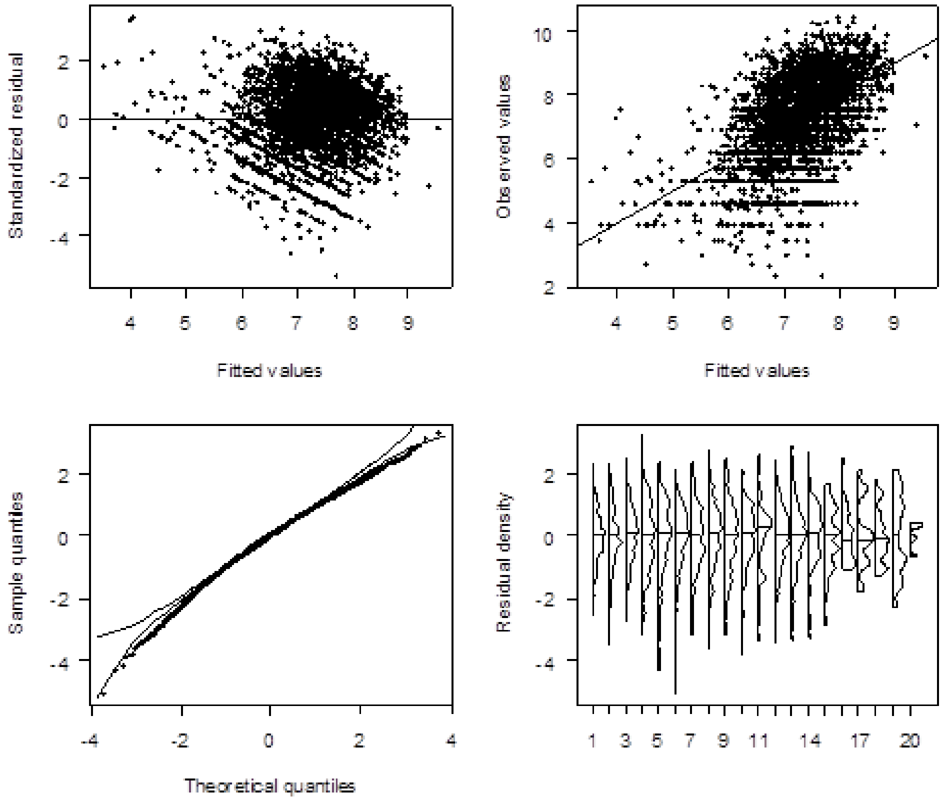


Figure D2d: SNARES 1991 WEEKLY ALL TARGET SPECIES. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

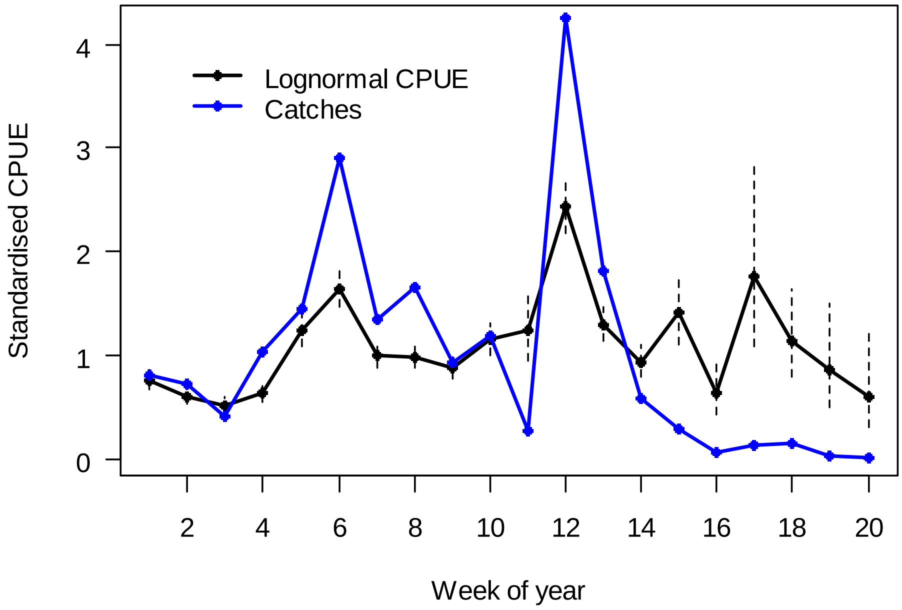
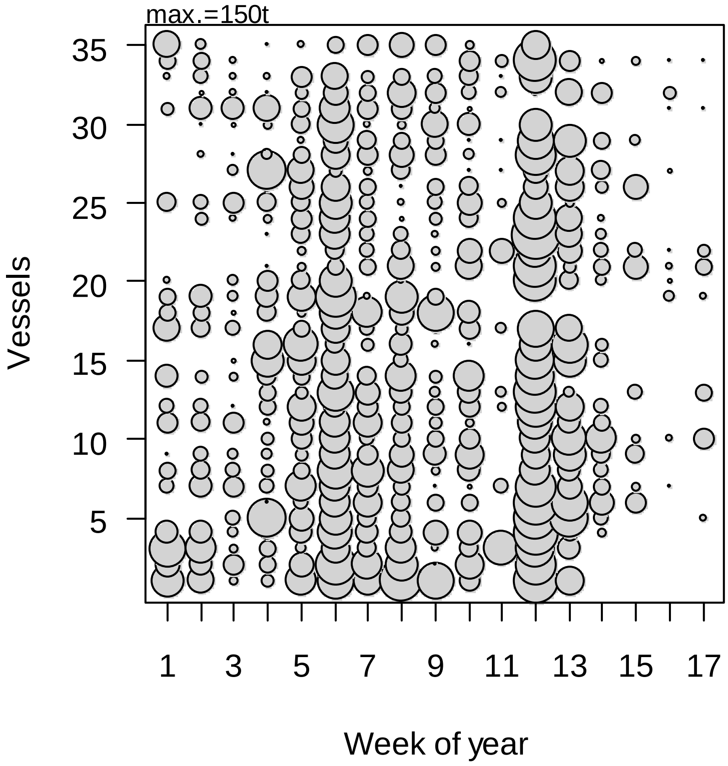
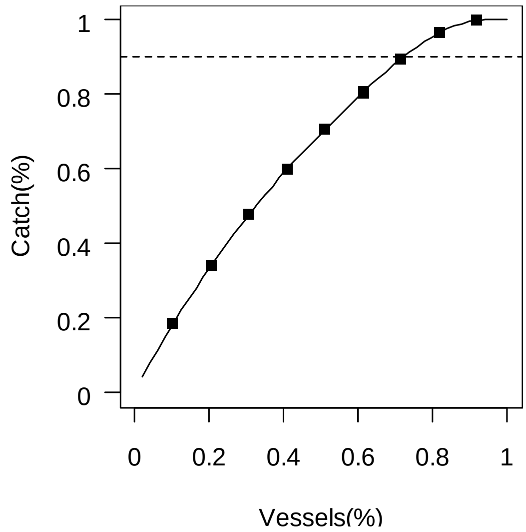


Figure D2: continued. SNARES 1991 WEEKLY ALL TARGET SPECIES. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

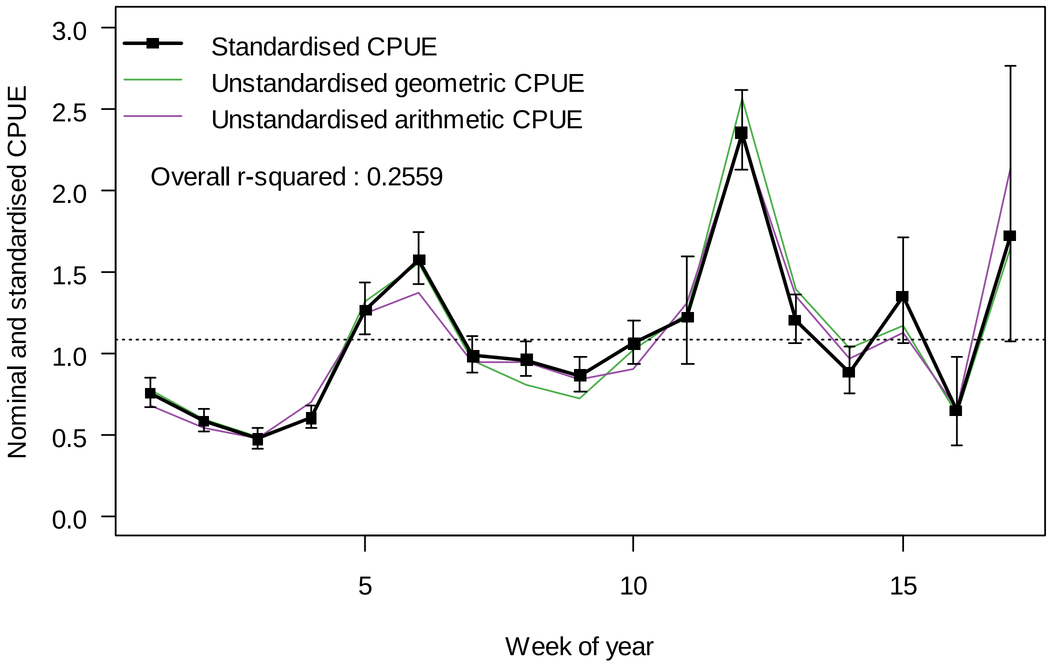


Figure D3a: SNARES 1991 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

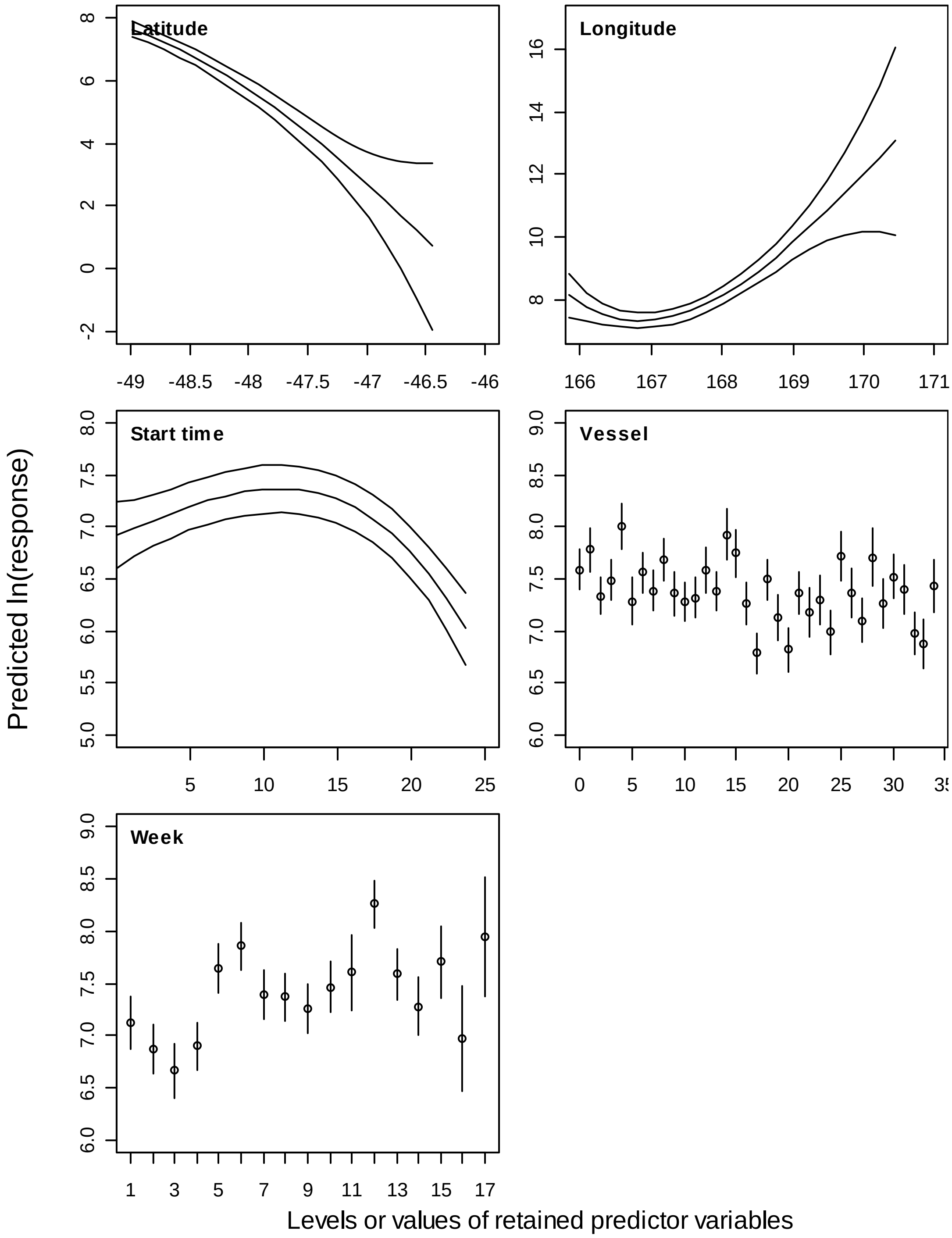
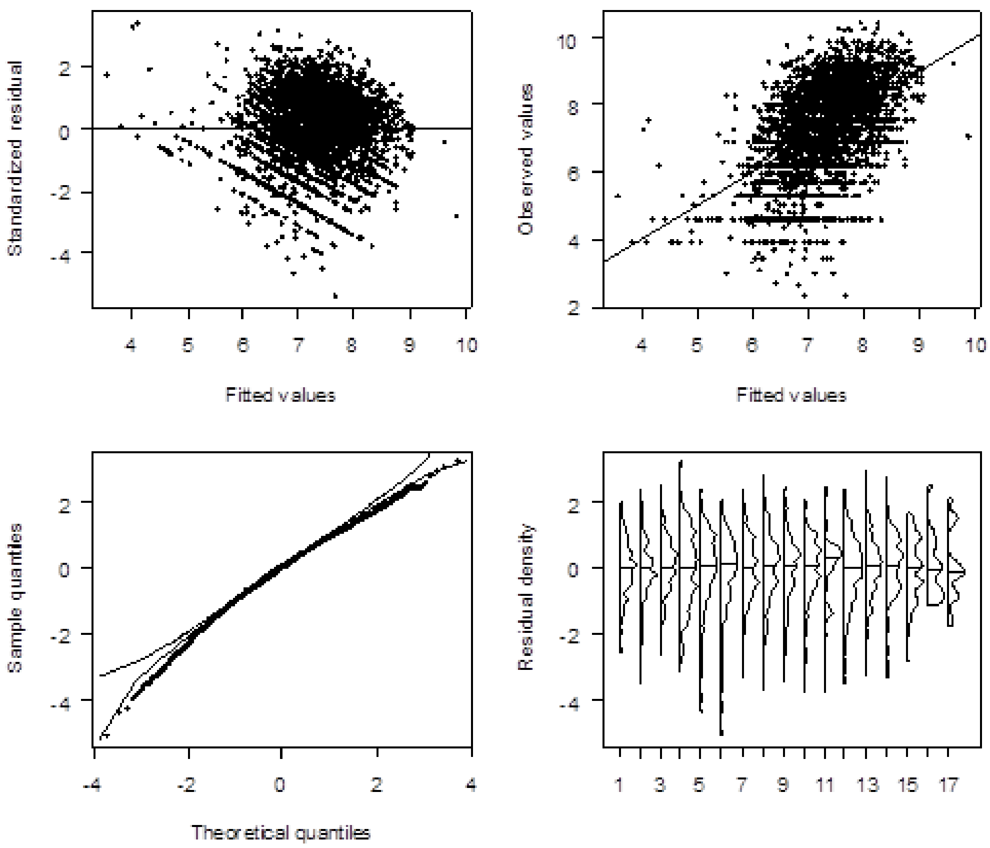


Figure D3d: SNARES 1991 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

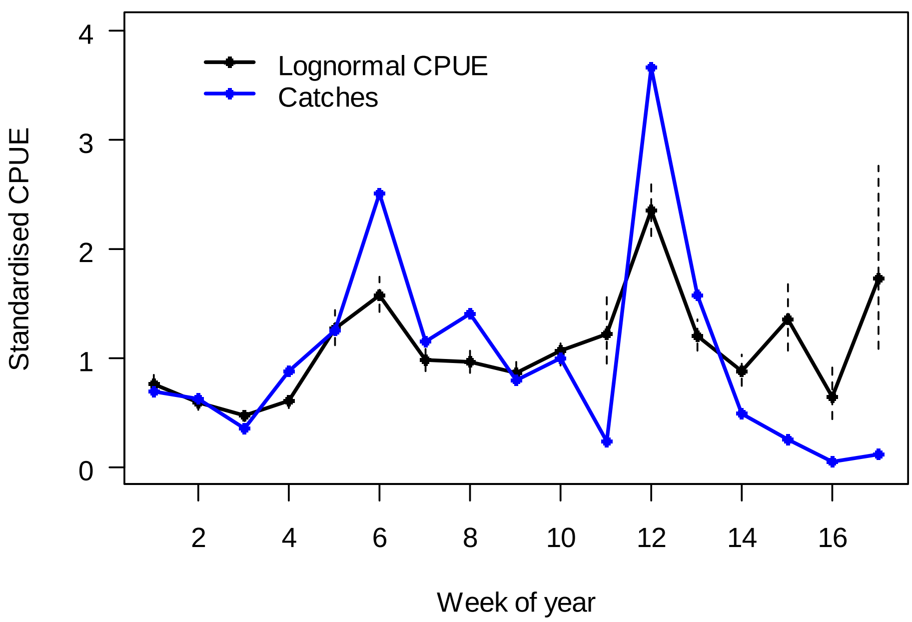


Figure D3: SNARES 1991 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

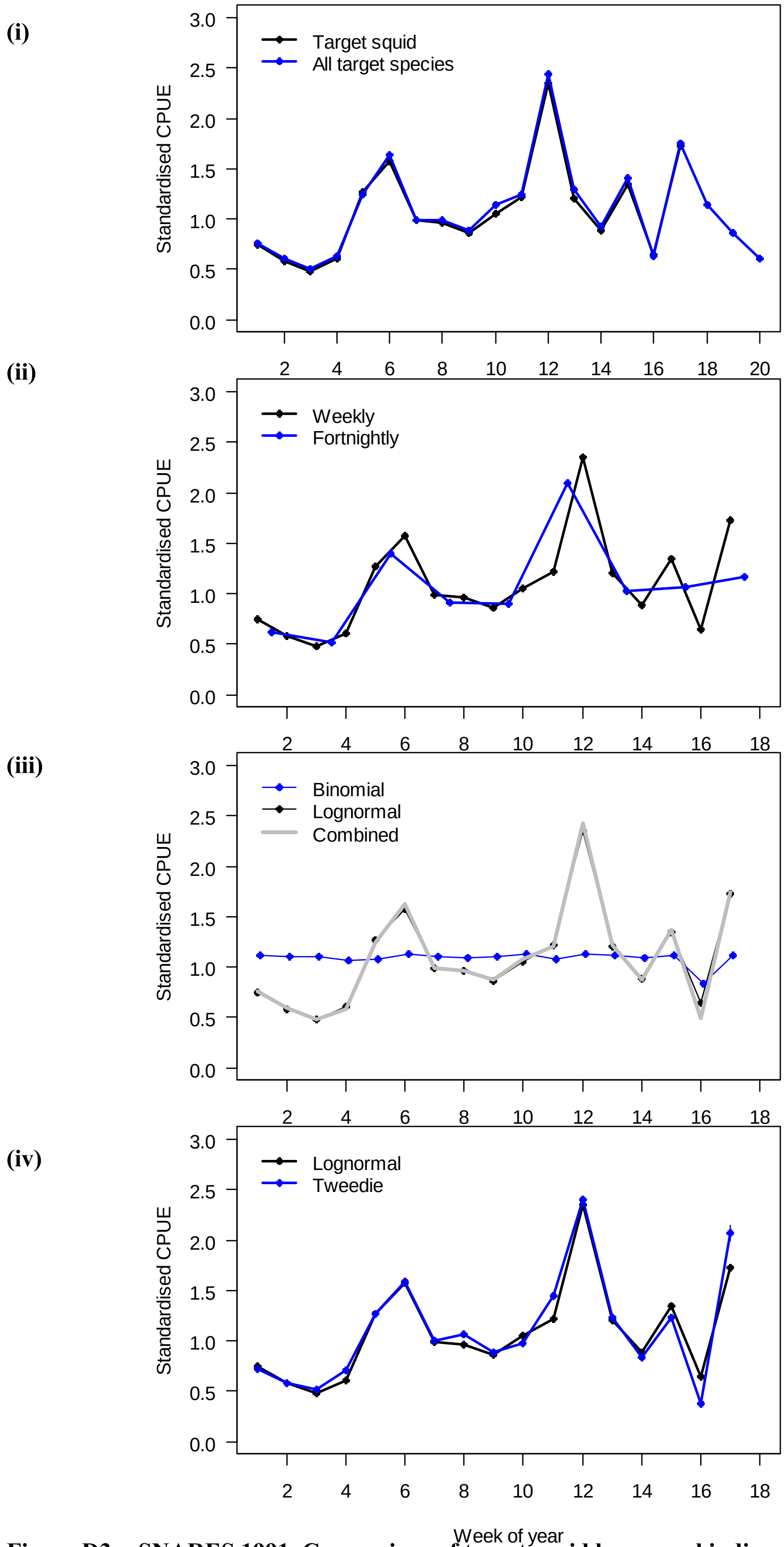
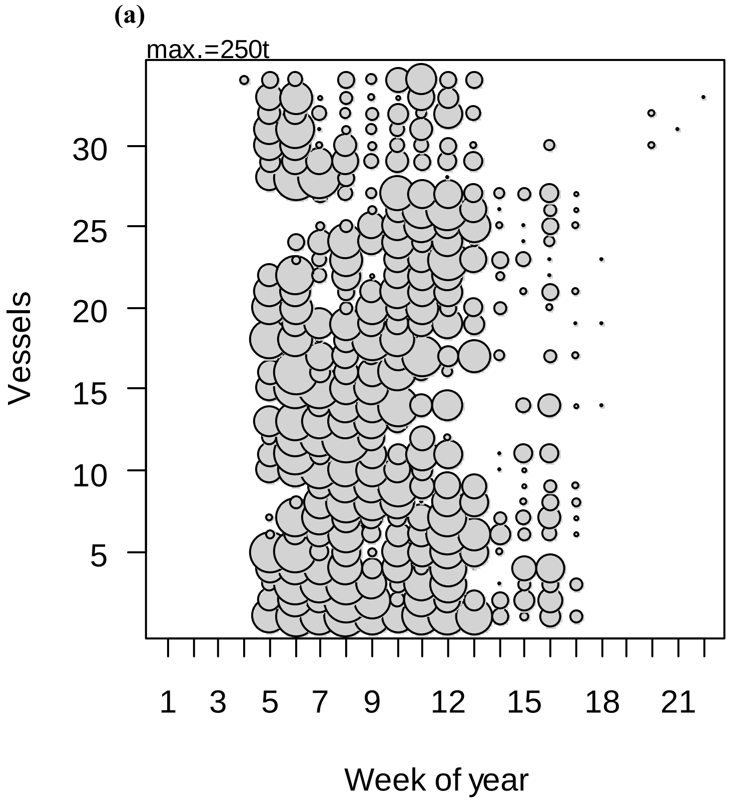
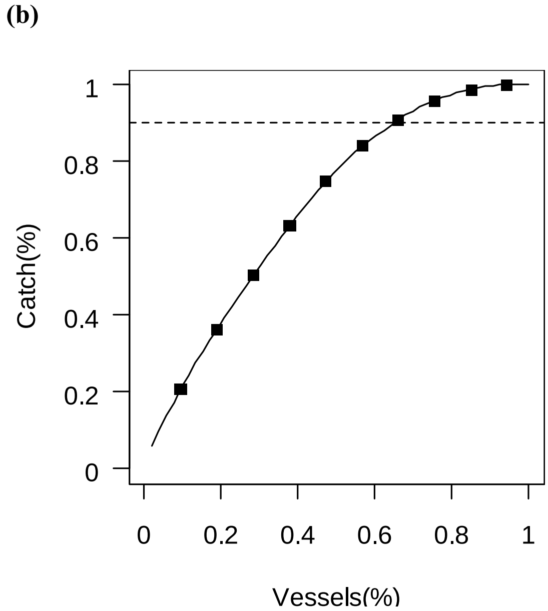


Figure D3g: SNARES 1991. Comparison of target squid lognormal indices by week, with (i) all target species lognormal weekly model; (ii) target squid lognormal fortnight model; (iii) target squid lognormal, binomial and combined models (iv) target squid tweedie model.





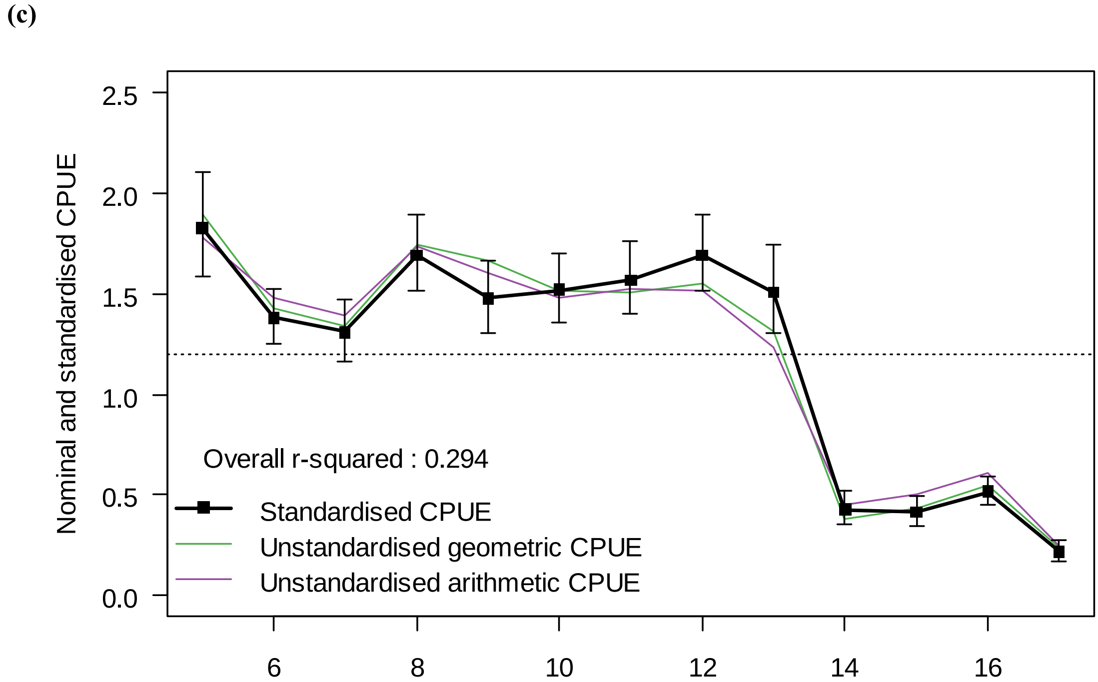


Figure D4a: SNARES 1992 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

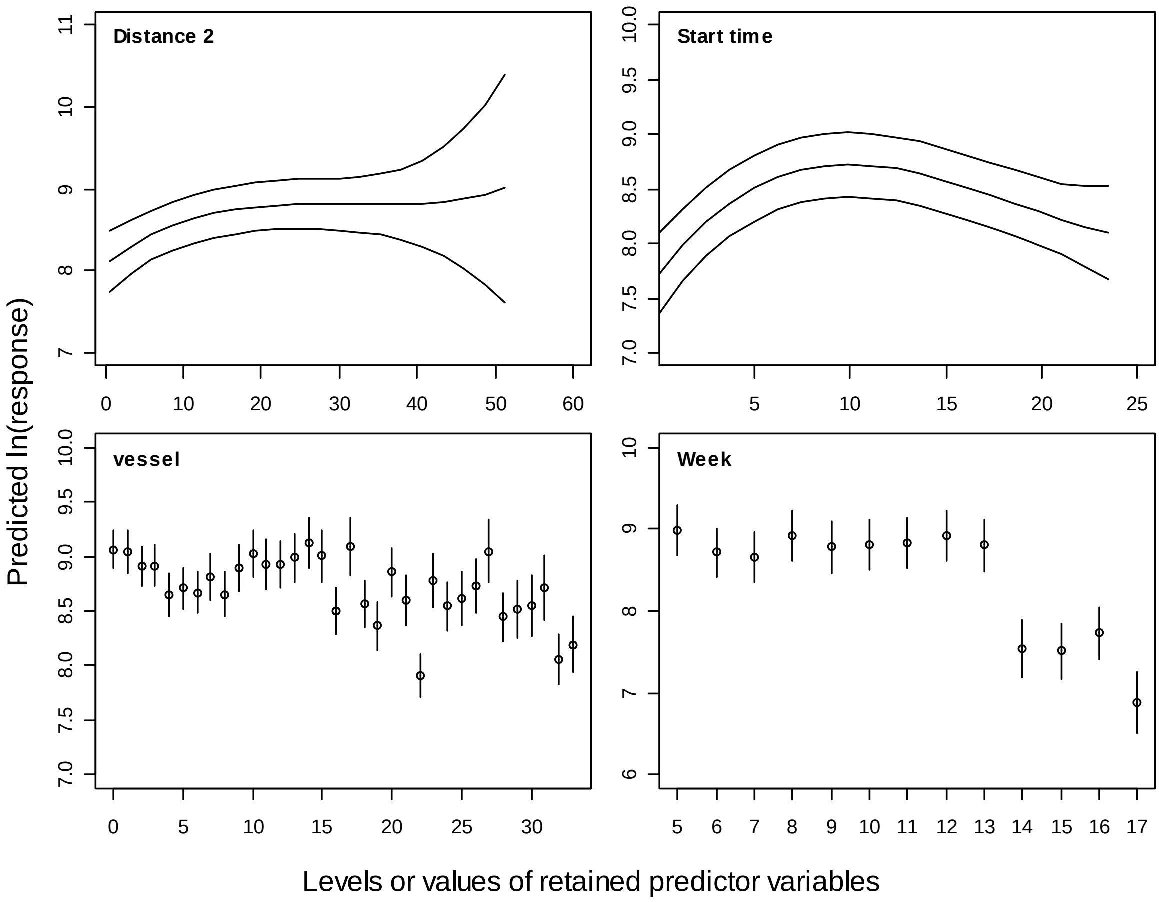
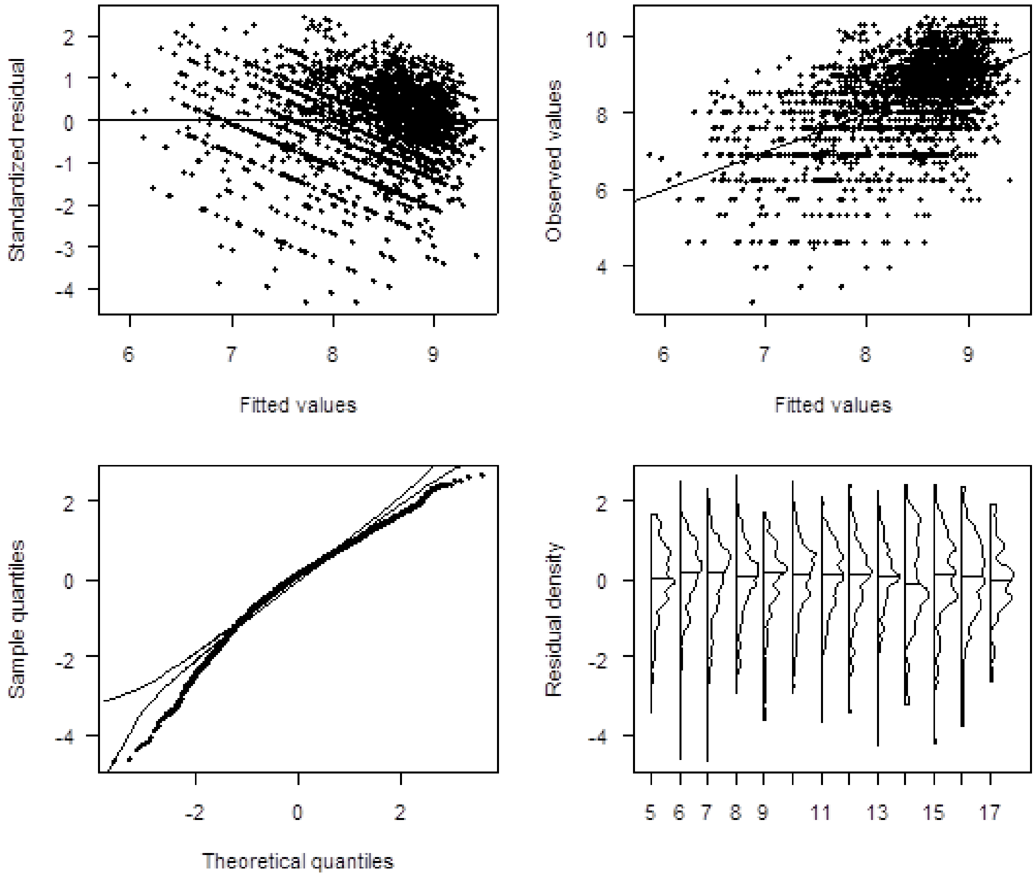


Figure D4d: SNARES 1992 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

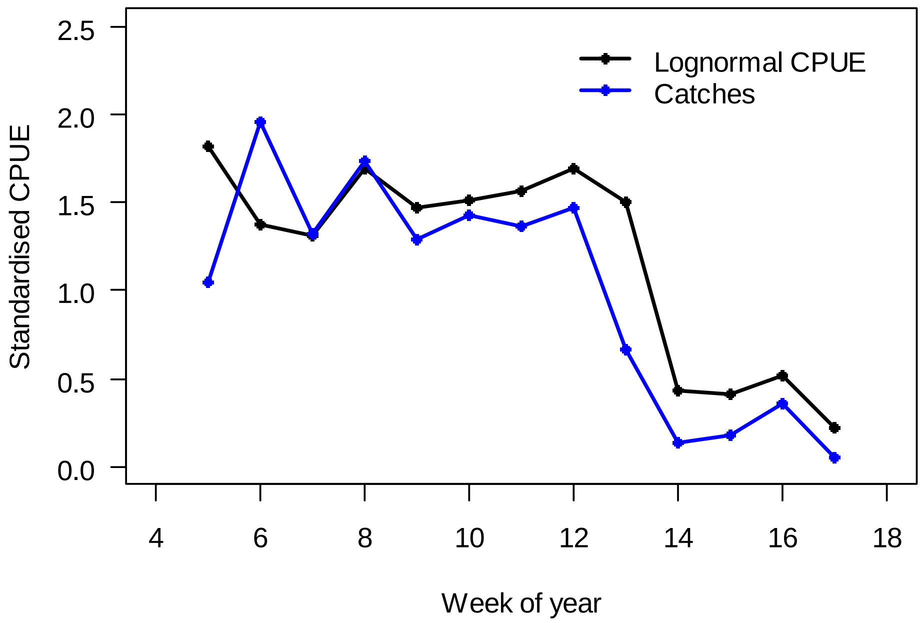


Figure D4: SNARES 1992 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)

(b)

(c)

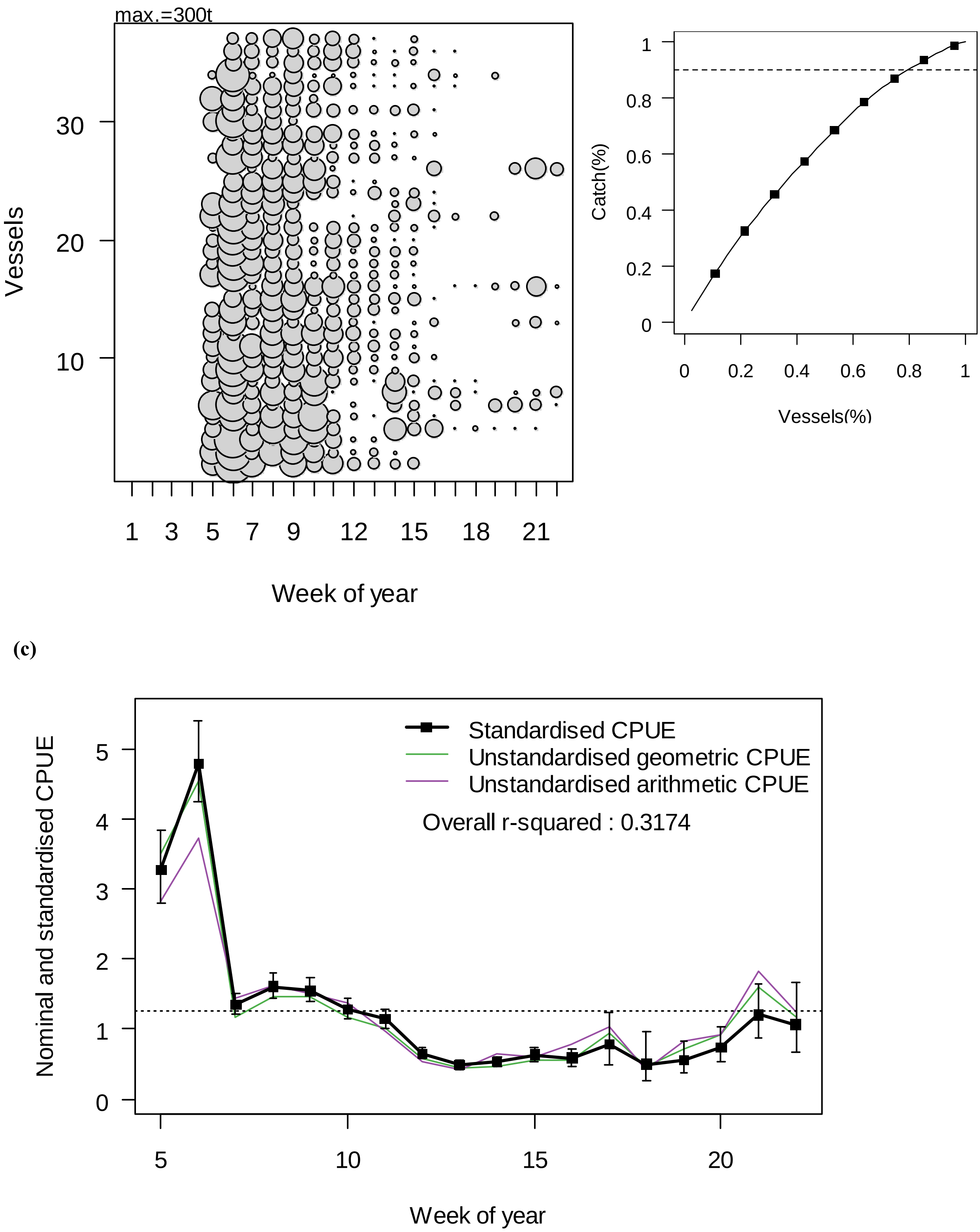


Figure D5a: SNARES 1993 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

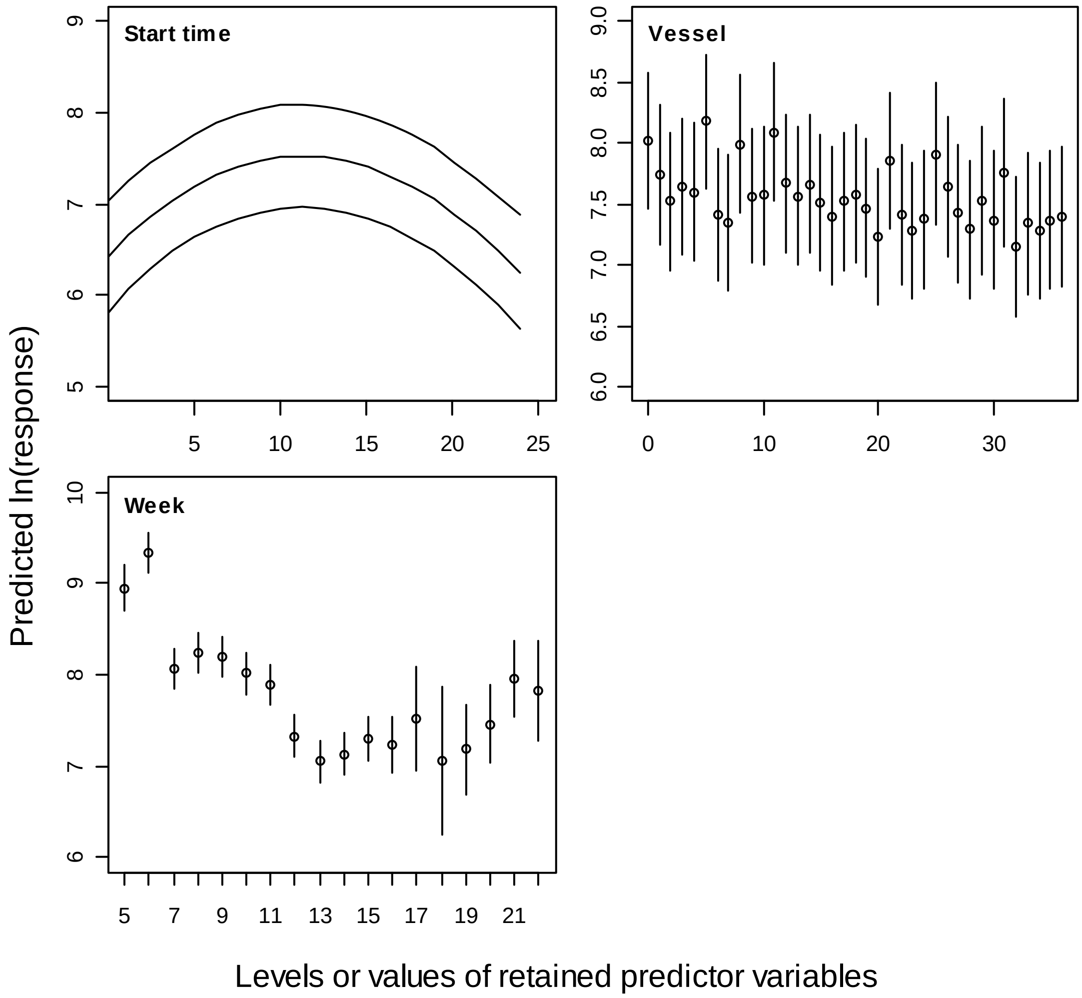
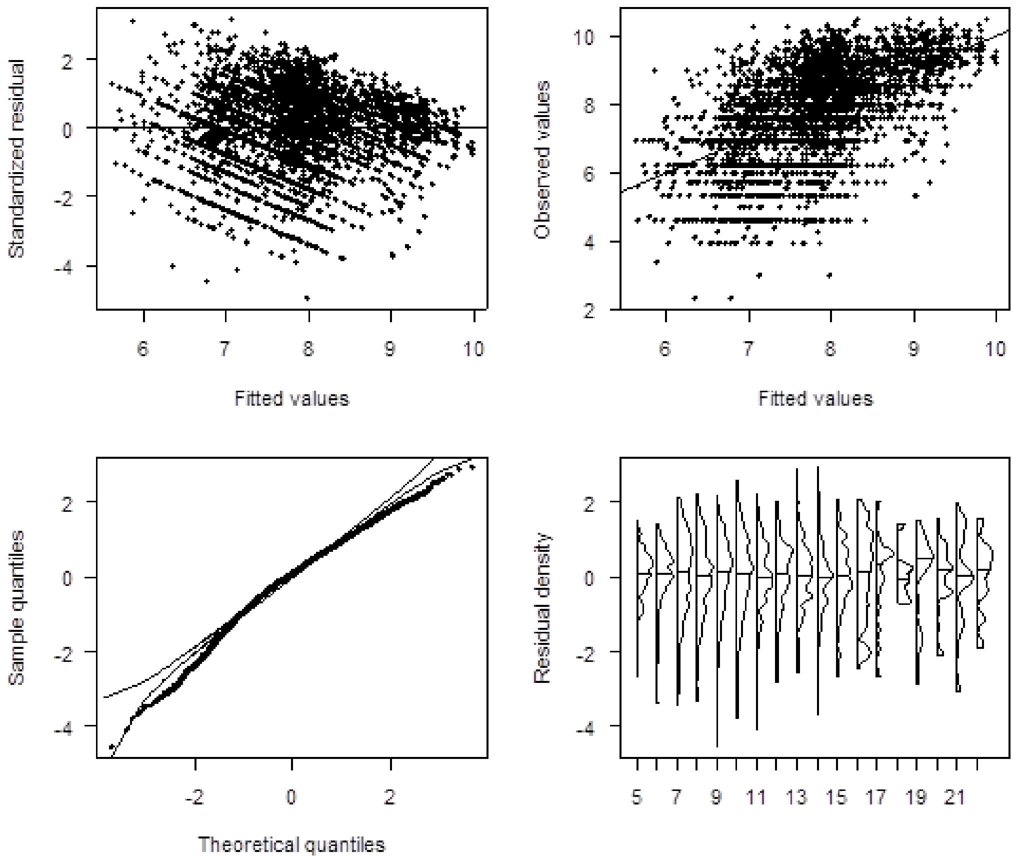


Figure D5d: SNARES 1993 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

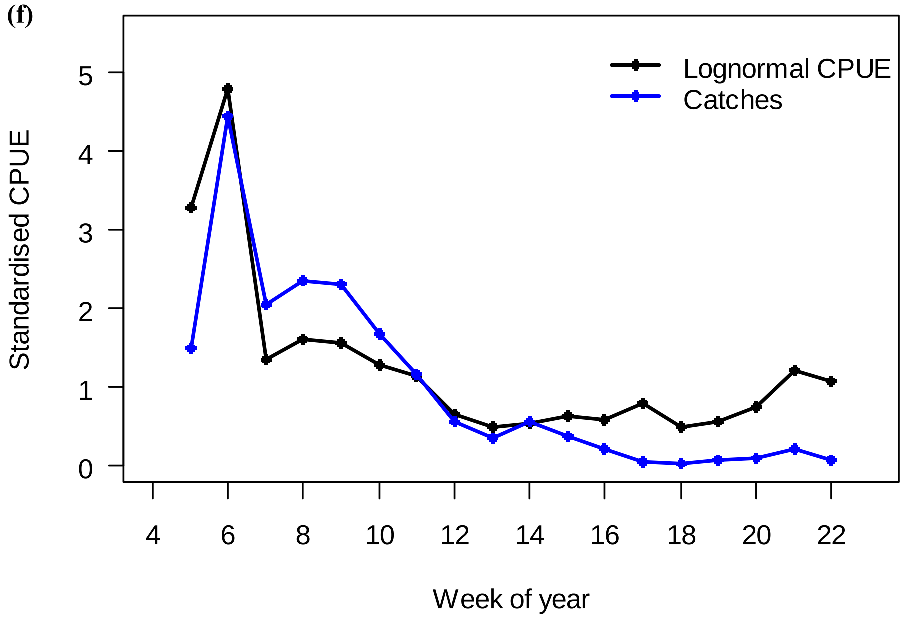
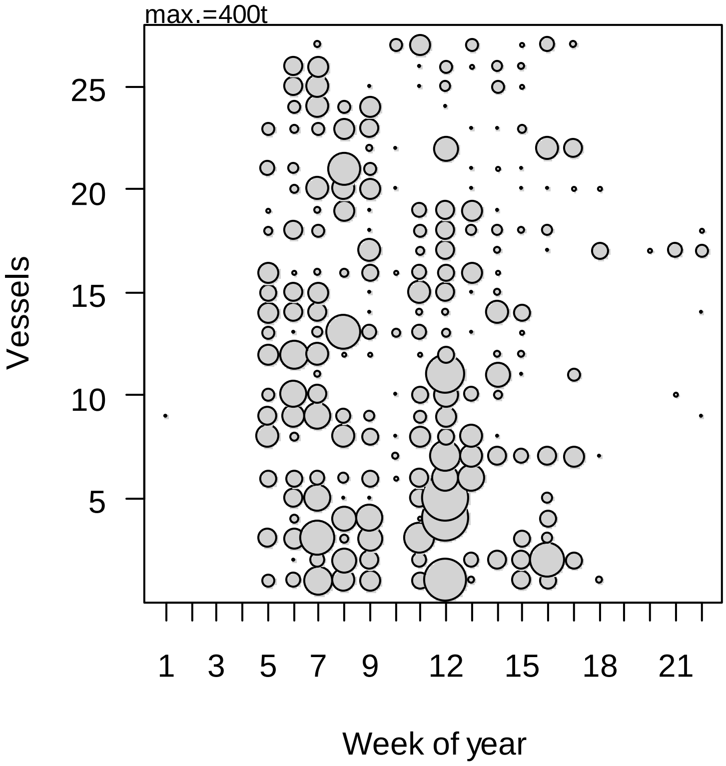
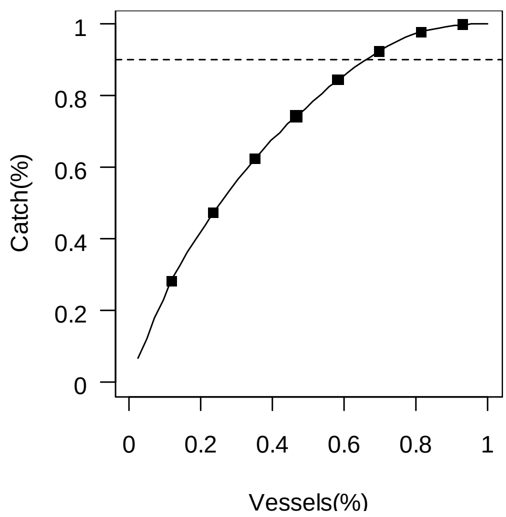


Figure D5: SNARES 1993 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)

(b)





(c)

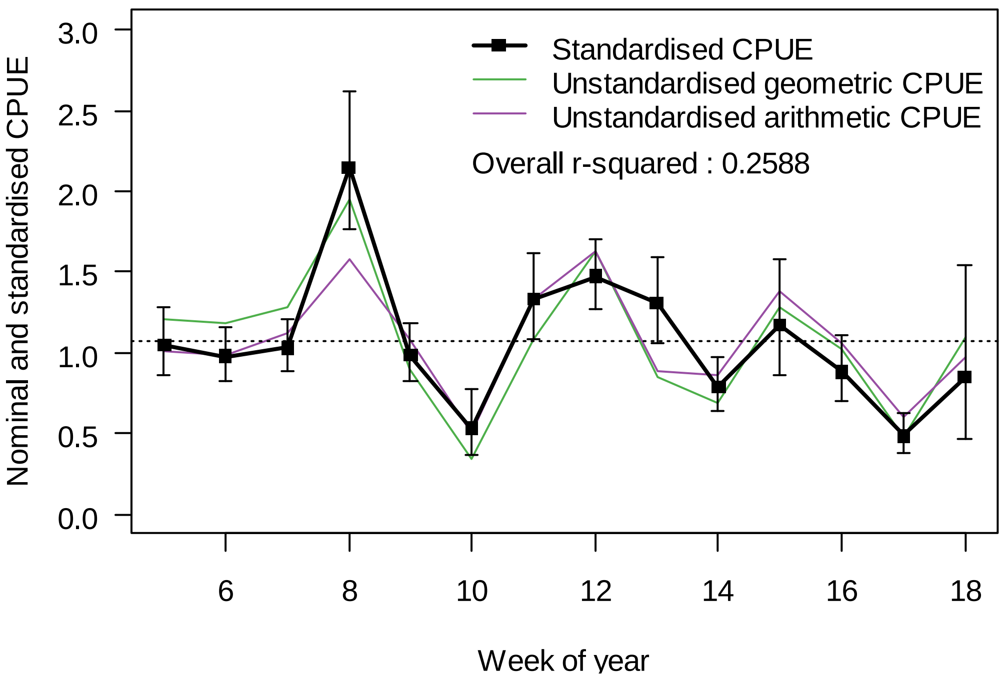


Figure D6a: SNARES 1994 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

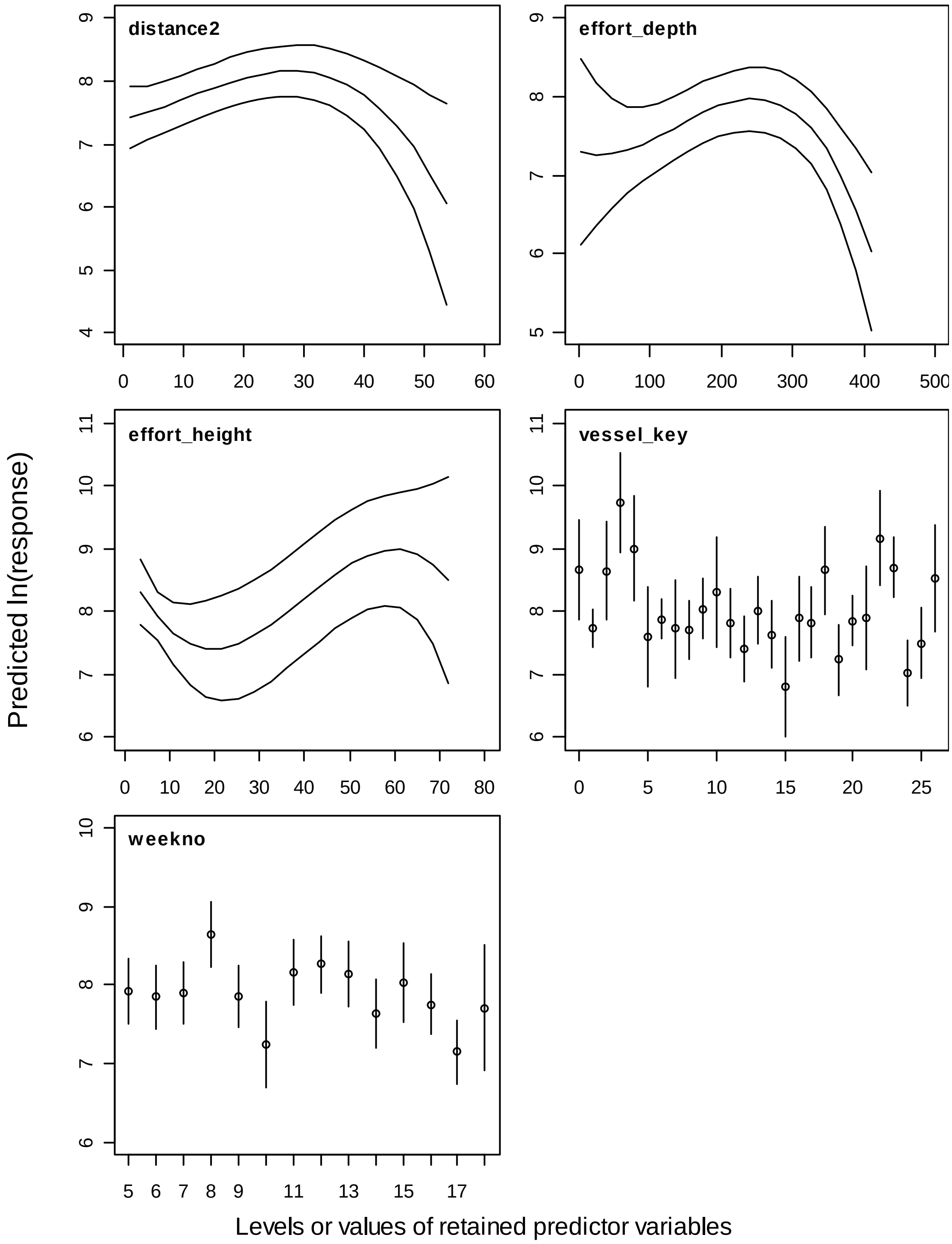
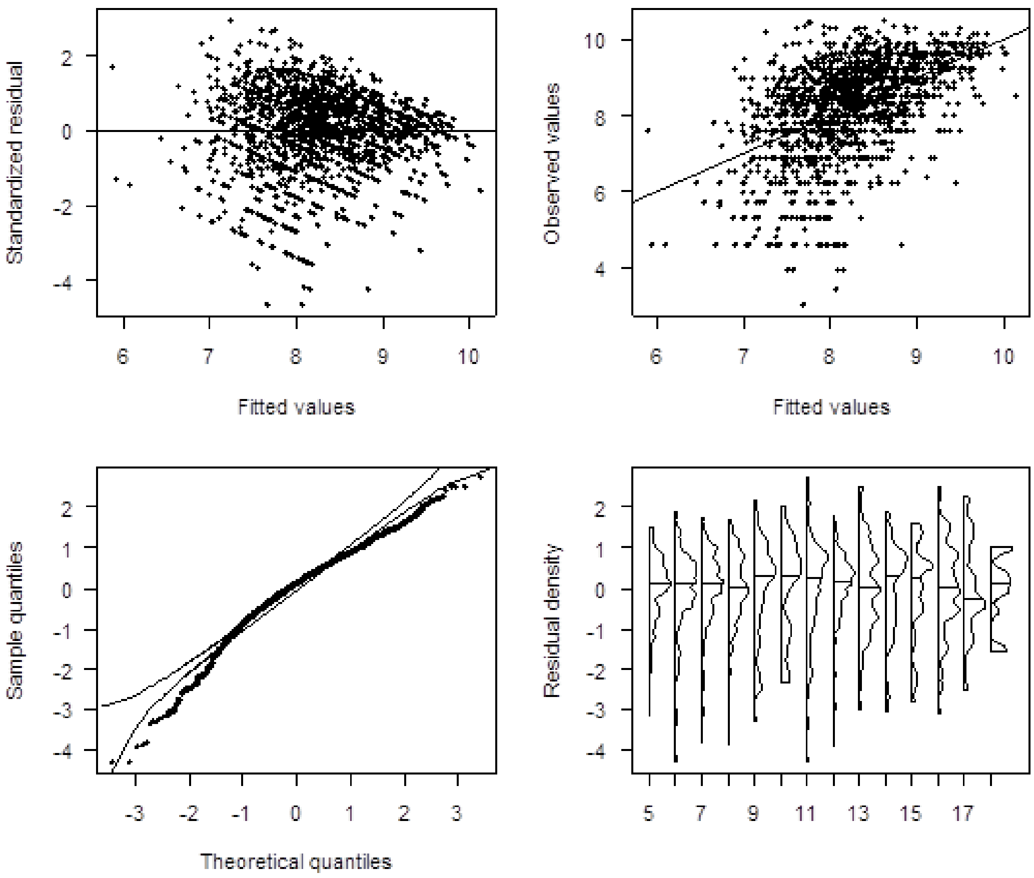


Figure D6d: SNARES 1994 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

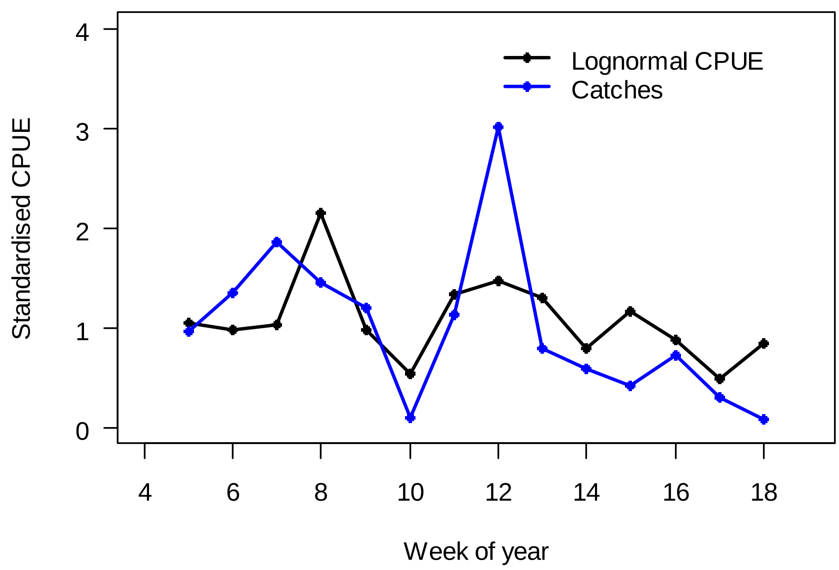


Figure D6: SNARES 1994 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

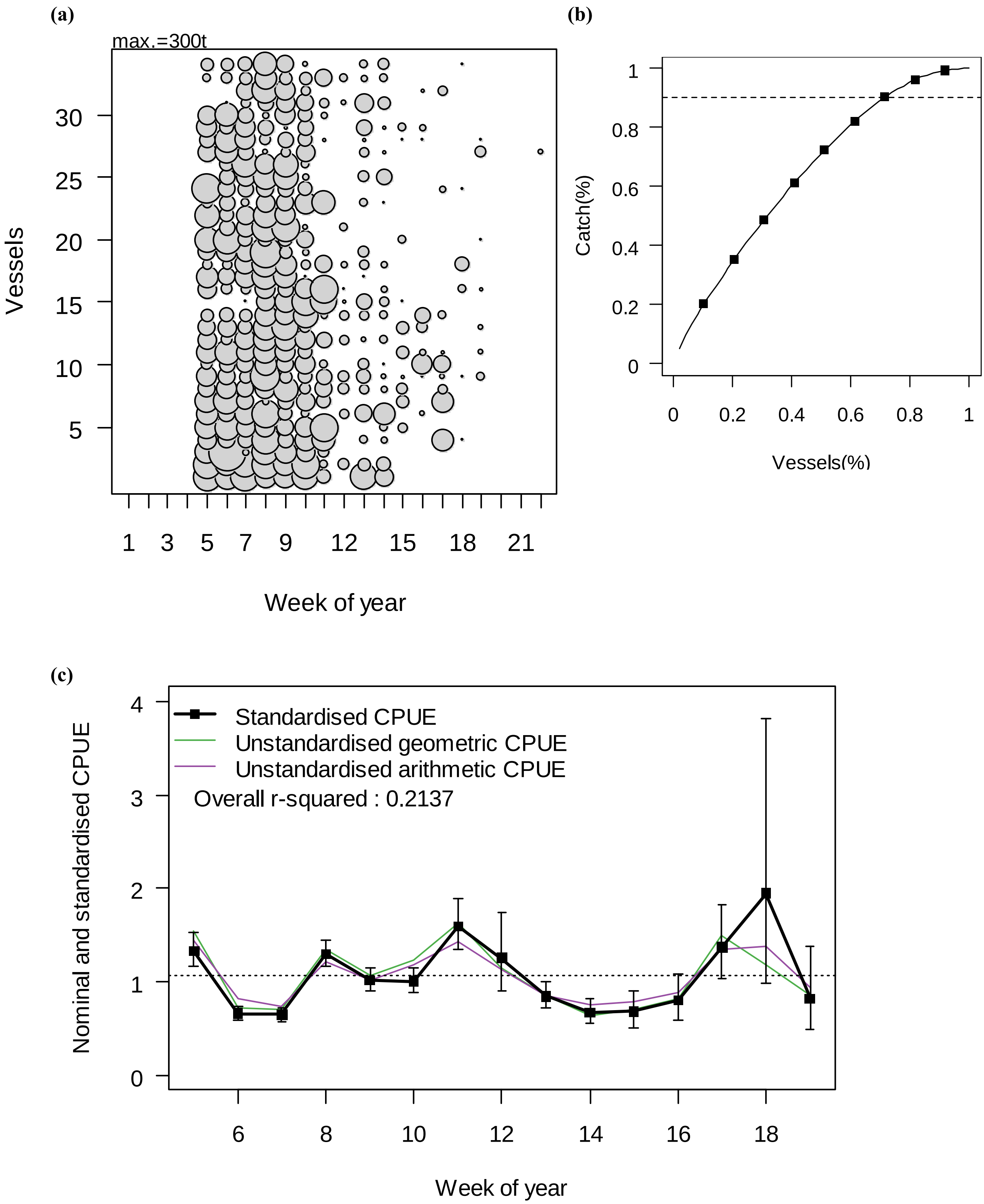


Figure D7a: SNARES 1995 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

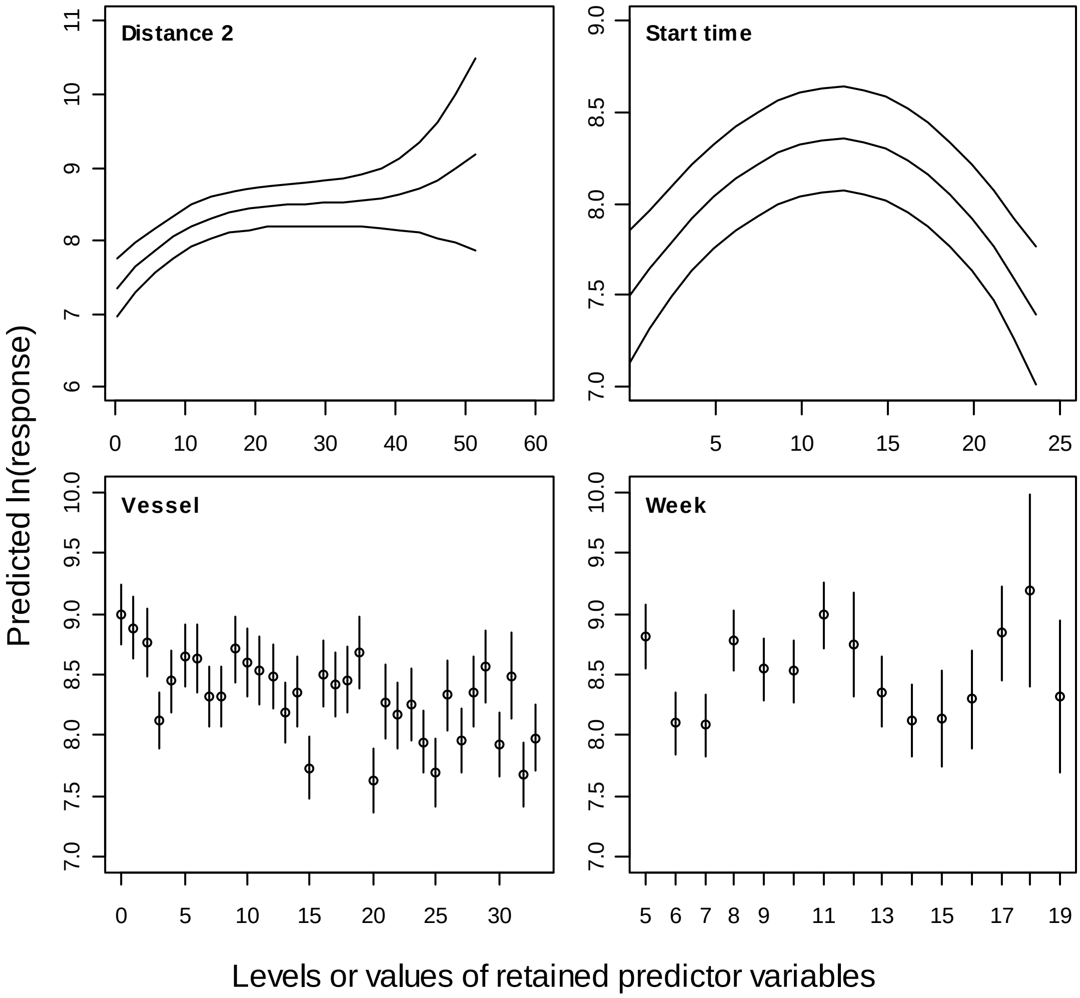
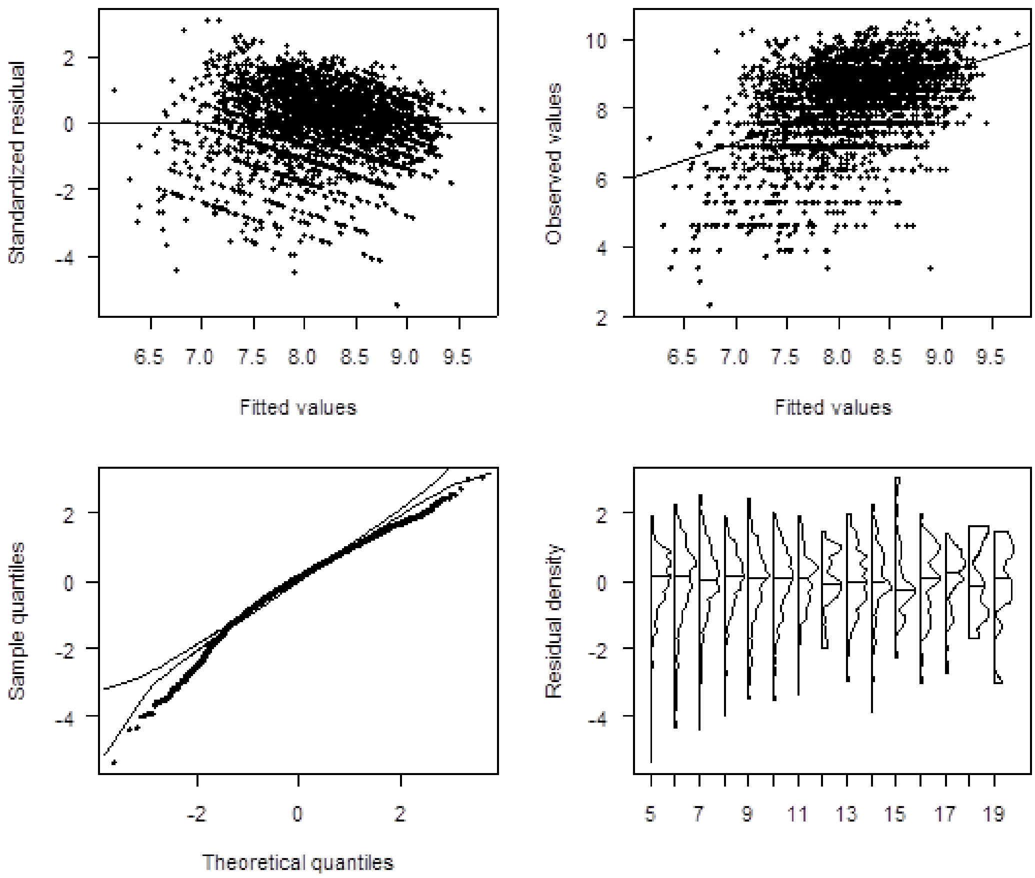


Figure D7d: SNARES 1995 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

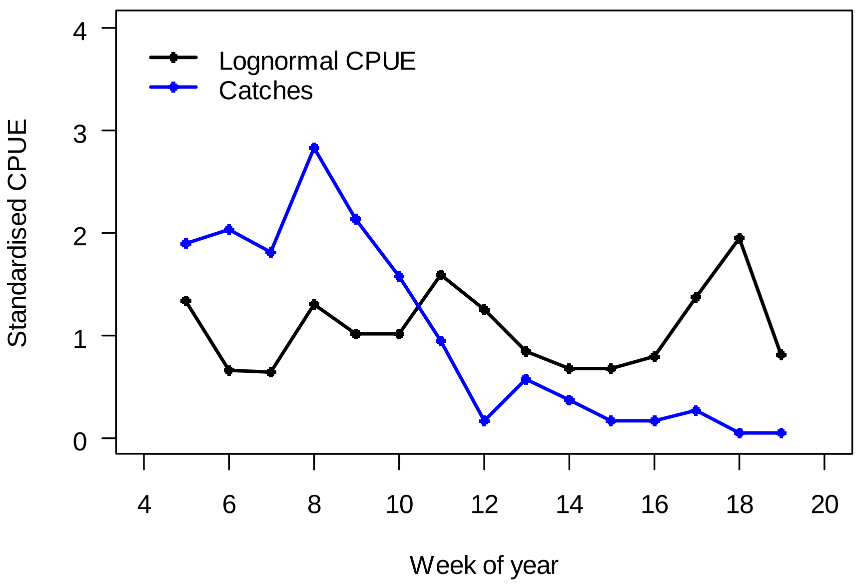
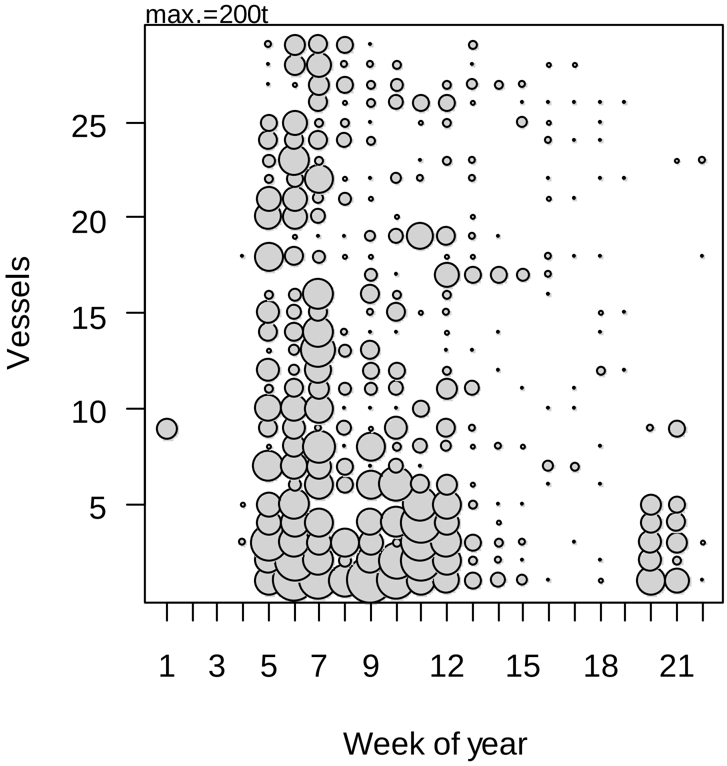
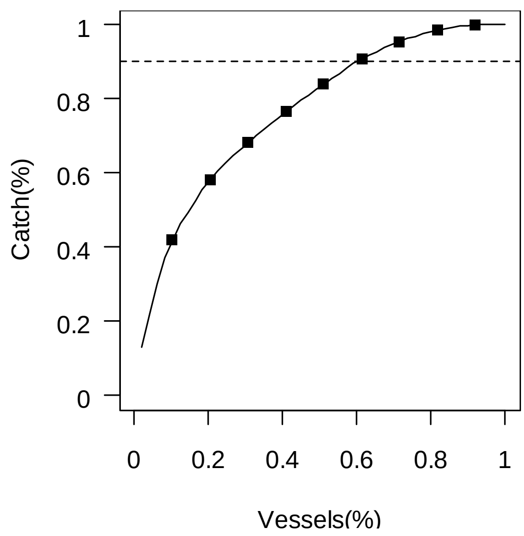


Figure D7: SNARES 1995 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

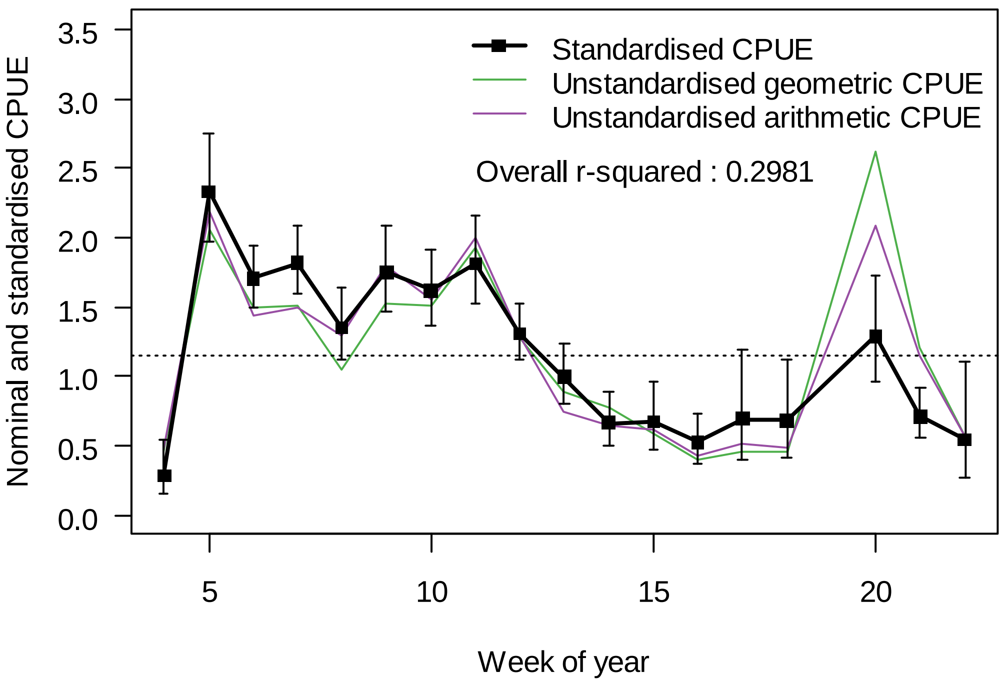


Figure D8a: SNARES 1996 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

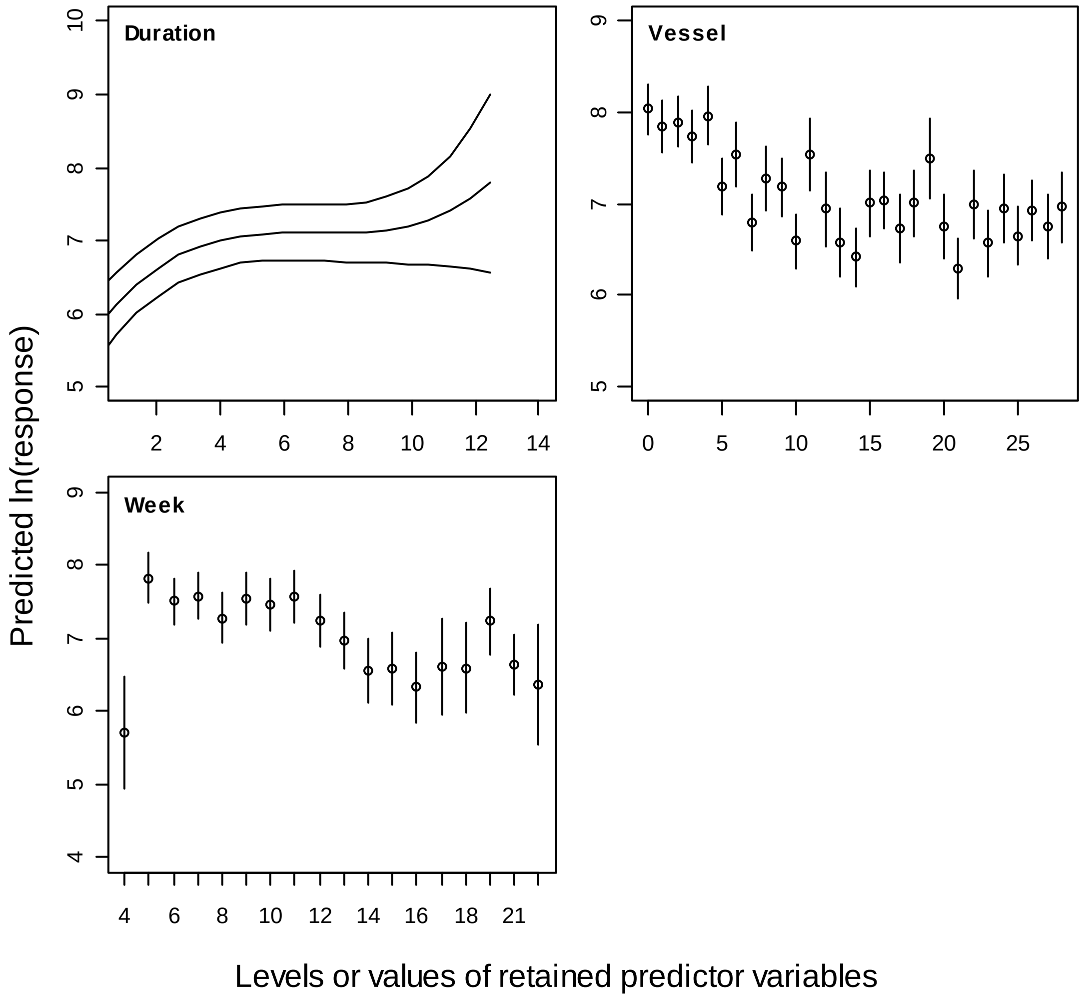
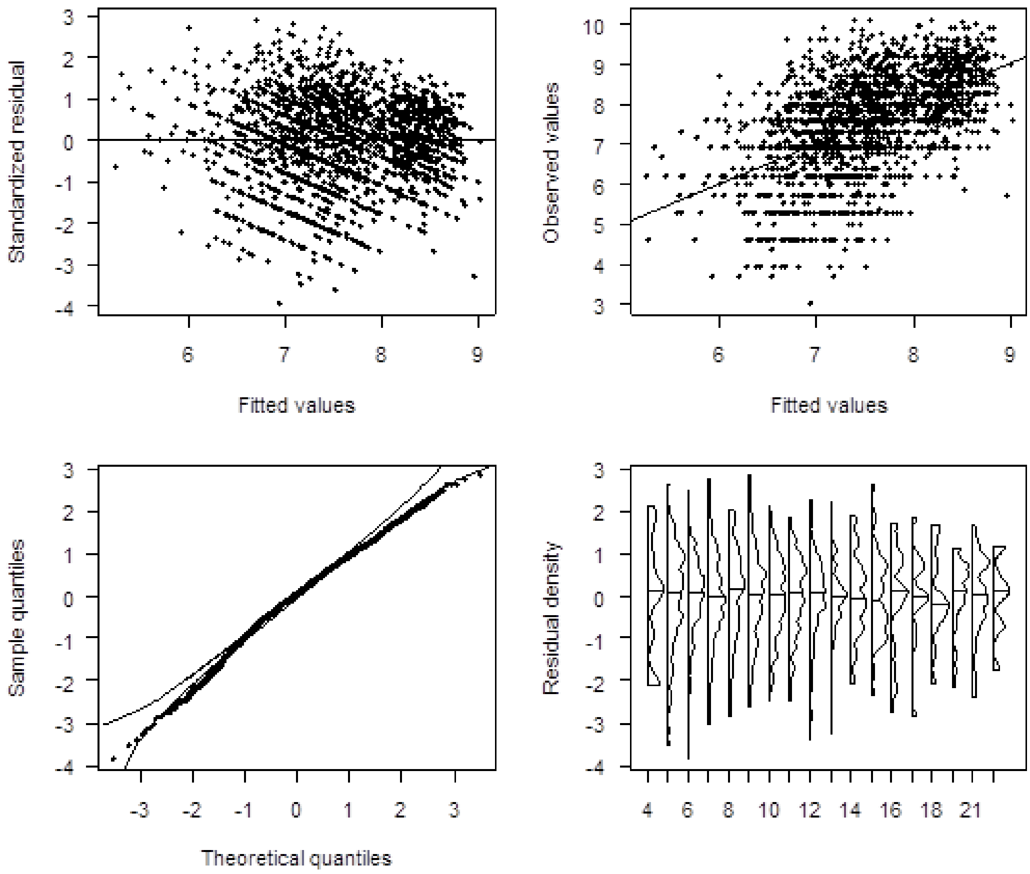


Figure D8d: SNARES 1996 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

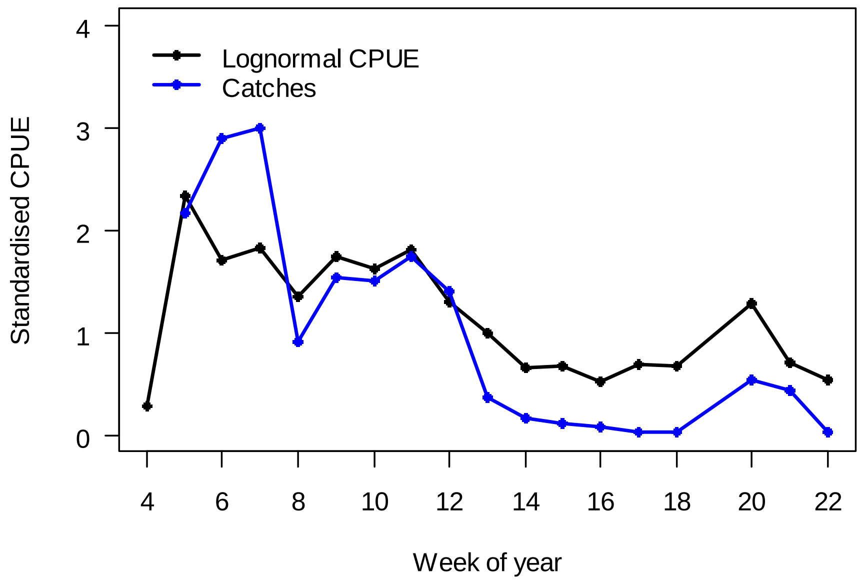


Figure D8: SNARES 1996 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

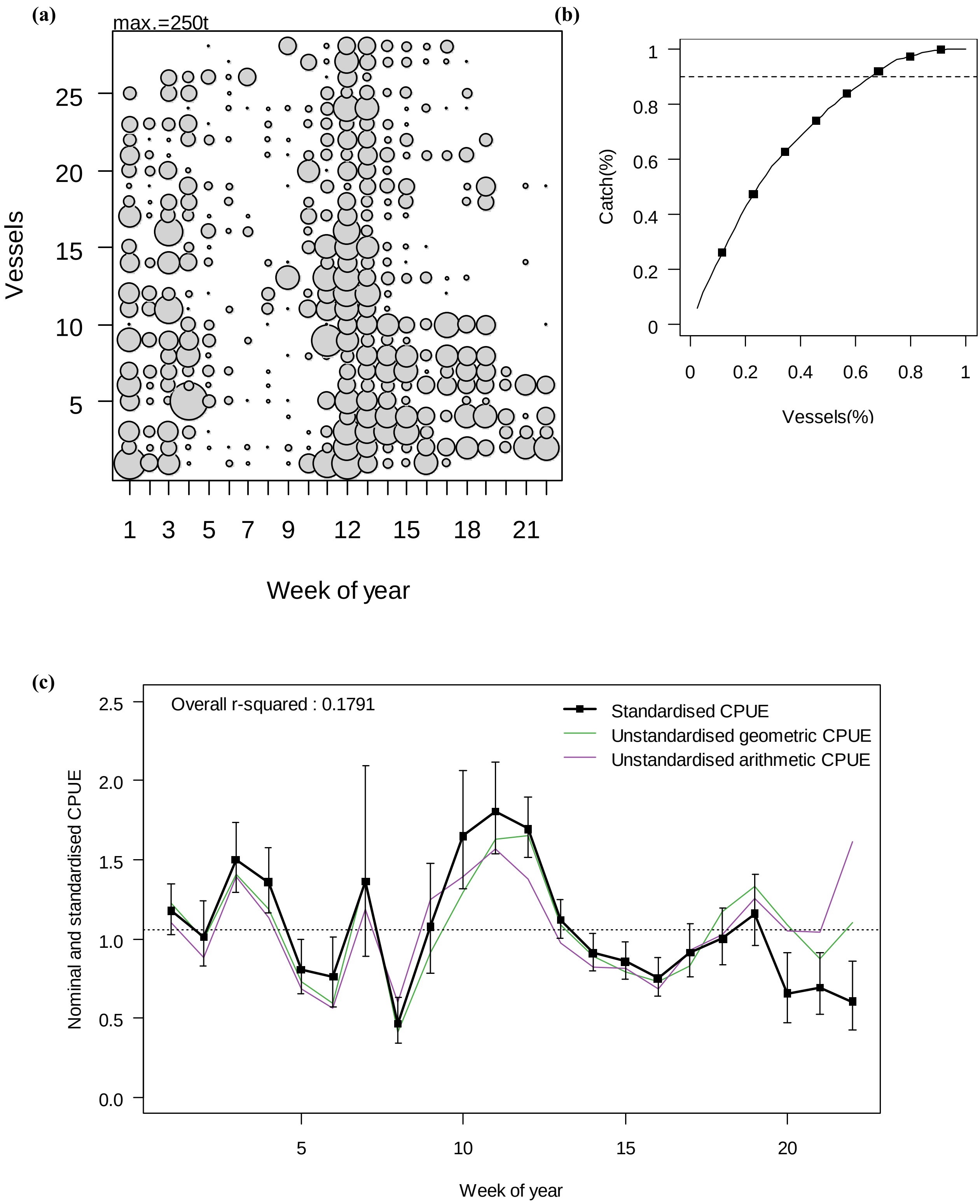


Figure D9a: SNARES 1997 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

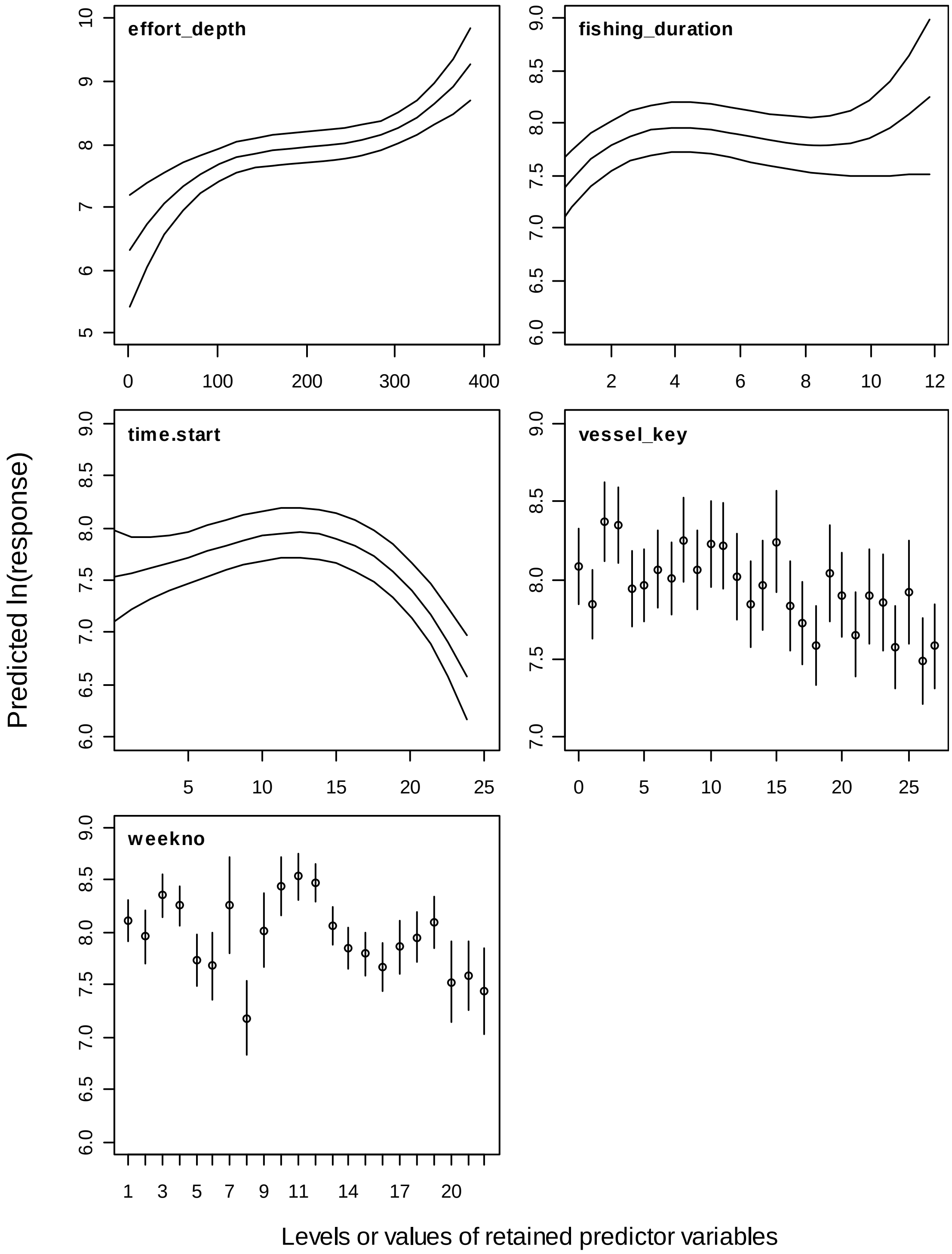
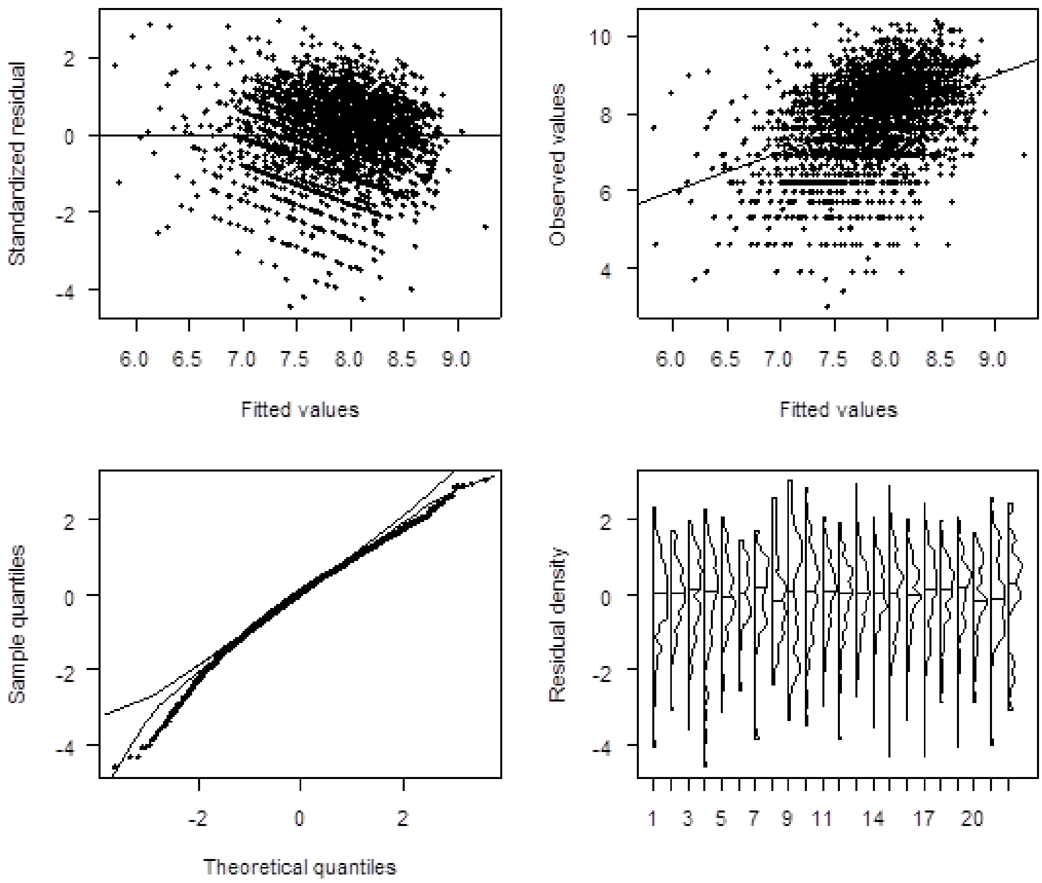


Figure D9d: SNARES 1997 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

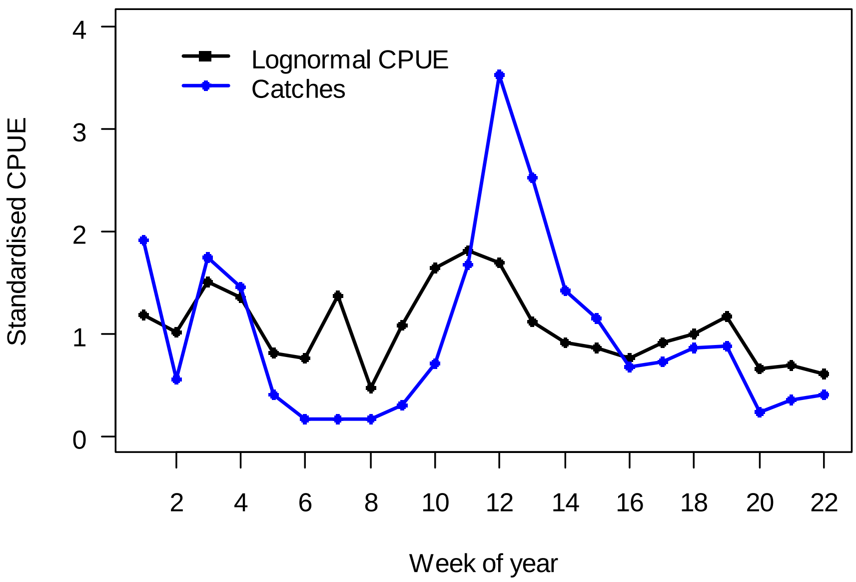
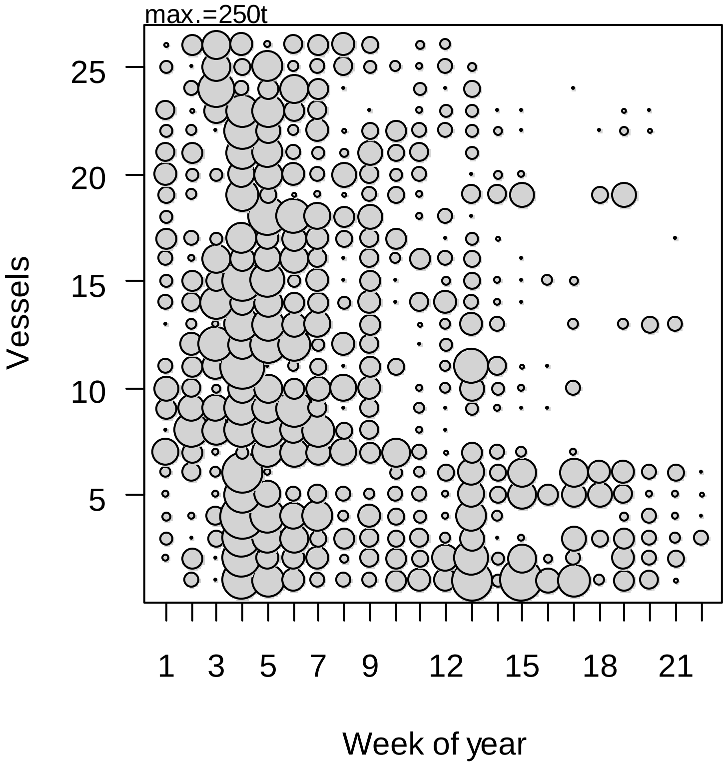
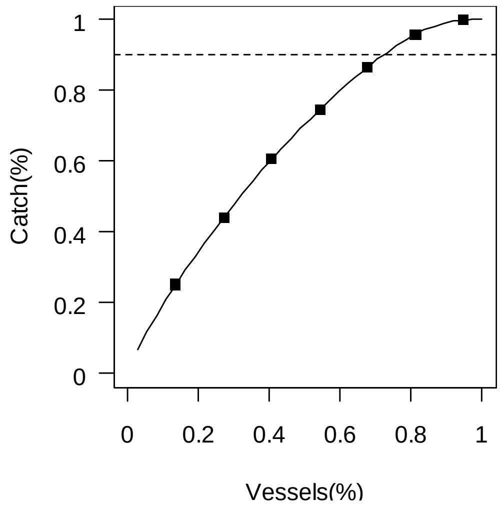


Figure D9: SNARES 1997 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

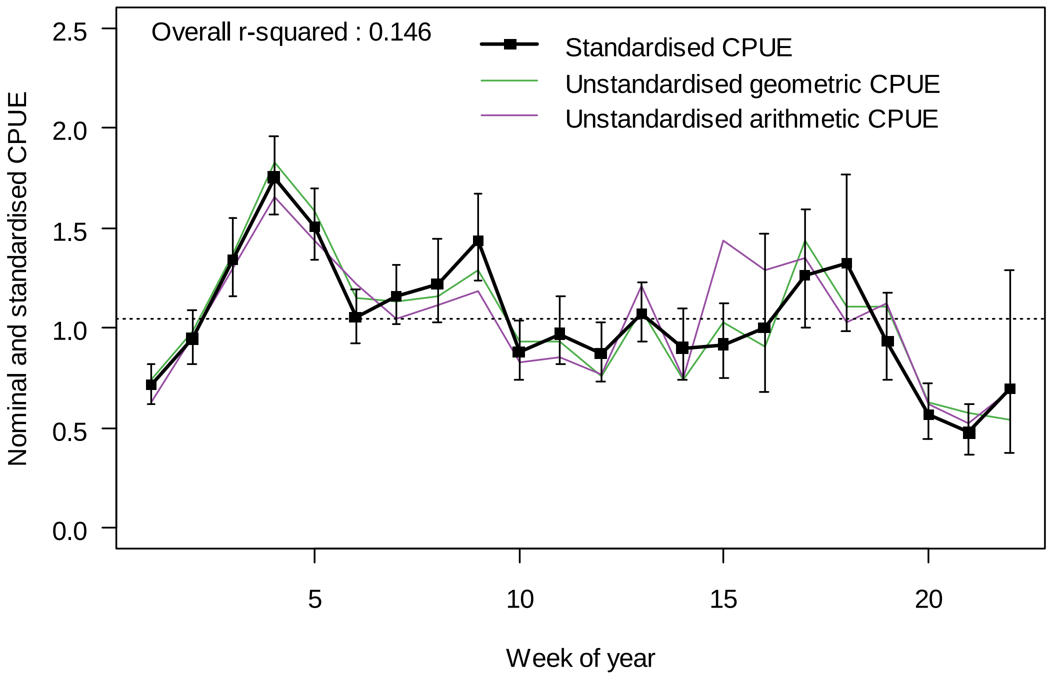


Figure D10a: SNARES 1998 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

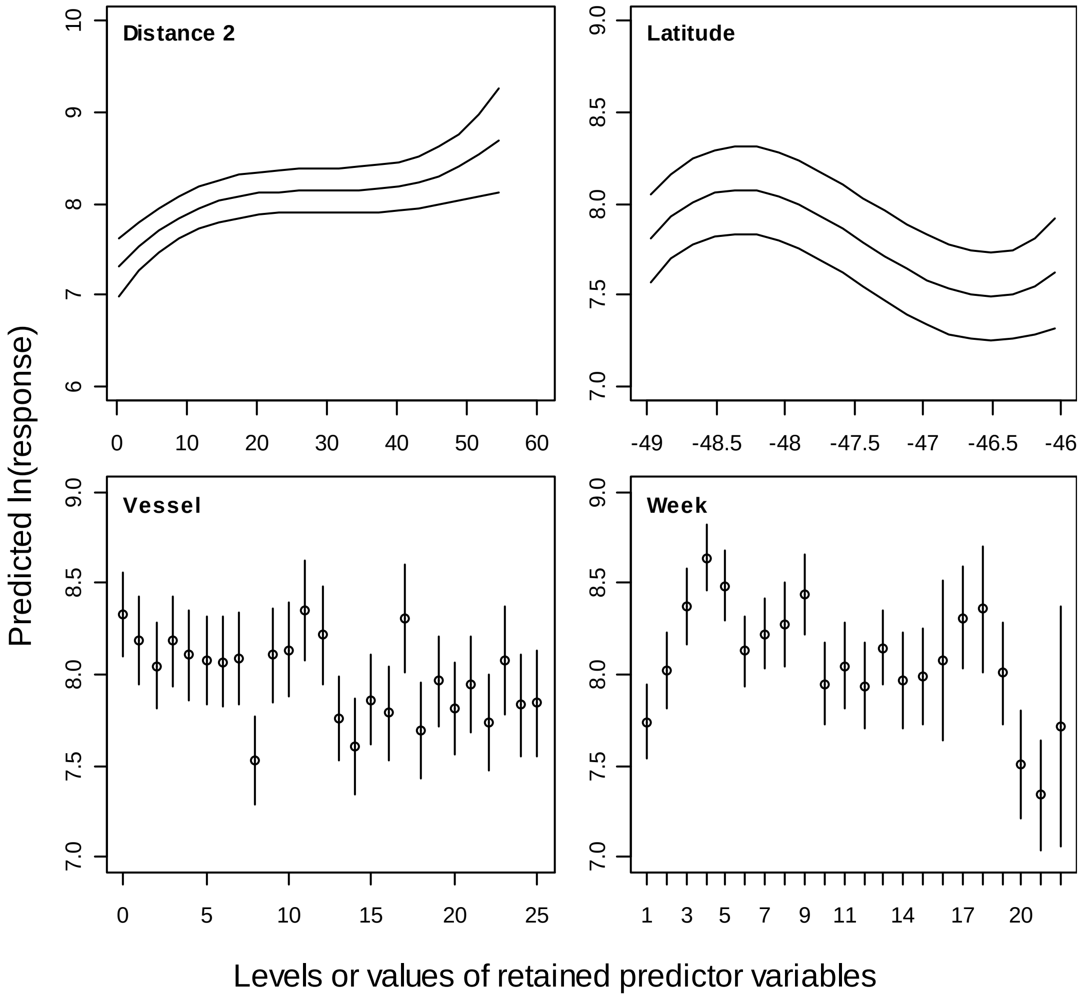
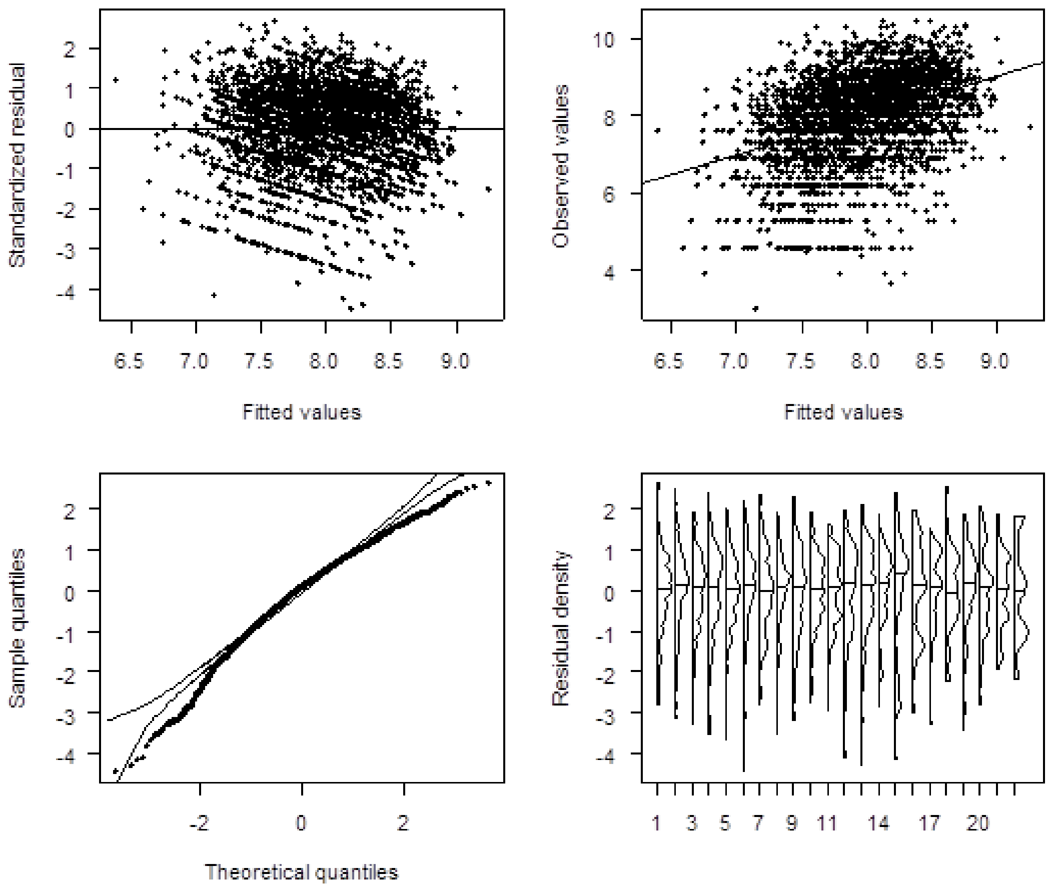


Figure D10d: SNARES 1998 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

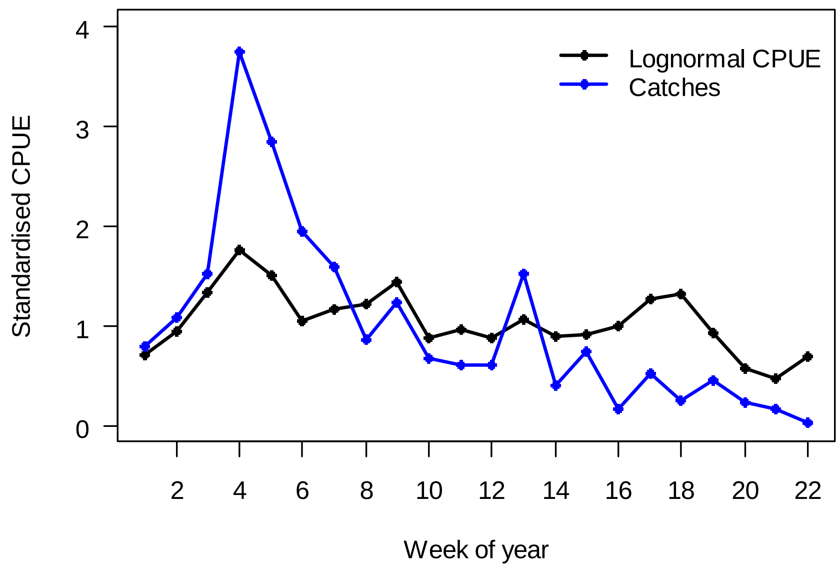
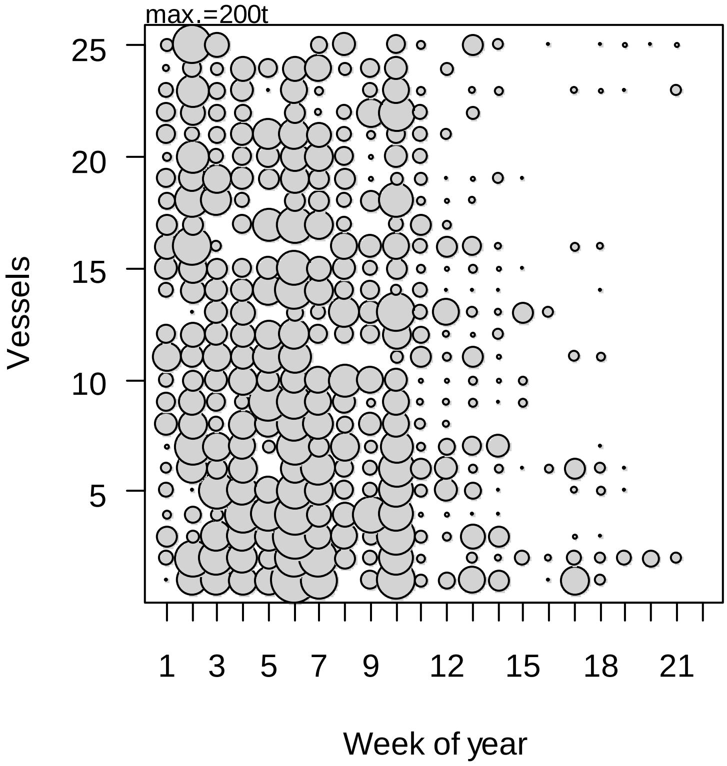
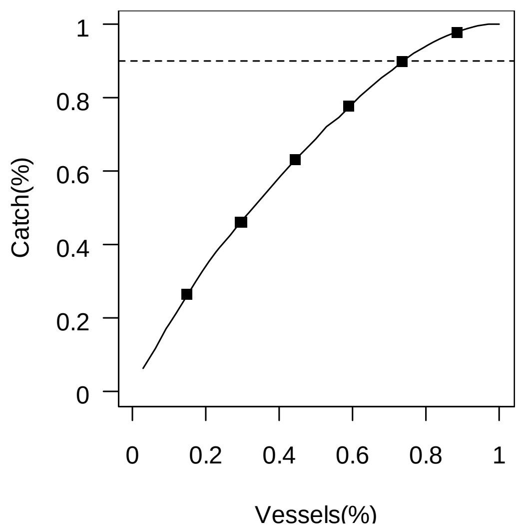


Figure D10: SNARES 1998 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

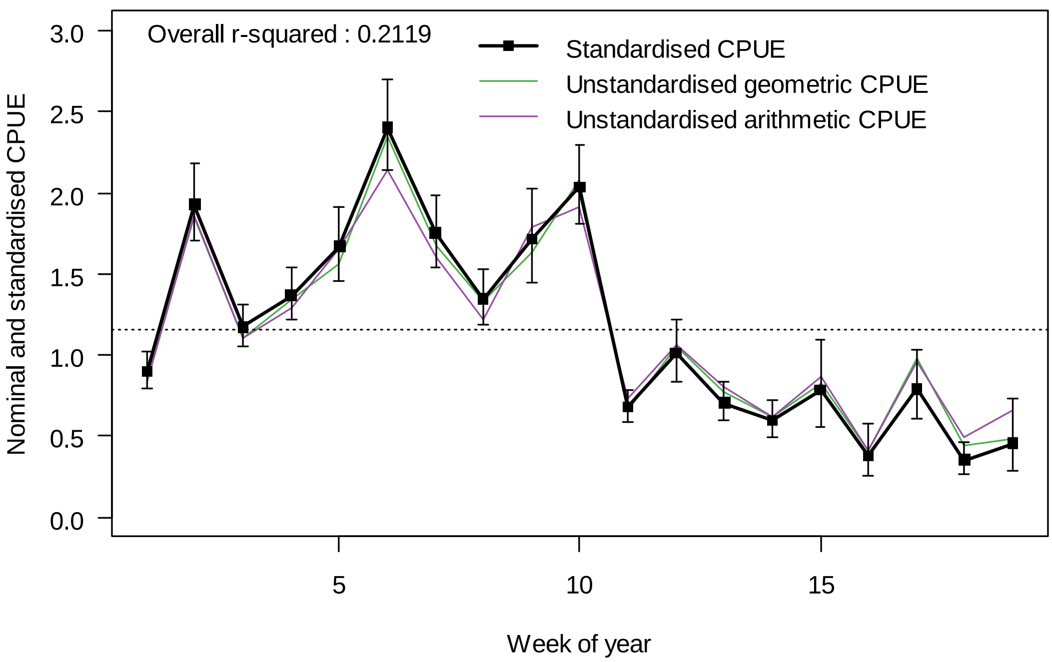


Figure D11a: SNARES 1999 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

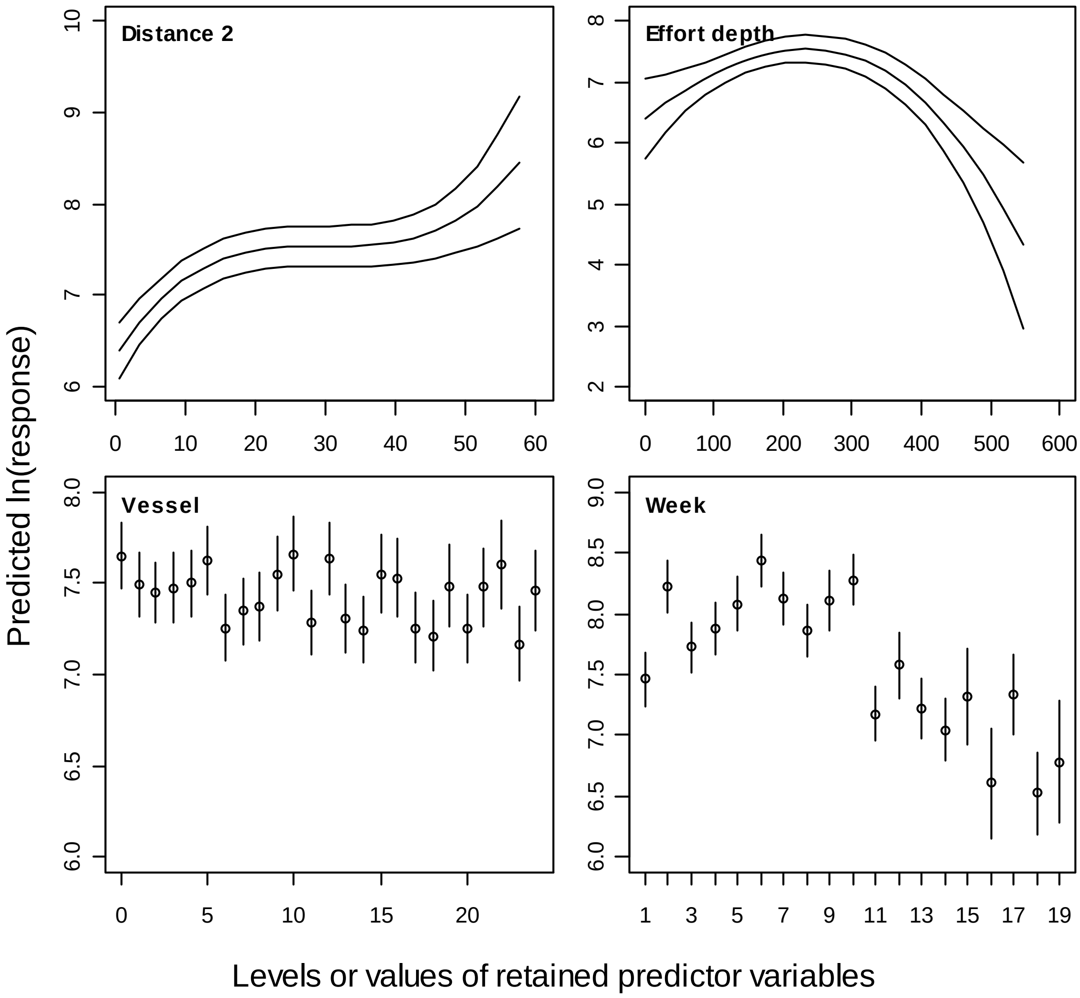
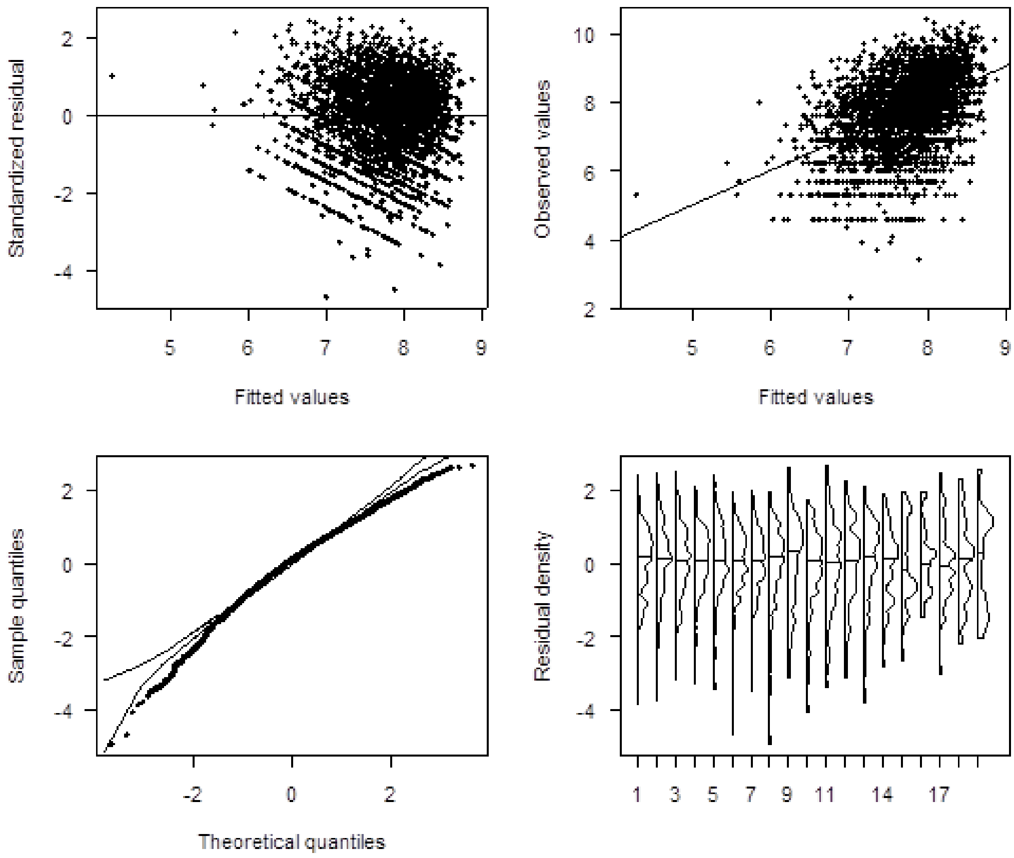


Figure D11d: SNARES 1999 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

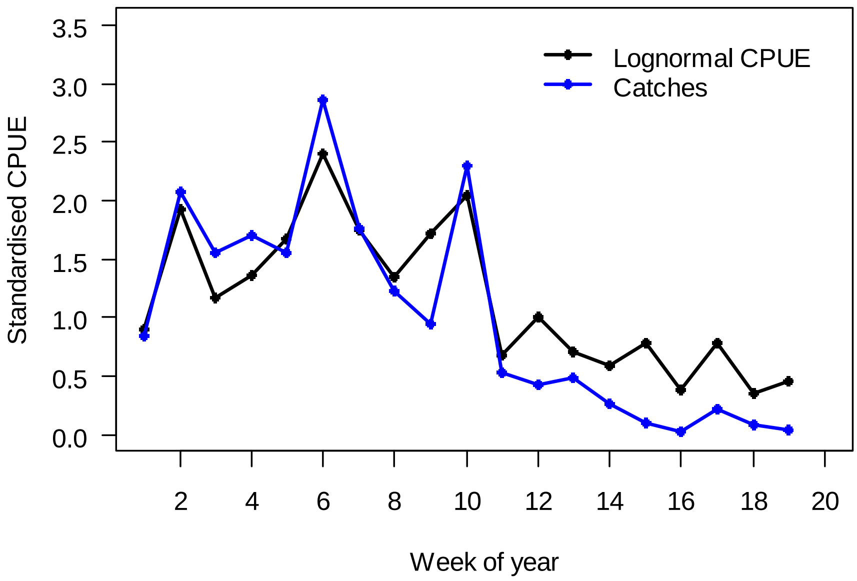
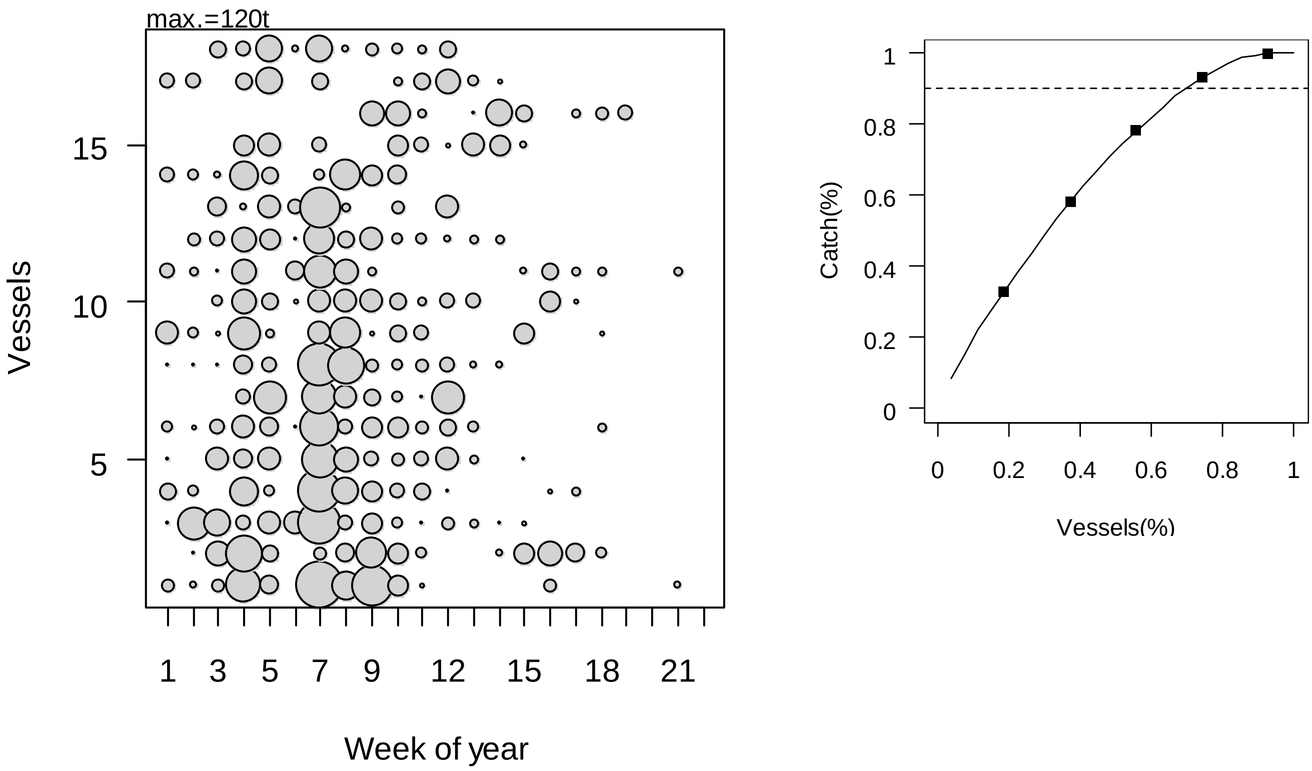


Figure D11: SNARES 1999 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)

(b)



(c)

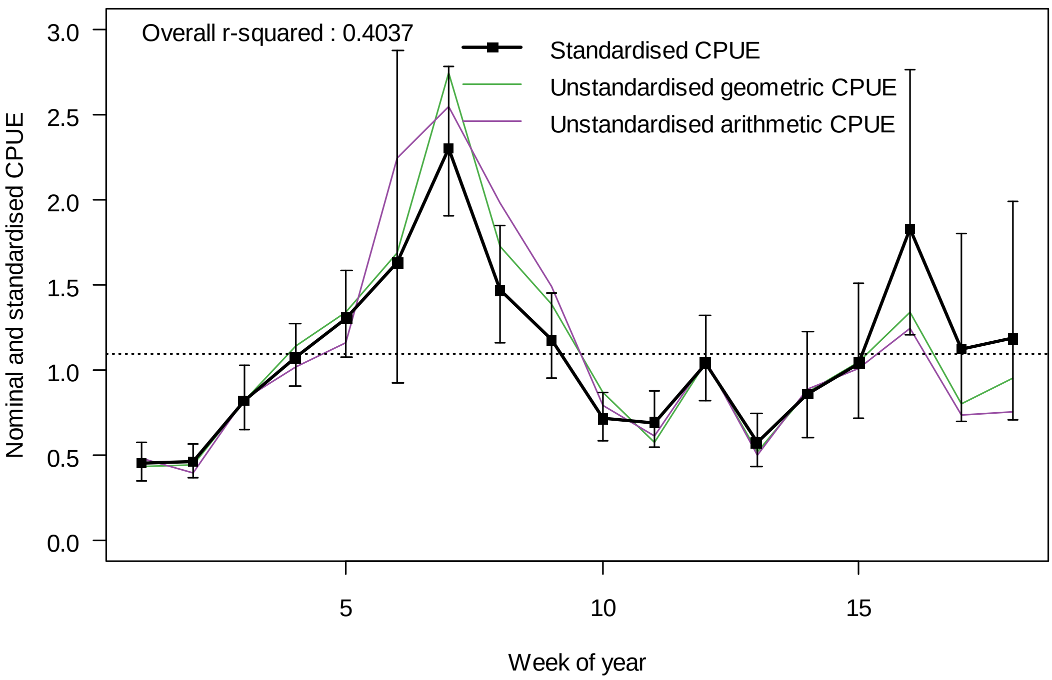


Figure D12a: SNARES 2000 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

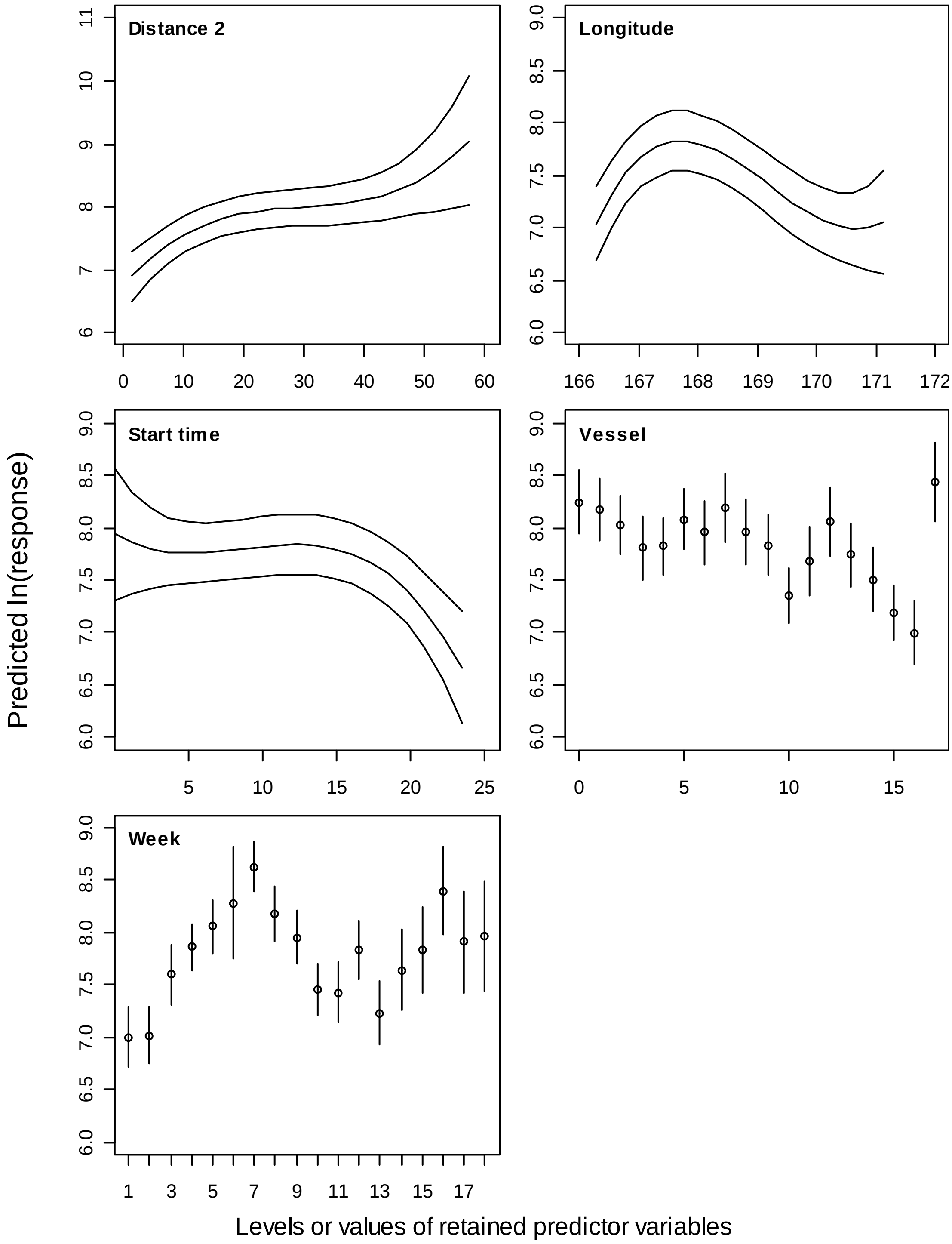
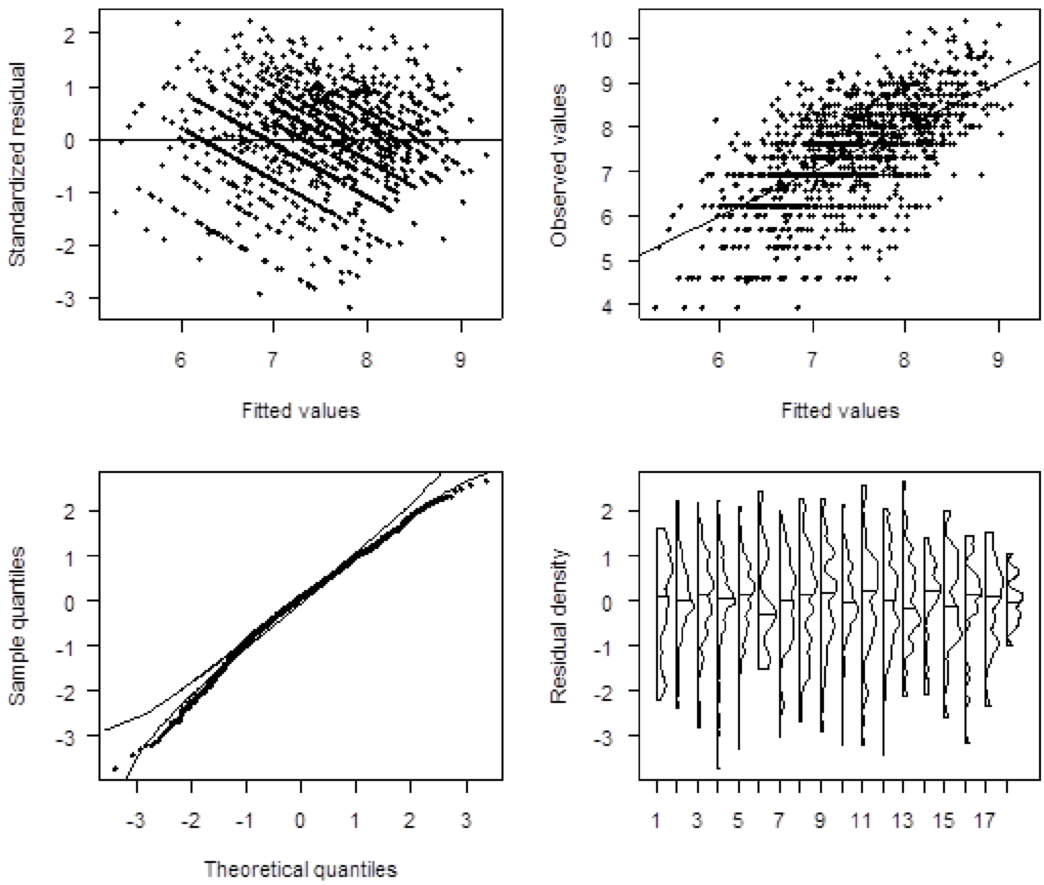


Figure D12d: SNARES 2000 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

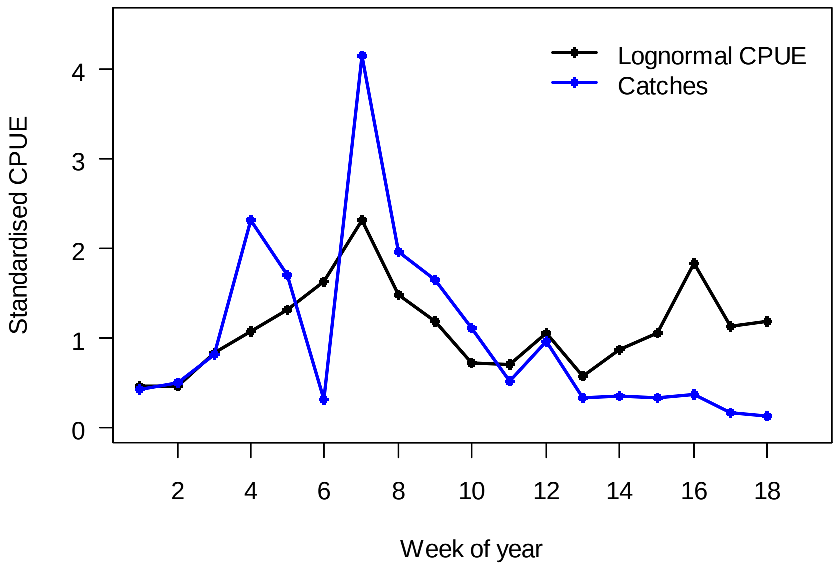
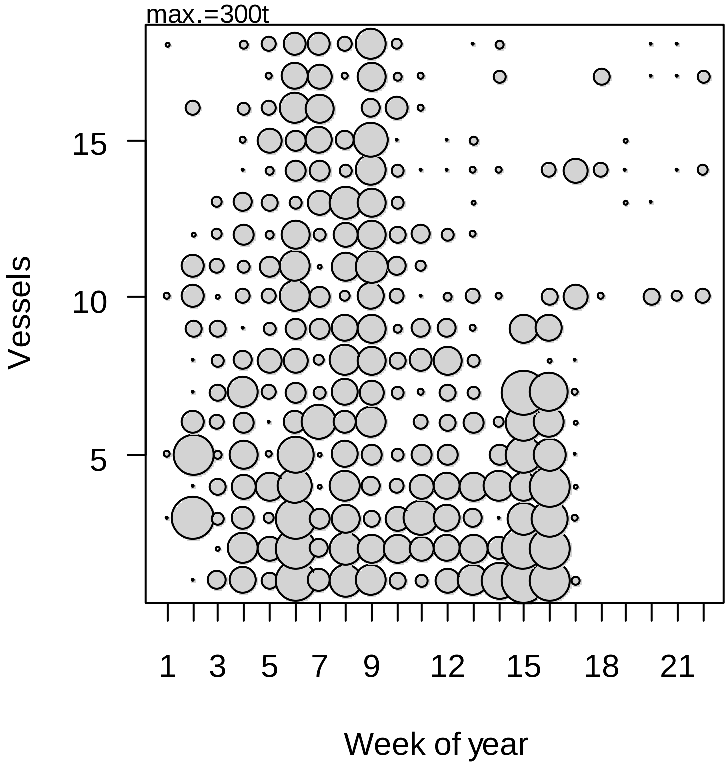
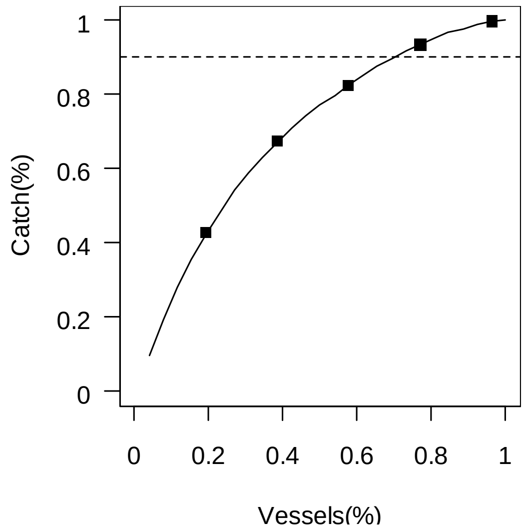


Figure D12: SNARES 2000 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

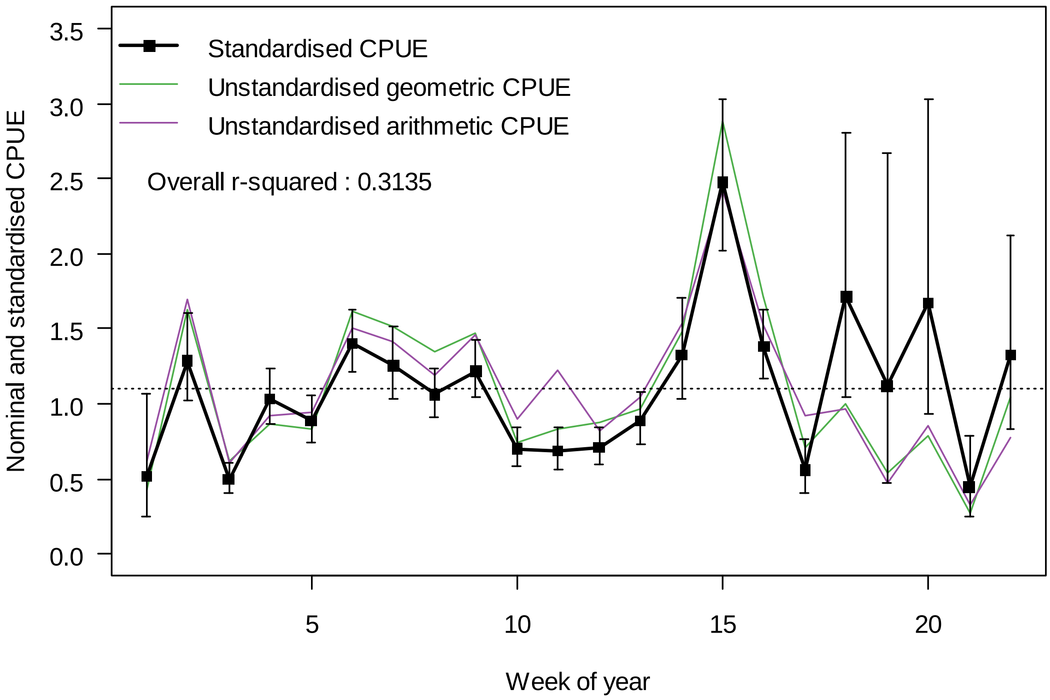


Figure D13a: SNARES 2001 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

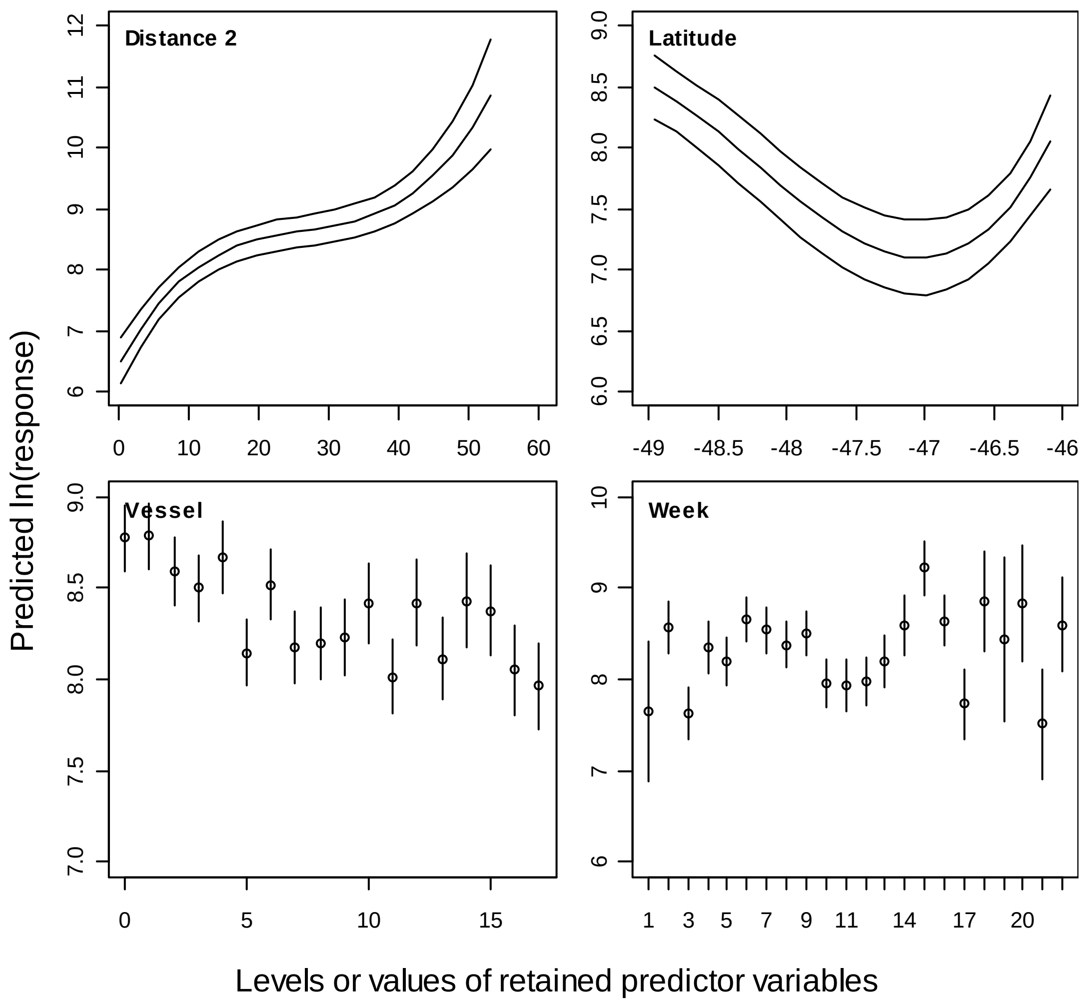
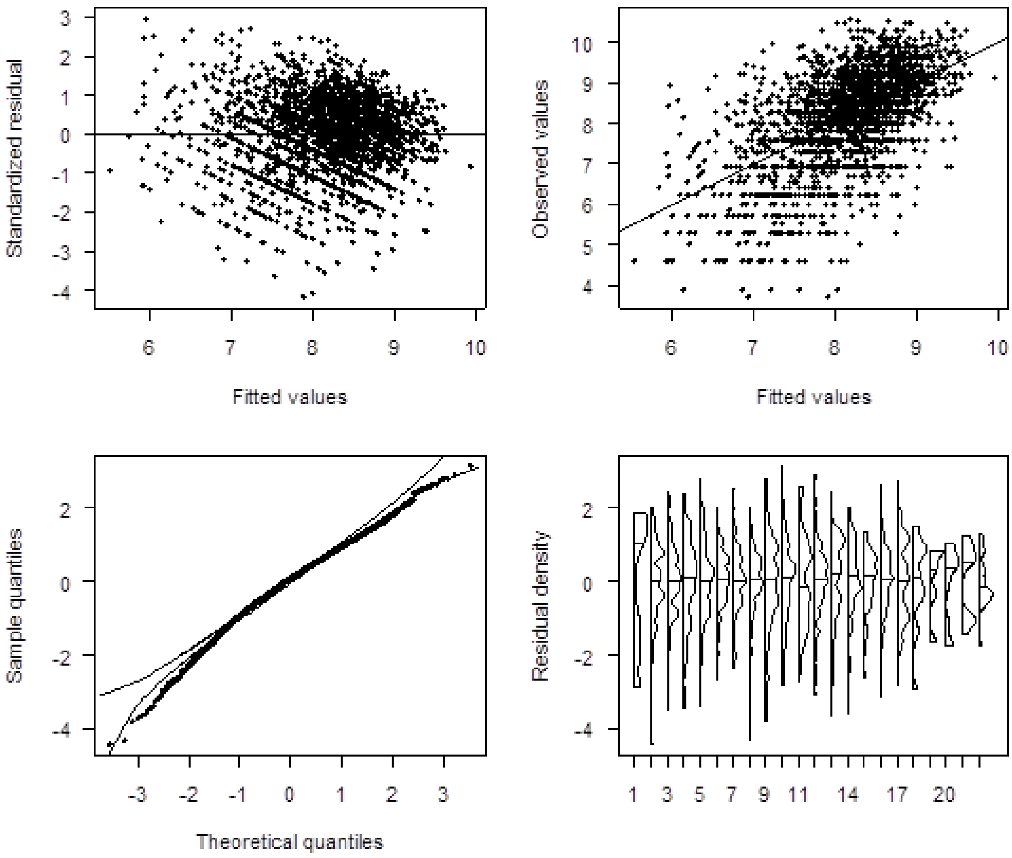


Figure D13d: SNARES 2001 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

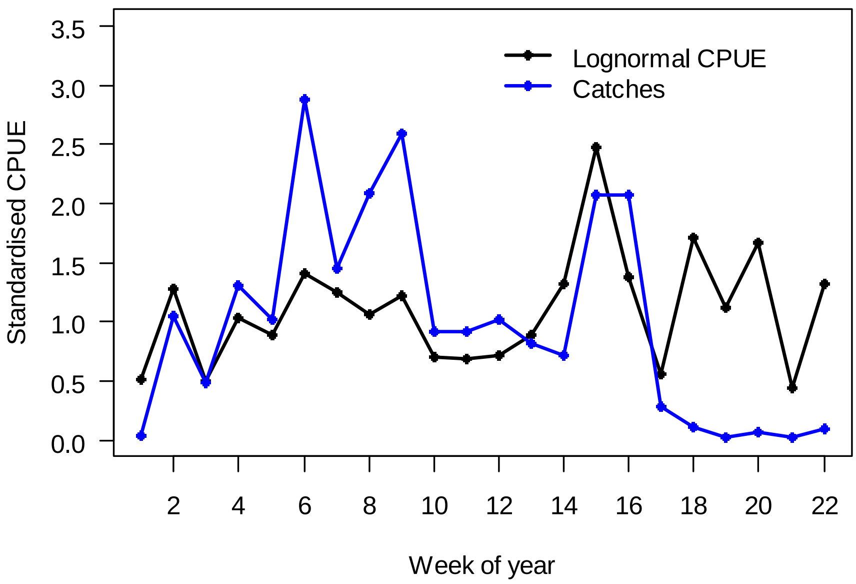


Figure D13: SNARES 2001 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

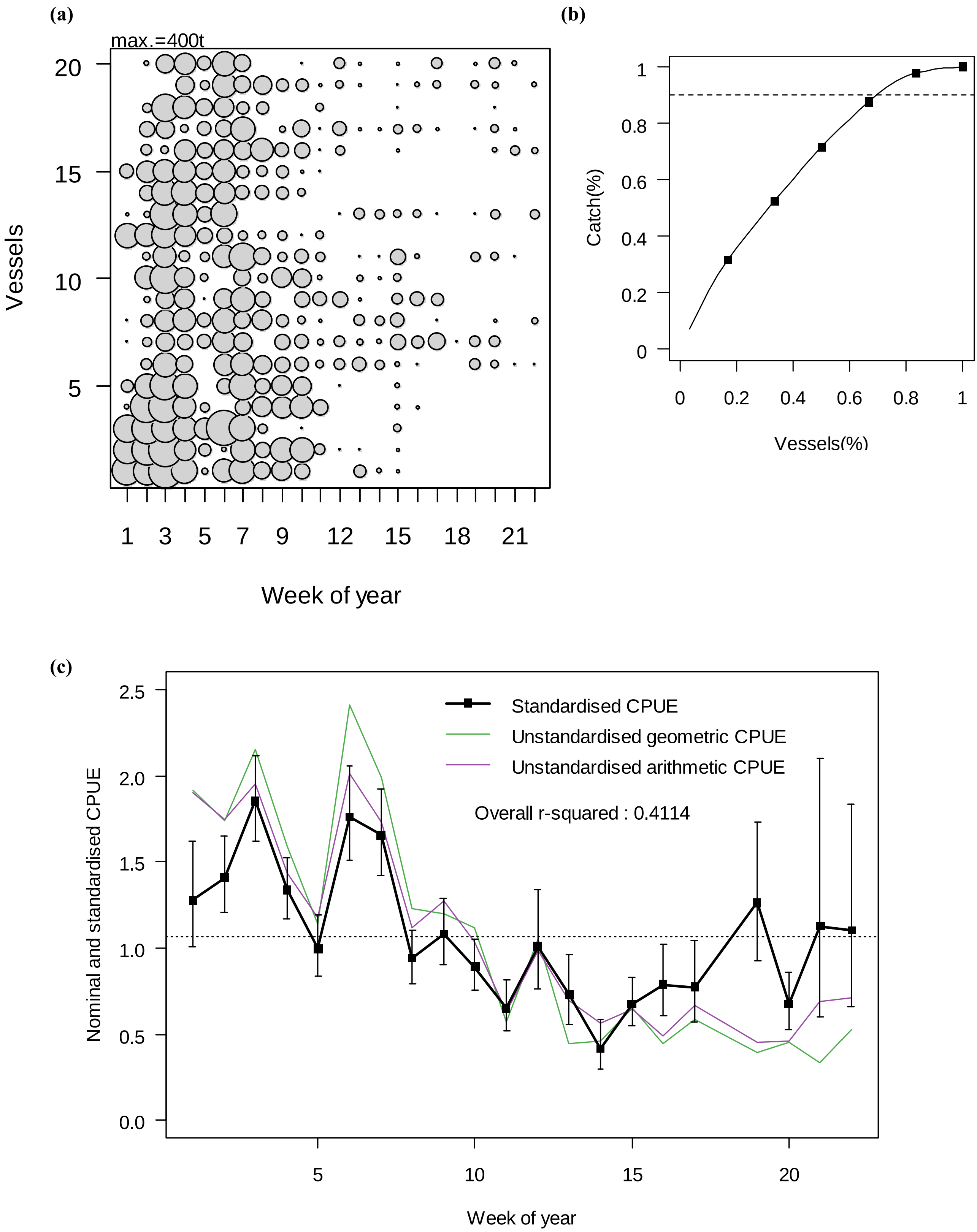


Figure D14a: SNARES 2002 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

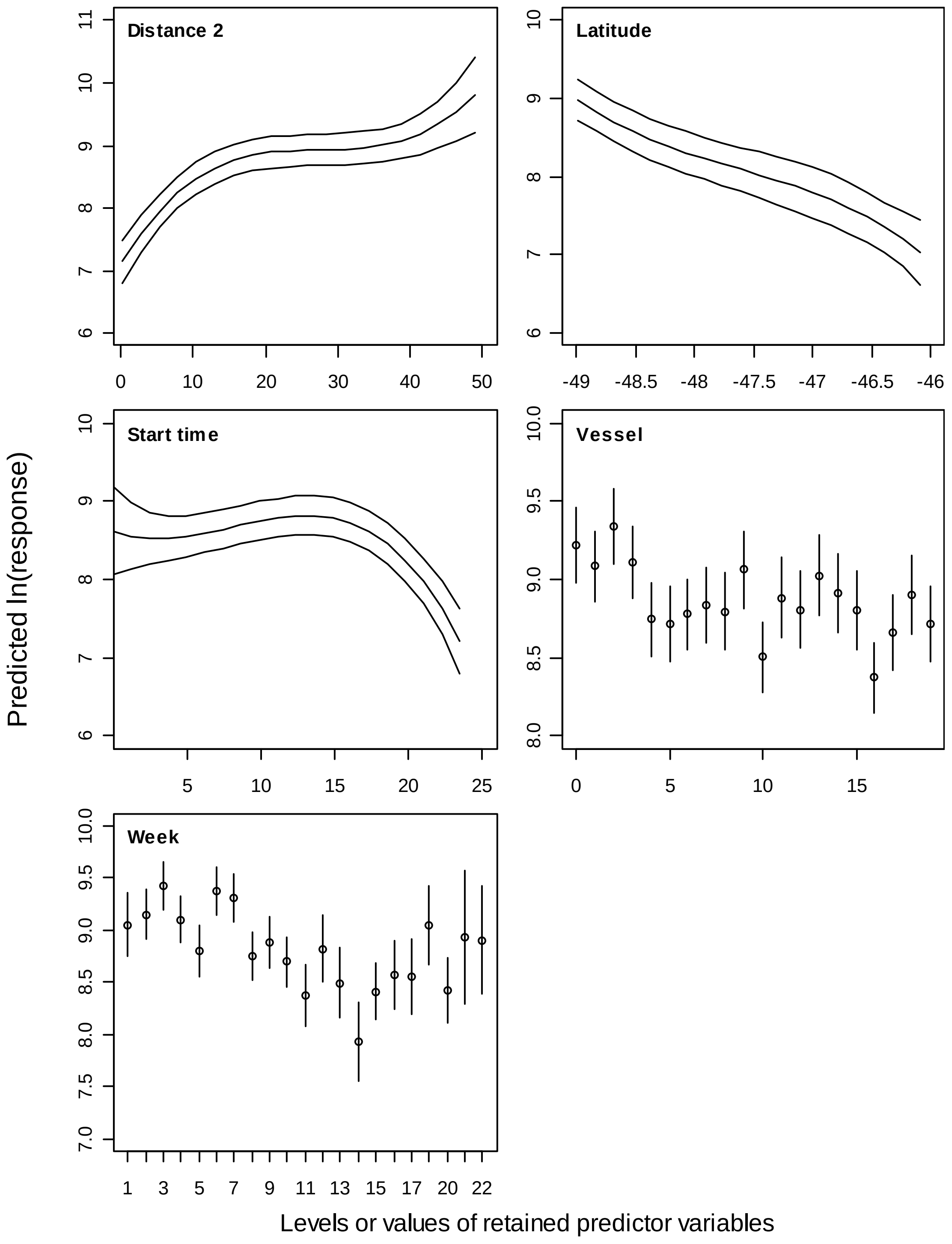
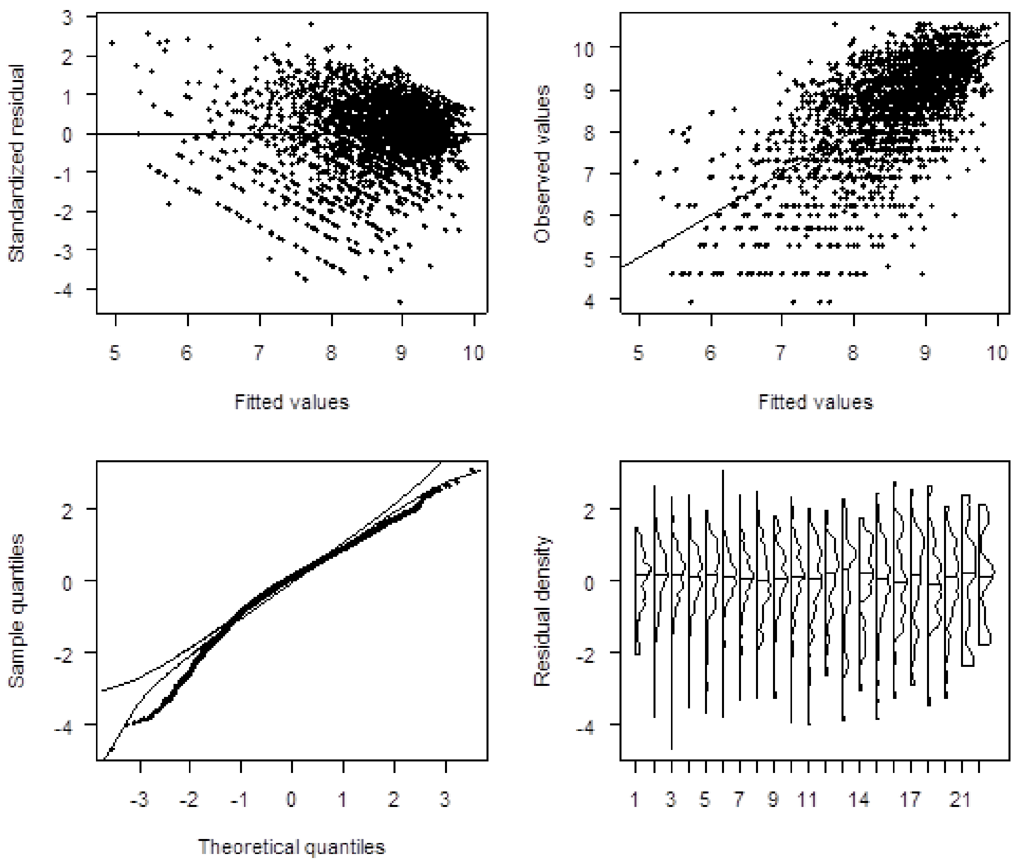


Figure D14d: SNARES 2002 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

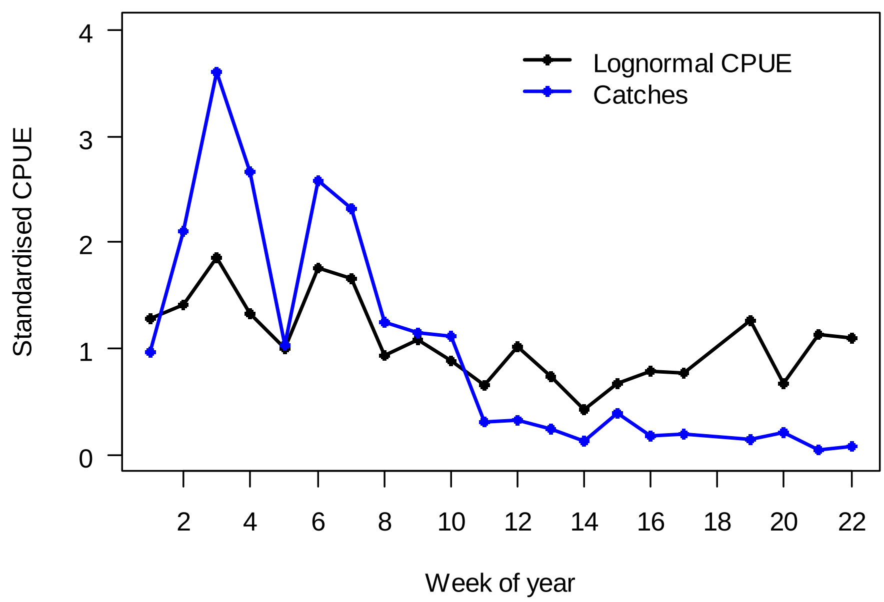
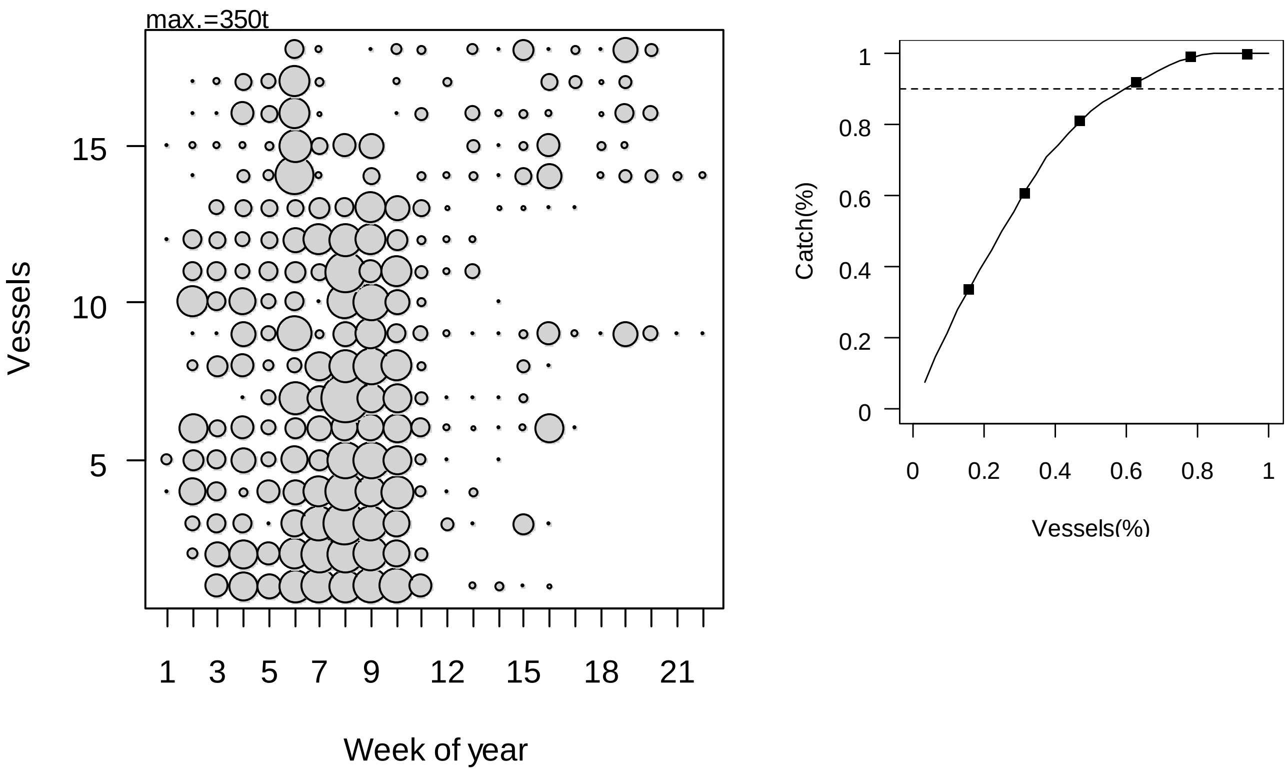


Figure D14: SNARES 2002 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)

(b)



(c)

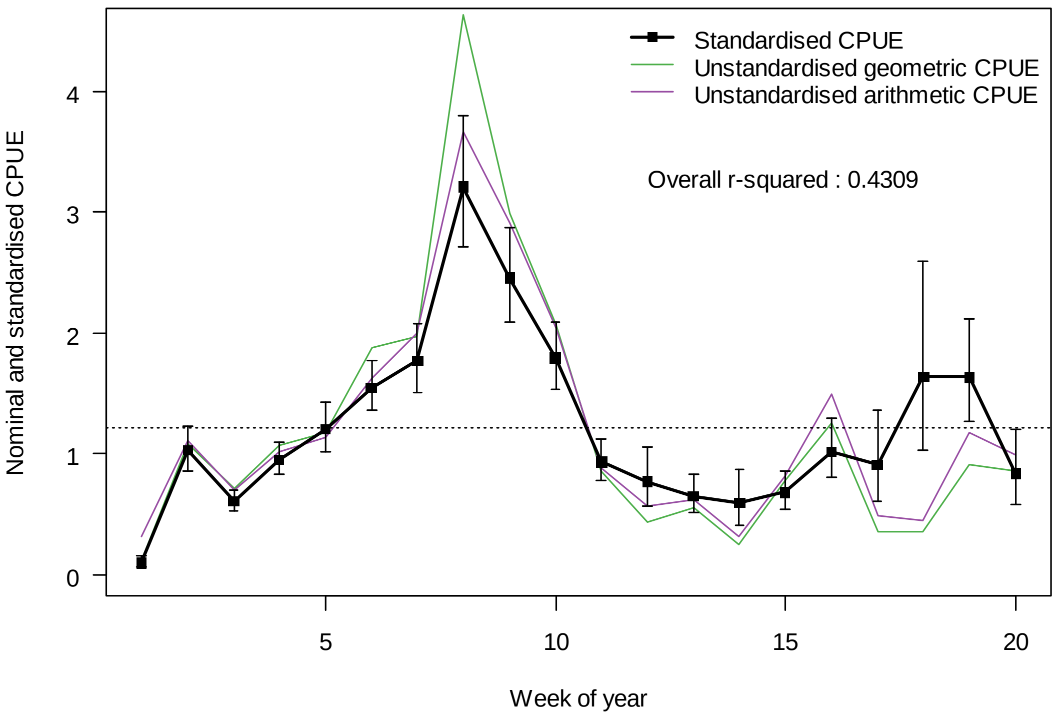


Figure D15a: SNARES 2003 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

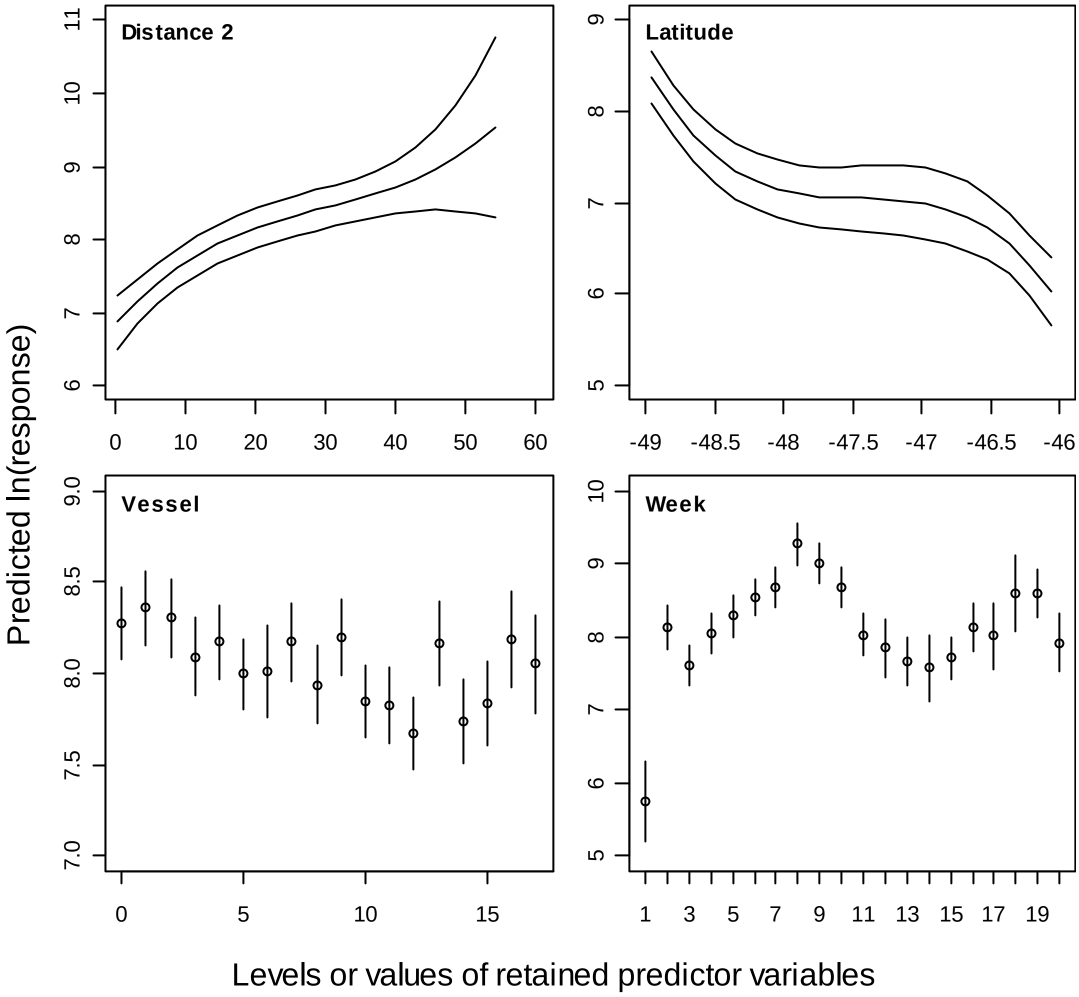
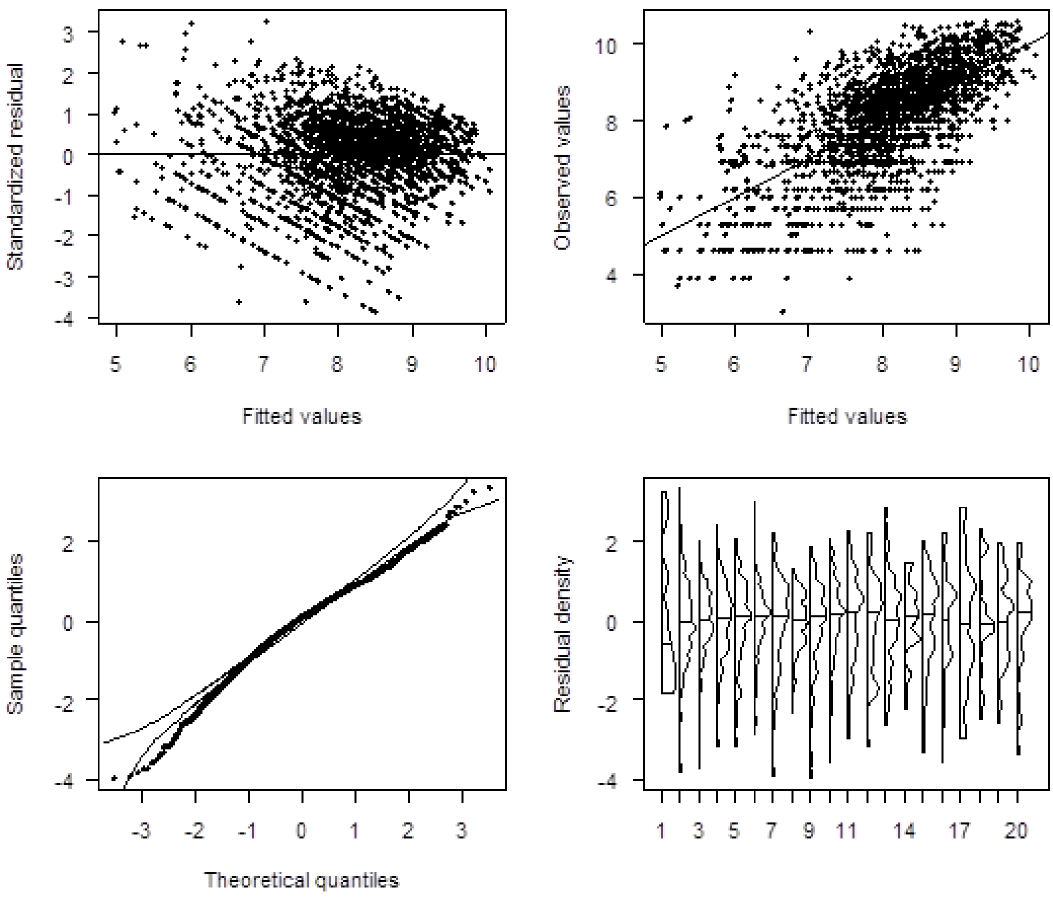


Figure D15d: SNARES 2003 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

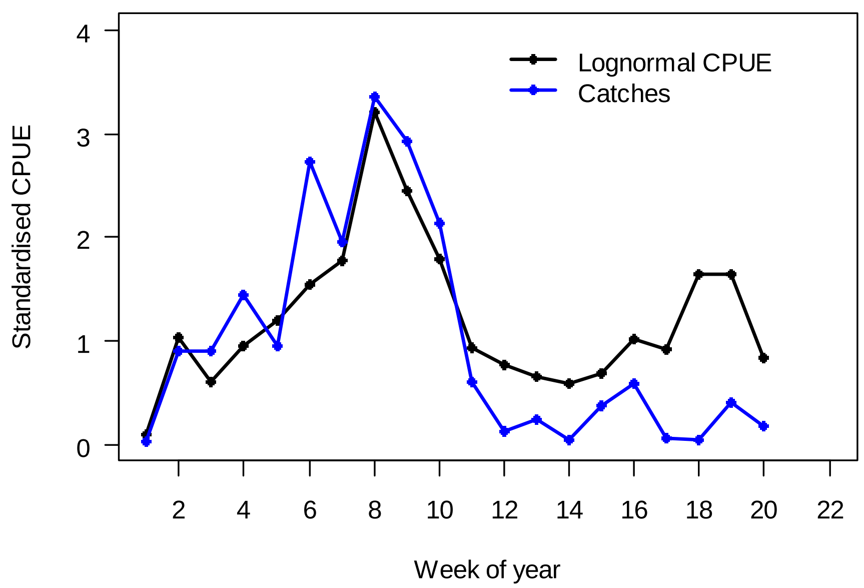


Figure D15: SNARES 2003 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

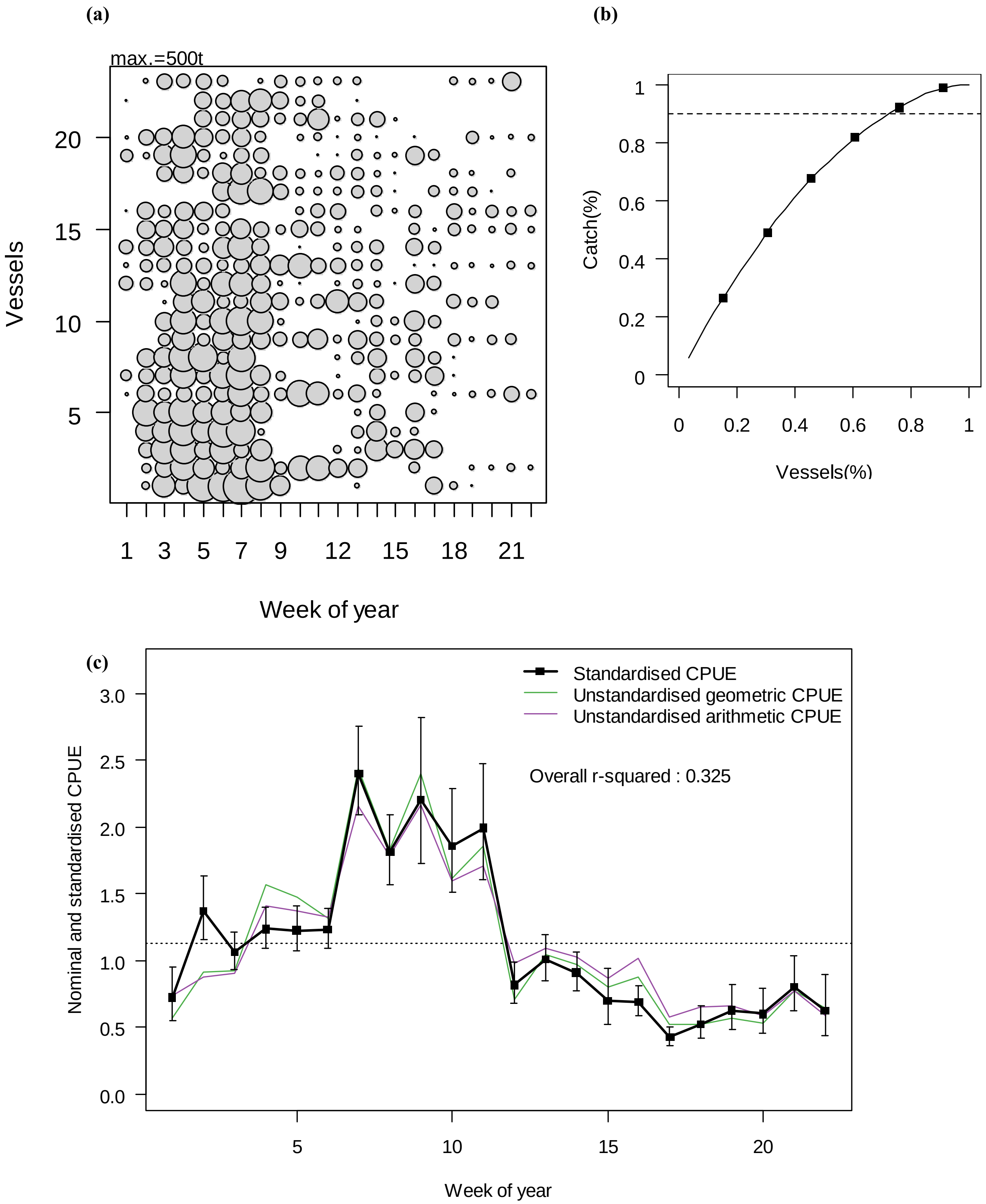


Figure D16a: SNARES 2004 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

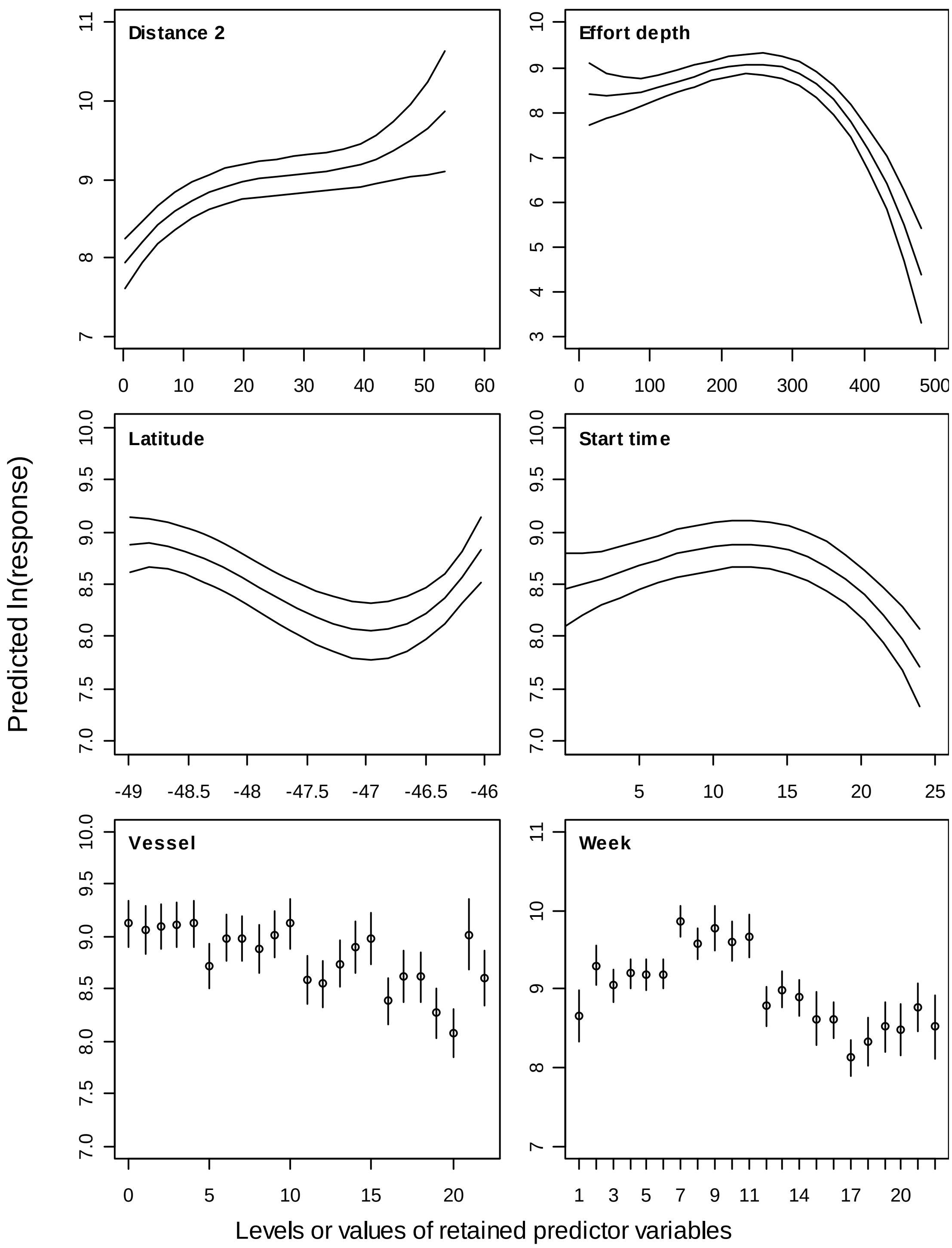
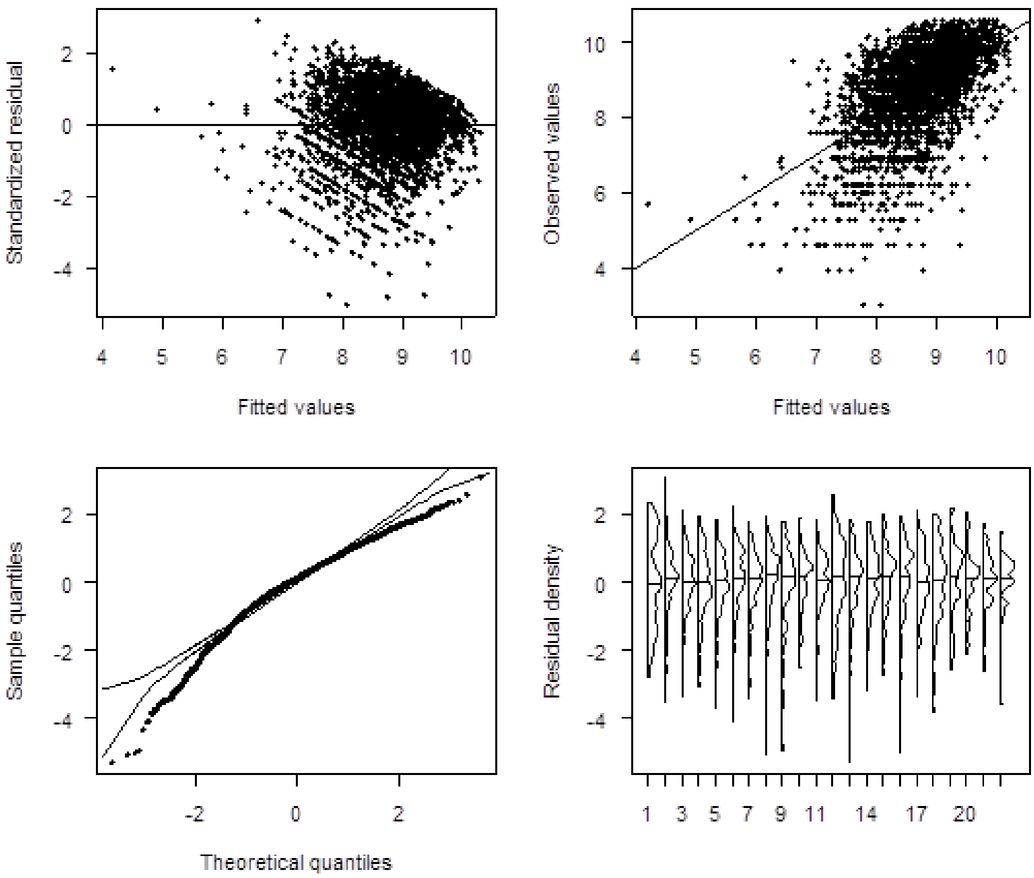


Figure D16d: SNARES 2004 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

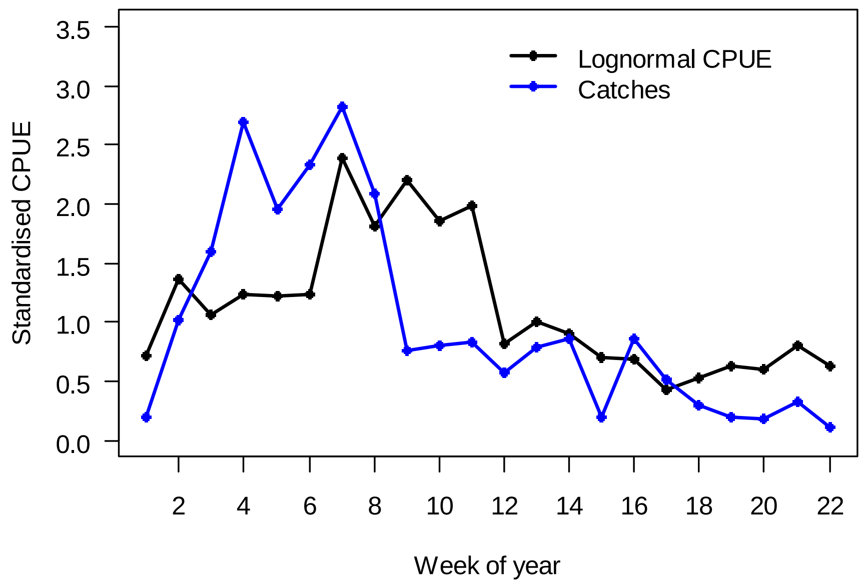
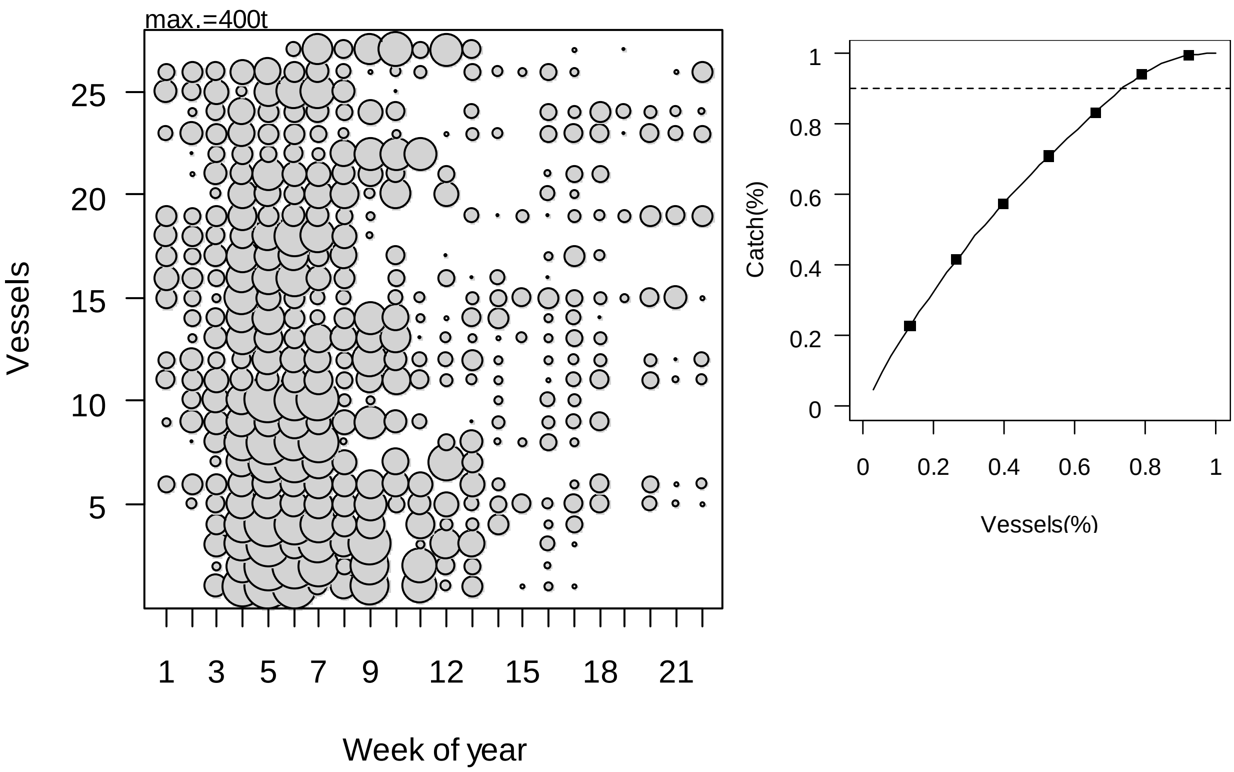


Figure D16: SNARES 2004 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a)

(b)



(c)

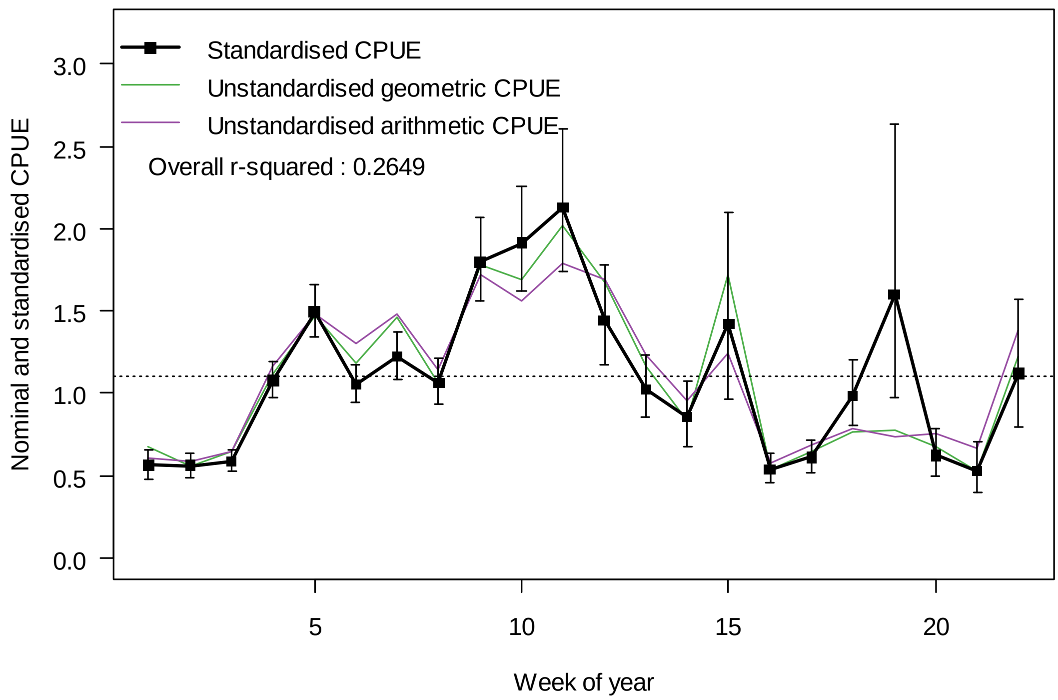


Figure D17a: SNARES 2005 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

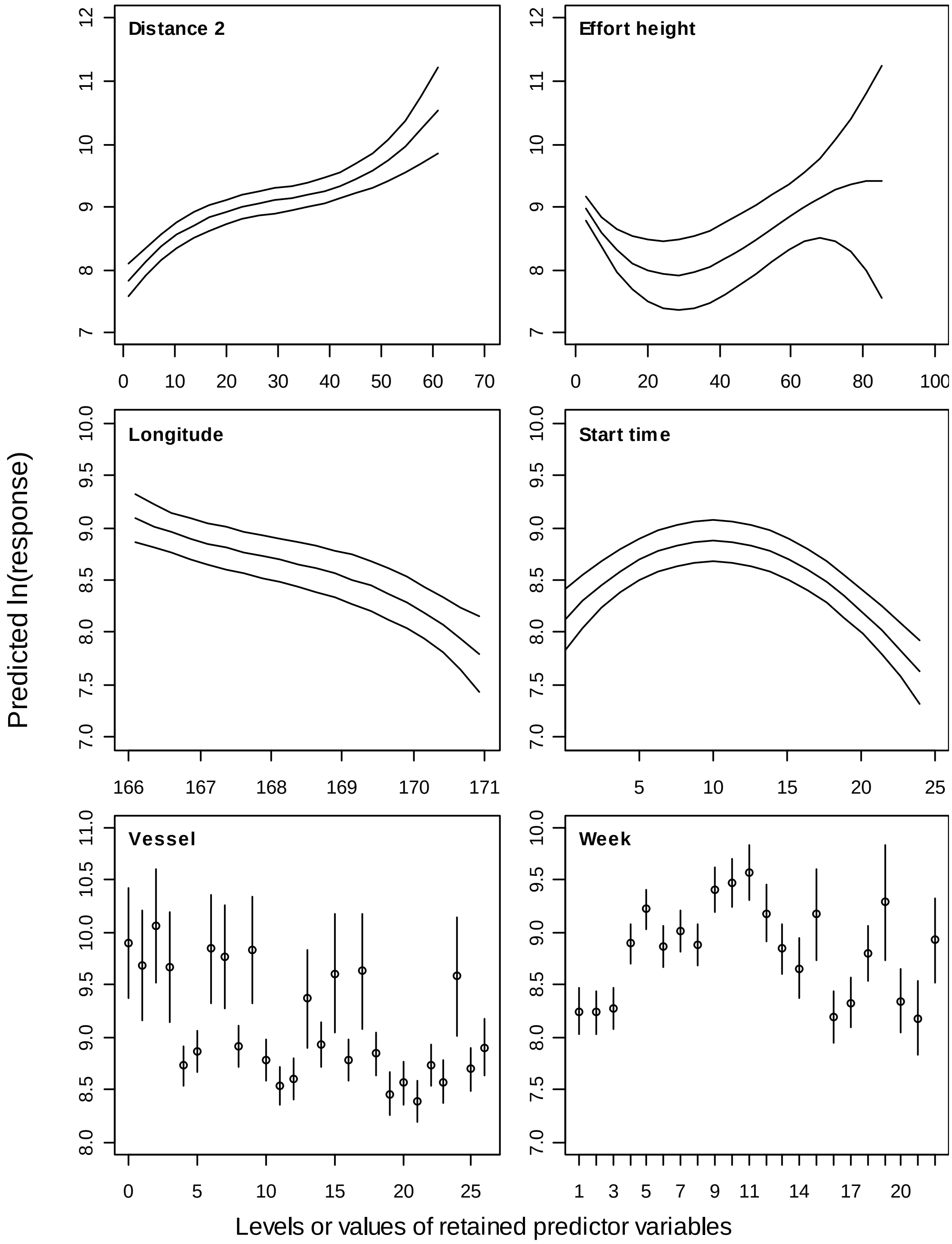
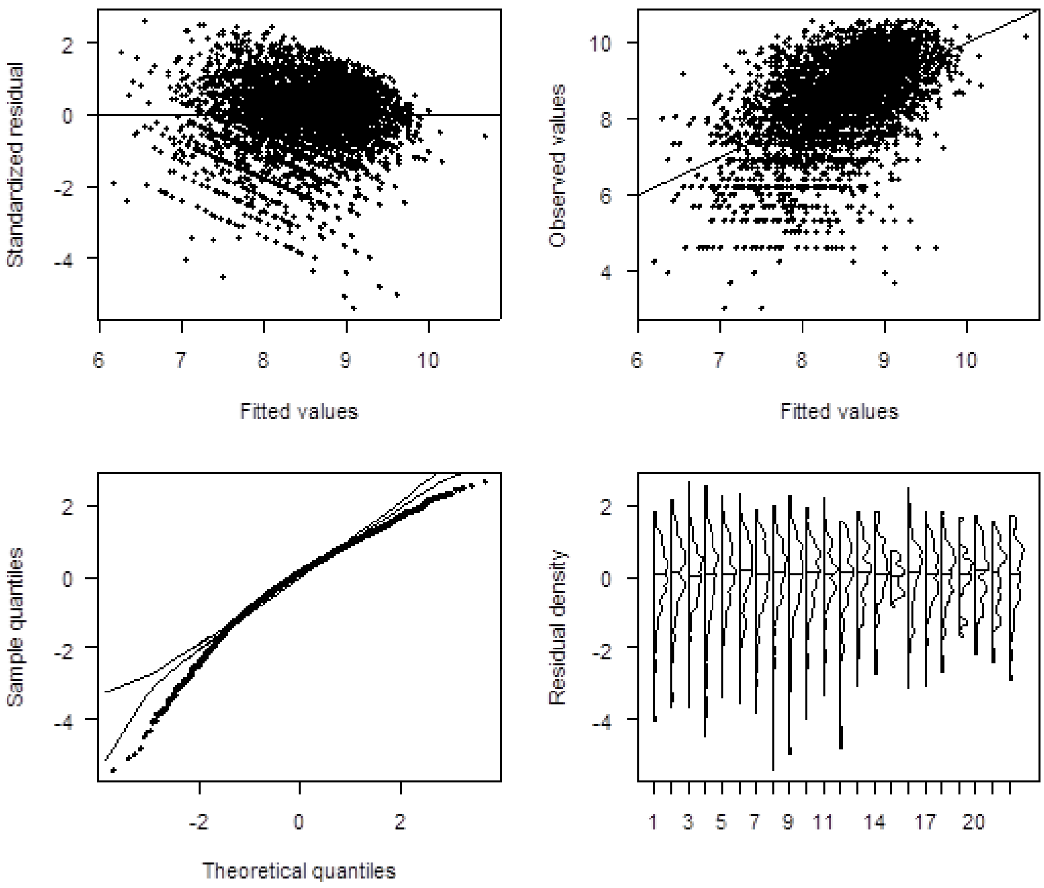


Figure D17d: SNARES 2005 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

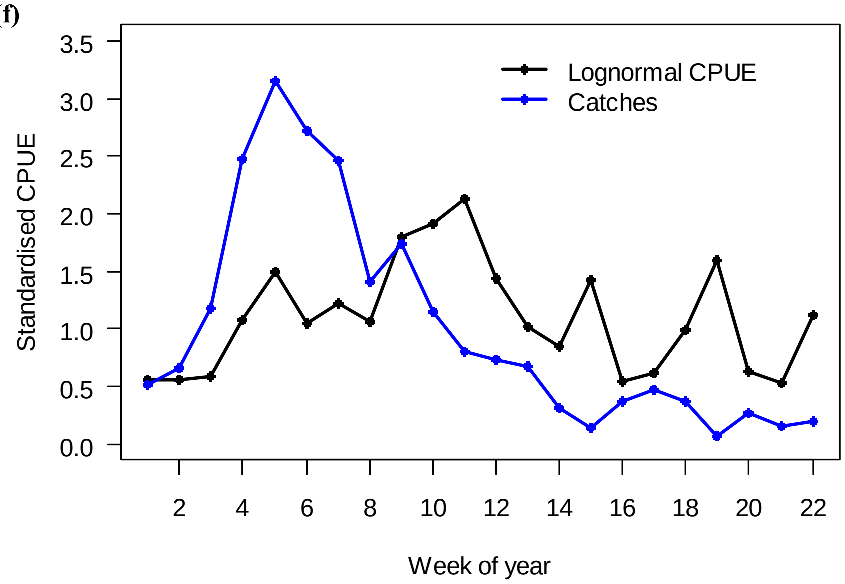
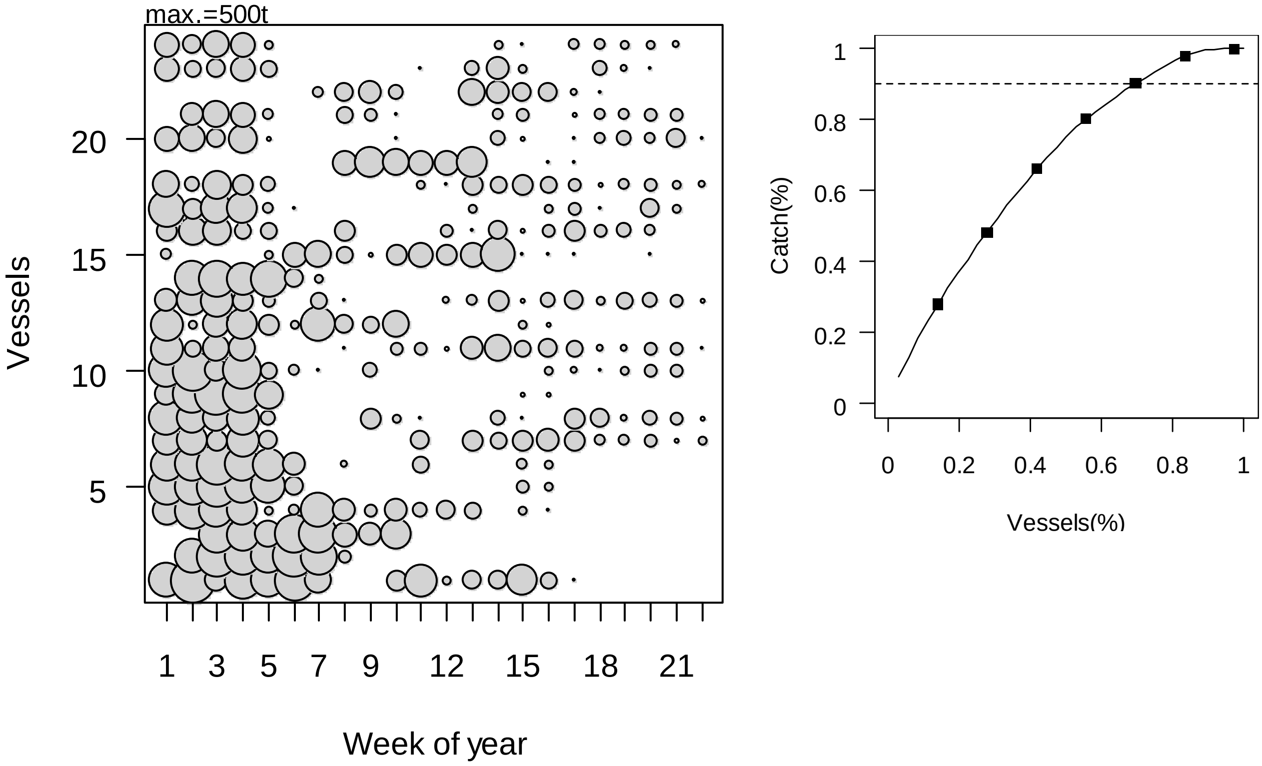


Figure D17: SNARES 2005 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

(a) **(b)**



(c)

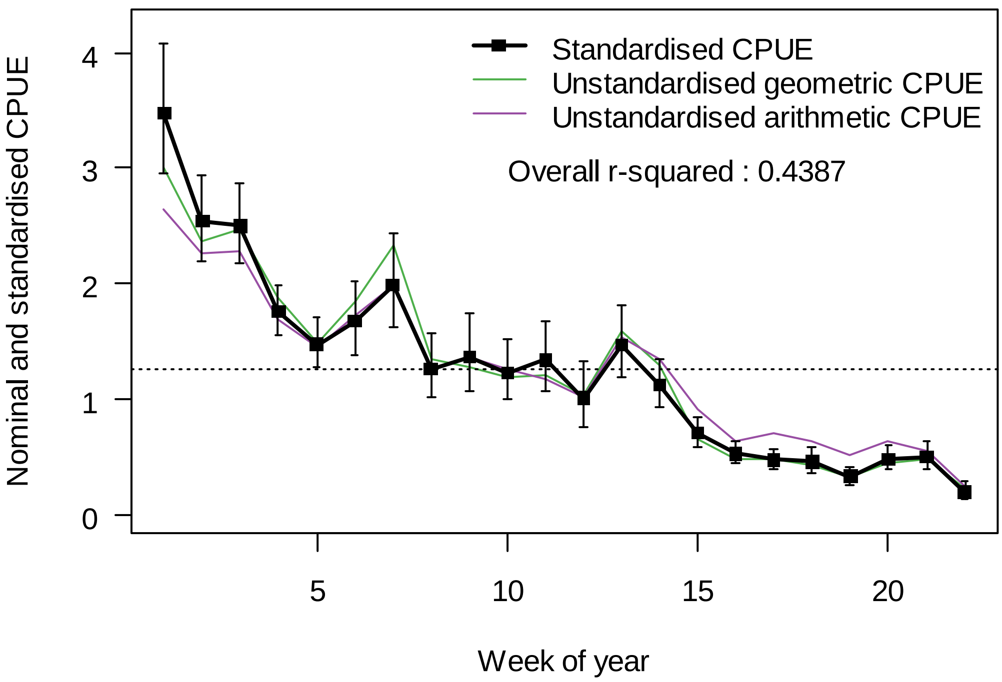


Figure D18a: SNARES 2006 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

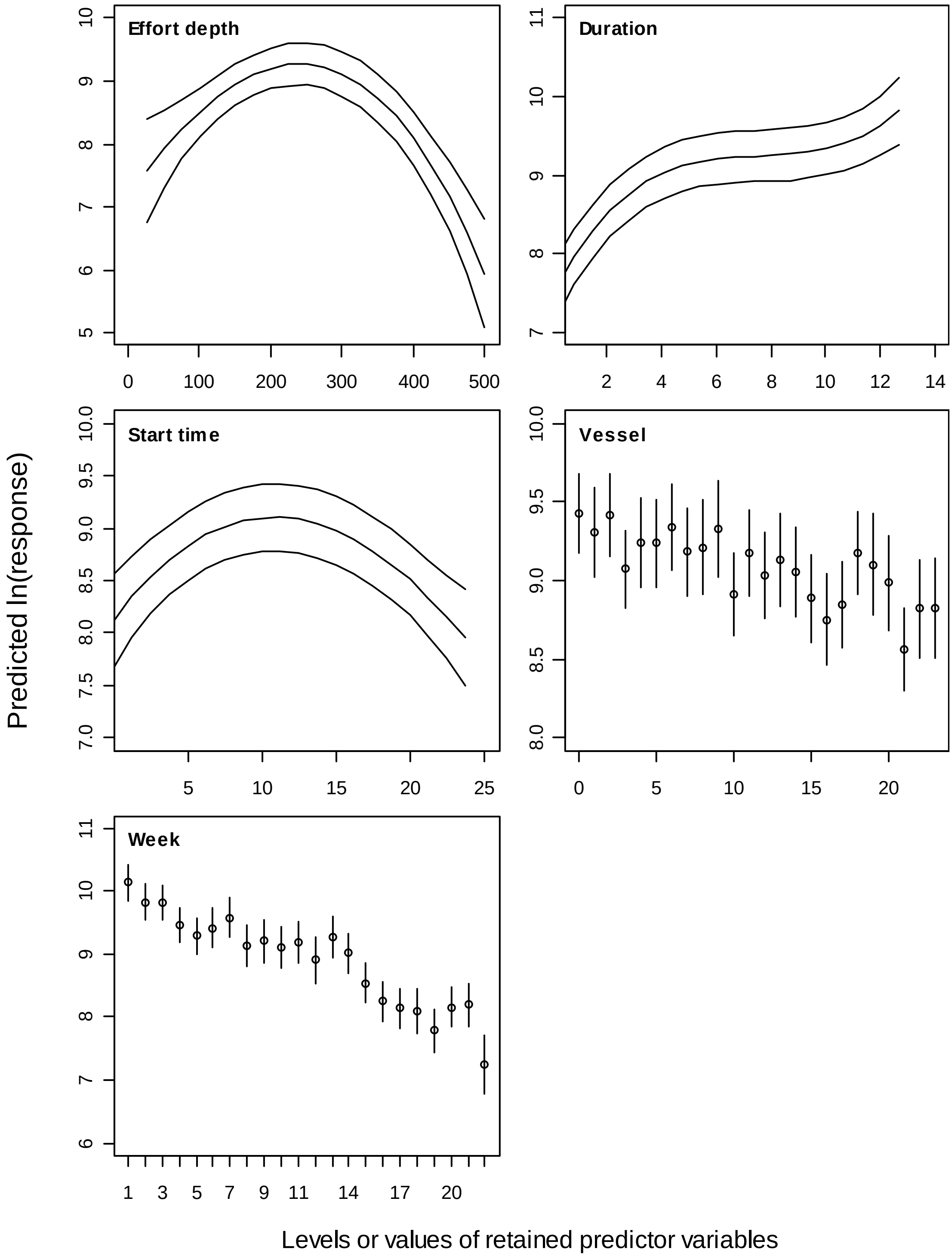
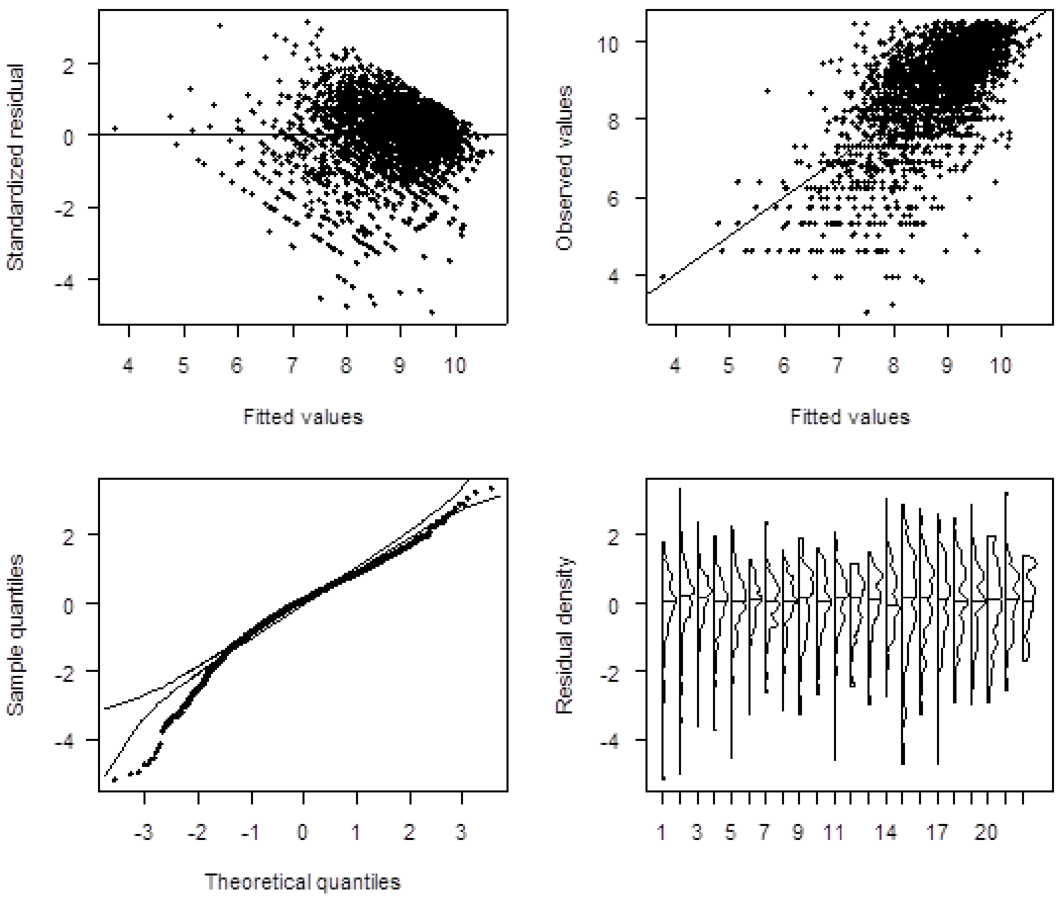


Figure D18d: SNARES 2006 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

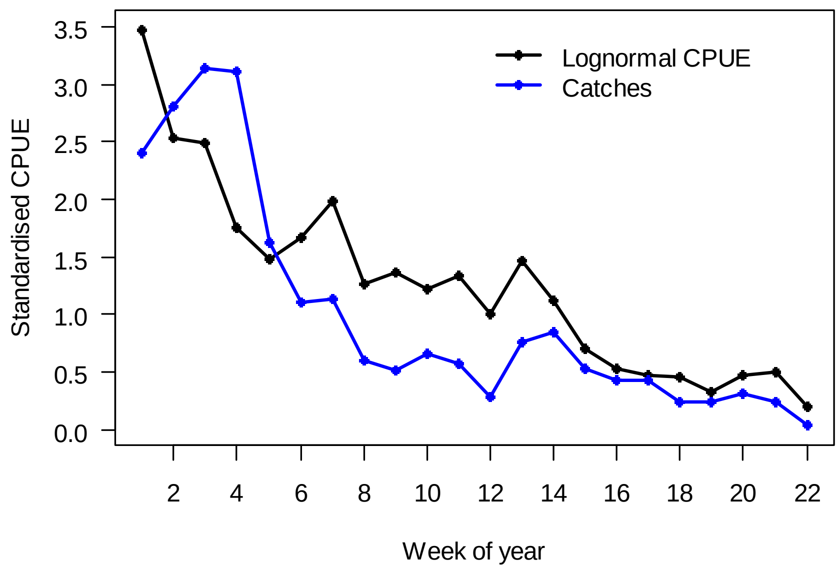


Figure D18: SNARES 2006 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

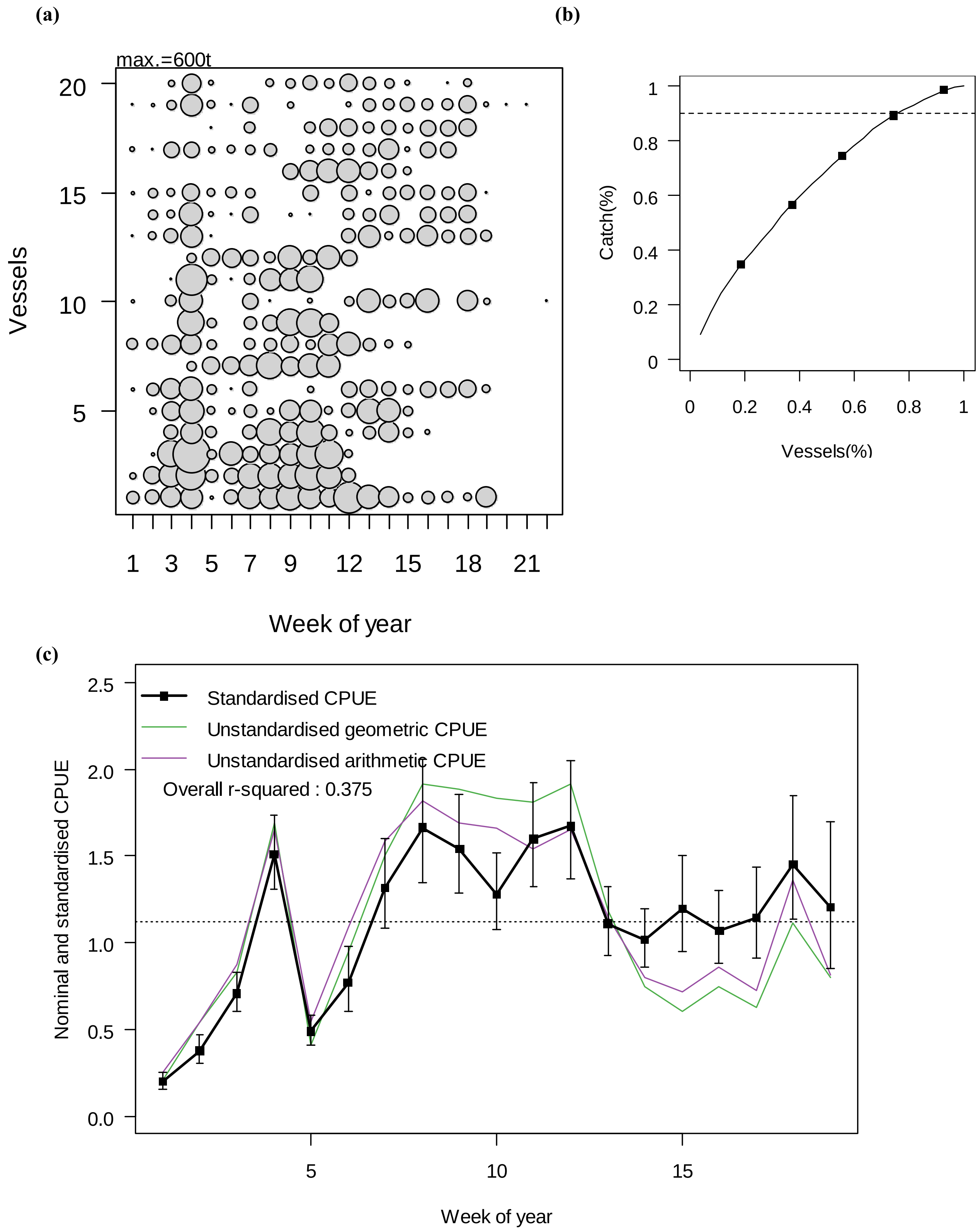


Figure D19a: SNARES 2007 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

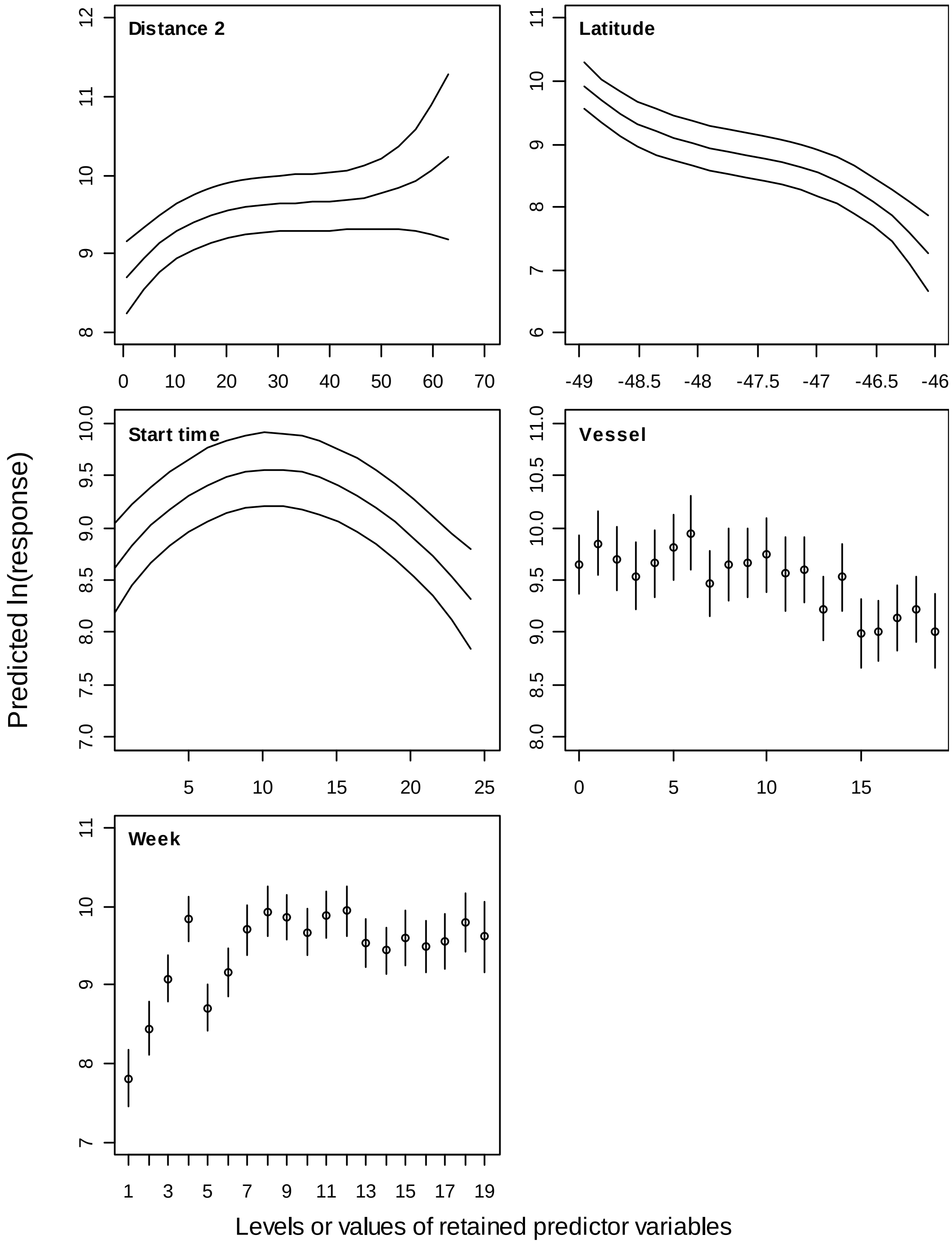
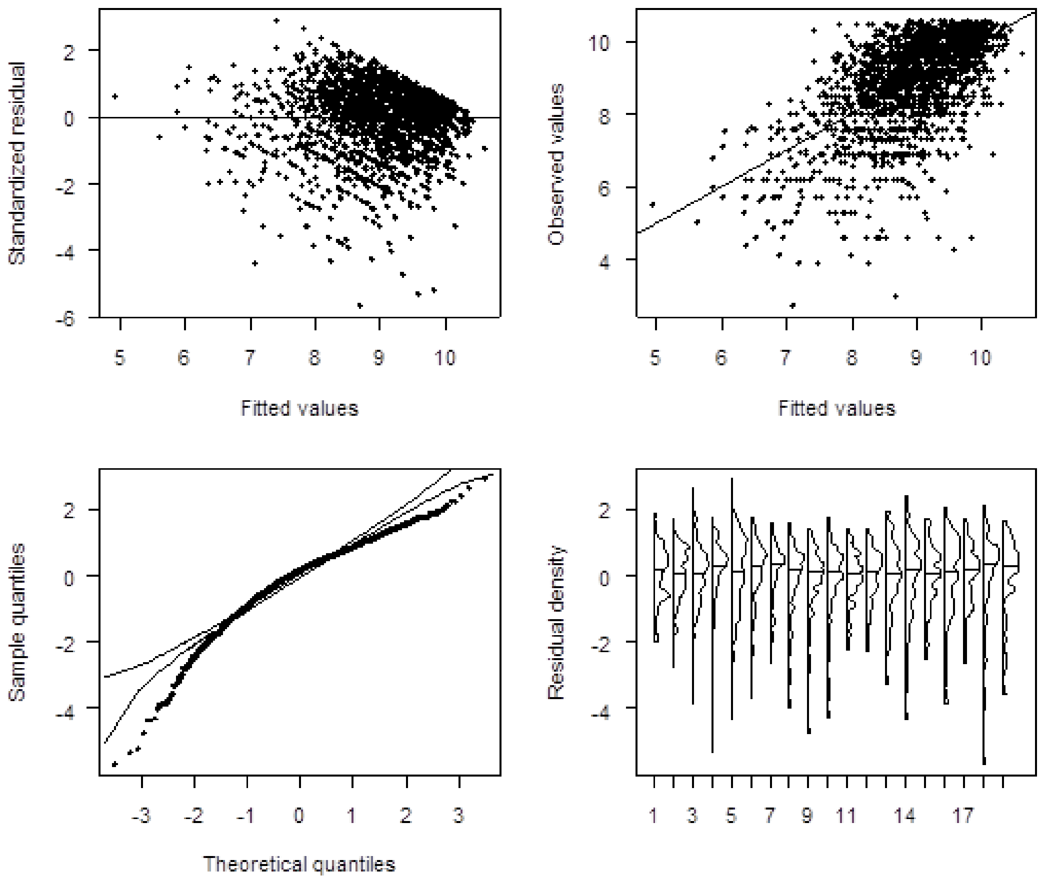


Figure D19d: SNARES 2007 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

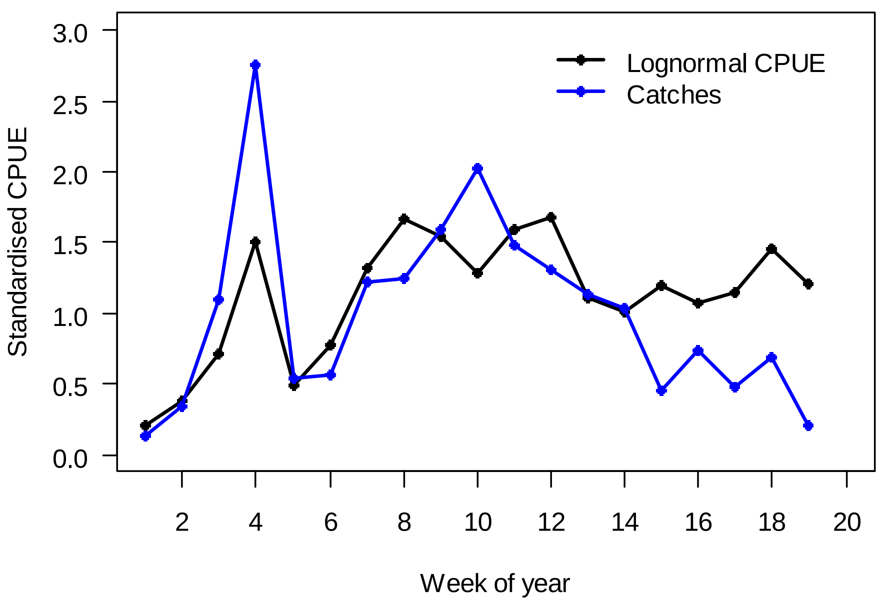


Figure D19: SNARES 2007 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

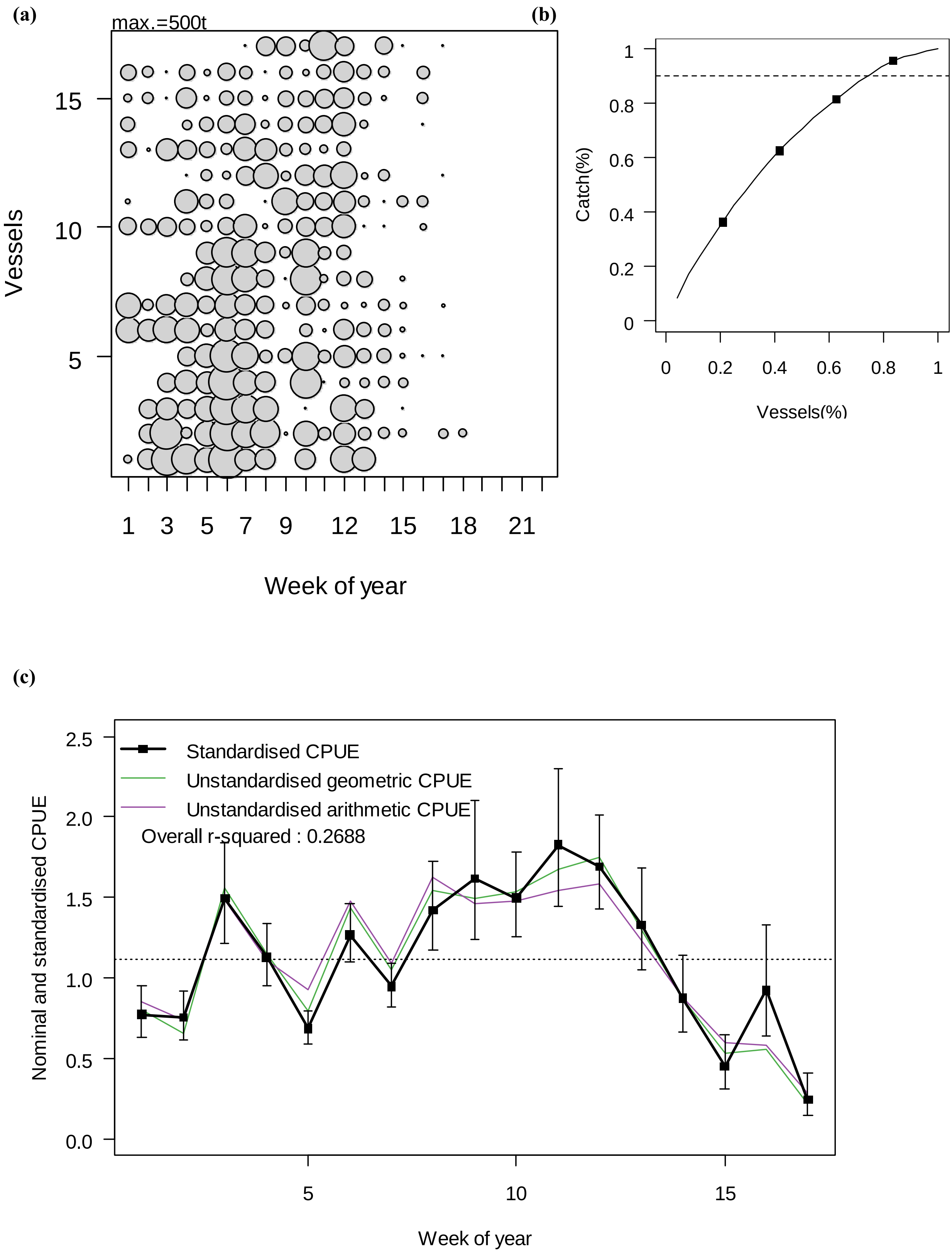


Figure D20a: SNARES 2008 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

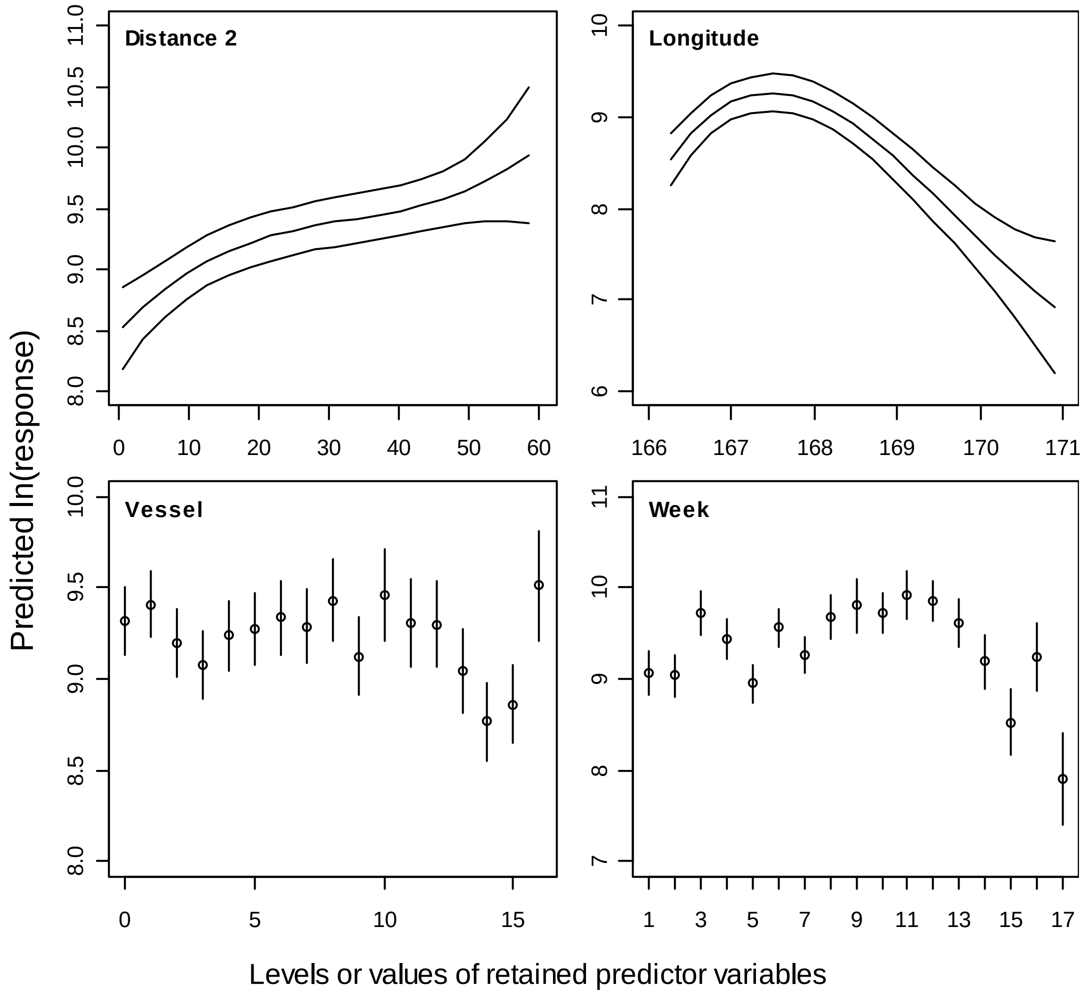
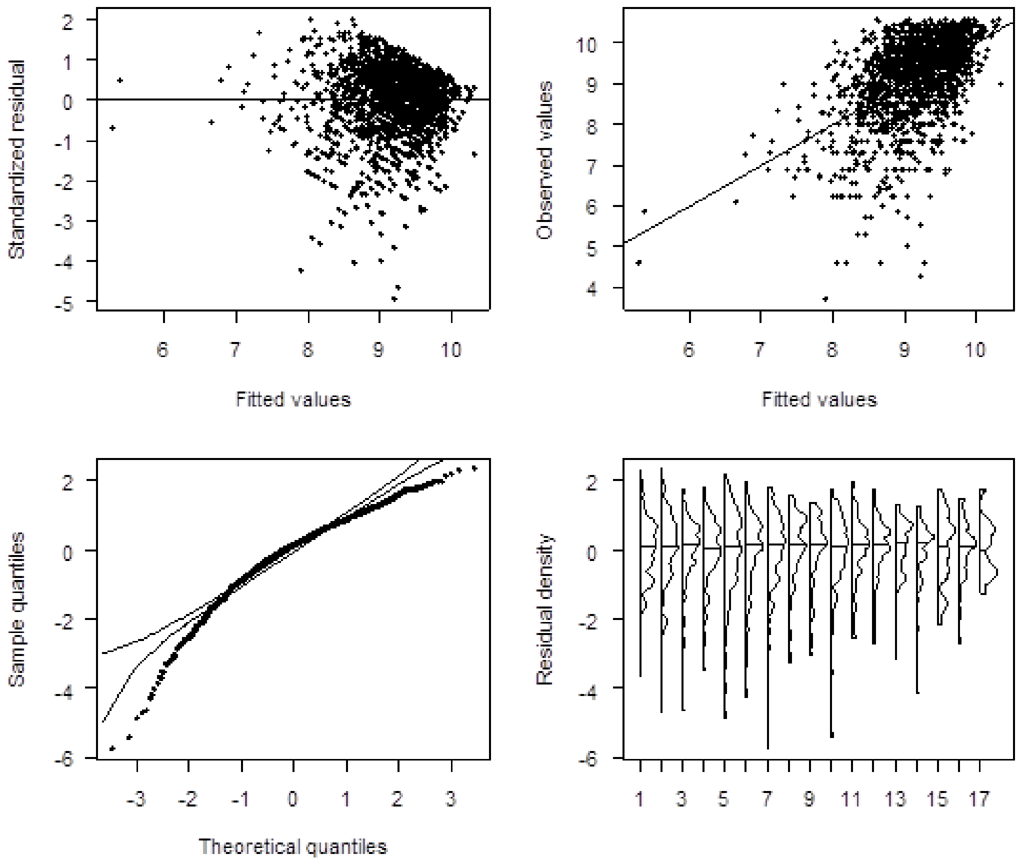


Figure D20d: SNARES 2008 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

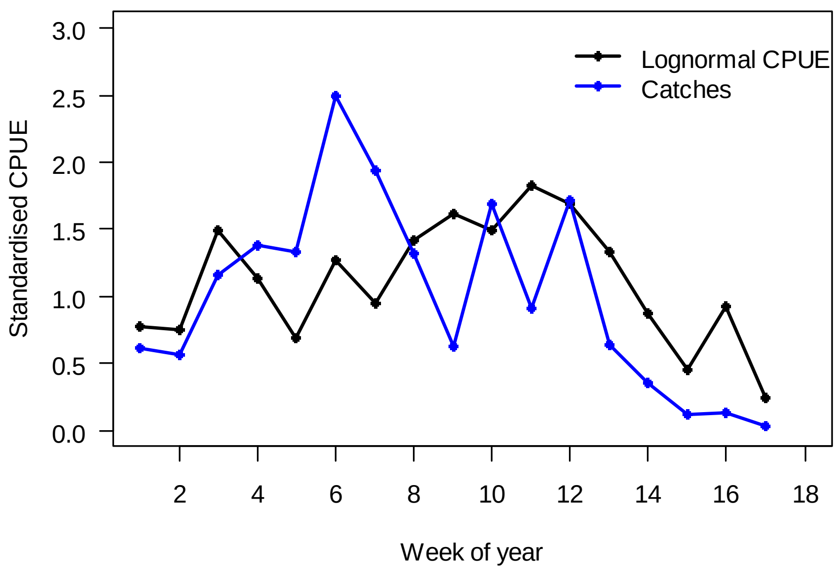


Figure D20: SNARES 2008 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

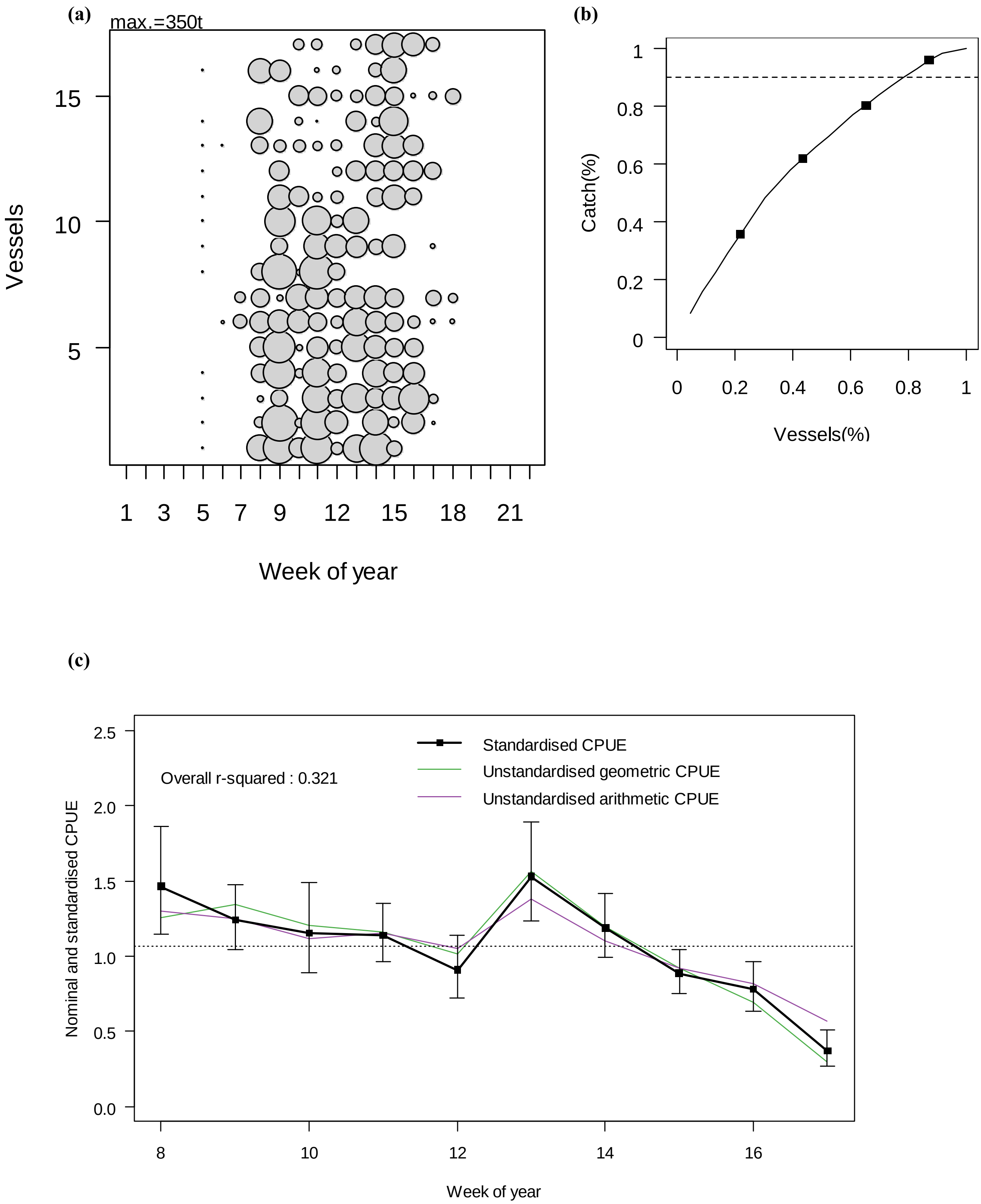


Figure D21a: AUCKLAND IS. 2008 WEEKLY TARGET SQUID. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU by week.

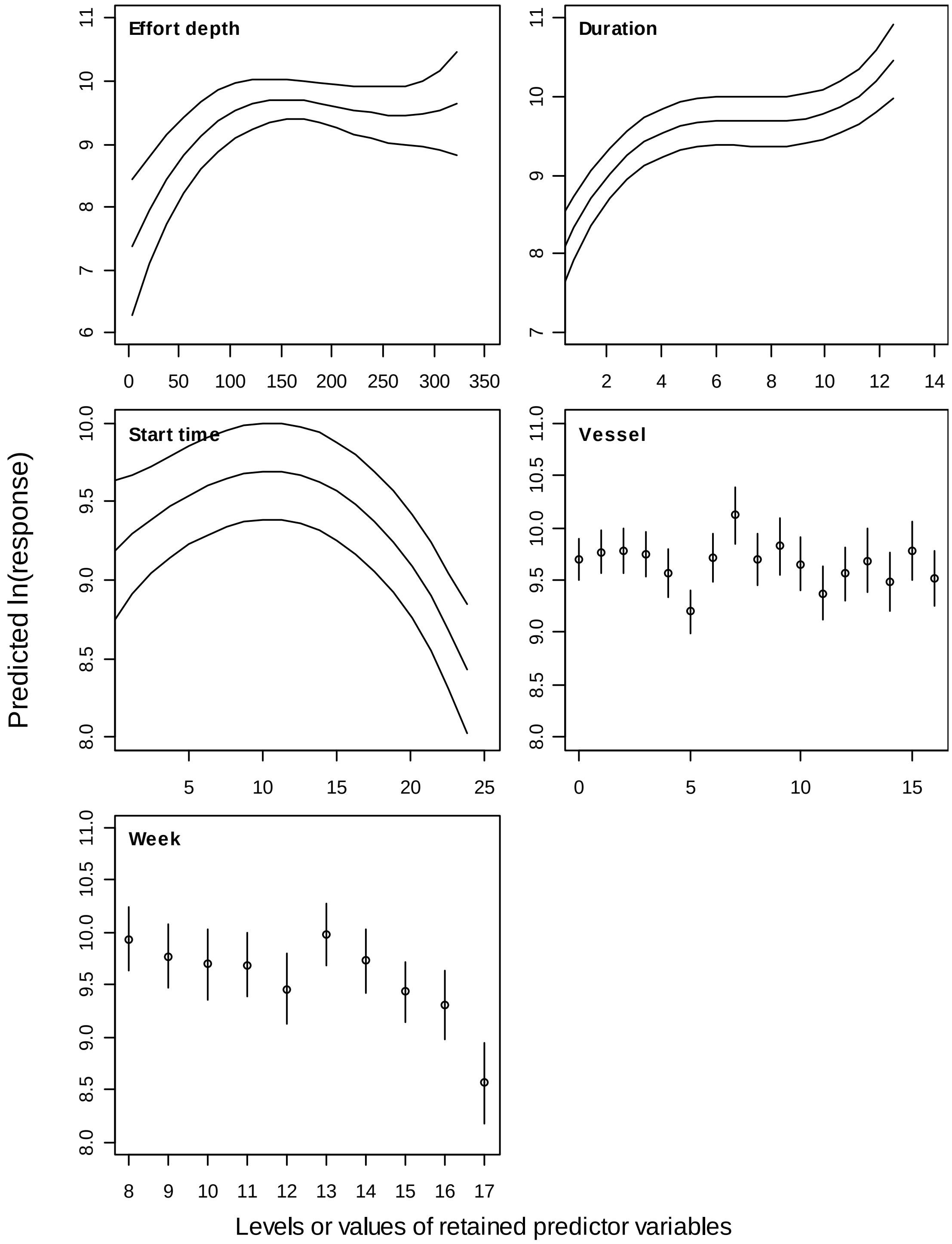
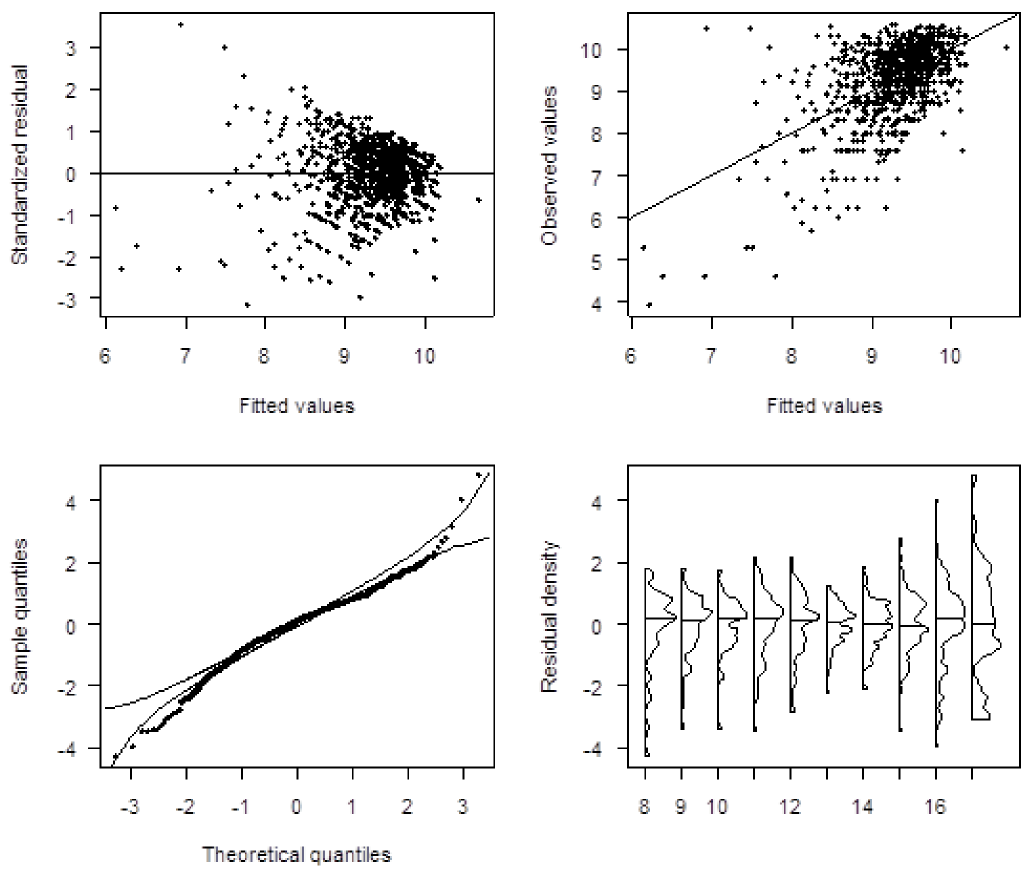


Figure D21d: AUCKLAND IS. 2008 WEEKLY TARGET SQUID. Predictor variables retained in the GLM analysis and their distributions by factor levels.

(e)



(f)

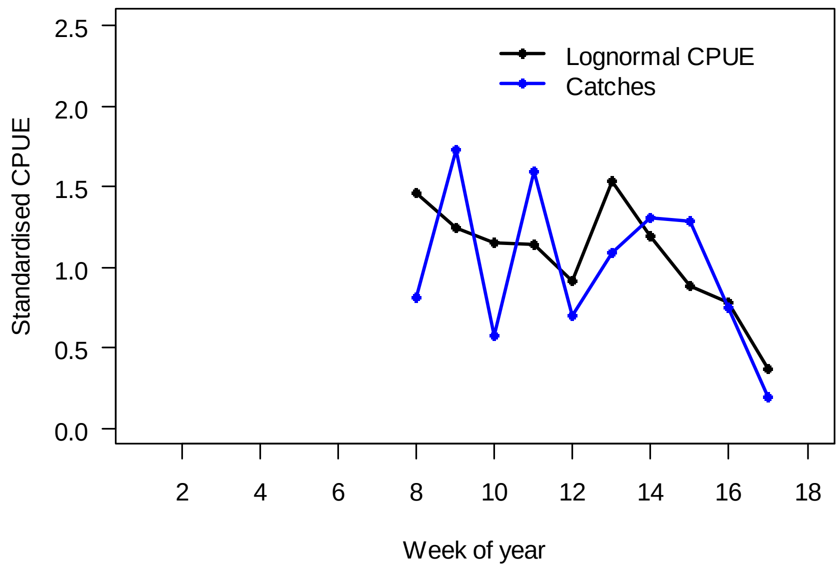


Figure D21: AUCKLAND IS. 2008 WEEKLY TARGET SQUID. (e) Residual diagnostic plots describing the fit of the GLM CPUE model. (f) Comparison of CPUE indices by week, with standardised target squid catches by week.

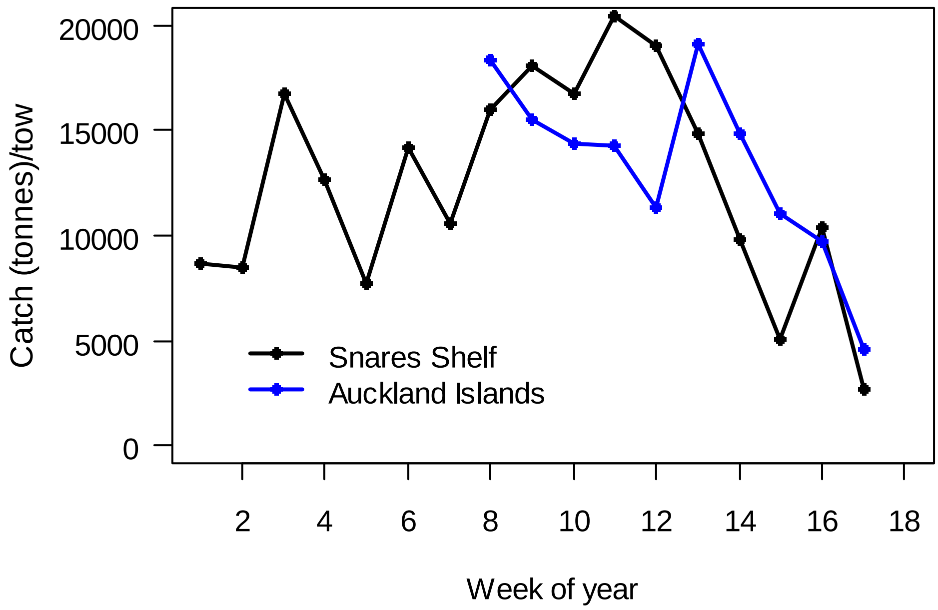
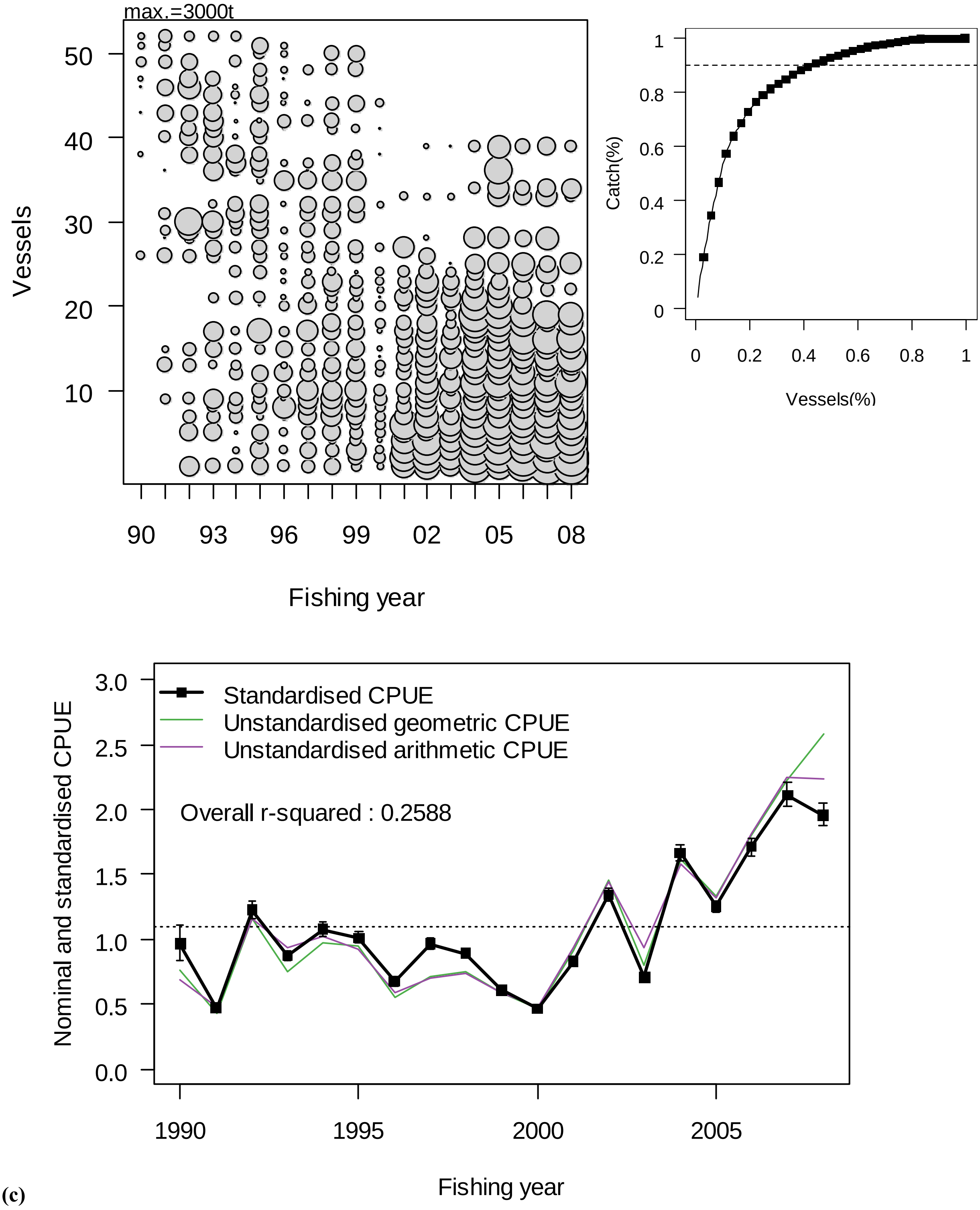


Figure D21: AUCKLAND IS. 2008 WEEKLY TARGET SQUID. (g) Comparison of expected non-zero catch rates with Snares 2008 expected non-zero catch rates .

(a) (b)



(c)

Figure D22: SNARES TARGET SQUID YEARLY LOGNORMAL CPUE Model. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU years 1990 to 2008.

(d)

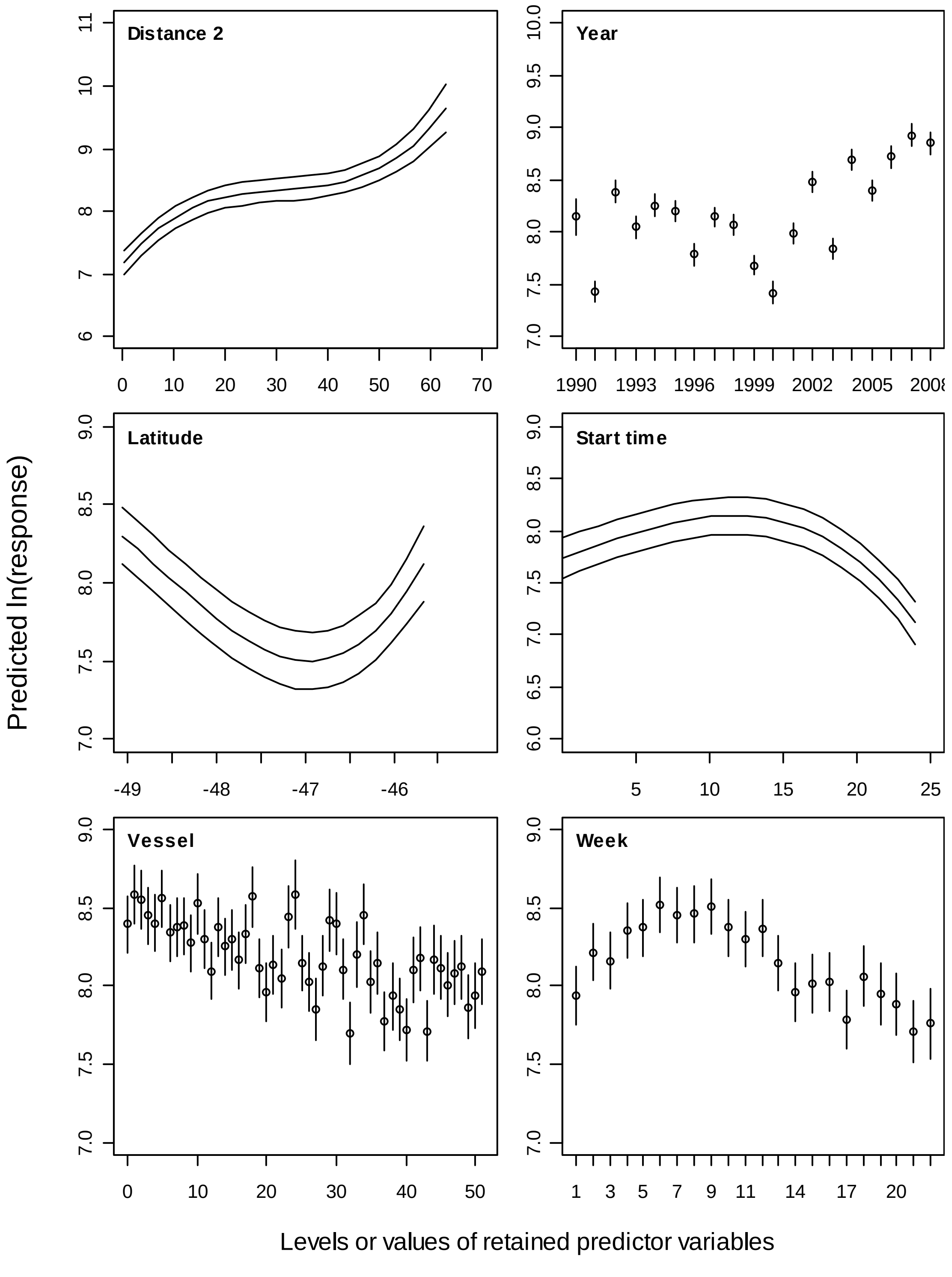


Figure D22: continued. SNARES TARGET SQUID YEARLY LOGNORMAL CPUE Model. (d) Predictor variables retained in the GLM analysis and their distributions by factor levels.

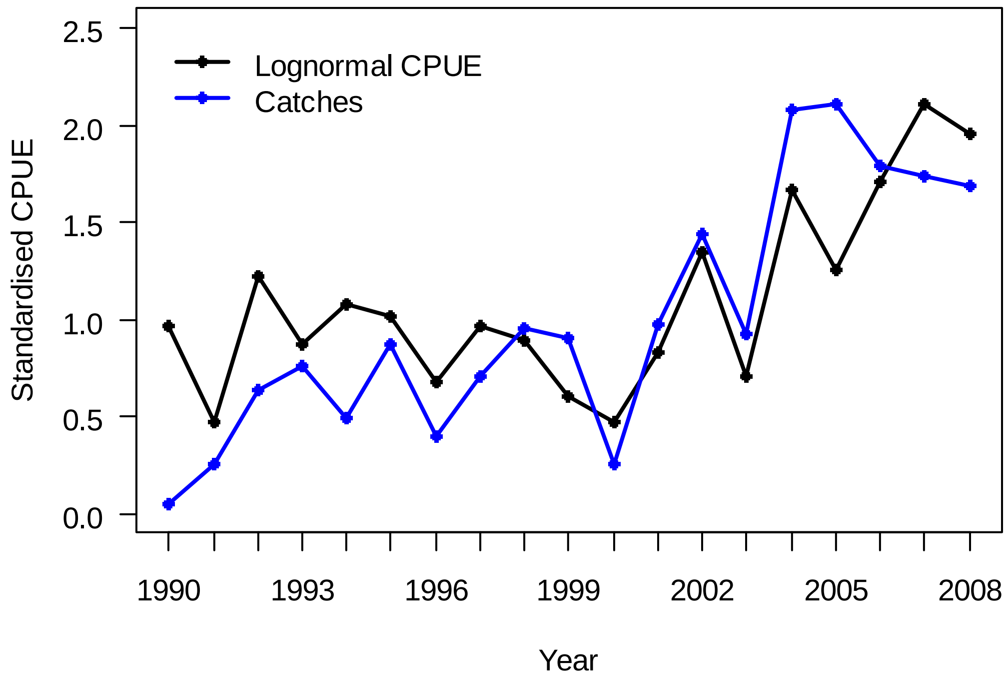
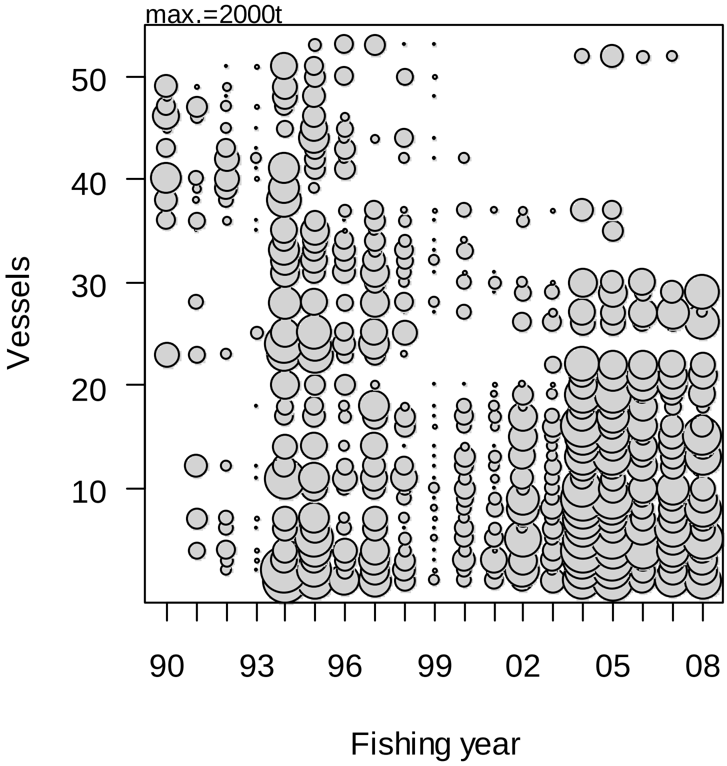
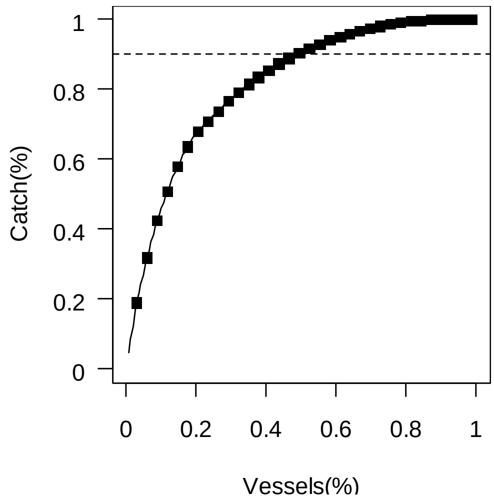


Figure D22: continued. SNARES TARGET SQUID YEARLY LOGNORMAL CPUE Model. (e) Comparison of lognormal target squid CPUE indices by week, with standardised target squid catches by week.

(a)



(b)



(c)

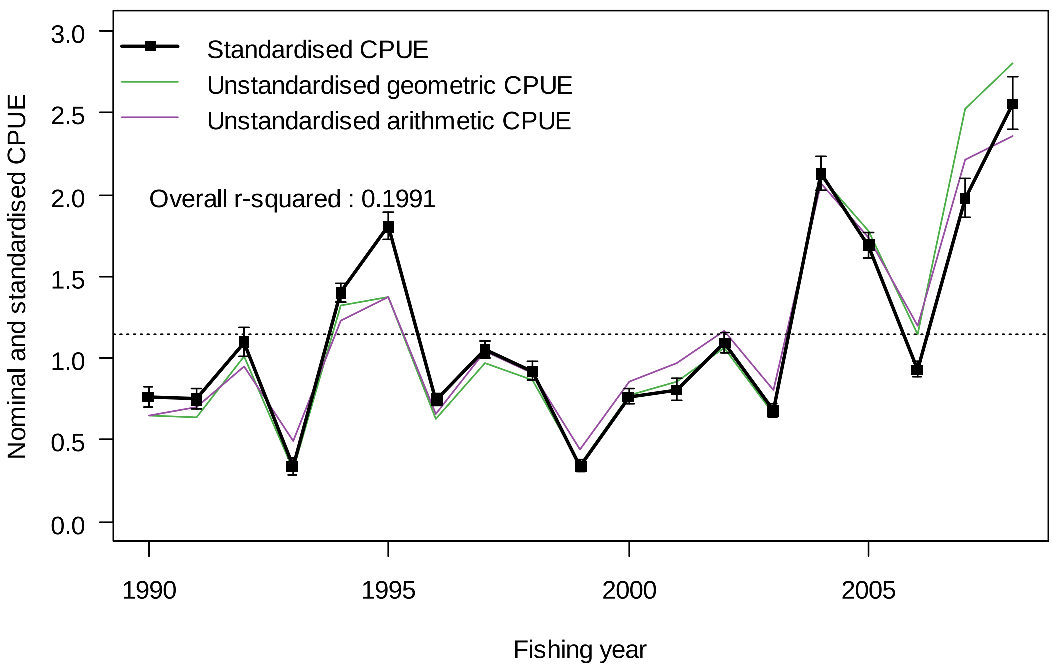


Figure D23: AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. a) scaled annual catch by vessel. b) Cumulative proportion of SQU catch ranked by vessel. c) arithmetic, geometric and standardised CPUE indices for SQU years 1990 to 2008.

(d)

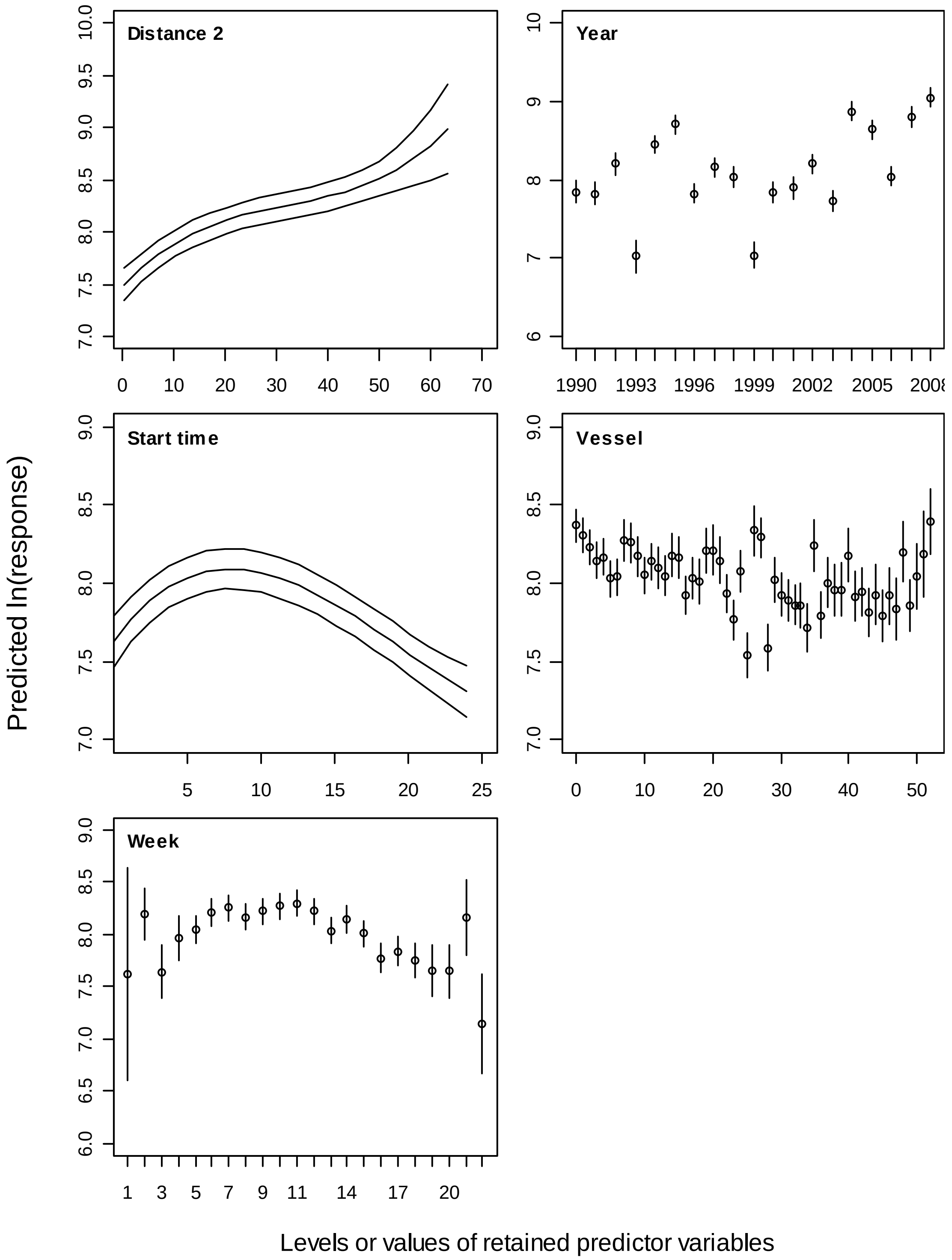


Figure D23: continued. AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. (d) Predictor variables retained in the GLM analysis and their distributions by factor levels.

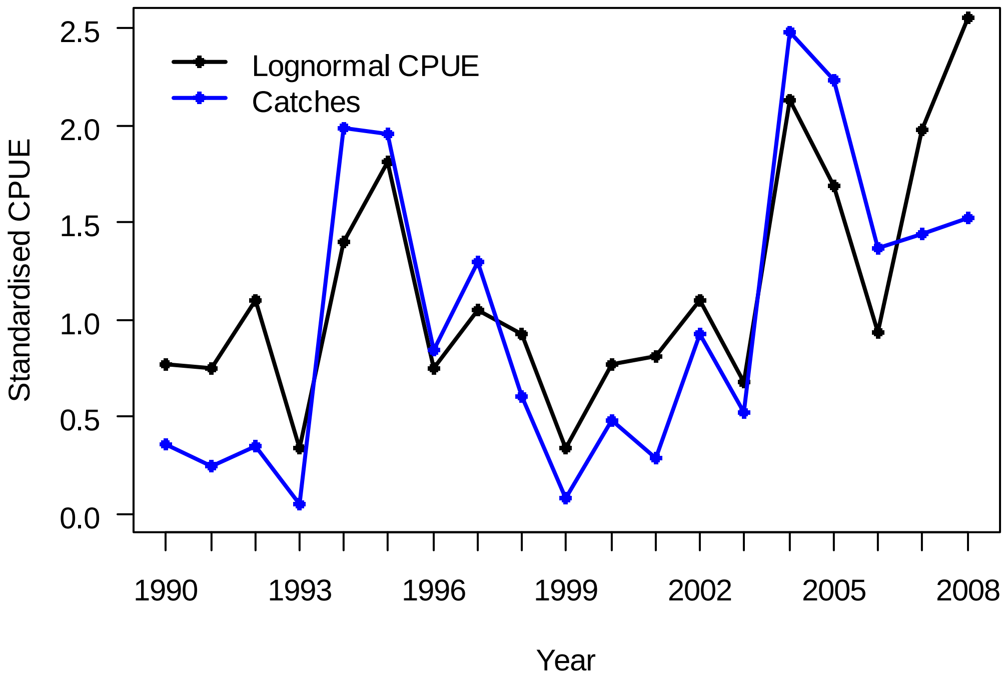
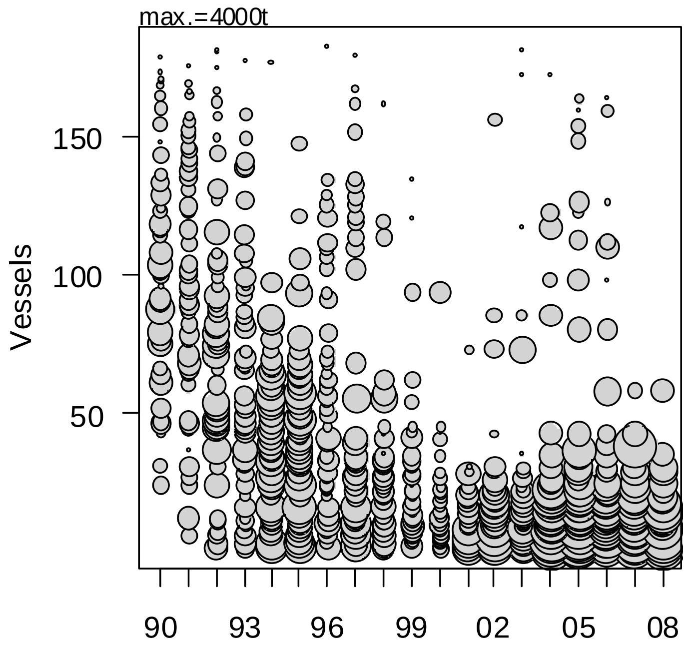


Figure D23: continued. AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. (e) Comparison of lognormal target squid CPUE indices by week, with standardised target squid catches by week.

Snares and Auck Is

(a) All vessels



(b) Core vessels (0.9 catch, threshold fishyr=4)

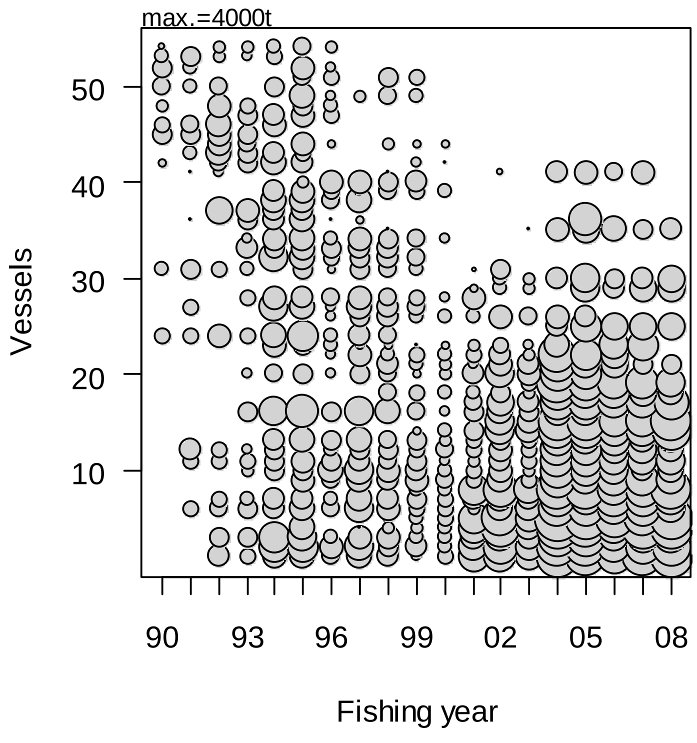
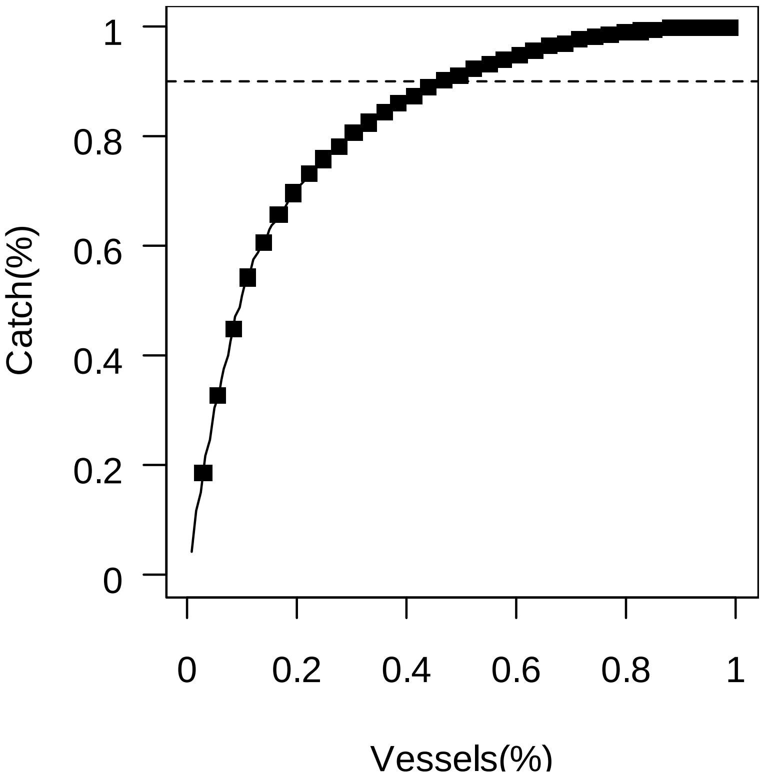


Figure D24: SNARES and AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. a) scaled annual catch by all vessels. b) scaled annual catch by core vessels for SQU, years 1990 to 2008.

(c)



(d)

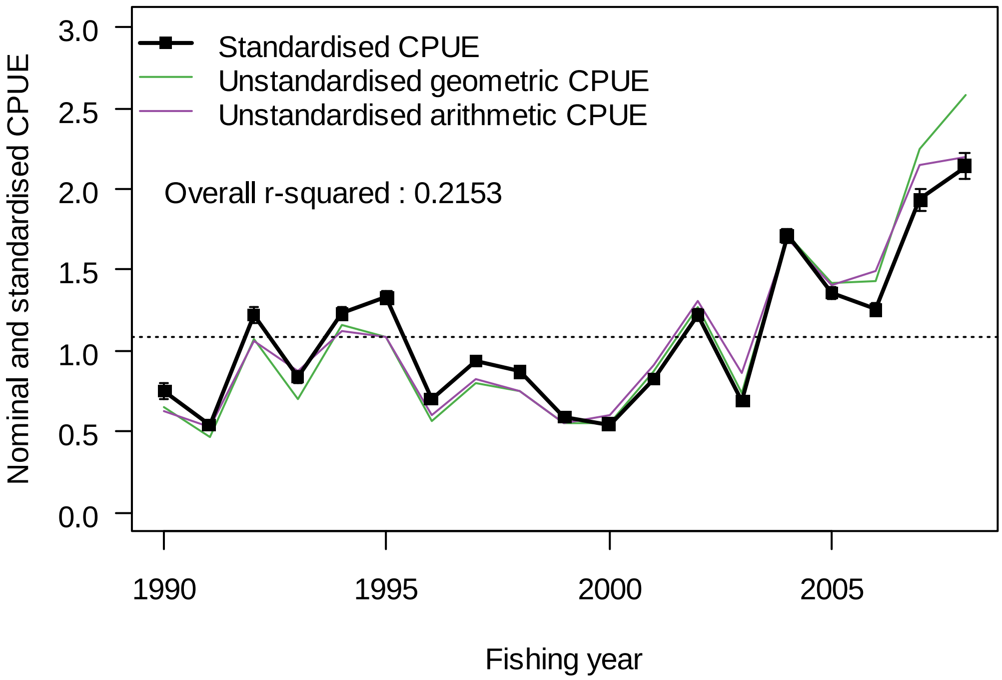


Figure D24: SNARES and AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. c) Cumulative proportion of SQU catch ranked by vessel. d) arithmetic, geometric and standardised CPUE indices for SQU years 1990 to 2008.

(e)

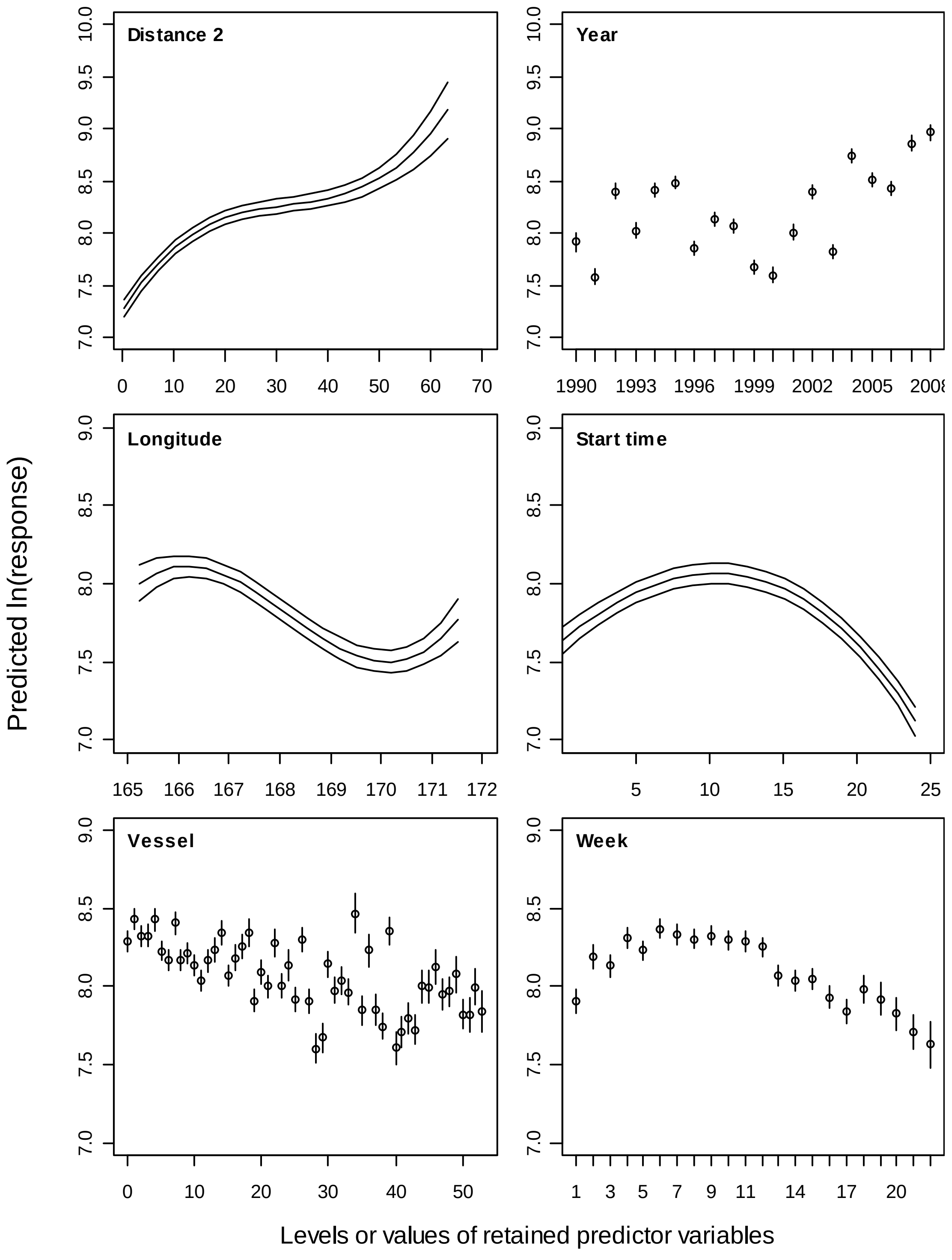


Figure D24: continued. SNARES and AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. (e) Predictor variables retained in the GLM analysis and their distributions by factor levels.

(f)

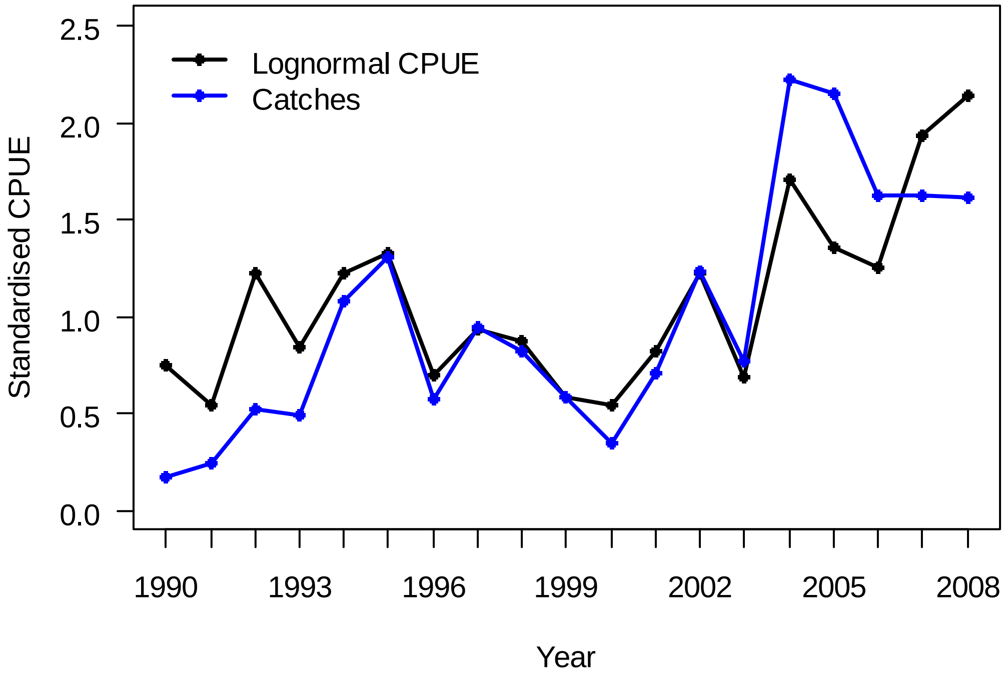
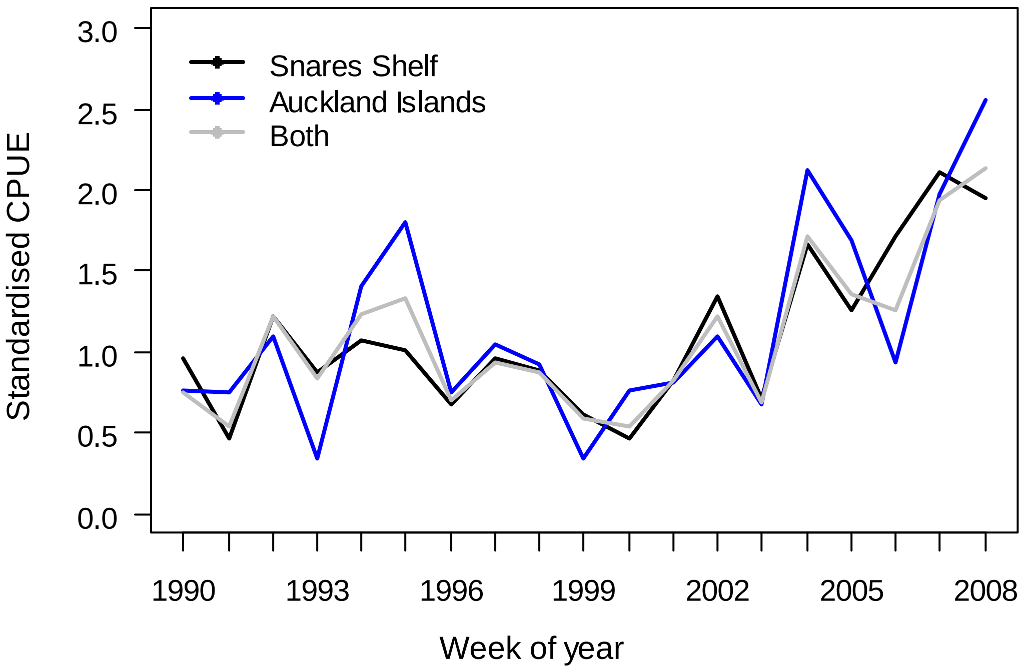


Figure D24: continued. SNARES and AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE Model. (f) Comparison of lognormal target squid CPUE indices by week, with standardised target squid catches by week.

(g)



(h)

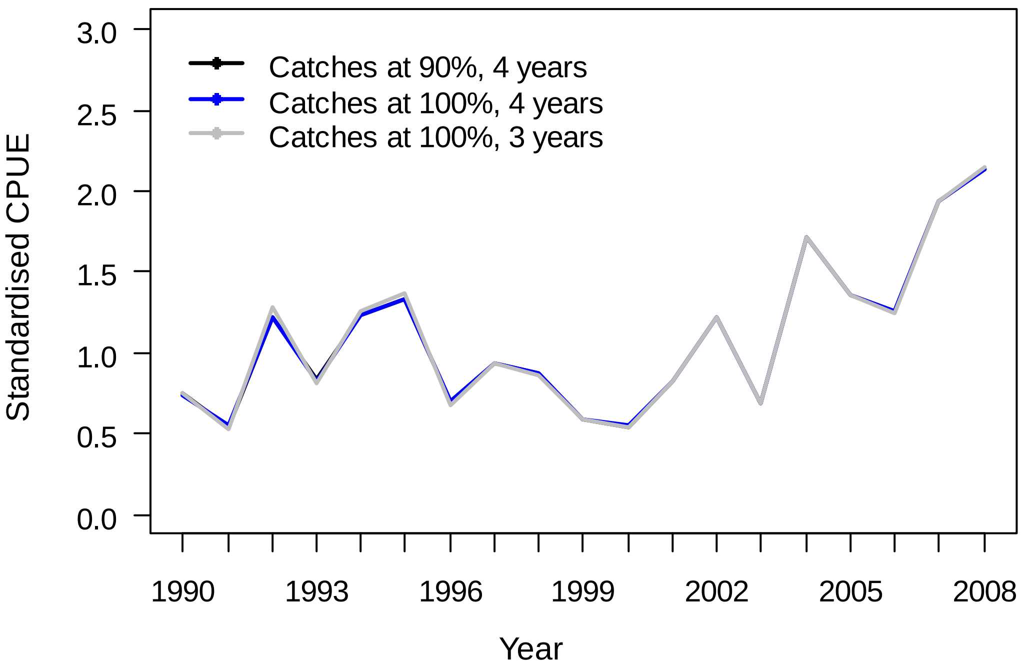


Figure D24 continued: SNARES and AUCKLAND IS. TARGET SQUID YEARLY LOGNORMAL CPUE. (g) Comparison with Snares and Auckland Island indices. (h) Comparison of core vessels (Catch threshold 90%, threshold year = 4) with catch threshold 100% , threshold year = 4, and 90% threshold catch , threshold year = 3.

19. APPENDIX E. POTENTIAL MANAGEMENT APPROACHES

Table E1. Correlation coefficients (r) for accumulating unstandardised weekly CPUE (weeks 3–8) for all years and two separate periods (1990–99 and 2000–08) against annual standardised CPUE and catch, for all vessel targeting squid in the Snares target bottom trawl fishery.

	Accumulating CPUE by week					
	3	4	5	6	7	8
Correlation vs. all years CPUE	0.70	0.83	0.80	0.80	0.88	0.92
Correlation vs. all years catch	0.54	0.65	0.70	0.69	0.75	0.76
Correlation vs. 1990–99 CPUE	0.79	0.71	0.64	0.54	0.67	0.76
Correlation vs. 1990–99 catch	-0.64	-0.32	0.41	0.37	0.37	0.38
Correlation vs. 2000–08 CPUE	0.62	0.78	0.80	0.83	0.88	0.94
Correlation vs. 2000–08 catch	0.53	0.65	0.70	0.71	0.75	0.77

Table E2. Correlation coefficients for accumulated monthly CPUE (in numbers per tow) and the effect of removal of the one strong abundance year (2008)

	Accumulated monthly CPUE	
	All years (*n*=12)	Years minus 2008 (*n*=11)
January	0.428	0.067
February	0.952	0.844
March	0.995	0.970

Table E3: Environmental data used for correlation analyses. SST, sea surface temperature; SOI, Southern Oscillation Index; Chl, Chlorophyll; SSH, sea surface height; IPO, Interdecadal Pacific Oscillation.

Data type	Area	Relevant period	Temporal scale	Data source
SST	Southland, Auckland Is see Figure E9	Sep. 1981–2008	Month, season	NCAR database[a]
Coastal SST	Invercargill	1982–2006	Annual	Hurst et al. 2012b
Southern Oscillation Index (SOI)	NZ	1981–2007	Annual	Hurst et al. 2012b
Kidson regimes	NZ	1981–2006	Annual	Dunn et al. 2009b
Trenberth indices[b]	NZ	1981–2007	Monthly	Hurst et al. 2009b
Ocean colour (Chl)	Puysegur	Sep. 1997–2008	Month	Hurst et al. 2009b
Ocean colour (Chl)	SubAntarctic	1997–2004	Annual	Dunn et al. 2009b
Ocean colour (Chl)	WCSI	1997–2004	Annual	Dunn et al. 2009b
SST	FMA 5, 6, 7	1982–2006	Annual	Dunn et al. 2009b
SSH	FMA 5, 6, 7	1992–2006	Annual	Dunn et al. 2009b
IPO	NZ	1982–2006	Annual	Dunn et al. 2009b

a SST data for this study are from the Research Data Archive (RDA) which is maintained by the Computational and Information Systems Laboratory (CISL) at the National Center for Atmospheric Research (NCAR). NCAR is sponsored by the National Science Foundation (NSF). The original data are available from the RDA (http://dss.ucar.edu) in dataset number ds277.7

b selected relevant indices only, Z2, M2, M3, MZ1

Table E4: Correlations of unstandardised and standardised CPUE indices for the Snares (SNAR) and Auckland Is, (AUCK) fisheries with annual environmental indices (as described in Table E3)

	Pre-season annual indices					In-season annual indices				
	Unstandardised CPUE		Standardised CPUE			Unstandardised CPUE		Standardised CPUE		
Environmental Index	SNAR	AUCK	SNAR	AUCK	SNAR+ AUCK	SNAR	AUCK	SNAR	AUCK	SNAR+ AUCK
Inverc. T	-0.06	-0.15	-0.19	-0.30	-0.36	-0.14	-0.02	-0.28	-0.19	-0.29
Trenberth Z2	0.27	0.30	-0.02	0.15	0.06	0.17	-0.03	0.00	-0.06	-0.05
Trenberth M2	0.14	0.02	0.01	-0.02	0.07	0.16	-0.09	0.39	0.03	0.28
Trenberth M3	0.01	-0.05	-0.03	0.06	0.08	0.17	-0.07	0.17	-0.03	0.09
Trenberth MZ1	-0.49	-0.22	-0.41	-0.12	-0.34	-0.36	-0.12	-0.37	0.02	-0.23
SOI	0.07	0.10	-0.11	-0.14	-0.21	0.06	0.13	-0.26	-0.24	-0.32
Kidson Trough	-0.06	-0.11	-0.09	0.03	0.02	0.14	0.13	-0.37	0.32	0.24
Kidson Zonal	0.13	0.15	-0.03	-0.04	-0.04	0.03	-0.12	0.11	-0.07	0.06
Kidson Blocking	-0.05	0.00	0.15	0.00	0.01	0.19	-0.07	-0.36	-0.40	-0.42
WCSIchl	-0.07	-0.12	0.07	-0.03	0.06	0.22	0.41	0.47	0.52	0.46
SubAchl	0.41	0.42	0.33	0.40	0.33	0.49	0.48	0.49	0.45	0.50
FMA5sst	0.20	0.09	0.20	0.02	0.02	0.13	0.10	-0.08	-0.30	-0.28
FMA6sst	0.02	0.01	0.42	0.27	0.29	-0.14	-0.05	0.15	-0.17	-0.05
FMA7sst	0.04	-0.05	-0.08	-0.20	-0.27	0.04	0.08	-0.23	-0.29	-0.35
FMA5ssh	0.45	0.42	0.30	0.21	0.20	0.11	-0.03	-0.20	-0.32	-0.41
FMA6ssh	0.54	0.51	0.42	0.29	0.33	0.14	-0.03	-0.17	-0.31	-0.39
FMA7ssh	0.22	0.09	0.08	-0.16	-0.08	0.00	-0.08	-0.28	-0.32	-0.45
IPO	**-0.69**	-0.53	-0.49	-0.34	-0.41	**-0.66**	-0.45	-0.36	-0.22	-0.27

Table E5: Correlations of unstandardised and standardised CPUE indices for the Snares (SNAR) and Auckland Is, (AUCK) fisheries with monthly Trenberth environmental indices (as described in Table E3)

	Pre-season annual indices					In-season annual indices				
	Unstandardised CPUE		Standardised CPUE			Unstandardised CPUE		Standardised CPUE		
Environmental index	SNAR	AUCK	SNAR	AUCK	SNAR+ AUCK	SNAR	AUCK	SNAR	AUCK	SNAR+ AUCK
Trenberth Z2										
Jan						0.13	0.02	0.08	0.12	0.10
Feb	0.12	0.08	0.10	0.02	0.13	-0.04	-0.15	-0.36	-0.33	-0.39
Mar	0.06	-0.13	-0.37	-0.48	-0.42	0.32	0.28	0.32	0.27	0.30
Apr	-0.08	-0.18	-0.22	-0.27	-0.25	0.00	0.18	0.03	0.29	0.17
May	-0.03	0.04	-0.23	-0.05	-0.19	-0.14	-0.21	-0.35	-0.25	-0.34
Jun	0.43	0.42	0.32	0.22	0.26					
Jul	0.31	0.16	0.23	-0.01	0.15					
Aug	0.09	0.11	0.09	0.13	0.14					
Sep	0.27	0.27	0.17	0.23	0.19					
Oct	0.06	0.28	-0.03	0.22	0.12					
Nov	0.33	0.48	0.47	**0.61**	0.53					
Dec	-0.08	-0.03	-0.35	-0.02	-0.25					
Trenberth M**3**										
Jan						-0.23	-0.28	-0.45	**-0.63**	-0.57
Feb	0.08	0.04	0.06	-0.05	0.00	0.15	0.22	0.20	0.34	0.23
Mar	0.09	0.12	0.04	0.02	0.03	0.15	0.09	0.25	0.17	0.27
Apr	0.30	0.41	0.15	0.36	0.27	0.13	-0.13	-0.11	-0.38	-0.26
May	0.01	-0.17	0.03	-0.25	-0.09	-0.05	-0.14	-0.12	-0.15	-0.15
Jun	0.15	0.05	0.02	0.09	0.08					
Jul	-0.12	-0.08	0.03	0.01	0.02					
Aug	-0.05	-0.15	-0.38	-0.25	-0.27					
Sep	-0.14	-0.07	-0.04	0.16	0.11					
Oct	-0.06	0.00	0.04	0.12	0.13					
Nov	0.19	0.13	0.13	0.10	0.08					
Dec	0.00	0.04	-0.03	0.04	0.03					

Table E6: Correlations of unstandardised and standardised CPUE indices for the Snares fishery with monthly SST environmental indices (as described in Table E3) for Southland (STHLD) and sub-areas (as in Figure E9).

	Unstandardised Snares CPUE				Standardised Snares CPUE			
	SNAR	ESTEW	WSTEW	STHLD	SNAR	ESTEW	WSTEW	STHLD
Pre-season								
Feb	-0.16	-0.22	-0.08	-0.15	-0.33	-0.30	-0.37	-0.35
Mar	-0.16	-0.20	-0.16	-0.17	-0.16	-0.22	-0.24	-0.21
Apr	0.01	0.01	0.09	0.04	0.07	0.02	0.13	0.08
May	0.11	0.17	0.20	0.16	0.21	0.22	0.21	0.22
Jun	-0.01	0.10	0.12	0.07	-0.03	0.00	0.00	-0.01
Jul	-0.03	0.04	0.11	0.04	-0.06	-0.09	-0.01	-0.05
Aug	0.05	0.09	0.12	0.09	0.25	0.20	0.16	0.21
Sep	0.02	0.14	0.13	0.10	0.16	0.24	0.16	0.19
Oct	-0.05	-0.05	-0.04	-0.05	0.13	0.11	0.00	0.08
Nov	-0.13	-0.24	-0.12	-0.16	-0.22	-0.25	-0.22	-0.23
Dec	-0.07	-0.12	-0.01	-0.06	0.05	0.02	0.09	0.05
In-season								
Jan	-0.16	-0.21	0.00	-0.12	-0.11	-0.10	0.03	-0.05
Feb	0.03	-0.06	0.14	0.05	-0.05	-0.05	0.01	-0.03
Mar	-0.13	-0.18	-0.03	-0.10	-0.30	-0.38	-0.19	-0.29
Apr	0.04	0.04	0.16	0.09	-0.14	-0.14	-0.06	-0.11
May	0.14	0.15	0.22	0.17	0.04	0.01	0.04	0.06

Table E7: Correlations of standardised CPUE indices for the Snares and Auckland Is. fisheries with season Chl indices from Puysegur, September. 1997–April 2008 (as described in Table E3).

	Pre-season (Jul–Sep)	Pre-season (Oct–Dec)	In-season (Jan–Apr)
Snares	**0.65**	**0.64**	**0.76**
Auckland Is	0.44	**0.65**	**0.87**
Snares + Auckland Is	**0.60**	**0.68**	**0.85**

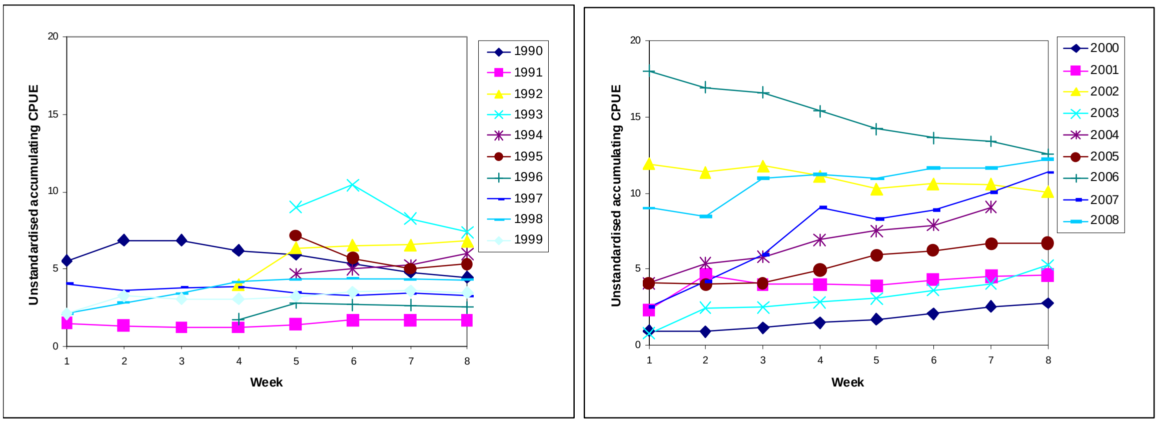


Figure E1: Weekly accumulated unstandardised CPUE (tonnes/tow) for weeks 1–8, for the 1990–1999 seasons (left) and 2000–2008 seasons (right), for all vessels targeting squid in the Snares target bottom trawl fishery, 1989/90 – 2007/08.

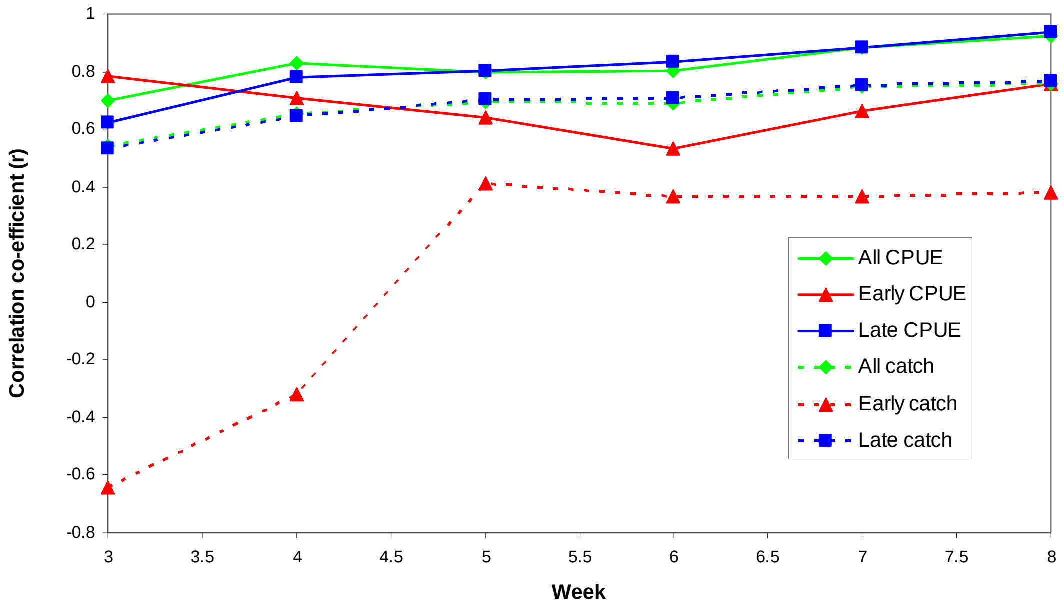


Figure E2: Correlation coefficients for accumulating unstandardised weekly CPUE (weeks 3–8) for all years and two separate periods (1990–99 and 2000–08) against annual standardised CPUE and catch, for all vessels targeting squid in the Snares target bottom trawl fishery.

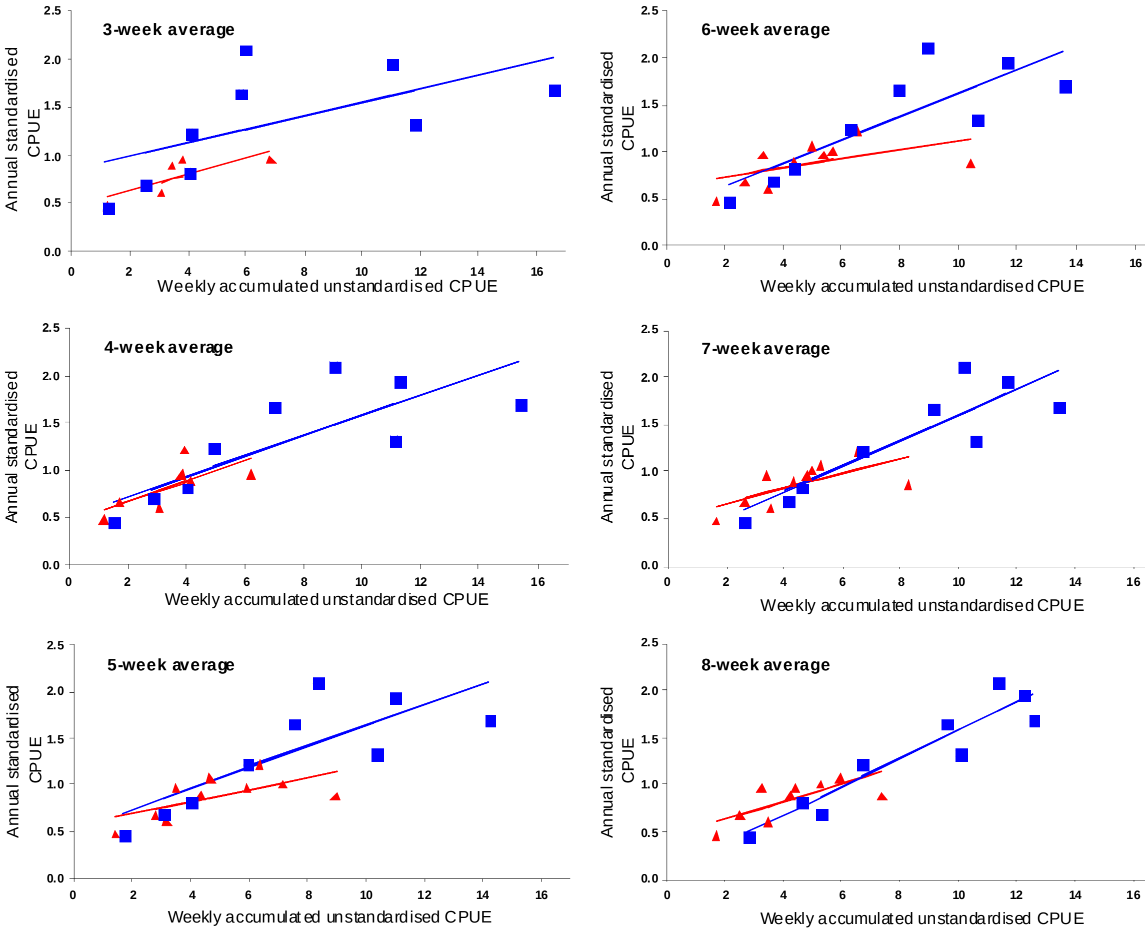


Figure E3 Correlations of weekly accumulated unstandardised CPUE (weeks 3–8) and annual standardised CPUE indices for two separate periods (1990–99 and 2000–08), for the Snares target bottom trawl fishery, 1989-90 – 2007-08.

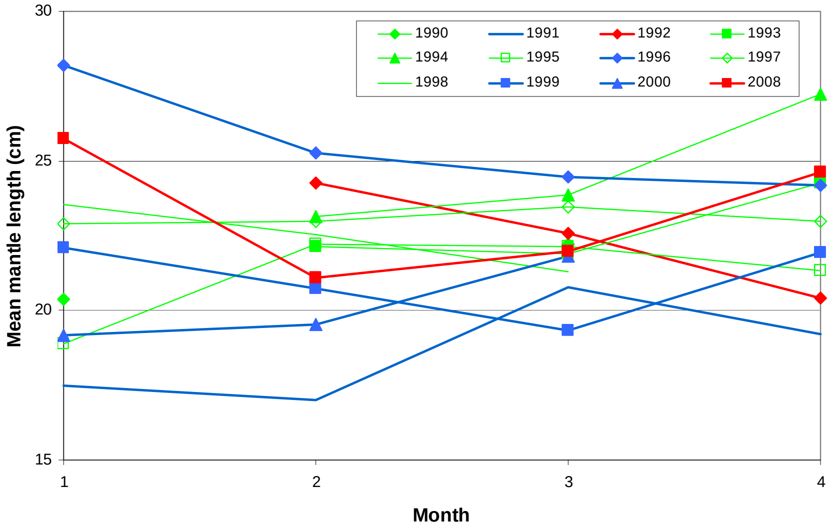


Figure E4: Mean size of squid from the Snares target bottom trawl fishery, by month (January–April). “High”, “medium” and “low” abundance years (see text for definitions) are indicated in red, green and blue, respectively.

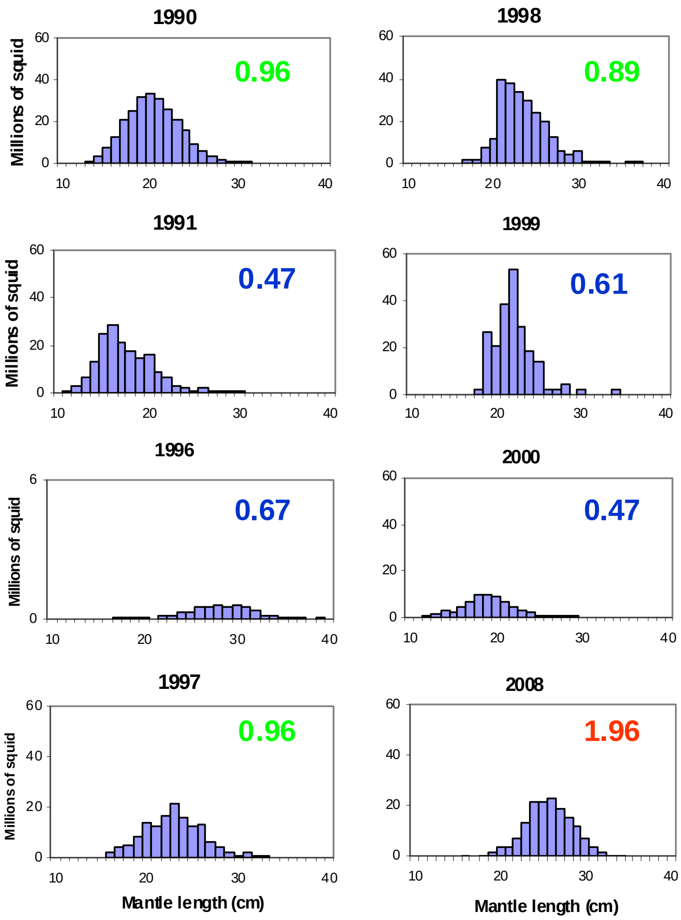


Figure E5: Scaled size frequencies of squid from the Snares target bottom trawl fishery for January. “High”, “medium” and “low” abundance years (see text for definitions) are indicated by numbers in red, green and blue, respectively.

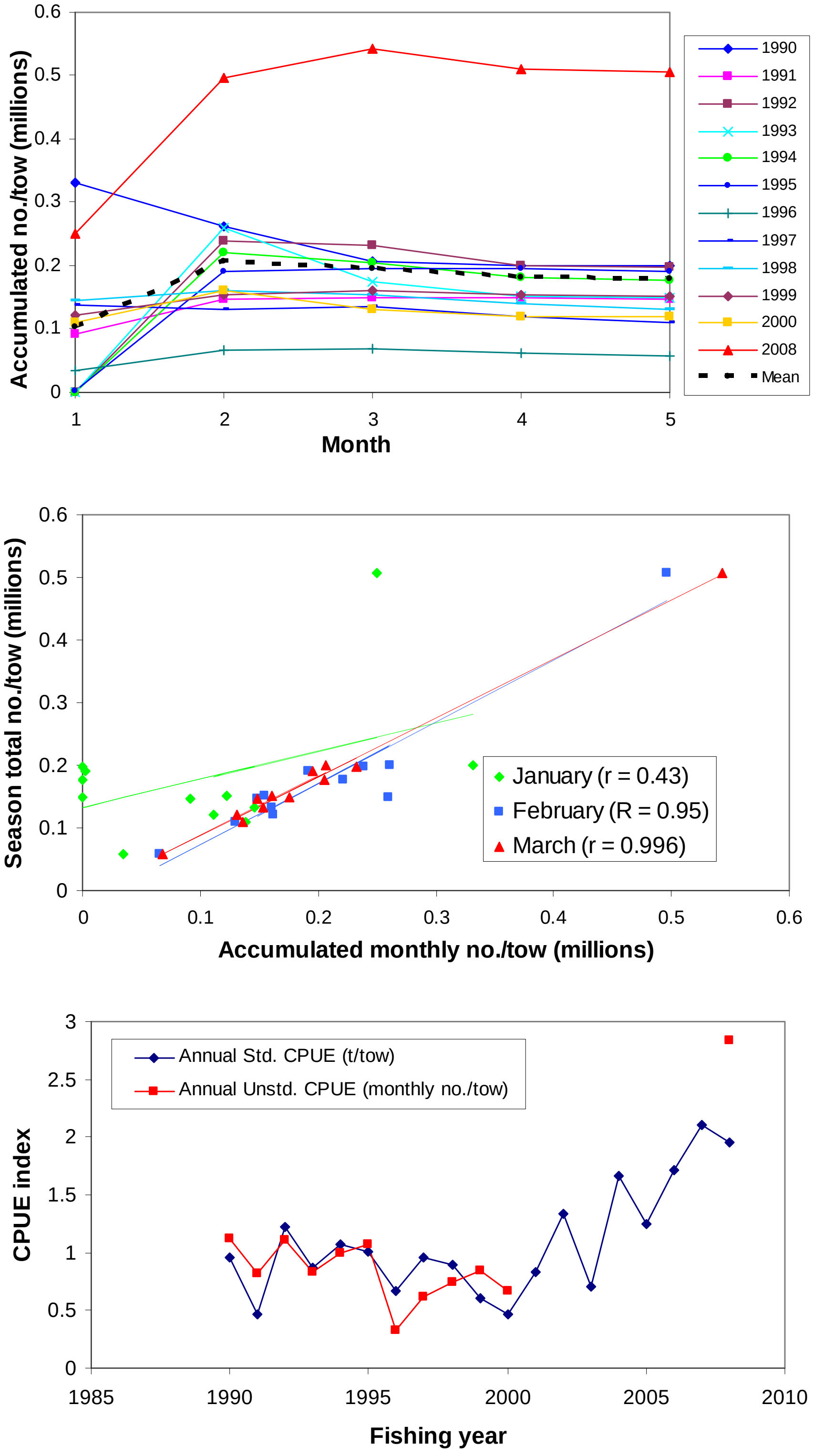


Figure E6: Accumulated unstandardised CPUE (numbers/tow) for months 1–5 (January–May, 1989–90 to 1999–2000 and 2007–08) (top); correlations of monthly indices for January–March with annual unstandardised CPUE indices (numbers/tow) for all vessels targeting squid (middle); and comparison of unstandardised CPUE in numbers per tow with standardised CPUE (t/tow), for the Snares target bottom trawl fishery.

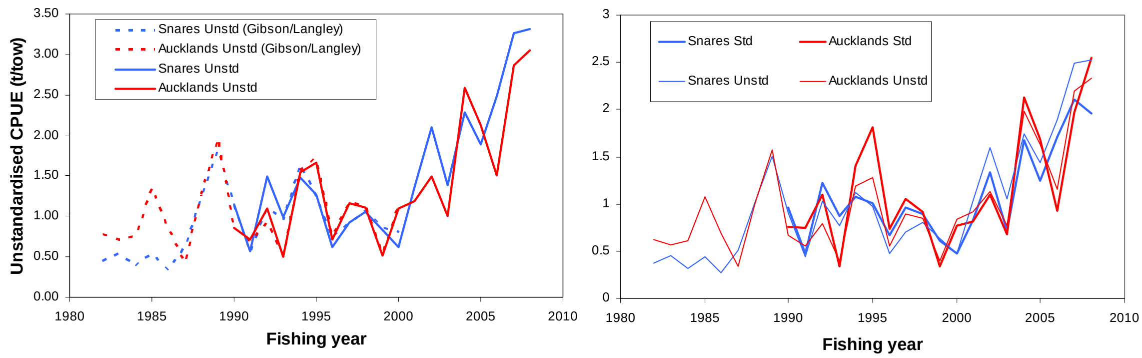


Figure E7: CPUE series for the Snares and Auckland Is. target trawl fisheries: unstandardised series derived from Gibson 1995 and Langley 2001 (1982–2000) and this study (1990–2008), including zero tows (left); and combined unstandardised CPUE series and standardised CPUE series from this study (1990–2008) (right).

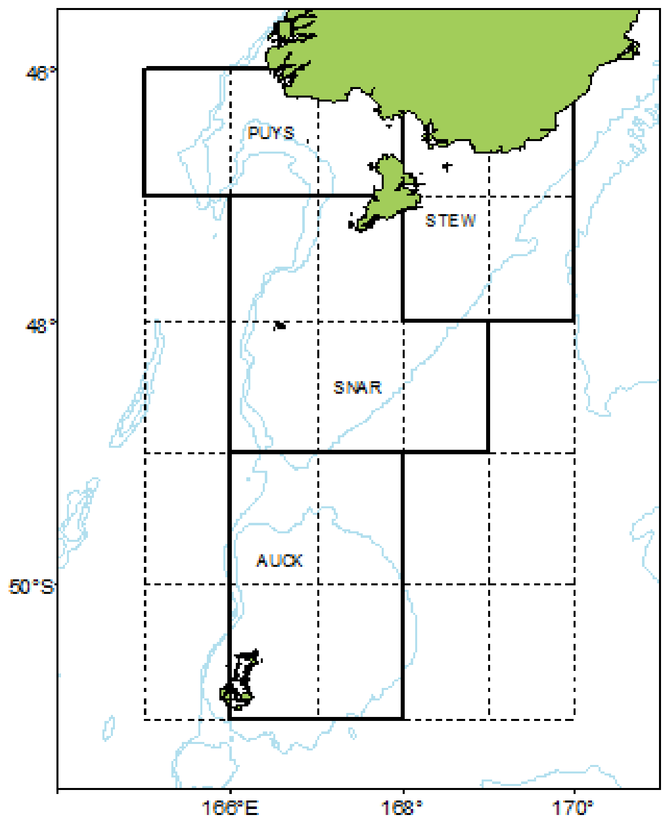


Figure E8: Areas defined for analysis of sea surface temperature (from 1° latitude x 1° longitudinal data): PUYS, Puysegur; STEW, eastern Stewart I.; SNAR, Snares Is.; and AUCK, Auckland Is.

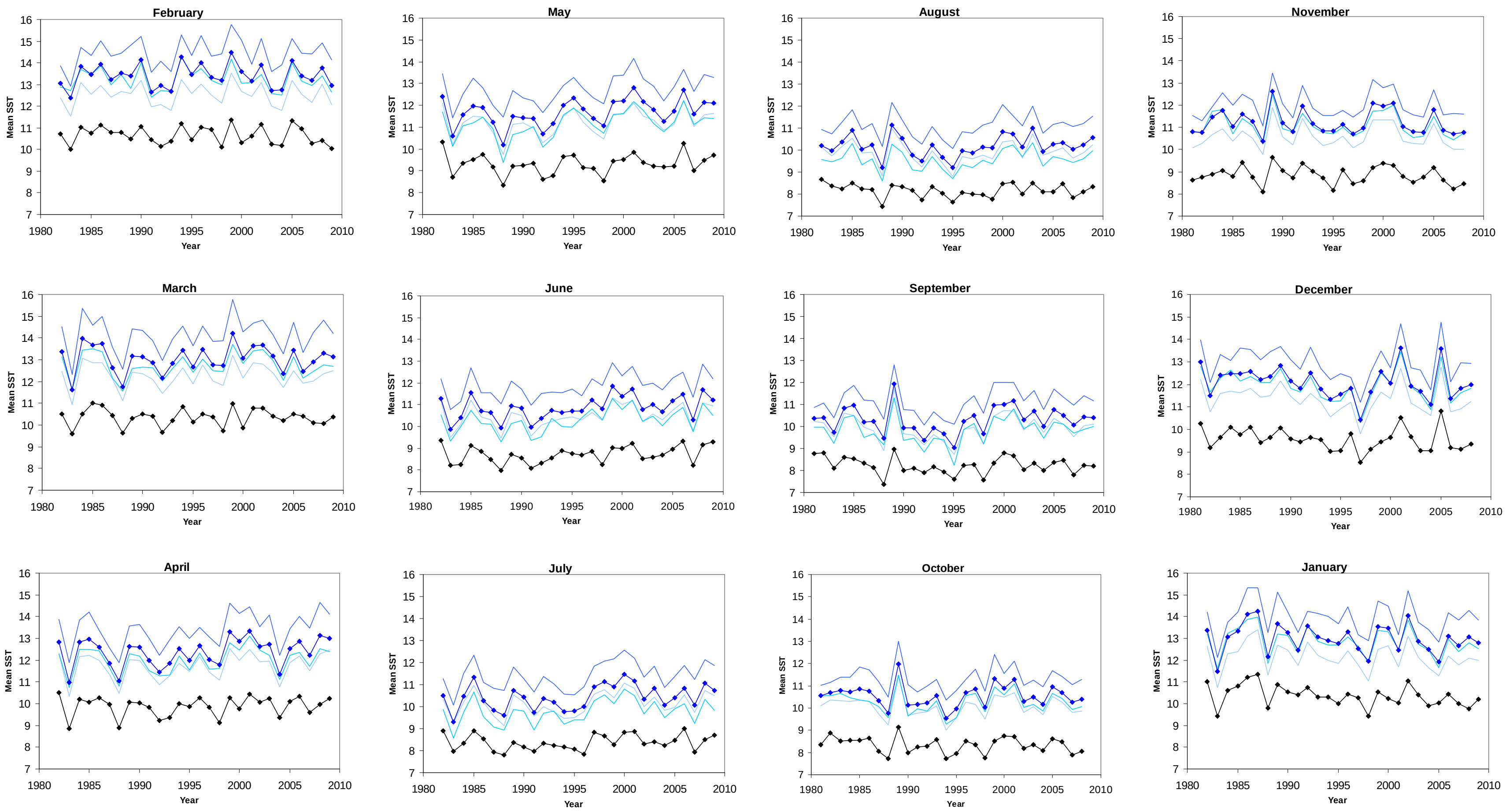


Figure E9: Monthly sea surface temperature for the STHLD (blue bold line with triangles) and AUCK (black bold line with triangles) areas. Sub-areas of Southland (fine blue lines with no symbol) are, from top to bottom: PUYS, STEW, SNAR (areas as in Figure E8).

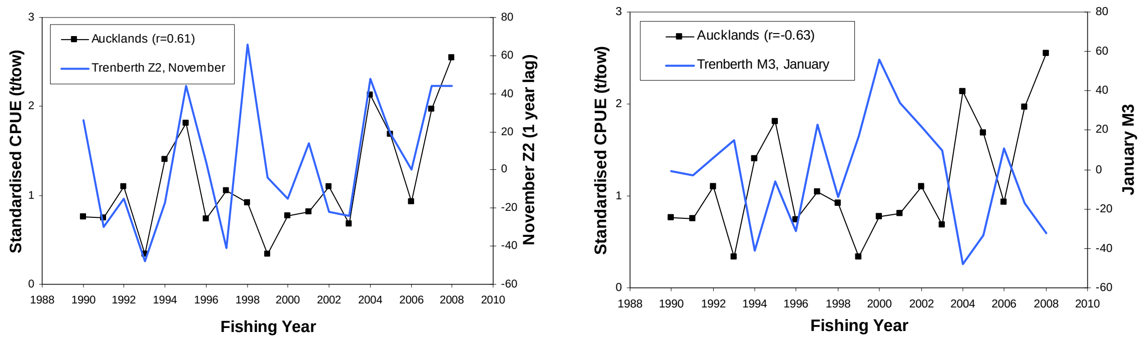


Figure E10a: CPUE series that showed the highest correlations with "Trenberth" indices: pre-season Auckland Is. CPUE and November Z2 (westerlies over southern NZ) (left); b. in-season Auckland Is. CPUE and January M3 (southerlies over western NZ) (right)

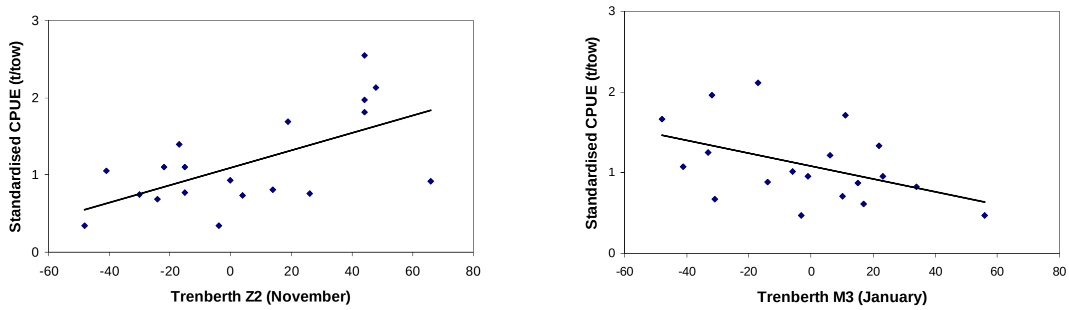


Figure E10b: Regression lines for pre-season Auckland Is. CPUE and November Z2 (westerlies over southern NZ) (left); in-season Auckland Is. CPUE and January M3 (southerlies over western NZ) (right).

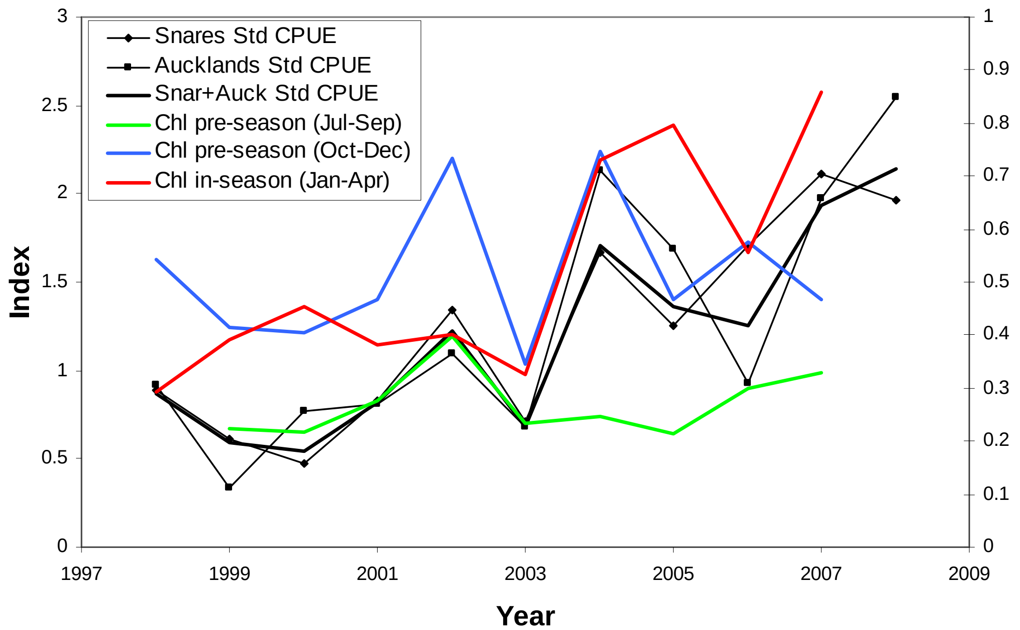


Figure E11a: Correlations of pre-season and in-season ocean colour (Chl) indices with Snares and Auckland Is. CPUE (separately and combined), September 1997– April 2008

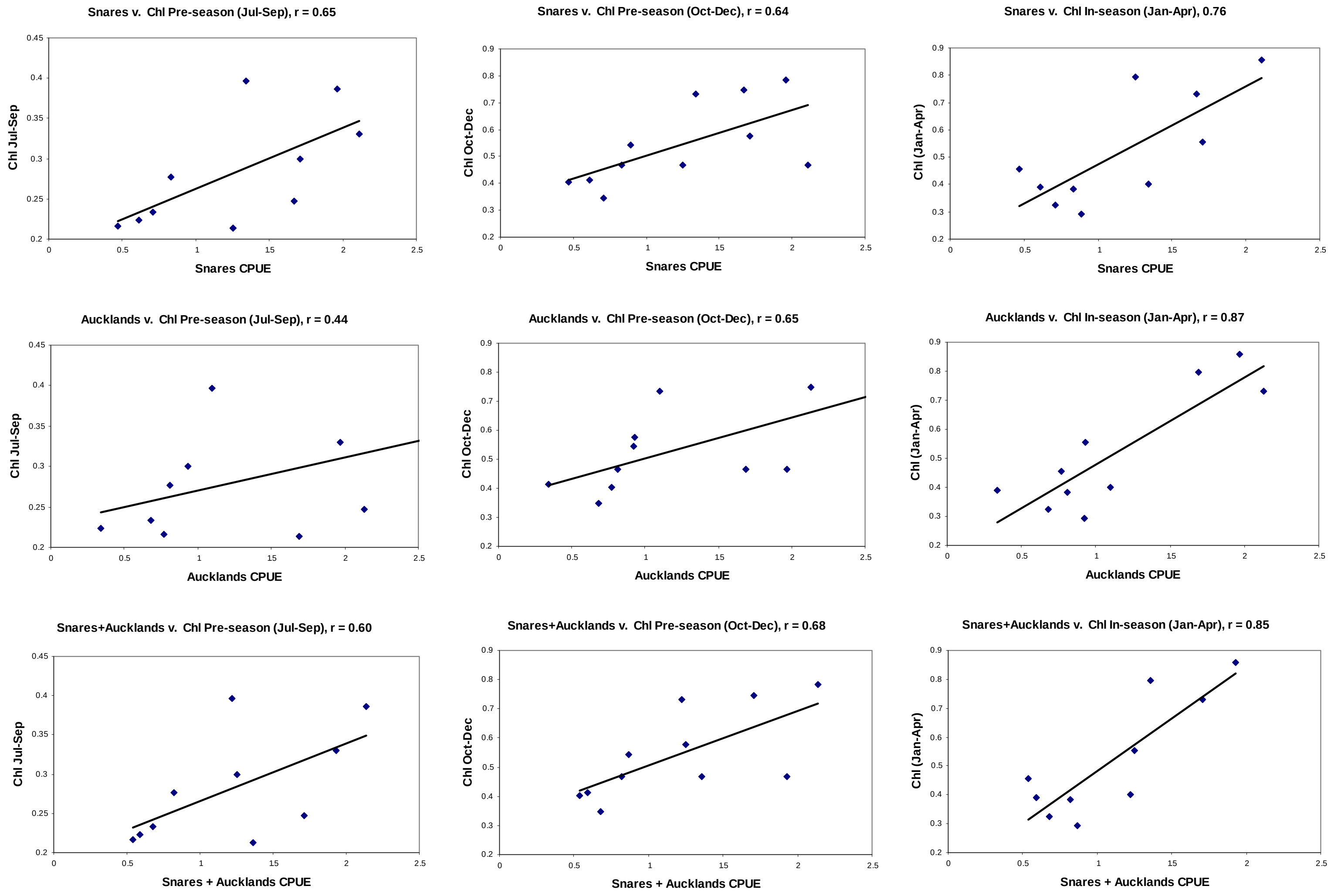


Figure E11b: Correlations of ocean colour (Chl) with Snares and Auckland Is. standardised CPUE (separately and combined), pre-season (Jul–Sep and Oct–Dec) and in-season (Jan–Apr).