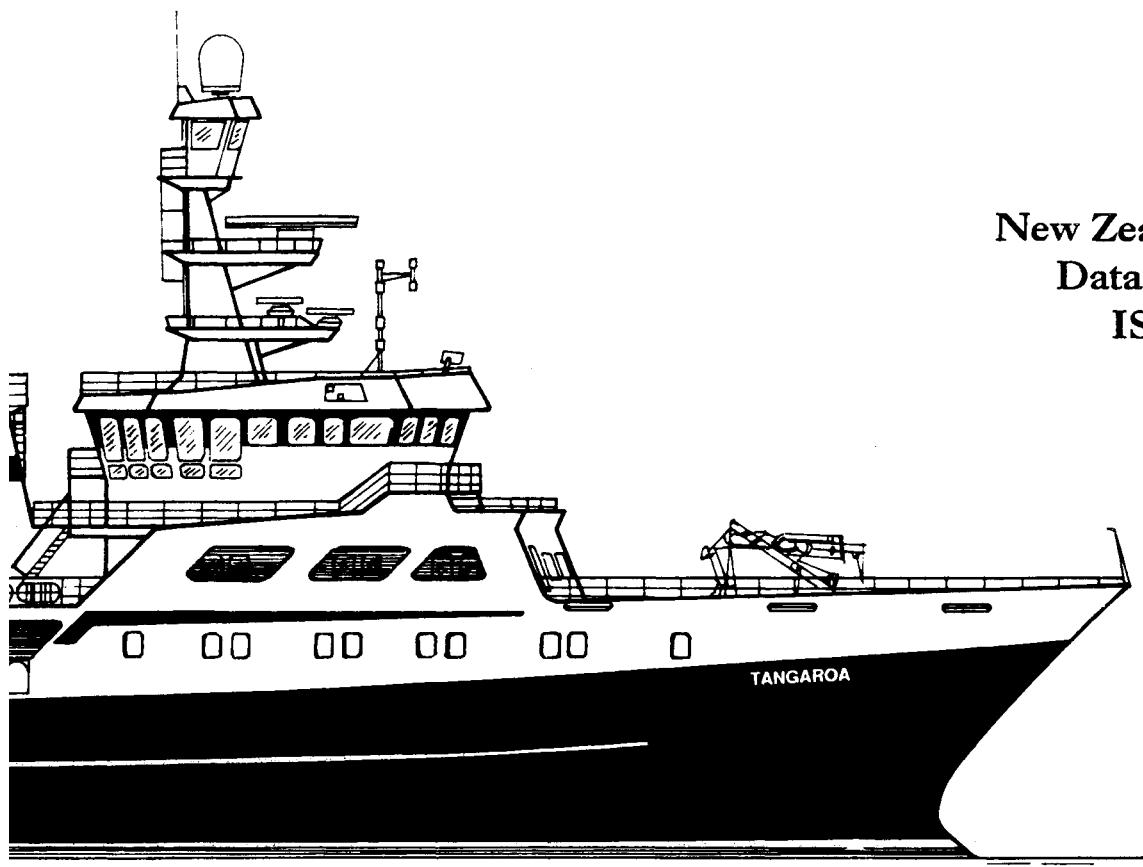


**Trawl survey of hoki and associated species
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November-December 1991
(TAN9105)**

**T. D. Chatterton
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Contents

Introduction

This report presents results from a bottom trawl survey of hoki (*Macruronus novaezelandiae*) and other middle depth species conducted during November-December 1991 in the Southland and Sub-Antarctic areas (TAN9105) from GRV *Tangaroa*. Its main purpose is to outline the survey design and methods, and to make available certain data on various ITQ and commercially important non-ITQ species which are relevant to stock assessment and fisheries management. Some preliminary results from this survey were presented by Chatterton *et al.* (1992).

It is currently assumed that there are two stocks of hoki: (1) the western stock comprising fish which spawn on the west coast South Island (WCSI) and Puysegur and reside for the rest of the year in the Sub-Antarctic, and (2) the eastern stock which spawns in Cook Strait and resides on the Chatham Rise (Livingston 1990, Livingston *et al.* 1992, Sullivan & Cordue 1992). Biomass estimates of the western stock are currently derived from models using catch per unit effort and acoustic data from the west coast fishery. For the eastern stock, biomass estimates have been determined from trawl surveys of the Chatham Rise in 1983, 1986, and 1989. However, recent stock assessments (Sullivan & Cordue 1992) have highlighted the uncertainty surrounding the estimates of both stock sizes.

Random trawl surveys of the southern area began in 1978–79 with the *Wesermünde* (Francis 1981). Subsequently there have been several random bottom trawl surveys covering the entire Southland and Sub-Antarctic Fisheries Management Areas (FMAs) – notably those with the *Amaltal Explorer* in 1989 (AEX8902) and 1990 (AEX9002) (Hurst & Schofield 1990, 1991).

The 1991 *Tangaroa* survey (TAN9105) of the Southland and Sub-Antarctic areas was the first of a new series of trawl surveys aimed at assessing changes in hoki biomass over the next 5–10 years. The results will be used to model changes in hoki biomass over time and to determine the optimum yield of the western stock.

The major objectives of the research programme are as follows.

1. To develop a time series of relative recruited biomass indices for hoki in the Southland and Sub-Antarctic FMAs.
2. To develop a time series of relative recruited biomass indices for associated species, including hake (*Merluccius australis*), ling (*Genypterus blacodes*), silver warehou (*Seriolella punctata*), and southern blue whiting (*Micromesistius australis*).
3. To provide data for determining growth rates, productivity, and stock relationships of hoki and associated species.

Objectives of the survey

The objectives of the survey were as follows.

1. To estimate recruited biomass of hoki in the Southland and Sub-Antarctic FMAs.
2. To estimate recruited biomass of southern blue whiting, hake, ling, and other associated species.
3. To collect biological data (length frequencies, sex ratios, otoliths, gonad state, genetic samples, morphometrics, etc.) for determination of recruited biomass, growth rates, productivity, and stock relationships of hoki and associated species.
4. To define major water mass characteristics within the survey area by recording surface and bottom temperatures at each trawl station.

5. To collect bathymetric data to refine stratum boundaries.

Project and voyage personnel

The voyage was divided into two parts with different vessel and scientific crews on each. Project leader: S. Hanchet. Part 1 (12 November-2 December): Voyage leader, S. Hanchet; Skipper, A. Leachman. Part 2 (4 December-23 December): Voyage leader, N. Bagley; Skipper, R. Goodison. Final database editing: T. Chatterton.

Methods

Survey area and design

The Southland and Sub-Antarctic survey areas were divided into 17 strata by depth (300–600 m, 600–800 m) and area (Figure 1 and Table 1). Known areas of foul ground were excluded from the survey. An additional depth zone, 800–1000 m, was added for the Puysegur area because earlier surveys had caught significant amounts of hake there. The stratum boundaries used and depth ranges sampled were similar to those used on the *Amalat Explorer* survey (AEX9001) in July-August 1990 (Hurst & Schofield 1991) except for the inclusion of the deeper stratum at Puysegur, the exclusion of the 600–800 m stratum on the Bounty Platform, and a change in stratum boundaries in each of the Puysegur strata.

The survey was of a two-phase stratified random trawl design (Francis 1984). Phase 1 stations were allocated objectively, based on the distribution and catch rates of hoki in previous surveys. The survey began on 13 November and finished on 23 December 1991. A total of 143 phase 1 stations were successfully completed, with 11 phase 2 stations sampled in strata 1, 4, and 14 (Figure 2, Table 1, and Appendix 1). These were aimed at improving the precision in biomass estimates of juvenile hoki, hake, and adult hoki respectively.

The Bounty Plateau (stratum 17) was not sampled because of time and weather constraints.

Vessel specifications

Tangaroa is a purpose-built research stern trawler operated by the New Zealand Ministry of Agriculture and Fisheries. It has the following specifications: length overall, 70.0 m; beam, 13.8 m; tonnage, 2282 GRT; horsepower, 3000 kW.

Gear specifications

The net was an 8 seam bottom trawl net with a 58.8 m groundrope and 45 m headrope. The codend mesh size was 60 mm. The sweeps were 100 m long, bridles were 50 m, and backstrops 12 m. Plans of the overall net, float positions, groundrope, codend, and sweeping gear are given in Appendix 2. Further details of the net design and assembly are given in Hurst *et al.* (1992). The trawl doors were Super-V type with an area of 6.1 m². Doorspread and headline heights were recorded from the SCANMAR system and Kaijo Denki net monitor

respectively at 2 minute intervals and the average for the tow calculated. Wingspread measurements could not be obtained because no wingspread sensors were available.

Trawling procedure

All station positions were randomly selected. If a station occurred in an area of foul ground, then the area within 3 n. miles of the position was searched for suitable bottom. If no tow was possible, then the station was abandoned and another random position chosen. If the depth was not in the correct range, the vessel steamed into deeper or shallower water until the appropriate depth was reached. Trawling was conducted between sunrise and sunset, with trawl times recorded as New Zealand Standard Time (NZST). If time was limiting at the end of the day and it was not possible to steam the full distance to the next tow position, then the vessel headed in the direction of the next tow and shot the trawl away leaving enough time to complete the tow before dark. All trawl paths were separated by a minimum of 3 n. miles. Tows were 3 n. miles in length and made at a speed over the ground of 3.5 knots. GPS was unavailable for three periods during the survey and SATNAV was used. When SATNAV was in use the speed of the ship was kept at about 3.5 knots and the net towed for 51 minutes, which corresponds to a distance of 3 n. miles: the calculated distance from latitude and longitude positions was ignored.

To maintain doorspread at 100–130 m, the following warp to depth (W:D) ratios were used:

Depth (m)	W:D ratio
300–350	2.6 : 1
350–500	2.4 : 1
500–800	2.3 : 1

These ratios were established from gear trials conducted in August 1991 (Hurst *et al.* 1992). Given a doorspread in the preferred range, the headline height should range from 6.0 to 7.5 m. Weather, sea conditions, and water currents were found to influence doorspread and headline height, but at most stations these parameters were maintained in the preferred range.

Surface and bottom temperatures

Surface temperature readings for each station were taken from the hull mounted sensor. Bottom temperatures were recorded by a SCANMAR temperature sensor attached to the net headline. The calibration of both sensors was uncertain, so surface and bottom temperatures should be treated as relative readings only. The SCANMAR temperature sensor was accurate to $\pm 0.1^\circ\text{C}$.

Catch and biological sampling

The catch at each station was sorted into species and weighed on motion-compensating electronic scales to the nearest 0.3 kg. Samples of up to 200 hoki and 50–200 of other commercial species were randomly selected from the catch to measure length and sex. Twenty fish of the main species (hoki, hake, ling, southern blue whiting, and silver warehou) were

then randomly selected for more detailed biological analysis on at least two tows per day. Data included length, fish weight, sex, gonad stage and weight, and stomach fullness, condition and contents. Hoki gonads were preserved from all hoki thus examined and taken back to MAF Fisheries Greta Point for histological examination by M. Livingston. Otoliths were taken from all fish examined for ageing studies. Additional otoliths were collected from hoki and southern blue whiting from each area to provide enough in each length class to enable age-length keys to be produced.

Data analysis

Doorspread biomass was estimated using the area-swept method described by Francis (1981, 1989). Vertical and areal availability (note that stratum areas do not include adjacent foul ground), and vulnerability were assumed to be 1 for all species biomass estimations. Total biomass refers to an estimate using catch data from all strata. Recruited biomass refers to the biomass calculated for fish greater than or equal to the mean size of 50% recruitment to the commercial fishery. For hoki this equates to a total length of 65 cm. For modelling purposes a hoki size at recruitment of 55 cm total length is also sometimes used and so a recruited biomass based on this length has also been included.

Mean values for doorspread and tow speed are contained in Table 2. Default values used in the trawl survey analysis programme were 126.5 m for constant doorspread and 3.5 knots for constant speed. Gear performance was set to match codes 1 and 2 only. Valid survey station numbers begin at 11 and end at 165 (stations 1 to 10 apply to gear trials carried out on the Chatham Rise and have been excluded from the trawl survey database). Station 23 was a foul shot and should be excluded from all analyses (see Appendix 1).

Phase 2 stations were 74 and 75 (stratum 14), 156, 157, 158 and 160 (stratum 1), and 161, 162, 163, 164, and 165 (stratum 4).

Scaled length frequencies were calculated using the FRC trawl survey biomass program (Version as at February, 1992). This program scales length frequency data from each station by the percentage of catch sampled (to represent the catch) and the area swept, and further scales these values by the stratum area and the ratio of calculated catch biomass over calculated length frequency biomass (to represent the total stratum population). On each length frequency figure is an estimate of the actual population number, and its coefficient of variation (c.v. %), and the number of tows sampled (*n*).

Results

Biomass estimates

Total and recruited biomass estimates for the major ITQ, commercial non-QMS, and non-commercial non-QMS species are contained in Table 3.

Total biomass estimates for the top 20 species by stratum are listed in Table 4. Recruited biomasses for hoki and southern blue whiting are also included.

Catch rates

Catch rates ($\text{kg} \cdot \text{km}^{-2}$) for the top 20 species by stratum are given in Table 5.

The station catch rates for hake, hoki, ling, silver warehou and southern blue whiting are shown in Figures 3a-e.

Surface and bottom temperatures

Surface and bottom temperature maps are shown in Figures 4 and 5. The isotherms have been fitted by eye.

Length frequencies and biological data

Scaled length frequencies for hoki are presented for the total area (Figure 6a) and by individual strata (Figure 6b). They are combined for southern blue whiting by area in Figure 6c, and presented for the total area for the remaining commercial species (ling, hake, silver warehou, white warehou, black oreo, orange roughy, lookdown dory, ribaldo, arrow squid, and spiny dogfish) in Figures 6d-i.

The number of length frequency and biological samples taken for each species is given in Table 6. The length-weight relationship coefficients used for the final scaling of length frequency data by the ratio of recorded biomass over calculated biomass are listed in Table 7.

Table 8 contains a summary of the reproductive states, as defined by stage of gonad maturity, of various species (hake, hoki, orange roughy, and southern blue whiting) sampled during the survey.

A list of all species caught is given in Appendix 3.

Discussion

This initial survey in the time series of trawl surveys of the Southland and Sub-Antarctic areas was successful in achieving its main objectives. The estimated recruited biomass of hoki of 79 479 t was relatively precise with a *c.v.* of only 6.7%. A good abundance index (*c.v.* = 6.8%) was also obtained for ling. The high biomass *c.v.s* for hake (43.4%), silver warehou (46.4%), and southern blue whiting (27.2%) are probably due to their patchy distribution and, for silver warehou and southern blue whiting, their demersal/pelagic life style. The station allocation for future surveys will remain similar although the number of phase one stations will be reduced slightly to enable more second phase sampling.

Acknowledgments

We thank the scientific staff who assisted on this survey, the officers and crew of GRV *Tangaroa* for their helpful cooperation, and G. Mackay and T. Crayford for producing the survey maps and catch rate figures.

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Table 1: Stratum areas and number of phase 1 and 2 stations surveyed and used in estimation of biomass

Stratum	Depth (m)	Area (km ²)	Phase 1		Phase 2		Total
			Planned	No. of stations Actual	No. of stations	No. of stations (per km ²)	
1	Puysegur	300–600	2 150	3	4	1 : 307	
2	Puysegur	600–800	798	3	0	1 : 266	
3	Puysegur	800–1000	823	4	0	1 : 206	
4	Snares Shelf	300–600	5 130	3	5	1 : 641	
5	Snares Shelf	600–800	20 727	8	0	1 : 2303	
6	Snares/Auckland Is	300–600	6 279	4	0	1 : 1570	
7	Auckland Is	300–600	16 767	8	0	1 : 2096	
8	Auckland Is	600–800	8 372	5	0	1 : 1674	
9	West Pukaki	600–800	17 349	15	0	1 : 1157	
10	West Campbell	300–600	27 359	14	0	1 : 1954	
11	West Campbell	600–800	11 145	11	0	1 : 1013	
12	Central Pukaki	600–800	23 121	11	9	1 : 2569	
13	Central Pukaki	300–600	45 227	21	0	1 : 2154	
14	N/E Campbell	300–600	36 090	10	2	1 : 3008	
15	East Campbell	300–600	27 404	15	0	1 : 1957	
16	East Campbell	600–800	15 034	10	9	1 : 1670	
17	Bounty Platform	300–600	11 357	0	0	0	
	Total		275 132	11	11	1 : 1787	

Table 2: Gear parameters by depth (s.d. is standard deviation)

Depth range (m)	No. of stations	Tow length (n. mile)		Tow speed (knots)		Doorspread (m)		Headline height (m)	
		Mean	s.d.	Mean	s.d.	Mean	s.d.	Mean	s.d.
300-600	85	3.0	0.18	3.5	0.03	126.1	5.90	6.6	0.33
600-800	65	3.0	0.12	3.5	0.08	126.9	8.47	6.7	0.29
800-1000	4	3.0	0.00	3.5	0.00	126.9	3.63	6.5	0.21
Total	154	3.0	0.15	3.5	0.06	126.5	7.05	6.6	0.31
								17.1	1.17

* Calculated as sweep angle = $-2.46 + 0.155$ doorspread (m) (after Hurst *et al.* 1992).

Table 3: Total and recruited biomass (t) estimates for the major species

Species code	Common name	Total biomass (t)	c.v. (%)	Recruited biomass (t)	c.v. (%)	Recruited size (cm)
ITQ species						
HOK	hoki	80 364	6.8	79 479	6.7	≥ 55
				73 887	6.4	≥ 65
LIN	ling	24 102	6.8	—	—	
HAK	hake	5 686	43.2	—	—	
BOE	black oreo	4 143	97.3	—	—	
SWA	silver warehou	942	46.4	—	—	
STA	stargazers	343	21.9	—	—	
NOS	arrow squid	257	31.2	—	—	
RCO	red cod	102	52.1	—	—	
ORH	orange roughy	70	67.9	46	99.4	≥ 32
SKI	gemfish	49	28.5	—	—	
SCH	school shark	24	71.9	—	—	
HAP	hapuku	10	100.0	—	—	
BNS	bluenose	9	100.0	—	—	
SSO	smooth oreo	< 1	54.5	—	—	
Commercial non-QMS species						
GSP	pale ghost shark	11 205	6.1	—	—	
SPD	spiny dogfish	8 502	55.4	—	—	
SBW	southern blue whiting	6 131	27.2	6 120	27.3	≥ 25
WWA	white warehou	1 422	55.2	—	—	
RIB	ribaldo	1 088	11.0	—	—	
LDO	lookdown dory	1 079	12.9	—	—	
GSH	dark ghost shark	1 034	25.4	—	—	
SSK	smooth skate	382	23.1	—	—	
SPE	sea perch	82	71.0	—	—	
EPT	deepsea cardinalfish	3	86.7	—	—	
RBM	Ray's bream	2	100.0	—	—	
JMM	Peruvian (slender) mackerel	1	100.0	—	—	
SOR	spiky oreo	1	100.0	—	—	
Non-commercial non-QMS species						
JAV	javelinfish	13 751	12.5	—	—	
WSQ	warty squid	1 561	8.1	—	—	
CAS	oblique banded rattail	1 538	31.2	—	—	
LCH	longnosed chimaera	742	13.4	—	—	
MCA	ridge-scaled rattail	707	38.6	—	—	
COL	Oliver's rattail	560	17.7	—	—	
MAN	finless flounder	550	14.7	—	—	
CSQ	leafscaled gulper dogfish	521	32.7	—	—	
SSI	silverside	520	14.4	—	—	
SND	shovelnosed dogfish	476	25.2	—	—	
BSH	seal shark	9	85.1	—	—	
Total	all species	170 182	6.0	—	—	

Table 4: Estimated biomass (t) and coefficients of variation* (%) of the 20 major species[†] by stratum. Recruited biomass has been included for the important commercial species.

Stratum	Total	HOK		LIN total	JAV total	GSP total	SPD total	SBW	
		Recruited ≥ 55	Recruited ≥ 65					Total	Recruited
1	2 012	1 176	215	646	19	5	32	0	0
	(75)	(68)	(48)	(21)	(44)	(68)	(60)	(0)	(0)
2	131	131	119	49	101	5	0	0	0
	(31)	(31)	(34)	(39)	(49)	(76)	(0)	(0)	(0)
3	79	79	78	17	166	2	0	0	0
	(55)	(55)	(56)	(83)	(41)	(91)	(0)	(0)	(0)
4	5 413	5 530	4 123	1 188	228	218	2 281	0	0
	(31)	(32)	(36)	(24)	(56)	(49)	(72)	(0)	(0)
5	6 563	6 363	6 278	812	767	2 299	40	0	0
	(44)	(44)	(45)	(26)	(15)	(12)	(52)	(0)	(0)
6	795	795	739	336	510	509	31	0	0
	(35)	(35)	(35)	(26)	(38)	(52)	(41)	(0)	(0)
7	8 244	8 229	6 466	1 345	307	166	5 516	154	154
	(28)	(28)	(22)	(22)	(55)	(73)	(80)	(68)	(68)
8	1 656	1 656	1 634	689	632	164	0	0	0
	(23)	(23)	(22)	(38)	(28)	(21)	(0)	(0)	(0)
9	4 102	4 102	3 987	1 219	2 751	726	91	1	1
	(13)	(13)	(13)	(14)	(30)	(14)	(32)	(100)	(100)
10	10 760	10 759	10 318	4 897	707	1 401	327	619	619
	(11)	(11)	(11)	(21)	(33)	(24)	(78)	(99)	(99)
11	4 073	4 073	4 053	464	569	211	0	0	0
	(25)	(25)	(25)	(34)	(18)	(21)	(0)	(0)	(0)
12	5 545	5 545	5 485	1 180	1 124	426	5	0	0
	(25)	(25)	(25)	(29)	(22)	(30)	(100)	(0)	(0)
13	8 272	8 272	8 169	4 462	1 341	2 699	165	3 037	3 026
	(13)	(14)	(14)	(15)	(23)	(32)	(75)	(31)	(31)
14	8 388	8 388	8 149	3 078	2 011	1 680	16	176	175
	(12)	(12)	(13)	(20)	(55)	(10)	(100)	(58)	(58)
15	9 164	9 164	9 017	2 566	1 212	615	0	2 145	2 145
	(16)	(16)	(16)	(18)	(54)	(21)	(0)	(57)	(57)
16	5 166	5 166	5 058	1 157	1 306	79	0	0	0
	(23)	(23)	(24)	(17)	(42)	(53)	(0)	(0)	(0)
17	—	—	—	—	—	—	—	—	—
Total	80 364	79 479	73 887	24 102	13 751	11 205	8 502	6 131	6 120
	(7)	(7)	(6)	(7)	(13)	(6)	(55)	(27)	(27)

* Coefficients of variation are in parentheses.

† Species codes are given in Appendix 3.

Table 4 – continued

Stratum	HAK total	BOE total	WSQ total	CAS total	WWA total	RIB total	LDO total	GSH total
1	2 (65)	0 (0)	< 1 (65)	1 (76)	4 (72)	9 (72)	9 (41)	49 (65)
2	85 (77)	0 (0)	8 (53)	0 (0)	2 (100)	36 (24)	1 (100)	1 (100)
3	134 (40)	0 (0)	7 (39)	0 (0)	3 (62)	19 (30)	0 (0)	0 (0)
4	2 752 (88)	0 (0)	2 (73)	36 (42)	927 (84)	8 (100)	76 (33)	185 (64)
5	425 (33)	0 (0)	106 (26)	0 (0)	201 (45)	127 (30)	37 (56)	0 (0)
6	238 (35)	0 (0)	42 (13)	9 (90)	0 (0)	58 (56)	0 (0)	101 (100)
7	276 (44)	0 (0)	53 (30)	632 (73)	14 (66)	46 (84)	185 (45)	527 (34)
8	41 (80)	0 (0)	87 (39)	0 (0)	0 (0)	55 (45)	13 (66)	0 (0)
9	738 (33)	0 (0)	146 (24)	3 (71)	59 (51)	208 (17)	16 (69)	0 (0)
10	690 (26)	0 (0)	121 (36)	51 (55)	58 (48)	108 (35)	104 (36)	86 (100)
11	62 (58)	0 (0)	142 (18)	1 (69)	10 (70)	63 (35)	0 (0)	3 (100)
12	83 (67)	4 109 (98)	186 (26)	12 (87)	39 (71)	274 (26)	6 (82)	67 (100)
13	115 (60)	34 (100)	166 (29)	366 (20)	59 (35)	10 (100)	234 (18)	15 (100)
14	45 (100)	0 (0)	187 (20)	252 (24)	26 (54)	15 (100)	219 (28)	0 (0)
15	4 (100)	0 (0)	145 (29)	170 (52)	13 (51)	0 (0)	89 (49)	0 (0)
16	0 (0)	0 (0)	162 (27)	7 (80)	8 (100)	53 (53)	92 (50)	0 (0)
17	–	–	–	–	–	–	–	–
Total	5 686 (43)	4 143 (97)	1 561 (95)	1 538 (8)	1 422 (31)	1 088 (55)	1 079 (11)	1 034 (13)

Table 4 – continued

Stratum	SWA total	LCH total	MCA total	COL total	MAN total	CSQ total	All species total
1	8 (100)	0 (0)	0 (0)	5 (38)	0 (0)	96 (75)	3 193
2	0 (0)	0 (0)	0 (0)	3 (65)	0 (0)	31 (89)	790
3	0 (0)	0 (0)	5 (58)	1 (100)	0 (0)	1 (100)	753
4	900 (48)	12 (56)	1 (100)	8 (85)	0 (0)	0 (0)	14 019
5	0 (0)	76 (55)	86 (36)	130 (36)	13 (68)	0 (0)	11 809
6	0 (0)	8 (62)	19 (58)	72 (59)	3 (100)	199 (63)	3 123
7	22 (76)	0 (0)	0 (0)	0 (0)	0 (0)	4 (100)	16 733
8	0 (0)	24 (44)	21 (100)	19 (65)	6 (100)	81 (61)	3 583
9	7 (71)	20 (42)	0 (0)	198 (35)	15 (37)	79 (80)	10 222
10	0 (0)	81 (29)	0 (0)	26 (26)	21 (51)	0 (0)	20 185
11	0 (0)	8 (58)	173 (59)	49 (50)	10 (25)	30 (100)	6 533
12	5 (100)	23 (73)	338 (72)	20 (55)	3 (100)	0 (0)	14 112
13	0 (0)	231 (22)	0 (0)	< 1 (100)	126 (29)	0 (0)	22 472
14	0 (0)	201 (31)	0 (0)	3 (53)	191 (34)	0 (0)	16 414
15	0 (0)	40 (42)	0 (0)	2 (67)	130 (19)	0 (0)	17 352
16	0 (0)	20 (76)	65 (80)	26 (54)	32 (32)	0 (0)	8 889
17	—	—	—	—	—	—	—
Total	942 (46)	742 (13)	707 (39)	560 (18)	550 (15)	521 (33)	170 182 (6)

Table 5: Catch rates ($\text{kg} \cdot \text{km}^{-2}$) and standard deviation[†] of the 20 major species* by stratum

Stratum	HOK	LIN	JAV	GSP	SPD	SBW	HAK	BOE	WSQ	CAS	WWA	RIB	LDO	GSH	SWA	LCH	MCA	COL	MAN	CSO	All species
1	936 (1866)	301 (168)	9 (10)	2 (4)	15 (24)	0 (0)	1 (1)	0 (0)	<1 (<1)	2 (1)	2 (4)	4 (8)	4 (4)	23 (39)	4 (10)	0 (0)	0 (0)	2 (2)	0 (0)	45 (89)	1 485 (1829)
2	164 (89)	61 (41)	127 (106)	6 (8)	0 (0)	0 (0)	0 (141)	0 (0)	0 (0)	10 (3)	0 (3)	45 (19)	1 (2)	2 (3)	0 (0)	0 (0)	0 (0)	4 (4)	0 (0)	38 (59)	991 (516)
3	96 (106)	20 (33)	202 (166)	2 (4)	0 (0)	0 (129)	0 (0)	0 (0)	162 (14)	0 (4)	3 (14)	23 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (5)	1 (2)	0 (0)	1 (1)	915 (659)
4	1 055 (935)	232 (158)	44 (70)	43 (59)	0 (0)	536 (1 336)	0 (0)	1 (1)	7 (8)	181 (429)	2 (4)	15 (14)	36 (66)	2 (4)	175 (241)	2 (4)	2 (1)	2 (4)	0 (0)	0 (0)	2 733 (1 458)
5	317 (419)	39 (30)	111 (17)	2 (41)	0 (3)	0 (20)	0 (0)	5 (4)	0 (0)	21 (13)	0 (6)	10 (3)	6 (3)	2 (6)	0 (0)	0 (0)	4 (5)	6 (7)	1 (1)	0 (0)	570 (399)
6	127 (87)	53 (27)	81 (62)	5 (84)	0 (4)	38 (26)	0 (0)	7 (2)	1 (0)	0 (0)	9 (10)	0 (0)	16 (0)	0 (0)	1 (2)	3 (3)	3 (2)	1 (1)	<1 (1)	32 (40)	497 (173)
7	492 (391)	80 (49)	18 (29)	329 (21)	9 (743)	16 (18)	0 (21)	3 (0)	38 (78)	1 (2)	3 (7)	10 (14)	1 (3)	1 (3)	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	998 (923)
8	198 (100)	82 (71)	76 (48)	20 (9)	0 (0)	0 (0)	5 (0)	0 (0)	10 (0)	0 (0)	0 (0)	7 (10)	2 (0)	0 (0)	0 (0)	0 (0)	3 (3)	2 (2)	1 (1)	0 (0)	428 (178)
9	236 (116)	70 (37)	159 (183)	42 (22)	5 (6)	<1 (<1)	43 (55)	0 (0)	8 (8)	<1 (1)	3 (7)	12 (8)	1 (2)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	589 (297)
10	393 (155)	179 (143)	26 (32)	51 (45)	12 (35)	23 (84)	25 (25)	0 (0)	4 (6)	2 (4)	2 (5)	4 (5)	3 (5)	0 (0)	3 (0)	0 (0)	3 (3)	0 (0)	1 (1)	0 (0)	738 (245)
11	366 (307)	42 (47)	51 (30)	19 (13)	0 (0)	0 (0)	6 (10)	0 (0)	13 (8)	<1 (<1)	1 (2)	6 (7)	0 (0)	<1 (1)	0 (0)	1 (1)	1 (1)	1 (1)	0 (0)	1 (0)	586 (380)
12	240 (181)	51 (44)	49 (33)	18 (16)	<1 (1)	0 (0)	0 (7)	4 (523)	1 (6)	4 (4)	2 (9)	2 (1)	0 (0)	<1 (1)	0 (0)	1 (1)	1 (1)	1 (1)	0 (0)	0 (0)	610 (497)
13	183 (105)	99 (70)	30 (31)	60 (33)	4 (96)	0 (0)	3 (7)	1 (4)	4 (5)	1 (5)	2 (7)	1 (2)	0 (1)	>1 (4)	5 (2)	0 (1)	5 (5)	0 (0)	0 (0)	3 (4)	455 (264)
14	232 (101)	85 (59)	56 (105)	47 (16)	<1 (2)	5 (10)	1 (4)	0 (0)	5 (4)	1 (0)	5 (1)	7 (1)	1 (1)	<1 (1)	6 (6)	0 (0)	0 (0)	6 (6)	0 (0)	0 (0)	455 (173)
15	334 (211)	94 (66)	44 (93)	22 (18)	0 (0)	78 (173)	0 (1)	5 (6)	0 (6)	<1 (1)	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	633 (340)
16	344 (241)	77 (38)	87 (110)	5 (8)	0 (0)	0 (0)	0 (0)	0 (0)	11 (9)	0 (9)	0 (9)	4 (6)	1 (6)	0 (0)	0 (0)	0 (0)	6 (6)	0 (0)	0 (0)	2 (2)	591 (315)
																				17	

[†] Standard deviations are in parentheses.

* Species codes are given in Table 10.

Table 6: Numbers of fish for which length, sex, and detailed biological data were collected

Species code [†]	Length frequency data				Biological data		
	No. of samples	No. of fish	No. of males	No. of females	No. of samples	No. of fish	No. of otoliths
BOE	2	237	94	107	0	0	0
HAK	61	669	337	332	50	271	271
HAP	1	2	1	1	0	0	0
HOK	152	18 491	7 405	11 086	61	1 186	> 1 186*
JMM	1	1	1	0	0	0	0
LDO	74	292	123	163	0	0	0
LIN	148	3 659	1 579	2 080	97	1 106	1 106
NOS	27	247	160	86	0	0	0
ORH	7	241	127	108	6	67	67
RBM	1	3	3	0	0	0	0
RCO	11	57	42	15	0	0	0
RIB	62	249	23	226	0	0	0
SBW	46	2 391	946	1 445	19	328	> 328*
SCH	2	2	0	2	0	0	0
SKI	10	23	15	8	0	0	0
SPD	28	292	108	184	0	0	0
SSO	3	6	4	2	3	6	6
STA	21	90	31	59	0	0	0
SWA	9	780	372	408	0	0	0
WWA	43	266	185	76	0	0	0

† Species codes are given in Appendix 3.

* Extra otoliths were collected from length frequency samples.

Table 7: Length weight relationships (log – log regression) used in scaled length frequency analysis

Species code*	<u>Regression coefficient</u>		<i>r</i>	<i>n</i>	Range (cm)	Data source
BOE	0.04050	2.809	–†	2 690	12–44	AEX8703
HAK	0.00606	3.049	0.975	669	49–128	TAN9105
HOK	0.00476	2.880	0.975	1 182	35–107	TAN9105
LDO	0.03133	2.887	–	20	12–56	SHI8301
LIN	0.00219	3.172	0.934	1 104	41–128	TAN9105
NOS	0.02900	3.000	–	–	≥ 3	Mattlin <i>et al.</i> (1985)
ORH	0.09630	2.680	–	2 500	9–45	KTN8201
RIB	0.00200	3.405	0.969	31	47–73	TAN9211
SBW	0.00141	3.406	0.983	327	23–58	TAN9105
SPD	0.00208	3.150	0.994	1 300	20–110	Hanchet (1986)
SWA	0.01158	3.112	0.984	70	30–60	AEX8902 and AEX9002
WWA	0.02900	2.971	–	–	–	Gavrilov (1979)

* Species codes are given in Appendix 3.

† Not given.

Table 8: Numbers of male and female hake, hoki, orange roughy (ORH), and southern blue whiting (SBW) at each reproductive stage*

Gonad stage	Hake			Hoki			Orange Roughy			Southern blue whiting		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
1	6	6	0	50	40	10	63	36	27	10	4	6
2	107	34	73	1 104	400	704	3	0	3	290	121	169
3	26	5	21	2	0	2	1	1	0	0	0	0
4	35	33	2	1	1	0	0	0	0	0	0	0
5	7	7	0	0	0	0	0	0	0	0	0	0
6	1	1	0	0	0	0	0	0	0	0	0	0
7	87	0	87	4	1	3	0	0	0	27	2	25
Total	269	86	183	1 161	442	719	67	37	30	327	127	200

* Stage: 1 – immature, 2 – resting, 3 – ripening, 4 – ripe, 5 – running ripe, 6 – partially spent, 7 – spent. Reproductive stages were described in detail by Hurst *et al.* (1992).

NB: Data from ling have not been shown because of uncertainty in staging their gonad maturity state.

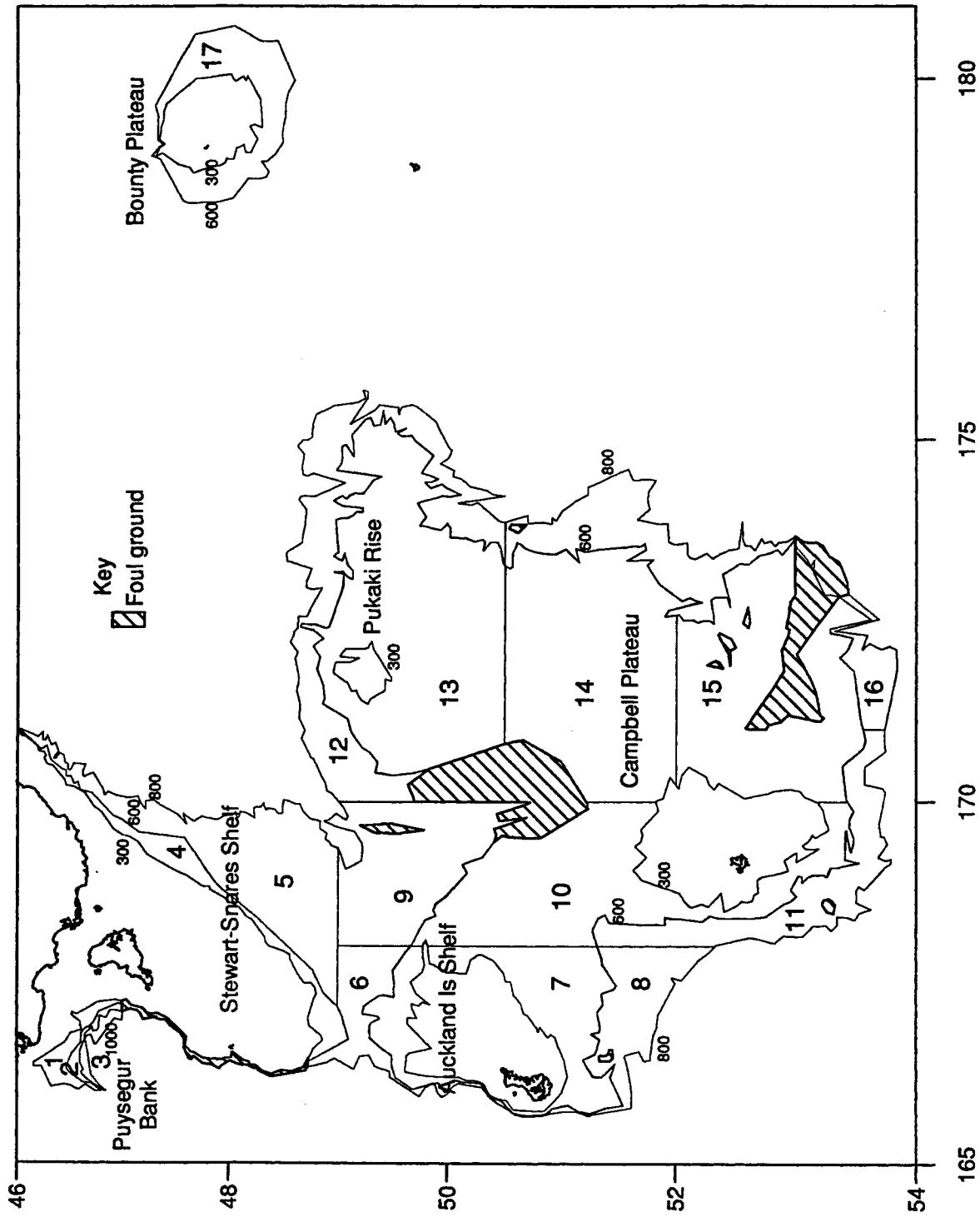
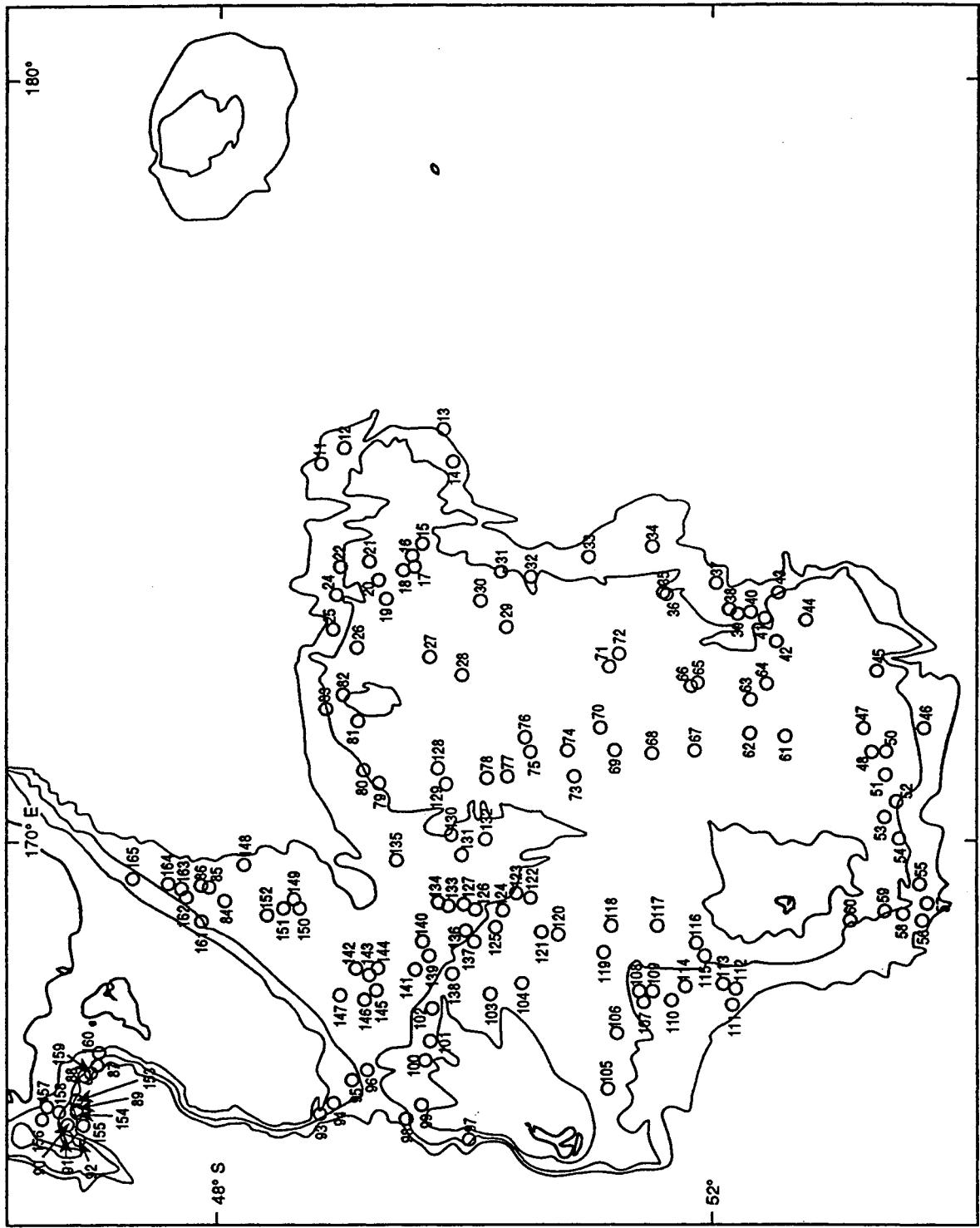


Figure 1. Strata boundaries and numbers.



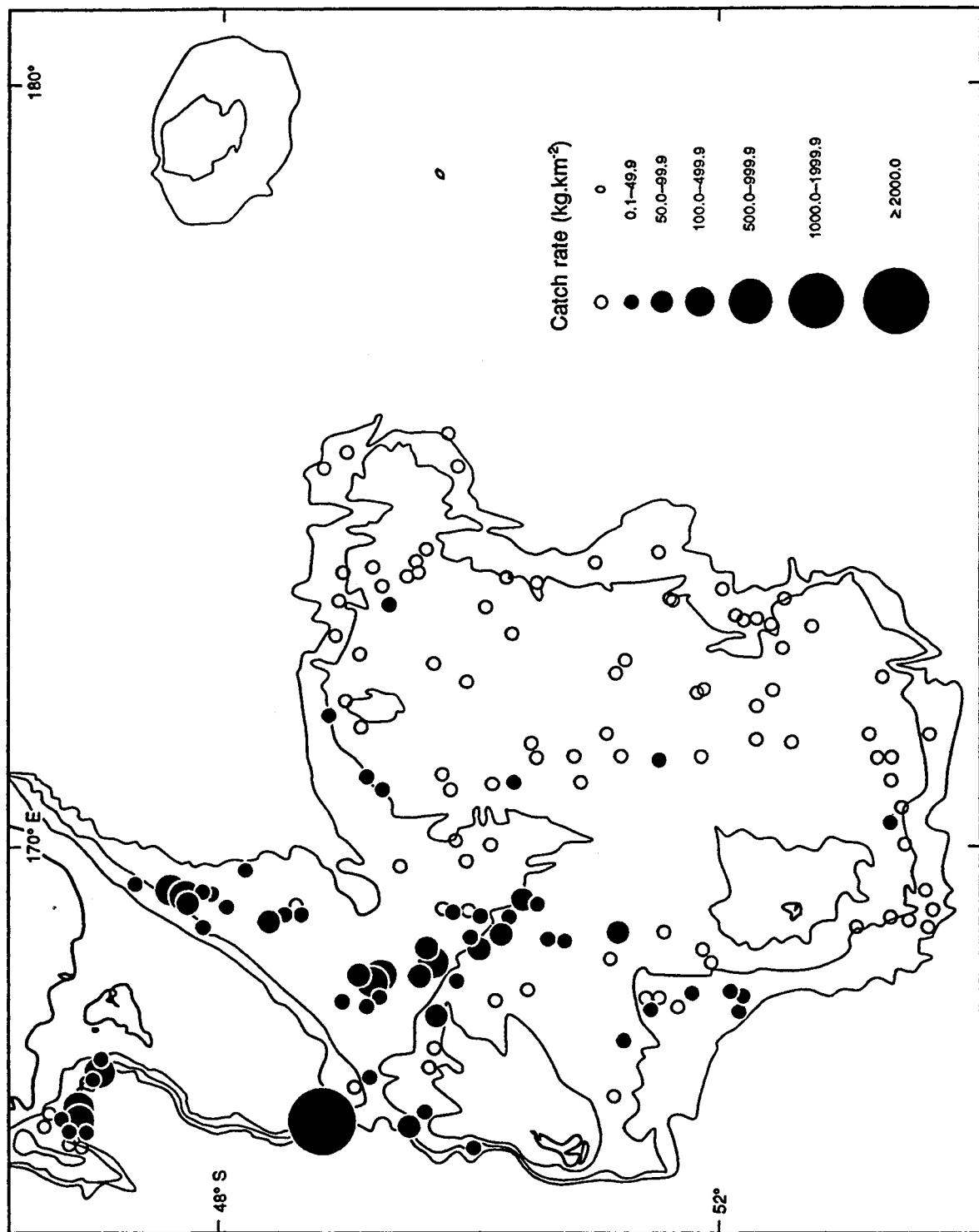


Figure 3a. Catch rates of hake.

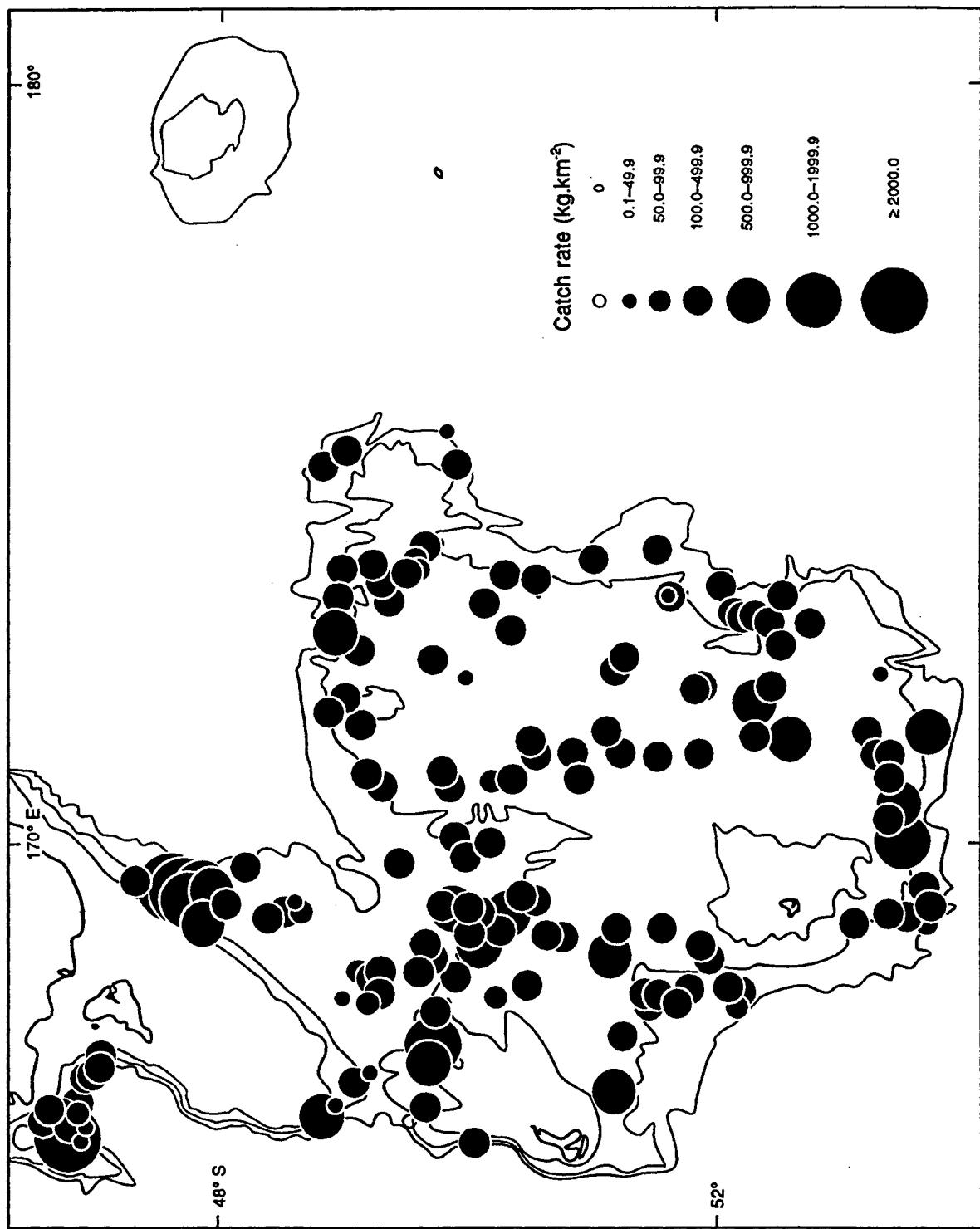


Figure 3b. Catch rates of hoki.

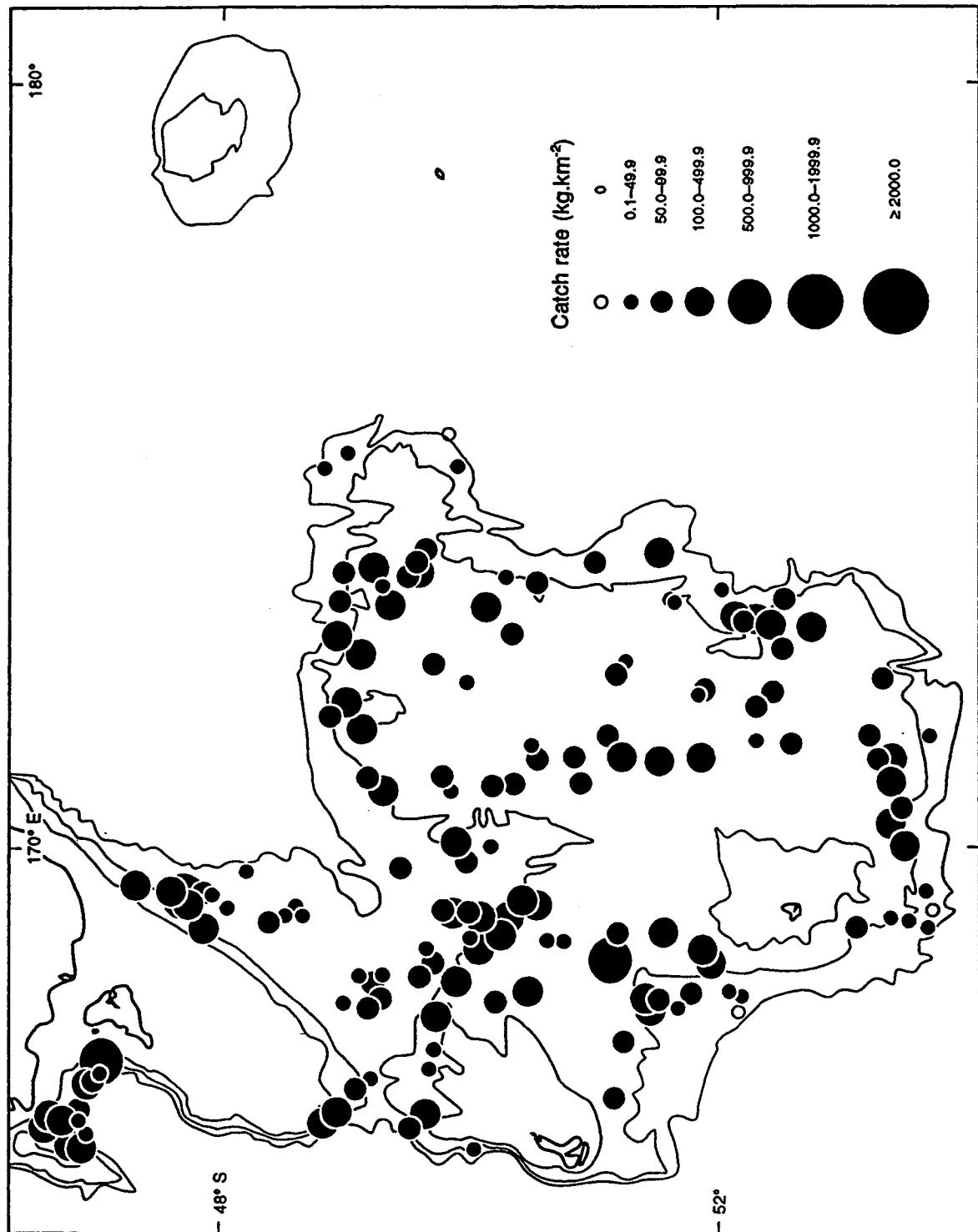


Figure 3c. Catch rates of ling.

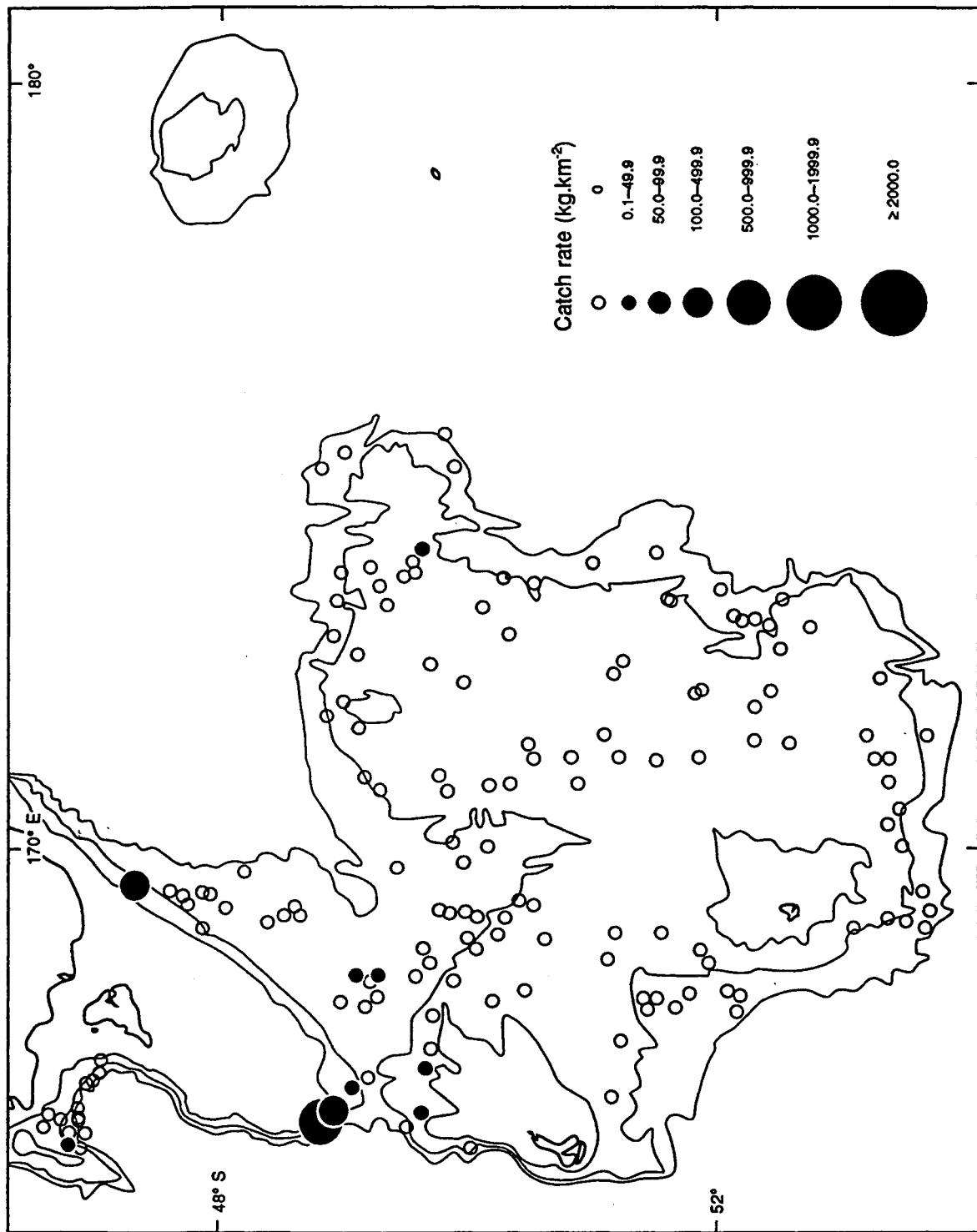


Figure 3d. Catch rates of silver warehou.

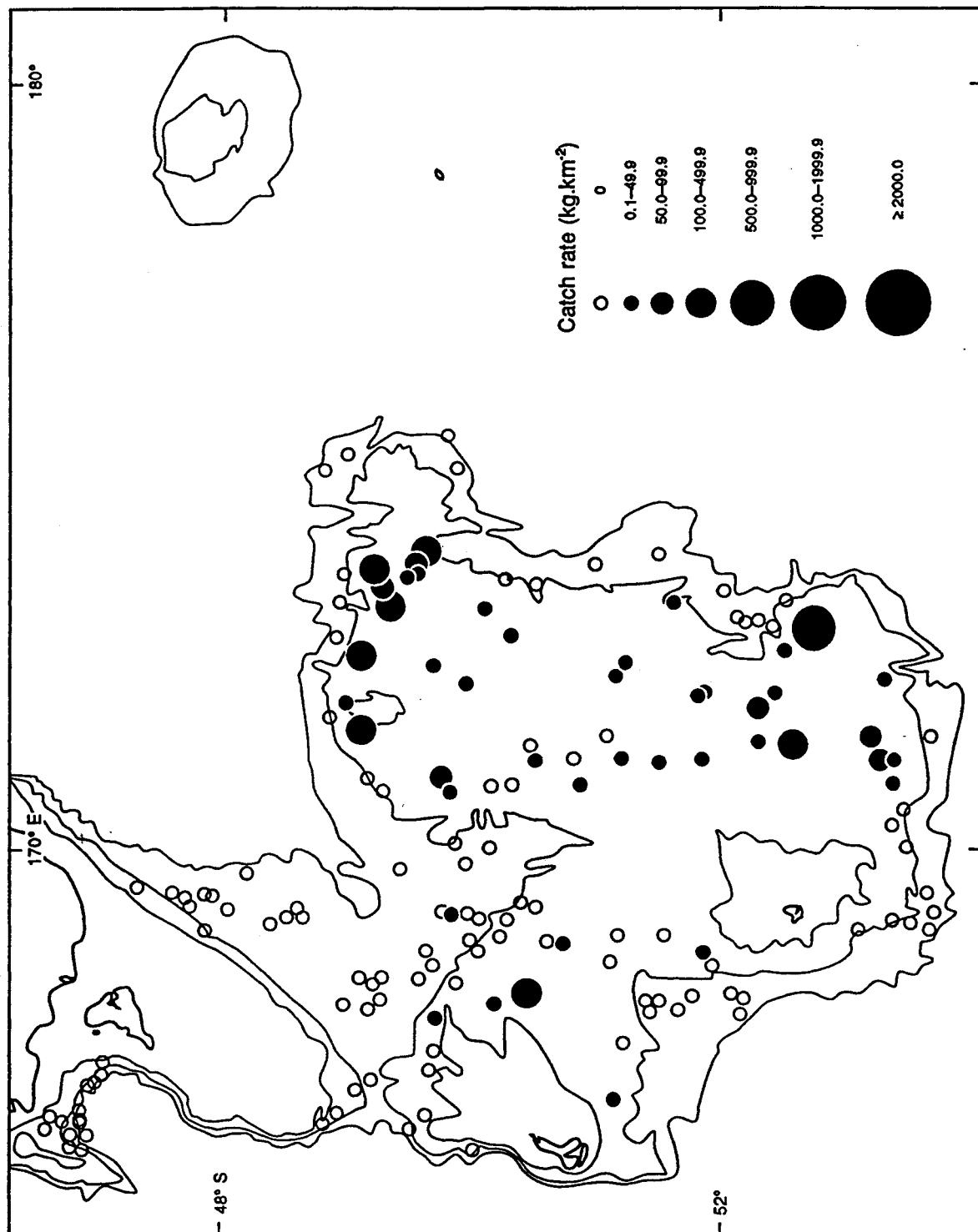


Figure 3e. Catch rates of southern blue whiting.

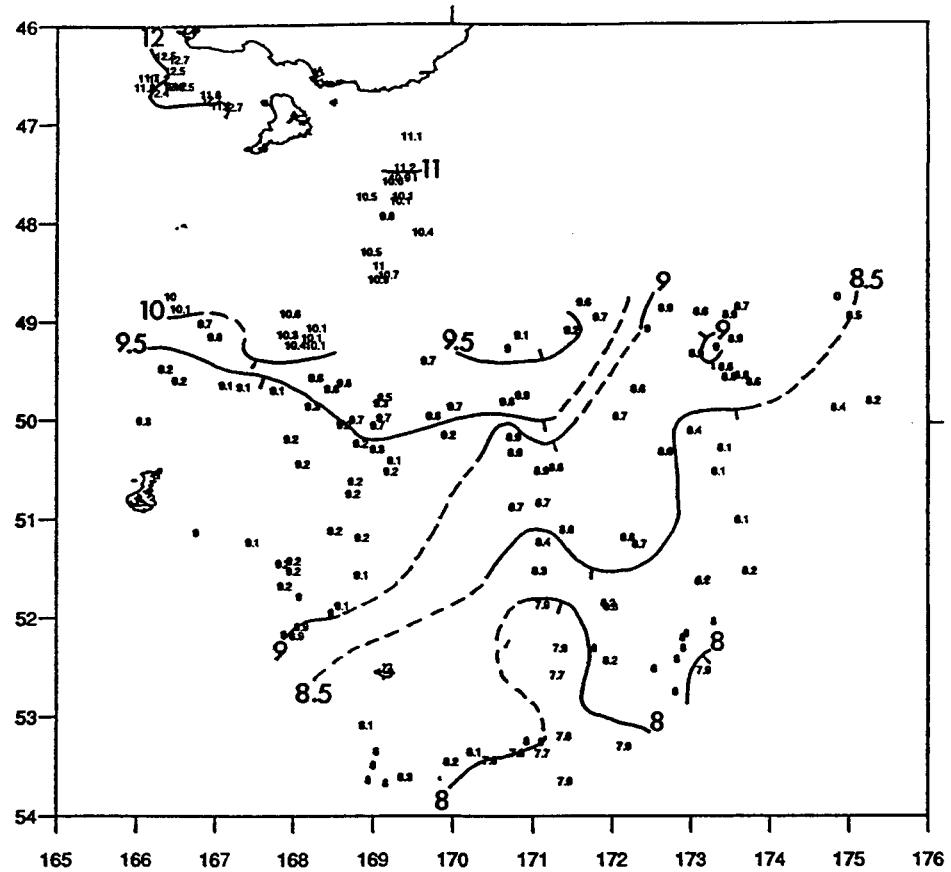


Figure 4. Surface temperature ($^{\circ}\text{C}$) contours

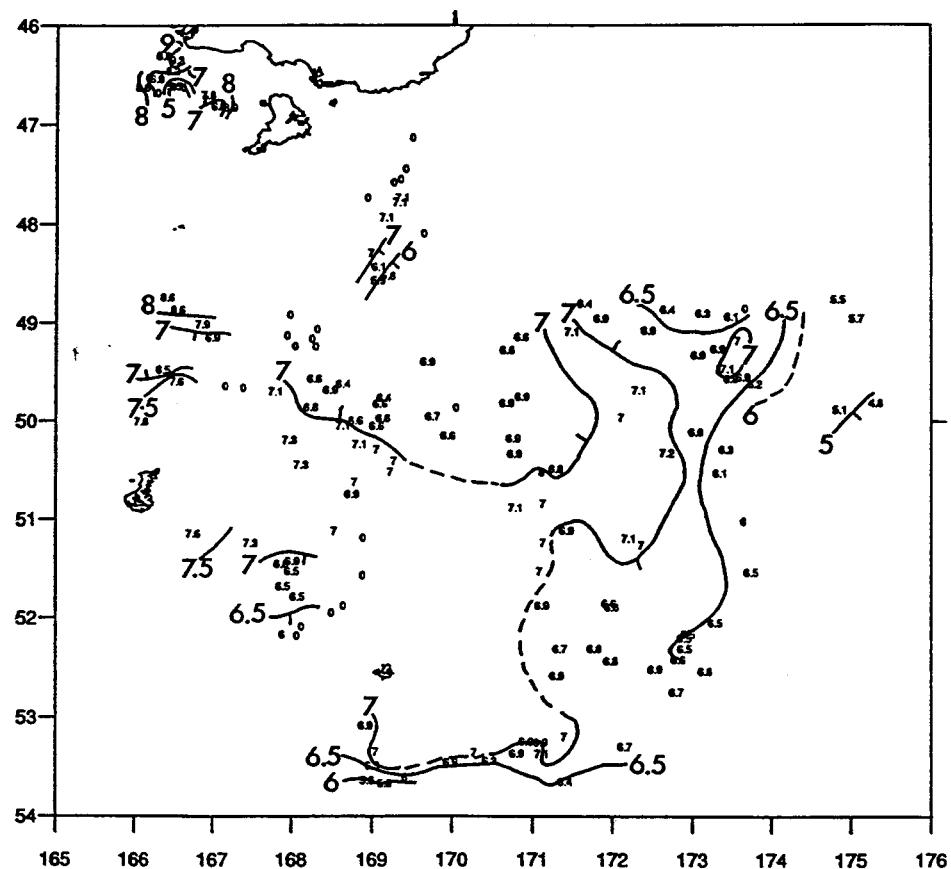


Figure 5. Bottom temperature ($^{\circ}\text{C}$) contours

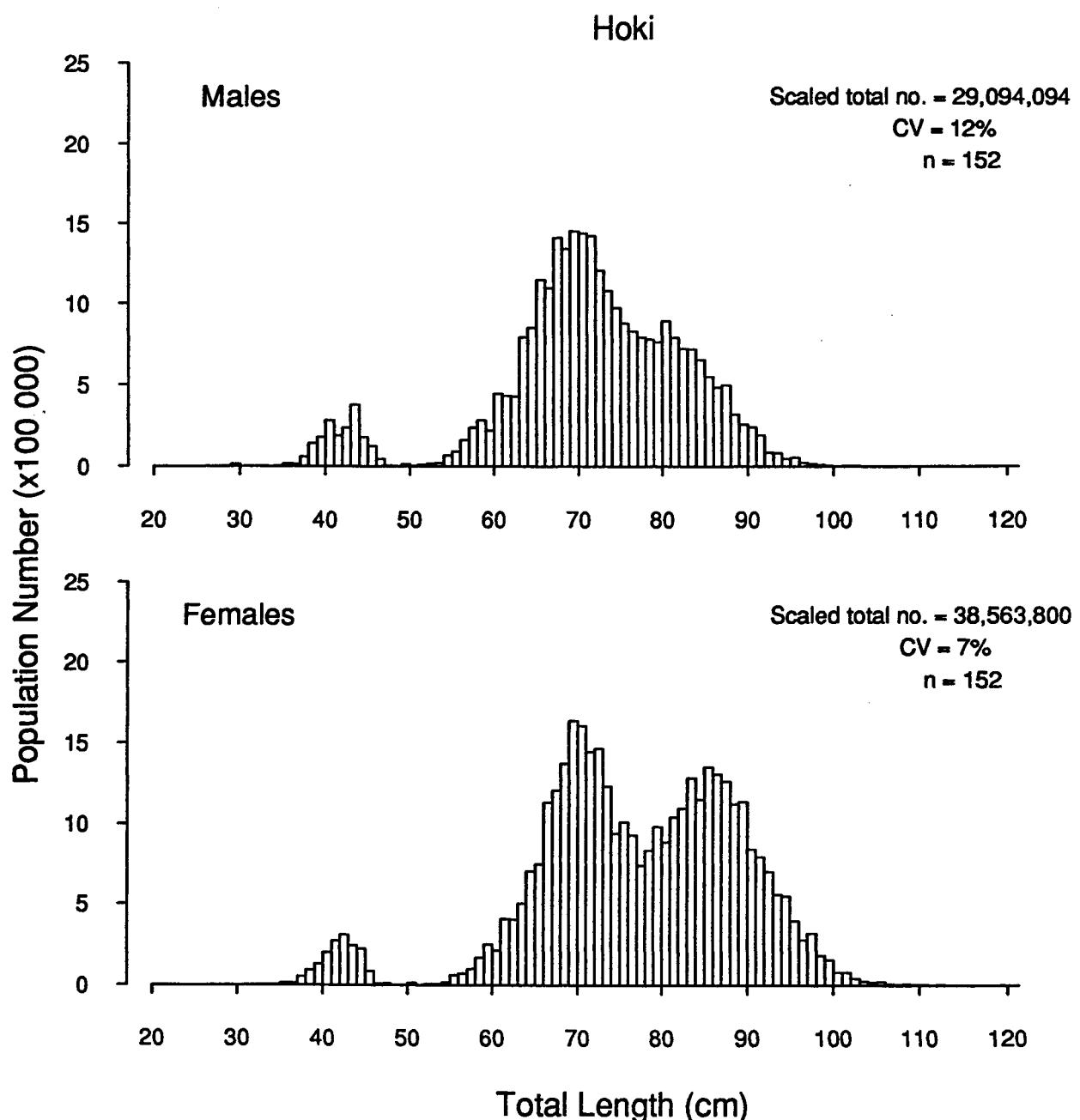


Figure 6a. Scaled length frequencies for male and female hoki for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

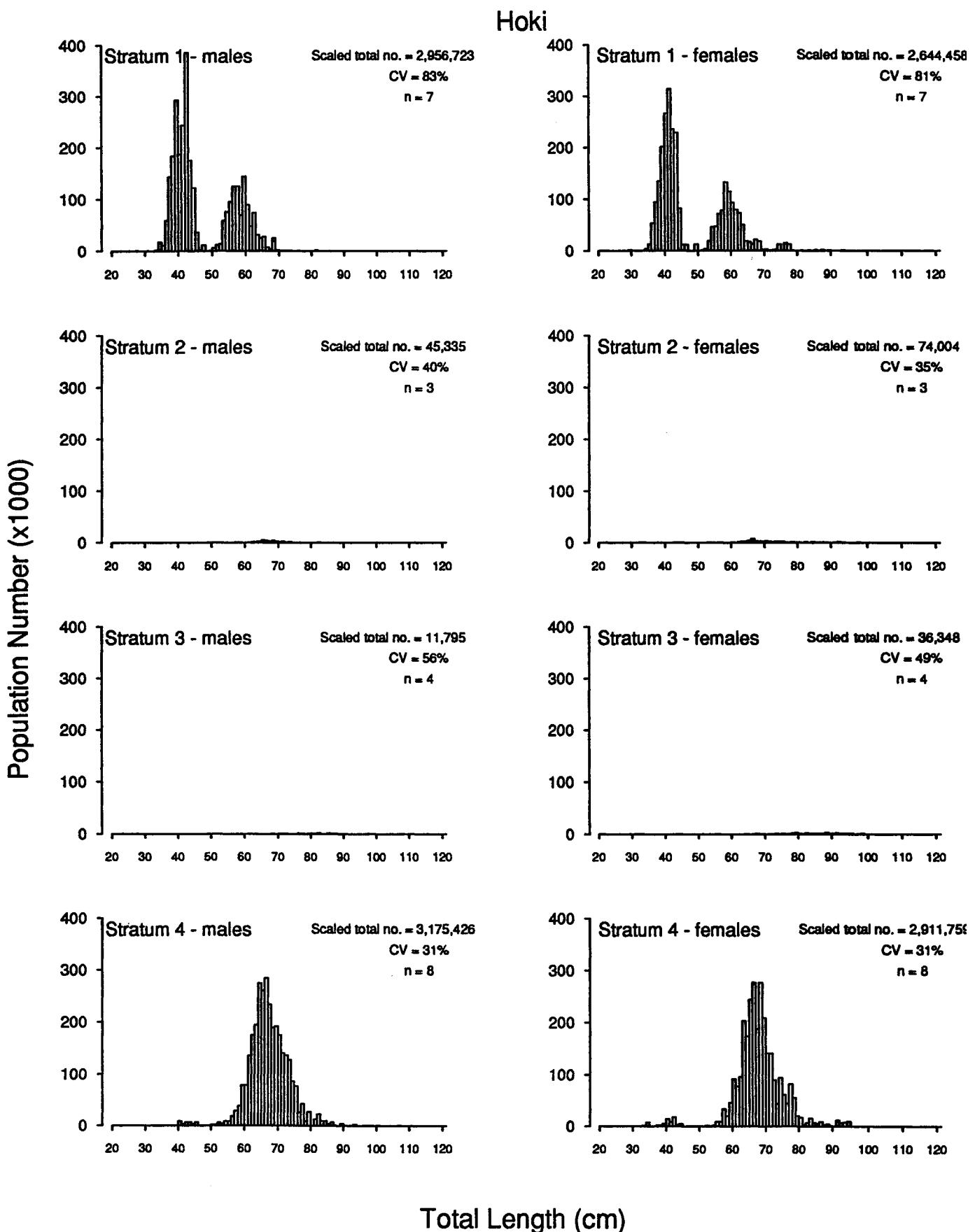


Figure 6b. Scaled length frequencies for male and female hoki for each stratum of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

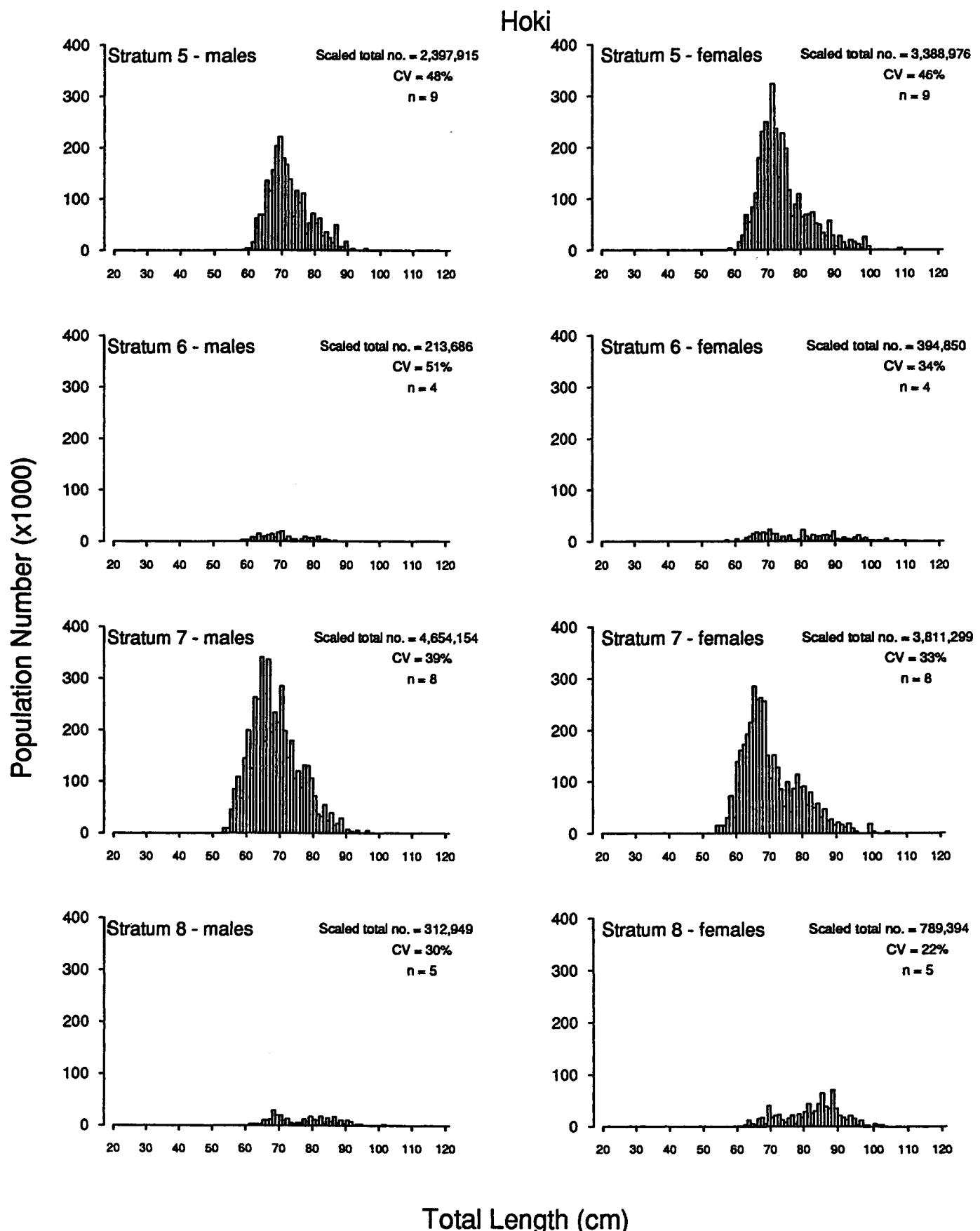


Figure 6b cont. Scaled length frequencies for male and female hoki for each stratum of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

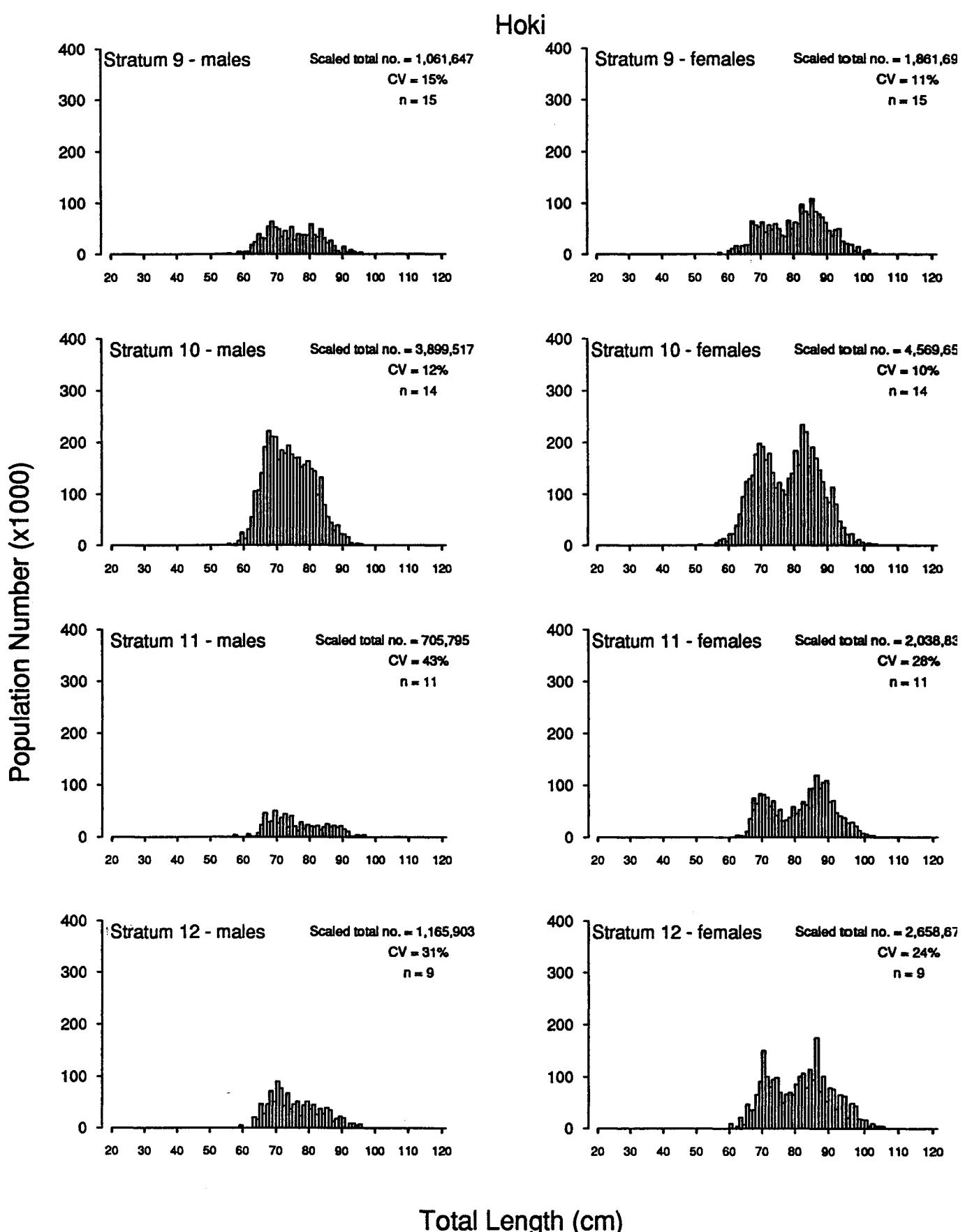


Figure 6b cont. Scaled length frequencies for male and female hoki for each stratum of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

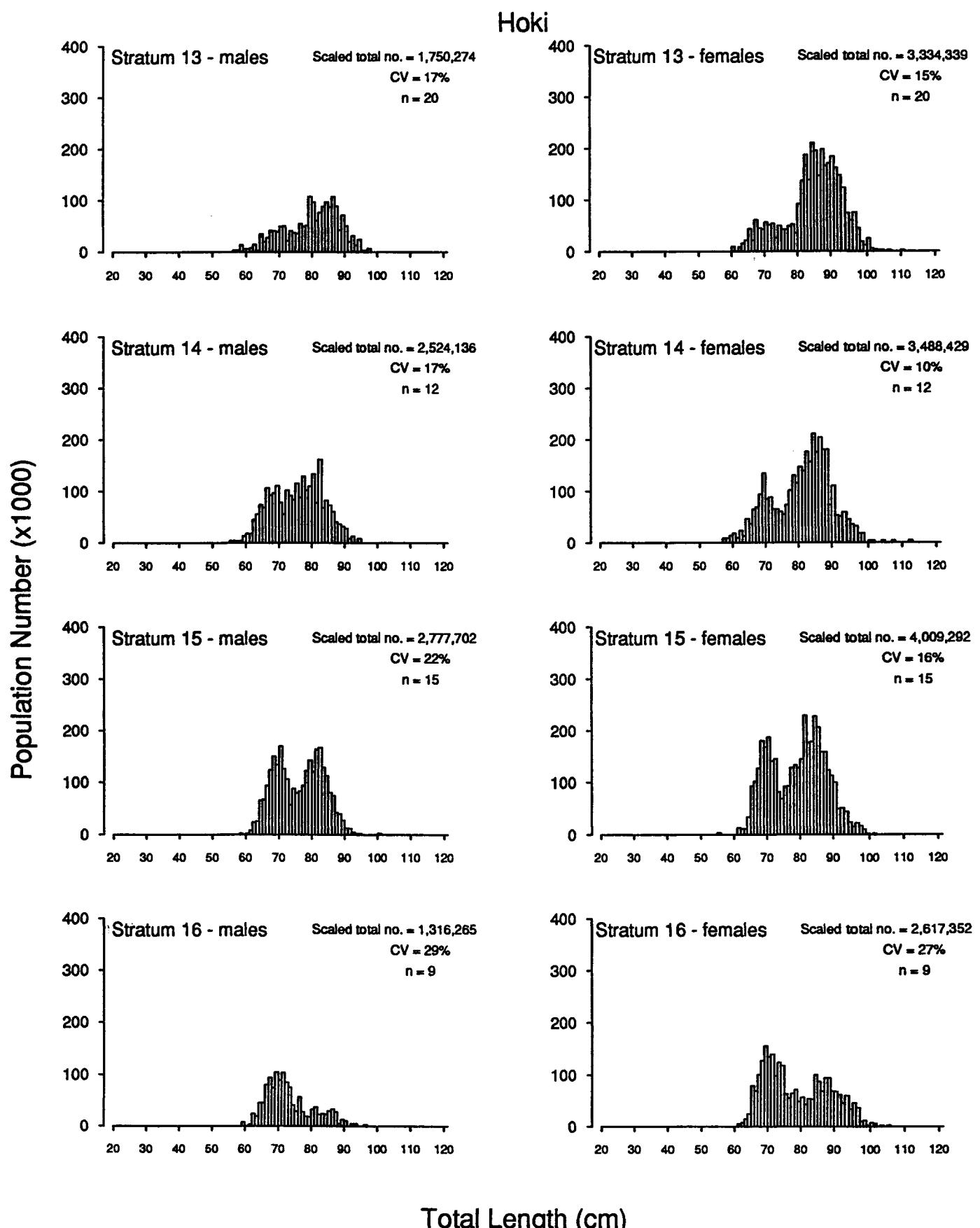


Figure 6b cont. Scaled length frequencies for male and female hoki for each stratum of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

Southern Blue Whiting

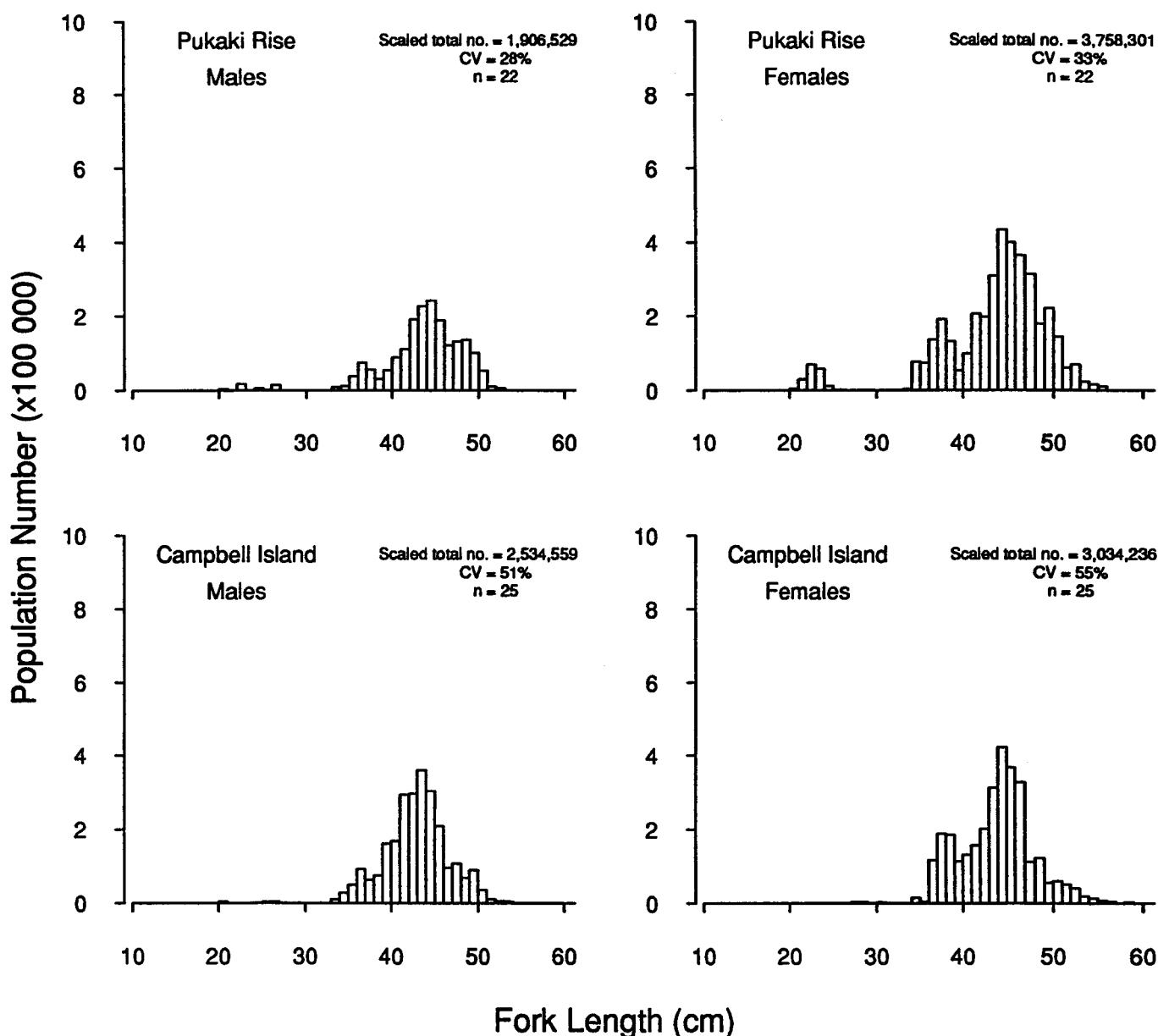


Figure 6c. Scaled length frequencies of southern blue whiting from the Pukaki Rise and Campbell Island areas of the 1991 Tangaroa (TAN9105) spring/summer survey of the Southland/Sub-Antarctic.

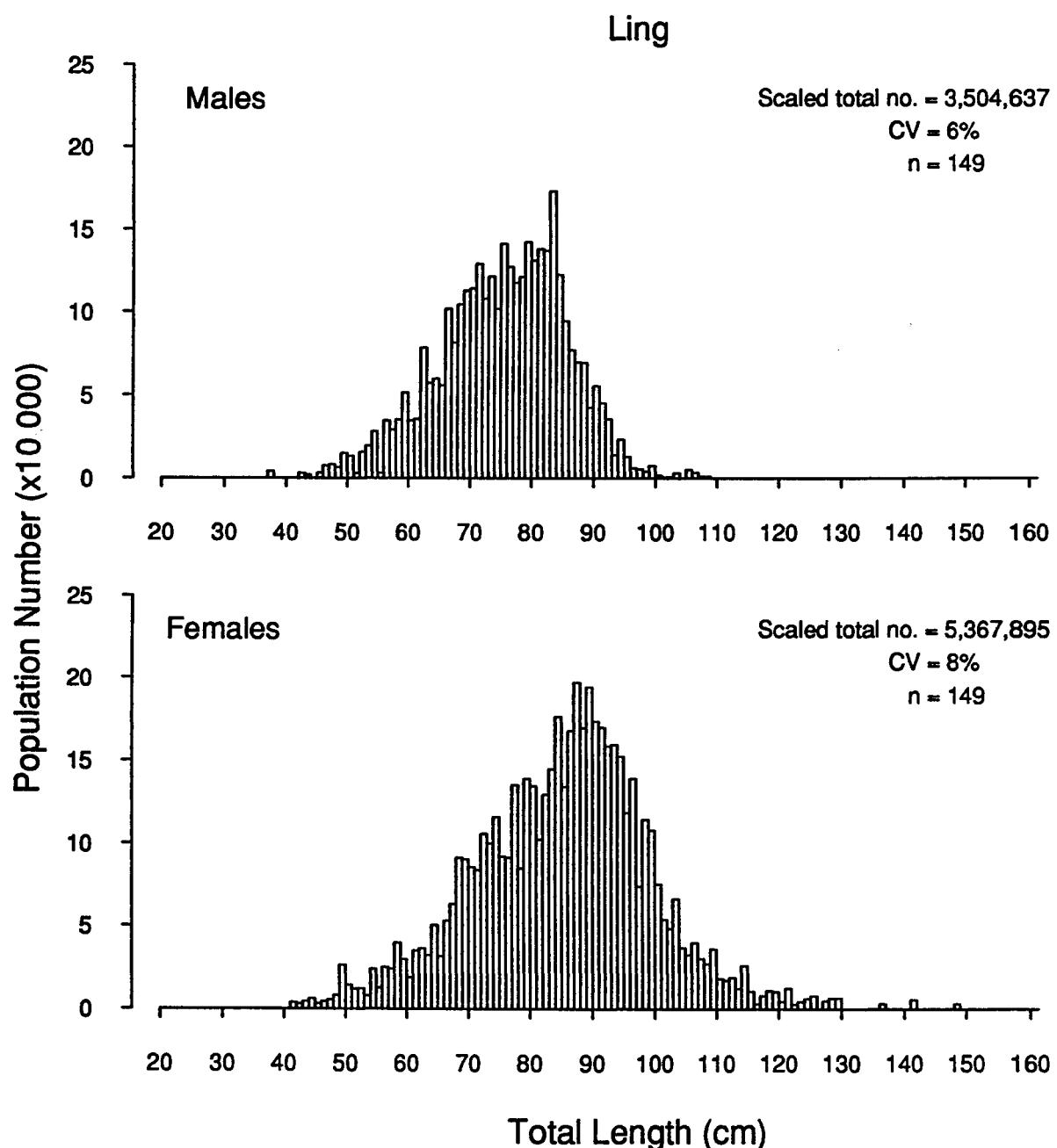


Figure 6d. Scaled length frequencies for male and female ling for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

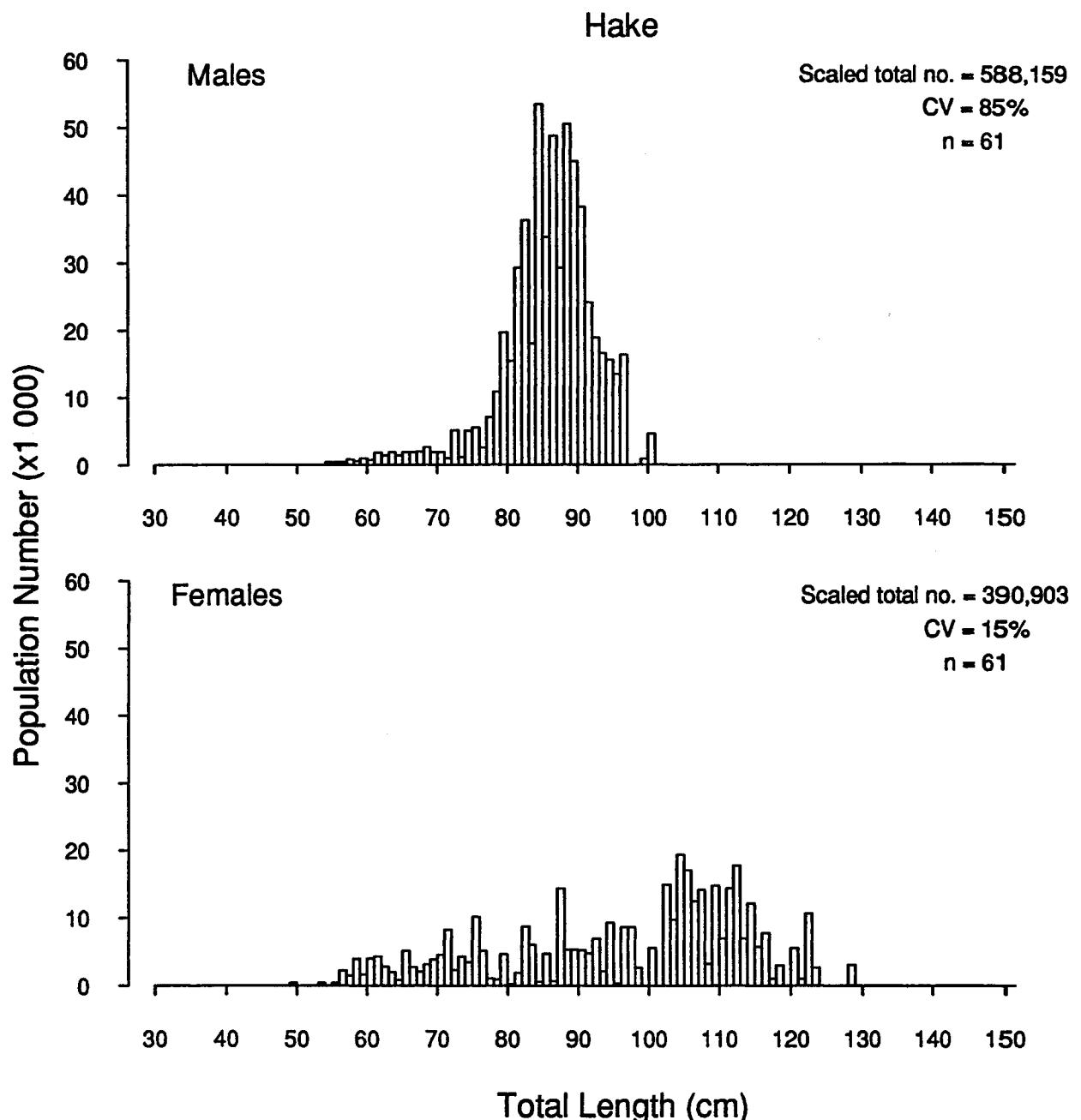


Figure 6e. Scaled length frequencies for male and female hake for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

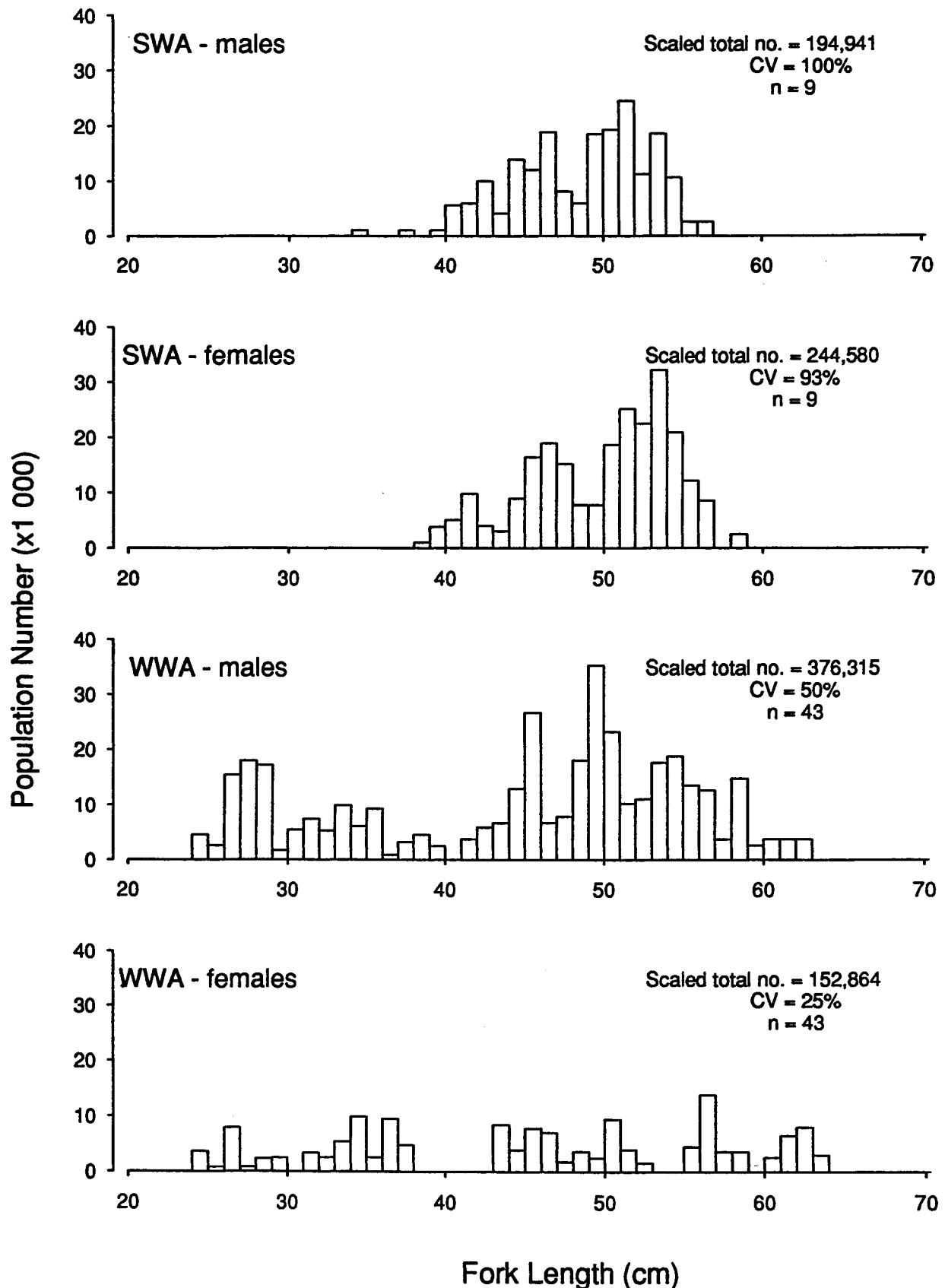


Figure 6f. Scaled length frequencies for silver warehou (SWA) and white warehou (WWA) for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

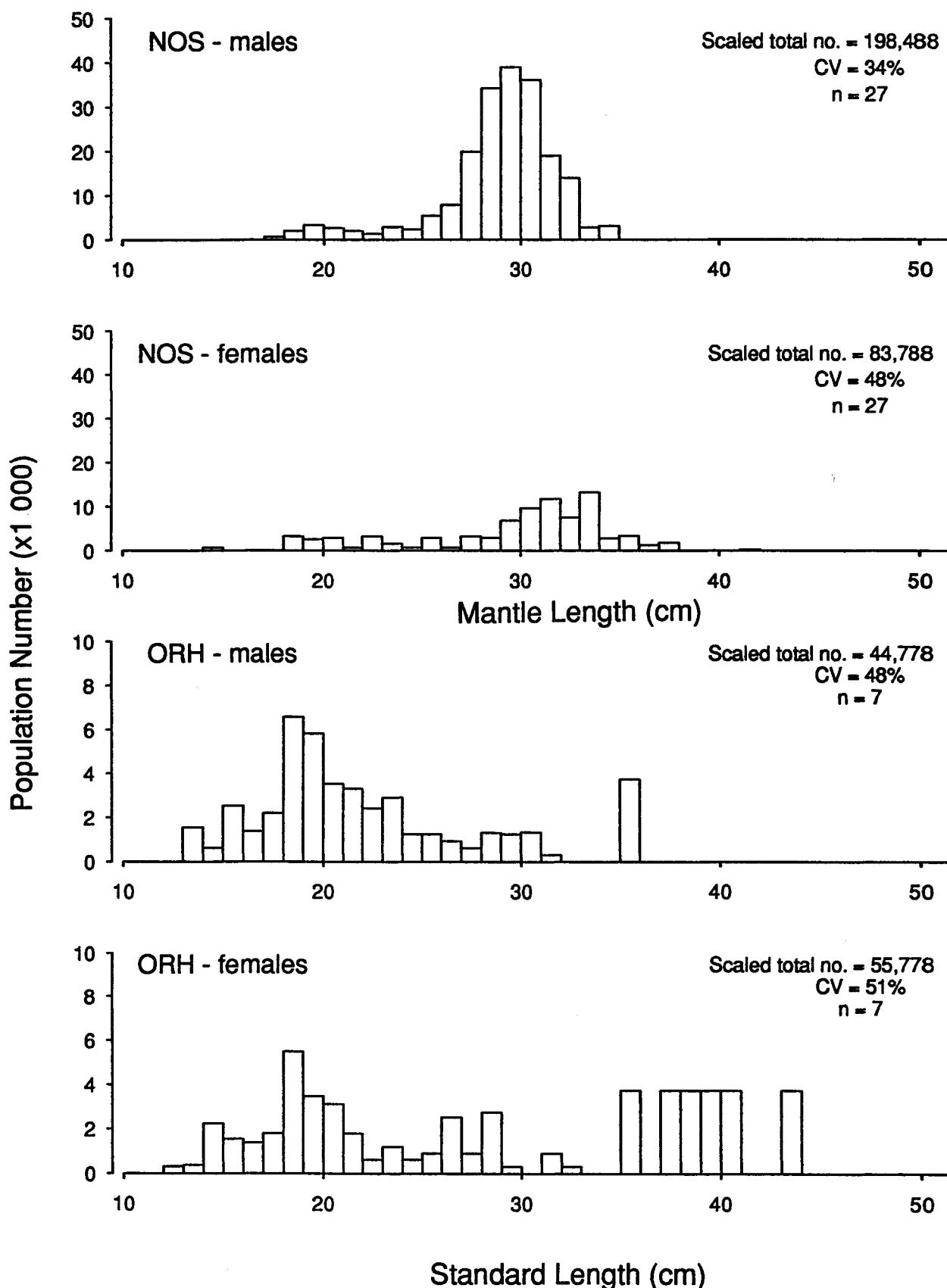


Figure 6g. Scaled length frequencies for arrow squid (NOS) and orange roughy (ORH) for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

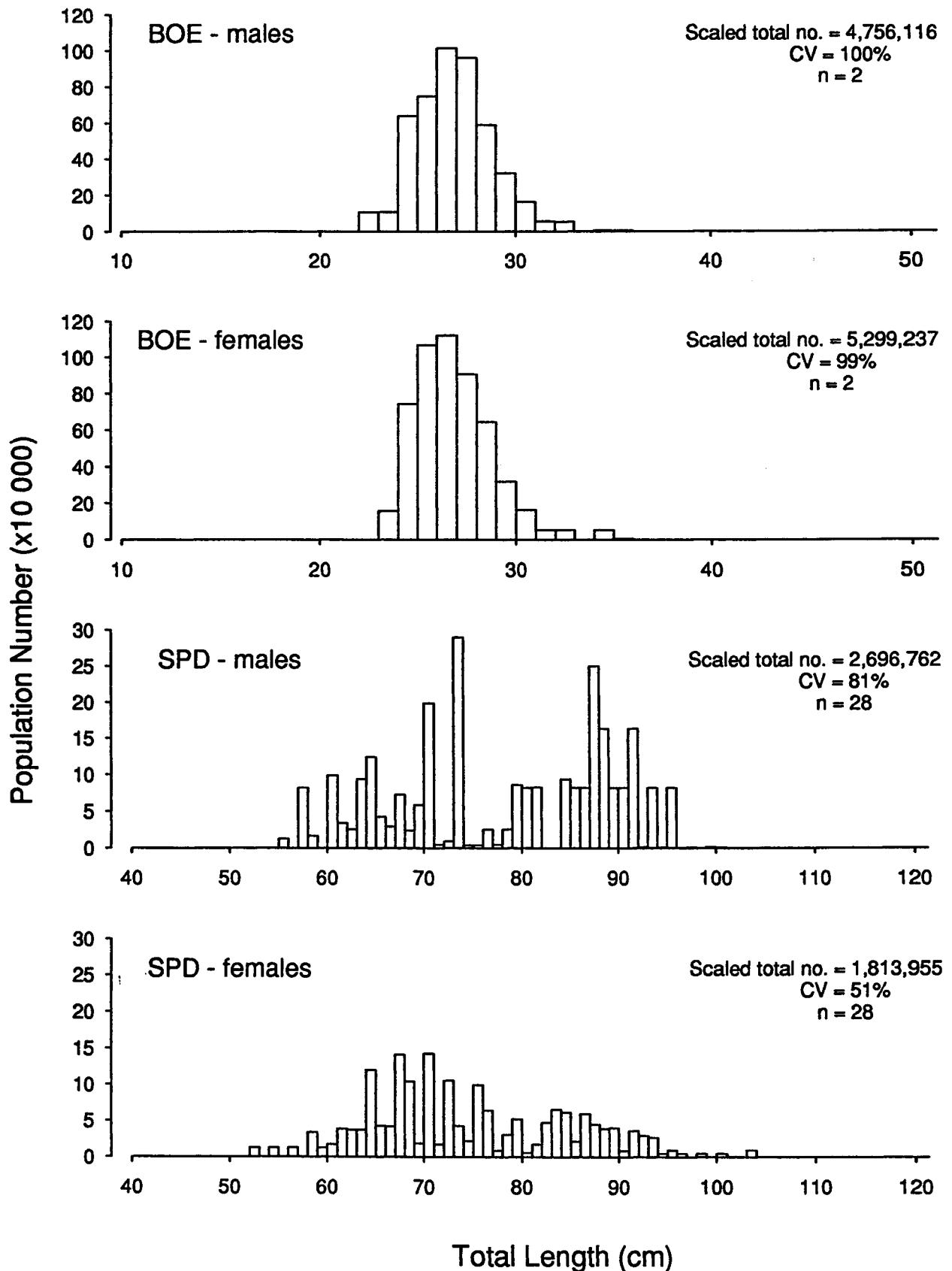


Figure 6h. Scaled length frequencies for black oreo (BOE) and spiny dogfish (SPD) for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

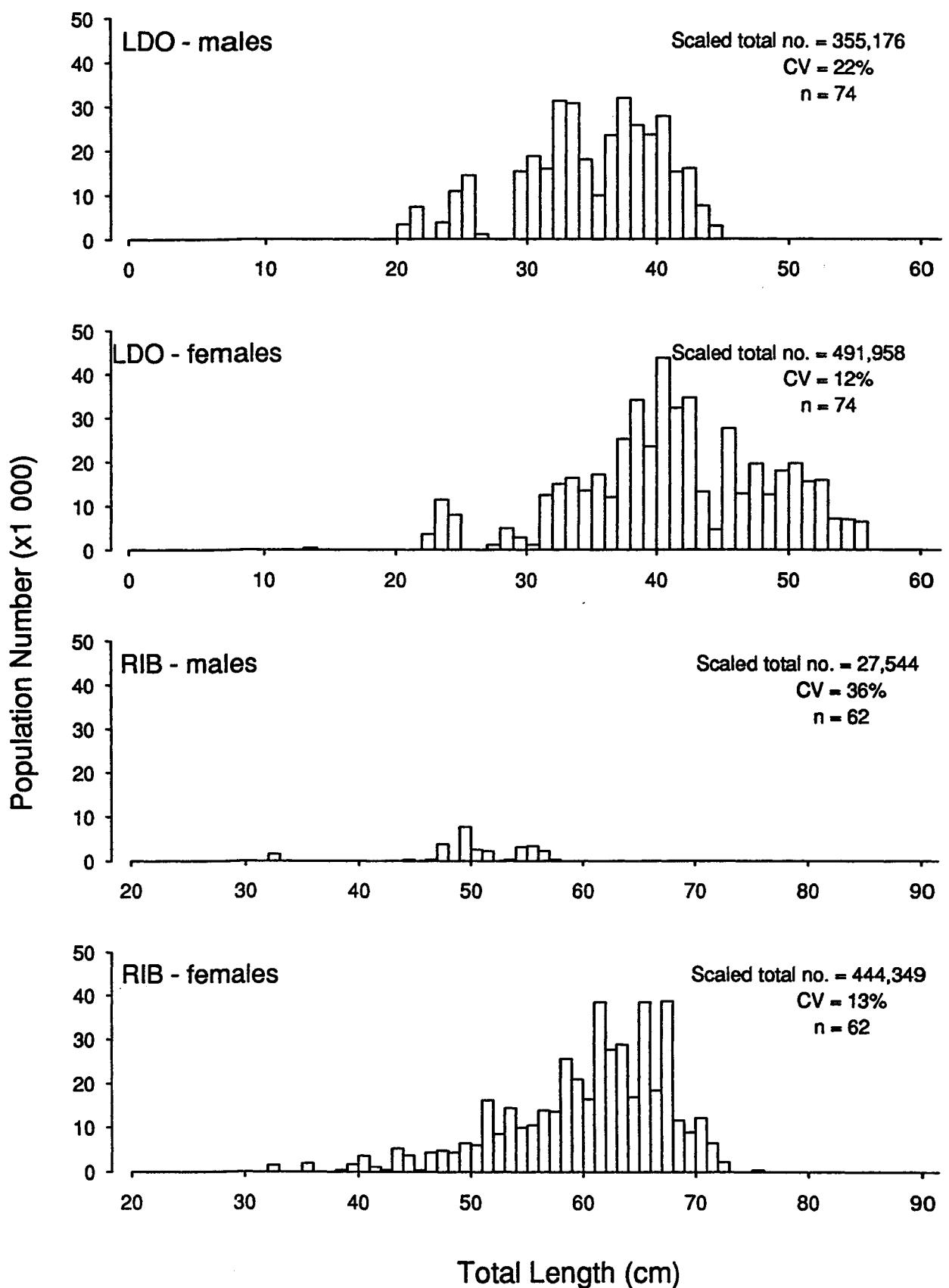


Figure 6i. Scaled length frequencies for lookdown dory (LDO) and ribaldo (RIB) for the total area of the 1991 Tangaroa (TAN9105) November/December survey of the Southland/Sub-Antarctic.

Appendix 1: Individual station data*

Station	Stratum	Date	Latitude	Longitude	Gear depth(m)		Head ht (m)	Door sp (m)	Hoki wt (kg)
			° S	° E	Min	Max			
11	0012	17 Nov 91	48 44.97	174 51.51	739	813	7.1	130.1	182.00
12	0012	17 Nov 91	48 56.63	175 04.90	665	699	6.6	125.8	130.10
13	0012	18 Nov 91	49 48.15	175 19.27	773	820	6.8	133.3	15.50
14	0012	18 Nov 91	49 52.46	174 52.85	705	720	7.0	122.1	79.10
15	0013	18 Nov 91	49 36.89	173 48.30	483	494	6.8	121.8	15.40
16	0013	18 Nov 91	49 32.75	173 39.28	473	479	6.4	129.5	70.90
17	0013	18 Nov 91	49 33.69	173 29.94	475	478	6.1	131.9	41.90
18	0013	19 Nov 91	49 27.69	173 27.47	465	475	5.8	134.6	73.70
19	0013	19 Nov 91	49 19.50	173 05.51	475	476	5.9	130.5	95.20
20	0013	19 Nov 91	49 15.37	173 20.24	494	499	7.9	127.1	03.10
21	0013	19 Nov 91	49 10.52	173 34.81	507	517	7.0	136.4	97.90
22	0012	19 Nov 91	48 55.75	173 30.68	618	622	6.3	141.3	19.20
24	0012	20 Nov 91	48 53.89	173 08.86	642	663	6.9	133.3	04.60
25	0012	20 Nov 91	48 51.73	172 42.14	627	641	6.8	130.0	33.30
26	0013	20 Nov 91	49 04.51	172 28.09	478	510	6.7	126.9	43.00
27	0013	20 Nov 91	49 40.90	172 21.13	449	458	6.6	129.9	01.40
28	0013	20 Nov 91	49 57.64	172 07.10	487	491	6.8	125.0	30.90
29	0013	21 Nov 91	50 19.34	172 41.94	493	500	6.3	134.4	80.20
30	0013	21 Nov 91	50 06.63	173 03.70	507	511	6.8	135.4	88.50
31	0013	22 Nov 91	50 17.03	173 26.62	589	598	6.3	135.4	13.50
32	0016	22 Nov 91	50 31.47	173 21.97	600	621	6.8	129.0	25.10
33	0016	22 Nov 91	51 00.80	173 39.25	651	658	6.3	131.9	39.90
34	0016	22 Nov 91	51 31.89	173 45.39	601	620	7.0	119.0	40.20
35	0016	22 Nov 91	51 37.40	173 10.23	733	758	7.1	120.7	17.40
36	0014	23 Nov 91	51 38.43	173 09.26	555	563	6.5	130.1	98.00
37	0016	23 Nov 91	52 02.68	173 17.90	652	653	6.5	136.6	65.90
38	0016	23 Nov 91	52 10.00	172 57.21	617	620	6.2	137.4	90.90
39	0016	23 Nov 91	52 12.43	172 54.43	613	614	6.7	132.0	69.60
40	0016	23 Nov 91	52 18.90	172 54.73	604	611	6.7	130.6	48.00
41	0015	23 Nov 91	52 25.38	172 49.78	574	586	6.3	131.3	64.30
42	0015	24 Nov 91	52 31.24	172 32.41	542	554	6.5	133.1	31.10
43	0015	24 Nov 91	52 32.50	173 10.25	576	578	6.3	131.2	13.10
44	0015	24 Nov 91	52 45.12	172 48.59	478	494	5.9	134.0	08.50
45	0015	24 Nov 91	53 18.02	172 09.62	448	458	6.6	126.2	2.30
46	0016	25 Nov 91	53 39.28	171 24.52	626	665	6.1	143.7	08.40
47	0015	25 Nov 91	53 11.95	171 23.85	434	442	6.4	135.5	01.40
48	0015	25 Nov 91	53 15.43	171 06.32	458	466	6.9	136.9	90.20
50	0015	26 Nov 91	53 22.28	171 07.06	481	497	6.4	134.1	80.00
51	0015	26 Nov 91	53 21.95	170 48.56	507	530	6.8	132.2	74.50
52	0011	26 Nov 91	53 26.37	170 27.92	654	691	6.3	133.5	52.40
53	0015	26 Nov 91	53 21.40	170 16.60	569	571	6.8	133.8	47.70
54	0011	26 Nov 91	53 27.69	169 59.23	620	640	6.6	138.5	82.80
55	0011	26 Nov 91	53 36.64	169 24.40	708	741	6.3	134.3	22.60
56	0011	27 Nov 91	53 38.38	168 56.59	770	799	6.2	145.5	69.00
57	0011	27 Nov 91	53 40.19	169 09.62	764	808	6.8	139.1	80.80
58	0011	27 Nov 91	53 29.40	169 00.35	721	737	6.7	139.5	63.70
59	0011	27 Nov 91	53 21.30	169 02.80	670	694	6.6	140.9	59.60
60	0011	27 Nov 91	53 05.30	168 55.36	610	641	6.4	136.3	44.70
61	0015	28 Nov 91	52 35.02	171 18.75	484	496	6.4	125.3	27.40
62	0015	28 Nov 91	52 18.78	171 21.23	529	530	6.9	128.6	08.80
63	0015	28 Nov 91	52 18.91	171 46.75	550	558	6.9	122.7	16.60
64	0015	28 Nov 91	52 26.33	171 59.30	548	554	6.6	123.9	01.10
65	0014	28 Nov 91	51 53.64	171 59.75	533	534	7.0	118.6	91.10
66	0014	28 Nov 91	51 51.27	171 57.72	532	532	6.5	123.1	85.20
67	0014	29 Nov 91	51 52.46	171 07.52	505	507	6.3	126.8	09.50
68	0014	29 Nov 91	51 31.54	171 05.35	523	525	6.8	121.6	20.00
69	0014	29 Nov 91	51 14.24	171 08.38	531	536	6.9	124.3	33.60

Appendix 1: – *continued*

Station	Stratum	Date	Latitude	Longitude	<u>Gear depth(m)</u>		Head ht (m)	Door sp (m)	Hoki wt (kg)
			° S	° E	Min	Max			
70	0014	29 Nov 91	51 06.71	171 26.11	524	526	6.5	123.8	40.30
71	0014	29 Nov 91	51 11.27	172 13.13	524	526	7.2	113.3	57.00
72	0014	29 Nov 91	51 15.62	172 22.04	526	527	7.3	124.4	02.20
73	0014	30 Nov 91	50 52.94	170 48.03	554	563	6.9	121.4	87.70
74	0014	30 Nov 91	50 50.32	171 08.16	534	543	6.6	128.6	45.00
75	0014	30 Nov 91	50 30.98	171 07.17	547	548	6.4	122.5	34.10
76	0013	30 Nov 91	50 29.11	171 18.18	536	539	6.6	124.0	26.60
77	0013	30 Nov 91	50 19.88	170 47.56	565	567	6.5	126.3	80.40
78	0013	30 Nov 91	50 10.36	170 46.37	554	564	6.6	129.0	59.60
79	0013	1 Dec 91	49 16.24	170 41.87	574	587	6.9	129.0	89.10
80	0012	1 Dec 91	49 08.31	170 52.60	612	616	7.0	118.6	99.10
81	0013	1 Dec 91	49 05.17	171 30.51	393	407	6.3	122.0	35.60
82	0013	1 Dec 91	48 57.14	171 52.12	516	521	6.9	128.0	59.20
83	0012	1 Dec 91	48 47.99	171 39.90	622	655	7.0	125.7	71.60
84	0005	2 Dec 91	47 55.87	169 11.71	649	653	6.9	127.2	67.30
85	0005	2 Dec 91	47 46.80	169 21.81	649	654	7.0	123.3	83.50
86	0005	2 Dec 91	47 43.93	169 23.38	643	653	7.0	118.2	73.00
87	0002	4 Dec 91	46 48.45	167 03.75	722	758	7.1	130.0	81.30
88	0001	4 Dec 91	46 41.86	166 56.29	540	579	6.6	125.3	72.30
89	0003	5 Dec 91	46 36.71	166 29.92	854	870	6.7	124.4	12.40
90	0002	5 Dec 91	46 32.23	166 16.73	603	665	6.4	117.2	73.00
91	0001	5 Dec 91	46 31.66	166 09.03	384	524	7.0	122.9	21.00
92	0001	5 Dec 91	46 37.32	166 05.97	476	514	6.9	118.1	8.10
93	0004	6 Dec 91	48 44.46	166 25.50	315	412	7.2	114.8	92.30
94	0004	6 Dec 91	48 52.03	166 33.76	369	431	6.8	121.7	24.20
95	0004	6 Dec 91	49 00.72	166 52.49	430	452	6.6	123.9	19.50
96	0006	6 Dec 91	49 08.76	167 00.03	627	666	7.0	127.7	32.80
97	0007	7 Dec 91	50 00.37	166 05.43	360	386	7.3	121.9	73.20
98	0006	7 Dec 91	49 28.66	166 22.28	636	644	6.5	126.8	58.40
99	0007	8 Dec 91	49 35.76	166 32.73	456	519	6.6	115.4	07.70
100	0007	9 Dec 91	49 38.62	167 08.60	340	353	6.4	115.7	08.80
101	0007	9 Dec 91	49 39.72	167 22.46	324	351	6.9	106.5	93.50
102	0007	9 Dec 91	49 41.96	167 48.44	526	553	6.8	126.5	88.50
103	0007	9 Dec 91	50 11.44	167 58.99	430	442	6.6	119.6	44.70
104	0010	9 Dec 91	50 26.84	168 07.55	466	493	6.5	128.4	00.30
105	0007	10 Dec 91	51 08.77	166 45.43	470	473	6.6	123.3	01.40
106	0007	10 Dec 91	51 14.43	167 29.34	576	577	7.2	129.0	37.30
107	0008	10 Dec 91	51 27.32	167 52.76	631	635	6.7	123.0	64.40
108	0008	10 Dec 91	51 25.64	168 01.00	624	624	6.4	124.4	11.00
109	0008	10 Dec 91	51 31.56	168 00.55	625	628	6.7	121.5	74.90
110	0008	10 Dec 91	51 40.67	167 54.15	643	644	6.5	133.7	77.30
111	0008	11 Dec 91	52 10.19	167 53.02	777	806	6.6	127.6	43.80
112	0011	11 Dec 91	52 10.96	168 02.93	701	734	6.3	133.4	97.10
113	0011	11 Dec 91	52 05.59	168 06.66	686	689	7.0	122.4	16.80
114	0011	11 Dec 91	51 47.21	168 04.87	634	645	6.5	125.5	86.10
115	0010	11 Dec 91	51 57.00	168 28.68	537	574	6.4	128.9	84.60
116	0010	11 Dec 91	51 52.80	168 37.42	471	500	6.5	122.1	90.60
117	0010	12 Dec 91	51 34.18	168 51.93	500	570	7.1	120.1	79.60
118	0010	12 Dec 91	51 11.38	168 52.32	547	548	6.7	131.3	26.10
119	0010	12 Dec 91	51 07.34	168 31.85	563	563	6.6	128.4	79.60
120	0010	12 Dec 91	50 44.70	168 45.32	570	580	6.3	129.7	66.00
121	0010	13 Dec 91	50 37.32	168 47.04	564	566	6.7	129.3	71.80
122	0010	13 Dec 91	50 31.19	169 14.32	584	588	6.7	127.6	26.10
123	0010	13 Dec 91	50 24.62	169 16.96	585	596	6.8	121.5	66.90
124	0010	13 Dec 91	50 17.50	169 03.83	591	593	6.6	125.3	87.20
125	0010	13 Dec 91	50 14.20	168 51.35	582	589	6.8	117.6	37.30
126	0009	13 Dec 91	50 03.30	169 04.27	618	635	6.8	118.0	70.30

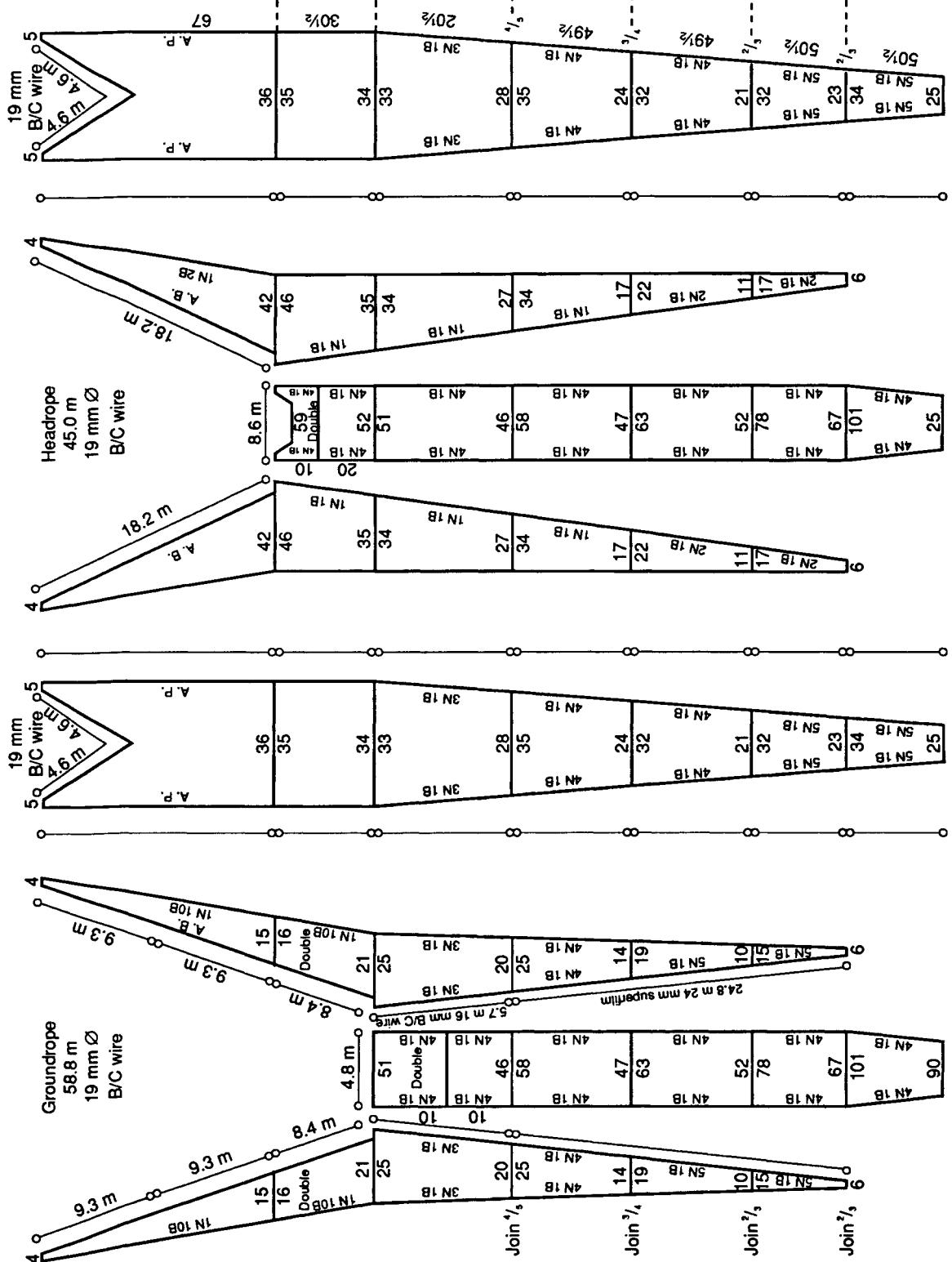
Appendix 1: – continued

Station	Stratum	Date	Latitude	Longitude	<u>Gear depth(m)</u>		Head ht (m)	Door sp (m)	Hoki wt (kg)
			° 'S	° 'E	Min	Max			
127	0009	13 Dec 91	49 58.37	169 09.07	635	637	7.0	127.2	97.10
128	0013	14 Dec 91	49 44.99	170 52.99	500	507	6.5	134.0	87.40
129	0013	14 Dec 91	49 48.80	170 41.54	520	532	6.6	133.3	84.70
130	0009	14 Dec 91	49 51.75	170 02.58	610	617	6.8	131.1	27.60
131	0009	14 Dec 91	49 57.49	169 46.58	630	633	6.4	139.8	00.70
132	0009	15 Dec 91	50 08.90	169 57.92	615	619	6.2	136.7	33.60
133	0009	15 Dec 91	49 49.66	169 06.91	651	660	6.8	116.2	36.80
134	0009	15 Dec 91	49 45.93	169 09.76	649	665	7.0	113.6	29.20
135	0009	15 Dec 91	49 23.95	169 42.61	660	662	6.9	113.3	10.20
136	0009	16 Dec 91	49 59.89	168 48.13	605	621	6.8	117.2	03.20
137	0010	16 Dec 91	50 02.94	168 38.81	587	590	6.8	119.7	43.40
138	0010	16 Dec 91	49 51.68	168 14.88	599	603	6.5	128.6	71.70
139	0009	16 Dec 91	49 41.06	168 29.60	666	669	6.9	124.1	39.50
140	0009	16 Dec 91	49 37.49	168 38.79	681	684	7.2	111.2	08.70
141	0009	16 Dec 91	49 34.13	168 17.73	657	659	6.7	119.0	22.90
142	0009	17 Dec 91	49 03.84	168 18.49	657	670	6.2	127.0	56.50
143	0009	17 Dec 91	49 09.78	168 14.44	643	650	6.4	123.3	48.20
144	0009	17 Dec 91	49 14.38	168 17.42	641	651	6.6	117.4	84.60
145	0006	17 Dec 91	49 14.08	168 01.87	667	689	6.4	119.3	16.30
146	0006	17 Dec 91	49 07.65	167 56.06	671	679	6.6	115.3	38.50
147	0005	17 Dec 91	48 55.03	167 58.22	660	667	6.6	119.8	18.10
148	0005	18 Dec 91	48 05.60	169 38.53	696	719	6.9	117.6	73.40
149	0005	18 Dec 91	48 31.47	169 12.76	699	712	6.2	131.6	30.20
150	0005	18 Dec 91	48 34.21	169 05.25	711	728	6.7	124.0	49.20
151	0005	18 Dec 91	48 25.91	169 05.55	667	688	6.6	115.6	64.90
152	0005	18 Dec 91	48 17.57	168 59.72	600	607	7.1	114.1	34.90
153	0003	19 Dec 91	46 37.12	166 35.79	820	828	6.5	124.2	73.70
154	0003	19 Dec 91	46 36.90	166 27.88	872	903	6.4	132.0	50.50
155	0003	19 Dec 91	46 40.84	166 16.35	961	968	6.2	126.9	31.70
156	0001	20 Dec 91	46 18.20	166 21.73	400	433	6.4	125.5	03.90
157	0001	20 Dec 91	46 20.86	166 31.85	353	361	6.1	125.4	70.30
158	0001	20 Dec 91	46 27.55	166 28.62	474	501	6.5	131.7	28.00
159	0002	20 Dec 91	46 44.54	166 56.83	600	669	6.6	126.8	87.50
160	0001	20 Dec 91	46 49.44	167 13.27	300	542	6.5	125.6	75.50
161	0004	21 Dec 91	47 44.00	168 56.12	496	522	6.1	124.5	35.50
162	0004	21 Dec 91	47 34.95	169 15.79	563	580	6.5	119.5	98.30
163	0004	21 Dec 91	47 32.81	169 21.15	553	559	6.7	122.8	50.40
164	0004	21 Dec 91	47 26.52	169 25.07	492	514	6.5	121.6	51.20
165	0004	21 Dec 91	47 07.71	169 30.01	393	449	6.2	118.5	43.40

* Head ht = headline height; Door sp = doorspread; Hoki wt = weight of hoki caught.

Appendix 2: The Tangaroa 8 seam hoki trawl including plans of net, float positions, groundrope assembly, codend, and sweeping gear.

Mesh and twine size	300 mm 5 mm olivene	300 mm 5 mm	300 mm 5 mm	240 mm 5 mm	180 mm 5 mm	120 mm 5 mm	80 mm 5 mm olivene
No. of meshes deep	67	30½	20½	49½	49½	50½	50½
Selvage wire and rope length	24 mm comb. wire 17.8 m	24 mm comb. wire, 8.0 m	24 mm comb. wire, 5.7 m	32 mm polyester 10.8 m	32 mm polyester 8.3 m	32 mm polyester 5.7 m	32 mm polyester, 3.9 m
Percentage slack	11%	13%	10%	10%	8%	6%	3%



Appendix 2—continued

FLOAT PLAN

Float position on headline

Head length 45 m

Floats: Headrope: 38

Selvages: 12

Total: 50

Nichimo UBE floats

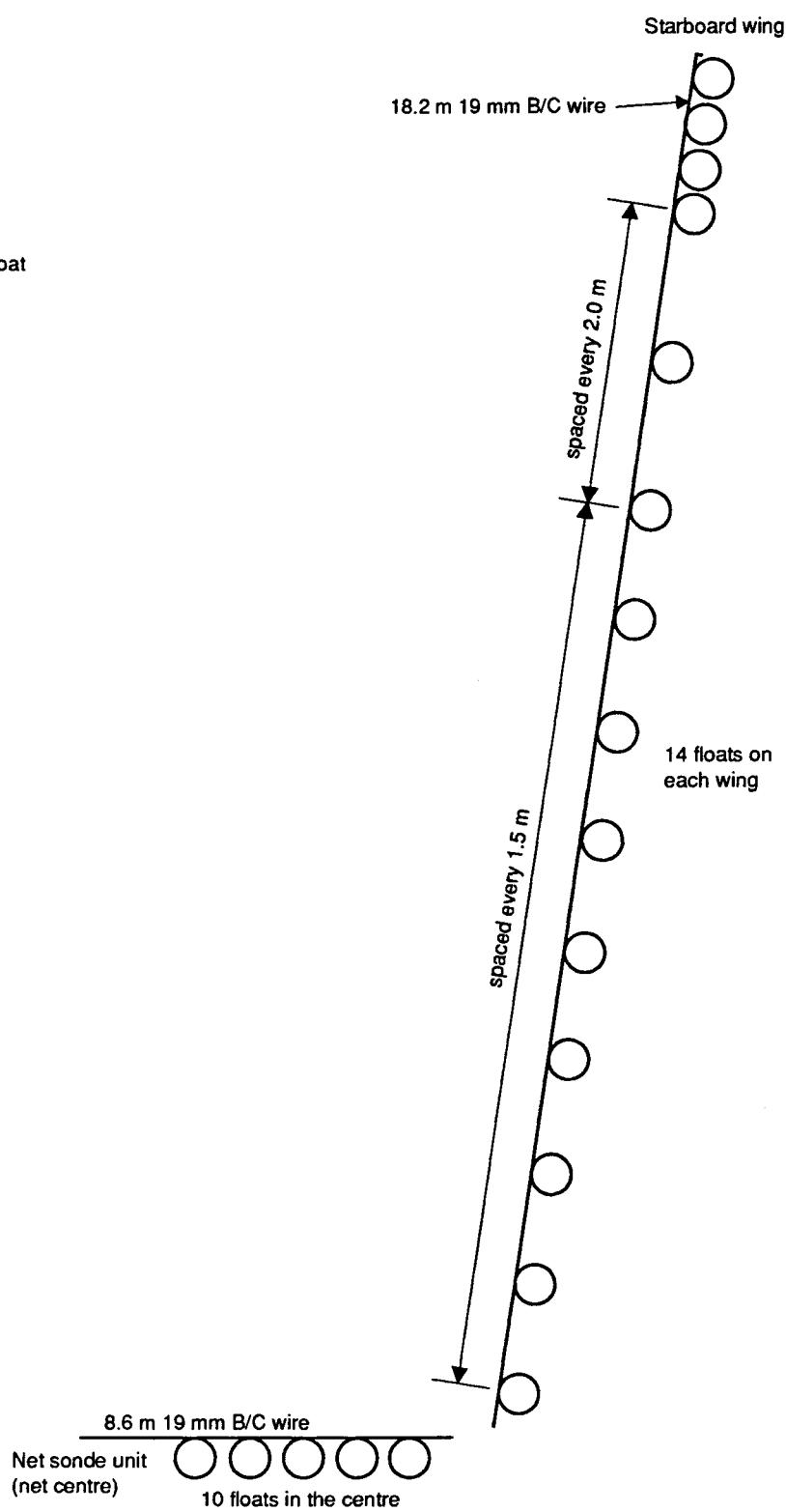
360 mm diameter

Rated to 1500 m

No. CT - 3615

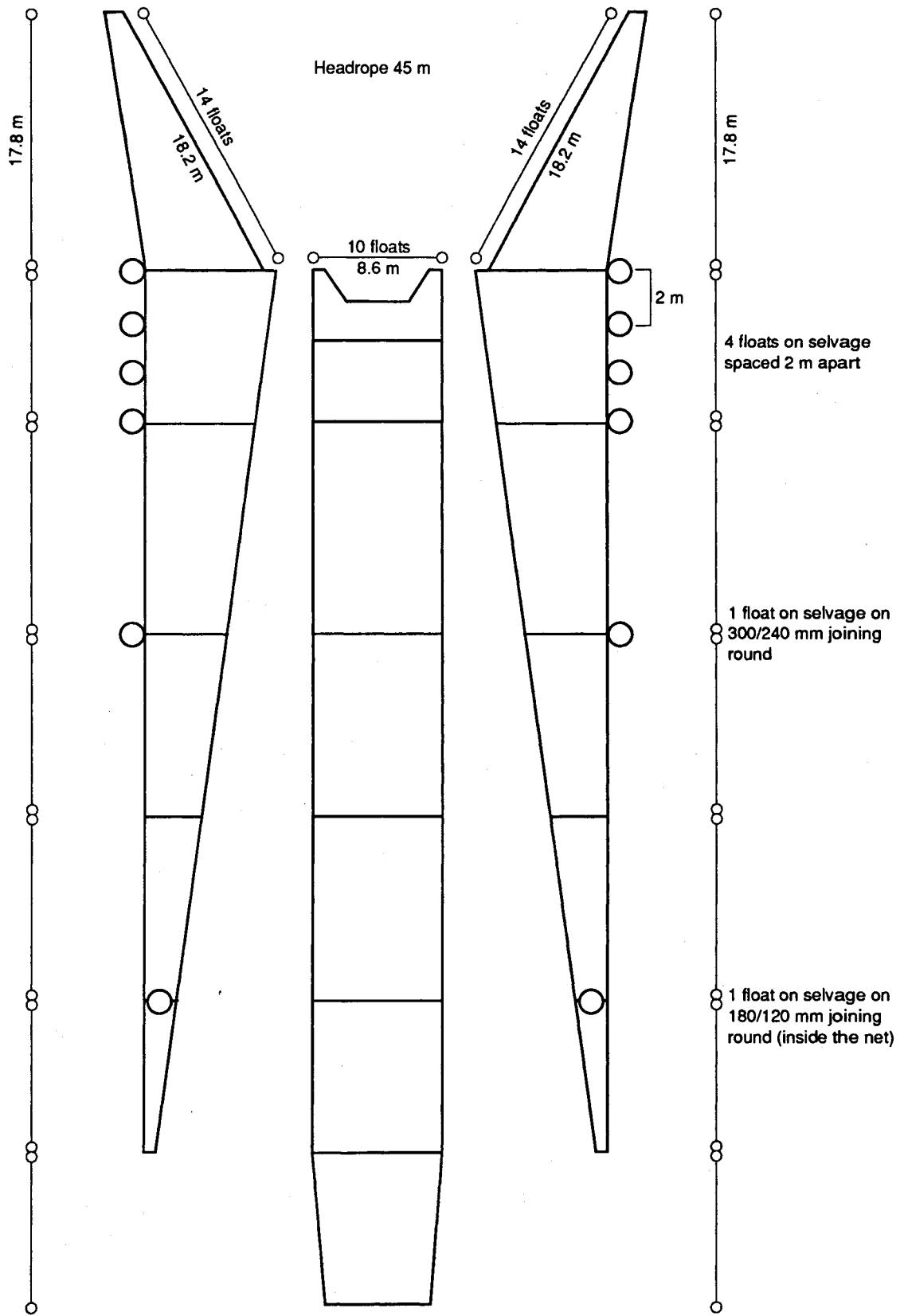
Buoyancy 13.3 kg per float

Toal buoyancy 665 kg

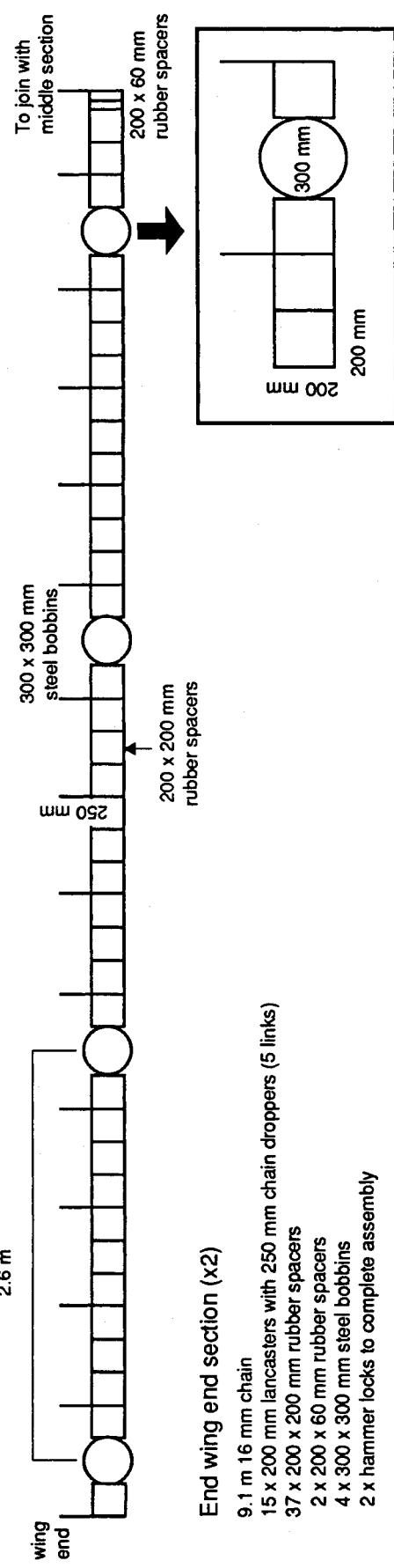
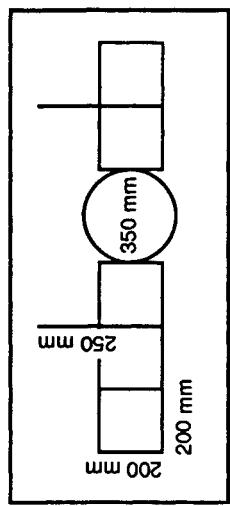
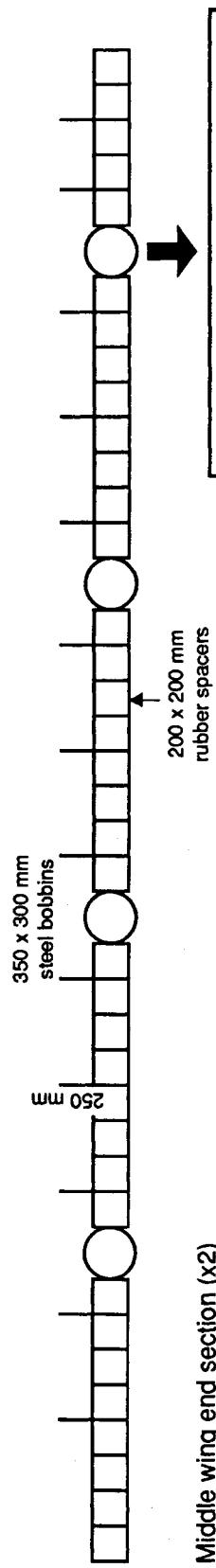


Appendix 2—continued

Float position on selvages

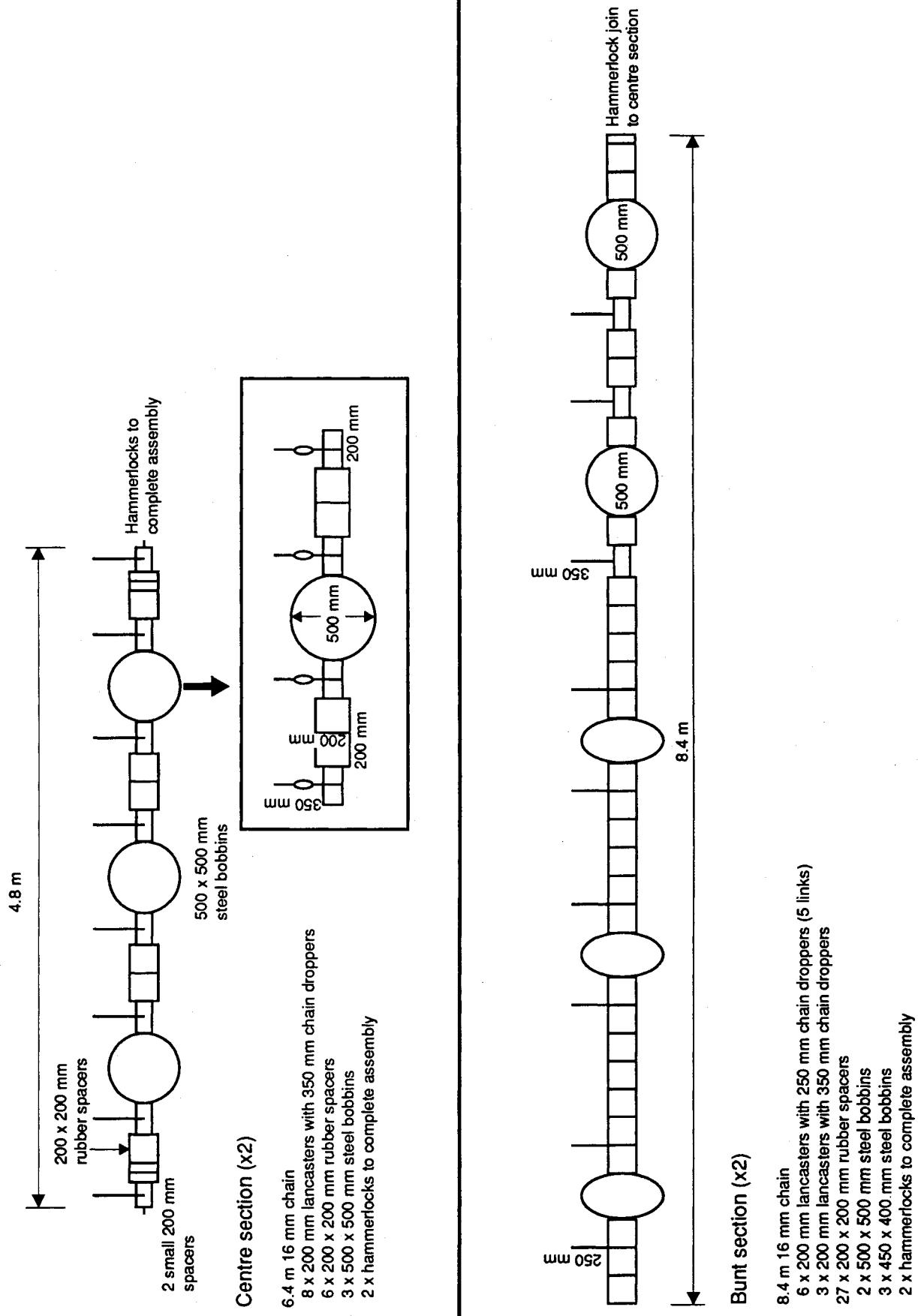


Appendix 2—continued



Appendix 2—continued

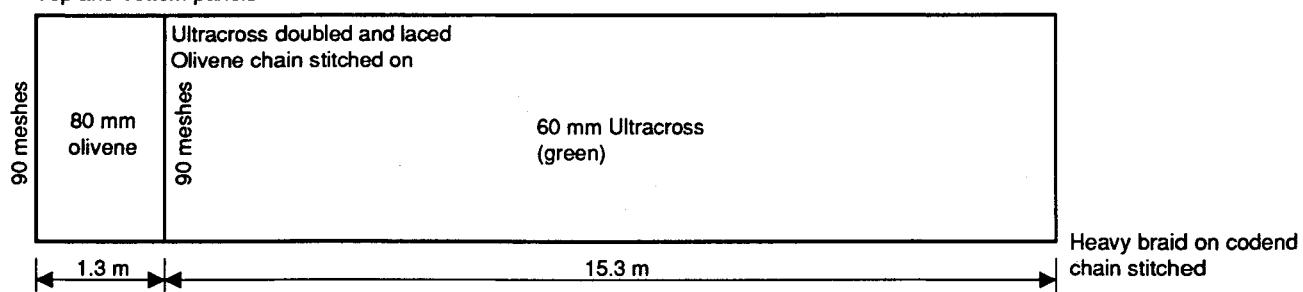
GROUNDROPE PLAN



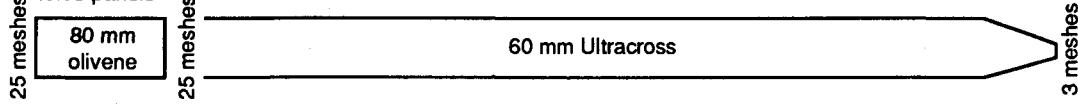
Appendix 2—continued

CODENDS

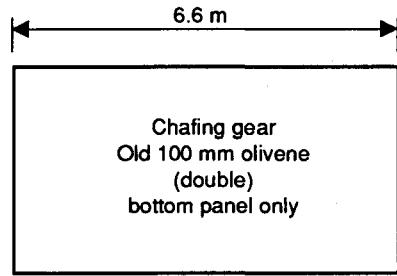
Top and bottom panels



Side panels



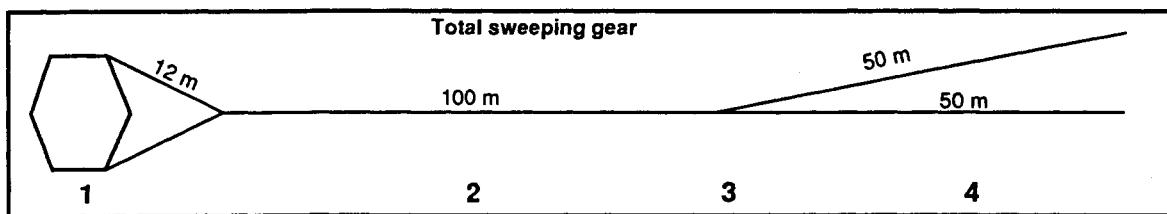
Beckets: 11 placed 800 – 1400 mm apart in irregular pattern (average 1100 mm apart).
A mixture of superfilm and polyethylene rope of varying sizes.
Superfilm toggles.
Rope selvages, one piece each side using thimble at the codend (i.e., the mid-point of the rope)



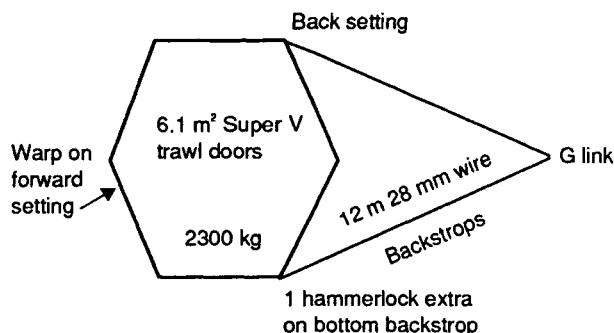
Overhangs end of codend

Appendix 2—continued

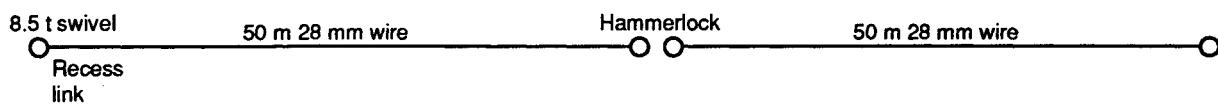
SWEEPING GEAR



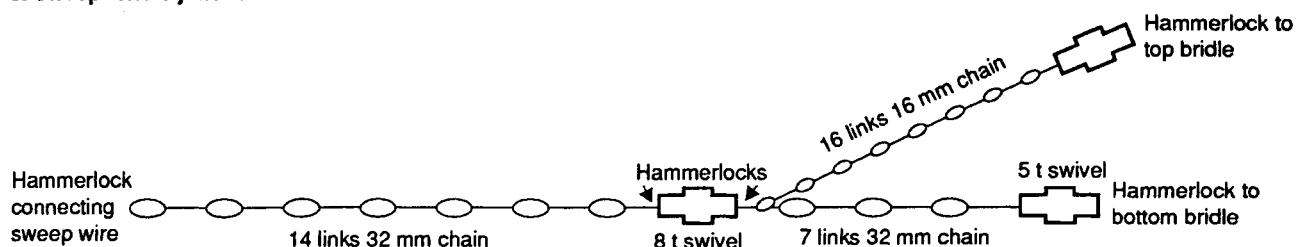
1. Trawl door setting



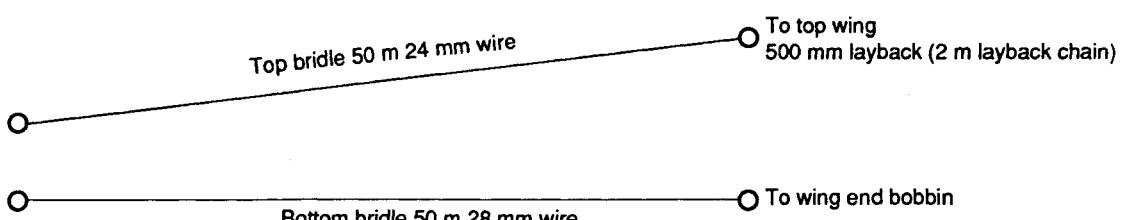
2. Sweep



3. Sweep-bridle junction



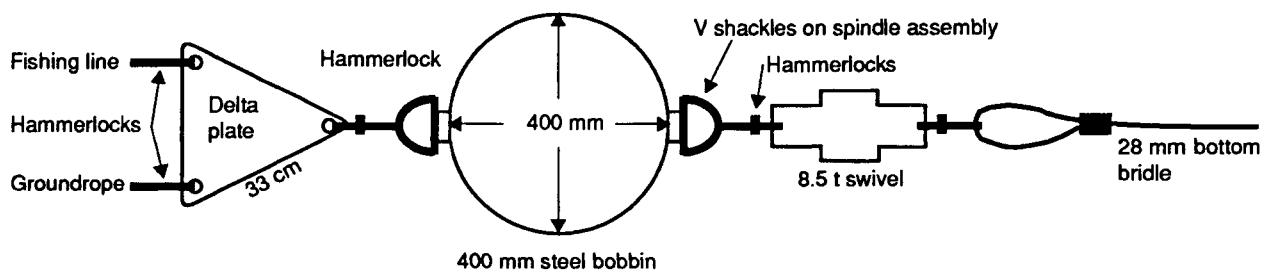
4. Bridles



There may be chain in between the wire and the bobbin or top wing to even up the bridles.

Appendix 2—continued

WINGED BOBBIN AND DELTA PLATE ASSEMBLY



Note: To even up the groundrope and to stop twisting, there may be an extra hammerlock joining the delta plate to the groundrope. On the gear trials it was on the starboard side fishing line.

Appendix 3: Species taken during the survey.

The occurrence of each species in the 154 tows is also shown. Taxonomic order and names follow Paulin *et al.* (1989).

Scientific name	Common name	Species code	Occurrence
Chondrichthyes			
Squalidae: dogfishes			
<i>Centrophorus squamosus</i>	deepwater spiny dogfish	CSQ	13
<i>Centroscymnus crepidator</i>	deepwater dogfish	CYP	9
<i>C. owstoni</i>	Owston's spiny dogfish	CYO	4
<i>Deania calcea</i>	shovelnosed spiny dogfish	SND	19
<i>Etmopterus baxteri</i>	Baxter's dogfish	ETB	34
<i>E. lucifer</i>	lucifer dogfish	ETL	54
<i>Scymnorhinus licha</i>	seal shark	BSH	6
<i>Scymnodon plunketi</i>	plunket shark	PLS	7
<i>Squalus acanthias</i>	spiny dogfish	SPD	43
Species not identified	unidentified deepwater dogfish	DWD	1
Lamnidae: mackerel sharks			
<i>Lamna nasus</i>	porbeagle shark	POS	1
Scyliorhinidae: cat sharks			
<i>Haleaelurus dawsoni</i>	Dawson's catshark	DCS	6
Triakidae: smoothhounds			
<i>Galeorhinus galeus</i>	school shark	SCH	2
Species not identified	unidentified sharks	OSD	6
Rajidae: skates			
<i>Pavoraja asperula</i>	smooth deepsea skate	BTA	12
<i>P. spinifera</i>	prickly deepsea skate	BTS	2
Species not identified	unidentified bluntnosed skates	BTH	14
<i>Raja innominata</i>	smooth skate	SSK	18
<i>R. nasuta</i>	rough skate	RSK	3
Chimaeridae: chimaeras, ghost sharks			
<i>Hydrolagus novaezelandiae</i>	dark ghost shark	GSH	20
<i>Hydrolagus</i> sp.	pale ghost shark	GSP	135
Rhinochimaeridae: longnosed chimaeras			
<i>Harriotta raleighana</i>	longnosed chimaera	LCH	64
Osteichthyes			
Notacanthidae: spiny eels			
<i>Notacanthus sexspinis</i>	spineback	SBK	33
Synaphobranchidae: cutthroat eels			
<i>Diastobranchus capensis</i>	basketwork eel	BEE	2
Congridae: conger eels			
<i>Bassanago bulbiceps</i>	swollenheaded conger	SCO	65
<i>B. hirsutus</i>	hairy conger	HCO	49
Clupeidae: sardines, sprats			
<i>Sprattus antipodum</i>	slender sprat	SPA	1
Gonorynchidae: sandfish			
<i>Gonorynchus gonorynchus</i>	sandfish	GON	1
Argentinidae: silversides			
<i>Argentina elongata</i>	silverside	SSI	89
Aleocephalidae: slickheads			
<i>Aleocephalus australis</i>	smallscaled brown slickhead	SSM	4
Photichthyidae: lighthouse fishes			
Species not identified	lighthouse fish	PHO	3
Paralepididae: barracudinas			
<i>Magnisudis prionosa</i>	barracudina	BCA	3

Appendix 3 – continued

Scientific name	Common name	Species code	Occurrence
Moridae: morid cods			
<i>Antimora rostrata</i>	violet cod	VCO	3
<i>Halargyreus johnsoni</i>	slender cod	HJO	3
<i>Lepidion</i> sp.	giant lepidion	LEG	1
<i>Mora moro</i>	ribaldo	RIB	71
<i>Pseudophycis batus</i>	red cod	RCO	11
Gadidae: cods			
<i>Micromesistius australis</i>	southern blue whiting	SBW	47
Merlucciidae: hakes			
<i>Macruronus novaezelandiae</i>	hoki	HOK	154
<i>Merluccius australis</i>	hake	HAK	62
Macrouridae: rattails, grenadiers			
<i>Coelorinchus aspercephalus</i>	oblique banded rattail	CAS	84
<i>C. bollonsi</i>	big-eye rattail	CBO	32
<i>C. fasciatus</i>	banded rattail	CFA	100
<i>C. innotabilis</i>	notable rattail	CIN	4
<i>C. kaiyomaru</i>	Kaiyomaru rattail	CKA	4
<i>C. matamua</i>	Mahia rattail	CMA	4
<i>C. oliverianus</i>	Oliver's rattail	COL	73
<i>C. subserrulatus</i>	four-rayed rattail	CSU	8
<i>Coryphaenoides</i> sp. B	long barbel rattail	CBA	1
<i>C. murrayi</i>	abyssal rattail	CMU	6
<i>Lepidorhynchus denticulatus</i>	javelinfish	JAV	148
<i>Macrourus carinatus</i>	ridgescaled rattail	MCA	24
<i>Ventifossa nigromaculata</i>	blackspot rattail	VNI	3
<i>Trachyrincus</i> sp.	white rattail	WHX	2
Species not identified	all unidentified rattails	RAT	3
Ophidiidae: cusk eels			
<i>Genypterus blacodes</i>	ling	LIN	151
Trachipteridae: dealfishes			
<i>Desmodema polystictum</i>	dealfish	DEA	1
Trachichthyidae: roughies			
<i>Hoplostethus atlanticus</i>	orange roughy	ORH	7
<i>H. mediterraneus</i>	silver roughy	SRH	4
Zeidae: dories			
<i>Capromimus abbreviatus</i>	capro dory	CDO	2
<i>C. traversi</i>	lookdown dory	LDO	83
Oreosomatidae: oreos			
<i>Allocyttus niger</i>	black oreo	BOE	3
<i>Neocytthus rhomboidalis</i>	spiky oreo	SOR	1
<i>Pseudocyttus maculatus</i>	smooth oreo	SSO	3
Macrorhamphosidae: snipefishes			
<i>Centriscops obliquus</i>	redbanded bellowsfish	BBE	7
Scorpaenidae: scorpionfishes			
<i>Helicolenus percoides</i>	Jock Stewart	SPE	4
<i>Trachyscorpia capensis</i>	cape scorpionfish	TRS	1
Hoplichthyidae: ghostflatheads			
<i>Hoplichthys haswelli</i>	deepsea flathead	FHD	4
Psychrolutidae: toadfishes			
<i>Neophryinchthys angustus</i>	pale toadfish	TOP	37
<i>N. latus</i>	dark toadfish	TOD	3
Percichthyidae: temperate basses			
<i>Polypriion oxygeneios</i>	hapuku	HAP	1

Appendix 3 – continued

Scientific name	Common name	Species code	Occurrence
Apogonidae: cardinalfishes			
<i>Epigonus robustus</i>	cardinalfish	EPR	3
<i>E. telescopus</i>	black cardinalfish	EPT	3
Carangidae: jacks, trevallies, kingfishes			
<i>Trachurus murphyi</i>	slender mackerel	JMM	1
Bramidae: pomfrets			
<i>Brama brama</i>	Ray's bream	RBM	1
Uranoscopidae: armourhead stargazers			
<i>Kathetostoma giganteum</i>	giant stargazer	STA	21
Gempylidae: snake mackerels			
<i>Rexea solandri</i>	gemfish	SKI	10
Centrolophidae: raftfishes, medusafishes			
<i>Centrolophus niger</i>	rudderfish	RUD	6
<i>Hyperoglyphe antarctica</i>	bluenose	BNS	1
<i>Icichthys australis</i>	ragfish	RAG	1
<i>Seriola caerulea</i>	white warehou	WWA	53
<i>S. punctata</i>	silver warehou	SWA	10
Bothidae: lefteyed flounders			
<i>Arnoglossus scapha</i>	witch	WIT	4
<i>Neoachiropsetta milfordi</i>	finless flounder	MAN	66
Triacanthodidae: spikefishes			
<i>Macrorhamphosodes uradoi</i>	spikefish	SPK	1
Cephalopoda			
Opisthoteuthidae			
<i>Opisthoteuthis</i> sp.	umbrella octopus	OPI	2
Amphitretidae			
<i>Amphitretus</i> sp.	deepwater octopus	DWO	9
Histioteuthidae			
<i>Histioteuthis miranda</i>	violet squid	VSQ	3
Ommastrephidae			
<i>Nototodarus sloanii</i>	arrow squid	NOS	30
<i>Ommastrephes bartrami</i>	red squid	RSQ	12
Species not identified	squid	SQX	1
Onychoteuthidae			
<i>Moroteuthis</i> spp.	warty squid	WSQ	121
Crustacea			
Nephropsidae			
<i>Metanephrops challenger</i>	scampi	SCI	4
Decapoda			
<i>Lithodes murrayi</i>	southern stone crab	LMU	7
<i>Jacquinotia edwardsi</i>	giant spider crab	GSC	1
<i>Leptomithrax australis</i>	giant masking crab	SSC	5
<i>Lipkius holthuisi</i>	omega prawn	LHO	3
Species not identified	prawn	PRA	3
Species not identified	crab	CRB	1
Echinodermata			
Echinodea			
Species not identified	sea urchin	SUR	1



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