NIWA
Taihoro Nukurangi

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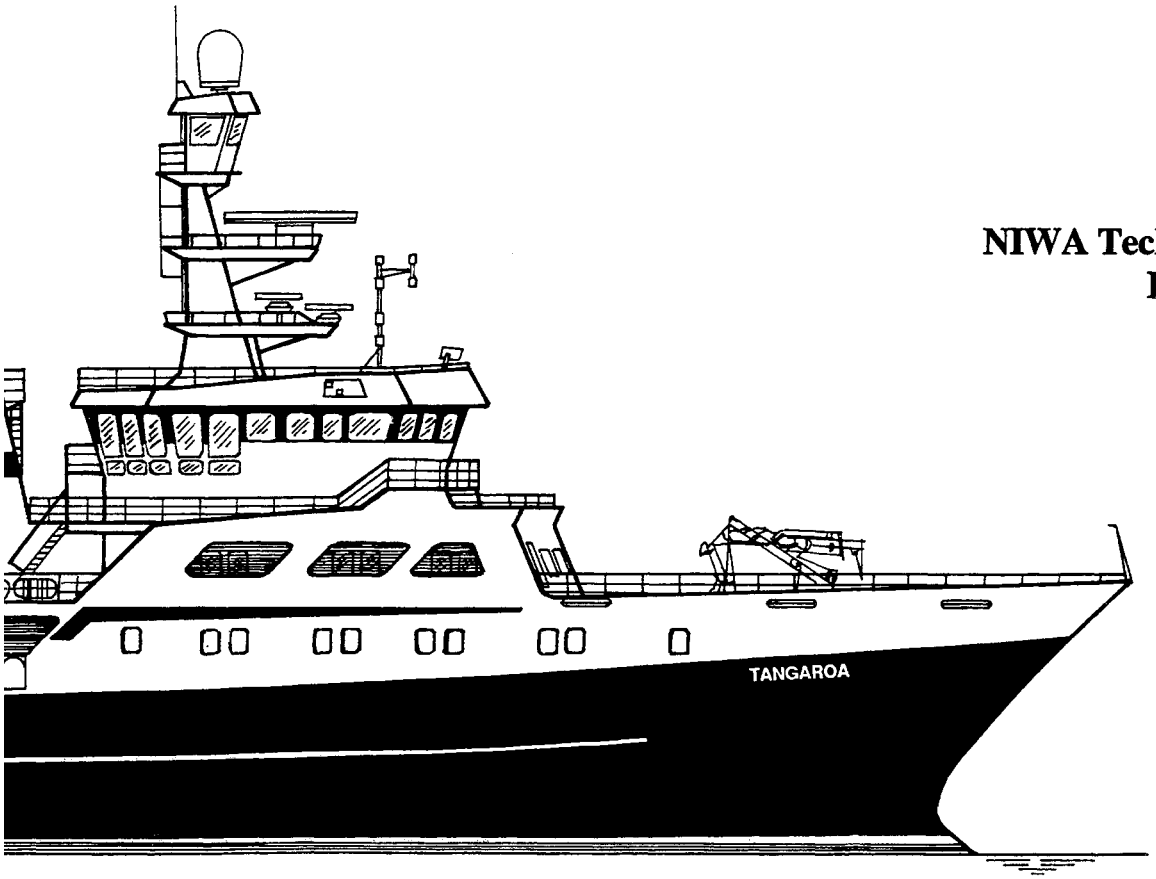

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Contents

Introduction

This report summarises the results of the sixth random trawl survey in a time series by RV *Tangaroa* providing annual relative biomass indices for hoki and other commercially important species at depths of 200–800 m on the Chatham Rise. Trawling during this voyage (TAN9701) was carried out from 2 January 1997 to 24 January 1997.

The major objectives of the trawl survey programme are as follows.

1. To provide a time series of comparable indices of abundance for adult hoki on the Chatham Rise.
2. To estimate future recruitment to the spawning hoki fisheries by determining the relative year class strength of juvenile hoki on the Chatham Rise.
3. To develop a time series of relative abundance for hake, ling, and other middle depth species on the Chatham Rise.
4. To collect biological data on hoki and other middle depth species for studies on growth and stock separation.
5. To define major water mass characteristics within the survey area.
6. To collect bathymetric data to refine stratum boundaries.

Earlier surveys in the Chatham Rise series were reported by Horn (1994a, 1994b), Schofield & Horn (1994), and Schofield & Livingston (1995, 1996). Other random trawl surveys before this series were referred to by Schofield & Livingston (1995).

Methods

Survey area and design

As in previous years, the survey was of a two-phase random design (*after* Francis 1984). Allocation of phase 1 stations took into account stratum area and combined this with an optimal design for sampling the distribution of 2+ juvenile and recruited hoki from the six most recent surveys (December 1989, January 1992, January 1993, January 1994, January 1995, and January 1996) based on simulation studies. The survey design was the same as last year's, with 20 strata rather than the 25 strata used before 1996 (Table 1). The survey area (Figure 1) totalled 139 528 km^2.

It was planned to complete 99 phase 1 stations and up to 8 stations in phase 2, to be allocated towards the end of the survey to improve the coefficient of variation for juvenile hoki.

Vessel specifications

RV *Tangaroa* is a purpose-built research stern trawler with the following specifications: length overall, 70 m; beam, 14 m; gross tonnage, 2282 t; power, 3000 kW (4000 hp).

Gear specifications

The net was the same as that used on the first five surveys of this series, i.e., the eight seam hoki bottom trawl with a 58.8 m groundrope and 45 m headrope (*see* appendix 1 of Chatterton & Hanchet (1994) for the net plan and rigging details). The codend mesh size was 60 mm. The sweeps were 100 m long, bridles were 50 m, and backstrops were 12 m. The trawl doors were Super Vee type with an area of 6.1 m^2. The doorspread and headline height was recorded every 5 minutes during the tow (from the Scanmar system and the Kaijo Denki net monitor, respectively) and the average calculated at the end of each tow.

Trawling procedure

All station positions were selected randomly using the Random Stations Generation Program (version 1.6) developed by Foster Clark and Jean-Pierre Ots (NIWA, Greta Point). If a station occurred in an area of foul ground, then an area within 3 n. miles of the position was searched for suitable bottom. If suitable ground was not found, the station was abandoned and another random position chosen. Trawl paths were always separated by a minimum of 3 n. miles. Trawling was conducted during the hours of daylight. If time was running short at the end of the day, the vessel steamed towards the last station and the trawl was shot on that transect line in time to ensure completion of the tow by sunset. At each station it was planned to tow for 3 n. miles at a speed over the ground of 3.5 knots. However, if foul ground was encountered during trawling, the tow was considered valid only if a distance of at least 2 n. miles had been covered. Tows less than 2 n. miles long were replaced with another random station in the same stratum. The average speed over the ground was calculated at the end of each tow.

Gear configuration was maintained as constant as possible during the survey and within the ranges described as desirable by Hurst *et al.* (1992).

Hydrology

Surface temperatures were obtained at the start of each tow from an uncalibrated temperature sensor mounted on the hull at a depth of about 5 m. Bottom temperatures were obtained from a Scanmar temperature sensor mounted on the trawl headline about 6.5 m above the bottom.

After the last trawl of the day, a CTD shot was made, but after six shots the sensor failed and no further data could be collected.

Catch sampling

The catch at each station was sorted into species and weighed on motion-compensating electronic scales accurate to within 0.3 kg. For large catches of assorted rattails, the weights of individual species were estimated by subsample, i.e., the subsample was sorted and weighed by species and the total catch was apportioned according to the percentage weight of each species in the subsample.

Samples of up to 200 hoki and 50–200 of other commercial species were randomly selected from the catch to measure length and determine sex. At almost every station they occurred, 20

fish of hoki, ling, hake, silver warehou, and white warehou were selected for detailed biological analysis and otolith removal. Data collected were fish length, weight, sex, gonad stage and weight, stomach fullness, stomach contents, and prey condition.

Length, weight, and sex data were also collected from samples of dark and pale ghost shark, lookdown dory, rough and smooth skates, scampi, sea perch, and giant stargazer for calculation of length-weight relationships and to improve the precision of biomass estimates for these species. Gonad stage data were also collected for rough and smooth skates.

Data analysis

Biomass was estimated by the area-swept method of Francis (1984), the standardised approach being adopted (Francis 1989). The coefficient of variation (*c.v.*) is a measure of the precision of the biomass estimate, and is calculated by:

$$c.v.\ (\%) = S_B / B \times 100$$

where S_B is the standard error of the biomass (B).

The catchability coefficient (an estimate of the proportion of fish in the survey area available to be caught in the net) is the product of vulnerability (v), vertical availability (u_v), and areal availability (u_a) as defined by Francis (1989). These factors were all set to 1 in these analyses, the assumptions being that fish were randomly distributed over the bottom within a stratum; fish distribution did not extend above the headline height of the net; all fish in the path of the doors were caught; and the herding effect of the doors, sweeps, and bridles was constant.

Scaled length frequencies were calculated for the main species with the Trawlsurvey Analysis Program version 3.2 as documented by Vignaux (1994). The data from each station are scaled by the percentage of the catch sampled (to represent each catch) and by the ratio of the area swept to stratum area (to represent the total population). A further correction is made to ensure that the biomass calculated from length frequency data is close to the biomass calculated from catch data.

Data from all stations with satisfactory gear performance (codes 1 or 2) were used to estimate biomass.

Results

Survey area

Of the 99 planned phase 1 stations, 96 were completed (*see* Table 1). Three planned phase 1 stations in stratum 7 were dropped because of time constraints. Seven phase 2 stations were completed, of which two were incorporated during phase 1 (stations 63 and 64 in stratum 10) to economise steaming time and the other five phase 2 stations were carried out once phase 1 was completed (stations 101–105 in stratum 20). Stations 29 and 93 were excluded from the analyses because of poor gear performance.

Station density in individual strata (after completion of phase 2) ranged from 1 : 274 in stratum 17 to 1 : 2939 km^2 in stratum 2 (*see* Table 1). Mean station density over the whole survey area was 1 : 1355 km^2. The positions of all stations occupied are shown in Figure 1 and individual station data are given in Appendix 1.

Gear performance

Gear parameters by depth zone indicated that the gear configuration remained fairly constant over the 200–800 m depth range (Table 2). Mean doorspread measurements ranged from 104.0 to 133.1 m and mean headline heights ranged from 5.5 to 7.5 m, each falling within the accepted range (Hurst *et al.* 1992).

Hydrology

Surface temperatures were recorded over the entire survey area and ranged from 12.7 to 16 °C (Figure 2a). Bottom temperatures ranged from 6.6 to 9.9 °C (Figure 2b). Higher temperatures were generally associated with shallower depths. A warm (9 °C) area was found in stratum 19, as in previous years. Analysis of the time series data showed this warm zone to be associated with a shallow area of less than 240 m in which no hoki were caught. This area may be excluded from future surveys of hoki.

Catch composition

During the voyage 135 species were caught including 29 elasmobranchs, 82 teleosts, and 4 cephalopods. A full list of species caught, and the number of stations at which they occurred, is given in Appendix 2.

The total catch for the survey was 151.2 t, of which 87.4 t (57.8%) was hoki, 4.5 t (2.9%) was ling, 4.0 t (2.6%) was black oreo, 2.7 t (1.8%) was alfonsino, 2.0 t (1.3%) was spiky oreo, 1.4 t (0.9%) was white warehou and giant stargazer, 1.2 t (0.8%) was silver warehou, 1.1 t (0.7%) was hake, and 0.8 t (0.5%) was arrow squid (Table 3).

Biomass estimation

Estimates of the biomass of the major commercial and non-commercial species are given in Table 3 and biomass by stratum for hoki in the 1+, 2+, and adult cohorts in Table 4. Estimates of biomass by stratum of the next 18 most abundant species are presented in Table 5. Parameters of length-weight relationships used in the Trawlsurvey Analysis Program to calculate length frequencies are given in Table 6.

Hoki was clearly the most abundant species, though 71% of the biomass was not commercially valuable as the fish were below 70 cm TL. Black oreo, ling, spiky oreo, alfonsino, hake, giant stargazer, silver warehou, smooth oreo, and arrow squid were the other important commercial species. Much of the alfonsino and oreos were of a size considered too small by commercial fishers. Of the commercial non-ITQ species listed in Table 3, only white warehou and ribaldo are regularly processed. A substantial biomass of non-commercial species, primarily rattail species, silver dory, shovelnosed dogfish, smooth skate, and Baxter's dogfish occurs on the Chatham Rise.

Species distribution

Catch rates of the 20 most abundant species are given by stratum in Table 7 and by station in Figure 3.

Although hoki were widely distributed in depths of 200–800 m over the Chatham Rise, both the 1+ and 2+ cohorts were most abundant in 200–400 m in stratum 20. The 1+ cohort was also abundant in strata 19 and 18 (200–400 m) whereas the 2+ cohort was also abundant in strata 15, 8, and 7 (400–600 m). Ling were also widely and evenly distributed in 200–800 m depths over the Chatham Rise. The highest catch rates for hake were in stratum 11 (400–600 m) and strata 1 and 2 (600–800 m). Alfonsino were most abundant in 200–400 m in the central (stratum 20) and eastern Rise (stratum 9). Silver and white warehou were patchily distributed in depths of 200–400 m but were most abundant near the Chatham Islands. Giant stargazer were most common in depths of 200–400 m over the whole survey area. Oreos were generally in the 600–800 m strata: black and smooth oreos in the south, and spiky oreo to the north and east. Bigeyed rattail were most abundant in depths of 200–600 m across the Rise. The two ghost shark species were separated by the 400 m contour, the dark ghost shark occurring mainly in the shallower zone. Lookdown dory were common over the whole area, but were in greatest abundance on the central and eastern Rise in depths of 200–600 m. Sea perch were most common in depths of 200–400 m on the central Rise. Javelinfish were common throughout the survey area, particularly in depths of 400–800 m. Spiny dogfish and arrow squid were most abundant in 200–400 m. Silver dory were also common in 200–400 m, but the highest catch rates were west of the Chatham Islands. Shovelnosed dogfish were most abundant in the north at depths greater than 600 m, and smooth skate were most common in less than 600 m depth across the Rise. Orange perch were caught in depths of 200–400 m, but mainly in stratum 9.

Biology

The numbers of fish of each species measured or examined in more detail are given in Table 8. Length frequency histograms, by sex, of the major commercial species are shown in Figure 4. The length frequencies represent the population structure for the survey area, as sampled by bottom trawl. Length frequencies of hoki by sex, depth, and area are given in Figure 5. Length frequencies by sex and depth zone are given for ling (Figure 6), hake (Figure 7), and alfonsino (Figure 8).

Scaled length frequency distributions of hoki show a very strong 2+ cohort, with a mode at 50 cm total length, mainly caught on the eastern Rise at 200–400 m depth and on the west at 400–600 m. The 1+ cohort with a mode at 40 cm is weak compared to last year's and was caught in 200–400 m depth. The 3+ and 4+ cohorts (with modes at 59 and 65 cm for males and 62 and 68 cm for females) were most abundant in 200–400 m on the eastern Rise and in 400–600 m depth across the Rise. Adult hoki were present in small numbers in all areas. The mean size of hoki increased with increasing depth. Length frequencies of hoki by strata are given in Appendix 3.

Sex ratios were about even for most species except hapuku, orange roughy, rubyfish, spiny dogfish, banded giant stargazer, and rough skate, which were predominantly female (1 : 1.5), and barracouta, slender and jack mackerel, northern spiny dogfish, red cod, school shark, sea perch, and tarakihi, which were predominantly male (sex ratios exceeded 1.5 : 1).

A summary of the gonad stages of hoki, hake, ling, silver warehou, and white warehou is given in Table 9. All hoki were either immature or resting. Of adult hake, 62% of males and 34% of females were in active reproductive stages (ripening to partially spent: stages 3–6). Of adult ling, 53% of males and 16% of females had active reproductive stages. Adult silver warehou and white warehou were mainly resting, although 25% of female white warehou were stage 3.

Discussion

The allocation of phase 1 stations, based on a combined optimal design for 2+ and adult hoki from simulation studies and the combining of strata, achieved the target precision levels. Phase 2 stations were targeted at reducing the biomass *c.v.* for 2+ hoki in strata 10 and 20. The *c.v.*s for 2+ (12%), and 3++ hoki (8%) were good, as was the biomass *c.v.* for ling at 10%.

The optimisation of the survey design for 2+ and adult hoki, and a reduction in station numbers, resulted in a less than optimal design for some other species, particularly hake (objective 3). The biomass *c.v.* for hake was low at 17%, but the biomass was also lower than in previous surveys (except for 1996), possibly because the survey missed the main aggregations. It is recommended that the survey be expanded on a 2 yearly basis to ensure that objective 3 can be met.

The survey has shown that the Chatham Rise continues to be a nursery ground for hoki. A comparison of this survey and the previous surveys has shown that the 1991, 1992, and 1994 year classes were strong compared to the 1990 and 1993 cohorts. The 1995 year class (1 year olds in this survey) are also comparatively weak. The total hoki biomass was slightly higher than last year's due to growth of last year's strong 1+ cohort into 2 year olds.

RV *Tangaroa* is a consistent sampling platform enabling interannual comparisons of biomass estimates for a range of species. With time, it should be possible to distinguish real changes in abundance from apparent changes caused by changes in vulnerability.

Stratum boundaries will continue to be modified as the bathymetric database improves.

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Table 1: Stratum description and station allocation*

Stratum	Pre-1996 stratum	Area (km^2)	Number of stations P1	C1	C2	Station density (km^2 per station)	Depth range (m)
1	1	2 439	3	3	0	813	600–800
2	2 & 3	11 756	4	4	0	2 939	600–800
3	21	3 499	3	3	0	1 166	200–400
4	4 & 5	11 315	5	5	0	2 263	600–800
5	22	4 076	6	6	0	679	200–400
6	6	8 146	4	4	0	2 037	600–800
7	7	5 233	10	7	0	748	400–600
8	8 & 9	9 008	7	7	0	1 287	400–600
9	23	5 136	4	4	0	1 284	200–400
10	10	6 321	4	4	2	1 054	400–600
11	11 & 25	11 758	5	5	0	2 352	400–600
12	12	6 578	5	5	0	1 316	400–600
13	13	6 684	6	6	0	1 114	400–600
14	14	5 928	5	5	0	1 186	400–600
15	15	5 883	4	4	0	1 471	400–600
16	16 & 17	11642	8	8	0	1 455	400–600
17	24	822	3	3	0	274	200–400
18	18	4 704	4	4	0	1 176	200–400
19	19	9 013	4	4	0	2 253	200–400
20	20	9 586	5	5	5	959	200–400
Total		139 528	99	96	7	(1 355)	

* Number of stations; P1, proposed phase 1 stations; C1, completed phase 1 stations; C2, completed phase 2 stations.

Table 2: Tow and gear parameters by depth range. Values shown are sample size (*n*), and for each parameter the mean, standard deviation (*s.d.*), and range

	n	Mean	*s.d.*	Range
Tow parameters				
Tow length (n. mile)	103	2.98	0.15	2.00–3.15
Tow speed (knots)	103	3.5	0.08	3.1–3.7
Gear parameters (m)				
200–400 m				
Headline height	34	6.8	0.3	6.0–7.3
Doorspread	33	118.8	6.4	104.0–128.6
400–600 m				
Headline height	53	6.8	0.3	5.7–7.5
Doorspread	50	122.4	5.6	110.3–133.1
600–800 m				
Headline height	16	6.8	0.4	5.5–7.3
Doorspread	16	120.8	3.3	115.0–127.0
Total depth range				
Headline height	103	6.8	0.3	5.5–7.5
Doorspread	99	121.0	5.8	104.0–133.1

Table 3: Estimated biomass, with *c.v.* in parentheses, and catch of all important ITQ species, important commercial non-ITQ species, and major non-commercial species. Dashes indicate that the fish were not sexed

	Species code	Total biomass (t) All fish		Females		Males		Catch (kg)
ITQ species								
Hoki	HOK	157 974	(8.4)	91 754	(8.2)	66 219	(8.9)	87 408
Black oreo	BOE	12 493	(34.5)	6 055	(34.2)	6 438	(35.7)	3 962
Ling	LIN	8 543	(9.8)	4 253	(11.4)	4 289	(10.2)	4 459
Spiky oreo	SOR	6 770	(36.7)	2 854	(35.3)	3 914	(37.8)	1 977
Alfonsino	BYS	4 152	(62.9)	2 124	(65.7)	2 017	(60.4)	2 712
Hake	HAK	2 811	(16.7)	1 767	(16.3)	1 044	(24.7)	1 130
Giant stargazer	STA	2 328	(14.5)	1 665	(13.7)	662	(26.2)	1 419
Silver warehou	SWA	2 101	(31.8)	1 124	(37.7)	977	(27.3)	1 201
Smooth oreo	SSO	1 474	(92.6)	723	(93.3)	751	(91.9)	444
Arrow squid	NOS	904	(25.9)	459	(26.2)	444	(26.7)	791
Slender mackerel	JMM	335	(42.5)	114	(45.0)	220	(42.4)	216
Red cod	RCO	296	(31.4)	159	(32.3)	126	(40.0)	216
School shark	SCH	226	(37.2)	64	(74.2)	161	(40.7)	121
Tarakihi	TAR	224	(54.5)	72	(62.9)	152	(53.7)	179
Barracouta	BAR	209	(44.7)	96	(50.9)	114	(43.1)	146
Hapuku	HAP	79	(36.5)	40	(52.2)	39	(59.5)	54
Lemon sole	LSO	48	(23.3)	4	(55.4)	3	(56.4)	37
Scampi	SCI	31	(14.7)	10	(17.9)	18	(17.2)	17
Bluenose	BNS	31	(100)	0	(0)	31	(100)	7
Orange roughy	ORH	28	(90.4)	22	(88.1)	6	(100)	8
Commercial non-ITQ species								
Spiny dogfish	SPD	9 570	(14.0)	7 898	(13.0)	1 672	(22.0)	5 808
Lookdown dory	LDO	6 568	(7.6)	4 650	(8.7)	1 900	(8.3)	3 502
Dark ghost shark	GSH	6 242	(11.7)	3 488	(12.0)	2 754	(12.9)	3 915
Orange perch	OPE	3 882	(83.7)	–		–		1 723
Pale ghost shark	GSP	2 871	(12.2)	1 449	(13.6)	1 422	(15.6)	1 330
Sea perch	SPE	2 773	(14.2)	1 029	(14.6)	1 526	(14.9)	1 496
White warehou	WWA	2 287	(20.0)	1 061	(22.4)	994	(22.0)	1 400
Southern blue whiting	SBW	618	(99.8)	259	(99.8)	358	(99.8)	349
Ribaldo	RIB	333	(21.3)	178	(25.7)	155	(29.9)	174
Ray's bream	RBM	280	(31.4)	133	(36.8)	147	(28.9)	165
Non-commercial species								
Bigeyed rattail	CBO	6 936	(19.8)	–		–		3 385
Javelinfish	JAV	5 181	(9.8)	–		–		2 086
Silver dory	SDO	4 518	(51.2)	–		–		3 894
Shovelnosed dogfish	SND	3 724	(38.4)	–		–		1 320
Smooth skate	SSK	1 932	(22.3)	1 205	(28.2)	727	(33.5)	1 033
Baxter's dogfish	ETB	1 575	(66.5)	–		–		1 083
Oblique-banded rattail	CAS	1 477	(17.7)	–		–		1 219
Oliver's rattail	COL	1 158	(26.3)	–		–		484
Rudderfish	RUD	862	(22.0)	–		–		329
Longnosed chimaera	LCH	587	(23.6)	–		–		263
Silverside	SSI	299	(22.4)	–		–		151
Moroteuthis ingens	MIQ	256	(13.2)	–		–		115

Table 4: Estimated biomass (and *c.v.* %) of hoki by cohort and stratum

			Cohort					
			1+		2+		Adult	
Stratum		Total	(< 44 cm)		(44–56 cm)		(> 56 cm)	
1	2 467	(29)	0		231	(51)	1 011	(28)
2	3 742	(50)	0		3	(100)	3 739	(50)
3	9 710	(44)	80	(100)	2 727	(29)	6 903	(54)
4	5 388	(10)	0		143	(96)	5 244	(11)
5	4 248	(45)	30	(62)	2 067	(46)	2 151	(47)
6	4 087	(28)	0		437	(40)	3 650	(29)
7	9 509	(12)	4	(100)	5 729	(16)	3 776	(19)
8	15 542	(29)	0		5 807	(30)	9 736	(31)
9	4 859	(58)	11	(100)	2 982	(62)	1 867	(59)
10	5 612	(54)	2	(68)	1 558	(50)	4 052	(56)
11	6 370	(18)	32	(78)	2 484	(28)	3 855	(22)
12	7 576	(29)	8	(42)	1 992	(45)	5 577	(32)
13	8 248	(26)	0		925	(41)	7 323	(27)
14	9 273	(21)	7	(66)	1 779	(34)	7 487	(24)
15	12 342	(9)	5	(100)	6 310	(10)	6 027	(13)
16	10 486	(30)	14	(62)	3 931	(41)	6 541	(26)
17	332	(54)	0		44	(76)	288	(51)
18	5 415	(58)	310	(47)	3 043	(67)	2 061	(46)
19	9 650	(47)	1 083	(52)	5 279	(46)	3 289	(63)
20	23 118	(31)	1 600	(71)	15 267	(36)	6 251	(21)
Total	157 974	(8)	3 184	(40)	62 738	(12)	92 052	(8)

Table 5: Estimated biomass (and *c.v.* %) of the 18 most abundant species, other than hoki, by stratum*

Stratum	Species code																	
	BOE		SPD		LIN		CBO		SOR		LDO		GSH		JAV		SDO	
1	0		0		204	(37)	82	(23)	151	(43)	18	(56)	0		239	(37)	0	
2	0		0		556	(48)	102	(21)	2 080	(31)	146	(31)	0		1 576	(20)	0	
3	0		2 318	(50)	227	(51)	29	(91)	0		476	(37)	571	(53)	142	(97)	6	(82)
4	3 446	(75)	3	(100)	352	(32)	164	(30)	4 509	(53)	254	(26)	0		668	(17)	0	
5	0		1 472	(17)	360	(27)	81	(30)	0		295	(33)	1 049	(31)	13	(39)	3 816	(60)
6	9 046	(38)	0		426	(42)	178	(19)	2	(100)	28	(32)	0		309	(18)	0	
7	0		77	(48)	531	(32)	164	(15)	26	(90)	54	(33)	0		142	(40)	0	
8	0		126	(45)	455	(58)	363	(57)	0		437	(22)	105	(52)	29	(29)	0	
9	0		466	(53)	162	(61)	23	(97)	0		156	(63)	191	(62)	12	(90)	697	(52)
10	0		306	(66)	291	(35)	263	(44)	0		278	(19)	224	(76)	104	(45)	0	
11	0		361	(64)	604	(21)	235	(36)	0		416	(28)	269	(69)	316	(65)	0	
12	0		216	(36)	281	(15)	418	(38)	0		531	(20)	147	(93)	168	(50)	0	
13	0		699	(31)	347	(15)	326	(38)	2	(100)	392	(24)	114	(65)	111	(40)	0	
14	0		634	(37)	432	(23)	641	(32)	0		560	(26)	0		320	(43)	0	
15	0		315	(34)	355	(18)	415	(14)	0		265	(28)	0		140	(34)	0	
16	0		329	(32)	1 199	(28)	1 026	(21)	0		449	(22)	0		619	(29)	0	
17	0		109	(56)	11	(48)	1	(100)	0		6	(30)	138	(62)	0.3	(100)	0	
18	0		352	(29)	340	(78)	180	(48)	0		378	(48)	322	(22)	10	(51)	0	
19	0		1 044	(13)	616	(70)	1 425	(89)	0		498	(48)	1 378	(26)	94	(73)	0	
20	0		741	(39)	794	(24)	820	(30)	0		930	(16)	1 736	(17)	168	(39)	0	
Total	12 493	(35)	9 570	(14)	8 543	(10)	6 936	(20)	6 770	(37)	6 568	(8)	6 242	(12)	5 181	(10)	4 518	(51)

Table 5 – *continued*

Stratum	Species code																	
	BYS		OPE		SND		GSP		HAK		SPE		STA		WWA		SWA	
1	0		0		680	(56)	46	(32)	95	(25)	3	(51)	7	(50)	0		0	
2	5	(100)	0		2 739	(50)	317	(76)	428	(51)	71	(100)	35	(64)	0		0	
3	13	(40)	0		0		0		28	(83)	178	(93)	34	(62)	305	(54)	48	(48)
4	0		0		220	(63)	90	(44)	141	(40)	42	(48)	0		0		0	
5	167	(47)	24	(74)	0		0		25	(45)	35	(35)	377	(36)	545	(39)	224	(32)
6	0		0		11	(58)	481	(32)	115	(45)	17	(100)	27	(61)	42	(79)	4	(100)
7	0		0		27	(88)	173	(23)	84	(33)	11	(53)	29	(52)	19	(50)	5	(100)
8	50	(85)	0		0		189	(26)	132	(27)	202	(29)	114	(70)	0		39	(89)
9	605	(73)	3 189	(100)	0		0		24	(100)	72	(58)	204	(21)	551	(58)	447	(87)
10	111	(70)	0		0		42	(42)	72	(53)	37	(34)	16	(100)	15	(56)	60	(87)
11	436	(60)	1	(100)	0		58	(41)	992	(38)	83	(38)	55	(100)	153	(50)	21	(62)
12	21	(90)	0		5	(100)	74	(36)	94	(87)	36	(25)	64	(81)	60	(100)	519	(99)
13	0		0		8	(100)	327	(25)	53	(48)	117	(34)	7	(65)	5	(100)	6	(100)
14	1	(100)	0		26	(100)	237	(36)	77	(31)	146	(35)	18	(63)	0		97	(44)
15	0		0		0		398	(19)	91	(43)	82	(54)	12	(100)	36	(80)	7	(100)
16	0		0		0		257	(25)	214	(29)	57	(34)	91	(21)	153	(38)	130	(65)
17	0		0		0		0		0		2	(100)	112	(21)	1	(100)	14	(90)
18	2	(100)	1	(100)	0		0		9	(58)	132	(36)	230	(33)	111	(77)	240	(32)
19	99	(100)	666	(96)	8	(100)	131	(75)	79	(76)	494	(43)	713	(36)	179	(55)	152	(51)
20	2 642	(97)	1	(100)	0		52	(66)	56	(29)	953	(26)	183	(46)	113	(39)	89	(27)
Total	4 152	(63)	3 882	(84)	3 724	(38)	2 871	(12)	2 811	(17)	2 773	(14)	2 328	(14)	2 287	(20)	2 101	(32)

* Species codes are given in Table 3.

Table 6: Length-weight relationship parameters *a* and *b* used in the Trawlsurvey Analysis Program to calculate length frequencies*

	a	*b*	*n*	r^2	Range	Data source
Dark ghost shark	0.003336	3.154065	114	0.97	28–74	This survey
Giant stargazer	0.004751	3.315037	18	0.98	42–70	This survey
Hake	0.001806	3.313273	295	0.98	43–126	This survey
Hoki	0.003262	2.973415	793	0.98	38–109	This survey
Ling	0.001027	3.349249	588	0.99	38–155	This survey
Lookdown dory	0.026059	2.955319	39	0.99	23–53	This survey
Pale ghost shark	0.039787	2.559277	24	0.82	63–81	This survey
Scampi	0.434377	3.078018	135	0.88	2–6.9	This survey
Sea perch	0.005876	3.299961	101	0.99	17–38	This survey
Silver warehou	0.006840	3.263780	144	0.87	41–57	This survey
Smooth skate	0.017677	3.024078	54	0.98	61–155	This survey
White warehou	0.019447	3.044881	128	0.98	19–62	This survey
Alfonsino	0.013041	3.167414	235	0.99	19–45	Survey TAN9601
Arrow squid	0.0290	3.00	–	–	–	Annala (1993)
Barracouta	0.0091	2.88	730	0.95	25–95	Hurst & Bagley (1987)
Black oreo	0.0248	2.950	9 790	0.98	11–44	DB, Chat. Rise, Nov-Mar
Lemon sole	0.02323	2.833	–	–	–	DB, IKA8003
Orange roughy	0.0687	2.792	7 880	0.99	9–44	DB, Chat. Rise, Nov-Mar
Red cod	0.0092	3.003	923	0.98	13–72	Beentjes (1992)
Ribaldo	0.002300	3.408922	54	0.97	35–71	Survey TAN9601
School shark	0.00702	2.91	804	–	30–166	Seabrook-Davison, Unp.
Slender mackerel	0.0255	2.77	90	0.91	44–62	DB, Stew/Sn, Feb-Mar
Smooth oreo	0.0309	2.895	9 147	0.98	10–57	DB, Chat. Rise, Nov-Mar
Southern blue whiting	0.003	3.2	444	–	19–55	Hatanaka *et al.* (1989)
Spiky oreo	0.054	2.78	20	–	26–42	DB, Chat. Rise, March
Spiny dogfish	0.001890	3.194061	170	0.97	53–106	Survey TAN9601
Tarakihi	0.02	2.98	–	–	–	Annala (1993)

* $W = aL^b$ where W is weight (g) and L is length (cm); n, sample number; r^2 is correlation coefficient; Range, length range of fish (cm); DB, NIWA (previously MAF Fisheries) trawl database; Stew/Sn, Stewart-Snares shelf; Unp., Unpublished.

Table 7: Catch rates (kg.km^{-2}) with standard deviations (in parentheses) by stratum for the 20 species most abundant in the catch*

Stratum	Species code									
	HOK	BOE	SPD	LIN	CBO	SOR	LDO	GSH	JAV	SDO
1	1 011	0	0	84	34	62	7	0	98	0
	(517)	(0)	(0)	(54)	(13)	(46)	(7)	(0)	(62)	(0)
2	318	0	0	47	9	177	12	0	134	0
	(318)	(0)	(0)	(46)	(4)	(111)	(8)	(0)	(53)	(0)
3	2 775	0	662	65	8	0	136	163	41	2
	(2 092)	(0)	(568)	(57)	(13)	(0)	(88)	(151)	(68)	(2)
4	476	305	0.3	31	14	398	22	0	59	0
	(106)	(513)	(0.7)	(23)	(10)	(474)	(13)	(0)	(23)	(0)
5	1 042	0	361	88	20	0	72	257	3	936
	(1 161)	(0)	(153)	(58)	(15)	(0)	(58)	(193)	(3)	(1 374)
6	502	1 110	0	52	22	0.2	3	0	38	0
	(283)	(846)	(0)	(44)	(8)	(0.4)	(2)	(0)	(13)	(0)
7	1 817	0	15	101	31	5	10	0	27	0
	(583)	(0)	(19)	(85)	(12)	(12)	(9)	(0)	(28)	(0)
8	1 725	0	14	51	40	0	48	12	3	0
	(1 333)	(0)	(17)	(78)	(60)	(0)	(29)	(16)	(2)	(0)
9	946	0	91	32	4	0	30	37	2	136
	(1 107)	(0)	(96)	(39)	(9)	(0)	(38)	(46)	(4)	(140)
10	888	0	48	46	42	0	44	35	16	0
	(1 177)	(0)	(79)	(39)	(44)	(0)	(21)	(66)	(18)	(0)
11	542	0	31	51	20	0	35	23	27	0
	(219)	(0)	(44)	(24)	(16)	(0)	(22)	(35)	(39)	(0)
12	1 152	0	33	43	63	0	81	22	25	0
	(738)	(0)	(27)	(14)	(54)	(0)	(37)	(46)	(28)	(0)
13	1 234	0	105	52	49	0.2	59	17	17	0
	(780)	(0)	(79)	(19)	(45)	(0.6)	(34)	(27)	(16)	(0)
14	1 564	0	107	73	108	0	94	0	54	0
	(741)	(0)	(89)	(37)	(76)	(0)	(55)	(0)	(51)	(0)
15	2 098	0	54	60	71	0	45	0	24	0
	(395)	(0)	(36)	(21)	(20)	(0)	(25)	(0)	(16)	(0)
16	901	0	28	103	88	0	39	0	53	0
	(769)	(0)	(26)	(81)	(52)	(0)	(24)	(0)	(43)	(0)
17	404	0	132	13	2	0	8	167	0.3	0
	(376)	(0)	(128)	(11)	(3)	(0)	(4)	(179)	(0.6)	(0)
18	1 151	0	75	72	38	0	80	68	2	0
	(1 327)	(0)	(43)	(113)	(37)	(0)	(78)	(30)	(2)	(0)
19	1 071	0	116	68	158	0	55	153	10	0
	(1 000)	(0)	(30)	(96)	(282)	(0)	(53)	(80)	(15)	(0)
20	2 412	0	77	83	86	0	97	181	18	0
	(2 388)	(0)	(95)	(63)	(80)	(0)	(49)	(100)	(22)	(0)

Table 7–*continued*

Stratum	Species code									
	BYS	OPE	SND	GSP	HAK	SPE	STA	WWA	SWA	SSK
1	0	0	279	19	39	1	3	0	0	0
	(0)	(0)	(269)	(11)	(17)	(1)	(3)	(0)	(0)	(0)
2	0.4	0	233	27	36	6	3	0	0	0
	(0.8)	(0)	(233)	(41)	(37)	(12)	(4)	(0)	(0)	(0)
3	4	0	0	0	8	51	10	87	14	18
	(3)	(0)	(0)	(0)	(12)	(82)	(10)	(81)	(12)	(31)
4	0	0	19	8	12	4	0	0	0	0
	(0)	(0)	(27)	(8)	(11)	(4)	(0)	(0)	(0)	(0)
5	41	6	0	0	6	9	93	134	55	7
	(47)	(11)	(0)	(0)	(7)	(7)	(82)	(127)	(43)	(13)
6	0	0	1	59	14	2	3	5	0.5	19
	(0)	(0)	(2)	(37)	(13)	(4)	(4)	(8)	(1)	(37)
7	0	0	5	33	16	2	6	4	1	3
	(0)	(0)	(12)	(20)	(14)	(3)	(8)	(5)	(2)	(7)
8	6	0	0	21	15	22	13	0	4	33
	(12)	(0)	(0)	(14)	(10)	(17)	(23)	(0)	(10)	(68)
9	118	621	0	0	5	14	40	107	87	9
	(172)	(1 240)	(0)	(0)	(9)	(16)	(16)	(125)	(151)	(8)
10	18	0	0	7	11	6	2	2	10	22
	(30)	(0)	(0)	(7)	(15)	(5)	(6)	(3)	(20)	(42)
11	37	0.1	0	5	84	7	5	13	2	12
	(49)	(0.3)	(0)	(5)	(72)	(6)	(10)	(15)	(2)	(12)
12	3	0	1	11	14	5	10	9	79	40
	(7)	(0)	(2)	(9)	(28)	(3)	(18)	(20)	(175)	(48)
13	0	0	1	49	8	18	1	1	1	6
	(0)	(0)	(3)	(30)	(9)	(15)	(2)	(2)	(2)	(9)
14	0.2	0	4	40	13	25	3	0	16	0
	(0.4)	(0)	(10)	(32)	(9)	(19)	(4)	(0)	(16)	(0)
15	0	0	0	68	16	14	2	6	1	0
	(0)	(0)	(0)	(26)	(13)	(15)	(4)	(10)	(3)	(0)
16	0	0	0	22	18	5	8	13	11	15
	(0)	(0)	(0)	(16)	(15)	(5)	(5)	(14)	(21)	(31)
17	0	0	0	0	0	2	136	1	17	0
	(0)	(0)	(0)	(0)	(0)	(4)	(48)	(1)	(26)	(0)
18	0.3	0.2	0	0	2	28	49	24	51	0
	(0.7)	(0.4)	(0)	(0)	(2)	(20)	(32)	(36)	(33)	(0)
19	11	74	1	14	9	55	79	20	17	13
	(22)	(142)	(2)	(22)	(13)	(47)	(57)	(22)	(17)	(27)
20	276	0.1	0	5	6	99	19	12	9	49
	(843)	(0.5)	(0)	(11)	(5)	(82)	(28)	(15)	(8)	(63)

* Species codes are given in Table 3.

Table 8: Species measured or selected for length frequencies and biological analysis, showing numbers of samples and numbers of fish examined

	Length frequency samples				Biological samples	
	No. of fish measured			No. of	No. of	No. of
Species	Total†	Male	Female	samples	fish	samples
Barracouta	98	61	37	9	0	
Banded giant stargazer	3	1	2	1	0	
Bluenose	1	1	0	1	0	
Black oreo	568	299	269	6	0	
Alfonsino	1 111	629	463	37	0	
Blue mackerel	1	1	0	1	0	
Deepsea cardinalfish	1	0	1	1	0	
Dark ghost shark	2 097	1 024	1 073	49	115 *	2
Pale ghost shark	635	349	268	68	24 *	1
Hake	308	149	159	77	299	72
Hapuku, groper	9	3	6	7	0	
Hoki	19 714	8 705	11 007	99	824	39
Jack mackerel	3	2	1	2	0	
Slender mackerel	168	108	59	19	0	
Lookdown dory	3 800	1 744	2 013	102	39 *	1
Ling	1 440	837	601	98	588	53
Lemon sole	80	5	4	14	0	
Arrow squid	942	498	442	50	0	
Northern spiny dogfish	26	19	7	6	0	
Orange roughy	15	4	11	2	0	
Ray's bream	120	60	60	31	0	
Rubyfish	45	13	32	1	0	
Red cod	256	145	83	26	0	
Ribaldo	94	54	39	25	0	
Rough skate	3	1	2	3	3 ‡	3
Southern blue whiting	87	50	37	2	0	
School shark	9	7	2	7	0	
Scampi	136	81	55	38	136 *	38
Spiky oreo	695	413	282	14	0	
Spiny dogfish	2 149	482	1 667	76	0	
Sea perch	1 870	1 127	640	87	101 *	1
Smooth skate	54	22	32	29	54 ‡	29
Smooth oreo	206	114	92	9	0	
Giant stargazer	367	162	202	56	18 *	1
Silver warehou	525	265	260	50	144	8
Tarakihi	135	96	39	5	0	
White warehou	789	324	326	48	128	19

* Length, sex, and weight data only collected.

‡ Length, sex, weight, and gonad stage data collected.

† Total is sometimes greater than the sum of male and female fish due to the sex of some fish not recorded.

Table 9: Numbers of male and female hoki, hake, ling, and silver warehou at each reproductive stage*

	Hoki		Hake		Ling	
Stage	Male	Female	Male	Female	Male	Female
1	107	142	60	35	103	73
2	156	354	30	75	108	145
3	0	0	7	34	64	27
4	0	0	4	2	53	1
5	0	0	36	0	1	0
6	0	0	6	4	6	0
7	0	0	2	3	0	1
Total	263	496	145	153	335	247

	Silver warehou		White warehou	
Stage	Male	Female	Male	Female
1	0	0	31	18
2	64	63	24	30
3	0	3	3	10
4	0	0	0	0
5	1	0	0	0
6	0	4	0	0
7	5	4	9	0
Total	70	74	67	58

* 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).

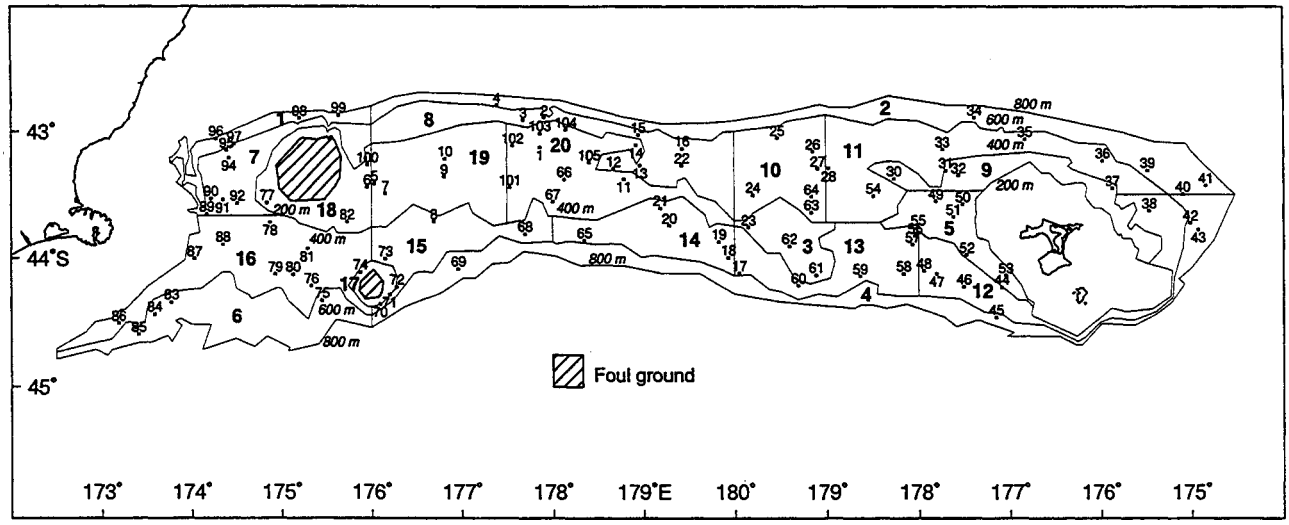


Figure 1: Trawl survey area showing stratum boundaries and trawl station positions.

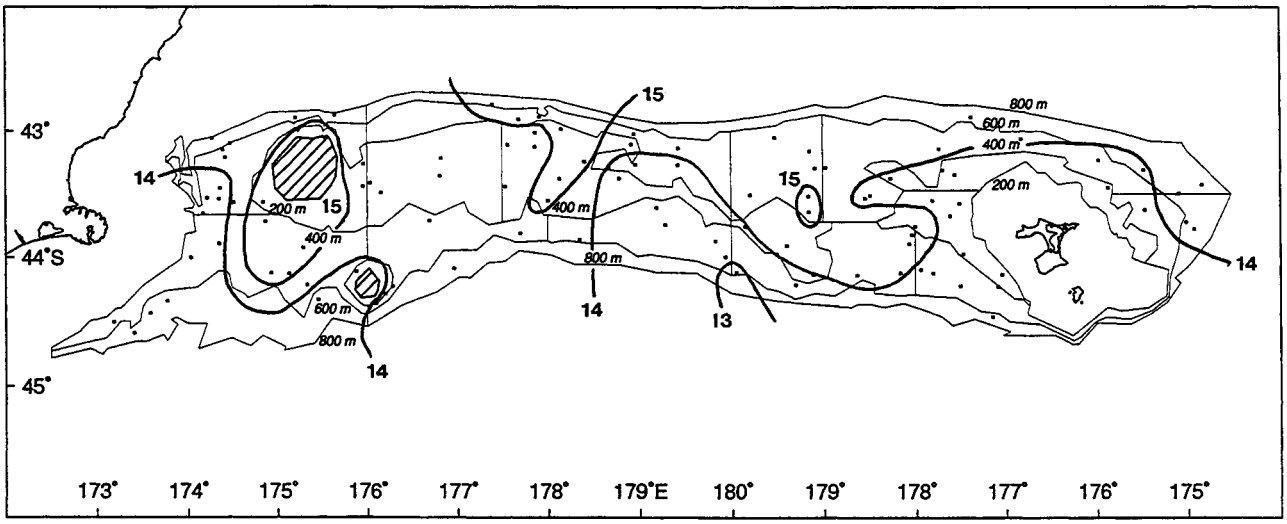


Figure 2a: Positions of surface temperature recordings and isotherms estimated from these data.

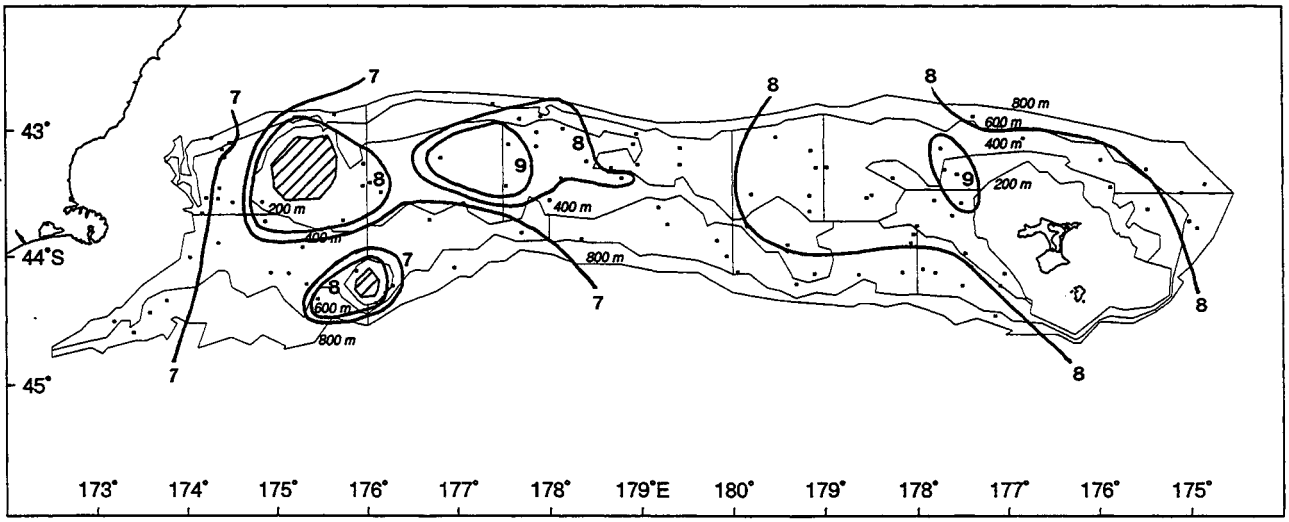


Figure 2b: Positions of bottom temperature recordings and isotherms estimated from these data.

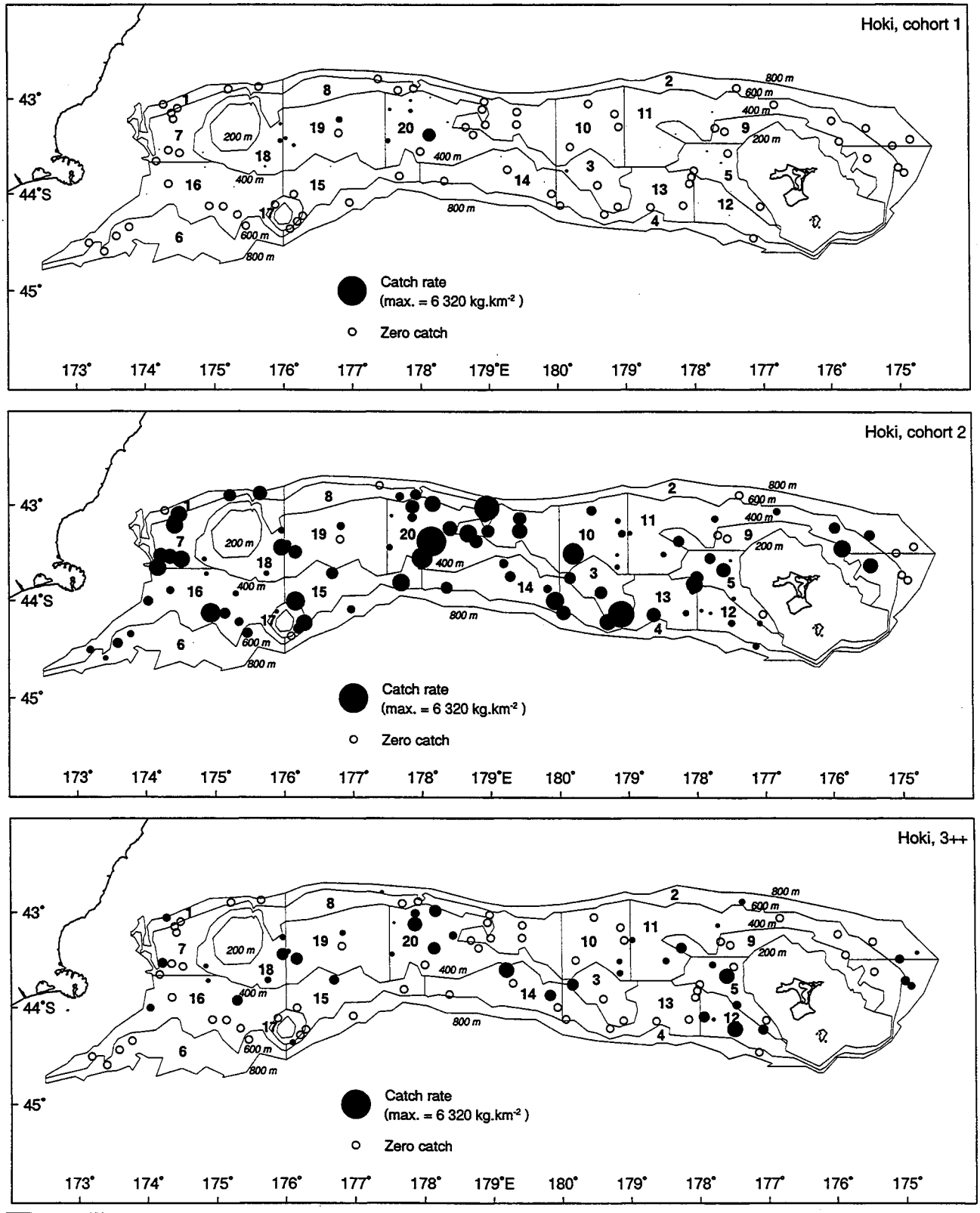


Figure 3: Catch rates (kg.km^{-2}) of hoki, ling, and other important species. Circle area is proportional to catch rate. Max, maximum catch rate.

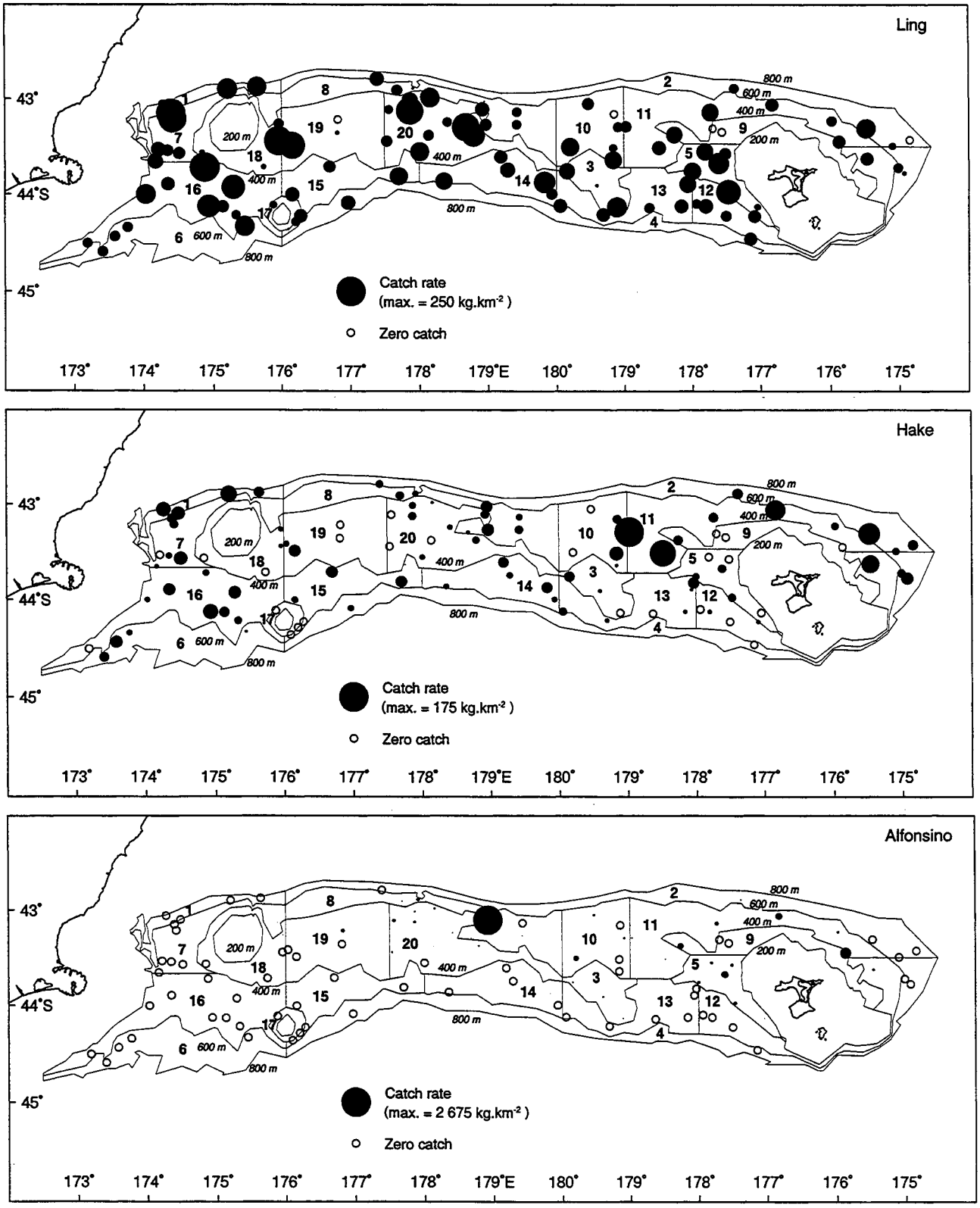


Figure 3—*continued*

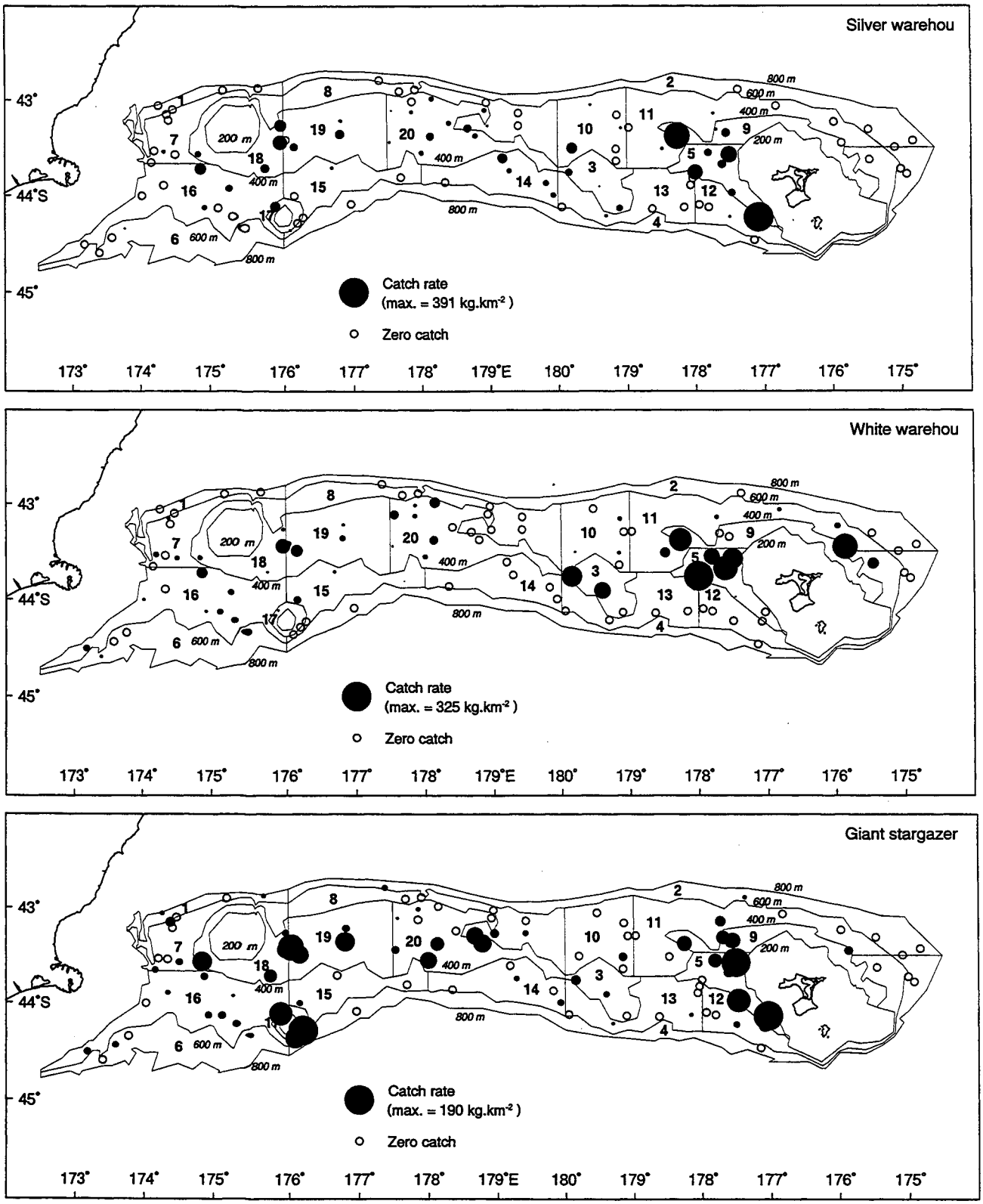


Figure 3—*continued*

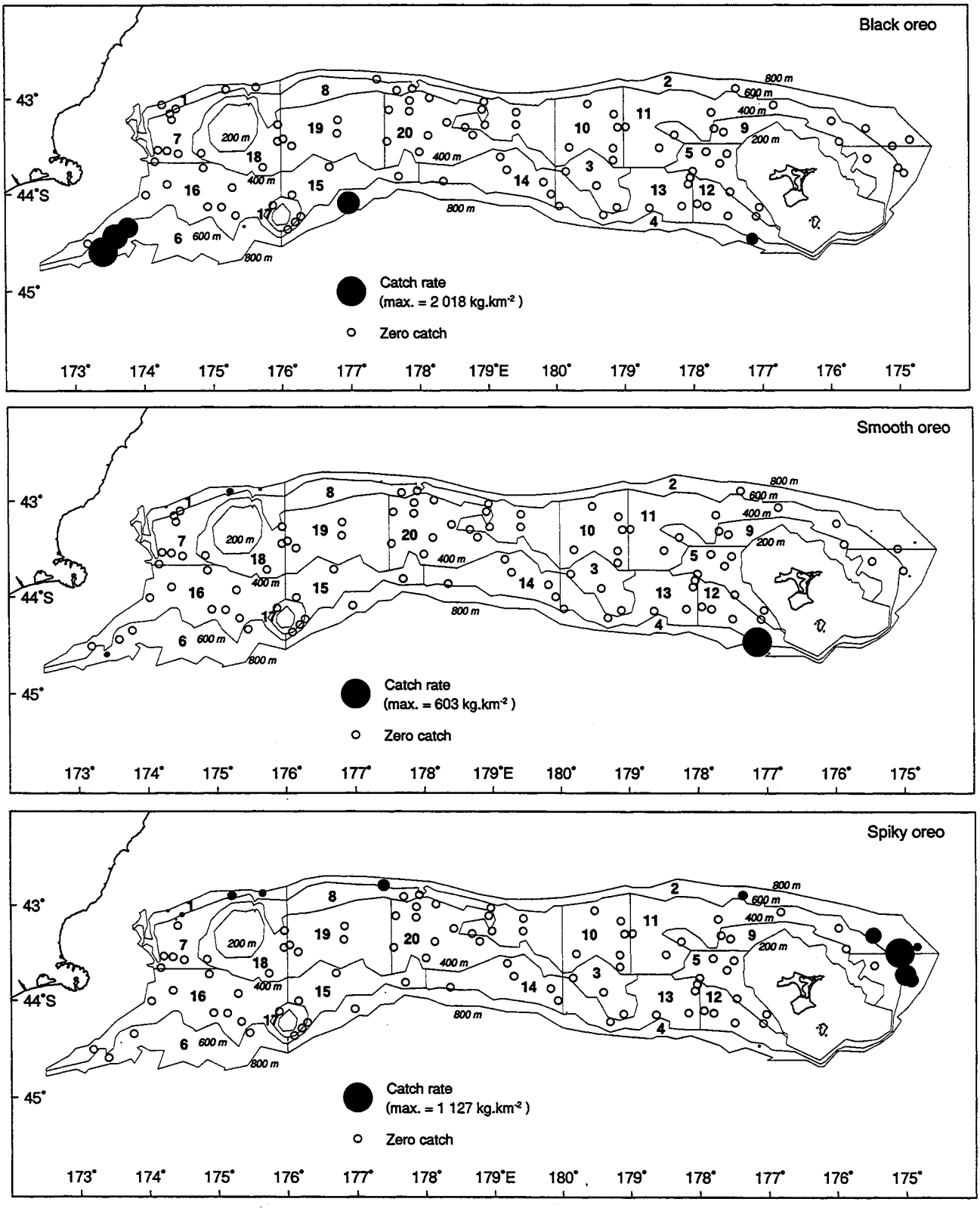


Figure 3—*continued*

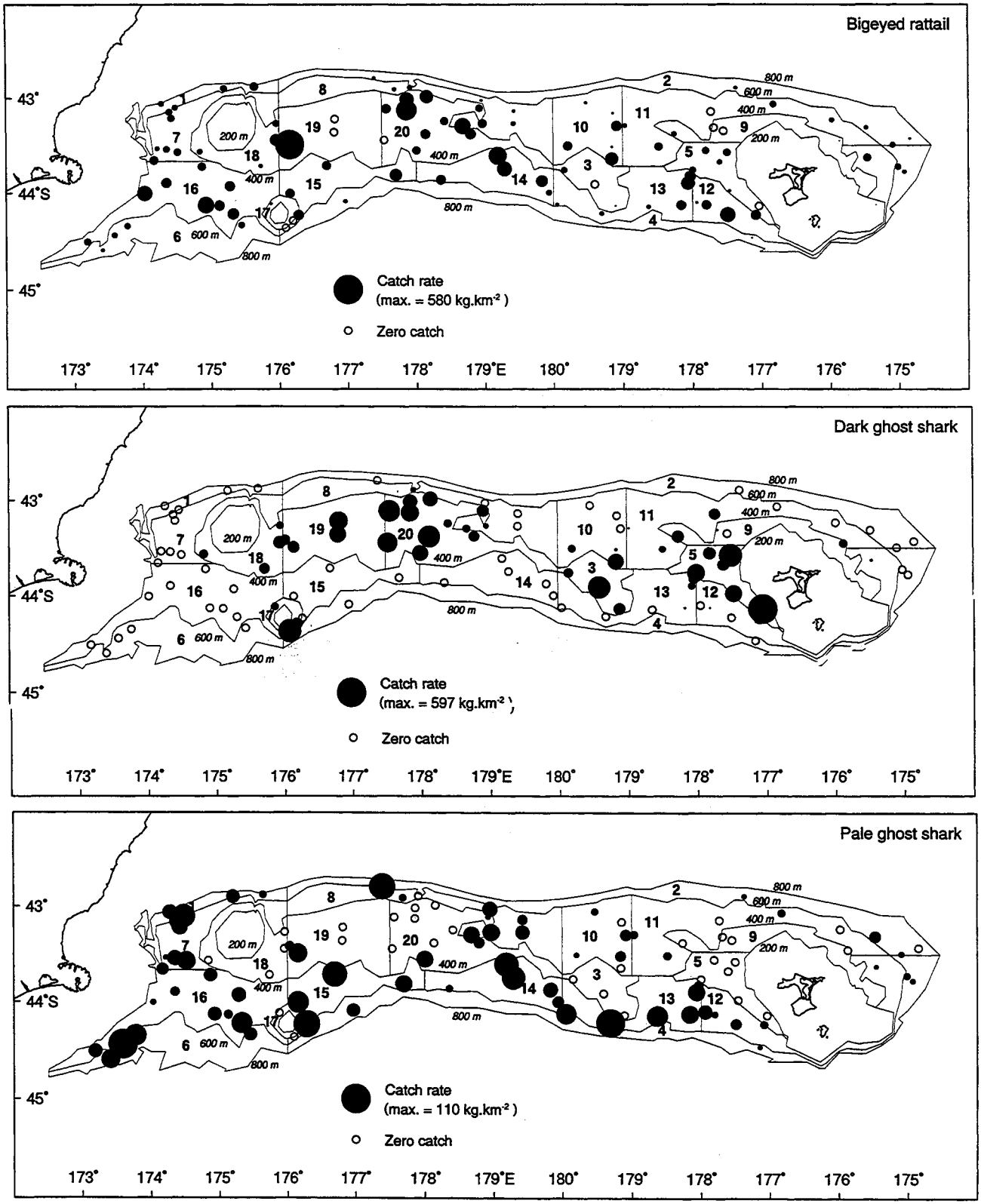


Figure 3—*continued*

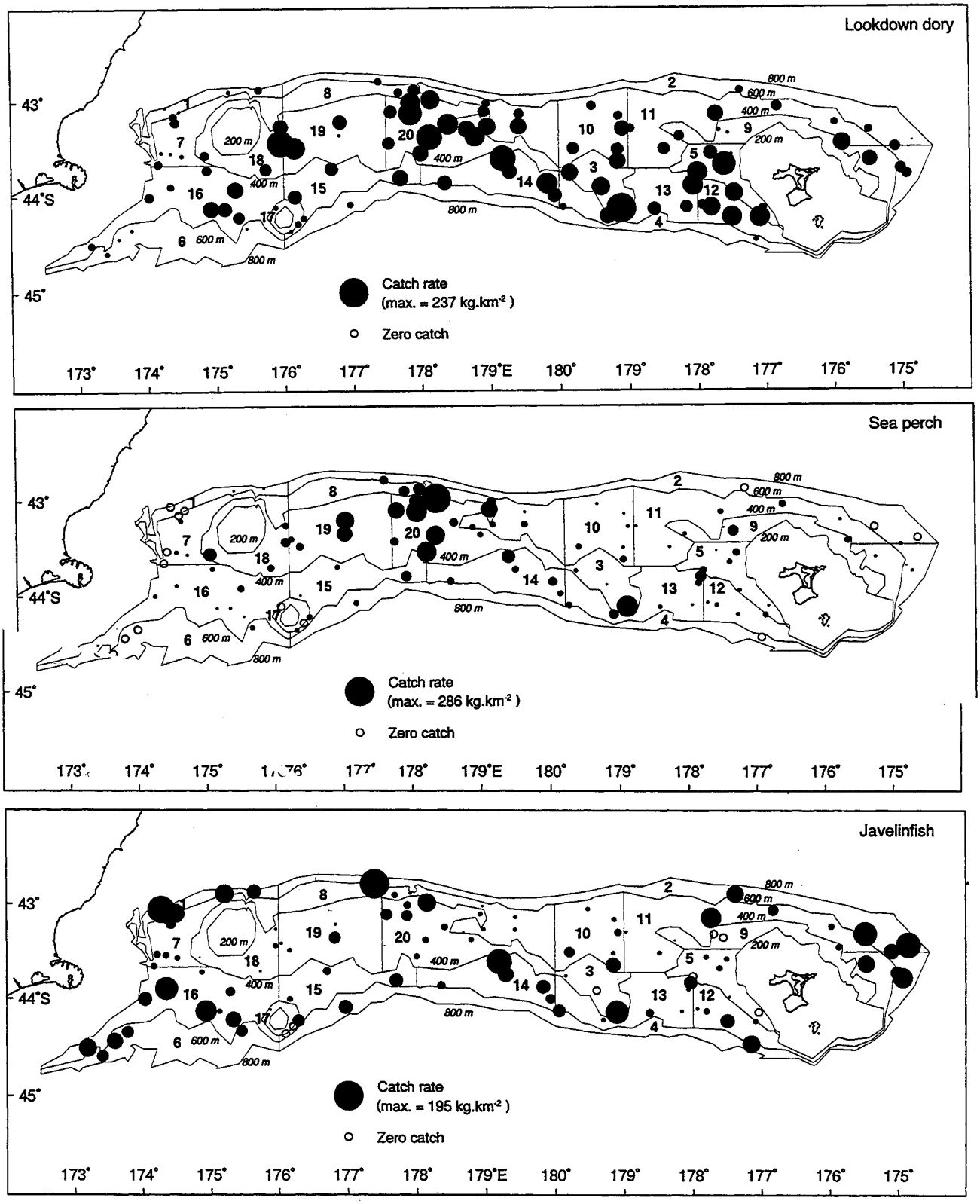


Figure 3—*continued*

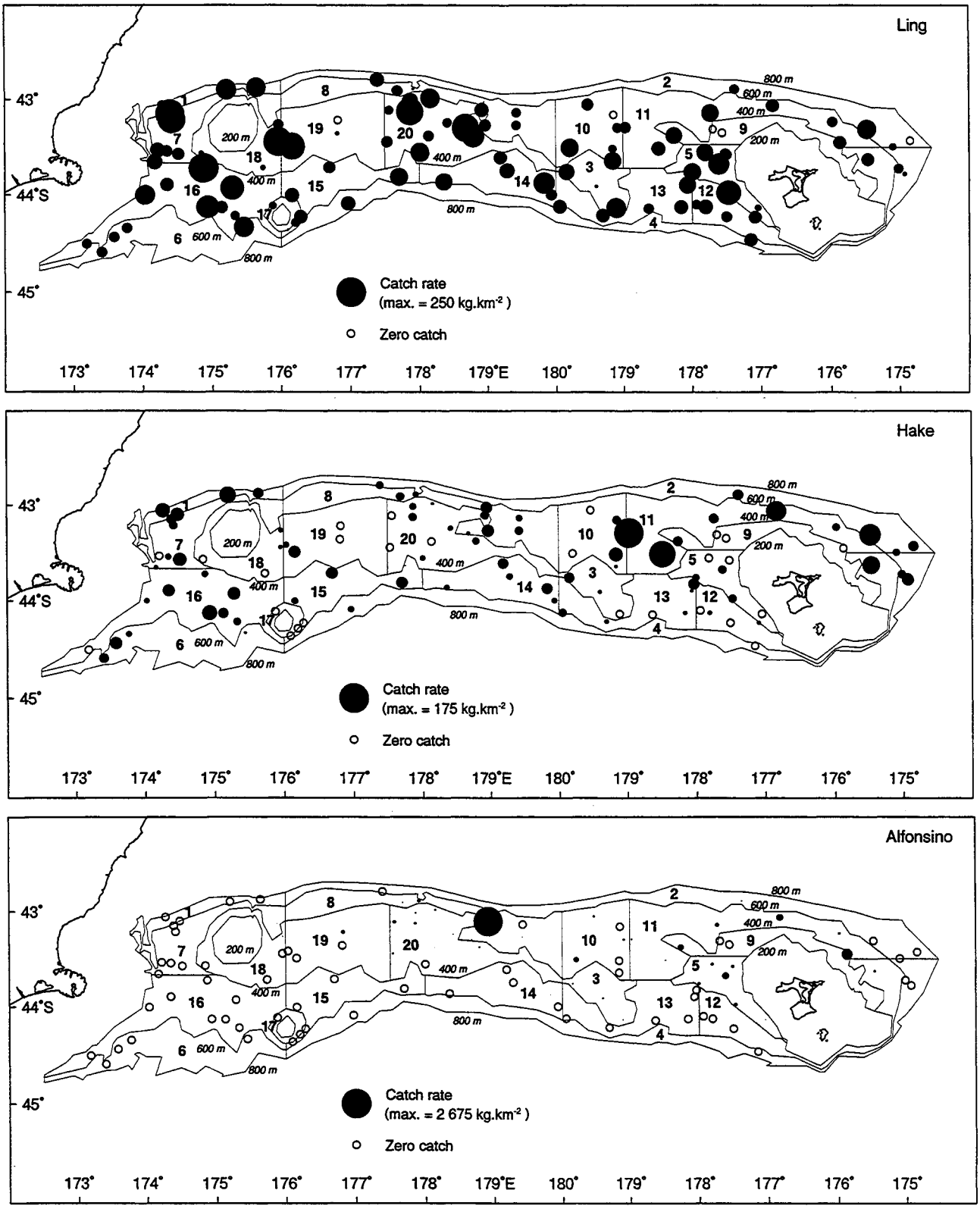


Figure 3—*continued*

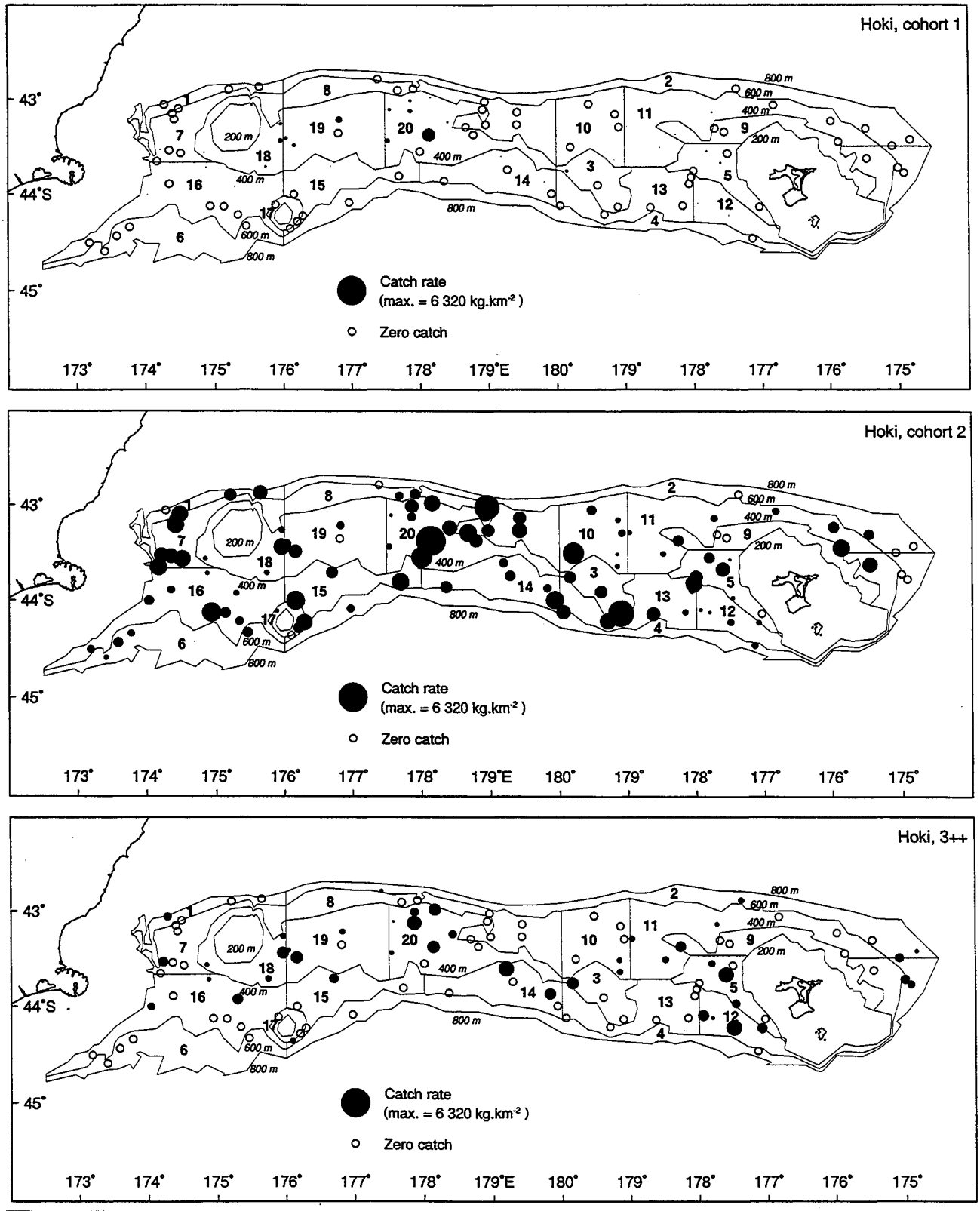


Figure 3: Catch rates (kg.km^{-2}) of hoki, ling, and other important species. Circle area is proportional to catch rate. Max, maximum catch rate.

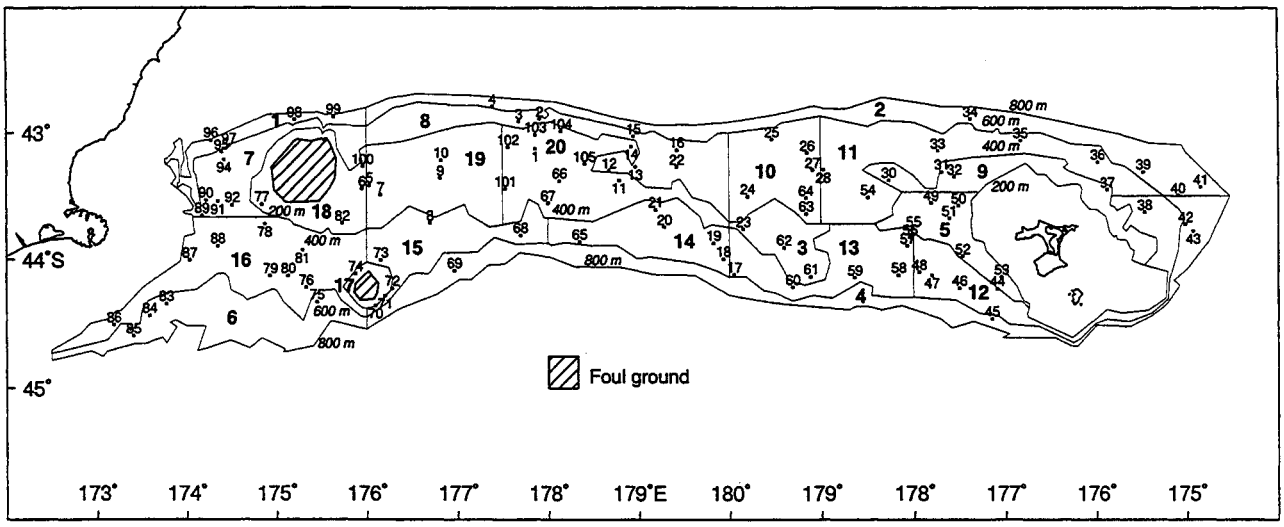


Figure 1: Trawl survey area showing stratum boundaries and trawl station positions.

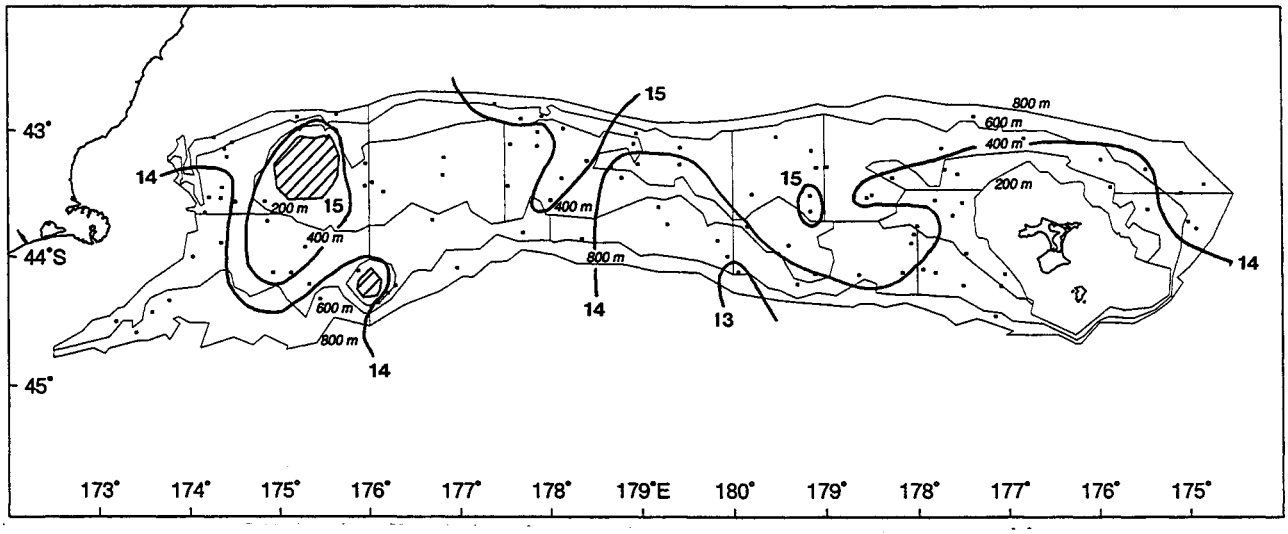


Figure 2a: Positions of surface temperature recordings and isotherms estimated from these data.

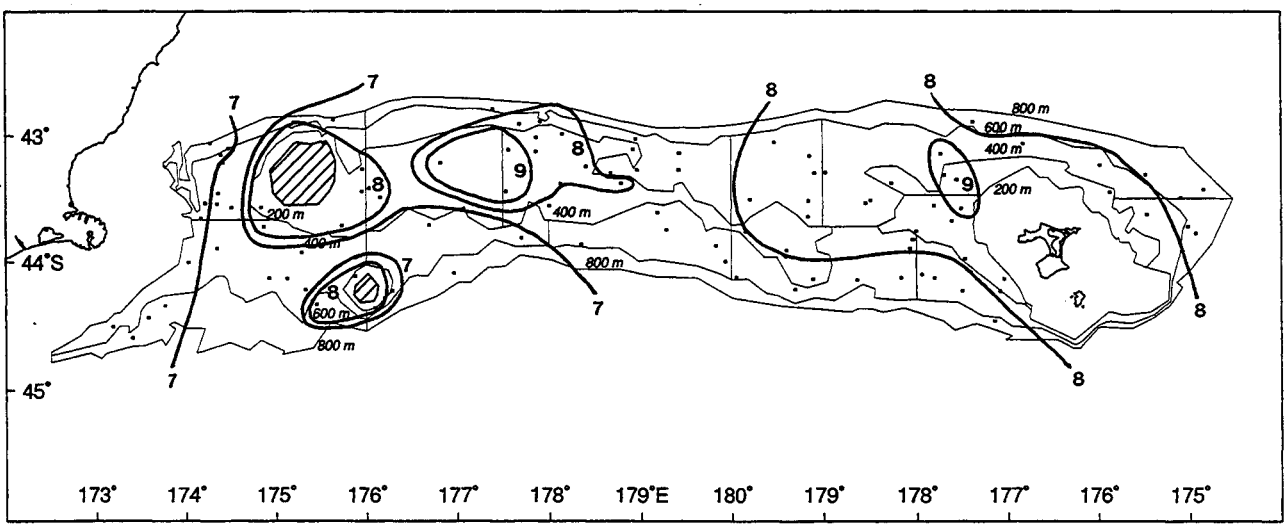


Figure 2b: Positions of bottom temperature recordings and isotherms estimated from these data.

Table 9: Numbers of male and female hoki, hake, ling, and silver warehou at each reproductive stage*

	Hoki		Hake		Ling	
Stage	Male	Female	Male	Female	Male	Female
1	107	142	60	35	103	73
2	156	354	30	75	108	145
3	0	0	7	34	64	27
4	0	0	4	2	53	1
5	0	0	36	0	1	0
6	0	0	6	4	6	0
7	0	0	2	3	0	1
Total	263	496	145	153	335	247

	Silver warehou		White warehou	
Stage	Male	Female	Male	Female
1	0	0	31	18
2	64	63	24	30
3	0	3	3	10
4	0	0	0	0
5	1	0	0	0
6	0	4	0	0
7	5	4	9	0
Total	70	74	67	58

* 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).

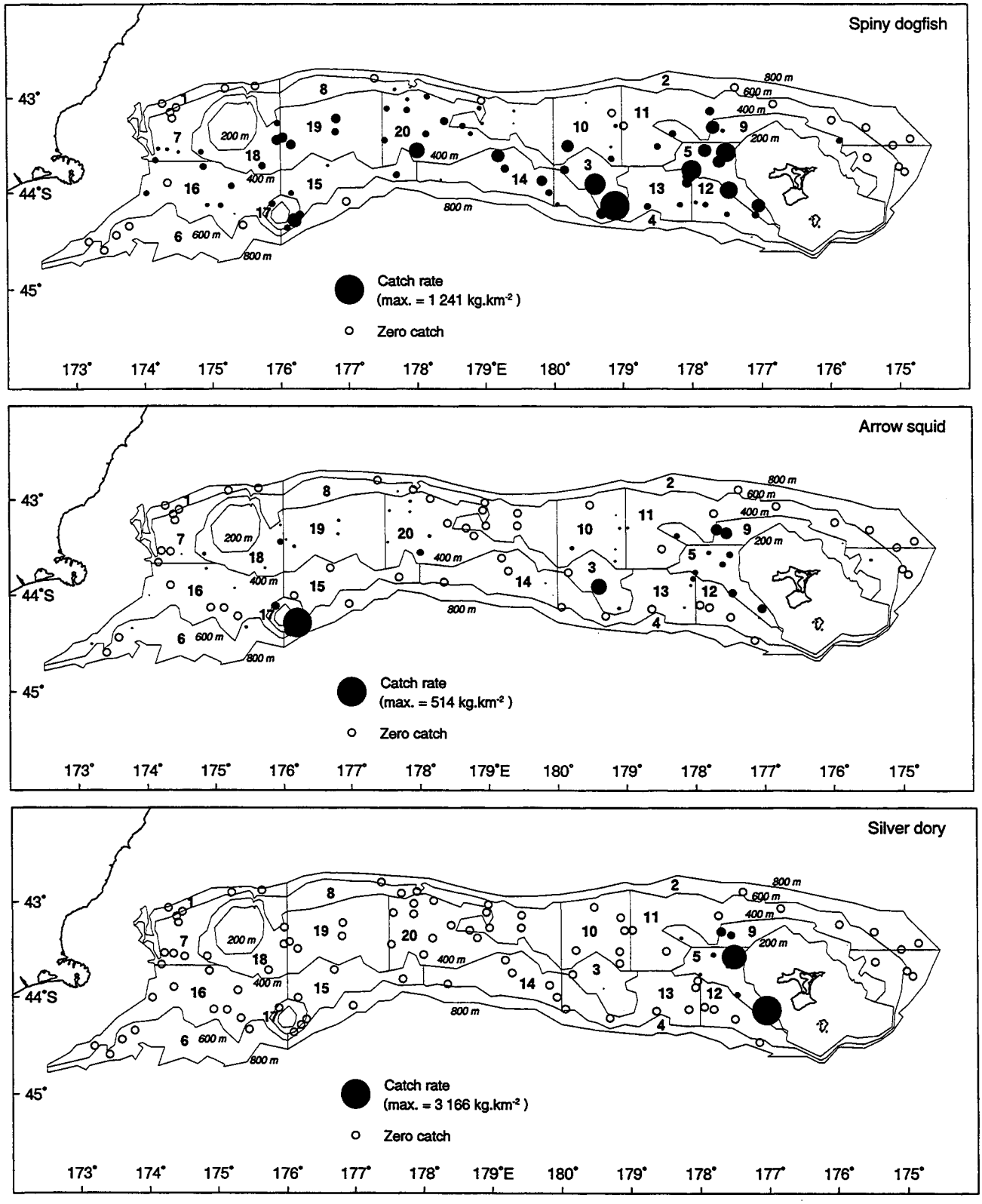
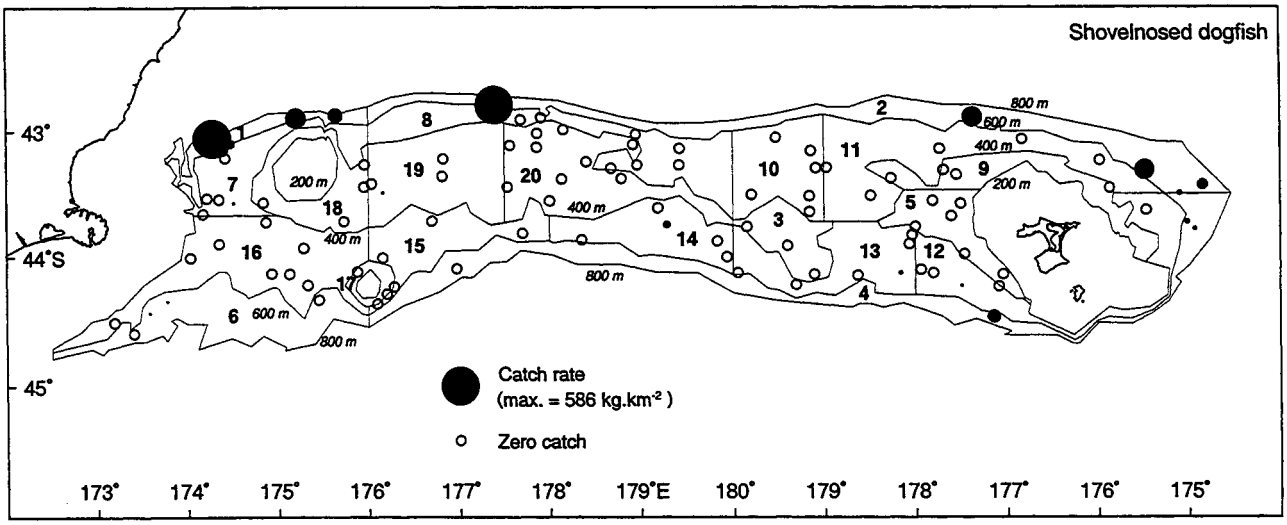
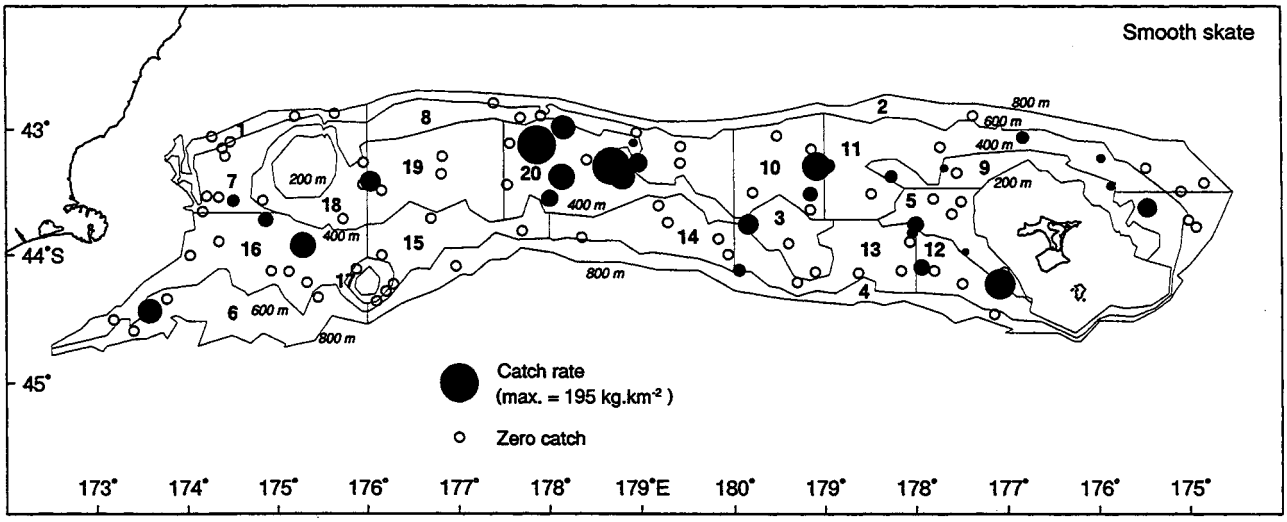


Figure 3—*continued*





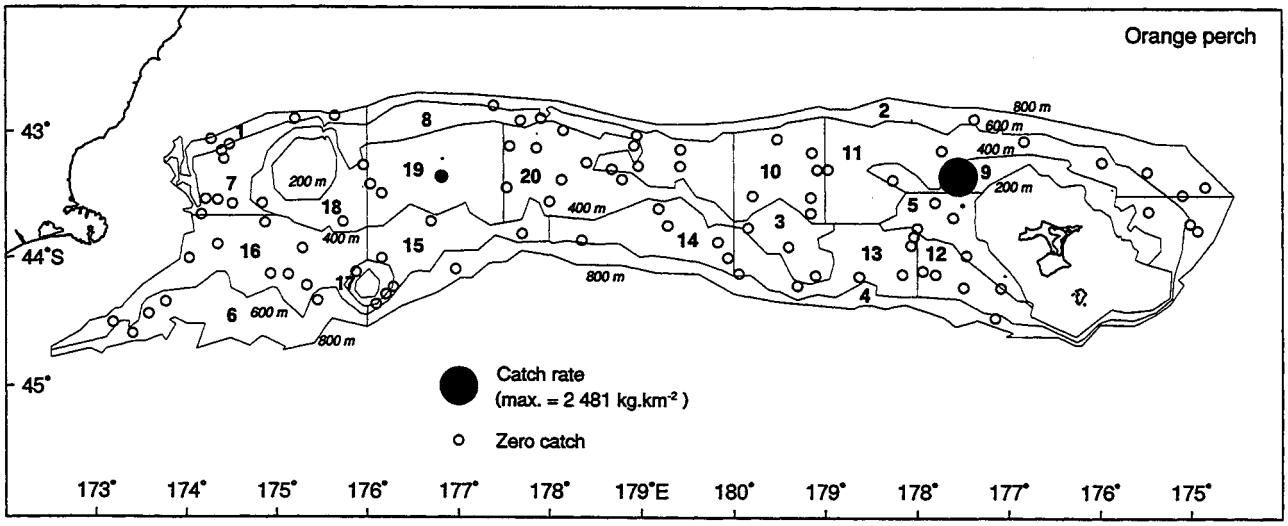


Figure 3—*continued*

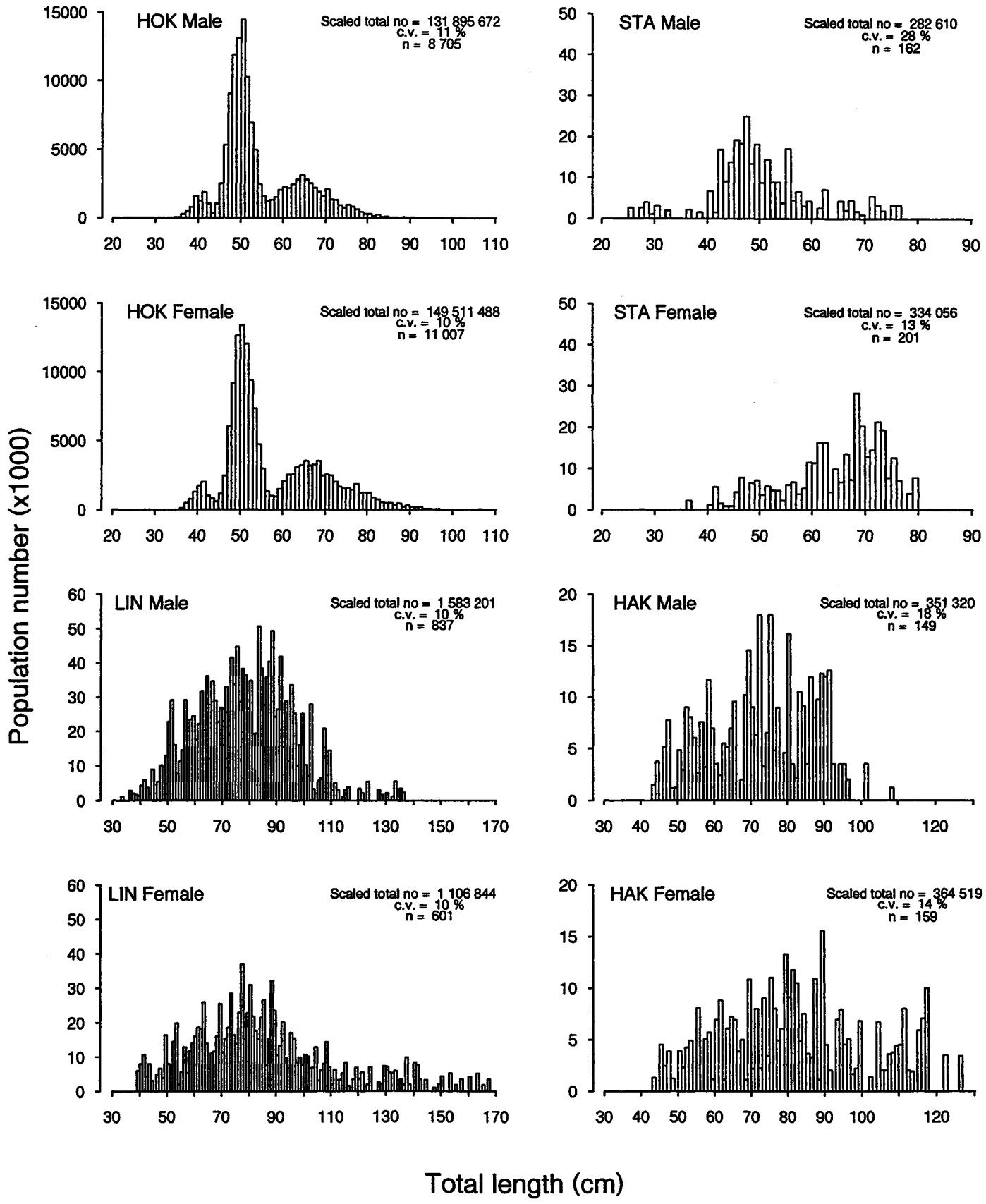


Figure 4: Length frequency, by sex, of species measured. Data have been scaled to represent total population in the entire survey area (= Scaled total no.) with its c.v. (%); n = number of measured fish.

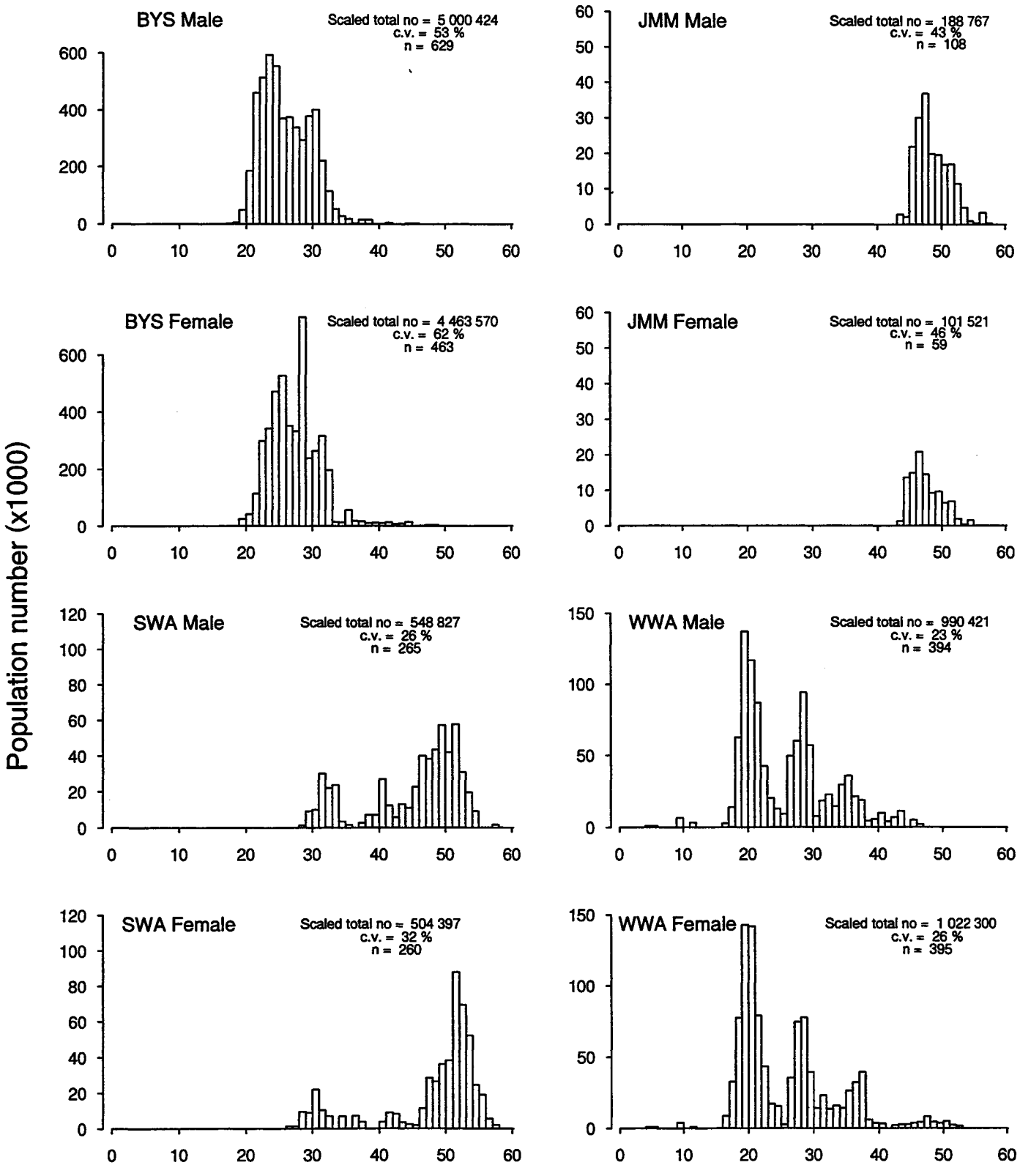


Figure 4: continued

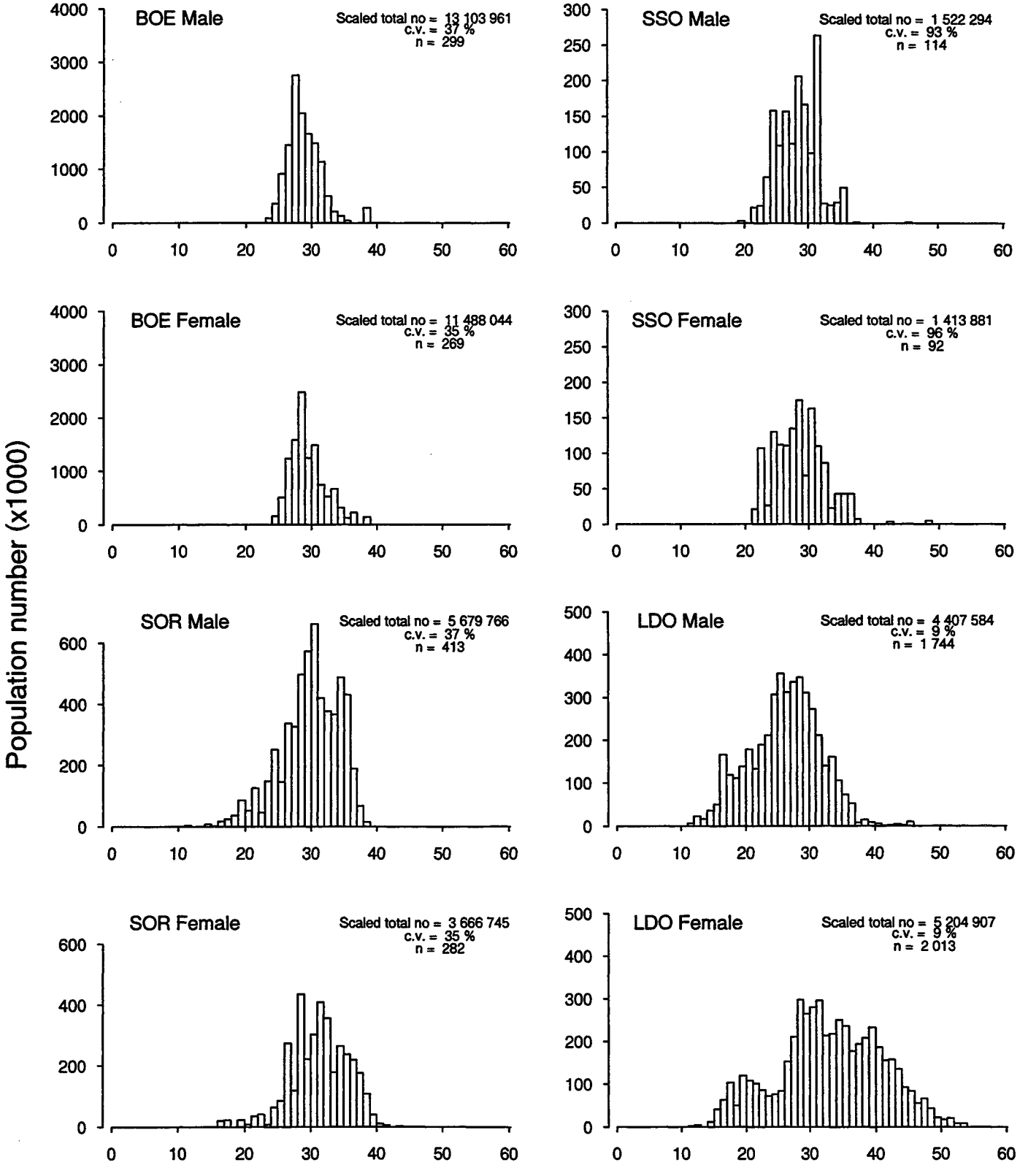


Figure 4: continued

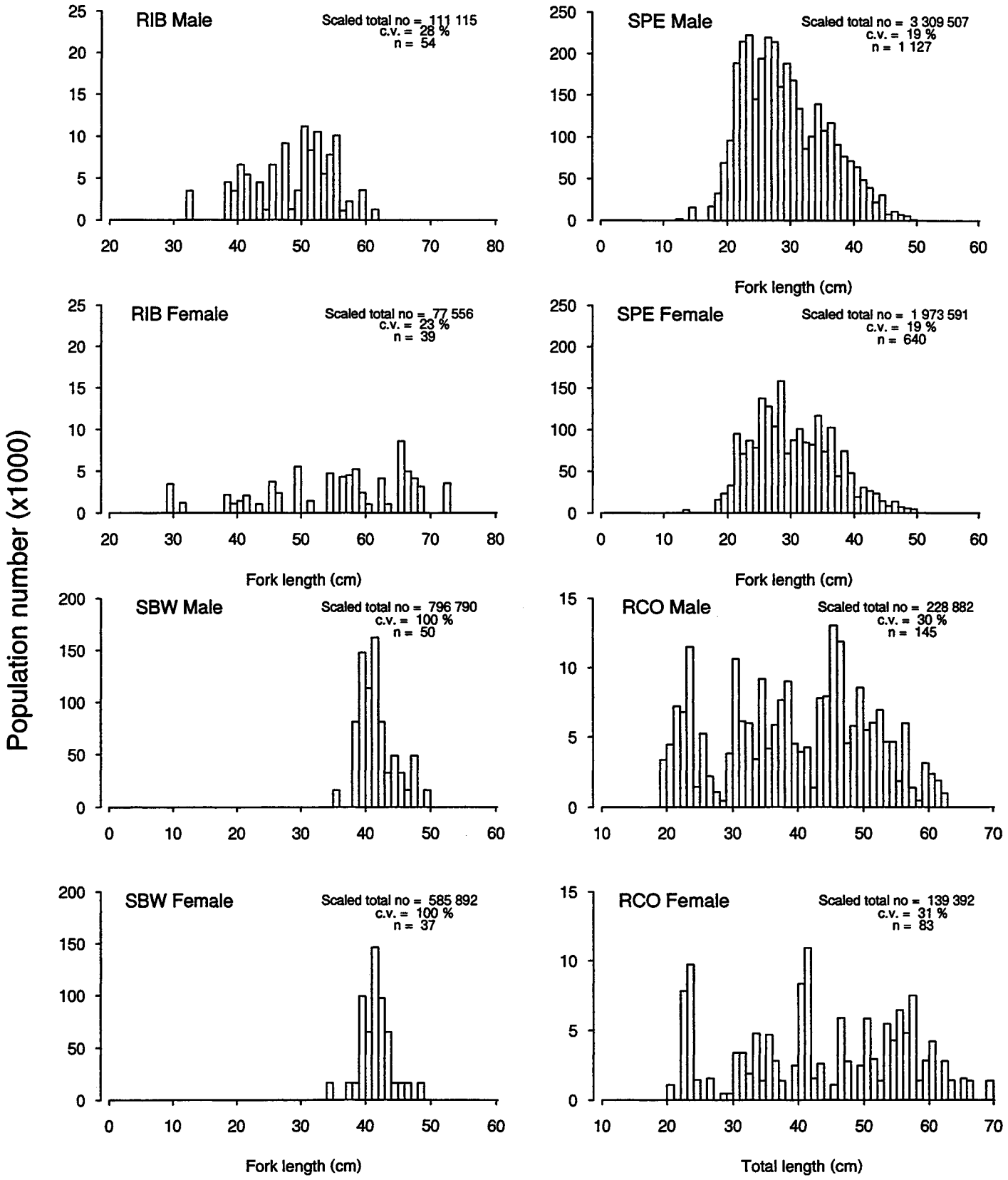


Figure 4: continued

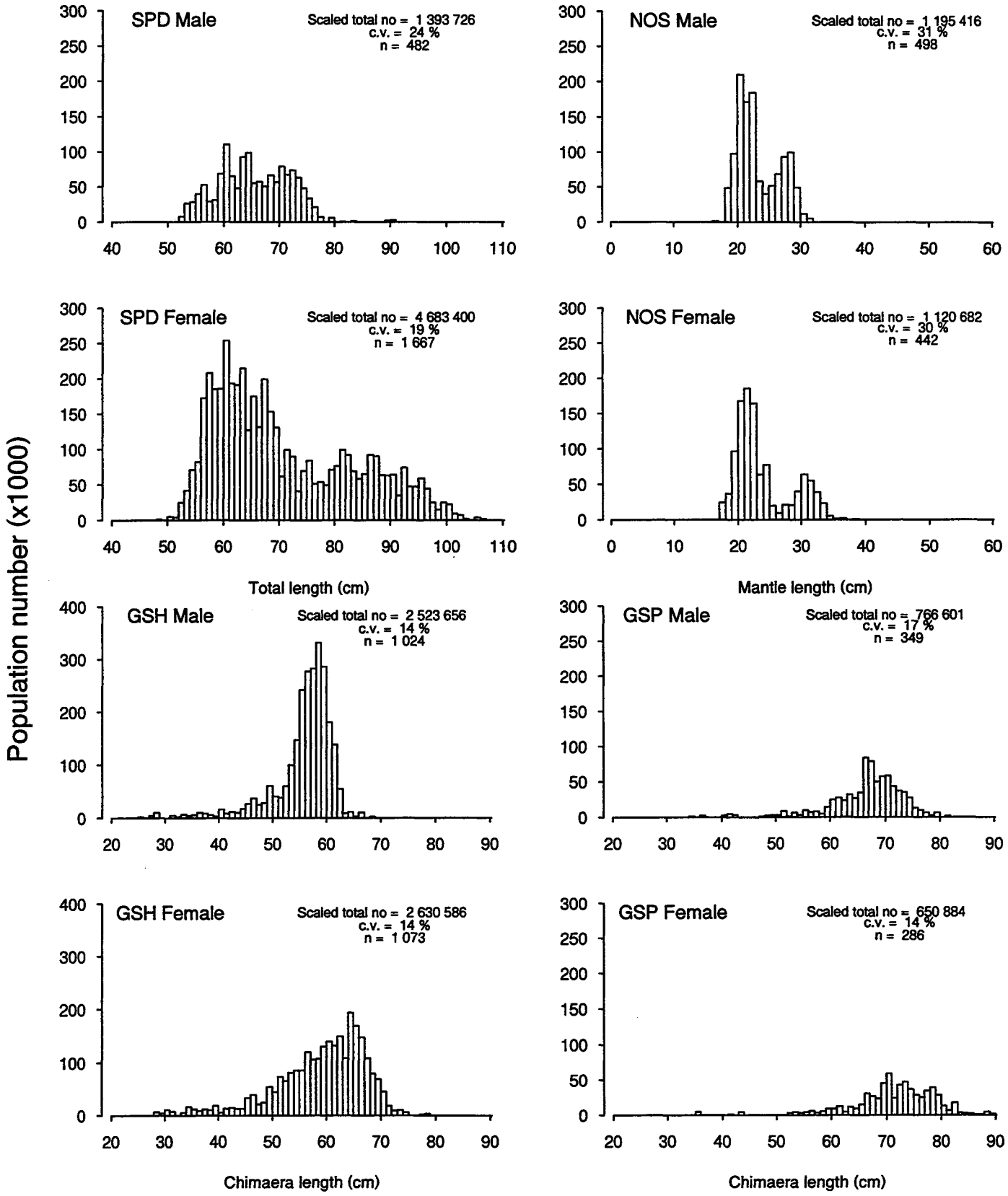


Figure 4: continued

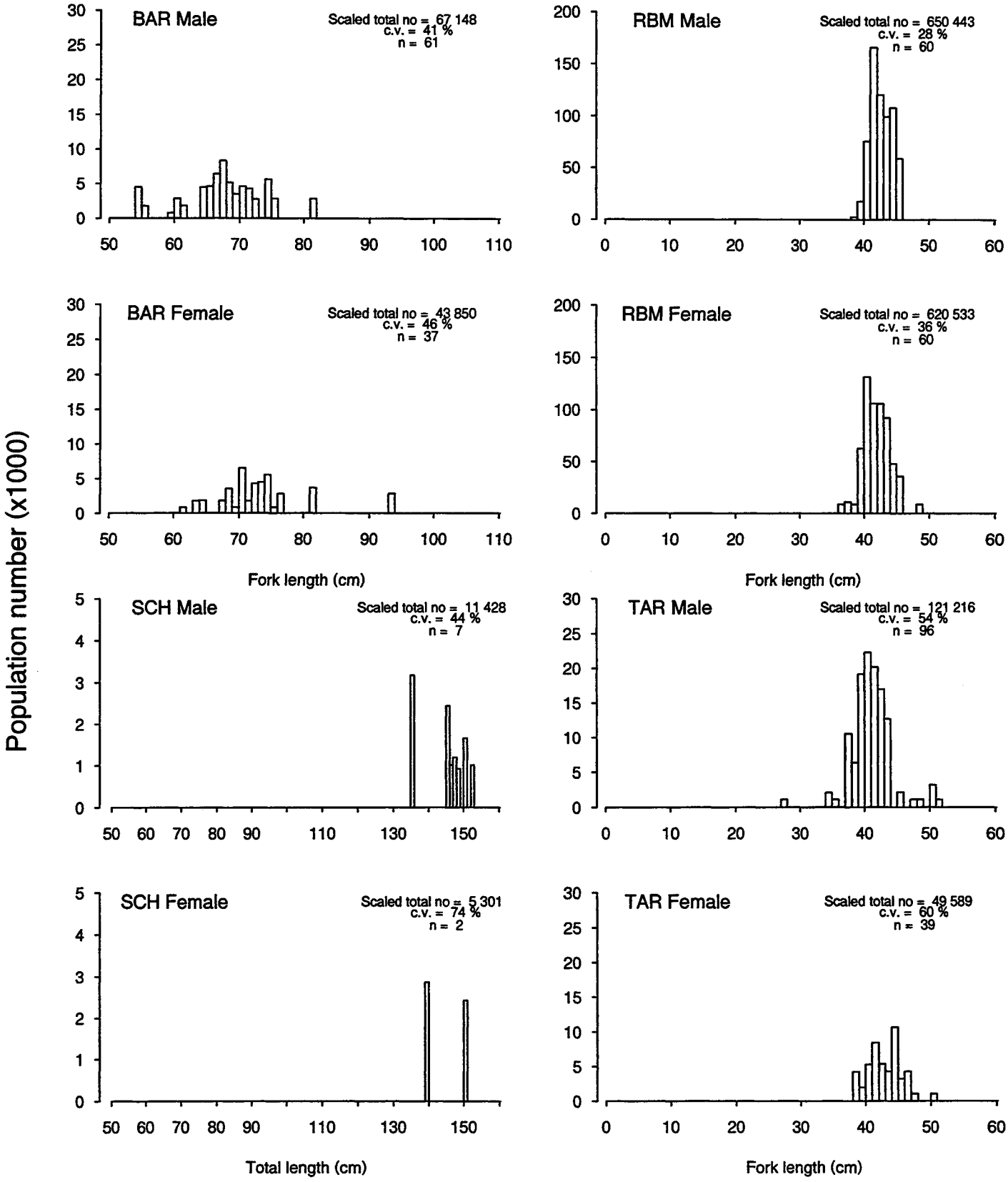


Figure 4: continued

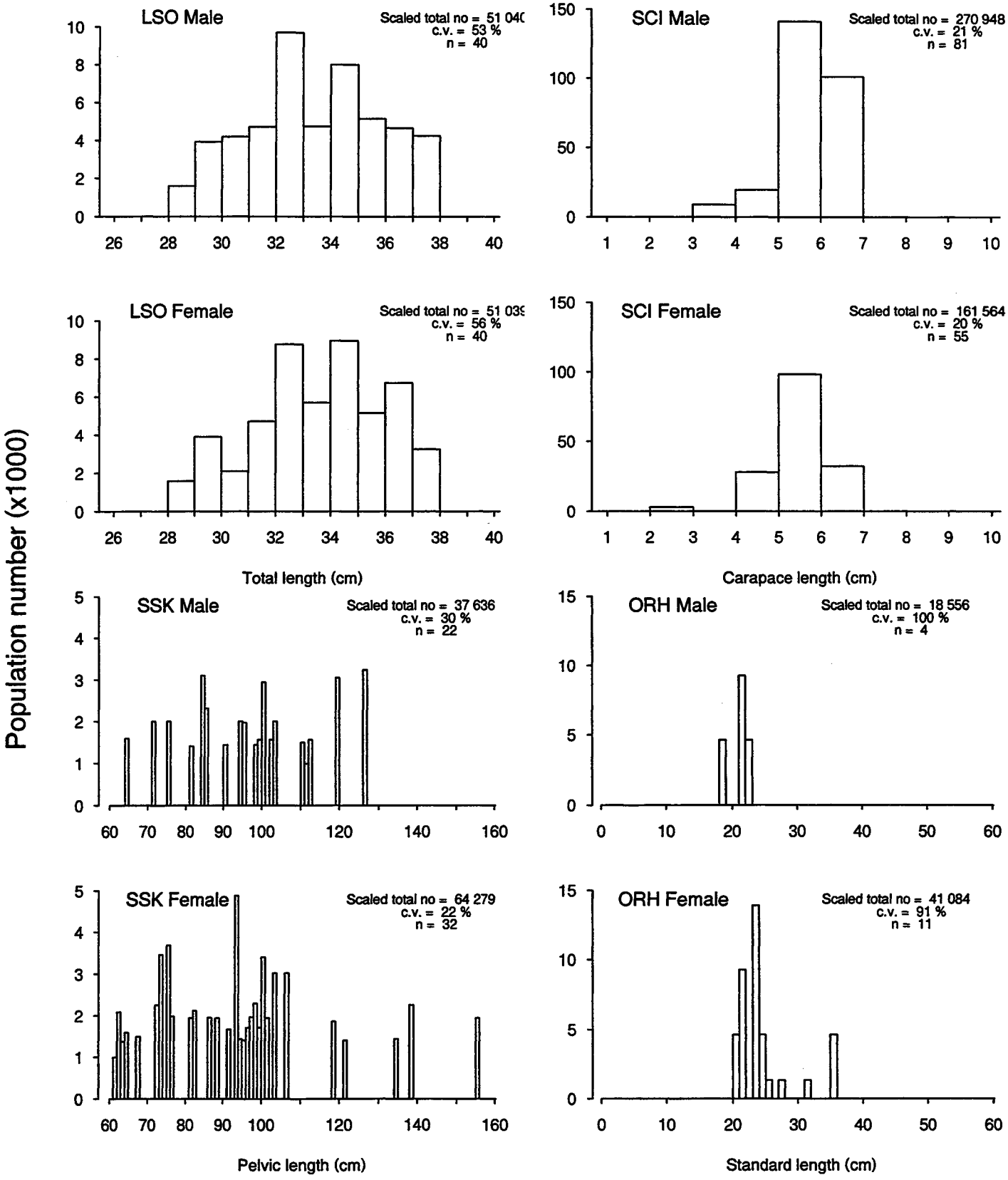


Figure 4: continued

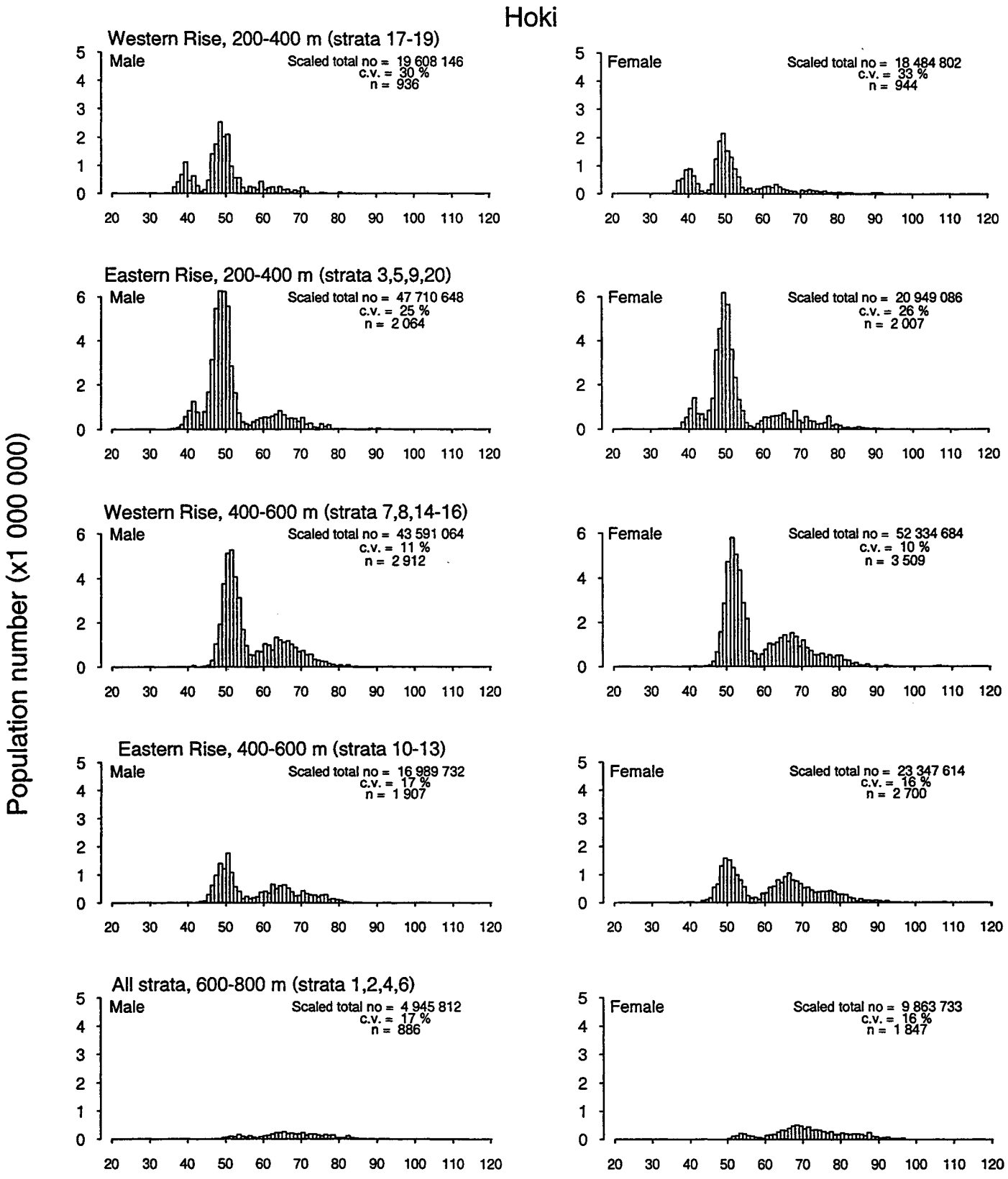


Figure 5: Scaled length frequencies for hoki by sex, depth zone (200-400, 400-600, 600-800 m), and area (Eastern Rise, Western Rise).

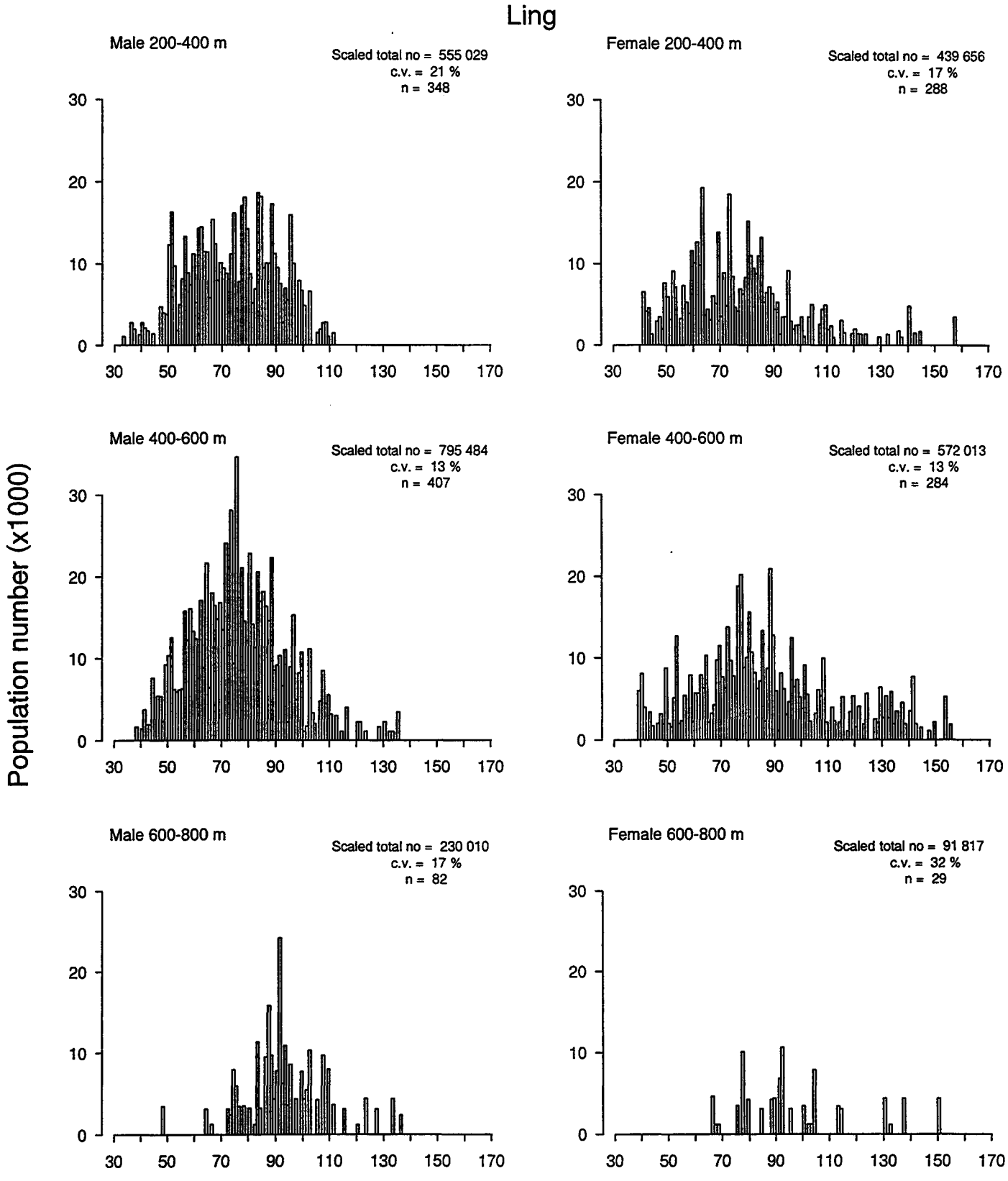


Figure 6: Scaled length frequencies for ling by sex and depth zone (200-400, 400-600, 600-800 m).

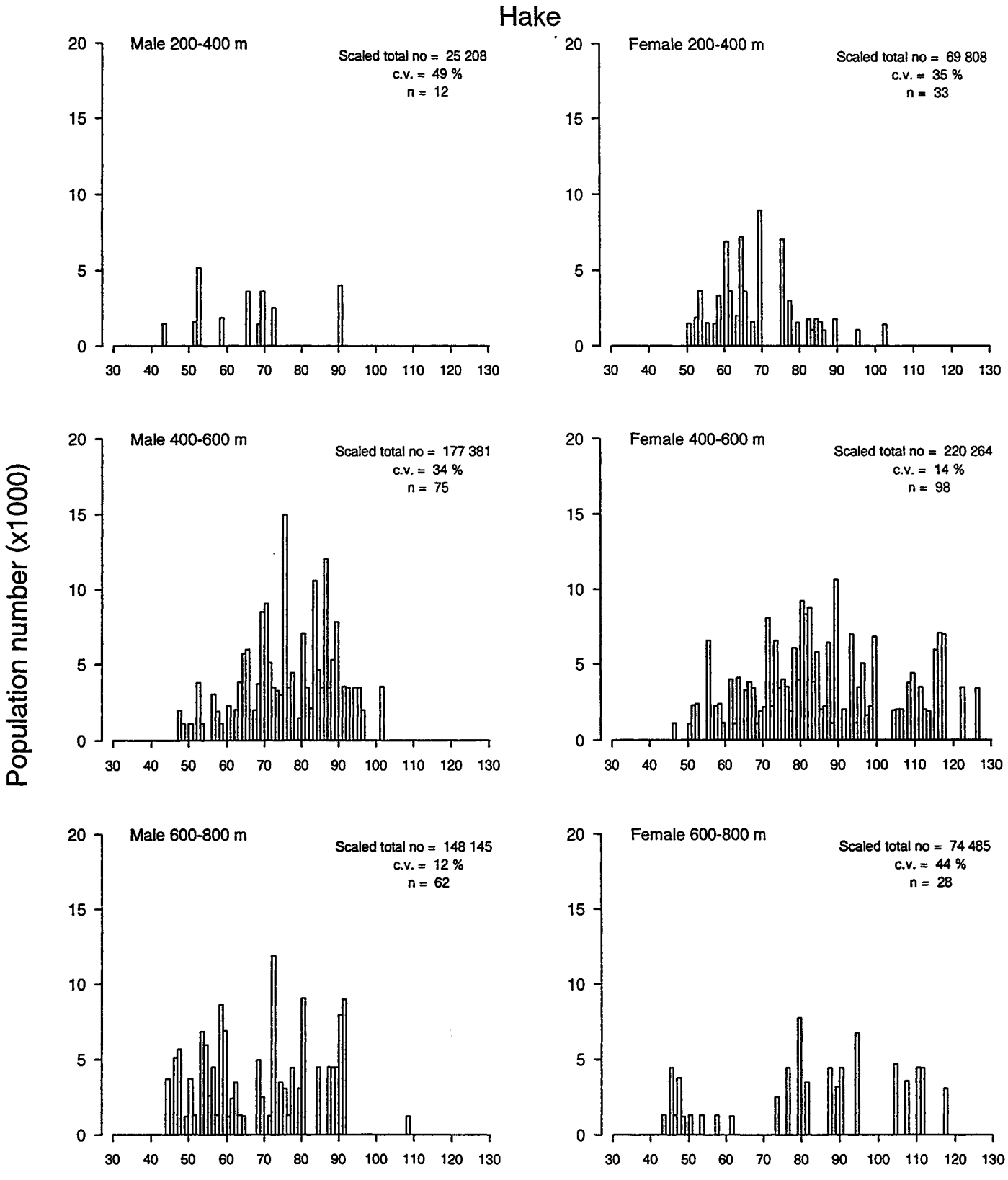


Figure 7: Scaled length frequencies for hake by sex and depth zone (200-400, 400-600, 600-800 m).

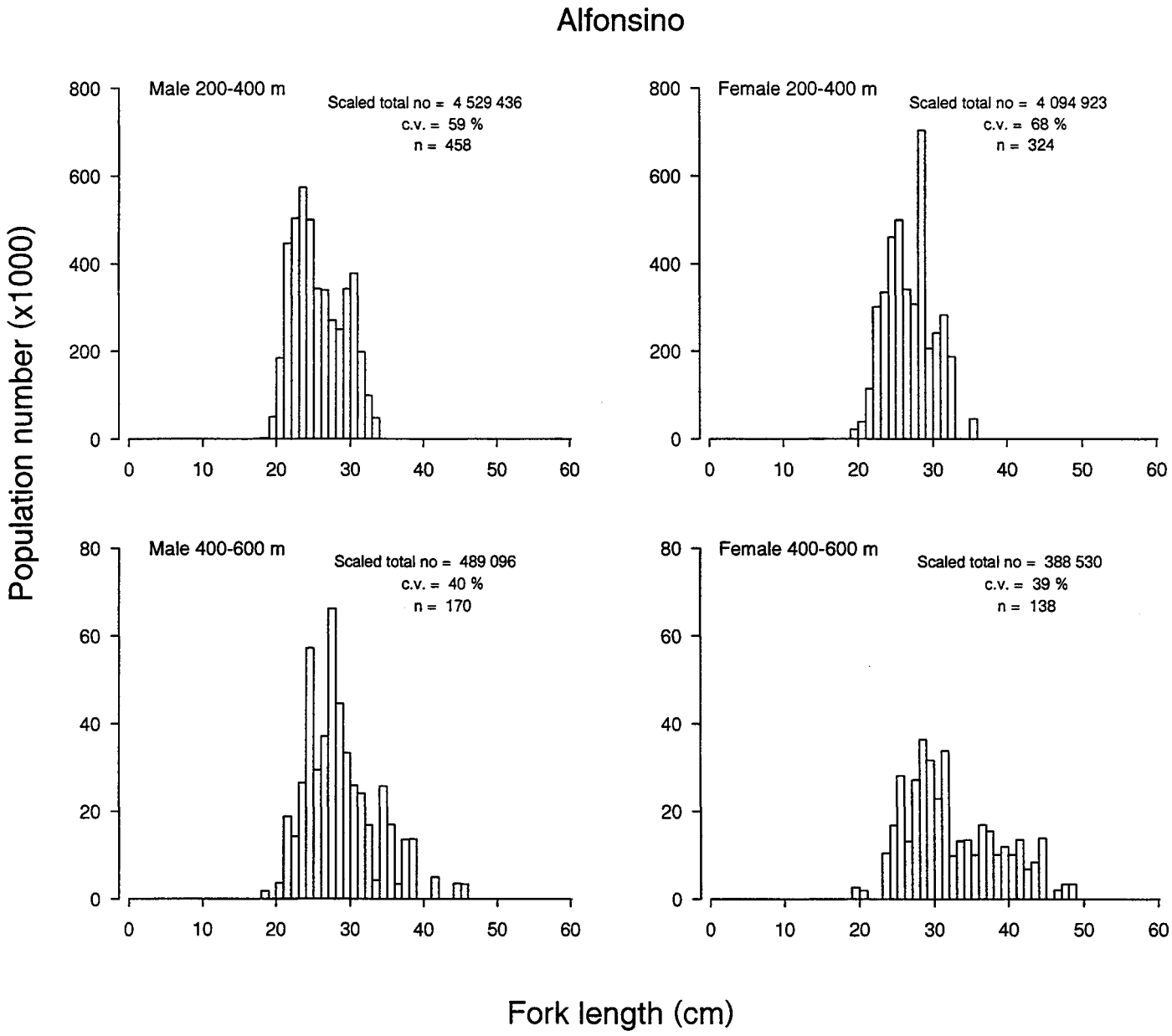


Figure 8: Scaled length frequencies for alfonsino by sex and depth zone (200-400, 400-600 m).

Appendix 1: Individual station data.

Stn.	Stra.	Date	Start of tow Time	Latitude ° ′S	Longitude ° ′E/W		Gear depth (m) Min.	Gear depth (m) Max.	Door-spread (m)	Dist. towed (n. mile)	Headline height (m)
1	0020	3 Jan 97	1044	43 07.53	177 52.07	E	347	354	118.0	2.87	6.6
2	0008	3 Jan 97	1332	42 53.44	177 54.92	E	429	431	130.8	3.02	6.6
3	0008	3 Jan 97	1536	42 54.56	177 41.33	E	414	417	129.5	3.02	6.2
4	0002	3 Jan 97	1804	42 47.43	177 23.61	E	672	673	127.0	3.00	5.5
5	0019	4 Jan 97	0520	43 25.00	176 02.10	E	368	368	126.5	3.03	6.0
6	0018	4 Jan 97	0729	43 26.64	175 57.33	E	359	383	119.1	3.01	6.3
7	0019	4 Jan 97	0946	43 29.56	176 09.32	E	375	379	119.0	2.96	6.4
8	0015	4 Jan 97	1312	43 42.74	176 41.90	E	454	462	117.0	2.99	7.1
9	0019	4 Jan 97	1621	43 21.57	176 48.92	E	268	275	119.0	3.03	7.3
10	0019	4 Jan 97	1813	43 13.07	176 49.55	E	286	287	118.8	3.00	7.3
11	0020	5 Jan 97	0538	43 22.55	178 47.34	E	372	398	124.3	3.02	6.8
12	0008	5 Jan 97	0737	43 17.86	178 40.77	E	407	414	121.2	3.01	6.8
13	0008	5 Jan 97	1029	43 16.17	178 58.17	E	413	422	127.4	2.99	6.8
14	0020	5 Jan 97	1300	43 06.56	178 55.32	E	377	377	128.0	3.00	6.9
15	0008	5 Jan 97	1502	43 01.68	178 57.14	E	467	468	129.7	3.00	6.8
16	0008	5 Jan 97	1808	43 08.23	179 25.75	E	451	461	130.7	3.00	6.8
17	0013	6 Jan 97	0509	44 07.06	179 56.81	W	503	583	122.0	3.01	6.6
18	0014	6 Jan 97	0719	43 59.65	179 56.13	E	466	491	118.5	3.03	6.8
19	0014	6 Jan 97	0923	43 52.28	179 49.77	E	431	453	112.5	3.02	6.0
20	0014	6 Jan 97	1310	43 44.66	179 17.18	E	475	488	116.7	3.02	6.6
21	0014	6 Jan 97	1532	43 36.42	179 11.48	E	412	437	110.3	3.02	5.7
22	0008	6 Jan 97	1849	43 16.21	179 25.24	E	430	432	121.1	3.00	6.8
23	0003	7 Jan 97	0447	43 45.54	179 50.57	W	370	372	124.6	3.01	6.8
24	0010	7 Jan 97	0716	43 30.32	179 47.60	W	414	415	121.5	3.01	6.8
25	0010	7 Jan 97	1043	43 03.27	179 31.43	W	526	538	124.1	3.00	7.0
26	0010	7 Jan 97	1420	43 09.61	179 08.36	W	513	522	133.1	3.00	6.8
27	0010	7 Jan 97	1628	43 17.86	179 05.11	W	451	464	132.9	3.02	7.5
28	0011	7 Jan 97	1837	43 17.68	178 58.28	W	451	471	126.9	3.00	7.1
29*	0011	8 Jan 97	0449	43 32.13	178 32.40	W	414	436	134.0	2.99	7.6
30	0009	8 Jan 97	0943	43 22.61	178 15.78	W	378	399	120.0	3.01	6.7
31	0009	8 Jan 97	1314	43 18.60	177 41.38	W	341	345	112.9	3.00	7.2
32	0009	8 Jan 97	1518	43 20.86	177 33.04	W	311	319	108.8	3.00	7.2
33	0011	8 Jan 97	1800	43 08.47	177 43.84	W	424	457	115.6	3.00	7.1
34	0002	9 Jan 97	0455	42 53.42	177 22.57	W	680	703	122.0	3.01	7.0
35	0011	9 Jan 97	0821	43 03.79	176 49.73	W	492	518	129.2	3.02	6.6
36	0011	9 Jan 97	1245	43 13.99	175 58.97	W	526	536	125.5	2.99	6.8
37	0009	9 Jan 97	1514	43 27.16	175 52.19	W	382	388	117.8	3.00	7.0
38	0012	9 Jan 97	1813	43 37.69	175 27.96	W	465	504	122.6	3.01	6.9
39	0002	10 Jan 97	0452	43 18.64	175 28.84	W	654	655	122.3	3.01	6.8
40	0004	10 Jan 97	0750	43 29.69	175 05.61	W	600	629	122.0	3.00	6.8
41	0002	10 Jan 97	1006	43 25.76	174 50.62	W	773	793	119.7	3.03	6.9
42	0004	10 Jan 97	1329	43 43.36	175 00.87	W	615	618	118.8	2.99	7.0
43	0004	10 Jan 97	1526	43 46.61	174 55.86	W	653	692	120.3	3.02	6.8
44	0012	11 Jan 97	0734	44 13.68	177 05.38	W	400	425	121.5	2.99	6.7
45	0004	11 Jan 97	1000	44 27.69	177 08.91	W	667	730	115.0	3.05	6.8
46	0012	11 Jan 97	1339	44 13.40	177 29.92	W	473	480	123.0	3.00	6.9
47	0012	11 Jan 97	1607	44 07.30	177 48.09	W	483	484	124.3	3.02	7.3
48	0012	11 Jan 97	1749	44 05.90	177 56.32	W	480	483	119.4	2.64	7.0
49	0005	12 Jan 97	0447	43 33.26	177 48.23	W	371	393	123.8	3.01	6.7
50	0005	12 Jan 97	0727	43 34.57	177 30.34	W	296	310	112.4	3.01	6.9
51	0005	12 Jan 97	0923	43 40.58	177 36.38	W	377	386	119.2	3.02	6.8
52	0005	12 Jan 97	1204	43 58.47	177 28.02	W	361	372	125.0	2.99	6.8
53	0005	12 Jan 97	1449	43 08.11	177 02.47	W	290	298	113.7	3.00	7.1

Appendix 1: *continued*

Stn.	Stra.	Date	Start of tow Time	Latitude ° ′S	Longitude ° ′E/W		Gear depth (m) Min.	Gear depth (m) Max.	Door-spread (m)	Dist. towed (n. mile)	Headline height (m)
54	0011	13 Jan 97	0454	43 30.73	178 29.09	W	415	436	123.5	3.03	6.8
55	0005	13 Jan 97	0843	43 45.59	177 59.82	W	376	378	124.3	3.03	6.8
56	0013	13 Jan 97	1026	43 49.46	177 01.87	W	412	412	128.6	2.99	6.6
57	0013	13 Jan 97	1211	43 53.61	178 03.90	W	437	447	122.9	3.00	6.9
58	0013	13 Jan 97	1449	44 07.35	178 09.67	W	486	488	130.0	3.00	6.9
59	0013	13 Jan 97	1757	44 08.54	178 37.83	W	482	483	117.7	3.00	6.8
60	0013	14 Jan 97	0506	44 12.84	179 18.06	W	417	455	119.7	3.00	6.8
61	0003	14 Jan 97	0802	44 07.98	179 06.20	W	344	362	118.3	3.01	6.8
62	0003	14 Jan 97	1108	43 54.42	179 23.80	W	291	292	110.4	3.00	7.1
63	0010	14 Jan 97	1404	43 38.40	179 09.41	W	405	417	118.5	2.63	6.8
64	0010	14 Jan 97	1814	43 31.09	179 09.43	W	450	451	125.3	2.00	6.7
65	0014	15 Jan 97	0534	43 51.55	178 21.45	E	529	548	115.0	3.00	6.9
66	0020	15 Jan 97	0922	43 22.82	178 08.38	E	329	356	118.1	3.00	6.8
67	0020	15 Jan 97	1138	43 33.33	178 00.30	E	354	359	117.6	3.00	6.8
68	0015	15 Jan 97	1419	43 48.57	177 42.24	E	497	540	119.0	2.75	6.8
69	0004	15 Jan 97	1829	44 05.11	176 58.34	E	654	654	122.0	3.00	6.8
70	0017	16 Jan 97	0442	44 21.65	176 05.62	E	241	337	104.0	2.99	7.1
71	0017	16 Jan 97	0614	44 17.11	176 12.24	E	209	349	104.3	3.01	7.1
72	0015	16 Jan 97	0747	44 13.68	176 17.10	E	484	579	111.6	3.02	7.0
73	0015	16 Jan 97	1015	44 00.24	176 09.43	E	477	492	118.5	2.99	6.5
74	0017	16 Jan 97	1258	44 06.70	175 52.70	E	218	296	109.2	3.00	6.9
75	0006	16 Jan 97	1628	44 19.89	175 27.02	E	615	659	119.7	3.01	7.3
76	0016	16 Jan 97	1827	44 13.13	175 19.69	E	535	551	113.4	3.00	7.0
77	0018	17 Jan 97	0515	43 34.04	174 50.32	E	366	389	125.0	3.02	6.7
78	0016	17 Jan 97	0703	43 43.22	174 52.03	E	446	457	122.4	3.08	6.7
79	0016	17 Jan 97	1018	44 07.59	174 55.54	E	505	522	122.4	2.99	6.9
80	0016	17 Jan 97	1239	44 07.74	175 07.44	E	505	507	126.7	3.00	7.0
81	0016	17 Jan 97	1458	43 55.61	175 16.85	E	447	460	118.8	3.00	7.0
82	0018	17 Jan 97	1813	43 42.97	175 43.90	E	332	337	122.6	2.00	6.9
83	0006	18 Jan 97	0539	44 20.54	173 46.39	E	660	674	118.6	3.01	6.8
84	0006	18 Jan 97	0738	44 26.21	173 35.38	E	671	683	123.3	3.01	6.9
85	0006	18 Jan 97	0952	44 35.65	173 24.71	E	634	754	116.2	2.99	6.8
86	0016	18 Jan 97	1239	44 30.45	173 11.19	E	498	548	120.0	3.00	7.0
87	0016	18 Jan 97	1735	44 00.24	174 01.99	E	478	484	117.0	3.00	7.0
88	0016	19 Jan 97	0529	43 53.57	174 20.92	E	534	542	129.0	3.01	6.8
89	0007	19 Jan 97	0810	43 39.31	174 10.06	E	469	486	123.7	3.00	7.0
90	0007	20 Jan 97	0520	43 32.05	174 12.82	E	506	538	118.1	3.00	6.8
91	0007	20 Jan 97	0713	43 32.67	174 20.83	E	559	560	125.5	3.01	6.8
92	0007	20 Jan 97	0904	43 34.22	174 30.44	E	523	544	122.4	3.04	6.8
93*	0007	20 Jan 97	1137	43 27.41	174 21.73	E	561	569	127.5	0.91	6.8
94	0007	20 Jan 97	1551	43 12.86	174 25.12	E	565	577	124.2	3.01	6.8
95	0007	20 Jan 97	1744	43 09.17	174 23.64	E	582	596	126.3	3.01	6.8
96	0001	21 Jan 97	0519	43 03.55	174 16.48	E	687	792	116.8	3.01	7.0
97	0007	21 Jan 97	0719	43 06.18	174 28.77	E	561	598	121.8	3.03	7.0
98	0001	21 Jan 97	1133	42 53.97	175 12.06	E	624	641	125.4	3.01	7.0
99	0001	21 Jan 97	1430	42 52.45	175 38.49	E	650	663	123.0	3.00	6.8
100	0018	21 Jan 97	1808	43 16.07	175 57.47	E	358	374	123.6	2.99	6.8
101	0020	22 Jan 97	0515	43 26.61	177 32.22	E	298	325	128.6	3.15	6.3
102	0020	22 Jan 97	0757	43 06.84	177 33.99	E	312	342	121.1	3.00	6.7
103	0020	22 Jan 97	1015	43 00.89	177 52.13	E	331	370	123.1	3.00	6.7
104	0020	22 Jan 97	1221	42 59.26	178 09.63	E	356	361	122.1	3.00	6.7
105	0020	22 Jan 97	1509	43 14.77	178 24.85	E	372	386	117.4	3.00	7.0

* Stations with poor gear performance omitted from biomass estimations.

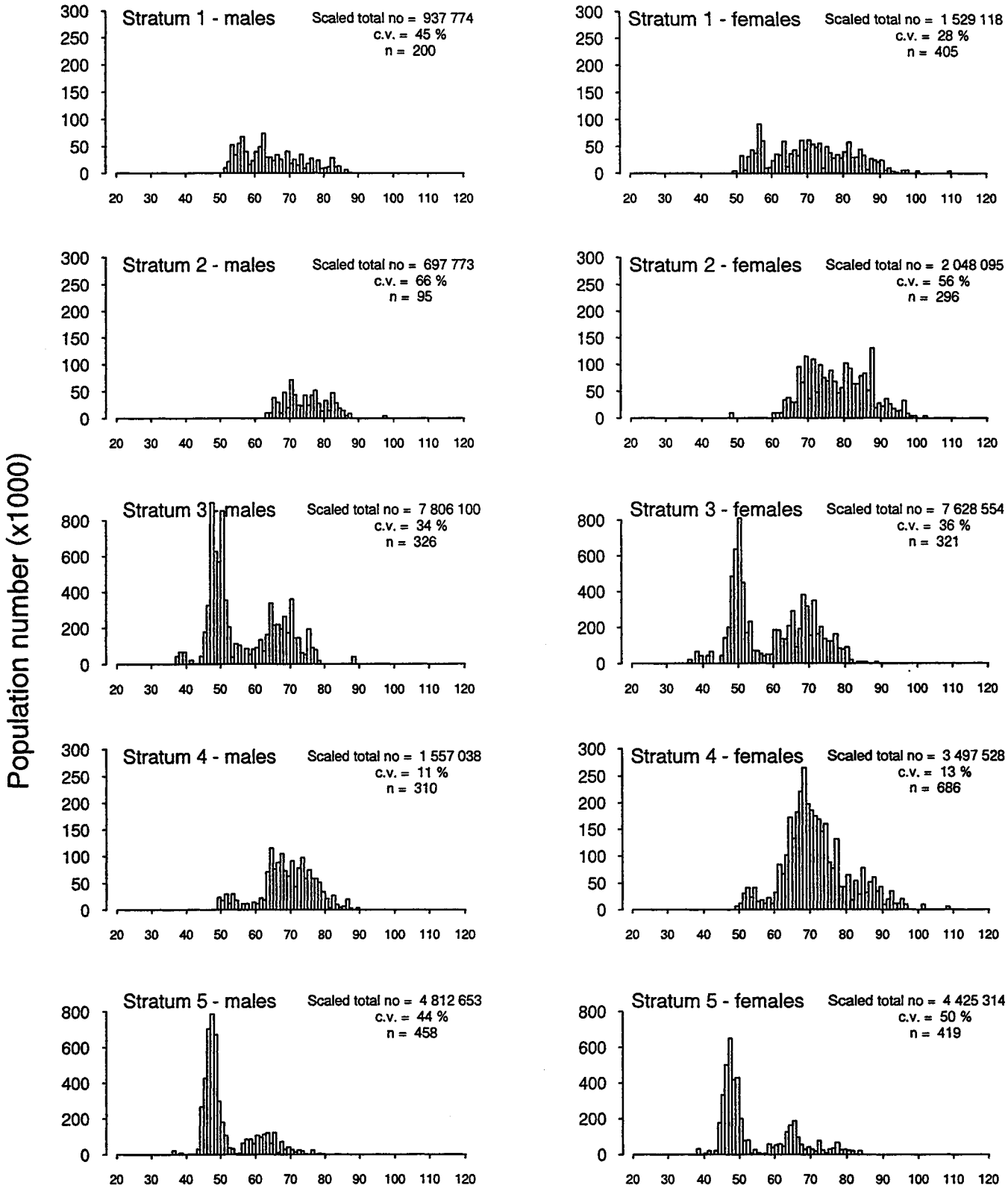
Appendix 2: Scientific and common names, and species codes of fish, squid, and crustacea caught during the voyage. The occurrence (Occ.) of each species in the 103 tows is also shown.

Scientific name	Common name	Species code	Occ.
Chondrichthyes			
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	5
Centroscymnus crepidater	longnosed velvet dogfish	CYP	5
C. owstoni	smoothskin dogfish	CYO	3
C. plunketi	Plunket's shark	PLS	6
Deania calcea	shovelnosed dogfish	SND	19
Etmopterus baxteri	Baxter's dogfish	ETB	13
E. lucifer	Lucifer dogfish	ETL	52
Scymnodalatias sherwoodi	Sherwood's dogfish	SHE	1
Scymnorhinus licha	seal shark	BSH	17
Squalus acanthias	spotted spiny dogfish	SPD	77
S. mitsukurii	northern spiny dogfish	NSD	6
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	5
Lamnidae: mackerel sharks			
Isurus oxyrinchus	mako	MAK	1
Scyliorhinidae: cat sharks			
Apristurus sp.	deepsea catshark	APR	1
Cephaloscyllium isabellum	carpet shark	CAR	1
Halaelurus dawsoni	Dawson's catshark	DCS	2
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	7
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	1
Narkidae: blind electric rays			
Typhlonarke sp.	numbfish	BER	2
Rajidae: skates			
Amblyraja sp.	deepwater spiny skate	DSK	1
Pavoraja asperula	smooth bluntnosed skate	BTA	8
P. spinifera	prickly bluntnosed skate	BTS	6
Raja innominata	smooth skate	SSK	29
R. nasuta	rough skate	RSK	3
Chimaeridae: chimaeras, ghost sharks			
Hydrolagus novaezelandiae	dark ghost shark	GSH	49
Hydrolagus sp. B	pale ghost shark	GSP	68
Rhinochimaeridae: longnosed chimaeras			
Chimaera sp. B	giant chimaera	CHG	1
Harriotta raleighana	longnosed chimaera	LCH	30
Rhinochimaera pacifica	widenosed chimaera	RCH	1
Osteichthyes			
Halosauridae: halosaurs			
Halosaurus pectoralis	abyssal halosaur	HAL	1
Notacanthidae: spiny eels			
Notacanthus sexspinis	spineback	SBK	32
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	38
B. hirsutus	hairy conger	HCO	17
Argentinidae: silversides			

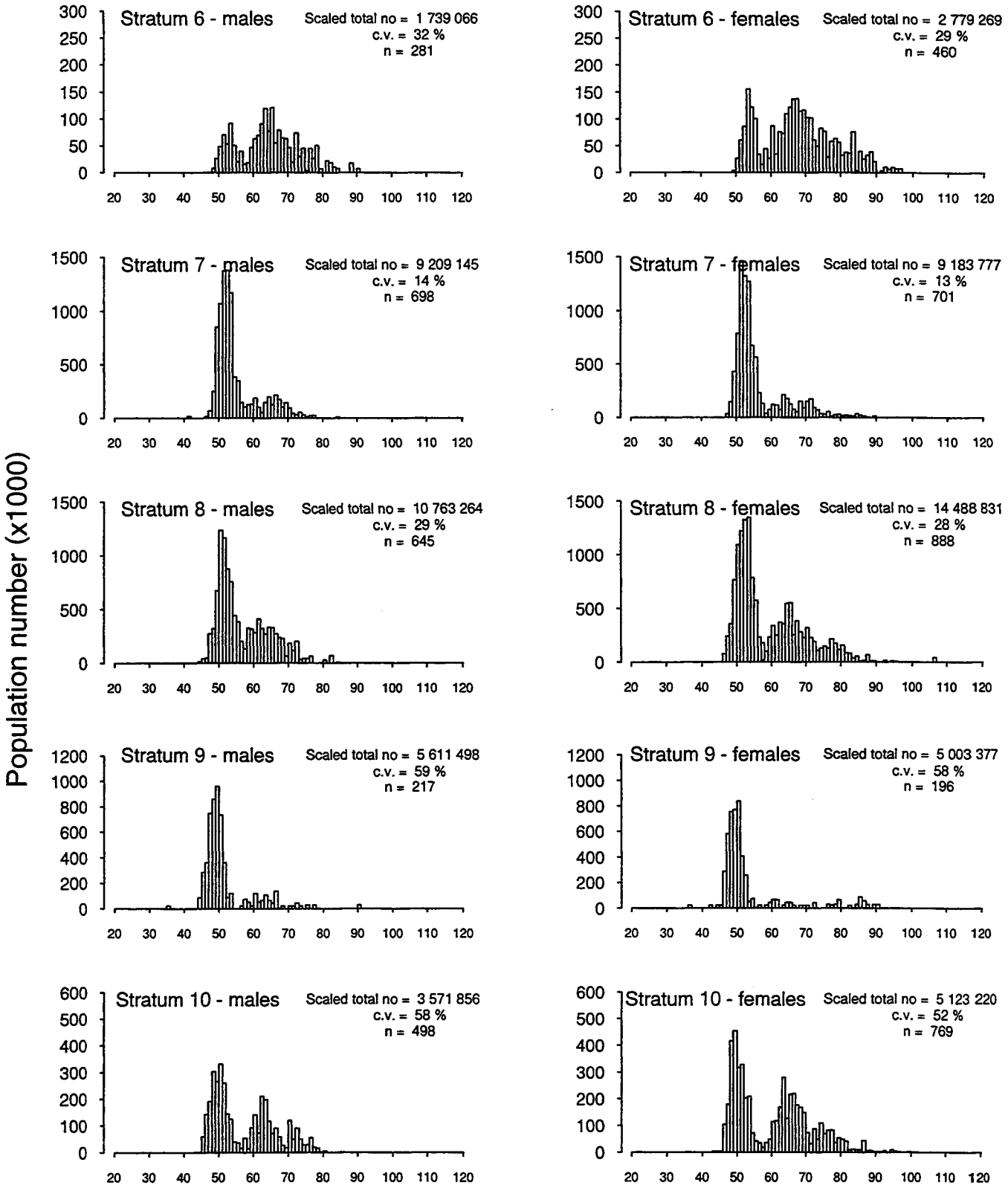
Argentina elongata	silverside	SSI	64
Bathylagidae: deepsea smelts			
Bathylagus sp.	deepsea smelt	DSS	1
Alepocephalidae: slickheads			
Xenodermichthys socialis	black slickhead	BSL	1
Photichthyidae: lighthouse fishes			
Species not identified	lighthouse fish	PHO	3
Chlorophthalmidae: cucumber fishes			
Chlorophthalmus nigripinnis	cucumberfish	CUC	1
Myctophidae: lanternfishes			
Species not identified	lanternfish	LAN	3
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	1
Austrophycis marginata	dwarf cod	DCO	4
Halargyreus johnsoni	slender cod	HJO	4
Mora moro	ribaldo	RIB	25
Pseudophycis bachus	red cod	RCO	26
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	2
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	99
Merluccius australis	hake	HAK	77
Macrouridae: rattails, grenadiers			
Caelorinchus aspercephalus	oblique-banded rattail	CAS	72
C. biclinozonalis	two saddle rattail	CBI	6
C. bollonsi	bigeyed rattail	CBO	93
C. fasciatus	banded rattail	CFA	40
C. innotabilis	notable rattail	CIN	4
C. matamua	Mahia rattail	CMA	4
Coryphaenoides oliverianus	Oliver's rattail	COL	50
C. serrulatus	serrulate rattail	CSE	4
C. subserrulatus	fourrayed rattail	CSU	3
C. sp. B	long barbel rattail	CBA	3
Lepidorhynchus denticulatus	javelinfish	JAV	96
Nezumia namatahi	squashedfaced rattail	NNA	3
Ventrifossa nigromaculata	blackspot rattail	VNI	10
Trachyrincus aphyodes	unicorn rattail	WHX	3
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	98
Linophrynidae: linophrynids			
Linophryne arborifera	black anglerfish	BAF	1
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	2
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	2
H. mediterraneus	silver roughy	SRH	21
Paratrachichthys trailli	common roughy	RHY	6
Berycidae: alfonsinos			
Beryx splendens	slender beryx	BYS	39
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	13
Cyttus novaezelandiae	silver dory	SDO	12
C. traversi	lookdown dory	LDO	103
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	6
Neocyttus rhomboidalis	spiky oreo	SOR	15

Pseudocyttus maculatus	smooth oreo	SSO	9
Macrorhamphosidae: snipefishes			
Centriscops obliquus	redbanded bellowsfish	BBE	60
Notopogon Fernandezianus	orange bellowsfish	NOF	1
Scorpaenidae: scorpionfishes			
Helicolenus sp.	sea perch	SPE	89
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	2
Congiopodus leucopaecilus	southern pigfish	PIG	2
Triglidea: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	3
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	33
Psychrolutidae: toadfishes			
Neophrynichthys angustus	pale toadfish	TOP	35
N. latus	dark toadfish	TOD	2
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	7
Serranidae: sea perches			
Callanthias allporti	splendid perch	SPP	1
Lepidoperca aurantia	orange perch	OPE	9
L. sp. B	wavy line perch	WLP	2
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	1
E. robustus	cardinalfish	EPR	10
E. telescopus	black cardinalfish	EPT	1
Carangidae: jacks, trevallies, kingfishes			
Trachurus murphyi	slender mackerel	JMM	19
T. declivis	jack mackerel	JMD	2
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	31
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	7
Plagiogeneion rubiginosus	rubyfish	RBY	1
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	TAR	5
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	56
Kathetostoma sp.	banded giant stargazer	BGZ	1
Callionymidae: dragonets			
Species not identified	dragonet	DGT	1
Gempylidae: snake mackerels			
Thyrsites atun	barracouta	BAR	9
Trichiuridae: cutlassfishes			
Benthodesmus sp.	slender frostfish	BEN	1
Scombridae: mackerels, tunas			
Scomber australasicus	blue mackerel	EMA	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	31
Hyperoglyphe antarctica	bluenose	BNS	1
Icichthys australis	ragfish	RAG	8
Seriolella caerulea	white warehou	WWA	49
S. punctata	silver warehou	SWA	50
Tubbia tasmanica	none	TUB	6
Nomeidae: eyebrowfishes, driftfishes			
Cubiceps sp.	cubehead	CUB	3

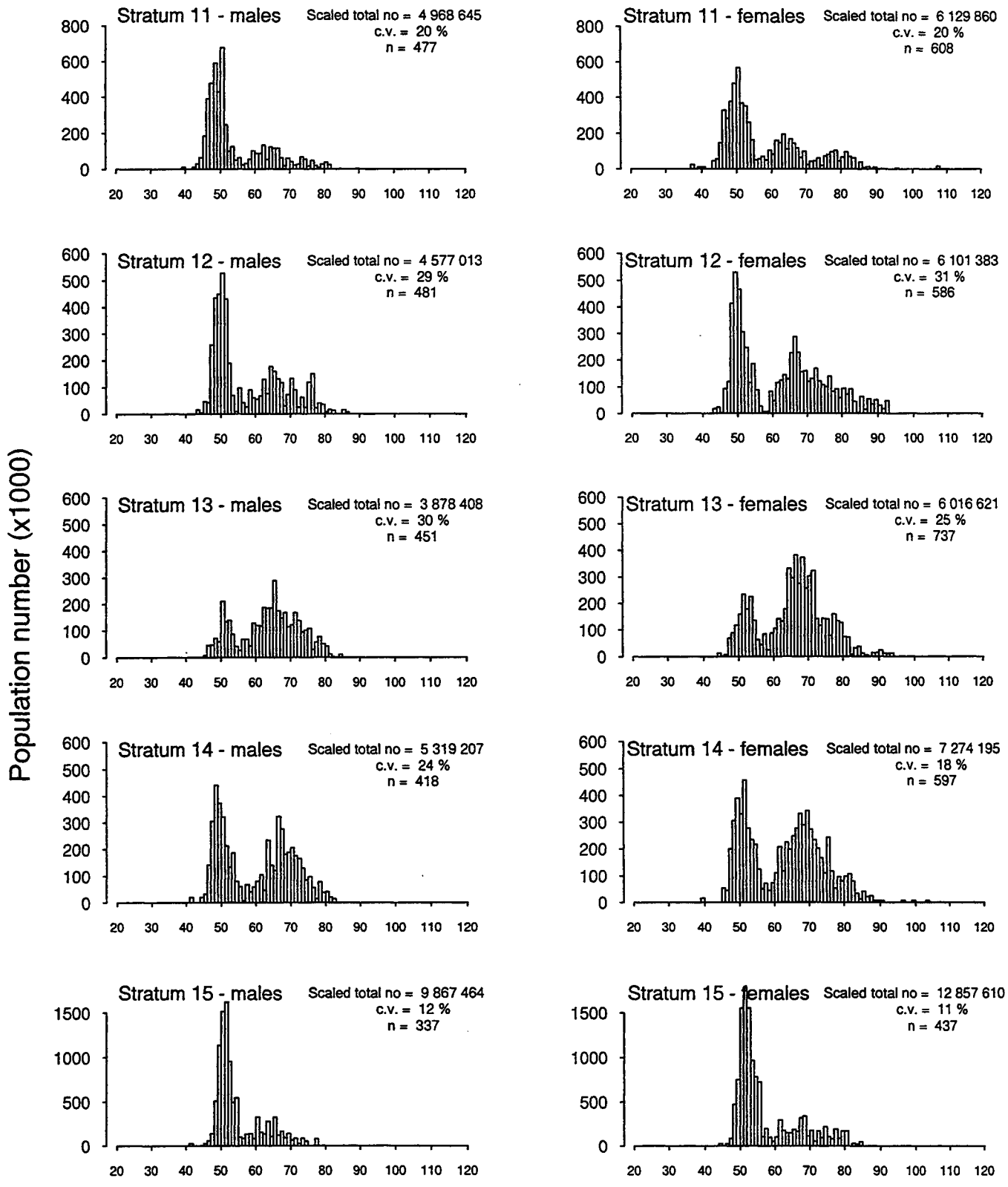
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	10
Neoachiropsetta milfordi	finless flounder	MAN	6
Pleuronectidae: righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	14
Colistium guntheri	brill	BRI	1
Cephalopoda			
Histioteuthidae			
Histioteuthis miranda	violet squid	VSQ	2
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	51
Ommastrephes bartrami	red squid	RSQ	33
Onychoteuthidae			
Moroteuthis ingens	warty squid	MIQ	41
Crustacea			
Homolidae			
Paromola petterdi	antlered crab	ATC	2
Lithodidae			
Lithodes murrayi	southern stone crab	LMU	1
Nephropsidae			
Metanephrops challengeri	scampi	SCI	43
Decapoda			
Species not identified	prawn	PRA	3
Species not identified	crab	CRB	1
Other marine organisms			
Porifera	sponges	ONG	18
Coelenterata			
Anthozoa	sea anemones	ANT	18
Anthozoa	coral	COU	5
Scyphozoa	jellyfish	JFI	1
Mollusca			
Cephalopoda	squid	SQX	4
Octopoda	deepwater octopus	OCT/DWO	14
Molluscs	unidentified	MOL	1
Echinodermata			
Asteroidea	starfish	SFI/ASR	43
Echinodea	sea urchin	SUR	2
Holothurian	sea cucumber	SCC	3
Echinidae			
Gracilechinus multidentatus	sea urchin	GRM	1
Echinothuriidae			
Phormosoma bursarium	Tam O' Shanter urchin	PBU/TAM	4



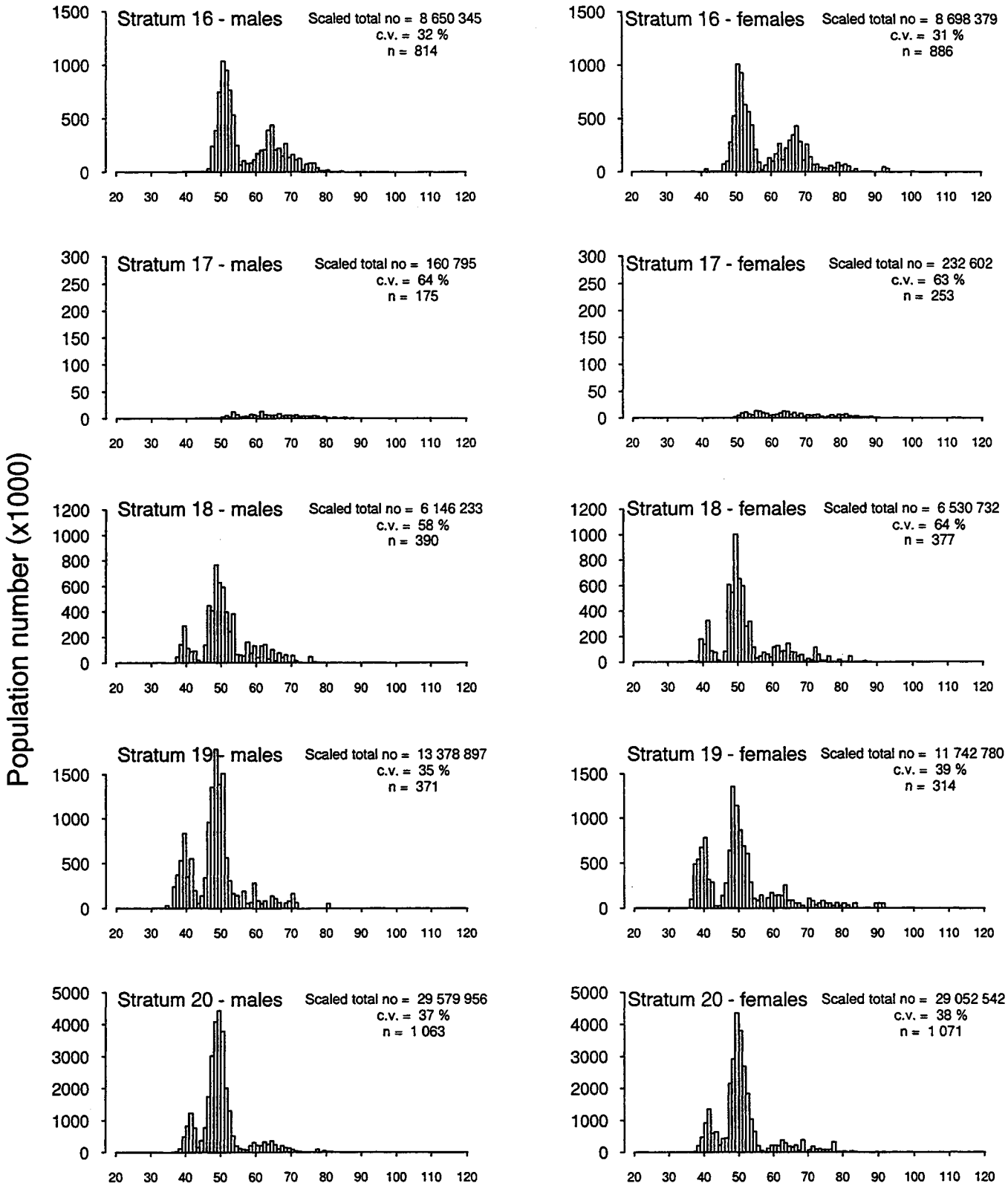
Appendix 3: Scaled length frequencies of male and female hoki by stratum.



Appendix 3 cont.



Appendix 3 cont.



Appendix 3 cont.