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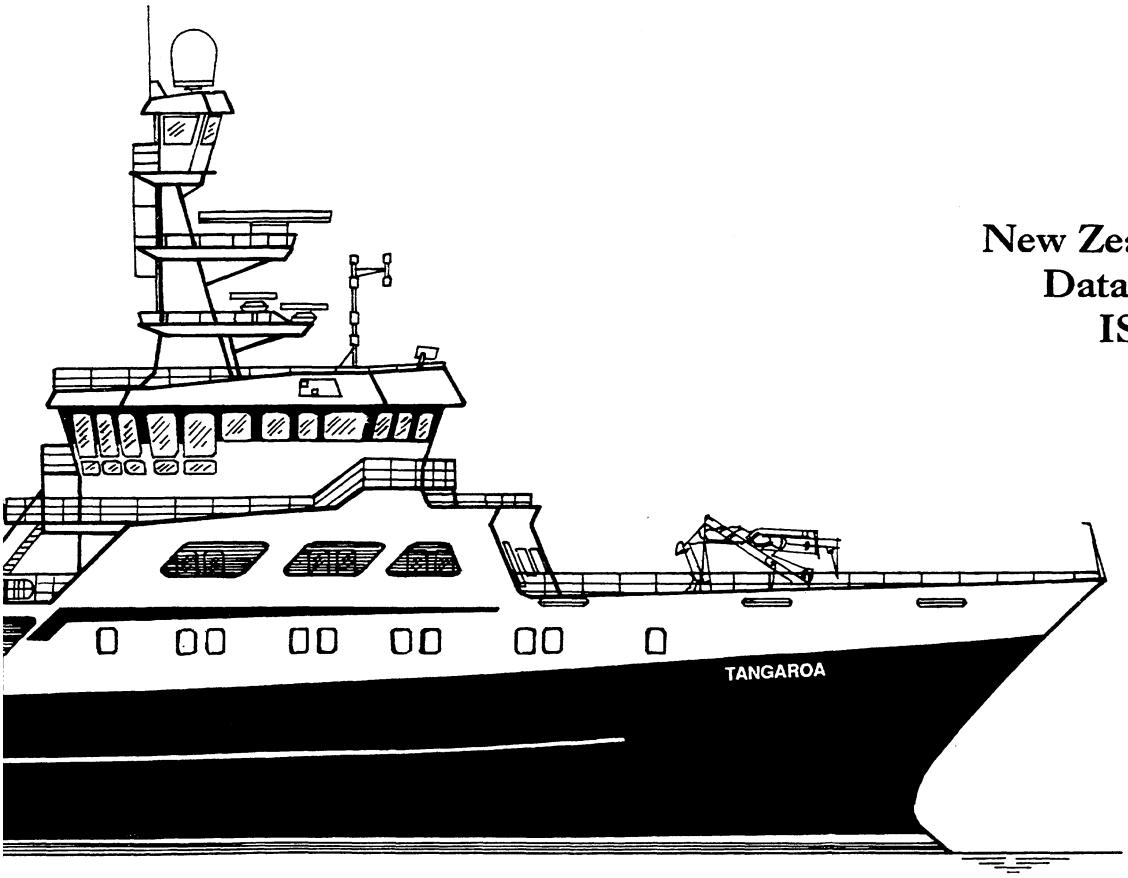

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Contents

Introduction

This report presents the results of the third annual random trawl survey aimed at providing a time series of comparable biomass indices for hoki and other commercially important species in depths of 200–800 m on the Chatham Rise. Trawling during this voyage (TAN9401) was conducted from 2 to 31 January 1994. The first survey in this series took place in December 1991-January 1992 (Horn 1994a) and the second in December 1992-February 1993 (Horn 1994b).

The major objectives of the 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 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.

Previous random trawl surveys of depths from 50 to 800 m on the Chatham Rise were conducted using *Shinkai Maru* in March 1983 (Fenaughty & Uozumi 1989), November-December 1983 (Hatanaka *et al.* 1989), and July 1986 (Livingston *et al.* 1991). In December 1989, *Amaltal Explorer* surveyed depths of 200–800 m (Hurst & Schofield 1990, Livingston & Schofield in press). Depths from 50 to 400 m around the Chatham Islands were surveyed in December 1984 and 1985 by *Akebono Maru No. 73* (Hurst & Bagley 1987, 1992). Although these surveys are not directly comparable because different vessels and gear were used, they have provided abundance estimates for a variety of commercial species (Hurst & Fenaughty 1985, Livingston *et al.* 1991).

Methods

Survey area and design

The survey area was divided into 25 strata by depth (200–400, 400–600, 600–800 m) and longitude (Figure 1). The stratum boundaries were similar to those used in the *Tangaroa* survey in January 1993, but some modifications were made to strata 13 and 21 after the analysis of new bathymetric data from that survey.

The survey was designed as a two-phase stratified random trawl survey (*after* Francis 1984). Allocation of phase 1 stations took into account stratum area and the distribution of juvenile and recruited hoki in the three most recent surveys (December 1989, January 1992, and January 1993). About 60% of stations were allocated according to past distributions of juvenile hoki and the others were based on distribution of recruited fish. It was planned to complete 150 phase 1 stations. Phase 2 stations were planned for any remaining survey time to improve the coefficients of variation for target species, particularly juvenile hoki.

The objectives specific to this survey were as follows.

1. To estimate the recruited and juvenile biomass of hoki on the Chatham Rise.
2. To estimate recruited biomass of ling, hake, and other commercially important species.

3. To collect biological data (length frequencies, sex ratios, otoliths, gonad state, samples for genetic analysis) 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 bottom temperatures at each trawl station.
5. To collect bathymetric data to refine stratum boundaries.

Vessel specifications

GRV *Tangaroa* is a purpose-built research stern trawler with the following specifications: length overall, 70.0 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 two 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. Doorspread was recorded from the Scanmar system every 5 min during the tow, and an average spread was calculated for each tow. No wingspread measurements were collected. Headline heights were recorded from the Kaijo Denki net monitor every 5 min and an average was calculated for each tow.

Trawling procedure

All station positions were selected randomly. 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 no tow was possible, the station was abandoned and another random position chosen. All trawl paths were separated by a minimum of 3 n. miles. Trawling was conducted between sunrise and sunset. 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 aborted at less than 2 n. miles were replaced with another random station in the same stratum.

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.

Catch sampling

The catch at each station was sorted into species and weighed on motion-compensating electronic scales accurate to within 0.3 kg. Weights of some large skates were estimated. At stations producing large quantities of mixed rattails, the weights of individual species were estimated by subsample, i.e., a percentage of the total rattail catch was identified and weighed, and the total catch was apportioned according to the percentage 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 and sex. Each day, 40 each of hoki, ling, and hake were selected for more detailed biological analysis and otolith removal. Data collected were fish length, weight, sex, gonad stage and weight, stomach fullness, stomach contents, and prey condition. Generally, 20 hoki were randomly selected from each of two tows, one in the morning and one in the afternoon. Ling and hake were selected from all tows until 40 had been sampled that day. Samples of ling for detailed analysis were non-random so as to comprehensively sample the full size range in the catch. Additional otoliths were collected from large hoki to improve age-length keys.

Detailed biological analyses (as described above) were also conducted on samples of silver warehou, white warehou, and southern blue whiting as time and fish availability permitted. Length, weight, and sex data were also collected from samples of ribaldo, lookdown dory, sea perch, giant stargazer, alfonsino, pale ghost shark, dark ghost shark, and slender mackerel to enable the calculation of length-weight relationships for these species which are becoming commercially important.

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 at 1 in the analysis presented here.

Scaled length frequencies were calculated for the main species with the MAF Fisheries 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 the same as the biomass calculated from catch data.

Data from all stations were used to estimate biomass as all had satisfactory gear performance (code 1 or 2).

Results

Survey area

The defined survey area (*see* Figure 1) totalled 139 938 km^2. Some stratum boundaries were found to be inaccurate and will be altered before the next survey.

Of the 150 planned phase 1 stations, 149, numbered 1–147 and 150–151, were completed (Table 1). Sixteen phase 2 stations (148–149 and 152–165) were completed and were allocated to improve the coefficient of variation of the 1+ and 2+ hoki cohorts. At the completion of phase 2, the coefficients of variation were reduced by 1% for each cohort, i.e., from 21 to 20% for the 1+ cohort and from 19 to 18% for the 2+ cohort.

Station density in individual strata (after completion of phase 2) ranged from 1:204 to 1:2253 km^2 (*see* Table 1). Mean station density over the whole area was 1:848 km^2. The positions of all stations occupied are shown in Figure 1 and individual station data are presented 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). The mean doorspread of individual tows ranged from 102.7 to 132.0 m, with only two tows falling outside the desired range of 100–130 m (Hurst *et al.* 1992).

Hydrology

Surface temperatures were recorded for the first 76 tows of the survey (after which the temperature sensor failed) and covered the survey area east of 177° E. Surface temperatures ranged from 11.7 to 16.0 °C and increased with decreasing latitude (Figure 2a).

Bottom temperatures ranged from 5.2 to 10.8 °C (Figure 2b). Higher temperatures were generally associated with shallower depths: a warmer (9–10 °C) area was found in stratum 19, as in previous years (Horn 1994a, 1994b).

Catch composition

During the voyage 139 species were identified, including 1 agnathan, 31 elasmobranchs, 93 teleosts, 8 cephalopods, and 6 crustaceans. 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 251.6 t, of which 127.5 t (51%) was hoki, 12.6 t (5%) was alfonsino, 8.7 t (3%) was silver warehou, and 8.6 t (3%) was ling (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 about 80% of the fish were not commercially valuable as they were below 70 cm TL. Alfonsino, silver warehou, ling, black oreo, hake, and giant stargazer were the other important commercial species (but much of the black oreo and alfonsino biomass comprised fish 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 significant biomass of non-commercial species (primarily rattail species, shovelnosed dogfish, and spiky oreo) occurs on the Chatham Rise.

Species distribution

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

Hoki were widely distributed in depths of 200–600 m over the Chatham Rise, but the 1+ cohort was most abundant in 200–400 m on the Mernoo Bank. Ling were also widely distributed and most abundant in depths of 200–600 m. Alfonsino were most abundant in 200–600 m on the eastern Rise, particularly in stratum 23 and between 200 and 400 m in stratum 19. Silver warehou were patchily distributed in depths of 200–400 m and were most abundant on the Mernoo Bank, close to the Chatham Islands, and in stratum 21. White warehou were patchily distributed across the Rise, mainly in depths shallower than 600 m. Most hake were taken in depths below 400 m and were more abundant in the north. Giant stargazer were common in depths of 200–400 m over the whole area and the highest catch rates were on the Mernoo Bank. Oreos were generally in the 600–800 m strata: black oreo and smooth oreo were most abundant in the southwest and spiky oreos in the northeast. Bigeyed rattail were most abundant on the southwestern Rise, particularly in depths of 400–600 m. The two ghost shark species were separated by the 400 m contour, the pale shark occurring mainly in the deeper zone. Lookdown dory and sea perch were common over the whole area, but were in greatest abundance on the central Rise in depths of 200–600 m. Javelinfish were also common throughout the survey area, particularly in depths of 400–800 m. Spiny dogfish, barracouta, and arrow squid were most abundant in 200–400 m with spiny dogfish and arrow squid more abundant on the Mernoo Bank and barracouta concentrated closer to the Chatham Islands.

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 strong 1+ and 2+ cohorts with modes at 36–40 and 50–54 cm total length. The 1+ cohort was particularly abundant in the 200–400 m depths of the western Rise and the 2+ cohort was more abundant in 400–600 m on the western Rise and between 200–600 m on the eastern Rise. Adult hoki were present in all areas, but were more abundant on the eastern Rise. The mean size of hoki increases with increasing depth. Length frequencies of hoki by strata are given in Appendix 3.

Sex ratios were about even for most species except spiny dogfish, which were predominantly female (0.12 : 1), and alfonsino, slender mackerel, red cod, and smooth oreo which were predominantly male (sex ratios exceeded 1.5 : 1).

A summary of the gonad stages of hoki, hake, ling, silver warehou, white warehou, and southern blue whiting is given in Table 9. Most hoki, white warehou, and southern blue whiting were immature or resting. Silver warehou appeared to have spawned recently and most fish were spent or resting. Of adult hake, over 50% of males and 20% of females were in active reproductive stages (ripening to partially spent: stages 3–6). Adult ling were also mainly resting, though 47% of males and 12% of females were in active reproductive stages.

Discussion

The survey design used appears to provide satisfactory biomass estimates for the main commercial middle depth species. The high coefficient of variation for the biomass for silver warehou (48.6%) is expected given the known patchy distribution of this species.

The allocation of phase 1 stations based on hoki catch rates from previous surveys was successful, and phase 2 stations were targeted at reducing the coefficient of variation for juvenile hoki in strata 18 and 7. Biomass coefficients of variation were low enough for the survey to end 9 days ahead of schedule.

Stratum boundaries will continue to be modified for some years as the bathymetric database builds up.

Acknowledgments

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Table 1: Stratum description and station allocation*

Stratum	Area (km^2)	Number of stations P1	C1	C2	Station density (km^2 per station)	Depth range (m)
1	2 572	3	3	0	857	600–800
2	3 258	3	3	0	1 086	600–800
3	9 014	4	4	0	2 253	600–800
4	5 893	4	4	0	1 473	600–800
5	5 426	4	4	0	1 357	600–800
6	8 157	6	6	0	1 360	600–800
7	5 231	6	6	5	476	400–600
8	3 295	5	5	0	659	400–600
9	5 730	7	7	0	819	400–600
10	6 314	5	5	0	1 263	400–600
11	6 534	5	5	0	1 307	400–600
12	6 578	4	4	0	1 645	400–600
13	6 691	4	4	0	1 673	400–600
14	5 921	5	5	0	1 184	400–600
15	5 893	12	12	0	491	400–600
16	4 695	9	10	0	470	400–600
17	6 826	12	11	0	621	400–600
18	4 701	12	12	11	204	200–400
19	9 018	10	10	0	902	200–400
20	9 585	8	7	0	1 369	200–400
21	3 510	6	6	0	585	200–400
22	4 068	4	4	0	1 017	200–400
23	5 146	4	4	0	1 287	200–400
24	821	3	3	0	274	200–400
25	5 061	5	5	0	1 012	400–600
Total	139 938	150	149	16	848	

* 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)		2.96	0.20	2.0–3.38
Tow speed (knots)		3.6	0.12	3.2–4.2
Gear parameters (m)				
200–400 m				
Headline height	57	6.5	0.5	5.5–7.5
Doorspread	57	114.0	5.8	102.7–124.2
400–600 m				
Headline height	84	6.5	0.4	5.7–7.6
Doorspread	84	118.5	4.1	108.8–132
600–800 m				
Headline height	24	6.5	0.3	5.9–6.9
Doorspread	24	120.5	4.9	109.3–131.2
Total depth range				
Headline height	165	6.5	0.4	5.5–7.6
Doorspread	165	117.3	5.4	102.7–132.0

Wingspread = 27.3 m. based on measurements from previous hoki trawl surveys (TAN9106, TAN9204).
Ratio of doorspread to wingspread is 4.3 : 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*

	Species code	Total biomass (t) All fish		Total biomass (t) Females		Total biomass (t) Males		Catch (kg)
ITQ species								
Hoki	HOK	145 633	(9.8)	83 490	(9.4)	62 070	(11.0)	127 529
Alfonsino	BYS	25 854	(90.0)	8 352	(88.1)	16 921	(93.9)	12 639
Silver warehou	SWA	11 632	(48.6)	6 949	(51.0)	4 656	(45.5)	8 742
Ling	LIN	10 129	(6.5)	5 601	(7.4)	4 528	(7.6)	8 608
Black oreo	BOE	6 972	(26.4)	3 526	(26.7)	3 446	(26.3)	3 370
Hake	HAK	3 353	(9.6)	2 129	(8.7)	1 224	(16.6)	2 232
Giant stargazer	STA	2 853	(11.9)	2 156	(12.1)	686	(16.4)	3 518
Barracouta	BAR	1 416	(76.6)	1 032	(82.2)	384	(62.8)	923
Arrow squid	NOS	966	(24.4)	438	(35.8)	254	(28.5)	1 195
Smooth oreo	SSO	808	(50.8)	316	(50.7)	489	(51.6)	418
Slender mackerel	JMM	771	(49.5)	709	(59.7)	446	(43.4)	648
Red cod	RCO	640	(27.2)	288	(33.2)	340	(31.2)	779
School shark	SCH	194	(40.8)	42	(71.5)	67	(83.2)	129
Orange roughy	ORH	185	(67.4)	98	(68.4)	86	(66.5)	97
Tarakihi	TAR	165	(55.4)	102	(67.2)	61	(49.8)	119
Hapuku	HAP	128	(31.1)	65	(34.8)	63	(29.3)	91
Bluenose	BNS	80	(31.3)	34	(38.0)	18	(44.6)	79
Lemon sole	LSO	65	(32.2)	11	(77.7)	12	(71.1)	58
Commercial non-ITQ species								
Dark ghost shark	GSH	10 359	(15.3)	6 311	(18.1)	3 671	(13.4)	10 688
Lookdown dory	LDO	7 664	(7.2)	5 526	(7.6)	2 125	(8.1)	5 597
Pale ghost shark	GSP	5 899	(8.6)	3 092	(9.2)	2 672	(9.3)	4 449
Sea perch	SPE	3 914	(10.8)	1 571	(12.0)	1 682	(12.6)	2 843
Spiny dogfish	SPD	3 449	(12.7)	2 633	(13.2)	236	(18.2)	4 066
White warehou	WWA	1 572	(27.1)	530	(24.0)	669	(31.5)	1 431
Ribaldo	RIB	660	(10.4)	407	(12.8)	195	(13.4)	517
Redbait	RBT	522	(91.5)	–		–		556
Orange perch	OPE	288	(52.4)	–		–		345
Southern blue whiting	SBW	131	(94.5)	67	(94.7)	64	(95.2)	298
Non-commercial species								
Bigeyed rattail	CBO	16 832	(9.1)	–		–		14 005
Javelinfish	JAV	6 690	(17.7)	–		–		10 872
Oliver's rattail	COL	2 750	(14.5)	–		–		2 269
Shovelnosed dogfish	SND	1 844	(19.6)	–		–		3 253
Oblique-banded rat.	CAS	457	(25.1)	–		–		1 571
Unicorn rattail	WHX	354	(32.6)	–		–		193
Spiky oreo	SOR	202	(42.9)	113	(51.5)	88	(35.7)	1 500

* – = not sexed.

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

			Cohort					
			1+		2+		Adult	
Stratum		Total	(< 46 cm)		(46–59 cm)		(> 59 cm)	
1	1 057	(40)	20	(98)	220	(95)	817	(29)
2	638	(13)	0		11	(100)	627	(12)
3	4 972	(65)	0		7	(73)	4 965	(65)
4	1 460	(28)	0		0		1 460	(28)
5	2 323	(17)	0		84	(35)	2 238	(17)
6	2 338	(27)	1	(100)	556	(56)	1 781	(29)
7	14 066	(35)	3 271	(57)	8 170	(39)	2 624	(31)
8	2 323	(9)	51	(41)	1 035	(15)	1 238	(7)
9	8 633	(26)	3	(77)	4 192	(38)	4 437	(16)
10	7 453	(10)	10	(62)	990	(23)	6 454	(11)
11	4 687	(27)	4	(65)	1 523	(25)	3 159	(39)
12	4 479	(36)	0		59	(50)	4 420	(36)
13	10 077	(52)	53	(100)	466	(76)	9 558	(56)
14	8 118	(21)	4	(100)	812	(43)	7 302	(22)
15	5 556	(14)	137	(29)	1 130	(19)	4 288	(14)
16	6 942	(26)	625	(37)	2 982	(36)	3 336	(26)
17	4 356	(19)	51	(25)	873	(16)	3 432	(21)
18	7 800	(17)	4 724	(25)	1 622	(26)	1 454	(17)
19	5 659	(33)	2 177	(65)	1 029	(36)	2 452	(21)
20	11 610	(36)	488	(79)	1 900	(48)	9 223	(37)
21	4 653	(28)	786	(75)	1 269	(57)	2 597	(16)
22	17 315	(56)	2 103	(56)	12 420	(57)	2 792	(52)
23	3 211	(54)	0		1 809	(65)	1 402	(66)
24	770	(81)	82	(100)	368	(98)	320	(61)
25	5 138	(23)	37	(63)	1 183	(33)	3 918	(26)
Total	145 633	(10)	14 628	(20)	44 711	(18)	86 295	(9)

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

Stratum	BYS		CBO		SWA		GSH		LIN		LDO		BOE		JAV		GSP	
	Species code																	
1	1	(100)	132	(32)	7	(100)	0	(0)	115	(51)	27	(30)	0	(0)	269	(37)	324	(33)
2	0	(0)	15	(16)	0	(0)	0	(0)	27	(54)	34	(29)	0	(0)	0	(0)	135	(12)
3	118	(100)	116	(35)	0	(0)	0	(0)	270	(52)	171	(21)	0	(0)	0	(0)	223	(17)
4	7	(100)	159	(47)	0	(0)	0	(0)	192	(34)	117	(23)	614	(100)	0	(0)	146	(30)
5	0	(0)	684	(15)	0	(0)	0	(0)	315	(26)	73	(38)	1 738	(70)	1 063	(39)	424	(22)
6	0	(0)	486	(37)	0	(0)	0	(0)	667	(40)	34	(43)	4 578	(27)	1 150	(68)	874	(36)
7	4	(100)	858	(32)	50	(43)	36	(95)	934	(19)	147	(16)	1	(89)	587	(15)	359	(21)
8	22	(46)	95	(20)	8	(75)	14	(71)	202	(47)	98	(17)	0	(0)	327	(68)	91	(28)
9	7	(63)	346	(46)	36	(75)	41	(73)	487	(31)	359	(30)	0	(0)	0	(0)	140	(22)
10	68	(97)	486	(79)	300	(50)	3	(100)	241	(41)	352	(43)	0	(0)	0	(0)	130	(28)
11	670	(60)	123	(57)	75	(54)	301	(48)	334	(25)	255	(12)	0	(0)	0	(0)	5	(100)
12	465	(100)	657	(24)	45	(62)	195	(100)	557	(34)	636	(26)	0	(0)	0	(0)	163	(34)
13	0	(0)	1 016	(16)	173	(91)	567	(66)	689	(25)	407	(32)	0	(0)	0	(0)	415	(32)
14	0	(0)	1991	(42)	4	(100)	0	(0)	553	(13)	856	(17)	0	(0)	0	(0)	670	(39)
15	0	(0)	2 204	(29)	10	(54)	2	(75)	507	(16)	694	(32)	0	(0)	659	(42)	502	(15)
16	0	(0)	1 706	(21)	57	(45)	29	(85)	648	(15)	217	(12)	5	(62)	369	(32)	419	(14)
17	0	(0)	1 885	(12)	12	(69)	0	(0)	601	(19)	270	(18)	36	(44)	1 521	(25)	463	(23)
18	3	(90)	138	(34)	555	(18)	916	(14)	385	(31)	218	(18)	0	(0)	41	(42)	3	(100)
19	795	(81)	621	(32)	481	(58)	1 998	(31)	346	(40)	258	(27)	0	(0)	75	(82)	4	(100)
20	72	(49)	2 516	(31)	433	(63)	1 525	(21)	999	(25)	1 438	(21)	0	(0)	0	(0)	139	(37)
21	94	(75)	124	(62)	2 849	(89)	1 749	(30)	301	(47)	157	(19)	0	(0)	0	(0)	27	(82)
22	86	(83)	0	(0)	258	(52)	1 248	(46)	283	(39)	49	(78)	0	(0)	0	(0)	99	(100)
23	23 423	(99)	2	(100)	5 982	(84)	377	(75)	154	(56)	411	(44)	0	(0)	0	(0)	0	(0)
24	0	(0)	2	(75)	52	(95)	1 045	(98)	8	(100)	15	(59)	0	(0)	0	(0)	1	(100)
25	19	(36)	473	(52)	244	(70)	314	(71)	312	(32)	370	(32)	0	(0)	629	(90)	141	(52)

Table 5 – *continued*

Stratum	SPE		SPD		HAK		STA		COL		SND		WWA		BAR		NOS	
	Species code																	
1	7	(70)	0	(0)	112	(65)	38	(51)	25	(59)	1 284	(0)	7	(100)	0	(0)	8	(30)
2	2	(100)	0	(0)	111	(45)	36	(56)	17	(43)	0	(0)	0	(0)	0	(0)	1	(100)
3	34	(21)	0	(0)	577	(39)	48	(58)	29	(45)	0	(0)	25	(100)	0	(0)	0	(0)
4	17	(41)	0	(0)	237	(33)	0	(0)	18	(26)	0	(0)	0	(0)	0	(0)	0	(0)
5	46	(51)	9	(61)	58	(58)	0	(0)	292	(20)	0	(0)	10	(58)	0	(0)	1	(100)
6	30	(47)	0	(0)	78	(56)	14	(64)	415	(33)	0	(0)	38	(49)	0	(0)	2	(66)
7	108	(38)	8	(60)	246	(20)	46	(52)	126	(64)	546	(66)	35	(53)	0	(0)	28	(14)
8	127	(42)	11	(100)	41	(28)	21	(52)	10	(40)	0	(0)	9	(43)	0	(0)	4	(100)
9	165	(48)	79	(80)	303	(25)	21	(58)	2	(65)	0	(0)	24	(65)	0	(0)	28	(60)
10	52	(37)	42	(61)	383	(19)	4	(100)	8	(34)	0	(0)	5	(100)	0	(0)	5	(64)
11	48	(44)	13	(61)	86	(58)	125	(38)	0	(0)	0	(0)	52	(24)	0	(0)	18	(54)
12	132	(32)	128	(39)	76	(38)	70	(35)	6	(84)	0	(0)	39	(49)	0	(0)	6	(47)
13	171	(38)	208	(43)	82	(47)	89	(63)	66	(86)	0	(0)	63	(83)	0	(0)	26	(71)
14	335	(25)	44	(43)	136	(21)	0	(0)	417	(55)	0	(0)	0	(0)	0	(0)	22	(68)
15	190	(22)	31	(51)	80	(28)	67	(52)	154	(52)	0	(0)	61	(64)	0	(0)	13	(24)
16	66	(31)	42	(51)	88	(23)	84	(29)	94	(26)	0	(0)	214	(60)	0	(0)	11	(36)
17	66	(25)	15	(40)	55	(13)	119	(22)	1 066	(24)	0	(0)	26	(37)	0	(0)	4	(31)
18	108	(23)	775	(27)	32	(30)	664	(31)	0	(67)	13	(70)	71	(33)	44	(26)	239	(25)
19	624	(26)	313	(36)	66	(44)	461	(27)	1	(77)	0	(0)	62	(50)	3	(100)	280	(77)
20	1 247	(27)	527	(20)	308	(39)	208	(31)	0	(0)	0	(0)	358	(78)	0	(0)	29	(25)
21	202	(45)	437	(47)	17	(52)	11	(51)	0	(0)	0	(0)	288	(93)	0	(0)	107	(47)
22	7	(100)	537	(38)	0	(0)	242	(63)	0	(0)	0	(0)	49	(96)	1 266	(85)	24	(35)
23	9	(74)	0	(0)	0	(0)	266	(38)	0	(0)	0	(0)	69	(91)	102	(100)	80	(47)
24	3	(74)	23	(31)	0	(0)	87	(12)	0	(0)	0	(0)	1	(100)	0	(0)	15	(52)
25	119	(30)	210	(69)	182	(19)	132	(63)	5	(52)	0	(0)	69	(56)	0	(0)	14	(62)

* 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
Alfonsino	0.016687	3.108198	183	0.99	19–52	This survey
Dark ghost shark	0.000919	3.476190	50	0.92	50–71	This survey
Giant stargazer	0.007300	3.202134	99	0.98	27–79	This survey
Hake	0.001785	3.313532	444	0.99	39–125	This survey
Hoki	0.002824	3.006239	1 002	0.98	34–105	This survey
Ling	0.001026	3.343948	896	0.99	36–162	This survey
Lookdown dory	0.020022	3.023065	201	0.99	11–45	This survey
Pale ghost shark	0.005080	3.031583	79	0.97	38–82	This survey
Ribaldo	0.002398	3.400389	116	0.98	24–70	This survey
Sea perch	0.012401	3.067271	194	0.99	14–46	This survey
Silver warehou	0.013979	3.081886	160	0.99	22–56	This survey
White warehou	0.016988	3.091715	52	0.96	31–46	This survey
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, Chatham Rise, Nov-Mar
Lemon sole	0.02323	2.833	–	–	–	DB, IKA8003
Orange roughy	0.0687	2.792	7 880	0.99	9–44	DB, Chatham Rise, Nov-Mar
Red cod	0.0092	3.003	923	0.98	13–72	Beentjes 1992
Slender mackerel	0.0255	2.77	90	0.91	44–62	DB, Stew/Sn shelf, Feb-Mar
Smooth oreo	0.0309	2.895	9 147	0.98	10–57	DB, Chatham 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, Chatham Rise, March
Spiny dogfish	0.000323	3.620	937	0.97	55–102	DB, Stew/Sn shelf, Feb–Mar
Tarakihi	0.02	2.98	–	–	–	Annala 1993

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

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

Stratum	HOK	BYS	CBO	SWA	GSH	LIN	LDO	BOE	JAV	GSP
	Species code									
1	411	1	51	3	0	45	11	0	105	126
	(284)	(1)	(28)	(4)	(0)	(39)	(5)	(0)	(67)	(72)
2	196	0	4	0	0	8	10	0	0	41
	(45)	(0)	(1)	(0)	(0)	(8)	(5)	(0)	(0)	(9)
3	552	13	13	0	0	30	19	0	40	25
	(717)	(26)	(9)	(0)	(0)	(31)	(8)	(0)	(0)	(9)
4	248	1	27	0	0	33	20	104	0	25
	(140)	(2)	(25)	(0)	(0)	(22)	(9)	(208)	(0)	(15)
5	428	0	126	0	0	58	14	320	196	78
	(144)	(0)	(38)	(0)	(0)	(31)	(10)	(450)	(108)	(35)
6	289	0	60	0	0	82	4	561	141	107
	(191)	(0)	(55)	(0)	(0)	(80)	(4)	(369)	(135)	(94)
7	2689	1	164	10	7	179	28	0	112	69
	(3103)	(2)	(175)	(14)	(22)	(113)	(14)	(1)	(35)	(49)
8	705	7	29	3	4	61	30	0	99	28
	(143)	(7)	(13)	(4)	(7)	(65)	(11)	(0)	(117)	(17)
9	1507	1	60	6	7	85	63	0	36	24
	(1035)	(2)	(74)	(12)	(14)	(70)	(49)	(0)	(0)	(14)
10	1180	11	77	48	1	38	56	0	0	21
	(262)	(23)	(136)	(53)	(1)	(35)	(54)	(0)	(0)	(13)
11	717	103	19	12	46	51	39	0	0	1
	(431)	(139)	(24)	(14)	(49)	(29)	(11)	(0)	(0)	(2)
12	681	71	100	7	30	85	97	0	0	25
	(496)	(141)	(48)	(8)	(59)	(58)	(51)	(0)	(0)	(17)
13	1506	0	152	26	85	103	61	0	0	62
	(1559)	(0)	(48)	(47)	(112)	(52)	(39)	(0)	(0)	(40)
14	1371	0	336	1	0	93	145	0	0	113
	(656)	(0)	(317)	(1)	(0)	(27)	(56)	(0)	(0)	(98)
15	943	0	374	2	0	86	118	0	112	85
	(463)	(0)	(376)	(3)	(1)	(49)	(130)	(0)	(149)	(45)
16	1479	0	363	12	6	138	46	1	79	89
	(1229)	(0)	(246)	(17)	(16)	(66)	(17)	(2)	(50)	(39)
17	638	0	276	2	0	88	40	5	223	68
	(401)	(0)	(105)	(4)	(0)	(55)	(23)	(8)	(148)	(51)
18	1659	1	29	118	195	82	46	0	9	1
	(1338)	(3)	(48)	(101)	(134)	(123)	(40)	(0)	(12)	(3)
19	627	88	69	53	222	38	29	0	8	0
	(659)	(226)	(71)	(97)	(221)	(49)	(24)	(0)	(19)	(1)
20	1211	8	262	45	159	104	150	0	49	14
	(1161)	(10)	(213)	(75)	(90)	(69)	(84)	(0)	(0)	(14)
21	1326	27	35	812	498	86	45	0	35	8
	(921)	(49)	(53)	(1766)	(372)	(99)	(21)	(0)	(0)	(15)
22	4526	21	0	64	307	70	12	0	0	24
	(4750)	(35)	(0)	(65)	(285)	(55)	(19)	(0)	(0)	(49)
23	624	4552	0	1163	73	30	80	0	0	0
	(672)	(9033)	(1)	(1955)	(110)	(33)	(70)	(0)	(0)	(0)
24	937	0	2	63	1272	9	19	0	0	2
	(1318)	(0)	(2)	(104)	(2163)	(16)	(19)	(0)	(0)	(3)
25	1015	4	93	48	62	62	73	0	124	28
	(525)	(3)	(108)	(75)	(98)	(44)	(52)	(0)	(158)	(32)

Table 7- *continued*

Stratum	SPE	SPD	HAK	STA	COL	SND	WWA	BAR	NOS	SSO
	Species code									
1	3	0	44	15	10	499	3	0	3	10
	(3)	(0)	(49)	(13)	(10)	(0)	(4)	(0)	(2)	(17)
2	1	0	34	11	5	0	0	0	0	23
	(1)	(0)	(27)	(11)	(4)	(0)	(0)	(0)	(0)	(24)
3	4	0	64	5	3	0	3	0	0	1
	(2)	(0)	(50)	(6)	(3)	(0)	(6)	(0)	(0)	(1)
4	3	0	40	0	3	0	0	0	0	12
	(2)	(0)	(27)	(0)	(2)	(0)	(0)	(0)	(0)	(16)
5	8	2	11	0	54	0	2	0	0	0
	(9)	(2)	(12)	(0)	(22)	(0)	(2)	(0)	(0)	(0)
6	4	0	10	2	51	0	5	0	0	77
	(4)	(0)	(13)	(3)	(41)	(0)	(6)	(0)	(0)	(121)
7	21	2	47	9	24	104	7	0	5	0
	(26)	(3)	(32)	(15)	(51)	(120)	(12)	(0)	(3)	(0)
8	39	3	13	6	3	59	3	0	1	0
	(36)	(7)	(8)	(7)	(3)	(0)	(3)	(0)	(3)	(0)
9	29	14	53	4	0	0	4	0	5	0
	(36)	(29)	(35)	(6)	(1)	(0)	(7)	(0)	(8)	(0)
10	8	7	61	1	1	0	1	0	1	0
	(7)	(9)	(26)	(1)	(1)	(0)	(2)	(0)	(1)	(0)
11	7	2	13	19	0	0	8	0	3	0
	(7)	(3)	(17)	(16)	(0)	(0)	(4)	(0)	(3)	(0)
12	20	19	12	11	1	0	6	0	1	0
	(13)	(15)	(9)	(7)	(2)	(0)	(6)	(0)	(1)	(0)
13	26	31	12	13	10	0	9	0	4	0
	(20)	(27)	(12)	(17)	(17)	(0)	(15)	(0)	(5)	(0)
14	57	7	23	0	70	0	0	0	4	0
	(32)	(7)	(11)	(0)	(86)	(0)	(0)	(0)	(6)	(0)
15	32	5	14	11	26	0	10	0	2	0
	(25)	(9)	(13)	(21)	(47)	(0)	(23)	(0)	(2)	(0)
16	14	9	19	18	20	0	46	0	2	0
	(14)	(14)	(14)	(17)	(16)	(0)	(87)	(0)	(3)	(0)
17	10	2	8	17	156	0	4	0	1	0
	(8)	(3)	(3)	(13)	(126)	(0)	(5)	(0)	(1)	(0)
18	23	165	7	141	0	3	15	9	51	0
	(25)	(215)	(10)	(212)	(0)	(5)	(24)	(12)	(60)	(0)
19	69	35	7	51	0	0	6	0	31	0
	(57)	(40)	(10)	(44)	(0)	(0)	(11)	(1)	(76)	(0)
20	130	55	32	22	0	0	37	0	3	0
	(93)	(30)	(33)	(18)	(0)	(0)	(77)	(0)	(2)	(0)
21	58	124	5	3	0	0	82	0	31	0
	(63)	(144)	(6)	(4)	(0)	(0)	(186)	(0)	(35)	(0)
22	2	132	0	60	0	0	12	311	6	0
	(3)	(100)	(0)	(75)	(0)	(0)	(23)	(531)	(4)	(0)
23	2	0	0	52	0	0	13	20	16	0
	(3)	(0)	(0)	(39)	(0)	(0)	(25)	(40)	(15)	(0)
24	4	28	0	106	0	0	1	0	18	0
	(5)	(15)	(0)	(21)	(0)	(0)	(2)	(0)	(16)	(0)
25	24	41	36	26	1	0	14	0	3	0
	(16)	(64)	(15)	(37)	(1)	(0)	(17)	(0)	(4)	(0)

* 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 samples	No. of fish measured			No. of samples	No. of fish
		Total	Male	Female		
Hoki	160	30 213	13 642	16 562	50	1 005
Ling	157	2 890	1 541	1 349	67	898
Hake	123	648	293	355	91	46
Silver warehou	84	2 001	926	804	8	160
White warehou	76	863	441	306	3	53
Southern blue whiting	4	267	128	139	1	20
Lookdown dory	130	4 483	1 756	2 702	6	216*
Pale ghost shark	96	1 842	915	927	5	79*
Giant stargazer	95	917	420	491	6	101*
Sea perch	82	2 345	1 003	979	4	194*
Dark ghost shark	59	2 103	964	1 137	2	50*
Ribaldo	45	223	104	119	15	116*
Alfonsino	34	1 461	751	436	4	183*
Slender mackerel	24	317	194	121	2	3*
Arrow squid	54	1 251	524	709	0	0
Spiny dogfish	53	855	94	758	0	0
Red cod	40	644	398	227	0	0
Black oreo	20	1 205	628	577	0	0
Barracouta	17	366	151	215	0	0
Smooth oreo	13	296	184	106	0	0
Spiky oreo	8	130	61	68	0	0
Hapuku	8	12	7	5	0	0
Tarakihi	7	68	35	33	0	0
Bluenose	6	17	7	10	0	0
Orange roughy	5	234	115	119	0	0
Lemon sole	5	41	27	14	0	0
School shark	4	5	3	2	0	0
Jack mackerel	2	2	0	2	0	0
Gurnard	1	16	6	10	0	0
Southern kingfish	1	1	0	1	0	0

* Length, sex, and weight data only collected.

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

	Hoki		Hake		Ling	
Stage	Male	Female	Male	Female	Male	Female
1	167	116	53	26	163	93
2	233	484	59	127	161	274
3	1	0	10	31	61	33
4	0	0	8	10	46	1
5	0	0	17	3	2	0
6	0	0	46	5	41	2
7	0	2	12	39	9	4
Total	401	602	205	241	483	407

	Silver warehou		White warehou		Southern blue whiting	
Stage	Male	Female	Male	Female	Male	Female
1	18	9	13	7	0	5
2	35	41	18	10	5	6
3	3	5	0	0	2	1
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	13	35	3	2	1	0
Total	69	90	34	19	8	12

* 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).

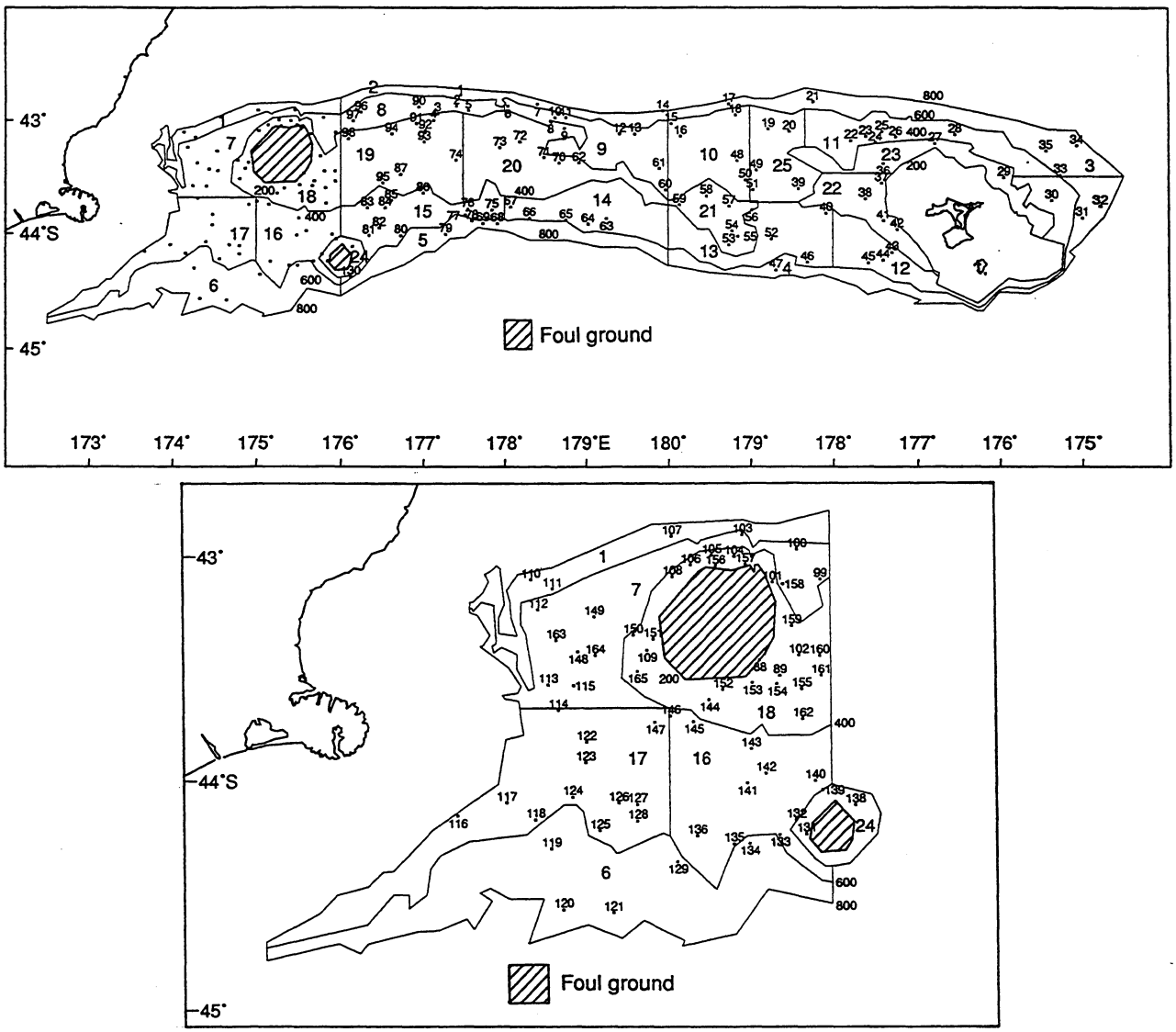


Figure 1: Trawl survey area showing stratum boundaries and trawl station positions.

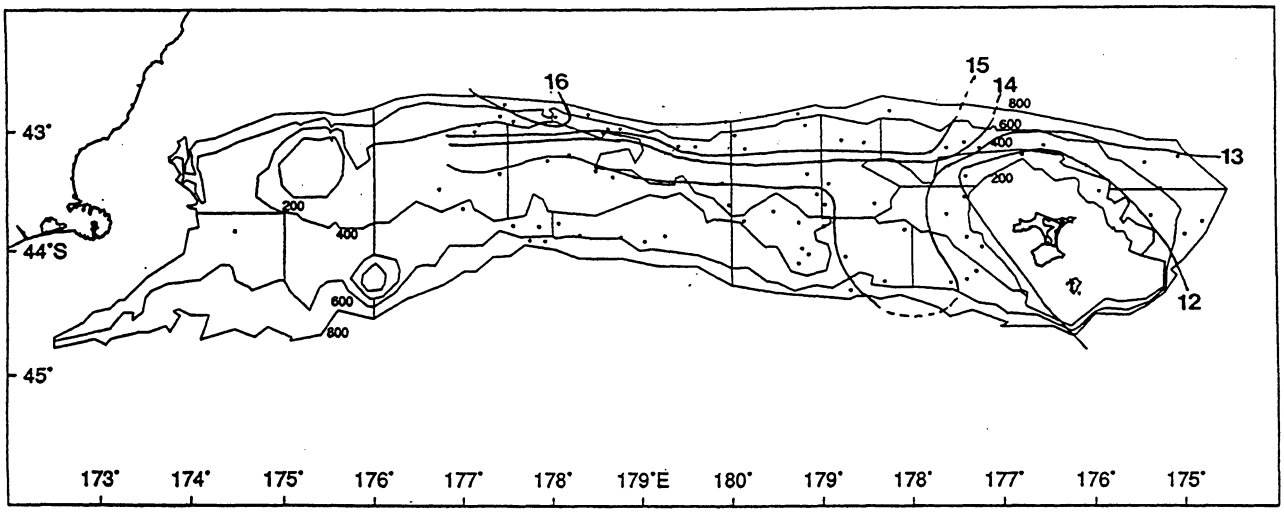


Figure 2a: Positions of surface temperature recordings and isotherms estimated from these data.

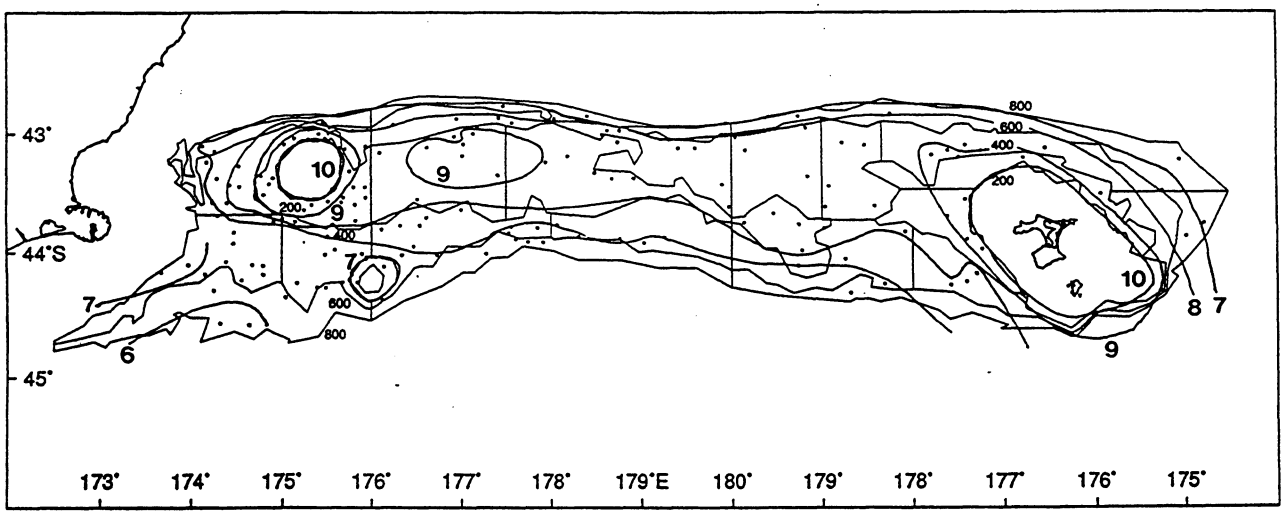


Figure 2b: Positions of bottom temperature recordings and isotherms estimated from these data.

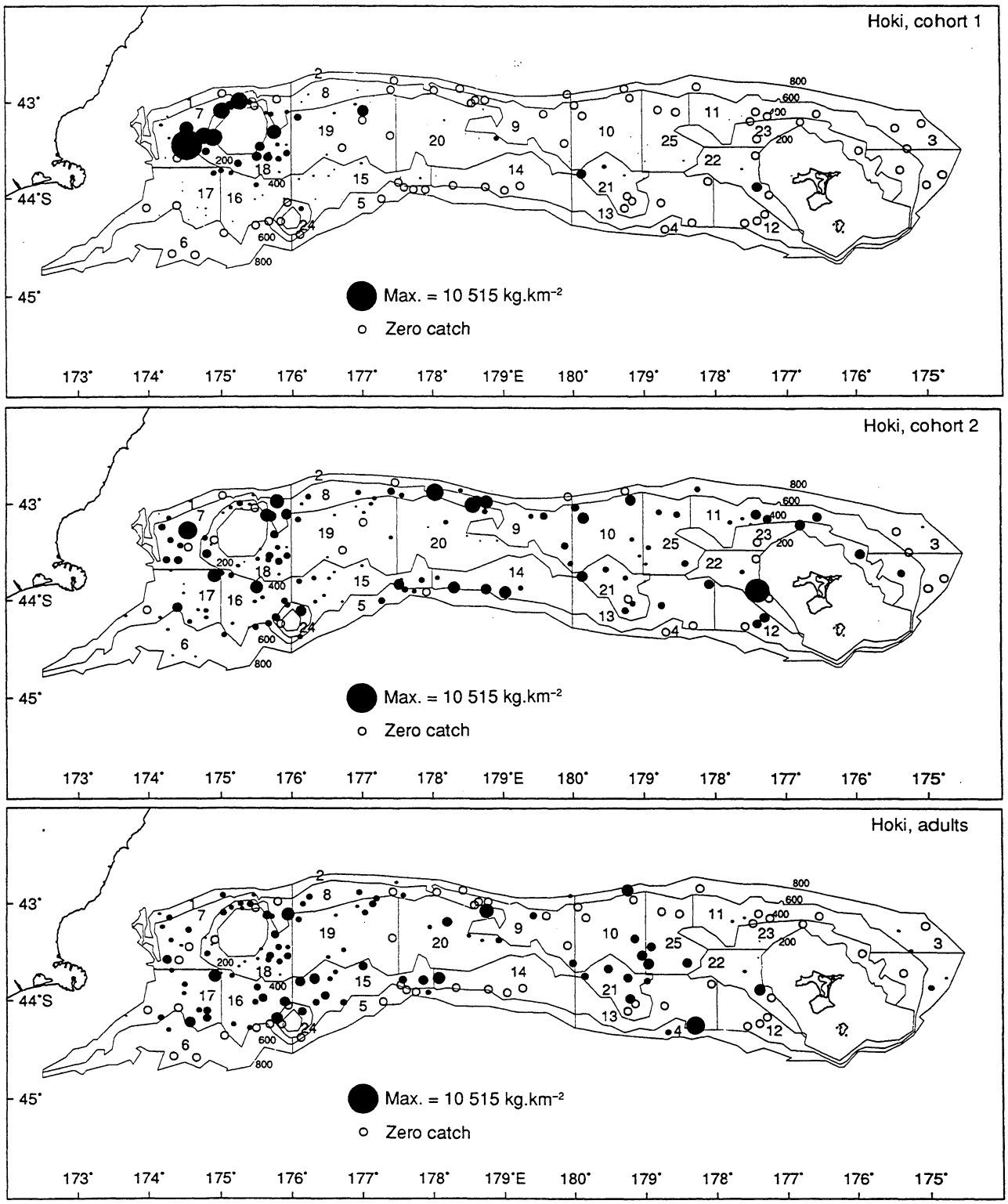


Figure 3: Catch rates (kg.km^{-2}) of hoki, ling, hake, and other important species. Circle area is proportional to catch rate. Max. = maximum catch rate (kg.km^{-2}).

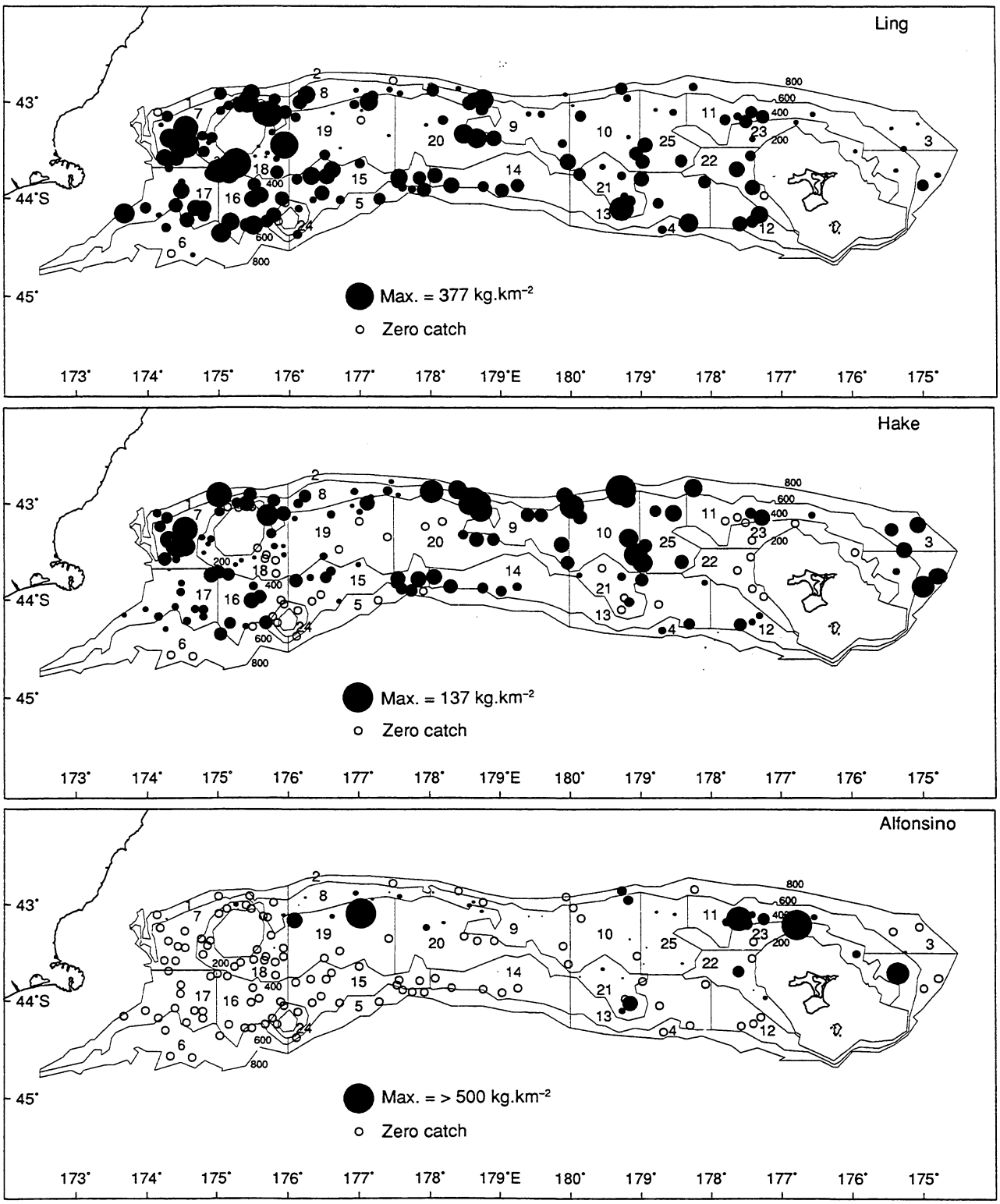


Figure 3—*continued*

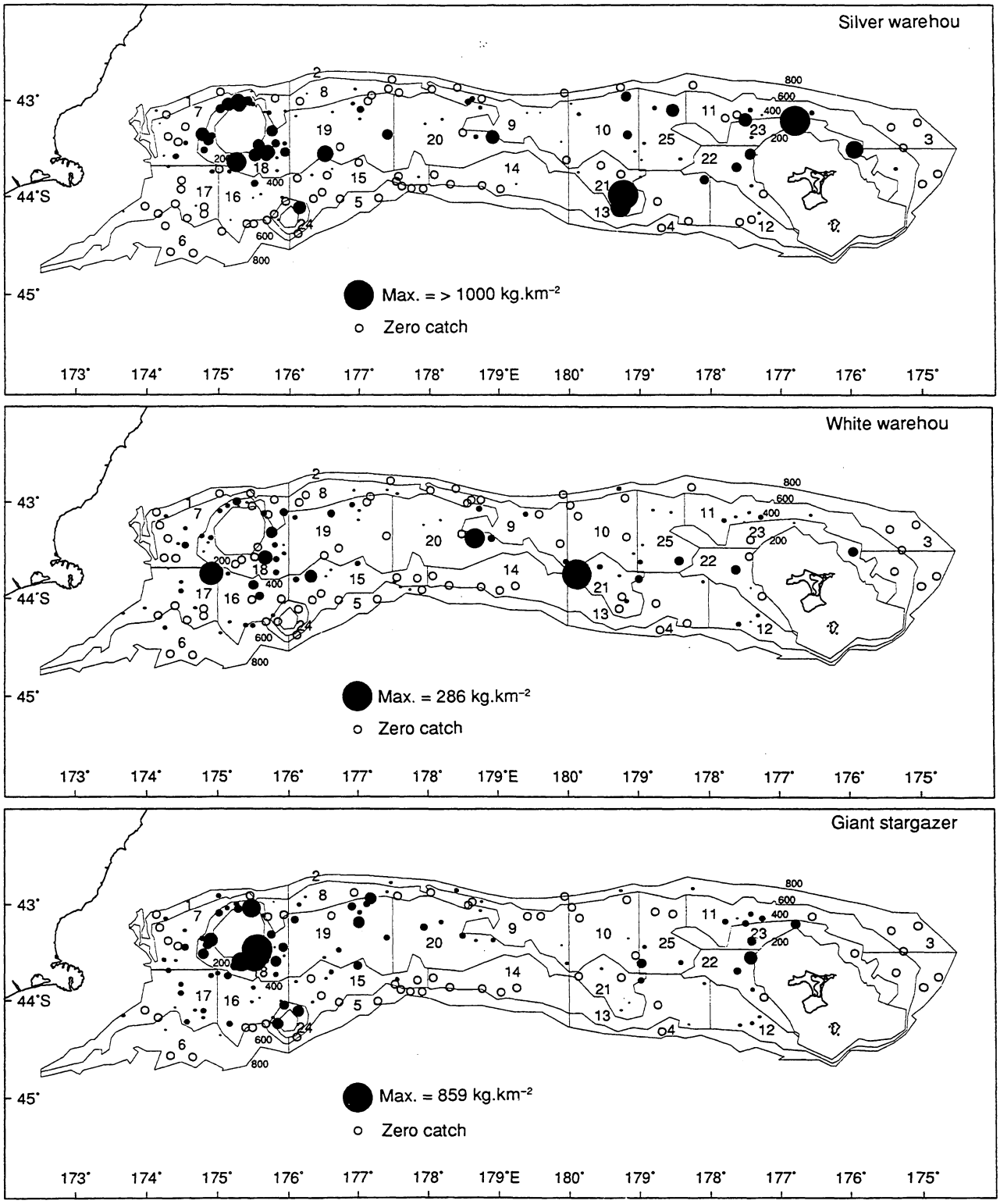


Figure 3—*continued*

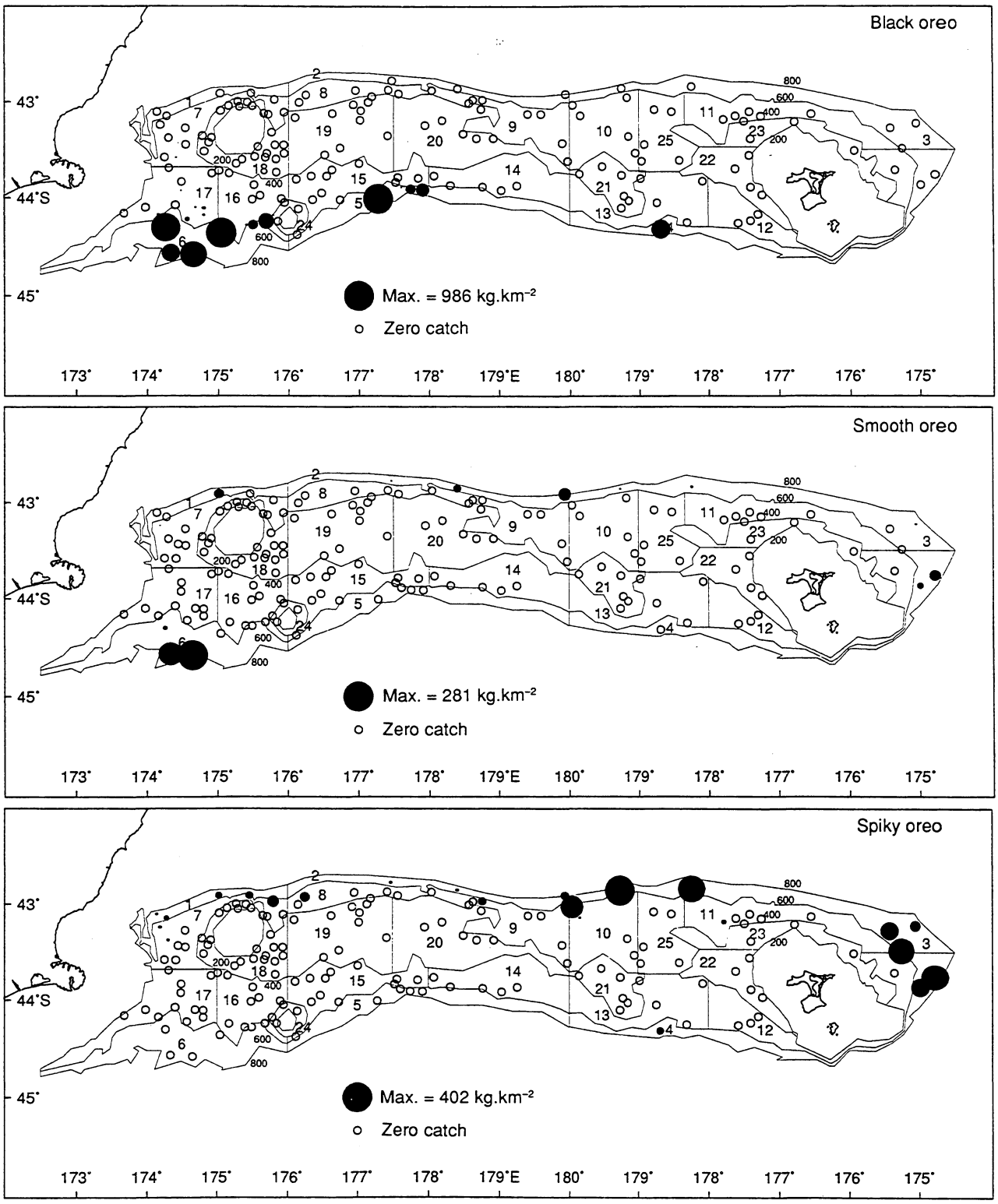


Figure 3—*continued*

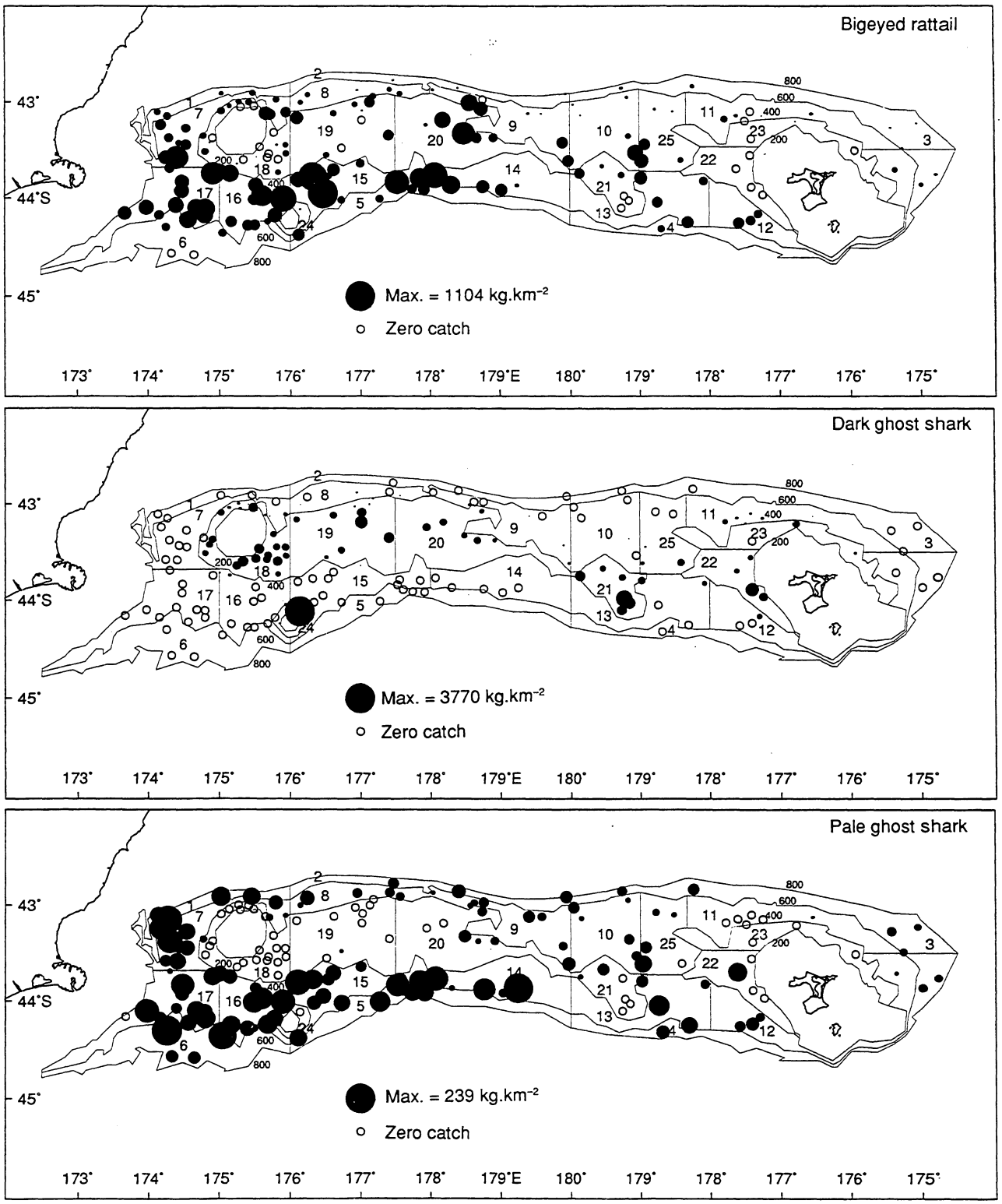


Figure 3—*continued*

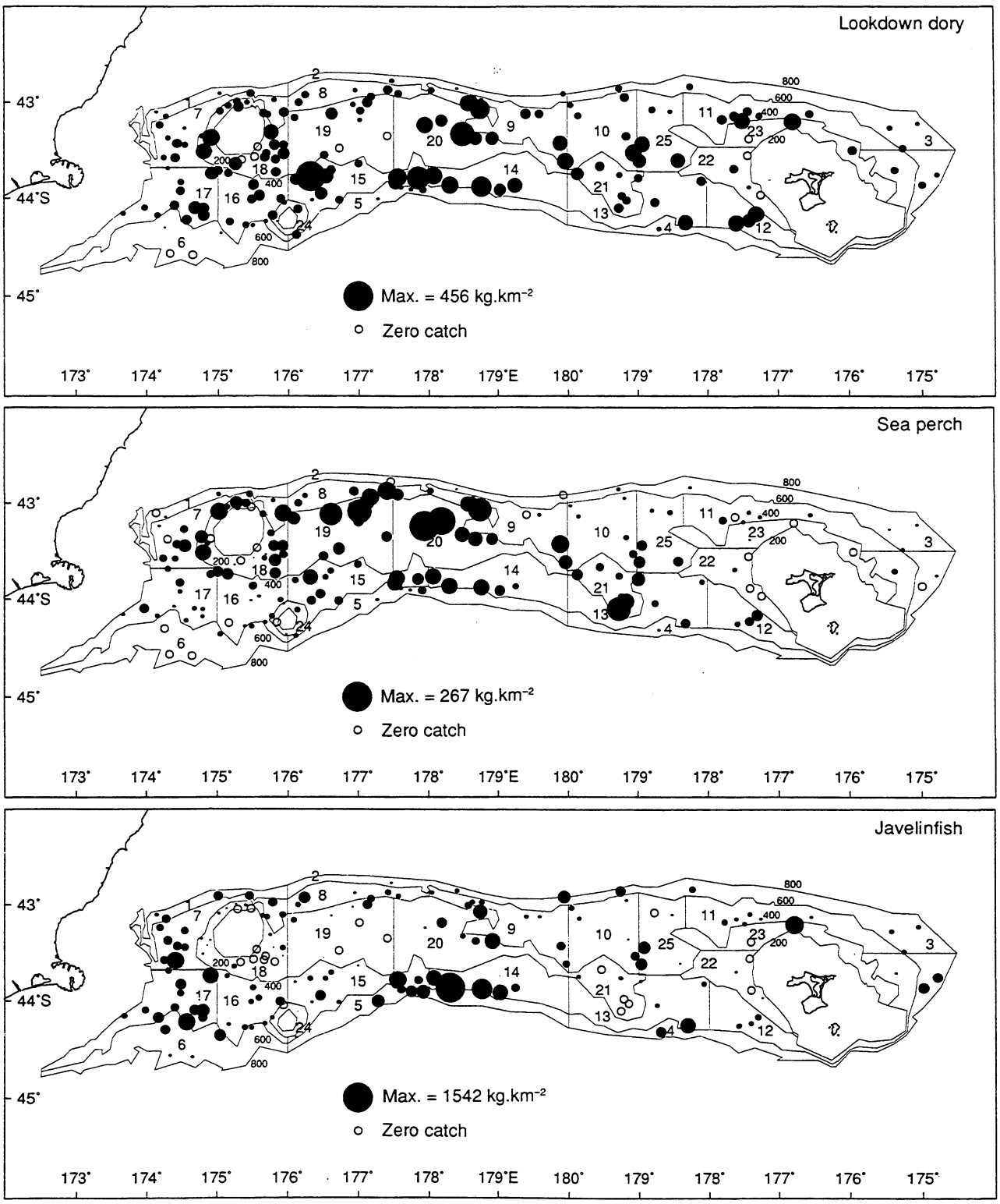


Figure 3—*continued*

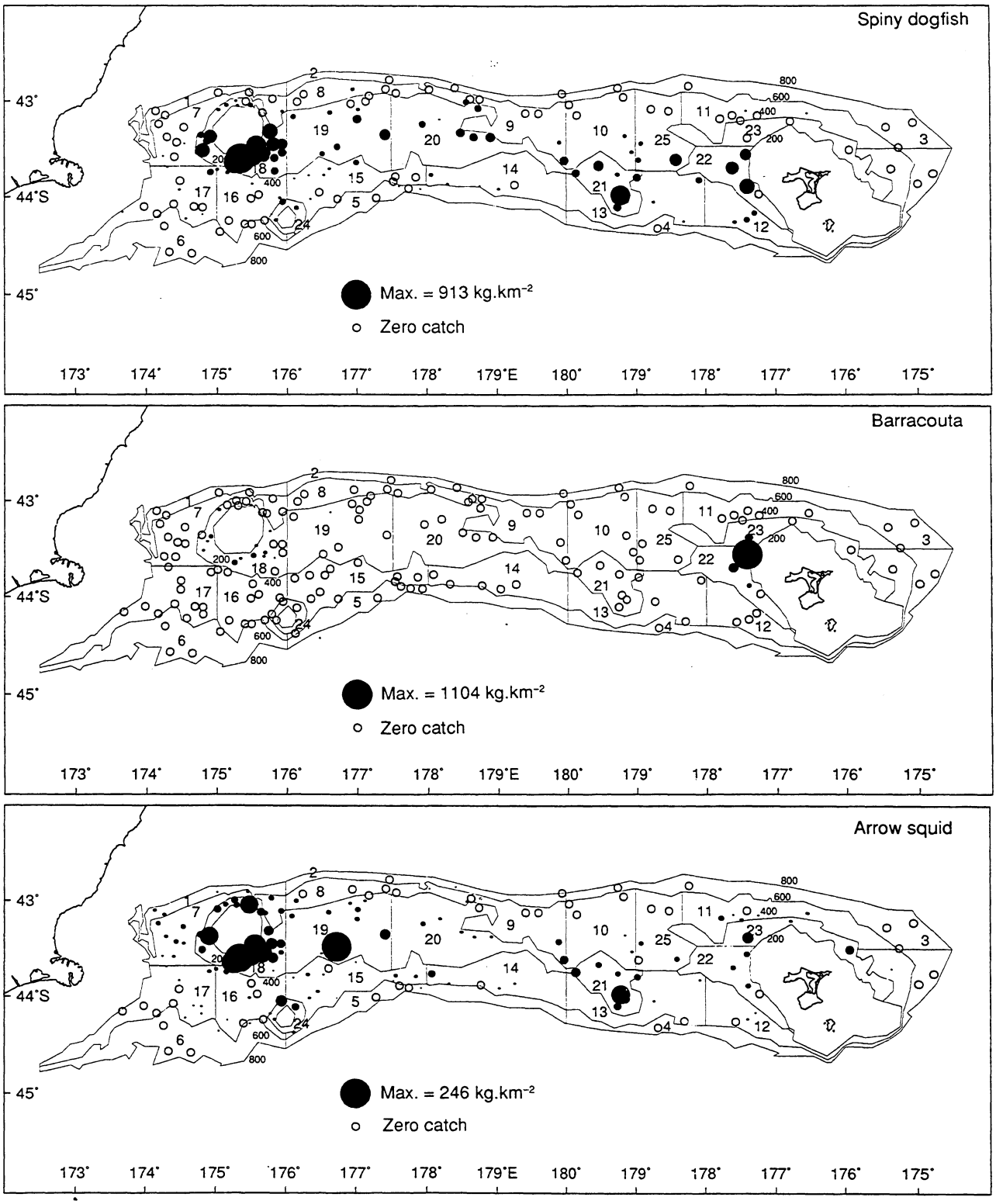


Figure 3—*continued*

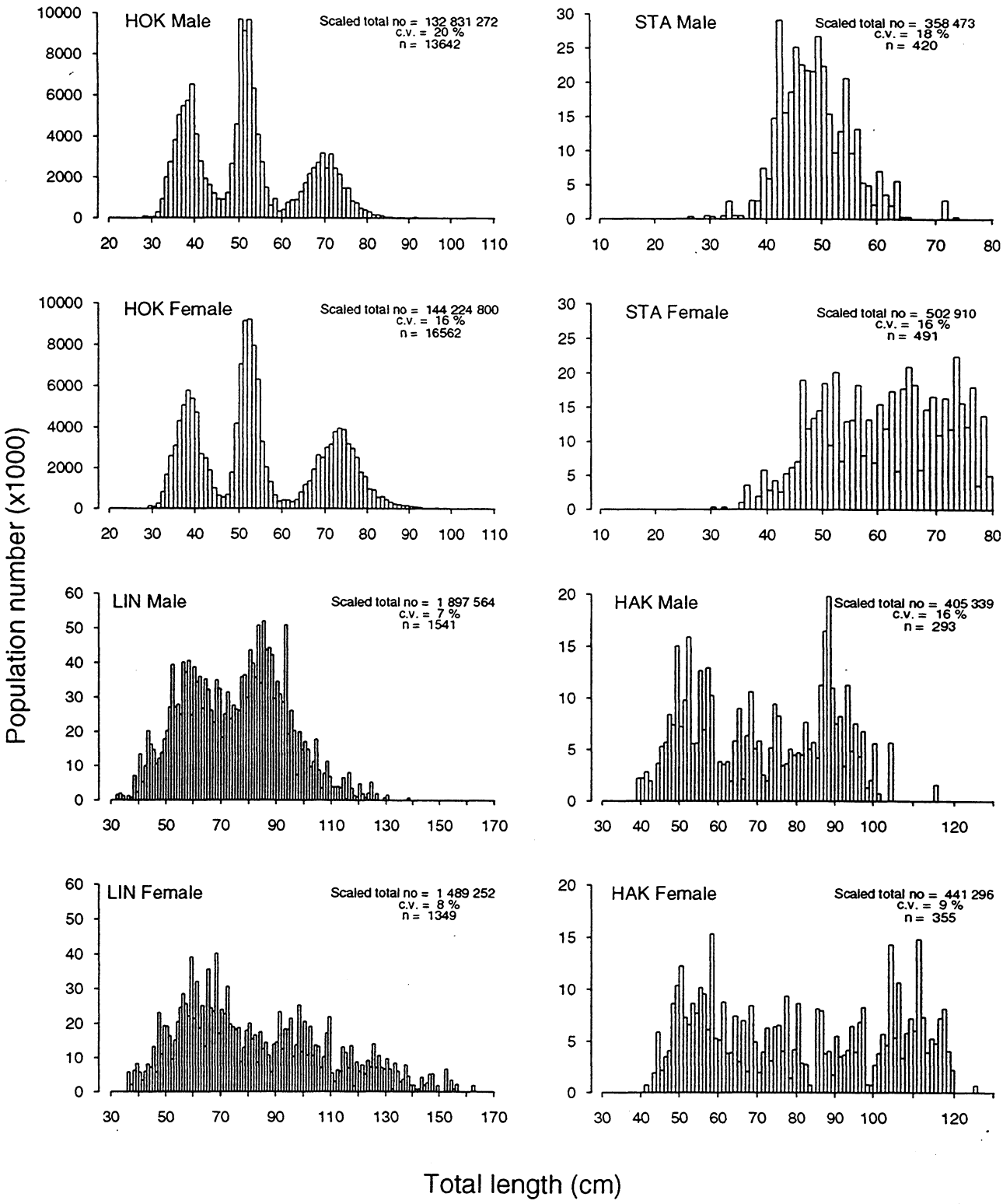


Figure 4: Length frequency, by sex, of species measured. Data have been scaled to represent total population in the entire survey area (= Scaled total no.) with its c.v. (%); n = number of measured fish.

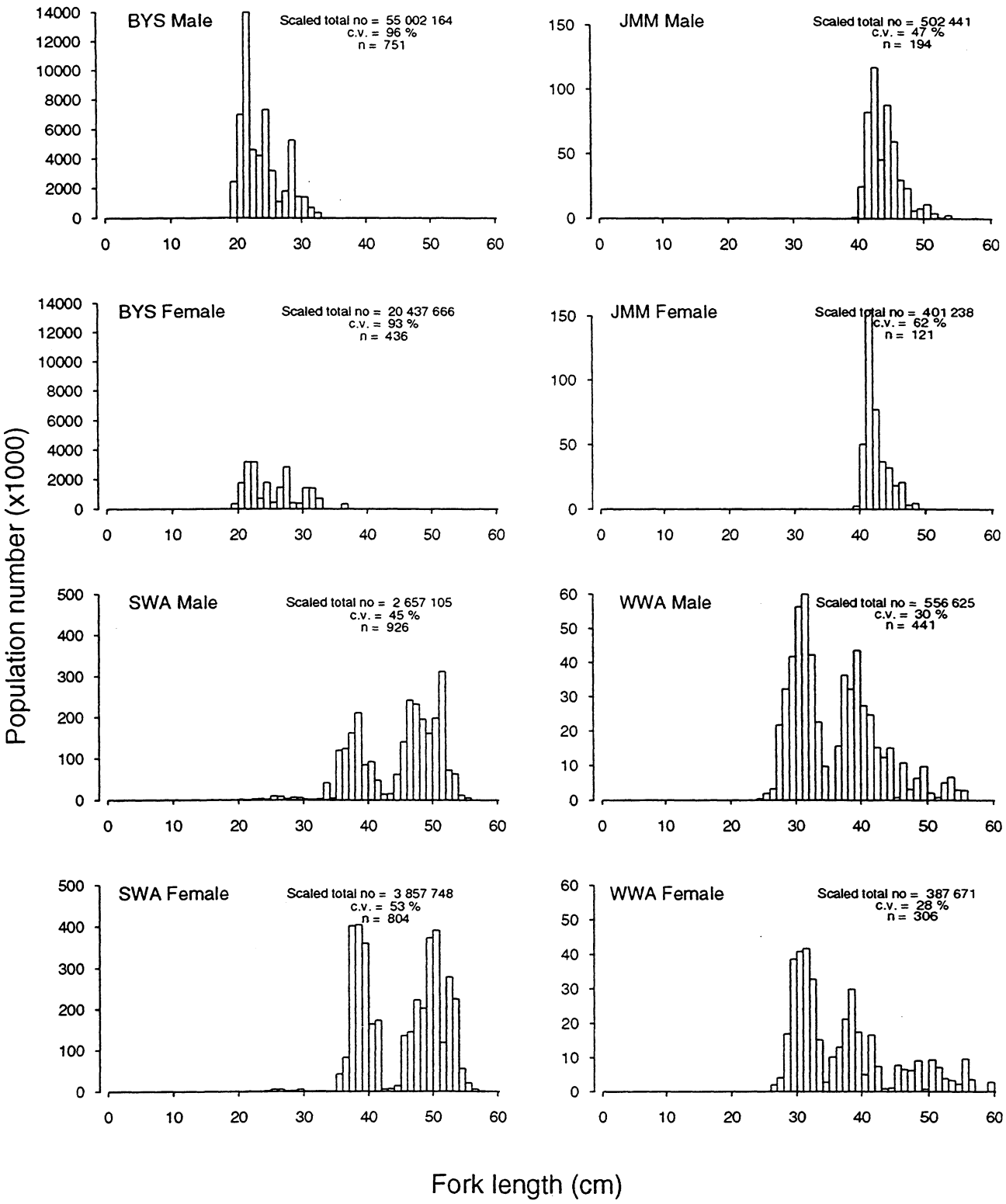


Figure 4—*continued*

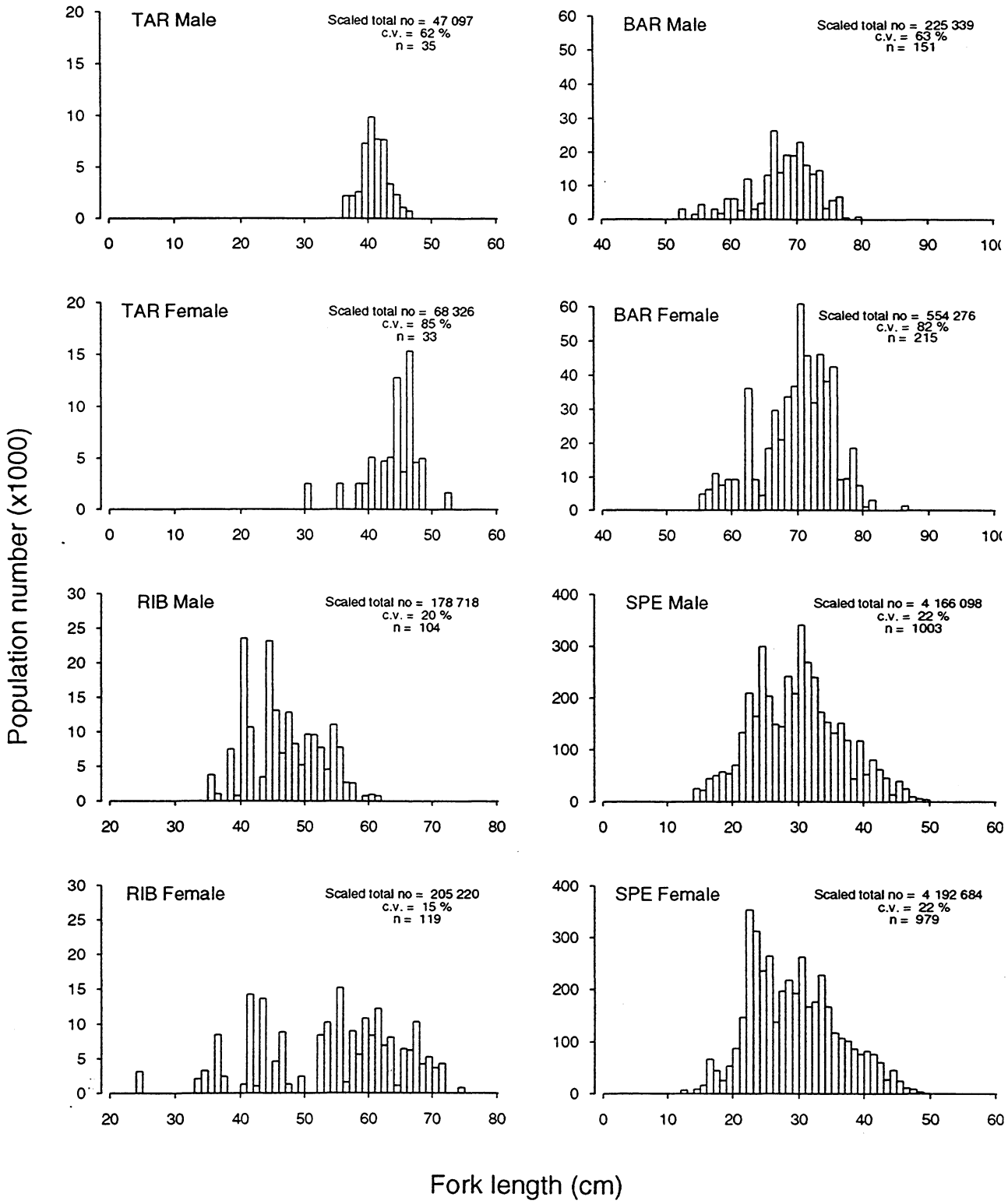


Figure 4—*continued*

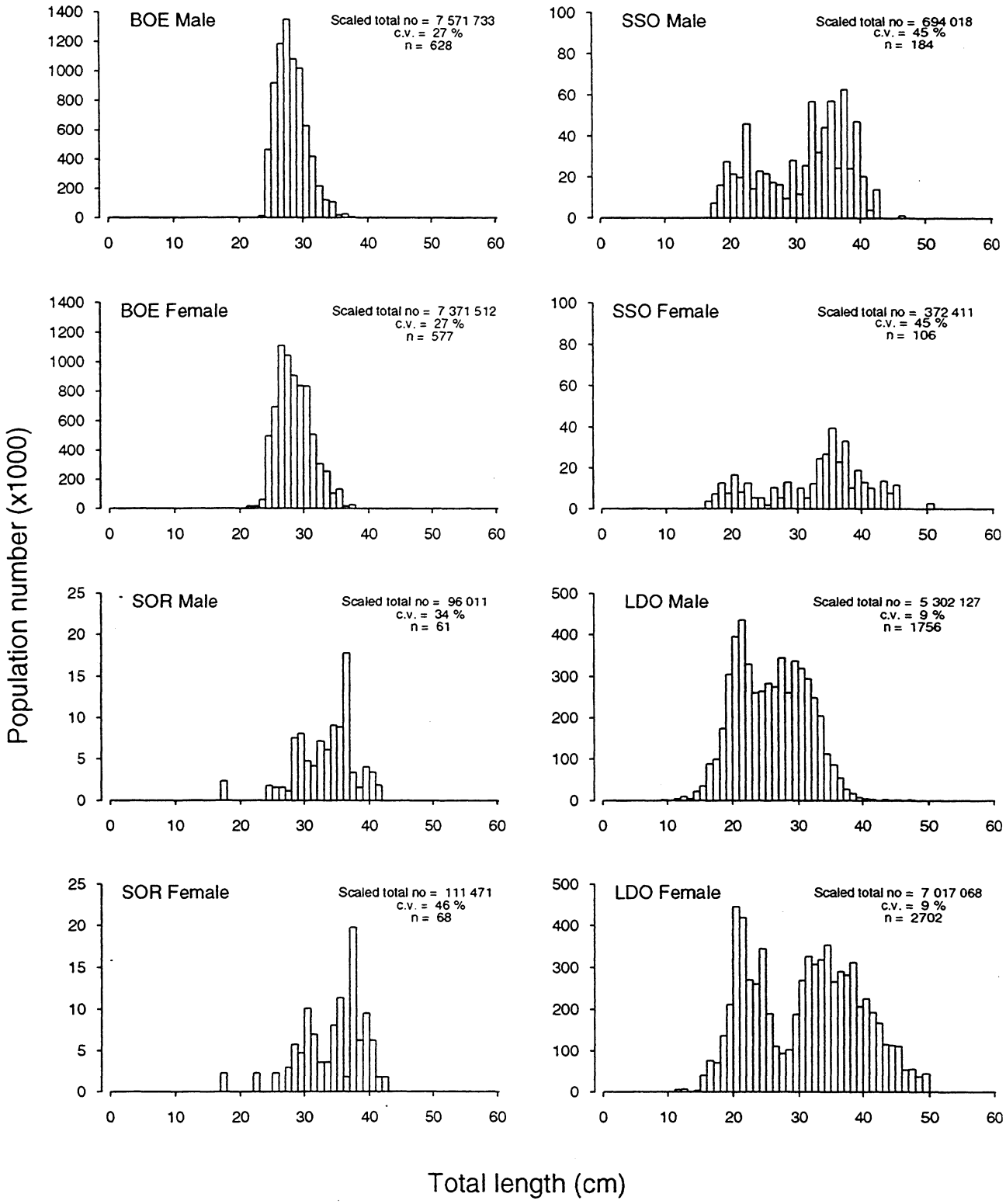


Figure 4—*continued*

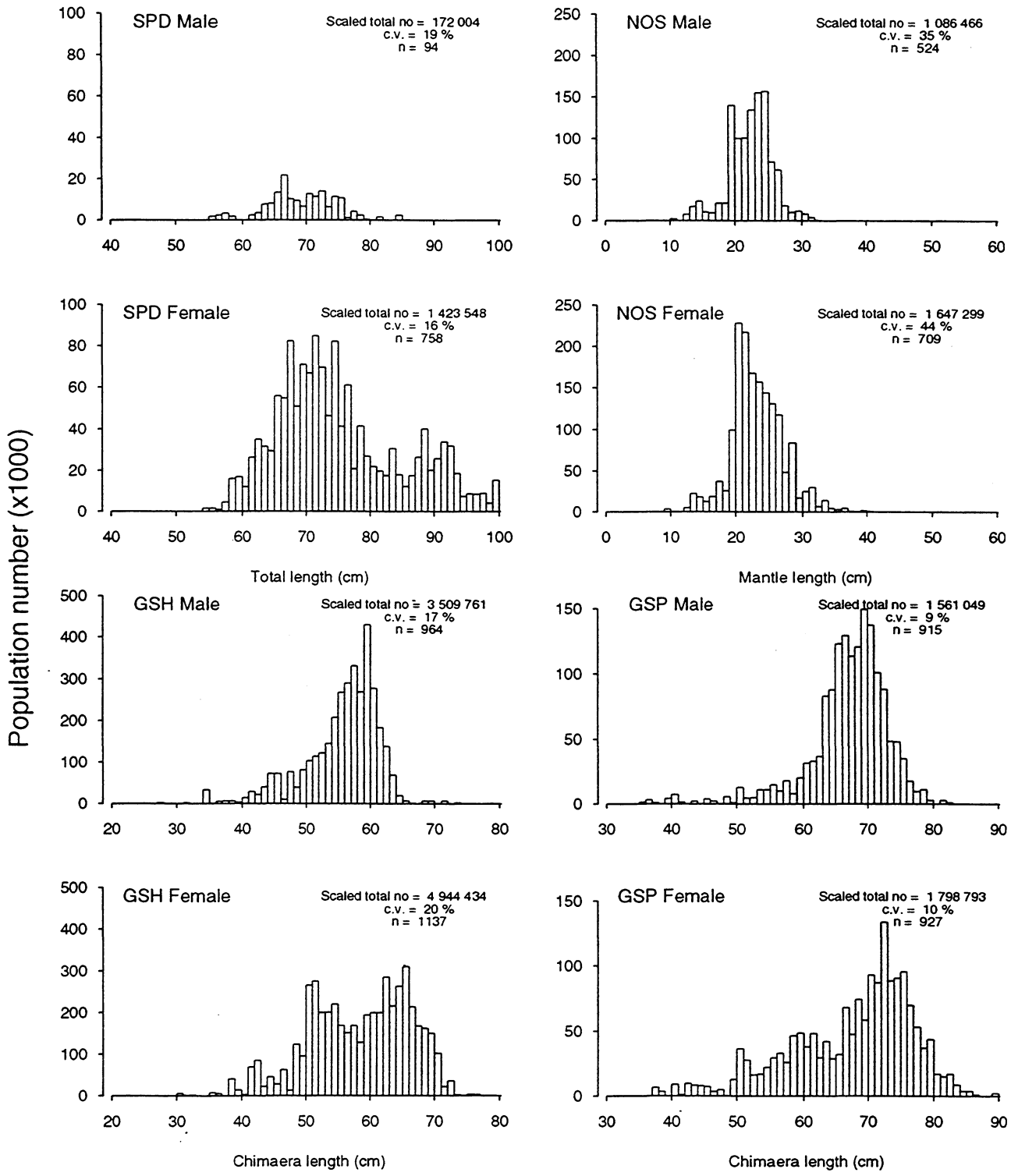


Figure 4—*continued*

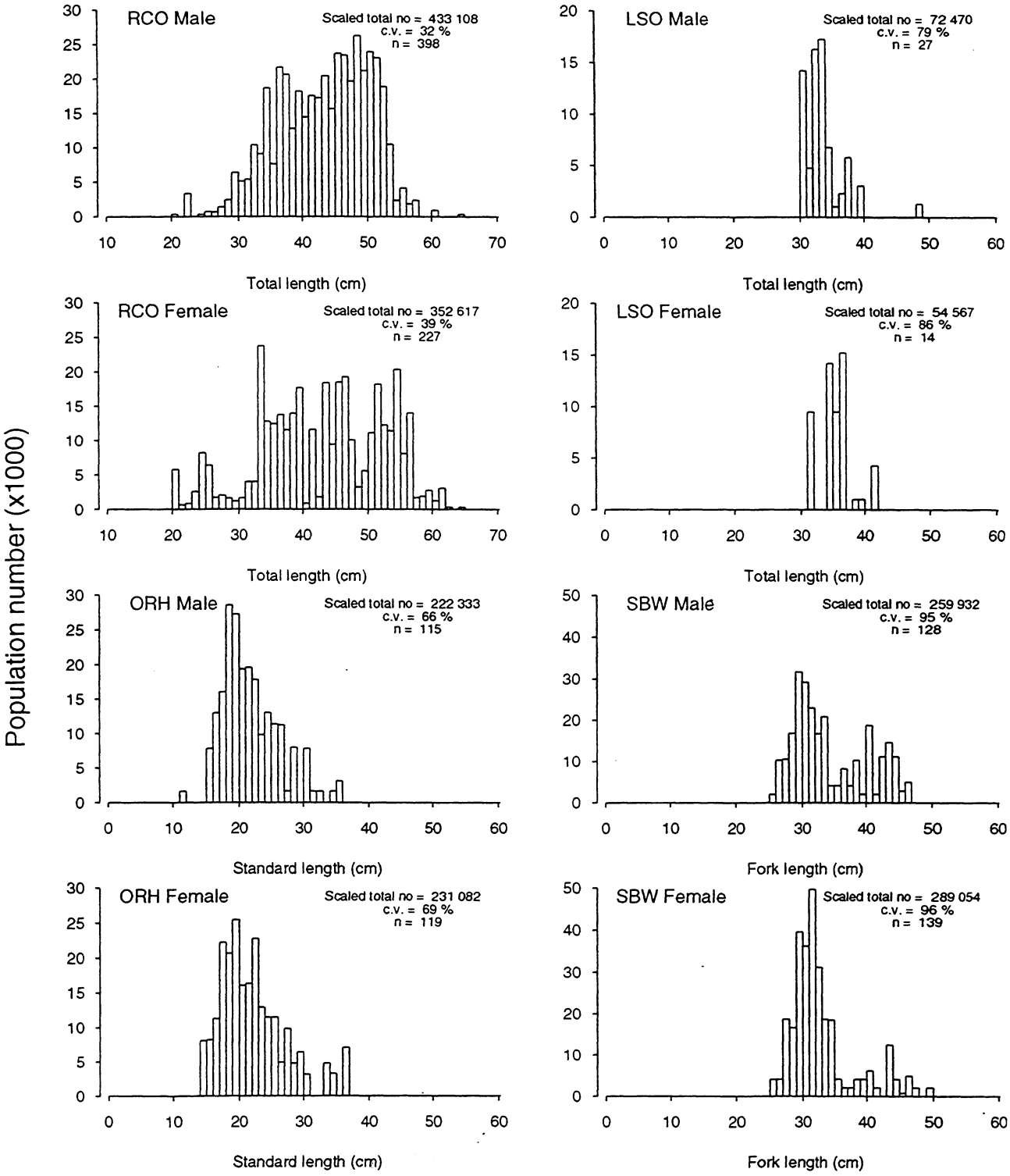


Figure 4—*continued*

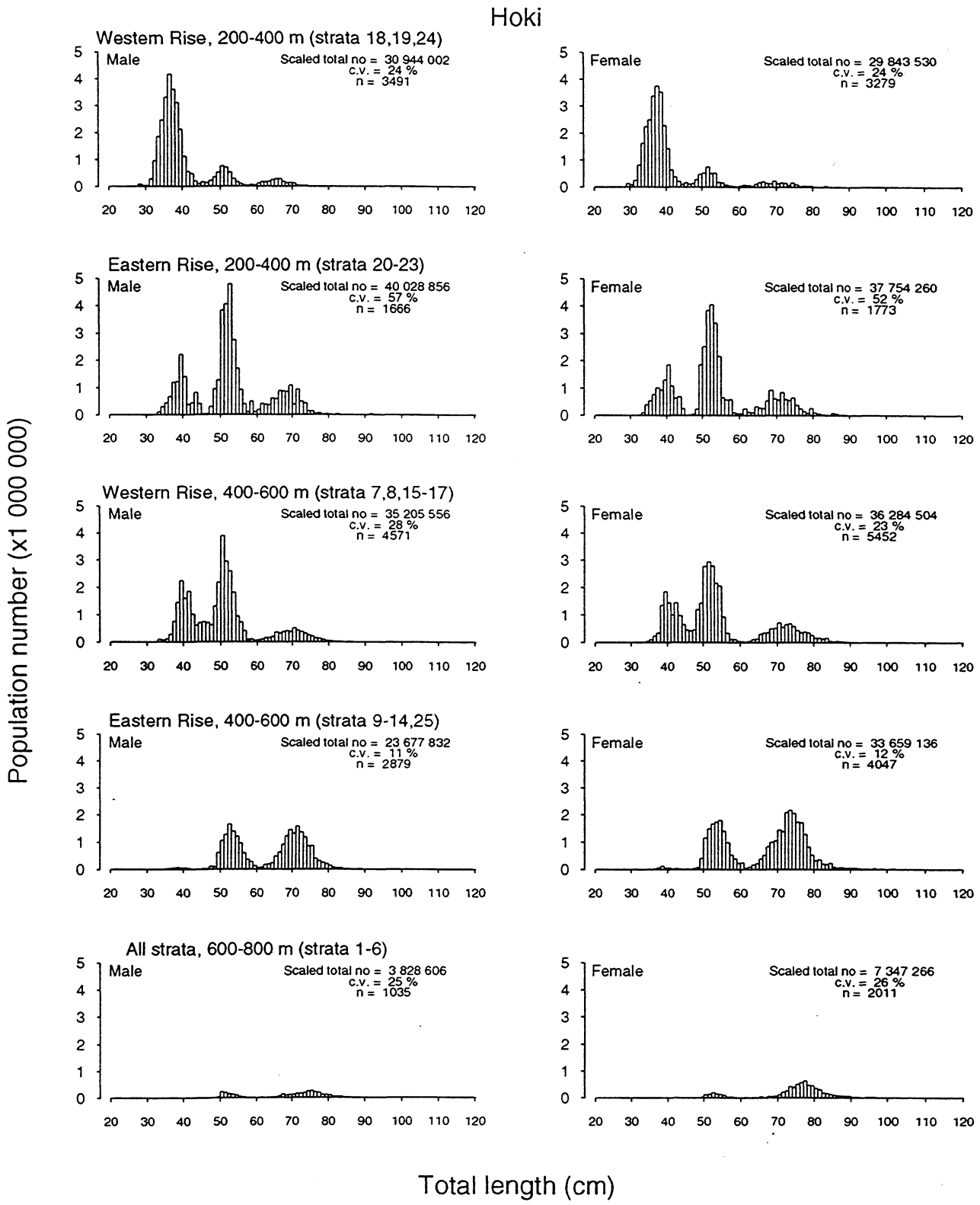


Figure 5: Length frequency of hoki by sex, depth (200–400, 400–600, 600–800 m), and area (Eastern Rise, Western Rise). Data have been scaled to represent total population in each depth zone (= Scaled total no.) with its c.v. (%); n = number of fish measured.

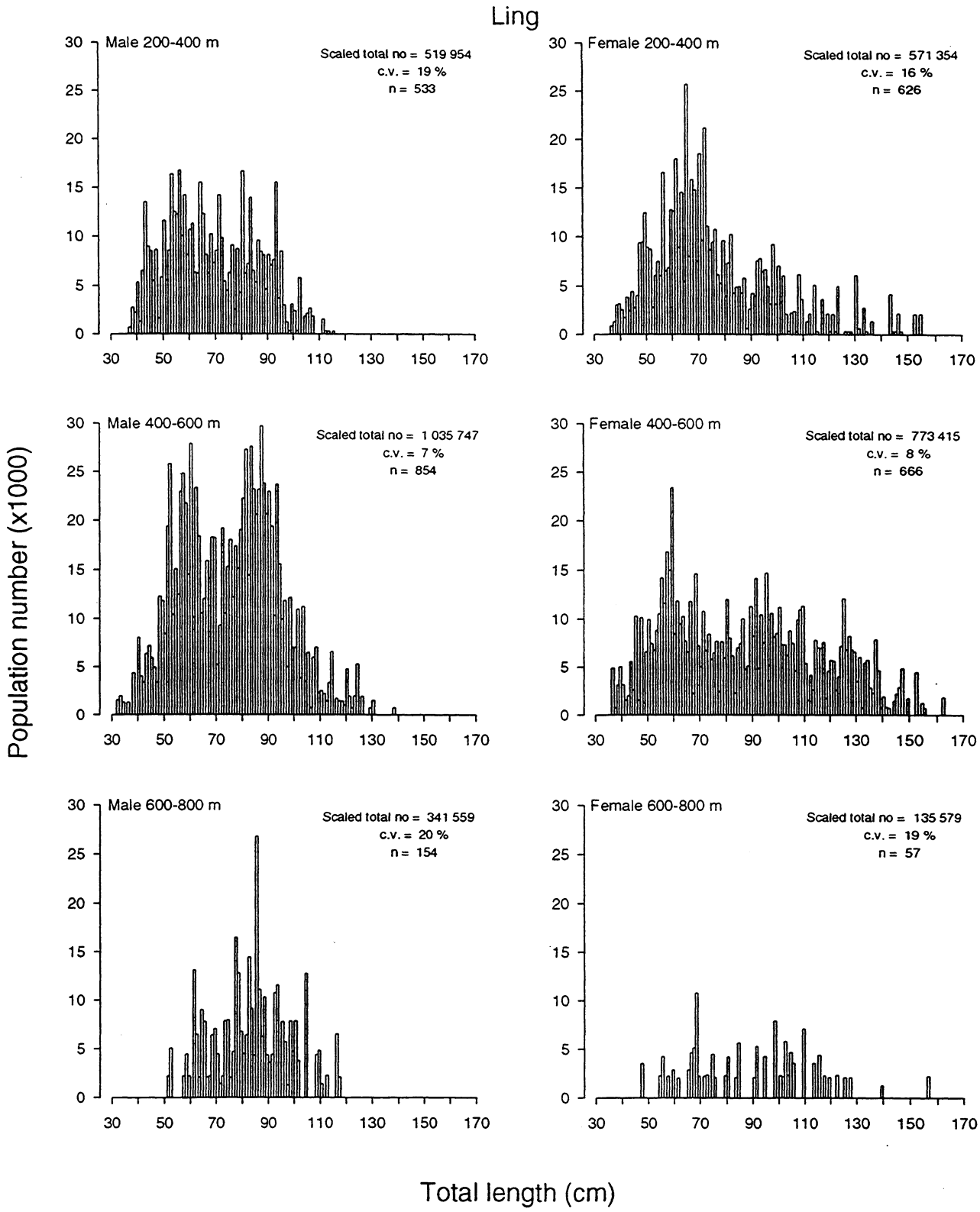


Figure 6: Length frequency of ling by sex and depth (200–400, 400–600, 600–800 m). Data have been scaled to represent total population in each depth zone (= Scaled total no.) with its c.v. (%); n = number of fish measured.

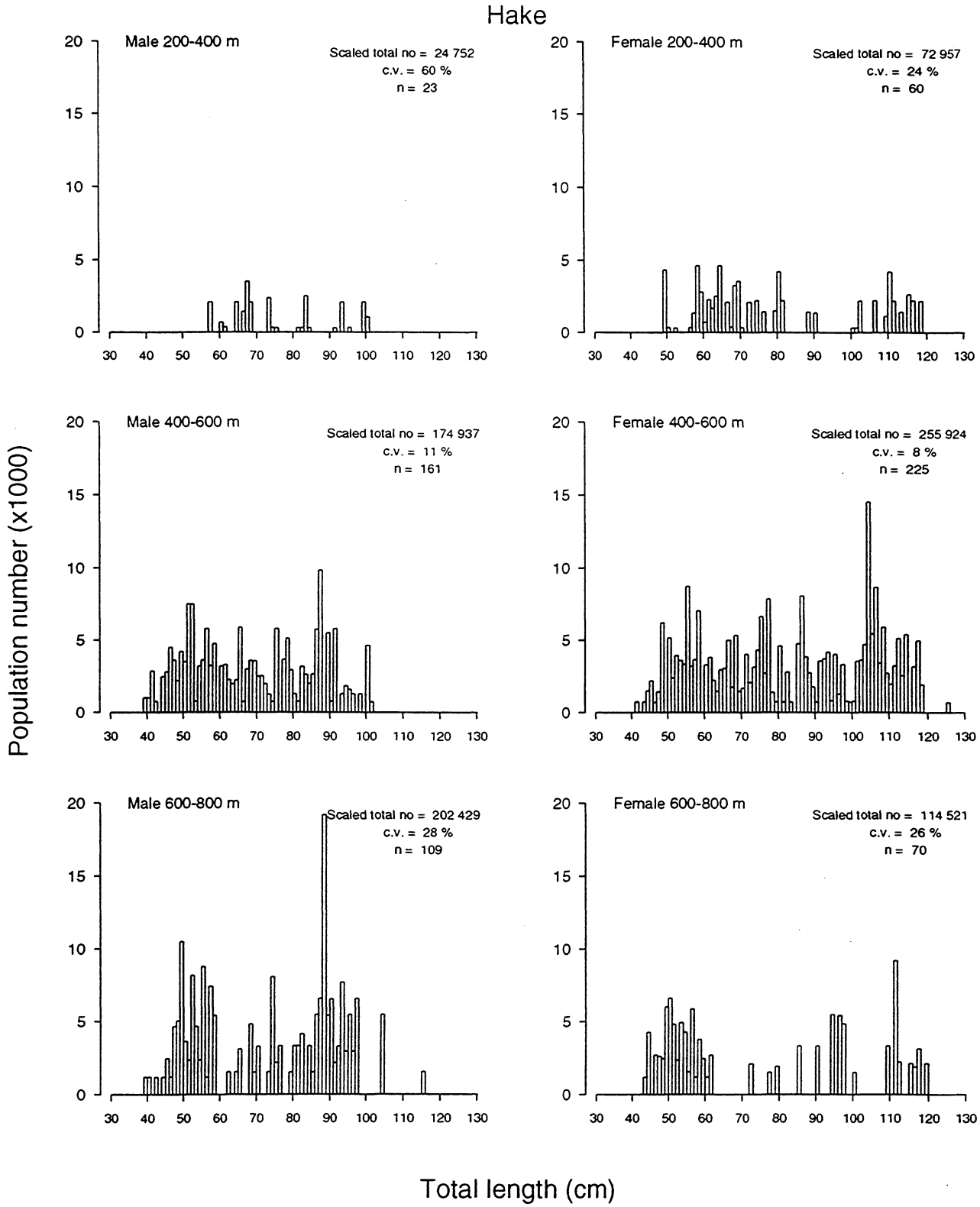


Figure 7: Length frequency of hake by sex and depth (200–400, 400–600, 600–800 m). Data have been scaled to represent total population in each depth zone (= Scaled total no.) with its c.v. (%); n = number of fish measured.

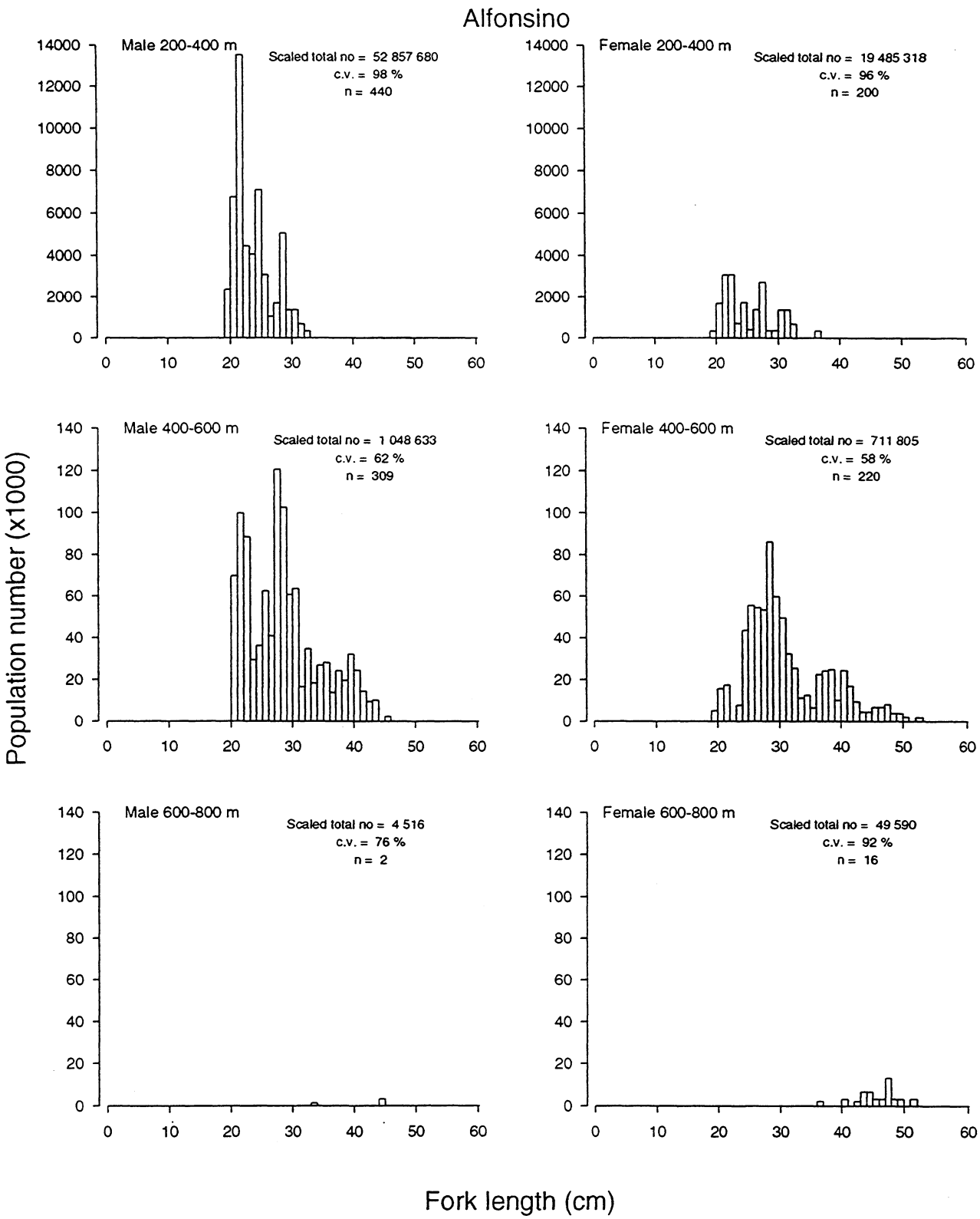


Figure 8: Length frequency of alfonsino by sex and depth (200–400, 400–600, 600–800 m). Data have been scaled to represent total population in each depth zone (= Scaled total no.) with its c.v (%); n = number of fish measured.

Appendix 1: Individual station data.

Stn.	Date Jan 94	Time	Start of tow Latitude °	'S	Longitude °	'E/W	Gear depth Min.	Max.	Distance towed (n. mile)	Headline height (m)	Door-spread (m)
1	2	0515	42	46.54	177	28.68 E	724	756	3.07	6.6	119.6
2	2	0740	42	52.33	177	25.48 E	419	478	3.00	6.6	115.4
3	2	1012	42	56.47	177	11.17 E	350	357	2.82	6.3	120.9
4	2	1200	43	00.03	177	08.37 E	353	377	3.00	6.0	118.0
5	2	1559	42	54.72	177	34.29 E	408	417	3.00	6.5	119.7
6	2	1843	42	52.60	178	02.83 E	461	482	3.00	5.9	118.5
7	3	0500	42	51.52	178	24.81 E	768	782	3.00	6.6	123.6
8	3	0728	43	00.62	178	34.52 E	386	399	3.00	6.3	116.6
9	3	0931	43	04.30	178	44.81 E	386	400	3.14	6.1	116.0
10	3	1210	42	58.44	178	37.75 E	487	489	3.00	6.1	119.0
11	3	1348	42	58.59	178	46.00 E	530	532	3.00	6.1	118.5
12	3	1719	43	07.37	179	24.85 E	452	464	3.00	6.0	118.7
13	3	1859	43	07.34	179	35.99 E	483	495	2.00	6.3	119.9
14	4	0457	42	55.04	179	56.53 E	694	775	3.01	6.1	124.7
15	4	0650	43	01.77	179	57.34 W	546	588	3.00	7.2	119.0
16	4	0845	43	08.59	179	50.60 W	521	527	3.00	6.5	121.0
17	4	1308	42	51.36	179	15.04 W	649	699	3.00	6.2	120.1
18	4	1519	42	57.28	179	10.24 W	540	549	3.00	6.5	125.5
19	4	1756	43	04.70	178	46.38 W	508	512	3.00	6.6	126.5
20	5	0446	43	06.11	178	31.21 W	506	518	3.00	6.6	123.2
21	5	0808	42	50.42	178	13.92 W	614	647	3.00	6.7	121.6
22	5	1140	43	10.86	177	46.47 W	402	438	2.30	6.5	115.3
23	5	1345	43	08.69	177	36.33 W	414	419	3.00	6.7	122.9
24	5	1517	43	12.01	177	29.32 W	380	394	3.00	6.6	119.3
25	5	1803	43	06.13	177	24.75 W	463	470	3.00	6.9	121.1
26	6	0443	43	08.92	177	14.93 W	412	439	3.00	6.9	117.4
27	6	0738	43	12.41	176	46.78 W	336	351	3.00	6.7	110.5
28	6	0954	43	07.63	176	32.65 W	479	490	3.00	6.6	124.1
29	6	1341	43	30.61	175	56.05 W	320	323	2.10	6.4	113.3
30	6	1648	43	42.77	175	21.35 W	524	592	2.80	6.7	132.0
31	7	0450	43	51.80	174	59.01 W	679	695	3.00	6.9	120.2
32	7	0700	43	45.60	174	47.36 W	721	738	3.00	6.7	117.0
33	7	1118	43	29.20	175	14.95 W	609	639	3.00	6.7	121.6
34	7	1400	43	13.57	175	02.85 W	772	796	3.38	6.8	119.2
35	7	1656	43	16.52	175	25.28 W	665	678	3.00	6.7	120.5
36	8	0442	43	23.00	177	23.80 W	216	235	3.00	7.3	113.8
37	8	0644	43	33.51	177	24.87 W	252	283	3.00	6.5	106.0
38	8	0854	43	41.83	177	36.40 W	380	394	3.00	6.2	116.8
39	8	1440	43	36.52	178	24.42 W	402	420	3.00	6.3	117.4
40	8	1746	43	49.39	178	04.32 W	415	418	3.00	6.5	118.0
41	9	0440	43	53.20	177	23.67 W	283	312	3.00	6.4	111.2
42	9	0627	43	57.97	177	14.13 W	296	301	3.00	6.1	109.8
43	9	0852	44	09.88	177	17.86 W	407	411	3.00	6.2	118.5
44	9	1056	44	13.82	177	24.00 W	460	477	3.00	6.2	120.1
45	9	1241	44	15.35	177	34.39 W	496	505	3.00	6.6	119.2
46	9	1619	44	15.01	178	18.20 W	549	566	3.00	6.5	116.8
47	9	1856	44	19.04	178	40.77 W	649	655	2.53	6.6	115.2
48	10	0452	43	21.63	179	09.03 W	452	457	3.02	6.7	122.9
49	10	0944	43	26.71	178	55.00 W	438	441	2.50	6.4	122.0
50	10	1146	43	31.80	179	02.96 W	455	459	3.00	6.2	120.0
51	10	1350	43	37.06	178	57.59 W	424	452	3.00	6.2	118.6
52	10	1740	44	02.88	178	44.29 W	434	444	3.00	6.5	119.9
53	11	0617	44	06.03	179	15.45 W	279	320	3.00	6.8	109.3
54	11	0802	43	58.67	179	12.96 W	220	281	3.00	6.8	102.7
55	11	0948	44	01.51	179	08.66 W	290	300	3.00	6.8	115.8

Appendix 1: *continued*

Stn.	Date Jan 94	Time	Start of tow Latitude °	'S	Longitude °	'E/W	Gear depth Min.	Max.	Distance towed (n. mile)	Headline height (m)	Door-spread (m)
56	11	1300	43	47.62	178	58.42 W	399	410	3.00	6.2	120.9
57	11	1541	43	45.66	179	15.21 W	381	388	3.00	6.9	120.9
58	11	1745	43	40.19	179	31.73 W	348	353	3.00	6.7	115.8
59	12	0453	43	44.94	179	51.41 W	371	373	3.00	6.6	120.0
60	12	0700	43	36.96	179	58.52 E	408	409	3.00	6.2	117.1
61	12	0925	43	25.74	179	53.78 E	422	431	3.00	6.2	120.1
62	12	1732	43	22.62	178	55.45 E	373	397	2.47	6.6	116.8
63	13	0444	43	52.16	179	15.35 E	496	502	3.00	6.7	121.0
64	13	0652	43	54.95	179	02.10 E	516	541	3.00	6.8	114.8
65	13	0900	43	52.81	178	45.80 E	524	525	3.00	6.7	116.0
66	13	1143	43	51.78	178	18.56 E	530	550	3.00	6.9	115.6
67	13	1402	43	45.91	178	04.62 E	478	492	3.00	6.5	111.0
68	13	1629	43	54.66	177	55.25 E	650	666	3.00	6.7	115.9
69	13	1821	43	54.48	177	44.96 E	665	671	3.00	6.7	109.3
70	14	0510	43	22.69	178	40.89 E	367	379	3.00	6.4	116.0
71	14	0711	43	19.85	178	29.56 E	393	397	3.00	6.7	115.7
72	14	1018	43	11.29	178	11.75 E	354	367	2.52	6.5	117.4
73	14	1223	43	14.55	177	56.98 E	306	324	2.07	6.8	119.8
74	14	1852	43	21.18	177	24.91 E	245	246	3.00	6.7	105.6
75	15	0453	43	47.42	177	51.40 E	488	510	2.90	6.7	116.0
76	15	0719	43	47.00	177	33.65 E	484	501	3.00	6.3	117.8
77	15	0933	43	50.10	177	32.06 E	554	563	3.00	6.3	114.5
78	15	1145	43	53.28	177	36.83 E	627	637	3.00	6.4	126.2
79	15	1426	44	00.36	177	17.10 E	674	692	3.00	6.5	121.1
80	15	1808	44	00.99	176	44.01 E	547	548	3.00	6.8	117.6
81	16	0500	44	01.10	176	20.62 E	463	519	2.79	6.5	120.0
82	16	0634	43	56.92	176	28.28 E	495	520	3.00	6.5	114.1
83	16	0931	43	46.38	176	19.34 E	425	428	3.00	6.5	111.0
84	16	1142	43	46.33	176	32.53 E	451	461	3.00	6.0	109.4
85	16	1337	43	42.44	176	36.98 E	437	443	3.00	6.3	115.6
86	16	1602	43	38.52	177	00.26 E	401	411	3.01	6.5	120.0
87	16	1901	43	28.76	176	44.03 E	254	256	2.02	6.6	108.0
88	17	0451	43	28.18	175	33.96 E	201	234	3.00	6.6	105.0
89	17	0646	43	32.40	175	41.36 E	266	273	3.00	6.5	106.0
90	20	0506	42	52.80	176	57.39 E	410	433	2.99	6.3	124.4
91	20	0729	43	01.67	176	55.60 E	353	391	3.03	5.8	115.6
92	20	0918	43	05.52	177	02.02 E	281	318	3.08	5.7	122.7
93	20	1133	43	11.48	177	01.32 E	246	275	3.02	6.2	112.5
94	20	1401	43	07.21	176	37.41 E	325	350	3.05	6.0	121.1
95	20	1846	43	33.21	176	31.05 E	362	365	3.03	7.2	117.9
96	21	0457	42	55.73	176	14.80 E	528	531	3.01	6.3	118.3
97	21	0636	43	00.33	176	09.23 E	472	499	3.01	5.7	120.0
98	21	0832	43	09.87	176	05.84 E	383	390	3.02	5.6	119.0
99	21	1050	43	06.60	175	56.42 E	380	447	3.05	6.1	124.0
100	21	1342	42	58.47	175	47.95 E	524	551	3.03	6.2	121.8
101	21	1545	43	07.29	175	39.05 E	375	381	3.02	6.0	116.4
102	21	1826	43	26.97	175	48.51 E	275	297	3.00	6.2	121.0
103	22	0513	42	54.45	175	27.85 E	508	597	3.02	6.2	120.6
104	22	0713	43	00.28	175	24.78 E	355	385	2.99	5.5	124.2
105	22	0851	42	59.98	175	16.44 E	216	377	2.95	5.5	117.9
106	22	1034	43	02.59	175	08.53 E	302	338	3.01	6.0	121.7
107	22	1338	42	54.71	175	01.54 E	650	689	3.04	5.9	128.0
108	22	1553	43	05.70	175	01.82 E	210	350	3.00	6.0	118.0
109	22	1835	43	25.59	174	51.95 E	301	310	2.12	5.9	120.6
110	23	0508	43	06.39	174	08.69 E	682	687	3.04	6.5	124.2

Appendix 1: *continued*

Stn.	Date Jan 94	Time	Start of tow Latitude °	'S	Longitude °	'E/W		Gear depth Min.	Max.	Distance towed (n. mile)	Headline height (m)	Door-spread (m)
111	23	0659	43	08.94	174	16.94	E	603	620	3.02	5.9	115.6
112	23	0849	43	14.57	174	11.30	E	575	588	2.96	5.8	123.0
113	23	1148	43	34.68	174	15.16	E	526	532	3.03	6.1	123.0
114	23	1333	43	41.33	174	18.77	E	536	540	3.04	6.4	123.0
115	23	1545	43	34.89	174	24.71	E	550	556	3.02	6.4	117.0
116	24	0506	44	09.32	173	40.83	E	416	450	3.03	6.4	112.5
117	24	0719	44	05.87	173	59.03	E	524	527	3.01	6.0	114.9
118	24	1034	44	10.35	174	09.84	E	575	596	3.00	6.3	120.0
119	24	1231	44	17.94	174	15.88	E	632	659	3.04	6.3	123.0
120	24	1517	44	33.88	174	20.29	E	775	799	3.00	6.9	131.2
121	24	1745	44	34.70	174	38.93	E	777	800	3.03	6.7	116.3
122	25	0448	43	49.85	174	29.29	E	550	560	3.00	6.8	113.0
123	25	0624	43	55.30	174	28.97	E	558	568	3.02	6.5	116.7
124	25	0820	44	04.34	174	24.09	E	574	579	3.00	6.6	116.7
125	25	1044	44	13.16	174	34.06	E	576	587	3.00	6.0	112.6
126	25	1248	44	05.94	174	41.11	E	516	536	3.02	6.2	110.2
127	25	1427	44	06.35	174	47.94	E	512	531	3.04	6.6	115.6
128	25	1613	44	10.68	174	47.98	E	538	546	3.00	7.1	114.2
129	25	1836	44	21.44	175	02.79	E	601	624	3.01	6.8	113.3
130	26	0512	44	22.67	176	07.32	E	480	498	3.02	7.4	121.0
131	26	0735	44	14.27	175	50.77	E	215	264	3.01	6.7	104.7
132	26	0916	44	10.59	175	46.90	E	488	576	3.00	6.7	121.5
133	26	1116	44	14.43	175	40.82	E	602	636	3.02	6.2	121.3
134	26	1335	44	16.70	175	29.77	E	604	636	3.03	6.2	123.0
135	26	1548	44	16.76	175	23.82	E	587	592	3.03	7.0	124.9
136	26	1746	44	14.63	175	10.27	E	540	556	2.99	6.6	117.8
137	27	0459	43	48.39	176	06.58	E	435	472	3.00	7.5	121.0
138	27	0945	44	06.71	176	08.49	E	343	362	3.01	7.1	113.8
139	27	1233	44	02.77	175	56.76	E	349	371	2.15	6.5	116.0
140	27	1659	44	00.31	175	53.98	E	521	538	3.01	7.0	117.3
141	28	0449	44	00.89	175	28.92	E	486	503	2.98	7.6	119.6
142	28	0637	43	58.33	175	35.85	E	490	500	3.03	7.6	115.1
143	28	0847	43	51.80	175	30.46	E	419	454	3.00	6.8	116.3
144	28	1140	43	38.76	175	14.98	E	305	312	3.06	6.4	105.0
145	28	1437	43	44.61	175	09.13	E	410	417	3.00	6.5	112.7
146	28	1618	43	43.03	175	00.63	E	416	435	3.00	6.8	121.2
147	28	1758	43	44.72	174	54.78	E	447	455	3.00	7.0	108.8
148	29	0452	43	25.91	174	26.44	E	510	530	3.01	7.3	123.6
149	29	0658	43	16.38	174	32.51	E	475	515	3.02	6.5	120.4
150	29	0919	43	21.36	174	46.96	E	370	392	2.95	7.1	115.5
151	29	1106	43	22.47	174	54.36	E	276	297	3.05	6.2	106.5
152	29	1410	43	36.03	175	20.10	E	215	232	3.00	6.6	104.4
153	29	1543	43	34.34	175	31.13	E	248	255	3.02	6.9	108.0
154	29	1716	43	34.67	175	40.28	E	262	280	3.00	7.4	112.2
155	29	1851	43	35.96	175	49.31	E	289	303	3.01	7.5	109.5
156	30	0450	43	02.94	175	17.80	E	250	293	3.00	6.9	108.7
157	30	0657	43	02.48	175	29.03	E	210	266	3.00	7.2	103.0
158	30	0903	43	07.87	175	42.65	E	441	445	2.97	7.1	118.0
159	30	1155	43	19.15	175	45.74	E	299	320	3.03	6.6	106.0
160	30	1353	43	27.11	175	56.02	E	349	377	3.04	6.2	120.5
161	30	1653	43	32.35	175	56.45	E	305	340	3.03	6.5	114.3
162	30	1848	43	43.93	175	49.66	E	320	345	3.01	6.8	120.0
163	31	0457	43	22.70	174	18.25	E	562	587	3.00	7.4	114.6
164	31	0701	43	26.74	174	32.87	E	446	491	2.97	6.4	118.0
165	31	0916	43	31.12	174	48.34	E	333	357	2.98	6.5	116.1

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 165 tows is also shown.

Scientific name	Common name	Species code	Occ.
Agnatha			
Myxinidae: hagfishes			
Eptatretus cirrhatus	hagfish	HAG	1
Chondrichthyes			
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	8
Centroscymnus crepidator	deepwater dogfish	CYP	15
C. owstoni	smoothskin dogfish	CYO	6
Deania calcea	shovelnosed dogfish	SND	58
Etmopterus baxteri	Baxter's dogfish	ETB	31
E. lucifer	Lucifer dogfish	ETL	97
E. pusillus	smooth lanternshark	ETP	1
Scymnodon plunketi	Plunket's shark	PLS	17
Scymnorhinus licha	seal shark	BSH	41
Squalus acanthias	spotted spiny dogfish	SPD	92
S. mitsukurii	northern spiny dogfish	NSD	3
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	5
Cephaloscyllium isabellum	carpet shark	CAR	1
Halaelurus dawsoni	Dawson's catshark	DCS	4
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	7
Mustelus lenticulatus	rig	SPO	1
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	3
Narkidae: blind electric rays			
Typhlonarke sp.	numbfish	BER	9
Rajidae: skates			
Bathyraja shuntovi	longnosed deepsea skate	PSK	1
Pavoraja asperula	smooth bluntnosed skate	BTA	6
P. spinifera	prickly bluntnosed skate	BTS	3
Pavoraja sp.	bluntnosed skate	BTH	1
Raja innominata	smooth skate	SSK	39
R. nasuta	rough skate	RSK	9
Species not identified	skates	SKA	1
Chimaeridae: chimaeras, ghost sharks			
Chimaera sp. B	giant chimaera	CHG	3
Hydrolagus novaezelandiae	dark ghost shark	GSH	80
Hydrolagus sp. B	pale ghost shark	GSP	113
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnosed chimaera	LCH	68
Rhinochimaera pacifica	widenosed chimaera	RCH	3
Osteichthyes			
Halosauridae: halosaurs			
Halosaurus pectoralis	common halosaur	HPE	2
Notacanthidae: spiny eels			
Notacanthus sexspinis	spineback	SBK	63

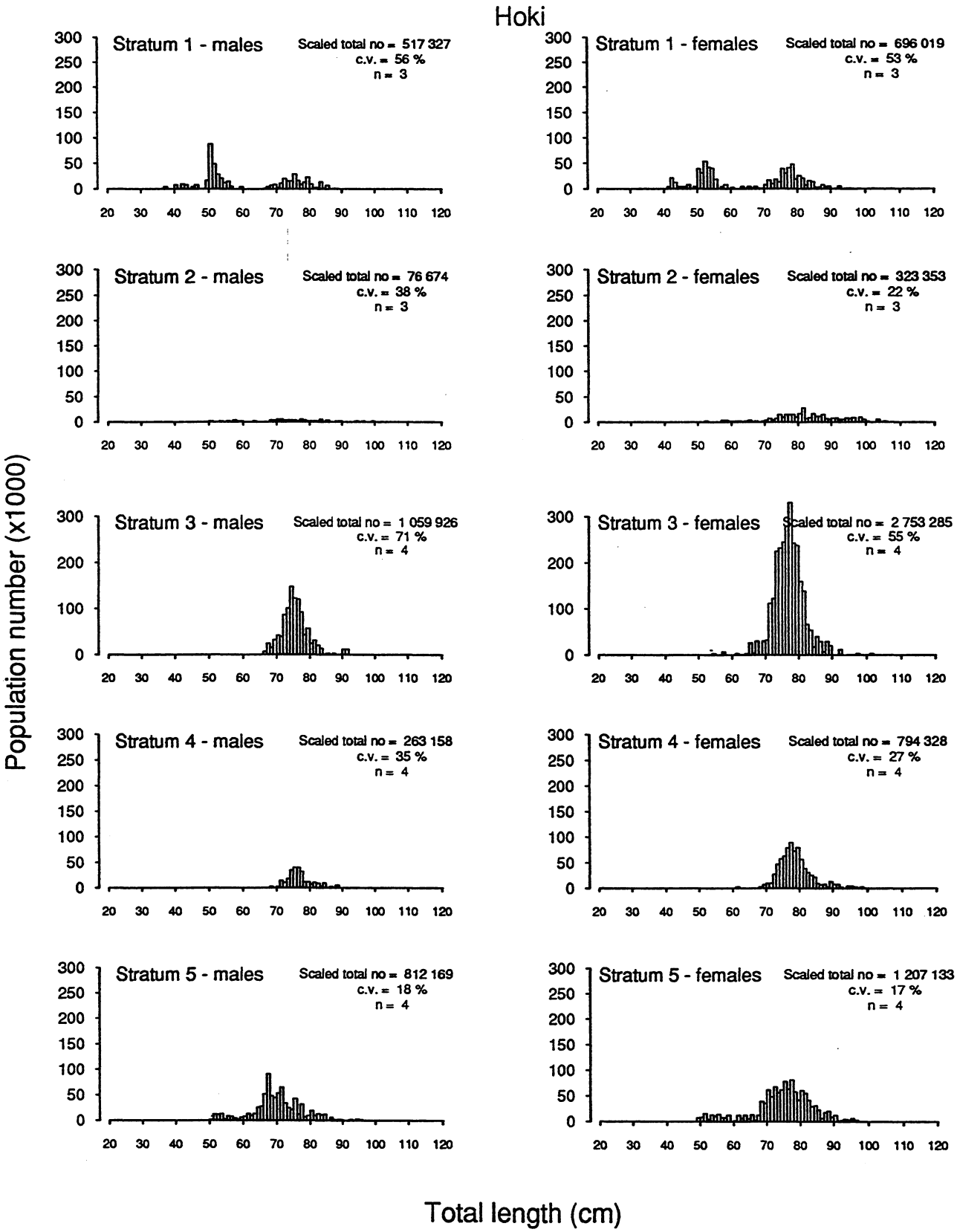
Nemichthyidae: snipe eels			
Nemichthys scolopaceus	slender snipe eel	NEM	1
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	2
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	53
B. hirsutus	hairy conger	HCO	48
Gonorynchidae: sandfish			
Gonorynchus gonorynchus	sandfish	GON	1
Argentinidae: silversides			
Argentina elongata	silverside	SSI	86
Alepocephalidae: slickheads			
Alepocephalus australis	smallscaled brown slickhead	SSM	1
Xenodermichthys socialis	black slickhead	BSL	3
Sternoptychidae: hatchetfishes			
Species not identified	hatchetfish	HAT	2
Photichthyidae: lighthouse fishes			
Vinciguerria sp.	frilled lighthousefish	VIN	1
Species not identified	lighthousefish	PHO	5
Astronesthidae: snaggletooths			
Species not identified	snaggletooths	AST	1
Malacosteidae: loosejaws			
Species not identified	loosejaws	MAL	1
Myctophidae: lanternfishes			
Notoscopelus sp.	notoscopelus	NCO	1
Species not identified	lanternfish	LAN	2
Moridae: morid cods			
Austrophycis marginata	dwarf cod	DCO	4
Halargyreus johnsoni	slender cod	HJO	11
Lepidion microcephalus	smallheaded cod	SMC	1
Mora moro	ribaldo	RIB	58
Pseudophycis bachus	red cod	RCO	49
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	5
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	162
Merluccius australis	hake	HAK	125
Macrouridae: rattails, grenadiers			
Caelorinchus aspercephalus	oblique-banded rattail	CAS	98
C. biclinozonalis	two saddle rattail	CBI	18
C. bollonsi	bigeyed rattail	CBO	139
C. fasciatus	banded rattail	CFA	44
C. innotabilis	notable rattail	CIN	11
C. matamua	Mahia rattail	CMA	9
C. oliverianus	Oliver's rattail	COL	88
Caelorinchus sp. C	small banded rattail	CCX	3
Caelorinchus sp. D	dark banded rattail	CDX	22
Caelorinchus sp. G	dusky rattail	CGX	2
Coryphaenoides sp. A	slender rattail	CBA	3
C. murrayi	abyssal rattail	CMU	6
C. serrulatus	serrulate rattail	CSE	9
C. subserrulatus	fourrayed rattail	CSU	6
Lepidorhynchus denticulatus	javelinfish	JAV	145
Macrourus carinatus	ridgescaled rattail	MCA	2
Ventrifossa nigromaculata	blackspot rattail	VNI	16
Trachyrincus sp.	unicorn rattail	WHX	13
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	157

Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	2
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	5
H. mediterraneus	silver roughy	SRH	30
Paratrachichthys trailli	common roughy	RHY	11
Berycidae: alfonsinos			
Beryx decadactylus	longfinned beryx	BYD	4
B. splendens	slender beryx	BYS	51
Beryx sp.	alfonsino	BYX	1
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	15
Cyttus novaezelandiae	silver dory	SDO	27
C. traversi	lookdown dory	LDO	155
Zeneon leptolepis	elongated dory	ZDO	1
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	22
Neocyttus rhomboidalis	spiky oreo	SOR	24
Pseudocyttus maculatus	smooth oreo	SSO	13
Macrorhamphosidae: snipefishes			
Centriscops humerosus	bluebanded bellowsfish	BLB	11
C. obliquus	redbanded bellowsfish	BBE	90
Notopogon lilliei	crested bellowsfish	CBE	2
Scorpaenidae: scorpionfishes			
Helicolenus sp.	sea perch	SPE	144
Congiopodidae: pigfishes			
C. leucopaecilus	southern pigfish	PIG	3
Triglidea: gurnards			
Chelidonichthys kumu	red gurnard	GUR	1
Lepidotrigla brachyoptera	scaly gurnard	SCG	20
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	61
Psychrolutidae: toadfishes			
Psychrolutes sp.	blobfish	PSY	1
Nepphrynichthys angustus	pale toadfish	TOP	19
N. latus	dark toadfish	TOD	11
Percichthyidae: temperate basses			
Polyprion americanus	bass	BAS	2
P. oxygeneios	hapuku	HAP	10
Serranidae: sea perches			
Lepidoperca sp. A	orange perch	OPE	19
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeyed cardinalfish	EPL	7
E. robustus	cardinalfish	EPR	6
E. telescopus	black cardinalfish	EPT	15
Carangidae: jacks, trevallies, kingfishes			
Trachurus murphyi	slender mackerel	JMM	31
T. declivis	jack mackerel	JMD	2
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	31
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	18
Plagiogeneion rubiginosus	rubyfish	RBY	4
Pentacerotidae: boarfishes			
Pseudopentaceros richardsoni	southern boarfish	SBO	1
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	TAR	12
Latrididae: moki, trumpeters			
Latris lineata	trumpeter	TRU	2

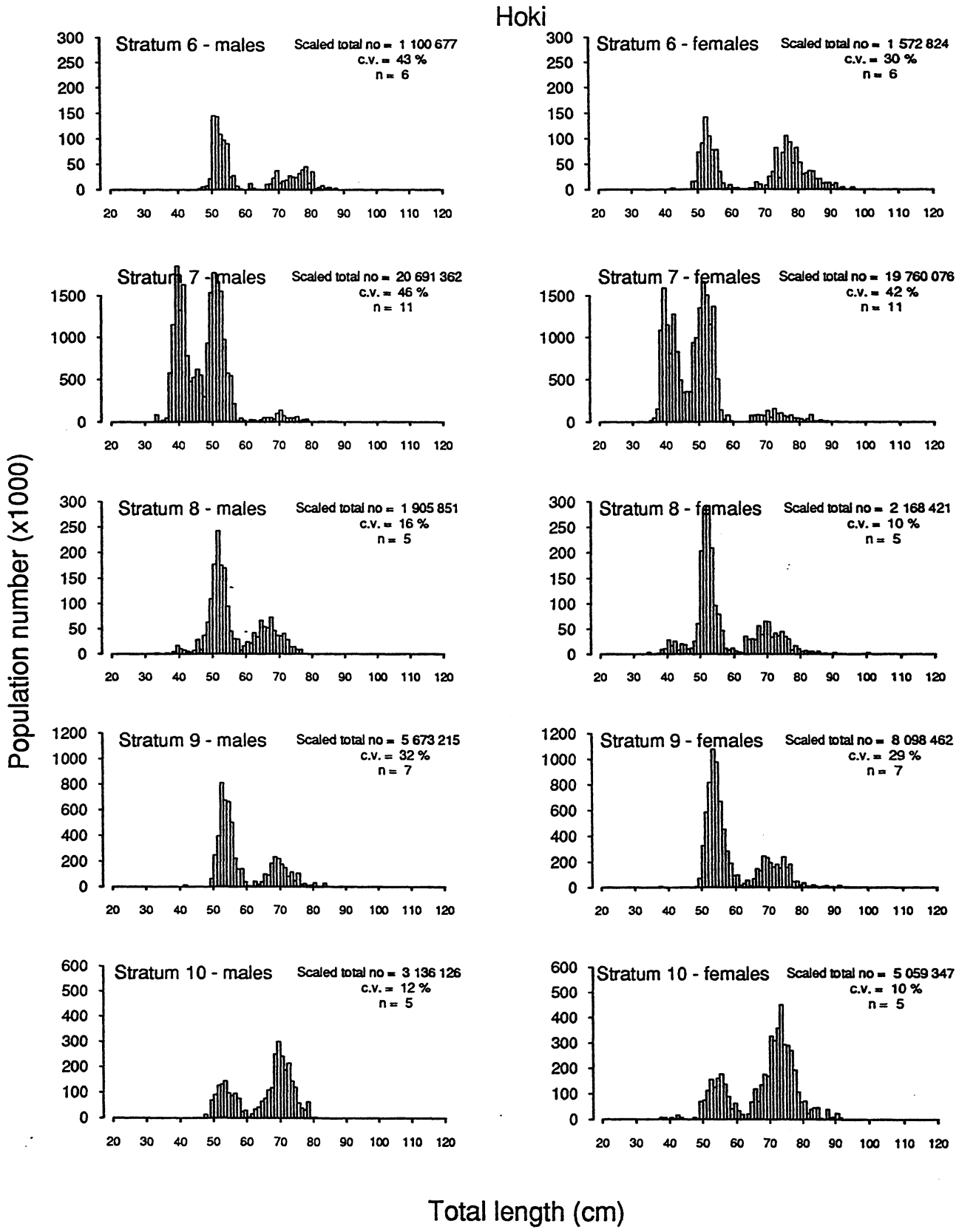
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	108
Gempylidae: snake mackerels			
Rexea solandri	gemfish	SKI	1
Thyrsites atun	barracouta	BAR	18
Trichiuridae: cutlassfishes			
Lepidopus caudatus	frostfish	FRO	4
Scombridae: mackerels, tunas			
Scomber australasicus	blue mackerel	EMA	2
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	44
Hyperoglyphe antarctica	bluenose	BNS	10
Icichthys australis	ragfish	RAG	10
Seriolella caerulea	white warehou	WWA	90
S. punctata	silver warehou	SWA	94
Schedophilus sp.	raftfish	SUS	1
Nomeidae: driftfishes			
Cubiceps baxteri	cubehead	CBX	1
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	40
Neoachiropsetta milfordi	finless flounder	MAN	2
Pleuronectidae: righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	19
Cephalopoda			
Cranchiidae			
Species not identified	cranchiid squid	CHQ	5
Histioteuthidae			
Histioteuthis miranda	violet squid	VSQ	5
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	119
Ommastrephes bartrami	red squid	RSQ	12
Onychoteuthidae			
Moroteuthis ingens	warty squid	MIQ	50
M. robsoni	warty squid	MRQ	
Moroteuthis spp.	warty squid	WSQ	56
Sepiolidae			
Species not identified	sepiolid squid	SEQ	1
Opisthoteuthidae			
Opisthoteuthis sp.	umbrella octopus	OPI	1
Octopodidae			
Octopus maorum	octopus	OCT	5
Crustacea			
Homolidae			
Paromola petterdi	antlered crab	ATC	3
Lithodidae			
Paralomis hystrix	king crab	PHS	1
Majidae			
Jacquinotia edwardsii	giant spider crab	GSC	2
Leptomithrax australis	giant masking crab	SSC	2
Nephropsidae			
Metanephrops challengeri	scampi	SCI	36
Decapoda			
Lipkius holthuisi	omega prawn	LHO	2
Species not identified	prawn	PRA	3
Species not identified	crab	CRB	7

Other marine organisms			
Porifera	sponges	ONG	1
Coelenterata			
Anthozoa	sea-anemones	ANT	1
Anthozoa	coral	COU	1
Scyphozoa	jellyfish	JFI	1
Mollusca			
Gastropoda	gastropods	GAS	1
Bivalvia	cockle	COC	3
Decapoda	squid	SQX	1
Octopoda	deepwater octopus	DWO	1
Echinodermata			
Holothurian	sea cucumber	SCC	1
Echinoidea	sea urchin	ECH	1
Asteroidea	starfish	SFI	1
Thaliacea			
Salpa	salps	SAL	5

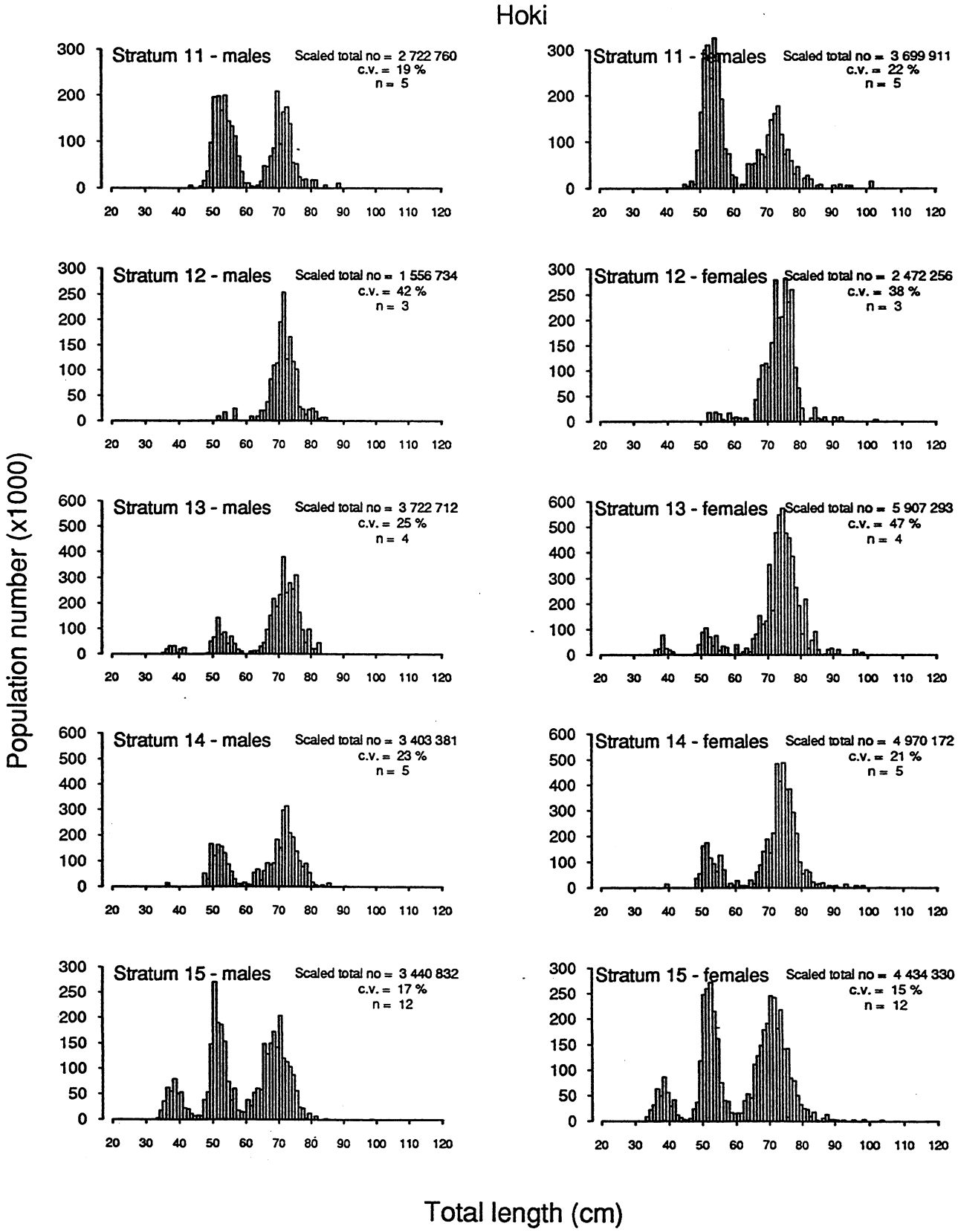
Appendix 3: Scaled length frequency of hoki by sex and stratum.



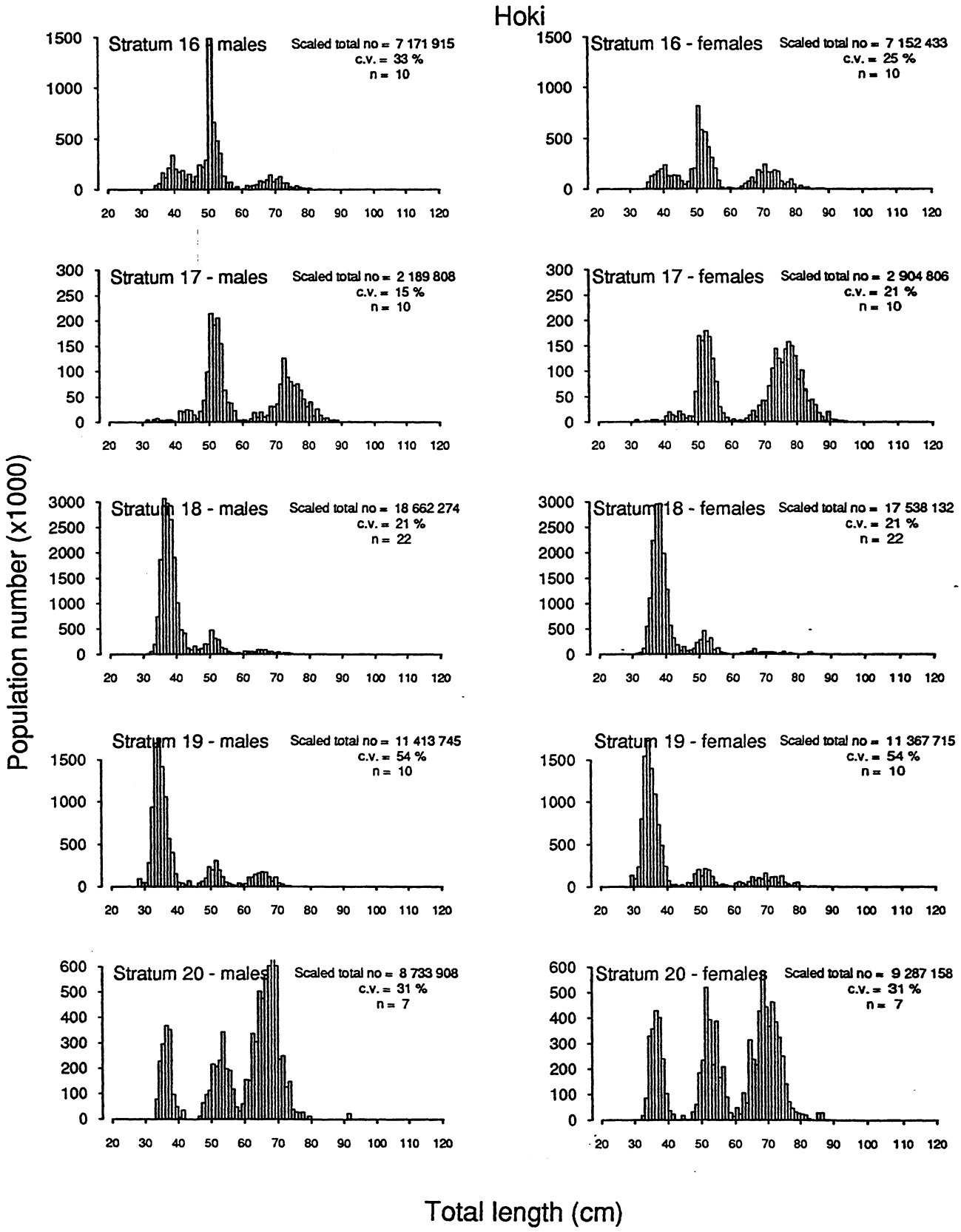
Appendix 3—*continued*



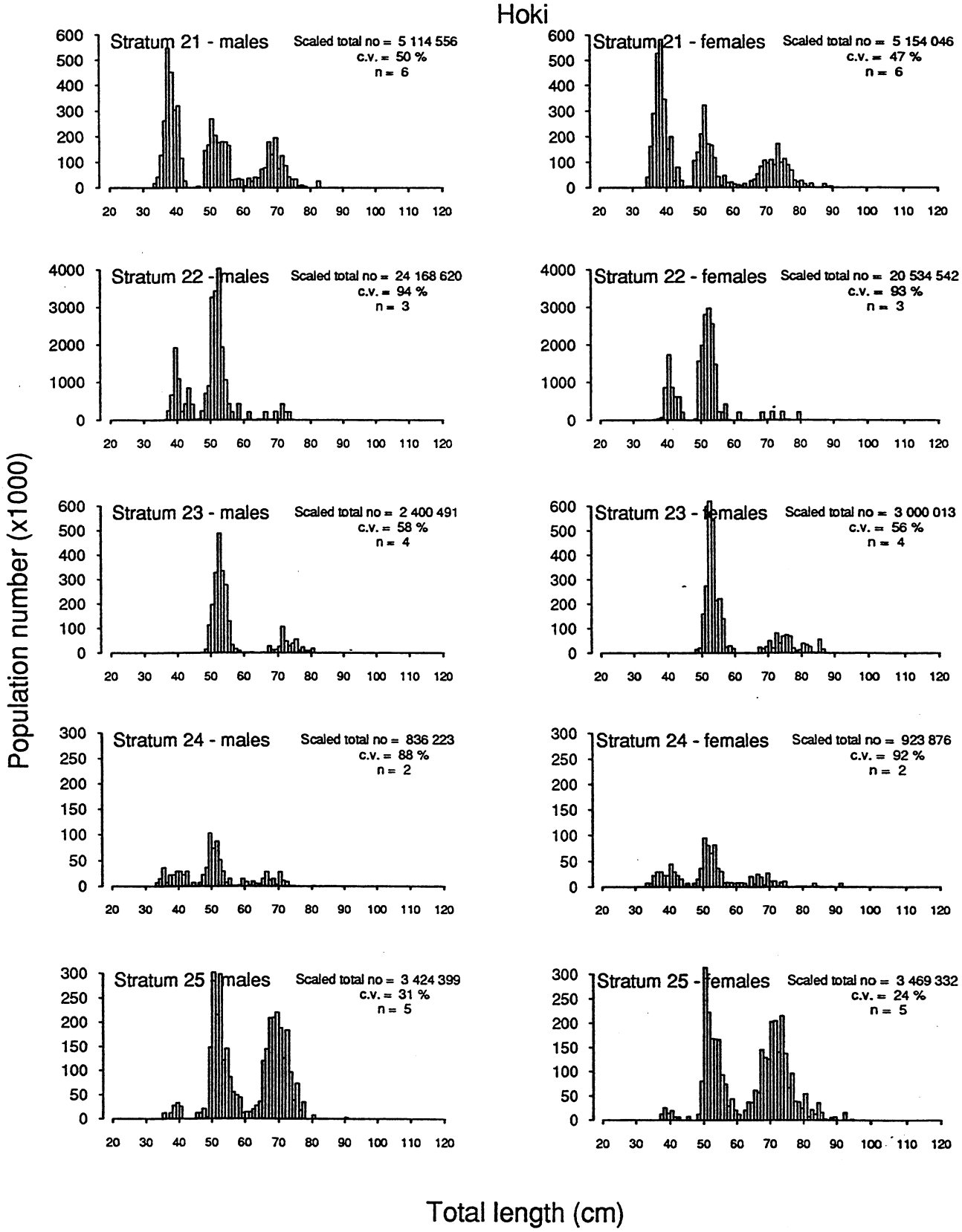
Appendix 3—*continued*



Appendix 3—*continued*



Appendix 3—*continued*



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