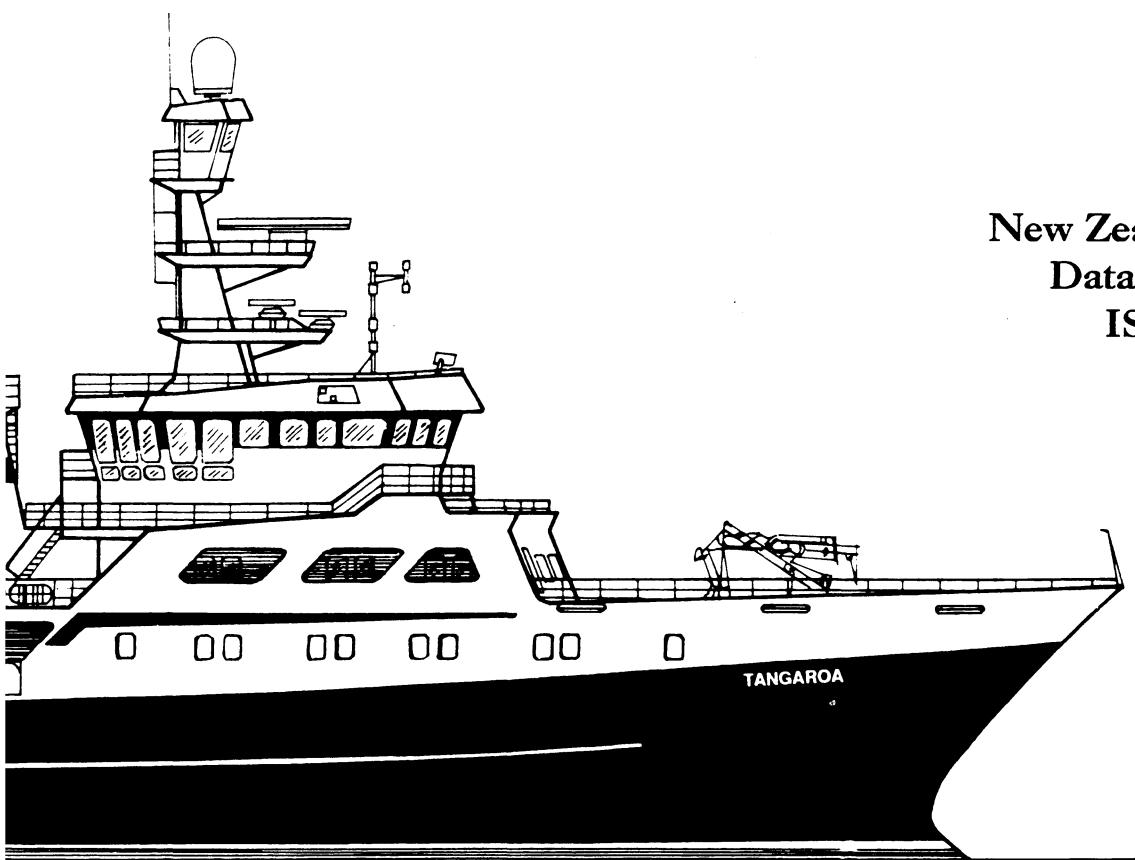


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(TAN9106)**

Peter L. Horn



New Zealand Fisheries
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Introduction

The fishery for hoki (*Macruronus novaezelandiae*) is currently New Zealand's largest with a TAC of about 200 000 t. From 1986 to 1990 the bulk of the catch was taken from spawning grounds off the west coast of the South Island (WCSI) during July and August. Since 1991 the industry has taken increasing quantities of fish from other areas; fisheries on spawning hoki have developed in Cook Strait and the Puysegur area, and there have also been increased catches from the Snares shelf, the east coast of the South Island (ECSI), and the Chatham Rise outside the spawning season. In the 1990–91 and 1991–92 fishing years, the combined catch from these areas was about 60 000 t and 110 000 t, respectively (Annala 1993). It is believed that fish caught in Cook Strait and off ECSI are a separate eastern stock that resides for much of the year on the Chatham Rise (Livingston 1990).

The consistent presence on the western Chatham Rise of juvenile hoki (i.e., fish < 65 cm total length) implies that this area is a major nursery ground (Livingston *et al.* 1991). In other areas of the EEZ where significant quantities of hoki are known to occur, larger fish dominate the population, so it seems likely that hoki from the Chatham Rise recruit to other grounds. To improve management of both postulated stocks it will be necessary to derive relative estimates of juvenile year class strength and recruitment variability for use in projection models.

Substantial commercial fisheries are conducted on the Chatham Rise in depths between 50 and 1300 m. Several middle depth species (hoki, ling, silver warehou) are targeted in various seasons. Significant bycatches of hake, barracouta, arrow squid, alfonsino, giant stargazer, and ghost sharks are also taken. Hake, barracouta, and arrow squid have been target fisheries in some years.

Random trawl surveys of depths from 50 to 800 m on the Chatham Rise were conducted from *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). 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 due to the use of different vessels and gear, they have provided abundance estimates for a variety of commercial species (Hurst & Fenaughty 1985, Livingston *et al.* 1991). In conjunction with other trawl surveys in the EEZ, they have shown that the western Chatham Rise is the major nursery ground for hoki (Livingston *et al.* 1991).

This report presents the results of the first in an annual series of random trawl surveys aimed at providing a time series of comparable biomass indices for hoki and other important species on the Chatham Rise. Trawling was conducted from 28 December 1991 to 1 February 1992.

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.

Methods

Survey area and design

The survey area was divided into 24 strata by depth zone (200–400 m, 400–600 m, 600–800 m) and longitude (Figure 1). Previous surveys, including some conducted below 800 m, had indicated that catches of hoki, hake, and ling would be negligible in waters less than 200 m and over 800 m deep. The depth boundaries were similar to those used in the 1989 *Amaltal Explorer* survey, with some slight modifications made 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). Phase 1 stations were allocated subjectively, giving consideration to the distribution of juvenile and recruited hoki in past surveys, and to stratum area. Relatively more weight was given to data from summer surveys (December 1989 and November–December 1983) and to past distributions of juvenile hoki. It was planned to complete 150 phase 1 stations. Phase 2 stations would be conducted in any remaining survey time, and would aim 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 hake, ling, and other associated 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 surface and 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 operated by the N.Z. Ministry of Agriculture and Fisheries. It has the following specifications: length overall, 70 m; beam, 14 m; gross tonnage, 2280 t; power, 3000 kW (4000 hp).

Gear specifications

The net used on this survey was an eight seam bottom trawl with a 58.8 m groundrope and 45 m headrope (see Appendix 1 of Chatterton & Hanchet (1994) for a complete description). The codend mesh size was 60 mm. The sweeps were 100 m long, bridles were 50 m, and backstrops were 12 m long. The trawl doors were Super Vee type with an area of 6.1 m². Doorspread was recorded from the Scanmar system every 5 min during the tow, and an average spread was calculated for each tow. Wingspread measurements were also obtained from the Scanmar, but only at 23 stations. Headline heights were recorded from the Kaijo Denki net monitor every 5 min and averaged.

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 that were aborted before 2 n. miles had been fished were replaced with another random station in the same stratum.

It is important to maintain as constant a gear configuration as possible at each station. A mean doorspread of 113.5 m was considered desirable, giving a mean sweep angle of 15° (Hurst *et al.* 1992). Gear trials indicated that to obtain a doorspread in the desired range of 100–130 m, the following warp length to depth (W:D) ratios should be used:

Depth	W:D ratio
200–300 m	2.8:1
300–350 m	2.6:1
350–500 m	2.4:1
500–800 m	2.3:1

Given a doorspread in the preferred range, the headline height should range from 6.0 to 7.5 m. Weather and sea conditions and sea currents influenced doorspread (and headline height), but at most stations these parameters were maintained in the preferred ranges.

Hydrological observations

Surface temperatures were obtained at the start of each tow from a 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. The hull-mounted sensor was uncalibrated. The Scanmar sensor was accurate to $\pm 0.1^\circ\text{C}$.

Catch sampling

The catch at each station was sorted into species and weighed using motion compensating electronic scales accurate to within 0.3 kg. Weights of some large sharks and rays were estimated by eye. All other landings were weighed directly, except for one shot where the hoki component was estimated by eye to be 7 t. At several stations producing large quantities of mixed rattails, the weights of individual species were estimated by subsample, i.e., 5–40% 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, and stomach fullness, contents, and condition. Generally, 20 hoki were randomly selected from each of two shots, one in the morning and one in the afternoon. Ling and hake were selected from all shots until 40 had been sampled that day. Samples of ling were non-random so as to comprehensively sample the full size range in the catch. Additional otoliths were collected from large hoki and ling to improve age-length keys.

Samples of scampi were frozen for genetic analysis. Several unusual and rare fish, waterlogged wood, and whale bones were retained for study at the Museum of New Zealand.

Data analysis

Biomass was estimated using 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 using the MAF Fisheries trawl survey biomass program. This program scales data from each station by the percentage of the catch sampled (to represent each catch) and the area swept, and further scales these values by stratum area (to represent the total population), and lastly by the ratio of the calculated catch biomass over the calculated length frequency biomass.

Biomasses were calculated using data from all stations where gear performance was considered to be satisfactory, i.e., the gear performance code was 1 or 2 (this excluded stations 118 and 143). Phase 1 stations were those numbered 1–147 and 151. The database contains estimates of mean doorspread and distance towed for each station.

Results

Survey area

The defined survey area was 135 842 km² (Figure 1). Some stratum boundaries were found to be inaccurate (particularly the 600 m and 800 m depth contours) and will be altered before the next survey.

Of the 150 planned phase 1 stations, 148 were completed (Table 1), although 2 (stations 118 and 143) were considered unsuitable for use in analyses of biomass because of unsatisfactory gear performance. The 38 phase 2 stations completed were aimed at improving the coefficients of variation for hoki juveniles (< 50 cm TL), hake, and silver warehou. Station density (after completion of phase 2) ranged from 1:245 to 1:1487 km² (Table 1).

Mean station density over the whole area was 1:738 km². The positions of all stations occupied are shown in Figure 2 and individual station data are presented in Appendix 1.

Gear performance

Gear parameters by depth zone (Table 2) indicated that the gear configuration remained relatively constant over the 200–800 m depth range. The mean doorspread of individual tows ranged from 104.2 to 137.3 m. The desirable range (100–130 m) was exceeded on 12 out of 186 occasions, but this was not considered to be a problem and these tows were not excluded from biomass calculations (Hurst *et al.* 1992).

Hydrology

Surface temperatures at phase 1 stations only ranged from 13.0 to 17.8 °C and showed a complex pattern of mixing (Figure 3). Temperatures generally decreased with increasing latitude. By phase 2, surface temperatures had risen about 2 °C in stratum 16 and about 1 °C in stratum 19.

Bottom temperature data were incomplete due to the malfunction of the temperature sensor during the first part of the voyage (Figure 4). Bottom temperatures ranged from 6.6 to 11.5 °C, and the pattern did not appear to change much between phase 1 and phase 2. Higher temperatures were generally associated with shallower depths (over 11 °C on the Mernoo Bank and over 9 °C on the Veryan Bank), but an area of warmer temperatures (over 11 °C) was also apparent in stratum 19.

Catch composition

In all, 127 species were recorded: 1 agnathan, 26 elasmobranchs, 89 teleosts, 8 cephalopods, and 4 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 238.7 t, of which 131.6 t (55%) was hoki.

Biomass estimation

Estimates of biomass of major commercial and non-commercial species are given in Table 3. Estimates of biomass by stratum of the 12 most abundant species are presented in Table 4. Parameters of length-weight relationships used to calculate recruited biomass and biomass by sex are given in Table 5.

Hoki was clearly the most abundant species, although over half the hoki biomass was not yet recruited into the fishery. Black oreo, ling, alfonsino, silver warehou, and hake were the other important commercial species, but much of the black oreo and alfonsino biomass was also unrecruited. Of the commercial non-ITQ species listed in Table 3, the first five are processed only sporadically. A significant biomass of non-commercial species (primarily rattail species and deepwater dogfish) occurs on the Chatham Rise.

Species distribution

Catch rates by stratum of the 20 species most abundant in the catch are presented in Table 6. Catch rates by station are given for hoki, ling, hake, alfonsino, silver warehou, and giant stargazer in Figure 5.

Hoki were most abundant on the western Chatham Rise in 200–600 m. Ling and bigeye rattail were also abundant in the west, but primarily in depths of 400–600 m. Most hake were taken from the north and east of the survey area in depths below 400 m, and particularly in stratum 10 (an area where commercial targeting for this species occurs). Silver warehou, white warehou, giant stargazer, sea perch, and spiny dogfish were most abundant in depths of 200–400 m over the whole area. The two ghost shark species were separated by the 400 m contour, with the pale shark occurring in the deeper zone. Oreos were in the 600–800 m strata: black oreo were abundant in the south and particularly the west, and spiky oreo occurred primarily in the north and east. Alfonsino were patchily distributed, with small fish occurring in the shallow strata and large fish being most common in the deepest strata to the north and east. Lookdown dory were common over the whole area, but began to decline in abundance deeper than 600 m. Javelinfish were most abundant in depths of 400–800 m on the north Chatham Rise. The oblique banded rattail was abundant in the 200–400 m zone on the Veryan Bank, and silver dory and common roughy occurred primarily in the same depth zone adjacent to the Chatham Islands.

Biology

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

The gonad stages of hoki, hake, and ling are summarised in Table 8. Most hoki and ling were immature or resting, although there was some indication of pre- and post-spawning activity by ling. Most male hake (65%) were in active reproductive stages (ripe to spent), but only 26% of females were in the same range.

Discussion

The survey design used here appears to provide satisfactory indices of abundance for the main commercial species. The high biomass coefficient of variation for silver warehou is not unexpected given the known patchy distribution of this species. Much of the uncertainty surrounding the estimate of hake biomass is due to catch rate variability in stratum 10. A hake spawning area is situated in the east of that stratum and large catches of hake are often taken there. In future surveys it is proposed to split stratum 10 at longitude 179° W in an attempt to better define the spawning area.

The allocation of phase 1 stations based on hoki catch rates from previous surveys was moderately successful, although phase 2 stations were necessary to reduce the coefficient of variation for juvenile hoki in strata 15–19. Allocation of phase 1 stations for the second

survey in this time series will be based on hoki catch rates from this survey and the 1989 summer survey.

Some stratum boundary changes will also be made before the next survey. It is expected that boundary revision will be an on-going process for some years as the bathymetric database builds up.

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Table 1: Stratum description and station allocation*

Stratum	Area (km ²)	Number of stations			Station density (km ² per station)	Depth range (m)
		P1	C1	C2		
1	2 395	3	3	0	798	600–800
2	2 765	6	6	0	461	600–800
3	8 920	5	5	1	1 487	600–800
4	5 151	4	4	0	1 288	600–800
5	5 553	9	9	0	617	600–800
6	7 642	7	7	0	1 092	600–800
7	4 928	9	9	0	548	400–600
8	3 625	7	7	0	518	400–600
9	5 753	7	7	0	822	400–600
10	9 811	7	7	3	981	400–600
11	6 888	3	3	6	765	400–600
12	6 996	9	9	0	777	400–600
13	7 466	7	7	0	1 067	400–600
14	5 728	8	8	0	716	400–600
15	5 880	8	8	4	490	400–600
16	4 689	7	7	5	391	400–600
17	6 851	11	11	2	527	400–600
18	4 648	4	4	5	516	200–400
19	8 191	5	5 [†]	12	512	200–400
20	9 287	10	9 [†]	0	1 161	200–400
21	2 515	4	3	0	838	200–400
22	3 892	3	3	0	1 297	200–400
23	5 532	4	4	0	1 383	200–400
24	736	3	3	0	245	200–400

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

[†] Strata where one station was excluded from biomass calculations due to unsatisfactory trawl performance.

Table 2: Mean gear parameters by depth range (standard deviations in parentheses)

Parameter	Depth range (m)		
	200–400	400–600	600–800
No. of samples	46	103	35
Headline height (m)	6.57 (0.44)	6.55 (0.40)	6.71 (0.39)
Speed (knots)	3.52 (0.05)	3.50 (0.05)	3.49 (0.05)
Doorspread (DS) (m)	116.6 (6.7)	121.8 (5.9)	120.7 (6.4)
No. of samples	3	14	6
Wingspread (WS) (m)	26.2 (1.35)	27.4 (0.78)	26.9 (0.70)
WS:DS	4.34 (0.19)	4.36 (0.15)	4.32 (0.14)
Sweep angle (degrees)	15.6 (0.77)	16.5 (0.73)	16.0 (0.94)

Table 3: Estimated biomass (and c.v. %) of all important ITQ species, important commercial non-ITQ species, and major non-commercial species*

Species code		Total biomass (t)			
		All fish	Females	Males	
ITQ species					
Hoki (all fish)	HOK	120 190	(7.7)	68 900	(7.4)
Hoki (\geq 65 cm)	HOK	52 340	(7.8)	-	-
Hoki (\leq 50 cm)	HOK	2 910	(27.5)	-	-
Black oreo	BOE	12 650	(27.0)	6 850	(37.6)
Ling	LIN	8 930	(5.8)	5 660	(6.8)
Alfonsino	BYS	6 600	(50.9)	3 990	(59.7)
Silver warehou	SWA	4 490	(54.2)	2 150	(56.8)
Hake	HAK	4 180	(14.9)	2 540	(11.0)
Giant stargazer	STA	2 570	(11.1)	1 830	(11.6)
Arrow squid	NOS	1 230	(38.3)	750	(54.1)
Barracouta	BAR	1 150	(11.1)	520	(6.6)
Smooth oreo	SSO	540	(49.9)	240	(46.2)
Slender mackerel	JMM	510	(54.8)	-	-
Tarakihi	TAR	340	(29.6)	100	(16.5)
Red cod	RCO	330	(34.7)	190	(43.0)
Bluenose	BNS	160	(33.7)	-	-
Hapuku	HAP	140	(36.8)	-	-
School shark	SCH	90	(44.2)	-	-
Orange roughy	ORH	40	(63.4)	-	-
Commercial non-ITQ species					
Dark ghost shark	GSH	6 700	(11.1)	-	-
Pale ghost shark	GSP	6 060	(5.7)	-	-
Lookdown dory	LDO	4 800	(5.6)	3 220	(7.8)
Sea perch	SPE	3 050	(11.8)	-	-
Spiny dogfish	SPD	2 390	(13.6)	-	-
White warehou	WWA	2 170	(29.5)	1 020	(32.0)
Ribaldo	RIB	530	(10.0)	-	-
Non-commercial species					
Bigeyed rattail	CBO	10 840	(13.4)	-	-
Javelinfish	JAV	8 960	(15.3)	-	-
Shovelnosed dogfish	SND	5 090	(14.0)	-	-
Spiky oreo	SOR	4 660	(37.5)	-	-
Other species		84 491			
Total		238 581			

* - = not calculated.

Table 4: Estimated biomass (and c.v. %) of the 12 most abundant species by stratum*

Stratum	HOK							GSH
	Total	Recruited	CBO	LIN	JAV	BOE		
1	2 129 (62)	1 847 (83)	87 (23)	90 (88)	161 (22)	0 -	0 -	
2	468 (22)	460 (22)	40 (58)	155 (41)	567 (55)	0 -	0 -	
3	1 077 (19)	1 026 (19)	93 (28)	432 (30)	957 (14)	4 (100)	0 -	
4	1 574 (13)	1 455 (11)	76 (41)	208 (15)	326 (44)	370 (58)	0 -	
5	5 840 (29)	4 836 (28)	521 (33)	403 (27)	387 (20)	1 888 (36)	1(100)	
6	4 366 (36)	3 716 (36)	370 (39)	550 (26)	344 (21)	10 116 (33)	54(100)	
7	4 523 (23)	2 126 (22)	1 241 (43)	516 (20)	208 (22)	0 -	20 (62)	
8	3 830 (33)	1 418 (33)	356 (51)	312 (30)	472 (34)	0 -	2 (73)	
9	5 023 (17)	1 933 (26)	224 (26)	375 (13)	153 (18)	0 -	48 (89)	
10	5 052 (28)	2 332 (20)	444 (33)	791 (15)	357 (39)	0 -	167 (80)	
11	5 900 (28)	2 178 (29)	366 (30)	483 (52)	1 416 (72)	0 -	72 (40)	
12	2 214 (21)	1 631 (26)	208 (24)	556 (17)	237 (40)	0 -	12 (67)	
13	3 080 (36)	1 590 (18)	286 (17)	607 (11)	148 (18)	264 (97)	82 (94)	
14	2 456 (33)	1 079 (33)	184 (33)	259 (19)	355 (38)	0 -	12(100)	
15	14 084 (27)	5 489 (25)	1 452 (19)	621 (15)	1 162 (60)	0 -	2 (45)	
16	12 127 (32)	2 915 (14)	1 496 (20)	736 (19)	298 (33)	5 (96)	63 (72)	
17	17 631 (26)	9 817 (25)	903 (26)	695 (15)	488 (42)	0 -	1(100)	
18	7 473 (36)	1 640 (42)	269 (55)	316 (42)	224 (90)	0 -	886 (16)	
19	7 054 (25)	1 545 (28)	1 532 (77)	126 (63)	72 (83)	0 -	1 997 (14)	
20	6 334 (28)	1 268 (24)	463 (31)	418 (25)	293 (34)	0 -	1 341 (26)	
21	4 380 (29)	1 054 (10)	60 (100)	82 (26)	76 (100)	0 -	519 (14)	
22	142 (78)	95 (68)	5 (100)	133 (90)	31 (50)	0 -	755 (50)	
23	3 263 (51)	848 (42)	145 (74)	45 (39)	222 (75)	0 -	299 (68)	
24	173 (100)	39 (100)	18 (100)	24 (46)	< 1 (100)	0 -	370 (88)	
Stratum	GSP	SND	LDO	BYs	SWA	HAK		
1	173 (21)	747 (23)	24 (51)	0 -	0 -	129 (50)		
2	238 (16)	1 680 (33)	58 (26)	0 -	0 -	51 (38)		
3	217 (22)	1 478 (24)	212 (14)	3 134 (99)	0 -	819 (24)		
4	217 (33)	265 (57)	60 (47)	3 (100)	2 (100)	153 (39)		
5	303 (26)	38 (73)	86 (28)	0 -	10 (74)	47 (58)		
6	610 (26)	106 (57)	27 (58)	0 -	0 -	76 (29)		
7	272 (19)	233 (33)	129 (24)	< 1 (100)	4 (100)	147 (31)		
8	145 (22)	33 (74)	223 (28)	24 (75)	0 -	153 (30)		
9	263 (25)	0 -	315 (25)	5 (73)	0 -	156 (14)		
10	152 (20)	53 (56)	441 (23)	129 (48)	313 (41)	1 331 (42)		
11	32 (43)	29 (64)	277 (30)	152 (59)	227 (50)	262 (19)		
12	258 (28)	120 (29)	296 (13)	4 (69)	27 (74)	170 (47)		
13	613 (19)	39 (35)	346 (19)	0 -	3 (100)	58 (47)		
14	864 (16)	31 (100)	268 (9)	0 -	3 (100)	99 (34)		
15	805 (14)	14 (65)	558 (27)	< 1 (100)	48 (72)	210 (23)		
16	216 (14)	30 (32)	228 (20)	< 1 (84)	13 (56)	67 (33)		
17	555 (21)	195 (26)	212 (16)	0 -	12 (76)	86 (27)		
18	2 (100)	0 -	146 (33)	0 -	360 (52)	10 (100)		
19	13 (84)	0 -	121 (31)	408 (96)	2 740 (88)	5 (63)		
20	109 (74)	0 -	432 (9)	98 (88)	366 (77)	112 (51)		
21	0 -	0 -	141 (8)	2 245 (52)	36 (59)	36 (52)		
22	0 -	0 -	2 (51)	0 -	23 (40)	0 -		
23	0 -	0 -	188 (36)	396 (93)	281 (12)	0 -		
24	0 -	< 1 (100)	7 (100)	0 -	18 (25)	0 -		

* Species codes are given in Table 3. Recruited hoki are defined as fish ≥ 65 cm TL.

Table 5. Length-weight relationship parameters a and b used to calculate biomass by sex and recruited biomass

	<i>a</i>	<i>b</i>	<i>n</i>	Data source
Hoki	0.00337	2.965	1 353	This survey
Ling	0.00126	3.294	1 045	This survey
Hake	0.00209	3.273	506	This survey
Black oreo	0.0248	2.950	9 790	DB, Chatham Rise, Nov-Mar
Alfonsino	0.0226	3.018	?	Annala (1993)
Silver warehou	0.0264	2.901	256	DB, all NZ, Nov-Mar
Giant stargazer	0.0136	3.059	350	DB, all NZ, all months
Smooth oreo	0.0309	2.895	9 147	DB, Chatham Rise, Nov-Mar
Tarakihi	0.02	2.98	?	Annala (1993)
Red cod	0.011	2.97	?	Annala (1993)
Orange roughy	0.0687	2.792	4 689	DB, Chatham Rise, Nov-Mar
Lookdown dory	0.0288	2.939	197	DB, all NZ, Nov-Mar
White warehou	0.029	2.971	?	DB (biomass program default)
Arrow squid	0.0290	3.00	?	Annala (1993)
Barracouta	0.0091	2.88	730	Hurst & Bagley (1987)

* $W = aL^b$ where W = weight (g), and L = length (cm); n = sample number; DB = MAF Fisheries trawl database.

Table 6: Catch rates ($\text{kg} \cdot \text{km}^{-2}$) and standard deviations (in parentheses) by stratum for the 20 species most abundant in the catch*

Stratum	HOK	CBO	LIN	JAV	BOE	GSH	GSP	SND	LDO	BYs
1	889 (958)	36 (15)	38 (57)	67 (25)	0 (0)	0 (0)	72 (26)	312 (126)	10 (9)	0 (0)
2	169 (93)	14 (21)	56 (56)	205 (275)	0 (0)	0 (0)	86 (34)	607 (498)	21 (13)	0 (0)
3	121 (56)	10 (7)	48 (35)	107 (37)	0 (1)	0 (0)	24 (13)	166 (96)	24 (8)	351 (853)
4	306 (82)	15 (12)	40 (12)	63 (55)	72 (83)	0 (0)	42 (28)	51 (59)	12 (11)	1 (1)
5	1052 (920)	94 (94)	73 (60)	70 (43)	340 (370)	0 (1)	55 (42)	7 (15)	15 (13)	0 (0)
6	571 (549)	48 (50)	72 (50)	45 (25)	1324 (1154)	7 (19)	80 (54)	14 (21)	4 (5)	0 (0)
7	918 (622)	252 (326)	105 (64)	42 (28)	0 (0)	4 (7)	55 (32)	47 (47)	26 (19)	0 (0)
8	1057 (921)	98 (134)	86 (69)	130 (116)	0 (0)	1 (1)	40 (23)	9 (18)	61 (46)	7 (13)
9	873 (393)	39 (26)	65 (22)	27 (13)	0 (0)	8 (20)	46 (30)	0 (0)	55 (36)	1 (2)
10	515 (453)	45 (47)	81 (37)	36 (45)	0 (0)	17 (43)	16 (10)	5 (10)	45 (32)	13 (20)
11	857 (724)	53 (47)	70 (110)	206 (441)	0 (0)	10 (12)	5 (6)	4 (8)	40 (36)	22 (39)
12	316 (195)	30 (21)	79 (40)	34 (41)	0 (0)	2 (3)	37 (31)	17 (15)	42 (16)	1 (1)
13	413 (388)	38 (17)	81 (23)	20 (9)	35 (91)	11 (27)	82 (41)	5 (5)	46 (23)	0 (0)
14	429 (397)	32 (30)	45 (24)	62 (67)	0 (0)	2 (6)	151 (69)	5 (16)	47 (11)	0 (0)
15	2395 (2243)	247 (163)	106 (57)	198 (413)	0 (0)	0 (1)	137 (64)	2 (5)	95 (87)	0 (0)
16	2586 (2875)	319 (222)	157 (102)	64 (73)	1 (4)	13 (34)	46 (22)	6 (7)	49 (34)	0 (0)
17	2574 (2377)	132 (121)	101 (57)	71 (107)	0 (0)	0 (0)	81 (60)	28 (26)	31 (17)	0 (0)
18	1608 (1736)	58 (96)	68 (85)	48 (130)	0 (0)	191 (92)	0 (1)	0 (0)	31 (31)	0 (0)
19	861 (852)	187 (579)	15 (39)	9 (29)	0 (0)	244 (139)	2 (5)	0 (0)	15 (18)	50 (191)
20	682 (534)	50 (44)	45 (32)	32 (30)	0 (0)	144 (106)	12 (24)	0 (0)	46 (12)	11 (26)
21	1741 (872)	24 (41)	32 (14)	30 (52)	0 (0)	206 (49)	0 (0)	0 (0)	56 (8)	893 (796)
22	37 (49)	1 (2)	34 (53)	8 (7)	0 (0)	194 (168)	0 (0)	0 (0)	1 (1)	0 (0)
23	590 (598)	26 (39)	8 (6)	40 (60)	0 (0)	54 (74)	0 (0)	0 (0)	34 (24)	72 (134)
24	236 (408)	24 (42)	33 (26)	1 (1)	0 (0)	503 (769)	0 (0)	1 (2)	9 (16)	0 (0)

Table 6 – continued

Stratum	SWA	HAK	SPE	SOR	SPD	STA	WWA	CAS	SDO	RHY
1	0 (0)	54 (47)	4 (4)	70 (52)	0 (0)	3 (6)	0 (0)	0 (0)	0 (0)	0 (0)
2	0 (0)	19 (17)	10 (3)	62 (75)	0 (0)	20 (24)	0 (0)	0 (0)	0 (1)	0 (0)
3	0 (0)	92 (54)	3 (3)	230 (162)	0 (0)	3 (5)	5 (9)	0 (0)	0 (0)	0 (0)
4	0 (1)	30 (23)	4 (3)	326 (632)	0 (0)	5 (6)	0 (0)	0 (0)	0 (0)	0 (0)
5	2 (4)	9 (15)	17 (12)	1 (3)	0 (0)	6 (7)	0 (0)	0 (0)	0 (0)	0 (0)
6	0 (0)	10 (8)	2 (3)	0 (1)	0 (0)	8 (11)	0 (0)	0 (0)	0 (0)	0 (0)
7	1 (2)	30 (28)	11 (10)	9 (15)	9 (22)	18 (44)	6 (12)	2 (7)	0 (0)	0 (0)
8	0 (0)	42 (33)	53 (62)	5 (7)	1 (3)	10 (10)	0 (0)	2 (5)	0 (0)	0 (0)
9	0 (0)	27 (10)	19 (7)	0 (1)	4 (6)	4 (5)	15 (35)	1 (2)	0 (0)	0 (0)
10	32 (41)	136 (181)	11 (12)	1 (5)	1 (3)	5 (4)	2 (4)	2 (7)	0 (0)	0 (0)
11	33 (49)	38 (22)	14 (17)	0 (1)	1 (2)	8 (8)	22 (31)	1 (3)	0 (1)	0 (1)
12	4 (9)	24 (34)	16 (17)	68 (76)	3 (6)	7 (9)	2 (3)	0 (0)	0 (0)	0 (0)
13	0 (1)	18 (9)	11 (9)	2 (6)	9 (22)	7 (8)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (1)	17 (17)	14 (13)	0 (0)	0 (1)	3 (4)	1 (2)	0 (0)	0 (0)	0 (0)
15	8 (21)	36 (28)	24 (25)	0 (0)	5 (8)	6 (7)	14 (25)	10 (16)	0 (0)	0 (0)
16	3 (5)	14 (16)	18 (29)	0 (0)	9 (16)	14 (17)	72 (159)	8 (10)	0 (0)	0 (0)
17	2 (5)	13 (12)	6 (8)	0 (0)	5 (10)	10 (12)	1 (2)	14 (19)	0 (0)	0 (0)
18	77 (121)	2 (6)	34 (47)	0 (0)	143 (143)	54 (40)	58 (107)	44 (46)	31 (49)	0 (0)
19	335 (1173)	1 (1)	60 (40)	0 (0)	86 (65)	48 (58)	9 (19)	34 (31)	2 (5)	15 (51)
20	39 (86)	12 (18)	88 (90)	0 (0)	44 (38)	27 (31)	44 (62)	24 (34)	0 (0)	0 (0)
21	14 (15)	14 (13)	62 (42)	0 (0)	76 (83)	9 (8)	221 (362)	6 (11)	0 (0)	1 (2)
22	6 (4)	0 (0)	2 (4)	0 (0)	26 (23)	141 (74)	0 (0)	0 (0)	848 (1088)	721 (1248)
23	51 (12)	0 (0)	24 (31)	0 (0)	2 (2)	35 (23)	13 (14)	0 (0)	73 (133)	2 (2)
24	25 (11)	0 (0)	6 (7)	0 (0)	42 (29)	197 (243)	4 (6)	623 (843)	0 (0)	0 (0)

* Most species codes are given in Table 3: CAS = oblique banded rattail; SDO = silver dory; RHY = common roughy.

Table 7: Species measured or selected for more detailed biological analysis

Fish measured	Stations sampled	Number of Biological samples
Hoki	29 483	1 353
Lookdown dory	5 439	0
Ling	2 416	1 048
Black oreo	2 024	0
Arrow squid	1 587	0
Alfonsino	1 412	0
Silver warehou	1 068	0
White warehou	918	0
Giant stargazer	853	0
Hake	627	506
Red cod	537	0
Barracouta	370	0
Slender mackerel	350	0
Smooth oreo	313	0
Ribaldo	215	0
Tarakihi	128	0
Orange roughy	105	0
Pale ghost shark	69	0
Lemon sole	30	0
Hapuku	22	0
Bluenose	21	0
Slender cod	15	0
Southern blue whiting	2	0
Jack mackerel	2	0
Blue mackerel	1	0

Table 8: Numbers of male and female hoki, hake, and ling at each reproductive stage*

Stage	Hoki		Hake		Ling	
	Male	Female	Male	Female	Male	Female
1	170	120	21	11	85	71
2	393	659	43	108	201	404
3	0	1	22	70	100	7
4	0	0	19	11	134	5
5	0	1	72	4	0	0
6	0	0	68	37	21	12
7	0	1	1	15	0	0

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

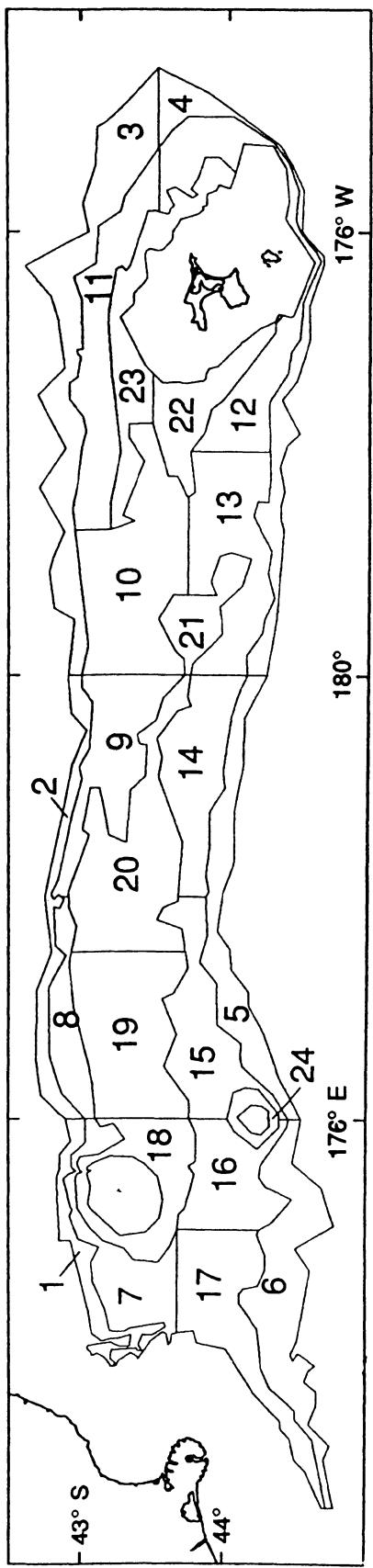


Figure 1: Trawl survey area showing stratum boundaries.

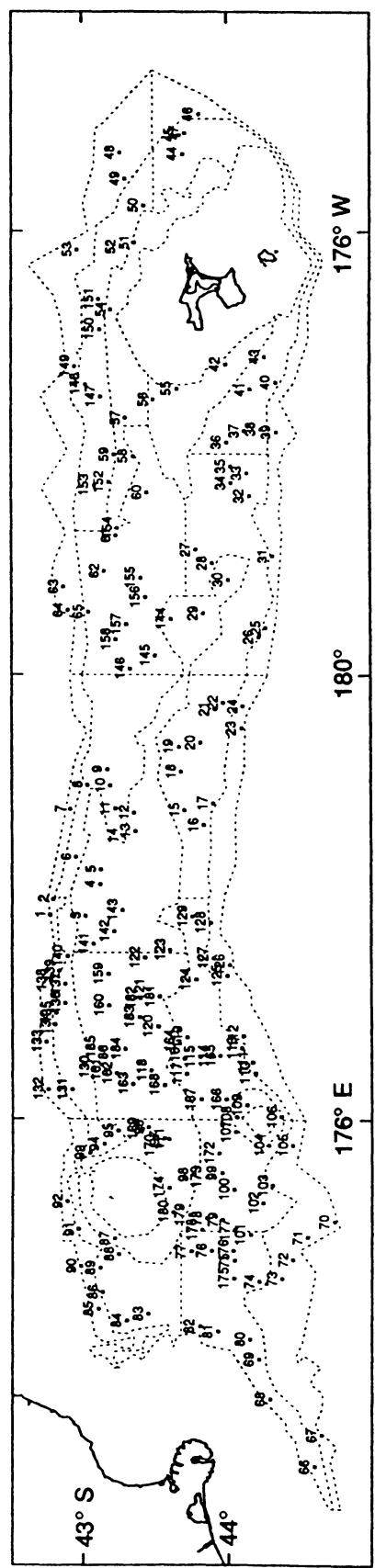


Figure 2: Trawl station positions and numbers.

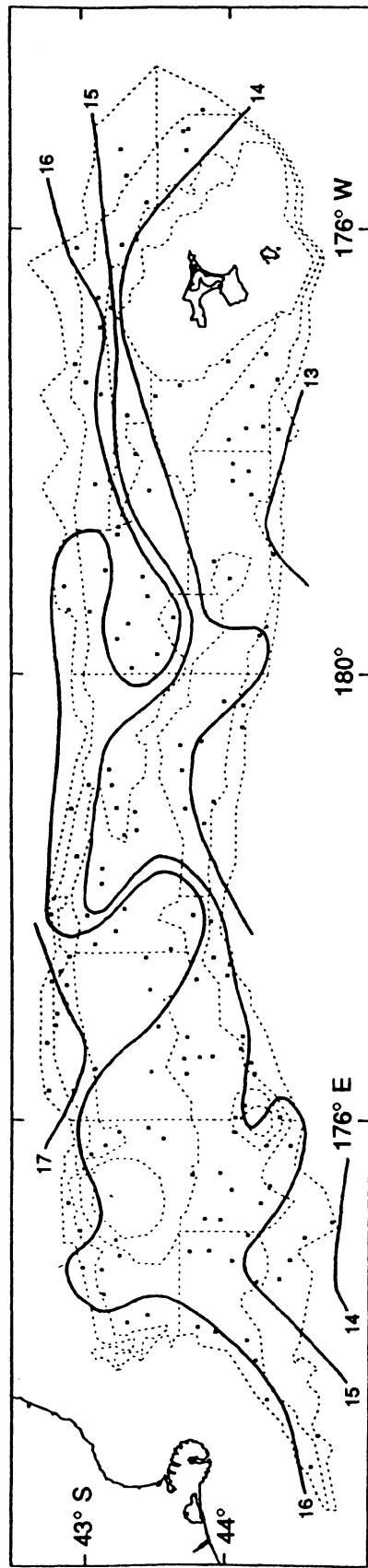


Figure 3: Positions of surface temperature recordings (from phase 1 stations only) and isotherms estimated from these data.

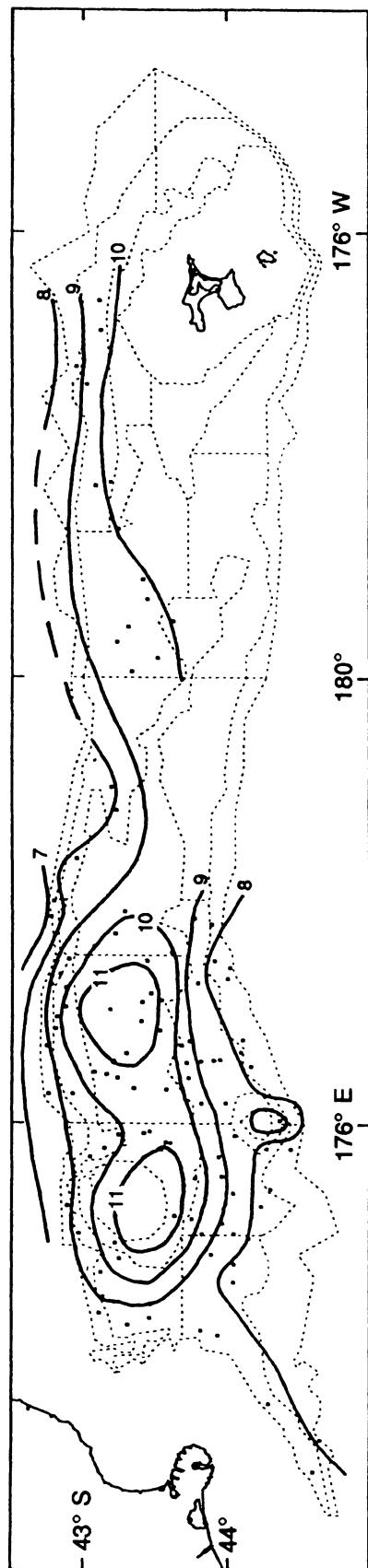


Figure 4: Positions of bottom temperature recordings (from the entire survey) and isotherms estimated from these data.

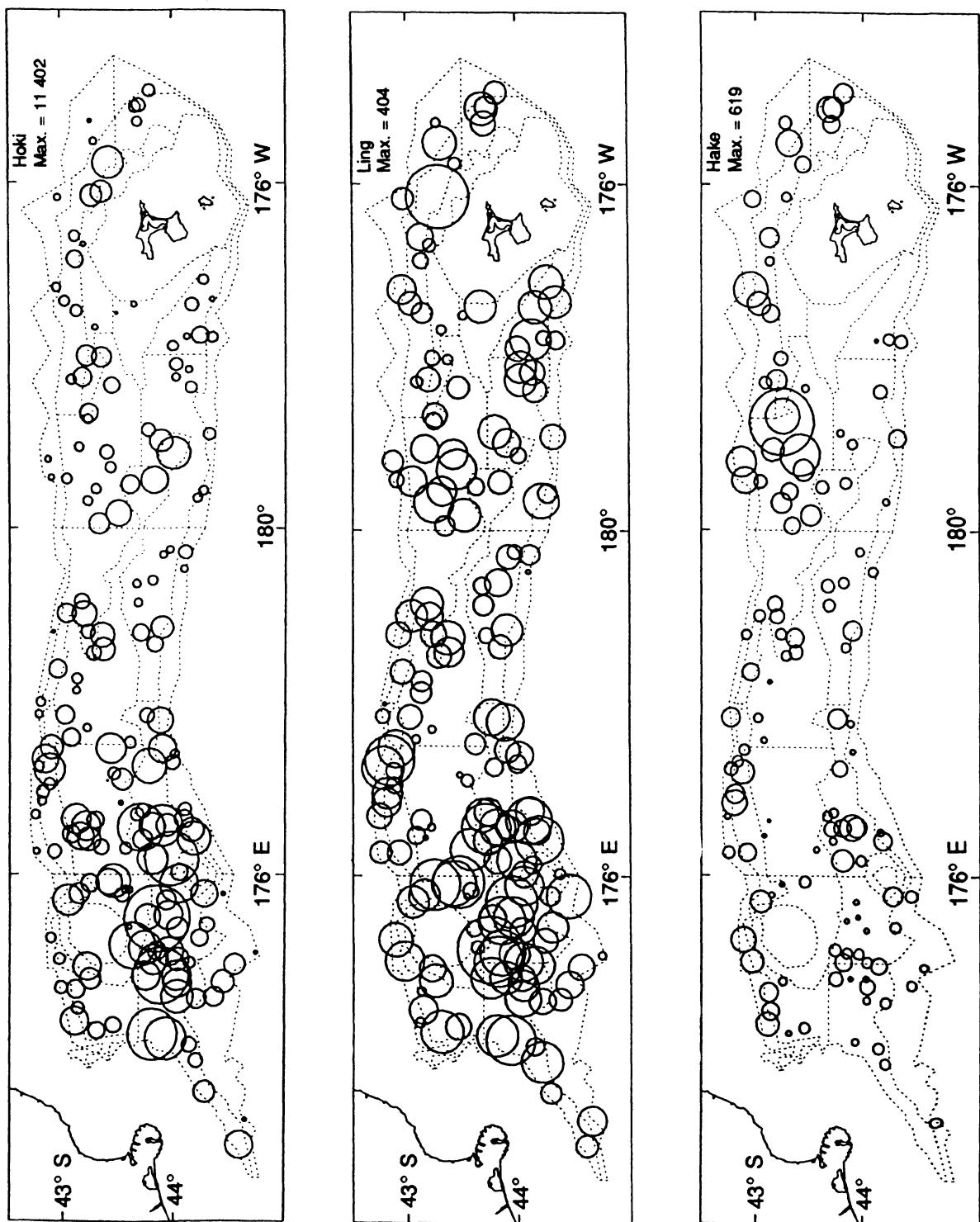


Figure 5: Catch rates ($\text{kg} \cdot \text{km}^{-2}$) of hoki, ling, hake, alfonsoino, silver warehou, and giant stargazer. Circle area is proportional to catch rate. Max. = maximum catch rate($\text{kg} \cdot \text{km}^{-2}$).

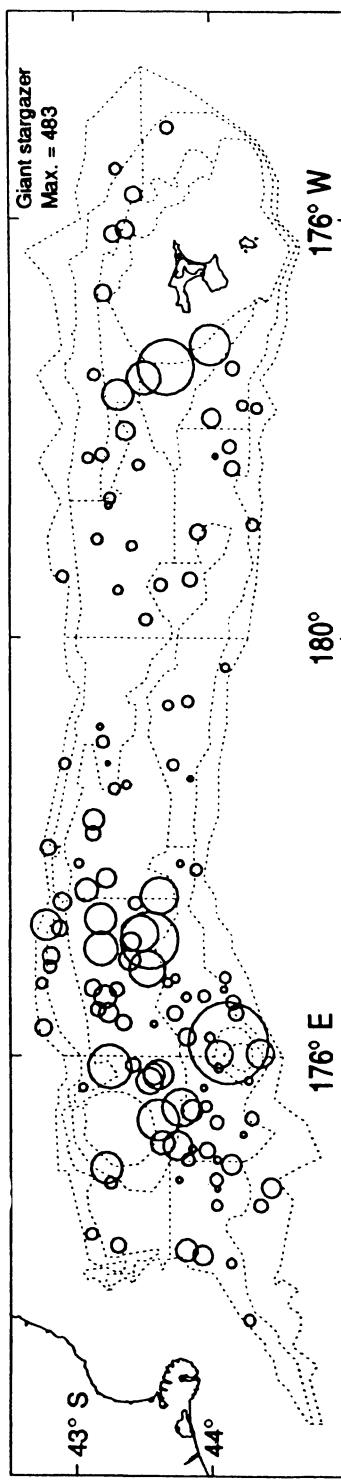
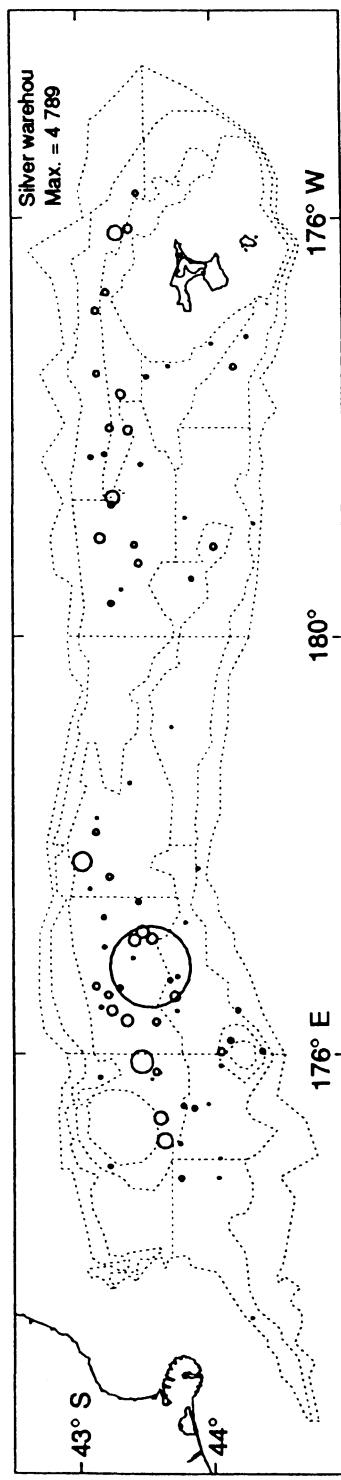
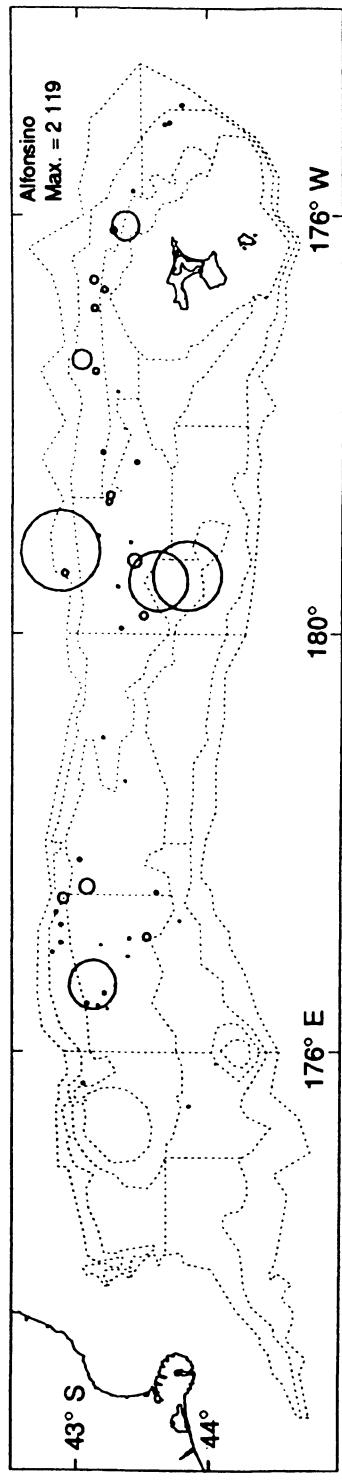


Figure 5—continued

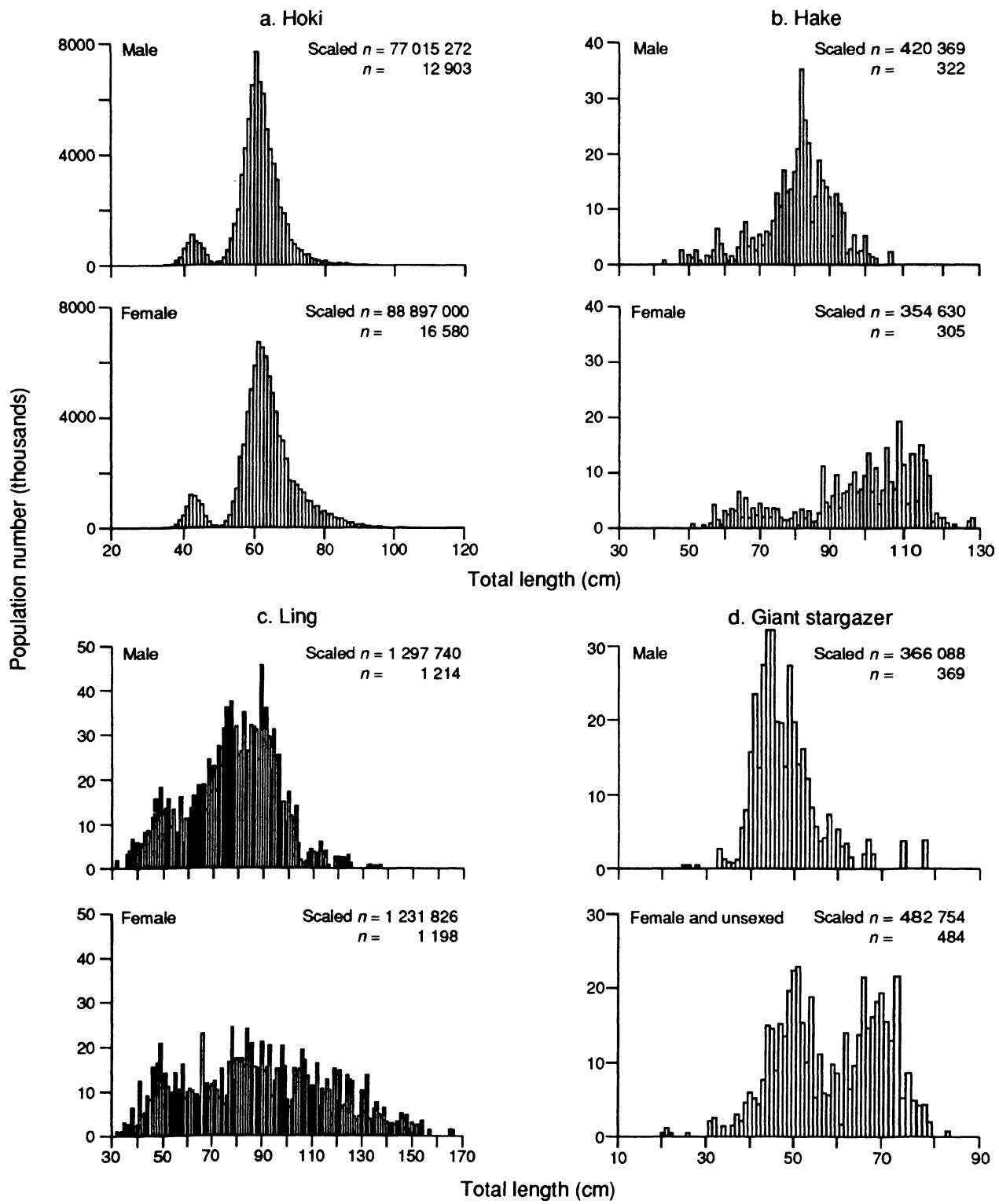
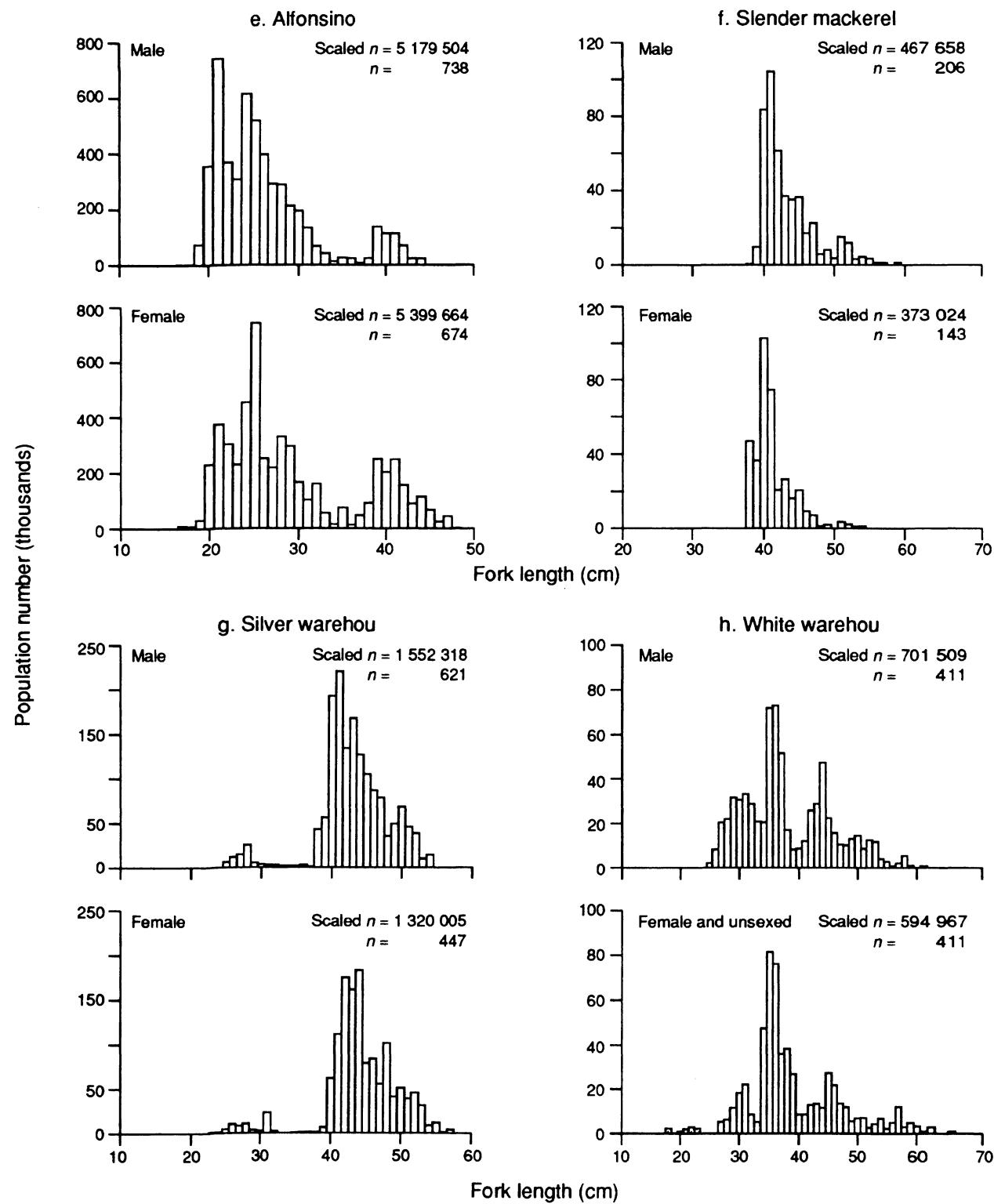
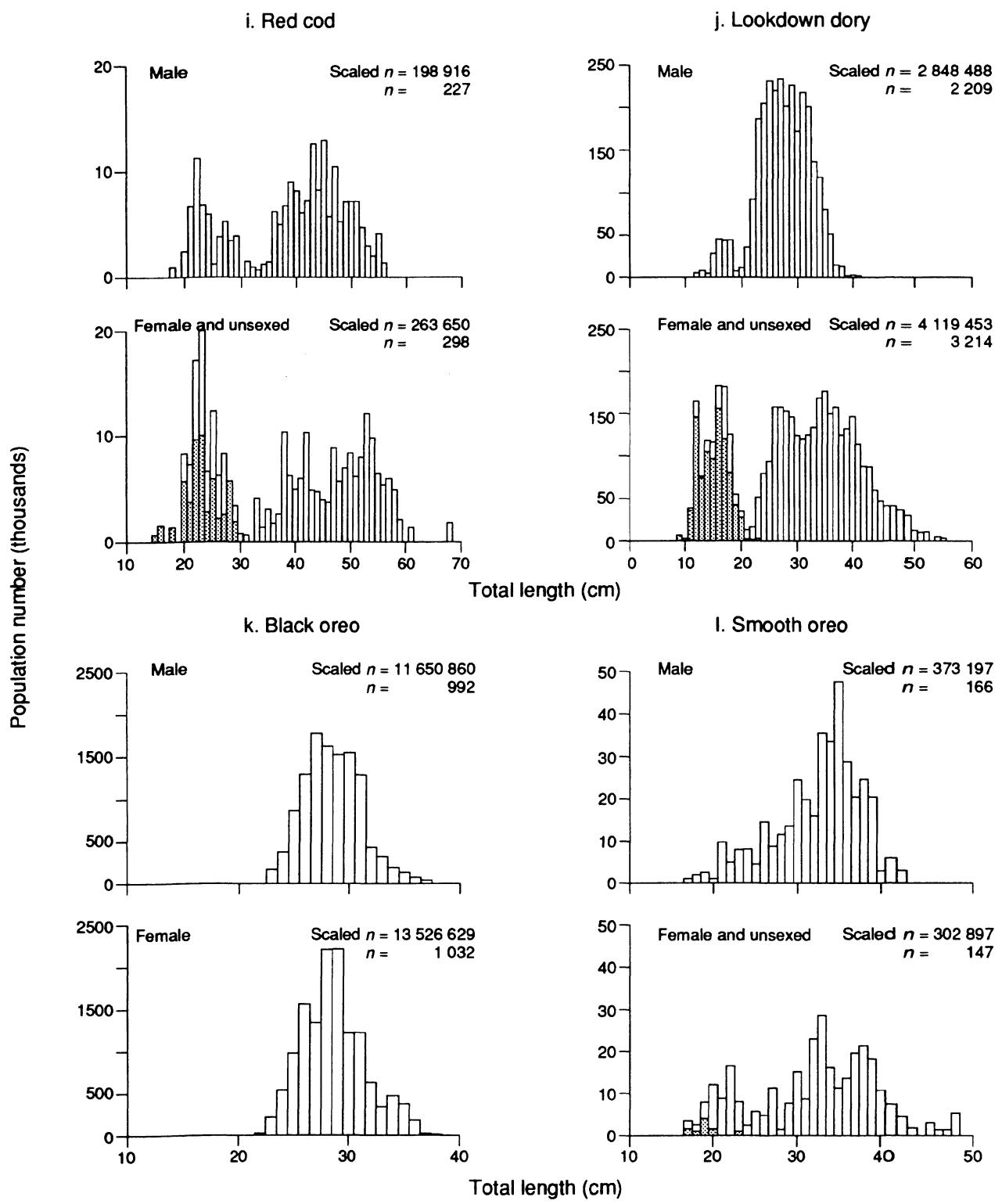
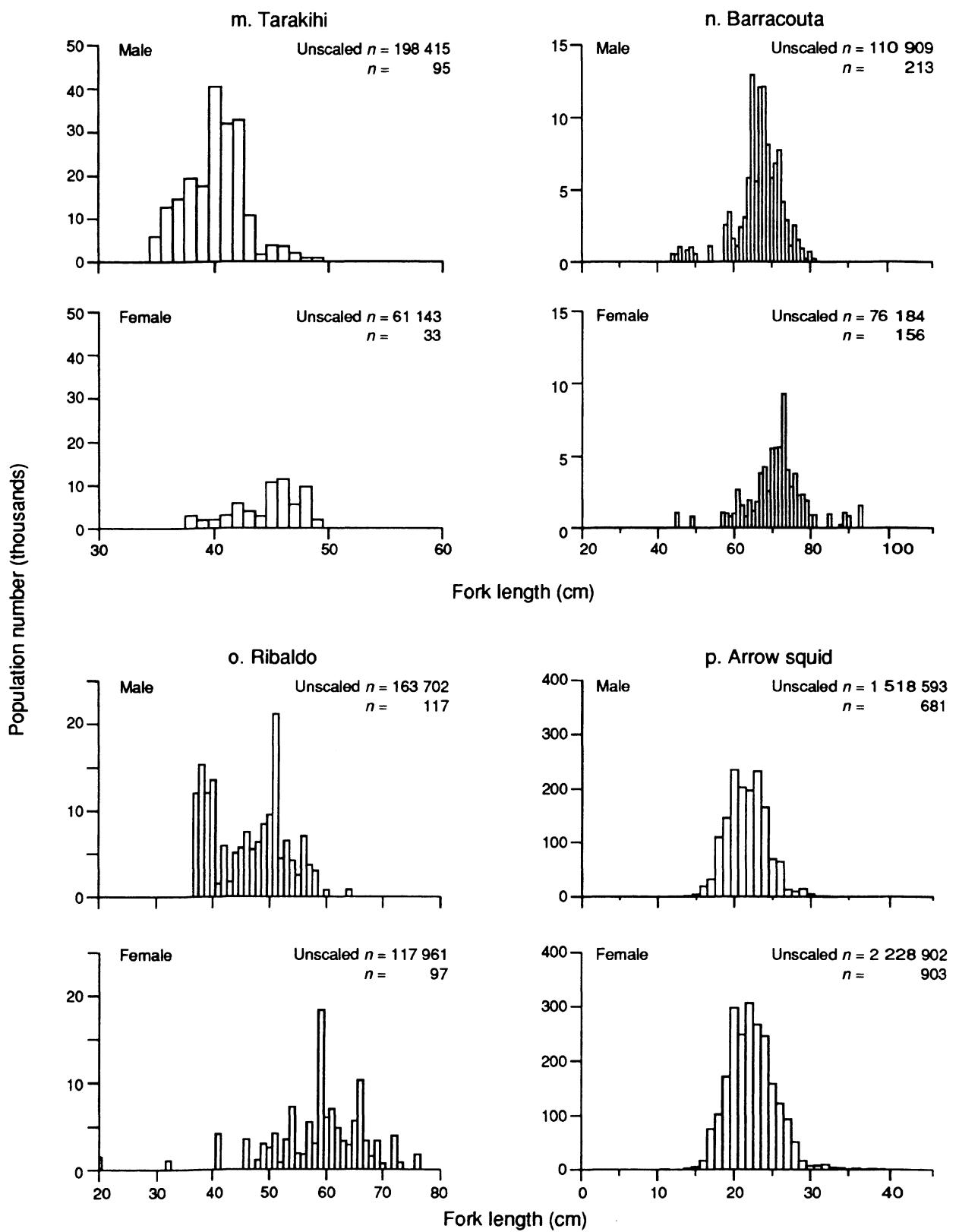


Figure 6 a–p: Length frequency, by sex, of species measured. Data have been scaled to represent total population numbers in the entire survey area (= scaled n). n = number of fish measured.







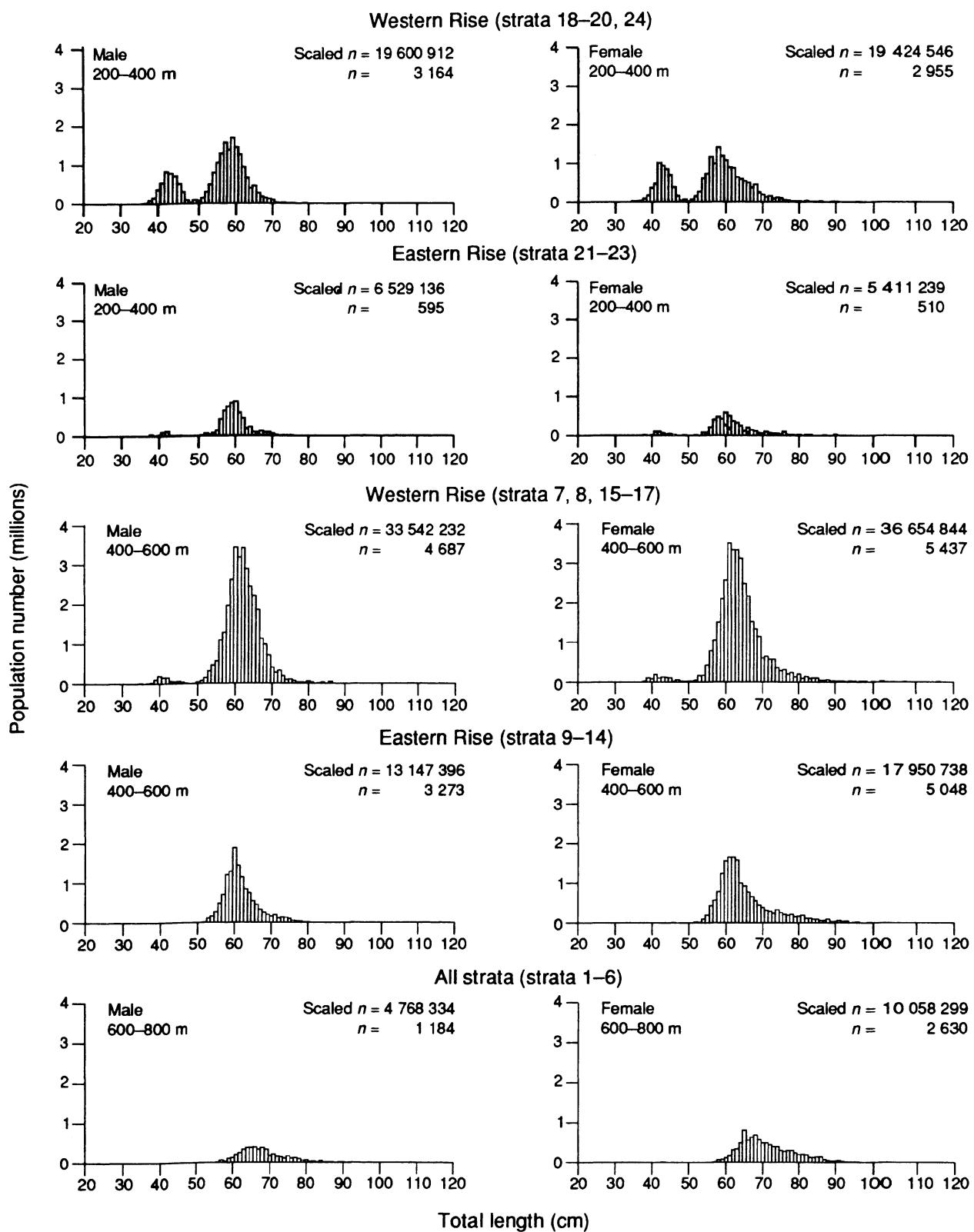


Figure 7: Length frequency of hoki, by sex, depth zone (200–400, 400–600, 600–800 m), and area (Eastern Rise, Western Rise). Data have been scaled to represent total population numbers in each depth zone (= scaled n). n = number of fish measured.

Ling

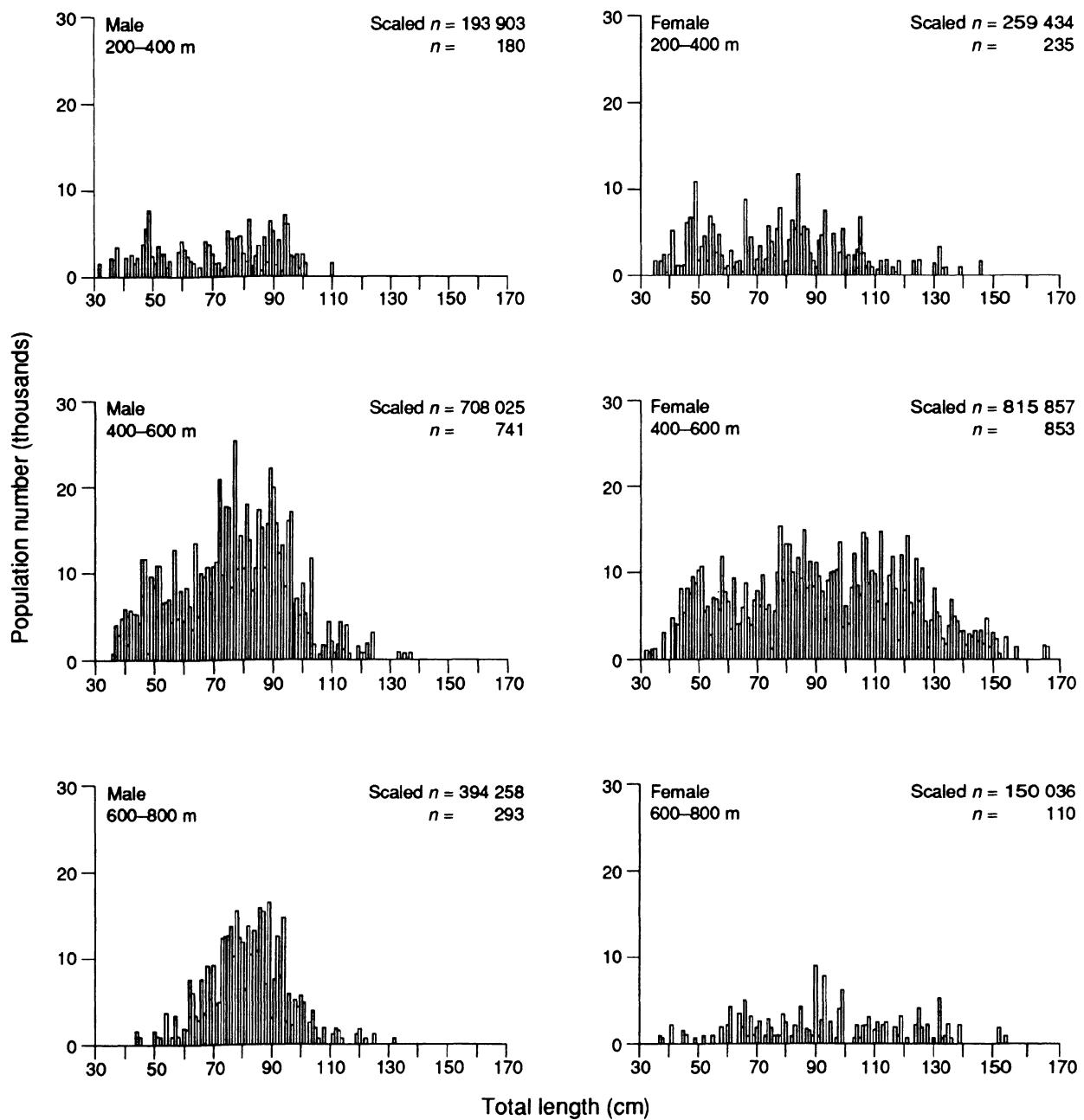
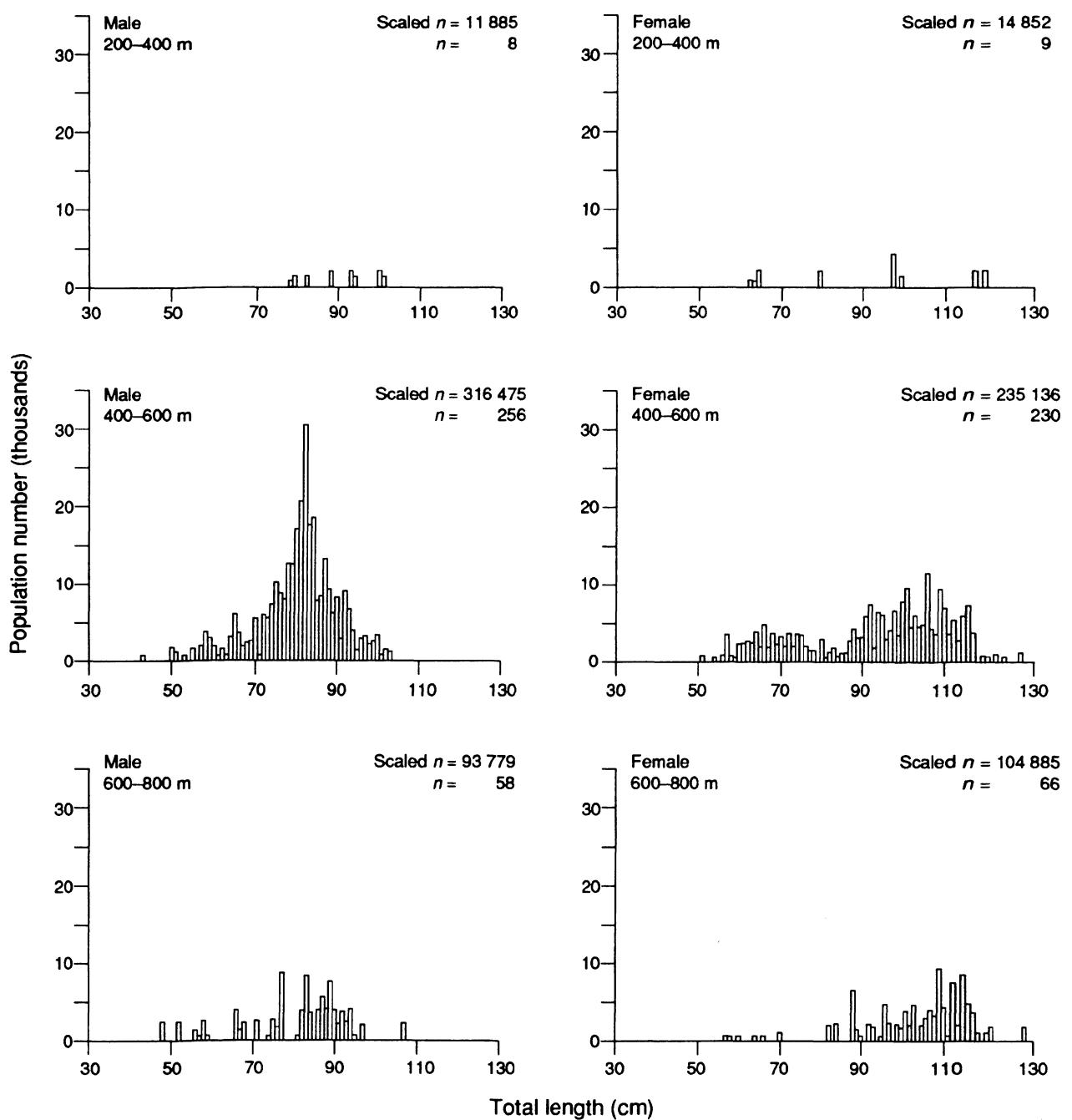
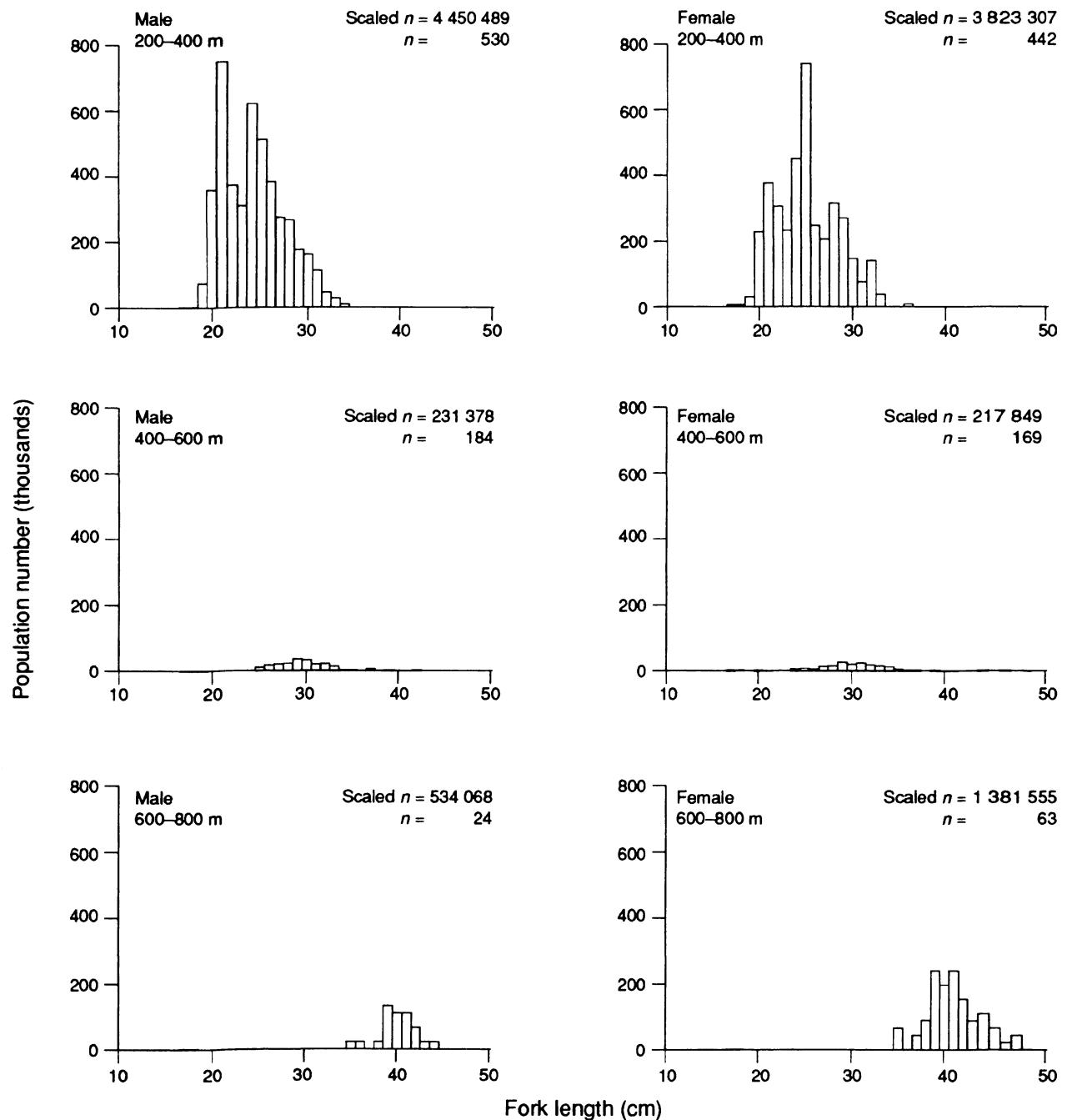


Figure 8: Length frequency of ling, hake, and alfonsino, by sex, depth zone (200–400, 400–600, 600–800 m), and area (Eastern Rise, Western Rise). Data have been scaled to represent total population numbers in each depth zone (= scaled n). n = number of fish measured.

Hake



Alfonsino



Appendix 1: Individual station data

Station	Date	Time	Start of tow		Gear depth (m)	Distance towed (n. mile)	Doorspread (m)
			Latitude ° S	Longitude ° E/W			
1	28 Dec 91	0518	42 46.30	177 50.70 E	736	744	3.08
2	28 Dec 91	0716	42 47.40	177 59.20 E	675	717	3.08
3	28 Dec 91	1110	43 01.18	177 50.33 E	332	358	3.06
4	28 Dec 91	1330	43 07.40	178 07.40 E	374	386	2.96
5	28 Dec 91	1512	43 07.70	178 15.40 E	358	371	2.81
6	28 Dec 91	1748	42 57.10	178 22.00 E	448	473	3.07
7	29 Dec 91	0507	42 54.77	178 47.83 E	754	758	3.02
8	29 Dec 91	0741	43 02.10	179 00.80 E	465	470	2.88
9	29 Dec 91	1018	43 10.50	179 09.20 E	420	425	2.49
10	29 Dec 91	1345	43 11.82	179 00.49 E	403	426	3.00
11	29 Dec 91	1620	43 13.90	178 48.10 E	414	415	2.93
12	29 Dec 91	1900	43 21.70	178 45.80 E	390	396	2.95
13	30 Dec 91	0536	43 22.33	178 35.85 E	365	381	3.01
14	30 Dec 91	0756	43 17.00	178 33.30 E	402	409	3.22
15	30 Dec 91	1258	43 42.73	178 47.49 E	433	436	2.97
16	30 Dec 91	1653	43 50.50	178 39.49 E	478	489	3.04
17	30 Dec 91	1846	43 54.20	178 51.10 E	531	542	3.04
18	31 Dec 91	0457	43 41.25	179 08.32 E	438	460	2.97
19	31 Dec 91	0716	43 40.50	179 21.80 E	456	477	2.97
20	31 Dec 91	0935	43 49.32	179 24.02 E	490	492	3.03
21	31 Dec 91	1209	43 54.94	179 41.86 E	478	492	2.90
22	31 Dec 91	1401	43 58.39	179 45.28 E	490	525	3.02
23	31 Dec 91	1625	44 05.80	179 31.70 E	700	715	2.97
24	31 Dec 91	1902	44 06.45	179 43.37 E	645	684	3.02
25	01 Jan 92	0500	44 16.08	179 34.10 W	630	679	3.06
26	01 Jan 92	0720	44 12.90	179 39.30 W	560	598	2.90
27	02 Jan 92	0452	43 47.55	178 51.62 W	401	423	3.02
28	02 Jan 92	0745	43 54.10	178 59.20 W	408	413	2.92
29	02 Jan 92	1151	43 50.47	179 26.42 W	293	308	3.07
30	02 Jan 92	1510	44 00.60	179 08.00 W	300	309	2.94
31	02 Jan 92	1843	44 19.00	178 54.92 W	634	665	3.26
32	03 Jan 92	0512	44 09.47	178 22.54 W	486	488	3.03
33	03 Jan 92	0824	44 08.35	178 10.17 W	484	495	3.03
34	03 Jan 92	1046	44 01.80	178 15.40 W	453	465	2.89
35	03 Jan 92	1256	44 01.90	178 06.40 W	456	465	2.94
36	03 Jan 92	1503	44 00.20	177 53.60 W	456	464	2.91
37	03 Jan 92	1720	44 07.36	177 47.24 W	480	492	3.02
38	03 Jan 92	1901	44 14.30	177 46.20 W	507	529	3.07
39	04 Jan 92	0456	44 20.81	177 47.75 W	626	631	3.01
40	04 Jan 92	0746	44 20.54	177 21.05 W	528	531	3.00
41	04 Jan 92	1026	44 09.82	177 24.76 W	441	455	3.04
42	04 Jan 92	1325	43 59.75	177 11.47 W	243	274	3.06
43	04 Jan 92	1703	44 15.87	177 07.38 W	427	447	2.99
44	05 Jan 92	0459	43 42.35	175 17.23 W	571	585	3.02
45	05 Jan 92	0658	43 41.12	175 06.83 W	576	580	2.94
46	05 Jan 92	0956	43 48.90	174 55.63 W	656	683	3.07
47	05 Jan 92	1215	43 43.30	175 05.80 W	574	592	2.92
48	05 Jan 92	1621	43 16.25	175 16.66 W	653	687	2.97
49	05 Jan 92	1905	43 18.36	175 30.91 W	636	653	3.04
50	06 Jan 92	0454	43 26.19	175 45.49 W	439	442	3.04
51	06 Jan 92	0728	43 22.44	176 05.71 W	392	392	1.94

Station	Date	Time	Start		Gear depth (m)		Distance towed (n. mile)	Doorspread (m)
			Latitude ° S	Longitude ° E/W	Min.	Max.		
52	06 Jan 92	0917	43 16.81	176 08.41 W	447	461	3.06	121.4
53	06 Jan 92	1240	42 58.01	176 09.96 W	731	760	3.02	121.2
54	06 Jan 92	1738	43 12.28	176 42.27 W	313	377	3.03	117.1
55	07 Jan 92	0452	43 39.96	177 24.38 W	240	253	3.02	109.8
56	07 Jan 92	0709	43 30.16	177 30.50 W	282	296	2.00	112.0
57	07 Jan 92	0937	43 18.59	177 40.50 W	340	346	3.01	108.0
58	07 Jan 92	1342	43 21.90	178 01.28 W	364	368	3.05	120.9
59	07 Jan 92	1642	43 13.70	178 00.23 W	444	450	3.02	120.8
60	08 Jan 92	0451	43 27.57	178 20.81 W	426	430	3.03	123.5
61	08 Jan 92	0747	43 14.49	178 44.20 W	456	480	3.06	121.3
62	08 Jan 92	1036	43 09.47	179 03.54 W	508	517	3.02	121.9
63	08 Jan 92	1347	42 52.03	179 12.20 W	626	662	3.04	116.4
64	08 Jan 92	1547	42 53.99	179 25.03 W	642	646	3.02	125.1
65	08 Jan 92	1757	43 02.49	179 25.84 W	526	534	2.97	125.7
66	11 Jan 92	0718	44 36.05	172 52.98 E	445	484	3.01	122.0
67	11 Jan 92	1214	44 38.93	173 10.35 E	702	780	2.98	112.3
68	11 Jan 92	1543	44 17.15	173 29.43 E	422	516	3.09	121.8
69	11 Jan 92	1848	44 12.51	173 50.96 E	568	576	3.16	113.1
70	12 Jan 92	0501	44 44.50	175 05.67 E	757	798	3.24	120.7
71	12 Jan 92	0753	44 33.26	174 57.36 E	713	754	3.06	132.6
72	12 Jan 92	1040	44 27.00	174 45.15 E	666	672	2.98	113.0
73	12 Jan 92	1422	44 22.26	174 34.81 E	649	650	2.57	124.7
74	12 Jan 92	1818	44 12.70	174 33.38 E	575	586	3.10	127.5
75	13 Jan 92	0501	44 02.44	174 44.35 E	495	508	3.08	131.4
76	13 Jan 92	0850	43 53.21	174 49.73 E	468	471	2.73	133.1
77	13 Jan 92	1148	43 45.09	174 49.42 E	464	467	3.01	133.0
78	13 Jan 92	1508	43 51.22	175 07.06 E	433	441	3.00	135.0
79	13 Jan 92	1751	43 57.79	175 06.53 E	451	463	2.99	128.6
80	14 Jan 92	0516	44 08.82	174 01.73 E	538	558	3.03	124.6
81	14 Jan 92	0739	43 55.71	174 06.16 E	441	465	2.99	119.0
82	14 Jan 92	0930	43 48.43	174 09.12 E	447	463	3.00	119.0
83	14 Jan 92	1245	43 27.13	174 15.51 E	548	570	2.37	120.3
84	14 Jan 92	1445	43 18.23	174 11.78 E	575	576	3.01	115.0
85	14 Jan 92	1714	43 06.43	174 18.09 E	626	676	3.00	127.0
86	14 Jan 92	1910	43 08.16	174 26.97 E	552	586	3.05	124.4
87	15 Jan 92	0447	43 13.13	174 56.04 E	270	314	3.02	108.1
88	15 Jan 92	0703	43 14.92	174 47.47 E	420	450	2.64	122.4
89	15 Jan 92	0850	43 07.09	174 40.01 E	514	553	2.98	126.5
90	15 Jan 92	1212	42 59.04	174 41.11 E	709	740	3.01	117.3
91	15 Jan 92	1510	42 58.06	175 01.03 E	545	582	3.03	124.0
92	15 Jan 92	1806	42 53.23	175 15.86 E	631	648	3.05	122.8
93	16 Jan 92	0447	43 02.75	175 42.23 E	466	494	2.82	122.0
94	16 Jan 92	0702	43 08.86	175 46.84 E	445	454	3.56	120.1
95	16 Jan 92	0941	43 14.68	175 54.26 E	401	442	3.18	118.0
96	16 Jan 92	1339	43 27.51	175 55.94 E	359	371	2.39	122.7
97	16 Jan 92	1813	43 34.08	175 50.03 E	274	289	3.05	113.9
98	17 Jan 92	0601	43 46.04	175 30.92 E	333	380	3.04	126.4
99	17 Jan 92	0900	43 57.39	175 31.79 E	462	480	3.09	129.8
100	17 Jan 92	1205	44 02.30	175 22.70 E	482	495	2.78	132.1
101	17 Jan 92	1548	44 08.92	174 58.42 E	500	518	3.01	127.2
102	17 Jan 92	1838	44 14.38	175 15.65 E	544	568	3.11	123.9
103	18 Jan 92	0509	44 18.23	175 24.88 E	602	654	3.05	125.0
104	18 Jan 92	0913	44 16.86	175 46.62 E	533	565	2.41	125.0

Station	Date	Time	Start		Gear depth (m)	Distance towed (n. mile)	Doorspread (m)
			Latitude ° S	Longitude ° E/W			
					Min.	Max.	
105	18 Jan 92	1306	44 26.97	175 46.54 E	716	763	2.03
106	18 Jan 92	1534	44 22.14	176 02.02 E	268	274	2.96
107	18 Jan 92	1853	44 03.11	175 53.71 E	400	482	3.22
108	19 Jan 92	0500	44 03.36	176 01.61 E	355	383	2.99
109	19 Jan 92	0758	44 07.67	176 08.07 E	200	262	2.48
110	19 Jan 92	1044	44 11.15	176 25.27 E	606	620	3.00
111	19 Jan 92	1849	44 09.98	176 31.22 E	610	624	3.17
112	20 Jan 92	0458	44 06.33	176 45.30 E	601	637	3.02
113	20 Jan 92	0722	44 05.76	176 38.53 E	560	600	3.10
114	20 Jan 92	0940	43 54.07	176 34.37 E	479	485	3.15
115	20 Jan 92	1137	43 48.64	176 34.10 E	455	470	3.13
116	20 Jan 92	1347	43 42.48	176 33.18 E	418	436	2.96
117	20 Jan 92	1717	43 43.48	176 24.82 E	414	428	3.02
118	21 Jan 92	0459	43 28.69	176 26.25 E	300	340	2.23
119	21 Jan 92	0814	43 43.74	176 44.59 E	464	472	2.97
120	21 Jan 92	1045	43 31.51	176 50.10 E	263	272	2.35
121	21 Jan 92	1316	43 28.02	177 10.19 E	251	276	3.09
122	21 Jan 92	1705	43 26.19	177 27.56 E	267	278	2.93
123	21 Jan 92	1901	43 36.68	177 31.74 E	305	328	2.89
124	22 Jan 92	0448	43 47.21	177 15.63 E	500	506	3.00
125	22 Jan 92	0727	43 59.79	177 17.93 E	649	716	2.99
126	22 Jan 92	0934	44 00.83	177 23.71 E	721	752	3.06
127	22 Jan 92	1203	43 54.22	177 27.42 E	609	624	2.99
128	22 Jan 92	1439	43 53.18	177 46.84 E	613	629	2.95
129	22 Jan 92	1653	43 45.91	177 50.33 E	460	485	3.00
130	23 Jan 92	0457	43 04.54	176 28.21 E	382	388	2.97
131	23 Jan 92	0711	42 55.27	176 16.30 E	518	566	3.26
132	23 Jan 92	0926	42 45.12	176 16.33 E	707	726	3.08
133	23 Jan 92	1250	42 44.52	176 41.62 E	681	725	3.02
134	23 Jan 92	1502	42 48.21	176 51.15 E	464	568	2.99
135	23 Jan 92	1725	42 48.60	176 57.27 E	457	558	3.00
136	23 Jan 92	1914	42 52.58	177 02.75 E	408	425	3.06
137	24 Jan 92	0501	42 52.50	177 12.86 E	401	494	3.08
138	24 Jan 92	0809	42 46.41	177 14.85 E	692	703	3.08
139	24 Jan 92	0908	42 50.09	177 20.05 E	488	531	2.97
140	24 Jan 92	1154	42 53.60	177 28.17 E	416	441	3.00
141	24 Jan 92	1413	43 04.59	177 34.84 E	313	357	2.96
142	24 Jan 92	1608	43 13.34	177 41.70 E	300	305	2.95
143	24 Jan 92	1755	43 17.07	177 53.63 E	295	301	2.95
144	25 Jan 92	1008	43 37.40	179 29.44 W	372	380	2.98
145	25 Jan 92	1314	43 30.84	179 49.41 W	398	411	2.61
146	25 Jan 92	1748	43 20.26	179 56.67 W	435	445	3.01
147	26 Jan 92	0501	43 08.04	177 29.00 W	429	471	3.01
148	26 Jan 92	0814	43 01.61	177 22.35 W	518	566	2.99
149	26 Jan 92	1037	42 57.15	177 12.72 W	601	674	3.07
150	26 Jan 92	1420	43 07.61	176 52.85 W	449	493	2.98
151	26 Jan 92	1717	43 07.29	176 36.64 W	452	498	3.05
152	27 Jan 92	0502	43 11.46	178 15.18 W	440	491	3.08
153	27 Jan 92	0713	43 05.24	178 16.97 W	521	522	3.07
154	27 Jan 92	1005	43 15.01	178 40.23 W	447	456	3.13
155	27 Jan 92	1307	43 24.77	179 07.15 W	450	454	3.08
156	27 Jan 92	1454	43 26.66	179 17.62 W	451	453	2.99
157	27 Jan 92	1714	43 18.76	179 32.62 W	478	491	3.04

Station	Date	Time	Start		Gear depth (m)		Distance towed (n. mile)	Doorspread (m)
			Latitude ° S	Longitude ° E/W	Min.	Max.		
158	27 Jan 92	1901	43 14.18	179 40.86 W	504	513	3.15	119.6
159	28 Jan 92	0758	43 10.71	177 18.39 E	237	243	3.08	106.8
160	28 Jan 92	0955	43 11.03	177 01.38 E	252	274	3.07	109.7
161	28 Jan 92	1317	43 09.55	176 26.81 E	309	324	2.96	118.2
162	28 Jan 92	1608	43 14.23	176 24.94 E	287	307	3.01	115.4
163	28 Jan 92	1751	43 20.95	176 19.42 E	289	304	2.61	112.8
164	29 Jan 92	0454	43 40.44	176 42.31 E	423	445	3.06	116.4
165	29 Jan 92	0752	43 56.72	176 34.64 E	488	513	3.12	123.5
166	29 Jan 92	1051	43 59.22	176 11.18 E	485	502	3.19	126.0
167	29 Jan 92	1304	43 48.87	176 11.34 E	428	455	2.18	123.3
168	29 Jan 92	1526	43 34.14	176 18.69 E	372	379	3.04	126.2
169	29 Jan 92	1855	43 24.99	175 55.23 E	350	394	2.15	126.8
170	30 Jan 92	0449	43 32.04	175 46.05 E	262	274	3.12	119.2
171	30 Jan 92	0739	43 35.93	175 49.77 E	285	291	3.09	123.1
172	30 Jan 92	1212	43 56.35	175 42.36 E	463	495	3.05	122.9
173	30 Jan 92	1425	43 51.06	175 29.40 E	422	428	2.96	115.9
174	30 Jan 92	1733	43 35.87	175 23.79 E	215	284	2.96	104.2
175	31 Jan 92	0502	44 02.24	174 34.96 E	530	548	2.96	107.0
176	31 Jan 92	0716	44 02.03	174 49.60 E	482	492	3.06	112.4
177	31 Jan 92	0917	44 02.53	175 00.85 E	469	483	3.05	116.1
178	31 Jan 92	1134	43 49.25	175 00.97 E	437	442	3.06	112.8
179	31 Jan 92	1351	43 44.55	175 09.13 E	404	413	3.10	117.4
180	31 Jan 92	1559	43 37.72	175 10.77 E	306	346	3.01	109.8
181	01 Feb 92	0507	43 32.32	177 06.32 E	253	279	3.00	110.9
182	01 Feb 92	0707	43 24.39	177 05.38 E	227	239	2.91	113.7
183	01 Feb 92	0918	43 23.75	176 55.15 E	252	265	3.14	115.6
184	01 Feb 92	1230	43 17.89	176 38.15 E	257	296	5.72	117.8
185	01 Feb 92	1528	43 07.36	176 38.82 E	318	362	3.14	126.9
186	01 Feb 92	1803	43 12.68	176 33.99 E	305	320	2.91	126.1

Appendix 2: Species caught during the voyage and occurrence (Occ) of each in the 186 tows

Scientific name	Common name	Code	Occ
Agnatha			
Myxinidae: hagfishes			
<i>Eptatretus cirrhatus</i>	hagfish	HAG	2
Chondrichthyes			
Hexanchidae: cow sharks			
<i>Heptranchias perlo</i>	sharp snout sevengill	HEP	1
<i>Hexanchus griseus</i>	sixgill shark	HEX	1
Squalidae: dogfishes			
<i>Centrophorus squamosus</i>	deepsea spiny dogfish	CSQ	22
<i>Centroscymnus crepidator</i>	deepwater dogfish	CYP	12
<i>Deania calcea</i>	shovelnosed dogfish	SND	82
<i>Etmopterus baxteri</i>	Baxter's dogfish	ETB	34
<i>E. lucifer</i>	Lucifer spiny dogfish	ETL	113
<i>Scymnorhinus licha</i>	seal shark	BSH	59
<i>Somniosus pacificus</i>	Pacific sleepershark	SOP	1
<i>Squalus acanthias</i>	spotted spiny dogfish	SPD	77
<i>S. mitsukurii</i>	northern spiny dogfish	NSD	11
Oxynotidae: rough sharks			
<i>Oxynotus brunneus</i>	prickly dogfish	PDG	18
Lamnidae: mackerel sharks			
<i>Isurus oxyrinchus</i>	mako	MAK	3
Scyliorhinidae: cat sharks			
<i>Apristurus</i> sp.	deepsea catshark	APR	1
<i>Cephaloscyllium isabellum</i>	carpet shark	CAR	3
<i>Haleaelurus dawsoni</i>	Dawson's catshark	DCS	3
Triakidae: smoothhounds			
<i>Galeorhinus galeus</i>	school shark	SCH	6
Torpedinidae: electric rays			
<i>Torpedo fairchildi</i>	electric ray	ERA	2
Narkidae: blind electric rays			
<i>Typhlonarke</i> sp.	numbfish	BER	9
Rajidae: skates			
<i>Raja innominata</i>	smooth skate	SSK	38
<i>R. nasuta</i>	rough skate	RSK	7
Species not identified	skates	SKA	41
Myliobatidae: eagle rays			
<i>Myliobatus tenuicaudatus</i>	eagle ray	EGR	1
Chimaeridae: chimaeras, ghost sharks			
<i>Chimaera</i> sp.	giant ghost shark	CHI	6
<i>Hydrolagus novaezelandiae</i>	dark ghost shark	GSH	80
<i>Hydrolagus</i> sp.	pale ghost shark	GSP	136
Rhinochimaeridae: longnosed chimaeras			
<i>Harriotta raleighana</i>	longnosed chimaera	LCH	85
<i>Rhinochimaera pacifica</i>	widenosed chimaera	RCH	4

Osteichthyes

Notacanthidae: spiny eels <i>Notacanthus sexspinis</i>	spineback	SBK	60
Synaphobranchidae: cutthroat eels <i>Diastobranchus capensis</i>	basketwork eel	BEE	3
Congridae: conger eels <i>Bassanago bulbiceps</i>	swollenheaded conger	SCO	59
<i>B. hirsutus</i>	hairy conger	HCO	53
Serrivomeridae: sawtooth eels <i>Serrivomer samoensis</i>	sawtooth eel	SAW	1
Gonorynchidae: sandfish <i>Gonorynchus gonorynchus</i>	sandfish	GON	3
Argentinidae: silversides <i>Argentina elongata</i>	silverside	SSI	99
Sternopychidae: hatchetfishes Species not identified	hatchetfish	HAT	1
Photichthyidae: lighthouse fishes Species not identified	lighthouse fish	PHO	1
Notosudidae: waryfishes <i>Scopelosaurus</i> sp.	slender silverside	SPL	2
Myctophidae: lanternfishes Species not identified	lanternfish	LAN	5
Moridae: morid cods <i>Austrophycis marginata</i>	dwarf cod	DCO	2
<i>Halargyreus johnsoni</i>	slender cod	HJO	10
<i>Lotella rhacinus</i>	rock cod	ROC	1
<i>Mora moro</i>	ribaldo	RIB	80
<i>Pseudophycis bachus</i>	red cod	RCO	36
<i>Tripterygion gilchristi</i>	grenadier cod	GRC	2
Euclichthyidae: Eucla cod <i>Euclichthys polynemus</i>	eucla cod	EUC	7
Gadidae: cods <i>Micromesistius australis</i>	southern blue whiting	SBW	2
Merlucciidae: hakes <i>Macruronus novaezealandiae</i>	hoki	HOK	180
<i>Merluccius australis</i>	hake	HAK	124
Macrouridae: rattails, grenadiers <i>Caelorinchus aspercephalus</i>	oblique-banded rattail	CAS	78
<i>C. biclinozonalis</i>	two saddle rattail	CBI	13
<i>C. bollonsi</i>	bigeyed rattail	CBO	166
<i>C. fasciatus</i>	banded rattail	CFA	61
<i>C. innotabilis</i>	notable rattail	CIN	3
<i>C. matamua</i>	Mahia rattail	CMA	14
<i>C. oliverianus</i>	Oliver's rattail	COL	103
<i>Caelorinchus</i> sp. C	small banded rattail	CCX	1
<i>Caelorinchus</i> sp. D	dark banded rattail	CDX	2
<i>Coryphaenoides</i> sp. A	slender rattail	CBA	13
<i>C. serrulatus</i>	serrulate rattail	CSE	5
<i>C. subserrulatus</i>	fourrayed rattail	CSU	7
<i>Lepidorhynchus denticulatus</i>	javelinfish	JAV	165
<i>Macrourus carinatus</i>	ridgescaled rattail	MCA	3
<i>Ventrifossa nigromaculata</i>	blackspot rattail	VNI	21
<i>Trachyrincus</i> sp.	unicorn rattail	WHX	13
Ophidiidae: cusk eels <i>Genypterus blacodes</i>	ling	LIN	174
Ceratiidae: seadevils <i>Cryptopsaras couesi</i>	seadevil	SDE	1
Regalecidae: oarfishes <i>Regalecus glesne</i>	oarfish	OAR	4

Trachichthyidae: roughies				
<i>Hoplostethus atlanticus</i>	orange roughy	ORH	5	
<i>H. mediterraneus</i>	silver roughy	SRH	41	
<i>Paratrachichthys trailli</i>	common roughy	RHY	11	
Diretmidae: discfishes				
<i>Diretmus argenteus</i>	discfish	DIS	1	
Berycidae: alfonsinos				
<i>Beryx splendens</i>	alfonsino	BYS	51	
Zeidae: dories				
<i>Capromimus abbreviatus</i>	capro dory	CDO	16	
<i>Cyttus novaezelandiae</i>	silver dory	SDO	21	
<i>C. traversi</i>	lookdown dory	LDO	172	
<i>Zenopsis nebulosus</i>	mirror dory	MDO	5	
Oreosomatidae: oreos				
<i>Allocyttus niger</i>	black oreo	BOE	24	
<i>Neocytthus rhomboidalis</i>	spiky oreo	SOR	44	
<i>Pseudocyttus maculatus</i>	smooth oreo	SSO	18	
Macrorhamphosidae: snipefishes				
<i>Centriscops obliquus</i>	redbanded bellowsfish	BBE	95	
<i>Notopogon lilliei</i>	crested bellowsfish	CBE	8	
Scorpaenidae: scorpionfishes				
<i>Helicolenus</i> sp.	sea perch	SPE	167	
Congiopodidae: pigfishes				
<i>Alertichthys blacki</i>	alert pigfish	API	3	
<i>Congiopodus coriaceus</i>	deepsea pigfish	DSP	1	
<i>C. leucopaecilus</i>	southern pigfish	PIG	1	
Triglidae: gurnards				
<i>Chelidonichthys kumu</i>	red gurnard	GUR	1	
<i>Lepidotrigla brachyoptera</i>	scaly gurnard	SCG	19	
Hoplichthyidae: ghostflatheads				
<i>Hoplichthys haswelli</i>	deepsea flathead	FHD	57	
Psychrolutidae: toadfishes				
<i>Cottunculus nudus</i>	bony skull toadfish	COT	2	
<i>Nephrynichthys angustus</i>	pale toadfish	TOP	25	
<i>N. latus</i>	dark toadfish	TOD	6	
Percichthyidae: temperate basses				
<i>Polyprion oxygeneios</i>	hapuku	HAP	17	
Serranidae: sea perches				
<i>Lepidoperca</i> sp. A	orange perch	OPE	29	
Apogonidae: cardinalfishes				
<i>Epigonus lenimen</i>	bigeyed cardinalfish	EPL	10	
<i>E. robustus</i>	cardinalfish	EPR	5	
<i>E. telescopus</i>	black cardinalfish	EPT	25	
Carangidae: jacks, trevallies, kingfishes				
<i>Trachurus murphyi</i>	slender mackerel	JMM	34	
<i>T. declivis</i>	jack mackerel	JMD	2	
Bramidae: pomfrets				
<i>Brama brama</i>	Ray's bream	RBM	20	
Emmelichthyidae: bonnetmouths, rovers				
<i>Emmelichthys nitidus</i>	redbait	RBT	13	
Pentacerotidae: boarfishes				
<i>Pseudopentaceros richardsoni</i>	southern boarfish	SBO	2	
Cheilodactylidae: tarakihi, morwongs				
<i>Nemadactylus macropterus</i>	tarakihi	TAR	8	
Uranoscopidae: armourhead stargazers				
<i>Kathetostoma giganteum</i>	giant stargazer	STA	127	
Pinguipedidae: weevlers				
<i>Parapercis gilliesi</i>	yellow weever	YCO	1	

Gempylidae: snake mackerels				
<i>Ruvettus pretiosus</i>	oilfish	OFH	1	
<i>Thyrsites atun</i>	barracouta	BAR	25	
Trichiuridae: cutlassfishes				
<i>Lepidopus caudatus</i>	frostfish	FRO	7	
Scombridae: mackerels, tunas				
<i>Scomber australasicus</i>	blue mackerel	EMA	2	
Centrolophidae: raftfishes, medusafishes				
<i>Centrolophus niger</i>	rudderfish	RUD	38	
<i>Hyperoglyphe antarctica</i>	bluenose	BNS	16	
<i>Icichthys australis</i>	ragfish	RAG	1	
<i>Seriola caerulea</i>	white warehou	WWA	69	
<i>S. punctata</i>	silver warehou	SWA	79	
Bothidae: lefteyed flounders				
<i>Arnoglossus scapha</i>	witch	WIT	22	
<i>Neoachiropsetta milfordi</i>	finless flounder	MAN	4	
Pleuronectidae: righteyed flounders				
<i>Pelotretis flavilatus</i>	lemon sole	LSO	15	
Cephalopoda				
Architeuthidae				
<i>Architeuthis</i> sp.	giant squid	GSQ	1	
Histioteuthidae				
<i>Histioteuthis miranda</i>	violet squid	VSQ	2	
Ommastrephidae				
<i>Nototodarus sloanii</i>	arrow squid	NOS	108	
<i>Ommastrephes bartrami</i>	red squid	RSQ	5	
Species not identified	squid	SQX	2	
Onychoteuthidae				
<i>Moroteuthis</i> spp.	warty squid	WSQ	68	
Opisthoteuthidae				
<i>Opisthoteuthis</i> sp.	umbrella octopus	OPI	5	
Amphitretidae				
<i>Amphitretus</i> sp.	deepwater octopus	AMP	2	
Octopodidae				
<i>Octopus maorum</i>	cctopus	OCT	5	
Crustacea				
Nephropsidae				
<i>Metanephrops challengeri</i>	scampi	SCI	33	
Scyllaridae				
<i>Ibacus</i> sp.	prawn killer	PRK	3	
Decapoda				
Species not identified	prawn	PRA	1	
Species not identified	crab	CRB	12	



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