Trawl survey of hake and middle depth species in the Southland and Sub-Antarctic areas, April-May 1998 (TAN9805)

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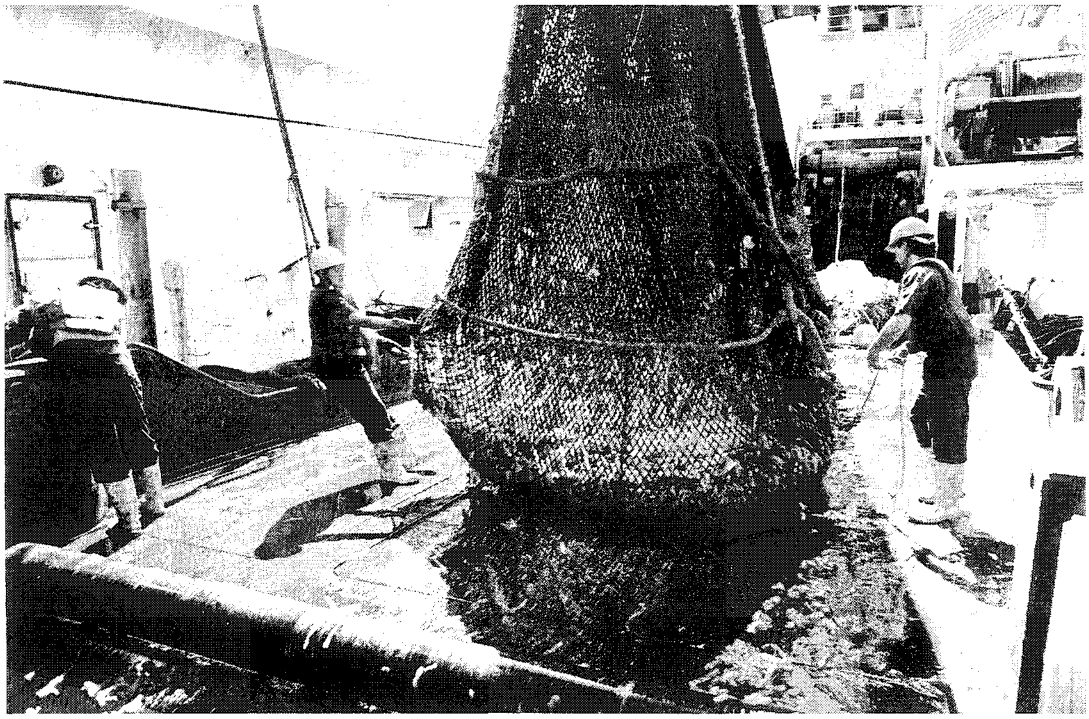

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Contents

Introduction

This report presents results from a bottom trawl survey of middle depth species carried out from 7 April to 1 May 1998 in the Southland and Sub-Antarctic areas. Its main purpose is to outline the survey design and methods and to make available data on commercially important species which are relevant to stock assessment and fisheries management.

Seasonal trawl surveys have indicated that the relative abundance of hoki, hake, and ling can vary considerably during the year because of aggregation and migration behaviour associated with spawning (Chatterton & Hanchet 1994, Ingerson & Hanchet 1995, Ingerson *et al.* 1995, Schofield & Livingston 1994a, 1994b, 1994c, Colman 1996). Ling and hake appear to be in a dispersed phase and most available to trawling during April, at which time few hoki have begun their migration to the west coast of the South Island to spawn.

The main aim of this programme was to obtain abundance indices of hake and ling while they were in this dispersed phase, at which time the variance in catch rates was expected to be low and the population more available to the trawl. Information on age structure and reproductive biology was also collected.

Sub-Antarctic surveys in autumn 1992 and 1993 (Schofield & Livingston 1994a, 1994c) were the first two surveys in the time series and the survey in April 1996 (Colman 1996) the third. The 1998 survey was optimised for estimating the abundance of hake in the survey area because the coefficients of variation of both hoki and ling have been low in the past.

Programme objective

To continue a time series of relative abundance indices primarily for ling and hake, and secondarily for hoki, in the Southland and Sub-Antarctic QMAs.

Objectives for 1997–98

1. To carry out a trawl survey in April 1998 to continue the time series of relative abundance indices for hake (HAK 1), ling (LIN 5 and 6), and hoki (western stock) on the Southern Plateau. The survey will be optimised on hake (target coefficient of variation (*c.v.*) of the estimate of 20%), with target *c.v.* for hoki and ling of 15%.
2. To determine the population age and size structure and reproductive biology of hake, ling and hoki from data collected in the trawl survey.

Survey objectives

1. To continue a time series of relative abundance estimates for hake and ling at a time when these species are dispersed.
2. To estimate the relative abundance of hoki and other middle depths species.
3. To collect biological data and samples including length, sex, gonad stage, and otoliths (at least 800 hoki and 500 ling) from middle depths species of commercial interest.
4. To check strata boundary positions using new survey depth data.

Voyage personnel

P. McMillan was the voyage leader; the skipper was R. Goodison. N. Bagley was responsible for the final database editing.

Methods

Survey area and design

The survey was of a two-phase stratified random design (*after* Francis 1981, 1989), stratified by area and depth. The allocation of stations in phase 1 was designed to optimise the sampling strategy for hake, but hoki and ling sampling was also considered. This analysis used data collected on three previous *Tangaroa* trawl surveys in this area run at this time of year. Details of this optimisation program (Allo2, developed by K. Sullivan, Ministry of Fisheries) were given by Hurst & Bagley (1994).

The survey area was the same as that of the 1996 survey (Figure 1). It was divided into 19 strata by depth (300–600, 600–800, and 800–1000 m) and area (Table 1). In the deeper water (800–1000 m), neighbouring pairs of strata used in the 1996 survey (18 and 18a, 19 and 19a, 21 and 21a, 22 and 22a) were amalgamated into four new strata (25, 26, 27, and 28) because of similar catch rates between pairs. As for the 1996 survey, there was no 800–1000 m stratum along the eastern side of the survey area as catches of hake, hoki, and ling were small from all other surveys in this area. Known areas of foul ground were excluded from the survey.

Station positions were selected randomly using the Random Stations Generation Program (Version 1.6) developed at NIWA, Greta Point. A minimum distance between stations of 3 n. miles was used. If a station was found to be on foul ground, a search was made for suitable ground within 3 n. miles of the station position. If no suitable ground could be found, the station was abandoned and another random position was substituted.

A total of 73 stations was planned for phase 1. Stratum areas and the number of stations completed are given in Table 1. About 12 phase 2 stations were to be allocated to strata with high *c.v.*s for hake, hoki, or ling after phase 1 was completed.

Vessel and gear specifications

Tangaroa is a purpose-built research stern trawler of 70 m overall length, a beam of 14 m, with 3000 kW (4000 hp) of power and a gross tonnage of 2282 t. The net was the same as that used on previous surveys of middle depth species by *Tangaroa,* i.e., an eight-seam hoki bottom trawl with 100 m sweeps, 50 m bridles, 12 m backstrops, 58.8 m groundrope, 45 m headline, and 60 mm codend mesh (*see* Chatterton & Hanchet (1994) for net plan and rigging details). The trawl doors were Super Vee type with an area of 6.1 m^2. Measurements of doorspread, (from the Scanmar 400 system) and headline height (from the Furuno net monitor) were recorded every 5 min during each tow and average values calculated.

Trawling procedure

At each station it was planned to tow during daylight hours (as defined by Hurst *et al.* 1992), for 3 n. miles at a speed over the ground of 3.5 knots. Shooting the trawl commenced no earlier than 0700 hours in the morning and no later than 1720 hours. If foul ground was encountered, or the tow hauled early due to reducing daylight, the tow was included as valid only if at least 2 n. miles had been covered. If time ran short at the end of the day and it was not possible to reach the last station, the vessel headed towards the next station and the trawl was shot on that course before 1720 hours, if at least 50% of the steaming distance to the next station was covered.

Towing speed and gear configuration were maintained as constant as possible during the survey, following the guidelines given by Hurst *et al.* (1992). The average speed over the ground was calculated from readings taken every 5 min during the tow.

Hydrology

Surface temperatures were obtained at the beginning of each tow from a temperature sensor mounted on the hull at a depth of about 5 m. Bottom temperatures were recorded from the Furuno net monitor and a CTD sensor (datalogger), both mounted on the headline of the trawl about 7.0 m above the bottom. Averaged temperature differences between the CTD datalogger and the ships equipment made from a voyage in January 1999 were -0.3 ^{0}C at the surface and +0.3 ^{0}C near the bottom (Bagley & Hurst 1998). No adjustment for this difference was made.

Catch sampling

At each station all items in the catch were sorted into species and weighed on Seaway motion-compensating electronic scales accurate to about 0.3 kg. Where possible, finfish, squid, and crustaceans were identified to species and other benthic fauna to species or family.

Biological sampling

For each species of commercial importance, samples of up to 200 individuals were randomly selected from the catch for sexing and measuring. More detailed biological data were also collected on a sub-set of these and included fish length, weight, sex, gonad stage, gonad weight, and occasional observations on stomach fullness, and contents and prey condition. Otoliths were taken from the main species, hake, hoki, and ling for age determination, and also from black oreo, bluenose, gemfish, orange roughy, ribaldo, smooth oreo, southern blue whiting and white warehou. A description of the macroscopic gonad stages used for the three main species is given in Appendix 1.

Data analysis

Biomass was estimated by the swept area method of Francis (1981, 1989) using the formulas in Vignaux (1994). The *c.v.* of the biomass was calculated, overall and for each stratum separately, from:

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

where B is biomass and S_B is the standard error of the biomass.

The catchability coefficient (an estimate of the proportion of fish in the path of the net which are caught) is the product of vulnerability, vertical availability, and areal availability. These factors were set at 1 for the analysis, the assumptions being that fish were randomly distributed over the bottom, that no fish were present above the height of the headline, and that all fish within the path of the doors were caught.

Scaled length frequencies were calculated for the main species with the Trawlsurvey Analysis Program, version 3.2, as documented by Vignaux (1994), using length-weight data from this survey when data were adequate, or using data from other relevant surveys.

Biomass estimate subtotals are given for the main species for the 300–800 m depth range (strata 1 to 15) to enable comparisons of results with previous surveys where the maximum depth was 800 m. For hoki, the biomasses of fish above 55 cm, above 65 cm, and above 74 cm were also calculated. These lengths roughly equate to fish in year classes 2+ and over, 3+ and over and adult fish respectively and enable comparisons with previous reports.

Data from all stations where the gear performance was satisfactory (codes 1 or 2) were included for estimating biomass and calculating length frequencies.

Results

Survey area and stations sampled

A total of 77 stations were occupied during the voyage with 72 phase 1 and 5 phase 2 stations (Appendix 2) distributed through 19 strata (*see* Table 1). Station 22 in stratum 9 was not included in the analysis because the trawl came fast. The total survey area covered was 320 640 km^2 with an average station density of 1:4219 km^2 achieved.

Gear performance

Gear parameters by depth and for all observations are summarised in Table 2. The headline height was obtained on every tow, but there were no doorspread readings for three tows. Missing doorspread values were calculated from data collected in the same depth range on this voyage. Doorspreads exceeded the recommended values given by Hurst *et al.* (1992) on 10 tows. Rough weather is thought to influence doorspread (Hurst & Bagley 1992) and swell heights over 4.0 m and rough to very rough sea conditions would have been a contributing factor. The doorspreads over 130 m were not considered a problem and these tows were included in the analysis. Both headline height and doorspread were similar to those obtained on other voyages of *Tangaroa* in this area when the same gear was used.

Catch

One hundred and seventeen species or species groups were recorded: 76 teleosts, 25 elasmobranchs, 5 cephalopods, and 11 crustaceans. Other benthic and pelagic organisms were recorded in broad groupings. A list of all species caught, their species codes, and the number of stations at which they occurred is given in Appendix 3.

The total catch of 45.0 t was mainly hoki (11.7 t), ling (4.1 t), black oreo (4.0 t), javelinfish (3.0 t), smooth oreo (2.8 t), and southern blue whiting (2.1 t).

Biomass estimates

Biomass estimates and catch weights of the 19 most abundant commercial species and the 14 most abundant non-commercial species are given in Table 3. Estimates of hoki biomass by stratum and size class, and in total, are given in Table 4. Biomass estimates by stratum are given for the 11 most abundant commercial species in Table 5a, and for 8 non-commercial species in Table 5b.

Catch rates

The catch rates and standard deviations of the 12 most abundant commercial species and of the 8 most abundant non-commercial species by stratum are given in Tables 6a and 6b. The distribution and catch rates at each station for hake, hoki, and ling are given in Figures 2 to 4, and for other commercial species in Figures 5a to 5i.

Catch rates of hake were highest on the Puysegur Bank and northern Pukaki Rise and were spread across all depths. Few hake were taken in the east of the survey area. Hoki and ling were fairly evenly distributed throughout, but catches were small below 800 m depth. Hoki were taken on all but one of the biomass stations and ling were taken on all stations in less than 800 m depth. Southern blue whiting catch rates were highest in the eastern half of the survey area in three strata (12, 13 and 14, eastern Pukaki to Campbell). Orange roughy, black oreo, and smooth oreo were taken in the northeastern strata deeper than 800 m. Orange roughy were also caught at Puysegur. Pale ghost shark were widely distributed throughout most of the survey area, whereas dark ghost shark, ribaldo, spiny dogfish, and white warehou were caught only on a few stations in the northwest and at Puysegur.

Biological data

The numbers of fish of each species measured or examined in more detail are shown in Table 7. Length-weight relationships used to scale length frequency data are given in Table 8. Length frequency histograms by sex for hake, hoki, and ling are shown in Figure 6, and for the other most abundant commercial species in Figure 7.

Hake length frequencies were irregular, but with a similar range of sizes as the 1996 survey. Hoki length frequencies show three juvenile cohorts (the relatively strong 1994 and weaker 1995 and 1996 year classes), with modes at about 62–63, 55–56 (age 2+), and 43–44 cm (age 1+) respectively. Numbers of 1+ and 2+ hoki were lower than were taken in the 1996 survey. The 1993 cohort is also detectable in the female length frequency distribution with a mode at about 66 cm. There is a further mode, of adults, at about 72 cm (males) and 74 cm (females). Ling length frequencies show a reduction in the modal size of larger male and female fish compared to the 1996 results. The southern blue whiting length frequency distribution was dominated by males from 35 to 42 cm and females from 38 to 45 cm. Otoliths taken from hake, hoki, and ling have been aged and calculated numbers at age are given in Appendix 4.

Gonad stages for gemfish, hake, hoki, ling, lookdown dory, orange roughy, ribaldo, southern blue whiting, and white warehou are summarised in Table 9. Most hoki, southern blue whiting, and female ling were resting (stage 2); female hake were also mainly resting, with some mature fish (stage 3), but males included some ripe (stage 4) and running ripe (stage 5) fish. Gemfish, orange roughy, ribaldo, and white warehou had some maturing fish. Hoki were showing some early signs of maturation (stage 3) towards the end of the voyage.

Hydrology

Surface temperatures (Figure 8) varied from 7.2 °C in the southeast of the survey area to 12.7 °C on Puysegur Bank in the northwest. Recorded bottom temperatures from the Furuno net monitor ranged from 5.7 to 7.9 °C in the Sub-Antarctic area (Figure 9). The warmest bottom temperatures of about 10.0 °C were recorded at Puysegur.

Discussion

The survey was successfully completed with the loss of about 2 days to bad weather. Seventy-seven trawl stations were completed out of the planned 85 in the 25 days *Tangaroa* spent in the survey area. The number of stations carried out each day was limited by the approximately 12 hours of daylight in April and the large distances between stations.

The *c.v.*s of the biomass estimates for the three target species were all within the acceptable range for the survey of 20% for hake and 15% for ling and hoki. The values for ling and hoki were low, reflecting the widespread and relatively even distribution of catches of these two species, with the exception of the 800–1000 m strata for ling where abundance was low. This suggests that the survey design and stratification for those species is appropriate to achieve the target *c.v.*s. Hake distribution was much more patchy with two relatively high and several nil catches contributing to a slightly higher *c.v.* on the biomass estimate.

Hoki was the dominant species caught on the survey, followed by ling and southern blue whiting. These were also the top three in the 1996 survey, except that the order of ling and southern blue whiting was reversed. The biomass estimates for the three target species were not significantly different from estimates in the 1996 survey (i.e., hoki, 71 738 t and 67 832 t; ling, 30 950 t and 32 520 t; hake, 3946 t and 2850 t, respectively).

The hoki length distribution from the 1998 survey is substantially different from that of the 1996 survey. In 1998, there were two relatively weak year classes, with modal lengths of about 44 (age 1+) and 55 cm (age 2+), compared to fish of 62 cm TL and greater. This is reflected in the calculated numbers at age (*see* Appendix 4) which indicate a predominance of 3+ to 6+ year old hoki, reflecting the relatively strong recruitment from 1991 to 1994. Corresponding biomass estimates by stratum show fewer fish below 60 cm in important strata for 1+ and 2+ hoki (strata 1, 2, 3, and 4) than in the 1996 survey.

The ling length distribution from 1998 appears similar to that from 1996 except for more fish in the 60–70 cm range. A decline in numbers of large ling was suggested by Colman (1996), but the 1998 distribution is similar to that from the 1996 survey. Hake length distributions from the 1996 and 1998 surveys were erratic and comparison is difficult. The low numbers of fish caught on these surveys may be a problem for developing reliable time series of numbers at age.

The bathymetric contours used to define the strata for this survey were not accurate in a few areas. This does not present a problem in comparison of relative biomass estimates between surveys. Correcting the stratum boundaries was outside the scope of this project but, it would be sensible to analyse available bathymetry data to refine the strata before any future survey.

Acknowledgments

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Table 1: **Stratum areas, depths, number of valid (biomass) phase 1 and phase 2 stations and station density**

Stratum	Name	Depth (m)	Area (km^{2})	Number of stations phase 1	Number of stations phase 2	Station density (km^{2})
1	Puysegur Bank	300–600	4 441	3	–	1 : 1 480
2	Puysegur Bank	600–800	1 319	3	–	1 : 440
3	Stewart-Snares	300–600	6 163	3	–	1 : 2 054
4	Stewart-Snares	600–800	20 727	4	–	1 : 5 182
5	Snares-Auckland	600–800	6 279	3	–	1 : 2 093
6	Auckland Is.	300–600	16 767	3	–	1 : 5 589
7	South Auckland	600–800	8 372	3	–	1 : 2 791
8	NE Auckland	600–800	17 349	6	–	1 : 2 892
9	N Campbell Is.	300–600	27 359	5	–	1 : 5 472
10	S Campbell Is.	600–800	11 145	3	–	1 : 3 715
11	NE Pukaki Rise	600–800	23 120	4	–	1 : 5 780
12	Pukaki	300–600	45 226	6	–	1 : 7 538
13	NE Camp. Plateau	300–600	36 075	5	–	1 : 7 215
14	E Camp. Plateau	300–600	27 403	4	–	1 : 6 851
15	E Camp. Plateau	600–800	15 033	3	–	1 : 5 011
25 (18+18A)*	Puysegur Bank	800–1 000	1 927	3	–	1 : 642
26 (19+19A)*	SW Campbell Is.	800–1 000	30 512	4	–	1 : 7 628
27 (21+21A)*	NE Pukaki Rise	800–1 000	12 990	3	5	1 : 1 624
28 (22+22A)*	E Stewart Is.	800–1 000	8 433	3	–	1 : 2 811
Total			320 640	71	5	1: 4 219

* Figures in brackets are equivalent strata from the 1996 survey.

Table 2: **Survey tow and gear parameters (recorded values only). Values are number of tows (*n*), and the mean, standard deviation (*s.d.*), and range of observations for each parameter**

	n	Mean	*s.d*	Range
Tow parameters				
Tow length (n.miles)	76	2.99	0.11	2.01–3.04
Tow speed (knots)	76	3.43	0.18	2.8–3.7
Gear parameters (m)				
300–600 m				
Headline height	29	7.3	0.34	6.7–8.3
Doorspread	24	117.1	6.07	107.8–128.2
600–800 m				
Headline height	29	7.2	0.36	6.7–8.5
Doorspread	27	121.4	6.73	110.8–133.7
800–1000 m				
Headline height	18	7.2	0.21	6.9–7.6
Doorspread	17	122.6	8.49	111.6–135.3
All stations 300–1000 m				
Headline height	76	7.2	0.32	6.7–8.5
Doorspread	68	120.2	7.27	107.8–135.3

Table 3: **Biomass estimates, coefficients of variation, and catch of the major species**

	Species code	Biomass (t)	*c.v* (%)	Catch (kg)
Commercial species where biomass > 100 t				
Hoki (all)	HOK	71 738	10.2	11 666
Hoki (> 74 cm)	HOK	47 411	12.2	–*
Hoki (> 65 cm)	HOK	66 738	10.5	–*
Hoki (> 55 cm)	HOK	71 287	10.2	–*
Ling	LIN	30 950	8.8	4 082
Southern blue whiting	SBW	22 199	23.2	2 063
Pale ghost shark	GSP	15 758	10.0	2 073
Black oreo	BOE	11 602	63.3	3 954
Smooth oreo	SSO	8 884	27.0	2 769
Hake	HAK	3 946	16.2	1 185
White warehou	WWA	2 887	67.8	759
Ghost shark	GSH	2 490	44.0	346
Spiny dogfish	SPD	2 125	48.3	610
Ribaldo	RIB	1 067	13.0	455
Orange roughy	ORH	718	17.4	324
Arrow squid	NOS	711	22.9	153
Smooth skate	SSK	536	62.1	87
Lookdown dory	LDO	529	32.6	86
Giant stargazer	STA	225	29.3	80
Gemfish	SKI	212	76.3	88
Bluenose	BNS	137	100.0	40
Barracouta	BAR	135	100.0	59
Non-commercial species where biomass > 1000 t				
Javelinfish	JAV	18 890	10.3	3 049
Ridge scaled rattail	MCA	5 102	18.4	842
Oblique banded rattail	CAS	3 547	17.0	459
Silverside	SSI	3 334	19.2	308
Shovelnose dogfish	SND	2 442	51.4	2 092
Longnose chimaera	LCH	2 439	29.5	279
Warty squid	MIQ	2 245	8.8	375
Oliver's rattail	COL	2 210	22.8	447
Baxter's dogfish	ETB	2 027	16.2	534
Leafscale gulper shark	CSQ	2 018	44 6	1 233
Small scale brown slickhead	SSM	1 938	28.9	352
Banded rattail	CFA	1 897	9.0	387
Longnose velvet dogfish	CYP	1 674	21.1	1 114
Finless flounder	MAN	1 164	18.2	118

* Catch was not calculated for separate hoki size classes

Table 4: **Estimated biomass (t) of hoki by stratum and length; coefficients of variation in parentheses (%)**

		Total length (cm)			
Stratum	Total	< 55	55–65	66–74	> 74
1	770 (75)	232 (55)	377 (82)	77 (92)	84(100)
2	566 (15)	9(100)	190 (40)	171 (18)	195 (64)
3	3 412 (62)	170 (51)	777 (45)	723 (69)	1 742 (84)
4	2 915 (13)	6(100)	262 (20)	696 (24)	1 950 (16)
5	1 639 (32)	2(100)	263 (48)	566 (48)	807 (15)
6	4 834 (28)	0	747 (33)	2 308 (31)	1 778 (22)
7	1 580 (9)	0	61 (50)	309 (8)	1 210 (12)
8	4 255 (16)	3 (65)	381 (29)	1 105 (21)	2 766 (18)
9	9 042 (31)	18 (27)	1 929 (37)	2 532 (16)	4 562 (50)
10	5 633 (85)	0	21 (52)	1 080 (89)	4 533 (84)
11	9 487 (24)	0	14(100)	921 (31)	8 552 (24)
12	9 707 (19)	6(100)	108 (54)	2 432 (38)	7 161 (21)
13	4 986 (38)	5(100)	312 (83)	2 028 (53)	2 641 (22)
14	6 716 (19)	0	225 (50)	2 087 (41)	4 404 (12)
15	2 536 (35)	0	6(100)	407 (82)	2 150 (29)
Subtotal (Strata 1–15)	68 106 (11)	450 (34)	5 675 (17)	17 443 (13)	44 537 (12)
25	117 (34)	0	3(100)	33 (77)	81 (34)
26	820 (22)	0	9(100)	60 (75)	751 (22)
27	1 277 (22)	0	4 (65)	80 (28)	1 193 (22)
28	1 418 (52)	0	48 (64)	280 (57)	1 089 (51)
Total (All strata)	71 738 (10)	450 (34)	5 739 (16)	17 896 (12)	47 652 (12)

Table 5a: **Estimated biomass (t) and coefficients of variation (%, in parentheses) of the major commercial species* by stratum**

Stratum	LIN	SBW	GSP	BOE	SSO	HAK	WWA	GSH	SPD	RIB	ORH
1	111.2	0	25	0	0	93	0	78	1 151	46	0
	(37)		(77)			(100)		(100)	(86)	(100)	
2	63	0	4	0	0	140	40	0	0	126	34
	(64)		(60)			(65)	(100)			(24)	(100)
3	1 817	1	125	0	0	356	2 017	144	18	28	0
	(39)	(100)	(71)			(55)	(96)	(100)	(100)	(100)	
4	1 307	0	2 032	0	0	362	280	0	6	91	0
	(30)		(6)			(45)	(58)		(100)	(51)	
5	500	0	508	0	0	169	11	6	0	63	0
	(30)		(34)			(44)	(100)	(100)		(8)	
6	2 040	307	154	0	0	252	152	2 241	471	0	0
	(23)	(99)	(100)			(60)	(43)	(48)	(42)		
7	422	3	143	0	11	134	0	5	0	52	29
	(35)	(100)	(42)		(100)	(54)		(100)		(51)	(100)
8	1 414	2	1 379	0	0	286	57	0	16	185	0
	(24)	(100)	(35)			(34)	(72)		(72)	(28)	
9	3 167	961	2 775	0	0	173	68	16	8	135	0
	(16)	(59)	(36)			(62)	(63)	(100)	(100)	(42)	
10	485	0	307	0	0	123	0	0	0	64	25
	(49)		(36)			(51)				(45)	(100)
11	2 133	1 547	606	0	23	89	0	0	13	46	0
	(39)	(56)	(34)		(100)	(100)			(100)	(51)	
12	5 931	9 555	4 481	0	0	38	160	0	151	0	0
	(13)	(35)	(14)			(100)	(38)		(55)		
13	5 329	4 322	1 139	0	0	59	101	0	30	0	0
	(32)	(40)	(29)			(100)	(74)		(62)		
14	4 536	5 216	1 325	0	0	199	0	0	261	0	0
	(27)	(64)	(55)			(100)			(58)		
15	1 578	284	117	0	0	80	0	0	0	0	0
	(28)	(53)	(35)			(100)					
Subtotal	30 833	22 199	15 118	0	34	2 554	2 887	2 490	2 125	837	89
(Strata 1–15)	(9)	(23)	(10)		(75)	(18)	(68)	(44)	(48)	(14)	(58)
25	17	0	15	0	1	89	0	0	0	84	44
	(54)		(76)		(23)	(43)				(20)	(39)
26	48	0	315	3	32	97	0	0	0	91	39
	(100)		(45)	(100)	(60)	(64)				(58)	(52)
27	25	1	76	7 945	4 531	753	0	0	0	11	471
	(67)	(100)	(44)	(89)	(35)	(52)				(66)	(22)
28	28	0	234	3 654	4 286	452	0	0	0	45	75
	(100)		(27)	(55)	(42)	(49)				(100)	(46)
Total	30 950	22 199	15 758	11 602	8 884	3 946	2 887	2 490	2 125	1 067	718
(All strata)	(9)	(23)	(10)	(63)	(27)	(16)	(68)	(44)	(48)	(13)	(17)

* Species codes are given in Table 3

Table 5b: **Estimated biomass (t) and coefficients of variation (%, in parentheses) of other major species* by stratum**

Stratum	JAV	MCA	CAS	SND	COL	ETB	CSQ	CYP
1	65	0	5	1 161	4	0	790	0
	(93)		(43)	(100)	(100)		(100)	
2	219	4	0	1 001	29	1	457	221
	(29)	(100)		(46)	(51)	(100)	(59)	(91)
3	311	0	584	0	1	3	0	23
	(61)		(60)		(100)	(100)		(100)
4	790	18	4	0	499	229	0	0
	(28)	(100)	(100)		(61)	(37)		
5	363	13	0	58	19	211	209	0
	(43)	(100)		(100)	(63)	(81)	(79)	
6	292	0	100	0	0	0	193	0
	(66)		(52)				(100)	
7	654	317	0	14	313	51	191	0
	(31)	(96)		(100)	(48)	(100)	(100)	
8	1 192	54	11	0	342	99	87	0
	(30)	(100)	(46)		(39)	(45)	(100)	
9	1 671	0	412	0	98	56	83	0
	(38)		(43)		(57)	(100)	(100)	
10	349	196	0	22	245	26	0	0
	(22)	(57)		(100)	(62)	(51)		
11	3 172	397	7	157	296	165	0	0
	(14)	(63)	(59)	(66)	(87)	(41)		
12	3 538	0	976	0	0	24	0	0
	(20)		(30)			(100)		
13	2 335	0	927	0	0	0	0	0
	(37)		(32)					
14	1 975	0	518	0	105	13	0	0
	(62)		(34)		(100)	(100)		
15	734	0	3	0	6	46	0	0
	(18)		(100)		(54)	(71)		
Subtotal	17 659	999	3 547	2 413	1 957	922	2 010	244
(strata 1–15)	(11)	(41)	(17)	(53)	(25)	(25)	(45)	(83)
(300 – 800 m)								
25	75	18	0	20	7	24	7	429
	(50)	(50)		(20)	(100)	(83)	(89)	(23)
26	77	3 111	0	0	2	144	0	172
	(43)	(25)			(100)	(39)		(45)
27	915	771	0	9	33	695	0	645
	(35)	(38)		(100)	(95)	(31)		(39)
28	164	204	0	0	211	242	0	184
	(62)	(24)			(60)	(34)		(36)
Total	18 890	5 103	3 547	2 442	2 210	2 027	2 018	1 674
(All strata)	(10)	(18)	(17)	(51)	(23)	(16)	(45)	(21)
(300 – 1000 m)								

* Species codes are given in Table 3.

Table 6a: **Catch rates (kg.km^{-2}) and standard deviations (in parentheses) of the major commercial species* by stratum**

Stratum	HOK	LIN	SBW	GSP	BOE	SSO	HAK	WWA	GSH	SPD	RIB	ORH
1	173	25	0	6	0	0	21	0	18	259	10	0
	(226)	(16)		(7)			(36)		(31)	(387)	(18)	
2	429	48	0	3	0	0	106	30	0	0	95	26
	(112)	(53)		(3)			(120)	(53)			(39)	(45)
3	554	295	1	20	0	0	58	327	23	3	5	0
	(596)	(201)	(1)	(25)			(55)	(547)	(40)	(5)	(8)	
4	140	63	0	98	0	0	17	14	0	1	4	0
	(37)	(38)		(13)			(16)	(16)		(1)	(4)	
5	261	80	0	81	0	0	27	2	1	0	10	0
	(144)	(42)		(48)			(21)	(3)	(2)		(1)	
6	288	122	18	9	0	0	15	9	134	28	0	0
	(138)	(48)	(31)	(16)			(16)	(7)	(112)	(20)		
7	189	50	1	17	0	1	16	0	1	0	6	4
	(30)	(31)	(1)	(12)		(2)	(15)		(1)		(5)	(6)
8	245	82	1	79	0	0	16	3	0	1	11	0
	(95)	(48)	(1)	(69)			(14)	(6)		(2)	(7)	
9	330	116	35	101	0	0	6	2	1	1	5	0
	(229)	(40)	(46)	(82)			(9)	(4)	(1)	(1)	(5)	
10	505	43	0	28	0	0	11	0	0	0	6	2
	(740)	(37)		(17)			(10)				(5)	(4)
11	410	92	67	26	0	1	4	0	0	1	2	0
	(194)	(71)	(75)	(18)		(2)	(8)			(1)	(2)	
12	215	131	211	99	0	0	1	4	0	3	0	0
	(102)	(43)	(181)	(35)			(2)	(3)		(5)		
13	138	148	120	32	0	0	2	3	0	1	0	0
	(118)	(107)	(106)	(20)			(4)	(5)		(1)		
14	245	166	190	48	0	0	7	0	0	10	0	0
	(94)	(90)	(244)	(53)			(15)			(11)		
15	171	105	19	8	0	0	5	0	0	0	0	0
	(105)	(50)	(17)	(5)			(9)					
25	61	9	0	8	0	1	46	0	0	0	43	23
	(36)	(8)		(10)		(1)	(34)				(15)	(16)
26	27	2	0	10	1	1	3	0	0	0	3	1
	(12)	(3)		(9)	(1)	(1)	(4)				(3)	(1)
27	98	2	1	6	612	349	58	0	0	0	1	36
	(61)	(4)	(1)	(7)	(1 539)	(350)	(85)				(1)	(23)
28	168	3	0	28	433	508	54	0	0	0	5	9
	(153)	(6)		(13)	(415)	(367)	(46)				(9)	(7)

* Species codes are given in Table 3.

Table 6b: **Catch rates (kg.km^{-2}) and standard deviations (in parentheses) of other major species* by stratum**

Stratum	JAV	MCA	CAS	SND	COL	ETB	CSQ	CYP
1	15	0	1	262	1	0	178	0
	(24)		(1)	(453)	(1)		(308)	
2	166	3	0	759	22	1	347	168
	(83)	(5)		(599)	(20)	(1)	(353)	(266)
3	50	0	95	0	1	1	0	4
	(53)		(98)		(1)	(1)		(6)
4	38	1	1	0	24	11	0	0
	(22)	(2)	(1)		(30)	(8)		
5	58	2	0	9	3	34	33	0
	(43)	(3)		(16)	(3)	(47)	(45)	
6	17	0	6	0	0	0	11	0
	(20)		(5)				(20)	
7	78	38	0	2	37	6	23	0
	(42)	(63)		(3)	(31)	(11)	(40)	
8	69	3	1	0	20	6	5	0
	(50)	(8)	(1)		(19)	(6)	(12)	
9	61	0	15	0	4	2	3	0
	(51)		(15)		(5)	(5)	(7)	
10	31	18	0	2	22	2	0	0
	(12)	(17)		(3)	(23)	(2)		
11	137	17	1	7	13	7	0	0
	(38)	(22)	(1)	(9)	(22)	(6)		
12	78	0	22	0	0	1	0	0
	(39)		(16)			(1)		
13	65	0	26	0	0	0	0	0
	(53)		(19)					
14	72	0	19	0	4	1	0	0
	(89)		(13)		(8)	(1)		
15	49	0	1	0	1	3	0	0
	(15)		(1)		(1)	(4)		
25	39	9	0	10	4	12	4	223
	(33)	(8)		(4)	(6)	(18)	(6)	(87)
26	3	102	0	0	1	5	0	6
	(2)	(51)			(1)	(4)		(5)
27	70	59	0	1	3	53	0	50
	(69)	(64)		(2)	(7)	(47)		(55)
28	19	24	0	0	25	29	0	22
	(21)	(10)			(26)	(17)		(14)

* Species codes are given in Table 3.

Table 7: **Numbers of fish for which length, sex, and biological data were collected**

Species	Length frequency data				Biological data	
	No. of samples	No. of fish	No. of males	No. of females	No. of samples	No. of fish
Arrow squid	26	234	125	109	1	1
Barracouta	1	23	4	19	0	0
Black oreo	10	1 017	515	500	1	20
Bluenose	1	3	0	3	1	3
Blue warehou	1	4	1	3	0	0
Cardinalfish	2	12	6	6	0	0
Dark ghost shark	8	280	152	128	4	142
Gemfish	2	14	9	5	1	12
Giant stargazer	8	20	5	15	0	0
Hake	46	318	104	214	46	280
Hapuku	1	3	0	3	0	0
Hoki	75	7 583	3 149	4 428	73	1 633
Ling	64	1 585	816	767	63	1 040
Lookdown dory	17	88	26	61	1	17
Oblique banded rattail	3	155	0	155	0	0
Orange roughy	20	576	196	216	11	109
Pale ghost shark	69	1 149	565	584	50	887
Ray's bream	9	24	10	14	2	4
Red cod	2	39	24	15	1	0
Ribaldo	37	206	32	174	33	154
Rough skate	3	4	2	2	3	4
Scampi	3	27	18	9	3	27
Silverside	29	1 190	566	619	2	232
Silver warehou	1	6	1	5	0	0
Smooth oreo	17	1 689	877	801	1	20
Smooth skate	3	4	1	3	3	4
Southern blue whiting	30	2 808	1 416	1 391	27	445
Spiky oreo	1	1	0	1	0	0
Spiny dogfish	20	206	44	162	0	0
White warehou	20	238	164	68	19	166
Yellow-eyed rattail	6	134	51	83	6	134

Table 8: **Length-weight regression parameters* used to scale length frequencies**

Species	Regression parameters *a*	*b*	r^2	*n*	Length range (cm)	Data source
Black oreo	0.024800	2.9500	0.98	9 790	11–44	Schofield & Livingston 1996
Dark ghost shark	0.005682	3.020959	0.92	142	42–69	TAN9805
Pale ghost shark	0.009228	2.888717	0.98	887	24–84	TAN9805
Hake	0.002479	3.241382	0.98	280	51–116	TAN9805
Hoki	0.006291	2.829721	0.95	1 633	41–106	TAN9805
Ling	0.001260	3.310141	0.97	1 040	37–123	TAN9805
Orange roughy	0.032675	3.020391	0.98	109	12–43	TAN9805
Ribaldo	0.003204	3.308889	0.96	154	31–71	TAN9805
Smooth oreo	0.030900	2.8950	0.98	9 147	10–57	Schofield & Livingston 1996
Southern blue whiting	0.004688	3.093100	0.98	445	21–57	TAN9805
Spiny dogfish	0.0002	3.74	0.94	845	49–107	Bagley & Hurst 1996
White warehou	0.013197	3.150885	0.99	166	23–62	TAN9805

* $W = aL^b$ where W is weight (g) and L is length (cm); r^2 is the correlation coefficient, *n* is the number of samples.

Table 9: **Numbers of fish at each reproductive stage***

Species		Reproductive stage 1	2	3	4	5	6	7	Total
Hake	Male	30	5	5	24	20	7	0	91
	Female	100	37	43	0	0	6	2	188
Hoki	Male	61	471	58	0	0	0	0	590
	Female	108	892	41	0	0	0	0	1 041
Lookdown dory	Male	0	0	0	0	0	0	0	0
	Female	0	11	1	0	0	0	5	17
Ling	Male	108	208	137	71	2	0	0	526
	Female	156	308	0	0	0	0	0	464
Orange roughy	Male	8	4	42	0	0	0	0	54
	Female	17	11	26	0	0	0	0	54
Ribaldo	Male	0	2	10	0	0	0	0	12
	Female	1	73	54	0	0	0	0	128
Southern blue whiting	Male	10	164	0	0	0	0	0	174
	Female	15	222	0	0	0	0	0	237
Gemfish	Male	0	0	8	0	0	0	0	8
	Female	0	0	4	0	0	0	0	4
White warehou	Male	33	40	31	0	0	0	0	104
	Female	26	8	21	0	0	0	1	56

* See Appendix 1 for description of gonad stages

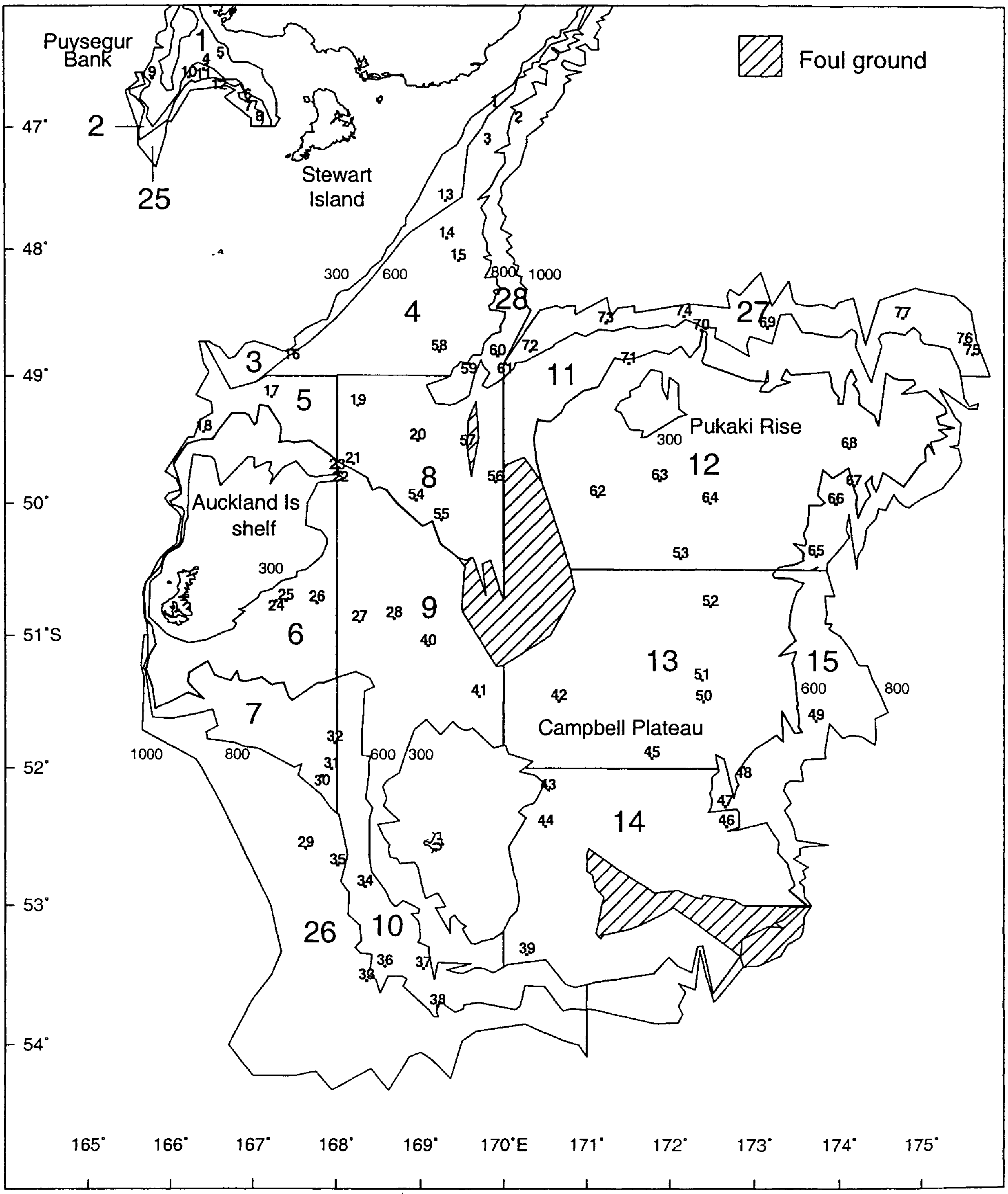

Figure 1: Survey area,depth contours, strata, and station positions.

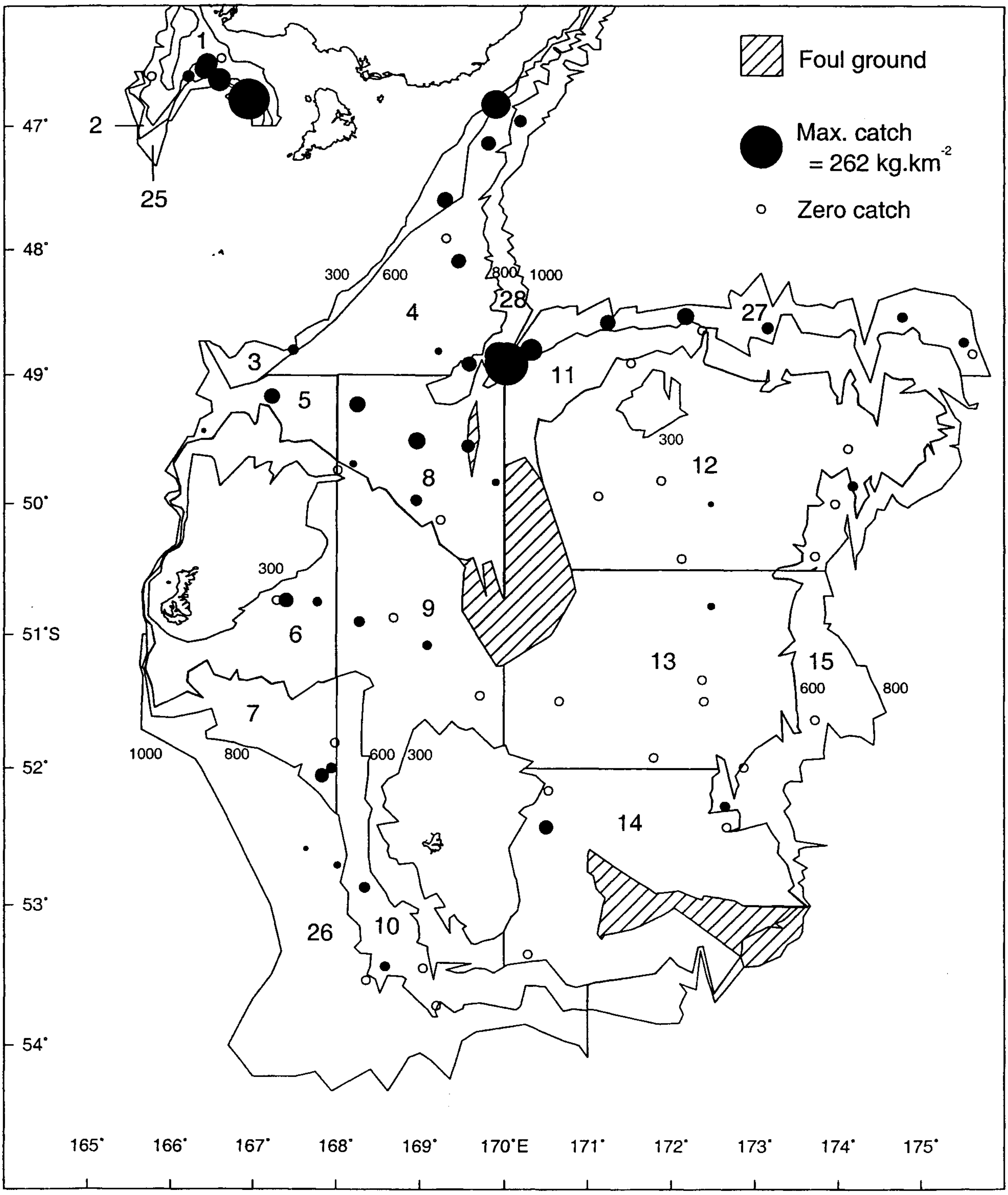

Figure 2: Distribution and catch rates of hake. Circle area is proportional to the maximum catch rate (Max. catch).

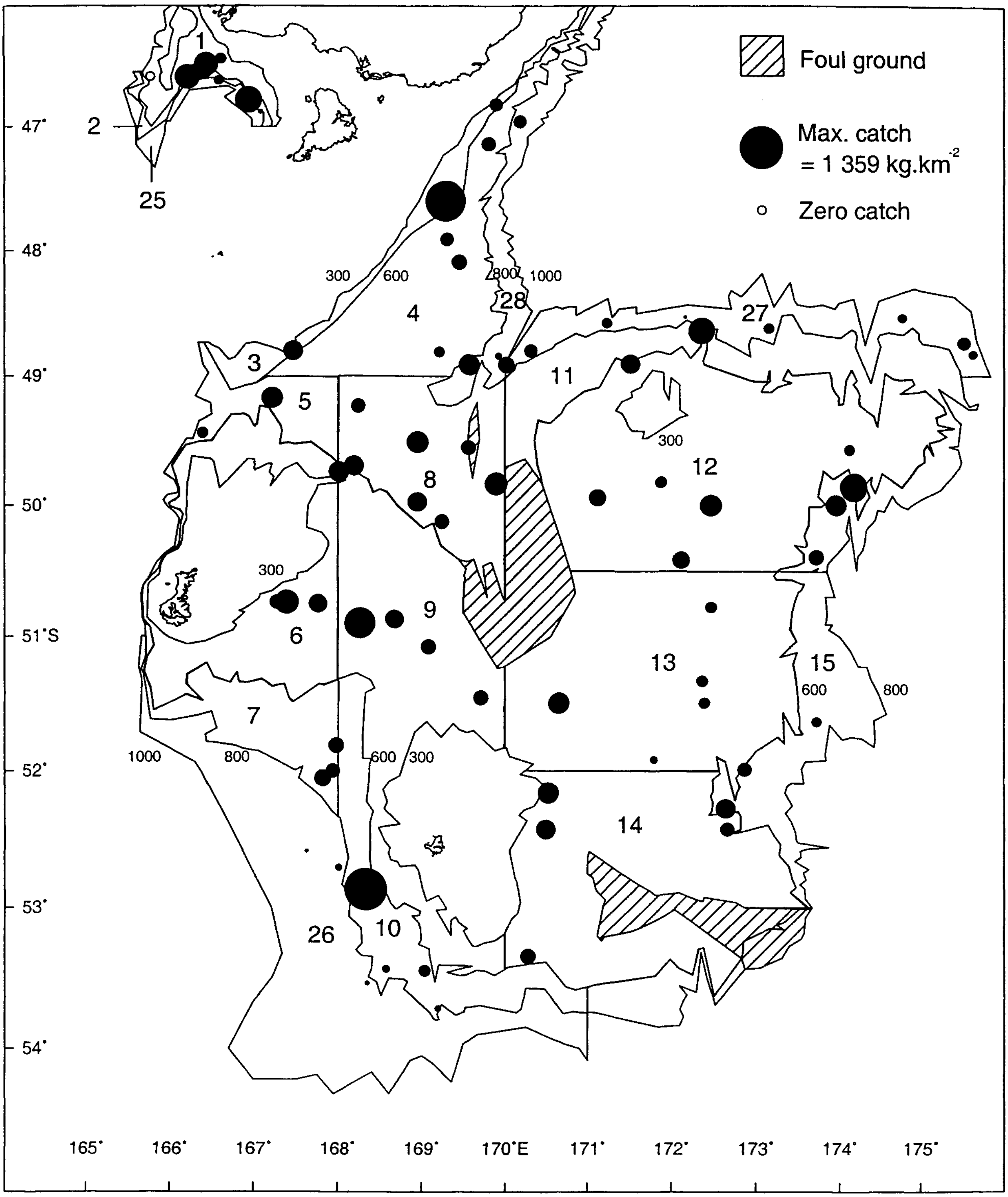

Figure 3: Distribution and catch rates of hoki. Circle area is proportional to the maximum catch rate (Max. catch).

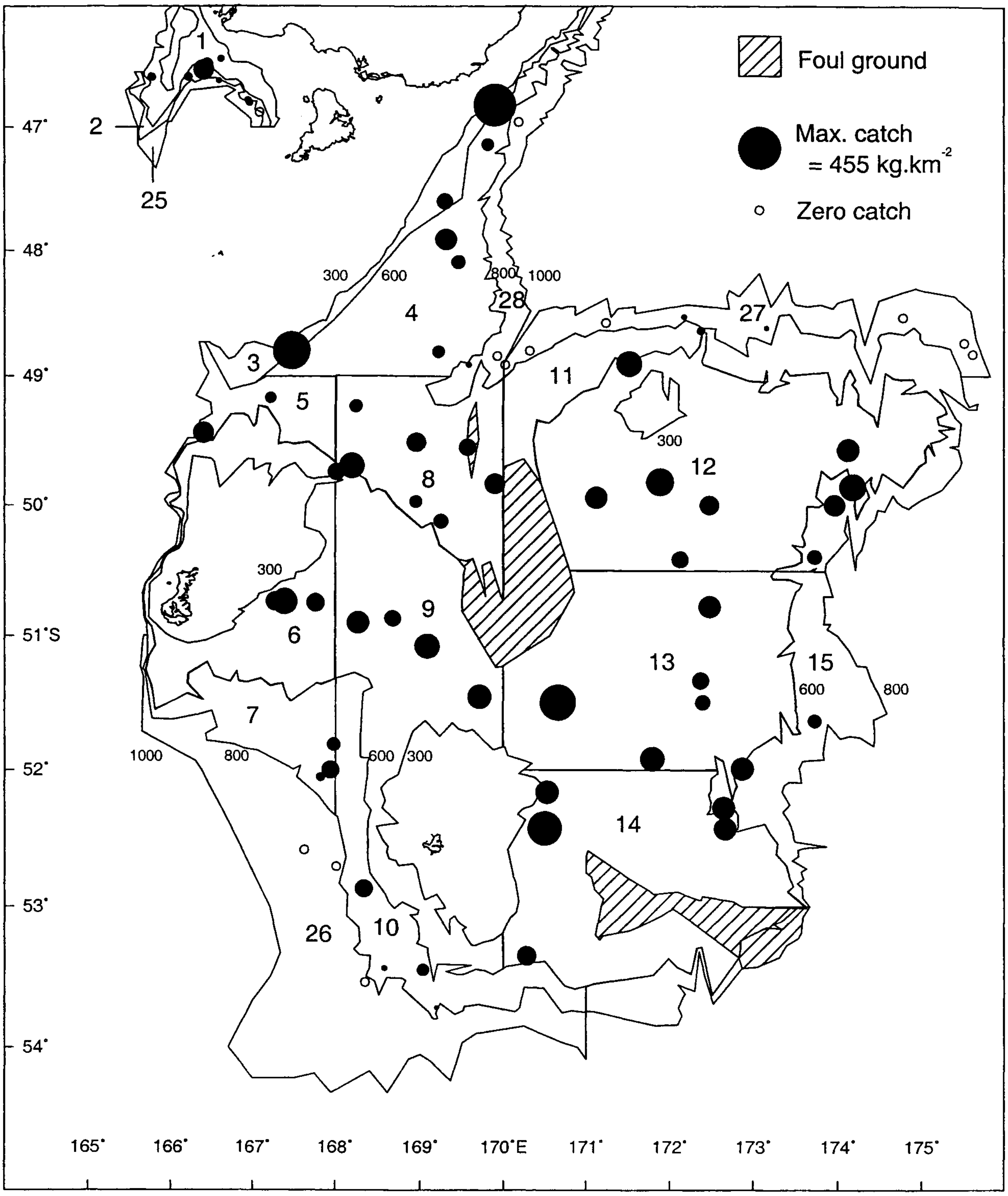

Figure 4: Distribution and catch rates of ling. Circle area is proportional to the maximum catch rate (Max. catch).

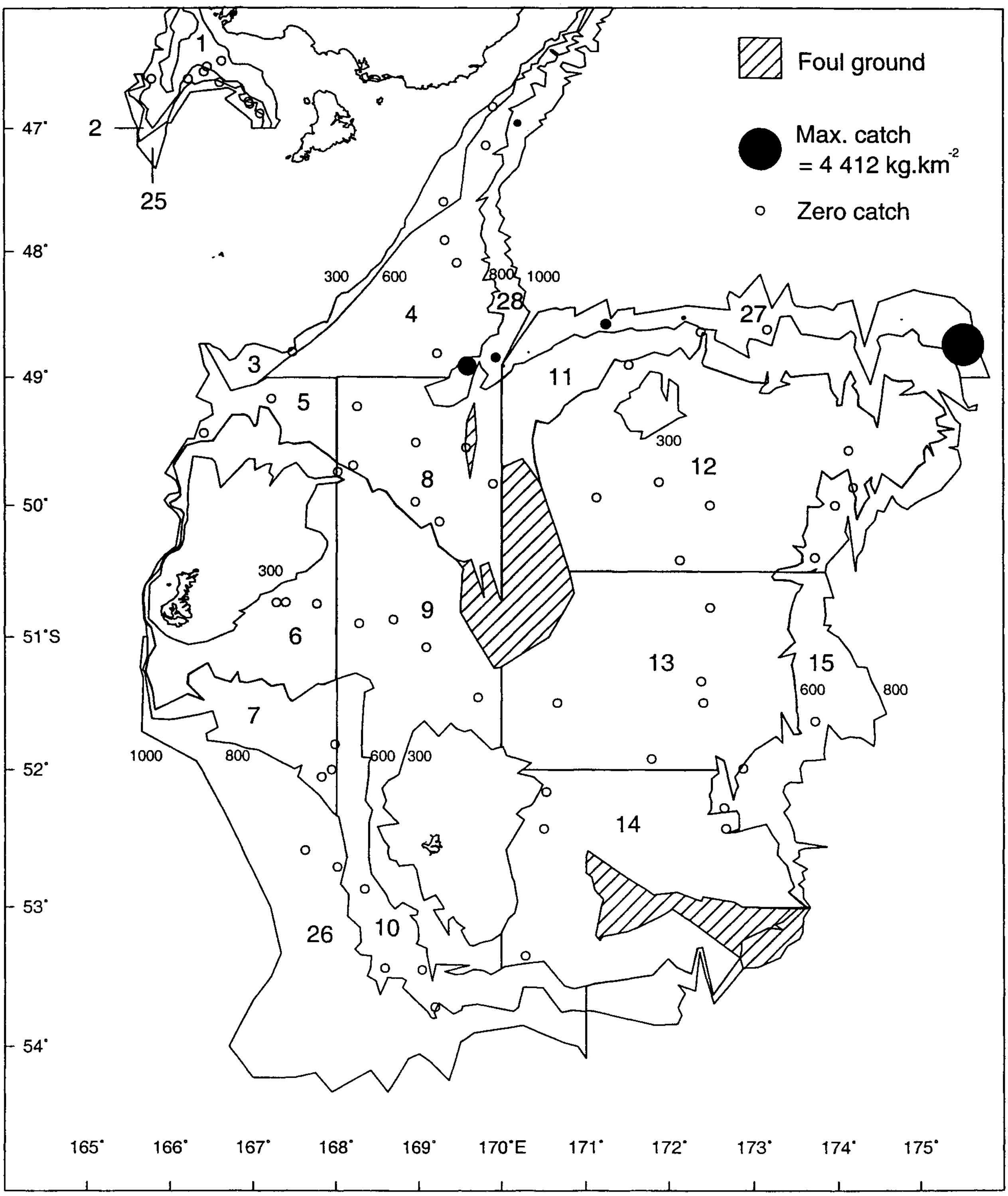

Figure 5a: Distribution and catch rates of black oreo. Circle area is proportional to the maximum catch rate (Max. catch).

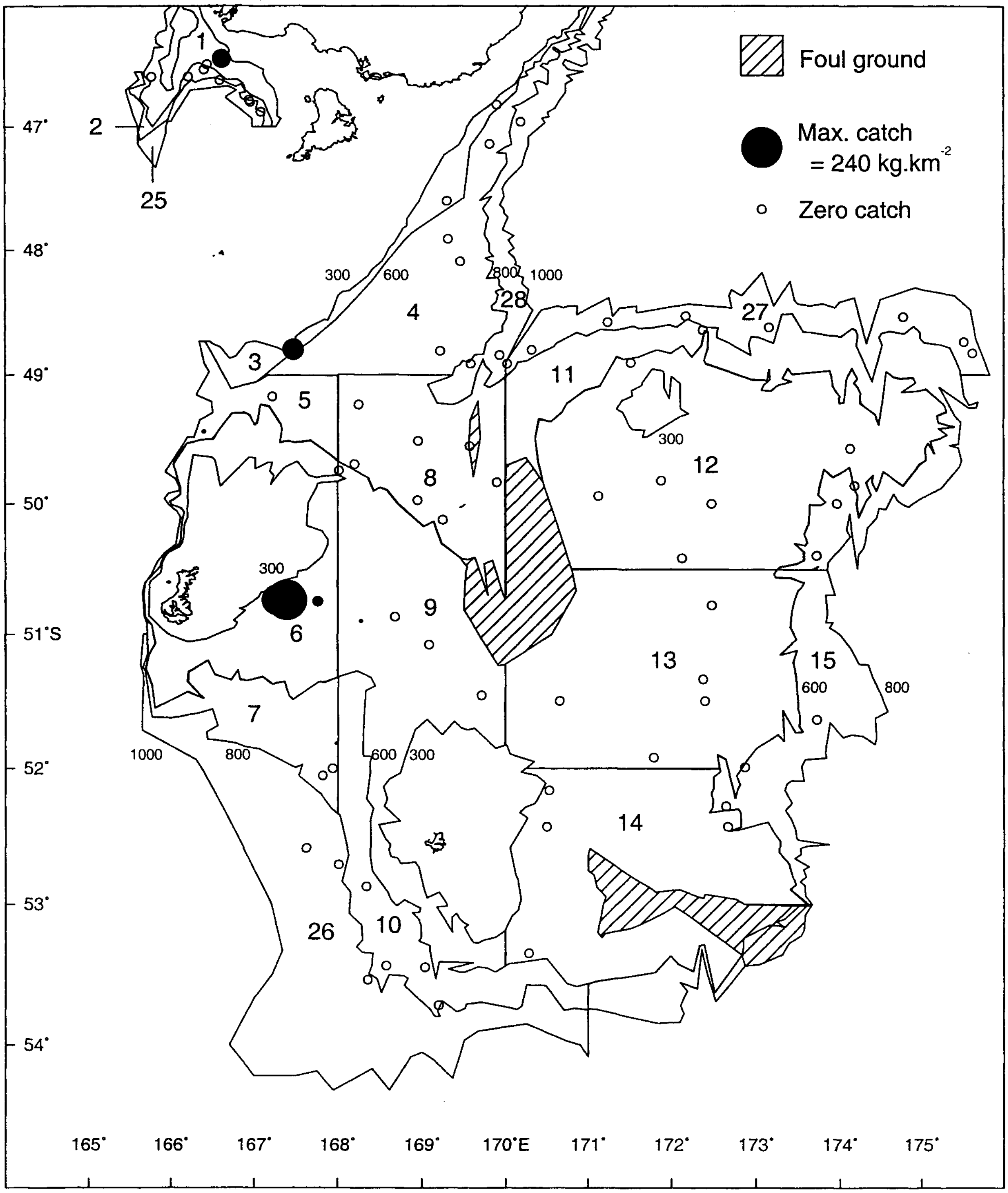

Figure 5b: Distribution and catch rates of dark ghost shark. Circle area is proportional to the maximum catch rate (Max. catch).

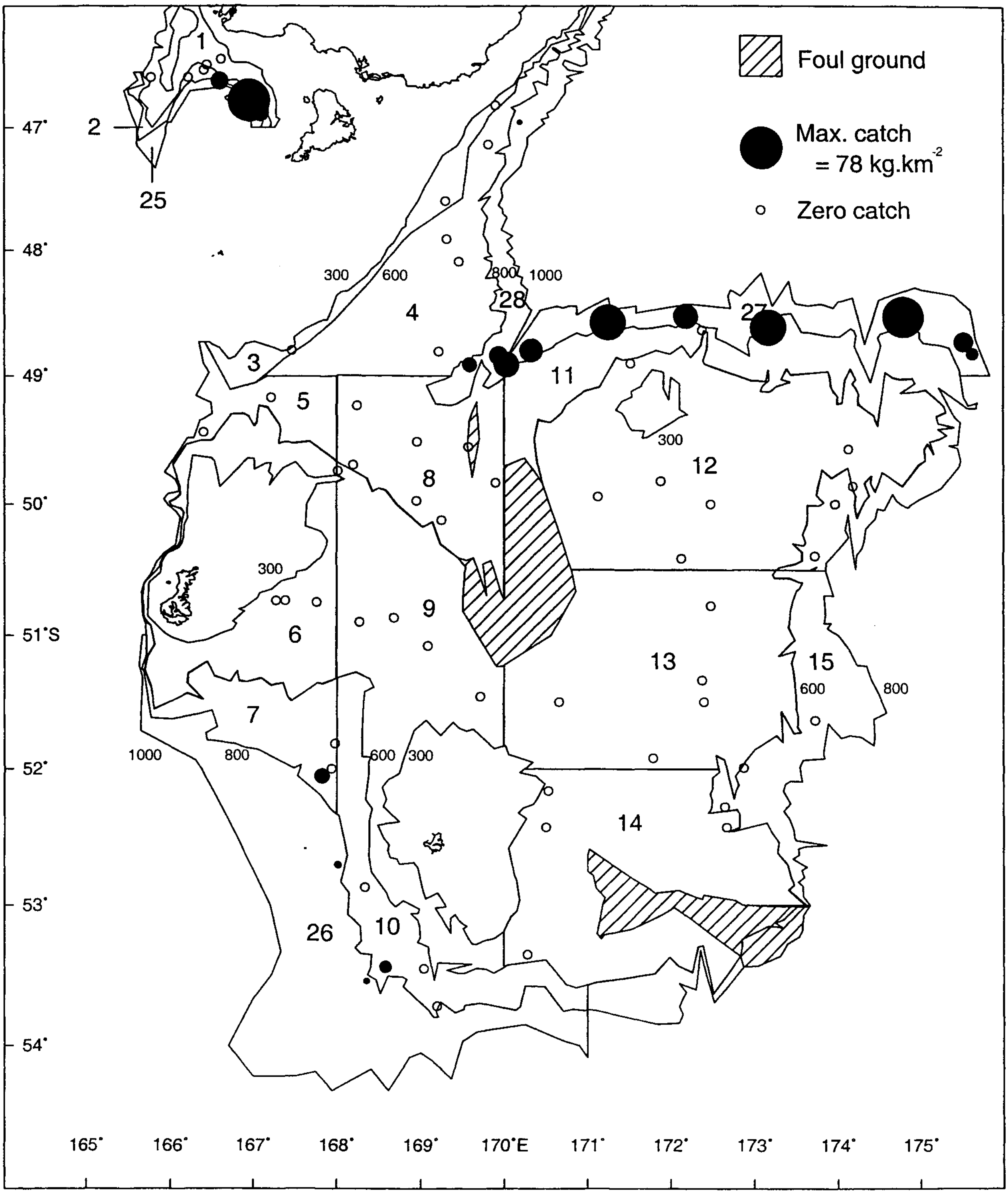

Figure 5c: Distribution and catch rates of orange roughy. Circle area is proportional to the maximum catch rate (Max. catch).

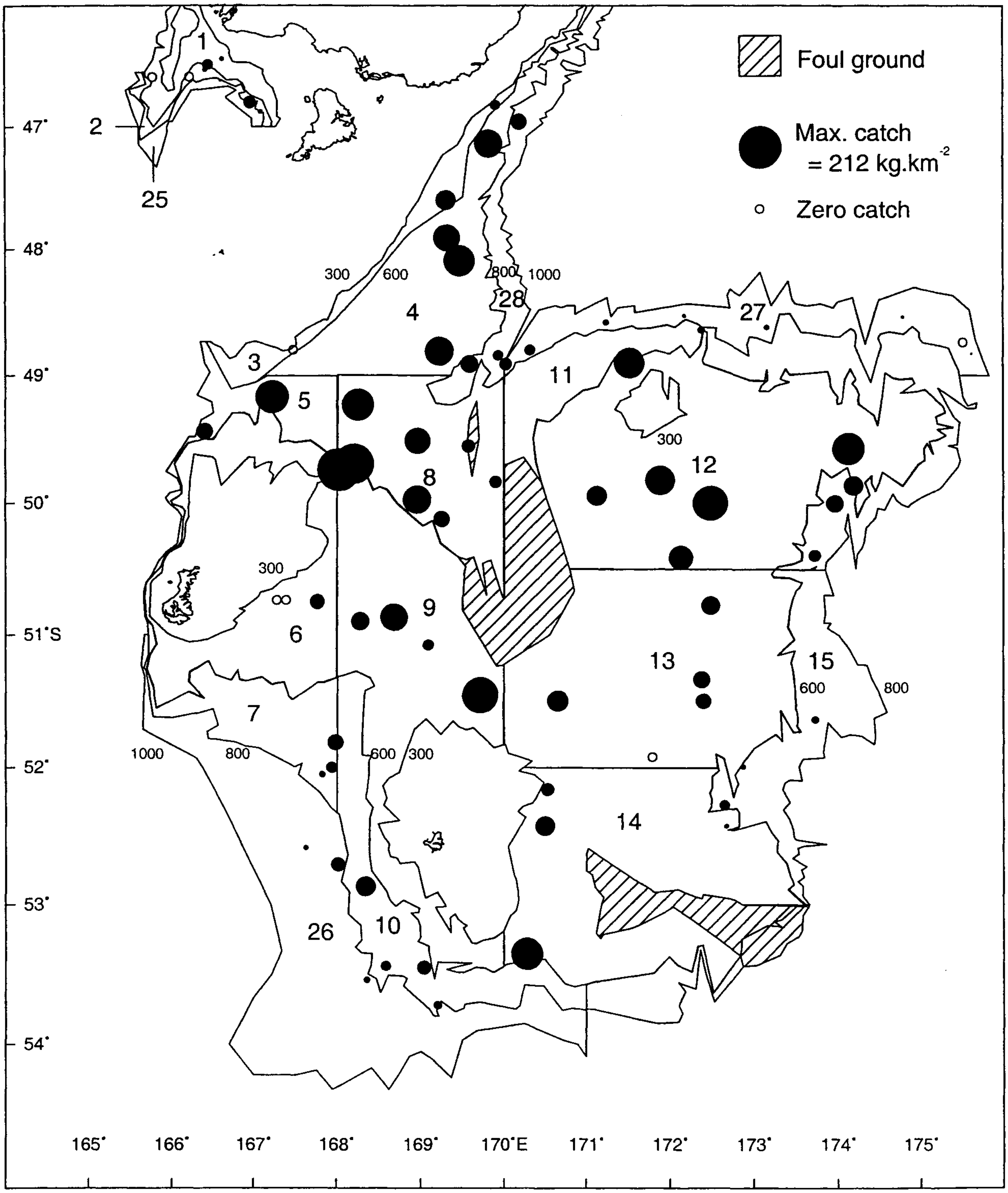

Figure 5d: Distribution and catch rates of pale ghost shark. Circle area is proportional to the maximum catch rate (Max. catch).

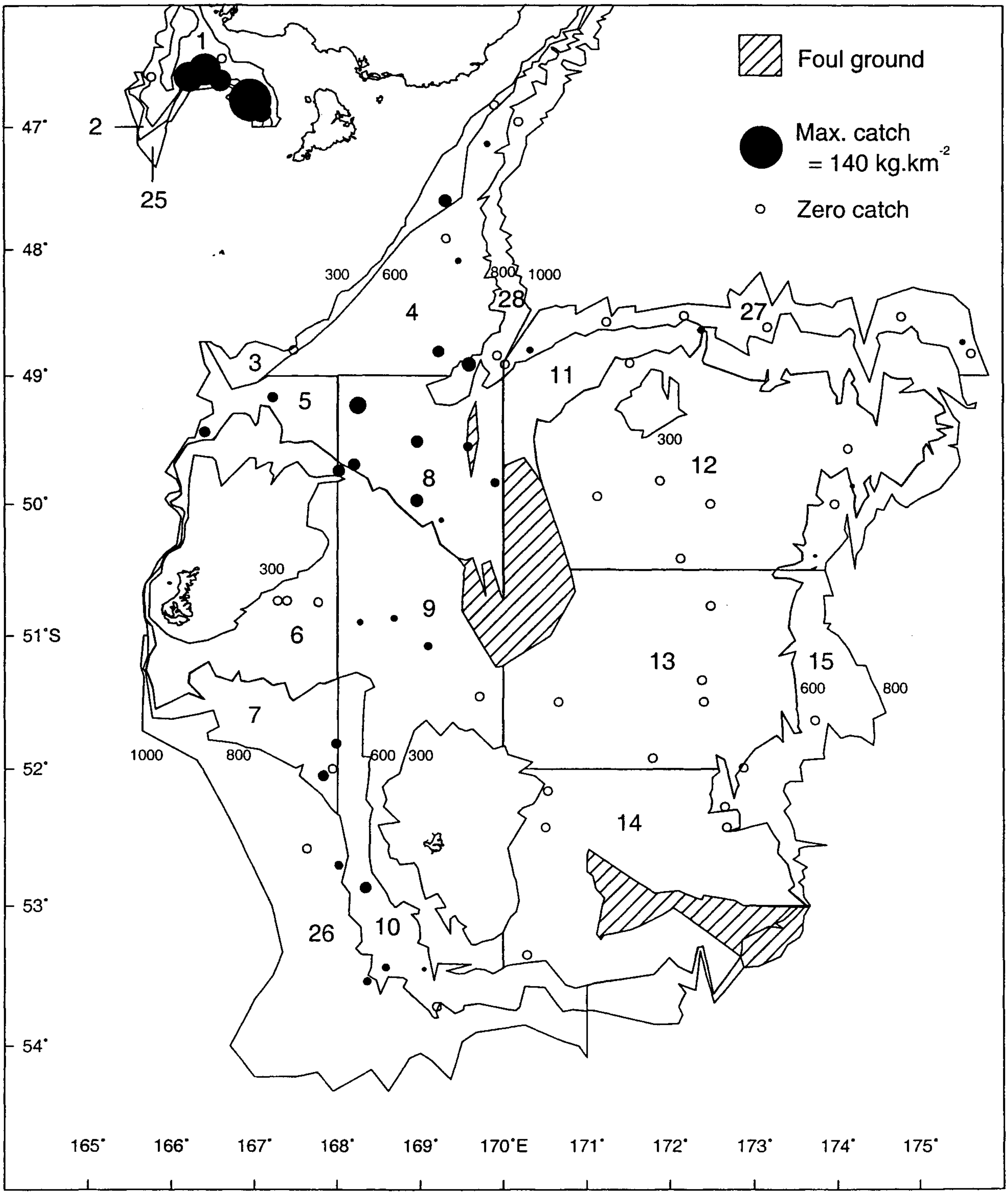

Figure 5e: Distribution and catch rates of ribaldo. Circle area is proportional to the maximum catch rate (Max. catch).

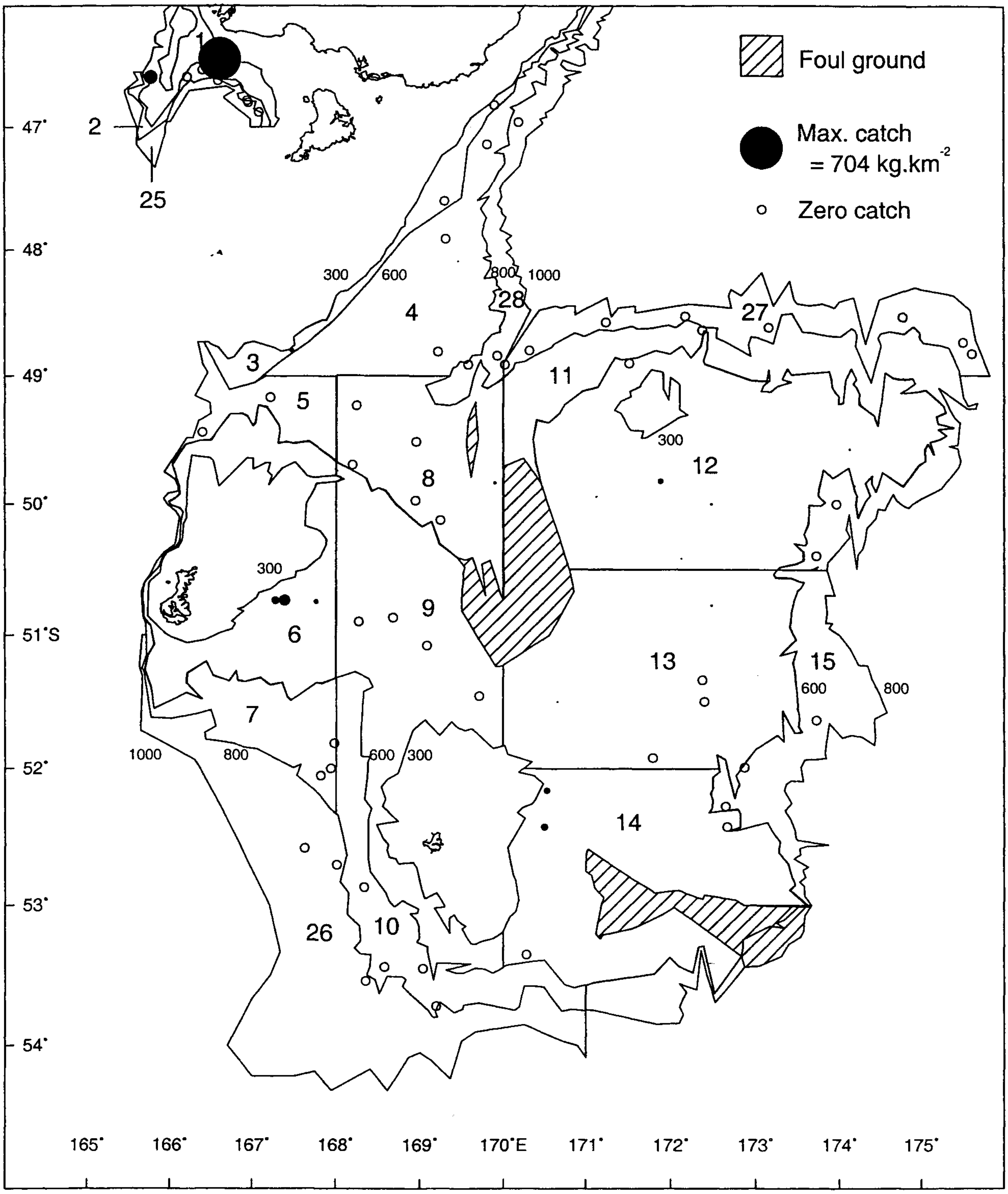

Figure 5f: Distribution and catch rates of spiny dogfish. Circle area is proportional to the maximum catch rate (Max. catch).

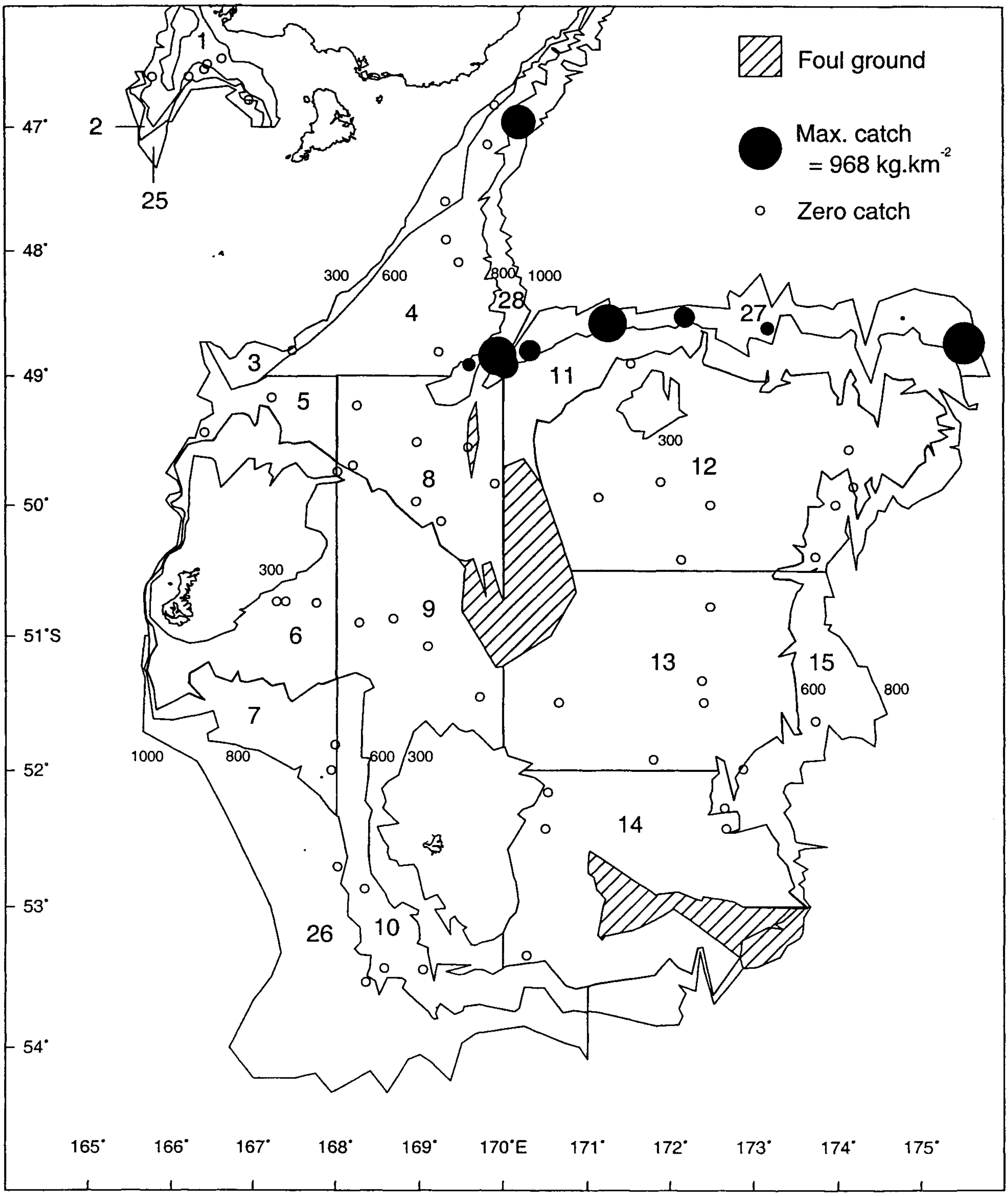

Figure 5g: Distribution and catch rates of smooth oreo. Circle area is proportional to the maximum catch rate (Max. catch).

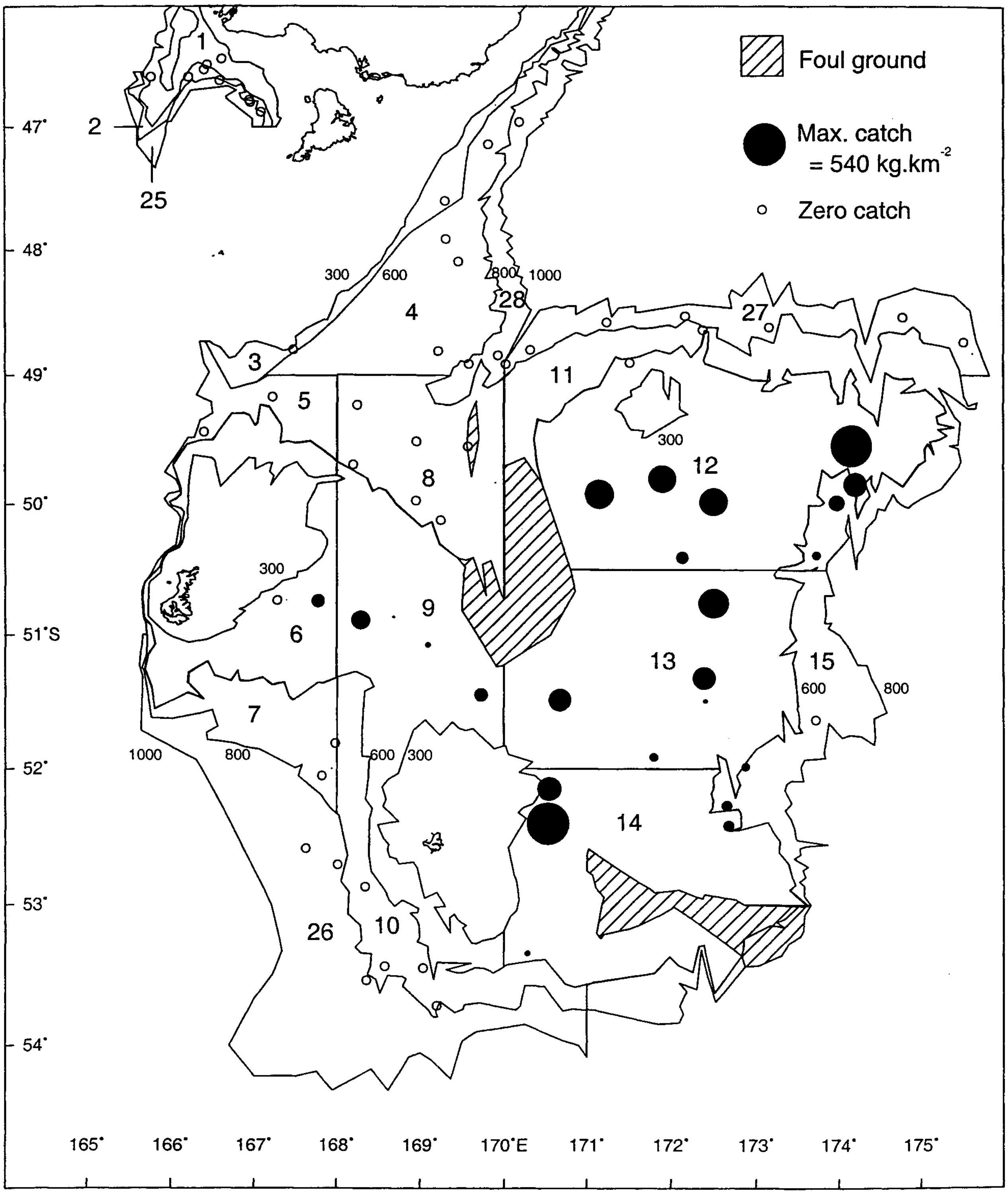

Figure 5h: Distribution and catch rates of southern blue whiting. Circle area is proportional to the maximum catch rate (Max. catch).

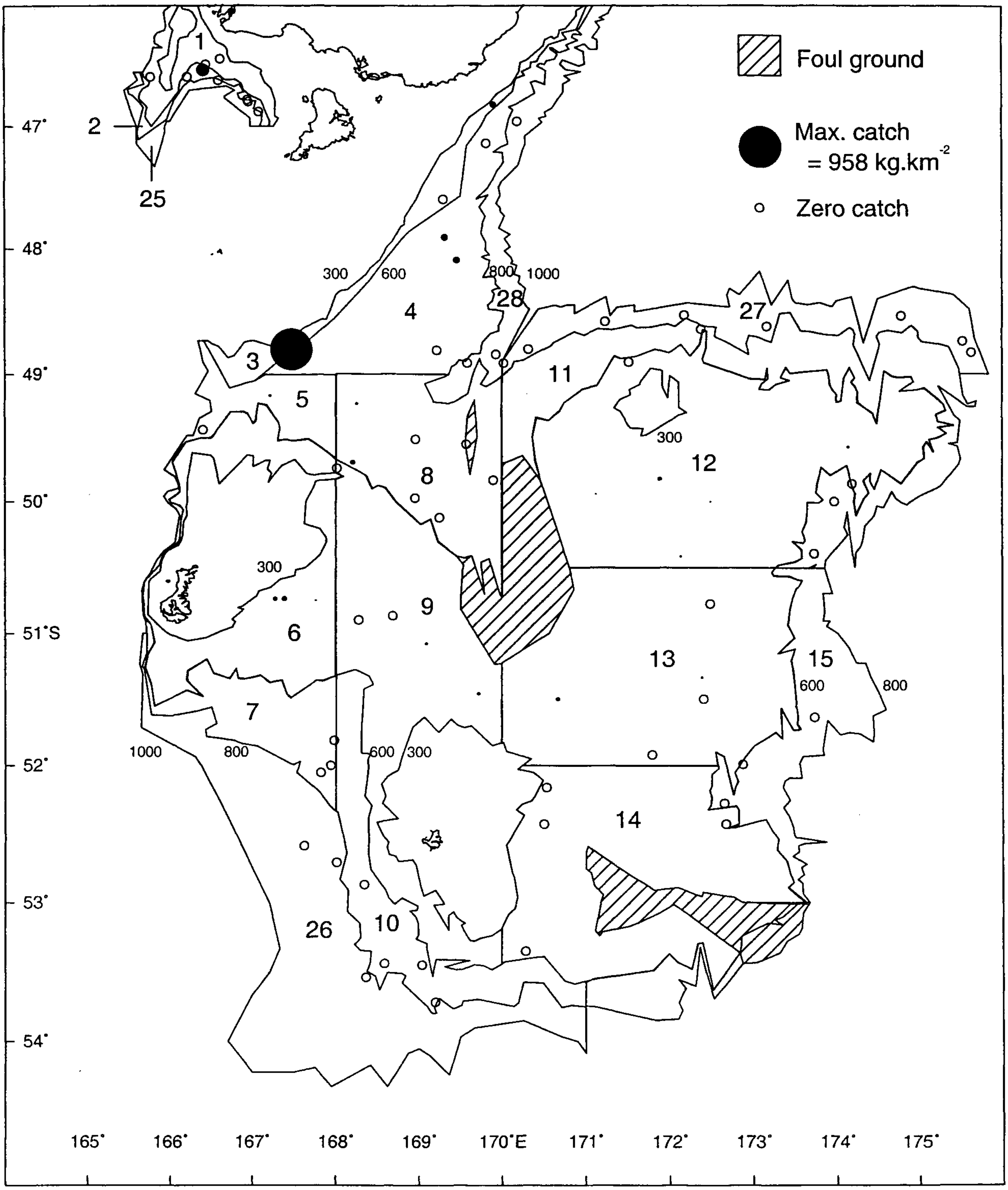

Figure 5i: Distribution and catch rates of white warehou. Circle area is proportional to the maximum catch rate (Max. catch).

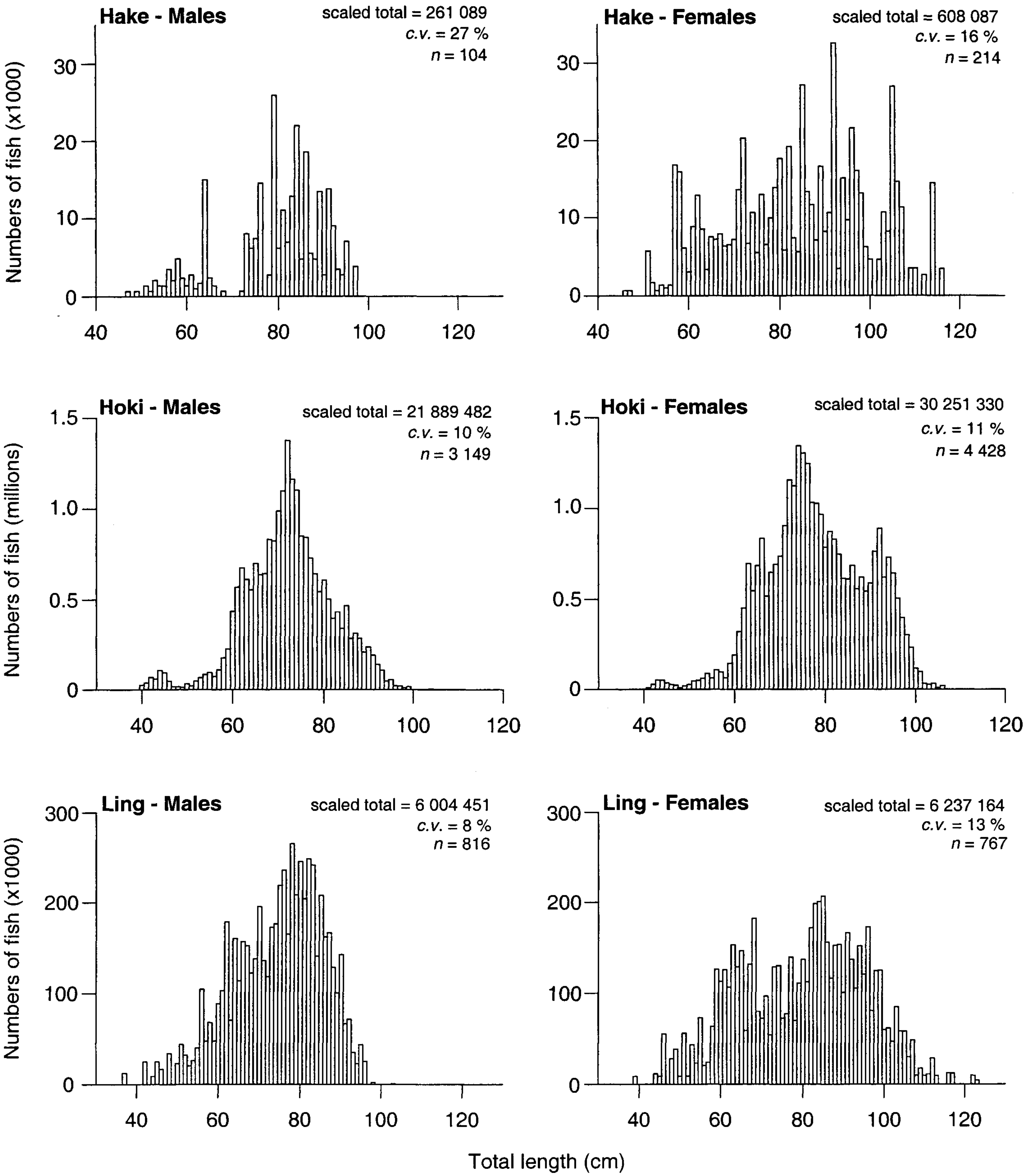

Figure 6: Length frequency by sex of hake, hoki, and ling with the estimated number of fish in the population (*c.v.*, coefficient of variation; *n*, number of fish measured).

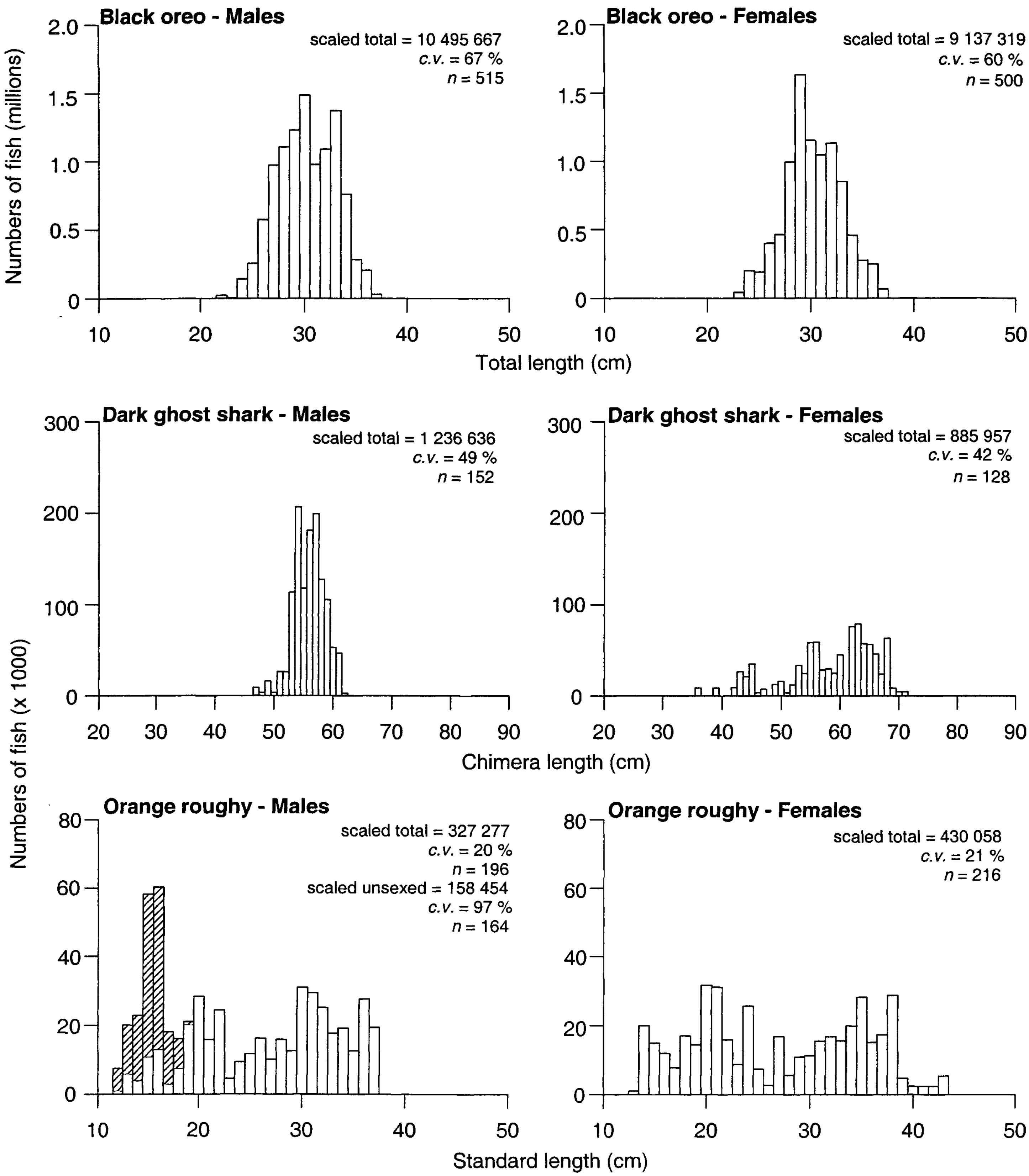

Figure 7: Length frequency by sex of other important species, with the estimated totoal number of fish in the population (c.v., coefficient of variation; *n*, number of fish measured; hatched bars; unsexed fish).

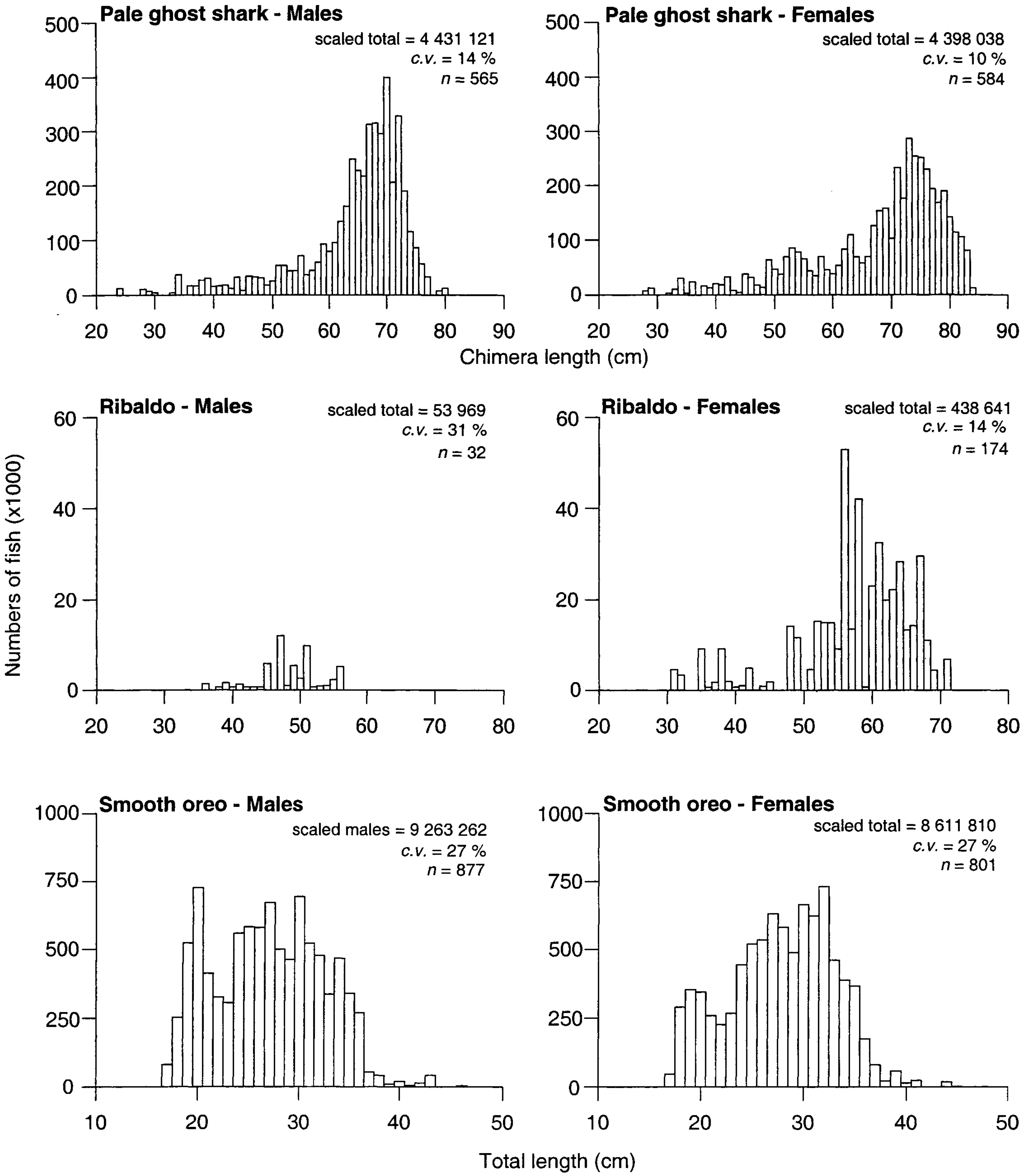

Figure 7 : continued

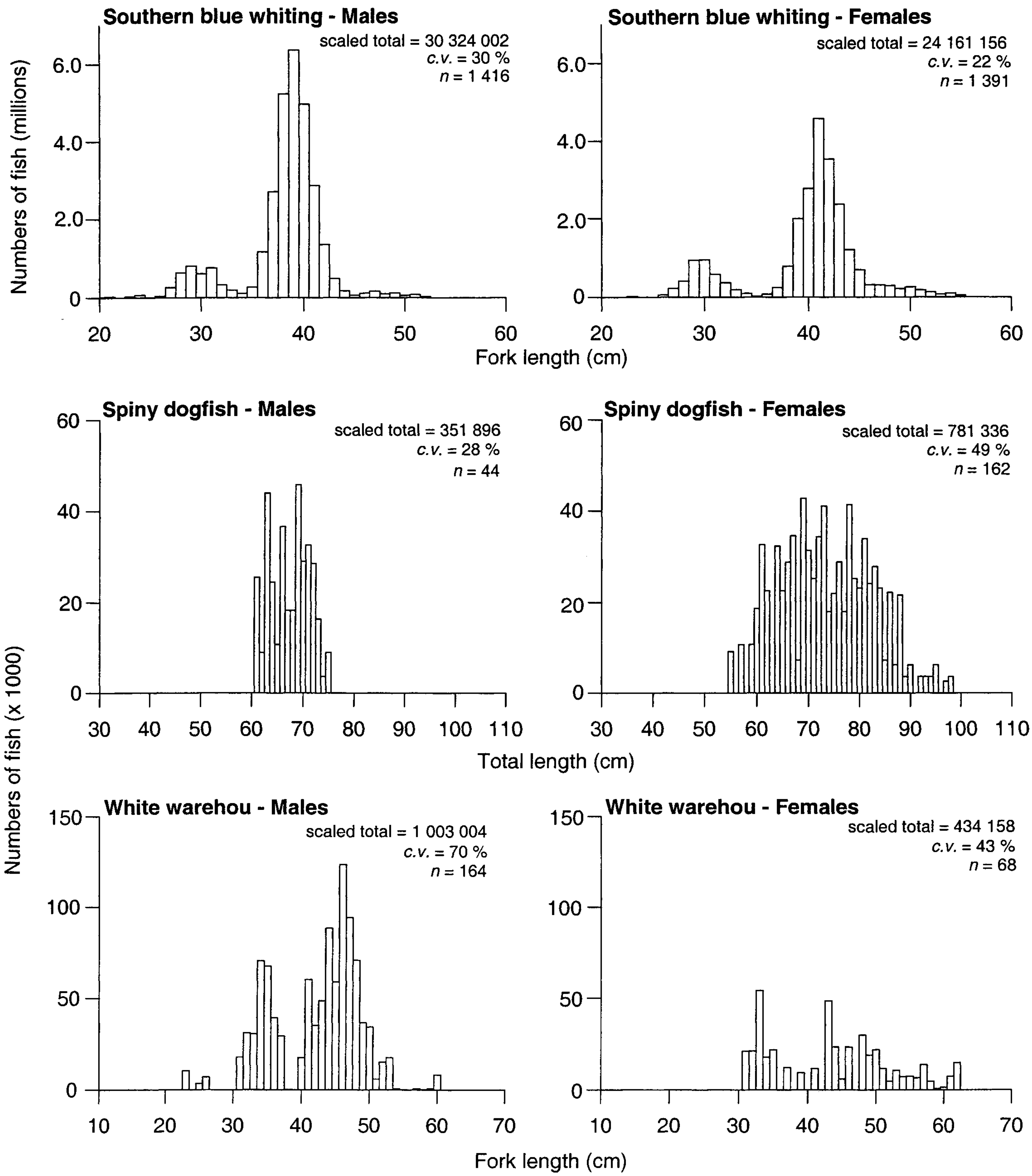

Figure 7 : ***Continued***

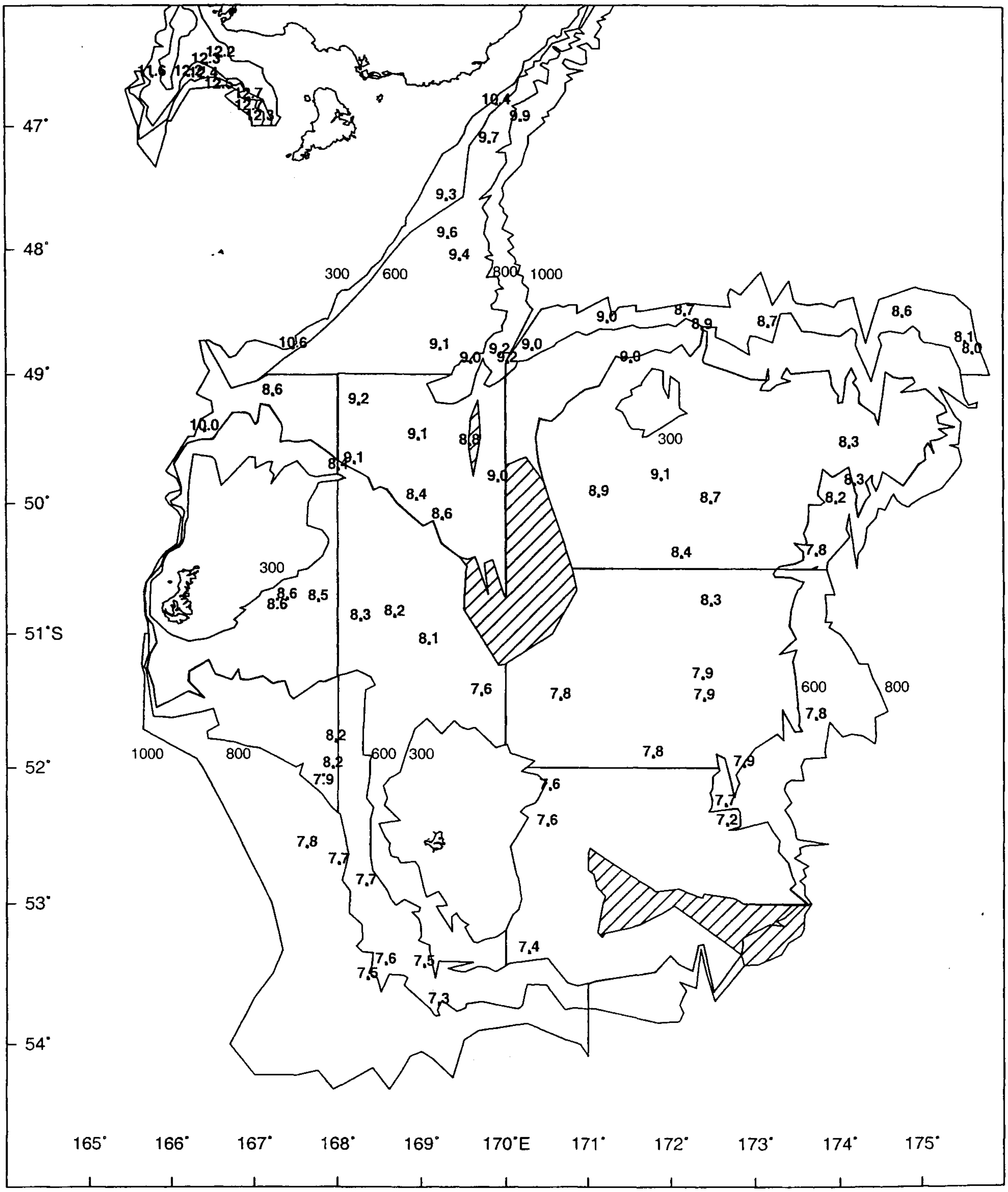

Figure 8: Surface water temperatures (°C).

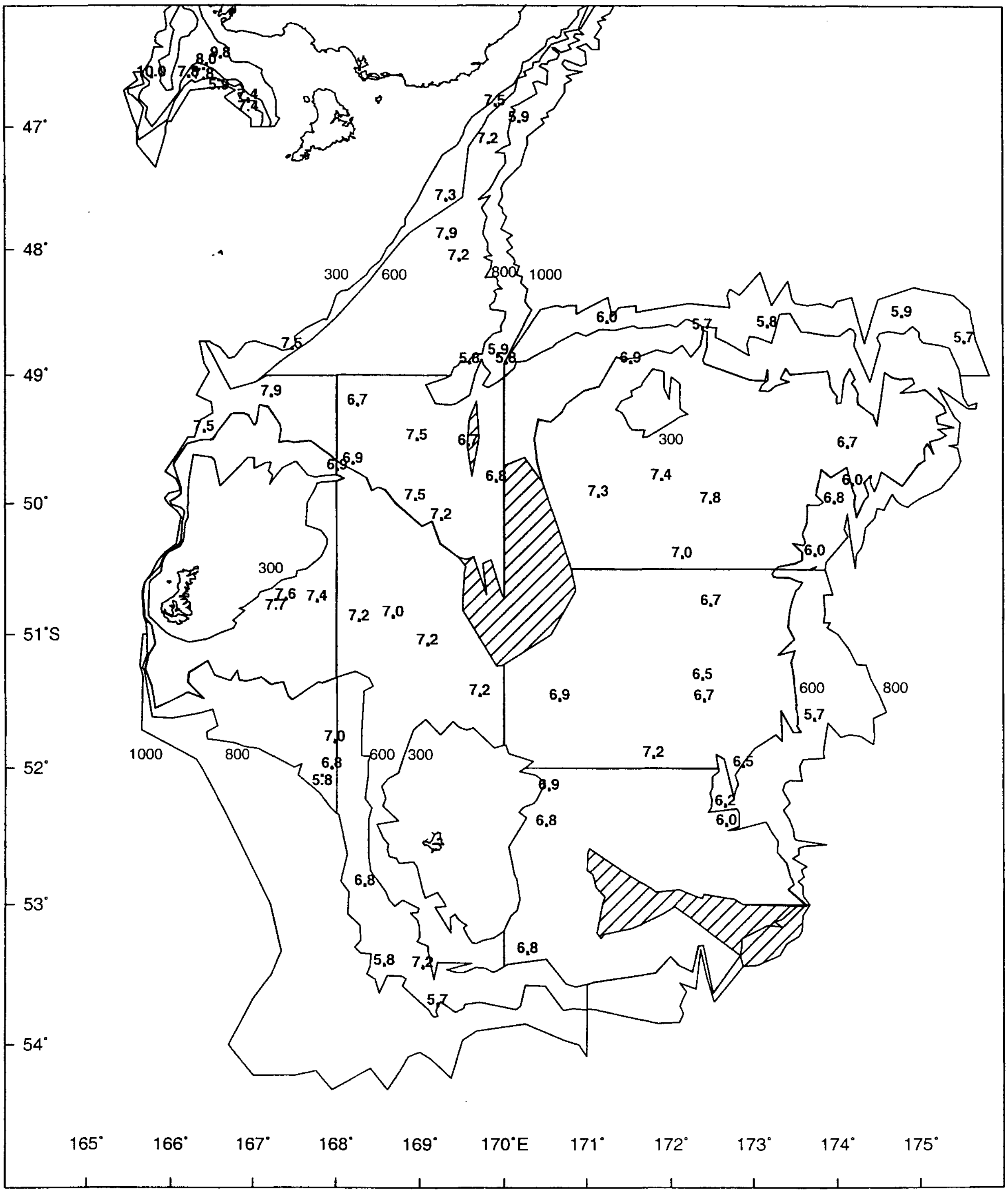

Figure 9: Bottom water temperatures (°C).

Appendix 1: Description of gonad development used for staging male and female teleosts

Gonad stage		Males	Females
1	Immature	Testes small and translucent, threadlike or narrow membranes.	Ovaries small and translucent. No developing oocytes.
2	Resting	Testes are thin and flabby; white or transparent.	Ovaries are developed, but no developing eggs are visible.
3	Ripening	Testes are firm and well developed, but no milt is present.	Ovaries contain visible developing eggs, but no hyaline eggs present.
4	Ripe	Testes large, well developed; milt is present and flows when testis is cut, but not when body is squeezed.	Some or all eggs are hyaline, but eggs are not extruded when body is squeezed.
5	Running-ripe	Testis is large, well formed; milt flows easily under pressure on the body.	Eggs flow freely from the ovary when it is cut or the body is pressed.
6	Partially spent	Testis somewhat flabby and may be slightly bloodshot, but milt still flows freely under pressure on the body.	Ovary partially deflated, often bloodshot. Some hyaline and ovulated eggs present and flowing from a cut ovary or when the body is squeezed.
7	Spent	Testis is flabby and bloodshot. No milt in most of testis, but there may be some remaining near the lumen. Milt not easily expressed even when present.	Ovary bloodshot; ovary wall may appear thick and white. Some residual ovulated eggs may still remain but will not flow when body is squeezed.

Appendix 2: Individual station data

Station number	Stratum	Date	Start latitude ° ‘ S	Start longitude ° ‘ E	Depth (m) min.	Depth (m) max.	Headline height (m)	Doorspread distance m)
1	3	07-Apr-98	46 49.47	169 53.76	428	440	7.3	111.3
2	28	07-Apr-98	46 57.59	170 11.11	855	946	7.0	128.8
3	4	07-Apr-98	47 08.29	169 48.52	681	698	8.0	120.5
4	1	08-Apr-98	46 29.34	166 25.57	562	570	7.5	120.1
5	1	08-Apr-98	46 26.11	166 35.90	315	350	7.2	117.1
6	2	09-Apr-98	46 46.66	166 55.92	755	777	6.9	121.2
7	25	09-Apr-98	46 47.75	166 56.23	800	842	7.2	122.3
8	25	09-Apr-98	46 52.82	167 04.10	850	877	7.2	135.3
9	1	10-Apr-98	46 35.62	165 46.38	310	344	8.3	108.5
10	2	10-Apr-98	46 35.55	166 12.84	690	697	8.5	116.0
11	2	10-Apr-98	46 31.68	166 23.68	636	680	6.9	126.0
12	25	10-Apr-98	46 37.25	166 34.71	827	884	7.6	122.8
13	3	11-Apr-98	47 36.06	169 18.25	576	591	7.7	113.0
14	4	11-Apr-98	47 54.46	169 18.88	654	662	6.9	131.3
15	4	11-Apr-98	48 05.17	169 27.42	608	615	6.9	133.7
16	3	12-Apr-98	48 47.76	167 27.42	453	512	7.8	107.8
17	5	12-Apr-98	49 09.95	167 12.41	708	713	7.3	117.2
18	5	12-Apr-98	49 26.42	166 23.39	632	651	7.4	111.8
19	8	13-Apr-98	49 13.92	168 15.25	637	639	7.3	119.2
20	5	13-Apr-98	49 30.30	168 57.86	672	678	7.3	115.4
21	8	13-Apr-98	49 41.18	168 11.72	622	644	7.0	116.4
*22	9	13-Apr-98	49 45.38	168 02.58	587	600	$^{\alpha}$–	117.1
23	9	13-Apr-98	49 44.37	168 00.45	587	593	7.5	116.8
24	6	14-Apr-98	50 44.56	167 15.90	427	441	7.6	117.7
25	6	14-Apr-98	50 44.49	167 22.84	429	440	7.4	119.5
26	6	14-Apr-98	50 45.27	167 45.66	467	501	7.0	122.8
27	9	14-Apr-98	50 53.97	168 16.26	591	594	6.9	124.4
28	9	14-Apr-98	50 52.31	168 40.68	591	595	7.0	123.4
29	26	15-Apr-98	52 35.37	167 37.39	977	990	7.0	130.2
30	7	15-Apr-98	52 03.22	167 49.32	741	777	7.0	122.8
31	7	15-Apr-98	52 00.15	167 56.33	680	715	7.1	121.4
32	7	15-Apr-98	51 48.37	167 58.53	651	651	7.1	132.6
33	26	16-Apr-98	53 32.37	168 21.65	835	836	7.0	123.3
34	10	16-Apr-98	52 51.97	168 20.30	662	680	6.9	127.8
35	26	16-Apr-98	52 42.81	168 00.86	876	884	7.1	130.4
36	10	17-Apr-98	53 26.25	168 34.64	789	794	6.8	130.2
37	10	20-Apr-98	53 27.05	169 02.11	706	719	7.0	131.8
38	26	20-Apr-98	53 43.12	169 12.24	824	840	7.1	131.6
39	14	20-Apr-98	53 20.98	170 16.52	547	575	7.0	126.8
40	9	21-Apr-98	51 04.80	169 05.31	555	557	7.4	112.2
41	9	21-Apr-98	51 27.68	169 42.49	469	480	7.4	113.2
42	13	21-Apr-98	51 29.73	170 39.48	510	517	7.2	117.1
43	14	22-Apr-98	52 09.79	170 31.72	412	441	7.2	116.6
44	14	22-Apr-98	52 25.65	170 29.75	428	445	6.7	120.6
45	13	22-Apr-98	51 55.30	171 47.16	525	533	6.9	117.1
46	14	23-Apr-98	52 25.55	172 40.04	580	592	6.8	128.2
47	15	23-Apr-98	52 16.86	172 39.20	605	607	7.2	121.0
48	15	23-Apr-98	51 59.55	172 52.12	607	608	7.1	122.2
49	15	23-Apr-98	51 38.52	173 43.50	631	638	7.3	120.6
50	13	24-Apr-98	51 30.01	172 24.10	523	524	7.4	115.8
51	13	24-Apr-98	51 20.44	172 22.85	525	525	7.3	111.4
52	13	24-Apr-98	50 47.03	172 28.99	523	528	7.0	121.2
53	12	24-Apr-98	50 25.06	172 07.86	492	497	6.9	125.4
54	8	25-Apr-98	49 58.22	168 56.78	634	636	7.0	121.0

Appendix 2 — *continued*

Station number	Stratum	Date	Start latitude ° ' S	Start longitude ° ' E	Depth (m) min.	Depth (m) max.	Headline height (m)	Doorspread distance m)
55	8	25-Apr-98	50 07.25	169 15.01	623	628	7.4	120.4
56	8	25-Apr-98	49 49.57	169 54.21	624	634	7.1	118.6
57	8	25-Apr-98	49 32.77	169 34.39	668	676	7.2	122.0
58	4	26-Apr-98	48 48.32	169 13.31	733	736	7.4	112.8
59	28	26-Apr-98	48 54.43	169 34.91	800	830	7.5	112.6
60	28	26-Apr-98	48 50.51	169 55.68	916	959	7.2	115.8
61	27	26-Apr-98	48 54.35	170 01.27	879	894	7.3	112.4
62	12	27-Apr-98	49 56.66	171 08.05	502	504	7.2	110.0
63	12	27-Apr-98	49 49.03	171 53.03	463	467	7.4	117.1
64	12	27-Apr-98	49 59.77	172 29.06	496	502	7.2	111.0
65	11	28-Apr-98	50 23.88	173 43.83	682	684	7.3	116.4
66	11	28-Apr-98	49 59.71	173 57.90	623	633	7.3	112.4
67	11	28-Apr-98	49 51.36	174 11.30	602	621	7.4	110.8
68	12	28-Apr-98	49 33.91	174 07.67	496	502	7.1	112.6
69	27	29-Apr-98	48 37.27	173 09.70	804	817	6.9	134.8
70	11	29-Apr-98	48 38.52	172 22.86	775	787	6.7	128.0
71	12	29-Apr-98	48 54.15	171 31.07	587	592	7.0	117.1
72	27	30-Apr-98	48 48.15	170 19.25	844	880	7.4	117.8
73	27	30-Apr-98	48 34.92	171 14.29	868	884	7.2	111.6
74	27	30-Apr-98	48 31.89	172 10.44	866	872	7.1	120.8
75	27	01-May-98	48 49.80	175 37.07	900	932	7.5	112.2
76	27	01-May-98	48 44.64	175 31.35	859	875	7.3	115.2
77	27	01-May-98	48 32.28	174 46.57	852	890	6.9	129.2

* Foul trawl shot not used in analysis.

$^{\alpha}$ No data available

Appendix 3: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms in the 76 successful biomass tows

Scientific name	Common name	Species code	Occ.
Chondrichthyes			
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	12
Centroscymnus crepidater	longnose velvet dogfish	CYP	21
C. owstoni	smooth skin dogfish	CYO	8
C. plunketi	Plunket's shark	PLS	6
Deania calcea	shovelnose dogfish	SND	13
Etmopterus baxteri	Baxter's dogfish	ETB	40
E. lucifer	Lucifer dogfish	ETL	29
Scymnorhinus licha	seal shark	BSH	8
Somniosus rostratus	little sleeper shark	SOM	1
Squalus acanthias	spiny dogfish	SPD	20
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	4
Scyliorhinidae: cat sharks			
Apristurus spp	deepsea catsharks	APR	2
Halaelurus dawsoni	Dawson's catshark	DCS	4
Arhynchobatidae: longtailed skate			
Arhynchobatis asperrimus	softnosed skate	LSK	1
Rajidae: skates			
Bathyraja shuntovi	longnosed deepsea skate	PSK	4
Pavoraja asperula	smooth bluntnosed skate	BTA	7
P. spinifera	prickly bluntnosed skate	BTS	9
Raja innominata	smooth skate	SSK	5
R. nasuta	rough skate	RSK	3
Chimaeridae: chimaeras, ghost sharks			
Chimaera phantasma	giant chimaera	CHG	2
Chimaera sp	brown chimaera	CHP	1
Hydrolagus novaezelandiae	dark ghost shark	GSH	8
Hydrolagus sp. B	pale ghost shark	GSP	69
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	41
Rhinochimaera pacifica	widenose chimaera	RCH	13
Osteichthyes			
Notacanthidae: spiny eels			
Notacanthus sexspinis	spineback	SBK	26
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	14
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	18
B. hirsutus	hairy conger	HCO	25
Gonorynchidae: sandfish			
Gonorynchus gonorynchus	sandfish	GON	2
Argentinidae: silversides			
Argentina elongata	silverside	SSI	31
Alepocephalidae: slickheads			
Alepocephalus australis	small scale brown slickhead	SSM	16
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	2
Chauliodontidae: viperfishes			
Chauliodus sloani	viper fish	CHA	3
Idiacanthhidae: black dragonfishes			
Idiacanthus spp.		IDI	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	6

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Paralepididae: barracudinas			
Magnisudis prionosa	barracudina	BCA	1
Myctophidae: lanternfishes			
Species not identified	lanternfish	LAN	2
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	10
Lepidion microcephalus	small headed cod	SMC	6
Halargyreus johnsoni	slender cod	HJO	12
Mora moro	ribaldo	RIB	37
Pseudophycis bachus	red cod	RCO	2
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	30
Merlucciidae: hakes			
Lyconus sp.		LYC	3
Macruronus novaezelandiae	hoki	HOK	75
Merluccius australis	hake	HAK	46
Macrouridae: rattails, grenadiers			
Caelorinchus aspercephalus	oblique-banded rattail	CAS	35
C. biclinozonalis	two saddle rattail	CBI	1
C. bollonsi	bigeyed rattail	CBO	15
C. fasciatus	banded rattail	CFA	69
C. innotabilis	notable rattail	CIN	15
C. kaiyomaru	Kaiyomaru rattail	CKA	11
C. matamua	Mahia rattail	CMA	4
C. oliverianus	Oliver's rattail	COL	41
Coryphaenoides serrulatus	serrulate rattail	CSE	8
C. subserrulatus	fourrayed rattail	CSU	24
C. sp. B	long barbel rattail	CBA	9
Lepidorhynchus denticulatus	javelinfish	JAV	73
Macrourus carinatus	ridge scaled rattail	MCA	29
Mesobius antipodum	black javelinfish	BJA	4
Trachyrincus aphyodes	white rattail	WHX	5
T. longirostris	unicorn rattail	WHR	3
Ventrifossa nigromaculata	blackspot rattail	VNI	7
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	64
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	20
Diremidae: discfishes			
Diretmus argenteus	discfish	DIS	1
Diretmoides parini	spinyfin	SFN	1
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	1
Cyttus novaezelandiae	silver dory	SDO	2
C. traversi	lookdown dory	LDO	19
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	11
Neocyttus rhomboidalis	spiky oreo	SOR	1
Pseudocyttus maculatus	smooth oreo	SSO	18
Macrorhamphosidae: snipefishes			
Centriscops obliquus	redbanded bellowsfish	BBE	3
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	2
Congiopodus coriaceus	deepsea pigfish	DSP	1
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	1

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Psychrolutidae: toadfishes			
Cottunculus nudus	bonyskull toadfish	COT	1
Neophrynichthys angustus	pale toadfish	TOP	19
Psychrolutes sp	blobfish	PSY	6
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	1
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	4
E. telescopus	black cardinalfish	EPT	4
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	25
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	1
Nototheniidae: ice cods			
Paranotothenia microlepidota	smallscaled cod	SCD	2
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	8
Gempylidae: snake mackerels			
Thyrsites atun	barracouta	BAR	1
Rexea solandri	gemfish	SKI	2
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	4
Hyperoglyphe antarctica	bluenose	BNS	1
Seriolella brama	blue warehou	WAR	1
S. caerulea	white warehou	WWA	20
S. punctata	silver warehou	SWA	2
Schedophilus huttoni		SUH	3
S. maculatus	pelagic butterfish	SUM	2
Tubbia tasmanica		TUB	2
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	2
Neoachiropsetta milfordi	finless flounder	MAN	29
Cephalopoda			
Histioteuthidae			
Histioteuthis miranda	violet squid	VSQ	3
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	27
Todarodes filippovae	Antarctic flying squid	TSQ	3
Onychoteuthidae			
Moroteuthis ingens	warty squid	MIQ	65
M. robsoni	warty squid	MRQ	2
Crustacea			
Acanthephyra pelagica	prawn	APE	1
Lithodes murrayi		LMU	16
Neolithodes brodiei		NEB	10
Paromola petterdi	antlered crab	ATC	1
Paralomis hystrix	stone crab	PHS	1
P. zelandica	stone crab	PZE	2
Nephropsidae			
Metanephrops challengeri	scampi	SCI	3
Decapoda			
Camplyonotus rathbonae	sabre prawn	CAM	1
Lipkius holthuisi	omega prawn	LHO	17
Pasiphaea barnardi		PBA	3
Species not identified	crab	CRB	1

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Other marine organisms			
Porifera	sponges	ONG	36
Coelenterata			
Anthozoa	sea anemones	ANT	37
Scyphozoa	jellyfish	JFI	17
Mollusca			
Gastropoda	shellfish	GAS	6
Opisthoteuthis	umbrella octopus	OPI	4
Graneledone spp.	deepwater octopus	DWO	8
Echinodermata			
Asteroidea	starfish	SFI	49
Echinoid	sea urchin	ECH	3
Holothurian	sea cucumber	SCC	46
Peribolaster lictor	starfish	PLI	1
Echinidae			
Gracilechinus multidentatus	sea urchin	GRM	1
Echinothuriidae			
Araeosoma coriaceum	Tam O' Shanter urchin	ACO	8
Araeosoma spp.	Tam O' Shanter urchin	ARA	17
Thaliacea			
Salpidae	salps	SAL	10

Appendix 4: Calculated numbers at age (*n*) of the populations of hoki, hake, and ling in the survey area, by sex. Coefficients of variation are presented for individual year classes (*c.v.*) and as a mean weighted value for each species (Mean *c.v.*)

Age	Hoki				Hake				Ling			
	Male		Female		Male		Female		Male		Female	
	n	*c.v.*	*n*	*c.v.*	*n*	*c.v.*	*n*	*c.v.*	*n*	*c.v.*	*n*	*c.v.*
1	460770	0.562	226084	0.637	0	0	0	0	0	0	0	0
2	636244	0.202	889774	0.143	0	0	0	0	64324	0.522	98804	0.631
3	4500208	0.089	4995112	0.074	11318	0.202	44579	0.255	270431	0.271	439282	0.262
4	2892831	0.161	3745769	0.150	21888	0.400	75498	0.240	722914	0.185	634221	0.215
5	6054755	0.096	6565258	0.104	14494	0.886	53714	0.262	746835	0.186	769880	0.179
6	3683777	0.130	4208299	0.128	24593	0.393	55359	0.367	488161	0.231	525512	0.215
7	768675	0.281	838699	0.308	10643	0.623	90149	0.340	608391	0.222	525028	0.218
8	554852	0.302	1659277	0.204	27364	0.357	25412	0.695	620412	0.220	508310	0.232
9	764584	0.232	3012056	0.147	9103	0.726	52121	0.406	412598	0.277	601825	0.226
10	762536	0.257	1904195	0.193	20144	0.470	42516	0.437	259363	0.338	376171	0.278
11	224343	0.466	417702	0.409	13527	0.639	42199	0.467	446643	0.268	322754	0.297
12	308021	0.414	457732	0.377	13369	0.721	39385	0.419	350274	0.285	321985	0.312
13	45604	0.967	690486	0.312	13541	1.144	4802	1.256	85830	0.521	299375	0.298
14	134005	0.539	108604	0.680	6112	0.703	0	0	198515	0.358	229846	0.337
15	0	0	208361	0.531	3306	1.009	32585	0.541	232012	0.328	228994	0.323
16	0	0	33010	0.828	23190	0.631	6948	0.859	241599	0.305	164562	0.357
17	0	0	0	0	14236	0.761	9551	0.565	206884	0.370	207940	0.330
18	0	0	0	0	11851	0.730	18645	0.726	83027	0.547	117701	0.464
19	0	0	0	0	6762	0.981	4802	1.256	55350	0.606	48843	0.762
20	0	0	0	0	9471	0.877	11823	0.533	60647	0.686	20849	1.216
21	0	0	0	0	0	0	0	0	38106	0.753	48293	0.935
22	0	0	0	0	5963	1.272	0	0	16151	0.897	0	0
23	0	0	0	0	0	0	0	0	8814	1.487	12747	1.396
24	0	0	0	0	4015	2.946	2460	2.839	18478	1.065	12585	1.347
25	0	0	0	0	0	0	3584	1.383	0	0	0	0
26	0	0	0	0	0	0	0	0	17412	1.036	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	4015	2.946	0	0	7377	1.156	0	0
No. aged	300		343		89		186		219		349	
Mean *c.v.*				0.155				0.507				0.278

NIWA

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