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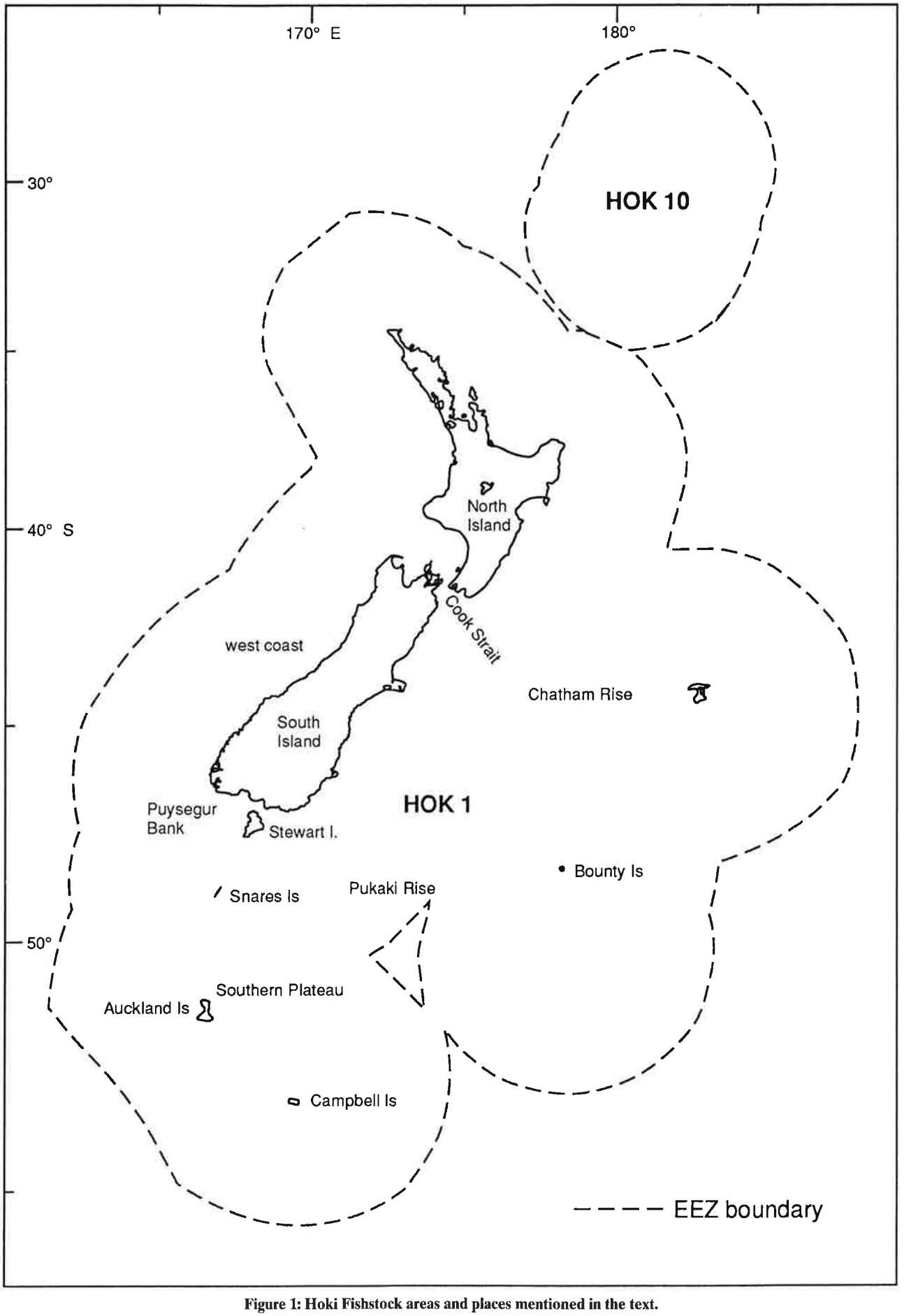

Figure 1: Hoki Fishstock areas and places mentioned in the text.

Abstract

Livingston, M. E. & Schofield, K. A. 1992: Trawl survey of hoki and associated species south of New Zealand, October-November 1989. *N.Z. Fisheries Technical Report No. 36.* 39 p.

A random trawl survey of the Southland and Sub-Antarctic areas of New Zealand's Exclusive Economic Zone was carried out in October-November 1989 by *Amaltal Explorer*. The survey area was bounded by latitudes 46° and 54° S and longitudes 165° E and 179° W, and covered bottom depths of 200–800 m. The main aim of the survey was to obtain relative biomass estimates for hoki (*Macruronus novaezelandiae*) and other commercial species in the area. Hoki made up 28% of the catch from 125 trawl stations. Other important species included hake (*Merluccius australis*), ling (*Genypterus blacodes*), southern blue whiting (*Micromesistius australis*), and silver warehou (*Seriolella punctata*). The relative distribution of catch rates and size classes within the survey area differed from earlier surveys in 1979 and 1983. Absolute catch rates, and therefore the estimates of biomass, were lower than those of 1983. It is not known if the differences reflect real changes in biomass, or differences in fishing power and gear efficiency between the vessels used.

Introduction

The fishery for hoki (*Macruronus novaezelandiae)* is New Zealand's largest with a Total Allowable Commercial Catch (TACC) of 210 000 t in 1991–92. Hoki are caught in all parts of the Exclusive Economic Zone (EEZ), though most of the catch is taken around the South Island (Figure 1), particularly off the west coast during the spawning season (Sullivan 1991).

Previous trawl surveys of hoki around the South Island have shown that outside the spawning season up to 80% of adult biomass (i.e., fish over 65 cm total length (TL)) resides on the Southern Plateau (i.e., Southland and Sub-Antarctic area), and up to 90% of juvenile biomass (35–65 cm TL) is found on the Chatham Rise (Hurst *et al.* 1988). There are spawning grounds off both the west and east coasts, at Puysegur Bank and in Cook Strait, respectively (Livingston 1990a). Pre-recruits (less than 35 cm TL) are found in most coastal areas of the South Island (Patchell 1982), but the Chatham Rise is the only known area of significant juvenile biomass (Livingston *et al.* 1991).

There are no differences in hoki mitochondrial DNA from Cook Strait and west coast spawning sites (P. J. Smith, MAF Fisheries Greta Point, pers. comm.), though adult hoki from these sites differ morphometrically and have different growth rates (Livingston *et al.* 1992). Currently, hoki are assessed as two stocks with separate procedures to assess yields and sustainability of catch levels (Livingston 1990b, Sullivan 1991).

The distribution of adult hoki changes seasonally. In summer, they are dispersed widely across the Sub-Antarctic area and Chatham Rise, yielding low but consistent catch rates (Sullivan 1991): they are not found on their spawning grounds off the west coast of the South Island or in Cook Strait. In winter, they aggregate in dense schools in the spawning areas. At some point in spring and in autumn, they migrate to and from their dispersed areas to the spawning grounds.

Acoustic surveys and catch per hour towed by the commercial fleet are being used to monitor relative changes in spawning biomass off the west coast (Cordue 1991, Sullivan 1991, Vignaux 1992) where schools are too densely aggregated for bottom trawl surveys. However, as not all adult hoki spawn in any one year (Hurst & Schofield 1991, Livingston *et al.* 1991) summer surveys during the dispersed phase are needed to assess the relative abundance of the whole population.

In 1989, summer surveys were carried out on the Chatham Rise and in the Sub-Antarctic to assess relative changes in the total population biomass since 1983. Preliminary results were presented by Hurst & Schofield (1990) and Schofield (1990).

In this report, we further analyse the biomass, length frequency, and biological data collected during the 1989 Southland and Sub-Antarctic area survey, and compare the results with previous surveys of the area.

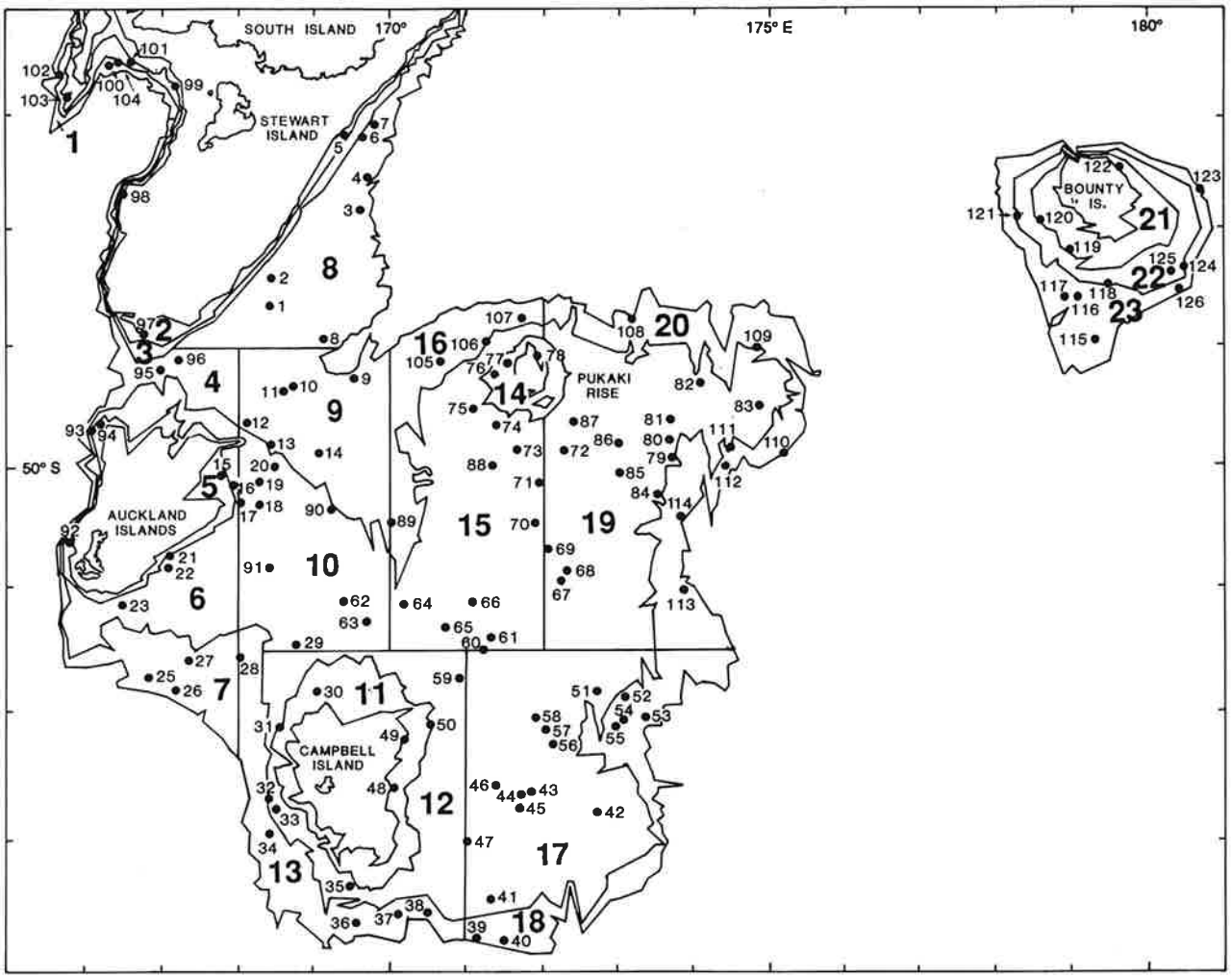

Figure 2: Survey area showing strata and station positions.

Objectives

The main objectives of the survey were as follows.

1. To map the distribution and estimate the abundance of hoki and associated fish species at depths of 200–800 m in the Southland and Sub-Antarctic areas.
2. To gather length frequency and other biological information on hoki, hake, ling, silver warehou, southern blue whiting, and other commercial species.
3. To take sufficient water temperature measurements to define any major water mass characteristics within the survey area.
4. To obtain bathymetric data to update existing survey charts.

Table 1: Stratum areas and number of stations

Stratum	Location	Depth (m)	Area (km²)	No. of stations
1	Puysegur	600–800	1 508	3
2	Stewart-Snares shelf	200–400	5 685	3
3	Stewart-Snares shelf	400–600	6 175	3
4	Snares/Auckland Islands	600–800	7 059	2
5	Auckland Islands	200–400	4 401	3
6	Auckland Islands	400–600	14 356	5
7	Auckland Islands	600–800	8 340	3
8	Stewart-Snares shelf	600–800	20 682	7
9	West Pukaki	600–800	17 188	6
10	West Pukaki	400–600	20 585	9
11	West Campbell	200–400	9 967	4
12	West Campbell	400–600	16 902	6
13	West Campbell	600–800	11 163	5
14	Central Pukaki	200–400	3 177	3
15	Central Pukaki	400–600	27 098	10
16	Central Pukaki	600–800	14 302	4
17	East Campbell	400–600	39 859	10
18	East Campbell	600–800	11 456	6
19	East Pukaki	400–600	39 859	14
20	East Pukaki	600–800	20 526	7
21	Bounty Platform	200–400	6 785	3
22	Bounty Platform	400–600	7 670	4
23	Bounty Platform	600–800	11 840	5
Sub-totals by depth		200–400	30 015	16
		400–600	164 319	61
		600–800	124 064	48
Total		200–800	318 398	125

Methods

Vessel and gear

FV *Amaltal Explorer*, a New Zealand factory trawler owned by Amaltal Fishing Company Limited, was used for the survey. It has the following specifications: overall length 65.0 m; beam 12.0 m; gross tonnage 1000 t; horsepower 2700; maximum speed 14 knots.

A high-opening bottom trawl net (Appendix 1) with a 60 mm codend, 90 m sweeps, 55 m bridles with Super Vee trawl doors of 1800 kg (6.5 m^2 area) was used during the survey. A SCANMAR 400 system provided data on doorspread, headline height, water temperature, and depth.

Survey area and design

The survey took place between 19 October and 25 November 1989 in an area bounded by latitudes 46° S and 54° S and longitudes 165° E and 179° W, in depths of 200–800 m, excluding the Antipodes Island shelf. The total survey area of 318 398 km^2 was divided into 23 strata, stratified by depth and area (Figure 2). As the survey area was so large, we considered it wise to sample all areas equally rather than stratify on the basis of earlier surveys. Therefore, the 125 randomly selected stations were allocated approximately in proportion to the area of each stratum, with a minimum of three per stratum (Table 1). Station densities averaged one per 2500 km^2: the minimum distance between stations was 5 km.

A single-phase stratified random trawl survey design was used. Tows were about 3 n. miles in length and conducted during daylight hours only. Daylight was defined as the period between 30 min after official sunrise to 30 min before official sunset. An average of 4.5 tows per day was achieved.

Catch and biological sampling

The catch at each station was sorted into species and weighed on motion-compensating electronic scales to the nearest 0.3 kg. When the catch was over 1.5 t, the weight of the main species was estimated from the number of filled fish cases. Any rare or unusual fish were kept for the Museum of New Zealand collection.

Samples of up to 300 hoki were routinely measured (total length) and sexed. Length frequency data were gathered for all other ITQ species and some commercial non-ITQ species.

At each station, 20 individuals of the five main species (hoki, hake, ling, silver warehou, and southern blue whiting) were chosen at random to obtain information on length-weight relationships, reproductive condition, and diet by recording the total or fork length, total body weight, sex, gonad stage and weight, and stomach fullness, species composition, and state of digestion. Table 2 lists the species sampled, the number of fish measured, and species sex ratios.

Bathymetry

Bathymetric data were collected throughout the survey area. Depths were recorded from a Furuno FCV 161 ET echosounder, and position was measured by a Trimble Series 3 global positioning system (GPS) and atomic clock or taken from satellite navigation fixes.

Hydrology

Surface water temperatures were recorded from the ship's hull-mounted thermometer which was calibrated with a hand-held thermometer. Bottom temperature at each station was obtained from sensors (part of the SCANMAR system, accurate to 0.1° C) mounted on the trawl net.

Biomass estimation

When survey results are to be used to obtain biomass indices, it is important that the area swept by the trawl gear is accurately monitored, and that gear performance is noted. Gear performance was assessed tow by tow as consistency of headline height and doorspread within a tow, as well as the proportion of the tow that the gear was on the bottom. Tows when gear was on the bottom for less than 2 n. miles, or where headline height or doorspread exceeded 20% above or below average, were excluded.

Biomass indices were estimated by the area swept method (Francis 1984) assuming that fish were randomly and evenly distributed over the bottom within a stratum; fish distribution did not extend above the headline height of the net; all fish in the path of the doors were caught; and the herding effects of the doors, sweeps, and bridles were constant.

Biomass indices presented here assume that the doors define the effective area of influence of the gear on the fish. They cannot be used to estimate absolute biomass, however, as the true vulnerability and catchability of hoki are unknown.

Biomass indices and coefficients of variation were calculated using the formulae given in Livingston *et al.* (1991) (*after* Francis 1984).

Length frequency distribution

Length frequency data have been standardised by proportion of catch sampled, distance towed, and stratum area, and so represent the population sampled rather than the measured sample.

Table 2: Number of fish measured and sexed, percentage of females, and number of fish examined in detail (Biol.)

Species	No. of fish measured Total	Male	Female	Female (%)	Biol.
Arrow squid (*N. sloanii*)	499	343	152	31	0
Barracouta	3	3	0	0	0
Baxter's dogfish	68	43	25	37	0
Black shark	1	0	1	100	0
Bluenose	9	0	9	100	0
Deepwater spiny dogfish	29	4	24	86	0
Gemfish	24	9	15	62	16
Giant stargazer	57	19	38	67	0
Greenback flounder	4	1	3	75	0
Hake	121	45	76	63	100
Hapuku	4	1	3	75	0
Hoki	8 732	3 491	5 241	60	1 799
Jack mackerel	3	3	0	0	3
Ling	1 828	760	1 067	58	882
Lookdown dory	55	60	90	60	0
Lucifer dogfish	102	40	60	60	0
Orange roughy	9	3	6	67	9
Ray's bream	18	8	10	56	0
Red cod	50	33	15	31	0
Red squid*	8	–	–	–	0
Ribaldo	396	42	353	90	0
Rudderfish*	2	–	–	–	0
School shark	5	0	5	100	0
Silver warehou	331	189	141	43	57
Small-scaled notothenid	46	21	25	54	0
Smooth oreo*	6	–	–	–	0
Southern blue whiting	6 785	3 351	2 939	51	1 230
Spiky oreo	195	88	105	54	0
Spiny dogfish	142	46	95	68	0
Warty squid (*M. ingens*)*	343	–	–	–	0
Warty squid (*M. robsoni*)*	5	–	–	–	0
White warehou	84	39	36	48	0

* Not sexed.

Results

Gear performance and station coverage

A total of 125 tows was successfully completed at an average of 4.5 a day (Appendix 2). As some stations fell on rough ground or outside the depth range, 9 of the 126 planned stations were changed to alternative positions and 1 was abandoned. Small areas of foul ground were found around Puysegur Bank (stratum 1), west Stewart-Snares shelf (stratum 3), between the Stewart and Snares shelf and the Auckland Islands shelf (stratum 4), southeast Campbell Plateau (strata 17 and 18), and the Bounty Platform (stratum 23). The stratum areas have not been adjusted for this survey.

Doorspread increased slightly with depth (Bagley 1991), and was more than the theoretical value of 100 m. Headline height ranged from 7.0 to 12.3 m (mean 9.5 m): some adjustments to warp length were made during all tows to try to achieve a standard headline height of 10 m. During the 1989 survey, the SCANMAR doorspread readings were up to twice those of the theoretical values or those obtained by a trawl geometry method (Bagley 1991). As the behaviour of trawl warps in the water differs from the theoretical (e.g., Nomura & Yamakazi 1977), some differences are expected. However, such a wide spread may not have been desirable for sampling hoki and associated species. Given the uncertainty surrounding the performance of the gear used in 1989, we consider that the relative herding efficiency of the gear used in this survey may differ from that of other surveys which used flume-tank tested nets of standard design and known performance.

Hydrology

Surface water temperatures (Figure 3) were higher over the Stewart-Snares shelf (10.0–12.8° C) and on the Bounty Platform (9.5–10.4° C) than over the remainder of the Pukaki Rise and Campbell Plateau (7.0–9.0° C). Bottom temperatures (Figure 4) were higher on the Stewart-Snares shelf, though

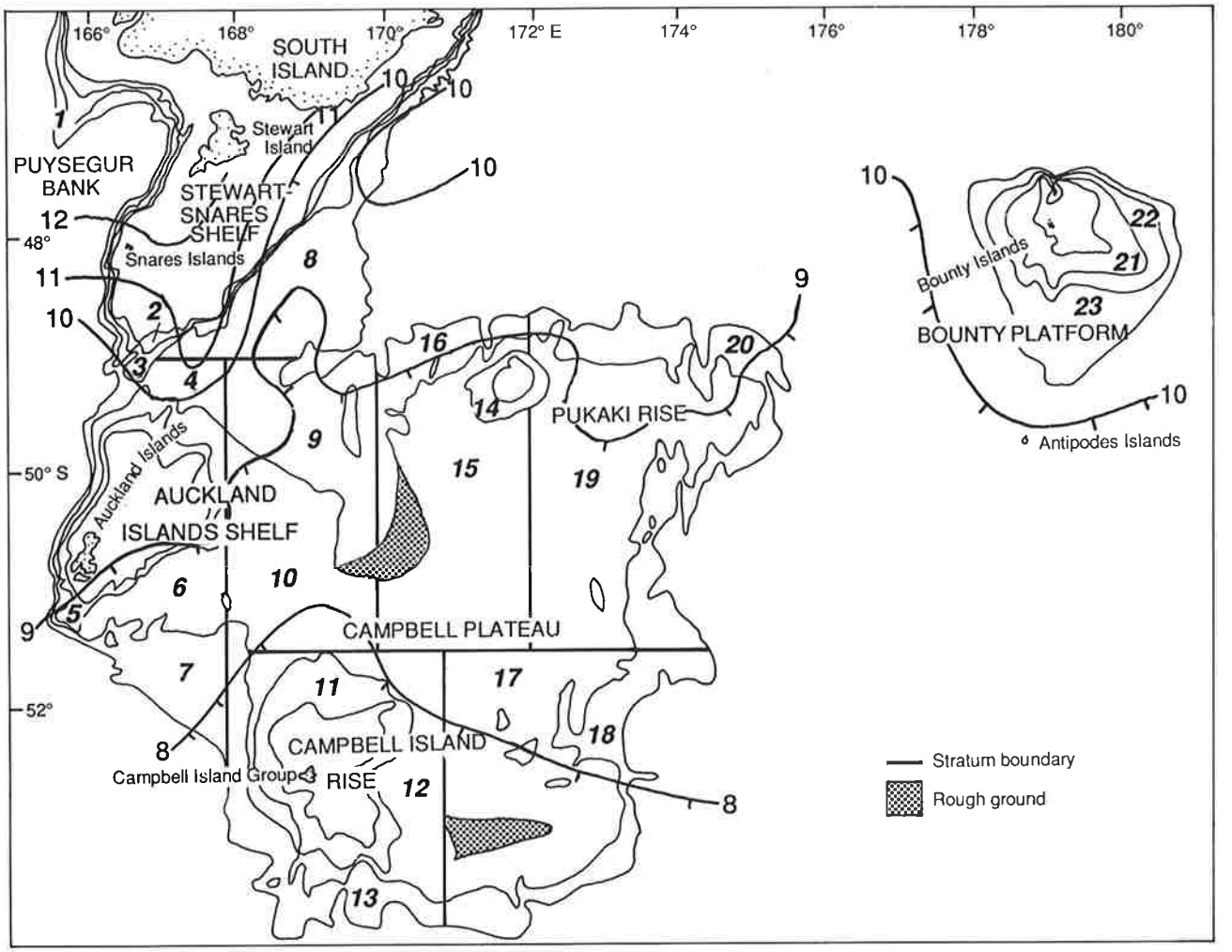

Figure 3: Sea surface temperatures.

there were cooler areas at Puysegur and in the deeper water at the southern end of the shelf. Bottom temperatures east of the Stewart-Snares shelf and across the centre of the Campbell Plateau averaged about 7° C, but were slightly higher around the Auckland and Campbell Islands and the top of the Pukaki Rise. On the Bounty Platform, bottom temperatures were lower (average about 5° C). The survey area can be divided into three regions on the basis of water temperature:

1. Stewart-Snares shelf and the Auckland Islands shelf, characterised by relatively warm, well mixed water (strata 1–5 and 8);
2. Pukaki Rise and central and southern Campbell Plateau, characterised by cooler waters with a consistent difference of about 2° C between surface and bottom (strata 6–7 and 9–20);
3. Bounty Platform, characterised by warm surface waters, but much colder bottom temperatures than elsewhere during the survey (strata 21–23).

Catch summary

The total catch from 125 stations was 61 t, of which 17 t (28%) were hoki (Table 3). Hoki, ling, javelinfish, pale ghost shark, and warty squid (*see*

Table 3: Catch, percentage composition by weight, and occurrence of the 25 main species

Species	Catch (kg)	% of total (all species)	Occurrence (no. of stations)
Hoki	17 220	28.13	112
Southern blue whiting	9 819	16.04	51
Ling	5 961	9.74	107
Basking shark*	5 000	8.17	1
Pale ghost shark	4 703	7.68	110
Javelinfish	4 027	6.58	104
Spotted spiny dogfish	2 231	3.64	42
Silver warehou	872	1.42	5
Ribaldo	860	1.40	49
Baxter's dogfish	822	1.34	38
Hake	758	1.24	34
Warty squid (*M. ingens*)	631	1.03	101
Longnosed chimaera	615	1.00	72
Silverside	596	0.97	75
Deepwater spiny dogfish	588	0.96	11
Olique banded rattail	561	0.92	73
Arrow squid (*N. sloanii*)	399	0.65	32
Shovelnosed spiny dogfish	381	0.62	14
Banded rattail	346	0.56	88
Smallscaled cod	344	0.56	8
Finless flounder	318	0.52	74
Deepwater dogfish	306	0.50	3
White warehou	290	0.47	14
Dark ghost shark	245	0.40	15
Ridgescaled rattail	233	0.38	21
Total	61 226		

* Excluded from biomass analyses.

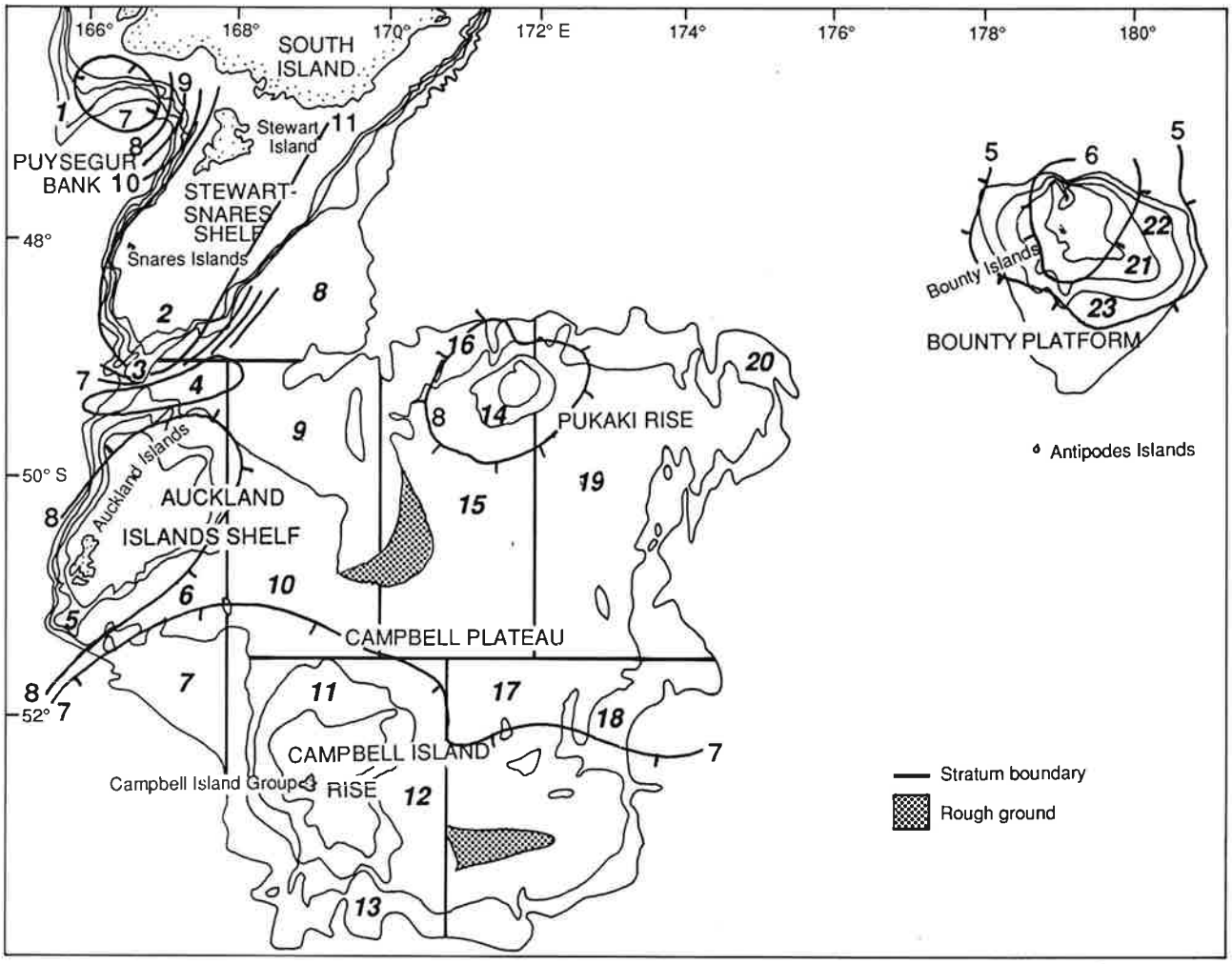

Figure 4: Bottom temperatures.

Appendix 3 for scientific names) were widely distributed throughout the the survey area and were caught at more than 100 stations. Southern blue whiting, longnosed chimaera, silverside, oblique-banded rattail, banded rattail, and finless flounder were also widely distributed (present at 50–100 stations), though the last three species each made up less than 1% of the total catch (Table 3).

Catch distribution

Catch rates (kg per 3 n. miles) of hoki, southern blue whiting, ling, hake, and silver warehou were used to infer their distribution in the survey area.

The highest catch rates of hoki were at depths of 200–400 m east of Campbell Island and northeast of the Auckland Islands. Hoki were virtually absent on the Bounty Platform, along the western edge of the Stewart-Snares shelf, and on the Auckland Islands shelf. Elsewhere, catches were consistently low to moderate (Figure 5).

The highest catch rates of southern blue whiting were at depths of 200–600 m on the Bounty Platform: moderate catches were taken on the Pukaki Rise and southern Campbell Plateau (Figure 6). Southern blue whiting were virtually absent from the Stewart-Snares and Auckland Islands shelves and from depths greater than 600 m all around the Southern Plateau.

Ling were widely distributed with the highest catch rates at Puysegur Bank (Figure 7). Ling were absent below 400 m on the Bounty Platform. Catches of hake were mainly in the 600–800 m depth range (Figure 8), and were much lower and patchy compared with ling. Hake were absent from the Bounty Platform. Silver warehou occurred at only five stations: most of the catch was taken in 200–400 m at one station in stratum 2 along the east side of the Stewart-Snares shelf (Figure 9).

Among other species of importance (over 1% of total catch), pale ghost shark, longnosed chimaera, javelinfish, and banded and oblique-banded rattails were associated with deeper strata throughout most of the survey area, as was finless flounder, except at Puysegur Bank. Warty squid were taken in most tows, and silverside were common in most strata just south of the Stewart-Snares shelf and near the Auckland Islands. All these species were present on the Bounty Plateau.

Other species of commercial interest were distributed as follows. Arrow squid and giant stargazer on Puysegur Bank, Stewart-Snares shelf,

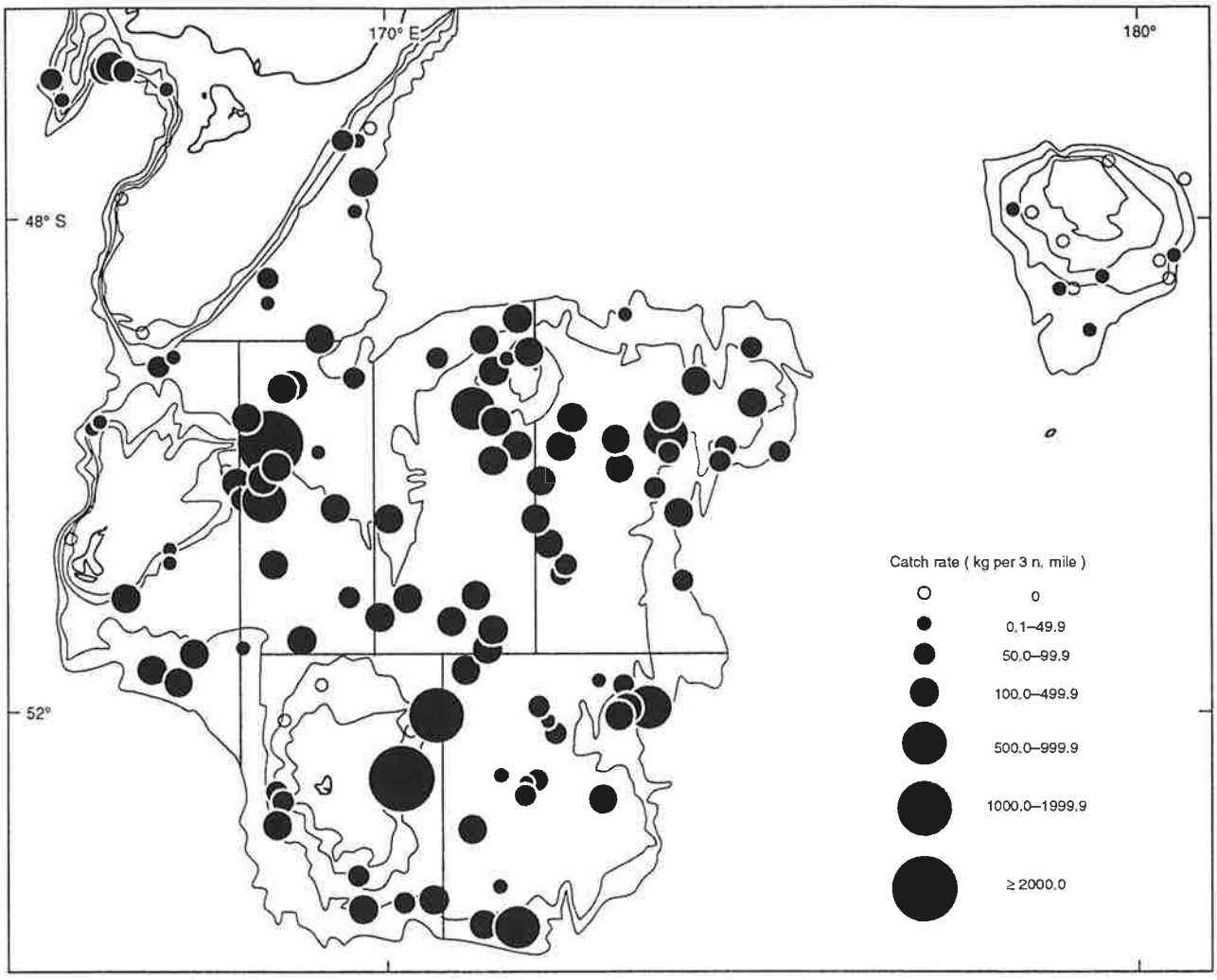

Figure 5: Catch rates of hoki.

Pukaki Rise, south Campbell Plateau, and Bounty Platform; smooth oreo on the Bounty Platform; orange roughy on Puysegur Bank; and school shark, hapuku, and bluenose on the Stewart-Snares shelf.

The distribution by stratum of the other 83 species caught is given in Appendix 3.

Biomass estimates

The estimated total biomass of demersal fish in the survey area was almost 195 000 t, which comprised 32% hoki, 18% southern blue whiting, 10% ling, 9% pale ghost shark, 7% javelinfish, 3% other macrourid rattail species, and 3.5% spiny dogfish (Table 4).

Hoki, southern blue whiting, ling, silver warehou, and spiny dogfish formed the bulk of the biomass in depth strata 200–400 m: hoki, southern blue whiting, and ling were also important in depth strata 400–600 m, as were pale ghost sharks, javelinfish, and other macrourid rattails (Appendix 4). In the deepest strata, 600–800 m, hoki dominated the biomass estimates, and pale ghost shark, ling, hake, ribaldo, javelinfish, and other macrourid rattails contributed significantly to the total estimate.

Table 4: Biomass estimates and coefficient of variation (*c.v.*) for the main quota and bycatch species (*see* Appendix 4 for stratum subtotals)

Species	Biomass	*c.v.* (%)
Hoki	62 083	20
Southern blue whiting	35 514	30
Ling	20 017	13
Hake	2 662	21
Silver warehou	2 617	89
White warehou	877	79
Arrow squid	1 043	34
Lookdown dory	762	18
Pale ghost shark	17 629	90
Ghost shark	867	27
Spiny dogfish	6 829	84
Javelinfish	14 240	12
Ribaldo	2 298	12
Lucifer's dogfish	2 834	31
Warty squid	2 469	–
Other rattails*	5 210	–
Spiky oreo	173	60
Smooth oreo	5	72
Bluenose	118	71
Orange roughy	10	10
Others	16 581	–
Total†	194 838	11

* See Appendix 4 for species list.
† Excluding basking shark.

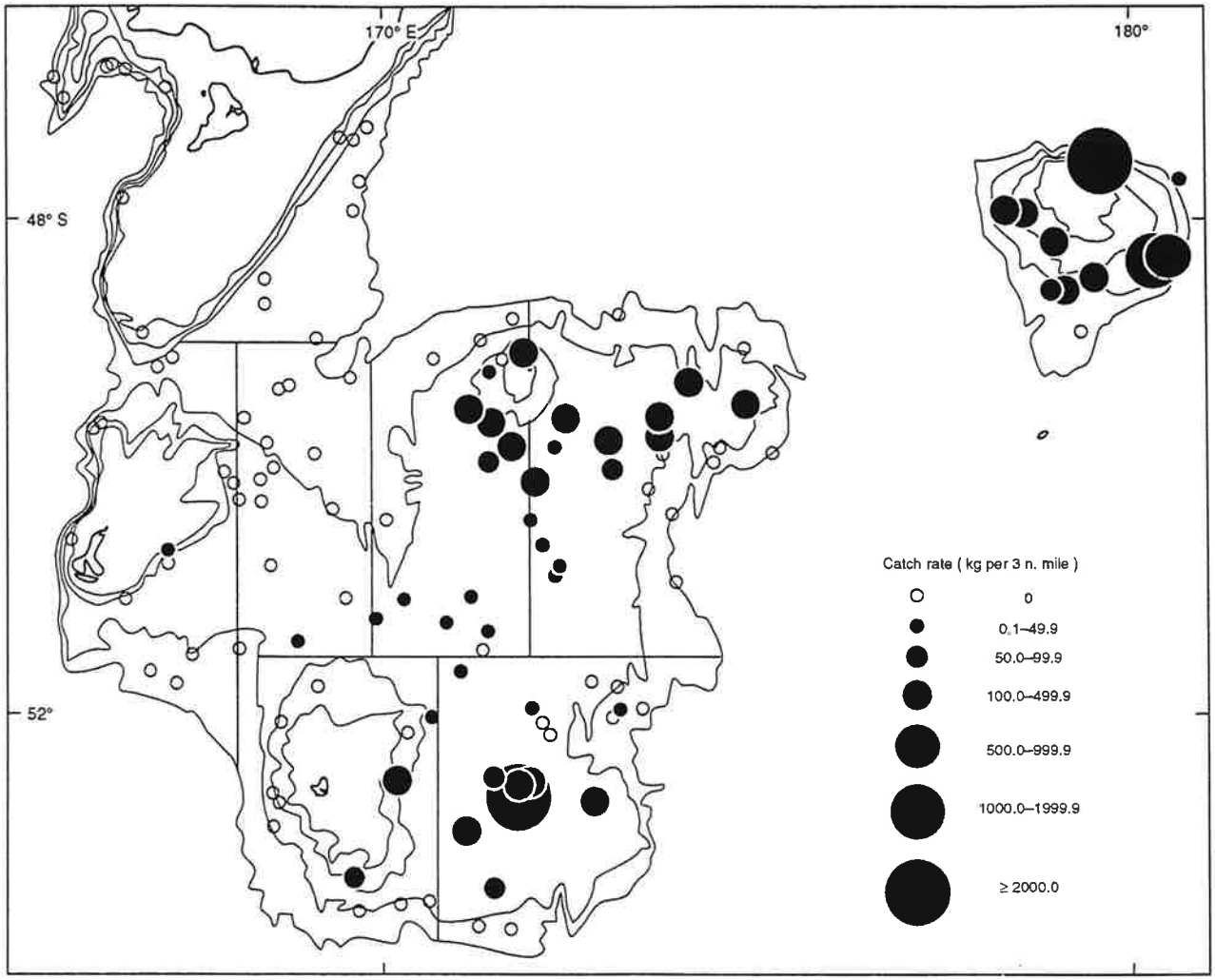

Figure 6: Catch rates of southern blue whiting.

The biomass of hoki, ling, hake, ribaldo, and stargazer was dominated by females, males were dominant for arrow squid and spiny dogfish, and southern blue whiting, silver warehou, and white warehou had an equal split between the sexes (Table 5).

Length distribution of the main target species

Total length frequency distributions (by sex) of the main target species (hoki, southern blue whiting, hake, ling, and silver warehou) are shown in Figure 10. Length frequencies for each stratum for hoki are shown in Appendix 5, and trends summarised for the main species in Figures 11–15. The length weight relationships of these species are given in Appendix 6.

Hoki

A small modal peak at 48 cm and a large one at 75 cm characterise the total length distribution of hoki (*see* Figure 10). Most of the hoki taken in the survey were adult size.

Most of the juveniles (less than 55 cm) were found along the east side of the Stewart-Snares shelf: a few were also found at the Auckland Islands and on the Pukaki Rise (Figure 11). Few fish just below mature size (55–70 cm) were found in most strata, although there were more on the Auckland Island shelf. Mature fish (70–90 cm) were widespread, and dominated all strata east of the Auckland Islands shelf on the Campbell Plateau. Fish larger than 90 cm were rare, and were usually found in deeper strata (18 and 20). A few very large hoki were found on the Bounty Platform.

Southern blue whiting

Three modal peaks at 23, 33, and 37 cm characterise the total length frequency distribution of southern blue whiting (*see* Figure 10). Spawning concentrations rarely contain fish less than 33 cm long (males) and 37 cm (females) (Hanchet 1991). The population sampled in this survey comprised both juvenile and adult fish.

There were additional modes at 43 and 48 cm (*see* Appendix 5). Young southern blue whiting (under 30 cm) from just north of Campbell Island (stratum 11) and on the Bounty Platform (stratum 21) had prominent modes, while fish about 33 cm long were evident to the east of the Auckland

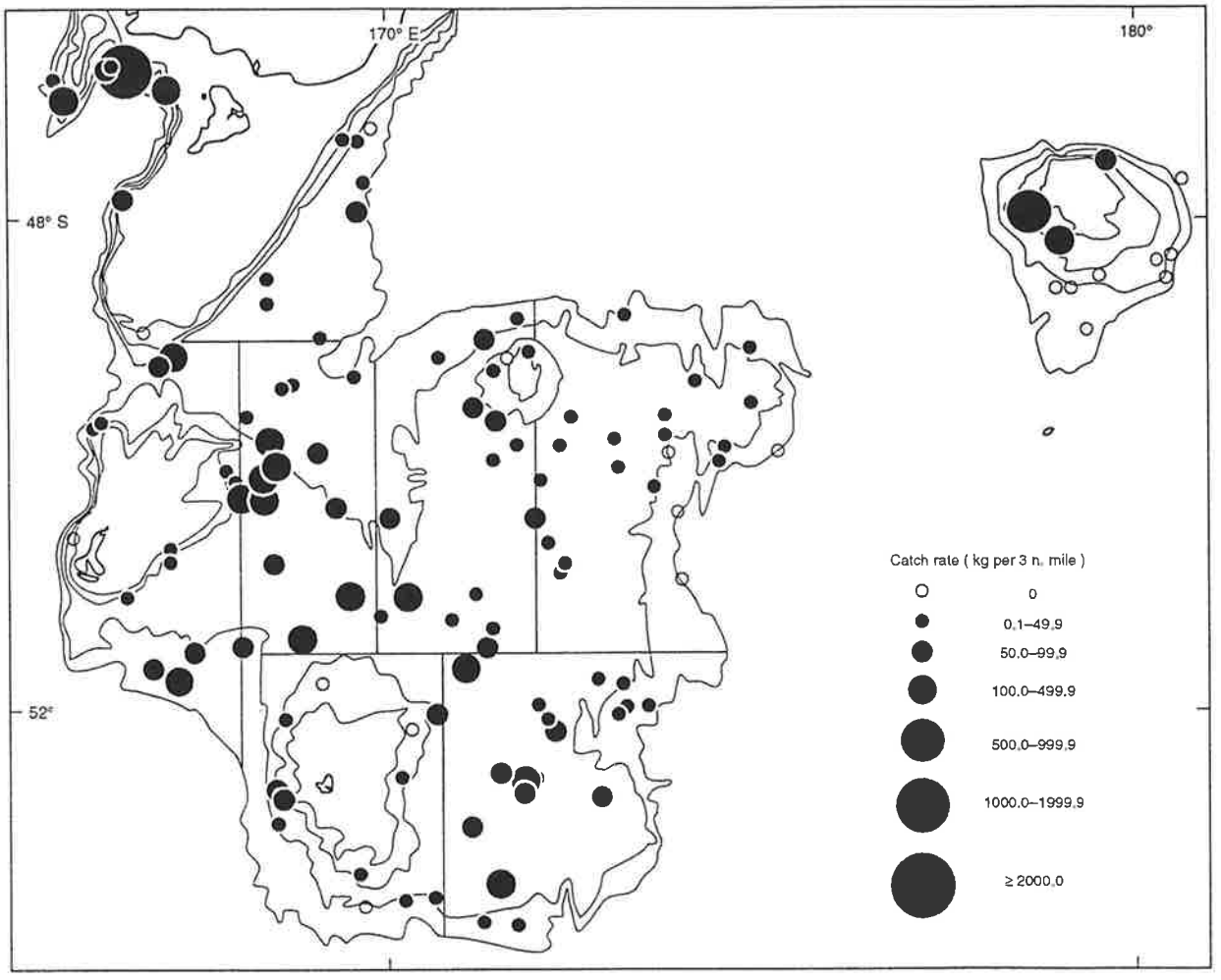

Figure 7: Catch rates of ling.

Islands (strata 6 and 19) (Figure 12). A definite mode of fish at 32 cm was evident to the east of Pukaki Rise (stratum 19) while on the Bounty Platform (stratum 21) the same cohort seemed to be slightly larger, peaking at 34 cm (Figure 12). Larger fish with modes at 37 and 46 cm were evident throughout the central Campbell Plateau and on the Bounty Platform (strata 10, 12, 14, 17, 19, 22, and 23). Fish larger than 45 cm were relatively rare, although some were evident in deep strata on the Bounty Platform and southeast Campbell Plateau (strata 18 and 23).

Table 5: Biomass of major species by sex

	Biomass (t)			
Species	Female	Male	Unsexed	% female
Hoki	38 529	23 552	708	62
Southern blue whiting	16 294	18 512	0	47
Ling	13 449	6 566	0	67
Spiny dogfish	2 594	4 151	8	39
Hake	2 204	456	0	83
Ribaldo	2 228	66	4	97
Silver warehou	1 281	1 334	2	49
Lookdown dory	541	197	14	73
White warehou	395	382	88	51
Arrow squid	370	666	2	36
Stargazer	314	126	0	71

Ling

The peak at 77–85 cm in the total length frequency distribution probably reflects several year classes (*see* Figure 10). The population sampled by the survey almost certainly includes juveniles (under 70 cm), though the reproductive cycle and size at maturity of ling is not well defined (J. A. Colman, MAF Fisheries Greta Point, pers comm.).

Young fish were most common in the shallow shelf areas around the Auckland Islands, Campbell Island, and the Pukaki Rise, and 70–110 cm fish dominated virtually all strata, except on the Bounty Platform where a few very large individuals were caught (Figure 13).

Hake

The few individuals caught and measured resulted in a highly variable total length frequency distribution: males peaked at 84 cm and females at several points between 93 and 118 cm (*see* Figure 10). Spawning concentrations of hake rarely include fish less than 70 cm (males) or 72 cm (females) (Patchell 1981), which suggests that most hake sampled in this survey were adults.

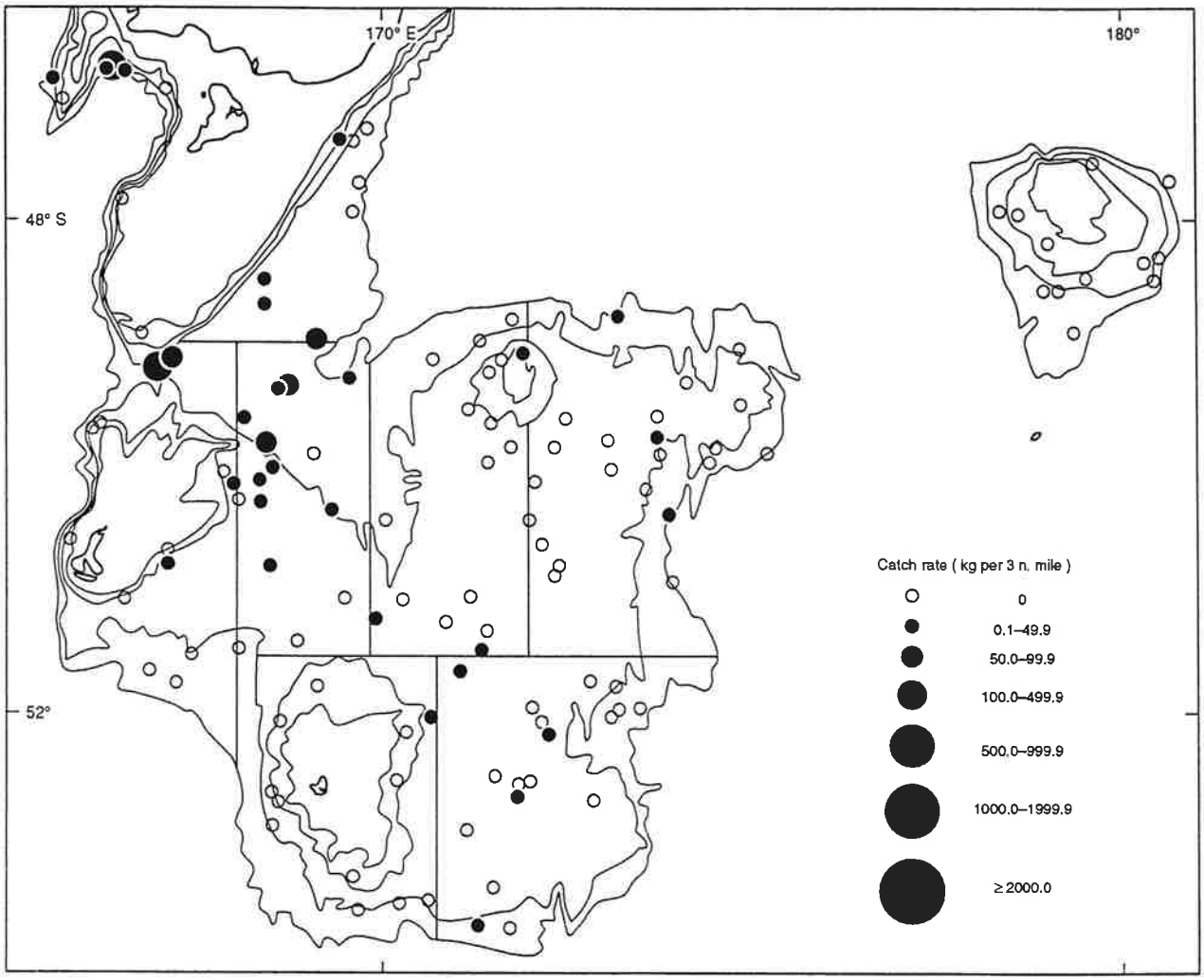

Figure 8: Catch rates of hake.

Most of the smaller fish (under 75 cm) were taken from Puysegur Bank (stratum 1): larger hake (75–125 cm) were found throughout most strata, but particularly in 600–800 m south and east of the Stewart-Snares shelf (Figure 14).

Silver warehou

Two modal peaks are evident in the total length frequency distribution of silver warehou (*see* Figure 10): that at 37 cm is mostly males caught on the Bounty Platform (stratum 21), and the larger fish (modes 47 cm for male fish and 50 cm for females) were taken from the Stewart-Snares shelf and near the Auckland Islands (Figure 15). Both groups of fish may be considered adult size (*see* Gavrilov 1979).

Ovary condition and stomach contents

Examination of the ovaries showed that most hoki and southern blue whiting were in a resting state (Stage 2); some hake had recently spawned (Stage 7) and others were ripening (Stage 3); some ling and silver warehou were ripening (Stage 3) (Table 6).

A few individuals of other species were examined: gemfish were mainly resting, orange roughy and white warehou had recently spawned or were resting, and jack mackerel were in the late maturing stage.

Less than 50% of hoki, southern blue whiting, ling, and hake had food in their stomachs (Table 7). Hoki, ling, and hake had been feeding mostly on prawns and fish, and southern blue whiting had been feeding on euphausids and amphipods (Table 8).

Table 6: Female gonad condition (*after* Livingston 1990a) of the five main target species*

Gonad stage	Percent occurrence				
	HOK	HAK	LIN	SBW	SWA
1 (juvenile)	7	5	11	66	2
2 (resting)	84	21	51	17	16
3 (maturing)	< 1	36	20	< 1	16
4 (ripening)	0	13	17	0	23
5 (ripe)	0	9	< 1	0	28
6 (partially spent)	< 1	7	< 1	1	5
7 (spent)	8	9	< 1	15	11
Total no. examined	1 797	100	880	1 230	57

* Species codes are given in Appendix 3.

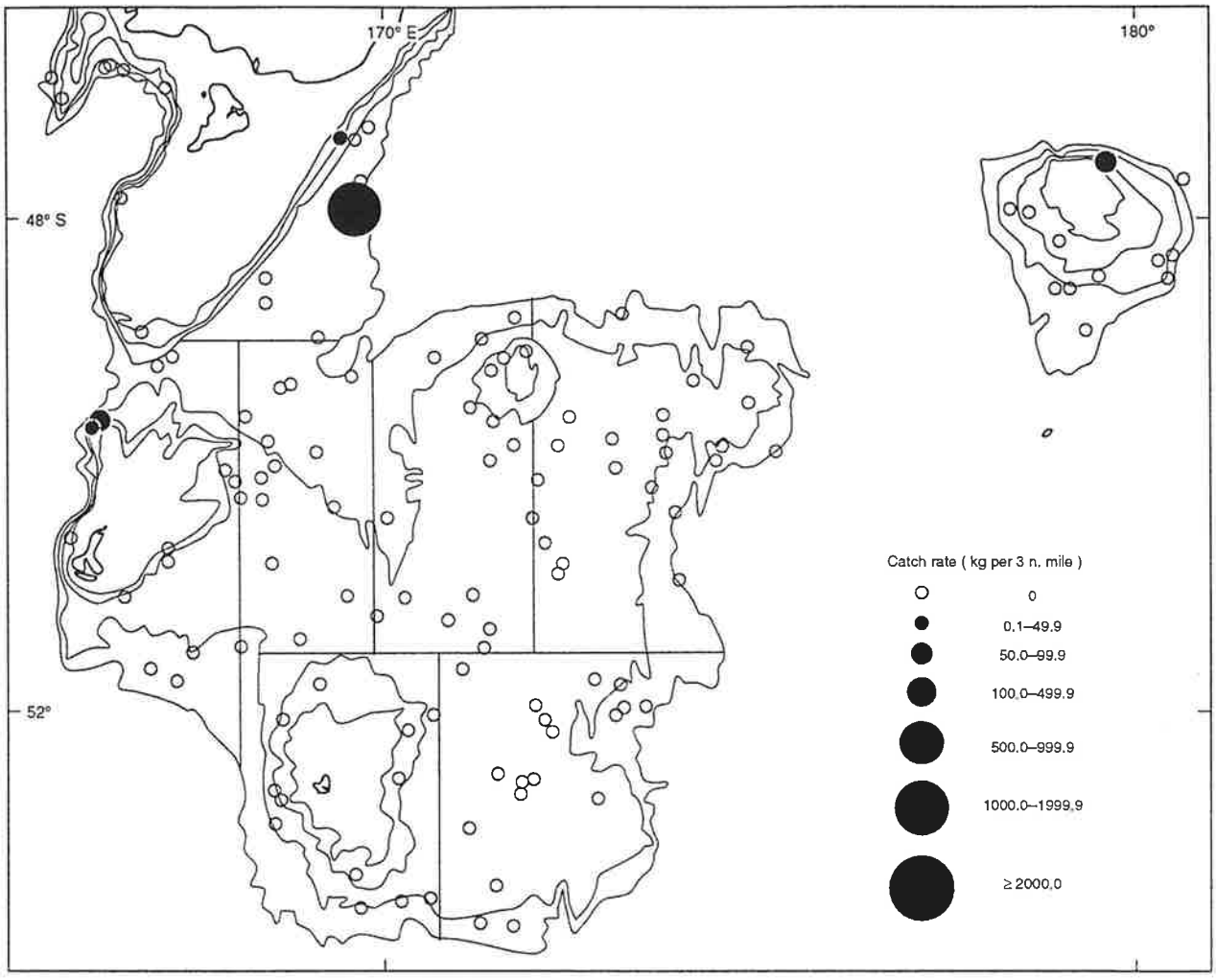

Figure 9: Catch rates of silver warehou.

Table 7: Stomach state of the target species examined

	Empty		Full or partly full		Everted		
Species	no.	%	no.	%	no.	%	Total
Hoki	912	51	785	43	102	6	1 799
Southern blue whiting	843	69	317	26	70	6	1 230
Ling	558	63	313	36	11	1	882
Hake	51	51	46	46	3	3	100
Total	2 364		1 461		186		4 011

Table 8: Stomach contents of the target species sampled

	Hoki		Ling		Hake		Southern blue whiting	
Prey	N*	%†	N	%	N	%	N	%
Prawns	356	42	50	16	4	8	141	31
Fish	299	36	218	71	45	85	95	21
Euphausid	88	11	1	< 1	0	0	94	21
Squid	43	5	8	3	3	5	5	1
Amphipod	25	3	2	< 1	0	0	91	20
Other	19	2	23	7	1	2	19	4
Unidentified	10	1	5	2	0	0	8	2
Total	840		307		53		453	

* Number of occurrences of prey in the stomachs examined.
† Percentage occurrence of prey species.

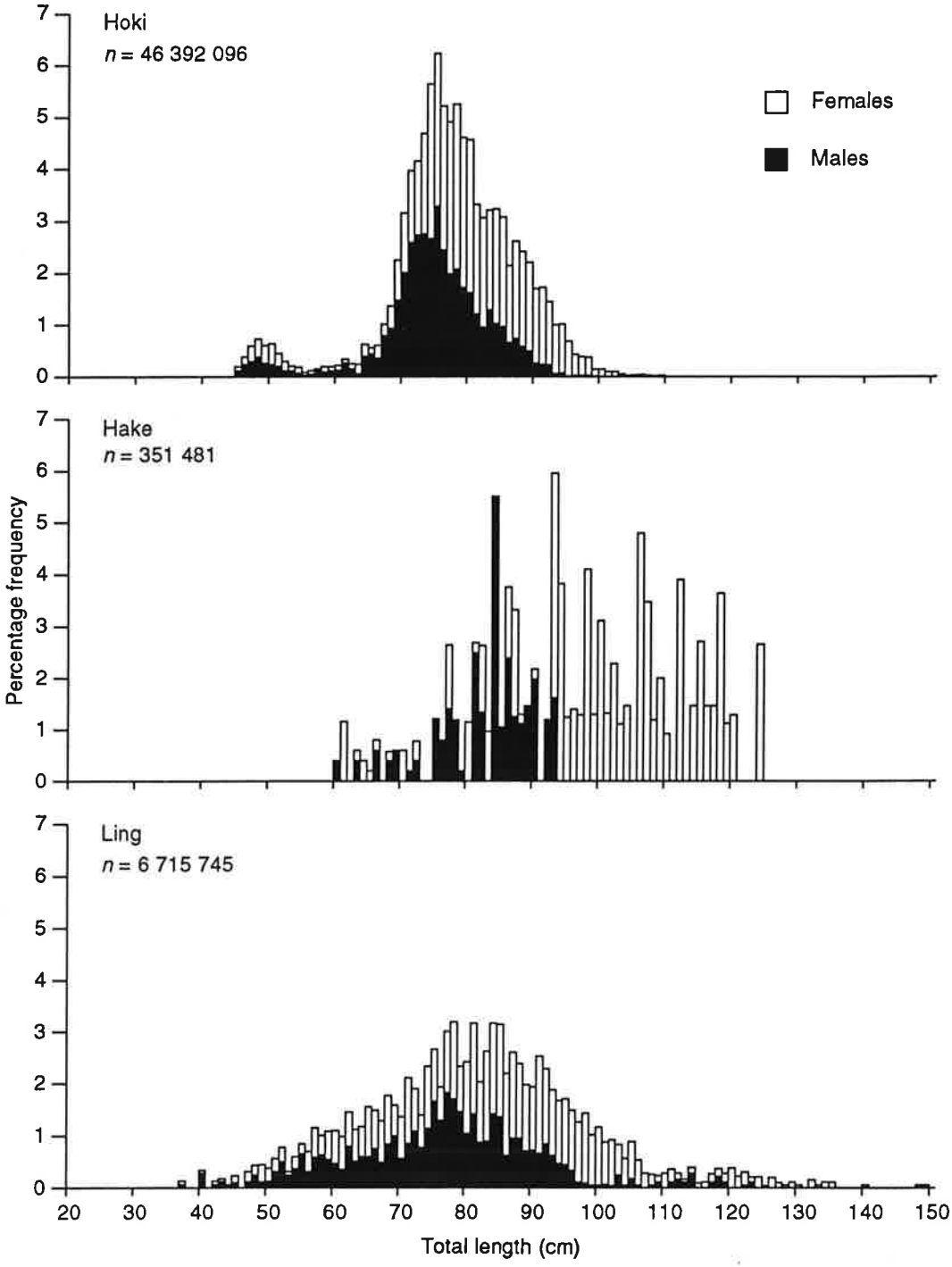

Figure 10: Length frequency of the five main target species (*n* is estimated population size).

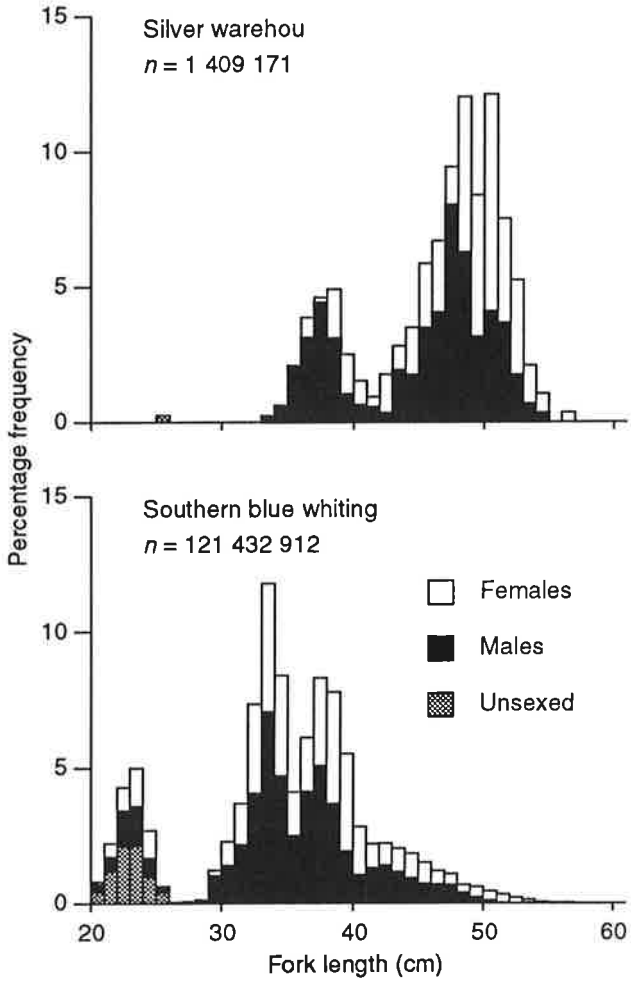

Figure 10 — *continued*

Discussion

In the 1989 trawl survey 125 stations were successfully completed, and all strata in the Southland and Sub-Antarctic area from 200 to 800 m were sampled. Coefficients of variation were less than 20% for hoki, ling, and hake, so the abundance estimates were sufficiently precise for use in stock assessment. The other target species, southern blue whiting and silver warehou, had higher coefficients of variation, but this is not unusual or unexpected as these species are not truly demersal and are more easily caught with midwater gear. The size range of fish, their stomach contents, and reproductive condition were generally similar to those found on previous random trawl surveys of the area in October-November 1979 (Kerstan & Sahrhage 1980) and October-November 1983 (Hatanaka *et al.* 1989). The survey in 1979 was conducted from the German research vessel *Wesermünde*, and that in 1983 from the Japanese research vessel *Shinkai Maru*. Both surveys followed a standard random trawl survey design (Francis 1984).

Biomass estimates

The biomass estimates of hoki, hake, ling, and southern blue whiting were substantially lower in 1989 than in 1983 (Table 9). The index for silver warehou was higher, but the high coefficient of variation made the difference statistically insignificant. The 1989 biomass indices were much closer to the 1979 values, and differences between them are not statistically significant (Table 9).

Catch rates

As with the biomass estimates, catch rates of most species (kg. km^{-2}) by area and depth strata were low in 1989 and 1979 compared with 1983. In 1989, the deepest water, 600–800 m, yielded relatively high catch rates of hoki, along with waters 200–400 m around the Campbell Islands (Table 9). In 1979, the highest catch rates of hoki were in 400–600 m depths off the eastern Stewart-Snares shelf and 600–800 m between the Stewart-Snares Shelf and Pukaki Rise: in 1983, however, the highest

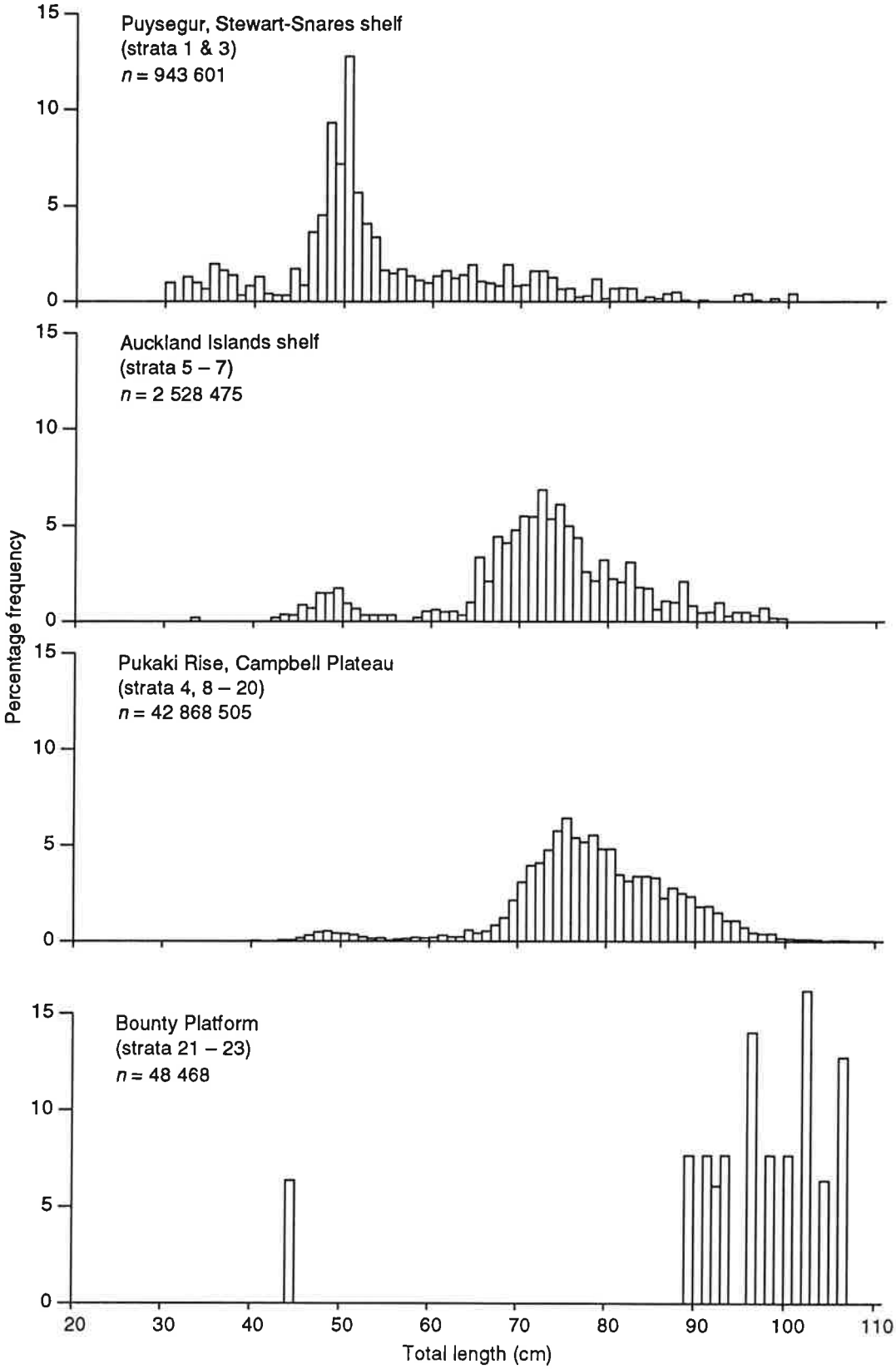

Figure 11: Length frequency of hoki by area (*n* is estimated population size).

catch rates were in 400–800 m around the Auckland and Campbell Islands and 600–800 m around the southeast edge of the Campbell Plateau (Table 10).

Hake catch rates in 1989 were very low, as in 1979 (Table 11). Catch rates were higher in 1983, particularly in deep strata off the southeast edge of the Stewart-Snares shelf and west Pukaki Rise.

Ling catch rates in the 1989 survey were high and similar to those of 1983 (Table 12). Highest catch rates in both surveys were off the Stewart-Snares shelf (400–600 m), Auckland Islands (400–600 m), west Pukaki Rise (400–800 m), and the Bounty Plateau (200–400 m).

Catches of southern blue whiting on the Bounty Plateau were good in 1989, but poor in 1979. Catch rates were highest in 1983, particularly in shallow water on Pukaki Rise (200–600 m), at the Campbell Islands, and on the Campbell Plateau (Table 13).

Catch rates of silver warehou were low in all surveys, the highest occurring in depths of 200–400 m in 1989, particularly around the Stewart-Snares shelf (Table 14).

Length frequency distributions

The size distribution of hoki in all three surveys shows an essentially adult population with most fish longer than 65 cm TL: there has been a shift to the left in the main peak indicating a smaller mean size (Figure 16). Juvenile fish formed a small portion of the population, the various modal peaks presumably reflecting individual year classes. In 1989 small fish (peak at 49 cm) were caught at Puysegur, but the dominant mode was at 73 cm. By comparison, in 1979 the small fish at Puysegur had modal peaks at 35 and 42 cm. A strong modal peak of 50–60 cm fish occurred at the Auckland Islands in 1979, but elsewhere most fish were over 65 cm TL. Puysegur was not sampled in 1983. Juvenile hoki were taken in quantity only from the eastern side of the Stewart-Snares shelf.

A comparison of length frequencies from the three surveys shows that the Southern Plateau continues to be an area of mostly adult hoki (Livingston *et al.* 1991), whereas the Chatham Rise is an area of mostly juvenile hoki. Surveys around the EEZ have identified the Chatham Rise as the only area with abundant juvenile hoki, so most hoki on the Southern Plateau presumably recruit from the Chatham Rise. The size at recruitment to the Southern Plateau coincides with the onset of sexual maturity, so it is likely that sexual development is a driving force for the recruitment process.

Juveniles formed an important part of the southern blue whiting population in both 1989 and 1983, whereas in 1979 most were adult size (Figure 17). In 1983 juveniles (modal peak at 29 cm) were found on Pukaki Rise and older fish (modal peaks at 36 and 44 cm) were found at Campbell Island and over most of the Campbell Plateau. Southern blue whiting were not caught at the Auckland Islands in 1983, unlike in 1989.

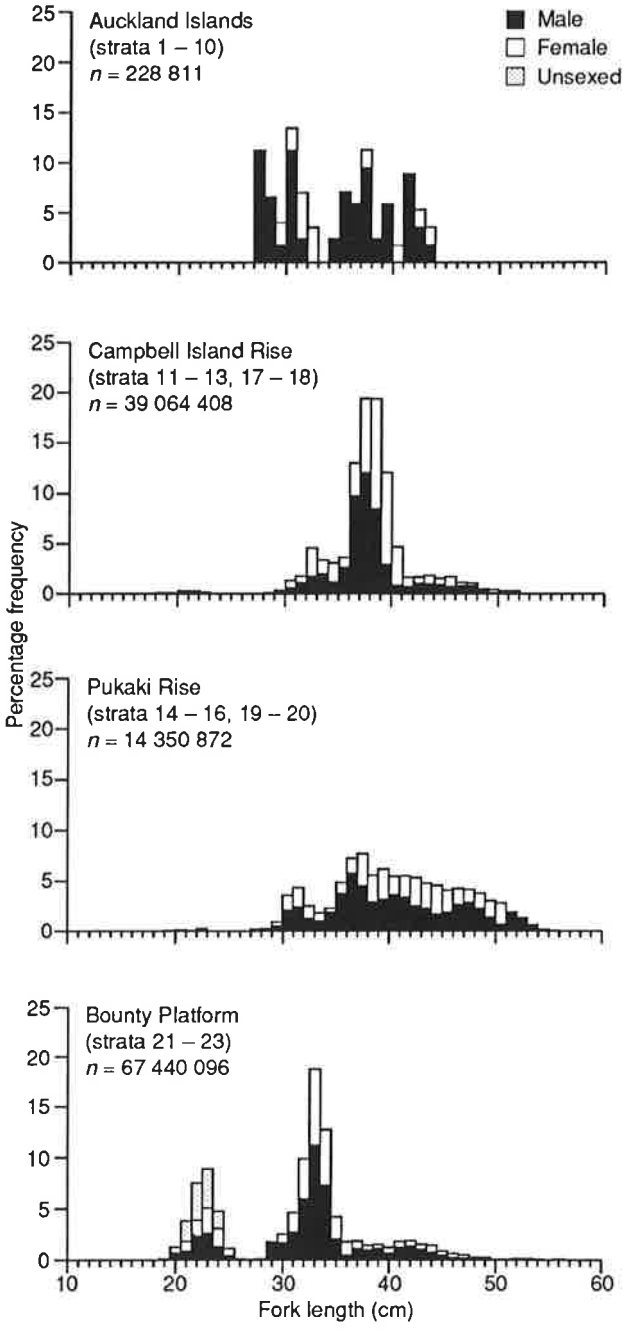

Figure 12: Length frequency of southern blue whiting by area (*n* is estimated population size).

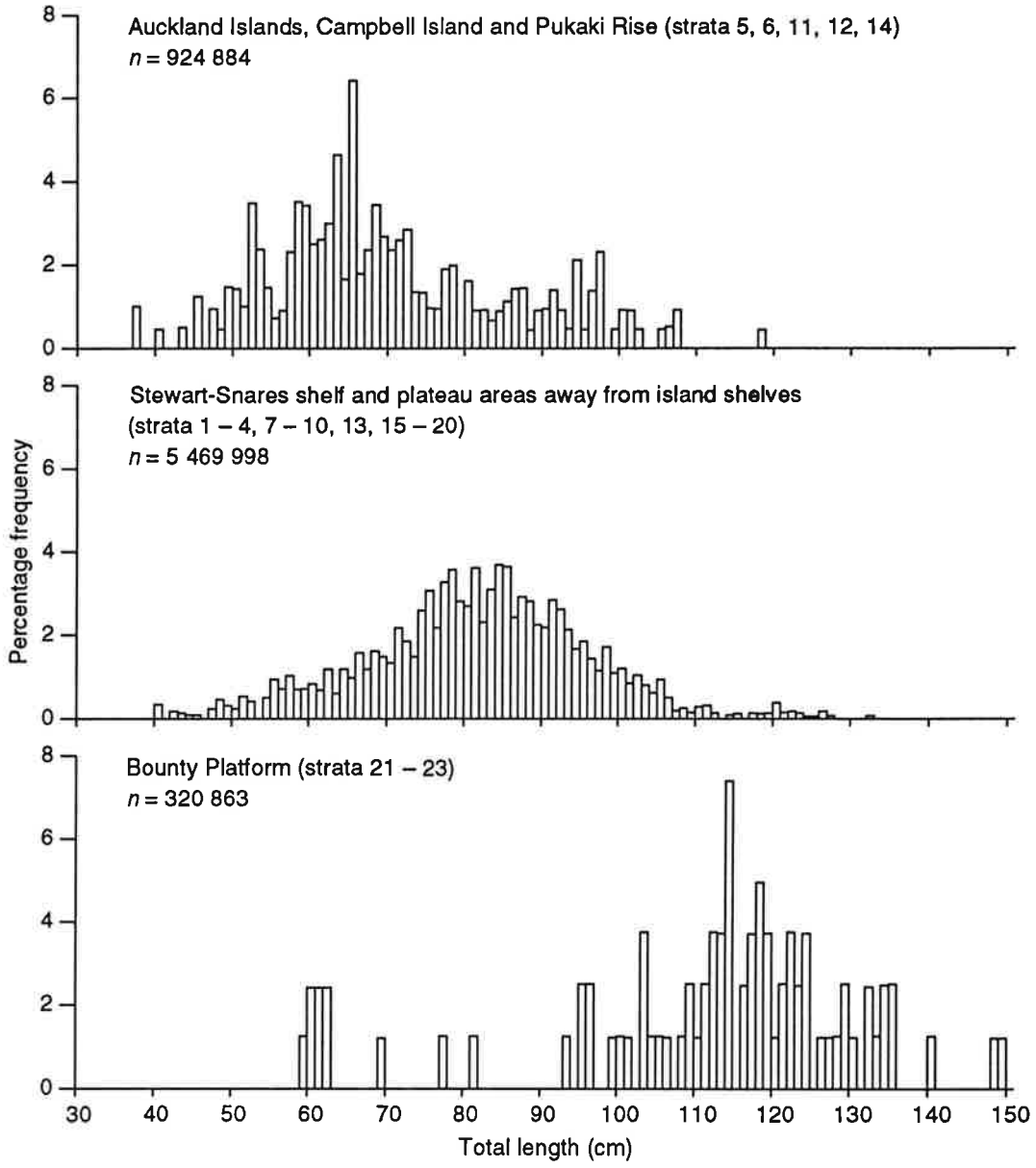

Figure 13: Length frequency of ling by area (*n* is estimated population size).

Ling had a similar size range in all three surveys, though the shapes of the length frequency distributions are quite different (Figure 18). Ling less than 60 cm TL were found in shallow water around the Auckland and Campbell Islands in all three surveys: larger fish were distributed widely over the survey area. Total size distributions of hake were similar in 1989 and 1983 (Figure 19), with an even size distribution among strata. Few hake were caught in 1979. The length frequency distributions of silver warehou were similar in 1989 and 1983: both modal peaks were present in each of the strata (Figure 20). They were not caught in 1979.

Differences between surveys

To properly compare biomass indices, catch rates, and length frequency distributions of fish from different surveys, the survey areas, strata, bottom depths, number of stations, vessel (and hence fishing power), and the trawl gear design and set up should be identical. As discussed by Hurst & Schofield (1990), this has not been possible with the 1979, 1983, and 1989 surveys. The surveys in 1979 and 1983 differed from the 1989 survey in terms of area surveyed, stratum definition, and number of stations as well as vessel and trawl gear (Table 15; Appendix 7).

Table 9: Doorspread biomass indices (t) and percentage distribution (%) from October-November surveys in 1979, 1983, and 1989 (Stewart-Snares shelf, strata 1–3, 8; Sub-Antarctic, all other strata, *see* Figure 2)

Species		Stewart-Snares shelf, Puysegur (t)	(%)	Sub-Antarctic (t)	(%)	Total	Coefficient of variation (%)
Hoki	1979	4 121	(7)	56 167	(93)	60 288	14
	1983	14 154	(7)	197 112	(93)	211 266	10
	1989	3 713	(6)	58 370	(94)	62 083	20
Hake	1979	5 277	(75)	1 766	(25)	7 037	35
	1983	3 984	(42)	5 469	(58)	9 453	20
	1989	1 507	(57)	1 115	(43)	2 622	21
Ling	1979	4 500	(38)	7 447	(62)	11 947	23
	1983	3 862	(13)	26 846	(87)	30 708	9
	1989	5 735	(29)	14 282	(71)	20 017	9
Southern blue whiting	1979	0	(0)	17 122	(100)	17 122	18
	1983	0	(0)	58 114	(100)	58 114	20
	1989	0	(0)	35 514	(100)	35 514	30
Silver warehou	1979	16 014	(100)	0	(0)	1 694	34
	1983	155	(84)	29	(16)	184	50
	1989	2 318	(88)	299	(12)	2 617	89

Data sources: 1979 (MAF Fisheries Research Database and Francis 1981).
1983 (MAF Fisheries and Hatanaka *et al.* 1989).
1989 (Present survey).

Note: Biomass indices from 1983 adjusted to 1989 survey area and doorspread average (*after* Hurst & Schofield 1990).

Table 10: Catch rates (kg.km^{-2}) of hoki by location and depth in 1979, 1983, and 1989 surveys

	Depth (m)		1979	1983	1989
Stewart-Snares shelf	200–400		0	0	0.6
	400–600		1 322.2	435.2	44.0
	600–800	(Puysegur)	48.0	–*	153.9
	600–800	(Channel + West)	–	702.6	49.1
	600–800	(East)	269.7	560.8	138.2
Auckland Islands	200–400		0	240.8	5.3
	400–600	(West)	368.7	1 132.0	105.0
	400–600	(East)	368.7	1 215.1	267.7
	600–800		0	594.6	154.4
Campbell Islands	200–400		0	249.6	855.3
	400–600		102.9	1 442.4	361.0
	600–800		33.6	2 054.5	142.7
Pukaki	200–400		0	0	216.0
	400–600	(West)	136.7	832.1	218.8
	400–600	(East)	136.7	350.1	181.3
	600–800	(West)	1 076.7	635.7	544.6
	600–800	(Central)	280.8	587.1	176.3
	600–800	(East)	280.8	772.8	75.1
Campbell Plateau	400–600		102.9	578.0	65.3
	600–800		33.6	1 213.9	381.7
Bounty Platform	200–400		0	0	0
	400–600		0	9.2	5.0
	600–800		0	21.0	6.6

* Not sampled.

Table 11: Catch rates (kg.km^{-2}) of hake by location and depth in 1979, 1983, and 1989 surveys

	Depth (m)		1979	1983	1989
Stewart-Snares shelf	200–400		0	0	0
	400–600		25.4	72.8	7.2
	600–800	(Puysegur)	12.6	–*	60.2
	600–800	(Channel + West)	–	200.6	124.1
	600–800	(East)	12.6	170.0	23.9
Auckland Islands	200–400		0	33.2	0
	400–600	(West)	21.7	19.9	6.1
	400–600	(East)	21.7	51.2	13.3
	600–800		17.7	10.2	0
Campbell Islands	200–400		0	0	0
	400–600		1.6	18.4	3.2
	600–800		0	7.4	0
Pukaki Rise	200–400		0	0	2.1
	400–600	(West)	2.4	10.6	1.3
	400–600	(East)	2.4	4.8	1.1
	600–800	(West)	0	99.0	31.2
	600–800	(Central)	0	0	0
	600–800	(East)	0	8.6	1.1
Campbell Plateau	400–600		1.6	1.3	2.5
	600–800		0	7.4	1.0
Bounty Platform	200–400		0	0	0
	400–600		0	0	0
	600–800		0	0	0

* Not sampled.

Table 12: Catch rates (kg.km^{-2}) of ling by location and depth in 1979, 1983, and 1989 surveys

	Depth (m)		1979	1983	1989
Stewart-Snares shelf	200–400		0	66.7	40.6
	400–600		73.8	525.9	667.9
	600–800	(Puysegur)	26.6	–*	34.5
	600–800	(Channel + West)	–	82.5	10.4
	600–800	(East)	26.6	46.4	28.8
Auckland Islands	200–400		9.0	1.1	2.4
	400–600	(West)	51.5	124.5	8.8
	400–600	(East)	51.5	279.5	123.4
	600–800		50.7	79.4	72.4
Campbell Islands	200–400		37.8	2.1	13.5
	400–600		35.4	164.0	81.7
	600–800		0	86.0	24.2
Pukaki Rise	200–400		0	1.8	19.0
	400–600	(West)	35.6	96.2	59.4
	400–600	(East)	35.6	55.0	28.6
	600–800	(West)	19.2	234.8	50.8
	600–800	(Central)	19.2	40.4	41.3
	600–800	(East)	19.2	15.1	10.3
Campbell Plateau	400–600		35.4	97.3	60.0
	600–800		0	33.7	26.7
Bounty Platform	200–400		0	312.0	372.2
	400–600		0	0	0
	600–800		0	0	0

* Not sampled.

Table 13: Catch rates (kg.km^{-2}) of southern blue whiting by location and depth in 1979, 1983, and 1989 surveys

	Depth (m)		1979	1983	1989
Stewart-Snares shelf	200–400		0	0	0
	400–600		0	0	0
	600–800	(Puysegur)	0	–*	0
	600–800	(Channel + West)	–	0.1	0
	600–800	(East)	0	0	0
Auckland Islands	200–400		0	0	0
	400–600	(West)	12.8	0.4	2.2
	400–600	(East)	12.8	16.9	1.5
	600–800		0	0	0
Campbell Islands	200–400		0	322.4	31.3
	400–600		166.1	864.3	95.8
	600–800		0	0	0
Pukaki Rise	200–400		0	1 962.2	45.4
	400–600	(West)	197.5	19.6	70.9
	400–600	(East)	0	62.1	112.7
	600–800	(West)	0	1.5	0
	600–800	(Central)	0	< 0.1	0
	600–800	(East)	0	0.3	0
Campbell Plateau	400–600		166.1	837.7	373.6
	600–800		0	0	0.2
Bounty Platform	200–400		0	17.8	1 274.3
	400–600		0	702.0	772.9
	600–800		0	59.7	46.3

* Not sampled.

Table 14: Catch rates (kg.km^{-2}) of silver warehou by location and depth in 1979, 1983, and 1989

	Depth (m)		1979	1983	1989
Stewart-Snares shelf	200–400		0	55.1	407.8
	400–600		0	3.2	0
	600–800	(Puysegur)	0	–*	0.3
	600–800	(Channel + West)	–	0	0
	600–800	(East)	0	0.4	0
Auckland Islands	200–400		0	0	31.8
	400–600	(West)	0	0.7	0.1
	400–600	(East)	0	0	0
	600–800		0	0	0
Campbell Islands	200–400		0	0	0
	400–600		0	0	0
	600–800		0	0	0
Pukaki Rise	200–400		0	9.2	0
	400–600	(West)	0	0	0
	400–600	(East)	0	0	0
	600–800	(West)	0	0	0
	600–800	(Central)	0	0	0
	600–800	(East)	0	0	0
Campbell Plateau	400–600		0	0	0
	600–800		0	0	0
Bounty Platform	200–400		0	0	22.2
	400–600		0	0	0
	600–800		0	0	0

* Not sampled.

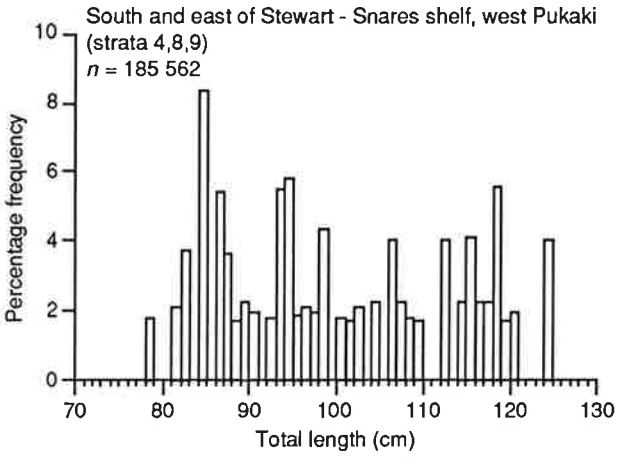

Figure 14: Length frequency of hake in deeper strata south and east of the Stewart-Snares shelf (*n* is estimated population size).

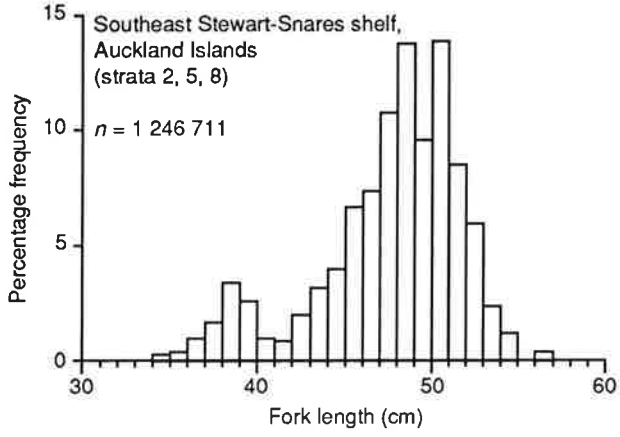

Figure 15: Length frequency of silver warehou on the Stewart-Snares shelf and at the Auckland Islands (*n* is estimated population size).

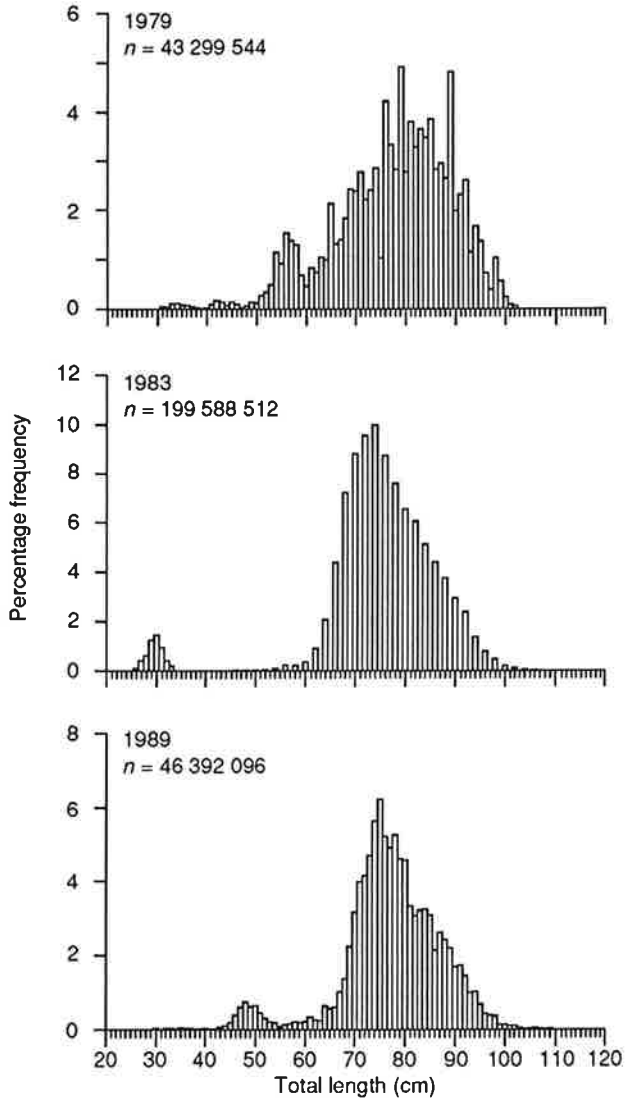

Figure 16: Length frequency of hoki in the survey area in 1979, 1983, and 1989 (*n* is estimated population size).

Table 15: Survey and gear parameters from spring-summer surveys of the Sub-Antarctic in 1979, 1983, and 1989

	Wesermünde Oct-Nov 1979	*Shinkai Maru* Oct-Nov 1983	*Amaltal Explorer* Oct-Nov 1989
Depth (m)	0–1 000	250–800	200–800
Survey area (km2)	385 049	346 309	318 398
No. of strata	32	27	23
No. of stations	115	184	125
Mean tow length	2.0 n. mile	30 min	3.0 n. mile
Mean tow speed (knots)	4.1	3.2	3.4
Mean headline height (m)	10.3	7.3	9.8
Mean warp : depth ratio	not known	2.06	1.96
Mean doorspread (m)	130	122	129
Doorspread : wingspread	3.7	3.6	4.3
Groundrope length (m)	76	95.7	56.2
Net length (m)	not known	83.7	62.7
Sweep length (m)	not known	93	90.0
Bridle length (m)	not known	102	55.0
Sweep angle (°)	not known	12	16–19
Codend mesh (mm)	100	80	60
Net type	Wingless 2 seam bottom trawl	Japanese multi-panel bottom trawl	High opening butterfly bottom trawl

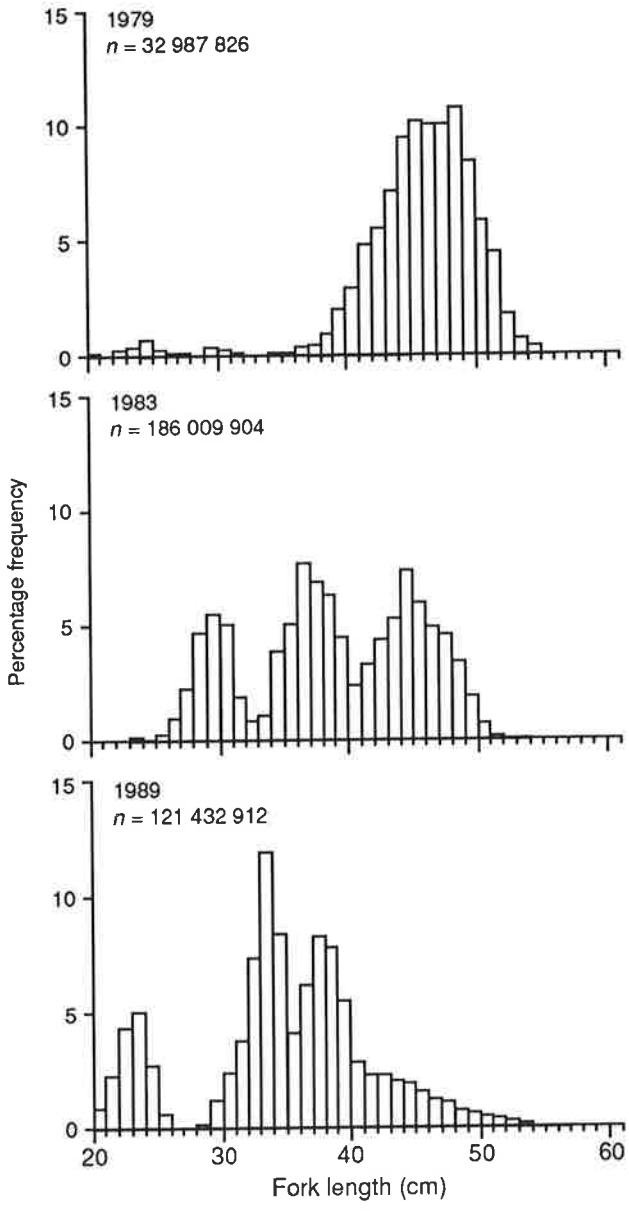

Figure 17: Length frequency of southern blue whiting in the survey area in 1979, 1983, and 1989 (*n* is estimated population size).

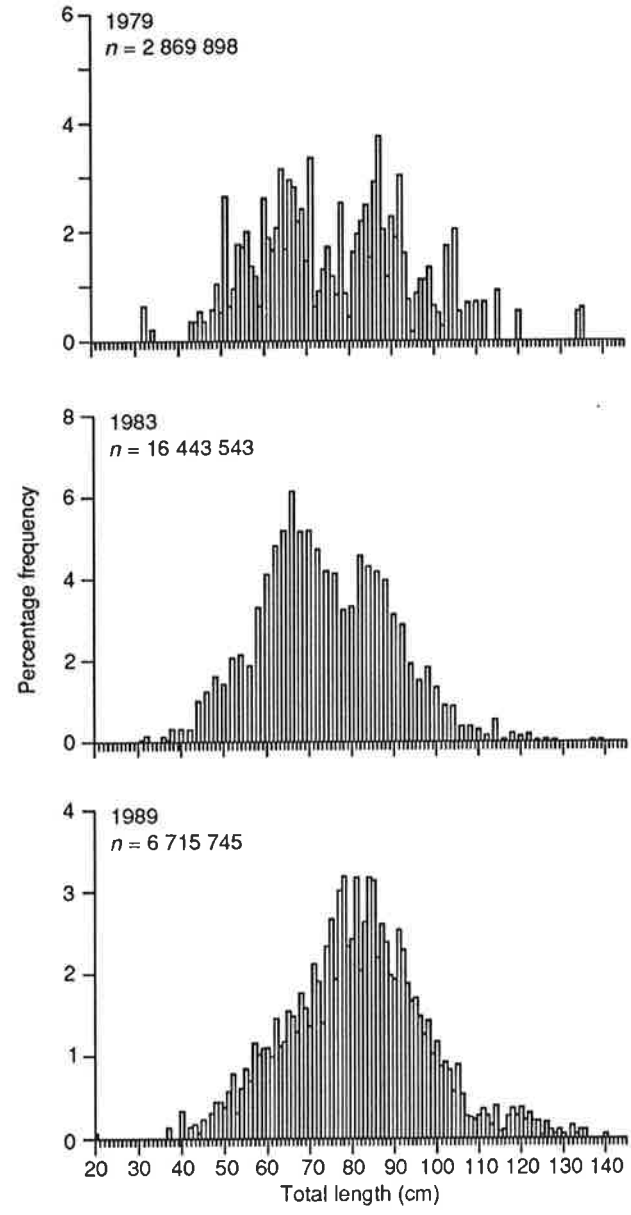

Figure 18: Length frequency of ling in the survey area in 1979, 1983, and 1989 (*n* is estimated population size).

The net designs used in the three surveys were fundamentally different and thus each may have caught significantly different proportions or size ranges of the species in the path of the net (Nomura & Yamakazi 1977).

Gear differences between vessels may explain the large differences in catches (and hence apparent abundances) between the present survey and those of 1983 and 1979. Any real changes in abundance between years cannot easily be distinguished from those introduced by gear differences. Hurst & Schofield (1990) tried to derive an index of fishing power for *Shinkai Maru* using the rationale that bycatch species had not been commercially exploited between surveys (unlike hoki, hake, ling, and southern blue whiting) and that their relative biomass therefore remained unchanged. However, biomass estimates adjusted by this method and used for stock assessment in 1990 were rejected in 1991 (Hurst & Schofield 1991, Sullivan 1991) on the grounds that knowledge of the distribution and population dynamics of the bycatch species is inadequate.

Other factors potentially affecting catch rates (and therefore biomass estimates) include changes in water mass properties, changes in catchability, and recruitment variability.

The hydrological conditions were similar in 1989, 1983, and 1979 (Hatanaka *et al.* 1989, unpublished data held on MAF Fisheries database). The Southland Front (the interface between warm subtropical water and cooler subantarctic water) lay along the eastern edge of the Stewart-Snares shelf and the Auckland Islands shelf. Bottom temperatures were similar in all years and averaged about 7° C everywhere except on the Bounty

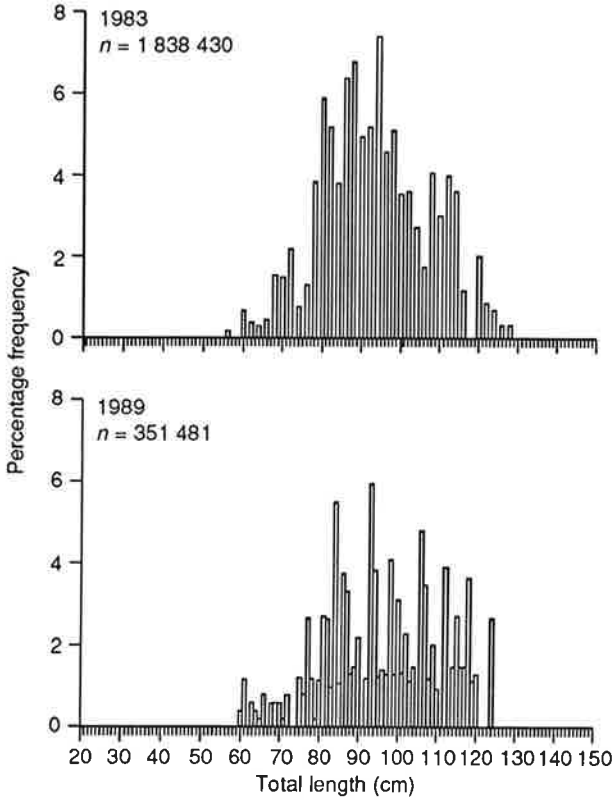

Figure 19: Length frequency of hake in the survey area in 1983 and 1989 (*n* is estimated population size).

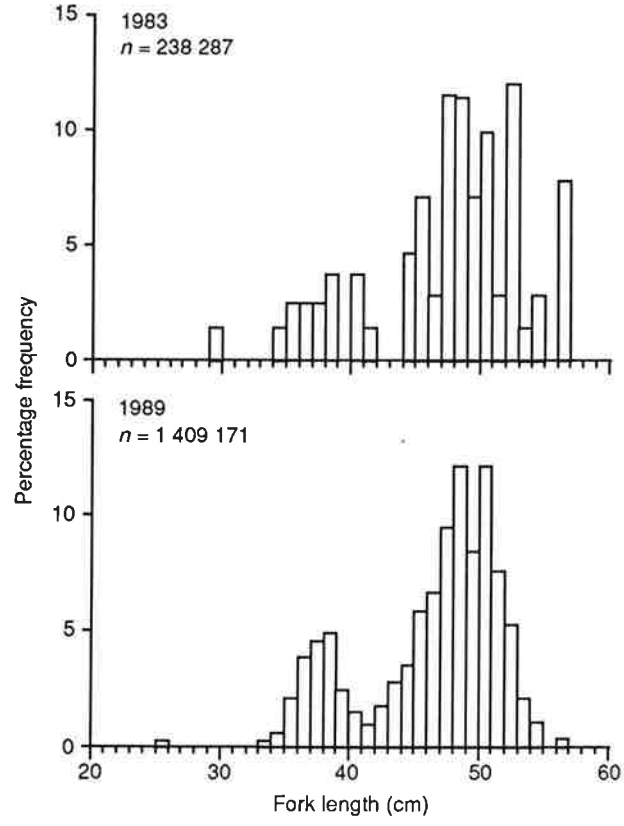

Figure 20: Length frequency of silver warehou in the survey area in 1983 and 1989 (*n* is estimated population size).

Platform where they were 5–6° C. Hydrology does not, therefore, account for differences in catch.

We have not tested the assumptions about fish catchability. It is unlikely that fish are randomly and evenly distributed over the sea bed. It is unlikely that fish distribution did not extend above the headline of the net. Most of the species surveyed can be caught with midwater gear and are semi-pelagic at times. It is unlikely that all fish in the path of the doors are caught, or that the herding effect of the gear is constant. Fish behaviour may change according to differences in current speeds, food availability, and season, leading to changes in catches. Although violations of the assumptions probably lead to increased variability in the data, the three-fold difference in hoki biomass between 1983 and 1989 would require a large scale systematic difference to have occurred between surveys.

Recruitment of hoki and southern blue whiting fluctuates (Hanchet 1991, Sullivan & Cordue 1992). The skew in the size distribution of hoki in 1983 (*see* Figure 17) suggests a strong year class (or year classes) of hoki of 72–76 cm TL. Although the 1989 peak is also skewed to the right, about 800 000 t of mature size hoki was taken by the commercial fleet between 1983 and 1989, so a population dominated by newly recruited fish is to be expected.

Without an understanding of the effect of the gear on the fish, it is difficult to interpret the abundance fluctuations for each species.

The main objectives of the survey were met, showing that the random trawl survey approach to estimating the distribution and relative abundance of bottom species remains a useful one. The difficulties in using the data to update biomass estimates from earlier surveys of the area have highlighted the need for continuity of vessel and gear type used. Other problems, such as the validity of assumptions about fish vulnerability and their distribution, cannot be resolved in the short term. A time series of random trawl surveys south of New Zealand and on the Chatham Rise using MAF Fisheries' new research vessel *Tangaroa* began in December 1991. These will go a long way towards minimising between-survey differences, as well as monitoring hoki recruitment variability. Trawl surveys of hoki and associated species will therefore continue to be an important part of assessing these stocks.

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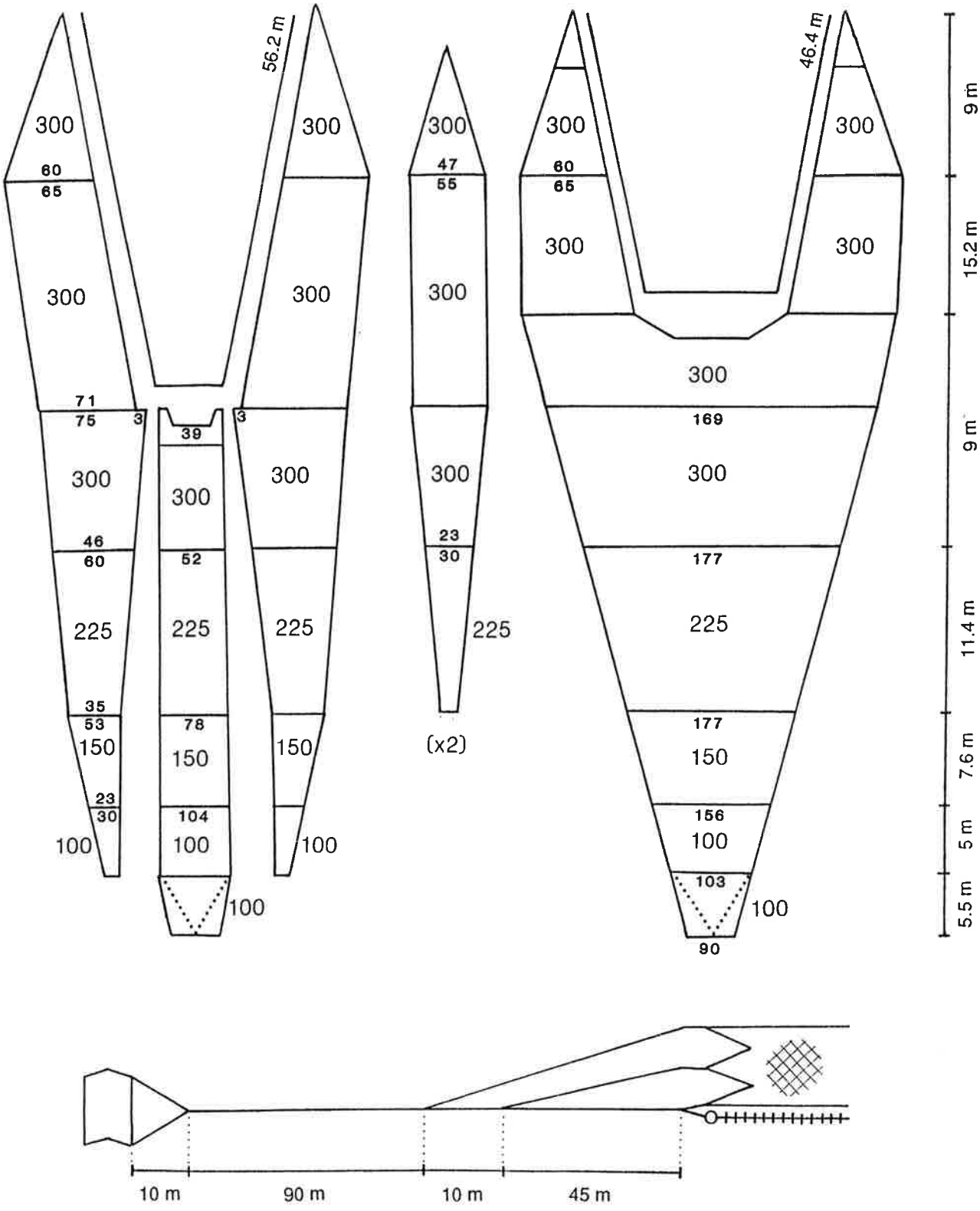
Appendix 1

Details of high opening butterfly trawl net

(Large figures denote mesh size in terms of "knot to knot" and small figures denote the number of meshes)



Appendix 2

Individual station data

Station	Stratum	Date	Latitude	Longitude	Depth (m) Min.	Depth (m) Max.	Head ht (m)	Door spread (m)
001	08	20 Oct 89	47°03.95′ S	169°49.32′ E	664	679	8.6	130.0
002	08	20 Oct 89	47°10.70′ S	169°38.28′ E	612	628	12.9	133.0
003	02	20 Oct 89	47°09.40′ S	169°24.99′ E	206	235	10.6	114.0
004	08	20 Oct 89	47°31.54′ S	169°43.00′ E	668	771	13.9	121.0
005	08	20 Oct 89	47°48.16′ S	169°36.41′ E	718	722	11.2	124.0
006	08	21 Oct 89	48°23.07′ S	168°25.77′ E	670	677	11.0	140.0
007	08	21 Oct 89	48°37.73′ S	168°25.95′ E	679	684	11.3	121.0
008	08	21 Oct 89	48°54.60′ S	169°07.84′ E	678	712	10.5	125.0
009	09	21 Oct 89	49°14.29′ S	169°32.22′ E	707	748	12.5	132.0
010	09	22 Oct 89	49°18.79′ S	168°44.66′ E	752	767	9.7	35.0
011	09	22 Oct 89	49°20.47′ S	168°37.34′ E	730	744	11.1	130.0
012	09	22 Oct 89	49°36.79′ S	168°07.79′ E	650	658	12.5	132.0
013	09	22 Oct 89	49°48.56′ S	168°25.38′ E	608	611	12.4	127.0
014	09	22 Oct 89	49°52.66′ S	169°04.95′ E	639	657	10.6	125.0
015	05	23 Oct 89	50°03.48′ S	167°50.41′ E	260	279	10.8	113.0
016	06	23 Oct 89	50°09.38′ S	167°59.04′ E	448	470	13.3	122.0
017	10	23 Oct 89	50°17.87′ S	168°04.90′ E	476	496	12.4	131.0
018	10	23 Oct 89	50°18.84′ S	168°19.21′ E	572	596	12.6	130.0
019	10	23 Oct 89	50°06.85′ S	168°19.28′ E	531	584	12.0	140.0
020	10	23 Oct 89	49°59.91′ S	168°31.51′ E	600	617	13.0	135.0
021	06	24 Oct 89	50°43.08′ S	167°06.32′ E	409	425	10.0	130.0
022	06	24 Oct 89	50°49.20′ S	167°06.00′ E	452	467	9.5	29.5
023	06	25 Oct 89	51°06.91′ S	166°29.51′ E	502	514	8.8	39.0
025	07	25 Oct 89	51°41.72′ S	166°50.14′ E	514	708	10.0	145.0
026	07	25 Oct 89	51°48.27′ S	167°11.98′ E	702	710	8.2	45.0
027	07	25 Oct 89	51°33.25′ S	167°22.78′ E	620	672	9.5	38.0
028	13	26 Oct 89	51°31.69′ S	168°03.94′ E	624	627	9.2	37.0
029	10	26 Oct 89	51°25.76′ S	168°48.35′ E	519	526	10.0	136.0
030	11	26 Oct 89	51°48.49′ S	169°04.86′ E	230	282	10.1	121.0
031	11	26 Oct 89	52°05.05′ S	168°36.25′ E	260	286	10.5	114.0
032	12	27 Oct 89	52°39.12′ S	168°27.63′ E	543	558	9.5	40.0
033	12	27 Oct 89	52°43.78′ S	168°32.26′ E	500	511	7.5	36.0
034	13	27 Oct 89	52°54.98′ S	168°27.76′ E	653	653	10.0	136.0
035	12	27 Oct 89	53°19.87′ S	169°30.93′ E	459	463	8.5	34.0
036	13	27 Oct 89	53°35.03′ S	169°35.47′ E	666	691	8.0	41.0
037	13	28 Oct 89	53°31.82′ S	170°08.03′ E	746	758	11.1	143.0
038	13	28 Oct 89	53°30.75′ S	170°32.39′ E	730	740	8.1	42.0
039	18	28 Oct 89	53°42.39′ S	171°10.72′ E	714	714	8.0	38.0
040	18	28 Oct 89	53°43.84′ S	171°33.10′ E	672	690	10.6	135.0
041	17	28 Oct 89	53°25.10′ S	171°22.74′ E	478	481	8.3	30.0
042	17	29 Oct 89	52°44.73′ S	172°46.00′ E	494	501	9.3	28.8
043	17	29 Oct 89	52°34.83′ S	171°53.38′ E	519	523	6.5	28.8
044	17	29 Oct 89	52°36.47′ S	171°45.83′ E	490	508	10.2	128.8
045	17	29 Oct 89	52°41.89′ S	171°45.51′ E	460	476	10.1	128.8
046	17	30 Oct 89	52°32.25′ S	171°25.65′ E	500	510	9.8	20.0
047	12	30 Oct 89	52°57.97′ S	171°02.30′ E	443	446	10.4	122.0
048	11	30 Oct 89	52°33.89′ S	170°07.23′ E	365	380	9.6	19.0
049	11	30 Oct 89	52°10.66′ S	170°14.31′ E	208	218	9.5	05.0
050	12	30 Oct 89	52°03.78′ S	170°36.37′ E	408	420	12.6	123.0
051	17	31 Oct 89	51°47.27′ S	172°45.15′ E	570	574	10.0	129.0
052	18	31 Oct 89	51°50.04′ S	173°07.06′ E	610	647	11.5	128.0
053	18	31 Oct 89	52°00.00′ S	173°24.37′ E	683	718	10.0	121.0
054	18	31 Oct 89	52°00.78′ S	173°06.38′ E	616	618	9.5	27.0
055	18	31 Oct 89	52°03.98′ S	173°00.33′ E	630	632	10.5	124.0
056	17	31 Oct 89	52°11.90′ S	172°09.60′ E	578	587	9.6	33.0
057	17	01 Nov 89	52°05.47′ S	172°04.77′ E	558	566	10.8	127.0
058	17	01 Nov 89	51°59.78′ S	171°56.73′ E	534	541	9.0	35.0
059	12	01 Nov 89	51°41.04′ S	170°57.71′ E	510	510	9.0	33.0
060	15	01 Nov 89	51°30.61′ S	171°16.34′ E	528	530	10.7	128.0
061	15	01 Nov 89	51°21.84′ S	171°21.26′ E	528	528	10.8	123.6
062	10	02 Nov 89	51°05.28′ S	169°26.85′ E	563	563	9.4	29.0
063	10	02 Nov 89	51°15.01′ S	169°45.13′ E	526	535	9.7	34.0
064	15	02 Nov 89	51°06.17′ S	170°13.63′ E	560	562	9.1	26.0
065	15	02 Nov 89	51°17.12′ S	170°46.28′ E	540	544	9.6	28.8
066	15	02 Nov 89	51°04.91′ S	171°07.93′ E	540	542	9.7	25.8
067	19	03 Nov 89	50°54.70′ S	172°16.60′ E	522	525	8.8	30.0
068	19	03 Nov 89	50°49.64′ S	172°20.44′ E	523	530	10.0	133.0
069	19	03 Nov 89	50°39.17′ S	172°05.90′ E	502	502	9.7	29.0

Appendix 2 – *continued*

Station	Stratum	Date	Latitude	Longitude	Depth (m) Min.	Depth (m) Max.	Head ht (m)	Door spread (m)
070	15	03 Nov 89	50°26.47′ S	171°55.85′ E	506	508	8.9	27.0
071	19	03 Nov 89	50°06.82′ S	172°00.11′ E	502	502	9.1	30.5
072	19	03 Nov 89	49°51.22′ S	172°18.18′ E	482	484	10.1	128.0
073	15	04 Nov 89	49°50.25′ S	171°41.98′ E	468	473	8.2	30.0
074	15	04 Nov 89	49°38.32′ S	171°25.81′ E	430	439	8.0	28.8
075	15	04 Nov 89	49°30.02′ S	171°07.21′ E	452	462	8.0	28.8
076	14	04 Nov 89	49°12.20′ S	171°24.36′ E	287	349	10.3	111.5
077	14	04 Nov 89	49°06.53′ S	171°35.05′ E	294	317	10.0	111.5
078	14	04 Nov 89	49°02.93′ S	171°53.52′ E	375	406	8.0	11.5
079	19	05 Nov 89	49°54.82′ S	173°42.75′ E	566	569	8.0	28.8
080	19	05 Nov 89	49°45.95′ S	173°40.85′ E	513	525	10.0	127.0
081	19	05 Nov 89	49°35.81′ S	173°41.74′ E	483	485	8.0	31.0
082	19	05 Nov 89	49°17.23′ S	174°04.12′ E	507	518	9.6	29.0
083	19	05 Nov 89	49°28.64′ S	174°50.15′ E	525	547	10.4	116.8
084	19	06 Nov 89	50°13.00′ S	173°31.58′ E	590	608	8.5	20.4
085	19	06 Nov 89	50°02.27′ S	173°02.27′ E	514	515	8.3	20.6
086	19	06 Nov 89	49°47.66′ S	173°00.66′ E	490	497	8.1	23.1
087	19	06 Nov 89	49°36.29′ S	172°25.33′ E	444	447	7.3	19.4
088	15	06 Nov 89	49°58.21′ S	171°22.93′ E	502	511	10.5	127.4
089	16	07 Nov 89	50°26.54′ S	170°00.35′ E	607	614	9.0	26.0
090	10	07 Nov 89	50°20.83′ S	169°16.72′ E	586	597	7.8	36.0
091	10	07 Nov 89	50°49.23′ S	168°27.56′ E	573	590	9.0	27.0
092	05	08 Nov 89	50°36.69′ S	165°46.53′ E	224	224	10.5	111.5
093	06	08 Nov 89	49°40.91′ S	166°05.56′ E	408	410	10.0	125.0
094	05	08 Nov 89	49°38.40′ S	166°11.72′ E	272	276	10.0	95.0
095	04	08 Nov 89	49°10.11′ S	166°57.87′ E	622	669	8.1	27.0
096	04	09 Nov 89	49°05.17′ S	167°12.51′ E	674	683	10.5	132.8
097	02	09 Nov 89	48°51.22′ S	166°44.97′ E	233	234	10.6	95.9
098	02	10 Nov 89	47°40.70′ S	166°30.98′ E	196	230	9.0	13.0
099	03	10 Nov 89	46°44.00′ S	167°09.00′ E	416	455	8.0	32.0
100	01	11 Nov 89	46°31.88′ S	166°18.76′ E	646	656	10.0	142.0
101	03	11 Nov 89	46°31.50′ S	166°33.80′ E	503	517	9.4	41.0
102	01	11 Nov 89	46°37.09′ S	165°37.69′ E	600	643	9.5	30.0
103	03	12 Nov 89	46°49.37′ S	165°44.85′ E	421	452	8.1	28.5
104	01	12 Nov 89	46°30.90′ S	166°22.63′ E	759	762	11.7	132.8
105	16	17 Nov 89	49°05.57′ S	170°40.82′ E	660	662	8.5	24.0
106	16	17 Nov 89	48°55.55′ S	171°17.21′ E	614	615	9.6	34.7
107	16	17 Nov 89	48°44.12′ S	171°45.71′ E	659	666	10.5	137.0
108	20	17 Nov 89	48°44.28′ S	173°10.00′ E	744	758	11.7	133.3
109	20	18 Nov 89	48°59.43′ S	174°48.41′ E	626	638	10.4	143.0
110	20	18 Nov 89	49°53.47′ S	175°09.07′ E	767	770	11.1	141.0
111	20	18 Nov 89	49°50.13′ S	174°28.06′ E	704	716	12.1	142.0
112	20	18 Nov 89	49°58.25′ S	174°23.35′ E	725	732	9.8	44.0
113	20	19 Nov 89	50°59.32′ S	173°51.36′ E	776	786	9.3	36.4
114	20	19 Nov 89	50°23.85′ S	173°49.41′ E	715	725	10.5	128.0
115	23	20 Nov 89	48°53.23′ S	179°17.68′ E	669	682	9.9	24.0
116	23	20 Nov 89	48°31.56′ S	179°03.11′ E	660	675	10.7	130.0
117	23	20 Nov 89	48°31.50′ S	178°53.40′ E	695	721	8.7	31.0
118	22	20 Nov 89	48°25.25′ S	179°27.03′ E	541	548	11.1	128.0
119	21	21 Nov 89	48°06.53′ S	178°57.33′ E	301	304	10.0	118.0
120	21	21 Nov 89	47°51.86′ S	178°34.46′ E	374	386	11.4	116.0
121	22	21 Nov 89	47°49.41′ S	178°17.84′ E	554	602	10.0	128.3
122	21	21 Nov 89	47°25.16′ S	179°35.94′ E	374	376	9.8	20.0
123	22	22 Nov 89	47°35.64′ S	179°22.10′ W	714	720	11.6	132.0
124	22	22 Nov 89	48°15.87′ S	179°34.61′ W	592	596	6.7	34.0
125	22	22 Nov 89	48°17.84′ S	179°44.08′ W	554	562	8.7	31.0
126	23	22 Nov 89	48°27.14′ S	179°37.43′ W	755	770	8.3	24.0

Note: Station 24 was abandoned because of rough ground.

Appendix 3

Species taken during the survey

Scientific name	Common name	Species code	Strata in which present
Elasmobranchii			
Cetorhinidae			
Cetorhinus maximus	Basking shark	BSK	2
Scyliorhinidae			
Halaelurus dawsoni	Dawson's catshark	DCS	14
Carcharhinidae			
Galeorhinus galeus	School shark	SCH	2
Squalidae			
Centrophorus squamosus	Deepwater spiny dogfish	CSQ	1, 3, 4, 7, 9, 13
Centroscymnus crepidator	Deepwater dogfish	CYP	1, 7
C. owstonii	Owston's spiny dogfish	CYO	1
Deania calcea	Shovelnosed spiny dogfish	SND	1, 3, 8, 13, 17, 18, 20
Etmopterus baxteri	Baxter's dogfish	ETB	1, 2, 4, 8, 9, 13, 16–18, 20–23
E. lucifer	Lucifer dogfish	ETL	1, 3, 4, 7, 8, 9, 13, 16, 18–20
Oxynotus bruniensis	Prickly dogfish	PDG	8, 15, 21
Scymnodon plunketi	Plunket's shark	PLS	1, 8, 13, 17
Squalus acanthias	Spotted spiny dogfish	SPD	2–6, 8–12, 14, 15, 17–19
Dalatiidae			
Dalatias licha	Black shark	BSH	1, 3
Torpedinidae			
Torpedo fairchildi	Electric ray	ERA	3
Rajidae			
Bathyraja sp.	Bluntnosed skate	BTH	8, 12, 17, 19
Pavoraja asperula	Deepsea skate	BTA	1, 2, 3, 6, 10, 13, 15, 16, 19, 21, 22
P. spinifera	Prickly deepsea skate	BTS	1–4, 10, 15–17, 19, 20, 22, 23
Raja innominata	Smooth skate	SSK	2, 4, 5, 8, 9, 11, 12, 18–21, 23
R. nasuta	Rough skate	RSK	2, 5, 6, 7, 11–15, 17, 19, 21, 22
Chimaeridae			
Chimaera phantasma	Giant ghost shark	CHP	3, 4, 20–22
Hydrolagus novaezelandiae	Dark ghost shark	GSH	1–3, 6, 7, 10–12
Hydrolagus sp.	Pale ghost shark	GSP	1–4, 6–10, 12–23
Rhinochimaeridae			
Harriotta raleighana	Longnosed chimaera	LCH	1, 4, 7–10, 12, 13, 15–23
Rhinochimaera pacifica	Widenosed chimaera	RCH	8, 9, 20
Teleostei			
Notacanthidae: spiny eels			
Notacanthus sexspinis	Spineback	SBK	1, 4, 8, 9, 13, 16, 18, 20, 23
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	Basketwork eel	BEE	23
Congridae: conger eels			
Bassanago bulbiceps	Swollenheaded conger	SCO	1, 3, 7–10, 12, 13, 15–20, 23
B. hirsutus	Hairy conger	HCO	1, 4, 6–10, 12–20, 22, 23
Gnathophis habenatus	Silver conger	SEE	8
Gonorynchidae: sandfish			
Gonorynchus gonorynchus	Sandfish	GON	5
Argentinidae: silversides			
Argentina elongata	Silverside	SSI	3, 4, 6, 8–19, 22
Sternoptychidae: hatchetfishes			
Species not identified	Hatchetfish	HAT	18, 20
Photichthyidae: lighthouse fishes			
Species not identified	Lighthouse fish	PHO	9, 18, 20
Myctophidae: lanternfishes			
Species not identified	Lanternfish	LAN	6, 8, 10, 19, 16, 20, 23
Moridae: morid cods			
Antimora rostrata	Violet cod	VCO	3
Austrophycis marginata	Dwarf cod	DCO	1, 8, 13, 16–19, 22, 23
Mora moro	Ribaldo	RIB	1, 3, 4, 5, 7–10, 12, 13, 16, 18–20
Pseudophycis bachus	Red cod	RCO	1–6, 9, 10, 14, 19, 21
Gadidae: true cods			
Micromesistius australis	Southern blue whiting	SBW	6, 10–12, 14–15, 17–19, 21–23
Merlucciidae: hakes			
Macruronus novaezelandiae	Hoki	HOK	1–20, 22, 23
Merluccius australis	Hake	HAK	1, 3, 4, 6, 8–10, 12, 14, 15, 17–20
Macrouridae: rattails, grenadiers			
Caelorinchus aspercephalus	Oblique banded rattail	CAS	3, 5–7, 9–12, 14–19, 21–23
C. bollonsi	Bigeye rattail	CBO	1, 3, 4, 8
C. fasciatus	Banded rattail	CFA	1–4, 7–10, 12, 13, 15–20, 22–23

Appendix 3 — *continued*

C. innotabilis	Notable rattail	CIN	1, 13, 20, 23
C. kaiyomaru	Kaiyo Maru rattail	CKA	23
C. matamua	Mahia rattail	CMA	1, 9, 13, 18, 20
C. oliverianus	Oliver's rattail	COL	1, 3, 7–10, 13, 15, 16, 18–20
Coryphaenoides murrayi	Abyssal rattail	CMU	1, 8, 9, 13, 20, 22, 23
C. subserrulatus	Four-rayed rattail	CSU	4, 7, 8, 20, 23
Lepidorhynchus denticulatus	Javelinfish	JAV	1, 3, 4, 6–10, 12, 13, 15–20
Macrourus carinatus	Ridgescaled rattail	MCA	8, 9, 13, 17, 18, 20, 22, 23
Ventrifossa nigromaculata	Blackspot rattail	VNI	1, 3, 4, 7, 8, 10, 13, 17, 18, 20
Ophidiidae: cusk eels			
Genypterus blacodes	Ling	LIN	1–21
Trachichthyidae: roughies			
Hoplostethus atlanticus	Orange roughy	ORH	1
Optivus elongatus	Slender roughy	SLR	1, 3
Paratrachichthys trailli	Common roughy	RHY	3
Diretmidae: discfishes			
Diretmus argenteus	Discfish	DIS	3, 13
Zeidae: dories			
Capromimus abbreviatus	Capro dory	CDO	3
Cyttus novaezelandiae	Silver dory	SDO	6
C. traversi	Lookdown dory	LDO	1, 3, 4, 6–10, 12, 13, 15–23
Oreosomatidae: oreos			
Neocyttus rhomboidalis	Spiky oreo	SOR	1, 8, 20, 22
Pseudocyttus maculatus	Smooth oreo	SSO	23
Macrorhamphosidae: snipefishes			
Centriscops obliquus	Redbanded bellowsfish	BBE	8, 10, 15, 23
Scorpaenidae: scorpionfishes			
Helicolenus percoides	Jock stewart	SPE	1–3, 21
Congiopodidae: pigfishes			
Alertichthys blacki	Alert pigfish	API	4, 6, 12, 15, 16, 18, 19, 22
Congiopodus coriaceus	Deepsea pigfish	DSP	5, 11, 17
C. leucopaecilus	Southern pigfish	PIG	21
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	Deepsea flathead	FHD	1, 3, 8
Cottidae: sculpins			
Antipodocottus megalops	Sculpin	AME	21
Psychrolutidae: toadfishes			
Cottunculus nudus	Bonyskull toadfish	COT	11
Neophrynichthys angustus	Pale toadfish	TOP	6, 10–13, 15–20, 22, 23
N. latus	Dark toadfish	TOD	11
Psychrolutes sp.	Blobfish	PSY	8, 23
Percichthyidae: temperate basses			
Polyprion oxygeneios	Hapuku	HAP	2
Apogonidae: cardinalfishes			
Epigonus lenimen	Bigeye cardinalfish	EPL	1, 3, 7, 8
E. telescopus	Deepsea cardinalfish	EPT	1
Carangidae: jacks, trevallies, kingfishes			
Trachurus murphyi	Slender mackerel	JMM	2
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	2, 9
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	Redbait	RBT	3
Nototheniidae: ice cods			
Paranotothenia microlepidota	Smallscaled cod	NOT	11, 12, 21
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	Giant stargazer	STA	2–6, 14, 15, 19, 21
Percophidae: opalfishes			
Hemerocoetes monopterygius	Opalfish	OPA	5, 11, 12
Gempylidae: snake mackerels			
Rexea solandri	Gemfish	SKI	1–3
Thyrsites atun	Barracouta	BAR	2, 5, 8
Trichiuridae: cutlassfishes			
Lepidopus caudatus	Frostfish	FRO	2
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	Rudderfish	RUD	8, 19, 20
Hyperoglyphe antarctica	Bluenose	BNS	1, 3
Seriolella caerulea	White warehou	WWA	3, 6, 8, 9, 12, 16, 17, 19, 21
S. punctata	Silver warehou	SWA	2, 5, 6, 8, 21
Tetragonuridae: squaretails			
Tetragonurus cuvieri	Squaretail	TET	6
Bothidae: lefteyed flounders			
Achiropsetta tricholepsis	Black flounder	ACT	22
Arnoglossus scapha	Witch	WIT	5, 8
Neoachiropsetta milfordi	Finless flounder	MAN	7–10, 12–15, 17–23
Pleuronectidae: righteyed flounders			
Rhombosolea plebeia	Greenback flounder	GFL	11

Appendix 3 — *continued*

Cephalopoda			
Amphitretidae			
Amphitretus sp.	Deepwater octopus	DWO	1, 8, 13, 17, 20
Histioteuthidae			
Histioteuthis miranda	Violet squid	VSQ	13, 20
Ommastrephidae			
Nototodarus sloanii	Arrow squid	NOS	1–11, 14, 16, 17, 21–22
Ommastrephes bartrami	Red squid	RSQ	6, 7, 9, 10, 15, 18, 20
Onychoteuthidae			
Moroteuthis ingens	Warty squid	MIQ	1, 3–13, 15–23
M. robsoni	Warty squid	WRQ	13, 20

Appendix 4

Biomass estimates (t) for the main quota and bycatch species by stratum, grouped by depth. Species codes are given in Appendix 3

											Species
Stratum	HOK	SBW	LIN	HAK	SWA	WWA	NOS	LDO	GSP	GSH	SPD
200–400 m											
2	4	0	231	0	2 318	0	125	0	4	233	6 080
5	23	0	11	0	140	0	634	0	0	0	11
11	8 525	312	134	0	0	0	4	0	0	158	36
14	686	144	61	10	0	0	2	0	70	0	12
21	0	8 646	2 525	0	151	17	7	7	1 563	0	0
Subtotal	9 238	9 102	2 962	10	2 609	17	772	7	1 637	391	6 139
400–600 m											
3	272	0	4 124	45	0	723	105	93	29	1	10
6	1 508	32	127	88	2	0	68	16	66	441	16
10	5 510	31	2 541	273	0	0	12	102	1 807	28	127
12	6 102	1 619	1 381	54	0	6	0	58	1 087	3	151
15	5 930	1 922	1 609	35	0	0	0	65	2 501	0	139
17	2 068	11 834	1 900	80	0	6	5	84	767	0	92
19	7 225	4 494	1 139	44	0	58	0	71	2 971	0	72
22	38	5 928	0	0	0	0	3	2	258	0	0
Subtotal	28 653	25 860	12 821	619	2	793	193	491	9 486	473	607
600–800 m											
1	232	0	52	91	0	0	26	3	14	3	0
4	347	0	733	876	0	0	15	23	1 049	0	28
7	1 288	0	604	0	0	0	11	85	279	0	0
8	2 858	0	595	495	6	32	19	27	2 405	0	7
9	9 360	0	873	537	0	19	3	9	1 307	0	32
13	1 593	0	270	0	0	0	0	20	461	0	0
16	2 522	0	590	0	0	16	4	21	601	0	0
18	4 373	3	306	12	0	0	0	65	95	0	16
20	1 541	0	211	22	0	0	0	7	229	0	0
23	78	549	0	0	0	0	0	4	66	0	0
Subtotal	24 192	552	4 234	2 033	6	67	78	264	6 506	3	83
Total	62 083	35 514	20 017	2 662	2 617	877	1 043	762	17 629	867	6 829
c.v. (%)	20	30	13	21	89	79	34	18	9	27	84

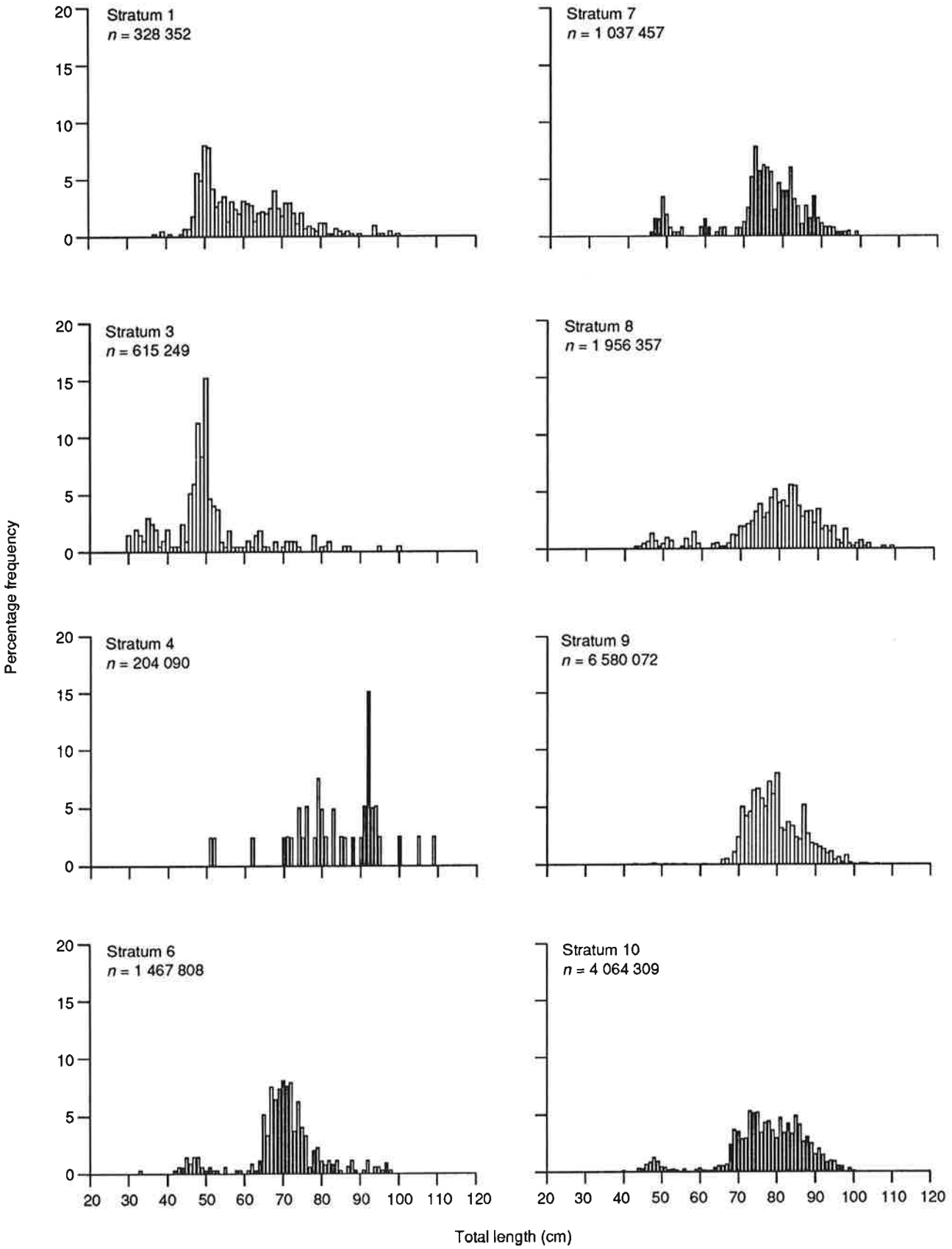
Appendix 4 – *continued*

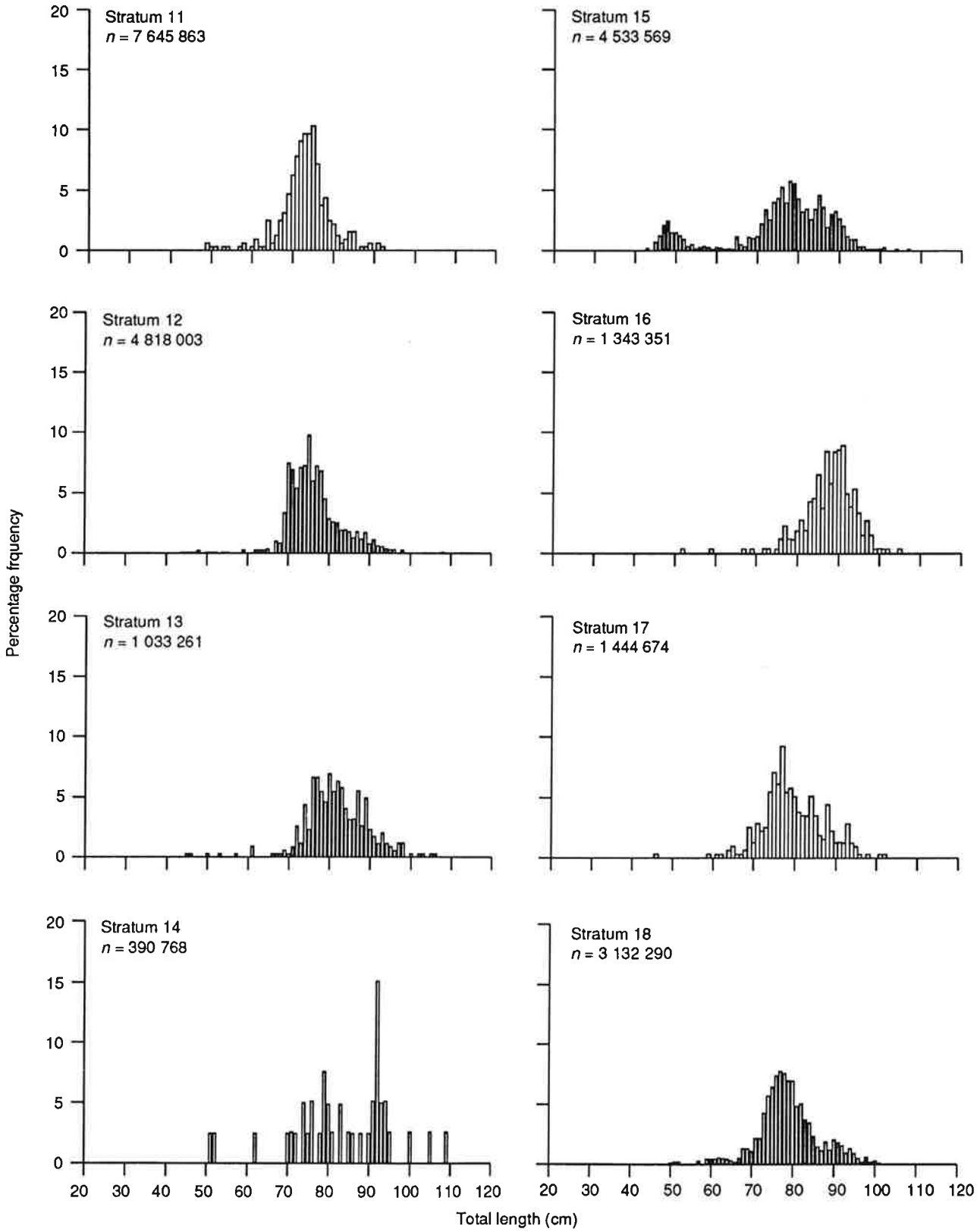
										Species
Stratum	JAV	RIB	ETB	WSQ	RAT	SOR	SSO	BNS	ORH	Total
200–400 m										
2	0	0	0	0	1	0	0	0	0	24 986*
5	0	12	0	1	16	0	0	0	0	1 041
11	0	0	0	28	145	0	0	0	0	11 202
14	0	0	0	0	61	0	0	0	0	1 188
21	0	0	811	32	522	0	0	0	0	15 477
Subtotal	0	12	811	61	745	0	0	0	0	53 894*
400–600 m										
3	62	27	0	4	125	0	0	52	0	6 734
6	46	0	0	54	158	0	0	0	0	2 874
10	1 123	125	0	101	420	0	0	0	0	12 710
12	658	6	0	101	306	0	0	0	0	12 229
15	1 646	0	0	112	300	0	0	0	0	15 468
17	364	0	4	203	258	0	0	0	0	19 129
19	2 500	51	0	526	375	0	0	0	0	21 608
22	19	0	248	72	90	1	0	0	0	6 914
Subtotal	6 418	209	252	1 173	2 032	1	0	52	0	97 666
600–800 m										
1	201	161	0	0	29	95	0	66	10	1 603
4	300	350	202	112	157	0	0	0	0	4 623
7	390	142	0	92	244	0	0	0	0	3 645
8	771	197	215	148	351	46	0	0	0	8 906
9	1 255	427	317	151	346	0	0	0	0	15 130
13	775	256	283	123	340	0	0	0	0	4 623
16	1 369	77	15	146	125	0	0	0	0	5 820
18	680	75	5	135	140	0	0	0	0	6 189
20	2 035	392	293	229	309	31	0	0	0	5 878
23	46	0	441	99	394	0	5	0	0	1 953
Subtotal	7 822	2 077	1 771	1 235	2 435	172	5	66	10	58 370
Total	14 240	2 298	2 834	2 469	5 210	173	5	118	10	208 930*
c.v. (%)	12	12	31	–	–	60	72	71	10	11

c.v. = coefficient of variation.
*Includes basking shark 15 092 t.

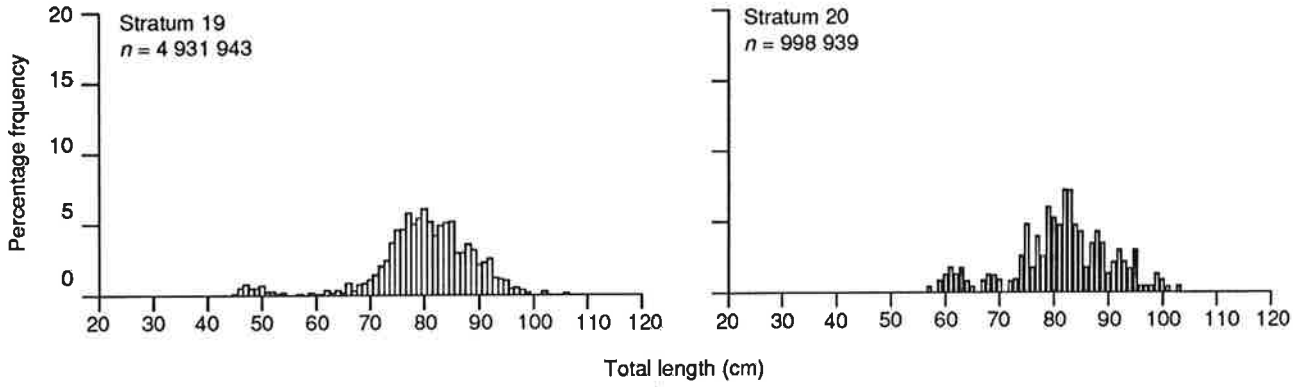
Appendix 5

Length frequency distribution by stratum of hoki




Stratum 11
n = 7 645 863
Stratum 12
n = 4 818 003
Stratum 13
n = 1 033 261
Stratum 14
n = 390 768
Stratum 15
n = 4 533 569
Stratum 16
n = 1 343 351
Stratum 17
n = 1 444 674
Stratum 18
n = 3 132 290
Percentage frquency
Total length (cm)
0
5
10
15
20
20 30 40 50 60 70 80 90 100 110 120

Appendix 5 — *continued*



Appendix 6

Length-weight relationships: *L* = length (cm), *W* = weight (g), *s.d.* = standard deviation

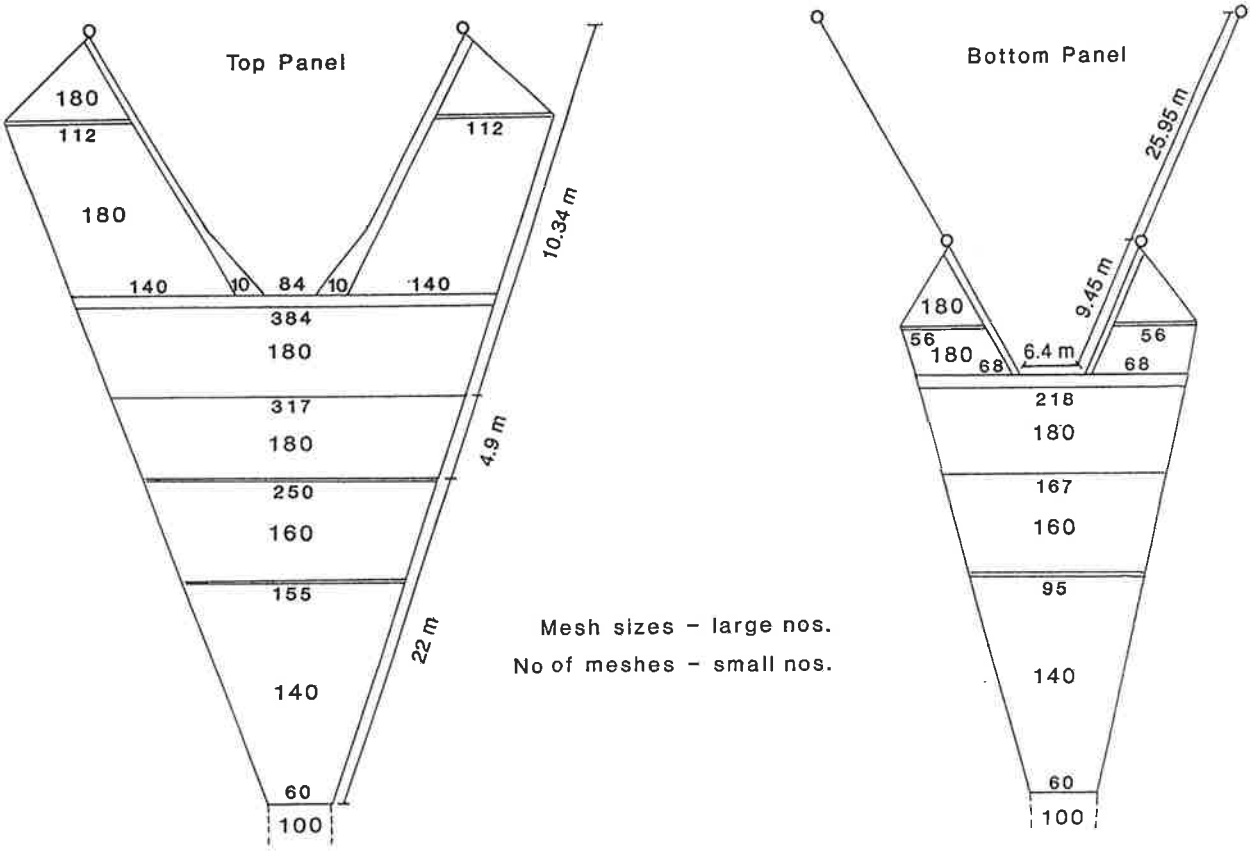
		Length (cm)				Weight (g)				
	No.	Mean	*s.d.*	Range		Mean	*s.d.*	Range	Equation	Regression coefficient (*r*)
Hoki										
Males	644	74.23	11.92	30–103		1 241	491	93–4 250	$W = 0.0059 \times L^{2.83}$	95.8
Females	1 153	80.59	12.38	30–109		1 576	603	101–3 870	$W = 0.0049 \times L^{2.87}$	95.9
All fish	1 797	78.31	12.59	30–109		1 456	588	93–4 250	$W = 0.0051 \times L^{2.86}$	96.0
Hake										
Males	37	78.95	8.70	60 – 93		3 878	1 356	1 540 – 6 400	$W = 0.0021 \times L^{3.29}$	93.4
Females	62	97.89	16.06	61–124		8 030	3 624	1 620–16 700	$W = 0.0043 \times L^{3.13}$	93.8
All fish	99	90.81	16.53	60–124		6 478	3 595	1 540–16 700	$W = 0.0035 \times L^{3.17}$	95.5
Ling										
Males	347	78.11	16.68	37–123		2 674	1 936	216–10 000	$W = 0.0019 \times L^{3.22}$	97.5
Females	530	85.61	18.19	40–149		3 723	2 820	320–20 500	$W = 0.0016 \times L^{3.26}$	97.1
All fish	877	82.64	17.98	37–149		3 308	2 559	216–20 500	$W = 0.0016 \times L^{3.25}$	97.4
Southern blue whiting										
Males	579	39.63	7.28	19.8–53.0		458	240	39–1 121	$W = 0.0032 \times L^{3.20}$	98.6
Females	605	42.34	8.01	21–57.1		564	305	63–1 392	$W = 0.0032 \times L^{3.19}$	98.8
All fish	1 216	40.56	8.28	16.1–57.1	*	503	285	25–1 392	$W = 0.0039 \times L^{3.14}$	98.8
Silver warehou										
Males	39	40.05	5.47	34–51		1 202	608	638–2 460	$W = 0.0042 \times L^{3.38}$	96.1
Females	18	43.33	5.58	36–53		1 617	647	890–2 890	$W = 0.0187 \times L^{3.00}$	98.2
All fish	57	41.09	5.67	34–53		1 333	645	638–2 890	$W = 0.0050 \times L^{3.34}$	96.3

* Includes some immature fish, station 48.

Appendix 7

Wesermünde trawl net plan, 1979 survey

(Large figures denote mesh size in terms of "knot to knot" and small figures denote the number of meshes)



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