Abundance, distribution, and spawning condition of hoki and other mid-slope fish on the Chatham Rise, July 1986

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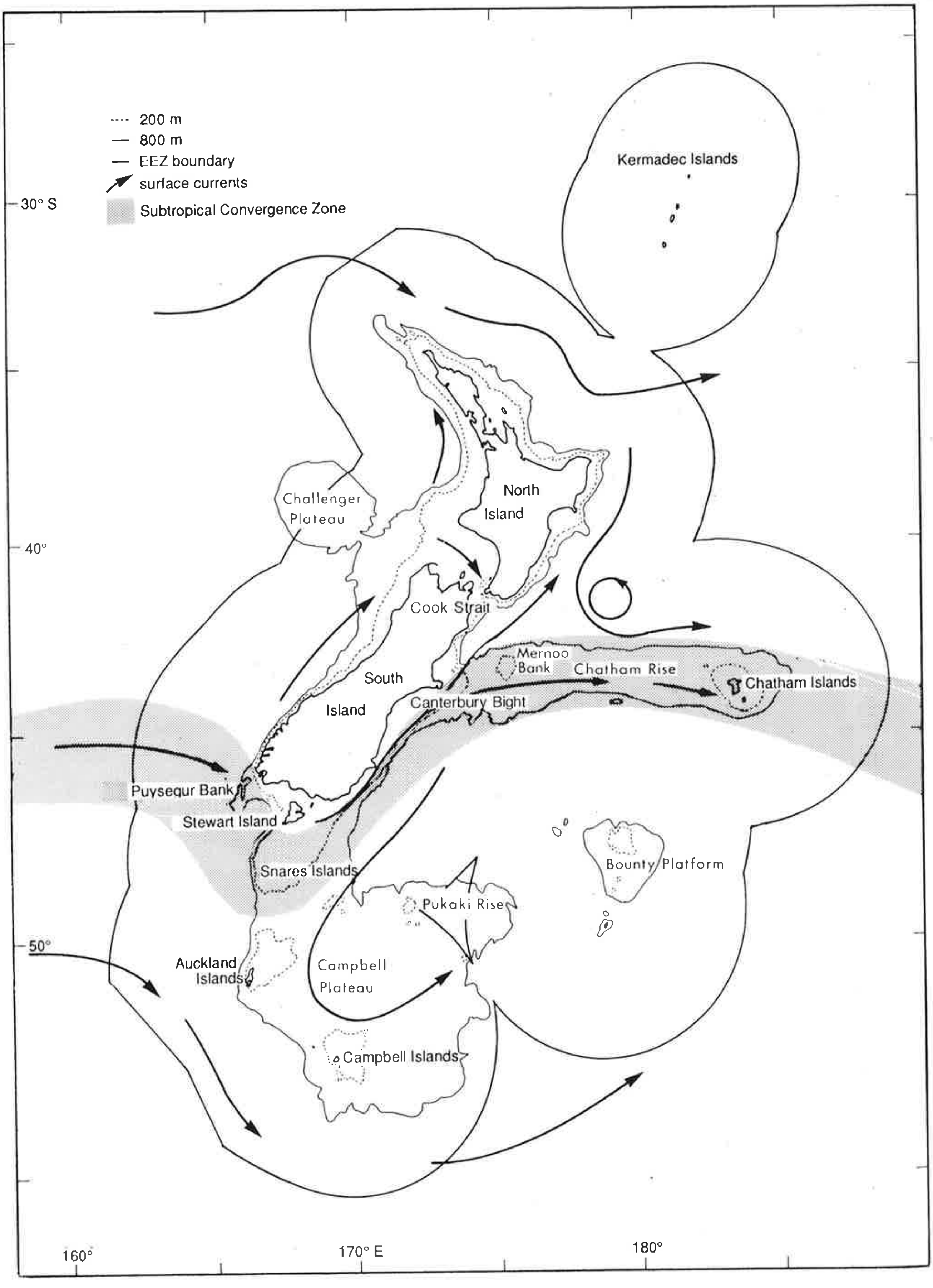


Figure 1: The New Zealand region, showing the Exclusive Economic Zone (EEZ), hydrological features, and places mentioned in the text.

Abstract

Livingston, M. E., Uozumi, Y., and Berben, P. H. 1991: Abundance, distribution, and spawning condition of hoki and other mid-slope species on the Chatham Rise, July 1986. *N.Z. Fisheries Technical Report No. 25.* 47 p.

A stratified random trawl survey of the Chatham Rise, including the Chatham Islands shelf, in July 1986, caught 121 species of fish, squids, and crustaceans. Barracouta dominated the shelf areas (50–200 m) and hoki dominated continental slope areas (200–800 m). Important bycatch species included ling, silver warehou, hake, and alfonsino. Relative abundance, distribution, and catch rates are described for the 25 most abundant species caught. Of the total biomass, hoki was 51%, macrourid rattails 17%, ling, silver warehou, and alfonsino 3% each, and hake 1%.

Size class composition, reproductive state, and stomach contents of nine commercially important species are described. These data suggest that the Chatham Rise is a winter spawning ground for hake, lookdown dory, giant stargazer, silver and white warehou, and possibly oreos. The hoki population was dominated by pre-adult sizes, although evidence of maturation among some adult females suggests that some spawning may occur in spring.

The results of the survey are compared with previous surveys of the Chatham Rise and the Chatham Islands Shelf. Variation in year-class strength and fish movements into and out of the area are proposed as the principle explanations for differences in biomass and size class distributions of hoki.

Introduction

The Chatham Rise, including the Chatham Islands Shelf, is a large area of continental shelf and slope east of the South Island, New Zealand (Figure 1). The area is characterised by strong currents, subtropical water in the north, and subantarctic surface water in the south. The interface of these water masses, the Subtropical Convergence Zone, lies approximately east–west along the Chatham Rise (Heath 1981). Apart from the Mernoo Saddle, the area has rather low primary and secondary productivity, especially near 176° E (Bradford and Roberts 1978, Bradford 1983). Despite this, the Chatham Rise supports substantial commercial fisheries at depths between 50 and 1200 m. These fisheries contribute substantially to the annual catch taken in New Zealand's Exclusive Economic Zone (EEZ). In the 1987–88 fishing year (1 October–30 September), 9% of the deepwater EEZ catch came from the Chatham Rise (Table 1). It is one of the most consistent and productive deepwater fishing areas in New Zealand because several species, targeted in various seasons, make up the fishery (*see* Appendix 9 for specific names). Trawl surveys have targeted specific areas and a range of depths on the Chatham Rise to obtain relative biomass estimates of the species (Hurst and Fenaughty 1985, Fincham *et al.* 1987, Hurst and Bagley 1987, Fenaughty and Uozumi 1989, Hatanaka *et al.* 1989).

This report is primarily concerned with the shelf and mid-slope fisheries between 50 and 800 m depths. The shallow areas of the Chatham Rise (less than 200 m), in particular the Chatham Islands Shelf, but also including the Mernoo, Reserve, Veryan, and Matheson Banks (Figure 2), are dominated by barracouta (*Thyrsites atun*), and the deeper areas (200–800 m) are dominated by hoki (*Macruronus novaezelandiae*) (Hurst and Bagley 1987, Fenaughty and Uozumi 1989, Hatanaka *et al.* 1989).

Commercial hoki exploitation is greatest on the west coast of the South Island in winter, although large catches have also been taken from the Chatham Rise at other times of year (Hurst *et al.* 1988). There are no consistent fishing patterns on the Chatham Rise, although this may be determined by the seasonality of other major fisheries elsewhere.

The total allowable catch (TAC) for hoki was increased from 100 000 to 250 000 t for the 1986–87 fishing year. Random trawl surveys of the Chatham Rise in spring, summer, and autumn have estimated hoki biomass as high as 1.8 million t (Table 2), so hoki exploitation in this area may have the potential to increase. If this occurs, catches of other species, in particular hake (*Merluccius australis*), silver warehou (*Seriolella punctata*), and ling (*Genypterus blacodes*), may also increase. This survey aimed to provide winter biomass estimates of hoki and other species for comparison with earlier surveys (Fenaughty and Uozumi 1989, Hatanaka *et al.* 1989).

Table 1: Green weights (t) of species caught on the Chatham Rise and in the total New Zealand EEZ* by foreign chartered and foreign licensed vessels, October 1987–September 1988†

Species‡	Chatham Rise§	Total EEZ	% of total EEZ
Hoki	12 200	223 261	5.5
Arrow squid	425	27 431	1.6
Jack mackerel	657	15 775	4.2
Barracouta	1 623	13 580	12.0
Orange roughy	542	12 836	4.2
Silver warehou	1 440	7 589	19.0
Ling	677	5 689	11.9
Smooth oreo	2 893	5 301	54.6
Hake	512	4 567	11.2
Black oreo	435	2 662	16.3
Red cod	73	958	7.6
Tarakihi	180	696	25.9
White warehou	161	583	27.6
Ghost shark	135	320	42.2
Alfonsino	78	86	90.7
Other	11 081	33 421	33.2
Total	33 112	354 755	9.3

* 200 n. mile Exclusive Economic Zone.
† MAF Fisheries Greta Point unpublished data.
‡ Scientific names are given in Appendix 9.
§ EEZ areas C_M and D (*see* p. 9 in Baird and McKoy 1988).

Chatham Rise hoki tend to be small, under 70 cm total length (TL), compared with hoki from other commercially fished areas (Patchell 1982, Kuo and Tanaka 1984a, Fenaughty and Uozumi 1989, Hatanaka *et al.* 1989) perhaps because they are young. Some adult-size hoki are found on the Chatham Rise, and Patchell (1986) suggested that these fish migrate to the west coast in winter to spawn on known spawning grounds. However, others have reported hoki spawning on the west Chatham Rise (Blagodyorov and Nosov 1978, Kuo and Tanaka 1984a) and it is possible that the adult hoki remain on the east coast to spawn, rather than migrate to the west coast. Before this study, there was little evidence of large quantities of hoki spawning anywhere on the east coast, i.e., no data describing spawning fish were presented by Blagodyorov and Nosov (1978), and very low numbers of ripe females were described by Kuo and Tanaka (1984a). Since the number of spawning grounds and the stock structure of hoki is fundamental to the management of the hoki fishery, an important aim of this survey was to determine the extent, if any, of spawning hoki on the Chatham Rise in July 1986.

Table 2: Mean biomass estimates* (t) of hoki from the Chatham Rise, 1966–83 (–, no data)

Date of data collection	Vessel	Total area surveyed (km²)	Survey design	No. of sample stations	c.v. (%)	Biomass estimate (areas west of 176° E)	Biomass estimate (areas east of 176° E)	Information source
Autumn								
Mar 1983	*Shinkai Maru*	143 570	Random trawl	126	11	614 000	1 157 000	MAF Fisheries Greta Point
Apr 1979	*Wesermunde*	124 068	Random trawl	20	79	–	143 000–1 000 000	Francis (1981)‡
May 1976	*Shinkai Maru*	137 858	Exploratory	91	–	65 000	212 000	Francis and Fisher (1979)
Winter								
1966–77	Russian vessel(s)	34 817§	Commercial	–	–	130 000¶	–	Blagodyorov and Nosov (1978)
Spring								
Oct 1979	*Wesermunde*	170 763	Random trawl	33	78	25 000–400 000	34 000–540 000	Francis (1981)‡
Nov 1979	*Wesermunde*	124 068	Random trawl	23	78	–	100 000–480 000	Francis (1981)‡
Summer								
Nov-Dec 1983	*Shinkai Maru*	108 752	Random trawl	90	15	–	454 000	Hatanaka *et al.* (1989)

* These estimates are only indirectly comparable because of differences in area surveyed and gear used.
‡ Francis (1981) gives ranges only.
§ Estimate of suitable hoki depths in Area C, taken from the *Shinkai Maru* surveys (*see* p. 9 in Baird and McKoy 1988).
¶ Mean of annual estimates, 1966–77.

Main aims of the survey

1. To estimate the relative abundance and distribution of hoki and other commercial species in depths of 50–800 m on the Chatham Rise and the Chatham Islands Shelf.
2. To determine the gonad maturity and spawning activities of hoki and other commercial species to enable the significance of the Chatham Rise as winter spawning grounds to be assessed.
3. To determine the size class structure, sex ratios, and length-weight relationships of hoki and other commercial species.
4. To measure sea temperatures in the survey area to locate the Subtropical Convergence Zone, and to assess species distribution in relation to the water masses.
5. To carry out a 2 day surface plankton survey to search for fish eggs near Pegasus Canyon.

This report presents the results of the trawl and surface plankton surveys. The results are compared with two earlier surveys of the Chatham Rise in 1983 (Fenaughty and Uozumi 1989, Hatanaka *et al.* 1989), and a survey of the Chatham Islands Shelf in 1984 (Hurst and Bagley 1987).

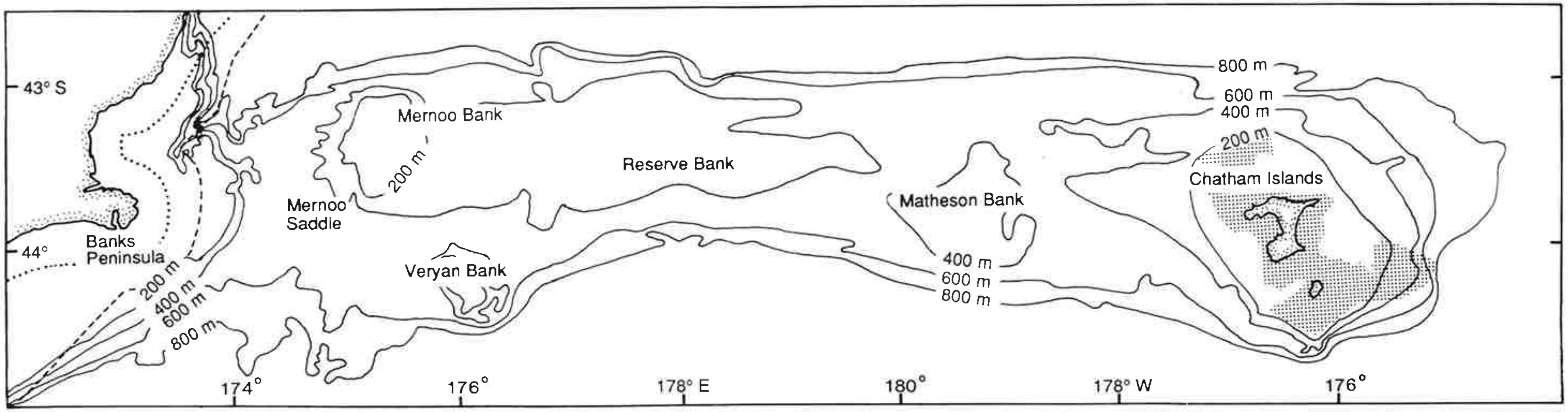


Figure 2: The Chatham Rise survey area, with bathymetry, and named features on the rise.

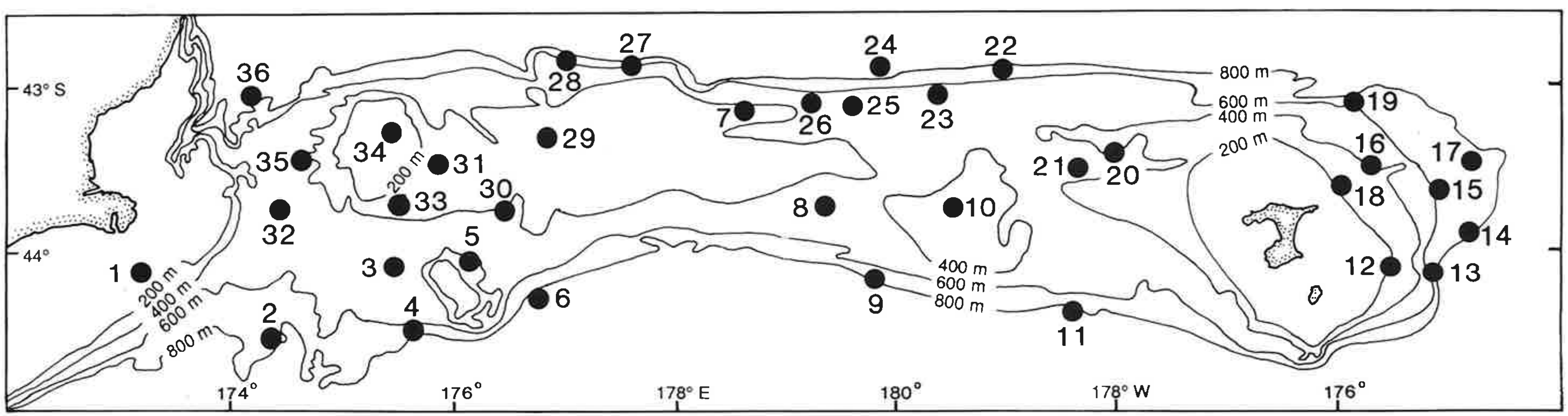


Figure 3: Expendable bathythermograph (XBT) station positions in the survey area.

Methods

Survey area and bathymetry

The survey was conducted in depths of 50–800 m between 42° 30′ S and 45° 00′ S, east of the 25 n. mile restricted fishing zone on the east coast of the South Island, to 174° 30′ W, east of the Chatham Islands and including territorial waters around the Chatham Islands (Figure 2).

Depth strata in the survey area were defined, where possible, using published bathymetric charts. The exceptions were the Chatham Islands strata, which were defined by Hurst and Bagley (1987). Bathymetry for uncharted areas was derived from data collected during previous research cruises by MAF and the Department of Scientific and Industrial Research (DSIR) with an integrative chart plotting system available through Geophysics Division, DSIR (Livingston and Fenaughty 1987).

Hydrology

The position of the Subtropical Convergence Zone across the Chatham Rise can be identified by sharp temperature gradients; in winter it appears to follow the surface contour of 10 °C (Robertson *et al.* 1978). Thirty-six expendable bathythermograph (XBT) drops were made opportunistically (Figure 3), each providing a continuous recording of temperature readings from the surface to the sea floor (Appendix 1). These readings, and bottom temperature readings obtained from the net sounder on the trawl, were used to identify the approximate position of the Subtropical Convergence Zone.

Adjacent XBT station thermoprofiles were plotted and linear interpolations were used to determine the position of the 10 °C isotherm at 2 m below the surface, at 50 m, and on the sea bed. The 10 °C isotherm reached the sea bed at only three stations, so zones of greatest thermal gradient were identified to locate the seabed position of the Subtropical Convergence Zone, and the 8 °C isotherm was used to plot its position. The XBT data were used only to represent average conditions and no attempt to adjust for changes during the survey period was made.

Vessel and net features

Shinkai Maru, a stern trawler chartered by Japan Marine Fishery Resource Research Centre (JAMARC), was used for the survey. It has been used for several exploratory surveys and joint New Zealand-Japan quantitative surveys in the past (Livingston 1987). The vessel has the following specifications: length 94.9 m; beam 16.0 m; gross tonnage 3393 t; horsepower (French) 5000 ps at 230 rpm; maximum speed 16.4 knots.

During the survey, two nets (A and B) were used (Appendix 2). Net A was used for 97 stations and net B for 10 stations while repairs were being made to net A. Although net A was smaller than net B (Table 3) (a wingspread : doorspread ratio of 4.65 compared with 4.14 for net B), wingspread estimates were similar for both nets, and for biomass calculations no calibration between the two was made for areas swept.

The doorspread (x) and the wingspread (y) were calculated as follows:

$$x = c(b-a) + a$$
$$y = ex / d$$

where a is distance between warps at the top rollers, b is distance between warps 1 m aft of the top rollers, c is length of warp between top roller and otter board, d is distance between otter board and codend mouth, and e is distance between wingtip and codend mouth (after Kawahara and Tokusa 1981). For those stations where doorspread was not measured, a mean value of doorspread for that 100 m depth interval was used.

Trawl survey design

The survey followed the design of a single phase random trawl survey (Francis 1984) to determine relative abundance and distribution.

The survey area was divided into 27 depth strata (Figure 4) and the estimated number of possible tows (98) was allocated on a random basis (minimum of 3 stations per stratum; minimum distance between stations 5 km).

Table 3: Comparison of features of trawl nets A and B

Net feature	Net A*	Net B†
Codend (length)	25.0 m	25.0 m
Lengthener and overhang	46.9 m	54.8 m
Wings (length)	25.1 m	28.8 m
Codend mesh size	60.0 mm	60.0 mm
Depths 400–600 m		
Mean doorspread	152.7 m	145.3 m
Mean wingspread	33.4 m	35.1 m
Mean headline height	6.0 m	6.9 m
No. of tows measured	28	8
Depths 600–800 m		
Mean doorspread	147.5 m	128.4 m
Mean wingspread	32.3 m	31.0 m
Mean headline height	5.8 m	7.2 m
No. of tows measured	14	2

* Tows 1–64, 75–107.
† Tows 65–74.

Trawling procedure

Whenever possible, intended trawl station positions were surveyed during the preceeding night to allow trawl positions to be adjusted if necessary. Tows were made between sunrise and sunset to minimise problems associated with the vertical migration of hoki at night to feed.

Tows were intended to cover a bottom distance of 3 nautical miles (n. mile), although rough sea bed and tidal effects occasionally caused tows to be longer. A pragmatic approach was adopted, whereby if the next randomly chosen station was too far away to sample, the nearest station position on the list was sampled instead. Similarly, late in the day, the ship would steam towards the next station position and then begin the tow, allowing time to complete the tow within daylight hours.

Catch sampling

Most of the catch was sorted into species and weighed to the nearest 0.1 kg. Macrourid rattails were not separated into species because of their large numbers in most catches, and the occasional difficulty in identifying the species. Instead a list of species present was made after McMillan (1985), and the percent by weight of javelinfish, and of other rattail species combined, was estimated for each catch. Therefore, the biomass estimates for javelinfish and other rattail species have been combined.

When the catch was too large to sort and weigh, it was processed in the vessel's factory and the green weight was back-calculated from the product weight.

Biological records

At each station, up to 300 fish of each commercial species were randomly selected to have their lengths measured: total length (TL) for hoki, ling, oreos, stargazer, hake, lookdown dory; mantle length (ML) for arrow squid; and fork length (FL) for other finfish. All fish measured, except the stargazers, were sexed. More detailed information was gathered from selected subsamples of 20 fish of each species. Data included total weight (to the nearest gram), sex, gonad stage (Appendix 3), gonad weight (to the nearest gram), and stomach contents. To ensure that gonad details were collected from mature fish, large hoki were selected from the length frequency samples; other species were selected randomly. Gonadosomatic Index (GSI) was calculated for each species sampled as follows:

$$\text{GSI} = \frac{\text{Gonad weight}}{\text{Total weight}} \times 100$$

Length frequency histograms were scaled up by percentage of catch sampled to fully represent the size composition of each catch. Where the size distribution of the population is discussed by depth, the data have also been scaled by stratum area. The ages of fish caught were interpreted from length frequency modes and published data where possible. Otoliths were taken from all hoki biological samples for future ageing work (beyond the scope of the present publication).

To estimate the number of fish in a size class within a stratum (f_i), the number of fish measured per tow (f_j) (already corrected for % sampled) was scaled by the area swept by the net as follows:

$$f_i = \sum_{j=1}^{n_i} (f_j) * a_i \Big/ \sum_{j=1}^{n_i} (b_{ij} * d_{ij})$$

where f_i = estimated number of fish in a size class, within stratum i
n_i = number of tows in stratum i
f_j = estimated number of fish in a size class for tow j
a_i = area of stratum i (km^2)
b_{ij} = average net mouth width at station j in stratum i (km)
d_{ij} = distance towed at station j in stratum i (km).

To estimate the total number of fish (F) in a size class within the survey area, the f_i values were then summed.

Calculations to estimate biomass

Relative abundance was calculated using the following formulae:

$$B = \sum_{i=1}^{n} (x_i\, a_i)/v$$

$$x_i = (1/m) \sum_{j=1}^{m} c_{ij}/(b_{ij}\, d_{ij})$$

$$S_B = 1/v \sqrt{\sum_{i}^{n} (S_i^2\, a_i^2)}$$

where a_i = area of stratum i (km^2)
b_{ij} = net mouth width at station j in stratum i (km)
c_{ij} = catch at station j in stratum i (kg)
d_{ij} = distance towed at station j in stratum i (km)
n = number of strata

m = number of stations in stratum i
v = catchability and escapement coefficient
x_i = mean density in stratum i (kg.km^{-2})
B = biomass (kg)
S_B = standard error of biomass
S_i = standard error of density in stratum i.

Ninety-five percent confidence limits (CL) were calculated as:

$$CL = B \pm 2 S_B$$

The coefficient of variation (cv) is a measure of precision of the relative abundance estimates:

$$cv = S_B / B \times 100$$

All stations, excluding those where the gear operated inefficiently or came fast, were included in the biomass calculations. Biomass estimates based on wingspread and doorspread are presented.

To compare the results with those of previous surveys, an attempt to estimate the biomass of each size class of hoki was made by calculating stock size by number and using the average weight of each size class from length-weight data (data held at MAF Fisheries Greta Point). Male and female numbers per size class were also compared in this way.

Assumptions and interpretation of biomass estimations

Area swept. The herding effects of the otterboards and sweeps on species likely to be caught during this survey are unknown, and for this reason doorspread and wingspread biomass estimates are both given. However, only wingspread estimates were used for comparison with previous surveys.

Vulnerability. Escapement from the net was assumed to be zero because the mesh size was 60 mm (40 mm smaller than commercial mesh size). As in other surveys (Hurst and Fenaughty 1985), we used a catchability of 1.0, which assumes that all accessible fish in the water column, and all fish encountered by the net, were caught. This provides a conservative estimate.

Availability. Hoki are known to occur at depths greater than 800 m, although only at low densities (MAF Fisheries Greta Point, unpublished data). Biomass estimates refer only to depth strata sampled in the survey (50–800 m); no attempt was made to estimate hoki biomass at greater depths. Although hoki may move up in the water column at night, it was assumed that during the day 100% were associated with the sea bed. Therefore, the survey will provide a conservative estimate of biomass if hoki are present higher in the water column during the day.

Net dimensions. Biomass was calculated from individual station data and took into account the differences in wingtip spread between the two nets. Although headline height of the larger net (B) was 20% greater than that of the smaller net (A) (Table 3), no adjustment for the difference was made in the biomass estimations (*see* "Vessel and net features" above).

Plankton survey

A 0.5 m diameter net with a mesh size of 0.35 mm was used in a grid survey of 16 stations over Pegasus Canyon (Appendix 4). Surface tows (duration 20 mins) were made on the assumption that hoki eggs, if present in large numbers, would occur at the surface. Gear restrictions prevented oblique hauls from being made. During the plankton survey, two trawl shots were made to examine the length frequency and gonad stage of hoki in the immediate area.

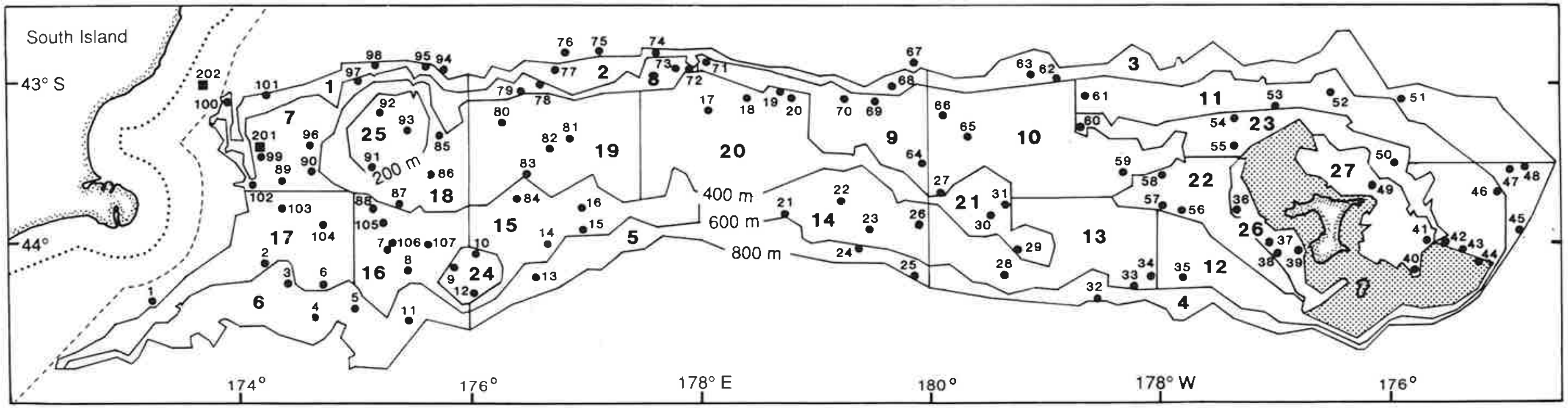


Figure 4: Trawl survey strata and station positions in the survey area.

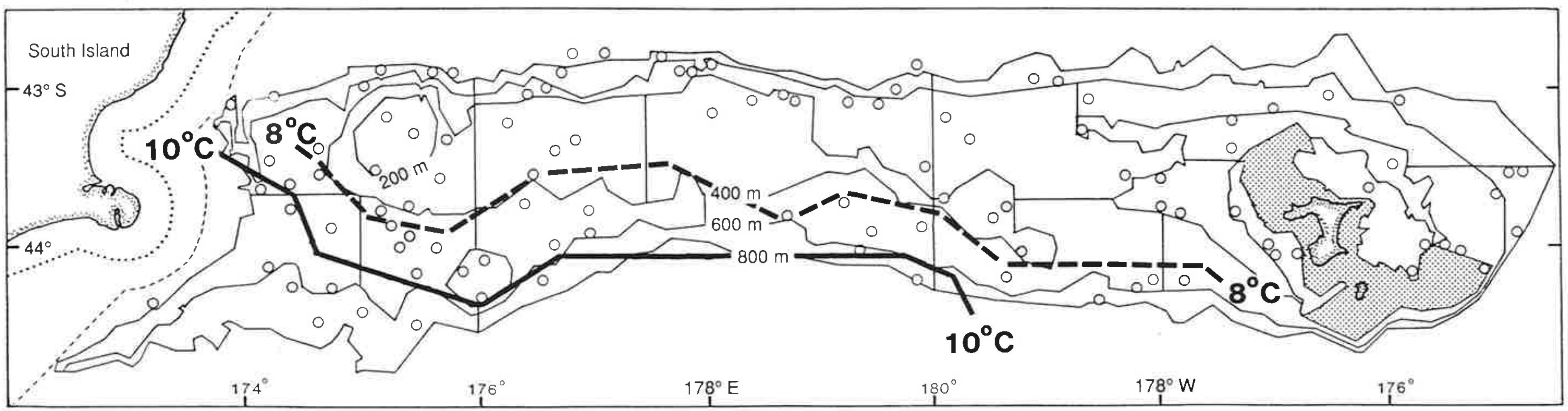


Figure 5: Surface (8 °C) and bottom (10 °C) isotherms indicating the location of the Subtropical Convergence Zone during the survey.

Results

Temperature contours at 7 m and at the sea bed, and temperature profiles (Appendices 5 and 6), showed that the average position of the Subtropical Convergence Zone was south of the Chatham Rise at the surface, and followed the southern side of the bank along the Chatham Rise at the sea bed (Figure 5).

The thermal gradients (Appendix 6) indicated that the warmer subtropical water extended well south over Mernoo Bank, as far as 44°20′ S in places, and over the Veryan Bank.

To the east, over the central part of the Chatham Rise, warm surface waters extended south throughout the survey area. However, near the sea bed the Subtropical Convergence lay along the southern contours of the Reserve Bank.

Further east again, warm surface waters extended well south of the Matheson Bank and appeared to cover the entire Chatham Islands Shelf where the waters were well mixed. At the sea bed, subantarctic water penetrated to Matheson Bank, but was not evident around the Chatham Islands (Figure 5).

Satellite-derived sea surface temperature charts published weekly by the N.Z. Meteorological Service, Wellington show that the 10 °C isotherm moved north during the survey period (Appendix 7). Such extensive movements are, however, more likely to indicate surface cooling than a shift in the Subtropical Convergence Zone during the survey period (J. Wilkin, N.Z. Oceanographic Institute, DSIR, pers. comm.).

Trawl survey

Ninety-eight stations were completed in phase one and an additional nine stations were allocated equally among strata 7, 16, and 17 (stations 99–107) in a second phase (Figure 4). Three stations were abandoned because the bottom was untrawlable (resulting in the exclusion of stratum 24 from biomass estimation), and four stations had to be shifted to maximise trawling time during daylight. Stratum areas and station numbers are given in Table 4, and station record data is summarised in Appendix 8.

All stations fell within the expected stratum depth range (±50 m depth range above or below the stratum boundary). Seven stations (1, 44, 46, 67, 75, 76, 94) fell outside marked stratum boundaries, but were within the depth ranges for those boundaries (Figure 4). Since the strata boundaries do not precisely follow depth contours, these stations have been included within the depth strata without altering the strata boundaries for biomass estimations.

Catch summary

One hundred and twenty-one species were caught (Appendix 9). Fifty-five percent of the total catch weight was hoki, and 16% was rattails and javelinfish combined. Of the 25 most abundant species hoki, rattails, javelinfish, silver warehou, hake, ling, arrow squid, lookdown dory, and giant stargazer were widespread and occurred in a large percentage of tows; barracouta, alfonsino, and dark ghost sharks had a much lower occurrence (Appendix 9).

Relative abundance

The total biomass of fish on the Chatham Rise during this survey was estimated to be between about 610 000 t (mean doorspread estimate) and 2 772 000 t (mean wingspread estimate). Hoki formed about 51% of total biomass, followed by rattails and javelinfish (17%), ling (3%), alfonsino (3%), and silver warehou (3%) (Table 5).

A breakdown of biomass by stratum shows that 62% of the total biomass lay in depths of 400–600 m, of which 59% was hoki (Table 6).

Table 4: Stratum areas, depth ranges, and number of stations sampled

Stratum	Approximate depth range (m)	Bottom area (km²)	No. of stations
1	600–800	2 129	5
2	600–800	3 498	4
3	600–800	8 751	4
4	600–800	5 265	5
5	600–800	5 439	3
6	600–800	7 559	4
7	400–600	5 021	6
8	400–600	1 828	4
9	400–600	5 174	5
10	400–600	9 423	4
11	400–600	6 828	3
12	400–600	7 318	3
13	400–600	7 546	4
14	400–600	5 618	3
15	400–600	5 693	4
16	400–600	4 619	6
17	400–600	6 907	5
18	200–400	4 633	3
19	200–400	8 135	5
20	200–400	9 826	4
21	200–400	2 528	3
22	200–400	3 930	3
23	200–400	4 824	4
24	50–400	1 243	3
25	50–200	2 563	3
26	50–200	1 784	4
27	50–200	3 726	3
		Total 141 808	Total 107

Fish distribution and catch rates

The distributions and catch rates of the 15 most abundant species are discussed below, in order of abundance (Figure 6).

Although taken from all stations at depths greater than 200 m, hoki were more prevalent on the western Chatham Rise, in particular southwest of Mernoo Bank, where catch rates reached 7 t. km^{-1} (Figure 6a). Rattail and javelin species (Figure 6b, 6c) and ling (Figure 6d) were also widespread with more even catch rates than hoki. Catch rates on the western Chatham Rise and northern slopes tended to be higher than in other areas. Alfonsino were not generally caught; the stations with high catch rates were in the warmer subtropical water to the northeast part of the Chatham Rise (Figure 6e).

Table 5: Mean biomass estimates of the most abundant species and all other species combined, Chatham Rise, July 1986 (survey area 141 808 km^2, depths 50–800 m)

Species	Doorspread biomass (t)	Wingspread biomass (t)	Coefficient of variation (%)
Hoki	312 163	1 414 891	17
Macrourid rattails	103 716	471 438	12
Ling	18 954	85 314	8
Alfonsino	17 261	75 508	49
Silver warehou	16 218	73 946	25
Pale ghost shark	15 560	70 727	9
Barracouta	12 681	57 867	29
Dark ghost shark	11 061	50 279	22
Sea perch	10 384	47 201	10
Lookdown dory	8 611	38 906	9
Black oreo	7 647	34 928	46
Hake	7 613	33 810	13
Giant stargazer	6 824	31 091	19
Spiny dogfish	6 208	28 217	14
Spiky oreo	5 590	25 409	30
Shovelnosed dogfish	4 203	19 107	17
White warehou	3 791	17 156	30
Ribaldo	3 256	14 803	49
Silverside	2 797	12 714	15
Bellows fish	2 281	10 370	52
School shark	2 099	9 557	25
Tarakihi	2 040	9 315	25
Arrow squid	1 732	7 888	15
Orange roughy	1 660	5 755	85
All other species	27 617	125 534	-
Total	609 704	2 771 791	

Silver warehou tended to centre around the Mernoo area in similar depths to hoki although highest catch rates were east of Mernoo (Figure 6f). Higher catches of pale ghost shark were taken on the south Chatham Rise and tended to occur in the deeper strata (Figure 6g). Barracouta were found in any quantity only in warm shallow waters at the Chatham Islands (Figure 6h).

Dark ghost shark were clearly associated with shallow banks, i.e., Mernoo, Reserve, Veryan, Matheson Banks and the western edge of the Chatham Islands Shelf (Figure 6i). Lookdown dory were fairly evenly distributed within depths of 400–600 m with no obvious association with any particular water masses (Figure 6j).

Hake were caught throughout the survey area, but catch rates were consistently higher at depths of 600–800 m along the northern slopes (Figure 6k). Giant stargazer were also widely distributed; the higher catch rates were taken from shallower strata around Mernoo Bank and the Chatham Islands Shelf (Figure 6l).

White warehou were widely distributed, but with generally low catch rates (Figure 6m). School shark were found across the shallowest parts of the Chatham Rise from Mernoo Bank east to the Chatham Islands (Figure 6n). Arrow squid were taken from most stations, but in low numbers (Figure 6o).

Other species of commercial interest included orange roughy, hapuku, and oreos. The depth distribution of orange roughy and oreos virtually excluded them from the survey, although a few were caught at deeper stations. Hapuku are generally associated with rough ground, but some were caught on Mernoo Bank and at the Chatham Islands.

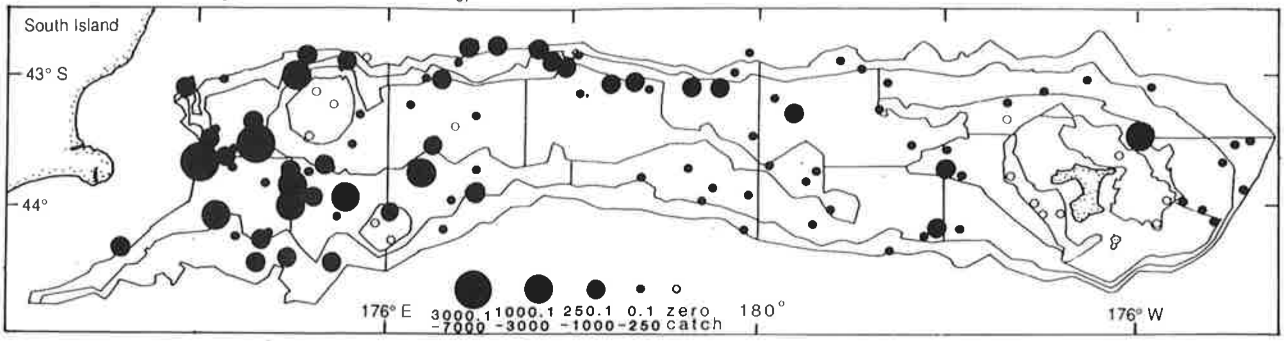
Length frequency and biological records

Hoki. The length frequencies show a bimodal distribution with peaks at about 50 cm and 58 cm (Figure 7a). Ninety percent of the population surveyed were less than 65 cm, smaller than mature spawning fish on the west coast of the South Island (mode 88 cm, Patchell 1982). Larger fish were found at greater depths (Figure 8a).

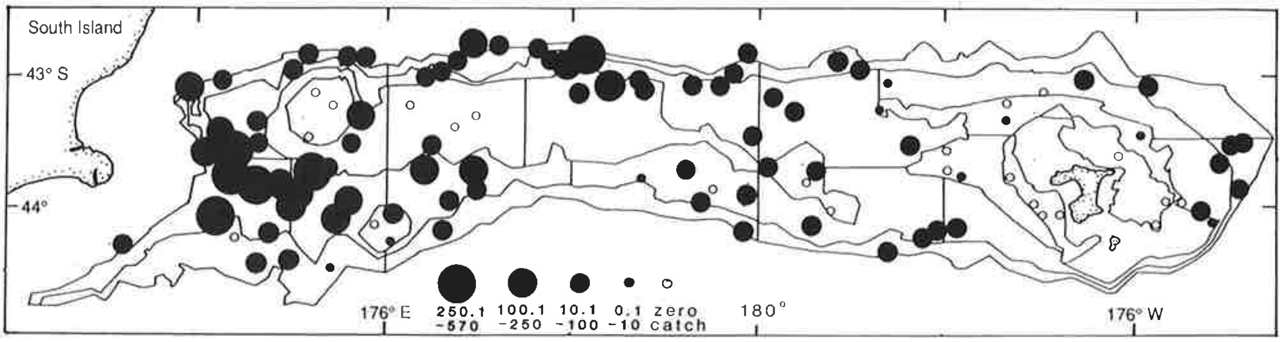
Table 6: Biomass composition (as % of total wingspread biomass) by depth zone of 10 important species

Depth zone (m)	Hoki	Ling	Silver warehou	Barracouta	Ling	Hake	Rattails	Javelinfish	Dark ghost shark	Pale ghost shark	Other species	All species (t)	Mean density of all species (kg.km^{-2})
50–200	0	3	<1	60	0	0	0	0	30	1	7	91 401	39.2
200–400	45	5	4	<1	<1	<1	5	7	8	9	16	525 596	93.1
400–600	59	3	3	0	4	<1	10	9	<1	11	4	1 705 434	247.4
600–800	38	3	<1	0	<1	4	10	10	0	35	<1	449 361	82.8
												2 771 792	

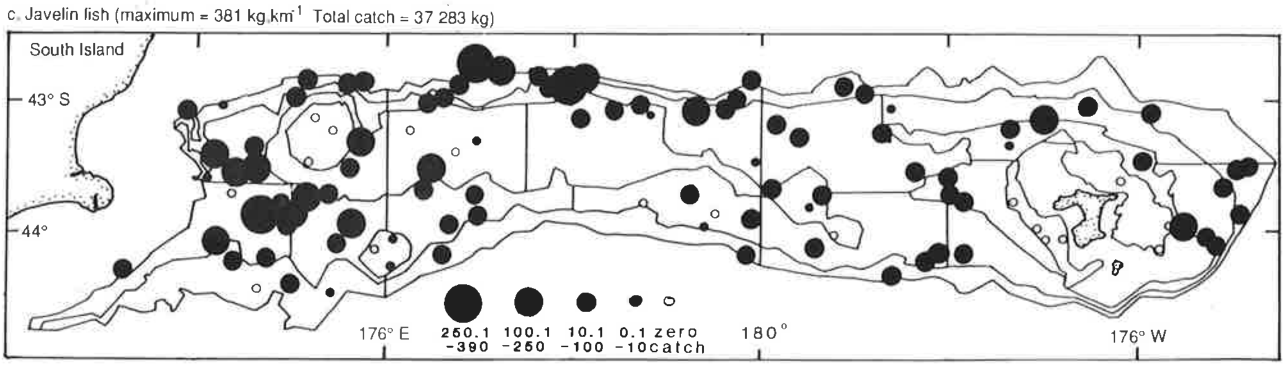
a. Hoki (maximum = 6 645 kg.km^{-1} Total catch = 270 534 kg)



b. Rattail species (except Javelin fish, maximum = 567 kg.km^{-1} Total catch = 43 784 kg)



c. Javelin fish (maximum = 381 kg.km^{-1} Total catch = 37 283 kg)



d. Ling (maximum = 109 kg.km^{-1} Total catch = 13 449 kg)

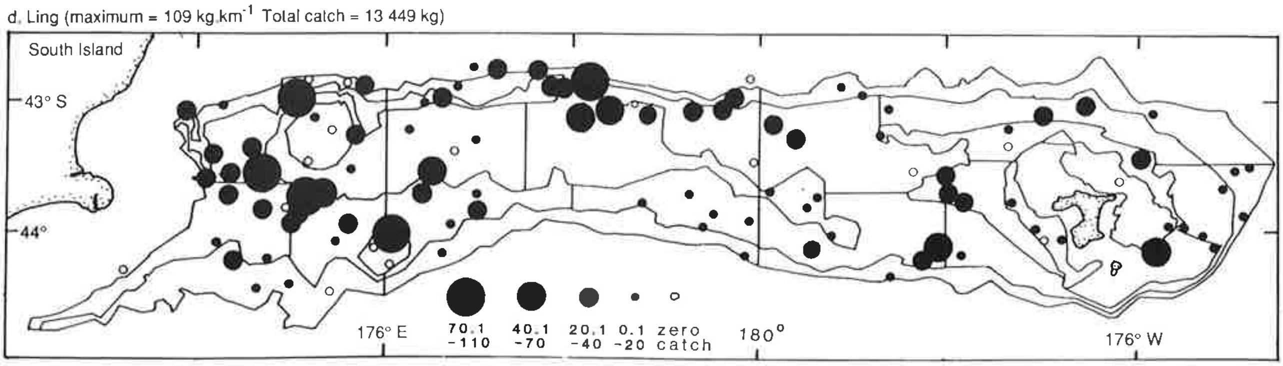
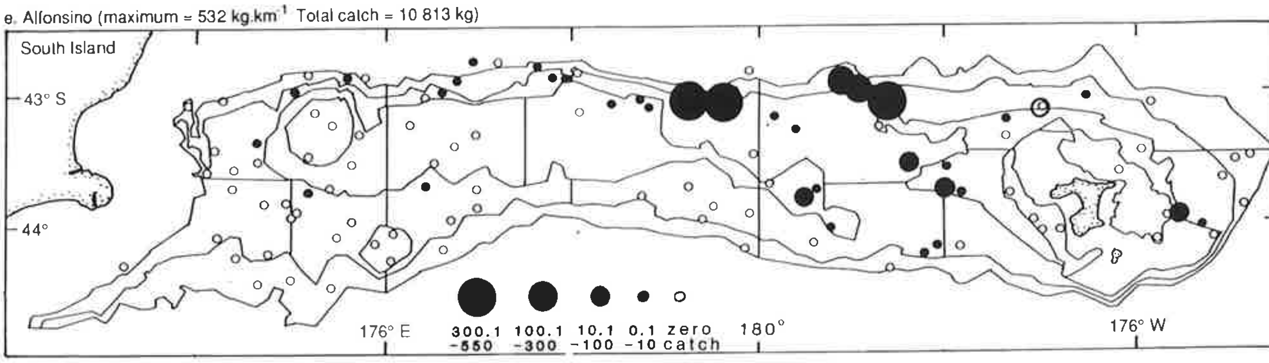
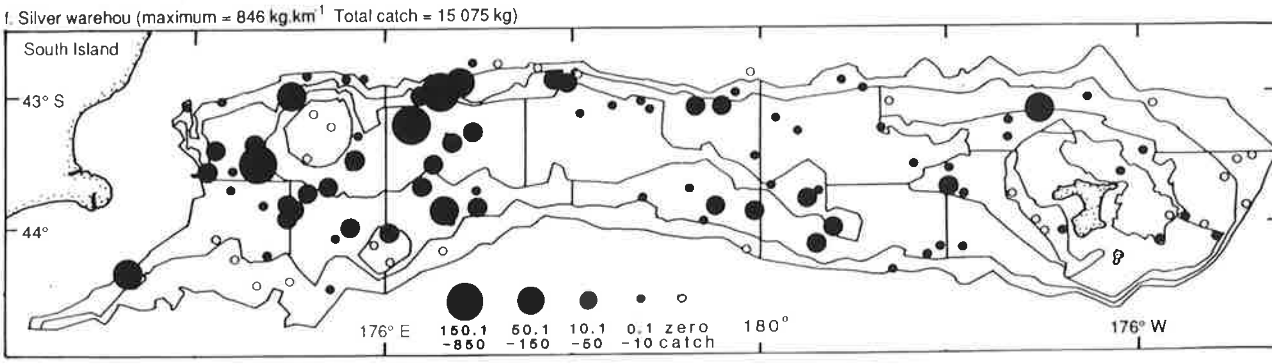


Figure 6a–d: Catch rate (kg.km^{-1}) distribution of important species.

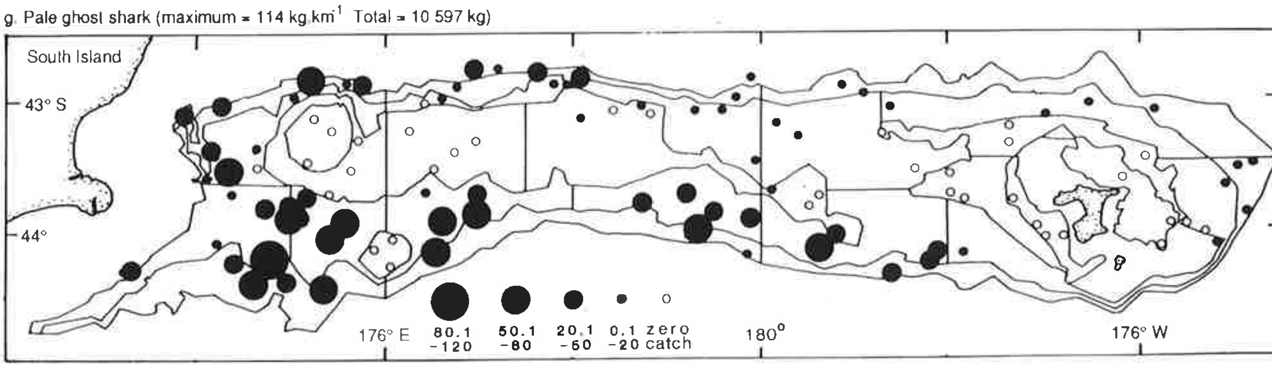
e. Alfonsino (maximum = 532 kg.km^{-1} Total catch = 10 813 kg)



f. Silver warehou (maximum = 846 kg.km^{-1} Total catch = 15 075 kg)



g. Pale ghost shark (maximum = 114 kg.km^{-1} Total = 10 597 kg)



h. Barracouta (maximum = 490 kg.km^{-1} Total catch = 13 358 kg)

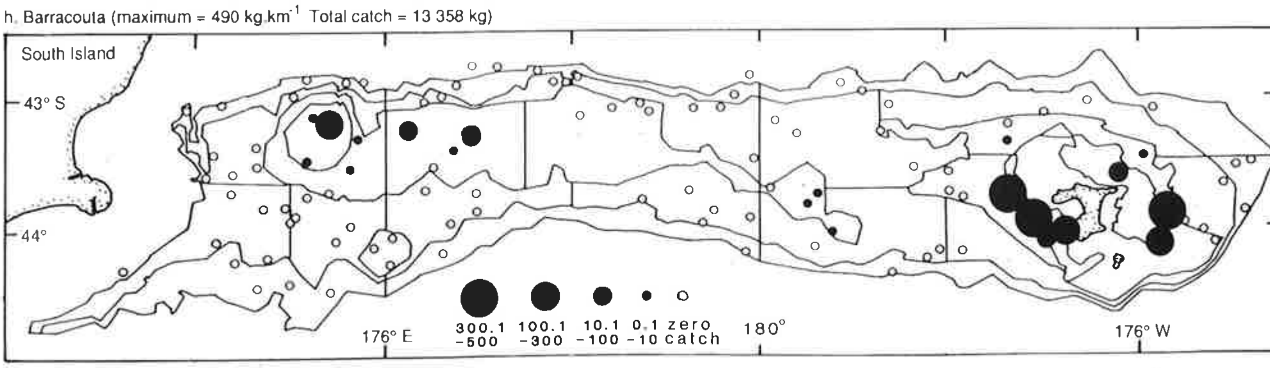
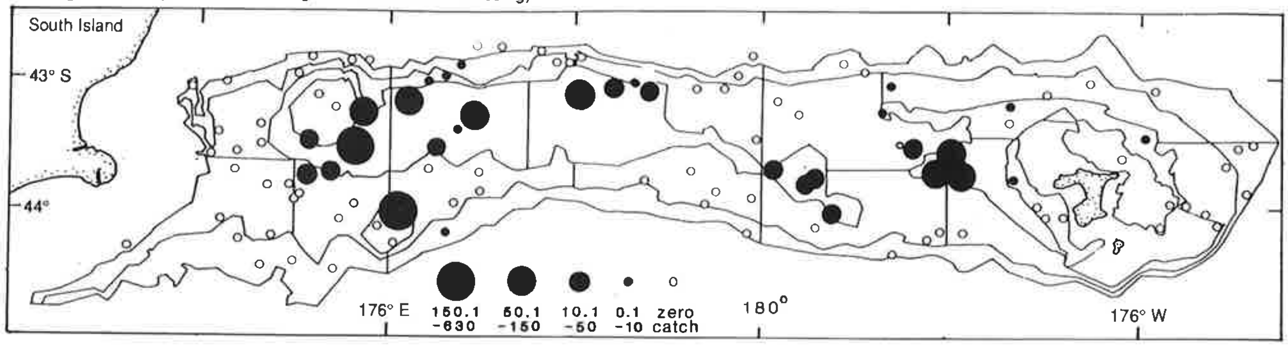
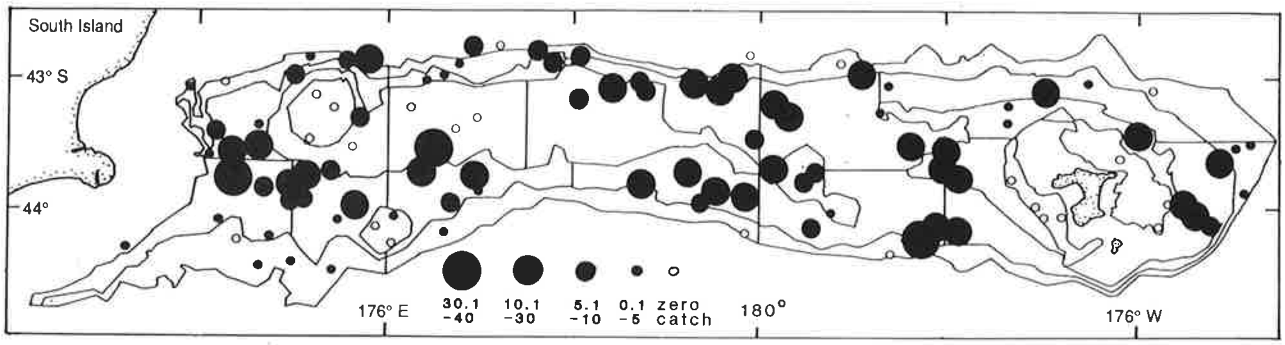


Figure 6a–d: Catch rate (kg.km^{-1}) distribution of important species.

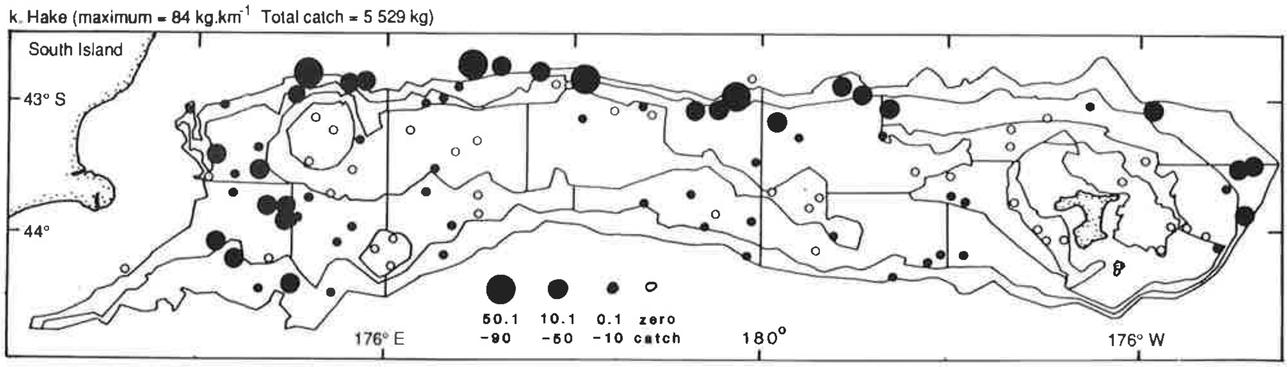
i. Dark ghost shark (maximum = 103 kg.km^{-1} Total catch = 4 469 kg)



j. Lookdown dory (maximum = 37 kg.km^{-1} Total catch = 5 198 kg)



k. Hake (maximum = 84 kg.km^{-1} Total catch = 5 529 kg)



l. Giant stargazer (maximum catch = 103 kg.km^{-1} Total catch = 4 469)

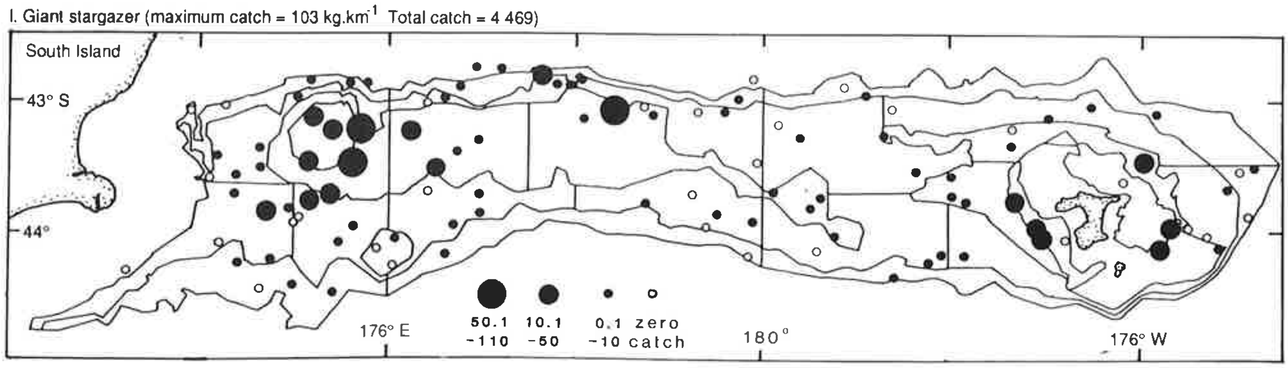
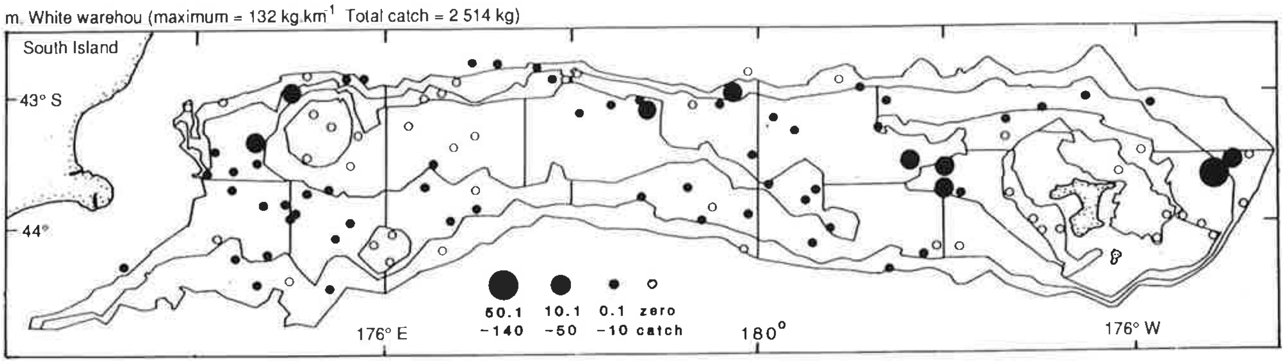
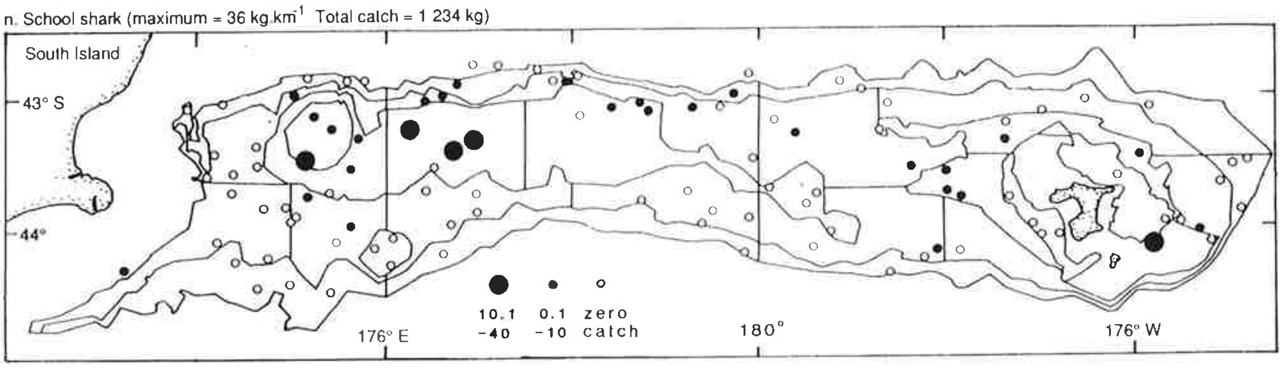


Figure 6i–l: Catch rate (kg.km^{-1}) distribution of important species.

m. White warehou (maximum = 132 kg.km^{-1} Total catch = 2 514 kg)



n. School shark (maximum = 36 kg.km^{-1} Total catch = 1 234 kg)



o. Arrow squid (maximum = 55 kg.km^{-1} Total catch = 1 503 kg)

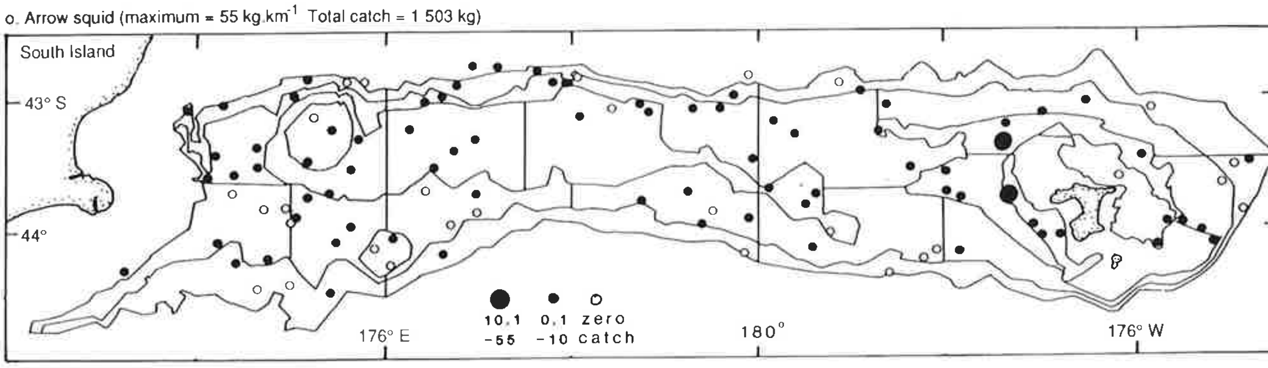


Figure 6m–o: Catch rate (kg.km^{-1}) distribution of important species.

The length frequency modes at 50 and 58 cm were interpreted to represent 3 and 4 year old fish respectively (*see* Discussion). The 30 cm fish in the shallow strata probably represent 1 year old fish which suggests that 2 year old fish were either absent, formed a weak year class, or were poorly sampled in this survey (Figure 8a).

Gonad staging of hoki during length frequency measurements showed that of the 21 650 fish examined, 752 females and 147 males had maturing gonads (stages 3 and 4). Of the female fish selected for more detailed examination, 72% were stage 2 (resting) and had a mean GSI of less than 1% (Table 7). Twenty-seven percent of fish were stage 3, but GSIs were mostly less than 10% (mean 3.0) compared with 15–20% on the west coast South Island (Livingston and Berben 1987). No running ripe or spent females were found throughout the survey. Of the male fish examined, 75% were stage 2 and 19% maturing with milt present in the testes. Fifteen males were running ripe, but GSIs were less than 10%. The sex ratio was 50 : 50 up to about 60 cm TL, after which females increasingly dominated, reaching 100% from 96 cm TL (Figure 9a). From the large number of fish sexed and staged, it is clear that hoki on the Chatham Rise

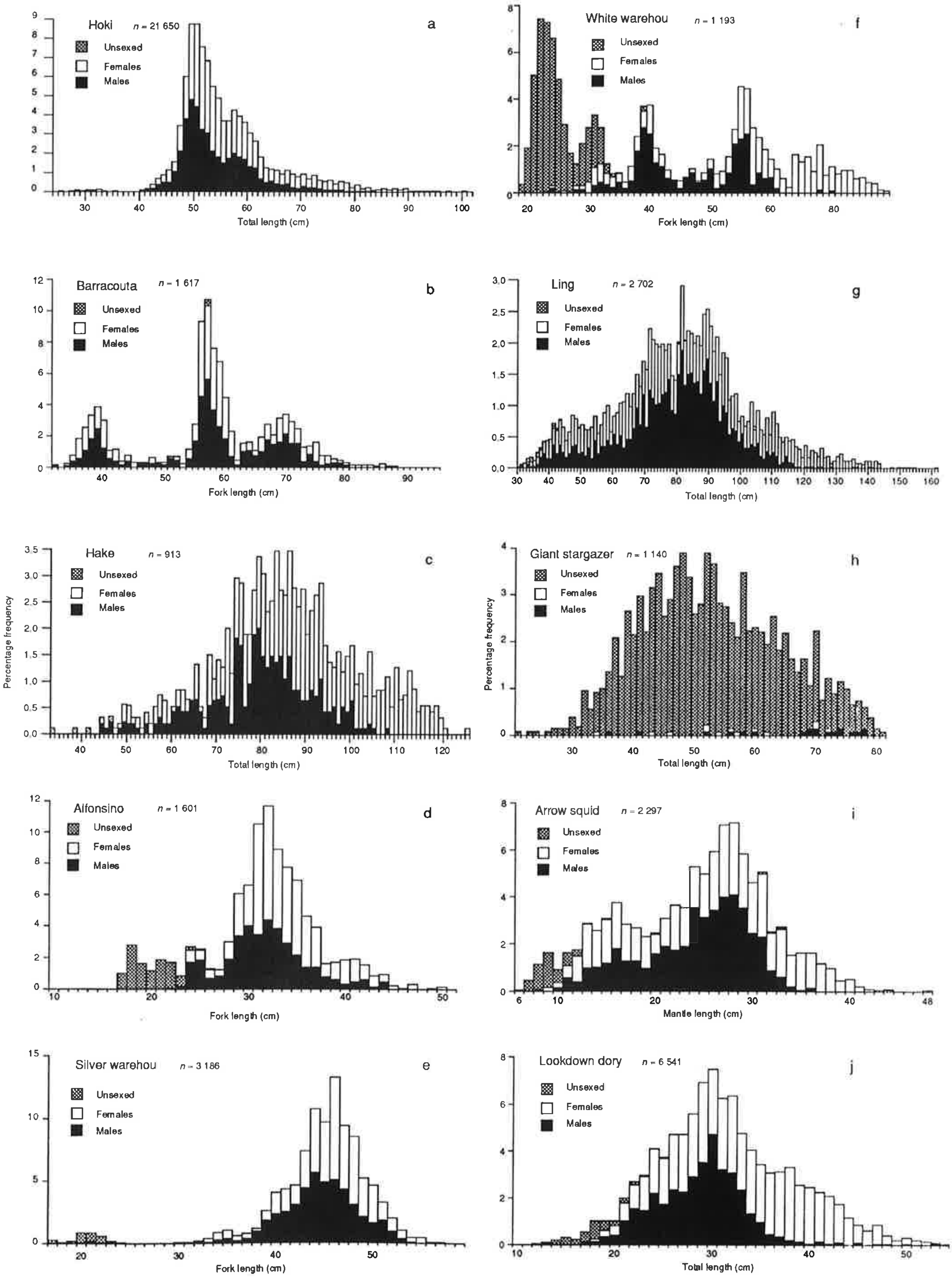


Figure 7a–j: Length frequency histograms of species measured.

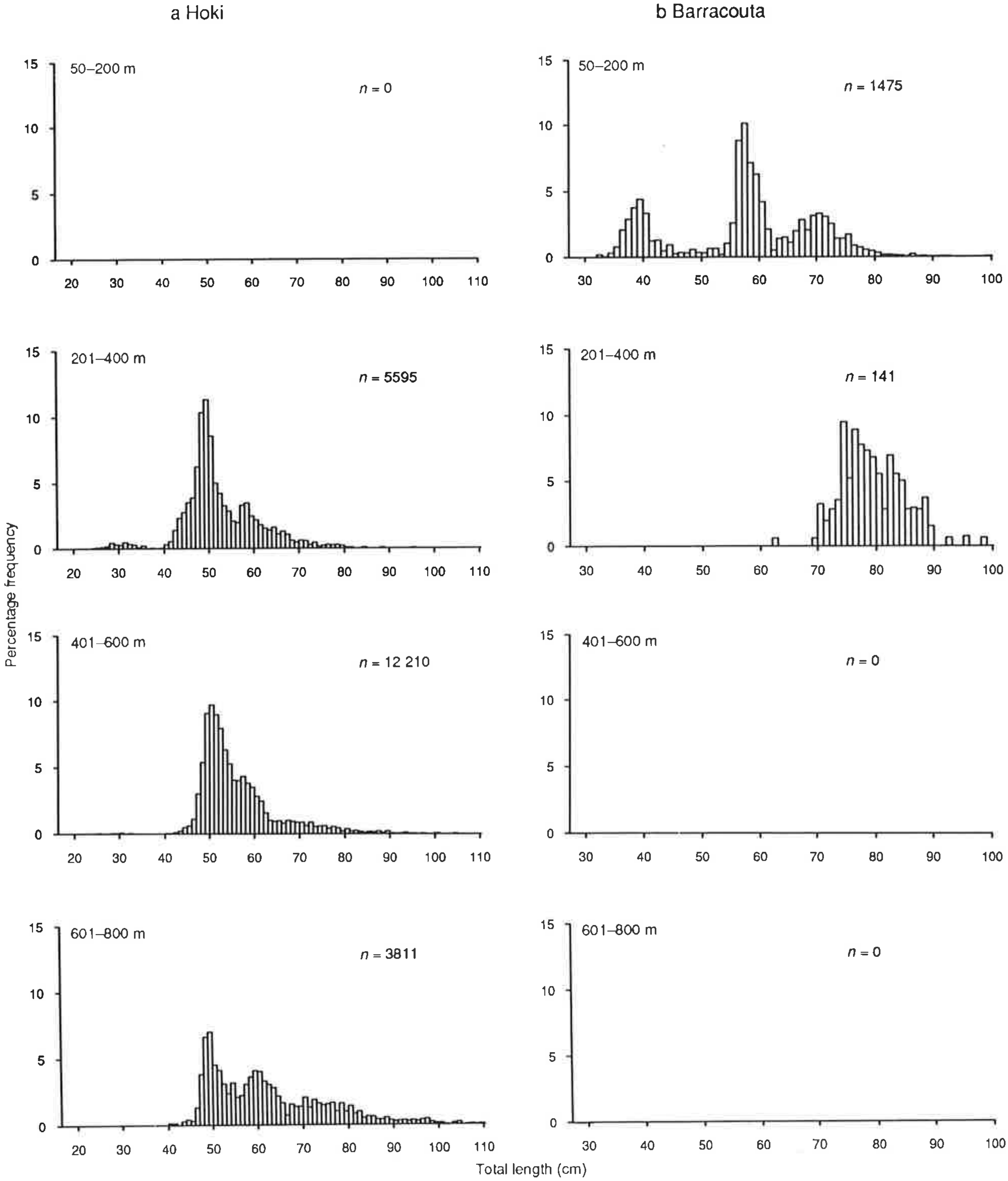


Figure 8a–b: Total length frequency distribution with depth. Note: length frequencies scaled by percent of catch sampled.

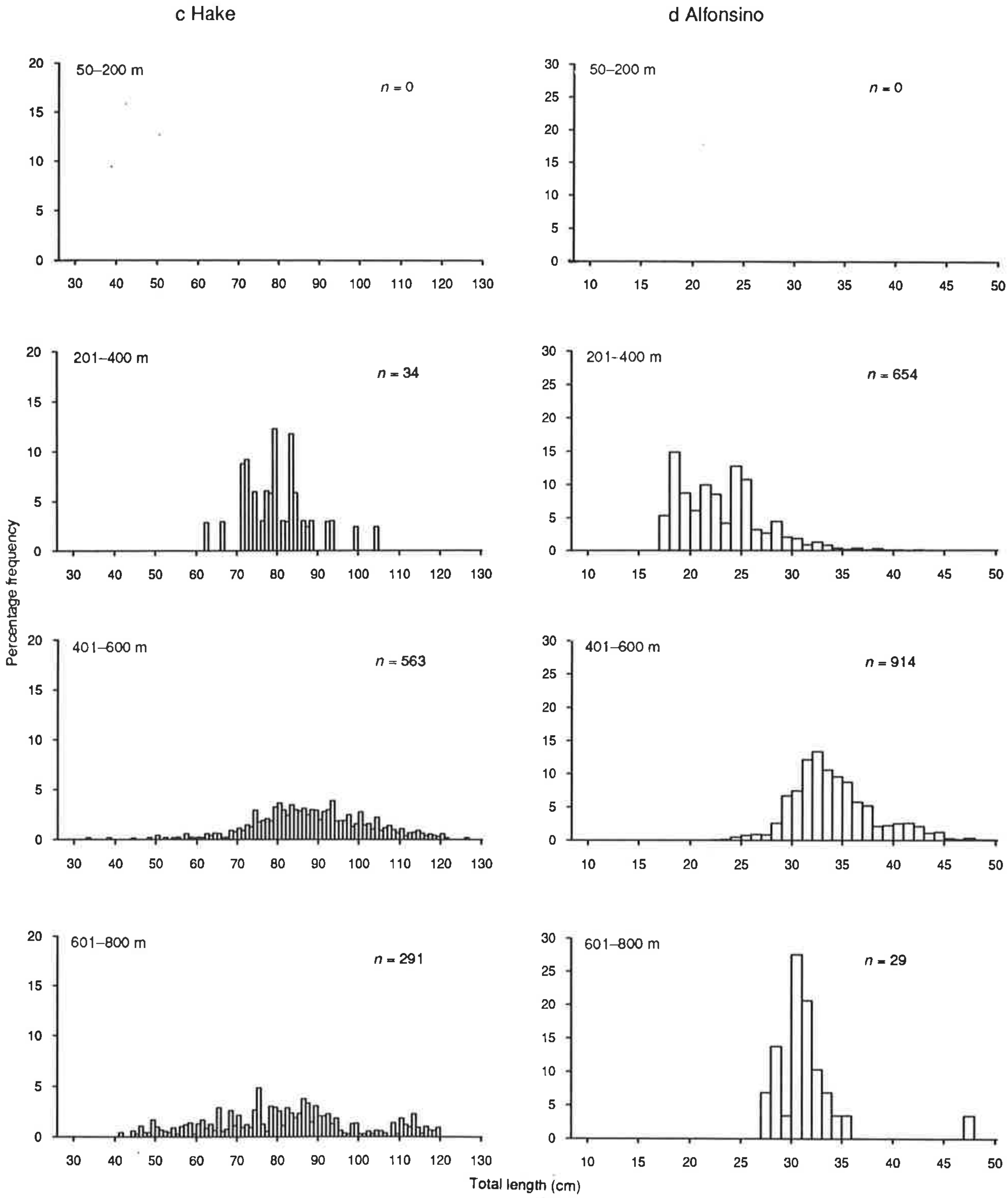


Figure 8c–d: Total length frequency distribution with depth. Note: length frequencies scaled by percent of catch sampled.

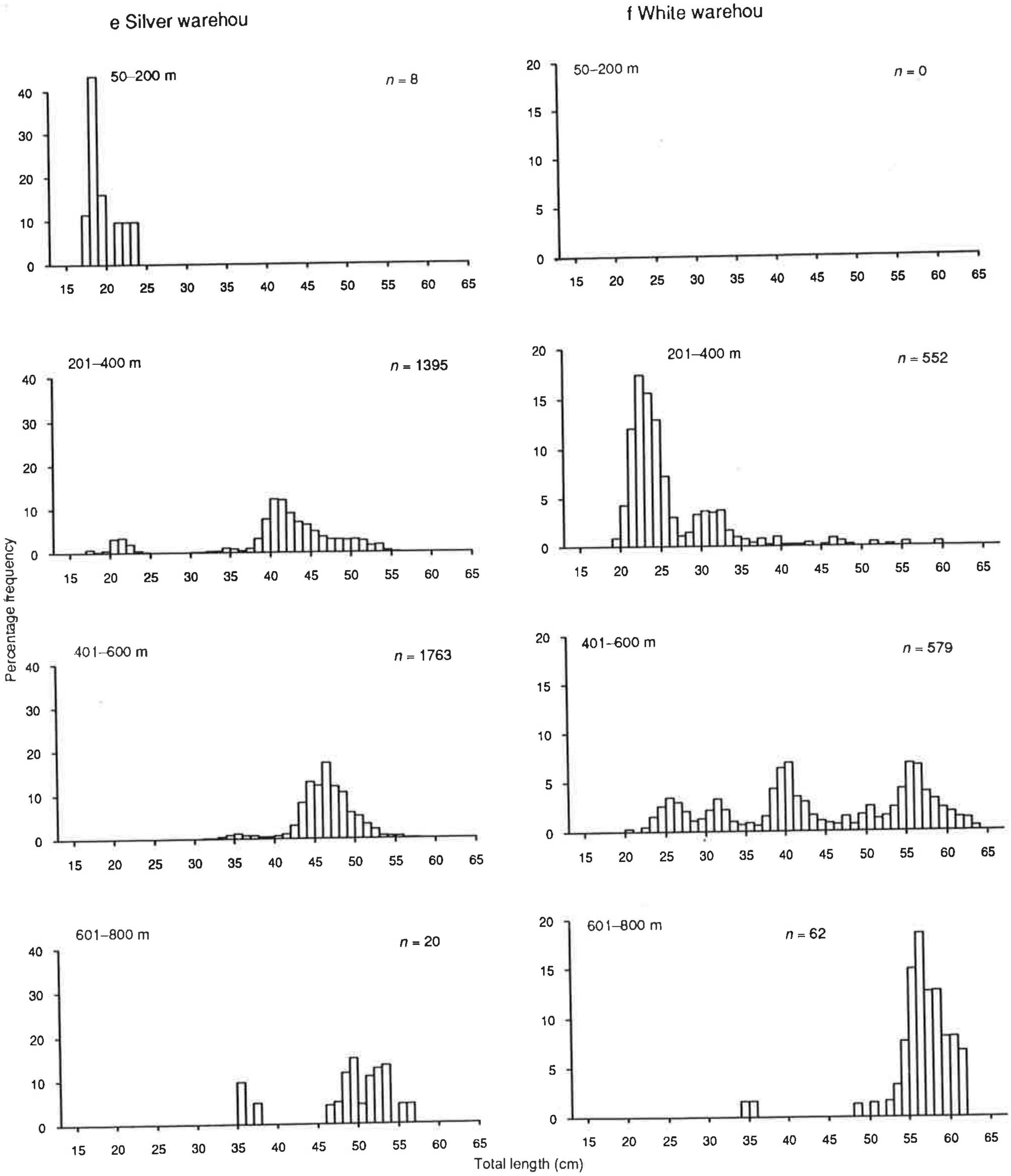


Figure 8e–f: Total length frequency distribution with depth. Note: length frequencies scaled by percent of catch sampled.

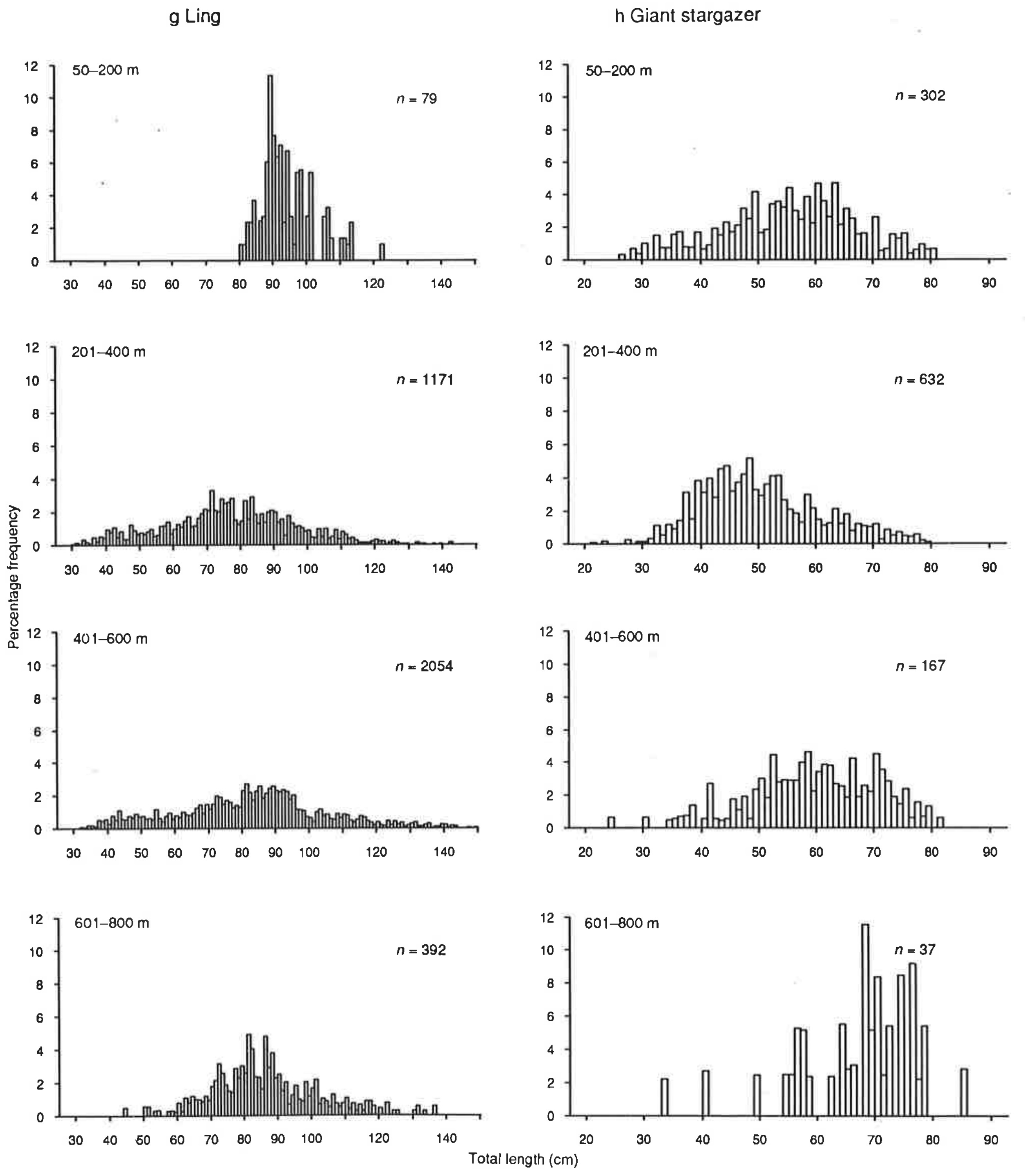


Figure 8g–h: Total length frequency distribution with depth. Note: length frequencies scaled by percent of catch sampled.

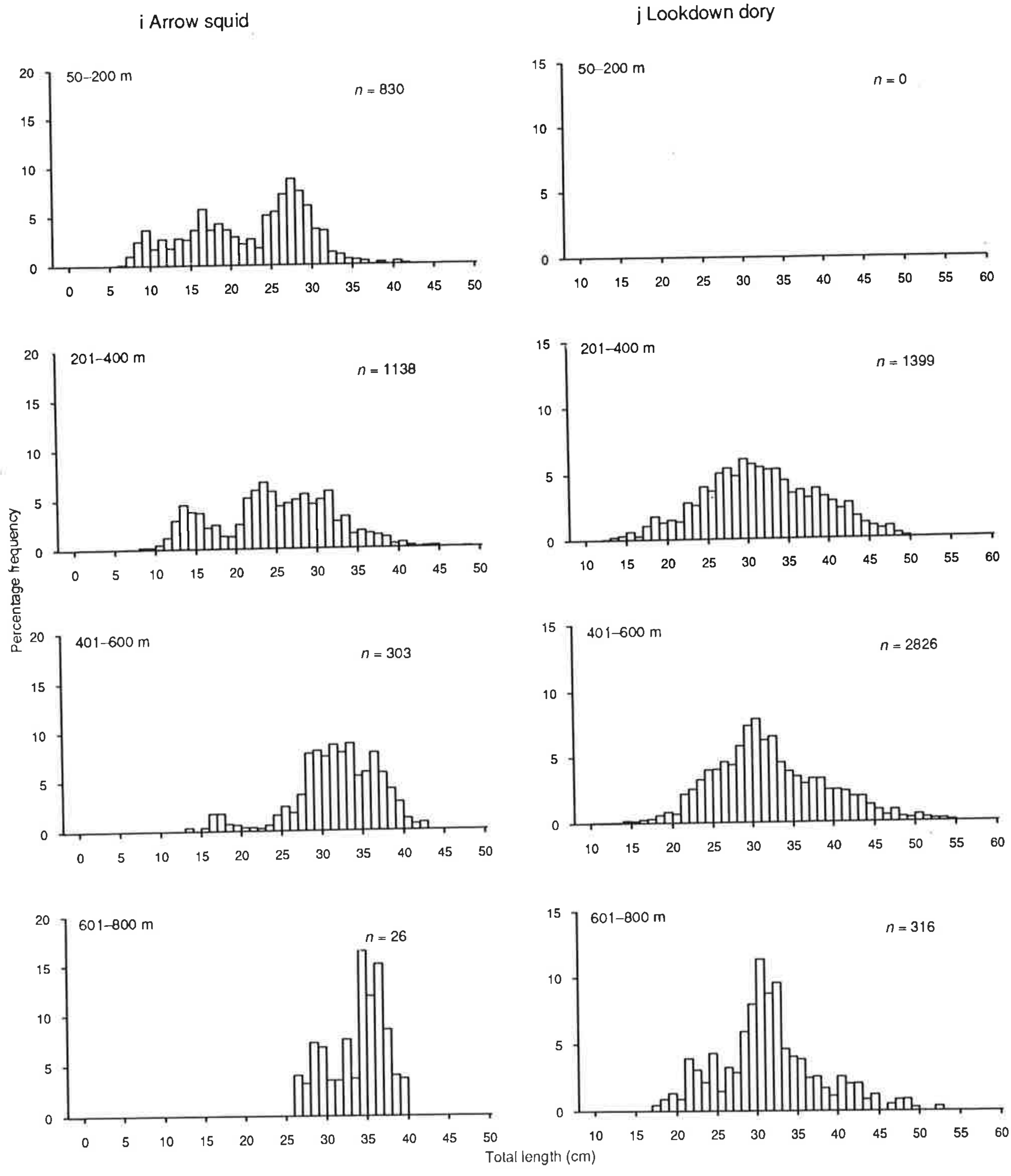


Figure 8i–j: Total length frequency distribution with depth. Note: length frequencies scaled by percent of catch sampled.

were from an essentially juvenile population (90% <65 cm TL) with a few adults (4%) that showed some sign of spawning maturation (Figure 10). Two additional tows at stations 201 and 202 (Figure 4) yielded catches of hoki with up to 75% of adult females undergoing maturation.

Barracouta. The length frequency histograms show clear modal peaks at 38, 57, and 70 cm (Figure 7b). The 57 and 70 cm peaks correspond to age classes of 3+ and 5+, as suggested by Hurst and Bagley (1987). The 38 cm peak presumably corresponds to 1+ fish, which were absent from the data presented by Hurst and Bagley (1987). The smaller fish were found only in the shallowest strata (50–200 m) (Figure 8). Fish normally associated with spawning stocks are generally larger than 54 cm (Hurst and Bagley 1987). The fish caught here were mostly adults with resting gonads (although milt was present in a few male fish) and GSIs were low (Table 7). Proportions of males and females were 50 : 50 up to 80 cm FL, after which females predominated (Figure 9b).

Hake. Hake had an essentially unimodal length distribution with males peaking at 77 cm and females at 85 cm (Figure 7c). There was no obvious change in size distribution with depth (Figure 8c). Most fish were adult size (> 60 cm, Patchell 1981).

Most male hake (55%) taken in the survey were running ripe (stage 5) with GSIs of up to 13%. Female hake were largely stages 2 and 3 with GSIs of up to 14%, although 1 running ripe and 11 spent females were also collected (Table 7). Despite low catch rates in the survey, the possibility of winter spawning of hake on the Chatham Rise as well as on the west coast of the South Island cannot be ruled out. The ratio of males to females was about 50 : 50 up to 85 cm TL, above which females predominated, reaching 100% at about 105 cm TL (Figure 9c).

Alfonsino. Two modes at 25 and 32 cm were evident in the length frequency histogram (Figure 7d). Smaller unsexed fish (15–25 cm FL) were associated with depths 200–400 m and fish larger than 25 cm FL were found deeper (Figure 8d). Fork length at ages 1–5 years are reputed as 8.82, 19.13, 25.78, 30.07, and 32.83 cm respectively (Ikenouye 1969) suggesting most fish caught were 4 and 5 year olds. Most alfonsino in this survey were below the maturation size range, i.e., 35–50 cm (B. Massey, MAF Fisheries Napier, pers. comm.). Running ripe alfonsino have never been captured around New Zealand, and fish examined in this survey were stage 2 with mean GSI values less than 1.5% (Table 7). A few fish had maturing gonads. Female fish increasingly predominated above 30 cm FL, and reached 100% at about 35 cm FL (Figure 9d).

Silver warehou. The length frequency histogram is dominated by a single mode at 46 cm (Figure 7e). According to Gavrilov (1979), fish 32–56 cm make up 70–80% of mature fish in spawning schools on the Chatham Rise. The silver warehou in this survey clearly fall within this adult size range. The 46 cm mode may represent 4+ age fish (Gavrilov 1974). There is a clear shift from small to larger fish with increasing depth (Figure 8e).

Table 7: Gonad stage and mean gonadosomatic index (GSI) of 10 commercial species

Species	Gonad stage	*n*	Mean GSI
Hoki			
males	1	65	<1
	2	229	<1
	3	19	2.5
	4	22	4.2
	5	15	4.2
females	1	3	<1
	2	733	<1
	3	282	3.0
	4	0	-
	5	0	-
Hapuku			
males	2	10	<1
	3	6	7.1
	4	6	11.7
	5	1	10.7
	6	5	10.7
females	2	8	<1
	3	14	7.3
Lookdown dory			
males	not staged		
females	2	4	1.3
	4	1	2.6
	6	8	1.5

Species	Gonad stage	*n*	Mean GSI
Giant stargazer			
males	3	1	1.4
	4	2	<1
	5	5	<1
females	1	1	2.5
	2	1	2.5
	4	4	5.8
	5	1	4.8
	6	5	<1
Ling			
males	1	6	<1
	2	5	<1
	3	8	<1
	4	3	<1
	5	4	<1
females	2	20	1.2
	3	20	1.2
	6	1	<1
Alfonsino			
males	1	1	<1
	2	8	<1
	3	5	2.2
females	2	19	1.5
	3	7	3.2

Species	Gonad stage	*n*	Mean GSI
White warehou			
males	4	10	9.6
females	3	9	5.9
	6	1	1.5
Silver warehou			
males	1	2	<1
	2	4	<1
	3	8	3.4
	4	20	7.9
	5	12	10.0
	6	1	14.3
females	2	5	1.1
	3	55	3.8
Hake			
males	1	1	<1
	2	10	<1
	3	5	1.2
	4	25	3.2
	5	50	5.1
	6	1	3.2
females	2	39	1.0
	3	26	3.5
	4	6	3.7
	5	1	3.0
	6	11	2.2

Species	Gonad stage	*n*	Mean GSI
Barracouta			
males	2	10	1.0
	3	6	2.2
	4	3	2.5
	5	1	5.7
	6	5	1.4
females	2	16	1.3

See Appendix 3 for gonad stage criteria

$$GSI = \frac{\text{gonad weight}}{\text{total weight}} \times 100$$

Out of the 60 female fish examined, 55 had gonads at stage 3 with GSI values up to 8% (Table 7); of the 47 males, 20 had gonads at stage 4 and 12 had gonads at stage 5. With GSI values up to 13%, this indicates some spawning maturation. As with most species in this survey, females dominated the larger size classes (Figure 9e).

White warehou. Five modal peaks show clearly in Figure 7f, at 23 and 31 cm (unsexed fish), 40 and 55 cm (both sexes), and 68 cm (females only). A shift to larger fish was apparent with increasing depth (Figure 8f). We have no information on the ages of white warehou. Of the 10 female fish examined, 9 were maturing (stage 3) with GSIs of up to 7% and 1 fish was spent. Male fish were all stage 4 with a mean GSI of 9.6% (max. 13%) (Table 7). Below 50 cm FL, white warehou were predominantly male, while above, females increasingly dominated (Figure 9f).

Ling. Possible length frequency modes are evident at 43, 72, 81, and 90 cm, although it could be argued that the histogram is unimodal (Figure 7g). Small fish were mostly found in 200-600 m depths; larger fish were present in all depth zones (Figure 8g). Ling probably start to mature around 80 cm (M. W. Cawthorn, Department of Conservation, pers. comm.) and the shortest stage 3 male and female fish examined were 93 and 81 cm, respectively. There is no information on the ageing of ling. Most ling showed signs of maturation (stage 3) and running ripe males were taken (Table 7). The shift from a 50 : 50 male to female ratio to dominance by females was at about 100 cm TL (Figure 9g).

Giant stargazer. The length frequency histogram is unimodal (Figure 7h) and shows little change with depth from 50-600 m. However, fish tended to be larger at 600-800 m depth (Figure 8h). From biological data, length at maturity appears to be about 40 cm for females. The fish sampled were mainly spawning or mature adults and GSI values were low compared with other species (Table 7).

Arrow squid. Mantle length (ML) distribution was bimodal with peaks at 16 and 27 cm (Figure 7i). Female squid over 25 cm ML are capable of copulating (R. Mattlin, MAF Fisheries Greta Point, pers. comm.). Many females greater than 25 cm had copulated, but a large portion of the catch was immature. Deeper strata tended to have larger squid (Figure 8i). Females predominate from about 32 cm ML (Figure 9h).

Lookdown dory. The length frequency modes peaked at 30 cm TL (Figure 7j). Little change was observed with depth (Figure 8j). Maturity probably occurs between 30 and 38 cm (Clark 1985) and it would seem, in view of the proportion of spent females (Table 7), that some spawning had recently occurred. The shift to female dominance was at about 34 cm TL (Figure 9i).

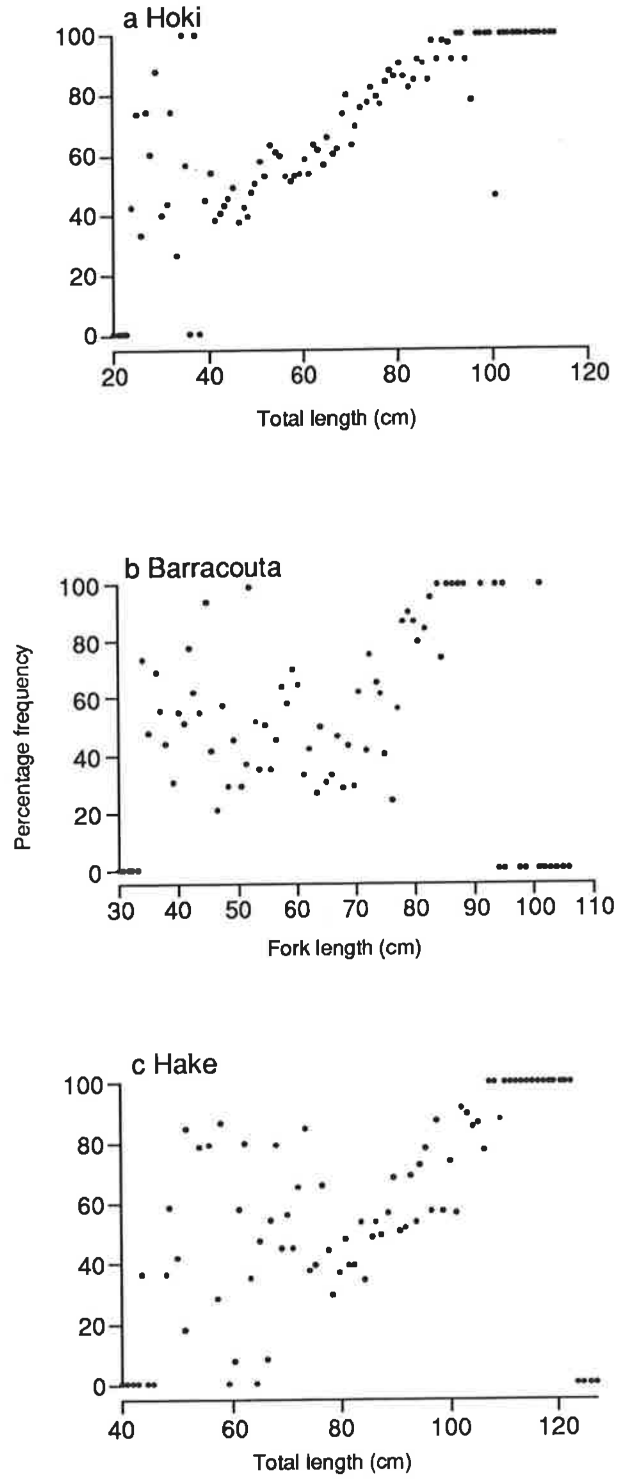


Figure 9 a–c: Percentage frequency of females by size class.

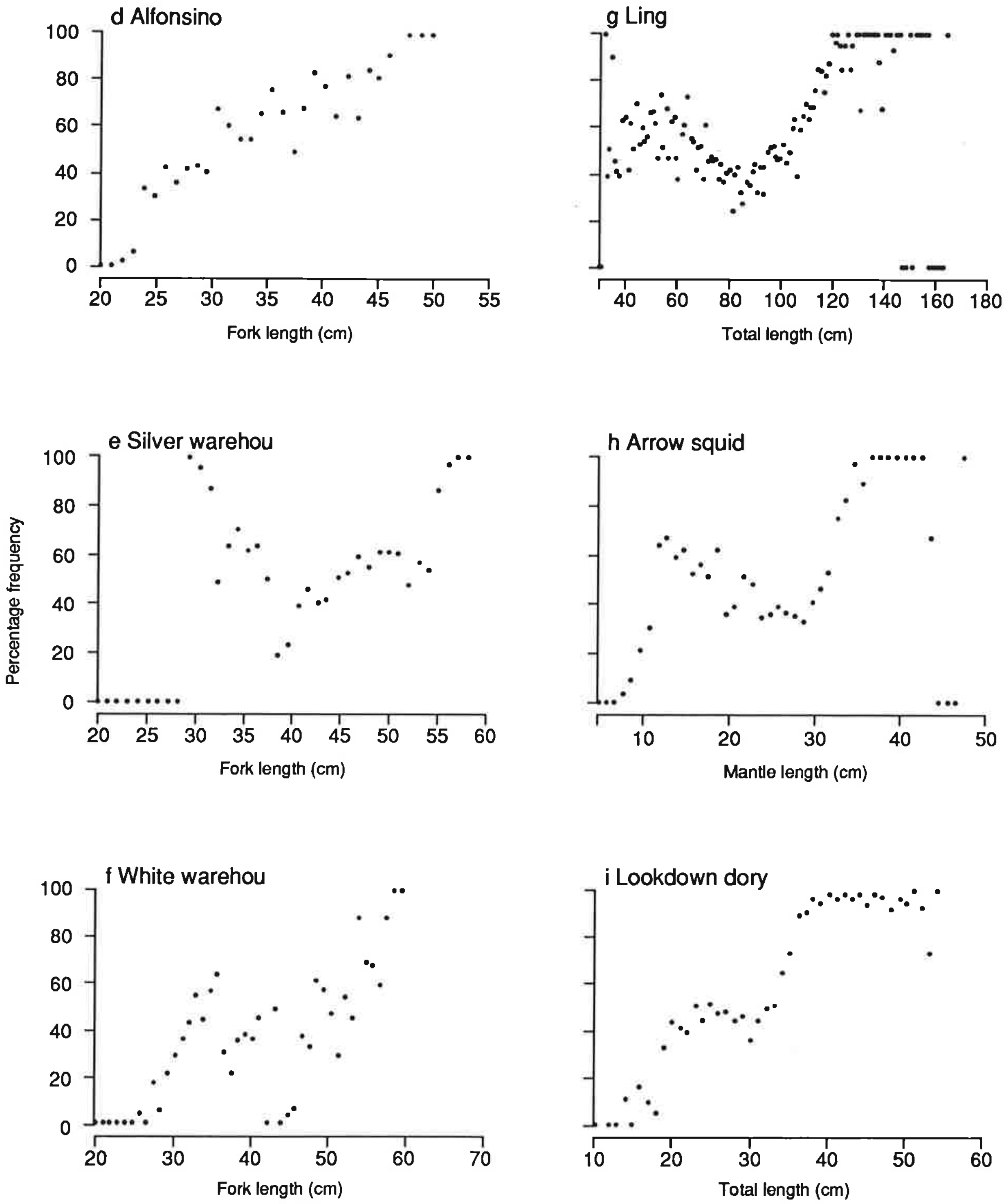


Figure 9d–i: Percentage frequency of females by size class.

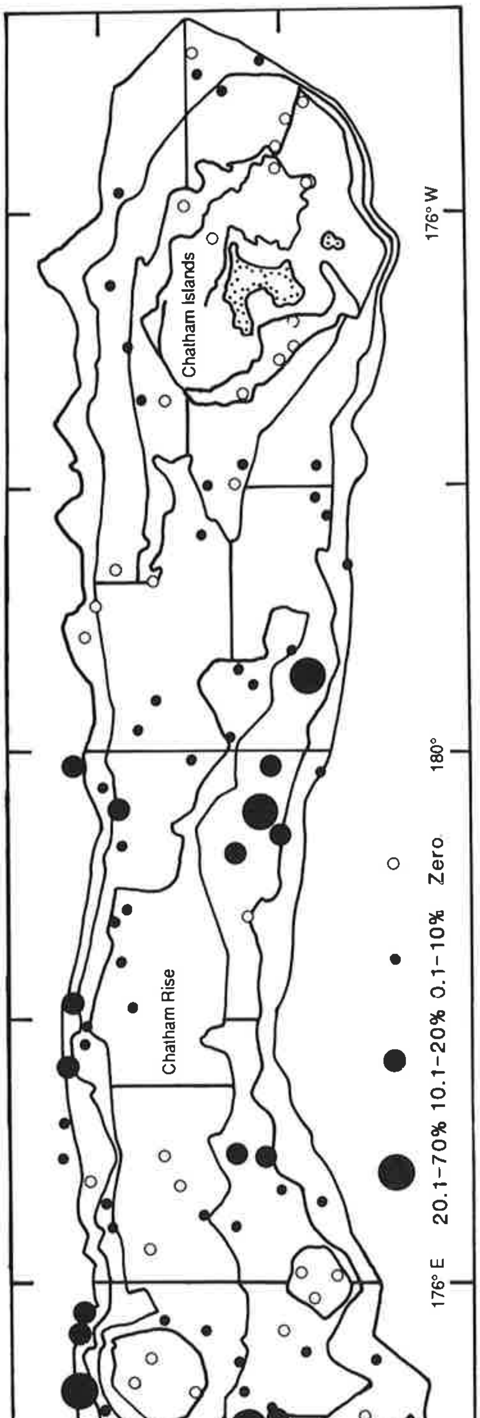


Figure 10: Distribution of female hoki with maturing ovaries (i.e., eggs visible) expressed as percent of catch per tow.

Other species examined biologically included hapuku, bluenose, Bollon's rattail, sea perch, southern blue whiting, jack mackerel, tarakihi, spiky oreo, smooth oreo, javelinfish, ribaldo, and red cod. Of these, hapuku, smooth and spiky oreos, sea perch, ribaldo, and javelinfish showed significant signs of maturation and/or spawning (Table 8).

Stomach contents

The stomach contents of hoki, silver warehou, and hake subsamples were examined to determine the main food items of these fish.

Stomach eversion as a result of swim bladder expansion with depth change occurred in less than 2% of the fish caught of these species (Figure 11). Most hoki and hake examined had empty stomachs, and silver warehou usually had some food remains in their stomachs. Natant decapod prawns and fish (lanternfishes and other small mesopelagic species) (*see* Appendix 10 for species list) were the most frequent food items of hoki and hake (Figure 11). Silver warehou had fed almost exclusively on pelagic salps.

Table 8: Summarised length frequency and female gonad data of minor species

Species	Length frequency range (cm)	Gonad stage	Max. GSI	*n*
Jack mackerel	51–60	1 or 2	-	96
Tarakihi	39–50	1 or 2	-	711
Bluenose	47–73	1 or 2	-	215
Spiky oreo	32–37	3–4	6.0	2 197
Smooth oreo	36–34	3–4	5.6	239
Sea perch	29–38	3–4	2.5	20
Bollon's rattail	39–54	2–3	5	40
Javelinfish	38–50	2	(1 running ripe, GSI = 26)	36
Ribaldo	46–64	3–6	18	15
Red cod	37–60	2, 5		229
Southern blue whiting	<37	1	-	20

Table 9: Hoki stomach contents (% frequency of occurrence) among different size classes (total length)

	Size class			
	20–39 cm (*n* = 18)	40–59 cm (*n* = 175)	60–79 cm (*n* = 766)	>80 cm (*n* = 445)
Empty	66.7	82.9	61.6	62.9
Prawn	22.2	11.0	22.9	16.4
Lampanyctodes hectoris	5.6	-	-	-
Other lanternfish	5.6	1.1	2.6	-
Other fish	-	4.6	12.9	16.4
Squid	-	0.6	2.5	2.5
Salps	-	0.6	-	2.5
Hoki	-	-	0.4	0.9
Oliver's rattail	-	-	0.1	0.2
Maurolicus muelleri	-	-	0.1	0.2
Silverside	-	-	0.1	-
Photichthys argenteus	-	-	0.1	-
Chauliodontidae	-	-	0.1	-
Serrivomeridae	-	-	0.1	-
Deepsea flathead	-	-	-	0.2
Malacosteidae	-	-	-	0.2

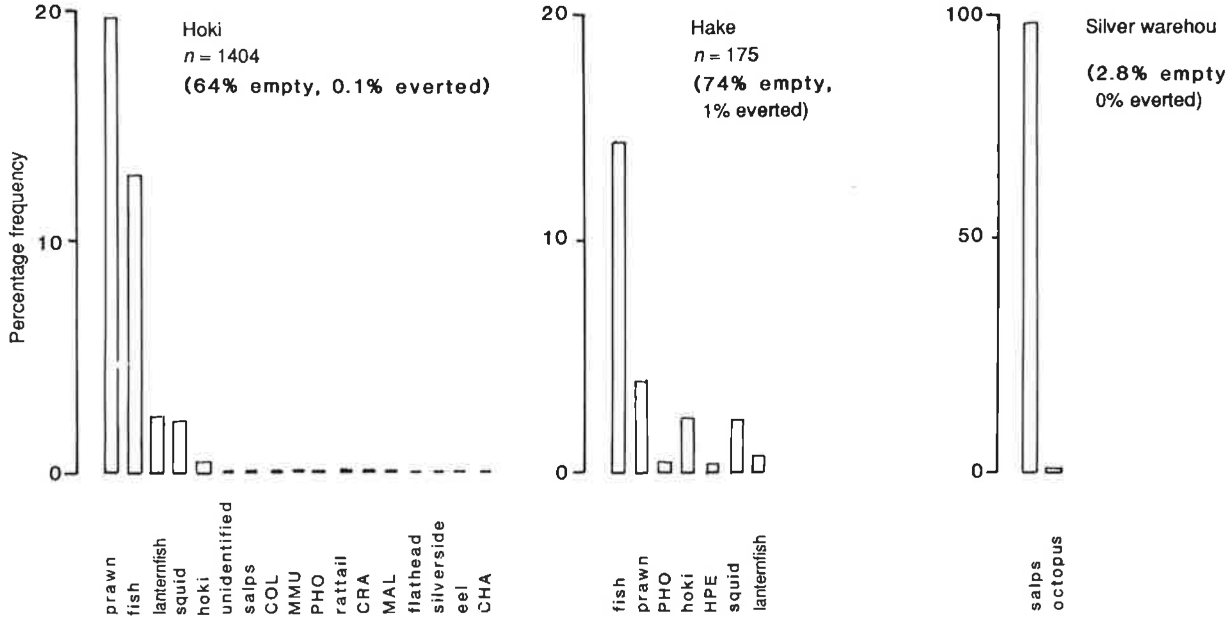


Figure 11: Principle dietary components as indicated by stomach contents of hoki, hake, and silver warehou (all size classes combined).

Diet did not vary significantly with size class of hoki except for an increase in prey diversity with increasing size (Table 9). Samples of silver warehou and hake were not large enough to divide into size class groups.

Plankton survey

No hoki or other fish eggs were found in any of the 16 surface tows taken over Pegasus Canyon.

Discussion

During the survey period, the Subtropical Convergence Zone lay along the south side of the Chatham Rise, including shallow ground such as the Veryan Bank. The position of the 10 and 8 °C isotherms at the surface and sea bed, respectively, generally marked the zone of greatest thermal gradient and indicated a southward shearing of the frontal zone from sea floor to surface. From satellite statistics, it would appear that conditions at the surface were slightly cooler than average (Appendix 7), but it is not clear whether this reflects surface cooling caused by local air temperatures or a real drop in subsurface temperature.

Despite the slight cooling of surface waters, the position of the Subtropical Convergence Zone in July 1986 was typical from records from hydrological surveys of the Chatham Rise in winter (Heath 1981), and anomalous fish distributions or abundance cannot be attributed to unusual hydrological conditions.

The present survey estimated a total biomass of fish and squids of about 2.8 million tonnes (wingspread), similar to the 3.1 million tonnes estimated in the March 1983 survey (Fenaughty and Uozumi 1989). In both surveys, hoki made up about half of the total biomass and were mostly juvenile fish (i.e., < 65 cm TL). Clear modal peaks were evident in both surveys, although the relative proportions of fish in each modal peak differed. In July 1986, the length frequency distribution was dominated by a peak at 50 cm with a smaller peak at 58 cm. In March 1983, fish of 60–62 cm TL dominated the length frequency distribution, but there were well defined peaks at about 42 cm and 54 cm TL (Fenaughty and Uozumi 1989).

Another survey of the Chatham Rise east of 176° E in November/December 1983 found a high proportion of even smaller fish centred around 35 cm TL (Hatanaka *et al.* 1989). The length frequency distributions from all three surveys (adjusted to area surveyed east of 176° E) are compared in Figure 12. The differences may be a result of year-class strength variation, seasonal availability of different size classes, differences in trawl gear selectivity between surveys, or some combination of effects. It is clear, however, that large hoki do not dominate the Chatham Rise population in any season, unlike in waters south of New Zealand (van den Broek *et al.* 1984).

The predominance of juvenile hoki on the Chatham Rise in all seasons suggests that the area is a major nursery ground from which most (about 80%) hoki either disperse to other areas as they reach maturity or die. It has been proposed that as hoki reach mature size, they recruit to the adult population and then migrate to the west coast of the South Island to spawn every winter (Patchell 1986). East of 176° E the relative biomass of hoki almost halved between the March and November/December 1983 surveys, and the July 1986 estimate was in between (Table 10). A comparison of the relative biomass of each modal peak between surveys suggests that male hoki may move off the Chatham Rise 1 year before females (cf. peaks D and E, Table 10). The drop in biomass between March and November/December 1983 of modal peaks D and E of both sexes also suggests that if hoki do move away from the Chatham Rise as they reach maturity, they do so during the winter months (Table 10).

Our results also show that some adult hoki remain on the Chatham Rise in winter (28% of total hoki biomass) and that, of these, about 25% of female fish had maturing ovaries. Since the spawning season on the west coast of the South Island had already begun, it is unlikely that these fish would migrate there to spawn. We assume, therefore, that some hoki would have spawned either on or near the Chatham Rise during winter 1986. However, we did not find dense spawning schools in the survey area, and could not interpret the scale of spawning. In addition, it is clear that a large number of fish do not necessarily spawn in any one year. Our observations are, therefore, no more conclusive than those of Kuo and Tanaka (1984a).

Since July 1986, further research has found dense schools of hoki spawning in Cook Strait, and some fish spawning in Pegasus Canyon (west Chatham Rise) and the Conway Trough (Kaikoura Peninsula) in August and September (Livingston 1990a). There is evidence from plankton surveys of spawning

Table 10: Percentage of wingtip biomass of hoki in different size classes July 1986, March 1983, Nov/Dec 1983, east of 176° E, Chatham Rise (*see* Figure 12 for size classes A–E)

Size class	Mar 1983	Nov/Dec 1983	Jul 1986
Sexes combined			
A	1	10	< 1
B	5	11	1
C	18	37	44
D	51	27	27
E	27	15	28
Biomass (t)	871 000	433 000	674 000
Females			
A	< 1	8	< 1
B	4	8	1
C	14	38	39
D	45	27	25
E	37	19	35
Biomass (t)	526 000	312 000	395 000
Males			
A	< 1	15	< 1
B	6	15	2
C	25	35	51
D	60	27	30
E	9	8	17
Biomass (t)	276 000	169 000	278 000

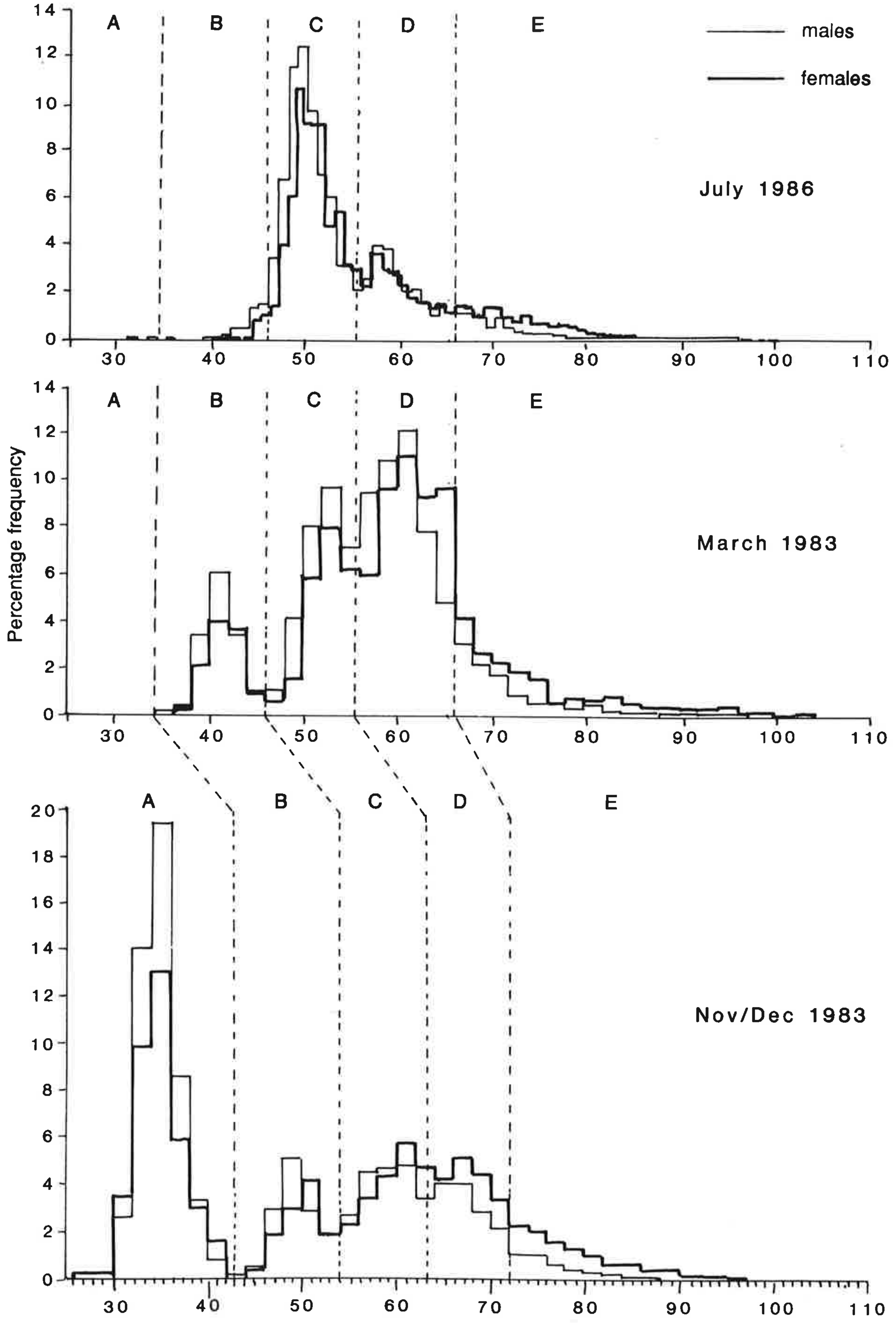


Figure 12: Size composition of hoki male and female populations east of 176° E sampled in three Chatham Rise trawl surveys.

Table 11: Biomass estimates (wingspread) and coefficients of variation (c.v.) of 10 important species east of 176° E on the Chatham Rise (Area D¶) from three *Shinkai Maru* surveys of the Chatham Rise

Species	Mar 1983* Biomass (t)	c.v. (%)	Nov/Dec 1983† Biomass (t)	c.v. (%)	Jul 1986 Biomass (t)	c.v. (%)
Hoki	1 137 600	11	454 300	15	717 500	17
Javelinfish and rattails	220 000	10	201 800	12	249 800	12
Silver warehou	16 000	33	66 600	40	43 100	25
Ling	57 400	27	47 200	9	61 900	8
Sea perch	39 700	12	42 800	7	42 500	10
Hake	41 700	12	29 700	12	25 200	13
Lookdown dory	34 400	9	31 200	6	32 000	9
Black oreo	35 500	47	108 000‡	50	11 700	46
Arrow squid	10 900	26	12 000	22	6 330	15
Barracouta	12 300	33	9 400§	63	52 100	29
Net headline height (m)	8.4		7.0		6.2	

* From Fenaughty and Uozumi (1989).
† From Hatanaka *et al.* (1989).
‡ Includes spiky oreos.
§ From Hurst and Fenaughty (1985).
¶ *See* p. 9 in Baird and McKoy (1988).

outside the west coast, South Island (Murdoch and Chapman 1989, Uozumi 1988). Thus maturing hoki caught on the Chatham Rise in July 1986 were probably part of these spawning populations. The implications of this for the stock structure of hoki and future management of the fishery was discussed by Livingston (1990b).

The remaining 50% of estimated biomass comprised a wide range of species, mainly macrourid rattails. A similar division of biomass was found in previous surveys (Fenaughty and Uozumi 1989, Hatanaka *et al.* 1989). Biomass estimates of commercially fished species east of 176° E indicate that, apart from hoki, only silver warehou, black oreos, arrow squid, and barracouta show large differences between surveys (Table 11).

Table 12: A comparison of wingspread biomass estimates from winter (present survey) and summer (Hurst and Bagley 1987*) at the Chatham Islands in depths of 50–400 m

Species	Jul 1986 (14 stations)	c.v. (%)	Dec 1984 (80 stations)	c.v. (%)
Hoki	77 388	75	11 113	30
Barracouta	49 739	32	46 222	12
Dark ghost shark	9 267	13	152	26
Javelinfish	8 579	13	15	78
Tarakihi	7 641	28	4 058	30
Ling	7 476	28	1 190	12
Spiny dogfish	6 060	23	3 017	64
Stargazer	4 933	18	1 157	14
Lookdown dory	3 885	42	565	10
Arrow squid	2 871	32	6 346	16
Silverside	2 571	26	1	100
School shark	2 500	65	1 582	19
Alfonsino	2 474	73	658	50
Hapuku	2 453	82	3 618	12
Silver dory	1 928	54	–	–
Silver warehou	1 591	53	10 834	22
White warehou	1 245	43	1 387	27
Bluenose	1 048	59	364	26
Jack mackerel	905	61	1 238	34
Sea perch	829	46	423	17
Redbait	515	89	972	82
Hake	127	47	245	50
Common roughy	5	69	8 846	88
Other species	8 508	–	4 344	–
Total	204 538	31	107 934	10

* Mesh size 100 mm; mean headline height 6.6 m; vessel *Akebono Maru No. 73*.

Silver warehou length frequency distributions differed considerably between surveys. There was a predominantly adult size range in July 1986 and November/December 1983 compared with March 1983 when juvenile modal peaks were more evident (Fenaughty and Uozumi 1989). Silver warehou were near to or actually spawning in July 1986 and November/December 1983, and the length frequency distributions probably reflect the concentration of adults in the area. Seasonal biomass differences reflect either changes in vulnerability to the trawl or migration of fish to and from the area (Gavrilov 1979).

None of the surveys sampled depths greater than 800 m, so although black oreo were found in 600–1100 m (Fincham *et al.* 1987), differences in biomass may reflect sampling bias rather than real changes.

Arrow squid abundance can vary greatly from year to year as individual fish live for less than 2 years. Any differences in biomass observed between surveys may be linked to a number of variables that cannot be distinguished from year class variability.

For barracouta, differences between surveys almost certainly reflect differences in sampling around the Chatham Islands. In 1986, we sampled inside the 12 mile territorial limit, whereas in 1983 this area was omitted. Because most of the stations inside the 12 mile limit are less than 400 m, more barracouta were caught in 1986 (Table 10).

A more appropriate comparison of the shallower water species found at the Chatham Islands may be with the results of a more comprehensive survey carried out on the same strata in December 1984 (Hurst and Bagley 1987). Mean headline height of the net used in both surveys was similar, but mesh sizes were different (December 1984 mesh size was 100 mm). It is, therefore, difficult to distinguish mesh selection effects from real changes in biomass that may occur between the two surveys. Even comparing size class differences does not necessarily indicate whether these differences result from mesh size, or from differences in relative abundance of the size classes. Large differences (2 standard deviations or more) in total biomass between the surveys, in particular for ghost sharks, javelinfish, ling, stargazer, silverside, school shark, silver warehou, and common roughy, are apparent (Table 12).

A comparison of barracouta and hoki length frequencies (Figure 13), shows that the smaller size classes were more prevalent in the present survey than in the December 1984 survey (Hurst and Bagley 1987). Barracouta spawn in summer at the Chatham Islands (Hurst and Bagley 1987), but not in winter (present report) and it is possible that mature sized fish move elsewhere during winter. Barracouta school by size class (R. Hurst, pers. comm.), and the few stations sampled at the Chatham Islands in July 1986 probably provided an unrepresentative sample of barracouta. Spawning hoki have not been reported from the Chatham Islands; mature size fish present in summer may move elsewhere to spawn during winter.

Stomach contents of hoki, silver warehou, and hake were similar to those found in previous surveys of the Chatham Rise (Fenaughty and Uozumi 1989, Hurst and Bagley 1987). During this survey hoki stomach contents were also similar to those in other areas of the EEZ (Kuo and Tanaka 1984b, Clark 1985) and off Tasmania (Bulman and Blaber 1986). All these studies found a slight shift in diet with increasing size of hoki, from crustaceans and small fish to fish and molluscs, but this was not evident from the present survey.

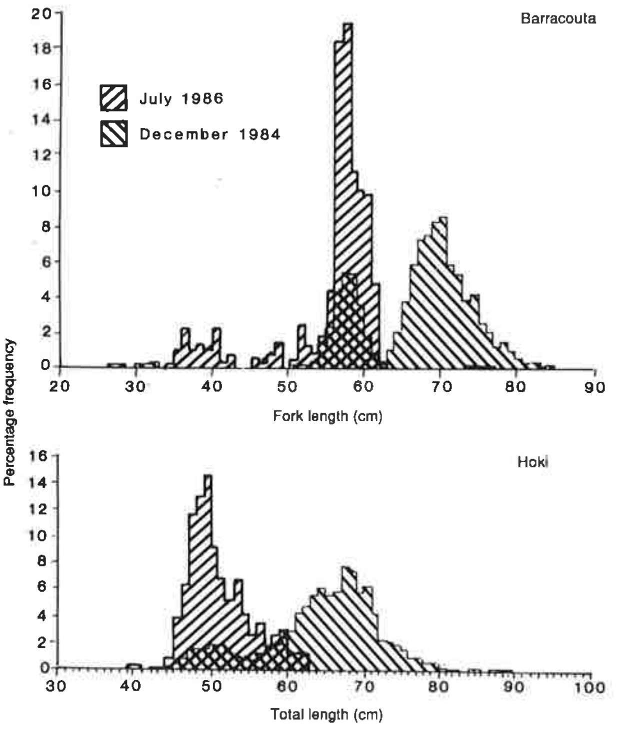


Figure 13: Barracouta and hoki length frequencies on Chatham Islands shelf, as measured in trawl surveys during July 1986 and December 1984 (*after* Hurst and Bagley 1987). Note: scaled by percent sampled and length of tow.

Acknowledgments

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Appendix 1

Expendable bathythermograph (XBT) station positions

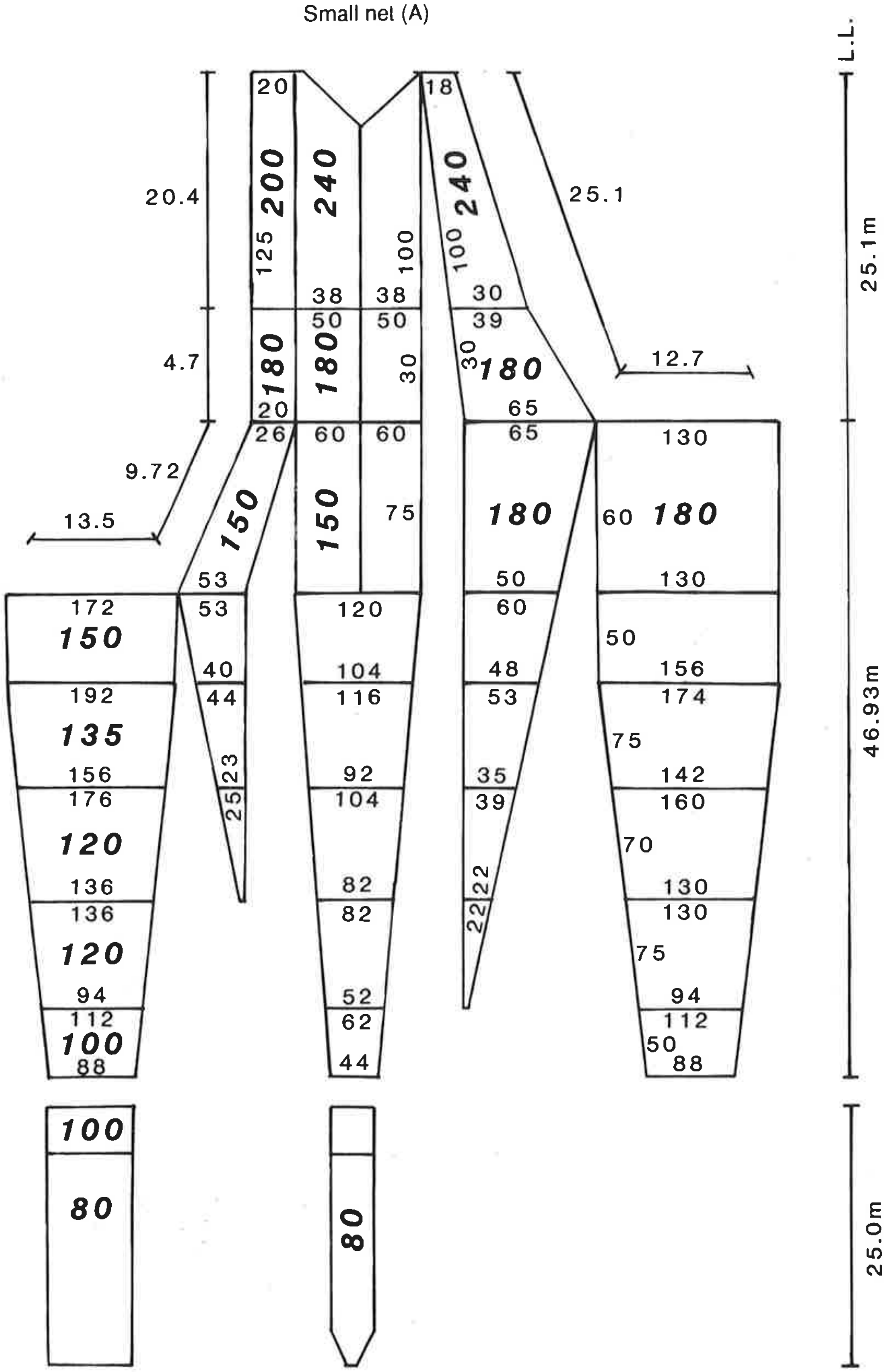
Date (1986)	Station no.	Position: Latitude	Position: Longitude	Depth (m) of bottom	Temperature (°C): Surface	Temperature (°C): Bottom
25 June	1	44° 02.2′ S	173° 20.4′ E	442	10.2	8.7
26 June	2	44° 27.3′ S	174° 34.2′ E	742	9.6	6.6
27 June	3	44° 02.1′ S	175° 20.3′ E	493	11.3	7.6
28 June	4	44° 28.3′ S	175° 32.6′ E	764	9.4	6.4
27 June	5	44° 06.3′ S	176° 07.4′ E	361	10.7	8.5
28 June	6	44° 16.9′ S	176° 38.2′ E	660	10.7	7.3
30 June	7	43° 05.9′ S	178° 30.0′ E	369	11.0	8.7
1 July	8	43° 41.3′ S	179° 17.9′ E	478	10.7	7.6
3 July	9	44° 10.2′ S	179° 47.9′ E	736	10.3	6.6
4 July	10	43° 45.6′ S	179° 31.7′ W	327	12.0	9.0
5 July	11	44° 22.9′ S	178° 25.9′ W	740	10.5	7.0
7 July	12	44° 06.4′ S	175° 46.4′ W	135	12.1	12.1
7 July	13	44° 08.7′ S	175° 09.2′ W	650	12.2	8.0
8 July	14	43° 54.5′ S	174° 57.3′ W	723	12.2	7.5
8 July	15	43° 35.4′ S	175° 02.1′ W	599	12.2	6.9
8 July	16	43° 30.3′ S	175° 52.6′ W	727	12.1	7.6
8 July	17	43° 32.6′ S	174° 42.9′ W	776	12.5	7.2
9 July	18	43° 39.9′ S	176° 05.3′ W	134	12.0	11.7
9 July	19	43° 26.9′ S	176° 02.0′ W	362	12.2	10.5
9 July	20	43° 02.6′ S	175° 58.0′ W	688	12.2	8.0
11 July	21	43° 33.6′ S	178° 23.4′ W	410	11.3	8.5
12 July	22	42° 52.9′ S	179° 08.2′ W	610	12.5	8.3
13 July	23	43° 08.9′ S	179° 56.1′ W	520	12.7	8.3
14 July	24	42° 51.4′ S	179° 48.8′ E	898	12.4	6.0
14 July	25	43° 05.7′ S	179° 28.3′ E	483	12.2	8.5
14 July	26	43° 05.6′ S	179° 12.5′ E	457	11.7	8.5
15 July	27	42° 48.6′ S	177° 32.1′ E	597	11.5	8.2
16 July	28	42° 47.0′ S	177° 04.9′ E	600	11.8	7.4
17 July	29	43° 20.9′ S	176° 50.8′ E	280	11.4	11.0
17 July	30	43° 47.1′ S	176° 23.6′ E	440	10.2	7.5
18 July	31	43° 22.0′ S	175° 44.1′ E	299	11.2	10.0
19 July	32	43° 36.9′ S	174° 26.8′ E	557	10.6	7.4
19 July	33	43° 32.1′ S	175° 14.0′ E	157	11.2	11.2
20 July	34	43° 08.8′ S	175° 19.0′ E	116	11.1	11.1
21 July	35	43° 18.9′ S	174° 39.4′ E	456	11.0	8.8
22 July	36	43° 01.3′ S	174° 20.6′ E	847	11.0	6.7

Appendix 2

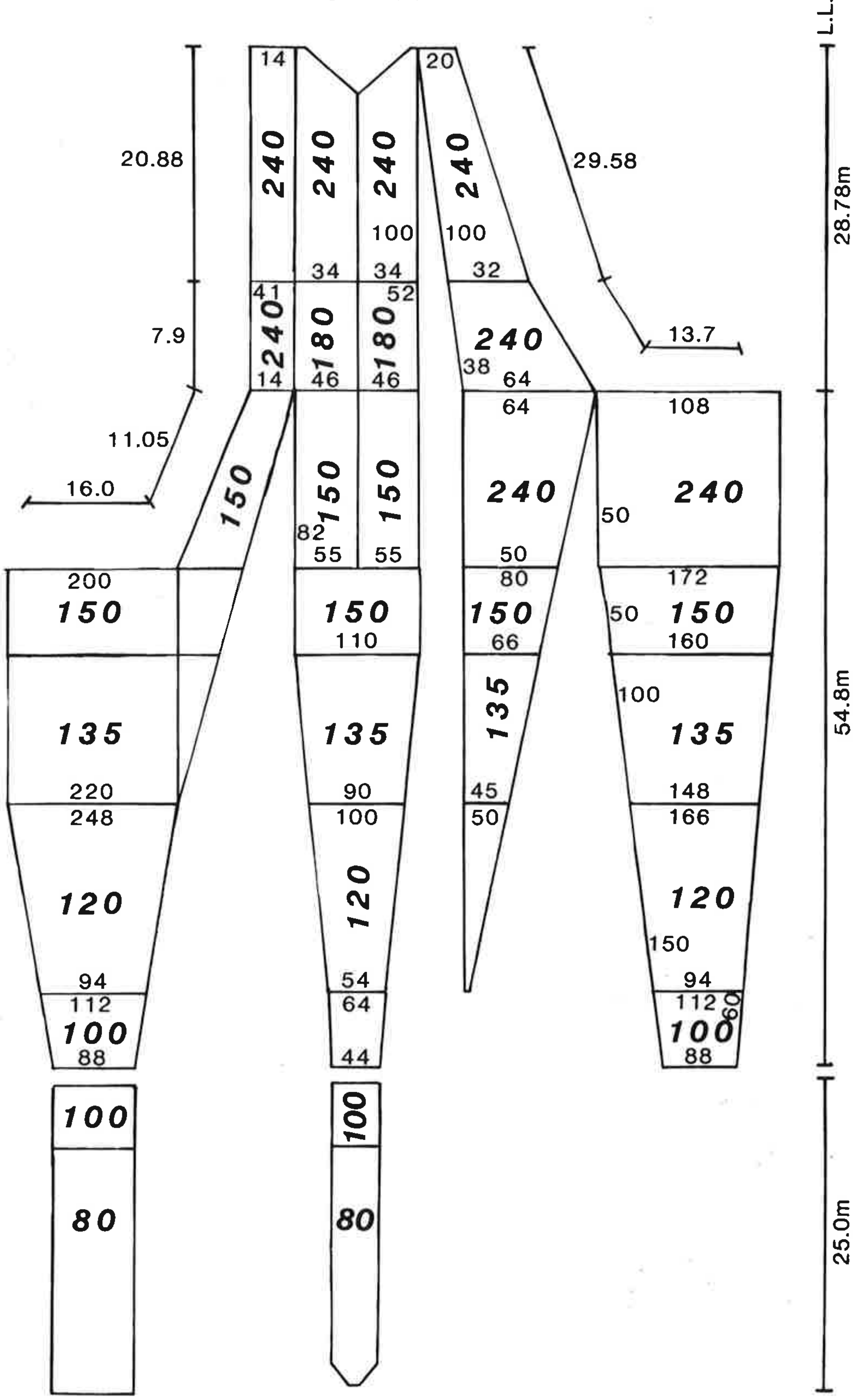
Trawl net plans

Large figures denote mesh size (knot to knot) and small figures denote the number of meshes.

Small net (A)



Large net (B)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Appendix 3

Criteria used for staging gonads (after Pankhurst *et al.* (1987))

Stage	Males	Females
1	Immature or regressed; testis threadlike	Immature or regressed; ovary clear
2	Testis increased in size but no milt expressible	Ovary increased in size; no eggs visible to naked eye
3	Partially spermiated; viscous milt expressible	Ovary opaque white; eggs visible to naked eye
4	Fully spermiated; hydrated free flowing milt	Mature ovary; hyaline oocytes present
5	Spent; testis bloody or grey; no milt expressible	Ovulated; eggs flow freely from abdomen
6	–	Spent; ovary flaccid and bloody; residual eggs sometimes present in oviduct

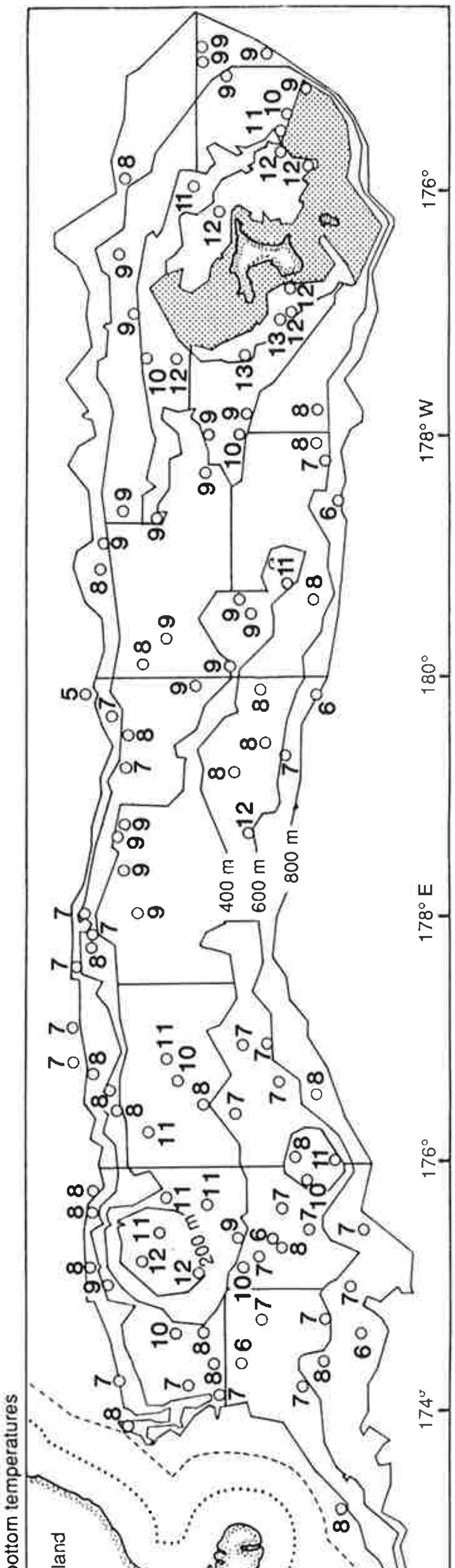
Appendix 4

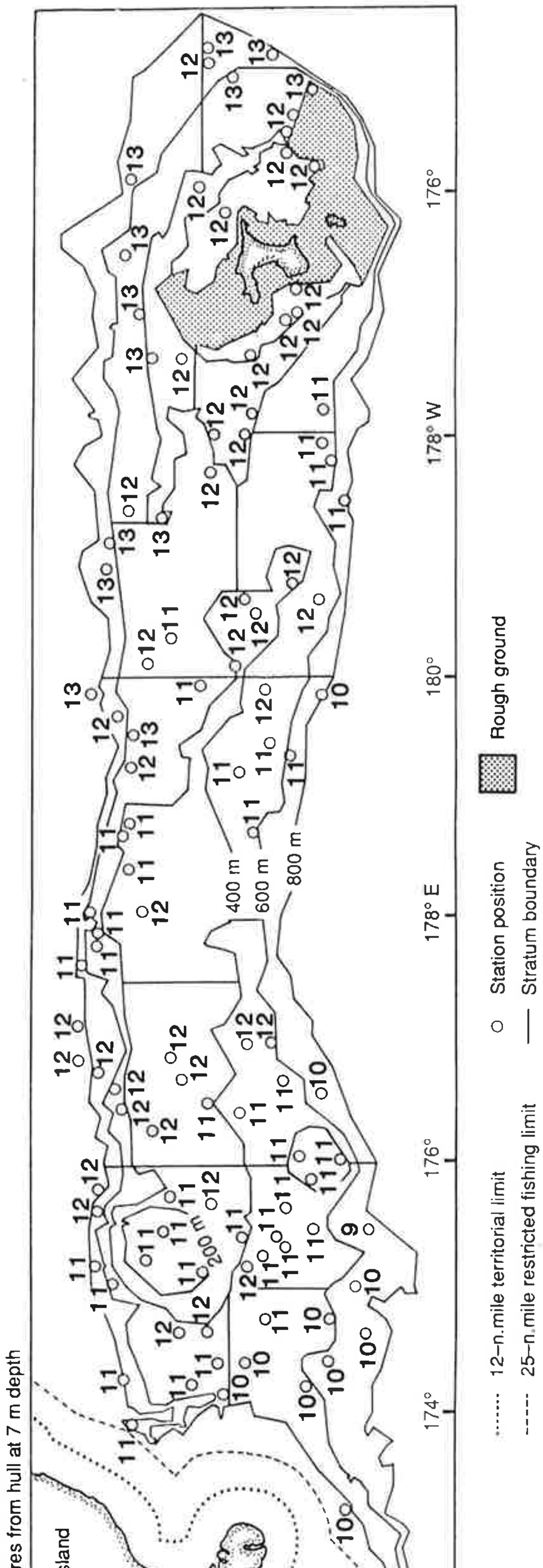
Surface plankton survey station records

Station no.	Date (1986)	Start time	Start position		Tow time (min)	Speed (kn)	Distance towed (n. mile)
			Latitude	Longitude			
1	22 July	2200	43° 13.8′ S	173° 50.0′ E	20	2.7	0.9
2	22 July	2330	43° 15.4′ S	173° 40.0′ E	20	2.5	0.8
3	23 July	0510	43° 23.8′ S	174° 10.6′ E	20	2.2	0.7
4	23 July	0630	43° 15.2′ S	174° 09.8′ E	20	2.1	0.7
5	23 July	0730	43° 15.3′ S	174° 00.0′ E	20	2.5	0.8
6	23 July	0830	43° 05.0′ S	174° 00.0′ E	20	2.5	0.8
7	23 July	0930	43° 05.6′ S	174° 10.0′ E	20	2.5	0.8
8	23 July	1040	42° 55.7′ S	174° 10.0′ E	20	2.5	0.8
9	23 July	1140	42° 54.8′ S	174° 00.4′ E	20	2.5	0.8
10	23 July	1235	42° 55.2′ S	173° 50.7′ E	20	2.5	0.8
11	23 July	1340	42° 55.5′ S	173° 40.6′ E	20	2.5	0.8
12	23 July	1745	43° 04.7′ S	173° 39.1′ E	20	2.2	0.7
13	23 July	1840	43° 04.6′ S	173° 48.0′ E	20	2.2	0.7
14	23 July	2055	43° 24.7′ S	173° 39.1′ E	20	2.5	0.8
15	23 July	2150	43° 24.9′ S	173° 49.4′ E	20	2.5	0.8
16	23 July	2245	43° 23.7′ S	173° 59.6′ E	20	2.5	0.8

Appendix 5

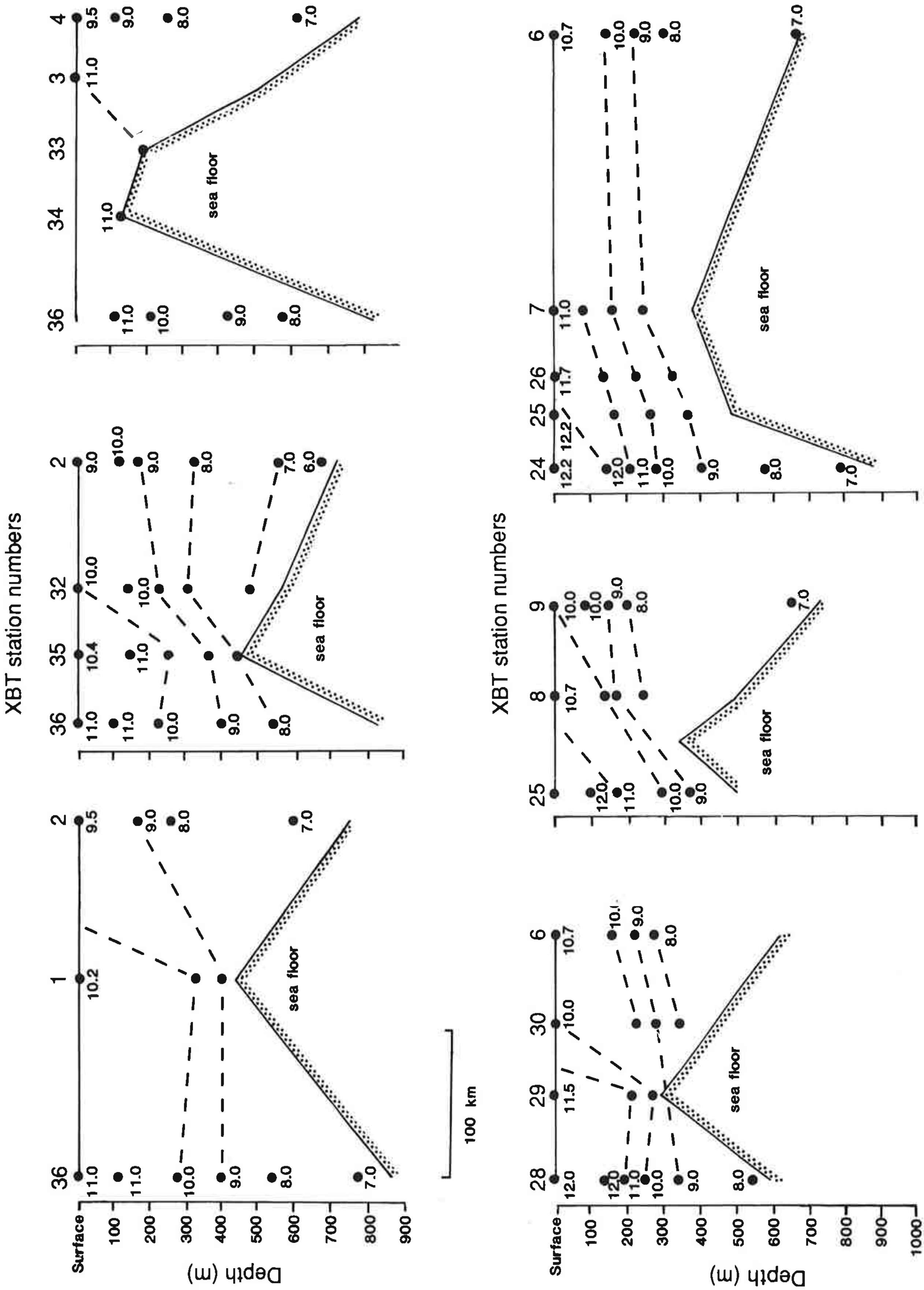
Station temperature readings (°C)





Appendix 6

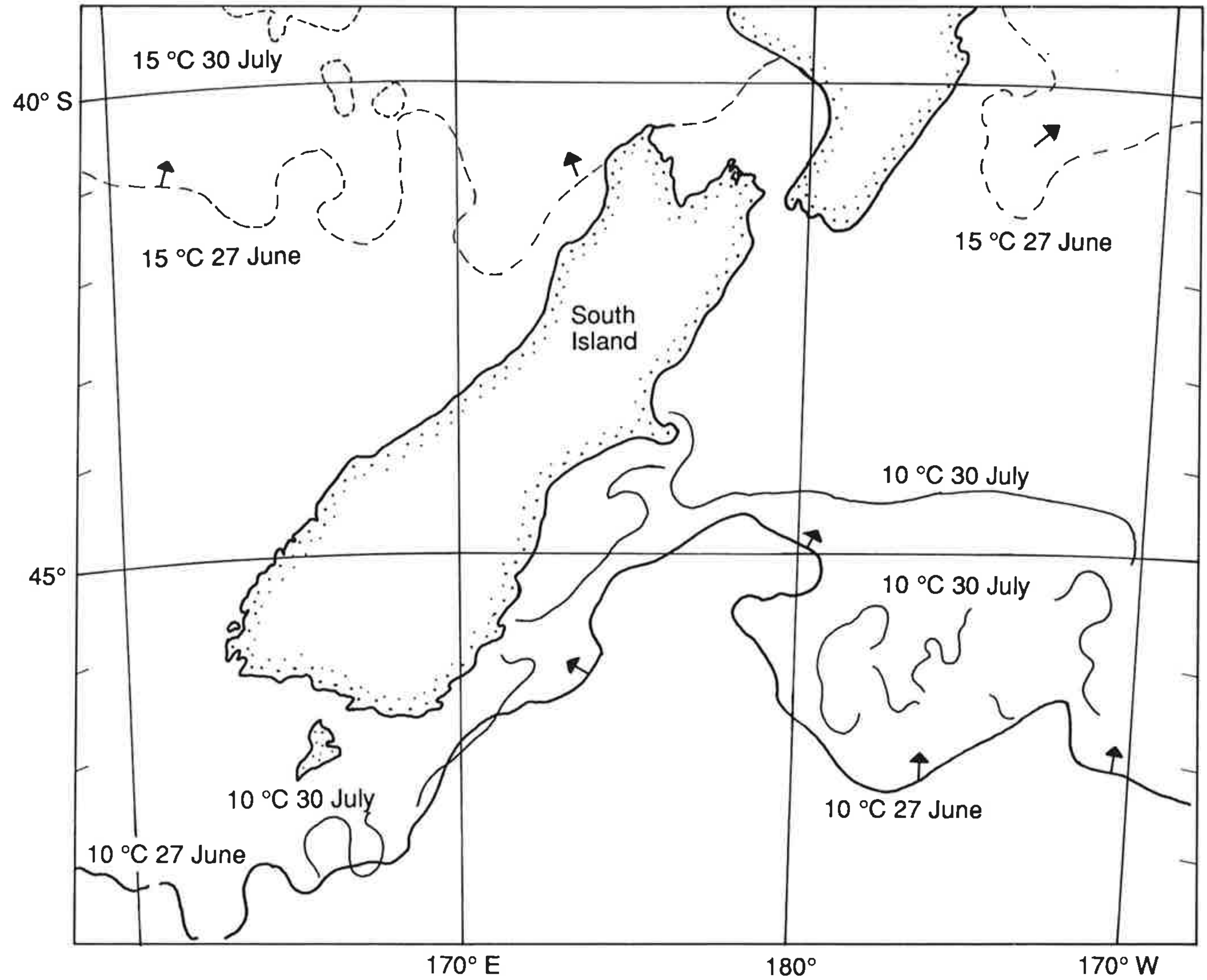
Temperature profiles (°C)



Appendix 7

Isotherms (10 °C and 15 °C) for weeks ending 27 June and 30 July from satellite-derived sea surface temperatures

(Compiled from N.Z. Meteorological Service data)



Appendix 8

Station records, *Shinkai Maru* trawl survey, Chatham Rise, July 1986

Net type, bottom trawl; mesh size, 60 mm; ground rope length, 84.5 m

Station no.	Stratum	Date	Start time	Start position: Latitude	Start position: Longitude	Trawling time (min)	Gear depth (m): Minimum	Gear depth (m): Maximum	Distance between doors (m)	Warp length (m)	Distance between wings (m)	Speed (knots)	Bottom distance trawled (n. mile)	Headline height (m)
1	17B	25 June	0800	44° 24.4′ S	173° 15.0′ E	50	440	445	139	954	30.3	3.8	3.2	6.5
2	17A	25 June	1325	44° 08.3′ S	174° 14.4′ E	50	560	569	154	1 139	33.8	4.0	3.3	5.7
3	6C	25 June	1630	44° 15.4′ S	174° 25.3′ E	50	620	633	145	1 239	31.8	3.5	3.0	6.0
4	6A	26 June	0755	44° 28.5′ S	174° 39.0′ E	70	714	730	154	1 380	33.7	2.8	3.1	6.0
5	6B	26 June	1230	44° 25.0′ S	175° 00.0′ E	60	652	657	145	1 220	31.8	3.6	3.6	6.0
6	17C	26 June	1600	44° 16.1′ S	174° 43.8′ E	60	565	582	154	1 200	33.8	3.3	3.3	6.0
7	16A	27 June	0755	44° 02.0′ S	175° 16.2′ E	55	490	498	146	995	31.9	3.3	3.0	6.0
8	16B	27 June	1035	44° 09.0′ S	175° 27.0′ E	50	550	555	154	1 100	33.8	3.6	3.0	6.0
9*	24C	27 June	1325	44° 08.4′ S	175° 51.7′ E	35	142	250	127	520	27.7	4.1	2.4	7.0
10	24A	27 June	1525	44° 04.3′ S	176° 02.4′ E	65	335	340	159	672	34.8	3.7	4.0	7.0
11	6D	28 June	0740	44° 28.8′ S	175° 26.5′ E	70	730	758	165	1 360	36.1	2.5	3.0	5.5
12*	24B	28 June	1210	44° 18.8′ S	176° 02.0′ E	15	160	160	127	450	27.7	3.2	0.8	7.0
13	5B	28 June	1535	44° 11.8′ S	176° 32.5′ E	75	647	654	155	1 239	33.9	2.8	3.5	5.7
14	15C	29 June	0730	43° 58.5′ S	176° 40.0′ E	70	508	516	164	1 017	35.9	2.8	3.2	5.5
15	15E	29 June	1020	43° 55.0′ S	176° 59.0′ E	55	538	548	156	1 050	34.2	3.6	3.3	5.0
16	15A	29 June	1325	43° 46.2′ S	176° 56.8′ E	60	485	491	152	–	33.3	3.6	3.6	5.5
17	20F	30 June	0815	43° 10.8′ S	178° 05.0′ E	52	361	388	181	980	39.6	3.5	3.0	5.0
18	20I	30 June	1150	43° 04.7′ S	178° 26.1′ E	52	347	368	159	–	34.8	3.5	3.0	5.0
19	20G	30 June	1415	43° 02.7′ S	178° 42.6′ E	50	395	403	186	967	40.7	3.5	2.9	5.5
20	20B	30 June	1605	43° 05.9′ S	178° 49.1′ E	50	378	380	159	–	34.8	3.4	2.8	5.8
21	14C	1 July	0715	43° 50.3′ S	178° 43.3′ E	55	490	494	172	1 200	37.7	3.5	3.2	5.5
22	14B	1 July	1040	43° 42.9′ S	179° 15.0′ E	50	478	480	150	917	32.8	3.6	3.0	6.3
23	14A	1 July	1335	43° 53.8′ S	179° 29.5′ E	50	507	520	152	967	33.2	3.3	2.8	6.0
24	5C	1 July	1555	44° 01.1′ S	179° 22.9′ E	60	615	706	162	1 155	35.4	3.1	2.6	6.0
25	5A	3 July	0740	44° 12.5′ S	179° 51.0′ E	50	746	790	154	1 400	33.7	3.6	3.0	7.0
26	13B	3 July	1120	43° 52.1′ S	179° 53.9′ E	45	416	446	152	850	33.3	4.0	3.0	7.8
27	21A	3 July	1410	43° 40.9′ S	179° 53.6′ W	75	379	488	155	651	34.8	2.6	3.3	8.0
28	13C	4 July	0710	44° 11.4′ S	179° 21.2′ W	50	396	418	159	779	33.3	3.6	3.0	7.0
29	21B	4 July	1000	44° 03.6′ S	179° 14.7′ W	53	278	290	159	529	33.9	2.8	3.0	7.5
30	21C	4 July	1305	43° 49.3′ S	179° 29.4′ W	53	321	328	159	590	34.8	3.7	3.3	7.4
31	10D	4 July	1535	43° 45.0′ S	179° 21.2′ W	65	378	405	159	750	34.8	3.7	4.0	6.9
32	4C	5 July	0710	44° 22.0′ S	178° 32.0′ W	70	768	804	154	1 440	33.7	3.0	3.5	7.2
33	13D	5 July	1030	44° 15.6′ S	178° 13.0′ W	65	534	570	154	1 050	33.8	3.2	3.4	6.0
34	13A	5 July	1240	44° 12.2′ S	178° 04.4′ W	50	508	516	154	940	33.8	3.6	3.0	6.4
35	12C	5 July	1520	44° 11.5′ S	177° 48.2′ W	70	495	506	154	920	33.8	3.4	4.0	6.5
36	26A	6 July	0730	43° 46.8′ S	177° 20.2′ W	60	195	205	130	450	28.5	4.0	4.0	7.0
37	26B	6 July	1025	44° 00.0′ S	177° 02.0′ W	60	156	165	124	389	27.2	4.2	4.2	6.5
38	26C	6 July	1225	44° 03.8′ S	176° 58.5′ W	50	164	165	130	380	28.5	3.4	2.8	6.5
39	26E	6 July	1430	44° 02.6′ S	176° 47.2′ W	35	82	120	122	322	26.8	3.8	2.2	6.5
40	27B	7 July	0700	44° 09.7′ S	175° 46.7′ W	45	134	140	125	330	27.4	4.0	3.0	7.0
41	27A	7 July	0900	44° 00.4′ S	175° 40.2′ W	50	170	228	135	500	29.5	4.0	3.6	6.0
42	12B	7 July	1055	43° 59.6′ S	175° 32.0′ W	50	366	432	154	839	33.7	3.7	3.1	6.0
43	12A	7 July	1305	44° 03.8′ S	175° 22.6′ W	50	440	467	152	845	33.3	2.5	2.1	7.0
44	4A	7 July	1525	44° 07.8′ S	175° 13.6′ W	65	584	655	140	1 120	30.6	3.1	3.4	6.0
45	4D	8 July	0655	43° 52.0′ S	174° 52.0′ W	60	723	740	178	1 350	39.0	3.0	3.0	6.0
46	4E	8 July	1026	43° 40.0′ S	175° 03.0′ W	60	600	602	174	1 089	38.1	3.0	3.0	5.5
47	3D	8 July	1300	43° 42.2′ S	174° 56.6′ W	60	672	726	153	1 200	33.6	3.1	3.1	6.0
48	4B	8 July	1505	43° 31.4′ S	174° 48.7′ W	75	753	774	156	1 339	34.1	3.3	4.1	6.0
49	27C	9 July	0655	43° 31.4′ S	176° 09.4′ W	55	133	134	138	350	30.2	3.6	3.2	7.0
50	23B	9 July	0950	43° 29.0′ S	175° 56.2′ W	75	340	354	175	789	38.3	2.6	3.2	6.0
51	3C	9 July	1410	43° 04.8′ S	175° 53.3′ W	70	680	688	154	1 389	33.7	3.3	3.9	5.8
52	11A	10 July	0650	43° 03.7′ S	176° 29.5′ W	70	532	558	162	1 100	35.5	3.4	4.0	5.6
53	11C	10 July	1025	43° 10.0′ S	176° 59.0′ W	65	399	424	162	839	35.5	3.2	3.4	6.0
54	23E	10 July	1310	43° 12.4′ S	177° 20.6′ W	50	396	410	177	839	38.9	3.6	3.0	5.5
55	23A	10 July	1540	43° 23.4′ S	177° 21.1′ W	50	240	243	156	600	34.3	3.1	2.6	5.7
56	22F	11 July	0710	43° 48.2′ S	177° 48.1′ W	50	372	374	142	839	31.1	3.9	3.3	5.6
57	22C	11 July	0920	43° 45.4′ S	177° 58.5′ W	55	378	378	–	789	–	2.9	3.0	6.0
58	22B	11 July	1205	43° 34.1′ S	177° 58.0′ W	60	368	376	142	800	31.0	3.0	3.0	5.0
59	10C	11 July	1535	43° 33.4′ S	178° 18.6′ W	65	407	424	150	889	32.9	3.0	3.2	5.8
60	23C	12 July	0710	43° 15.6′ S	178° 40.6′ W	45	453	462	–	–	–	4.0	3.0	6.8
61	11B	12 July	0935	43° 03.5′ S	178° 38.2′ W	55	527	530	–	1 017	–	3.2	3.0	6.2
62	3A	12 July	1245	42° 59.5′ S	178° 55.7′ W	55	530	541	–	1 000	–	2.7	2.5	6.2
63	3B	12 July	1525	42° 55.8′ S	179° 05.8′ W	60	563	610	–	1 050	–	3.2	3.2	6.0

* Came fast.
– Not measured.
\# New net.

Appendix 8 *continued*

Station no.	Stratum	Date	Start time	Start position Latitude	Start position Longitude	Trawling time (min)	Gear depth (m) Minimum	Gear depth (m) Maximum	Distance between doors (m)	Warp length (m)	Distance between wings (m)	Speed (knots)	Bottom distance trawled (n. mile)	Headline height (m)
64	9A	13 July	0720	43°29.3′S	179°57.0′E	50	412	422	138	950	30.2	3.7	3.2	6.0
65#	10B	13 July	1125	43°19.5′S	179°38.7′W	70	490	512	127	972	30.7	2.7	3.2	7.0
66#	10A	13 July	1410	43°11.7′S	179°51.6′W	80	521	523	152	1 000	36.9	2.4	3.2	7.5
67#	2D	14 July	0700	42°51.3′S	179°52.6′E	60	893	898	142	1 567	34.3	3.0	3.0	7.5
68#	9E	14 July	1020	43°01.2′S	179°42.7′E	65	528	586	151	1 139	36.4	2.9	3.1	7.0
69#	9D	14 July	1240	43°05.6′S	179°33.2′E	65	482	492	161	1 017	38.9	3.1	3.4	6.5
70#	9C	14 July	1515	43°05.4′S	179°17.4′E	90	440	457	143	939	34.5	2.7	4.0	7.0
71#	9B	15 July	0715	42°50.2′S	178°04.0′E	60	561	576	129	1 167	31.2	3.0	3.0	7.0
72#	8D	15 July	0945	42°55.0′S	177°55.5′E	60	399	410	147	900	35.6	3.6	3.6	7.0
73#	8C	15 July	1210	42°53.2′S	177°48.2′E	60	442	449	153	967	37.0	3.6	3.6	6.5
74#	2C	15 July	1440	42°48.7′S	177°39.1′E	80	606	613	115	1 239	27.9	2.9	3.8	7.0
75	2B	16 July	720	42°47.3′S	177°09.0′E	55	598	602	115	1 240	25.2	3.2	3.0	5.5
76	2A	16 July	0950	42°46.8′S	176°52.1′E	50	598	602	137	1 139	29.5	3.7	3.1	6.0
77	8A	16 July	1205	42°54.0′S	176°46.0′E	65	412	418	133	867	29.2	3.0	3.2	6.5
78	8B	16 July	1415	43°00.2′S	176°38.7′E	50	409	414	142	900	31.1	3.6	3.0	6.5
79	19A	16 July	1610	43°03.5′S	176°27.8′E	65	402	410	163	889	35.7	3.2	3.5	6.0
80	19C	17 July	0700	43°14.4′S	176°17.8′E	60	235	253	168	639	36.7	3.2	3.2	6.0
81	19E	17 July	0855	43°20.0′S	176°54.6′E	45	284	290	151	689	33.0	4.0	3.0	6.0
82	19D	17 July	1050	43°23.5′S	176°43.3′E	45	256	260	148	650	32.3	4.0	3.0	6.5
83	19B	17 July	1330	43°34.9′S	176°29.7′E	60	395	403	142	900	31.1	3.6	3.6	6.0
84	15X	17 July	1540	43°43.5′S	176°25.5′E	60	422	440	142	1 000	31.1	3.1	3.1	7.1
85	18C	18 July	0720	43°18.5′S	175°44.5′E	60	299	317	152	717	73.2	3.6	3.6	5.7
86	18B	18 July	0950	43°34.0′S	175°40.0′E	50	270	280	151	650	33.0	3.4	3.0	6.0
87	18A	18 July	1220	43°44.6′S	175°24.4′E	45	368	420	–	800	–	3.5	2.6	7.0
88	16C	18 July	1435	43°45.9′S	175°11.2′E	90	423	429	140	989	31.9	2.6	3.9	5.7
89	7C	19 July	0740	43°35.5′S	174°23.4′E	70	557	562	150	1 200	32.9	2.5	3.0	6.0
90	7B	19 July	1200	43°32.8′S	174°39.0′E	65	444	460	152	950	33.2	3.3	3.6	6.0
91	25E	19 July	1610	43°31.6′S	175°09.6′E	65	155	167	121	405	26.5	3.2	3.4	8.0
92	25C	20 July	0720	43°10.7′S	175°13.8′E	45	116	130	127	439	27.7	4.0	3.0	8.0
93	25A	20 July	0935	43°16.0′S	175°27.6′E	40	95	109	114	350	24.9	3.5	2.3	7.5
94	1D	20 July	1330	42°54.7′S	175°47.0′E	75	609	613	141	1 350	30.8	3.0	3.8	5.5
95	1B	20 July	1600	42°52.0′S	175°37.7′E	75	660	671	–	1 470	–	3.1	3.9	6.0
96	7W	21 July	0710	43°22.5′S	174°38.3′E	55	443	452	166	989	36.2	3.5	3.2	5.5
97	7Q	21 July	1110	42°59.7′S	175°02.3′E	70	495	500	154	1 050	33.6	2.6	3.0	6.3
98	1A	21 July	1335	42°52.6′S	175°12.2′E	85	690	703	122	1 472	26.7	2.8	3.9	6.0
99	7A	22 July	0750	43°26.3′S	174°11.9′E	60	567	579	137	1 220	30.1	3.4	3.4	5.1
00	1E	22 July	1210	43°06.3′S	173°55.1′E	45	664	684	160	1 350	31.8	3.5	2.6	6.5
01	1C	22 July	1505	43°03.2′S	174°14.6′E	70	789	799	117	1 600	25.6	2.7	3.1	5.5
02	7G	24 July	0810	43°38.0′S	174°08.2′E	70	468	476	146	1 067	31.9	3.1	3.6	6.0
03	17W	24 July	1100	43°46.1′S	174°23.3′E	45	558	562	133	1 239	29.2	3.2	2.4	6.0
04	17X	24 July	1340	43°52.6′S	174°43.2′E	70	495	500	146	1 122	29.8	3.2	3.8	6.0
05	16R	25 July	0725	43°51.6′S	175°14.4′E	70	444	464	168	950	36.9	2.8	3.3	6.5
06	16V	25 July	0945	44°00.4′S	175°18.2′E	60	478	496	160	1 039	35.0	3.4	3.4	7.0
07	16E	25 July	1230	44°00.4′S	175°36.9′E	70	514	560	180	1 139	39.5	3.0	3.5	6.5

* Came fast.
– Not measured.
New net.

Appendix 9

Species caught, total weight, and occurrence at trawl stations

(Maximum depth trawled 850 m)

Common name	Species code	Scientific name	Total catch (kg)	% of catch by weight	Mean catch rate (kg.km⁻¹)	Occurrence in 107 trawls
Hoki	HOK	*Macruronus novaezelandiae*	270 534.0	54.9	409.2	92
Rattails	RAT	(see below)	43 783.7	8.5	64.6	83
Javelinfish	JAV	*Lepidorhynchus denticulatus*	37 282.7	7.6	57.0	91
Silver warehou	SWA	*Seriolella punctata*	15 075.1	3.1	22.8	82
Ling	LIN	*Genypterus blacodes*	13 448.7	2.7	20.8	99
Barracouta	BAR	*Thyrsites atun*	13 358.2	2.7	19.9	18
Alfonsino	BYX	*Beryx splendens*	10 813.3	2.2	16.1	39
Pale ghost shark	GSP	*Hydrolagus* sp.	10 596.5	2.1	16.5	69
Dark ghost shark	GSH	*Hydrolagus novaezelandiae*	9 245.2	1.9	13.9	31
Sea perch	SPE	*Helicolenus* sp.	7 194.4	1.5	11.1	85
Hake	HAK	*Merluccius australis*	5 528.9	1.1	8.5	70
Lookdown dory	LDO	*Cyttus traversi*	5 198.2	1.1	8.2	87
Spiny dogfish	SPD	*Squalus acanthias*	4 637.4	0.9	7.2	62
Giant stargazer	GIZ	*Kathetostoma giganteum*	4 469.4	0.9	6.9	85
Shovelnosed dogfish	SND	*Deania calcea*	4 100.6	0.8	6.2	46
Black oreo	BOE	*Allocyttus niger*	3 772.7	0.8	6.2	11
Spiky oreo	SOR	*Neocyttus rhomboidalis*	3 449.9	0.7	5.5	22
White warehou	WWA	*Seriolella caerulea*	2 514.2	0.5	4.1	68
Ribaldo	RIB	*Mora moro*	2 494.1	0.5	4.0	46
Tarakihi	TAR	*Nemadactylus macropterus*	1 887.1	0.4	3.2	11
Silverside	SSI	*Argentina elongata*	1 753.7	0.4	1.7	66
Arrow squid	ASQ	*Nototodarus sloanii*	1 502.7	0.3	2.3	80
Bellowsfish	BEL	*Centriscops obliquus*	1 350.7	0.3	2.0	42
Orange roughy	ORH	*Hoplostethus atlanticus*	1 285.9	0.3	2.1	8
School shark	SCH	*Galeorhinus australis*	1 233.8	0.3	2.0	32
Deepsea shark	CYP	*Centroscymnus crepidater*	895.8	0.2	1.5	10
Hapuku	HAP	*Polyprion oxygeneios*	853.2	0.2	1.3	22
Spineback	SBK	*Notacanthus sexpinis*	826.6	0.2	1.5	37
Long nose chimaera	LCH	*Harriotta raleighana*	768.3	0.2	1.2	40
Hairy conger eel	HCO	*Bassango hirsutus*	677.1	0.2	1.0	56
Smooth oreo	SSO	*Pseudocyttus maculatus*	645.8	0.1	1.0	12
Bluenose	BNS	*Hyperoglyphe antarctica*	649.6	0.1	1.1	19
Redbait	RBT	*Emmelichthys nitidus*	603.5	0.1	1.1	13
Warty squid	WSQ	*Moroteuthis ingens*	587.5	0.1	<1.0	48
Red cod	RCO	*Pseudophycis bachus*	546.8	0.1	<1.0	15
Silver dory	SDO	*Cyttus novaezelandiae*	483.8	<0.1	<1.0	14
Baxter's dogfish	ETB	*Etmopterus baxteri*	411.8	<0.1	<1.0	14
Deepsea cardinalfish	EPT	*Epigonus telescopus*	411.8	<0.1	<1.0	17
Orange perch	OPE	*Lepidoperca pulchella*	373.3	<0.1	<1.0	5
Plunket shark	PLS	*Centroscymnus plunketi*	286.3	<0.1	<1.0	18
Swollen conger eel	SCO	*Bassanago bubiceps*	178.6	<0.1	<1.0	7
Seal shark	BSH	*Dalatias licha*	257.7	<0.1	<1.0	16
Northern spiny dogfish	NSD	*Squalus blainvillei*	218.2	<0.1	<1.0	5
Jack mackerel	JMA	*Trachurus declivis*	217.7	<0.1	<1.0	17
Small eye cardinalfish	EPR	*Epigonus robustus*	211.1	<0.1	<1.0	15
Scampi	SCI	*Metanephrops challengeri*	193.5	<0.1	<1.0	32
Gurnard	GUR	*Chelidonichthys kumu*	182.8	<0.1	<1.0	6
Smooth skate	SSK	*Raja innominata*	969.4	0.2	<1.0	44
Owston's spiny dogfish	CYO	*Centroscymnus owstoni*	169.9	<0.1	<1.0	4
Rough skate	RSK	*Raja nasuta*	147.5	<0.1	<1.0	5
Octopus	OCT	*Octopus maorum*	142.0	<0.1	<1.0	16
Lemon sole	LSO	*Pelotretis flavilatus*	141.2	<0.1	<1.0	11
Dark toadfish	TOD	*Neophrynichthys latus*	140.1	<0.1	<1.0	20
Deepsea flathead	FHD	*Hoplichthys haswelli*	137.3	<0.1	<1.0	31
Black slickhead	BSL	*Xenodermichthys* sp.	127.3	<0.1	<1.0	3
Johnson's cod	JCO	*Halargyreus johnsonii*	125.6	<0.1	<1.0	12
Rudderfish	RUD	*Centrolophus niger*	122.4	<0.1	<1.0	11
Basketwork eel	BEE	*Diastobranchus capensis*	118.4	<0.1	<1.0	3
Common warehou	WAR	*Seriolella brama*	115.0	<0.1	1.0	2
Witch	WIT	*Arnoglossus scapha*	110.5	<0.1	<1.0	17
Lucifer dogfish	ETL	*Etmopterus lucifer*	106.4	<0.1	<1.0	30
Deepsea dogfish	CSQ	*Centrophorus squamosus*	104.6	<0.1	<1.0	6
Deepsea skate	RTH	*Bathyraja asperula*	104.9	<0.1	<1.0	16
Frostfish	FRO	*Lepidopus caudatus*	103.9	<0.1	<1.0	7
Todarodes squid	TSQ	*Todarodes* sp.	101.1	<0.1	<1.0	35
Stingray	STR	*Dasyatis brevicaudatus*	100.0	<0.1	<1.0	1
Blue cod	BCO	*Parapercis colias*	87.6	<0.1	1.0	3
Ray's bream	RBM	*Brama brama*	83.8	<0.1	<1.0	13

Appendix 9 *continued*

Common name	Species code	Scientific name	Total catch (kg)	% of catch by weight	Mean catch rate (kg.km^{-1})	Occurrence in 107 trawls
Scaley gurnard	SCG	*Lepidotrigla brachyoptera*	80.4	<0.1	<1.0	11
Small headed cod	SMC	*Lepidion microcephalus*	79.9	0.2	<1.0	6
Blue moki	MOK	*Latridopsis ciliaris*	67.0	<0.1	<1.0	1
Giant chimaera	CHG	*Chimaera phantasma*	59.0	<0.1	<1.0	2
Trumpeter	TRU	*Latris lineata*	55.0	<0.1	<1.0	4
Gemfish	SKI	*Rexea solandri*	53.7	<0.1	<1.0	2
Conger eel	CON	*Conger verreauxi*	47.8	<0.1	<1.0	2
Widenose chimaera	RCH	*Rhinochimaera pacifica*	47.0	<0.1	<1.0	1
Prickly dogfish	PDG	*Oxynotus bruniensis*	38.5	<0.1	<1.0	13
Carpet shark	CAR	*Cephaloscyllium isabella*	35.8	<0.1	<1.0	8
Southern blue whiting	SBW	*Micromesistius australis*	34.9	<0.1	<1.0	4
Pale toadfish	TOP	*Neophrynichthys angustus*	32.7	<0.1	<1.0	8
Deepwater octopus	DWO	*Amphitretus* sp.	32.1	<0.1	<1.0	7
Finless flounder	MAN	*Mancopsetta milfordi*	30.2	<0.1	<1.0	8
Deepsea catshark	APR	*Apristurus macrorhynchus*	25.0	<0.1	<1.0	4
Large scale slickhead	SBI	*Alepocephalus* sp.	21.7	<0.1	<1.0	2
Six gill shark	HEX	*Hexanchus griseus*	16.3	<0.1	<1.0	3
Silver roughy	SRH	*Hoplostethus mediterraneus*	14.6	<0.1	<1.0	17
Capro dory	CDO	*Capromimus abbreviatus*	13.7	<0.1	<1.0	0
Electric ray	ERA	*Torpedo fairchildi*	12.9	<0.1	<1.0	2
Halosaur	HPE	*Halosaurus pectoralis*	12.3	<0.1	<1.0	4
Southern boarfish	SBO	*Pseudopentaceres richardsoni*	9.8	<0.1	<1.0	3
Frill shark	FRS	*Chlamydoselache anguineus*	8.8	<0.1	<1.0	1
Hagfish	HAG	*Eptatretus cirrhatus*	8.6	<0.1	<1.0	4
Rubyfish	RBY	*Plagiogeneion rubiginosus*	4.4	<0.1	<1.0	6
Blind electric ray	BER	*Typhlonarke* sp.	6.8	<0.1	<1.0	7
Big scale pomfret	BSP	*Taractichthys longipinnis*	4.8	<0.1	<1.0	1
Blue mackerel	EMA	*Scomber australasicus*	2.0	<0.1	<1.0	1
Yellow cod	YCO	*Parapercis gilliesi*	1.0	<0.1	<1.0	1
Common roughy	RHY	*Paratrachichthys trailli*	0.9	<0.1	<1.0	2
Grenadier cod	GRC	*Tripterophycis gilchristi*	4.4	<0.1	<1.0	5
Bastard red cod	BRC	*Pseudophycis breviusculus*	0.5	<0.1	<1.0	4
Alert pigfish	API	*Alertichthys blacki*	0.7	<0.1	<1.0	4
Dawson's catshark	DCS	*Halaelurus dawsoni*	0.7	<0.1	<1.0	4
Prickly deepsea skate	BTS	*Bathyraja spinifera*	0.2	<0.1	<1.0	1
Lanternfish	LAN	Myctophidae	0.1	<0.1	<1.0	1
Snake eel	OSE	*Ophisurus serpens*	0.1	<0.1	<1.0	1
Snipefish	SNI	*Macrorhamphosus scolopax*	0.1	<0.1	<1.0	1
		Total catch	490 567.1			

Rattails includes:

Coelorinchus bollonsi
C. aspercephalus
C. fasciatus
C. matamua
C. oliverianus
C. innotabilis
C. species C
C. species D
C. species M

Trachyrhincus longirostris
Macrourus carinatus
Coryphaenoides subserrulatus
C. barbel = species B

(*C.* species C, *C.* species D, *C.* species M: *see* McMillan (1985))

Appendix 10

Fish species identified from hoki stomach contents

Family	Species	Family	Species
Serrivomeridae	*Serrivomer samoensis*	Myctophidae	*D. hudsoni*
Nemichthyidae	*Nemichthys scolopaceus*	Myctophidae	*D. danae*
Searsiidae	*Persparsia kopua*	Myctophidae	*Lampanyctodes hectoris*
Gonostomatidae	*Woodsia meyerwaardeni*	Myctophidae	*Lampadena notialis*
Photichthyidae	*Photichthys argenteus*	Myctophidae	*Lampanyctus achirus*
Sternoptychidae	*Argyropelecus aculeatus*	Myctophidae	*L. festivus*
Sternoptychidae	*Maurolicus muelleri*	Myctophidae	*L. mendeleevi*
Malacosteidae	*Malacosteus* sp.	Myctophidae	*L. australis*
Chauliodontidae	*Chauliodus sloani*	Myctophidae	*L. lepidolychnus*
Scopelosauridae	*Scopelosaurus* sp.	Myctophidae	*L. intracarius*
Myctophidae	*Protomyctophum normani*	Myctophidae	*Gymnoscopelus piabilis*
Myctophidae	*Electrona carlsbergi*	Myctophidae	*Lampichthys procerus*
Myctophidae	*E. ventralis*	Myctophidae	*Hintonia candens*
Myctophidae	*E. paucirastra*	Merlucciidae	*Macruronus novaezelandiae*
Myctophidae	*Symbolophorus* sp. B.	Macrouridae	*Coelorinchus oliverianus*
Myctophidae	*S.* sp. C	Oreosomatidae	*Pseudocyttus maculatus* (?)
Myctophidae	*Diaphus ostenfeldi*	Hoplichthyidae	*Hoplichthys haswelli*

Appendix 11

Biomass estimates (t) per stratum of 27 fish species

Stratum	Depth (m)	HOK	LIN	SWA	BYX	BAR	LDO	HAK	GIZ	WWA	SCH	ASQ	HAP	BNS	SOR	BOE
1	600–800	17 488	918	87	5	0	383	1 438	134	39	0	28	0	13	444	3
2	600–800	51 635	2 372	233	115	0	631	4 870	617	289	0	157	0	0	2 800	0
3	600–800	15 507	2 418	69	2 313	0	1 527	6 604	181	1 750	0	71	0	310	14 893	0
4	600–800	5 849	723	15	0	0	678	1 015	208	3 669	0	9	0	25	3 665	1 377
5	600–800	22 050	1 872	27	0	0	323	959	144	40	0	20	0	0	0	10 294
6	600–800	58 371	4 078	67	0	0	130	2 214	173	406	0	47	0	0	0	23 250
Total		170 900	12 381	498	2 433	0	3 672	17 100	1 457	6 193	0	332	0	348	2 182	34 924
7	400–600	376 521	6 634	24 723	49	0	1 411	1 585	173	1 760	169	360	0	176	0	0
8	400–600	32 796	1 575	6 439	114	0	297	190	103	16	132	87	131	24	0	0
9	400–600	34 235	6 209	1 320	26 689	0	2 307	5 527	213	921	155	111	118	213	3 608	0
10	400–600	52 687	4 222	821	1 161	0	2 585	1 383	600	3 515	385	310	0	0	0	0
11	400–600	15 843	3 667	6 030	39 880	0	1 313	2 640	654	389	0	298	1 852	2 809	0	0
12	400–600	17 439	2 977	595	2 081	0	5 072	208	449	4	309	342	0	1 365	0	0
13	400–600	38 831	6 846	2 852	2	0	4 944	720	614	201	201	150	0	0	0	2
14	400–600	33 099	2 486	1 092	0	0	2 895	471	104	128	0	88	0	0	0	0
15	400–600	159 242	4 352	5 868	44	0	1 623	605	702	159	0	13	96	0	0	2
16	400–600	141 778	4 366	2 798	2	0	1 180	1 089	786	349	75	195	0	0	0	0
17	400–600	103 235	3 406	1 503	0	0	2 334	1 521	837	574	103	232	0	0	0	0
Total		1 005 706	46 740	53 859	70 022	0	25 961	15 939	5 315	8 016	1 426	2 186	2 197	4 587	3 608	4
18	200–400	44 345	3 932	1 680	2	201	671	32	9 510	57	752	614	290	0	0	0
19	200–400	38 402	3 790	13 042	23	2 332	2 527	399	2 299	238	3 086	1 034	290	144	0	0
20	200–400	73 299	10 487	1 938	190	0	2 373	213	5 199	1 169	762	359	0	0	0	0
21	200–400	4 849	394	1 339	364	23	634	0	233	239	0	411	0	0	0	0
22	200–400	16 358	3 553	1 072	2 336	0	2 075	89	851	1 099	612	440	82	59	0	0
23	200–400	61 031	1 516	510	138	148	992	38	1 284	145	276	867	42	671	0	0
Total		238 284	23 672	19 581	3 053	2 704	9 272	771	19 376	2 947	5 488	3 725	624	874	0	0
25	50–200	0	113	0	0	5 571	0	0	2 146	0	931	82	643	0	0	0
26	50–200	0	200	2	0	19 038	0	0	1 004	0	0	984	117	0	0	0
27	50–200	0	2 208	7	0	30 554	0	0	1 795	0	1 612	579	242	0	0	0
Total			2 521	9	0	55 163	0	0	4 945	0	2 543	1 645	1 002	0	0	0

Species codes: HOK hoki, LIN ling, SWA silver warehou, BYX alfonsino, BAR barracouta, LDO lookdown dory, HAK hake, GIZ giant stargazer, WWA white warehou, SCH school shark, ASQ arrow squid, HAP hapuku, BNS bluenose, SOR spiky oreo, BOE black oreo.

Appendix 11 *continued*

Stratum	Depth (m)	RAT	JAV	GSP	GSH	SPE	SPD	SND	RIB	SSI	BEZ	TAR	ORH
1	600–800	4 512	3 437	2 252	0	283	0	3 208	619	0	133	0	216
2	600–800	11 322	18 461	2 135	0	1 711	0	3 724	1 427	0	398	0	4 863
3	600–800	6 071	7 540	1 857	0	1 620	0	1 381	1 364	17	175	0	0
4	600–800	4 547	4 556	1 600	0	305	120	3 176	1 427	0	225	0	647
5	600–800	7 023	3 567	7 131	33	558	15	244	1 364	0	0	0	29
6	600–800	10 027	5 801	11 373	0	251	0	2 190	398	4	0	0	0
Total		43 502	43 362	26 348	33	4 728	135	13 923	6 599	21	931	0	5 755
7	400–600	23 222	16 125	3 341	0	1 321	403	857	171	245	121	0	0
8	400–600	4 064	6 060	277	75	2 988	365	0	1 505	60	294	0	0
9	400–600	21 350	14 032	2 096	0	3 818	238	1 143	339	454	1 053	0	0
10	400–600	5 057	7 118	1 125	3 831	2 348	571	41	7	1 206	5 812	0	0
11	400–600	2 832	10 373	501	12	1 139	0	0	7 387	319	1 188	0	0
12	400–600	2 287	21 083	1 344	194	508	796	0	110	126	0	0	0
13	400–600	8 412	15 785	7 612	0	3 920	1 448	312	336	307	249	0	0
14	400–600	1 726	742	5 505	0	3 095	473	55	10	365	246	0	0
15	400–600	16 386	6 697	7 568	0	2 651	697	393	329	1 493	0	0	0
16	400–600	26 069	15 860	5 193	408	1 304	1 401	639	248	749	0	0	0
17	400–600	62 120	32 929	8 808	0	640	1 505	1 676	166	419	1	0	0
Total		173 525	146 804	43 370	4 520	23 732	7 897	5 116	10 606	5 743	8 964	0	0
18	200–400	10 853	10 712	0	16 022	846	3 769	0	159	1 624	0	0	0
19	200–400	517	11 447	0	11 145	5 646	7 086	0	228	1 402	207	15	0
20	200–400	13 002	7 641	978	6 288	11 135	898	0	0	1 175	0	0	0
21	200–400	562	421	29	2 047	453	1 536	0	0	144	40	0	0
22	200–400	0	5 937	0	8 782	618	1 618	0	0	2 178	0	0	0
23	200–400	488	2 643	0	438	199	1 251	67	0	376	227	23	0
Total		25 442	38 801	1 007	44 722	18 715	16 158	67	387	6 899	474	38	0
25	200–400	0	0	0	958	14	837	0	0	34	0	1 659	0
26	200–400	0	0	0	47	0	645	0	0	0	0	2 966	0
27	200–400	0	0	0	0	12	2 542	0	0	17	0	4 651	0
Total		0	0	0	1 005	26	4 024	0	0	51	0	9 276	0

Species codes: RAT rattails (excl. JAV), JAV javelinfish, GSP pale ghost shark, GSH dark ghost shark, SPE sea perch, SPD spiny dogfish, SND shovelnosed dogfish, RIB ribaldo, SSI silverside, BEZ bellowsfish, TAR tarakihi, ORH orange roughy.

Appendix 12

Density (kg.km^{-2}) per stratum of some commercially important species

Stratum	Depth (m)	HOK	LIN	SWA	BYX	BAR	LDO	HAK	GIZ	WWA	SCH	ASQ	HAP	BNS	SOR	BOE
1	600–800	270.6	14.2	1.3	0.1	0	5.9	22.3	2.1	0.6	0	0.4	0	0.2	6.9	0
2	600–800	22.3	22.3	2.2	1.1	0	5.9	45.9	5.8	2.7	0	1.5	0	0	26.4	0
3	600–800	58.4	9.1	0.3	8.7	0	5.7	24.9	0.7	6.6	0	0.3	0	1.2	56.1	0
4	600–800	36.6	4.5	0.1	0	0	4.2	6.4	1.3	23.0	0	0.1	0	0.2	22.9	8.6
5	600–800	133.6	11.3	0.2	0	0	2.0	5.8	0.9	0.2	0	0.1	0	0	0	62.4
6	600–800	254.4	17.8	0.3	0	0	0.6	9.6	0.8	1.8	0	0.2	0	0	0	101.3
7	400–600	2 470.7	43.5	162.2	0.3	0	9.3	10.4	1.1	11.5	1.1	2.4	0	1.2	0	0
8	400–600	591.1	28.4	116.1	2.0	0	5.4	3.4	1.9	0.3	2.4	1.6	2.4	0.4	0	0
9	400–600	218.0	39.5	8.4	170.0	0	14.7	35.2	1.4	5.9	1.0	0.7	0.8	1.4	23.0	0
10	400–600	184.2	14.8	2.9	4.1	0	9.0	4.8	2.4	12.3	1.3	1.1	0	0	0	0
11	400–600	76.4	17.7	29.1	192.4	0	6.3	12.7	3.2	1.9	0	1.4	8.9	13.6	0	0
12	400–600	78.5	13.4	2.7	9.4	0	22.8	0.9	2.0	0	1.4	1.5	0	0	0	0
13	400–600	169.5	29.9	12.5	0	0	21.6	3.1	2.7	0.9	0.9	0.7	0	0	0	0
14	400–600	194.1	14.6	6.4	0	0	17.0	2.8	0.6	0.7	0	0.5	0	0	0	0
15	400–600	921.6	25.2	32.9	0.3	0	9.4	3.5	4.1	0.9	0	0.1	0.6	0	0	0
16	400–600	1 011.3	31.1	20.0	0	0	8.4	7.8	5.6	2.5	0.5	1.4	0	0	0	0
17	400–600	492.4	16.2	7.2	0	0	11.1	7.3	4.0	2.7	0.5	1.1	0	0	0	0
18	200–400	315.4	28.0	11.9	0	1.4	4.8	0.2	67.6	0.4	5.4	4.4	2.1	0	0	0
19	200–400	155.5	15.4	52.8	0.1	9.4	10.2	1.6	9.3	1.0	12.5	4.2	6.8	6.6	0	0
20	200–400	245.8	35.2	6.5	0.6	0	8.0	0.7	17.4	3.9	2.6	1.2	0	0	0	0
21	200–400	63.2	5.1	17.5	4.7	0.3	8.3	0	3.0	3.1	0	5.4	0	0	0	0
22	200–400	137.1	29.8	9.0	19.6	0	17.4	0.7	7.1	9.2	5.1	3.7	0.7	0.5	0	0
23	200–400	416.8	10.4	3.5	0.9	1.0	6.8	0.3	8.8	1.0	1.9	5.9	0.3	4.6	0	0
25	50–200	0	1.5	0	0	71.6	0	0	27.6	0	12.0	1.1	8.3	0	0	0
26	50–200	0	3.7	0	0	351.6	0	0	18.5	0	0	18.2	2.2	0	0	0
27	50–200	0	19.5	0.1	0	270.2	0	0	15.9	0	14.3	5.1	19.6	0	0	0

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