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New Zealand Fisheries
Technical Report No. 12
ISSN 0113-2180
1989

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New Zealand Fisheries
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Published by MAFFish
Wellington
1989

ISBN 0-477-08081-2

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Fisheries Research Centre,
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Wellington,
New Zealand.

Edited by S. J. Baird and G. G. Baird

Set in 10 on 11 English Times

Typesetting by Industrial Art and Communication Ltd.

Printed by Thames Publications Ltd.

Cover: *Shinkai Maru*.

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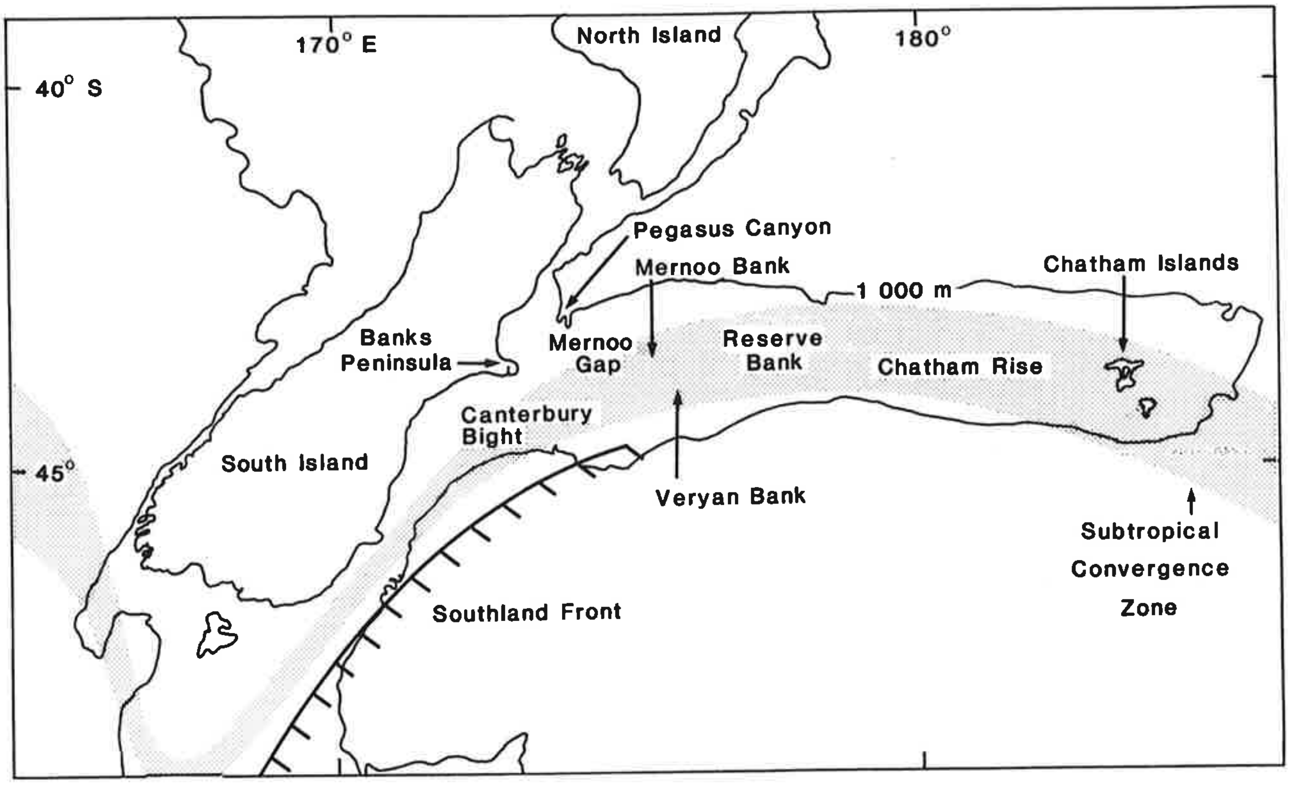


Figure 1: Hydrological features and place names mentioned in the text.

Abstract

Fenaughty, J. M. and Uozumi, Y. 1989: A survey of demersal fish stocks on the Chatham Rise, New Zealand, March 1983. *N.Z. Fisheries Technical Report No. 12*. 42 p.

The Japanese research vessel *Shinkai Maru* carried out a random trawl survey of the Chatham Rise off the east coast of the South Island, New Zealand, in March 1983. Catches from the 127 trawls in depths of 87–809 m were used to calculate biomass indices for the main catch components. Biological and size-frequency data were collected for the major catch species. Hoki were the most common fish taken during the survey and occurred in most trawls over 200 m. A biomass index of 1 772 000 t of hoki was calculated for the entire survey area. A correlation was found between the size of hoki and the depth of water; size increased with depth.

Introduction

The Chatham Rise is a broad plateau between 42° 30′ and 45° 00′ S which extends some 540 n. miles east of Banks Peninsula (Figure 1). The plateau varies between 200 and 600 m along its central axis and interrupts the north-south flow of major water masses. It also influences the position of the Subtropical Convergence Zone which lies along its axis for most of the year. The mixing of water masses along the Chatham Rise and the upwelling which occurs in the Mernoo Gap (which separates the Chatham Rise from the South Island continental shelf) may benefit primary planktonic production along this plateau. The convergence is a zone of pronounced faunal change and affects the distribution of several nektonic groups which are abundant along the Chatham Rise (Robertson *et al.* 1978, Robertson and Mito 1979). The mesopelagic faunas found here are major items in the diet of hoki (*Macruronus novaezelandiae*) and many other commercial fish species.

Before 1960 domestic vessels fished here sporadically, mainly around the Mernoo Bank for groper (which included hapuku (*Polyprion oxygeneios*), bass groper (*P. moeone*), and bluenose (*Hyperoglyphe antarctica*)), and near the Chatham Islands for blue cod (*Parapercis colias*). Substantial fishing effort on the Chatham Rise began when Soviet trawlers fished on the Mernoo Bank in 1964. Effort was steadily increased by the Soviets and the Japanese in the late 1960s. Catch data from Japanese trawlers in this area for 1972–77 are summarised in Table 1 (Soviet data are not available). The main target species until 1977 were: hoki, barracouta (*Thyrsites atun*), warehou (most were probably silver warehou (*Seriolella punctata*)), jack mackerels (*Trachurus* spp.), and red cod (*Pseudophycis bachus*).

A substantial bottom longline fishery for ling (*Genypterus blacodes*) had been developed by the 1970s, initially by Japanese trotliners and later by Korean vessels (Table 2).

The Chatham Rise fisheries now include: a seasonal trawl fishery for orange roughy (*Hoplostethus atlanticus*) in 800–1200 m on the northern, eastern, and southern slopes; exploitation of black oreo (*Allocyttus niger*) and smooth oreo (*Pseudocyttus maculatus*) stocks on the south-western and southern slopes; and a shallower multi-species trawl fishery on the northern Chatham Rise in depths down to 800 m.

Table 1: Japanese catches (t) of the major species from the Chatham Rise, 1972–77

	Total wetfish		Hoki		Barracouta		Warehou	
Year	A*	B†	A	B	A	B	A	B
1972	22 641	192	1 154	8	12 038	4	1 777	45
1973	18 644	-‡	4 211	-	5 397	-	4 109	-
1974	16 447	824	1 263	484	8 846	83	1 693	34
1975	17 365	2 743	1 802	1 042	4 745	53	1 347	596
1976	18 082	5 601	1 783	1 813	4 712	205	1 343	962
1977	34 896	13 735	1 744	4 334	6 347	2 510	1 913	2 651

* The area from 42° 00′ to 45° 00′ S west of 173° 30′ E.
† The rest of the Chatham Rise east of 173° 30′ E.
‡ No catch reported.

During the summer arrow squid (*Nototodarus sloanii*) are fished by jig boats over shallow areas of the Chatham Rise and are caught near the Chatham Islands as a major by-catch of the trawl fishery.

Since the declaration of the New Zealand 200 n. mile Exclusive Economic Zone (EEZ) in 1978, deepwater fish stocks have been managed as controlled fisheries. Exploitation has been restricted by the setting of total allowable catch levels based on the most reliable stock assessment data available. As part of this process of stock assessments joint New Zealand-Japan trawl surveys were planned for 1983. In March and April 1983 stratified random trawl surveys were conducted on the Chatham Rise and the Snares shelf-Aucklands Shelf as joint programmes between the Japanese Far Seas Research Laboratory, the Japan Marine Fishery Resource Research Center (JAMARC), and the New Zealand Fisheries Research Division (FRD) (now part of MAFFish). This report presents the results from the Chatham Rise survey.

The main aims were to collect catch and biological data on hoki, barracouta, arrow squid, and other commercial species and to record associated environmental data such as water temperature, weather and sea conditions, and bottom topography.

Table 2: Combined Japanese-Korean longline catches (t) of ling from the Chatham Rise, 1975–80

Year	Catch	Year	Catch
1975	9 269	1978	6 405
1976	19 381	1979	5 347
1977	28 265	1980	3 540

Hydrology

The Chatham Rise is a fairly shallow topographical feature which acts as a barrier to the southward movement of water at any depth greater than itself (Heath 1975). The hydrology of the Chatham Rise is dominated by the Subtropical Convergence Zone, which varies in width and in the distance it extends across the area. The variations are thought to be indirectly due to regular fluctuations in the East Australian Current, from which the Southland Current is derived (Heath 1975). The Southland Current is a northward-moving flow of mainly subtropical water, mixed with some Australasian subantarctic water, which moves up the east coast of the South Island close inshore.

Further east, a broad mass of cool subantarctic water also moves north. The boundary between these masses is the Southland Front. North of the Chatham Rise a warm tongue of subtropical water projects southwards along the North Island east coast. By limiting the southern flow of subtropical water the Chatham Rise determines the position where the subtropical water flowing south converges with cool subantarctic water flowing north.

Materials and methods

Survey area

This survey of the Chatham Rise middle depth (200–800 m) trawl stocks was conducted from 2 to 30 March 1983. The survey area was the part of EEZ area C from about the Pegasus Canyon to 44° 30′ S and area D (Chatham Rise) in waters shallower than 800 m, but outside the 12 n. mile territorial sea and the restricted fishing zone off the South Island east coast (Figure 2).

Vessel and gear

Shinkai Maru (a stern trawler chartered by JAMARC) was used. It has the following specifications: length, 94.9 m; tonnage, 3393 GRT; beam, 16.0 m; maximum speed, 16.4 knots (kn); horsepower, 5000 PS at 230 rpm.

Two types of multi-panel trawl net were used during the survey (Appendix 1). The groundrope lengths were 83 m for net No. 81-2 and 96 m for net No. 81-3. No significant difference was observed in the performance of the nets. All stations except stations 9–13 were sampled by net No. 81-2.

Twenty randomly selected cod-end meshes were measured and a mean measurement of 65.6 mm inside-knot to inside-knot was obtained. This mesh size was assumed during all trawls. High-aspect steel trawl boards with inbuilt floatation were used to spread the net. These were 4.55 m high and 2.80 m wide — a total area of about 13 m^2.

The position of the vessel was fixed by satellite navigation by use of a Toshiba Tosnav 706-H receiver interfaced with a Koden OR166 Omega receiver. The accuracy of the latter in New Zealand waters was uncertain because of the lack of close transmitting stations. If it is assumed that the inherent system error for this receiver is similar to that of other units of the same design (i.e., about 80–100 m root mean square (0.04–0.05 n. mile) with an additional error of about 0.2 n. mile for each knot of unknown ship's velocity), positional error would be about 0.1 n. mile. Some positions may also have been based on direct reckoning time between position updates, but in general a fix about every 75 minutes would be expected at 43° S (Stansell 1978).

Ship speed was measured by a Hokushindenki electromagnetic log (EML-12), expected to be accurate to within 0.1 kn, interfaced with the satellite navigator. Trawl speed ranged from 2.4 to 4.8 kn (mean 3.3).

Bottom depth was recorded from a Kaijo Denki echo-sounder which operated at 24 kHz. In simultaneous use for much of the time were a Koden Chromascope fish finder (50 kHz) and a Simrad fish finder (TR101 transducer, HR800 recorder) (38 kHz). A Furuno Type NR 200 net recorder (200 kHz) was used on the headline, and it gave a bottom temperature reading with an accuracy of about ± 1 °C.

Trawl stations

The survey area was divided into 21 strata by the 200, 400, 600, and 800 m isobaths (Figure 3). The area and station density for each stratum are given in Table 3. Station positions were generated from random number tapes before the survey began. The position of stations within each stratum was defined in terms of a 5 n. miles² grid. The number of stations in each stratum was proportional to the size of that stratum.

The minimum number of stations per stratum was four. If the chosen position was unsuitable for trawling, such as at stations 32, 108, and 109, the nearest trawlable area was sampled. Actual starting positions for each station are shown in Figure 4. All fishing was carried out during daylight (about 0505–1906 h New Zealand Standard Time).

If untrawlable bottom was encountered after fishing had begun, the net was flown above the bottom until suitable ground was found. The tow duration and recorded distance are the time the net actually fished on the bottom. The distance for these tows was calculated from the electromagnetic log. Headline height and board spread measurements were made to check that the net was fishing properly.

Trawl duration was usually 30 minutes except when the net was damaged. The starting time for each station was the time the net actually began to fish on the bottom, as observed by the net recorder. The end of each tow was the time the winches started to haul. All trawls were bottom trawls.

The distance between trawl boards was calculated (after Koyama 1974) for each station (except when weather and sea conditions made this operation dangerous) and was then used to calculate the spread between the wingtips of the trawl. This measurement is based on the assumption that the triangle made by the top of the cod-end and the two trawl boards is proportional to the smaller triangle defined by the net measured from the forward edge of the cod-end and each of the wingtips. The accuracy of this method of measurement decreases as warp lengths increase.

Table 3: Stratum area, station density, and depth sampled

Stratum	Area (km²)	Station No.	Station Density (km²)	Actual depth range sampled (m)
1	768	4	192	87–101
2	989	4	247	93–130
3	1 358	4	339	225–325
4	2 071	4	518	608–731
5	3 869	4	957	489–579
6	11 346	8	1 418	437–556
7	7 957	5	1 591	622–735
8	5 584	4	1 396	292–380
9	2 456	4	614	118–163
10	1 248	4	312	130–353
11	3 704	4	926	597–777
12	7 120	4	1 780	408–503
13	12 279	8	1 535	409–533
14	5 419	4	1 355	656–780
15	19 276	14	1 483	235–415
16	1 145	3	286	214–237
17	10 482	7	1 497	610–809
18	10 838	9	1 204	411–583
19	17 190	14	1 228	325–507
20	6 160	5	1 232	639–805
21	12 320	9	1 369	139–375

Catch weight and biological parameters

The total catch was sorted by species and weighed on platform scales to within ± 0.1 kg per fish box. It was sometimes necessary to calculate a major species catch weight from product weights after processing. Large catches of species not processed aboard (such as pale ghost shark (*Hydrolagus* sp.) or various species of deepwater dogfish) were boxed and a predetermined weight per fish box was applied to obtain a final species total weight.

The lengths of 100 fish of each major commercial species at each station were recorded on plastic punch cards and the fish were sexed. Longer fish (such as barracouta and hoki) were grouped by 2 cm intervals, smaller fish by 1 cm. A punch hole which occurred on a centimetre line was promoted to the higher 1 or 2 cm group.

In addition, at least one full biological examination was made daily for each major commercial species. These data included: total length (TL), mantle length (ML), or fork length (FL) (to the nearest millimetre); total body weight (g); sex; gonad weight and maturation; stomach contents (weight and fullness); and parasite numbers. Otoliths were collected for aging studies.

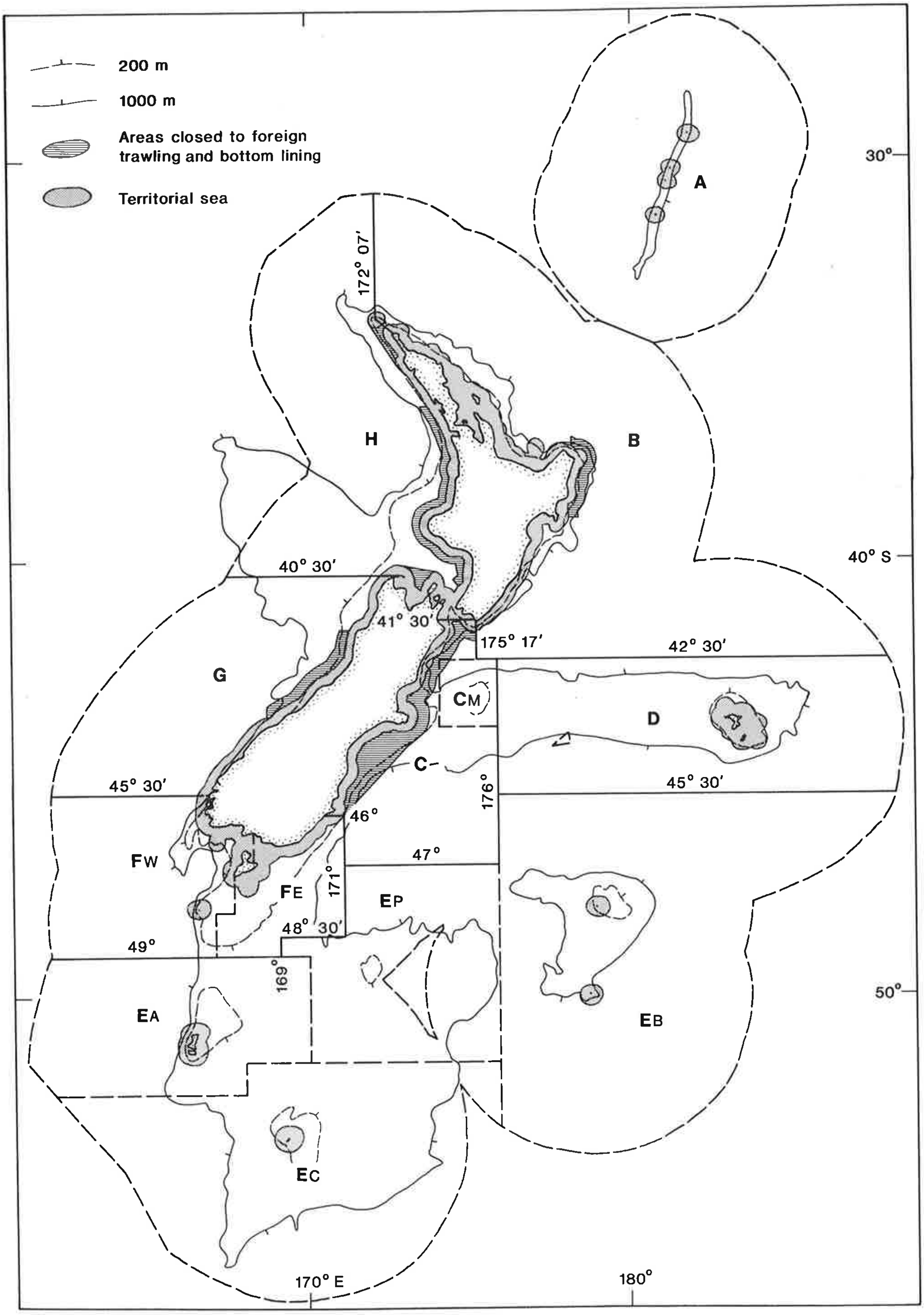


Figure 2: New Zealand 200 n. mile EEZ areas.

Biomass estimation

Biomass is used here as an index of abundance not as a measure of absolute abundance. Indices were calculated by the swept area method from data collected on randomly generated trawl stations. The following formulas were used:

$$B = (\Sigma_i X_i A_i)/V$$

$$SB = (\Sigma_i S_i^2 A_i^2)^{1/2}/V$$

where B = biomass (t), SB = standard error of B, X_i = mean catch rate (t.km^{-2}) in the i-th stratum, A_i = area (km^2) in the i-th stratum, V = species vulnerability, S_i = standard error of X_i.

Comparison of the initial strata boundaries (*see* **Figure 3**) and the latest bathymetric charts produced by FRD from recently collected soundings (Figure 5) show major differences. The actual bottom depths at stratum 16 were all deeper than 200 m, though this stratum is shown as a rise shallower than 200 m. In addition, there were bottom depths less than 400 m in stratum 19. Therefore, strata used for this survey should be regarded more as arbitrary divisions of the survey area which have some correlation with bottom depth rather than as boundaries which follow the actual depth contours.

Arbitrary values of one were assigned to vulnerability and accessibility for the following reasons:

1. As in previous surveys of this type neither the reaction of various fish species to the sampling gear nor the degree to which these species can avoid entrapment by the gear was known (Francis 1981).
2. The accessibility (i.e., the proportion of fish directly above the swept area of the gear) was not known.

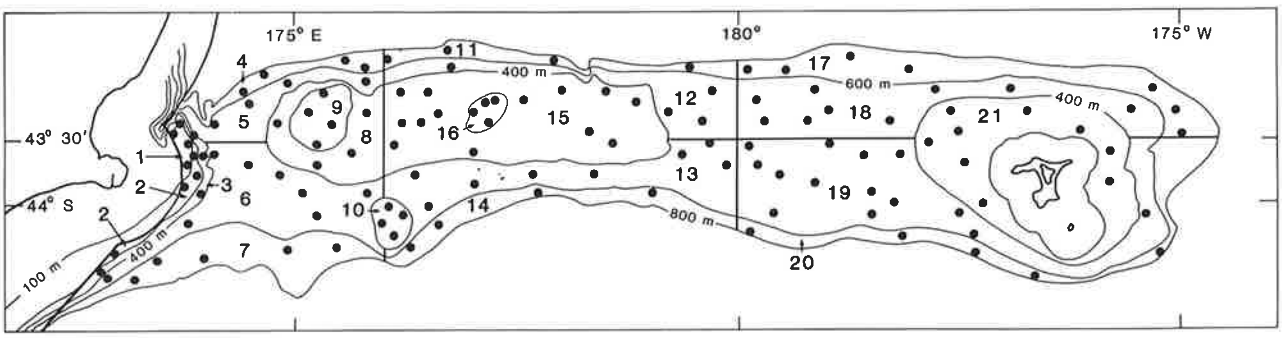


Figure 3: Predetermined trawl stations in EEZ areas C and D (numbers refer to strata).

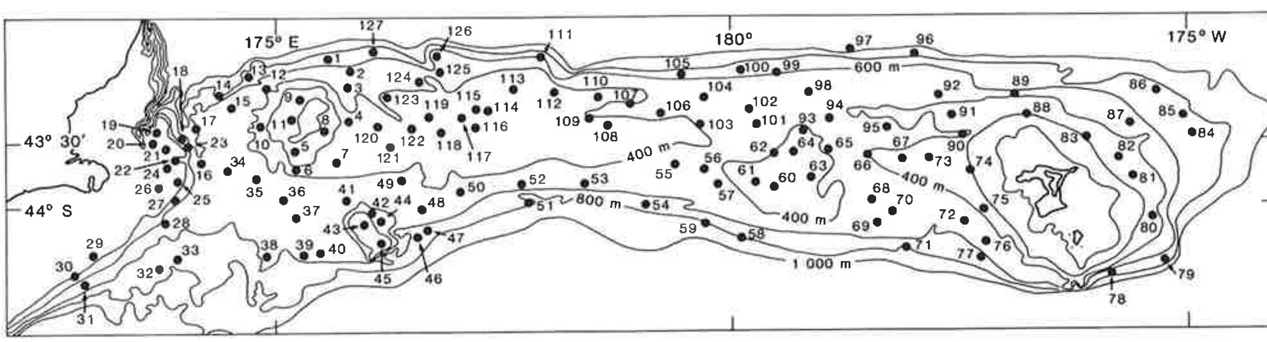


Figure 4: Actual trawl stations during the survey.

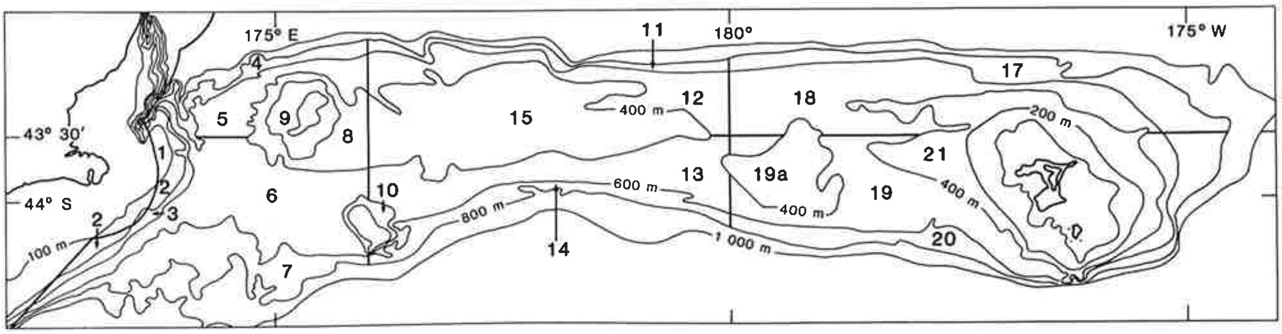


Figure 5: Revised bathymetry of the Chatham Rise and survey strata.

Therefore, it was assumed that there were no fish in the water column higher than the headline of the net and that all fish in the path of the net were vulnerable.

It was assumed that any increase in the density of fish at the net mouth as a result of shepherding by the doors and sweeps was compensated by escapment over the extension wires, over the headline, and through the meshes of the net itself. Thus, the width between the wingtips was used to define the width of the swept area.

The method used for the calculation of stratum area is given in Appendix 2.

Results and discussion

Hydrology

A total of 33 expendable bathythermograph drops were made (Figure 6). No record of the drop at 43° S 176° E was obtained. The thermocline across the Chatham Rise is shown in Figure 7.

Isotherms at various depths have been plotted in Figure 8. The surface temperature contour shows a tongue of water pushing southwards over the Mernoo Bank region into the Canterbury Bight. Contours at 50, 100, and 200 m show a northwards movement of cooler water between the Mernoo Bank and the Reserve Bank.

There is a steep temperature gradient north-east of the Chatham Islands down to 800 m. In addition, there appears to be a back-eddy, down to 600 m, which may be caused by the Chatham Islands and Chatham Islands shelf acting as a barrier to the eastward flow of water across the Chatham Rise. This eddy could not be confirmed because no sampling was done further east.

Ridgway (1975) noted a southward interruption of the eastward flow east of the Chatham Islands in both 34.3–34.9 ‰ isohalines and 9–11 °C isotherms between 20 January and 9 February 1969.

Another prominent feature in depths over 400 m was the presence of much warmer water, 3-4 °C higher, south-west of the Veryan Bank where the Chatham Rise joins the South Island slope.

Plots taken from the National Oceanographic and Atmospheric Agency satellite 7 during the survey time were examined. These four or five day composite plots gave surface temperatures for 1 km² areas. The temperatures derived from the plots should be regarded more as relative rather than as absolute. Plots for weeks ending 7, 21, and 28 March 1983 showed

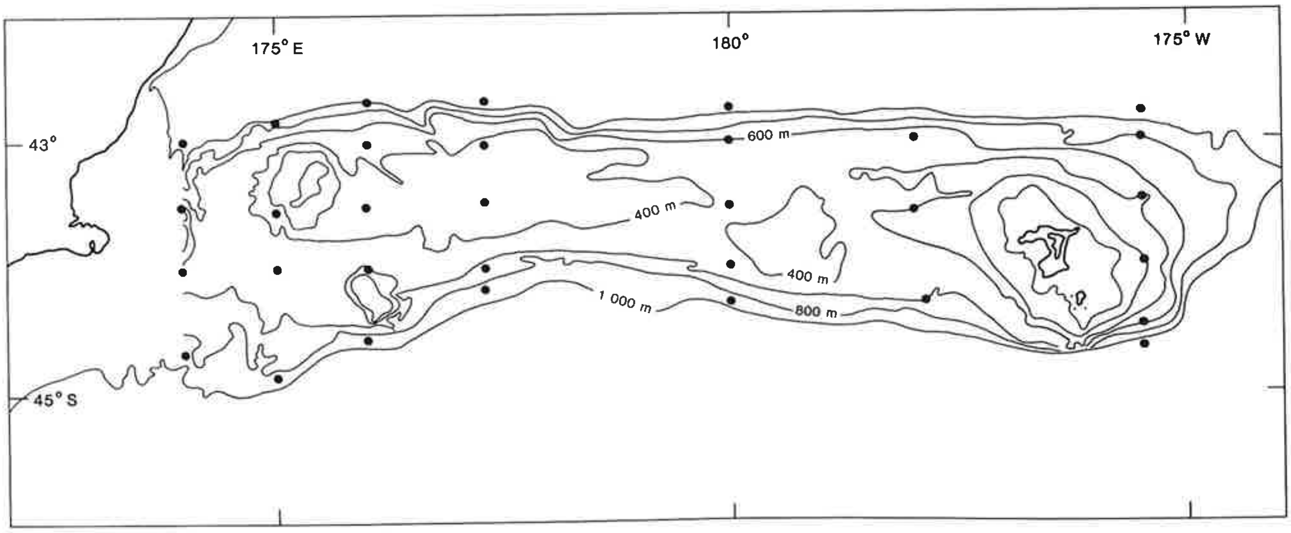


Figure 6: Expendable bathythermograph station positions.

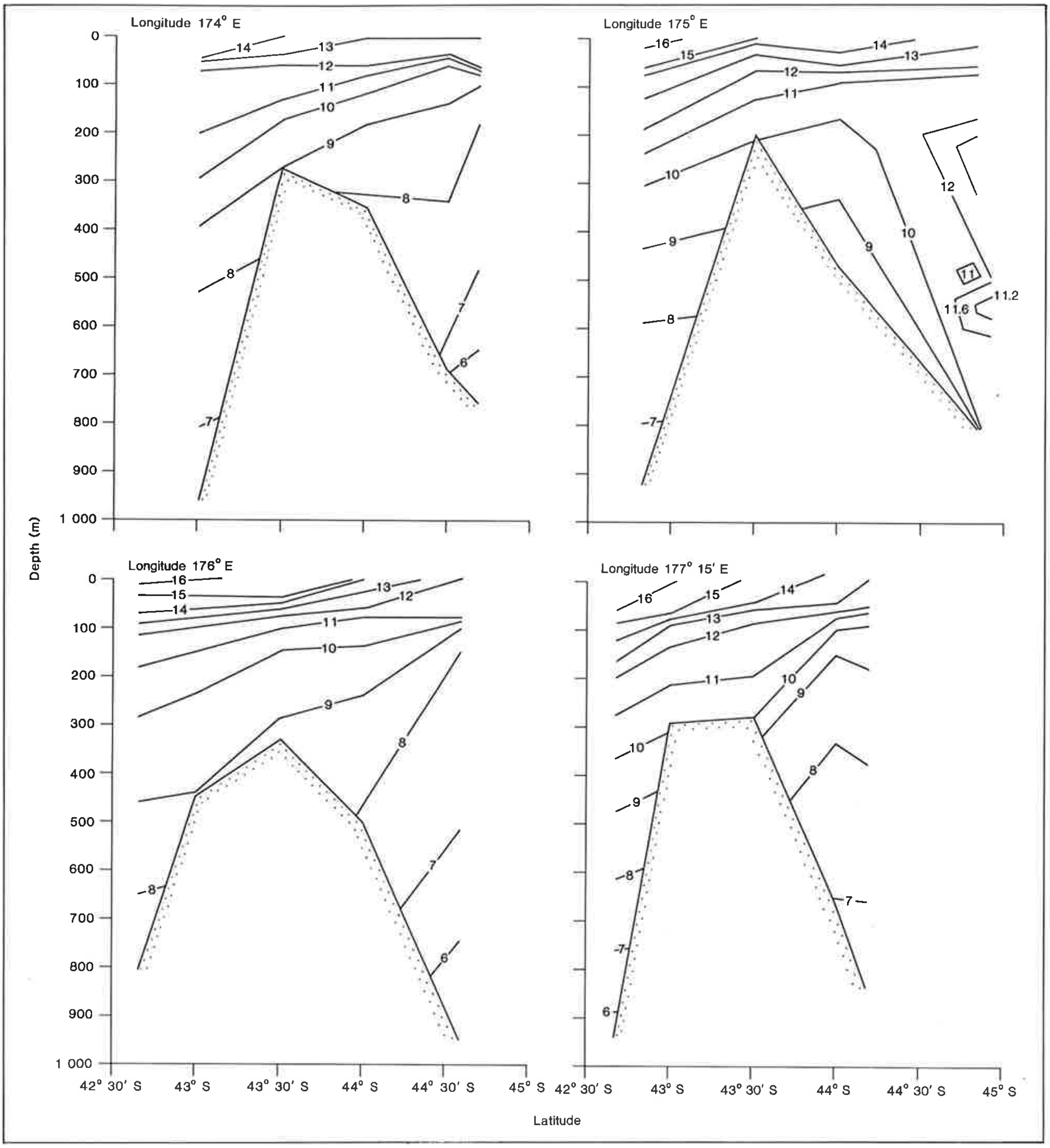


Figure 7: Expendable bathythermograph profiles plotted by latitude along lines of longitude.

a southward tongue of warm water in the Mernoo Bank and the Reserve Bank area. This feature was less pronounced in the last plot.

The data were grouped by latitude and plotted by depth across the Chatham Rise (Figure 9). There was a general decrease in temperature from north to south. The warm cell of deeper water (down to more than 800 m) at 175 ° E is apparent in these data and could be a result of the passage of water from the Southland Front through the Mernoo Gap to the north-west. A similar, though less pronounced, region is present at 180 °.

Catch rates and composition

The short sampling period of 29 days reduced the effect of seasonal variation and simplified the task of mapping the distribution and abundance of the most important species.

The plotted catch values represent only those fish vulnerable to bottom trawl gear. Other factors must also be taken into account: the presence of fish higher in the water column or in untrawlable ground and the escapment of small fish through the net meshes. Species taken during the survey are listed in Appendix 3.

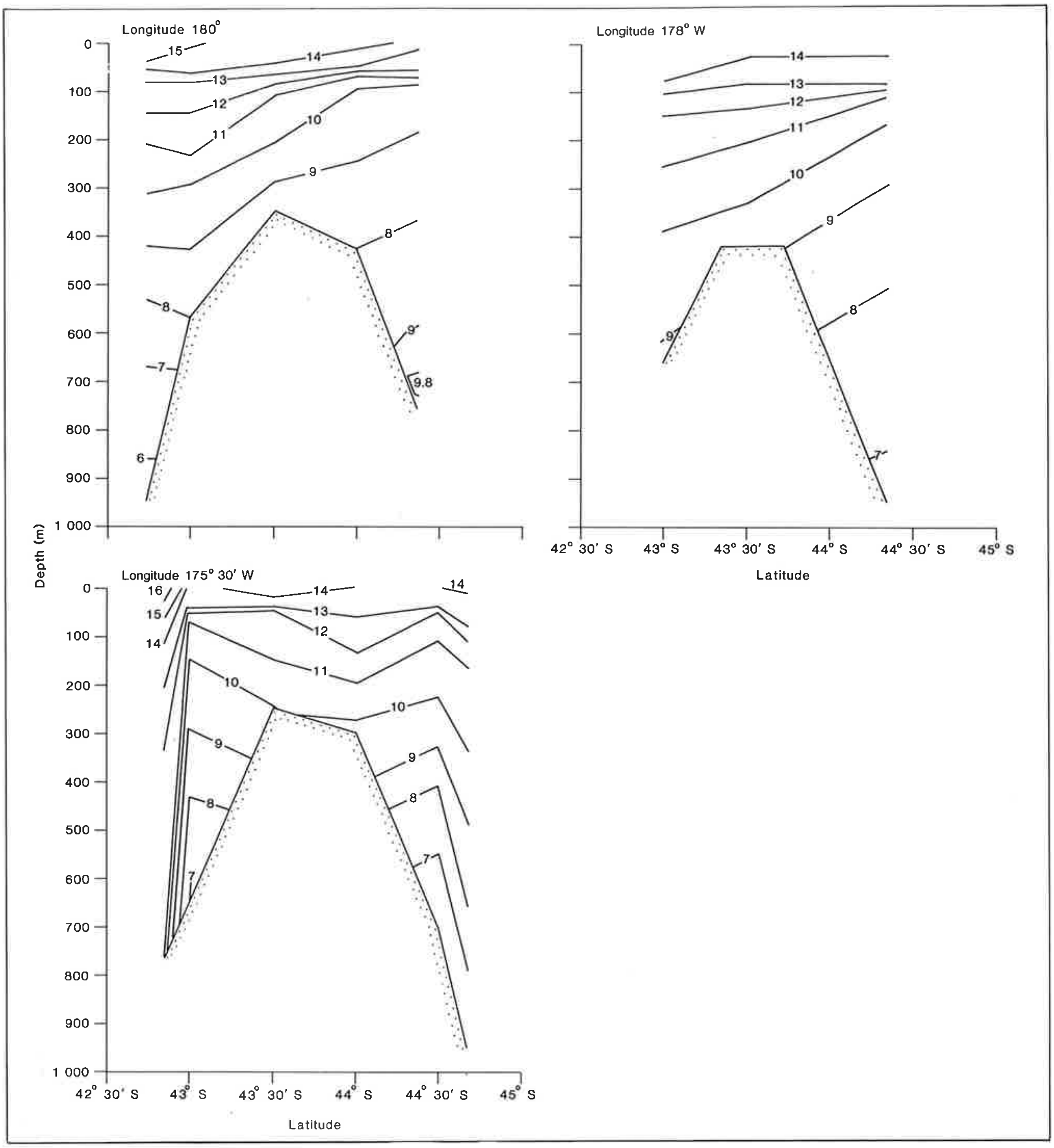


Figure 7—*continued.*

The catch rates of the 17 most abundant commercial species are shown in Figures 10–26. Catch rates (t.km^{-2}) for major species are shown by depth and by temperature in Figure 27. These analyses are mean values at each depth and temperature range for all stations (i.e., nil values are included). A full catch summary is given in Appendix 4. Catch rates by stratum are given in Appendices 5 and 6.

Hoki

Hoki were the most common fish taken during the survey (Figure 10). They were caught in nearly every trawl over 200 m. Catches were consistently large (mean catch rate 12.8 t.km^{-2}). Catch rates were higher west of 180° and the highest were recorded from the area covered by a northward push of cooler water, particularly strata 4, 5, and 11.

Pale ghost shark

Specimens taken during the survey appeared to be all one species. This chimaerid ranged deeper than the dark ghost shark and was present in most trawls made in the intermediate depths between 300 and 500 m (Figure 11).

Spiky oreo

Several good catches (over 9 $t.km^{-2}$) of spiky oreo were taken during the survey (Figure 12). They were irregular components of the catch at deep stations and were not restricted to the southern slopes of the Chatham Rise, as were black oreo.

Spiny dogfish

Spiny dogfish were mainly limited to the shelf edge off Banks Peninsula, the Mernoo Bank, and the Veryan Bank (Figure 13). Small catches were recorded in other areas in shallow strata.

Black oreo

Several good hauls (over 11 $t.km^{-2}$) of black oreo were made (Figure 14). This species was taken only over the southern slopes of the Chatham Rise in depths over 635 m and at times was caught with spiky oreo, though the latter were generally found in shallower water.

Ling

One good catch of ling (28.8 $t.km^{-2}$) was taken north-west of the Chatham Islands (Figure 15). Generally catches were small (under 0.5 $t.km^{-2}$), but ling were taken in 83% of the trawls.

Barracouta

Catches of barracouta ranged from 0.1 to 10.0 $t.km^{-2}$ and were restricted to shallower depths: mainly the shelf edge west of the Mernoo Gap, on the Mernoo Bank, and the shelf north-west of the Chatham Islands (Figure 16).

Hake

Small but consistent quantities of hake (mean catch rate 0.36 $t.km^{-2}$) were taken and catches from the northern Chatham Rise tended to be larger (Figure 17).

Arrow squid

Arrow squid were present at most stations, though they only constituted about 1.4% of the total survey catch. However, it is possible that they were not caught while the net was fishing on the bottom, but while it was being raised or lowered. Highest catches (over 0.9 $t.km^{-2}$) were generally restricted to the Mernoo Bank, the Veryan Bank, and the shelf edge south-east of Banks Peninsula (Figure 18), where small squid (10–12 cm ML) were common. Catches on the eastern Chatham Rise were lower (under 0.3 $t.km^{-2}$), though one haul of 2.1 $t.km^{-2}$ was taken north of the Chatham Islands.

Sea perch

Another common catch component in most hauls was sea perch, though many of the larger catches (over 12.4 $t.km^{-2}$) were in the shallower waters of the northern and central Chatham Rise just east of the Mernoo Bank (Figure 19). More than one species was taken, but the taxonomy of these fish is unresolved (C. Paulin pers. comm.). Juvenile sea perch were common around the Reserve Bank.

Giant stargazer

Giant stargazer were also common in shallower trawls (Figure 20). Some good catches (over 1.7 $t.km^{-2}$) were taken. A mean catch of 0.4 $t.km^{-2}$ was recorded.

Silver warehou

Silver warehou were caught mainly in shallower waters (under 450 m) (Figure 21). They were more common west of 178° E. Their highest catch rates (over 1.7 $t.km^{-2}$) were recorded in 200–300 m. Small fish (about 200 mm FL) were abundant on the Mernoo Bank and the Reserve Bank.

Lookdown dory

Lookdown dory were caught at all except the shallowest stations (those under 142 m) (Figure 22).

Alfonsino

Alfonsino were taken at only 38 stations. Several large catches (up to 16 $t.km^{-2}$) were made. Generally this species appeared to be more common on rugged slopes in 300–400 m (Figure 23).

Dark ghost shark

Dark ghost shark occurred mainly on shallower grounds west of 178° E north-west of the Chatham Rise and on the shelf edge off the South Island east coast (Figure 24).

Red cod

Catches were mostly restricted to the shelf west of the Mernoo Gap, though some small catches were made in shallower waters on the Chatham Rise, such as around the Veryan Bank and around the Chatham Islands (Figure 25).

Tarakihi

The highest tarakihi catch rates (over 18.7 $t.km^{-2}$) were taken around the Pegasus Canyon and in shallower waters around the Chatham Islands (Figure 26). A few fish per haul were taken intermittently on shallow grounds on the northern Chatham Rise.

Deepwater dogfish

Large catches of various deepwater squalids, notably *Deania* and two species of *Centroscymnus*, were common at all but the shallower stations. Although they are not commercially harvested, the recovery of

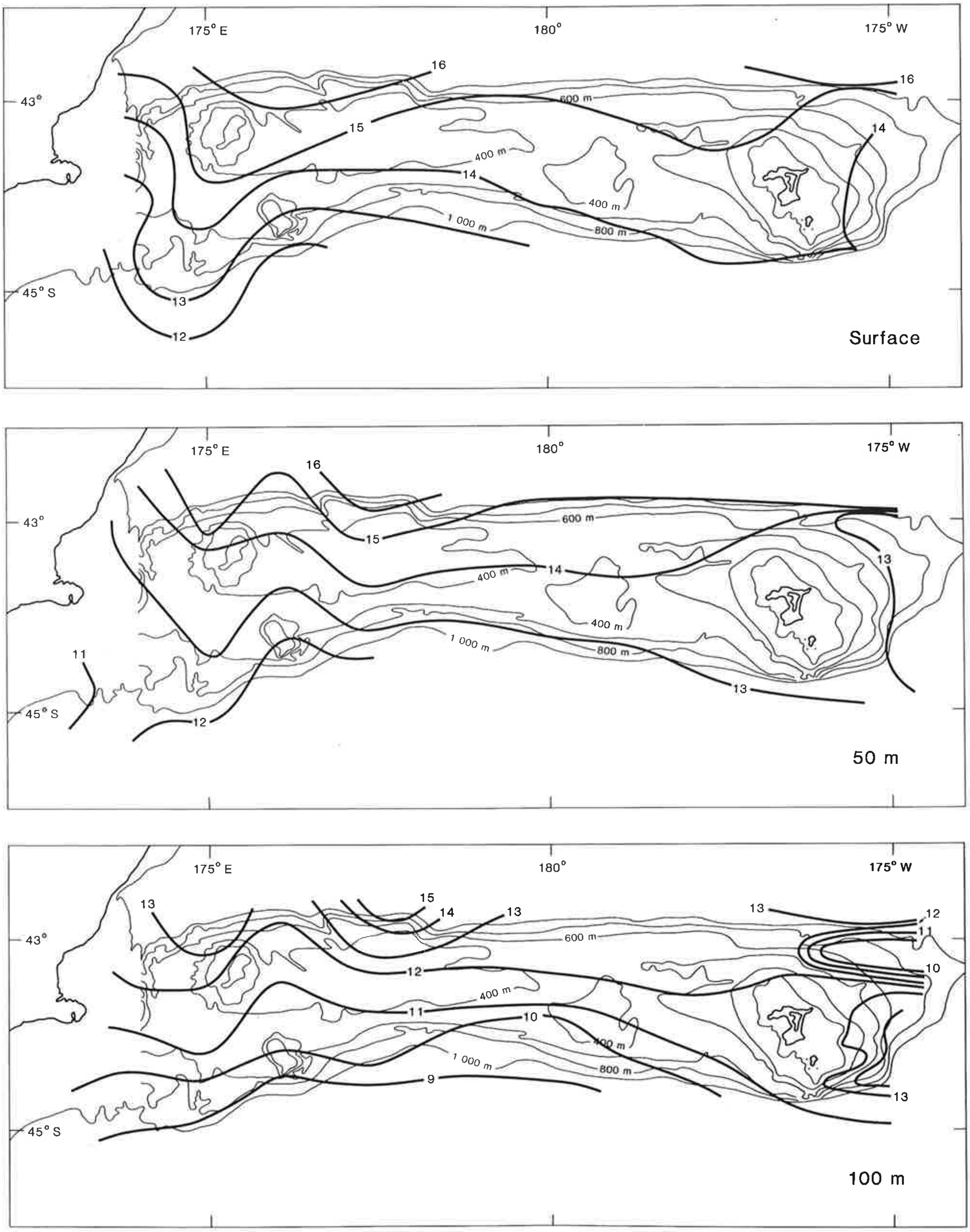


Figure 8: Temperature (°C) contours.

squalene from their livers is increasing the value of this by-catch. In addition, they are important because of the damage they cause to the nets and because they are probably the major predators and scavengers in these depths.

Other species

Several good catches (over 2 t.km^{-2}) of spawning orange perch (*Lepidoperca* sp.) were taken north-west of the Chatham Islands and on the Reserve Bank.

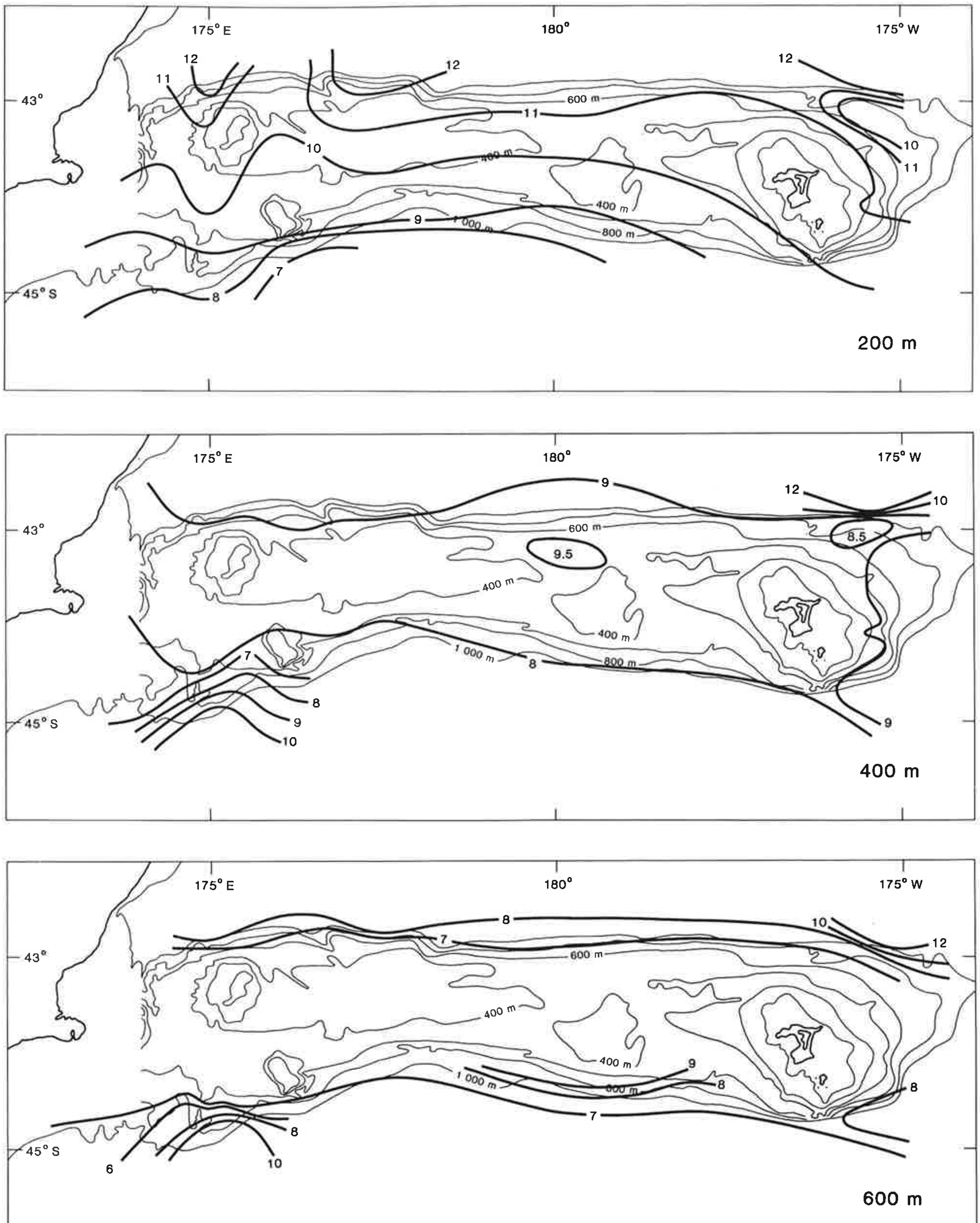


Figure 8—*continued*.

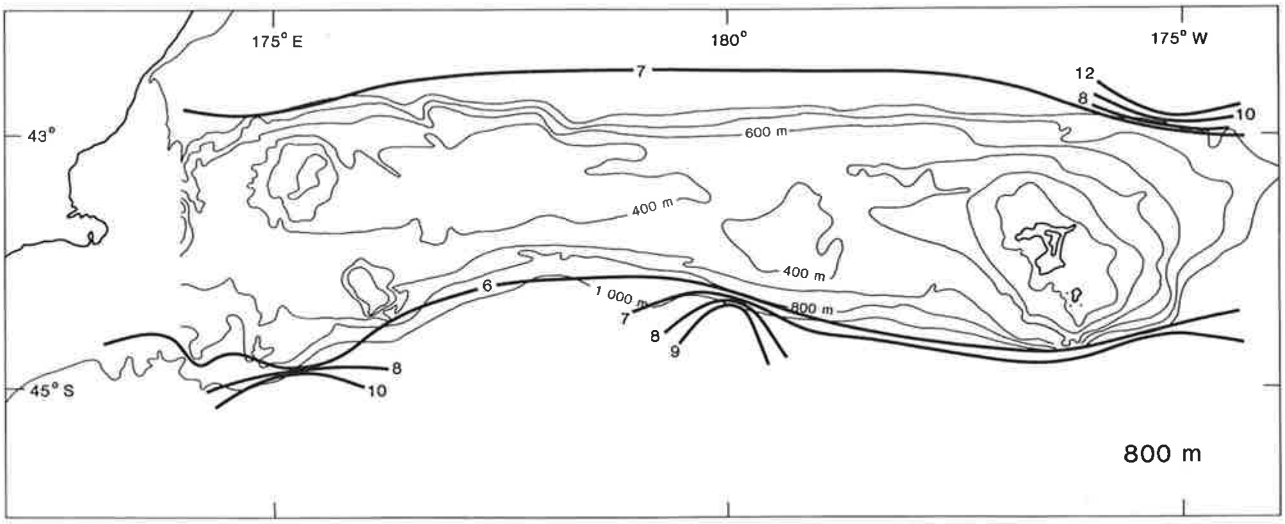


Figure 8—*continued.*

Biomass estimates

Biomass estimates for the major species and all other species are given in Table 4. Biomass estimates by stratum are given in Appendix 7.

Hoki made up nearly 57% of the total biomass for the Chatham Rise in depths shallower than 800 m. A catch frequency histogram for hoki is shown in Figure 28. The consistently high catches generally reached 0.5 t per 30 minute haul.

Hoki

A length-weight regression for hoki was based on measurements from 525 fish 20–108 cm long. The equation $W = 0.0055L^{2.85}$ was obtained from this regression, where W = weight (g) and L = total length (cm).

Fish less than 45 cm TL constituted about 3.6% of the total weight of hoki; 46–54 cm, 11.3%; 55–58 cm, 8.0%; 59–66 cm, 32.9%; over 66 cm, 44.2%. From data collected during this survey and from previously collected unvalidated FRD age records, these percentages are considered to represent the 2+ to 6+ year classes (G. J. Patchell pers. comm.).

Kerstan and Sahrhage (1980) reported that hoki were mature at 57–65 cm. Patchell (1982) regarded hoki less than 65 cm as immature and noted that females and males generally did not mature until over 70 and 60 cm respectively. Thus, 55.8% of the total length-frequency sample of 13 762 hoki measured can be considered to be immature fish.

Comparison of the length-frequency data from this survey with that from spawning hoki on the west coast during winter 1982 (G. J. Patchell pers. comm.) showed the west coast spawning hoki were larger (Figure 29). Patchell (1982) also noted that Soviet data (Blagodyorov and Nosov 1978) suggested that most of the hoki taken by the Soviet fleet on the Chatham Rise during recent years were juveniles. It should be stressed that the 60 mm cod-end mesh used during this survey would permit greater escapment of smaller fish, particularly those 20–40 cm long.

From the total biomass of hoki on the Chatham Rise (1 772 000 t), the following indices were obtained: 2+ year class, 63 790 t; 3+, 200 240 t; 4+, 141 760 t; and 5+, 582 990 t. Mature fish (i.e., over 66 cm TL) would constitute a total biomass index of about 783 220 t, or 44.2% of the total hoki biomass index. Biomass estimates from other surveys for the Mernoo Bank and the Chatham Rise are given in Table 5.

Other species

Other important commercial species in the Chatham Rise fishery at depths to 800 m are black and smooth oreos, pale ghost shark, ling, hake, and sea perch.

Among the non-commercial species about 12 species of the family Macrouridae, notably javelin fish, unicorn rattail, and notable rattail represented nearly 10% of the total biomass. Javelin fish were the most abundant species. The biomass calculated for this group is lower than expected, probably because the long slender body shape of these species would have allowed considerable escapment through the cod-end meshes.

Other macrourids were generally classed as "rattails" for the purposes of biomass estimates because they were not considered to be of commercial interest. Various *Coelorinchus* species, mainly *C. oliverianus*, constituted the bulk of this group.

Deepwater squalids, mainly shovelnosed spiny dogfish (*Deania calcea*) and three species of *Centroscymnus*, were also a major catch component.

Problems with biomass estimation

The gear performance data for each station is included in Appendix 8. Parameters such as the headline height and board spread, observed speed (from the ship's log), and calculated speed (distance

Table 4: Biomass estimates* (t) for the major species and all other species caught on the Chatham Rise†

Species	Species code	Lower bound	Biomass estimate	Upper bound	Coefficient of variation (%)	Biomass % of total (all species)
Hoki	HOK	1 370 487	1 771 718	2 172 950	11	56.6
Javelin fish	JAV	138 943	169 600	200 256	9	5.5
Pale ghost shark	GSP	73 396	103 394	133 392	15	3.3
Rattails	RAT	102 882	129 175	155 468	10	4.2
Shovelnosed spiny dogfish	SND	48 326	83 632	118 938	21	2.7
Spiky oreo	SOR	47 293	118 361	189 430	30	3.8
Spiny dogfish	SPD	21 209	30 052	38 896	15	1.0
Black oreo	BOE	5 248	95 611	185 974	47	3.1
Ling	LIN	31 024	67 559	104 095	27	2.2
Barracouta	BAR	9 783	28 519	47 255	33	1.0
Hake	HAK	38 136	50 800	63 464	12	1.7
Arrow squid	ASQ	12 905	27 097	41 290	26	0.9
Sea perch	SPE	35 036	45 745	56 455	12	1.5
Giant stargazer	STA	23 726	36 907	50 087	18	1.2
Silver warehou	SWA	12 830	38 573	64 317	33	1.3
Lookdown dory	LDO	32 547	40 147	47 747	9	1.3
Alfonsino	BYX	0	26 334	66 614	76	0.9
Dark ghost shark	GSH	11 231	17 633	24 034	18	0.6
Red cod	RCO	0	6 267	13 220	55	0.2
Spineback	SBK	12 063	17 025	21 987	15	0.6
Tarakihi	TAR	1 755	5 205	8 655	33	0.2
Other species		274 633	219 009	148 752		6.2
Total (all species)		2 303 453	3 128 363	3 953 276		100.0

* Lower and upper bounds ± 2.0 standard deviation. Vulnerability is assumed to be one.

† Net width calculated for each station: minimum = 16.6 m, mean = 28.3 m, maximum = 37.7 m. Distance towed ranged from 1.0 to 2.6 n. miles, mean 1.6 n. miles.

trawled in recorded time) were tested for significant correlations. Observed and calculated speed and door spread showed no significant correlation at the 5% level ($F_{1,121}$ = 2.85 and $F_{1,121}$ = 1.3). There was a significant negative correlation at the 5% level ($F_{1,121}$ = 15.05) between headline height and door spread (i.e., gear width). However, there was a high proportion of variance, which probably reflected measurement error in the present method of proportional calculation. Therefore, a major parameter for the estimation of biomass indices, the width of the swept area, cannot be determined accurately.

Analysis of wingtip spread (which is calculated as a proportion of door spread) plotted against depth suggests that gear width increases with depth, to at least 300 m (Figure 30). Therefore, the wingtip spread for each station has been used to define the gear width in the biomass computations.

The difference in the abundance indices calculated in this manner, and those that resulted when a mean gear width from all stations was used, was more than 70 000 t for hoki and 101 000 t for all species. Although these differences are not great in terms of the final estimate (4 and 3% increase respectively), they highlight the need for the direct measurement of gear dimensions in trawls used for abundance estimation.

For the above reasons, and because variables such as accessibility and vulnerability could not be measured, the credibility of abundance estimates from this and all similar surveys must be suspect.

Actual observations of gear performance on all New Zealand trawl surveys has been limited. The only measure of trawl performance during fishing operations has been assessed from net recorder transmissions. This equipment indicates when the net reaches the bottom, shows the headline height and the presence of fish swimming under the headline, and supplies a crude bottom temperature reading. This information is adequate for standard commercial fishing operations, but is insufficient for stock abundance surveys.

Table 5: Hoki biomass estimates from this and other surveys for the Mernoo Bank and the Chatham Rise

Survey year	Stock size (t) (min.-max.)	Vessel
1977*	212 000–501 000	*Shinkai Maru* and various commercial
1978†	225 000	Various commercial
1979‡	140 000–1 000 000 (autumn)	*Wesermünde*
1979	34 000–540 000 (winter)	*Wesermünde*
1979	100 000–480 000 (spring)	*Wesermünde*
1968§	180 000	Various commercial
1969	160 000	
1970	170 000	
1971	300 000	
1972	150 000	
1973	160 000	
1974	175 000	
1975	170 000	
1976	140 000	
1977	130 000	
1983‖	1 770 000	*Shinkai Maru*

* This estimate excluded the Mernoo Bank, from Francis and Fisher (1979).

† From Anon. (1978).

‡ All 1979 estimates from Francis (1981).

§ 1968–77 estimates are from the Mernoo Bank, from Blagodyorov and Nosov (1978).

‖ Estimates from this survey.

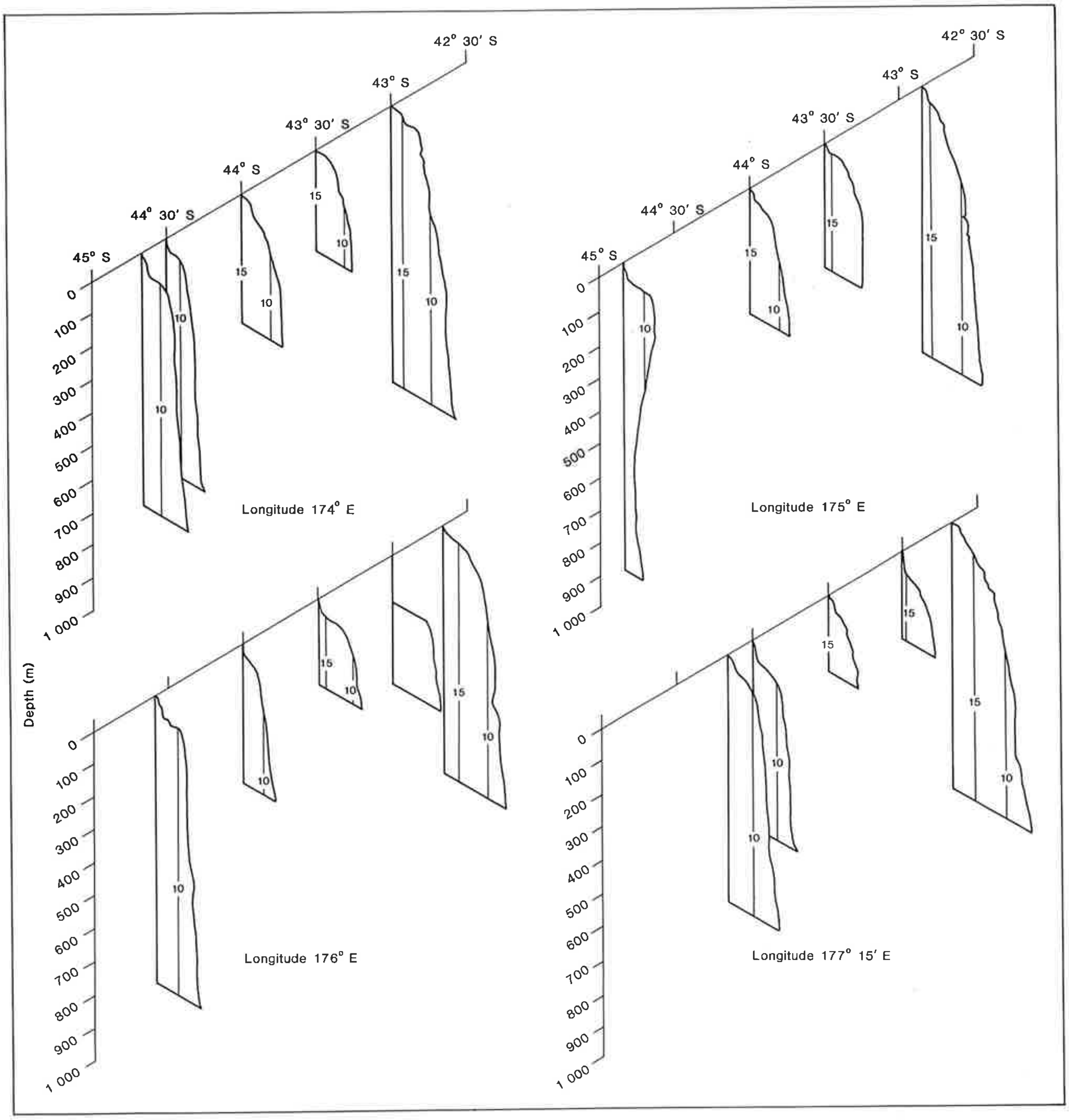


Figure 9: Temperature (°C) profiles.

In addition to data supplied by the net recorder, minimum requirements should include: the constant monitoring of both trawl door and wingtip spread, some measure of the amount of fish passing over the headline, and the provision of extra monitoring equipment on the square and body of the trawl net to record the passage of fish down the net towards the cod-end.

This additional information would increase the accuracy of abundance estimates by increasing the precision of gear and area swept measurements and of the assessment of the density of fish schools, the time fish were caught relative to the length of total fishing time, and the escapment or avoidance of fish during the trawl.

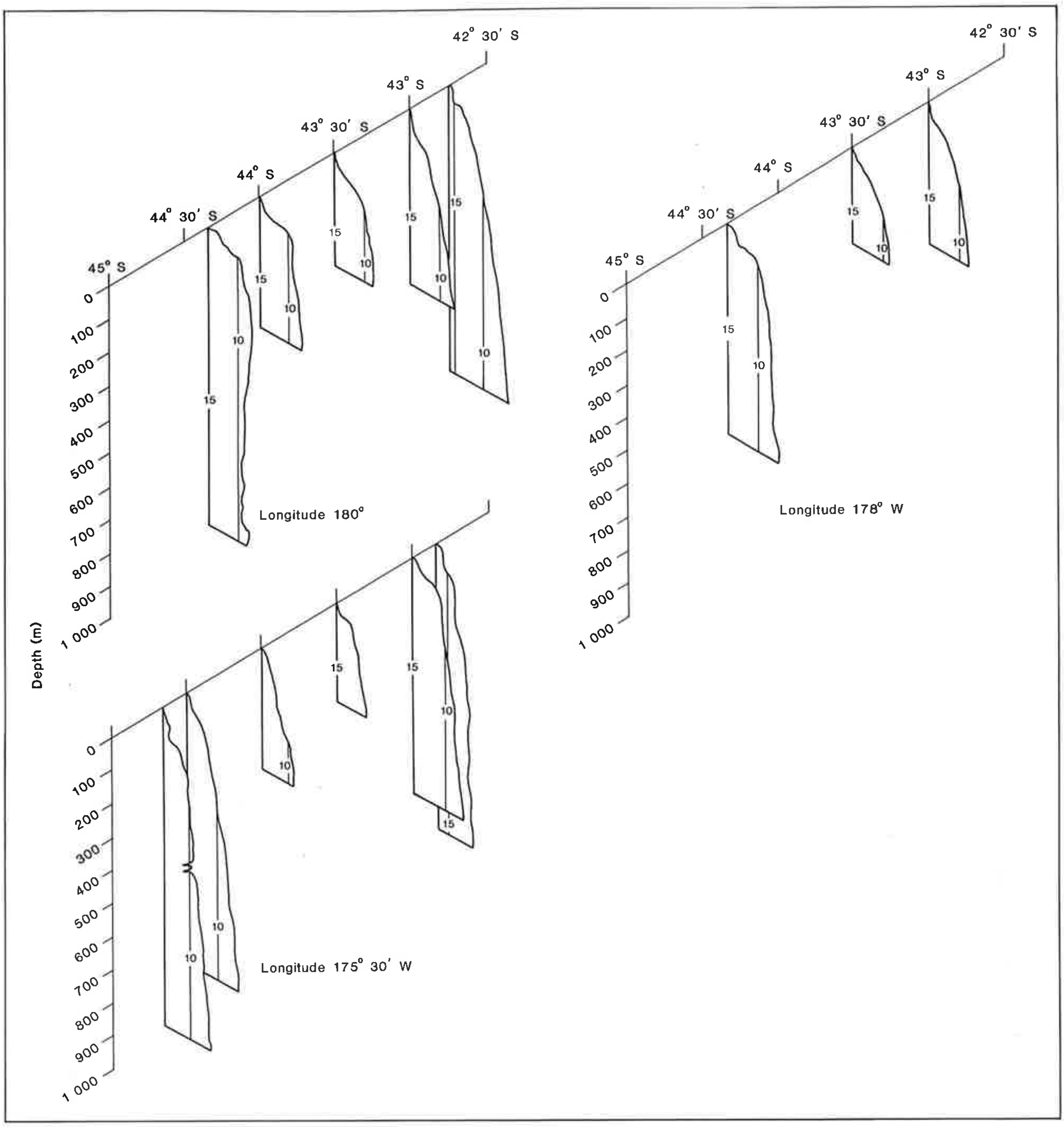
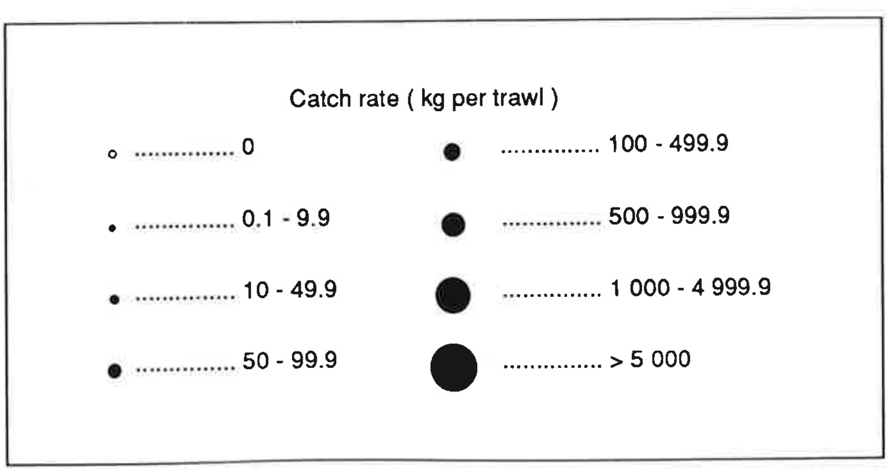


Figure 9—*continued*.



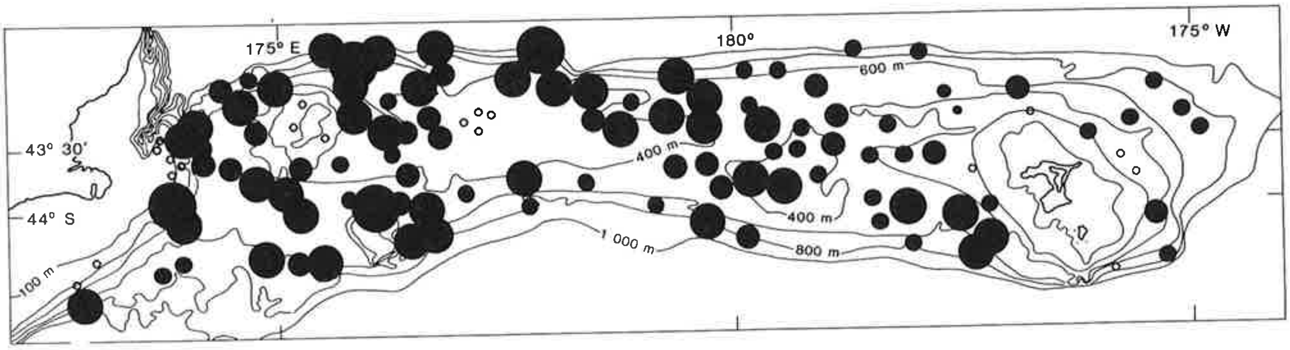


Figure 10: Hoki catch rates (*see* key on page 19).

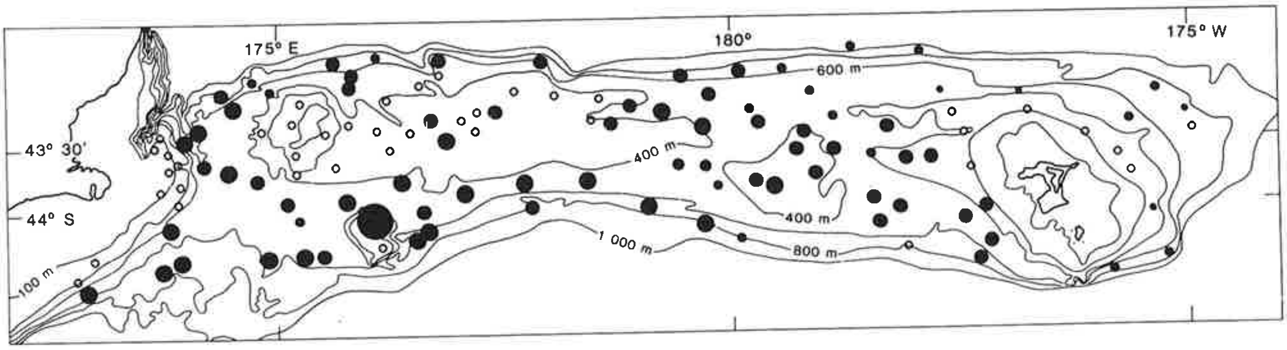


Figure 11: Pale ghost shark catch rates (*see* key on page 19).

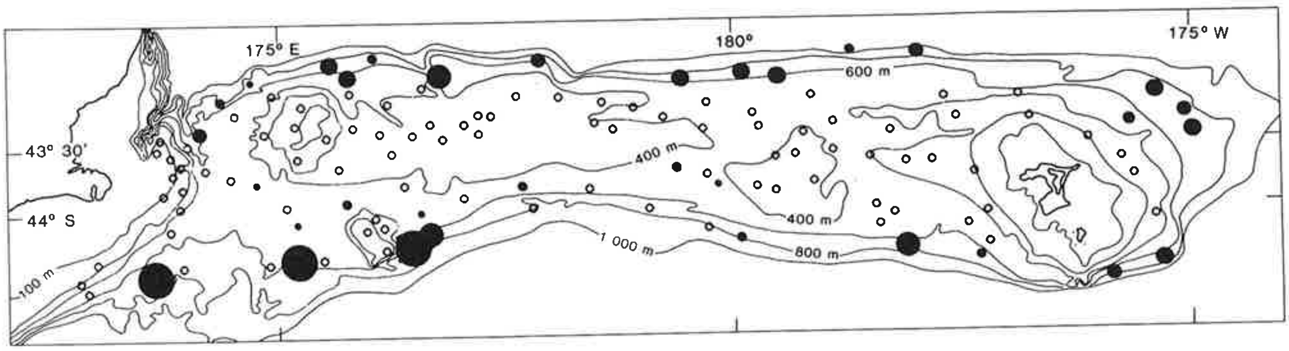


Figure 12: Spiky oreo catch rates (*see* key on page 19).

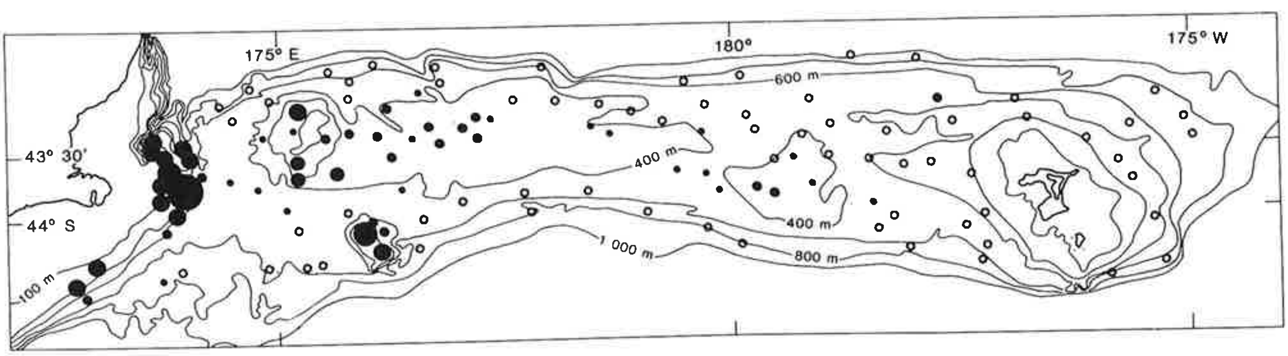


Figure 13: Spiny dogfish catch rates (*see* key on page 19).

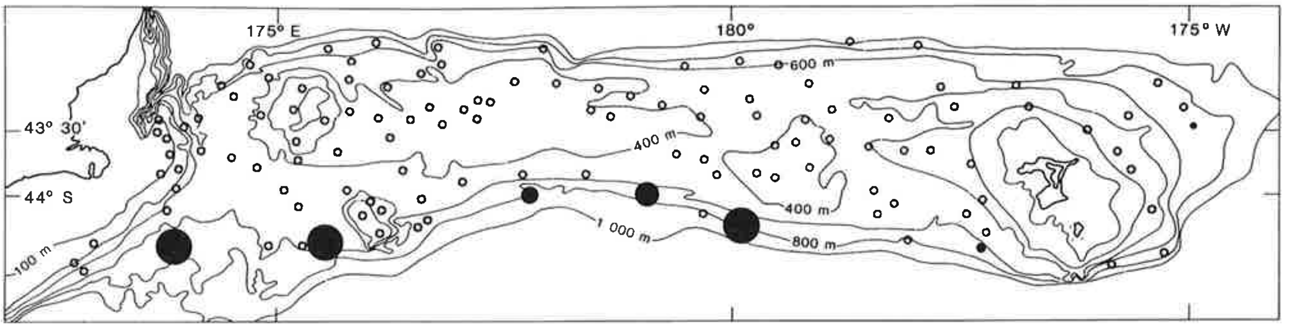


Figure 14: Black oreo catch rates (*see* key on page 19).

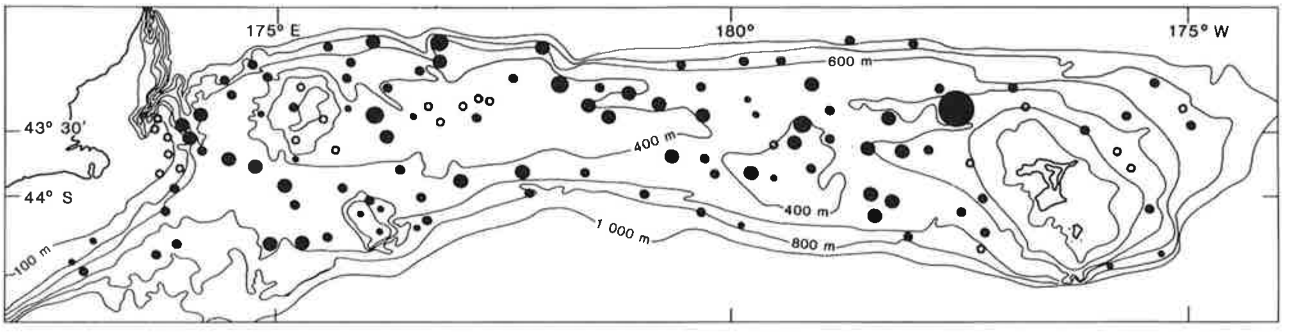


Figure 15: Ling catch rates (*see* key on page 19).

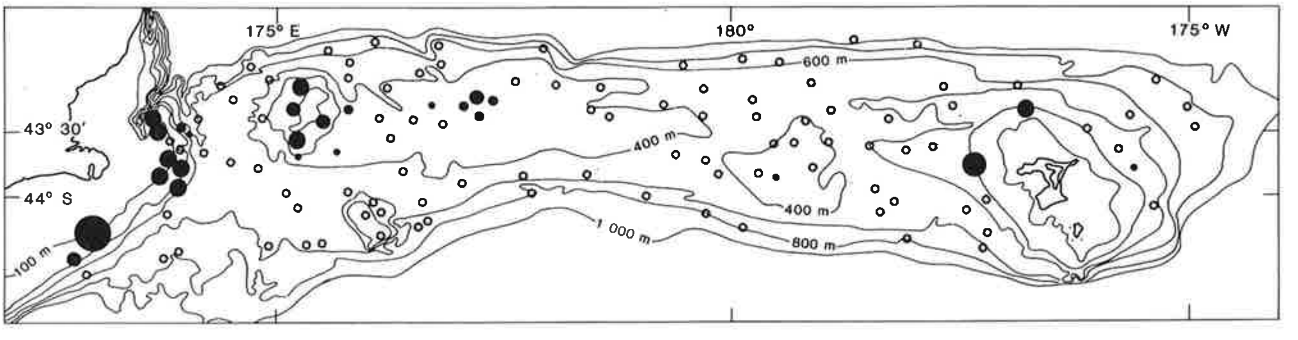


Figure 16: Barracouta catch rates (*see* key on page 19).

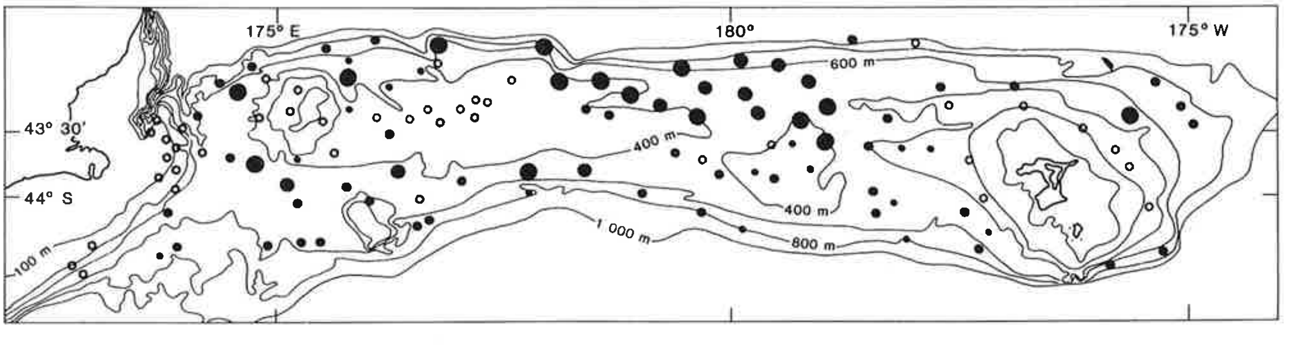


Figure 17: Hake catch rates (*see* key on page 19).

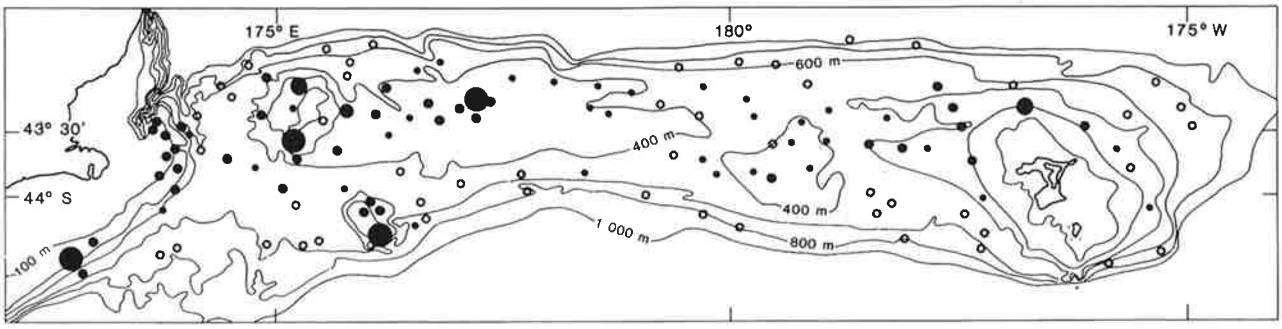


Figure 18: Arrow squid catch rates (*see* key on page 19).

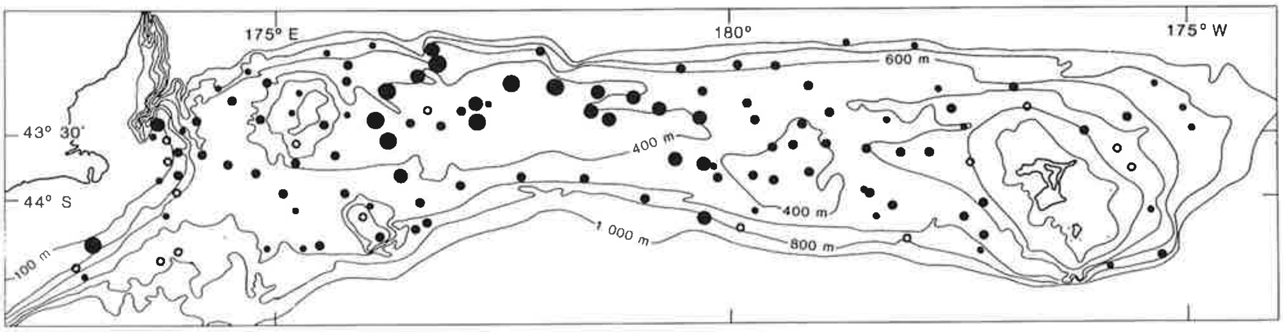


Figure 19: Sea perch catch rates (*see* key on page 19).

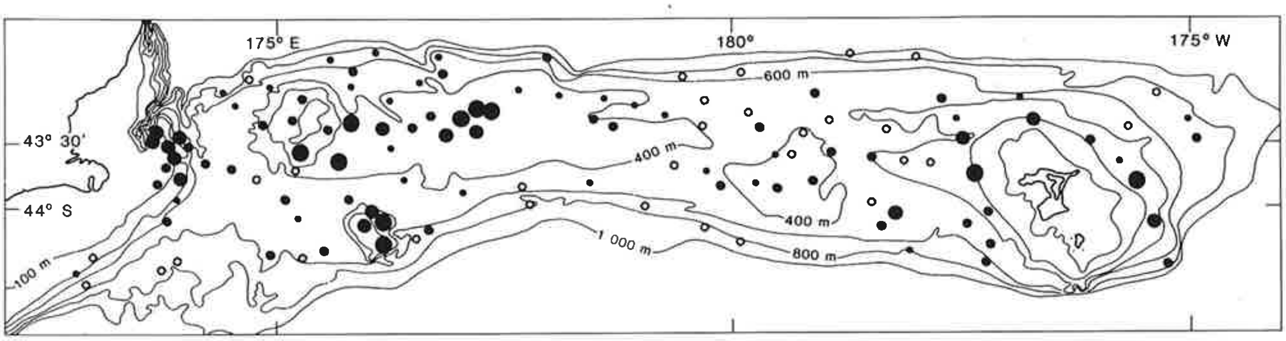


Figure 20: Giant stargazer catch rates (*see* key on page 19).

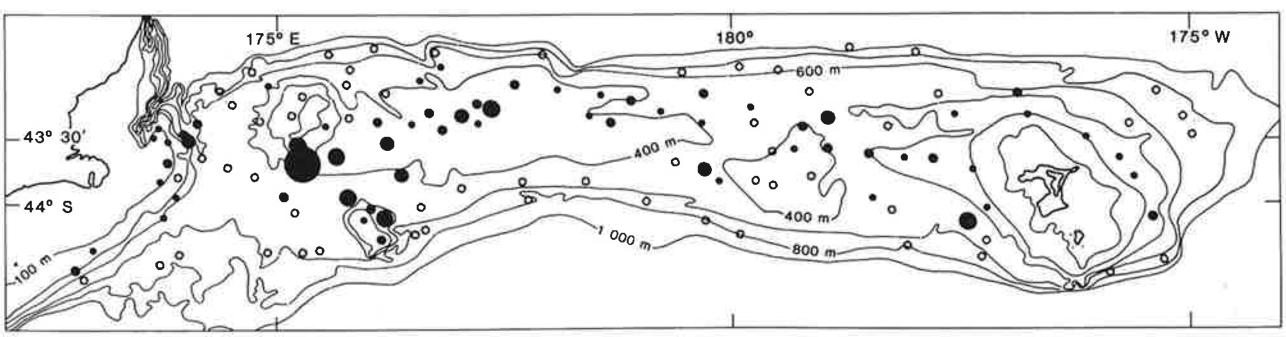


Figure 21: Silver warehou catch rates (*see* key on page 19).

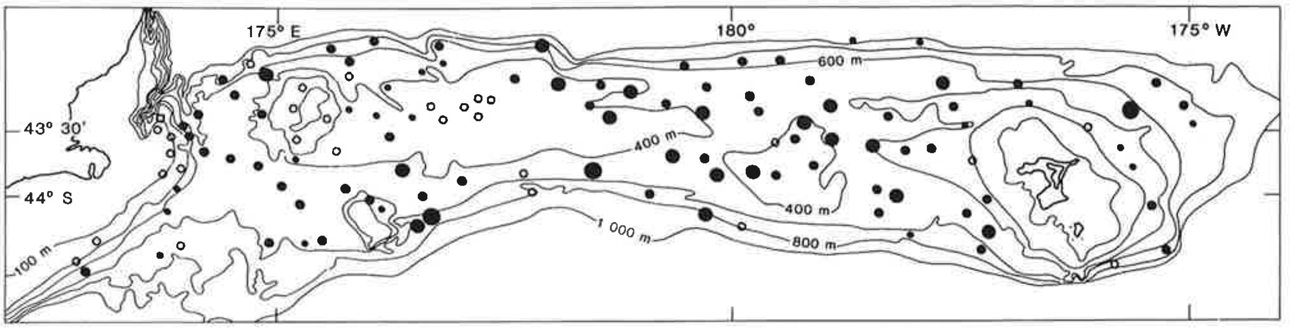


Figure 22: Lookdown dory catch rates (*see* key on page 19).

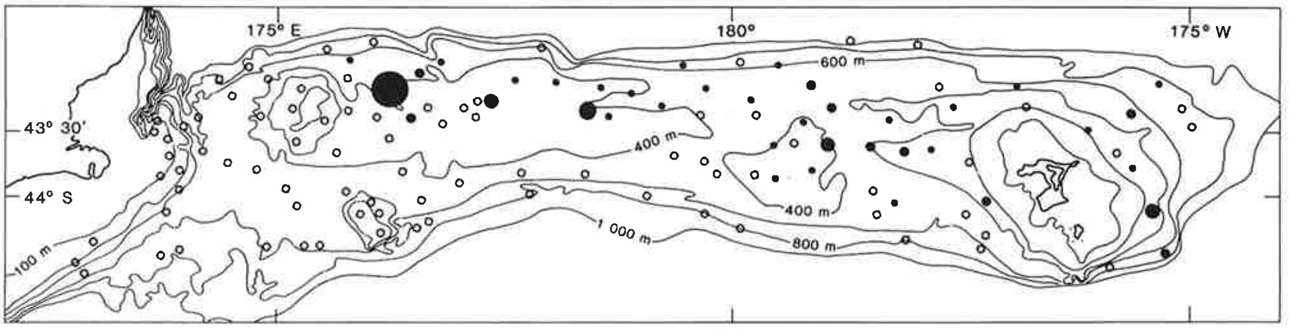


Figure 23: Alfonsino catch rates (*see* key on page 19).

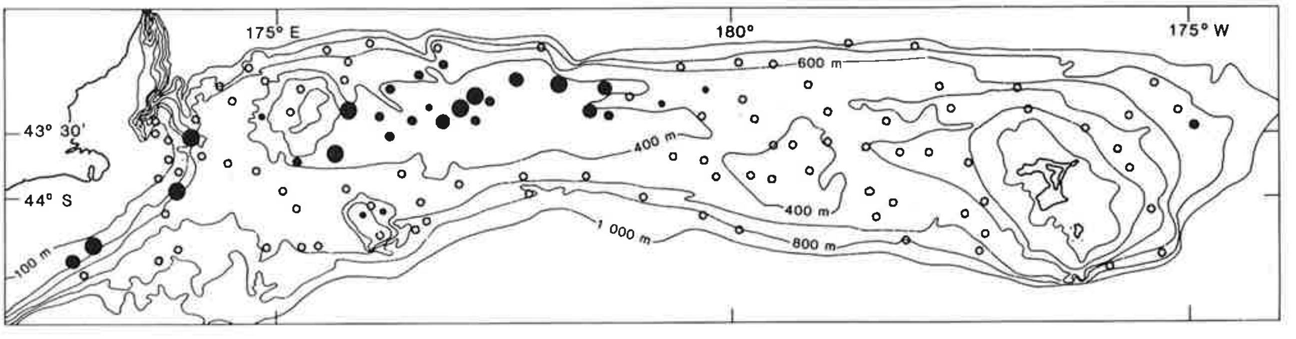


Figure 24: Dark ghost shark catch rates (*see* key on page 19).

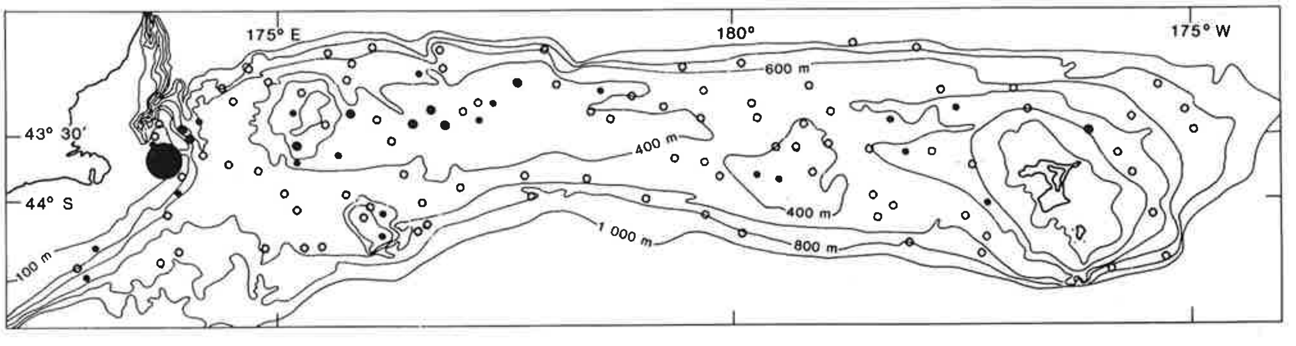


Figure 25: Red cod catch rates (*see* key on page 19).

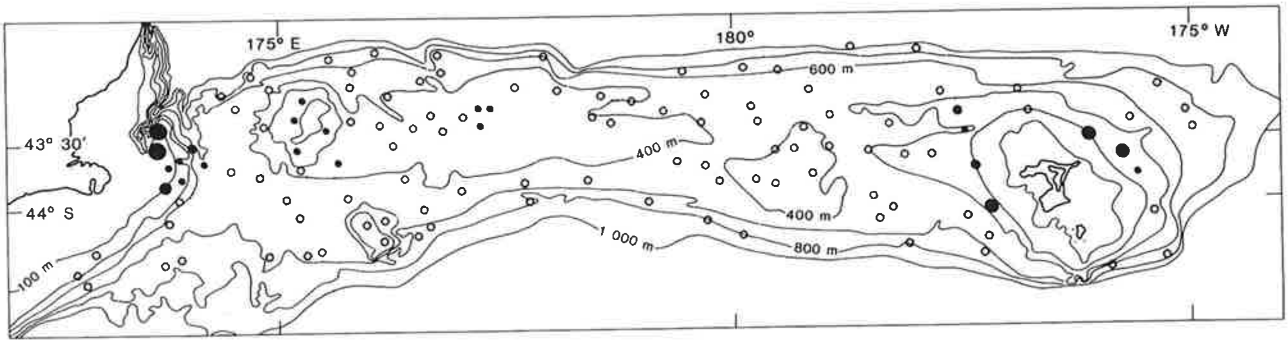


Figure 26: Tarakihi catch rates (*see* key on page 19).

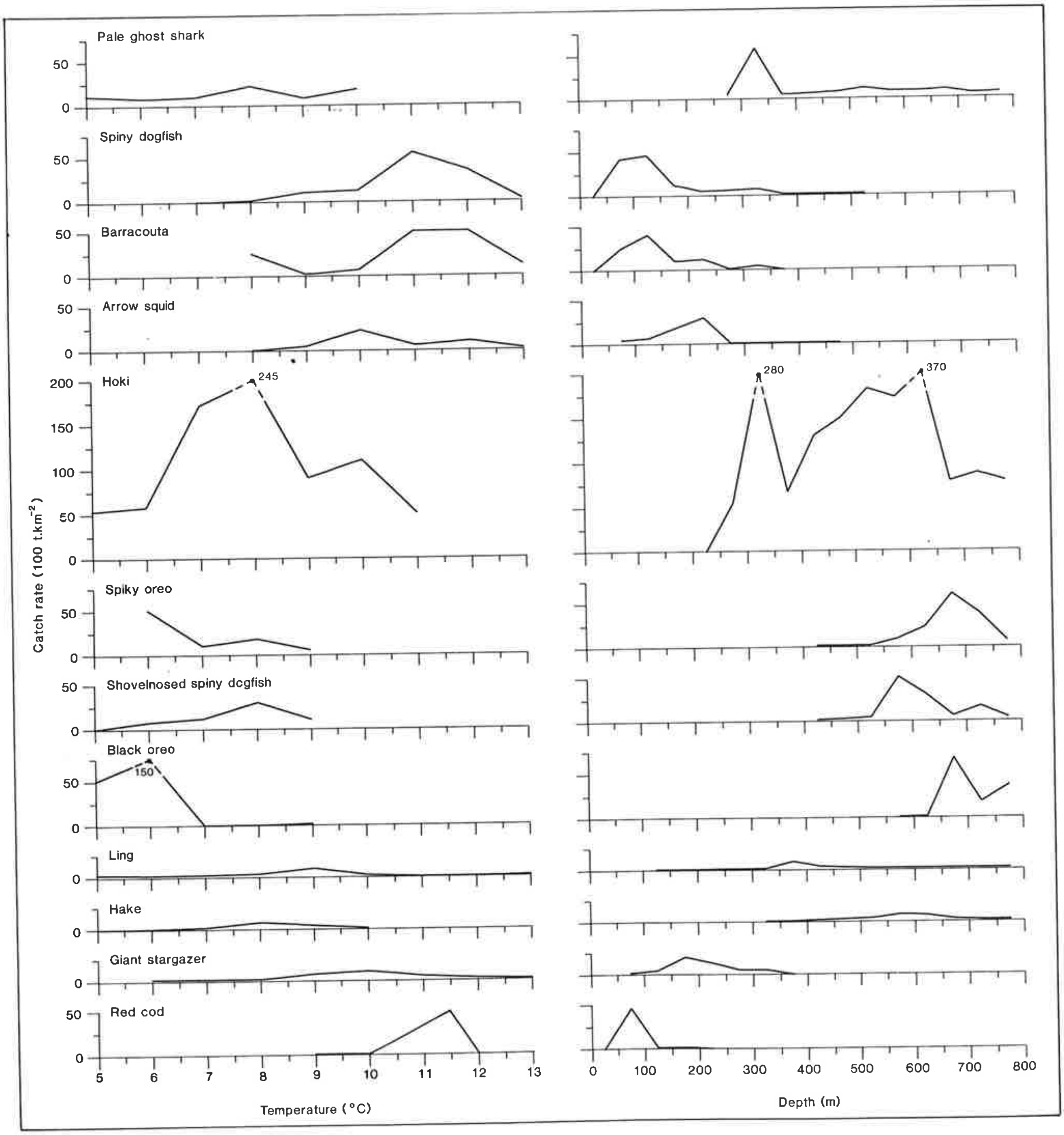


Figure 27: Catch rates of the major species by temperature and depth.

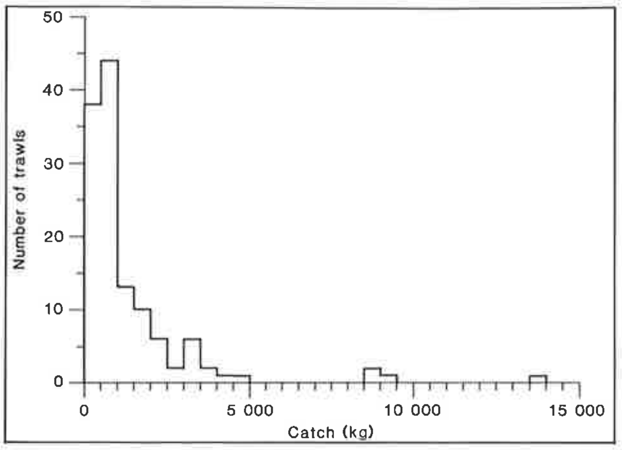


Figure 28: Catch frequency of hoki by trawl.

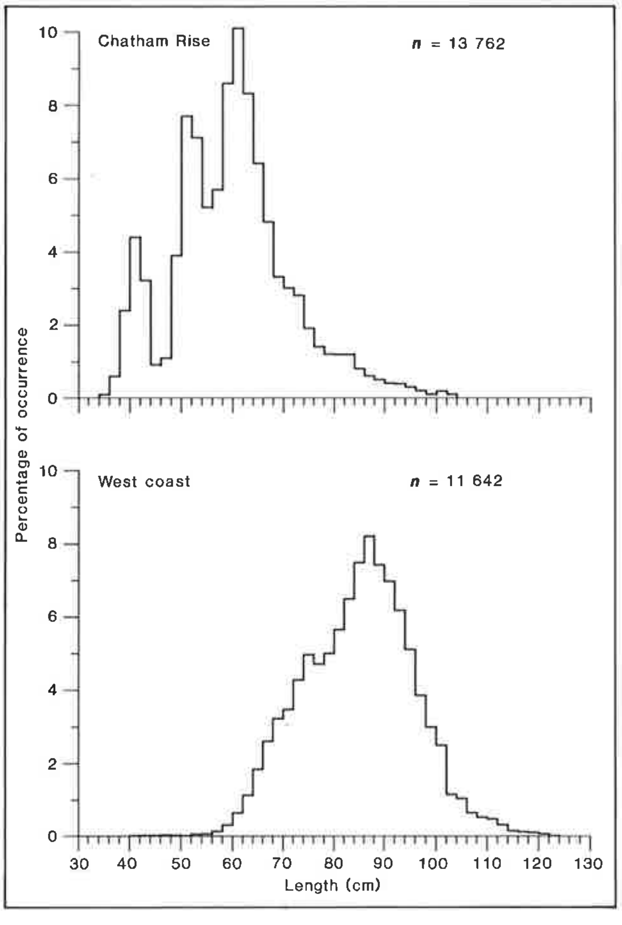


Figure 29: Length-frequency distribution of hoki from the Chatham Rise and the west coast spawning population.

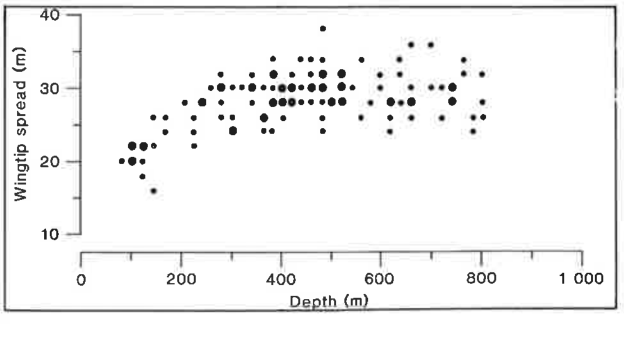


Figure 30: Wingtip spread by depth.

Biological observations

Biological data were collected for the major commercial species (Table 6). When possible, at least 20 fish were sampled for each station. The infestation of barracouta flesh by the cestode *Gymnorhynchus thyrsitae* was investigated for possible stock separation purposes. Additional information was collected for arrow squid, mainly female maturation, based on observations of the gonad, oviduct, and nidamental gland. Species for which sufficient information was collected are discussed below. (This biological information is held on computer file at the Fisheries Research Centre (New Zealand) and at the Far Seas Fisheries Research Laboratory (Japan).)

Hoki

All hoki examined were sexually immature and, with only one exception, were either in an undeveloped or, in the case of older fish, a resting gonad state. The ratio of males to females was about 2 : 3. The linear correlation between gonad weight for both sexes and the size and weight of the fish is shown in Figure 31.

Hoki stomachs contained various prawns (including mysid shrimps and cumaceans), salps, amphipods, isopods, and fish (mainly myctophids, but also rattails, javelin fish, silverside (*Argentina elongata*), and small morid cods).

Arrow squid

The ratio of males to females was 45 : 55. Most females greater than 30 cm ML had completed copulation (Figure 32). A mean mantle length of 28.7 cm was recorded for copulated females from both biological measurements and general length-frequency data.

Positive correlations were obtained between gonad weight and body weight for male and female squid (Figure 33) and between nidamental gland weight (also an index of maturity) and body weight and mantle length (Figure 34).

Table 6: Species sampled for biological observations

Species	No. of specimens
Hoki	525
Arrow squid	120
Barracouta	79
Silver warehou	80
Lookdown dory	20
Alfonsino	20
Tarakihi	20
Hake	35
Ling	40
Orange roughy	40
White warehou	20
Spiky oreo	20
Black oreo	80

Of the male squid, 51% were immature (i.e., they had small testes and empty spermatophoric sacs), and 49% were maturing. Of the female squid, 68% were immature, 8% were developing (eggs forming and the nidamental gland opaque), and 24% were mature (eggs in the oviduct and a large white nidamental gland).

About 48% of the stomachs contained food. Fish were found in 35% of non-empty stomachs, squid in 30%, and crustacea in 28%. Most food items occurred in stomachs of squid throughout the size range, but crustacea were found only in squid less than 26 cm ML.

Barracouta

The ratio of males to females was 1 : 1. The gonad stages of males ranged from immature to spent: 26% immature, 28% maturing, and 46% mature (running ripe or nearly spent). Females were either immature (65%) or maturing (35%). There was no apparent relationship between the size, weight, or gonad condition of these fish. Females from around the Chatham Islands were at a more advanced stage of gonad development.

Examination of the flesh for *G. thyrsitae* showed 69% of fish had some infestation and nearly 36% of these were heavily affected. Stomach contents were mainly squid, *Munida*, shrimps, and fish (most were small hoki, silver warehou, and myctophids).

Silver warehou

The ratio of males to females was 1 : 1. Most fish were immature or resting. Only 12.5% of females and 20.4% of males had begun to show any gonad development. No correlation was evident between gonad condition and size and weight of the fish. Salps were the dominant food item.

Black oreo

The ratio of males to females was 1 : 1. Most males (84%) were immature, about 15% were developing, and one spent fish was seen. More females were immature or undeveloped, and only two had any development of the ovary. Prey appeared to be diverse and included mysid shrimps, cumaceans, amphipods, and salps.

Hake

Some fish examined appeared to have recently spawned. Running ripe males were prevalent. Female gonad condition ranged from developing to nearly ripe.

Length-weight relationships

Length-weight relationships of some of the more important commercial species sampled are shown in Figure 35.

Size-frequency data

Size-frequency data were collected for 17 major species (Table 7).

Hoki were measured and usually sexed at almost every station. Length increased as bottom depth increased (Figure 36). There were modal peaks at about 40, 50, and 60 cm TL, which represented the 1+, 2+, and 3+ year classes (Fisheries Research Centre unpublished data). In 400–600 m there were still 50 and 60 cm peaks, but many more larger older fish. Hoki from the deepest stations (600–800 m) were mostly over 60 cm, in the 5+ year class, but modes were difficult to distinguish over 70 cm. As product recovery decreases to an uneconomic level for the smaller fish, particularly for hoki less than about 60 cm, this size stratification by depth may provide an important natural protection for the juvenile stock on the Chatham Rise.

For arrow squid there were three distinct modal groups at 12, 19, and 24 cm ML (Figure 37). These groups may represent different spawning cohorts. More of the 19 cm group appeared to be females; however, it was difficult to differentiate the sex of smaller squid by use of the hectocotylised arm, which at this stage had just begun to develop. Therefore, immature squid may have been recorded as females. Most mature squid (over 28 cm ML) were females. No males over 31 cm were taken, whereas females up to 38 cm were caught.

Size-frequency data for other species are shown in Figure 38. The prominent mode of 19 cm FL for silver warehou was composed of fish which were almost all taken around the slopes of the Mernoo Bank.

There was a wide range of lengths of ling and lookdown dory. Both species are slow growing, which makes it difficult to isolate any modal groups from these data.

A broad range of lengths was recorded for white warehou. However, the small sample size limited further analysis.

There was only one major size peak for black oreo, which is consistent with other surveys which have shown a distinct group of smaller black oreo at the shallower end of their depth range and the absence of larger fish, though a modal peak at 28 cm was recorded (P. J. McMillan pers. comm.). There were two modes for spiky oreo, which favour shallower waters than black oreo.

Table 7: Species collected for size-frequency data

Species	No. of times sampled	Total fish measured
Hoki	97	13 762
Silver warehou	13	1 090
Spiky oreo	8	890
Black oreo	6	785
Barracouta	11	716
Lookdown dory	6	596
Ling	13	557
Hake	12	417
Arrow squid	24	370
Silverside	2	262
Orange roughy	3	211
Tarakihi	3	210
Orange perch	1	165
White warehou	3	129
Red cod	1	107
Smooth oreo	1	47
Jack mackerel	1	37

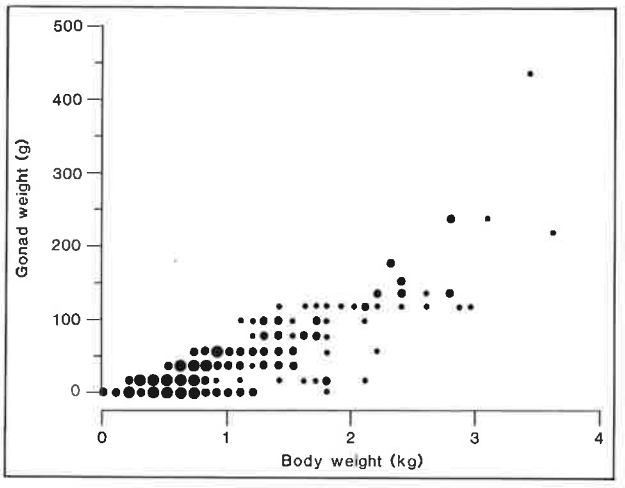


Figure 31: Hoki gonad weight plotted against body weight (males and females combined).

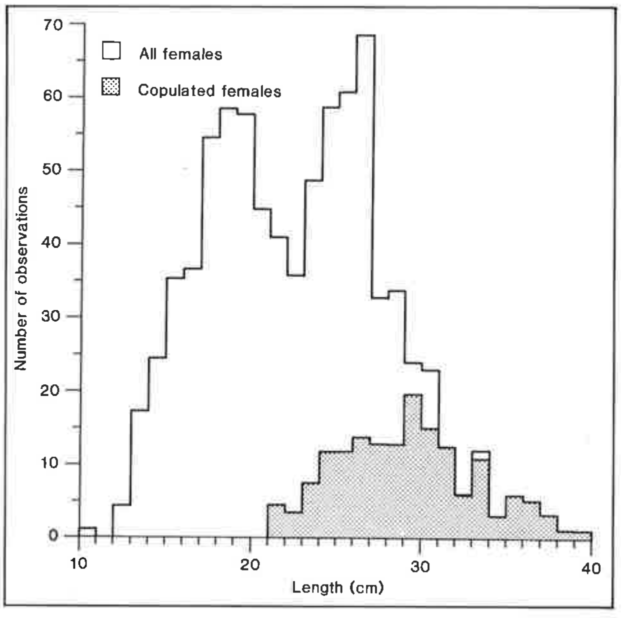


Figure 32: Length frequency of copulated and all female arrow squid.

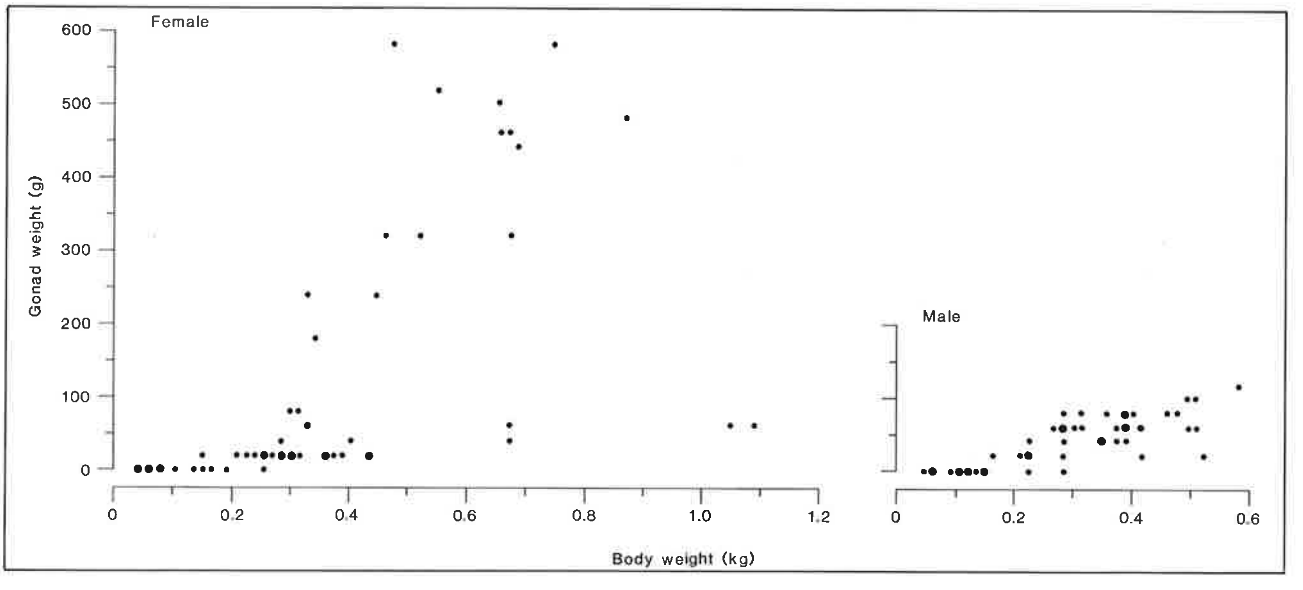


Figure 33: Arrow squid gonad weight plotted against body weight.

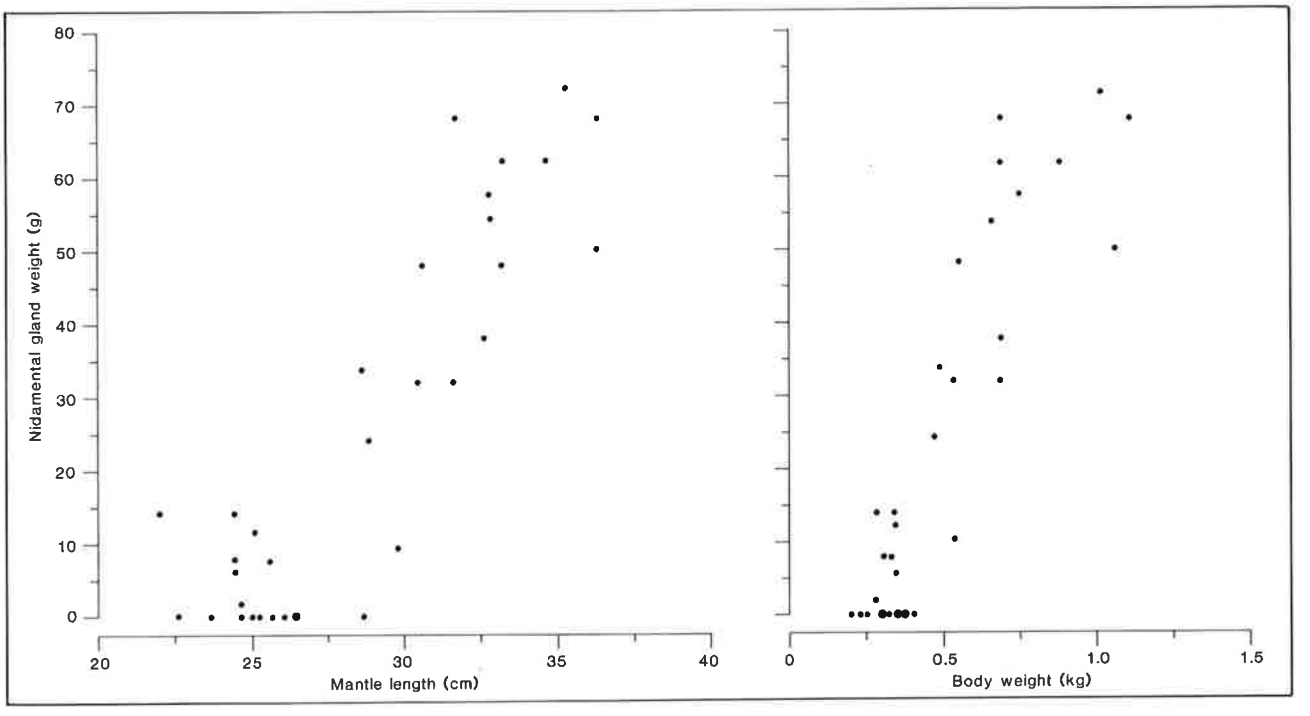


Figure 34: Arrow squid nidamental gland weight plotted against mantle length and body weight.

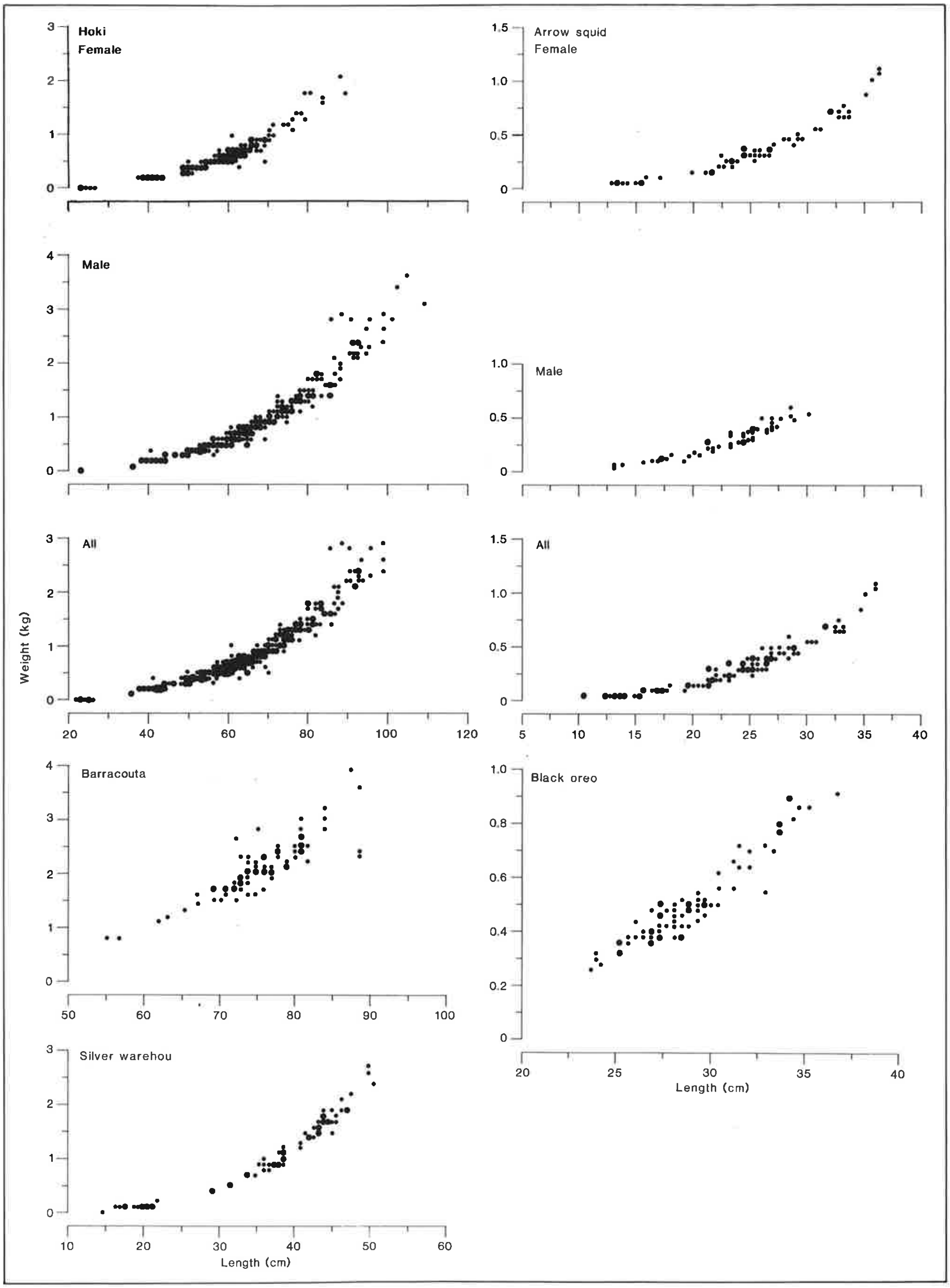


Figure 35: Length-weight relationships.

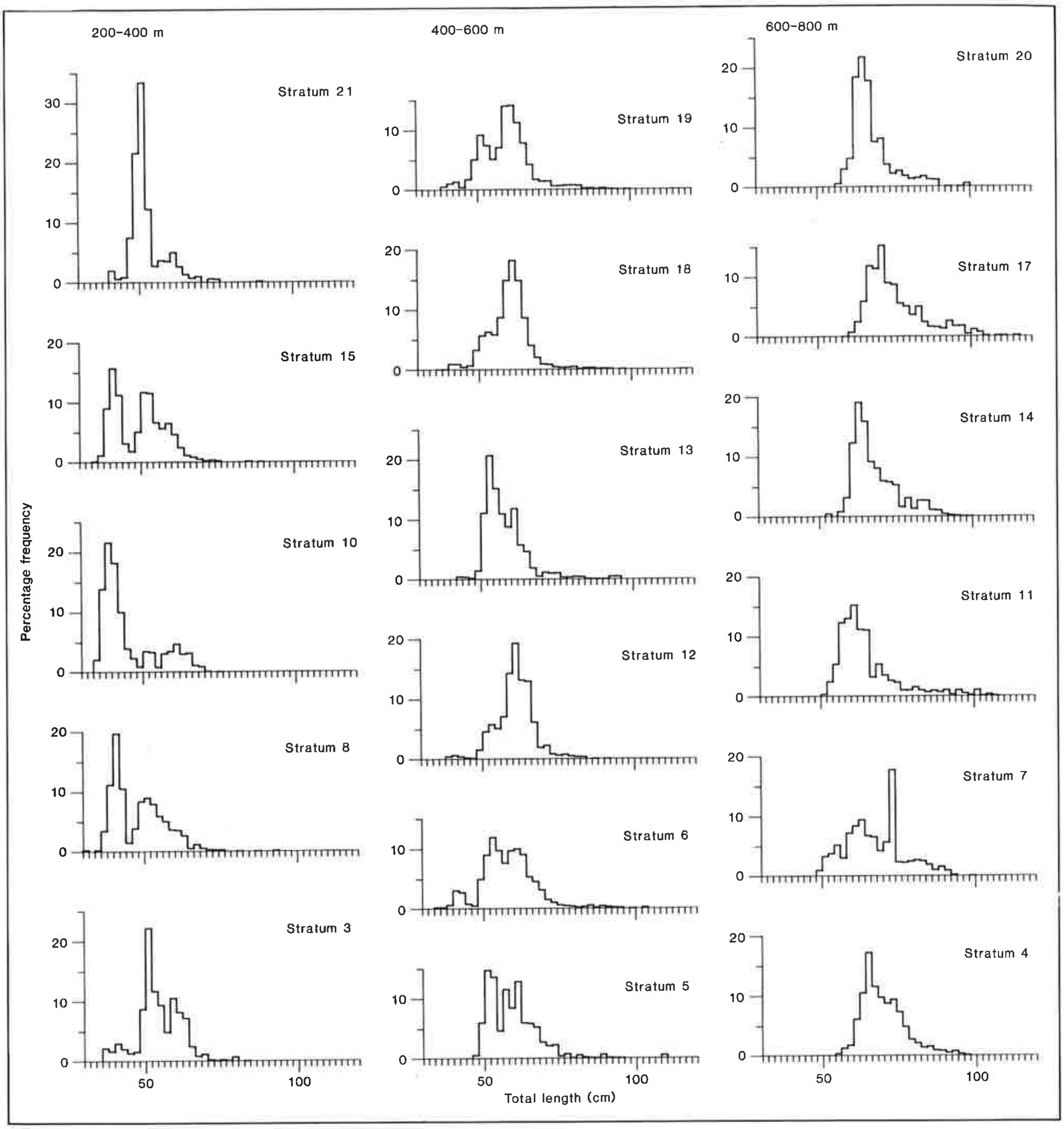


Figure 36: Hoki length frequency by depth.

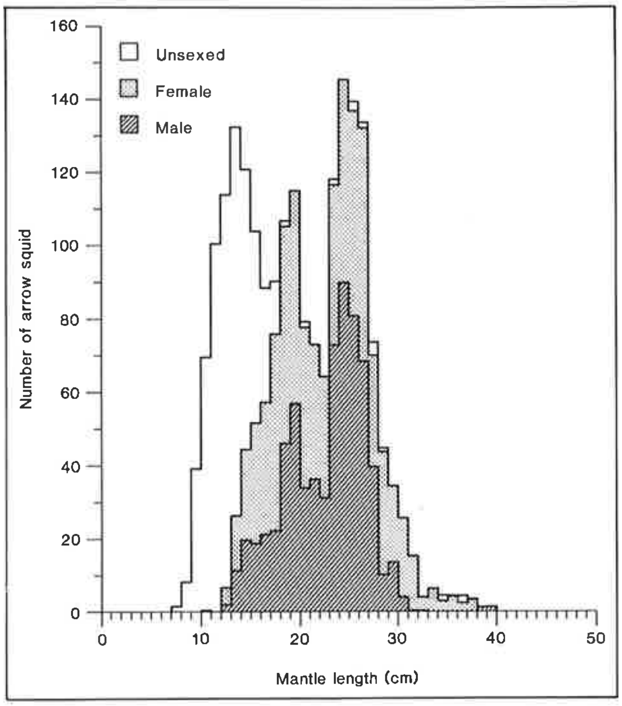


Figure 37: Arrow squid length frequency.

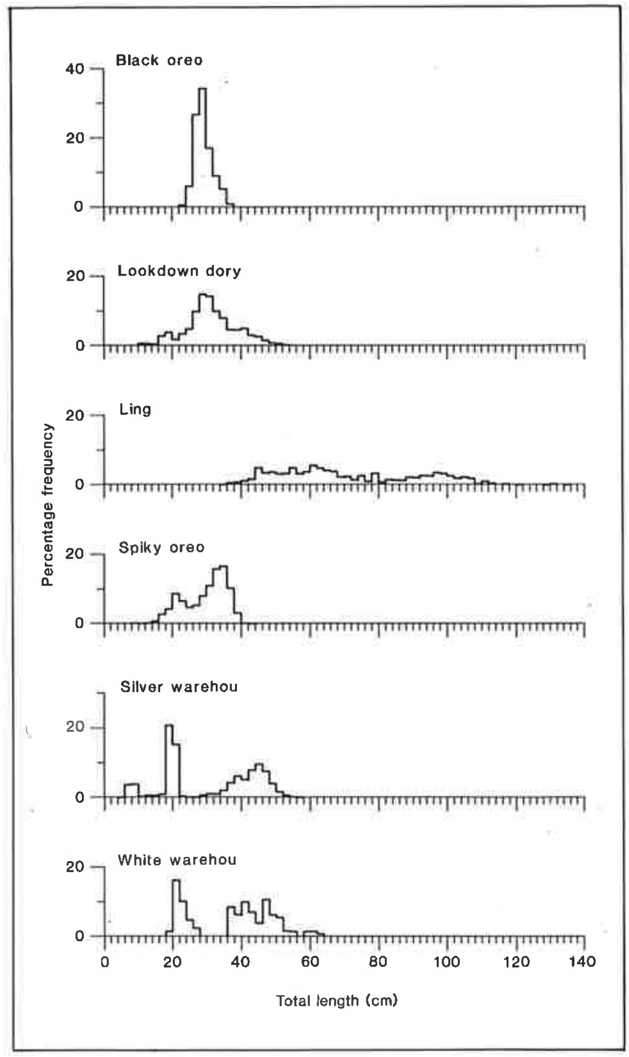


Figure 38: Length frequencies of other species.

Acknowledgments

We thank the following: the captain and crew of *Shinkai Maru*, A. Yatsu and M. Aizawa for assistance in data collection, and D. Esterman for the data analysis programs. The manuscript was critically appraised by D. A. Robertson, H. Hatanaka, P. J. McMillan, G. J. Patchell, and J. L. McKoy; their help is gratefully acknowledged.

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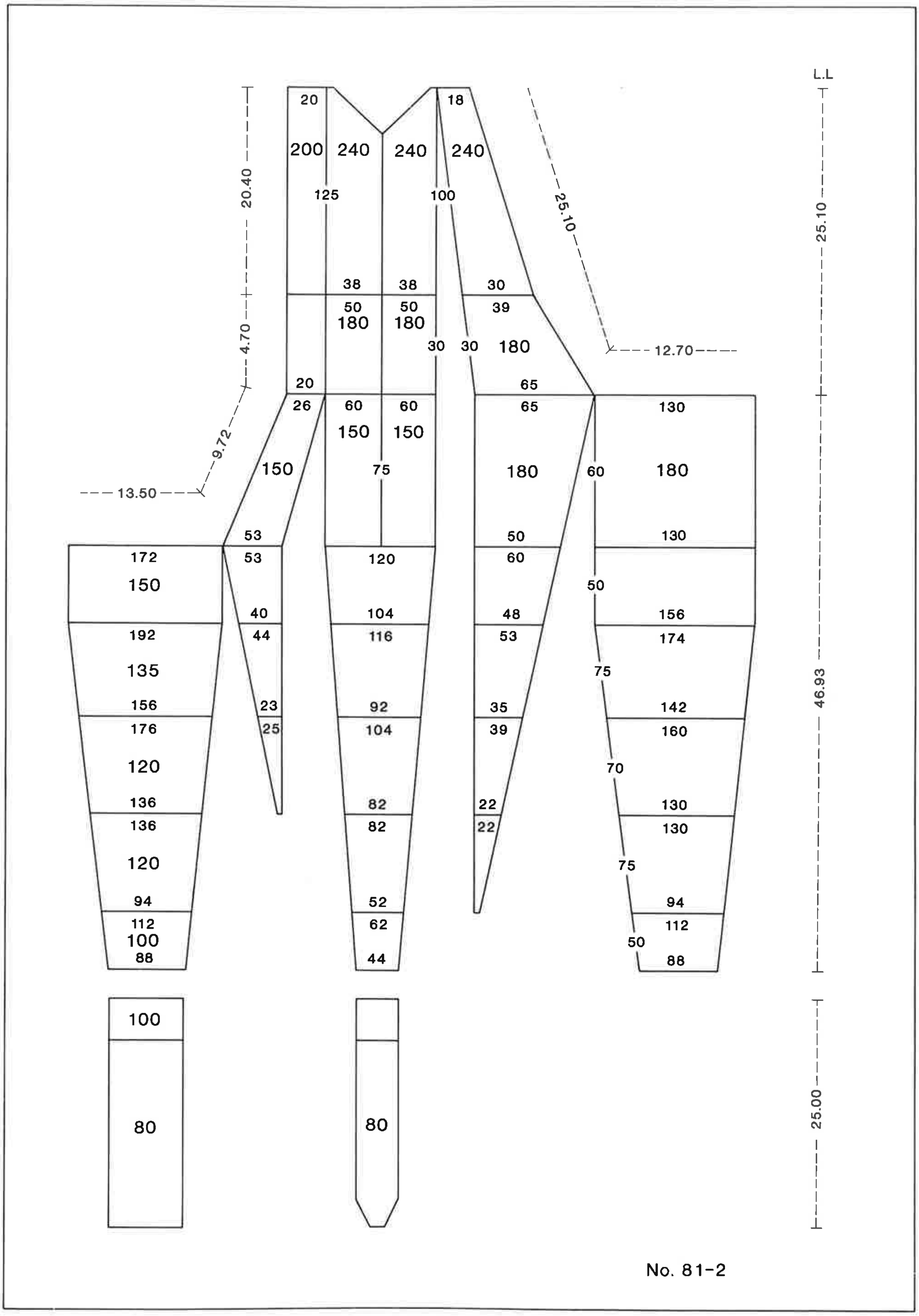
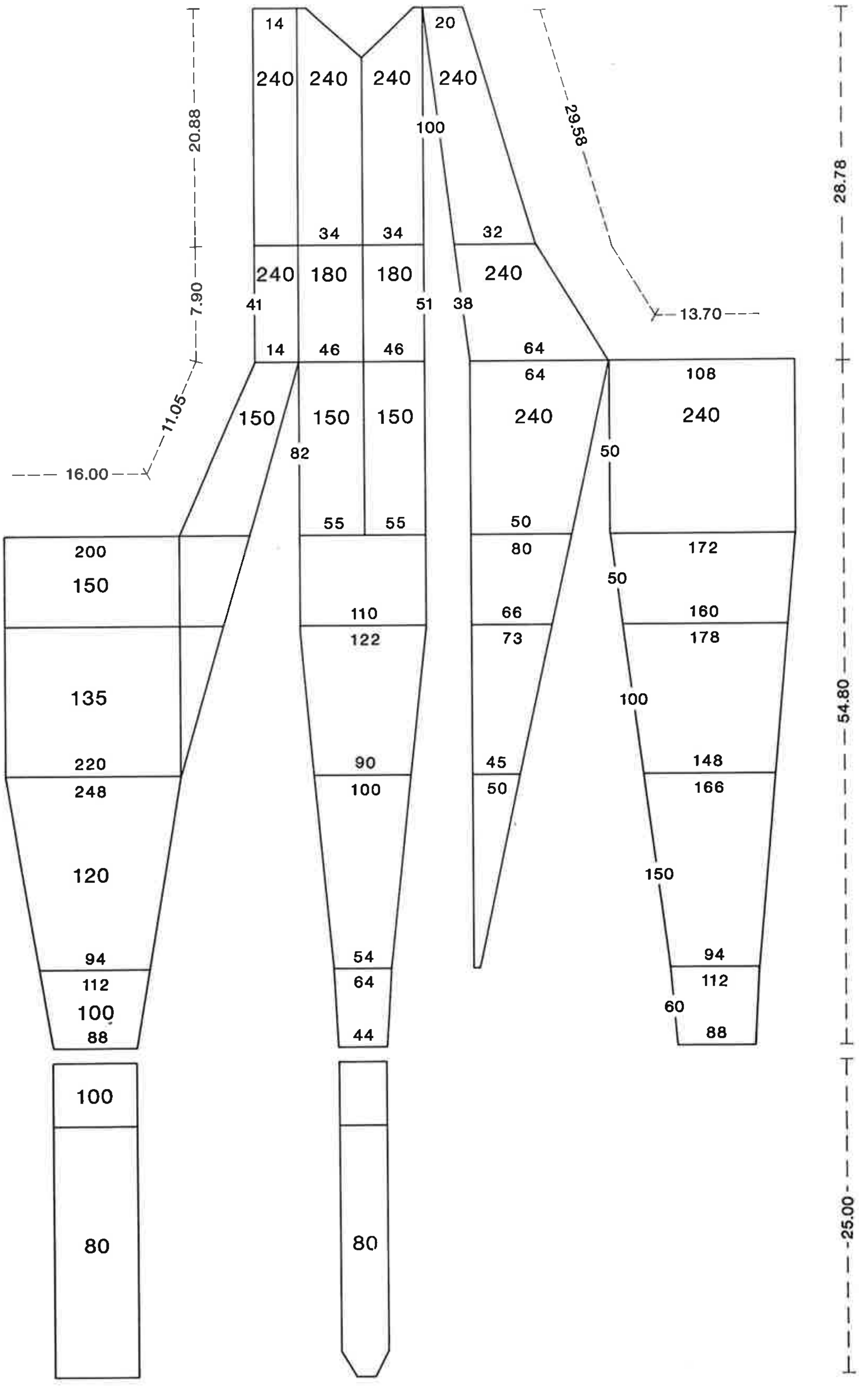
Appendix 1

Trawl net plans

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



Appendix 1—*continued*



No. 81–3

Appendix 2

The calculation of stratum area

Stratum areas were calculated by the following method. Digitised points from each stratum were converted to co-ordinates of latitude and longitude. The area of the stratum was then computed from its polyline representation (Roberts 1965). In general, for a closed polyline on n points (x_i, y_i), $i = 0, n - 1$, labelled clockwise around a polygonal boundary, the area of the polygon is:

$$\tfrac{1}{2} \sum_{i=1}^{n} (x_i y_{i+1} - x_{i+1} y_i)$$

where subscript calculations are modulo n. The formula can be proved by considering it to be the sum of signed areas of triangles, each having a vertex at the origin, or of parallelograms constructed by dropping perpendiculars from the polyline points to an axis.

Appendix 3

Fish species taken during the survey

Scientific name	Common name
Agnatha	
Eptatretidae	
Eptatretus cirrhatus	Hagfish
Elasmobranchii	
Cetorhinidae	
Cetorhinus maximus	Basking shark
Scyliorhinidae	
Apristurus spp.	Deepsea catshark
Cephaloscyllium isabella	Carpet shark
Halaelurus dawsoni	Dawson's catshark
Triakidae	
Mustelus lenticulatus	Rig
Carcharhinidae	
Galeorhinus galeus	School shark
Squalidae	
Centrophorus squamosus	Deepwater spiny dogfish
Centroscymnus crepidator	Deepwater dogfish
C. owstonii	Owston's spiny dogfish
C. plunketi	Plunket's dogfish
Deania calcea	Shovelnosed spiny dogfish
Etmopterus baxteri	Baxter's dogfish
E. lucifer	Lucifer dogfish
Oxynotus bruniensis	Prickly dogfish
Squalus acanthias	Spiny dogfish
S. blainvillei	Grey spiny dogfish
Dalatiidae	
Dalatias licha	Seal shark
Narkidae	
Typhlonarke aysoni	Blind electric ray
Rajidae	
Arhynchobatis asperrimus	Long-tailed skate
Pavoraja asperula	Deepsea skate
P. spinifera	Prickly deepsea skate
Raja innominata	Smooth skate
R. nasuta	Rough skate
Callorhinchidae	
Callorhynchus milii	Elephant fish
Chimaeridae	
Chimaera phantasma	Giant ghost shark
Hydrolagus novaezelandiae	Dark ghost shark
Hydrolagus sp.	Pale ghost shark
Rhinochimaeridae	
Harriotta raleighana	Long-nosed chimaera
Rhinochimaera pacifica	Wide-nosed chimaera
Teleostei	
Congridae	
Bassanago bulbiceps	Swollenheaded conger
Conger verreauxi	Conger eel
Halosauridae	
Halosaurus pectoralis	Halosaur
Notacanthidae	
Notacanthus sexspinis	Spineback
Argentinidae	
Argentina elongata	Silverside
Alepocephalidae	
Rouleina sp.	Slickhead
Gonorynchidae	
Gonorynchus gonorynchus	Sandfish
Chlorophthalmidae	
Chlorophthalmus nigripinnis	Cucumber fish
Paralepididae	
Magnisudis prionosa	Barracudina
Moridae	
Austrophycis marginata	Dwarf cod
Halargyreus johnsonii	Johnson's cod
Lepidion microcephalus	Smallheaded cod
Mora moro	Ribaldo
Pseudophycis bachus	Red cod
Tripterophycis gilchristi	Grenadier cod
Gadidae	
Micromesistius australis	Southern blue whiting
Merlucciidae	
Macruronus novaezelandiae	Hoki
Merluccius australis	Hake

Appendix 3—*continued*

Macrouridae	
Coelorinchus aspercephalus	Oblique banded rattail
C. biclinozonalis	Two banded rattail
C. bollonsi	Big-eye rattail
C. fasciatus	Banded rattail
C. innotabilis	Notable rattail
C. kaiyomaru	Kaiyo maru rattail
C. matamua	Mahia rattail
C. oliverianus	Short-nosed rattail
Coryphaenoides serrulatus	Rattail
Coryphaenoides sp.	Long barbel rattail
Lepidorhynchus denticulatus	Javelin fish
Trachyrincus sp.	Unicorn rattail
Ophidiidae	
Genypterus blacodes	Ling
Trachichthyidae	
Hoplostethus atlanticus	Orange roughy
H. mediterraneus	Silver roughy
Paratrachichthys trailli	Common roughy
Berycidae	
Beryx splendens	Alfonsino
Zeidae	
Capromimus abbreviatus	Capro dory
Cyttus novaezelandiae	Silver dory
C. traversi	Lookdown dory
Oreosomatidae	
Allocyttus niger	Black oreo
Neocyttus rhomboidalis	Spiky oreo
Pseudocyttus maculatus	Smooth oreo
Macrorhamphosidae	
Centriscops humerosus	Blue banded bellowsfish
C. obliquus	Red banded bellowsfish
Notopogon lilliei	Crested bellowsfish
Scorpaenidae	
Helicolenus sp.	Sea perch
Triglidae	
Chelidonichthys kumu	Red gurnard
Lepidotrigla brachyoptera	Scaly gurnard
Hoplichthyidae	
Hoplichthys haswelli	Deepsea flathead
Congiopodidae	
Alertichthys blacki	Alert pigfish
Congiopodus leucopaecilus	Southern pigfish
Psychrolutidae	
Neophrynichthys angustus	Pale toadfish
N. latus	Dark toadfish

Percichthyidae	
Polyprion moeone	Bass
P. oxygeneios	Hapuku
Serranidae	
Lepidoperca sp.	Orange perch
Apogonidae	
Epigonus lenimen	Big-eye cardinal fish
E. telescopus	Deepsea cardinal fish
Carangidae	
Trachurus spp.	Jack mackerel
Bramidae	
Brama brama	Ray's bream
Emmelichthyidae	
Emmelichthys nitidus	Redbait
Plagiogeneion rubiginosus	Ruby fish
Pentacerotidae	
Pseudopentaceros richardsoni	Southern boarfish
Cheilodactylidae	
Nemadactylus macropterus	Tarakihi
Latridae	
Latridopsis ciliaris	Moki
Latris lineata	Trumpeter
Mugiloididae	
Parapercis colias	Blue cod
P. gilliesi	Weever
Percophidae	
Hemerocoetes sp.	Opalfish
Uranoscopidae	
Kathetostoma giganteum	Giant stargazer
Gempylidae	
Rexea solandri	Southern kingfish
Thyrsites atun	Barracouta
Trichiuridae	
Lepidopus caudatus	Frostfish
Centrolophidae	
Centrolophus niger	Rudderfish
Hyperoglyphe antarctica	Bluenose
Icichthys australis	Ragfish
Seriolella brama	Common warehou
S. caerulea	White warehou
S. punctata	Silver warehou
Bothidae	
Arnoglossus scapha	Witch
Neoachiropsetta milfordi	Finless flounder
Pleuronectidae	
Pelotretis flavilatus	Lemon sole

Appendix 4

Catch summary

Species	Weight (kg)	% of total	Catch rate (t.km^{-2})
Hoki	139 305	55.3	12.78
Javelin fish	12 070	4.8	1.11
Pale ghost shark	9 641	3.8	0.88
Rattails	8 654	3.4	0.79
Shovelnosed spiny dogfish	7 977	3.2	0.73
Spiky oreo	7 670	3.0	0.70
Spiny dogfish	5 495	2.2	0.50
Black oreo	5 171	2.1	0.47
Ling	5 081	2.0	0.47
Basking shark	5 000	2.0	0.46
Barracouta	4 264	1.7	0.39
Hake	3 709	1.5	0.34
Arrow squid	3 565	1.4	0.33
Sea perch	3 349	1.3	0.31
Giant stargazer	3 213	1.3	0.29
Silver warehou	2 977	1.2	0.27
Lookdown dory	2 772	1.1	0.25
Alfonsino	2 040	0.8	0.19
Dark ghost shark	1 640	0.7	0.15
Red cod	1 473	0.6	0.13
Spineback	1 057	0.4	less than 0.10
Long-nosed chimaera	888	0.4	
Swollenheaded conger	780	0.3	
Tarakihi	779	0.3	
Plunket's dogfish	776	0.3	
Deepwater dogfish	763	0.3	
Squid (unspecified)	757	0.3	
Banded bellowsfish	756	0.3	
Silverside	723	0.3	
Ribaldo	710	0.3	
White warehou	675	0.3	
Skate (unspecified)	619	0.2	
Orange perch	545	0.2	
Baxter's dogfish	497	0.2	
Hapuku	454	0.2	
Lucifer dogfish	430	0.2	
Cardinal fish	398	0.2	
Owston's dogfish	389	0.2	
Silver dory	373	0.1	
Orange roughy	237	0.1	
School shark	233	0.1	
Seal shark	232	0.1	
Scampi	228	0.1	
Ray's bream	221	0.1	
Warty squid	216	0.1	
Toadfish (pale)	182	0.1	
Witch	181	0.1	
Bass	170	0.1	
Southern kingfish	161	0.1	
Smooth oreo	155	0.1	
Spiny flathead	151	0.1	
Common warehou	139	0.1	
Black slickhead	121		
Frostfish	115		
Blue cod	115		
Rubyfish	114		
Unicorn rattail	110		
Bluenose	108		
Smooth skate	105		
Dwarf cod	99		
Common roughy	92		
Crested bellowsfish	88		
Smallheaded cod	87		
Rudderfish	70		
Lemon sole	69		
Jack mackerel	66		
Octopus	60		
Capro dory	55		
Carpet shark	51		
Prickly dogfish	40		
Grey spiny dogfish	39		
Deepsea skate	39		
Silver roughy	37		
Umbrella octopus	37		
Wide-nosed chimaera	36		
Blind electric ray	34		
Rig	33		
Crab (unspecified)	31		
Trumpeter	29		
Johnson's cod	29		
Southern boarfish	28		
Moki	23		
Red gurnard	20		
Finless flounder	19		
Dawson's catshark	14		
Weever	14		
Deepwater spiny dogfish	13		
Giant ghost shark	13		
Deepsea catshark	12		
Conger eel	11		
Southern spider crab	10		
Southern pigfish	9		
Halosaur	8		
Ragfish	8		
Barracudina	7		
Scaly gurnard	6		
Hagfish	5		
Redbait	4		
Elephant fish	4		
Pale toadfish	3		
Sandfish	2		
Southern blue whiting	2		
Lucifer dogfish	2		
Shark (unidentified)	2		
Cucumber fish	2		
Cod (unidentified)	1		
Alert pigfish	1		

Total catch	252 103 kg
Total distance trawled	385.40 km
Total catch rate	654.1 t.km^{-2}

Appendix 5

Mean catch rates (t.km^{-2}) and standard deviations for the 10 major species and all others by stratum*

	Area	No. of	Species†											
Stratum	(km²)	stations	HOK	JAV	GSP	RAT	SND	SOR	SPD	BOE	LIN	BAR	Other	Total
1	768	4	0.00	0.00	0.00	0.00	0.00	0.00	2.97	0.00	0.00	2.97	9.19	15.13
			(0.00)‡	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(1.19)	(0.00)	(0.01)	(2.73)	(7.85)	(9.24)
2	989	4	0.00	0.00	0.00	0.00	0.00	0.00	8.81	0.00	0.01	6.15	3.99	18.96
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(5.10)	(0.00)	(0.02)	(5.33)	(2.28)	(4.36)
3	1 358	4	37.19	0.34	0.84	0.47	0.00	0.00	2.80	0.00	0.41	1.34	22.56	65.94
			(59.67)	(0.47)	(1.67)	(0.43)	(0.00)	(0.00)	(0.95)	(0.00)	(0.36)	(2.23)	(33.95)	(94.27)
4	2 071	4	37.55	2.06	0.60	0.85	4.32	0.87	0.00	0.00	0.40	0.00	3.12	49.77
			(41.82)	(2.36)	(0.31)	(0.68)	(2.93)	(0.84)	(0.00)	(0.00)	(0.13)	(0.00)	(1.68)	(49.09)
5	3 869	4	41.59	1.72	1.01	1.21	1.80	0.14	0.00	0.00	0.38	0.00	2.57	50.42
			(41.66)	(1.62)	(0.76)	(1.17)	(0.81)	(0.28)	(0.00)	(0.00)	(0.17)	(0.00)	(0.50)	(38.87)
6	11 346	8	19.06	0.70	1.04	1.93	0.43	0.04	0.16	0.00	0.36	0.00	2.28	25.99
			(11.57)	(0.35)	(0.67)	(1.05)	(0.51)	(0.12)	(0.21)	(0.00)	(0.26)	(0.00)	(1.30)	(10.61)
7	7 957	5	7.93	1.96	1.34	1.55	0.08	4.65	0.00	7.56	0.33	0.00	2.46	27.87
			(7.46)	(1.37)	(0.30)	(1.04)	(0.09)	(6.12)	(0.01)	(11.38)	(0.28)	(0.00)	(1.22)	(14.21)
8	5 584	4	8.20	0.08	0.00	0.28	0.00	0.00	0.57	0.00	0.04	0.06	5.85	15.08
			(4.18)	(0.09)	(0.00)	(0.20)	(0.00)	(0.00)	(0.40)	(0.00)	(0.04)	(0.06)	(3.85)	(5.72)
9	2 456	4	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.07	2.32	5.62	9.55
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(2.14)	(0.00)	(0.14)	(1.98)	(6.19)	(7.23)
10	1 248	4	15.92	0.00	10.61	0.45	0.00	0.00	2.33	0.00	0.14	0.00	5.91	35.35
			(25.38)	(0.00)	(21.21)	(0.59)	(0.00)	(0.00)	(2.81)	(0.00)	(0.18)	(0.00)	(4.83)	(42.87)
11	3 704	4	59.41	3.41	0.44	0.35	10.07	2.30	0.00	0.00	0.70	0.00	4.92	81.60
			(65.62)	(3.34)	(0.21)	(0.26)	(8.84)	(2.08)	(0.00)	(0.00)	(0.41)	(0.00)	(1.76)	(65.34)
12	7 120	4	27.85	1.50	0.77	0.79	0.05	0.00	0.00	0.00	0.57	0.00	3.22	34.75
			(17.53)	(1.22)	(0.55)	(0.60)	(0.06)	(0.00)	(0.01)	(0.00)	(0.17)	(0.00)	(0.97)	(18.26)
13	12 279	8	11.16	1.11	1.41	1.62	0.11	0.05	0.02	0.00	0.47	0.00	3.21	19.15
			(11.27)	(0.79)	(0.98)	(1.28)	(0.20)	(0.09)	(0.02)	(0.00)	(0.11)	(0.00)	(1.62)	(12.64)
14	5 419	4	11.77	1.24	1.23	1.07	0.06	7.38	0.00	3.38	0.25	0.00	3.02	29.40
			(9.27)	(0.70)	(0.23)	(0.78)	(0.09)	(9.45)	(0.00)	(4.07)	(0.15)	(0.00)	(0.93)	(12.39)
15	19 276	14	10.31	0.78	0.27	1.47	0.00	0.00	0.10	0.00	0.43	0.02	4.98	18.36
			(8.68)	(0.98)	(0.53)	(1.85)	(0.00)	(0.00)	(0.12)	(0.00)	(0.47)	(0.05)	(3.90)	(9.65)
16	1 145	3	0.00	0.00	0.00	0.14	0.00	0.00	0.28	0.00	0.12	0.50	11.59	12.63
			(0.00)	(0.00)	(0.00)	(0.19)	(0.00)	(0.00)	(0.13)	(0.00)	(0.21)	(0.41)	(5.50)	(5.68)
17	10 482	7	2.51	3.00	0.35	0.45	1.51	1.37	0.00	0.01	0.28	0.00	3.71	13.19
			(1.14)	(1.65)	(0.31)	(0.14)	(1.17)	(0.89)	(0.00)	(0.02)	(0.19)	(0.00)	(1.65)	(3.44)
18	10 838	9	5.33	1.00	0.38	0.43	0.10	0.01	0.02	0.00	0.33	0.00	2.91	10.51
			(2.94)	(0.63)	(0.28)	(0.26)	(0.28)	(0.03)	(0.06)	(0.00)	(0.29)	(0.00)	(1.34)	(3.22)
19	17 190	14	9.20	1.17	0.76	0.63	0.02	0.01	0.04	0.00	0.46	0.00	2.44	14.74
			(8.25)	(1.38)	(0.33)	(0.36)	(0.03)	(0.05)	(0.10)	(0.00)	(0.22)	(0.01)	(1.26)	(8.80)
20	6 160	5	9.48	1.67	0.30	0.46	0.94	2.38	0.00	2.77	0.19	0.00	3.29	21.48
			(14.70)	(0.87)	(0.27)	(0.18)	(0.74)	(3.72)	(0.00)	(6.08)	(0.22)	(0.00)	(1.93)	(13.99)
21	12 320	9	1.55	0.23	0.19	0.13	0.00	0.00	0.00	0.00	1.58	0.92	2.82	7.43
			(2.32)	(0.27)	(0.38)	(0.11)	(0.00)	(0.00)	(0.00)	(0.00)	(4.36)	(2.06)	(1.58)	(5.37)

* Net width calculated for each station: minimum = 16.6 m, mean = 28.3 m, maximum = 37.7 m. Distance towed ranged from 1.0 to 2.6 n. miles, mean 1.6 n. miles.

† Species codes are given in Table 4.

‡ Standard deviations are in parentheses.

Appendix 6

Mean catch rates (t.km^{-2}) and standard deviations for 10 other major species by stratum*

Stratum	Area (km²)	No. of stations	Species†											
			HAK	ASQ	SPE	STA	SWA	LDO	BYX	GSH	RCO	SBK	TAR	Total
1	768	4	0.00	0.26	0.33	0.57	0.16	0.00	0.00	0.00	4.42	0.00	1.72	7.47
			(0.00)‡	(0.15)	(0.64)	(0.30)	(0.24)	(0.00)	(0.00)	(0.00)	(8.84)	(0.00)	(2.59)	(8.41)
2	989	4	0.00	0.38	0.61	0.44	0.11	0.00	0.00	0.47	0.13	0.00	0.22	2.37
			(0.00)	(0.16)	(0.99)	(0.42)	(0.17)	(0.00)	(0.00)	(0.93)	(0.26)	(0.00)	(0.39)	(1.68)
3	1 358	4	0.00	2.34	0.00	0.22	0.23	0.16	0.00	0.93	0.27	0.00	0.04	4.19
			(0.00)	(4.23)	(0.00)	(0.28)	(0.26)	(0.16)	(0.00)	(0.66)	(0.20)	(0.00)	(0.08)	(3.90)
4	2 071	4	0.25	0.00	0.08	0.10	0.00	0.16	0.00	0.00	0.00	0.10	0.00	0.69
			(0.13)	(0.00)	(0.11)	(0.12)	(0.00)	(0.22)	(0.00)	(0.00)	(0.00)	(0.12)	(0.00)	(0.48)
5	3 869	4	0.59	0.05	0.23	0.05	0.08	0.33	0.00	0.00	0.01	0.00	0.00	1.35
			(0.54)	(0.09)	(0.13)	(0.04)	(0.13)	(0.13)	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.30)
6	11 346	8	0.37	0.09	0.14	0.14	0.24	0.24	0.00	0.00	0.01	0.11	0.00	1.34
			(0.45)	(0.11)	(0.07)	(0.12)	(0.53)	(0.13)	(0.00)	(0.00)	(0.02)	(0.12)	(0.01)	(0.86)
7	7 957	5	0.23	0.00	0.03	0.06	0.00	0.09	0.00	0.00	0.00	0.41	0.00	0.83
			(0.17)	(0.00)	(0.04)	(0.08)	(0.00)	(0.10)	(0.00)	(0.00)	(0.00)	(0.46)	(0.00)	(0.68)
8	5 584	4	0.03	0.44	0.33	0.75	2.81	0.07	0.00	0.79	0.05	0.00	0.01	5.26
			(0.03)	(0.48)	(0.21)	(0.80)	(4.04)	(0.07)	(0.00)	(0.71)	(0.05)	(0.00)	(0.01)	(3.64)
9	2 456	4	0.00	2.18	0.11	0.97	0.87	0.00	0.00	0.00	0.11	0.00	0.08	4.33
			(0.00)	(3.02)	(0.14)	(1.09)	(1.66)	(0.00)	(0.00)	(0.00)	(0.22)	(0.00)	(0.04)	(5.82)
10	1 248	4	0.05	2.69	0.09	1.07	0.94	0.06	0.00	0.01	0.02	0.00	0.00	4.93
			(0.10)	(4.65)	(0.16)	(0.44)	(1.60)	(0.10)	(0.00)	(0.01)	(0.03)	(0.00)	(0.00)	(4.81)
11	3 704	4	1.84	0.00	0.24	0.08	0.00	0.29	0.00	0.00	0.00	0.06	0.00	2.52
			(1.26)	(0.00)	(0.20)	(0.10)	(0.00)	(0.23)	(0.00)	(0.00)	(0.00)	(0.02)	(0.00)	(1.70)
12	7 120	4	0.72	0.01	0.78	0.09	0.10	0.36	0.02	0.06	0.00	0.10	0.00	2.24
			(0.63)	(0.02)	(0.52)	(0.16)	(0.11)	(0.31)	(0.03)	(0.11)	(0.00)	(0.09)	(0.00)	(0.74)
13	12 279	8	0.52	0.01	0.41	0.04	0.16	0.55	0.00	0.00	0.00	0.31	0.00	1.99
			(0.49)	(0.01)	(0.16)	(0.04)	(0.29)	(0.47)	(0.00)	(0.00)	(0.00)	(0.31)	(0.00)	(0.85)
14	5 419	4	0.14	0.00	0.09	0.07	0.00	0.70	0.00	0.00	0.00	0.44	0.00	1.44
			(0.07)	(0.01)	(0.06)	(0.13)	(0.00)	(0.81)	(0.00)	(0.00)	(0.00)	(0.16)	(0.00)	(1.12)
15	19 276	14	0.41	0.09	0.93	0.51	0.26	0.18	1.21	0.42	0.06	0.04	0.00	4.12
			(0.77)	(0.08)	(0.91)	(1.05)	(0.38)	(0.21)	(3.91)	(0.40)	(0.12)	(0.11)	(0.01)	(3.85)
16	1 145	3	0.00	3.30	0.98	1.63	0.64	0.00	0.00	1.80	0.01	0.00	0.03	8.39
			(0.00)	(5.10)	(1.03)	(0.65)	(0.41)	(0.00)	(0.00)	(1.38)	(0.01)	(0.00)	(0.03)	(5.82)
17	10 482	7	0.35	0.00	0.08	0.03	0.00	0.15	0.01	0.08	0.00	0.14	0.00	0.84
			(0.24)	(0.00)	(0.07)	(0.05)	(0.00)	(0.13)	(0.03)	(0.20)	(0.00)	(0.15)	(0.00)	(0.36)
18	10 838	9	0.65	0.03	0.19	0.09	0.14	0.58	0.05	0.00	0.00	0.02	0.00	1.75
			(0.42)	(0.04)	(0.14)	(0.15)	(0.25)	(0.30)	(0.05)	(0.00)	(0.00)	(0.03)	(0.00)	(0.78)
19	17 190	14	0.18	0.06	0.23	0.23	0.34	0.44	0.11	0.00	0.01	0.06	0.00	1.64
			(0.22)	(0.07)	(0.14)	(0.27)	(1.03)	(0.18)	(0.19)	(0.00)	(0.02)	(0.08)	(0.00)	(1.16)
20	6 160	5	0.15	0.00	0.04	0.05	0.00	0.10	0.02	0.00	0.00	0.26	0.00	0.62
			(0.17)	(0.00)	(0.04)	(0.05)	(0.00)	(0.11)	(0.05)	(0.00)	(0.00)	(0.19)	(0.00)	(0.37)
21	12 320	9	0.00	0.32	0.13	0.52	0.03	0.06	0.02	0.00	0.03	0.00	0.27	1.37
			(0.01)	(0.60)	(0.16)	(0.51)	(0.05)	(0.06)	(0.05)	(0.00)	(0.06)	(0.00)	(0.34)	(0.64)

* Net width calculated for each station: minimum = 16.6 m, mean = 28.3 m, maximum = 37.7 m. Distance towed ranged from 1.0 to 2.6 n. miles, mean 1.6 n. miles.

† Species codes are given in Table 4.

‡ Standard deviations are in parentheses.

Appendix 7

Biomass estimates (t) by stratum*

Stratum	Area (km²)	No. of stations	HOK	JAV	GSP	RAT	SND	SOR	SPD	BOE	LIN	BAR	Other	Species† Total
1	768	4	0	0	0	0	0	0	2 283	0	3	2 279	7 057	11 621
2	989	4	0	0	0	0	0	0	8 711	0	8	6 084	3 951	18 754
3	1 358	4	50 506	458	1 135	643	0	0	3 802	0	551	1 824	30 633	89 551
4	2 071	4	77 757	4 270	1 241	1 759	8 946	1 809	0	0	822	0	6 468	103 070
5	3 869	4	160 904	6 655	3 923	4 674	6 973	534	0	0	1 484	0	9 938	195 085
6	11 346	8	216 238	7 941	11 784	21 885	4 823	493	1 777	0	4 086	0	25 844	294 871
7	7 957	5	63 072	15 615	10 651	12 365	628	37 023	37	60 136	2 627	0	19 604	221 758
8	5 584	4	45 782	451	0	1 539	0	0	3 205	0	237	313	32 681	84 208
9	2 456	4	0	0	0	0	0	0	3 784	0	170	5 705	13 802	23 462
10	1 248	4	19 871	0	13 236	562	0	0	2 902	0	169	0	7 376	44 116
11	3 704	4	220 039	12 648	1 630	1 289	37 300	8 512	0	0	2 606	0	18 221	302 246
12	7 120	4	198 283	10 708	5 508	5 608	338	0	19	0	4 078	0	22 894	247 437
13	12 279	8	136 987	13 638	17 361	19 880	1 325	639	199	0	5 717	0	39 364	235 111
14	5 419	4	63 792	6 734	6 655	5 809	351	39 976	0	18 316	1 355	0	16 347	159 336
15	19 276	14	198 711	14 953	5 220	28 419	0	0	2 023	0	8 371	314	95 966	353 977
16	1 145	3	0	0	0	159	0	0	321	0	137	576	13 266	14 459
17	10 482	7	26 291	31 451	3 719	4 691	15 777	14 387	0	81	2 974	0	38 844	138 216
18	10 838	9	57 735	10 851	4 110	4 683	1 121	125	233	0	3 522	0	31 520	113 902
19	17 190	14	158 226	20 074	13 048	10 788	260	209	756	0	7 947	30	41 972	253 311
20	6 160	5	58 412	10 276	1 849	2 827	5 788	14 655	0	17 077	1 171	0	20 284	132 339
21	12 320	9	19 111	2 877	2 325	1 594	0	0	0	0	19 524	11 394	34 708	91 533
	143 579	126												

Stratum	Area (km²)	No. of stations	HAK	ASQ	SPE	STA	SWA	LDO	BYX	GSH	RCO	SBK	TAR	Species Total
1	768	4	0	201	253	439	121	0	0	0	3 398	0	1 322	5 735
2	989	4	0	380	606	440	105	0	0	460	128	0	222	2 341
3	1 358	4	0	3 180	3	303	319	214	0	1 258	360	0	51	5 687
4	2 071	4	515	0	157	214	0	333	4	0	0	206	0	1 429
5	3 869	4	2 292	180	907	195	322	1 279	0	0	38	0	0	5 213
6	11 346	8	4 189	1 077	1 617	1 566	2 720	2 710	0	0	74	1 277	22	15 252
7	7 957	5	1 862	0	272	473	0	752	0	0	0	3 251	0	6 610
8	5 584	4	142	2 434	1 847	4 198	15 675	370	0	4 404	285	0	35	29 389
9	2 456	4	0	5 350	281	2 382	2 147	0	0	0	282	0	186	10 629
10	1 248	4	60	3 360	108	1 335	1 174	70	0	16	30	0	0	6 152
11	3 704	4	6 798	0	898	311	0	1 089	3	0	0	220	0	9 319
12	7 120	4	5 115	96	5 521	610	689	2 581	164	451	0	731	0	15 957
13	12 279	8	6 363	78	5 005	477	1 975	6 715	0	0	0	3 842	0	24 455
14	5 419	4	769	27	503	360	0	3 781	0	0	0	2 366	0	7 807
15	19 276	14	7 971	1 651	17 926	9 918	4 993	3 448	23 240	8 182	1 177	841	39	79 386
16	1 145	3	0	3 776	1 124	1 866	728	0	0	2 065	9	0	35	9 604
17	10 482	7	3 718	0	868	276	0	1 614	103	796	0	1 430	0	8 804
18	10 838	9	7 010	370	2 085	928	1 475	6 323	540	0	6	184	0	18 920
19	17 190	14	3 057	963	3 959	3 910	5 803	7 546	1 862	0	107	1 066	0	28 272
20	6 160	5	904	0	227	330	0	634	141	0	0	1 611	0	3 847
21	12 320	9	36	3 975	1 577	6 375	329	690	278	0	372	0	3 293	16 925
	143 579	126												

* Net width calculated for each station: minimum = 16.6 m, mean = 28.3 m, maximum = 37.7 m. Distance towed ranged from 1.0 to 2.6 n. miles, mean 1.6 n. miles.

† Species codes are given in Table 4.

Appendix 8

Performance data for trawl stations

Trawl No.	Duration (h)	Depth (m)	Headline height (m)	Board spread (m)	Wingtip spread (m)	Observed speed*	Calculated speed†	Distance (n. mile)	Warp length (m)
1	0.50	716	10.0	100.0	22.2	2.5	2.6	1.3	1 300
2	0.50	611	9.5	119.0	26.4	3.8	3.8	1.9	1 100
3	0.50	493	8.5	127.8	28.4	4.8	4.8	2.4	950
4	0.41	300	9.5	107.8	23.9	3.6	4.4	1.8	600
5	0.50	164	9.0	120.5	26.8	3.2	3.2	1.6	400
6	0.50	386	9.0	110.6	24.6	3.6	3.6	1.8	750
7	0.50	293	10.0	109.1	24.2	3.2	3.2	1.6	600
8	0.35	122	9.5	94.0	20.9	4.2	4.3	1.5	300
9	0.50	124	8.0	93.7	18.5	3.8	3.8	1.9	280
10	0.50	369	10.0	0.0	23.7	3.4	3.6	1.8	722
11	0.50	131	9.0	84.3	16.6	4.2	4.2	2.1	272
12	0.50	478	8.0	150.9	29.8	3.0	3.0	1.5	900
13	0.50	744	10.0	151.8	30.0	3.0	2.8	1.4	1 350
14	0.50	616	10.0	112.3	24.9	3.6	3.6	1.8	1 088
15	0.50	551	9.0	151.0	33.5	3.2	3.2	1.6	950
16	0.38	461	10.0	0.0	28.4	2.6	2.6	1.0	818
17	0.50	576	9.0	129.8	28.8	3.8	3.8	1.9	1 050
18	0.50	306	10.0	120.2	26.7	2.4	2.4	1.2	600
19	0.50	100	10.0	88.0	19.5	3.6	3.6	1.8	250
20	0.50	86	10.0	94.2	20.9	3.6	3.6	1.8	236
21	0.50	95	9.0	97.0	21.5	4.4	4.4	2.2	250
22	0.50	104	10.0	92.6	20.6	3.2	3.2	1.6	250
23	0.50	277	9.0	129.3	28.7	3.4	3.4	1.7	600
24	0.50	95	9.0	101.5	22.5	3.2	3.2	1.6	250
25	0.50	131	10.0	101.0	22.4	3.4	3.2	1.6	300
26	0.50	92	10.0	86.5	19.2	3.4	3.4	1.7	239
27	0.50	322	9.5	135.3	30.0	2.6	2.6	1.3	650
28	0.50	438	10.0	134.5	29.9	3.2	3.2	1.6	850
29	0.50	127	10.0	96.8	21.5	3.2	3.2	1.6	318
30	0.50	218	9.0	99.3	22.0	3.6	3.6	1.8	500
31	0.38	476	8.5	111.2	24.7	3.1	3.4	1.3	950
32	0.41	727	8.0	131.6	29.2	3.6	3.7	1.5	1 300
33	0.50	737	9.0	132.4	29.4	3.8	3.8	1.9	1 265
34	0.50	555	8.0	118.5	26.3	3.3	3.2	1.6	1 017
35	0.50	487	9.0	151.7	33.7	3.2	3.2	1.6	950
36	0.50	461	9.0	128.4	28.5	3.4	3.4	1.7	917
37	0.41	515	9.0	125.5	27.9	3.0	3.2	1.3	950
38	0.50	618	8.0	129.8	28.8	2.9	2.8	1.4	1 150
39	0.50	703	7.0	161.8	35.9	3.0	3.0	1.5	1 300
40	0.50	667	9.0	121.2	26.9	2.6	2.6	1.3	1 180
41	0.50	522	9.0	140.5	31.2	3.3	3.4	1.7	922
42	0.50	363	8.0	131.0	29.1	3.2	3.2	1.6	750
43	0.50	126	9.0	101.3	22.5	3.2	3.2	1.6	340
44	0.50	284	8.0	112.7	25.0	2.8	2.8	1.4	600
45	0.50	155	10.0	108.3	24.0	3.1	3.0	1.5	350
46	0.45	696	9.0	139.0	30.9	3.1	3.3	1.5	1 300
47	0.50	664	9.5	129.1	28.7	2.8	2.8	1.4	1 200
48	0.50	548	10.0	139.1	30.9	3.0	3.0	1.5	1 000
49	0.65	480	8.0	130.3	28.9	3.2	2.5	1.6	950
50	0.50	518	9.0	132.6	29.4	2.9	3.8	1.9	950
51	0.50	780	9.5	108.4	24.1	3.2	3.2	1.6	1 350
52	0.50	525	9.0	136.6	30.3	2.8	2.8	1.4	1 000
53	0.63	488	8.0	116.0	25.8	3.2	2.5	1.6	950
54	0.50	654	9.0	132.1	29.3	3.3	3.4	1.7	1 200
55	0.50	457	10.0	126.3	28.5	3.0	3.0	1.5	867
56	0.50	407	10.0	123.5	27.4	3.2	3.2	1.6	750
57	0.50	418	9.5	133.2	29.6	3.1	3.0	1.5	900
58	0.58	791	9.0	121.4	27.0	2.7	2.8	1.6	1 450
59	0.58	514	9.5	133.0	29.5	2.7	2.8	1.6	918
60	0.80	333	9.0	140.1	31.1	3.6	2.3	1.8	680
61	0.58	388	8.0	127.2	28.2	2.8	2.8	1.6	800
62	0.96	363	10.0	115.9	25.7	3.0	1.6	1.5	700
63	0.50	396	9.0	121.2	26.9	2.8	2.8	1.4	800
64	0.50	405	9.5	123.5	27.4	3.5	3.4	1.7	750
65	0.50	460	8.5	153.7	34.1	3.5	3.4	1.7	850
66	0.50	415	9.0	125.2	27.8	3.2	3.2	1.6	800
67	0.61	385	9.0	129.2	28.7	3.2	2.6	1.6	750
68	0.50	455	10.0	134.5	29.9	3.4	3.4	1.7	850
69	0.50	476	9.0	169.8	37.7	3.3	5.2	2.6	918
70	0.50	479	9.0	130.7	29.0	2.9	2.8	1.4	918

Appendix 8—*continued*

Trawl No.	Duration (h)	Depth (m)	Headline height (m)	Board spread (m)	Wingtip spread (m)	Observed speed*	Calculated speed†	Distance (n. mile)	Warp length (m)
71	0.50	734	8.5	122.8	27.3	3.2	3.2	1.6	1 300
72	0.50	454	8.0	137.4	30.5	3.4	3.4	1.7	900
73	0.50	372	9.5	123.6	27.4	3.0	3.0	1.5	750
74	0.50	207	8.5	129.8	28.8	3.6	3.6	1.8	468
75	0.50	376	8.0	131.7	29.2	3.6	3.6	1.8	790
76	0.65	474	9.0	145.6	32.3	3.0	2.3	1.5	925
77	0.50	635	8.5	143.4	31.8	3.1	3.2	1.6	1 250
78	0.50	805	8.0	117.8	26.2	3.0	3.0	1.5	1 450
79	0.50	656	10.0	165.1	36.7	2.8	2.8	1.4	1 200
80	0.50	458	9.0	144.2	32.0	3.2	3.2	1.6	900
81	0.50	332	9.0	123.0	27.3	3.4	3.4	1.7	650
82	0.35	280	8.0	139.3	30.9	2.8	2.9	1.0	650
83	0.50	295	8.0	131.0	29.1	3.6	3.6	1.8	650
84	0.50	713	8.0	115.3	25.6	2.8	2.8	1.4	1 250
85	0.58	746	8.5	0.0	28.4	3.4	3.4	2.0	1 300
86	0.66	774	8.0	116.3	25.8	3.3	3.3	2.2	1 300
87	0.50	592	8.0	137.7	30.6	3.0	3.0	1.5	1 050
88	0.50	135	8.0	119.8	26.6	3.0	3.0	1.5	322
89	0.50	475	8.5	146.4	32.5	3.5	3.6	1.8	900
90	0.50	270	8.5	142.6	31.7	3.4	3.4	1.7	550
91	0.50	338	8.5	139.2	30.9	4.0	4.0	2.0	650
92	0.50	439	9.0	129.5	28.8	4.0	4.0	2.0	830
93	0.50	461	8.0	139.6	31.0	2.8	2.8	1.4	900
94	0.50	459	8.5	143.0	31.7	3.3	3.2	1.6	850
95	0.50	415	8.5	142.7	31.7	3.5	3.6	1.8	822
96	0.50	750	9.0	141.3	31.4	3.6	3.6	1.8	1 322
97	0.50	808	8.0	140.6	31.2	3.1	3.0	1.5	1 422
98	0.50	520	9.0	127.0	28.2	3.0	3.0	1.5	950
99	0.50	612	8.0	124.0	27.5	4.0	4.0	2.0	1 150
100	0.50	659	8.0	129.8	28.8	3.4	3.4	1.7	1 150
101	0.50	468	8.0	142.1	31.5	2.8	2.8	1.4	950
102	0.50	511	8.5	146.7	32.6	3.2	3.2	1.6	917
103	0.50	424	9.0	139.2	30.9	3.2	3.2	1.6	800
104	0.50	501	8.0	121.7	27.0	2.6	2.6	1.3	900
105	0.50	646	8.5	154.9	34.4	2.9	2.8	1.4	1 100
106	0.50	444	8.0	151.1	33.5	3.6	3.6	1.8	800
107	0.50	411	8.5	128.0	28.4	3.6	3.6	1.8	700
108	0.50	404	8.0	131.0	29.1	3.0	3.0	1.5	717
109	0.50	381	9.0	145.1	32.2	3.6	3.6	1.8	777
110	0.65	386	8.0	150.4	33.4	3.6	2.8	1.8	785
111	0.50	631	8.0	129.8	28.8	3.2	3.2	1.6	1 150
112	0.50	389	9.0	145.0	32.2	3.0	3.0	1.5	717
113	0.50	336	9.0	131.0	29.1	2.8	2.8	1.4	650
114	0.50	239	9.0	122.5	27.2	3.2	3.2	1.6	477
115	0.50	220	8.5	112.7	25.0	2.8	2.8	1.4	450
116	0.50	239	9.0	124.0	27.5	3.2	3.2	1.6	450
117	0.50	214	9.0	104.0	23.1	3.4	3.4	1.7	400
118	0.50	255	9.0	135.8	30.2	3.6	3.6	1.8	527
119	0.50	276	8.5	136.2	30.2	3.4	3.4	1.7	577
120	0.50	374	8.0	142.2	31.6	3.6	3.6	1.8	700
121	0.50	384	8.5	141.0	31.3	3.4	3.4	1.7	750
122	0.50	282	8.5	138.0	30.6	3.6	3.6	1.8	567
123	0.50	349	9.0	138.7	30.8	3.8	3.8	1.9	640
124	0.50	356	8.0	119.5	26.5	3.6	3.6	1.8	700
125	0.50	409	8.5	131.0	29.1	3.0	3.0	1.5	800
126	0.50	606	9.0	147.0	32.6	3.8	3.8	1.9	1 200
127	0.63	765	8.0	154.0	34.2	3.3	2.5	1.6	1 450

* From the ship's log.
† Distance trawled in recorded time.

Printed by Thames Publications Ltd. under the authority of
V. R. WARD, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND—1989