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Preliminary biomass estimates of hoki and selected species from trawl surveys of Southland/Sub-Antarctic and the Chatham Rise, Oct-Dec. 1989, and comparison with previous *Shinkai Maru* surveys

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1. Introduction

This report gives preliminary biomass estimates of ITQ and other selected main species from stratified random trawl surveys of Southland/Sub–Antarctic (Oct/Nov 1989) and the Chatham Rise (Nov/Dec. 1989), in depths of 200–800m, by Amaltal Explorer.

The main aim of these surveys was to update biomass estimates of hoki and associated middle depth species obtained from surveys done by Shinkai Maru in 1982, 1983 and 1986 (see Hurst et al. 1988). The 1989 surveys were similar in design to the earlier surveys but covered a narrower depth range (200–800m) because they were primarily designed to estimate hoki biomass. Therefore, some of the species with shallower depth distributions were not as well sampled by these 1989 surveys (e.g. barracouta, arrow squid, blue warehou). Also, the 1989 Southland/Sub–Antarctic survey included the Puysegur Bank area which was not surveyed in 1982 or 1983.

Survey details and wingspread biomass estimates from earlier Shinkai Maru surveys are given in individual publications (Mar/Apr. 1982 – van den Broek et al. 1984; Oct/Nov. 1983 – Hatanaka et al, 1989a; Nov/Dec 1983 – Hatanaka et al 1989b; Mar, 1983 – Fenaughty & Uozumi 1989; Jul. 1986 – Livingston et al in press) and data from 1980–1984 surveys were summarised by Hurst and Fenaughty (1985). The presentation of data here follows a similar format to this earlier summary (i.e. details of the survey area and design, trawl gear specifications, and biomass estimates of selected species by stratum are summarised), but in this paper the estimates are based on the area swept by the doors, not the wings.

This paper also attempts to compare biomass estimates from the 1989 surveys with the earlier Shinkai Maru estimates. This necessitated recalculation of Shinkai Maru estimates because of the different methods used to measure or estimate doorspread.

2. Survey and gear parameters

Survey areas and stations are shown in Figs. 1 & 2. Important parameters of the 1989 surveys and gear are given in Table 1; net plans are given in Appendix 1. Comparative data from earlier surveys are given in Table 2 (note that the doorspread/wingspread ratios for Shinkai Maru surveys in late 1983 have been changed from those given by Hurst & Fenaughty 1985).

3. Comparison of Amaltal Explorer 1989 and Shinkai Maru 1982–86 biomass estimates and length frequencies.

3.1 Biomass

Six main problems were found in comparing biomass estimates from the 1989 surveys with earlier Shinkai Maru estimates:

i. the surveys did not cover exactly the same area; i.e. the 1989 surveys did not include depths less than 200m; the Nov./Dec. 1983 survey only covered part of the Chatham Rise (i.e. EEZ area D – the area to the east of 176°E in Fig 2); the 1989 Southern area survey included Puysegur Bank;

ii. the timing of the surveys varied and there could be seasonal changes in biomass with fish migrating to or from the survey areas;

iii. there are long time intervals between surveys, particularly in the southern area (6 years);

iv. the vessels are both stern trawlers, but of different size and horsepower: the Amaltal Explorer is a Spanish built New Zealand owned vessel, 65m length overall, gross tonnage 1000t, horsepower 2700; the Shinkai Maru is a Japanese vessel, 94.9m length overall, gross tonnage 3393t, horsepower 5000.

v. the trawl gear was different (e.g. net plans, trawl doors, sweep angles etc.) and hence, the vulnerabilities of fish to the net may have differed;

vi. the doorspread (and hence wingspread) was measured on the Amaltal Explorer with Scanmar doorspread measuring equipment, which gave significantly greater and more accurate results than those using the trawl geometry method (after Koyama 1974). A comparison of the two methods (Table 3), clearly shows that the Koyama method underestimated doorspread and that the discrepancies increased with increasing depth, to over 30% in over 400m depth (see Bagley, in prep. for more detailed results).

Published biomass estimates from Shinkai Maru surveys are all derived using wingspread estimates calculated after Koyama (1974), although doorspread measuring equipment was used on some tows in the July 1986 survey. Results from the 1986 survey (Uozumi, unpub. data) showed that Koyama's method also underestimated doorspread when compared with measurements from the doorspread measuring gear; the discrepancy was less than 10% in under 200m depth, and increased to a mean of about 15% in 200–600m depth.

Results from the southern area Amaltal Explorer survey in 1989 also showed that Koyama's method gave a smaller doorspread than the theoretical doorspread (i.e. 100m from net design) in all depth ranges, but that the Scanmar measurements were greater than the theoretical value in all depths over 200m.

To derive a set of relative biomass indices for Amaltal Explorer 1989 and Shinkai Maru 1982–86 surveys, we addressed the problems listed above in the following manner (N.B. this involved recalculation of many of the original doorspread biomass estimates):

i. The 1989 surveys covered depths of 200–800m. Therefore, only species which predominantly occur in this depth range are compared and any biomass in less than 200m on Shinkai Maru surveys has been subtracted from totals. The Nov/Dec. Chatham Rise survey in 1983 only covered EEZ area D, so in order to compare this with the Nov/Dec. 1989 survey we have calculated the area D component of the biomass for the 1989 survey (and the other two complete Chatham Rise surveys) (Note: the western (EEZ area C) end of the Chatham Rise often has a large part of the hoki biomass). The biomass from the Puysegur Bank area in 1989 has also been subtracted from the tables of relative biomass indices, as it was not included in previous surveys.

ii. The 1989 southern area survey was carried out in Oct/Nov, as was a previous southern area Shinkai Maru survey in 1983. The 1989 Chatham Rise surveys was in Nov./Dec., but the comparable 1983 survey only covered EEZ area D, so a table of area D only biomass indices was calculated. Comparative indices for area D in Mar. 1983 provide some indication of possible seasonal effects within one year.

iii. The time lag between surveys is difficult to allow for. Little is known of the natural annual variability in any of the species caught. In choosing species to compare across surveys we tried to select those which we know, or suspect, are moderately long–lived as these probably undergo less pronounced annual changes in abundance than shorter–lived species.

iv. The difference in vessel size and horsepower is also difficult to allow for, as the vessels have not fished alongside each other commercially. The Amaltal Explorer towed at a similar speed to the Shinkai Maru and is of sufficient size and power to efficiently catch most of the species considered here, and so we have not tried to adjust for the difference in vessel size and power.

v. The Shinkai Maru gear was similar in all surveys, except from Oct.–Dec. 1983, when shorter sweeps were used, resulting in a lower doorspread:wingspread ratio (see Table 2), but the theoretical sweep angle remained similar, i.e. about 11 – 12 degrees. We have assumed that the vulnerability of species to the net was the same for all Shinkai Maru surveys (although there was probably some difference in vulnerability to the gear set–up in Oct.–Dec. 1983). The Amaltal Explorer gear had a similar doorspread/wingspread ratio and headline height to the Shinkai Maru gear, and the warp to depth ratio was similar (i.e. about 2:1), but the sweep angle was greater (i.e. 16 – 19 degrees). The difference in these sweeps angles may have resulted in different herding efficiencies of the sweeps for some species (e.g. see Okonski 1967, Foster et al. 1981, Wardle 1983 for discussion of the effect of sweep angles and other aspects of gear on fish vulnerabilities in the Northern Hemisphere). Hence, fish vulnerability cannot be assumed to be the same for both gear types, but, because of the lack of quantitative data on how species such as hoki might react to differences in gear, we have used the same vulnerability values in calculating the relative biomass indices.

   In an attempt to determine if the vulnerability of the two gear types might be different, a range of bycatch species were selected for comparison between Amaltal Explorer and Shinkai Maru surveys. If it could be assumed that there has been little change in bycatch species biomass because of minimal exploitation of these species in the survey areas, it might be possible to derive a correction factor for biomass indices for one of the vessels. However, very little is known of the stock structure, life history, or natural variability in abundance of these bycatch species, and the level of exploitation since 1983 may have had an effect, particularly on the Chatham Rise and in Southland/Puysegur. Also, exploitation of some species in other areas (e.g. hoki and hake on the west coast of the South Island) may also have had an effect on biomass in the survey areas.

vi. For all Shinkai Maru surveys, we have assumed that there was underestimation of doorspread (and hence, wingspread) by the "Koyama" method used, and that the 1986 Chatham Rise survey doorspread measurement data mentioned above can be used to correct for this on all Shinkai Maru surveys. All the doorspread biomass estimates of selected species have therefore been adjusted downwards by 15%, to obtain relative biomass indices which can be compared to Amaltal Explorer data.

Doorspread biomass estimates assuming catchability = 1.0 (vulnerability, vertical and areal availability = 1.0) for the main ITQ and other selected species from the 1989 Amaltal Explorer surveys are given in Table 4 (biomass estimates of the main ITQ species, by stratum, are given in Appendix 2). Comparative data for the 1989 and Shinkai Maru surveys are given in Tables 5–7. Table 8 is a summary of the percentage change in relative biomass indices. Indices were compared using t–test and all changes are significant ($p<0.05$) unless indicated.

3.2 Length frequencies

Preliminary length frequencies of hoki, hake and ling from the 1989 surveys (Figs. 3–5) were compiled in order to determine if there had been any change in the size structure of the populations which might be related to any change in biomass. These length frequencies have been scaled by percentage sampled, area swept and stratum area. For the southern area ling, the Puysegur Bank stations have been omitted to make the data comparable with earlier surveys.

4. Results and Discussion

4.1 Relative biomass indices

4.1.1 Southland/Sub-Antarctic

Biomass indices for all 7 selected species from the 1989 survey (Table 5, 8) appeared to be lower, except for pale ghost shark and lookdown dory, where the 1989 survey indices were greater than the 1982 indices (not statistically significant for lookdown dory). There were significant declines ($p<0.05$) of 71 – 77% in 1989 hoki biomass compared to both of the previous survey indices (for all hoki and adults >65cm). Hake, ling, and javelin fish indices in 1989 were also significantly lower than both of the previous survey indices (28 – 83%); southern blue whiting were significantly lower than in 1982 (62%) and lookdown dory were lower than in 1983. Hoki, hake, ling and southern blue whiting have all been subject to considerable levels of fishing pressure since 1983 and this may have contributed to declines in biomass in the survey area.

The total of all species showed a significant decline of 59% (53% if hoki is omitted) from the 1983 survey to the 1989 survey (Mar/Apr. 1982 data for all species not available).

4.1.2 Chatham Rise

Total area: Hoki biomass indices were again significantly lower in the 1989 survey than in the previous 2 complete Chatham Rise surveys in 1983 and 1986 (Table 6; 71% and 63% for all hoki; 59% and 48% for hoki >65cm). Biomass indices for all of the other 9 selected species also appeared to be lower, except for hake and shovelnose dogfish which appeared greater than the 1986 survey estimates (only shovelnose dogfish were significantly greater). Of the 18 possible comparisons of the 9 species other than hoki in 1989 to other survey biomass indices, 13 showed significant declines, ranging from 41–90%, and only 1 showed a significant increase (Table 8). The total of all species on the Chatham Rise survey showed a decline of 61% (46% if hoki is omitted) from the Mar. 1983 survey, and 56% (48% minus hoki) from the Jul. 1986 survey.

Area D: Data for Area D only are given for all surveys (i.e. Mar. and Nov/Dec. 1983, Jul. 1986 and Nov/Dec. 1989 (Table 7)), to compare changes in seasonal biomass indices (1983 and 1986 surveys), and changes in annual biomass indices (Nov/Dec. surveys 1983 and 1989). Comparing the two Shinkai Maru surveys in 1983, for 9 species, shows that the total hoki biomass was significantly less and the dark ghost shark was significantly greater in the Nov/Dec. survey. However, the difference in adult hoki (>65cm) biomass was not significant between the two surveys. Thus, it appears that any seasonal changes in biomass due to movement in/out of the area or up/down in the water column, were minor or not detected by the surveys.

Comparison with the 1989 survey biomass indices shows similar declines in 1989 biomass to the wider area Chatham Rise survey comparisons. For hoki, the declines in biomass indices are significant for all hoki and adults only (31 – 65%). Of the 26 possible comparisons of the other 9 species in 1989 to previous survey biomass indices, 18 of them showed significant declines (38 – 96%) and none showed significant increases.

4.1.3 Comparisons between Shinkai Maru surveys

When relative biomass indices of the selected bycatch species are compared between Shinkai Maru surveys, there are no consistent trends (i.e. there is no one survey which estimates consistently more/less than any other survey) in the Chatham Rise surveys. On the Chatham Rise complete surveys in 1983 and 1986 (Table 6), only 3 of the 9 species biomass indices showed significant changes; dark ghost shark and javelin fish were less abundant and shovelnose dogfish were more abundant in 1983, compared with 1986. The three Area D surveys (Table 7)

show a similar pattern; most species were similar except for dark ghost shark which were less abundant in Mar.1983 than in Nov/Dec. 1983 and Jul. 1986, and shovelnose dogfish which were more abundant in Mar. 1983 than in Jul. 1986 (Nov/Dec. 1983 estimate not available).

In the Southland/Sub–Antarctic surveys (Table 5), 5 of the 6 bycatch species were significantly more abundant in the 1983 survey, compared with 1982, (i.e. all except southern blue whiting which were less abundant but not significantly so).

4.1.4 Comparisons between Shinkai Maru and Amaltal Explorer surveys

The fact that the biomass indices of most of the selected bycatch species appeared to be lower in the 1989 surveys suggests that the catchability of the Amaltal Explorer vessel/gear was less than that of the Shinkai Maru; that biomass has declined; or a combination of the two. If it is assumed that many of the species other than hoki should have remained relatively similar in abundance to earlier survey estimates is valid, then it might be possible to estimate a correction factor for the Amaltal Explorer estimates. This factor could be between 1.8 and 2.1 (i.e. based on the 43–53% significant decline in relative biomass indices of all species minus hoki, given in Table 8).

Applying a correction factor of 2.1 to the hoki biomass estimates from the 1989 survey still results in a significant reductions of 39% in biomass from the 1983 survey and 51% (all hoki) and 41% (adults only) reductions from the 1982 survey in the southern area. If the 2.1 factor is applied to the Chatham Rise estimates, only the total hoki in 1989 is significantly less than March 1983 (38%) for the whole rise, and none of the Area D comparisons are significantly different. Applying the same correction factor to 1989 hake and ling estimates also results in no significant differences between surveys in both areas.

If it is assumed that the abundance of the bycatch species has declined also (because of hoki and other target fisheries in the survey areas) then the correction factor would be less and the declines in the hoki biomass would be greater than those suggested above.

4.2 Length frequencies: hoki, hake, ling.

A preliminary look at total length frequency data for hoki, hake and ling (Figs 3–5) suggests few differences from earlier data (see published reports; references given in the introduction). The comparison given here is only preliminary as the data need to be examined in more detail, including analysis by sex, and scaling of previous survey data by area swept and stratum area, where this has not been done. The numbers given on the length frequency figures represent the number of fish measured.

Hoki: Southland/Sub–Antarctic length frequencies for 1989 and Oct/Nov. 1983, by sex, are given in Fig 3A. Although there are marked differences in the modal groups of smaller fish, the maximum size for both surveys (about 100 cm) is similar and there is little change in the shape of the histogram for fish over 65cm.

Chatham Rise length frequencies for 1989 and the two previous complete Chatham Rise surveys, by sex, are given in Fig 3B. Again, there are differences in the modal groups of smaller fish, but the main range of lengths for all surveys (30–100 cm) is similar and there is little change in the shape of the graph for fish over 65cm.

Ling: Southern/Sub–Antarctic length frequencies from Oct/Nov. 1983 and Oct/Nov. 1989 (Fig. 4a) have a similar range of fish sizes (about 40 – 130cm), but there is a slightly lower percentage of small fish (<70cm) in 1989 (note: the Puysegur stations have been removed from the 1989 data set to make it comparable to 1983; March/April 1982 data were not available); the 1989 data has one main peak between 50 – 110 cm, with most fish between 70 – 100 cm; the 1983 data has several peaks, with most fish between

60 – 80 cm. Given the time lag between the surveys it may be this dominant peak in 1983 is present as the 70 – 100 peak in 1989.

Chatham Rise comparisons are possible over three surveys: Nov/Dec. 1983 (Area D only), Jul. 1983 and Nov/Dec. 1989 (Fig. 5a)(N.B. Mar. 1983 data are not scaled by stratum area). The length frequencies are similar: lengths range from 40 – 140 cm, with most fish between 70 – 100 cm and a secondary peak between 45 – 70 cm in both the Nov/Dec surveys.

Hake: Southern/Sub–Antarctic length frequencies from Oct/Nov. 1983 and Oct/Nov. 1989 (Fig. 4b) are similar; the main length range is 60 – 130 cm, with the three most prominent modes occurring between 80 – 100 cm. March/April 1982 data were not available.

Chatham Rise length frequencies from Jul. 1986 and Nov/Dec. 1989 (Fig. 5b) were also similar; the main length range is 45 – 120 cm, with most fish between 70–95 cm. There are slight differences in that the 1989 survey has a lower percentage of fish over 90 cm and more between 50 – 65 cm, but this needs to be related to fish numbers, as the 1989 survey had a higher biomass estimate (i.e. it probably reflects recruitment of some strong year classes rather than a decline in larger fish).

5. Conclusions

In attempting to compare relative biomass indices between the 1989 and earlier Shinkai Maru surveys, two serious problems remain; the use of the different vessel and trawl gear in 1989. Other differences have been overcome to some extent by making adjustments to areas surveyed and applying a correction factor for the Shinkai Maru doorspread estimates. This paper is a preliminary analysis of data collected on the 1989 trawl surveys. It may be that with further more detailed analysis, some method of resolving the problems of comparability may be found.

There are 4 main conclusions from data presented in this paper:

i. Doorspread measuring equipment is essential; Koyama's method underestimates doorspread, but the amount of underestimation varies with depth and gear and is therefore difficult to correct for, but could be significant (up to 36% from the 1989 survey data presented here).

ii. The relative biomass indices of many species in the Chatham Rise area, and a few species in the Sub–Antarctic, are significantly lower than indices from earlier surveys in 1982–86. Interpretation of the declines is complicated by the unknown relative catchability of the two vessel/gear combinations used. If there have been significant declines in the biomass of hoki, hake and ling, there are few apparent differences in the overall length frequency distributions in 1989 compared to earlier surveys.

iii. There may have been a greater relative decline of adult hoki biomass in the southern area compared to the Chatham Rise. The suggested decline in the southern area is still significant if correction factors of 1.8 to 2.1 are applied to the Amaltal Explorer estimates, to allow for lower catchability compared to the Shinkai Maru. The Chatham Rise decline of adult hoki is not significant if these correction factors are applied.

iv. Given the uncertainties in interpreting the data from the 1989 survey, the most reliable method to extend the time series of biomass indices from the Shinkai Maru would be to either use the Shinkai Maru (or use an equivalent vessel with identical gear), or involve the Shinkai Maru and gear in comparative fishing trials with any new survey vessel and gear.

6. References

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Table 1. Survey and gear parameters, Amaltal Explorer (AEX), 1989.

	Southland/ Sub-Antarctic	Chatham Rise
Trip code	AEX 8902	AEX 8903
Survey area (km^2)	318,398 Fig. 1	134,550 Fig. 2
Depth (m)	200-800	200-800
No. strata	23	24
No. stations	125	116
Station density / km^2	1:2547	1:1160
Mean tow length (n.ml.)	3.00	2.96
Mean tow speed (knots)	3.36	3.60
Mean headline height (m)	9.8	9.5
Mean doorspread (DS) (m)		
200-400m	111.5	128.8
400-600m	128.8	132.8
600-800m	132.8	133.5
Mean wingspread (WS) (m)*		
400-600m	29.6	
Ratio DS:WS	4.3478	
Cod-end mesh†	60	60

* In these surveys the doorspread was measured by Scanmar doorspread measuring gear. Wingspread was also measured on 6 tows by attaching the gear to the wing ends. An estimate of the mean wingspread over the whole survey was obtained from the ratio (0.23) of the mean values of wingspread to doorspread measurements within the 400-600m depth range on the Southland/Sub-Antarctic survey. This is close to the theoretical ratio for the net parameters of 0.22. Other theoretical net parameters were DS: 100m; WS: 22m.

† nominal inside-knot to inside-knot measurement.

Table 2. Survey areas and gear parameters used on Shinkai Maru surveys of the Southland/Sub-Antarctic and the Chatham Rise, 1982-86.

A. Southland/Sub-Antarctic

Trip code	Mar/Apr. 1982 SHI 8201	Oct/Nov.1983 SHI 8303
Survey area (km^2)	344,033	346,309
Depth (m)	<800	<800
No. strata	28	27
No. stations	218	184
Station density/km^2	1:1578	1:1882
Mean tow length (min.)	30	30
Mean tow speed (knots)	3.5	3.2
Mean headline height (m)	9.3	7.3
Mean doorspread (DS) /wingspread (WS) (m)	120/28.6	122/34.1
Ratio DS:WS	4.2	3.57
Cod-end mesh*	60?	80

B. Chatham Rise

Trip code	Mar.1983 SHI 8301	Nov/Dec.1983 SHI 8304	Jul.1986 SHI 8602
Survey area (km^2)	143,579	108,635	143,018
Depth (m)	<800	<800	<800
No. strata	21	12	27
No. stations	124	84	107
Station density/km^2	1:1158	1:1293	1:1337
Mean tow length	30 min	30 min	3 n.m
Mean tow speed (knots)	3.3	3.3	3.3
Mean headline height (m)	8.9	7.0	6.3+
Mean doorspread (DS) /wingspread (WS) (m)	127/28.3	120/33.7	149/33+
Ratio DS:WS	4.5	3.57	4.54+
Cod-end mesh*	80	80	80

* The nominal cod-end mesh size is given in the net plans as 80 mm "knot to knot". In Fenaughty & Uozumi (1989), the mean "inside-knot to inside-knot" measurement is given as 65.6 mm.

+ Two different nets were used in July 1986 the means given here represent the survey means.

Table 3. Comparison of the two doorspread (DS) measurements methods used on the Southern area survey, 1989.

Depth (m)	Scanmar DS (m) n.	Scanmar DS (m) mean	Koyama DS (m) n.	Koyama DS (m) mean	% Koyama underestimates doorspread
0-200	8	96.6	8	84.7	12.3
200-400	13	111.5	2	84.5	24.2
400-600	54	128.8	10	89.4	30.6
600-800	48	132.8	7	84.6	36.3
Total	123		27		

Table 4. Preliminary doorspread biomass estimates (t) and percentage coefficients of variation (c.v.) of selected* species from Amaltal Explorer surveys of Southland/Sub-Antarctic and the Chatham Rise, 200-800m, Oct-Dec. 1989.

Species	Southland/Sub-Antarctic AEX 8902 biomass	c.v.	Chatham Rise AEX 8903 biomass	c.v.
Hoki - total	62 081	20	99 464 †	10
->65cm	60 553	20	43 422 †	15
Hake	2 660	21	9 463	65
Ling	20 016	13	7 849	9
Pale ghost shark	17 629	9	11 460	8
Dark ghost shark	867	27	940	44
Sthn. blue whiting	35 514	30	0	
Silver warehou	2 617	89	21 491	73
Lookdown dory	762	18	4 297	6
Javelin fish	14 242	12	7 623	14
Shovelnose dogfish	568	25	5 045	9
Sea perch	167	50	1 587	12
White warehou	878	79	3 175	30
Stargazer	440	42	1 823	19
Black oreo	0		19 831	28
Smooth oreo	0		5 824	35
Spikey oreo	0		510	44
All species	201 580	11	220 845	10

* selected because they are either ITQ species or were important bycatch species.

† minor changes to stratum boundaries since the March 1990 draft manuscript have resulted in minor changes to species biomass for cruise AEX 8903. Only the hoki estimates have been corrected here.

Table 5. Relative biomass indices of hoki and selected* species from Southland/Sub-Antarctic surveys 1982-89 (Shinkai Maru (SHI): all strata > 200m; Amaltal Explorer (AEX): all strata except Puysegur; n, number of comparable stations; NA, data not available on the FRC database,).

	SHI 8201 Mar/Apr. n = 132		SHI 8303 Oct/Nov. n = 158		AEX 8902 Oct/Nov. n = 119	
Species	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.
Hoki - total	265 757	9	213 738	10	62 081	20
->65cm	215 741	9	208 437	10	60 553	20
Hake	5 195	15	10 333	20	2 660	21
Ling	22 006	~9	30 048	9	15 840	9
S. blue whiting	93 480	30	56 905	20	35 514	30
Pale ghost shark	12 532	10	21 238	6	17 629	9
Javelin fish	34 939	10	84 217	9	14 242	12
Lookdown dory	384	30	1 712	12	565	18
All species	NA		511 148	6	210 580	11
All species minus hoki	NA		297 140		139 499	

* selected because they are relatively abundant bycatch species, adequately sampled by the depth range of the survey, and with relatively low coefficients of variation.

Table 6. Relative biomass indices of hoki and selected* species from Chatham Rise surveys 1983-89 (Shinkai Maru (SHI): all strata > 200m; Amaltal Explorer (AEX); n, number of comparable stations: all strata)

	SHI 8301 Mar. n = 113		SHI 8602 Jul. n = 96		AEX 8903 Nov/Dec. n = 116	
Species	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.
Hoki - total	335 045	11	265 339	17	97 958	10
->65cm	106 377	11	84 776	14	43 769	15
Hake	9 606	12	6 741	13	9 463	65
Ling	12 741	27	15 635	8	7 849	9
Pale ghost shark	19 552	15	13 093	9	11 460	8
Dark ghost shark	3 248	18	9 241	~22	940	44
Javelin fish	31 967	9	43 295	11	14 242	12
Lookdown dory	7 592	9	7 319	9	4 297	6
Stargazer	6 363	18	4 739	19	1 823	19
Shovelnose dog.	15 815	21	3 573	17	5 045	9
Sea perch	8 435	12	8 821	10	1 587	12
All species	564 080	7	503 679	8	220 845	10
All spp. minus hoki	229 035		238 340		122 887	

* see footnote Table 5.

Table 7. Relative biomass indices of hoki and selected* species from Chatham Rise surveys 1983-89, EEZ area D only (Shinkai Maru (SHI): all area D strata > 200m; Amaltal Explorer (AEX): all area D strata; n, number of comparable stations; NA, data not available on the FRC database).

	SHI 8301 Mar. n = 82		SHI 8304 Nov/Dec. n = 85		SHI 8602 Jul. n = 65		AEX 8903 Nov/Dec. n = 87	
Species	Biomass	cv	Biomass	cv	Biomass	cv	Biomass	cv
Hoki - total	214 018	15	108 167	15	126 313	22	74 265	12
- >65cm	68 847	12	53 284	14	74 940	15	34 192	18
Hake	7 880	14	7 071	12	5 893	16	9 047	68
Ling	10 815	32	11 238	9	13 247	10	5 564	10
P. ghost shark	11 586	10	9 320	14	8 742	10	7 207	9
D. ghost shark	2 158	21	5 420	19	7 569	18	782	53
Javelin fish	25 253	10	26 393	12	27 569	15	5 933	18
Lookdown dory	6 504	11	7 429	6	7 213	10	3 760	7
Stargazer	4 810	24	3 798	25	3 007	28	1 567	22
Shovelnose dog.	11 782	28	NA		2 354	26	3 286	10
Sea perch	7 501	13	9 608	9	9 595	10	1 247	13
All species	387 344	9	297 534	8	286 088	12	164 843	13
All species minus hoki	173 326		189 367		159 775		90 578	

* see footnote Table 5.

Table 8. Percentage change in relative biomass indices from 1989 surveys compared to previous surveys; values are given where the difference is significant ($p<0.05$) (SHI, Shinkai Maru; AEX, Amaltal Explorer, NS, not significant; NA, data not available on the FRC database).

	Southland/ Sub-Antarctic		Chatham Rise		Chatham Rise Area D only		
	AEX 8902 cf.		AEX 8903 cf.		AEX 8903 cf.		
	SHI8201 Mar/Apr.	SHI8303 Oct/Nov.	SHI8301 Mar.	SHI8602 Jul.	SHI8301 Mar	SHI8304 Nov/Dec.	SHI8602 Jul.
Species							
Hoki - total	-77	-71	-71	-63	-65	-31	-41
- >65cm	-72	-71	-59	-48	-50	-36	-54
Hake	-49	-74	- 1 NS	+40 NS	+15 NS	+28 NS	+53 NS
Ling	-28	-47	-38 NS	-50	-49 NS	-51	-58
S. blue whiting	-62	-38 NS					
Pale ghost shark	+41	-17 NS	-41	-12 NS	-38	-23 NS	-18 NS
Dark ghost shark			-71	-90	-96	-86	-90
Javelin fish	-59	-83	-55	-67	-76	-78	-78
Lookdown dory	+47 NS	-67	-43	-41	-42	-49	-48
Stargazer			-71	-62	-67	-59	-48 NS
Shovelnose dog.			-68	+41	-72	NA	+39 NS
Sea perch			-81	-82	-83	-87	-87
All species	NA	-59	-61	-56	-57	-45	-42
All species minus hoki	NA	-53	-46	-48	-48	-52	-43

Figures

Appendices.

Figure 1 : Subantarctic strata and station positions, 1989.

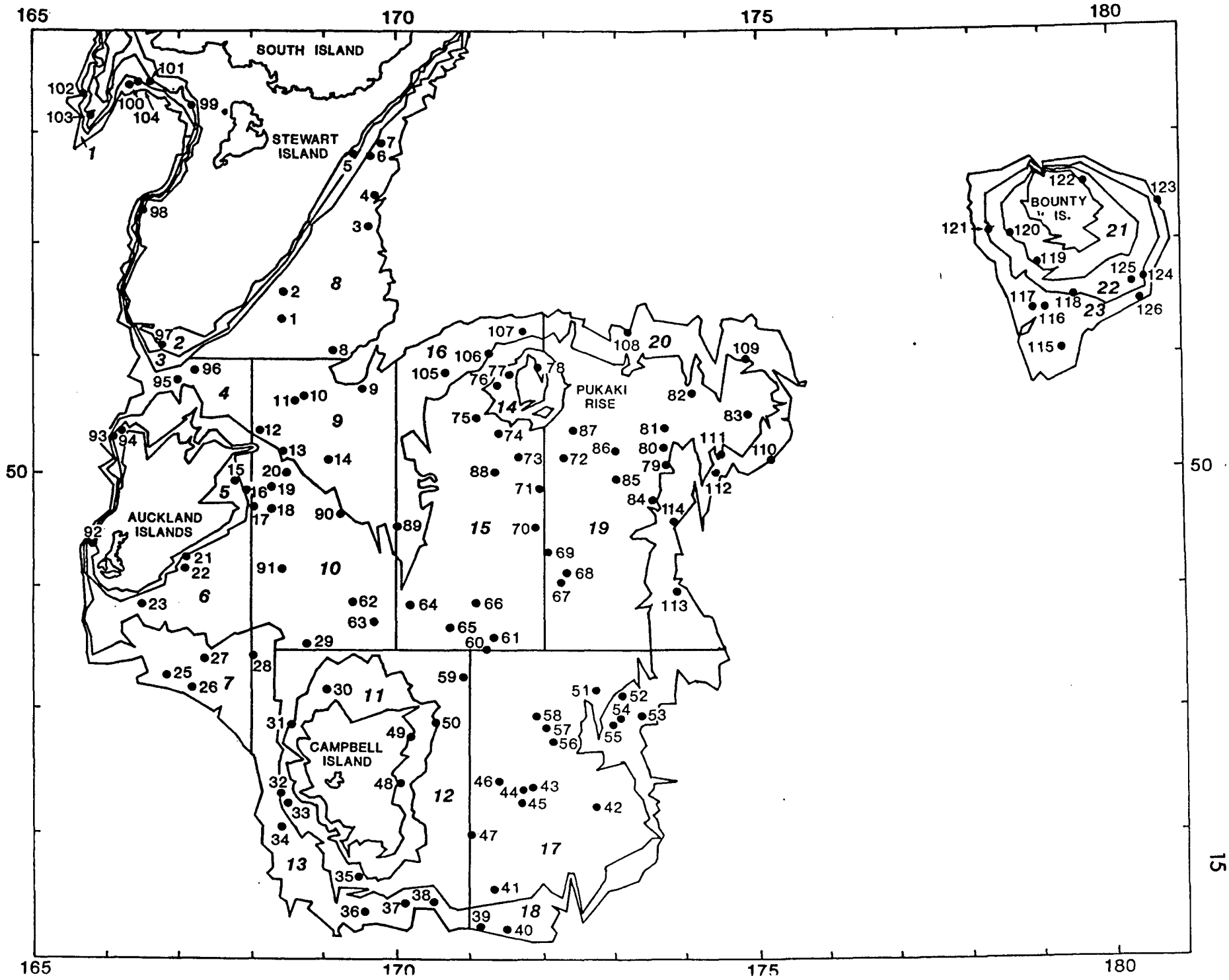
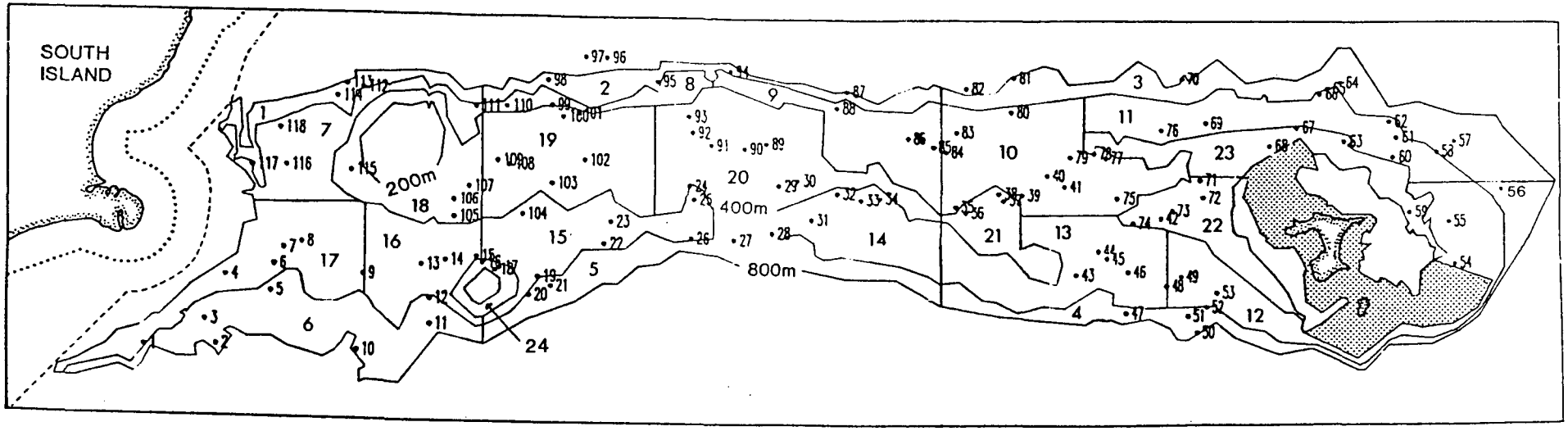


Fig 2. Chatham Rise strata and station positions, 1989.



KEY

····· 12-mile territorial limit

----- 25-mile restricted fishing limit

—— stratum boundary

▒ rough ground

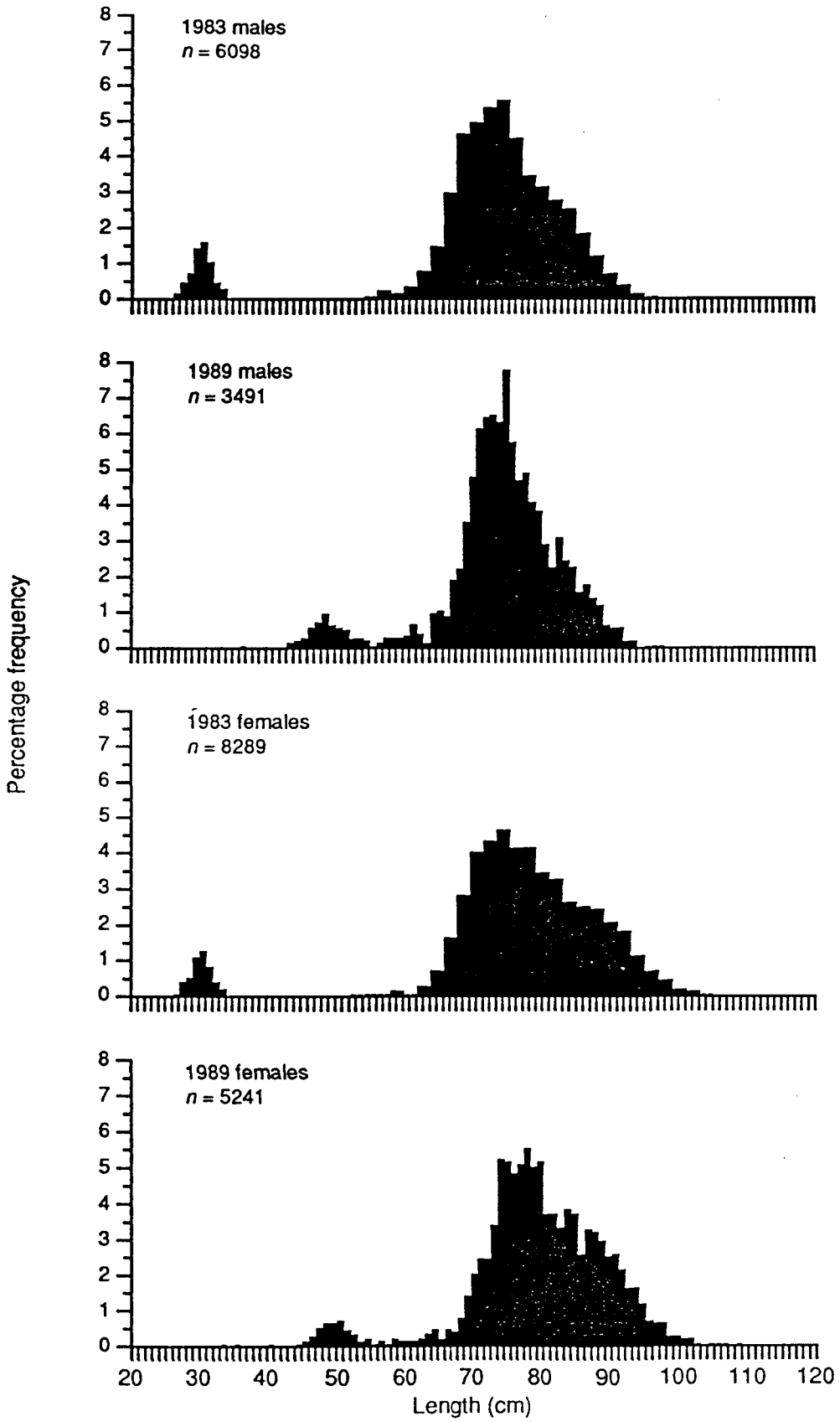


Fig. 3A Length frequency of hoki caught in random trawl surveys of the Southern Plateau:
(a) Shinkai Maru Oct/Nov 1983
(b) Amaltal Explorer Oct/Nov 1989

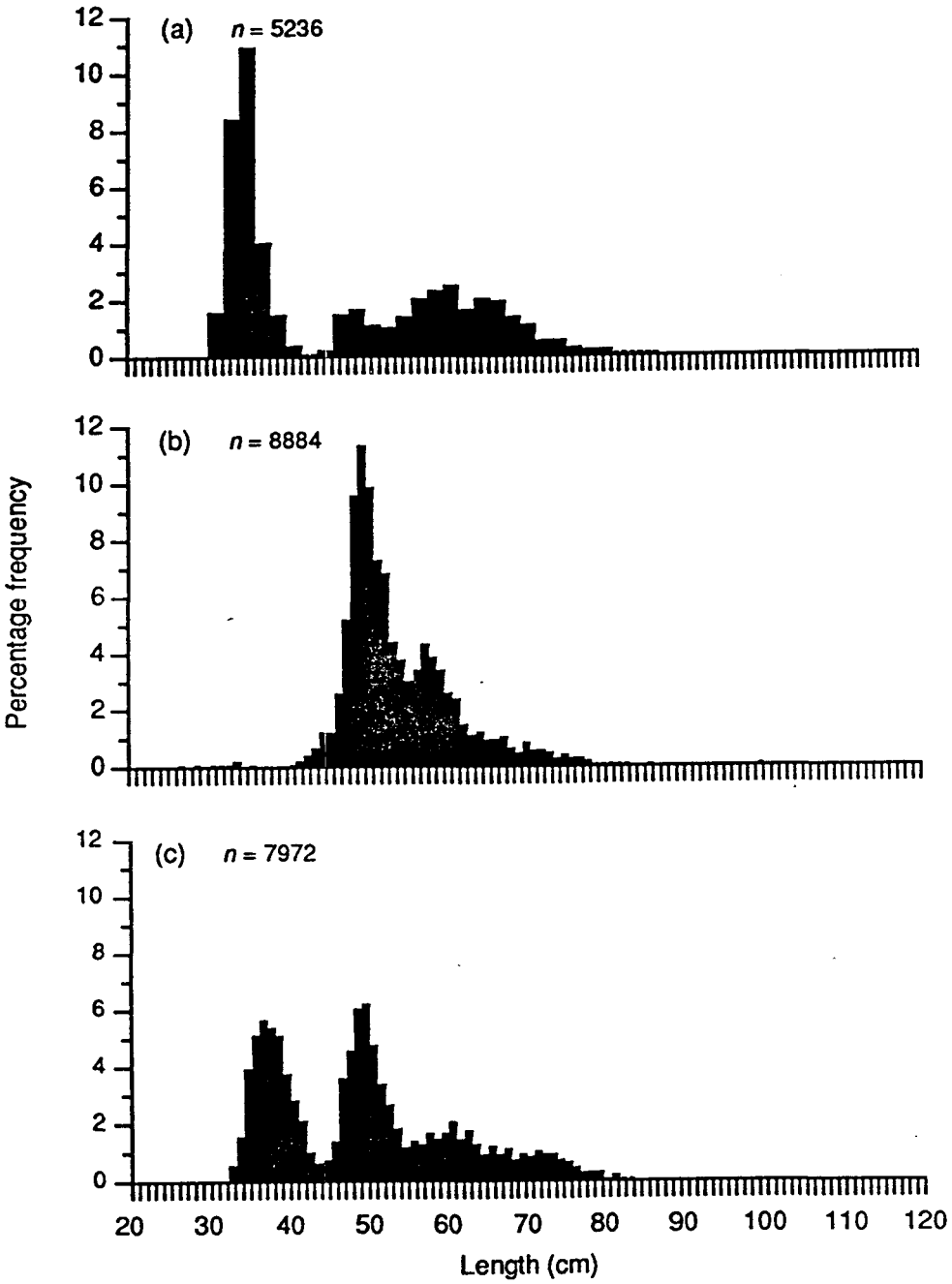


Fig. 3B Length frequency of male hoki caught in random trawl surveys of the Chatham Rise:
(a) Shinkai Maru March 1983
(b) Shinkai Maru July 1986
(c) Amaltal Explorer Nov/Dec 1989

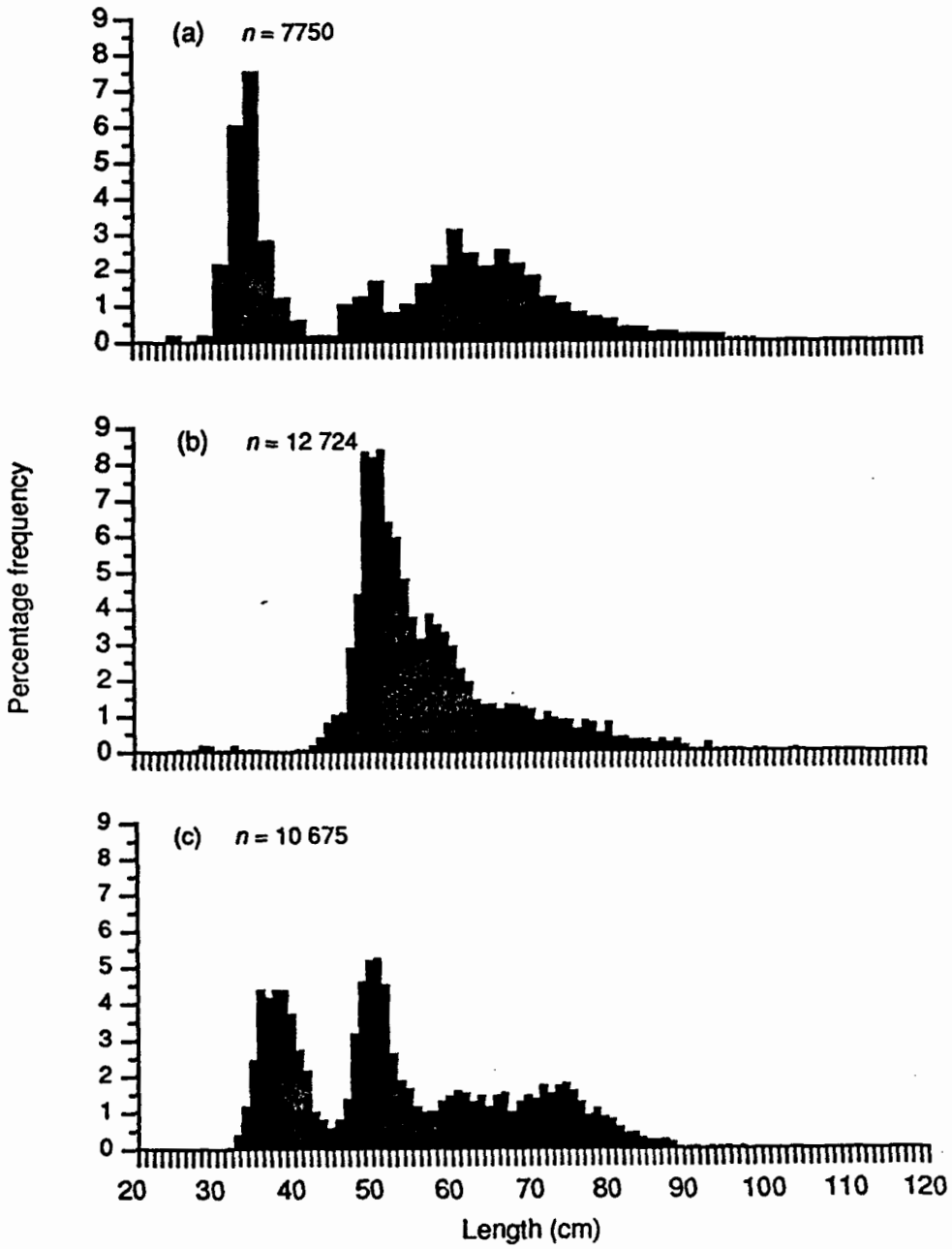
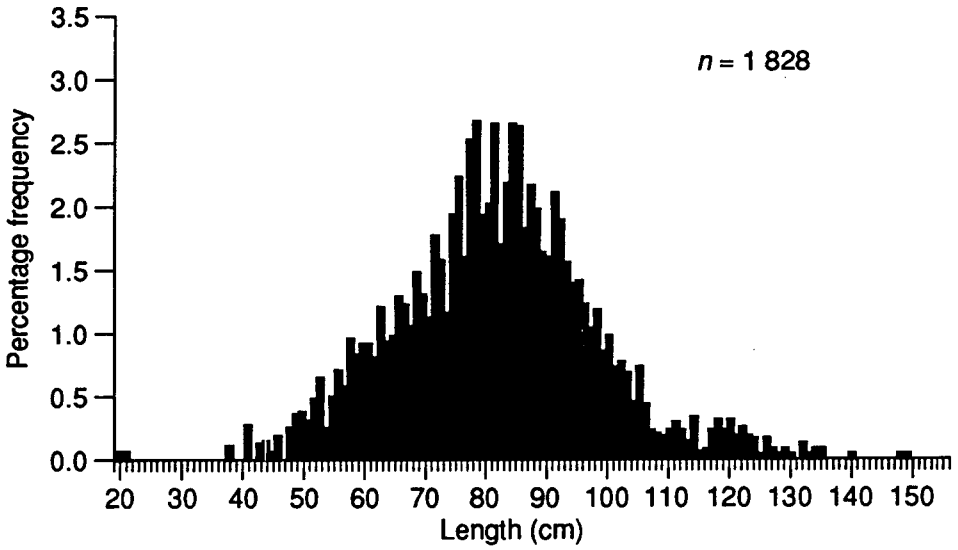


Fig. 3C Length frequency of female hoki caught in random trawl surveys of the Chatham Rise:
(a) Shinkai Maru March 1983
(b) Shinkai Maru July 1986
(c) Amaltal Explorer Nov/Dec 1989

Figure 4: Ling and hake length frequencies, Southland/Sub-Antarctic, Oct/Nov 1989

(a) Ling



(b) Hake

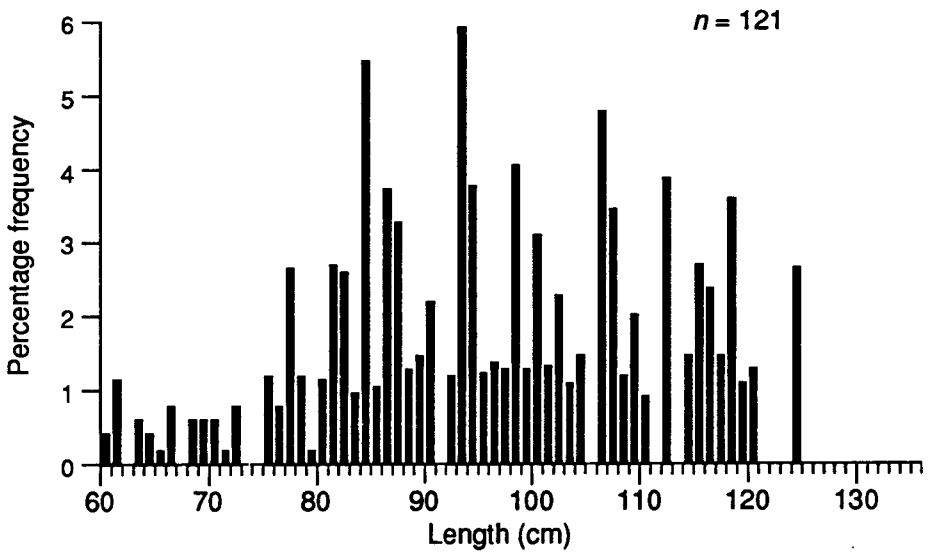
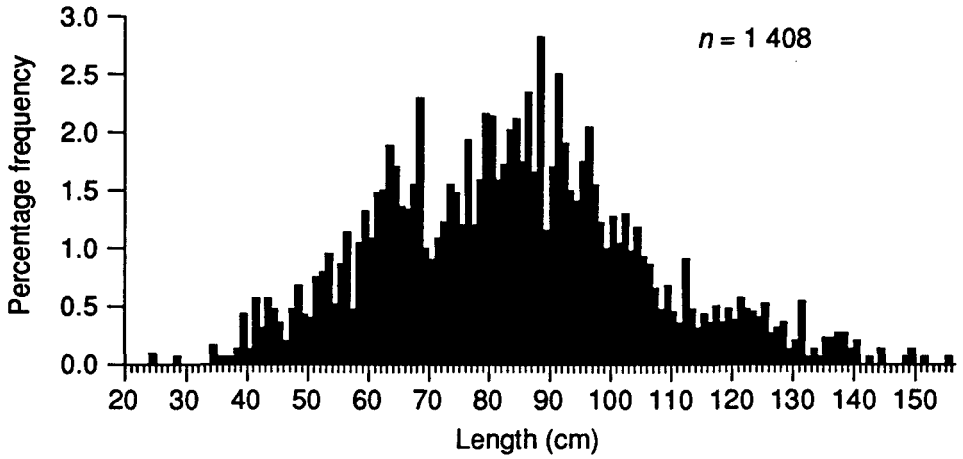
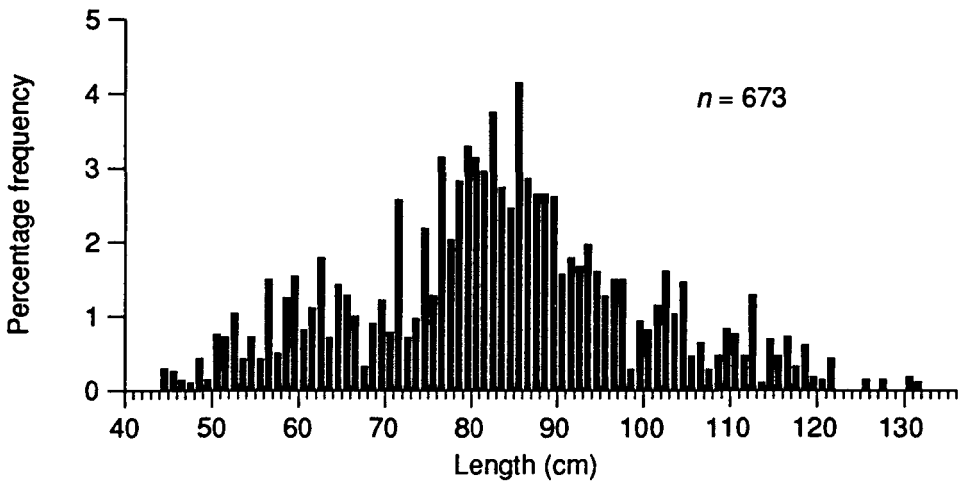


Figure 5: Ling and hake length frequencies, Chatham Rise, Nov/Dec 1989

(a) Ling

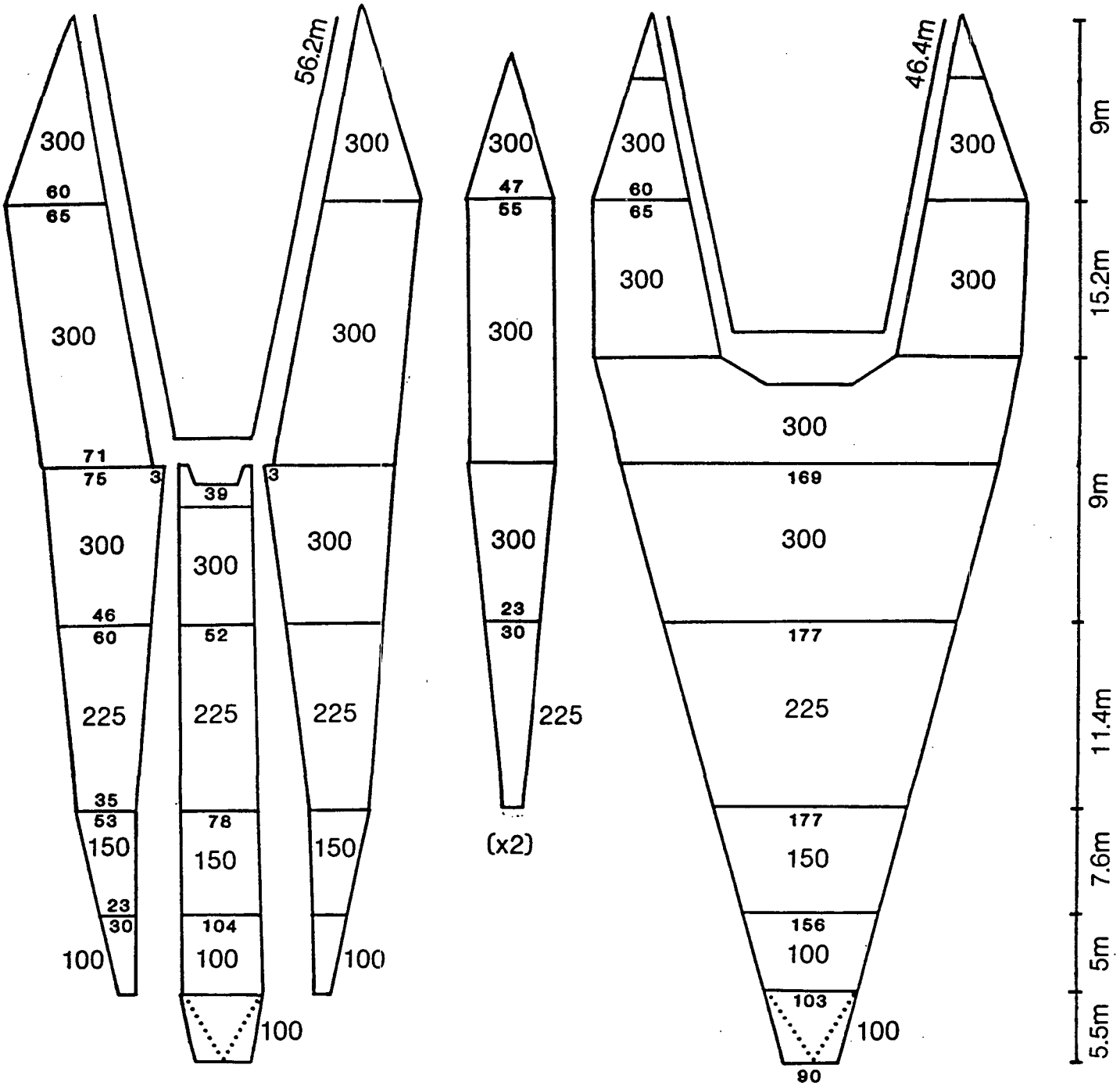


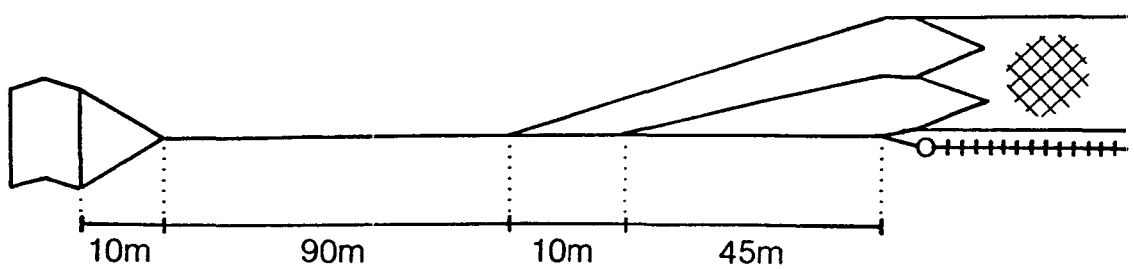
(b) Hake



Appendix 1: Details of High Opening Butterfly Trawl Net.

Note: large figures denote mesh size in terms of 'knot to knot' and small figures denote the number of meshes.





Appendix 2. Doorspread biomass estimates (t) of the main ITQ species (HOK, hoki; HAK, hake; LIN, ling; SWA, silver warehou) and southern blue whiting (SBW), by stratum, 1989.

A. Southland/Sub-Antarctic

Stratum	Area	no. stns	HOK	SBW	LIN	HAK	SWA
1	1 508	3	232	0	52	91	0
2	5 685	3	4	0	231	0	2 318
3	6 175	3	272	0	4 124	45	0
4	7 059	2	347	0	733	876	0
5	4 401	3	23	0	11	0	140
6	14 356	5	1 508	32	127	88	2
7	8 340	3	1 288	0	604	0	0
8	20 682	7	2 858	0	595	495	6
9	17 188	6	9 360	0	873	537	0
10	20 585	9	5 510	31	2 541	273	0
11	9 967	4	8 524	312	134	0	0
12	16 902	6	6 102	1 619	1 382	54	0
13	11 163	5	1 593	0	270	0	0
14	3 177	3	684	144	61	10	0
15	27 098	10	5 923	1 922	1 609	35	0
16	14 302	4	2 522	0	590	0	0
17	31 674	10	2 068	11 834	1 900	80	0
18	11 456	6	4 373	3	306	12	0
19	39 859	14	7 225	4 494	1 139	44	0
20	20 526	7	1 541	0	211	22	0
21	6 785	3	0	8 646	2 525	0	151
22	7 670	4	39	5 928	0	0	0
23	11 840	5	76	549	0	0	0
Total	318 398	125	62 081	35 514	20 016	2 660	2 617

B. Chatham Rise

Stratum	Area	no. stns	HOK†	LIN	HAK	SWA	STA
1	2 394	3	334	201	9	0	0
2	3 325	3	2 289	347	479	0	43
3	8 917	6	1 411	310	389	7	43
4	5 146	4	590	238	21	0	13
5	5 554	4	6 622	606	94	2	0
6	7 641	6	2 689	279	83	2	0
7	4 929	3	5 512	523	256	117	23
8	1 786	4	5 107	180	103	1	1
9	5 156	3	3 610	225	311	0	18
10	9 824	8	3 610	505	6 813	141	21
11	6 887	6	1 995	486	230	76	106
12	7 464	7	8 170	581	114	312	159
13	7 463	6	6 292	283	111	289	46
14	5 766	5	8 781	382	97	98	9
15	5 880	5	5 824	263	103	15 884	30
16	4 695	4	2 623	407	23	50	51
17	6 845	5	7 582	718	42	52	35
18	4 637	4	2 748	108	3	61	72
19	8 189	7	4 682	296	43	198	272
20	9 881	8	10 132	370	22	112	331
21	2 515	4	1 439	92	14	74	147
22	3 893	3	2 995	329	32	1 495	49
23	5 056	4	2 223	73	72	1 811	280
24	737	3	2 206	50	0	703	75
Total	143 580	116	97 958	7 849	9 463	21 491	1 823

† minor changes to stratum boundaries since the March 1990 draft manuscript have resulted in minor changes to species biomass for the Chatham Rise cruise. Only the hoki estimates have been corrected here and the stratum areas have not been adjusted.