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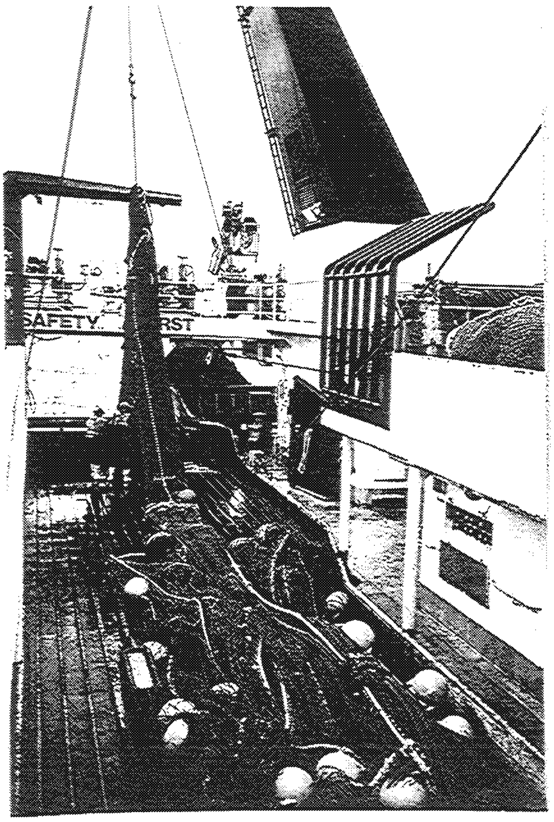

NIWA Technical Report 110
ISSN 1174-2631
2002

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NIWA Technical Report 110
2002

Published by NIWA
Wellington
2002

Edited and produced by
Science Communication, NIWA,
P O Box 14901, Wellington, New Zealand

ISSN 1174-2631
ISBN 0-478-23250-0

Citation:
O'Driscoll, R.L.; Bagley, N.W.; Bull, B. (2002).
Trawl survey of middle depth species in the Southland and Sub-Antarctic areas, November–December 2000 (TAN0012).
NIWA Technical Report 110. 78 p.

Cover photograph by Richard O'Driscoll.

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Abstract

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A fourth summer trawl survey of the Southland and Sub-Antarctic area was carried out from *Tangaroa* from 26 November to 21 December 2000. A total of 103 successful stations (94 phase 1 and 9 phase 2) were completed in 21 strata. Target c.v.s were achieved for the key species: hoki (actual c.v. = 12.5%, target c.v. = 15%), hake (14.4%, 20%), and ling (6.9%, 15%). The biomass of hoki within the core 300–800 m survey area of 56 000 t was only 55–69% of the biomass in previous summer surveys from 1991 to 1993, and continues a downward trend observed during autumn surveys in 1996 and 1998. The hoki length distribution was unimodal and dominated by 1991–94 year classes. Biomass estimates for hake and ling were similar to those from recent surveys, but a higher proportion of small hake and ling were caught in 2000 than previously. Some hake and ling were in spawning condition at the time of the survey, but there were no large catches indicating spawning aggregations. Acoustic work in conjunction with the trawl survey suggested that most non-pelagic backscatter occurred within 50 m of the bottom. A two-day acoustic survey did reveal moderate densities of hake and hoki in areas that were too rough to be sampled by the bottom trawl. Additional effort was put into several trawl strata to increased the numbers of hake sampled. This strategy was successful, and 738 pairs of hake otoliths were collected, giving a mean weighted c.v. of 32% for the hake age frequency.

Introduction

This report presents results from a bottom trawl survey of middle depth species carried out from 26 November to 21 December 2000 in the Southland and Sub-Antarctic areas. Its main purpose is to outline the survey design and methods and to make available data on commercially important species which are relevant to stock assessment and fisheries management.

Two series of trawl surveys have been carried out in the Southland and Sub-Antarctic region from *Tangaroa*: a summer series in 1991, 1992, and 1993; and an autumn series in 1992, 1993, 1996, and 1998. Previous surveys were reviewed by O'Driscoll & Bagley (2001). The main focus of the early surveys (1991–93) was to estimate the abundance of hoki and to explore seasonal variation in relation to spawning. The later surveys (1996 and 1998) were developed primarily to estimate abundance of hake and ling. The 2000 survey is the fourth in the summer trawl series.

The 1998 Sub-Antarctic autumn survey showed a decline in the abundance of hoki (Bagley & McMillan 1999). Nevertheless, stock assessment results from 1999 (Ballara et al. 2000) were very optimistic, largely because an acoustic survey of spawning hoki on the west coast of the South Island (WCSI) in 1997 estimated an increase in hoki biomass there. Autumn is not the best time to survey hoki in the Sub-Antarctic because unknown proportions of the hoki adult biomass may have already left the survey area to spawn on the WCSI (Livingston et al. 1997). The trawl survey was moved back to November–December in 2000 to obtain another estimate of adult hoki biomass at a time when abundance should be maximal in Southland and the Sub-Antarctic. Trends in biomass of hoki from the Sub-Antarctic should theoretically mirror those of the WCSI, assuming that the proportion spawning is constant, and that the WCSI and Sub-Antarctic are the spawning and home ground for the "western stock" of hoki as defined in the assessment model (Cordue 2000).

A summer survey may not be optimal for hake and ling (O'Driscoll & Bagley 2001). Reproductive data from research and commercial observations indicated that some hake and ling are spawning during November–December (Bull et al. 2000). Spawning behaviour may cause problems for a trawl survey if fish are aggregated (high c.v.) or in midwater and unavailable to the bottom trawl.

The main aim of the 2000 survey was to obtain abundance indices for hoki, hake, and ling. An additional aim was to improve the sampling of hake. The middle-depth working group was concerned that the numbers of hake caught in previous surveys were insufficient to adequately determine population age structure (mean weighted c.v. across all ages of hake 50–60% in previous two surveys). The summer timing allowed more trawls per day because of extended daylight hours and provided the opportunity to collect more hake samples. Allocation of trawl stations was also optimised to improve sampling of hake age frequency (Bull et al. 2000).

A two-day acoustic survey was incorporated within the trawl survey to address the potential problems associated with spawning ling and hake. The acoustic work aimed to determine whether a substantial proportion of fish were aggregated in midwater or in areas that could not be sampled by the bottom trawl.

Programme objective

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

Survey objectives

1. To carry out a trawl survey to continue the time series of relative abundance indices for hoki (western stock), hake (HAK 1), and ling (LIN 5 and 6) on the Southern Plateau. Target c.v.s for the trawl survey were 20% for hake and 15% for hoki and ling. This objective also included a two-day acoustic survey to assess the proportion of hake and ling that are in midwater and are not available to the research bottom trawl.
2. To collect data for determining the population age and size structure and reproductive biology of hake, ling, and hoki.
3. To collect acoustic data from the Sub-Antarctic to describe mark types for future analyses.

Voyage personnel

N. Bagley was the voyage leader, R. O'Driscoll was the project leader, and the master of *Tangaroa* was A. Morrice. N. Bagley was responsible for the final database editing.

Methods

Trawl survey area and design

The survey was of a two-phase stratified random design (after Francis 1984), stratified by area and depth. The allocation of stations in phase 1 was based on a statistical analysis of catch rate data from the previous *Tangaroa* summer trawl surveys. Details of the station allocation process were given by Bull et al. (2000). A total of 96 stations were planned for phase 1, with a minimum of three stations per stratum. Phase 2 stations were allocated at sea to improve c.v.s for hoki, hake, and ling and to increase the number of hake sampled. Stratum areas and the number of stations completed are given in Table 1.

The survey area was the same as that of the 1996 and 1998 autumn surveys (Figure 1). The area was divided into 21 strata by depth (300–600, 600–800, and 800–1000 m) and area (Table 1). Strata boundaries and definitions were similar to those in 1998 except that Strata 3 and 5 were subdivided to increase the level of coverage in the region where hake and ling aggregations were thought to occur (Bull et al. 2000). The area of Stratum 1 (Puysegur 300–600 m) was also less than reported for the 1996 and 1998 surveys (Colman 1996, Bagley & McMillan 1999), because in these years the Stratum 1 boundary was erroneously based on the 200 m rather than 300 m bathymetric contour (O'Driscoll & Bagley 2001). As in the 1996 and 1998 surveys, there was no 800–1000 m stratum along the eastern side of the survey area as catches of hake, hoki, and ling from adjacent strata were small. Known areas of foul ground were excluded from the survey.

Vessel and gear specifications

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

Trawling procedure

Trawling followed the standardised procedures described by Hurst et al. (1992). Station positions were selected randomly before the voyage using the Random Stations Generation Program (Version 1.6) developed at NIWA, Wellington. A minimum distance between stations of 3 n. miles was used. If a station was found to be on foul ground, a search was made for suitable ground within 3 n. miles of the station position. If no suitable ground could be found, the station was abandoned and another random position was substituted. Tows were carried out during daylight hours (as defined by Hurst et al. 1992). The trawl was shot no earlier than 0520 h NZDST in the morning and no later than 2000 h NZDST. At each station the trawl was towed for 3 n. miles at a speed over the ground of 3.5 knots. If foul ground was encountered, or the tow hauled early due to reducing daylight, the tow was included as valid only if at least 2 n. miles had been covered. If time ran short at the end of the day and it was not possible to reach the last station, the vessel headed towards the next station and the trawl was shot on that course before 2000 h, if at least 50% of the steaming distance to the next station was covered.

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

Acoustic survey and data collection

An acoustic survey was carried out on 9–10 December using the hull-mounted 38 kHz and 12 kHz CREST systems. The survey covered Strata 3b and 5a (Figure 1) where the commercial fishery had recorded relatively high catch rates of hake and ling in midwater trawls (Bull et al. 2000), as well as the steep ground to the west of Stratum 3b that is unable to be sampled by bottom trawl. A systematic survey design with a random start point was used to ensure good spatial coverage of the area. Twenty transects were run during daylight hours, with three duplicate transects at night, and two at dawn/dusk to investigate diurnal changes in vertical distribution. Targeted midwater trawls were carried out to identify acoustic marks.

Acoustic data were also collected using the hull-mounted CREST system while trawling and while steaming between trawl stations (during both day and night).

Hydrology

Surface temperatures were obtained at the beginning of each tow from a temperature sensor mounted on the hull at a depth of about 5 m. Bottom temperatures were recorded from the Furuno net monitor mounted on the headline of the trawl about 7.0 m above the bottom. The calibration of temperature sensors was uncertain and temperature data should be regarded as relative within this survey only.

Catch sampling

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

Biological sampling

An approximately random sample of up to 200 individuals of each commercially important species from every successful tow was measured and sex determined. More detailed biological data were also collected on a subset of species and included fish length, weight, sex, gonad stage, gonad weight, and occasional observations on stomach fullness, and contents and prey condition. Otoliths were taken from hake, hoki, and ling for age determination. A description of the macroscopic gonad stages used for the three main species is given in Appendix 1.

Trawl data analysis

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

$$\text{c.v. } (\%) = 100\, S_B / B \times 100$$

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

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

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

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

Acoustic data analysis

Acoustic data collected during the two-day acoustic survey were analysed using NIWA's Echo Sounder Package (ESP2) software. Data were integrated in 10 m vertical bins using standard techniques (MacLennan & Simmonds 1992) to obtain estimates of acoustic backscatter. No attempt was made to estimate fish biomass because of uncertainties about species composition and target strength, but backscatter was subjectively divided into "pelagic" (consisting mainly of myctophids and other mesopelagic organisms) and "non-pelagic" (hoki, hake, ling, and other demersal species) components. Marks were identified as "pelagic" if they formed surface referenced layers and/or appeared relatively strong on 12 kHz echograms compared to 38 kHz echograms (Bull 2000). The proportions of total integrated "non-pelagic" backscatter in the zones 0–10 m, 0–20 m, ... 0–100 m from the bottom were estimated.

Acoustic recordings made during the trawl survey (both during trawls and while steaming between stations) were visually examined and a qualitative classification scheme was constructed to group marks into categories. Descriptive statistics were produced on the frequency of occurrence of different mark types and were presented in a separate report by O'Driscoll (2001).

Results

Survey area and stations sampled

A total of 105 trawl survey bottom-trawl stations were completed in 21 strata (Table 1, Figure 2). Successful stations included 94 phase 1 stations and 9 phase 2 stations. The first station was a gear trial and one other station (Station 47 in Stratum 6) was considered unsuitable for biomass estimation due to coming fast. Two planned phase 1 stations were dropped: one in Stratum 26 because extensive backtracking was required to pick up alternative tows; and one in Stratum 27 due to nil or very small catches of hoki, hake, or ling made on the other five stations in this stratum. The total survey area covered was 320 195 km^2 with an average station density of 1:3109 km^2 achieved. Four midwater trawls were carried out in support of the acoustic survey. Individual station details from all trawl stations are given in Appendix 2.

Gear performance

Gear parameters by depth and for all observations are summarised in Table 2. The headline height was obtained on every successful tow, but there were no doorspread readings for 35 tows. Missing doorspread values were calculated from data collected in the same depth range on this voyage. Both headline height and doorspread were similar to those obtained on other voyages of *Tangaroa* in this area when the same gear was used.

Catch

One hundred and sixty-four species or species groups were recorded including 98 teleosts, 20 elasmobranchs, 11 cephalopods, and 14 crustaceans. The remaining 21 species or groups were assorted benthic and pelagic organisms. A list of all species caught, their species codes, and the number of stations at which they occurred is given in Appendix 3.

Biomass estimates

Biomass estimates and catch weights for the 27 most abundant commercial species and the 12 most abundant non-commercial species are given in Table 3. Biomass estimate subtotals are given for hoki, hake, and ling for the 300–800 m depth range (Strata 1–15) in Table 4 to enable comparisons with results of previous summer surveys where the maximum depth was 800 m over much of the area (O'Driscoll & Bagley 2001). Biomass estimates by stratum are given for the 11 most abundant commercial species in Table 5a, and for 9 non-commercial species in Table 5b.

Biomass of hoki in 2000 was the lowest in the summer time series and only 55–69% of the biomass observed in the early 1990s. Hoki biomass in 2000 was also lower than in the most recent autumn surveys (see Table 4). The only Sub-Antarctic survey with lower hoki biomass was in autumn 1993 when the survey was conducted late (May–June) and it is thought many hoki had already left the survey area for spawning (Livingston et al. 1997).

Biomass of ling in 2000 was the highest in the summer time-series and similar to estimates of biomass in recent autumn surveys: biomass of hake was also similar to recent surveys, but lower than in the summer survey in 1991 and autumn survey in 1992 (see Table 4). About a third of the hake biomass in 2000 occurred in 800–1000 m strata, which were not sampled in previous summer trawl surveys.

Catch rates

The catch rates and standard deviations of the 11 most abundant commercial species and of the 9 most abundant non-commercial species by stratum are given in Tables 6a and 6b. The distribution and catch rates at each station for hoki, ling, and hake are given in Figures 3–5, and for 13 other species in Figures 6a–m.

Hoki were widespread throughout the core 300–800 m survey area, occurring at almost all trawl stations (Figure 3). As in previous surveys (O'Driscoll & Bagley 2001), high catches of hoki occurred more frequently in the west, on the Stewart-Snares shelf, on the western side of the Campbell Rise, and at Puysegur. Hoki were also caught in low numbers in 800–1000 m strata.

Ling were also widely distributed (Figure 4). Largest catches occurred on the Stewart-Snares shelf, at Puysegur, and in the western part of the survey area between the Campbell and Auckland Islands. Ling were seldom caught deeper than 800 m.

Hake were concentrated at Puysegur and on the western part of the Stewart-Snares shelf (Figure 5). Most hake were caught in 600–1000 m strata. As noted previously, a third of the hake biomass came from 800–1000 m strata (see Table 4).

Black and smooth oreo were taken in northeastern strata deeper than 800 m. Small-scaled brown slickhead were also taken deeper than 800 m, but were more widespread, occurring in the south and at Puysegur as well as in the north. Several species, including javelinfish, lookdown dory, ribaldo, spiny dogfish, and ridge scaled rattail were most abundant in the western 300–800 m strata and at Puysegur. Pale ghost shark and silverside were widely distributed over the Southern Plateau, but were not caught in large numbers at Puysegur. Dark ghost shark and white warehou were caught in only a few tows in the northwest. Catches of southern blue whiting were highest in the east in 300–600 m strata. These distribution patterns were consistent with those observed in previous Sub-Antarctic surveys (O'Driscoll & Bagley 2001).

Biological data

The numbers of fish of each species measured or selected for biological analysis are shown in Table 7. Otoliths were removed from 1531 hoki, 991 ling, and 738 hake. The number of hake otoliths collected was more than twice the number collected in any previous survey of this area. Otoliths were aged using validated ageing methods (Horn 1993, 1997, Horn & Sullivan 1996) and age-length keys constructed. Numbers at age were calculated from observed length frequencies and the age-length keys using software developed specifically for this task by NIWA.

Length-weight relationships used to scale length frequency data are given in Table 8. Length frequency histograms by sex for hoki, ling, and hake are compared to those from previous Sub-Antarctic surveys in Figure 7. Length frequencies for hoki in 2000 are also presented by strata (Figure 8). Length frequencies for another 11 species are shown in Figure 9, and data for southern blue whiting are separated by sub-area in Figure 10. Numbers at age for hoki, ling, and hake in 2000 are tabulated in Appendix 4 and compared to previous Sub-Antarctic surveys in Figure 11.

Hoki length frequencies in 2000 (Figure 7a) showed a clear mode centred on 80 cm for males and about 85 cm for females. Ageing shows that these are fish from the strong year classes in 1991–94 seen in 2000 as 6–9 year olds (Figure 11a, Appendix 4). Few smaller, younger hoki were seen compared to previous surveys (Figures 7a, 11a). Almost all hoki less than 50 cm were caught at Puysegur in depths less than 600 m (Stratum 1) (Figure 8). Small hoki (modal length about 65 cm) were also taken from 300–600 m depth on the Stewart-Snares shelf (Strata 3a and 3b). Modal lengths of hoki in other strata ranged from 80 to 90 cm (Figure 8).

The modal length of both male and female ling was about 75 cm, although larger females were more common than larger males (Figure 7b). The increase in the numbers of younger fish in 2000 (Figure 11b) may reflect good recruitment in the mid–late 1990s.

The length frequency distribution of hake was broad with no clear modes (Figure 7c). This was reflected in the age frequency (Figure 11c) which showed a wide range of ages. There were more smaller, younger fish sampled in 2000 than in previous trawl surveys of the Sub-Antarctic. A high proportion of young hake were caught deeper than 800 m, particularly at Puysegur (Figure 7c).

The southern blue whiting length frequency distribution showed three clear modes at about 29 cm, 35 cm, and 42–46 cm (Figure 9). There was some indication of a difference in size between sub-areas. Large female southern blue whiting (more than 40 cm) were more abundant on the Campbell Plateau than on the Pukaki Rise (Figure 10). Other common species tended to show unimodal or patchy length distributions (Figure 9).

Gonad stage data are summarised in Table 9. Most hoki, southern blue whiting, ribaldo, and white warehou were in the resting phase, with smaller proportions of spent and immature fish. A few male hoki still exuded sperm and were classified as partially spent. Some hake, ling, and male ridge scaled rattail were observed in spawning condition (stages 4 and 5), suggesting that spawning of these species was still occurring at the time of the trawl survey (Table 9). However, most hake and ling were immature or resting. Lookdown dory were recorded in all reproductive states except running ripe (stage 5).

Acoustic results

The two days of acoustics work in the gap between the Stewart-Snares shelf and the Auckland Islands Shelf was carried out during a period of settled weather from 9-10 December. Twenty transects were surveyed using the 12 kHz and 38kHz CREST systems (Figure 12). All transects were sampled during the day with three repeat transects run at night and two during the dawn/dusk period. Four midwater trawls (three day and one night) were targeted on marks. Catch weights and species composition for midwater trawls are summarised in Table 10.

The spatial distribution of "non-pelagic" backscattering is shown in Figure 12 and summarised in Table 11. There were few obvious midwater aggregations of hake or ling during the acoustic survey. Most midwater marks encountered were layers of small mesopelagic species (e.g. Figure 13, Tow 54 in Table 10). A small aggregation of "non-pelagic" type marks was encountered along Transect 6 (Figure 12) on a small knob at 400–500 m depth (Figure 14). Midwater trawls on this mark at night (Tow 56) and during the day (Tow 57) caught mainly hake and hoki (Table 10). Non-pelagic marks were also detected in deeper water (500–900 m) on transects 8, 9, 12, and 13 (Figure 12). Trawling on these transects was not attempted because of the steep, rough terrain.

About 30% of the non-pelagic acoustic backscatter detected during the acoustic survey was within 20 m of the bottom (Table 11), although individual targets were detected over 100 m from the bottom (e.g., Figure 14).

There was some evidence of fish response to the midwater trawl. The mark on Transect 6 (Figure 14) became compressed close to the bottom during the daytime trawl and the crew felt that most of the fish had escaped below the net. The catch of hake from this mark at night contained larger fish and a higher proportion of females than the catch during the day, although sample sizes were very small.

A total of 231 acoustic data files (105 "trawl" files and 126 "steam" files) were recorded during the trawl survey. Periods of good weather with slight sea provided high quality recordings from both frequencies during the survey. The classification and description of acoustic marks was described in a separate report (O'Driscoll 2001).

Hydrology

Surface temperatures (Figure 15) varied from 8.3 °C in the southeast of the survey area to 13.7 °C on Puysegur Bank in the northwest. Recorded bottom temperatures from the Furuno net monitor ranged from 4.8 to 10.8 °C in the Sub-Antarctic area (Figure 16). The warmest bottom temperatures were recorded at Puysegur.

Discussion

The trawl survey and acoustic work were completed with the loss of only about 2 days to bad weather. A total of 103 successful bottom trawl stations were completed out of the planned 115 in the 26 days *Tangaroa* spent in the survey area. An average of 4.3 biomass stations per day was achieved. The number of trawls carried out each day was limited by the large distances between stations.

The c.v.s of the biomass estimates for the three key species were all within the survey targets of 20% for hake and 15% for ling and hoki. As in previous surveys (see O'Driscoll & Bagley 2001), catches of hoki and ling were relatively even and widespread, with the exception of the 800–1000 m strata for ling where abundance was low. This suggests that the survey design and stratification for those species is appropriate to achieve the target c.v.s. The distribution of hake was more patchy than that of ling or hoki, but the c.v was similar to that from most previous surveys (O'Driscoll & Bagley 2001). Fewer hake were caught in deep 800–1000 m strata in the north and east of the survey area than in autumn surveys in 1996 and 1998.

There was no evidence of large aggregations of spawning hake or ling. Although some individuals of both species, especially hake, were in spawning condition (see Table 9), there were no large catches of spawning hake such as in December 1991 (Chatterton & Hanchet 1994). The acoustic survey suggested that most non-pelagic acoustic back-scattering occurs within 50 m of the bottom (Table 11), although some hoki and hake were detected in midwater over 100 m from the bottom during the day and at night.

The acoustic survey revealed moderate densities of fish in areas that were too rough to be sampled with a bottom trawl. There are large areas of untrawlable ground especially on the edge of the Stewart-Snares shelf and it is uncertain what proportion of the overall biomass of hoki, hake, and ling occur in these areas. We suggest that the use of midwater trawls by the commercial fishery in Strata 3 and 5 (Bull et al. 2000) may be related as much to the nature of the ground (not suitable for bottom trawling) as to the vertical distribution of the target species.

The biomass of hoki within the core 300–800 m was much lower than in previous summer surveys in the early 1990s. The hoki length distribution was unimodal and dominated by the 1991–94 year classes. The 1994 year-class in 2000 was weaker at age 6 than the 1987 year-class in the summer 1993 survey, suggesting that that the 1987 year-class was the stronger of these two strong year-classes. This differs from the model estimates of year-class strength in the 1999 assessment which indicated that the 1994 year-class was the strongest in the time series (Cordue 2000). There was no evidence for strong recent recruitment of young hoki to the Sub-Antarctic.

Biomass of hake and ling were similar to those observed on previous summer and autumn surveys. A higher proportion of small hake and ling were caught in 2000 than in previous surveys and this may reflect good recent recruitment. The additional effort put into strata to increase numbers of hake sampled was successful. A total of 738 pairs of hake otoliths were collected, giving a mean weighted c.v. of 32% for the hake age frequency.

Acknowledgments

Thanks to the scientific staff who participated in this voyage and to the master, officers, and crew of *Tangaroa*. Mary Livingston provided valuable comments on an earlier draft of this report. This work was carried out by NIWA under contract to the Ministry of Fisheries (Contract No. MDT2000/01).

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

Stratum	Name	Depth (m)	Area (km^2)	Number of stations phase 1	Number of stations phase 2	Station density (km^2)
1	Puysegur Bank	300–600	2 150	4	–	1 : 538
2	Puysegur Bank	600–800	1 318	4	–	1 : 330
3a*	Stewart-Snares	300–600	4 548	4	–	1 : 1 137
3b*	Stewart-Snares	300–600	1 556	4	–	1 : 389
4	Stewart-Snares	600–800	21 018	5	–	1 : 4 204
5a*	Snares-Auckland	600–800	2 981	4	1	1 : 596
5b*	Stewart-Snares	600–800	3 281	3	–	1 : 1 094
6	Auckland Is.	300–600	16 682	5	1	1 : 2 780
7	South Auckland	600–800	8 497	3	–	1 : 2 832
8	NE Auckland	600–800	17 294	8	–	1 : 2 161
9	N Campbell Is.	300–600	27 398	8	2	1 : 2 740
10	S Campbell Is.	600–800	11 288	4	–	1 : 2 822
11	NE Pukaki Rise	600–800	23 008	4	1	1 : 4 602
12	Pukaki	300–600	45 259	5	–	1 : 9 052
13	NE Camp. Plateau	300–600	36 051	5	1	1 : 6 009
14	E Camp. Plateau	300–600	27 659	5	–	1 : 5 532
15	E Camp. Plateau	600–800	15 179	3	–	1 : 5 060
25	Puysegur Bank	800–1 000	1 928	4	3	1 : 275
26‡	SW Campbell Is.	800–1 000	31 778	3	–	1 :10 593
27‡	NE Pukaki Rise	800–1 000	12 986	5	–	1 : 2 597
28‡	E Stewart Is.	800–1 000	8 336	4	–	1 : 2 084
Total			320 195	94	9	1: 3 109

* sub-division of strata used in the 1998 survey.
‡ these strata were not surveyed in previous Sub-Antarctic summer surveys in 1991–93.

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

	n	Mean	s.d	Range
Tow parameters				
Tow length (n.miles)	103	2.92	0.22	2.00–3.12
Tow speed (knots)	103	3.52	0.08	3.3–3.7
Gear parameters (m)				
300–600 m				
Headline height	43	6.9	0.19	6.5–7.6
Doorspread	34	121.0	5.67	106.0–131.3
600–800 m				
Headline height	41	6.9	0.12	6.7–7.2
Doorspread	28	122.2	4.52	114.0–132.4
800–1000 m				
Headline height	19	7.1	0.27	6.7–7.6
Doorspread	6	119.8	5.87	108.9–125.5
All stations 300–1000 m				
Headline height	103	7.0	0.20	6.5–7.6
Doorspread	68	121.4	5.22	106.0–132.4

Table 3: **Biomass estimates, coefficients of variation, and catch of the major species in all strata.**

	Species code	Total Biomass (t)	Total c.v. (%)	Males Biomass (t)	Males c.v. (%)	Females Biomass (t)	Females c.v. (%)	Total catch (kg)
Commercial species								
Hoki	HOK	56 407	12.5	17 909	14.8	38 478	11.8	12 290
Ling	LIN	33 033	6.9	11 503	8.6	21 530	8.0	7 649
Pale ghost shark	GSP	17 823	12.4	9 683	16.8	8 140	10.9	3 353
Southern blue whiting	SBW	17 492	15.2	6 617	28.1	10 871	15.4	1 850
Black oreo	BOE	13 095	75.7	6 385	76.4	6 711	75.1	2 450
Spiny dogfish	SPD	4 173	11.6	856	20.2	3 317	10.9	964
Hake	HAK	3 103	14.4	667	23.4	2 435	14.7	2 047
Smooth oreo	SSO	3 004	48.6	1 481	47.1	1 516	50.0	866
Ghost shark	GSH	1 459	89.6	716	95.2	743	84.4	416
Ribaldo	RIB	938	13.4	43	37.9	895	13.2	395
Lookdown dory	LDO	921	15.2	203	26.5	673	18.6	243
Smooth skate	SSK	495	59.0	56	88.5	439	65.5	99
Orange roughy	ORH	356	26.8	137	31.8	218	31.1	158
Arrow squid	NOS	331	56.0	157	42.1	169	70.9	355
White warehou	WWA	266	38.7	67	55.0	199	46.3	72
Giant stargazer	STA	211	31.8	37	37.4	175	35.0	162
Rough skate	RSK	201	56.4	55	55.0	146	67.5	36
Ray's bream	RBM	88	36.8	39	54.6	49	38.2	42
Spiky oreo	SOR	68	77.6	31	75.2	37	80.0	105
Red cod	RCO	38	43.3	26	54.4	11	34.3	49
School shark	SCH	36	73.6	–	–	–	–	49
Sea perch	SPE	25	92.7	15	100.0	9	81.5	50
Silver warehou	SWA	21	65.0	1	100.0	20	64.5	22
Bluenose	BNS	9	100.0	0		9	100.0	14
Hapuku	HAP	8	100.0	0		8	100.0	9
Gemfish	SKI	4	100.0	4	100.0	0		5
Cardinalfish	EPT	1	71.2	1	100.0	1	100.0	3
Non-commercial species where biomass > 1000 t								
Javelinfish	JAV	18 773	12.3	–		–		4 251
Ridge scaled rattail	MCA	9 278	10.9	6 023	26.6	3 253	22.6	1 359
Small-scale slickhead	SSM	4 221	34.7	–		–		925
Baxter's dogfish	ETB	2 540	16.0	–		–		628
Warty squid	MIQ	2 191	9.5	–		–		440
Silverside	SSI	1 810	15.4	768	16.0	1 042	17.3	263
Oblique banded rattail	CAS	1 749	14.2	–		–		234
Longnose chimaera	LCH	1 720	21.5	–		–		228
Banded rattail	CFA	1 607	13.6	–		–		366
Longnose velvet dogfish	CYP	1 482	18.6	–		–		633
Finless flounder	MAN	1 164	18.2	–		–		131
Oliver's rattail	COL	1 110	12.3	–		–		350

– Biomass by sex could not be calculated

Table 4: **Biomass estimates of hoki, hake, and ling for all surveyed strata and for core 300–800 m strata. Estimates from previous Sub-Antarctic surveys are from O'Driscoll & Bagley (2001) and are given for comparison.**

	Core strata (300 to 800 m)		All strata (300 to 1000 m)	
HOKI	Biomass	c.v. (%)	Biomass	c.v. (%)
Summer series				
1991	80 285	7		
1992	87 359	6		
1993	99 695	9		
2000	55 663	13	56 407	13
Autumn series				
1992	67 831	8		
1993	53 466	10		
1996	89 029	9	92 650	9
1998	67 709	11	71 738	10
HAKE				
Summer series				
1991	5 553	44		
1992	1 822	12		
1993	2 286	12		
2000	2 194	17	3 103	14
Autumn series				
1992	5 028	15		
1993	3 221	13		
1996	2 026	12	2 825	12
1998	2 506	18	3 898	16
LING				
Summer series				
1991	24 085	7		
1992	21 368	6		
1993	29 747	12		
2000	33 023	7	33 033	7
Autumn series				
1992	42 334	6		
1993	33 553	5		
1996	32 133	8	32 363	8
1998	30 776	9	30 893	9

Table 5a: **Estimated biomass (t) and coefficients of variation (%, in parentheses) of the major (more than 500 t biomass) commercial species by stratum. Species codes are given in Table 3. Sub-totals are provided for core strata (1–15) and core + Puysegur 800–1000 m (Strata 1–25).**

Stratum	HOK	LIN	GSP	SBW	BOE	SPD	HAK	SSO	GSH	RIB	LDO
1	561	523	0	0	0	73	9	0	2	10	37
	(44)	(24)				(90)	(76)		(79)	(100)	(84)
2	262	106	4	0	4	0	8	0	0	22	6
	(35)	(9)	(100)		(100)		(45)			(28)	(9)
3a	270	675	121	0	0	142	26	0	2	16	25
	(38)	(31)	(88)			(66)	(45)		(100)	(60)	(27)
3b	436	371	2	0	0	61	42	0	119	0	20
	(46)	(73)	(100)			(80)	(100)		(83)		(69)
4	2 530	2 269	1 297	0	0	114	351	0	0	248	0
	(23)	(17)	(24)			(52)	(54)			(24)	
5a	534	398	172	0	0	62	185	0	7	25	15
	(34)	(19)	(39)			(58)	(44)		(61)	(44)	(35)
5b	273	471	457	0	0	58	202	0	0	42	3
	(19)	(27)	(18)			(55)	(47)			(45)	(100)
6	4 719	2 576	429	38	0	658	256	0	1 329	12	190
	(39)	(43)	(26)	(84)		(44)	(70)		(98)	(100)	(39)
7	1 566	469	95	0	0	49	181	0	0	87	23
	(35)	(45)	(51)			(69)	(59)			(77)	(100)
8	3 262	1 850	1 025	0	274	122	303	0	0	187	12
	(19)	(28)	(21)		(100)	(48)	(36)			(27)	(100)
9	11 090	6 784	3 858	596	0	697	154	0	0	21	150
	(49)	(18)	(35)	(79)		(36)	(44)			(67)	(33)
10	1 224	448	256	0	0	96	79	0	0	44	0
	(56)	(58)	(52)			(86)	(58)			(34)	
11	7 689	2 032	748	0	9 785	85	136	0	0	56	25
	(15)	(25)	(53)		(100)	(42)	(63)			(49)	(26)
12	3 819	5 573	4 640	6 659	0	241	0	0	0	0	96
	(19)	(16)	(29)	(33)		(32)					(53)
13	6 573	3 595	2 384	2 142	0	717	64	0	0	31	83
	(31)	(15)	(35)	(51)		(19)	(100)			(100)	(54)
14	6 769	3 938	1 100	7 932	0	687	120	0	0	0	193
	(41)	(17)	(41)	(12)		(24)	(62)				(29)
15	4 086	945	171	124	0	309	77	0	0	71	44
	(13)	(8)	(27)	(88)		(20)	(100)			(52)	(100)
Subtotal	55 663	33 023	16 937	17 491	10 063	4 173	2 194	0	1 459	873	921
(Strata 1–15)	(13)	(7)	(13)	(15)	(97)	(12)	(17)		(90)	(14)	(15)
25	98	10	16955	0	1	0	463	17	0	41	0
	(33)	(55)	(13)		(80)		(41)	(82)		(43)	
Subtotal	55 760	33 033	22 199	17 491	10 064	4 173	2 657	17	1 459	914	921
(Strata 1–25)	(13)	(7)	(13)	(15)	(97)	(12)	(16)	(82)	(90)	(14)	(15)
26	177	0	451	0	0	0	191	49	0	0	0
	(100)		(68)				(55)	(100)			
27	406	0	82	1	546	0	106	1 776	0	24	0
	(47)		(61)	(100)	(51)		(61)	(75)		(100)	
28	64	0	336	0	2 486	0	148	1 161	0	0	0
	(69)		(39)		(62)		(62)	(50)			
Total	56 407	33 033	17 823	17 492	13 096	4 173	3 103	3 004	1 459	938	921
(All strata)	(13)	(7)	(12)	(15)	(76)	(12)	(14)	(49)	(90)	(13)	(15)

Table 5b: **Estimated biomass (t) and coefficients of variation (%, in parentheses) of other major (more than 1500 t biomass) species by stratum. Species codes are given in Table 3.**

Stratum	JAV	MCA	SSM	ETB	MIQ	SSI	CAS	LCH	CFA
1	46	0	0	0	0	0	< 0.5	0	< 0.5
	(62)						(100)		(60)
2	31	0	0	0	0	0	0	2	2
	(29)							(100)	(50)
3a	106	0	0	8	34	25	29	12	55
	(28)			(63)	(47)	(31)	(80)	(100)	(58)
3b	3	0	0	0	1	< 0.5	19	0	< 0.5
	(93)				(100)	(100)	(47)		(100)
4	1 088	75	0	89	165	5	0	201	151
	(40)	(78)		(71)	(37)	(61)		(14)	(39)
5a	99	2	0	68	3	0	1	0	20
	(57)	(100)		(100)	(41)		(61)		(55)
5b	375	7	0	66	13	1	0	5	22
	(62)	(59)		(63)	(60)	(68)		(58)	(58)
6	271	0	0	0	41	50	59	0	43
	(35)				(51)	(42)	(68)		(51)
7	770	100	0	106	60	0	0	19	41
	(24)	(83)		(100)	(28)			(65)	(28)
8	1 389	51	0	256	139	13	0	52	197
	(18)	(71)		(46)	(31)	(29)		(29)	(17)
9	3 469	0	0	2	194	440	183	176	224
	(30)			(100)	(29)	(30)	(37)	(43)	(23)
10	324	378	0	115	79	0	0	21	62
	(34)	(47)		(81)	(39)			(100)	(7)
11	1 737	0	0	235	247	10	9	16	167
	(20)			(47)	(34)	(63)	(64)	(90)	(36)
12	2 222	0	0	0	79	382	744	792	79
	(34)				(48)	(31)	(20)	(44)	(47)
13	3 709	0	0	0	399	547	496	220	46
	(45)				(19)	(28)	(35)	(26)	(24)
14	2 117	0	0	0	152	315	194	62	22
	(26)				(22)	(47)	(28)	(60)	(71)
15	582	83	0	62	149	21	16	28	33
	(23)	(100)		(64)	(18)	(90)	(68)	(100)	(30)
Subtotal	18 340	694	0	1 004	1 754	1 810	1 749	1 606	1 164
(strata 1–15)	(13)	(32)		(24)	(9)	(15)	(14)	(23)	(10)
25	291	196	222	1	18	0	0	1	4
	(42)	(50)	(52)	(80)	(45)			(82)	(44)
Subtotal	18 631	890	222	1 006	1 772	1 810	1 749	1 606	1 168
(strata 1–25)	(12)	(27)	(52)	(24)	(9)	(15)	(14)	(23)	(10)
26	3	7 453	3 375	669	158	0	0	68	251
	(100)	(12)	(43)	(39)	(75)			(87)	(71)
27	138	571	200	340	146	0	0	9	93
	(48)	(54)	(93)	(51)	(27)			(73)	(32)
28	1	364	424	525	115	0	0	37	96
	(100)	(30)	(19)	(16)	(28)			(48)	(18)
Total	18 773	9 278	4 221	2 540	2 191	1 810	1 749	1 720	1607
(All strata)	(12)	(11)	(35)	(16)	(10)	(15)	(14)	(22)	(14)

Table 6a: **Catch rates (kg km^{-2}) and standard deviations (in parentheses) of the major commercial species by stratum. Species codes are given in Table 3.**

Stratum	HOK	LIN	GSP	SBW	BOE	SPD	HAK	SSO	GSH	RIB	LDO
1	261	243	0	0	0	34	4	0	1	5	17
	(228)	(119)				(61)	(7)		(1)	(10)	(29)
2	199	81	3	0	3	0	6	0	0	17	4
	(141)	(14)	(6)		(6)		(6)			(9)	(1)
3a	59	148	27	0	0	31	6	0	1	4	5
	(45)	(91)	(47)			(41)	(5)		(1)	(4)	(3)
3b	436	239	1	0	0	39	27	0	76	0	13
	(46)	(350)	(2)			(63)	(54)		(126)		(18)
4	120	108	62	0	0	5	17	0	0	12	0
	(61)	(42)	(33)			(6)	(20)			(6)	
5a	179	133	58	0	0	21	62	0	2	8	5
	(135)	(55)	(51)			(27)	(62)		(3)	(8)	(4)
5b	83	144	139	0	0	18	62	0	0	13	1
	(31)	(76)	(49)			(20)	(57)			(12)	(2)
6	283	154	26	2	0	39	15	0	80	1	11
	(246)	(148)	(15)	(4)		(39)	(24)		(175)	(2)	(10)
7	184	55	11	0	0	6	21	0	0	10	3
	(112)	(43)	(10)			(7)	(22)			(14)	(5)
8	189	107	70	0	16	7	18	0	0	11	1
	(104)	(86)	(42)		(45)	(10)	(18)			(8)	(2)
9	405	248	141	22	0	25	6	0	0	1	6
	(631)	(140)	(155)	(54)		(29)	(8)			(2)	(6)
10	108	40	23	0	0	9	7	0	0	4	0
	(122)	(46)	(24)			(15)	(8)			(3)	
11	334	88	33	0	425	4	6	0	0	2	1
	(113)	(50)	(17)		(951)	(3)	(8)			(3)	(1)
12	84	123	103	147	0	5	0	0	0	0	2
	(37)	(44)	(67)	(108)		(4)					(3)
13	182	100	66	59	0	20	2	0	0	1	2
	(141)	(37)	(57)	(74)		(9)	(4)			(2)	(3)
14	245	142	40	287	0	25	4	0	0	0	7
	(226)	(54)	(36)	(77)		(14)	(6)				(5)
15	269	62	11	8	0	20	5	0	0	5	3
	(61)	(8)	(5)	(12)		(7)	(9)			(4)	(5)
25	51	5	9	0	1	0	240	9	0	22	0
	(44)	(7)	(9)		(1)		(262)	(19)		(25)	
26	6	0	14	0	0	0	6	2	0	0	0
	(10)		(17)				(6)	(3)			
27	31	0	6	1	42	0	8	137	0	2	0
	(33)		(9)	(1)	(48)		(11)	(230)		(4)	
28	8	0	40	0	298	0	18	139	0	0	0
	(11)		(32)		(367)		(22)	(140)			

Table 6b: **Catch rates (kg km^{-2}) and standard deviations (in parentheses) of other major species by Stratum. Species codes are given in Table 3.**

Stratum	JAV	MCA	SSM	ETB	MIQ	SSI	CAS	LCH	CFA
1	21	0	0	0	0	0	1	0	1
	(27)						(1)		(1)
2	24	0	0	0	0	0	0	1	1
	(14)							(2)	(1)
3a	23	0	0	2	7	6	6	3	12
	(13)			(2)	(7)	(3)	(10)	(5)	(14)
3b	2	0	0	0	1	1	12	0	1
	(4)				(1)	(1)	(11)		(1)
4	52	4	0	4	8	1	0	10	7
	(46)	(6)		(7)	(7)	(1)		(3)	(6)
5a	33	1	0	23	1	0	1	0	7
	(43)	(1)		(51)	(1)		(1)		(8)
5b	114	2	0	20	4	1	0	2	7
	(141)	(2)		(25)	(5)	(1)		(2)	(8)
6	16	0	0	0	3	3	4	0	3
	(13)				(3)	(3)	(5)		(3)
7	91	12	0	12	7	0	0	2	5
	(38)	(17)		(22)	(3)			(3)	(3)
8	80	3	0	15	8	1	0	3	11
	(41)	(6)		(19)	(7)	(1)		(2)	(6)
9	127	0	0	1	7	16	7	6	8
	(122)			(1)	(7)	(15)	(8)	(9)	(6)
10	29	34	0	10	7	0	0	2	6
	(20)	(31)		(17)	(5)			(4)	(1)
11	76	0	0	10	11	1	1	1	7
	(34)			(11)	(8)	(1)	(1)	(1)	(6)
12	49	0	0	0	2	8	16	18	2
	(37)				(2)	(6)	(7)	(17)	(2)
13	103	0	0	0	11	15	14	6	1
	(114)				(5)	(10)	(12)	(4)	(1)
14	77	0	0	0	6	11	7	2	1
	(44)				(3)	(12)	(4)	(3)	(1)
15	38	6	0	4	10	1	1	2	2
	(16)	(9)		(5)	(3)	(2)	(1)	(3)	(1)
25	151	102	115	1	9	0	0	1	2
	(169)	(133)	(158)	(2)	(11)			(1)	(2)
26	1	235	106	21	5	0	0	2	8
	(1)	(51)	(79)	(14)	(6)			(3)	(10)
27	11	44	15	26	11	0	0	1	7
	(11)	(53)	(32)	(30)	(7)			(1)	(5)
28	1	44	51	63	14	0	0	4	11
	(1)	(26)	(20)	(20)	(8)			(4)	(4)

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

	Length frequency data				Biological data	
Species	No. of samples	No. of fish	No. of males	No. of females	No. of samples	No. of fish
Arrow squid	20	242	167	72	0	0
Barracouta	2	13	3	10	1	1
Black oreo	14	1 017	523	494	10	261
Black shark	1	3	2	1	0	0
Bluenose	1	1	0	1	1	1
Cardinalfish	1	2	1	1	0	0
Dark ghost shark	13	314	160	154	5	28
Gemfish	1	1	1	0	1	1
Giant stargazer	13	45	17	28	7	32
Hake	66	799	380	419	66	738
Hapuku	1	1	0	1	0	0
Hoki	102	7 315	2 820	4 493	90	1 837
Ling	85	3 464	1 763	1 700	70	1 278
Lookdown dory	49	204	83	121	47	204
Orange roughy	16	224	103	114	7	35
Pale ghost shark	93	1 915	1 072	843	56	848
Pearlside	2	433	0	0	2	433*
Ray's bream	14	67	31	36	0	0
Red cod	7	46	36	10	1	20
Ribaldo	49	197	37	160	46	192
Rough skate	8	12	7	5	8	12
School shark	1	3	0	3	0	0
Sea perch	3	28	16	12	1	26
Shovelnose dogfish	11	93	71	22	9	72
Silverside	45	1 343	602	740	4	231
Silver warehou	3	8	1	7	1	1
Smooth oreo	13	973	535	435	11	485
Smooth skate	8	8	3	5	7	7
Southern blue whiting	26	2 303	865	1 436	15	491
Spiky oreo	2	128	60	68	2	128
Spiny dogfish	65	400	110	290	62	367
White warehou	11	65	32	33	11	65
Ridge scaled rattail	30	746	412	330	12	247

* recorded on biological form due to small size and measurement recorded to nearest attained mm

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

Species	Regression parameters *a*	*b*	r^2	*n*	Length range (cm)	Data source
Black oreo	0.027676	2.914205	0.89	261	22–37	TAN0012
Dark ghost shark	0.005682	3.020959	0.92	142	42–69	TAN9805
Hake	0.002051	3.281360	0.98	738	48–121	TAN0012
Hoki	0.005603	2.844446	0.96	1 837	35–109	TAN0012
Ling	0.001131	3.321545	0.98	1 278	36–129	TAN0012
Lookdown dory	0.019459	3.057875	0.99	204	13–53	TAN0012
Pale ghost shark	0.009131	2.891429	0.97	848	24–85	TAN0012
Ribaldo	0.004431	3.220597	0.98	192	28–73	TAN0012
Silverside	0.016824	2.707345	0.78	231	22–35	TAN0012
Smooth oreo	0.023739	2.975832	0.98	485	16–44	TAN0012
Southern blue whiting	0.003062	3.191658	0.98	491	25–57	TAN0012
Spiny dogfish	0.000671	3.426493	0.94	367	54–102	TAN0012
White warehou	0.028278	2.926514	0.99	65	27–60	TAN0012
Ridge scaled rattail	0.001751	3.254704	0.98	247	22–91	TAN0012

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

Table 9: **Numbers of fish at each reproductive stage* for the key species.**

Species		Reproductive stage 1	2	3	4	5	6	7	Total
Hake	Male	112	186	16	24	25	12	4	379
	Female	115	191	71	11	0	7	22	417
Hoki	Male	181	2 033	7	2	5	163	225	2 616
	Female	133	3 719	13	1	0	1	393	4 260
Lookdown dory	Male	10	27	7	2	0	0	0	46
	Female	7	8	39	0	0	6	7	67
Ling	Male	103	365	123	368	112	54	12	1 137
	Female	155	718	48	64	5	3	4	997
Ribaldo	Male	1	24	0	0	0	0	11	36
	Female	12	97	1	0	0	1	41	152
Southern blue whiting	Male	30	111	0	0	0	0	12	153
	Female	16	269	0	0	0	0	9	294
White warehou	Male	0	1	0	0	0	0	1	2
	Female	0	6	2	0	0	0	1	9
Ridge scaled rattail	Male	23	15	5	19	0	1	0	63
	Female	11	19	14	0	0	2	42	88

* See Appendix 1 for description of gonad stages

Table 10: **Catches in midwater trawls carried out to identify acoustic marks. Tow positions are shown in Figure 12.**

Tow number	54	55	56	57
Gear depth (m)	340–360	361–379	451–620	442–447
Bottom depth (m)	362–378	361–379	471–650	453–475
Tow distance (nmi)	1.16	0.90	3.25	2.17
Start time (NZST)	13:35	17:24	02:47	08:02
Total Catch (kg)	43.8	40.6	133.1	270.2
Pearlside	10.4	3.4	0	0
Ray's bream	23.5	31.1	4.1	4.3
Salps	9.8	5.9	0	40.0
Squid	0	0.1	4.1	0
Hoki	0	0	18.2	155.5
Hake	0	0	100.1	70.1
Other	0.1	0	6.6*	0.3

* Included dealfish (5.0 kg) and spiny dogfish (1.4 kg).

Table 11: **Vertical distribution of "non pelagic" backscatter (see text for definition) recorded during the acoustic survey. "All" is a summary of all daytime survey transects on which "non-pelagic" marks were identified (in bold).**

			Proportion of total "non-pelagic" backscatter					
Transect	Time	Mean areal backscatter ($m^{-2} \times 10^{-6}$)	0–10 m	0–20 m	0–30 m	0–40 m	0–50 m	0–100 m
1	Day	0						
2	**Day**	**0.68**	**0.13**	**0.52**	**0.78**	**0.91**	**0.95**	**0.97**
3	Day	0						
4	Day	0						
Trawl 54	Day	0						
Trawl 55	Day	2.73	0.22	0.85	0.99	1.00	1.00	1.00
3	Dusk	0						
4	Night	0						
5	Night	2.42	0.18	0.28	0.37	0.43	0.49	0.54
6	Night	5.39	0.21	0.36	0.51	0.59	0.65	0.71
Trawl 56	Night	7.18	0.26	0.36	0.48	0.59	0.67	0.72
5	Dawn	4.60	0.17	0.27	0.37	0.47	0.57	0.64
5	**Day**	**5.69**	**0.17**	**0.28**	**0.40**	**0.52**	**0.60**	**0.67**
6	**Day**	**8.62**	**0.25**	**0.32**	**0.41**	**0.50**	**0.57**	**0.70**
Trawl 57	Day	22.70	0.50	0.71	0.77	0.81	0.83	0.86
7	Day	0						
8	**Day**	**6.08**	**0.14**	**0.23**	**0.29**	**0.35**	**0.40**	**0.45**
9	**Day**	**9.44**	**0.32**	**0.41**	**0.47**	**0.52**	**0.57**	**0.61**
10	Day	0						
11	Day	0						
12	**Day**	**9.28**	**0.11**	**0.20**	**0.28**	**0.36**	**0.42**	**0.48**
13	**Day**	**4.16**	**0.17**	**0.28**	**0.36**	**0.44**	**0.52**	**0.59**
14	Day	0						
15	Day	0						
16	Day	0						
17	Day	0						
18	Day	0						
19	Day	0						
20	Day	0						
All	**Day**		**0.19**	**0.30**	**0.40**	**0.49**	**0.55**	**0.62**

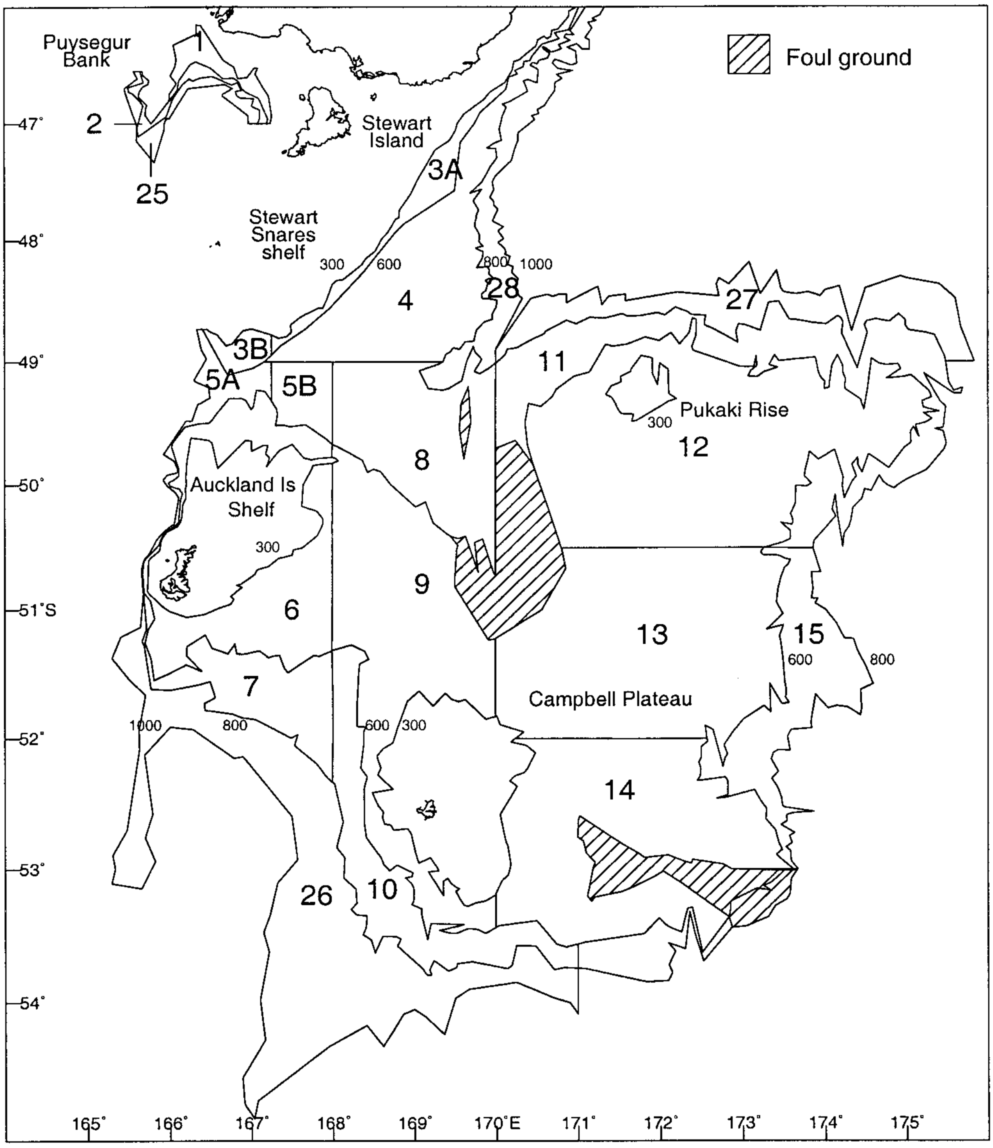

Figure 1: **Survey area and stratum boundaries and numbers for the November/December 2000 Sub-Antarctic trawl survey.**

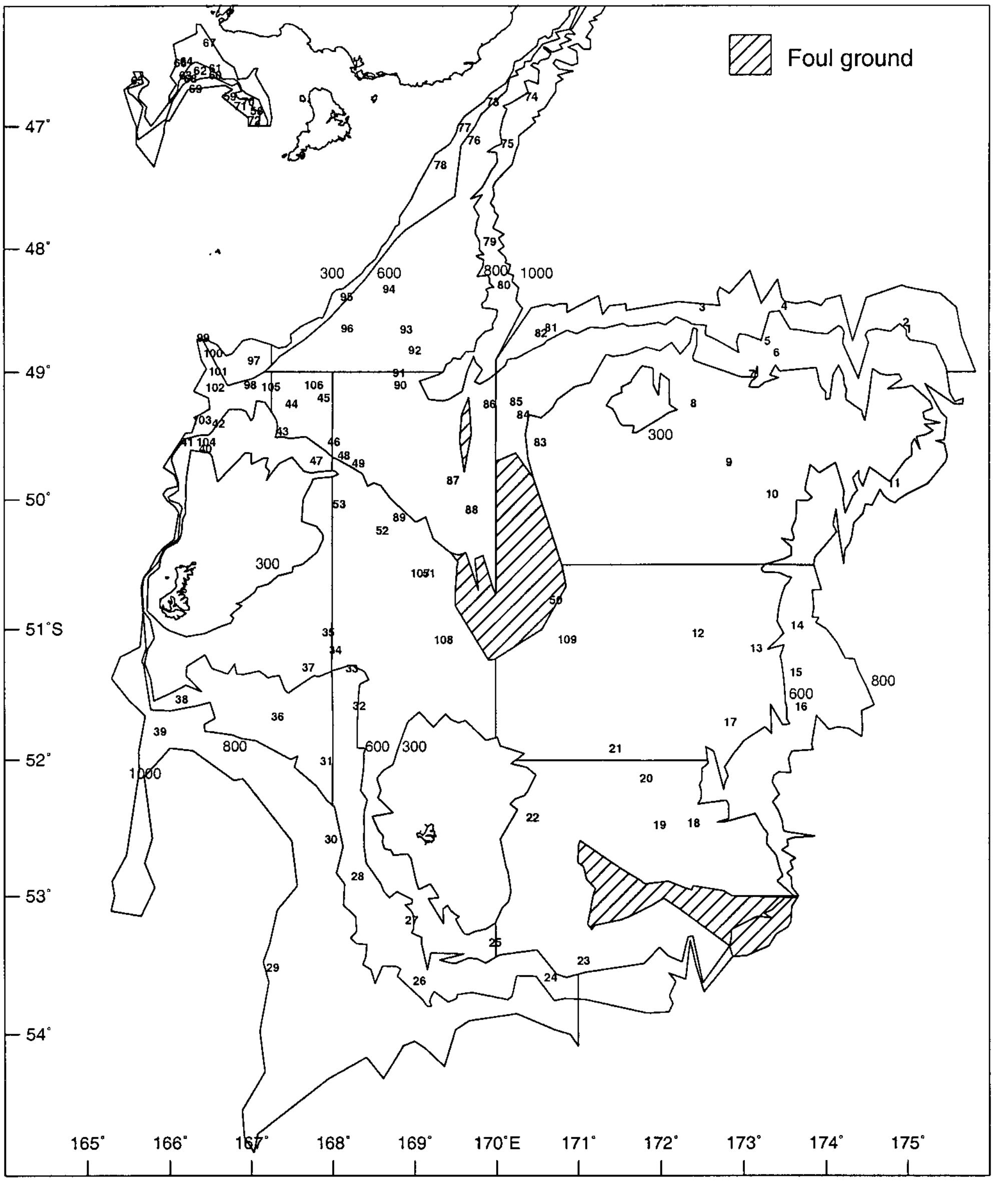

***Figure 2*: Bottom trawl station positions.**

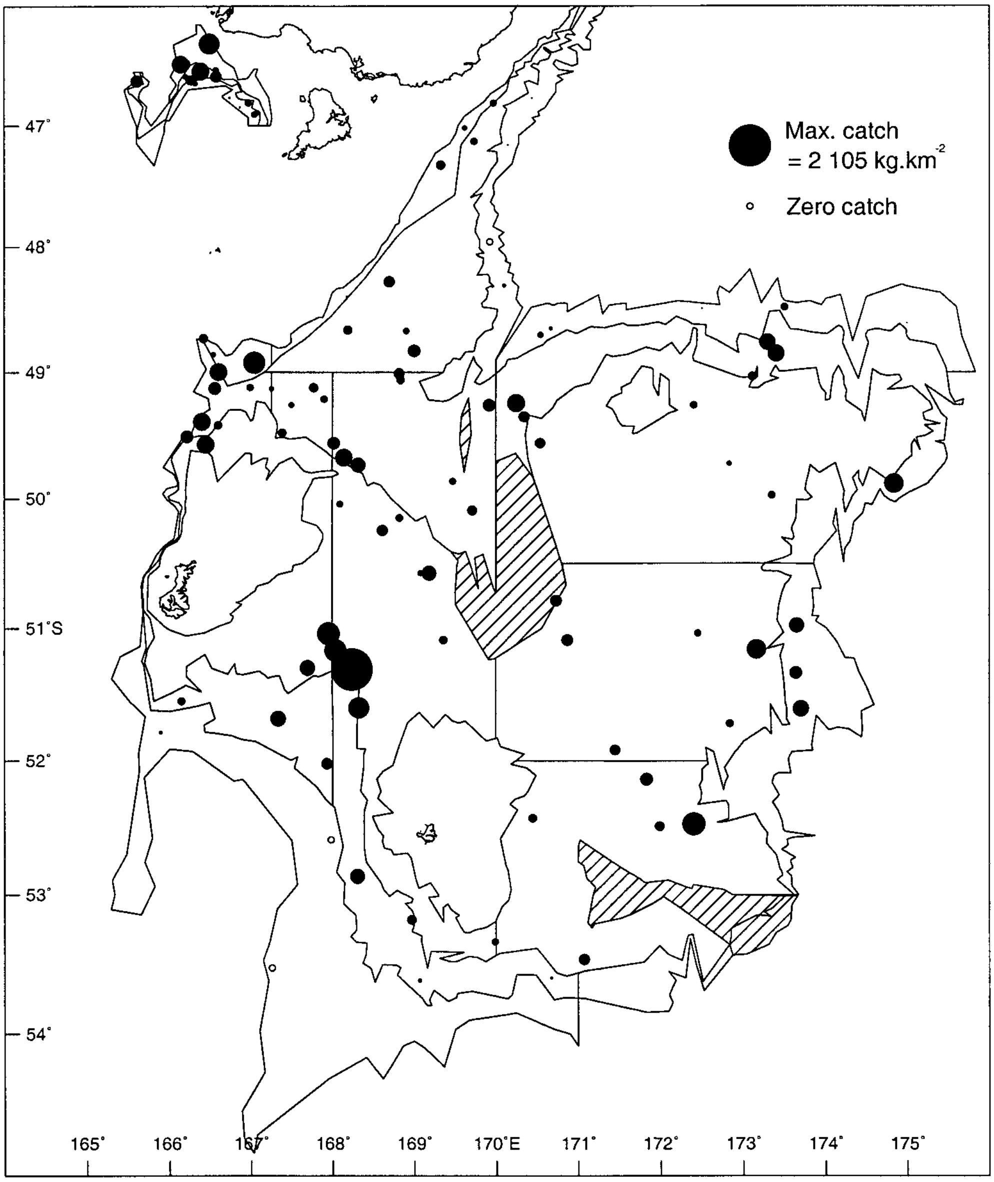

Figure 3: **Distribution and catch rates of hoki. Circle area is proportional to the catch rate.**

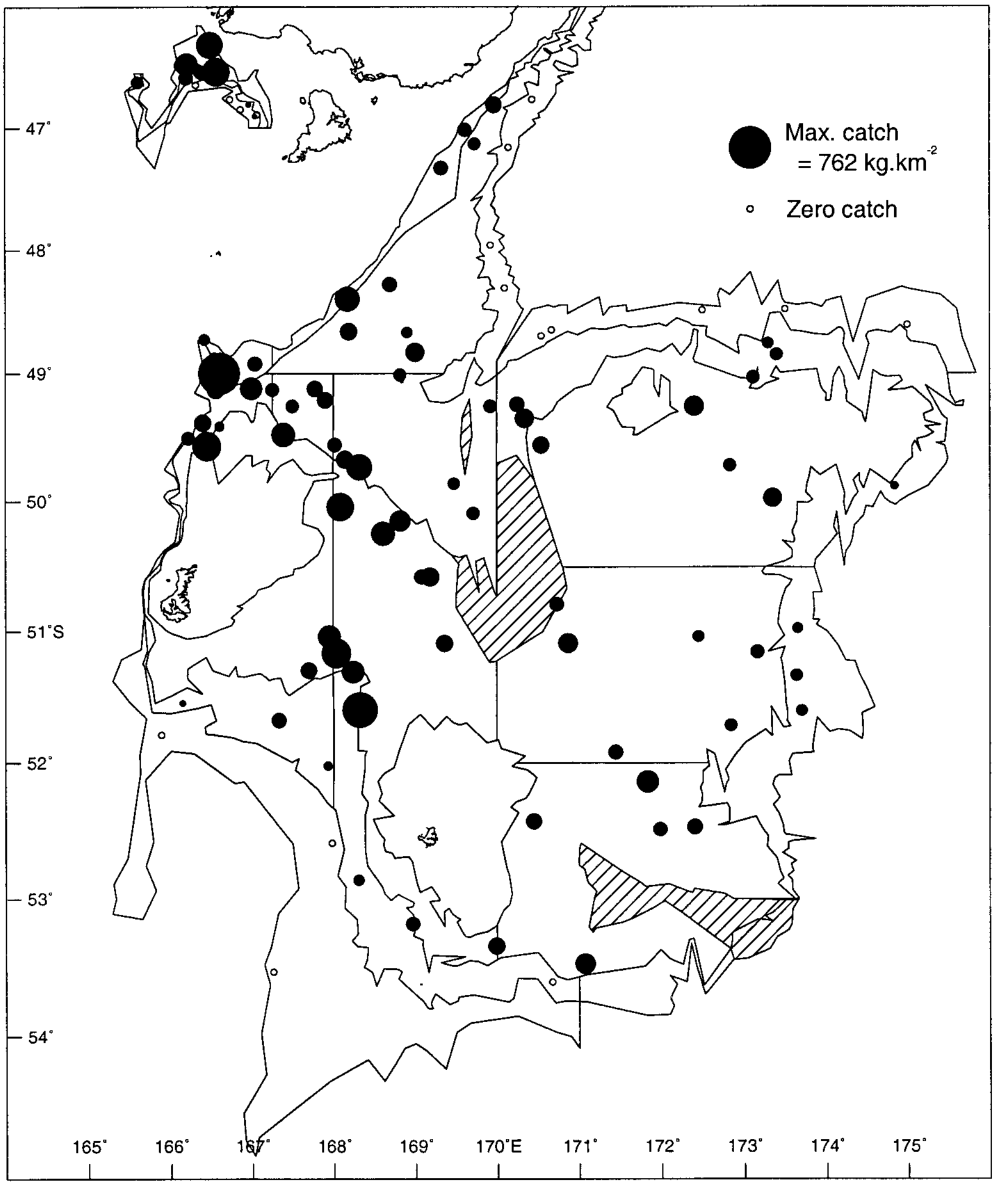

Figure 4: **Distribution and catch rates of ling. Circle area is proportional to the catch rate.**

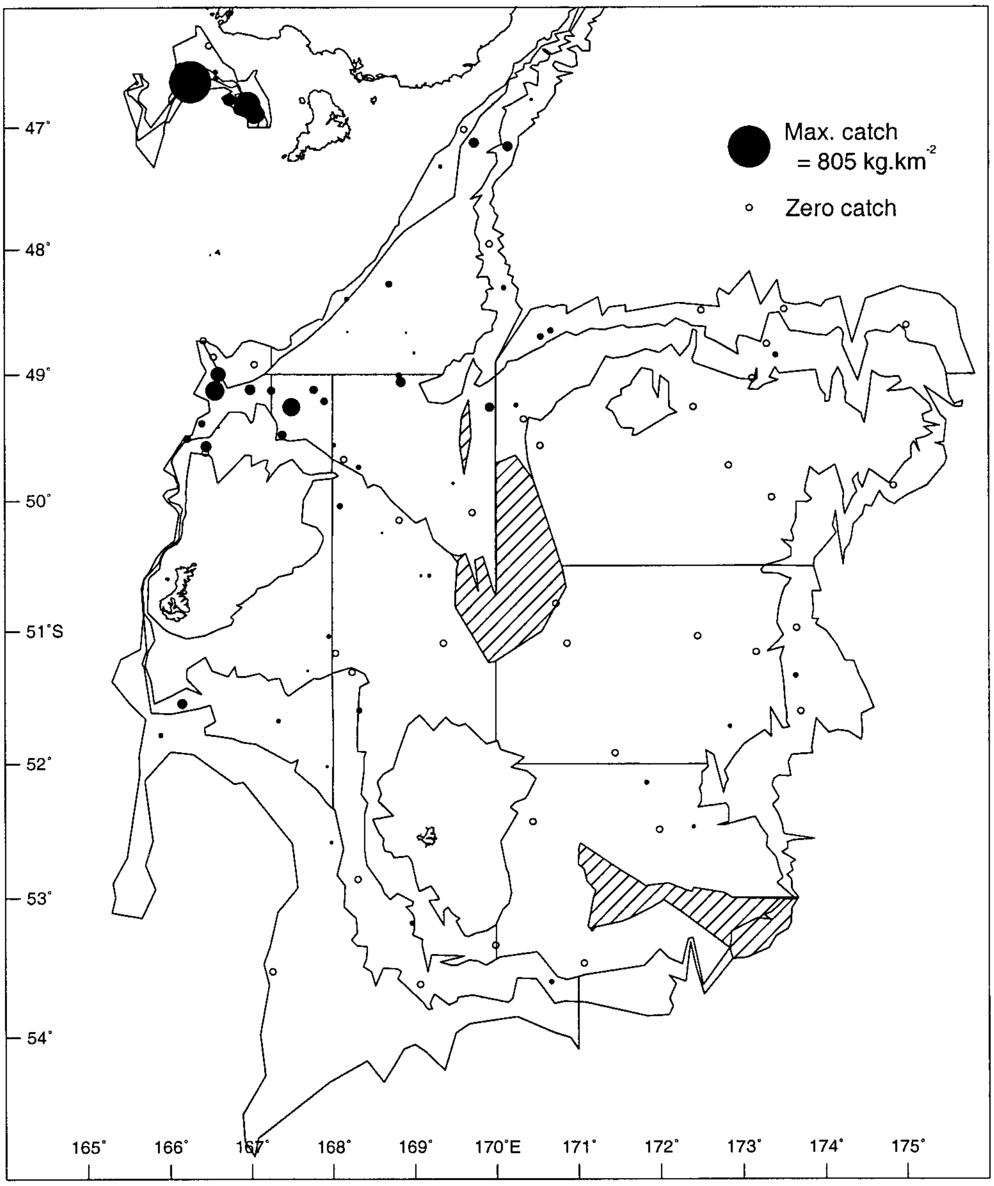

Figure 5: **Distribution and catch rates of hake. Circle area is proportional to the catch rate.**

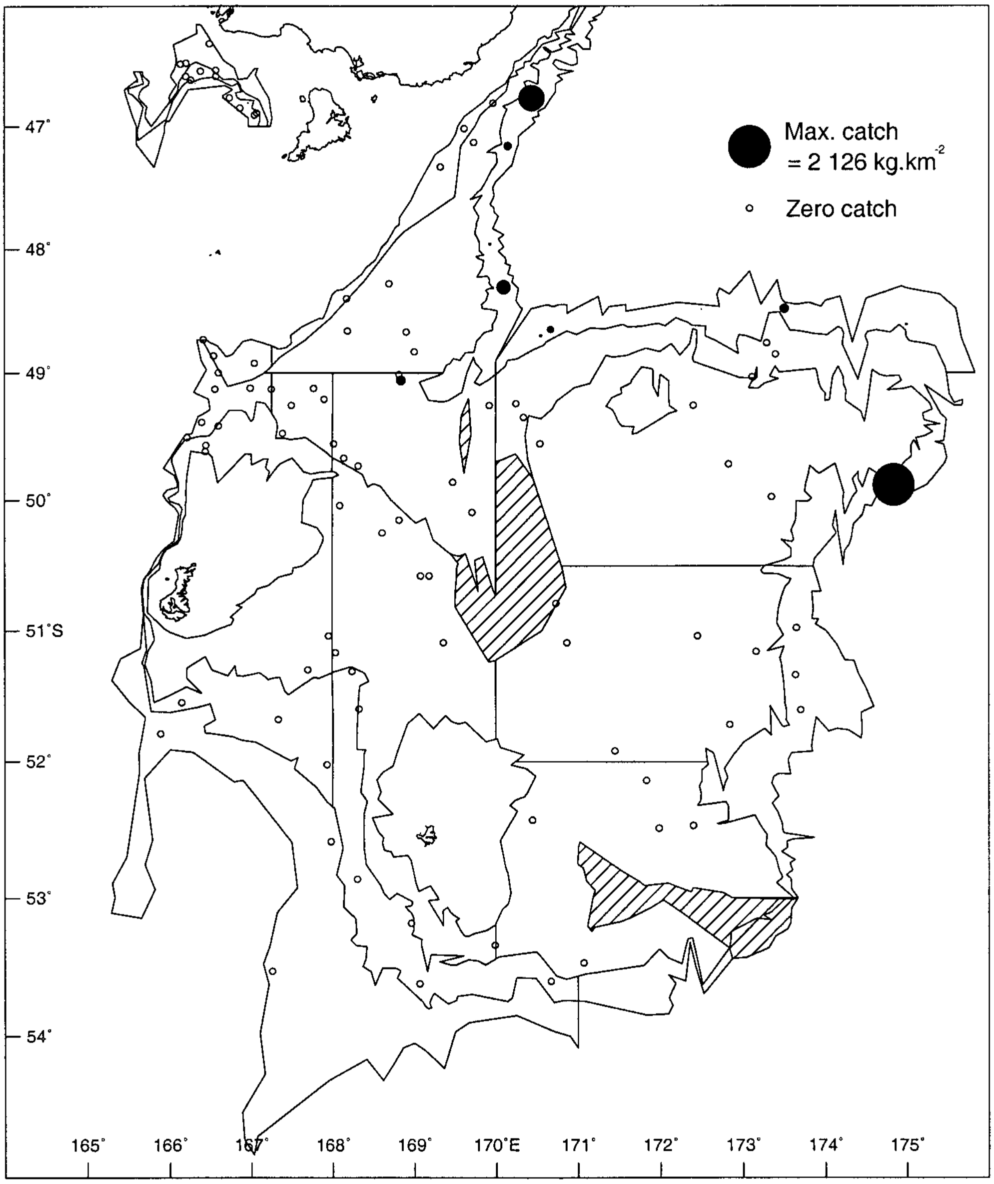

Figure 6a: **Distribution and catch rates of black oreo. Circle area is proportional to the catch rate.**

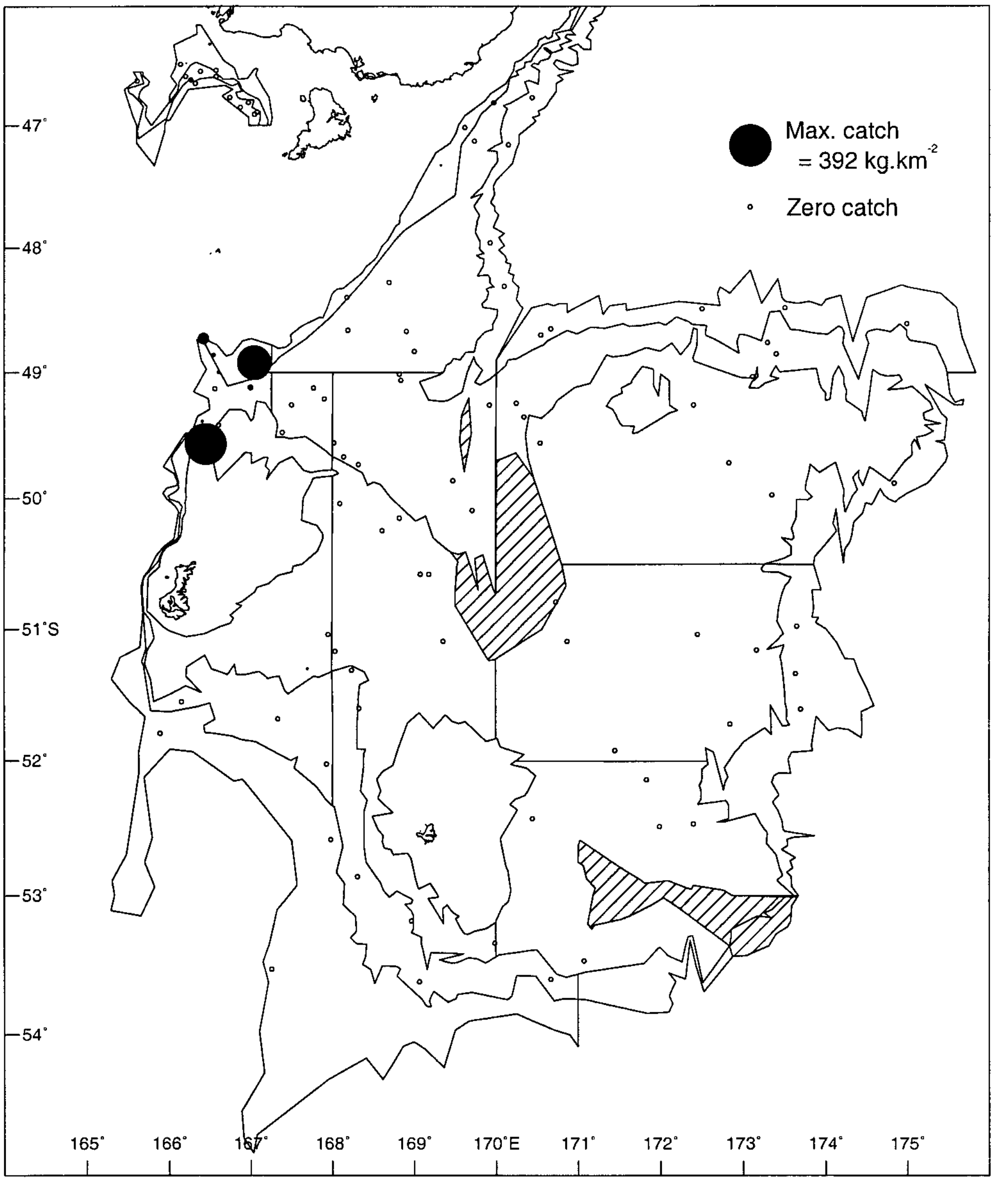

Figure 6b: **Distribution and catch rates of dark ghost shark. Circle area is proportional to the catch rate.**

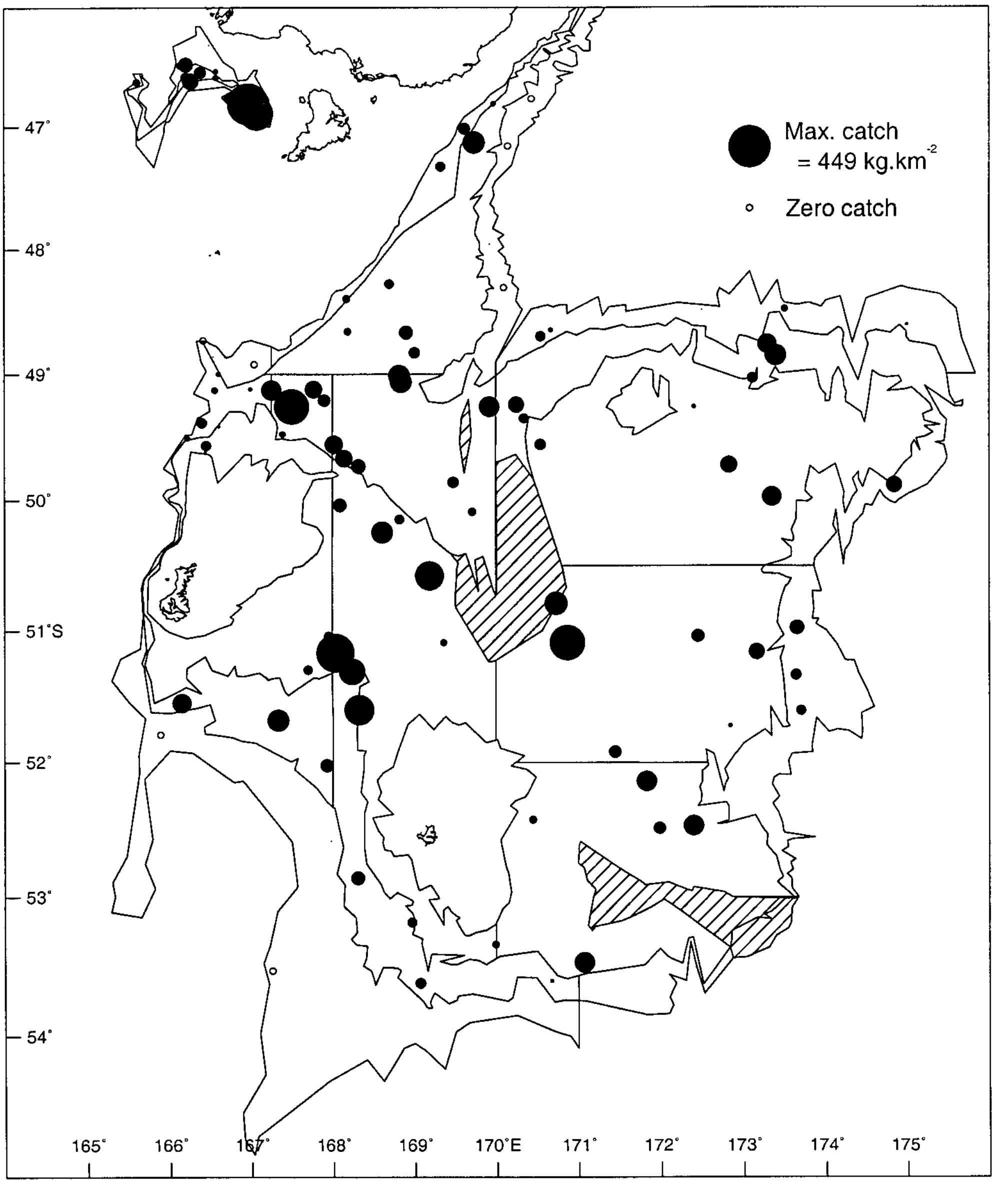

Figure 6c: **Distribution and catch rates of javelinfish. Circle area is proportional to the catch rate.**

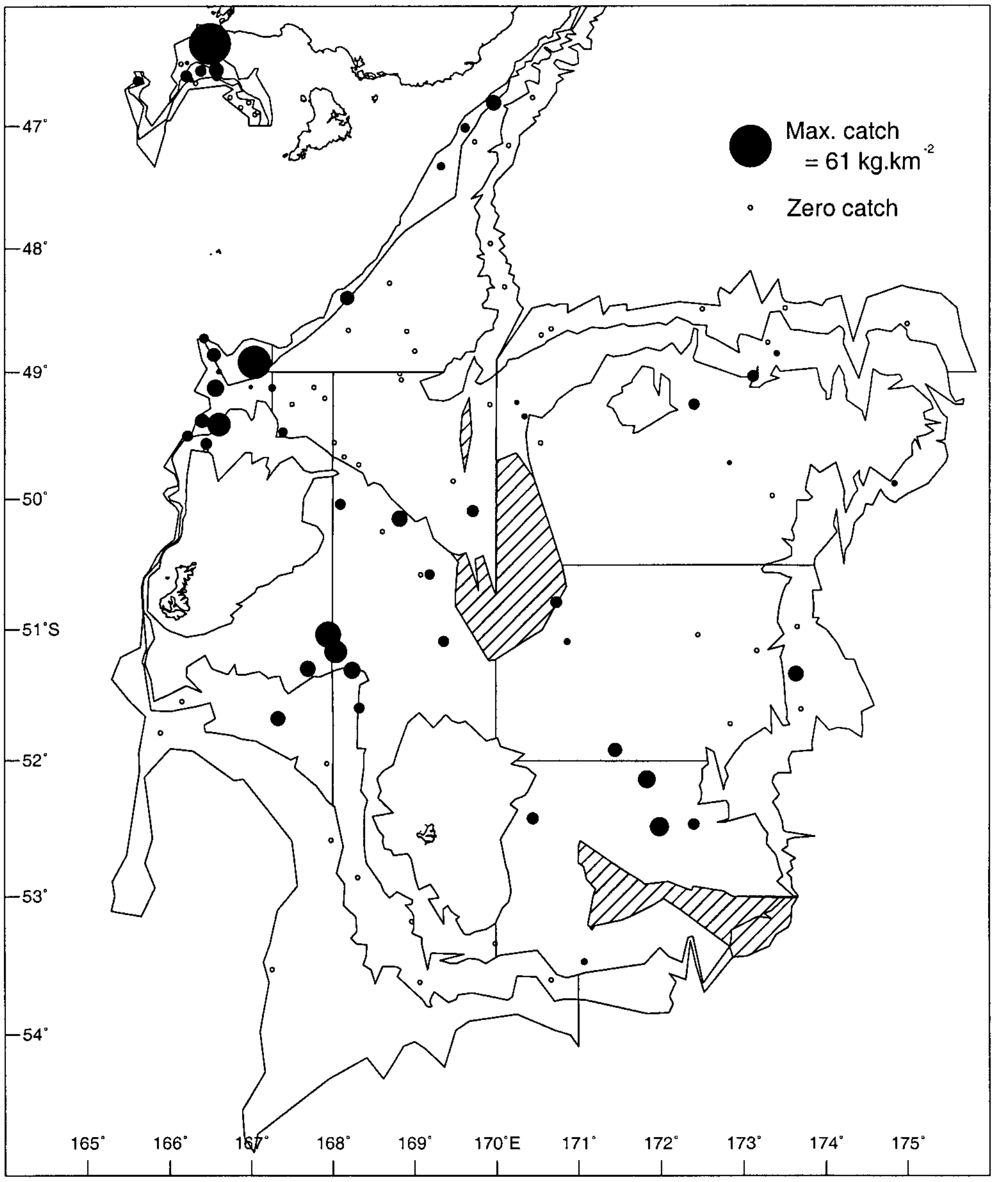

Figure 6d: **Distribution and catch rates of lookdown dory. Circle area is proportional to the catch rate.**

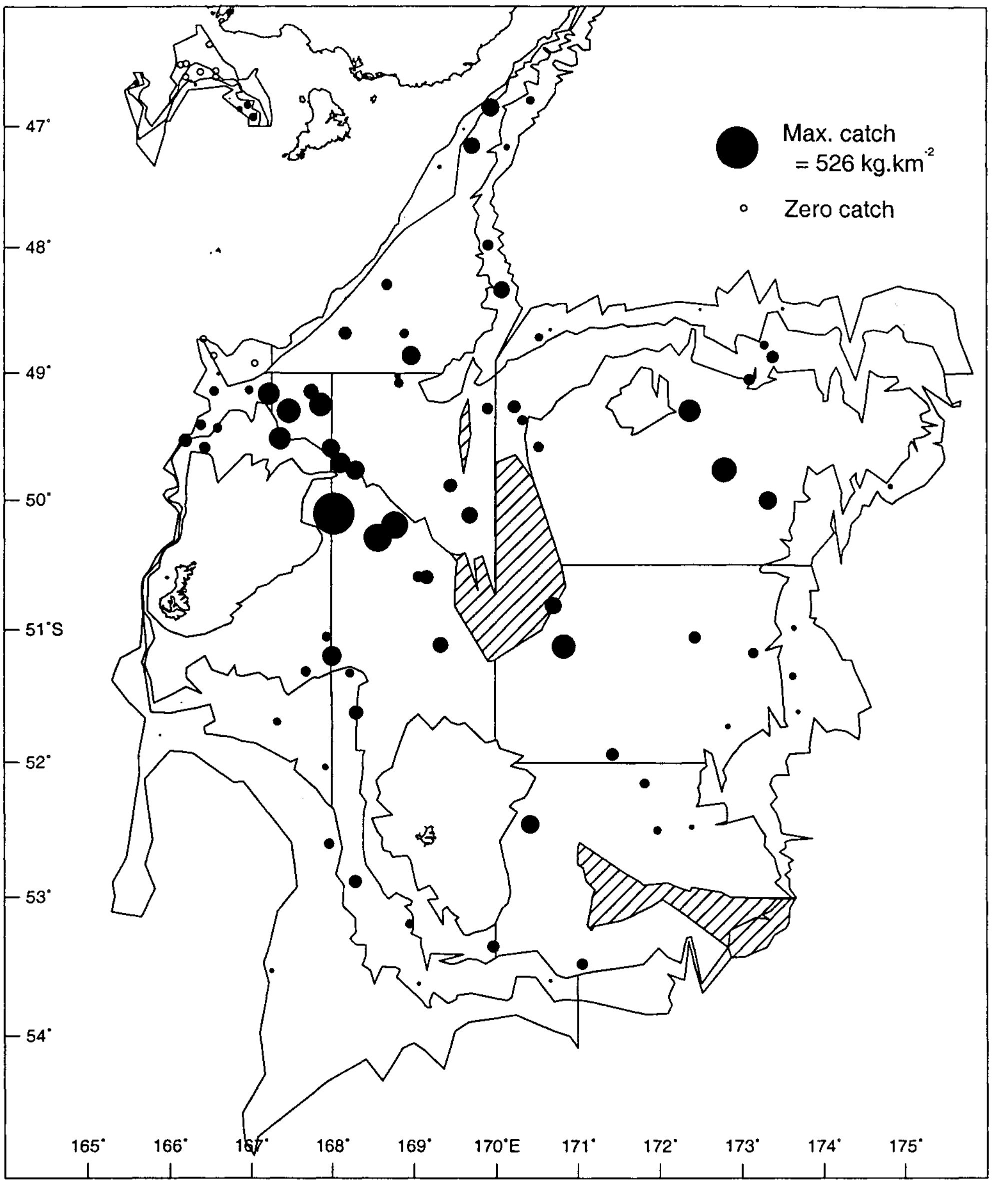

Figure 6e: **Distribution and catch rates of pale ghost shark. Circle area is proportional to the catch rate.**

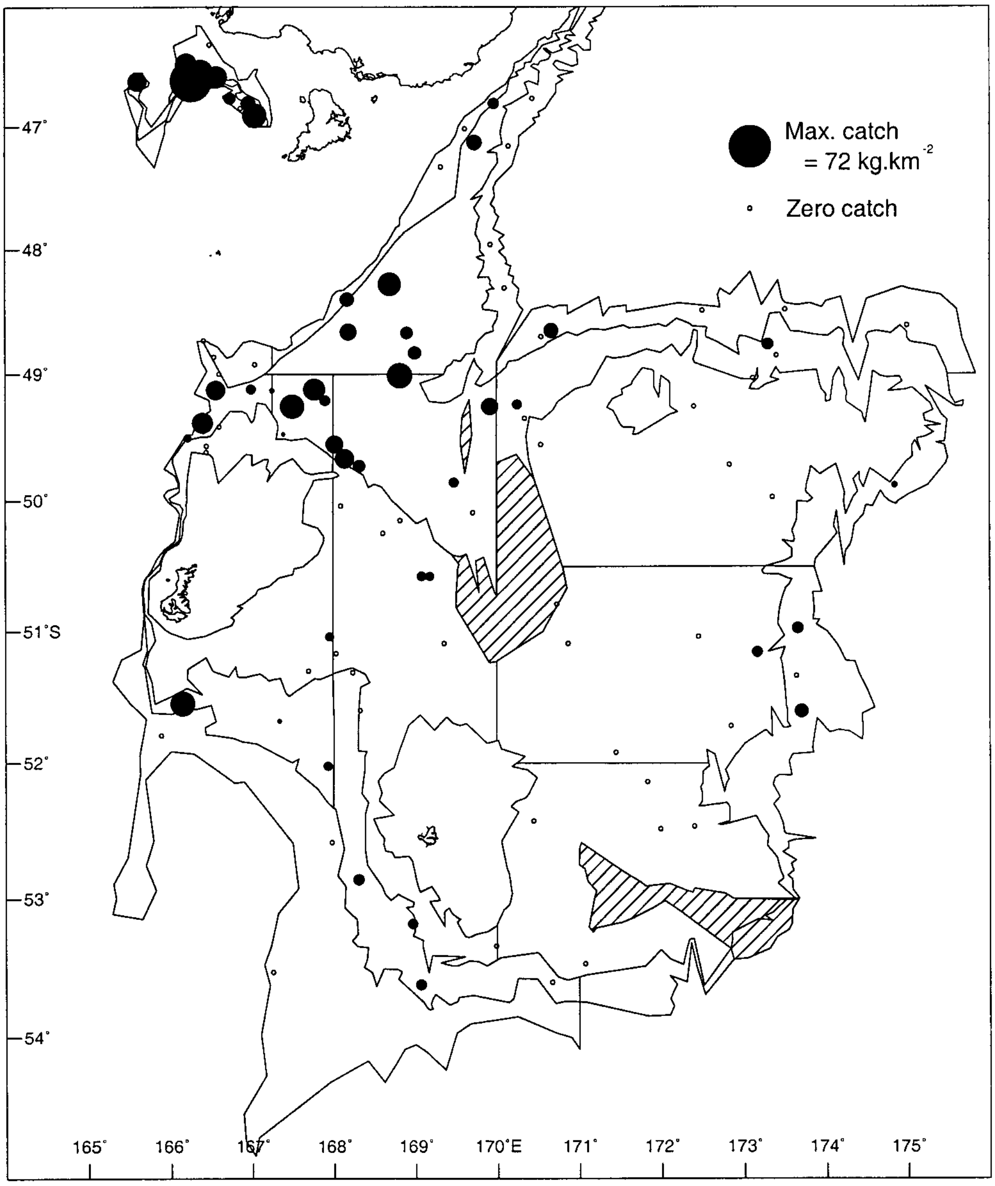

Figure 6f: **Distribution and catch rates of ribaldo. Circle area is proportional to the catch rate.**

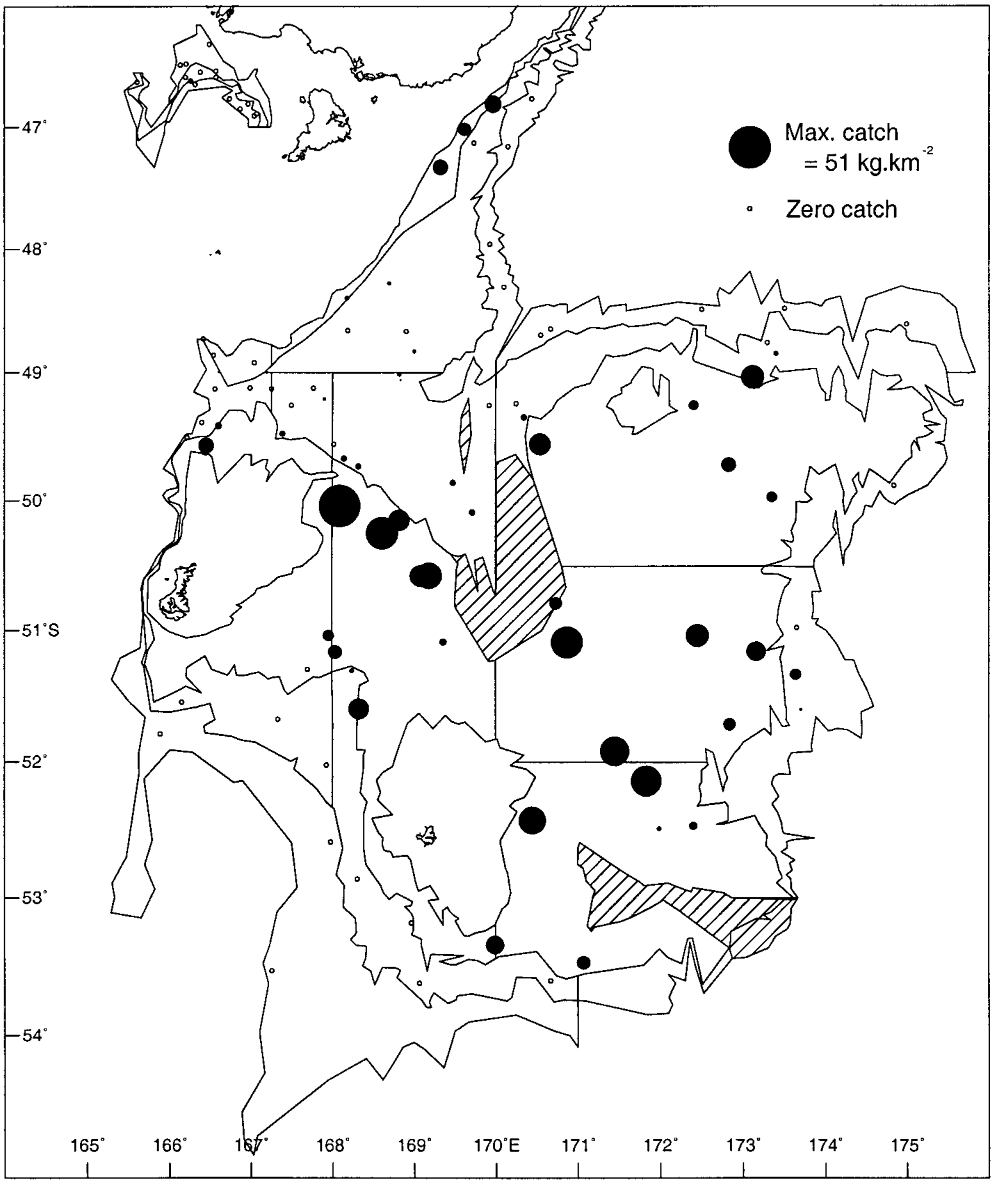

Figure 6g: **Distribution and catch rates of silverside. Circle area is proportional to the catch rate.**

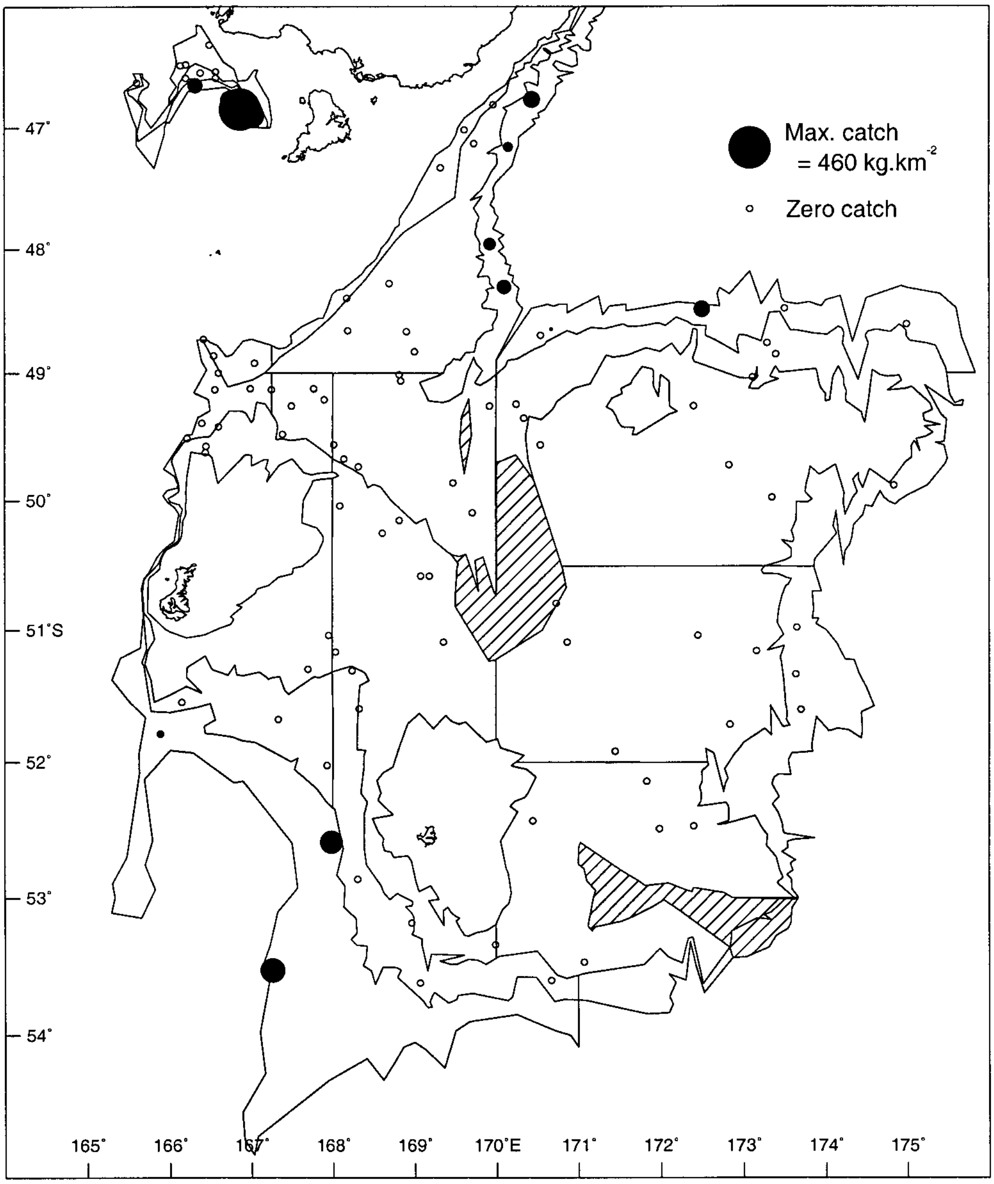

Figure 6h: **Distribution and catch rates of small-scale brown slickhead. Circle area is proportional to the catch rate.**

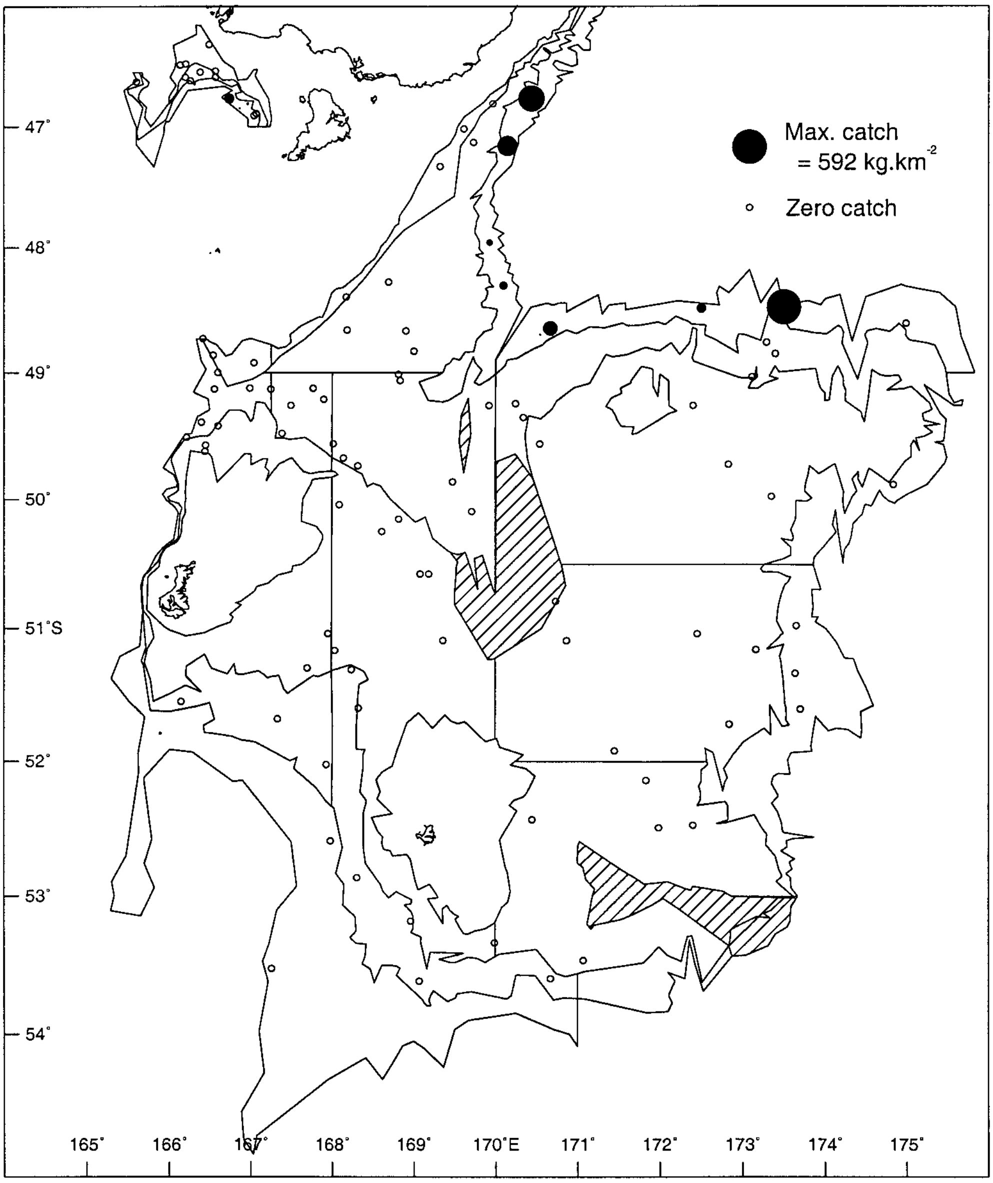

Figure 6i: **Distribution and catch rates of smooth oreo. Circle area is proportional to the catch rate.**

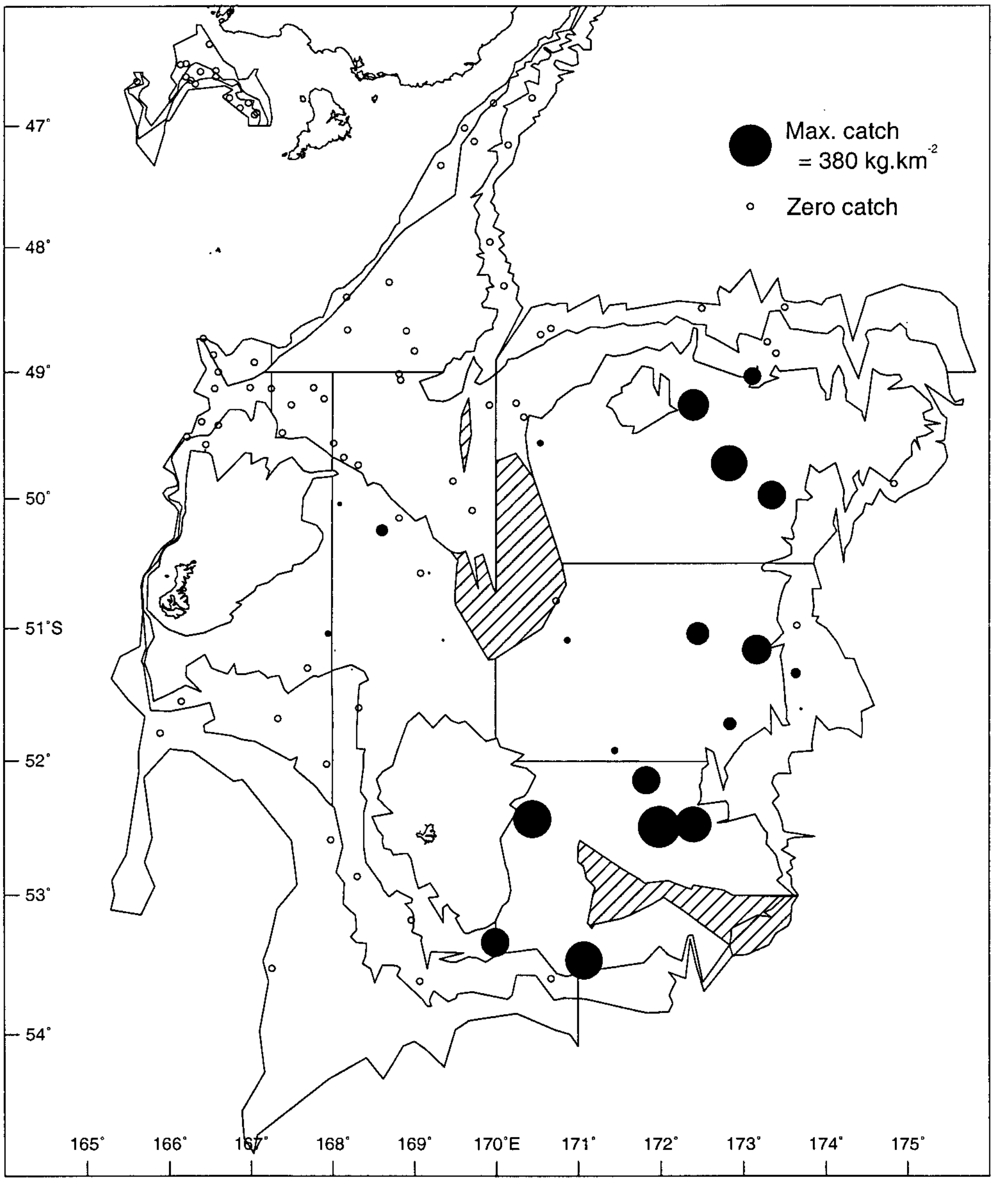

Figure 6j: **Distribution and catch rates of southern blue whiting. Circle area is proportional to the catch rate.**

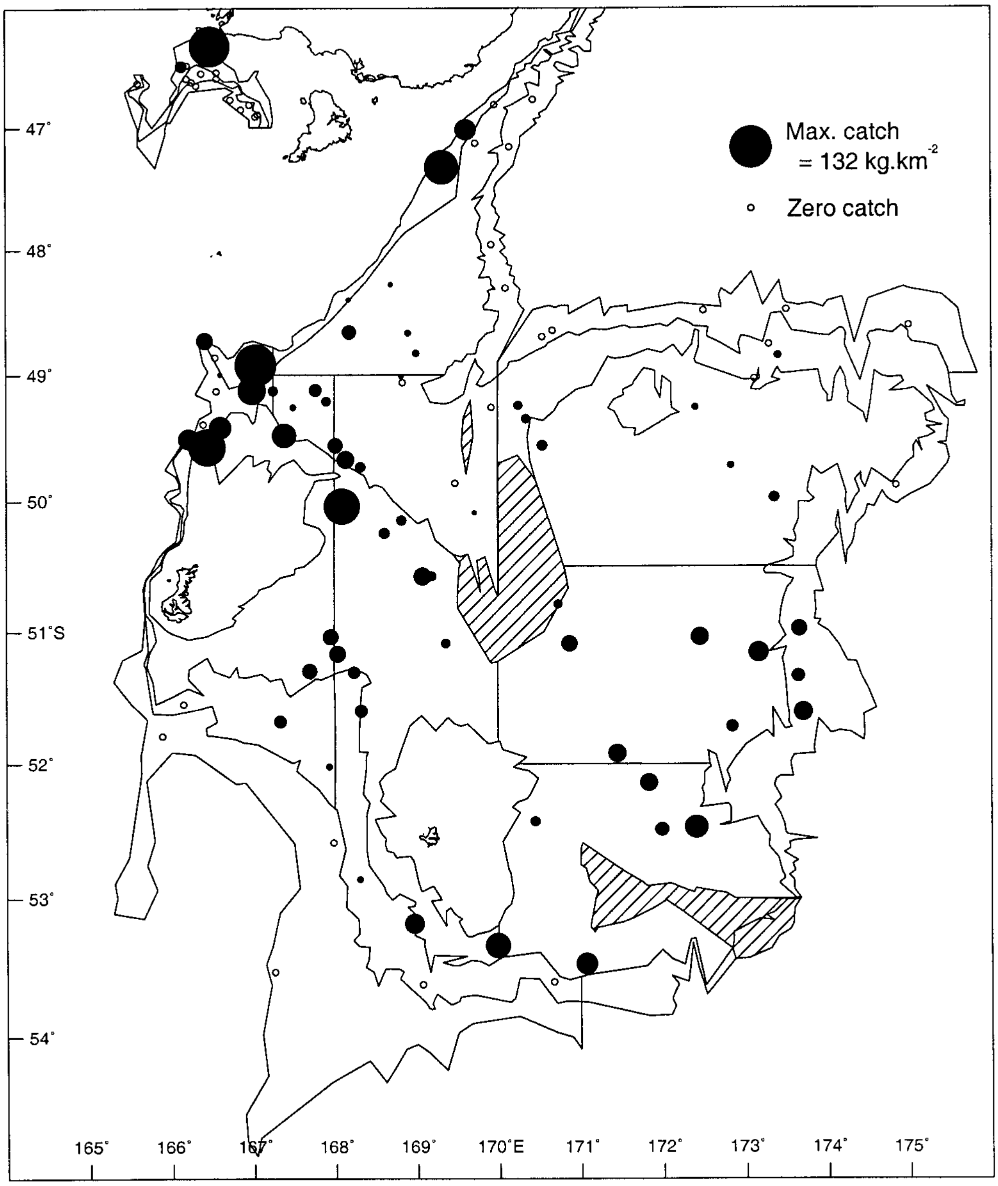

Figure 6k: **Distribution and catch rates of spiny dogfish. Circle area is proportional to the catch rate.**

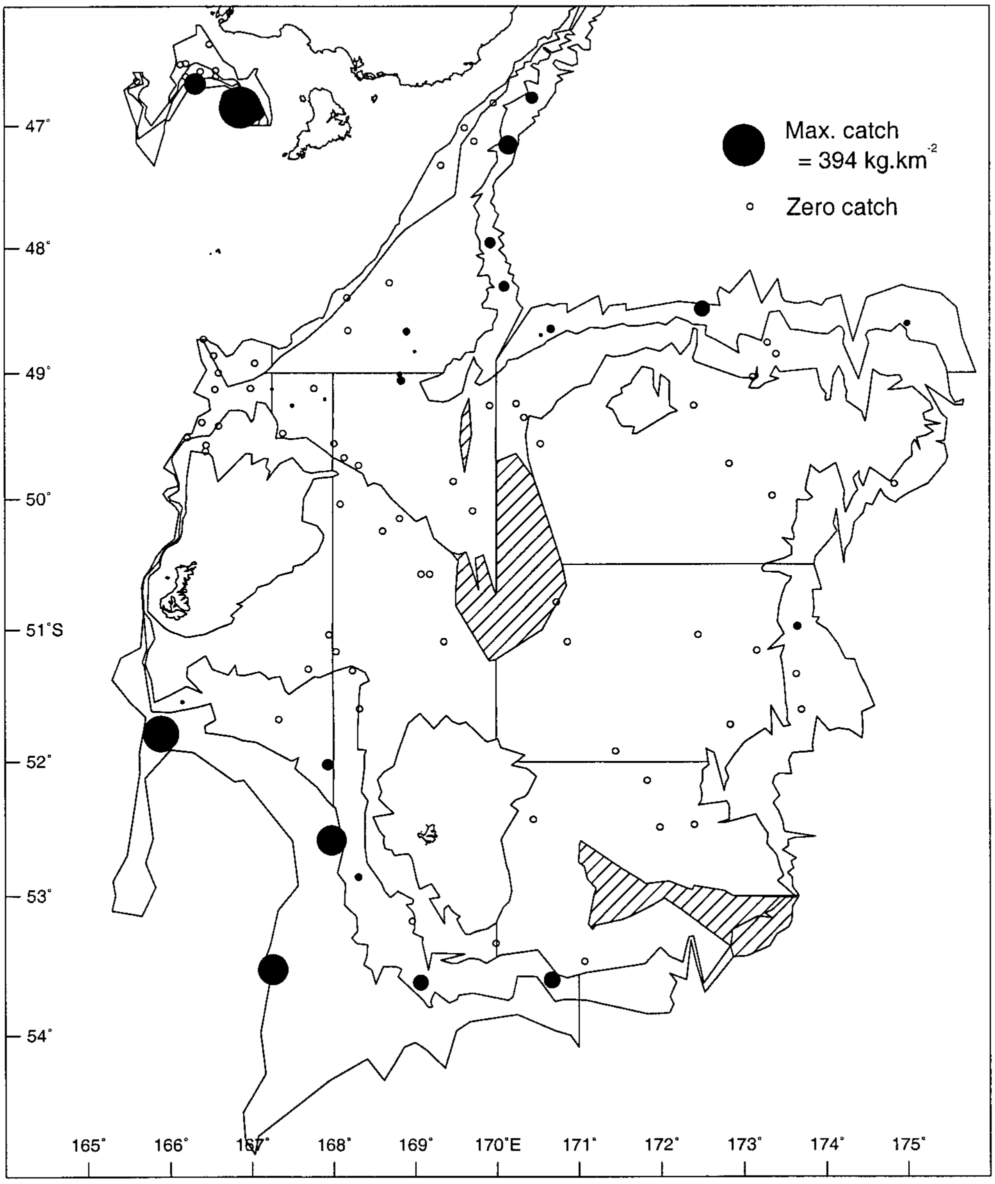

Figure 6m: **Distribution and catch rates of ridge scaled rattail. Circle area is proportional to the catch rate.**

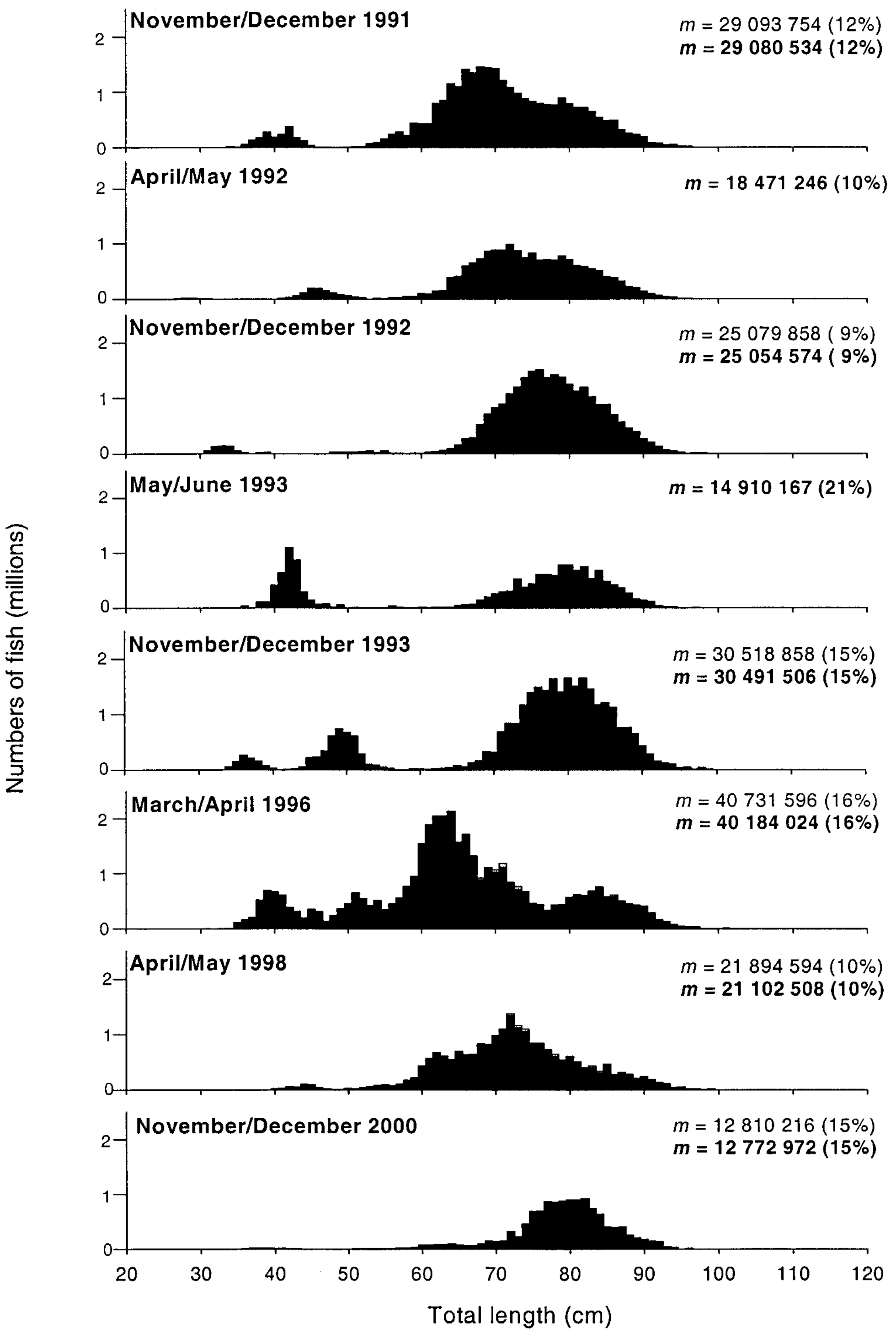

Figure 7a: **Scaled length frequencies for male hoki from Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as grey bars. *m* values above are for all strata and below (in bold) for core strata.**

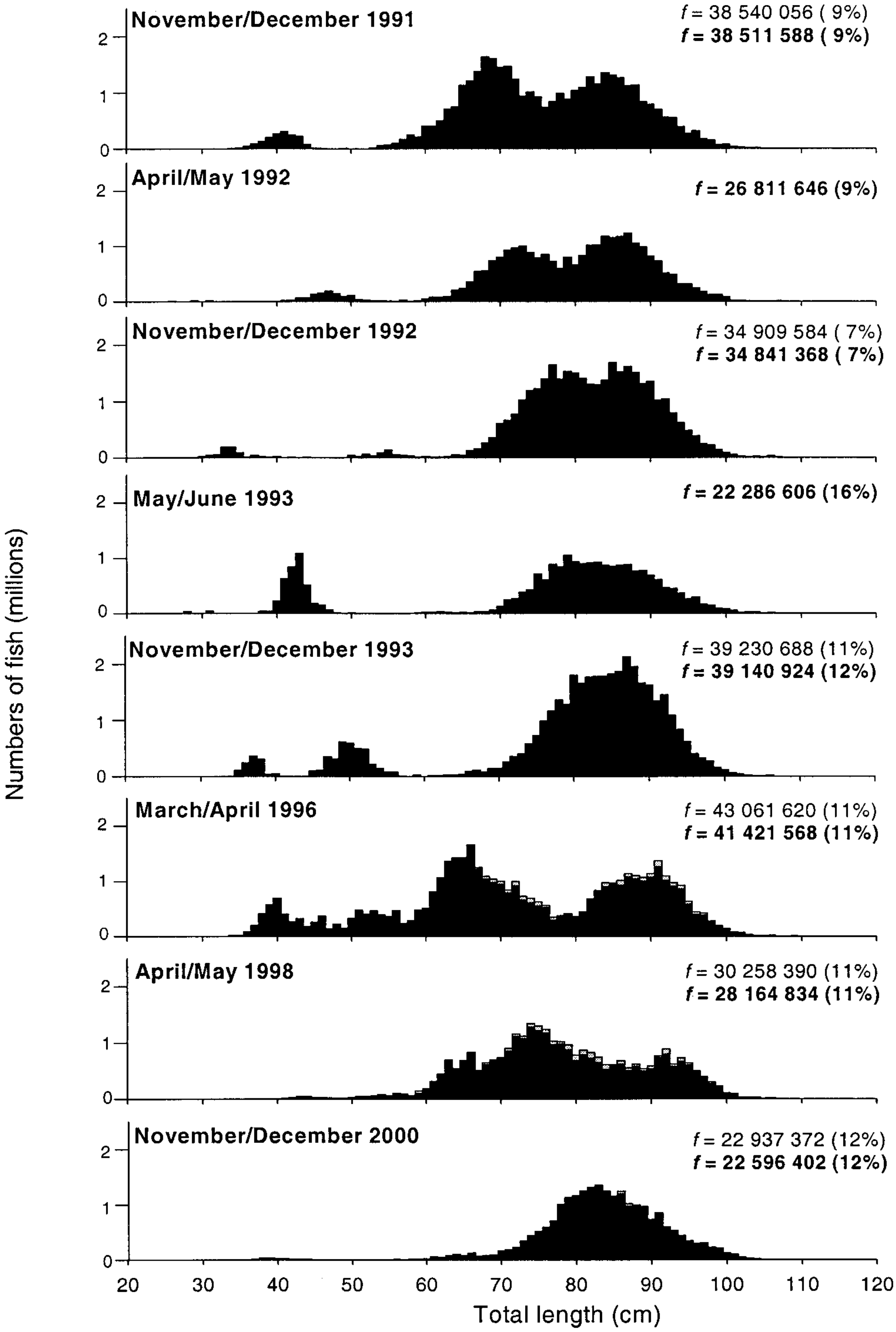

***Figure 7a (cont.)*: Scaled length frequencies for female hoki from Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as grey bars. *f* values above are for all strata and below (in bold) for core strata.**

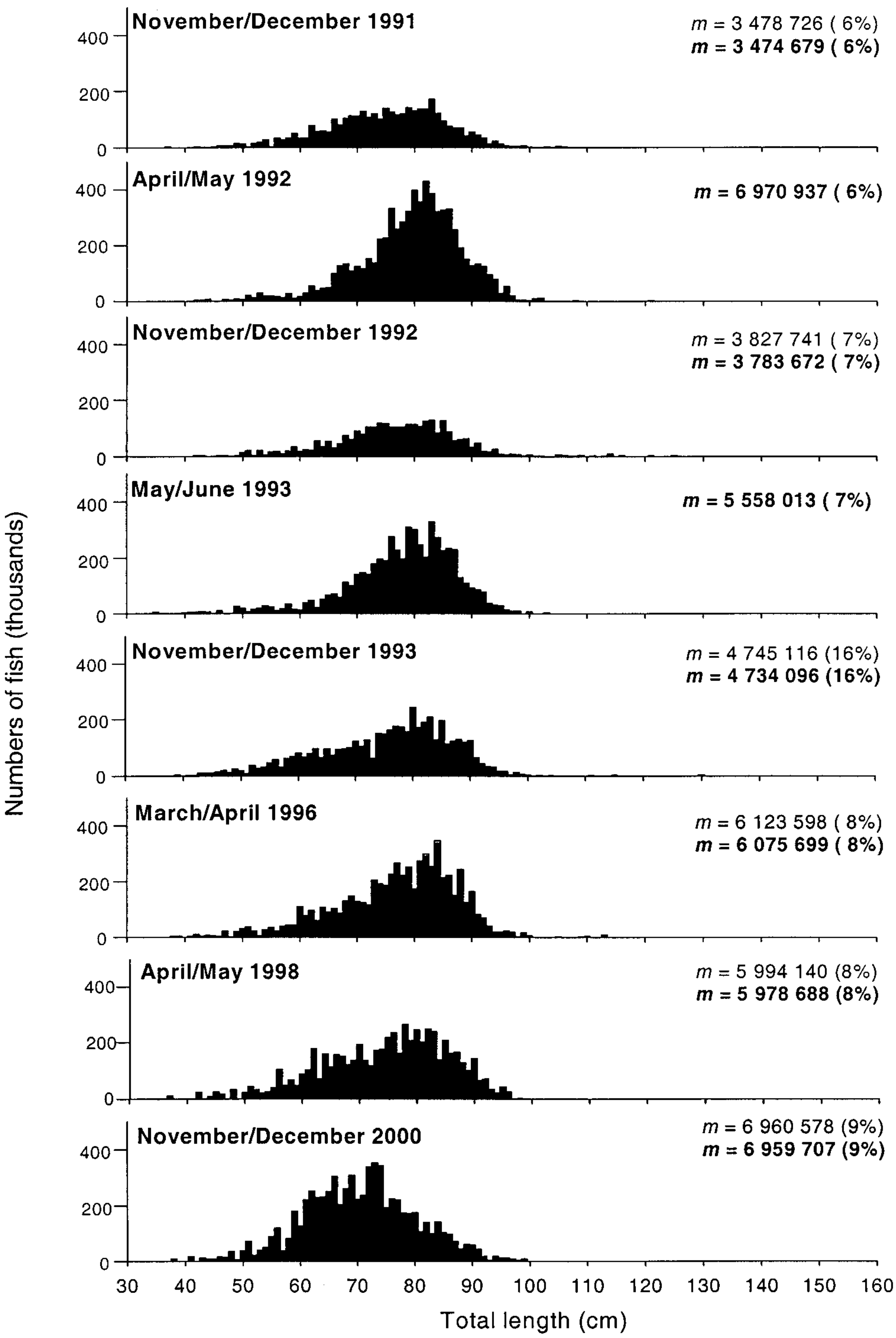

***Figure 7b*: Scaled length frequencies for male ling from Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as grey bars. *m* values above are for all strata and below (in bold) for core strata.**

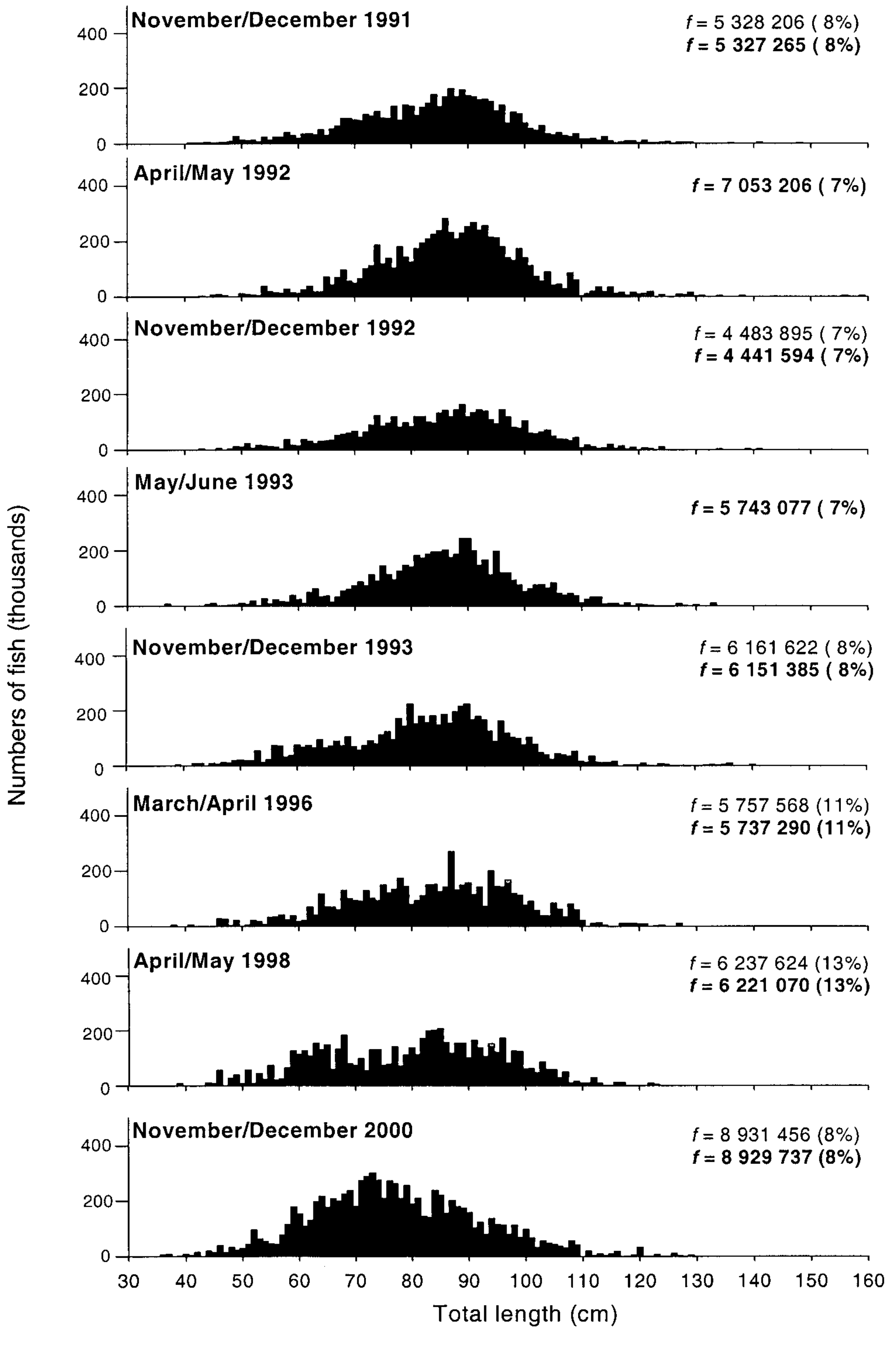

Figure 7b (cont.): Scaled length frequencies for female ling from Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as grey bars. *f* values above are for all strata and below (in bold) for core strata.

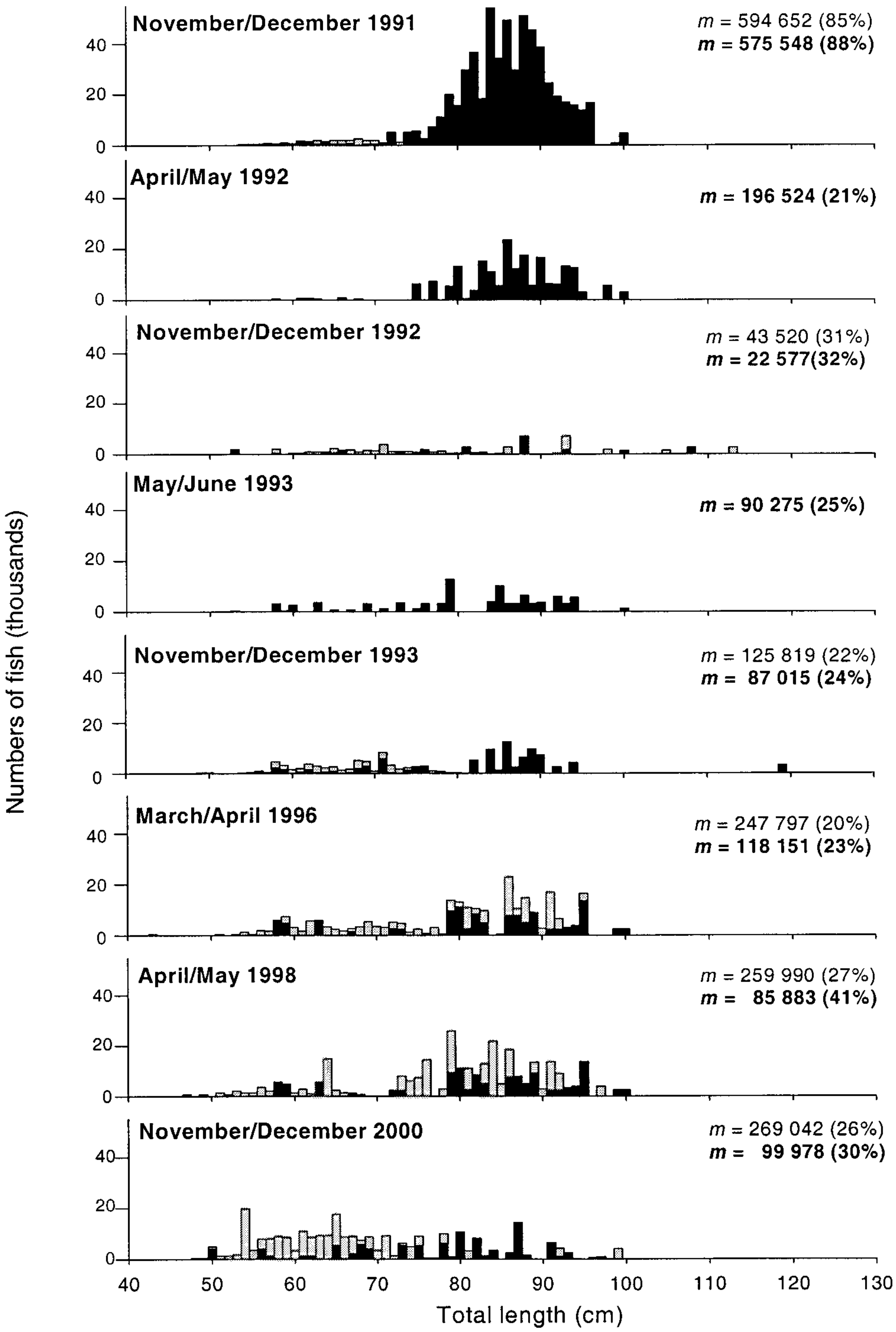

Figure 7c: **Scaled length frequencies for male hake from Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as grey bars. *m* values above are for all strata and below (in bold) for core strata.**

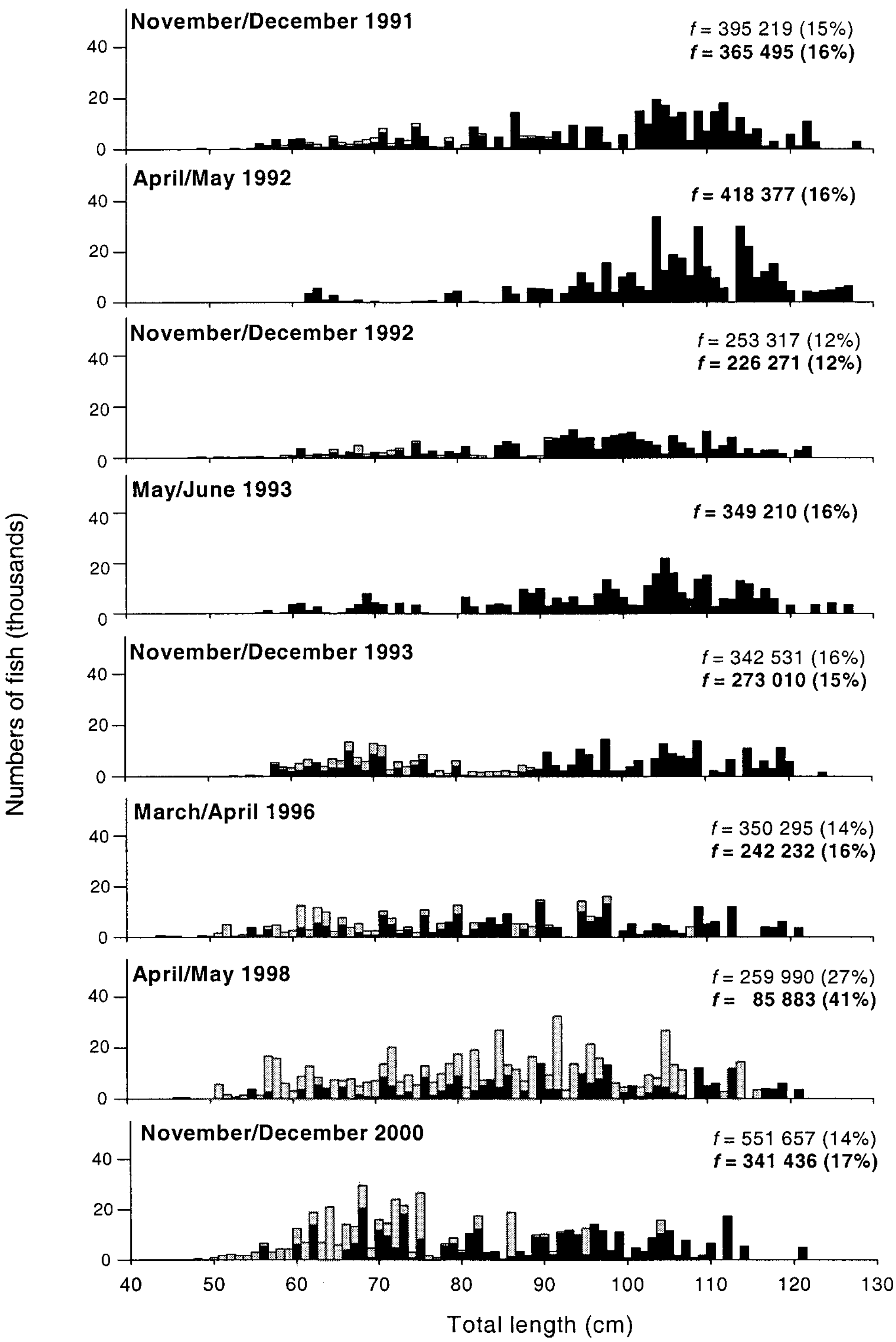

Figure 7c (cont.): **Scaled length frequencies for female hake from Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as grey bars. *f* values above are for all strata and below (in bold) for core strata.**

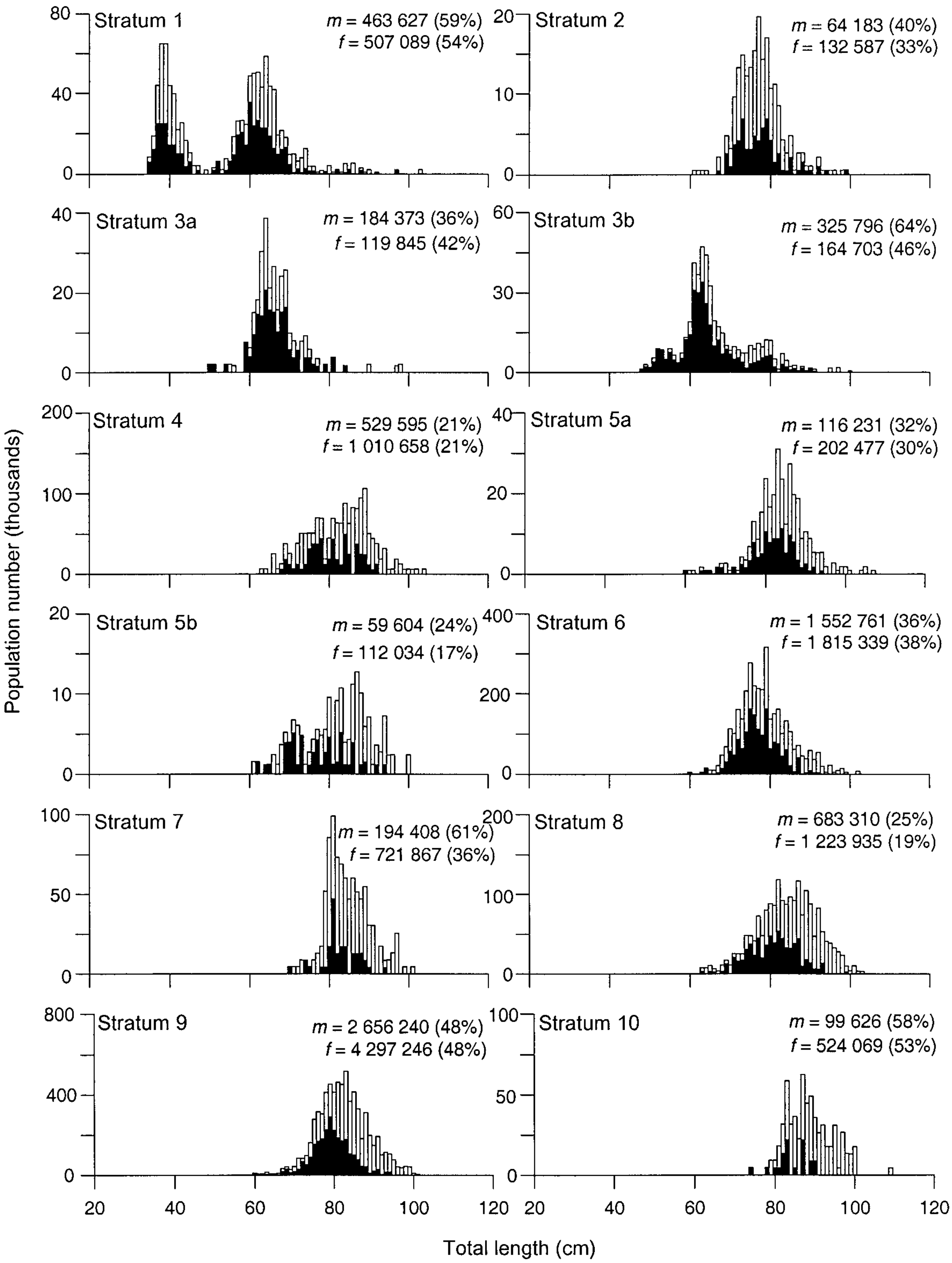

***Figure 8*: Scaled length frequencies for hoki in the November–December 2000 survey by strata. Males are shown as black bars, and females as stacked white bars with sample sizes, and c.v.s in parentheses. Strata boundaries are shown in Figure 1.**

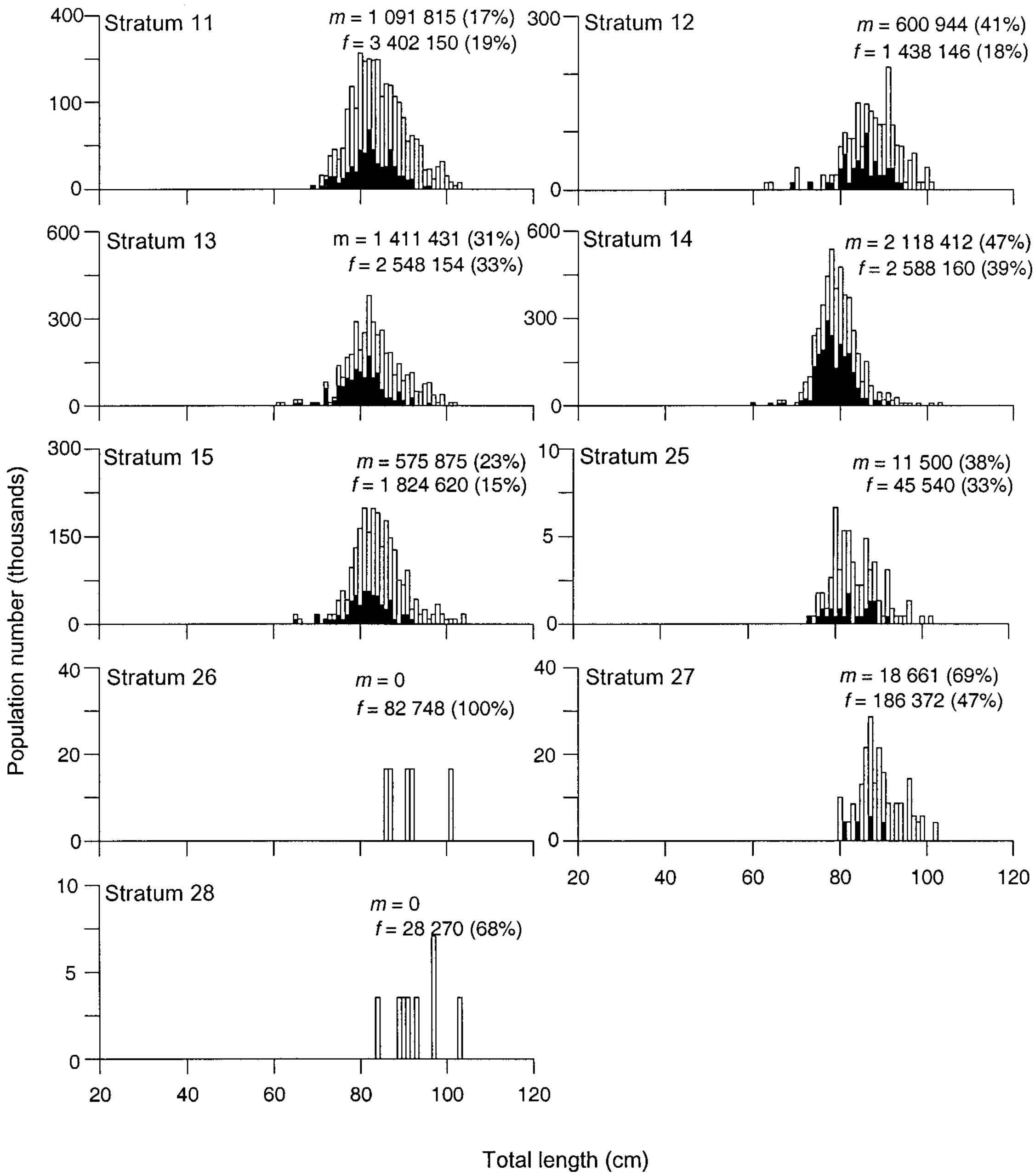

Figure 8 (cont.): **Scaled length frequencies for hoki in the November–December 2000 survey by strata.**

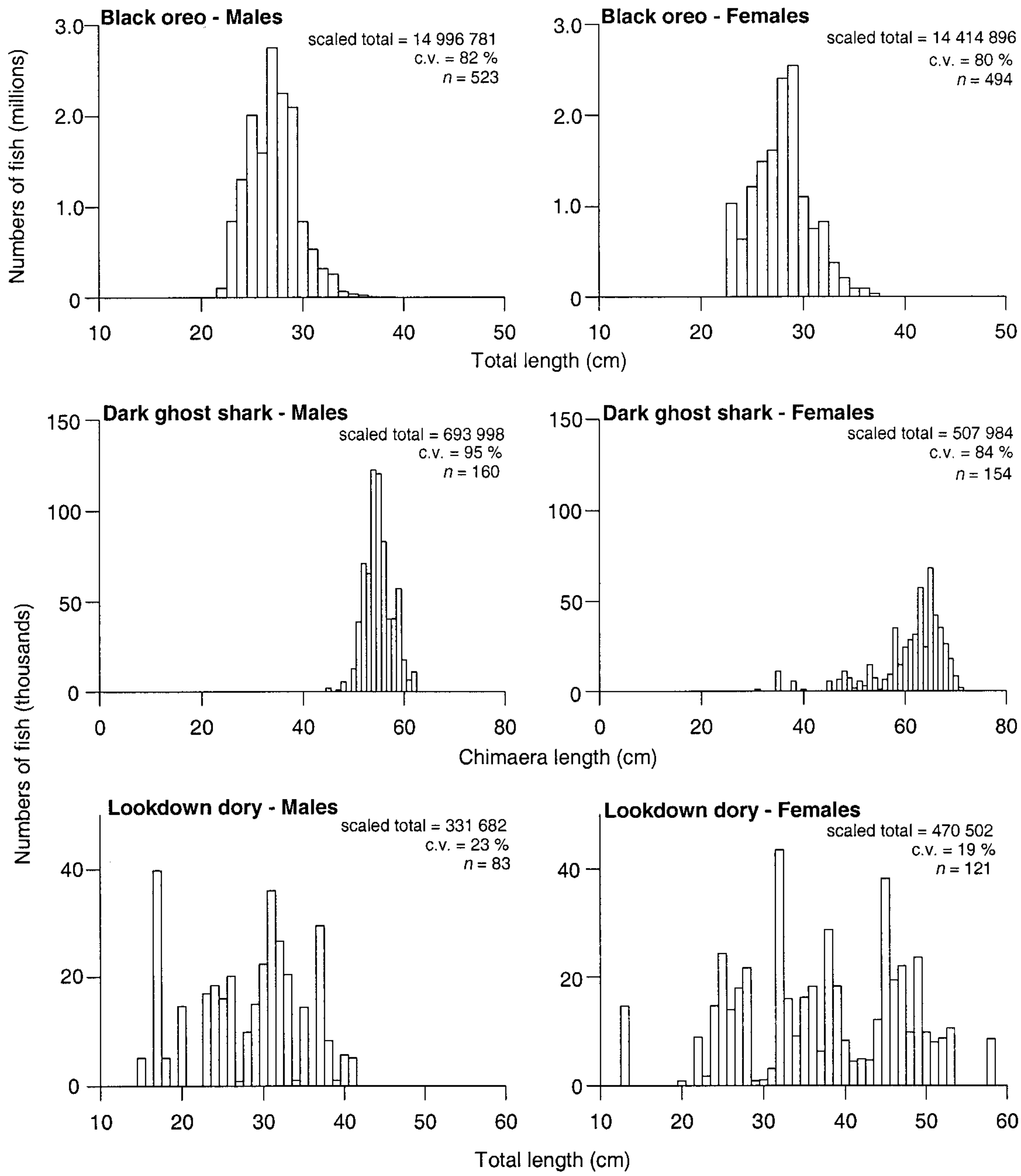

Figure 9: **Length frequency by sex of other important species in the November–December 2000 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured. Hatched bars indicate unsexed fish.**

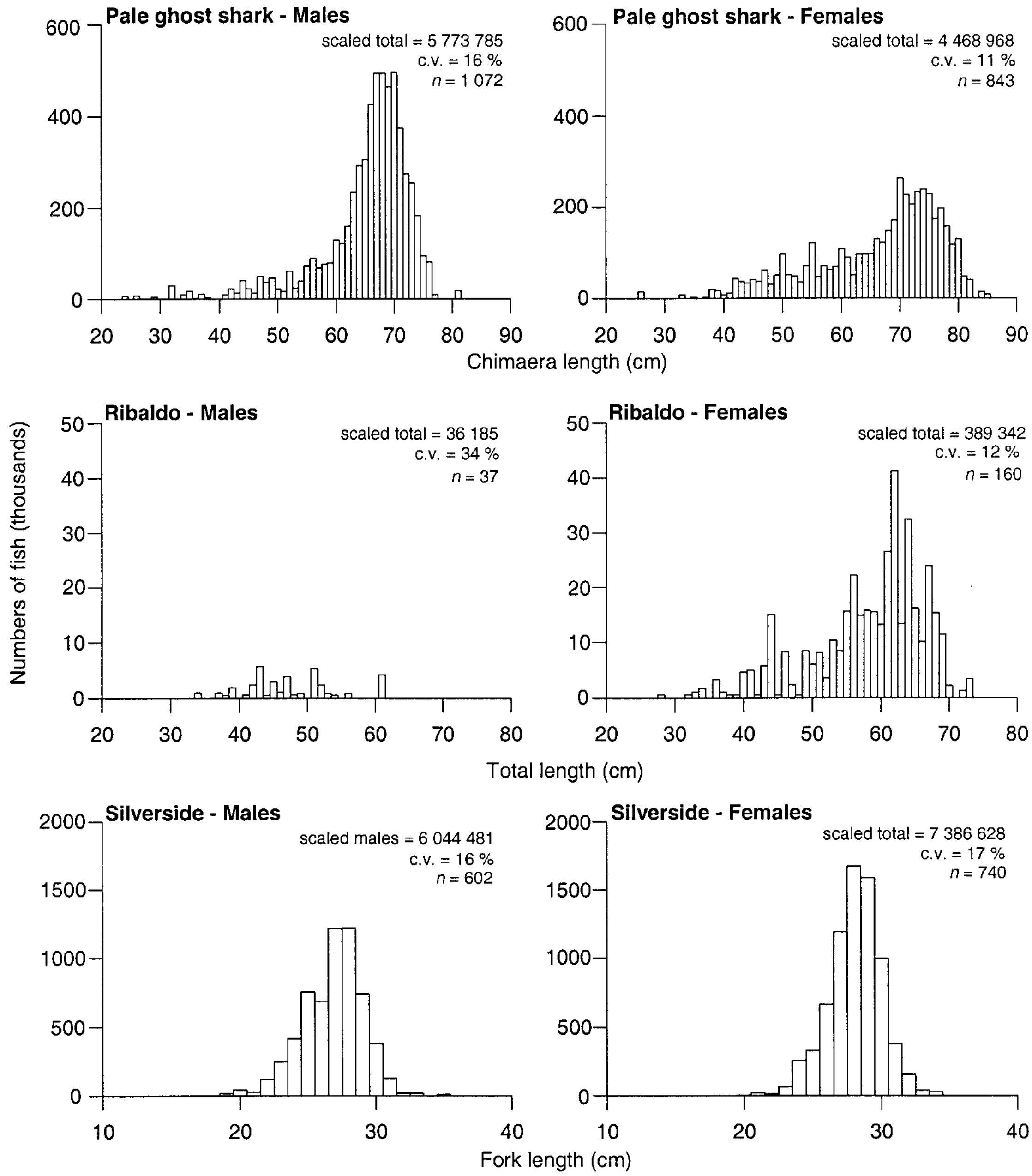

***Figure 9 (cont.)*: Length frequency by sex of other important species in the November–December 2000 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured. Hatched bars indicate unsexed fish.**

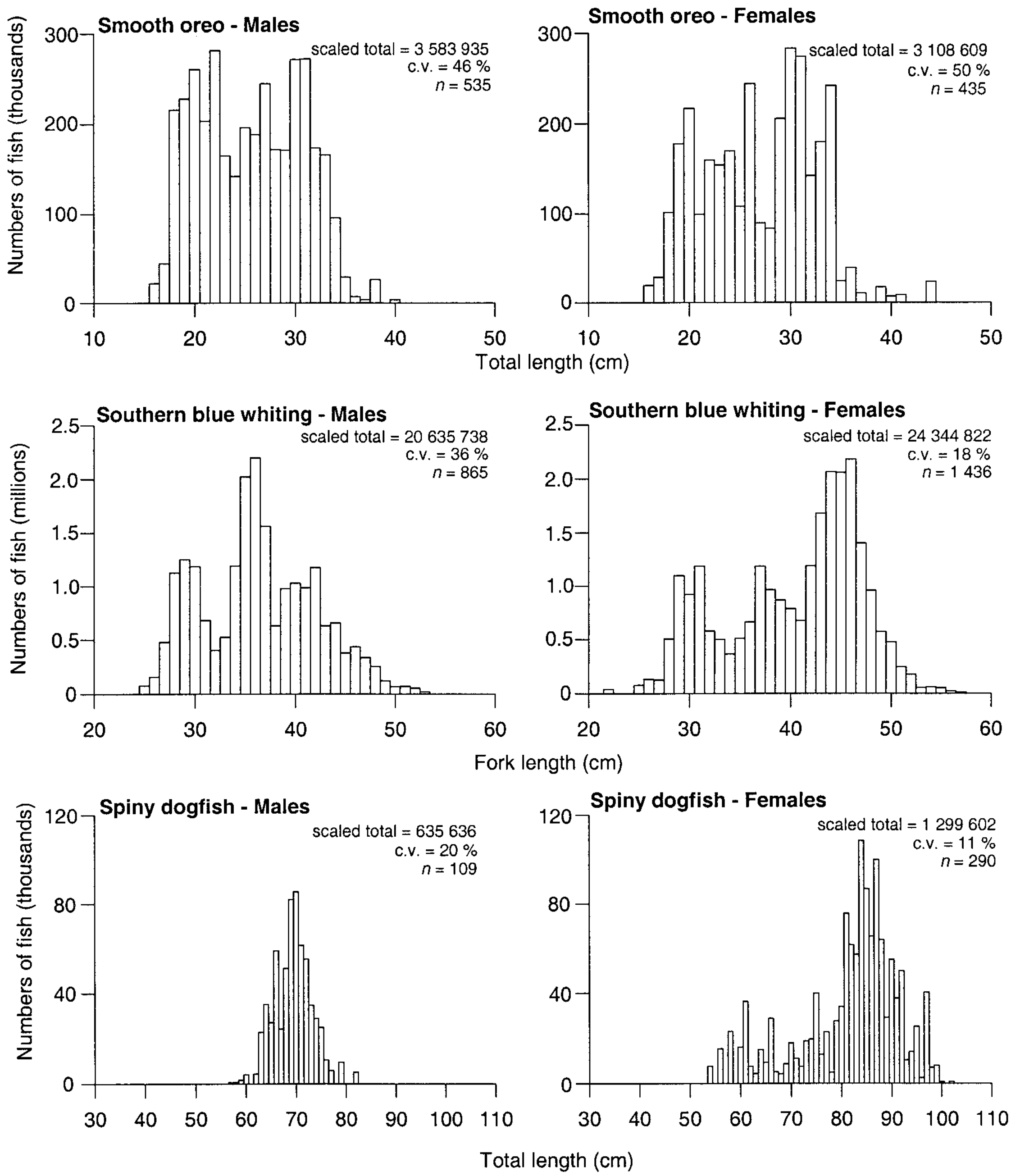

***Figure 9 (cont.)*:** **Length frequency by sex of other important species in the November–December 2000 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured. Hatched bars indicate unsexed fish.**

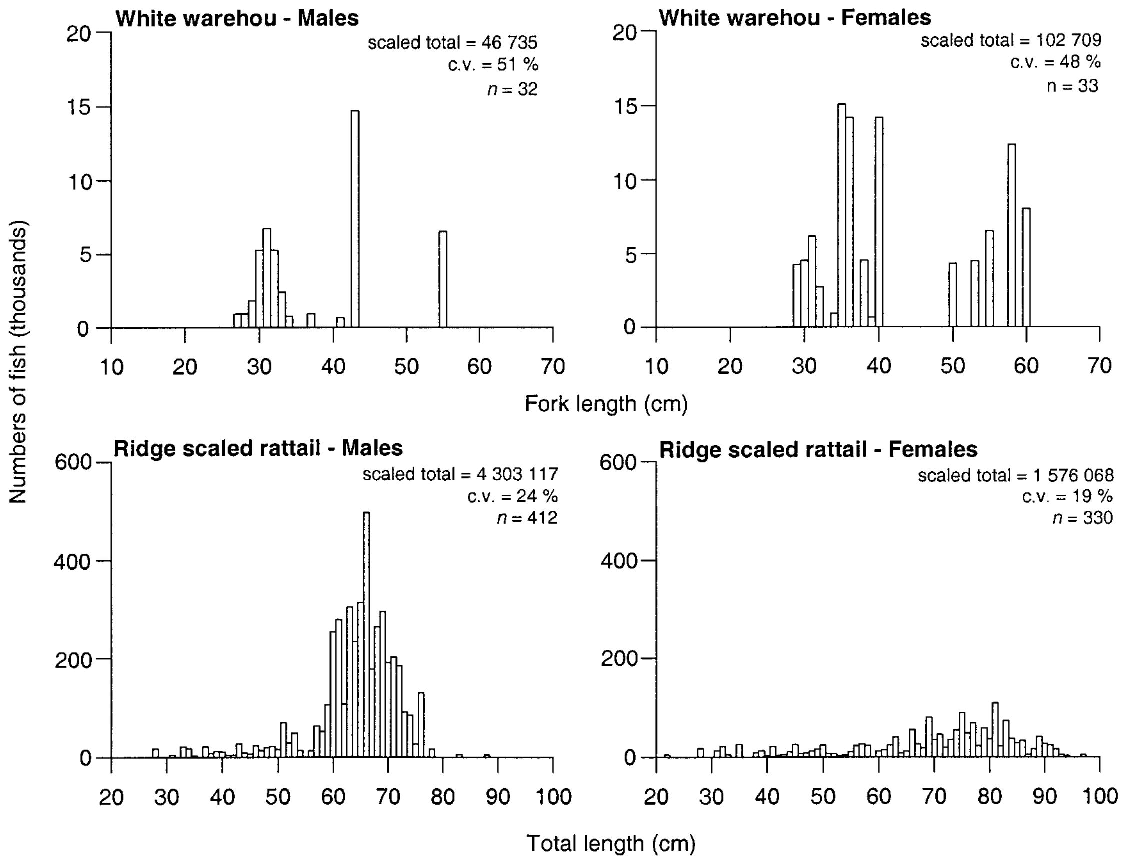

***Figure 9 (cont.)*: Length frequency by sex of other important species in the November–December 2000 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured. Hatched bars indicate unsexed fish.**

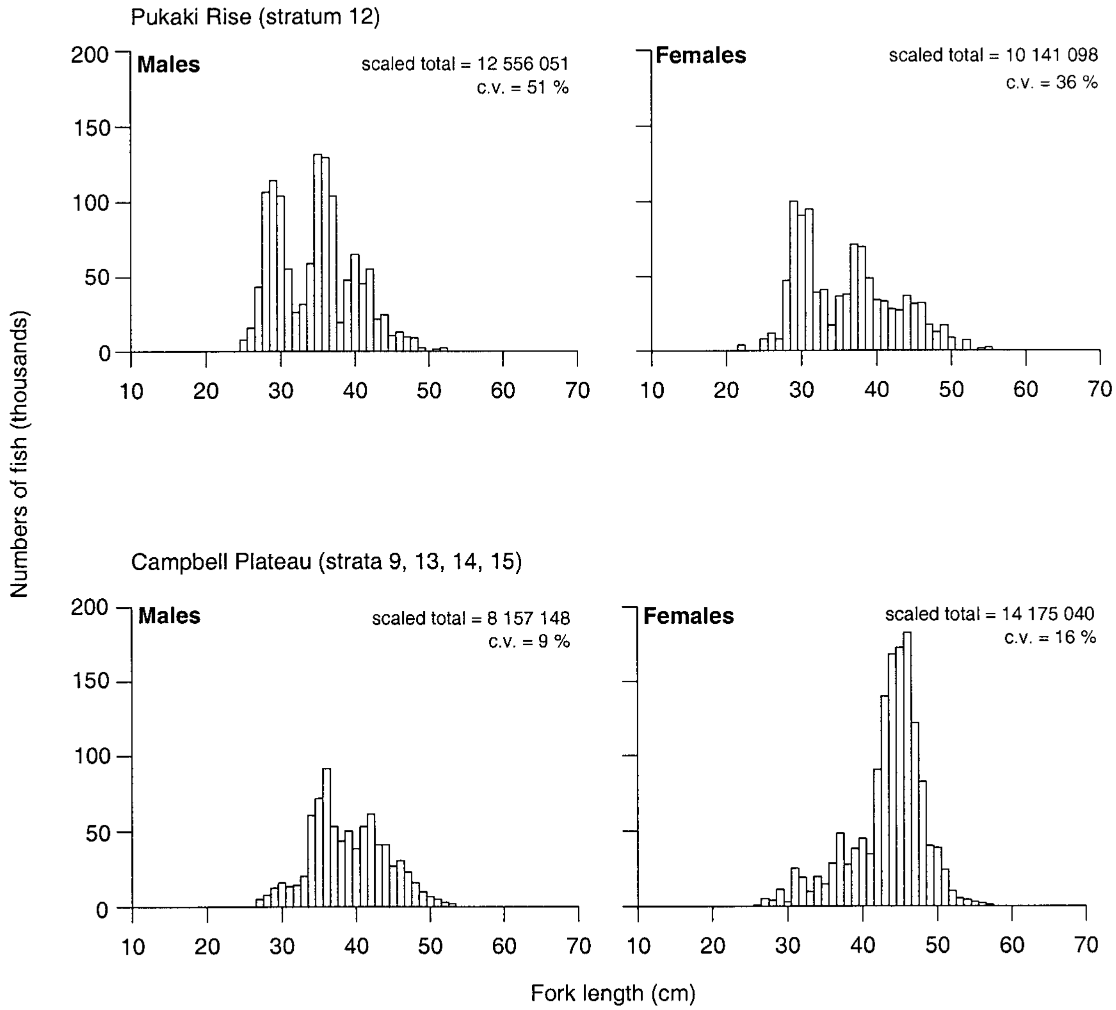

Figure 10: **Length frequency of southern blue whiting by sex for the two subareas which correspond to the Pukaki Rise and Campbell Plateau stocks.**

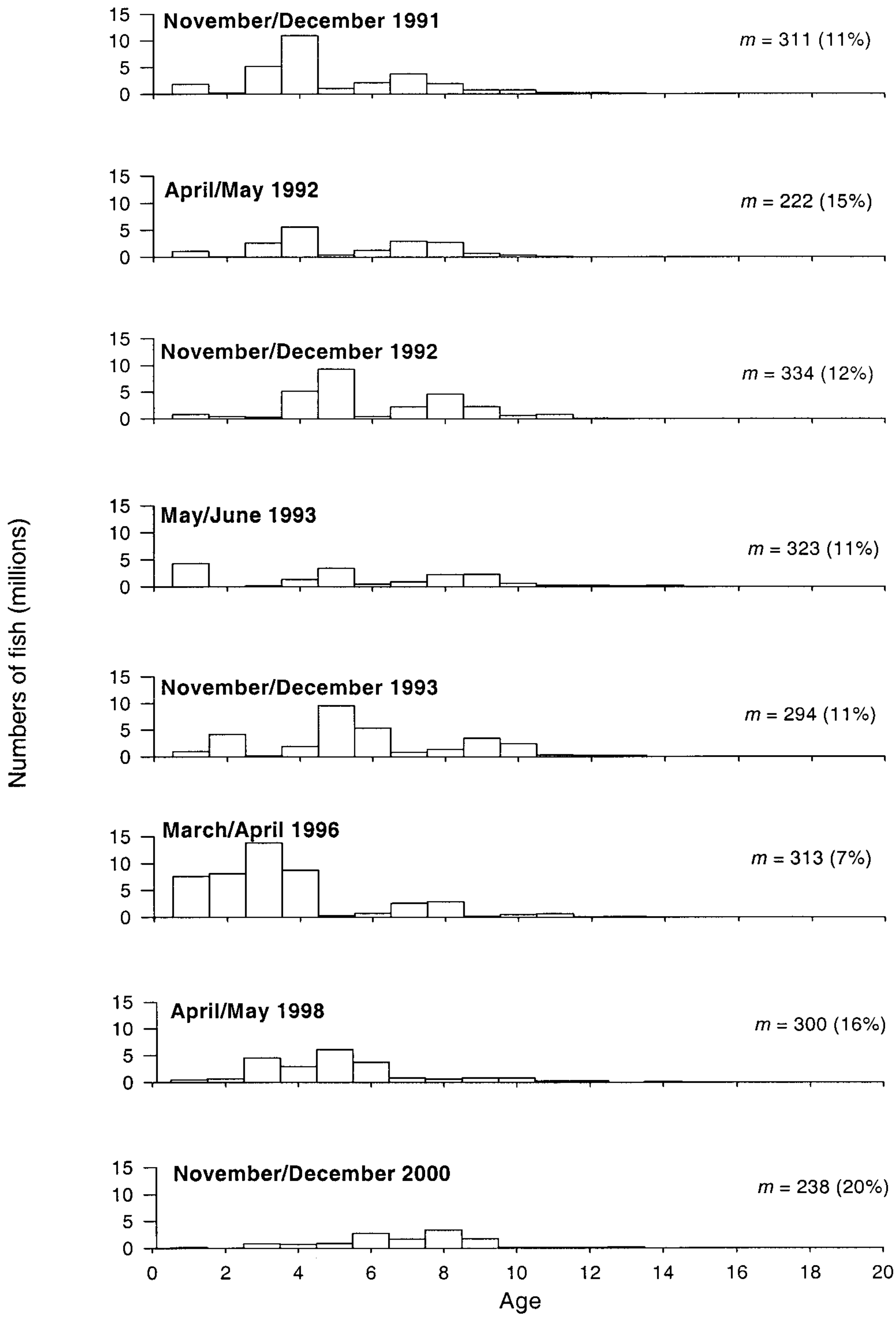

Figure 11a: **Scaled age frequencies for male hoki from Sub-Antarctic *Tangaroa* time series all strata. Number of fish aged (*m*) shown with coefficients of variation (c.v.) given in parentheses.**

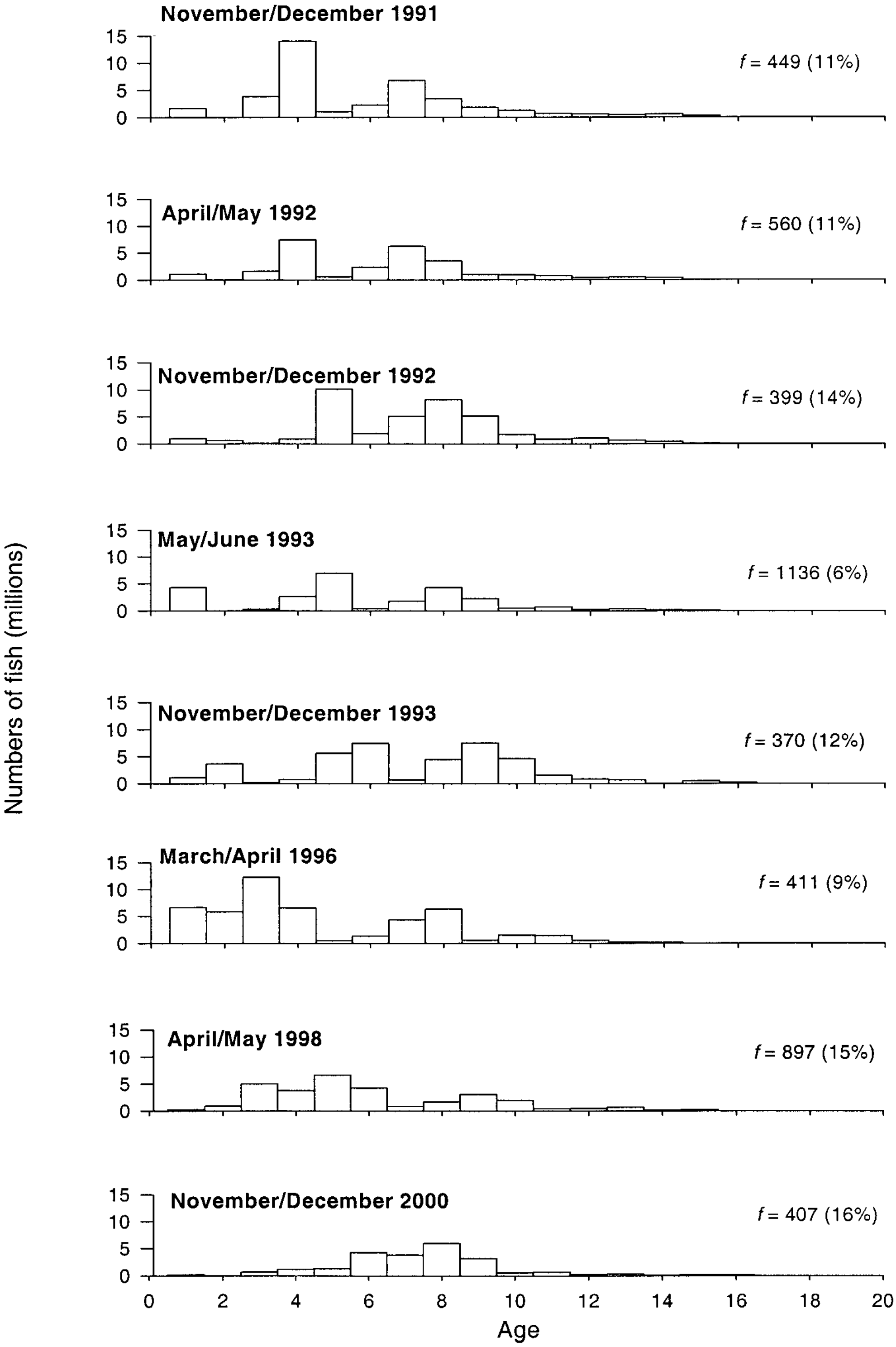

Figure 11a (cont.): **Scaled age frequencies for female hoki from Sub-Antarctic *Tangaroa* time series all strata. Number of fish aged (*f*) shown with coefficients of variation (c.v.) given in parentheses.**

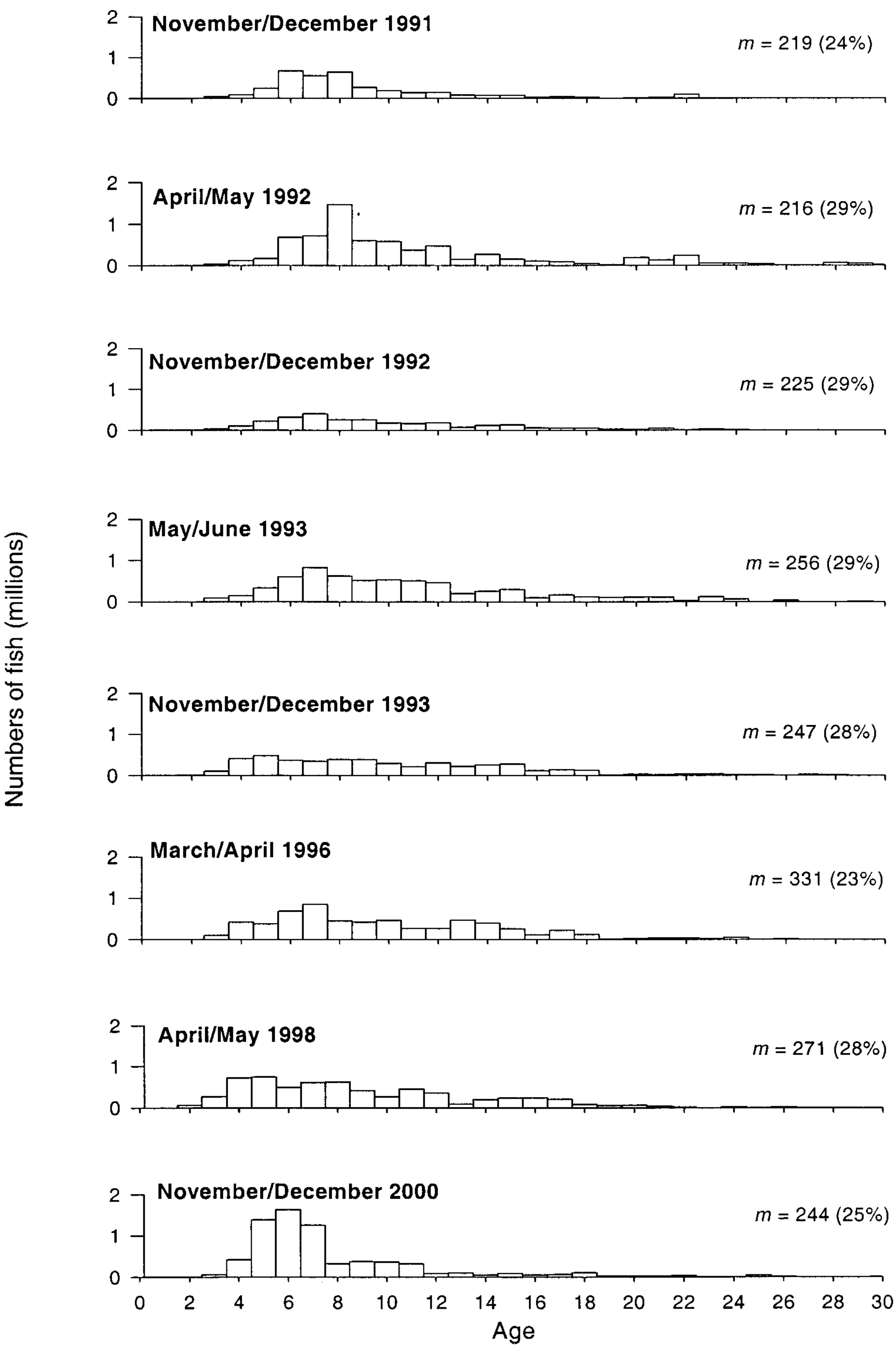

Figure 11b: **Scaled age frequencies for male ling from Sub-Antarctic *Tangaroa* time series all strata. Number of fish aged (*m*) shown with coefficients of variation (c.v.) given in parentheses.**

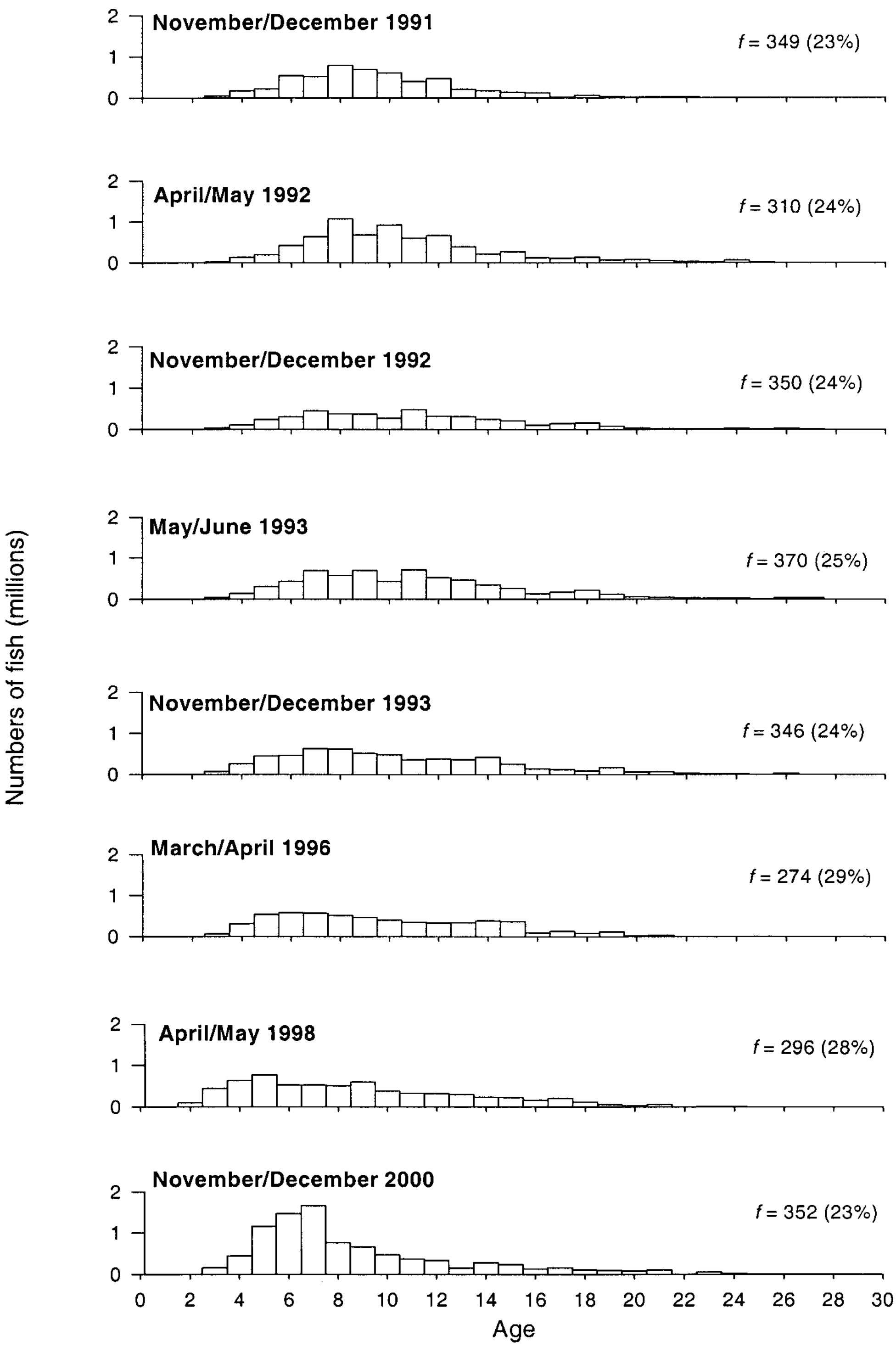

Figure 11b (cont.): **Scaled age frequencies for female ling from Sub-Antarctic *Tangaroa* time series all strata. Number of fish aged (*f*) shown with coefficients of variation (c.v.) given in parentheses.**

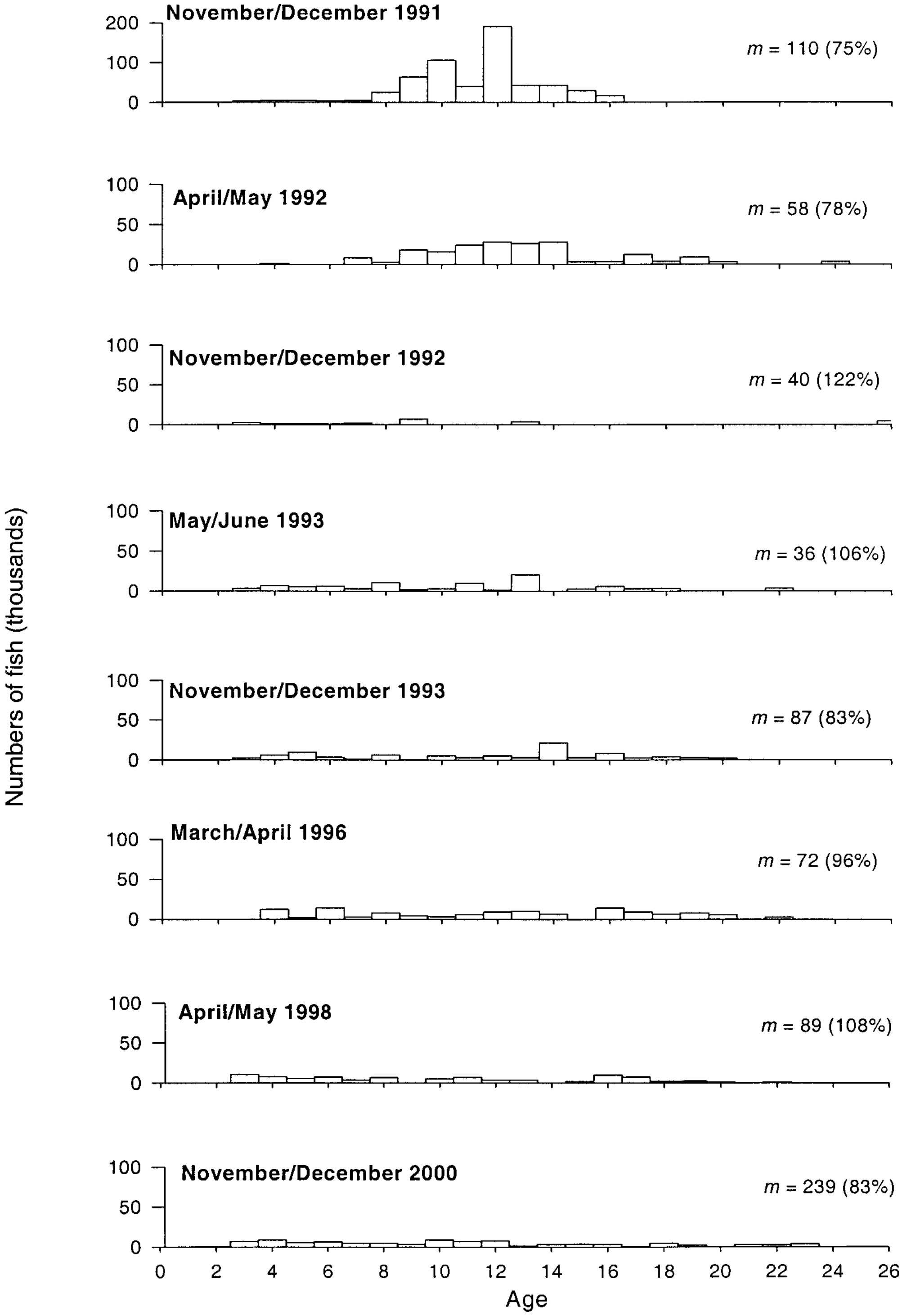

Figure 11c: **Scaled age frequencies for male hake from Sub-Antarctic *Tangaroa* time series in core 300–800 m strata. Number of fish aged (*m*) shown with coefficients of variation (c.v.) given in parentheses. Note change of scale between November/December 1991 and subsequent years.**

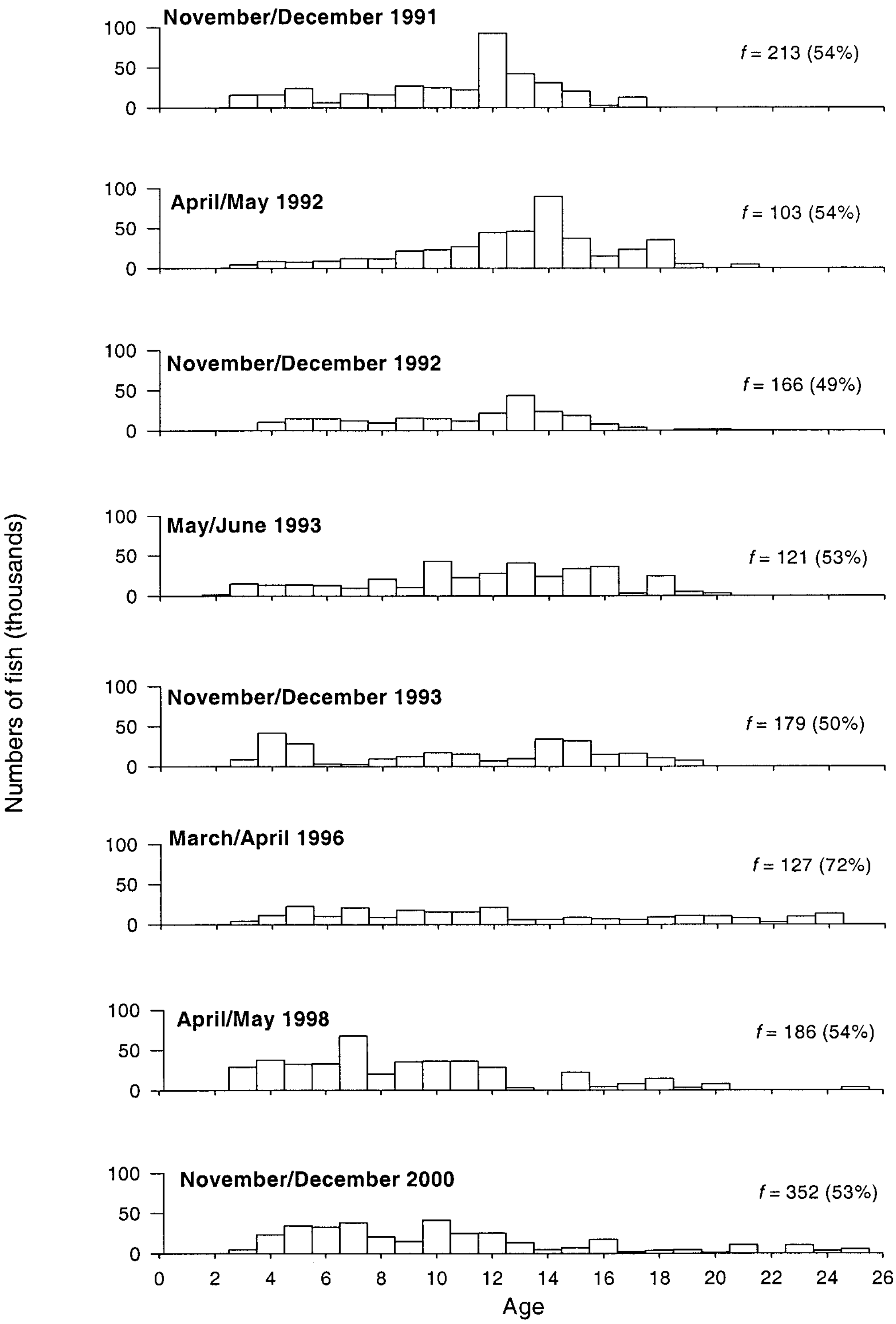

Figure 11c (cont.): **Scaled age frequencies for female hake from Sub-Antarctic *Tangaroa* time series in core 300–800 m strata. Number of fish aged (*f*) shown with coefficients of variation (c.v.) given in parentheses.**

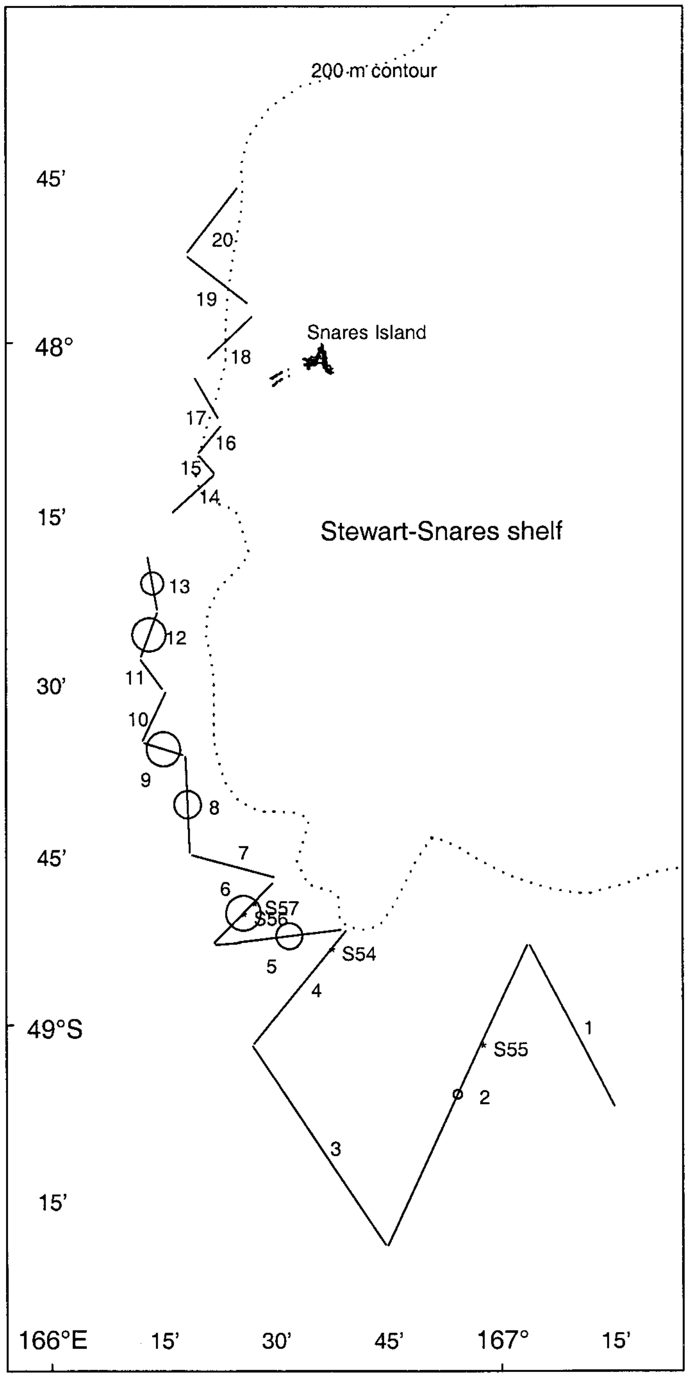

Figure 12: **Location of acoustic transects and spatial distribution of non-pelagic backscatter. Circle areas are proportional to the mean areal backscatter recorded along each transect. Positions of midwater trawls are indicated by asterices.**

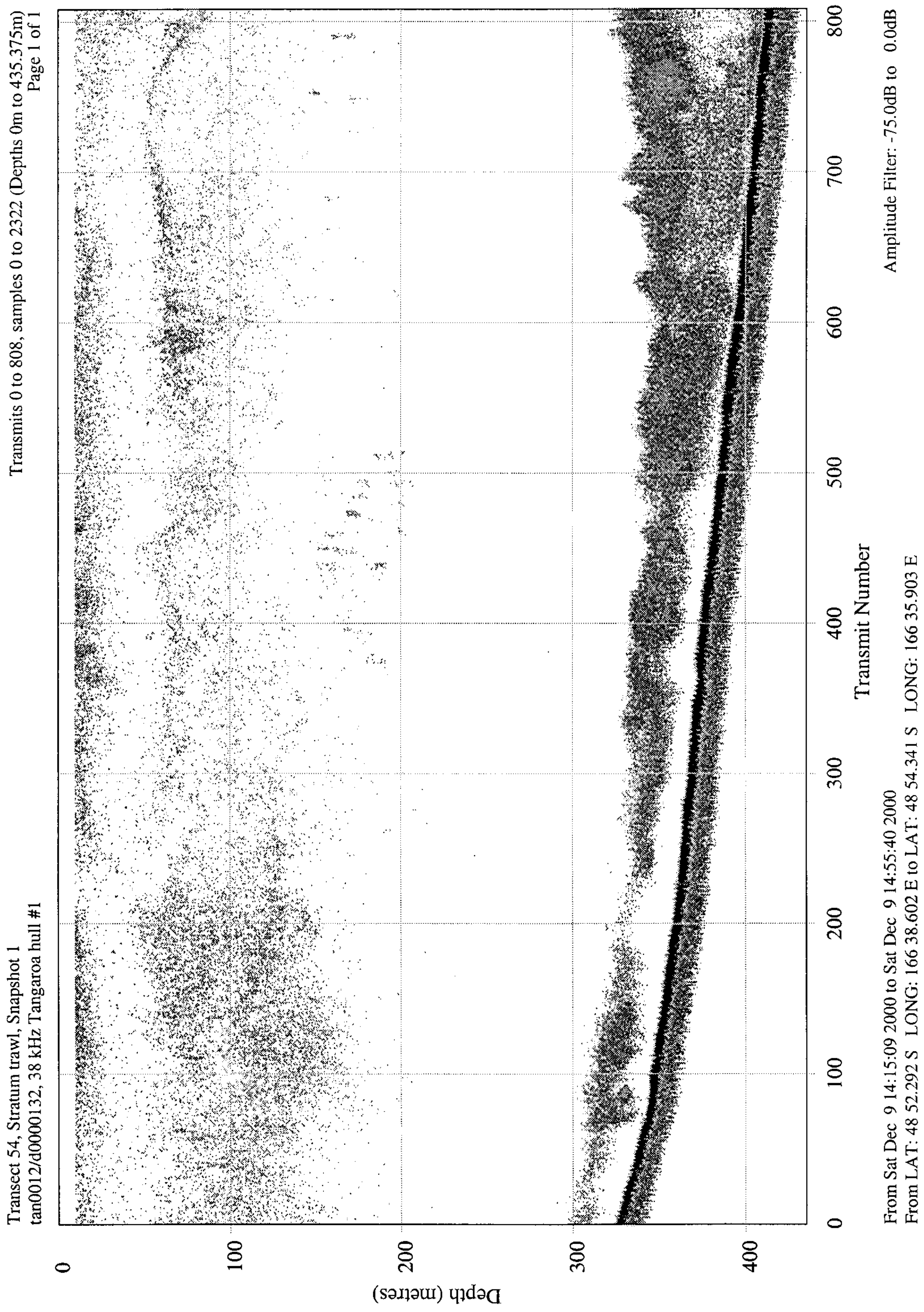

Figure 13: **A typical echogram showing a layer of mesopelagic fish ("pelagic" backscatter). A midwater trawl targeted at this layer (Set 54 in Table 10) caught Ray's bream, pearlside, and salps.**

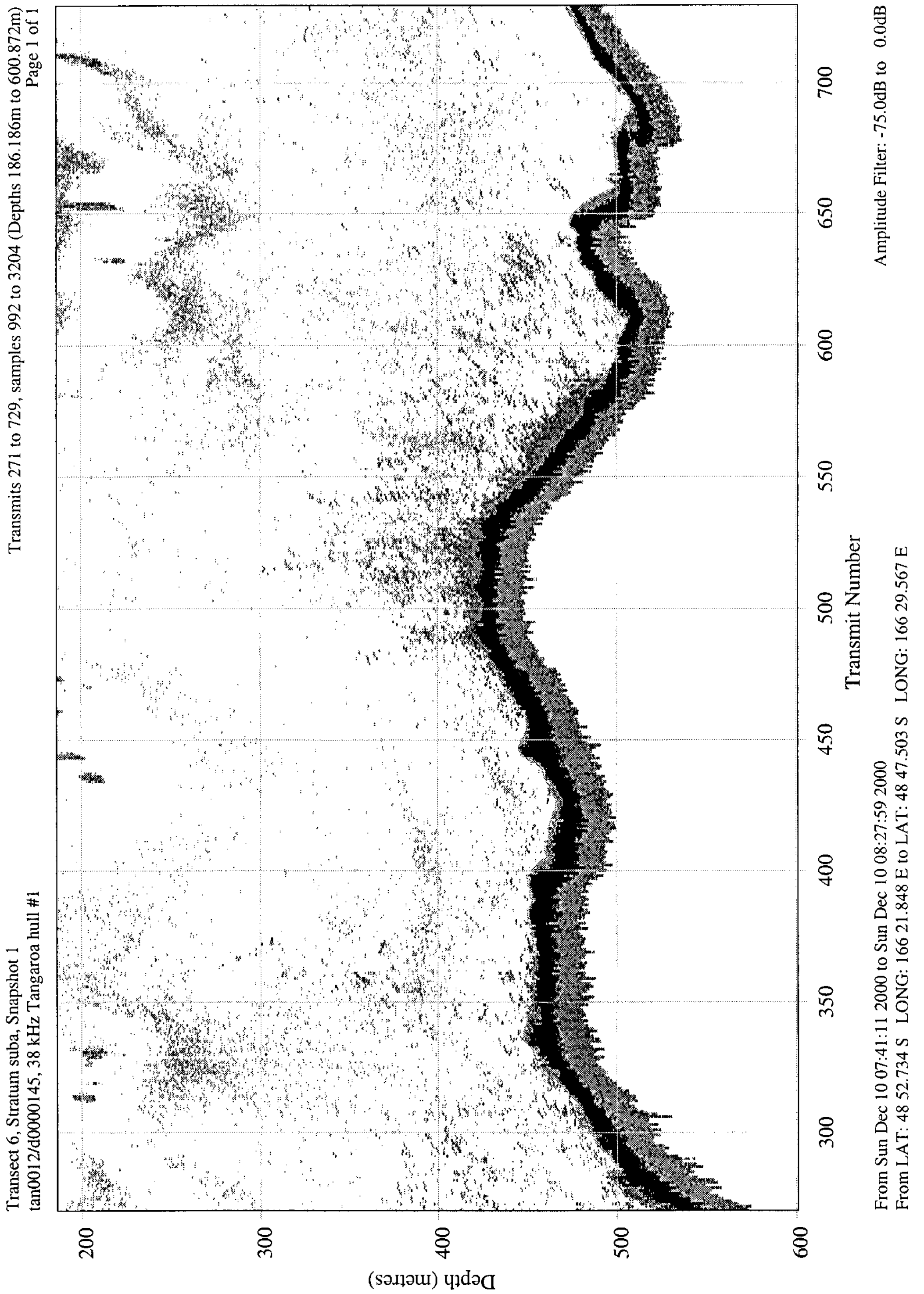

Figure 14: **Echogram showing an example of a "non-pelagic" mark. The mark is between Transmits 470 and 600 and is densest close to the bottom, although individual fish are visible over 100 m from the bottom. Two midwater trawls targeted at this mark (Sets 56 and 57 in Table 10) caught hoki and spawning hake.**

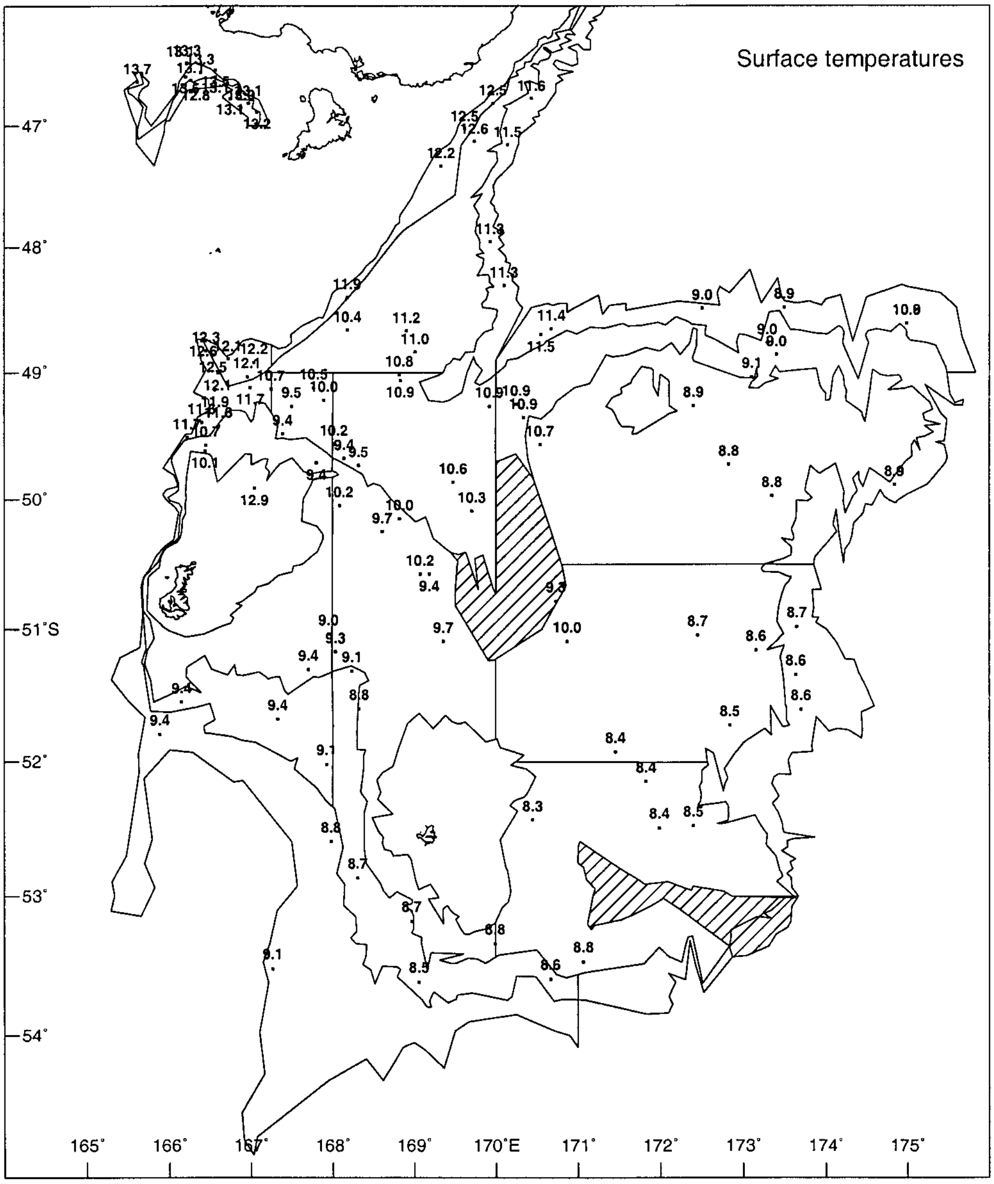

Figure 15: **Surface water temperatures (°C). Dots indicate station positions.**

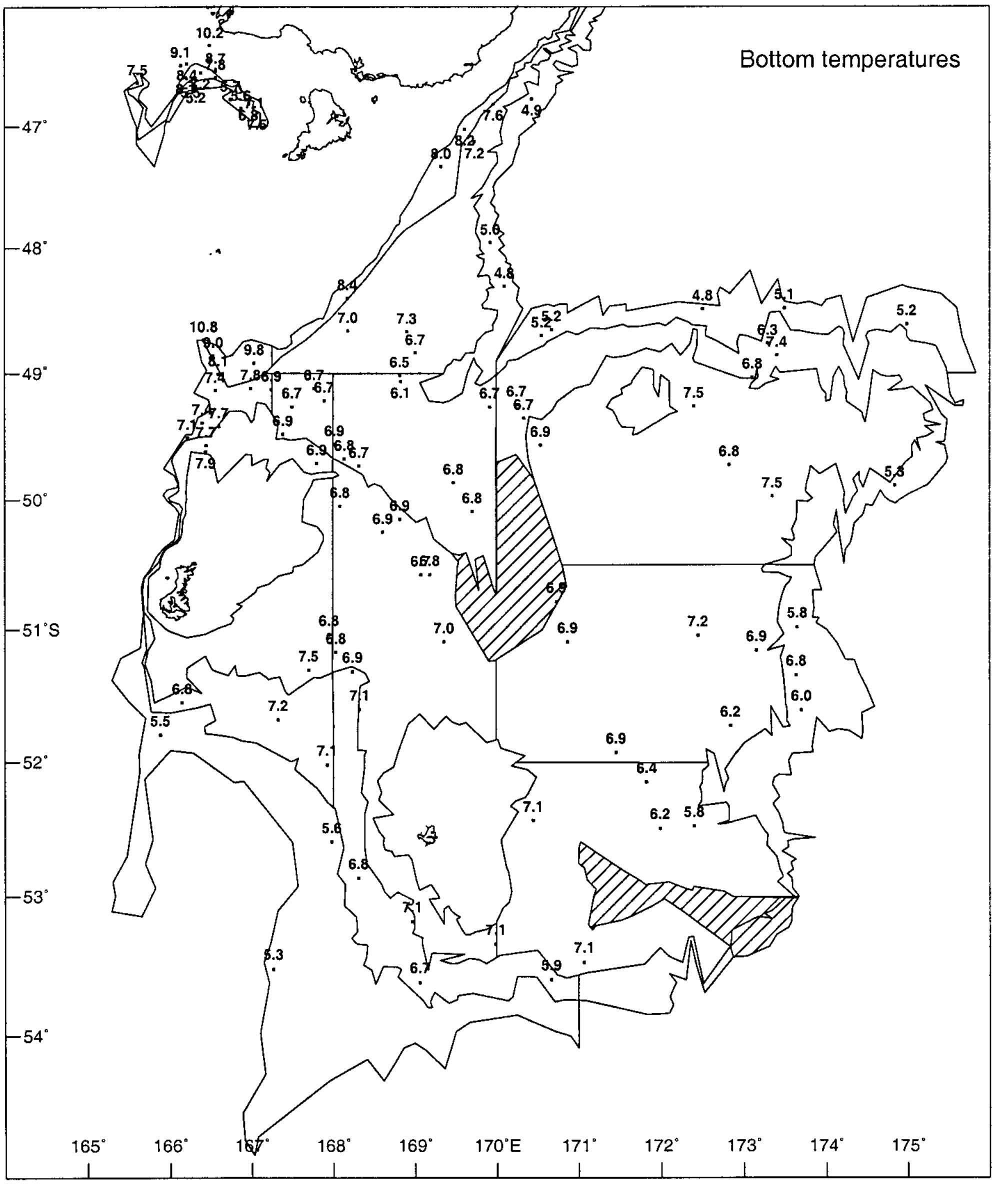

Figure 16: **Bottom water temperatures (°C). Dots indicate station positions.**

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

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

Appendix 2: **Station details and catch of hoki, ling, and hake**

Station number	Latitude start	Longitude start	Stratum	Date	Gear method	Depth gear (m)	Catch (kg) Hoki	Ling	Hake
1	48 36.45	174 59.18	Gear trial	26-Nov-00	BT	801	0.0	0.0	0.0
2	48 36.44	174 59.21	27	26-Nov-00	BT	801	1.8	0.0	0.0
3	48 29.15	172 30.24	27	27-Nov-00	BT	982	2.2	0.0	0.0
4	48 28.78	173 29.83	27	27-Nov-00	BT	870	52.0	0.0	0.0
5	48 45.58	173 17.54	11	27-Nov-00	BT	716	226.6	42.2	0.0
6	48 51.19	173 24.13	11	27-Nov-00	BT	653	194.9	43.6	9.7
7	49 01.79	173 06.57	12	27-Nov-00	BT	560	69.0	57.7	0.0
8	49 15.42	172 24.10	12	28-Nov-00	BT	429	50.1	118.2	0.0
9	49 43.18	172 49.74	12	28-Nov-00	BT	472	24.3	49.6	0.0
10	49 58.05	173 21.02	12	28-Nov-00	BT	525	49.7	103.4	0.0
11	49 53.02	174 50.32	11	28-Nov-00	BT	723	306.1	22.6	0.0
12	51 02.57	172 27.15	13	29-Nov-00	BT	530	50.5	46.8	0.0
13	51 09.41	173 09.45	13	29-Nov-00	BT	576	284.3	56.3	0.0
14	50 58.90	173 39.02	15	29-Nov-00	BT	652	177.2	34.4	0.0
15	51 20.64	173 38.37	15	29-Nov-00	BT	605	135.2	47.0	10.1
16	51 36.35	173 42.17	15	29-Nov-00	BT	610	225.0	42.9	0.0
17	51 43.45	172 50.28	13	30-Nov-00	BT	559	55.9	52.4	7.6
18	52 28.32	172 23.95	14	30-Nov-00	BT	572	454.2	77.1	6.8
19	52 29.38	171 59.36	14	30-Nov-00	BT	540	84.1	64.6	0.0
20	52 08.54	171 49.71	14	30-Nov-00	BT	554	118.6	122.9	7.0
21	51 55.26	171 27.28	13	30-Nov-00	BT	516	81.9	59.0	0.0
22	52 25.83	170 26.85	14	1-Dec-00	BT	427	65.9	77.0	0.0
23	53 28.39	171 04.09	14	1-Dec-00	BT	533	96.5	111.6	0.0
24	53 35.84	170 39.98	10	1-Dec-00	BT	788	8.5	0.0	9.8
25	53 20.63	169 59.29	9	1-Dec-00	BT	502	46.5	89.8	0.0
26	53 37.18	169 03.93	10	2-Dec-00	BT	775	15.5	2.1	0.0
27	53 10.91	168 58.12	10	2-Dec-00	BT	644	77.9	60.5	8.7
28	52 51.68	168 18.66	10	2-Dec-00	BT	680	181.7	39.8	0.0
29	53 31.56	167 15.87	26	2-Dec-00	BT	993	0.0	0.0	0.0
30	52 35.57	167 58.73	26	3-Dec-00	BT	879	0.0	0.0	4.4
31	52 00.93	167 55.51	7	3-Dec-00	BT	717	112.8	27.5	3.8
32	51 35.99	168 19.84	9	3-Dec-00	BT	597	361.8	366.7	12.7
33	51 18.89	168 14.60	9	3-Dec-00	BT	597	1365.1	149.6	0.0
34	51 10.20	168 02.20	9	3-Dec-00	BT	595	398.6	252.7	0.0
35	51 02.14	167 57.15	6	4-Dec-00	BT	573	454.1	169.6	7.8
36	51 40.71	167 19.60	7	4-Dec-00	BT	650	207.6	70.7	8.4
37	51 18.28	167 42.27	6	4-Dec-00	BT	575	212.2	89.7	2.7
38	51 32.96	166 09.17	7	4-Dec-00	BT	767	59.3	15.4	33.2
39	51 47.64	165 53.19	26	5-Dec-00	BT	934	11.5	0.0	7.9
40	49 36.98	166 26.56	6	5-Dec-00	BT	338	5.5	0.0	0.0
41	49 30.56	166 13.07	5A	6-Dec-00	BT	616	147.2	59.4	21.1
42	49 25.20	166 36.16	6	6-Dec-00	BT	550	41.4	19.9	1.9
43	49 28.79	167 23.42	5B	6-Dec-00	BT	651	53.2	134.2	20.1
44	49 15.77	167 29.83	5B	7-Dec-00	BT	714	30.7	56.6	102.0
45	49 12.83	167 53.74	5B	7-Dec-00	BT	702	49.3	81.9	19.1
46	49 33.59	168 01.13	8	7-Dec-00	BT	667	143.5	67.2	7.7
47	49 42.57	167 48.23	6	7-Dec-00	BT	532	0.0	0.0	28.0
48	49 40.23	168 08.48	8	7-Dec-00	BT	639	211.8	77.6	0.0
49	49 43.70	168 19.14	8	7-Dec-00	BT	625	185.1	200.9	9.8

Station number	Latitude start	Longitude start	Stratum	Date	Gear method	Depth gear (m)	Catch (kg) Hoki	Ling	Hake
50	50 47.12	170 43.90	13	8-Dec-00	BT	562	106.2	58.4	0.0
51	50 34.75	169 11.30	9	8-Dec-00	BT	592	183.4	107.8	6.5
52	50 14.90	168 36.64	9	8-Dec-00	BT	562	116.0	176.4	2.7
53	50 02.68	168 05.19	9	8-Dec-00	BT	530	40.5	219.5	12.5
54	48 53.45	166 37.05		9-Dec-00	MWT	340	0.0	0.0	0.0
55	49 01.85	166 57.16		9-Dec-00	MWT	361	0.0	0.0	0.0
56	48 50.36	166 25.30		10-Dec-00	MWT	451	18.2	0.0	100.1
57	48 49.43	166 26.75		10-Dec-00	MWT	442	155.5	0.0	70.1
58	46 53.28	167 04.22	25	11-Dec-00	BT	844	26.4	0.0	93.8
59	46 46.30	166 44.61	25	11-Dec-00	BT	896	6.6	0.0	51.8
60	46 35.43	166 34.06	2	11-Dec-00	BT	714	114.6	43.6	8.4
61	46 32.19	166 34.02	1	11-Dec-00	BT	544	35.2	227.8	9.0
62	46 33.08	166 22.82	2	11-Dec-00	BT	682	262.1	60.2	2.4
63	46 35.50	166 11.91	2	11-Dec-00	BT	656	31.0	64.6	0.0
64	46 28.62	166 12.62	1	11-Dec-00	BT	550	62.2	155.1	2.3
65	46 37.98	165 36.67	2	12-Dec-00	BT	600	130.5	49.3	6.1
66	46 29.30	166 08.17	1	12-Dec-00	BT	447	246.8	54.7	0.0
67	46 19.46	166 29.43	1	12-Dec-00	BT	367	360.3	213.3	0.0
68	46 37.26	166 15.79	25	13-Dec-00	BT	808	91.6	2.8	539.0
69	46 39.04	166 19.44	25	13-Dec-00	BT	953	25.4	0.0	107.7
70	46 48.79	166 58.11	25	13-Dec-00	BT	866	47.5	11.0	210.1
71	46 50.85	166 52.48	25	13-Dec-00	BT	985	5.0	0.0	51.1
72	46 54.56	167 02.39	25	13-Dec-00	BT	965	36.3	9.3	72.1
73	46 48.69	169 57.94	3A	14-Dec-00	BT	524	37.5	70.2	1.9
74	46 46.21	170 26.12	28	14-Dec-00	BT	927	2.3	0.0	4.2
75	47 09.32	170 08.74	28	14-Dec-00	BT	954	2.5	0.0	33.0
76	47 07.74	169 44.41	4	14-Dec-00	BT	659	49.9	51.5	33.3
77	47 01.41	169 37.30	3A	14-Dec-00	BT	438	22.3	51.0	0.0
78	47 19.90	169 19.79	3A	15-Dec-00	BT	500	79.8	65.0	5.1
79	47 57.30	169 55.83	28	15-Dec-00	BT	910	0.0	0.0	0.0
80	48 18.36	170 06.03	28	15-Dec-00	BT	896	15.6	0.0	10.3
81	48 38.92	170 40.46	27	15-Dec-00	BT	875	13.5	0.0	13.0
82	48 41.75	170 33.06	27	15-Dec-00	BT	850	25.5	0.0	10.7
83	49 33.88	170 32.43	12	16-Dec-00	BT	548	92.7	85.4	0.0
84	49 20.94	170 20.34	11	16-Dec-00	BT	600	104.0	111.2	0.0
85	49 14.65	170 15.10	11	16-Dec-00	BT	668	260.8	70.9	8.4
86	49 15.75	169 55.36	8	16-Dec-00	BT	695	137.9	57.1	27.7
87	49 51.61	169 28.55	8	16-Dec-00	BT	649	45.0	47.1	3.8
88	50 05.16	169 42.51	8	16-Dec-00	BT	614	85.9	54.3	0.0
89	50 08.86	168 49.22	9	17-Dec-00	BT	590	54.2	131.1	0.0
90	49 03.54	168 50.21	8	17-Dec-00	BT	785	71.0	6.0	35.2
91	49 00.88	168 49.19	8	17-Dec-00	BT	732	103.3	53.4	13.8
92	48 49.98	169 00.77	4	17-Dec-00	BT	634	139.3	111.0	3.0
93	48 40.03	168 54.53	4	17-Dec-00	BT	729	39.9	42.6	2.0
94	48 16.95	168 41.78	4	18-Dec-00	BT	602	107.2	68.2	15.8
95	48 24.08	168 10.67	3A	18-Dec-00	BT	570	8.8	182.6	7.7
96	48 39.47	168 11.14	4	18-Dec-00	BT	640	71.8	93.5	2.2
97	48 55.07	167 02.13	3B	18-Dec-00	BT	344	273.5	45.5	0.0
98	49 06.90	166 59.37	5A	18-Dec-00	BT	614	46.7	152.5	37.5
99	48 43.93	166 25.13	3B	19-Dec-00	BT	300	62.1	33.9	0.0
100	48 51.48	166 32.19	3B	19-Dec-00	BT	388	25.0	20.4	0.0

Station number	Latitude start	Longitude start	Stratum	Date	Gear method	Depth gear (m)	Catch (kg) Hoki	Ling	Hake
101	49 00.24	166 35.74	3B	19-Dec-00	BT	530	243.5	498.8	70.0
102	49 08.04	166 33.65	5A	19-Dec-00	BT	616	133.8	92.3	110.2
103	49 23.41	166 24.05	5A	19-Dec-00	BT	653	256.8	89.0	16.5
104	49 33.98	166 26.84	6	19-Dec-00	BT	529	246.8	238.5	37.7
105	49 07.68	167 14.75	5A	20-Dec-00	BT	723	25.2	60.1	21.4
106	49 06.92	167 46.37	5B	20-Dec-00	BT	657	77.2	78.8	22.0
107	50 34.86	169 04.64	9	20-Dec-00	BT	573	33.1	65.8	3.0
108	51 05.53	169 21.43	9	21-Dec-00	BT	572	62.9	89.6	0.0
109	51 05.36	170 52.23	13	21-Dec-00	BT	547	118.7	116.4	0.0

Key to abbreviations:

BT = bottom trawl
MWT = midwater trawl

Appendix 3: **Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms**

Scientific name	Common name	Species code	Occ.
Chondrichthyes			
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	16
Centroscymnus coelolepis	Portuguese dogfish	CYL	1
C. crepidater	longnose velvet dogfish	CYP	22
C. owstoni	smooth skin dogfish	CYO	12
C. plunketi	Plunket's shark	PLS	1
Deania calcea	shovelnose dogfish	SND	13
Etmopterus baxteri	Baxter's dogfish	ETB	37
E. lucifer	Lucifer dogfish	ETL	42
Scymnorhinus licha	seal shark	BSH	7
Squalus acanthias	spiny dogfish	SPD	65
Laminidae: mackerel sharks			
Isurus oxyrinchus	mako shark	MAK	1
Scyliorhinidae: cat sharks			
Apristurus spp	deepsea catsharks	APR	8
Halaelurus dawsoni	Dawson's catshark	DCS	4
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	2
Rajidae: skates			
Bathyraja shuntovi	longnosed deepsea skate	PSK	2
Dipturus innominata	smooth skate	SSK	8
D. nasuta	rough skate	RSK	8
Pavoraja asperula	smooth bluntnosed skate	BTA	15
P. spinifera	prickly bluntnosed skate	BTS	9
Rajidae	skate (unidentified)	SKA	2
Chimaeridae: chimaeras, ghost sharks			
Chimaera phantasma	giant chimaera	CHG	1
Hydrolagus novaezelandiae	dark ghost shark	GSH	13
Hydrolagus sp. B	pale ghost shark	GSP	93
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	48
Rhinochimaera pacifica	widenose chimaera	RCH	13
Osteichthyes			
Notacanthidae: spiny eels			
Notacanthus sexspinis	spineback	SBK	47
Nemichthyidae: Snipe eels			
Nemichthys scolopaceus	snipe eel	NEM	1
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	18
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	36
B. hirsutus	hairy conger	HCO	37
Serrivomeridae: sawtooth eels			
Serrivomer sp.	saw tooth eel	SAW	1
Argentinidae: silversides			
Argentina elongata	silverside	SSI	49
Bathylagidae: deepsea smelts			
Bathylagus spp.	deepsea smelt	DSS	4
Alepocephalidae: slickheads			
Alepocephalus australis	small-scale brown slickhead	SSM	15
Rouleina sp.	large headed slickhead	BAT	1
Xenodermichthys spp.	black slickhead	BSL	1
Gonostomatidae: lightfishes			
Gonostoma elongatum	elongate lightfish	GEL	2

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Sternoptychidae: hatchetfishes			
Sternoptychidae	hatchetfish	HAT	1
Maurolicus australis	pearlside	MMU	2
Platytroctidae: tubeshoulders			
Holtbyrnia sp.	tubeshoulder	HOL	2
Platytroctidae		SID	5
Chauliodontidae: viperfishes			
Chauliodus sloani	viper fish	CHA	3
Stomiidae: scaly dragonfishes			
Stomias spp	scaly dragonfish	STO	4
Melanostomiidae: scaleless black dragonfishes			
Melanostomiidae	scaleless black dragonfish	MST	1
Echiostoma barbatum	dragonfish	EBA	2
Melanostomias spp.		MEN	2
Idiacanthhidae: black dragonfishes			
Idiacanthus spp.		IDI	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	21
Paralepididae: barracudinas			
Paralepididae	barracudina's	PAL	1
Evermannellidae: sabretooth fishes			
Evermanella indica		SAB	1
Myctophidae: lanternfishes			
Species not identified	lanternfish	LAN	10
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	6
Austrophycis marginata	dwarf cod	DCO	7
Halargyreus johnsoni	slender cod	HJO	15
Laemonema spp.		LAE	7
Mora moro	ribaldo	RIB	49
Pseudophycis bachus	red cod	RCO	7
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	27
Merlucciidae: hakes			
Lyconus sp.		LYC	4
Macruronus novaezelandiae	hoki	HOK	102
Merluccius australis	hake	HAK	66
Macrouridae: rattails, grenadiers			
Bathygadus cottoides	codheaded rattail	BAC	6
Caelorinchus aspercephalus	oblique-banded rattail	CAS	46
C. bollonsi	bigeyed rattail	CBO	32
C. fasciatus	banded rattail	CFA	92
C. innotabilis	notable rattail	CIN	15
C. kaiyomaru	Kaiyomaru rattail	CKA	17
C. matamua	Mahia rattail	CMA	5
C. oliverianus	Oliver's rattail	COL	56
Coryphaenoides murrayi	abyssal rattail	CMU	20
Coryphaenoides serrulatus	serrulate rattail	CSE	14
C . subserrulatus	fourrayed rattail	CSU	23
Lepidorhynchus denticulatus	javelinfish	JAV	96
Macrourus carinatus	ridge scaled rattail	MCA	31
Mesobius antipodum	black javelinfish	BJA	1
Nezumia namatahi	squashed face rattail	NNA	3
Trachyrincus aphyodes	white rattail	WHX	9
T. longirostris	unicorn rattail	WHR	1
Ventrifossa nigromaculata	blackspot rattail	VNI	16

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	85
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	3
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	1
Regalecidae: oarfishes			
Agrostichthys parkeri	ribbonfish	AGR	1
Regalecus glesne	oarfish	OAR	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	16
H. mediterraneus	silver roughy	SRH	5
Paratrachichthys trailli	common roughy	RHY	1
Diremidae: discfishes			
Diretmus argenteus	discfish	DIS	1
Anoplogastridae: fangtooth			
Anoplogaster cornuta	fangtooth	ANO	1
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	2
Cyttus novaezelandiae	silver dory	SDO	1
C. traversi	lookdown dory	LDO	50
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	3
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	14
Neocyttus rhomboidalis	spiky oreo	SOR	2
Pseudocyttus maculatus	smooth oreo	SSO	13
Macrorhamphosidae: snipefishes			
Centriscops obliquus	redbanded bellowsfish	BBE	2
Syngnathidae: pipefishes			
Syngnathidae	pipefish	PIP	2
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	1
Psychrolutidae: toadfishes			
Cottunculus nudus	bonyskull toadfish	COT	1
Neophrynichthys angustus	pale toadfish	TOP	35
N. latus	dark toadfish	TOD	1
Psychrolutes sp.	blobfish	PSY	3
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	1
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	6
E. robustus	cardinalfish	EPR	2
E. telescopus	black cardinalfish	EPT	2
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	15
Nototheniidae: ice cods			
Paranotothenia microlepidota	smallscaled cod	SCD	2
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	13
Gempylidae: snake mackerels			
Thyrsites atun	barracouta	BAR	2
Rexea solandri	gemfish	SKI	1

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	12
Hyperoglyphe antarctica	bluenose	BNS	1
Seriolella caerulea	white warehou	WWA	11
S. punctata	silver warehou	SWA	3
Schedophilus huttoni		SUH	1
S. maculatus	pelagic butterfish	SUM	1
Tubbia tasmanica		TUB	2
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	1
Neoachiropsetta milfordi	finless flounder	MAN	34
Pleuronectidae: righteyed flounders			
Azygopus pinnifasciatus	spotted flounder	SDF	1
Cephalopoda			
Unidentified squid		SQX	1
Cranchiidae			
Cranchiidae		CHQ	1
Histioteuthidae			
Histioteuthis spp.	violet squid	VSQ	3
Octopoteuthiidae			
Taningia danae		OSQ	4
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	24
Todarodes filippovae	Antarctic flying squid	TSQ	18
Onychoteuthidae			
Moroteuthis ingens	warty squid	MIQ	80
M. robsoni	warty squid	MRQ	14
Octopoda			
Graneledone spp.	deepwater octopus	DWO	12
Octopus spp.	octopus	OCT	1
Opisthoteuthis spp.	umbrella octopus	OPI	22
Crustacea			
Decapoda			
Crab unidenified	crab unidentified	CRB	18
Jacquinotia edwardsii	giant spider crab	GSC	4
Leptomithrax australis	masking crab	SSC	1
Lithodes murrayi		LMU	15
Neolithodes brodiei		NEB	5
Pagurid		PAG	2
Paralomis hystrix	stone crab	PHS	3
Funchalia spp.		FUN	1
Haliporoides sibogae		HSI	1
Lipkius holthuisi	omega prawn	LHO	23
Oplophorus novaezeelandiae		ONO	1
Pasiphaea spp.		PAS	7
Prawn unidentified	prawn	PRA	3
Nephropsidae			
Metanephrops challengeri	scampi	SCI	3

Appendix 3 — *continued*

Scientific name	Common name	Species code	Occ.
Other marine organisms			
Annelida			
Polychaeta	polychaete unspecified	POL	1
Cnidaria			
Coral unspecified	coral unspecified	COU	6
Seatulip unspecified	seatulip unspecified	TUL	3
Coelenterata			
Anthozoa	sea anemones	ANT	46
Scyphozoa	jellyfish	JFI	18
Echinodermata			
Asteroidea	starfish	SFI	90
Peribolaster lictor	starfish	PLI	1
Hippasteria trojana	starfish	HTR	2
Cidaridae		CID	1
Goniocidaris parasol		GPA	1
Echinoid	sea urchin	ECH/ECN	16
Holothurian	sea cucumber	SCC	62
Echinothuriidae			
Echinothuriidae	Tam O'Shanter urchin	TAM	30
Mollusca			
Gastropoda	shellfish	GAS	26
Phaeophyta	brown seaweed	SEO	1
Porifera	sponges	ONG	63
Thaliacea			
Salpidae	salps	SAL	71

Appendix 4a: **Calculated numbers at age (*n*) of hoki. Numbers are given by sex for the total survey area (All strata) and for the core survey area (300–800 m) and the 800–1000 m Puysegur stratum (Core + Puysegur). The core + Puysegur area was sampled consistently in all summer surveys (O'Driscoll & Bagley 2001) and are the numbers used in the hoki assessment model**

	All strata				Core + Puysegur			
	Male		Female		Male		Female	
Age	*n*	c.v.	*n*	c.v.	*n*	c.v.	*n*	c.v.
1	154 709	0.717	197 647	0.691	154 709	0.740	197 647	0.712
2	70 094	0.406	40 606	0.532	70 094	0.405	40 606	0.565
3	776 674	0.169	708 060	0.2	776 674	0.180	708 060	0.198
4	697 303	0.281	1 204 353	0.229	697 303	0.297	1 204 353	0.228
5	860 612	0.296	1 299 065	0.244	860 612	0.253	1 296 193	0.239
6	2 764 009	0.153	4 284 194	0.118	2 761 663	0.146	4 265 430	0.113
7	1 674 588	0.208	3 794 886	0.124	1 671 592	0.193	3 751 341	0.122
8	3 339 106	0.135	5 918 317	0.089	3 333 321	0.131	5 821 855	0.084
9	1 727 608	0.186	3 164 356	0.123	1 721 209	0.186	3 099 422	0.135
10	162 035	0.557	546 075	0.283	162 035	0.577	536 327	0.316
11	149 618	0.475	686 792	0.261	149 618	0.529	667 310	0.233
12	113 504	0.633	271 321	0.395	112 348	0.612	261 639	0.393
13	221 663	0.45	322 122	0.375	221 663	0.489	310 912	0.353
14	0	0	162 864	0.485	0	0	154 417	0.517
15	0	0	213 384	0.432	0	0	208 801	0.465
16	0	0	155 677	0.559	0	0	153 156	0.606
17	0	0	33 355	1.043	0	0	27 823	1.124
18	0	0	30 874	0.952	0	0	30 186	1.046
19	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
21	0	0	29 657	1.084	0	0	29 079	0.975
No. aged	238		407		238		407	
Mean c.v.				**0.132**				**0.130**

Appendix 4b: **Calculated numbers at age (*n*) of ling. Numbers are given by sex for the total survey area (All strata). Few ling were caught in strata deeper than 800 m, so numbers are comparable with previous surveys (O'Driscoll & Bagley 2001)**

	All strata			
	Male		Female	
Age	*n*	c.v.	*n*	c.v.
1	0	0	0	0
2	0	0	6 563	1.949
3	59 269	0.796	160 951	0.510
4	422 534	0.342	438 550	0.308
5	1 391 755	0.171	1 155 459	0.193
6	1 635 368	0.146	1 471 459	0.152
7	1 261 920	0.153	1 661 139	0.116
8	322 119	0.287	764 668	0.209
9	379 620	0.292	664 768	0.213
10	368 337	0.294	468 777	0.257
11	323 422	0.267	368 207	0.270
12	88 918	0.473	326 791	0.303
13	98 477	0.544	149 713	0.413
14	52 880	0.722	284 497	0.292
15	85 767	0.539	239 225	0.325
16	50 177	0.771	131 056	0.374
17	68 032	0.625	160 435	0.345
18	107 219	0.463	103 625	0.468
19	29 006	0.789	91 050	0.459
20	28 501	0.720	81 791	0.478
21	28 263	0.805	107 870	0.447
22	35 707	0.729	8 099	1.146
23	4 698	0.988	55 553	0.627
24	0	0	19 808	0.852
25	38 538	0.686	3 769	1.663
26	12 497	0.994	9 927	1.260
27	0	0	0	0
28	0	0	6 640	1.616
29	0	0	0	0
30	14 967	1.127	0	0
No. aged	244		352	
Mean c.v.				**0.177**

Appendix 4c: **Calculated numbers at age (*n*) of hake. Numbers are given by sex for the total survey area (All strata) and for the 300–800 m core survey area (Core). The core area was sampled consistently in all summer and autumn surveys (O'Driscoll & Bagley 2001) and are the numbers used in the hake assessment model**

	All strata				Core			
	Male		Female		Male		Female	
Age	*n*	c.v.	*n*	c.v.	*n*	c.v.	*n*	c.v.
1	0	0	0	0	0	0.000	0	0.000
2	3 623	1.392	420	1.805	0	0.000	0	0.000
3	39 316	0.410	26 103	0.339	7 094	1.003	4 619	0.853
4	68 443	0.182	70 564	0.269	8 861	0.588	22 907	0.538
5	36 801	0.268	80 855	0.281	5 367	0.724	34 057	0.424
6	23 211	0.333	62 616	0.250	6 671	0.799	32 500	0.390
7	8 262	0.635	60 779	0.307	4 799	0.836	37 637	0.361
8	9 338	0.544	29 431	0.367	4 815	0.958	20 337	0.489
9	7 219	0.640	22 638	0.460	3 526	0.829	14 760	0.574
10	10 267	0.618	46 997	0.312	8 676	0.607	40 838	0.358
11	7 823	0.771	29 466	0.497	7 025	0.847	24 716	0.509
12	7 646	0.599	28 396	0.444	7 638	0.634	25 146	0.461
13	6 001	0.853	16 984	0.632	1 658	1.202	13 527	0.605
14	3 131	1.101	5 022	0.810	3 130	1.153	4 538	0.805
15	4 547	0.714	7 545	0.686	3 747	0.861	7 344	0.698
16	5 298	0.830	17 351	0.545	3 514	0.851	17 152	0.609
17	299	2.102	2 935	1.385	299	2.389	1 791	1.353
18	4 898	0.733	5 869	0.874	4 888	0.628	3 581	1.072
19	2 112	1.430	4 417	0.941	2 111	1.406	4 420	0.951
20	0	0	1 032	1.564	0	0.000	1 031	1.464
21	4 711	0.905	10 557	0.650	2 929	0.923	10 563	0.692
22	2 598	0.905	0	0	2 589	0.836	0	0.000
23	3 971	0.950	10 146	0.840	3 964	0.998	10 140	0.835
24	4 236	1.315	3 201	1.749	0	0.000	3 197	1.690
25	837	1.397	5 445	0.964	834	1.395	5 443	0.975
26	958	1.875	0	0	957	1.635	0	0.000
No. aged	239		352		239		352	
Mean c.v.				**0.318**				**0.457**