New Zealand Fisheries
Assessment Report
2009/9
February 2009
ISSN 1175-1584

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New Zealand Fisheries Assessment Report 2009/9
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Published by Ministry of Fisheries
Wellington
2009

ISSN 1175-1584

Bagley, N.W.; O'Driscoll, R.L.; Francis, R.I.C.C.; Ballara, S.L. (2009).
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November–December 2007 (TAN0714).
New Zealand Fisheries Assessment Report 2009/9. 63 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

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***New Zealand Fisheries Assessment Report 2009/9*. 63 p**.

The eleventh *Tangaroa* summer trawl survey of the Southland and Sub-Antarctic areas was carried out from 24 November to 23 December 2007. Ninety-eight trawls were successfully completed in 21 strata.

Biomass estimates (and c.v.s) for all strata were 46 003 t (16%) for hoki, 26 492 t (8%) for ling, and 2622 t (15%) for hake. The biomass estimate for hoki in 2007 was three times that of 2006 and back to the 2001–02 biomass levels. Biomass estimates for hake and ling in 2007 also increased from 2006 by 65% and 35% respectively. There was some evidence for an increase in survey catchability in 2007: hoki biomass increased across all age classes; and 10 of 12 major species monitored by the survey increased from 2006. However, the increase in catch rates was not related to survey methodology: the survey design and gear parameters were consistent with previous years, and there were also increases in commercial catch-per-unit-effort for hoki during the survey period.

The size distribution of hoki was relatively broad, with the highest number of hoki caught since the 2000 survey. Modes were present at ages 1–5 (2006 to 2002 year-classes) and age 7 (2000 year-class), with some larger older fish (ages 9–16) also present. The age distributions for hake and ling were broad, with most fish aged between 3 and 14 for hake and 4 and 14 for ling.

Acoustic data were also collected during the trawl survey. Total acoustic backscatter from all bottom-referenced marks in 2007 was at the highest level since 2002. There was a weak positive correlation between acoustic density from bottom marks and trawl catch rates.

1. INTRODUCTION

Trawl surveys of the Southland and Sub-Antarctic region (collectively referred to as the "Southern Plateau") provide fishery-independent abundance indices for hoki, hake, and ling. Although the TACC for hoki has been reduced from 250 000 t to 90 000 t since 2000–01, hoki is still New Zealand's largest fishery. The Southland and Sub-Antarctic region is believed to be the principal residence area for the hoki that spawn off the west coast of the South Island (WCSI) in winter ("western" stock). Annual catches of hoki from the Southern Plateau (including Puysegur) peaked between 35 000 and 36 500 t from 1999–00 to 2001–02, but have declined to between 6000 and 8000 t in 2004–05 to 2006–07 (Ballara 2008). Hoki are managed as a single stock throughout the EEZ, but there is an agreement to split the catch between western and eastern areas. The catch limit for hoki from western areas (including the Southern Plateau) in 2006–07 was 40 000 t, reducing to 25 000 t in 2007–08. Hake and ling are also important commercial species in Southland and the Sub-Antarctic. The catches of hake and ling in 2005–06 were 2742 t (HAK 1, includes the western Chatham Rise), 3522 t (LIN 5, Southland), and 3553 t (LIN 6, Sub-Antarctic).

Two time series of trawl surveys have been carried out from *Tangaroa* in the Southland and Sub-Antarctic region: a summer series in November–December 1991, 1992, 1993, 2000, 2001, 2002, 2003, 2004, 2005, and 2006; and an autumn series in March–June 1992, 1993, 1996 and 1998 (reviewed by O'Driscoll & Bagley (2001)). The main focus of the early surveys (1991–93) was to estimate the abundance of hoki. The surveys in 1996 and 1998 were aimed primarily at hake and ling. Autumn was chosen for these species as the biomass estimates were generally higher and more precise at this time of year. Autumn surveys also allowed the proportion of hoki maturing to spawn to be estimated (Livingston et al. 1997, Livingston & Bull 2000). However, interpretation of trends in the autumn trawl survey series was complicated by the possibility that different proportions of the hoki adult biomass may have already left the survey area to spawn. The timing of the trawl survey was moved back to November–December in 2000 to obtain an estimate of total adult hoki biomass at a time when abundance should be at a maximum in the Southland and the Sub-Antarctic areas.

The hoki biomass estimate from the four most recent Southern Plateau surveys in 2003–06 were the lowest observed in either the summer or autumn Sub-Antarctic trawl time-series (O'Driscoll & Bagley 2004, 2006a, 2006b, 2008). The biomass estimate in 2006 was 28% lower than in 2005, the second lowest in the time series (after 2003), and less than 20% of the biomass observed in the Sub-Antarctic in the early 1990s (O'Driscoll & Bagley 2008). The stock status for "western" hoki stock from the 2007 assessment suggested that current biomass was 15–24% B_0 and that there was an extended period of poor recruitment from 1995 to 2001 (Francis 2008). The 2007 survey, carried out from 24 November to 23 December 2007 (TAN0714) provides an eleventh summer estimate of western hoki biomass in time for the 2008 assessment. With the discontinuation of the WCSI acoustic surveys, this is the only abundance index available for western hoki.

1.1 Project objectives

The trawl survey was carried out under contract to the Ministry of Fisheries (project MDT2007/01).
The specific objectives for the project were as follows.

1. To continue the time series of relative abundance indices for hoki, hake, (HAK 1) and ling (LIN 5 and 6) on the Southern Plateau.

2. To determine the population age and size structure and reproductive biology of hoki, hake, and ling.

3. To determine the proportions at age of hoki taken in the survey using otolith samples.

4. To collect acoustic and related data during the trawl survey.

5. To collect gonad samples from female hoki for studies on the proportion spawning.

6. To collect and preserve specimens of unidentified organisms taken during the trawl survey, and identify them later ashore.

2. METHODS

2.1 Survey design

As in previous years, the survey was a two-phase stratified random design (after Francis 1984). The survey area was divided into 21 strata by depth (300–600, 600–800, and 800–1000 m) and area (Figure 1). There are 15 core 300–800 m strata (Strata 1 to 15) which have been surveyed in all previous summer and autumn surveys (Table 1). Strata 3 and 5 were subdivided in 2000 to increase the coverage in the region where hake and ling aggregations were thought to occur (Bull et al. 2000). Deeper 800–1000 m strata (Strata 25–28) have been surveyed since 1996. There is no 800–1000 m stratum along the eastern side of the survey area as catches of hake, hoki, and ling from adjacent strata are small. Known areas of foul ground were excluded from the survey.

The allocation of stations in phase 1 was based on a statistical analysis of catch rate data from the seven most recent surveys (2000–06) using the ‘allocate’ procedure of Bull et al. (2000) as modified by Francis (2006). A minimum of three stations per stratum was used. Conservative target coefficients of variation (c.v.s) of 17% for hake and 12% for hoki and ling were used in the statistical analysis to increase the chance that the usual Ministry of Fisheries target c.v.s of 20% for hake and 15% for hoki and ling would be met. Additional stations were added to some strata outside the statistical framework because of the need to focus effort on covering the full distributional range of hake age classes. A total of 83 stations was originally planned for phase 1 (Table 1), with phase 2 stations to be allocated at sea to improve c.v.s for hoki, hake, ling, and southern blue whiting, and to increase the number of hake sampled.

2.2 Vessel and gear specifications

R.V. *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 trawl was the same as that used on previous surveys of middle depth species by *Tangaroa*. The net is 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.

2.3 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)), with all trawling between 0445 h and 2014 h NZST. 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 1900 h NZST, 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). Measurements of doorspread (from a Scanmar 400 system), headline height (from a Furuno net monitor), and vessel speed were recorded every 5 min during each tow and average values calculated.

2.4 Acoustic data collection

Acoustic data were collected during trawling and while steaming between trawl stations (both day and night) using a custom-built *CREST* system (Coombs et al. 2003) with hull-mounted Simrad single-beam 12 kHz and 38 kHz transducers. *CREST* is a computer-based "software echo-sounder" which supports multiple channels. The transmitter was a switching type with a nominal power output of 2 kW rms. Transmitted pulse length was 1 ms with 3 s between transmit pulses. The 38 kHz transducer has been calibrated following standard procedures (Foote et al. 1987). The 12 kHz transducer was not calibrated. Data collected on 12 kHz were used only to make visual comparisons with 38 kHz data and were not analysed quantitatively.

2.5 Hydrology

Temperature and salinity data were collected using a calibrated Seabird SM-37 Microcat CTD datalogger (serial number 2958) mounted on the headline of the trawl. Data were collected at 5 s intervals throughout the trawl, providing vertical profiles. Surface values were read off the vertical profile at the beginning of each tow at a depth of about 5 m, which corresponded to the depth of the hull temperature sensor used in previous surveys. Bottom values were about 7.0 m above the sea-bed (i.e., the height of the headline).

2.6 Catch and biological 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 were identified to species, genera, or family. Unidentified organisms were collected and frozen at sea. Specimens are being stored at NIWA for subsequent identification.

An approximately random sample of up to 200 individuals of each commercial, and some common non-commercial, 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 weight, sex, gonad stage, gonad weight, and occasional observations on stomach fullness, 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.

Liver and gutted weights were recorded from up to 20 hoki per station to determine condition indices. Female gonads from the subset of hoki with recorded organ weights were preserved in formalin and are available for histological examination to estimate proportion spawning (Grimes & O'Driscoll 2006).

2.7 Estimation of biomass and length frequencies

Doorspread biomass was estimated by the swept area method of Francis (1981, 1989) using the formulae of Vignaux (1994). Total survey biomass was estimated for the top 20 species in the catch by weight.

Biomass and c.v. were also calculated by stratum for major species. The group of 12 major species was defined by O'Driscoll & Bagley (2001), and includes the three target species (hoki, hake, ling), eight other commercial species (black oreo, dark ghost shark, lookdown dory, pale ghost shark, ribaldo, southern blue whiting, spiny dogfish, white warehou), and one non-commercial species (javelinfish).

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 major species with the Trawlsurvey Analysis Program, version 3.2 (Vignaux 1994), using length-weight data from this survey.

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

2.8 Estimation of numbers at age

Hoki, hake, and ling otoliths were prepared and aged using validated ageing methods (hoki, Horn & Sullivan (1996) as modified by Cordue et al. (2000); hake, Horn (1997); ling, Horn (1993)).

Subsamples of 746 hoki otoliths and 576 ling otoliths were selected from those collected during the trawl survey. Subsamples were obtained by randomly selecting otoliths from 5 cm length bins covering the bulk of the catch and then systematically selecting additional otoliths to ensure the tails of the length distributions were represented. The numbers aged approximated the sample size necessary to produce mean weighted c.v.s of less than 20% across all age classes. All 649 hake otoliths collected were read.

Numbers at age were calculated from observed length frequencies and age-length keys using customised NIWA catch-at-age software (Bull & Dunn 2002). For hoki, this software also applied the "consistency scoring" method of Francis (2001), which uses otolith ring radii measurents to improve the consistency of age estimation.

2.9 Acoustic data analysis

Acoustic recordings made during the trawl survey (both during trawls and while steaming between stations) were visually examined. Marks were classified into seven main categories based on the relative depth of the mark in the water column, mark orientation (surface- or bottom-referenced), mark structure (layers or schools) and the relative strength of the mark on 38 kHz and 12 kHz. Descriptive statistics were produced on the frequency of occurrence of different marks. Brief descriptions of the mark types are given below. Example echograms may be found in O'Driscoll (2001).

1. Surface layers

These occurred within the upper 100 m of the water column and tended to be stronger on 12 kHz than on 38 kHz.

2. Pelagic layers
Surface-referenced midwater layers which were typically continuous for more than 1 km and much stronger on 12 kHz than on 38 kHz.

3. Pelagic schools
Well defined schools in midwater which were generally stronger on 38 kHz and appeared as crescents on 12 kHz.

4. Pelagic clouds
Surface-referenced midwater marks which were more diffuse and dispersed than pelagic layers, typically over 100 m thick with no clear boundaries.

5. Bottom layers
Bottom-referenced layers which were continuous for more than 1 km and were generally stronger on 38 kHz than on 12 kHz.

6. Bottom clouds
Bottom-referenced marks which were more diffuse and dispersed than bottom layers with no clear upper boundary.

7. Bottom schools
Distinct schools close to the bottom. These appeared as crescents on 12 kHz.

As part of the qualitative description, the quality of acoustic data recordings was subjectively classified as 'good', 'marginal', or 'poor' (see appendix 2 of O'Driscoll & Bagley (2004) for examples). Only good or marginal quality recordings were considered suitable for quantitative analysis.

A quantitative analysis was carried out on daytime trawl recordings. Acoustic data collected on 38-kHz during each tow were integrated using custom Echo Sounder Package (ESP2) software (McNeill 2001). Three values of the mean acoustic backscatter per square kilometre were calculated for each trawl. The first estimate was based an integration height of 10 m above the acoustic bottom, which was similar to the measured headline height of the trawl (average 7.0 m). The second acoustic estimate integrated all backscatter from bottom referenced marks (bottom layers, clouds, and schools) up to 100 m off the bottom, but excluded all other mark types. The final acoustic estimate was of the total acoustic backscatter throughout the water column. Acoustic density estimates (backscatter per km^2) from bottom-referenced marks were then compared with trawl catch rates (kg per square kilometre). No attempt was made to scale acoustic estimates by target strength, correct for differences in catchability, or carry out species decomposition (O'Driscoll 2002, 2003).

3. RESULTS

3.1 Survey coverage

The trawl survey and acoustic work contracted for this voyage were successfully completed. Weather conditions were reasonable thoughout the voyage and no time was lost due to unfavourable sea conditions.

Ninety-eight successful trawl survey stations were completed in 21 strata (Figure 2, Table 1). This total included 82 phase 1 stations and 16 phase 2 stations. Only 3 of the 4 planned phase 1 stations in stratum 3B were completed – one station was rejected due to poor gear performance, and the substitute station required considerable steaming. One additional station was completed in each of strata 6, 10, and 13 during phase 1 of the survey due to variable catches of hoki in these strata. Otherwise a large steaming time would have been required to return to these areas to complete phase 2 work at the end of the survey.

Most phase 2 effort was directed at reducing the c.v. for hoki. The hoki c.v. after phase 1 was 27%, mainly due to a large catch (4.4 t) in Stratum 3A, and 5 additional stations were added in this stratum. Phase 2 stations were also completed in Strata 4 and 11. The additional effort reduced the hoki c.v. down to 15.7%. Four phase 2 stations were completed in Stratum 25 (Puysegur) to reduce the hake c.v. and collect additional hake otoliths. Two phase 2 stations were completed in stratum 12 to reduce the c.v. for southern blue whiting, reducing the c.v. for this stratum from 40% to 28%.

Eight stations were considered unsuitable for biomass estimation: station 52 came fast just before hauling and the net suffered damage to the port wing; stations 78 and 85 were non-random tows to attempt to collect more hake otoliths; stations 69, 80, 94, 99, and 103 were rejected due to poor performance, hauling early due to foul and one trial tow.

Stratum 26, south of Campbell Island, was completed this year. Often this stratum is dropped should time be lost due to weather or other factors (2003, 2004, and 2006). No hoki, hake, or ling were caught in this stratum.

3.2 Gear performance

Gear parameters by depth and for all observations are summarised in Table 2. The headline height was obtained for 97 of the 98 successful tows, and doorspread readings were available for 94 tows. Missing values were calculated from data collected in the same depth range on this voyage. Measured gear parameters in 2007 were within the range of those obtained on other voyages of *Tangaroa* in this area when the same gear was used (Table 3). However, mean doorspread was the lowest in the time series. There was a slight reduction in doorspread in some areas in 2007 due to tide and proliferation of salps, particularly around the Stewart-Snares shelf. The gear was checked and measured on numerous occasions, and was consistent with specifications. Warp-to-depth ratios were the same as in previous years, following the recommendations of Hurst et al. (1992).

3.3 Catch

A total catch of 47.9 t was recorded from all trawl stations (44.7 t from valid biomass tows). From the 208 species or species groups caught, 94 were teleosts, 28 elasmobranchs, 12 cephalopods, and 18 crustaceans (Appendix 2). Hoki accounted for 33.1%**,** ling 14.5%, and hake 4.7% of the total catch.

One giant squid estimated at 120 kg was caught on tow 89. It was intact, in good condition, and was frozen and retained for Te Papa.

3.4 Biomass estimates

Total survey biomass estimates for the 20 species with highest catch weights are given in Table 4. Biomass estimates are presented by stratum for the 12 major species (as defined by O'Driscoll & Bagley (2001)) in Table 5. Subtotals for these species are given for the core 300–800 m depth range (Strata 1–15) and core + Puysegur 800–1000 m (Strata 1–25) in Table 5 to allow comparison with results of previous surveys where not all deep (800–1000 m) strata were surveyed. The time series of core estimates for the 12 major species are plotted in Figure 3.

The biomass estimate for hoki in 2006 was 46 003 t, which was three times that of 2006 and back to the 2001–02 biomass levels (Figure 3). Despite this large increase, hoki biomass is still less than 50% of the biomass observed in the Sub-Antarctic in the early 1990s (Table 6, Figure 3). The biomass estimates for length ranges corresponding to 1+ (less than 46 cm) and 2+ (46–59 cm) hoki were 1032 t (c.v. 54%) and 1949 t (c.v. 41%) respectively.

Biomass estimates for hake and ling in 2007 increased from 2006 by 65% and 35% respectively, to levels similar to those observed in 2001 (Table 6, Figure 3). Eight of the nine other major species also increased from 2006 for the core 300 to 800 m strata, although the changes were generally small and within the levels of the sampling uncertainty (Figure 3).

3.5 Species distribution

The distribution and catch rates at each station for hoki, hake, and ling are given in Figures 4–6. Hoki were widespread throughout the core survey area, occurring in 88 of the 98 successful trawl stations. One large catch of 4.4 tonnes was taken on the eastern side of the Stewart/Snares shelf. As in previous surveys (review by O'Driscoll & Bagley 2001), hoki catch rates were generally higher in the west, on the Stewart-Snares shelf, on the western side of the Campbell Rise, and at Puysegur (Figure 4a). Moderate catches of small (1 and 2 year-old) hoki were made in Stratum 1 (300–600 m) at Puysegur and in stratum 3B on the Stewart-Snares shelf (Figures 4b and 4c). Hake were concentrated in deeper water (more than 600 m) at Puysegur and to the south of the Stewart-Snares shelf (Figure 5). Ling were widely distributed over most of the survey area between 300–800 m (Figure 6). Both hoki and ling were seldom caught deeper than 800 m.

3.6 Biological data

The numbers of fish of each species measured or selected for biological analysis are shown in Table 7. Pairs of otoliths were removed from 1621 hoki, 1140 ling, and 649 hake. Length-weight relationships used to scale length frequency data are given in Table 8. Length frequency histograms by sex for hoki, hake, and ling are compared to those observed in previous surveys in Figures 7–9. Length frequencies for the other major species are shown in Figure 10.

Hoki length frequencies in 2007 show a broad size range (Figure 7), with the highest number of hoki since the 2000 survey. There were increases across all year classes compared to the 2006 survey, although there were fewer small 1+ and 2+ hoki than in the 2003 and 2004 surveys. Modes at 33–47 cm and 48–60 cm correspond to hoki from the 2006 and 2005 year-classes (Figure 8). Although these juvenile year-classes were abundant by number, they contributed relatively little to the biomass (see Section 3.4). Modes from 60 to 90 cm consisted of fish from the 2002–04 year classes at ages 3–5, with ageing indicating a mode at age 5 (2002 year-class) for both males and females (Figure 8). Some larger older hoki were also present between 90 and 110 cm for the females and 90 and 100 cm for the males (see Figure 7), with a strong showing of the 2000 year class at age 7 (Figure 11).

The length frequency distribution of hake showed no clear modes (see Figure 8). As in some previous surveys small (50–70 cm) hake were captured in quite high numbers at 800–1000 m depth at Puysegur (Stratum 25). Since 1998 there has been a lower proportion of old hake (older than age 12) than were observed in surveys in the early 1990s (Figure 12). The modal age in 2007 for was 5 years for males and 10 years for females.

The length frequency distribution of ling was broad (see Figure 9). The age frequency for ling showed most fish were between 4 and 14 years old, with the mode at age 5 for males and 7 for females (Figure 13).

The length frequency distribution of southern blue whiting caught in 2007 had modes at 36 and 39 cm for males and 37 cm and 43 cm for females see Figure 10. Black oreo were slightly smaller than those observed in 2006, with modal lengths of 29 cm for males and 30 cm for females (see Figure 10). Other points of interest in Figure 10 included: the bimodal length distribution of javelinfish, which was also observed in the previous three surveys (O'Driscoll & Bagley 2006a, 2006b, 2008); the continuing high proportion of female ribaldo; and the difference in the length frequencies of male and female spiny dogfish.

Gonad stages for hoki, hake, and ling are summarised in Table 9. Immature hoki made up 28% of fish examined, and these were typically fish smaller than 70 cm. Most adult hoki were in the resting phase. About 5% of female hoki and 10% of male hoki were macroscopically staged as partially spent or spent. Female ling were mostly resting (74%) or immature (20%), but male ling of all gonad stages were recorded, with 56% in spawning condition (ripe and running ripe). Similarly, about 35% of male hake were ripe or running ripe, but most female hake were immature (43%), resting (31%), or ripening (22%). Aggregations of spawning hake, present in the survey area in early December 2005 (O'Driscoll & Bagley 2006b), were not observed in 2007.

3.7 Hoki condition indices

Liver and gutted weights were recorded from 1262 hoki. Mean hoki liver condition index (LCI = liver weight divided by gutted weight) and somatic condition factor (CF = gutted weight divided by length cubed) are given in Table 10. Somatic and liver condition were relatively high in 2007, suggesting good feeding conditions (Table 10).

As in 2001–06 (O'Driscoll & Bagley 2003a, 2003b, 2004, 2006a, 2006b, 2008), female hoki that were macroscopically staged as spent (stage 7) tended to have lower LCI (average LCI = 3.04%, n = 56) than resting (stage 2) females (average LCI = 3.27%, n = 660), suggesting that fish that have recently spawned may have lower condition than fish that either spawned earlier or did not spawn. A similar pattern was observed for male hoki in 2005 (O'Driscoll & Bagley 2006b), 2006 (O'Driscoll & Bagley 2008), and 2007. In 2007, the average LCI for male hoki that were partially spent or spent (stages 6–7) was 2.80% (n = 92) compared to the average LCI of 3.10% (n = 329) for resting (stage 2) males.

Gonad samples were taken from 741 female hoki and preserved in 10% buffered formalin. These are available for histological examination to estimate proportion spawning (Grimes & O'Driscoll 2006).

3.8 Acoustic results

A total of 194 acoustic data files (105 trawl files and 89 steam files) was recorded during the 2007 survey. Data quality was generally good, but deteriorated during periods of bad weather. About 20% of the acoustic files were considered too noisy to be analysed quantitatively (Table 11).

Mark types were similar to those described for previous surveys (O'Driscoll 2001, O'Driscoll & Bagley 2003a, 2003b, 2004, 2006a, 2006b, 2008). The frequency of occurrence in 2007 of each of the seven mark categories is given in Table 12. Surface layers were observed in most (84%) daytime echograms and all night echograms in 2007 (Table 12). The identity of organisms in these surface layers is unknown because no tows have been targeted at the surface in this region. Acoustic scattering is probably contributed by a number of pelagic zooplankton (including gelatinous organisms such as salps) and fish. Pelagic schools and layers were also common and likely contain mesopelagic fish species such as pearlsides (*Maurolicus australis*) and myctophids, which are important prey of hoki. Bottom layers, which are associated with a mix of demersal fish species, were observed in 43% of day steam files, 38% of overnight steams, and 39% of trawl files in 2007. This was higher than in 2006, but within the range of surveys from 2000–05 (Table 12). Pelagic and bottom layers tend to disperse at night, to form pelagic and bottom clouds respectively. Consequently, cloud marks were detected more often in night recordings (Table 12). As in previous years (O'Driscoll 2001, O'Driscoll & Bagley 2006b), bottom schools were occasionally observed during the day in 300–600 m water depth, and were often associated with catches of southern blue whiting in the bottom trawl.

Acoustic data from 75 trawl files were integrated. Data from the other 30 trawl recordings were not included in the quantitative analysis because the acoustic data were too noisy (24 files) or because the accompanying bottom trawl was not considered suitable for biomass estimation (6 files). Average acoustic backscatter from bottom-referenced regions in 2007 was 82% higher than in 2006 and the highest since 2002 (Table 13). In this respect acoustic results were consistent with the increased trawl catch rates (Table 13). However, there was no evidence that fish were particularly dense close to the bottom in 2007. Estimates of acoustic backscatter in the bottom 10 m were higher than in 2006, but lower than in 2005 (Table 13).

There was a weak positive correlation between acoustic backscatter and trawl catch rates (Figure 14). Trawl catch rates were much more strongly correlated with total acoustic backscatter from bottom-referenced marks than with backscatter from the bottom 10 m only (Figure 14). This suggests that the trawl may be vertically herding fish from more than 10 m above the bottom. Weak, but significant, positive correlations between backscatter and catches have been observed in previous surveys in 2000, 2001, 2003, and 2005 (O'Driscoll 2002, O'Driscoll & Bagley 2004, 2006b), but not in 2002, 2004, or 2006 (O'Driscoll & Bagley 2003b, 2006a, 2008).

Acoustic methods are unlikely to provide alternative abundance estimates for demersal species in the Sub-Antarctic because of the relatively low fish densities and mixed species composition. However, we believe it is useful to continue to collect acoustic data to monitor other components of the ecosystem (especially mesopelagic fish) and to aid in the interpretation of trawl survey results. Analysis of analogous acoustic data from the Chatham Rise trawl survey series (O'Driscoll et al. in press) suggests that there is 2–5 times more total backscatter on the Chatham Rise (38–54 m^2 km^{-2}) than in the Sub-Antarctic (9–15 m^2 km^{-2}, see Table 13).

3.9 Hydrological data

Temperature profiles were available from 101 CTD casts. Surface (5 m depth) temperatures ranged between 7.4 and 13.6 °C (Figure 15), while bottom temperatures were between 4.2 and 10.2 °C (Figure 16). Bottom temperature decreased with depth, with lowest bottom temperatures recorded from water deeper than 900 m on the margins of the Campbell Plateau. Highest surface and bottom temperatures were at Puysegur. As in previous years, there was a general trend of increasing water temperatures towards the north and west (Figures 15–16).

The average surface temperature in 2007 of 9.5 °C was similar to that observed in 2006 (9.2 °C), and within the range of average surface temperatures observed in 2002–05 (8.8–10.3 °C). In general there is a negative correlation between surface temperature and depth of the thermocline (Figure 17), with lower surface temperatures in years when the thermocline is deep (e.g., 2003), and higher surface temperatures when there is a shallow mixed layer (e.g., 2002). O'Driscoll & Bagley (2006b) hypothesised that the depth of the thermocline is related to the amount of surface mixing and extent of thermal stratification, with shallower mixed layers in those years with warmer, more settled weather. The thermocline in 2007 was at about 80–150 m, which is average for this time of year (e.g., see Figure 17). Average bottom temperatures in 2007 (6.7 °C) were at the lower end of the range observed in 2002–06 (6.7–7.0 °C). At some locations (e.g., Figure 17), bottom temperatures were the lowest observed. It is difficult to compare temperatures with those observed on Sub-Antarctic surveys before 2002 because temperature sensors were uncalibrated.

4. DISCUSSION

There was a very large (threefold) increase in estimates of hoki abundance between the 2006 and 2007 trawl surveys. This increase could not be fitted by the stock assessment model in 2008. Two possible explanations for this increase are: 1) recruitment of hoki to the Sub-Antarctic from the Chatham Rise; 2) a change in trawl survey catchability between 2006 and 2007. Neither hypothesis can be discounted, but there is more supporting evidence for a change in trawl catchability. Biomass estimates in core strata for 11 of the 12 major species increased from 2006 to 2007 (see Figure 3). Hoki abundance also increased across all age classes (Figure 18), which is not consistent with the hypothesis of recruitment from the Chatham Rise which mainly occurs at ages 3–7 (Livingston et al. 2002). It is not clear whether catchability was unusually high in 2007 and/or unusually low in 2006. However, there was also a consistent increase across all hoki age classes from 2005 to 2007 (Figure 18), suggesting that it was more likely the catchability in 2007 was exceptionally high.

The apparent change in trawl survey catchability in 2007 was not related to changes in gear or gear performance. The trawl was repeatedly measured and was consistent with specifications. Measured gear parameters in 2007 were within the range of those obtained on previous surveys (see Table 3), although there was a slight reduction in mean doorspread in some areas in 2007. This appeared to be related to currents and a proliferation of salps rather than the way the gear was rigged (see Section 3.2). Unstandardised commercial catch rates of hoki were also high during the survey period in 2007 (Figure 19), suggesting that the change in hoki catchability was not restricted to the research survey.

Total acoustic backscatter from all bottom-referenced marks in 2007 was also at the highest level since 2002 (see Section 3.8). However, there was no evidence from the acoustic results that fish were particularly dense close to the bottom in 2007 (which could increase catchability in a bottom trawl).

5. CONCLUSIONS

The biomass estimate for hoki in 2007 was three times that of 2006. Biomass estimates for hake and ling in 2007 increased by 65% and 35% respectively. Although the survey methodology was consistent with that of previous years, there was some evidence for an increase in survey catchability in 2007. A further survey in November–December 2008 is required to determine whether apparent increases in fish abundance are maintained. Despite the large increase in the estimated hoki biomass, back to the 2001–02 levels, the 2007 estimate is still less than 50% of the biomass observed in the Sub-Antarctic in the early 1990s.

6. ACKNOWLEDGMENTS

Thanks to the scientific staff who participated in this voyage, and the master, officers, and crew of *Tangaroa* who contributed to the success of this voyage. Thanks to the scientific staff involved with the otolith preparation and reading of the hake, hoki, and ling otoliths, and Peter Horn for the calculation of the age frequencies. Identification of unidentified organisms taken during the trawl survey was co-ordinated by Sadie Mills, and our thanks to Sadie and the team of experts for the identification of material collected. This work was carried out by NIWA under contract to the Ministry of Fisheries (Contract No. MDT2007/01).

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Table 1: Stratum areas, depths, and number of successful biomass stations from the November–December 2007 Southland and Sub-Antarctic trawl survey. Stratum boundaries are shown in Figure 1, and station positions are plotted in Figure 2.

Stratum	Name	Depth (m)	Area (km^2)	Proposed phase 1 stations	Completed phase 1 stations	Completed phase 2 stations
1	Puysegur Bank	300–600	2 150	4	4	
2	Puysegur Bank	600–800	1 318	4	4	
3a	Stewart-Snares	300–600	4 548	3	3	5
3b	Stewart-Snares	300 -600	1 556	4	3	
4	Stewart-Snares	600–800	21 018	4	4	1
5a	Snares-Auckland	600–800	2 981	4	4	
5b	Snares-Auckland	600–800	3 281	4	4	
6	Auckland Is.	300–600	16 682	4	4	1
7	South Auckland	600–800	8 497	3	3	
8	N.E. Auckland	600–800	17 294	5	5	
9	N. Campbell Is.	300–600	27 398	8	8	
10	S. Campbell Is.	600–800	11 288	3	3	1
11	N.E. Pukaki Rise	600–800	23 008	3	3	1
12	Pukaki	300–600	45 259	6	6	2
13	N.E. Camp. Plateau	300–600	36 051	4	4	1
14	E. Camp. Plateau	300–600	27 659	3	3	
15	E. Camp. Plateau	600–800	15 179	3	3	
25	Puysegur Bank	800–1 000	1 928	4	4	4
26	S.W. Campbell Is.	800–1 000	31 778	3	3	
27	N.E. Pukaki Rise	800–1 000	12 986	3	3	
28	E. Stewart Is.	800–1 000	8 336	4	4	
Total			**320 159**	**83**	**82**	**16**

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)	98	2.99	0.13	2.22–3.18
Tow speed (knots)	98	3.5	0.07	3.3–3.6
Gear parameters (m)				
300–600 m				
Headline height	43	7.1	0.19	6.8–7.6
Doorspread	43	113.0	6.40	97.8–123.5
600–800 m				
Headline height	36	7.2	0.23	6.7–7.6
Doorspread	35	113.8	8.85	97.5–130.8
800–1000 m				
Headline height	18	7.3	0.27	7.0–8.0
Doorspread	16	118.5	5.11	110.5–125.3
All stations 300–1000 m				
Headline height	97	7.2	0.23	6.7–8.0
Doorspread	94	114.3	7.43	97.5–130.8

Table 3: Comparison of doorspread and headline measurements from all surveys in the summer *Tangaroa* time-series. Values are the mean and standard deviation (s.d.). The number of tows with measurements (n) and range of observations is also given for doorspread.

	Doorspread (m)					Headline height (m)	
Survey	*n*	mean	s.d.	min	max	mean	s.d.
1991	152	126.5	7.05	106.5	145.5	6.6	0.31
1992	127	121.4	6.03	105.0	138.4	7.4	0.38
1993	138	120.7	7.14	99.9	133.9	7.1	0.33
2000	68	121.4	5.22	106.0	132.4	7.0	0.20
2001	95	117.5	5.19	103.5	127.6	7.1	0.25
2002	97	120.3	5.92	107.0	134.5	6.8	0.14
2003	13	123.1	3.80	117.3	129.7	7.0	0.22
2004	85	120.0	6.11	105.0	131.8	7.1	0.28
2005	91	117.1	6.53	104.0	134.4	7.2	0.22
2006	85	120.5	4.82	104.0	129.7	7.0	0.24
2007	94	114.3	7.43	97.5	130.8	7.2	0.23

Table 4: Biomass estimates, coefficients of variation, and catch of the 20 species with highest catch weights in the 2007 Sub-Antarctic trawl survey. Estimates are from successful biomass stations for all strata combined. Biomass estimates from 2006 (from O'Driscoll & Bagley 2008) are shown for comparison. - indicates that no biomass was estimated for this species.

		2007 (TAN0714)			2006 (TAN0617)		
Species	Species code	Catch (kg)	Biomass (t)	c.v. (%)	Catch (kg)	Biomass (t)	c.v. (%)
Hoki	HOK	15 672	46 003	16	5 801	14 747	11
Ling	LIN	5 477	26 492	8	4 963	19 661	12
Javelinfish	JAV	2 691	12 066	12	3 844	14 573	28
Pale ghost shark	GSP	2 119	13 107	11	2 123	12 619	10
Hake	HAK	2 012	2 662	15	2 292	1 588	17
Arrow squid	NOS	1 753	2 161	86	153	-	-
Spiny dogfish	SPD	1 590	3 589	17	1 066	3 039	19
White warehou	WWA	1 450	1 707	61	431	646	26
Ridge-scaled rattail	MCA	1 098	8 544	19	585	2 581	17
Southern blue whiting	SBW	966	8 165	24	529	6 962	52
Longnose velvet dogfish	CYP	924	2 176	26	1 273	2 343	43
Black oreo	BOE	433	2 674	72	1 262	6 802	70
Baxter's lantern dogfish	ETB	431	2 583	20	705	3 318	20
Red cod	RCO	427	585	86	83	-	-
Small-scaled slickhead	SSM	391	3 295	20	451	972	30
Shovelnosed dogfish	SND	381	261	32	1 501	827	22
Oblique-banded rattail	CAS	380	2 223	22	148	-	-
Silver warehou	SWA	349	514	38	28	-	-
Glass sponge	HYA	348	4 095	59	1 736	-	-
Deepwater spiny dogfish	CSQ	338	1 154	25	380	831	35
Total catch (all species)		44 748			36 413		

Table 5: Estimated biomass (t) and coefficients of variation (%, below in parentheses) of the 12 major species by stratum. Species codes are given in Appendix 2. Subtotals are provided for core strata (1–15) and core + Puysegur 800–1000 m (Strata 1–25).

Stratum	HOK	LIN	HAK	BOE	GSH	GSP
1	1 365 (74)	302 (17)	19 (71)	0	35 (62)	2 (100)
2	206 (35)	64 (41)	31 (48)	1 (100)	0	11 (66)
3a	6 480 (65)	999 (21)	49 (53)	0	26 (100)	170 (30)
3b	461 (39)	46 (18)	0	0	168 (53)	0
4	3 432 (49)	1 757 (25)	373 (26)	1 900 (99)	0	1 196 (26)
5a	811 (45)	315 (9)	1 003 (29)	0	0	63 (43)
5b	661 (28)	336 (24)	73 (9)	0	0	225 (9)
6	3 711 (55)	2 837 (36)	142 (51)	0	223 (46)	656 (60)
7	1 429 (46)	1 091 (66)	74 (25)	0	0	248 (30)
8	3 871 (45)	1 180 (43)	250 (72)	0	0	937 (25)
9	3 840 (16)	3 253 (14)	39 (51)	0	201 (100)	1 680 (11)
10	2 107 (56)	966 (46)	52 (61)	0	0	307 (12)
11	5 853 (53)	1 103 (60)	0	79 (100)	0	332 (45)
12	6 682 (48)	4 322 (15)	83 (100)	0	0	3 215 (21)
13	3 264 (19)	4 960 (17)	0	0	6 (100)	3 251 (32)
14	728 (77)	2 429 (37)	0	0	0	303 (15)
15	976 (30)	528 (29)	0	0	0	141 (57)
Subtotal (strata 1–15)	**45 876** **(16)**	**26 486** **(8)**	**2 188** **(17)**	**1 979** **(95)**	**659** **(37)**	**12 738** **(11)**
25	83 (40)	6 (67)	283 (32)	1 (100)	0	5 (27)
Subtotal (strata 1–25)	**45 958** **(16)**	**26 492** **(8)**	**2 470** **(15)**	**1 979** **(95)**	**659** **(37)**	**12 744** **(11)**
26	0	0	0	0	0	176 (80)
27	0	0	0	480 (79)	0	80 (38)
28	45 (64)	0	151 (78)	216 (34)	0	107 (23)
Total (All strata)	**46 003** **(16)**	**26 492** **(8)**	**2 622** **(15)**	**2 675** **(72)**	**659** **(37)**	**13 107** **(11)**

Table 5 (cont): Estimated biomass (t) and coefficients of variation (%, below in parentheses) of the 12 major species by stratum. Species codes are given in Appendix 2. Subtotals are provided for core strata (1–15) and core + Puysegur 800–1000 m (Strata 1–25).

Stratum	JAV	LDO	RIB	SBW	SPD	WWA
1	20	11	5	0	408	1 088
	(35)	(42)	(100)		(66)	(95)
2	90	7	32	0	0	0
	(34)	(50)	(23)			
3a	177	30	0	0	316	85
	(34)	(20)			(22)	(59)
3b	0	3	0	0	397	52
		(100)			(39)	(67)
4	1 009	36	196	0	58	137
	(44)	(65)	(38)		(100)	(65)
5a	125	11	29	0	4	5
	(42)	(40)	(62)		(100)	(100)
5b	296	0	14	0	26	0
	(23)		(66)		(30)	
6	967	136	0	1 042	302	15
	(30)	(62)		(49)	(76)	(100)
7	1 201	0	94	0	0	9
	(14)		(23)			(100)
8	1 138	0	261	2	227	85
	(36)		(31)	(100)	(42)	(57)
9	418	63	98	777	967	32
	(15)	(66)	(48)	(84)	(34)	(56)
10	317	0	133	0	0	10
	(28)		(42)			(100)
11	1 228	43	200	0	23	146
	(16)	(100)	(24)		(100)	(100)
12	1 360	260	0	3 747	188	30
	(42)	(31)		(28)	(42)	(100)
13	1 919	89	0	518	623	15
	(52)	(49)		(48)	(43)	(100)
14	220	36	0	1 772	49	0
	(66)	(100)		(77)	(100)	
15	992	0	0	307	0	0
	(2)			(61)		
Subtotal (strata 1–15)	**11 475**	**725**	**1 062**	**8 165**	**3 589**	**1 706**
	(12)	**(20)**	**(13)**	**(24)**	**(17)**	**(61)**
25	134	0	24	0	0	1
	(39)		(37)			(100)
Subtotal (strata 1–25)	**11 608**	**725**	**1 086**	**8 165**	**3 589**	**1 707**
	(12)	**(20)**	**(13)**	**(24)**	**(17)**	**(61)**
26	3	22	0	0	0	0
	(100)	(100)				
27	351	0	0	0	0	0
	(100)					
28	103	0	0	0	0	0
	(89)					
Total (All strata)	**12 065**	**748**	**1 086**	**8 165**	**3 589**	**1 707**
	(12)	**(20)**	**(13)**	**(24)**	**(17)**	**(61)**

Table 6: Time series of biomass estimates of hoki, hake, and ling for core 300–800 m strata and for all surveyed strata from Sub-Antarctic trawl surveys.

		Core strata (300–800 m)		All strata (300–1000 m)	
		Biomass	c.v. (%)	Biomass	c.v. (%)
HOKI	Summer series				
	1991	80 285	7		
	1992	87 359	6		
	1993	99 695	9		
	2000	55 663	13	56 407	13
	2001	38 145	16	39 396	15
	2002	39 890	14	40 503	14
	2003	14 318	13	14 724	13
	2004	17 593	11	18 114	12
	2005	20 440	13	20 679	13
	2006	14 336	11	14 747	11
	2007	45 876	16	46 003	16
	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
	2001	1 831	24	2 360	19
	2002	1 293	20	2 037	16
	2003	1 335	24	1 898	21
	2004	1 250	27	1 774	20
	2005	1 133	20	1 624	17
	2006	998	22	1 588	17
	2007	2 188	17	2 622	15
	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
	2001	25 059	7	25 167	6
	2002	25 628	10	25 635	10
	2003	22 174	10	22 192	10
	2004	23 744	12	23 794	12
	2005	19 685	9	19 755	9
	2006	19 637	12	19 661	12
	2007	26 486	8	26 492	8
	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 7: Numbers of fish for which length, sex, and biological data were collected; - no data.

	Length frequency data				Length-weight data	
	No. of fish measured			No. of	No. of	No. of
Species	Total †	Male	Female	Samples	fish	samples
Arrow squid	596	302	294	17	227	4
Banded rattail	1 155	0	7	71	437	27
Basketwork eel	160	0	0	16	145	15
Baxter's lantern dogfish	380	186	194	36	342	30
Bigeye cardinalfish	3	0	0	1	3	1
Black javelinfish	111	10	5	7	91	6
Black oreo	441	191	249	12	265	9
Blackspot rattail	3	0	0	2	1	1
Bollons's rattail	184	27	77	19	175	15
Bronze bream	1	0	1	1		
Brown chimaera	5	4	1	3	5	3
Catshark	11	6	5	7	7	4
Dark ghost shark	319	174	145	15	217	14
Dawson's catshark	1	1	0	1	1	1
Deepwater spiny dogfish	42	16	26	22	41	21
Finless flounder	56	1	4	20	49	18
Four-rayed rattail	1 504	0	12	18	317	7
Gemfish	7	0	7	2	6	1
Giant chimera	2	0	2	2	2	2
Giant stargazer	72	14	58	26	63	23
Hairy conger eel	63	0	0	27	56	23
Hake	652	221	431	53	652	53
Hapuku	3	2	1	2	3	2
Hoki	7 565	3 255	4 308	89	2 029	79
Humpback rattail	7	0	5	6	7	6
Javelinfish	7 281	0	204	83	1 021	21
Johnson's cod	78	6	21	13	70	11
Kaiyomaru rattail	103	0	0	15	63	7
Ling	2 648	1 179	1 469	84	1 491	73
Longnose velvet dogfish	463	219	244	22	429	20
Longnosed chimaera	94	53	41	34	84	32
Lookdown dory	141	47	93	41	123	36
Lyconus sp	1	0	0	1	1	1
Lucifer dogfish	217	126	89	35	73	24
Mahia rattail	12	0	1	6	6	3
Notable rattail	178	0	0	19	44	8
Oblique banded rattail	1 254	0	12	43	400	15
Oliver's rattail	2 202	0	56	41	522	9
Orange roughy	225	112	104	16	225	16
Owston's dogfish	79	43	36	9	41	7
Pale ghost shark	1 184	555	629	85	1 077	73
Parvoraja spp (skate)	5	1	2	5	4	4
Plunket's shark	6	4	2	5	6	5
Prickly dogfish	1	0	1	1	1	1
Ray's bream	111	53	58	19	82	15
Red cod	166	110	48	11	36	8
Ribaldo	178	29	149	40	171	38
Ridge-scaled rattail	658	293	256	28	571	25
Robust cardinalfish	5	0	0	2		
Rough skate	18	10	8	6	17	5
Rudderfish	1	0	1	1	1	1
Scampi	16	12	4	3	16	3

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

	Length frequency data				Length-weight data	
	No. of fish measured			No. of	No. of	No. of
Species	Total †	Male	Female	Samples	fish	samples
Sea perch	12	3	4	6	8	5
Seal shark	13	3	10	8	12	7
Serrulate rattail	95	0	0	13	8	4
Shovelnosed dogfish	162	105	57	15	162	15
Silver warehou	230	93	137	12	160	11
Silverside	1 583	0	7	34	203	12
Slender smooth- hound	1	0	1	1	1	1
Small banded rattail	4	0	0	1		
Small-headed cod	17	1	2	9	14	7
Small-scaled slickhead	298	131	101	13	241	10
Smooth oreo	434	226	201	15	431	13
Smooth skate	11	3	8	10	9	8
Southern blue whiting	1 858	983	874	30	1 351	29
Spiky oreo	22	5	1	4	6	3
Spineback	196	0	4	32	177	27
Spiny dogfish	967	496	471	47	755	41
Swollenhead conger	76	0	1	25	71	22
Violet cod	44	7	3	6	44	6
White rattail	87	10	6	13	58	8
White warehou	358	233	121	30	196	26
Widenosed chimaera	21	12	9	11	19	9

†Total is sometimes greater than the sum of male and female fish because the sex of some fish was not recorded.

Table 8: Length-weight regression parameters* used to scale length frequencies for the 12 major species.

	Regression parameters				Length	
Species	*a*	*b*	r^2	*n*	range (cm)	Data source
Black oreo	0.054516	2.702361	.83	264	24.3 – 39.3	TAN0714
Dark ghost shark	0.002431	3.228043	.98	217	35.1 – 68.6	TAN0714
Javelinfish	0.000855	3.261952	.97	914	18.3 – 58.9	TAN0714
Hake	0.001482	3.360596	.98	646	44.3 – 128.2	TAN0714
Hoki	0.004172	2.914241	.97	1 955	35.9 – 111.8	TAN0714
Ling	0.001732	3.226877	.98	1 485	37.8 – 129.1	TAN0714
Lookdown dory	0.035144	2.888083	.95	123	12.0 – 47.6	TAN0714
Pale ghost shark	0.015366	2.765741	.96	1 067	26.8 – 84.9	TAN0714
Ribaldo	0.006671	3.120449	.98	170	28.2 – 72.2	TAN0714
Southern blue whiting	0.005382	3.052143	.97	1 345	20.9 – 57.7	TAN0714
Spiny dogfish	0.000519	3.482526	.92	751	53.8 – 96.8	TAN0714
White warehou	0.034225	2.857873	.97	195	25.4 – 61.7	TAN0714

* $W = aL^b$ 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 hoki, hake, and ling at each reproductive stage*.

	Hoki		Hake		Ling	
Reproductive stage	Male	Female	Male	Female	Male	Female
1	1 131	994	75	186	155	293
2	1 780	3 056	62	132	290	1 088
3	15	13	7	93	50	32
4	8	4	38	7	633	43
5	2	3	39	1	22	5
6	236	44	0	3	20	0
7	82	191	0	8	7	5
Total staged	3 254	4 305	221	430	1 177	1 466

*See Appendix 1 for description of gonad stages.

Table 10: Average liver condition index (LCI) and somatic condition factor (CF) for hoki sampled during Sub-Antarctic trawl surveys 2001–07.

	LCI		CF	
Year	Male	Female	Male	Female
2001	2.58	3.12	2.61	2.57
2002	2.37	2.74	2.63	2.60
2003	2.36	2.93	2.62	2.60
2004	2.71	3.25	2.63	2.59
2005	3.01	3.15	2.75	2.68
2006	2.66	2.98	2.71	2.70
2007	3.03	3.22	2.70	2.68

LCI = liver weight (g) / gutted weight (g) x 100
CF = gutted weight (g) / (length (cm))^3 x 1000

Table 11. Quality of acoustic data collected during trawl surveys in the Sub-Antarctic between 2000 and 2007. The quality of each recording was subjectively categorised as "good", "marginal" or "poor" based on the appearance of the 38 kHz echograms (see appendix 2 of O'Driscoll & Bagley (2004) for examples).

Survey	Number of recordings	% of recordings Good	Marginal	Poor
2000 (TAN0012)	234	57	21	22
2001 (TAN0118)	221	65	20	15
2002 (TAN0219)	202	78	12	10
2003 (TAN0317)	169	37	25	38
2004 (TAN0414)	163	61	25	14
2005 (TAN0515)	197	75	16	9
2006 (TAN0617)	195	46	25	29
2007 (TAN0714)	194	63	16	20

Table 12: Percentage occurrence of the seven acoustic mark types classified by O'Driscoll (2001) in trawl surveys of the Sub-Antarctic between 2000 and 2007. Several mark types were usually present in the same echogram. *n* is the number of acoustic files examined.

				Pelagic marks			Bottom marks		
Acoustic file	Survey	*n*	Surface layer	School	Layer	Cloud	Layer	Cloud	School
Day steam	2000 (TAN0012)	90	93	71	63	6	58	17	11
	2001 (TAN0118)	85	91	71	72	41	54	26	12
	2002 (TAN0219)	72	92	72	75	19	79	19	14
	2003 (TAN0317)	64	94	56	53	47	67	30	13
	2004 (TAN0414)	49	82	63	55	43	69	31	12
	2005 (TAN0515)	75	91	77	73	63	67	59	16
	2006 (TAN0617)	73	88	53	67	37	30	34	3
	2007 (TAN0714)	65	94	74	57	43	43	52	12
Night steam	2000 (TAN0012)	36	97	22	14	33	17	67	3
	2001 (TAN0118)	26	100	23	19	85	38	85	8
	2002 (TAN0219)	23	100	13	13	96	39	91	0
	2003 (TAN0317)	22	95	14	14	86	32	73	0
	2004 (TAN0414)	22	95	14	23	68	36	95	0
	2005 (TAN0515)	23	100	61	44	100	57	91	4
	2006 (TAN0617)	24	96	33	42	75	13	83	4
	2007 (TAN0714)	24	100	42	33	83	38	96	0
Trawl	2000 (TAN0012)	108	90	50	52	23	37	20	10
	2001 (TAN0118)	110	81	60	62	32	35	26	15
	2002 (TAN0219)	108	91	60	59	32	41	31	15
	2003 (TAN0317)	83	86	37	53	28	46	25	4
	2004 (TAN0414)	92	63	47	48	29	38	33	10
	2005 (TAN0515)	99	85	65	60	55	38	52	6
	2006 (TAN0617)	95	67	40	54	29	29	25	1
	2007 (TAN0714)	105	78	53	41	43	39	30	10

Table 13. Average trawl catch (excluding benthic organisms) and acoustic backscatter from tows where acoustic data quality was suitable for echo integration for Sub-Antarctic surveys between 2000 and 2007 All tows were conducted during daylight. Data for 2000–06 are from O'Driscoll & Bagley (2008). Only bottom-referenced regions were integrated in 2000–04.

Survey	Number of recordings	Trawl catch (kg km^{-2})		Average acoustic backscatter (m^2 km^{-2})		
		Mean	Median	Bottom 10 m only	All bottom marks	Entire echogram
2000 (TAN0012)	100	697	590	0.502	3.37	–
2001 (TAN0118)	101	779	567	0.506	2.90	–
2002 (TAN0219)	96	726	443	0.657	4.08	–
2003 (TAN0317)	48	568	351	0.622	2.50	–
2004 (TAN0414)	80	1 031	393	0.484	1.77	–
2005 (TAN0515)	87	691	457	0.623	2.40	14.88
2006 (TAN0617)	69	543	436	0.475	1.89	8.80
2007 (TAN0714)	75	833	525	0.541	3.45	12.06

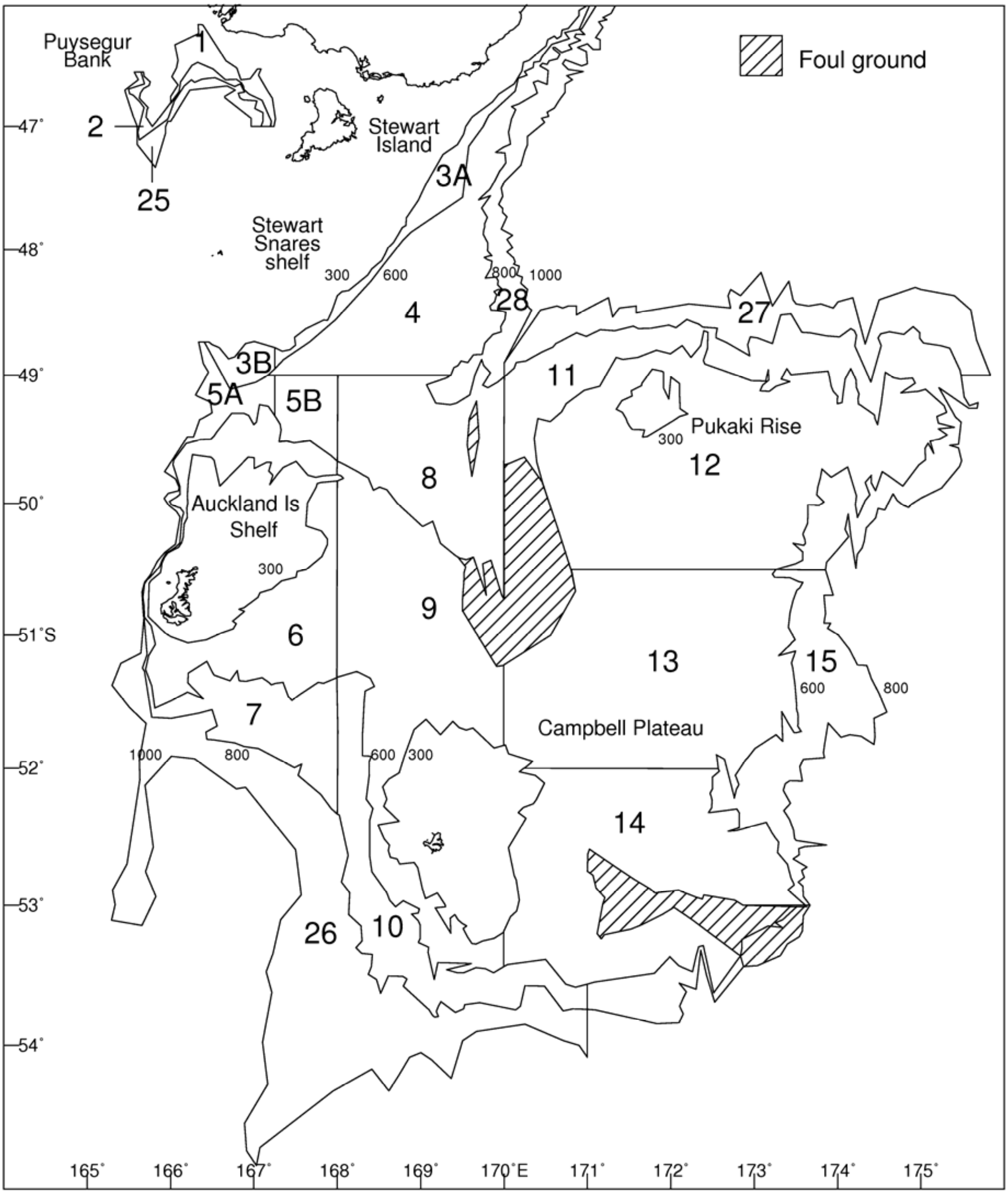


Figure 1: Stratum boundaries for the November–December 2007 Southland and Sub-Antarctic trawl survey.

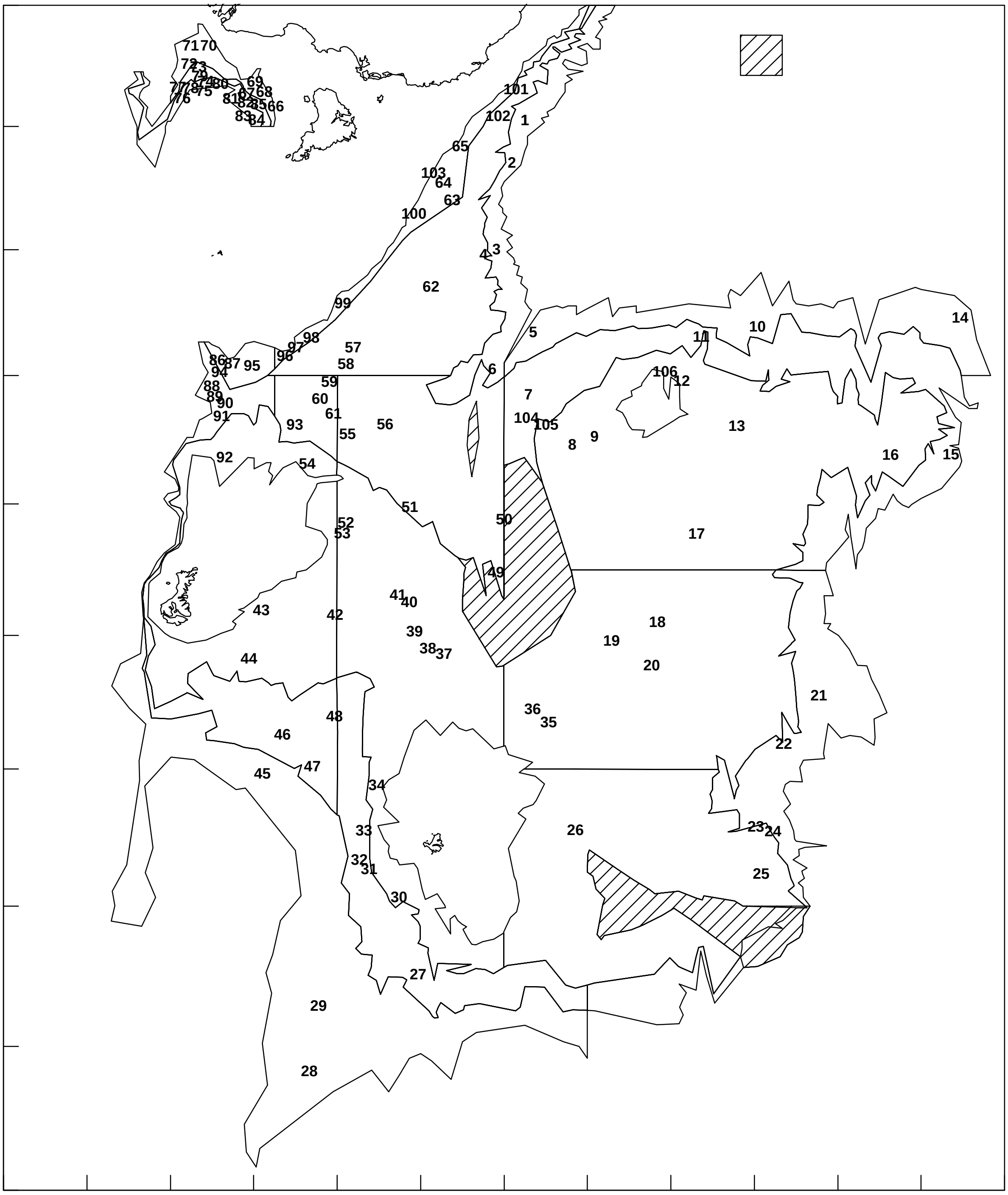


Figure 2: Map showing start positions of all bottom trawls (including unsuccessful stations) from the November–December 2007 Southland and Sub-Antarctic trawl survey.

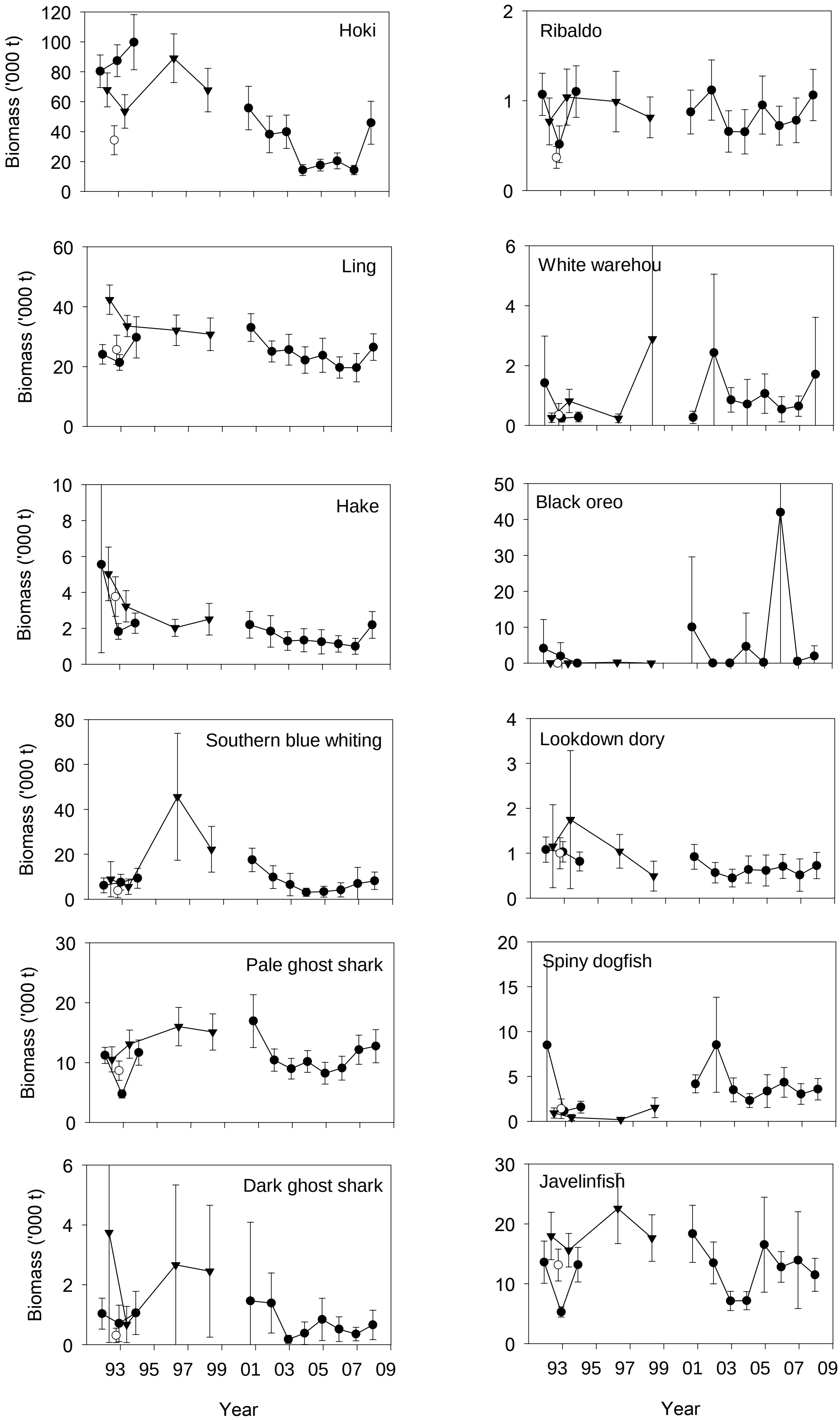


Figure 3: Trends in biomass (± 2 standard errors) of major species in the core 300–800 m strata in all Sub-Antarctic trawl surveys from *Tangaroa*. Solid circles show the summer time series and solid triangles the autumn time series. The open circle shows biomass from a survey of the same area in September–October 1992.

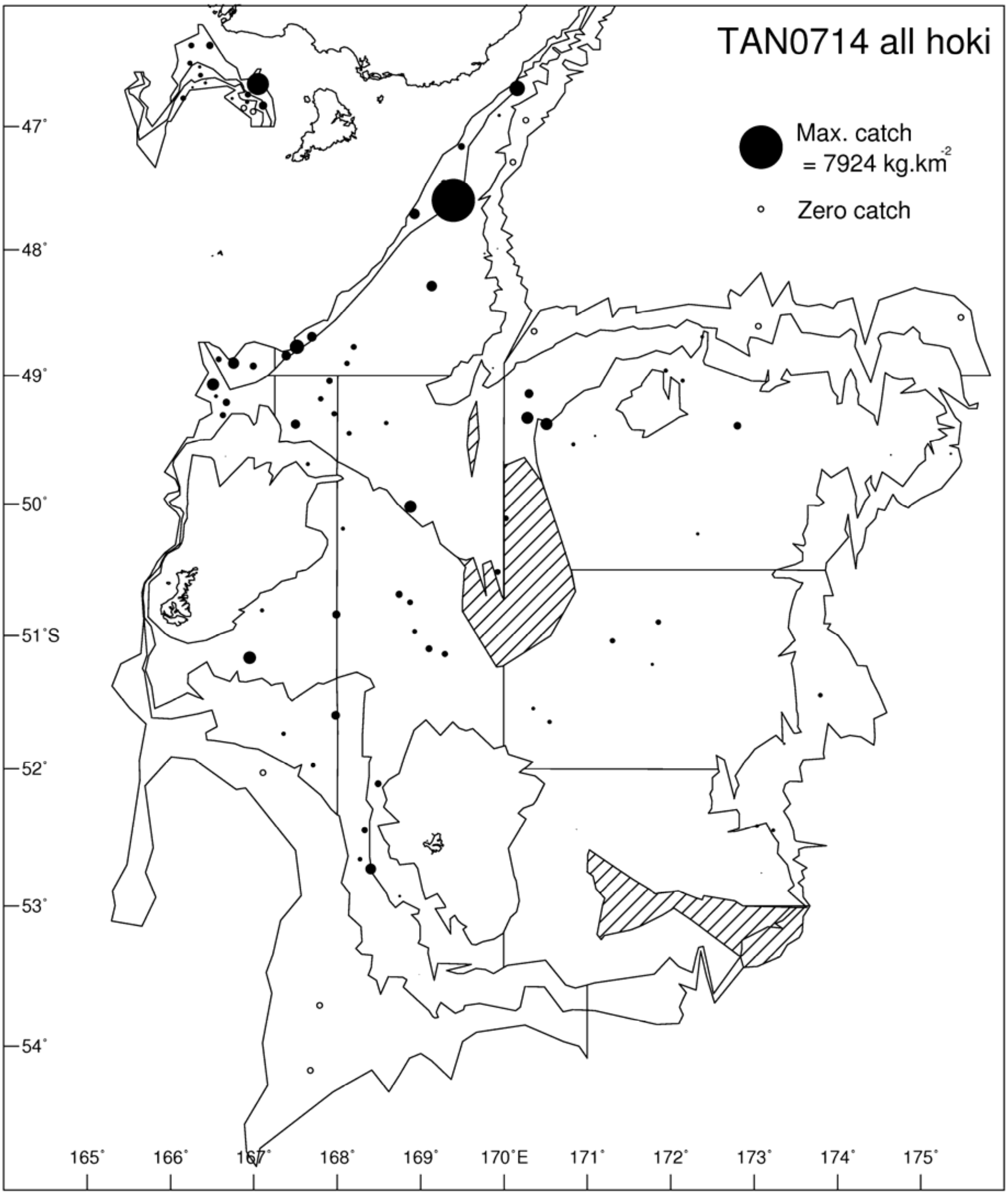


Figure 4a: Distribution and catch rates of all hoki in the summer 2007 trawl survey. Circle area is proportional to catch rate.

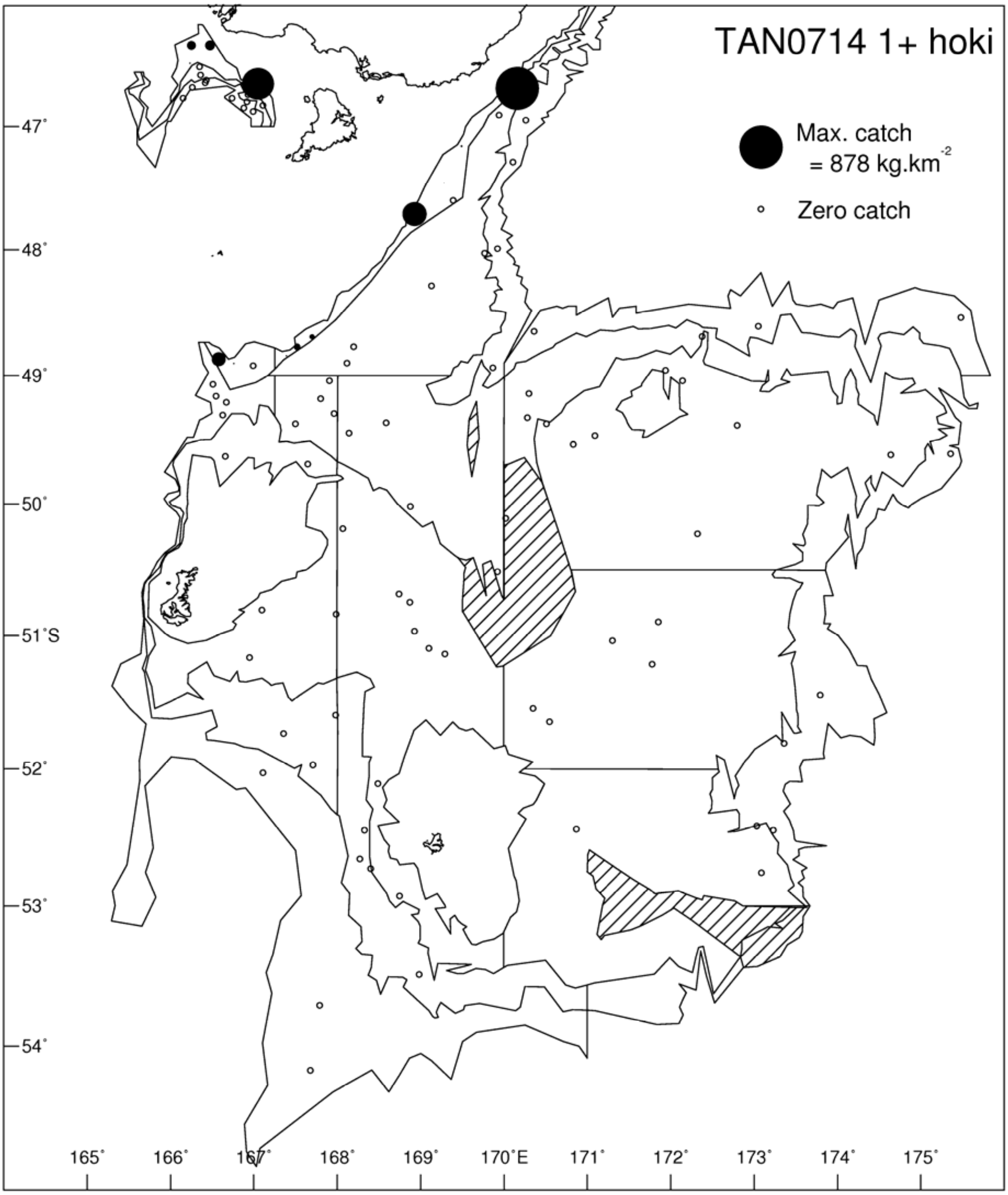


Figure 4b: Distribution and catch rates of 1+ (<45 cm) hoki in the summer 2007 trawl survey. Circle area is proportional to catch rate.

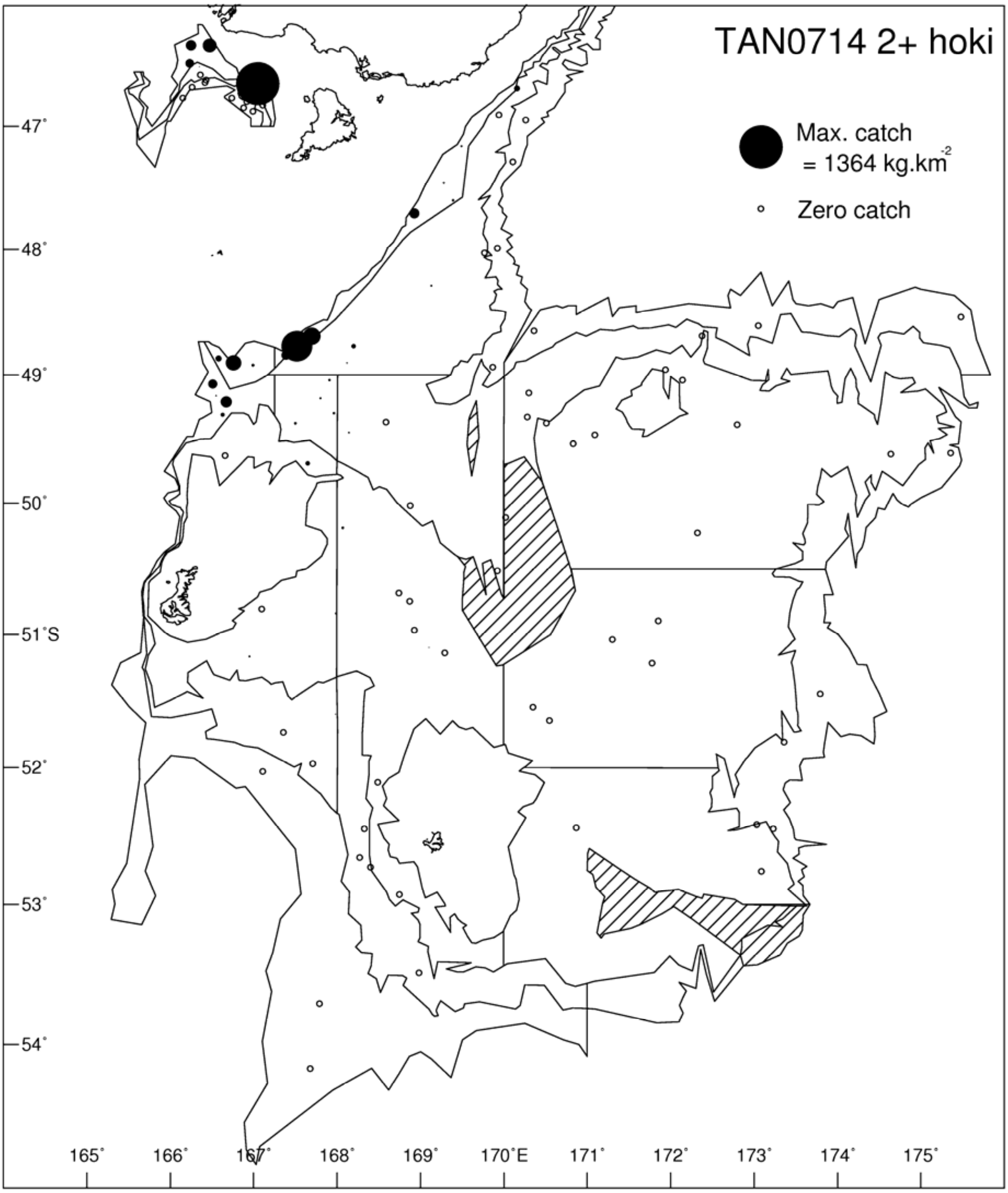


Figure 4c: Distribution and catch rates of 2+ (45–59 cm) hoki in the summer 2007 trawl survey. Circle area is proportional to catch rate.

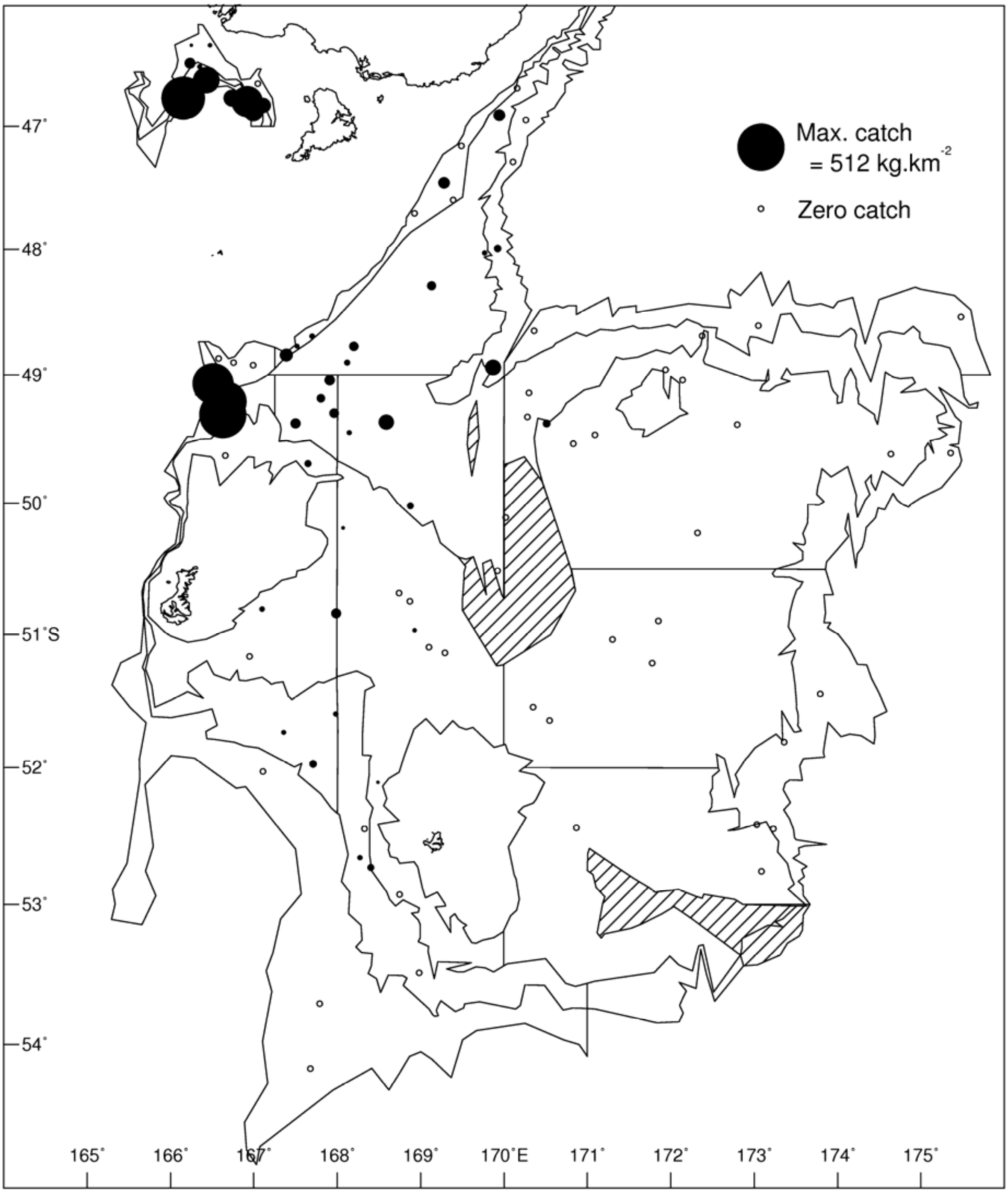


Figure 5: Distribution and catch rates of hake in the summer 2007 trawl survey. Circle area is proportional to catch rate.

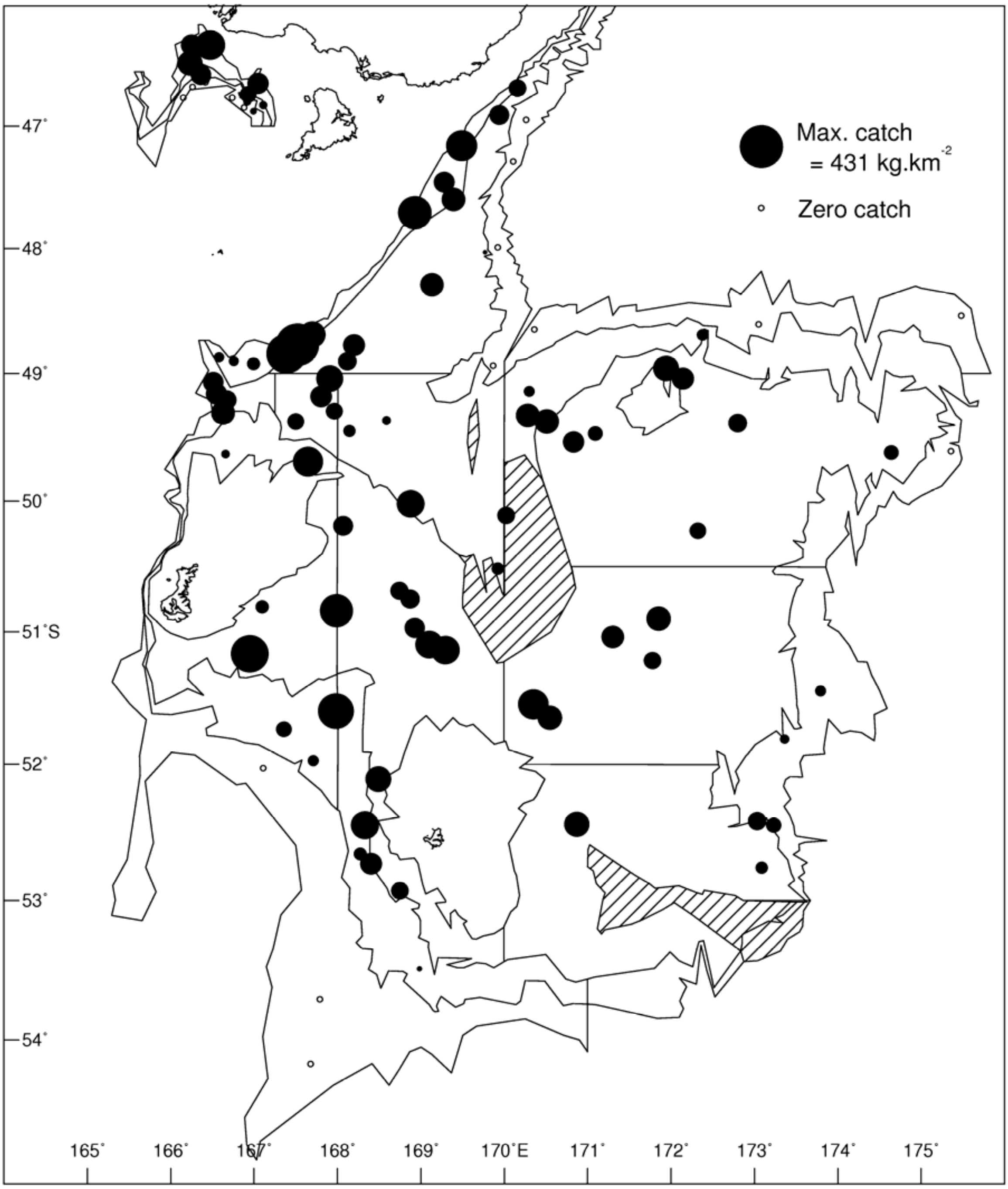


Figure 6: Distribution and catch rates of ling in the summer 2007 trawl survey. Circle area is proportional to catch rate.

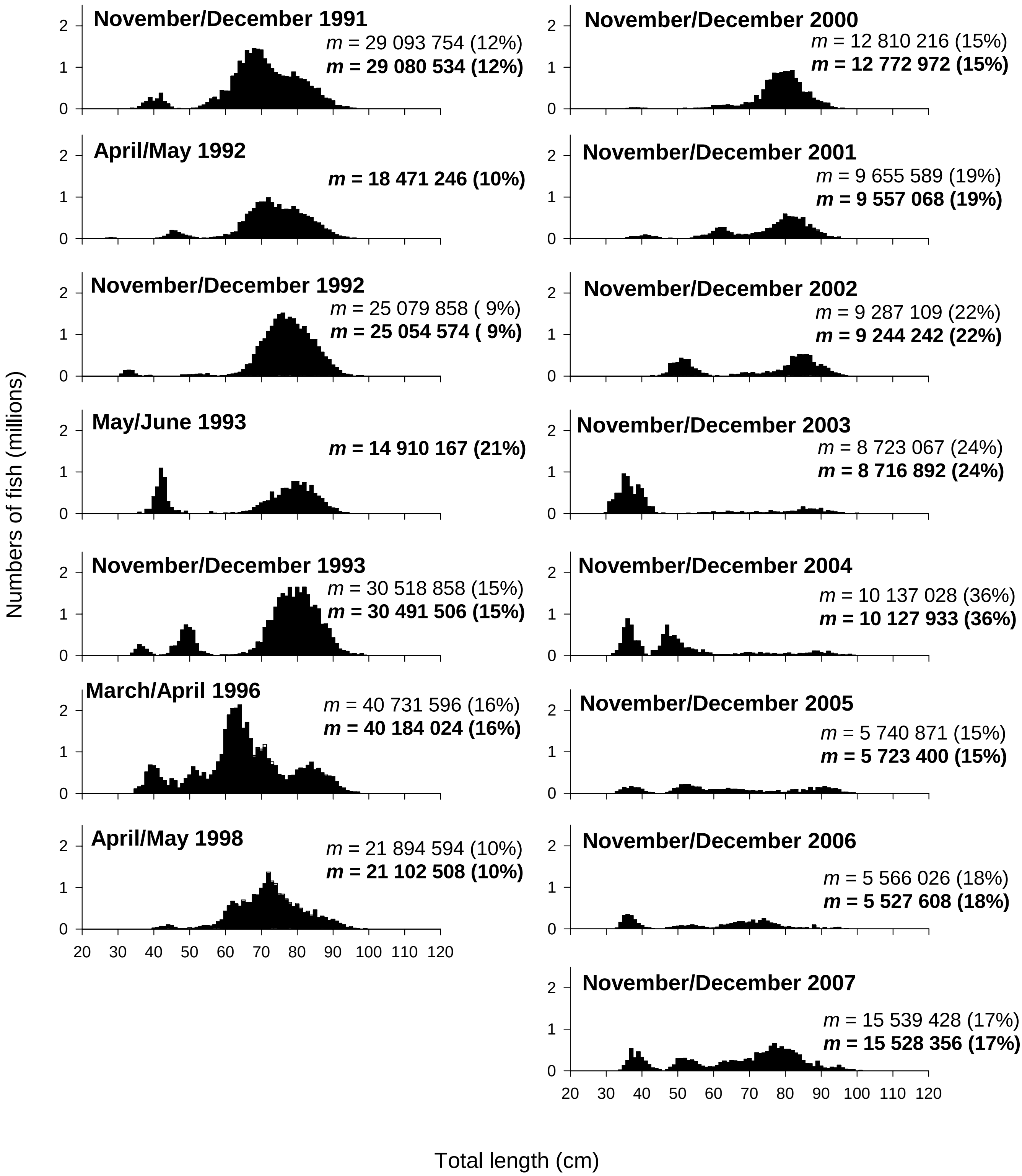


Figure 7a: Scaled length frequency for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (*m* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

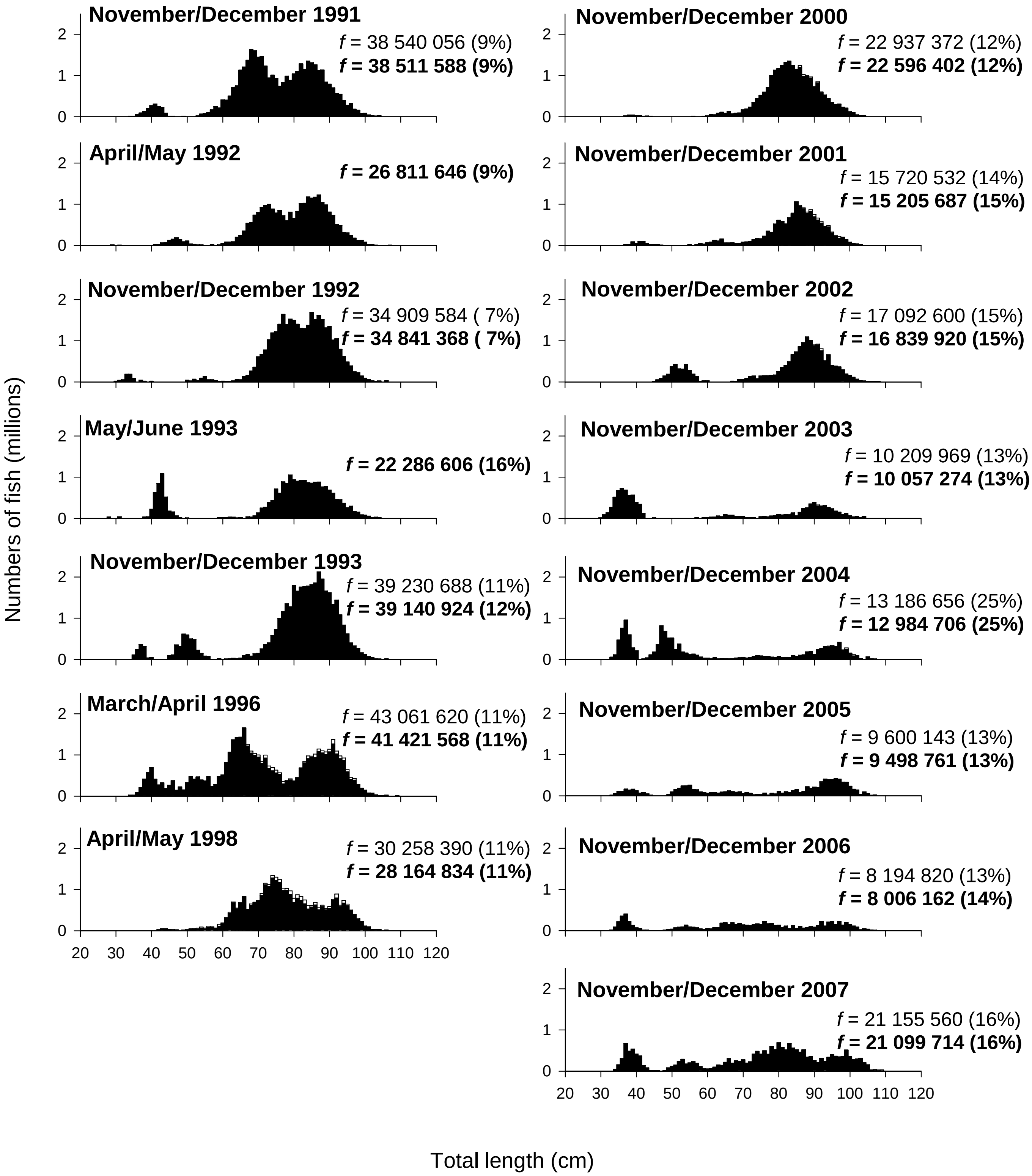


Figure 7b: Scaled length frequency for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (*f* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

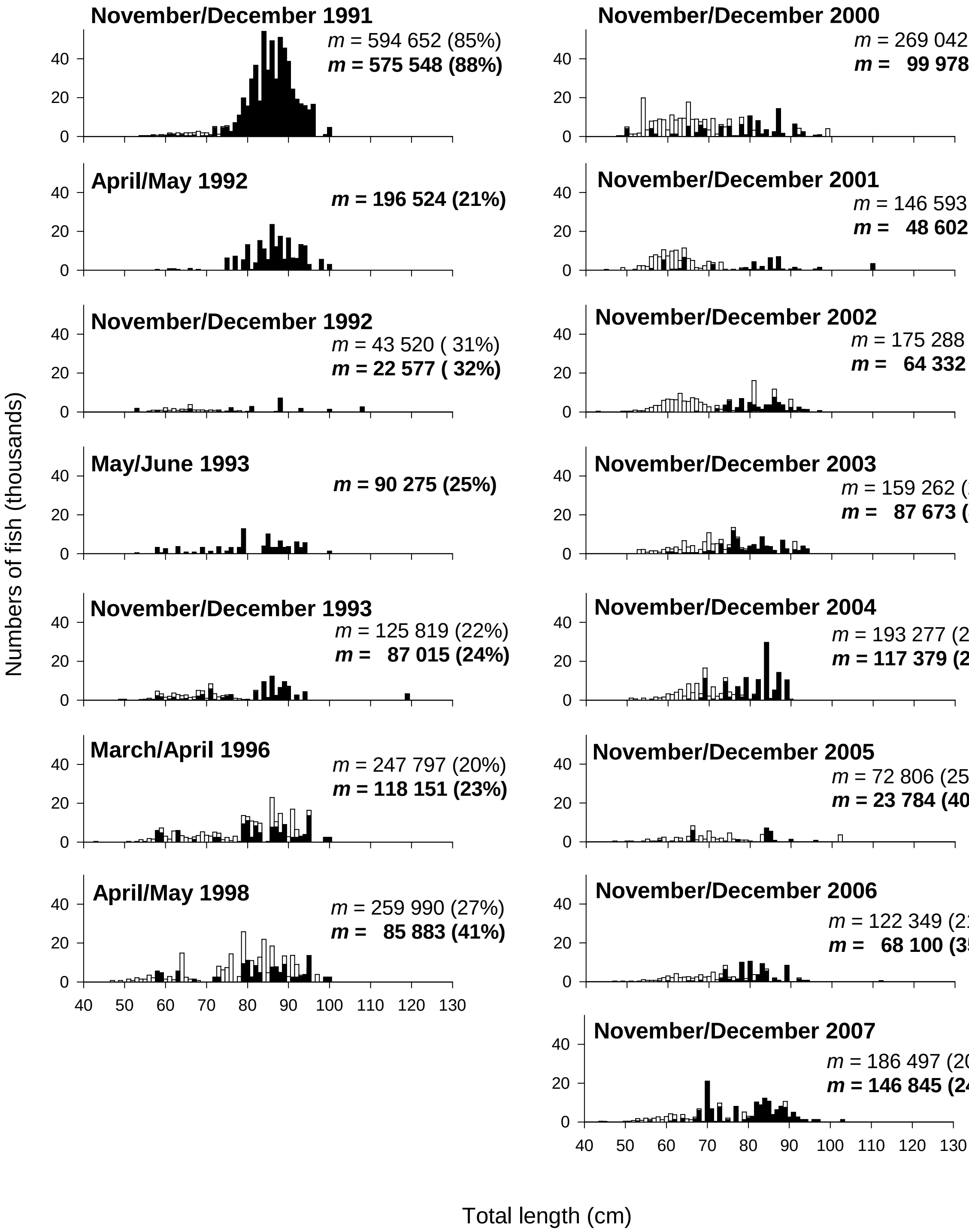


Figure 8a: Scaled length frequency for male hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (*m* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

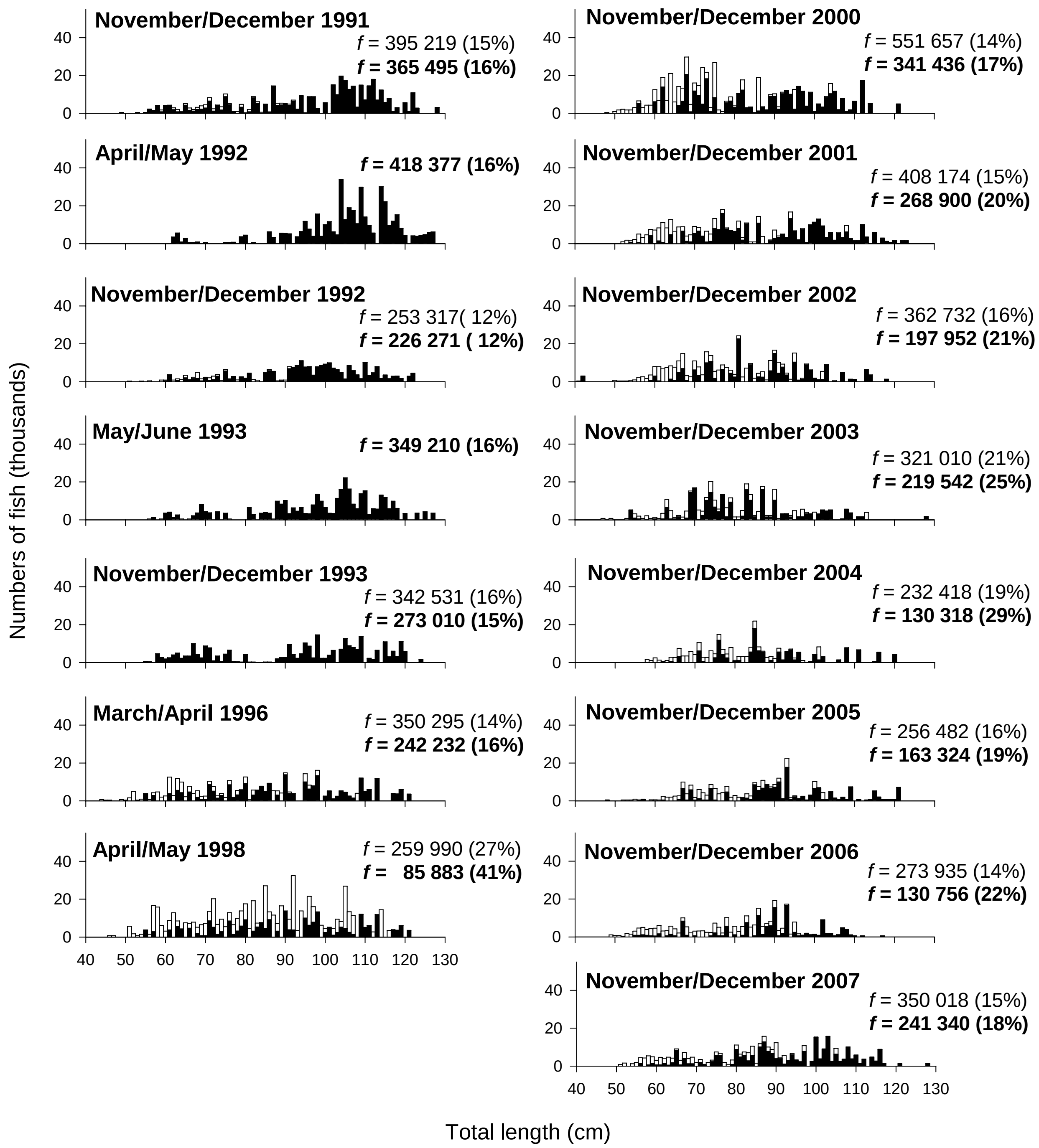


Figure 8b: Scaled length frequency for female hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (*f* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

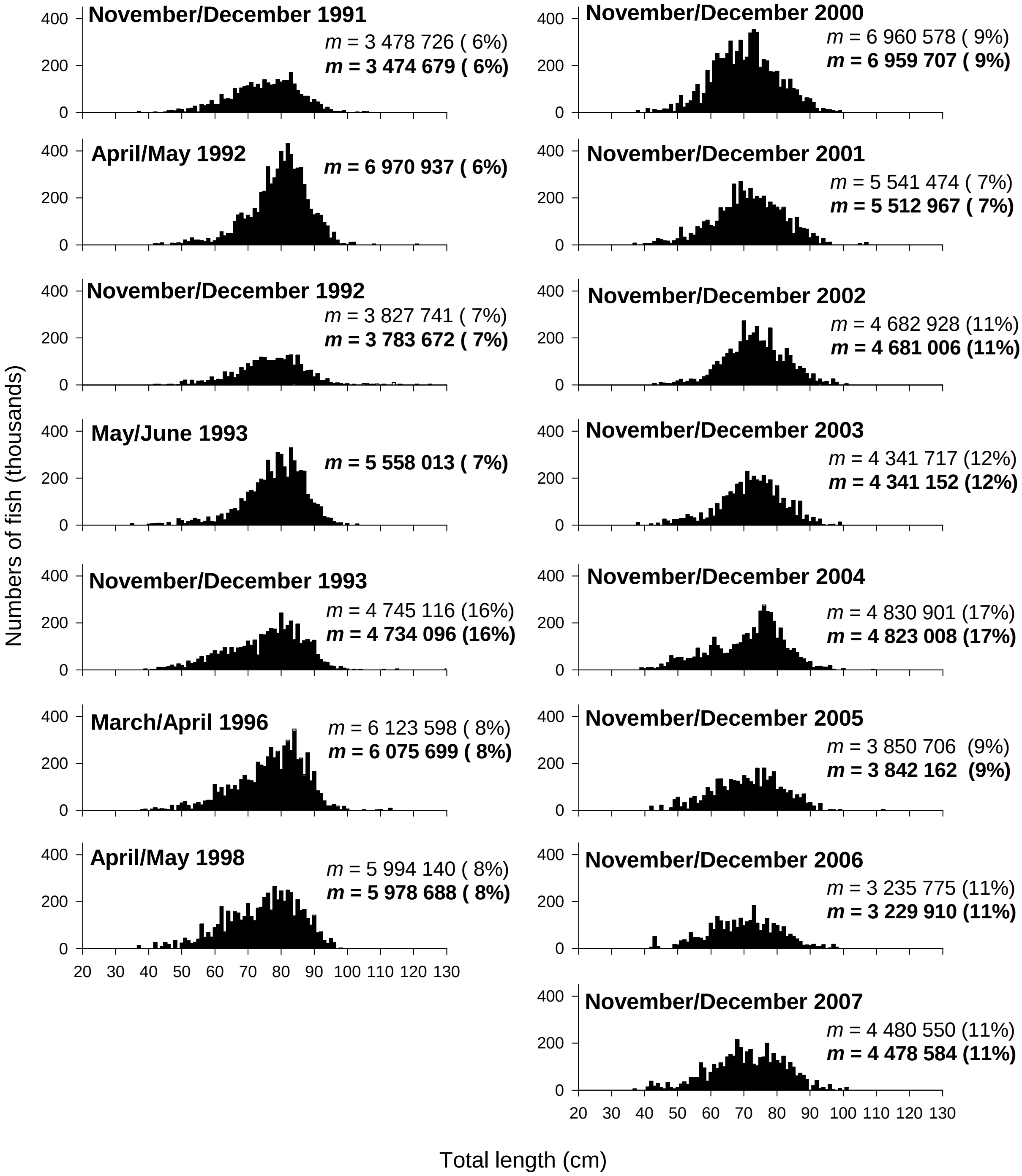


Figure 9a: Scaled length frequency for male ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (*m* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

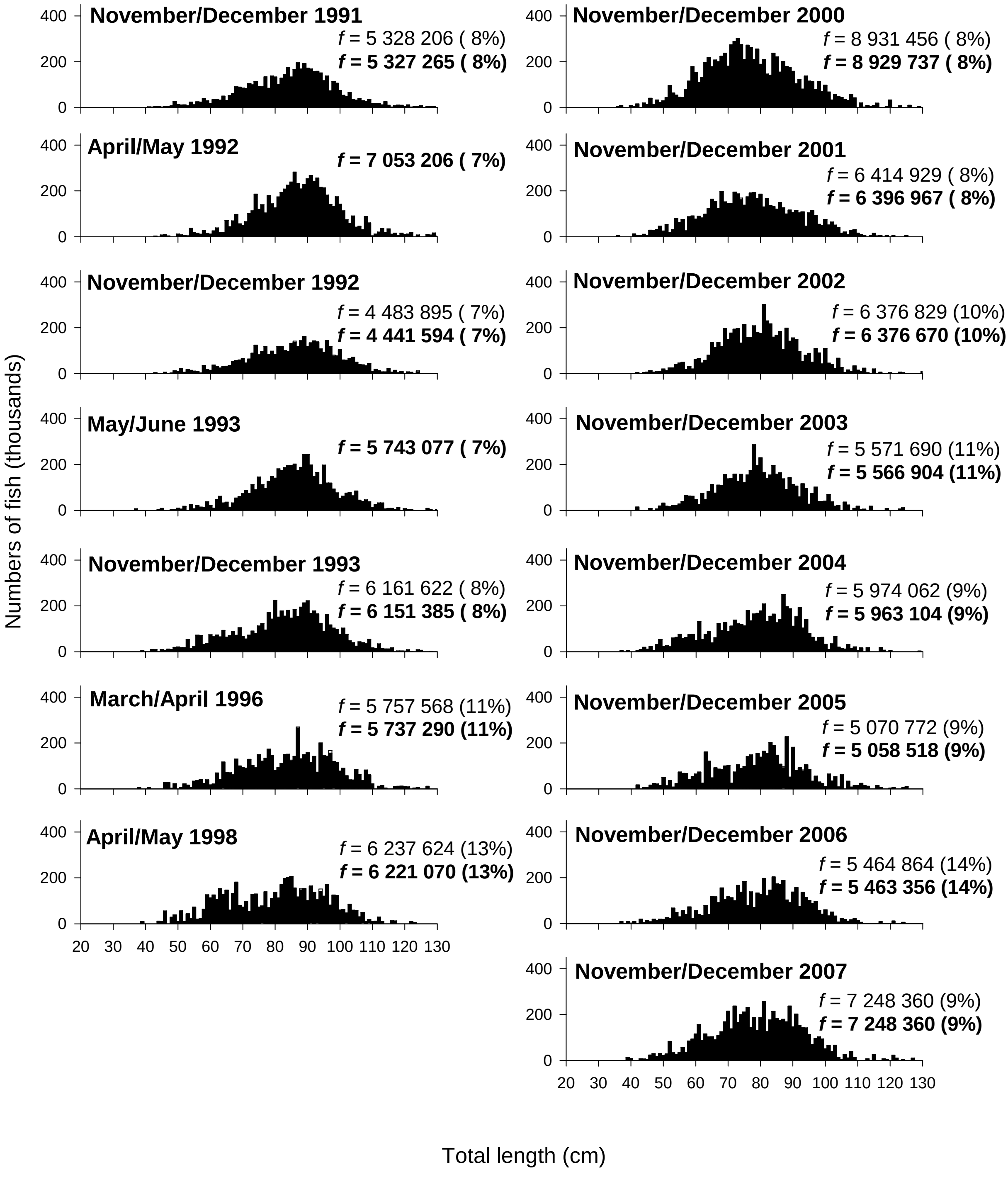


Figure 9b: Scaled length frequency for female ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (*f* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

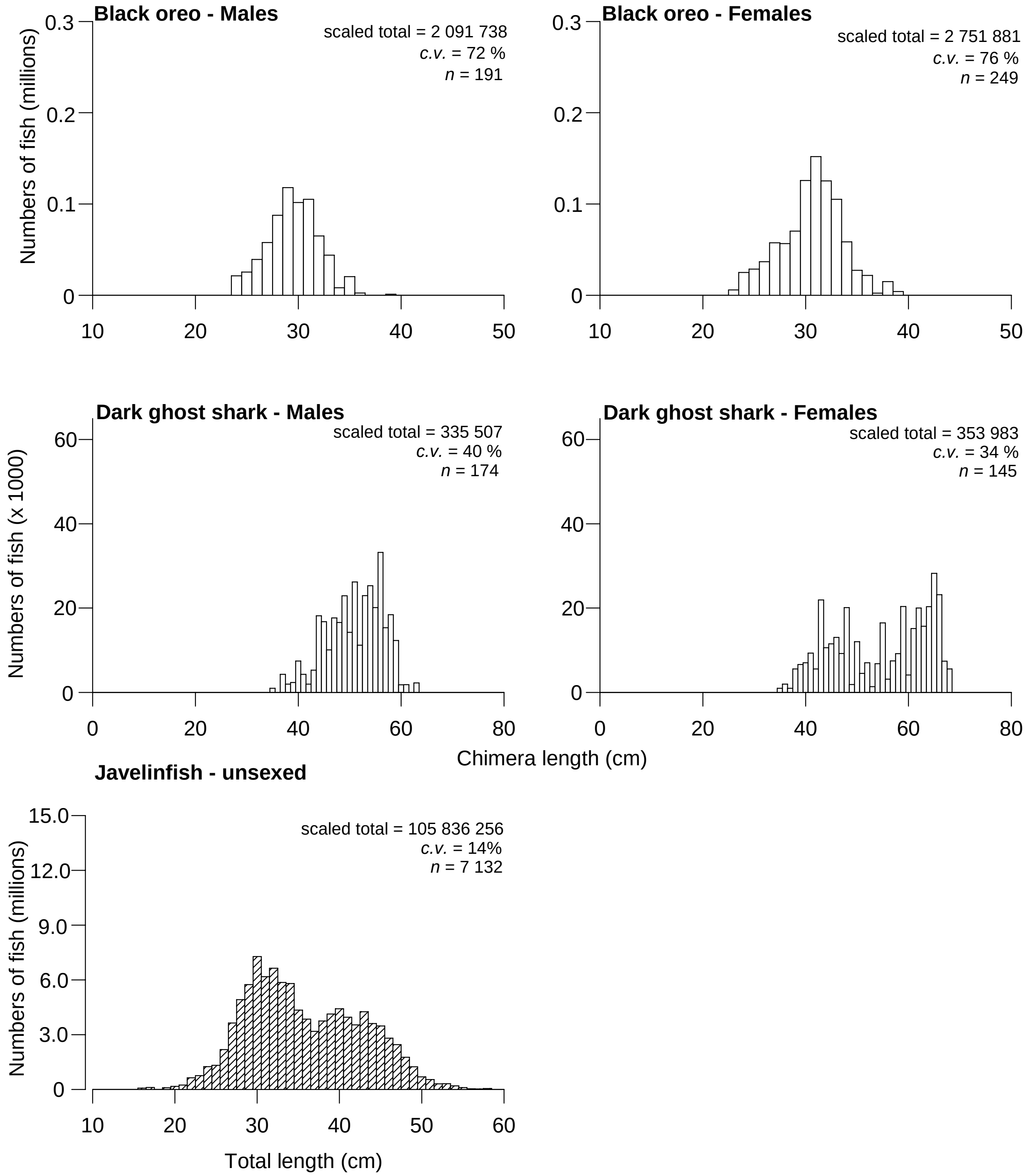


Figure 10: Length frequency distributions by sex of other major species in the November–December 2007 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured. Hatched bars are unsexed fish.

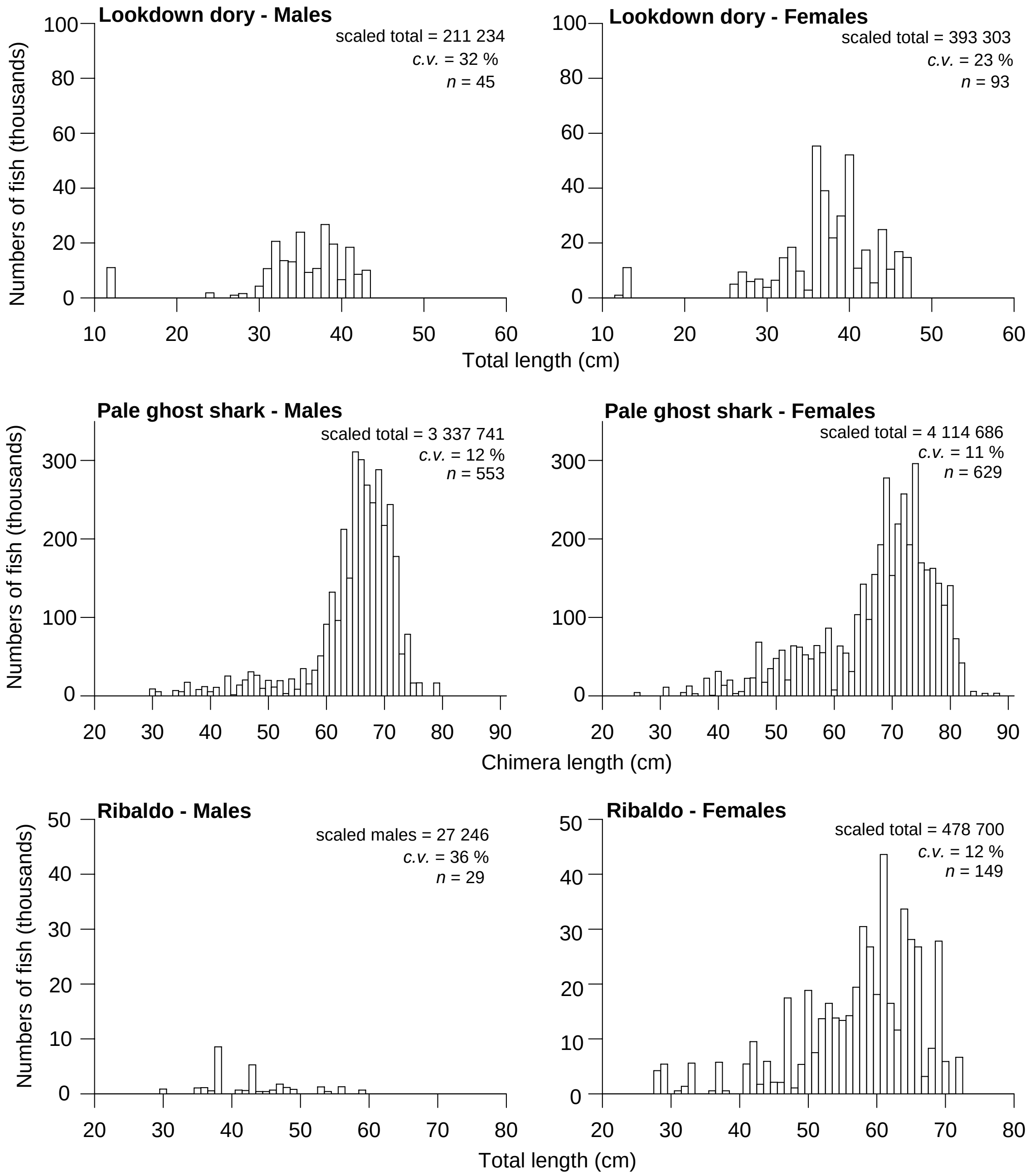


Figure 10 cont: Length frequency distributions by sex of other major species in the November–December 2007 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured.

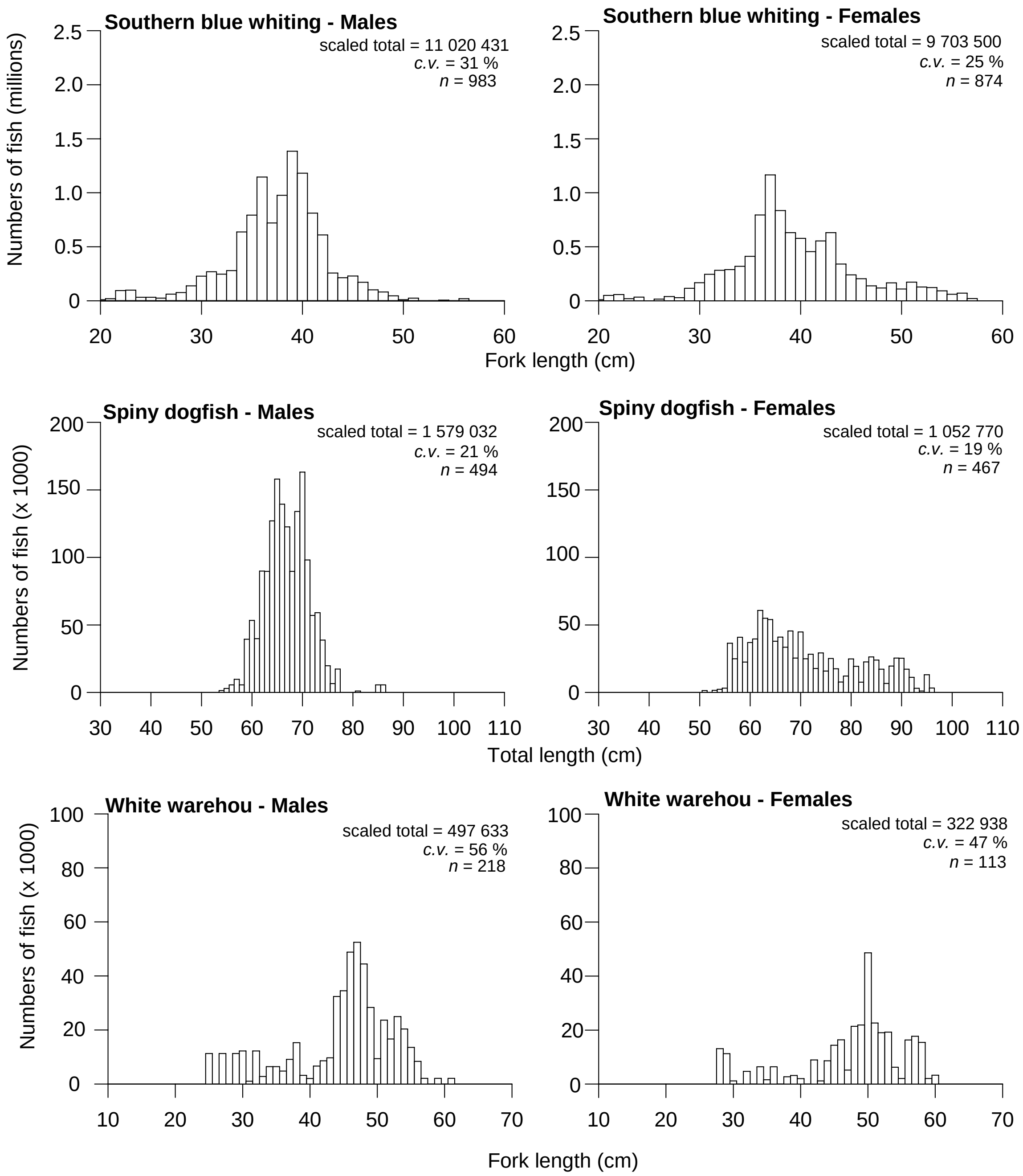


Figure 10 cont: Length frequency distributions by sex of other major species in the November–December 2007 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *n* is the number of fish measured.

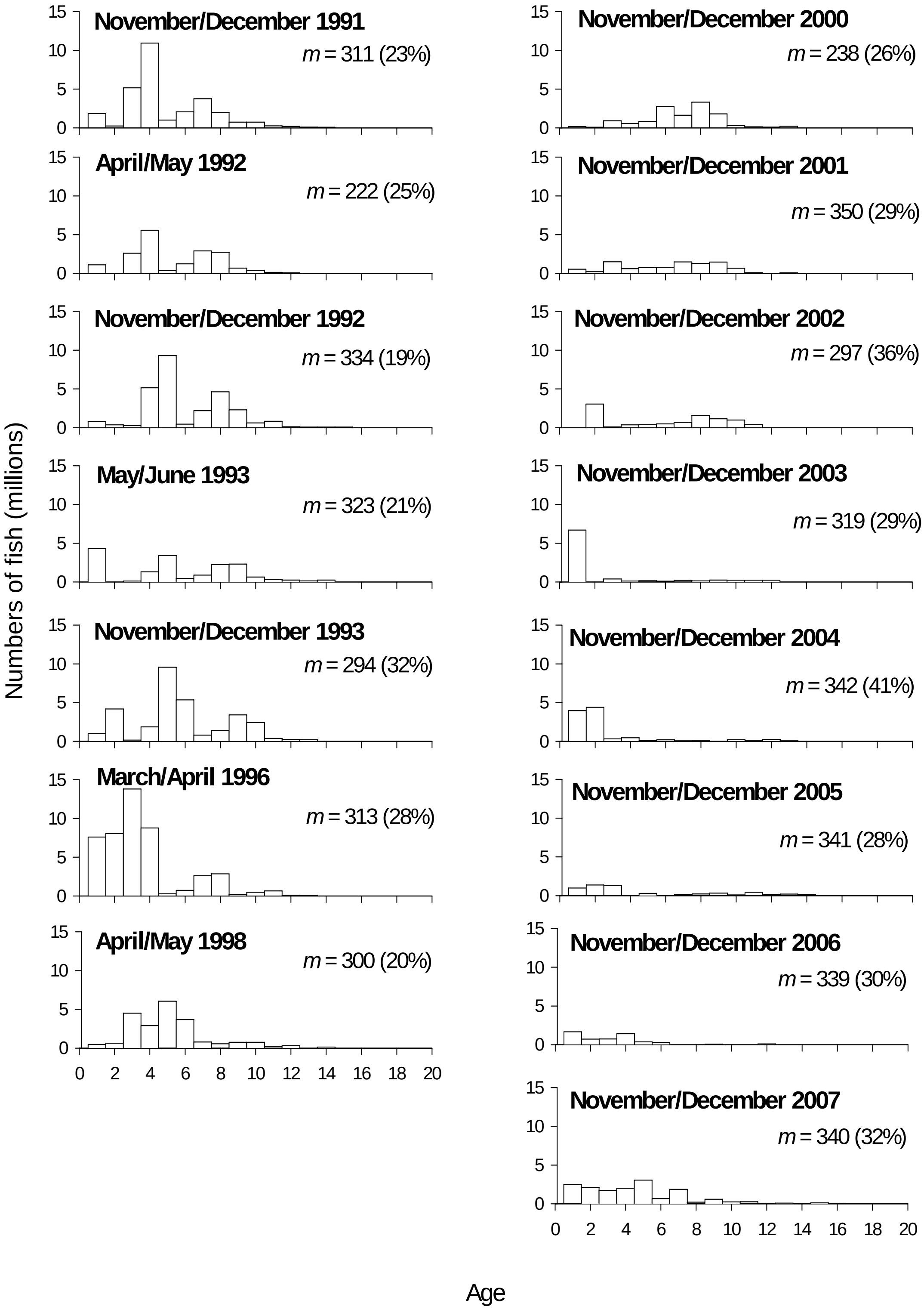


Figure 11a: Scaled age frequency for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with c.v.s in parentheses.

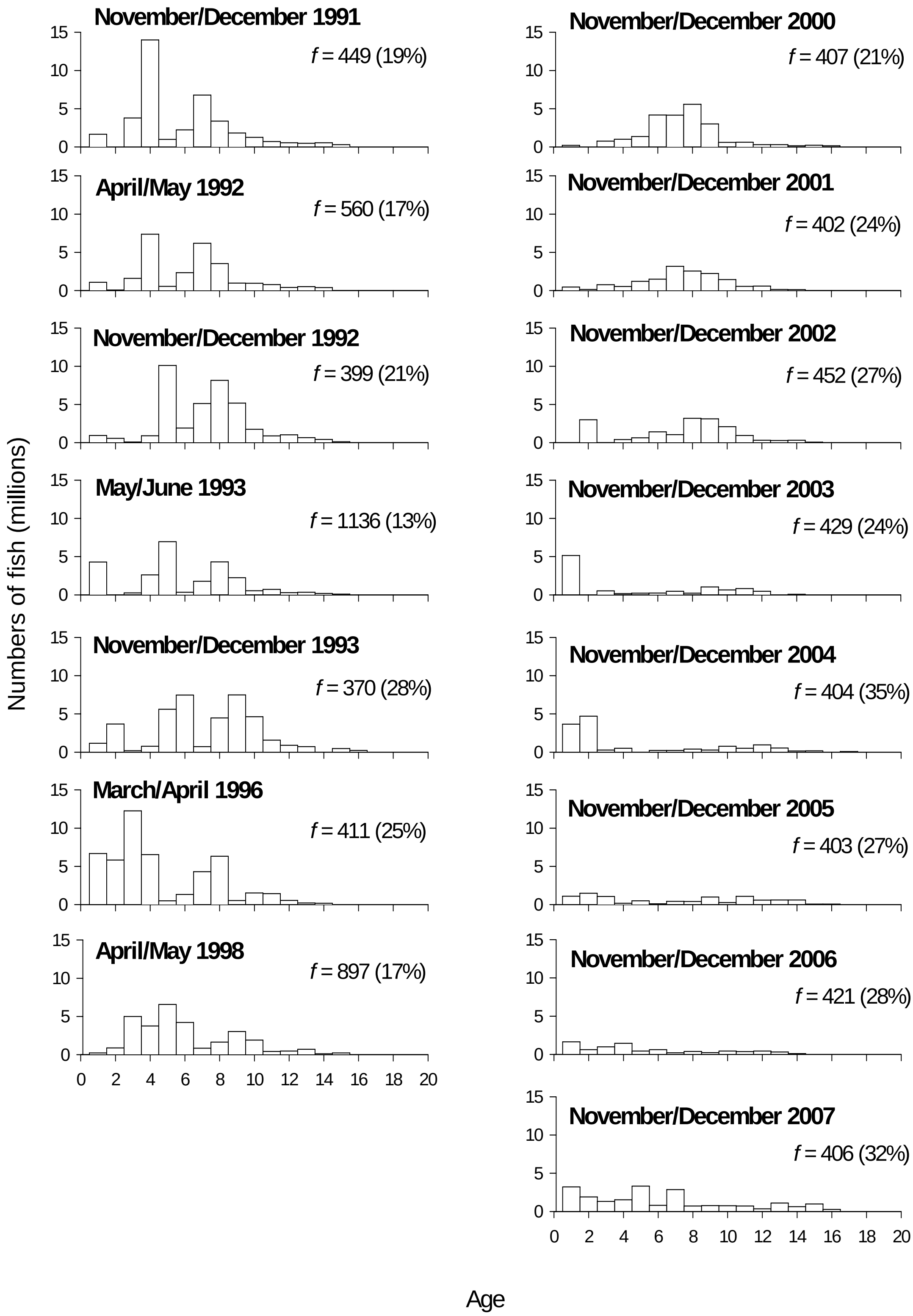


Figure 11b: Scaled age frequency for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with c.v.s in parentheses.

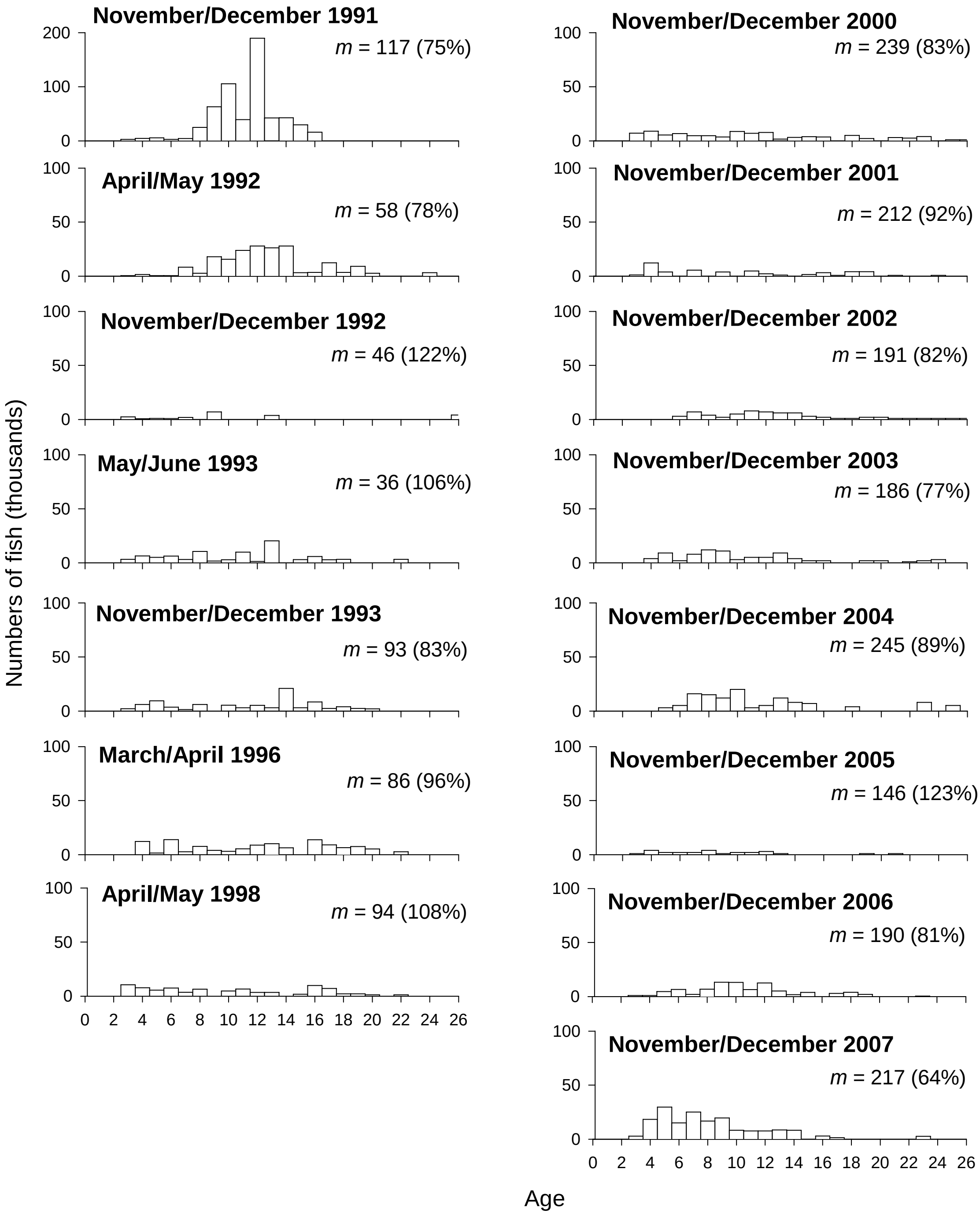


Figure 12a: Scaled age frequency for male hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with c.v.s in parentheses.

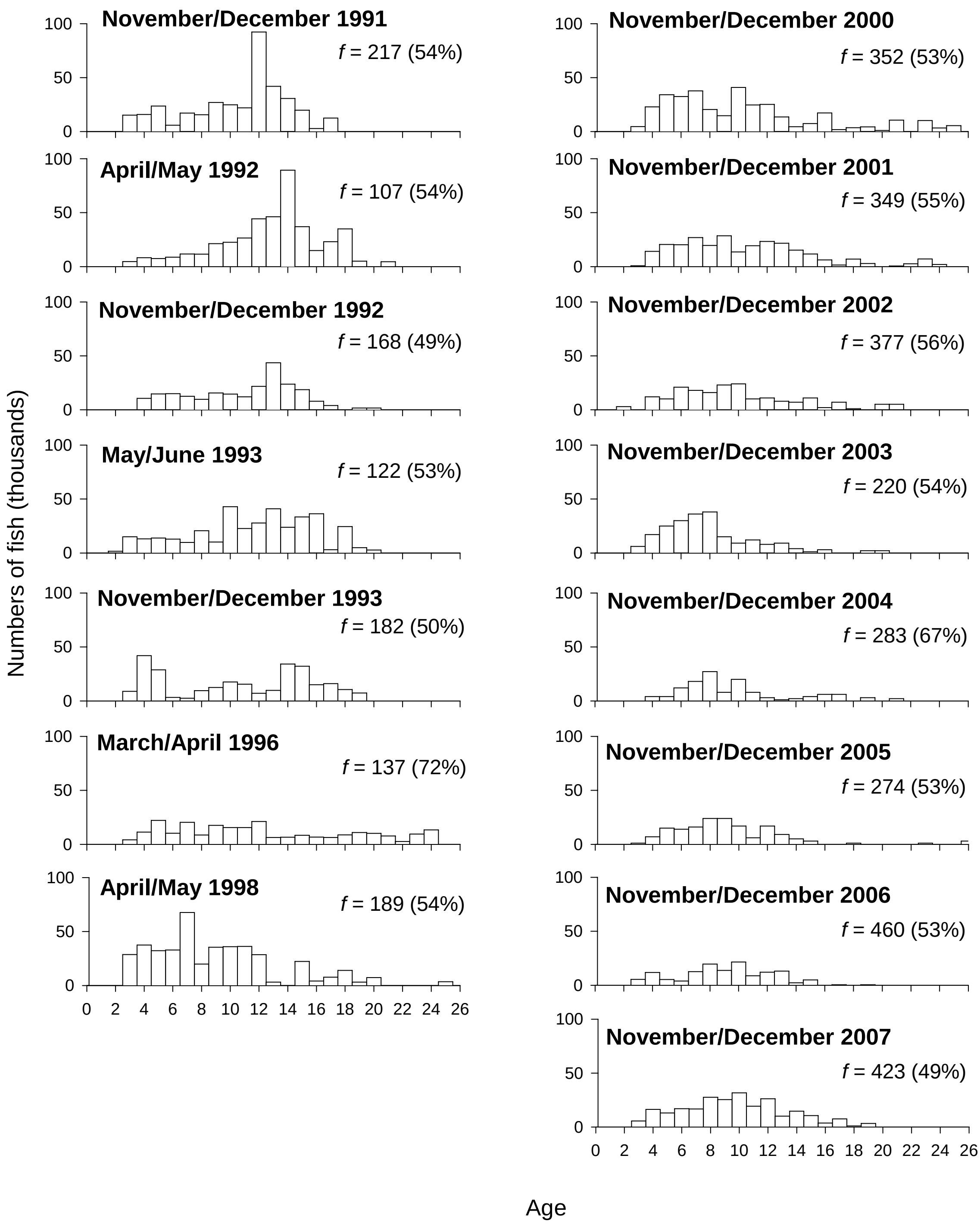


Figure 12b: Scaled age frequency for female hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with c.v.s in parentheses.

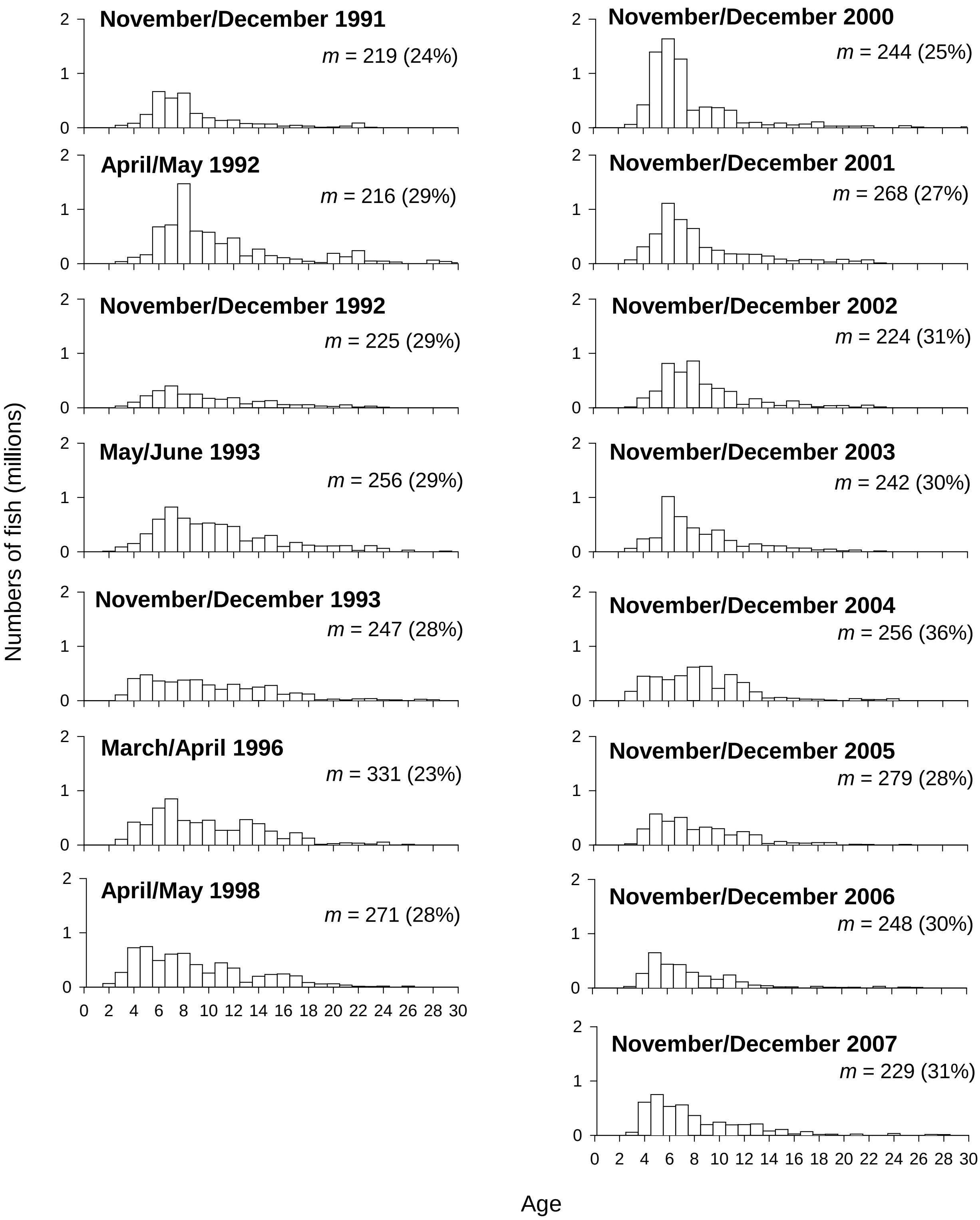


Figure 13a: Scaled age frequency for male ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with c.v.s in parentheses.

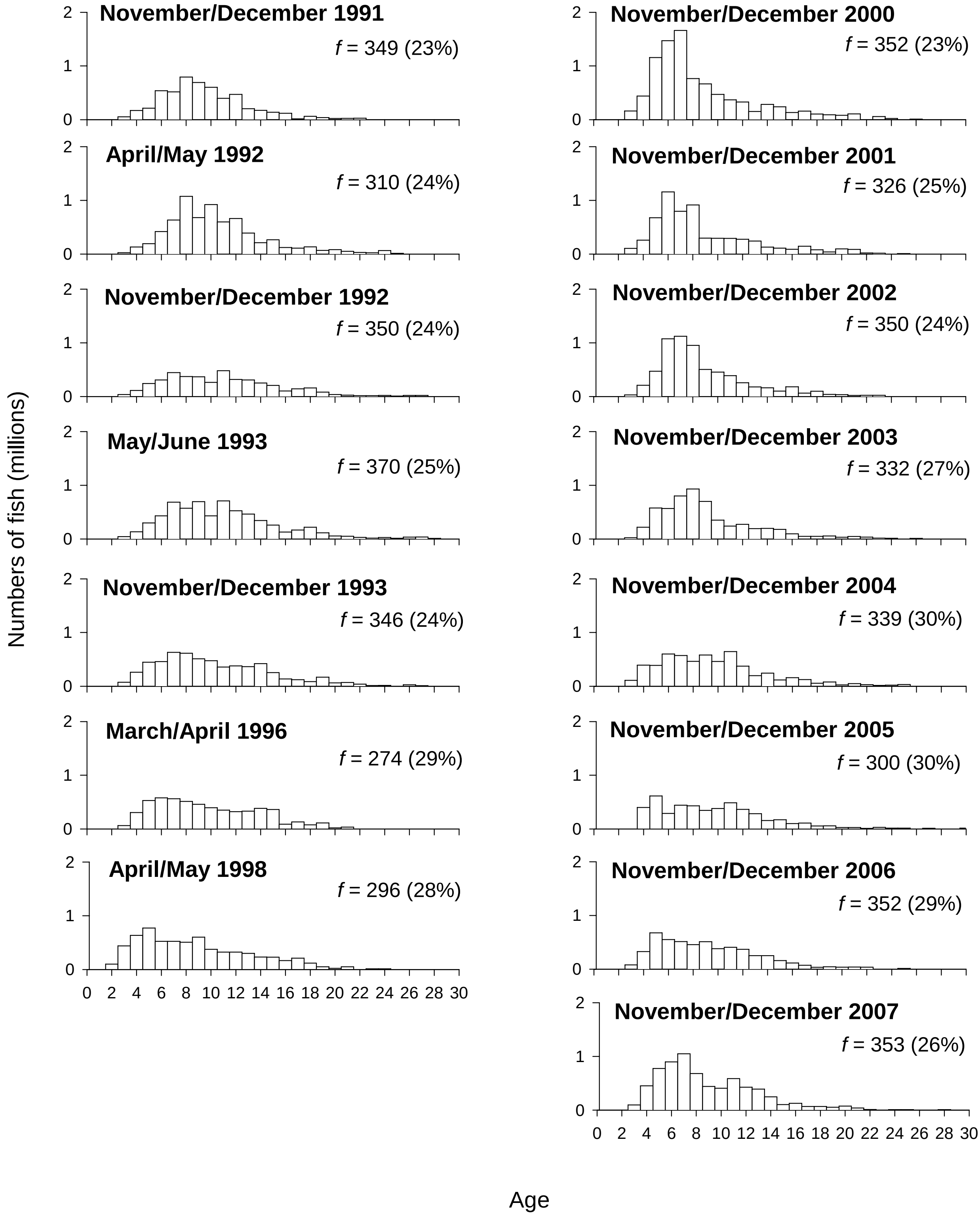
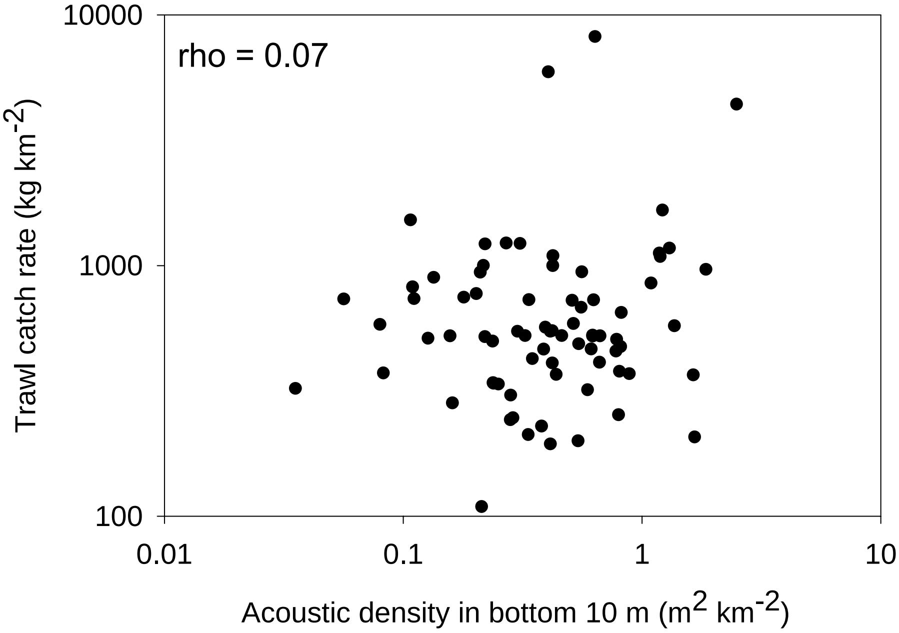


Figure 13b: Scaled age frequency for female ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with c.v.s in parentheses.



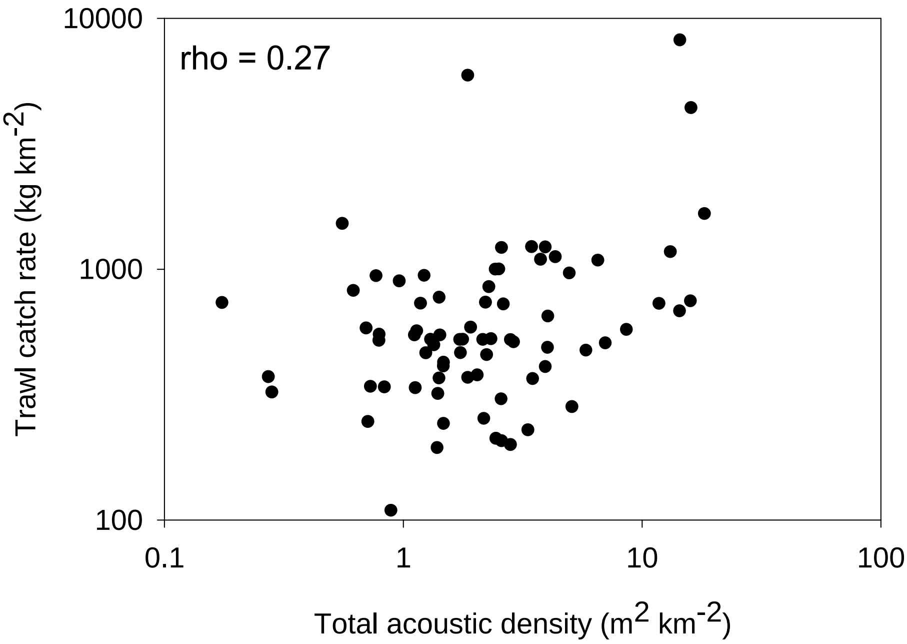


Figure 14. Relationship between total trawl catch rate (all species excluding benthic invertebrates) and acoustic backscatter recorded during the trawl in the Sub-Antarctic in 2007. Rho values are Spearman's rank correlation coefficients.

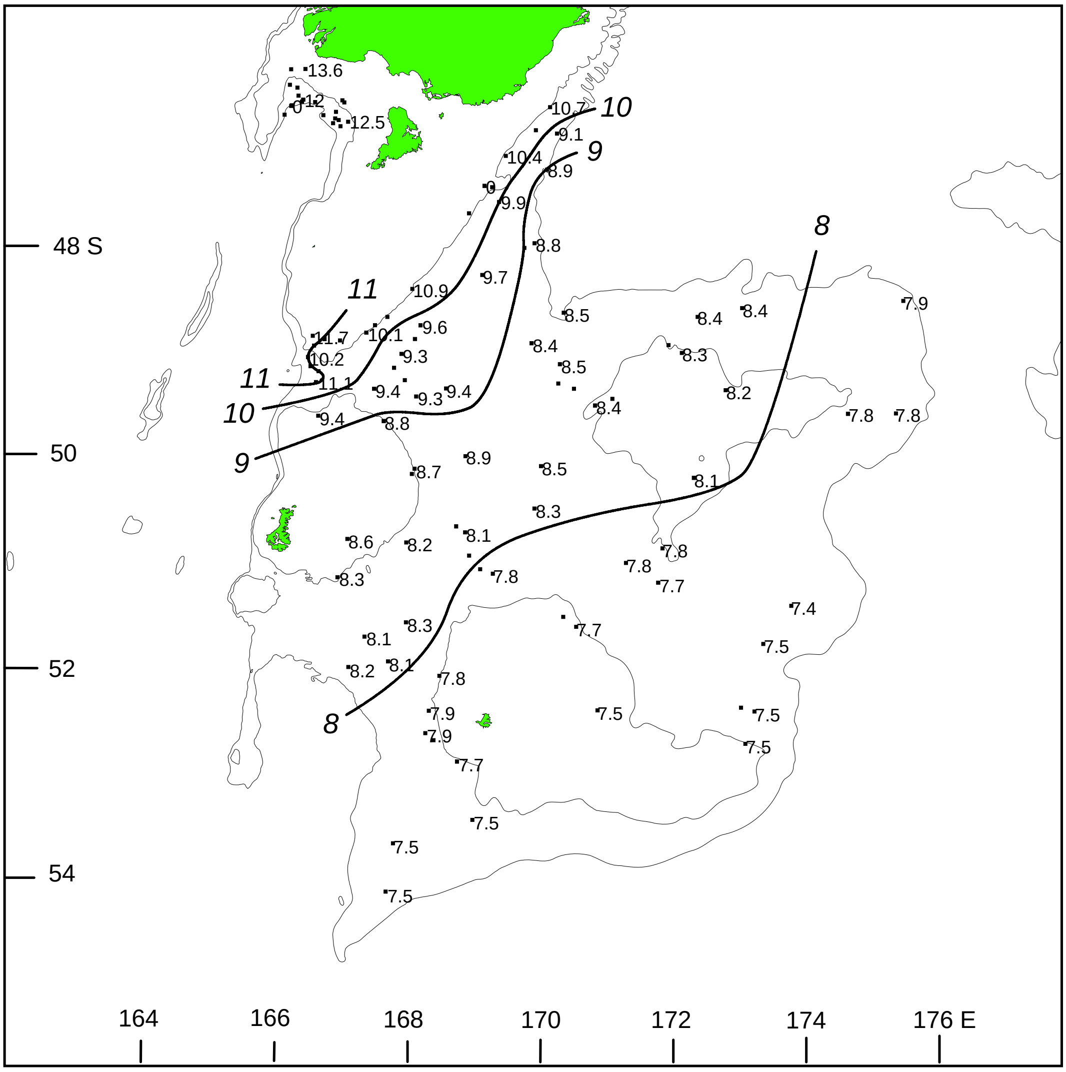


Figure 15: Surface water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

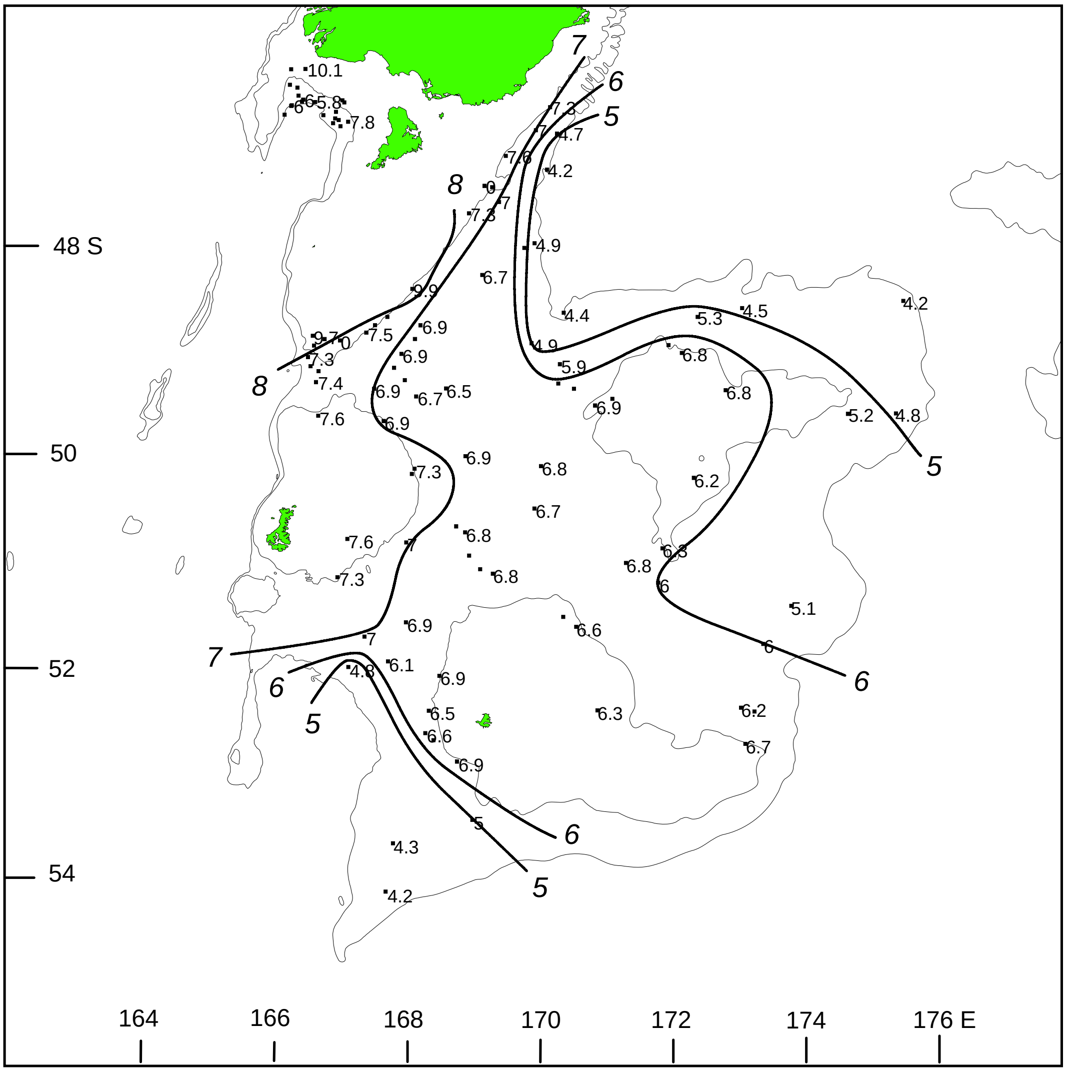


Figure 16: Bottom water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

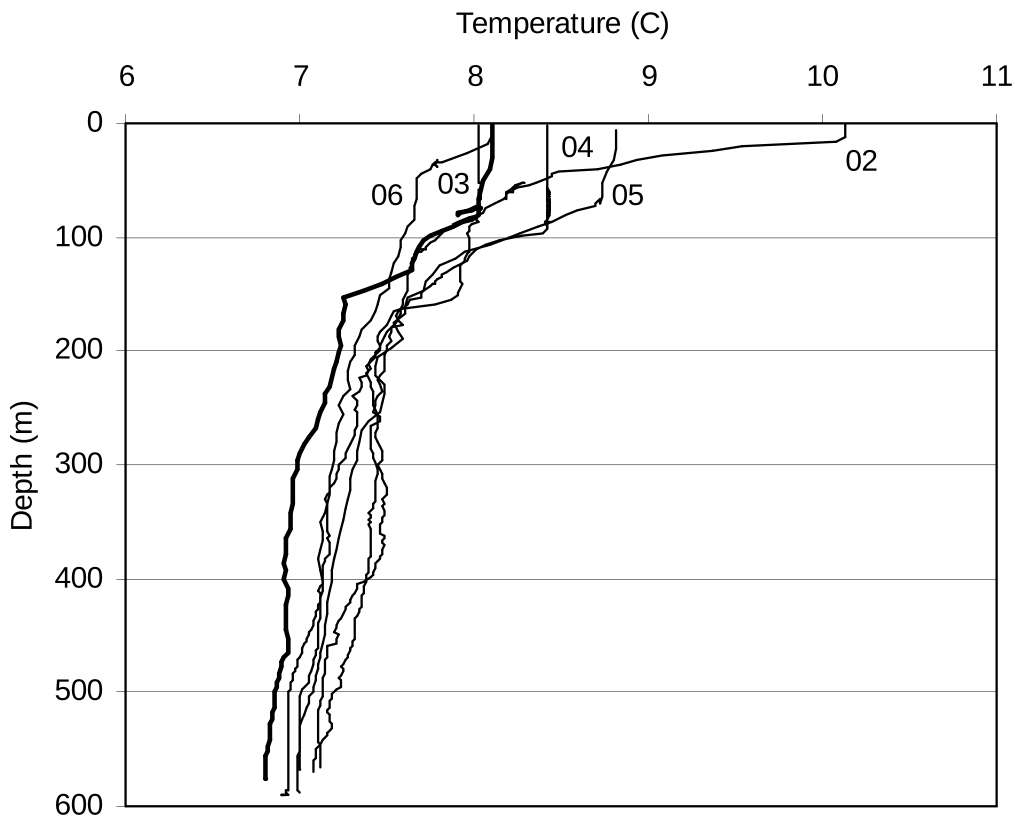


Figure 17: Comparison of vertical profiles of temperature from the net-mounted CTD on tows in stratum 9 at approximately 50 45’ S and 169 00’ E in 2002 (TAN0219 station 54, on 6 December), 2003 (TAN0317 station 45, on 29 November), 2004 (TAN0414 station 54, on 14 December), 2005 (TAN0515 station 42, on 6 December), 2006 (TAN0617 station 33, on 5 December), and 2007 (TAN0714 station 40, on 7 December). The profile from 2007 is the bold line. Labels on the other lines indicate the year (i.e., 2002 is ‘02’).

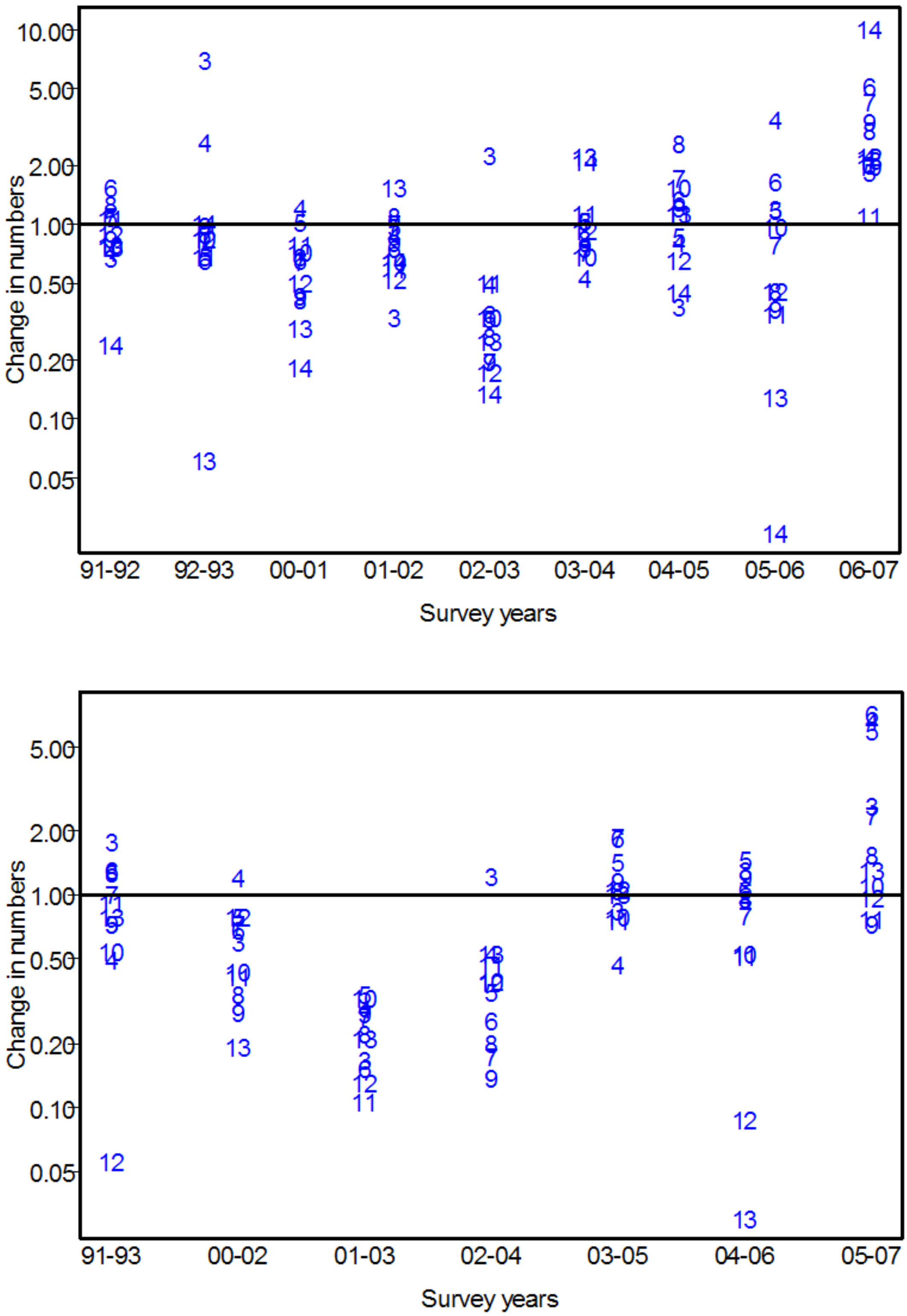


Figure 18: Change in the ratio of numbers of hoki by cohort between Sub-Antarctic trawl surveys one year (upper plot) and two years (lower plot) apart. The horizontal line (ratio of 1.0) indicates that there was the same number of hoki from that cohort observed in both surveys. A ratio of 5 indicates there were 5 times more hoki from that cohort observed in the second survey. Labels refer to the age of the fish in the first of the paired surveys (i.e., a label of 6 in the upper plot refers to fish aged 6 in the first survey and 7 in the second survey, and similarly fish labelled 6 in the lower plot are age 6 in the first survey and 8 in the second survey).

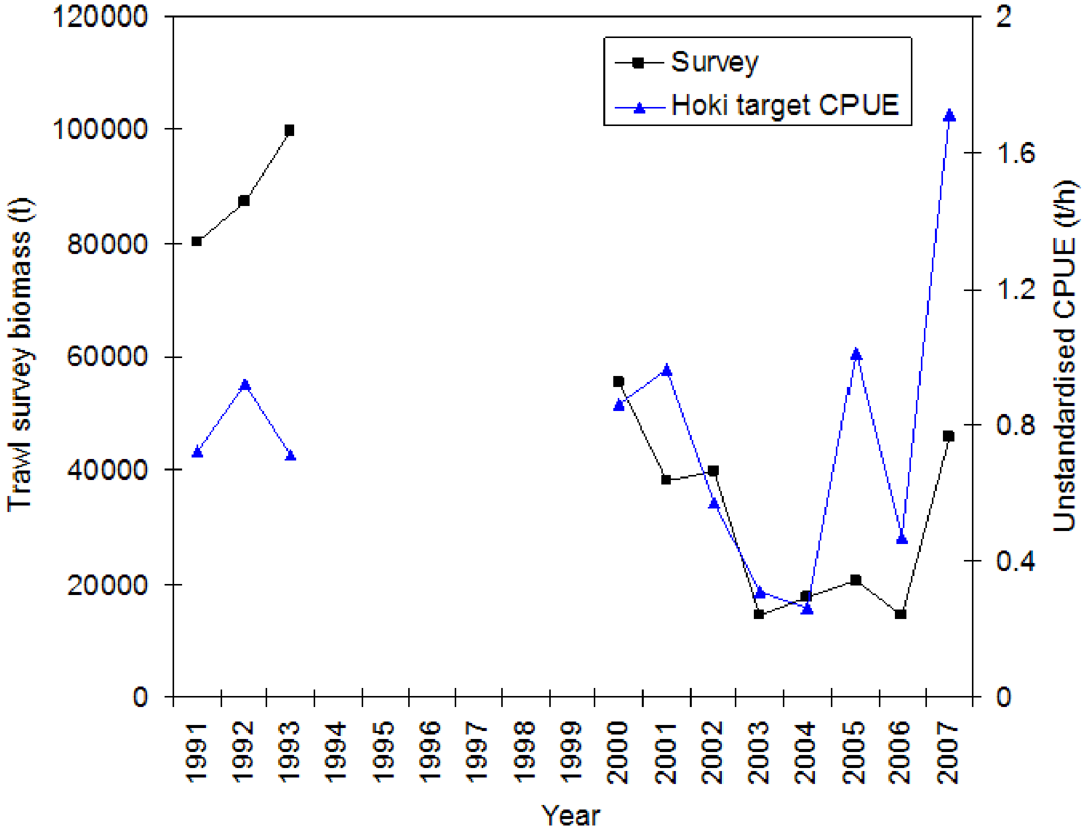


Figure 19: Annual unstandardised catch rates (tonnes per hour) of hoki in target bottom trawls in the Sub-Antarctic area during the trawl survey period (15 November to 23 December). Hoki abundance indices from the trawl survey are plotted for comparison.

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 thin and flabby; white or transparent.	Ovaries are developed, but no developing eggs are visible.
3	Ripening	Testes 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: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Agnatha			
Eptatretidae: hagfishes			
Eptatretus cirrhatus	hagfish	HAG	1
Chondrichthyes			
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	22
C. crepidater	longnose velvet dogfish	CYP	25
C. owstoni	smooth skin dogfish	CYO	12
C. plunketi	Plunket's shark	PLS	6
Deania calcea	shovelnose dogfish	SND	15
Etmopterus baxteri	Baxter's dogfish	ETB	38
E. lucifer	Lucifer dogfish	ETL	44
Scymnorhinus licha	seal shark	BSH	12
Somniosus rostratus	Little sleeper shark	SOM	1
Squalus acanthias	spiny dogfish	SPD	47
Proscylliidae: finback cat sharks			
Gollum attenuatus	slender smoothhound	SSH	1
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	2
Scyliorhinidae: cat sharks			
Apristurus spp	deepsea catsharks	APR	10
Halaelurus dawsoni	Dawson’s catshark	DCS	1
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	1
Rajidae: skates			
Bathyraja richardsoni	Richardson’s skate	RIS	1
B. shuntovi	longnosed deepsea skate	PSK	3
Dipturus innominata	smooth skate	SSK	12
D. nasuta	rough skate	RSK	6
Notoraja spp	bluntnosed skate	BTH	8
Notoraja asperula	smooth deepsea skate	BTA	15
N. spinifera	prickly deepsea skate	BTS	8
Chimaeridae: chimaeras, ghost sharks			
Chimaera sp	brown chimaera	CHP	4
Chimaera lignaria	giant chimaera	CHG	2
Hydrolagus bemisi	pale ghost shark	GSP	89
H. novaezelandiae	dark ghost shark	GSH	15
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	37
Rhinochimaera pacifica	widenose chimaera	RCH	13
Osteichthyes			
Notacanthidae: spiny eels			
N. sexspinis	spineback	SBK	39
Nemichthyidae: snipe eels			
Nemichthys spp	snipe eels	NEX	2
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	20
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	28
B. hirsutus	hairy conger	HCO	32

Appendix 2 cont: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Gonorynchiformes: sandfish			
Gonorynchus forsteri & *greyi*	sandfish	GON	5
Argentinidae: silversides			
Argentina elongata	silverside	SSI	38
Bathylagidae: deepsea smelts			
Bathylagus spp	deepsea smelt	DSS	2
Alepocephalidae: slickheads			
Alepocephalus australis	small-scaled brown slickhead	SSM	17
Alepocephalus sp.	big-scaled brown slickhead	SBI	1
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	4
Chauliodontidae: viperfishes			
Chauliodus sloani	viperfish	CHA	4
Stomiidae: scaly dragonfishes			
Stomias spp	scaly dragonfish	STO	4
Astronesthidae: snaggletooths			
Borostomias antarcticus		BAN	1
Melanostomiidae: scaleless black dragonfishes			
Melanostomias spp	scaleless black dragonfish	MEN	2
Opostomias micripnus	scaleless black dragonfish	OMI	1
Malacosteidae: loosejaws			
Species not identified	loosejaw	MAL	2
Idiacanthidae: black dragonfishes			
Idiacanthus sp	black dragonfish	IDI	3
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	Giant hatchetfish	AGI	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	6
Paralepididae: barracudinas			
Species not identified	barracudina	PAL	1
Myctophidae: lanternfishes			
Species not identified	lanternfish	LAN	8
Diaphus sp.		DIA	1
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	9
Austrophycis marginata	dwarf cod	DCO	2
Halargyreus johnsoni	Johnson's cod	HJO	20
Laemonema spp.		LAE	3
Lepidion microcephalus	small-headed cod	SMC	9
Mora moro	ribaldo	RIB	43
Pseudophycis bachus	red cod	RCO	11
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	30
Merlucciidae: hakes			
Lyconus sp		LYC	2
Macruronus novaezelandiae	hoki	HOK	98
Merluccius australis	hake	HAK	53

Appendix 2 cont: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Macrouridae: rattails, grenadiers			
Caelorinchus aspercephalus	oblique-banded rattail	CAS	48
C. bollonsi	Bollons's rattail	CBO	22
C. fasciatus	banded rattail	CFA	80
C. innotabilis	notable rattail	CIN	24
C. kaiyomaru	Kaiyomaru rattail	CKA	17
C. matamua	Mahia rattail	CMA	7
C. oliverianus	Oliver's rattail	COL	46
C. parvifasciatus	small-banded rattail	CCX	3
Coryphaenoides dossenus	humpback rattail	CBA	9
C. serrulatus	serrulate rattail	CSE	16
C . subserrulatus	fourrayed rattail	CSU	23
Lepidorhynchus denticulatus	javelinfish	JAV	94
Macrourus carinatus	ridge-scaled rattail	MCA	31
Mesobius antipodum	black javelinfish	BJA	7
Nezumia namatahi	squashed face rattail	NNA	1
Trachonurus villosus		TVI	2
Trachyrincus aphyodes	white rattail	WHX	11
Trachyrincus longirostris	unicorn rattail	WHR	7
Ventrifossa nigromaculata	blackspot rattail	VNI	8
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	86
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	3
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	2
Regalecidae: oarfishes			
Agrostichthys parkeri	ribbonfish	AGR	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	20
H. mediterraneus	silver roughy	SRH	6
Diremidae: discfishes			
Diretmus argenteus	discfish	DIS	4
Zeidae: dories			
Cyttus novaezealandiae	silver dory	SDO	5
C. traversi	lookdown dory	LDO	41
Lampridae: Opahs			
Lampris immaculatus	opah	PAH	1
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	6
Scorpaenidae: scorpionfishes			
Helicolenus spp	sea perch	SPE	6
Trachyscorpia capensis	cape scorpionfish	TRS	3
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	12
Neocyttus rhomboidalis	spiky oreo	SOR	6
Pseudocyttus maculatus	smooth oreo	SSO	16
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	2

Appendix 2 cont: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Psychrolutidae: toadfishes			
Cottunculus nudus	bonyskull toadfish	COT	2
Neophrynichthys angustus	pale toadfish	TOP	14
N. latus	dark toadfish	TOD	1
Psychrolutes sp	blobfish	PSY	5
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	2
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	2
E. robustus	cardinalfish	EPR	3
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	19
Xenobrama microlepis	bronze bream	BBR	1
Pentacerotidae: boarfishes, armourheads			
Pseudopentaceros richardsoni	southern boarfish	SBO	1
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	27
Gempylidae: snake mackerels			
Rexea solandri	gemfish	SKI	2
Trichiuridae: cutlassfishes			
Benthodesmus spp	scabbard fish	BEN	1
B. elongatus	scabbard fish	BNE	1
B. tenuis	scabbard fish	BNT	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	3
Icichthys australis	ragfish	RAG	1
Schedophilus huttoni		SUH	1
Seriolella caerulea	white warehou	WWA	30
S. punctata	silver warehou	SWA	12
Tubbia tasmanica		TUB	2
Bothidae: lefteyed flounders			
Neoachiropsetta milfordi	finless flounder	MAN	36

Other marine organisms

Porifera	unspecified sponges	ONG	1
Hexactinellida: glass sponges			
Hyalascus sp.	floppy tubular sponge	HYA	32
Pachastrellidae			
Thenea novaezelandiae	yoyo sponge	THN	1
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	7
Callyspongidae			
Callyspongia cf. *ramosa*	airy finger sponge	CRM	2
Callyspongia ramosa	airy finger sponge	CRS	1
Irciniidae			
Psammocinia cf. *hawere*	rubber sponge	PHW	3
Corallistidae: rock sponges			
Corallistes fulvodesmus	smooth white cup sponge	CFU	1
Hymedesmiidae			
Phorbas sp.	grey fibrous massive sponge	PHB	3

Appendix 2 cont: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Cnidaria			
Hydrozoa	Unidentified hydroid	HDR	1
Scyphozoa	unspecified jellyfish	JFI	3
Anthozoa			
Actiniaria	unspecified sea anemones	ANT	3
Actiniidae			
Bolocera spp	smooth deepsea anemone	BOC	3
Actinostolidae	deepsea anemone	ACS	32
Alcyoniidae			
Anthomastus spp		SOC	1
Hormathiidae	warty deepsea anemone	HMT	23
Liponematidae			
Liponema spp	deepsea anemone	LIP	1
Gorgonacea	gorgonian coral	GOC	2
Isididae: bamboo coral			
Lepisisis spp.	bamboo coral	LLE	1
Primnoidae			
Thouarella spp.	bottlebrush coral	THO	1
Scleractinia			
Flabellum spp	flabellum coral	COF	2
Epizoanthidae			
Epizoanthus sp.	zoanthid anemone	EPZ	2
Tunicata			
Thaliacea	unspecified salps	SAL	7
Mollusca			
Gastropoda: gastropods			
Ranellidae			
Fusitron magellanicus		FMA	6
Bivalvia			
Limidae			
Acesta maui	giant file shell	AMA	1
Pectinidae			
Zygochlamys delicatula	queen scallop	QSC	1
Cephalopoda: squid and octopus	unspecified squid	SQX	2
Teuthoidea: squids			
Architeuthidae: giant squids			
Architeuthis spp.	giant squid	GSQ	1
Cranchiidae: Glass squids			
Cranchiid spp.	glass squid	CHQ	1
Histioteuthidae			
Histioteuthis spp	violet squid	VSQ	3
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	21
Todarodes filippovae	Antarctic flying squid	TSQ	20
Onychoteuthidae			
Moroteuthis ingens	warty squid	MIQ	71
M. robsoni	warty squid	MRQ	7

Appendix 2 cont: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Pholidoteuthidae			
Pholidoteuthis massyae boschmai	large red scaly squid	PSQ	2
Octopoda: Octopus			
Octopodidae			
Graneledone spp	deepwater octopus	DWO	10
Opisthoteuthididae		OSQ	1
Opisthoteuthis spp.	umbrella octopus	OPI	1
Arthropoda			
Crustacea			
Decapoda			
Caridea			
Aristeidae			
Aristaeopsis edwardsiana	scarlet prawn	PED	1
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	25
Oplophoridae			
Acanthephyra pelagica		APE	2
Notostomus auriculatus		NAU	1
Pandalidae			
Plesionika martia	golden prawn	PLM	1
Pasiphaeidae			
Pasiphaea barnardi	deepsea prawn	PBA	6
Pasiphaea sp		PAS	1
Nephropidae: clawed lobsters			
Metanephrops challengeri	scampi	SCI	3
Lophogastridae			
Neognathophausia ingens	giant red mysid	NEI	1
Anomura			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	1
Lithodidae			
Lithodes cf *longispinus*	long-spined king crab	LLT	1
Lithodes murrayi	southern stone crab	LMU	5
Neolithodes brodiei		NEB	6
Majidae			
Jacquinotia edwardsii	giant spider crab	GSC	2
Leptomithrax garricki	Garrick's masking crab	GMC	1
Leptomithrax longipes	long-legged masking crab	LLC	1
Terratomaia richardsoni	spiny masking crab	SMK	2
Parapaguridae			
Parapagu latimanus		PAG	2
Echinodermata			
Asteroidea	unspecified asteroid	ASR	3
Brisingidae: Armless stars			
Brisinga sp.		BRG	1
Asteriidae			
Pseudechinaster rubens		PRU	2

Appendix 2 cont: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms.

Scientific name	Common name	Species code	Occ.
Zoroasteridae			
Zoroaster spp	rat-tail star	ZOR	38
Benthopectinidae			
Benthopecten spp.		BES	1
Echinasteridae			
Henricia compacta		HEC	1
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	20
Psilaster acuminatus	geometric star	PSI	2
Proserpinaster neozelanicus		PNE	1
Radiasteridae			
Radiaster gracilis		RGR	3
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	18
Hippasteria trojana	trojan star	HTR	22
Lithosoma novaezelandiae	rock star	LNV	12
Pillsburiester aoteanus		PAO	21
Mediaster arcatus		No code	1
Odontasteridae			
Odontaster benhami	pentagonal tooth-star	ODT	1
Pterasteridae			
Diplopteraster sp.		DPP	1
Solasteridae			
Crossaster japonicus	sun star	CJA	3
Solaster torulatus	chubby sun-star	SOT	3
Echinoidea	unspecified sea urchin	ECN	2
Cidaridae			
Goniocidaris parasol	Parasol urchin	GPA	2
Ogmocidaris benhami		OBE	1
Echinidae			
Derechinus horridus	deepsea urchin	DHO	1
Gracilechinus multidentatus	deepsea kina	GRM	1
Echinothuriidae	unspecified Tam O'Shanter urchin	TAM	20
Histocidaridae			
Histocidaris spp.		HIS	2
Poriocidaris purpurata		PCD	4
Ophiuroidea			
Gorgonocephalidae			
Gorgonocephalus sp	Gorgons head basket-star	GOR	1
Holothuroidea	unspecified sea cucumbers	HTH	4
Aspidochirotida			
Synallactidae			
Bathyplotes moseleyi		BAM	2
Pseudostichopus mollis		PMO	28