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Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2011 (TAN1117)

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EXECUTIVE SUMMARY

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The fourteenth *Tangaroa* summer trawl survey of the Southland and Sub-Antarctic areas was carried out from 24 November to 23 December 2011. Ninety eight trawls were successfully completed in 21 strata.

Biomass estimates (and c.v.s) for all strata were 46 757 t (15%) for hoki, 23 336 t (12%) for ling, and 2004 t (23%) for hake. The hoki biomass was lower than the 2009 estimate of 66 157 t but similar to estimates from 2007 and 2008, confirming the increase from the time-series low of 14 747 t recorded in 2006. The hake estimate from all strata in 2011 was higher than the equivalent estimate of 1602 t from 2009, but the hake biomass in stratum 25 (800–1000 m) at Puysegur was less than half of that observed in 2008 (1088 t in 2008 down to 450 t in 2009 and 2011). The biomass estimate for ling was similar to that in 2008 and 2009. There was no consistent trend in the abundance of nine other key species from 2009 to 2011: the estimate for southern blue whiting was nearly seven times lower than that recorded in 2009; the biomass of javelinfish continued downwards from the time series high in 2008; estimates for dark ghost shark in 2011 were higher than those recorded in 2009; while lookdown dory, ribaldo, spiny dogfish. white warehou, and black oreo had similar or lower estimates.

Hoki length frequencies in 2011 showed a broad size range from 35–113 cm. The strong cohort of fish between 45 and 58 cm observed as age 2+ fish in 2009 was not seen as a strong cohort of 4+ fish in 2011. Length modes from about 70–95 cm consisted of fish at ages 4–9. There were fewer larger, older female hoki of age 10 and above, but slightly more males age 8 and above compared with earlier surveys from 2002. Very few fish between 33 and 45 cm (age 1+) were taken in 2011.

The length frequency distribution of hake showed no clear modes. Small (50–70 cm) male hake, sometimes caught in high numbers at 800–1000 m depth at Puysegur (stratum 25), were not abundant in 2011. The evidence of recruitment with higher numbers of hake at age 3 for both sexes and age 4 for females observed in 2009 was not seen as strong year classes at ages 5 and 6 in 2011. The length distribution of ling was broad, with a slight decrease in the numbers of fish between 85 and 100 cm for females and more male ling between 68 and 87 cm. The age frequency for ling was similar to previous surveys with most fish between 3 and 16 years old, with the mode at age 6 for both sexes. The good recent recruitment of ling reported at ages 3 and 4 in 2008 did not clearly follow through to 2011 in the age frequencies.

Acoustic data were also collected during the trawl survey. Acoustic indices of mesopelagic fish abundance were the highest in the time-series, driven by an increase in backscatter on the eastern Campbell Plateau. 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 catch limit for hoki has been greatly reduced since 2000–01, hoki is still New Zealand’s largest fishery, with a TACC of 130 000 t from 1 October 2011. 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 at over 35 000 t in 1999–00 to 2001–02, declined to a low of about 8000 t in 2006–07, and then increased slowly to 13 800 t in 2010–11 (Ballara & O’Driscoll 2012). 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) was 70 000 t in 2011–12. Hake and ling are also important commercial species in Southland and the Sub-Antarctic. The catches of hake and ling in the southern areas in 2010–11 were 1904 t (HAK 1, includes the western Chatham Rise) and 3856 t (LIN 5, Southland), and 1335 t (LIN 6, Sub-Antarctic) (Ministry for Primary Industries 2012).

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 1991–93 and 2000–11; and an autumn series in March–June 1992, 1993, 1996 and 1998 (reviews by O’Driscoll & Bagley 2001 and Bagley et al. in press). The main focus of the early surveys (1991–93) was to estimate the abundance of hoki. The surveys in 1996 and 1998 were developed primarily for 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.

Hoki biomass estimates from the four surveys in 2003 to 2006 were the lowest observed in either the summer or autumn Sub-Antarctic trawl time-series. There was a very large (threefold) increase in estimates of hoki abundance between the 2006 and 2007 trawl surveys (Bagley et al. 2009). The biomass estimates from the last two surveys were also much higher than in 2003–06, increasing to 65 017 t in 2009 (O’Driscoll & Bagley 2009, Bagley & O’Driscoll 2012). Despite the large increase in the estimated hoki biomass, the 2007–09 estimates were still less than the biomass observed in the Sub-Antarctic in the early 1990s.

Other middle depth species monitored by this survey time series include commercial species such as hake, ling, lookdown dory and ribaldo, as well as a wide range of non-commercial fish and invertebrate species. For most of these species, the trawl survey is the only fisheries-independent estimate of abundance in the Sub-Antarctic, and the survey time-series fulfils an important “ecosystem monitoring” role (e.g., Tuck et al. 2009), as well as providing inputs into single-species stock assessment. A recent review of all the summer Sub-Antarctic trawl survey *Tangaroa* time series gave distributions, biomass estimates and trends for 134 species, and catch rates and population scaled length frequencies for a subset of 35 species (Bagley et. al. in press)

Acoustic data have been recorded during trawls and while steaming between stations on all trawl surveys of the Sub-Antarctic since 2000. Data from previous surveys were analysed to describe mark types (O’Driscoll 2001, O’Driscoll & Bagley 2003a, 2003b, 2004, 2006a, 2006b, 2008, 2009, Bagley et al. 2009, Bagley & O’Driscoll 2012), to provide estimates of the ratio of acoustic vulnerability to trawl catchability for hoki and other species (O’Driscoll 2002, 2003), and to estimate abundance of mesopelagic fish (McClatchie & Dunford 2003, O’Driscoll et al. 2009, 2011, Bagley & O’Driscoll 2012). Acoustic data also provide qualitative information on the amount of backscatter that is not available to the bottom trawl, either through being off the bottom, or over areas of foul ground.

Other work carried out concurrently with the trawl survey included sampling and preservation of unidentified organisms caught in the trawl.

The continuation of the time series of trawl surveys on the Southern Plateau is a high priority to provide information required to update the assessment of hoki and other middle depth species. In the 10-year Deepwater Research Programme, the survey is scheduled to be carried out biennially. The 2010 survey was postponed until 2011 due to the late arrival of the *Tangaroa* back from a major refit in Singapore. The 2011 survey provided a fourteenth summer estimate of western hoki biomass in time for the 2012 stock assessment.

1.1 Project objectives

The trawl survey was carried out under contract to the Ministry for Primary Industries (project MDT201001A). 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 collect data for determining 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.

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

5. 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 extensive 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 previous summer surveys using the *allocate* procedure of Bull et al. (2000) as modified by Francis (2006). Allocation of stations for hoki was based on the 2005–09 surveys, as these best reflect recent changes in hoki abundance. Allocation of stations for hake and ling was based on all surveys from 2000–09. A minimum of three stations per stratum was used. As in previous years, conservative target 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 for Primary Industries target c.v.s of 20% for hake and 15% for hoki and ling would be met. An additional 6 stations were added outside of the statistical framework because of the need to focus effort on covering the full distributional range of hake age classes. A total of 87 stations was planned for phase 1

(Table 1), with phase 2 stations to be allocated at sea to improve c.v.s for hoki, hake, and ling, 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 0500 h and 1957 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 ScanBas system), headline height (from a Furuno CN22 net monitor), and vessel speed (GPS speed over the ground, cross checked against distance travelled during the tow) were recorded every 5 min during each tow and average values calculated.

Petroleum exploration seismic surveying was planned in the Great South Basin (off the south east of the South Island) during this voyage. Liaison with the company involved with the seismic work ensured trawl survey stations with the area of operation were completed well before any seismic surveying commenced.

2.4 Acoustic data collection

Acoustic data were collected during trawling and while steaming between trawl stations (both day and night) with the *Tangaroa* multi-frequency (18, 38, 70, 120, and 200 kHz) Simrad EK60 echosounders with hull-mounted transducers. All frequencies were regularly calibrated following standard procedures (Foote et al. 1987), with the most recent calibration on 30 August 2011 in the Marlborough Sounds. The system and calibration parameters are given in Appendix 1 of O'Driscoll et al. (2012).

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, genus, or family. Unidentified organisms were collected and frozen at sea 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 2.

Liver and gutted weights were recorded from up to 20 hoki per station to determine condition indices.

Additional data were collected from deepwater shark species for Ministry of Primary Industries Research Project ENV2008/04, and a NIWA core-funded project. The number of eggs and the yolk diameter were measured from stage-3 female sharks (mature) to collect information on potential fecundity. Twenty hoki were sampled for muscle, liver and ovary tissues for a gene expression study of reproductive physiology.

2.7 Estimation of biomass and length frequencies

Doorspread biomass was estimated by the swept area method of Francis (1981, 1989). The analysis programme *SurvCalc* (Francis 2009) was used to calculate biomass. Formulae followed those of the original Trawl Survey Analysis program (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 key species. The group of 12 key species was defined by O'Driscoll & Bagley (2001), and comprises 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 trawl doors were caught.

Scaled length frequencies were calculated for the key species with *SurvCalc*, 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)). Sub-samples of 750 hoki otoliths, 580 ling and 600 hake otoliths were selected for ageing. Sub-samples were derived by randomly selecting otoliths from each of a series of 1 cm length bins covering the bulk of the catch, and then systematically selecting additional otoliths to ensure the tails of the length distribution were represented. The chosen sample size approximates that necessary to produce a mean weighted c.v. of less than 20% across all age classes.

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 measurements to improve the consistency of age estimation.

2.9 Acoustic data analysis

Acoustic analysis followed the methods applied to recent Sub-Antarctic trawl surveys (e.g., Bagley & O'Driscoll 2012) and generalised by O'Driscoll et al. (2011).

All acoustic recordings made during the trawl survey 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 the five frequencies. Most of the analyses in this report are based on the 38 kHz data as this frequency was the only one available (along with uncalibrated 12 kHz data) for all previous surveys that used the old CREST acoustic system (Coombs et al. 2003). We did not attempt to do a full multifrequency analysis of mark types for this report.

Descriptive statistics were produced on the frequency of occurrence of the seven different mark types: surface layers, pelagic layers, pelagic schools, pelagic clouds, bottom layers, bottom clouds, and bottom schools. Brief descriptions of the marks types are provided in previous reports (e.g., Bagley & O'Driscoll 2012). Example echograms may be found in O'Driscoll (2001).

As part of the qualitative description, the quality of acoustic data recordings was subjectively classified as 'good', 'marginal', or 'poor' (see 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 and night steam recordings using custom Echo Sounder Package (ESP2) software (McNeill 2001). Estimates of the mean acoustic backscatter per square kilometre from bottom referenced marks (bottom layers, clouds, and schools) were calculated for each recording based on integration heights of 10 m, 50 m, and 100 m above the detected acoustic bottom. Total acoustic backscatter was also integrated throughout the water column in 50 m depth bins. Acoustic density estimates (backscatter per km^2) from bottom-referenced marks were compared with trawl catch rates (kg per km^2). 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).

O'Driscoll et al. (2009, 2011) developed a time series of relative abundance estimates for mesopelagic fish on the Sub-Antarctic based on that component of the acoustic backscatter that migrates into the upper 200 m of the water column at night (nyctoepipelagic backscatter). We updated the mesopelagic time series to include data from 2011. The methods were the same as those used by O'Driscoll et al.

(2011) and Bagley & O'Driscoll (2012). Day estimates of total backscatter were calculated using total mean area backscattering coefficients estimated from each trawl recording. Night estimates of demersal backscatter were based on data recorded while steaming between 2000 h and 0500 h NZST. Acoustic data were stratified into three broad subareas (O'Driscoll et al. 2011):

1. Puysegur: 165° 00′E – 168° 00′E, 46° 00′S – 48° 00′S
2. West Sub-Antarctic: 165° 00′E – 169° 00′E, 48° 00′S – 54° 00′S
3. East Sub-Antarctic: 169° 00′E – 176° 00′E, 46° 00′S – 54° 00′S

3. RESULTS

3.1 Survey coverage

The trawl survey and acoustic work contracted for this voyage were successfully completed. Weather conditions were moderate for most of the voyage with about 1.5 days lost due to unfavourable sea conditions.

Ninety eight successful trawl survey stations were completed in 21 strata (Figure 2, Table 1). This total included 87 phase 1 stations and 11 phase 2 stations. One phase 2 station was completed during phase 1 of the survey in stratum 13 due to variable catches of hoki and because of the long steaming distance to return to this area for any phase 2 work. Other phase 2 effort was directed at reducing the c.v. for hake in stratum 3B after a catch of 1.3 t, and increasing the number of hake sampled in stratum 25.

Five stations were considered unsuitable for biomass estimation: station 41 came fast and the net suffered minor damage; station 60 was rejected due to a main engine shut down during hauling; tow 71 was rejected due to an unacceptably high headline height and poor bottom contact; tow 88 where foul ground necessitated hauling early; and tow 1 was a gear trial shot to test the trawl systems and electronics conducted enroute to the survey area in the Canterbury Bight.

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 (as in 2003, 2004 and 2006). Single specimens of hoki, and hake, and two ling were caught in this stratum in 2011. Station details are given in Appendix 1.

3.2 Gear performance

Gear parameters by depth and for all observations are summarised in Table 2. The headline height was obtained for all successful tows, and doorspread readings were available for 95 of the 98 valid biomass tows. Missing doorspread values were calculated from data collected in the same depth range on this voyage. Measured gear parameters in 2011 were within the range of those obtained on other voyages of *Tangaroa* in this area when the same gear was used (Table 3), Mean doorspreads for the 2007–09 surveys have been slightly lower than earlier surveys (Bagley & O'Driscoll 2012). During an overhaul of the trawl doors in 2010 one door was found to be slightly twisted. Repairs were made and the 2011 mean doorspreads increased by about 4–6 m. 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 47.5 t was recorded from all trawl stations (45.8 t from valid biomass tows). For the key species hoki accounted for 33.4%, ling 15.8%, and hake 7.9% of the total catch, while 5.4% of the catch was javelinfish, 4.4 % shovelnosed dogfish and 4.2% pale ghost shark. From the 209 species or species groups caught: 97 were teleosts, 28 elasmobranchs, 9 cephalopods, and 22 crustaceans (Appendix 3). Specimens retained for later identification ashore are listed in Appendix 4.

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 key 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 (Table 6). The time series of core estimates for the 12 key species are plotted in Figure 3.

The biomass estimate for hoki for all strata in 2011 was 46 757 t. This was a decrease of 29% from the 2009 estimate of 66 157 t. However the 2011 estimate again confirmed the large increase from the time series low in 2006 of 14 747 t (Figure 3). The hoki biomass from core stations was 46 070 t, with few hoki caught deeper than 800 m. The biomass estimates for length ranges corresponding to ages 1+ (less than 45 cm) and 2+ (45–57 cm) hoki were 16 t (c.v. 100%) and 2271 t (c.v. 21%) respectively. The biomass of age 1+ hoki (2010 year-class) was the smallest ever recorded from the time series with fish of this size only caught on one station. The biomass of 2+ fish (2009 year-class) was much less that in 2009 (11 124 t) which was the highest in the time series, but still higher than 2007 and 2008 estimates. The biomass of fish age 3+ or greater decreased to 43 913 t in 2011 from 52 564 t in 2009, with smaller catches in some of the eastern strata. Despite the large increases from 2007 the hoki biomass is still much lower than the biomass observed in the Sub-Antarctic in the early 1990s (Table 6).

The hake estimate from all strata was 2004 t, higher than 2009 (1602 t), but lower than that in 2008 (2355 t). The estimate from core 300–800 m strata (1434 t) increased from the 2009 survey when the estimate was the lowest in the summer time series at 992 t. The hake biomass in stratum 25 at Puysegur (800–1000 m) was 450 t, the same as in 2009, but less than half that observed in 2008 (1088 t) (see Table 6).

The estimate of ling biomass in 2011 was 23 336 t, similar to the estimates of 22 772 t in 2009 and 22 879 t in 2008 (Table 6).

Of the nine other key species, only dark ghost shark increased from the 2009 estimate for the total survey area. Most changes were generally small and within the levels of the sampling uncertainty (Figure 3). However, the biomass of southern blue whiting was nearly seven times lower than the highest biomass recorded in the summer time series in 2009 and javelin fish dropped further from the time series high in 2008 to below half of the 2009 estimate. White warehou dropped from 2093 t in 2009 to 393 t in 2011, but high c.v.s associated with higher estimates indicate that these are typically the result of one-off large catches. Estimates for pale ghost shark, ribaldo, black oreo, lookdown dory, spiny dogfish were also lower than in 2009 (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 79 of the 80 core stations and 95 of the 98 successful total trawl stations. As in previous surveys, hoki catch rates were generally higher in the west, on the edge of the Stewart-Snares shelf, on the western side of the Campbell Rise, and at Puysegur (Figure 4a). Larger catches (greater than 1400 kg km^{-2}) were taken: on the edge of the Stewart/Snares shelf in strata 3A and 3B; and at Puysegur in stratum 1. Small 1+ hoki were caught at only one station. The catch of 2+ hoki followed a similar distribution to that observed in previous surveys, and were taken in stratum 1 (300–600 m) at Puysegur and in the 300–600 m strata (3A and 3B) along the edge of the Stewart-Snares shelf (Figures 4b and 4c).

Hake catches were dominated by a single large catch of spawning fish in stratum 3B (Figure 5).
Hake were also concentrated in deeper water at Puysegur in stratum 25 (800–1000 m). Most stations in the east and south of the survey area caught no hake. Ling were caught on 83 of the 98 stations, with higher catches at Puysegur (Figure 6). Both hoki and ling were seldom caught deeper than 800 m. As noted in Section 3.1, one hoki, one hake, and two ling were taken in stratum 26 (800–1000 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 1576 hoki, 1151 ling, and 889 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 key species for the 2011 survey only are shown in Figure 10.

Hoki length frequencies in 2011 showed a broad size range. The overall length range was similar to the 2009 survey (Figure 7), however there were few fish at age 1+. The strong cohort of fish between 45 and 58 cm observed as age 2+ fish in 2009 was not obvious as a strong cohort of 4+ fish in 2011. Length modes from about 70–95 cm consisted of fish at ages 4–9. The strong 2002 year-class observed at younger ages in the 2007–2009 surveys followed through weakly at age 9 in 2011 (Figure 11). There were few larger, older female hoki of age 10 and above, but slightly more males age 8 and above compared with earlier surveys from 2002. Very few fish between 33 and 45 cm (age 1+) were taken in 2011, with only 49 fish of this size caught. Similarly low numbers of 1+ hoki were recorded from surveys in 2000–2002.

The length frequency distribution of hake showed no clear modes (see Figure 8). Small (50–70 cm) male hake were not captured in high numbers at 800–1000 m depth at Puysegur (stratum 25) in 2011, although there were similarities in the length frequency of females with those from previous surveys. The one off large catch of 1.3 t of hake in stratum 3B consisted of mostly males and is reflected in the core strata length frequency for 2011. Hake were taken in low numbers outside strata 25 and 3B. Since 1998 there has been a lower proportion of large hake (older than age 12) than were observed in surveys in the early 1990s (Figure 12). The evidence of recruitment with higher numbers of hake at age 3 for both sexes and age 4 for females observed in 2009 was not seen as strong year classes at ages 5 and 6 in 2011.

The length frequency distribution of ling was broad, with a slight decrease in the numbers of fish between 85 and 100 cm for females and more small male ling between 68 and 87 cm (see Figure 9). The age frequency for ling was similar to previous surveys with most fish between 3 and 16 years old, with the mode at age 6 for both sexes (Figure 13). The good recent recruitment of ling reported at ages 3 and 4 in 2008 (O’Driscoll & Bagley 2009) did not clearly follow through to the 2009 or 2011 age frequencies.

The length frequency distribution of southern blue whiting caught in 2011 had main length modes between 33 and 43 cm for both sexes with modal peaks of 36 cm for males and 38 cm for females (Figure 10). The very strong mode seen in 2009 between 28 and 37 cm (Bagley & O’Driscoll 2012) was not evident as larger fish. Black oreo showed two modes at 22–26 cm and 28–35 cm (see Figure 10). Other points of interest in Figure 10 included: a large mode at 42–44 cm in the length distribution for female and unsexed javelinfish; the continuing high proportion of female ribaldo; and the difference in the length frequencies of male and female spiny dogfish caught in 2011.

Gonad stages for hoki, hake, and ling are summarised in Table 9. Immature hoki made up 32% of fish examined, and these were typically fish smaller than 70 cm. Most adult hoki (65%) were in the resting phase. About 1% of female and male hoki were macroscopically staged as partially spent (males) or spent (females). Female ling were mostly resting (69%) or immature (15%), but male ling of all gonad stages were recorded, with 35% in spawning condition (ripe and running ripe) and 39% resting. Immature stage hake made up 11% of the observations for both sexes. About 61% of male hake were ripe or running ripe, while 66% females were resting and maturing.

3.7 Hoki condition indices

Liver and gutted weights were recorded from 1308 hoki in 2011. Liver condition was higher in 2011 than that in 2008 or 2009, and close to the long-term average (Table 10). Somatic condition (measured as the estimated average weight of a 75 cm hoki) was the highest observed in the summer time series (Table 11).

3.8 Acoustic results

A total of 261 acoustic data files (101 trawl, 70 day steam, and 90 night-time) was recorded during the 2011 survey. Data quality was good for about half of the time, but deteriorated during periods of bad weather. About 17% of the acoustic files were considered too noisy to be analysed quantitatively (Table 12).

Expanding symbol plots of the distribution of total acoustic backscatter from good and adequate quality recordings observed during daytime trawls and night transects are shown in Figure 14. As noted by O'Driscoll et al. (2011), there is a consistent spatial pattern in total backscatter, with highest acoustic densities at Puysegur and on the Stewart-Snares shelf and lowest densities in the southeastern Sub-Antarctic.

The frequency of occurrence of each of the seven mark categories is given in Table 13. Often several types of mark were present in the same echogram. The percentage occurrence of acoustic mark types was generally similar to that observed in previous surveys, but higher percentages of pelagic layers and clouds were observed in 2011 (Table 13).

Surface layers were observed in 91% of daytime steam echograms, 83% of trawls, and 96% of night echograms in 2011 (Table 13). 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 are likely to 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 53% of day steam files, 27% of overnight steams, and 35% of trawl files in (Table 13). Bottom schools were occasionally observed during the day, mostly in less than 600 m water depth. In previous surveys, bottom schools were sometimes associated with catches of southern blue whiting in the trawl (O'Driscoll 2001, O'Driscoll & Bagley 2006b, 2009, Bagley et al. 2009, Bagley & O'Driscoll 2012). Pelagic and bottom layers tend to disperse at night, to form pelagic and bottom clouds respectively. However, dispersed cloud marks were also frequently observed in daytime recordings during trawls and while steaming in 2011 (Table 13).

The vertical distribution of acoustic backscatter in 2011 is compared to the average vertical distribution from all years in the Sub-Antarctic time-series in Figure 15. The pattern of diel vertical migration was less apparent in 2011 than in previous years. In 2011, most of the backscatter was concentrated in the upper 200 m both day and night (Figure 15). However, the proportion of backscatter shallower than 200 m increased at night and fish were more widespread through the water column during the day, indicating that some components were vertically migrating.

The time-series of day and night estimates of total acoustic backscatter are plotted in Figure 16. In surveys from 2000–09, night estimates of total backscatter were always higher than day estimates, which O'Driscoll et al. (2009) suggested might be due to increased noise in night data. In 2011, day and night estimates of total backscatter were very similar (Figure 16). Backscatter in the bottom 50 m has been relatively consistent since 2000, but increased in 2011 and was the highest in the time-series (Figure 16).

O'Driscoll et al. (2011) developed a day-based estimate of mesopelagic fish abundance in the Sub-Antarctic by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same subarea and year that was observed in the upper 200 m (Table 14). The estimated acoustic indices calculated using this method are summarised in Table 15 and plotted in Figure 17 for the entire sub-Antarctic and for the three subareas. The mesopelagic indices for the Sub-Antarctic are similar to estimates of total backscatter (see Figure 16). The indices decreased from 2000 to 2006, but have subsequently increased, and the estimate from 2011 was the highest in the acoustic time-series. The increase in 2011 was largely due to increased mesopelagic backscatter in the eastern subarea (Figure 17). An example of an echogram from the eastern Campbell Plateau is given in Figure 18, showing relatively strong mesopelagic marks in the upper 200 m during the day (consistent with the vertical distribution summarised in Figure 15). Mesopelagic indices for the western subarea were similar in 2008–11, and the index for Puysegur had declined from 2009 (see Figure 17). Because the station density at Puysegur was disproportionate to its small area (only 1.5% of total Sub-Antarctic area), stratification reduced the influence of the Puyegur subarea on the overall index.

There was a weak positive correlation between acoustic backscatter in the bottom 50 m during the day and trawl catch rates (Figure 19). Weak, but significant, positive correlations between backscatter and catches have been observed in previous surveys in 2000, 2001, 2003, 2005, 2007, 2008, and 2009 (O'Driscoll 2002, O'Driscoll & Bagley 2003a, 2004, 2006b, 2009, Bagley et al. 2009, Bagley & O'Driscoll 2012), but not in 2002, 2004, or 2006 (O'Driscoll & Bagley 2003b, 2006a, 2008).

3.9 Hydrological data

Temperature profiles were available from 101 CTD casts and included foul shots. Surface (5 m depth) temperatures ranged between 7.5 and 13.5 °C (Figure 20), while bottom temperatures were between 4.5 and 10.1 °C (Figure 21). Bottom temperature decreased with depth, with lowest bottom temperatures recorded from water deeper than 800 m on the margins of the Campbell Plateau. Highest surface temperatures were at Puysegur, while the highest bottom temperatures were at Puysegur and in stratum 3B at the bottom of the Stewart/Snares shelf. As in previous years, there was a general trend of increasing water temperatures towards the north and west (Figures 20–21).

The average surface temperature in 2011 of 9.1 °C was similar than that observed in 2009 (9.0 °C), and within the range of average surface temperatures observed in 2002–07 (8.8–10.3 °C). In general there is a negative correlation between surface temperature and depth of the thermocline (Figure 22), with cooler surface temperatures in years when the thermocline is deep (e.g., 2003), and warm 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. This was in keeping with observations in 2011 with mostly moderate weather during the survey. Average bottom temperatures in 2011 were the same as observed in 2009 (7.0 °C) and were within the range of average temperatures observed in 2002–08 (6.7–7.0 °C). 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 large (threefold) increase in estimates of hoki abundance between the 2006 and 2007 trawl surveys (Bagley et al. 2009). This biomass increase was sustained in 2008, with a further increase in 2009 (O'Driscoll & Bagley 2009, Bagley & O'Driscoll 2012). The 2011 abundance estimate was similar to that in 2007 and 2008, but 29% lower than the estimate from 2009.

The series of Sub-Antarctic trawl indices for hoki could not be fitted by the stock assessment model after the threefold increase in estimated biomass between the 2006 and 2007 surveys, even when the survey biomass observations were upweighted (McKenzie & Francis 2009, McKenzie 2012). Furthermore, the trawl survey data shows large annual changes in numbers-at-age which cannot be explained by changes in abundance, and are suggestive of a change in catchability for the survey.

Bagley et al. (2009) reported that any apparent changes in trawl survey catchability were unlikely to be related to changes in gear or gear performance. The trawl has been within consistent specifications throughout the time series (see Table 3). Average doorspread measurements decreased slightly (but significantly) in 2007–09. After a routine overhaul and the removal of a slight twist in one of the doors in 2010, the 2011 survey mean was similar to the pre 2007 averages. Some care needs to be made interpreting these values as SCANMAR reports the accuracy of the sensors to plus or minus 3% of the displayed value. Further, Bagley et al. (2009) found that unstandardised commercial catch rates of hoki during the survey period also increased considerably from 2006 to 2007, suggesting that any change in hoki catchability was not restricted to the research survey. The catch of other species over the same period have not shown the same pattern as hoki, although biomass estimates in core strata for 11 of the 12 key species increased from 2006 to 2007 (see Figure 3). This supports the hypothesis that there was a change in catchability between these two surveys. There was no such consistent change in catchability between the 2009 and 2011 surveys: five species (look-down dory, javelinfish, southern blue whiting, spiny dogfish and white warehou) biomass estimates decreased; black oreo, ribaldo, ling and pale ghost shark were similar; and dark ghost shark increased.

In 2010 and 2012, an alternative approach to upweighting was used for Sub-Antarctic trawl indices, which assumed that the catchability changed over time (Ministry of Fisheries 2010, Ministry for Primary Industries 2012). This alternative approach was explored in runs in which two catchabilities were fitted for the Sub-Antarctic series, instead of just one, and were found to improve the fit substantially. All stock assessment model runs showed that the biomasses of the eastern and western hoki stocks were at their lowest points in about 2005 and are now increasing, and that the W stock experienced seven consecutive years of poor recruitment from 1995 to 2001 inclusive. However, recruitment for the W stock is estimated to have been near or above average in the last four years, except for in 2010 where it is below average (Ministry for Primary Industries 2012). The current status of the W stock is similar to that in the 2011 assessment. Biomass is estimated to have nearly tripled from a historical low of 14% B_0 that occurred in 2004. According to the Harvest Strategy Standard the western stock is now considered to be fully rebuilt (at least a 70% probability that the target has been achieved) (Ministry for Primary Industries 2012).

5. CONCLUSIONS

The hoki biomass in 2011 was similar to the estimates in 2007 and 2008 but lower than 2009. However biomass estimates were above the levels of surveys in 2001 to 2006. The overall abundance in 2009 was boosted by a high estimate of 2+ hoki, and this did not follow through as a strong year class in 2011. The biomass of fish age 3+ or greater decreased to 43 913 t in 2011 from 52 564 t in 2009 with smaller catches in some of the eastern strata. Very few hoki, at age 1+ were caught in 2011 - the biomass of this age-class was the lowest (16 t) in the time series. The hoki age frequency observed in 2011 comprised mostly of fish between 4–9 years old with a progression of modes associated with the 2002–09 year classes. The strong 2+ year class seen in 2009 did not track through in 2011 as age 4+ fish.

The survey methodology was consistent with previous years, but it has been suggested that trawl catchability was unusually high in 2007–09 or unusually low in 2003–06 (Ministry of Fisheries 2010). Despite the large increase in the estimated hoki biomass in the past four surveys the 2011 estimate is still less than the biomass observed in the Sub-Antarctic in the early 1990s.

The hake biomass from all and core strata was higher than that in 2009, mainly due to a one off large catch. This is reflected in the c.v.s for hake, with 2011 having the highest c.v. for all strata in the time series and second highest for core strata. A similar one off large catch occurred in 1991 accounting for the highest c.v. in the time series for the core survey area. Hake are known to aggregate to spawn at this time of year, often over rough ground untrawlable with our standard survey trawl. The 1991 and 2011 catches comprised of spawning hake caught close to the known spawning area at the southern edge of the Stewart/Snares shelf.

The biomass estimate for ling was very similar to that in 2008 and 2009. There was no consistent increase or decrease from the time series in the abundance of the nine other key species. However large decreases continued for javelinfish from the 2008 survey and southern blue whiting from the 2009 survey.

Acoustic indices of mesopelagic fish abundance were the highest in the time-series, driven by an increase in backscatter on the eastern Campbell Plateau. There was a weak positive correlation between acoustic density from bottom marks and trawl catch rates.

6. ACKNOWLEDGMENTS

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Table 1: Stratum areas, depths, and number of successful biomass stations from the November–December 2011 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	7	7	
3b	Stewart-Snares	300 -600	1 556	4	4	7
4	Stewart-Snares	600–800	21 018	4	4	
5a	Snares-Auckland	600–800	2 981	5	5	
5b	Snares-Auckland	600–800	3 281	4	4	
6	Auckland Is.	300–600	16 682	3	3	
7	South Auckland	600–800	8 497	3	3	
8	N.E. Auckland	600–800	17 294	4	4	
9	N. Campbell Is.	300–600	27 398	6	6	
10	S. Campbell Is.	600–800	11 288	3	3	
11	N.E. Pukaki Rise	600–800	23 008	6	6	
12	Pukaki	300–600	45 259	6	6	
13	N.E. Camp. Plateau	300–600	36 051	3	3	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	5	5	3
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	87	87	11

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	2.98	0.17	2.20–3.37
Tow speed (knots)	98	3.5	0.04	3.3–3.6
Gear parameters (m)				
300–600 m				
Headline height	45	7.0	0.30	6.5–7.8
Doorspread	44	117.7	6.16	101.2–128.1
600–800 m				
Headline height	35	6.9	0.22	6.5–7.3
Doorspread	34	120.8	6.19	109.6–130.5
800–1000 m				
Headline height	18	6.9	0.20	6.5–7.4
Doorspread	17	124.6	4.60	116.3–133.2
All stations 300–1000 m				
Headline height	98	6.9	0.26	6.5–7.8
Doorspread	95	120.0	6.39	101.2–133.2

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
2008	92	115.5	5.05	103.8	128.3	6.9	0.22
2009	81	116.6	7.07	93.8	129.7	7.0	0.21
2011	95	120.0	6.39	101.2	133.2	6.9	0.26

Table 4: Biomass estimates, coefficients of variation, and catch of the 20 species with highest catch weights in the 2011 Sub-Antarctic trawl survey. Estimates are from successful biomass stations for all strata combined. Biomass estimates from 2009 (from Bagley & O'Driscoll 2012) are shown for comparison.

		2011 (TAN0117)			2009 (TAN0911)		
Species	Species code	Catch (kg)	Biomass (t)	c.v. (%)	Catch (kg)	Biomass (t)	c.v. (%)
Hoki	HOK	15 311	46 575	15	21 772	66 157	16
Ling	LIN	7 393	23 336	12	4 321	22 772	10
Hake	HAK	3 883	2 004	23	2 135	1 602	18
Javelinfish	JAV	2 498	9 140	25	4 785	21 663	16
Shovelnosed dogfish	SND	2 076	1 082	14	1 637	999	28
Pale ghost shark	GSP	1 945	12 579	9	1 945	13 553	9
Ridge-scaled rattail	MCA	1 164	9 913	25	961	7 610	28
Spiny dogfish	SPD	853	1 941	19	1 838	4 296	34
Southern blue whiting	SBW	830	7 642	31	4 686	51 860	75
Baxter's lantern dogfish	ETB	819	5 088	28	695	3 008	17
Longnose velvet dogfish	CYP	755	2 723	42	1 710	2 575	24
Black oreo	BOE	574	2 038	36	1 289	4 888	52
Dark ghost shark	GSH	520	3 709	75	173	433	43
Smooth oreo	SSO	500	2 181	54	1 942	6 324	86
Deepwater spiny dogfish	CSQ	446	680	31	874	1 104	34
White warehou	WWA	443	393	27	1 043	2 093	65
Ribaldo	RIB	382	1 050	17	465	1 255	13
Warty squid	MIQ	374	1 920	11	318	1 779	11
Small-scaled brown slickhead	SSM	350	2 769	16	575	2 587	11
Oliver's rattail	COL	329	1 324	31	655	3 058	24
Total catch (all species)		45 839			64 202		

Table 5: Estimated biomass (t) and coefficients of variation (%, below in parentheses) of the 12 key species by stratum. Species codes are given in Appendix 3. 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	635	1 909	8	0	1	3
	(30)	(69)	(44)		(100)	(100)
2	386	127	56	0	0	4
	(32)	(20)	(95)			(24)
3a	2 645	1 373	21	0	1	124
	(51)	(31)	(52)		(100)	(28)
3b	1 208	147	401	0	42	8
	(24)	(16)	(78)		(37)	(53)
4	1 536	1 778	211	56	0	665
	(24)	(64)	(48)	(61)		(18)
5a	164	160	145	0	1	40
	(30)	(29)	(48)		(100)	(41)
5b	806	371	119	0	0	447
	(55)	(43)	(66)			(23)
6	4 812	1 664	0	0	3 665	165
	(56)	(7)			(76)	(76)
7	1 274	678	0	0	0	86
	(69)	(53)				(43)
8	5 945	1 635	194	11	0	1 933
	(31)	(47)	(100)	(100)		(20)
9	10 949	4 959	160	0	0	1 610
	(36)	(26)	(74)			(25)
10	877	75	102	0	0	165
	(52)	(100)	(100)			(42)
11	2 106	365	16	58	0	335
	(29)	(70)	(100)	(92)		(29)
12	6 019	3 286	0	0	0	3 426
	(38)	(17)				(23)
13	5 700	2 632	0	0	0	1 942
	(59)	(39)				(23)
14	328	1 610	0	0	0	659
	(47)	(41)				(48)
15	859	408	0	0	0	63
	(83)	(19)				(72)
Subtotal (strata 1–15)	**46 070**	**23 178**	**1 434**	**125**	**3 709**	**11 677**
	(15)	**(12)**	**(30)**	**(52)**	**(75)**	**(10)**
25	131	15	451	0	0	7
	(50)	(49)	(31)			(41)
Subtotal (strata 1–25)	**46 200**	**23 194**	**1 885**	**125**	**3 709**	**11 684**
	(15)	**(12)**	**(24)**	**(52)**	**(75)**	**(10)**
26	46	138	64	0	0	477
	(100)	(100)	(100)			(41)
27	385	0	0	463	0	178
	(67)			(84)		(43)
28	125	5	54	1 450	0	240
	(66)	(100)	(59)	(42)		(23)
Total (All strata)	**46 757**	**23 336**	**2 004**	**2 038**	**3 709**	**12 579**
	(15)	**(12)**	**(23)**	**(36)**	**(75)**	**(9)**

Table 5 (cont): Estimated biomass (t) and coefficients of variation (%, below in parentheses) of the 12 key species by stratum. Species codes are given in Appendix 3. 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	21	7	2	0	65	81
	(44)	(40)	(100)		(100)	(79)
2	54	6	29	0	0	1
	(17)	(32)	(39)			(100)
3a	101	25	6	1	334	13
	(38)	(30)	(100)	(65)	(59)	(39)
3b	8	11	0	0	59	64
	(45)	(36)			(19)	(36)
4	2 829	0	138	0	148	19
	(74)		(41)		(69)	(100)
5a	61	11	70	0	0	7
	(52)	(55)	(17)			(61)
5b	684	0	12	1	73	12
	(29)		(41)	(59)	(38)	(100)
6	61	9	0	2 513	252	0
	(31)	(100)		(86)	(52)	
7	371	58	43	0	0	10
	(32)	(67)	(50)			(100)
8	1 723	0	236	363	104	41
	(37)		(36)	(58)	(78)	(100)
9	590	13	81	1 340	125	23
	(75)	(100)	(38)	(62)	(34)	(100)
10	496	0	210	0	0	15
	(24)		(49)			(100)
11	718	0	19	70	0	0
	(29)		(100)	(75)		
12	408	209	48	2 036	470	32
	(29)	(51)	(100)	(22)	(52)	(64)
13	226	0	0	942	213	0
	(9)			(30)	(58)	
14	242	0	15	306	97	29
	(39)		(100)	(53)	(61)	(100)
15	267	0	107	71	0	44
	(59)		(66)	(100)		(100)
Subtotal (strata 1–15)	**8 860**	**349**	**1 017**	**7 642**	**1 941**	**390**
	(26)	**(33)**	**(17)**	**(31)**	**(19)**	**(27)**
25	181	0	33	0	0	3
	(24)		(29)			(100)
Subtotal (strata 1–25)	**9 041**	**349**	**1 050**	**7 642**	**1 941**	**393**
	(25)	**(33)**	**(17)**	**(31)**	**(19)**	**(27)**
26	6	0	0	0	0	0
	(100)					
27	53	0	0	0	0	0
	(29)					
28	39	0	0	1	0	0
	(76)			(100)		
Total (All strata)	**9 410**	**349**	**1 050**	**7 642**	**1 941**	**393**
	(25)	**(33)**	**(17)**	**(31)**	**(19)**	**(27)**

Table 6: Time series of biomass estimates of hoki and hake 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
	2008	46 980	14	48 340	14
	2009	65 017	16	66 157	16
	2011	46 070	15	46 757	15
	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
	2008	1 074	23	2 355	16
	2009	992	22	1 602	18
	2011	1 434	30	2 004	23
	Autumn series				
	1992	5 028	15		
	1993	3 221	13		
	1996	2 026	12	2 825	12
	1998	2 506	18	3 898	16

Table 6 cntd: Time series of biomass estimates of 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. (%)
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
	2008	22 831	10	22 879	10
	2009	22 713	10	22 772	10
	2011	23 178	12	23 336	12
	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	193	79	44	28	158	21
Antarctic flying squid	14	-	-	11	14	11
Banded rattail	2 043	12	68	65	721	39
Basketwork eel	157	2	-	13	31	4
Barracouta	27	11	16	1	27	1
Baxter's lantern dogfish	667	346	321	36	516	35
Bigeye cardinalfish	58	1	2	4	11	1
Bigscaled brown slickhead	1	1	-	1	1	1
Black cardinalfish	58	1	2	4	15	3
Black javelinfish	64	6	5	3	10	2
Black oreo	740	389	346	12	251	12
Blackspot rattail	23	-	-	11	15	8
Bluenose	1	-	1	1	1	1
Bollon's rattail	270	39	63	24	217	19
Brown chimaera	2	1	1	2	2	2
Catshark	32	21	11	13	32	13
Common warehou	13	8	5	1	13	1
Bigeye cardinalfish	75	1	3	4	75	3
Dawson's catshark	2	-	2	2	2	2
Dark ghost shark	433	246	187	16	278	15
Leafscale gulper shark	87	50	37	23	87	23
Deepwater spiny skate	6	2	3	3	6	3
Slender lantern shark	3	1	2	2	3	2
Finless flounder	42	10	12	18	41	17
Four-rayed rattail	1 365	26	33	25	248	14
Gemfish	6	1	5	2	6	2
Giant stargazer	59	11	48	22	59	22
Hairy conger	6	-	-	5	3	2
Hake	920	427	492	42	897	42
Hapuku	2	2	-	1	2	1
Hoki	8 220	3 302	4 914	97	1 749	86
Humpback rattail	10	-	9	10	9	9
Javelinfish	5 180	31	393	87	1 499	57
Johnson's cod	133	31	59	14	122	13
Kaiyomaru rattail	35	-	-	11	27	10
Ling	2 611	1 279	1 331	85	1 746	76
Longnose velvet dogfish	337	129	208	30	282	26
Longnosed chimaera	103	48	55	35	103	35
Longnose deepsea skate	2	1	1	2	2	2
Lookdown dory	104	50	53	33	102	32
Lucifer dogfish	575	314	261	52	371	47
Mahia rattail	7	1	3	5	5	3
Notable rattail	179	-	-	15	123	12
Oblique banded rattail	1 002	-	-	45	453	31
Oliver's rattail	2 435	-	-	45	476	24
Orange roughy	219	110	108	15	127	15
Owston's dogfish	19	10	9	6	19	6
Pale ghost shark	1 165	530	635	84	1 051	82
Pale toadfish	4	-	-	2	4	2
Patagonian toothfish	1	-	-	1	1	1
Plunket's shark	51	20	31	17	51	17
Ray's bream	46	20	20	17	40	15
Red cod	78	54	24	10	76	8

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
Ribaldo	217	54	163	43	217	43
Ridge-scaled rattail	648	335	287	33	431	30
Rough skate	6	1	5	5	5	4
Rudderfish	17	4	11	12	16	11
Scampi	14	-	-	2	14	2
School shark	2	2	-	2	2	2
Sea perch	34	15	19	8	32	6
Seal shark	22	8	14	11	21	10
Serrulate rattail	43	1	2	8	34	7
Shovelnosed dogfish	482	135	347	20	197	18
Silver dory	70	4	16	4	19	3
Silver warehou	75	35	40	9	75	9
Silverside	697	-	-	29	327	15
Small banded rattail	33	-	-	4	26	3
Small-headed cod	38	17	14	6	38	6
Small-scaled slickhead	259	142	116	13	223	13
Smooth deepsea skate	6	5	1	16	6	6
Smooth oreo	729	405	324	16	273	16
Smooth skate	18	2	16	13	18	13
Southern blue whiting	1 684	840	793	34	1 020	32
Spiky oreo	31	18	13	4	31	4
Spineback	296	0	62	27	112	9
Spiny dogfish	593	307	286	44	492	41
Swollenhead conger	16	-	-	7	11	3
Two saddle rattail	30	-	-	1	30	1
Unicorn rattail	25	-	-	2	25	2
Violet cod	47	23	10	6	45	5
Warty squid (O. *ingens*)	512	5	31	69	318	48
Warty squid (O. *robonsi*)	4	-	-	3	4	3
White rattail	87	58	27	8	76	7
White warehou	220	161	59	29	217	28
Widenosed chimaera	40	26	14	13	40	13
Witch	2	-	-	1	2	1
Totals	**37 092**	**10 255**	**12 497**	**1 615**	**18 757**	**1 345**

†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 key species.

	Regression parameters				Length	
Species	*a*	*b*	r^2	*n*	range (cm)	Data source
Black oreo	0.018311	3.0415	0.94	251	21.9 – 39.0	TAN1117
Dark ghost shark	0.001653	3.3256	0.96	278	31.3 – 71.3	TAN1117
Javelinfish	0.001154	3.1885	0.94	1 453	17.6 – 58.2	TAN1117
Hake	0.001197	3.4038	0.97	891	49.3 – 126.6	TAN1117
Hoki	0.004911	2.8808	0.97	1 737	39.1 – 109.8	TAN1117
Ling	0.001490	3.2582	0.97	1 739	39.6 – 126.2	TAN1117
Lookdown dory	0.033832	2.8965	0.94	102	24.9 – 49.7	TAN1117
Pale ghost shark	0.014274	2.7717	0.97	1 046	25.6 – 84.4	TAN1117
Ribaldo	0.005000	3.1920	0.98	208	30.0 – 70.7	TAN1117
Southern blue whiting	0.006693	2.9712	0.96	1 014	22.9 – 56.4	TAN1117
Spiny dogfish	0.001351	3.2666	0.92	485	52.4 – 97.7	TAN1117
White warehou	0.032462	2.8725	0.97	215	27.6 – 58.2	TAN1117

* 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	1 094	1 512	28	96	221	208
2	2 067	3 242	79	175	502	912
3	38	32	32	167	71	26
4	9	0	81	18	425	178
5	1	2	182	29	29	2
6	75	2	22	4	25	2
7	0	76	2	3	4	2
Total staged	3 284	4 866	426	492	1 277	1 330

*See Appendix 2 for description of gonad stages.

Table 10: Hoki liver condition indices for the Sub-Antarctic and each of the three acoustic strata (see Figure 14 for area boundaries). Updated from O'Driscoll et al. (2011).

	All areas		East		Puysegur		West	
Survey	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.
2001 (TAN0118)	2.94	1.7	3.45	2.3	2.48	3.8	2.49	2.8
2002 (TAN0219)	2.73	1.8	3.11	2.9	1.99	3.5	2.68	2.6
2003 (TAN0317)	2.76	2.2	3.17	3.4	2.24	5.6	2.55	3.0
2004 (TAN0414)	3.07	2.0	3.45	3.3	2.28	5.9	2.99	2.8
2005 (TAN0515)	3.10	1.6	3.20	2.6	2.27	3.9	3.36	2.4
2006 (TAN0617)	2.88	1.7	3.01	3.4	2.27	4.3	3.02	2.2
2007 (TAN0714)	3.15	1.6	3.42	2.5	2.07	4.5	3.34	2.1
2008 (TAN0813)	2.63	1.6	2.96	2.2	1.87	4.7	2.58	2.6
2009 (TAN0911)	2.49	1.7	2.74	2.5	1.96	5.5	2.34	2.5
2011 (TAN1117)	2.91	1.7	3.31	2.5	2.21	3.9	2.74	2.4
Mean	2.86	0.6	3.17	0.9	2.16	1.4	2.82	0.8

Table 11: Estimated length-weight parameters for hoki from Sub-Antarctic trawl surveys, and derived weight of a 75 cm fish (W(75 cm)), which was used as an index of somatic condition. W = aL^b where W is weight (g) and L is length (cm)). Updated from O'Driscoll et al. (2011).

	LW parameters		W(75 cm)
Survey	a	b	(g)
2000 (TAN0012)	0.005603	2.844446	1 208
2001 (TAN0118)	0.005681	2.842391	1 214
2002 (TAN0219)	0.004172	2.914928	1 219
2003 (TAN0317)	0.003975	2.922135	1 198
2004 (TAN0414)	0.003785	2.933285	1 197
2005 (TAN0515)	0.005824	2.840234	1 233
2006 (TAN0617)	0.004363	2.903530	1 214
2007 (TAN0714)	0.004172	2.914241	1 215
2008 (TAN0813)	0.005024	2.871200	1 215
2009 (TAN0911)	0.004245	2.906240	1 195
2011 (TAN1117)	0.004911	2.880800	1 238
Mean			1 213

Table 12: Quality of acoustic data collected during trawl surveys in the Sub-Antarctic between 2000 and 2011. 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	0	0	100
2005 (TAN0515)	197	75	16	9
2006 (TAN0617)	195	46	25	29
2007 (TAN0714)	194	63	16	20
2008 (TAN0813)	235	61	28	11
2009 (TAN0911)	319	46	33	20
2011 (TAN1117)	261	37	36	17

* There was a problem with synchronisation of scientific and ship's echosounders in TAN0414 (O'Driscoll & Bagley 2006a), so data from this survey were not suitable for quantitative analysis due to the presence of acoustic interference.

Table 13: Percentage occurrence of the seven acoustic mark types classified by O'Driscoll (2001) in trawl surveys of the Sub-Antarctic between 2000 and 2011. 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
	2008 (TAN0813)	74	86	80	59	74	59	89	19
	2009 (TAN0911)	124	89	81	52	63	47	70	10
	2011 (TAN1117)	70	91	76	70	84	53	84	11
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
	2008 (TAN0813)	64	98	19	20	72	36	83	3
	2009 (TAN0911)	104	98	10	11	78	29	70	1
	2011 (TAN1117)	90	96	31	63	99	27	86	1

Table 13 cntd: Percentage occurrence of the seven acoustic mark types classified by O'Driscoll (2001) in trawl surveys of the Sub-Antarctic between 2000 and 2011. 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
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
	2008 (TAN0813)	97	78	56	45	69	45	69	9
	2009 (TAN0911)	91	84	73	51	58	43	52	7
	2011 (TAN1117)	102	83	59	71	86	35	67	7

Table 14: Estimates of the proportion of total day backscatter in each stratum and year in the Sub-Antarctic which is assumed to be mesopelagic fish. Estimates were derived from the observed proportion of night backscatter in the upper 200 m with no correction for the surface acoustic deadzone (see O'Driscoll et al. 2011 for details).

			Stratum
Year	East	Puysegur	West
2000 (TAN0012)	0.64	0.66	0.58
2001 (TAN0118)	0.56	0.39	0.57
2002 (TAN0219)	0.54	0.77	0.60
2003 (TAN0317)	0.60	0.66	0.67
2005 (TAN0515)	0.59	0.38	0.54
2006 (TAN0617)	0.55	0.32	0.56
2007 (TAN0714)	0.56	0.46	0.51
2008 (TAN0813)	0.63	0.58	0.62
2009 (TAN0911)	0.58	0.78	0.63
2011 (TAN1117)	0.58	0.37	0.54

Table 15: Mesopelagic indices for the Sub-Antarctic. Indices were derived by multiplying daytime estimates of total backscatter by the estimated proportion of night backscatter in the upper 200 m and calculating averages in each area (see Table 14). Unstratified indices were calculated as the unweighted average over all available acoustic data. Stratified indices were obtained as the weighted average of stratum estimates, where weighting was the proportional area of the stratum (Puysegur 1.5% of total area, west 32.6%, east 65.9%).

	Acoustic index (m^2/km^2)									
	Unstratified		East		Puysegur		West		Stratified	
Survey	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.
2000 (TAN0012)	14.1	9	10.8	12	28.8	10	12.6	17	11.6	10
2001 (TAN0118)	13.3	17	9.2	16	29.9	45	13.1	11	10.8	10
2002 (TAN0219)	10.4	12	6.8	13	31.2	28	9.0	7	7.9	8
2003 (TAN0317)	9.8	10	8.1	23	18.9	15	9.2	8	8.6	14
2005 (TAN0515)	8.0	7	7.8	10	6.0	7	8.7	12	8.0	8
2006 (TAN0617)	4.5	6	4.8	10	3.4	13	4.7	9	4.7	7
2007 (TAN0714)	6.4	8	5.7	15	7.3	12	6.2	12	5.9	11
2008 (TAN0813)	9.9	11	7.0	12	13.3	12	12.3	23	8.9	12
2009 (TAN0911)	9.4	11	6.6	12	17.2	13	9.9	21	7.8	11
2011 (TAN1117)	12.3	5	13.5	9	10.6	9	11.8	7	12.9	7

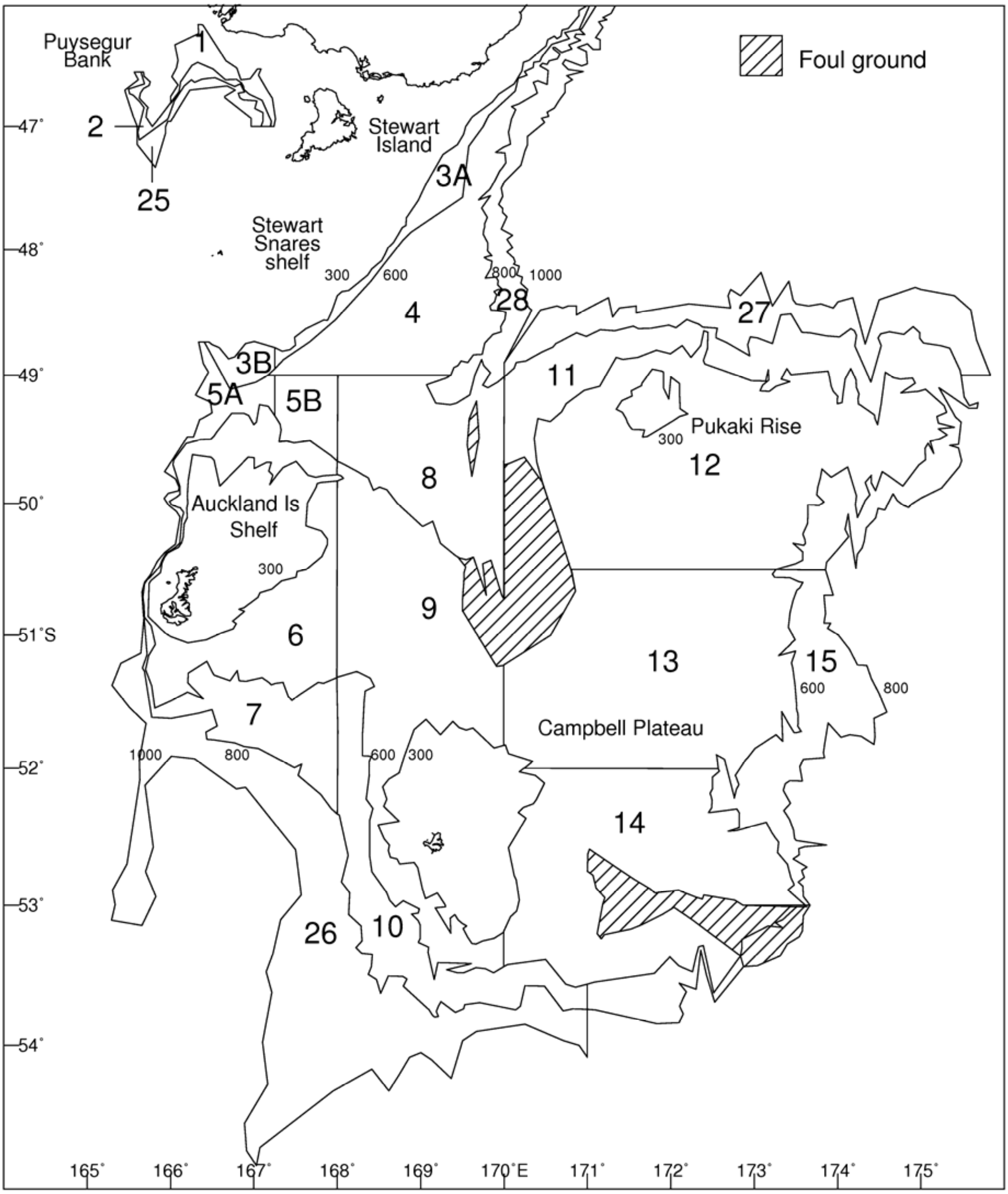


Figure 1: Stratum boundaries for the November–December 2011 Southland and Sub-Antarctic trawl survey.

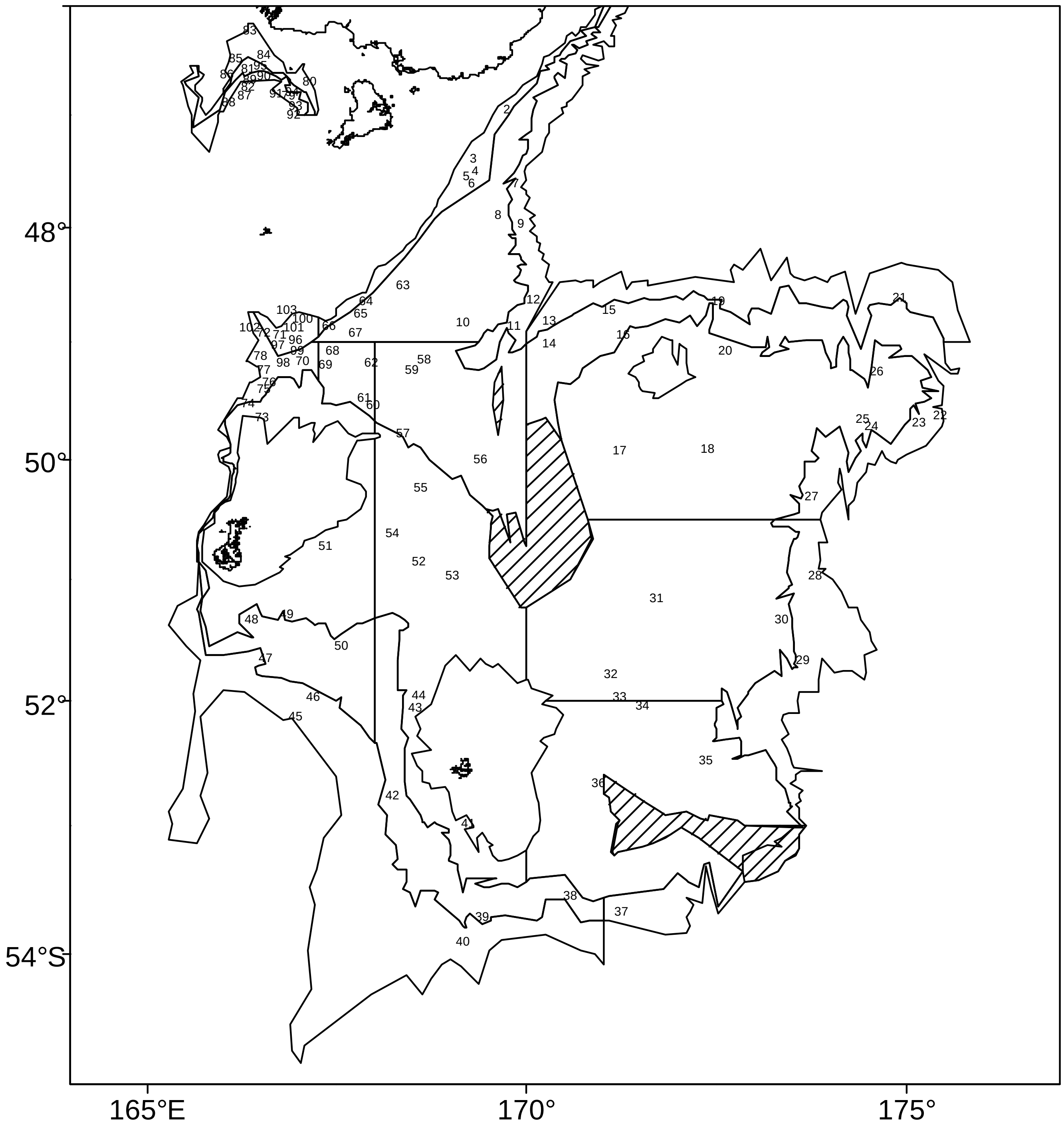


Figure 2: Map showing start positions of all bottom trawls (including unsuccessful stations) from the November–December 2011 Southland and Sub-Antarctic trawl survey.

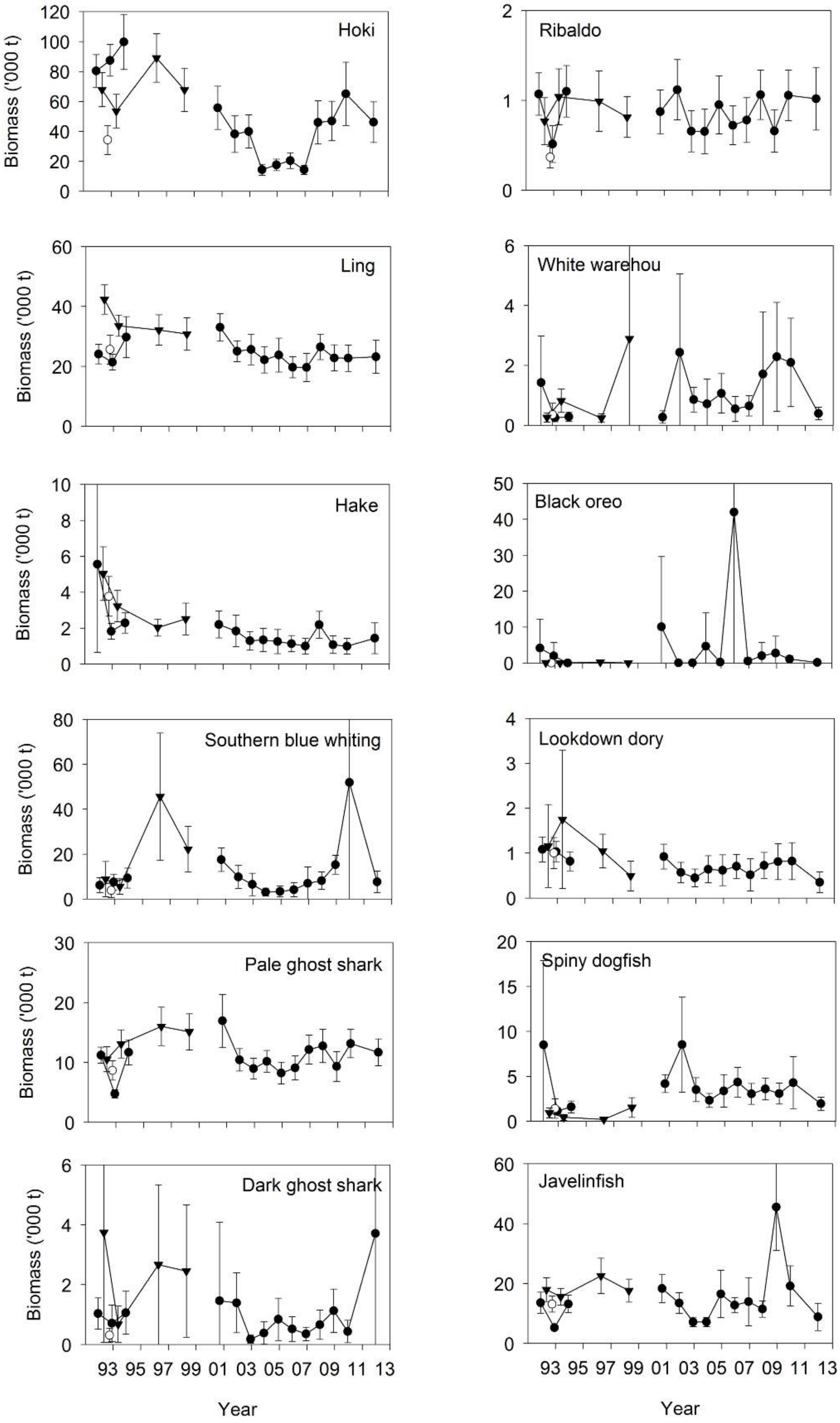


Figure 3: Trends in biomass (plus or minus two standard errors) of key species in the core 300–800 m strata in all Sub-Antarctic trawl surveys from *Tangaroa*. Solid circles show the summer time series and solid triangles the autumn time series. The open circle shows biomass from a survey of the same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

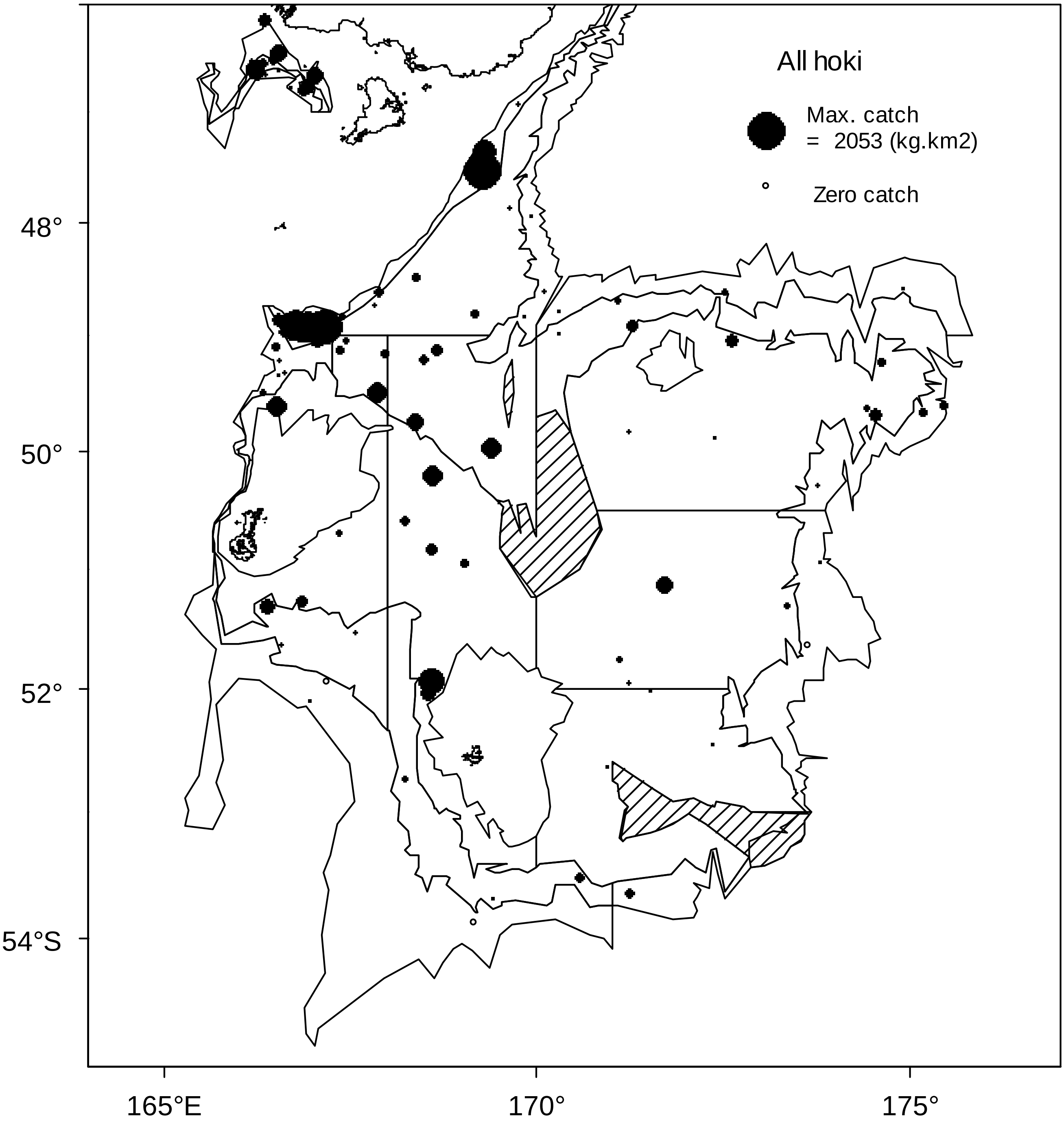


Figure 4a: Distribution and catch rates of all hoki in the summer 2011 trawl survey. Circle area is proportional to catch rate.

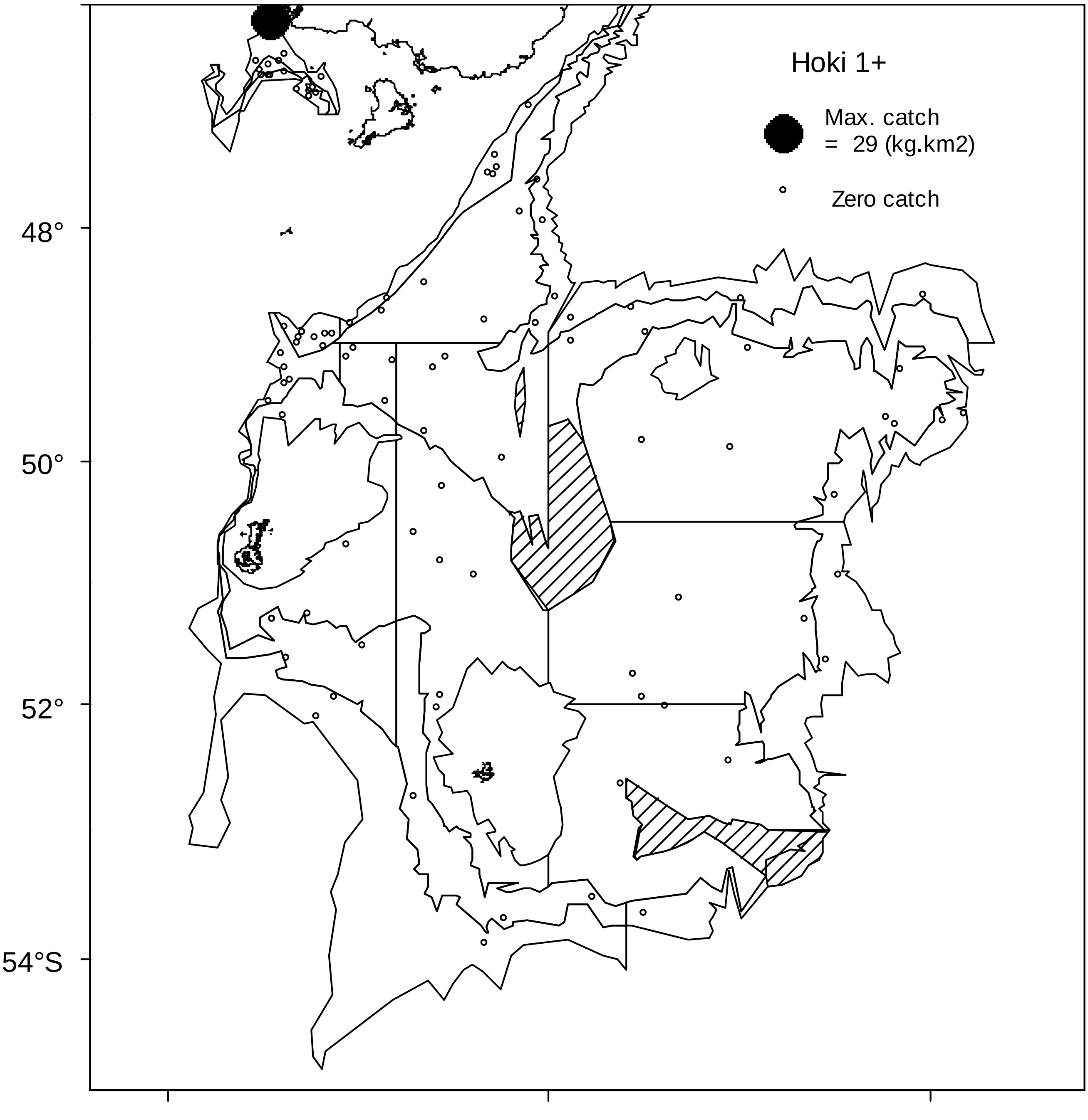


Figure 4b: Distribution and catch rates of 1+ (less than 45 cm) hoki in the summer 2011 trawl survey. Circle area is proportional to catch rate. 1+ hoki were only caught on one station in stratum 1.

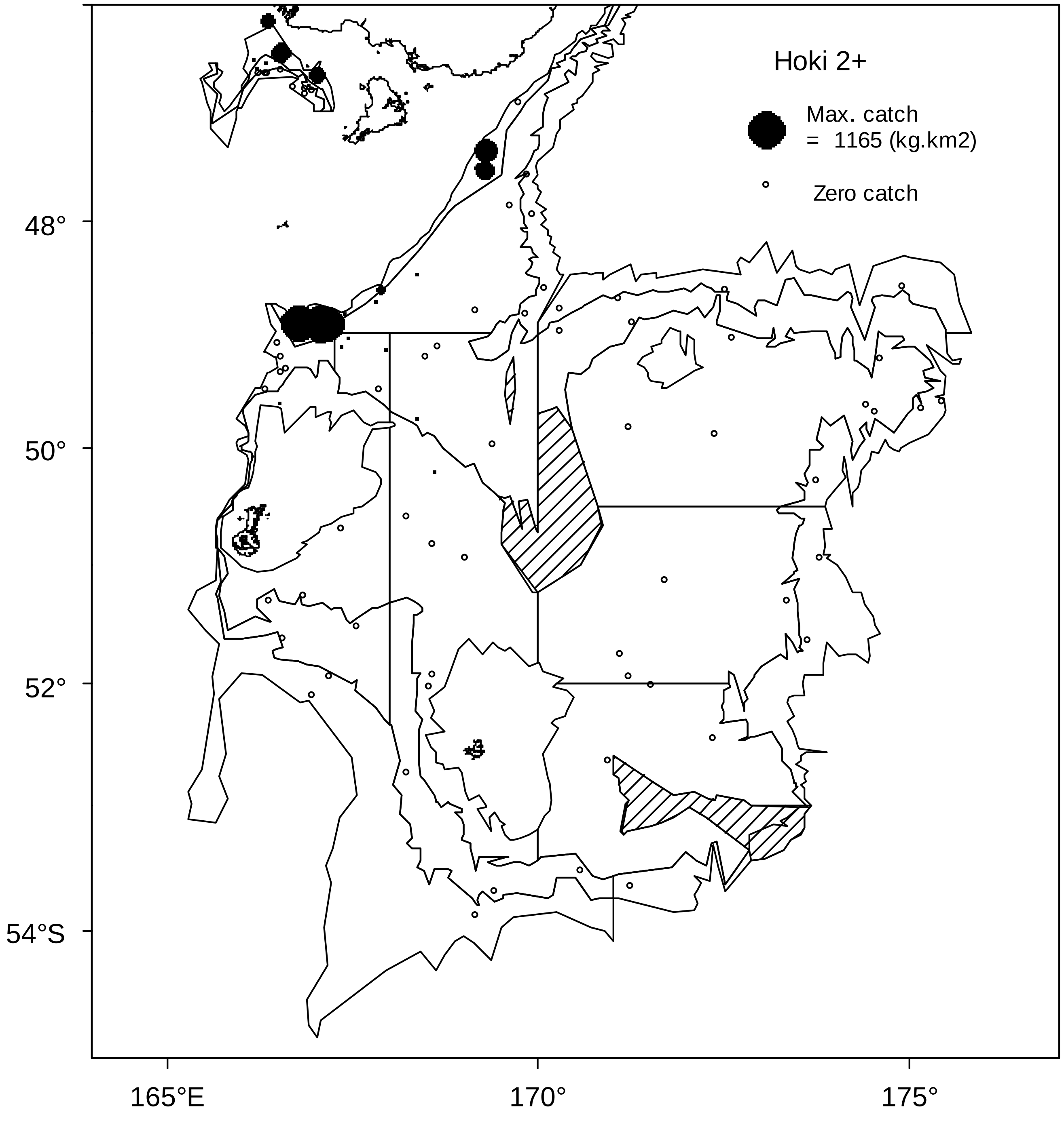


Figure 4c: Distribution and catch rates of 2+ (45–60 cm) hoki in the summer 2011 trawl survey. Circle area is proportional to catch rate.

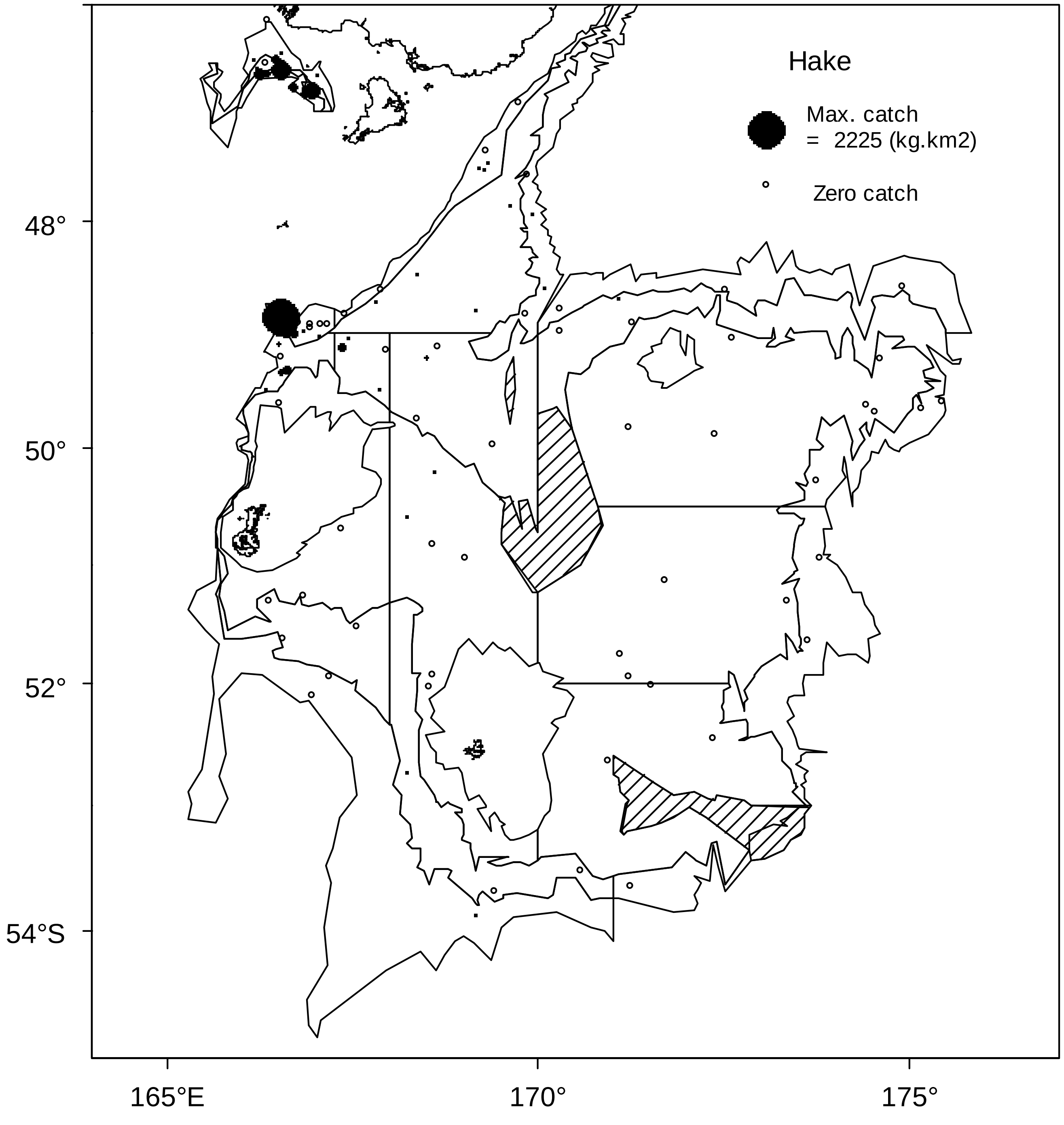


Figure 5: Distribution and catch rates of hake in the summer 2011 trawl survey. Circle area is proportional to catch rate.

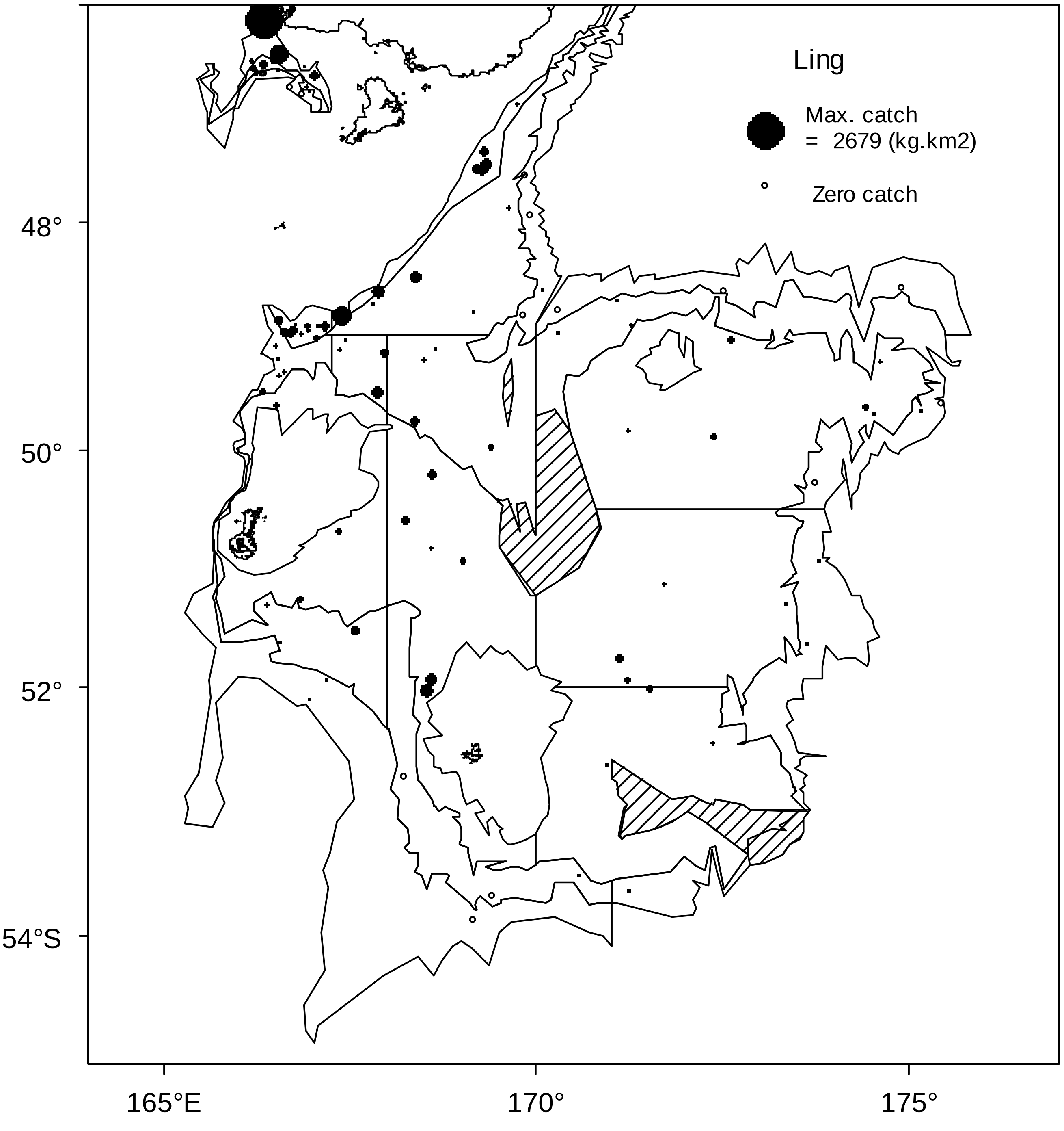


Figure 6: Distribution and catch rates of ling in the summer 2011 trawl survey. Circle area is proportional to catch rate.

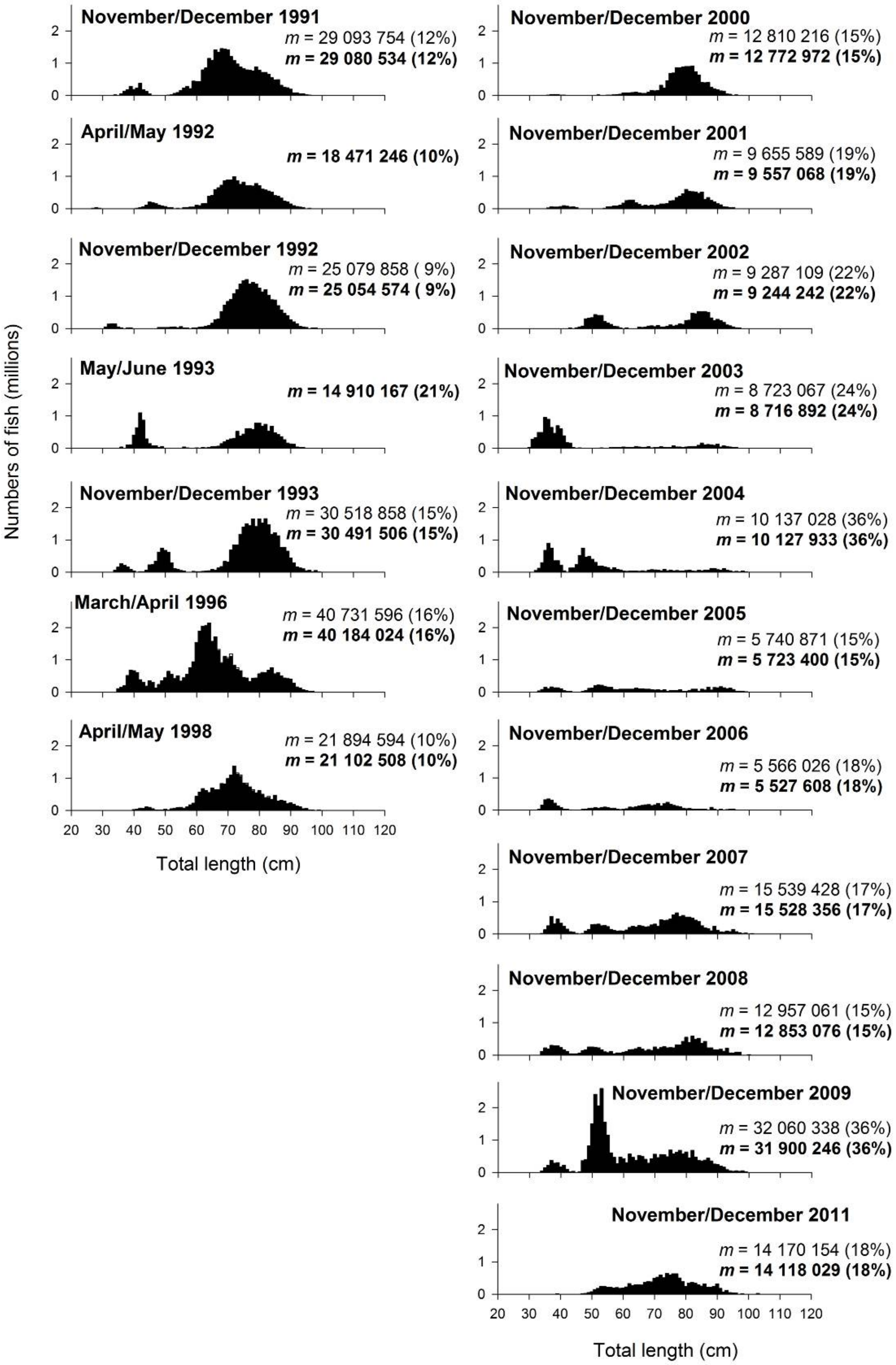


Figure 7a: Scaled length frequency for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (*m* values) above are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

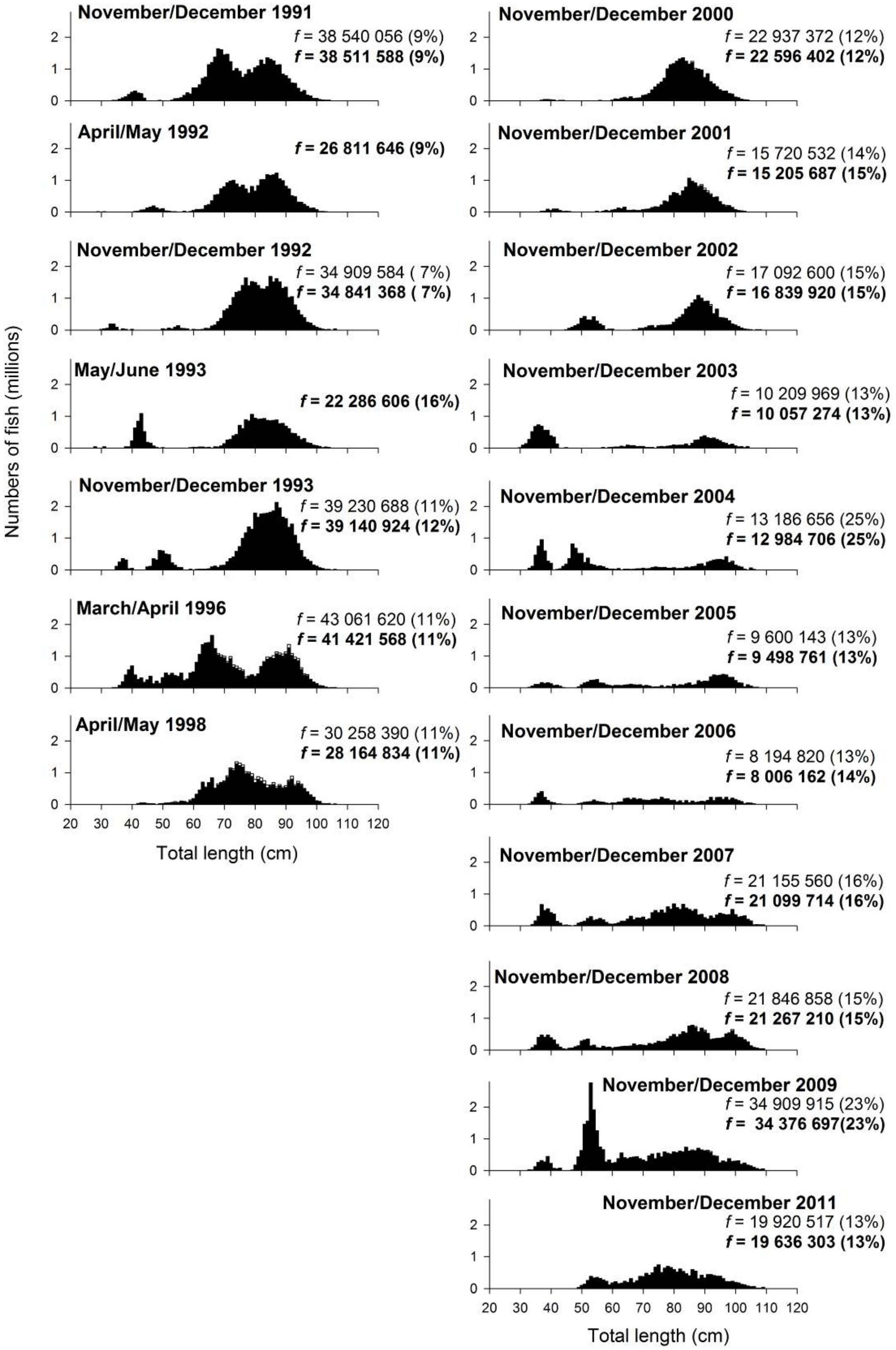


Figure 7b: Scaled length frequency for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (*f* values) above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

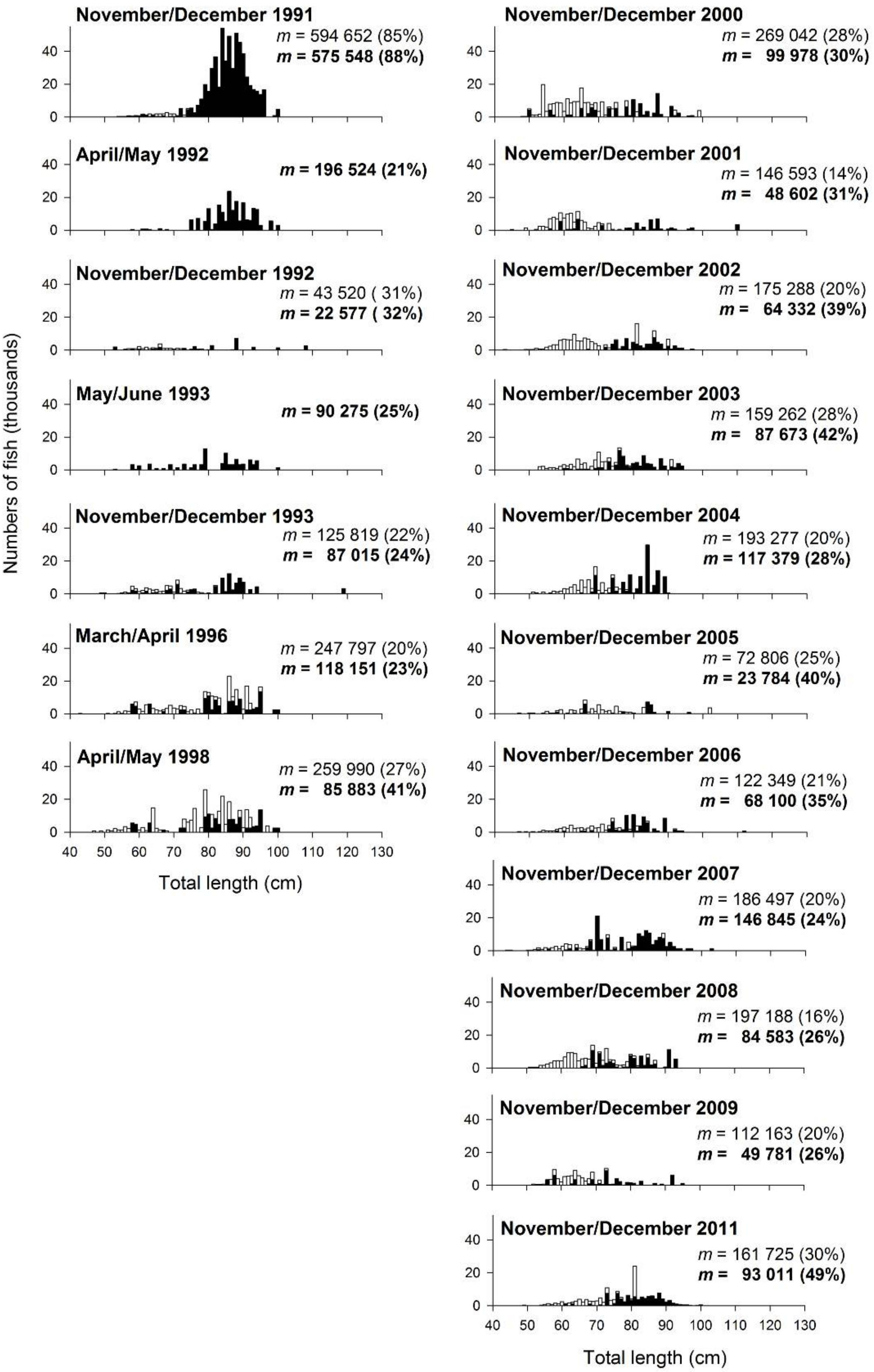


Figure 8a: Scaled length frequency for male hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (*m* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

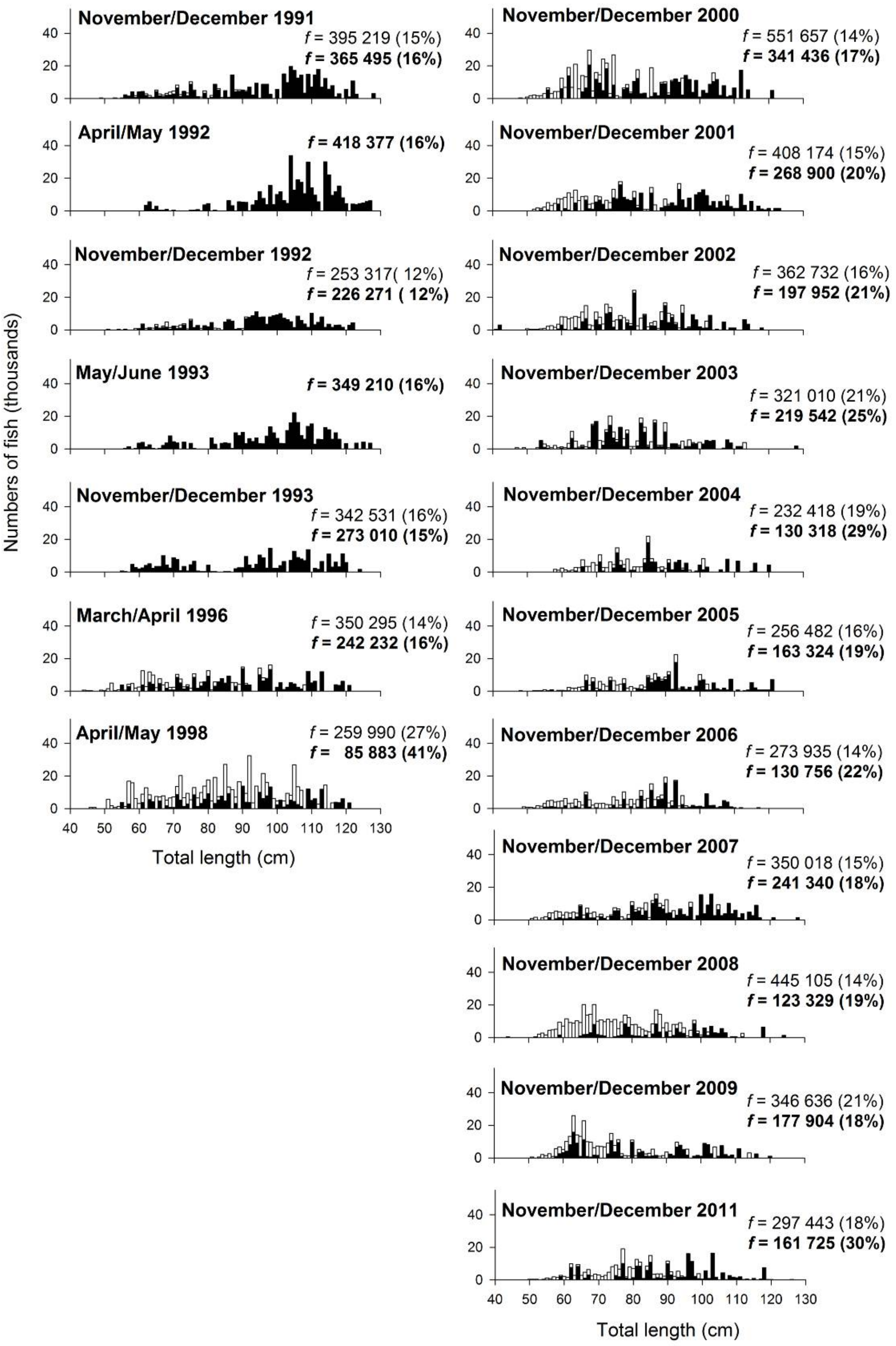


Figure 8b: Scaled length frequency for female hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (*f* values) above are for all strata and below (in bold) for core strata with c.v.s in parentheses.

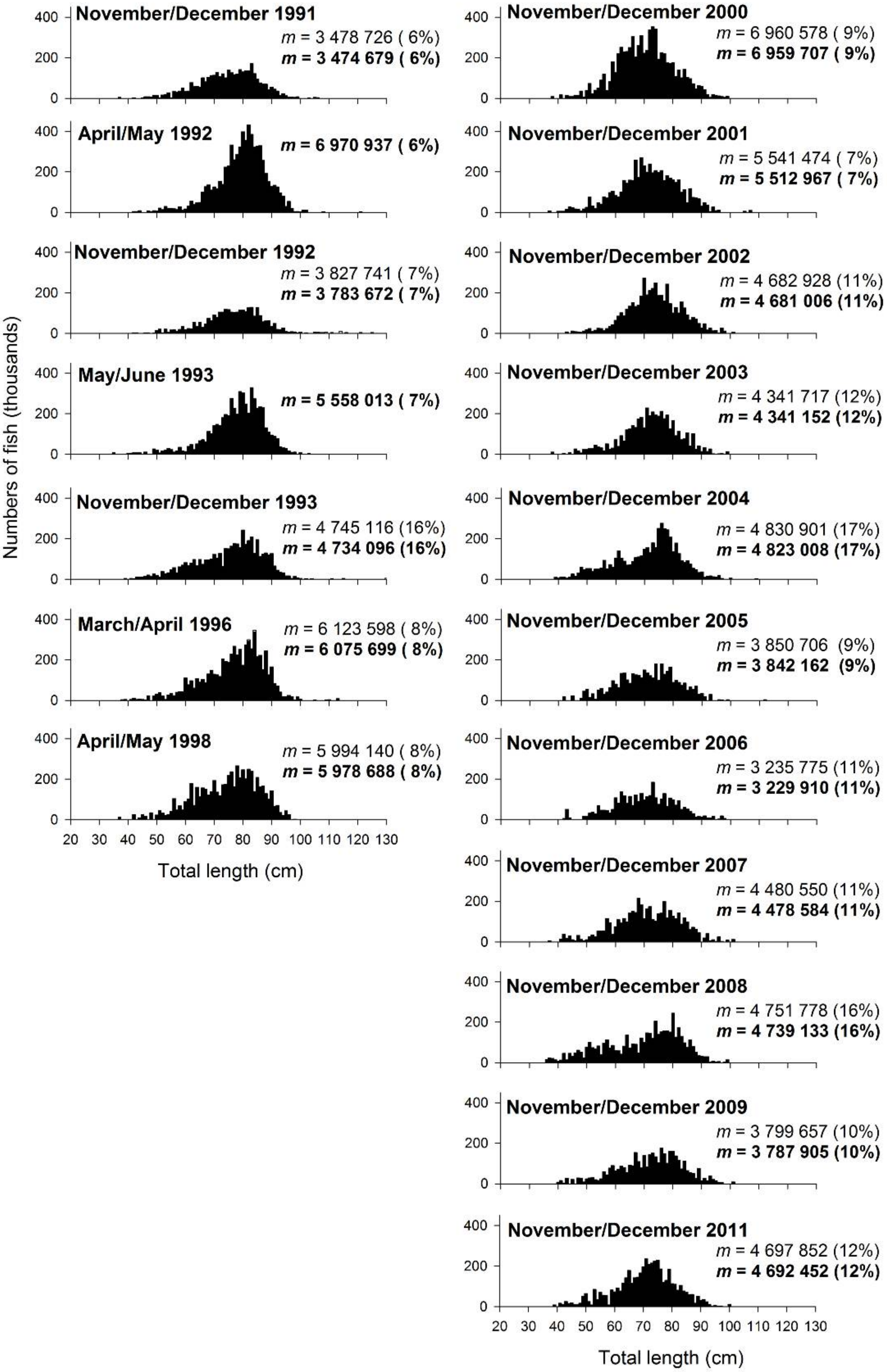


Figure 9a: Scaled length frequency for male ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (*m* values) above are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

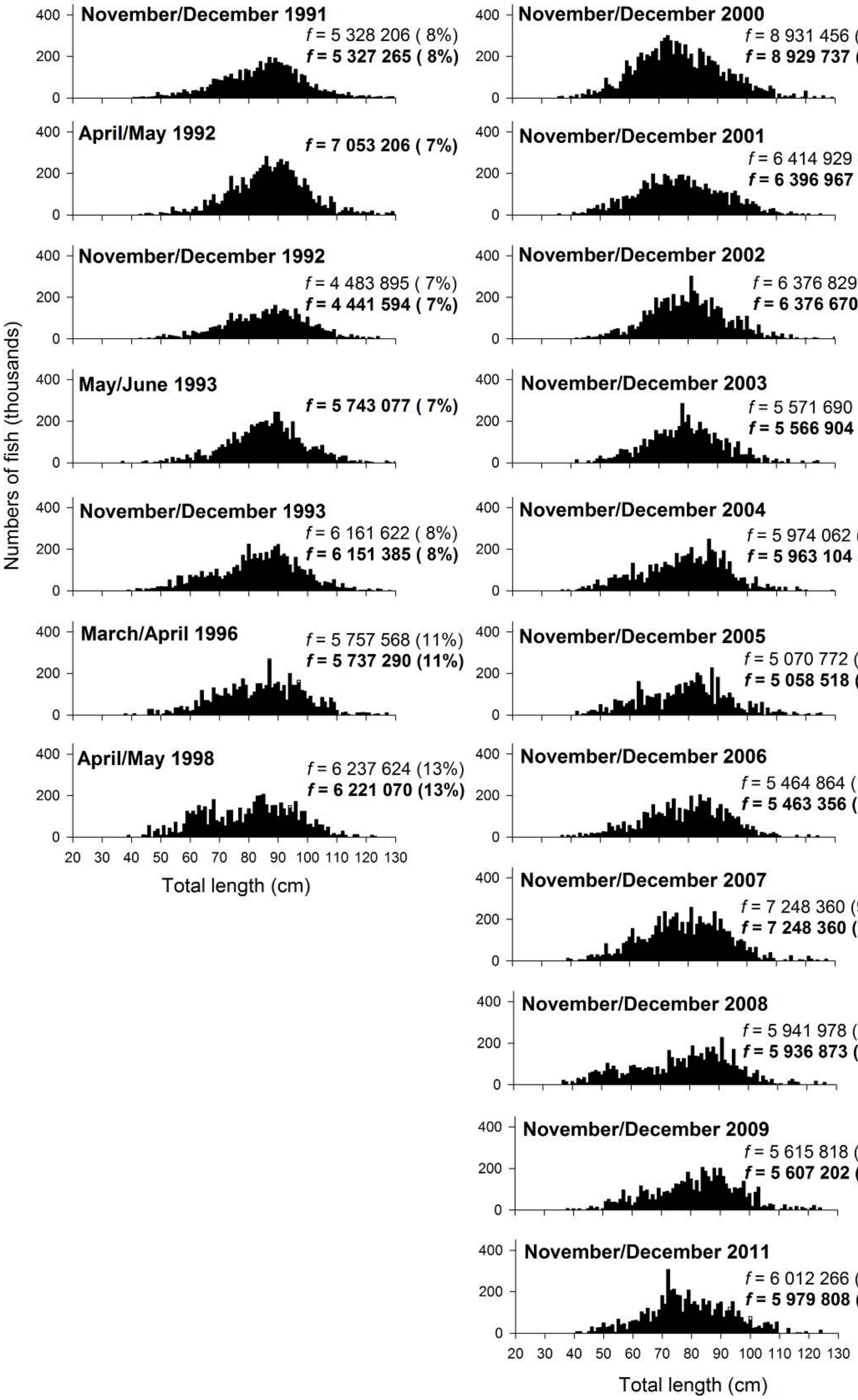


Figure 9b: Scaled length frequency for female ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (*f* values) above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

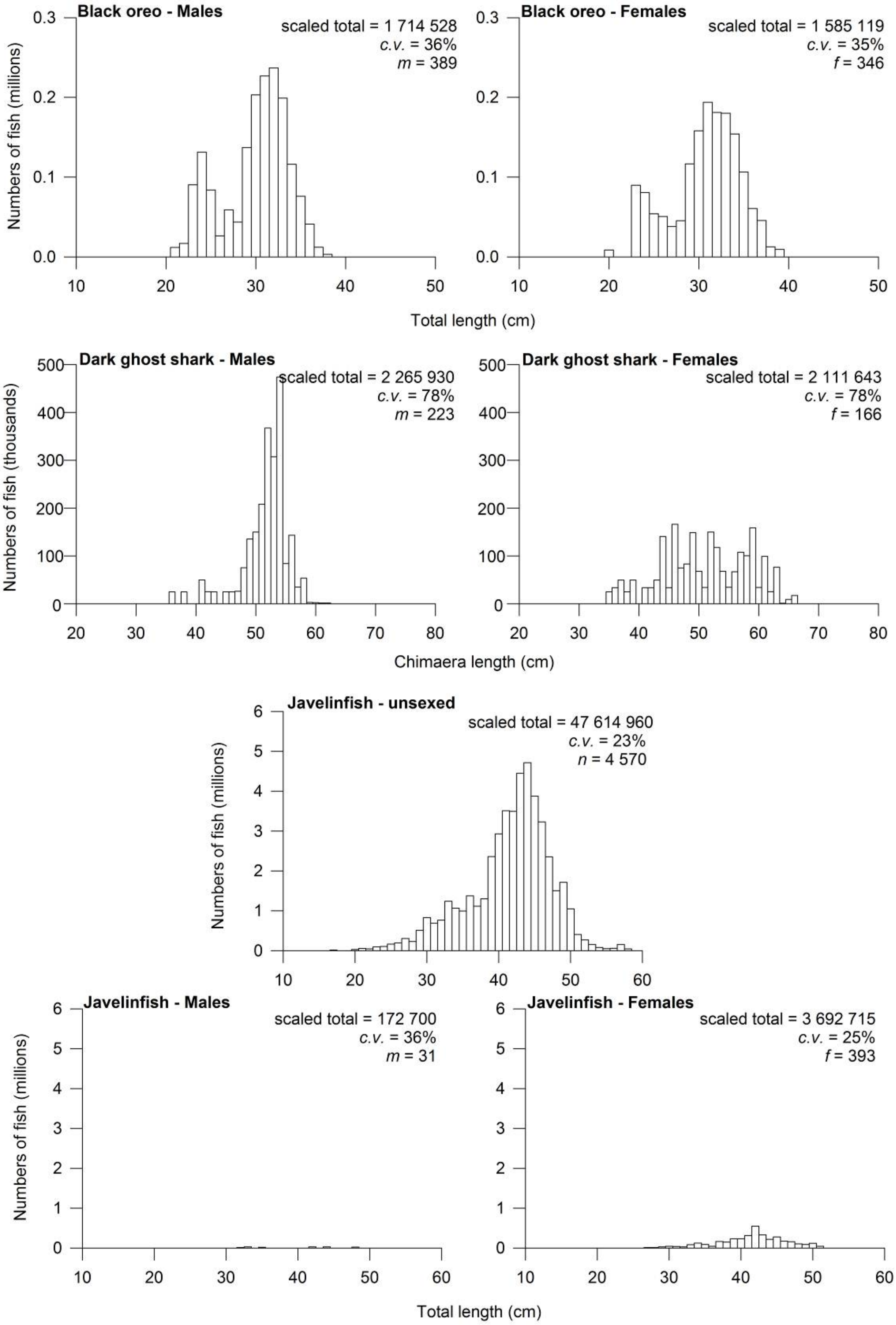


Figure 10: Length frequency distributions by sex of other key species in the November–December 2011 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *m*, *f*, and *n* values are the number of males, females, and unsexed fish measured.

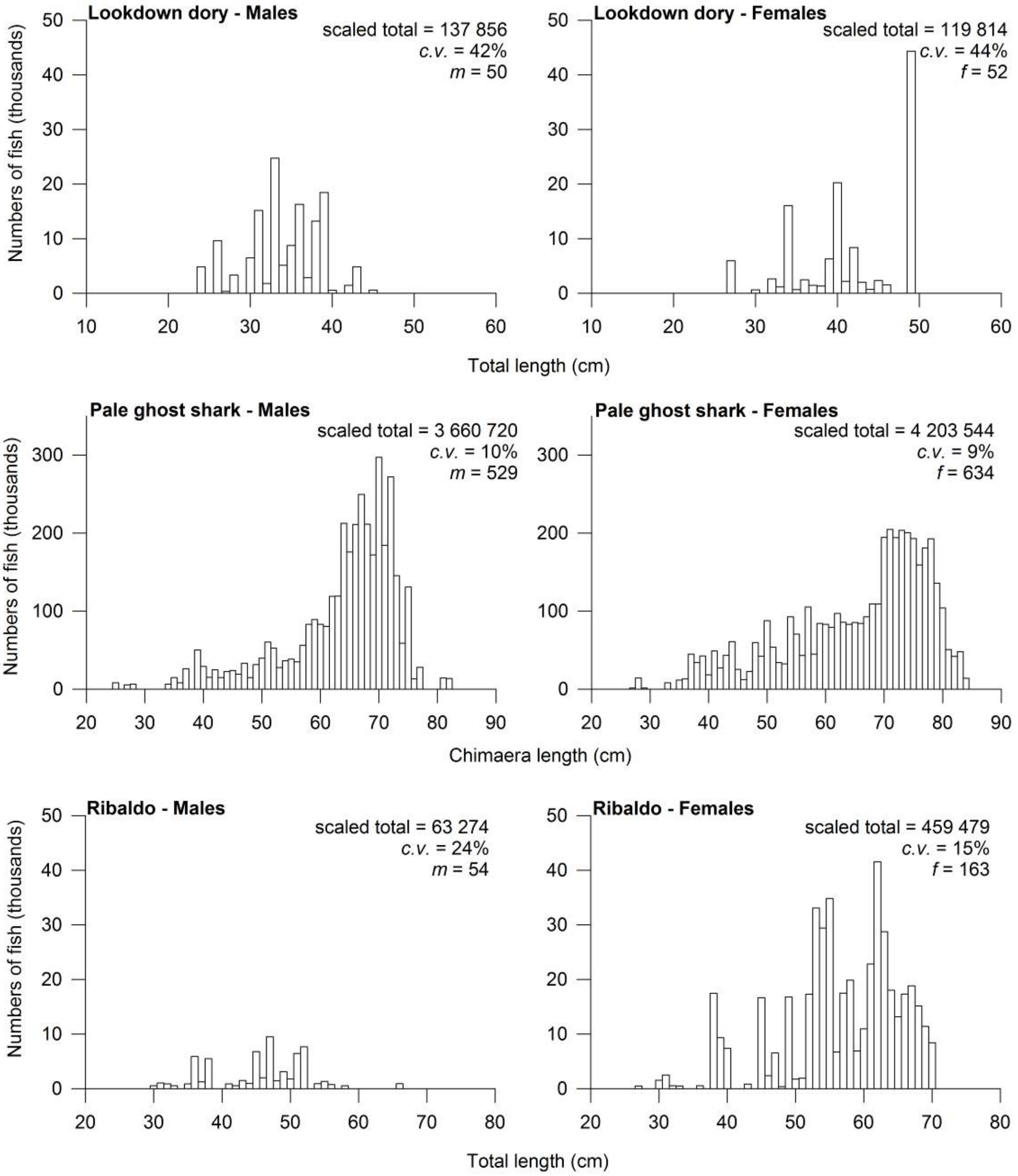


Figure 10 cont: Length frequency distributions by sex of other key species in the November–December 2011 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *m* and *f* values are the number of males and females measured.

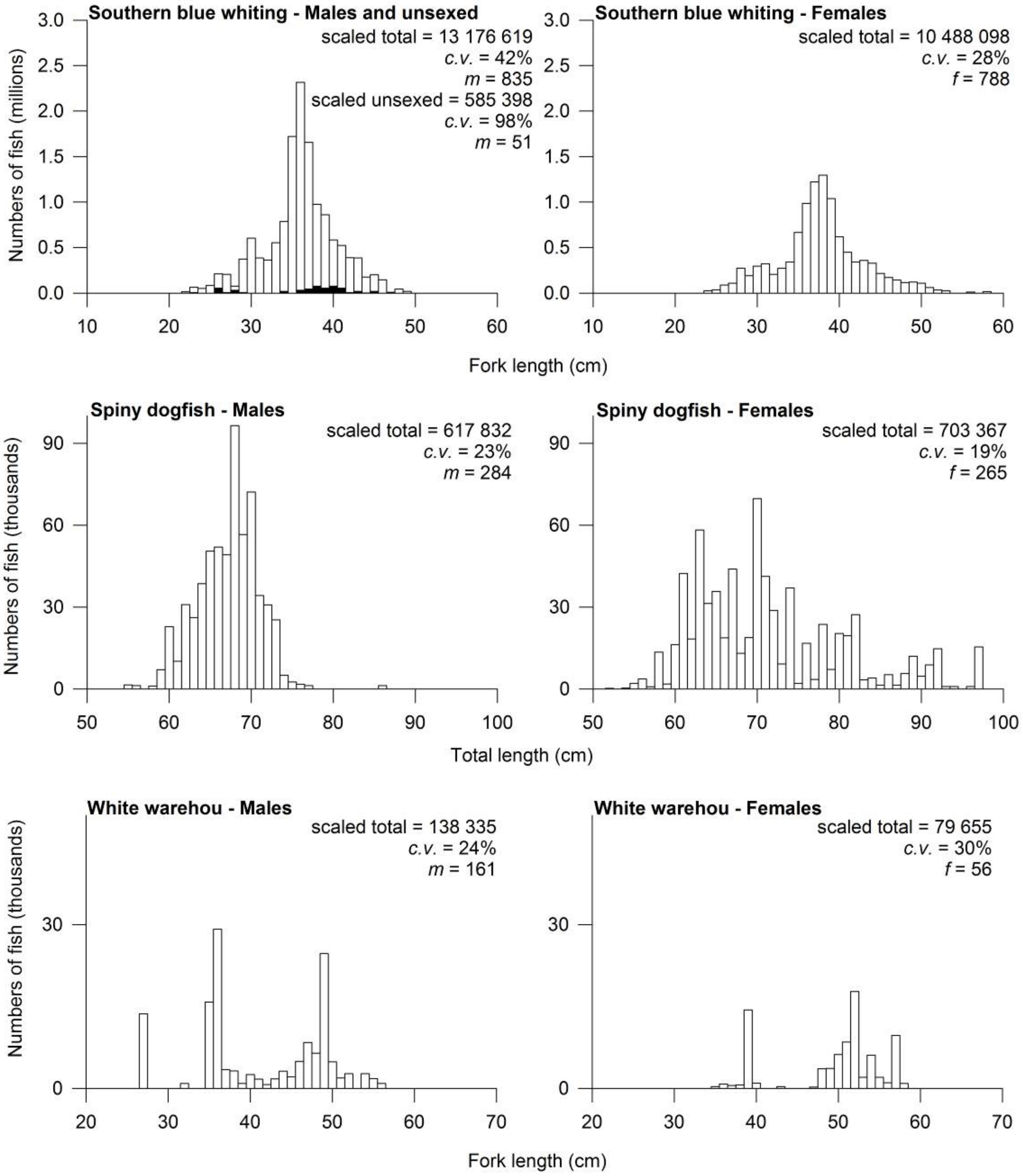


Figure 10 cont: Length frequency distributions by sex of other key species in the November–December 2011 survey. Scaled total is the estimated total number of fish in the surveyed area, c.v. is the coefficient of variation, *m* and *f* values are the number of males and females measured.

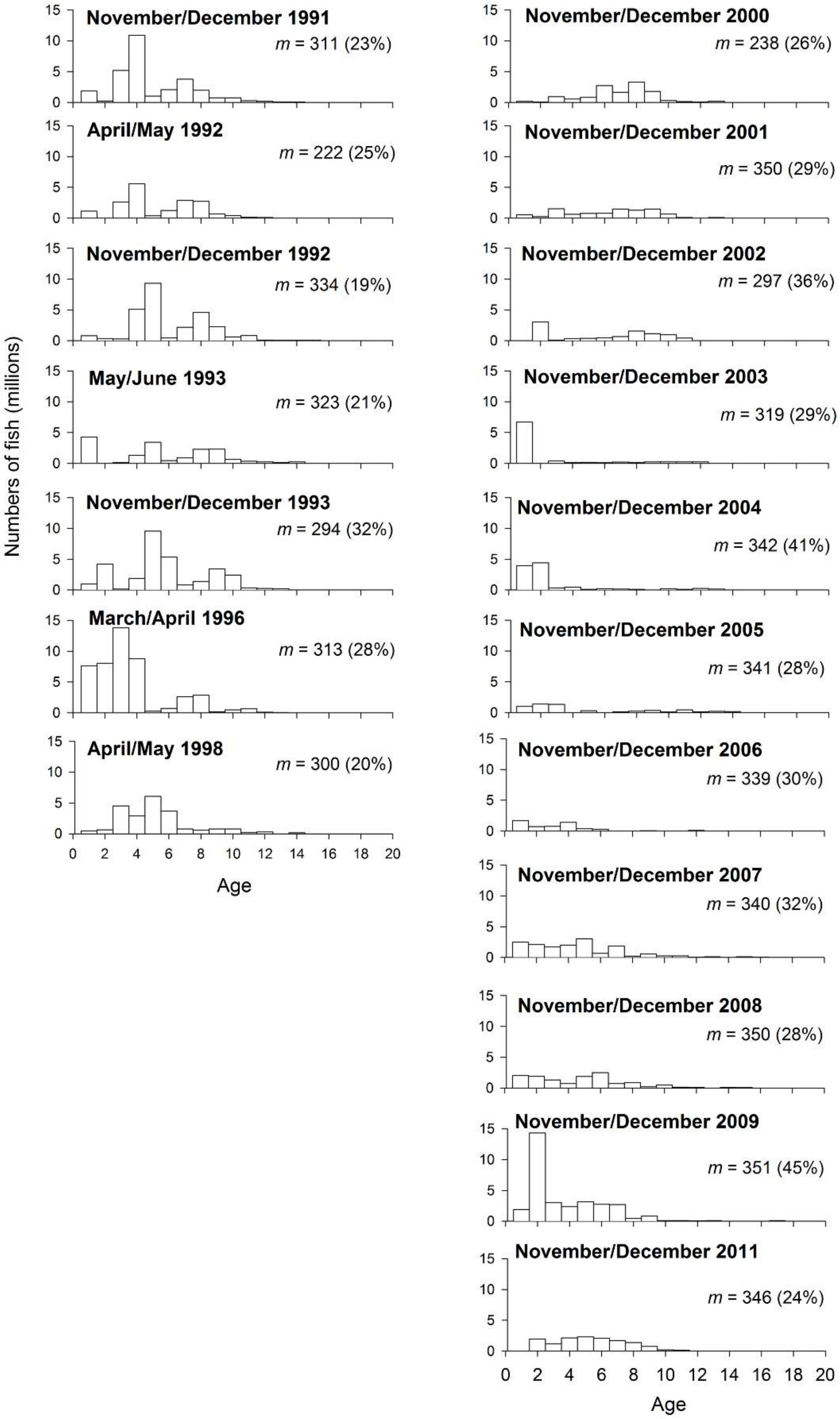


Figure 11a: Scaled age frequency for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with c.v.s in parentheses.

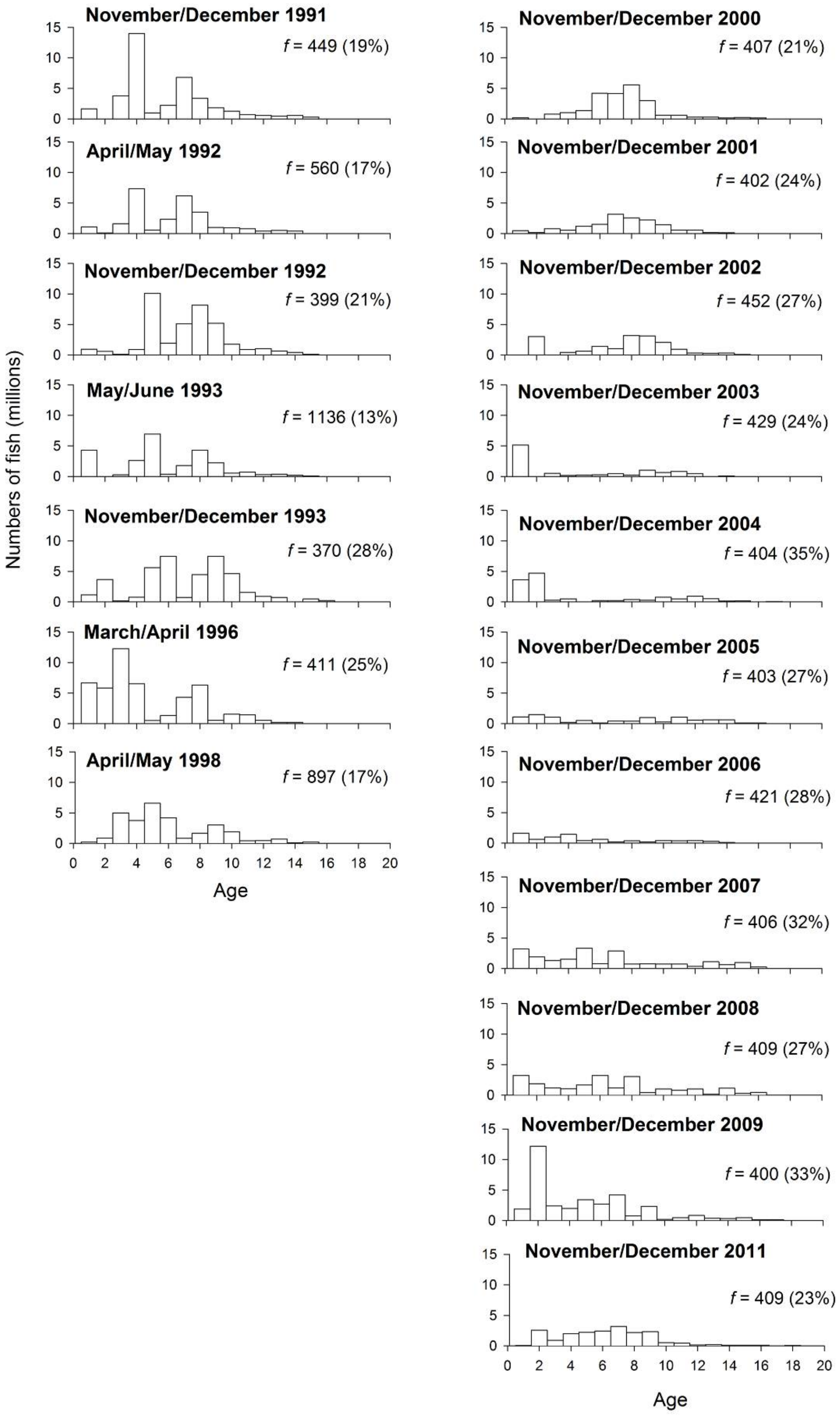


Figure 11b: Scaled age frequency for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with c.v.s in parentheses.

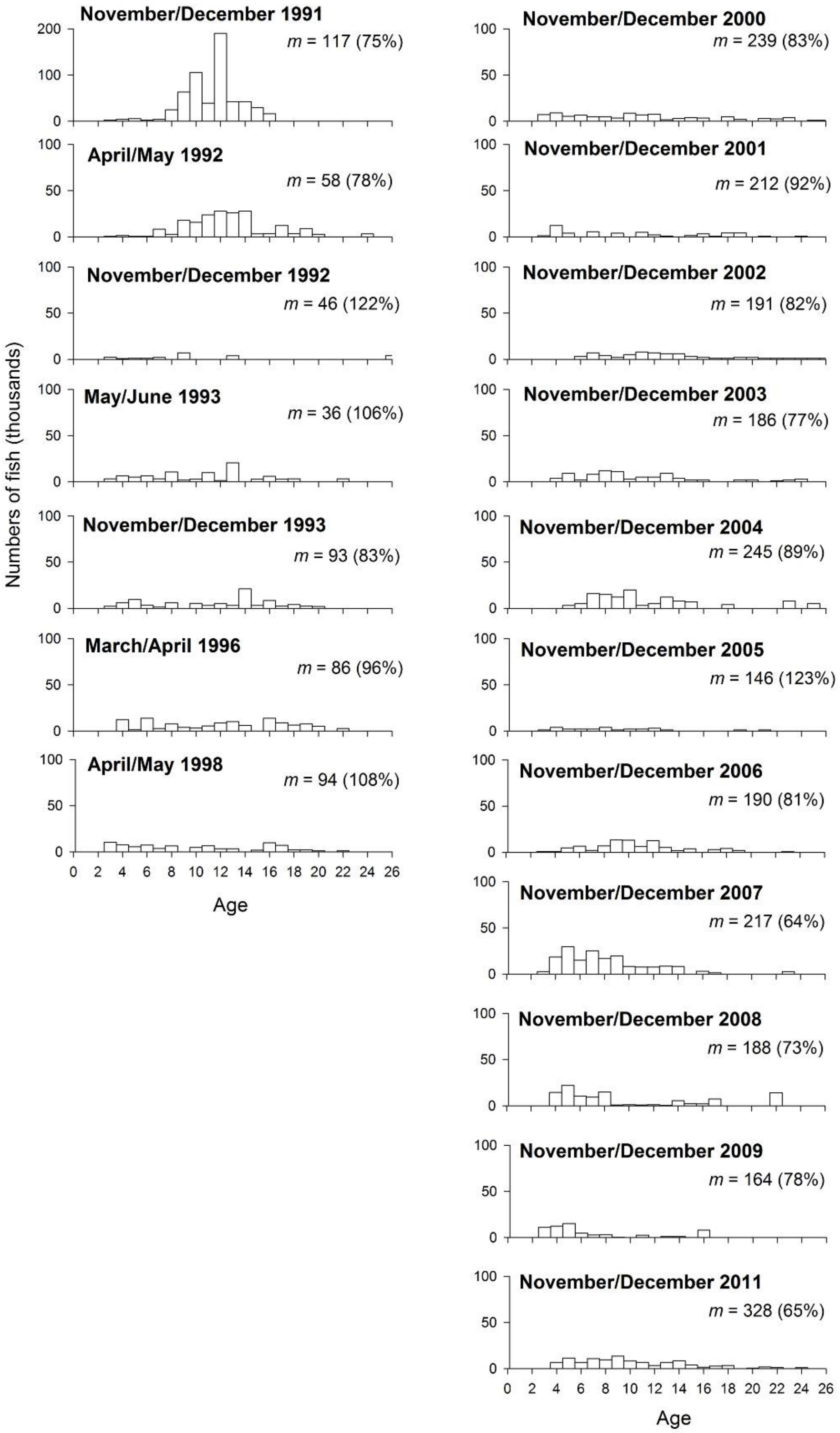


Figure 12a: Scaled age frequency for male hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with c.v.s in parentheses.

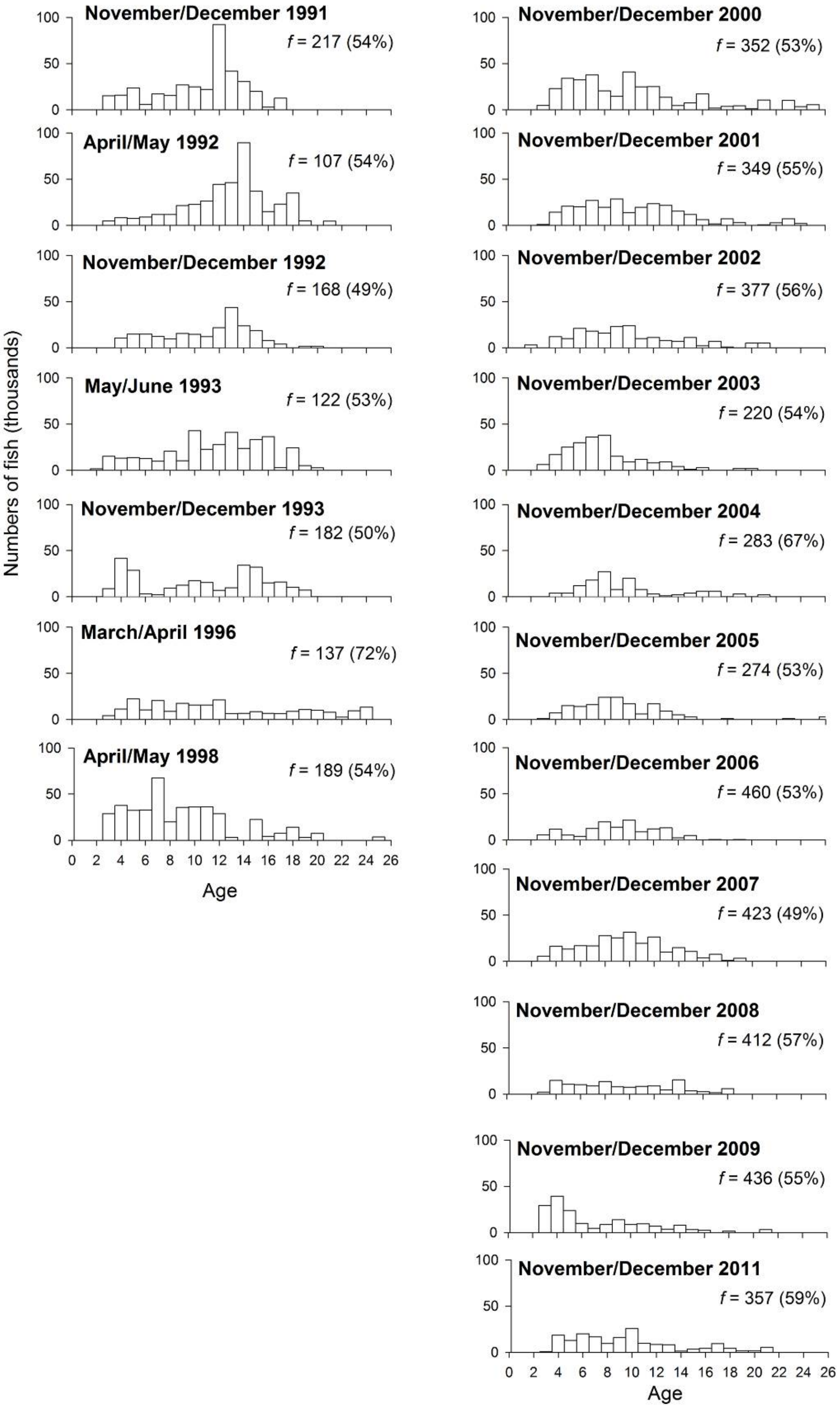


Figure 12b: Scaled age frequency for female hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with c.v.s in parentheses.

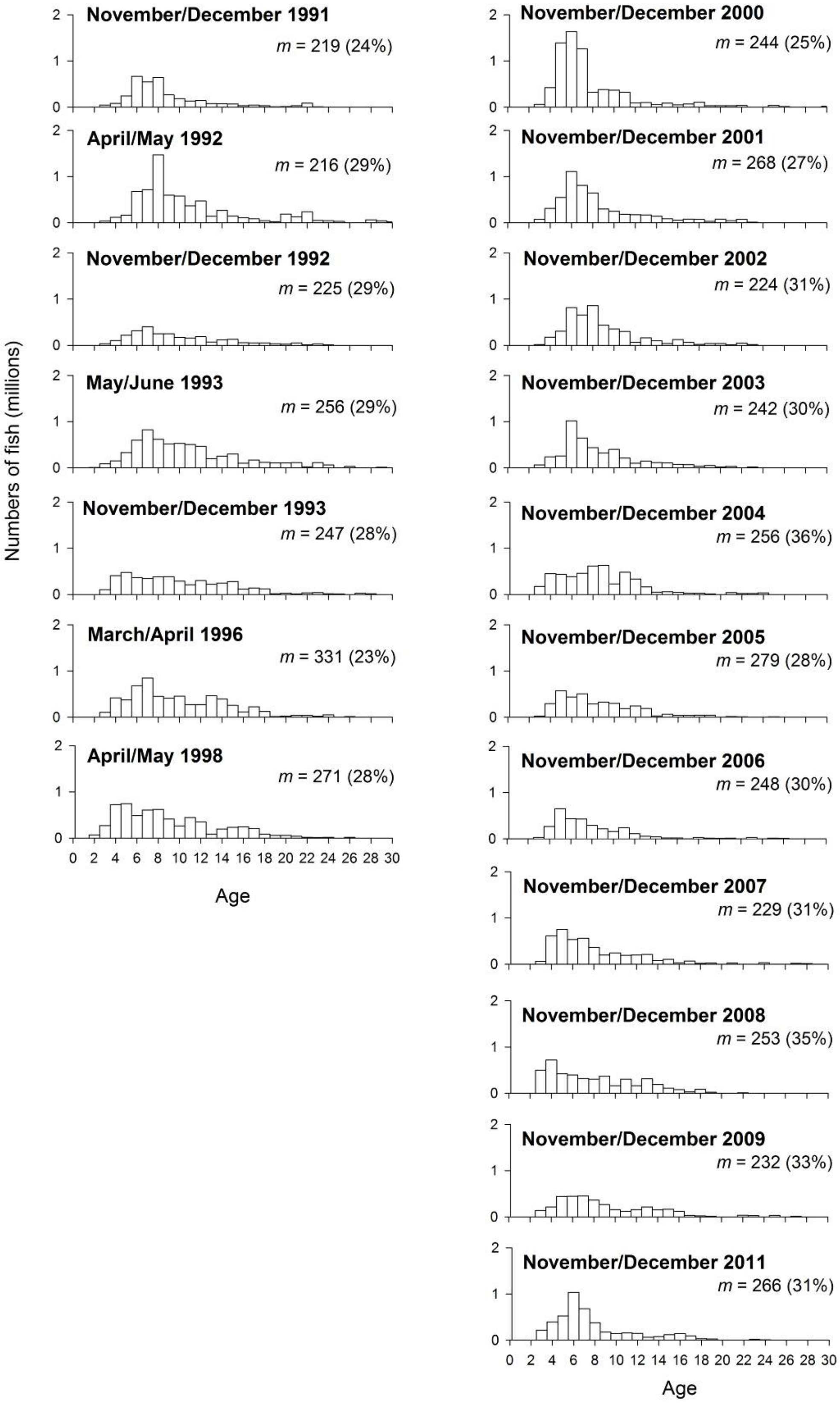


Figure 13a: Scaled age frequency for male ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with c.v.s in parentheses.

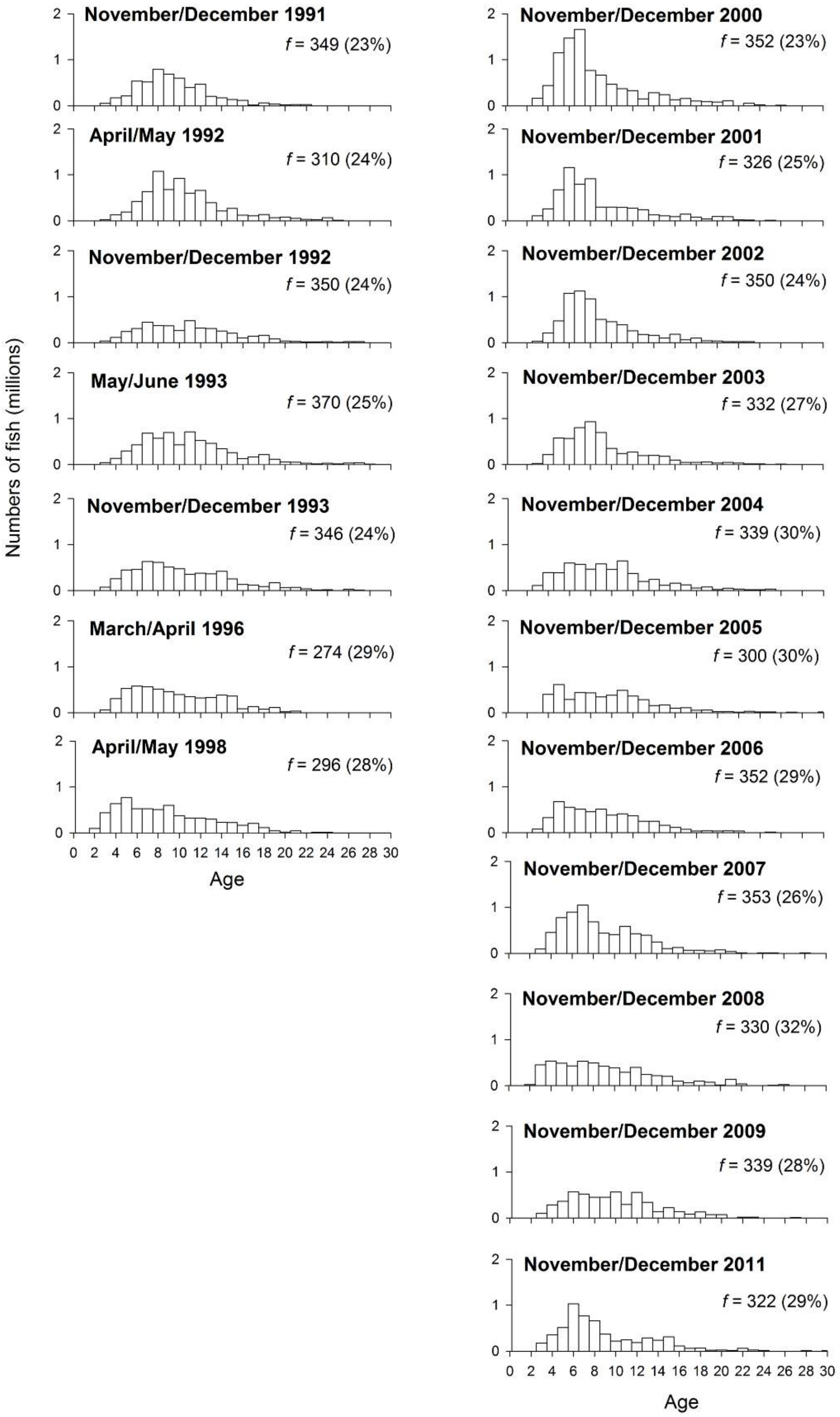


Figure 13b: Scaled age frequency for female ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with c.v.s in parentheses.

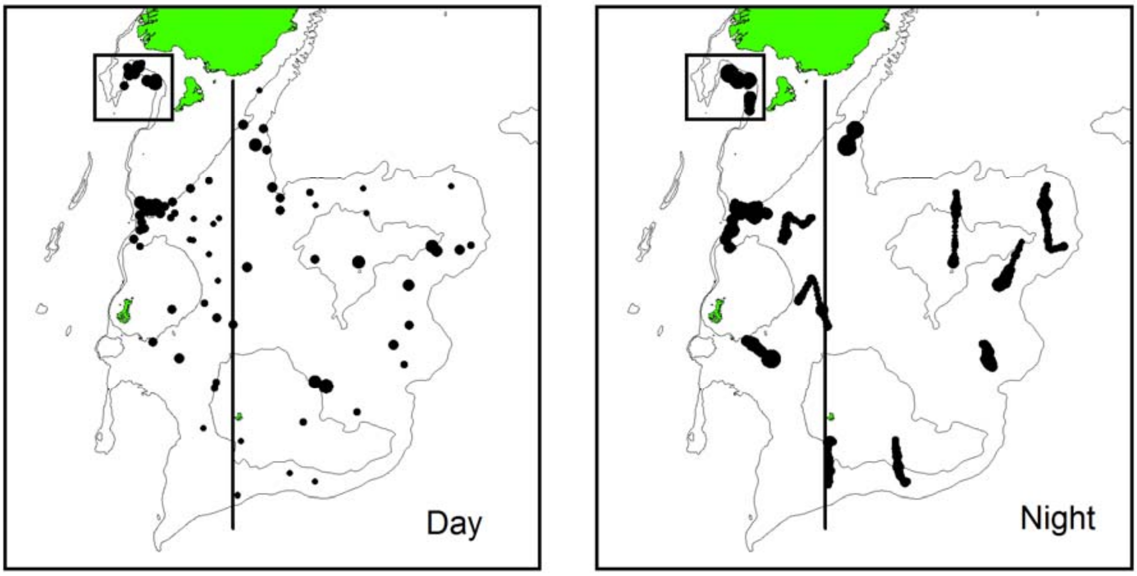


Figure 14: Spatial distribution of total acoustic backscatter in the Sub-Antarctic observed during day trawl stations and night steams. Circle area is proportional to the acoustic backscatter (maximum symbol size 500 m^2/km^2). Lines separate the three acoustic strata.

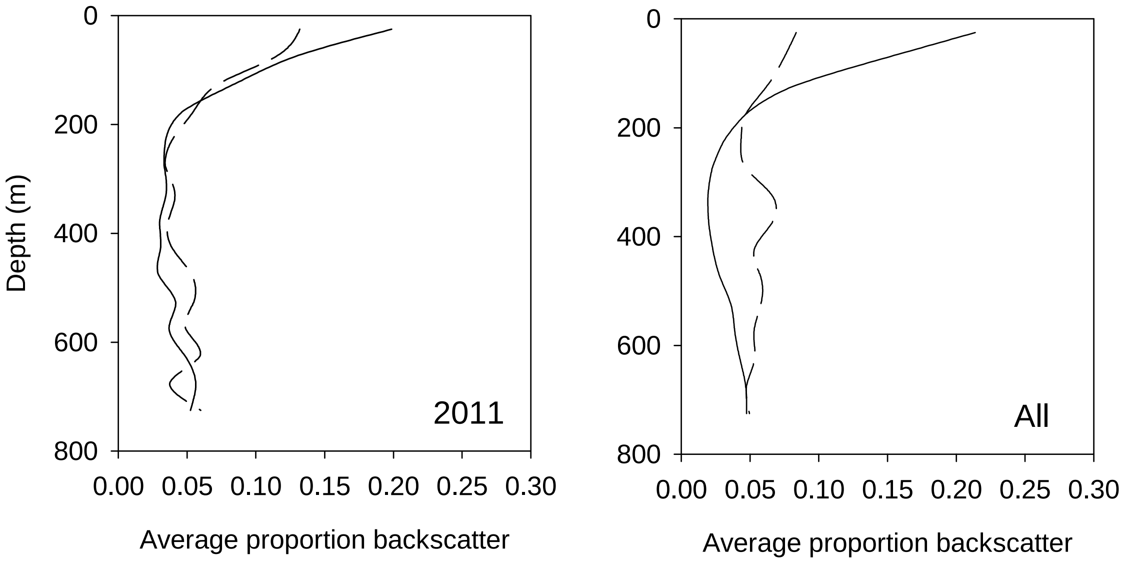


Figure 15: Distribution of total acoustic backscatter integrated in 50 m depth bins on the Sub-Antarctic observed during the day (dashed lines) and at night (solid lines) in 2011 (left panel) and average distribution from 2000–11 (right panel).

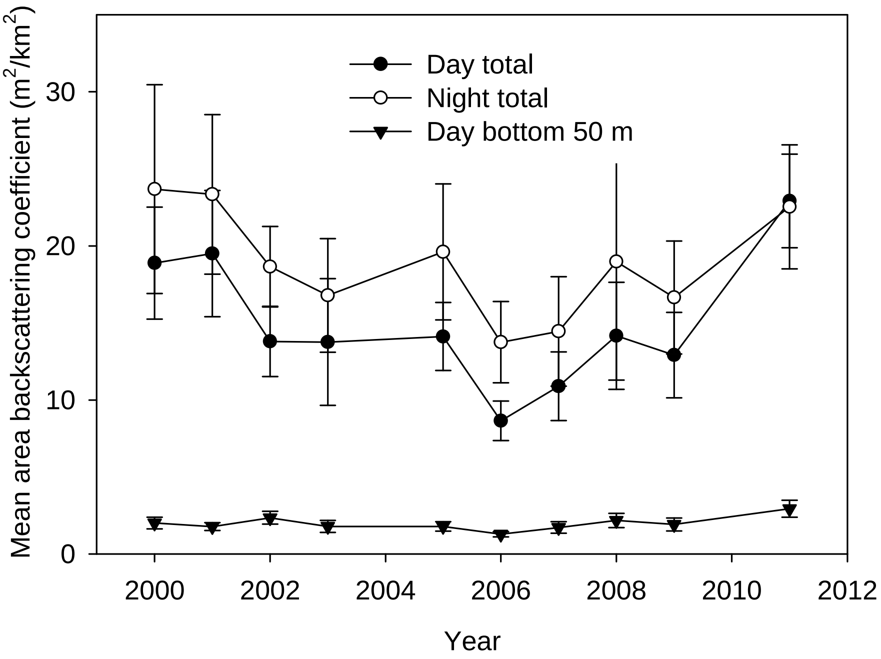


Figure 16: Total acoustic abundance indices for the Sub-Antarctic based on (strata-averaged) mean areal backscatter (sa). Error bars are plus or minus two standard errors.

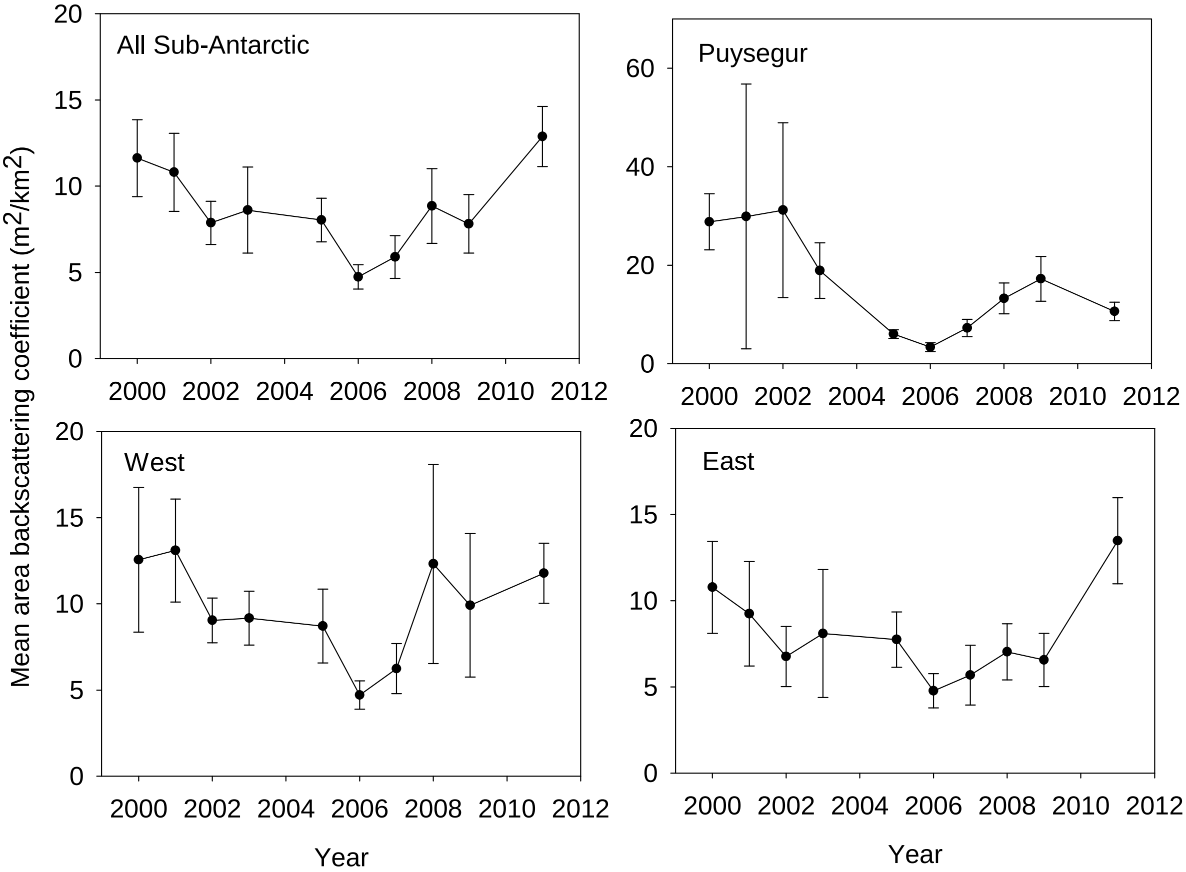


Figure 17: Time-series of mesopelagic indices for the Sub-Antarctic (from Table 15). Panels show indices for the entire Sub-Antarctic and for three subareas. Error bars are plus or minus two standard errors.

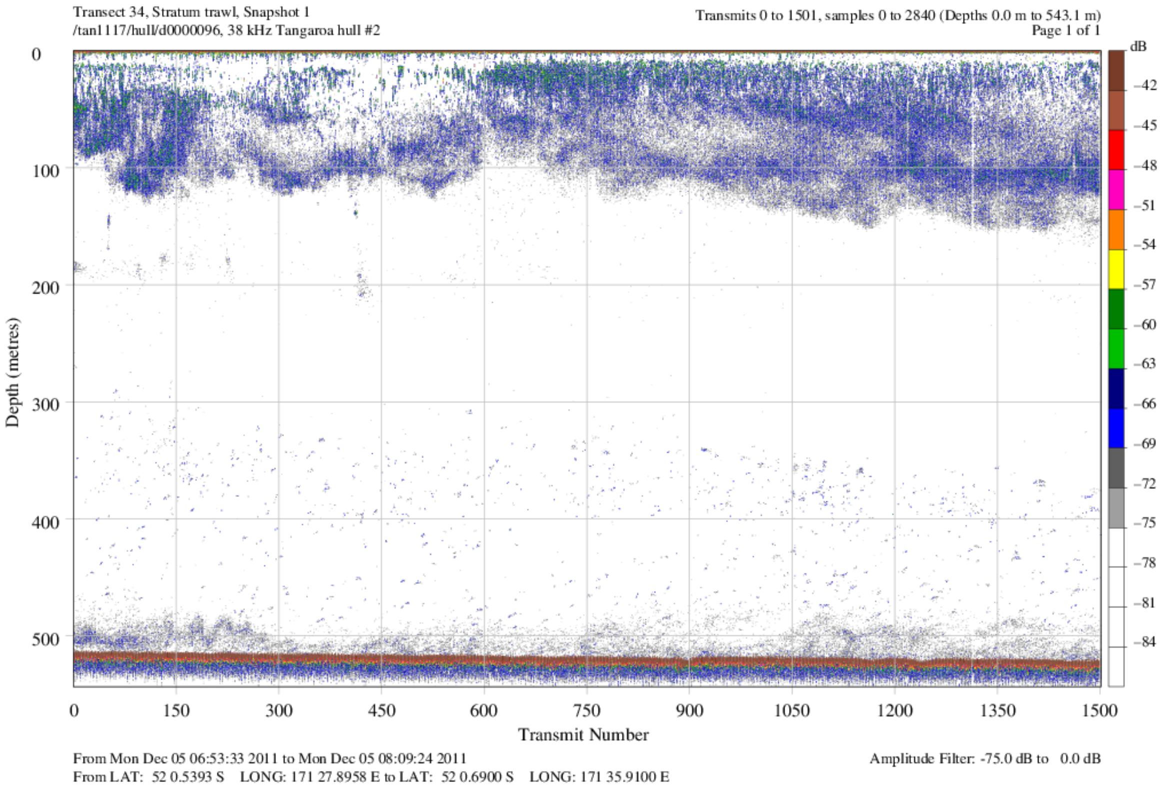


Figure 18: Example of echogram showing relatively strong daytime mesopelagic marks in the upper 200 m in the eastern subarea. Data were recorded during tow 34 on 5 December.

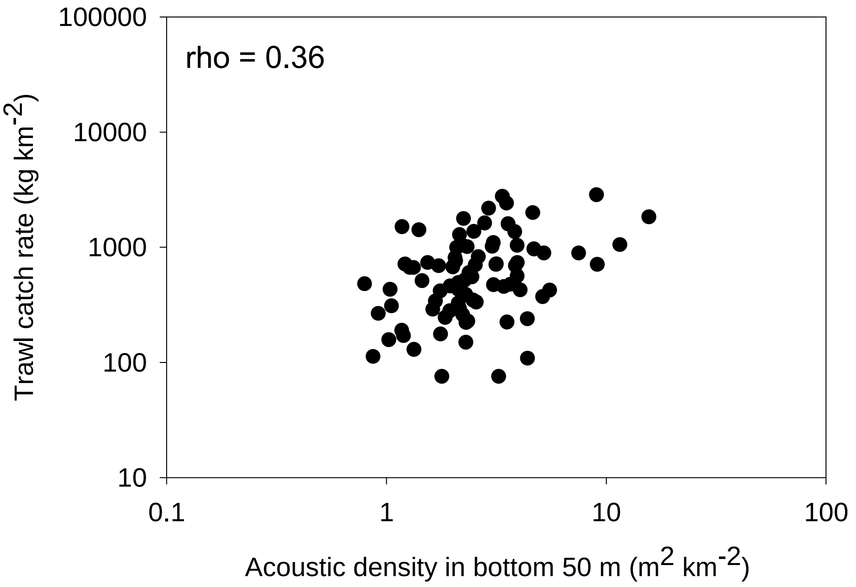


Figure 19: Relationship between total trawl catch rate (all species excluding benthic invertebrates) and acoustic backscatter recorded during the trawl in the Sub-Antarctic in 2011. Rho value is the Spearman's rank correlation coefficient.

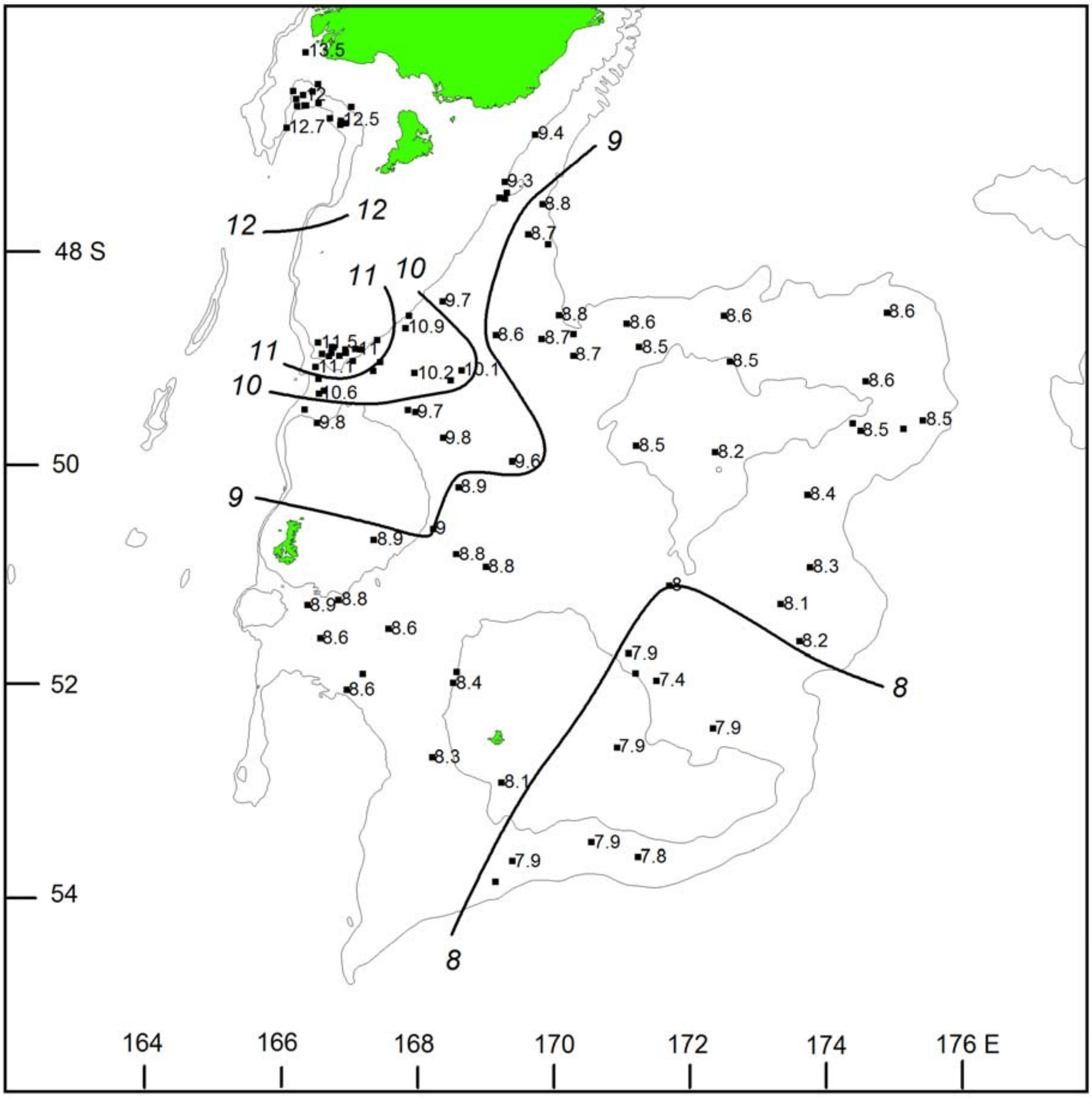


Figure 20: Surface water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

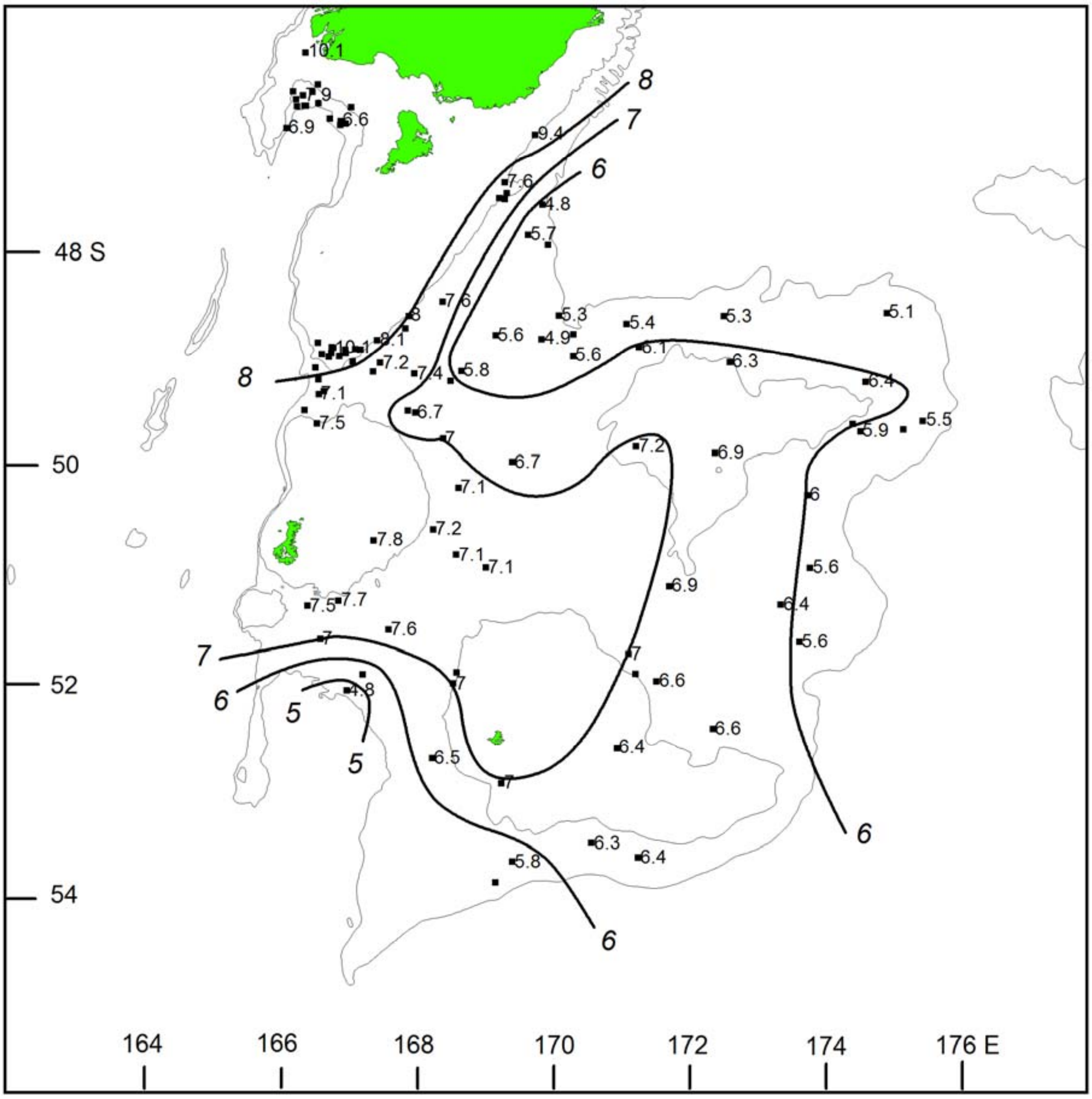
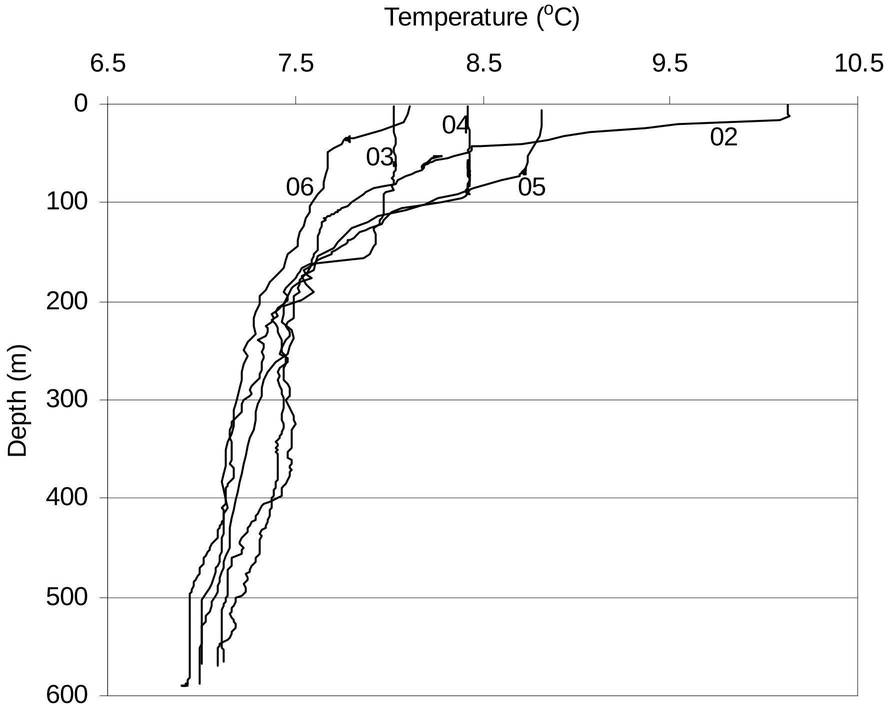


Figure 21: Bottom water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.



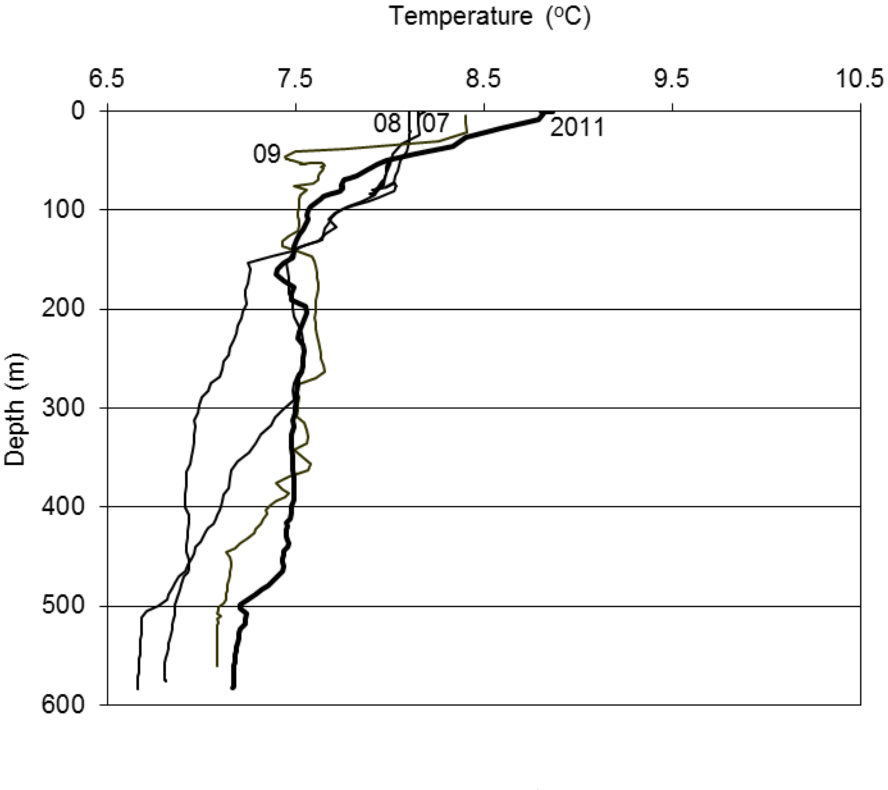


Figure 22: Comparison of vertical profiles of temperature (^oC) from the net-mounted CTD on tows in stratum 9 at approximately 50^o 45' S and 169^o 00' E in 2002 (TAN0219 station 54, on 6 December), 2003 (TAN0317 station 45, on 29 November), 2004 (TAN0414 station 54, on 14 December), 2005 (TAN0515 station 42, on 6 December), 2006 (TAN0617 station 33, on 5 December) (above), 2007 (TAN0714 station 40, on 7 December), 2008 (TAN0813 station 17, on 30 November) and from 2009 (TAN0911 station 46, on 9 December). The profile for 2011(station 53, on 9 December) is the bold line (below). Labels on the other lines indicate the year (i.e., 2002 is '02').

Appendix 1: Station details and catch of hoki, ling, and hake. * indicates station considered unsuitable for biomass estimation.

Station number	Date	Stratum	Start latitude (S)	Start longitude (E)	Distance (n miles)	Hoki (kg)	Ling (kg)	Hake (kg)
1*	25-Nov-11	TEST	44 52.12	172 09.19	1.3			
2	27-Nov-11	3A	46 55.19	169 43.85	3.1	25.0	44.2	0
3	27-Nov-11	3A	47 21.84	169 17.35	3.0	542.6	110.7	0
4	27-Nov-11	3A	47 27.76	169 18.72	3.0	114.0	150.8	8.4
5	27-Nov-11	3A	47 30.61	169 12.13	3.0	292.6	130.9	3.5
6	27-Nov-11	3A	47 31.10	169 17.05	3.0	1252.7	147.9	8.5
7	28-Nov-11	28	47 34.34	169 50.48	3.0	2.6	0	0
8	28-Nov-11	4	47 51.21	169 37.60	3.0	30.0	36.7	16.6
9	28-Nov-11	28	47 56.64	169 55.32	3.0	2.0	0	7.7
10	29-Nov-11	4	48 47.11	169 09.18	3.0	76.3	21.8	5.2
11	29-Nov-11	28	48 49.44	169 49.64	3.0	6.8	0	0
12	29-Nov-11	28	48 35.99	170 04.77	3.0	31.3	1.6	10.5
13	29-Nov-11	27	48 46.61	170 17.71	2.3	2.2	0	0
14	29-Nov-11	11	48 59.00	170 17.82	3.0	16.6	1.4	0
15	30-Nov-11	11	48 40.71	171 04.87	3.0	38.5	3.8	2.9
16	30-Nov-11	11	48 53.99	171 15.59	3.0	141.4	49.2	0
17	30-Nov-11	12	49 49.29	171 12.81	3.1	29.3	42.7	0
18	30-Nov-11	12	49 52.86	172 22.73	3.0	6.3	46.0	0
19	1-Dec-11	27	48 36.51	172 30.68	3.0	49.0	0	0
20	1-Dec-11	12	49 02.24	172 35.89	3.0	178.0	66.2	0
21	1-Dec-11	27	48 34.66	174 54.39	3.0	11.6	0	0
22	2-Dec-11	11	49 35.23	175 26.11	3.0	64.8	0	0
23	2-Dec-11	11	49 39.90	175 08.93	3.0	83.7	12.4	0
24	2-Dec-11	12	49 40.99	174 31.28	3.0	218.8	15.2	0
25	2-Dec-11	12	49 36.95	174 24.36	3.0	48.4	74.8	0
26	2-Dec-11	12	49 13.36	174 35.77	3.0	63.4	46.1	0
27	3-Dec-11	11	50 16.51	173 44.35	3.1	33.2	0	0
28	3-Dec-11	15	50 57.25	173 46.62	3.1	14.3	11.6	0
29	3-Dec-11	15	51 38.61	173 37.38	3.1	0	22.0	0
30	4-Dec-11	13	51 17.82	173 20.77	3.0	46.8	12.3	0
31	4-Dec-11	13	51 07.65	171 42.21	3.0	304.0	25.2	0
32	4-Dec-11	13	51 45.28	171 06.36	3.0	55.7	95.7	0
33	5-Dec-11	13	51 56.31	171 12.74	3.0	33.6	66.7	0
34	5-Dec-11	14	52 00.61	171 30.88	3.0	15.3	69.0	0
35	5-Dec-11	14	52 27.14	172 21.05	2.9	6.1	35.1	0
36	5-Dec-11	14	52 37.95	170 56.28	3.0	2.8	14.5	0
37	6-Dec-11	15	53 39.15	171 14.57	3.0	106.8	22.5	0
38	6-Dec-11	10	53 31.06	170 33.35	3.0	100.4	14.2	0
39	6-Dec-11	10	53 41.42	169 23.83	3.0	3.0	0	0
40	6-Dec-11	26	53 53.01	169 09.01	3.0	0	0	4.4
41*	7-Dec-11	9	52 57.73	169 13.96	2.6	10.4	18.5	0
42	7-Dec-11	10	52 43.67	168 13.06	3.2	65.3	0	20.4
43	7-Dec-11	9	52 01.71	168 31.38	2.6	203.6	206.8	0
44	7-Dec-11	9	51 55.71	168 34.45	3.0	717.5	189.3	0
45	8-Dec-11	26	52 05.58	166 57.70	3.0	3.0	5.3	0
46	8-Dec-11	26	51 56.64	167 11.59	3.0	0	3.8	0
47	8-Dec-11	7	51 36.96	166 34.50	3.0	36.7	9.6	0
48	8-Dec-11	7	51 18.43	166 22.91	3.0	254.8	48.3	0
49	8-Dec-11	6	51 15.52	166 50.08	3.0	132.1	67.8	0

Appendix 1 Cntd.

Station number	Date	Stratum	Start latitude (S)	Start longitude (E)	Distance (n miles)	Hoki (kg)	Ling (kg)	Hake (kg)
50	9-Dec-11	7	51 31.81	167 34.49	3.0	29.2	112.7	0
51	9-Dec-11	6	50 41.71	167 21.43	3.3	46.8	58.6	0
52	9-Dec-11	9	50 49.85	168 34.15	3.0	136.2	38.9	0
53	9-Dec-11	9	50 56.93	169 00.32	3.0	61.5	46.8	0
54	10-Dec-11	9	50 35.62	168 14.02	3.0	91.9	83.1	5.8
55	10-Dec-11	9	50 12.35	168 36.33	3.0	364.5	124.6	15.7
56	10-Dec-11	8	49 58.07	169 23.52	3.0	393.0	55.3	0
57	10-Dec-11	8	49 44.95	168 22.80	3.0	288.0	142.9	0
58	11-Dec-11	8	49 07.29	168 39.07	3.0	118.1	8.7	0
59	11-Dec-11	8	49 12.77	168 29.26	3.0	88.4	36.8	27.6
60*	11-Dec-11	5B	49 30.48	167 58.21	3.0	227.3	101.2	27.1
61	11-Dec-11	5B	49 29.47	167 51.52	2.8	375.9	140.5	9.8
62	11-Dec-11	5B	49 08.60	167 57.28	3.0	85.4	77.2	0
63	12-Dec-11	4	48 28.46	168 22.25	2.6	54.3	135.4	3.3
64	12-Dec-11	5A	48 36.46	167 52.58	3.0	94.3	221.7	0
65	12-Dec-11	4	48 43.35	167 49.40	3.0	28.4	6.2	1.8
66	12-Dec-11	3A	48 50.08	167 24.16	3.0	49.9	516.7	0
67	12-Dec-11	3B	48 55.10	167 04.91	3.0	926.2	20.8	0
68	13-Dec-11	5B	49 02.60	167 26.96	3.0	57.3	13.5	14.9
69	13-Dec-11	5B	49 07.45	167 20.87	3.0	72.6	43.2	66.9
70	13-Dec-11	3B	49 02.05	167 02.79	3.0	224.0	53.7	3.1
71*	13-Dec-11	3B	48 53.89	166 44.63	3.1	146.2	6.5	0
72	13-Dec-11	3B	48 51.41	166 32.13	2.7	175.6	80.6	1297.0
73	14-Dec-11	6	49 36.57	166 31.44	2.6	289.7	54.1	0
74	14-Dec-11	5A	49 29.15	166 20.09	3.0	42.1	66.1	4.1
75	14-Dec-11	5A	49 20.18	166 33.09	3.4	12.4	31.0	65.7
76	14-Dec-11	5A	49 18.70	166 37.35	3.0	26.4	40.7	74.0
77	14-Dec-11	5A	49 12.00	166 32.69	3.0	26.0	5.8	0
78	14-Dec-11	5A	49 05.14	166 30.09	3.0	72.7	31.0	19.4
79	15-Dec-11	25	46 47.36	166 52.31	3.0	136.2	8.8	45.7
80	15-Dec-11	1	46 39.52	167 01.46	3.0	281.7	117.9	1.4
81	15-Dec-11	2	46 33.02	166 19.10	3.0	92.6	102.0	0
82	15-Dec-11	25	46 38.84	166 20.07	3.0	18.5	0	54.2
83	16-Dec-11	1	46 09.26	166 21.22	3.0	201.5	1867.0	0
84	16-Dec-11	1	46 26.90	166 32.22	3.0	274.8	419.0	3.6
85	16-Dec-11	1	46 30.79	166 10.01	3.0	32.8	39.1	4.9
86	16-Dec-11	2	46 35.16	166 12.71	3.0	352.8	60.9	4.0
87	16-Dec-11	25	46 39.07	166 13.62	3.0	166.9	19.9	169.2
88*	16-Dec-11	25	46 51.14	166 04.46	1.2	152.4	3.4	321.1
89	17-Dec-11	25	46 38.87	166 21.78	3.0	19.6	0	52.1
90	17-Dec-11	25	46 37.26	166 32.70	2.3	7.6	9	332.6
91	17-Dec-11	25	46 45.92	166 42.55	3.0	6.5	0	108.6
92	17-Dec-11	25	46 49.57	166 51.85	3.0	4.5	0	100.5
93	17-Dec-11	25	46 48.83	166 56.92	3.0	7.3	2.3	302.7
94	17-Dec-11	2	46 44.80	166 54.81	3.0	240.0	37.6	0
95	18-Dec-11	2	46 30.94	166 27.48	3.0	100.3	62.1	116.5
96	19-Dec-11	3B	48 54.17	166 45.58	2.6	827.9	19.8	0
97	19-Dec-11	3B	48 57.12	166 44.08	3.0	186.8	81.6	0
98	19-Dec-11	3B	48 59.16	166 41.84	3.0	110.2	65.7	76.7

Appendix 1 Cntd.

Station number	Date	Stratum	Start latitude (S)	Start longitude (E)	Distance (n miles)	Hoki (kg)	Ling (kg)	Hake (kg)
99	19-Dec-11	3B	48 57.24	166 56.50	3.0	448.9	43.4	0
100	19-Dec-11	3B	48 55.35	167 09.68	2.9	1061.8	117.0	0
101	19-Dec-11	3B	48 55.33	166 56.09	2.2	656.2	46.7	0
102	20-Dec-11	3B	48 57.62	166 35.85	3.0	86.7	75.9	304.9
103	20-Dec-11	3B	48 58.91	166 50.91	3.0	295.9	29	8.4

Appendix 2: 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 3: Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms. Note species codes, particularly invertebrates, are continually updated on the database following this and other surveys.

Scientific name	Common name	Species code	Occ.
Porifera	unspecified sponges	ONG	17
Hexactinellida:	glass sponges	GLS	1
Hyalascus spp.	floppy tubular sponge	HYA	26
Geodiidae			
Geodia regina	ostrich egg sponge	GRE	2
Pachymatisma sp.	rock dumpling sponge	PAZ	1
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	19
Hymedesmiidae			
Phorbas spp.	grey fibrous massive sponge	PHB	2
Tetillidae			
Tetilla leptoderma	furry oval sponge	TLD	1
T. australe	Bristle ball sponge	TTL	4
Cnidaria			
Scyphozoa	unspecified jellyfish	JFI	2
Anthozoa			
Octocorallia			
Alcyonacea	unspecified soft coral	SOC	1
Keratoisis spp.	branching bamboo coral	BOO	1
Actiniaria	unspecified sea anemones	ANT	4
Actiniidae			
Bolocera spp.	smooth deepsea anemone	BOC	2
Actinostolidae	deepsea anemone	ACS	20
Alcyoniidae			
Hormathiidae	warty deepsea anemone	HMT	15
Gorgonacea	unspecified coral	GOC	3
Thouarella spp.	bottlebrush corals	THO	2
Caryophylliidae			
Desmophyllum dianthus	crested cup coral	DDI	1
Flabellidae			
Flabellum spp.	Flabellum cup corals	COF	3
Stylasteridae			
Errina spp.	red hyrdocorals	ERR	1
Pennatulacea			
Pteroeidiae			
Gyrophyllum sibogae	siboga sea pen	GYS	1
Ascidiacea			
Tunicata			
Thaliacea	unspecified salps	SAL	6
Salpidae			
Pyrosoma atlanticum		PYR	37
Mollusca			
Gastropoda: gastropods			
Ranellidae			
Fusitron magellanicus		FMA	12

Appendix 3 cntd:

Scientific name	Common name	Species code	Occ.
Cephalopoda: squid and octopus			
Teuthoidea: squids	unspecified squid	SQX	2
Histioteuthidae			
Histioteuthis spp.	violet squid	VSQ	2
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	35
Todarodes filippovae	Antarctic flying squid	TSQ	11
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	76
O. robsoni	warty squid	MRQ	3
Octopoda: Octopus			
Octopodidae			
Graneledone spp.	deepwater octopus	DWO	11
Opisthoteuthididae			
Opisthoteuthis spp.	umbrella octopus	OPI	8
Octopoteuthidae			
Taningia danae	squid	TDQ	8
Arthropoda: Isopods, amphipods, mysids, prawns, lobsters, crabs, barnacles, sea spiders			
Crustacea			
Malacostraca			
Aristaeidae	unspecified prawn	PRA	2
Aristaeopsis edwardsiana	scarlet prawn	PED	2
Campylonotidae			
Camplyonotus rathbonae	sabre prawn	CAM	2
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	29
Oplophoridae			
Acanthephyra spp.		ACA	1
Pasiphaeidae			
Pasiphaea barnardi	deepwater prawn	PBA	2
P. aff. tarda	deepwater prawn	PTA	4
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	3
Anomura	unspecified crab	CRB	1
Lithodidae			
Lithodes robertsoni	Robertson's king crab	LRO	4
L. aotearoa	New Zealand king crab	LAO	2
Neolithodes brodiei	Brodie's king crab	NEB	1
Paralomis zelandica	prickly king crab	PZE	2
Paguridae	unidentified hermit crab	PAG	1
Diacanthurus rubricatus	hermit crab	DIR	1
Parapoguridae	unidentified hermit crab	PAG	1
Sympagurus dimorphus	hermit crab	SDM	6
Brachyura			
Majidae			
Jacquinotia edwardsii	giant spider crab	GSC	1
Leptomithrax longipes	long-legged masking crab	LLC	1
Teratomaia richardsoni	spiny masking crab	SMK	2

Appendix 3 cntd:

Scientific name	Common name	Species code	Occ.
Portunidae			
Nectocarcinus bennetti	smooth red swimming crab	NEC	1
Nephropidae			
Metanephrops challengeri	scampi	SCI	2
Pycnogonida			
Colossendeidae			
Colossendeis spp.	giant sea spiders	PYC	2
Echinodermata			
Asteroidea	Sea stars		
Asteriidae			
Pseudechinaster rubens		PRU	1
Sclerasterias mollis	cross-fish	SMO	1
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	20
Psilaster acuminatus	geometric star	PSI	4
Proserpinaster neozelanicus		PNE	3
Benthopectenidae			
Benthopecten spp.		BES	2
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	26
Hippasteria trojana	trojan star	HTR	26
Lithosoma novaezelandiae	rock star	LNV	9
Mediaster sladeni	Sladen’s star	MSL	1
Pillsburiester aoteanus		PAO	11
Pterasteridae			
Diplopteraster spp.	starfish	DPP	2
Solasteridae			
Crossaster multispinus	sun star	CJA	5
Solaster torulatus	chubby sun-star	SOT	3
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	27
Crinoidea	sea lilies and feather stars	CRI	1
Echinoidea	unspecified sea urchin	ECT/ECN	2
Regularia			
Cidaridae: cidarid urchins			
Goniocidaris parasol	parasol urchin	GPA	6
G. umbraculum	umbrella urchin	GOU	2
Echinothuriidae, Phormosomatidae	unspecified Tam O’Shanter urchin	TAM	16
Echinidae			
Dermechinus horridus	deepsea urchin	DHO	2
Spatangidae			
Spatangus multispinus	purple heart urchin	SPT	1
Ophiuroidea			
Gorgonocephalidae			
Gorgonocephalus spp.	gorgons head basket-star	GOR	9

Appendix 3 cntd:

Scientific name	Common name	Species code	Occ.
Holothuroidea	sea cucumbers	HTH	4
Aspidochirotida			
Synallactidae			
Bathyplotes spp.	Sea cucumber	BAM	2
Pseudostichopus mollis		PMO	45
Pannychia moseleyi		PAM	4

Agnatha

Scientific name	Common name	Species code	Occ.
Myxinidae: hagfishes			
Eptatretus cirrhatus	hagfish	HAG	1

Chondrichthyes

Scientific name	Common name	Species code	Occ.
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	2
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	24
Centroscymnus crepidater	longnose velvet dogfish	CYP	31
C. owstoni	smooth skin dogfish	CYO	6
Deania calcea	shovelnose dogfish	SND	21
Etmopterus baxteri	Baxter's dogfish	ETB	38
E. lucifer	lucifer dogfish	ETL	59
E. pusillus	smooth lanternshark	ETP	2
Proscymnodon plunketi	Plunket's shark	PLS	18
Scymnorhinus licha	seal shark	BSH	11
Squalus acanthias	spiny dogfish	SPD	45
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	2
Lamnidae: mackerel sharks			
Lamna nasus	porbeagle shark	POS	1
Proscylliidae: finback cat sharks			
Gollum attenuatus	slender smoothhound	SSH	1
Scyliorhinidae: cat sharks			
Apristurus spp.	deepsea catsharks	APR	13
Bythaelurus dawsoni	Dawson’s catshark	DCS	4
Rajidae: skates			
Amblyraja hyperborea	deepwater spiny skate	DSK	4
Bathyraja shuntovi	longnosed deepsea skate	PSK	2
Brochiraja asperula	smooth deepsea skate	BTA	9
B. spinifera	prickly deepsea skate	BTS	3
Dipturus innominata	smooth skate	SSK	13
Zearaja nasuta	rough skate	RSK	5
Chimaeridae: chimaeras, ghost sharks			
Chimaera spp.	brown chimaera	CHP	2
C. lignaria	giant chimaera	CHG	1
Hydrolagus bemisi	pale ghost shark	GSP	86
H. novaezelandiae	dark ghost shark	GSH	13
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	37
Rhinochimaera pacifica	widenose chimaera	RCH	13

Osteichthyes

Appendix 3 cntd:

Scientific name	Common name	Species code	Occ.
Notacanthidae: spiny eels			
Notocanthus sexspinis	spineback	SBK	40
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	16
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	40
B. hirsutus	hairy conger	HCO	16
Gonorynchidae: beaked sandfishes			
Gonorynchus forsteri & G. greyi	sandfish	GON	5
Argentinidae: silversides			
Argentina elongata	silverside	SSI	36
Bathylagidae: deepsea smelts			
Bathylagus spp.	deepsea smelt	DSS	3
Alepocephalidae: slickheads			
Alepocephalus antipodianus	small-scaled brown slickhead	SSM	13
Alepocephalus australis	big-scaled brown slickhead	SBI	2
Gonostomatidae: bristlemouths			
Gonostoma elongatum	elongate lightfish	GEL	6
Diplophos spp.	lightfish	DIP	2
Microstomatidae: pencilsmelts			
Melanolagus bericoides	bigscaled smelt	MEB	1
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	5
Chauliodontidae: viperfishes			
Chauliodus sloani	viperfish	CHA	8
Stomiidae: scaly dragonfishes			
Opostomias micripnus	giant black dragonfish	OMI	1
Stomias spp.	scaly dragonfish	STO	3
Melanostomiidae: scaleless black dragonfishes		MST	1
Malacosteidae: loosejaws	unspecified loosejaw	MAL	1
Malacosteus australis	southern loosejaw	MAU	2
Idiacanthidae: black dragonfishes			
Idiacanthus spp.	black dragonfish	IDI	3
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	1
Maurolicus australis	pearlside	MMU	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	8
Myctophidae: lanternfishes	unspecified lanternfish	LAN	14
Lampanyctus spp.	lanternfish	LPA	1
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	7
Notophycis marginata	dwarf cod	DCO	4
Halargyreus johnsoni	Johnson’s cod	HJO	14
Lepidion microcephalus	small-headed cod	SMC	7
Mora moro	ribaldo	RIB	45
Pseudophycis bachus	red cod	RCO	11
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	35
Merlucciidae: hakes			
Lyconus sp.		LYC	1
Macruronus novaezelandiae	hoki	HOK	99
Merluccius australis	hake	HAK	42

Appendix 3 cntd:

Scientific name	Common name	Species code	Occ.
Macrouridae: rattails, grenadiers	rattails	RAT	1
Coelorinchus aspercephalus	oblique-banded rattail	CAS	48
C. biclinozonalis	two saddle rattail	CBI	1
C. bollonsi	Bollons's rattail	CBO	26
C. fasciatus	banded rattail	CFA	72
C. innotabilis	notable rattail	CIN	18
C. kaiyomaru	Kaiyomaru rattail	CKA	12
C. matamua	Mahia rattail	CMA	7
C. oliverianus	Oliver's rattail	COL	57
C. parvifasciatus	small-banded rattail	CCX	5
Coryphaenoides dossenus	humpback rattail	CBA	10
C. serrulatus	serrulate rattail	CSE	9
C . subserrulatus	fourrayed rattail	CSU	29
Lepidorhynchus denticulatus	javelinfish	JAV	94
Lucigadus nigromaculatus	blackspot rattail	VNI	17
Macrourus carinatus	ridge-scaled rattail	MCA	34
Mesobius antipodum	black javelinfish	BJA	3
Nezumia namatahi	velvet rattail	NNA	1
Trachyrincus aphyodes	white rattail	WHX	9
T. longirostris	unicorn rattail	WHR	2
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	87
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate	ECR	1
Regalecidae: oarfishes			
Agrostichthys parkeri	ribbonfish	AGR	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	15
H. mediterraneus	silver roughy	SRH	4
Paratrachichthys trailli	common roughy	RHY	3
Diremidae: discfishes			
Diretmus argenteus	discfish	DIS	2
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	1
Cyttus novaezealandiae	silver dory	SDO	4
C. traversi	lookdown dory	LDO	36
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	2
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	8
Trachyscorpia eschmeyeri	Cape scorpionfish	TRS	2
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	12
Neocyttus rhomboidalis	spiky oreo	SOR	4
Pseudocyttus maculatus	smooth oreo	SSO	17
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	3
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	18
Cottunculus nudus	bonyskull toadfish	COT	1
Neophrynichthys latus	dark toadfish	TOD	1
Psychrolutes spp.	blobfish	PSY	4
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	1

Appendix 3 cntd:

Scientific name	Common name	Species code	Occ.
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	11
E. robustus	cardinalfish	EPR	3
E. telescopus	black cardinalfish	EPT	6
Bramidae: pomfrets			
Brama australis & B. brama	Ray's bream	RBM	17
Nototheniidae: cod icefishes			
Dissostichus eleginoides	Patagonian toothfish	PTO	1
Chiasmodontidae: swallowers			
Chiasmodon microcephalus	black swallower	CML	1
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	22
Gempylidae: snake mackerels			
Paradiplospinus gracilis	false frostfish	PDS	1
Rexea solandri	gemfish	SKI	2
Thyrsites atun	barracouta	BAR	1
Trichiuridae: cutlassfishes			
Benthodesmus elongatus	bigeye scabbard fish	BEN	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	12
Hyperoglyphe antarctica	bluenose	BNS	1
Icichthys australis	ragfish	RAG	1
Seriolella brama	blue warehou	WAR	1
S. caerulea	white warehou	WWA	29
S. punctata	silver warehou	SWA	9
Tubbia tasmanica	Tasmanian ruffe	TUB	2
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	2
Neoachiropsetta milfordi	finless flounder	MAN	26

Appendix 4: Scientific and common names of benthic invertebrates formally identified following the voyage.

NIWA No.	Voyage/Station	Phylum	Class	Order	Family	Genus	Species
80622	TAN1117/3	Porifera	Demospongiae	Haplosclerida	Callyspongiidae	Dactylia	palmata
80623	TAN1117/8	Porifera	Demospongiae	Hadromerida	Suberitidae	Suberites	affinis
80624	TAN1117/9	Porifera	Demospongiae	Spirophorida	Tetillidae	Craniella	cf. leptoderma
80625	TAN1117/10	Porifera	Demospongiae	Spirophorida	Tetillidae	Craniella	cf. leptoderma
80626	TAN1117/11	Porifera	Demospongiae	Spirophorida	Tetillidae	Cinachyra	n. sp. 4
62435	TAN1117/11	Porifera	Demospongiae	Spirophorida	Tetillidae	Craniella	cf. leptoderma
62436	TAN1117/11	Porifera	Demospongiae	Spirophorida	Tetillidae	Craniella	cf. metaclada
80643a	TAN1117/24	Echinodermata	Asteroidea	Valvatida	Goniasteridae	Hippasteria	phrygiana
80643b	TAN1117/24	Echinodermata	Asteroidea	Valvatida	Goniasteridae	Hippasteria	phrygiana
80627	TAN1117/34	Porifera	Demospongiae	Poecilosclerida	Coelosphaeridae	Lissodendoryx	n. sp. 1
80628	TAN1117/38	Porifera	Demospongiae	Spirophorida	Tetillidae	Cinachyra	n. sp. 4
80638	TAN1117/41	Arthropoda	Malacostraca	Decapoda	Nematocarcinidae	Nematocarcinus	
80629	TAN1117/42	Porifera	Demospongiae	Spirophorida	Tetillidae	Tetilla	australis
80630	TAN1117/61	Porifera	Demospongiae	Astrophorida	Geodiidae	Pachymatisma	n. sp. 2
80640	TAN1117/61	Chordata	Ascidiacea [Tunicates]	Enterogona Aplousobranchia		Polyclinidae	Synoicum
80631	TAN1117/66	Porifera	Demospongiae	Haplosclerida	Callyspongiidae	Dactylia	n. sp. 2
80632	TAN1117/69	Porifera	Hexactinellida	Lyssacinosida	Rossellidae		undet.
80633	TAN1117/69	Porifera	Demospongiae	Haplosclerida	Callyspongiidae	Callyspongia	n. sp. 2
80634	TAN1117/70	Porifera	Demospongiae	Halichondrida	Halichondriidae	Topsentia	n. sp. 5
80635	TAN1117/71	Porifera	Demospongiae	Halichondrida	Halichondriidae	Topsentia	n. sp. 5
80646	TAN1117/97	Cnidaria	Anthozoa	Gorgonacea	Primnoidae	Thouarella	
80647	TAN1117/97	Porifera	Demospongiae	Astrophorida	Ancorinidae	Stelletta	cf. phialimorpha
80893	TAN1117/97	Porifera	Demospongiae	Poecilosclerida	Coelosphaeridae	Lissodendoryx	bifacialis
80644	TAN1117/98	Annelida	Polychaeta	Eunicida	Eunicidae	Eunice	
80645a	TAN1117/98	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	Desmophyllum	dianthus
80645b	TAN1117/98	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	Crypthelia	?cymas
80605	TAN1117/98	Annelida	Polychaeta	Eunicida	Eunicidae	Eunice	
80639	TAN1117/91	Arthropoda	Malacostraca	Decapoda	Munidopsidae	Munidopsis	victoriae
80641	TAN1117/61	Cnidaria	Anthozoa	Actiniaria			
80642	TAN1117/24	Cnidaria	Anthozoa	Actiniaria			