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Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2012 (TAN1215)

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

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The fifteenth *Tangaroa* summer trawl survey of the Southland and Sub-Antarctic areas was carried out from 25 November to 23 December 2012. Ninety one tows were successfully completed in 20 strata.

Biomass estimates (and CVs) for all strata were 56 131 t (15%) for hoki, 27 036 t (11%) for ling, and 2443 t (22%) for hake. The hoki biomass was 21% higher than the 2011 estimate of 46 575 t, but lower than the recent peak of 66 157 t in 2009. The hake estimate from all strata in 2012 was also higher than the equivalent estimate from 2011 (2004 t), and the biomass estimate for ling was the highest observed in the time series surveys since 2000. There was no consistent change in the abundance of the other key species from 2011 to 2012: the estimates for pale ghost shark, southern blue whiting, javelinfish, lookdown dory, and white warehou increased from 2011; while estimates for spiny dogfish, dark ghost shark, ribaldo, and black oreo decreased.

Hoki length frequencies in 2012 showed a broad size range from 30–115 cm, with a mode from about 70–95 cm consisting of fish at ages 4–9. The strong 2002 year class has persisted and can still be tracked in the population at age 10, but there were few larger, older hoki (age 11 and above) caught. Few hoki from the 2010 year-class were taken at age 2+ (49–55 cm) in 2012, following on from very low numbers of fish from this year-class at age 1+ in the 2011 survey. The length frequency distribution of hake showed no clear modes. Most hake were ages 4–11, with smaller (50–70 cm) hake taken at 800–1000 m depth at Puysegur (stratum 25). The length distribution of ling in 2012 was broad, with an increase in the numbers of fish of both sexes between 60 and 70 cm compared to the 2011 survey. Most ling were between 4 and 11 years old, with the mode at age 6 for males and age 7 for females.

Acoustic data were also collected during the trawl survey. Data quality in 2012 was generally poor, due to rough weather and sea conditions and acoustic interference from another echosounder, and only 40% of acoustic files were suitable for quantitative analysis. Acoustic indices of mesopelagic fish abundance on the Campbell Plateau in 2012 had declined from a peak in 2011, but were at a similar level to indices from the equivalent areas in 2006 and 2007. 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 reduced since 2000–01, hoki is still New Zealand's largest fishery, with a TACC of 130 000 t from 1 October 2012, increasing to 150 000 t from 1 October 2013. 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 17 000 t in 2011–12 (Ballara & O'Driscoll 2014). 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 2012–13. 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 2011–12 were 1948 t (HAK 1, includes the western Chatham Rise) and 3649 t (LIN 5, Southland), and 2047 t (LIN 6, Sub-Antarctic) (Ministry for Primary Industries 2013).

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, 2000–09 and 2011–12; and an autumn series in March–June 1992, 1993, 1996 and 1998 (reviews by O'Driscoll & Bagley 2001 and Bagley et al. 2013a). 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 since 2007 were also much higher than in 2003–06, increasing to a high of 65 017 t in 2009 (O'Driscoll & Bagley 2009, Bagley & O'Driscoll 2012). Despite the large increase in the estimated hoki biomass, the 2007–11 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 provided 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. 2013a).

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, Bagley et al. 2013b), 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, Bagley et al. 2013b). 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 collection of material for training, detailed reproductive observations on some deepwater shark species, the collection of hoki and ling tissue samples, and the collection of fish stomachs from selected species.

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 2012 survey provided a fifteenth summer estimate of western hoki biomass in time for the 2013 stock assessment.

1.1 Project objectives

The trawl survey was carried out under contract to the Ministry for Primary Industries (project MDT2010-02A). The specific objectives for the project were as follows:

1. To carry out a trawl survey in December 2012 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 collect acoustic and related data during the trawl survey.

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

2. METHODS

2.1 Survey design

The survey was a two-phase stratified random design (after Francis 1984). The survey area was divided into 20 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. Stratum 26, at 800–1000 m depth south of Campbell Island, was dropped in 2012 due to the number of survey days being cut from 30 to 29. There is also 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. Trawls were conducted in the Campbell East and Sub-Antarctic Deep Benthic Protected Areas (BPAs). Written approval to sample within these BPAs was granted under MPI special permit 542

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 2006–09 and 2011 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 and 2011. A minimum of three stations per stratum was used. As in previous years, conservative target CVs of 17% for hake and 12% for hoki and ling were used in the statistical analysis to increase the chance that the Ministry for Primary Industries target CVs 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 85 stations was planned for phase 1 (Table 1), with phase 2 stations to be allocated at sea to improve CVs 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 1956 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.

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 21 July 2012 in Tasman Bay. The system and calibration parameters are given in Appendix 1 of O'Driscoll et al. (2014).

2.5 Hydrology

Temperature and salinity data were collected using calibrated Seabird SM-37 Microcat CTD dataloggers (serial numbers 4083 for stations 1–30, and 4098 for stations 31–100) 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, cephalopods, 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 ashore. This work is now under a separate contract with MPI (DAE201001C) and scheduled for completion in the 2013/14 financial year.

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 middle depths 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 four deepwater shark species. The number of eggs, the yolk diameter, uterus width and pup size measured from stage-3 female sharks (mature) were recorded to collect information on potential fecundity. Hoki, ling, southern blue whiting, oblique-banded rattail, and arrow squid, either had their stomachs removed and stored in individually labelled bags or collected whole, and will be analysed later in the laboratory to determine diet. The diet will be quantitatively described, and the data will help inform ecosystem models being developed for the Sub-Antarctic region. This research is being funded by NIWA core funds. Samples of smooth oreo, southern blue whiting, and small numbers of a variety of other fish species, were collected for teaching at Victoria University of Wellington. The samples will be used to demonstrate the variety of fish morphology, and to teach fish dissection, during the year-3 undergraduate course BIOL372 Applied Marine Biology. This work is a collaboration between NIWA and Victoria University. Tissue samples were collected from hoki and ling to examine the movements of fish in the open ocean using stable isotope techniques. This work is being conducted by Brittany Graham, a post-doctoral fellow working at NIWA.

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 CV 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. Population 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, 600 ling and all 764 hake otoliths were selected for ageing. Sub-samples for hoki and ling 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 that the tails of the length distribution were represented. The chosen sample size approximates that necessary to produce a mean weighted CV 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 et al. 2013b) 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 km^2 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 2012. The methods were the same as those used by O'Driscoll et al. (2011) and Bagley et al. (2013b). 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 3 days lost due to unfavourable sea conditions. Due to poor weather on the eastern side of Stewart Island at the start of the survey, the Puysegur area, where conditions were better, was surveyed about 2.5 weeks earlier than usual.

Ninety-one successful trawl survey stations were completed in the 20 strata (Figure 2, Table 1). This included 84 phase 1 stations and 7 phase 2 stations. One phase 1 station in stratum 25 was not sampled because of bad weather at the end of the survey. Five phase 2 stations were directed at reducing the CV for hoki in strata 1, 13, 15 and 10. These were conducted during phase 1 due to variable catches of hoki, and long steaming distances making it unlikely to return to these strata for any phase 2 work. Other phase 2 effort was directed at reducing the CV for hake in stratum 5A.

Nine further stations were considered unsuitable for biomass estimation: stations 13 and 14 in stratum 25 had unacceptably low doorspreads and high headline heights due to strong currents; stations 71, 72, 89 and 94 came fast; stations 78 and 85 were hauled early due to foul ground along the tow line with the net sustaining damage on tow 85; and tow 83 was given a bad gear performance as discarded sweep wires were caught in the port wing and this was considered to have had an effect on the trawl's performance. Individual station details from all trawl stations, including the catch of hoki, hake and ling are listed in Appendix 1.

3.2 Gear performance

Gear parameters by depth and for all observations are summarised in Table 2. The headline height and doorspread readings were obtained for all valid biomass tows. Measured gear parameters in 2012 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 were 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 mean doorspreads increased in 2011, but were lower again in 2012, with a mean doorspread of 116.8 m (Table 3). 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 51.7 t was recorded from all trawl stations (47.8 t from valid biomass tows). For the target species from valid biomass stations, hoki accounted for 32.8%, ling 17.7%, and hake 7.9% of the total catch, while 7.8% of the catch was javelinfish, 6.2 % pale ghost shark and 5.4% southern blue whiting. From the 200 species or species groups caught, 88 were teleosts, 25 elasmobranchs, 12 cephalopods, and 21 crustaceans with the remainder comprising assorted benthic and pelagic invertebrates (Appendix 3).

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 removal of stratum 26 from the 2012 survey will have little effect on the time series of total abundance estimates for the three target species as few hoki, hake or ling were caught in this stratum. The time series of core (300–800 m) estimates for the 12 key species are plotted in Figure 3.

Biomass estimates for hoki for all strata in 2012 was 56 131 t, an increase of 21% from the 2011 estimate of 46 070 t, but lower than the recent peak of 66 157 t in 2009. The 2012 estimate again confirmed the large increase from the time series low in 2006 of 14 747 t (Figure 3, Table 6). The hoki biomass from core stations was 55 739 t, so few hoki were caught deeper than 800 m. The biomass estimates for length ranges corresponding to ages 1+ (less than 49 cm) and 2+ (49–55 cm) hoki were 937 t (CV 44%) and 186 t (CV 60%) respectively. The low abundance of age 2+ hoki (2010 year-class) was consistent with the very low estimate of this year-class at age 1+ year class in the 2011 survey. The biomass of fish age 3+ or greater increased to 55 007 t in 2012 from 43 913 in 2011, with larger catches in some of the eastern strata. Despite the large increases from 2006, the hoki biomass is still much lower than was observed in the Sub-Antarctic in the early 1990s (Table 6).

The hake estimate from all strata was 2443 t, 22% higher than that in 2011 (2004 t). The estimate from core 300–800 m strata (1943 t) also increased from 2011 (1434 t), and was nearly double that 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 485 t, similar to the biomass in this stratum in 2009 and 2011, but less than half that observed in 2008 (1088 t). The estimate of ling biomass in 2012 was the highest recorded since 2000 at 27 010 t (Table 6). Few ling are taken deeper than 800 m.

Of the nine other key species, pale ghost shark, white warehou, southern blue whiting, lookdown dory and javelinfish increased from the 2011 estimates for the core survey area. Most changes were generally small and within the levels of the sampling uncertainty (Figure 3). However, the biomass of pale ghost shark was the highest since 2000 at 16 181 t. White warehou increased from 393 t in 2011 to 1259 t in 2012, but high CVs associated with higher estimates indicate that these are typically the result of one-off large catches. The biomass of southern blue whiting was 21 485 t, about 3 times higher than the 2011 estimate of 7642 t, but well below the time series high of 51 860 t in 2009. Estimates for ribaldo, black oreo, spiny dogfish and dark ghost shark in 2012 were lower than those from 2011 (Figure 3), with the estimated biomass of spiny dogfish in 2012 the lowest observed since the 1990s.

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 77 of the 80 core stations and 86 of the 91 successful total trawl stations. As in previous surveys, hoki catch rates were generally higher in the west at Puysegur, but lower along on the eastern edge of the Stewart-Snares shelf. The 2012 survey saw larger catches, over 1000 kg km^{-2} to the west and northeast of the Campbell Rise in stratum 13 and 10, and at Puysegur (Figure 4a). Small 1+ and 2+ hoki were mostly taken at Puysegur (Figure 4b and Figure 4c). Few small hoki were caught in the 300–600 m strata (3A and 3B) along the edge of the Stewart-Snares shelf where 2+ hoki are usually taken (Figures 4b and 4c).

Hake were concentrated in deeper water at Puysegur in stratum 25 (800–1000 m) and between the Auckland Islands and Stewart-Snares shelf in stratum 5A (Figure 5). Most stations in the east and south of the survey area caught no hake. Ling were caught on 77 of the 80 core stations, with higher catches at Puysegur and along the eastern edge of the Stewart-Snares shelf (Figure 6). Both hoki and ling were seldom caught deeper than 800 m.

3.6 Biological data

The numbers of fish of each species measured or selected for biological analysis are shown in Table 7. Otoliths were removed from 1757 hoki, 1285 ling, and 764 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 2012 survey are shown in Figure 10.

Hoki length frequencies in 2012 showed a broad size range. The overall length range was similar to that from the 2011 survey (Figure 7), but as noted previously there were few fish at the length range corresponding to age 2+ (49–55 cm) in 2012. Numbers of 1+ hoki in 2012 were about average for the time series. Length modes from about 70–95 cm consisted of fish at ages 4–9, with a modal peak at age 7 for both sexes. The apparently strong cohort of fish from the 2007 year-class observed as age 2+ in 2009 did not show strongly at 5+ in 2012.The strong 2002 year-class observed at younger ages in the 2007–09 surveys followed through weakly at age 10 in 2012 (Figure 11). There were few larger, older female hoki of age 11 and above, but slightly more males age 9 and above compared with earlier surveys from 2002.

The length frequency distribution of hake showed no clear modes (see Figure 8). Small (50–75 cm) hake were captured in higher numbers at 800–1000 m depth at Puysegur (stratum 25) compared with the 2011 survey. Since 1998 there has been a lower proportion of large hake (older than age 12) than were observed in surveys in the early 1990s with most hake between ages 5 and 10 for males, and 4 and 11 for females in 2012 (Figure 12). The length frequency distribution of ling was broad, with a slight decrease in the numbers of fish over 80 cm for males, and more small ling of both sexes between 60 and 70 cm than was observed in 2011 (Figure 9). Most ling were between 2 and 14 years old for males and 2 to 18 years for females with the mode between ages 5 and 9 (Figure 13).

The length frequency distribution of southern blue whiting caught in 2012 had the main length mode between 30 and 42 cm for both sexes, with modal peaks of 37 cm for males, and 34 and 38 cm for females (Figure 10). The length frequency distributions for black oreo were bimodal (see Figure 10). Other points of interest in Figure 10 included: a large mode at 42–48 cm in the length distribution for female javelinfish with fewer males; the continuing high proportion of female ribaldo; and strong modal peaks for pale ghost shark, between 60 and 75 cm for males, and 60 and 82 cm for females.

Gonad stages for hoki, hake, and ling are summarised in Table 9. Immature hoki made up 18% of fish examined, and these were typically fish smaller than 70 cm. Most adult hoki (72%) were in the resting phase. About 9% of female and male hoki were macroscopically staged as partially spent or spent. Female ling were mostly resting (62%) or immature (25%), but male ling of all gonad stages were recorded, with 39% in spawning condition (ripe and running ripe) and 32% resting. Immature stage hake made up 8% of the observations for both sexes. About 38% of male hake were ripe or running ripe, while 88% of females were resting or maturing.

3.7 Hoki condition indices

Liver and gutted weights were recorded from 1391 hoki in 2012. Both liver condition (Table 10) and somatic condition (measured as the estimated average weight of a 75 cm hoki, Table 11) were lower in 2012 than those recorded in 2011. Hoki liver condition in 2012 was below the long term average observed in the summer time series (Table 10), but somatic condition was slightly above the long-term average (Table 11).

3.8 Acoustic results

A total of 294 acoustic data files (100 trawl, 77 day-time steam, and 117 night-time steams) were recorded during the 2012 survey. Of these, 60% were not suitable for quantitative analysis because the data was of poor quality (Table 12). The high percentage of poor quality data in 2012 was mainly due to rough weather and sea conditions. However, at the start of the voyage, the ship's officers insisted on running another ship's echosounder unsynchronised and this affected data quality from 55 files, which were also classed as being of poor quality due to acoustic interference. The remaining 40% of files were either of good (18%) or marginal (22%) data quality (Table 12) and were used for quantitative analysis.

Expanding symbol plots of the distribution of total acoustic backscatter from good and marginal quality recordings observed during daytime trawls and night transects are shown in Figure 14. No data of suitable quality were collected at Puysegur in 2012. Spatial distribution of total backscatter in the remainder of the survey area was similar to that observed in previous years (O'Driscoll et al. 2011), with highest acoustic densities on the Stewart-Snares shelf and lowest densities in the southeastern Sub-Antarctic.

Table 13 shows the frequency of occurrence of each of the seven mark categories. Several mark types were often present in the same echogram. The percentage occurrence of mark types in 2012 was similar to the average over the whole time series, but with slightly lower occurrence of daytime pelagic layers than was observed in 2011 (Table 13).

Surface layers were observed in 96% of daytime steam echograms, 90% of trawls, and 95% of night echograms in 2012 (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 39% of day steam files, 36% of overnight steams, and 35% of trawl files in 2012 (Table 13). Bottom schools were occasionally observed during the day, mostly in less than 500 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).

The vertical distribution of acoustic backscatter in 2012 is compared to the average vertical distribution from all years in the Sub-Antarctic time series in Figure 15. As in previous years, vertical migration into the upper 200 m of the water column occurred at night (Figure 16). The component of acoustic backscatter that vertically migrates upward at dusk is assumed to be dominated by mesopelagic fish (McClatchie & Dunford 2003, O'Driscoll et al. 2009). However, not all midwater layers vertically migrate. An example of an echogram from the eastern Campbell Plateau showing mesopelagic marks remaining at depth, as well as moving upwards at dusk is shown in Figure 16.

The time series of day and night estimates of total acoustic backscatter are plotted in Figure 17. As in surveys from 2000–09, night estimates of total backscatter were higher than day estimates. O'Driscoll et al. (2009) suggested that this might be due to increased noise in night data. Day and night estimates of total backscatter were very similar in 2011 (Bagley et al. 2013b). The bottom backscatter (in the lower 50 m) has been relatively consistent since 2000 (Figure 17).

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 18 for the entire Sub-Antarctic and for the three subareas, noting that no acoustic data were available from Puysegur in 2012. As in previous years, the mesopelagic indices are similar to estimates of total backscatter for the Sub-Antarctic (see Figure 18). Estimates of mesopelagic backscatter on the eastern Sub-Antarctic in 2012 had declined by 60% from the peak observed in 2011, but were at a similar level to indices from this area in 2006–09 and 2007 (Figure 19). The mesopelagic acoustic index on the western Sub-Antarctic was also lower (by 24%) than that in 2011, but was around the average for the time series in this area

There was a weak positive correlation between acoustic backscatter in the bottom 50 m during the day and trawl catch rates (number of tows = 43, Spearman's rank correlation = 0.29, $p = 0.06$). Weak, but significant, positive correlations between backscatter and catches have been observed in previous surveys in 2000, 2001, 2003, 2005, 2007, 2008, 2009 and 2011 (O'Driscoll 2002, O'Driscoll & Bagley 2003a, 2004, 2006b, 2009, Bagley et al. 2009, Bagley & O'Driscoll 2012, Bagley et al. 2013b), but not in 2002, 2004, or 2006 (O'Driscoll & Bagley 2003b, 2006a, 2008).

3.9 Hydrological data

Temperature profiles were available from 98 CTD casts (including foul shots). Surface (5 m depth) temperatures ranged between 8.2 and 11.9 °C (Figure 20), while bottom temperatures were between 4.5 and 10.7 °C (Figure 21). Highest surface temperatures were in shallow water at Puysegur and in stratum 3B at the bottom of the Stewart/Snares shelf. Bottom temperature decreased with depth and to the east of the survey area, with lowest bottom temperatures recorded from water deeper than 800 m on the margins of the Campbell Plateau. 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 2012 of 9.6 °C was slightly higher than that observed in 2011 (9.1 °C), but within the range of average surface temperatures observed in 2002–11 (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). The 2012 survey followed a similar pattern to 2002 with higher surface temperature associated with a shallow thermocline at about 40 m. 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. However, this was not the situation in 2012 with mostly moderate to rough weather during the survey. Average bottom temperatures in 2012 (7.1 °C) were slightly higher than those observed in 2011 (7.0 °C) and the range of average temperatures observed in 2002–11 (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). The biomass has remained relatively high for all five surveys since 2007, with the estimate of hoki biomass in 2012 falling within the range of estimates recorded since 2007 (see Table 6). The summer Sub-Antarctic trawl survey series shows large annual changes in numbers-at-age (particularly between 2006 and 2007) which cannot be explained by changes in abundance, and are suggestive of a change in catchability (McKenzie & Francis 2009, McKenzie 2012).

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 returned to the pre-2007 averages, however the mean doorspreads for the 2012 survey dropped back to values seen in 2007–09. 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 consistent change in the abundance of the key species from 2011 to 2012: the estimates for hoki, hake, ling, pale ghost shark, southern blue whiting, javelinfish, lookdown dory, and white warehou increased from 2011; while estimates for spiny dogfish, dark ghost shark, ribaldo, and black oreo decreased.

In the 2011 and 2012 stock assessments, model sensitivities were run in which two catchabilities were fitted for the Sub-Antarctic summer time series, instead of just one, and these were found to improve the model fit substantially (McKenzie 2013). In 2013, three base models were run, two of which fitted two catchabilities to the Sub-Antarctic summer trawl series (Ministry for Primary Industries 2013). All three stock assessment model runs in 2013 showed that the biomass of the western hoki stock was at its lowest point (21–33% B_0) in the mid-2000s, but is now estimated to be about double this value and is considered to be fully rebuilt (Ministry for Primary Industries 2013). The western stock experienced an extended period of poor recruitment from 1995 to 2001. Year-classes after 2001 are estimated to be stronger, with five to six years in which recruitment is estimated to be near or above the long-term average, but the 2010 recruitment was well below average and 2011 was well above average. Biomass of the western hoki stock is expected to increase slowly over the next five years at current (2012–13) western fishery catch levels (Ministry for Primary Industries 2013).

5. CONCLUSIONS

The estimated hoki biomass in 2012 was the second highest since 2000, and about 10 000 t lower than the recent peak in 2009. Despite the large increase in the estimated hoki biomass in the past five surveys, the 2012 estimate is still less than the biomass observed in the Sub-Antarctic in the early 1990s. The survey methodology was consistent with previous years, but there is some evidence that there have been changes in trawl catchability in the Sub-Antarctic summer time series.

Low estimates of hoki at age 2+ in 2012 follow a time series low of 1+ hoki observed in 2011. Estimates of 1+ hoki for 2012 were about average for the time series from 2006. The biomass of fish age 3+ or greater was the highest observed in recent years. This increase in biomass of older fish mostly came from the eastern strata. The hoki age frequency observed in 2012 comprised mainly fish between 4 and 9 years old, with a progression of modes associated with the 2002–09 year classes. The 2+ year class seen in 2009 did not track through as age 5+ fish in 2012, while the strong 2002 year-class observed at younger ages in the 2007–09 surveys was detected weakly at age 10 in 2012

The estimated biomass of hake from the core strata in 2012 was slightly higher than that in 2011 and similar to the estimates in 2007 and 2008. Larger catches of hake were taken in stratum 5A to the south of the Stewart-Snares shelf. Hake are known to aggregate to spawn at this time of year, often over rough ground untrawlable with the standard survey trawl. The biomass estimate for ling in 2012 was the highest since 2000, but similar to the 2007 estimate. Pale ghost shark increased to its highest level since 2000, while spiny dogfish estimates were the lowest since the time series resumed in 2000. There was no consistent increase or decrease from the time series in the abundance of the other key species.

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Table 1: Stratum areas, depths, and number of successful biomass stations from the November–December 2012 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	1
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	
4	Stewart-Snares	600–800	21 018	4	4	
5a	Snares-Auckland	600–800	2 981	5	5	2
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	1
10	S. Campbell Is.	600–800	11 288	3	3	
11	N.E. Pukaki Rise	600–800	23 008	5	5	
12	Pukaki Rise	300–600	45 259	7	7	
13	N.E. Camp. Plateau	300–600	36 051	4	4	2
14	E. Camp. Plateau	300–600	27 659	3	3	
15	E. Camp. Plateau	600–800	15 179	3	3	1
25	Puysegur Bank	800–1 000	1 928	5	4	
27	N.E. Pukaki Rise	800–1 000	12 986	3	3	
28	E. Stewart Is.	800–1 000	8 336	4	4	
Total			288 417	85	84	7

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)	91	2.92	0.25	2.09–3.15
Tow speed (knots)	91	3.5	0.04	3.3–3.6
Gear parameters (m)				
300–600 m				
Headline height	42	7.1	0.31	6.7–8.0
Doorspread	42	117.5	5.99	102.8–127.0
600–800 m				
Headline height	38	7.0	0.23	6.5–7.6
Doorspread	38	118.3	6.44	104.7–130.1
800–1000 m				
Headline height	11	7.4	0.27	7.0–7.8
Doorspread	11	109.3	6.29	99.3–118.5
All stations 300–1000 m				
Headline height	91	7.1	0.30	6.5–8.0
Doorspread	91	116.8	6.77	99.3–130.1

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
2012	91	116.8	6.77	99.3	130.1	7.1	0.30

Table 4: Biomass estimates, coefficients of variation, and catch of the 20 species with highest catch weights in the 2012 Sub-Antarctic trawl survey. Estimates are from successful biomass stations for all strata combined. Biomass estimates from 2011 (from Bagley et. al. 2013b) are shown for comparison. Note: stratum 26 was dropped in 2012.

		2012 (TAN1215)			2011 (TAN1117)		
Species	Species code	Catch (kg)	Biomass (t)	CV (%)	Catch (kg)	Biomass (t)	CV (%)
Hoki	HOK	15 717	56 131	15	15 311	46 575	15
Ling	LIN	8 484	27 036	11	7 393	23 336	12
Javelinfish	JAV	3 748	15 241	12	2 498	9 140	25
Hake	HAK	3 287	2 443	22	3 883	2 004	23
Pale ghost shark	GSP	2 966	16 814	12	1 945	12 579	9
Southern blue whiting	SBW	2 593	21 485	35	830	7 642	31
Oliver's rattail	COL	1 080	4 491	16	329	1 324	31
Shovelnosed dogfish	SND	1 053	724	32	2 076	1 082	14
Arrow squid	NOS	937	711	41	137	131	15
Deepwater spiny dogfish	CSQ	918	833	26	446	680	31
White warehou	WWA	918	1 259	29	443	393	27
Ridge-scaled rattail	MCA	517	2 518	41	1 164	9 913	25
Baxter's dogfish	ETB	497	2 128	13	819	5 088	28
Spiny dogfish	SPD	480	843	12	853	1 941	19
Dark ghost shark	GSH	465	1 794	68	520	3 709	75
Ribaldo	RIB	457	914	16	382	1 050	17
Longnose velvet dogfish	CYP	428	909	23	755	2 723	42
Warty squid (*Onykia ingens*)	MIQ	410	2 229	10	374	1 920	11
Small-scaled brown slickhead	SSM	381	925	58	350	2 769	16
Silverside	SSI	377	2 939	12	500	1 541	20
Total catch (all species)		47 837			45 839		

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	3 739	1 504	31	0	183	4
	(58)	(84)	(45)		(56)	(60)
2	429	342	106	0	0	16
	(25)	(41)	(32)			(21)
3a	374	1 565	31	0	0	83
	(35)	(32)	(58)			(34)
3b	49	43	3	0	3	30
	(100)	(75)	(100)		(59)	(100)
4	1 654	1 210	0	34	0	1 740
	(42)	(32)		(100)		(18)
5a	341	253	888	0	0	81
	(28)	(17)	(39)			(46)
5b	854	427	84	0	0	486
	(53)	(19)	(51)			(5)
6	4 334	2 801	224	0	1 602	358
	(60)	(4)	(88)		(76)	(71)
7	2 456	380	34	0	0	114
	(86)	(55)	(100)			(39)
8	4 603	1 079	246	0	0	597
	(28)	(25)	(63)			(37)
9	6 018	3 404	249	0	0	1 536
	(40)	(27)	(51)			(32)
10	4 274	1 491	12	0	0	705
	(57)	(40)	(100)			(20)
11	4 540	308	0	50	0	347
	(50)	(45)		(64)		(19)
12	6 931	4 124	0	0	5	4 460
	(22)	(22)			(100)	(29)
13	11 396	7 152	34	0	0	3 639
	(50)	(31)	(100)			(28)
14	1 256	732	0	0	0	1 841
	(51)	(41)				(54)
15	2 492	195	0	0	0	144
	(39)	(51)				(20)
Subtotal (strata 1–15)	**55 739**	**27 010**	**1 943**	**84**	**1 794**	**16 181**
	(15)	**(11)**	**(23)**	**(56)**	**(68)**	**(13)**
25	109	26	485	0	0	9
	(64)	(71)	(63)			(66)
Subtotal (strata 1–25)	**55 849**	**27 036**	**2 428**	**84**	**1 794**	**16 190**
	(15)	**(11)**	**(23)**	**(55)**	**(68)**	**(13)**
27	93	0	0	349	0	232
	(19)			(92)		(76)
28	189	0	15	846	0	392
	(49)		(100)	(39)		(23)
Total (All strata)	**56 131**	**27 036**	**2 443**	**1 279**	**1 794**	**16 814**
	(15)	**(11)**	**(22)**	**(36)**	**(68)**	**(12)**

Table 5 (continued): 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	38	7	0	0	73	487
	(54)	(48)			(37)	(40)
2	103	6	46	0	2	7
	(28)	(43)	(42)		(100)	(100)
3a	79	4	4	1	50	3
	(19)	(100)	(100)	(100)	(84)	(100)
3b	4	4	0	0	43	38
	(100)	(58)			(57)	(51)
4	1 462	21	61	0	45	21
	(66)	(100)	(48)		(64)	(100)
5a	133	12	64	0	0	0
	(20)	(52)	(19)			
5b	408	0	11	32	15	8
	(53)		(77)	(97)	(65)	(100)
6	423	66	23	930	111	8
	(58)	(92)	(100)	(47)	(20)	(100)
7	399	0	109	0	0	280
	(5)		(22)			(100)
8	1 120	0	149	30	3	103
	(35)		(68)	(56)	(100)	(58)
9	799	32	105	1 703	119	141
	(20)	(100)	(48)	(87)	(50)	(50)
10	943	7	108	53	0	10
	(27)	(100)	(31)	(67)		(100)
11	1 626	0	100	188	8	0
	(35)		(30)	(91)	(100)	
12	2 209	72	0	6 106	123	101
	(31)	(48)		(48)	(28)	(60)
13	1 858	121	0	7 969	217	52
	(26)	(43)		(81)	(16)	(55)
14	1 268	84	0	3 899	34	0
	(57)	(100)		(37)	(51)	
15	869	0	7	573	0	0
	(35)		(69)	(56)		
Subtotal (strata 1–15)	**13 722**	**436**	**787**	**21 483**	**843**	**1 259**
	(12)	**(29)**	**(17)**	**(35)**	**(12)**	**(29)**
25	513	2	97	0	0	0
	(72)	(58)	(58)			
Subtotal (strata 1–25)	**14 234**	**438**	**884**	**21 483**	**843**	**1 259**
	(12)	**(29)**	**(16)**	**(35)**	**(12)**	**(29)**
27	470	0	8	2	0	0
	(91)		(100)	(100)		
28	536	0	22	0	0	0
	(63)		(100)			
Total (All strata)	**15 241**	**438**	**914**	**21 485**	**843**	**1 259**
	(12)	**(29)**	**(16)**	**(35)**	**(12)**	**(29)**

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	CV (%)	Biomass	CV (%)
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
	2012	55 739	15	56 131	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
	2012	1 943	23	2 443	22
	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 continued: 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	CV (%)	Biomass	CV (%)
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
	2012	27 010	11	27 036	11
	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
Banded rattail	3 428	646	926	60	829	34
Barracouta	49	26	23	1	25	1
Basketwork eel	126	26	31	8	-	-
Baxter’s dogfish	419	184	234	36	392	33
Big-scaled brown slickhead	9	7	2	1	9	1
Black javelinfish	112	40	65	4	73	4
Black oreo	500	220	280	11	195	11
Blackspot rattail	13	0	0	1	-	-
Bollons’s rattail	332	111	147	16	189	12
Dark ghost shark	371	192	177	10	176	10
Dawson's catshark	1	0	1	1	1	1
Deepsea cardinalfish	6	4	2	2	6	2
Deepsea catsharks	4	3	1	3	3	2
Finless flounder	36	10	22	2	3	1
Four-rayed rattail	1 185	7	31	12	140	4
Frostfish	15	2	12	1	-	-
Gemfish	1	0	1	1	1	1
Giant chimaera	2	0	2	2	2	2
Giant stargazer	75	22	48	18	70	17
Hake	765	226	538	42	765	42
Hapuku	3	1	2	2	3	2
Hoki	6 254	2 376	3 875	88	1 809	84
Humpback rattail	7	0	7	4	7	4
Javelinfish	6 824	1 282	4 629	84	1043	40
Johnson's cod	97	58	37	5	50	4
Kaiyomaru rattail	202	49	74	8	150	7
Leafscale gulper shark	126	55	71	21	82	17
Ling	2 955	1 398	1 555	82	1 520	79
Longnose velvet dogfish	182	62	120	12	123	10
Longnose chimaera	182	84	98	52	181	52
Longnosed deepsea skate	2	0	2	2	2	2
Lookdown dory	67	29	38	30	65	29
Lucifer dogfish	738	453	285	51	431	41
Mahia rattail	1	0	0	1	1	1
Notable rattail	177	10	41	8	77	6
Arrow squid	739	433	293	37	307	28
Oblique-banded rattail	1 239	11	659	38	605	26
Oliver’s rattail	3 310	76	132	45	410	21
Orange roughy	164	79	78	10	51	9
Pale ghost shark	1 568	805	763	81	1 462	80
Plunket's shark	14	7	7	8	14	8
Portugese dogfish	42	25	17	3	42	3
Prickly deepsea skate	8	2	4	5	8	5
Prickly dogfish	2	1	1	1	2	1
Ray’s bream	17	10	6	10	12	9
Red cod	126	86	40	9	100	9
Ribaldo	238	53	184	45	213	44
Ridge-scaled rattail	323	144	177	26	312	24
Rough skate	4	2	2	4	4	4
Rudderfish	1	0	1	1	1	1
Scampi	19	11	7	3	19	3
School shark	4	2	2	3	4	3

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

	Length frequency data				Length-weight data	
	No. of fish measured			No. of	No. of	No. of
Species	Total †	Male	Female	Samples	fish	samples
Sea perch	6	2	4	3	6	3
Seal shark	30	13	17	12	25	9
Serrulate rattail	81	30	37	6	67	5
Shovelnose spiny dogfish	286	84	202	19	109	15
Silver dory	120	13	57	2	71	1
Silver warehou	8	5	3	2	8	2
Silverside	1 658	663	776	34	436	16
Small-banded rattail	47	37	10	1	-	-
Small-headed cod	8	3	4	3	8	3
Small-scaled brown slickhead	315	129	183	9	162	7
Smallscaled cod	8	1	7	1	8	1
Smooth deepsea skate	6	3	3	4	6	4
Smooth oreo	578	293	217	15	173	14
Smooth skate	7	4	3	7	7	7
Smooth skin dogfish	47	27	20	5	40	4
Southern blue whiting	2 982	1 424	1 500	42	845	42
Spiky oreo	5	4	1	1	5	1
Spineback	501	11	430	22	48	3
Spiny dogfish	183	81	102	42	183	42
Tarakihi	1	0	1	1	1	1
Velvet dogfish	1	0	1	1	1	1
Violet cod	49	14	17	4	49	4
White rattail	68	41	27	4	48	3
White warehou	399	287	110	29	292	28
Widenose chimaera	25	13	12	7	25	7
Totals	40 486	12 519	19 494		14 612	

†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	0.053757	2.7101	0.89	195	22.7 – 37.4	TAN1215
Dark ghost shark	0.003387	3.1415	0.97	176	35.9 – 73.0	TAN1215
Javelinfish	0.000979	3.2315	0.96	978	22.8 – 59.1	TAN1215
Hake	0.001307	3.3926	0.98	763	51.7 – 129.5	TAN1215
Hoki	0.004204	2.9136	0.97	1 792	34.4 – 115.5	TAN1215
Ling	0.001432	3.2690	0.98	1 505	34.3 – 129.5	TAN1215
Lookdown dory	0.028543	2.9482	0.98	64	11.8 – 48.4	TAN1215
Pale ghost shark	0.015015	2.7611	0.96	1 457	24.8 – 87.6	TAN1215
Ribaldo	0.005924	3.1518	0.98	213	26.3 – 75.0	TAN1215
Southern blue whiting	0.003130	3.1964	0.96	841	19.1 – 54.8	TAN1215
Spiny dogfish	0.000581	3.4623	0.92	181	55.9 – 96.1	TAN1215
White warehou	0.027810	2.9202	0.99	292	24.3 – 58.6	TAN1215

* $W = aL^b$ 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	493	590	14	46	180	400
2	1 414	2 937	91	198	446	956
3	2	27	35	278	182	66
4	2	6	37	6	547	120
5	1	2	48	2	24	2
6	202	20	1	5	9	2
7	179	165	0	3	5	3
Total staged	2 293	3 747	226	538	1 393	1 549

*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 strata boundaries).

	All areas		East		Puysegur		West	
Year	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2001	2.94	1.7	3.45	2.3	2.48	3.8	2.49	2.8
2002	2.73	1.8	3.11	2.9	1.99	3.5	2.68	2.6
2003	2.76	2.2	3.17	3.4	2.24	5.6	2.55	3.0
2004	3.07	2.0	3.45	3.3	2.28	5.9	2.99	2.8
2005	3.10	1.6	3.20	2.6	2.27	3.9	3.36	2.4
2006	2.88	1.7	3.01	3.4	2.27	4.3	3.02	2.2
2007	3.15	1.6	3.42	2.5	2.07	4.5	3.34	2.1
2008	2.63	1.6	2.96	2.2	1.87	4.7	2.58	2.6
2009	2.49	1.7	2.74	2.5	1.96	5.5	2.34	2.5
2011	2.91	1.7	3.31	2.5	2.21	3.9	2.74	2.4
2012	2.53	1.8	2.68	2.8	2.28	3.8	2.46	2.7
Mean	2.83	0.5	3.12	0.8	2.17	1.3	2.78	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)).

	LW parameters		W(75 cm)
Year	a	b	(g)
2000	0.005603	2.844446	1 208
2001	0.005681	2.842391	1 214
2002	0.004172	2.914928	1 219
2003	0.003975	2.922135	1 198
2004	0.003785	2.933285	1 197
2005	0.005824	2.840234	1 233
2006	0.004363	2.903530	1 214
2007	0.004172	2.914241	1 215
2008	0.005024	2.871200	1 215
2009	0.004245	2.906240	1 195
2011	0.004911	2.880800	1 238
2012	0.004204	2.913600	1 221
Mean			1 214

Table 12: Quality of acoustic data collected during trawl surveys in the Sub-Antarctic between 2000 and 2012. 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).

Year	Number of recordings	% of recordings		
		Good	Marginal	Poor
2000	234	57	21	22
2001	221	65	20	15
2002	202	78	12	10
2003	169	37	25	38
2004*	163	0	0	100
2005	197	75	16	9
2006	195	46	25	29
2007	194	63	16	20
2008	235	61	28	11
2009	319	46	33	20
2011	261	47	35	18
2012**	294	18	22	60

* 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.

** For 19% of all files in TAN1215 the scientific and ship’s echosounders were not synchronised, hence acoustic interference occurred. These files were treated as poor recording and were not suitable for quantitative analysis.

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 2012. Several mark types were usually present in the same echogram. *n* is the number of acoustic files examined.

				Pelagic marks			Bottom marks		
Acoustic file	Year	*n*	Surface layer	School	Layer	Cloud	Layer	Cloud	School
Day steam	2000	90	93	71	63	6	58	17	11
	2001	85	91	71	72	41	54	26	12
	2002	72	92	72	75	19	79	19	14
	2003	64	94	56	53	47	67	30	13
	2004	49	82	63	55	43	69	31	12
	2005	75	91	77	73	63	67	59	16
	2006	73	88	53	67	37	30	34	3
	2007	65	94	74	57	43	43	52	12
	2008	74	86	80	59	74	59	89	19
	2009	124	89	81	52	63	47	70	10
	2011	70	91	76	70	84	53	84	11
	2012	70	96	73	59	67	39	47	9
Night steam	2000	36	97	22	14	33	17	67	3
	2001	26	100	23	19	85	38	85	8
	2002	23	100	13	13	96	39	91	0
	2003	22	95	14	14	86	32	73	0
	2004	22	95	14	23	68	36	95	0
	2005	23	100	61	44	100	57	91	4
	2006	24	96	33	42	75	13	83	4
	2007	24	100	42	33	83	38	96	0
	2008	64	98	19	20	72	36	83	3
	2009	104	98	10	11	78	29	70	1
	2011	90	96	31	63	99	27	86	1
	2012	109	95	24	55	78	36	66	1

Table 13 continued: Percentage occurrence of the seven acoustic mark types classified by O'Driscoll (2001) in trawl surveys of the Sub-Antarctic between 2000 and 2012. 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	108	90	50	52	23	37	20	10
	2001	110	81	60	62	32	35	26	15
	2002	108	91	60	59	32	41	31	15
	2003	83	86	37	53	28	46	25	4
	2004	92	63	47	48	29	38	33	10
	2005	99	85	65	60	55	38	52	6
	2006	95	67	40	54	29	29	25	1
	2007	105	78	53	41	43	39	30	10
	2008	97	78	56	45	69	45	69	9
	2009	91	84	73	51	58	43	52	7
	2011	102	83	59	71	86	35	67	7
	2012	97	90	60	55	65	35	57	3

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). Note that the 2012 survey did not produce any data from Puysegur suitable for acoustic analysis.

	Stratum		
Year	East	Puysegur	West
2000	0.64	0.66	0.58
2001	0.56	0.39	0.57
2002	0.54	0.77	0.60
2003	0.60	0.66	0.67
2005	0.59	0.38	0.54
2006	0.55	0.32	0.56
2007	0.56	0.46	0.51
2008	0.63	0.58	0.62
2009	0.58	0.78	0.63
2011	0.58	0.37	0.54
2012	0.50	-	0.56

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%). Note that the 2012 survey did not produce any data from Puysegur suitable for acoustic analysis.

	Acoustic index (m^2/km^2)									
	Unstratified		East		Puysegur		West		Stratified	
Year	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2000	14.1	9	10.8	12	28.8	10	12.6	17	11.6	10
2001	13.3	17	9.2	16	29.9	45	13.1	11	10.8	10
2002	10.4	12	6.8	13	31.2	28	9.0	7	7.9	8
2003	9.8	10	8.1	23	18.9	15	9.2	8	8.6	14
2005	8.0	7	7.8	10	6.0	7	8.7	12	8.0	8
2006	4.5	6	4.8	10	3.4	13	4.7	9	4.7	7
2007	6.4	8	5.7	15	7.3	12	6.2	12	5.9	11
2008	9.9	11	7.0	12	13.3	12	12.3	23	8.9	12
2009	9.4	11	6.6	12	17.2	13	9.9	21	7.8	11
2011	12.3	5	13.5	9	10.6	9	11.8	7	12.9	7
2012	6.7	10	5.3	14	-	-	9.0	11	6.4	9

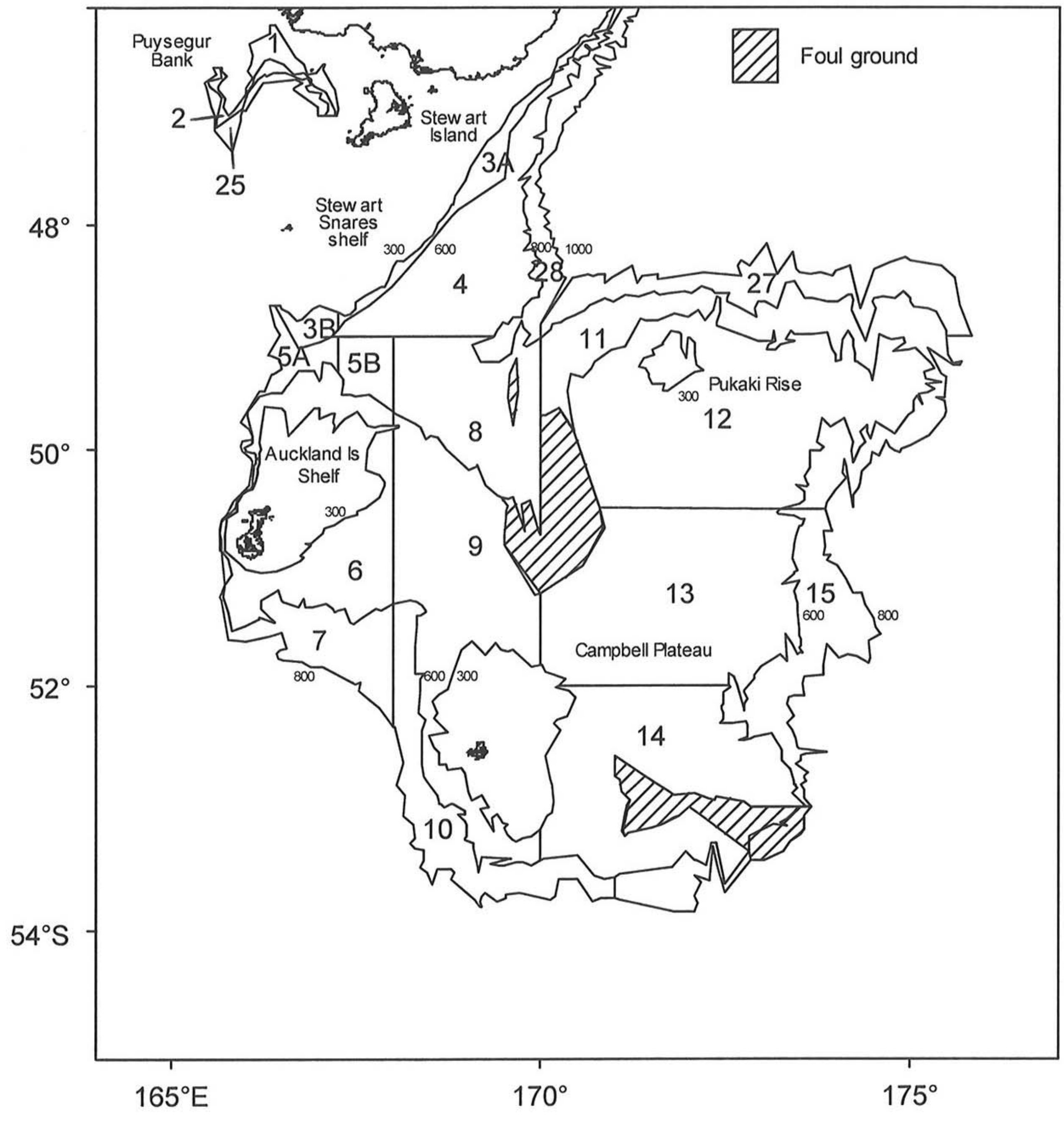


Figure 1: Stratum boundaries for the November–December 2012 Southland and Sub-Antarctic trawl survey.

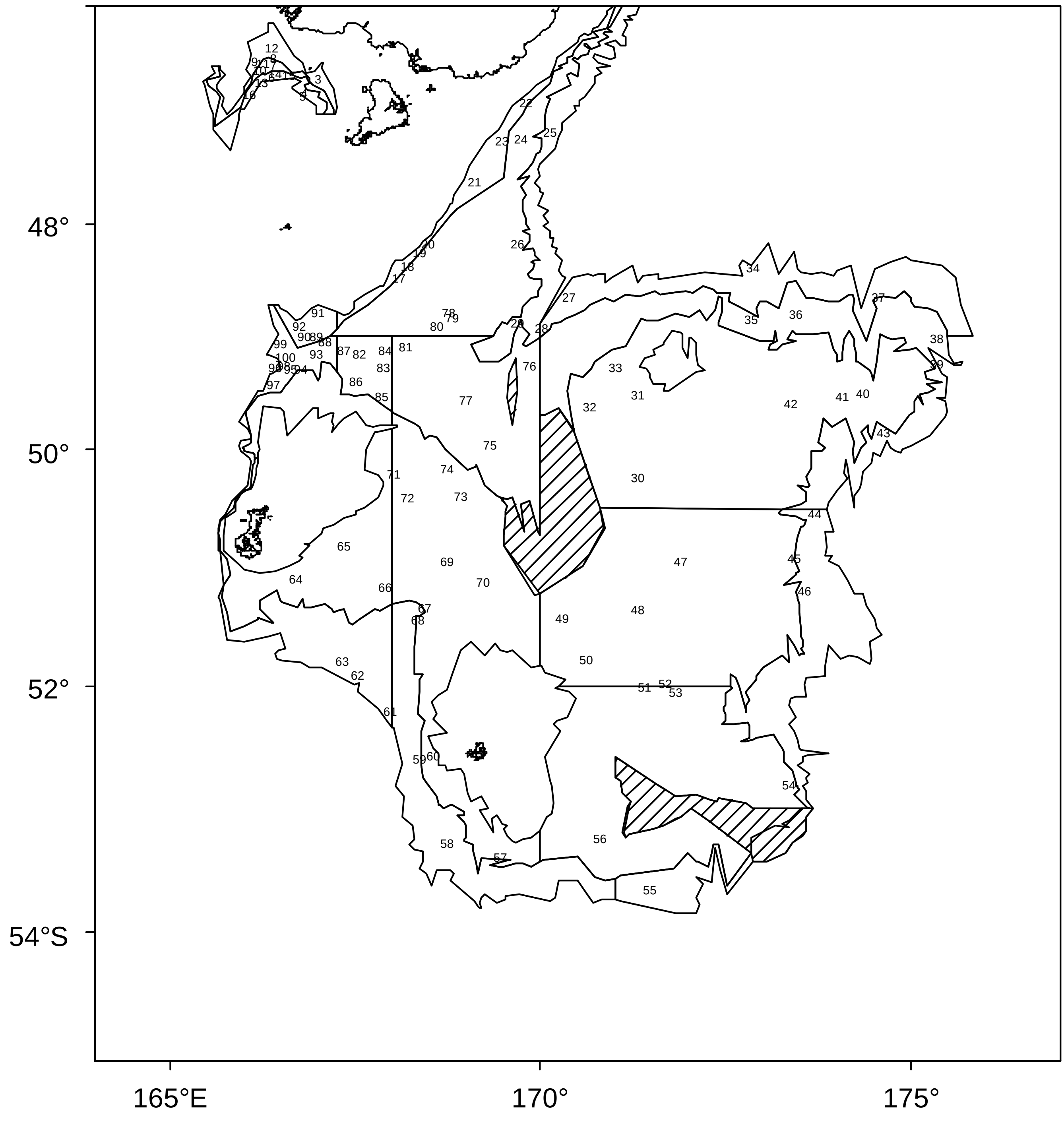


Figure 2: Map showing start positions of all bottom trawls (including unsuccessful stations) from the November–December 2012 Southland and Sub-Antarctic trawl survey.

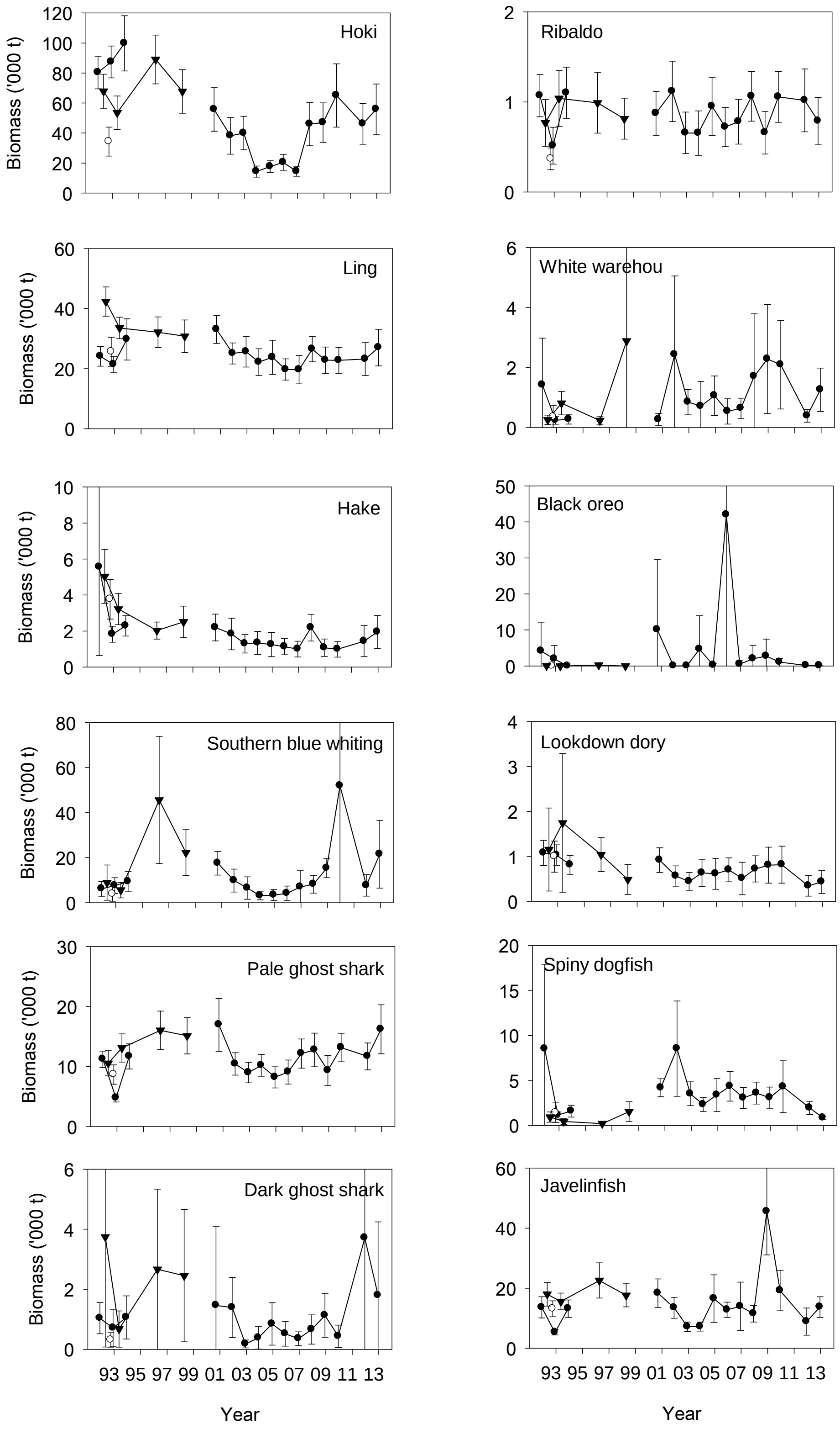


Figure 3: Trends in biomass (± 2 standard errors) of key species in the core 300–800 m strata in all Sub-Antarctic trawl surveys from *Tangaroa*. Solid circles show the summer time series and solid triangles the autumn time series. The open circle shows biomass from a survey of the same area in September–October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

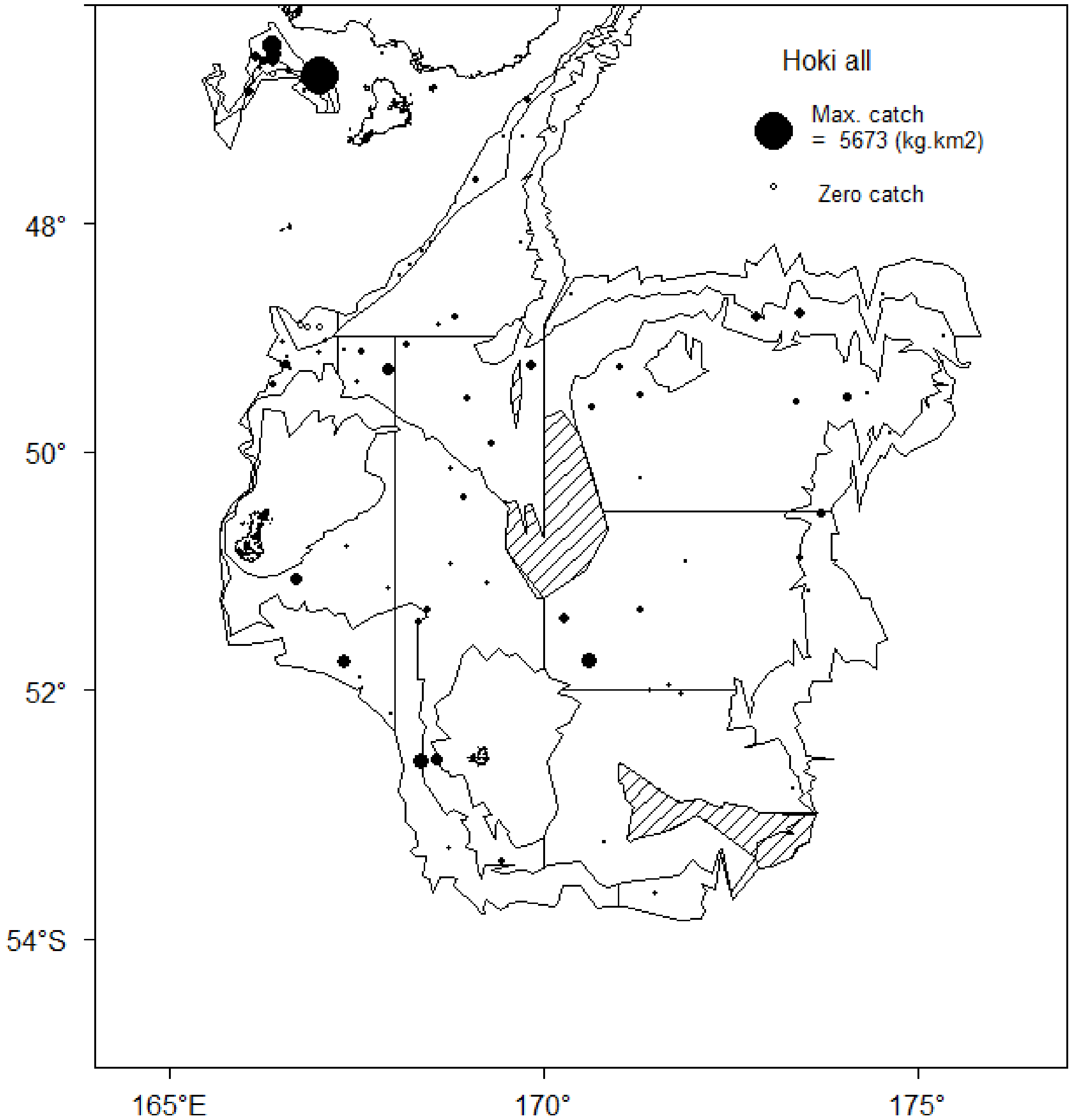


Figure 4a: Distribution and catch rates of all hoki in the summer 2012 trawl survey. Circle area is proportional to catch rate.

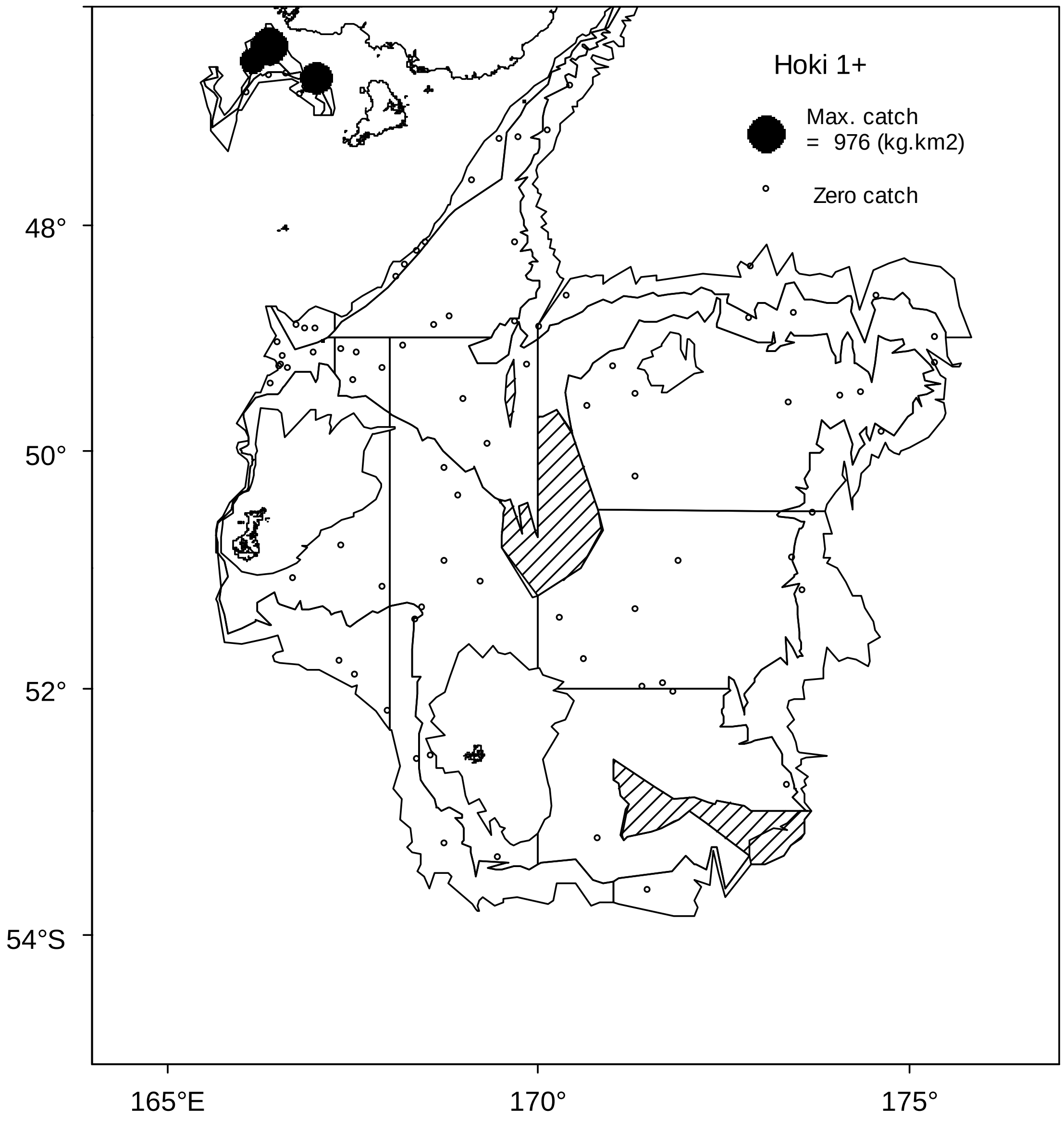


Figure 4b: Distribution and catch rates of 1+ (less than 45 cm) hoki in the summer 2012 trawl survey. Circle area is proportional to catch rate. 1+ hoki were only caught on 1 station in stratum 1.

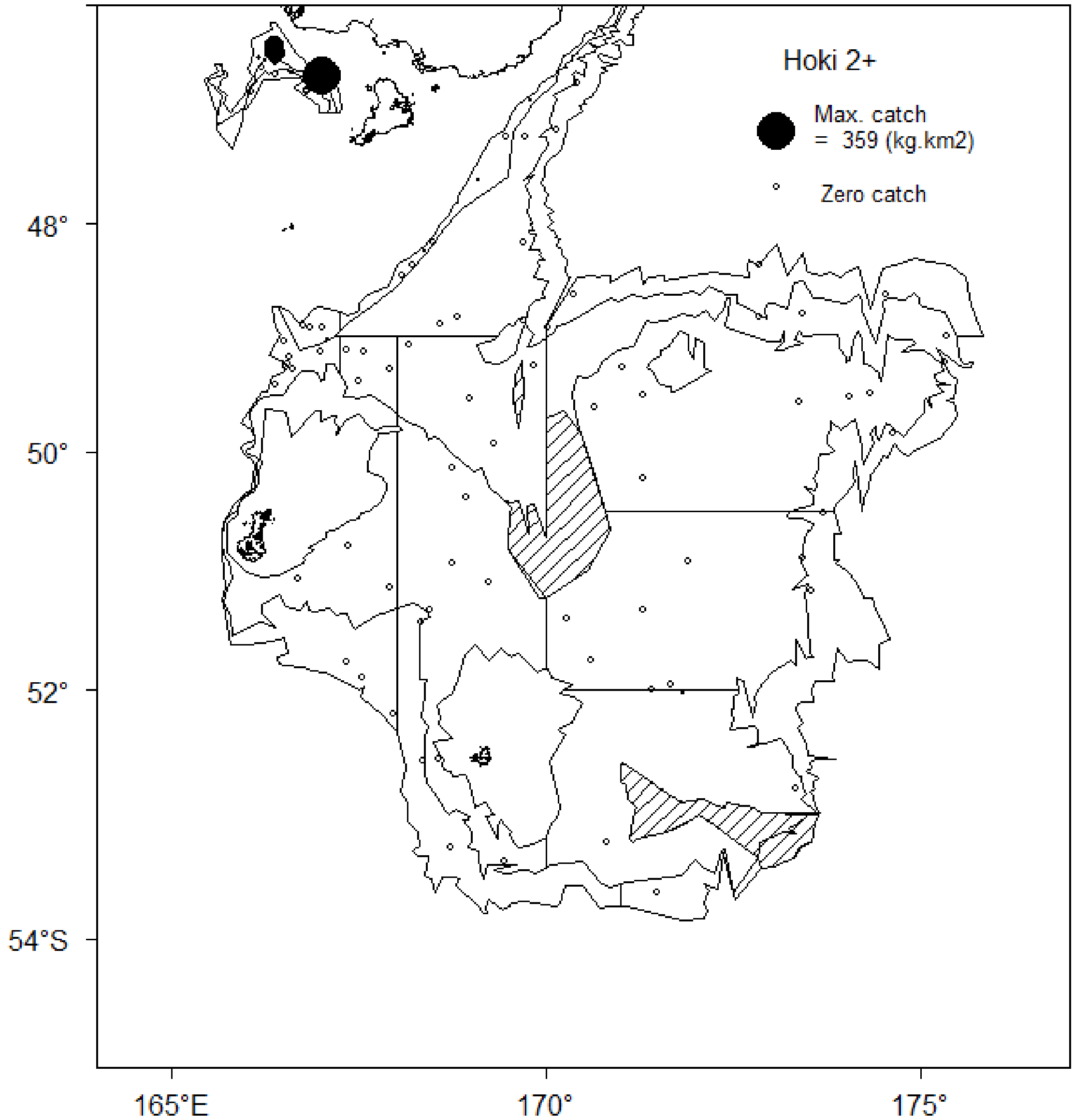


Figure 4c: Distribution and catch rates of 2+ (45–60 cm) hoki in the summer 2012 trawl survey. Circle area is proportional to catch rate.

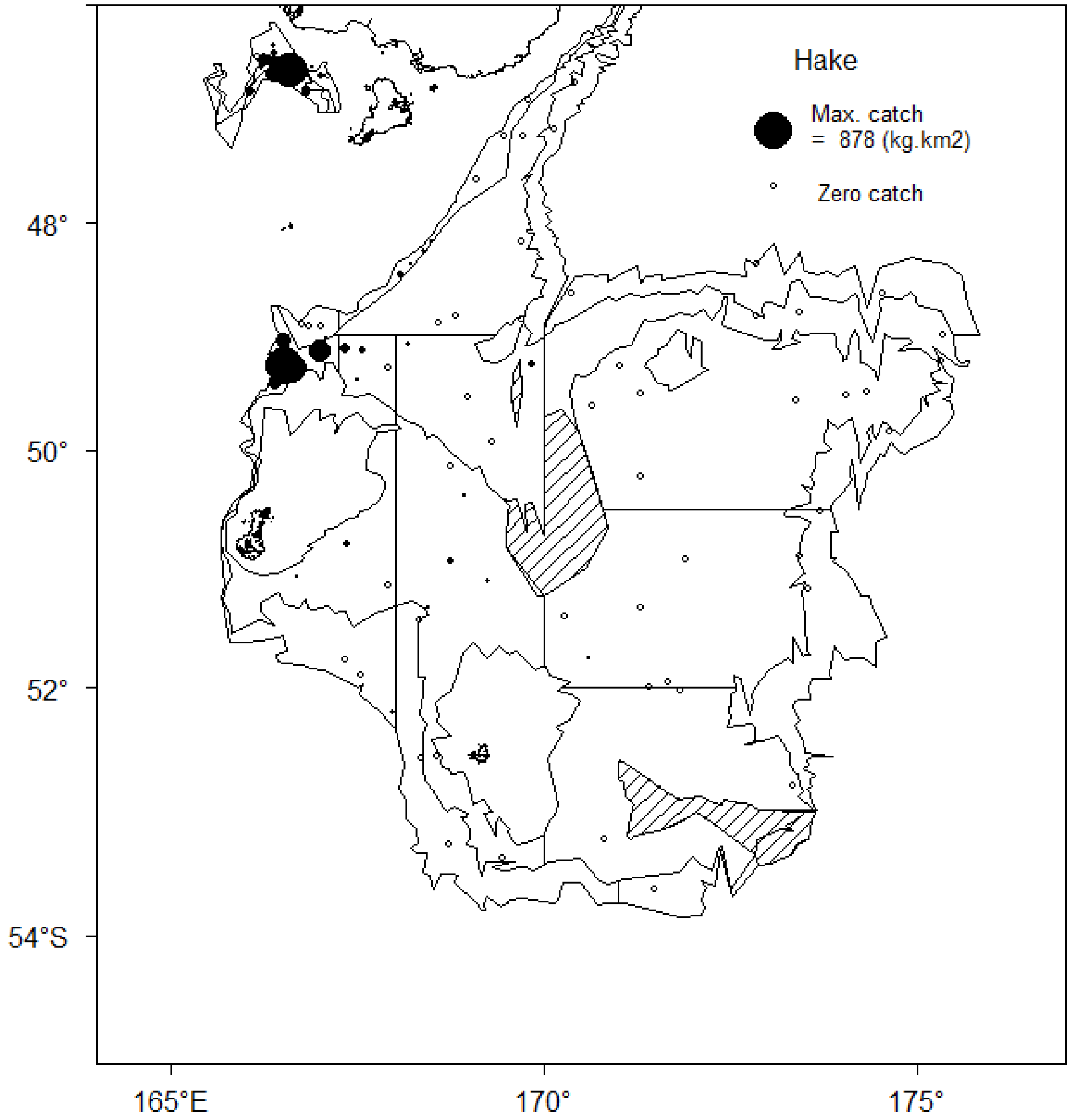


Figure 5: Distribution and catch rates of hake in the summer 2012 trawl survey. Circle area is proportional to catch rate.

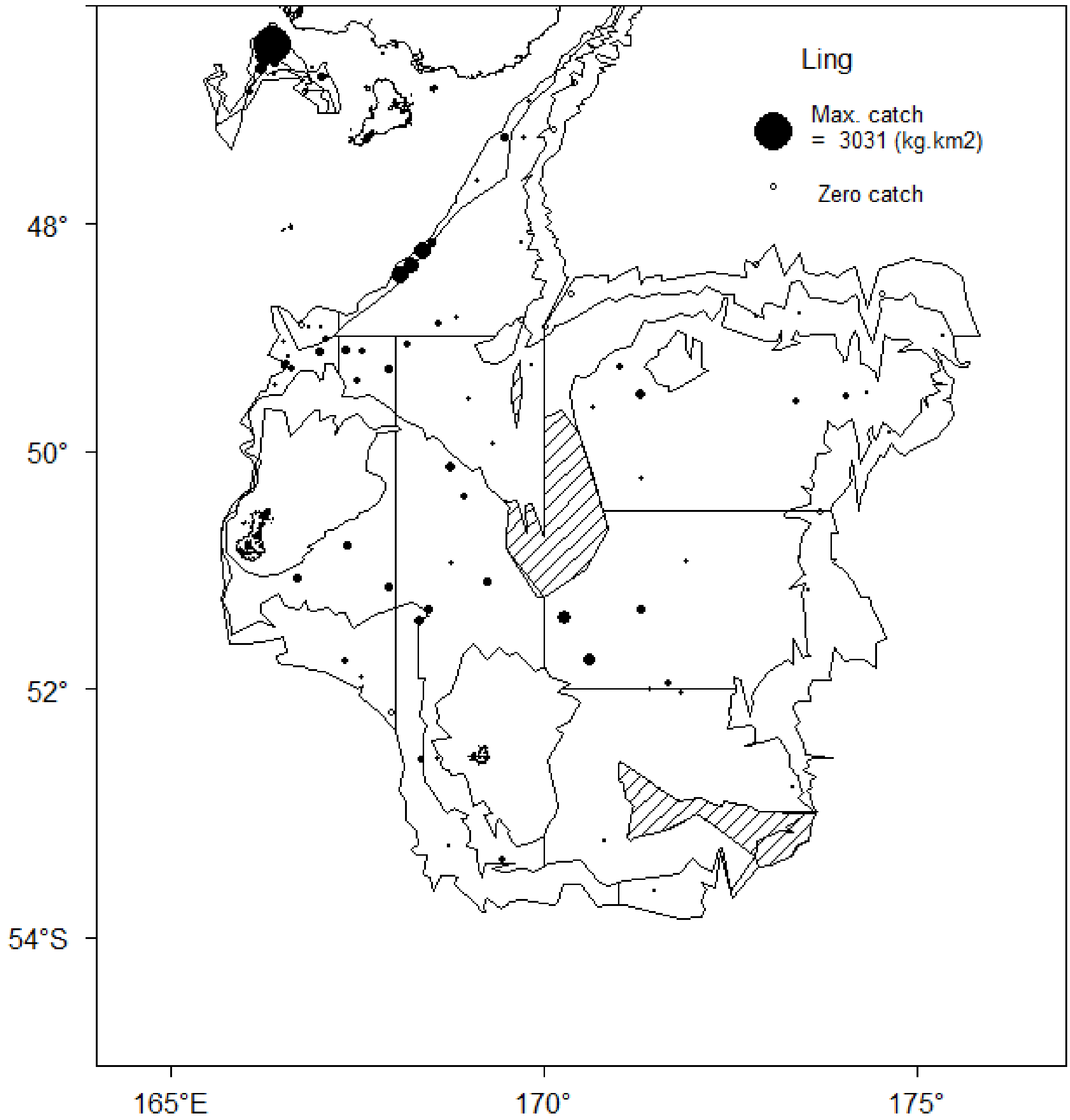


Figure 6: Distribution and catch rates of ling in the summer 2012 trawl survey. Circle area is proportional to catch rate.

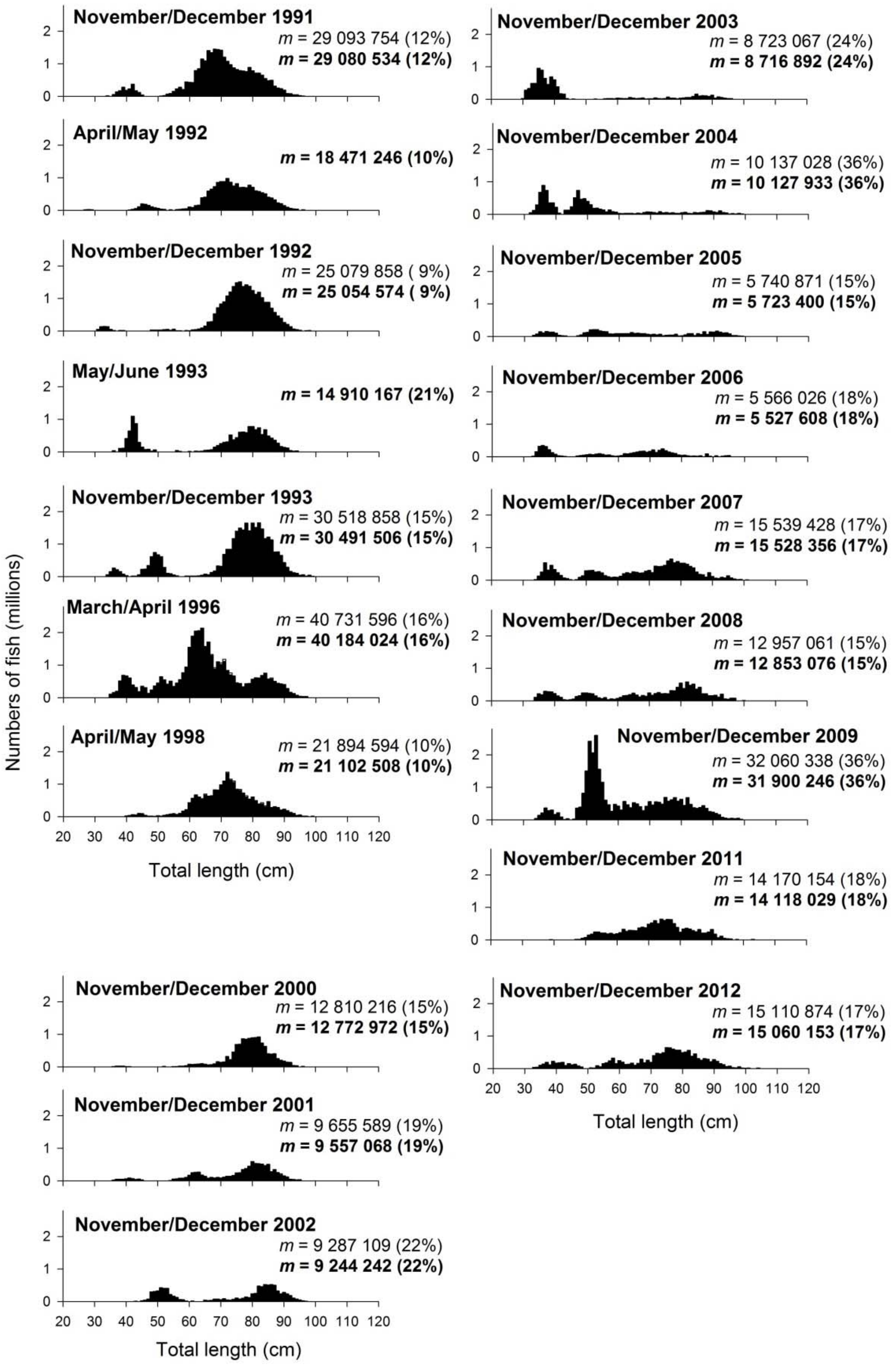


Figure 7a: Scaled length frequency for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (*m* values) above are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

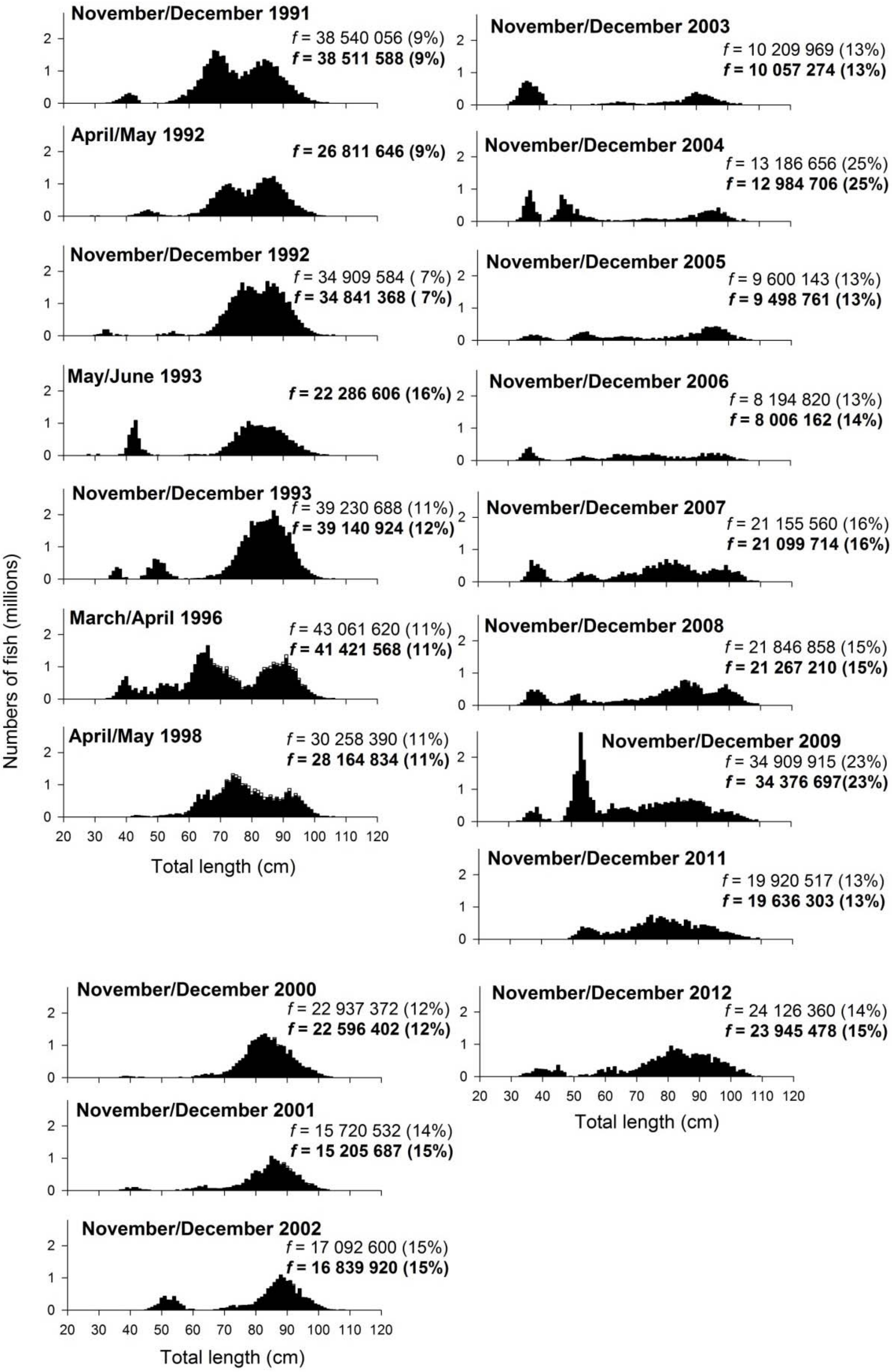


Figure 7b: Scaled length frequency for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (*f* values) above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

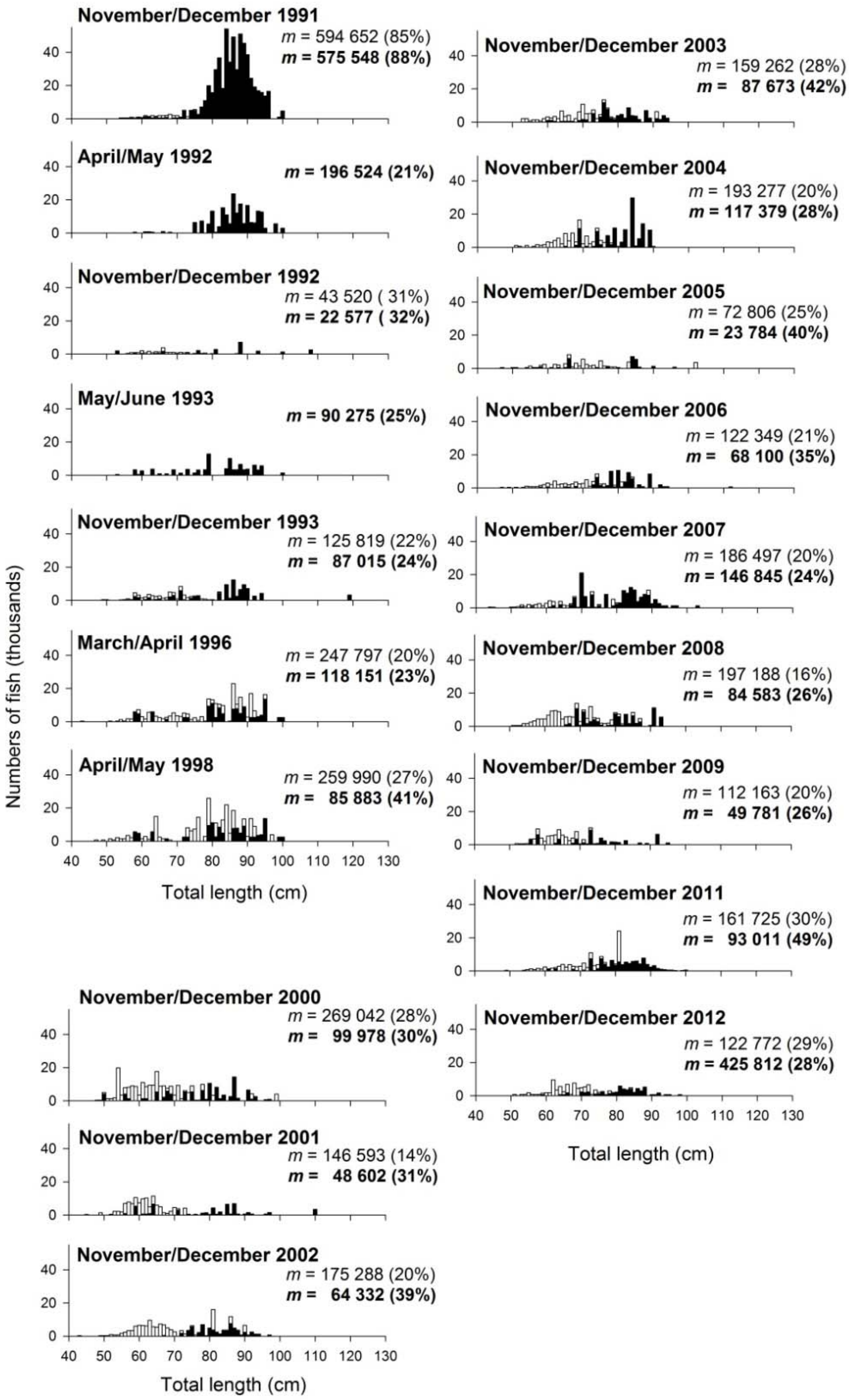


Figure 8a: Scaled length frequency for male hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (*m* values) above are for all strata and below (in bold) for core strata with CVs in parentheses.

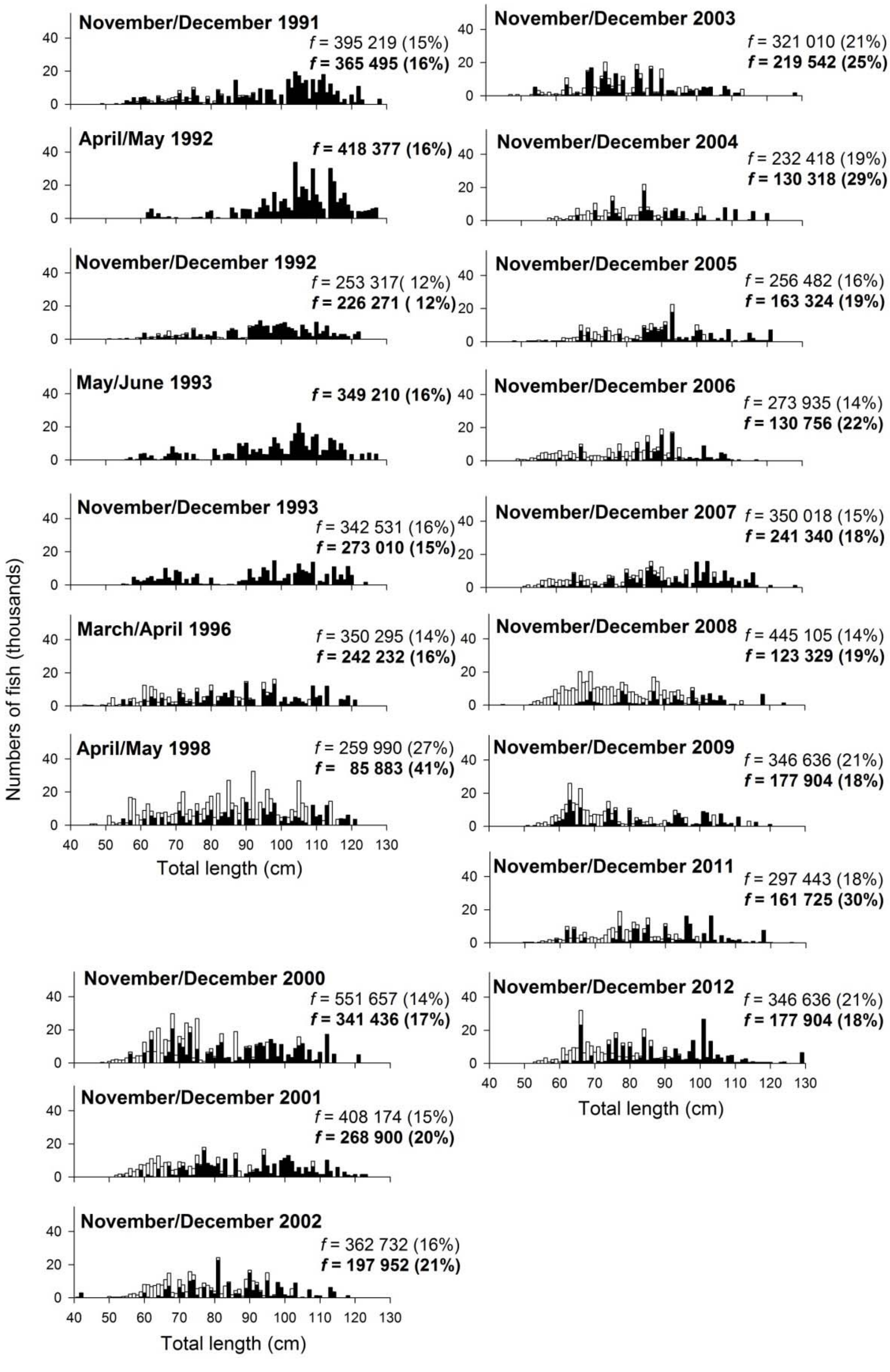


Figure 8b: Scaled length frequency for female hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (*f* values) above are for all strata and below (in bold) for core strata with CVs in parentheses.

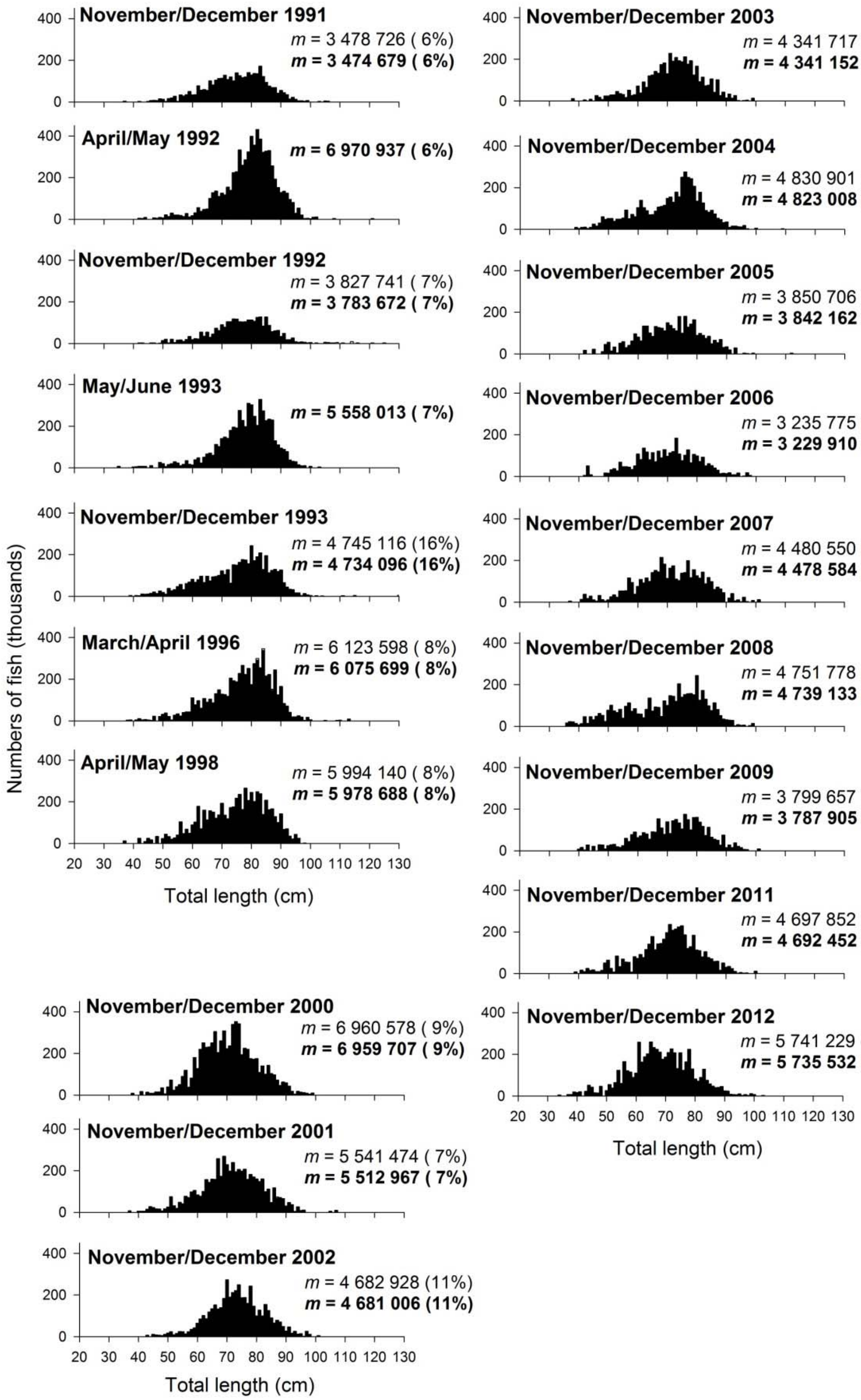


Figure 9a: Scaled length frequency for male ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (*m* values) above are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

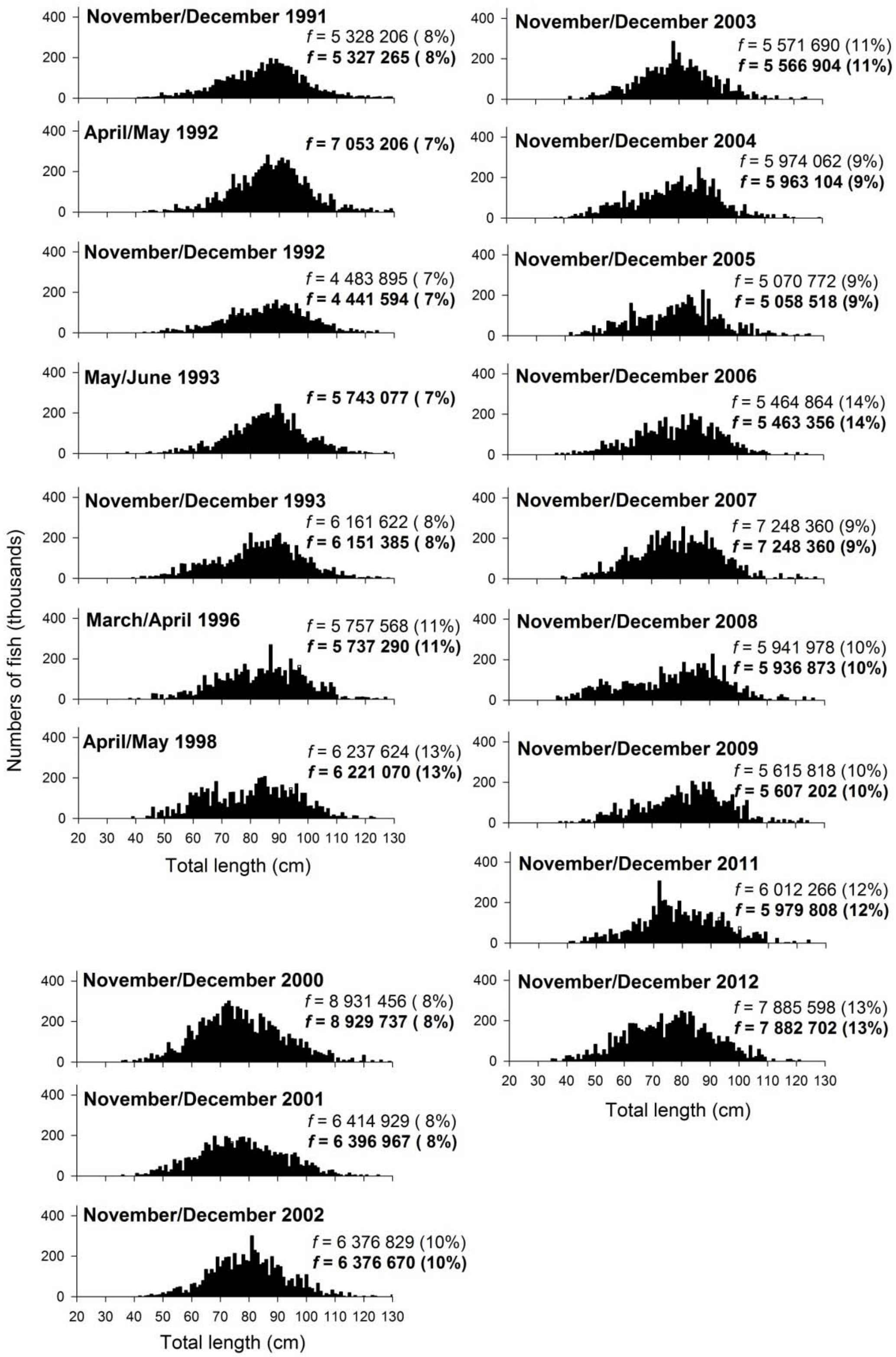


Figure 9b: Scaled length frequency for female ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (*f* values) above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

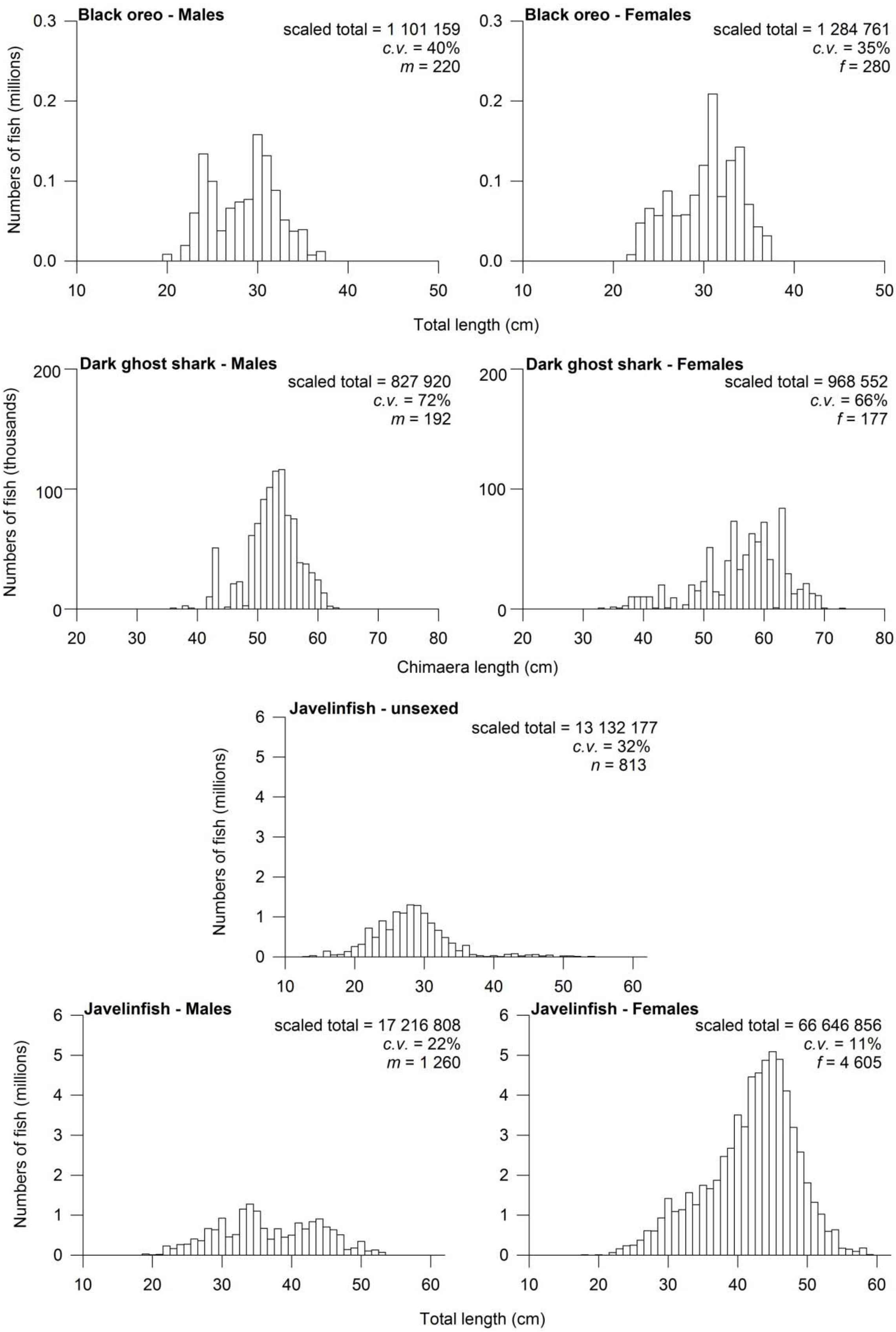


Figure 10: Length frequency distributions by sex of other key species in the November–December 2012 survey. Scaled total is the estimated total number of fish in the surveyed area, CV is the coefficient of variation, *m*, *f*, and *n* values are the number of males, females, and unsexed fish measured.

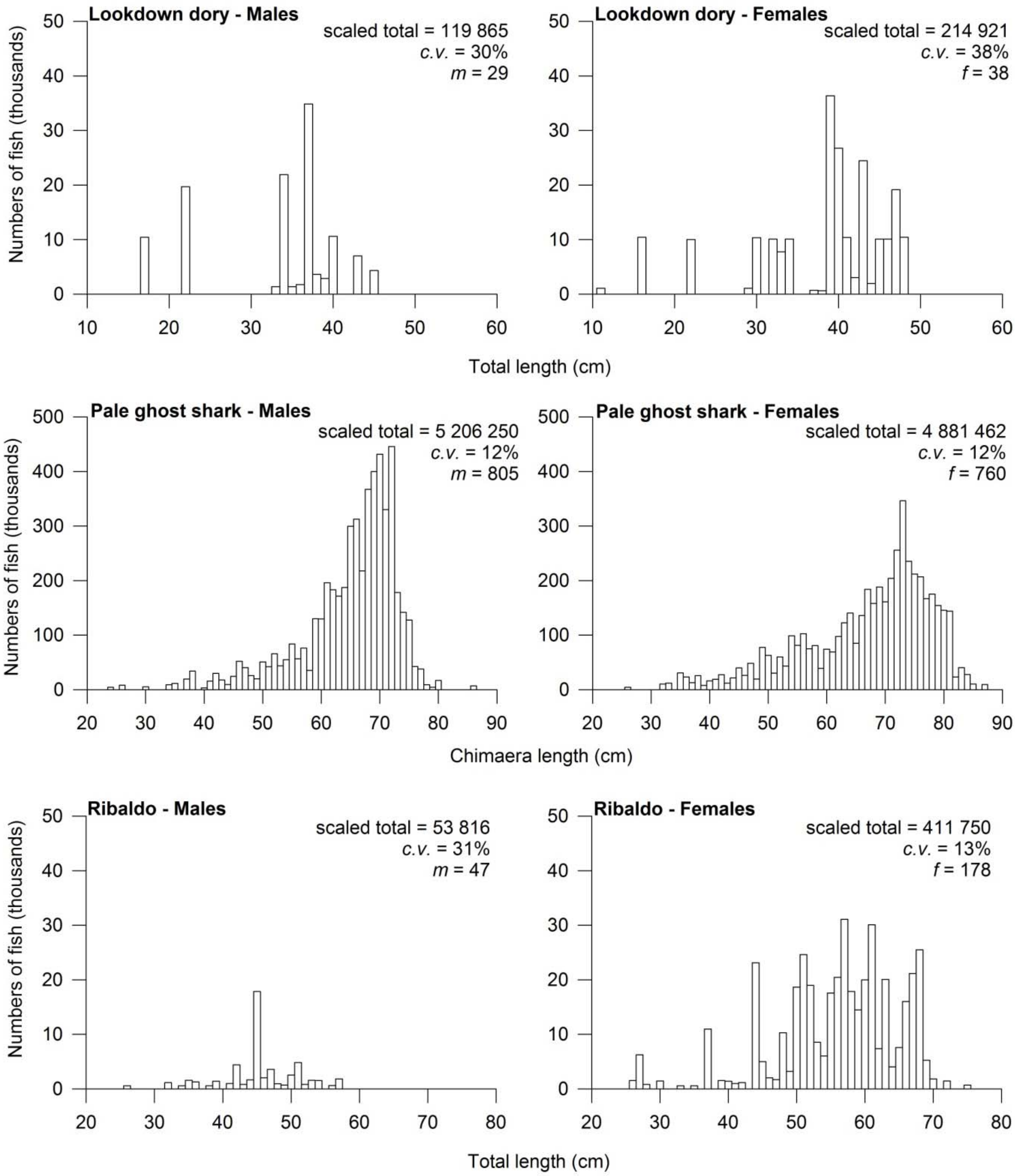


Figure 10 continued: Length frequency distributions by sex of other key species in the November–December 2012 survey. Scaled total is the estimated total number of fish in the surveyed area, CV is the coefficient of variation, *m* and *f* values are the number of males and females measured.

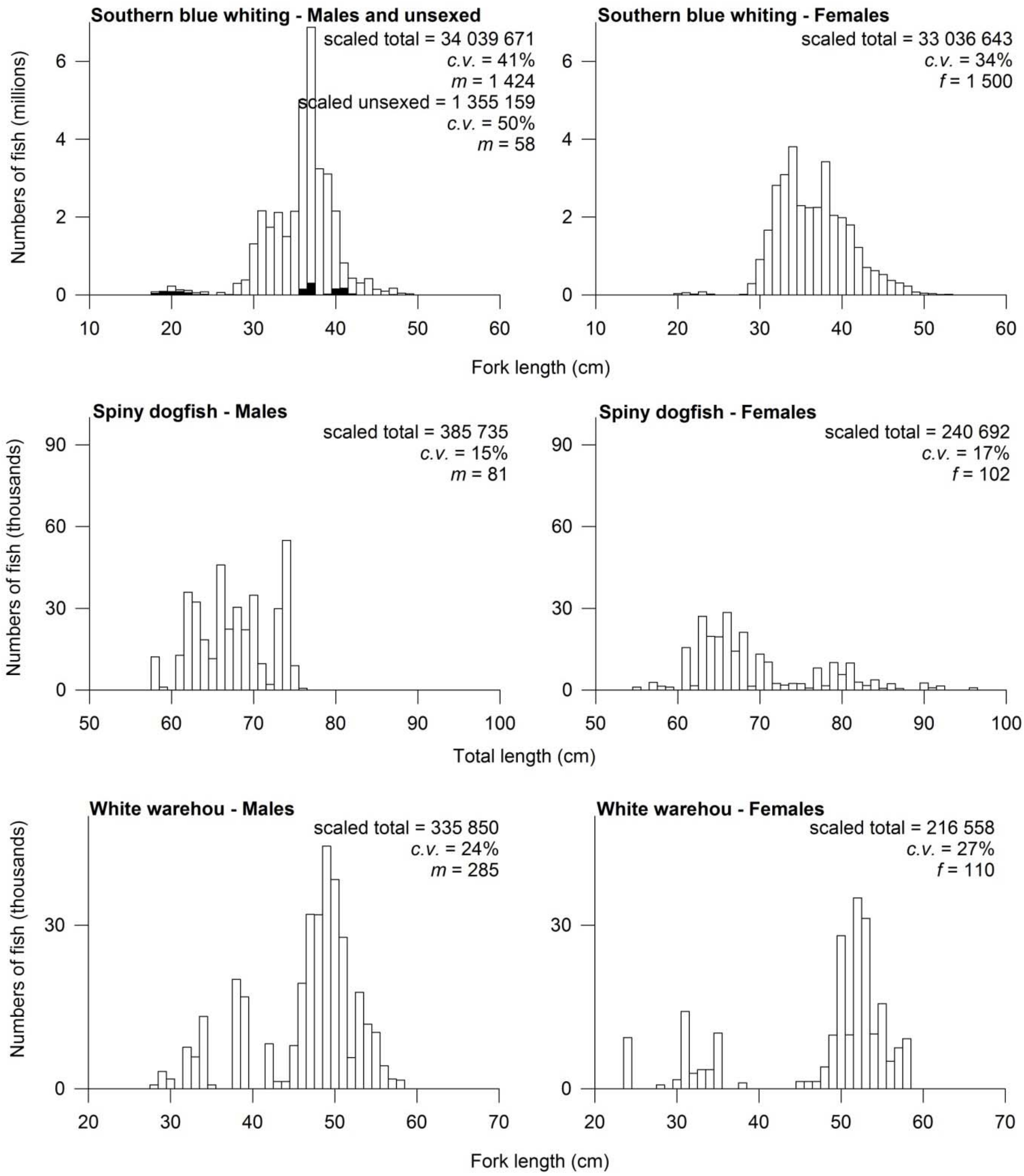


Figure 10 continued: Length frequency distributions by sex of other key species in the November–December 2012 survey. Scaled total is the estimated total number of fish in the surveyed area, CV is the coefficient of variation, *m* and *f* values are the number of males and females measured.

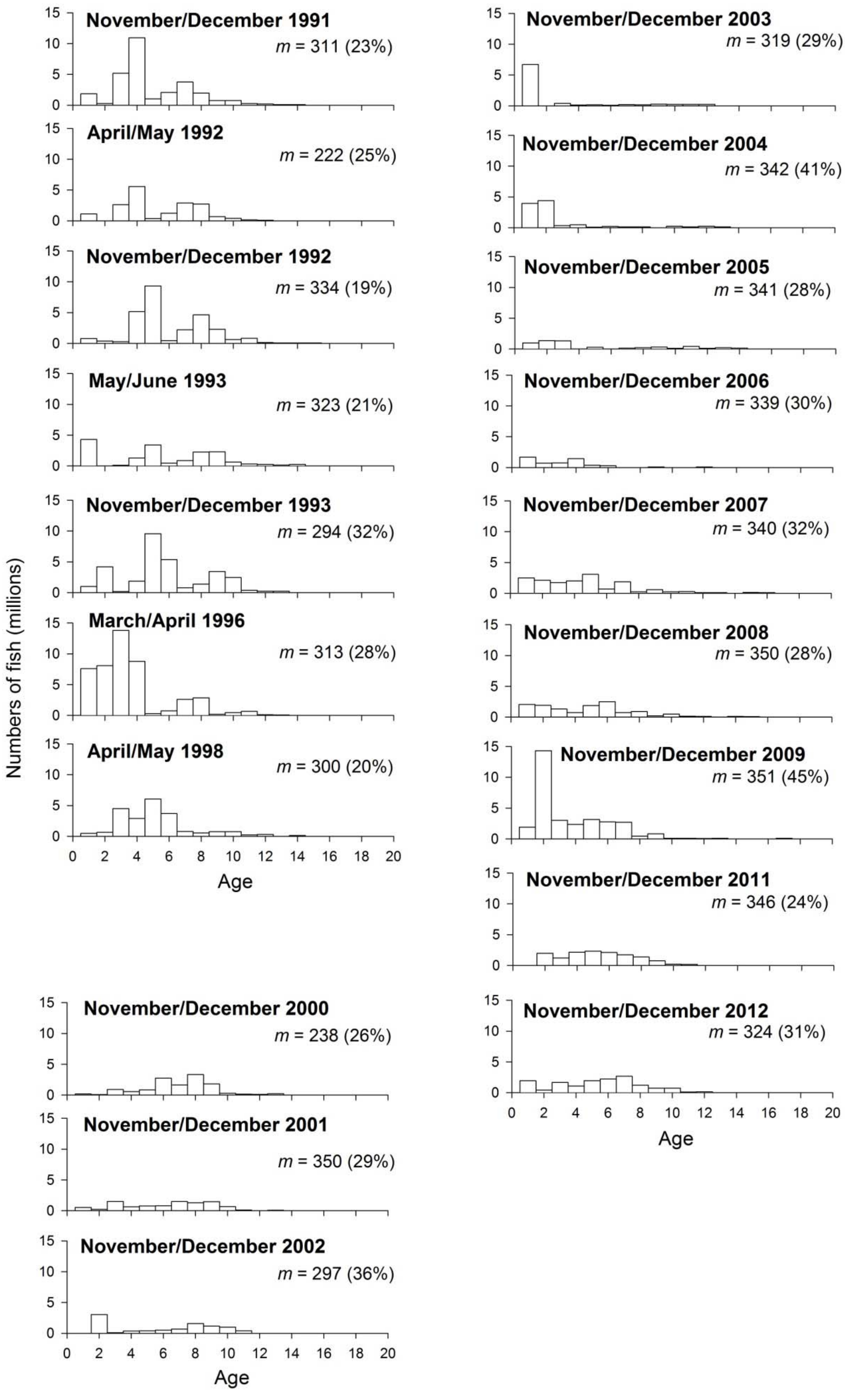


Figure 11a: Scaled age frequency for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with CVs in parentheses.

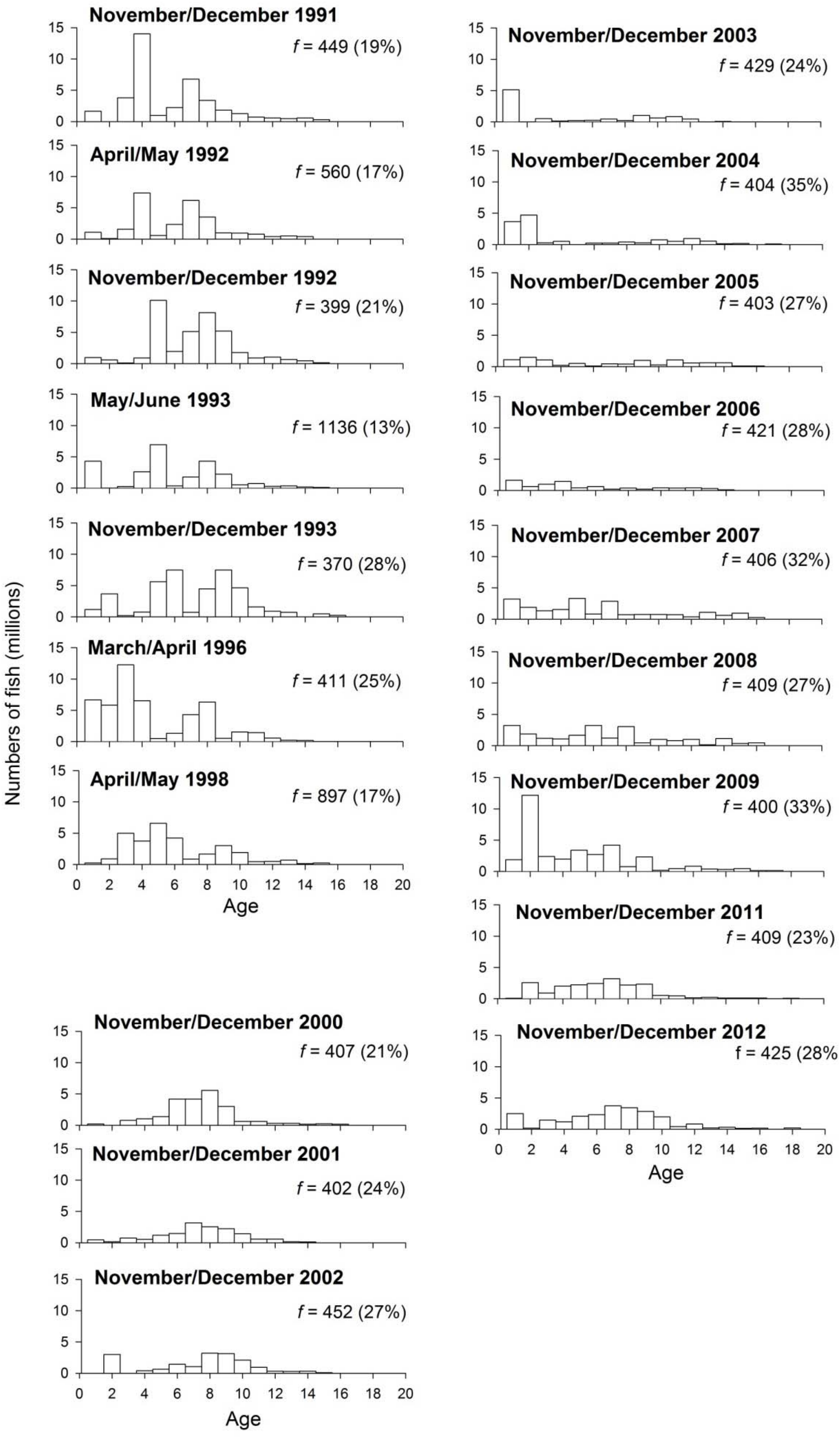


Figure 11b: Scaled age frequency for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with CVs in parentheses.

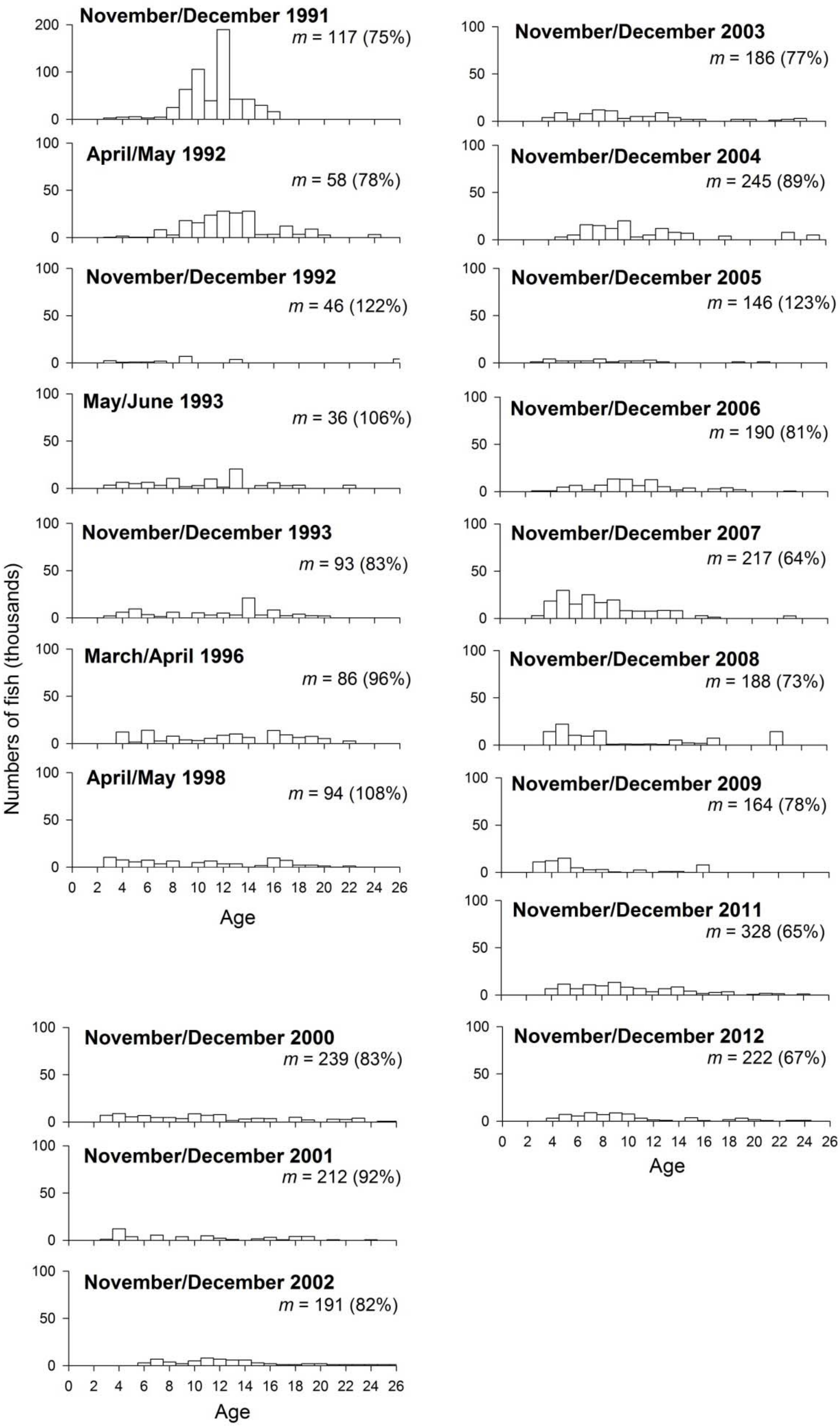


Figure 12a: Scaled age frequency for male hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with CVs in parentheses.

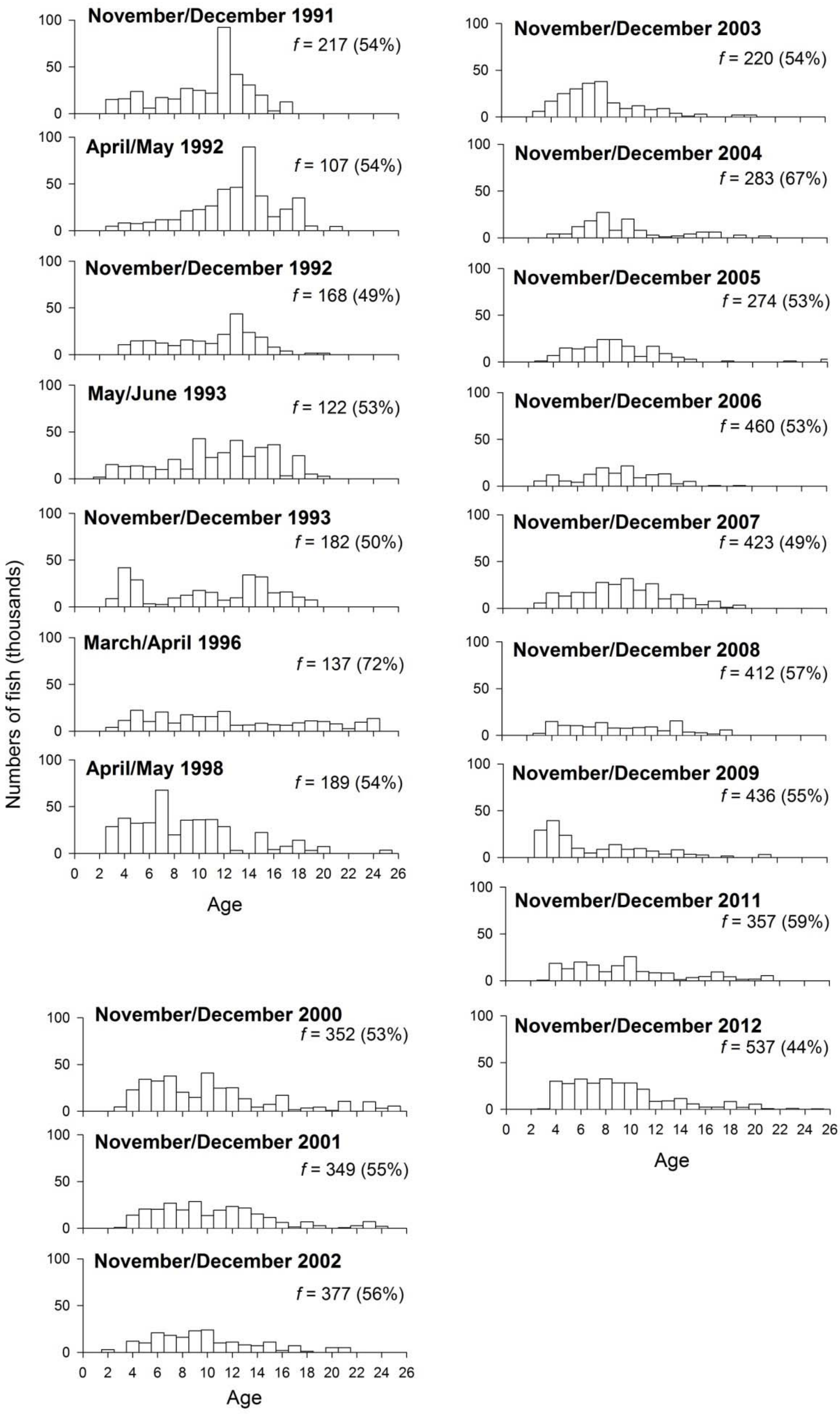


Figure 12b: Scaled age frequency for female hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with CVs in parentheses.

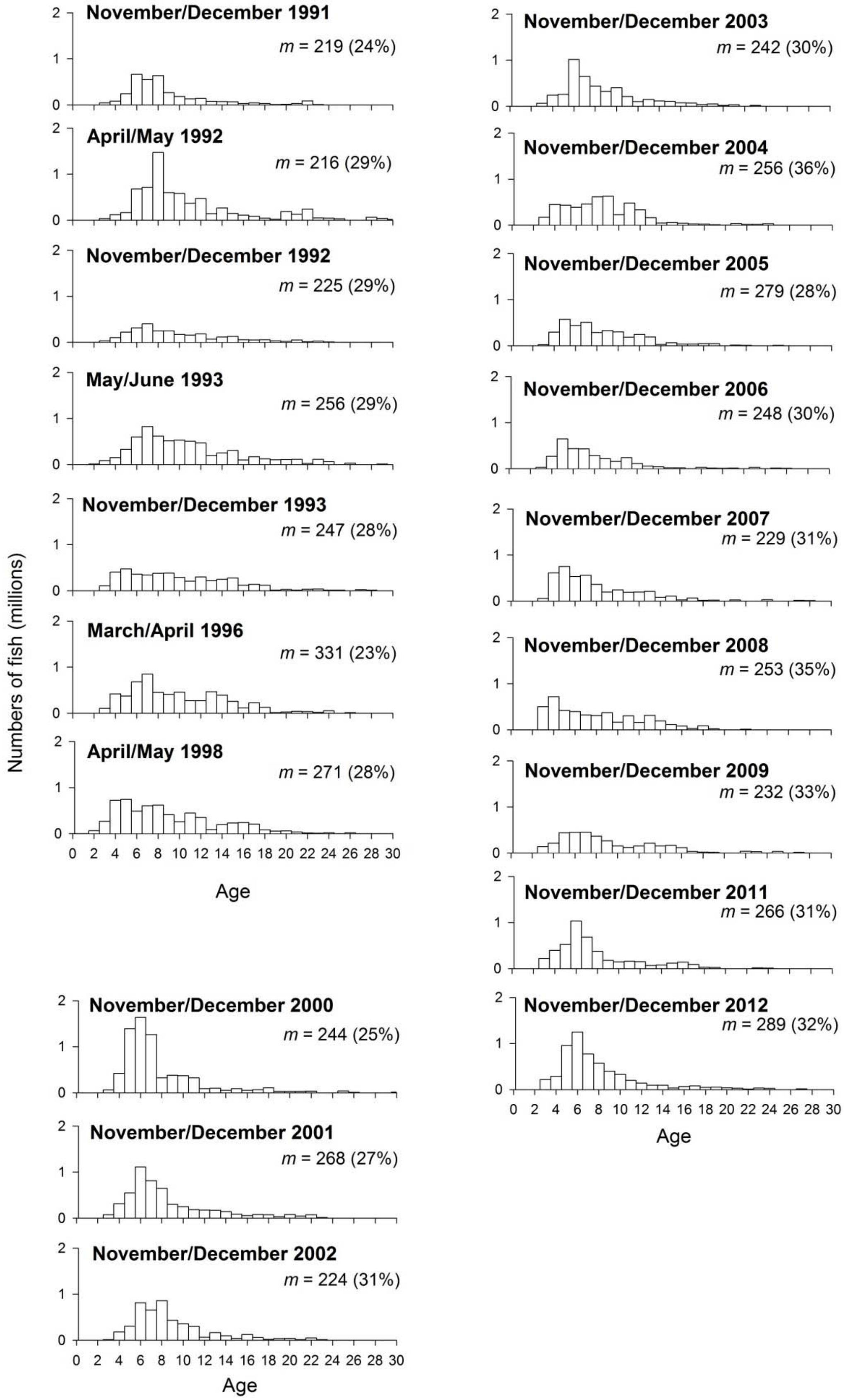


Figure 13a: Scaled age frequency for male ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*m* values) are given with CVs in parentheses.

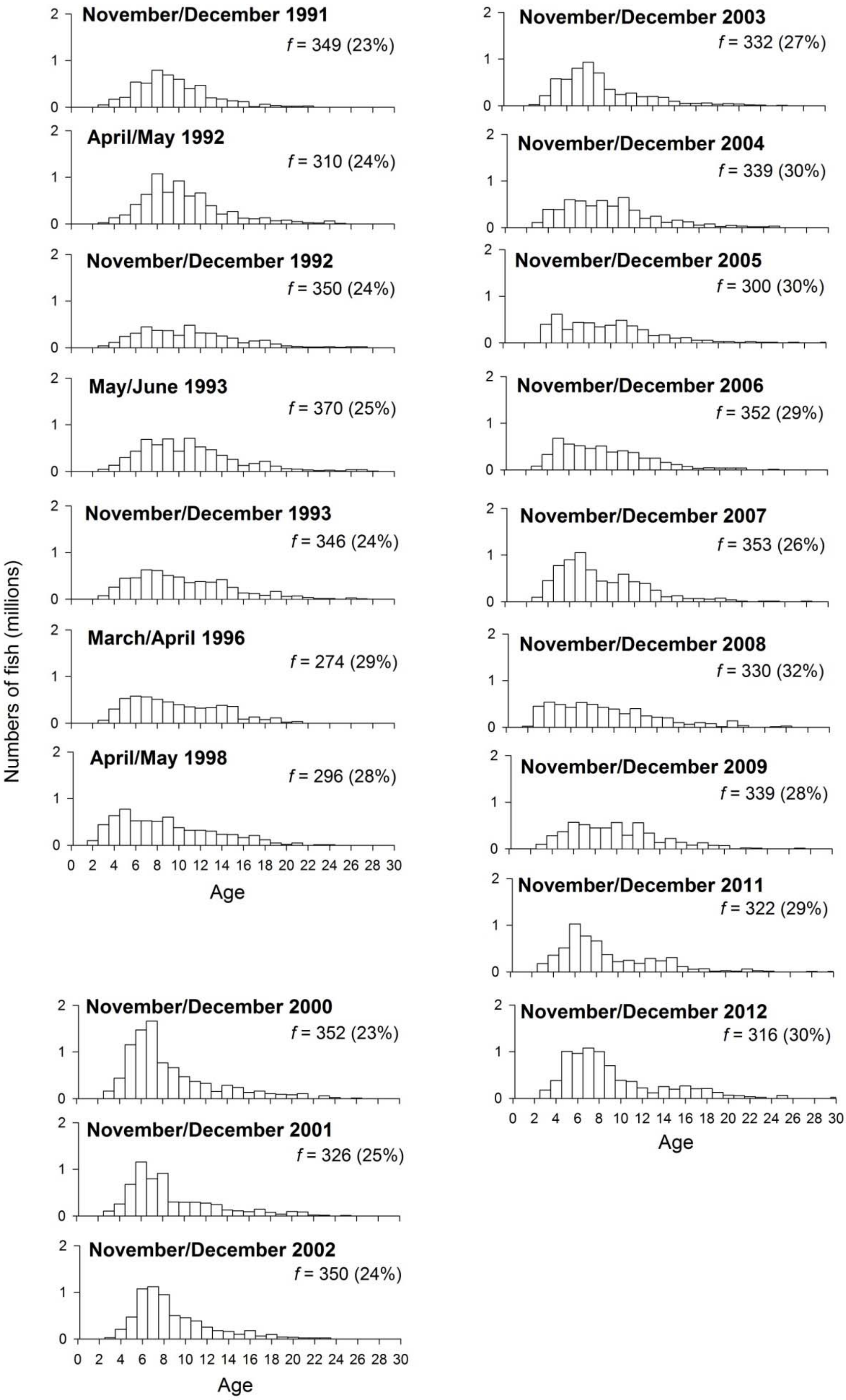


Figure 13b: Scaled age frequency for female ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (*f* values) are given with CVs in parentheses.

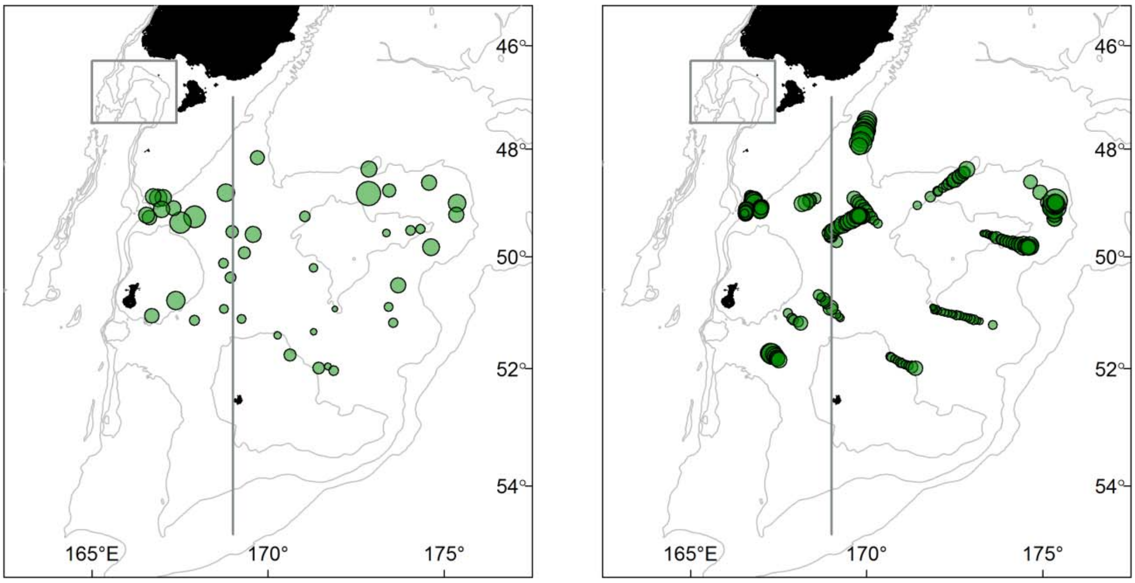


Figure 14: Spatial distribution of total acoustic backscatter in the Sub-Antarctic observed during day trawl stations and night steams. Circle area is proportional to the acoustic backscatter (maximum symbol size is 350 m^2 km^{-2}). The vertical line separates the east and west Sub-Antarctic strata, the upper left box represents the Puysegur stratum.

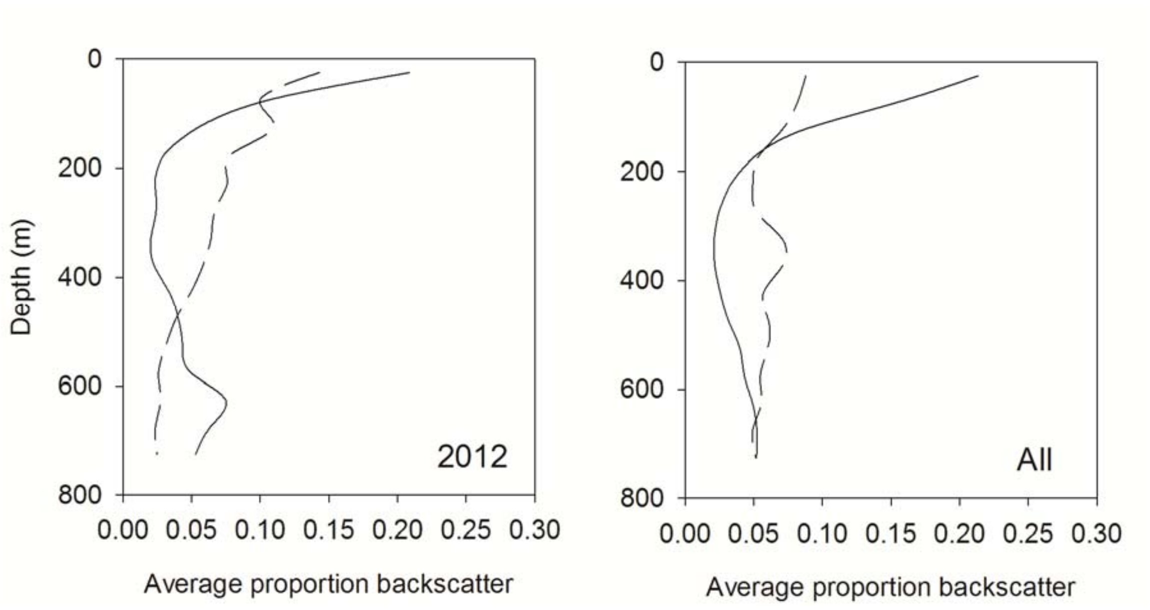


Figure 15: Distribution of total acoustic backscatter integrated in 50 m depth bins on the Sub-Antarctic observed during the day (dashed lines) and at night (solid lines) in 2012 (left panel) and average distribution from 2000–12 (right panel).

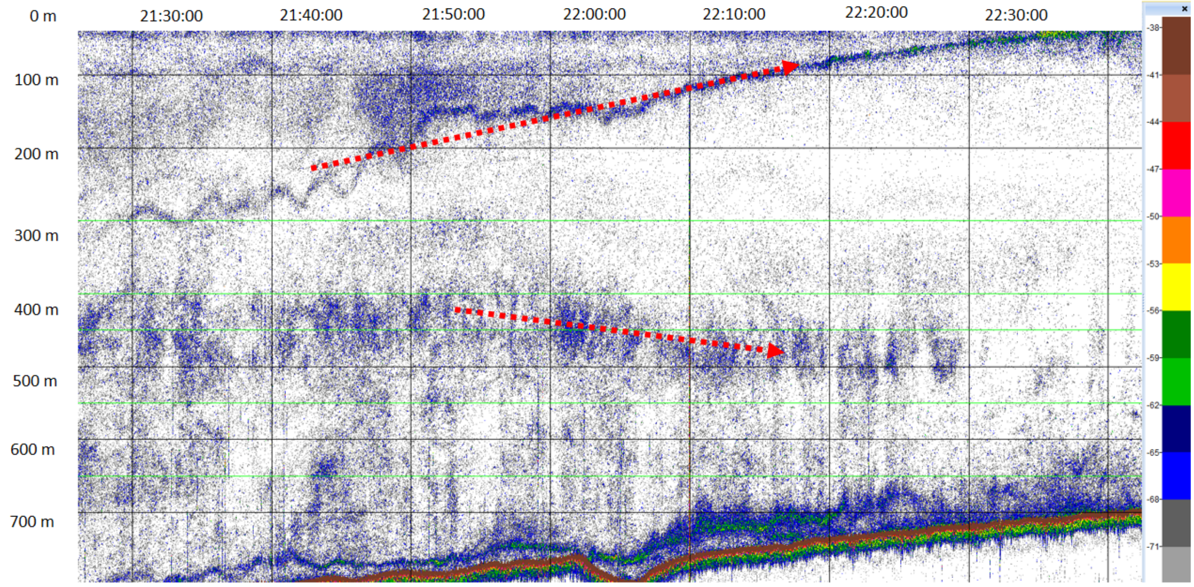


Figure 16: Example of echogram from the eastern Sub-Antarctic during a steam recording at dusk on 3 December 2012 showing a mesopelagic layer migrating upwards into the surface zone and a mesopelagic cloud remaining at 400–500 m depth. Change in layer depth indicated by dotted red lines.

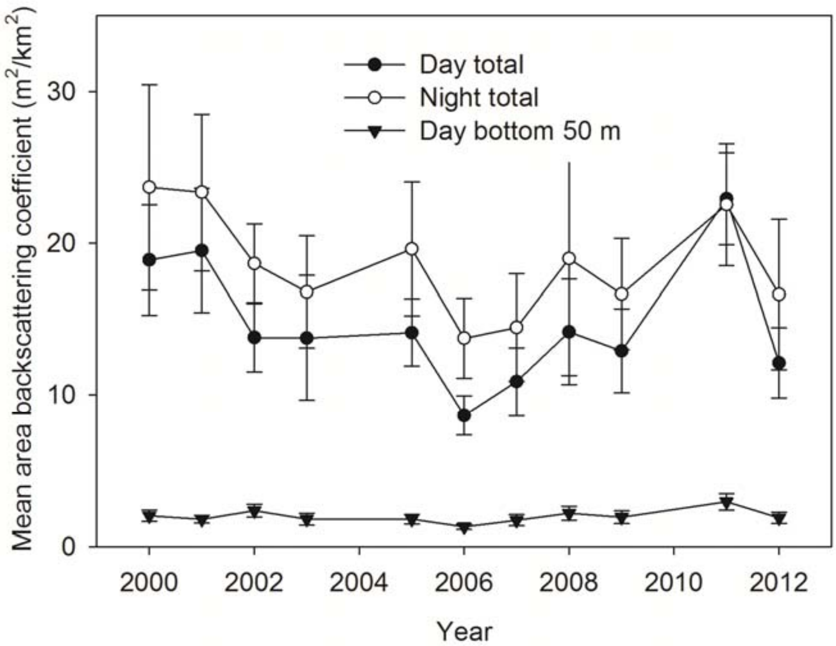


Figure 17: Total acoustic abundance indices for the Sub-Antarctic based on (strata-averaged) mean areal backscatter (sa). Error bars are ± 2 standard errors.

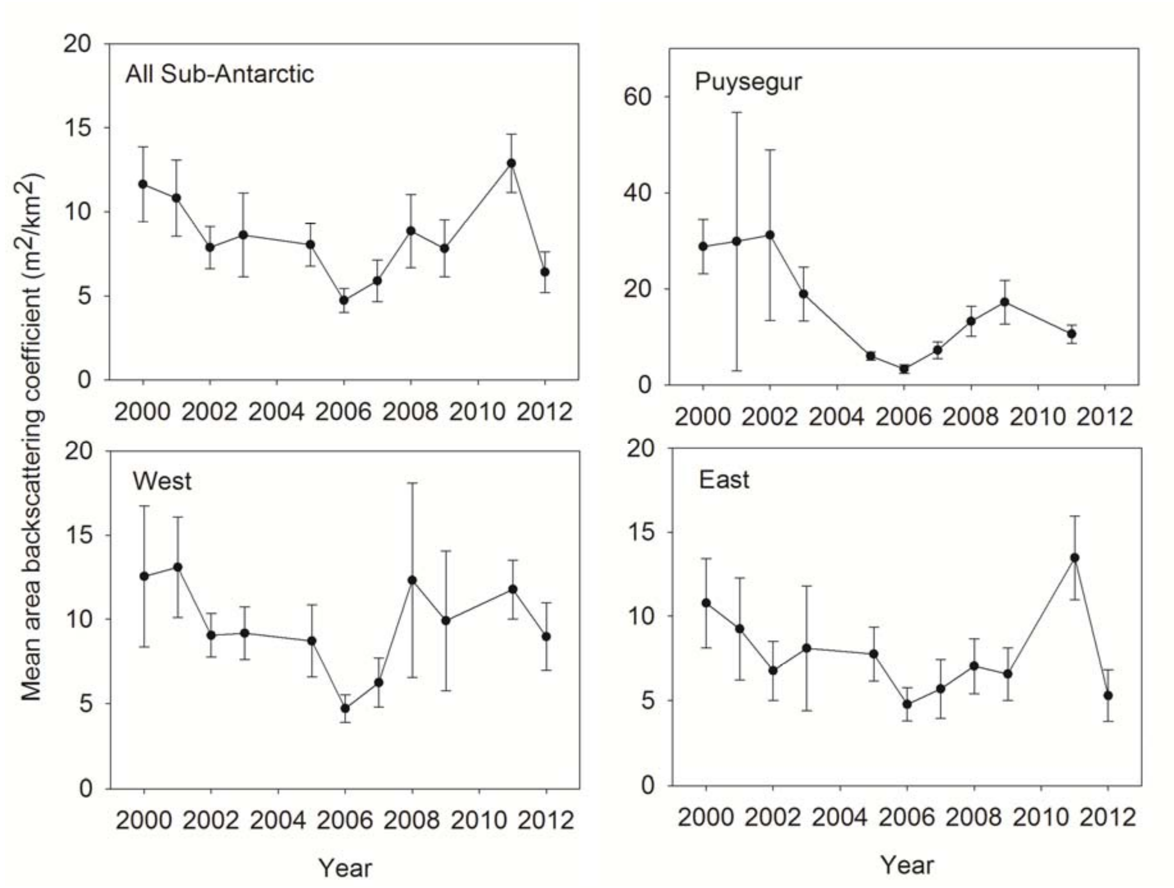


Figure 18: Time series of mesopelagic fish indices for the Sub-Antarctic (from Table 15). Panels show indices for the entire Sub-Antarctic and for three subareas. Error bars are ± 2 standard errors. Note that the 2012 survey did not produce any data from Puysegur suitable for acoustic analysis.

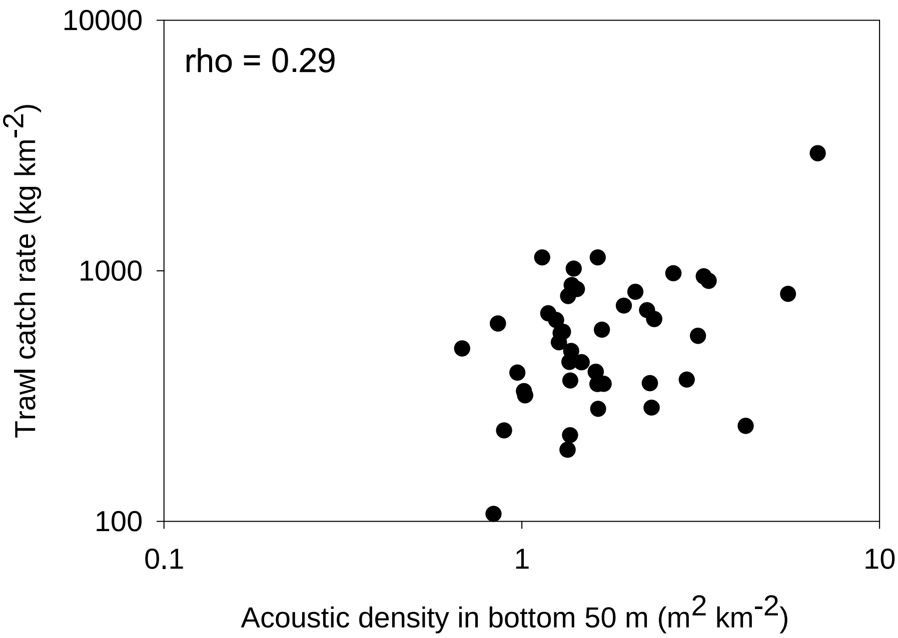


Figure 19: Relationship between total trawl catch rate (all species excluding benthic invertebrates) and acoustic backscatter recorded during the trawl in the Sub-Antarctic in 2012. Rho value is the Spearman's rank correlation coefficient.

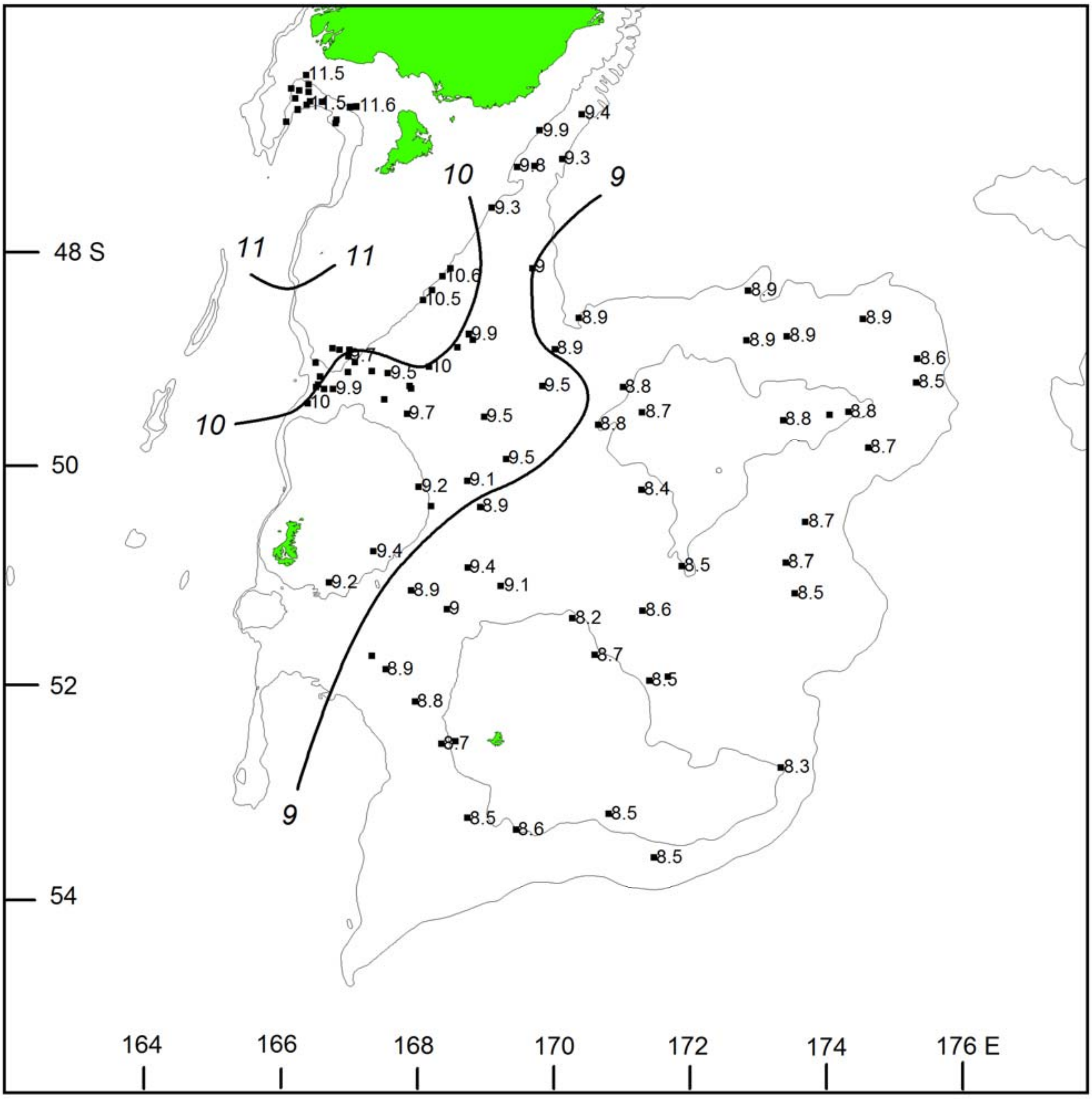


Figure 20: Surface water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

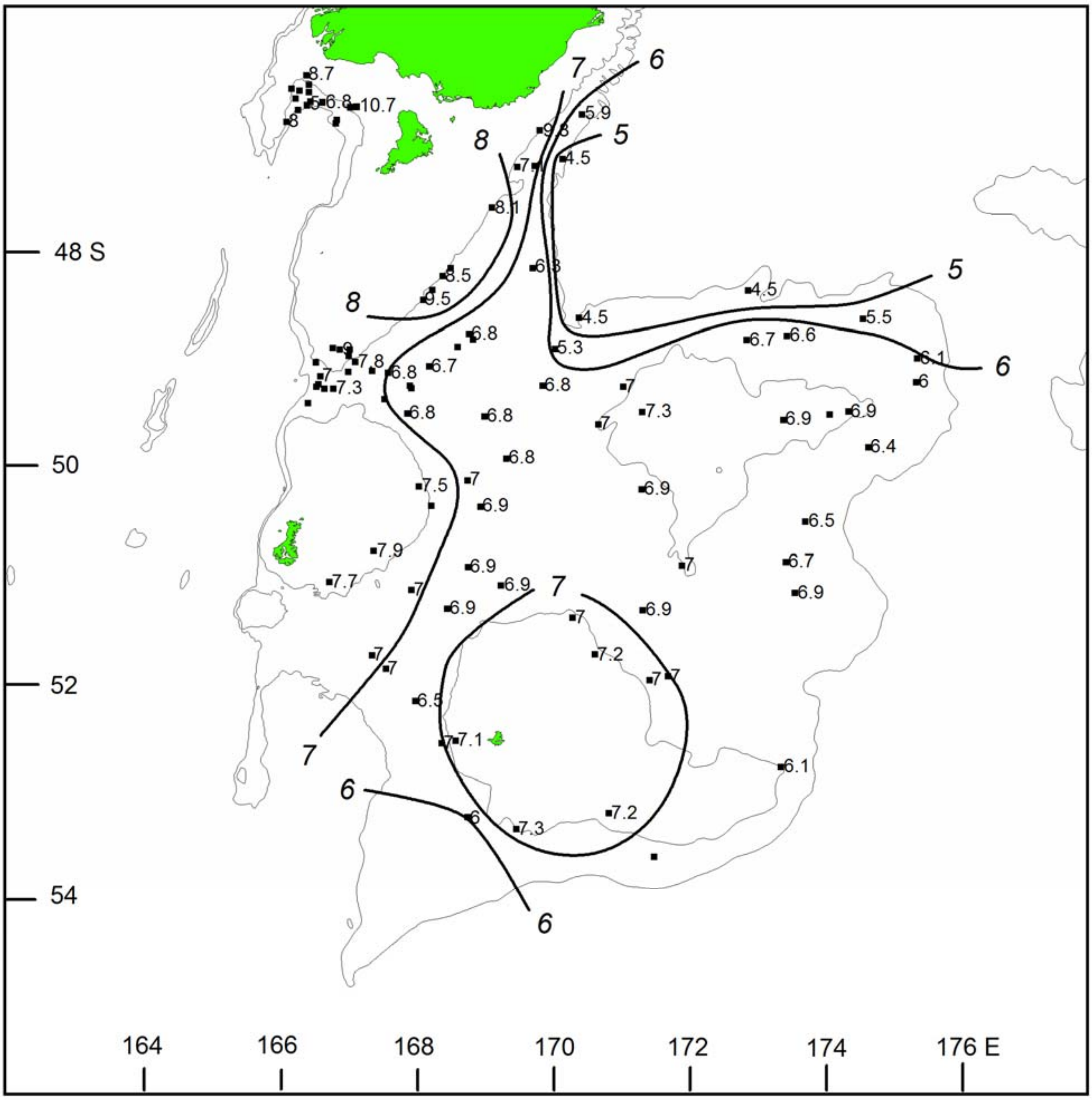
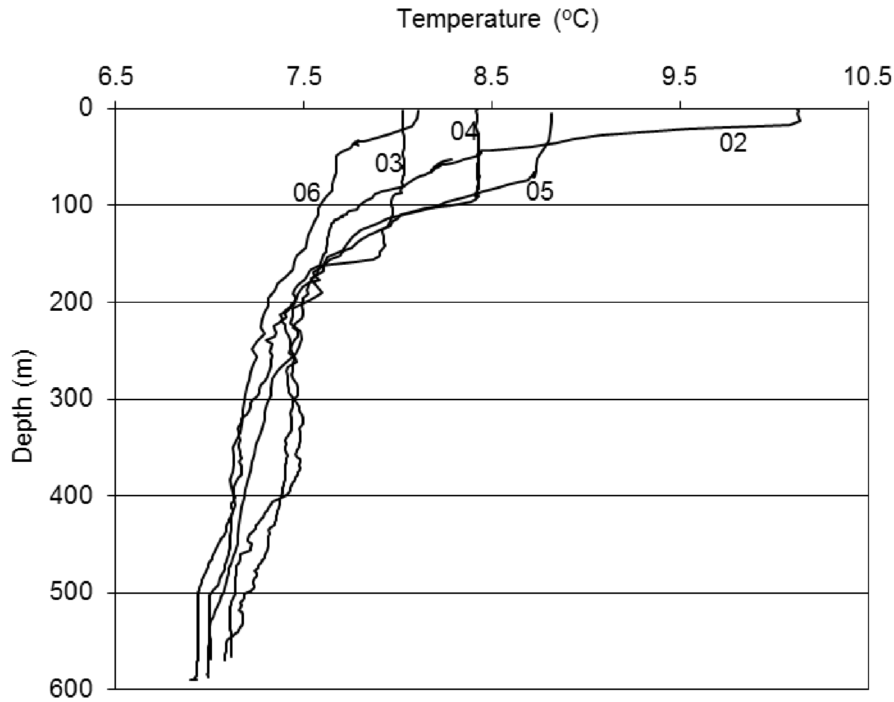


Figure 21: Bottom water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.



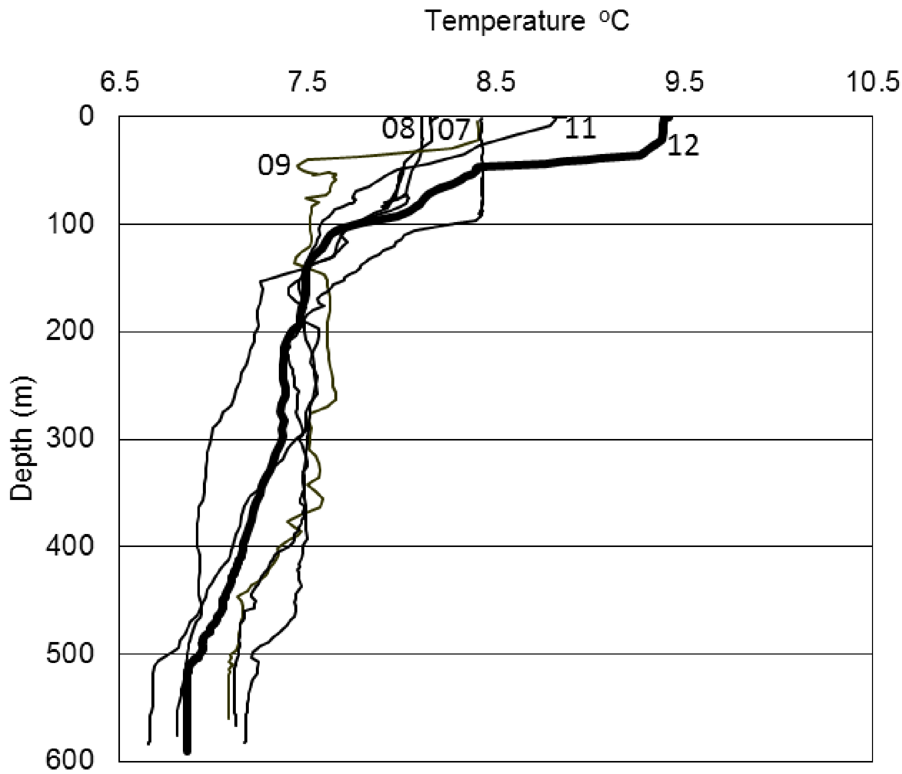


Figure 22: Comparison of vertical profiles of temperature (°C) from the net-mounted CTD on tows in stratum 9 at approximately 50° 45' S and 169° 00' E in 2002 (TAN0219 station 54, on 6 December), 2003 (TAN0317 station 45, on 29 November), 2004 (TAN0414 station 54, on 14 December), 2005 (TAN0515 station 42, on 6 December), 2006 (TAN0617 station 33, on 5 December) (above), 2007 (TAN0714 station 40, on 7 December), 2008 (TAN0813 station 17, on 30 November), 2009 (TAN0911 station 46, on 9 December) and 2011 (TAN1117 station 53, on 9 December). The profile for 2012 (station 69, on 13 December) is the bold line. 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 lat. (º ‘S)	Start long. (º ‘E)	Distance (nmi)	Hoki (kg)	Ling (kg)	Hake (kg)
1	27 Nov 12	0028	46 43.66	170 25.04	0.66	11.3	0	0.0
2	28 Nov 12	0001	46 39.46	167 06.30	3.06	10.0	14.3	0.0
3	28 Nov 12	0001	46 39.87	167 00.62	3.01	3 797.5	109.9	15.7
4	28 Nov 12	0025	46 46.79	166 48.84	3.02	31.7	25.5	34.3
5	28 Nov 12	0025	46 48.74	166 47.92	3.05	9.5	0	27.5
6	29 Nov 12	0025	46 38.64	166 22.68	3.01	225.3	2.6	13.1
7	29 Nov 12	0002	46 31.62	166 24.19	3.01	609.6	91.7	77.4
8	29 Nov 12	0001	46 27.36	166 24.12	3.01	271.7	170.3	21.4
9	29 Nov 12	0001	46 29.52	166 08.75	2.99	55.1	3.7	0
10	29 Nov 12	0002	46 35.01	166 12.56	3.02	222.4	195.8	7.1
11	29 Nov 12	0002	46 30.78	166 15.79	3.02	1 017.9	288.1	70.9
12	30 Nov 12	0001	46 22.11	166 22.26	3.01	12.0	1 988.2	10.5
13*	30 Nov 12	0025	46 41.30	166 14.50	2.98	68.3	12.8	376.2
14*	30 Nov 12	0025	46 36.73	166 25.70	2.99	88.2	2.5	331.0
15	30 Nov 12	0025	46 37.06	166 36.17	2.99	277.8	4.4	395.3
16	30 Nov 12	0002	46 47.85	166 04.36	3.01	46.6	60.8	39.8
17	1 Dec 12	003A	48 27.56	168 05.07	3.06	22.3	428.6	18.4
18	1 Dec 12	003A	48 21.82	168 12.85	2.99	24.0	375.9	1.8
19	1 Dec 12	003A	48 14.14	168 22.40	2.99	19.5	460.0	8.1
20	1 Dec 12	003A	48 09.70	168 29.50	3.06	122.5	115.7	3.1
21	1 Dec 12	003A	47 35.98	169 05.91	3.00	116.8	43.5	0
22	2 Dec 12	003A	46 52.71	169 47.97	3.00	11.5	38.5	0
23	2 Dec 12	003A	47 13.03	169 28.11	3.00	15.6	81.4	0
24	2 Dec 12	0004	47 12.63	169 43.51	2.98	0	33.8	0
25	2 Dec 12	0028	47 08.79	170 08.15	3.00	22.9	0	0
26	3 Dec 12	0004	48 09.61	169 41.88	3.01	4.7	6.7	0
27	3 Dec 12	0027	48 37.60	170 22.70	3.04	13.6	0	0
28	3 Dec 12	0028	48 54.59	170 01.32	3.02	33.9	0	4.6
29	3 Dec 12	0028	48 51.86	169 41.12	2.97	17.2	0	0
30	4 Dec 12	0012	50 13.36	171 17.85	3.02	165.0	48.7	0
31	4 Dec 12	0012	49 29.81	171 18.24	3.00	108.6	142.1	0
32	4 Dec 12	0012	49 36.88	170 39.70	3.02	131.7	51.3	0
33	4 Dec 12	0012	49 15.74	171 01.49	2.97	2.8	63.0	0
34	5 Dec 12	0027	48 22.24	172 51.86	2.99	228.9	0	0
35	5 Dec 12	0011	48 49.73	172 50.23	3.06	308.2	20.6	0
36	5 Dec 12	0011	48 47.52	173 25.74	3.00	5.4	13.1	0
37	5 Dec 12	0027	48 38.08	174 33.27	1.99	28.0	0	0
38	6 Dec 12	0011	49 00.11	175 21.15	3.01	23.0	2.5	0
39	6 Dec 12	0011	49 13.20	175 20.10	3.01	33.3	2.5	0
40	6 Dec 12	0012	49 29.58	174 20.28	3.00	175.9	21.9	0
41	6 Dec 12	0012	49 31.23	174 03.85	3.01	107.2	54.1	0
42	6 Dec 12	0012	49 34.38	173 22.68	3.00	22.4	59.9	0
43	7 Dec 12	0011	49 49.66	174 37.86	3.00	220.0	2.7	0
44	7 Dec 12	0015	50 31.17	173 42.23	3.02	107.0	0	0
45	7 Dec 12	0015	50 53.77	173 25.05	3.00	25.0	10.3	0
46	7 Dec 12	0015	51 10.92	173 32.95	2.99	45.9	4.3	0
47	8 Dec 12	0013	50 55.70	171 53.57	3.01	120.4	44.7	0
48	8 Dec 12	0013	51 20.60	171 18.73	3.01	253.3	116.1	0
49	8 Dec 12	0013	51 24.85	170 16.81	3.00	657.3	299.8	0
50	8 Dec 12	0013	51 45.31	170 36.48	3.02	11.3	194.1	3.5

Appendix 1: continued

Station number	Date	Stratum	Start lat. (º ‘S)	Start long. (º ‘E)	Distance (nmi)	Hoki (kg)	Ling (kg)	Hake (kg)
51	9 Dec 12	0013	51 59.67	171 24.70	3.01	60.6	43.5	0.0
52	9 Dec 12	0013	51 57.64	171 40.92	3.08	72.2	84.5	0
53	9 Dec 12	0014	52 01.99	171 49.58	3.06	64.5	31.4	0
54	9 Dec 12	0014	52 48.29	173 20.59	3.02	8.0	4.5	0
55	10 Dec 12	0015	53 38.41	171 28.99	3.02	89.6	21.3	0
56	10 Dec 12	0014	53 13.73	170 48.71	3.01	22.6	19.0	0
57	10 Dec 12	0009	53 22.73	169 27.07	3.03	122.0	65.0	0
58	11 Dec 12	0010	53 16.21	168 44.03	3.02	55.3	4.1	0
59	11 Dec 12	0010	52 35.07	168 21.46	3.03	694.9	72.8	0
60	11 Dec 12	0009	52 33.60	168 33.89	3.03	429.1	33.8	0
61	11 Dec 12	0007	52 11.32	167 57.97	3.06	23.3	0	8.6
62	12 Dec 12	0007	51 53.28	167 32.26	3.02	32.1	33.5	0
63	12 Dec 12	0007	51 45.93	167 19.79	3.05	528.9	57.5	0
64	12 Dec 12	0006	51 04.90	166 42.17	3.06	371.1	101.3	2.2
65	12 Dec 12	0006	50 47.76	167 21.43	3.02	50.4	106.4	22.0
66	13 Dec 12	0006	51 09.21	167 54.42	3.02	80.8	110.1	0
67	13 Dec 12	0010	51 19.79	168 26.44	3.02	147.2	109.3	2.9
68	13 Dec 12	0010	51 25.94	168 20.42	3.07	144.5	182.8	0
69	13 Dec 12	0009	50 56.61	168 44.77	2.14	69.4	19.7	11.0
70	13 Dec 12	0009	51 06.81	169 13.74	3.01	56.7	109.8	14.6
71*	15 Dec 12	0009	50 11.43	168 01.41	2.41	41.8	41.0	0
72*	15 Dec 12	0009	50 23.32	168 12.30	1.01	63.5	83.9	15.6
73	15 Dec 12	0009	50 22.95	168 55.56	3.05	113.0	86.8	5.8
74	15 Dec 12	0009	50 08.14	168 44.40	3.08	66.3	185.6	0
75	15 Dec 12	0008	49 56.09	169 18.54	3.03	124.0	38.4	0
76	16 Dec 12	0008	49 15.30	169 50.31	3.00	328.4	25.0	25.2
77	16 Dec 12	0008	49 32.34	168 59.30	3.02	142.6	33.0	0
78*	16 Dec 12	0004	48 46.36	168 45.59	0.39	33.6	5.2	0
79	16 Dec 12	0004	48 49.34	168 48.88	2.19	80.0	35.0	0
80	16 Dec 12	0004	48 53.66	168 35.63	2.09	41.4	46.3	0
81	17 Dec 12	0008	49 04.48	168 10.57	3.02	128.0	72.7	13.3
82	17 Dec 12	005B	49 07.99	167 33.89	2.97	107.8	63.8	23.1
83*	17 Dec 12	005B	49 15.34	167 53.16	2.94	91.8	54.4	0
84	17 Dec 12	005B	49 16.60	167 54.49	3.01	461.1	104.1	0
85*	17 Dec 12	005B	49 30.80	167 51.23	2.15	128.5	56.2	12.2
86	18 Dec 12	005B	49 22.65	167 30.90	2.12	70.3	41.9	5.2
87	18 Dec 12	005B	49 06.87	167 20.13	3.03	52.3	136.1	41.5
88	18 Dec 12	003B	49 02.04	167 05.23	3.03	80.5	58.1	4.5
89*	18 Dec 12	003B	48 58.66	166 59.29	1.83	17.1	17.4	0
90	18 Dec 12	003B	48 54.92	166 51.46	2.51	0	5.6	0
91	18 Dec 12	003B	48 55.07	167 00.37	2.95	0	5.7	0
92	18 Dec 12	003B	48 54.12	166 45.28	2.15	0	0	0
93	19 Dec 12	005A	49 07.51	166 58.99	2.93	62.1	93.2	207.1
94*	19 Dec 12	005A	49 16.86	166 45.87	0.57	20.5	23.0	283.6
95	19 Dec 12	005A	49 16.94	166 37.92	2.23	24.2	39.7	245.3
96	19 Dec 12	005A	49 15.73	166 30.98	2.91	42.7	74.3	574.7
97	19 Dec 12	005A	49 24.87	166 23.27	3.03	100.7	49.8	61.7
98	19 Dec 12	005A	49 14.47	166 32.79	2.12	126.3	37.3	41.7
99	20 Dec 12	005A	49 02.29	166 30.20	3.01	82.8	33.7	100.7
100	20 Dec 12	005A	49 10.06	166 34.49	2.71	14.6	20.4	5.0

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	4
Hexactinellida:	glass sponges		
Hyalascus spp.	floppy tubular sponge	HYA	21
Demospongiae	siliceous sponges		
Callyspongiidae			
Callyspongia cf ramosa	airy finger sponge	CRM	7
Pachymatisma sp.	rock dumpling sponge	PAZ	1
Coelosphaeridae			
Lissodendoryx bifacialis	floppy chocolate plate sponge	LBI	1
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	21
Hymedesmiidae			
Phorbas spp.	grey fibrous massive sponge	PHB	2
Tetillidae			
Tetilla leptoderma	furry oval sponge	TLD	8
T. australe	bristle ball sponge	TTL	1
Cnidaria			
Scyphozoa	unspecified jellyfish	JFI	14
Annelida	unspecified polychaete	POL	1
Octocorallia			
Alcyonacea	unspecified soft coral	SOC	3
Keratoisis spp.	branching bamboo coral	BOO	1
Actiniaria	unspecified sea anemones	ANT	4
Actiniidae			
Bolocera spp.	smooth deepsea anemone	BOC	2
Liponematidae			
Liponema spp.	deepsea anemone	LIP	1
Actinostolidae	deepsea anemone	ACS	31
Hormathiidae	warty deepsea anemone	HMT	25
Flabellidae			
Flabellum spp.	flabellum cup corals	COF	3
Stylasteridae			
Errina spp.	red hydrocorals	ERR	1
Zoantharia	zoanthids	ZAH	1
Epizoanthus spp.	zoanthid anemones	EPZ	1
Pennatulacea			
Pteroeidiae			
Gyrophyllum sibogae	siboga sea pen	GYS	1
Ascidiacea			
Tunicata			
Thaliacea	unspecified salps	SAL	22
Salpidae			
Pyrosoma atlanticum		PYR	30

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Mollusca			
Gastropoda: gastropods			
Ranellidae			
Fusitron magellanicus		FMA	16
Volutidae			
Provocator mirabilis	golden volute	GVO	1
Cephalopoda: squid and octopus			
Teuthoidea: squids			
Histioteuthidae			
Histioteuthis spp.	violet squid	VSQ	2
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	41
Todarodes filippovae	Antarctic flying squid	TSQ	5
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	72
O. robsoni	warty squid	MRQ	4
Sepiolida: Bobtail squids			
Sepioloidea spp.	bobtail squid	SSQ	1
Octopoda: Octopus	unspecified octopus	OCP	1
Octopodidae			
Benthoctopus spp.	deepwater octopus	BNO	7
Enteroctopus zealandicus	yellow octopus	EZE	4
Graneledone taniwha	deepwater octopus	GTA	5
G. spp.	deepwater octopus	DWO	1
Opisthoteuthididae			
Opisthoteuthis spp.	umbrella octopus	OPI	4
Arthropoda: Isopods, amphipods, mysids, prawns, lobsters, crabs, barnacles, sea spiders			
Crustacea			
Malacostraca			
Aristaeidae	unspecified prawn	PRA	2
Campylonotidae			
Camplyonotus rathbonae	sabre prawn	CAM	3
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	20
Oplophoridae			
Acanthephyra spp.		ACA	1
Pasiphaeidae			
Pasiphaea barnardi	deepwater prawn	PBA	2
P. aff. tarda	deepwater prawn	PTA	2
Sergestidae			
Sergestes spp.	sergestid prawn	SER	1
Lophogastrida			
Gnathophausiidae			
Noegnathophausia ingens	giant red mysid	NEI	2
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	2

Appendix 3 continued:

Species

Scientific name	Common name	code	Occ.
Anomura			
Lithodidae			
Lithodes aotearoa	New Zealand king crab	LAO	5
Neolithodes brodiei	Brodie's king crab	NEB	6
Paralomis zelandica	prickly king crab	PZE	2
Paguridae			
Diacanthurus rubricatus	hermit crab	DIR	2
Parapaguridae	unidentified hermit crab	PAG	13
Sympagurus dimorphus	hermit crab	SDM	2
Brachyura			
Majidae			
Jacquinotia edwardsii	giant spider crab	GSC	2
Teratomaia richardsoni	spiny masking crab	SMK	3
Nephropidae			
Metanephrops challengeri	scampi	SCI	3
Pycnogonida			
Colossendeidae			
Colossendeis spp.	giant sea spiders	PYC	4
Cirripedia: barnacles	unspecified barnacle	BRN	1
Echinodermata			
Asteroidea	sea stars		
Brisingidae	armless stars	BRG	1
Asteriidae	unidentified starfish	ASR	4
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	10
Psilaster acuminatus	geometric star	PSI	10
Benthopectenidae			
Benthopecten spp.		BES	2
Echinasteridae			
Henricia compacta		HEC	5
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	13
Hippasteria trojana	trojan star	HTR	35
Lithosoma novaezelandiae	rock star	LNV	17
Mediaster sladeni	Sladen's star	MSL	2
Pillsburiester aoteanus		PAO	21
Pterasteridae			
Diplopteraster spp.	starfish	DPP	3
Solasteridae			
Crossaster multispinus	sun star	CJA	12
Solaster torulatus	chubby sun-star	SOT	3
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	31
Echinoidea	unspecified sea urchin	ECT/ECN	2
Regularia			
Cidaridae: cidarid urchins			
Goniocidaris parasol	parasol urchin	GPA	7
G. umbraculum	umbrella urchin	GOU	2

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.

Echinothuriidae, Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	23
Echinidae			
Dermechinus horridus	deepsea urchin	DHO	1
Gracilechinus multidentatus	deepsea kina	GRM	1
Pedinoida			
Caenopedina porphyrogigas	giant purple pedinid	CAL	2
Phormosomatidae			
Phormosoma spp.	Tam O'Shanter urchin	PHM	3
Spatangidae			
Spatangus multispinus	purple heart urchin	SPT	1
Ophiuroidea			
Gorgonocephalidae			
Gorgonocephalus spp.	gorgons head basket-star	GOR	3
Holothuroidea	sea cucumbers	HTH	2
Aspidochirotida			
Synallactidae			
Bathyplotes spp.	sea cucumber	BAM	6
Pseudostichopus mollis		PMO	35
Pannychia moseleyi		PAM	2
Elasipodida			
Laetmogonidae			
Laetmogone spp.		LAG	4

Chondrichthyes

Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	4
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	19
Centroscymnus coelolepis	Portugese dogfish	CYL	1
C. crepidater	longnose velvet dogfish	CYP	11
C. owstoni	smooth skin dogfish	CYO	4
Deania calcea	shovelnose dogfish	SND	18
Etmopterus baxteri	Baxter's dogfish	ETB	35
E. lucifer	lucifer dogfish	ETL	50
Proscymnodon plunketi	Plunket's shark	PLS	9
Scymnorhinus licha	seal shark	BSH	12
Squalus acanthias	spiny dogfish	SPD	42
Zameus squamulosus	velvet dogfish	ZAS	1
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	3
Scyliorhinidae: cat sharks			
Apristurus spp.	deepsea catsharks	APR	5
Bythaelurus dawsoni	Dawson's catshark	DCS	5
Rajidae: skates			
Bathyraja shuntovi	longnosed deepsea skate	PSK	2
Brochiraja asperula	smooth deepsea skate	BTA	7
B. spinifera	prickly deepsea skate	BTS	11
Dipturus innominata	smooth skate	SSK	8
Zearaja nasuta	rough skate	RSK	4

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Chimaeridae: chimaeras, ghost sharks			

C. lignaria	giant chimaera	CHG	1
Hydrolagus bemisi	pale ghost shark	GSP	80
H. novaezelandiae	dark ghost shark	GSH	10
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	54
Rhinochimaera pacifica	widenose chimaera	RCH	7

Osteichthyes

Notacanthidae: spiny eels			
Notocanthus sexspinis	spineback	SBK	43
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	9
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	43
B. hirsutus	hairy conger	HCO	29
Argentinidae: silversides			
Argentina elongata	silverside	SSI	42
Bathylagidae: deepsea smelts			
Nansenia spp.	deepsea smelt	NAN	1
Alepocephalidae: slickheads			
Alepocephalus antipodianus	small-scaled brown slickhead	SSM	10
A. australis	big-scaled brown slickhead	SBI	1
Gonostomatidae: bristlemouths			
Gonostoma elongatum	elongate lightfish	GEL	2
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	5
Chauliodontidae: viperfishes			
Chauliodus sloani	viperfish	CHA	2
Stomiidae: scaly dragonfishes			
Borostomias antarcticus	snaggletooth	BAN	
Opostomias micripnus	giant black dragonfish	OMI	1
Stomias spp.	scaly dragonfish	STO	1
Melanostomiidae: scaleless black dragonfishes		MST	1
Malacosteidae: loosejaws	unspecified loosejaw	MAL	1
Malacosteus australis	southern loosejaw	MAU	1
Idiacanthidae: black dragonfishes			
Idiacanthus spp.	black dragonfish	IDI	1
Paralepididae: barracudinas			
Magnisudis prionosa	giant barracudina	BCA	1
Anotopteridae: daggertooths			
Anotopterus pharao	daggertooth	ANP	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	9
Myctophidae: lanternfishes	unspecified lanternfish	LAN	7
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	4
Notophycis marginata	dwarf cod	DCO	4
Halargyreus johnsoni	Johnson's cod	HJO	8
Lepidion microcephalus	small-headed cod	SMC	6
Mora moro	ribaldo	RIB	43
Pseudophycis bachus	red cod	RCO	9
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	42

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Merlucciidae: hakes			
Lyconus sp.		LYC	3

Macruronus novaezelandiae	hoki	HOK	86
Merluccius australis	hake	HAK	37
Trachipteridae			
Trachipterus trachipterus	dealfish	DEA	1
Macrouridae: rattails, grenadiers			
Coelorinchus aspercephalus	oblique-banded rattail	CAS	45
C. biclinozonalis	two saddle rattail	CBI	1
C. bollonsi	Bollons's rattail	CBO	23
C. fasciatus	banded rattail	CFA	76
C. innotabilis	notable rattail	CIN	10
C. kaiyomaru	Kaiyomaru rattail	CKA	11
C. matamua	Mahia rattail	CMA	9
C. oliverianus	Oliver's rattail	COL	61
C. parvifasciatus	small-banded rattail	CCX	5
Coryphaenoides dossenus	humpback rattail	CBA	5
C. serrulatus	serrulate rattail	CSE	9
C. subserrulatus	four-rayed rattail	CSU	20
Lepidorhynchus denticulatus	javelinfish	JAV	88
Lucigadus nigromaculatus	blackspot rattail	VNI	17
Macrourus carinatus	ridge-scaled rattail	MCA	27
Mesobius antipodum	black javelinfish	BJA	3
Nezumia namatahi	velvet rattail	NNA	2
Trachyrincus aphyodes	white rattail	WHX	5
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	80
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate	ECR	1
Diretmidae: spinyfin			
Diretmichthys parini	spinyfin	SFN	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	8
Paratrachichthys trailli	common roughy	RHY	1
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	2
Cyttus novaezealandiae	silver dory	SDO	3
C. traversi	lookdown dory	LDO	31
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	3
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	3
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	12
Neocyttus rhomboidalis	spiky oreo	SOR	1
Pseudocyttus maculatus	smooth oreo	SSO	13
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	1
Psychrolutidae: toadfishes			
Ambophthalmos angustus	**pale toadfish**	**TOP**	**15**
Neophrynichthys latus	**dark toadfish**	**TOD**	**11**
Psychrolutes spp.	blobfish	PSY	4
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	2

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	4
E. robustus	robust cardinalfish	EPR	4

E. telescopus	black cardinalfish	EPT	3
Bramidae: pomfrets			
Brama australis & B. brama	Ray's bream	RBM&SRB	9
Cheilodactylidae: morwongs			
Nemadactylus macropterus	tarakihi	TAR	1
Nototheniidae: cod icefishes			
Notothenia microlepidota	smallscaled cod	SCD	1
Percophidae: duckbills			
Hemerocoetes spp.	opalfish	OPA	1
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	18
Gempylidae: snake mackerels			
Rexea solandri	gemfish	SKI	1
Thyrsites atun	barracouta	BAR	2
Trichiuridae: cutlassfishes			
Lepidopus caudatus	frostfish	FRO	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	2
Icichthys australis	ragfish	RAG	2
Seriolella caerulea	white warehou	WWA	28
S. punctata	silver warehou	SWA	2
Bothidae: lefteyed flounders	flatfish unidentified	FLA	3
Arnoglossus scapha	witch	WIT	1
Neoachiropsetta milfordi	finless flounder	MAN	34