Ministry for Primary Industries
Manatū Ahu Matua

Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2014 (TAN1412)

New Zealand Fisheries Assessment Report 2017/58

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ISSN 1179-5352 (online)
ISBN 978-1-77665-702-5 (online)

October 2017

New Zealand Government

Growing and Protecting New Zealand

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EXECUTIVE SUMMARY

Bagley, N.W.; Ladroit, Y.; O'Driscoll, R.L. (2017). Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2014 (TAN1412).

New Zealand Fisheries Assessment Report 2017/58. 69 p.

The sixteenth *Tangaroa* summer trawl survey of the Southland and Sub-Antarctic areas was carried out from 26 November to 23 December 2014. Eighty seven tows were successfully completed in 20 strata.

Biomass estimates (and CVs) for all strata were 31 727 t (12.8%) for hoki, 30 011 t (8.8%) for ling, and 1485 t (25.0%) for hake. The hoki biomass was down by 43% from the 2012 estimate of 56 131 t, and is the lowest estimate since 2006. The hake estimate from all strata was the lowest in the time series, and the estimate for the core 300–800 m strata (1 101 t) was the third lowest in the time series. The ling estimates were similar for all and core strata (as very few ling are caught deeper than 800 m), and were the highest since the 2000 survey.

Hoki length frequency distributions in 2014 showed a broad size range, with a mode from about 70–95 cm consisting of fish at ages 4–9. Numbers of 1+ hoki (38–47 cm) in 2014 were low for the time series while numbers of 2+ hoki (50–59 cm) were average for the time series. The apparently strong cohort of fish from the 2007 year-class observed as age 2+ in 2009 showed weakly for males at age 7+ in 2014 . The length frequency distribution of hake showed no clear modes. Most hake were ages 7–11, with smaller (50–70 cm) hake taken at 800–1000 m depth at Puysegur (stratum 25). The length distribution of ling in 2014 was broad, with a slight decrease in the numbers of fish of both sexes under 60 and an increase of males over 80 cm and females over 100 cm compared to the 2012 survey. Most ling were between 4 and 12 years old, with the mode at ages 6–7 for males and age 7 for females.

Acoustic data were also collected during the trawl survey. Data quality in 2014 was variable due to periods of rough weather and sea conditions, and only 61% of acoustic files were suitable for quantitative analysis. Acoustic indices of mesopelagic fish abundance on the Campbell Plateau in 2014 were the second highest in the time series (after 2011). Mesopelagic backscatter was particularly strong in the Stewart/Snares shelf region. Mesopelagic layers were recorded within 100 m of the seabed during the day, leading to elevated estimates of backscatter in the demersal region. There was a weak positive correlation between acoustic density from demersal 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 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 20 700 t in 2013–14 (Ministry for Primary Industries, 2015). 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 90 000 t in 2013–14. 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 1883 t (HAK 1. TACC 3701, includes the western Chatham Rise) and 3935 t (LIN 5, TACC 3955, Southland), and 3221 t (LIN 6, TACC 8505, Sub-Antarctic) (Ministry for Primary Industries 2015).

Two time series of trawl surveys have been carried out from RV *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 frequency distributions 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, 2014), 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, 2014). 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, and were an important part of the recent review of Sub-Antarctic trawl survey catchability (O'Driscoll et al. 2015b).

Other sampling was conducted for students and other researchers as requested. This followed the MPI biosecurity requirements for samples collected outside 12 n. miles. NIWA biosecurity permit numbers 2014055496 and 2014055274 were used for the collection of non-viable marine biological samples and water samples. All material were returned to MPI Biosecurity approved transitional facilities at NIWA.

Samples included:

- unidentified organisms caught in the trawl
- deepwater squids and squid tissue for the Auckland University of Technology
- detailed reproductive observations on some deepwater shark species
- hoki and hake tissue samples for the Virginia Institute of Marine Science to improve hake (Merlucciidae, Gadiformes) classification and delineate their species limits
- rattail tissue samples of *Coryphaenoides* spp. for DNA analysis for Durham University in England
- specimens of prickly dogfish and pacific spookfish for Victoria University
- twice daily biogeochemical water sampling from the *Tangaroa* underway system.

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 2014 survey provided a sixteenth summer estimate of western hoki biomass in time for the 2015 stock assessment.

1.1 Project objectives

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

1. To carry out a trawl survey in December 2014 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.

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 and 14 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, 2011 and 2012 surveys, as these best reflect recent changes in hoki abundance. Allocation of stations for hake and ling was based on all surveys from 2000. 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. A total of 81 stations was planned for phase 1 (Table 1), with an additional 6 stations added outside of the statistical framework because of the need to focus effort on covering the full distributional range of hake age classes. Phase 2 stations were 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 minutes 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 (Demer et al. 2015), with the most recent calibration on 28 July 2013 in Tasman Bay. The system and calibration parameters are given in Appendix 1 of O'Driscoll et al. (2015a).

2.5 Hydrology

Temperature and salinity data were collected using calibrated Seabird SM-37 Microcat CTD datalogger (serial number 4958) 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 Marel motion-compensating electronic scales and recorded to the nearest 0.1 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.

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.

2.7 Estimation of relative biomass and length frequency distributions

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). Biomass for the key species were estimated for all strata, core strata plus stratum 25 (800–1000 m at Puysegur) and the core 300 to 800 m strata.

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 frequency distributions 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 frequency distributions.

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 707 hoki otoliths, 622 ling and all 217 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 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

All acoustic recordings made during the trawl survey were visually examined. The quality of acoustic data recordings was subjectively classified as ‘good’, ‘marginal’, or ‘poor’ (see appendix 2 of O’Driscoll & Bagley (2004) for examples). Only good or marginal quality recordings were considered suitable for quantitative analysis.

Acoustic analysis followed the methods applied to recent Sub-Antarctic trawl surveys (e.g. Bagley et al. 2014) and generalised by O’Driscoll et al. (2011, 2015b). However this report does not include discussion of mark classification or descriptive statistics on the frequency of occurrence of different mark types, as these were based on subjective classification, and were found not to vary much between surveys (e.g., Bagley et al. 2014).

Quantitative analysis was based on 38 kHz acoustic data from daytime trawl and night steam recordings. The 38 kHz data were used as this frequency was the only one available (other than uncalibrated 12 kHz data) for surveys before 2008 that used the old CREST acoustic system (Coombs et al. 2003). Analysis was carried out using custom Echo Sounder Package (ESP2) software (McNeill 2001).

Estimates of the mean acoustic backscatter per square kilometre from bottom-referenced marks 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, 2015b) 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 2014. The methods were the same as those used by O’Driscoll et al. (2015b). 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. Daytime acoustic data were stratified into four broad regions based on trawl survey strata (O’Driscoll et al. 2015a):

1. Puysegur (strata 1–2, and 25);
2. West Sub-Antarctic (strata 6–7 and 9–10);
3. East Sub-Antarctic (strata 11–15 and 27);
4. Stewart-Snares (strata 3–5, 8, and 28).

3. RESULTS

3.1 2014 survey coverage

The trawl survey and acoustic work contracted for this voyage were completed. Three days of survey time were lost due to vessel repairs and one further day lost to bad weather. With repairs to the stern ramp requiring the vessel to berth in Bluff the survey recommenced in the Puysegur area. This area was surveyed about two weeks earlier than surveys from 2000 to 2011 and at a similar time to 2012.

Eighty seven successful trawl survey stations were completed in the 20 strata (Figure 2, Table 1). This included 86 phase 1 stations and 1 phase 2 station. To make up for lost survey time, one phase 1 station in stratum 25 was not sampled as it would have required spending an extra day at Puysegur to complete the one remaining station). One phase 2 station was directed at reducing the CV for hake in stratum 14. These were conducted during phase 1 due to variable catches of hake, and long steaming distances making it unlikely to return to these strata for any phase 2 work.

Four stations were considered unsuitable for biomass estimation: station 1 was a gear trial, station 18 was out of the stratum depth range, station 60 came fast, and on station 71 the trawl gear bogged in soft sediment and the starboard trawl door ‘fell over’. Individual station details from all trawl stations, including the catch of hoki, ling and hake are listed in Appendix 1. Two trawls were conducted in the Campbell East Benthic Protected Areas (BPAs). Written approval to sample within these BPAs was granted under special permit 542. Care to ensure the permit conditions to trawl along the closest previously trawled tow line to the randomly generated station position were followed.

3.2 Gear performance

Gear parameters by depth and for all observations are summarised in Table 2. The headline height readings were obtained for all valid biomass tows while doorspreads were recorded for 86 tows. Measured gear parameters in 2014 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 from 2011. A mean doorspread of 122.6 m was recorded in 2014 (Table 3). Some caution should be exercised when interpreting the time series of doorspreads, as the accuracy of the sensors is reported as ±3% of the displayed value. 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 35.8 t was recorded from all trawl stations (34.7 t from valid biomass tows). For the target species from valid biomass stations, hoki accounted for 28.3%, ling 17.6%, and hake 2.6% of the total catch, while 6.5% of the catch was javelinfish, 6.0 % pale ghost shark and 5.0 % shovelnose dogfish. From the 215 species or species groups caught, 97 were teleosts, 23 were elasmobranchs, 16 were squids or octopuses, and 20 were crustaceans, with the remainder comprising assorted benthic and pelagic animals. (Appendix 3). A list of species returned for formal identification ashore is given in Appendix 4.

3.4 Relative biomass estimates

Total survey biomass estimates for the 20 species with the 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 and 2014 surveys will have little effect on the time series of total abundance estimates for the three target species as few hoki, hake and ling were ever 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 2014 was 31 727 t, a decrease of 43% from the 2012 estimate of 56 131 t, and the lowest since 2006. The 2014 estimate was higher than the time series low in 2006 of 14 747 t (Figure 3, Table 6). The hoki biomass from core stations was 31 329 t, similar to the estimate for all strata as few hoki were caught deeper than 800 m. The biomass estimates for length ranges corresponding to ages 1+ (less than 48 cm) and 2+ (50–60 cm) hoki were 250 t (CV 67%) and 1 720 t (CV 48%) respectively. The low abundance of age 1+ hoki (2013 year-class) in 2014 continued on low estimates of this year-class from the 2011 and 2012 surveys. Estimates of hoki biomass at age 2+ were higher than the 186 t recorded in 2012 but much less that the 2011 estimate of 11 124 t. The biomass of fish age 3+ or greater decreased from 55 007 t in 2012 to 29 757 t in 2014. Despite the 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 1485 t, 39% lower than that in 2012 (2443 t) and the lowest in the time series. The estimate from core 300–800 m strata (1101 t) decreased by 43% from 2012 (1943 t), and was the third lowest estimate since 2000. The hake biomass in stratum 25 at Puysegur (800–1000 m), an area where smaller hake are caught, was 376 t, lower than in previous years and 65% lower than 2008 (1088 t). The estimate of ling biomass in 2014 was the highest recorded since 2000 increasing by 11% to 30 011 t from the 2012 estimate of 27 010 t (Table 6). Few ling were taken deeper than 800 m.

Of the nine other key species, spiny dogfish was the only species with an increase in biomass (4 262 t) from 2012 (843 t). Changes were generally small and within the levels of the sampling uncertainty for lookdown dory, ribaldo, black oreo and dark ghost shark (Figure 3). White warehou decreased from 1259 t in 2012 to 211 t in 2014 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 and javelinfish in 2014 were about half of the 2012 estimates, with both species well below the time series highs from the 2009 survey. Estimates for pale ghost shark in 2014 were lower than those from 2012 (Figure 3).

3.5 Species distribution

The distribution and catch rates at each station for hoki, hake, and ling are given in Figures 4–6. Hoki were widespread throughout the core survey area, occurring in 75 of the 76 core stations and 83 of the 87 successful total trawl stations. Hoki catch rates were generally higher in the west with the two largest catches coming from the bottom of the Stewart/Snares shelf. Lower catch rates occurred along the eastern edge of the Stewart/Snares shelf and the south east of the survey area. High catch rates of 1+ and 2+ hoki were taken on the bottom of the Stewart/Snares shelf, Puysegur, and along the eastern edge of the Stewart/Snares shelf (Figure 4b and Figure 4c), locations where juvenile hoki are often taken.

Hake showed a similar distribution to previous years and 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. The exception was a few individuals taken in the south east in stratum 14. Ling were caught on 76 of the 77 core stations, with higher catches in the western strata (Figure 6). 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 1668 hoki, 1483 ling, and 217 hake. Length-weight relationships used to scale length frequency data are given in Table 8. Scaled length frequency histograms by sex for hoki, hake, and ling are compared to those observed in previous surveys in Figures 7–9. Length frequency distributions for the other key species in the 2014 survey are shown in Figure 10.

Hoki length frequency distributions in 2014 showed a broad size range. The overall length range in 2014 was similar to the 2012 survey except that there were fewer hoki at age 1+ (38–47 cm) and more hoki at age 2+ (50–59 cm) in 2014 (Figure 7). Numbers of 1+ hoki (2013 year class) in 2014 were low for the time series (Figure 11). Length modes from about 70–95 cm consisted of fish at ages 4–9, with a modal peak at age 7 for males and 8 for females (Figures 7 and 11). The apparently strong cohort of fish from the 2007 year-class observed as age 2+ in 2009 showed weakly for males at age 7+ in 2014 (Figure 11).

The length frequency distribution of hake showed no clear modes with small sample sizes, particularly for males, making interpretation of length modes difficult (Figure 8). Fewer small (50–75 cm) hake were captured in 800–1000 m at Puysegur (stratum 25) compared with the 2012 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 7 and 11 for females and about ages 5 and 10 for males (Figure 12). The length frequency distribution of ling was broad. Compared to 2012, there has been a slight decrease in the numbers of fish under 60 cm and an increase of larger fish over 80 cm for males and over 100 cm for females. Population scaled numbers for both sexes are less than 2012 even though the biomass was up by 11%, indicative of more larger or heavier fish in 2014. Most ling were between 4 and 12 years old with the mode at age 7 for females and 6–7 for males (Figure 13). There were fewer ling at age 3 than in 2012.

Most male southern blue whiting were between 29 and 45 cm while most females were between 29 and 50 cm, with modal peaks of 39 cm for males, and 33, 40 and 43 cm for females (Figure 10). The length frequency distributions for black oreo were bimodal (see Figure 10) with peaks around 25 and 30 cm for both sexes. Other points of interest in Figure 10 included: a broad range in the length distribution for female javelinfish with fewer and generally smaller males; the continuing high proportion of female ribaldo; and strong modal peaks for pale ghost shark, between 60 and 73 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 30% of fish examined, and these were typically fish smaller than 70 cm. Most adult hoki were in the resting phase. About 7% of female and male hoki were macroscopically staged as partially spent or spent. Female ling were mostly resting (67%) or immature (27%), but male ling of all gonad stages were recorded, with 31% in spawning condition (ripe and running ripe) and 33% resting. Immature hake made up 18% of the observations for both sexes. About 26% of male hake were ripe or running ripe, while 79% females were resting and maturing.

3.7 Hoki condition indices

Liver and gutted weights were recorded from 1330 hoki in 2014. Both liver condition (Table 10) and somatic condition (measured as the estimated average weight of a 75 cm hoki, Table 11) were lower in 2014 than those recorded in 2012 and below the long term averages observed in the summer time series, continuing the decline in condition since the recent peak in 2011 (Figure 14). Hoki condition indices in the Sub-Antarctic are lower than those from the Chatham Rise survey (which occurs a month later), but hoki condition in both areas follows the same general pattern (Figure 14), suggesting that processes that affect condition occur on a broader scale than the survey region.

3.8 Acoustic results

A total of 258 acoustic data files (91 trawls, 86 day-time steams, and 81 night-time steams) were recorded during the 2014 survey. Of these, 39% were not suitable for quantitative analysis because the data was of poor quality (Table 12). The remaining 61% of files were either of good (30%) or marginal (31%) 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 steams are shown in Figure 15. Only one night steam of suitable quality was recorded at Puysegur – this was mostly on the shelf shallower than 200 m and therefore outside the trawl survey area. Spatial distribution of total backscatter in the remainder of the survey area was generally 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 south eastern Sub-Antarctic.

The vertical distribution of acoustic backscatter in 2014 is compared to the average vertical distribution from all years in the Sub-Antarctic time series in Figure 16. As in previous years, the proportion of backscatter in the upper 200 m increased at night. 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). In 2014, there were also peaks in the daytime vertical distribution at 300–400 m and 450–550 m depth which corresponded with midwater layers.

The time series of day estimates of total acoustic backscatter are plotted in Figure 17. Total backscatter in the water column (from about 15 m below the surface to the seabed) in 2014 was the second highest in the time series (after 2011) and similar to that in 2001. As noted by O'Driscoll et al. (2015b), acoustic backscatter in the bottom 10 m has been relatively consistent throughout the time series. However, backscatter within 50 m and 100 m from the seabed increased in 2014, and the estimate from the bottom 100 m was the highest in the time series (Figure 17). The vertical distribution of backscatter within 100 m of the seabed also showed a very different pattern in 2014 from that observed in previous Sub-Antarctic surveys, with elevated backscatter throughout the bottom 100 m and a strong peak at 40–60 m from the seabed (Figure 18). This peak appeared to be associated with layers of mesopelagic fish close to the seabed during the day, as well as the presence of schooling demersal species such as southern blue whiting (Figure 19).

There was a weak positive correlation between acoustic backscatter in the bottom 50 m during the day and trawl catch rates (Figure 20, number of tows = 58, Spearman's rank correlation = 0.24, $p = 0.07$). Significant positive correlations between backscatter and catches ($p < 0.05$) 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, 2006, or 2012 (O'Driscoll & Bagley 2003b, 2006a, 2008, Bagley et al. 2014).

Estimated mesopelagic indices were calculated 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 13). Note that the estimation procedure for night-time data was still based on the three subareas defined by O'Driscoll et al. (2011) and shown in Figure 15, but mesopelagic indices were summarised in four regions as recommended by O'Driscoll et al. (2015b). Estimated mesopelagic indices by region are summarised in Table 14 and plotted in Figure 21. As in previous years, the mesopelagic indices were similar to estimates of total backscatter for the Sub-Antarctic (see Figure 17). Estimates of mesopelagic backscatter in 2014 had increased from 2012, and were the second highest in the time series (after 2011). Mesopelagic indices increased in all four regions, but were particularly high in the Stewart/Snares region where the 2014 index was the highest in the time series (Figure 21).

3.9 Hydrological data

Temperature profiles were available from 89 CTD casts (including foul shots). Surface (5 m depth) temperatures ranged between 8.0 and 11.9 °C (Figure 22), while bottom temperatures were between 4.1 and 10.0 °C (Figure 23). Highest surface temperatures, over 11 °C 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 waters to the south of Campbell Islands. As in previous years, there was a general trend of increasing water temperatures towards the north and west (Figures 22–23).

The average surface temperature in 2014 of 9.4 °C was slightly lower than that observed in 2012 (9.6 °C), but within the range of average surface temperatures observed in 2002–12 (8.8–10.3 °C). In general there is a negative correlation between surface temperature and depth of the thermocline (Figure 24), 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, 2012). The 2014 survey was slightly higher followed a similar trend to 2005 with higher surface temperature associated with a shallow thermocline at about 80 m. Average bottom temperatures in 2014 (7.1 °C) were the same as those observed in 2012 and at the higher end of the range of average temperatures observed in 2002–12 (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

In the 2008 stock assessment of hoki, the model was unable to fit the threefold increase in estimated biomass between the 2006 and 2007 trawl surveys (McKenzie & Francis 2009). Age data from the time series shows large annual changes in numbers-at-age which cannot be explained by changes in abundance, and are suggestive of a change in catchability for the survey. In the stock assessments since 2011, 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). The lower biomass in the November 2014 Southern Plateau trawl survey was interpreted as observation error (i.e. the survey underestimated the biomass by chance) in the 2015 hoki stock assessment (Ministry for Primary Industries 2015).

Ling biomass estimates have continued to increase from 2008 and in 2014 were the second highest in the time series. Hake biomass decreased from the 2012 estimate with few smaller fish caught in the deep 800 to 1000 m strata at Puysegur. Of the nine other key species, spiny dogfish were the only species with an increase in biomass compared with 2012. Changes were generally small and within the levels of the sampling uncertainty for lookdown dory, ribaldo, black oreo and dark ghost shark (see Figure 3). White warehou biomass decreased about 6 fold to 211 t while the biomass of southern blue whiting and javelinfish was about half of the 2012 estimate. Pale ghost shark in 2014 were lower than the 2012 estimate but in keeping with other estimates since 2007. (Figure 3).

5. CONCLUSIONS

The estimated hoki biomass in 2014 was the lowest recorded since 2006, about 24 000 t lower than in 2012, and about half the recent peak in 2009. 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.

The biomass of hoki at age 2+ in 2014 was about average for the time series while the biomass of 1+ hoki was the second lowest since 2000. Few fish of these age classes were taken on the eastern edge of the Stewart/Snares shelf. The biomass of hoki aged 3+ or greater was well down and the lowest estimate since 2006 and similar to estimates from the early 2000s. The hoki age frequency distribution observed in 2014 comprised mainly fish between 2 and 3, and 6 to 9 years old for males and 2 and 3 and 7 to 10 years for females. The 1+ year class seen in 2012 followed through to be the strongest age class at age 3+ in 2014 for both sexes. The large 2+ year class seen in 2009 tracked weakly through as age 7+ fish, while the above average 2002 year-class observed at younger ages in the 2007–09 surveys was negligible at age 12+ in 2014.

The estimated biomass of hake from core strata in 2014 was the third lowest in the time series. Larger catches of hake were taken in 800 to 1000 m (stratum 25) at Puysegur. Few smaller hake were caught in this stratum in 2014 compared to most years. Hake are known to aggregate to spawn at this time of year, often over rough untrawlable ground south of the Stewart/Snares shelf. Few spawning fish were caught in this area in 2014. The biomass estimate for ling in 2014 continued the gradual increase seen over the past few surveys and is close to the time series high recorded in 2000 of just over 33 000 t. Pale ghost shark decreased from the time series high in 2012 but was within the range of estimates in recent years, while spiny dogfish estimates increased and were similar to 2009. Javelin fish were half of the biomass estimate from 2012 and follow a general downward trend since the time series high in 2009. Similarly the southern blue whiting estimate was half of 2012, again following a decreasing trend since 2009. There was no consistent increase or decrease from the time series in the abundance of the other key species.

6. ACKNOWLEDGMENTS

Thanks to the scientific staff who participated in this voyage, and the master, officers, and crew of *Tangaroa* who contributed to the success of this voyage. Thanks to the scientific staff involved with the otolith preparation and reading of the hake, hoki, and ling otoliths, Sira Ballara and Peter Horn for the calculation of the age frequencies. This work was carried out by NIWA under contract to the Ministry for Primary Industries (Research Project MDT2010/02B). Thank you to Darren Stevens for reviewing this report.

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Table 1: Stratum areas, depths, and number of successful biomass stations from the November–December 2014 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)	Stations Phase 1	Phase 2	Total
1	Puysegur Bank	300–600	2 150	4		4
2	Puysegur Bank	600–800	1 318	4		4
3a	Stewart-Snares	300–600	4 548	6		6
3b	Stewart-Snares	300–600	1 556	4		4
4	Stewart-Snares	600–800	21 018	3		3
5a	Snares-Auckland	600–800	2 981	4		4
5b	Snares-Auckland	600–800	3 281	3		3
6	Auckland Is.	300–600	16 682	3		3
7	South Auckland	600–800	8 497	3		3
8	N.E. Auckland	600–800	17 294	4		4
9	N. Campbell Is.	300–600	27 398	6		6
10	S. Campbell Is.	600–800	11 288	3		3
11	N.E. Pukaki Rise	600–800	23 008	6		6
12	Pukaki	300–600	45 259	6		6
13	N.E. Camp. Plateau	300–600	36 051	6		6
14	E. Camp. Plateau	300–600	27 659	3	1	4
15	E. Camp. Plateau	600–800	15 179	3		3
25	Puysegur Bank	800–1 000	1 928	4		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	86	1	87

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)	87	2.97	0.17	2.10–3.14
Tow speed (knots)	87	3.5	0.03	3.4–3.6
Gear parameters (m)				
300–600 m				
Headline height	42	7.0	0.18	6.6–7.6
Doorspread	42	121.8	7.10	106.5–132.9
600–800 m				
Headline height	34	7.0	0.20	6.8–7.7
Doorspread	34	122.9	6.39	108.9–130.4
800–1000 m				
Headline height	11	7.1	0.25	6.8–7.7
Doorspread	10	124.7	5.19	118.6–133.9
All stations 300–1000 m				
Headline height	87	7.0	0.20	6.6–7.7
Doorspread	86	122.6	6.62	106.5–133.9

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
2014	86	122.6	6.62	106.5	133.9	7.0	0.20

Table 4: Biomass estimates, coefficients of variation, and catch of the 20 species with highest catch weights in the 2014 Sub-Antarctic trawl survey. Estimates are from successful biomass stations for all strata combined. Biomass estimates from 2012 (from Bagley et al. 2013) are shown for comparison.

		2014 (TAN1412)			2012 (TAN1215)		
Species	Species code	Catch (kg)	Biomass (t)	CV. (%)	Catch (kg)	Biomass (t)	CV (%)
Hoki	HOK	9 815	31 727	13	15 717	56 131	15
Ling	LIN	6 125	30 011	9	8 484	27 036	11
Javelinfish	JAV	2 260	7 525	13	3 748	15 241	12
Pale ghost shark	GSP	2 118	12 134	10	2 966	16 814	12
Shovelnosed dogfish	SND	1 723	1 054	15	1 053	724	32
Southern blue whiting	SBW	1 204	9 960	29	2 593	21 485	35
Spiny dogfish	SPD	1 176	4 262	29	480	843	12
Small-scaled brown slickhead	SSM	921	2 459	35	381	925	58
Hake	HAK	895	1 485	25	3 287	2 443	22
Ridge-scaled rattail	MCA	619	2 492	23	517	2 518	41
Baxter's dogfish	ETB	529	1 830	17	497	2 128	13
Oliver's rattail	COL	528	3 034	17	1 080	4 491	16
Longnose velvet dogfish	CYP	495	888	26	428	909	23
Deepwater spiny dogfish	CSQ	417	489	34	918	833	26
Silverside	SSI	404	3 490	23	377	2 939	12
Dark ghost shark	GSH	357	1 400	47	465	1 794	68
Banded rattail	CFA	328	1 462	12	476	2 349	12
Giant stargazer	GIZ	283	461	38	-	-	
Ribaldo	RIB	275	849	16	457	914	16
Black oreo	BOE	271	1 229	43	310	1 279	36
Total catch (all species)		34 742			47 837		

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	367	318	4	0	17	0
	(11)	(32)	(100)		(88)	
2	265	160	61	0	0	5
	(27)	(47)	(49)			(52)
3a	180	733	13	0	2	187
	(16)	(19)	(100)		(100)	(43)
3b	2 011	124	0	0	122	19
	(60)	(30)			(41)	(100)
4	1 452	2 600	0	505	0	1 232
	(31)	(62)		(98)		(29)
5a	723	564	123	0	0	109
	(41)	(18)	(33)			(26)
5b	406	426	28	0	0	298
	(30)	(32)	(61)			(21)
6	2 874	1 132	24	0	1 259	128
	(69)	(48)	(100)		(52)	(100)
7	389	307	57	0	0	145
	(37)	(65)	(54)			(16)
8	2 127	2 835	246	0	0	1 147
	(6)	(18)	(56)			(19)
9	4 698	5 896	85	0	0	2 042
	(26)	(18)	(64)			(14)
10	2 200	318	25	2	0	100
	(74)	(77)	(100)	(100)		(48)
11	3 492	1 578	57	2	0	319
	(30)	(17)	(100)	(100)		(18)
12	4 843	5 419	0	0	0	3 337
	(28)	(10)				(21)
13	3 610	4 314	88	0	0	2 113
	(39)	(26)	(100)			(36)
14	1 536	2 371	290	0	0	357
	(31)	(33)	(100)			(33)
15	155	909	0	0	0	188
	(14)	(45)				(49)
Subtotal (strata 1–15)	**31 329**	**30 005**	**1 101**	**508**	**1 400**	**11 725**
	(13)	**(9)**	**(32)**	**(97)**	**(47)**	**(10)**
25	331	6	376	0	0	1
	(74)	(100)	(34)			(75)
Subtotal (strata 1–25)	**31 660**	**30 011**	**1 477**	**508**	**1 400**	**11 726**
	(13)	**(9)**	**(25)**	**(97)**	**(47)**	**(10)**
27	34	0	0	349	0	112
	(50)			(92)		(71)
28	33	0	9	846	0	296
	(62)		(100)	(39)		(16)
Total (All strata)	**31 727**	**30 011**	**1 485**	**1 279**	**1 794**	**12 134**
	(13)	**(9)**	**(25)**	**(36)**	**(68)**	**(10)**

Table 5 (continued)

Stratum	JAV	LDO	RIB	SBW	SPD	WWA
1	23	5	0	0	58	4
	(24)	(77)			(59)	(100)
2	112	4	24	0	0	4
	(32)	(62)	(46)			(61)
3a	74	9	5	3	511	1
	(36)	(46)	(75)	(62)	(93)	(100)
3b	9	2	0	1	165	16
	(100)	(100)		(100)	(51)	(52)
4	850	13	125	0	110	0
	(48)	(100)	(44)		(58)	
5a	121	9	30	0	3	5
	(31)	(45)	(34)		(100)	(100)
5b	231	0	32	92	14	0
	(20)		(57)	(100)	(37)	
6	696	8	0	2 712	1 143	14
	(79)	(100)		(76)	(92)	(100)
7	296	0	162	0	0	0
	(38)		(34)			
8	704	0	169	31	230	0
	(18)		(41)	(70)	(24)	
9	1 107	0	171	453	674	57
	(61)		(40)	(27)	(15)	(78)
10	401	0	48	0	0	0
	(45)		(16)			
11	661	33	35	395	7	0
	(17)	(50)	(73)	(68)	(100)	
12	1 231	115	0	4 203	253	26
	(30)	(36)		(44)	(22)	(84)
13	525	56	0	516	719	68
	(29)	(68)		(23)	(48)	(92)
14	297	75	0	1 398	342	17
	(53)	(100)		(45)	(33)	(100)
15	356	24	11	157	30	0
	(12)	(100)	(55)	(54)	(53)	
Subtotal (strata 1–15)	**6 999**	**352**	**813**	**9 960**	**4 259**	**211**
	(13)	**(28)**	**(16)**	**(29)**	**(29)**	**(40)**
25	482	0	36	0	0	0
	(12)		(52)			
Subtotal (strata 1–25)	**8 177**	**352**	**849**	**9 960**	**4 259**	**211**
	(13)	**(28)**	**(16)**	**(29)**	**(29)**	**(40)**
27	31	0	0	0	0	0
	(100)					
28	13	0	0	0	3	0
	(100)				(100)	
Total (All strata)	**8 220**	**352**	**849**	**9 960**	**4 262**	**211**
	(13)	**(28)**	**(16)**	**(29)**	**(29)**	**(40)**

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
	2014	31 329	13	31 727	13
	Autumn series				
	1992	67 831	8		
	1993	53 466	10		
	1996	89 029	9	92 650	9
	1998	67 709	11	71 738	10
HAKE	Summer series				
	1991	5 553	44		
	1992	1 822	12		
	1993	2 286	12		
	2000	2 194	17	3 103	14
	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
	2014	1 101	32	1 485	25
	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)

		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
	2014	30 005	9	30 011	9
	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 bellowsfish	7	-	1	3	7	3
Banded rattail	2 743	5	41	62	1 096	57
Barracouta	1	1	-	1	1	1
Basketwork eel	236	70	89	9	193	9
Baxter's lantern dogfish	509	231	276	44	382	42
Black javelinfish	60	8	6	6	60	6
Black oreo	527	255	272	11	241	11
Blackspot rattail	64	6	11	4	48	8
Bluenose	1	0	1	1	1	1
Bollon's rattail	389	154	209	28	271	25
Bronze bream	1	1	-	1	1	1
Catshark (*Apristurus* sp.)	1	1	-	1	1	1
Dawson's catshark	1	1	-	1	1	1
Deepsea cardinalfish	9	1	1	3	9	3
Etmopterus pusillus	9	6	3	1	9	1
Finless flounder	52	9	14	22	47	20
Four-rayed rattail	1 115	4	25	13	302	13
Gemfish	3	-	3	2	3	2
Ghost shark	311	157	154	11	163	11
Giant chimaera	1	0	1	1	1	1
Giant stargazer	98	33	65	16	98	16
Hairy conger	116	24	32	27	97	24
Hake	217	41	175	31	217	31
Hapuku	1	-	1	1	1	1
Hoki	5 380	2 060	3 317	84	1 738	82
Humpback rattail	9	-	9	5	9	5
Javelin fish	5 594	1 130	4 006	70	1 267	60
Johnson's cod	173	73	48	10	70	10
Kaiyomaru rattail	137	1	1	9	135	8
Leafscale gulper shark	91	46	45	17	87	16
Ling	2 506	1 218	1 286	78	1 969	76
Long-nosed chimaera	147	85	62	40	146	39
Longnose velvet dogfish	197	55	141	15	134	13
Lookdown dory	69	28	41	29	69	29
Lucifer dogfish	479	297	182	48	348	46
Mahia rattail	11	5	6	4	11	4
NZ southern arrow squid	297	160	137	21	150	20
Notable rattail	185	3	14	11	89	9
Oblique banded rattail	508	15	306	29	233	26
Oliver's rattail	2 906	9	53	42	727	34
Orange roughy	62	28	33	9	62	9
Pale ghost shark	1 287	631	656	76	1 158	73
Plunket's shark	6	1	5	6	5	5
Prickly deepsea skate	2	2	-	1	2	1
Prickly dogfish	2	-	2	1	2	1
Psychrolutes	1	1	-	1	1	1
Red cod	86	61	24	10	86	10
Ribaldo	164	31	133	40	146	39
Ridge scaled rattail	379	165	210	14	259	13
Rough skate	2	1	1	2	2	2
Rudderfish	7	1	6	4	7	4
Sandfish	3	2	1	1	3	1

Table 7 (continued)

	Length frequency data				Length-weight data	
	No. of fish measured			No. of	No. of	No. of
Species	Total †	Male	Female	Samples	fish	samples
Scampi	7	4	3	3	7	3
Sea perch	9	2	7	3	9	3
Seal shark	10	6	4	7	9	6
Serrulate rattail	54	18	21	11	54	11
Shovelnose spiny dogfish	478	130	347	19	141	10
Silver dory	26	15	11	1	26	1
Silver roughy	36	-	-	1	20	1
Silver warehou	10	3	7	4	10	4
Silverside	1 362	12	36	32	373	25
Small banded rattail	162	-	-	3	90	3
Small-headed cod	29	15	10	5	29	5
Smallscaled slickhead	626	284	339	11	286	7
Smooth oreo	368	190	172	6	206	6
Smooth skate	19	5	14	15	18	14
Smooth skin dogfish	27	17	10	6	21	5
Southern bastard cod	1	0	1	1	1	1
Southern blue whiting	1 809	835	973	40	606	39
Southern Ray's bream	29	13	16	14	29	14
Spiky oreo	8	6	2	3	8	3
Spineback	217	5	87	29	172	29
Spiny dogfish	777	375	402	54	420	52
Swollenhead conger	95	23	18	32	89	29
Violet cod	46	20	15	4	46	4
White rattail	56	45	9	4	24	3
White warehou	42	21	21	17	42	17
Widenosed chimaera	64	29	34	6	64	6
Totals	**33 529**	**14 664**	**9 190**		**14 965**	

†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	0.053798	2.7074	0.93	241	21.1 – 35.7	TAN1412
Dark ghost shark	0.001643	3.3324	0.96	162	33.4 – 69.1	TAN1412
Javelinfish	0.001024	3.2149	0.96	1 255	23.2 – 65.8	TAN1412
Hake	0.002927	3.2067	0.97	213	56.0 – 117.2	TAN1412
Hoki	0.004803	2.8796	0.97	1 738	38.3 – 109.3	TAN1412
Ling	0.001375	3.2762	0.97	1 958	41.5 – 131.9	TAN1412
Lookdown dory	0.026655	2.9660	0.99	69	13.1 – 54.7	TAN1412
Pale ghost shark	0.012061	2.8246	0.96	1 134	24.9 – 85.6	TAN1412
Ribaldo	0.003901	3.2666	0.99	146	21.2 – 69.1	TAN1412
Southern blue whiting	0.002852	3.2084	0.98	606	22.0 – 56.0	TAN1412
Spiny dogfish	0.002537	3.1198	0.93	417	46.0 – 98.6	TAN1412
White warehou	0.025427	2.9356	0.99	41	30.5 – 57.6	TAN1412

* $W = aL^b$ 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	697	883	10	29	173	334
2	1 243	2 155	15	80	401	845
3	5	8	5	59	233	43
4	0	1	10	1	323	53
5	0	1	1	0	57	8
6	52	1	0	0	22	1
7	55	250	0	6	8	1
Total staged	2 052	3 299	41	175	1 217	1 258

*See Appendix 2 for description of gonad stages.

Table 10: Hoki liver condition indices for the Sub-Antarctic and each of the three subareas (see Figure 15 for subarea 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
2014	2.40	1.8	2.57	2.9	1.92	3.9	2.41	2.6
Mean	2.79	0.5	3.07	0.8	2.15	1.3	2.75	0.7

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
2014	0.004803	2.879567	1 205
Mean			1 213

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			% of recordings
	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
2014	258	30	31	39

* 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: Estimates of the proportion of total day backscatter 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 in three subareas 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 suitable for acoustic analysis from Puysegur.

			Region
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
2014	0.61	0.54*	0.62

*No night time data were available for Puysegur in 2014 so proportion was estimated as the average of 2000–11 = 0.54.

Table 14: 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 region. Total indices were obtained as the weighted average of region estimates, where weighting was the proportional area of the region (East 55.5% of total area, Puysegur 1.9%, Stewart-Snares 20.5%, West 22.1%). - indicates that the 2012 survey did not produce any data suitable for acoustic analysis from Puysegur.

										Acoustic index (m^2/km^2)
		East		Puysegur		Stewart-Snares		West		Total
Year	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
2000	8.37	15.9	28.80	9.9	14.97	18.1	10.97	13.2	10.68	9.2
2001	9.12	22.0	29.90	44.9	12.34	15.8	11.41	13.0	10.68	11.8
2002	7.05	14.9	31.19	28.4	8.35	8.8	8.64	11.6	8.13	8.2
2003	7.90	31.5	18.92	14.9	9.52	6.8	8.35	17.2	8.54	16.7
2005	7.45	14.8	6.04	7.1	8.51	12.8	8.60	14.9	7.90	9.0
2006	4.09	15.7	3.38	13.3	5.12	9.4	4.84	12.4	4.45	8.8
2007	5.54	19.0	7.26	12.2	6.88	13.3	4.74	14.0	5.67	11.1
2008	8.03	15.2	13.26	11.9	11.49	24.1	6.57	14.0	8.52	10.7
2009	7.43	16.2	17.23	13.2	10.01	23.7	6.17	15.1	7.86	10.8
2011	13.81	12.1	10.61	8.8	13.18	7.6	9.15	7.2	12.59	7.6
2012	5.21	16.8	-	-	9.79	9.6	5.44	25.0	6.10	9.9
2014	10.27	11.2	19.70	16.6	19.14	11.2	11.10	18.0	12.08	7.4

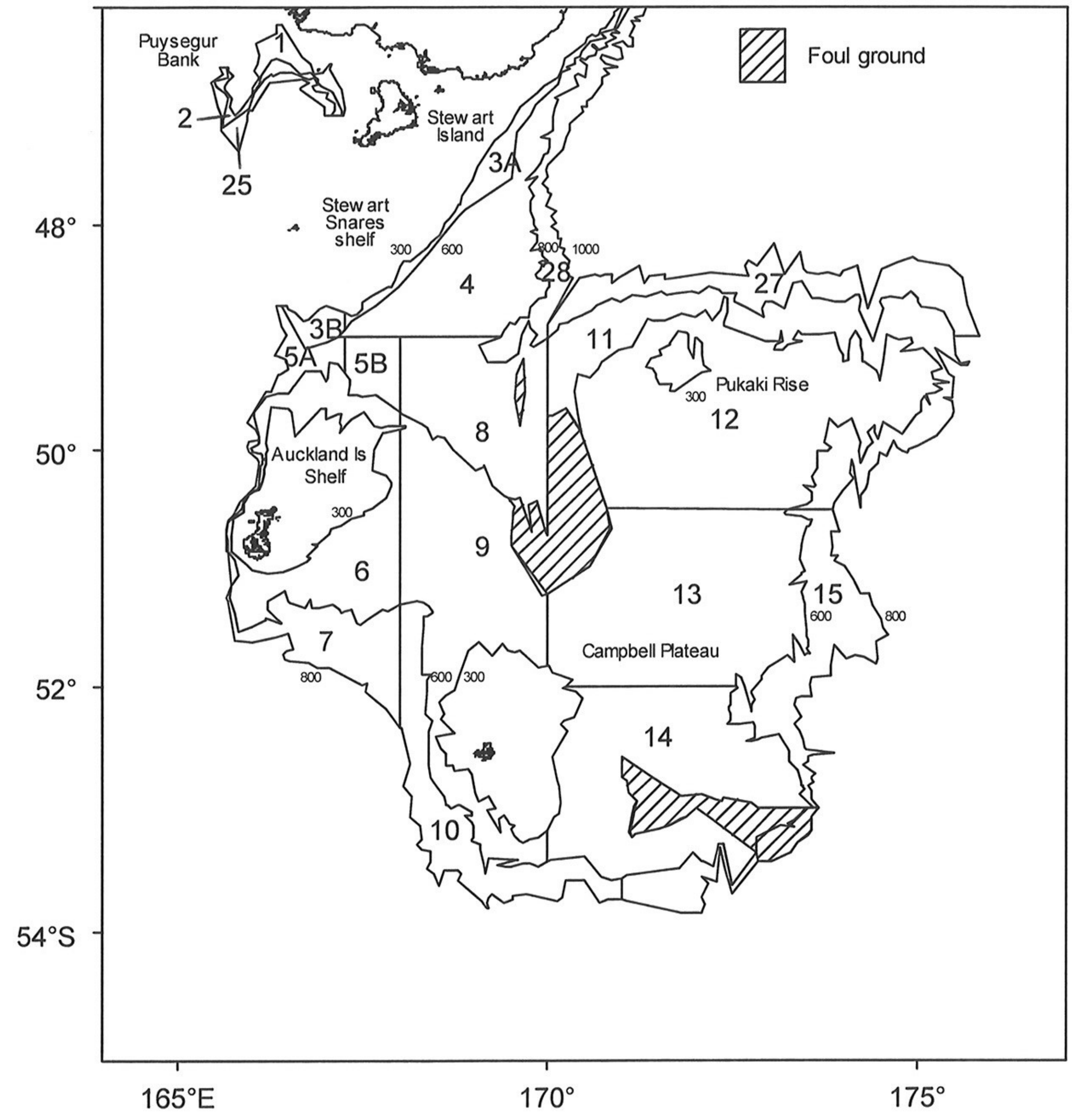


Figure 1: Stratum boundaries for the November–December 2014 Southland and Sub-Antarctic trawl survey.

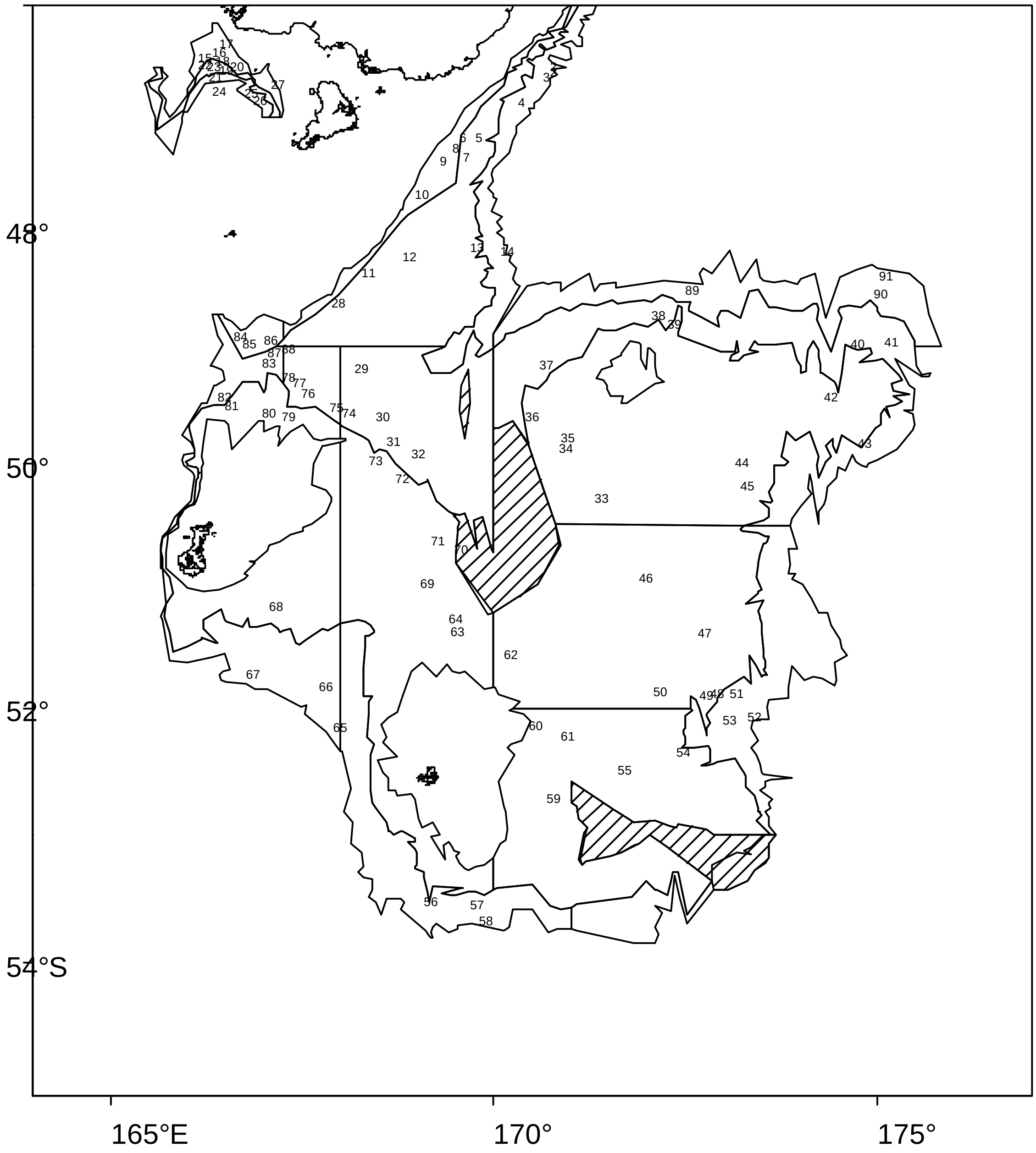


Figure 2: Map showing start positions of all bottom trawls (including unsuccessful stations) from the November–December 2014 Southland and Sub-Antarctic trawl survey.

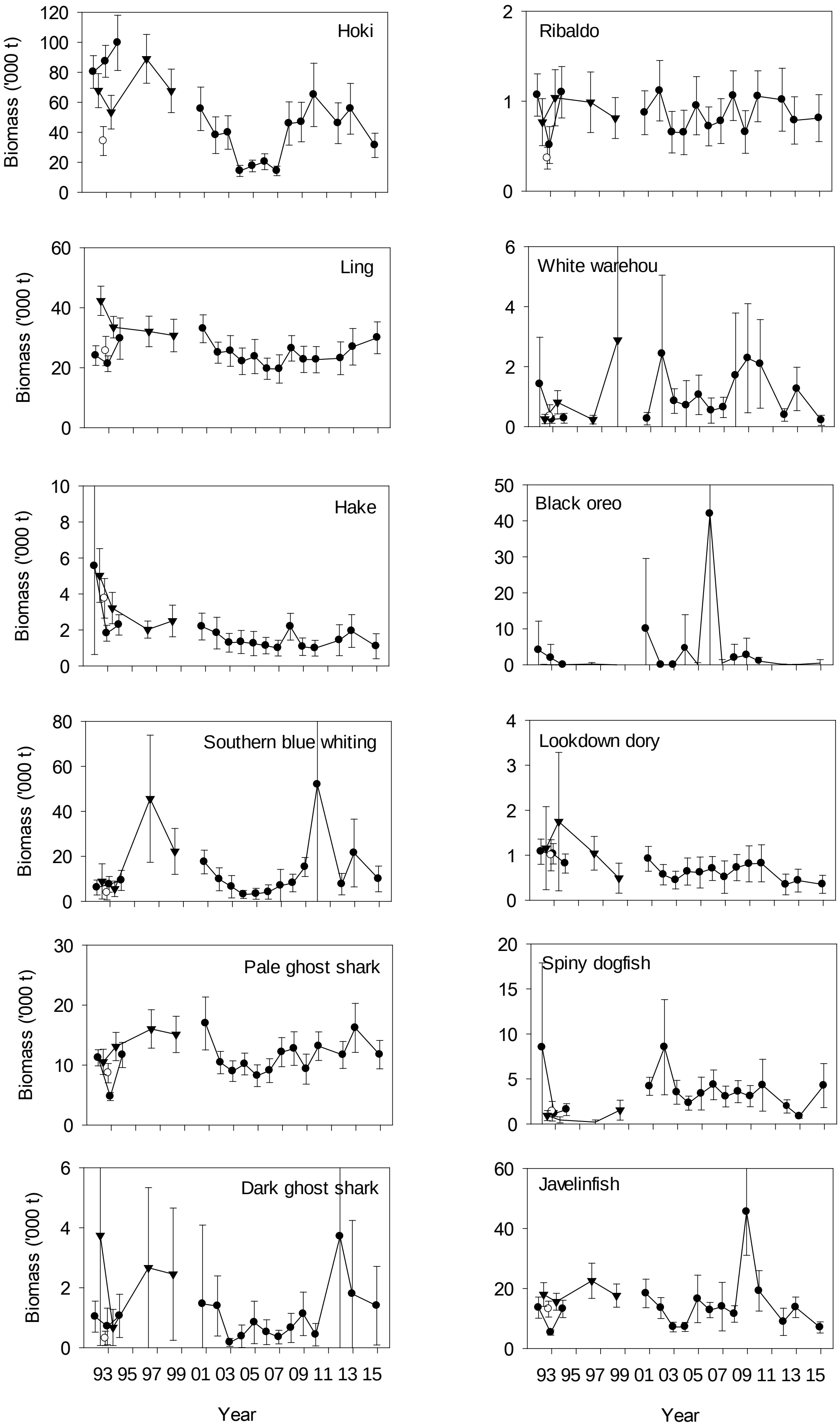


Figure 3: Trends in biomass (± 2 standard errors) of key species in the core 300–800 m strata in all Sub-Antarctic trawl surveys from *Tangaroa*. Solid circles show the summer time series and solid triangles the autumn time series. The open circle shows biomass from a survey of the same area in September–October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

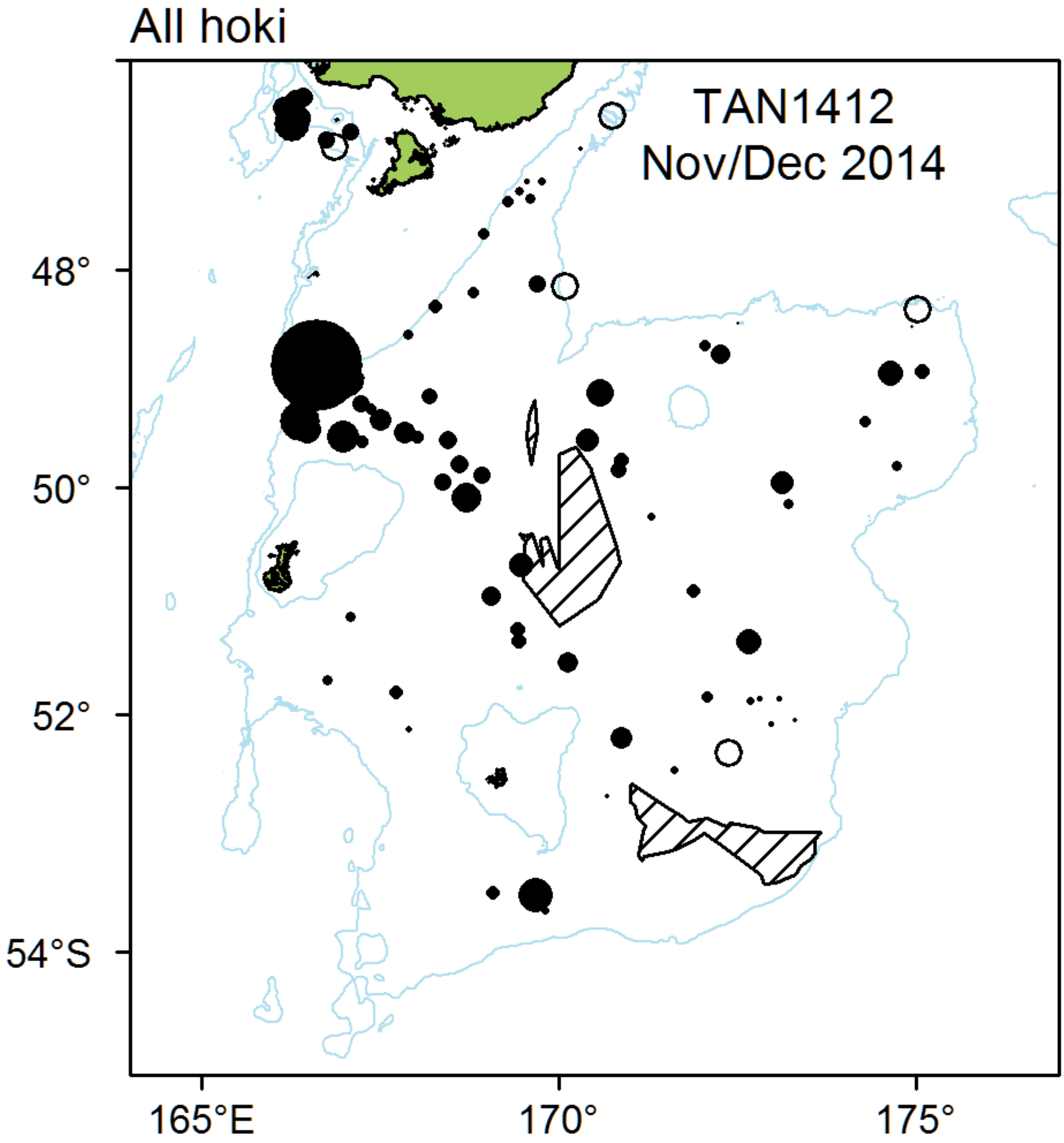


Figure 4a: Distribution and catch rates of all hoki in the summer 2014 trawl survey. Circle size is proportional to catch rate. Maximum catch rate is 3451 kg.km^{-2}, open circles represent zero catch.

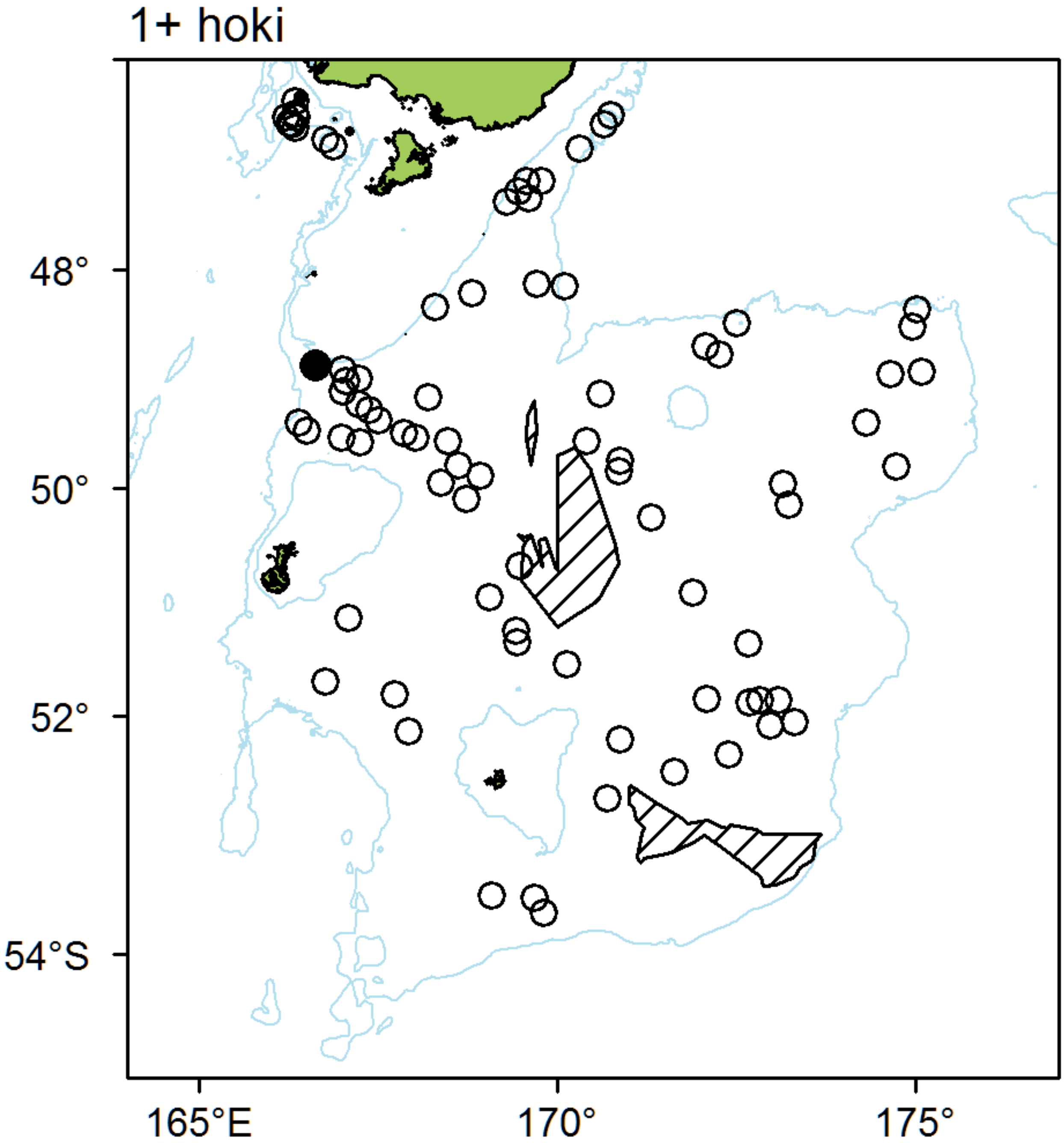


Figure 4b: Distribution and catch rates of 1+ (less than 48 cm) hoki in the summer 2014 trawl survey. Circle size is proportional to catch rate. Maximum catch rate is 426 kg.km^{-2}, open circles represent zero catch.

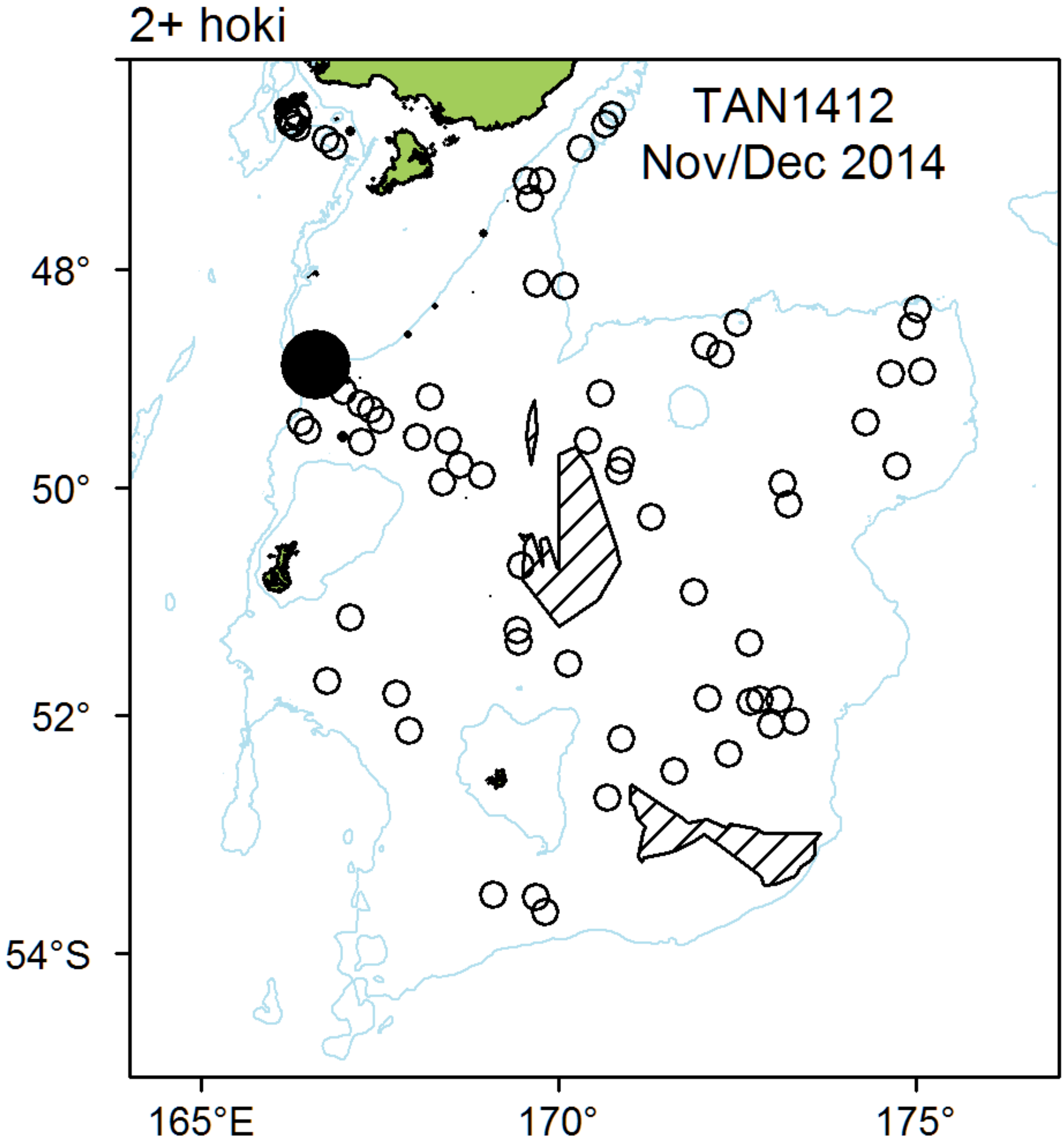


Figure 4c: Distribution and catch rates of 2+ (48-59 cm) hoki in the summer 2014 trawl survey. Circle size is proportional to catch rate. Maximum catch rate is 2089 kg.km^{-2}, open circles represent zero catch.

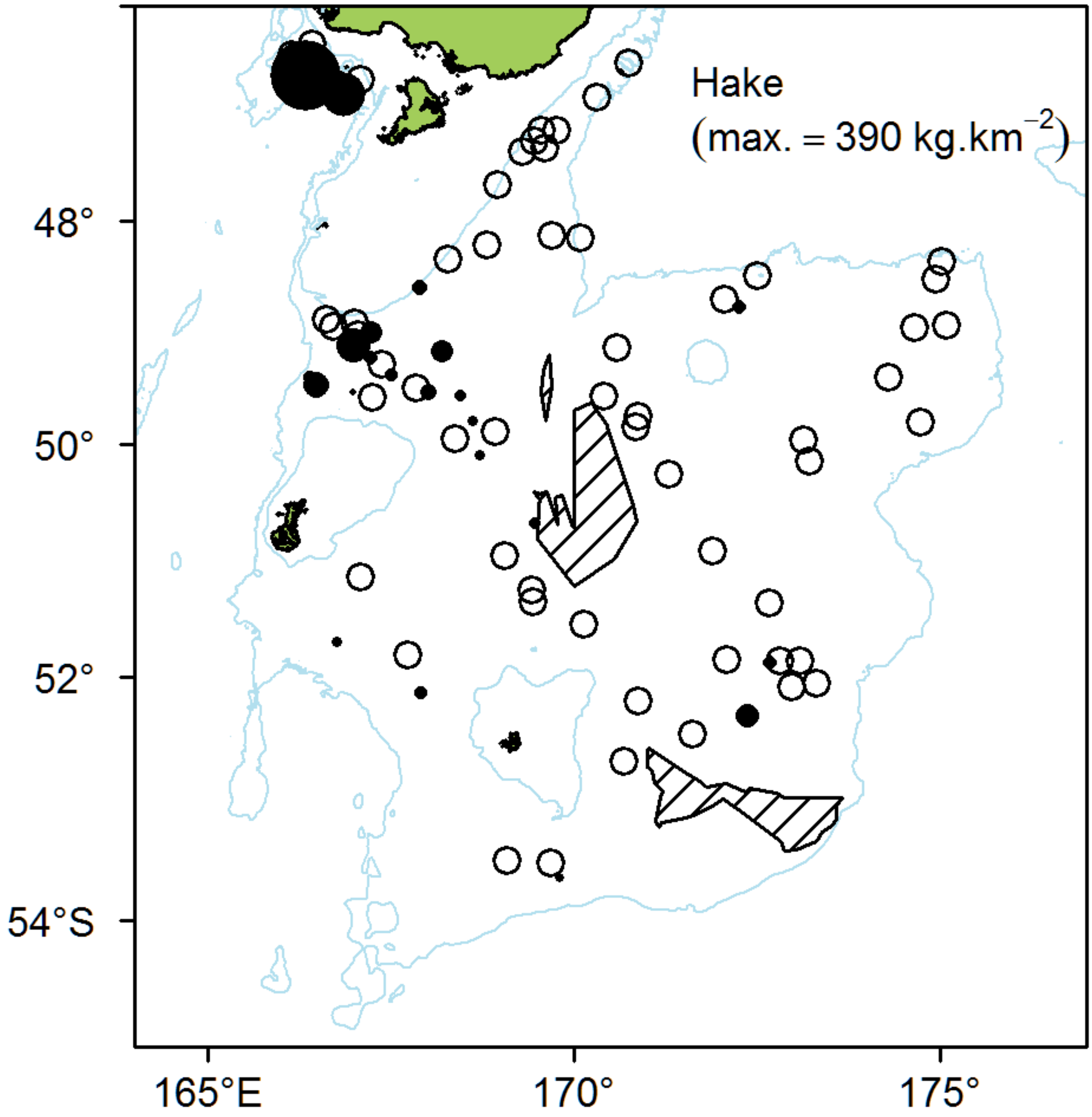


Figure 5: Distribution and catch rates of all hake in the summer 2014 trawl survey. Circle size is proportional to catch rate. Maximum catch rate is 389 kg.km^{-2}, open circles represent zero catch.

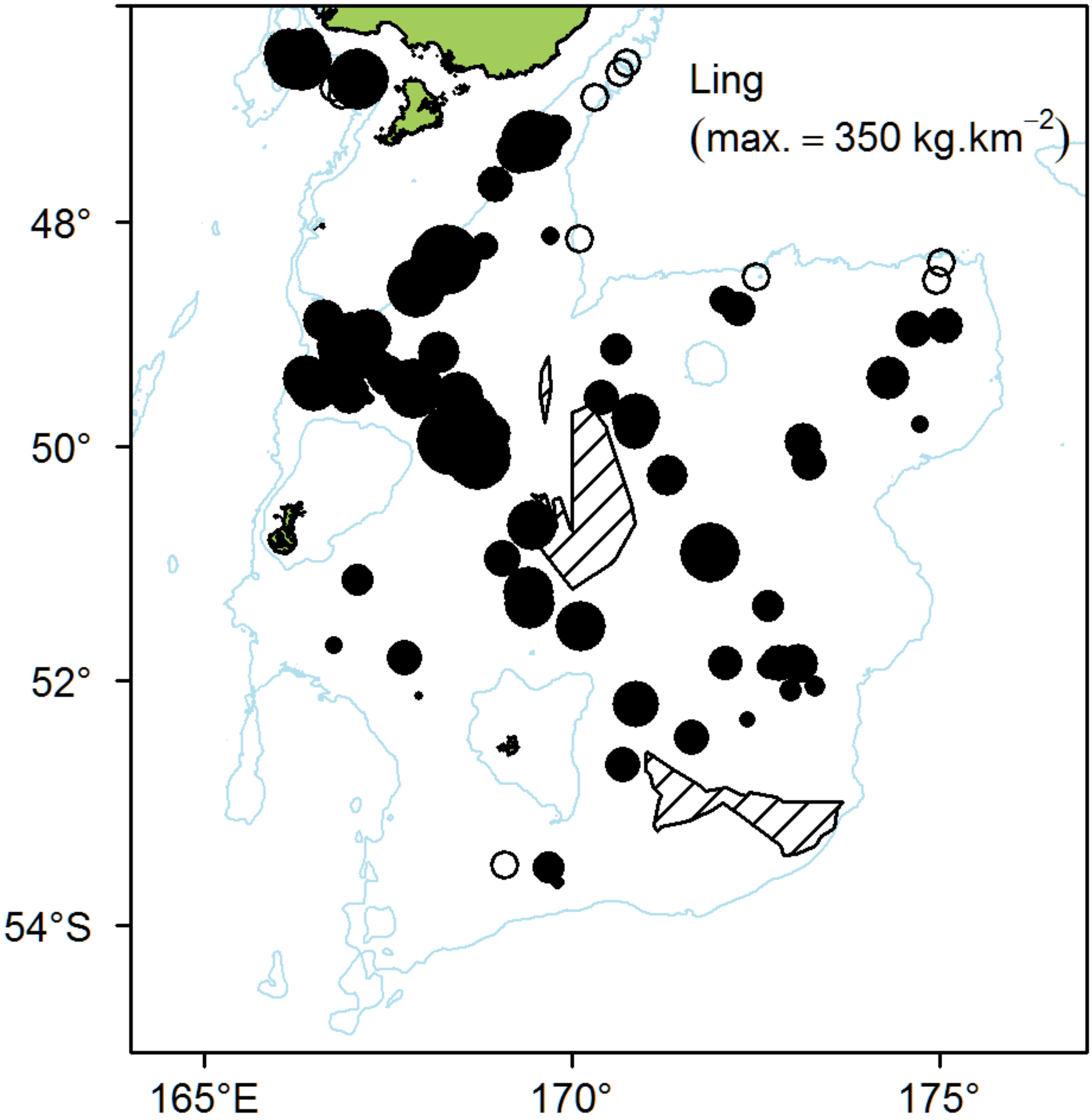


Figure 6: Distribution and catch rates of all ling in the summer 2014 trawl survey. Circle size is proportional to catch rate. Maximum catch rate is 352 kg.km^{-2}, open circles represent zero catch.

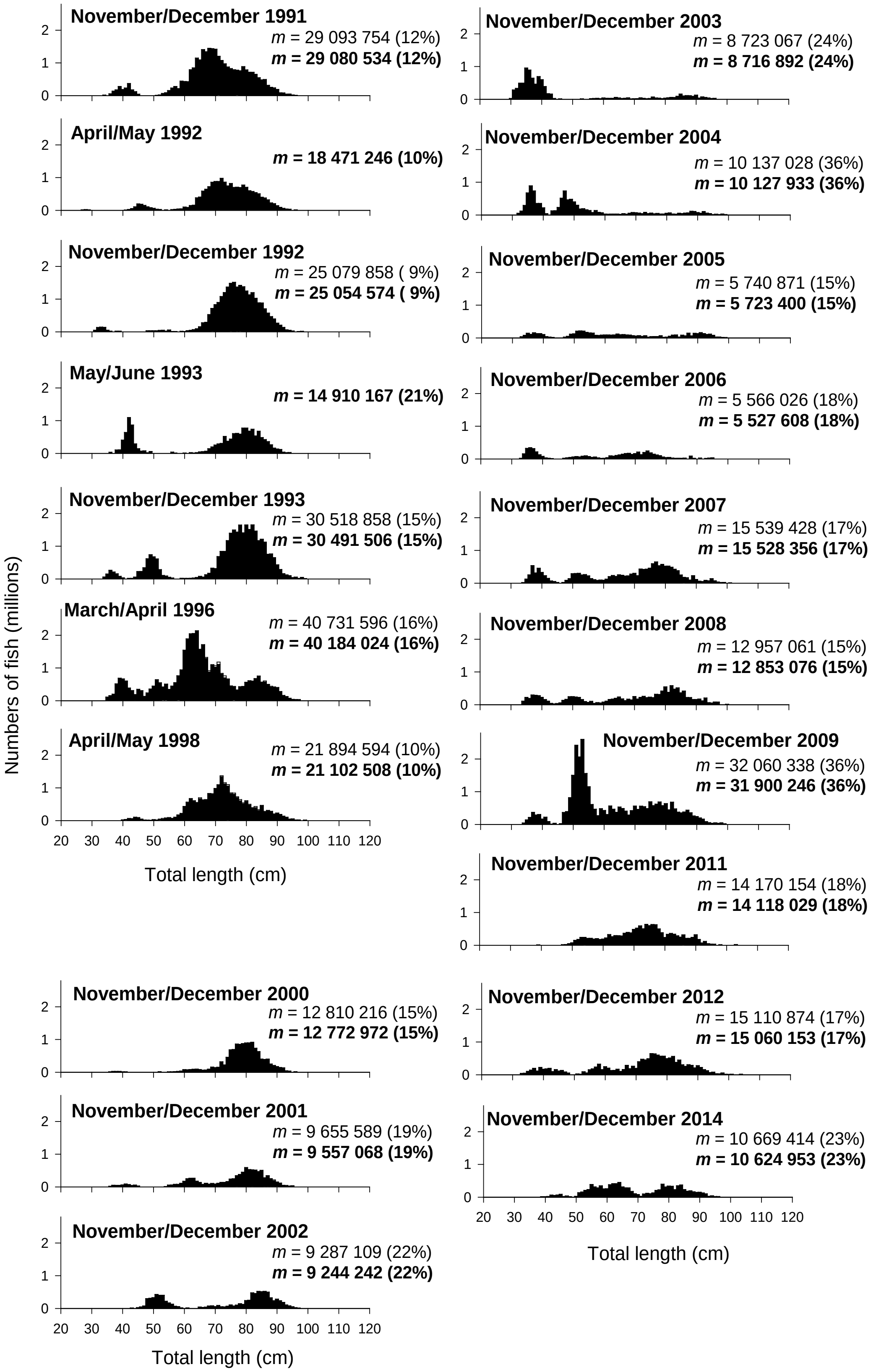


Figure 7a: Scaled length frequency distributions for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (m values)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

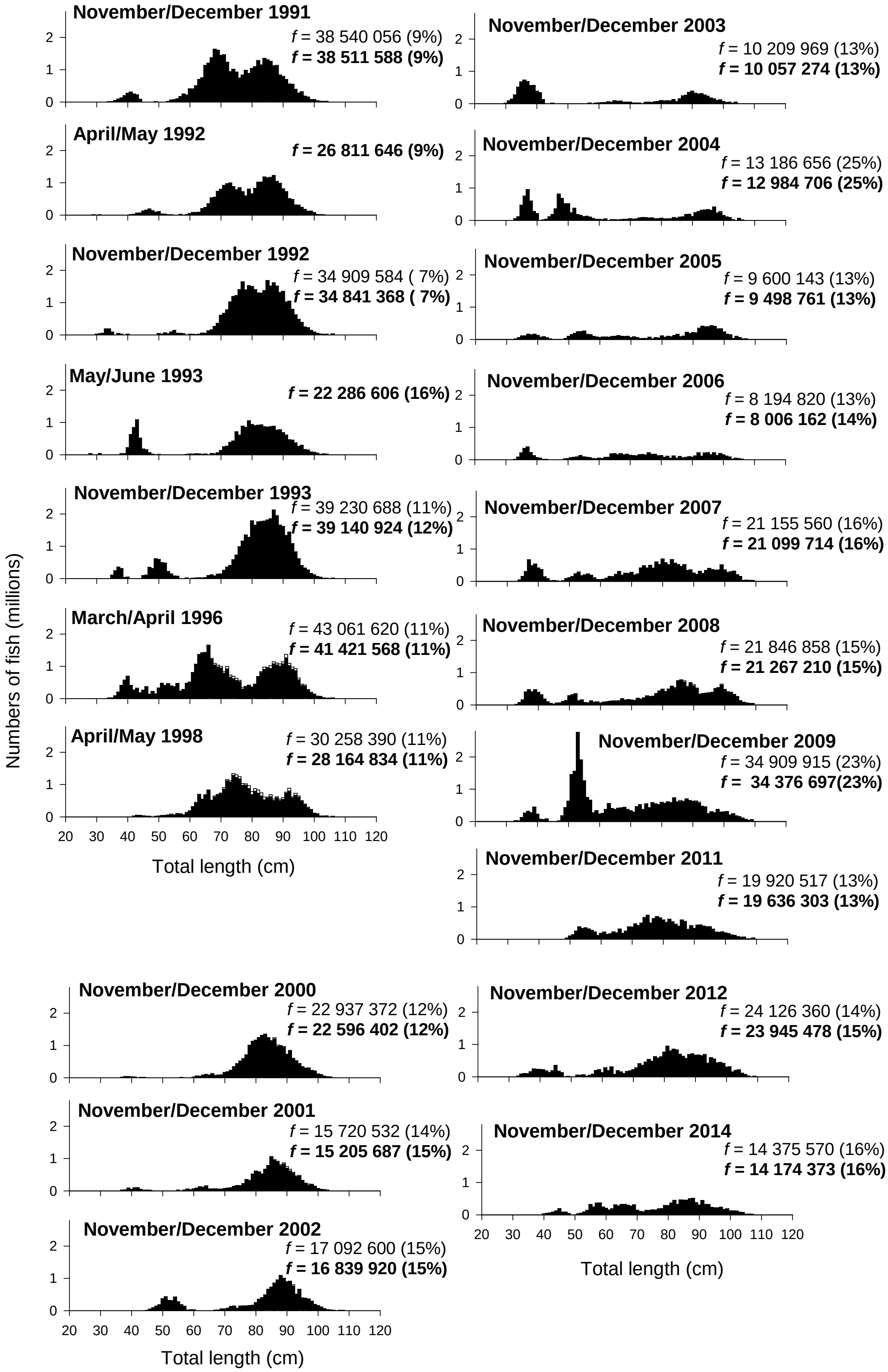


Figure 7b: Scaled length frequency distributions for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few hoki were caught outside core strata, white bars are very small. Numbers (f values)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

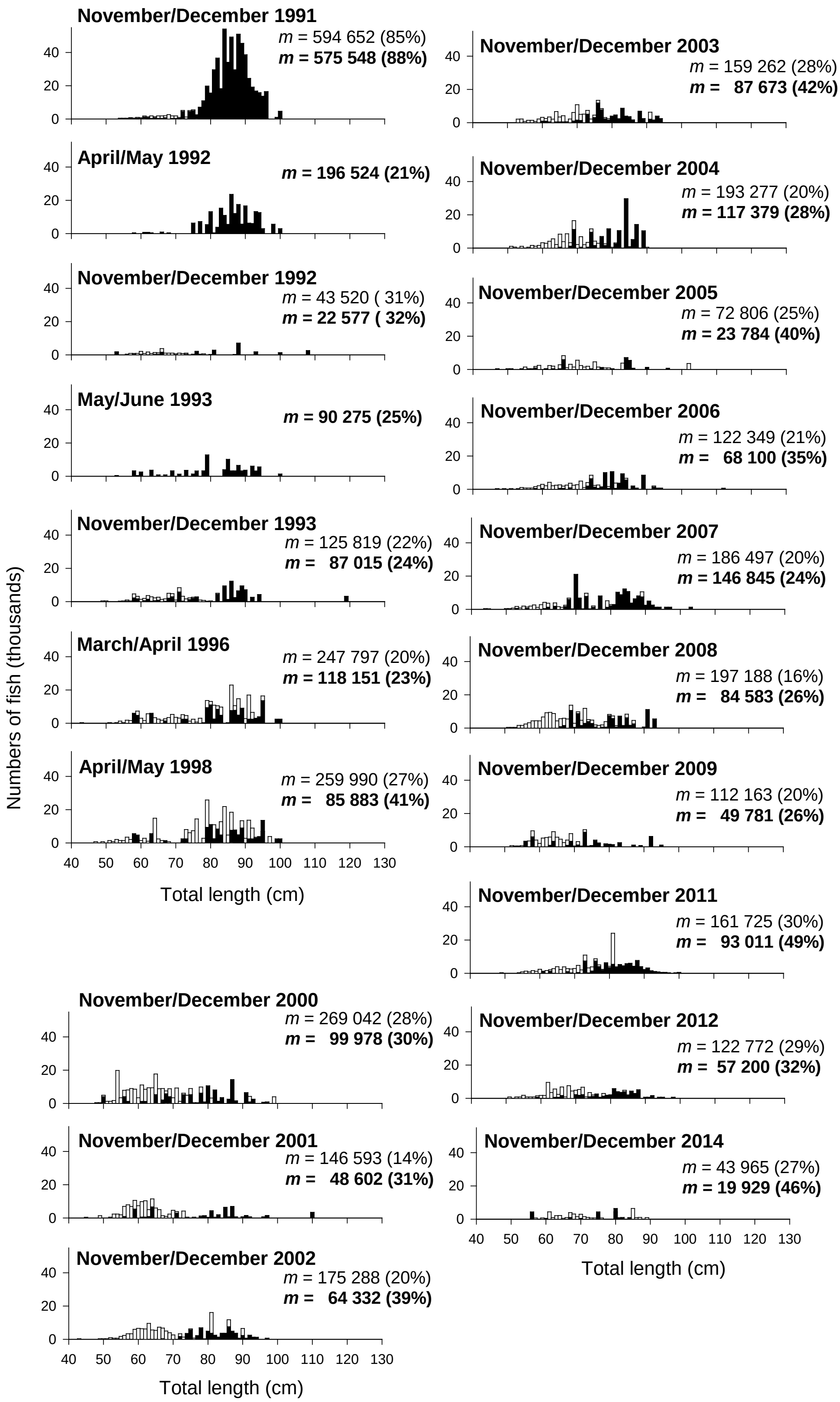


Figure 8a: Scaled length frequency distributions for male hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (m values) above are for all strata and below (in bold) for core strata with CVs in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

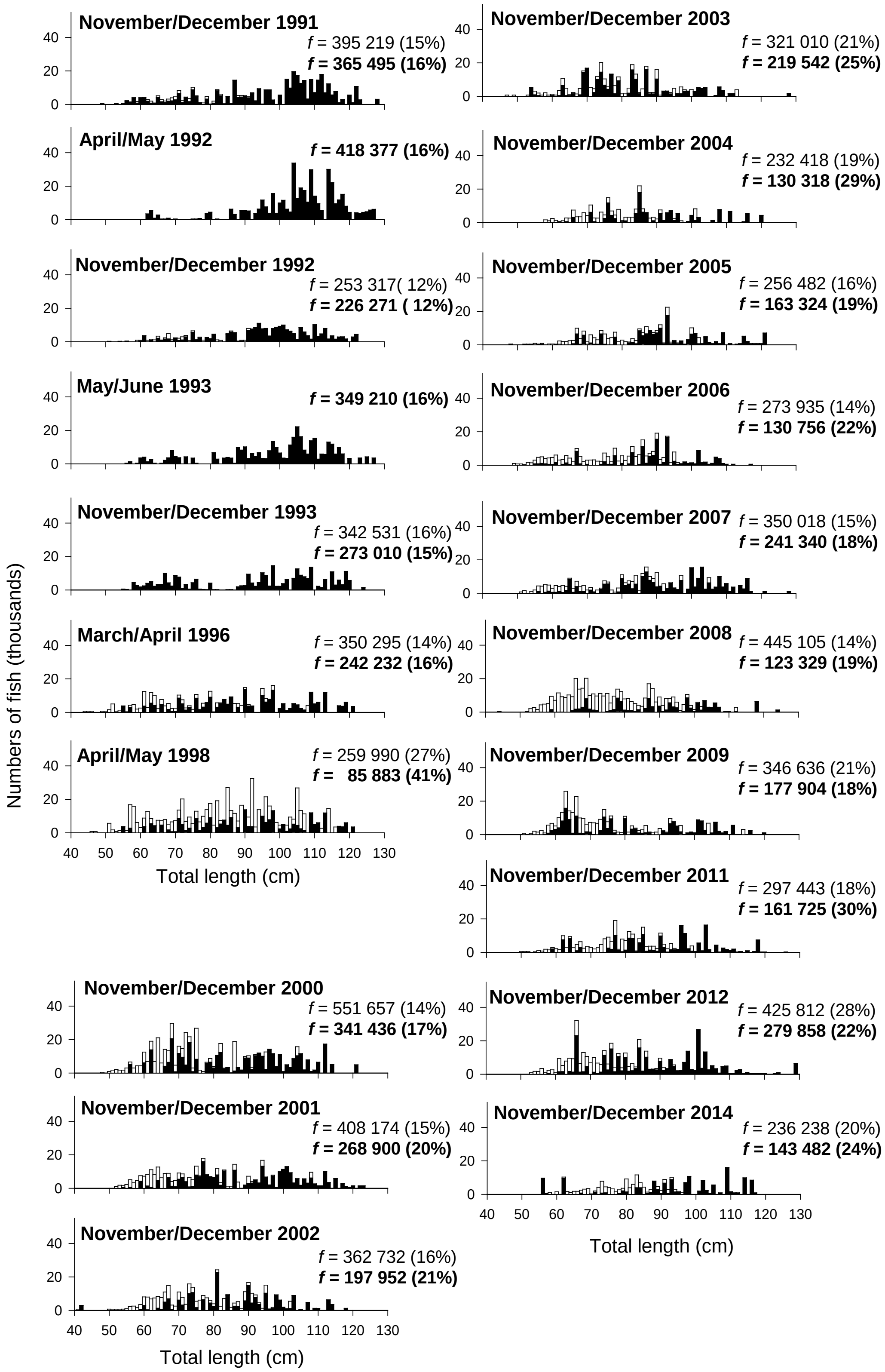


Figure 8b: Scaled length frequency distributions for female hake from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Numbers (f values) above are for all strata and below (in bold) for core strata with CVs in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

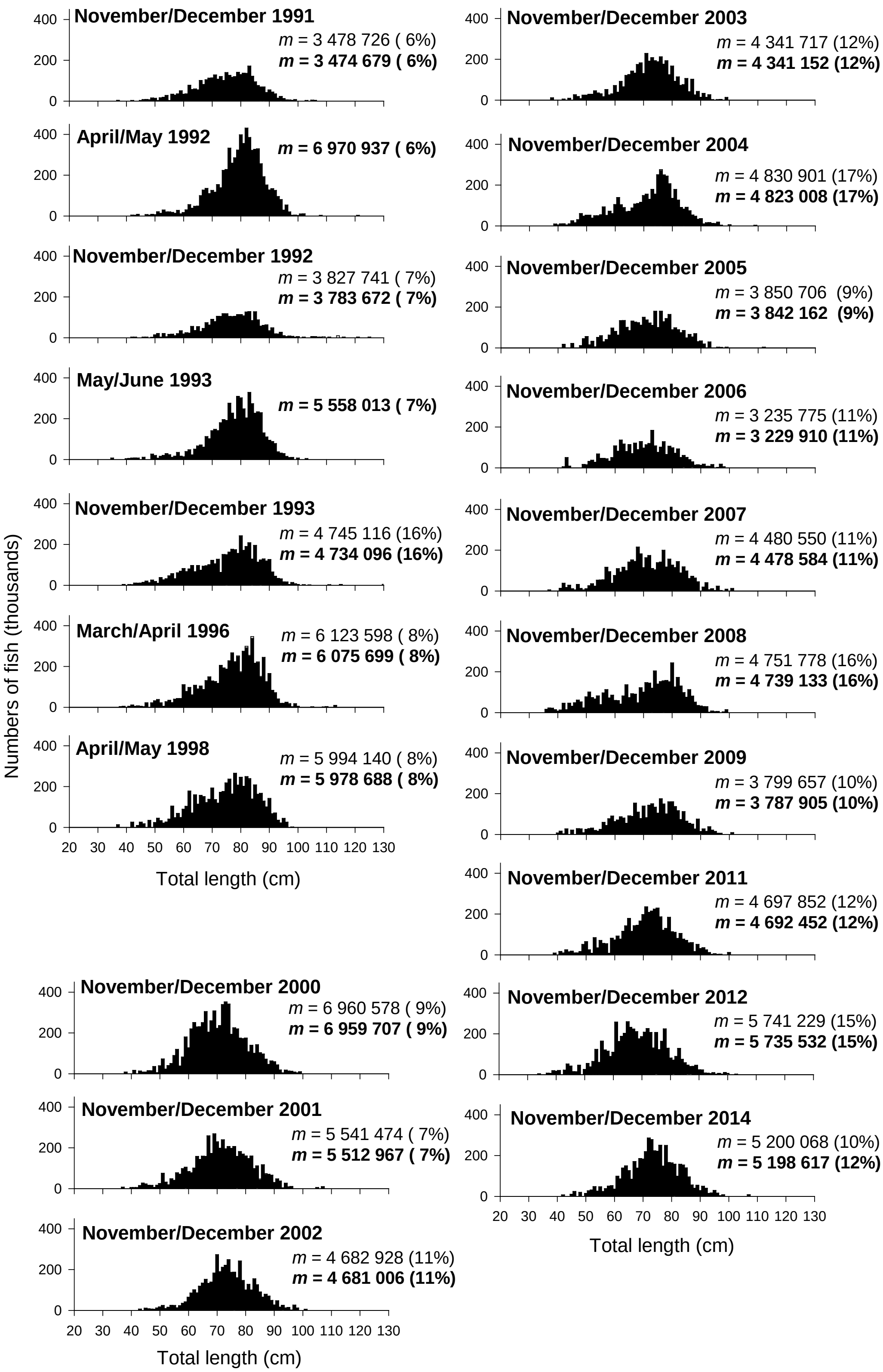


Figure 9a: Scaled length frequency distributions for male ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (m values)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

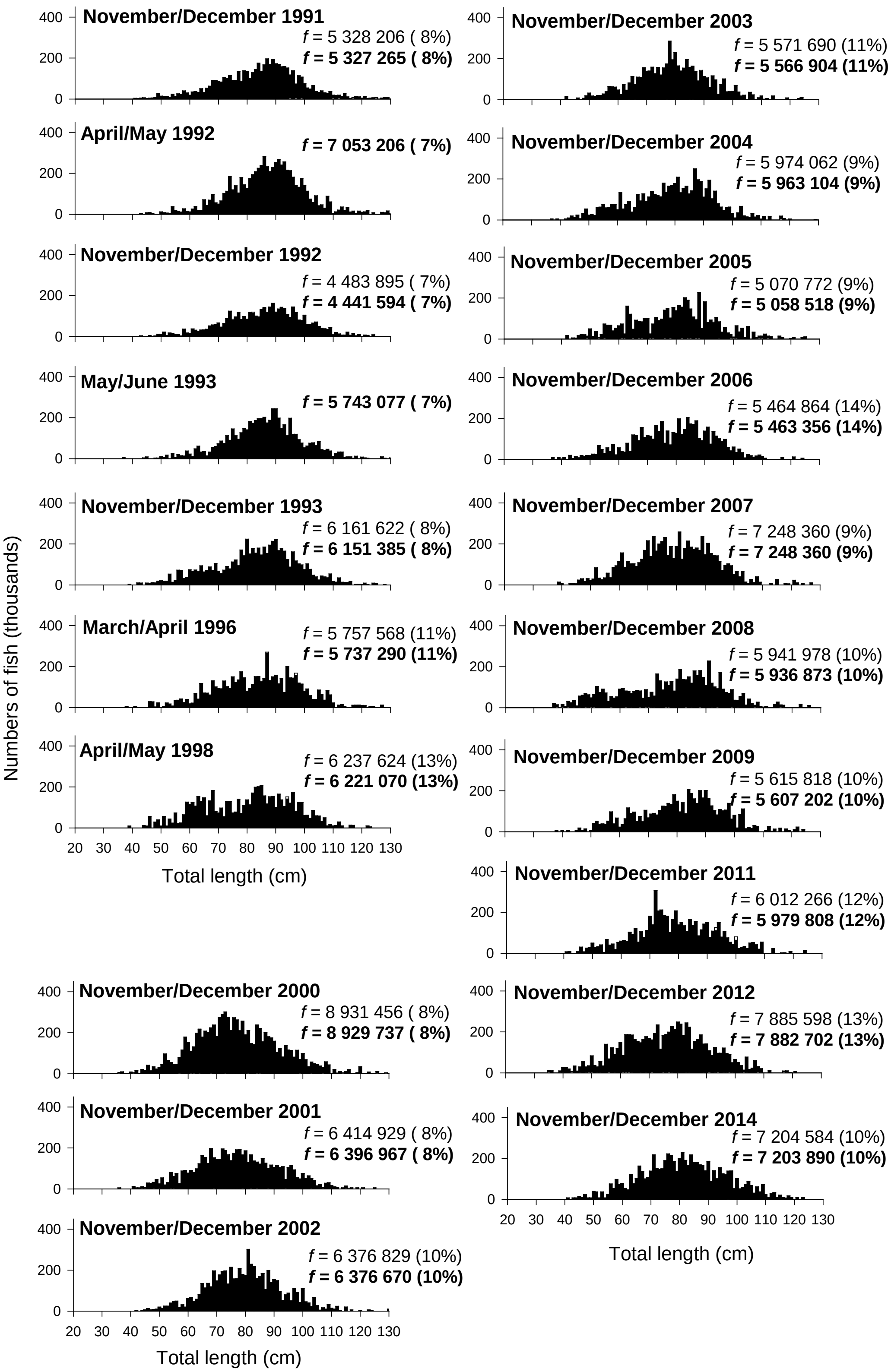


Figure 9b: Scaled length frequency distributions for female ling from all Sub-Antarctic *Tangaroa* trawl surveys. Population numbers for core strata are presented as black bars and for all strata as white bars. Because few ling were caught outside core strata, white bars are very small. Numbers (f values)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

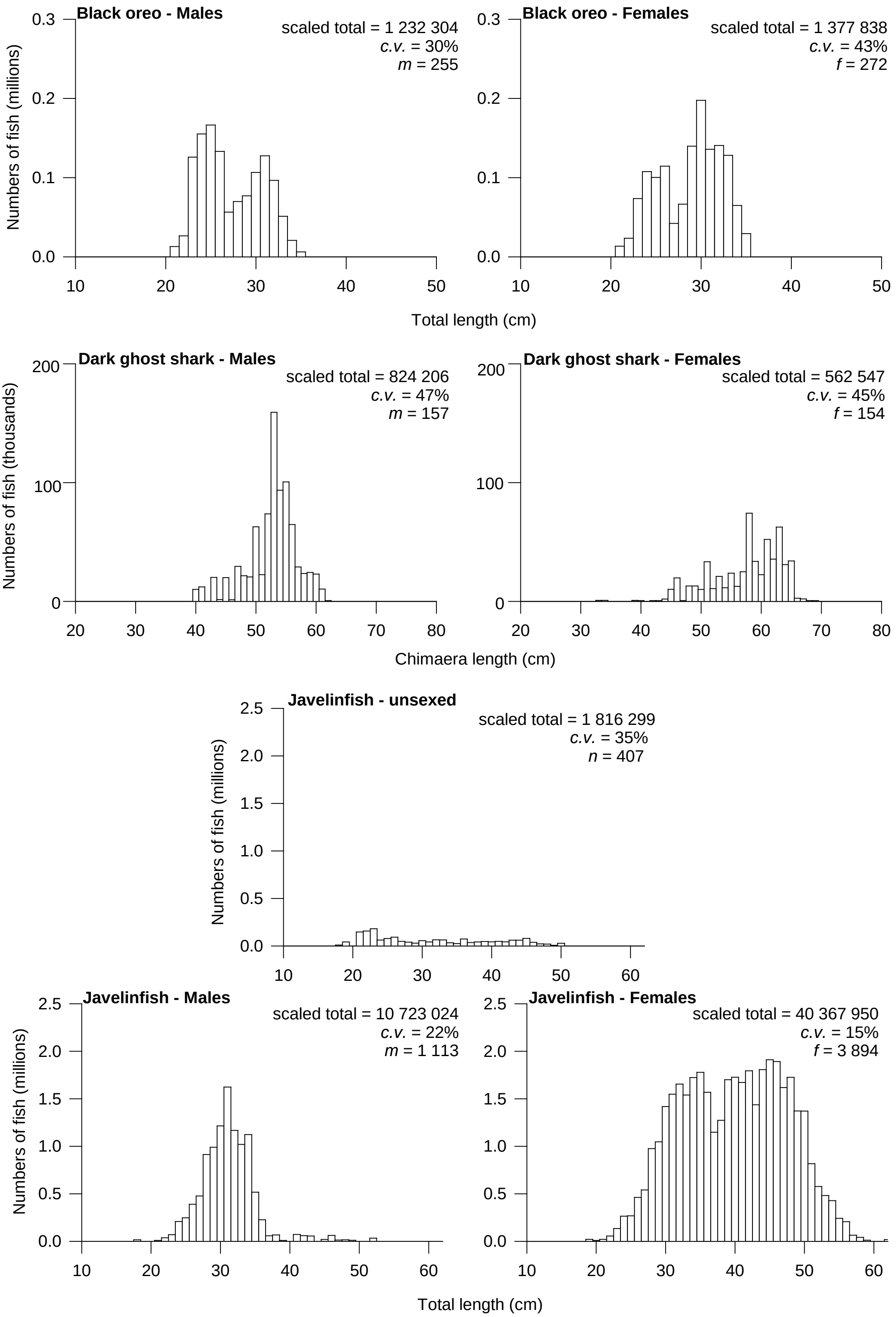


Figure 10: Length frequency distributions by sex of other key species in the November–December 2014 survey. Scaled total is the estimated total number of fish in the surveyed area, CV is the coefficient of variation, m, f, and n values are the number of males, females, and unsexed fish measured.

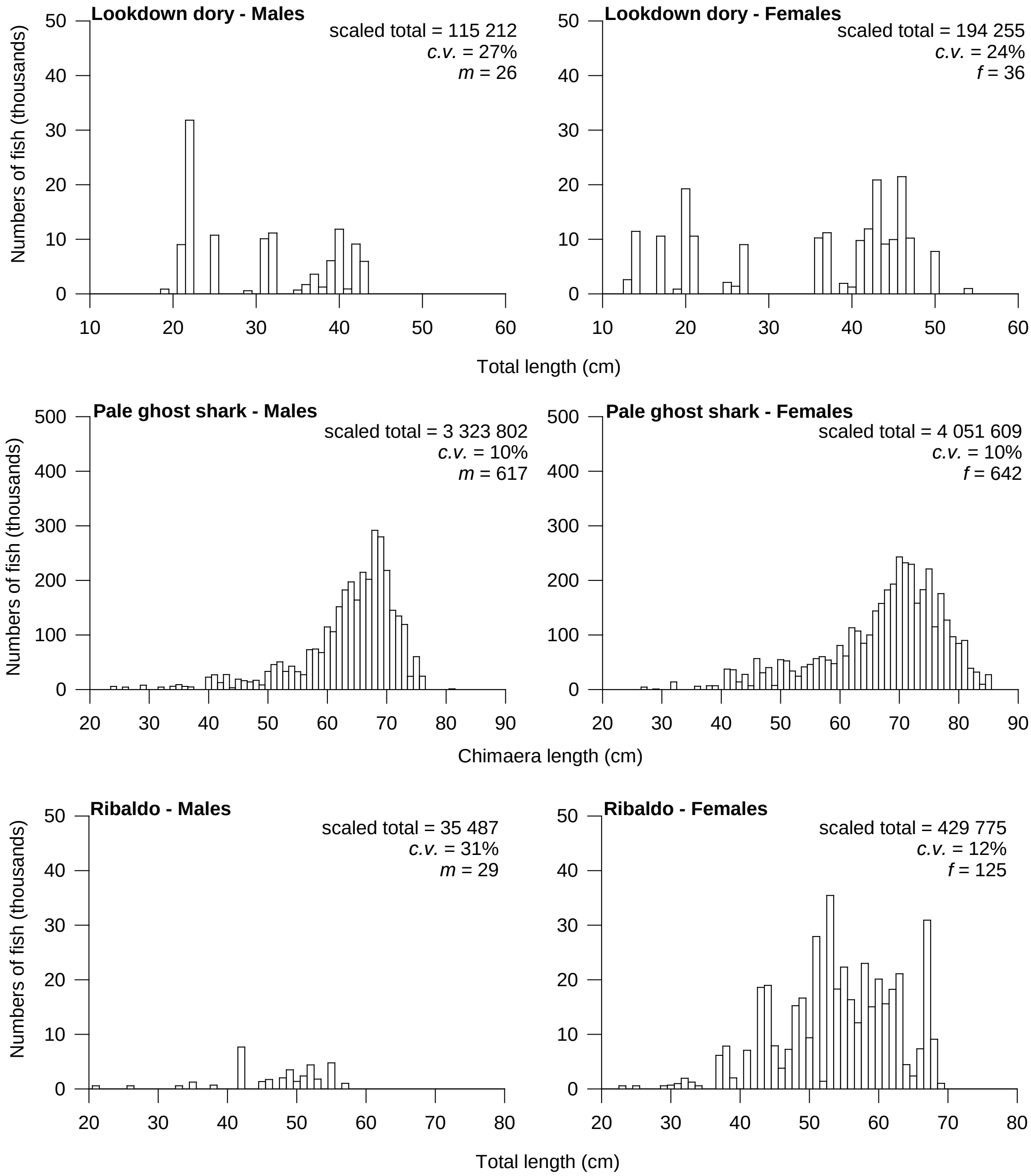


Figure 10 (continued)

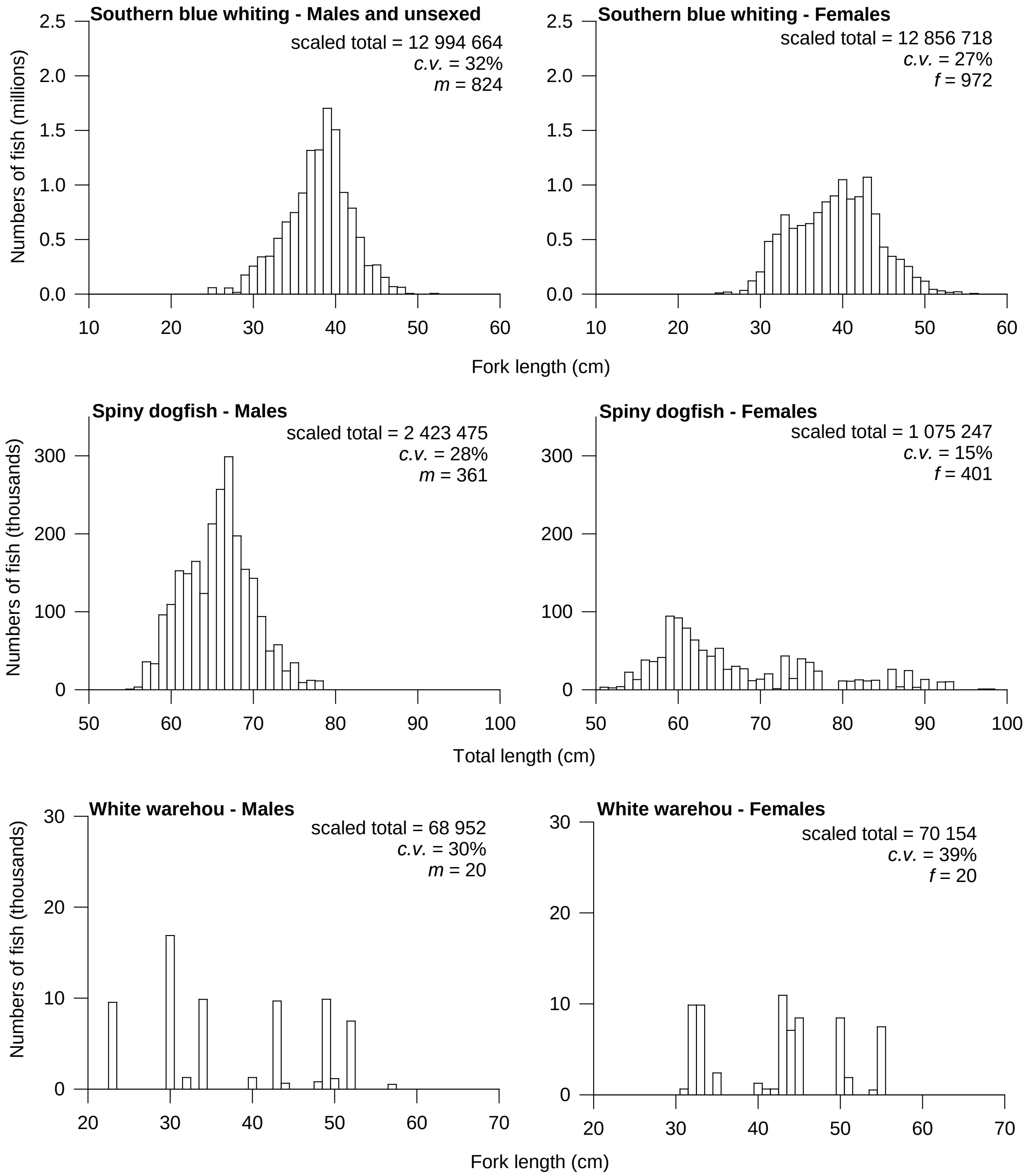


Figure 10 (continued)

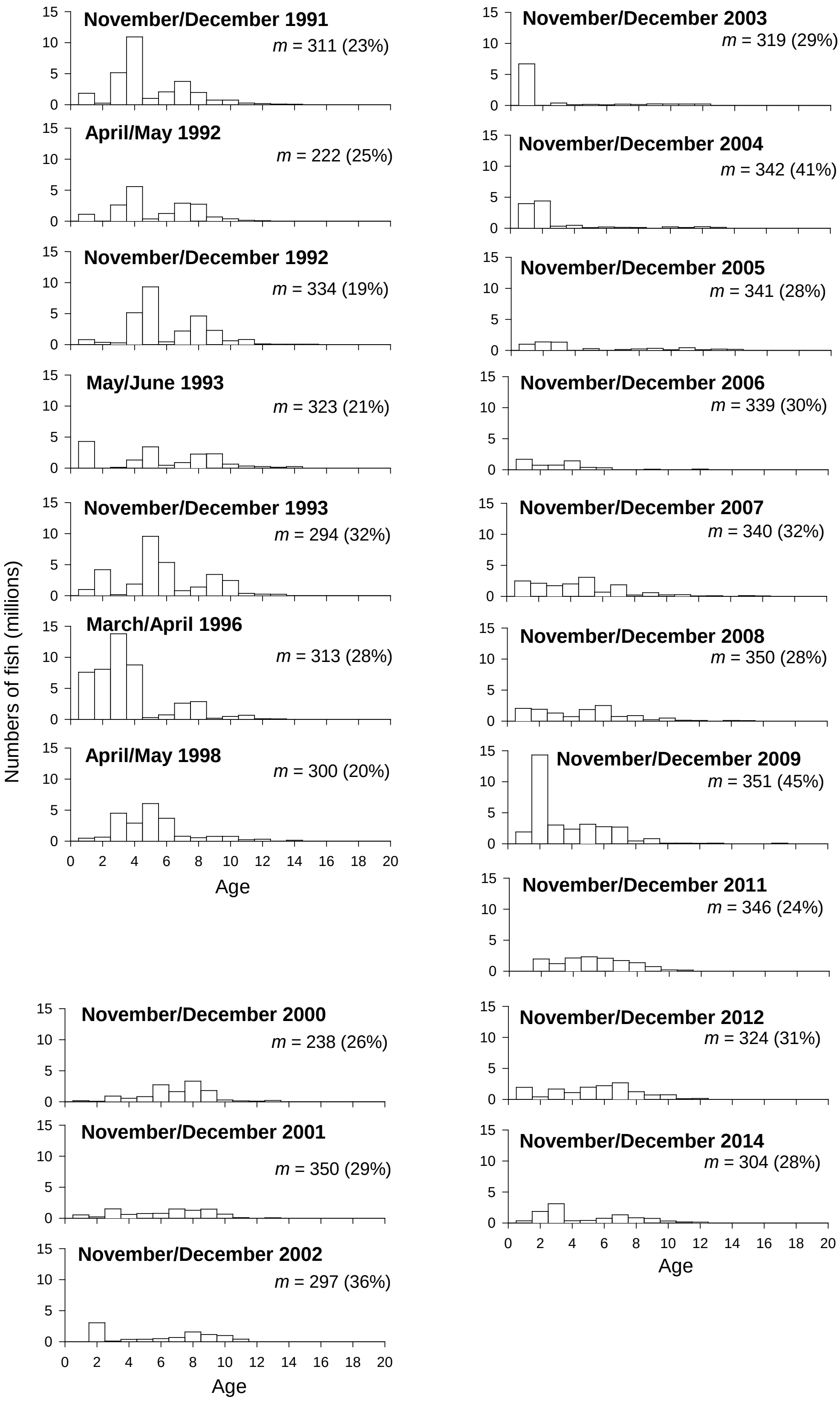


Figure 11a: Scaled age frequency distributions for male hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (m values) are given with CVs in parentheses.

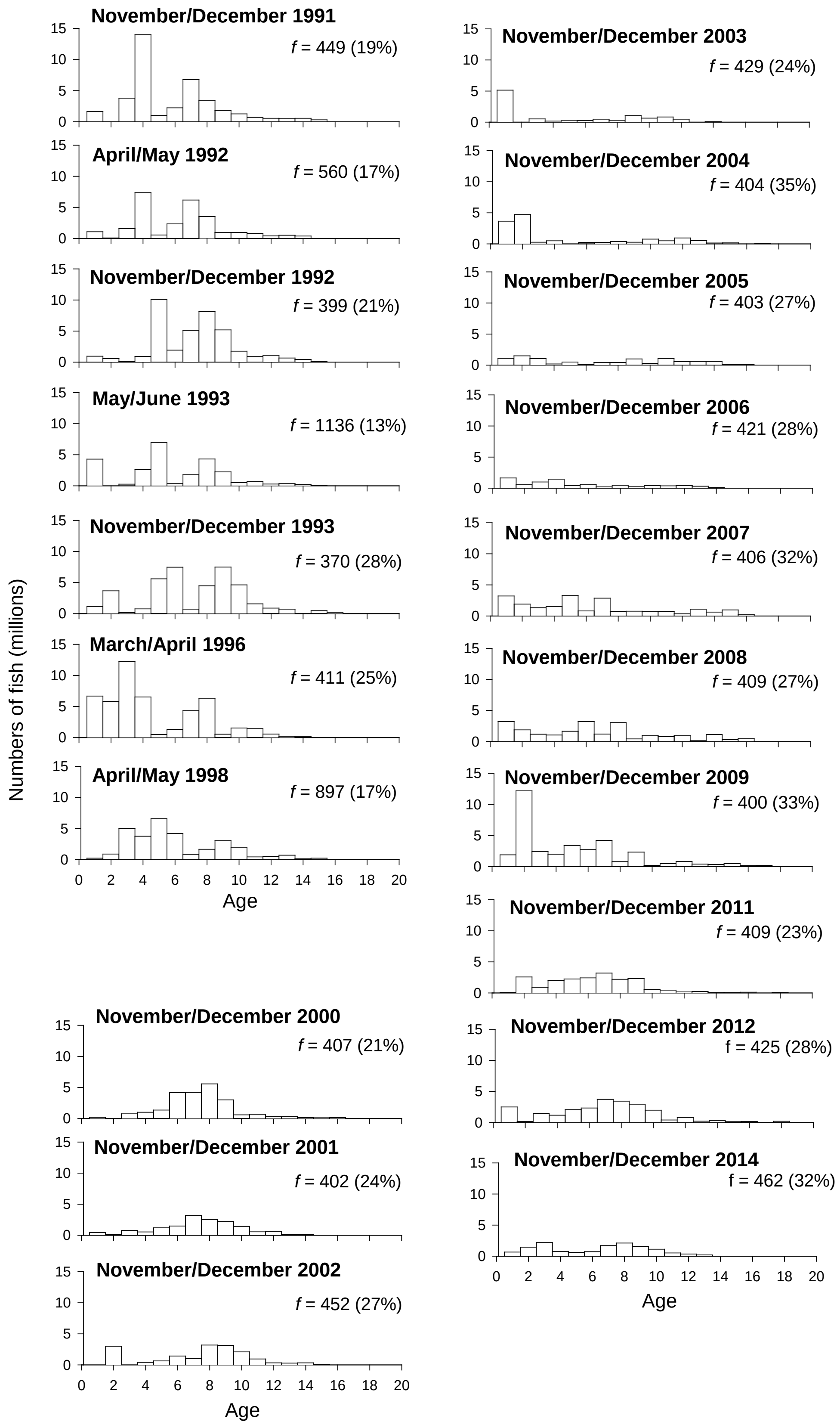


Figure 11b: Scaled age frequency distributions for female hoki from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (f values) are given with CVs in parentheses.

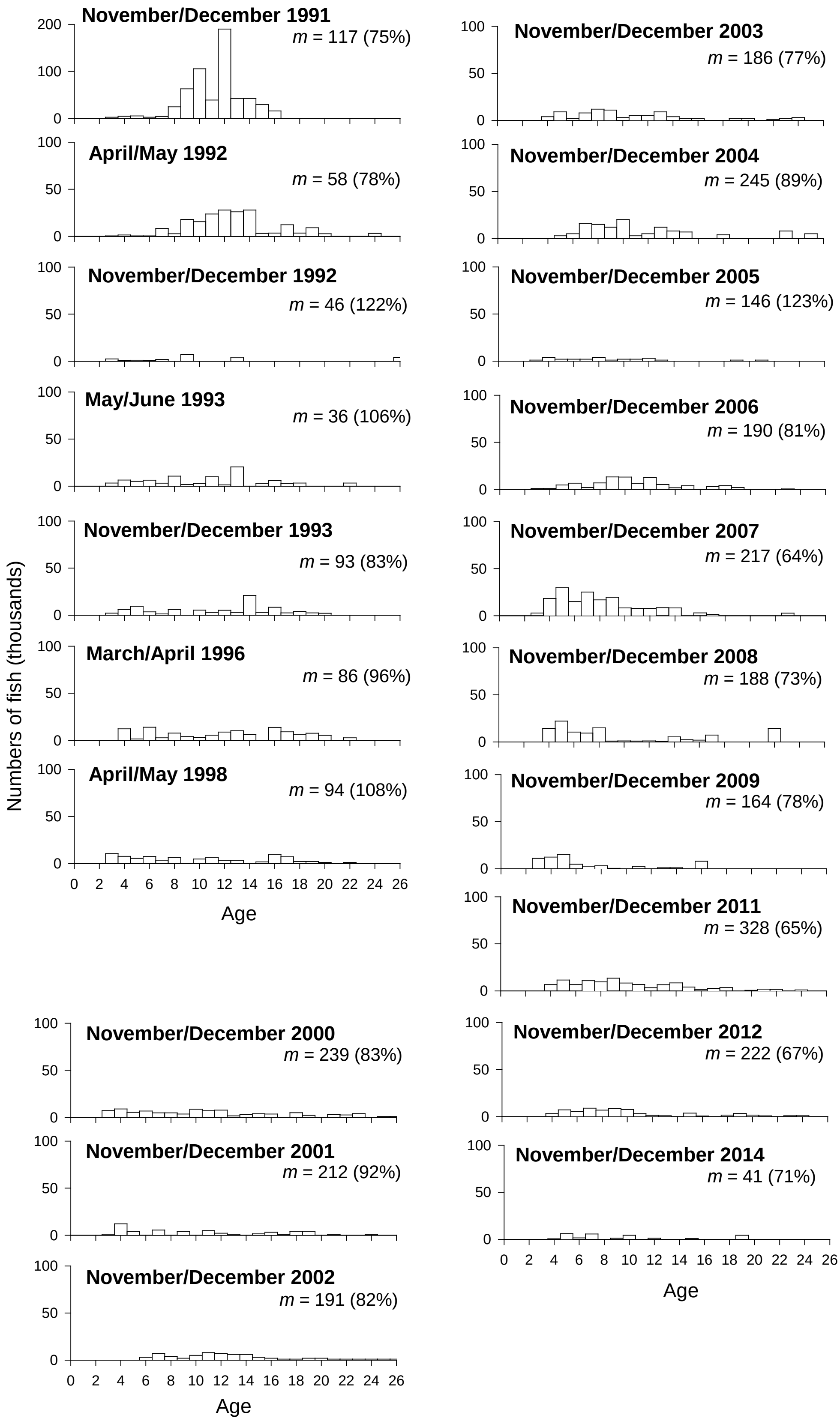


Figure 12a: Scaled age frequency distributions for male hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (m values) are given with CVs in parentheses.

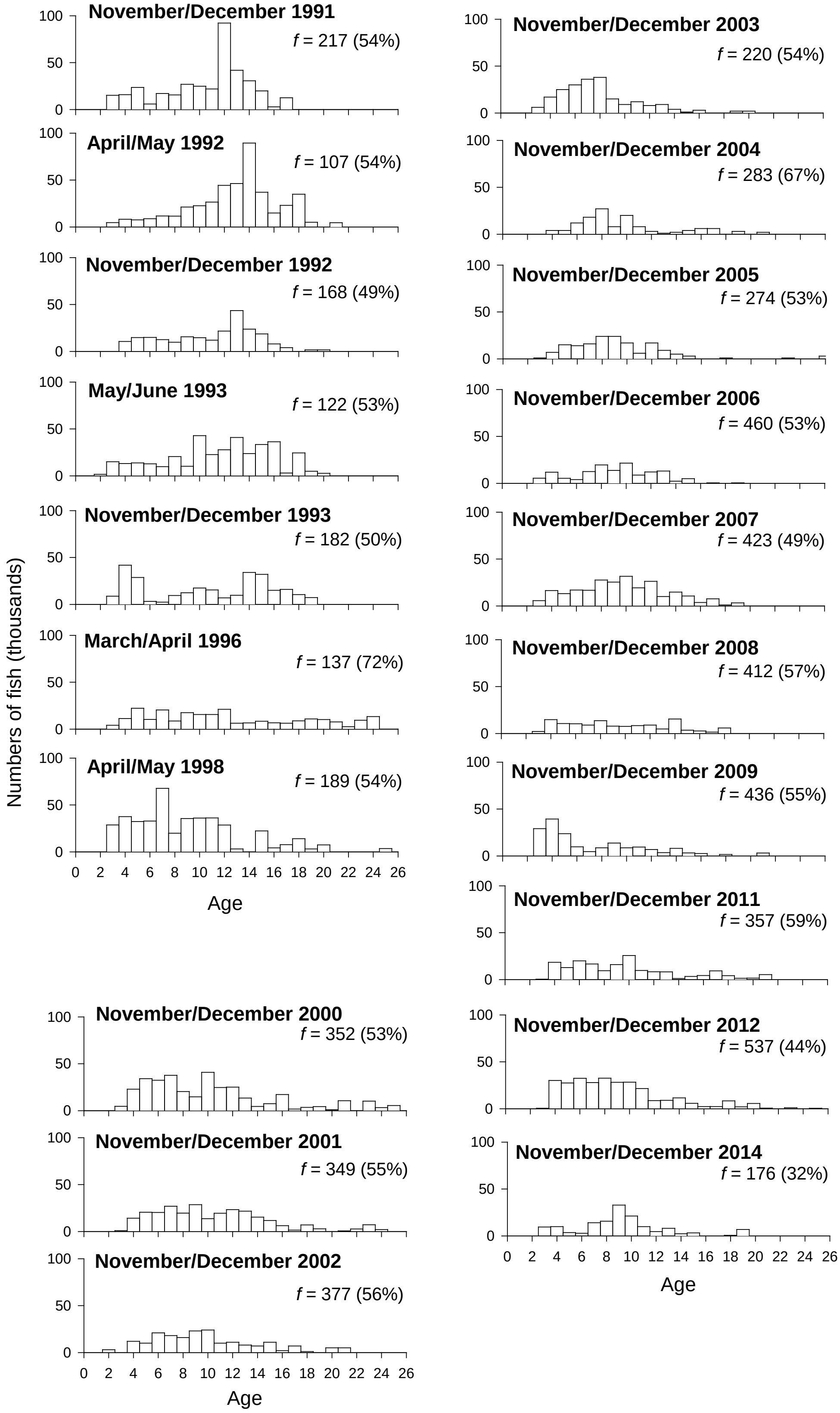


Figure 12b: Scaled age frequency distributions for female hake from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (f values) are given with CVs in parentheses.

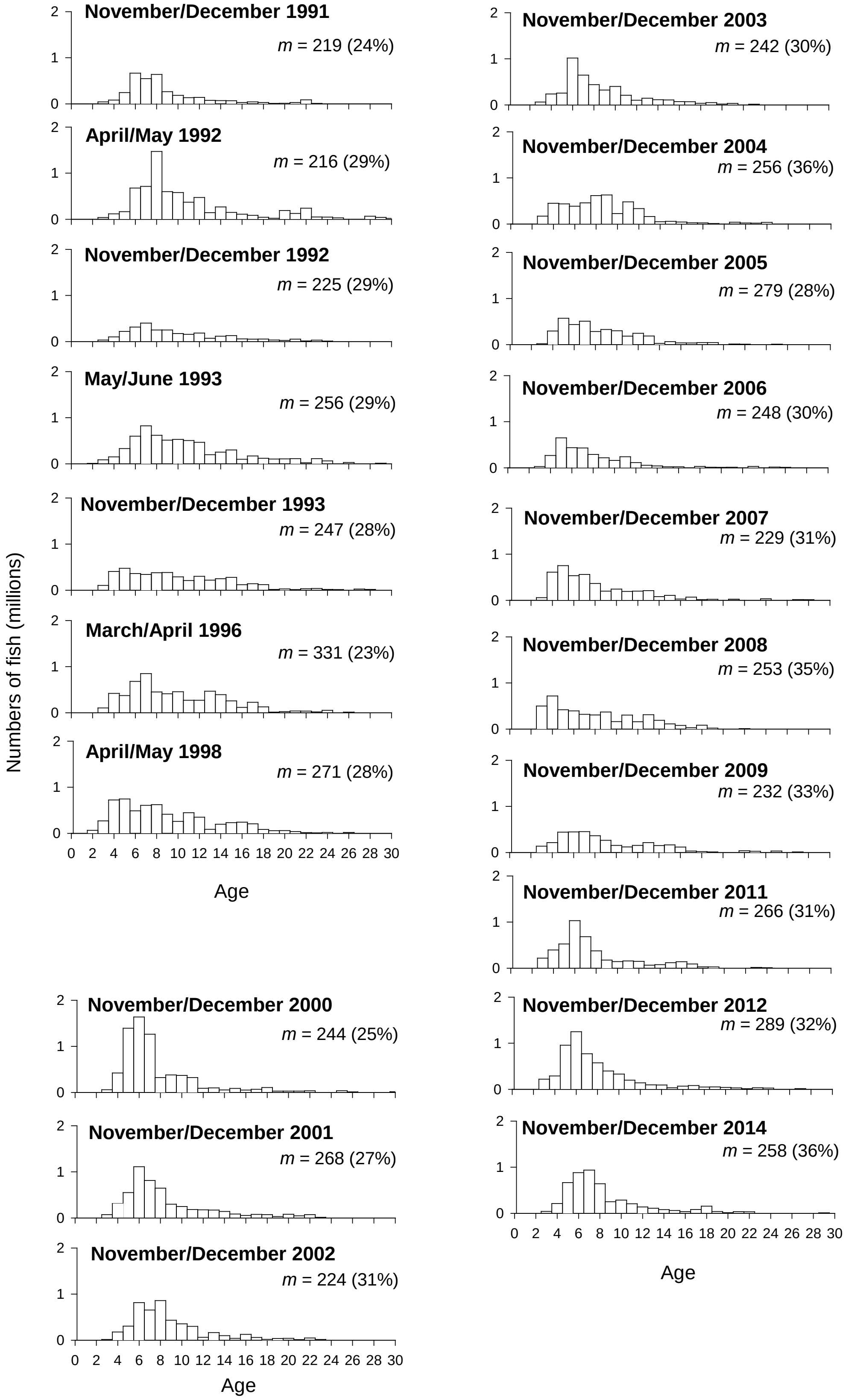


Figure 13a: Scaled age frequency distributions for male ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (m values) are given with CVs in parentheses.

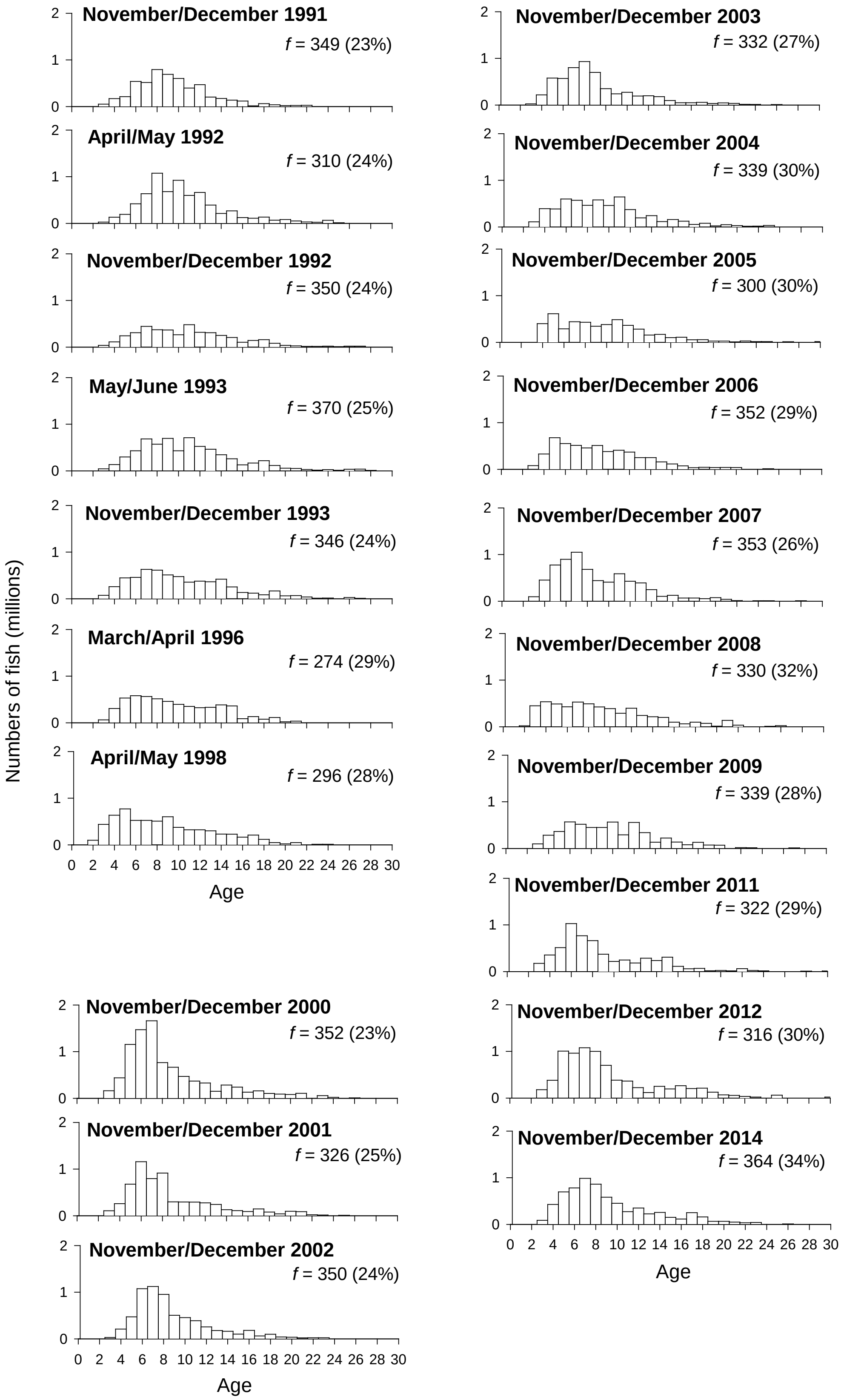


Figure 13b: Scaled age frequency distributions for female ling from all Sub-Antarctic *Tangaroa* trawl surveys for the core 300–800 m survey area. Number of fish aged (f values) are given with CVs in parentheses.

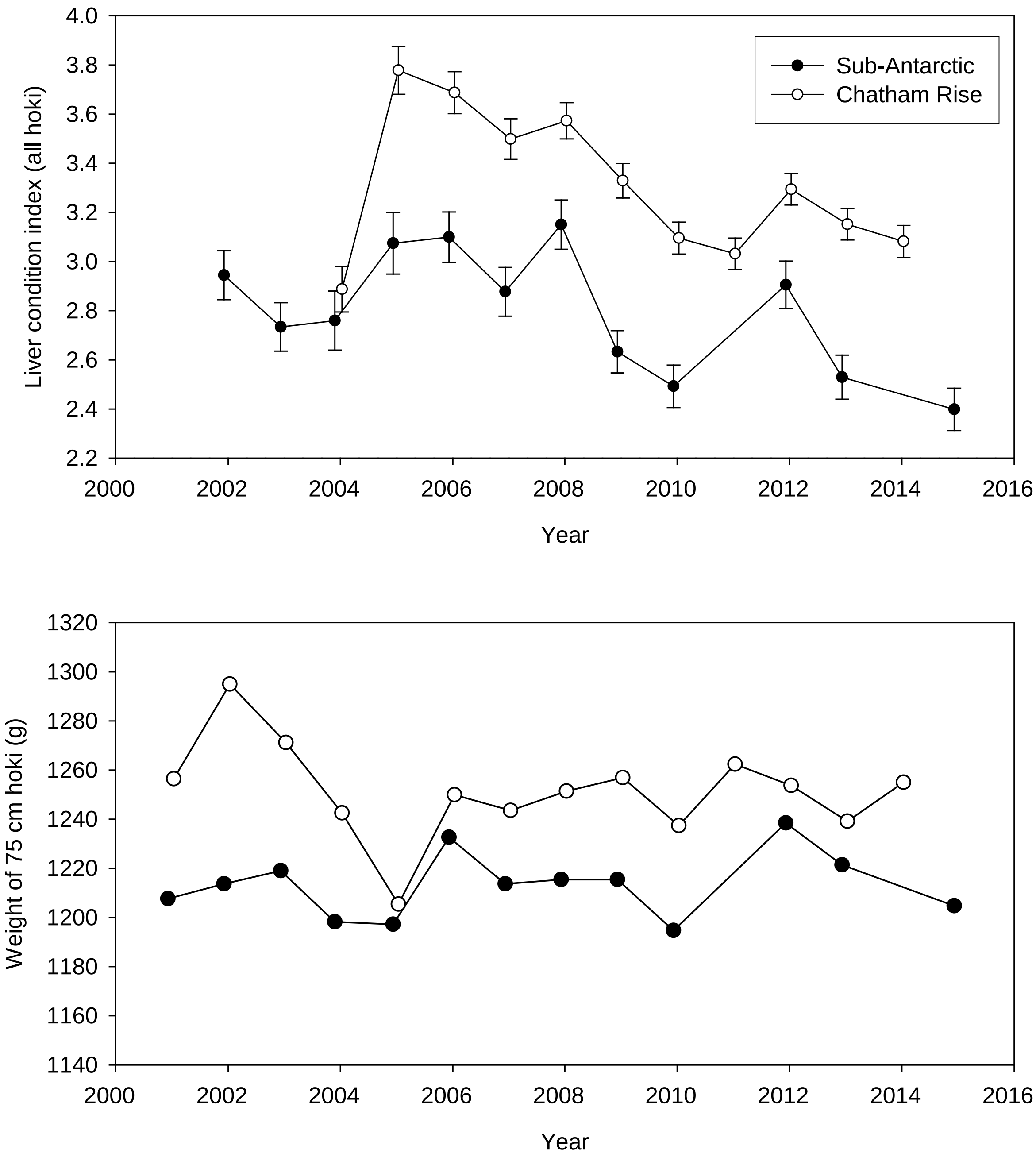


Figure 14: Liver (upper panel) and somatic (lower panel) condition indices of hoki sampled in the Sub-Antarctic summer trawl surveys since 2000. Condition indices are compared with those from the Chatham Rise survey (from Stevens et al. 2015).

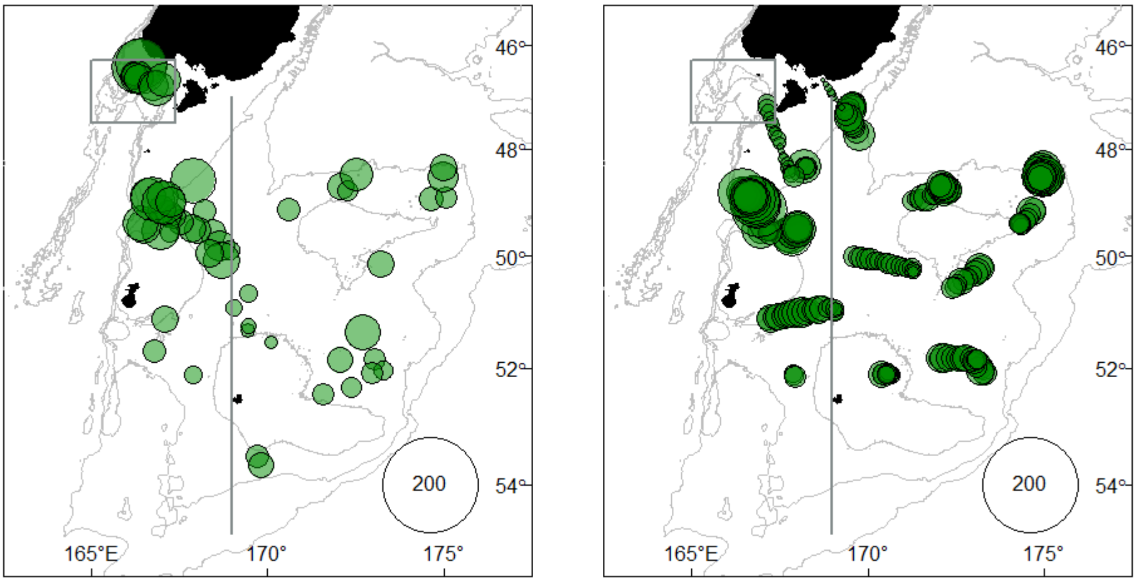


Figure 15: Spatial distribution of total acoustic backscatter (m^2 km^{-2}) in the Sub-Antarctic observed during day trawl stations and night steams. Circle area is proportional to the acoustic backscatter. The vertical line separates the east and west Sub-Antarctic sub-areas, the upper left box represents the Puysegur sub-area.

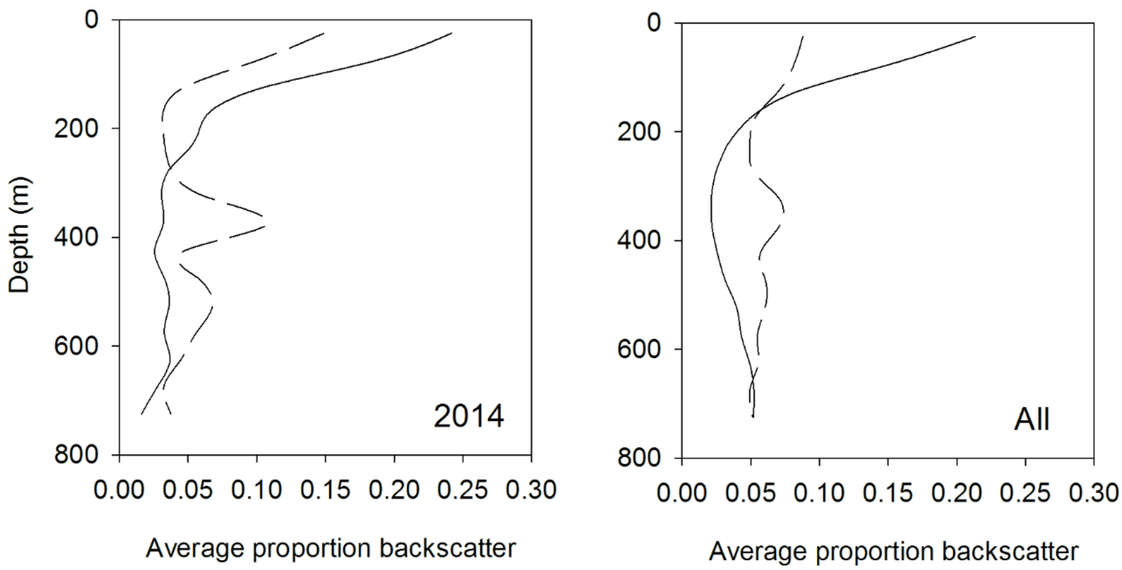


Figure 16: Distribution of total acoustic backscatter integrated in 50 m depth bins on the Sub-Antarctic observed during the day (dashed lines) and at night (solid lines) in 2014 (left panel) and average distribution from 2000–14 (right panel).

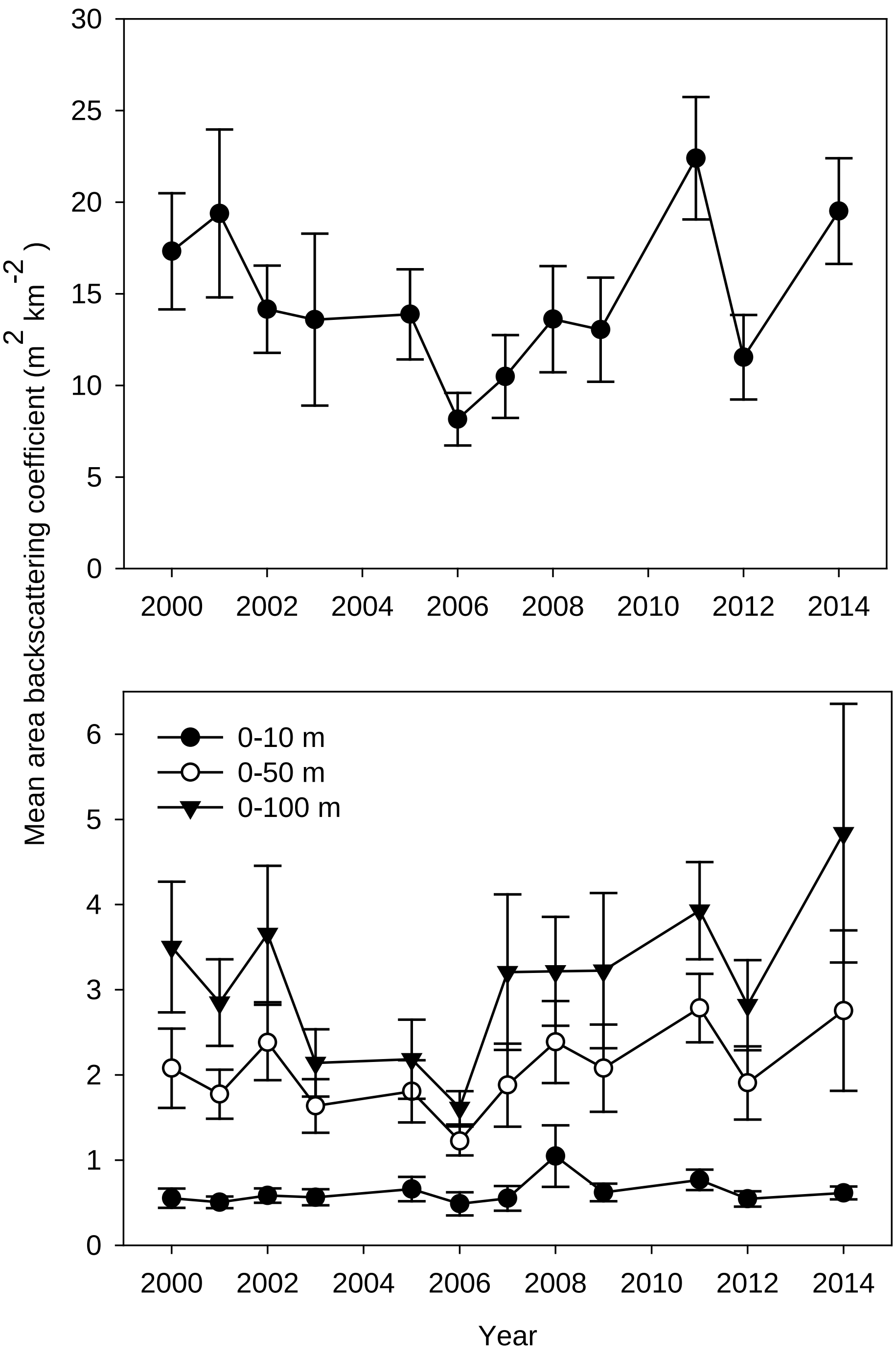


Figure 17: Estimates of total acoustic backscatter (upper panel), and backscatter in the bottom 10, 50, and 100 m (lower panel) from 38 kHz data collected during daytime trawls in 2000–14. Error bars are ± 2 standard errors.

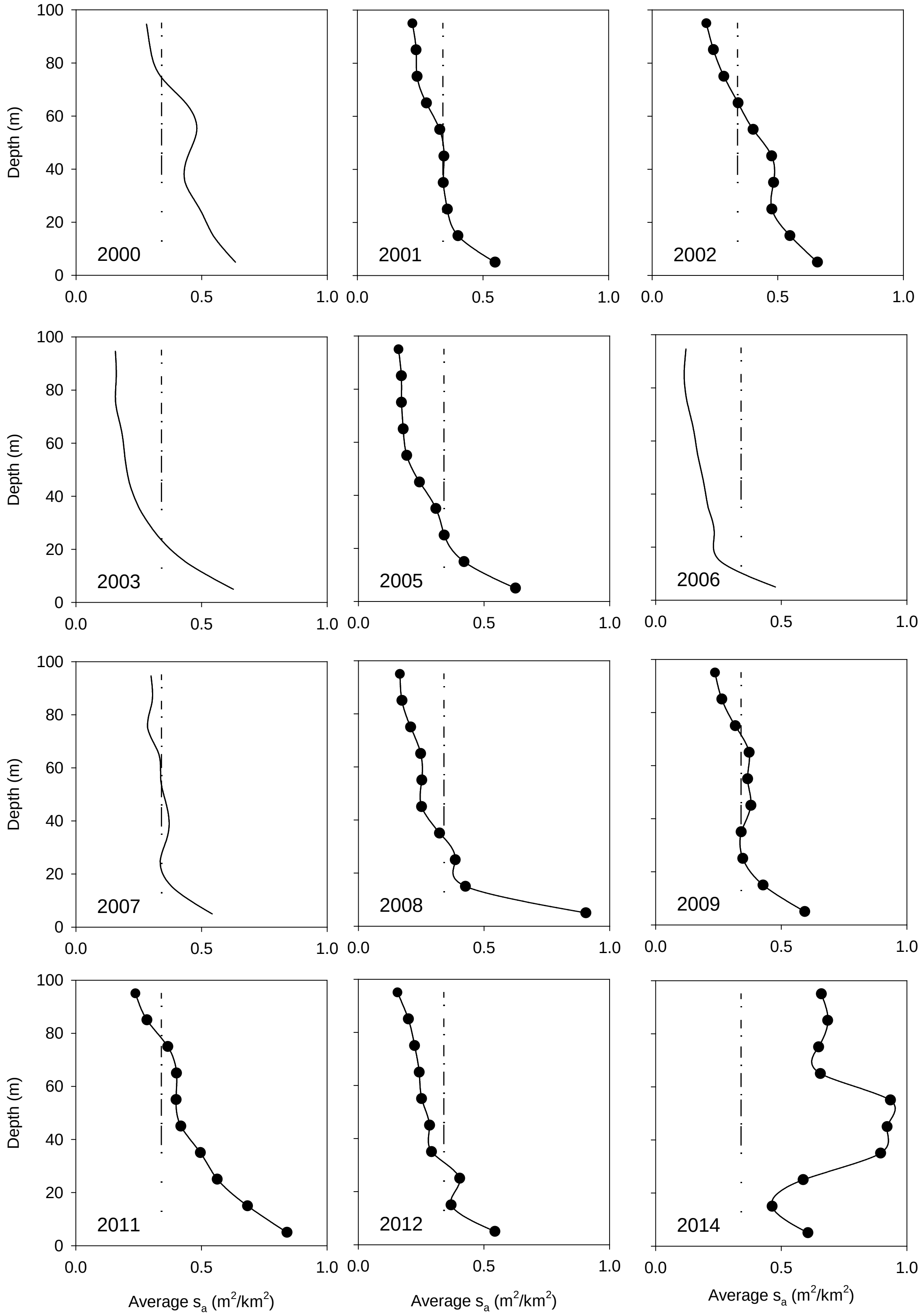


Figure 18: Average vertical profiles of acoustic backscatter within 100 m of the seabed from 38 kHz data collected during daytime trawls in 2000–14. Points show average areal backscattering in 10 m bins relative to the seabed. Dashed vertical line shows mean backscatter level in bottom 100 m across all surveys and is provided as a reference.

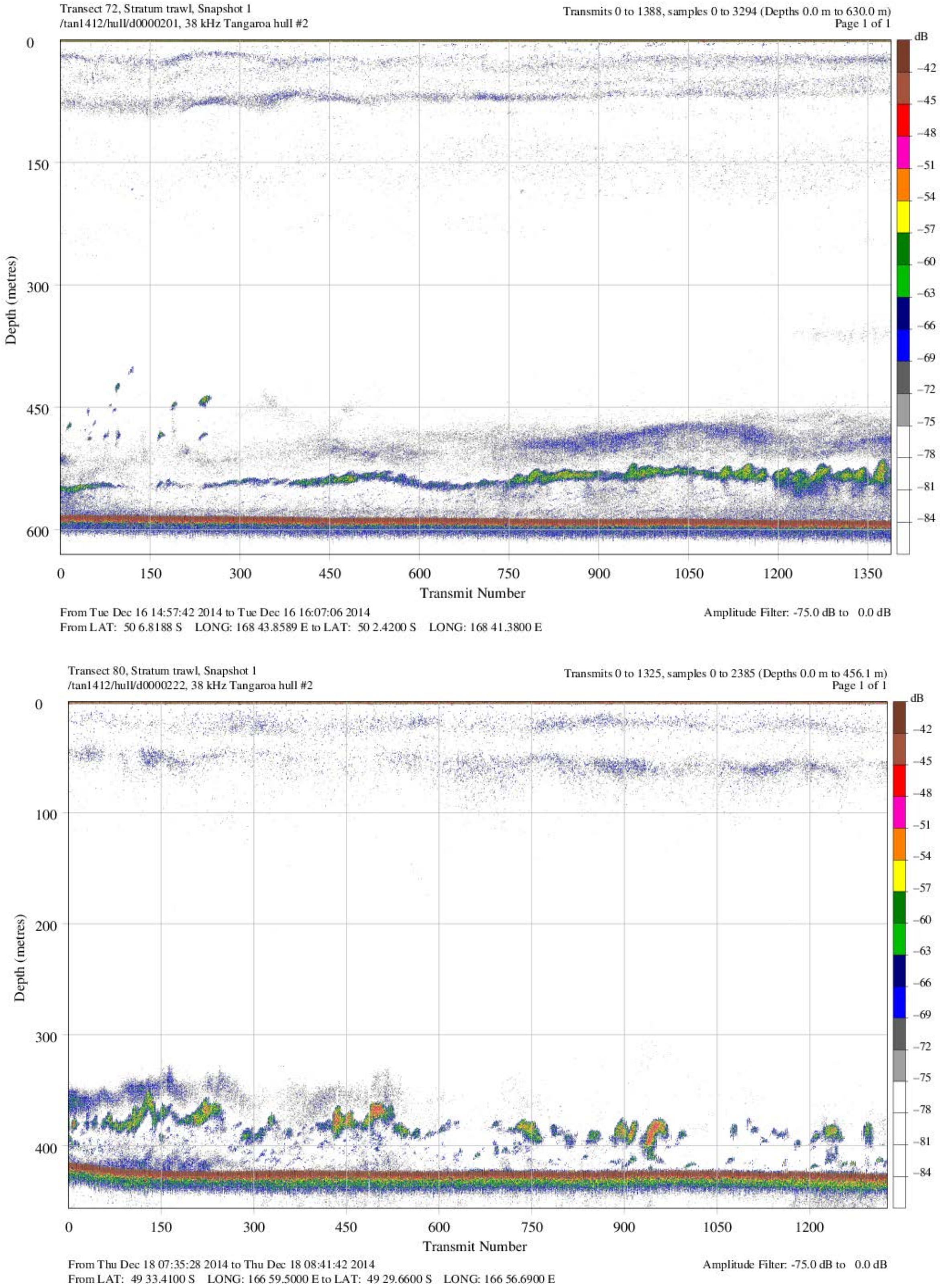


Figure 19: Echograms showing examples of strong backscatter in the bottom 100 m during daytime trawl files. The trawl corresponding to the upper echogram (tow 72) caught 570 kg of mainly hoki (234 kg), while the trawl associated with the lower echogram (tow 80) caught 848 kg including 241 kg of southern blue whiting and 244 kg of hoki.

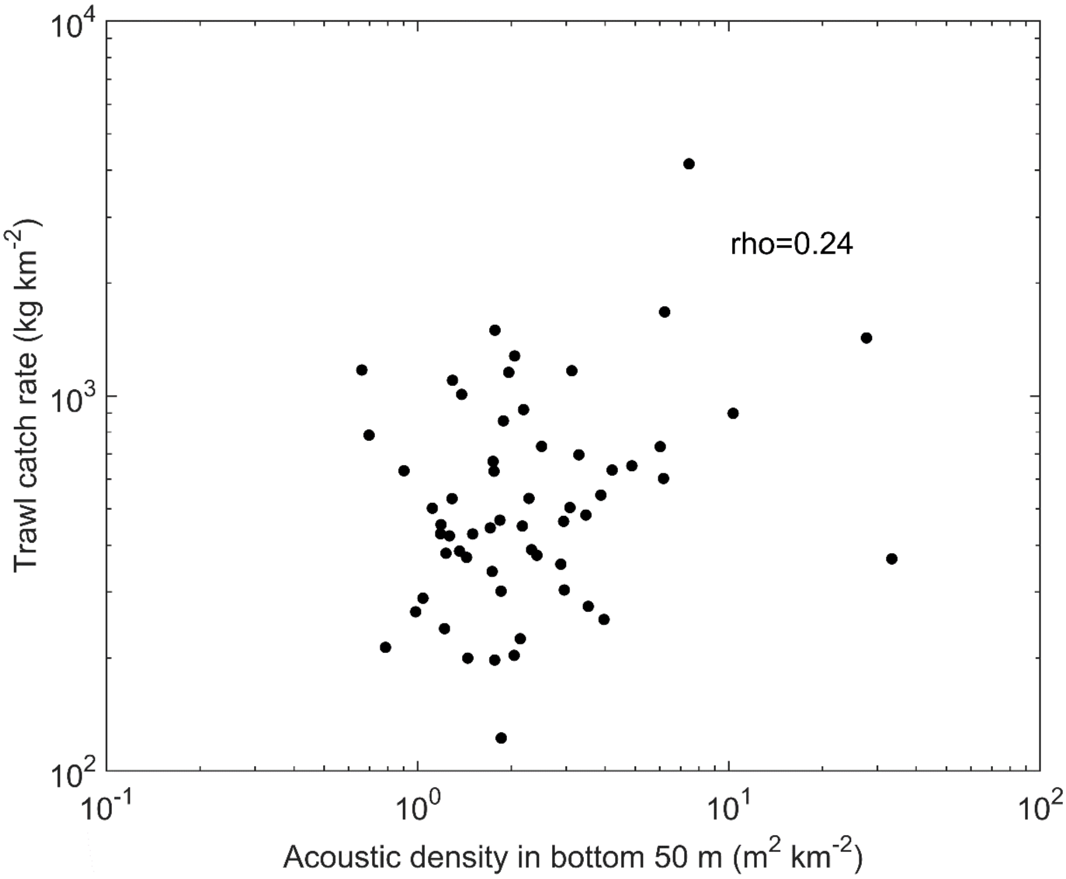


Figure 20: Relationship between total trawl catch rate (all species excluding benthic invertebrates) and acoustic backscatter recorded during the trawl in the Sub-Antarctic in 2014. Rho value is the Spearman's rank correlation coefficient.

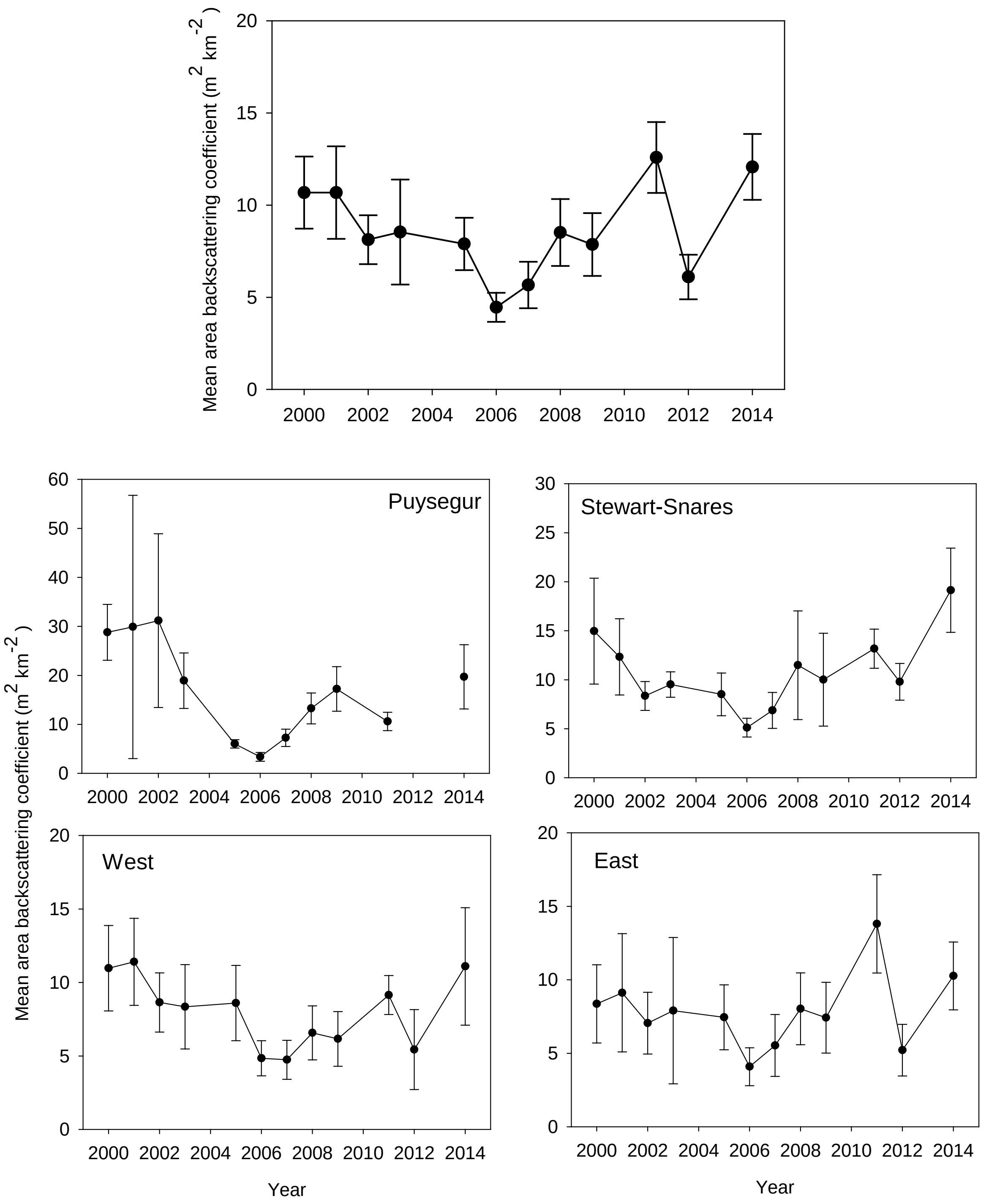


Figure 21: Time series of mesopelagic indices for the Sub-Antarctic (top panel) and by region (lower four panels). Error bars are ± 2 standard errors. Note that the 2012 survey did not produce any data suitable for acoustic analysis from Puysegur.

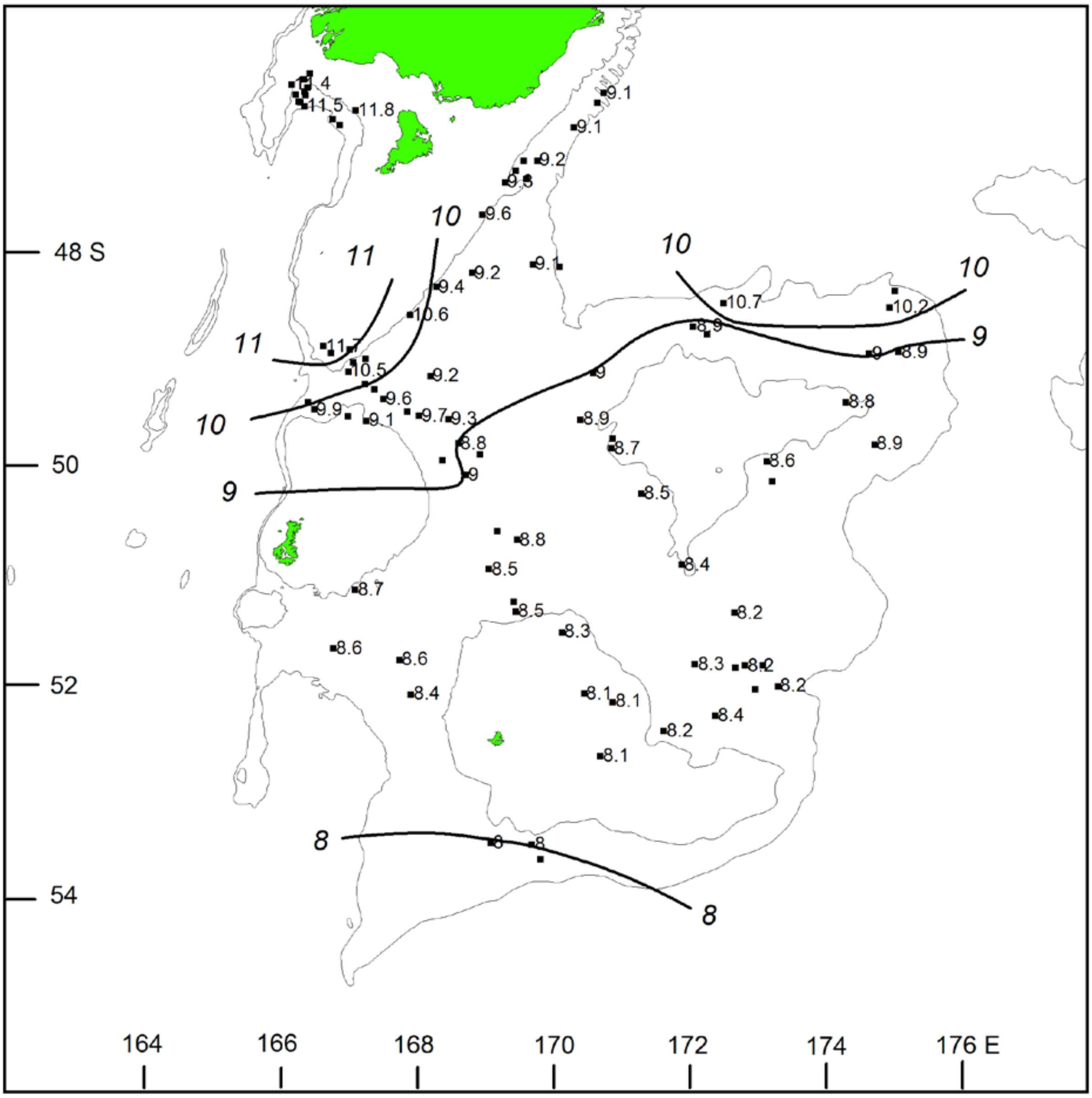


Figure 22: Surface water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

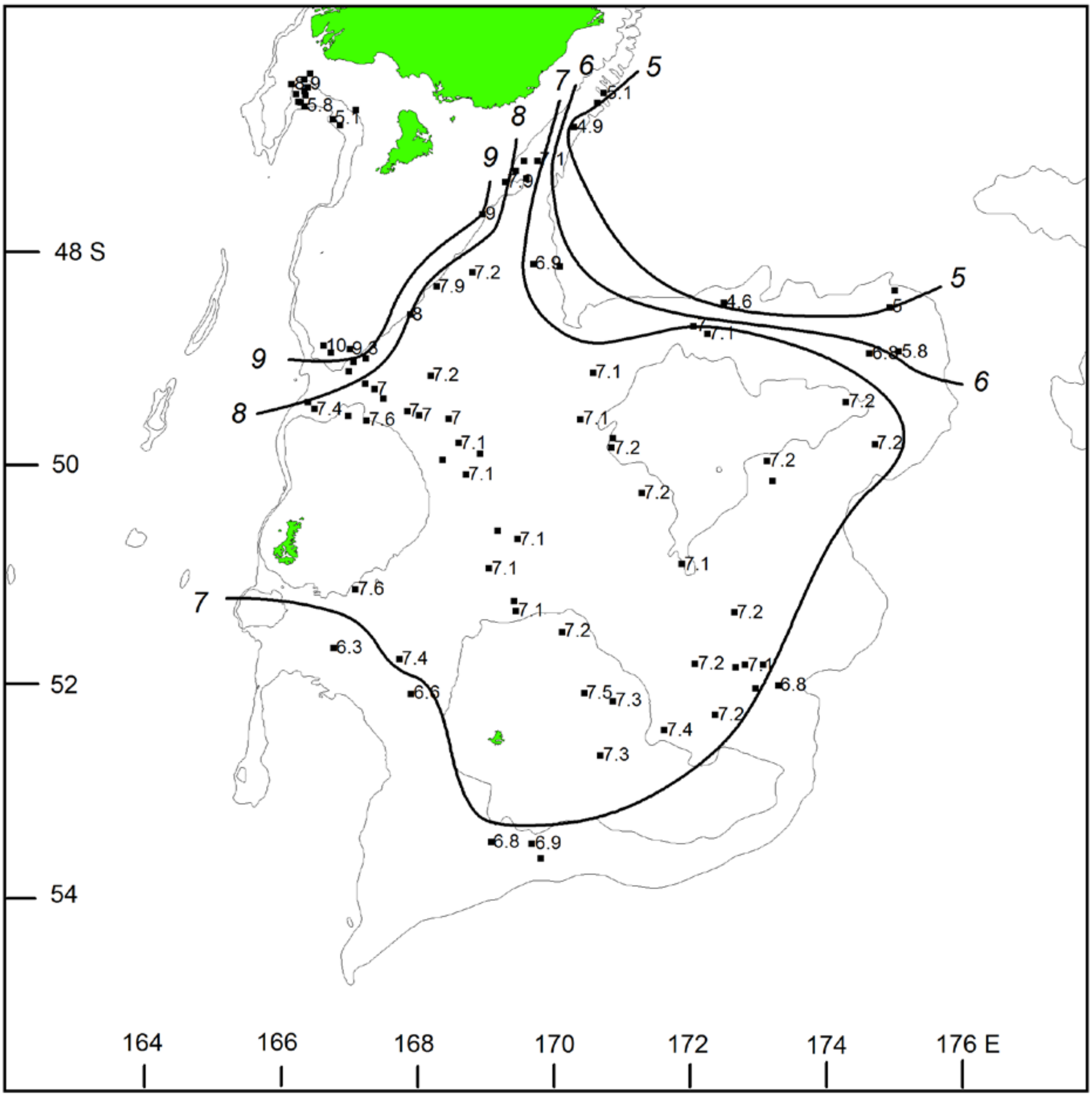
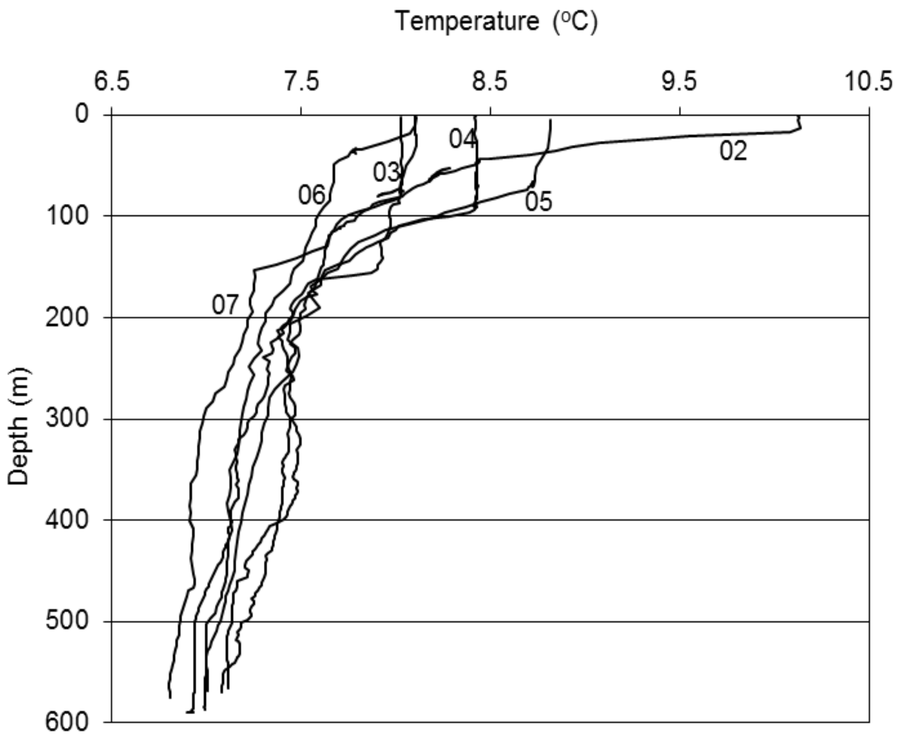


Figure 23: Bottom water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.



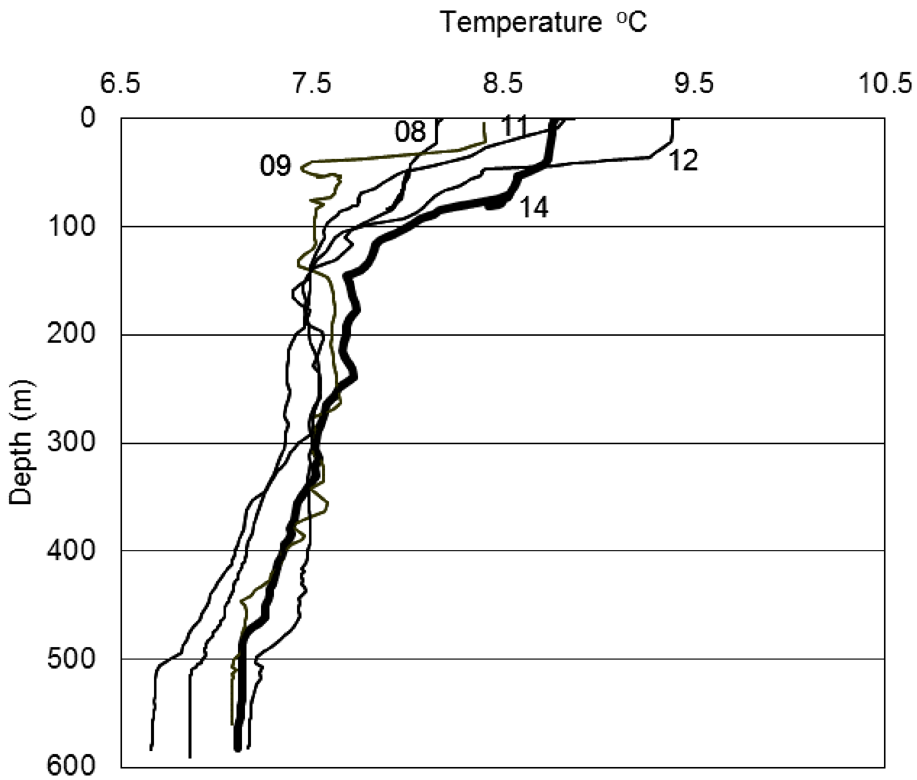


Figure 24: Comparison of vertical profiles of temperature (ºC) from the net-mounted CTD on tows in stratum 9 at approximately 50º 45' S and 169º 00' E in 2002 (TAN0219 station 54, on 6 December), 2003 (TAN0317 station 45, on 29 November), 2004 (TAN0414 station 54, on 14 December), 2005 (TAN0515 station 42, on 6 December), 2006 (TAN0617 station 33, on 5 December), 2007 (TAN0714 station 40 on 7 December) (above), 2008 (TAN0813 station 17, on 30 November), 2009 (TAN0911 station 46, on 9 December) 2011 (TAN1117 station 53, on 9 December) and 2012 (TAN1215 station 69, on 13 December). TAN1215 station 71 on 16 December 2014 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 (n.mi)	Hoki (kg)	Ling (kg)	Hake (kg)
1*	27-Nov-14	trial	44 54.19	172 06.57	0.34			
2	28-Nov-14	0028	46 31.91	170 44.43	2.93	0	0	0
3	28-Nov-14	0028	46 37.38	170 38.81	3.00	4.1	0	3.0
4	28-Nov-14	0028	46 50.96	170 18.33	3.02	7.4	0	0
5	28-Nov-14	0004	47 09.73	169 46.10	3.00	16.9	49.6	0
6	29-Nov-14	003A	47 09.89	169 33.72	3.04	8.9	66.2	0
7	29-Nov-14	003A	47 19.82	169 35.81	3.00	30.1	84.9	0
8	29-Nov-14	003A	47 15.42	169 26.94	2.67	18.0	158.6	0
9	29-Nov-14	003A	47 21.68	169 17.64	3.00	34.8	105.4	0
10	29-Nov-14	003A	47 39.69	168 57.54	2.46	32.4	57.4	0
11	30-Nov-14	0004	48 20.14	168 16.95	3.03	54	252.6	0
12	30-Nov-14	0004	48 12.31	168 48.60	3.01	36	35.4	0
13	30-Nov-14	0004	48 07.53	169 42.10	3.01	91.2	16.5	0
14	30-Nov-14	0028	48 08.96	170 05.36	2.85	0	0	0
15	4-Dec-14	0001	46 26.96	166 08.76	3.08	132.2	124.1	0
16	4-Dec-14	0001	46 24.19.	166 19.67	3.02	141.7	52.6	4.8
17	4-Dec-14	0001	46 20.87	166 25.20	3.00	107.7	46.6	0
18*	4-Dec-14	0001	46 28.81	166 22.81	2.49	70.3	104.4	32.2
19	4-Dec-14	0002	46 33.29	166 21.03	3.02	156.5	17.1	10.5
20	4-Dec-14	0002	46 30.94	166 20.29	2.53	65.1	137.2	58.0
21	4-Dec-14	0025	46 37.11	166 16.60	3.01	374.3	8.4	93.8
22	5-Dec-14	0002	46 32.75	166 12.64	3.03	73.9	121.2	5.7
23	5-Dec-14	0002	46 36.72	166 15.05	3.01	217.0	15.6	34.5
24	5-Dec-14	0025	46 39.18	166 20.44	3.01	12.2	0	264.8
25	5-Dec-14	0025	46 46.40	166 45.16	2.45	66.1	0	50.2
26	5-Dec-14	0025	46 49.89	166 51.59	2.10	0	0	75.3
27	5-Dec-14	0001	46 41.41	167 05.58	2.97	84.5	178.1	0
28	6-Dec-14	003A	48 35.72	167 53.60	3.04	29.3	154.0	10.8
29	6-Dec-14	0008	49 10.02	168 11.61	3.00	75.3	93.9	26.4
30	6-Dec-14	0008	49 34.12	168 27.63	3.01	85.7	121.6	7.5
31	6-Dec-14	0008	49 47.54	168 36.38	3.04	90.7	156.2	5.7
32	6-Dec-14	0008	49 53.42	168 55.21	3.02	78.5	67.6	0
33	7-Dec-14	0012	50 15.40	171 17.93	3.04	18.7	92.9	0
34	7-Dec-14	0012	49 50.20	170 51.15	3.01	76.6	91.2	0
35	7-Dec-14	0012	49 45.01	170 52.43	3.07	59.4	123.9	0
36	7-Dec-14	0012	49 34.30	170 23.90	3.13	158.1	62.2	0
37	7-Dec-14	0011	49 08.26	170 35.33	3.05	222.1	48.6	0
38	8-Dec-14	0011	48 42.34	172 03.48	3.01	40.3	36.9	0
39	8-Dec-14	0011	48 46.60	172 15.67	3.00	106.4	54.4	10.5
40	8-Dec-14	0011	48 57.43	174 38.81	3.02	181.8	66.8	0
41	8-Dec-14	0011	48 56.41	175 04.78	3.01	67.2	71.3	0
42	9-Dec-14	0012	49 24.60	174 18.11	3.03	36.1	92.5	0
43	9-Dec-14	0011	49 48.26	174 43.56	3.00	30.4	15.4	0
44	9-Dec-14	0012	49 57.55	173 08.47	3.01	149.5	73.3	0
45	9-Dec-14	0012	50 08.77	173 13.43	3.00	31.9	56.9	0
46	10-Dec-14	0013	50 55.10	171 53.44	3.02	59.2	187.2	0
47	10-Dec-14	0013	51 22.12	172 39.87	2.99	178.5	48.4	0
48	10-Dec-14	0013	51 51.34	172 49.15	3.01	10.4	69.7	0
49	10-Dec-14	0013	51 52.83	172 40.93	3.04	19.6	29.6	10.6
50	10-Dec-14	0013	51 50.94	172 04.79	3.01	41.1	57.9	0

Appendix 1 (continued)

Station number	Date	Stratum	Start lat. (º ‘S)	Start long. (º ‘E)	Distance (n.mi)	Hoki (kg)	Ling (kg)	Hake (kg)
51	11-Dec-14	0015	51 51.57	173 04.84	3.03	9.0	82.2	0
52	11-Dec-14	0015	52 03.15	173 18.38	3.01	5.3	22.4	0
53	11-Dec-14	0015	52 04.78	172 58.14	2.99	7.7	24.5	0
54	11-Dec-14	0014	52 19.52	172 22.65	3.00	0	13.8	30.2
55	11-Dec-14	0014	52 28.04	171 37.50	3.02	15.8	56.4	0
56	12-Dec-14	0010	53 30.55	169 04.86	3.02	53.9	0	0
57	12-Dec-14	0010	53 31.60	169 41.01	3.01	345.2	50.7	0
58	12-Dec-14	0010	53 39.70	169 48.58	3.03	19.7	9.6	4.7
59	12-Dec-14	0014	52 42.26	170 41.30	3.01	7	63.4	0
60*	14-Dec-14	0014	52 07.39	170 27.19	1.85	90.0	20.0	0
61	14-Dec-14	0014	52 12.00	170 52.39	3.00	135.8	112.1	0
62	14-Dec-14	0013	51 33.10	170 07.81	3.07	112.6	123	0
63	14-Dec-14	0009	51 21.60	169 26.70	2.25	39.3	85.8	0
64	14-Dec-14	0009	51 15.85	169 24.91	3.01	57.2	122.5	0
65	15-Dec-14	0007	52 07.71	167 54.41	3.05	13.5	4.3	9
66	15-Dec-14	0007	51 48.40	167 44.05	3.00	55.6	58.8	0
67	15-Dec-14	0007	51 41.96	166 45.81	2.99	27.5	13.7	5.2
68	15-Dec-14	0006	51 09.28	167 04.99	3.01	30.0	48.8	0
69	16-Dec-14	0009	50 57.74	169 03.08	3.03	97.5	60.6	0
70	16-Dec-14	0009	50 41.21	169 27.93	3.04	148.5	119.7	6.9
71*	16-Dec-14	0009	50 36.62	169 10.73	2.99	85.5	58.9	0
72	16-Dec-14	0009	50 05.28	168 42.91	3.02	233.7	190.5	5.2
73	16-Dec-14	0009	49 56.87	168 22.23	3.04	76.7	223.3	0
74	17-Dec-14	005B	49 32.17	168 01.21	3.02	40.1	45.7	13.5
75	17-Dec-14	005B	49 29.71	167 50.94	3.01	120.0	156.8	0
76	17-Dec-14	005B	49 22.68	167 30.08	3.02	122.3	79.9	8.3
77	17-Dec-14	005B	49 17.39	167 22.28	3.01	35.5	49.5	0
78	17-Dec-14	005A	49 14.30	167 13.83	3.03	76.6	74.5	10.2
79	18-Dec-14	0006	49 34.99	167 14.61	3.04	38.8	6.5	0
80	18-Dec-14	0006	49 32.40	166 58.69	3.01	243.8	72.4	2.6
81	18-Dec-14	005A	49 28.59	166 29.11	3.14	204.5	128.0	35.9
82	18-Dec-14	005A	49 24.59	166 23.50	3.01	446.3	103.3	8.6
83	18-Dec-14	005A	49 07.48	166 59.14	3.03	57.9	214.7	60.0
84	19-Dec-14	003B	48 53.15	166 37.07	3.04	2205.8	81.1	0
85	19-Dec-14	003B	48 56.83	166 43.47	3.01	835.4	61.6	0
86	19-Dec-14	003B	48 55.09	167 00.04	3.01	5.0	7.4	0
87	19-Dec-14	003B	49 02.06	167 03.22	3.02	256.7	53.9	0
88	19-Dec-14	005A	49 00.22	167 14.06	3.00	17.9	103.4	22.8
89	20-Dec-14	0027	48 29.14	172 30.25	2.94	2.7	0	0
90	21-Dec-14	0027	48 31.72	174 56.80	3.02	2.6	0	0
91	21-Dec-14	0027	48 22.33	175 01.05	3.01	0	0	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 caught during the survey (TAN1412). Note: species codes, particularly invertebrates are continually updated on the database following this and other surveys.

Scientific name	Common name	Species code	Occ.
Porifera: sponges	unspecified sponges	ONG	2
Hexactinellida:	glass sponges	GLS	1
Hyalascus spp.	floppy tubular sponge	HYA	25
Demospongiae	siliceous sponges		
Callyspongiidae			
Pachymatisma sp.	rock dumpling sponge	PAZ	3
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	9
Hymedesmiidae			
Phorbas spp.	grey fibrous massive sponge	PHB	3
Tetillidae			
Tetilla leptoderma	furry oval sponge	TLD	1
Crellidae			
Crella incrustans	orange frond sponge	CIC	1
Geodiidae			
Geodia regina	curling stone sponge	GRE	1
Irciniidae			
Psammocinia cf. *hawere*	sponge	PHW	2
Irciniidae			
Rhabdastrella sp.	pink ice egg sponge	RHA	1
Cnidaria: Hydroids and Hydrocorals			
Scyphozoa	unspecified jellyfish	JFI	6
Octocorallia			
Primnoidae			
Thouarella spp.	bottle brush coral	THO	3
Actiniaria	unspecified sea anemones	ANT	1
Actiniidae			
Bolocera spp.	smooth deepsea anemone	BOC	3
Actinostolidae	deepsea anemone	ACS	16
Hormathiidae	warty deepsea anemone	HMT	17
Chrysogorgiidae			
Chrysogorgia spp.	golden coral	CHR	6
Flabellidae			
Flabellum spp.	flabellum cup corals	COF	3
Stylasteridae			
Errina spp.	red hydrocorals	ERR	1
Pennatulacea			
Pteroeidiae			
Gyrophyllum sibogae	siboga sea pen	GYS	1
Hydrozoa		HDR	1
Ascidiacea: Tunicates, sea squirts	unspecified sea squirt	ASC	1
Tunicata: Salps			
Thaliacea	unspecified salps	SAL	27
Salpidae			
Pyrosoma atlanticum		PYR	44

Appendix 3 (continued)

Scientific name	Common name	Species code	Occ.
Mollusca			
Nudibranchia:sea slugs	unspecified sea slug	NUD	1
Gastropoda: gastropods			
Ranellidae			
Fusitron magellanicus		FMA	12
Cephalopoda: squid and octopus			
Teuthoidea: squids	unspecified squid	SQX	3
Histioteuthidae			
Histioteuthis atlantica	violet squid	HAA	3
H. spp.	violet squid	VSQ	7
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	21
Todarodes angolensis		TAG	18
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	69
O. robsoni	warty squid	MRQ	9
Sepiolida: Bobtail squids			
Sepiadariidae			
Stoloteuthis maoria	bobtail squid	IRM	1
Chiroteuthidae			
Chiroteuthis veryani	squid	CVE	2
Brachioteuthidae			
Brachioteuthis spp.	squid	SQB	1
Octopoda: Octopus			
Octopodidae			
Benthoctopus spp.	deepwater octopus	BNO	10
Graneledone challengeri	deepwater octopus	GCL	1
G. taniwha	deepwater octopus	GTA	6
G. spp.	deepwater octopus	DWO	2
Opisthoteuthididae			
Opisthoteuthis spp.	umbrella octopus	OPI	2
Octopoteuthidae			
Taningia danae	squid	TDQ	2
Arthropoda: Isopods, amphipods, mysids, prawns, lobsters, crabs, barnacles, sea spiders			
Crustacea			
Malacostraca			
Dendrobranchiata/Pleocyemata (prawns)	unspecified prawn	NAT	1
Dendrobranchiata			
Aristeidae			
Aristeus sp.	deepwater prawn	ARI	1
Sergestidae:			
Sergia potens	deepwater prawn	SEP	1
Pleocyemata			
Caridea			
Campylonotidae			
Camplyonotus rathbonae	sabre prawn	CAM	3
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	21
Oplophoridae			
Acanthephyra spp.	deepwater prawn	ACA	8
Oplophorus novaezeelandiae	deepwater prawn	ONO	1

Appendix 3 (continued)

Scientific name	Common name	Species code	Occ.
Pasiphaeidae			
Pasiphaea aff. tarda	deepwater prawn	PTA	6
P. spp.	deepwater prawn	PAS	5
Sergestidae			
Haliporoides sibogae	jackknife prawn	HSI	1
Lophogastrida			
Gnathophausiidae		GNA	1
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	3
Anomura			
Galatheoidea			
Lithodidae			
Lithodes aotearoa	New Zealand king crab	LAO	3
Paguridae			
Diacanthurus rubricatus	hermit crab	DIR	2
Parapaguridae	unspecified hermit crab	PAG	8
Sympagurus dimorphus	hermit crab	SDM	4
Brachyura: True crabs			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	1
Majidae			
Jacquinotia edwardsii	giant spider crab	GSC	2
Leptomithrax garricki	Garrick's masking crab	GMC	1
Nephropidae			
Metanephrops challengeri	scampi	SCI	3
Echinodermata			
Asteroidea	sea stars		
Asteriidae			
Cosmasterias dyscrita	cat's-foot star	CDY	1
Pseudechinaster rubens		PRU	2
Brisingidae	armless stars	BRG	2
Asteriidae	unspecified starfish	ASR	1
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	11
Plutonaster knoxi	abyssal star	PKN	2
Psilaster acuminatus	geometric star	PSI	2
Sclerasterias mollis	cross-fish	SMO	2
Benthopectenidae			
Benthopecten spp.		BES	1
Echinasteridae			
Henricia compacta		HEC	1
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	12
Hippasteria trojana	trojan star	HTR	9
Lithosoma novaezelandiae	rock star	LNV	9
Mediaster sladeni	Sladen's star	MSL	1
Pillsburiester aoteanus		PAO	15
Odontasteridae			
Odontaster spp.	pentagonal starfish	ODT	2
Pterasteridae			
Diplopteraster spp.	starfish	DPP	1
Solasteridae			
Crossaster multispinus	sun star	CJA	7
Solaster torulatus	chubby sun-star	SOT	1

Appendix 3 (continued)

Scientific name	Common name	Species code	Occ.
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	34
Crinoidea: sea lillies and feather stars			
Comatulida	feather star	CMT	1
Echinoidea	unspecified sea urchin	ECT/ECN	6
Regularia			
Cidaridae: cidarid urchins			
Goniocidaris parasol	parasol urchin	GPA	4
Echinothuriidae, Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	5
Echinidae			
Dermechinus horridus	deepsea urchin	DHO	2
Spatangoida (heart urchins)			
Spatangidae			
Paramaretia peloria	microsoft mouse	PMU	1
Ophiuroidea			
Gorgonocephalidae			
Gorgonocephalus spp.	gorgons head basket-star	GOR	3
Holothuroidea	sea cucumbers	HTH	3
Aspidochirotida			
Synallactidae			
Bathyplotes spp.	sea cucumber	BAM	7
Pseudostichopus mollis		PMO	33
Pannychia moseleyi		PAM	1
Elasipodida			
Laetmogonidae			
Laetmogone spp.		LAG	4
Chondrichthyes: cartilaginous fishes			
Squalidae: dogfishes			
Squalus acanthias	spiny dogfish	SPD	54
Centrophoridae: gulper sharks			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	17
Deania calcea	shovelnose dogfish	SND	19
Etmopteridae: lantern sharks			
Etmopterus baxteri	Baxter's dogfish	ETB	44
E. lucifer	lucifer dogfish	ETL	49
E. pusillus	dogfish	ETP	2
Somniosidae: sleeper sharks			
Centroscymnus crepidater	longnose velvet dogfish	CYP	15
C. owstoni	smooth skin dogfish	CYO	6
Proscymnodon plunketi	Plunket's shark	PLS	6
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	2
Dalatiidae: kitefin sharks			
Dalatias licha	seal shark	BSH	7
Scyliorhinidae: cat sharks			
Apristurus spp.	deepsea catsharks	APR	4
Bythaelurus dawsoni	Dawson's catshark	DCS	3
Rajidae: skates			
Brochiraja asperula	smooth deepsea skate	BTA	11
B. spinifera	prickly deepsea skate	BTS	9
Dipturus innominata	smooth skate	SSK	15
Notoraja spp.	deepsea bluntnose skates	BTH	1
Zearaja nasuta	rough skate	RSK	2

Appendix 3 (continued)

Scientific name	Common name	Species code	Occ.
Chimaeridae: chimaeras, ghost sharks			
Chimaera lignaria	giant chimaera	CHG	1
Hydrolagus bemisi	pale ghost shark	GSP	877
H. novaezelandiae	dark ghost shark	GSH	11
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	42
Rhinochimaera pacifica	widenose chimaera	RCH	6
Osteichthyes			
Notacanthidae: spiny eels			
Notocanthus sexspinis	spineback	SBK	44
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	10
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	42
B. hirsutus	hairy conger	HCO	39
Serrivomeridae: sawtooth eels			
Serrivomer spp.	sawtooth eel	SAW	1
Gonorynchidae:	sandfish		
Gonorynchus forsteri & *G. greyi*	sandfishes	GON	5
Argentinidae: silversides			
Argentina elongata	silverside	SSI	45
Bathylagidae: deepsea smelts			
Melanolagus bericoides	bigscale black smelt	MEB	1
Diplophidae:	diplophids		
Diplophos spp.	twin light dragonfishes	DIP	1
Alepocephalidae: slickheads			
Alepocephalus antipodianus	small-scaled brown slickhead	SSM	11
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	2
Chauliodontidae: viperfishes			
Chauliodus sloani	viperfish	CHA	2
Stomiidae: scaly dragonfishes			
Borostomias antarcticus	snaggletooth	BAN	1
Stomias spp.	scaly dragonfish	STO	3
Notosudidae: waryfishes			
Scopelosaurus spp.		SPL	1
Malacosteidae: loosejaws			
Malacosteus australis	southern loosejaw	MAU	1
Sternoptychidae: hatchetfishes			
Argyropelecus gigas.	giant hatchetfish	AGI	2
Idiacanthidae: black dragonfishes			
Idiacanthus spp.	black dragonfish	IDI	2
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	8
Woodsia meyerwaardeni	austral lightfish	WMY	1
Myctophidae: lanternfishes	unspecified lanternfish	LAN	2
Gymnoscopelus piabilis	Southern blacktip lanternfish	GYP	3
G. spp.	lanternfish	GYM	1
Lampanyctus spp.	lanternfish	LPA	8
Nannobranchium achirus	cripplefin lanternfish	LAC	2
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	7
Halargyreus johnsoni	Johnson’s cod	HJO	11

Appendix 3 (continued)

Scientific name	Common name	Species code	Occ.
Moridae: morid cods (continued)			
Lepidion microcephalus	small-headed cod	SMC	9
Mora moro	ribaldo	RIB	40
Notophycis marginata	dwarf cod	DCO	7
Pseudophycis bachus	red cod	RCO	10
Pseudophycis barbata	southern bastard cod	SBR	1
Tripterophycis gilchristi	grenadier cod	GRC	1
Melanonidae: pelagic cods			
Melanonus gracilis	pelagic cod	MEL	1
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	41
Merlucciidae: hakes			
Lyconus sp.		LYC	3
Macruronus novaezelandiae	hoki	HOK	85
Merluccius australis	hake	HAK	31
Macrouridae: rattails, grenadiers			
Coelorinchus aspercephalus	oblique-banded rattail	CAS	40
C. bollonsi	Bollons's rattail	CBO	30
C. fasciatus	banded rattail	CFA	77
C. innotabilis	notable rattail	CIN	17
C. kaiyomaru	Kaiyomaru rattail	CKA	10
C. matamua	Mahia rattail	CMA	5
C. oliverianus	Oliver's rattail	COL	61
C. parvifasciatus	small-banded rattail	CCX	5
Coryphaenoides dossenus	humpback rattail	CBA	4
C. serrulatus	serrulate rattail	CSE	11
C. subserrulatus	four-rayed rattail	CSU	16
Lepidorhynchus denticulatus	javelinfish	JAV	82
Lucigadus nigromaculatus	blackspot rattail	VNI	26
Macrourus carinatus	ridge-scaled rattail	MCA	17
Mesobius antipodum	black javelinfish	BJA	6
Trachyrincus aphyodes	white rattail	WHX	4
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	79
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate	ECR	2
Ceratiidae: seadevils			
Cryptopsaras couesi	seadevil	SDE	2
Himantolophidae: prickly anglerfishes			
Himantolophus spp.	prickly anglerfish	HIM	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	9
H. mediterraneus	silver roughy	SRH	7
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	29
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	4
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	3

Appendix 3 (continued)

Scientific name	Common name	Species code	Occ.
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	11
Neocyttus rhomboidalis	spiky oreo	SOR	3
Pseudocyttus maculatus	smooth oreo	SSO	10
Hoplichthyidae:	ghostflatheads		
Hoplichthys haswelli	deepsea flathead	FHD	2
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	15
Psychrolutes spp.	blobfish	PSY	4
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	1
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	5
E. robustus	robust cardinalfish	EPR	5
E. telescopus	black cardinalfish	EPT	3
Bramidae: pomfrets			
Brama australis	southern Ray’s bream	SRB	14
B. brama	Ray’s bream	RBM	1
Xenobrama microlepis	bronze bream	BBR	1
Nototheniidae: cod icefishes			
Notothenia microlepidota	smallscaled cod	SCD	1
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	GIZ	16
Gempylidae: snake mackerels			
Rexea solandri	gemfish	RSO	2
Thyrsites atun	barracouta	BAR	1
Trichiuridae: cutlassfishes			
Benthodesmus spp.		BEN	2
Centrolophidae: raftfishes, medusafishes	unspecified centrolophid	CPD	1
Centrolophus niger	rudderfish	RUD	4
Hyperoglyphe antarctica	bluenose	BNS	1
Seriolella caerulea	white warehou	WWA	17
S. punctata	silver warehou	SWA	4
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	1
Neoachiropsetta milfordi	finless flounder	MAN	33

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

NIWA No.	Station	Phylum	Class	Order	Family	Genus	Species
98553	25	Arthropoda	Malacostraca	Decapoda	Acanthephyridae	*Acanthephyra*	*pelagica*
98536	25	Arthropoda	Malacostraca	Decapoda	Aristeidae	*Aristeus*	sp.
98549	52	Arthropoda	Malacostraca	Decapoda	Nematocarcinidae	*Lipkius*	*holthuisi*
98534	4	Arthropoda	Malacostraca	Decapoda	Pasiphaeidae	*Pasiphaea*	*barnardi*
98535	2	Arthropoda	Malacostraca	Decapoda	Pasiphaeidae	*Pasiphaea*	*barnardi*
98537	66	Arthropoda	Malacostraca	Decapoda	Pasiphaeidae	*Pasiphaea*	*barnardi*
98550	14	Arthropoda	Malacostraca	Decapoda	Pasiphaeidae	*Pasiphaea*	*barnardi*
98552	3	Arthropoda	Malacostraca	Decapoda	Pasiphaeidae	*Pasiphaea*	*barnardi*
98554	89	Arthropoda	Malacostraca	Decapoda	Pasiphaeidae	*Pasiphaea*	*barnardi*
98609	82	Arthropoda	Malacostraca	Decapoda	Sergestidae	*Sergia*	*prehensilis*
98603	85	Cnidaria	Anthozoa	Alcyonacea	Primnoidae	*Thouarella*	sp.
98359	76	Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Flabellum*	*knoxi*
98532	8	Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Flabellum*	*knoxi*
98602	88	Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Flabellum*	*knoxi*
98619	60	Cnidaria	Hydrozoa	Leptothecata	Lafoeidae	*Acryptolaria*	*conferta*
98604	39	Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Hippasteria*	*muscipula*
98555	76	Echinodermata	Echinoidea	Echinoida	Echinidae	*Dermechinus*	*horridus*
98533	25	Echinodermata	Echinoidea	Echinoida	Echinidae	*Gracilechinus*	*multidentatus*
98613	76	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	sp.
98548	2	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*challengeri*
98610	85	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Octopus*	sp.
98547	25	Mollusca	Cephalopoda	Oegopsida	Chiroteuthidae	*Chiroteuthis*	*veranyi*
98612b	66	Mollusca	Cephalopoda	Oegopsida	Lycoteuthidae	*Lycoteuthis*	sp.
98611	69	Mollusca	Cephalopoda	Oegopsida	Onychoteuthidae	*Notonykia*	sp.
98612a	66	Mollusca	Cephalopoda	Oegopsida	Onychoteuthidae	*Onykia*	*ingens*
98606	62	Mollusca	Gastropoda Prosobranchia	Mesogastropoda	Naticidae		
98608	37	Mollusca	Gastropoda Prosobranchia	Neogastropoda	Volutidae	*Alcithoe*	*flemingi*
98614	76	Porifera	Demospongiae	Astrophorida	Geodiidae	*Pachymatisma*	*nodosa*
98616	60	Porifera	Demospongiae	Hadromerida	Trachycladidae	*Trachycladus*	sp.
98615	87	Porifera	Demospongiae	Halichondrida	Halichondriidae	*Topsentia*	sp.
98618	50	Porifera	Demospongiae	Poecilosclerida	Coelosphaeridae	*Coelosphaera*	*globosa*
98617	50	Porifera	Demospongiae	Poecilosclerida	Coelosphaeridae	*Lissodendoryx*	sp.