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Tini a Tangaroa

Trawl survey of hoki and middle-depth species in the Southland and Sub-Antarctic areas, November–December 2016 (TAN1614)

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EXECUTIVE SUMMARY

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The seventeenth *Tangaroa* trawl survey of the Sub-Antarctic summer series was conducted from 22 November to 22 December 2016. Previous summer surveys were in 1991–1993, 2000–2009, 2011, 2012 and 2014. Species monitored by the trawl survey include important commercial species such as hoki, hake and ling, as well as a wide range of non-commercial fish and invertebrate species. An unprecedented amount of survey time was lost due to bad weather (8 days) which meant that the core trawl survey strata (strata 1–25) were unable to be completed for the first time in the trawl time-series. A total of only 56 of the planned 82 phase 1 stations were successfully completed, with fewer than 2 stations carried out in core strata 1 (1 station), 3A (1 station), and 2 (no stations), and no stations in deep strata 25 and 27.

Biomass estimates were scaled up using factors based on the proportion of each species' biomass in 'missing strata' (defined as those with fewer than 2 tows in 2016) in previous surveys from 2000–14. This introduced additional uncertainty into abundance estimates, particularly for species where a high proportion of the abundance came from strata which were not surveyed in 2016.

The hoki biomass estimate and coefficient of variation (CV in parentheses) for completed core strata (those with more than two stations surveyed) was 33 390 t (14%). The scaled biomass estimate for hoki in all core (300–800 m) strata was 37 992 t (17%), up 21% from the core estimate in 2014 (31 329 t). Abundance estimates for completed strata and scaled for core strata were 23 534 t (13.8%) and 26 656 t (16 %) respectively for ling. The scaled ling biomass estimate was down by 11% from that in 2014 (30 005 t). Hake abundance estimates were 919 t (25%) and 1000 t (25%) for completed and scaled core strata respectively, a decrease of 9% from 2014 (1101 t). The scaled estimate for hake in 2016 was the third lowest in the summer trawl time series. Southern blue whiting were particularly abundant in the 2016 survey. The estimated biomass for southern blue whiting in core strata of 36 057 (13%), was the second highest in the time-series.

Several modes were present in the hoki scaled length frequency including some 1+ fish (2015 year-class) at about 32–42 cm and relatively few 2+ fish (2014 year-class) at 50–60 cm. There was a broad mode of older age classes of hoki ages 5–12. Age 1+ and 2+ hoki were concentrated in stratum 3B, south of the Snares Islands. The distribution of these younger year classes is consistent with previous surveys. There were too few hake caught to construct an informative length or age frequency distribution. The length distribution of ling in 2016 was broad, with the overall length frequency similar to that in 2014. Most ling were between 4 and 14 years old, with the mode at ages 5 for males and age 7 for females.

Acoustic data were also collected during the trawl survey. Data quality in 2016 was poor at times due to the rough weather and sea conditions, and only 73% of acoustic files were suitable for quantitative analysis. Total daytime backscatter in the water column was 28% lower than that recorded in 2014, but was higher than total backscatter in 2012, and about average for the time-series. The acoustic index of mesopelagic fish abundance was 33% lower than in 2014, due to reductions in backscatter in the eastern Sub-Antarctic and on the Stewart-Snares shelf. Mesopelagic backscatter increased in the western Sub-Antarctic and the 2016 value for this subarea was the highest in the time-series. There was no correlation between acoustic density from demersal marks and trawl catch rates.

As well as supporting the stock assessments for hoki, hake and ling, the trawl survey provides information on a number of bycatch species. A total of 130 species or species groups were caught, 16 291 fish or squid of 60 different species were measured, and 6388 fish were individually weighed during the 2016 survey. The liver condition of 815 hoki were recorded. Otoliths were collected from 891 hoki, 33 hake, and 775 ling.

1. INTRODUCTION

Trawl surveys of the Southland and Sub-Antarctic region (often collectively referred to as the "Southern Plateau") provide fishery-independent abundance indices for hoki, hake, and ling. Hoki is New Zealand's largest fishery, with a TACC of 150 000 t from 1 October 2015. The Southland and Sub-Antarctic region is 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 Southland and Sub-Antarctic (including Puysegur) peaked at over 35 000 t in 1999–00 to 2001–02 but have since declined and were about 7700 t in 2015–16. 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 in 2016–17 (including Southland and Sub-Antarctic) is 90 000 t with the remaining 60 000 t allocated to the eastern fishery. Hake and ling are also important commercial species in Southland and Sub-Antarctic. The catches of hake and ling in the southern areas in 2015–16 were 1584 t (HAK 1, includes the western Chatham Rise) and 3868 t (LIN 5, Southland), and 2222 t (LIN 6, Sub-Antarctic).

Two time series of trawl surveys have been carried out from RV *Tangaroa* in the Southland and Sub-Antarctic region (subsequently referred to as the Sub-Antarctic survey series): a summer series in November–December 1991–93, 2000–09, 2011–12 and 2014; 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. The autumn season 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 large (threefold) increase in estimates of hoki abundance between the 2006 and 2007 trawl surveys (Bagley et al. 2009). This biomass increase was sustained in 2008 (O'Driscoll & Bagley 2009), with further increases in 2009 (Bagley & O'Driscoll 2012), and 2012 (Bagley et al. 2014). The estimated hoki biomass from the 2014 survey was down by 43% from 2012 and the lowest since 2006 (Bagley et al. 2017), and this was interpreted by the 2016 hoki assessment model as observation error. There is some evidence for variable catchability in this survey series (O'Driscoll et al. 2015). Recent hoki assessments have been unable to fit the observations well and this leads to a relatively high process error (37%) being estimated for the Sub-Antarctic trawl surveys by the 2016 assessment model (McKenzie 2017).

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. The most recent review of all the summer Sub-Antarctic trawl survey *Tangaroa* time series gave distributions, biomass estimates and trends for 134 species, and catch rates and population scaled length frequencies for a subset of 35 species (Bagley et al. 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, 2017), 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, 2017). 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. 2015).

The continuation of the time series of trawl surveys in Southland and on the Sub-Antarctic is a high priority to provide information required to update the assessment of hoki and other middle depth species. The survey is currently now carried out biennially. The 2016 survey provided a seventeenth summer estimate of western hoki biomass in time for the 2017 stock assessment.

1.1 Project objectives

This report is the final reporting requirement for Ministry for Primary Industries Research Project DEE2016/01. The overall objective of this project is to continue a time series of relative abundance indices for hoki (*Macruronus novaezelandiae*), hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the Southland and Sub-Antarctic QMAs. The specific objectives were as follows:

1. To carry out a trawl survey in December 2016 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 of hoki, hake and ling.
3. To determine the proportions at age of hoki taken in the survey.
4. To collect acoustic and related data during the trawl survey.
5. To collect and preserve specimens of unidentified organisms taken during the trawl survey, and identify them later ashore.

2. METHODS

2.1 Survey design

A key aspect of the survey design was to ensure consistency with previous surveys in the time series. This required the survey to be carried out from *Tangaroa* using the same trawl gear used for previous surveys.

The 2016 survey was carried out from 22 November to 22 December 2016 and followed a two-phase stratified random design (after Francis 1984). The survey area was divided into 20 strata by depth (300–600, 600–800, and 800–1000 m) and area (Figure 1). There are 15 core 300–800 m strata (Strata 1 to 15) which have been surveyed in all previous summer and autumn surveys (Table 1). Strata 3 and 5 were subdivided in 2000 to increase the coverage in the region where hake and ling aggregations were thought to occur (Bull et al. 2000). Deeper 800–1000 m strata (Strata 25–28) have been surveyed since 1996. Stratum 26, at 800–1000 m depth south of Campbell Island, was dropped in 2012 due to a reduction in the number of survey days. 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 597.

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 2007–14 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 CV's of 20% for hake and 15% for hoki and ling would be met. A total of 82 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 equipment

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 survey used the same eight-seam hoki trawl (see Hurst et al. 1992 for net plan) that was used on previous surveys in the series. This net has 100 m sweeps, 50 m bridles, 12 m backstrops, 58.8 m groundrope, 45 m headline, and 60 mm codend mesh. The trawl doors were Super Vee type with an area of 6.1 m^2.

2.3 Trawling procedure and biological sampling

Random 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 by NIWA. A minimum distance between tows 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. Random bottom tows were only carried out during daylight hours, with all random tows carried out 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 trawl hauled early due to reducing daylight or strong marks on the net monitor, the tow was included as valid only if at least 2 n. miles was 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.

Measurements of doorspread (from a SCANMAR ScanBas system), headline height (from a Furuno CN22 net monitor), and vessel speed (GPS speed over the ground, cross checked against distance travelled during the tow) were recorded every 5 min during each tow and average values calculated. Towing speed and gear configuration for random tows were maintained as constant as possible during the survey, following the guidelines given by Hurst et al. (1992). Acoustic recordings were made for all tows using the multi-frequency hull-mounted transducers.

From each tow, all items in the catch were sorted into species and weighed on Marel motion-compensating electronic scales which resolved to about 0.1 kg. Where possible, finfish, squid, and crustaceans were identified to species and other benthic fauna were identified to species, genus, or family. Unidentified organisms were collected and frozen at sea for subsequent identification 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. Otoliths were also taken from ribaldo for future ageing work. A description of the macroscopic gonad stages used for teleosts and elasmobranchs is given in Appendix 1. Liver and gutted weights were recorded from up to 20 hoki per tow to determine condition indices.

2.4 Other data collection

Temperature and salinity data were collected using a calibrated Seabird SM-37 Microcat CTD datalogger 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 from about 7.0 m above the seabed (i.e., the height of the trawl headline).

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 27 August 2016 in the Marlborough Sounds. The system and calibration parameters are given in Appendix 1 of O'Driscoll et al. (in press).

2.5 Trawl data analysis

Doorspread biomass was estimated by the swept area method of Francis (1981, 1989) as implemented in the analysis programme *SurvCalc* (Francis 2009). Total survey abundance was estimated for all species in the catch. Only data from random trawl tows where the gear performance was satisfactory (codes 1 or 2) were included for estimating abundance. Survey biomass and CV by stratum were estimated for the top 50 species in the catch by weight.

Scaled length frequencies were calculated with *SurvCalc*, using length-weight data from this survey, where possible. Where there were insufficient data (fewer than 50 fish weighed, estimated r^2 of the length-weight regression less than 90%, or the length range of fish was too narrow) then length-weight data from all Sub-Antarctic summer series was used (Table 2).

Hoki and ling otoliths were prepared and aged using validated ageing methods (hoki, Horn & Sullivan (1996) as modified by Cordue et al. (2000); and ling, Horn (1993)). Otoliths were removed from 891 hoki, 775 ling, and 33 hake, and sub-samples of 706 hoki otoliths and 591 ling were selected for ageing. There were insufficient hake caught on the survey for an adequate age sample. Numbers-at-age were calculated from observed length frequencies from successful random tows and age-length keys using custom 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. Sub-samples for hoki and ling were derived by randomly selecting otoliths from each of a series of 1 cm length bins covering the bulk of the catch, and then systematically selecting additional otoliths to ensure that the tails of the length distribution were represented. The chosen sample size approximates that necessary to produce a mean weighted CV of less than 20% across all age classes.

2.6 Biomass and age data corrections

Because of bad weather in 2016 (see Section 3.1), five strata had fewer than two completed tows (1, 2, 3A, 25, and 27). Biomass estimates and CVs were calculated for core strata with more than two stations surveyed (i.e., strata 3B and 4–15), and then scaled up using a factor based on proportion of the species biomass in the 'missing' strata in the 13 previous surveys from 2000–14. It was not possible to include surveys from 1991–93 in the estimation of scaling factors as strata 3A and 3B were combined in these early surveys.

As the spatial distribution of a species may be correlated within a survey the totals were summed across the 3 (core) or 4 (core plus stratum 25 at Puysegur) missing strata to estimate what the scaling factor would have been in each of the previous surveys and then the mean of the annual scaling factors was applied to 2016. The CV of the scaled biomass estimate was also inflated based on the distribution of scaling factors in previous surveys (where the squared variances of the estimated biomass and scaling factors were combined).

$$\boldsymbol{B_{x,scaled}} = \boldsymbol{B_{x,observed}} \times \overline{\boldsymbol{sf}}_{\boldsymbol{x}}$$

$$\boldsymbol{CV_{x,scaled}} = \sqrt{\left(\boldsymbol{CV^2_{x,observed}} + \boldsymbol{CV^2_{sf,x}}\right)}$$

where $\boldsymbol{B_{x,scaled}}$ and $\boldsymbol{CV_{x,scaled}}$ are the scaled core biomass and CV for species *x* in the 2016 survey respectively, and $\overline{\boldsymbol{sf}}_{\boldsymbol{x}}$ and $\boldsymbol{CV_{sf,x}}$ are the mean and CV of the scaling factor for species *x* from surveys from 2000–14.

The scaling factor for species *x* in previous survey *i* ($\boldsymbol{sf_{x,i}}$) in core strata was calculated from:

$$\boldsymbol{sf_{x,i}} = \frac{\mathbf{1}}{\mathbf{1} - \left(\frac{\boldsymbol{B_{x,i,str(1,2,3A)}}}{\boldsymbol{B_{x,i,str(1-15)}}}\right)}$$

where $\boldsymbol{B_{x,i,str(1,2,3A)}}$ is the estimated biomass of species *x* in survey *i* in strata 1, 2, and 3A, and $\boldsymbol{B_{x,i,str(1-15)}}$ is the estimated biomass in all core strata (1–15). Similarly, a scaling factor was calculated for core strata plus stratum 25 at Puysegur by using the following ratio in the denominator:

$$\left(\frac{\boldsymbol{B_{x,i,str(1,2,3A,25)}}}{\boldsymbol{B_{x,i,str(1-15,25)}}}\right)$$

Proportions at length and age for hoki and ling in missing strata were estimated from the available length frequency data. The one tow from stratum 3A was used to estimate the length frequency in stratum 3A (with biomass estimated from mean annual scaling factor for stratum 3A in 2000–14). The single tow from stratum 1 was used to estimate the length frequency in both strata 1 and 2 (with biomass estimated from mean scaling factors for strata 1 and 2 combined in 2000–14).

2.7 Acoustic data analysis

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 the custom analysis software ESP3. This software includes an algorithm that allowed us to quantify the number of 'bad pings' in each acoustic recording. Bad pings were defined as those where values were significantly different from surrounding pings due to bubble aeration or noise spikes. Only acoustic data files where the proportion of bad pings was less than 30% were considered suitable for quantitative analysis.

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, 2015) 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 2016. The methods were the same as those used by O'Driscoll et al. (2015). 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. The estimation procedure for night-time data was still based on the three subareas defined by O'Driscoll et al. (2011) (i.e., east and west Sub-Antarctic separated at 169°E, and Puysegur), but mesopelagic indices were summarised in four broad regions based on trawl survey strata as recommended by O'Driscoll et al. (2015):

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 Data collection

A total of 56 successful trawl survey stations were completed in 14 strata (Figure 2, Table 1). One further tow (station 55) was unsuccessful due to poor gear performance (the trawl came off the seabed shortly after landing and would not come back down). Unprecedented bad weather for this time series prevented completion of the core survey. Stations were prioritised in an attempt to complete core strata, so only two trawls were carried out in deeper strata (both in stratum 28 at the start of the survey). When it became clear on 14 December that phase 1 would not be completed for the core strata, an attempt was made to carry out a minimum of two stations in each of the remaining strata. This was achieved for strata 5A, 5B, and 3B, but not for strata 1, 2, 3A, and 25 (see Table 1). No phase 2 shots were completed.

Individual station details from all trawl stations, including the catch of hoki, hake and ling are listed in Appendix 2. One trawl was conducted in the Campbell East Benthic Protected Area (BPA) (see Figure 1).

3.2 Gear performance

Gear parameters by depth for valid trawl survey tows are summarised in Table 3. Headline height and doorspread were obtained for all successful tows. Measured gear parameters in 2016 were generally within the range of those obtained on other voyages of *Tangaroa* in this area when the same gear was used, although mean doorspread was slightly higher than that in recent surveys (Table 4), probably due to the generally rough weather in 2016. Mean doorspread distances and headline heights for the Sub-Antarctic surveys were also consistent with those from the *Tangaroa* hoki and middle depths time series surveys on the Chatham Rise (e.g., Stevens et al. 2017). 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.

3.3 Catch

A total catch of 21.1 t was recorded from all trawl stations (Table 5). From the 130 species or species groups caught, 53 were teleosts, 22 were elasmobranchs, 9 were squids or octopuses, and 11 were crustaceans, with the remainder comprising assorted benthic and pelagic animals (Appendix 3). The greenweight of the top 50 species is given in Table 5 with hoki accounting for 34.9%, ling 20.0%, and southern blue whiting 17.4% of the total catch from all trawls. A total of 33 sample lots were retained from the catch for identification, or to confirm identification ashore. These were all invertebrates including sea-stars, corals, molluscs, and sponges. The DAE project that enables identification of these specimens was not funded by MPI in 2016–17, so these specimens have not yet been registered or identified.

3.4 Trawl abundance estimates

Abundance estimates and the trawl survey catch for strata with two or more stations in the core 300–800 m depth range (strata 3B–15), and scaled estimates for all core strata (the core 300–800 m depth range (strata 1–15) are given in Table 6. Estimated abundance and CVs (in parentheses) for core strata with more than two stations surveyed (i.e., strata 3B, and 4–15) were 33 390 t (14.1%) for hoki, 23 534 t (13.8%) for ling, and 919 t (24.5%) for hake. Scaled estimates for all core strata (i.e., 1–15) were 37 992 t (17%) for hoki, 26 656 t (16 %) for ling and 1000 t (25%) for hake (Table 6). Target CVs were met for unscaled biomass estimates for hoki and ling (target 15%), but not for hake (target 20%). Of the other species in the top 50 by unscaled biomass, CVs were below 20% for southern blue whiting, javelinfish, pale ghost shark, banded rattail, Bollons's rattail, Lucifer dogfish, and sea perch.

Abundance estimates by stratum are given in Table 7 and plotted in Figure 3. Hoki were spread over the survey area. Strata 3B and 4 (Stewart Snares shelf) accounted for 32% of the hoki abundance in 2016, higher than the contribution from these strata from the 2014 survey. The western Campbell Plateau (strata 9 and 10), Pukaki Rise (strata 11 and 12), and eastern Campbell Plateau (strata 13–15) contributed 18%, 18%, and 22% of estimated hoki biomass in 2016 respectively. Ling were caught in all strata, although strata 4, 9, and 12–14 accounted for most of the biomass in 2016, and 75% of ling were caught in 300–600 m strata. No hake were caught in strata 10–15.

Scaled core trawl estimates from 2016 were compared to previous surveys in the summer Sub-Antarctic time series in Table 8 and Figure 4. The scaled core hoki biomass index was up 21% from 2014. Estimates of hoki abundance in 2014 and 2016 were lower than core estimates from 2007–12 surveys, but higher than those from the 'four low years' in 2003–06 (Figure 4, Table 8). The scaled ling biomass estimate in 2016 was down by 11% from that in 2014 estimate. The scaled core estimate for hake in 2016 was the third lowest in the summer trawl time series, and down 9% from 2014. Southern blue whiting were particularly abundant in the 2016 survey. The estimated biomass for southern blue whiting in core strata of 36 057 (13%), was the second highest in the time-series, behind 2009. Scaled core biomass estimates for 24 of the other 34 species were lower in 2016 than in 2014 (Table 8, Figure 4). Because only two tows were carried out in 800–1000 m strata in 2016, biomass was not estimated for 'all' strata (Figure 4).

3.5 Species distribution

Hoki were widespread throughout the core survey area, occurring in 55 of the 56 trawl stations (Figure 5). Hoki catch rates were generally higher in the west, with the largest catch coming from the bottom of the Stewart/Snares shelf in stratum 3B. Most juvenile (1+ and 2+) hoki were also taken on the Stewart/Snares shelf.

Catch rates of the other main species are plotted in Figure 6. Hake showed a similar distribution to previous years and were concentrated between the Auckland Islands and Stewart/Snares shelf in strata 5A and 5B. Most stations in the east and south of the survey area caught no hake. Ling were caught on 53 of the 56 core stations, with higher catches in the western strata. Catch rates for many other species were also higher in western strata, and at the bottom of the Stewart/Snares shelf (see also Figure 3). However, lookdown dory, southern blue whiting, silverside, and warty squid had higher catch rates in eastern strata, and pale ghost shark and javelinfish were widespread (Figure 6).

3.6 Biological data

A total of 16 291 fish and squid of 60 different species were measured, and of these, 6388 fish were also individually weighed (Table 9). Additional data on fish condition (liver and gutted weight) were recorded from 815 hoki. Pairs of otoliths were removed from 891 hoki, 775 ling, and 33 hake. In addition, 22 ribaldo otoliths were removed for potential future ageing work.

Population scaled length frequencies for hoki, hake, and ling, calculated using length-weight data in Table 3, are compared to those observed in previous summer surveys in Figure 7. Scaled age frequency distributions for hoki and ling are presented in Figure 8. Because smaller hoki were more abundant in the 'missing strata' (strata 1–3A) in surveys from 2000–14 (Figure 9a), the proportions at age for hoki scaled to include these strata in 2016 showed an increase in the proportion of age 2+ fish (2014 year-class) compared to the unscaled age frequency (Figure 10). The size frequency of ling in 'missing strata' was generally similar to that in other core strata (see Figure 9b), so the unscaled and scaled proportions at age for ling were very similar (not shown). There were too few hake caught to estimate proportions at age.

The hoki length frequency distribution in 2016 showed a strong mode of 1+ fish at about 32–42 cm, and a broad mode of larger, older fish from about 70–95 cm (see Figure 7a). The proportion of hoki from 50–70 cm (2+ and 3+) was much lower in 2016 than in the previous survey in 2014 (Figure 7a). The modal ages for hoki were 1 (2015 year-class), 5 (2011 year-class), and 7 (2009 year-class) (see Figure 8a). There were too few hake caught to construct an informative length frequency distribution but lengths ranged from 78–131 cm (see Figure 7b).The length frequency distribution of ling was broad with few males over 95 cm or females over 120 cm, with the overall length frequency distribution similar to that in 2014 (see Figure 7c). Most ling were between 4 and 14 years old with the mode at age 5 for males and 7 for females (see Figure 8b).

Population scaled length frequency distributions using calculated length-weight data in Table 3 for other main species for the 2016 survey are presented in Figure 11. Most southern blue whiting were between 26 and 50 cm, with modal peaks of 29 and 35 cm for males, and 29 and 37 cm for females (Figure 11). Other points of interest in Figure 11 included: a broad range in the length distribution for female javelinfish with fewer, and generally smaller, males; the 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 staging of fish and elasmobranchs showed that many species were immature or resting during the survey (Table 10). About 18% of hoki were immature, and these were typically fish smaller than 70 cm. Most adult hoki were in the resting phase. Very few (only 0.3%) hoki were macroscopically staged as partially spent or spent in 2016. Female ling were mostly resting (84%), immature (6%), or ripe (8%), but 28% of male ling were ripe or running ripe. Very few hake were staged, and most were females that were resting or ripening.

A total of 33 sample lots were retained from the catch and frozen at sea to confirm identification ashore. These were all invertebrates including sea-stars, corals, molluscs, and sponges.

3.7 Hoki condition indices

Liver and gutted weights were recorded from 815 hoki in 2016. Both liver condition (Table 11) and somatic condition (measured as the estimated average weight of a 75 cm hoki) were higher in 2016 than those recorded in 2014 reversing the trend in declining condition since November-December 2011 (Figure 12). Liver condition in 2016 was the highest in the time-series going back to 2000, and somatic condition was the third highest (only lower than that in 2005 and 2011). 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 12), suggesting that processes that affect condition occur on a broader scale than the survey region.

3.8 Acoustic data

Over 61 GB of acoustic data were collected with the multi-frequency (18, 38, 70, 120, and 200 kHz) hull-mounted EK60 systems on each trawl station, while steaming between stations and on overnight steams.

Data were not collected while sheltering from bad weather. Of the 229 acoustic data files (57 trawls, 107 day-time steams, and 65 night-time steams) recorded during the 2016 survey, 27% were not suitable for quantitative analysis because the data were of poor quality (Table 12).

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 13. Only one trawl and no night steams of suitable quality were recorded at Puysegur. 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 the western side of the Campbell Plateau and lowest densities in the south eastern Sub-Antarctic.

The vertical distribution of acoustic backscatter in 2016 is compared to the average vertical distribution from all previous years in the Sub-Antarctic time series in Figure 14. 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 2016, there were peaks in daytime vertical distribution centred at about 100 m, 400 m and 600 m depth which corresponded with midwater layers. The daytime layer at 100 m depth was not apparent in previous surveys (Figure 14).

The time series of day estimates of total acoustic backscatter are plotted in Figure 15. Total daytime backscatter in the water column (from 10 m below the transducer to the seabed) in 2016 was 28% lower than that recorded in 2014, but was higher than total backscatter in 2012, and about average for the time-series. As noted by O'Driscoll et al. (2015), acoustic backscatter in the bottom 10 m has been relatively consistent over time. Backscatter within 50 m and 100 m from the seabed was lower than equivalent estimates in 2014, but both values were slightly above average for the time series (Figure 15).

There was a very weak and insignificant positive correlation between acoustic backscatter in the bottom 50 m during the day and trawl catch rates in 2016 (Figure 16, number of tows = 40, Spearman's rank correlation = 0.09, $p = 0.58$). 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, 2012, or 2014 (O'Driscoll & Bagley 2003b, 2006a, 2008, Bagley et al. 2014, 2017). Near-bottom layers may also contain mesopelagic species, which contribute to the acoustic backscatter, but which are not sampled by the bottom trawl (e.g., O'Driscoll et al. 2009), and conversely some fish caught by the trawl may not be measured acoustically (e.g., species close to bottom in acoustic deadzone).

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). Estimated mesopelagic indices by region are summarised in Table 14 and plotted in Figure 17. As in previous years, the mesopelagic indices were similar to estimates of total backscatter for the Sub-Antarctic (see Figure 15). Overall estimates of mesopelagic backscatter in 2016 were 33% lower than in 2014 due to reductions in the eastern Sub-Antarctic and on the Stewart-Snares shelf (Figure 17). Conversely, mesopelagic backscatter increased in western Sub-Antarctic strata and the 2016 value for this subarea was the highest in the time-series.

3.9 Hydrological data

Temperature profiles were available from 57 CTD casts (including the foul tow). Surface (5 m depth) temperatures ranged between 8.4 and 12.6 °C (Figure 18), while bottom temperatures were between 5.6 and 10.3 °C (Figure 19). The highest surface and bottom temperatures were in shallow water at Puysegur, with lowest 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 18–19).

The average surface temperature in 2016 of 9.5 °C was similar to that observed in 2014 (9.4 °C) and 2012 (9.6 °C), and 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, 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). Despite the rough conditions in 2016, there was a well-established thermocline east of the Auckland Islands, extending to over 100 m depth (Figure 20). Average bottom temperatures in 2016 (7.1 °C) were the same as those observed in 2014 and 2012, which were slightly higher than average bottom 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. The average bottom temperature in 2016 should also be interpreted with caution, as there were few deeper tows which have lower bottom temperatures.

4. DISCUSSION AND CONCLUSIONS

An unprecedented amount of survey time was lost due to bad weather (8 days) which meant that the core trawl survey strata were unable to be completed for the first time in the trawl time-series. Biomass estimates were scaled up using a factor based on proportion of each species biomass in missing strata in previous surveys. Some species may be poorly estimated by this procedure if a high proportion of biomass came from missing strata. Species with scaling factors greater than 1.5 (i.e., where, on average, more than 50% of the core biomass came from missing strata in previous surveys from 2000–14) included shovelnosed dogfish, giant stargazer, southern Ray's bream, sea perch, red cod, Bollons's rattail, silver warehou, and leafscale gulper shark. The increased 2016 survey uncertainty due to scaling is reflected in the high CVs for these species in Tables 6 and 8.

The estimated scaling factors for hoki, hake, and ling were 1.14, 1.09, and 1.13 respectively. The hoki biomass estimate for completed core strata (those with more than two stations surveyed) was 33 390 t (CV 14%). The scaled biomass estimate for hoki in all core (300–800 m) strata was 37 992 t (17%). Abundance estimates for completed strata and scaled for core strata were 23 534 t (13.8%) and 26 656 t (16 %) respectively for ling, and 919 t (25%) and 1000 t (25%) respectively for hake.

The scaled estimate of core hoki biomass in 2016 was 21% higher than that in 2014. Both the 2014 and 2016 estimates were lower than core estimates from 2007–12 surveys, but higher than those from the 'four low years' in 2003–06. 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 (O'Driscoll et al. 2015). Age data from the time series show 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. Recent hoki assessments have been unable to fit the survey biomass estimates well and this leads to a relatively high process error (37%) being estimated for the Sub-Antarctic trawl surveys by the 2016 assessment model (McKenzie 2017).

Ling biomass estimates increased from 2009 to 2014, but decreased by 11% in 2016. However, the 2016 ling estimate was still above average for the time series. Hake biomass decreased by 9% from 2014 and was the third lowest in the time series. Of nine other key species, southern blue whiting and lookdown dory showed large increases from 2014 to 2016. The 2016 estimate for southern blue whiting was 3.5 times higher than that in 2014, and the second highest in the time-series (behind 2009). The biomass of lookdown dory increased to previous levels after being low in 2011–14 (see Table 8, Figure 4). Changes in biomass from 2014 to 2016 were within the levels of the sampling uncertainty for spiny dogfish, black oreo, dark ghost shark, and white warehou. Both pale ghost shark and ribaldo showed large declines in 2016 and were at the lowest level in their respective time-series (see Table 8, Figure 4). Javelinfish also declined in 2016, to the second lowest point in their time-series (behind 1992).

For most Tier 2 species, the trawl survey provides the only fisheries-independent estimate of abundance in the Southland and Sub-Antarctic area, as well as providing biological data (length, sex, reproductive condition, age, etc.). It is difficult to assess the "quality" of trawl estimates for many of these species, as there are often no alternative indices of abundance (either from stock assessment or reliable CPUE indices). However, the relatively good precision (CVs) of survey estimates, consistency of abundance estimates and length-frequency distributions between surveys, and appropriate spatial and depth distribution, suggest that the Sub-Antarctic survey provides potential for monitoring species including lookdown dory, javelinfish, pale ghost shark, and ribaldo (see Bagley et al. 2013a).

The hoki age frequency in 2016 showed a strong mode of 1+ fish (2015 year-class), but fewer 2+ and 3+ fish than were recorded in the previous survey in 2014 (Figure 8a). The relatively large 2011 year class seen at age 3+ in 2014 tracked through as age 5+ fish in 2016. Ling continue to show a relatively broad age structure (Figure 8b). There were too few hake caught in 2016 to estimate proportions at age.

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7. TABLES

Table 1: Stratum areas, depths, and number of successful biomass stations from the November–December 2016 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)	Phase 1 allocation	Completed stations
1	Puysegur Bank	300–600	2 150	4	1
2	Puysegur Bank	600–800	1 318	4	0
3a	Stewart-Snares	300–600	4 548	4	1
3b	Stewart-Snares	300–600	1 556	4	2
4	Stewart-Snares	600–800	21 018	4	4
5a	Snares-Auckland	600–800	2 981	5	2
5b	Snares-Auckland	600–800	3 281	4	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	3	3
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	5	5
12	Pukaki	300–600	45 259	7	7
13	N.E. Camp. Plateau	300–600	36 051	5	5
14	E. Camp. Plateau	300–600	27 659	3	3
15	E. Camp. Plateau	600–800	15 179	3	3
25	Puysegur Bank	800–1 000	1 928	5	0
27	N.E. Pukaki Rise	800–1 000	12 986	3	0
28	E. Stewart Is.	800–1 000	8 336	4	2
Total			288 417	82	56

Table 2: Length-weight regression parameters* used to scale length frequencies. Where data source is given as 'All surveys' length-weight parameters were estimated from combined data from 1991–1993, and 2000–2009, 2011, 2012, 2014, and 2016 surveys. * 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.

Common name	Code	a	b	r^2	n	Length range	Data source
Banded rattail	CFA	0.003305	3.091944	91	215	18.7–35.6	tan1614
Baxter's lantern dogfish	ETB	0.002847	3.150190	98	3 919	20.3–82.4	All surveys
Black oreo	BOE	0.027405	2.915292	89	3 425	17.7–40.8	All surveys
Bollons's rattail	CBO	0.001073	3.436078	99	1 620	26.1–72.1	All surveys
Finless flounder	MAN	0.023639	2.740225	90	50	33.6–58.9	tan1614
Four–rayed rattail	CSU	0.003664	2.829288	86	1 983	12.9–40.7	All surveys
Dark ghost shark	GSH	0.002057	3.273146	97	3 250	25.8–74.2	All surveys
Hairy conger	HCO	0.000598	3.303166	98	224	24.6–95	All surveys
Hake	HAK	0.001946	3.298847	98	9 420	41.3–131	All surveys
Hoki	HOK	0.004681	2.889845	97	34 267	27.7–115.7	All surveys
Javelinfish	JAV	0.000977	3.229258	97	845	18.1–57.3	tan1614
Ling	LIN	0.001021	3.356020	97	746	43.4–125.8	tan1614
Long-nosed chimaera	LCH	0.003533	2.975893	97	952	23.2–97.9	All surveys
Longnose velvet dogfish	CYP	0.001590	3.255833	99	2 638	25.3–102.9	All surveys
Lookdown dory	LDO	0.017895	3.090515	99	110	13.7–51.5	tan1614
Lucifer dogfish	ETL	0.001355	3.236103	94	1 879	21.6–53.9	All surveys
NZ southern arrow squid	NOS	0.021894	3.027965	89	1 768	15.7–38.8	All surveys
Oblique banded rattail	CAS	0.002023	3.237181	92	391	19.1–44.9	tan1614
Oliver's rattail	COL	0.017678	2.449788	80	4 443	12.2–40.3	All surveys
Pale ghost shark	GSP	0.015348	2.765428	96	238	31.2–82.3	tan1614
Ribaldo	RIB	0.004946	3.194688	98	3 201	21.2–75	All surveys
Ridge scaled rattail	MCA	0.005782	2.970023	97	4 351	22.1–102	All surveys
Silverside	SSI	0.012568	2.800634	84	5 369	13.6–35.3	All surveys
Smallscaled brown slickhead	SSM	0.005609	3.119166	97	2 267	16.9–73.7	All surveys
Smooth oreo	SSO	0.028802	2.917161	98	4 106	15.8–51	All surveys
Southern blue whiting	SBW	0.004185	3.127680	98	525	16.8–52.1	tan1614
Southern Ray's bream	SRB	0.008443	3.190883	88	66	40.5–53.7	All surveys
Spineback	SBK	0.002149	2.958293	82	723	42–80.4	All surveys
Spiny dogfish	SPD	0.001093	3.317071	94	5 814	46–102.9	All surveys
Swollenhead conger	SCO	0.000064	3.811578	95	52	52.8–87.7	tan1614
White warehou	WWA	0.024080	2.963212	98	2 649	22.7–64.2	All surveys
Widenosed chimaera	RCH	0.000694	3.197716	98	319	28.6–155.6	All surveys

Table 3: Survey tow and gear parameters (recorded values only) from the November–December 2016 Southland and Sub-Antarctic trawl survey. Values are number of tows (n), and the mean, standard deviation (s.d.), and range of observations for each parameter.

	Depth of bottom (m)	n	Mean	s.d.	Range
Tow parameters					
Tow length (n.miles)		56	2.99	0.19	2.16–3.89
Tow speed (knots)		56	3.5	0.08	3.2–3.7
Gear parameters (m)					
Headline height	300–600	28	7.0		
	600–800	26	6.8		
	800–1000	2	6.8		
	All depths	56	6.9	0.27	6.3–7.8
Doorspread	300–600	28	122.3		
	600–800	26	126.3		
	800–1000	2	122.9		
	All depths	56	124.3	5.64	111.5–139.7

Table 4: Comparison of doorspread and headline measurements from all surveys in the summer *Tangaroa* Southland and Sub-Antarctic 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
2016	56	124.3	5.64	111.5	139.7	6.9	0.27

Table 5: Total catch of the top 50 species from all tows during the survey.

Code	Common name	Scientific name	Catch (kg)
HOK	Hoki	*Macruronus novaezelandiae*	7 365.2
LIN	Ling	*Genypterus blacodes*	4 217.0
SBW	Southern blue whiting	*Micromesistius australis*	3 661.8
SPD	Spiny dogfish	*Squalus acanthias*	1 248.4
JAV	Javelinfish	*Lepidorhynchus denticulatus*	897.3
GSP	Pale ghost shark	*Hydrolagus bemisi*	526.3
NOS	NZ southern arrow squid	*Nototodarus sloanii*	256.2
HAK	Hake	*Merluccius australis*	214.6
MIQ	Warty squid	*Onykia ingens*	210.9
GSH	Dark ghost shark	*Hydrolagus novaezealandiae*	191.3
CAS	Oblique banded rattail	*Coelorinchus aspercephalus*	160.3
COL	Oliver's rattail	*Coelorinchus oliverianus*	152.3
CSQ	Leafscale gulper shark	*Centrophorus squamosus*	140.6
HYA	Floppy tubular sponge	*Hyalascus sp.*	117.1
MAN	Finless flounder	*Neoachiropsetta milfordi*	92.9
ETB	Baxter's lantern dogfish	*Etmopterus baxteri*	91.4
TAM	Tam O shanter urchin	*Echinothuriidae & Phormosomatidae*	88.8
MCA	Ridge scaled rattail	*Macrourus carinatus*	85.0
SCO	Swollenhead conger	*Bassanago bulbiceps*	80.8
LCH	Long-nosed chimaera	*Harriotta raleighana*	80.6
LDO	Lookdown dory	*Cyttus traversi*	76.6
WWA	White warehou	*Seriolella caerulea*	71.9
CYP	Longnose velvet dogfish	*Centroscymnus crepidater*	64.5
PYR	*Pyrosoma atlanticum*	*Pyrosoma atlanticum*	62.2
HCO	Hairy conger	*Bassanago hirsutus*	55.3
RIB	Ribaldo	*Mora moro*	54.5
GIZ	Giant stargazer	*Kathetostoma giganteum*	51.6
SBK	Spineback	*Notacanthus sexspinis*	51.6
SSI	Silverside	*Argentina elongata*	45.9
SSK	Smooth skate	*Dipturus innominatus*	44.8
CFA	Banded rattail	*Coelorinchus fasciatus*	44.6
RCH	Widenosed chimaera	*Rhinochimaera pacifica*	42.1
SWA	Silver warehou	*Seriolella punctata*	40.5
SRB	Southern Ray's bream	*Brama australis*	37.9
SCH	School shark	*Galeorhinus galeus*	34.7
CBO	Bollons's rattail	*Coelorinchus bollonsi*	30.5
TSQ	*Todarodes filippovae*	*Todarodes filippovae*	30.4
PMO	*Pseudostichopus mollis*	*Pseudostichopus mollis*	26.1
RUD	Rudderfish	*Centrolophus niger*	25.2
ETL	Lucifer dogfish	*Etmopterus lucifer*	21.6
BOE	Black oreo	*Allocyttus niger*	21.4
RCO	Red cod	*Pseudophycis bachus*	19.9
MRQ	Warty squid	*Onykia robsoni*	19.6
TOP	Pale toadfish	*Ambophthalmos angustus*	16.5
WHU	Whale skull (unspecified)		15.0
PLS	Plunket's shark	*Proscymnodon plunketi*	14.3
SND	Shovelnose dogfish	*Deania calcea*	13.3
RSO	Gemfish	*Rexea solandri*	10.9
SSM	Smallscaled brown slickhead	*Alepocephalus antipodianus*	10.9
GTA	Deepwater octopus	*Graneledone taniwha*	10.6
Total			21 096

Table 6: Catch and core (300–800 m) abundance estimates with coefficient of variation (CV in parentheses) of species ranked in order of decreasing abundance for the top 50 species in the 2016 survey. Total abundance includes unsexed fish. Scaled biomass estimates and CVs were adjusted to account for 'missing' strata (those with fewer than 2 tows) using a factor based on proportion of the species biomass in the 'missing' strata in the 13 previous surveys from 2000–14 (see Section 2.6). –, most fish unsexed; *, scaled biomass unable to be calculated as not enough data from old surveys.

		Catch (kg)		Biomass (t)		Scaled biomass (t)
Common name	Code	Core	Core male	Core female	Core total	Core total
Southern blue whiting	SBW	3 661.8	17 016 (12.7)	18 058 (17.8)	36 051 (12.9)	36 057 (13.0)
Hoki	HOK	7 357.8	10 890 (19.3)	22 481 (12.4)	33 390 (14.1)	37 992 (17.0)
Ling	LIN	4 213.7	6 060 (10.7)	17 447 (15.8)	23 534 (13.8)	26 656 (16.0)
Javelinfish	JAV	890.1	512 (16.4)	5 449 (15.0)	6 012 (14.5)	6 152 (15.0)
Pale ghost shark	GSP	515.3	2 398 (12.6)	1 702 (13.9)	4 100 (10.8)	4 160 (11.0)
Spiny dogfish	SPD	1 248.4	1 555 (39.9)	1 149 (34.7)	2 704 (36.8)	3 524 (41.0)
Oblique banded rattail	CAS	160.3	22 (44.6)	1 314 (20.3)	1 350 (20.5)	1 513 (26.0)
Warty squid	MIQ	206.8	-	-	1 297 (11.4)	1 311 (11.0)
Floppy tubular sponge	HYA	117.1	-	-	1 124 (24.0)	*
Hake	HAK	214.6	16 (100.0)	903 (24.4)	919 (24.5)	1 000 (25.0)
Finless flounder	MAN	92.5	212 (25.1)	265 (38.0)	833 (20.5)	833 (20.0)
Long-nosed chimaera	LCH	80.3	303 (40.6)	441 (27.9)	744 (24.1)	764 (24.0)
Dark ghost shark	GSH	191.3	243 (62.6)	347 (65.5)	704 (68.8)	808 (69.0)
Oliver's rattail	COL	152.1	187 (52.1)	413 (51.9)	630 (48.2)	644 (48.0)
Lookdown dory	LDO	76.6	300 (25.6)	325 (32.3)	629 (24.0)	675 (24.0)
Swollenhead conger	SCO	80.8	374 (25.7)	123 (29.8)	561 (22.4)	572 (22.0)
Leafscale gulper shark	CSQ	140.6	-	550 (52.1)	550 (52.1)	872 (67.0)
Silverside	SSI	45.9	115 (25.1)	216 (25.4)	444 (23.5)	446 (24.0)
White warehou	WWA	71.9	169 (58.1)	254 (67.8)	437 (50.0)	609 (65.0)
Hairy conger	HCO	55.3	274 (28.2)	41 (41.2)	393 (22.1)	403 (22.0)
NZ southern arrow squid	NOS	256.2	201 (26.6)	188 (61.2)	389 (38.9)	531 (44.0)
Baxter's lantern dogfish	ETB	75.7	141 (30.8)	238 (31.1)	379 (26.4)	382 (26.0)
Pyrosoma atlanticum	PYR	60.0	-	-	375 (16.2)	*
Smooth skate	SSK	44.8	204 (80.4)	100 (100.0)	303 (50.2)	323 (50.0)
Ridge scaled rattail	MCA	64.2	51 (78.2)	245 (43.1)	296 (38.9)	296 (39.0)
Southern Ray's bream	SRB	37.9	118 (45.4)	153 (36.7)	271 (37.6)	1 275 (190.0)
Ribaldo	RIB	54.5	-	260 (28.7)	260 (28.7)	276 (29.0)
Spineback	SBK	51.6	21 (82.6)	196 (26.1)	220 (26.5)	220 (27.0)
Pseudostichopus mollis	PMO	25.5	-	-	210 (34.3)	*
Whale bone	WHU	15.0	-	-	200 (100.0)	*
Tam O shanter urchin	TAM	87.8	-	-	192 (100.0)	*
Todarodes filippovae	TSQ	29.3	-	-	170 (33.6)	*
Banded rattail	CFA	31.4	24 (20.8)	102 (20.5)	169 (18.5)	174 (19.0)
Warty squid	MRQ	19.6	-	-	127 (73.0)	*
Rudderfish	RUD	25.2	-	29 (100.0)	119 (79.7)	*
Pale toadfish	TOP	12.1	-	-	111 (53.1)	*
Bollons's rattail	CBO	30.5	3 (23.8)	94 (21.6)	105 (14.1)	185 (39.0)
Lucifer dogfish	ETL	21.6	57 (25.0)	25 (40.4)	82 (19.6)	94 (21.0)
Shovelnose dogfish	SND	13.3	20 (70.9)	54 (80.8)	74 (59.8)	796 (150.0)
Giant stargazer	GIZ	51.6	19 (91.7)	53 (86.3)	72 (67.7)	422 (173.0)
Plunket' shark	PLS	14.3	50 (100.0)	12 (100.0)	62 (82.9)	65 (84.0)
Silver warehou	SWA	40.5	47 (100.0)	4 (100.0)	51 (100.0)	85 (115.0)
Red cod	RCO	19.9	6 (11.4)	36 (70.7)	42 (60.5)	123 (161.0)
School shark	SCH	34.7	-	-	38 (100.0)	*
Deepwater octopus	GTA	10.6	-	-	29 (75.2)	*
Gemfish	RSO	10.9	8 (100.0)	5 (100.0)	14 (100.0)	*
Sea perch	SPE	7.3	5 (43.1)	3 (76.8)	9 (4.9)	29 (127.0)
Rough skate	RSK	6.6	6 (100.0)	-	6 (100.0)	6 (100.0)
Four-rayed rattail	CSU	0.6	-	-	3 (68.2)	2 (78.0)
Black oreo	BOE	0.3	-	2 (100.0)	2 (100.0)	2 (100.0)

Table 7: Estimated biomass (t) and CVs (%, below in parentheses) by stratum of the top 50 species in descending order of abundance in 2016 survey. Species codes are given in Appendix 3. Subtotal, biomass calculated from survey for strata 003B, 0004–0015; Core scaled, biomass scaled up for missing strata 0001, 0002, 003A; Core + 25 scaled, biomass scaled up for missing strata 0001, 0002, 003A and 0025. * Scaled biomass unable to be calculated as not enough data from old surveys.

							Species
Stratum	SBW	HOK	LIN	JAV	GSP	SPD	CAS
003B	-	3 568 (70.5)	130 (57.9)	-	-	1 237 (75.2)	5 (100.0)
0004	-	7 032 (28.6)	2 076 (20.1)	393 (39.4)	212 (45.1)	-	-
005A	-	198 (17.8)	543 (35.4)	56 (55.3)	55 (50.8)	25 (100.0)	-
005B	-	468 (42.3)	346 (41.6)	167 (9.4)	55 (11.3)	87 (54.1)	-
0006	1 060 (44.9)	578 (31.4)	1 326 (25.3)	168 (75.2)	304 (50.2)	226 (58.7)	235 (37.2)
0007	-	796 (32.4)	414 (44.6)	323 (29.7)	52 (64.3)	-	2 (100.0)
0008	17 (61.1)	2 138 (48.7)	1 223 (46.5)	312 (22.5)	209 (25.2)	19 (50.3)	-
0009	2 570 (35.5)	4 588 (33.4)	2 964 (31.0)	1 144 (37.5)	532 (26.7)	617 (47.4)	407 (59.6)
0010	-	675 (33.7)	67 (59.4)	137 (13.9)	37 (56.3)	-	-
0011	514 (63.7)	3 457 (11.7)	761 (30.4)	822 (14.5)	63 (44.7)	-	5 (100.0)
0012	12 751 (28.7)	2 598 (54.1)	3 639 (19.6)	202 (36.8)	1 206 (18.8)	146 (51.3)	329 (15.4)
0013	4 309 (28.2)	4 532 (50.2)	6 159 (46.7)	1 050 (38.7)	657 (44.0)	278 (43.2)	246 (33.8)
0014	10 522 (12.4)	1 810 (41.5)	3 365 (12.6)	718 (76.1)	614 (10.5)	69 (57.1)	115 (13.6)
0015	4 309 (45.9)	952 (53.0)	522 (26.3)	519 (36.0)	104 (7.3)	-	6 (100.0)
Core subtotal	36 051 (12.9)	33 390 (14.1)	23 534 (13.8)	6 012 (14.5)	4 100 (10.8)	2 704 (36.8)	1 350 (20.5)
Core scaled	36 057 (13.0)	37 992 (17.0)	26 656 (16.0)	6 152 (15.0)	4 160 (11.0)	3 524 (41.0)	1 513 (26.0)
Core + 25 scaled	36 057 (13.0)	38 199 (17.0)	26 677 (16.0)	6 328 (15.0)	4 163 (11.0)	3 524 (41.0)	1 513 (26.0)

								Species
Stratum	MIQ	HYA	HAK	MAN	LCH	GSH	COL	LDO
003B	-	-	-	-	-	144 (21.6)	-	9 (100.0)
0004	10 (89.9)	-	35 (100.0)	18 (100.0)	-	-	16 (47.2)	-
005A	18 (34.1)	-	59 (100.0)	-	2 (100.0)	-	2 (71.8)	1 (100.0)
005B	11 (18.1)	1 (100.0)	107 (50.2)	1 (100.0)	-	-	34 (8.8)	-
0006	9 (50.0)	-	226 (54.0)	-	-	502 (96.0)	-	35 (80.5)
0007	87 (21.6)	-	174 (55.9)	17 (52.6)	-	2 (100.0)	421 (71.0)	6 (100.0)
0008	126 (40.1)	-	173 (74.6)	-	15 (100.0)	-	47 (64.2)	4 (100.0)
0009	127 (32.4)	198 (83.6)	145 (31.8)	205 (60.2)	78 (63.8)	35 (100.0)	44 (62.1)	86 (67.1)
0010	196 (40.2)	17 (58.4)	-	15 (59.2)	7 (100.0)	-	18 (100.0)	-
0011	311 (24.4)	58 (56.0)	-	26 (64.8)	19 (100.0)	-	28 (70.7)	-
0012	30 (59.3)	164 (53.4)	-	75 (25.3)	316 (37.6)	23 (100.0)	-	145 (31.3)
0013	81 (36.0)	172 (46.3)	-	138 (54.3)	287 (42.0)	-	1 (100.0)	112 (42.7)
0014	101 (31.4)	437 (36.3)	-	321 (26.2)	21 (100.0)	-	1 (100.0)	201 (58.7)
0015	190 (28.6)	76 (90.6)	-	17 (52.6)	-	-	18 (63.1)	29 (53.0)
Core subtotal	1 297 (11.4)	1 124 (24.0)	919 (24.5)	833 (20.5)	744 (24.1)	704 (68.8)	630 (48.2)	629 (24.0)
Core scaled	1 311 (11.0)	*	1 000 (25.0)	833 (20.0)	764 (24.0)	808 (69.0)	644 (48.0)	675 (24.0)
Core + 25 scaled	1 326 (11.0)	*	1 373 (34.0)	833 (20.0)	764 (24.0)	808 (69.0)	644 (48.0)	676 (24.0)

Table 7: continued.

Stratum	SCO	CSQ	SSI	WWA	HCO	NOS	ETB	PYR
								Species
003B	-	-	-	30 (100.0)	-	267 (52.7)	-	2 (100.0)
0004	47 (67.1)	-	5 (61.5)	-	61 (47.5)	-	15 (100.0)	38 (55.8)
005A	-	136 (100.0)	-	-	-	2 (100.0)	41 (100.0)	-
005B	-	-	- (100.0)	-	2 (100.0)	1 (100.0)	7 (51.7)	2 (64.6)
0006	-	80 (100.0)	16 (100.0)	11 (100.0)	-	84 (62.0)	-	10 (33.6)
0007	78 (89.8)	194 (100.0)	-	-	35 (83.7)	4 (100.0)	-	78 (37.0)
0008	68 (27.7)	141 (100.0)	5 (50.1)	-	25 (57.3)	-	-	-
0009	155 (52.0)	-	115 (73.1)	-	115 (57.2)	31 (67.2)	-	20 (88.3)
0010	-	-	-	-	4 (100.0)	-	85 (44.8)	25 (43.9)
0011	37 (44.1)	-	-	-	11 (62.1)	-	131 (49.0)	47 (70.2)
0012	47 (45.8)	-	70 (69.6)	222 (64.8)	66 (33.2)	-	-	58 (36.9)
0013	90 (44.5)	-	88 (28.8)	-	54 (34.8)	-	-	10 (63.4)
0014	21 (100.0)	-	145 (17.0)	173 (93.1)	21 (100.0)	-	-	47 (8.8)
0015	17 (71.3)	-	1 (100.0)	-	-	-	100 (50.2)	37 (51.6)
Core subtotal	561 (22.4)	550 (52.1)	444 (23.5)	437 (50.0)	393 (22.1)	389 (38.9)	379 (26.4)	375 (16.2)
Core scaled	572 (22.0)	872 (67.0)	446 (24.0)	609 (65.0)	403 (22.0)	531 (44.0)	382 (26.0)	*
Core + 25 scaled	573 (22.0)	917 (68.0)	446 (24.0)	609 (65.0)	403 (22.0)	535 (44.0)	386 (26.0)	*

Stratum	SSK	MCA	SRB	RIB	SBK	PMO	WHU	TAM
								Species
003B	-	-	11 (100.0)	-	-	-	-	-
0004	303 (50.2)	22 (100.0)	47 (100.0)	68 (64.8)	23 (100.0)	-	-	-
005A	-	-	-	23 (9.5)	-	-	-	192 (100.0)
005B	-	-	-	7 (50.1)	33 (86.1)	-	-	-
0006	-	-	-	-	-	-	-	-
0007	-	87 (79.3)	-	42 (83.9)	34 (35.2)	4 (100.0)	-	-
0008	-	-	37 (100.0)	-	11 (100.0)	-	-	-
0009	-	-	18 (100.0)	13 (100.0)	-	44 (83.6)	-	-
0010	-	187 (47.9)	-	31 (57.4)	26 (8.6)	15 (100.0)	-	-
0011	-	-	-	76 (57.1)	92 (45.9)	32 (40.8)	-	-
0012	-	-	139 (55.7)	-	-	23 (50.1)	200 (100.0)	-
0013	-	-	20 (100.0)	-	-	30 (95.7)	-	-
0014	-	-	-	-	-	59 (83.0)	-	-
0015	-	-	-	-	-	2 (100.0)	-	-
Core subtotal	303 (50.2)	296 (38.9)	271 (37.6)	260 (28.7)	220 (26.5)	210 (34.3)	200 (100.0)	192 (100.0)
Core scaled	323 (50.0)	296 (39.0)	1 275 (190.0)	276 (29.0)	220 (27.0)	*	*	*
Core + 25 scaled	326 (50.0)	345 (40.0)	1 277 (190.0)	297 (29.0)	224 (27.0)	*	*	*

Stratum	TSQ	CFA	MRQ	RUD	TOP	CBO	ETL	SND
								Species
003B	-	-	-	-	-	-	-	-
0004	-	23 (54.6)	-	91 (100.0)	-	81 (12.9)	8 (47.5)	42 (100.0)
005A	4 (100.0)	24 (68.7)	-	29 (100.0)	-	6 (23.8)	11 (83.9)	-
005B	-	3 (42.9)	-	-	-	10 (53.6)	1 (50.9)	-
0006	29 (100.0)	-	-	-	-	-	4 (100.0)	-
0007	17 (100.0)	3 (32.6)	-	-	-	-	14 (68.5)	9 (100.0)
0008	26 (100.0)	8 (43.7)	80 (100.0)	-	-	-	1 (100.0)	-
0009	-	38 (43.3)	-	-	-	9 (100.0)	1 (100.0)	-
0010	38 (37.6)	7 (12.7)	47 (100.0)	-	-	-	41 (17.6)	23 (50.1)
0011	46 (73.9)	13 (47.5)	-	-	12 (100.0)	-	1 (100.0)	-
0012	-	8 (55.4)	-	-	42 (100.0)	-	-	-
0013	-	23 (46.7)	-	-	36 (100.0)	-	-	-
0014	-	13 (68.8)	-	-	9 (100.0)	-	-	-
0015	10 (100.0)	4 (28.8)	-	-	10 (100.0)	-	-	-
Core subtotal	170 (33.6)	169 (18.5)	127 (73.0)	119 (79.7)	111 (53.1)	105 (14.1)	82 (19.6)	74 (59.8)
Core scaled	*	174 (19.0)	*	*	*	185 (39.0)	94 (21.0)	796 (150.0)
Core + 25 scaled	*	175 (19.0)	*	*	*	187 (39.0)	96 (21.0)	976 (141.0)

Table 7: continued.

	Species							
Stratum	PLS	SWA	RCO	SCH	GTA	RSO	SPE	RSK
003B	-	51 (100.0)	17 (29.5)	38 (100.0)	-	14 (100.0)	9 (4.9)	6 (100.0)
0004	-	-	-	-	-	-	-	-
005A	-	-	-	-	20 (100.0)	-	-	-
005B	12 (100.0)	-	-	-	-	-	-	-
0006	-	-	-	-	-	-	-	-
0007	-	-	-	-	-	-	-	-
0008	-	-	-	-	-	-	-	-
0009	-	-	-	-	-	-	-	-
0010	-	-	-	-	-	-	-	-
0011	50 (100.0)	-	-	-	9 (100.0)	-	-	-
0012	-	-	25 (100.0)	-	-	-	-	-
0013	-	-	-	-	-	-	-	-
0014	-	-	-	-	-	-	-	-
0015	-	-	-	-	-	-	-	-
Core subtotal	62 (82.9)	51 (100.0)	42 (60.5)	38 (100.0)	29 (75.2)	14 (100.0)	9 (4.9)	6 (100.0)
Core scaled	65 (84.0)	85 (115.0)	123 (161.0)	*	*	*	29 (127.0)	6 (100.0)
Core + 25 scaled	75 (94.0)	85 (115.0)	123 (161.0)	*	*	*	29 (127.0)	6 (100.0)

	Species
Stratum	BOE
003B	-
0004	-
005A	-
005B	-
0006	-
0007	-
0008	-
0009	-
0010	-
0011	2 (100.0)
0012	-
0013	-
0014	-
0015	-
Core subtotal	2 (100.0)
Core scaled	2 (100.0)
Core + 25 scaled	2 (100.0)

Table 8: Trawl abundance estimates (t) and coefficients of variation (in parentheses) comparisons for main species for the core strata (300–800 m), and all strata (200–1000 m) from the surveys in the summer *Tangaroa* time series. Estimates from 2016 are scaled core biomass. Species are from the list of the top 50 in the 2016 survey where there were enough data from previous surveys, sorted alphabetically by species code.

	BOE		CAS		CBO	
Year	Core	All	Core	All	Core	All
1991	4 123 (97.3)	4 123 (97.3)	1 543 (31.0)	1 543 (31.0)	326 (21.1)	329 (20.9)
1992	1 959 (97.1)	1 959 (97.1)	1 862 (24.2)	1 863 (24.2)	413 (28.4)	415 (28.2)
1993	-	-	3 038 (14.3)	3 038 (14.3)	186 (29.4)	186 (29.3)
2000	10 063 (97.3)	13 096 (75.7)	1 749 (14.2)	1 749 (14.2)	667 (40.8)	670 (40.7)
2001	6 (83.9)	17 276 (57.8)	1 277 (20.3)	1 280 (20.3)	599 (27.7)	610 (27.2)
2002	12 (66.9)	19 719 (95.7)	1 418 (34.1)	1 418 (34.1)	336 (32.8)	336 (32.8)
2003	4 642 (99.8)	21 525 (71.1)	905 (25.1)	905 (25.1)	173 (41.5)	173 (41.5)
2004	198 (100.0)	867 (66.5)	1 752 (16.1)	1 752 (16.1)	208 (22.8)	220 (22.0)
2005	41 986 (100.0)	42 887 (97.9)	755 (17.4)	755 (17.4)	159 (17.8)	159 (17.8)
2006	482 (100.0)	6 802 (70.3)	1 352 (56.1)	1 352 (56.1)	166 (52.0)	180 (48.3)
2007	1 979 (95.1)	2 675 (71.9)	2 223 (22.4)	2 223 (22.4)	347 (25.4)	347 (25.4)
2008	2 708 (87.3)	7 848 (48.9)	1 805 (28.1)	1 806 (28.1)	551 (43.4)	552 (43.3)
2009	1 042 (76.3)	4 888 (52.3)	871 (23.4)	871 (23.4)	454 (19.2)	458 (19.0)
2011	125 (51.6)	2 038 (35.7)	755 (26.8)	755 (26.8)	245 (26.3)	245 (26.3)
2012	84 (55.6)	1 279 (36.1)	2 085 (26.1)	2 085 (26.1)	459 (59.1)	466 (58.3)
2014	508 (97.2)	1 229 (42.9)	574 (22.2)	574 (22.2)	627 (34.8)	628 (34.7)
2016	2 (100.0)	-	1 513 (26.0)	-	185 (39.0)	-

	CFA		COL		CSQ	
Year	Core	All	Core	All	Core	All
1991	349 (12.4)	349 (12.4)	565 (17.6)	567 (17.6)	541 (32.2)	542 (32.1)
1992	170 (17.9)	175 (17.6)	168 (11.9)	170 (11.8)	341 (30.5)	346 (30.1)
1993	949 (10.3)	952 (10.2)	1 173 (13.5)	1 173 (13.5)	631 (28.7)	653 (27.8)
2000	1 164 (10.4)	1 608 (13.6)	1 185 (12.3)	1 191 (12.3)	819 (38.0)	832 (37.4)
2001	883 (14.4)	1 338 (12.2)	1 611 (36.9)	1 620 (36.7)	575 (35.4)	627 (32.8)
2002	391 (36.6)	696 (23.9)	555 (22.5)	556 (22.4)	197 (36.2)	214 (33.4)
2003	694 (18.9)	826 (16.1)	1 407 (24.8)	1 407 (24.8)	348 (51.2)	375 (47.5)
2004	812 (21.9)	1 015 (20.1)	1 823 (31.2)	1 824 (31.2)	376 (48.9)	404 (45.6)
2005	835 (20.8)	1 130 (17.6)	2 284 (23.3)	2 302 (23.2)	560 (28.8)	594 (27.2)
2006	1 230 (11.6)	1 534 (10.4)	3 776 (16.7)	3 779 (16.7)	810 (36.0)	831 (35.2)
2007	484 (13.6)	630 (11.6)	1 587 (32.4)	1 587 (32.4)	1 135 (25.8)	1 155 (25.3)
2008	1 855 (16.2)	2 305 (13.7)	2 663 (16.4)	2 663 (16.4)	785 (26.7)	813 (25.9)
2009	1 006 (14.1)	1 359 (13.6)	2 451 (17.7)	3 058 (24.2)	1 079 (34.8)	1 104 (34.0)
2011	822 (12.9)	993 (11.4)	1 323 (31.2)	1 324 (31.2)	664 (32.0)	680 (31.3)
2012	1 717 (16.3)	2 349 (12.3)	4 489 (16.9)	4 491 (16.9)	804 (26.8)	833 (26.0)
2014	993 (11.9)	1 462 (12.1)	3 033 (17.2)	3 034 (17.2)	467 (35.4)	489 (33.9)
2016	174 (19.0)	-	644 (48.0)	-	872 (67.0)	-

	CSU		ETB		ETL	
Year	Core	All	Core	All	Core	All
1991	17 (78.0)	40 (40.0)	410 (22.2)	410 (22.2)	96 (17.7)	96 (17.6)
1992	4 (45.9)	14 (42.2)	686 (50.9)	686 (50.9)	381 (66.2)	383 (65.9)
1993	54 (49.4)	100 (48.1)	1 223 (22.3)	1 224 (22.3)	167 (18.7)	169 (18.4)
2000	8 (52.6)	949 (20.1)	1 004 (23.9)	2 540 (16.0)	102 (21.4)	109 (20.2)
2001	30 (80.6)	569 (33.5)	695 (31.0)	1 781 (15.7)	153 (20.5)	158 (19.9)
2002	12 (72.7)	631 (25.8)	734 (28.6)	2 334 (15.8)	156 (20.1)	161 (19.5)
2003	7 (40.5)	168 (24.5)	764 (30.2)	1 665 (25.3)	120 (24.0)	123 (23.4)
2004	15 (41.5)	358 (55.0)	994 (25.7)	1 628 (21.0)	246 (17.3)	256 (16.8)
2005	13 (63.6)	894 (50.0)	1 196 (33.6)	2 144 (22.0)	201 (14.4)	213 (13.9)
2006	8 (52.6)	242 (31.6)	1 942 (30.8)	3 318 (19.5)	301 (24.1)	304 (23.9)
2007	5 (77.9)	616 (27.3)	1 407 (32.1)	2 583 (20.4)	113 (21.5)	115 (21.0)
2008	31 (32.5)	677 (44.4)	831 (20.1)	2 269 (21.0)	153 (15.9)	167 (14.9)
2009	33 (43.5)	541 (30.8)	1 081 (22.4)	3 008 (16.8)	210 (23.4)	235 (21.9)
2011	33 (43.3)	625 (27.1)	3 136 (34.6)	5 088 (27.6)	247 (24.2)	255 (23.6)
2012	8 (66.0)	392 (27.5)	1 068 (20.4)	2 128 (13.6)	259 (12.7)	275 (12.9)
2014	58 (91.5)	405 (19.5)	1 039 (22.5)	1 830 (16.8)	235 (23.2)	237 (23.1)
2016	2 (78.0)	-	382 (26.0)	-	94 (21.0)	-

Table 8: continued.

Year	GIZ Core	GIZ All	GSH Core	GSH All	GSP Core	GSP All
1991	365 (21.6)	365 (21.6)	1 067 (25.6)	1 067 (25.6)	11 287 (6.1)	11 291 (6.1)
1992	342 (26.9)	344 (26.8)	715 (42.8)	716 (42.7)	4 795 (7.2)	4 797 (7.2)
1993	196 (29.4)	196 (29.4)	1 085 (33.3)	1 086 (33.3)	11 703 (9.4)	11 706 (9.4)
2000	211 (31.8)	211 (31.8)	1 459 (89.6)	1 459 (89.6)	16 937 (12.9)	17 823 (12.4)
2001	397 (41.3)	407 (40.3)	1 391 (35.7)	1 391 (35.7)	10 407 (9.3)	11 219 (8.8)
2002	409 (24.6)	409 (24.6)	175 (37.7)	175 (37.7)	8 971 (9.6)	9 297 (9.3)
2003	252 (43.2)	252 (43.2)	382 (48.9)	382 (48.9)	10 172 (8.8)	10 360 (8.7)
2004	294 (12.7)	298 (12.6)	843 (41.7)	843 (41.7)	8 215 (10.7)	8 549 (10.3)
2005	333 (33.8)	352 (32.1)	517 (40.2)	517 (40.2)	9 069 (10.5)	9 416 (10.2)
2006	187 (34.7)	214 (31.4)	354 (32.0)	354 (32.0)	12 142 (9.8)	12 619 (9.6)
2007	250 (24.6)	259 (23.9)	659 (37.2)	659 (37.2)	12 739 (10.9)	13 107 (10.6)
2008	371 (35.0)	371 (35.0)	1 128 (32.1)	1 128 (32.1)	9 334 (13.4)	10 097 (12.6)
2009	554 (32.7)	567 (31.9)	433 (43.1)	433 (43.1)	13 147 (9.1)	13 553 (8.8)
2011	290 (42.6)	291 (42.4)	3 709 (75.0)	3 709 (75.0)	11 677 (9.6)	12 579 (9.1)
2012	292 (28.8)	292 (28.8)	1 794 (68.3)	1 794 (68.3)	16 181 (12.6)	16 814 (12.2)
2014	461 (38.1)	461 (38.1)	1 400 (46.7)	1 400 (46.7)	11 725 (10.1)	12 134 (9.8)
2016	422 (173.0)	-	808 (69.0)	-	4 160 (11.0)	-

Year	HAK Core	HAK All	HCO Core	HCO All	HOK Core	HOK All
1991	6 134 (47.5)	6 447 (45.2)	392 (22.0)	397 (21.7)	81 631 (6.8)	81 816 (6.8)
1992	1 860 (12.0)	2 146 (11.7)	181 (21.2)	181 (21.2)	88 053 (6.1)	88 384 (6.1)
1993	2 348 (12.3)	3 007 (14.7)	480 (13.4)	480 (13.4)	100 629 (9.2)	101 112 (9.2)
2000	2 194 (17.0)	3 102 (14.4)	555 (19.3)	574 (18.9)	55 663 (12.6)	56 407 (12.4)
2001	1 831 (24.0)	2 360 (19.1)	416 (17.7)	425 (17.5)	38 145 (15.5)	39 396 (15.0)
2002	1 283 (19.8)	2 037 (16.3)	427 (20.7)	443 (20.0)	39 890 (13.7)	40 502 (13.5)
2003	1 335 (24.1)	1 898 (20.6)	366 (26.2)	378 (25.5)	14 318 (12.9)	14 723 (12.6)
2004	1 250 (26.7)	1 774 (20.1)	360 (72.4)	361 (72.1)	17 593 (11.8)	18 114 (11.6)
2005	1 133 (19.9)	1 624 (17.3)	184 (22.3)	206 (22.6)	20 440 (12.8)	20 680 (12.7)
2006	998 (22.1)	1 588 (16.6)	129 (28.8)	130 (28.7)	14 336 (10.7)	14 747 (10.5)
2007	2 188 (17.0)	2 622 (15.3)	440 (24.7)	453 (24.2)	45 876 (15.8)	46 003 (15.7)
2008	1 074 (22.6)	2 354 (15.6)	720 (19.8)	731 (19.6)	46 981 (13.9)	48 341 (13.6)
2009	992 (22.0)	1 602 (18.2)	306 (20.0)	309 (19.8)	65 017 (16.2)	66 157 (16.0)
2011	1 434 (30.0)	2 004 (22.8)	179 (46.2)	185 (44.7)	46 070 (14.7)	46 757 (14.5)
2012	1 943 (23.4)	2 443 (22.4)	459 (23.6)	468 (23.2)	55 739 (15.2)	56 131 (15.1)
2014	1 101 (31.7)	1 485 (25.0)	700 (23.7)	705 (23.5)	31 329 (12.9)	31 727 (12.8)
2016	1 000 (25.0)	-	403 (22.0)	-	37 992 (17.0)	-

Year	JAV Core	JAV All	LCH Core	LCH All	LDO Core	LDO All
1991	13 728 (12.6)	14 118 (12.3)	746 (13.4)	746 (13.4)	1 095 (12.8)	1 095 (12.8)
1992	5 365 (7.9)	5 517 (7.7)	694 (21.2)	694 (21.2)	1 048 (11.1)	1 048 (11.1)
1993	13 276 (11.4)	13 558 (11.1)	1 867 (15.2)	1 875 (15.1)	821 (13.2)	821 (13.2)
2000	18 340 (12.5)	18 773 (12.3)	1 606 (22.7)	1 720 (21.5)	921 (15.2)	921 (15.2)
2001	13 469 (12.8)	14 313 (12.1)	796 (20.2)	1 090 (21.6)	566 (19.7)	567 (19.6)
2002	7 118 (11.2)	7 525 (10.7)	1 179 (12.6)	1 242 (12.6)	446 (22.1)	446 (22.1)
2003	7 165 (10.6)	7 713 (10.1)	727 (30.2)	751 (29.2)	636 (23.7)	636 (23.7)
2004	16 515 (23.5)	17 517 (22.2)	435 (21.4)	517 (21.7)	614 (27.9)	614 (27.9)
2005	12 793 (10.0)	14 390 (9.7)	451 (20.2)	488 (18.9)	703 (19.1)	707 (18.9)
2006	13 928 (29.1)	14 573 (27.8)	1 178 (15.7)	1 219 (15.3)	513 (35.1)	514 (35.0)
2007	11 475 (12.0)	12 065 (11.8)	993 (25.5)	1 028 (24.7)	725 (20.0)	748 (19.6)
2008	45 605 (15.9)	48 695 (14.9)	625 (39.7)	697 (36.0)	811 (24.7)	813 (24.7)
2009	19 194 (17.5)	21 663 (16.1)	1 264 (18.2)	1 316 (17.5)	820 (25.1)	822 (25.1)
2011	8 860 (25.5)	9 140 (24.8)	726 (21.9)	862 (19.6)	349 (33.0)	349 (33.0)
2012	13 722 (12.4)	15 241 (12.0)	1 797 (15.8)	1 894 (15.0)	436 (29.1)	438 (29.0)
2014	7 695 (14.2)	8 220 (13.3)	889 (28.6)	985 (26.1)	352 (28.3)	352 (28.3)
2016	6 152 (15.0)	-	764 (24.0)	-	675 (24.0)	-

Table 8: continued.

	LIN		MAN		MCA	
Year	Core	All	Core	All	Core	All
1991	24 395 (6.8)	24 434 (6.7)	552 (14.7)	552 (14.7)	706 (38.7)	716 (38.1)
1992	21 633 (6.2)	21 652 (6.2)	453 (11.8)	453 (11.8)	180 (21.0)	183 (20.7)
1993	30 031 (11.4)	30 045 (11.4)	1 058 (12.7)	1 058 (12.7)	579 (35.9)	620 (33.8)
2000	33 023 (6.9)	33 033 (6.9)	1 064 (29.0)	1 064 (29.0)	695 (32.0)	9 278 (10.9)
2001	25 059 (6.5)	25 168 (6.5)	826 (18.4)	866 (17.7)	811 (39.0)	12 356 (29.3)
2002	25 628 (10.1)	25 635 (10.1)	843 (29.4)	847 (29.3)	620 (51.8)	12 892 (11.5)
2003	22 174 (10.2)	22 192 (10.2)	351 (17.2)	351 (17.2)	812 (41.9)	1 511 (25.6)
2004	23 744 (12.2)	23 794 (12.2)	530 (17.4)	537 (17.2)	248 (28.7)	888 (28.5)
2005	19 685 (8.5)	19 756 (8.5)	439 (17.8)	439 (17.8)	338 (35.5)	12 377 (59.0)
2006	19 637 (12.0)	19 661 (12.0)	870 (40.3)	874 (40.1)	827 (36.5)	2 581 (16.5)
2007	26 486 (8.3)	26 492 (8.3)	1 028 (19.3)	1 028 (19.3)	437 (42.6)	8 544 (19.1)
2008	22 832 (9.6)	22 880 (9.5)	1 164 (23.9)	1 195 (23.5)	951 (32.7)	11 198 (37.0)
2009	22 713 (9.7)	22 772 (9.6)	1 335 (25.6)	1 373 (25.0)	698 (54.3)	7 610 (28.0)
2011	23 178 (11.8)	23 336 (11.7)	523 (22.7)	524 (22.7)	1 321 (46.1)	9 913 (25.2)
2012	27 010 (11.3)	27 036 (11.3)	1 249 (34.7)	1 250 (34.7)	355 (31.5)	2 518 (41.6)
2014	30 005 (8.8)	30 011 (8.8)	513 (18.5)	513 (18.5)	672 (63.9)	2 492 (23.2)
2016	26 656 (16.0)	-	833 (20.0)	-	296 (39.0)	-

	MIQ		NOS		PLS	
Year	Core	All	Core	All	Core	All
1991	-	-	283 (32.3)	286 (32.0)	186 (38.4)	186 (38.4)
1992	1 863 (8.4)	1 872 (8.4)	105 (21.7)	106 (21.5)	134 (54.9)	134 (54.9)
1993	1 764 (9.0)	1 777 (9.0)	353 (53.7)	354 (53.6)	156 (46.9)	157 (46.8)
2000	1 754 (9.3)	2 191 (9.5)	328 (56.5)	331 (56.0)	-	3 (100.0)
2001	1 215 (12.4)	1 779 (10.6)	973 (21.2)	988 (20.9)	4 (74.2)	23 (78.7)
2002	1 151 (11.5)	1 414 (10.6)	298 (30.1)	303 (29.7)	322 (54.6)	327 (53.6)
2003	1 441 (14.0)	1 629 (12.8)	324 (40.4)	325 (40.3)	99 (76.2)	153 (57.7)
2004	1 489 (13.9)	1 690 (12.6)	232 (28.5)	232 (28.4)	6 (76.5)	11 (50.1)
2005	1 341 (11.2)	1 577 (10.0)	988 (35.6)	995 (35.3)	107 (73.8)	108 (73.2)
2006	1 251 (10.9)	1 359 (10.2)	235 (32.5)	239 (31.9)	103 (68.9)	114 (62.4)
2007	1 251 (15.7)	1 553 (13.2)	2 160 (85.9)	2 161 (85.9)	123 (67.9)	125 (66.8)
2008	1 161 (16.2)	1 484 (13.4)	388 (37.1)	396 (36.3)	- (100.0)	13 (86.5)
2009	1 454 (13.1)	1 779 (11.0)	561 (65.5)	563 (65.3)	197 (38.7)	202 (37.7)
2011	1 588 (12.5)	1 920 (10.7)	131 (15.0)	131 (15.0)	344 (47.5)	354 (46.1)
2012	1 958 (11.1)	2 229 (10.2)	707 (41.6)	711 (41.4)	158 (65.3)	203 (54.9)
2014	989 (13.7)	1 134 (12.2)	141 (19.1)	142 (19.0)	81 (58.4)	85 (55.6)
2016	1 311 (11.0)	-	531 (44.0)	-	65 (84.0)	-

	RCO		RIB		RSK	
Year	Core	All	Core	All	Core	All
1991	103 (51.4)	103 (51.4)	1 095 (10.9)	1 140 (10.6)	42 (72.8)	42 (72.8)
1992	72 (43.3)	72 (43.3)	535 (20.5)	589 (18.9)	52 (68.8)	52 (68.8)
1993	253 (62.1)	253 (62.1)	1 147 (12.6)	1 213 (12.2)	133 (56.9)	133 (56.9)
2000	38 (43.3)	38 (43.3)	873 (14.0)	938 (13.4)	201 (56.4)	201 (56.4)
2001	1 018 (79.7)	1 018 (79.7)	1 117 (14.6)	1 250 (13.3)	158 (51.3)	158 (51.3)
2002	60 (35.5)	60 (35.5)	656 (17.5)	722 (16.1)	55 (47.4)	83 (44.8)
2003	140 (49.3)	140 (49.3)	653 (18.9)	696 (17.9)	78 (42.9)	78 (42.9)
2004	2 765 (96.9)	2 765 (96.9)	951 (16.5)	1 091 (15.1)	25 (72.4)	25 (72.4)
2005	179 (49.4)	179 (49.4)	721 (14.6)	833 (13.4)	116 (45.9)	116 (45.9)
2006	72 (50.2)	72 (50.2)	780 (16.4)	936 (14.5)	159 (74.1)	159 (74.1)
2007	585 (85.9)	585 (85.9)	1 062 (13.5)	1 086 (13.2)	115 (67.3)	123 (63.5)
2008	332 (57.9)	332 (57.9)	658 (18.0)	786 (16.0)	362 (56.9)	362 (56.9)
2009	23 (48.3)	23 (48.3)	1 056 (13.4)	1 255 (12.9)	190 (52.4)	190 (52.4)
2011	65 (34.7)	65 (34.7)	1 017 (17.2)	1 050 (16.7)	106 (61.6)	106 (61.6)
2012	119 (58.0)	119 (58.0)	787 (16.7)	914 (15.9)	68 (75.4)	68 (75.4)
2014	147 (36.9)	147 (36.9)	813 (16.0)	849 (15.5)	11 (93.4)	11 (93.4)
2016	123 (161.0)	-	276 (29.0)	-	6 (100.0)	-

Table 8: continued.

Year	SBK Core	SBK All	SBW Core	SBW All	SCO Core	SCO All
1991	353 (35.7)	356 (35.4)	6 153 (27.3)	6 153 (27.3)	482 (12.8)	482 (12.8)
1992	81 (20.0)	84 (19.5)	7 611 (23.2)	7 611 (23.2)	344 (20.9)	344 (20.9)
1993	616 (27.2)	623 (26.9)	9 315 (24.1)	9 315 (24.1)	902 (15.8)	902 (15.8)
2000	583 (32.6)	632 (30.1)	17 491 (15.2)	17 492 (15.2)	722 (22.7)	739 (22.3)
2001	866 (40.9)	1 012 (35.5)	9 809 (26.1)	9 809 (26.1)	497 (25.2)	504 (24.9)
2002	319 (18.8)	394 (16.8)	6 517 (38.2)	6 517 (38.2)	435 (16.2)	451 (15.8)
2003	575 (63.1)	655 (56.0)	3 058 (28.8)	3 058 (28.8)	395 (27.6)	395 (27.6)
2004	273 (23.3)	395 (21.3)	3 346 (36.1)	3 346 (36.1)	446 (56.7)	447 (56.6)
2005	317 (33.3)	451 (29.6)	4 146 (38.0)	4 146 (38.0)	170 (20.3)	197 (20.7)
2006	462 (35.8)	532 (31.6)	6 962 (51.9)	6 962 (51.9)	344 (15.1)	349 (15.0)
2007	424 (33.4)	478 (30.1)	8 165 (23.8)	8 165 (23.8)	471 (25.2)	471 (25.2)
2008	714 (27.0)	1 038 (21.1)	15 269 (13.8)	15 269 (13.8)	1 302 (30.6)	1 308 (30.4)
2009	280 (24.2)	424 (20.6)	51 860 (74.7)	51 860 (74.7)	602 (16.1)	624 (15.7)
2011	490 (18.6)	536 (17.7)	7 642 (31.2)	7 642 (31.2)	837 (27.2)	848 (26.8)
2012	1 214 (17.6)	1 294 (16.9)	21 483 (35.0)	21 485 (35.0)	604 (25.8)	617 (25.3)
2014	484 (38.1)	504 (36.6)	9 960 (28.8)	9 960 (28.8)	630 (22.7)	630 (22.7)
2016	220 (27.0)	-	36 057 (13.0)	-	572 (22.0)	-

Year	SND Core	SND All	SPD Core	SPD All	SPE Core	SPE All
1991	493 (25.4)	656 (21.3)	8 908 (53.9)	8 908 (53.9)	97 (72.2)	97 (72.2)
1992	203 (24.5)	327 (16.4)	1 158 (15.5)	1 158 (15.5)	1 (100.0)	1 (72.6)
1993	596 (27.9)	768 (22.9)	1 649 (22.5)	1 649 (22.5)	2 (100.0)	2 (100.0)
2000	62 (34.7)	131 (21.7)	4 173 (11.6)	4 173 (11.6)	25 (92.7)	25 (92.7)
2001	360 (25.7)	612 (20.9)	8 528 (30.7)	8 528 (30.7)	23 (74.1)	23 (74.1)
2002	436 (34.4)	524 (28.9)	3 505 (18.8)	3 505 (18.8)	16 (61.4)	16 (61.4)
2003	190 (28.3)	263 (22.0)	2 317 (16.8)	2 317 (16.8)	11 (54.3)	11 (54.3)
2004	636 (19.5)	738 (17.4)	3 376 (27.3)	3 378 (27.3)	3 (94.8)	3 (94.8)
2005	480 (25.1)	583 (21.2)	4 344 (18.9)	4 344 (18.9)	13 (70.7)	13 (70.7)
2006	683 (25.9)	827 (21.7)	3 039 (19.3)	3 039 (19.3)	4 (86.6)	4 (86.6)
2007	196 (40.4)	261 (31.9)	3 589 (16.6)	3 589 (16.6)	8 (56.9)	8 (56.9)
2008	777 (30.4)	910 (26.3)	3 080 (19.1)	3 084 (19.0)	11 (83.0)	11 (83.0)
2009	697 (34.2)	999 (28.0)	4 296 (33.5)	4 296 (33.5)	53 (70.9)	53 (70.9)
2011	1 017 (15.0)	1 082 (14.4)	1 941 (18.9)	1 941 (18.9)	8 (41.4)	8 (41.4)
2012	428 (21.1)	724 (32.8)	843 (12.3)	843 (12.3)	5 (72.5)	5 (72.5)
2014	888 (12.7)	1 054 (15.1)	4 259 (28.7)	4 262 (28.7)	5 (59.9)	5 (59.9)
2016	796 (150.0)	-	3 524 (41.0)	-	29 (127.0)	-

Year	SRB Core	SRB All	SSI Core	SSI All	SSK Core	SSK All
1991	-	-	522 (14.4)	522 (14.4)	386 (23.0)	386 (23.0)
1992	-	-	396 (10.8)	396 (10.8)	119 (45.0)	119 (45.0)
1993	-	-	1 430 (18.0)	1 430 (18.0)	118 (43.3)	123 (42.0)
2000	-	-	1 810 (15.4)	1 810 (15.4)	435 (66.2)	495 (59.0)
2001	-	-	1 563 (38.6)	1 565 (38.6)	636 (43.4)	636 (43.4)
2002	20 (100.0)	57 (73.4)	1 404 (17.9)	1 407 (17.8)	299 (65.3)	299 (65.3)
2003	45 (96.4)	45 (96.4)	1 252 (11.0)	1 252 (11.0)	475 (60.3)	475 (60.3)
2004	34 (74.2)	50 (59.4)	1 330 (20.3)	1 330 (20.3)	331 (51.5)	331 (51.5)
2005	-	-	1 136 (48.5)	1 136 (48.5)	34 (85.6)	37 (78.8)
2006	-	-	2 615 (23.8)	2 616 (23.8)	995 (43.2)	999 (43.0)
2007	-	-	2 114 (22.4)	2 114 (22.4)	483 (52.3)	483 (52.3)
2008	13 (100.0)	13 (100.0)	1 932 (11.7)	1 932 (11.7)	1 406 (50.8)	1 406 (50.8)
2009	40 (50.4)	41 (49.4)	1 360 (27.1)	1 360 (27.1)	648 (75.7)	648 (75.7)
2011	-	-	1 541 (20.3)	1 541 (20.3)	1 660 (79.1)	1 684 (78.0)
2012	34 (100.0)	34 (100.0)	2 938 (12.7)	2 939 (12.7)	680 (74.1)	680 (74.1)
2014	240 (31.3)	245 (30.8)	3 490 (23.4)	3 490 (23.4)	1 012 (36.5)	1 012 (36.5)
2016	1 275 (190.0)	-	446 (24.0)	-	323 (50.0)	-

Table 8: continued.

	SWA		WWA	
Year	Core	All	Core	All
1991	1 113 (46.7)	1 113 (46.7)	1 599 (58.3)	1 605 (58.1)
1992	225 (63.8)	225 (63.8)	242 (25.8)	243 (25.7)
1993	164 (63.4)	164 (63.4)	282 (28.7)	293 (27.9)
2000	21 (65.0)	21 (65.0)	266 (38.7)	266 (38.7)
2001	1 069 (58.5)	1 069 (58.5)	2 429 (53.8)	2 433 (53.7)
2002	141 (62.1)	141 (62.1)	853 (24.1)	863 (23.9)
2003	22 (71.8)	22 (71.8)	709 (58.4)	709 (58.4)
2004	171 (33.9)	171 (33.9)	1 061 (30.8)	1 061 (30.8)
2005	1 198 (98.8)	1 198 (98.8)	538 (38.5)	538 (38.5)
2006	71 (56.0)	71 (56.0)	642 (25.9)	646 (25.8)
2007	514 (38.2)	514 (38.2)	1 706 (61.4)	1 707 (61.3)
2008	4 122 (54.9)	4 122 (54.9)	2 283 (39.8)	2 293 (39.6)
2009	3 620 (98.0)	3 620 (98.0)	2 093 (35.3)	2 093 (35.3)
2011	136 (61.0)	136 (61.0)	390 (26.7)	393 (26.5)
2012	13 (75.0)	13 (75.0)	1 259 (28.7)	1 259 (28.7)
2014	29 (71.6)	29 (71.6)	211 (39.5)	211 (39.5)
2016	85 (115.0)	-	609 (65.0)	-

Table 9: Numbers of fish for which length, sex, and biological data were collected from the November–December 2016 Southland and Sub-Antarctic trawl survey.

	Length frequency data				Length-weight data	
	No. of fish measured			No. of	No. of	No. of
Species	Total †	Female	Male	samples	fish	samples
Banded bellowsfish	1	1	0	1	1	1
Banded rattail	405	255	61	32	266	31
Basketwork eel	4	3	1	1	4	1
Baxter's lantern dogfish	58	31	27	15	58	15
Black javelinfish	3	2	1	1	3	1
Black oreo	48	23	25	3	33	3
Blackspot rattail	1	0	1	1	1	1
Bollons's rattail	43	28	14	10	36	9
Catshark	1	0	1	1	1	1
Dark ghost shark	145	69	64	7	74	7
Dawson's catshark	2	0	2	1	2	1
Finless flounder	52	27	25	14	52	14
Four-rayed rattail	67	54	4	3	27	2
Frostfish	1	0	1	1	1	1
Gemfish	18	7	11	1	18	1
Giant stargazer	13	10	3	6	13	6
Hairy conger	39	3	36	10	39	10
Hake	33	32	1	15	33	15
Hapuku	1	1	0	1	1	1
Hoki	2 675	1 671	997	55	915	55
Javelinfish	3 389	2 744	577	52	998	51
Kaiyomaru rattail	8	5	0	2	5	1
Leafscale gulper shark	9	9	0	4	9	4
Ling	1 382	767	612	53	910	53
Long-nosed chimaera	50	24	26	17	50	17
Longnose velvet dogfish	21	17	4	2	21	2
Lookdown dory	131	65	64	25	131	25
Lucifer dogfish	95	26	69	16	94	16
Notable rattail	2	1	0	2	2	2
NZ southern arrow squid	282	144	138	11	70	11
Oblique banded rattail	850	805	35	25	474	24
Oliver's rattail	979	573	325	22	358	21
Pale ghost shark	306	130	176	48	306	48
Plunket's shark	2	1	1	2	2	2
Prickly deepsea skate	2	0	2	2	2	2
Prickly dogfish	3	2	1	2	3	2
Red cod	21	9	11	4	21	4
Ribaldo	23	23	0	15	23	15
Ridge scaled rattail	42	27	15	8	42	8
Rough skate	2	1	1	2	2	2
Rudderfish	1	1	0	1	1	1
Scampi	2	1	1	1	2	1
School shark	3	1	2	1	3	1
Sea perch	9	4	5	2	9	2
Shovelnose dogfish	4	2	2	4	4	4
Silver warehou	20	1	19	1	20	1
Silverside	246	111	63	17	190	17
Smallscaled brown slickhead	11	8	3	2	11	2
Smallscaled cod	3	1	2	1	3	1
Smooth deepsea skate	4	1	3	3	4	3
Smooth oreo	34	12	22	2	34	2
Smooth skate	4	1	3	4	4	4
Smooth skin dogfish	2	0	2	2	2	2

Table 9 continued:

	Length frequency data				Length-weight data	
	No. of fish measured			No. of	No. of	No. of
Species	Total †	Female	Male	samples	fish	samples
Southern blue whiting	4 079	1 850	1 952	31	571	31
Southern Ray's bream	21	13	8	8	21	8
Spineback	106	99	6	12	87	12
Spiny dogfish	416	179	237	25	204	25
Swollenhead conger	53	13	40	12	53	12
White warehou	49	21	26	8	49	8
Widenosed chimaera	15	7	8	2	15	2
Total	16 291	9 916	5 736	632	6 388	625

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

Table 10: Gonad stages (see Appendix 1 for description of gonad stages) for species with more than 200 observations from the November–December 2016 Southland and Sub-Antarctic trawl survey. Hake (only 32 fish staged) are also included in this table as one of the target species. – indicates gonad stage not relevant for this species.

Species and sex	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Hoki female	210	1 380	3	0	3	0	2
Hoki male	255	725	0	0	0	1	6
Hake female	0	11	19	0	0	0	1
Hake male	0	0	1	0	0	0	0
Ling female	43	626	11	62	0	0	0
Ling male	51	290	94	144	23	0	0
Southern blue whiting female	124	1 687	1	0	0	0	0
Southern blue whiting male	136	1 807	0	0	0	0	1
Pale ghost shark female	51	44	30	3	0	-	-
Pale ghost shark male	27	6	143	-	-	-	-
Spiny dogfish female	98	53	16	6	4	-	-
Spiny dogfish male	43	7	187	-	-	-	-
Oblique banded rattail female	7	295	13	3	0	0	0
Oblique banded rattail male	5	1	0	0	0	0	0
Javelinfish female	52	357	3	0	0	0	0
Javelinfish male	42	10	0	0	0	0	0

Table 11: Hoki liver condition indices (LCI) for the Sub-Antarctic and each of the three subareas: Puysegur 165°–168°E, 46–48°S; West 165–169°E, 48°–54°S; East 169°–176°E, 46–54°S. –, too few observations were available to estimate hoki LCI from Puysegur in 2016.

	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
2016	3.36	2.0	3.41	2.7	-	-	3.37	3.1
Mean	2.82	0.5	3.09	0.8	2.15	1.3	2.78	0.7

Table 12: Quality of acoustic data collected during trawl surveys in the Sub-Antarctic between 2000 and 2016. In 2000–14, 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). In 2016, the subjective definition was replaced by an equivalent quantitative metric where “good” was defined as fewer than 10% bad pings, “marginal” was defined as 10–30% bad pings, and “poor” was defined as greater than 30% bad pings.

Year	Number of recordings	% of recordings Good	Marginal	Poor
2000	234	57	21	22
2001	221	65	20	15
2002	202	78	12	10
2003	169	37	25	38
2004*	163	0	0	100
2005	197	75	16	9
2006	195	46	25	29
2007	194	63	16	20
2008	235	61	28	11
2009	319	46	33	20
2011	261	47	35	18
2012**	294	18	22	60
2014	258	30	31	39
2016	229	40	33	27

* 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 & Stewart Snares
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
2016	0.56	0.54*	0.59

*No night time data were available for Puysegur in 2014 or 2016 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%). –, the 2012 survey did not produce any data suitable for acoustic analysis from Puysegur; *, there was only one data point at Puysegur in 2016.

										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
2016	5.91	13.5	21.10	*	7.18	15.5	13.13	9.8	8.06	7.1

8. FIGURES

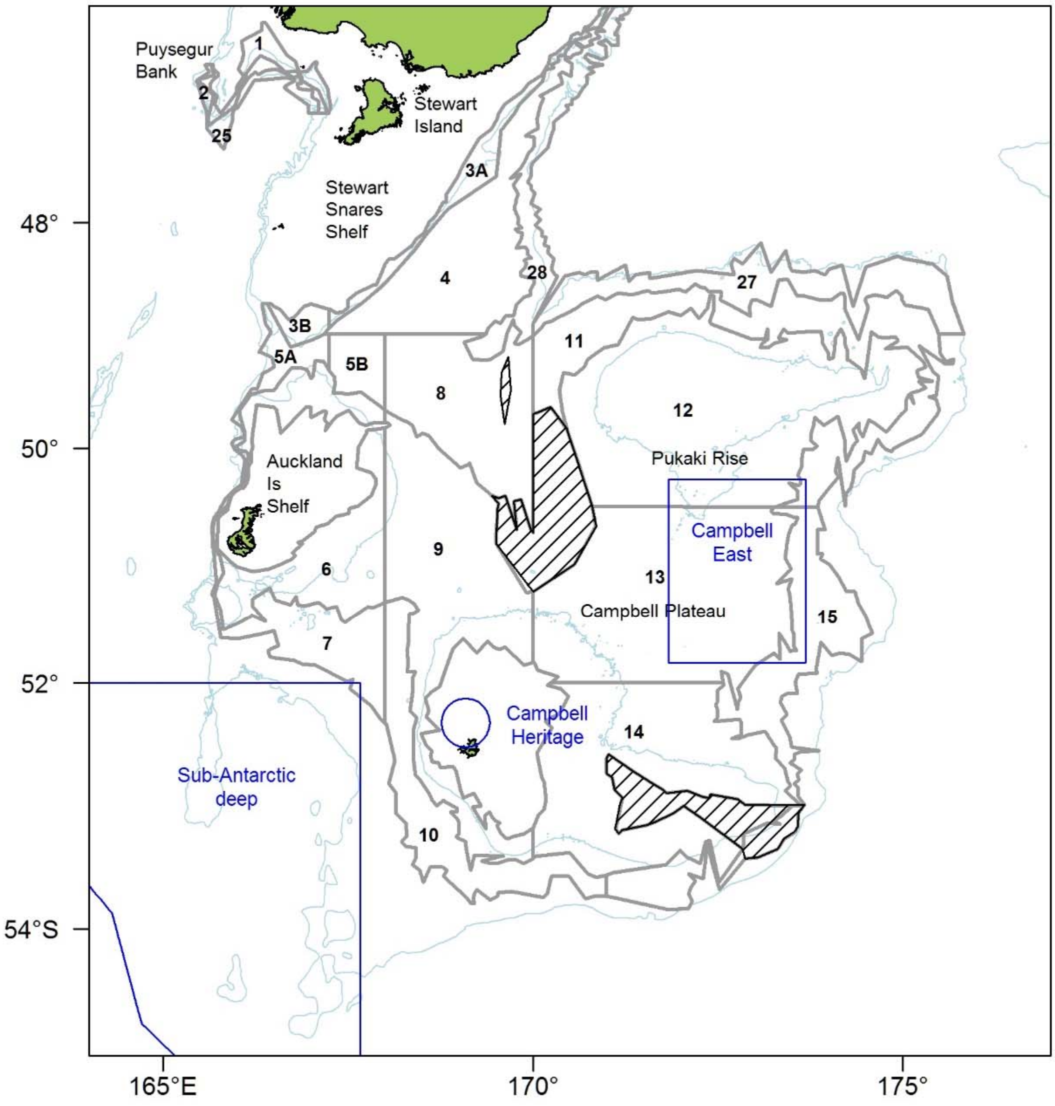


Figure 1: Stratum boundaries from the November–December 2016 Southland and Sub-Antarctic trawl survey. Stratum areas are given in Table 1. Blue areas are benthic protected areas.

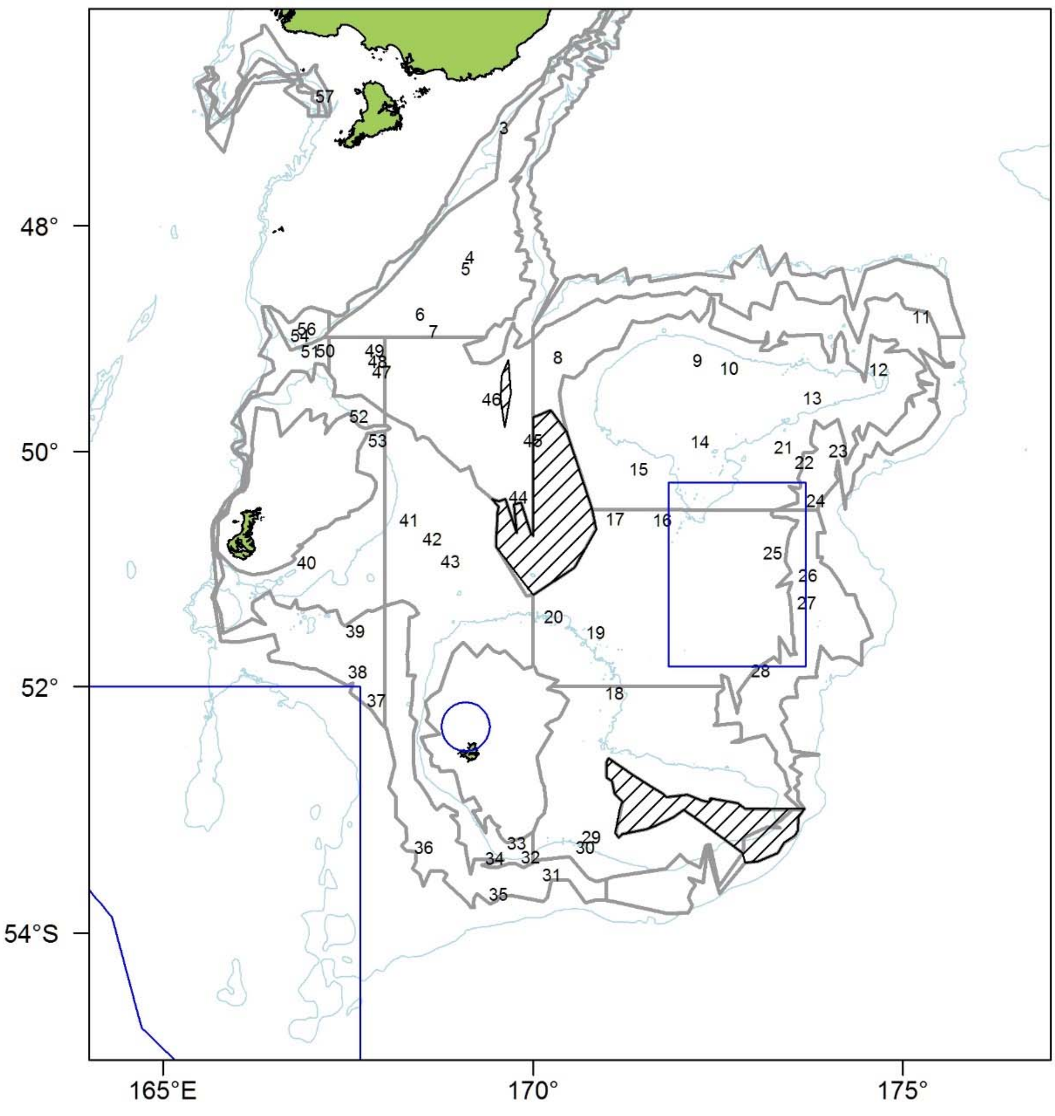


Figure 2: Trawl tow positions from the November–December 2016 Southland and Sub-Antarctic trawl survey. Labels show station numbers. Station details are given in Appendix 2. Blue areas are benthic protected areas.

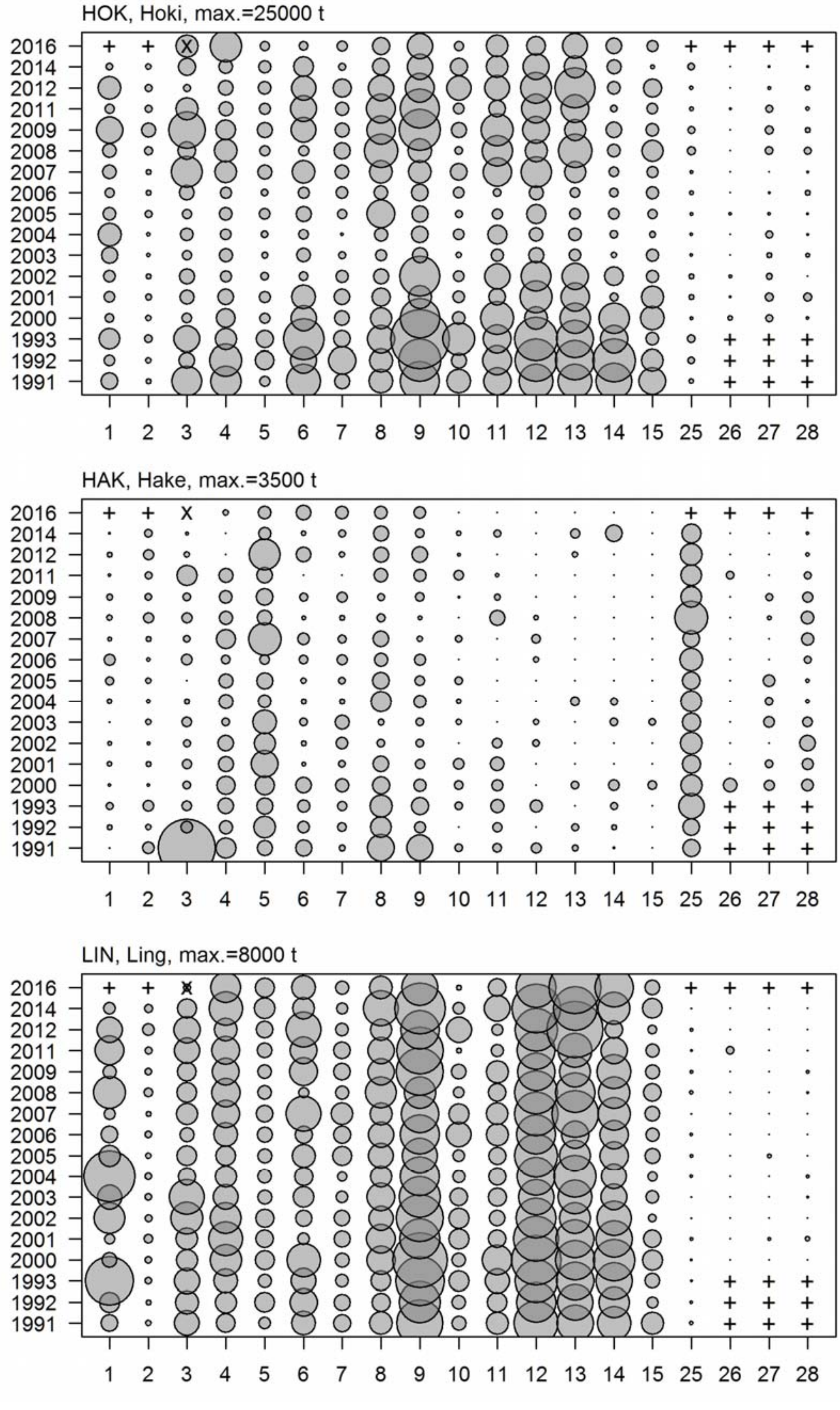


Figure 3: Relative biomass estimates by strata for selected species sampled from the Southland and Sub-Antarctic November–December *Tangaroa* surveys. +, stratum not surveyed in that year; ×, Strata 003A and 003B were combined into stratum 3, and in 2016 stratum 003A was not sampled.

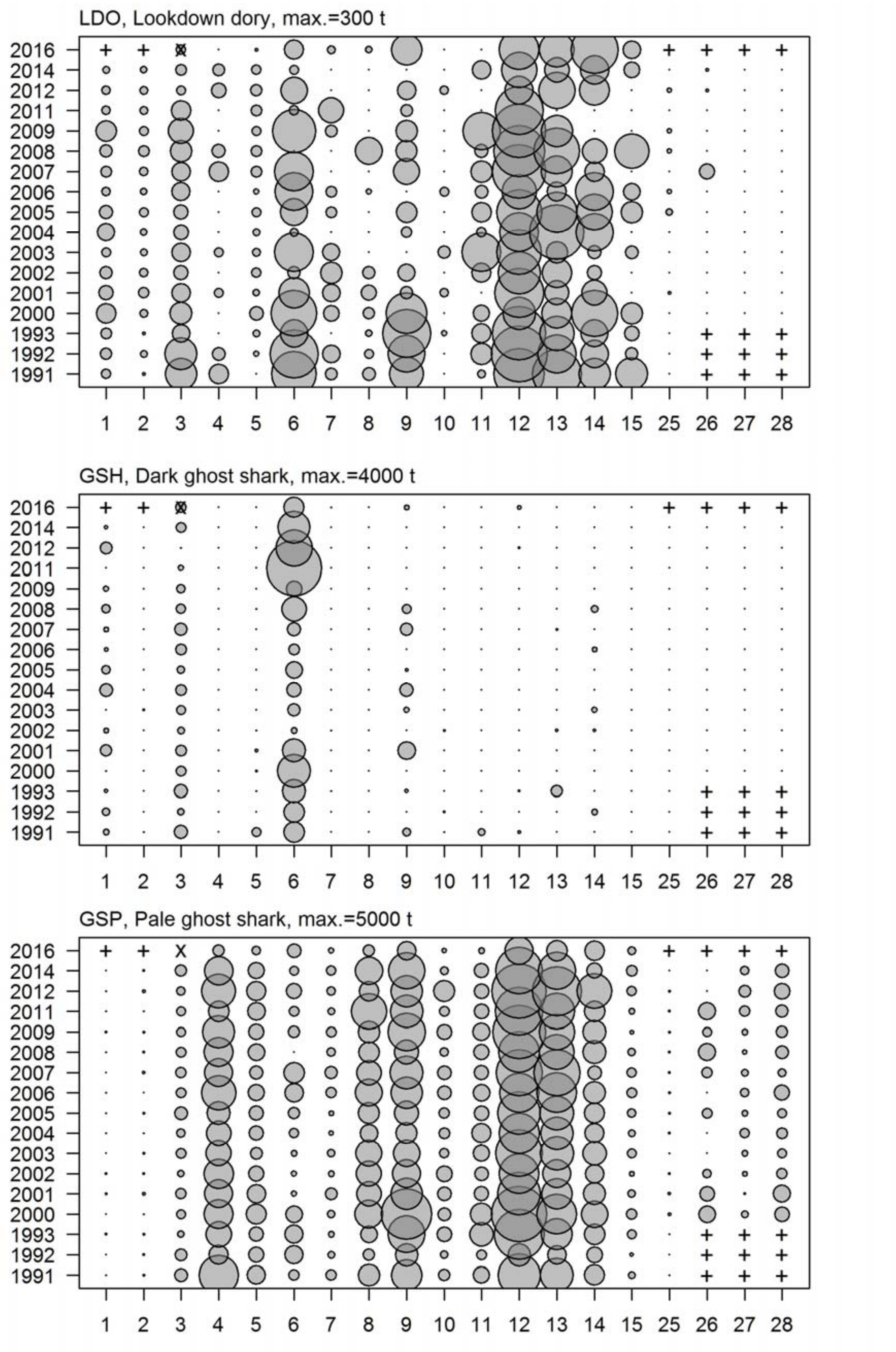


Figure 3: continued.

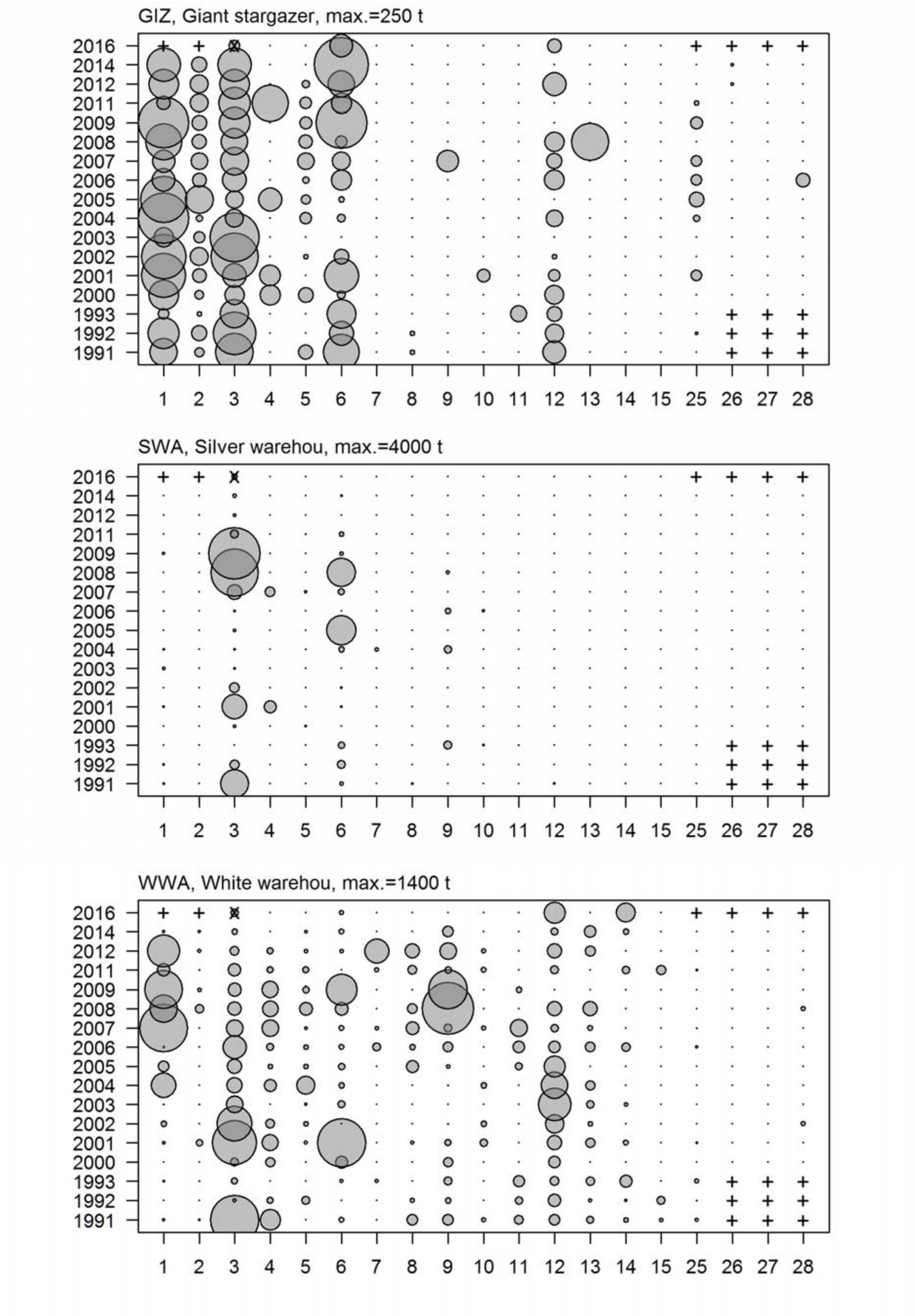
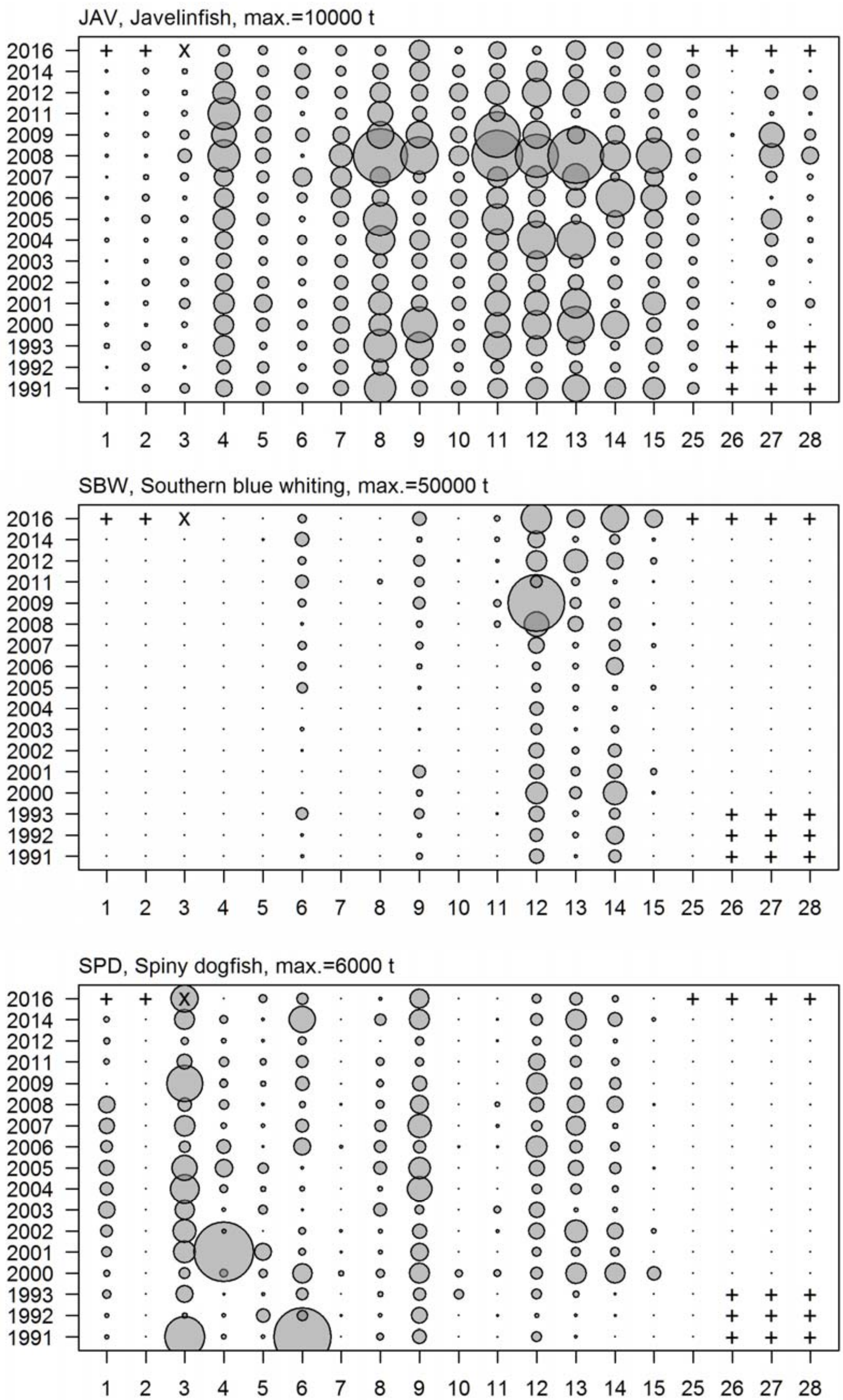


Figure 3: continued.



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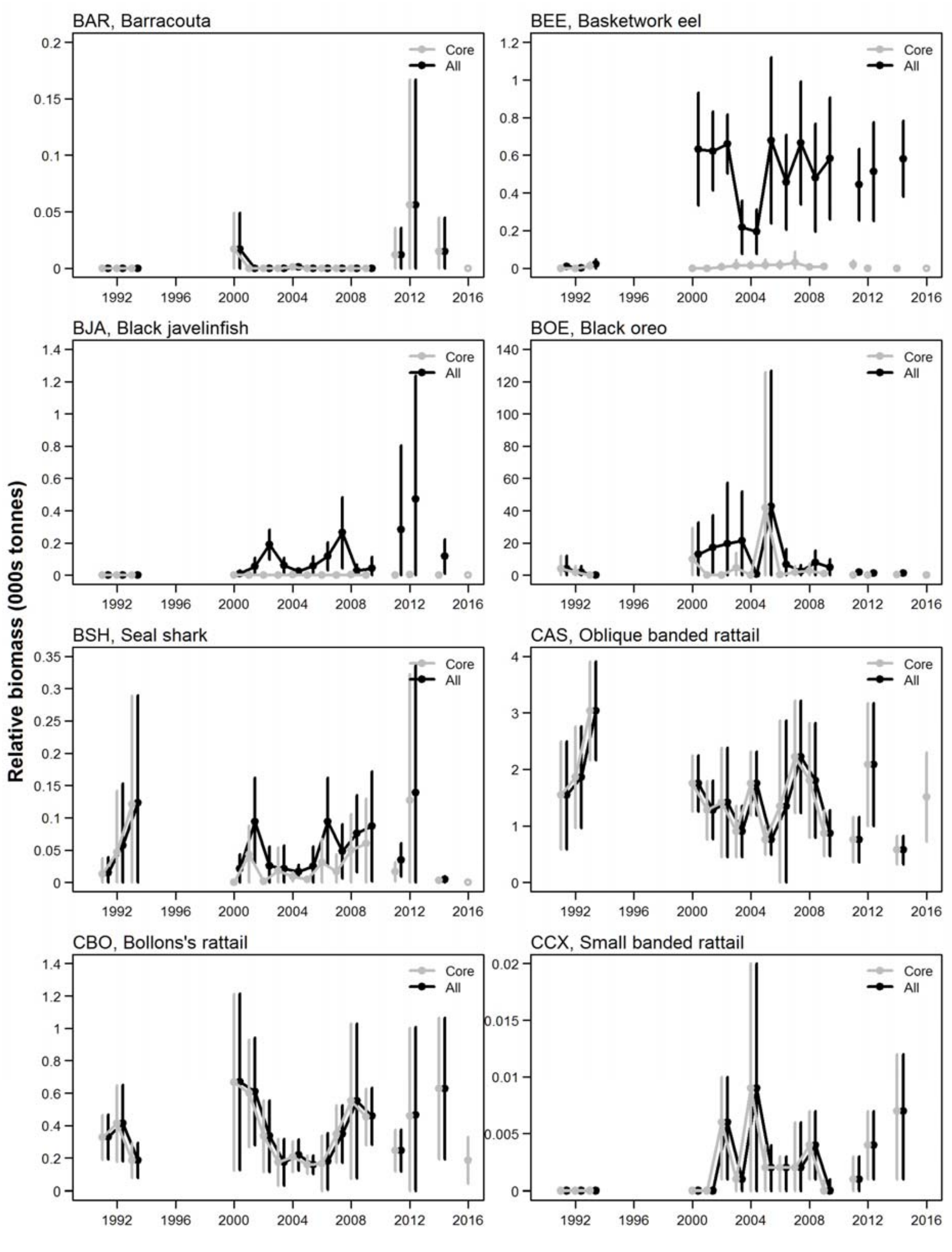


Figure 4: Relative biomass estimates (thousands of tonnes) of selected species sorted alphabetically by research code sampled by the Southland and Sub-Antarctic November–December *Tangaroa* surveys. Grey lines show fish from core (300–800 m) strata, black lines show fish from all strata (300–1000 m). Error bars show ± 2 standard errors. 2016 biomass is scaled core biomass.

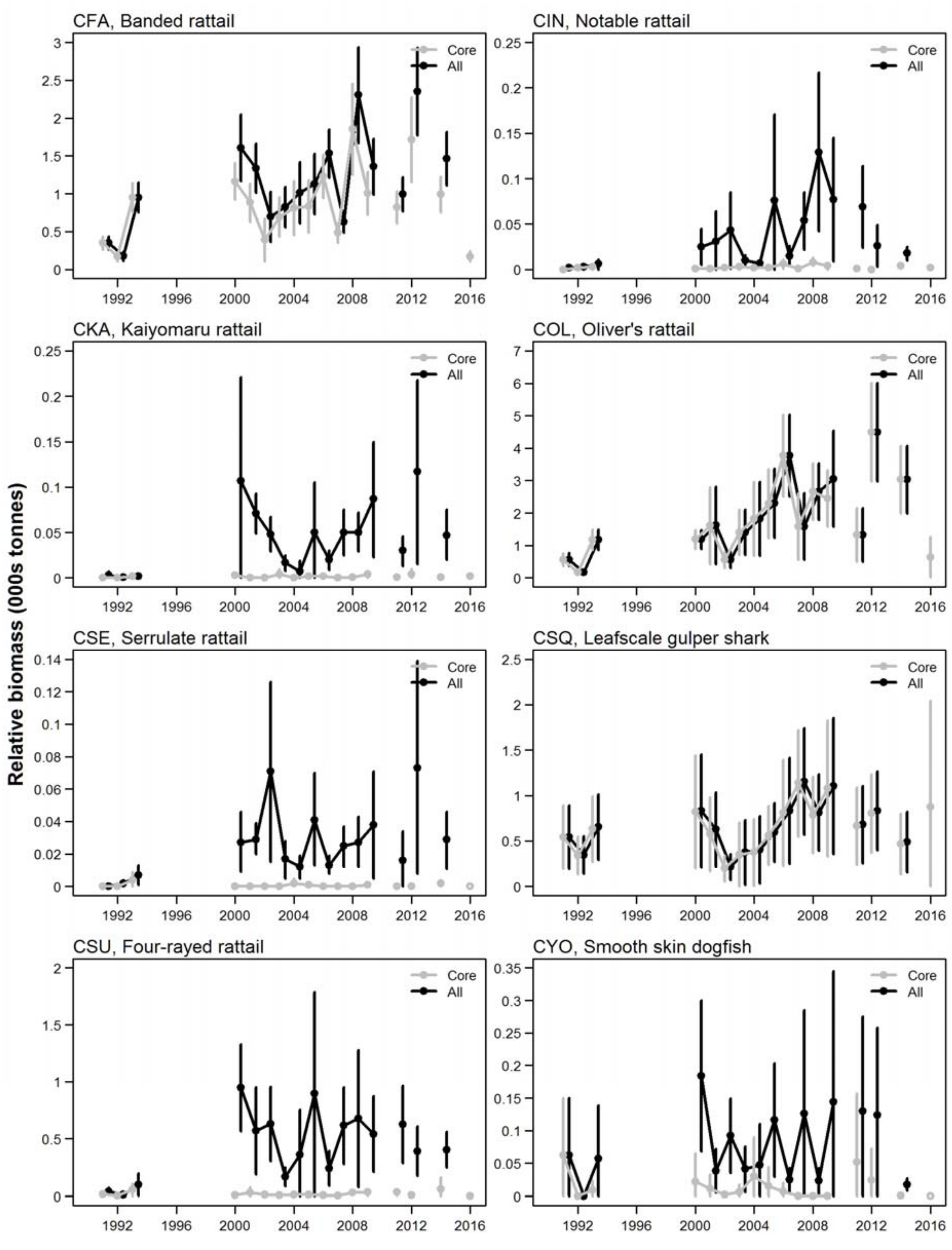


Figure 4: continued.

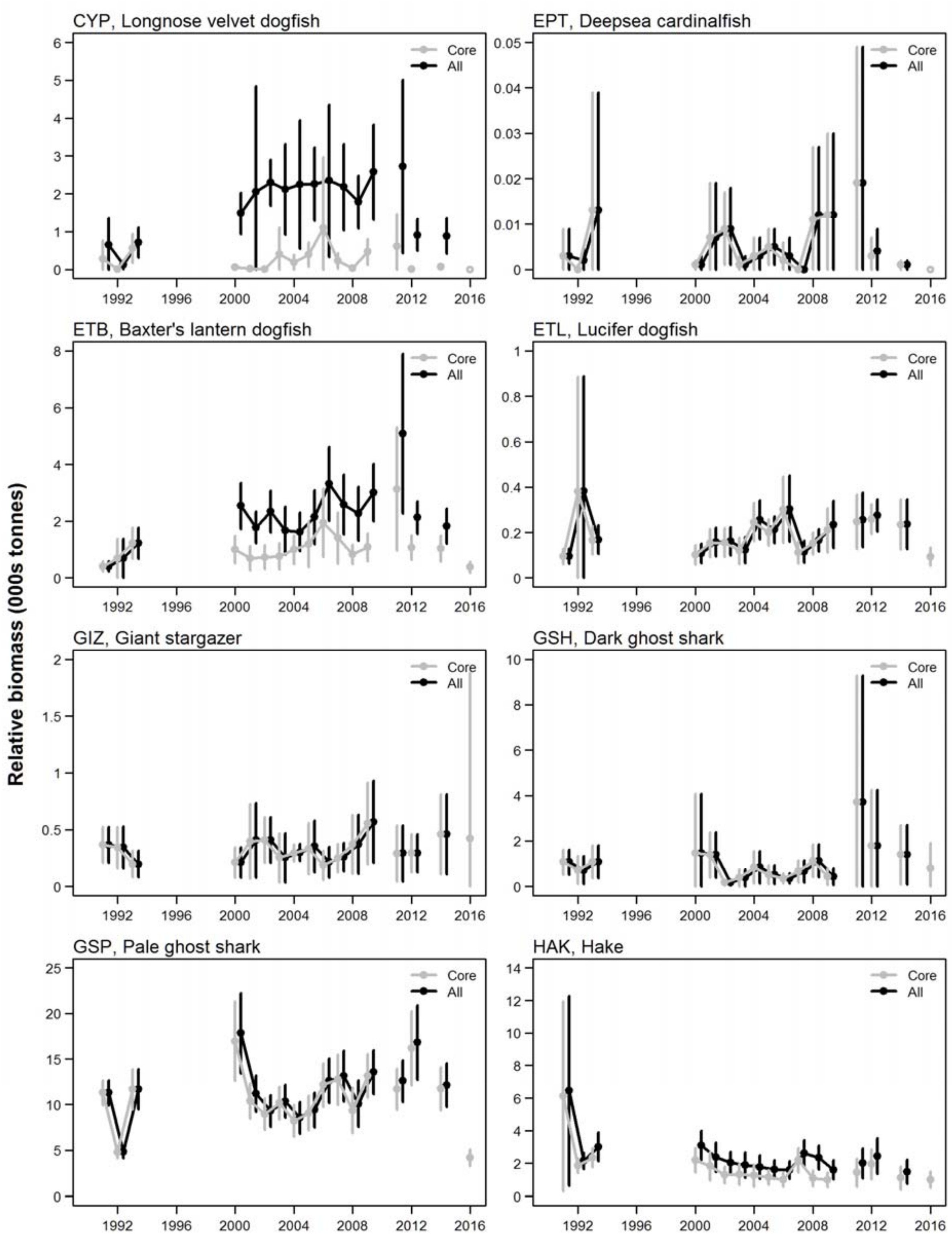


Figure 4: continued.

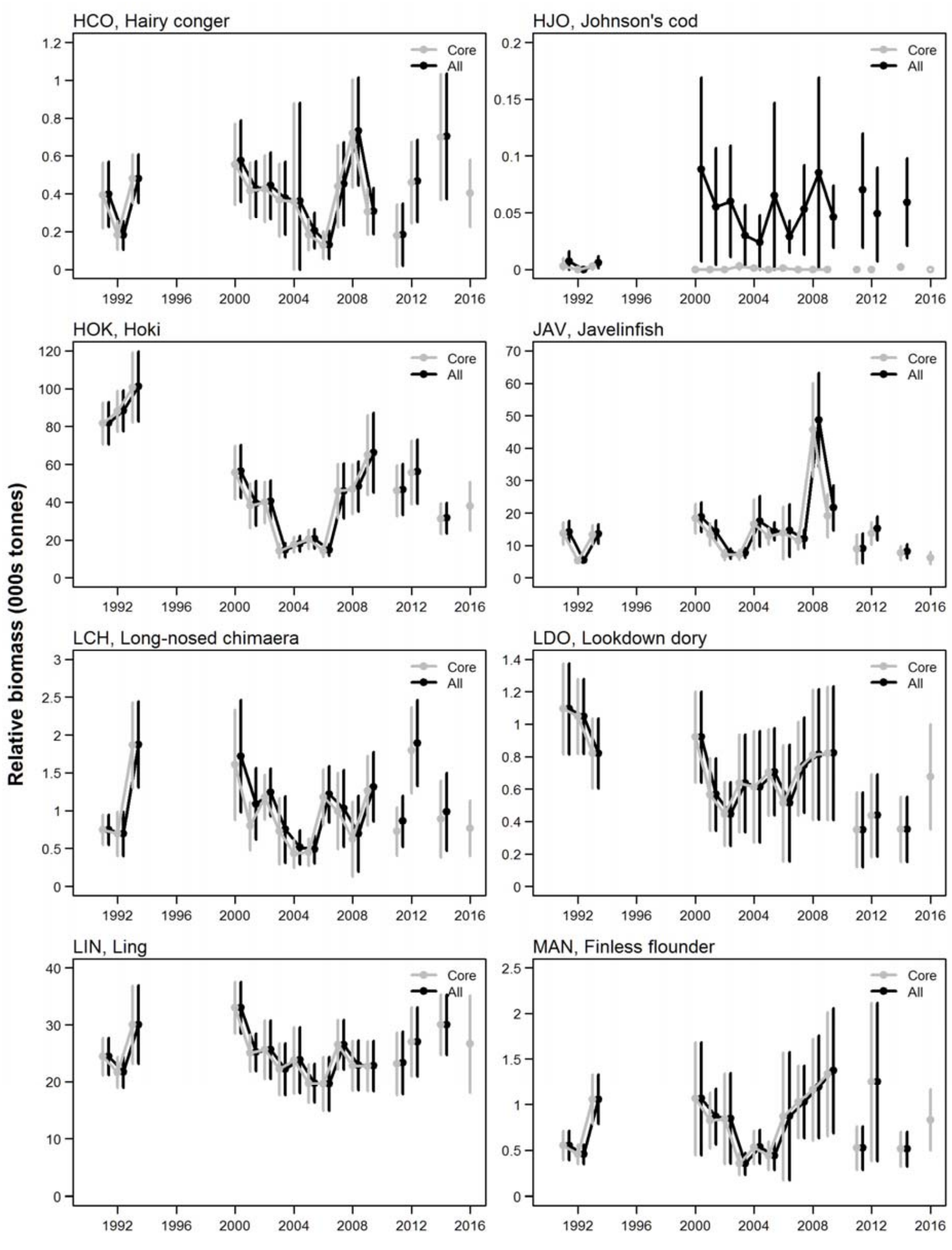


Figure 4: continued.

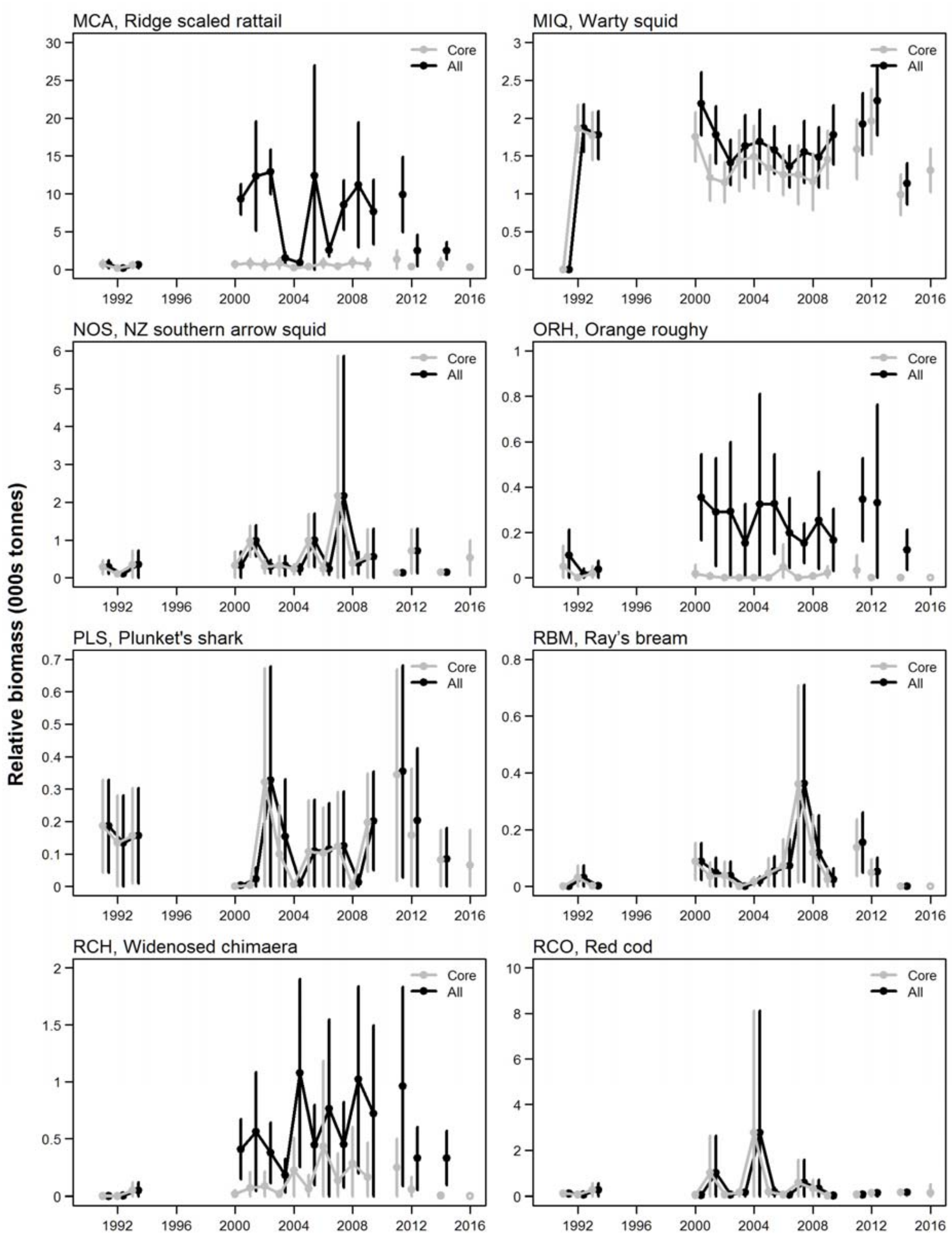


Figure 4: continued.

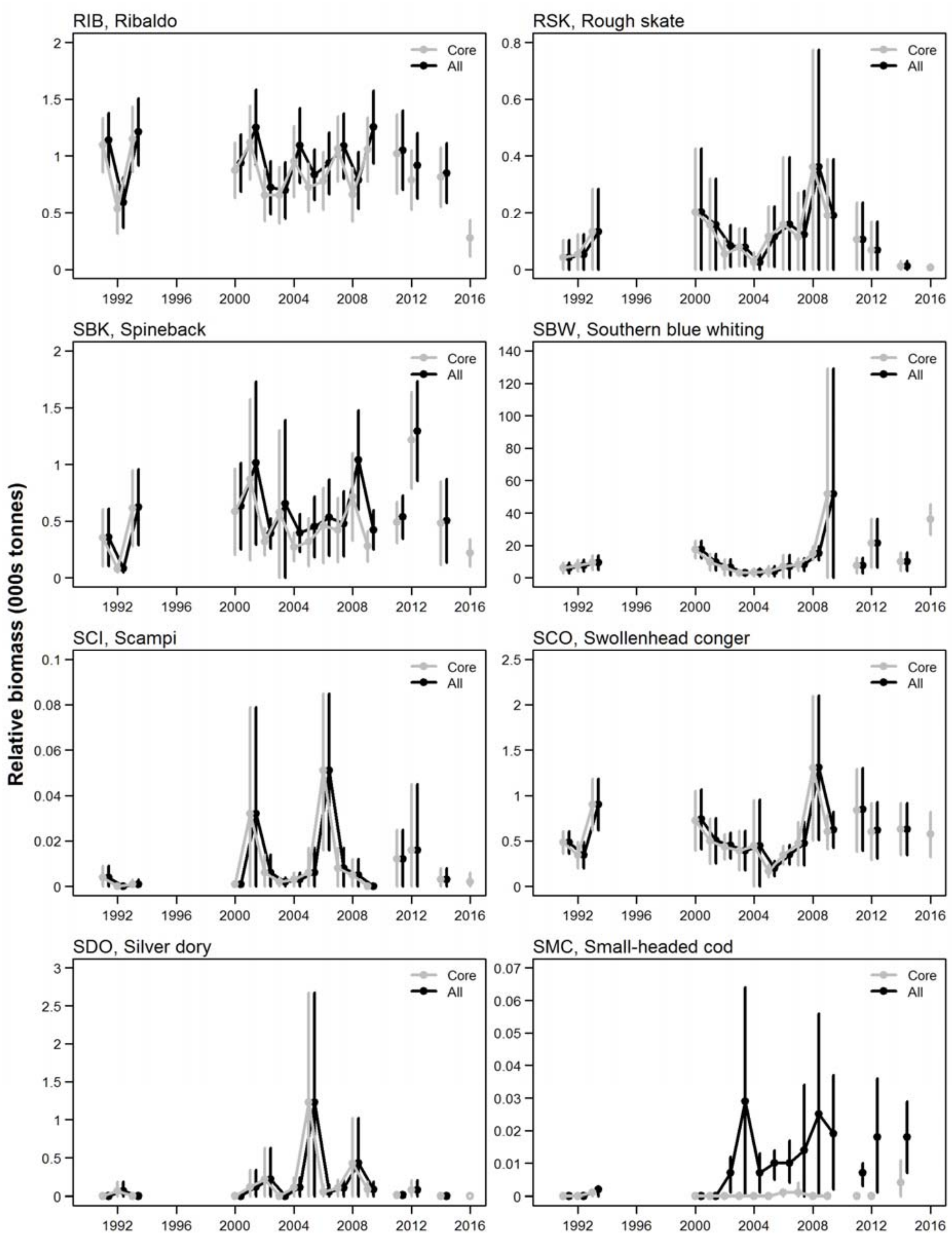


Figure 4: continued.

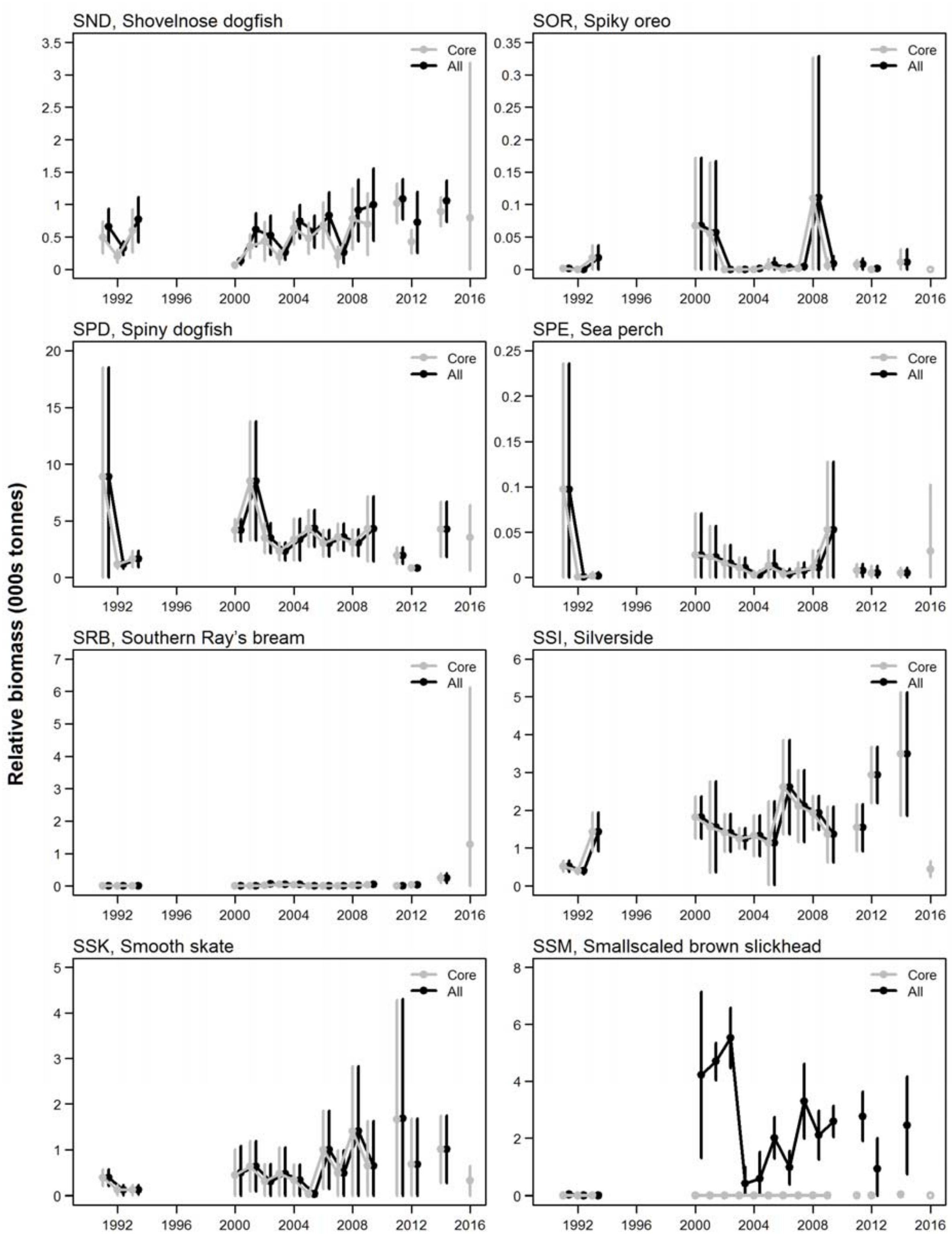


Figure 4: continued.

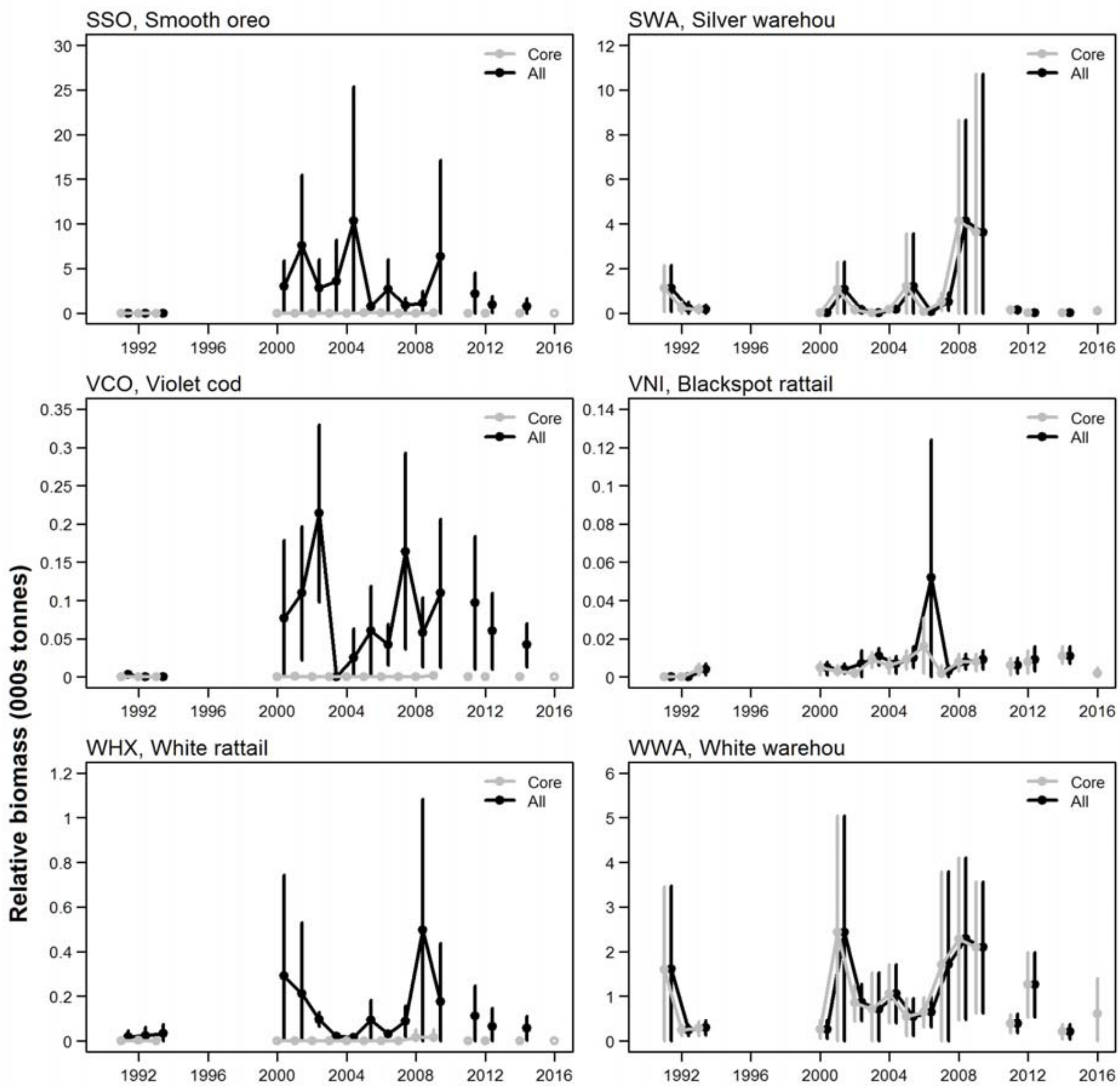


Figure 4: continued.

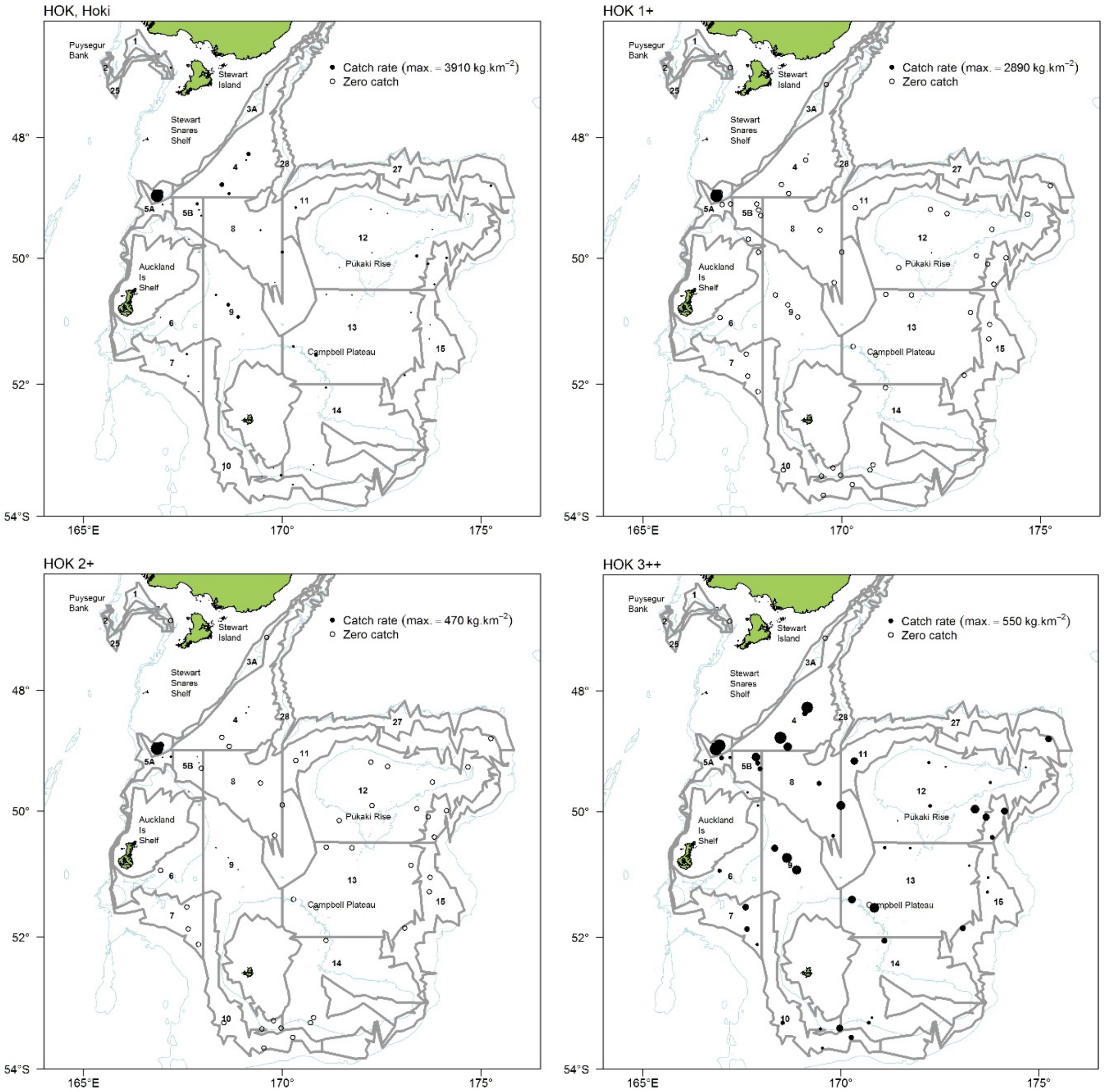


Figure 5: Distribution and catch rates of all, 1+ (less than 45 cm), 2+ (46 to less than 62 cm), and 3++ year old (more than 62 cm) hoki (HOK) from the November–December 2016 Southland and Sub-Antarctic trawl survey. Circle area is proportional to catch rate. Open circles indicate zero catches.

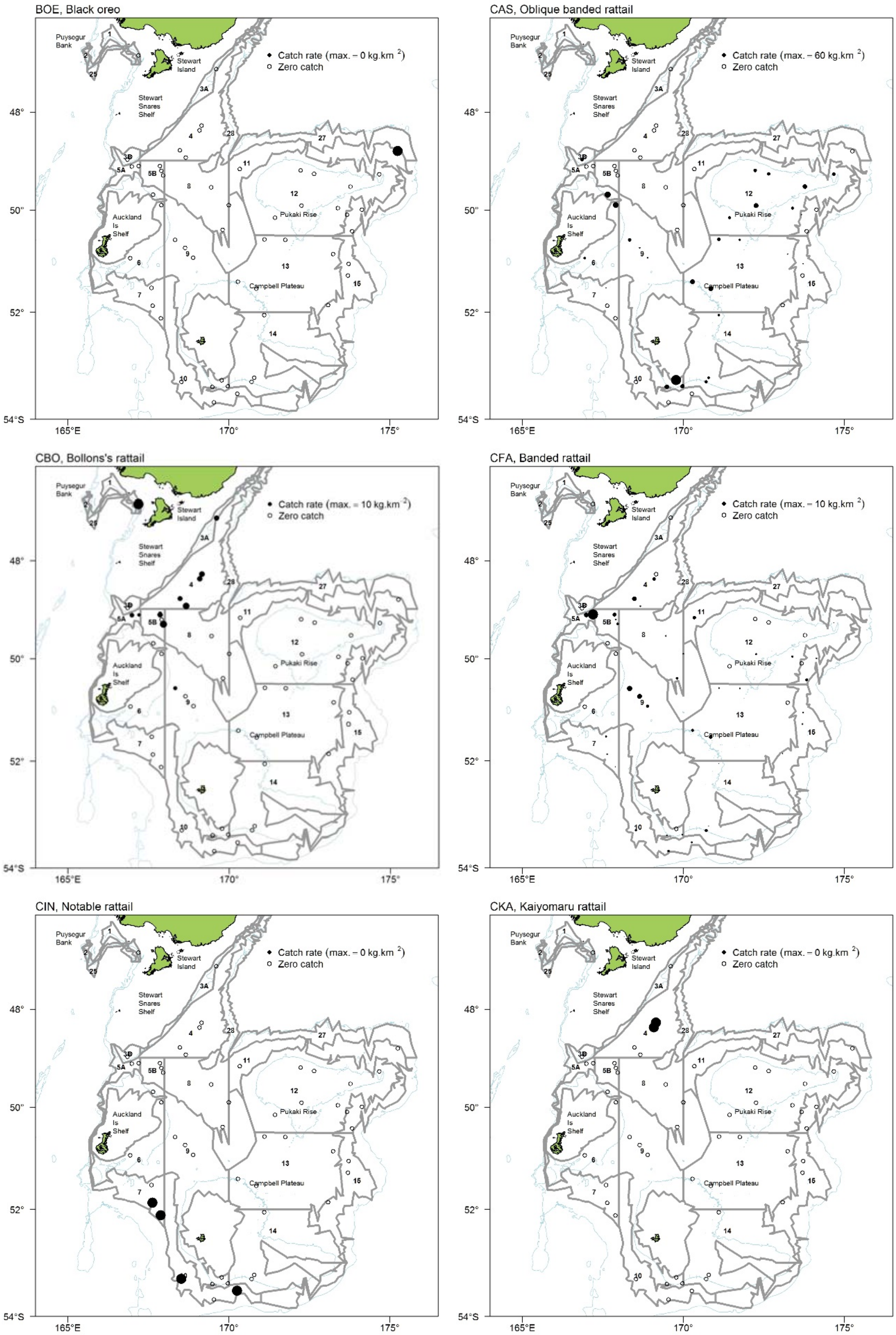


Figure 6: Distribution and catch rates of selected species sorted alphabetically by research code from the November–December 2016 Southland and Sub-Antarctic trawl survey. Circle area is proportional to catch rate. Open circles indicate zero catches.

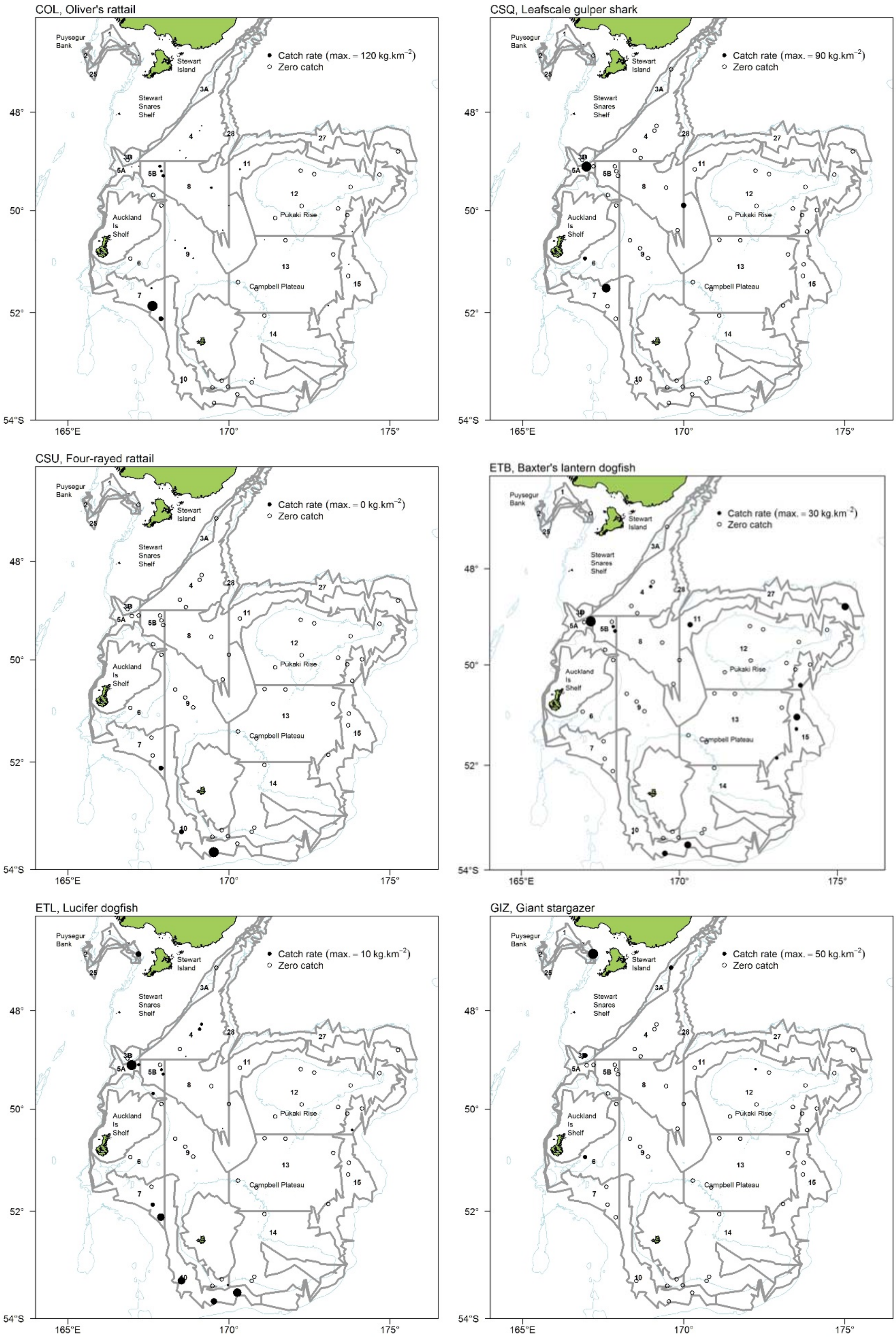


Figure 6 continued.

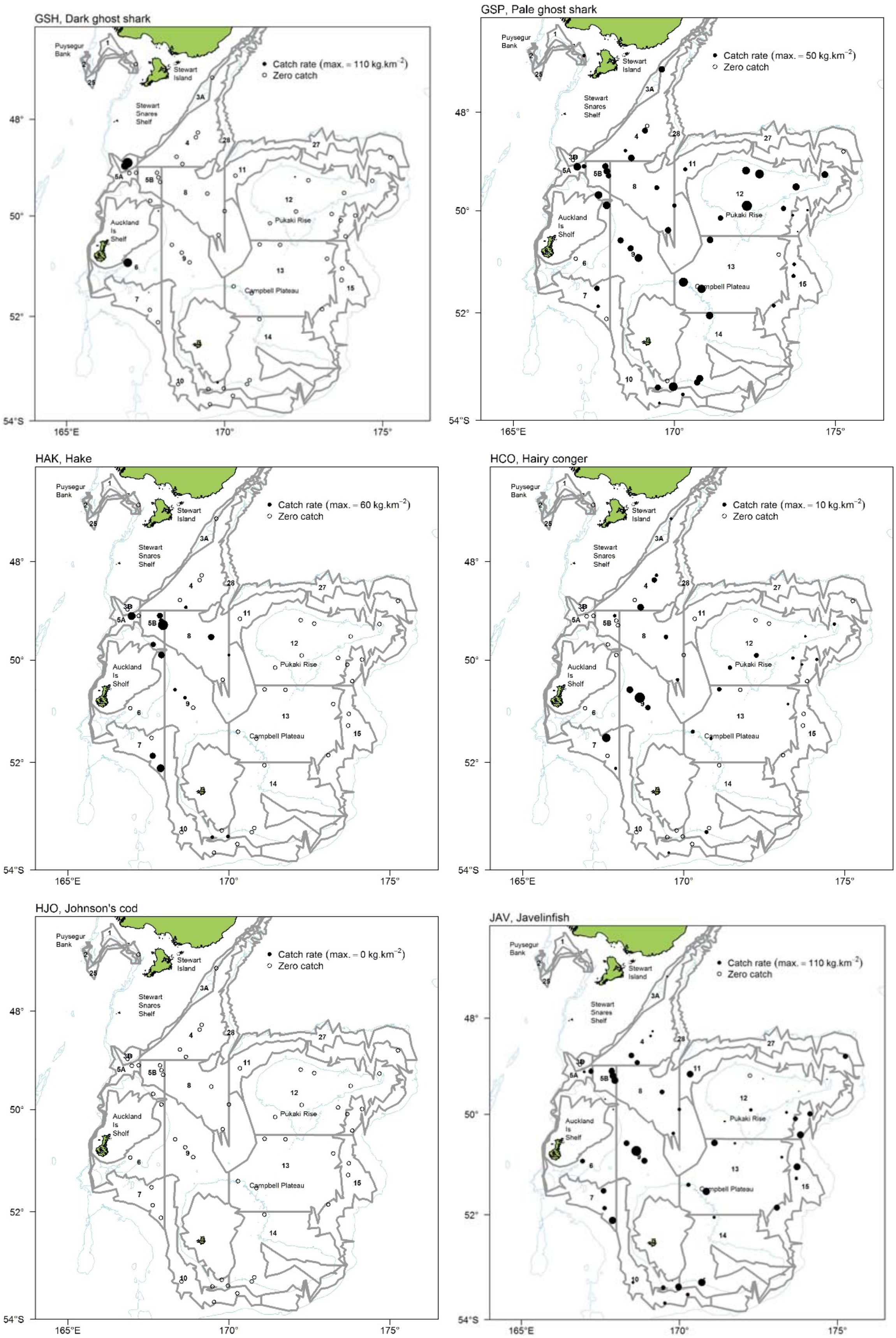


Figure 6 continued.

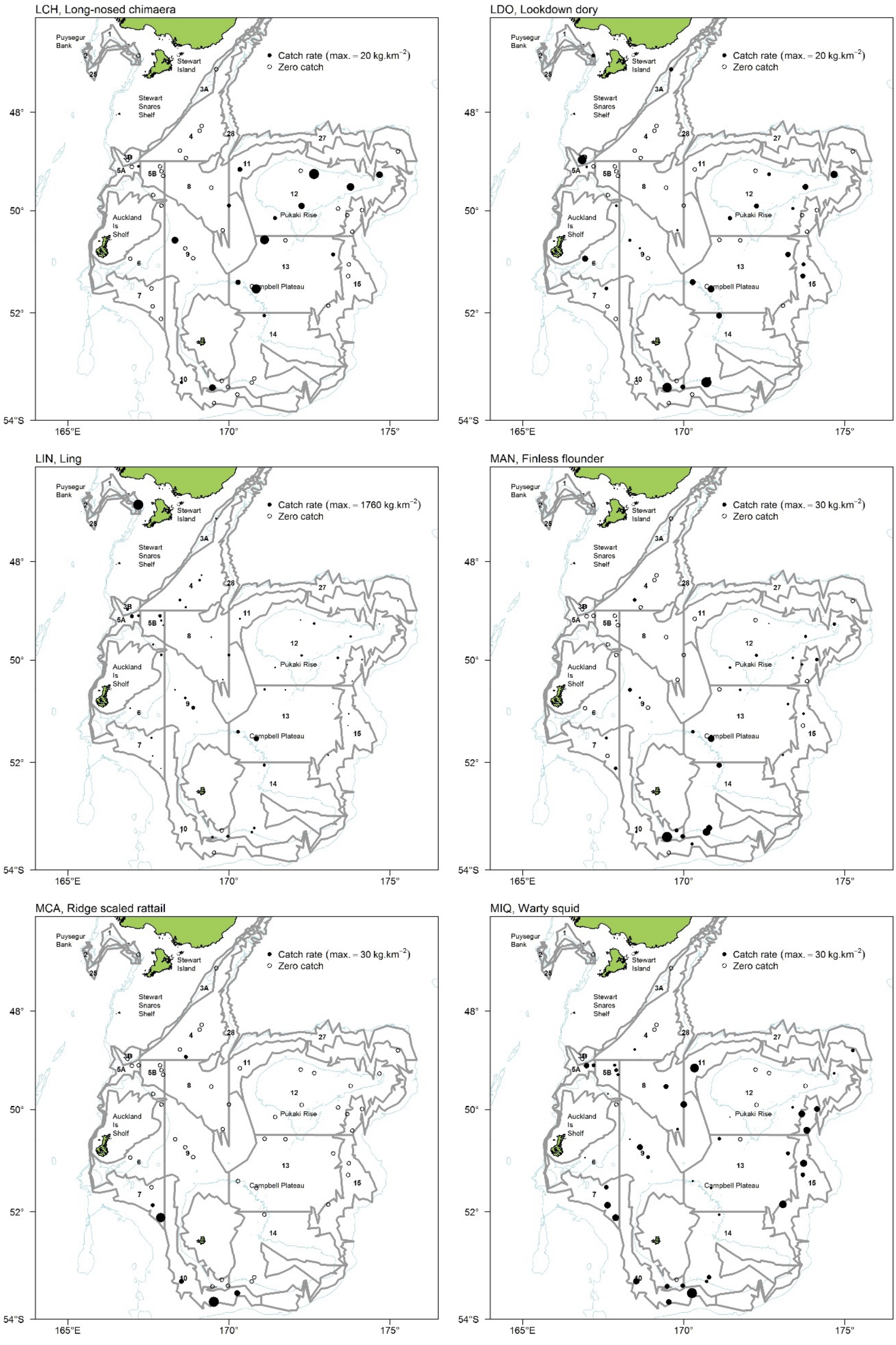


Figure 6 continued.

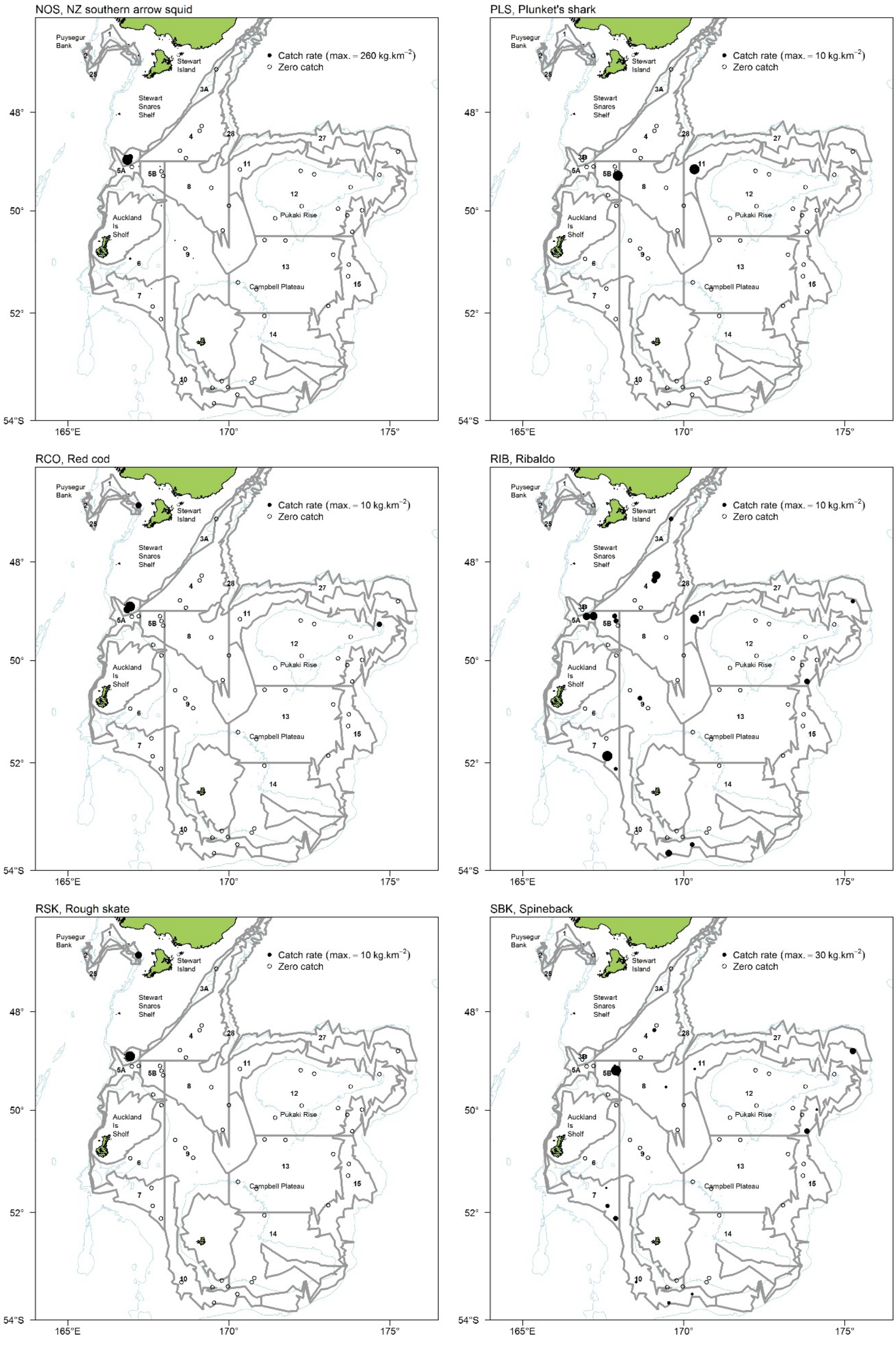


Figure 6 continued.

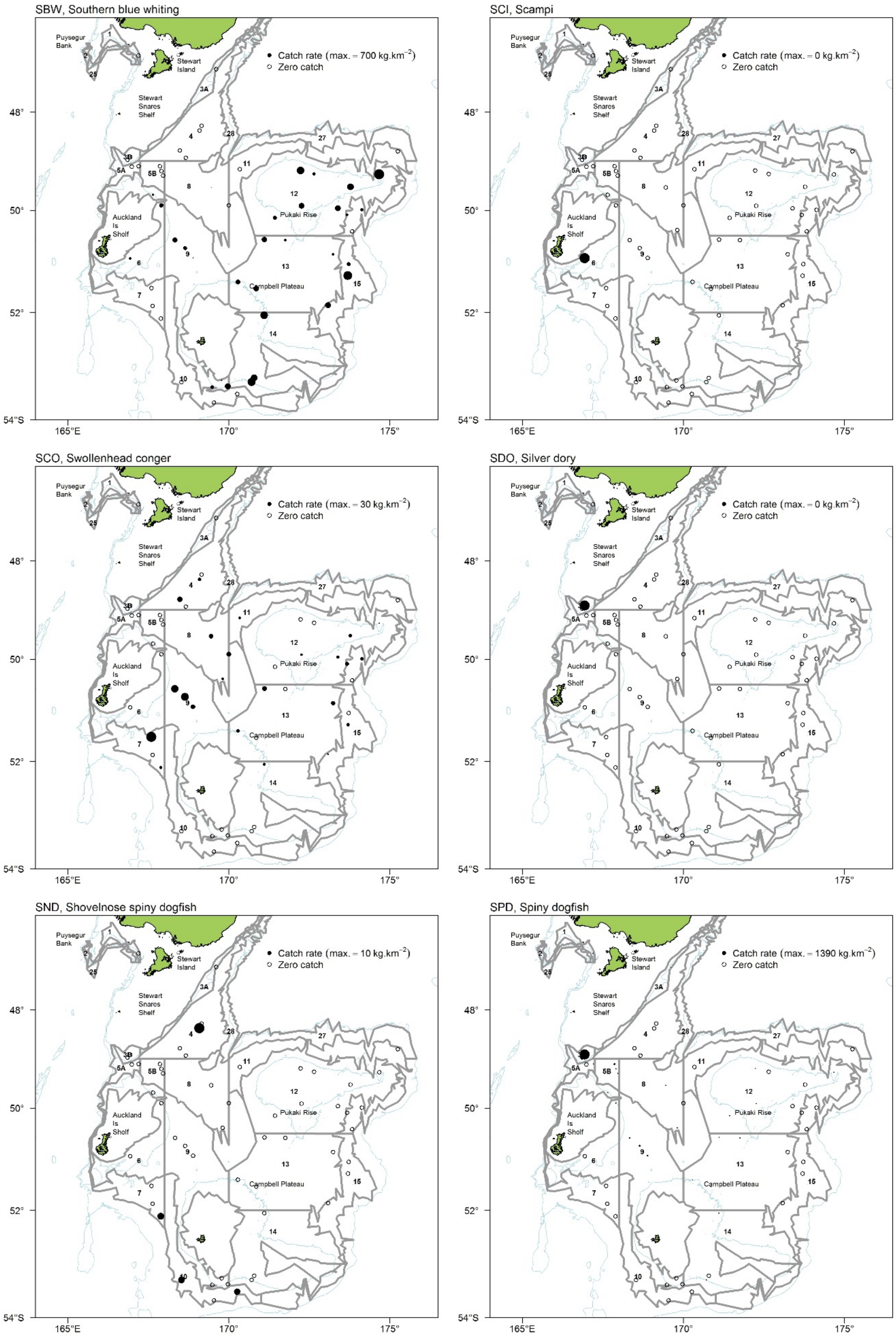


Figure 6 continued.

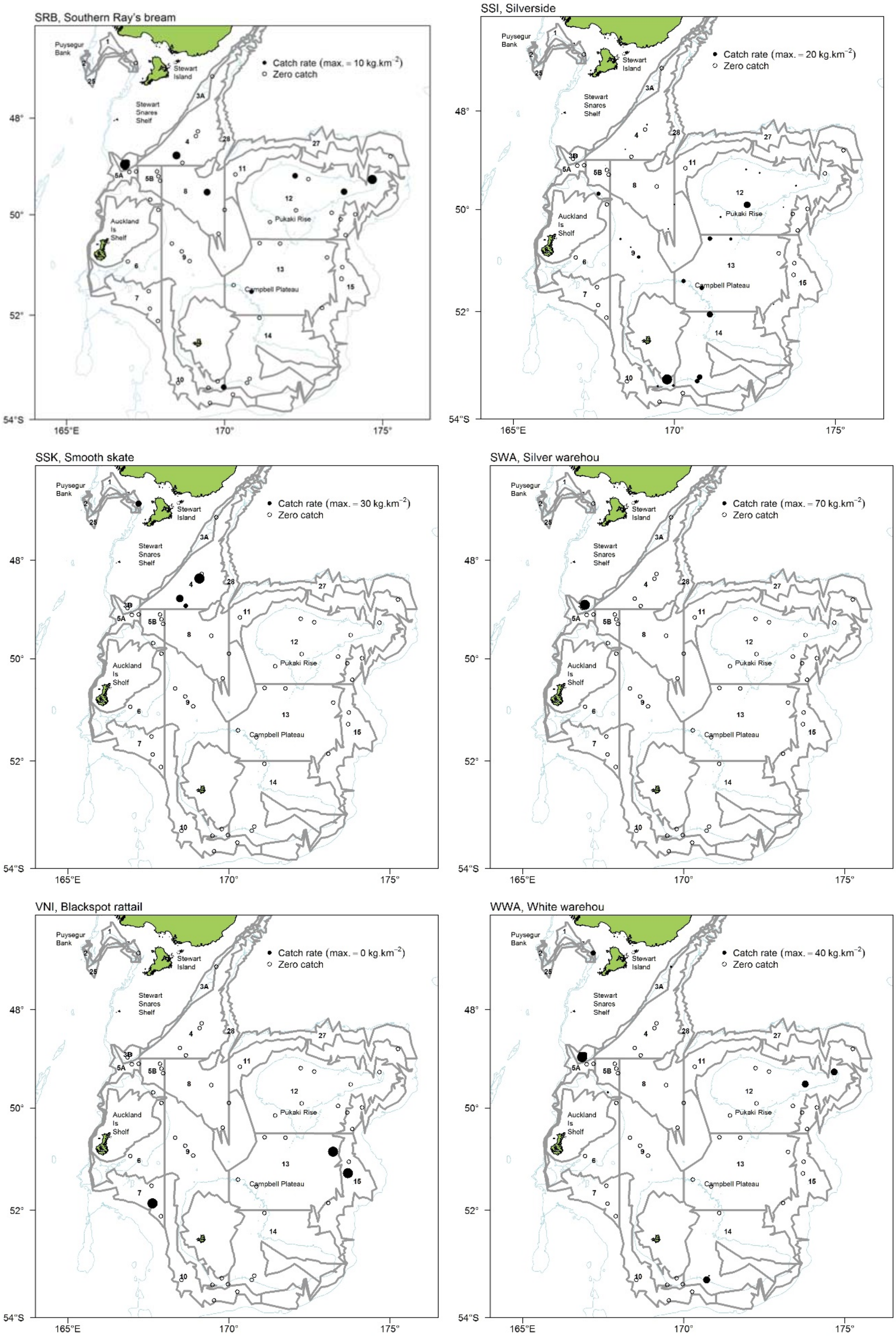


Figure 6 continued.

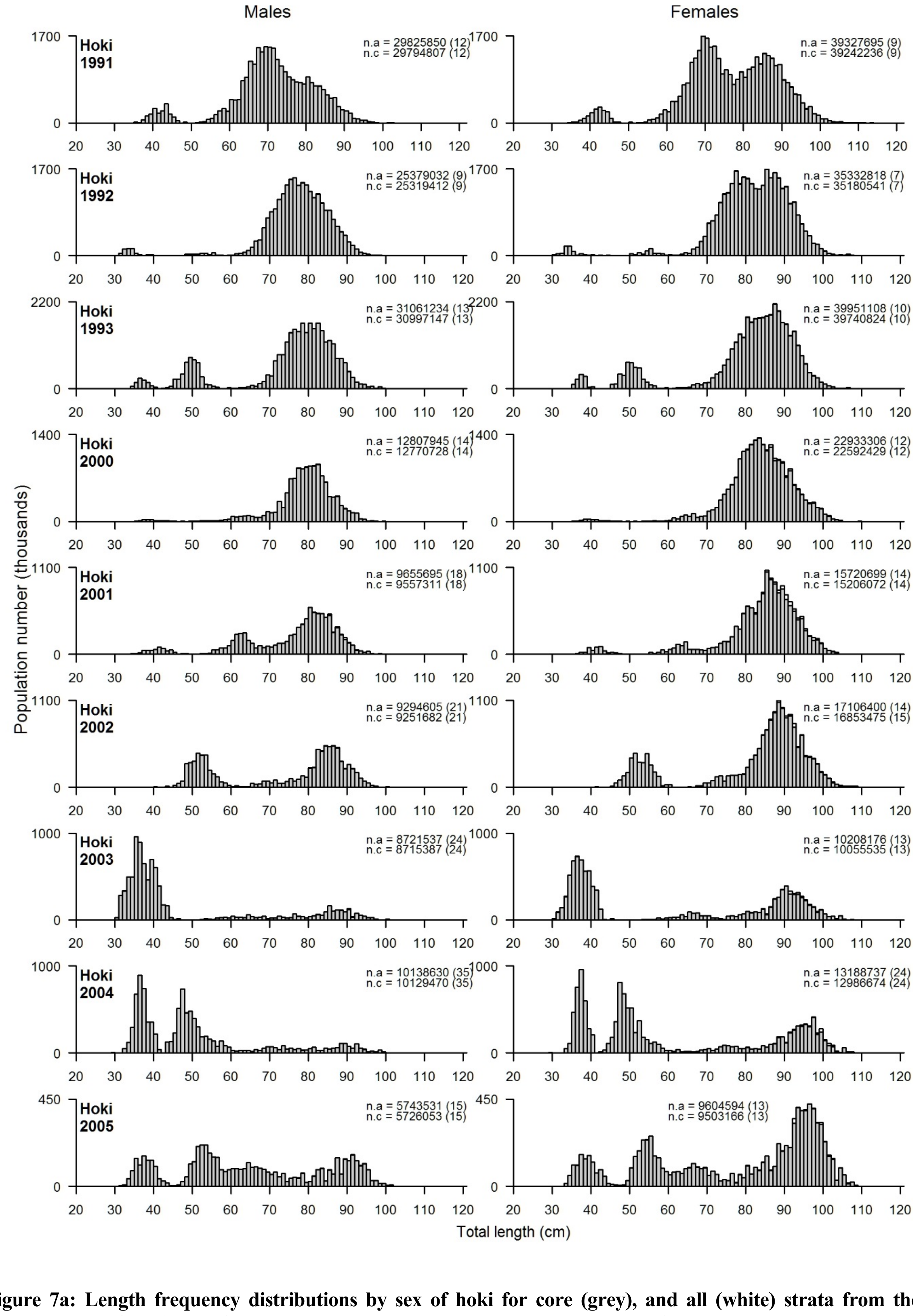


Figure 7a: Length frequency distributions by sex of hoki for core (grey), and all (white) strata from the Southland and Sub-Antarctic November–December *Tangaroa* surveys. n.a, estimated scaled total number of fish for all strata; n.c, estimated scaled total number of fish for core strata; and CV, the coefficient of variation (in parentheses).

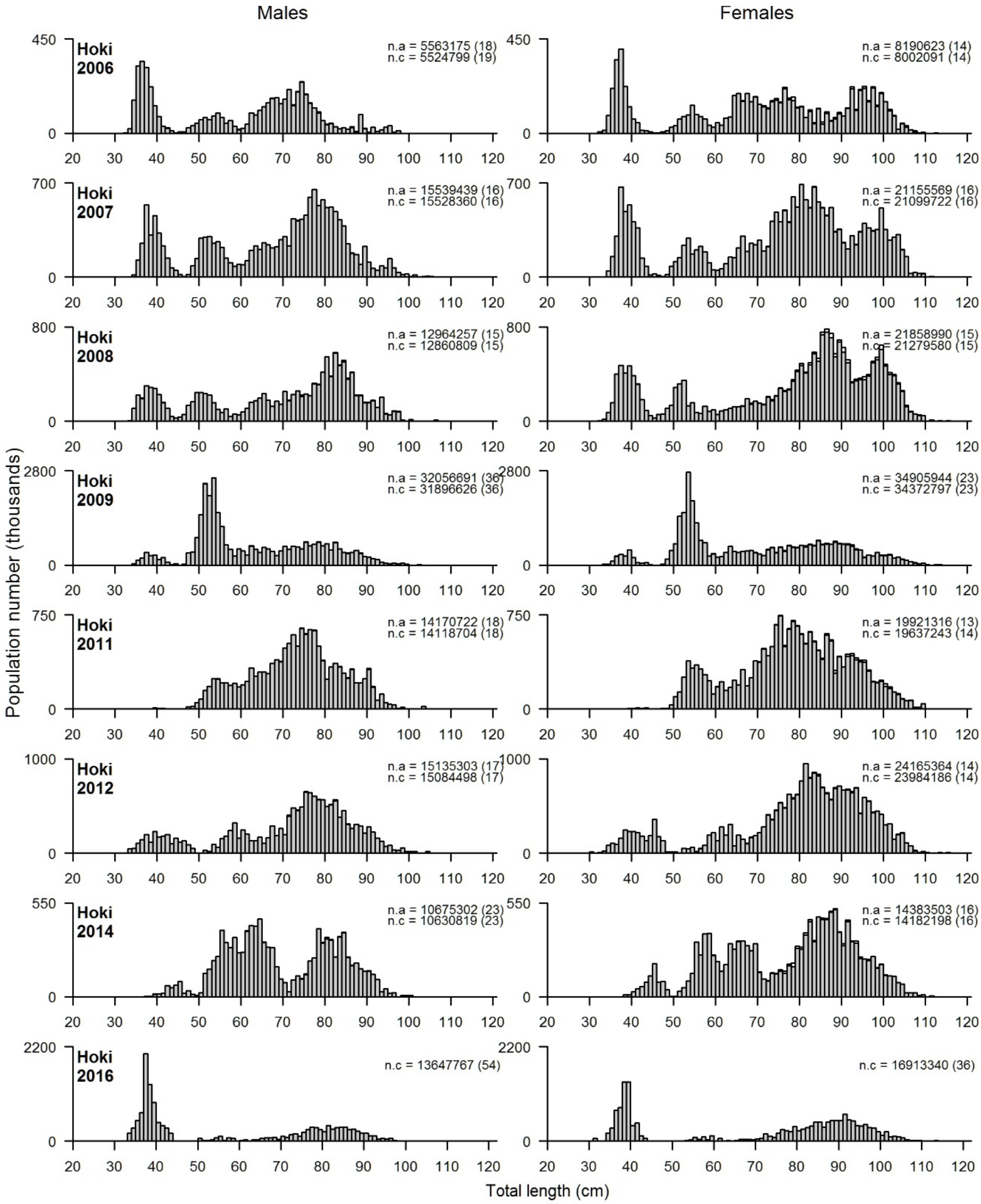


Figure 7a: continued.

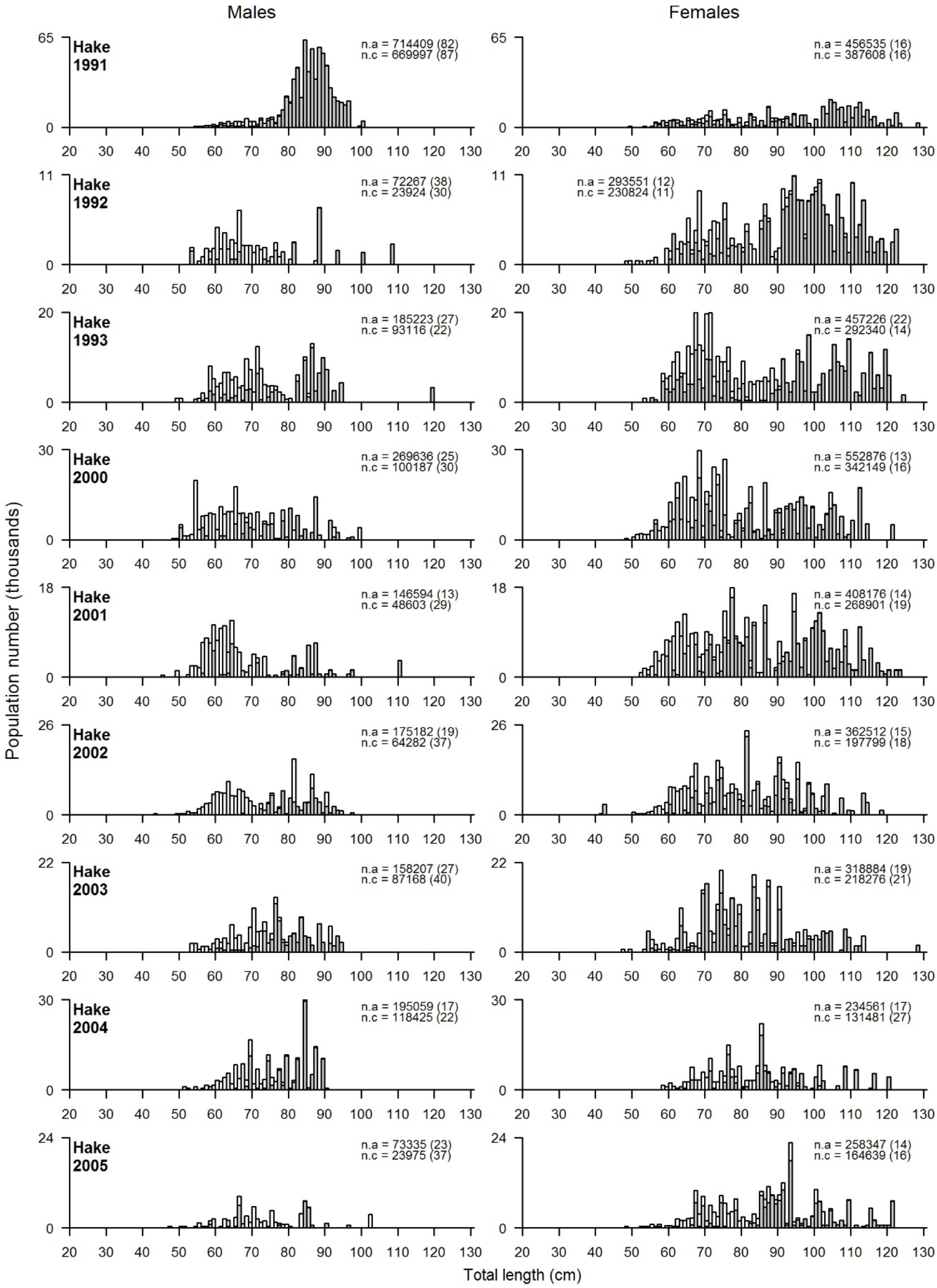


Figure 7b: Length frequency distributions by sex of hake for core (grey), and all (white) strata from the Southland and Sub-Antarctic November–December trawl surveys. n.a, estimated scaled total number of fish for all strata; n.c, estimated scaled total number of fish for core strata; and CV, the coefficient of variation (in parentheses).

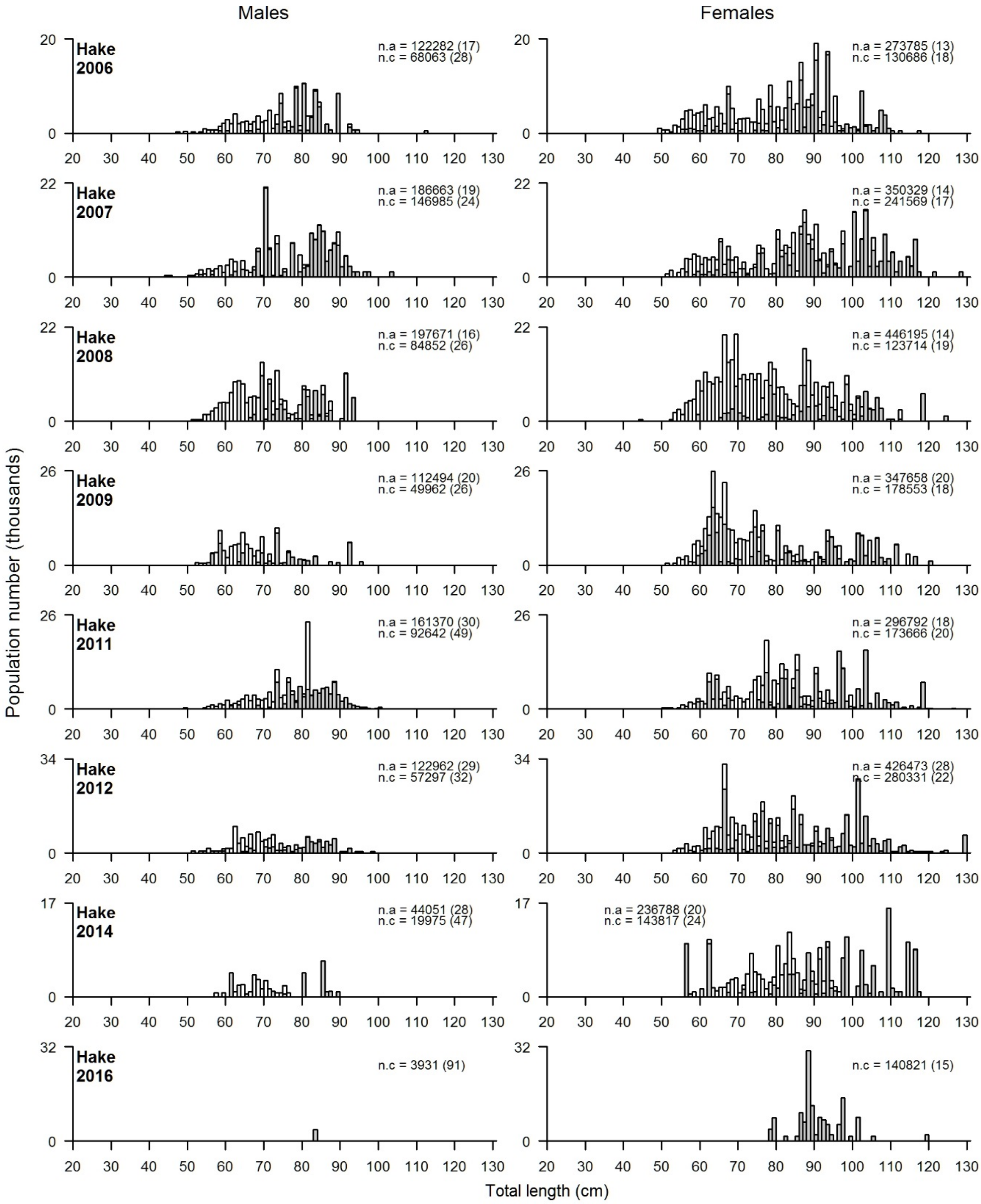


Figure 7b: continued.

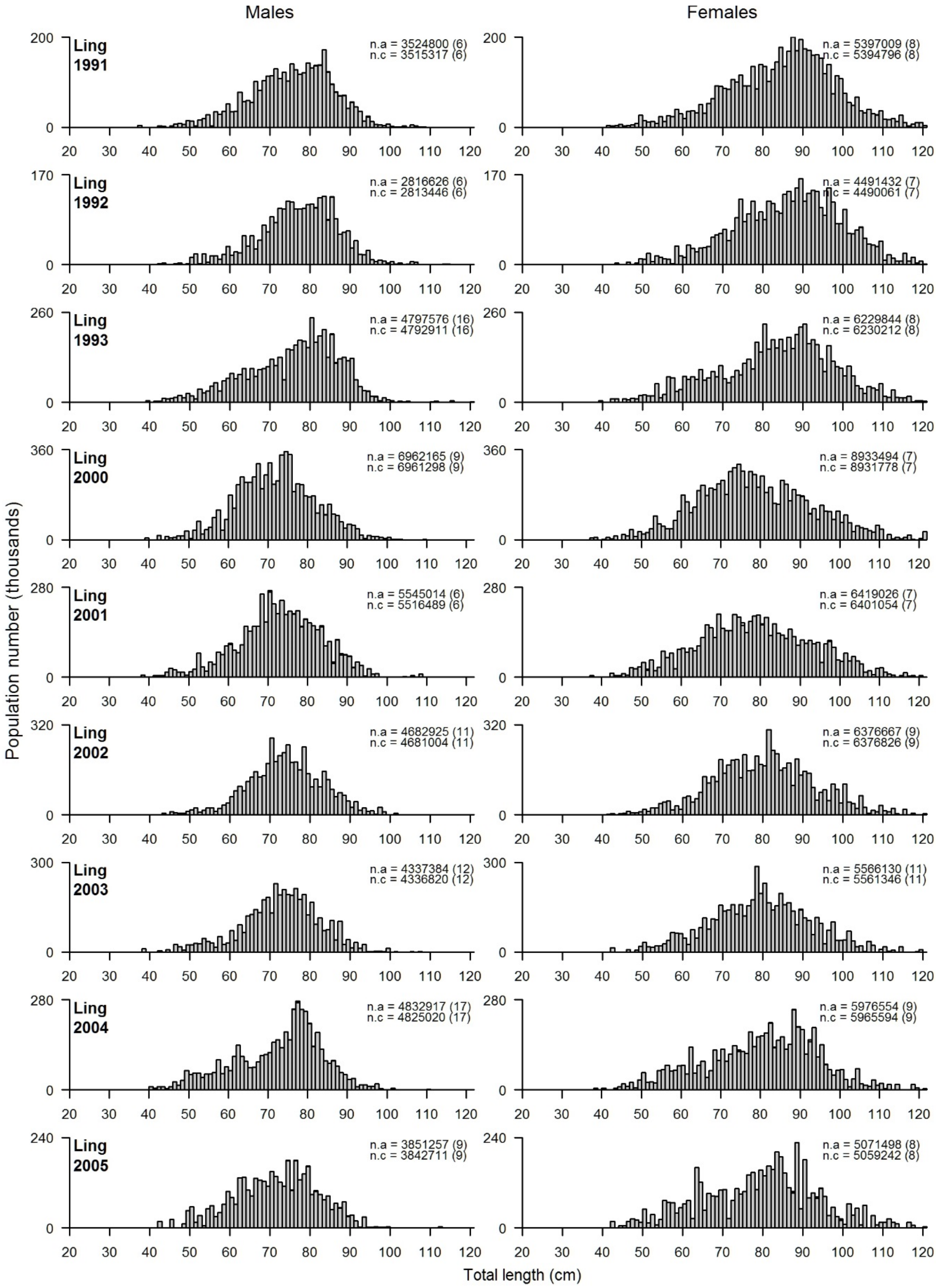


Figure 7c: Length frequency distributions by sex of ling for core (grey), and all (white) strata from the Southland and Sub-Antarctic November–December trawl surveys. n.a, estimated scaled total number of fish for all strata; n.c, estimated scaled total number of fish for core strata; and CV, the coefficient of variation (in parentheses).

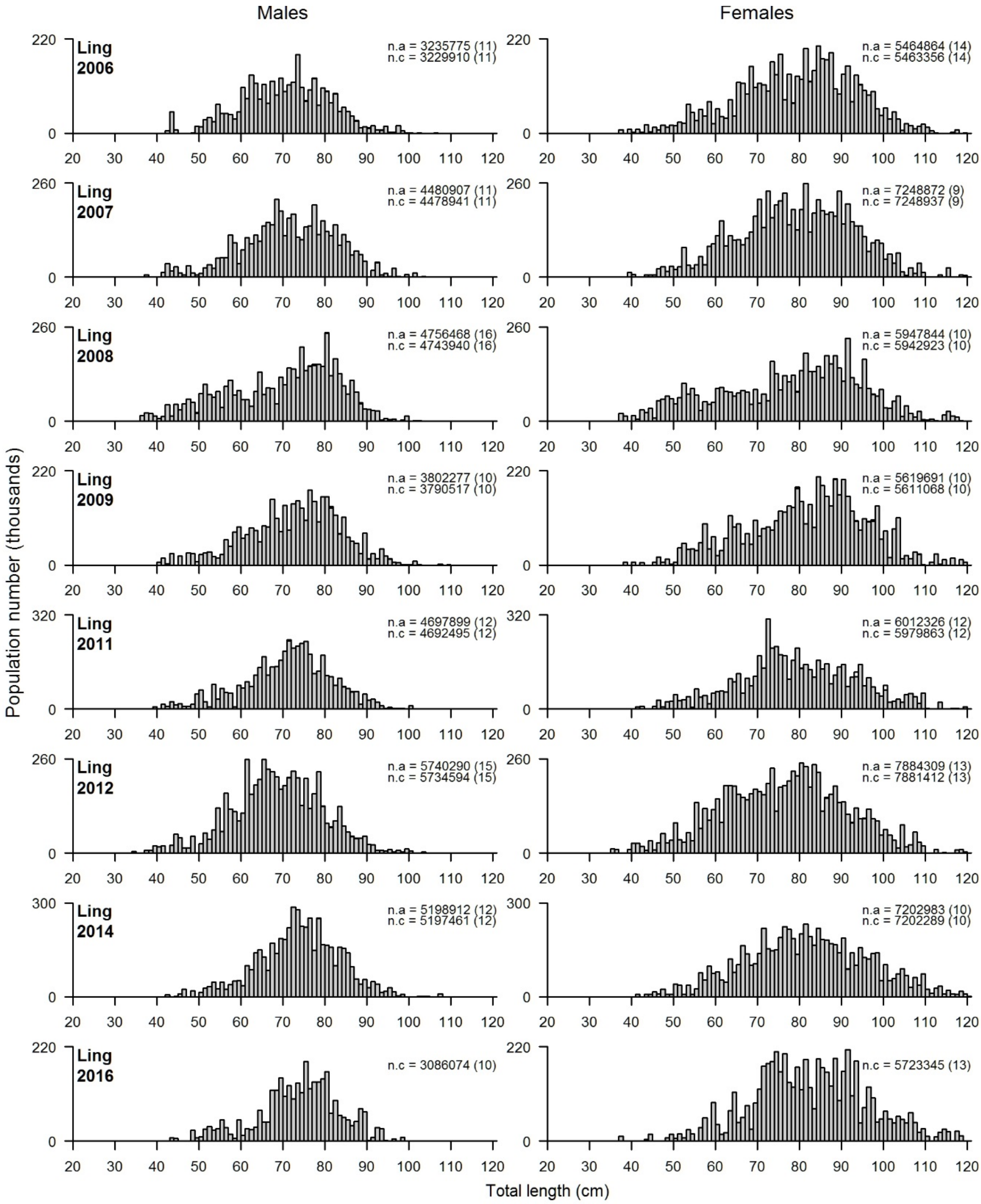


Figure 7c: continued.

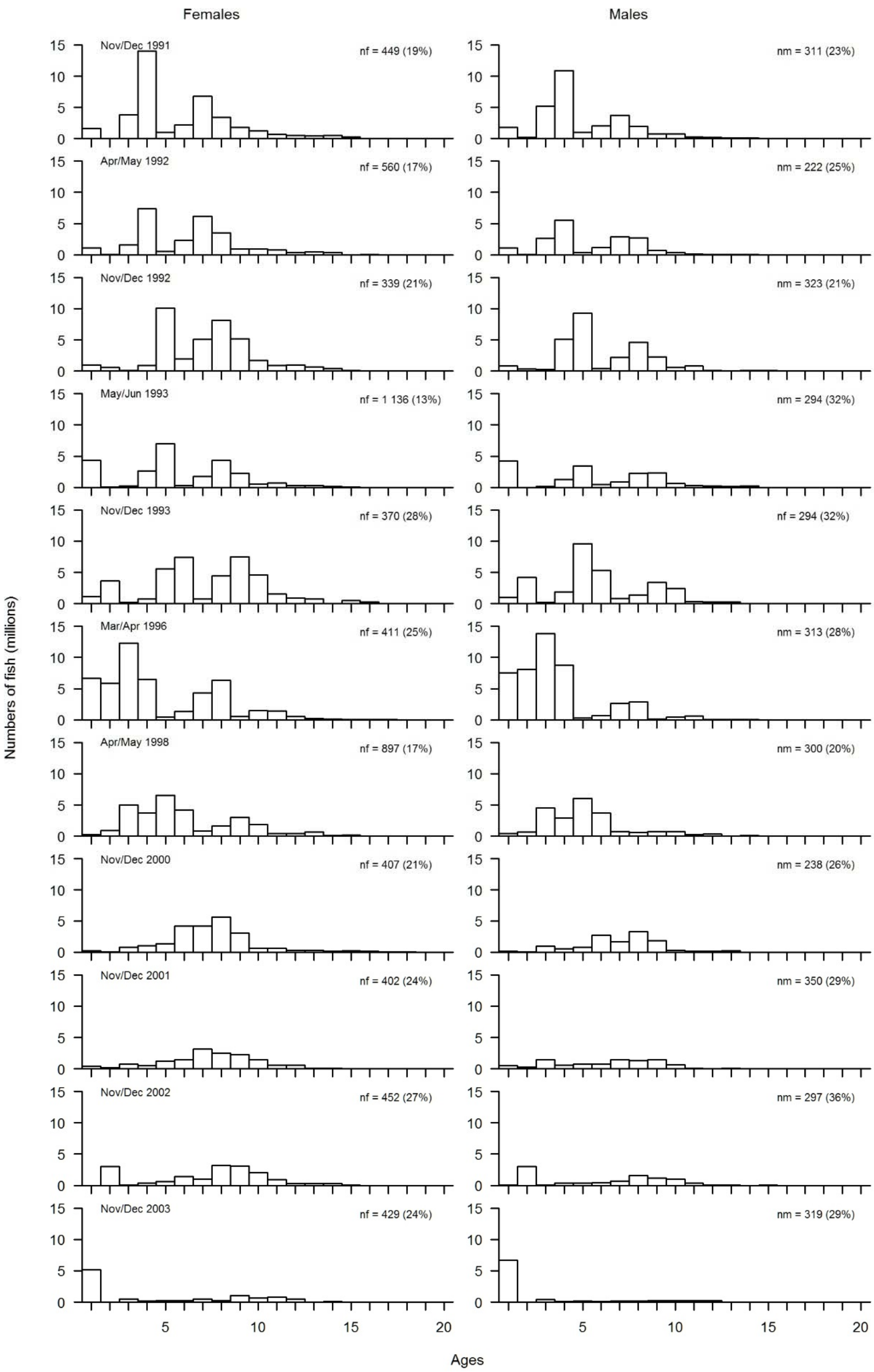


Figure 8a: Scaled age frequency for hoki in core strata from the Southland and Sub-Antarctic November–December *Tangaroa* surveys in 1991–1993, 2000–2009, 2011–2012, 2014, and 2016. Number of fish aged (nm, males; nf, females) are given with CVs in parentheses.

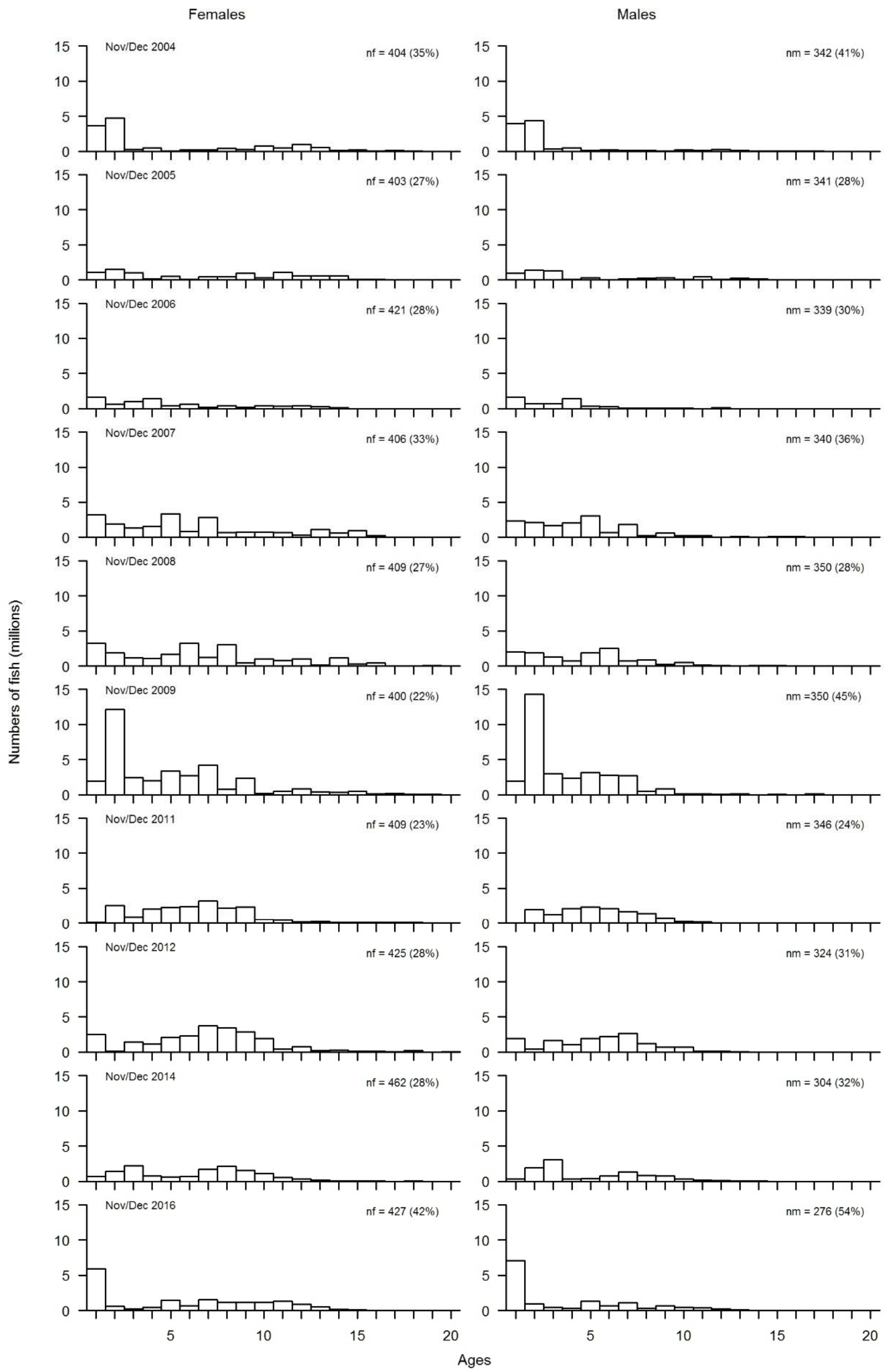


Figure 8a: Hoki continued.

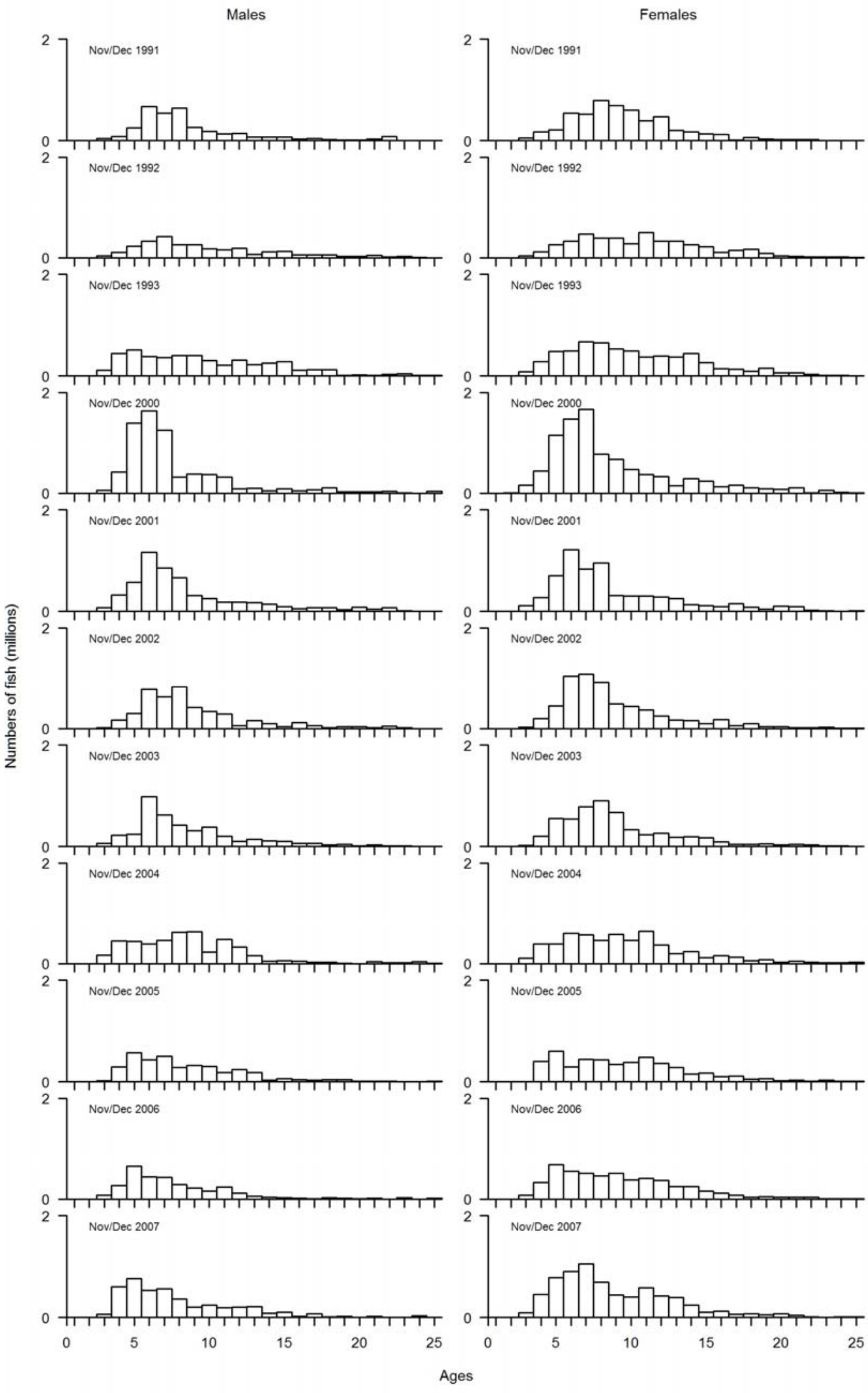


Figure 8b: Scaled age frequency for ling in core strata from the Southland and Sub-Antarctic November–December *Tangaroa* surveys in 1991–1993, 2000–2009, 2011–2012, 2014, and 2016.

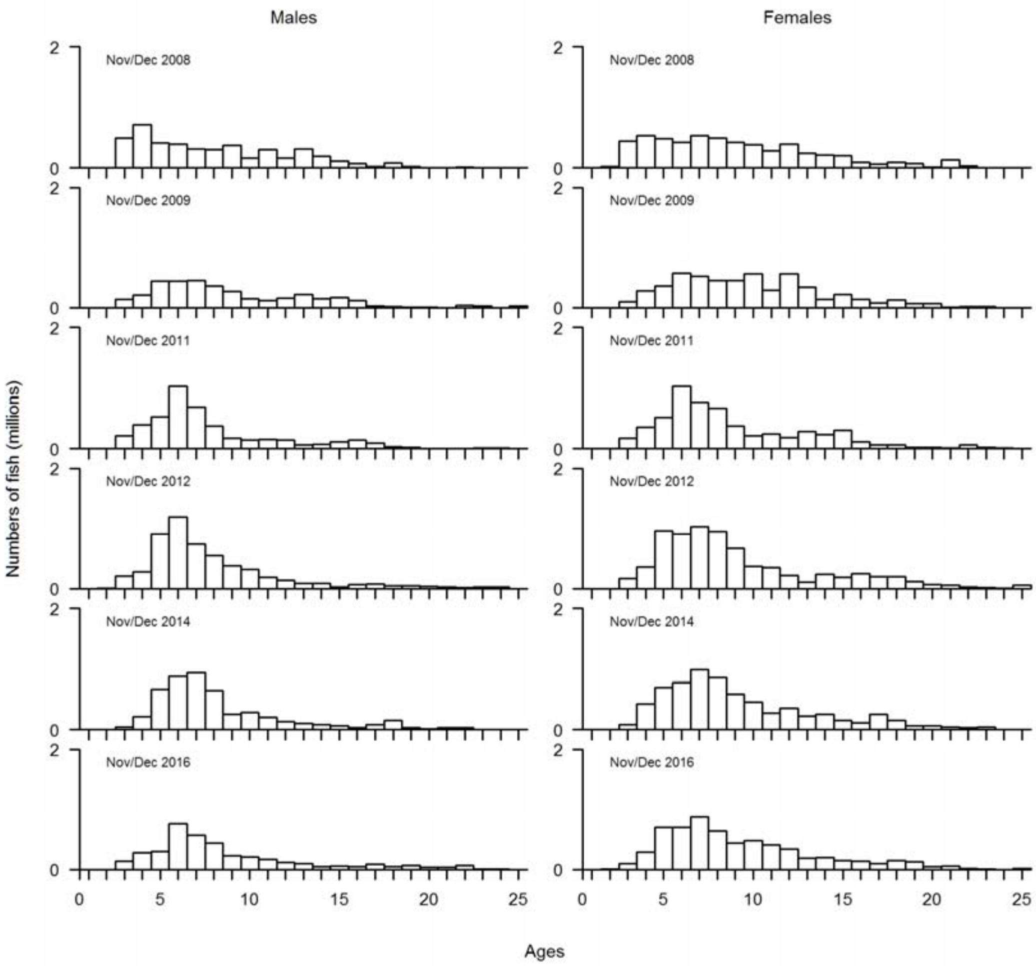


Figure 8b: Ling continued.

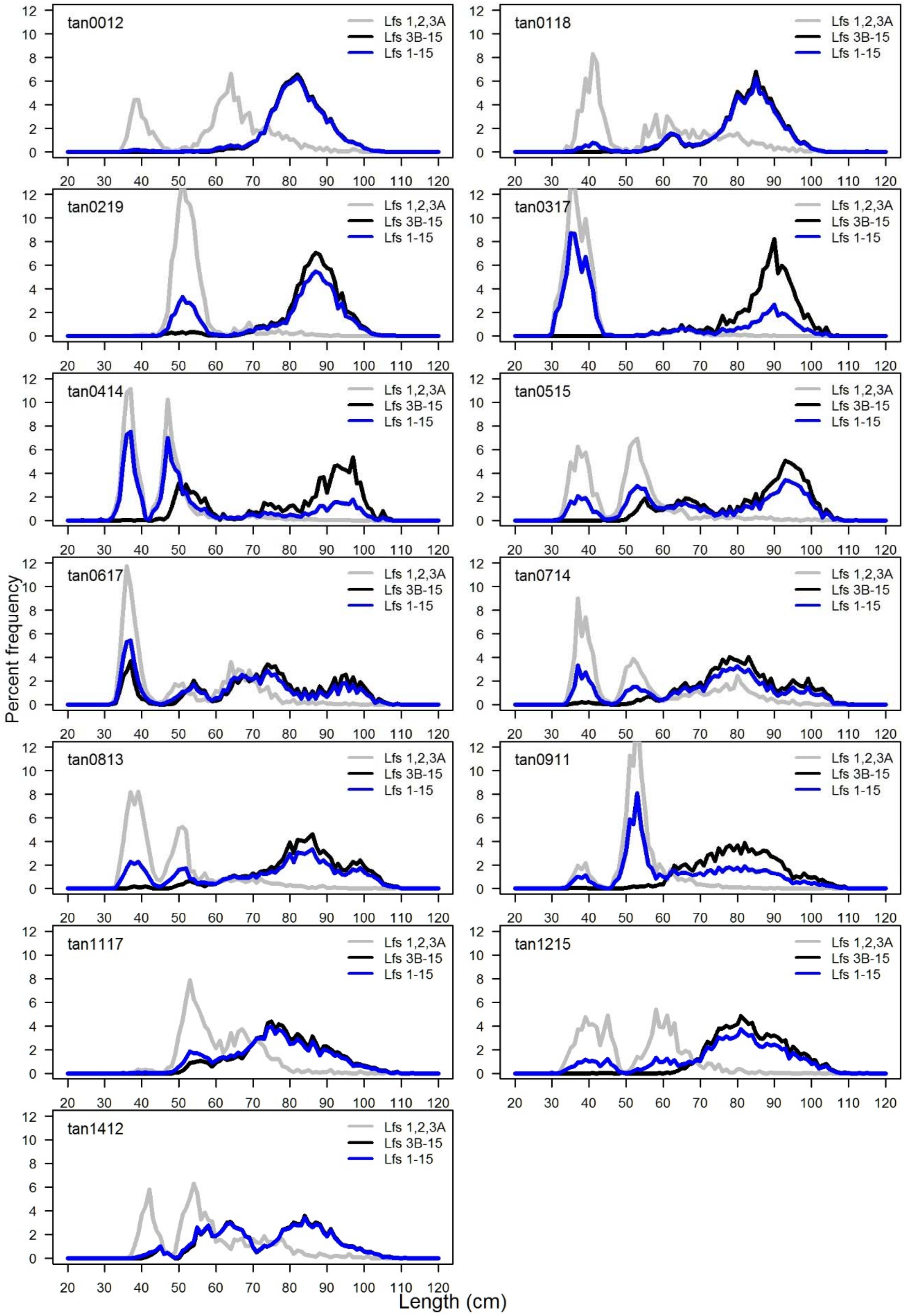


Figure 9a: Proportions at length of hoki in 'missing' strata (strata 1, 2, and 3A combined, grey), other core strata (strata 3B-15 combined, black), and for all core strata (strata 1–15, blue) for each previous Sub-Antarctic summer survey from 2000–2014.

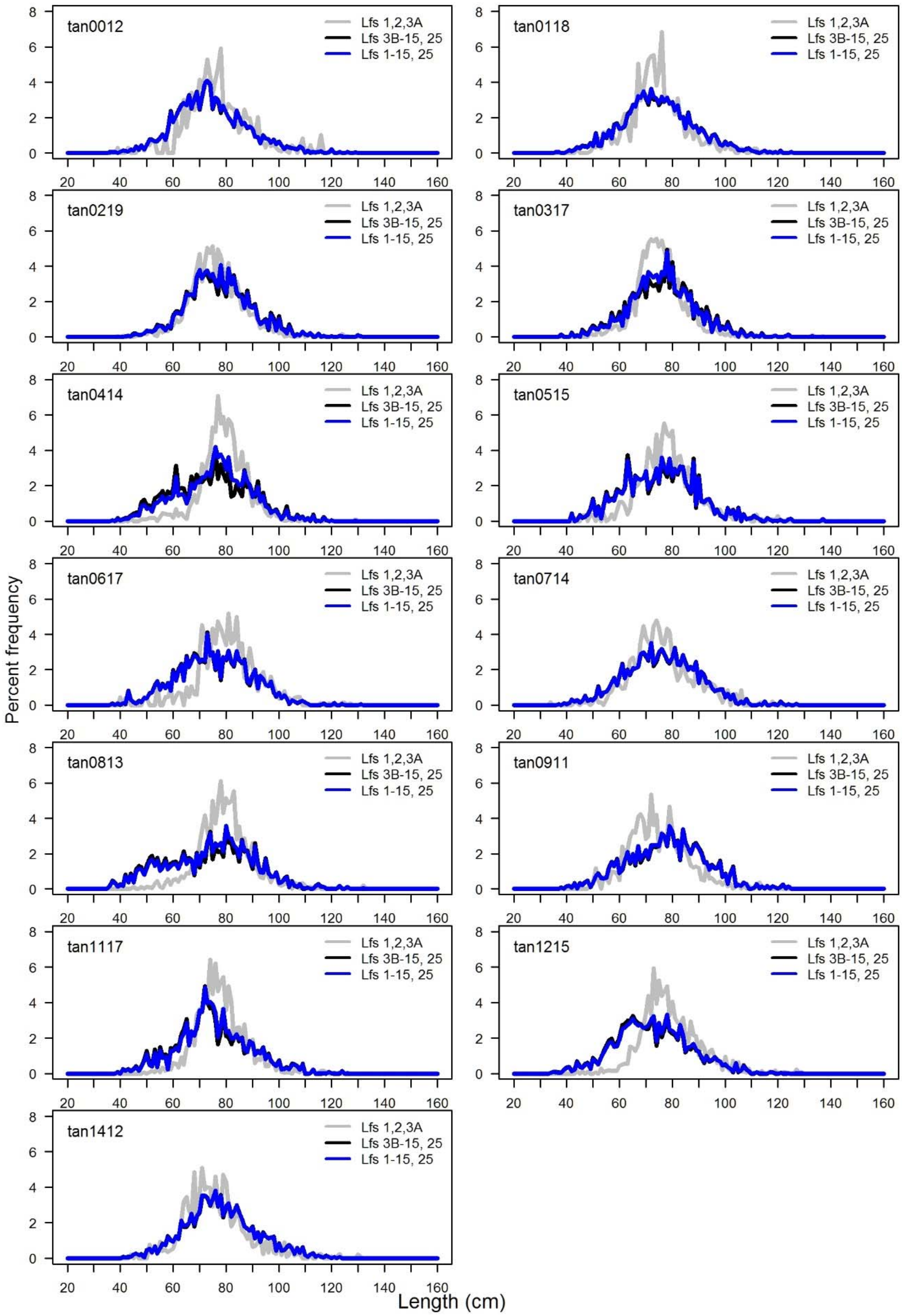


Figure 9b: Proportions at length of ling in 'missing' strata (strata 1, 2, and 3A combined, grey), other core strata (strata 3B–15 combined, black), and for all core strata (strata 1–15, blue) for each previous Sub-Antarctic summer survey from 2000–2014.

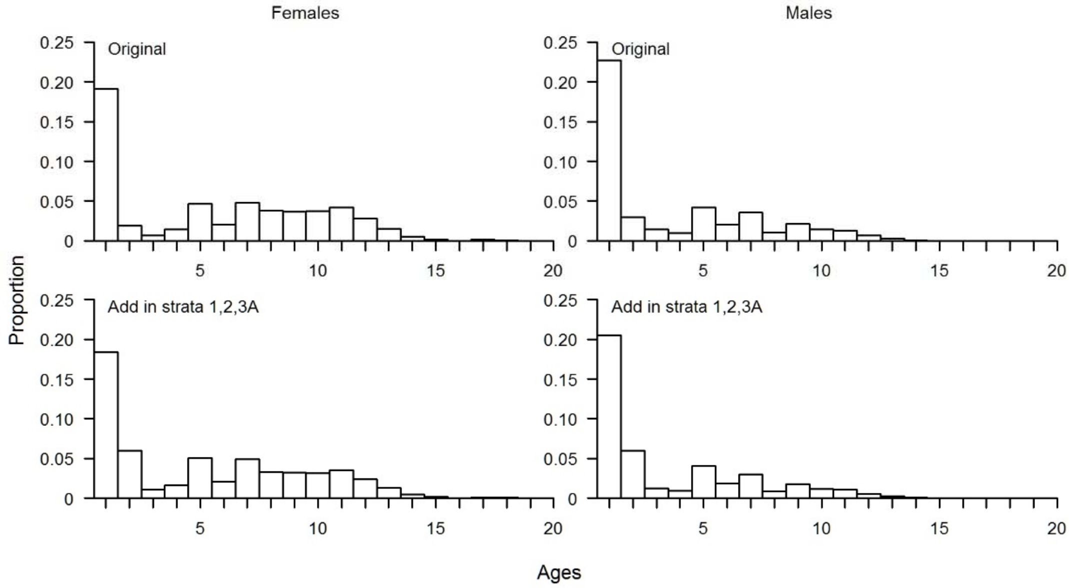


Figure 10: Comparison of unscaled ('Original') and scaled ('Add in strata 1,2,3A') age frequencies for hoki in core strata from the survey in 2016. See section 2.6 for details.

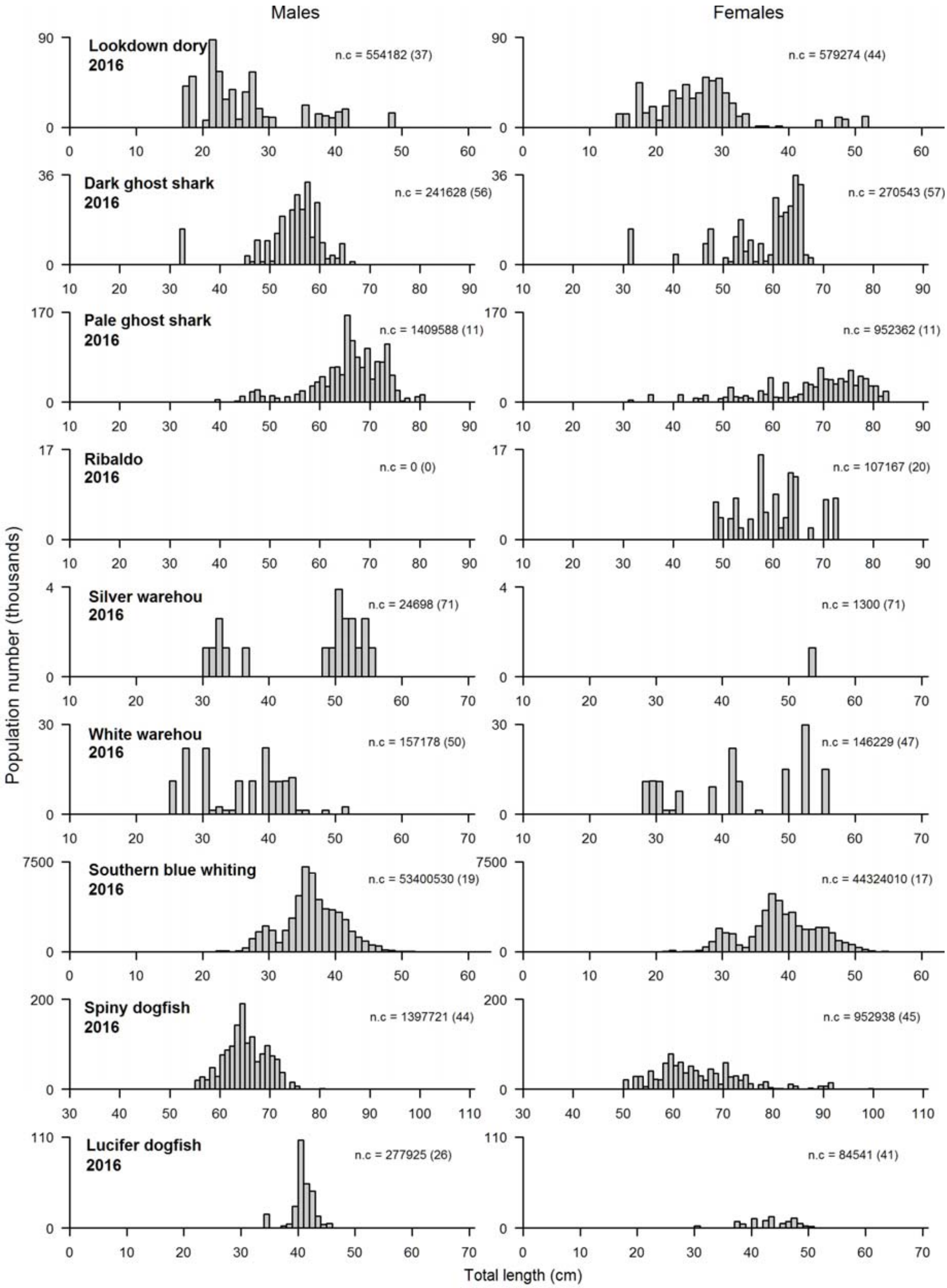


Figure 11: Length frequency distributions by sex of selected species for core (grey), and all (white) strata from the November–December 2016 Southland and Sub-Antarctic trawl survey. n.c, estimated scaled total number of fish for core strata; and CV, the coefficient of variation (in parentheses).

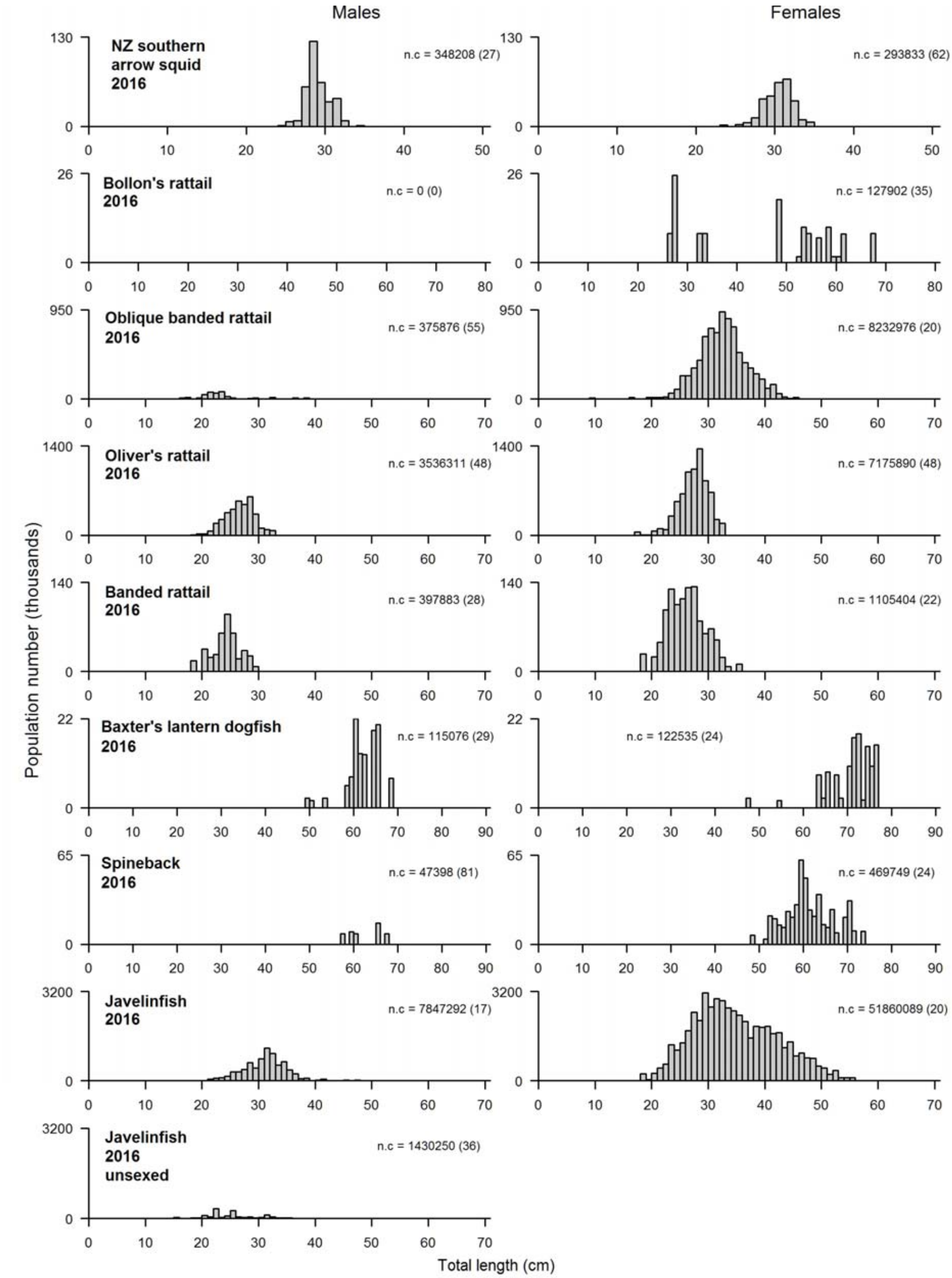
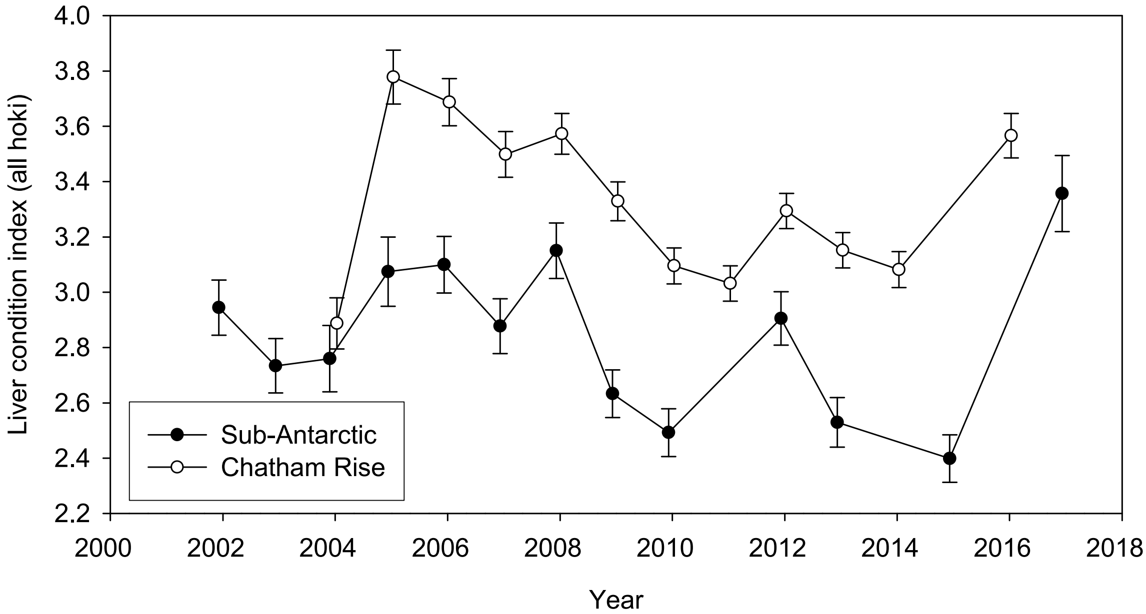


Figure 11: continued.



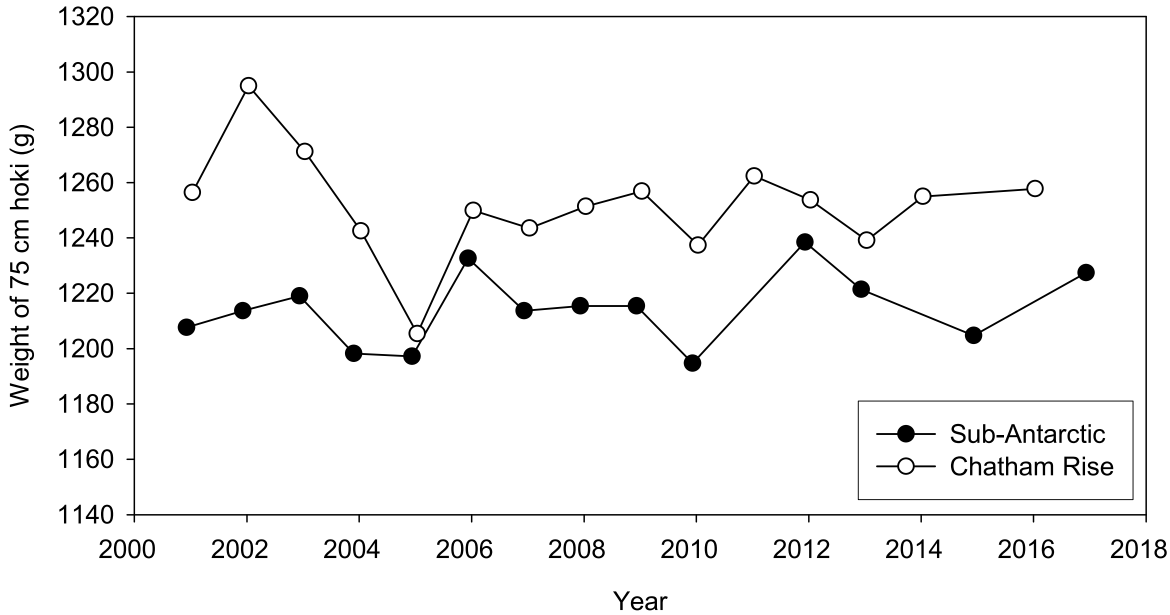


Figure 12: Liver (upper panel) and somatic (lower panel) condition indices of hoki sampled in the Sub-Antarctic summer trawl surveys since 2000. Condition indices are compared with those from the Chatham Rise survey (from Stevens et al. 2017).

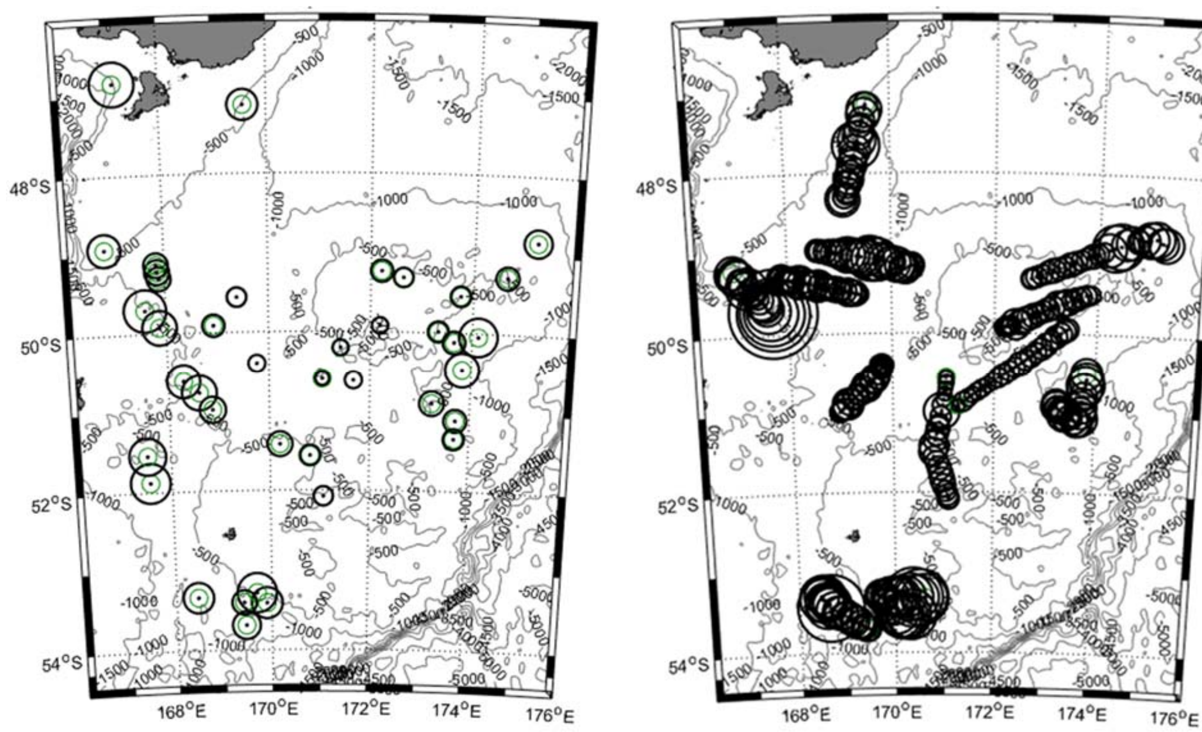


Figure 13: Spatial distribution of total acoustic backscatter ($m^2\ km^{-2}$) in the Sub-Antarctic observed during day trawl stations (left panel) and night steams (right panel). Circle area is proportional to the acoustic backscatter. Maximum circle size is 154 $m^2\ km^{-2}$.

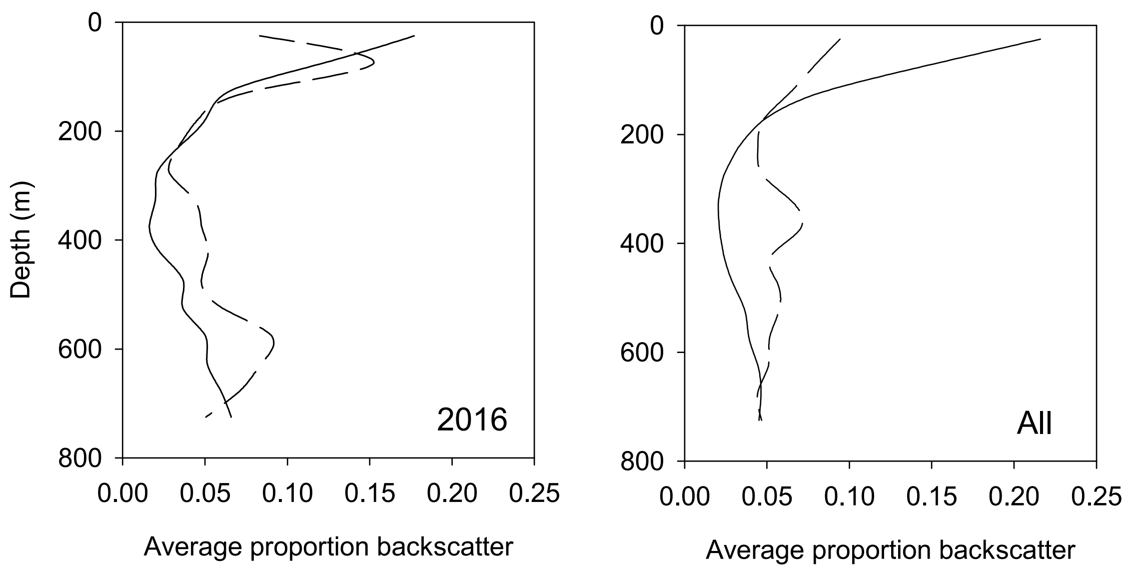


Figure 14: Distribution of total acoustic backscatter integrated in 50 m depth bins on the Sub-Antarctic observed during the day (dashed lines) and at night (solid lines) in 2016 (left panel) and average distribution from 2000–14 (right panel).

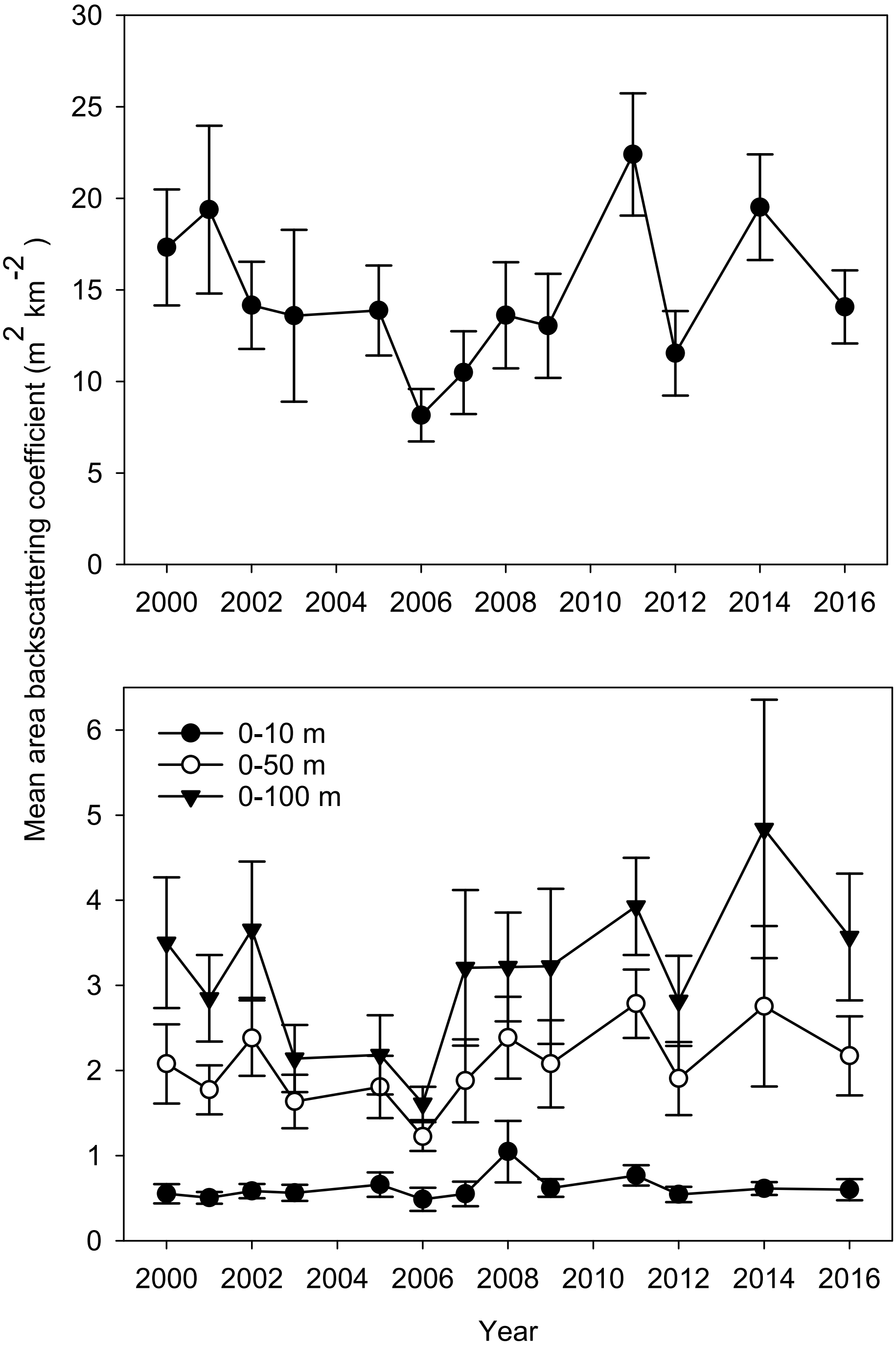


Figure 15: Estimates of total acoustic backscatter (upper panel), and backscatter in the bottom 10, 50, and 100 m (lower panel) from 38 kHz data collected during daytime trawls in 2000–16. Error bars are ± 2 standard errors.

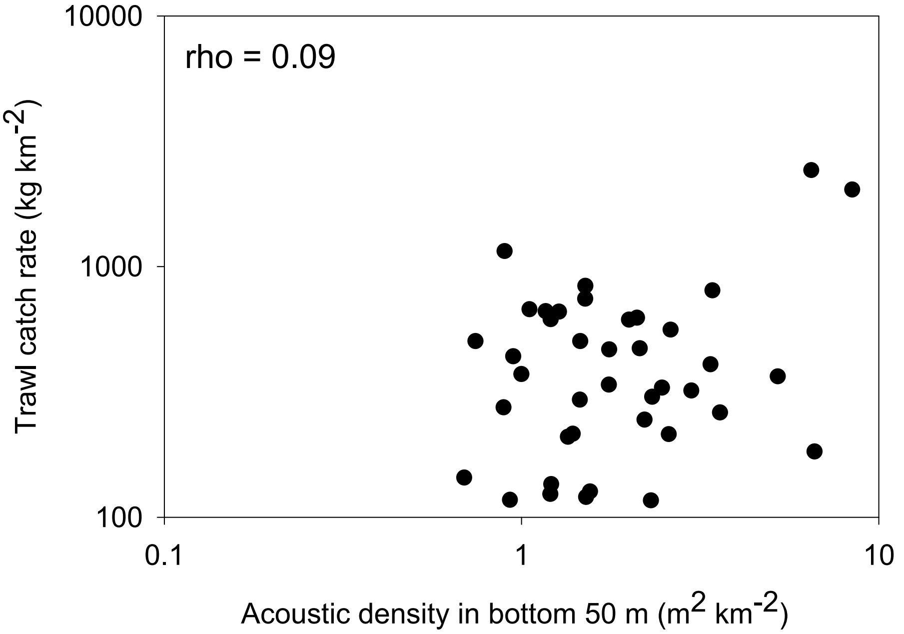


Figure 16: Relationship between total trawl catch rate (all species excluding benthic invertebrates) and acoustic backscatter recorded during the trawl in the Sub-Antarctic in 2016. Rho value is the Spearman's rank correlation coefficient.

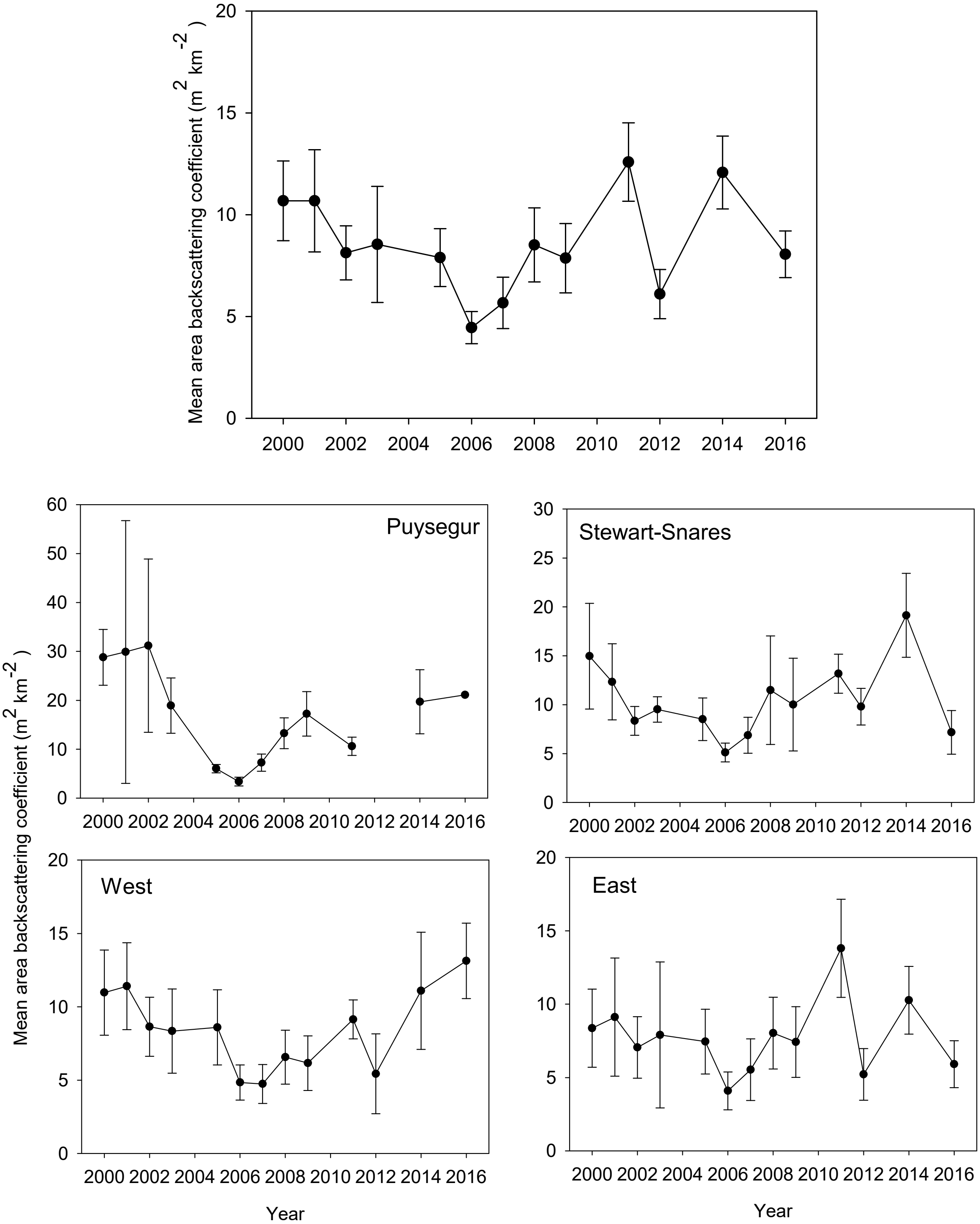


Figure 17: Time series of mesopelagic indices for the Sub-Antarctic (top panel) and by region (lower four panels). Error bars are ± 2 standard errors. Note that the 2012 survey did not produce any data suitable for acoustic analysis from Puysegur. There was only one data point for Puysegur in 2016.

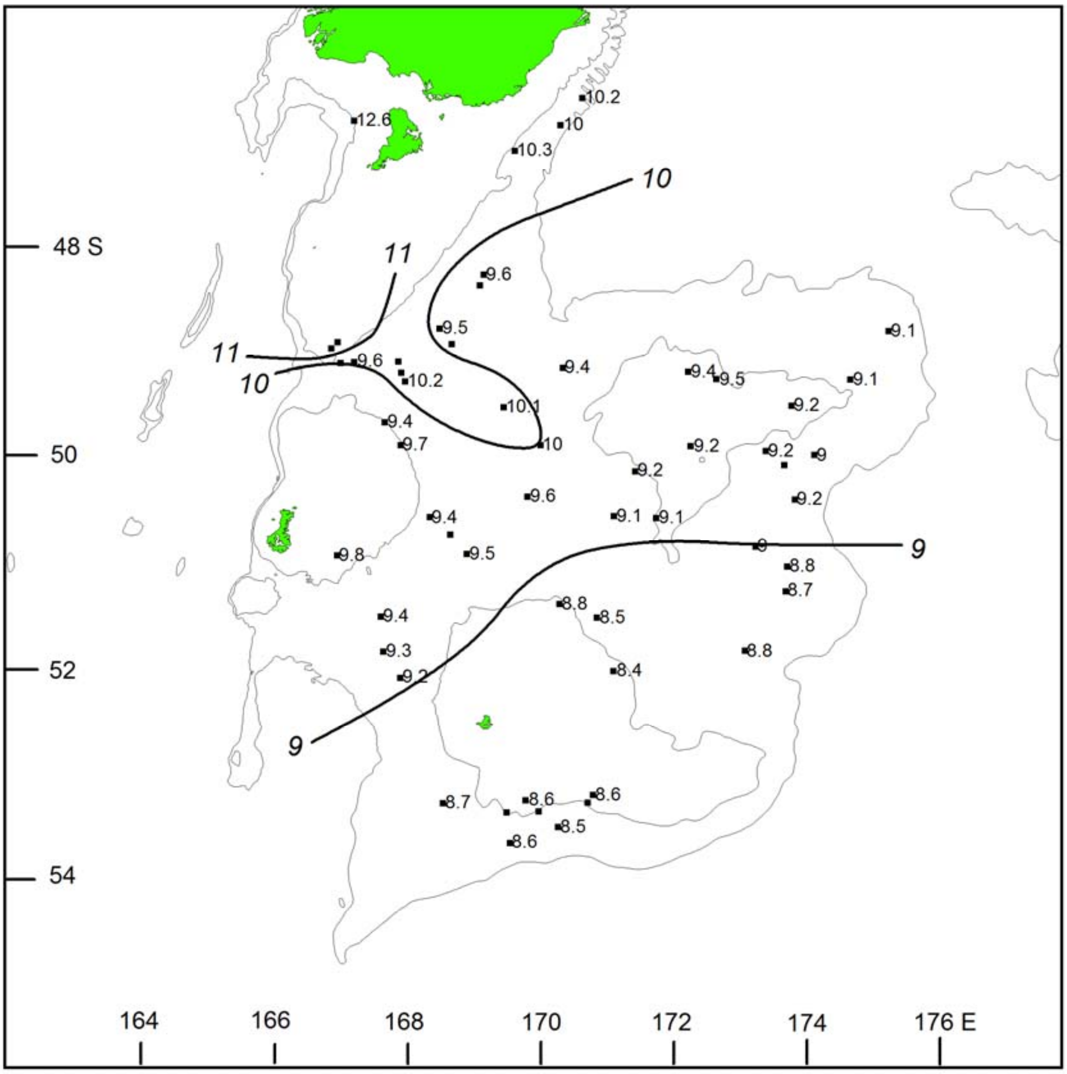


Figure 18: Surface water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

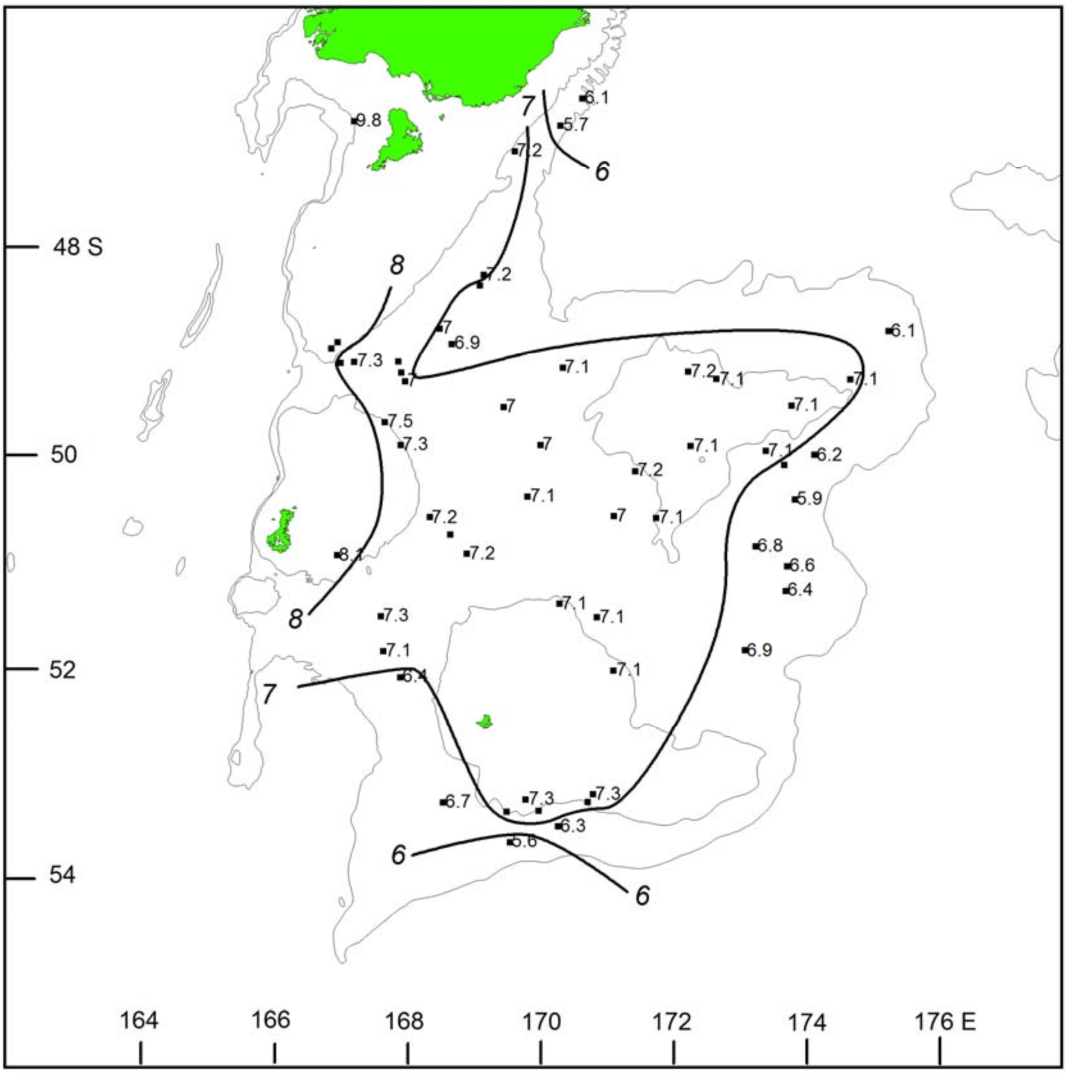


Figure 19: Bottom water temperatures (°C). Squares indicate station positions. Not all temperatures are labelled where two or more stations were close together. Contours show isotherms estimated by eye.

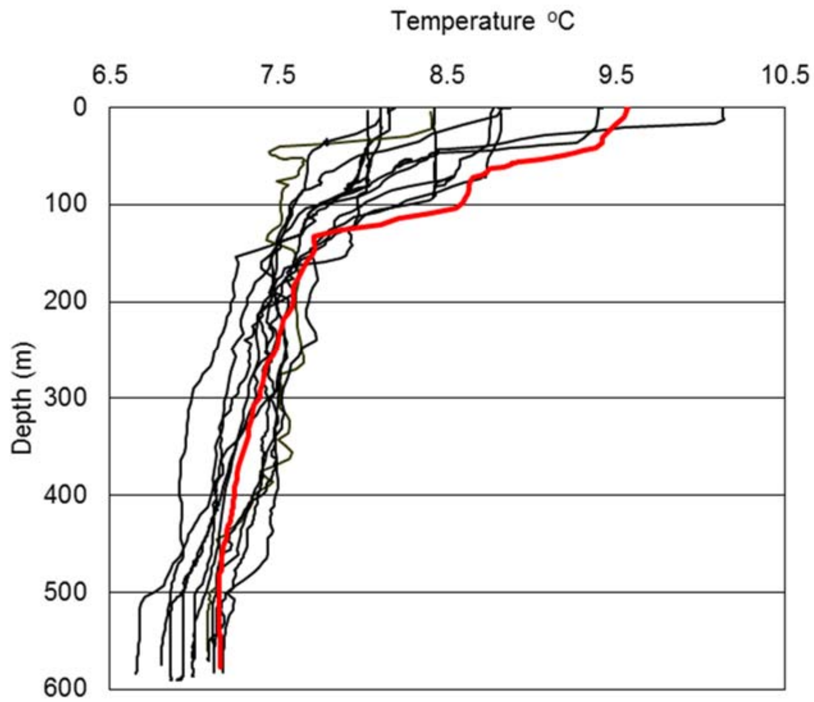


Figure 20: Comparison of vertical profiles of temperature from the net-mounted CTD on tows in stratum 9 at approximately 50° 45’ S and 169° 00’ E in 2002 (TAN0219 station 54, on 6 December), 2003 (TAN0317 station 45, on 29 November), 2004 (TAN0414 station 54, on 14 December), 2005 (TAN0515 station 42, on 6 December), 2006 (TAN0617 station 33, on 5 December), 2007 (TAN0714 station 40 on 7 December), 2008 (TAN0813 station 17, on 30 November), 2009 (TAN0911 station 46, on 9 December) 2011 (TAN1117 station 53, on 9 December) 2012 (TAN1215 station 69, on 13 December), 2014 (TAN1412 station 71, on 16 December), and 2016 (TAN1614 station 42, on 11 December). 2016 is the red line.

APPENDIX 1: Description of gonad staging for teleosts and elasmobranchs

Teleosts (Middle Depths method, MD)

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.

Elasmobranchs (Generalised shark and skate stage method, SS)

Research gonad stage		Males	Females
1	Immature	Claspers shorter than pelvic fins, soft and uncalcified, unable or difficult to splay open Testes small.	Ovaries small and undeveloped. Oocytes not visible, or small (pin-head sized) and translucent, whitish.
2	Maturing	Claspers longer than pelvic fins, soft and uncalcified, unable or difficult to splay open or rotate forwards.	Some oocytes enlarged, up to about pea-sized or larger, and white to cream.
3	Mature	Claspers longer than pelvic fins, hard and calcified, able to splay open and rotate forwards to expose clasper spine.	Some oocytes large (greater than pea-sized) and yolky (bright yellow).
4	Gravid I	-	Uteri contain eggs or egg cases but no embryos are visible.
5	Gravid II	-	Uteri contain visible embryos. Not applicable to egg laying sharks and skates.
6	Post-partum	-	Uteri flaccid and vascularised. Indicating recent birth.

APPENDIX 2: Station details and catch of hoki, ling, and hake.

Station	Date yyyy-mm-dd	Stratum	Start Latitude (S)	Start Longitude (E)	Distance (n. mile)	Hoki (kg)	Ling (kg)	Hake (kg)
1	2016-11-29	0028	46 35.68	170 37.79	3.02	7.4	-	-
2	2016-11-29	0028	46 51.10	170 18.33	3.00	-	3.3	-
3	2016-11-29	003A	47 05.84	169 36.72	3.00	12.0	36.7	-
4	2016-11-30	0004	48 16.61	169 08.77	3.00	327.7	41.2	-
5	2016-11-30	0004	48 22.77	169 05.30	3.00	66.1	74.9	-
6	2016-11-30	0004	48 47.46	168 29.06	2.45	293.6	87.9	-
7	2016-11-30	0004	48 56.31	168 39.90	3.00	182.9	53.2	4.6
8	2016-12-01	0011	49 10.07	170 20.52	3.00	120.0	39.5	-
9	2016-12-01	0012	49 12.15	172 13.60	2.16	17.8	14.3	-
10	2016-12-01	0012	49 16.41	172 39.17	2.99	11.0	81.0	-
11	2016-12-02	0011	48 48.74	175 14.98	3.00	96.6	20.9	-
12	2016-12-02	0012	49 16.55	174 40.21	3.03	10.6	21.9	-
13	2016-12-02	0012	49 31.59	173 47.09	3.00	23.6	73.7	-
14	2016-12-03	0012	49 54.60	172 15.74	3.00	30.9	63.7	-
15	2016-12-03	0012	50 09.12	171 25.72	3.04	6.7	35.1	-
16	2016-12-03	0013	50 35.65	171 44.70	3.02	17.0	29.0	-
17	2016-12-03	0013	50 34.53	171 06.33	3.04	30.3	66.2	-
18	2016-12-04	0014	52 03.10	171 06.14	3.00	78.6	101.6	-
19	2016-12-04	0013	51 32.56	170 51.00	3.01	224.4	301.0	-
20	2016-12-04	0013	51 24.83	170 17.09	3.03	139.3	160.9	-
21	2016-12-05	0012	49 57.49	173 23.65	3.01	160.8	81.2	-
22	2016-12-05	0011	50 05.59	173 40.43	2.99	113.3	16.1	-
23	2016-12-05	0011	49 59.66	174 07.70	2.96	103.5	28.9	-
24	2016-12-05	0011	50 25.05	173 50.04	2.98	60.2	1.9	-
25	2016-12-06	0013	50 52.02	173 14.40	3.00	14.1	20.5	-
26	2016-12-06	0015	51 03.56	173 43.16	3.05	18.7	25.6	-
27	2016-12-06	0015	51 17.53	173 41.90	3.01	23.9	13.1	-
28	2016-12-06	0015	51 51.47	173 05.00	3.00	95.3	36.2	-
29	2016-12-07	0014	53 13.73	170 47.45	3.01	18.1	71.9	-
30	2016-12-07	0014	53 18.32	170 42.60	3.01	36.8	75.9	-
31	2016-12-08	0010	53 32.04	170 15.89	3.00	72.4	4.2	-
32	2016-12-08	0009	53 23.25	169 58.30	3.04	111.1	113.9	6.0
33	2016-12-08	0009	53 17.01	169 46.53	3.01	1.4	-	-
34	2016-12-08	0009	53 23.77	169 29.61	3.01	26.8	72.5	5.3
35	2016-12-08	0010	53 41.23	169 32.32	3.04	19.6	-	-
36	2016-12-09	0010	53 18.53	168 32.01	3.89	57.9	12.2	-
37	2016-12-09	0007	52 06.86	167 53.17	2.99	28.5	11.0	28.8
38	2016-12-10	0007	51 51.98	167 38.02	2.99	68.1	29.0	15.2
39	2016-12-10	0007	51 32.00	167 35.95	3.04	106.2	65.9	-
40	2016-12-10	0006	50 57.02	166 56.46	2.97	40.0	39.5	-
41	2016-12-11	0009	50 35.23	168 20.01	3.00	112.8	33.2	5.2
42	2016-12-11	0009	50 45.13	168 38.68	2.99	243.1	70.7	5.6
43*	2016-12-11	0009	50 56.20	168 53.61	3.00	191.1	153.4	-
44	2016-12-12	0008	50 23.38	169 48.31	2.97	31.6	24.2	-
45	2016-12-12	0008	49 54.21	169 59.94	2.99	179.0	100.7	4.0
46	2016-12-12	0008	49 32.38	169 26.95	3.01	62.1	30.3	18.7
47	2016-12-13	005B	49 17.76	167 57.83	2.99	56.4	27.0	44.0
48	2016-12-13	005B	49 12.76	167 54.10	2.97	52.0	56.0	7.5
49	2016-12-13	005B	49 06.30	167 51.42	2.97	178.2	127.4	14.2

APPENDIX 2: continued.

Station	Date yyyy-mm-dd	Stratum	Start Latitude (S)	Start Longitude (E)	Distance (n. mile)	Hoki (kg)	Ling (kg)	Hake (kg)
50	2016-12-13	005A	49 06.74	167 11.76	3.02	37.8	81.5	-
51	2016-12-13	005A	49 07.21	166 59.22	3.04	53.3	168.2	27.1
52	2016-12-14	0006	49 41.14	167 39.17	3.02	17.0	44.4	10.9
53	2016-12-14	0006	49 53.97	167 53.73	2.98	16.2	83.3	17.5
54	2016-12-17	003B	48 58.92	166 50.89	3.01	2748.8	92.9	-
55	2016-12-17	003B	48 55.37	166 56.92	0.89	-	-	-
56	2016-12-17	003B	48 55.37	166 56.53	3.00	418.6	21.8	-
57	2016-12-18	0001	46 48.75	167 11.70	2.66	94.0	1076.5	-

APPENDIX 3: Species list

Scientific and common names, species codes and occurrence (Occ.) of fish, squid, and other organisms from all trawl tows. Note species codes, particularly invertebrates are continually updated on the database following identification ashore.

Scientific name	Common name	Species code	Occ.
Porifera: sponges	unspecified sponges	ONG	1
Hexactinellida:			
Hyalascus spp.	floppy tubular sponge	HYA	21
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	9
Hymedesmiidae			
Phorbas spp.	grey fibrous massive sponge	PHB	1
Tetillidae			
Tetilla australe	bristle ball sponge	TTL	1
Cnidaria: Hydroids and Hydrocorals			
Scyphozoa	unspecified jellyfish	JFI	6
Actiniidae			
Bolocera spp.	smooth deepsea anemone	BOC	4
Actinostolidae	deepsea anenome	ACS	6
Hormathiidae	warty deepsea anenome	HMT	5
Liponematidae			
Liponema spp.	deepsea anemone	LIP	1
Chrysogorgiidae			
Chrysogorgia spp.	Golden coral	CHR	1
Flabellidae			
Flabellum spp.	*Flabellum* cup corals	COF	1
Ascidiacea: Tunicates, sea squirts			
Tunicata: Salps			
Thaliacea	unspecified salps	SAL	5
Salpidae			
Pyrosoma atlanticum		PYR	39
Mollusca			
Nudibranchia:sea slugs	unidentified sea slug	NUD	1
Gastropoda: gastropods			
Buccinidae			
Aeneator recens	sea snail	AER	1
Ranellidae			
Fusitron magellanicus		FMA	2
Volutidae (volutes)			
Alicithoe wilsonae		AWI	2
Cephalopoda: squid and octopus			
Histioteuthidae			
Histioteuthis spp.	violet squid	VSQ	2
Ommastrephidae			
Ommastrephes spp.	red squid	OMM	1
Nototodarus sloanii	arrow squid	NOS	11
Todarodes filippovae	*Todarodes* squid	TSQ	11
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	43
O. robsoni	warty squid	MRQ	2

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Pholidoteuthidae			
Pholidoteuthis sp. 1 NZ	large red scaly squid	PSQ	1
Octopoda: Octopus			
	unspecified octopus	OCP	1
Octopodidae			
Enteroctopus zealandicus	yellow octopus	EZE	1
Graneledone. taniwha	deepwater octopus	GTA	2
G. spp.	deepwater octopus	DWO	3
Opisthoteuthididae			
Opisthoteuthis spp.	umbrella octopus	OPI	1
Arthropoda: Isopods, amphipods, mysids, prawns, lobsters, crabs, barnacles, sea spiders			
Crustacea			
Malacostraca			
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	14
Oplophoridae			
Oplophorus novaezeelandiae	deepwater prawn	ONO	1
Galatheoidea			
Lithodidae			
Lithodes aotearoa	New Zealand king crab	LAO	1
Parapaguridae			
Sympagurus dimorphus	hermit crab	SDM	2
Brachyura: True crabs			
Goneplacidae			
Pycnoplax victoriensis	two-spined crab	CVI	1
Majidae (spider crabs)			
Leptomithrax longipes	long-legged masking crab	LLC	1
Leptomithrax garricki	Garrick's masking crab	GMC	1
Teratomaia richardsoni	spiny masking crab	SMK	1
Nephropidae			
Metanephrops challengeri	scampi	SCI	1
Cirripedia: barnacles	unspecified barnacle	BRN	1
Echinodermata			
Asteroidea	sea stars		
Asteriidae			
Pseudechinaster rubens		PRU	1
Asteriidae	unidentified starfish	ASR	1
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	4
Psilaster acuminatus	geometric star	PSI	1
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	6
Hippasteria trojana	trojan star	HTR	4
Lithosoma novaezelandiae	rock star	LNV	1
Pillsburiester aoteanus		PAO	1

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	15
Crinoidea: sea lillies and feather stars			
Echinoidea	unspecified sea urchin	ECT	1
Echinothuriidae, Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	2
Ophiuroidea			
Gorgonocephalidae			
Gorgonocephalus spp.	gorgon's head basket-star	GOR	1
Synallactidae			
Pseudostichopus mollis		PMO	19
Pannychia moseleyi		PAM	2
Chondrichthyes: cartilaginous fishes			
Squalidae: dogfishes			
Centrophorus squamosus	deepwater spiny dogfish	CSQ	4
Centroscymnus crepidater	longnose velvet dogfish	CYP	2
C. owstoni	smooth skin dogfish	CYO	2
Deania calcea	shovelnose dogfish	SND	4
Etmopterus baxteri	Baxter's lantern dogfish	ETB	15
E. lucifer	Lucifer dogfish	ETL	17
Proscymnodon plunketi	Plunket's shark	PLS	2
Squalus acanthias	spiny dogfish	SPD	54
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	2
Scyliorhinidae: cat sharks			
Apristurus spp.	deepsea catsharks	APR	1
Bythaelurus dawsoni	Dawson's catshark	DCS	1
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	1
Rajidae: skates			
Brochiraja asperula	smooth deepsea skate	BTA	4
Bathraja shuntovi	longnosed deepsea skate	PSK	1
B. spinifera	prickly deepsea skate	BTS	4
Dipturus innominata	smooth skate	SSK	4
Zearaja nasuta	rough skate	RSK	2
Chimaeridae: chimaeras, ghost sharks			
Hydrolagus bemisi	pale ghost shark	GSP	48
H. novaezelandiae	dark ghost shark	GSH	7
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose chimaera	LCH	17
Rhinochimaera pacifica	widenose chimaera	RCH	2
Osteichthyes			
Notacanthidae: spiny eels			
Notocanthus sexspinis	spineback	SBK	15
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	1
Congridae: conger eels			
Bassanago bulbiceps	swollenheaded conger	SCO	23
B. hirsutus	hairy conger	HCO	25
Argentinidae: silversides			
Argentina elongata	silverside	SSI	26
Alepocephalidae: slickheads			
Alepocephalus antipodianus	small-scaled brown slickhead	SSM	2

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Paralepididae: barracudinas			
Magnisudis prionosa	giant barracudina	BCA	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	6
Moridae: morid cods			
Auchenoceros punctatus	ahuru	PCO	1
Mora moro	ribaldo	RIB	15
Pseudophycis bachus	red cod	RCO	4
Moridae: morid cods (continued)			
Pseudophycis barbata	southern bastard cod	SBR	1
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	31
Merlucciidae: hakes			
Lyconus sp.		LYC	1
Macruronus novaezelandiae	hoki	HOK	55
Merluccius australis	hake	HAK	15
Macrouridae: rattails, grenadiers			
Coelorinchus aspercephalus	oblique-banded rattail	CAS	29
C. bollonsi	Bollons’s rattail	CBO	11
C. fasciatus	banded rattail	CFA	41
C. innotabilis	notable rattail	CIN	4
C. kaiyomaru	Kaiyomaru rattail	CKA	4
C. matamua	Mahia rattail	CMA	8
C. oliverianus	Oliver's rattail	COL	30
C. subserrulatus	four-rayed rattail	CSU	5
Lepidorhynchus denticulatus	javelinfish	JAV	53
Lucigadus nigromaculatus	blackspot rattail	VNI	3
Mesobius antipodum	black javelinfish	BJA	1
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	53
Himantolophidae: prickly anglerfishes			
Himantolophus spp	prickly anglerfish	HIM	1
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	1
Diretmichthys parini	spinyfin	SFN	2
Zeidae: dories			
Cyttus novaezealandiae	silver dory	SDO	1
C. traversi	lookdown dory	LDO	26
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	2
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	2
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	3
Pseudocyttus maculatus	smooth oreo	SSO	2
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	1
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	6
Neophrynichthys latus	dark toadfish	TOD	1
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	1
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	1
Bramidae: pomfrets			
Brama australis	southern Ray’s bream	SRB	8

Appendix 3 continued:

Scientific name	Common name	Species code	Occ.
Nototheniidae: cod icefishes			
Notothenia microlepidota	smallscaled cod	SCD	1
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	GIZ	6
Gempylidae: snake mackerels			
Rexea solandri	gemfish	RSO	1
Trichiuridae: cutlassfishes			
Lepidopus caudatus	frostfish	FRO	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	2
Seriolella caerulea	white warehou	WWA	8
S. punctata	silver warehou	SWA	1
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	1
Neoachiropsetta milfordi	finless flounder	MAN	29
Pleuronectidae: righteyed flounders			
Azygopus pinnifasciatus	spotted flounder	SDF	1