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Trawl survey of hoki and middle-depth species on the Chatham Rise, January 2018 (TAN1801)

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EXECUTIVE SUMMARY

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The 25th trawl survey in a time series to estimate the relative biomass of hoki and other middle depth species on the Chatham Rise was carried out from 4 January to 3 February 2018. A random stratified sampling design was used, and 127 bottom trawls were successfully completed. These comprised 83 core (200–800 m) phase 1 biomass tows, 4 core phase 2 tows, and 40 deep (800–1300 m) tows.

Estimated relative biomass of all hoki in core strata was 122 097 t (CV 16.2%), an increase of 7% from January 2016. This increase was largely driven by the biomass estimates for 1+ year old hoki (2016 year class) of 30 499 t and 2+ hoki (2015 year-class) of 51 346 t. The biomass estimate for 2+ hoki was the third highest estimate in the time series. The relative biomass of recruited hoki (ages 3+ years and older) of 40 252 t declined by 26% from that in 2016 but recruited hoki were also observed in deep (800–1300 m) strata in 2018. The relative biomass of hake in core strata increased by 28% to 1660 t (CV 34.3%) between 2016 and 2018. The relative biomass of ling was 8758 t (CV 11.5%), 14% lower than that in January 2016, but the time-series for ling shows no overall trend.

The age frequency distribution for hoki was dominated by 1+ and 2+ year old fish. The age frequency distribution for hake was broad, with most aged between 3–9 years. The age distribution for ling was also broad, with most aged between 2–20 years.

In 2018 the survey again covered 800–1300 m depths around the entire Rise. The deep strata provide relative biomass indices for a range of deepwater sharks and other species associated with orange roughy and oreo fisheries.

Acoustic data were collected during the trawl survey. As in previous surveys, there was a weak positive correlation (rho = 0.29) between acoustic density from bottom marks and trawl catch rates. The acoustic index of mesopelagic fish abundance in 2018 decreased in all four sub-areas, and was 40% lower than that in 2016, and the lowest since 2011. Hoki liver condition was also lower than in 2016, and the lowest in the time-series of condition indices that goes back to 2004. There was a strong positive correlation (rho = 0.71) between hoki liver condition and indices of mesopelagic fish scaled by hoki abundance ("food per fish").

1. INTRODUCTION

In January 2018, the 25th in a time series of random trawl surveys on the Chatham Rise was completed. This and all previous surveys in the series were carried out from RV *Tangaroa* and form the most comprehensive time series of relative species abundance at water depths of 200 to 800 m in New Zealand's 200-mile Exclusive Economic Zone. Previous surveys in this time series were documented by Horn (1994a, 1994b), Schofield & Horn (1994), Schofield & Livingston (1995, 1996, 1997), Bagley & Hurst (1998), Bagley & Livingston (2000), Stevens et al. (2001, 2002, 2008, 2009a, 2009b, 2011, 2012, 2013, 2014, 2015, 2017), Stevens & Livingston (2003), Livingston et al. (2004), Livingston & Stevens (2005), and Stevens & O'Driscoll (2006, 2007). Trends in relative biomass, and the spatial and depth distributions of 142 species or species groups, were reviewed for the surveys from 1992–2010 by O'Driscoll et al. (2011b).

The main aim of the Chatham Rise surveys is to provide relative biomass estimates of adult and juvenile hoki. Hoki is New Zealand's largest finfish fishery, with an annual total allowable commercial catch (TACC) of 150 000 t from 1 October 2015. Although managed as a single fishery, hoki is assessed as two stocks, western and eastern. The hypothesis is that juveniles from both stocks mix on the Chatham Rise and recruit to their respective stocks as they approach sexual maturity. The Chatham Rise is also thought to be the principal residence area for the hoki that spawn in Cook Strait and off the east coast South Island in winter (eastern stock). Annual commercial catches of hoki on the Chatham Rise peaked at about 75 000 t in 1997–98 and 1998–99, decreased to a low of 30 700 t in 2004–05, and increased again from 2008–09 to 2011–12 (Ballara & O'Driscoll 2014). The catch from the Chatham Rise in 2016–17 was 39 900 t, making it the second largest fishery in the EEZ (behind the west coast South Island), and contributing about 28% of the total annual New Zealand hoki catch.

The hoki fishery is dominated by young fish and so it is strongly influenced by recruitment. To manage the fishery and minimise potential risks, it is important to have some predictive ability concerning recruitment into the fishery. Extensive sampling throughout the EEZ has shown that the Chatham Rise is the main nursery ground for hoki aged 2 to 4 years. Abundance estimation of 2+ hoki on the Chatham Rise provides the best index of recruitment to the adult stocks. The continuation of the time series of trawl surveys on the Chatham Rise is therefore a high priority to provide information required to update the assessment of hoki.

Other middle depth species are also monitored by this survey time series (O'Driscoll et al. 2011b). These include important commercial species such as hake and ling, 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 on the Chatham Rise, 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 assessments.

In January 2010, the survey was extended to sample deeper strata (800 to 1300 m) in the north and east of the Chatham Rise. In January 2016, the survey duration was increased by 6 days to also include deeper strata to the south and west of the Chatham Rise (Stevens et al. 2017). The 2018 survey again covered 800–1300 m depths around the whole Chatham Rise, providing fishery independent abundance indices for a range of common deepwater bycatch species in the orange roughy and oreo fisheries.

Acoustic data have been recorded during trawls and while steaming between stations on all trawl surveys on the Chatham Rise since 1995, except in 2004. Data from previous surveys were analysed to describe mark types (Cordue et al. 1998, Bull 2000, O'Driscoll 2001, Livingston et al. 2004, Stevens & O'Driscoll 2006, 2007, Stevens et al. 2008, 2009a, 2009b, 2011, 2012, 2013, 2014), to provide estimates of the ratio of acoustic vulnerability to trawl catchability for hoki and other species (O'Driscoll 2002, 2003), and to estimate abundance of mesopelagic fish (McClatchie & Dunford 2003, McClatchie et al. 2005, O'Driscoll et al. 2009, 2011a, Stevens et al. 2009b, 2011, 2012, 2013, 2014, 2015, 2017). Acoustic data also provide qualitative information on the amount of fish that are not available to the bottom trawl, either through being off the bottom, or over areas of foul ground.

1.1 Project objectives

The trawl survey was carried out under contract to the Ministry for Primary Industries (project MID2017/02). The specific objectives for the project were as follows:

1. To continue the time series of relative abundance indices of recruited hoki (eastern stock) and other middle depth and deepwater species on the Chatham Rise in January 2018 using trawl surveys and to determine year class strengths of juvenile hoki (1, 2 and 3 year olds), with target CV of 20 % for the number of two year olds.

2. To collect data required to support determination of the population age, size structure, and reproductive biology of hoki, hake, and ling on the Chatham Rise.

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

4. To sample deeper strata for deepwater species using a random trawl survey design.

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

2. METHODS

2.1 Survey area and design

As in previous years, the survey followed a two-phase random design (after Francis 1984). The main survey area of 200–800 m depth (Figure 1) was divided into 23 strata. Nineteen of these strata are the same as those used in 2003–11 (Livingston et al. 2004, Livingston & Stevens 2005, Stevens & O'Driscoll 2006, 2007, Stevens et al. 2008, 2009a, 2009b, 2011, 2012). In 2012, stratum 7 was divided into strata 7A and 7B at 175° 30'E to more precisely assess the biomass of hake which appeared to be spawning northeast of Mernoo Bank (in Stratum 7B). In 2013, the survey duration was reduced from 27 to 25 days, removing the contingency for bad weather and reducing the available time for phase 2 stations. To increase the time available for phase 2 stations in 2014, strata 10A and 10B were re-combined into a single stratum 10 and stratum 11A, 11B, 11C, 11D into a single stratum 11. These strata are in the 400–600 m depth range on the northeast Chatham Rise (Figure 1) and were originally split to reduce hake CVs. However, few hake were caught in these strata since 2000 and 18 phase 1 tows (3 in each sub-strata) assigned to this area is no longer justified.

Station allocation for phase 1 was determined from simulations based on catch rates from all previous Chatham Rise trawl surveys (1992–2016), using the 'allocate' procedure of Bull et al. (2000) as modified by Francis (2006). This procedure estimates the optimal number of stations to be allocated in each stratum to achieve the Ministry for Primary Industries target CV of 20% for 2+ hoki, and CVs of 15% for total hoki and 20% for hake. The initial allocation of 83 core stations in phase 1 is given in Table 1. Phase 2 stations for core strata were allocated at sea, to improve the CV for 2+ hoki and total hoki biomass.

As in 2016, the 2018 survey area included 11 deep strata from 800–1300 m around the entire Chatham Rise (Figure 1). The station allocation for the deep strata was determined based on catch rates of eight bycatch species (basketwork eel, four-rayed rattail, longnose velvet dogfish, Baxter's dogfish, ribaldo, bigscaled brown slickhead, shovelnose dogfish, and smallscaled brown slickhead) in the 2010–16 surveys. Orange roughy, black oreo, and smooth oreo are no longer considered target species. The 'allocate' programme (Francis 2006) was used to estimate the optimal number of stations to be allocated in each of strata 21–30 to achieve a target CV of 25% for these eight bycatch species. A minimum of three stations per stratum was used. This gave a total of 43 phase 1 deep stations (Table 1). There was no allowance for phase 2 trawling in deep strata.

2.2 Vessel and gear specifications

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 bottom trawl was the same as that used on previous surveys of middle depth species by *Tangaroa*. The net is an eight-seam hoki bottom trawl with 100 m sweeps, 50 m bridles, 12 m backstrops, 58.8 m groundrope, 45 m headline, and 60 mm codend mesh (see Hurst & Bagley (1994) for net plan and rigging details). The trawl doors were Super Vee type with an area of 6.1 m^2. Measurements of doorspread (from a Scanmar system) and headline height (from a Furuno net monitor) were recorded every five minutes during each tow and average values calculated.

2.3 Trawling procedure

Trawling followed the standardised procedures described by Hurst et al. (1992). Station positions were selected randomly before the voyage using the Random Stations Generation Program (Version 1.6) developed by NIWA. To maximise the amount of time spent trawling in the deep strata (800–1300 m) at night, the time spent searching for suitable core (200–800 m) tows at night was reduced by using the nearest known successful tow position to the random station. Care was taken to ensure that the centre positions of survey tows were at least 3 n. miles apart. For deep strata, there was often insufficient bathymetric data and few known tow positions, so these tows followed the standard survey methodology described by Hurst et al. (1992). If a random station position 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. Core biomass tows were carried out during daylight hours (as defined by Hurst et al. (1992)), with all trawling between 0503 h and 1853 h NZST.

At each station the trawl was towed for 3 n. miles at a speed over the ground of 3.5 knots. If foul ground was encountered, or the tow hauled early due to reducing daylight, the tow was included as valid only if at least 2 n. miles 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 gear was shot in time to ensure completion of the tow by sunset, if at least 50% of the steaming distance to the next station was covered.

Towing speed and gear configuration were maintained as constant as possible during the survey, following the guidelines given by Hurst et al. (1992). The average speed over the ground was calculated from readings taken every five minutes during the tow.

2.4 Acoustic data collection

Acoustic data were collected during trawling and while steaming between trawl stations (both day and night) with the *Tangaroa* multi-frequency (18, 38, 70, 120, and 200 kHz) Simrad EK60 echosounders with hull-mounted transducers. All frequencies are regularly calibrated following standard procedures (Demer et al. 2015), with the most recent calibration being used for any data processing. In the present case, the latest calibration of *Tangaroa* echosounders was on 27 August 2016 in East Bay, Marlborough Sounds at the start of the Campbell southern blue whiting acoustic survey (O'Driscoll et al. in press).

2.5 Hydrology

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).

2.6 Catch and biological sampling

At each station all items in the catch were sorted into species and weighed on Marel motion-compensating electronic scales accurate to about 0.1 kg. Where possible, fish, squid, and crustaceans were identified to species and other benthic fauna to species or family. Unidentified organisms were collected and frozen at sea and returned to NIWA for later identification.

An approximately random sample of up to 200 individuals of each commercial, and some common non-commercial, species from every successful tow was measured and the sex determined. More detailed biological data were also collected on a subset of species and included fish weight, gonad stage, and gonad weight. Otoliths were taken from hake, hoki, ling, black oreo, smooth oreo, and orange roughy for age determination. Additional data on liver condition were also collected from a subsample of 20 hoki per tow by recording gutted and liver weights.

2.7 Estimation of relative biomass and length frequencies

Doorspread biomass was estimated by the swept area method of Francis (1981, 1989) using the formulae in Vignaux (1994) as implemented in NIWA custom software SurvCalc (Francis 2009). The catchability coefficient (an estimate of the proportion of fish in the path of the net which are caught) is the product of vulnerability, vertical availability, and areal availability. These factors were set at 1 for the analysis.

Scaled length frequencies were calculated for the major species with SurvCalc, using length-weight data from this survey.

2.8 Estimation of numbers at age

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

Subsamples of 659 hoki otoliths and 600 ling otoliths were selected from those collected during the trawl survey. Subsamples were obtained by randomly selecting otoliths from 1 cm length bins covering the bulk of the catch and then systematically selecting additional otoliths to ensure that the tails of the length distributions were represented. The numbers aged approximated the sample size necessary to produce mean weighted CVs of less than 20% for hoki and 30% for ling across all age classes. All hake otoliths collected were prepared.

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

2.9 Acoustic data analysis

Acoustic data analysis followed the methods applied to recent Chatham Rise trawl surveys (e.g., Stevens et al. 2017), generalised by O’Driscoll et al. (2011a). This report does not include discussion of mark classification or descriptive statistics on the frequency of occurrence of different mark types, as these were based on subjective classification, and were found not to vary much between surveys (e.g., Stevens et al. 2014).

Quantitative analysis was based on 38 kHz acoustic data from daytime trawl and night steam recordings. The 38 kHz data were used as this frequency was the only one available (other than uncalibrated 12 kHz data) for surveys before 2008 that used the old CREST acoustic system (Coombs et al. 2003). Analysis was carried out using the custom analysis software ESP3 (Ladroit 2017). ESP3 includes an algorithm to identify 'bad pings' in each acoustic recording. "Bad pings" were defined as pings for which backscatter data were significantly different from surrounding pings, usually due to bubble aeration or noise spikes. Only acoustic data files where the proportion of bad pings was less than 30% of all pings in the file were considered suitable for quantitative analysis.

Estimates of the mean acoustic backscatter per km^2 from bottom-referenced marks were calculated for each recording, based on integration heights of 10 m, 50 m, and 100 m above the bottom. Total acoustic backscatter was also integrated throughout the water column in 50 m depth bins. Acoustic density estimates (m^2 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, 2011a) developed a time series of relative abundance estimates for mesopelagic fish on the Chatham Rise based on that component of the acoustic backscatter that migrates into the upper 200 m of the water column at night (nyctoepipelagic backscatter). Because some of the mesopelagic fish migrate very close to the surface at night, they move into the surface 'dead zone' (shallower than 14 m) where they are not detectable by the vessel's downward-looking hull-mounted transducer. Consequently, there is a substantial negative bias in night-time acoustic estimates. To correct for this bias, O'Driscoll et al. (2009) used night estimates of demersal backscatter (which remains deeper than 200 m at night) to correct daytime estimates of total backscatter.

The mesopelagic time series was updated to include data from 2018. Day estimates of total backscatter were calculated using total mean area backscattering coefficients estimated from each trawl recording. Night estimates of demersal backscatter were based on data recorded while steaming between 2000 h and 0500 h NZST. Acoustic data were stratified into four broad geographic sub-areas (O'Driscoll et al. 2011a). Stratum boundaries were:

- Northwest – north of 43° 30′ S and west of 177° 00 E;
- Northeast – north of 43° 30′ S and east of 177° 00′ E;
- Southwest – south of 43° 30′ S and west of 177° 00′ E;
- Southeast – south of 43° 30′ S and east of 177° 00′ E.

The amount of mesopelagic backscatter at each day trawl station was estimated by multiplying the total backscatter observed at the station by the estimated proportion of night-time backscatter in the same sub-area that was observed in the upper 200 m corrected for the estimated proportion in the surface dead zone:

$$sa(meso)_i = p(meso)_s * sa(all)_i$$

where $sa(meso)_i$ is the estimated mesopelagic backscatter at station i, $sa(all)_i$ is the observed total backscatter at station i, and $p(meso)_s$ is the estimated proportion of mesopelagic backscatter in the stratum s where station i is found. $p(meso)_s$ was calculated from the observed proportion of night-time backscatter observed in the upper 200 m in stratum s, $p(200)_s$, and the estimated proportion of the total backscatter in the surface dead zone, p_{sz}. p_{sz} was estimated as 0.2 by O'Driscoll et al (2009) and was assumed to be the same for all years and strata:

$$p(meso)_s = p_{sz} + p(200)_s * (1 - p_{sz})$$

3. RESULTS

3.1 2018 survey coverage

The trawl survey was successfully completed. The deepwater trawling objective meant that trawling was carried out both day (core and some deep tows) and night (deep tows only). About 54 hours were lost due to bad weather. Upon reaching the Chatham Rise survey area early on 5 January, *Tangaroa* was caught up in the cyclonic low that hit the east coast of New Zealand with gale north-easterlies followed by gale south-westerlies and heavy swells (4–6 m). This meant that only one tow was carried out in the first two days of the voyage. Weather conditions for the remainder of the survey were generally very good, with wind speeds less than 25 knots, until 1 February when very strong winds from another approaching low (former cyclone Fehi) forced trawling to stop 8 hours earlier than planned. Another 10 hours were lost on 23 January going to Lyttleton to pick up a replacement charger for the door sensors, which failed on 18 January.

A total of 127 successful trawl survey tows were completed, comprising 83 phase 1 tows and 4 phase 2 tows in core 200–800 m strata, and 40 deep tows (Tables 1 and 2, Figure 2, Appendix 1). Three further tows were considered unsuitable for estimating abundance: station 61 in deep stratum 25 was rejected because of a high headline height suggesting unsatisfactory gear performance; tow 102 in deep stratum 23 came fast; and tow 122 in stratum 6 came off the bottom. All planned phase 1 tows were carried out in core strata. There were three fewer deep tows than planned, because the rejected tows in strata 23 and 25 were not substituted, and bad weather on 1 February prevented the vessel from reaching the final tow position in stratum 30. Station details for all tows are given in Appendix 1.

Core station density ranged from 1 per 288 km^2 in stratum 17 (200–400 m, Veryan Bank) to 1 per 3841 km^2 in stratum 16 (400–600 m, southwest Chatham Rise). Deepwater station density ranged from 1 per 416 km^2 in stratum 21a (800–1000 m, NE Chatham Rise) to 1 per 5480 km^2 in stratum 30 (1000–1300 m, southwest Chatham Rise). Mean station density was 1 per 1701 km^2 (see Table 1).

3.2 Gear performance

Gear parameters are summarised in Table 3. A headline height value was obtained for all 127 successful tows, but doorspread readings were not available for 21 tows. Mean headline heights by 200 m depth intervals were 7.0–7.6 m, and averaged 7.3 m, and although slightly higher than those in previous surveys, were within the optimal range (Hurst et al. 1992) (Table 3). Mean doorspread measurements by 200 m depth intervals were 114.0–125.6 m, and averaged 121.0 m, and were consistent with previous surveys.

3.3 Hydrology

Temperatures were 15.0–19.3° C (mean 17.1° C) and bottom temperatures were 3.3–11.7° C (mean 7.5° C) (Figure 3). Surface temperatures in 2018 were very warm compared to previous surveys (Figure 4 top panel), but the warm surface layer typically only extended to 50 m depth. Bottom temperatures in 2018 were in the range of those observed in previous surveys (Figure 4 lower panel).

3.4 Catch composition

The total catch from all 127 valid biomass stations was 158.9 t, of which 67.7 t (42.6%) was hoki, 22.0 t (13.8%) was black oreo, 7.7 t (4.8%) was smooth oreo, 3.3 t (2.1%) was ling, 1.6 t (1.0%) was hake, and 0.6 t (0.4%) was orange roughy (Table 4).

Of the 314 species or species groups identified from valid biomass tows, 148 were teleosts, 34 were elasmobranchs, 1 was an agnathan, 25 were crustaceans, and 15 were cephalopods. The remainder consisted of assorted benthic and pelagic invertebrates. A full list of species caught in valid biomass tows, and the number of stations at which they occurred, is given in Appendix 2. This year all *Apristurus* catsharks (APR) were retained and most were identified to species onshore by NIWA and Te Papa staff.

Fifty-four invertebrate taxa were later identified (Appendix 3).

3.5 Relative biomass estimates

3.5.1 Core strata (200–800 m)

Relative biomass in core strata was estimated for 47 species (Table 4). The CVs achieved for hoki, hake, and ling from core strata were 16.0%, 34.3%, and 11.5% respectively. The CV for 2+ hoki (2015 year-class) was 19.1%, below the target CV of 20%. High CVs (over 30%) generally occurred when species were not well sampled by the gear. For example, alfonsino, barracouta, frostfish, southern Ray's bream, and slender mackerel are not strictly demersal and exhibit strong schooling behaviour and consequently catch rates of these are highly variable. Others, such as bluenose, hapuku, rough skate, and tarakihi, have high CVs as they are mainly distributed outside the core survey depth range (O'Driscoll et al. 2011b).

The combined relative biomass for the top 31 species in the core strata that are tracked annually (Livingston et al. 2002, see Table 4) was slightly higher than in 2016, lower than in 2013, like that in 2011, and above average for the time series (Figure 5, top panel). As in previous years, hoki was the most abundant species caught (Table 4, Figure 5, lower panel). The relative proportion of hoki in 2018 was about the same as 2016, like 2009 and 2014, and higher than that in 2010–13. The next most abundant QMS species in core strata were alfonsino, silver warehou, black oreo, spiny dogfish, lookdown dory, ling, dark ghost shark, sea perch, spiky oreo, giant stargazer, smooth oreo, and white warehou, each with an estimated relative biomass of over 2000 t (Table 4). The most abundant non-QMS species were javelinfish, Bollons' rattail, shovelnose dogfish, and oblique banded rattail (Table 4).

Estimated relative biomass of hoki in the core strata in 2018 was 122 097 t, 7% higher than the hoki biomass in January 2016 (Table 5, Figures 6a, 7a, 7b). This was largely driven by a high biomass estimate for 2+ hoki (2015-year class) of 51 346 t, the third highest in the time series, and a high biomass estimate for 1+ hoki of 30 499 t, the fourth highest in the time series (Table 6). The relative biomass of recruited hoki (ages 3+ years and older) was 40 252 t, 26% lower than in the 2016 survey and the lowest since 2008. However, the biomass estimate of recruited hoki from all strata was only 7% lower than in 2016, due to a large catch of adult hoki (2181 kg) in stratum 27. About 21% of the biomass of recruited hoki in 2018 was estimated to come from stratum 27, although the CV for this estimate was high (98.3%).

The relative biomass of hake in core strata was 1660 t, 28% higher than 2016, one of the higher estimates in recent years, but still low compared to the early 1990s (see Table 5, Figures 6a, 7a, 7b). This was mainly driven by a large catch of 1007 kg in stratum 7b, the largest in the time series.

The relative biomass of ling was 8758 t, 14% lower than in January 2016, although the time series for ling shows no overall trend (Figures 6a, 7a, 7b).

The relative biomass estimates for giant stargazer, lookdown dory, sea perch, and spiny dogfish were higher than 2016 estimates, silver warehou were about the same, and dark ghost shark, pale ghost shark, and white warehou were lower than the 2016 estimate (Figures 6a, 7a, 7b).

3.5.2 Deep strata (800–1300 m)

Relative biomass and CVs were estimated for 27 species (Table 4). The relative biomass of orange roughy in all strata in 2018 was 1302 t, compared to 6916 t in 2016 (Figures 6b, 7c). Although the survey was not optimised for orange roughy in 2018, there were no large catches so the precision was reasonable with a CV of 20.8%.

As a result of a 25 t mixed catch (station 128) in stratum 27, which included 18.1 t of black oreo, 88% of the total relative biomass of black oreo (105 837 t) was estimated to occur in the deep strata (Table 4, Figures 6b, 7c). This is compared to 32% of the total biomass in deep strata in the 2016 survey. The estimated relative biomass of smooth oreo in deep strata was 33 514 t but precision was poor with a CV of 69.3%. It was also influenced by the same 25 t catch, which included 4.4 t of smooth oreo.

Deepwater sharks were relatively abundant in deep strata, with 33%, 60%, and 84% of the total survey biomass of shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish occurring in deep strata (Figures 6b, 7c). In 2018, bigscaled and smallscaled brown slickhead were restricted to deep strata, and basketwork eel, and four-rayed rattail were largely restricted to deeper strata. Spiky oreo were mainly caught in core strata (Figures 6b, 7c).

The deep strata contained 9.1% of the total survey hoki biomass, 8.4% of total survey hake biomass, and 0.3% of total survey ling biomass. This indicates that the core survey strata are likely to have sampled most of the ling available to the trawl survey method on the Chatham Rise, but missed some hoki and hake (Table 4). The deep biomass estimate for hoki (12 196 t) was the highest in the time series, due to a single catch of 2.2 t (part of the 25 t mixed catch in stratum 27) and precision was poor with a CV of 86.7%.

3.6 Catch distribution

Spatial distribution maps of catches (Figures 8–9) were generally like those from previous surveys.

Hoki

In the 2018 survey, hoki were caught in 83 of the 87 core biomass stations. They were not captured in 4 shallow tows: (less than 250 m) on the Reserve Bank (stratum 19); and east of the Chatham Islands (stratum 9). The highest catch rates were at 200–400 m depths on Veryan Bank (stratum 17) and Mernoo Bank (stratum 18), and east of Chatham Islands at 400–600 m depths (stratum 11) (Table 7a, Figure 8). The highest individual catch of hoki in 2018 was 21 572 kg on Veryan Bank in stratum 17, and was mostly 1+ hoki (Figure 8, Appendix 1). Other high individual hoki catches were two 5.1 t catches around Mernoo Bank in stratum 18, and a 3.6 t catch east of Chatham Islands in stratum 11. For the first time in the time series (Figure 7b), a reasonable catch (2.2 t) of large hoki were caught in one of the deep strata (stratum 27). The year class of hoki aged 1+ (2016 year-class) was largely restricted to 200–400 m western strata around Veryan, Mernoo, and Reserve Banks (strata 17, 18, 20) (Figure 8). The strong year class of hoki aged 2+ (2015 year-class) were found over much of the Rise at 200–600 m depths but were more abundant around Mernoo Bank (stratum 18) and east of Chatham Islands (stratum 11) (Figure 8). Recruited hoki (3+ and older) were widespread but the highest catch rates were on southwest Chatham Rise in stratum 27 (850 m depth) and east of Chatham Islands in stratum 11 (Figure 8).

Hake

Catch rates of hake were dominated by a large catch (1007 kg) of mature hake in Stratum 7b, northeast of Mernoo Bank. This was the highest catch in the Chatham Rise time series, surpassing a catch of 839 kg from the same strata in 2009. A further 93 kg were caught in an adjacent station in the same strata. Other hake catches were consistently low throughout much of the survey area. (Figure 9).

Ling

As in previous years, catches of ling were distributed throughout most strata in the core survey area (Figure 7a, 9). The highest catch rates were at 400–600 metres around Mernoo Bank (strata 7A,7B, 15, 16).

Other species

As with previous surveys, lookdown dory, sea perch and spiny dogfish were widely distributed throughout the survey area at 200–600 m depths. The largest catch rates for sea perch were taken at 200–400 m on Mernoo Bank (stratum 18) and Reserve Bank (strata 19, 20), the largest catch rate of lookdown dory was taken in stratum 11, and the largest catch rates of spiny dogfish were taken around the Mernoo Bank, Reserve Bank, and west of the Chatham Islands (Figure 9). Dark ghost shark was mainly caught at 200–400 m depths on the western Rise and was particularly abundant on Veryan and Reserve Banks; while pale ghost shark was mostly caught in deeper water at 400–800 m depth, with higher catch rates to the south. Giant stargazer was mainly caught in shallower strata, with the largest catch taken east of Mernoo Bank in stratum 18. Silver warehou and white warehou were patchily distributed at depths of 200–600 m, with the largest catches in the west (Figure 9). Javelinfish and Bollons' rattail were widely distributed throughout the survey area. The largest catch rate of javelinfish was taken east of the Chatham Islands in stratum 11 while the largest catch rates of Bollons' rattail were taken around Mernoo and Veryan Banks (Figure 7a). Ribaldo were widespread at 400–1000 m with the largest catch rates mainly to the north (Figure 9).

Orange roughy was widespread on the north and east Rise at 800–1300 m depths (Figure 9). In contrast to many previous surveys there were no large catches, the largest was 100 kg taken on the northeast Rise in 1044 m in stratum 24 (Table 7b, Figure 9). As with previous surveys, black oreo was mostly caught on the southwest Rise at 600–1000 m depths. Catch rates of black oreo and smooth oreo were dominated by a mixed 25 t catch in stratum 27 at 850 m, which included 18.1 t of black oreo, 4.4 t of smooth oreo, and 2.2 t of large hoki. A further 1.8 t of smooth oreo was captured on the southeast Rise in stratum 28 at 1160 m. No black oreo or smooth oreo were caught in stratum 30 (1000–1300 m) (Table 7a, Figure 9). Spiky oreo were widespread and abundant on the north Rise at 500–850 m, with the largest catch rates taken in strata 1, 2b and 12 (Table 7a, Figure 7). Shovelnose dogfish, longnose velvet dogfish, basketwork eel, bigscaled brown slickhead and four-rayed rattail were also more abundant on the north Rise. Baxter's dogfish and smallscaled brown slickhead were more abundant on the south Rise (Table 7a, Figures 7, 9).

3.7 Biological data

3.7.1 Species sampled

The number of species and the number of samples for which length and length-weight data were collected are given in Table 8.

3.7.2 Length frequencies and age distributions

Length-weight relationships used in the SurvCalc program to scale length frequencies and calculate relative biomass and catch rates are given in Table 9.

Hoki
Length and age frequency distributions were dominated by hoki aged 1+ (less than 48 cm) and 2+ (48–59 cm) (Figures 10 and 11). There were relatively few fish longer than 70 cm (Figure 13) or older than 6 years (Figure 14). Female hoki were estimated to be slightly more abundant than males (ratio of 1.05 female: 1 male).

Hake
Length frequency and calculated number at age distributions (Figures 12 and 13) were relatively broad, with most male fish aged 3–15 years and female fish 3–14 years. Female hake were estimated to be more abundant than males (1.23 female: 1 male).

Ling
Length frequency and calculated number-at-age distributions (Figures 14 and 15) indicated a wide range of ages, with most fish aged 2–20. There is evidence of a period of good recruitment from 1999–2006 (Figure 15). Male ling were estimated to be more abundant than females (1 female: 1.17 male).

Other species
Length frequency distributions for key core and deepwater species are shown in Figures 16. Clear modes are apparent in the size distribution of silver warehou and white warehou, which may correspond to individual cohorts.

Length frequency distributions for giant stargazer, lookdown dory, dark ghost shark, pale ghost shark, and several shark species (spiny dogfish, Baxter's dogfish, longnose velvet dogfish, and shovelnose dogfish) indicate that females grow larger than males (Figure 16).

The deep strata contained a high proportion of large shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish (Figure 16b).

Length frequency distributions were similar for males and females of sea perch (*Helicolenus barathri*), silver warehou, white warehou, orange roughy, black oreo, smooth oreo, and spiky oreo. The length frequency distribution for orange roughy was broad, with a mode at about 30–37 cm, but included fish as small as 7 cm (Figure 16).

The catches of spiny dogfish, bigscaled brown slickhead, and basketwork eels were dominated by females (greater than 1.5 female: 1 male) while the catch of ribaldo was dominated by males (1.59 male: 1 female) (Figure 16).

3.7.3 Reproductive status

Gonad stages of hake, hoki, ling, and several other species are summarised in Table 10. Almost all hoki were recorded as either resting or immature. About 29% of male ling were maturing or ripe, with few females showing signs of spawning. About 68% of male hake were ripe, running ripe, partially spent, or spent, but most females were immature or resting (39%) or maturing (56%) (Table 10). Most other species for which reproductive state was recorded did not appear to be reproductively active, except spiny dogfish and some deepwater sharks (Table 10).

3.8 Acoustic data quality

Acoustic data were recorded continuously throughout the survey. Over 96 GB of data were collected during trawling and steaming between stations. Weather and sea conditions during the survey were generally very good, meaning acoustic data quality was high overall. Only 7 out of the 130 trawl transects (5.4% of trawls) exceeded the threshold of 30% bad pings and so were not suitable for quantitative analysis. Similarly, only 3 out of the 47 night-time steam transects (6.4% of night steams) were not suitable for analysis.

Expanding symbol plots of the distribution of total acoustic backscatter from daytime trawls and night transects in the overall survey area (200–1300 m) are shown in Figure 17. As noted by O'Driscoll et al. (2011), there is a consistent spatial pattern in total backscatter on the Chatham Rise, with higher backscatter in the west.

3.8.1 Comparison of acoustic backscatter with bottom trawl catches

Acoustic data from 85 core trawl files were integrated and compared with trawl catch rates (Table 11). Data from another two recordings made during core daytime tows were not included in the analysis because the acoustic data were too noisy. Average acoustic backscatter values from the entire water column in 2018 was 30% lower than that in 2016, despite an increase in average trawl catch rates (Table 11). Average acoustic backscatter in the bottom 10 m and 50 m were also lower than those in 2016, but were within the range of previous surveys in the time-series (Table 11).

There was a positive correlation (Spearman's rank correlation, rho = 0.29, $p < 0.01$) between acoustic backscatter in the bottom 100 m during the day and trawl catch rates (Figure 18). In previous Chatham Rise surveys from 2001–16, rank correlations between trawl catch rates and acoustic density estimates ranged from 0.15 (in 2006) to 0.50 (in 2013). The correlation between acoustic backscatter and trawl catch rates (Figure 18) is not perfect (rho = 1) because the daytime bottom-referenced layers on the Chatham Rise may also contain a high proportion of mesopelagic species, which contribute to the acoustic backscatter, but which are not sampled by the bottom trawl (O'Driscoll 2003, O'Driscoll et al. 2009), and conversely some fish caught by the trawl may not be measured acoustically (e.g., close to the bottom in the acoustic deadzone). This, combined with the diverse composition of demersal species present, means that it is unlikely that acoustics will provide an alternative biomass estimate for hoki on the Chatham Rise.

3.8.2 Time-series of relative mesopelagic fish abundance

In 2018, most acoustic backscatter was between 250 and 500 m depth during the day, and migrated into the surface 200 m at night (Figure 19). The daytime vertical distribution was like the pattern observed in all previous years except 2011 (O'Driscoll et al. 2011a, Stevens et al. 2013, 2014, 2015, 2017). In 2011, there was a different daytime distribution of backscatter, with a concentration of backscatter between 150 and 350 m, no obvious peak at 350–400 m, and smaller peaks centred at around 550 and 750 m (Stevens et al. 2012). In 2018, a higher proportion of backscatter remained at depth during the night than in some previous years, with an obvious night-time peak at around 500 m (Figure 19).

The vertically migrating component of acoustic backscatter is assumed to be dominated by mesopelagic fish (see McClatchie & Dunford, 2003 for rationale and caveats). In 2018, between 44 and 75% of the total backscatter in each of the four sub-areas was in the upper 200 m at night and was estimated to be from vertically migrating mesopelagic fish (Table 12). The proportion of backscatter attributed to mesopelagic fish in 2018 was lower than that in 2016 in all sub-areas except the southeast, but within the range of other surveys in the time-series (Table 12).

Day estimates of total acoustic backscatter over the Chatham Rise were consistently higher than night estimates (Figure 20) because of the movement of fish into the surface deadzone (shallower than 14 m) at night (O'Driscoll et al. 2009). In 2018, night estimates were closer to day estimates than most previous years, possibly because a lower proportion of backscatter was migrating into the near-surface waters at night (see Figure 19). The only other exception to this general pattern was in 2011, when night estimates were higher than day estimates (Figure 20). However, there was relatively little good quality acoustic data available from the southeast Chatham Rise in 2011 due to poor weather conditions (Stevens et al. 2012).

Total daytime backscatter in 2018 was 27% lower than that observed in 2016. Backscatter within 50 m of the bottom during the day decreased from 2001 to 2011, increased from 2012 to 2016, but decreased in 2018 (Figure 20). Backscatter close to the bottom at night has been relatively low throughout the time-series, but showed an increasing trend over the past nine years (Figure 20).

Acoustic indices of mesopelagic fish abundance are summarised in Table 13 and plotted in Figure 21 for the entire Chatham Rise and for the four sub-areas. The overall mesopelagic estimate for the Chatham Rise in 2018 decreased by 40% from 2016 and was the lowest since 2011. The mesopelagic index decreased in all four sub-areas, with the highest percentage decrease (58%) in the southwest, which was typically the most variable sub-area over the time-series (Table 13, Figure 21).

3.9 Hoki condition

Liver condition (defined as liver weight divided by gutted weight) for all hoki on the Chatham Rise decreased by 24% from 2014 to 2016, and was the lowest in the time-series of condition indices that goes back to 2004 (Figure 22. This decrease in overall condition occurred across all length classes, but was particularly apparent for 60–80 cm hoki (Figure 22). Stevens et al. (2014) suggested that hoki condition may be related to both food availability and hoki density, and estimated an index of "food per fish" from the ratio of the acoustic estimate of mesopelagic fish abundance divided by the trawl estimate of hoki abundance. The significant positive correlation between liver condition and the food per fish index reported previously was strengthened with the addition of the 2018 data (Figure 23, Spearman's correlation coefficient, rho = 0.71, n = 12, $p < 0.01$).

4. CONCLUSIONS

The 2018 survey successfully extended the January Chatham Rise time series to 25 points (annual from 1992–2014, then biennial), and provided abundance indices for hoki, hake, ling, and a range of associated middle-depth species.

The estimated relative biomass of hoki in core strata was 7% higher than that in 2016, due to relatively high biomass estimates of 2+ hoki (2015 year-class) and of 1+ hoki (2016 year-class). The estimated biomass of 3++ (recruited) hoki declined by 26% from that in 2016, but 3++ hoki were also observed in deep (800–1300 m) strata in 2018.

The relative biomass of hake in core strata was 28% higher than in 2016, but was still at low levels compared to the early 1990s. The relative biomass of ling in core strata was 14% lower than in 2016, but the time series for ling shows no overall trend.

In 2018 the survey area covered 800–1300 m depths around the entire Rise for only the second time. The deep strata provide relative biomass estimates for a range of deepwater species associated with orange roughy and oreo fisheries. A high proportion of the estimated biomass of deepwater sharks (shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish) occurred in deep strata, and bigscaled brown slickheads, smallscaled brown slickheads, basketwork eels, and four-rayed rattails were largely restricted to deeper strata.

The acoustic index of mesopelagic fish abundance in 2018 decreased in all four sub-areas, and was 40% lower than that in 2016, and the lowest since 2011. Hoki liver condition was also lower than in 2016, and the lowest in the time-series of condition indices that goes back to 2004. Mesopelagic fish species, which contribute to the acoustic backscatter, are not sampled by the bottom trawl and conversely some fish caught by the trawl may not be measured acoustically (e.g., close to the bottom in the acoustic deadzone). This, combined with the diverse composition of demersal species present, means that it is unlikely that acoustics will provide an alternative biomass estimate for hoki on the Chatham Rise.

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6. REFERENCES

Bagley, N.W.; Hurst, R.J. (1998). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1998 (TAN9801). *NIWA Technical Report 44*. 54 p.

Bagley, N.W.; Livingston, M.E. (2000). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1999 (TAN9901). *NIWA Technical Report 81*. 52 p.

Ballara, S.L.; O'Driscoll, R.L. (2014). Catches, size, and age structure of the 2012–13 hoki fishery, and a summary of input data used for the 2014 stock assessment. *New Zealand Fisheries Assessment Report 2014/41*. 123 p.

Bull, B. (2000). An acoustic study of the vertical distribution of hoki on the Chatham Rise. *New Zealand Fisheries Assessment Report 2000/5*. 59 p.

Bull, B.; Bagley, N.W.; Hurst, R.J. (2000). Proposed survey design for the Southern Plateau trawl survey of hoki, hake and ling in November-December 2000. Final Research Report to the Ministry of Fisheries for Project MDT1999/01 Objective 1. 31 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Bull, B.; Dunn, A. (2002). Catch-at-age user manual v1.06.2002/09/12. NIWA Internal Report 114. 23 p. (Unpublished report held in NIWA library, Wellington.)

Coombs, R.F.; Macaulay, G.J.; Knol, W.; Porritt, G. (2003). Configurations and calibrations of 38 kHz fishery acoustic survey systems, 1991–2000. *New Zealand Fisheries Assessment Report 2003/49.* 24 p.

Cordue, P.L.; Ballara, S.L.; Horn, P.L. (2000). Hoki ageing: recommendation of which data to routinely record for hoki otoliths. Final Research Report to the Ministry of Fisheries for Project MOF1999/01 (Hoki ageing). 24 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Cordue, P.L.; Macaulay, G.J.; Ballara, S.L. (1998). The potential of acoustics for estimating juvenile hoki abundance by age on the Chatham Rise. Final Research Report for Ministry of Fisheries Research Project HOK9702 Objective 3. 35 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Demer, D.A.; Berger, L.; Bernasconi, M.; Bethke, E.; Boswell, K.; Chu, D.; Domokos, R.; et al. (2015). Calibration of acoustic instruments. *ICES Cooperative Research Report No. 326*. 133 p.

Francis, R.I.C.C. (1981). Stratified random trawl surveys of deep-water demersal fish stocks around New Zealand. *Fisheries Research Division Occasional Publication 32.* 28 p.

Francis, R.I.C.C. (1984). An adaptive strategy for stratified random trawl surveys. *New Zealand Journal of Marine and Freshwater Research 18:* 59–71.

Francis, R.I.C.C. (1989). A standard approach to biomass estimation from bottom trawl surveys. New Zealand Fisheries Assessment Research Document 89/3. 3 p. (Unpublished report held in NIWA library, Wellington.)

Francis, R.I.C.C. (2001). Improving the consistency of hoki age estimation. *New Zealand Fisheries Assessment Report 2001/12.* 18 p.

Francis, R.I.C.C. (2006). Optimum allocation of stations to strata in trawl surveys. *New Zealand Fisheries Assessment Report 2006/23*. 50 p.

Francis, R.I.C.C. (2009). SurvCalc User Manual. 39 p. (Unpublished report held at NIWA, Wellington.)

Horn, P.L. (1993). Growth, age structure, and productivity of ling, *Genypterus blacodes* (Ophidiidae), in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 27:* 385–397.

Horn, P.L. (1994a). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1991-January 1992 (TAN9106). *New Zealand Fisheries Data Report No. 43*. 38 p.

Horn, P.L. (1994b). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1992-January 1993 (TAN9212). *New Zealand Fisheries Data Report No. 44*. 43 p.

Horn, P.L. (1997). An ageing methodology, growth parameters and estimates of mortality for hake (*Merluccius australis*) from around the South Island, New Zealand. *Marine and Freshwater Research 48:* 201–209.

Horn, P.L.; Sullivan, K.J. (1996). Validated aging methodology using otoliths, and growth parameters for hoki (*Macruronus novaezelandiae*) in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 30:* 161–174.

Hurst, R.J.; Bagley, N.W. (1994). Trawl survey of middle depth and inshore bottom species off Southland, February-March 1993 (TAN9301). *New Zealand Fisheries Data Report No. 52.* 58 p.

Hurst, R.J.; Bagley, N.; Chatterton, T.; Hanchet, S.; Schofield, K.; Vignaux, M. (1992). Standardisation of hoki/middle depth time series trawl surveys. MAF Fisheries Greta Point Internal Report No. 194. 89 p. (Unpublished report held in NIWA library, Wellington.)

Ladroit, Y. (2017). ESP3: an open-source software for fisheries acoustic data processing. https://bitbucket.org/echoanalysis/esp3

Livingston, M.E.; Bull, B.; Stevens, D.W.; Bagley, N.W. (2002). A review of hoki and middle depth trawl surveys of the Chatham Rise, January 1992–2001. *NIWA Technical Report 113.* 146 p.

Livingston, M.E.; Stevens, D.W. (2005). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2004 (TAN0401). *New Zealand Fisheries Assessment Report 2005/21*. 62 p.

Livingston, M.E.; Stevens, D.W.; O'Driscoll, R.L.; Francis, R.I.C.C. (2004). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2003 (TAN0301). *New Zealand Fisheries Assessment Report 2004/16*. 71 p.

McClatchie, S.; Dunford, A. (2003). Estimated biomass of vertically migrating mesopelagic fish off New Zealand. *Deep-Sea Research Part I 50*: 1263–1281.

McClatchie, S.; Pinkerton, M.; Livingston, M.E. (2005). Relating the distribution of a semi-demersal fish, *Macruronus novaezelandiae*, to their pelagic food supply. *Deep-Sea Research Part I 52*: 1489–1501.

O'Driscoll, R.L. (2001). Analysis of acoustic data collected on the Chatham Rise trawl survey, January 2001 (TAN0101). Final Research Report for Ministry of Fisheries Research Project HOK2000/02 Objective 3. 26 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

O'Driscoll, R.L. (2002). Estimates of acoustic:trawl vulnerability ratios from the Chatham Rise and Sub-Antarctic. Final Research Report for Ministry of Fisheries Research Projects HOK 2001/02 Objective 3 and MDT2001/01 Objective 4. 46 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

O'Driscoll, R.L. (2003). Determining species composition in mixed species marks: an example from the New Zealand hoki (*Macruronus novaezelandiae*) fishery. *ICES Journal of Marine Science 60*: 609–616.

O'Driscoll, R.L.; Gauthier, S.; Devine, J. (2009). Acoustic surveys of mesopelagic fish: as clear as day and night? *ICES Journal of Marine Science 66*: 1310–1317.

O'Driscoll, R.L.; Hurst, R.J.; Dunn, M.R.; Gauthier, S.; Ballara, S.L. (2011a). Trends in relative biomass using time series of acoustic backscatter data from trawl surveys. *New Zealand Aquatic Environment and Biodiversity Report 2011/76.* 99 p.

O'Driscoll, R.L.; Large, K.; Marriott, P. (in press). Acoustic estimates of southern blue whiting from the Campbell Island Rise, August–September 2016 (TAN1610). *New Zealand Fisheries Assessment Report 2018/xx* 62 p.

O'Driscoll, R.L.; MacGibbon, D.; Fu, D.; Lyon, W.; Stevens, D.W. (2011b). A review of hoki and middle depth trawl surveys of the Chatham Rise, January 1992–2010. *New Zealand Fisheries Assessment Report 2011/47.* 72 p. + CD.

Schofield, K.A.; Horn, P.L. (1994). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1994 (TAN9401). *New Zealand Fisheries Data Report No. 53*. 54 p.

Schofield, K.A.; Livingston, M.E. (1995). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1995 (TAN9501). *New Zealand Fisheries Data Report No. 59*. 53 p.

Schofield, K.A.; Livingston, M.E. (1996). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1996 (TAN9601). *New Zealand Fisheries Data Report No. 71*. 50 p.

Schofield, K.A.; Livingston, M.E. (1997). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1997 (TAN9701). *NIWA Technical Report 6*. 51 p.

Stevens, D.W.; Livingston, M.E. (2003). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2002 (TAN0201). *New Zealand Fisheries Assessment Report 2003/19*. 57 p.

Stevens, D.W.; Livingston, M.E.; Bagley, N.W. (2001). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2000 (TAN0001). *NIWA Technical Report 104.* 55 p.

Stevens, D.W.; Livingston, M.E.; Bagley, N.W. (2002). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2001 (TAN0101). *NIWA Technical Report 116.* 61 p.

Stevens, D.W.; O'Driscoll, R.L. (2006). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2005 (TAN0501). *New Zealand Fisheries Assessment Report 2006/13.* 73 p.

Stevens, D.W.; O'Driscoll, R.L. (2007). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2006 (TAN0601). *New Zealand Fisheries Assessment Report 2007/5.* 73 p.

Stevens, D.W.; O'Driscoll, R.L.; Ballara, S.L.; Ladroit, Y. (2017). Trawl survey of hoki and middle-depth species on the Chatham Rise, January 2016 (TAN1601). *New Zealand Fisheries Assessment Report 2017/08*. 131 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; Ballara, S.L.; Horn, P.L. (2012). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2011 (TAN1101). *New Zealand Fisheries Assessment Report 2012/10.* 98 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; Ballara, S.L.; Horn, P.L. (2013). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2012 (TAN1201). *New Zealand Fisheries Assessment Report 2013/34.* 103 p.

Stevens, D.W.; O'Driscoll, R.L.; Dunn, M.R.; MacGibbon, D.; Horn, P.L.; Gauthier, S. (2011). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2010 (TAN1001). *New Zealand Fisheries Assessment Report 2011/10.* 112 p.

Stevens, D.W.; O'Driscoll, R.L.; Gauthier, S (2008). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2007 (TAN0701). *New Zealand Fisheries Assessment Report 2008/52.* 81 p.

Stevens, D.W.; O'Driscoll, R.L.; Horn, P.L. (2009a). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2008 (TAN0801). *New Zealand Fisheries Assessment Report 2009/18.* 86 p.

Stevens, D.W.; O'Driscoll, R.L.; Horn, P.L. (2009b). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2009 (TAN0901). *New Zealand Fisheries Assessment Report 2009/55.* 91 p.

Stevens, D.W.; O'Driscoll, R.L.; Ladroit, Y.; Ballara, S.L.; MacGibbon, D.J.; Horn, P.L. (2015). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2014 (TAN1401). *New Zealand Fisheries Assessment Report 2015/19*. 119 p.

Stevens, D.W.; O'Driscoll, R.L.; Oeffner, J.; Ballara, S.L.; Horn, P.L. (2014). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2013 (TAN1301). *New Zealand Fisheries Assessment Report 2014/02.* 110 p.

Tuck, I.; Cole, R.; Devine, J. (2009). Ecosystem indicators for New Zealand fisheries. *New Zealand Aquatic Environment and Biodiversity Report 42*. 188 p.

Vignaux, M. (1994). Documentation of Trawl survey Analysis Program. MAF Fisheries Greta Point Internal Report No. 225. 44 p. (Unpublished report held in NIWA library, Wellington.)

Table 1: The number of completed valid biomass tows (200–1300 m) by stratum during the 2018 Chatham Rise trawl survey.

Stratum number	Depth range (m)	Location	Area (km^2)	Phase 1 allocation	Phase 1 stations	Phase 2 stations	Total stations	Station density (1: km^2)
1	600–800	NW Chatham Rise	2 439	3	3		3	1:813
2A	600–800	NW Chatham Rise	3 253	3	3		3	1:1 084
2B	600–800	NE Chatham Rise	8 503	4	4		4	1:2 126
3	200–400	Matheson Bank	3 499	3	3		3	1:1 166
4	600–800	SE Chatham Rise	11 315	3	3		3	1:3 772
5	200–400	SE Chatham Rise	4 078	3	3		3	1:1 359
6	600–800	SW Chatham Rise	8 266	3	3		3	1:2 755
7A	400–600	NW Chatham Rise	4 364	3	3		3	1:1 455
7B	400–600	NW Chatham Rise	869	3	3		3	1:290
8A	400–600	NW Chatham Rise	3 286	3	3		3	1:1 095
8B	400–600	NW Chatham Rise	5 722	3	3		3	1:1 907
9	200–400	NE Chatham Rise	5 136	3	3		3	1:1 712
10	400–600	NE Chatham Rise	6 321	4	4		4	1:1 580
11	400–600	NE Chatham Rise	11 748	6	6	2	8	1:1 469
12	400–600	SE Chatham Rise	6 578	3	3		3	1:2 193
13	400–600	SE Chatham Rise	6 681	3	3		3	1:2 227
14	400–600	SW Chatham Rise	5 928	3	3		3	1:1 976
15	400–600	SW Chatham Rise	5 842	3	3		3	1:1 947
16	400–600	SW Chatham Rise	11 522	3	3		3	1:3 841
17	200–400	Veryan Bank	865	3	3		3	1:288
18	200–400	Mernoo Bank	4 687	4	4	2	6	1:781
19	200–400	Reserve Bank	9 012	7	7		7	1:1 287
20	200–400	Reserve Bank	9 584	7	7		7	1:1 369
Core	200–800		139 492	83	83	4	87	1:1 603
21A	800–1000	NE Chatham Rise	1 249	3	3		3	1:416
21B	800–1000	NE Chatham Rise	5 819	5	5		5	1:1 164
22	800–1000	NW Chatham Rise	7 357	7	7		7	1:1 051
23	1000–1300	NW Chatham Rise	7 014	5	4		4	1:1 754
24	1000–1300	NE Chatham Rise	5 672	3	3		3	1:1 891
25	800–1000	SE Chatham Rise	5 596	5	4		4	1:1 399
26	800–1000	SW Chatham Rise	5 158	3	3		3	1:1 719
27	800–1000	SW Chatham Rise	7 185	3	3		3	1:2 395
28	1000–1300	SE Chatham Rise	9 494	3	3		3	1:3 165
29	1000–1300	SW Chatham Rise	10 965	3	3		3	1:3 655
30	1000–1300	SW Chatham Rise	10 960	3	2		2	1:5 480
Deep	800–1300		76 469	43	40	0	40	1:1 912
Total	200–1300		215 967	126	123	4	127	1:1 701

Table 2: Survey dates and number of valid core (200–800 m depth) biomass tows in surveys of the Chatham Rise, January 1992–2014, 2016, and 2018. †, years where the deep component of the survey was carried out. The TAN1401 survey included an additional two days for ratcatcher bottom tows.

Trip code	Start date	End date	No. of valid core biomass tows
TAN9106	28 Dec 1991	1 Feb 1992	184
TAN9212	30 Dec 1992	6 Feb 1993	194
TAN9401	2 Jan 1994	31 Jan 1994	165
TAN9501	4 Jan 1995	27 Jan 1995	122
TAN9601	27 Dec 1995	14 Jan 1996	89
TAN9701	2 Jan 1997	24 Jan 1997	103
TAN9801	3 Jan 1998	21 Jan 1998	91
TAN9901	3 Jan 1999	26 Jan 1999	100
TAN0001	27 Dec 1999	22 Jan 2000	128
TAN0101	28 Dec 2000	25 Jan 2001	119
TAN0201	5 Jan 2002	25 Jan 2002	107
TAN0301	29 Dec 2002	21 Jan 2003	115
TAN0401	27 Dec 2003	23 Jan 2004	110
TAN0501	27 Dec 2004	23 Jan 2005	106
TAN0601	27 Dec 2005	23 Jan 2006	96
TAN0701	27 Dec 2006	23 Jan 2007	101
TAN0801	27 Dec 2007	23 Jan 2008	101
TAN0901	27 Dec 2008	23 Jan 2009	108
TAN1001†	2 Jan 2010	28 Jan 2010	91
TAN1101†	2 Jan 2011	28 Jan 2011	90
TAN1201†	2 Jan 2012	28 Jan 2012	100
TAN1301†	2 Jan 2013	26 Jan 2013	91
TAN1401†	2 Jan 2014	28 Jan 2014	87
TAN1601†	3 Jan 2016	2 Feb 2016	93
TAN1801†	4 Jan 2018	3 Feb 2018	87

Table 3: Tow and gear parameters by depth range for valid biomass tows (TAN1801). Values shown are sample size (*n*), and for each parameter the mean, standard deviation (s.d.), and range.

	n	Mean	s.d.	Range
Core tow parameters				
Tow length (n. miles)	87	2.8	0.35	2.1–3.2
Tow speed (knots)	87	3.5	0.05	3.3−3.7
All tow parameters				
Tow length (n. miles)	127	2.8	0.31	2.1–3.3
Tow speed (knots)	127	3.5	0.04	3.3−3.7
Gear parameters				
Headline height (m)				
200–400 m	30	7.4	0.35	6.5−7.9
400–600 m	41	7.0	0.44	6.0−7.9
600–800 m	16	7.2	0.30	6.6−7.7
800–1000 m	25	7.4	0.27	6.9−7.8
1000–1300 m	15	7.6	0.31	7.0−8.1
Core stations 200–800 m	87	7.2	0.42	6.0−7.9
All stations 200–1300 m	127	7.3	0.41	6.0−8.1
Doorspread (m)				
200–400 m	23	114.0	7.91	100.0−127.1
400–600 m	34	123.1	7.52	111.6−138.3
600–800 m	16	122.3	6.94	112.1−136.0
800–1000 m	22	121.3	6.16	109.8−134.4
1000–1300 m	11	125.6	7.09	111.2−133.5
Core stations 200–800 m	73	120.2	8.45	100.0−138.3
All stations 200–1300 m	106	121.0	8.01	100.0−138.3

Table 4: Catch (kg) and total relative biomass (t) estimates (also by sex) with coefficient of variation (CV, %) for QMS species, other commercial species, and key non-commercial species for valid biomass tows in the 2018 survey core strata (200–800 m); and catch and biomass estimates for deep strata (800–1300 m). Total biomass includes unsexed fish. (–, no data.). Arranged in descending relative biomass estimates for the core strata. –, no data. * indicates 30 key species defined by Livingston et al. (2002), the other was orange perch (OPE).

		Catch (kg)					Biomass (t)
Common name	**Code**	**Core**	**Deep**	**Core male**	**Core female**	**Core total**	**Deep total**
QMS species							
Hoki*	HOK	64 669	3 069	54 274 (16.7)	67 572 (15.5)	122 097 (16.0)	12 196 (86.7)
Alfonsino*	BYS	8 026	-	13 946 (92.1)	11 914 (89.7)	25 889 (90.9)	-
Silver warehou*	SWA	5 523	1	6 923 (45.8)	5 944 (43.1)	12 953 (44.2)	4 (100)
Black oreo*	BOE	2 242	19 722	6 001 (53.1)	6 349 (61.6)	12 359 (57.4)	93 478 (92.4)
Spiny dogfish*	SPD	4 286	1	1 747 (13.9)	8 428 (10.8)	10 175 (10.0)	4 (100)
Lookdown dory*	LDO	3 251	12	3 750 (48.4)	5 757 (19.9)	9 535 (27.2)	17 (45.3)
Ling*	LIN	3 303	21	3 927 (16.1)	4 830 (11.0)	8 758 (11.5)	28 (53.0)
Dark ghost shark*	GSH	3 508	-	2 253 (17.4)	3 321 (18.1)	5 580 (17.5)	-
Sea perch*	SPE	2 052	7	2 472 (11.7)	2 255 (11.6)	4 749 (11.3)	8 (72.8)
Spiky oreo*	SOR	1 394	196	2 219 (28.8)	1 903 (27.1)	4 137 (27.7)	312 (33.4)
Giant stargazer*	GIZ	1 530	5	806 (37.9)	2 230 (23.5)	3 035 (26.0)	8 (100)
Smooth oreo*	SSO	534	7135	1 272 (60.1)	1 359 (60.8)	2 634 (60.4)	33 514 (69.3)
White warehou*	WWA	901	-	1 110 (39.3)	969 (33.6)	2 102 (36.0)	-
Hake*	HAK	1 512	96	446 (38.0)	1 206 (33.9)	1 660 (34.3)	153 (41.8)
Pale ghost shark*	GSP	462	124	702 (18.1)	842 (16.8)	1 544 (15.0)	413 (41.4)
Smooth skate	SSK	565	-	463 (37.0)	1 066 (26.3)	1 529 (22.4)	-
Arrow squid*	NOS	589	1	568 (49.9)	623 (43.1)	1 209 (46.2)	2 (100)
Southern Ray’s bream	SRB	462	-	607 (40.8)	582 (38.3)	1 202 (39.1)	-
Tarakihi*	NMP	286	-	689 (89.2)	321 (46.5)	1 010 (70.6)	-
Red cod*	RCO	832	-	381 (40.7)	306 (21.1)	687 (29.9)	-
School shark*	SCH	195	-	429 (32.9)	36 (56.2)	465 (30.8)	-
Barracouta*	BAR	130	-	106 (81.5)	271 (67.5)	377 (61.9)	-
Hapuku*	HAP	113	-	161 (42.4)	136 (48.9)	297 (33.0)	-
Frostfish	FRO	80	-	187 (99.4)	108 (91.1)	296 (96.2)	-
Ribaldo*	RIB	101	50	72 (29.5)	203 (29.2)	275 (23.2)	79 (20.7)
Southern blue whiting	SBW	83	-	118 (54.3)	79 (59.4)	197 (52.6)	-
Bluenose	BNS	60	-	44 (70.1)	108 (60.9)	152 (61.2)	-
Deepsea cardinalfish	EPT	43	4	48 (44.6)	28 (32.4)	89 (36.8)	6 (100)
Slender mackerel*	JMM	38	-	19 (76.4)	57 (76.8)	76 (76.1)	-
Orange roughy	ORH	28	609	13 (73.7)	26 (53.6)	40 (59.6)	1 262 (21.3)
Jack mackerel	JMD	16	-	21 (100)	10 (100)	31 (100)	-
Lemon sole*	LSO	13	-	13 (47.2)	10 (48.5)	25 (28.3)	-
Redbait*	RBT	6	-	8 (64.6)	6 (73.5)	15 (60.2)	-
Scampi	SCI	6	-	7 (20.6)	5 (30.5)	13 (17.5)	-
Rough skate	RSK	8	-	2 (100)	8 (100)	10 (83.0)	-
Ray’s bream	RBM	4	-	4 (100)	3 (100)	9 (100)	-
Rubyfish	RBY	2	-	-	5 (75.0)	5 (75.0)	-
Commerical non-QMS species							
Shovelnose dogfish*	SND	1 458	986	1 460 (16.3)	2 107 (26.5)	3 567 (20.5)	1 759 (25.7)

Table 4 (continued)

Common name	Code	Catch (kg) Core	Deep	Biomass (t) Core male	Core female	Core total	Deep total
Non-commercial species							
Javelin fish*	JAV	2 481	391	795 (15.2)	6 227 (25.1)	7 173 (22.6)	762 (38.1)
Bollons' rattail*	CBO	2 381	16	3 460 (19.1)	2 835 (15.2)	6 490 (15.1)	25 (70.9)
Oblique banded rattail*	CAS	836	-	89 (27.3)	1 164 (14.0)	1 269 (14.0)	-
Longnose velvet dogfish	CYP	461	640	515 (58.7)	239 (39.5)	760 (51.3)	1 164 (20.9)
Oliver's rattail*	COL	248	6	365 (44.9)	363 (38.9)	743 (40.9)	9 (95.8)
Baxters lantern dogfish	ETB	61	380	230 (46.7)	80 (46.6)	309 (40.1)	1 638 (52.3)
Johnson's cod	HJO	22	402	19 (42.4)	18 (50.8)	38 (44.6)	1 558 (19.9)
Basketwork eel	BEE	4	473	12 (100)	9 (100)	21 (52.2)	1 513 (13.8)
Four-rayed rattail	CSU	11	518	3 (49.8)	10 (61.0)	18 (41.4)	1 156 (22.4)
Bigscaled brown slickhead	SBI	-	823	-	-	-	2 762 (13.3)
Smallscaled brown slickhead	SSM	-	414	-	-	-	1 975 (20.7)
Total (above)		114 816	36 102				
Grand total (all species)		119 731	39 202				

Table 5: Estimated core 200–800 m relative biomass (t) with coefficient of variation (%) for hoki, hake, and ling sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, and 2018. No. Stns, number of valid stations; CV, coefficient of variation. See also Figure 6.

			Hoki		Hake		Ling	
Year	Survey	No. stns	Biomass	CV	Biomass	CV	Biomass	CV
1992	TAN9106	184	120 190	7.7	4 180	14.9	8 930	5.8
1993	TAN9212	194	185 570	10.3	2 950	17.2	9 360	7.9
1994	TAN9401	165	145 633	9.8	3 353	9.6	10 129	6.5
1995	TAN9501	122	120 441	7.6	3 303	22.7	7 363	7.9
1996	TAN9601	89	152 813	9.8	2 457	13.3	8 424	8.2
1997	TAN9701	103	157 974	8.4	2 811	16.7	8 543	9.8
1998	TAN9801	91	86 678	10.9	2 873	18.4	7 313	8.3
1999	TAN9901	100	109 336	11.6	2 302	11.8	10 309	16.1
2000	TAN0001	128	72 151	12.3	2 152	9.2	8 348	7.8
2001	TAN0101	119	60 330	9.7	1 589	12.7	9 352	7.5
2002	TAN0201	107	74 351	11.4	1 567	15.3	9 442	7.8
2003	TAN0301	115	52 531	11.6	888	15.5	7 261	9.9
2004	TAN0401	110	52 687	12.6	1 547	17.1	8 248	7.0
2005	TAN0501	106	84 594	11.5	1 048	18.0	8 929	9.4
2006	TAN0601	96	99 208	10.6	1 384	19.3	9 301	7.4
2007	TAN0701	101	70 479	8.4	1 824	12.2	7 907	7.2
2008	TAN0801	101	76 859	11.4	1 257	12.9	7 504	6.7
2009	TAN0901	108	144 088	10.6	2 419	20.7	10 615	11.5
2010	TAN1001	91	97 503	14.6	1 701	25.1	8 846	10.0
2011	TAN1101	90	93 904	14.0	1 099	14.9	7 027	13.8
2012	TAN1201	100	87 505	9.8	1 292	14.7	8 098	7.4
2013	TAN1301	91	124 112	15.3	1 793	15.3	8 714	10.1
2014	TAN1401	87	101 944	9.8	1 377	15.2	7 489	7.2
2016	TAN1601	93	114 514	14.2	1 299	18.5	10 201	7.2
2018	TAN1801	87	122 097	16.0	1 660	34.3	8 758	11.5

Table 6: Relative biomass estimates (t in thousands) for hoki, 200–800 m depths, Chatham Rise trawl surveys January 1992–2014, 2016, and 2018 (CV, coefficient of variation; 3++, all hoki aged 3 years and older; (see Appendix 4 for length ranges used to define age classes.). See also Figure 6.

		1+ hoki			2+ hoki		3 ++ hoki		Total hoki	
Survey	1+ year class	t	% CV	2+ year class	t	% CV	t	% CV	t	% CV
1992	1990	3.0	(27.8)	1989	23.9	(13.1)	94.7	(7.8)	121.6	(7.7)
1993	1991	33.0	(33.4)	1990	8.8	(18.2)	144.5	(9.0)	186.2	(10.2)
1994	1992	14.7	(20.2)	1991	44.8	(18.4)	87.2	(9.4)	146.7	(9.8)
1995	1993	6.6	(12.9)	1992	42.7	(11.4)	71.8	(8.3)	121.2	(7.4)
1996	1994	27.6	(24.4)	1993	15.0	(13.3)	110.3	(10.3)	152.8	(9.7)
1997	1995	3.2	(40.3)	1994	61.4	(12.0)	93.4	(8.2)	158.0	(8.4)
1998	1996	4.4	(33.0)	1995	15.6	(19.1)	66.7	(10.7)	86.7	(10.9)
1999	1997	25.5	(30.6)	1996	13.8	(19.0)	70.1	(10.2)	109.3	(11.6)
2000	1998	14.4	(32.4)	1997	28.2	(20.7)	29.1	(9.2)	71.7	(12.4)
2001	1999	0.4	(72.9)	1998	26.3	(17.1)	33.7	(8.8)	60.3	(9.7)
2002	2000	22.5	(26.1)	1999	1.2	(21.2)	50.6	(12.7)	74.4	(11.4)
2003	2001	4.9	(46.0)	2000	27.2	(15.1)	20.4	(9.3)	52.5	(11.6)
2004	2002	14.4	(32.5)	2001	5.5	(20.4)	32.8	(12.9)	52.7	(12.6)
2005	2003	17.5	(23.4)	2002	45.8	(16.3)	21.2	(11.4)	84.6	(11.5)
2006	2004	25.9	(21.5)	2003	33.6	(18.8)	39.7	(10.3)	99.2	(10.6)
2007	2005	9.1	(27.5)	2004	32.8	(13.1)	28.8	(8.9)	70.7	(8.5)
2008	2006	15.6	(31.6)	2005	23.8	(15.6)	37.5	(7.8)	76.9	(11.4)
2009	2007	25.2	(28.8)	2006	65.2	(17.2)	53.7	(7.8)	144.1	(10.6)
2010	2008	19.3	(30.7)	2007	28.6	(15.4)	49.6	(16.3)	97.5	(14.6)
2011	2009	26.9	(36.9)	2008	26.3	(14.1)	40.7	(7.8)	93.9	(14.0)
2012	2010	2.6	(30.1)	2009	29.1	(16.6)	55.9	(8.0)	87.5	(9.8)
2013	2011	50.9	(24.5)	2010	1.0	(43.6)	72.1	(12.8)	124.1	(15.3)
2014	2012	5.7	(36.6)	2011	43.3	(14.2)	53.0	(10.9)	101.9	(9.8)
2016	2014	47.6	(27.6)	2013	12.9	(18.6)	54.0	(12.8)	114.5	(14.2)
2018	2016	30.5	(38.8)	2015	51.3	(19.1)	40.3	(14.8)	122.1	(16.0)

Table 7a: Estimated relative biomass (t) and coefficient of variation (% CV) for hoki, hake, ling, other key core strata species, and key deep strata species by stratum for the 2018 survey. See Table 4 for species code definitions. Core, total biomass from valid core tows (200–800 m); Deep, total biomass from valid deep tows (800–1300 m); Total, total biomass from all valid tows (200–1300 m); –, no data.

						Species code
Stratum	**HOK**	**HAK**	**LIN**	**GSH**	**GSP**	**LDO**
1	547 (12.9)	23 (50.5)	187 (48.5)	–	42 (36.6)	37 (31.1)
2A	849 (16.3)	19 (40.9)	46 (51.0)	–	47 (17.6)	18 (39.4)
2B	2 386 (26.3)	152 (59.0)	152 (28.5)	–	50 (38.3)	148 (22.4)
3	804 (12.0)	–	282 (20.1)	315 (19.1)	–	251 (15.2)
4	2 918 (61.8)	–	768 (58.0)	–	164 (43.7)	142 (46.8)
5	1 528 (28.4)	55 (56.9)	255 (33.7)	379 (19.4)	–	369 (21.3)
6	1 673 (47.9)	30 (100)	156 (50.0)	–	184 (45.0)	–
7A	4 207 (43.5)	218 (83.2)	865 (33.2)	37 (77.1)	50 (50.6)	175 (28.6)
7B	362 (21.0)	565 (89.0)	147 (46.2)	13 (68.1)	6 (75.4)	47 (54.7)
8A	1 001 (49.1)	3 (100)	173 (76.7)	9 (100)	10 (55.7)	42 (54.4)
8B	2 434 (46.3)	20 (50.5)	251 (42.6)	90 (100)	45 (50.2)	225 (24.1)
9	232 (100)	–	118 (100)	402 (56.9)	–	133 (100)
10	2 440 (28.1)	136 (44.4)	263 (29.0)	96 (85.9)	97 (42.2)	212 (25.6)
11	15 813 (73.0)	170 (68.7)	620 (21.0)	391 (46.8)	9 (65.6)	2 855 (82.1)
12	7 432 (34.0)	61 (68.8)	610 (30.7)	57 (100)	174 (45.9)	543 (22.7)
13	2 228 (22.1)	79 (100)	473 (27.0)	75 (73.0)	195 (78.4)	555 (26.7)
14	2 832 (51.0)	5 (100)	368 (14.4)	4 (100)	77 (46.8)	104 (31.3)
15	11 083 (47.7)	50 (100)	1 062 (22.2)	263 (31.1)	123 (42.1)	1 132 (45.7)
16	19 585 (30.1)	26 (100)	1 433 (49.5)	40 (100)	271 (23.7)	1 650 (54.8)
17	9 877 (95.6)	–	56 (48.3)	583 (47.1)	–	4 (66.7)
18	21 458 (39.8)	36 (72.9)	98 (62.1)	970 (42.4)	–	390 (57.8)
19	1 246 (47.9)	–	69 (82.1)	333 (29.1)	–	186 (87.7)
20	9 162 (21.3)	11 (100)	306 (45.0)	1 520 (49.6)	–	315 (28.2)
Core	122 097 (16.0)	1 660 (34.3)	8 758 (11.5)	5 580 (17.5)	1 544 (15.0)	9 535 (27.2)
21A	63 (54.2)	3 (100)	5 (100)	–	3 (69.9)	2 (100)
21B	261 (18.3)	7 (100)	4 (100)	–	20 (13.0)	4 (66.0)
22	629 (19.0)	138 (45.9)	8 (100)	–	29 (24.4)	2 (100)
23	–	5 (100)	–	–	9 (100)	–
24	108 (76.1)	–	–	–	6 (100)	–
25	177 (25.1)	–	10 (100)	–	17 (60.6)	6 (100)
26	200 (36.9)	–	–	–	23 (27.8)	3 (100)
27	10 758 (98.3)	–	–	–	298 (56.9)	–
28	–	–	–	–	8 (100)	–
29	–	–	–	–	–	–
30	–	–	–	–	–	–
Deep	12 196 (16.5)	153 (31.6)	28 (11.5)	– (17.5)	413 (14.7)	17 (27.2)
Total	134 293 (16.5)	1 813 (31.6)	8 785 (11.5)	5 580 (17.5)	1 957 (14.7)	9 552 (27.2)

Table 7a (continued)

						Species code
Stratum	**SPE**	**SPD**	**SWA**	**WWA**	**GIZ**	**RIB**
1	24 (42.6)	–	–	–	–	25 (30.3)
2A	9 (20.6)	–	–	–	–	23 (39.7)
2B	35 (37.4)	–	–	44 (100)	24 (100)	62 (41.3)
3	95 (51.3)	589 (11.9)	8 (90.3)	33 (49.7)	2 (100)	–
4	16 (53.3)	–	–	–	–	30 (52.5)
5	86 (41.7)	938 (5.5)	157 (90.6)	43 (28.6)	58 (85.5)	–
6	–	–	–	–	–	53 (51.5)
7A	51 (62.2)	191 (73.4)	58 (90.4)	3 (100)	57 (71.1)	13 (100)
7B	49 (21.0)	46 (50.3)	–	75 (97.2)	6 (92.7)	4 (100)
8A	75 (72.0)	62 (80.4)	–	16 (100)	27 (100)	–
8B	62 (15.3)	114 (64.3)	51 (86.6)	–	–	–
9	18 (56.2)	1 317 (46.2)	767 (92.2)	94 (100)	118 (41.7)	–
10	86 (37.5)	288 (78.6)	16 (57.7)	83 (51.3)	–	–
11	155 (25.5)	1 028 (45.9)	19 (53.4)	280 (57.6)	311 (71.1)	6 (85.1)
12	82 (41.7)	239 (85.5)	1 (100)	1 (100)	113 (30.8)	16 (100)
13	64 (6.9)	576 (7.7)	40 (57.9)	26 (30.5)	5 (100)	–
14	80 (81.9)	733 (12.4)	473 (58.1)	71 (49.6)	–	–
15	331 (22.7)	426 (27.9)	208 (53.8)	810 (86.5)	372 (21.1)	–
16	464 (73.2)	560 (39.9)	1 409 (80.7)	261 (63.4)	147 (55.1)	42 (100)
17	11 (73.9)	43 (37.3)	181 (65.3)	22 (96.9)	110 (35.2)	–
18	299 (70.0)	1 022 (23.8)	1 139 (39.2)	66 (80.7)	1 377 (53.6)	–
19	1 539 (15.6)	735 (21.7)	8 239 (67.1)	40 (63.4)	204 (33.4)	–
20	1 119 (20.2)	1 268 (30.0)	186 (35.8)	134 (47.9)	106 (33.6)	–
Core	4 749 (11.3)	10 175 (10.0)	12 953 (44.2)	2 102 (36.0)	3 035 (26.0)	275 (23.2)
21A	2 (100)	–	–	–	–	5 (67.7)
21B	1 (100)	–	–	–	–	20 (53.7)
22	5 (100)	–	–	–	8 (100)	26 (40.7)
23	–	–	–	–	–	–
24	–	–	–	–	–	–
25	–	–	–	–	–	28 (18.2)
26	–	4 (100)	4 (100)	–	–	–
27	–	–	–	–	–	–
28	–	–	–	–	–	–
29	–	–	–	–	–	–
30	–	–	–	–	–	–
Deep	8 (11.3)	4 (9.9)	4 (44.1)	– (36.0)	8 (25.9)	79 (18.6)
Total	4 757 (11.3)	10 179 (9.9)	12 957 (44.1)	2 102 (36.0)	3 043 (25.9)	354 (18.6)

Table 7a (continued)

						Species code
Stratum	**BOE**	**SSO**	**SOR**	**SND**	**CYP**	**ETB**
1	–	9 (21.7)	298 (59.5)	559 (19.4)	139 (94.3)	–
2A	2 (50.6)	–	30 (61.9)	672 (21.0)	470 (77.3)	10 (100)
2B	–	4 (100)	2 045 (42.1)	637 (26.6)	22 (100)	–
3	–	–	–	–	–	–
4	111 (94.2)	10 (100)	213 (49.1)	1 364 (49.7)	83 (51.0)	3 (70.1)
5	–	–	–	–	–	–
6	12 234 (58.0)	2 510 (63.2)	–	–	40 (62.1)	272 (45.0)
7A	–	–	5 (100)	87 (100)	7 (100)	–
7B	–	–	5 (100)	–	–	–
8A	–	–	–	–	–	–
8B	–	–	–	–	–	–
9	–	–	–	–	–	–
10	–	–	19 (100)	61 (75.5)	–	–
11	–	–	93 (100)	67 (59.4)	–	–
12	–	102 (100)	1 428 (50.7)	119 (52.0)	–	–
13	–	–	–	–	–	–
14	11 (100)	–	–	–	–	–
15	–	–	–	–	–	–
16	–	–	–	–	–	24 (63.0)
17	–	–	–	–	–	–
18	–	–	–	–	–	–
19	–	–	–	–	–	–
20	–	–	–	–	–	–
Core	12 359 (57.4)	2 634 (60.4)	4 137 (27.7)	3 567 (20.5)	760 (51.3)	309 (40.1)
21A	–	2 (42.4)	30 (68.8)	89 (35.6)	20 (78.9)	5 (50.8)
21B	1 (100)	5 (47.4)	165 (41.4)	353 (41.3)	310 (52.8)	9 (73.3)
22	–	8 (75.9)	6 (91.9)	205 (9.6)	325 (21.3)	4 (100)
23	–	45 (72.7)	–	17 (35.0)	41 (75.3)	14 (45.1)
24	–	480 (96.3)	–	102 (51.3)	174 (65.0)	35 (62.4)
25	286 (100)	3 (90.6)	92 (79.5)	856 (48.1)	234 (48.3)	22 (100)
26	1 770 (35.1)	1 186 (49.3)	–	35 (100)	13 (77.5)	78 (29.9)
27	91 416 (94.5)	22 368 (95.1)	–	10 (100)	22 (90.0)	1 231 (69.1)
28	5 (100)	9 343 (99.5)	19 (100)	92 (100)	24 (90.7)	145 (60.6)
29	–	74 (29.0)	–	–	–	17 (20.8)
30	–	–	–	–	–	79 (30.8)
Deep	93 478 (81.9)	33 514 (64.4)	312 (25.9)	1 759 (16.2)	1 164 (23.9)	1 638 (44.4)
Total	105 837 (81.9)	36 148 (64.4)	4 450 (25.9)	5 326 (16.2)	1 924 (23.9)	1 947 (44.4)

Table 7a (continued)

						Species code
Stratum	**SBI**	**SSM**	**BEE**	**CSU**	**CBO**	**JAV**
1	–	–	–	1 (100)	92 (31.1)	249 (36.1)
2A	–	–	–	13 (52.0)	8 (51.4)	114 (35.0)
2B	–	–	–	1 (100)	117 (19.8)	426 (15.0)
3	–	–	–	–	166 (21.5)	97 (54.3)
4	–	–	–	–	123 (59.0)	583 (22.9)
5	–	–	–	–	170 (33.1)	134 (35.2)
6	–	–	21 (52.2)	–	78 (37.7)	455 (33.6)
7A	–	–	–	–	790 (42.9)	628 (32.2)
7B	–	–	–	–	183 (67.8)	43 (45.5)
8A	–	–	–	–	41 (50.1)	50 (71.4)
8B	–	–	–	3 (100)	21 (34.5)	64 (21.3)
9	–	–	–	–	3 (100)	60 (100)
10	–	–	–	–	142 (53.2)	116 (15.1)
11	–	–	–	–	455 (18.3)	1 925 (80.1)
12	–	–	–	–	305 (37.2)	152 (30.1)
13	–	–	–	–	178 (34.1)	124 (34.0)
14	–	–	–	–	76 (14.4)	84 (28.5)
15	–	–	–	–	1 463 (29.5)	346 (27.1)
16	–	–	–	–	1 748 (44.0)	1 041 (29.5)
17	–	–	–	–	–	– (100)
18	–	–	–	–	213 (54.0)	230 (68.2)
19	–	–	–	–	24 (64.6)	145 (62.1)
20	–	–	–	–	94 (30.5)	105 (25.6)
Core	–	–	21 (52.2)	18 (41.4)	6 490 (15.1)	7 173 (22.6)
21A	47 (100)	1 (100)	8 (100)	2 (52.3)	2 (100)	29 (58.4)
21B	–	–	8 (82.6)	68 (30.7)	1 (100)	82 (40.0)
22	2 (100)	4 (100)	14 (100)	256 (59.6)	19 (93.1)	25 (64.3)
23	743 (40.0)	201 (32.6)	511 (31.5)	566 (32.9)	–	–
24	280 (12.2)	–	257 (24.4)	172 (47.7)	–	1 (100)
25	–	–	–	16 (70.4)	3 (36.2)	470 (57.1)
26	–	4 (100)	55 (49.7)	7 (31.9)	–	42 (46.3)
27	–	102 (71.4)	170 (19.0)	38 (100)	–	111 (91.8)
28	845 (18.5)	770 (47.6)	253 (33.8)	29 (68.8)	–	2 (100)
29	681 (16.9)	444 (24.2)	77 (20.3)	–	–	–
30	163 (45.2)	450 (23.8)	160 (39.8)	–	–	–
Deep	2 762 (13.3)	1 975 (20.7)	1 513 (13.6)	1 156 (22.1)	25 (15.1)	762 (20.7)
Total	2 762 (13.3)	1 975 (20.7)	1 534 (13.6)	1 174 (22.1)	6 515 (15.1)	7 935 (20.7)

Table 7b: Estimated relative biomass (t) and coefficient of variation (% CV) for pre-recruit (nominally < 20 cm SL), 20–30 cm, recruited (nominally > 30 cm SL), and total orange roughy. Core, total biomass from valid core tows (200–800 m; Deep, total biomass from valid deep tows (800–1300 m); Total, total biomass from all valid tows (200–1300 m); –, no data.

Stratum	Small	Medium	Large	Total
1	–	–	4 (100)	4 (100)
2A	14 (94.8)	16 (58.8)	5 (12.0)	35 (65.9)
2B	–	–	–	–
3	–	–	–	–
4	–	–	–	–
5	–	–	–	–
6	–	–	–	–
7A	–	–	–	–
7B	–	–	–	–
8A	–	–	–	–
8B	–	–	–	–
9	–	–	–	–
10	–	–	–	–
11	–	–	–	–
12	–	–	–	–
13	–	–	–	–
14	–	–	–	–
15	–	–	–	–
16	–	–	–	–
17	–	–	–	–
18	–	–	–	–
19	–	–	–	–
20	–	–	–	–
Core	14 (94.8)	16 (58.8)	10 (46.3)	40 (59.6)
21A	1 (57.5)	9 (83.9)	21 (100)	31 (91.6)
21B	7 (26.8)	51 (61.2)	77 (65.8)	135 (61.3)
22	24 (51.3)	80 (34.1)	199 (61.3)	303 (43.0)
23	2 (82.7)	10 (45.7)	135 (28.8)	147 (27.7)
24	–	58 (29.6)	443 (40.7)	501 (39.3)
25	4 (70.0)	20 (57.7)	23 (76.3)	48 (55.5)
26	–	–	–	–
27	–	–	–	–
28	1 (100)	8 (63.8)	90 (85.8)	98 (84.0)
29	–	–	–	–
30	–	–	–	–
Deep	39 (32.9)	236 (20.1)	988 (24.4)	1 262 (21.3)
Total	54 (35.0)	251 (19.2)	997 (24.2)	1 302 (20.8)

Table 8: Total numbers of fish, squid and scampi measured for length frequency distributions and biological samples from all tows. The total number of fish measured is sometimes greater than the sum of males and females because some fish were unsexed.

		Number measured			Number of
Common name	**Species code**	**Males**	**Females**	**Total**	**biological samples**
Abyssal rattail	CMU	-	7	7	3
Alfonsino	BYS	752	621	1 435	31
Arrow squid	NOS	390	427	825	50
Banded bellowsfish	BBE	18	30	2 055	50
Banded rattail	CFA	254	309	579	32
Barracouta	BAR	19	43	62	6
Barracudinas	PAL	1	1	2	1
Basketwork eel	BEE	97	382	484	27
Bass groper	BAS	2	-	2	1
Baxters lantern dogfish	ETB	125	147	272	37
Bigeye cardinalfish	EPL	63	38	102	9
Bigscaled brown slickhead	SBI	409	729	1 141	17
Black ghost shark	HYB	3	1	4	3
Black javelinfish	BJA	68	64	136	13
Black oreo	BOE	1 008	962	1 979	19
Black slickhead	BSL	215	184	423	13
Blackspot rattail	VNI	-	5	5	3
Blue mackerel	EMA	-	1	1	1
Bluenose	BNS	5	8	13	5
Bollons' rattail	CBO	1 289	1 270	2 569	76
Bonyskull toadfish	COT	1	1	2	1
Broadnose sevengill shark	SEV	1	-	1	1
Cape scorpionfish	TRS	6	5	11	7
Capro dory	CDO	1	1	151	2
Carpet shark	CAR	1	-	1	1
Catshark	APR	20	21	42	24
Chimaera, brown	CHP	1	3	4	3
Common halosaur	HPE	2	5	7	3
Common roughy	RHY	97	140	245	6
Conger eel	CON	-	1	1	1
Cranchiid squid	CHQ	-	-	10	4
Crested bellowsfish	CBE	-	4	91	3
Dark banded rattail	CDX	1	-	1	1
Dark ghost shark	GSH	908	1 064	1 973	50
Dawson's catshark	DCS	1	1	2	2
Dealfish	DEA	-	-	1	1
Deepsea cardinalfish	EPT	93	48	237	17
Deepsea flathead	FHD	2	4	6	5
Deepwater spiny skate (Arctic skate)	DSK	-	3	3	2
Electric ray	ERA	2	-	2	2
Filamentous rattail	GAO	1	1	3	2
Finless flounder	MAN	1	2	6	4
Four-rayed rattail	CSU	828	1 114	2 056	35
Frill shark	FRS	-	1	1	1
Frostfish	FRO	49	22	72	5
Gemfish	RSO	2	14	16	1
Giant spineback	NOC	-	1	1	1
Giant stargazer	GIZ	179	247	426	47
Hairy conger	HCO	20	25	45	24
Hake	HAK	143	115	259	42
Hapuku	HAP	9	7	16	9
Hoki	HOK	7 360	9 326	16 713	111
Humpback rattail	CBA	-	6	6	6
Jack mackerel	JMD	11	5	16	1
Javelin fish	JAV	1 513	5 006	6 983	98
Johnson's cod	HJO	452	406	862	46
Kaiyomaru rattail	CKA	4	4	32	10
Leafscale gulper shark	CSQ	10	19	29	16
Lemon sole	LSO	16	9	26	10
Ling	LIN	569	579	1 149	77

Table 8 (continued)

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Long-nosed chimaera	LCH	127	135	263	54
Longfinned beryx	BYD	3	3	6	1
Longnose velvet dogfish	CYP	527	378	914	41
Longnosed deepsea skate	PSK	2	2	4	4
Lookdown dory	LDO	1554	1915	3504	80
Lucifer dogfish	ETL	91	87	178	41
Mahia rattail	CMA	23	43	66	18
Mirror dory	MDO	4	10	14	2
Squashed face rattail	NNA	0	1	1	1
Northern spiny dogfish	NSD	2	0	2	2
Notable rattail	CIN	128	115	287	31
Numbfish	BER	1	0	1	1
Oblique banded rattail	CAS	251	1916	2218	45
Oliver's rattail	COL	563	602	1257	36
Orange perch	OPE	216	257	475	8
Orange roughy	ORH	383	394	810	27
Pale ghost shark	GSP	130	153	283	68
Pale toadfish	TOP	2	2	4	2
Pigfish	PIG	3	6	9	1
Plunket's shark	PLS	4	3	7	7
Pointynose blue ghost shark	HYP	0	1	1	1
Prickly deepsea skate	BTS	4	8	12	10
Prickly dogfish	PDG	7	4	11	8
Sea cucumber	PMO	0	0	87	21
Blobfish	PSY	1	0	1	1
Ray’s bream	RBM	1	1	3	1
Red cod	RCO	553	255	810	29
Redbait	RBT	7	4	11	3
Ribaldo	RIB	51	32	83	33
Ridge scaled rattail	MCA	115	131	251	21
Robust cardinalfish	EPR	101	75	177	3
Rough skate	RSK	1	1	2	2
Roughhead rattail	CHY	16	30	46	10
Spotty faced rattail	CTH	1	2	3	3
Rubyfish	RBY	0	2	2	2
Rudderfish	RUD	7	5	13	8
Scaly gurnard	SCG	0	0	18	3
Scampi	SCI	28	17	49	25
School shark	SCH	14	3	17	11
Sea perch	SPE	1480	1477	3021	82
Seal shark	BSH	14	20	34	22
Serrulate rattail	CSE	113	68	182	24
Shovelnose dogfish	SND	639	494	1133	51
Silver dory	SDO	107	87	195	7
Silver roughy	SRH	22	25	50	5
Silver warehou	SWA	793	635	1555	53
Silverside	SSI	30	14	534	29
Sixgill shark	HEX	2	1	3	2
Slender mackerel	JMM	8	24	32	4
Small-headed cod	SMC	14	5	19	12
Small banded rattail	CCX	28	35	67	11
Smallscaled brown slickhead	SSM	260	345	607	18
Smooth deepsea skate	BTA	6	3	9	8
Smooth oreo	SSO	959	840	1812	40
Smooth skate	SSK	13	25	38	26
Smooth skin dogfish	CYO	92	52	144	26
Southern blue whiting	SBW	115	78	193	14
Southern Ray’s bream	SRB	206	220	430	28
Spiky oreo	SOR	638	602	1254	31
Spineback	SBK	34	394	430	49

Table 8 (continued)

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Spiny dogfish	SPD	542	1800	2342	64
Swollenhead conger	SCO	22	25	47	24
Tarakihi	NMP	161	74	235	4
Thin tongue cardinalfish	EPM	65	45	110	11
Todarodes squid	TSQ	0	0	46	30
Tasmanian ruffe	TUB	1	0	1	1
Two saddle rattail	CBI	134	228	365	12
Violet cod	VCO	27	40	91	7
Violet squid	VSQ	0	0	5	3
Warty oreo	WOE	56	44	101	7
Warty squid	MIQ	0	0	110	42
Warty squid	MRQ	0	0	27	13
White rattail	WHX	121	137	264	29
White warehou	WWA	323	296	685	50
Widenosed chimaera	RCH	38	23	61	25
Witch	WIT	0	7	8	4
Yellow boarfish	YBO	0	1	1	1
Yellow cod	YCO	0	1	1	1
Total		29006	38197	71746	2614

Table 9: Length-weight regression parameters* used to scale length frequencies (data from TAN1801). CSU used data from all surveys as the r^2 value was less than 90% for TAN1801 data. Length measurement method: TL, total length; FL, fork length, CL, chimaera length; SL, standard length. See Table 8 or Appendix 2 for species names.

Species code	a (intercept)	b (slope)	r^2	n	Length range (cm)	Length measurement	Data source
BEE	0.000350	3.259708	91.46	260	61–129	TL	TAN1801
BOE	0.013315	3.123983	92.44	214	23–36	TL	TAN1801
CSU	0.013162	2.463235	75.75	1640	18–39	TL	All surveys
ETB	0.002866	3.142041	98.22	217	22–81	TL	TAN1801
GIZ	0.005929	3.257813	98.31	278	20–81	TL	TAN1801
GSH	0.002108	3.253263	93.89	877	34–73	CL	TAN1801
GSP	0.005885	2.989363	94.86	278	29–86	CL	TAN1801
HAK	0.002389	3.252507	98.43	257	49–133	TL	TAN1801
HOK	0.003257	2.972003	98.96	1989	34–109	TL	TAN1801
LDO	0.021564	3.003671	98.05	1258	12–54	TL	TAN1801
LIN	0.001557	3.245637	99.20	1028	38–160	TL	TAN1801
ORH	0.047963	2.898138	99.01	385	7–43	SL	TAN1801
RIB	0.003675	3.284111	97.79	83	25–72	TL	TAN1801
SBI	0.002822	3.317428	95.82	319	22–54	FL	TAN1801
SND	0.002462	3.089224	97.08	613	30–116	TL	TAN1801
SOR	0.021113	3.022074	98.39	486	11–43	TL	TAN1801
SPD	0.000518	3.493754	92.99	993	53–96	TL	TAN1801
SPE	0.009635	3.151037	98.74	1081	9–47	TL	TAN1801
SSM	0.003962	3.208199	98.62	277	16–68	FL	TAN1801
SSO	0.024514	2.984632	98.89	384	16–56	TL	TAN1801
SWA	0.006585	3.258541	99.56	580	14–54	FL	TAN1801
WWA	0.012180	3.150018	99.19	437	15–65	FL	TAN1801

* $W = aL^b$ where W is weight (g) and L is length (cm); r^2 is the correlation coefficient, n is the sample size.

Table 10: Numbers of fish measured at each reproductive stage. MD, middle depths staging method; SS, Cartilaginous fish gonad stages — see footnote below table for staging details. –, no data.

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
APR	Catshark	Female	SS	1	-	-	-	-	-	-	1
	(*Apristurus* spp.)	Male		2	2	11	-	-	-	-	15
BAR	Barracouta	Female	MD	-	-	41	2	-	-	-	43
		Male		-	-	1	15	3	-	-	19
BAS	Bass groper	Female	MD	-	-	-	-	-	-	-	-
		Male		-	1	1	-	-	-	-	2
BBE	Banded bellowsfish	Female	MD	5	17	2	-	-	-	-	24
		Male		9	7	1	-	-	-	-	17
BEE	Basketwork eel	Female	MD	1	101	32	-	-	-	-	134
		Male		5	27	-	-	-	-	-	32
BER	Numbfish	Female	SS	-	-	-	-	-	-	-	-
		Male		-	-	1	-	-	-	-	1
BJA	Black javelinfish	Female	MD	-	32	5	2	1	-	-	40
		Male		3	25	1	1	-	-	-	30
BNS	Bluenose	Female	MD	-	7	1	-	-	-	-	8
		Male		1	2	2	-	-	-	-	5
BOE	Black oreo	Female	MD	173	196	190	3	-	-	1	563
		Male		264	216	71	5	-	-	-	556
BSH	Seal shark	Female	SS	17	1	1	-	-	-	-	19
		Male		11	1	2	-	-	-	-	14
BSL	Black slickhead	Female	MD	14	3	61	5	-	1	-	84
		Male		8	75	1	-	-	-	-	84
BTA	Smooth deepsea skate	Female	SS	2	-	1	-	-	-	-	3
		Male		-	1	5	-	-	-	-	6
BTS	Prickly deepsea skate	Female	SS	2	3	2	1	-	-	-	8
		Male		3	-	1	-	-	-	-	4
BYD	Longfinned beryx	Female	MD	1	2	-	-	-	-	-	3
		Male		1	2	-	-	-	-	-	3
BYS	Alfonsino	Female	MD	72	62	-	-	-	-	6	140
		Male		109	66	-	-	-	-	-	175
CAR	Carpet shark	Female	SS	-	-	-	-	-	-	-	-
		Male		-	-	1	-	-	-	-	1
CAS	Oblique banded rattail	Female	MD	44	227	5	-	1	-	-	277
		Male		7	7	-	-	-	-	-	14
CBA	Humpback rattail	Female	MD	-	5	-	-	-	-	-	5
		Male		-	-	-	-	-	-	-	-
CBI	Two saddle rattail	Female	MD	3	62	49	3	-	1	1	119
		Male		2	50	12	1	-	-	-	65
CBO	Bollons' rattail	Female	MD	24	332	2	-	-	-	1	359
		Male		35	266	-	-	1	-	-	302
CCX	Small banded rattail	Female	MD	1	2	5	4	-	-	-	12
		Male		-	6	5	-	-	-	-	11
CDO	Capro dory	Female	MD	-	-	1	-	-	-	-	1
		Male		-	1	-	-	-	-	-	1
CDX	Dark banded rattail	Female	MD	-	-	-	-	-	-	-	-
		Male		1	-	-	-	-	-	-	1
CFA	Banded rattail	Female	MD	16	116	4	-	-	-	-	136
		Male		48	53	-	-	-	-	-	101
CHP	Brown chimaera	Female	SS	1	2	-	-	-	-	-	3
		Male		-	-	1	-	-	-	-	1
CHY	Roughhead rattail	Female	MD	3	2	24	1	-	-	-	30
		Male		2	10	4	-	-	-	-	16
CIN	Notable rattail	Female	MD	9	42	20	-	-	-	-	71
		Male		21	87	-	-	-	-	-	108
CKA	Kaiyomaru rattail	Female	MD	1	1	2	-	-	-	-	4
		Male		1	3	-	-	-	-	-	4
CKX	Spotty faced rattails (CHY and CTH)	Female	MD	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-

Table 10 (continued)

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
CMA	Mahia rattail	Female	MD	2	34	1	2	-	-	1	40
		Male		-	21	1	-	-	-	-	22
CMU	Murray’s rattail	Female	MD	1	5	-	-	-	-	-	6
		Male		-	-	-	-	-	-	-	-
COL	Oliver's rattail	Female	MD	33	137	3	-	-	-	-	173
		Male		15	70	1	-	-	-	-	86
CON	Conger eel	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
CSE	Serrulate rattail	Female	MD	3	30	17	-	-	-	-	50
		Male		3	76	3	-	-	-	-	82
CSQ	Leafscale gulper shark	Female	SS	2	11	3	1	-	-	-	17
		Male		3	1	5	-	-	-	-	9
CSU	Four-rayed rattail	Female	MD	54	195	69	-	-	-	-	318
		Male		38	66	1	-	-	-	-	105
CTH	Roughhead rattail	Female	MD	-	1	-	-	-	-	-	1
		Male		-	1	-	-	-	-	-	1
CYO	Smooth skin dogfish	Female	SS	11	29	6	2	1	2	-	51
		Male		14	3	74	-	-	-	-	91
CYP	Longnose velvet dogfish	Female	SS	144	59	25	11	5	-	-	244
		Male		120	26	100	-	-	-	-	246
DCS	Dawson's catshark	Female	SS	-	-	1	-	-	-	-	1
		Male		-	1	-	-	-	-	-	1
DSK	Deepwater spiny skate (Arctic skate)	Female	SS	2	1	-	-	-	-	-	3
		Male		-	-	-	-	-	-	-	-
EMA	Blue mackerel	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
EPL	Bigeye cardinalfish	Female	MD	6	11	-	-	-	-	-	17
		Male		10	27	1	-	-	-	-	38
EPM	Thin tongue cardinalfish	Female	MD	2	5	33	5	-	-	-	45
		Male		3	25	36	1	-	-	-	65
EPR	Robust cardinalfish	Female	MD	-	1	21	-	-	-	-	22
		Male		1	13	31	-	-	-	-	45
EPT	Deepsea cardinalfish	Female	MD	21	4	1	-	-	-	-	26
		Male		59	3	-	-	-	-	-	62
ERA	Electric ray	Female	SS	-	-	-	-	-	-	-	-
		Male		-	1	1	-	-	-	-	2
ETB	Baxter's lantern dogfish	Female	SS	28	65	26	7	-	20	-	146
		Male		31	11	81	-	-	-	-	123
ETL	Lucifer dogfish	Female	SS	36	31	9	4	3	-	-	83
		Male		32	34	25	-	-	-	-	91
FHD	Deepsea flathead	Female	MD	1	2	-	-	-	1	-	4
		Male		-	2	-	-	-	-	-	2
FRO	Frostfish	Female	MD	3	4	3	1	-	-	-	11
		Male		-	7	9	7	1	-	-	24
FRS	Frill shark	Female	SS	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
GAO	Filamentous rattail	Female	MD	-	-	-	-	-	-	-	-
		Male		-	1	-	-	-	-	-	1
GIZ	Giant stargazer	Female	MD	36	58	109	9	-	3	7	222
		Male		24	113	9	-	-	-	-	146
GSH	Dark ghost shark	Female	SS	80	247	136	5	-	-	-	468
		Male		45	40	306	-	-	-	-	391
GSP	Pale ghost shark	Female	SS	21	75	54	1	-	-	-	151
		Male		27	16	86	-	-	-	-	129
HAK	Hake	Female	MD	19	20	65	5	1	-	5	115
		Male		25	14	7	26	28	39	4	143
HAP	Hapuku	Female	MD	-	7	-	-	-	-	-	7
		Male		2	4	2	-	-	1	-	9
HCO	Hairy conger	Female	MD	-	11	9	-	-	-	-	20
		Male		1	10	5	-	-	-	-	16

Table 10 (continued)

Species			Staging	Reproductive stage							
code	**Common name**	**Sex**	**method**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
HEX	Sixgill shark	Female	SS	1	-	-	-	-	-	-	1
		Male		2	-	-	-	-	-	-	2
HJO	Johnson's cod	Female	MD	72	117	30	-	-	-	-	219
		Male		110	131	56	32	-	-	-	329
HOK	Hoki	Female	MD	6 895	2 380	1	3	2	-	13	9 294
		Male		6 384	909	1	1	-	-	3	7 298
HPE	Common halosaur	Female	MD	-	-	5	-	-	-	-	5
		Male		-	1	1	-	-	-	-	2
HYB	Black ghost shark	Female	SS	-	-	1	-	-	-	-	1
		Male		-	-	3	-	-	-	-	3
HYP	Pointynose blue ghost shark	Female	SS	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
JAV	Javelinfish	Female	MD	72	558	38	-	-	-	3	671
		Male		73	65	48	-	-	-	-	186
JMD	Jack mackerel	Female	MD	-	-	5	-	-	-	-	5
		Male		-	-	1	5	5	-	-	11
JMM	Slender mackerel	Female	MD	-	1	20	-	1	-	-	22
		Male		-	1	-	4	-	-	-	5
LCH	Long-nosed chimaera	Female	SS	38	59	31	1	-	-	-	129
		Male		27	12	69	-	-	-	-	108
LDO	Lookdown dory	Female	MD	136	316	287	3	-	1	26	769
		Male		89	378	81	37	-	-	2	587
LIN	Ling	Female	MD	181	387	6	-	-	-	2	576
		Male		184	214	93	73	-	3	-	567
LSO	Lemon sole	Female	MD	-	2	1	-	-	-	-	3
		Male		2	5	-	-	-	-	-	7
MAN	Finless flounder	Female	MD	-	2	-	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-
MCA	Ridge scaled rattail	Female	MD	36	67	9	-	-	-	-	112
		Male		55	43	1	1	-	-	-	100
MDO	Mirror dory	Female	MD	-	5	-	-	-	-	-	5
		Male		1	3	-	-	-	-	-	4
NMP	Tarakihi	Female	MD	-	14	11	2	1	-	-	28
		Male		-	2	15	4	2	-	-	23
NNA	Squashed face rattail	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
NOC	Giant spineback	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
NSD	Northern spiny dogfish	Female	SS	-	-	-	-	-	-	-	-
		Male		1	-	1	-	-	-	-	2
OPE	Orange perch	Female	MD	2	9	43	7	1	-	-	62
		Male		5	10	12	5	4	-	-	36
ORH	Orange roughy	Female	MD	112	90	100	-	-	-	-	302
		Male		125	126	41	-	-	-	-	292
PAL	Barracudinas	Female	MD	-	1	-	-	-	-	-	1
		Male		-	1	-	-	-	-	-	1
PDG	Prickly dogfish	Female	SS	1	2	1	-	-	-	-	4
		Male		-	-	7	-	-	-	-	7
PLS	Plunket's shark	Female	SS	-	3	-	-	-	-	-	3
		Male		-	-	4	-	-	-	-	4
PSK	Longnosed deepsea skate	Female	SS	1	-	1	-	-	-	-	2
		Male		-	1	1	-	-	-	-	2
PSY	Blobfish	Female	MD	-	-	-	-	-	-	-	-
		Male		-	1	-	-	-	-	-	1
RBM	Ray’s bream	Female	MD	-	1	-	-	-	-	-	1
		Male		-	1	-	-	-	-	-	1
RBT	Redbait	Female	MD	-	-	3	1	-	-	-	4
		Male		-	-	2	1	-	-	-	3
RBY	Rubyfish	Female	MD	-	1	1	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-

Table 10 (continued)

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
RCH	Widenosed chimaera	Female	SS	6	11	3	1	-	1	-	22
		Male		15	5	18	-	-	-	-	38
RCO	Red cod	Female	MD	70	60	16	5	-	1	-	152
		Male		83	34	34	31	3	1	-	186
RHY	Common roughy	Female	MD	-	2	15	12	12	-	-	41
		Male		1	32	-	-	-	-	-	33
RIB	Ribaldo	Female	MD	2	26	3	-	-	-	-	31
		Male		2	33	15	-	-	-	-	50
RSK	Rough skate	Female	SS	1	-	-	-	-	-	-	1
		Male		-	-	1	-	-	-	-	1
RSO	Gemfish	Female	MD	1	13	-	-	-	-	-	14
		Male		1	1	-	-	-	-	-	2
RUD	Rudderfish	Female	MD	-	2	3	-	-	-	-	5
		Male		-	1	1	4	-	-	-	6
SBI	Bigscaled brown slickhead	Female	MD	22	46	108	35	14	1	-	226
		Male		11	30	20	12	1	1	-	75
SBK	Spineback	Female	MD	4	42	177	20	2	-	3	248
		Male		3	3	3	12	5	-	-	26
SBW	Southern blue whiting	Female	MD	5	44	-	-	-	-	-	49
		Male		18	47	-	-	-	-	-	65
SCH	School shark	Female	SS	2	1	-	-	-	-	-	3
		Male		1	2	9	-	-	-	-	12
SCO	Swollenhead conger	Female	MD	2	10	10	-	-	-	-	22
		Male		3	10	4	-	-	-	-	17
SDO	Silver dory	Female	MD	5	15	1	2	3	-	-	26
		Male		15	29	-	-	-	-	-	44
SEV	Broadnose sevengill shark	Female	SS	-	-	-	-	-	-	-	-
		Male		1	-	-	-	-	-	-	1
SMC	Small-headed cod	Female	MD	2	2	-	-	-	-	-	4
		Male		8	5	-	-	-	-	-	13
SND	Shovelnose dogfish	Female	SS	57	180	18	4	1	-	-	260
		Male		43	53	249	-	-	-	-	345
SOR	Spiky oreo	Female	MD	45	74	120	9	-	2	5	255
		Male		61	118	40	9	-	-	1	229
SPD	Spiny dogfish	Female	SS	24	149	40	80	322	2	-	617
		Male		1	14	205	-	-	-	-	220
SPE	Sea perch	Female	MD	87	277	4	2	15	-	-	385
		Male		47	291	98	6	2	-	1	445
SRB	Southern Ray's bream	Female	MD	17	96	8	-	-	-	-	121
		Male		24	75	4	-	-	-	-	103
SRH	Silver roughy	Female	MD	3	7	-	-	-	-	-	10
		Male		4	6	2	-	-	-	-	12
SSI	Silverside	Female	MD	7	4	-	-	-	-	-	11
		Male		20	3	-	-	-	-	-	23
SSK	Smooth skate	Female	SS	3	14	-	-	-	-	-	17
		Male		4	7	2	-	-	-	-	13
SSM	Smallscaled brown slickhead	Female	MD	30	97	26	1	-	-	-	154
		Male		25	53	21	10	-	-	-	109
SSO	Smooth oreo	Female	MD	312	185	125	6	1	-	1	630
		Male		370	187	86	63	2	-	-	708
SWA	Silver warehou	Female	MD	32	177	3	-	-	-	-	212
		Male		90	223	10	-	-	3	1	327
TOP	Pale toadfish	Female	MD	-	-	2	-	-	-	-	2
		Male		-	2	-	-	-	-	-	2
TRS	Cape scorpionfish	Female	MD	-	5	-	-	-	-	-	5
		Male		2	4	-	-	-	-	-	6
VCO	Violet cod	Female	MD	25	15	-	-	-	-	-	40
		Male		18	3	-	-	-	-	-	21
VNI	Blackspot rattail	Female	MD	-	2	2	1	-	-	-	5
		Male		-	-	-	-	-	-	-	-

Table 10 (continued)

Species		Staging		Reproductive stage							
Code	**Common name**	**Sex**	**method**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
WHX	White rattail	Female	MD	8	95	6	-	-	-	1	110
		Male		29	62	2	-	-	-	-	93
WIT	Witch	Female	MD	-	5	-	-	-	-	-	5
		Male		-	-	-	-	-	-	-	-
WOE	Warty oreo	Female	MD	11	3	2	-	-	-	-	16
		Male		19	2	1	-	-	-	-	22
WWA	White warehou	Female	MD	85	69	26	-	-	1	-	181
		Male		116	71	6	-	-	11	1	205
YBO	Yellow boarfish	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
YCO	Yellow cod	Female	MD	1	-	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-

Middle depths (MD) gonad stages: 1, immature; 2, resting; 3, ripening; 4, ripe; 5, running ripe; 6, partially spent; 7, spent (after Hurst et al. 1992).
Cartilaginous fish (SS) gonad stages: male – 1, immature; 2, maturing; 3, mature: female – 1, immature; 2, maturing; 3, mature; 4, gravid I; 5, gravid II; 6, post-partum.

Table 11: Average trawl catch (excluding benthic organisms) and acoustic backscatter from daytime core tows where acoustic data quality was suitable for echo integration on the Chatham Rise in 2001–18.

			Average acoustic backscatter (m^2 km^{-2})			
Year	No. of recordings	Average trawl catch (kg km^{-2})	Bottom 10 m	Bottom 50 m	All bottom marks (to 100 m)	Entire echogram
2001	117	1 858	3.63	22.39	31.80	57.60
2002	102	1 849	4.50	18.39	22.60	49.32
2003	117	1 508	3.43	19.56	29.41	53.22
2005	86	1 783	2.78	12.69	15.64	40.24
2006	88	1 782	3.24	13.19	19.46	48.86
2007	100	1 510	2.00	10.83	15.40	41.07
2008	103	2 012	2.03	9.65	13.23	37.98
2009	105	2 480	2.98	15.89	25.01	58.88
2010	90	2 205	1.87	10.80	17.68	44.49
2011	73	1 997	1.79	8.72	12.94	34.79
2012	85	1 793	2.60	15.96	26.36	54.77
2013	76	2 323	3.74	15.87	27.07	56.89
2014	48	1 790	3.15	14.96	24.42	48.45
2016	90	1 890	3.49	20.79	31.81	61.34
2018	85	2 429	2.66	13.88	23.18	42.95

Table 12: Estimates of the proportion of total daytime backscatter in each stratum and year on the Chatham Rise which is assumed to be mesopelagic fish (*p(meso)s*). Estimates were derived from the observed proportion of night backscatter in the upper 200 m corrected for the proportion of backscatter estimated to be in the surface acoustic deadzone.

				Stratum
Year	Northeast	Northwest	Southeast	Southwest
2001	0.64	0.83	0.81	0.88
2002	0.58	0.78	0.66	0.86
2003	0.67	0.82	0.81	0.77
2005	0.72	0.83	0.73	0.69
2006	0.69	0.77	0.76	0.80
2007	0.67	0.85	0.73	0.80
2008	0.61	0.64	0.84	0.85
2009	0.58	0.75	0.83	0.86
2010	0.48	0.64	0.76	0.63
2011	0.63	0.49	0.76	0.54
2012	0.40	0.52	0.68	0.79
2013	0.34	0.50	0.54	0.66
2014	0.54	0.62	0.74	0.78
2016	0.69	0.57	0.71	0.84
2018	0.44	0.50	0.75	0.60

Table 13: Mesopelagic indices for the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same sub-area observed in the upper 200 m (see Table 12) corrected for the estimated proportion in the surface deadzone (from O'Driscoll et al. 2009). Unstratified indices for the Chatham Rise were calculated as the unweighted average over all available acoustic data. Stratified indices were obtained as the weighted average of stratum estimates, where weighting was the proportional area of the stratum (northwest 11.3% of total area, southwest 18.7%, northeast 33.6%, southeast 36.4%).

Acoustic index (m^2 km^{-2})

Survey	Year	Unstratified		Northeast		Northwest		Southeast		Southwest		Stratified	
		Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
TAN0101	2002	47.1	8	21.8	11	61.1	13	36.8	12	92.6	16	44.9	8
TAN0201	2003	35.8	6	25.1	11	40.3	11	29.6	13	54.7	13	34.0	7
TAN0301	2004	40.6	10	30.3	23	32.0	12	52.4	19	53.9	11	42.9	10
TAN0501	2005	30.4	7	28.4	12	44.5	21	25.2	8	29.5	23	29.3	7
TAN0601	2006	37.0	6	30.7	10	47.9	12	38.1	12	36.7	19	36.4	7
TAN0701	2007	32.4	7	23.0	10	43.3	12	27.2	13	35.9	20	29.2	7
TAN0801	2008	29.1	6	17.8	5	27.9	19	38.1	10	36.2	12	29.8	6
TAN0901	2009	44.7	10	22.4	22	54.3	12	39.3	16	84.8	18	43.8	9
TAN1001	2010	27.0	8	16.5	11	33.4	11	35.1	17	34.0	24	28.5	10
TAN1101	2011	21.4	9	23.4	15	27.2	14	12.6	23	15.8	17	18.5	9
TAN1201	2012	30.8	8	17.6	13	41.1	34	33.5	11	51.1	12	32.3	8
TAN1301	2013	28.8	7	15.5	15	45.9	12	27.3	13	31.7	13	26.3	7
TAN1401	2014	31.7	9	19.4	8	37.6	12	35.8	18	44.6	24	32.1	10
TAN1601	2016	41.7	8	27.8	14	40.1	13	41.6	15	68.7	16	41.8	8
TAN1801	2018	24.1	8	16.1	10	26.7	16	30.9	22	28.6	20	25.0	11

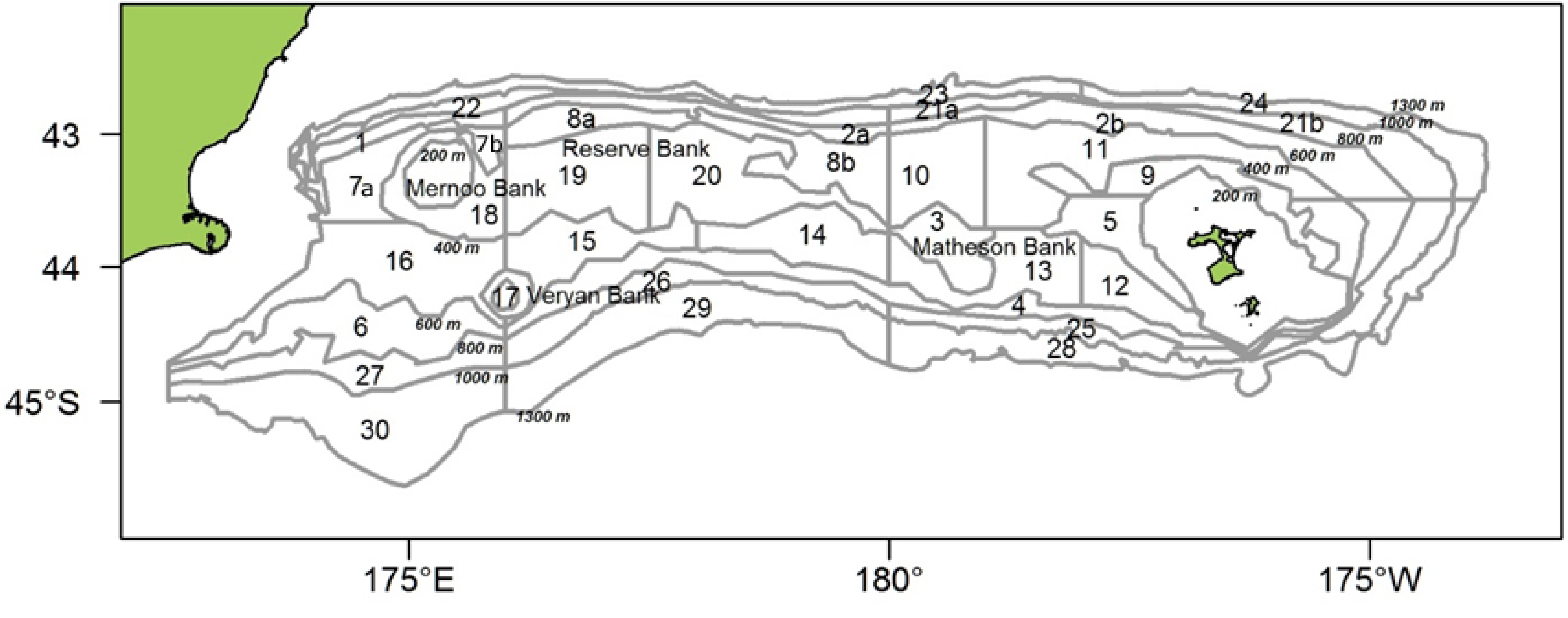


Figure 1: Chatham Rise trawl survey area showing stratum boundaries.

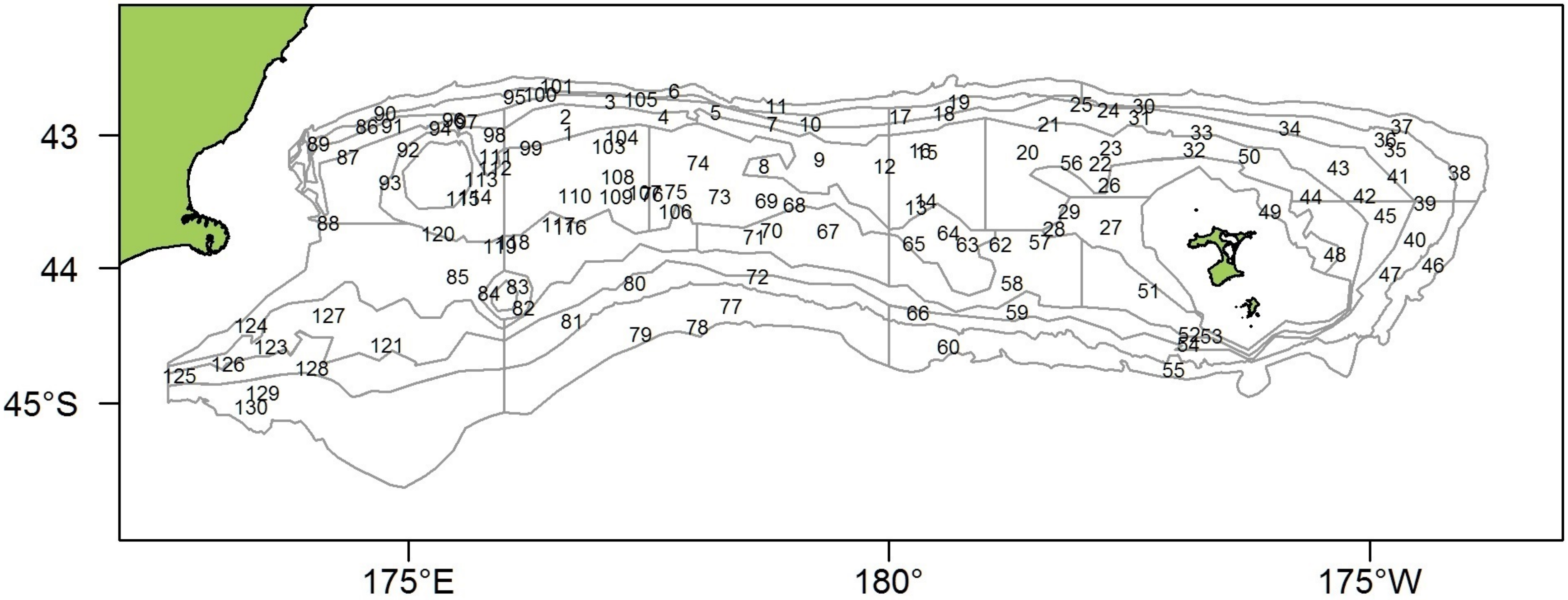


Figure 2: Trawl survey area showing positions of valid biomass stations (n = 127 stations) for TAN1801. In this and subsequent figures actual stratum boundaries are drawn for the deepwater strata.

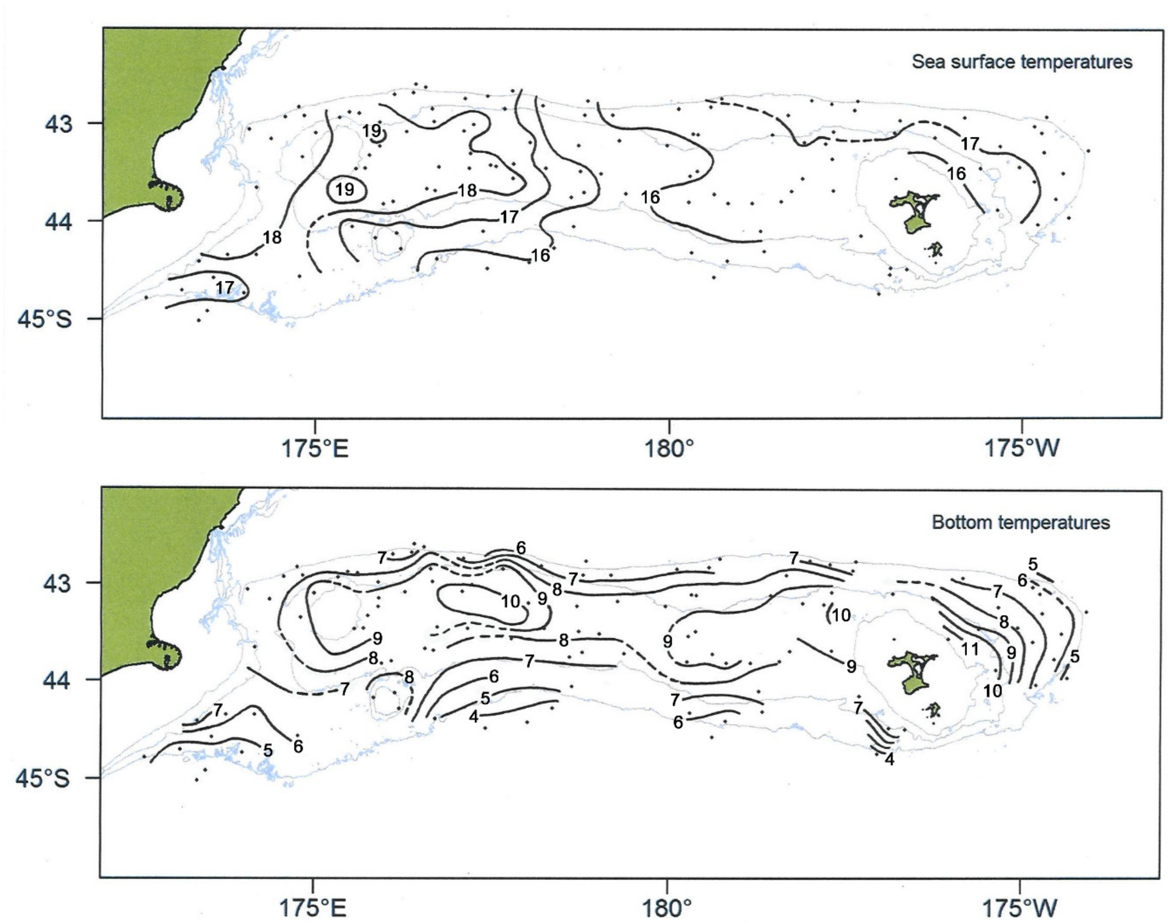


Figure 3: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (ºC) interpolated by eye for TAN1801. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow.

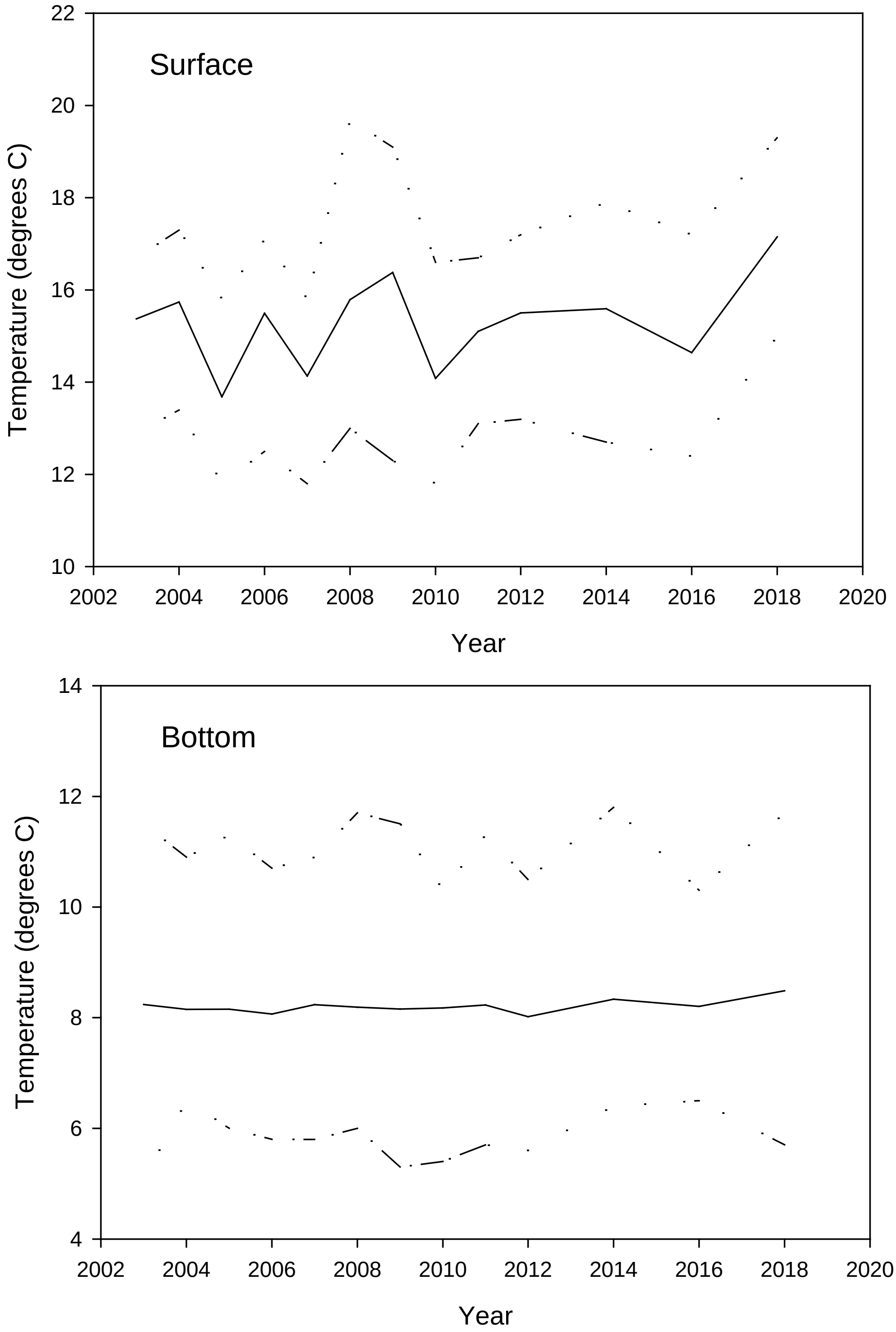


Figure 4: Time series of sea surface (upper panel) and bottom (lower panel) temperature recordings within the core (200–800 m) survey area from the calibrated Seabird CTD recordings made during each tow. Solid line is the mean temperature. Dashed lines are minimum and maximum values in each year.

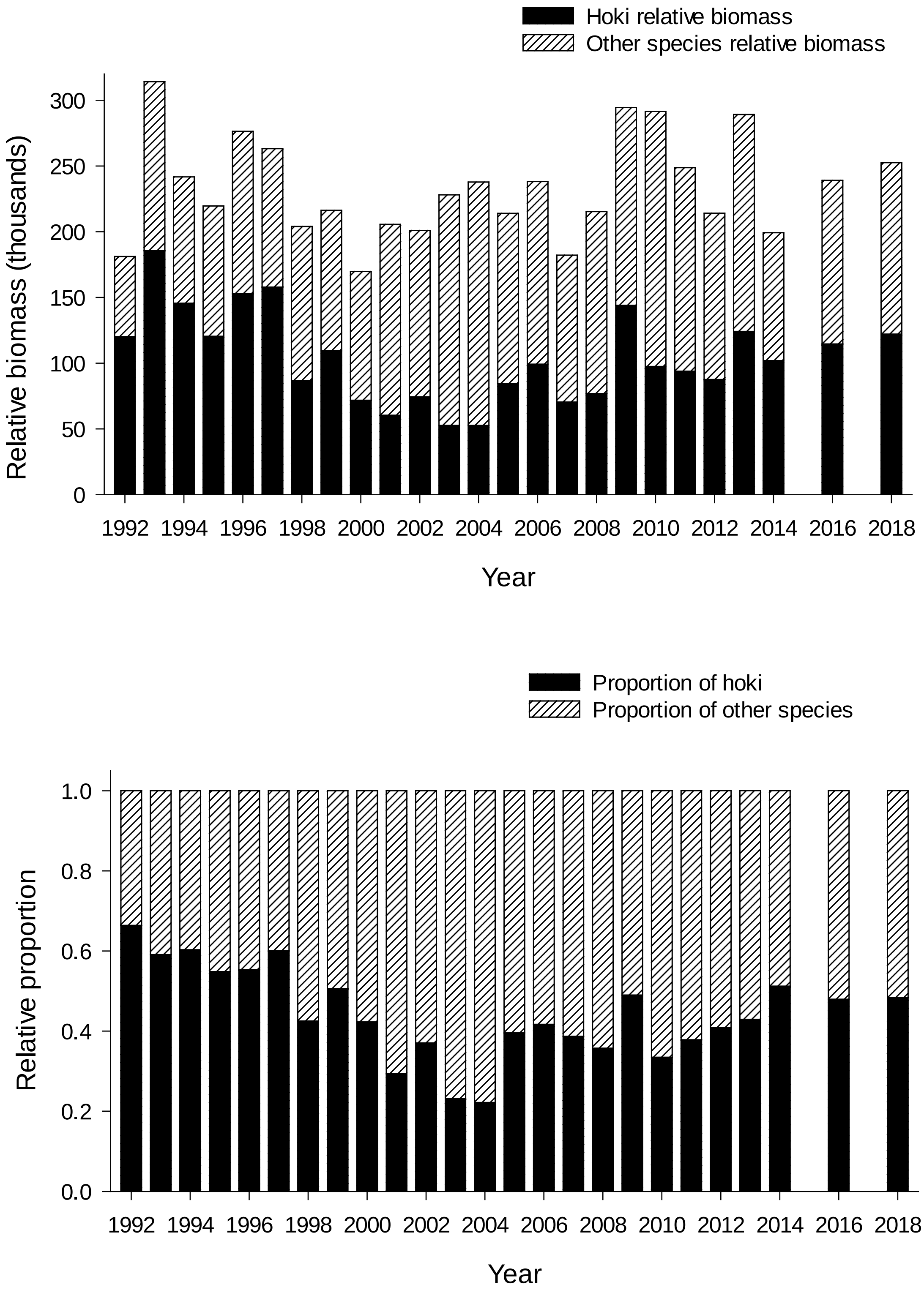


Figure 5: Relative biomass (top panel) and relative proportions of hoki and 30 other key species, as defined by Livingston et al (2002) and indicated in Table 4, (lower panel) from trawl surveys of the Chatham Rise, January 1992–2018 (core strata only).

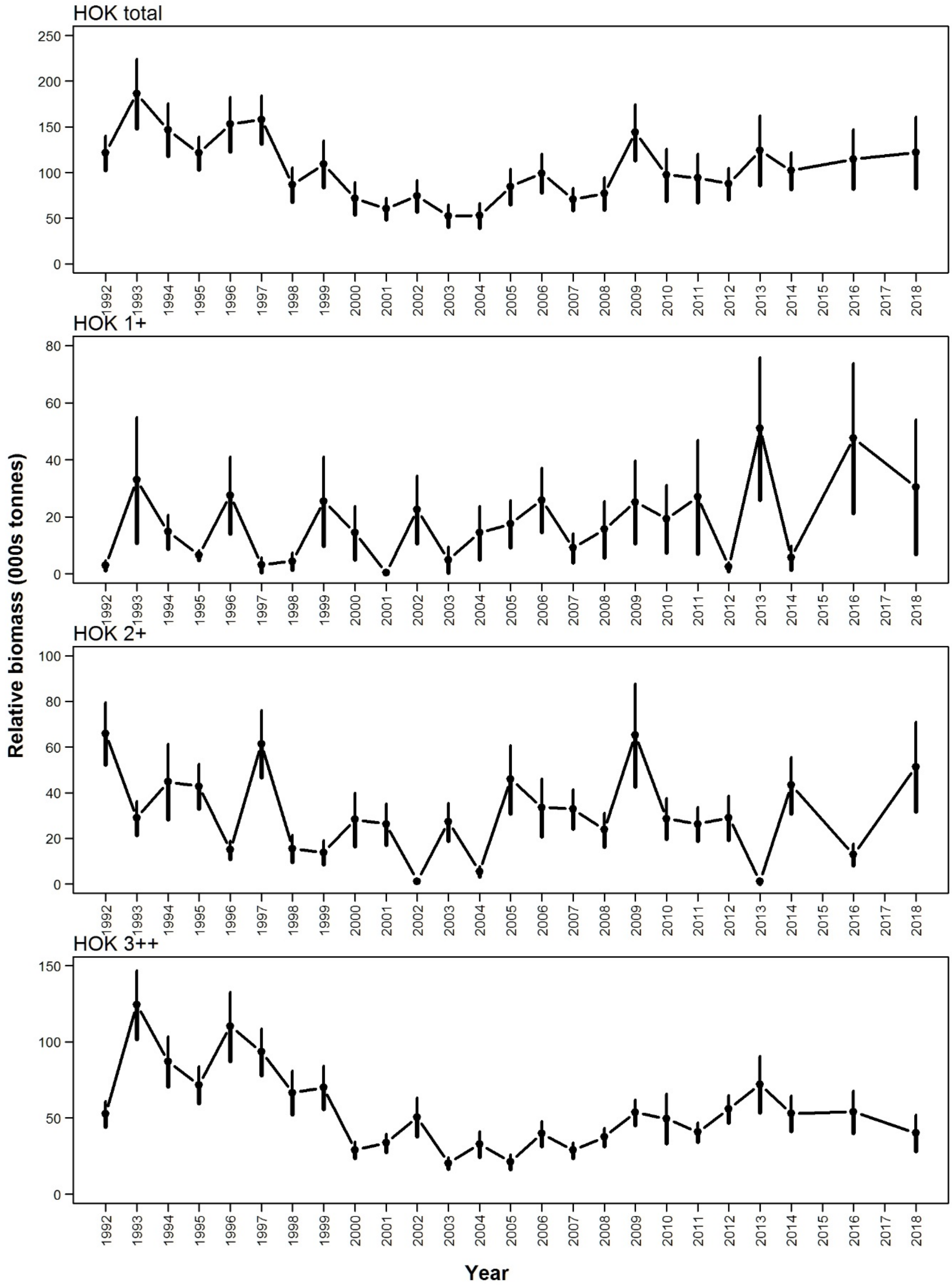


Figure 6a: Relative biomass estimates (thousands of tonnes) of hoki, hake, ling, and 8 other selected commercial species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, and 2018 (core strata only). Error bars show ± 2 standard errors.

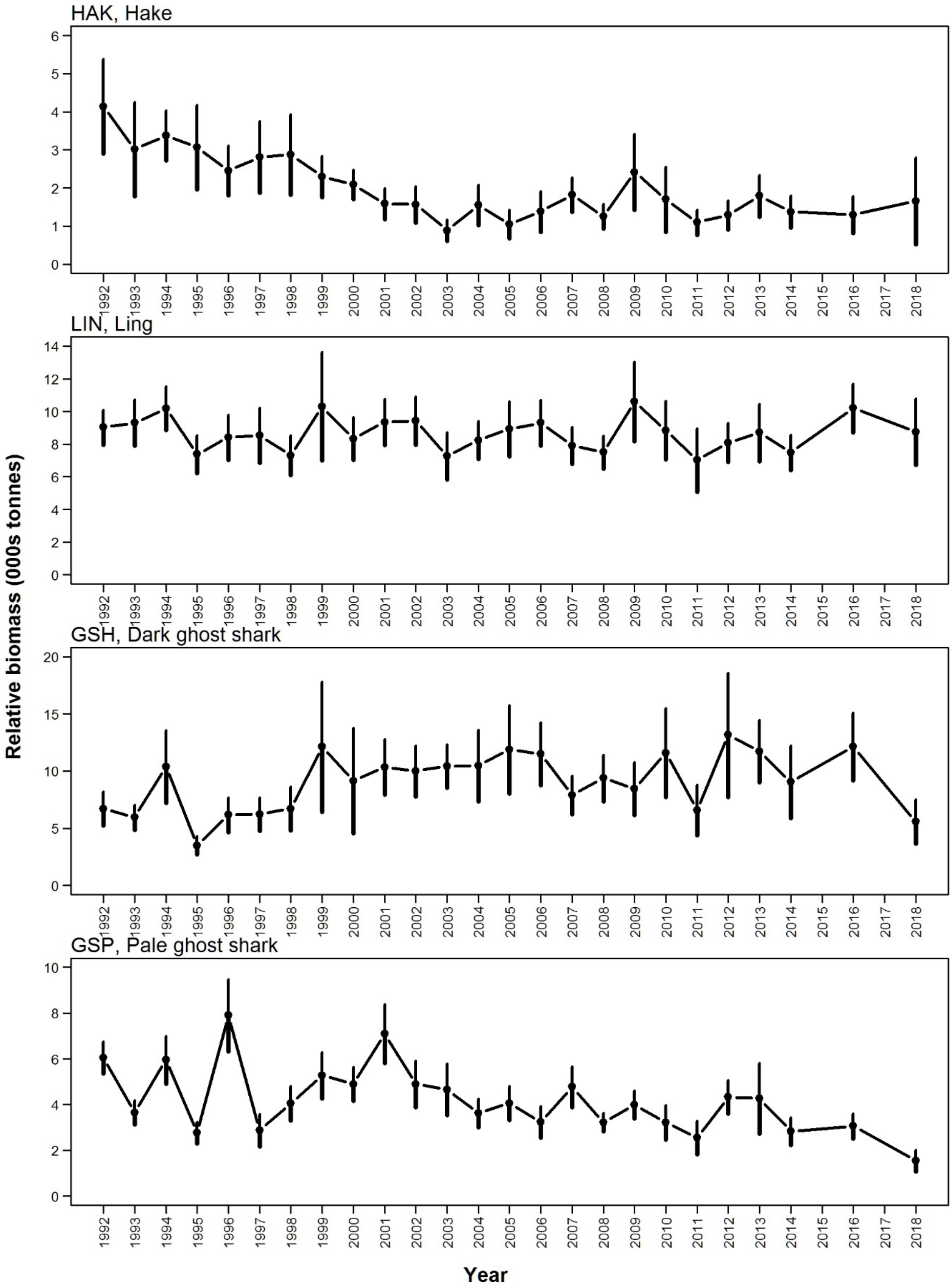


Figure 6a (continued)

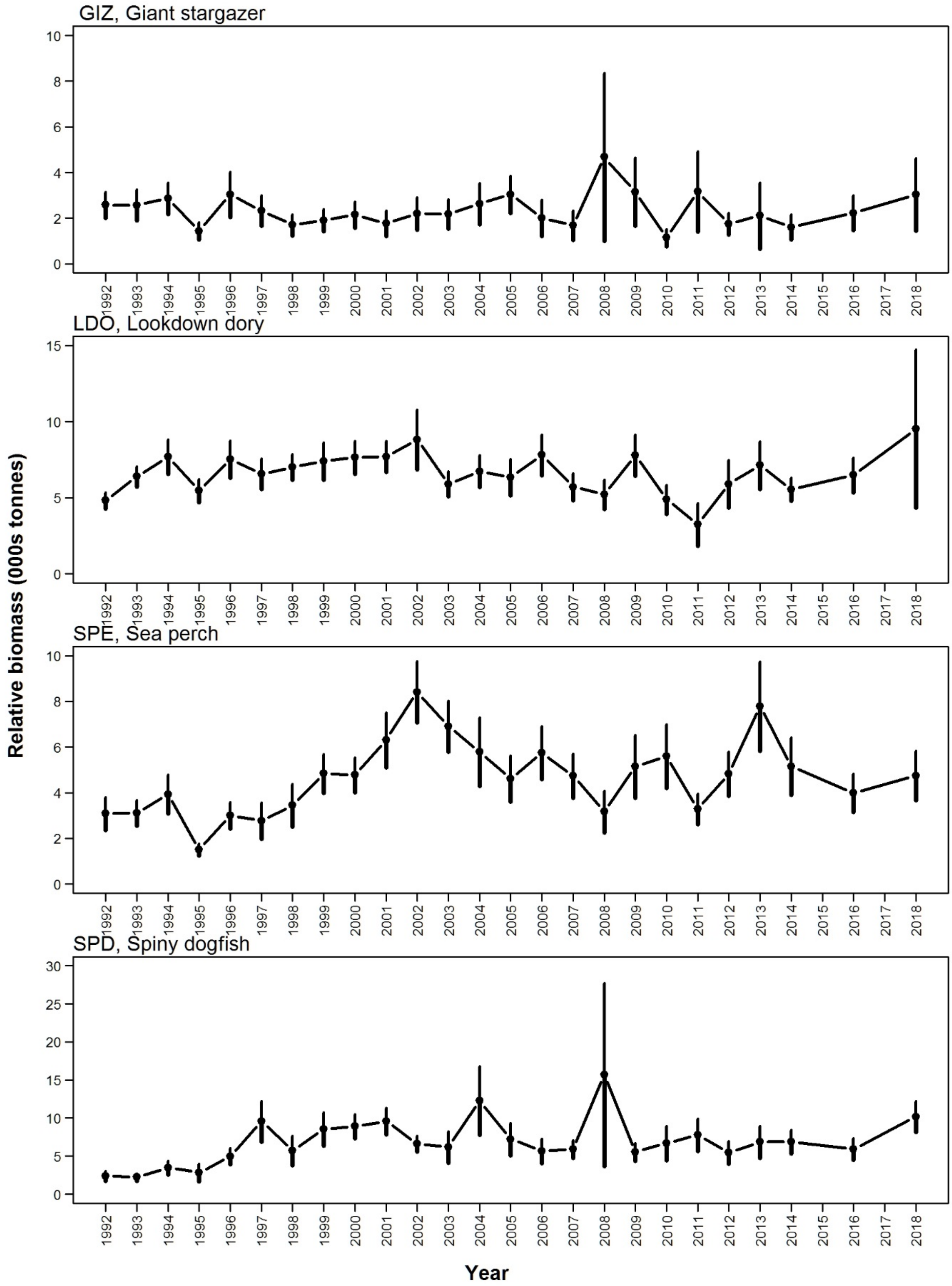


Figure 6a (continued)

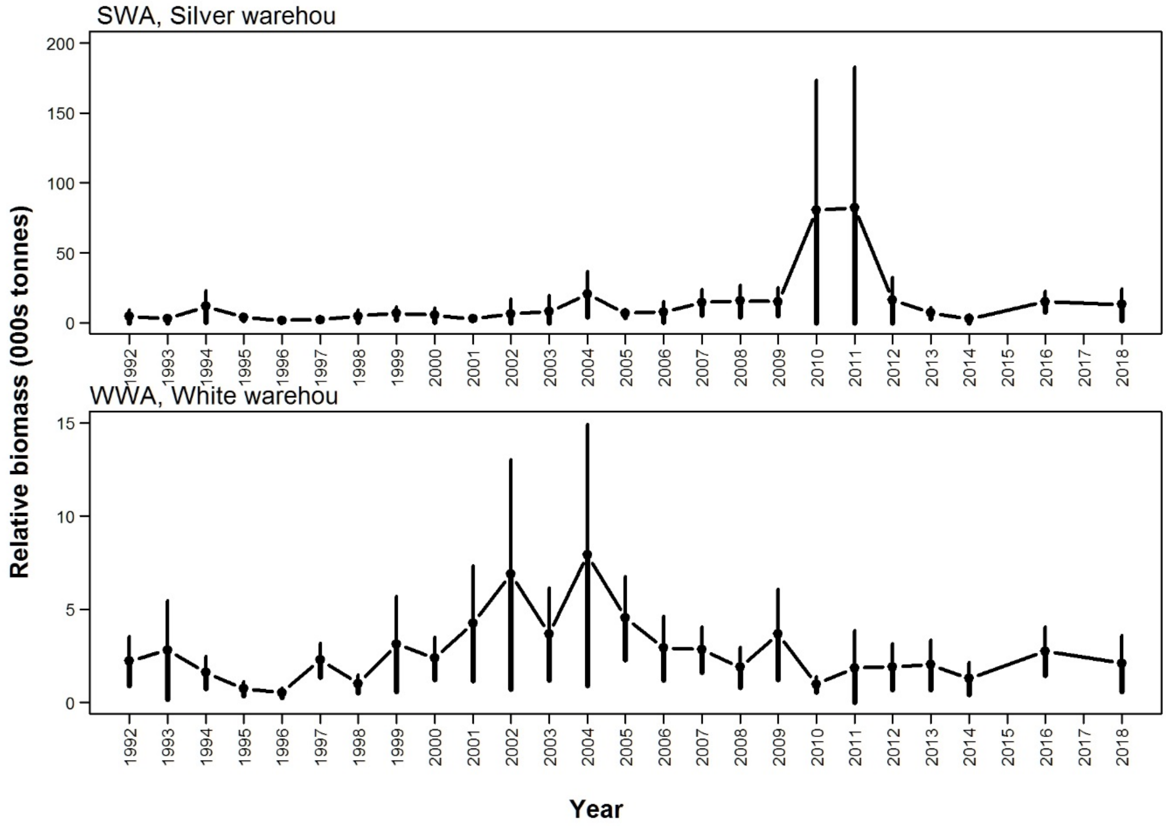


Figure 6a (continued)

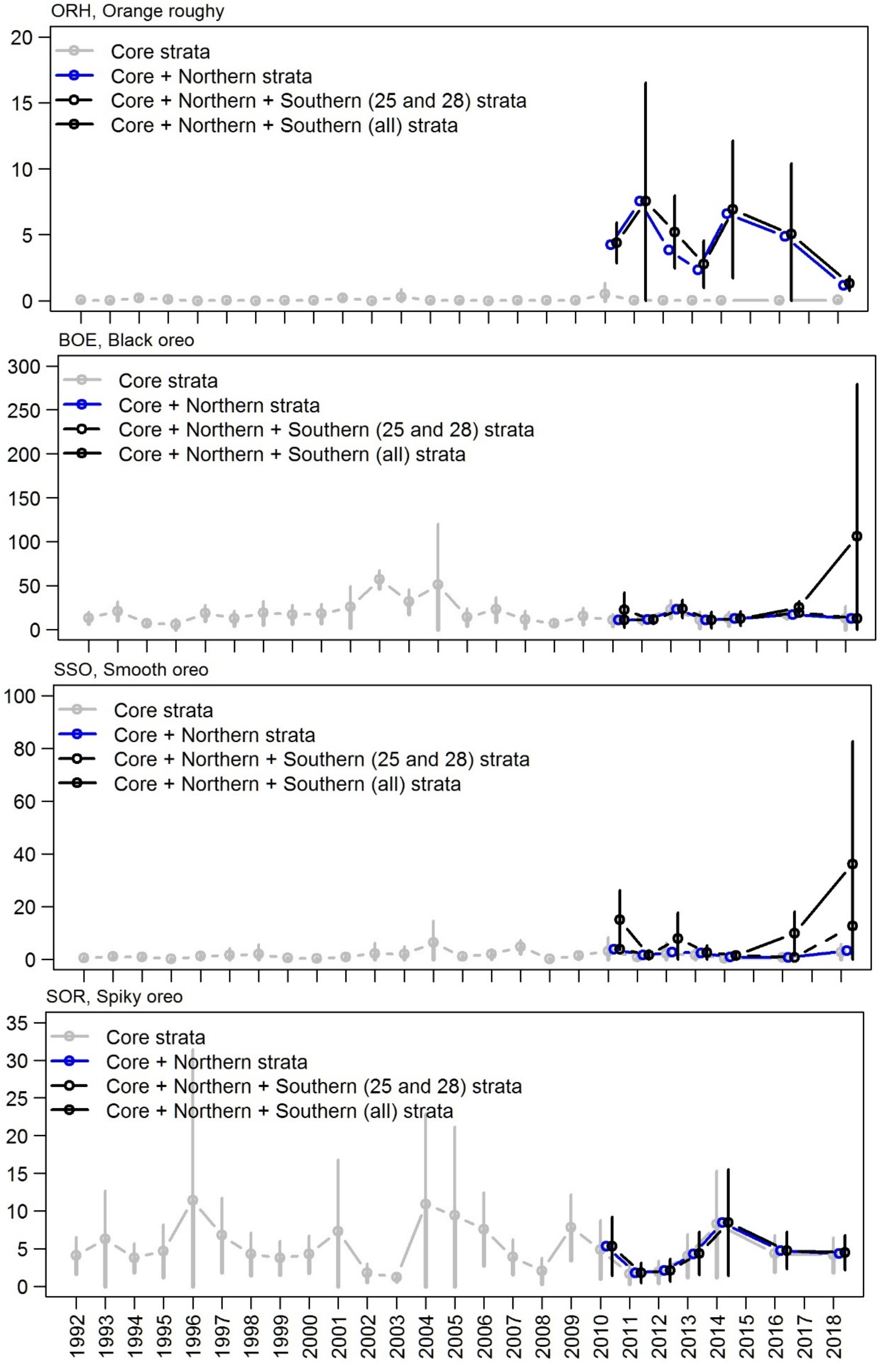


Figure 6b: Relative biomass estimates (thousands of tonnes) of orange roughy, black oreo, smooth oreo, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, and 2018. Grey lines show fish from core (200–800 m) strata. Blue lines show fish from core strata plus the northern deep (800–1300 m) strata. Black solid lines show fish from core strata plus the northern and southern deep (800–1300 m) strata, and black dashed lines show fish from core strata plus the northern and southern 25 and 28 deep strata (800–1300 m). Error bars show ± 2 standard errors.

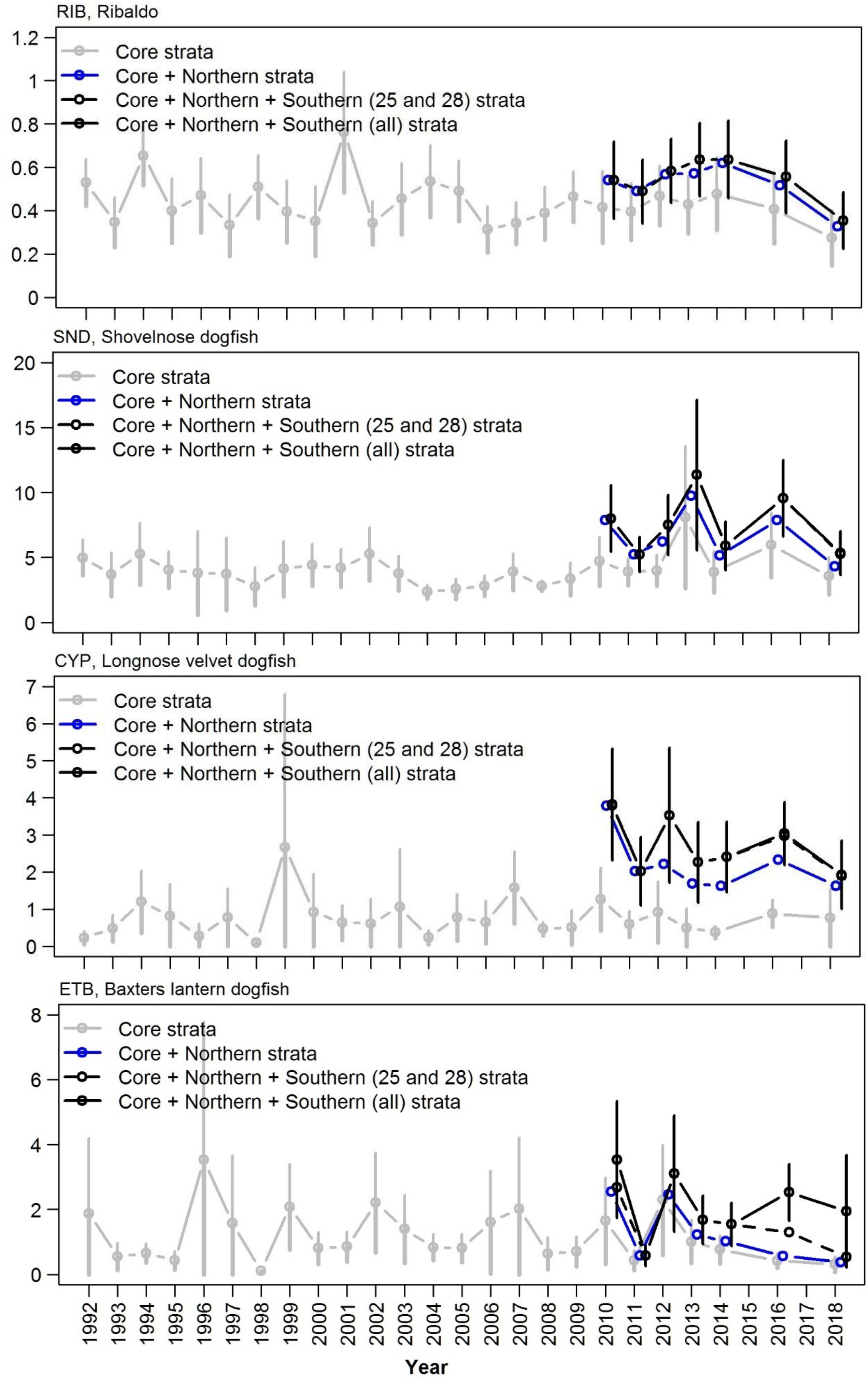


Figure 6b (continued)

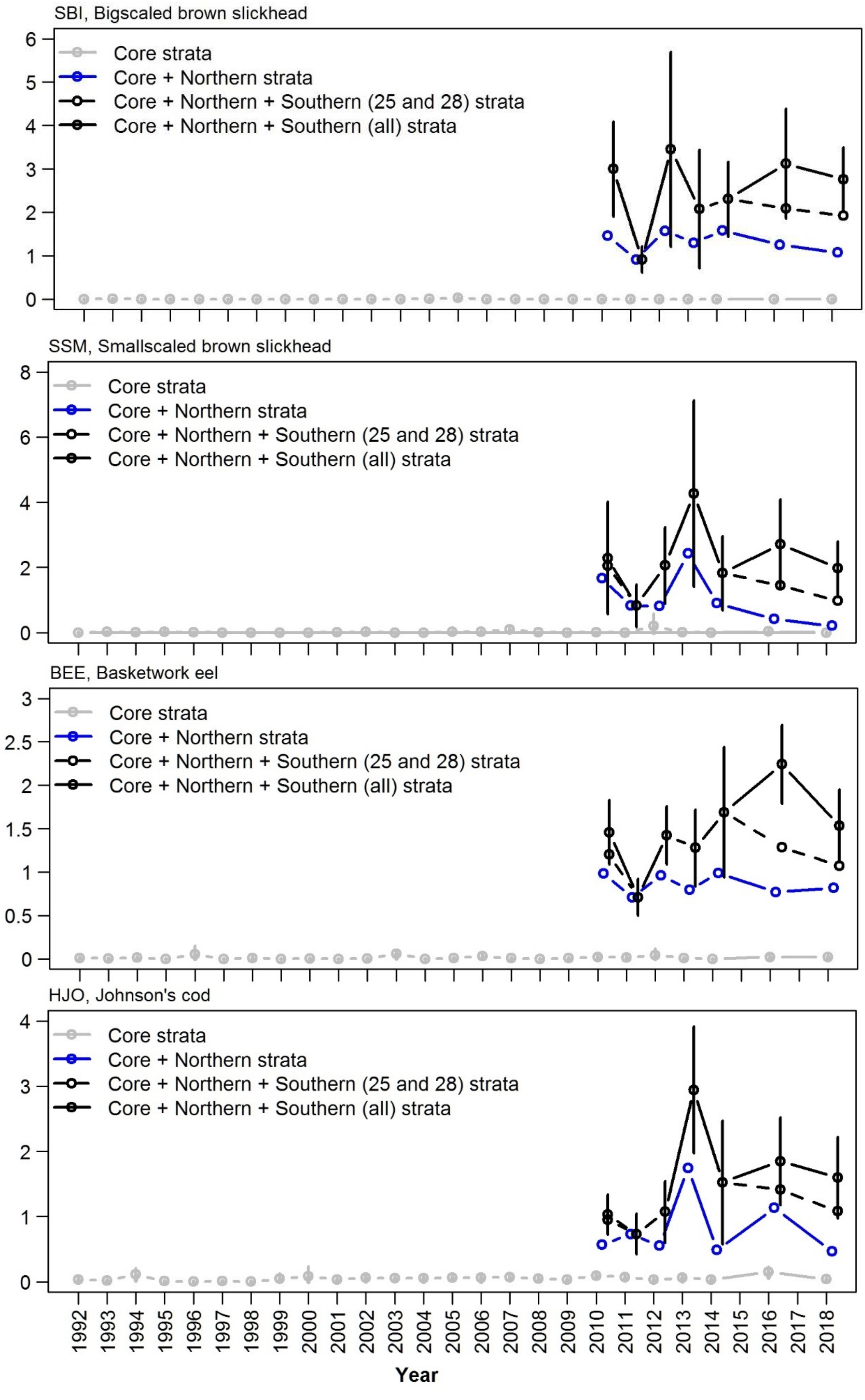


Figure 6b (continued)

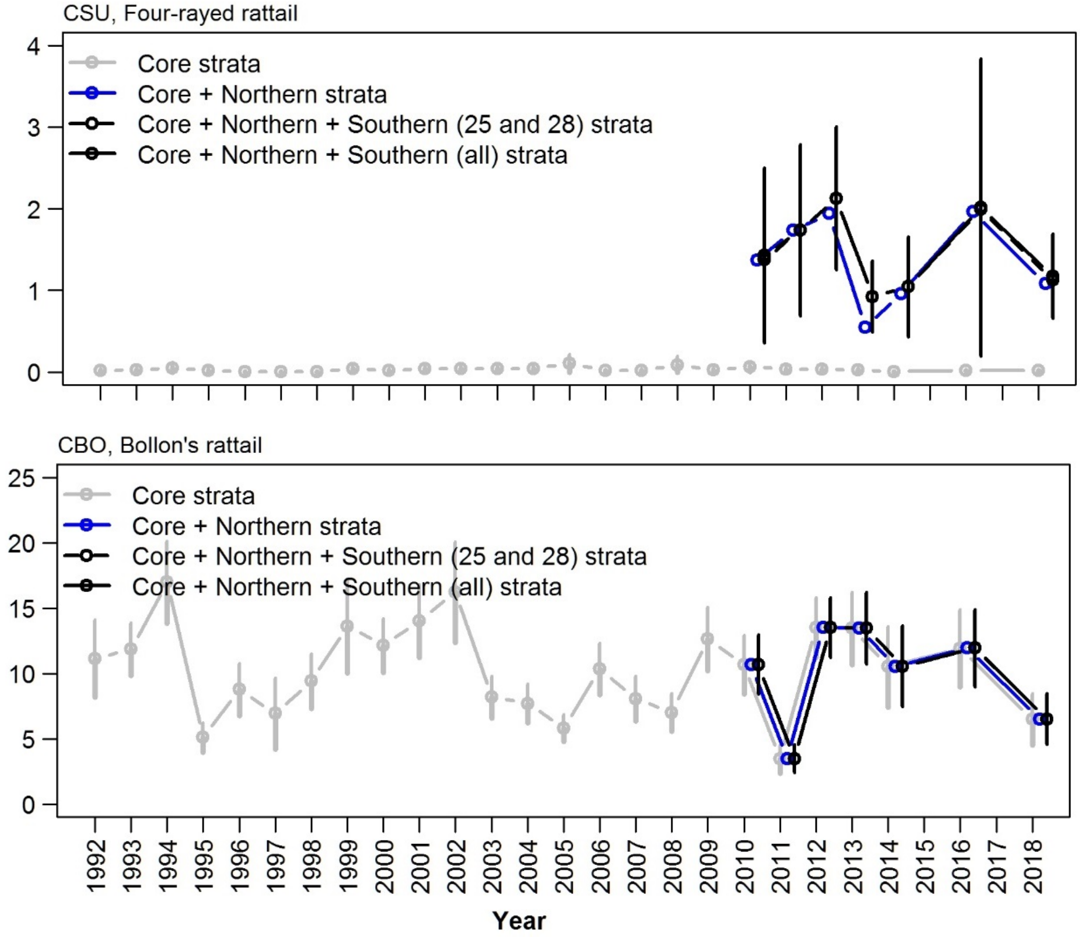


Figure 6b (continued)

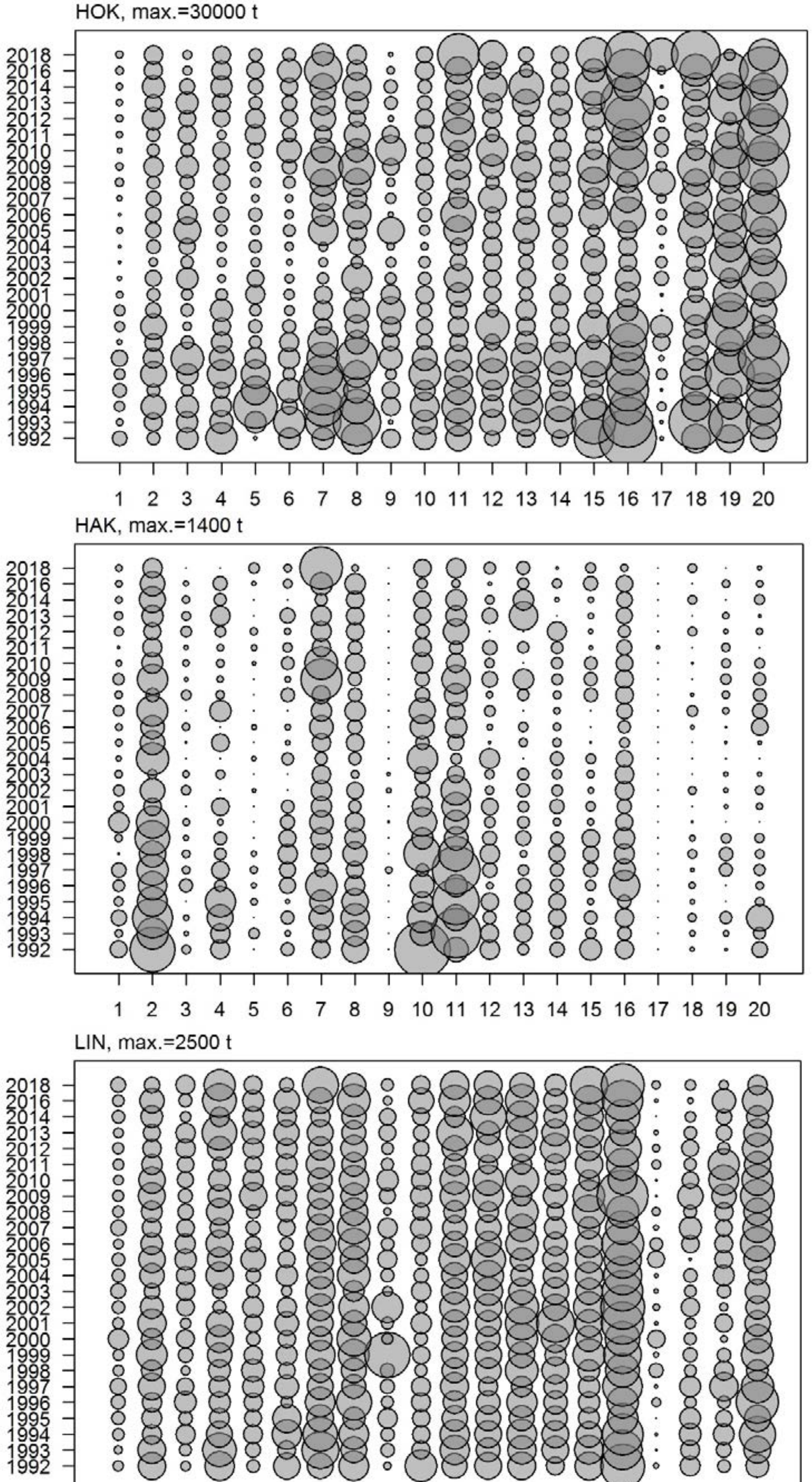


Figure 7a: Relative core (200–800 m) biomass estimates by stratum (1–20, x-axis) for hoki, and 8 other selected species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, and 2018.

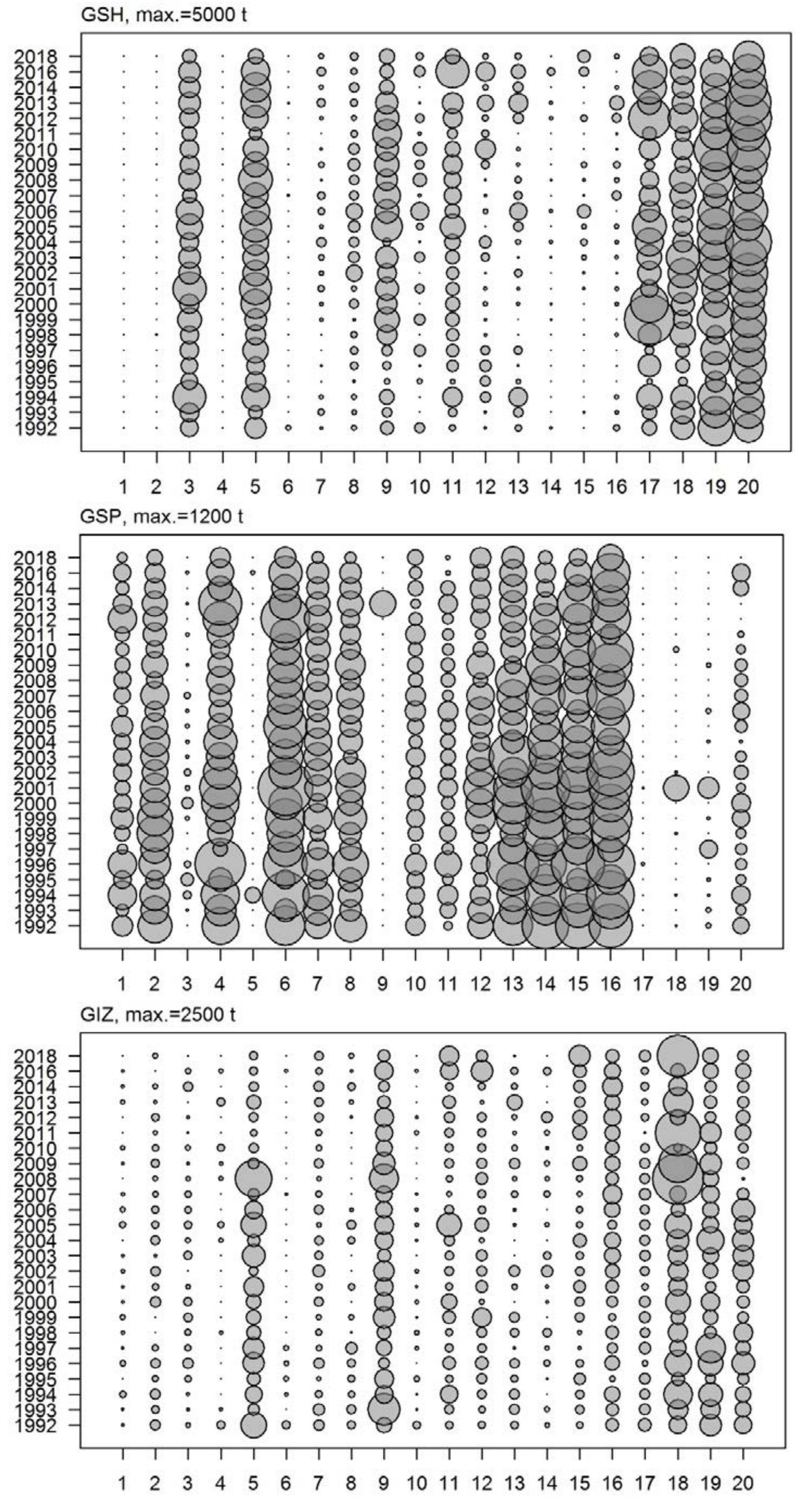


Figure 7a (continued)

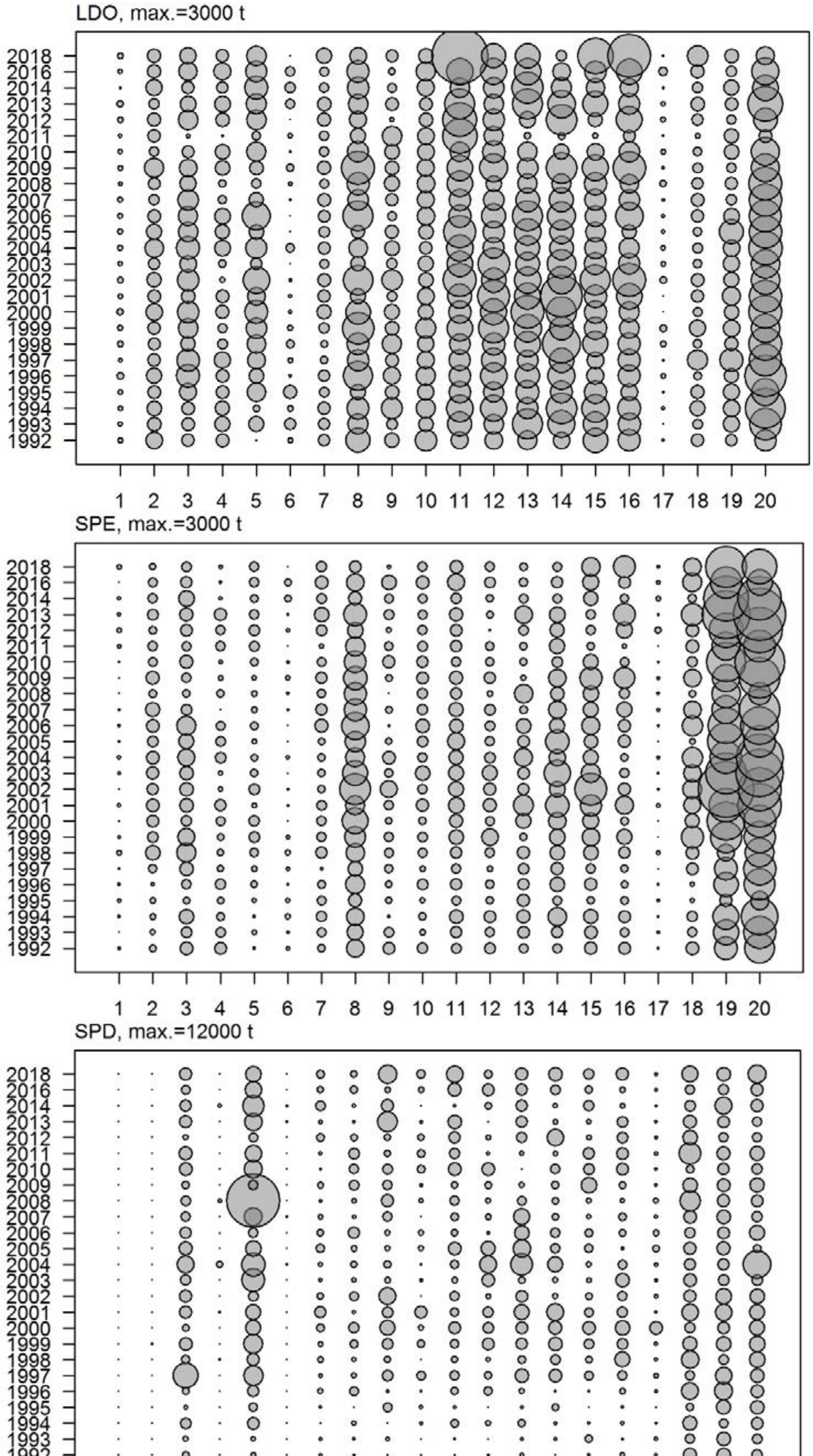
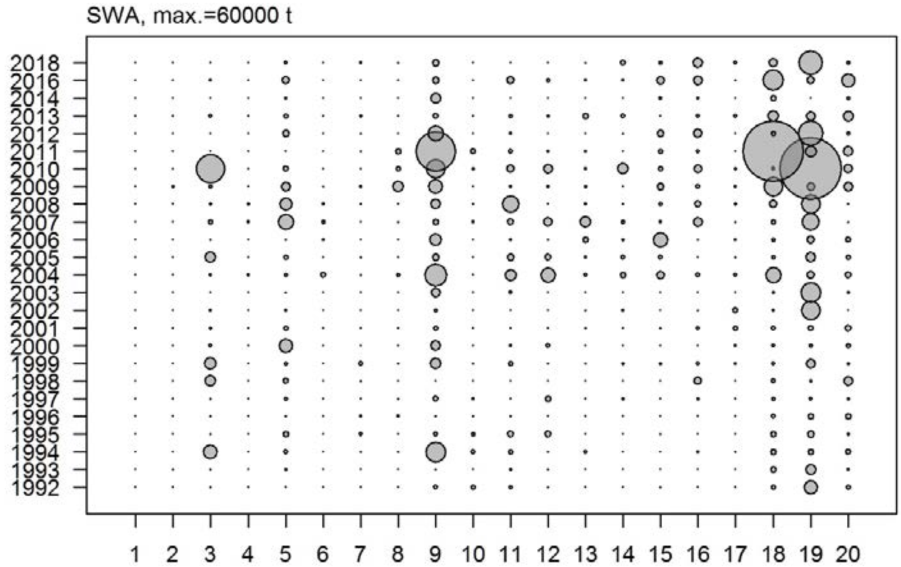


Figure 7a (continued)



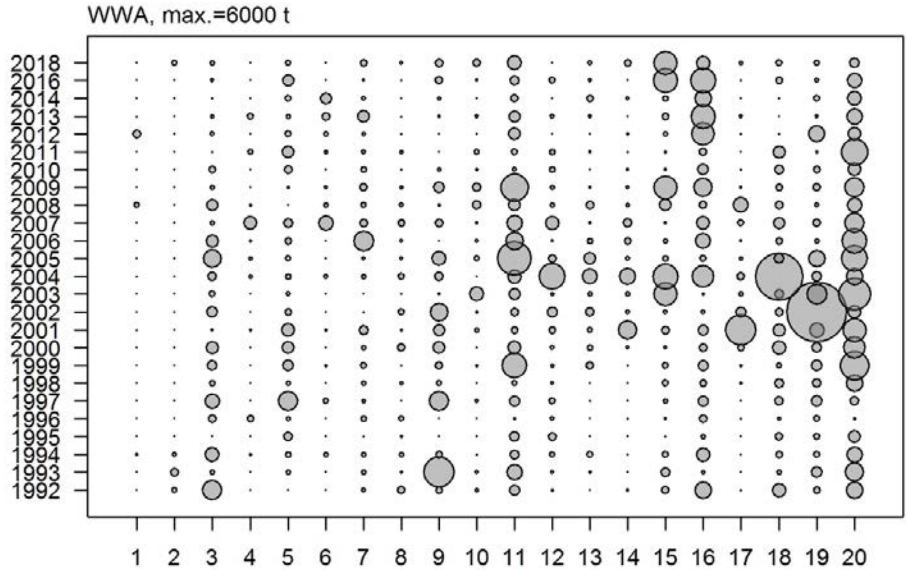


Figure 7a (continued)

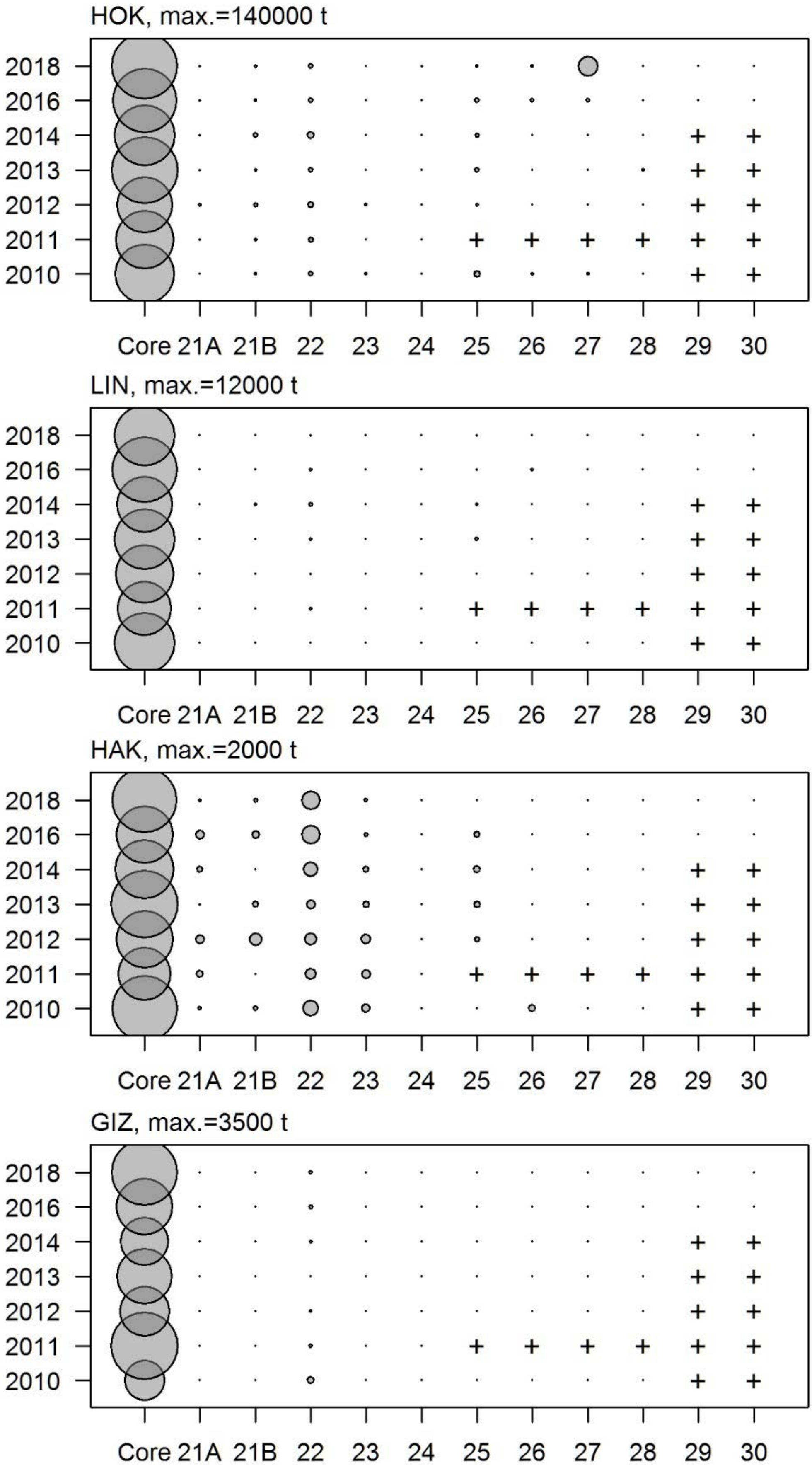


Figure 7b: Total core and deep (800–1300 m) relative biomass estimates by stratum for hoki and 8 other selected species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, and 2016. Cross indicates stratum not sampled. Cross indicates stratum not sampled.

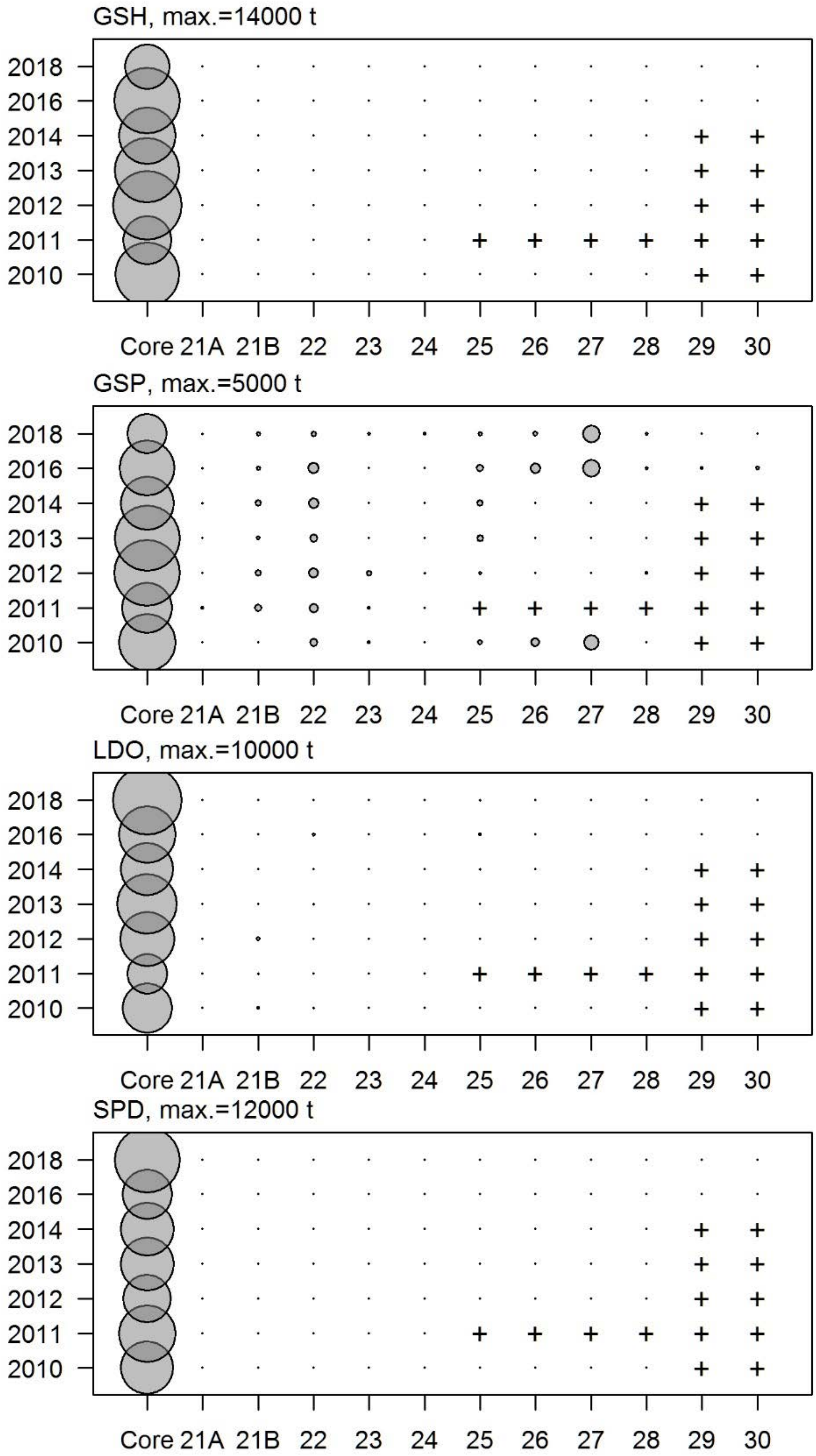


Figure 7b (continued)

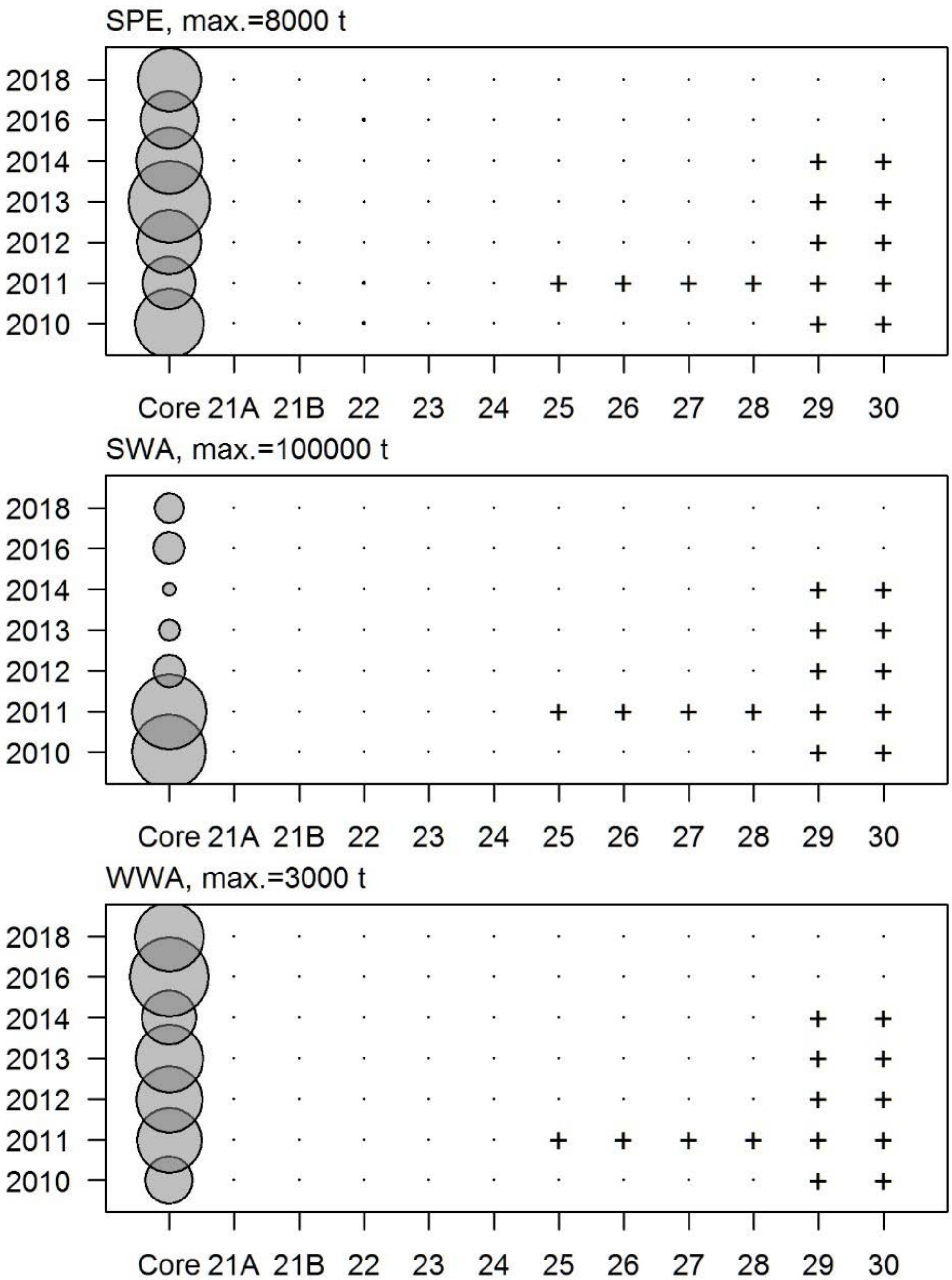


Figure 7b (continued)

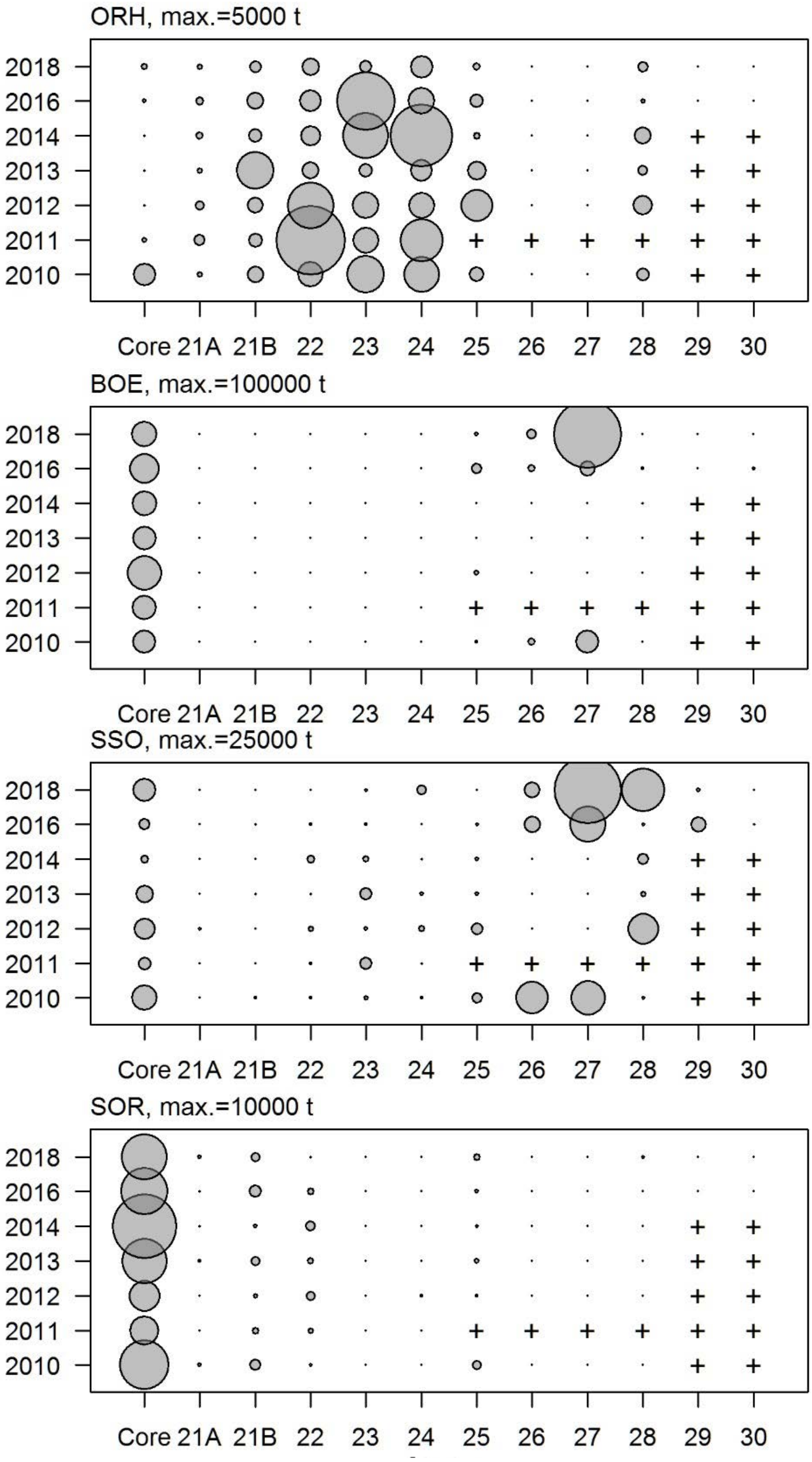


Figure 7c: Relative deep (800–1300 m) biomass estimates by strata for orange roughy, oreo species, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, 2016, and 2018. Cross indicates stratum not sampled.

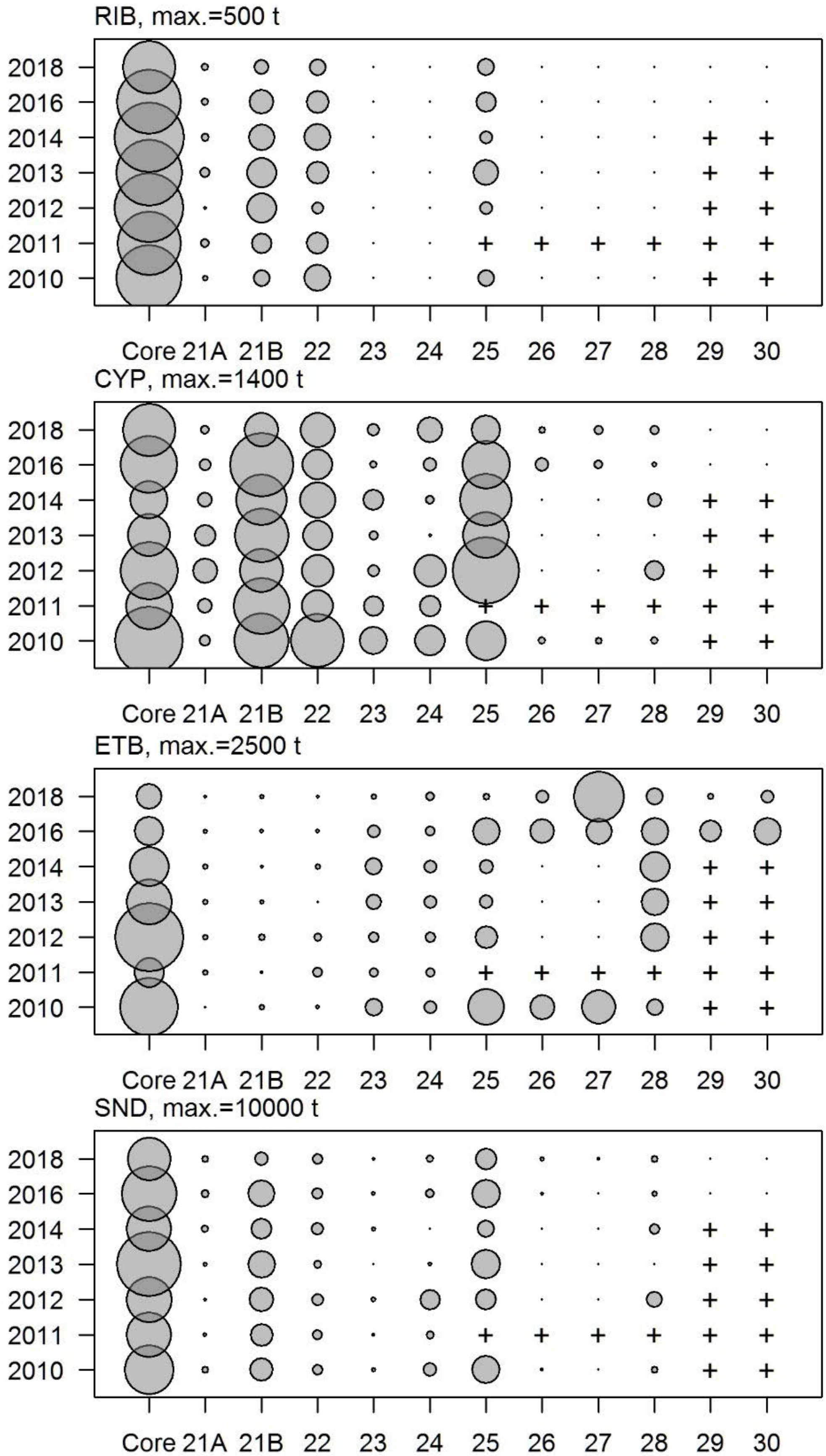


Figure 7c (continued)

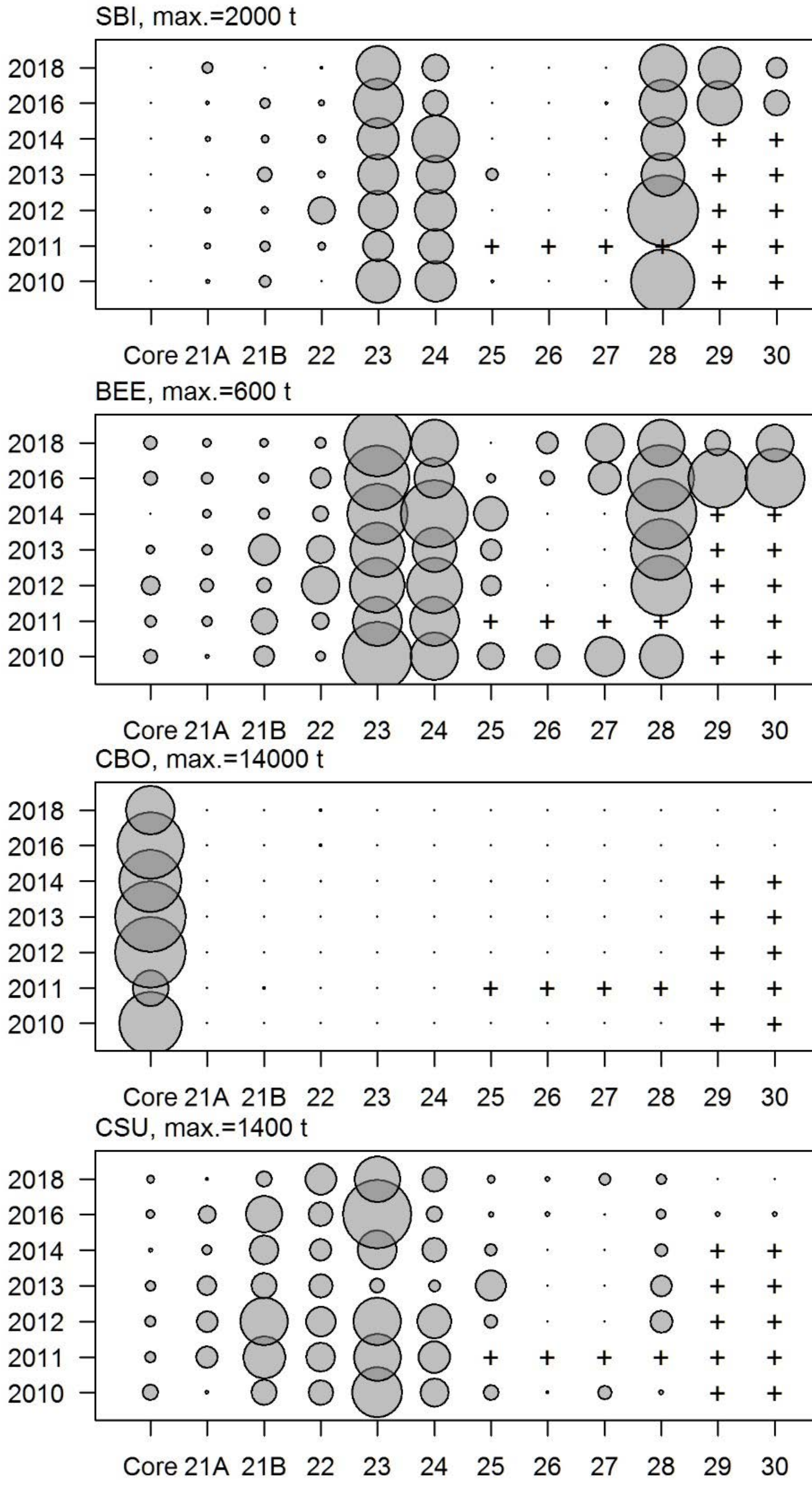


Figure 7c (continued)

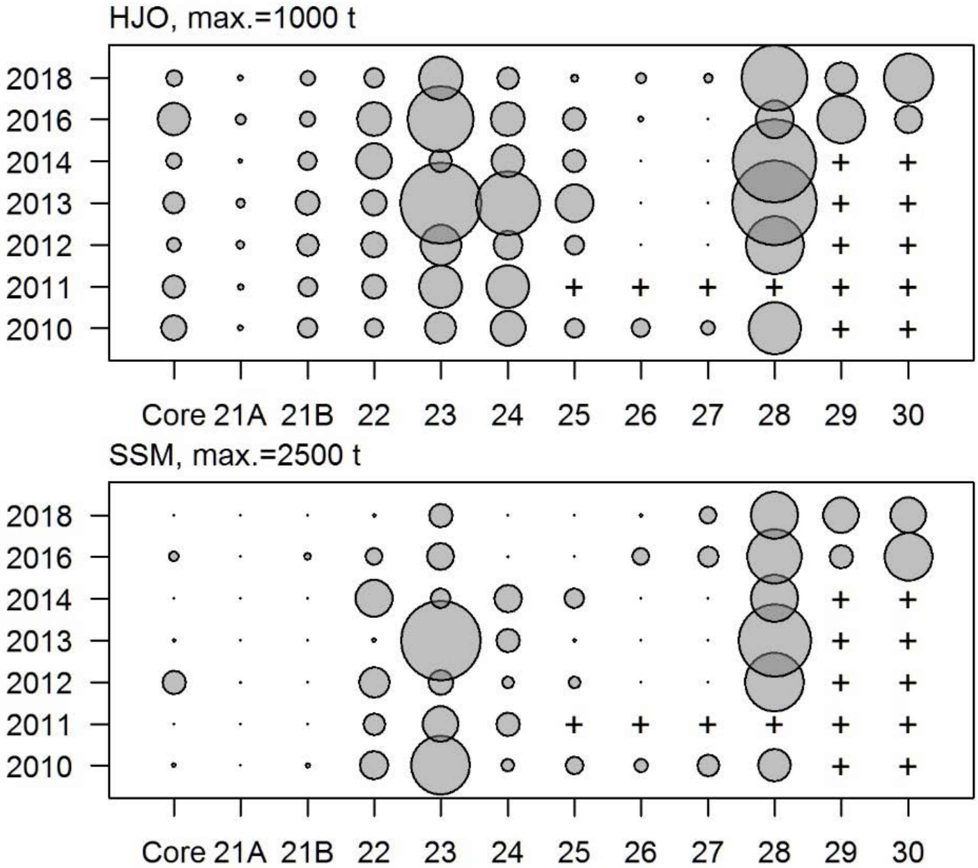


Figure 7c (continued)

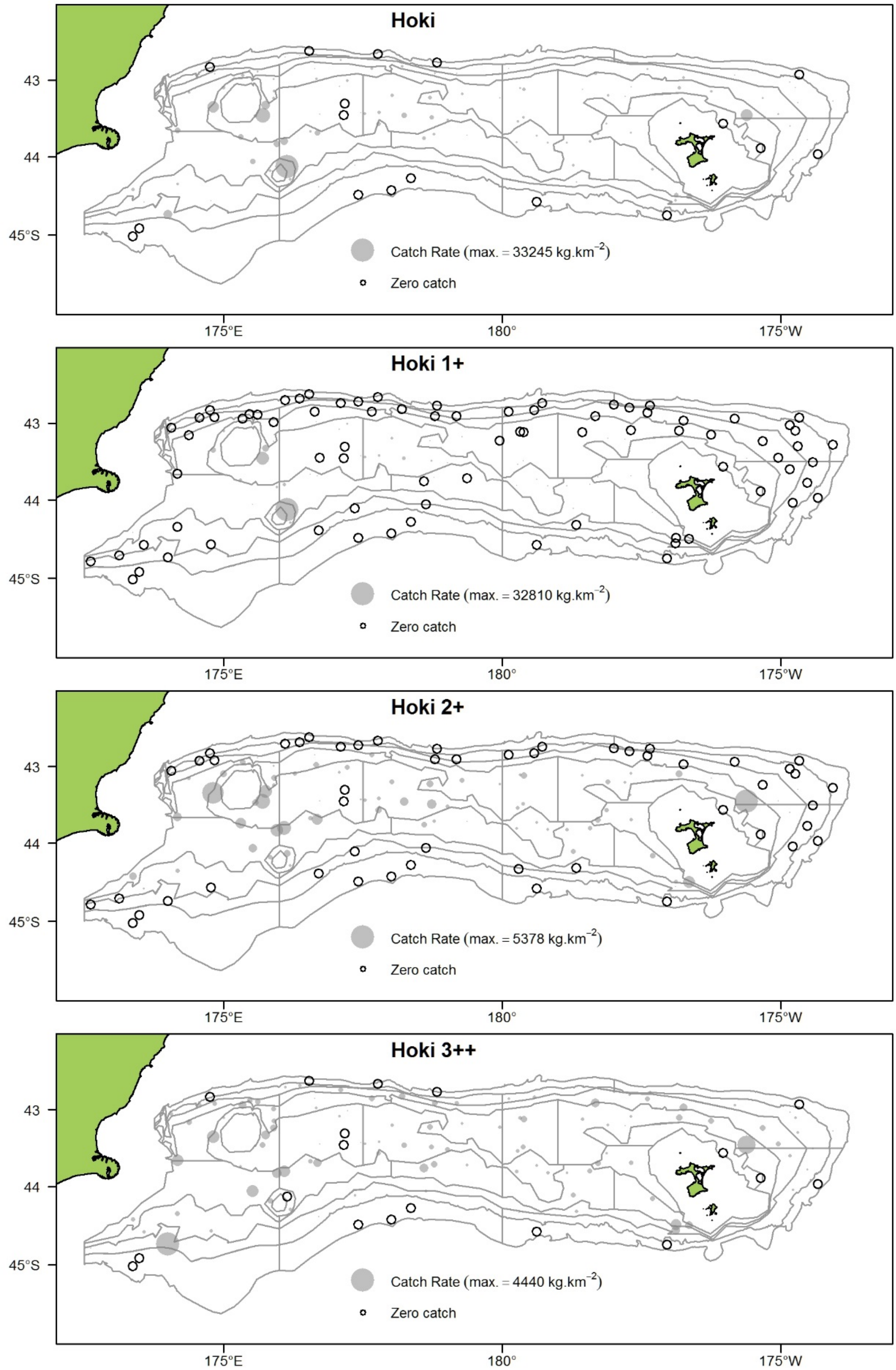


Figure 8: Hoki 1+, 2+, 3++ age class (year) and total catch distribution in 2018. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate (max.) is shown on each plot.

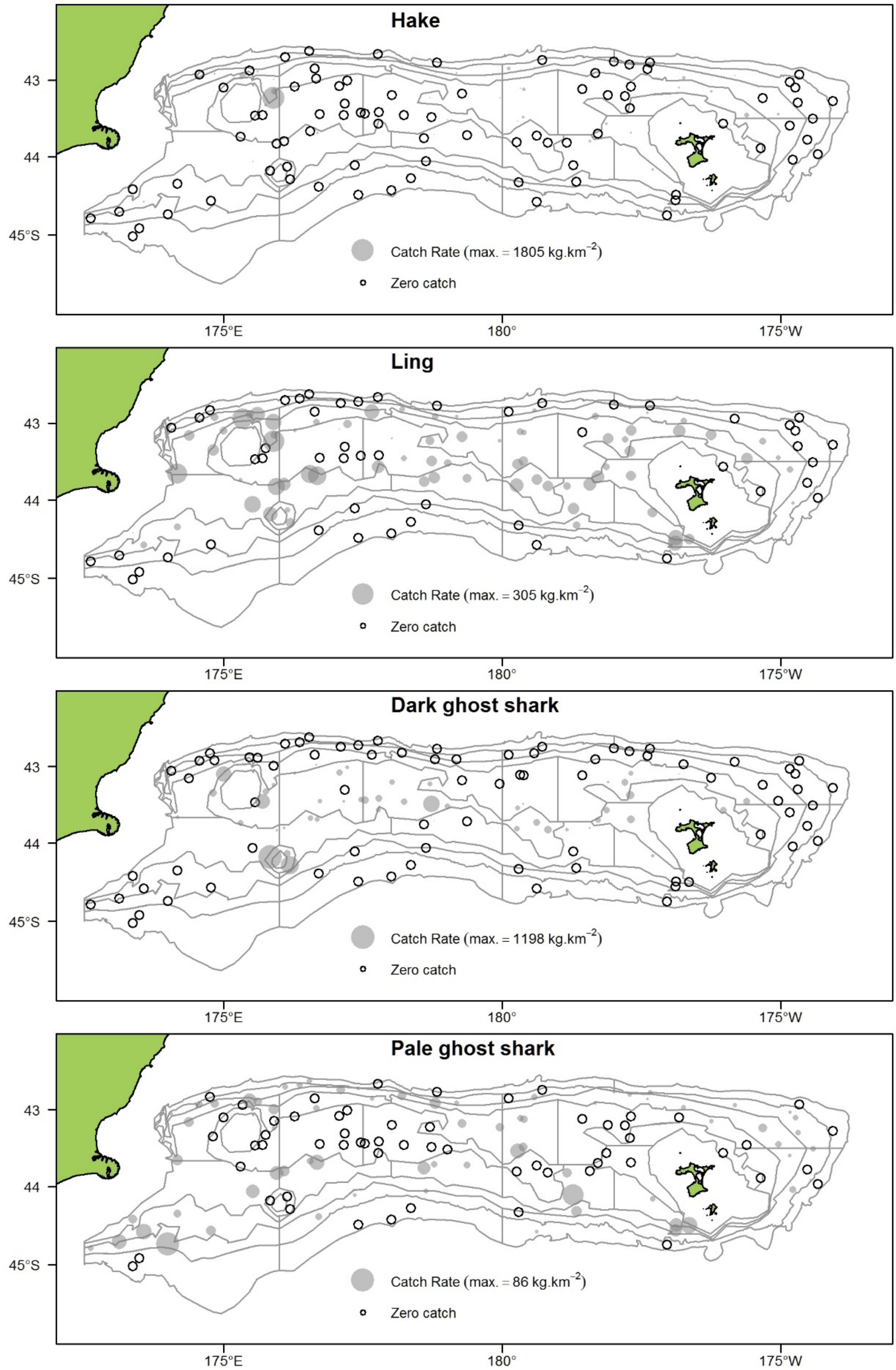


Figure 9: Catch rates (kg km^{-2}) of selected core and deepwater commercial and bycatch species in 2018. Filled circle area is proportional to catch rate. Open circles are zero catch. max., maximum catch rate.

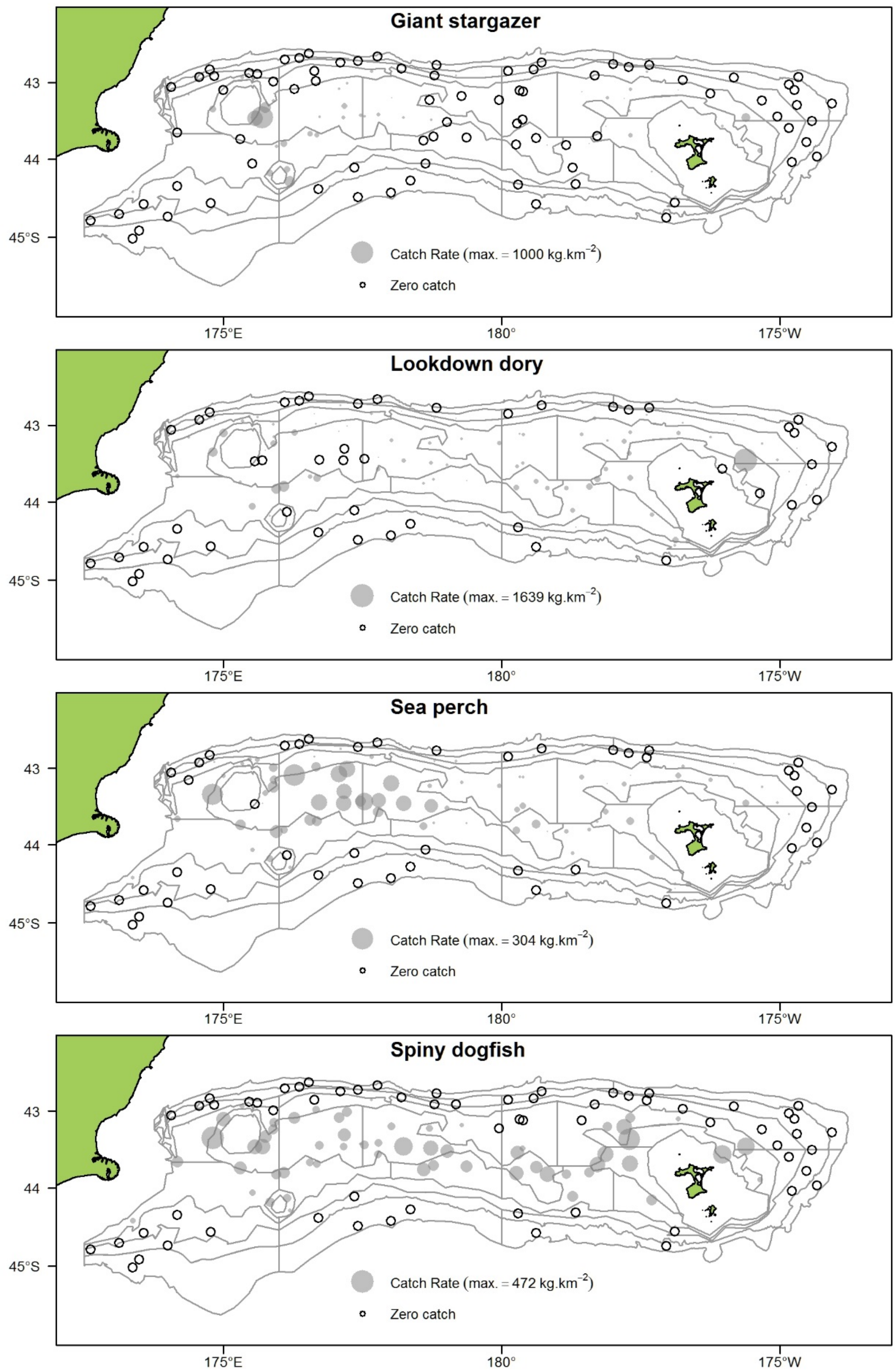


Figure 9 (continued)

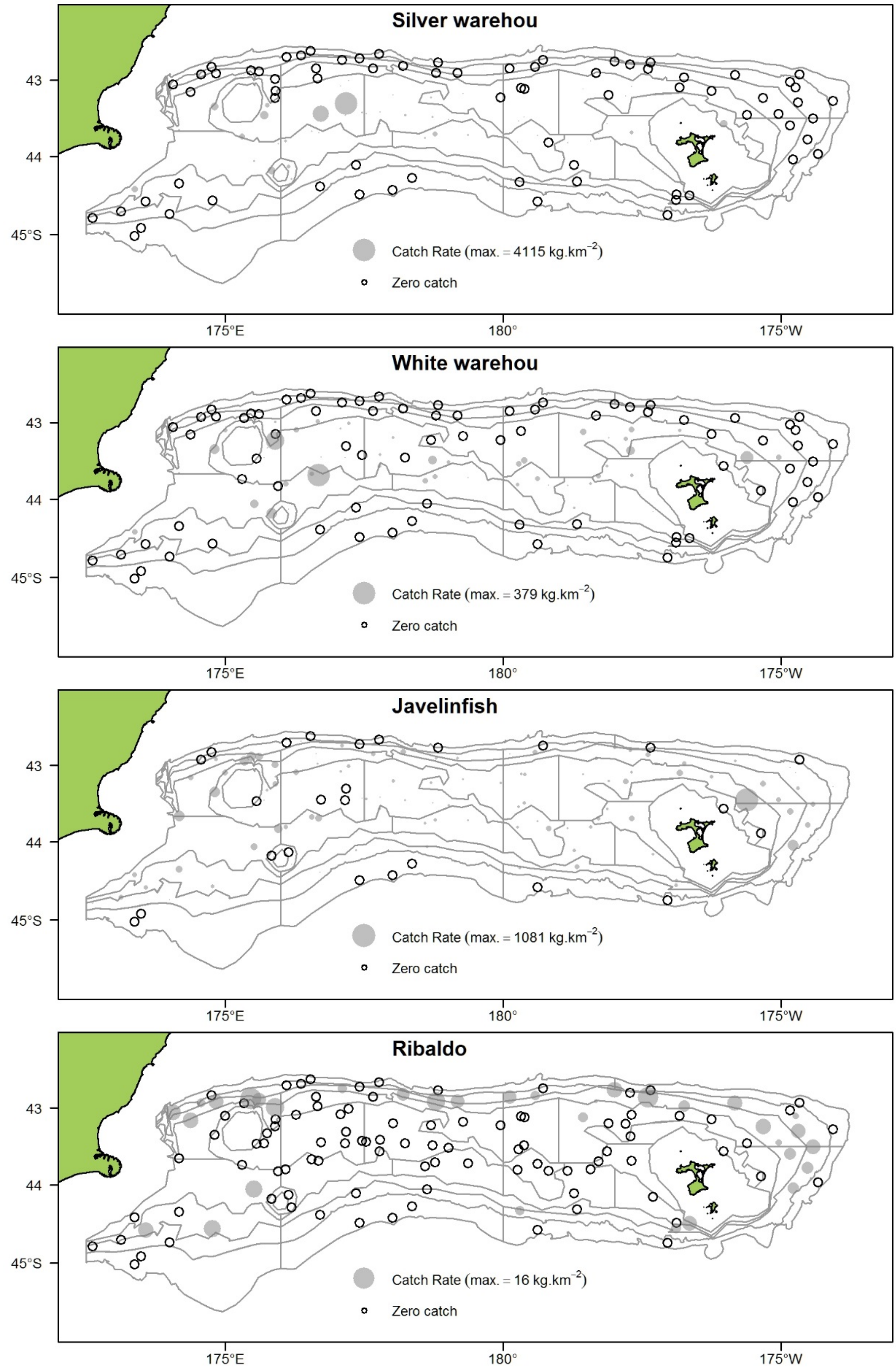


Figure 9 (continued)

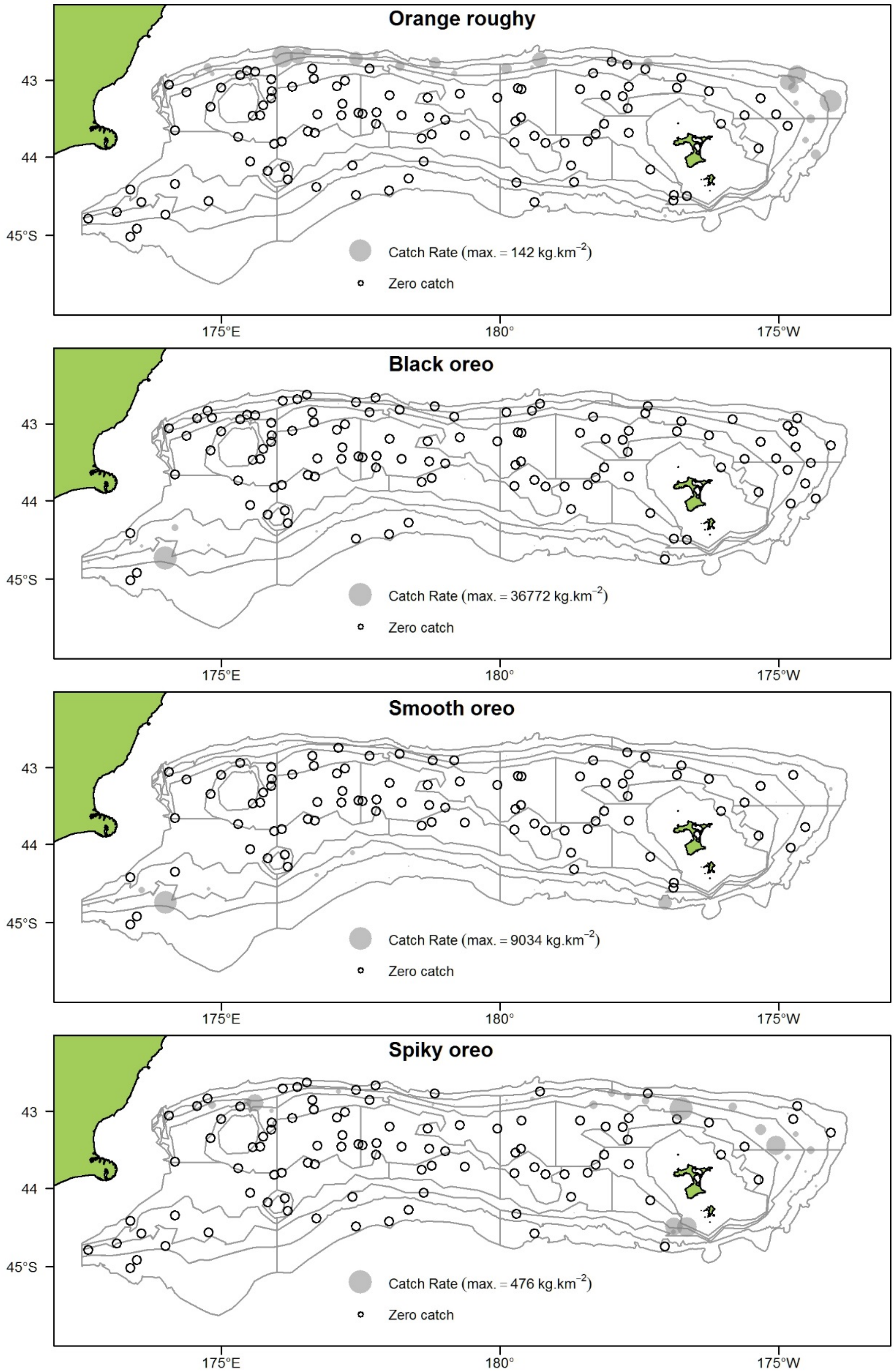


Figure 9 (continued)

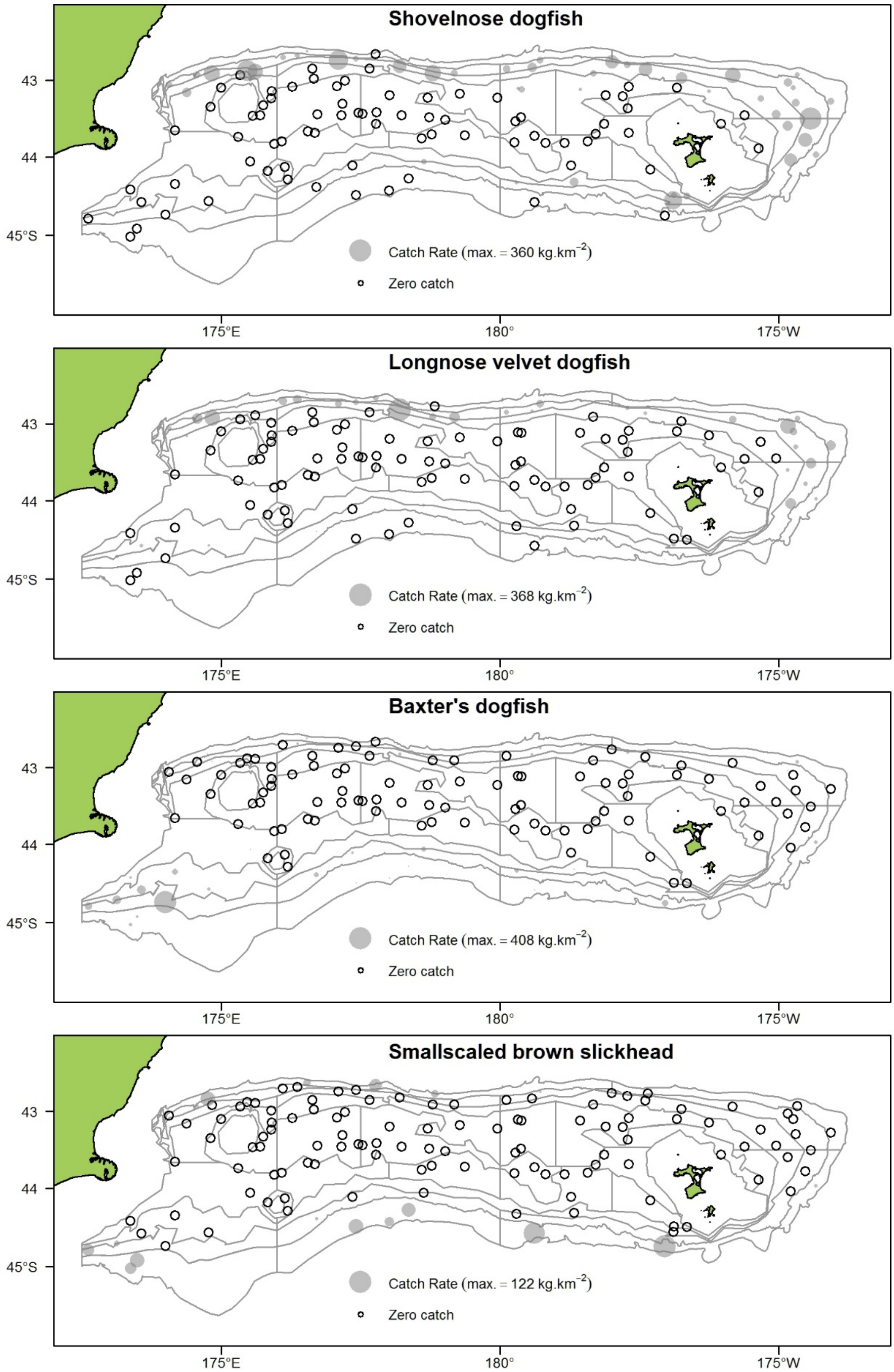


Figure 9 (continued)

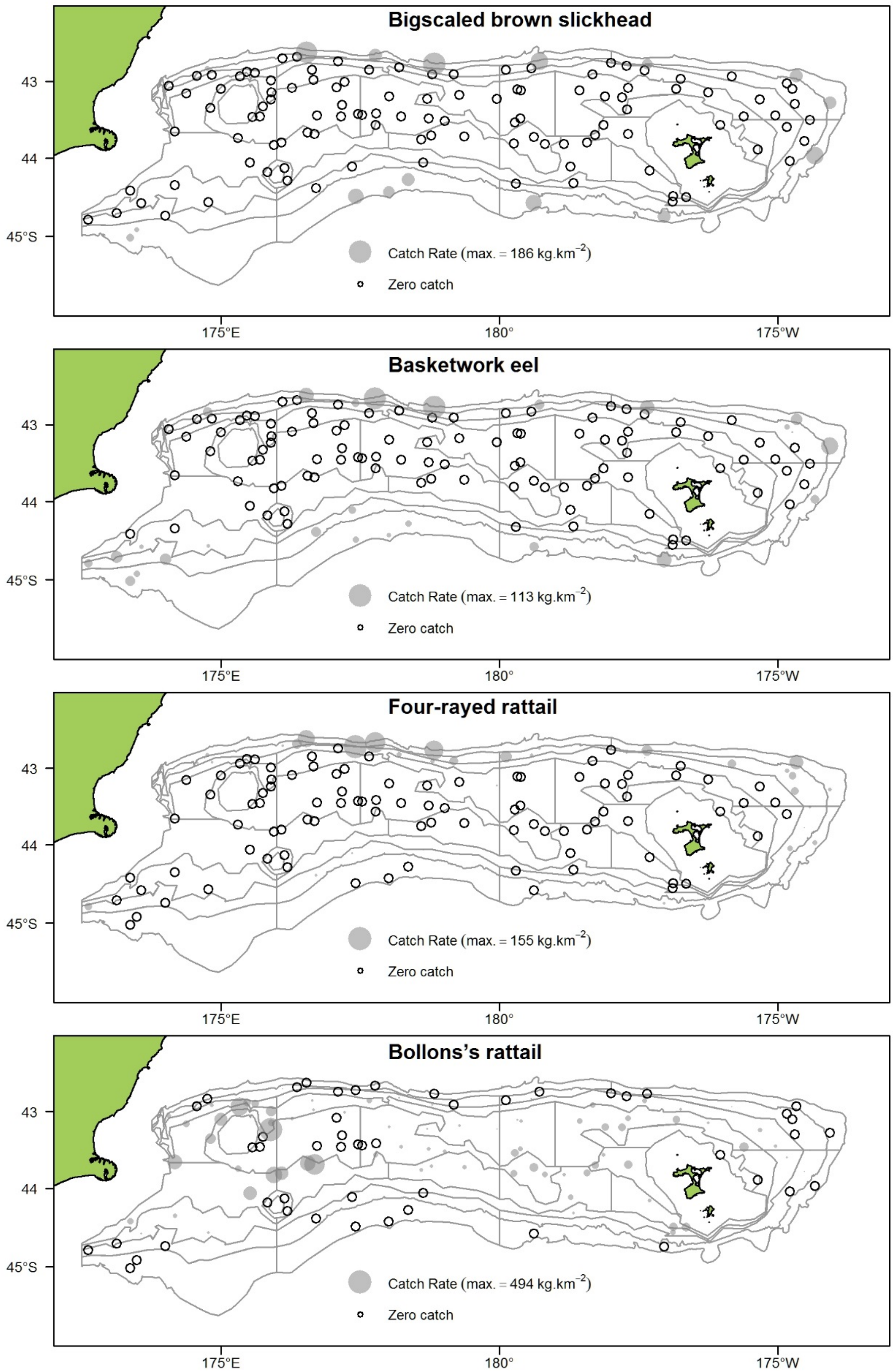


Figure 9 (continued)

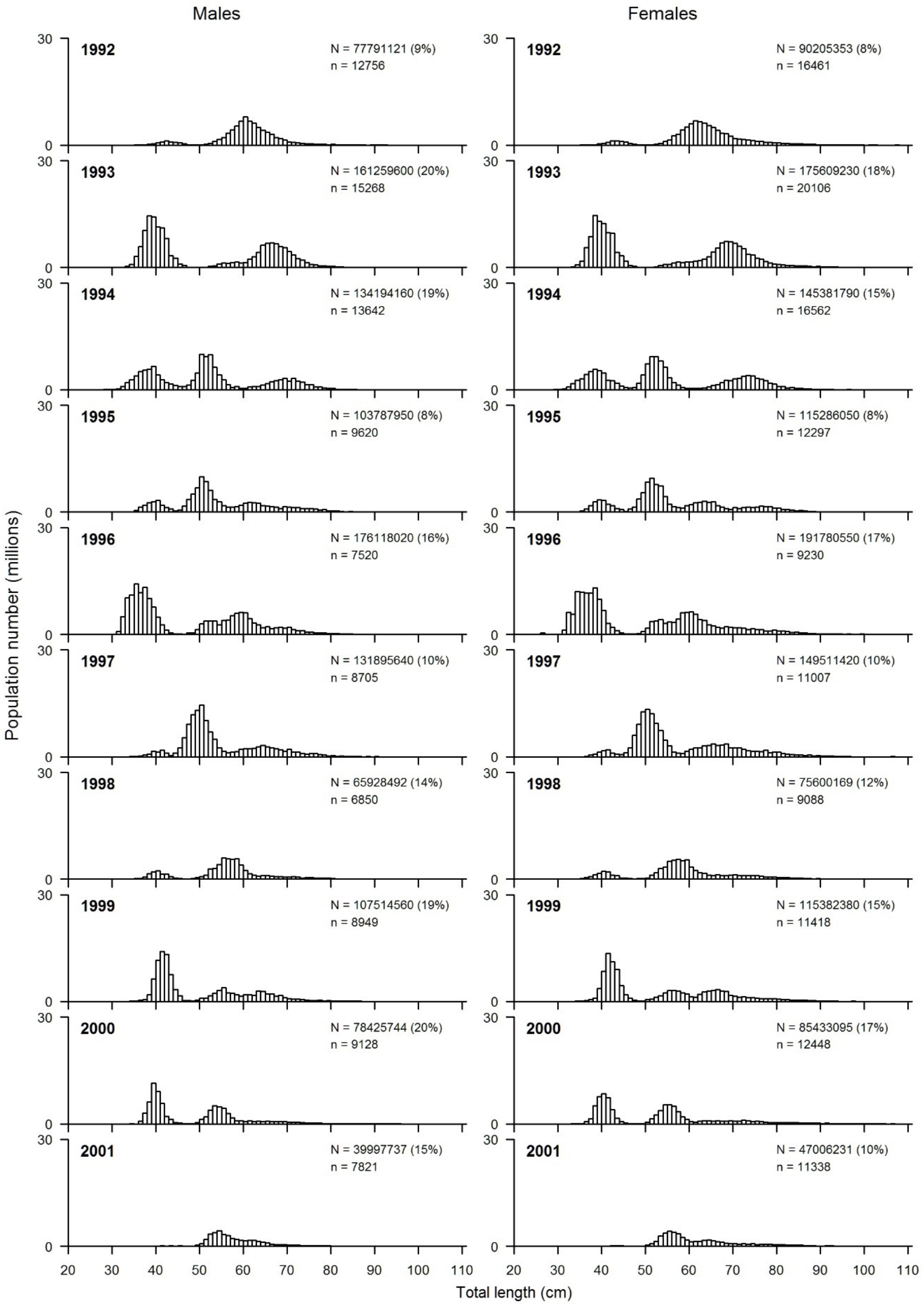


Figure 10: Estimated length frequency distributions of the male and female hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, and 2018 for core strata. N, estimated population number of male hoki (left panel) and female hoki (right panel); CV (in parentheses), coefficient of variation; n., numbers of fish measured.

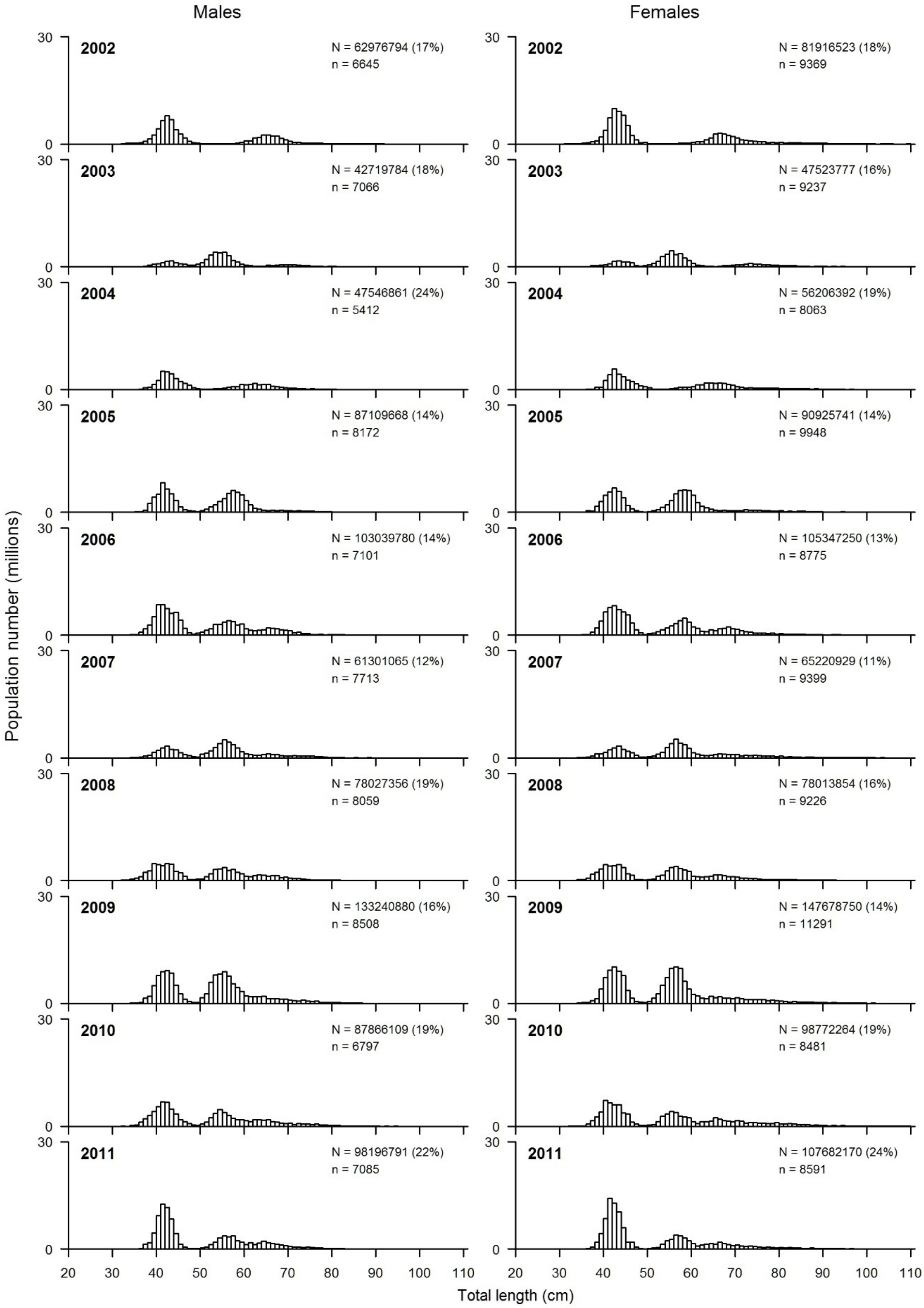


Figure 10 (continued)

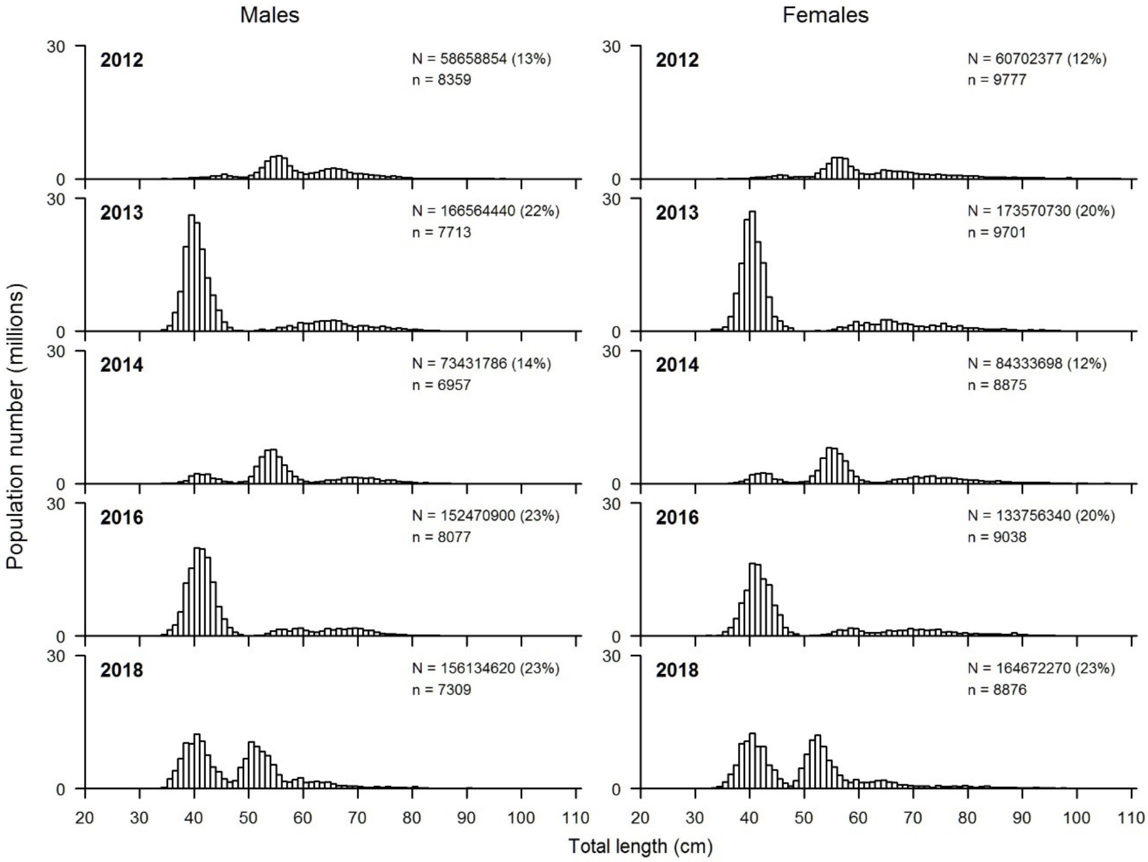


Figure 10 (continued)

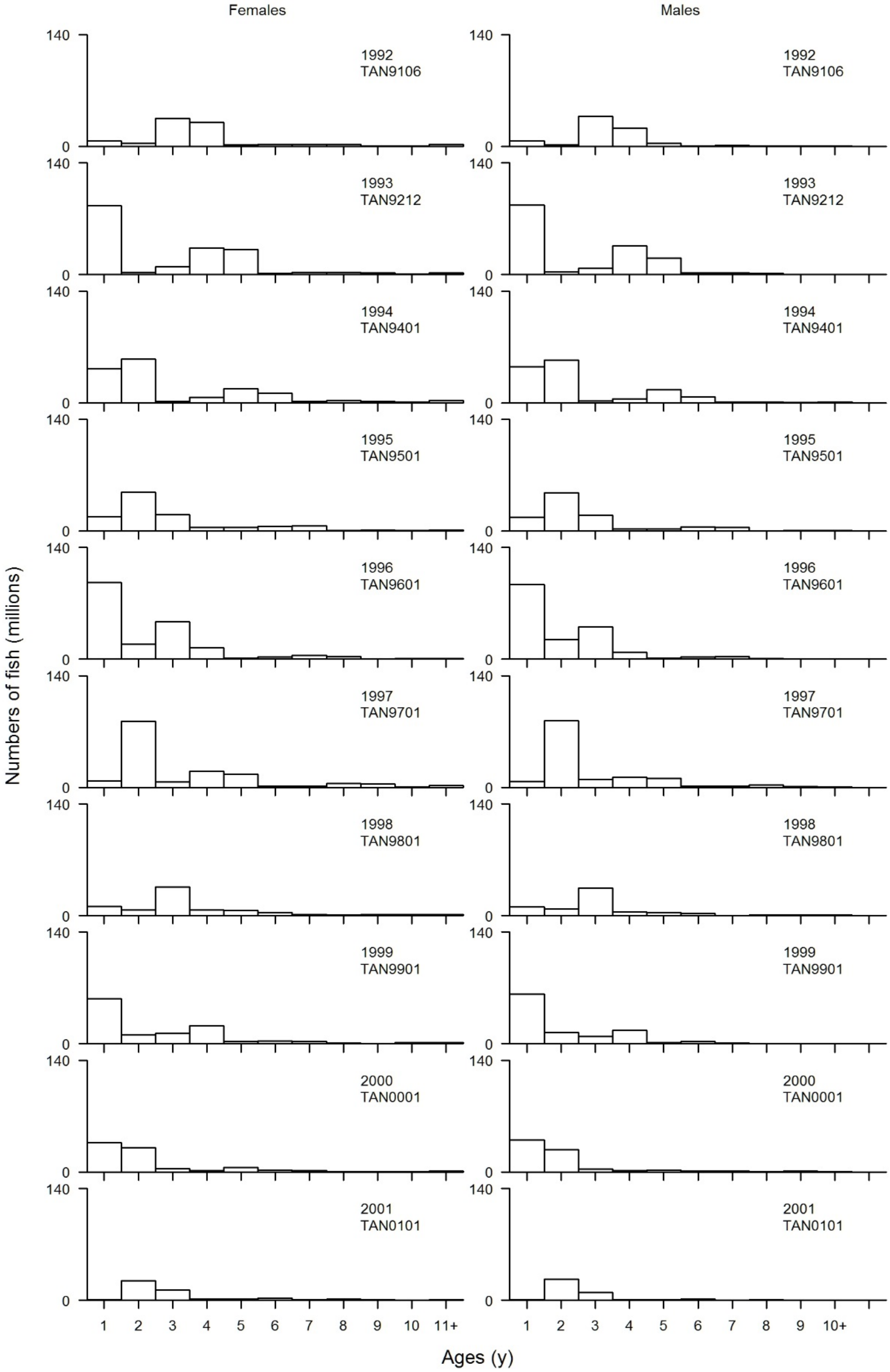


Figure 11: Estimated population numbers-at-age for hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, 2016, and 2018. +, indicates plus group of combined ages.

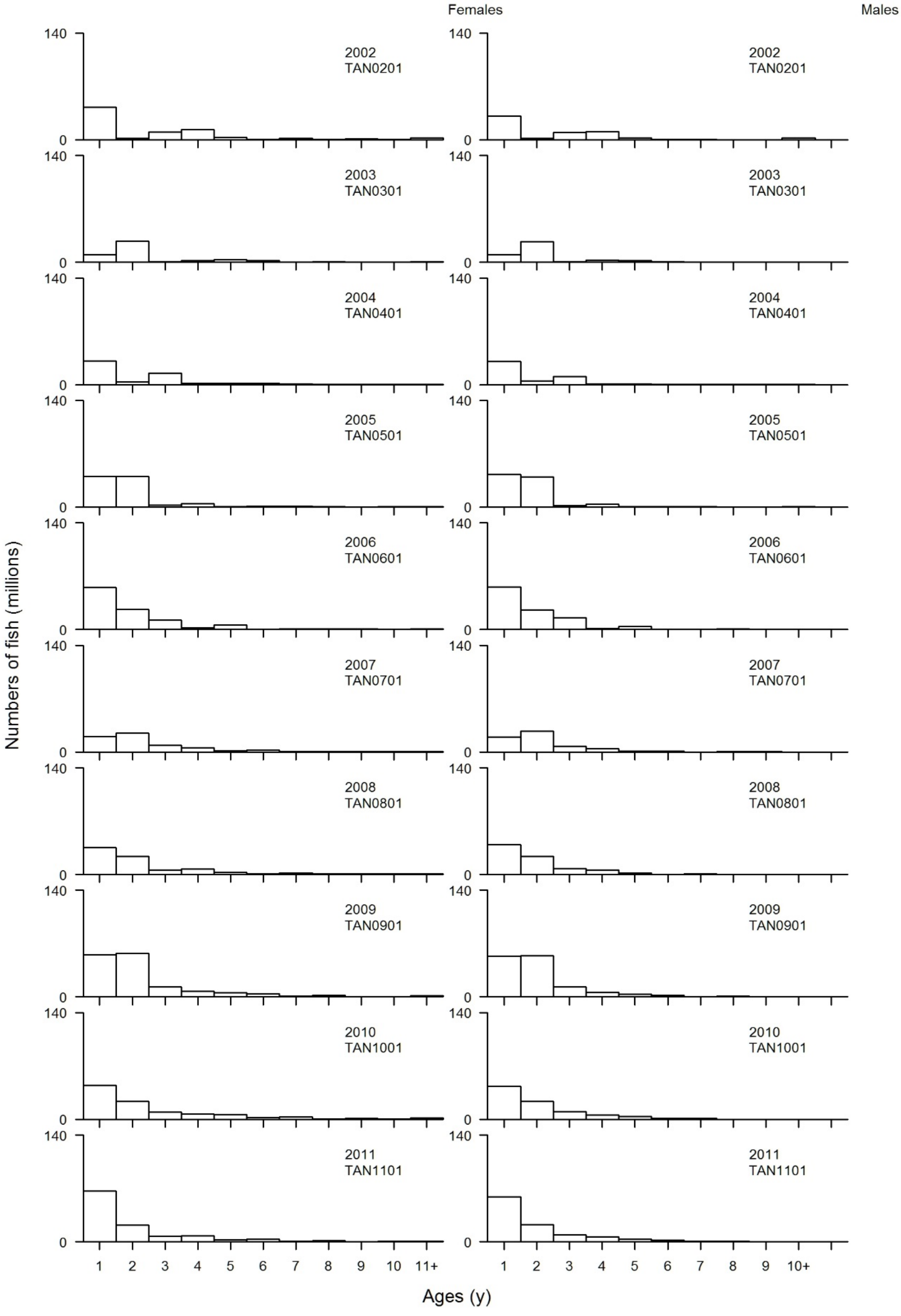


Figure 11 (continued)

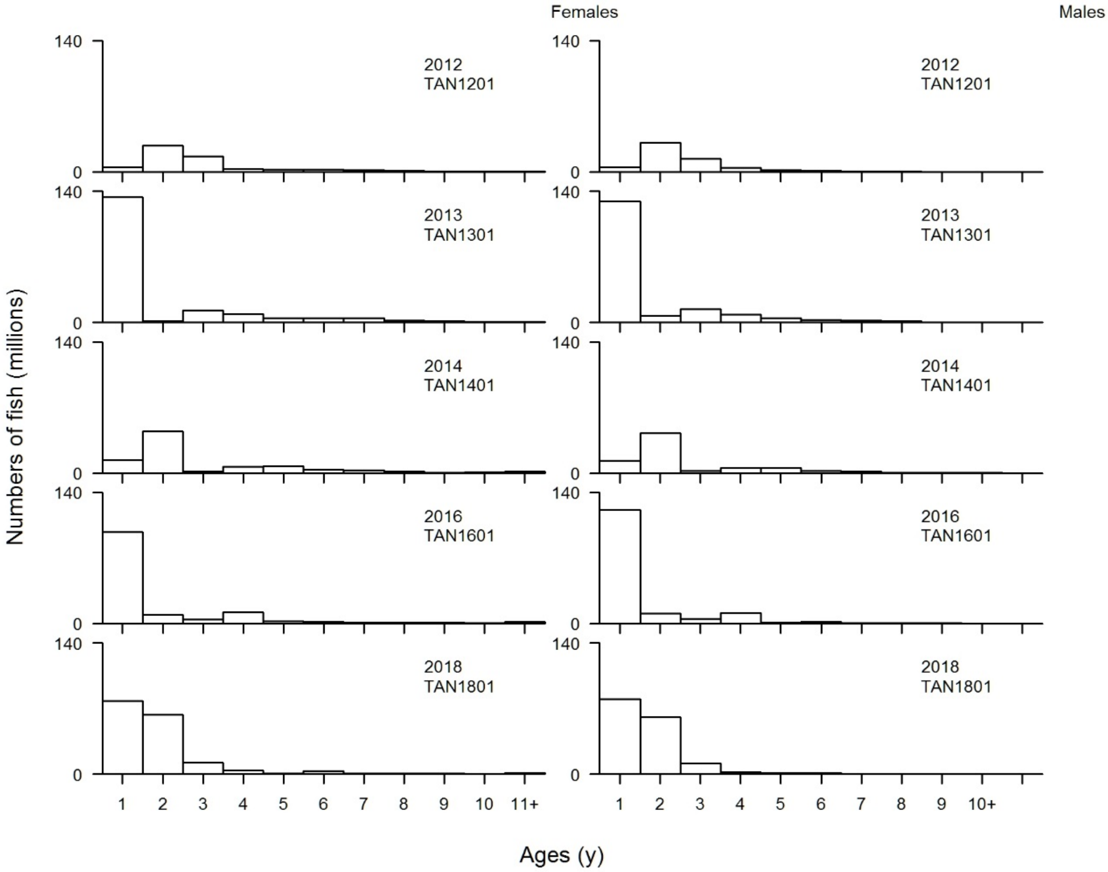


Figure 11 (continued)

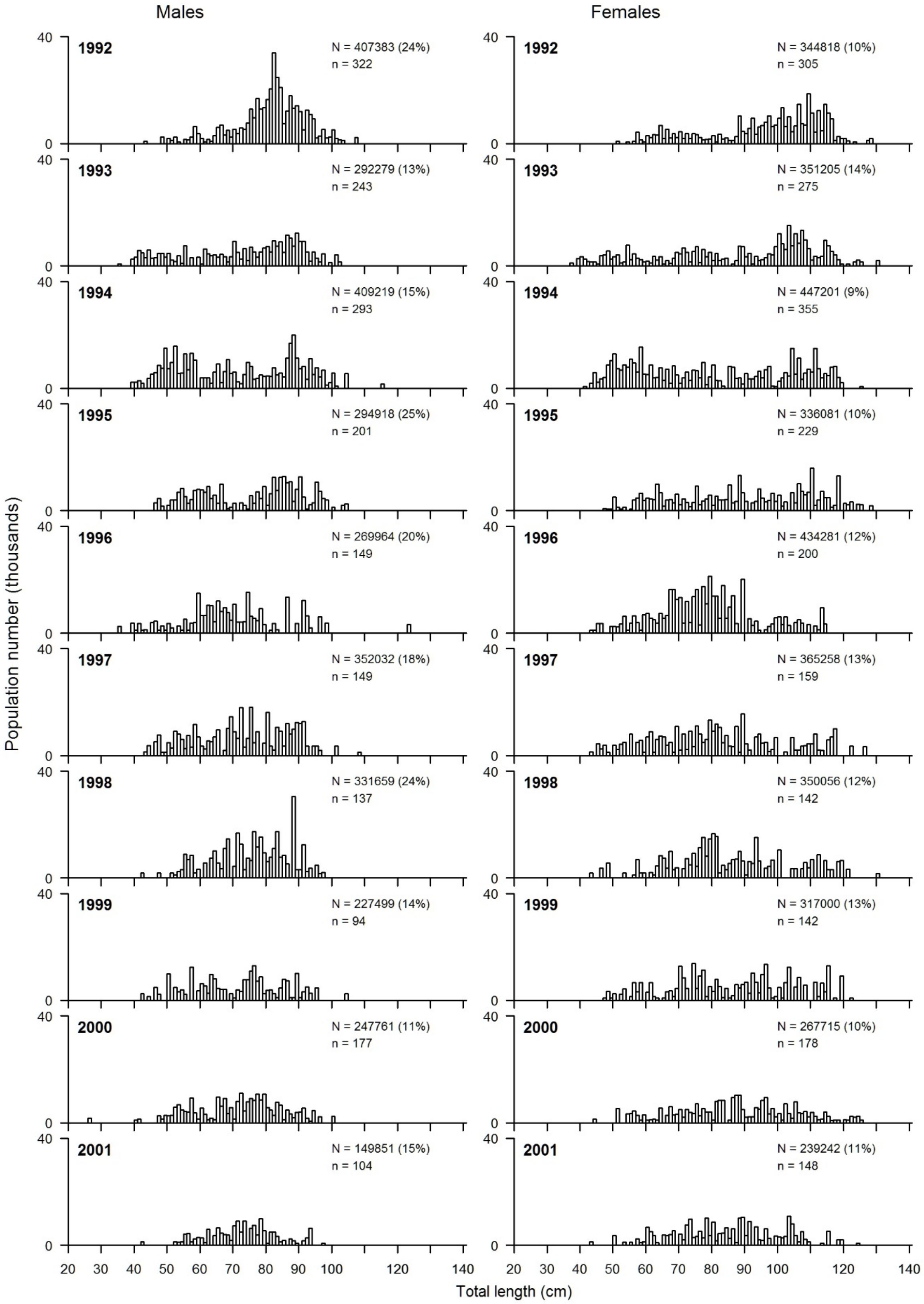


Figure 12: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, and 2018 for core strata. N, estimated population number of male hake (left panel) and female hake (right panel); CV (in parentheses), coefficient of variation; *n*., numbers of fish measured.

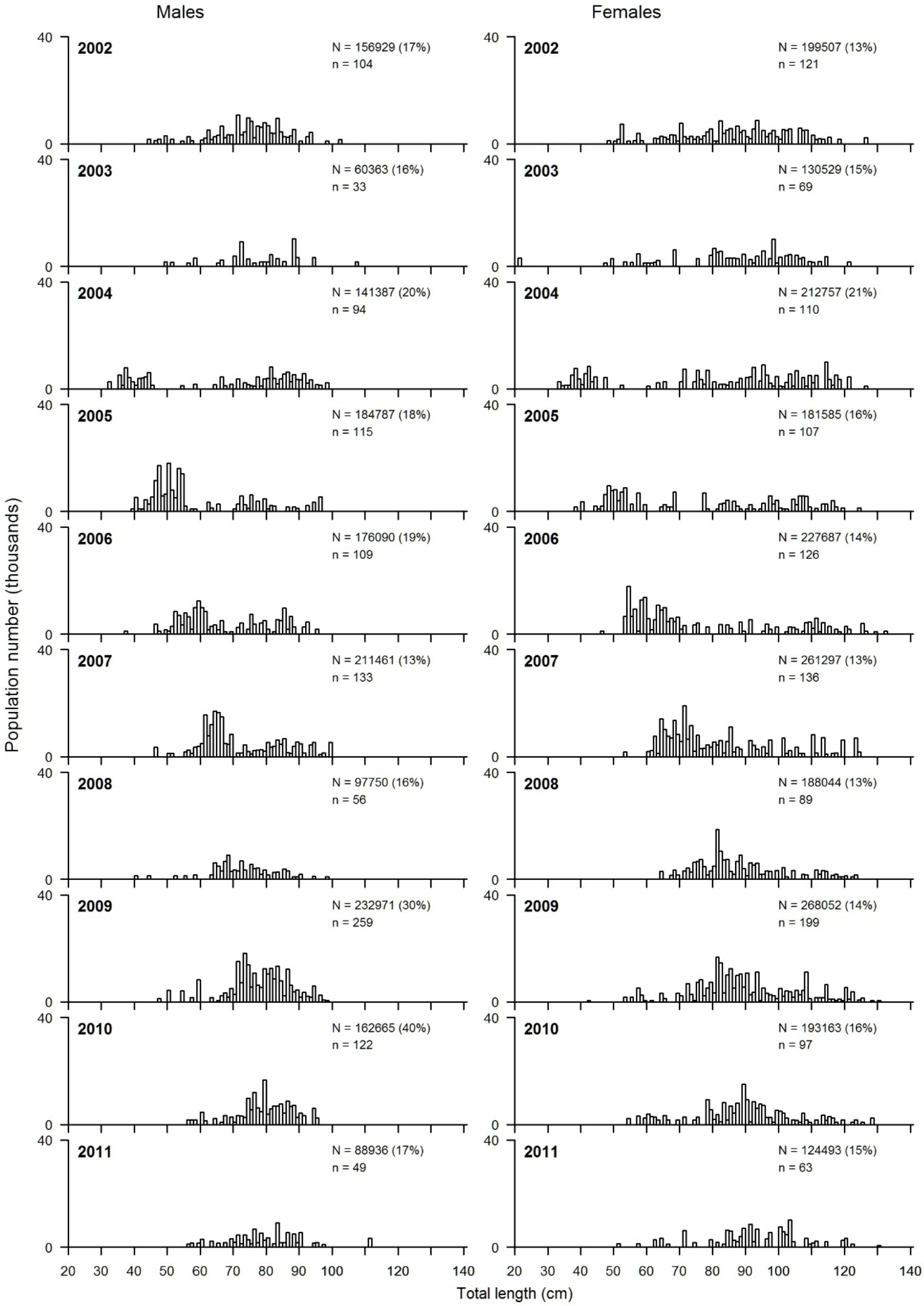


Figure 12 (continued)

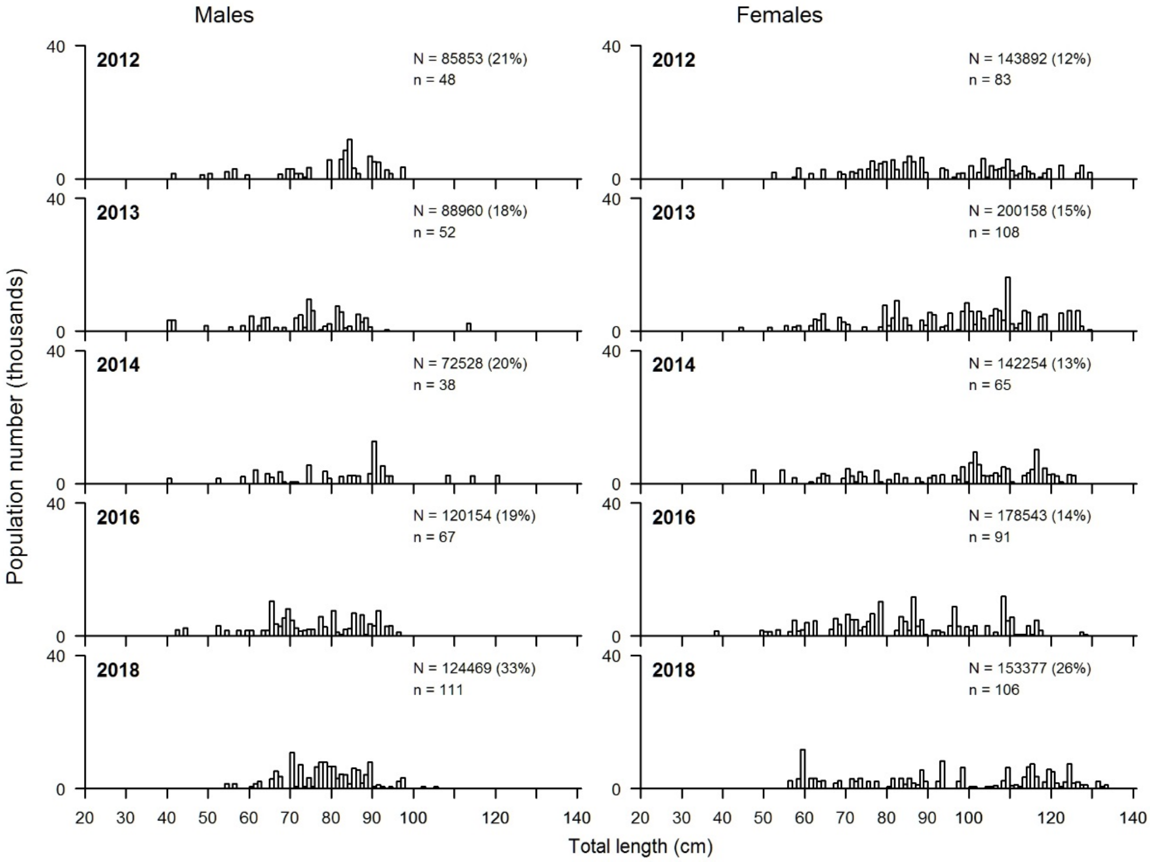


Figure 12 (continued)

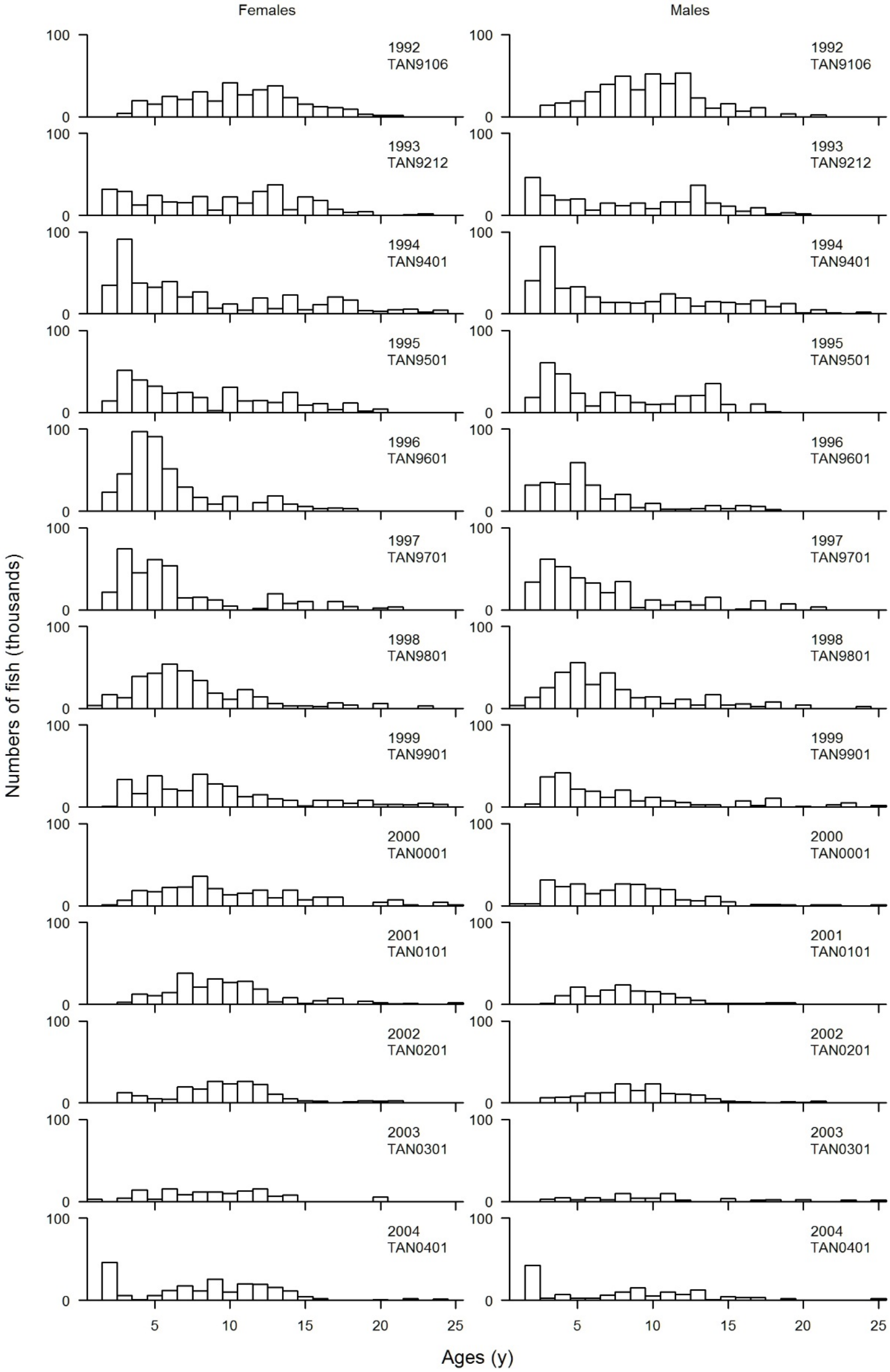


Figure 13: Estimated population numbers-at-age for male and female hake from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, 2016, and 2018.

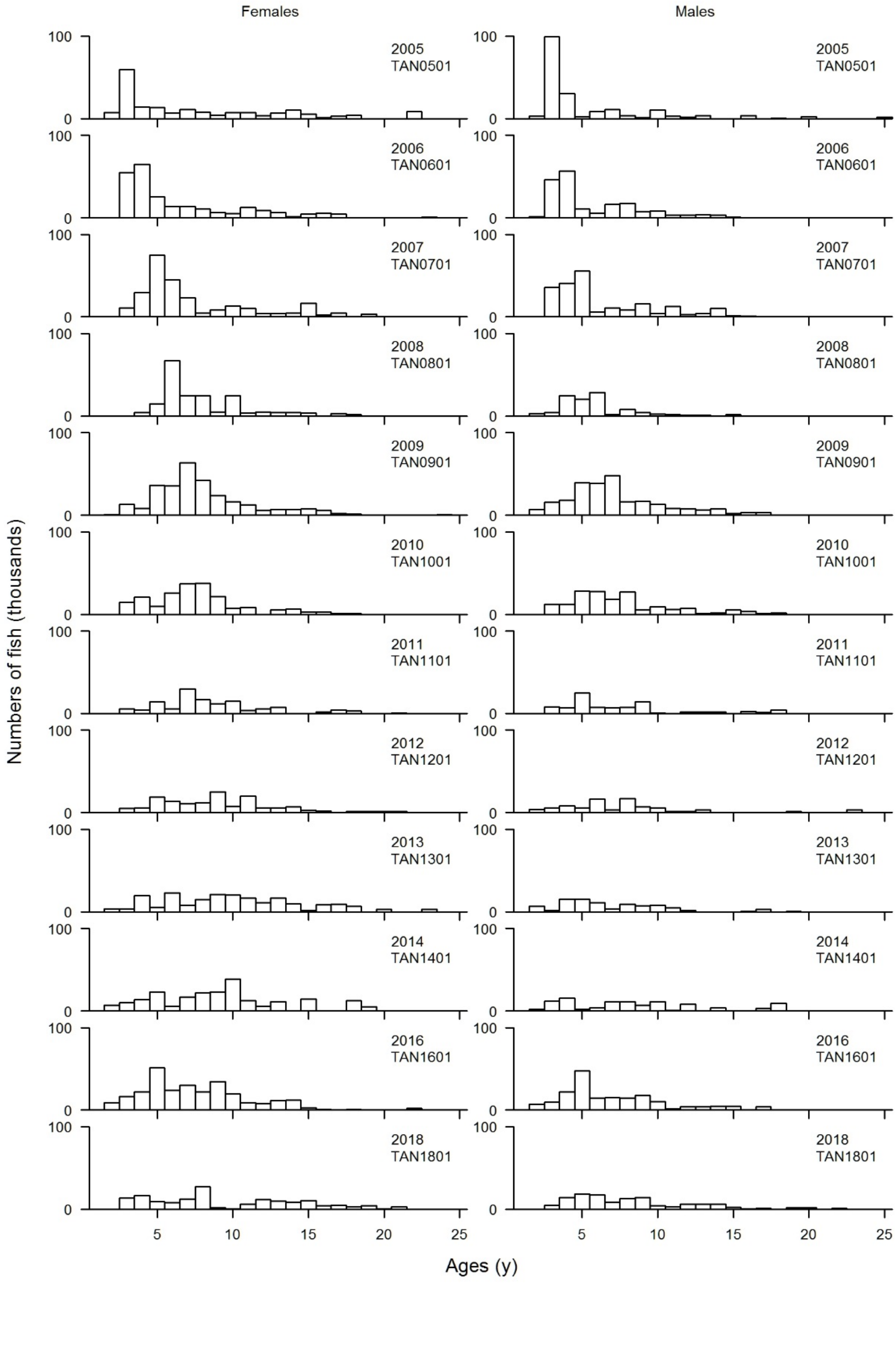


Figure 13 (continued)

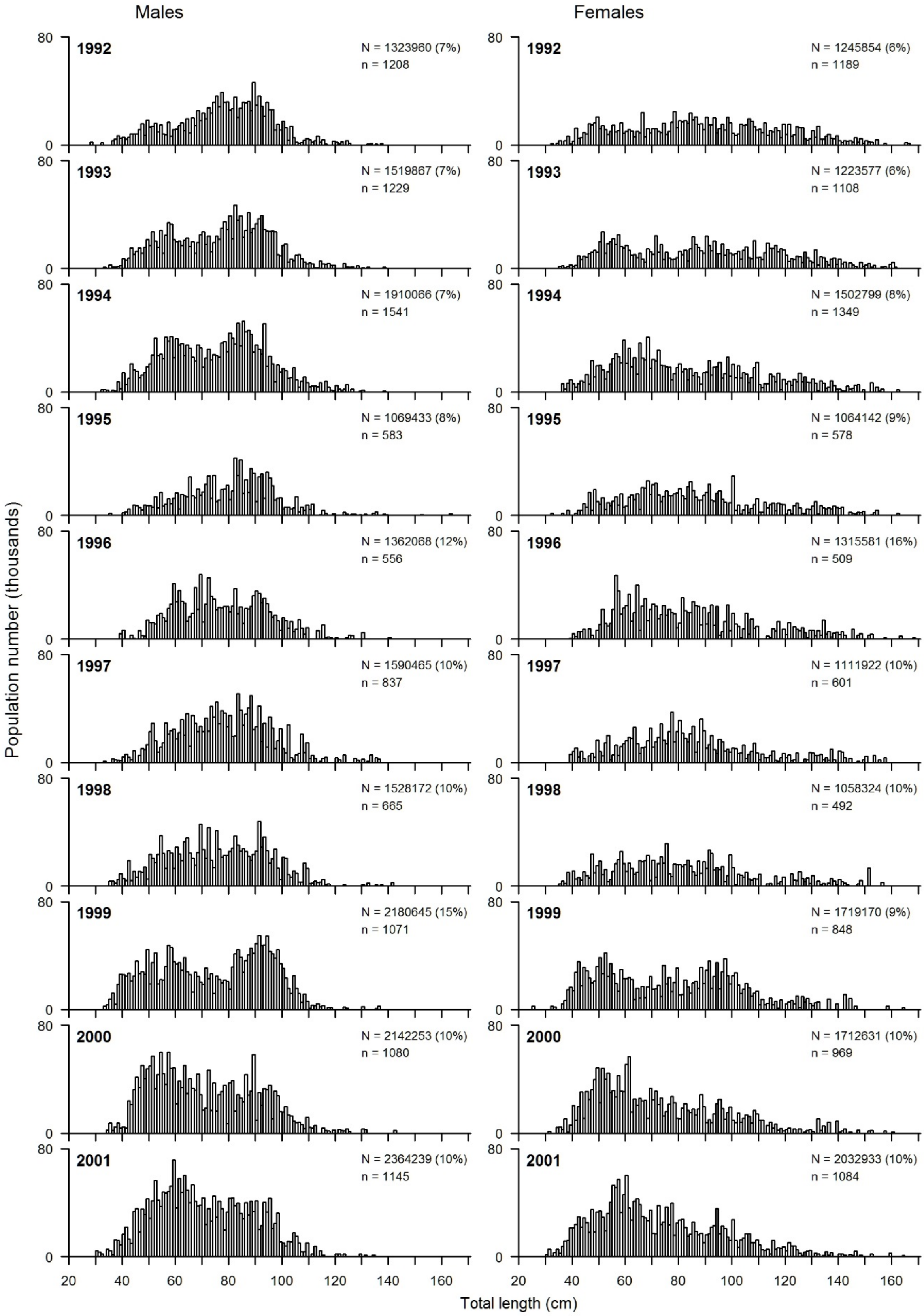


Figure 14: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, and 2018 for core strata. N, estimated population number of male ling (left panel) and female ling (right panel); CV (in parentheses), coefficient of variation; n., numbers of fish measured.

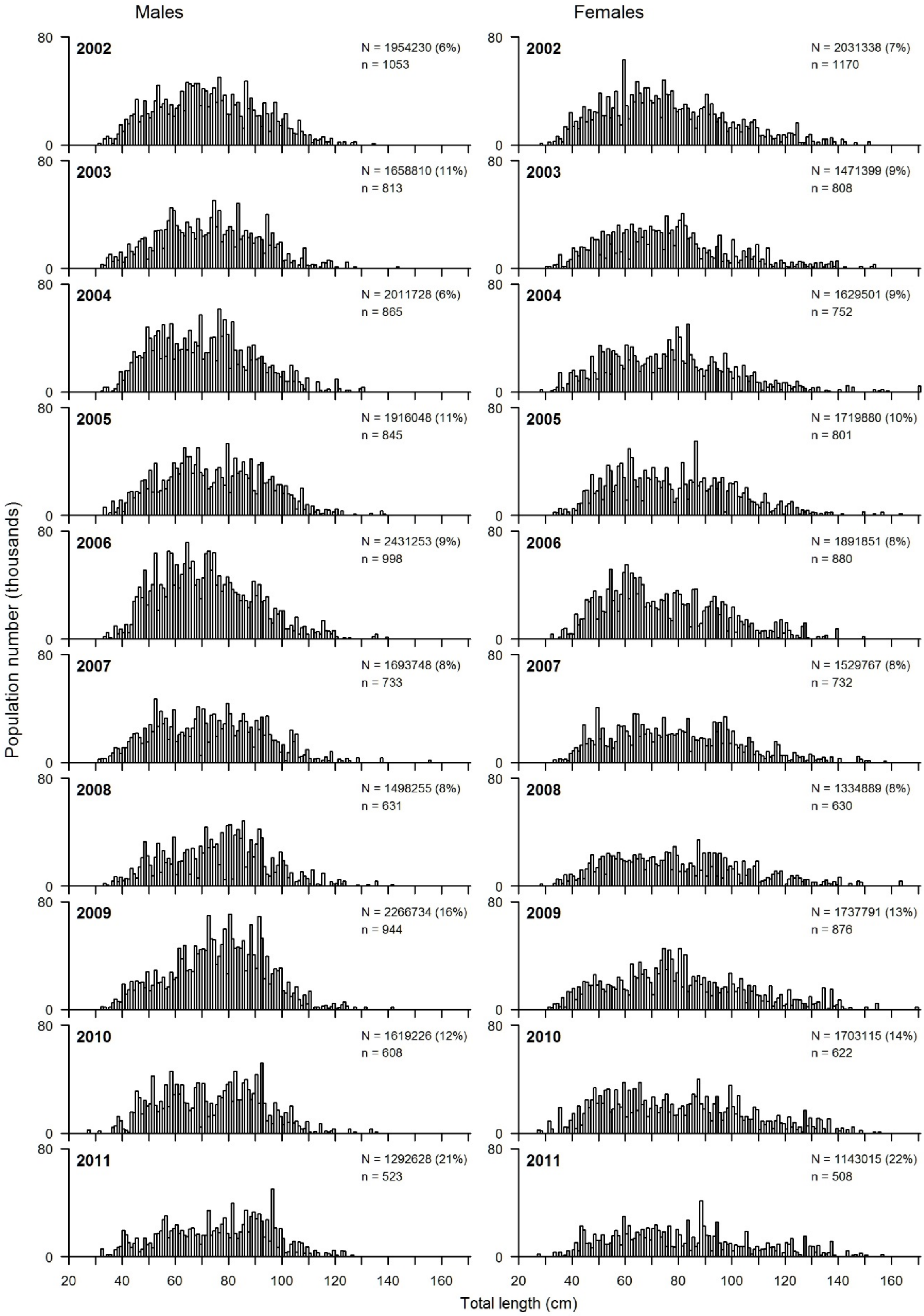


Figure 14 (continued)

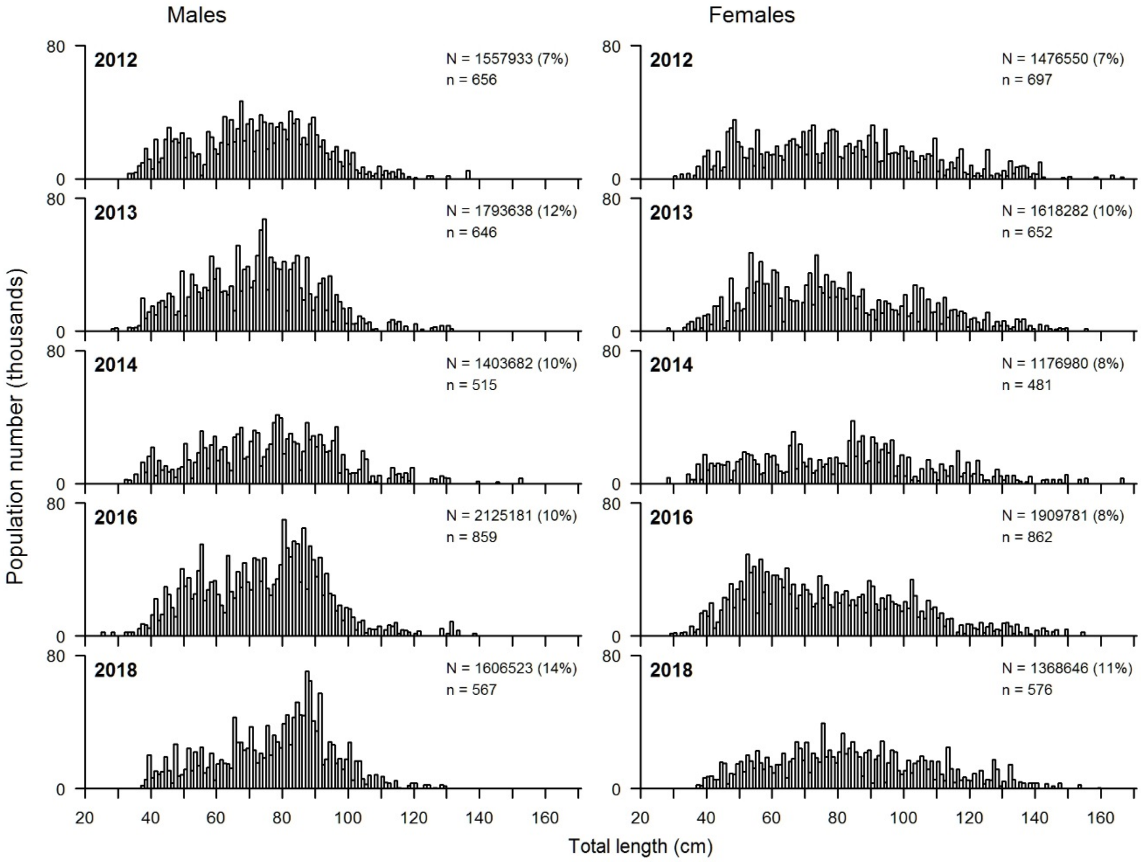


Figure 14 (continued)

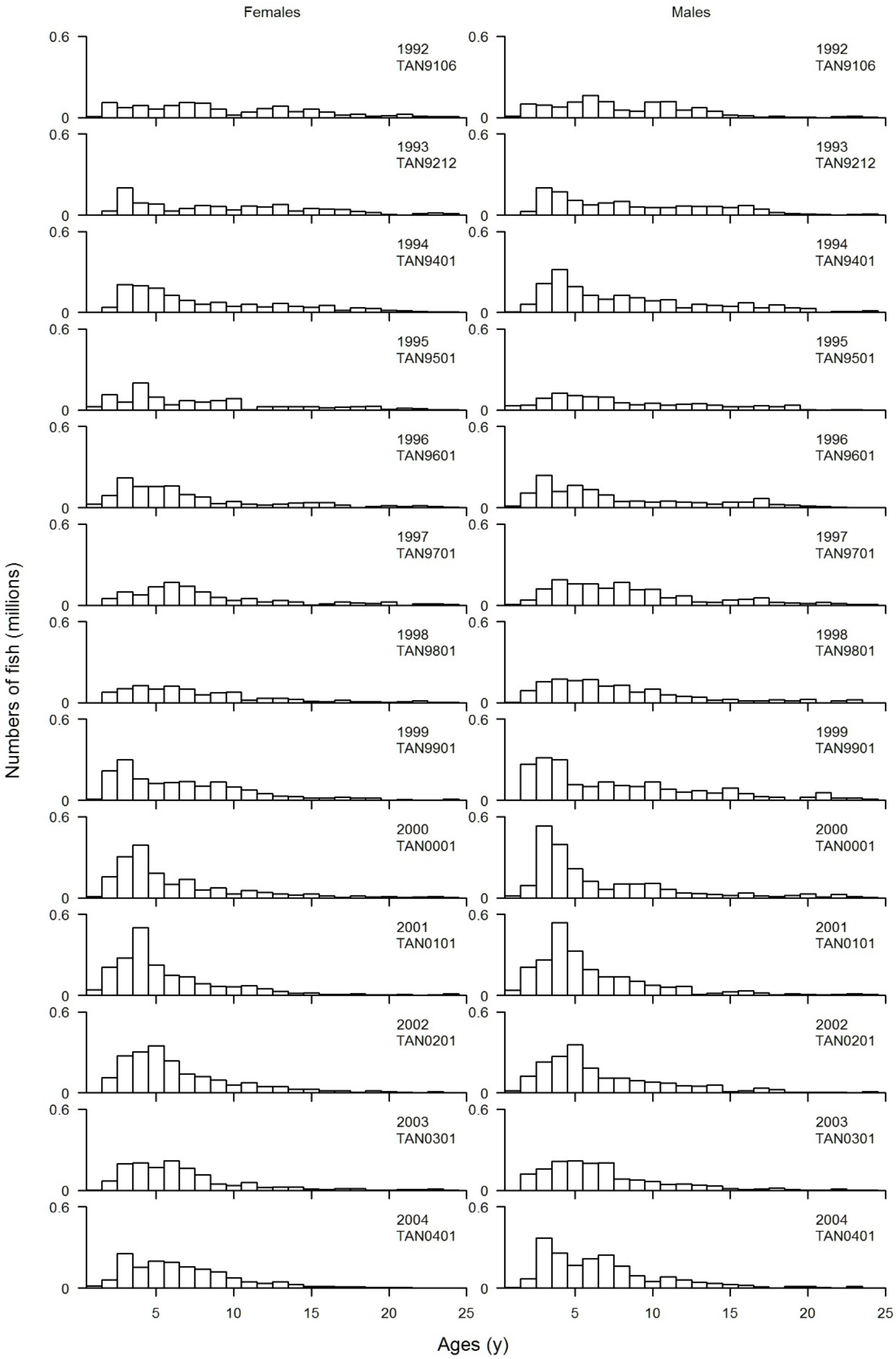


Figure 15: Estimated population numbers-at-age for male and female ling from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, 2016, and 2018.

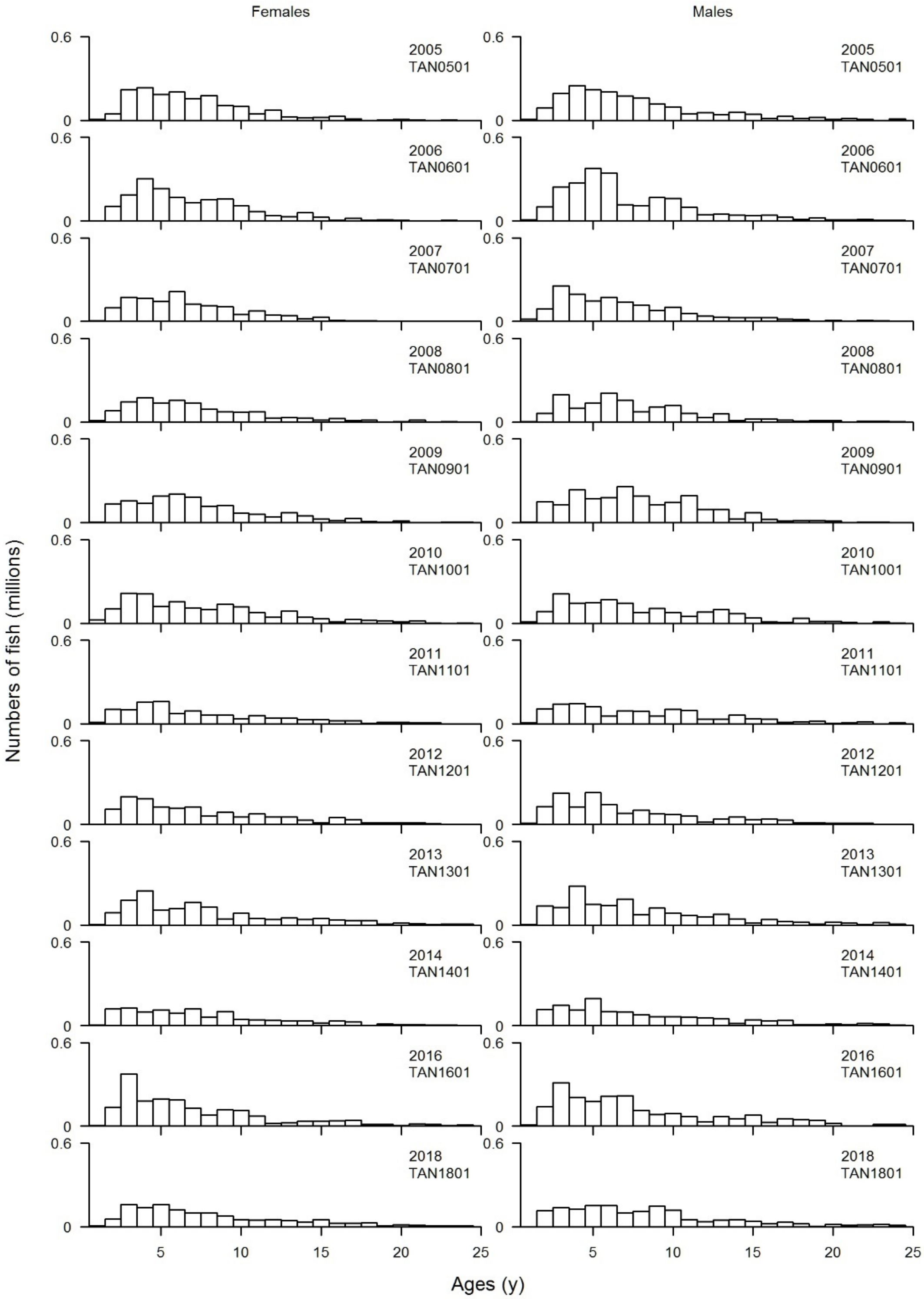


Figure 15 (continued)

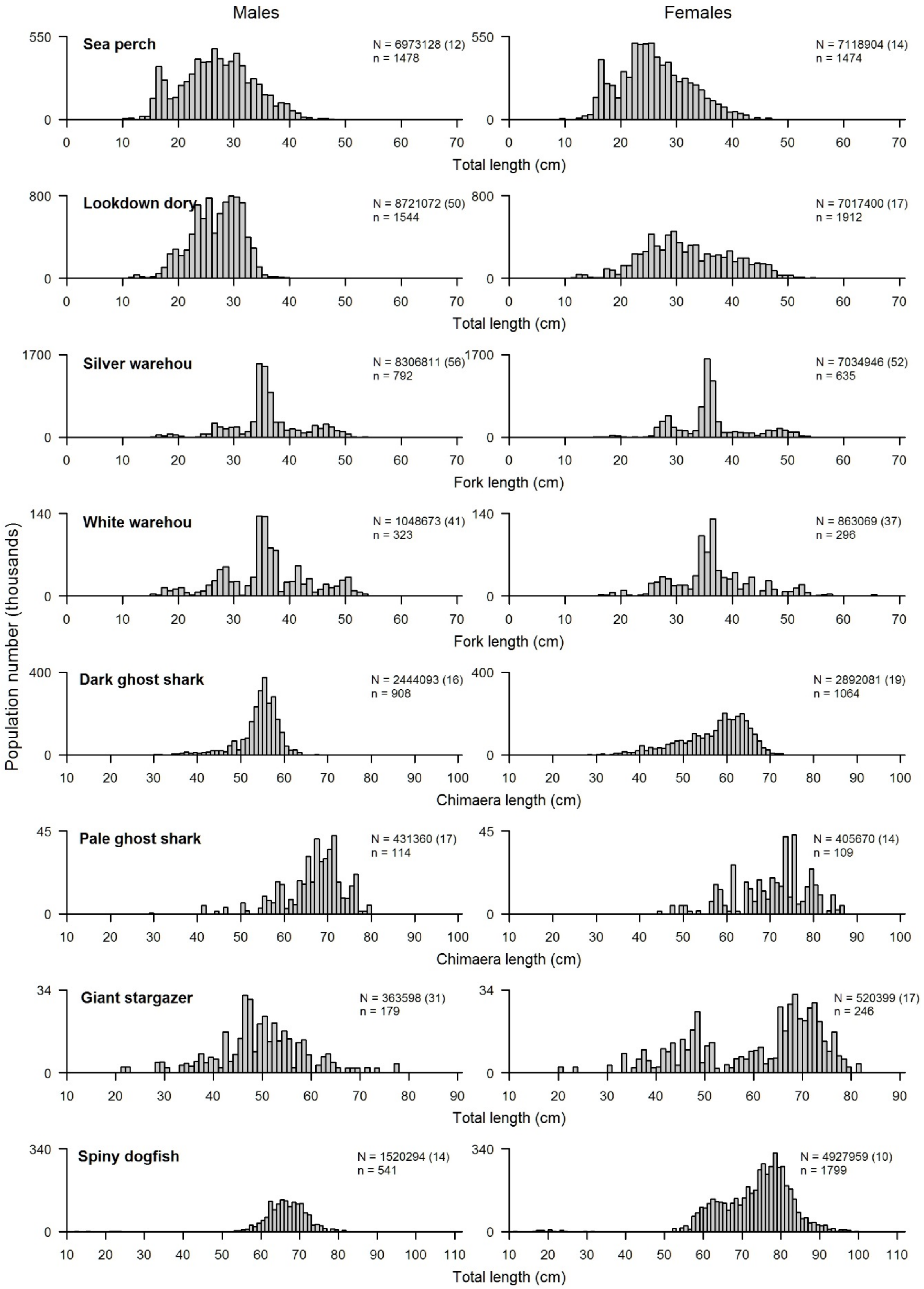


Figure 16a: Length frequency distributions of eight selected commercial species on the Chatham Rise 2018, scaled to population size by sex. N, estimated population number of male fish (left panel) and female fish (right panel); CV (in parentheses), coefficient of variation; n., numbers of fish measured.

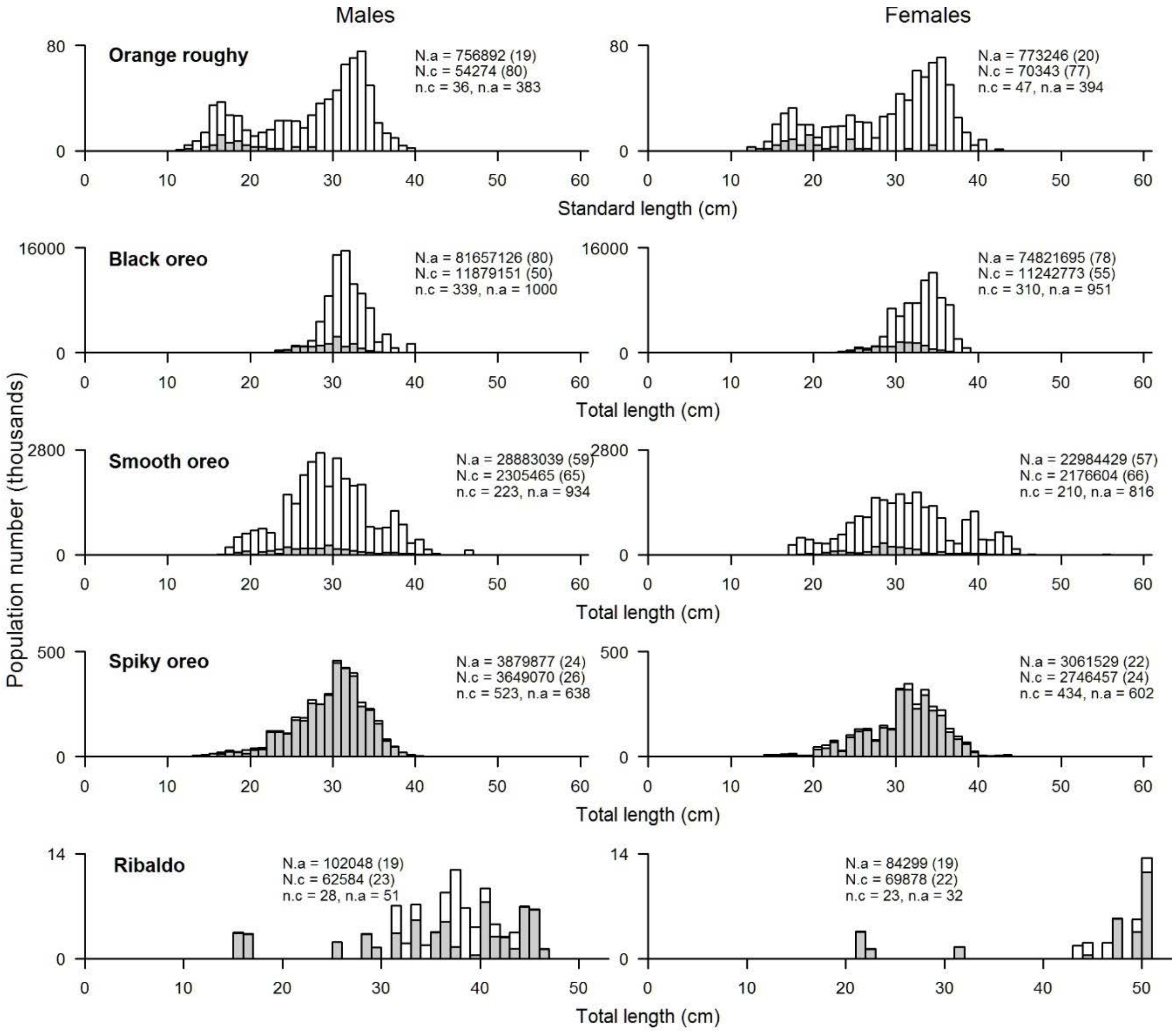


Figure 16b: Length frequency distributions of orange roughy, oreo species, and other selected deepwater species on the Chatham Rise 2018, scaled to population size by sex. N.a, estimated number of male fish (left panel) and female fish (right panel) from all (200–1300 m) strata; N.c, estimated number of male fish (left panel) and female fish (right panel) from core (200–800 m) strata; CV (in parentheses), coefficient of variation; n.c, number of fish measured from core strata; n.a, number of fish measured from all strata. White bars show fish from all strata. Black bars show fish from core strata.

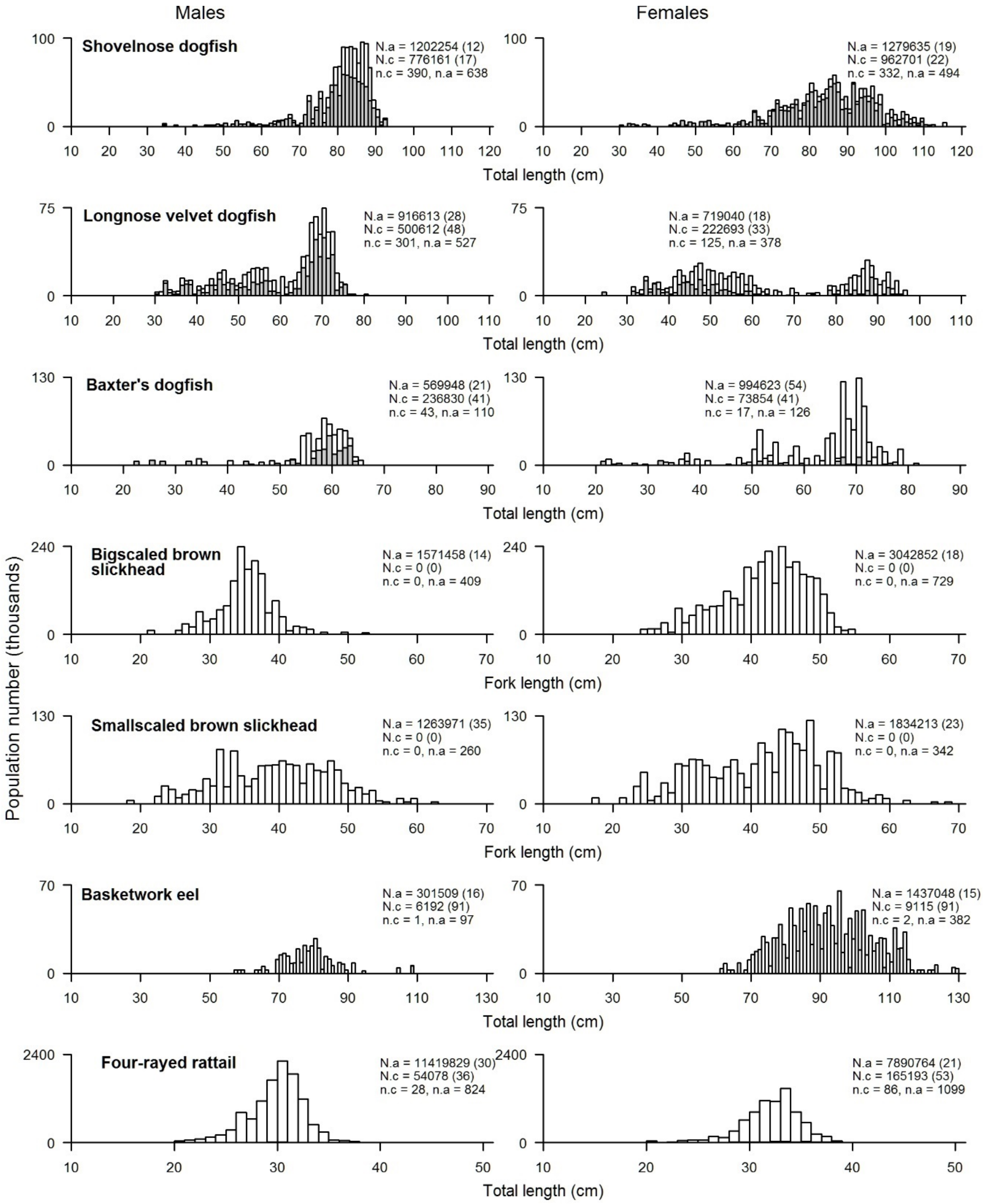


Figure 16b (continued)

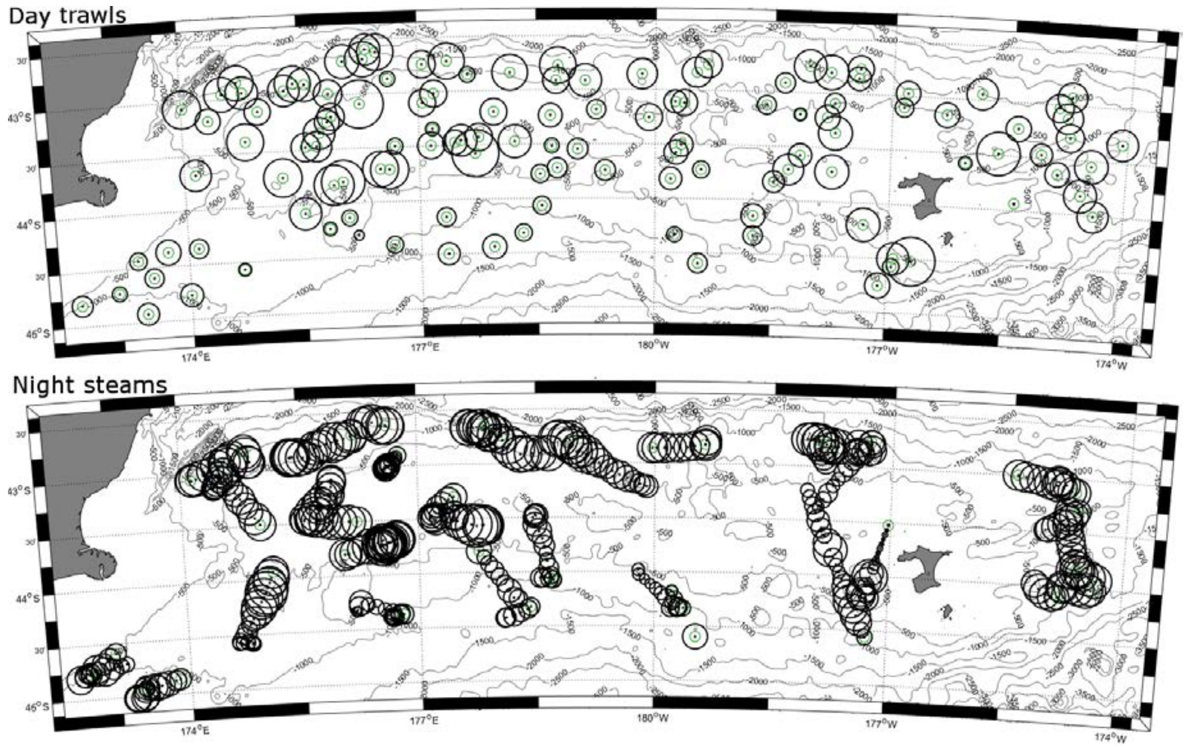


Figure 17: Distribution of total acoustic backscatter through the water column (10 m deep to bottom) (open black circles) observed on the Chatham Rise during day trawls (upper panel) and night-time steams (lower panel) throughout the entire survey area in January 2018. Green circles indicate start positions of recordings. Measurement is the (sliced) area backscattering coefficient s_a (in m^2 km^{-2}) represented in logarithmic scale (base 10). A value of 10 m^2 km^{-2} is shown as a circle of 20 km radius.

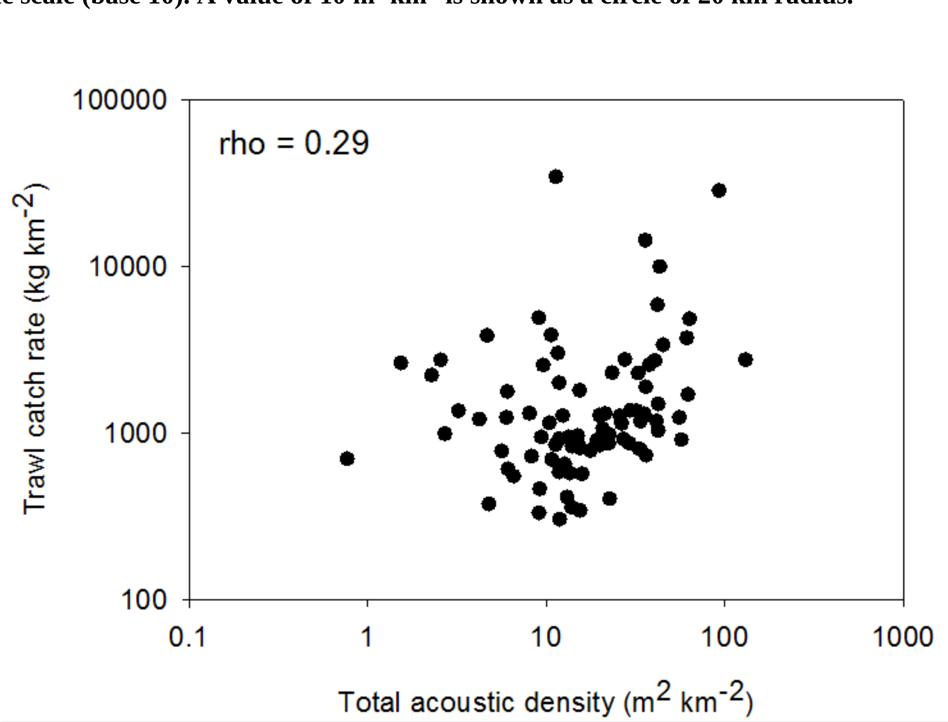


Figure 18: Relationship between total trawl catch rate (all species combined) and bottom-referenced acoustic backscatter recorded during each tow on the Chatham Rise in 2018. Rho value is Spearman's rank correlation coefficient.

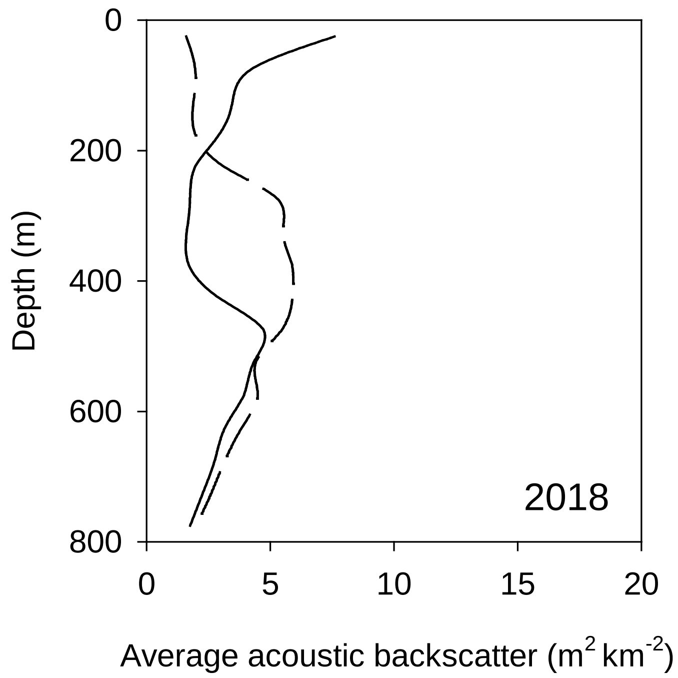


Figure 19: Vertical distribution of the average acoustic backscatter for the day (dashed lines) and at night (solid line) for the Chatham Rise survey in 2018.

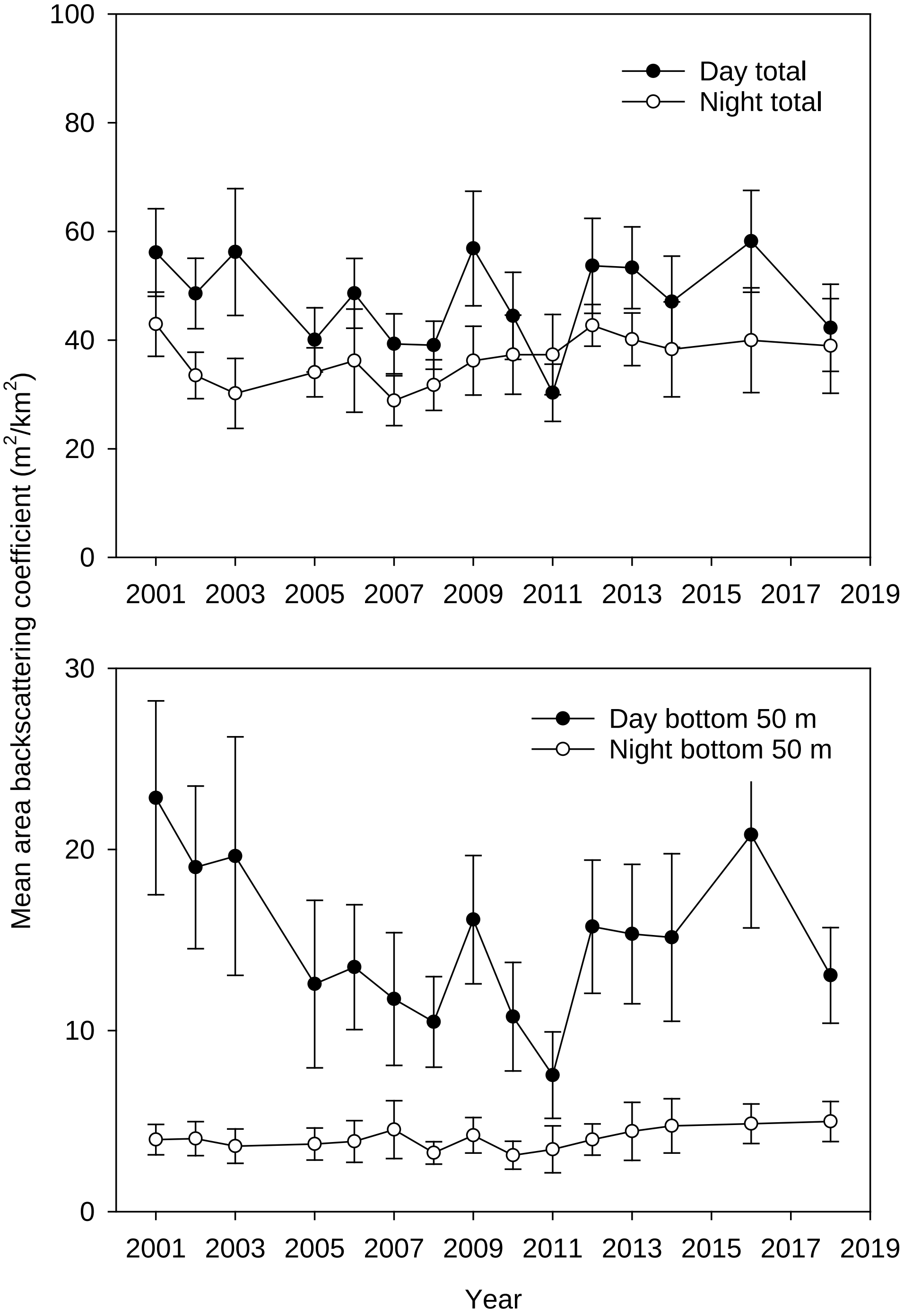


Figure 20: Comparison of relative acoustic abundance indices for the core Chatham Rise area based on (strata-averaged) mean areal backscatter. Error bars are ± 2 standard errors.

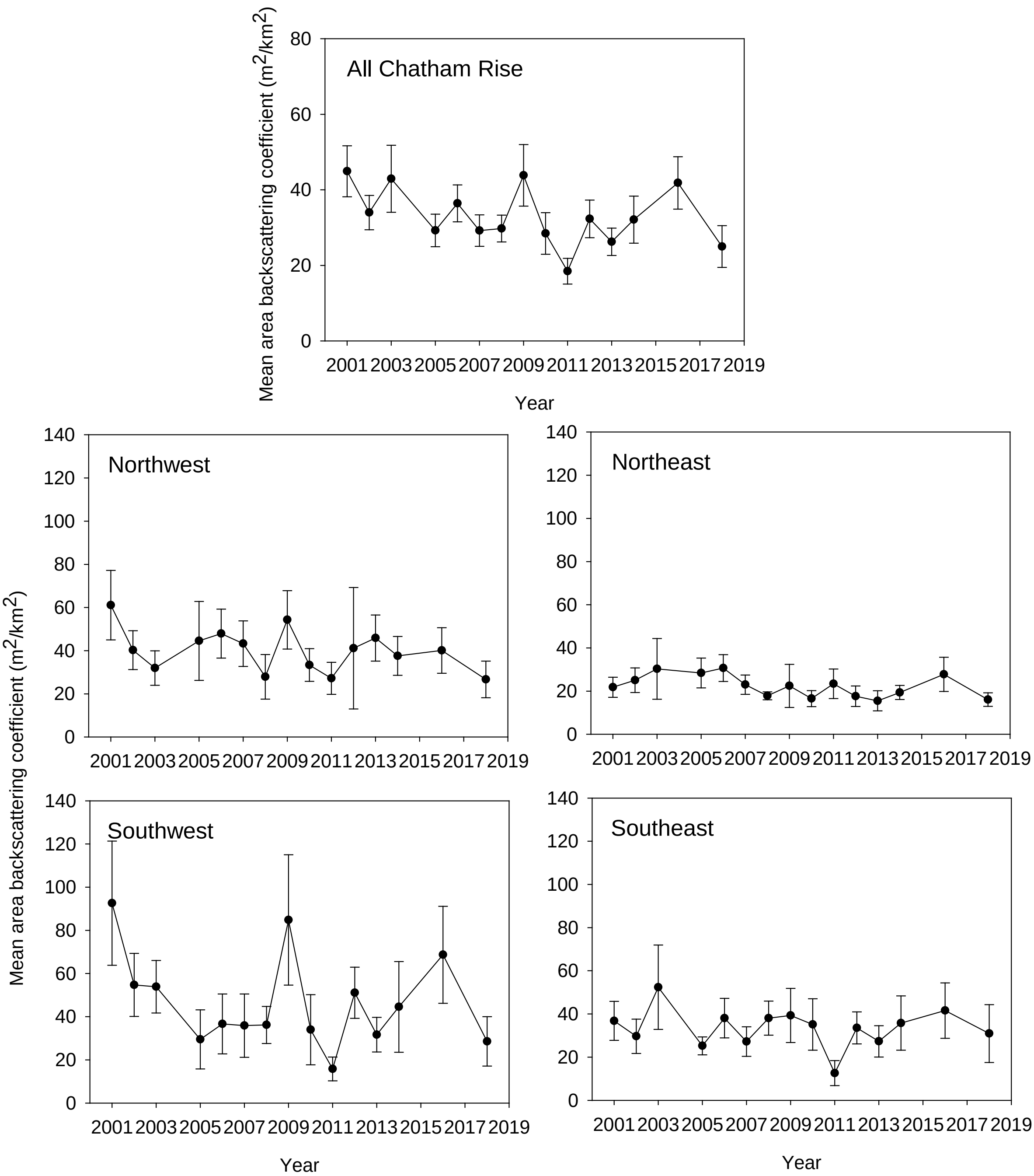


Figure 21: Relative acoustic abundance indices for mesopelagic fish on the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same sub-area observed in the upper 200 m corrected for the estimated proportion in the surface deadzone. Panels show indices for the entire Chatham Rise and for four sub-areas. Error bars are ± 2 standard errors.

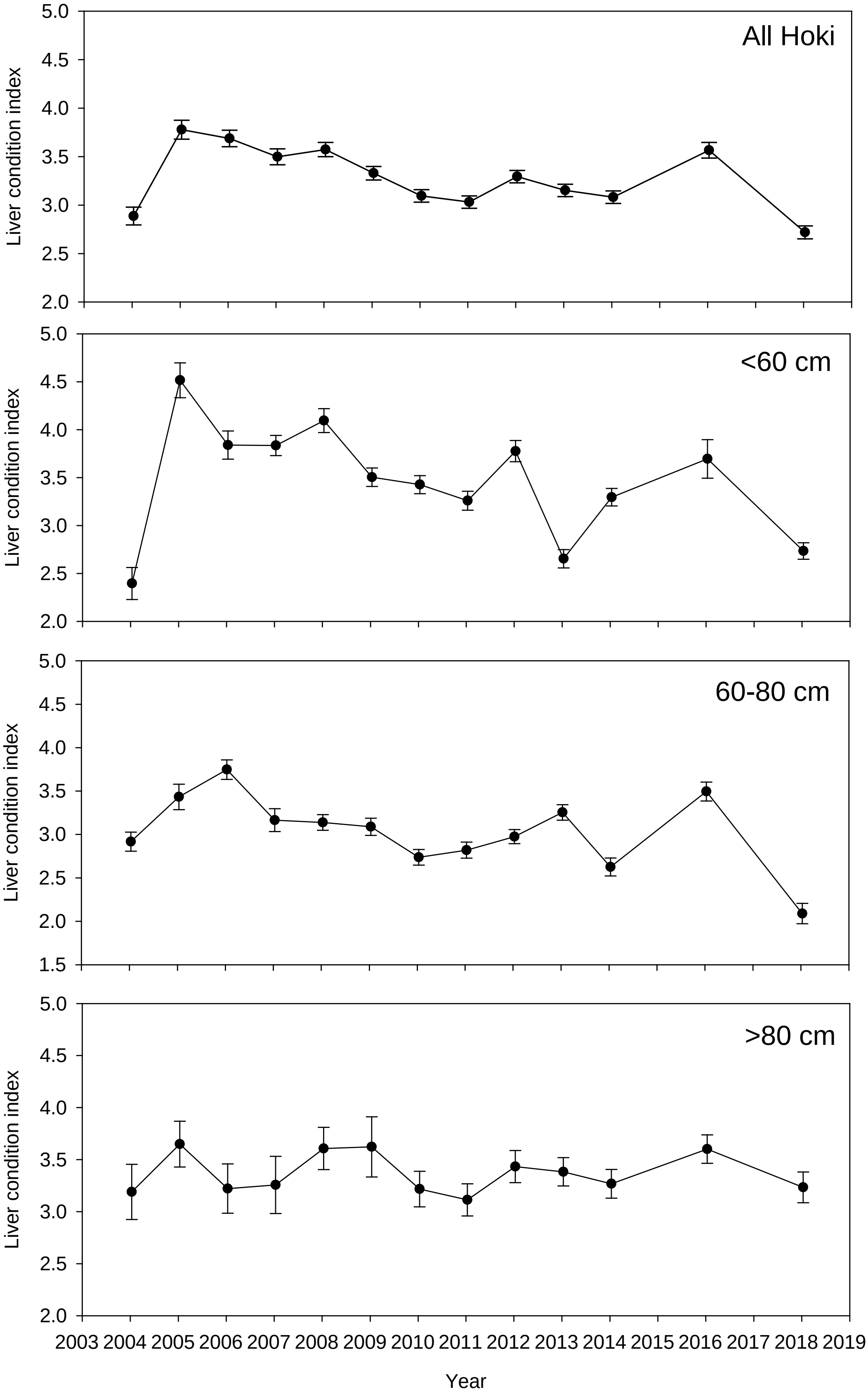


Figure 22: Time-series of hoki liver condition indices on the Chatham Rise from 2004–18. Data are plotted for all hoki, then three different size classes (<60 cm, 60–80 cm, and >80 cm). Error bars show ± 2 standard errors.

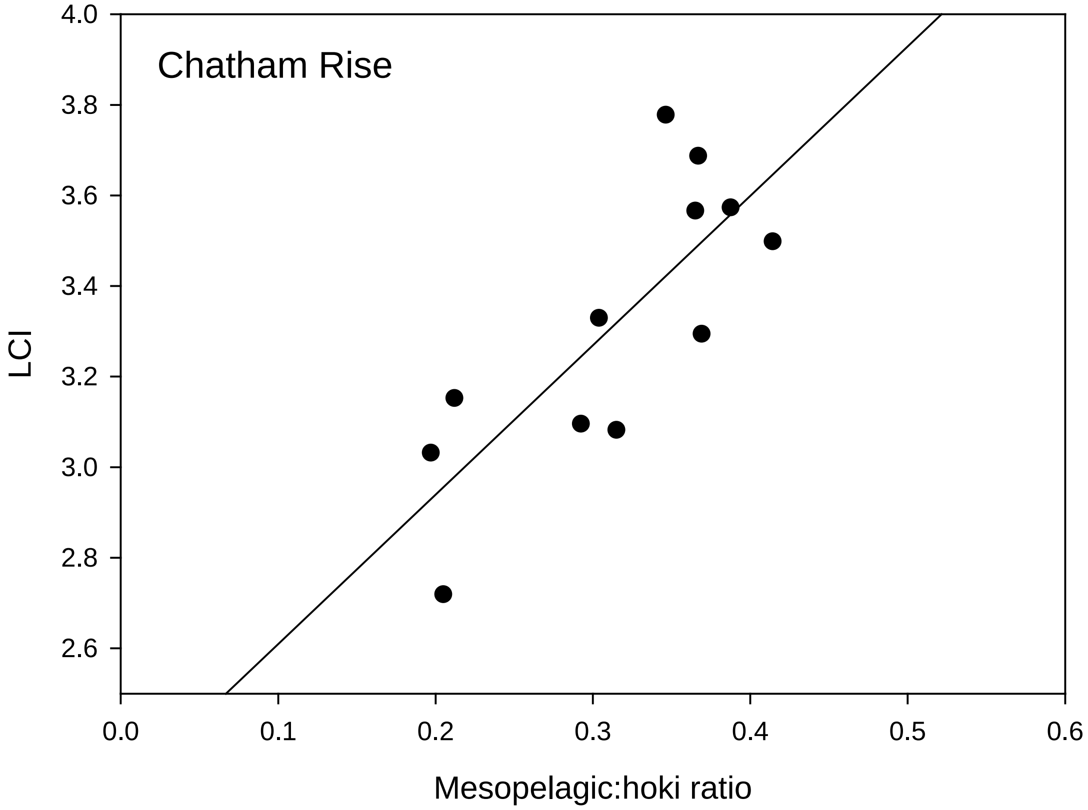


Figure 23: Correlation between hoki liver condition (LCI) and the ratio between the acoustic estimate of mesopelagic fish abundance divided by the trawl estimate of hoki abundance (food per fish) for Chatham Rise surveys 2004–2018.

Appendix 1: Individual station data for all stations conducted during the survey (TAN1801). Stn., station number. Type; P1, phase 1 trawl survey biomass tow; P2, phase 2 trawl survey biomass tow. Strat., Stratum number; *, foul trawl stations. Time is NZST, Latitude (S), and Longitude as degrees and minutes. Dist., distance towed.

			Start tow					Gear depth (m)		Dist.	Catch (kg)		
Stn.	Type	Strat.	Date	Time	Latitude	Longitude	E/W	min.	max.	n.mile	hoki	hake	ling
1	P1	8A	6-Jan-18	530	42 59.07	176 39.78	E	407	408	2.11	206.6	0	14.0
2	P1	8A	7-Jan-18	516	42 51.29	176 38.55	E	448	489	2.99	11.7	0	0
3	P1	2A	7-Jan-18	827	42 44.31	177 06.10	E	774	790	2.97	141.0	1.5	0
4	P1	8A	7-Jan-18	1229	42 50.77	177 39.82	E	506	524	2.70	333.7	2.0	85.1
5	P1	2A	7-Jan-18	1615	42 49.09	178 12.27	E	756	768	2.92	246.2	3.9	13.8
6	P1	23	7-Jan-18	2318	42 39.59	177 45.98	E	1188	1195	2.83	0	0	0
7	P1	2A	8-Jan-18	556	42 54.69	178 47.19	E	745	756	3.02	188.9	7.5	17.4
8	P1	8B	8-Jan-18	1028	43 14.01	178 42.22	E	422	422	2.90	532.5	3.2	31.9
9	P1	8B	8-Jan-18	1410	43 10.93	179 16.60	E	442	446	2.92	209.1	0	50.9
10	P1	22	8-Jan-18	1744	42 54.38	179 10.82	E	802	818	3.00	112.7	9.0	5.7
11	P1	23	8-Jan-18	2151	42 46.38	178 50.08	E	1240	1263	2.96	0	0	0
12	P1	8B	9-Jan-18	510	43 13.73	179 57.15	E	488	492	3.02	121.0	4.3	7.0
13	P1	10	9-Jan-18	823	43 32.30	179 42.90	W	416	424	2.99	206.8	2.9	50.1
14	P1	10	9-Jan-18	1034	43 29.26	179 37.22	W	433	455	2.95	254.3	25.6	37.2
15	P1	10	9-Jan-18	1406	43 07.01	179 36.39	W	525	528	2.90	469.4	27.5	11.4
16	P1	10	9-Jan-18	1616	43 06.39	179 40.73	W	520	526	3.01	150.1	4.5	20.3
17	P1	22	9-Jan-18	2035	42 51.21	179 52.91	W	893	900	2.99	32.6	37.8	0
18	P1	21A	10-Jan-18	54	42 49.66	179 25.97	W	816	822	2.97	65.0	4.0	7.9
19	P1	21A	10-Jan-18	331	42 44.61	179 16.64	W	939	949	3.00	3.1	0	0
20	P1	11	10-Jan-18	816	43 07.10	178 33.59	W	513	520	3.00	129.1	0	0
21	P1	11	10-Jan-18	1058	42 54.83	178 19.88	W	567	577	2.90	498.8	0	20.1
22	P1	11	10-Jan-18	1521	43 12.85	177 48.06	W	418	433	3.04	82.4	0	17.1
23	P1	11	10-Jan-18	1731	43 05.55	177 41.36	W	451	454	3.00	91.0	0	40.3
24	P1	21B	10-Jan-18	2212	42 48.27	177 43.16	W	872	875	3.01	29.0	0	2.2
25	P1	21A	11-Jan-18	145	42 45.41	178 00.30	W	865	893	2.92	33.8	0	0
26	P1	9	11-Jan-18	733	43 22.37	177 42.88	W	355	379	2.99	81.5	0	41.5
27	P1	5	11-Jan-18	1151	43 41.53	177 41.70	W	392	403	2.88	167.7	8.6	35.5
28	P1	5	11-Jan-18	1539	43 42.07	178 16.83	W	369	374	3.00	384.9	0	66.4
29	P1	5	11-Jan-18	1739	43 33.91	178 08.00	W	373	380	2.98	160.3	16.2	17.5
30	P1	24	12-Jan-18	102	42 45.98	177 20.86	W	1037	1043	2.89	31.2	0	0
31	P1	2B	12-Jan-18	519	42 51.52	177 23.50	W	750	756	2.99	119.6	0	3.1
32	P1	11	12-Jan-18	924	43 06.13	176 49.53	W	450	482	3.00	549.1	11.1	63.8
33	P1	2B	12-Jan-18	1149	42 58.15	176 44.80	W	617	626	2.94	336.5	27.8	16.8
34	P1	21B	12-Jan-18	1738	42 56.39	175 50.05	W	830	835	2.99	35.0	4.0	0
35	P1	21B	12-Jan-18	2356	43 05.93	174 44.30	W	880	882	2.99	27.8	0	0
36	P1	21B	13-Jan-18	321	43 01.85	174 50.26	W	900	906	3.01	11.7	0	0
37	P1	24	13-Jan-18	641	42 55.62	174 40.37	W	1067	1087	2.99	0	0	0
38	P1	24	13-Jan-18	1217	43 16.94	174 04.00	W	1044	1061	2.94	6.8	0	0
39	P1	25	13-Jan-18	1610	43 30.64	174 25.75	W	827	837	3.00	26.2	0	0
40	P1	25	13-Jan-18	1944	43 47.02	174 31.67	W	832	839	2.97	17.4	0	0
41	P1	21B	14-Jan-18	100	43 18.02	174 42.04	W	835	841	2.93	44.4	0	0
42	P1	2B	14-Jan-18	505	43 26.98	175 03.24	W	628	636	2.97	123.5	20.2	9.8
43	P1	2B	14-Jan-18	802	43 14.30	175 19.79	W	692	697	3.00	171.2	0	18.4
44	P1	11	14-Jan-18	1110	43 27.41	175 36.42	W	472	500	2.10	3644.4	36.1	34.7
45	P1	4	14-Jan-18	1719	43 35.92	174 50.46	W	689	704	3.00	65.1	0	16.7
46	P1	28	14-Jan-18	2217	43 58.09	174 20.40	W	1158	1163	3.09	0	0	0
47	P1	25	15-Jan-18	202	44 02.66	174 47.68	W	844	854	2.89	36.1	0	5.2
48	P1	9	15-Jan-18	608	43 53.62	175 21.64	W	231	246	3.02	0	0	0
49	P1	9	15-Jan-18	1152	43 33.91	176 02.43	W	218	225	2.12	0	0	0
50	P2	11	15-Jan-18	1552	43 08.92	176 14.83	W	516	523	3.01	193.9	11.9	45.7

Appendix 1: (continued)

Stn.	Type	Strat.	Date	Time	Start tow Latitude	Longitude	E/W	Gear depth (m) min.	max.	Dist. n.mile	Catch (kg) hoki	hake	ling
51	P1	12	16-Jan-18	530	44 09.80	177 17.89	W	404	415	3.00	353.1	14.7	41.7
52	P1	12	16-Jan-18	516	44 29.48	176 53.04	W	516	533	2.41	550.1	0	79.1
53	P1	12	16-Jan-18	827	44 30.29	176 39.29	W	537	584	2.98	1193.8	4.1	44.2
54	P1	4	16-Jan-18	1229	44 33.64	176 53.23	W	659	683	2.94	351.8	0	89.4
55	P1	28	16-Jan-18	1615	44 45.17	177 02.12	W	1160	1200	2.99	0	0	0
56	P2	11	17-Jan-18	2318	43 12.12	178 05.94	W	455	456	3.00	220.9	0	44.0
57	P1	13	17-Jan-18	556	43 48.00	178 25.73	W	432	451	3.01	255.0	25.7	71.9
58	P1	13	17-Jan-18	1028	44 06.74	178 43.17	W	463	487	2.93	291.6	0	50.8
59	P1	4	17-Jan-18	1410	44 18.92	178 40.18	W	651	655	3.01	71.2	0	22.7
60	P1	28	17-Jan-18	1744	44 34.72	179 22.89	W	1219	1226	2.99	0	0	0
61*	P1	25	18-Jan-18	2151	44 25.45	179 11.30	W	956	967	3.00	10.0	0	0
62	P1	13	18-Jan-18	510	43 49.43	178 50.49	W	413	426	2.98	141.3	0	24.8
63	P1	3	18-Jan-18	823	43 49.04	179 10.96	W	353	370	2.93	133.6	0	44.0
64	P1	3	18-Jan-18	1034	43 43.68	179 23.09	W	376	400	2.98	142.6	0	44.0
65	P1	3	18-Jan-18	1406	43 48.64	179 44.12	W	375	380	2.99	197.0	0	78.3
66	P1	25	18-Jan-18	1616	44 19.82	179 41.96	W	822	833	2.95	9.1	0	0
67	P1	14	19-Jan-18	2035	43 43.23	179 22.13	E	475	487	3.00	49.3	0	31.6
68	P1	20	19-Jan-18	54	43 31.33	179 01.01	E	340	376	3.05	211.3	5.2	20.5
69	P1	20	19-Jan-18	331	43 29.55	178 43.71	E	338	343	2.08	571.1	0	29.6
70	P1	14	19-Jan-18	816	43 42.56	178 46.86	E	441	446	2.98	312.3	1.7	52.6
71	P1	14	19-Jan-18	1058	43 45.40	178 36.11	E	427	437	3.02	643.2	0	45.9
72	P1	26	19-Jan-18	1521	44 03.56	178 37.91	E	816	824	2.91	38.6	0	0
73	P1	20	20-Jan-18	1731	43 27.84	178 14.55	E	340	347	2.13	862.8	0	10.2
74	P1	20	20-Jan-18	2212	43 11.78	178 01.25	E	334	351	3.01	498.1	0	1.4
75	P1	20	20-Jan-18	145	43 25.31	177 47.11	E	306	328	2.52	344.0	0	0
76	P1	20	20-Jan-18	733	43 26.28	177 32.43	E	301	317	3.00	363.9	0	1.3
77	P1	29	21-Jan-18	1151	44 16.60	178 21.50	E	1150	1173	3.26	0	0	0
78	P1	29	21-Jan-18	1539	44 25.93	178 00.67	E	1208	1210	3.01	0	0	0
79	P1	29	21-Jan-18	1739	44 29.32	177 25.20	E	1263	1289	3.01	0	0	0
80	P1	26	21-Jan-18	102	44 06.85	177 21.45	E	839	888	3.03	32.9	0	0
81	P1	26	21-Jan-18	519	44 23.11	176 42.89	E	885	909	2.95	7.3	0	0
82	P1	17	22-Jan-18	924	44 17.29	176 12.24	E	242	349	2.96	357.6	0	32.3
83	P1	17	22-Jan-18	1149	44 07.82	176 08.60	E	267	274	3.01	21571.6	0	12.2
84	P1	17	22-Jan-18	1738	44 10.93	175 50.18	E	300	342	3.04	295.8	0	81.3
85	P1	16	22-Jan-18	2356	44 03.36	175 31.49	E	511	538	2.99	1250.7	4.8	125.0
86	P1	22	23-Jan-18	321	42 55.99	174 34.30	E	915	932	2.99	59.3	0	0
87	P1	7A	23-Jan-18	641	43 09.59	174 22.90	E	589	600	2.68	226.7	5.7	41.6
88	P1	7A	23-Jan-18	1217	43 39.34	174 10.06	E	472	487	2.91	1200.9	5.2	179.0
89	P1	22	23-Jan-18	1610	43 03.32	174 04.25	E	845	868	3.03	79.2	4.6	0
90	P1	23	24-Jan-18	1944	42 49.98	174 45.69	E	1037	1044	3.02	0	2.0	0
91	P1	1	24-Jan-18	100	42 55.48	174 50.54	E	741	745	3.01	110.8	8.7	25.7
92	P1	18	24-Jan-18	505	43 06.09	175 00.26	E	348	380	2.14	412.2	0	18.9
93	P1	18	24-Jan-18	802	43 21.10	174 48.75	E	363	393	2.94	5105.9	8.2	52.5
94	P1	7A	24-Jan-18	1110	42 56.19	175 20.65	E	515	529	2.10	349.6	61.4	121.7
95	P1	22	24-Jan-18	1719	42 41.72	176 06.84	E	883	906	3.02	36.2	0	0
96	P1	1	25-Jan-18	2217	42 52.89	175 27.91	E	630	645	2.97	170.6	0	25.3
97	P1	1	25-Jan-18	202	42 53.46	175 36.52	E	627	632	3.00	152.2	10.0	96.7
98	P1	7B	25-Jan-18	608	42 59.27	175 54.08	E	537	543	2.99	152.3	5.9	104.3
99	P1	19	25-Jan-18	1152	43 05.63	176 17.02	E	384	400	2.09	137.7	0	3.6
100	P1	22	25-Jan-18	1552	42 40.92	176 22.03	E	887	892	3.01	58.6	6.8	0
101	P1	23	25-Jan-18	1954	42 37.13	176 32.48	E	1156	1181	2.99	0	0	0
102*	P1	23	25-Jan-18	2350	42 35.30	176 24.53	E	1199	1217	2.09	0	0	0
103	P1	19	26-Jan-18	856	43 04.98	177 04.99	E	315	340	2.09	76.4	0	0.4
104	P1	19	26-Jan-18	1034	43 00.40	177 13.20	E	323	352	3.16	304.3	0	30.5

Appendix 1: (continued)

						Start tow		Gear depth (m)		Dist.			Catch (kg)
Stn.	Type	Strat.	Date	Time	Latitude	Longitude	E/W	min.	max.	n.mile	hoki	hake	ling
105	P1	22	26-Jan-18	1415	42 43.04	177 25.18	E	968	976	2.95	23.3	27.8	0
106	P1	20	27-Jan-18	538	43 34.23	177 46.85	E	382	397	3.00	851.4	0	67.9
107	P1	19	27-Jan-18	837	43 26.05	177 27.53	E	270	286	2.21	23.8	0	0
108	P1	19	27-Jan-18	1135	43 18.61	177 11.04	E	219	231	2.64	0	0	0
109	P1	19	27-Jan-18	1353	43 27.60	177 09.75	E	250	275	2.98	0	0	0
110	P1	19	27-Jan-18	1727	43 26.92	176 43.77	E	253	261	3.04	3.4	0	0
111	P1	7B	28-Jan-18	538	43 09.12	175 54.38	E	405	430	3.04	359.5	93.2	23.8
112	P1	7B	28-Jan-18	738	43 14.66	175 54.14	E	414	442	2.70	267.2	1007.3	170.3
113	P1	18	28-Jan-18	937	43 19.56	175 45.31	E	301	312	2.08	1924.2	13.4	0
114	P1	18	28-Jan-18	1213	43 27.44	175 42.02	E	279	283	2.28	5087.6	0	0
115	P2	18	28-Jan-18	1545	43 28.15	175 34.28	E	205	229	2.12	272.1	0	0
116	P1	15	29-Jan-18	559	43 41.32	176 40.79	E	447	449	3.02	1129.0	16.6	149.3
117	P1	15	29-Jan-18	804	43 40.17	176 33.37	E	407	416	2.99	268.6	0	138.2
118	P1	15	29-Jan-18	1230	43 48.03	176 05.20	E	441	442	2.97	2281.7	0	65.4
119	P1	16	29-Jan-18	1424	43 49.92	175 57.08	E	462	468	2.22	1190.0	0	90.3
120	P2	18	29-Jan-18	1813	43 44.62	175 18.42	E	383	396	2.43	836.7	0	4.2
121	P1	6	30-Jan-18	554	44 33.95	174 46.55	E	750	775	3.02	59.2	0	0
122*	P1	6	30-Jan-18	1202	44 20.73	173 46.08	E	670	676	2.06	170.9	0	11.1
123	P1	6	30-Jan-18	1448	44 35.06	173 34.48	E	722	726	2.12	60.9	5.3	13.9
124	P1	16	30-Jan-18	1745	44 25.20	173 22.23	E	487	525	2.12	363.2	0	0.7
125	P1	27	31-Jan-18	39	44 47.49	172 37.16	E	916	937	3.00	5.0	0	0
126	P1	27	31-Jan-18	429	44 42.42	173 07.56	E	869	870	2.73	24.8	0	0
127	P1	6	31-Jan-18	1105	44 21.20	174 10.21	E	670	680	2.10	187.1	0	13.5
128	P1	27	31-Jan-18	1548	44 44.44	174 00.04	E	843	850	2.22	2181.4	0	0
129	P1	30	1-Feb-18	36	44 55.35	173 29.23	E	1148	1199	2.90	0	0	0
130	P1	30	1-Feb-18	410	45 01.09	173 21.97	E	1199	1213	2.29	0	0	0

Appendix 2: Scientific and common names of species caught from all tows (TAN1801). The occurrence (Occ.) of each species (number of tows caught) in all 130 tows is also shown. Note that species codes are continually updated on the database following this and other surveys.

Scientific name	Common name	Species	Occ.
Algae	unspecified seaweed	SEO	2
Porifera	unspecified sponges	ONG	5
Astrophorida (sandpaper sponges)			
Ancorinidae			
Ecionemia novaezelandiae	knobbly sandpaper sponge	ANZ	3
Geodiidae			
Geodia vestigifera	ostrich egg sponge	GVE	1
Hadromerida (woody sponges)			
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	7
Haplosclerida (air sponges)			
Callyspongiidae			
Callyspongia cf. *ramosa*	airy finger sponge	CRM	3
Spirophorida (spiral sponges)			
Tetillidae			
Tetilla australe	bristle ball sponge	TTL	1
T. leptoderma	furry oval sponge	TLD	2
Hexactinellida (glass sponges)	unspecified glass sponge	GLS	1
Hexactinosida (lacey honeycomb sponges)			
Farreidae			
Farrea sp.	lacey honeycomb sponge	FAR	1
Lyssacinosida (glass horn sponges)			
Euplectellidae			
Euplectella regalis	basket-weave horn sponge	ERE	3
Rossellidae			
Caulophacus cf. *lotifolium*		CLC	1
Hyalascus sp.	floppy tubular sponge	HYA	30
Poecilosclerida (bright sponges)			
Coelosphaeridae			
Lissodendoryx bifacialis	floppy chocolate plate sponge	LBI	6
Crellidae			
Crella incrustans	orange frond sponge	CIC	1
Hymedesmiidae			
Phorbas sp.	grey fibrous massive sponge	PHB	3
Cnidaria			
Scyphozoa	unspecified jellyfish	JFI	41
Anthozoa			
Octocorallia			
Alcyonacea (soft corals)	unspecified soft coral	SOC	1
Alcyoniidae			
Heteropolypus spp.		SOC	1
Isididae			
Keratoisis spp.	branching bamboo coral	BOO	1
Paragorgiidae			
Paragorgia spp.	bubblegum coral	PAB	2
Plexauridae	plexaurid sea fans	PLE	1
Primnoidae			
Narella spp.	rasta coral	NAR	1
Thourella spp.	bottlebrush coral	THO	3
Pennatulacea (sea pens)	unspecified sea pens	PTU	2
Funiculinidae			
Funiculina quadrangularis	rope-like sea pen	FQU	10

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Halipteridae			
Halipteris willemoesi	two-toothed sea pen	HWL	1
Pennatulidae			
Pennatula spp.	purple sea pen	PNN	3
Protoptilidae			
Distichoptilum gracile	two-lined sea pen	DGR	5
Virgulariidae			
Stylatula austropacifica	armoured sea pen	STF	1
Hexacorallia			
Zoanthidea (zoanthids)			
Epizoanthidae			
Epizoanthus sp.		EPZ	5
Corallimorpharia (coral-like anemones)			
Corallimorphidae			
Corallimorphus spp.	coral-like anemone	CLM	2
Actinaria (anemones)	unspecified anemone	ANT	3
Actiniidae			
Bolocera spp.	deepsea anemone	BOC	1
Actinostolidae (smooth deepsea anemones)		ACS	25
Hormathiidae (warty deepsea anemones)		HMT	15
Scleractinia (stony corals)			
Caryophyllidae			
Caryophyllia profunda	carnation cup coral	CAY	1
Desmophyllum dianthus	crested cup coral	DDI	6
Goniocorella dumosa	bushy hard coral	GDU	5
Flabellidae			
Flabellum spp.	flabellum coral	COF	2
Oculinidae			
Madrepora oculata	madrepora coral	MOC	1
Hydrozoa (hydroids)	unspecified hydroids	HDR	2
Anthoathecata			
Stylasteridae			
Calyptopora reticulata	white hydrocoral	CRE	2
Errina spp.	red hydrocorals	ERR	1
Leptothecata			
Lafoeidae			
Acryptolaria spp.		HDR	1
Cryptolaria prima		HDR	1
Tunicata			
Thaliacea			
Pyrosomida (pyrosomes)			
Pyrosomatidae			
Pyrosoma atlanticum		PYR	73
Salpida (salps)	unspecified salps	SAL	7
Salpidae			
Thetys vagina		ZVA	13
Mollusca			
Gastropoda (gastropods)	unspecified gastropods	GAS	1
Buccinidae (whelks)			
Aeneator recens		AER	1
Austrofusus glans	knobbed whelk	KWH	1
Ranellidae (tritons)			
Fusitriton magellanicus		FMA	3
Nudibranchia (nudibranchs)	unspecified nudibranch	NUD	3
Bivalvia (bivalves)			

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Limidae			
Acesta maui	giant file shell	AMA	1
Mytilidae			
Perna sp.	unspecified *Perna* mussels	MUS	1
Pectinidae (scallops)			
Veprichlamys kiwaensis		VKI	1
Cephalopoda			
Sepiolida (bobtail squids)			
Sepiadariidae			
Sepioloidea spp.	bobtail squid	SSQ	1
Sepiolidae			
Stoloteuthis maoria	bobtail squid	IRM	1
Teuthoidea (squids)			
Octopoteuthidae			
Octopoteuthis spp.	squid	OPO	1
Taningia spp.	squid	TDQ	1
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	52
O. robsoni	warty squid	MRQ	16
Pholidoteuthidae			
Pholidoteuthis spp.	large red scaly squid	PSQ	1
Histioteuthidae (violet squids)			
Histioteuthis spp.	violet squid	VSQ	12
Ommastrephidae	unspecified ommastrephid	OMQ	1
Nototodarus sloanii	Sloan's arrow squid	NOS	53
Todarodes filippovae	Todarodes squid	TSQ	43
Cranchiidae	unspecified cranchiid	CHQ	13
Teuthowenia pellucida	squid	TPE	1
Octopodiformes			
Octopoda			
Cirrata (cirrate octopus)			
Opisthoteuthidae			
Opisthoteuthis spp.	umbrella octopus	OPI	2
Incirrata (incirrate octopus)			
Octopodidae			
Graneledone spp.	deepwater octopus	DWO	7
Octopus spp.	octopus	OCO	1
Vampyromorpha			
Vampyroteuthidae			
Vampyroteuthis infernalis	vampire squid	VAM	1
Polychaeta			
Eunicida			
Eunicidae			
Eunice spp.	Eunice sea worm	EUN	2
Onuphidae			
Hyalinoecia tubicola	quill worm	HTU	2
Phyllodocida			
Aphroditidae			
Aphrodita spp.	sea mouse	ADT	1
Pycnogonida	unspecified sea spider	PYC	1
Crustacea			
Cirripedia (barnacles)	unspecified barnacles	BRN	1
Malacostraca			
Dendrobranchiata/Pleocyemata	unspecified prawn	NAT	1
Dendrobranchiata			

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Aristeidae			
Aristaeopsis edwardsiana	scarlet prawn	PED	1
Austropenaeus nitidus	deepwater prawn	ANI	2
Pleocyemata			
Caridea			
Campylonotidae			
Campylonotus rathbunae	sabre prawn	CAM	2
Oplophoridae			
Acanthephyra spp.	SubAntarctic ruby prawn	ACA	12
Notostomus auriculatus	scarlet prawn	NAU	1
Oplophorus novaezeelandiae	deepwater prawn	ONO	1
Oplophorus spp.	deepwater prawn	OPP	3
Pasiphaeidae			
Pasiphaea barnardi	deepwater prawn	PBA	10
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	34
Achelata			
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	27
Palinura			
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	7
Anomura			
Galatheoidea			
Chirostylidae (chirostylid squat lobsters)			
Gastroptychus spp.	squat lobster	GAT	1
Uroptychus spp.	squat lobster	URP	1
Galatheidae (galatheid squat lobsters)			
Munida gregaria	squat lobster	MGA	1
Lithodidae (king crabs)			
Lithodes aotearoa	New Zealand king crab	LAO	1
L. robertsoni	Robertson's king crab	LRO	1
Neolithodes brodiei	Brodie's king crab	NEB	3
Paralomis zealandica	Prickly king crab	PZE	1
Paguroidea (unspecified hermit crabs)		PAG	1
Lophogastrida			
Gnathophausiidae			
Neognathophausia ingens	giant red mysid	NEI	3
Brachyura (true crabs)			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	1
Goneplacidae			
Pycnoplax victoriensis	two-spined crab	CVI	4
Homolidae			
Dagnaudus petterdi	antlered crab	DAP	7
Inachidae			
Vitjazmaia latidactyla	deepsea spider crab	VIT	5
Majidae (spider crabs)			
Teratomaia richardsoni	spiny masking crab	SMK	6
Portunidae (swimming crabs)			
Ovalipes molleri	swimming crab	OVM	1
Echinodermata			
Crinoidea (sea lilies and feather stars)			
Comatulida (feather stars)	unspecified feather stars	CMT	2
Asteroidea (starfish)			

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Asteriidae			
Cosmasterias dyscrita	cat's-foot star	CDY	1
Pseudechinaster rubens	starfish	PRU	6
Sclerasterias mollis	cross-fish	SMO	6
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	27
Plutonaster knoxi	abyssal star	PKN	21
Proserpinaster neozelanicus	starfish	PNE	12
Psilaster acuminatus	geometric star	PSI	29
Benthopectinidae			
Benthopecten spp.	starfish	BES	1
Brisingida	unspecified Brisingid	BRG	19
Goniasteridae			3
Hippasteria phrygiana	trojan starfish	HTR	8
Lithosoma novaezelandiae	rock star	LNV	8
Mediaster sladeni	starfish	MSL	4
Pillsburiaster aoteanus	starfish	PAO	1
Solasteridae			
Crossaster multispinus	sun star	CJA	6
Solaster torulatus	chubby sun-star	SOT	9
Pterasteridae			
Diplopteraster sp.	starfish	DPP	2
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	42
Ophiuroidea (basket and brittle stars)	unspecified brittle star		
Ophiuridae			
Ophiomusium lymani	brittle star	OLY	4
Euryalina (basket stars)			
Gorgonocephalidae			
Gorgonocephalus spp.	Gorgon's head basket stars	GOR	7
Echinoidea (sea urchins)			
Regularia			
Cidaridae			
Goniocidaris parasol	parasol urchin	GPA	3
Histiocidaridae			
Histiocidaris spp.		HIS	2
Echinothuriidae/Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	35
Echinothuriidae (Tam O'Shanters)	unspecified Tam O'Shanter urchin	ECT	9
Phormosomatidae			
Phormosoma spp.		PHM	4
Echinidae			
Dermechinus horridus	deepsea urchin	DHO	3
Gracilechinus multidentatus	deepsea kina	GRM	21
Spatangoida (heart urchins)			
Spatangidae			
Spatangus multispinus	purple-heart urchin	SPT	13
Holothuroidea	unspecified holothurian	HTH	5
Aspidochirotida			
Synallactidae			
Bathyplotes sp.	sea cucumber	BAM	2
Pseudostichopus mollis	sea cucumber	PMO	30
Elasipodida			
Laetmogonidae			
Laetmogone sp.	sea cucumber	LAG	6
Pannychia moseleyi	sea cucumber	PAM	3
Psychropotidae			
Benthodytes sp.	sea cucumber	BTD	6

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Agnatha (jawless fishes)			
Myxinidae: hagfishes			
Eptatretus cirrhatus	hagfish	HAG	2
Chondrichthyes (cartilaginous fishes)			
Chlamydoselachidae: frilled sharks			
Chlamydoselachus anguineus	frill shark	FRS	1
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	2
Notorynchus cepedianus	broadnose sevengill shark	SEV	1
Squalidae: dogfishes			
Squalus acanthias	spiny dogfish	SPD	65
S. griffini	northern spiny dogfish	NSD	2
Centrophoridae: gulper sharks			
Centrophorus squamosus	leafscale gulper shark	CSQ	16
Deania calcea	shovelnose spiny dogfish	SND	51
Etmopteridae: lantern sharks			
Etmopterus granulosus	Baxter's dogfish	ETB	37
E. lucifer	lucifer dogfish	ETL	41
Somniosidae: sleeper sharks			
Centroselachus crepidater	longnose velvet dogfish	CYP	42
Centroscymnus owstoni	Owston’s dogfish	CYO	27
Scymnodon plunketi	Plunket's shark	PLS	7
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	8
Dalatiidae: kitefin sharks			
Dalatias licha	seal shark	BSH	22
Scyliorhinidae: cat sharks			
Apristurus ampliceps	roundfin catshark	AAM	2
A. exsanguis	New Zealand catshark	AEX	15
A. garracki	Garrick’s catshark	AGK	7
A. melanoasper	fleshynose catshark	AML	3
Bythaelurus dawsoni	Dawson's catshark	DCS	2
Cephaloscyllium isabella	carpet shark	CAR	1
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	11
Torpedinidae: electric rays			
Tetronarce nobiliana	electric ray	ERA	2
Narkidae: blind electric rays			
Typhlonarke spp.	numbfish	BER	1
Arhynchobatidae: softnose skates			
Bathraja shuntovi	longnosed deepsea skate	PSK	5
Brochiraja asperula	smooth deepsea skate	BTA	11
B. spinifera	prickly deepsea skate	BTS	14
Rajidae: skates			
Amblyraja hyperborea	deepwater spiny (Arctic) skate	DSK	2
Dipturus innominatus	smooth skate	SSK	26
Zearaja nasuta	rough skate	RSK	2
Chimaeridae: chimaeras, ghost sharks			
Chimaera carophila	brown chimaera	CHP	3
Hydrolagus bemisi	pale ghost shark	GSP	69
H. homonycteris	black ghost shark	HYB	3
H. novaezealandiae	dark ghost shark	GSH	50
H. trolli	pointynose blue ghost shark	HYP	1
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose spookfish	LCH	55
Rhinochimaera pacifica	Pacific spookfish	RCH	25

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Osteichthyes (bony fishes)			
Halosauridae: halosaurs			
Halosaurus pectoralis	common halosaur	HPE	5
Notocanthidae: spiny eels			
Notacanthus chemnitzi	giant spineback	NOC	1
N. sexspinis	spineback	SBK	60
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	28
Simenchelys parasitica	snubnosed eel	SNE	3
Nemichthyidae: snipe eels	unspecified snipe eel	NEX	1
Nemichthys curvirostris	slender snipe eel	NCU	1
Congridae: conger eels	unspecified conger eel	CON	1
Bassanago bulbiceps	swollenhead conger	SCO	28
B. hirsutus	hairy conger	HCO	26
Serrivomeridae: sawtooth eels			
Serrivomer spp.	sawtooth eel	SAW	2
Gonorynchidae: sandfish			
Gonorynchus forsteri	sandfishes	GFO	3
Argentinidae: silversides			
Argentina elongata	silverside	SSI	45
Bathylagidae: deepsea smelts			
Bathylagichthys parini	Parin's deepsea smelt	BPA	3
Bathylagus spp.	deepsea smelts	DSS	2
Melanolagus bericoides	bigscale blacksmelt	MEB	10
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	4
Alepocephalidae: slickheads			
Alepocephalus antipodianus	smallscaled brown slickhead	SSM	19
A. australis	bigscaled brown slickhead	SBI	18
Xenodermichthys copei	black slickhead	BSL	16
Diplophidae: portholefishes			
Diplophos rebainsi	twin light dragonfishes	DRB	2
Gonostomatidae: bristlemouths			
Sigmops bathyphilus	black lightfish	GBT	1
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	6
Photichthyidae: lighthouse fishes			
Phosichthys argenteus	lighthouse fish	PHO	27
Stomiidae: barbeled dragonfishes			
Chauliodus sloani	viperfish	CHA	12
Idiacanthus atlanticus	black dragonfish	IAT	10
Malacosteus australis	southern loosejaw	MAU	2
Melanostomias spp.	scaleless black dragonfishes	MEN	1
Astronesthidae: snaggletooths			
Borostomias antarcticus		BAN	2
B. mononema		BMO	1
Notosudidae: waryfishes			
Scopelosaurus spp.		SPL	1
Paralepididae: barracudinas	unspecified barracudinas	PAL	1
Macroparalepis macrogeneion	headband barracudina	MMA	1
Magnisudis prionosa	giant barracudina	BCA	1
Alepisauridae: lancetfishes			
Alepisaurus brevirostris	shortsnouted lancetfish	ABR	1
Myctophidae: lanternfishes	unspecified lanternfish	LAN	5
Diaphus danae	dana lanternfish	DDA	2
Gymnoscopelus piabilis	southern blacktip lanternfish	GYP	1
Gymnoscopelus spp.	lanternfish	GYM	3
Lampadena speculigera	mirror lanternfish	LSP	3

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Myctophidae: lanternfishes (cont.)	unspecified lanternfish	LAN	7
Lampanyctus intricarius	intricate lanternfish	LIT	8
Lampanyctus spp.	lanternfish	LPA	1
Symbolophorus boops	bogue lanternfish	SBP	1
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	1
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	7
Guttigadus nudicephalus	nakedhead codling	MOD	1
Halargyreus spp.	‘Johnson's’ cod	HJO	47
Lepidion microcephalus	small-headed cod	SMC	15
L. schmidti	Schmidt’s cod	LPS	1
Mora moro	ribaldo	RIB	34
Notophycis marginata	dwarf cod	DCO	3
Pseudophycis bachus	red cod	RCO	29
Tripterophycis gilchristi	grenadier cod	GRC	1
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	14
Chaunacidae: seatoads			
Chaunax russatus	red frogmouth	CHX	1
Melanocetidae: humpback anglerfishes			
Melanocetus johnsonii	Humpback anglerfish	MEJ	1
Ceratiidae: seadevils			
Cryptopsaras couesii	warty seadevil	SDE	2
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	112
Merluccius australis	hake	HAK	43
Ophidiidae: cuskeels			
Genypterus blacodes	ling	LIN	78
Bythitidae: viviparous brotulas			
Cataetyx niki	brown brotula	CAN	1
Macrouridae: rattails, grenadiers			
Coelorinchus acanthiger	spotty faced rattail	CTH	5
C. aspercephalus	oblique banded rattail	CAS	50
C. biclinozonalis	two saddle rattail	CBI	13
C. bollonsi	Bollons’ rattail	CBO	79
C. fasciatus	banded rattail	CFA	40
C. innotabilis	notable rattail	CIN	42
C. kaiyomaru	Kaiyomaru rattail	CKA	11
C. matamua	Mahia rattail	CMA	19
C. maurofasciatus	dark banded rattail	CDX	1
C. oliverianus	Oliver's rattail	COL	51
C. parvifasciatus	small banded rattail	CCX	13
C. trachycarus	roughhead rattail	CHY	13
Coryphaenoides dossenus	humpback rattail	CBA	6
C. murrayi	Murray’s rattail	CMU	3
C. serrulatus	serrulate rattail	CSE	29
C. striaturus	striate rattail	CTR	1
C. subserrulatus	four-rayed rattail	CSU	37
Gadomus aoteanus	filamentous rattail	GAO	3
Lepidorhynchus denticulatus	javelinfish	JAV	103
Lucigadus nigromaculatus	blackspot rattail	VNI	13
Macrourus carinatus	ridge scaled rattail	MCA	23
Mesobius antipodum	black javelinfish	BJA	14
Nezumia namatahi	squashedfaced rattail	NNA	2
Trachonurus gagates	velvet rattail	TRX	3
Trachyrincus aphyodes	white rattail	WHX	30
T. longirostris	unicorn rattail	WHR	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	2
Regalecidae: oarfishes			
Agrostichthys parkeri	ribbonfish	AGR	1
Melamphaidae: bigscalefishes			
Sio nordenskjoldii	black bigscalefish	SNO	1
Trachichthyidae: roughies, slimeheads			
Hoplostethus atlanticus	orange roughy	ORH	29
H. mediterraneus	silver roughy	SRH	24
Paratrachichthys trailli	common roughy	RHY	7
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	4
Diretmichthys parini	spinyfin	SFN	1
Anoplogastridae: fangtooth			
Anoplogaster cornuta	fangtooth	ANO	2
Berycidae: alfonsinos			
Beryx decadactylus	longfinned beryx	BYD	1
B. splendens	alfonsino	BYS	31
Melamphaidae: bigscalefishes	unspecified bigscalefish	MPH	4
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	11
Cyttus novaezealandiae	silver dory	SDO	9
C. traversi	lookdown dory	LDO	81
Zenopsis nebulosa	mirror dory	MDO	2
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	20
A. verrucosus	warty oreo	WOE	8
Neocyttus rhomboidalis	spiky oreo	SOR	31
Pseudocyttus maculatus	smooth oreo	SSO	41
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	70
Notopogon lilliei	crested bellowsfish	CBE	4
Scorpaenidae: scorpionfishes			
Helicolenus barathri	sea perch	SPE	82
Trachyscorpia eschmeyeri	Cape scorpionfish	TRS	7
Congiopodidae: pigfishes			
Congiopodus leucopaecilus	pigfish	PIG	1
Triglidae: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	9
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	26
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	16
Cottunculus nudus	bonyskull toadfish	COT	1
Neophrynichthys latus	dark toadfish	TOD	1
Psychrolutes microporos	blobfish	PSY	1
Percichthyidae: temperate basses			
Polyprion americanus	bass groper	BAS	1
P. oxygeneios	hapuku	HAP	9
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	8
Epigonidae: deepwater cardinalfishes			
Epigonus denticulatus	white cardinalfish	EPD	4
E. lenimen	bigeye cardinalfish	EPL	11
E. machaera	thin tongue cardinalfish	EPM	17
E. robustus	robust cardinalfish	ERB	8
E. telescopus	deepsea cardinalfish	EPT	17
Rosenblattia robusta	rotund cardinalfish	ROS	6

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Carangidae: trevallies, kingfishes			
Trachurus declivis	greenback jack mackerel	JMD	1
T. murphyi	slender jack mackerel	JMM	4
Bramidae: pomfrets			
Brama australis	southern Ray's bream	SRB	29
B. brama	Ray's bream	RBM	1
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	3
Plagiogeneion rubiginosum	rubyfish	RBY	2
Pentacerotidae: boarfishes, armourheads			
Pentaceros decacanthus	yellow boarfish	YBO	1
Pseudopentaceros richardsoni	southern boarfish	SBO	1
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	NMP	4
Zoarcidae: eelpouts			
Melanostigma gelatinosum	limp eel pout	EPO	2
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	GIZ	47
Pinguipedidae: sandperches, weevers			
Parapercis gilliesi	yellow cod	YCO	1
Gempylidae: snake mackerels			
Rexea solandri	gemfish	RSO	1
Thyrsites atun	barracouta	BAR	6
Trichiuridae: cutlassfishes			
Lepidopus caudatus	frostfish	FRO	5
Scombridae: mackerels, tunas			
Scomber australasicus	blue mackerel	EMA	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	8
Hyperoglyphe antarctica	bluenose	BNS	5
Seriolella caerulea	white warehou	WWA	51
S. punctata	silver warehou	SWA	53
Tubbia tasmanica	Tasmanian ruffe	TUB	2
Nomeidae: eyebrowfishes, driftfishes			
Cubiceps spp.	cubehead	CUB	3
Tetragonuridae: squaretails			
Tetragonurus cuvieri	squaretail	TET	2
Achiropsettidae: southern flounders			
Neoachiropsetta milfordi	finless flounder	MAN	6
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	6
Pleuronectidae: righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	10

Appendix 3: Scientific and common names of mesopelagic and benthic invertebrates identified following the voyage.

NIWA No.	Cruise/station_no.	Phylum	Class	Order	Family	Genus	Species
126917	TAN1801/13	Annelida	Polychaeta	Eunicida	Eunicidae	*Eunice*	sp.
126892	TAN1801/37	Arthropoda	Malacostraca	Decapoda	Aristeidae	*Austropenaeus*	*nitidus*
126881	TAN1801/25	Arthropoda	Malacostraca	Decapoda	Chirostylidae	*Uroptychus*	sp.
126879	TAN1801/25	Arthropoda	Malacostraca	Decapoda	Goneplacidae	*Pycnoplax*	*victoriensis*
126928	TAN1801/13	Arthropoda	Malacostraca	Decapoda	Homolidae	*Dagnaudus*	*petterdi*
126872	TAN1801/122	Arthropoda	Malacostraca	Decapoda	Lithodidae	*Paralomis*	*zealandica*
126895	TAN1801/67	Cnidaria	Anthozoa	Alcyonacea	Alcyoniidae	*Heteropolypus*	sp.
126913	TAN1801/129	Cnidaria	Anthozoa	Alcyonacea	Isididae	*Keratoisis*	sp.
126870	TAN1801/25	Cnidaria	Anthozoa	Alcyonacea	Primnoidae	*Narella*	*hypsocalyx*
126957	TAN1801/48	Cnidaria	Anthozoa	Alcyonacea	Primnoidae	*Thouarella*	sp.
126932	TAN1801/2	Cnidaria	Anthozoa	Pennatulacea	Halipteridae	*Halipteris*	*willemoesi*
126920	TAN1801/3	Cnidaria	Anthozoa	Pennatulacea	Pennatulidae	*Pennatula*	sp.
126964	TAN1801/97	Cnidaria	Anthozoa	Pennatulacea	Protoptilidae	*Distichoptilum*	*gracile*
126965	TAN1801/129	Cnidaria	Anthozoa	Pennatulacea	Virgulariidae	*Stylatula*	*austropacifica*
126915	TAN1801/48	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Caryophyllia*	*profunda*
126894	TAN1801/25	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Desmophyllum*	*dianthus*
126923	TAN1801/13	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Desmophyllum*	*dianthus*
126927	TAN1801/14	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Desmophyllum*	*dianthus*
126926	TAN1801/13	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Goniocorella*	*dumosa*
126929	TAN1801/14	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Goniocorella*	*dumosa*
126963	TAN1801/74	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Goniocorella*	*dumosa*
126966	TAN1801/48	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Goniocorella*	*dumosa*
126887	TAN1801/91	Cnidaria	Anthozoa	Scleractinia	Flabellidae	*Flabellum*	*knoxi*
126919	TAN1801/15	Cnidaria	Hydrozoa	Anthoathecata	Stylasteridae	*Calyptopora*	*reticulata*
126930	TAN1801/14	Cnidaria	Hydrozoa	Anthoathecata	Stylasteridae	*Calyptopora*	*reticulata*
126622	TAN1801/48	Cnidaria	Hydrozoa	Anthoathecata	Stylasteridae	*Errina*	sp.
126889	TAN1801/25	Cnidaria	Hydrozoa	Leptothecata	Lafoeidae	*Acryptolaria*	sp.
126914	TAN1801/48	Cnidaria	Hydrozoa	Leptothecata	Lafoeidae	*Cryptolaria*	*prima*
126873	TAN1801/74	Echinodermata	Asteroidea	Forcipulatida	Stichasteridae	*Pseudechinaster*	*rubens*
126967	TAN1801/122	Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Hippasteria*	*phrygiana*
126968	TAN1801/26	Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Hippasteria*	*phrygiana*
126924	TAN1801/14	Echinodermata	Echinoidea	Camarodonta	Echinidae	*Dermechinus*	*horridus*
126888	TAN1801/125	Echinodermata	Echinoidea	Camarodonta	Echinidae	*Echinus*	*multidentatus*
126886	TAN1801/74	Echinodermata	Echinoidea	Cidaroida	Histocidaridae	*Histocidaris*	sp.
126871	TAN1801/98	Echinodermata	Ophiuroidea	Euryalida	Gorgonocephalidae	*Gorgonocephalus*	sp.
126931	TAN1801/15	Echinodermata	Ophiuroidea	Euryalida	Gorgonocephalidae	*Gorgonocephalus*	sp.
126971	TAN1801/15	Echinodermata	Ophiuroidea	Euryalida	Gorgonocephalidae	*Gorgonocephalus*	sp.
126970	TAN1801/25	Echinodermata	Ophiuroidea	Euryalida	Gorgonocephalidae	*Gorgonocephalus*	sp.
126925	TAN1801/14	Mollusca	Bivalvia	Limida	Limidae	*Acesta*	*maui*
126921	TAN1801/1	Mollusca	Bivalvia	Mytilida	Mytilidae	*Perna*	sp.
126972	TAN1801/103	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Octopus*	sp.
126974	TAN1801/7	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
128472	TAN1801/77	Mollusca	Cephalopoda	Oegopsida	Octopoteuthidae	*Octopoteuthis*	sp.
126976	TAN1801/36	Mollusca	Cephalopoda	Oegopsida	Pholidoteuthidae	*Pholidoteuthis*	sp.
126973	TAN1801/112	Mollusca	Cephalopoda	Sepiida	Sepiolidae	*Iridoteuthis*	*maoria*
126975	TAN1801/25	Mollusca	Cephalopoda	Vampyromorphida	Vampyroteuthidae	*Vampyroteuthis*	*infernalis*
126877	TAN1801/25	Mollusca	Gastropoda	Neogastropoda	Buccinidae	*Aeneator*	*recens*
126916	TAN1801/48	Porifera	Demospongiae	Poecilosclerida	Crellidae	*Crella*	*incrustans*
126885	TAN1801/77	Porifera	Demospongiae	Spirophorida	Tetillidae	*Tetilla*	sp.
126874	TAN1801/74	Porifera	Demospongiae	Tetractinellida	Ancorinidae	*Ecionemia*	*novaezealandiae*
126874	TAN1801/74	Porifera	Demospongiae	Tetractinellida	Ancorinidae	*Ecionemia*	*novaezealandiae*
126896	TAN1801/48	Porifera	Demospongiae	Tetractinellida	Geodiidae	*Geodia*	*vestigifera*
126896	TAN1801/48	Porifera	Demospongiae	Tetractinellida	Geodiidae	*Geodia*	*vestigifera*
126969	TAN1801/25	Porifera	Hexactinellida	Lyssacinosida	Rossellidae	*Caulophacus*	cf. *lotifolium*

Appendix 4: Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomass values given in Figure 6 1992 and 1993 length ranges were revised from those in Stevens et al. (2017).

Survey	Age group		
	1+	2+	3++
Jan 1992	< 50	50 – 60	≥ 60
Jan 1993	< 50	50 – 60	≥ 60
Jan 1994	< 46	46 – 58	≥ 59
Jan 1995	< 46	46 – 58	≥ 59
Jan 1996	< 46	46 – 54	≥ 55
Jan 1997	< 44	44 – 55	≥ 56
Jan 1998	< 47	47 – 55	≥ 53
Jan 1999	< 47	47 – 56	≥ 57
Jan 2000	< 47	47 – 60	≥ 61
Jan 2001	< 49	49 – 59	≥ 60
Jan 2002	< 52	52 – 59	≥ 60
Jan 2003	< 49	49 – 61	≥ 62
Jan 2004	< 51	51 – 60	≥ 61
Jan 2005	< 48	48 – 64	≥ 65
Jan 2006	< 49	49 – 62	≥ 63
Jan 2007	< 48	48 – 62	≥ 63
Jan 2008	< 49	49 – 59	≥ 60
Jan 2009	< 48	48 – 61	≥ 62
Jan 2010	< 48	48 – 61	≥ 62
Jan 2011	< 48	48 – 61	≥ 62
Jan 2012	< 49	49 – 59	≥ 60
Jan 2013	< 47	47 – 54	≥ 55
Jan 2014	< 48	48 – 60	≥ 61
Jan 2016	< 49	49 – 62	≥ 62
Jan 2018	< 48	48 – 59	≥ 59