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Trawl survey of hoki and middle depth species on the Chatham Rise, January 2022 (TAN2201)

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D.W. Stevens,
S.L. Ballara,
P.C. Escobar-Flores,
R.L. O'Driscoll

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Fisheries New Zealand
Ministry for Primary Industries
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EXECUTIVE SUMMARY

Stevens, D.W.[1]; Ballara, S.L.; Escobar-Flores, P.C.; O'Driscoll, R.L. (2023). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2022 (TAN2201).

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The 27th 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 2022. A random stratified sampling design was used and 130 bottom trawls were successfully completed. These comprised 82 core (200–800 m) phase 1 biomass tows, 6 core phase 2 tows, and 42 deep (800–1300 m) tows.

Estimated relative biomass of all hoki in core strata was 97 419 t (CV 10.1%), an increase of 8.8% from January 2020. This increase was largely driven by an above average biomass estimate for 2+ year old hoki (2019 year class) of 36 036 t, one of the higher estimates in the time series. The biomass estimate for 1+ hoki (2020 year class) of 8420 t was one of the lowest in the time series. The relative biomass of recruited hoki (ages 3+ years and older) in core strata was 52 963 t, an increase of 7.7% from that in 2020. Recruited hoki were also observed in deep (800–1300 m) strata in 2022, with an estimated biomass estimate from these deeper strata of 5446 t. The relative biomass of hake in core strata increased by 59.2% to 1651 t (CV 20.4%) between 2020 and 2022 and is about the same as the 2018 estimate. The relative biomass of ling was 7293 t (CV 10.7%), 3.7% lower than that in January 2020, but the time series for ling shows no overall trend.

The age frequency distribution for hoki was dominated by 2+ year old fish, with most hoki less than age 5+. The age frequency distribution for hake was broad, with most aged between 5 and 12 years. The age distribution for ling was also broad, with most aged between 3 and 14 years.

In 2022, 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 throughout the trawl survey. As in previous surveys, there was a weak positive correlation (rho = 0.30) between acoustic density from bottom marks and trawl catch rates. The acoustic index of mesopelagic fish abundance in 2022 was 23% lower than that in 2020 and below the average for the acoustic time series (since 2001). Hoki liver condition was also lower than that in 2020 and below average in the time series of condition indices (that goes back to 2004). There was a strong positive correlation (r = 0.71) between hoki liver condition and indices of mesopelagic fish scaled by hoki abundance ("food per fish").

[1] All authors: National Institute of Water and Atmospheric Research (NIWA), New Zealand.

1. INTRODUCTION

In January 2022, the 27th 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 (EEZ). 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, 2018, 2021), 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 to 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 a current annual catch limit of 110 000 t, reduced from 115 000 t on 1 October 2021. Although managed as a single stock, hoki is assessed as two stocks in the New Zealand region, 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 2019–20 was 32 900 t, making this the second largest hoki fishery in the EEZ (behind the west coast South Island), and contributing about 31% of the total New Zealand hoki catch (Fisheries New Zealand 2022).

To manage the hoki 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 juvenile hoki. Abundance estimation of two-year old hoki provides the best index of potential recruitment to the adult fisheries, while the index of one year old hoki is also informative. The survey data from both juvenile and adult abundance are used directly in the stock assessment to estimate recruitment parameters, determine current stock size, and inform projections of future stock status. The continuation of the time series of trawl surveys on the Chatham Rise is a high priority to provide information required to update the assessment of hoki, hake, ling, and other middle depth species and to provide abundance information for a wide variety of bycatch species.

Other commercial middle depth species (particularly hake and ling) and a wide range of non-commercial fish and invertebrates are also monitored by this survey. A review of the time series estimated biomass for 142 species or groups, with 49 of these species considered relatively well estimated (coefficient of variation (CV) less than 40%) (O'Driscoll et al. 2011b). For most of these species, the trawl survey is the only fishery-independent estimate of abundance on the Chatham Rise. The survey time series fulfils an important "ecosystem monitoring" role (e.g., Tuck et al. 2009), as well as providing inputs into single-species stock assessment.

In January 2010, the survey was extended to sample deeper strata (800 to 1300 m) to 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. The 2022 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, 2018, 2021, Escobar-Flores et al. 2019). Acoustic data also provide qualitative information on the amount of backscatter that is not available to the bottom trawl, either through being off the bottom, or over areas of foul ground.

1.1 Project objectives

The trawl survey was carried out under contract to the Ministry for Primary Industries (project MID2018/01). 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 2020 and 2022 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 for determining the population age, size structure, and reproductive biology of hoki, hake, and ling on the Chatham Rise.
3. To collect data to underpin the development of assessment and monitoring capabilities for biodiversity and ecosystems.
4. To collect and preserve specimens of unidentified organisms taken during the trawl survey and identify them later ashore.
5. To sample deeper strata for deepwater species using a random trawl survey design.

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 have been caught in these strata since 2000 and 18 phase 1 tows (3 in each sub-strata) assigned to this area are no longer justified.

Station allocation for phase 1 was determined from simulations based on catch rates from all previous Chatham Rise trawl surveys (1992–2020), 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 Fisheries New Zealand target CV of 20% for 2+ hoki, and CVs of 15% for total hoki and 20% for hake. The initial allocation of 82 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 1+ and 2+ hoki biomass.

As in 2020, the 2022 survey area included 11 deep strata from 800 to 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 2010–20 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 21A–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 were 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 0512 h and 1821 h NZST. Exemption was received from Fisheries New Zealand on 7 December 2021 to carry out research trawling on known tows in the Mid Chatham Rise and the East Chatham Rise benthic protection areas (BPAs).

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/EK80 echosounders with hull-mounted transducers. All frequencies are regularly calibrated following standard procedures (Demer et al. 2015). The previous calibration of *Tangaroa* echosounders in New Zealand waters was done on 30 August 2019 in Resolution Bay, Marlborough Sounds at the start of the Campbell southern blue whiting acoustic survey (TAN1905; Ladroit et al. 2020b), with this calibration being used for any data processing. There was a more recent calibration in the Ross Sea, Antarctica, on 22 January 2021 (O'Driscoll et al. 2021). Results from the 2021 calibration were consistent with those from 2019 (values for the 38 kHz echosounder within 0.05 dB), but we chose to use the 2019 calibration values because these were obtained in environmental conditions more similar to those on the Chatham Rise.

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, orange roughy, silver warehou, ribaldo, slender jack mackerel (*Trachurus murphyi*), greenback jack mackerel (*Trachurus declivis*), barracouta, and gemfish 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. On this survey, for the first time, arrow squid were staged using a new five-stage gonad maturity scale (Appendix 5).

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 given by 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 768 hoki otoliths and 621 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 146 collected hake otoliths 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. 2021), and 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 et al. 2020a). ESP3 includes an algorithm to identify 'bad pings' in each acoustic recording. 'Bad pings' are 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 square kilometre from bottom-referenced marks were calculated for each recording, based on integration heights of 10 m, 50 m, and 100 m above the 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. 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.

We updated the mesopelagic time series to include data from 2022. 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 2022 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). Weather conditions during the survey were generally good, although on occasions, the wind reached 30 to 40 knots. About 4 hours were lost due to a strong southwest front on 27 January.

A total of 130 successful trawl survey tows were completed, comprising 82 phase 1 tows and 6 phase 2 tows in core 200–800 m strata, and 42 deep tows (Tables 1 and 2, Figure 2, Appendix 1). Five further tows were considered unsuitable for estimating abundance: stations 1 and 8 were rejected due to unsatisfactory gear performance; the generator stopped working during tow 39 and the tow exceeded the maximum allowable distance (3.85 n. miles); tow 57 was outside the stratum boundary; and tow 103 came fast. All planned phase 1 tows were carried out in core strata. Due to logistical issues arising from an 18 t catch of black oreo, one station in stratum 27 was not able to be completed. Station details for all tows are given in Appendix 1.

Five bottom trawl tows were carried out in the Mid Chatham Rise BPA and four bottom trawl tows in the East Chatham Rise BPA.

Core station density ranged from 1 per 217 km^2 in stratum 7B (400–600 m, NE of Mernoo 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 3655 km^2 in stratum 29 (1000–1300 m, southwest Chatham Rise). Mean station density was 1 per 1661 km^2 (see Table 1).

3.2 Gear performance

Gear parameters are summarised in Table 3. Doorspread and headline height readings were obtained for all 130 successful tows. Mean headline heights by 200 m depth intervals were 6.0–7.8 m, averaged 7.0 m, and were consistent with previous surveys and within the optimal range (Hurst et al. 1992) (Table 3). Mean doorspread measurements by 200 m depth intervals were 101.0–138.0 m, averaged 120.0 m, and were within the optimal range (Hurst et al. 1992).

3.3 Hydrology

Surface temperatures in 2022 were 14.4–18.1 °C (mean 16.8 °C) and bottom temperatures were 3.0–10.2 °C (mean 7.7 °C) (Figure 3). Surface temperatures within the survey area were 1.2 °C warmer on average than the 2020 survey and similar to the very warm surface temperatures observed in 2018 (Figure 4, top panel). Average bottom temperature in the core area in 2022 was slightly higher than that in 2020 and the highest observed in the time series, continuing the gradual warming trend since 2012 (Figure 4, lower panel).

3.4 Catch composition

The total catch from all 130 valid biomass stations was 158.1 t, of which 43.2 t (27.3%) was hoki, 21.0 t (13.3%) was black oreo, 20.8 t (13.2%) was silver warehou, 8.8 t (5.6%) was smooth oreo, 7.0 t (4.4%) was shovelnose dogfish, 5.3 t (3.4%) was dark ghost shark, 2.8 t (1.8%) was ling, 1.1 t (0.7%) was orange roughy, and 0.8 t (0.5%) was hake (Table 4).

Of the 336 species or species groups identified from valid biomass tows, 162 were teleosts, 34 were elasmobranchs, 31 were crustaceans, and 18 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. Ten invertebrate taxa were later identified ashore (Appendix 3).

3.5 Relative biomass estimates

3.5.1 Core strata (200–800 m)

Relative biomass in core strata was estimated for 50 species (Table 4). The CVs achieved for hoki, hake, and ling from core strata were 10.1%, 20.4%, and 10.7%, respectively. The CV for 2+ hoki (2019 year class) was 17.3%, below the target CV of 20%. High CVs (over 30%) generally occurred when species were not well sampled by the gear. For example, barracouta, frostfish, 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, hāpuku, rough skate, sea perch (*Helicolenus percoides*), and tarakihi, have high CVs because 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 22.5% higher than in 2020, but was about the same as the 2016 and 2018 estimates (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 2022 was 39.3%, 7.3% lower than in 2020 and lower than the previous 6 surveys. The next most abundant QMS species in core strata were silver warehou, spiky oreo, dark ghost shark, spiny dogfish, ling, lookdown dory, bigeye sea perch, pale ghost shark, black oreo, giant stargazer, 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, Oliver's rattail, and banded bellowsfish (Table 4).

Estimated relative biomass of hoki in the core strata in 2022 was 97 419, 8.8% higher than the hoki biomass in January 2020 (Table 5, Figures 6a, 7a, 7b). This was largely driven by an above average biomass estimate for 2+ hoki (2019 year class) of 36 036 t (Table 6, Figure 6a). The relative biomass of recruited hoki (ages 3+ years and older) was 52 963 t, 7.7% higher than in the 2020 survey and one of the higher estimates since 2000. However, the biomass estimate for 1+ hoki (2020 year class) of 8420 t was one of the lower estimates for the time series (Table 6, Figure 6a).

The relative biomass of hake in core strata was 1651 t, 37.2% higher than that in 2020, and was about the same as the 2018 estimate (Table 5, Figures 6a, 7a, 7b).

The relative biomass of ling was 7293 t, 3.7% lower than that in January 2020, and 16.7% lower than that in January 2018, although the time series for ling shows no overall trend (Figures 6a, 7a, 7b).

The relative biomass estimates for pale ghost shark and silver warehou were substantially higher than in 2020 and among the highest estimates in the time series. Dark ghost shark, sea perch (both species combined), and white warehou were higher; lookdown dory and spiny dogfish were about the same; and giant stargazer was lower than the 2020 estimate (Figures 6a, 7a, 7b).

3.5.2 Deep strata (800–1300 m)

Relative biomass and CVs were estimated for 27 species in the deep (800–1300 m) strata (Table 4). The relative biomass of orange roughy in all strata in 2022 was 1968 t, compared with 3087 t in 2020, 1302 t in 2018, and 6916 t in 2016 (Figures 6b, 7c). Although the survey was not optimised for orange roughy, there were no large catches in 2022 (the largest was 238 kg) and the precision was reasonable with a CV of 22.1%. The relative biomass estimates for black oreo was the highest in the time series due to a single catch of 18 t in stratum 27, while the estimate for smooth oreo was about the same as in 2020.

Deepwater sharks were relatively abundant in deep strata, with 49%, 94%, and 88% of the total survey biomass of shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish occurring in deep strata (Figures 6b, 7c). In 2022, bigscaled and smallscaled brown slickhead were restricted to deep strata, and basketwork eel and four-rayed rattail were almost entirely restricted to deeper strata. Spiky oreo were mainly caught in core strata (Figures 6b, 7c).

The deep strata contained 5.3% of the total survey hoki biomass, 8.3% of total survey hake biomass, and 0.7% 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 (5446 t) was largely due to a single catch of 506 kg captured in the same trawl as the 18 t of black oreo in stratum 27. Hoki catches in deep strata were highly variable and so precision of the estimate was poor with a CV of 74.4%.

3.6 Catch distribution

Spatial distribution maps of catches (Figures 8 and 9) were generally similar to those from previous surveys.

Hoki

In the 2022 survey, hoki were caught in 77 of the 88 core biomass stations. Hoki were not captured in 11 core biomass stations on the Veryan and Reserve banks (strata 17, 19, and 20); and west and east of the Chatham Islands (strata 5 and 9). The highest catch rates were at 300–400 m depths on the Reserve Bank (strata 19, 20, 14, 15) and around the Mernoo Bank (stratum 18), and 400–600 m in strata 7A, 7B, 13, and 14 (Table 7a, Figure 8). The highest individual catch of hoki in 2022 was 3924 kg on Reserve Bank in stratum 20 and was mostly 2+ hoki (Figure 8, Appendix 1). The next highest hoki catches were of 2394 kg and 1994 kg, and were also on Mernoo Bank in stratum 19 and stratum 20 (Figure 7a). The weak year class of hoki aged 1+ (2020 year class) was largely restricted to the Mernoo Bank (stratum 18) and Reserve Bank (stratum 19, 20). The above average year class of hoki aged 2+ (2019 year class) was mainly found on the western rise around Mernoo Bank and Reserve Bank (strata 18–20) and the adjacent 400–600 m strata (strata 7A, 7B, 14, 15) (Figure 8). Recruited hoki (3+ and older) were widespread, but the highest catch rates were in 400–600 m strata adjacent to the Mernoo Bank (strata 7A, 7B), Reserve Bank (strata 8A, 8B, 13, 14), and Matheson Bank (strata 10, 13), and a single catch in stratum 27 (Figure 8).

Hake

There were no large catches of hake in 2022, consistently low catches were made throughout the survey area (Figure 9). The highest catches were in 400–600 m east of Mernoo Bank in stratum 7B, the Matheson Bank in stratum 13, east of Matheson Bank in stratum 12, and east of Chatham Islands in stratum 11.

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 mainly at 400–600 m around Mernoo Bank and Reserve Bank (strata 7A,7B, 8A, 8B, 14, 15, 16).

Other species

As with previous surveys, lookdown dory, sea perch (mainly *Helicolenus barathri*), and spiny dogfish were widely distributed throughout the survey area in mainly 200–600 m depths. The highest catch rates for sea perch were taken at 200–400 m on Reserve Bank (strata 19, 20) and south of Matheson Bank (stratum 13); the highest catch rate of lookdown dory was taken in stratum 14; and the highest catch rates of spiny dogfish were taken around the Reserve Bank, Matheson Bank, and west of Chatham Islands (Figure 9). Dark ghost shark was mainly caught at 200–400 m depths on the western rise and was particularly abundant on Reserve Bank and south of Veryan Bank; 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 southeast of Mernoo Bank in stratum 18. Silver warehou and white warehou were patchily distributed at depths of 200–600 m, with the largest catch of silver warehou southwest of Chatham Islands and white warehou on eastern Reserve Bank and north of Chatham Islands (Figure 9). Javelinfish and Bollons' rattail were widely distributed throughout the survey area. The highest catch rate of javelinfish was taken south of Matheson Bank in stratum 13, and the highest catch rates of Bollons' rattail were taken on and to the south of Mernoo Bank and Reserve

Bank (Figure 7a). Ribaldo were widespread at 400–1000 m with the highest catch rates mainly to the north (Figure 9).

Orange roughy was widespread on the northern and eastern rise at 800–1300 m depths (Figure 9). The largest catch was 238 kg taken on the mid northern rise in 976 m in stratum 22 (Table 7b, Figure 9). As with previous surveys, black oreo was mostly caught on the southwest rise at 600–1000 m depths. The largest catch of black oreo was 18 000 kg from stratum 27 in 846 m (Appendix 1). Other larger catches were 561 kg from stratum 6 (southwest Rise) in 708 m and 518 kg from stratum (southeast Rise) 25 in 816 m. Smooth oreo were almost entirely taken on the southern rise at 800–1300 m depths, with the highest catch rates in stratum 25 (Table 7a, Figure 9). Spiky oreo were widespread and abundant on the northern rise at 500–850 m (Table 7a). Shovelnose dogfish, longnose velvet dogfish, and four-rayed rattail were widespread on the northern and eastern rise. Smallscaled brown slickhead were more abundant on the northern rise; Baxter's dogfish were more abundant on the southern rise; and basketwork eel and bigscaled brown slickhead were widespread (Table 7a, Figures 7c and 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 in the 2022 survey mainly comprised hoki aged 2+ (46–56 cm) and were similar to the 2014 survey (Figures 10 and 11). There were relatively few hoki aged 1+ (less than 46 cm) and few fish longer than 70 cm (Figure 10) or older than 5+ years (Figure 11). Female hoki were estimated to be more abundant than males (ratio of 1.39 female:1 male). The length ranges used to define hoki age classes are given in Appendix 4.

Hake

Length frequency and calculated number at age distributions (Figures 12 and 13) in the 2022 survey were relatively broad, although most male fish were aged 5–9 years and female fish were aged 6–12 years. Female hake were estimated to be more abundant than males (2.02 female:1 male).

Ling

Length frequency and calculated number-at-age distributions (Figures 14 and 15) in the 2022 survey indicated a wide range of lengths and ages, with most fish aged 3–14 and between 40–120 cm length. There is evidence of a period of good recruitment from 1999 to 2006 (Figure 15). There were estimated to be similar numbers of male and female ling (1.01 female:1 male).

Other species

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

Length frequencies 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 (Figures 16a and 16b).

The deep strata contained a high proportion of large longnose velvet dogfish, shovelnose dogfish, and Baxter's dogfish, and most, or all, black and smooth oreo, orange roughy, basketwork eel, bigscaled brown slickhead, four-rayed rattail, and smallscaled brown slickhead (Figure 16b). Large female deepwater dogfish (Baxter's dogfish, longnose velvet dogfish, and shovelnose dogfish) were mainly found in deep strata.

Length frequency distributions were similar for males and females of sea perch (mainly *Helicolenus barathri*), silver warehou, white warehou, orange roughy, and spiky and black oreos (Figures 16a, 16b). The length frequency distribution for orange roughy was broad and included many smaller fish, but most fish were between about 15–40 cm (Figure 16b).

The catches of Baxter's dogfish, spiny dogfish, bigscaled brown slickhead, basketwork eel, and four-rayed rattail were dominated by females (greater than 1.5 female:1 male), whereas the catch of ribaldo was dominated by males (1.46 male:1 female) (Figures 16a, 16b).

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 26% of male ling were ripe, with few females showing signs of spawning. About 61% of male hake were ripe or running ripe, but most females were immature or resting (46%) or maturing (44%) (Table 10). A high proportion of male barracouta, jack mackerel, smooth oreo, and spineback eel also appeared to be reproductively active. 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). Sloan's arrow squid (*Nototodarus sloanii*) were staged for the first time using a new five-stage gonad maturity scale; immature squid (stage 1) were rarely encountered but all other stages (preparatory to spent, stages 2 to 5) were well represented (Appendix 5).

3.8 Acoustic data quality

Acoustic data were recorded continuously throughout the survey. Over 2 TB of data were collected during trawling and steaming between stations. The substantial increase in volume of data collected compared to previous years was due to the collection of acoustic data in frequency modulated (FM, or broadband) mode at 18 and 70 kHz using the EK80 systems. Weather and sea conditions during the survey were generally very good, meaning acoustic data quality was high overall. Only 8 out of the 88 valid (i.e., those corresponding to trawls with satisfactory gear performance) core daytime trawl transects exceeded the threshold of 30% bad pings and were not suitable for quantitative analysis. Similarly, only one out of the 48 night steam transects was 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. O'Driscoll et al. (2011a) noted a consistent spatial pattern in total backscatter on the Chatham Rise, with higher backscatter in the west. This was consistent with what was observed in 2022, where the highest values were observed in the western area (Figure 17).

3.8.1 Comparison of acoustics with bottom trawl catches

Acoustic data from 80 core (200–800 m daytime) trawl files with sufficient data quality were integrated and compared with trawl catch rates (Table 11). The average acoustic backscatter value from the entire water column in 2022 was 35% lower than that in 2020, consistent with a 32% decrease in average trawl catch rate (Table 11). Average acoustic backscatter values in the bottom 10 m, 50 m, and 100 m were also lower than equivalent values in 2020 and below average compared with those from previous surveys in the time series (Table 11).

Acoustic backscatter in the bottom 100 m during the day was significantly positively correlated (Spearman's rank correlation, rho = 0.30, $p < 0.05$) with trawl catch rates (Figure 18). For previous Chatham Rise surveys between 2001 and 2020, the 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 overly high 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. For example, two tows in 2020 (stations 87 and 88) had large catches, dominated by dark ghost shark, but low acoustic backscatter (Stevens et al. 2021). Dark ghost sharks do not have a swimbladder, so are likely to be a weak acoustic target.

3.8.2 Relative mesopelagic fish abundance

In 2022, most acoustic backscatter was deeper than 200 m depth during the day. At night, a high proportion of backscatter migrated into the surface 200 m, but some remained deeper than 500 m (Figure 19). The mesopelagic peak was centred at 450–500 m in 2022, deeper than in previous years. The daytime peak observed at 750–800 m was due to a single high value recorded on a core daytime trawl (# 111 in stratum 1) (Figure 20); however, this was overrepresented because the values are proportions and a single high value has a large influence on other values. During 2001–2020, the daytime peak was typically centred at 400 m (Figure 19). The night vertical distribution was similar to the average pattern observed, where a higher proportion of backscatter remained at depth during the night than in some previous years (Figure 19).

The vertically migrating component of acoustic backscatter was assumed to be dominated by mesopelagic fish (see McClatchie & Dunford (2003) for rationale and caveats). In 2022, between 43 and 84% 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 2022 was within the range of other surveys in all sub-areas except in the northwest, where it was the lowest of the time series (Table 12).

Day estimates of total acoustic backscatter over the Chatham Rise were consistently higher than night estimates (Figure 21) because of the movement of fish into the surface dead zone (shallower than 14 m) at night (O'Driscoll et al. 2009). The exception to this general pattern occurred in 2011, when night estimates were higher than day estimates (Figure 21). However, relatively less good quality acoustic data were available from the southeast Chatham Rise in 2011 due to poor weather conditions (Stevens et al. 2012).

Total daytime backscatter in 2022 was 35% lower than that observed in 2020. Backscatter within 50 m of the bottom during the day also decreased by about 30% from 2020 and was at a similar level to that in 2003 to 2005 (Figure 21). Backscatter close to the bottom at night has been relatively low throughout the time series; backscatter showed a slight increasing trend from 2010 to 2020, with a drop in 2022 (Figure 21).

Acoustic indices of mesopelagic fish abundance are summarised in Table 13 and plotted in Figure 22 for the entire Chatham Rise and separately by the four sub-areas. The overall mesopelagic estimate for the Chatham Rise decreased by 23% from 2020 and was below average for the acoustic time series. The mesopelagic index decreased in all four sub-areas, with the highest percentage decrease (50%) in the northwest. The southeast sub-area had the highest estimated average density in 2020 and 2022, while the western areas have declined to the lowest values of the series (Figure 22). The southwest sub-area, which has been the most variable sub-area over the time series, has been decreasing since 2016 (Table 13, Figure 22).

3.9 Hoki condition

Liver condition (defined as liver weight divided by gutted weight) for all hoki on the Chatham Rise decreased by 16% from 2020 to 2022 and was below average in the time series of condition indices that goes back to 2004 (Figure 23). This decrease in overall condition was driven by hoki less than 80 cm; condition of fish greater than 80 cm was higher than that in the past two surveys (Figure 23).

Hoki condition indices on the Chatham Rise were consistently higher than those from the Sub-Antarctic trawl survey series, but this pattern is less apparent since the surveys became biennial (Figure 24). Hoki on the Chatham Rise in January 2016 and in the Sub-Antarctic in November-December 2016 were in relatively good condition. Condition indices in both areas continued to track similarly; both were lower in 2018, but increased in 2020 (Figure 24). The 2022 index from Sub-Antarctic trawl survey will be known after the survey in November–December 2022.

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 was maintained with the addition of the 2022 data (Figure 25, Pearson's correlation coefficient, $r = 0.71$, $n = 14$, $p < 0.01$).

4. CONCLUSIONS

The 2022 survey successfully extended the January Chatham Rise time series to 27 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 8.8% higher than that in 2020, due to an above average biomass estimate of 2+ hoki (2019 year class). The biomass estimate for 1+ hoki (2020 year class) was one of the lower estimates in the time series. The estimated biomass of 3++ (recruited) hoki increased by 7.7% from that in 2020, and, as in 2018 and 2020, 3++ hoki were also observed in deep water (800–1300 m).

The relative biomass of hake in core strata was 37% higher than in 2020, and about the same as the 2018 estimate. The hake estimates in the time series remain at low levels compared with the early 1990s. The relative biomass of ling in core strata was 3.7% lower than in 2020, but the time series for ling shows no overall trend.

In 2022, the survey area covered 800–1300 m depths around the entire Chatham Rise for only the fourth 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.

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7. TABLES

Table 1: The number of completed valid biomass tows (200–1300 m) by stratum during the 2022 Chatham Rise trawl survey.

Stratum number	Depth range (m)	Location	Area (km²)	Phase 1 allocation	Phase 1 stations	Phase 2 stations	Total stations	Station density (1: km²)
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		5	1:873
7B	400–600	NW Chatham Rise	869	3	3		3	1:217
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		6	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		4	1:1 172
19	200–400	Reserve Bank	9 012	7	7	3	10	1:1 287
20	200–400	Reserve Bank	9 584	6	6	3	9	1:1 198
Core	200–800		139 492	82	3	6	88	1:1 603
21A	800–1 000	NE Chatham Rise	1 249	3	3		3	1:416
21B	800–1 000	NE Chatham Rise	5 819	6	6		6	1:1 164
22	800–1 000	NW Chatham Rise	7 357	7	7		7	1:920
23	1 000–1 300	NW Chatham Rise	7 014	4	4		4	1:1 403
24	1 000–1 300	NE Chatham Rise	5 672	3	3		3	1:2 836
25	800–1 000	SE Chatham Rise	5 596	5	5		5	1:1 119
26	800–1 000	SW Chatham Rise	5 158	3	3		3	1:1 719
27	800–1 000	SW Chatham Rise	7 185	3	2		2	1:2 395
28	1 000–1 300	SE Chatham Rise	9 494	3	3		3	1:3 165
29	1 000–1 300	SW Chatham Rise	10 965	3	3		3	1:3 655
30	1 000–1 300	SW Chatham Rise	10 960	3	3		3	1:3 653
Deep	800–1 300		76 469	43	42		42	1:1 778
Total	200–1 300		215 967	125	124	6	130	1:1 661

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, 2018, 2020, and 2022. †, 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
TAN2001†	4 Jan 2020	3 Feb 2020	87
TAN2201†	4 Jan 2022	3 Feb 2022	88

Table 3: **Tow and gear parameters by depth range for valid biomass tows (TAN2201). 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)	88	2.9	0.29	2.0–3.1
Tow speed (knots)	88	3.5	0.04	3.4−3.6
All tow parameters				
Tow length (n. miles)	130	2.9	0.28	2.0–3.1
Tow speed (knots)	130	3.5	0.03	3.4−3.6
Headline height (m)				
200–400 m	35	7.0	0.36	6.2−7.8
400–600 m	37	6.7	0.34	6.0−7.5
600–800 m	16	7.0	0.26	6.5−7.4
800–1000 m	26	7.1	0.2	6.7−7.6
1000–1300 m	16	7.2	0.31	6.6−7.7
Core stations 200–800 m	88	6.8	0.38	6.0−7.8
All stations 200–1300 m	130	7.0	0.37	6.0−7.8
Doorspread (m)				
200–400 m	35	113.8	7.11	101.0−127.3
400–600 m	37	123.4	5.23	112.7−138.0
600–800 m	16	122.7	4.97	115.9−131.5
800–1000 m	26	121.6	4.92	113.7−130.2
1000–1300 m	16	120.1	3.35	111.9−124.9
Core stations 200–800 m	88	119.5	7.53	101.0−138.0
All stations 200–1300 m	130	120.0	6.70	101.0−138.0

Table 4: **Catch (kg) and 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 2022 survey core strata (200–800 m) and catch and biomass estimates for deep strata (800–1300 m). Biomass includes unsexed fish. Arranged in descending relative biomass estimates for the core strata. -, no data. * indicates hoki and the 30 key species defined by Livingston et al. (2002). Note: two species of sea perch (formerly species code SPE) are now recognised (bigeye sea perch, *H. barathri*, HBA; and sea perch, *H. percoides,* HPC).**

Species code	Common name	Catch (kg) Core	Catch (kg) Deep	Biomass (t) Core male	Biomass (t) Core female	Biomass (t) Core total	Biomass (t) Deep
HOK*	Hoki	41 718	1 495	39 793 (11.8)	57 480 (9.3)	97 419 (10.1)	5 446 (74.4)
SWA*	Silver warehou	20 794	5	24 174 (54.5)	25 713 (52.7)	49 888 (53.5)	11 (100.0)
JAV*	Javelinfish	4 430	345	1 475 (23.3)	9 750 (13.9)	11 318 (14.9)	475 (44.5)
SOR*	Spiky oreo	3 270	274	6 136 (46.0)	4 569 (44.0)	10 726 (45.0)	340 (31.2)
GSH*	Dark ghost shark	5 314	–	3 632 (19.2)	5 355 (17.6)	8 995 (17.9)	–
CBO*	Bollon's rattail	3 233	13	4 855 (16.6)	4 058 (13.0)	8 958 (12.0)	15 (50.4)
SPD*	Spiny dogfish	3 111	–	1 144 (16.8)	6 594 (11.3)	7 740 (10.9)	–
LIN*	Ling	2 753	38	2 975 (13.3)	4 318 (12.4)	7 293 (10.7)	54 (38.6)
LDO*	Lookdown dory	2 281	69	2 198 (10.1)	4 144 (13.3)	6 354 (11.0)	77 (44.4)
SND*	Shovelnose dogfish	3 140	3 826	2 331 (23.0)	3 627 (15.6)	5 961 (16.9)	5 615 (33.0)
HBA*	Bigeye sea perch	2 657	25	3 014 (16.5)	2 455 (14.6)	5 498 (15.4)	31 (53.1)
GSP*	Pale ghost shark	1 761	290	2 424 (15.5)	2 716 (10)	5 144 (11.5)	610 (20.2)
BOE*	Black oreo	1 174	19 796	2 545 (36.4)	2 548 (38.5)	5 093 (37.4)	148 440 (97.0)
COL*	Oliver's rattail	610	16	1 299 (33.1)	1 090 (25.5)	2 431 (28.3)	26 (64.8)
GIZ*	Giant stargazer	1 136	–	715 (40.7)	1 709 (28.6)	2 423 (31.3)	–
WWA*	White warehou	1 029	–	1 095 (31.3)	1 307 (33.7)	2 403 (31.6)	–
BBE	Banded bellowsfish	771	28	4 (54.2)	8 (67.7)	2 036 (24.2)	48 (53.8)
BAR*	Barracouta	704	–	965 (79.1)	901 (63.5)	1 866 (71.4)	–
HAK*	Hake	743	99	332 (21.1)	1 318 (25.2)	1 651 (20.4)	150 (42.8)
SSK	Smooth skate	431	34	392 (36.2)	606 (39.3)	1 266 (27.8)	61 (52.7)
NOS*	Arrow squid	560	1	497 (46.3)	636 (44.7)	1 139 (45.3)	2 (100.0)
OPE*	Orange perch	294	–	355 (64.4)	422 (62.6)	778 (63.0)	–
SCH*	School shark	373	–	478 (25.8)	276 (47.2)	754 (28.9)	–
CAS*	Oblique banded rattail	351	–	44 (31.5)	605 (22.4)	657 (21.8)	–
ETB	Baxter's lantern dogfish	142	825	462 (39.9)	156 (19.5)	619 (29.6)	4 333 (61.0)
RIB*	Ribaldo	228	86	172 (16.4)	359 (20.0)	532 (15.8)	113 (32.4)
JMM*	Slender mackerel	188	–	282 (54.0)	241 (51.8)	522 (52.7)	–
BYS*	Alfonsino	196	–	196 (42.8)	273 (41.9)	471 (35.9)	–
NMP*	Tarakihi	172	–	355 (84.0)	110 (58.8)	465 (72.7)	–
SSO*	Smooth oreo	122	8 667	227 (71.5)	196 (71.6)	423 (71.3)	25 344 (41.5)
BNS*	Bluenose	71	4	34 (89.4)	319 (100.0)	354 (90.7)	8 (100.0)
RCO*	Red cod	148	–	84 (47.8)	159 (38.3)	245 (38.9)	–
SRB	Southern Ray’s bream	93	–	101 (40.3)	105 (36.8)	206 (36.7)	–
HAP*	Hāpuku	81	–	52 (50.5)	125 (41.9)	177 (35.5)	–
HPC*	Sea perch	99	–	85 (57.3)	87 (59.8)	173 (58.4)	–
EPT	Deepsea cardinalfish	130	–	66 (25.5)	55 (44.3)	124 (29.1)	–
CYP	Longnose velvet dogfish	63	1 133	29 (46.8)	90 (58.4)	118 (48.1)	1 859 (24.5)
FRO	Frostfish	67	–	36 (86.5)	61 (48.8)	98 (60.7)	–
JMD	Jack mackerel	22	–	35 (64.3)	35 (81)	70 (60.1)	–
NSD	Northern spiny dogfish	23	–	–	–	70 (63.6)	–
LSO*	Lemon sole	19	–	30 (38.5)	19 (38.4)	49 (37.6)	–
SCI	Scampi	12	–	16 (25)	5 (25.6)	21 (20.0)	–
RSO	Gemfish	12	–	–	–	18 (–)	–
RBT	Redbait	8	–	8 (40.6)	9 (41.5)	17 (35.7)	–
HAS	Australasian slender cod	8	599	6 (26.3)	5 (21.2)	11 (9.4)	1 693 (23.9)
RSK	Rough skate	3	–	9 (–)	–	9 (–)	–
GUR	Red gurnard	3	–	–	–	7 (–)	–
BYD	Longfinned Beryx	2	–	7 (–)	–	7 (–)	–
ORH	Orange roughy	2	1 148	3 (65.3)	2 (100.0)	5 (69.7)	1 963 (22.1)
SBW	Southern blue whiting	2	–	3 (100.0)	1 (100.0)	4 (100.0)	–
CSU	Four–rayed rattail	2	1 002	1 (86.6)	2 (57.9)	3 (60.8)	2 057 (29.4)
RBY	Rubyfish	–	–	1 (62.0)	–	2 (48.6)	–
BEE	Basketwork eel	1	788	1 (100.0)	–	1 (100.0)	2 752 (5.8)
SBI	Bigscaled brown slickhead	–	1 126	–	–	–	4 079 (20.8)
SSM	Smallscaled brown slickhead	–	3 182	–	–	–	9 683 (34.3)

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, 2018, 2020, and 2022. 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
2020	TAN2001	87	89 557	14.4	1 037	20.1	7 577	7.9
2022	TAN2201	88	97 419	10.1	1 651	20.4	7 293	10.7

Table 6: Relative biomass estimates (t in thousands) for hoki, 200–800 m depths, Chatham Rise trawl surveys January 1992–2014, 2016, 2018, 2020, and 2022 (CV, coefficient of variation; 3++, all hoki aged 3 years and older (see Appendix 4 for length ranges used to define age classes.). YC is year class. See also Figure 6.

Survey	1+			2+			3++		Total (core)	
year	YC	Biomass	CV	YC	Biomass	CV	Biomass	CV	Biomass	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)
2020	2018	28.3	(34.2)	2017	12.3	(17.4)	48.9	(14.7)	89.6	(14.4)
2022	2020	8.4	(33.7)	2019	36.0	(17.3)	53.0	(9.0)	97.4	(10.1)

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 2022 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	1 083 (37.7)	44 (72.5)	82 (34.9)	2 (100.0)	251 (22.4)	31 (52.6)
2A	590 (38.8)	46 (38.5)	154 (29.0)	–	228 (28.5)	59 (13.5)
2B	2 611 (18.5)	178 (41.6)	295 (36.9)	–	103 (18.1)	126 (20.1)
3	1 744 (43.7)	–	48 (100.0)	950 (23.5)	–	263 (34.4)
4	1 631 (21.7)	52 (100.0)	426 (11.2)	–	579 (37.5)	254 (15.9)
5	1 280 (58.6)	–	86 (50.2)	676 (48.6)	–	177 (100.0)
6	1 590 (17.3)	23 (100.0)	375 (53.9)	–	864 (31.2)	131 (83.4)
7A	7 547 (18.6)	100 (85.2)	417 (13.9)	1 (100.0)	278 (19.3)	52 (37.4)
7B	676 (36.2)	73 (10.9)	75 (46.4)	4 (100.0)	73 (61.0)	49 (18.4)
8A	1 567 (13.1)	29 (100.0)	227 (47.6)	–	86 (46.2)	112 (10.2)
8B	2 378 (4.4)	124 (53.9)	353 (50.4)	72 (100.0)	104 (36.0)	312 (33.1)
9	1 227 (100.0)	–	42 (71.6)	159 (100.0)	–	26 (100.0)
10	4 874 (39.1)	105 (40.5)	245 (33.0)	20 (51.6)	48 (26.2)	225 (27.0)
11	4 843 (15.4)	257 (50.3)	191 (46.7)	139 (77.9)	74 (58.6)	330 (11.5)
12	2 520 (12.0)	183 (84.2)	434 (54.5)	314 (97.4)	277 (89.5)	690 (20.5)
13	9 719 (27.1)	188 (91.0)	925 (19.5)	224 (21.0)	509 (52.8)	1 136 (17.8)
14	7 950 (24.0)	55 (100.0)	554 (30.9)	20 (52.7)	437 (30.5)	716 (50.9)
15	10 167 (35.8)	33 (62.6)	915 (50.8)	89 (87.8)	206 (49.2)	347 (9.3)
16	9 434 (42.7)	123 (100.0)	663 (48.4)	13 (100.0)	1 018 (22.2)	676 (66.5)
17	1 (100.0)	–	–	244 (98.5)	–	7 (100.0)
18	3 926 (38.0)	14 (100.0)	168 (72.0)	915 (42.3)	–	110 (62.1)
19	6 337 (56.2)	–	61 (100.0)	3 140 (44.9)	–	41 (91.9)
20	13 727 (40.7)	25 (56.9)	560 (27.8)	2 013 (15.5)	9 (84.1)	484 (22.8)
Core	97 419 (10.1)	1 651 (20.4)	7 293 (10.7)	8 995 (17.9)	5 144 (11.5)	6 354 (11.0)
21A	140 (14.4)	4 (68.1)	4 (100.0)	–	19 (27.5)	19 (35.2)
21B	193 (29.2)	67 (83.3)	–	–	43 (33.0)	33 (95.7)
22	517 (52.0)	40 (48.5)	18 (70.6)	–	167 (31.8)	19 (54.1)
23	13 (100.0)	6 (100.0)	–	–	4 (100.0)	–
24	14 (54.4)	–	–	–	–	–
25	416 (56.8)	21 (100.0)	32 (50.0)	–	36 (66.8)	6 (80.0)
26	73 (35.9)	14 (100.0)	–	–	208 (5.7)	–
27	4 070 (99.2)	–	–	–	134 (80.2)	–
28	10 (100.0)	–	–	–	–	–
29	–	–	–	–	–	–
30	–	–	–	–	–	–
Deep	5 446 (74.4)	150 (42.8)	54 (38.6)	–	610 (20.2)	77 (44.4)
Total	102 865 (10.3)	1 801 (19.0)	7 347 (10.6)	8 995 (17.9)	5 754 (10.5)	6 431 (10.9)

Table 7a (continued).

	Species code					
Stratum	HBA	HPC	GIZ	SPD	SWA	WWA
1	28 (51.8)	–	6 (100.0)	–	–	–
2A	48 (46.3)	–	9 (100.0)	–	3 (100.0)	8 (100.0)
2B	38 (33.8)	–	58 (100.0)	–	–	–
3	188 (52.5)	–	55 (93.1)	456 (17.3)	7 253 (46.0)	20 (61.4)
4	41 (27.9)	–	26 (100.0)	23 (100.0)	–	26 (100.0)
5	102 (100.0)	5 (100.0)	215 (51.4)	981 (59.3)	27 173 (96.0)	16 (97.1)
6	38 (100.0)	–	–	46 (62.0)	–	63 (50.9)
7A	58 (40.0)	–	46 (62.6)	112 (58.2)	4 (100.0)	177 (99.0)
7B	22 (11.0)	–	0 (100.0)	8 (37.4)	–	–
8A	186 (17.8)	–	–	25 (78.9)	–	–
8B	192 (11.0)	–	–	43 (83.2)	–	32 (66.5)
9	–	10 (100.0)	164 (12.7)	408 (54.9)	1 125 (53.3)	8 (100.0)
10	74 (24.1)	–	5 (100.0)	238 (47.0)	–	26 (37.1)
11	222 (21.1)	–	78 (80.5)	272 (66.7)	7 (100.0)	718 (79.6)
12	95 (50.0)	–	145 (50.2)	253 (100.0)	1 826 (98.3)	9 (100.0)
13	802 (83.6)	–	50 (50.4)	692 (2.3)	32 (100.0)	255 (82.9)
14	281 (35.9)	–	99 (32.8)	845 (8.7)	313 (91.1)	5 (100.0)
15	200 (43.5)	–	148 (33.7)	390 (28.2)	402 (62.9)	172 (100.0)
16	265 (73.6)	–	63 (50.9)	597 (34.3)	3 223 (78.6)	141 (73.4)
17	23 (71.7)	0 (100.0)	35 (20.7)	5 (15.6)	– (100.0)	–
18	69 (92.3)	8 (100.0)	776 (93.4)	988 (25.8)	360 (89.5)	–
19	780 (33.8)	109 (83.7)	314 (33.4)	390 (18.4)	8 000 (37.6)	0 (100.0)
20	1 745 (18.6)	41 (100.0)	130 (51.8)	967 (27.7)	166 (56.6)	725 (49.7)
Core	5 498 (15.4)	173 (58.4)	2 423 (31.3)	7 740 (10.9)	49 888 (53.5)	2 403 (31.6)
21A	5 (54.6)	–	–	–	–	–
21B	9 (100.0)	–	–	–	–	–
22	18 (77.3)	–	–	–	–	–
23	–	–	–	–	–	–
24	–	–	–	–	–	–
25	–	–	–	–	11 (100.0)	–
26	–	–	–	–	–	–
27	–	–	–	–	–	–
28	–	–	–	–	–	–
29	–	–	–	–	–	–
30	–	–	–	–	–	–
Deep	31 (53.1)	–	–	–	11 (100.0)	–
Total	5 530 (15.3)	173 (58.4)	2 423 (31.3)	7 740 (10.9)	49 899 (53.5)	2 403 (31.6)

Table 7a (continued).

						Species code
Stratum	RIB	BOE	SSO	SOR	CSU	CBO
1	52 (16.0)	–	13 (100.0)	524 (50.7)	0 (100.0)	92 (35.8)
2A	49 (13.8)	–	–	116 (15.3)	1 (83.3)	32 (46.0)
2B	57 (43.3)	–	–	1 018 (34.8)	1 (100.0)	89 (31.7)
3	–	–	–	–	–	67 (100.0)
4	67 (51.2)	576 (100.0)	–	4 373 (99.5)	–	464 (39.5)
5	–	–	–	–	–	12 (100.0)
6	95 (48.4)	4 517 (40.2)	263 (100.0)	–	–	379 (41.8)
7A	45 (27.4)	–	–	–	–	320 (27.7)
7B	7 (57.2)	–	–	–	–	127 (25.5)
8A	14 (63.3)	–	–	–	–	270 (17.0)
8B	19 (58.8)	–	–	33 (89.9)	–	336 (36.9)
9	–	–	–	2 (100.0)	–	–
10	4 (100.0)	–	–	608 (100.0)	–	114 (70.4)
11	25 (45.7)	–	–	2 325 (64.1)	–	150 (20.2)
12	85 (56.9)	–	148 (100.0)	1 726 (72.0)	–	364 (46.6)
13	–	–	–	–	–	1 124 (11.7)
14	–	–	–	–	–	729 (35.7)
15	13 (100.0)	–	–	–	–	1 192 (29.4)
16	–	–	–	–	–	1 946 (40.3)
17	–	–	–	–	–	–
18	–	–	–	–	–	414 (80.6)
19	–	–	–	–	–	6 (100.0)
20	–	–	–	–	–	730 (40.9)
Core	532 (15.8)	5 093 (37.4)	423 (71.3)	10 726 (45.0)	3 (60.8)	8 958 (12.0)
21A	8 (50.7)	–	0 (100.0)	65 (51.7)	5 (51.0)	4 (84.0)
21B	64 (50.4)	0 (100.0)	3 (61.6)	106 (53.4)	556 (31.6)	2 (100.0)
22	25 (54.3)	–	78 (67.3)	102 (67.2)	189 (42.6)	10 (68.6)
23	–	–	16 (65.2)	–	850 (65.1)	–
24	–	–	40 (98.0)	40 (96.9)	125 (48.2)	–
25	16 (65.6)	1 232 (60.3)	9 206 (58.5)	26 (98.5)	118 (80.6)	–
26	–	2 295 (23.7)	4 469 (63.0)	–	40 (30.8)	–
27	–	144 698 (99.6)	8 654 (95.7)	–	20 (75.7)	–
28	–	33 (33.0)	2 738 (85.1)	–	146 (63.1)	–
29	–	158 (55.5)	124 (71.8)	–	8 (57.5)	–
30	–	22 (89.1)	16 (54.0)	–	1 (100.0)	–
Deep	113 (32.4)	148 440 (97.0)	25 344 (41.5)	340 (31.2)	2 057 (29.4)	15 (50.4)
Total	645 (14.2)	153 533 (93.8)	25 768 (40.9)	11 065 (43.6)	2 060 (29.3)	8 973 (12.0)

Table 7a (continued).

					Species code	
Stratum	BEE	SND	CYP	ETB	SBI	SSM
1	–	608 (48.3)	35 (60.3)	–	–	–
2A	–	2 700 (18.6)	22 (64.4)	–	–	–
2B	–	1 593 (45.6)	50 (100.0)	–	–	–
3	–	–	–	–	–	–
4	–	268 (65.4)	9 (100.0)	57 (73.3)	–	–
5	–	–	–	–	–	–
6	–	16 (100.0)	–	464 (34.9)	–	–
7A	1 (100.0)	253 (100.0)	1 (100.0)	1 (100.0)	–	–
7B	–	–	–	–	–	–
8A	–	17 (100.0)	–	–	–	–
8B	–	6 (100.0)	–	–	–	–
9	–	–	–	–	–	–
10	–	268 (82.0)	–	–	–	–
11	–	137 (63.4)	–	–	–	–
12	–	75 (60.7)	–	1 (100.0)	–	–
13	–	–	–	–	–	–
14	–	9 (100.0)	–	14 (100.0)	–	–
15	–	11 (100.0)	–	1 (100.0)	–	–
16	–	–	–	80 (91.4)	–	–
17	–	–	–	–	–	–
18	–	–	–	–	–	–
19	–	–	–	–	–	–
20	–	–	–	–	–	–
Core	1 (100.0)	5 961 (16.9)	118 (48.1)	619 (29.6)	–	–
21A	–	122 (20.7)	48 (67.3)	4 (67.4)	–	–
21B	34 (32.2)	4 211 (43.6)	844 (45.3)	12 (51.8)	40 (52.1)	1 (100.0)
22	42 (96.2)	350 (41.2)	266 (32.6)	2 (92.2)	2 (100.0)	35 (55.8)
23	450 (9.1)	6 (100.0)	27 (53.5)	58 (31.0)	1 175 (25.4)	7 172 (45.9)
24	370 (13.4)	48 (86.0)	114 (47.6)	81 (26.7)	588 (58.2)	56 (100.0)
25	63 (50.2)	730 (26.6)	358 (48.3)	278 (54.5)	–	20 (88.8)
26	276 (21.0)	19 (51.1)	89 (95.5)	240 (2.1)	1 (100.0)	144 (14.5)
27	104 (25.0)	–	106 (100.0)	3 099 (85.1)	–	104 (100.0)
28	704 (7.1)	129 (65.5)	6 (100.0)	224 (5.9)	1 102 (56.1)	1 324 (27.7)
29	443 (24.0)	–	–	216 (39.6)	828 (41.6)	534 (53.6)
30	267 (8.1)	–	–	119 (7.4)	344 (31.0)	292 (2.4)
Deep	2 752 (5.8)	5 615 (33.0)	1 859 (24.5)	4 333 (61.0)	4 079 (20.8)	9 683 (34.3)
Total	2 754 (5.8)	11 576 (18.2)	1 977 (23.2)	4 952 (53.5)	4 079 (20.8)	9 683 (34.3)

Table 7b: Estimated relative biomass (t) and coefficient of variation (% CV) for pre-recruit (small, nominally < 20 cm SL), medium, 20–30 cm, recruited (nominally > 30 cm SL), and total orange roughy for the 2022 survey. 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	–	–	–	–
2A	–	–	2 (100.0)	2 (100.0)
2B	<1 100.0	–	–	<1 100.0
3	–	–	–	–
4	–	–	–	–
5	–	–	–	–
6	–	–	–	–
7A	–	–	–	–
7B	–	–	–	–
8A	–	–	–	–
8B	–	1 (100.0)	2 (100.0)	3 (100.0)
9	–	–	–	–
10	–	–	–	–
11	–	–	–	–
12	–	–	–	–
13	–	–	–	–
14	–	–	–	–
15	–	–	–	–
16	–	–	–	–
17	–	–	–	–
18	–	–	–	–
19	–	–	–	–
20	–	–	–	–
Core	<1 100.0	1 (100.0)	4 (71.4)	5 (69.7)
21A	2 (100.0)	1 (100.0)	–	3 (100.0)
21B	14 (37.7)	151 (45.1)	391 (35.1)	557 (35.2)
22	47 (98.8)	260 (68.6)	506 (39.6)	814 (45.3)
23	4 (100.0)	23 (77.0)	63 (52.9)	91 (41.3)
24	2 (53.5)	46 (13.3)	223 (17.4)	271 (12.9)
25	16 (50.5)	49 (45.4)	70 (89.1)	135 (58.0)
26	–	–	–	–
27	–	–	–	–
28	3 (50.4)	27 (43.5)	62 (100.0)	92 (80.0)
29	–	–	–	–
30	–	–	–	–
Deep	89 (53.6)	557 (34.8)	1 317 (20.0)	1 963 (22.1)
Total	89 (53.4)	558 (34.7)	1 321 (20.0)	1 967 (22.1)

Table 8: **Total numbers of TAN2201 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. (Continued on next 2 pages)**

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Alfonsino	BYS	185	152	343	196
Arrow squid	NOS	399	408	812	408
Australasian slender cod	HAS	628	702	1 350	524
Banded bellowsfish	BBE	9	8	2 137	141
Banded rattail	CFA	234	534	798	337
Barracouta	BAR	113	100	213	67
Barracudina	BCA	1	3	4	4
Basketwork eel	BEE	286	533	827	437
Baxter's lantern dogfish	ETB	274	428	702	439
Bigeye cardinalfish	EPL	73	59	139	40
Bigeye sea perch	HBA	1 745	649	3 418	1 166
Bigscaled brown slickhead	SBI	544	890	1 442	340
Black ghost shark	HYB	2	–	2	2
Black javelinfish	BJA	24	36	61	60
Black oreo	BOE	810	820	1 631	300
Black slickhead	BSL	277	515	798	201
Blackspot rattail	VNI	3	12	20	20
Bluenose	BNS	2	4	6	6
Bollon's rattail	CBO	2 073	1 476	3 578	1 137
Brown chimaera	CHP	13	8	21	21
Bulldog catshark	APN	1	–	1	1
Cape scorpionfish	TRS	3	5	8	8
Capro dory	CDO	–	1	95	–
Carpet shark	CAR	1	2	3	3
Common halosaur	HPE	–	2	2	2
Common roughy	RHY	119	135	255	92
Crested bellowsfish	CBE	–	–	11	–
Cubehead	CUB	4	3	7	7
Dark banded rattail	CDX	7	3	10	10
Dark ghost shark	GSH	1 276	1 509	2 788	704
Dawson's catshark	DCS	1	–	1	1
Deepsea cardinalfish	EPT	180	179	369	205
Deepsea flathead	FHD	3	11	14	14
Deepwater spiny skate (Arctic skate)	DSK	–	1	1	1
Electric ray	ERA	2	–	2	2
Filamentous rattail	GAO	1	1	2	2
Finless flounder	MAN	4	4	8	8
Fleshynose catshark	AML	1	3	4	4
Four–rayed rattail	CSU	793	1 775	2 664	603
Freckled catshark	ASI	7	–	7	7
Frostfish	FRO	17	17	34	34
Garrick's catshark	AGK	1	2	3	3
Gemfish	RSO	3	2	5	5
Giant lepidion	LPI	2	–	2	2
Giant spineback	NOC	–	7	7	7
Giant stargazer	GIZ	219	206	425	287
Hairy conger	HCO	35	54	90	85
Hake	HAK	75	72	147	147
Hāpuku	HAP	18	21	39	39
Hoki	HOK	6 247	9 241	15 541	1 854
Humpback rattail (slender rattail)	CBA	–	12	13	13
Jack mackerel	JMD	12	10	22	21
Javelinfish	JAV	866	5 645	6 598	1 525
Johnson's cod	HJC	123	3	126	84
Johnson's cod	HJO	–	6	6	6
Kaiyomaru rattail	CKA	36	52	96	89
Leafscale gulper shark	CSQ	23	46	69	69
Lemon sole	LSO	24	13	37	37
Ling	LIN	430	479	909	767

Table 8 (continued).

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Long-nosed chimaera	LCH	215	273	490	408
Longfinned beryx	BYD	1	–	1	1
Longnose velvet dogfish	CYP	378	502	881	537
Longnosed deepsea skate	PSK	5	7	12	12
Lookdown dory	LDO	1 349	1 505	2 859	1 296
Lucifer dogfish	ETL	181	184	365	324
Mahia rattail	CMA	63	97	163	162
Messmate fish	ECR	–	–	38	–
Murray’s rattail	CMU	–	15	23	23
New Zealand catshark	AEX	23	14	37	37
Northern spiny dogfish	NSD	2	10	12	12
Notable rattail	CIN	239	381	651	377
Oblique banded rattail	CAS	298	1 467	1 824	557
Oliver's rattail	COL	1 114	1 233	2 489	793
Orange perch	OPE	207	210	418	151
Orange roughy	ORH	504	590	1 108	472
Pale ghost shark	GSP	572	635	1 208	839
Pigfish	PIG	6	9	16	16
Plunket's shark	PLS	7	4	11	11
Prickly deepsea skate	BTS	4	2	6	6
Prickly dogfish	PDG	1	11	12	12
Red cod	RCO	99	138	239	216
Red gurnard	GUR	1	1	2	2
Redbait	RBT	6	7	13	13
Ribaldo	RIB	132	88	220	220
Ridge scaled rattail	MCA	295	245	548	325
Rough skate	RSK	1	–	1	1
Roughhead rattail	CHY	43	39	82	81
Roundfin catshark	AAM	4	14	18	18
Rubyfish	RBY	3	1	6	6
Rudderfish	RUD	14	1	15	15
Scabbardfish	BEN	–	1	1	1
Scaly gurnard	SCG	–	–	28	–
Scampi	SCI	78	28	107	107
School shark	SCH	19	8	27	27
Sea perch	HPC	116	132	250	78
Seal shark	BSH	19	38	57	57
Serrulate rattail	CSE	267	176	447	393
Shovelnose dogfish	SND	938	981	1 920	715
Silver dory	SDO	81	73	156	54
Silver roughy	SRH	137	152	305	171
Silver warehou	SWA	1 258	1 221	2 482	606
Silverside	SSI	63	15	145	105
Slender mackerel	JMM	74	69	143	69
Small-headed cod	SMC	23	15	38	37
Smallbanded rattail	CCX	59	41	102	57
Smallscaled brown slickhead	SSM	589	594	1 187	374
Smooth deepsea skate	BTA	3	2	5	5
Smooth oreo	SSO	929	692	1 636	364
Smooth skate	SSK	13	17	35	30
Smooth skin dogfish	CYO	39	23	62	62
Southern bastard cod	SBR	–	1	1	1
Southern blue whiting	SBW	3	1	4	4
Southern Ray’s bream	SRB	34	30	64	64
Spiky oreo	SOR	1 094	863	1 991	626
Spineback	SBK	45	734	780	320
Spiny dogfish	SPD	354	1 581	1 936	897
Spottyface rattail	CTH	2	3	5	5
Squashedface rattail	NNA	–	2	4	4
Starnose black rat	NPU	1	2	3	3

Table 8 (continued).

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Striate rattail	CTR	–	1	2	2
Swollenhead conger	SCO	87	96	184	161
Tarakihi	NMP	110	30	140	52
Tasmanian ruffe	TUB	–	2	2	2
Thin tongue cardinalfish	EPM	172	157	341	157
Todarodes filippovae	TSQ	1	1	2	2
Two saddle rattail	CBI	218	292	515	219
Violet cod	VCO	96	89	186	123
Warty oreo	WOE	23	25	48	48
White rattail	WHX	178	272	454	426
White warehou	WWA	285	282	569	292
Widenosed chimaera	RCH	68	42	110	92
Witch	WIT	6	4	10	10
Yellow cod	YCO	1	–	1	–
Total	–	31 479	44 330	78 976	26 359

Table 9: Length-weight regression parameters* used to scale length frequencies (data from TAN2201). "All CHAT surveys" indicates data from all surveys were used because the r^2 value was less than 90% for TAN2201 data or n was less than 50. * W = aL^b where W is weight (g) and L is length (cm); r^2 is the correlation coefficient, n is the sample size.

Common name	Code	a (intercept)	b (slope)	r^2	n	Length range (cm)	Source
Alfonsino	BYS	0.019528	3.050235	98.45	195	17.1–47.1	tan2201
Arrow squid	NOS	0.013447	3.172955	94.96	3445	9.8–39.3	All CHAT surveys
Australasian slender cod	HAS	0.002136	3.274455	97.23	591	21.2–62.8	tan2201
Banded bellowsfish	BBE	0.002088	3.4732	95.72	138	14.3–26.7	tan2201
Banded rattail	CFA	0.001363	3.349286	89.15	1 617	16.2–39.5	All CHAT surveys
Basketwork eel	BEE	0.000822	3.076361	90.99	376	54.1–132.7	tan2201
Baxter's lantern dogfish	ETB	0.003979	3.064337	98.12	432	24.4–77.8	tan2201
Bigeye sea perch	HBA	0.009317	3.162686	97.99	1 174	14.7–48.2	tan2201
Bigscaled brown slickhead	SBI	0.002987	3.319063	92.58	306	24.7–56.8	tan2201
Black oreo	BOE	0.010747	3.198964	92.54	295	23.5–38.7	tan2201
Black slickhead	BSL	0.00747	3.008854	92.49	1 136	17.7–40.6	All CHAT surveys
Bollon's rattail	CBO	0.001555	3.332102	94.40	1 033	17.1–61	tan2201
Cardinalfishes	EPR	0.006524	3.254621	97.25	301	11.9–41.2	tan2201
Dark ghost shark	GSH	0.003123	3.156633	94.16	695	29.6–74.3	tan2201
Deepsea cardinalfish	EPT	0.006524	3.254621	97.25	301	11.9–41.2	tan2201
Four-rayed rattail	CSU	0.015753	2.416097	72.36	2 171	17.9–39.5	All CHAT surveys
Giant stargazer	GIZ	0.006559	3.228579	98.21	265	25.1–84	tan2201
Hake	HAK	0.001656	3.333529	96.76	141	60.8–133.9	tan2201
Hoki	HOK	0.003062	2.992958	98.50	1 786	32.8–110.8	tan2201
Javelinfish	JAV	0.001801	3.079533	95.41	1 347	20–60.7	tan2201
Johnson's cod	HJC	0.002136	3.274455	97.23	591	21.2–62.8	tan2201
Johnson's cod	HAS	0.002136	3.274455	97.23	591	21.2–62.8	tan2201
Ling	LIN	0.001588	3.239477	99.16	752	29.4–148	tan2201
Long-nosed chimaera	LCH	0.002696	3.040332	95.19	383	28.9–91.5	tan2201
Longnose velvet dogfish	CYP	0.002927	3.09593	98.57	511	31.2–101.5	tan2201
Lookdown dory	LDO	0.028407	2.919396	97.46	1 243	13.3–58.4	tan2201
Lucifer dogfish	ETL	0.000941	3.346992	97.94	303	13.5–53.1	tan2201
Mahia rattail	CMA	0.000572	3.538041	97.81	142	25.1–72.4	tan2201
Notable rattail	CIN	0.018326	2.383512	80.26	1 070	14.1–40.5	All CHAT surveys
Oblique banded rattail	CAS	0.00123	3.376784	96.49	503	16.7–42.1	tan2201
Oliver's rattail	COL	0.007104	2.726164	91.67	607	14.3–38.6	tan2201
Orange perch	OPE	0.024933	2.954907	92.63	131	18.6–36.8	tan2201
Orange roughy	ORH	0.048453	2.902108	99.00	463	6.9–40.6	tan2201
Pale ghost shark	GSP	0.008258	2.909591	95.39	806	35.5–88.9	tan2201
Red cod	RCO	0.008253	3.029428	98.63	204	19.3–59.8	tan2201
Ribaldo	RIB	0.005087	3.198267	97.90	208	24.8–71.1	tan2201
Ridge scaled rattail	MCA	0.00197	3.246629	97.73	313	19.2–78.3	tan2201
Robust cardinalfish	ERB	0.006524	3.254621	97.25	301	11.9–41.2	tan2201
Sea perch	HPC	0.009317	3.162686	97.99	1 174	14.7–48.2	tan2201
Serrulate rattail	CSE	0.007673	2.795595	85.79	1 270	18.6–52	All CHAT surveys
Shovelnose dogfish	SND	0.001848	3.157207	96.36	673	34.3–113	tan2201
Silver roughy	SRH	0.012991	3.223083	87.97	533	9.9–18.3	All CHAT surveys
Silver warehou	SWA	0.010236	3.147597	98.04	584	23.6–55.7	tan2201
Silverside	SSI	0.007705	2.955016	84.63	1 684	17.5–31.9	All CHAT surveys
Smallscaled brown slickhead	SSM	0.007411	3.061319	97.98	371	22.4–70.7	tan2201
Smooth oreo	SSO	0.023625	2.996526	98.22	350	16.5–51.7	tan2201
Spiky oreo	SOR	0.032302	2.890068	98.74	576	10.2–43.5	tan2201
Spineback	SBK	0.000219	3.542301	90.55	257	34.5–75	tan2201
Spiny dogfish	SPD	0.00078	3.394637	93.55	884	52.1–95.9	tan2201
Swollenhead conger	SCO	0.00023	3.494286	93.69	149	55.5–109.4	tan2201
Thin tongue cardinalfish	EPM	0.006524	3.254621	97.25	301	11.9–41.2	tan2201
Two saddle rattail	CBI	0.002292	3.198444	96.34	208	29–63.6	tan2201
Violet cod	VCO	0.001721	3.370678	97.15	123	22.8–55.1	tan2201
White rattail	WHX	0.000861	3.507725	97.70	415	23.9–93.7	tan2201
White warehou	WWA	0.017792	3.044678	98.79	238	16.7–60.4	tan2201

Table 10: Numbers of TAN2201 fish measured at each reproductive stage. 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; and female – 1, immature; 2, maturing; 3, mature; 4, gravid I; 5, gravid II; 6, post-partum. -, no data. Squid staging key is given in Appendix 5. (Continued on next 4 pages)

Species	Common		Staging	Reproductive stage							
code	name	Sex	method	1	2	3	4	5	6	7	Total
AAM	Roundfin catshark	Female	MD	1	3	7	0	3	0	0	14
		Male		3	0	1	0	0	0	0	4
AEX	New Zealand catshark	Female	MD	8	2	2	1	1	0	0	14
		Male		4	5	14	0	0	0	0	23
AGK	Garrick's catshark	Female	MD	1	1	0	0	0	0	0	2
		Male		1	0	0	0	0	0	0	1
AML	Fleshynose catshark	Female	MD	0	0	1	0	1	0	0	2
		Male		0	0	1	0	0	0	0	1
APN	Bulldog catshark	Female	MD	0	0	0	0	0	0	0	0
		Male		1	0	0	0	0	0	0	1
ASI	Freckled catshark	Female	MD	0	0	0	0	0	0	0	0
		Male		0	0	6	0	0	0	0	6
BAR	Barracouta	Female	MD	0	5	29	7	1	0	0	42
		Male		0	1	3	10	12	0	0	26
BCA	Barracudina	Female	MD	0	3	0	0	0	0	0	3
		Male		0	0	1	0	0	0	0	1
BEE	Basketwork eel	Female	MD	3	91	15	1	0	0	0	110
		Male		12	23	2	1	0	0	0	38
BEN	Scabbardfish	Female	MD	0	1	0	0	0	0	0	1
		Male		0	0	0	0	0	0	0	0
BJA	Black javelinfish	Female	MD	6	20	2	3	0	0	0	31
		Male		4	11	1	0	0	0	0	16
BNS	Bluenose	Female	MD	1	0	3	0	0	0	0	4
		Male		1	0	0	1	0	0	0	2
BOE	Black oreo	Female	MD	26	39	71	1	0	0	0	137
		Male		61	61	18	23	0	0	0	163
BSH	Seal shark	Female	SS	31	3	0	0	0	0	0	34
		Male		16	1	2	0	0	0	0	19
BSL	Black slickhead	Female	MD	7	3	44	7	0	3	0	64
		Male		1	37	3	0	0	0	0	41
BTA	Smooth deepsea skate	Female	SS	0	0	0	0	0	0	0	0
		Male		0	1	1	0	0	0	0	2
BTS	Prickly deepsea skate	Female	SS	0	0	0	0	0	0	0	0
		Male		0	2	2	0	0	0	0	4
BYD	Longfinned beryx	Female	MD	0	0	0	0	0	0	0	0
		Male		0	1	0	0	0	0	0	1
BYS	Alfonsino	Female	MD	11	50	1	0	0	0	11	73
		Male		31	35	5	0	0	0	0	71
CAR	Carpet shark	Female	SS	0	0	1	0	0	0	0	1
		Male		1	0	0	0	0	0	0	1
CAS	Oblique banded rattail	Female	MD	8	136	0	0	0	0	0	144
		Male		5	3	0	0	0	0	0	8
CBA	Humpback rattail (slender rattail)	Female	MD	0	6	2	0	0	0	0	8
		Male		0	0	0	0	0	0	0	0
CBI	Two saddle rattail	Female	MD	0	30	11	0	1	1	3	46
		Male		0	7	9	0	0	0	0	16
CBO	Bollon's rattail	Female	MD	7	165	9	0	0	0	0	181
		Male		26	166	4	0	0	0	0	196
CCX	Small banded rattail	Female	MD	0	2	7	4	0	0	0	13
		Male		4	13	3	0	0	0	0	20
CDX	Dark banded rattail	Female	MD	0	0	0	3	0	0	0	3
		Male		0	6	1	0	0	0	0	7
CFA	Banded rattail	Female	MD	4	68	0	0	0	0	0	72
		Male		16	14	0	0	0	0	0	30
CHP	Chimaera, brown	Female	SS	2	2	3	0	0	1	0	8
		Male		2	1	10	0	0	0	0	13

Table 10 (continued).

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
CHY	Roughhead rattail	Female	MD	0	2	12	0	0	0	0	14
		Male		0	15	2	0	0	0	0	17
CIN	Notable rattail	Female	MD	2	30	24	3	0	1	0	60
		Male		9	16	10	0	0	0	0	35
CKA	Kaiyomaru rattail	Female	MD	0	2	0	0	0	0	0	2
		Male		0	1	0	0	0	0	0	1
CMA	Mahia rattail	Female	MD	10	55	0	0	0	0	0	65
		Male		11	32	3	0	0	0	0	46
CMU	Abyssal rattail	Female	MD	0	10	0	0	0	0	0	10
		Male		0	0	0	0	0	0	0	0
COL	Oliver's rattail	Female	MD	13	92	0	0	0	0	0	105
		Male		14	58	2	0	0	0	0	74
CSE	Serrulate rattail	Female	MD	4	29	3	0	0	0	0	36
		Male		10	58	8	0	0	0	0	76
CSQ	Leafscale gulper shark	Female	SS	8	14	4	0	0	4	0	30
		Male		10	3	10	0	0	0	0	23
CSU	Four-rayed rattail	Female	MD	8	48	34	0	0	0	0	90
		Male		18	25	4	0	0	0	0	47
CTH	Roughhead rattail	Female	MD	0	2	0	0	0	0	0	2
		Male		0	0	0	0	0	0	0	0
CTR	Abyssal rattail	Female	MD	0	1	0	0	0	0	0	1
		Male		0	0	0	0	0	0	0	0
CYO	Smooth skin dogfish	Female	SS	9	3	6	0	1	2	0	21
		Male		3	0	36	0	0	0	0	39
CYP	Longnose velvet dogfish	Female	SS	193	36	34	6	1	15	0	285
		Male		154	15	65	0	0	0	0	234
DCS	Dawson's catshark	Female	SS	0	0	0	0	0	0	0	0
		Male		0	1	0	0	0	0	0	1
EPL	Bigeye cardinalfish	Female	MD	1	4	2	0	0	0	0	7
		Male		0	12	3	0	0	0	0	15
EPM	Thin tongue cardinalfish	Female	MD	0	0	15	5	1	0	0	21
		Male		0	9	10	0	0	0	0	19
EPT	Deepsea cardinalfish	Female	MD	36	17	0	0	0	0	0	53
		Male		48	11	1	0	0	0	0	60
ERA	Electric ray	Female	MD	0	0	0	0	0	0	0	0
		Male		0	1	1	0	0	0	0	2
ETB	Baxter's lantern dogfish	Female	SS	106	81	55	7	5	38	0	292
		Male		73	19	102	0	0	0	0	194
ETL	Lucifer dogfish	Female	SS	57	44	24	6	5	18	0	154
		Male		30	30	101	0	0	0	0	161
FHD	Deepsea flathead	Female	MD	1	4	0	0	0	0	0	5
		Male		0	2	0	0	0	0	0	2
FRO	Frostfish	Female	MD	0	0	12	5	0	0	0	17
		Male		1	0	2	6	8	0	0	17
GAO	Filamentous rattail	Female	MD	0	1	0	0	0	0	0	1
		Male		0	1	0	0	0	0	0	1
GIZ	Giant stargazer	Female	MD	10	86	47	6	1	0	4	154
		Male		14	109	19	0	0	0	0	142
GSH	Dark ghost shark	Female	SS	136	186	85	1	0	32	0	440
		Male		55	35	253	0	0	0	0	343
GSP	Pale ghost shark	Female	SS	123	147	134	7	3	46	0	460
		Male		108	49	251	0	0	0	0	408
GUR	Red gurnard	Female	MD	0	0	1	0	0	0	0	1
		Male		0	0	1	0	0	0	0	1
HAK	Hake	Female	MD	7	26	32	0	1	0	6	72
		Male		6	13	8	15	30	0	2	74
HAP	Hāpuku	Female	MD	0	19	0	0	0	0	2	21
		Male		1	16	1	0	0	0	0	18
HAS	Australasian slender cod	Female	MD	18	93	47	0	0	0	0	158
		Male		36	90	4	0	0	0	0	130
HBA	Bigeye sea perch	Female	MD	83	398	12	3	14	4	21	535
		Male		58	257	162	53	6	7	0	543

Table 10 (continued).

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
HCO	Hairy conger	Female	MD	0	8	19	5	0	0	0	32
		Male		2	11	6	0	0	0	0	19
HJC	Johnson's cod	Female	MD	0	1	1	0	0	0	0	2
		Male		2	11	26	19	1	0	0	59
HJO	Johnson's cod	Female	MD	0	5	0	0	0	0	1	6
		Male		0	0	0	0	0	0	0	0
HOK	Hoki	Female	MD	4 793	4 408	4	1	2	0	10	9 218
		Male		4 151	2 086	1	2	0	0	2	6 242
HPC	Sea perch	Female	MD	9	17	1	2	6	0	4	39
		Male		5	24	9	0	1	0	0	39
HPE	Common halosaur	Female	MD	0	0	2	0	0	0	0	2
		Male		0	0	0	0	0	0	0	0
HYB	Black ghost shark	Female	SS	0	0	0	0	0	0	0	0
		Male		0	0	2	0	0	0	0	2
JAV	Javelinfish	Female	MD	29	441	11	0	0	0	0	481
		Male		19	31	13	0	0	0	0	63
JMD	Jack mackerel	Female	MD	0	0	3	4	3	0	0	10
		Male		0	3	0	4	3	1	0	11
JMM	Slender mackerel	Female	MD	0	0	25	7	3	0	0	35
		Male		0	0	13	16	5	0	0	34
LCH	Long-nosed chimaera	Female	SS	60	88	60	5	0	20	0	233
		Male		38	35	119	0	0	0	0	192
LDO	Lookdown dory	Female	MD	47	274	280	71	0	7	30	709
		Male		105	325	101	101	1	0	0	633
LIN	Ling	Female	MD	188	267	3	1	0	0	0	459
		Male		188	97	16	108	1	0	0	410
LPI	Giant lepidion	Female	MD	0	0	0	0	0	0	0	0
		Male		0	1	1	0	0	0	0	2
LSO	Lemon sole	Female	MD	0	0	1	0	0	0	0	1
		Male		0	1	2	0	0	0	0	3
MAN	Finless flounder	Female	MD	0	2	0	0	0	0	0	2
		Male		0	1	0	0	0	0	0	1
MCA	Ridge scaled rattail	Female	MD	12	32	1	0	0	0	0	45
		Male		19	28	1	1	0	0	0	49
NMP	Tarakihi	Female	MD	1	10	8	0	0	0	0	19
		Male		0	12	10	10	0	2	0	34
NNA	Squashedface rattail	Female	MD	0	1	0	0	0	0	0	1
		Male		0	0	0	0	0	0	0	0
NOS	Arrow squid	Female	MD	4	60	55	55	18	2	0	194
		Male		2	42	57	52	38	1	1	193
NSD	Northern spiny dogfish	Female	SS	6	2	0	0	0	0	0	8
		Male		0	0	2	0	0	0	0	2
OPE	Orange perch	Female	MD	1	15	39	15	0	0	0	70
		Male		2	12	28	6	0	0	0	48
ORH	Orange roughy	Female	MD	68	53	117	0	0	0	0	238
		Male		114	41	68	0	0	0	0	223
PDG	Prickly dogfish	Female	SS	2	0	0	0	0	0	0	2
		Male		0	0	1	0	0	0	0	1
PIG	Pigfish	Female	MD	0	9	0	0	0	0	0	9
		Male		0	6	0	0	0	0	0	6
PLS	Plunket's shark	Female	SS	3	1	0	0	0	0	0	4
		Male		2	1	4	0	0	0	0	7
PSK	Longnosed deepsea skate	Female	SS	1	0	0	0	0	0	0	1
		Male		0	1	4	0	0	0	0	5
RBT	Redbait	Female	MD	0	1	5	1	0	0	0	7
		Male		0	3	2	0	1	0	0	6
RBY	Rubyfish	Female	MD	0	1	0	0	0	0	0	1
		Male		0	2	0	0	0	0	0	2
RCH	Widenosed chimaera	Female	SS	14	17	9	0	1	1	0	42
		Male		20	8	40	0	0	0	0	68
RCO	Red cod	Female	MD	42	65	1	0	0	1	3	112
		Male		39	31	7	3	0	0	1	81

Table 10 (continued).

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
RHY	Common roughy	Female	MD	0	6	1	11	0	0	0	18
		Male		0	7	8	0	0	0	0	15
RIB	Ribaldo	Female	MD	22	60	5	0	0	0	1	88
		Male		16	99	14	0	0	0	1	130
RSK	Rough skate	Female	MD	0	0	0	0	0	0	0	0
		Male		0	1	0	0	0	0	0	1
RSO	Gemfish	Female	MD	0	1	1	0	0	0	0	2
		Male		0	2	0	0	0	0	1	3
SBI	Bigscaled brown slickhead	Female	MD	20	39	108	12	2	0	3	184
		Male		14	42	33	18	1	0	0	108
SBK	Spineback	Female	MD	2	16	190	21	16	0	0	245
		Male		3	5	0	5	1	0	0	14
SBR	Southern bastard cod	Female	MD	0	1	0	0	0	0	0	1
		Male		0	0	0	0	0	0	0	0
SBW	Southern blue whiting	Female	MD	0	1	0	0	0	0	0	1
		Male		3	0	0	0	0	0	0	3
SCH	School shark	Female	SS	4	0	0	0	0	1	0	5
		Male		1	3	15	0	0	0	0	19
SCI	Scampi	Female	MD	3	6	0	0	0	0	0	9
		Male		0	0	0	0	0	0	0	0
SCO	Swollenhead conger	Female	MD	1	2	8	1	0	0	0	12
		Male		4	6	3	0	0	0	0	13
SDO	Silver dory	Female	MD	0	3	1	1	0	0	0	5
		Male		10	7	0	0	0	0	0	17
SMC	Small-headed cod	Female	MD	0	12	0	0	0	0	0	12
		Male		8	7	0	0	0	0	0	15
SND	Shovelnose dogfish	Female	SS	121	207	32	3	0	10	0	373
		Male		36	82	238	0	0	0	0	356
SOR	Spiky oreo	Female	MD	55	47	140	5	0	4	13	264
		Male		70	91	53	63	2	2	0	281
SPD	Spiny dogfish	Female	SS	120	153	30	124	290	36	0	753
		Male		10	10	120	0	0	0	0	140
SRB	Southern Ray’s bream	Female	MD	0	18	11	0	0	0	0	29
		Male		0	21	9	1	0	0	2	33
SRH	Silver roughy	Female	MD	2	23	0	0	1	0	0	26
		Male		6	35	2	0	0	0	0	43
SSI	Silverside	Female	MD	1	0	0	0	0	0	0	1
		Male		4	8	1	0	0	0	0	13
SSK	Smooth skate	Female	SS	4	3	0	0	0	0	0	7
		Male		6	4	3	0	0	0	0	13
SSM	Smallscaled brown slickhead	Female	MD	19	67	35	3	1	0	0	125
		Male		40	25	21	12	3	0	0	101
SSO	Smooth oreo	Female	MD	83	85	67	7	1	0	1	244
		Male		121	45	38	46	16	2	1	269
SWA	Silver warehou	Female	MD	38	350	38	0	0	11	3	440
		Male		48	353	26	0	0	0	0	427
TRS	Cape scorpionfish	Female	MD	0	3	0	0	0	0	0	3
		Male		0	0	0	0	0	0	0	0
TUB	Tasmanian ruffe	Female	MD	0	1	1	0	0	0	0	2
		Male		0	0	0	0	0	0	0	0
VCO	Violet cod	Female	MD	13	37	0	0	0	0	0	50
		Male		39	9	1	0	0	0	0	49
VNI	Blackspot rattail	Female	MD	0	0	0	3	0	0	0	3
		Male		0	1	0	0	0	0	0	1
WHX	White rattail	Female	MD	32	164	27	3	1	0	0	227
		Male		56	89	3	0	0	0	0	148
WIT	Witch	Female	MD	0	0	1	1	0	0	0	2
		Male		0	0	0	0	0	0	0	0
WOE	Warty oreo	Female	MD	1	6	16	1	0	0	0	24
		Male		2	10	8	2	0	0	1	23

Table 10 (continued).

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
WWA	White warehou	Female	MD	11	52	53	2	0	0	1	119
		Male		20	72	15	0	0	0	0	107
YCO	Yellow cod	Female	MD	0	0	0	0	0	0	0	0
		Male		0	1	0	0	0	0	0	1

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 2001–22.

Year	No. of recordings	Average trawl catch (kg km^{-2})	Average acoustic backscatter (m^2 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
2020	78	1 787	3.52	16.09	26.28	53.59
2022	75	1 224	2.62	11.57	18.08	34.83

Table 12: Estimates of the proportion of total day backscatter by stratum and year on the Chatham Rise that 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 dead zone.

				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
2020	0.56	0.57	0.76	0.63
2022	0.59	0.43	0.84	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 backscatter observed in the upper 200 m in the same sub-area (see Table 12) corrected for the estimated proportion in the surface dead zone (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 by 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
tan2001	2020	32.2	7	22.8	12	34.9	13	50.6	13	26.1	15	34.9	8
tan2201	2022	20.1	8	17.6	13	17.5	12	42.6	22	17.6	19	26.7	5

8. FIGURES

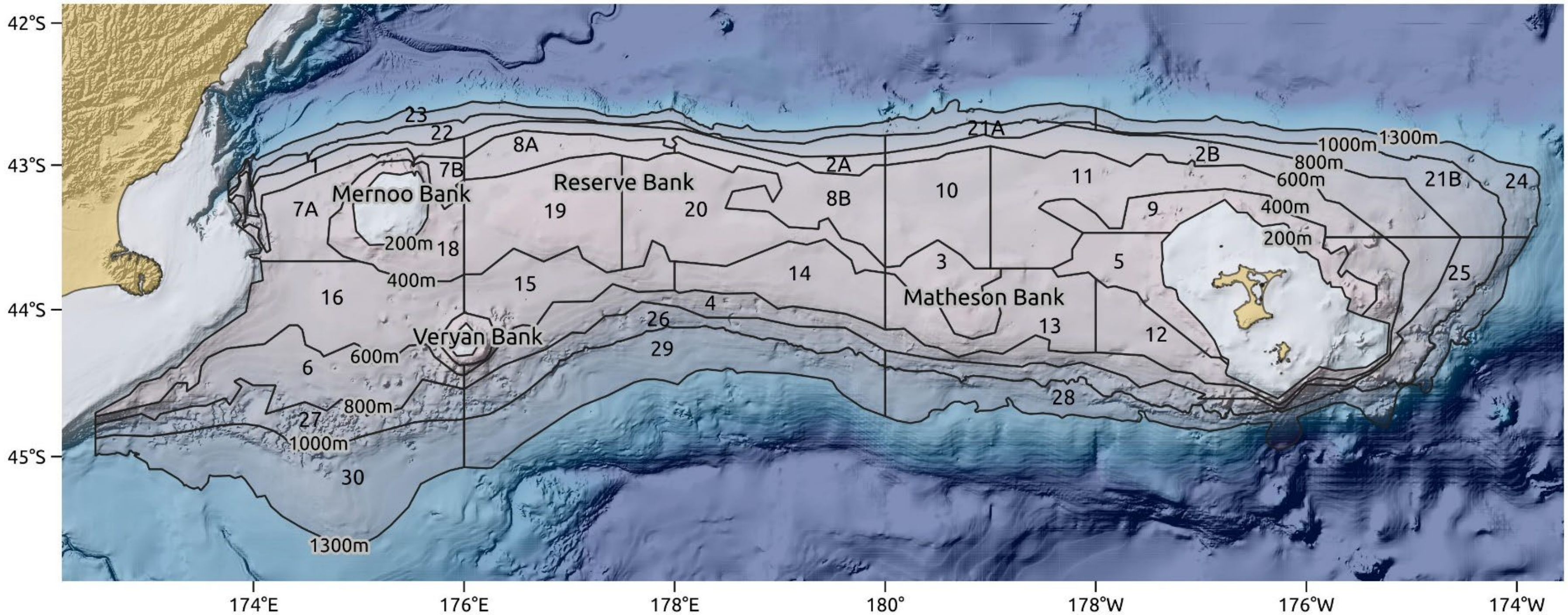


Figure 1: Chatham Rise trawl survey area showing stratum boundaries.

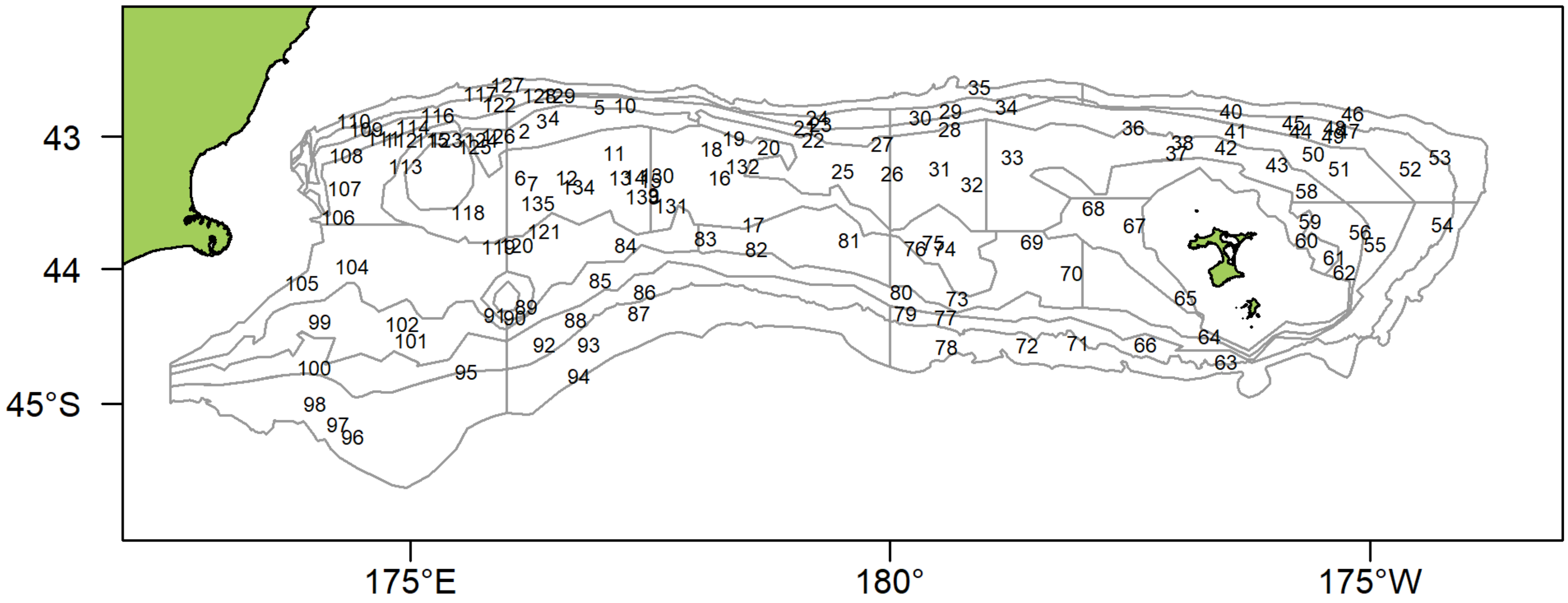


Figure 2: Trawl survey area showing positions of valid biomass stations (n = 130 stations) for TAN2201. In this and subsequent figures, actual stratum boundaries are drawn for the deepwater strata.

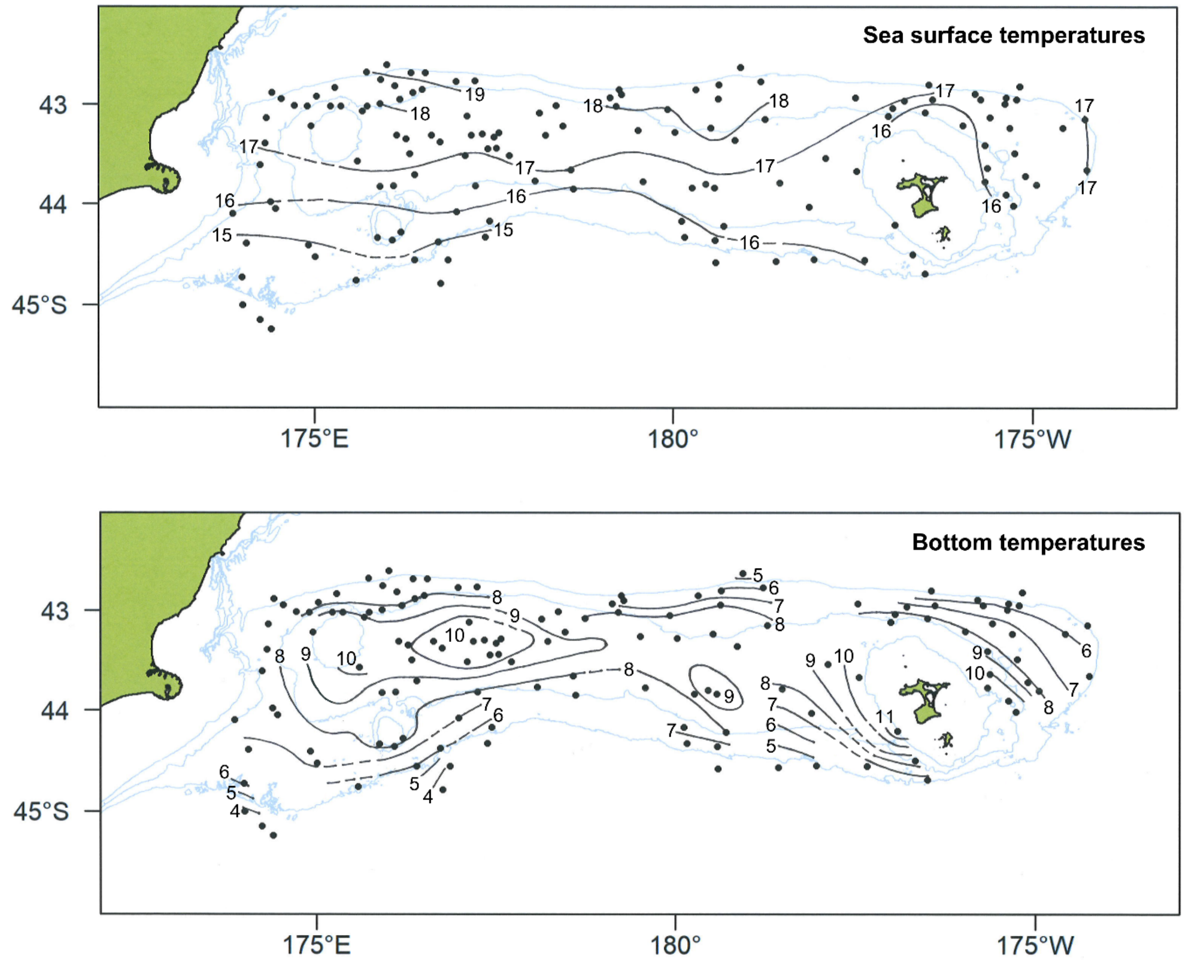
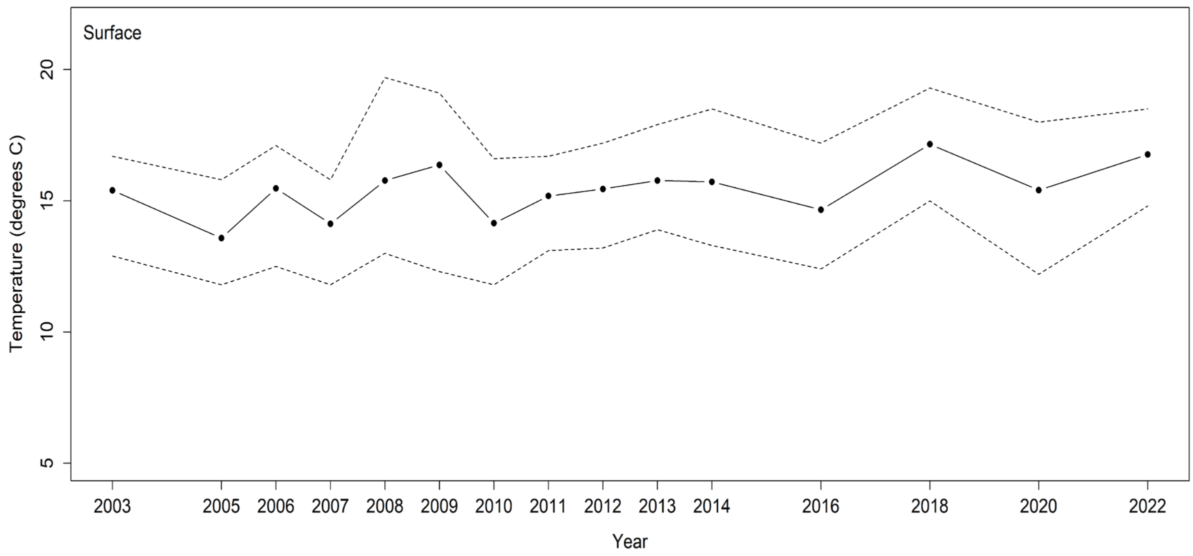


Figure 3: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (°C), interpolated by eye, for TAN2201. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow.



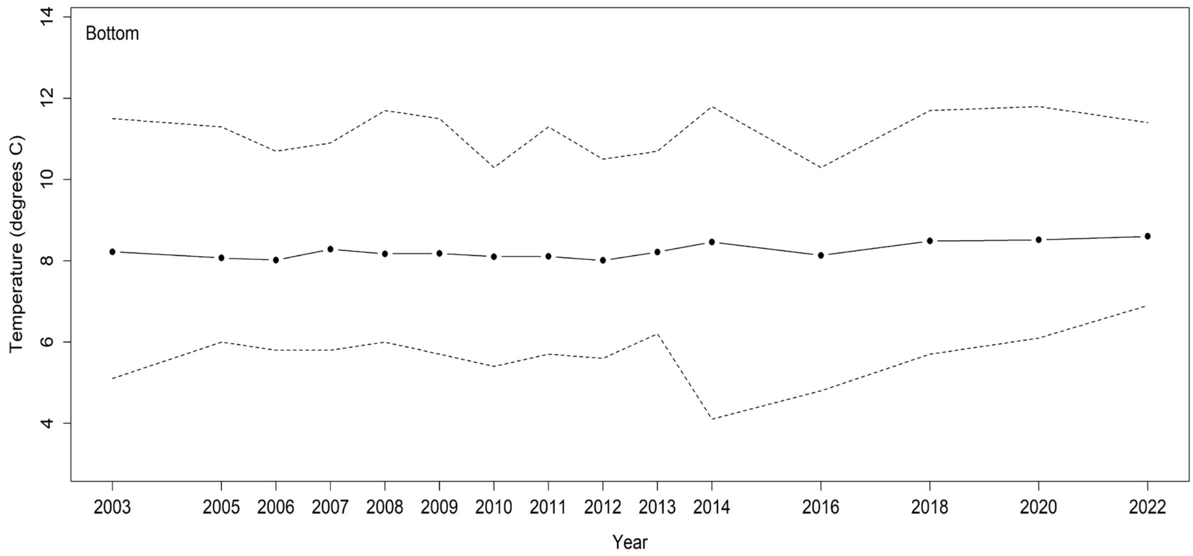


Figure 4: Time series of sea surface (upper panel) and bottom (lower panel) temperature recordings within the core (200–800 m) survey area from the calibrated Seabird CTD recordings made during each tow. Solid line is the mean temperature. Dashed lines are minimum and maximum values in each year.

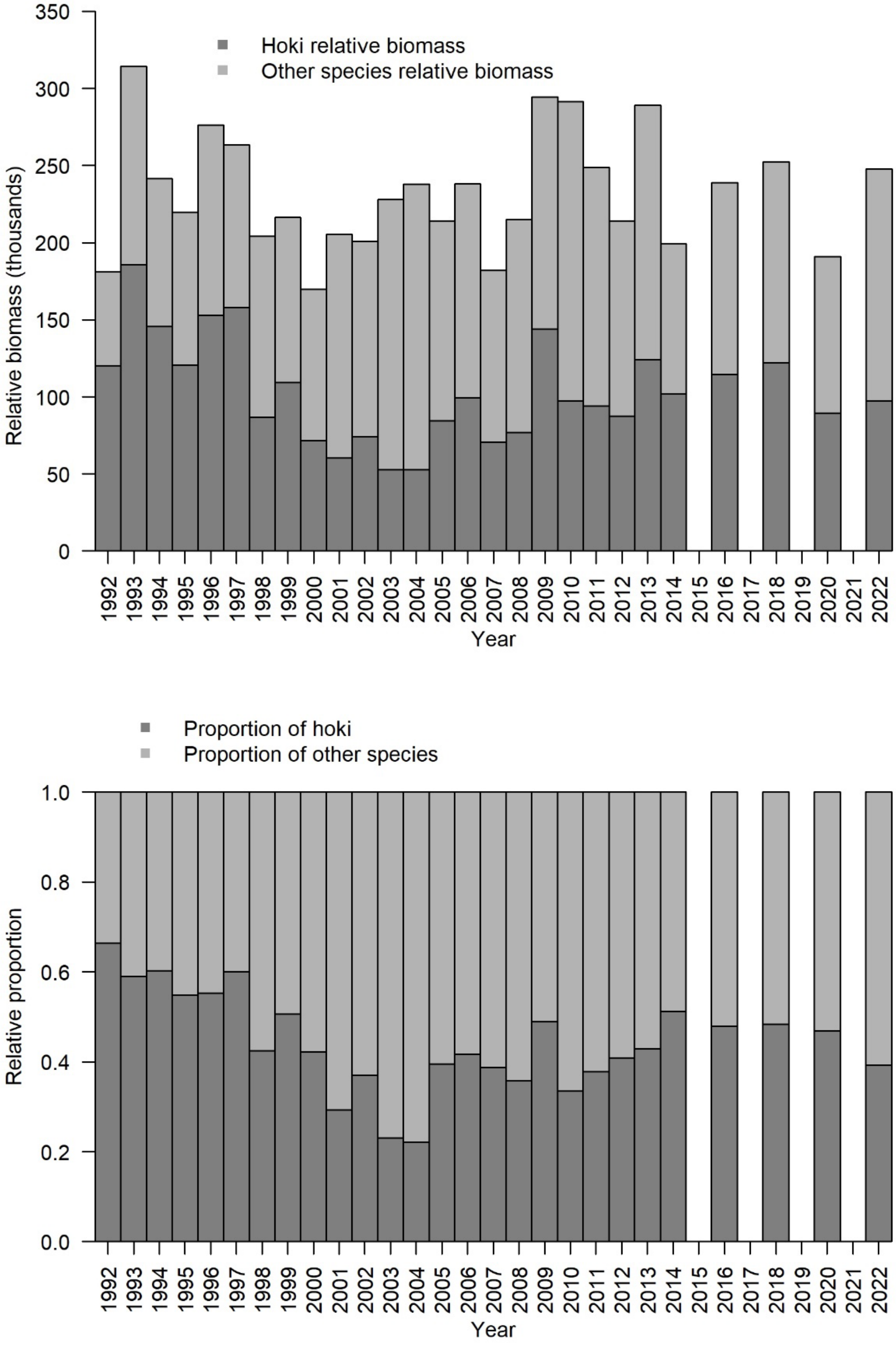


Figure 5: Relative biomass (top panel) and relative proportions (lower panel) of hoki and 30 other key species, as defined by Livingston et al. (2002) and indicated in Table 4, from trawl surveys of the Chatham Rise, January 1992–2022 (core strata only).

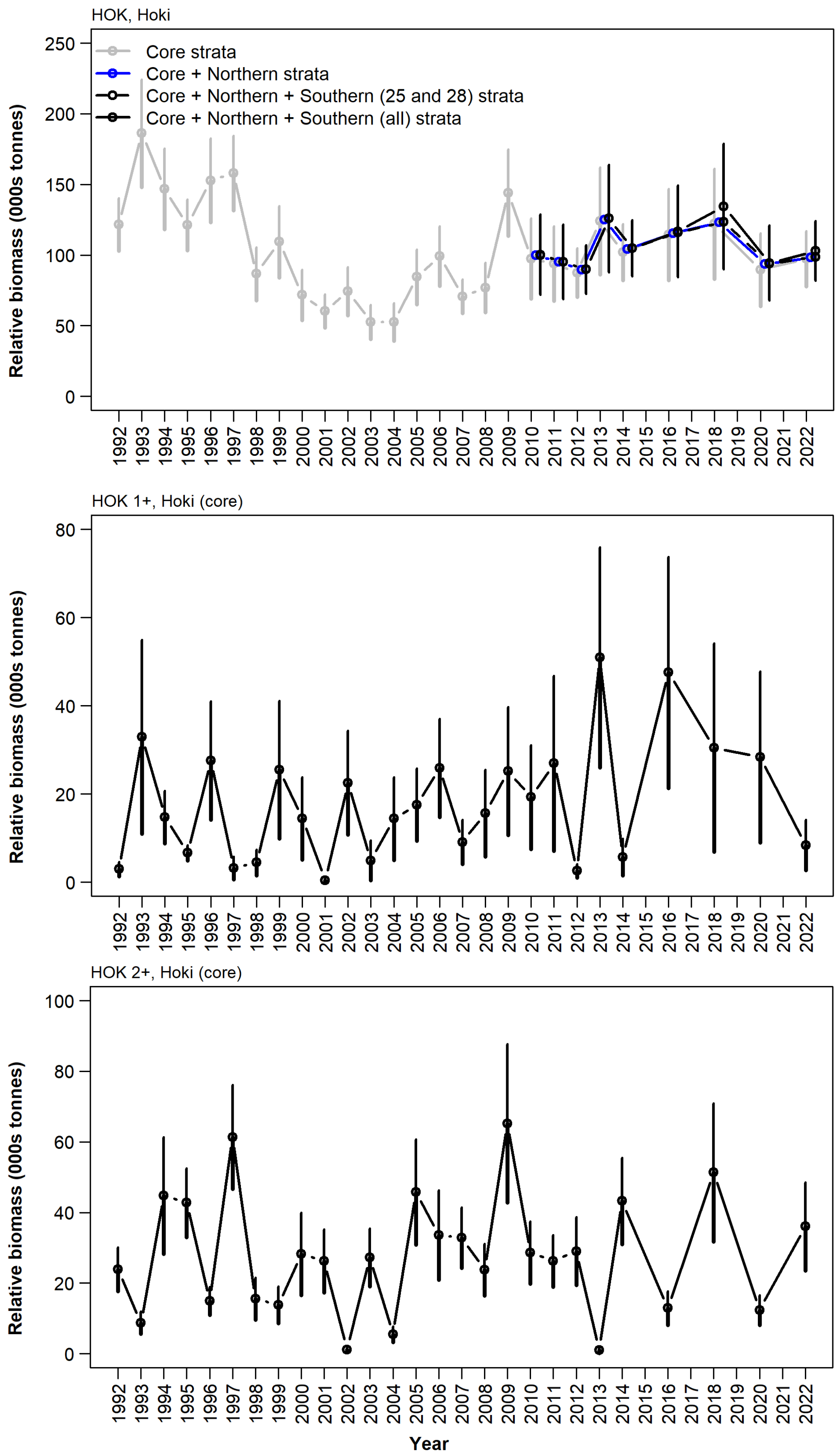


Figure 6a: Relative biomass estimates (thousands of tonnes) of hoki, hake, ling, and 8 other selected commercial species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022 (core and all strata). Error bars show ± 2 standard errors.

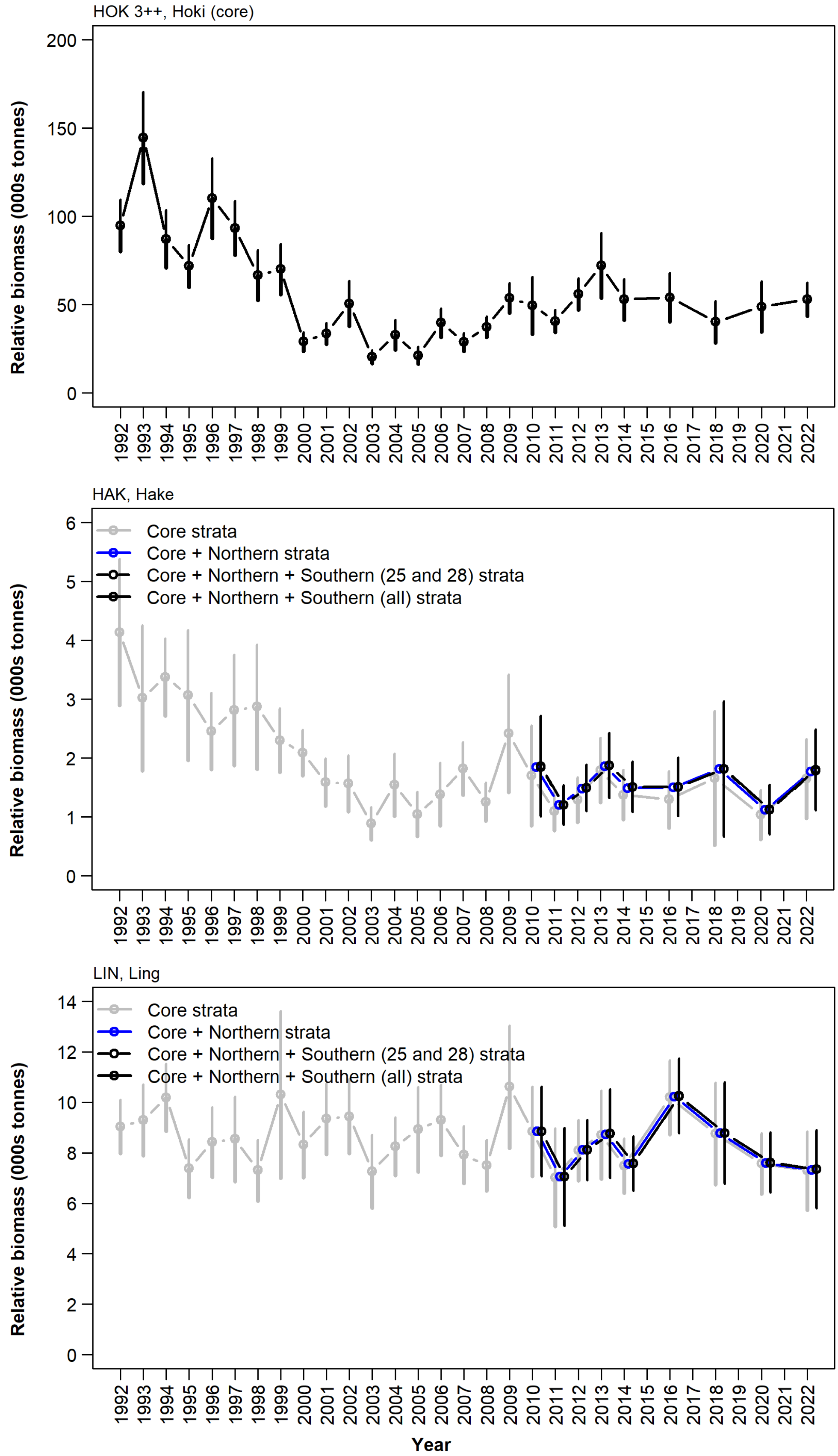
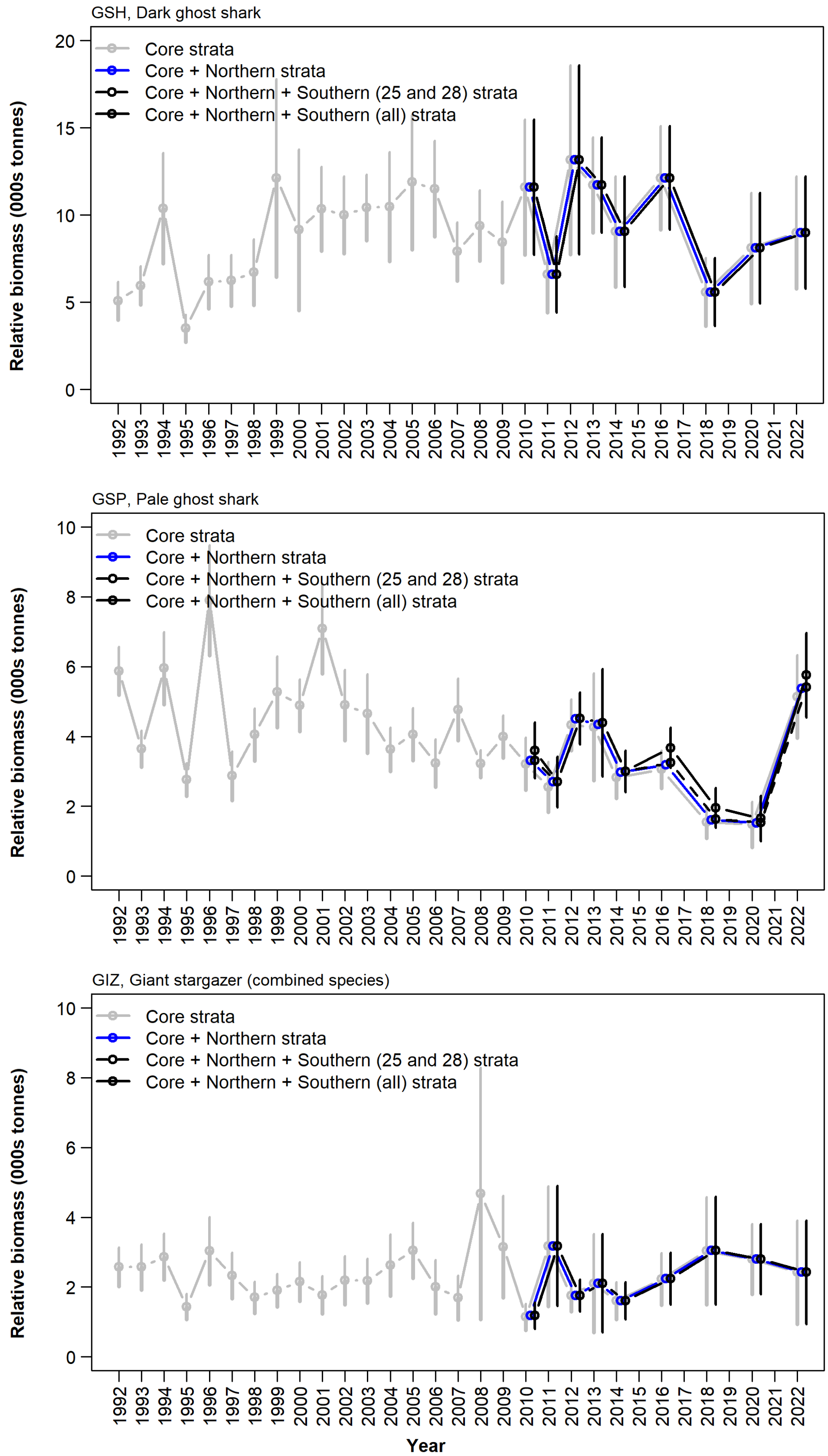


Figure 6a (continued).



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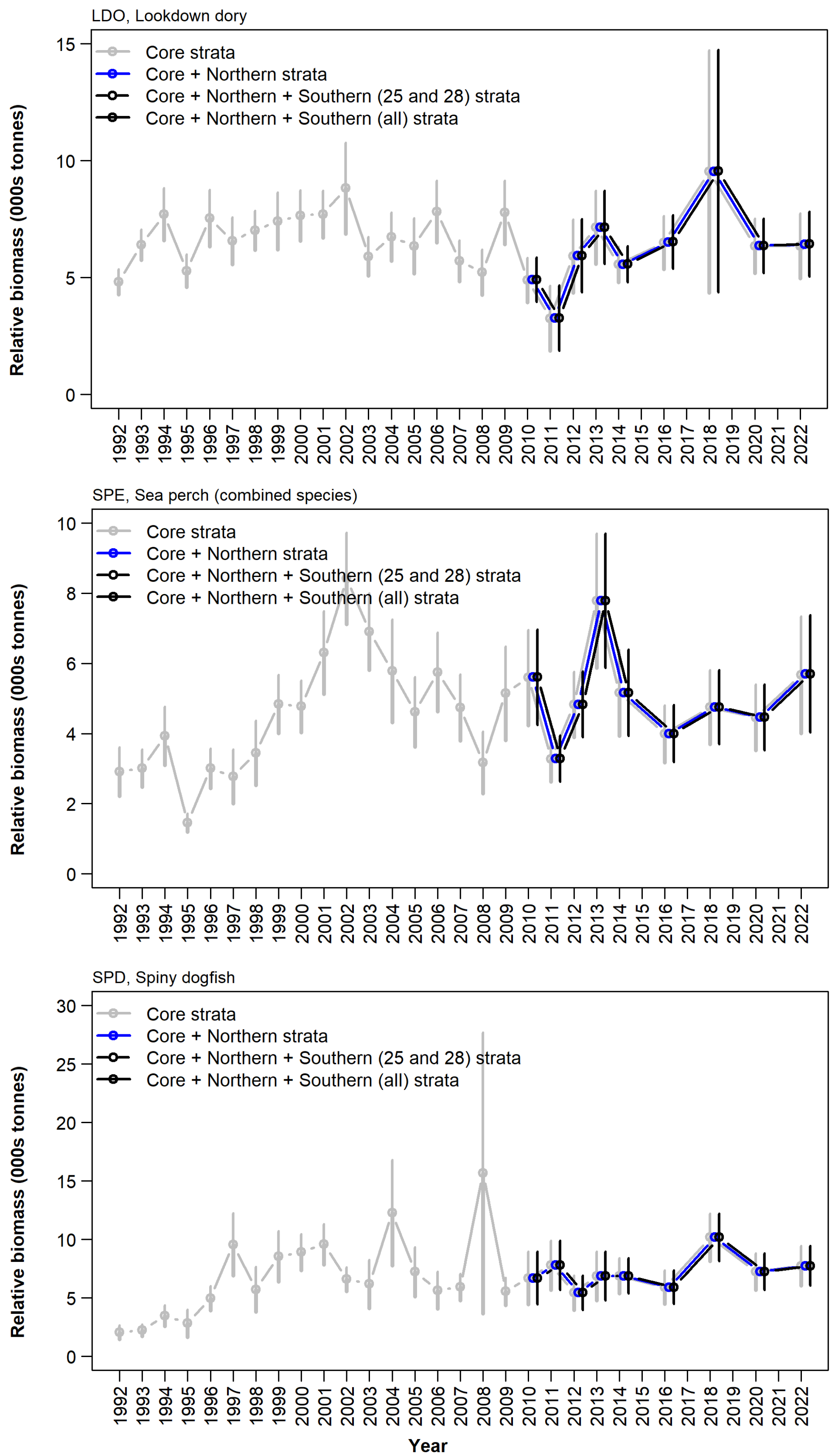

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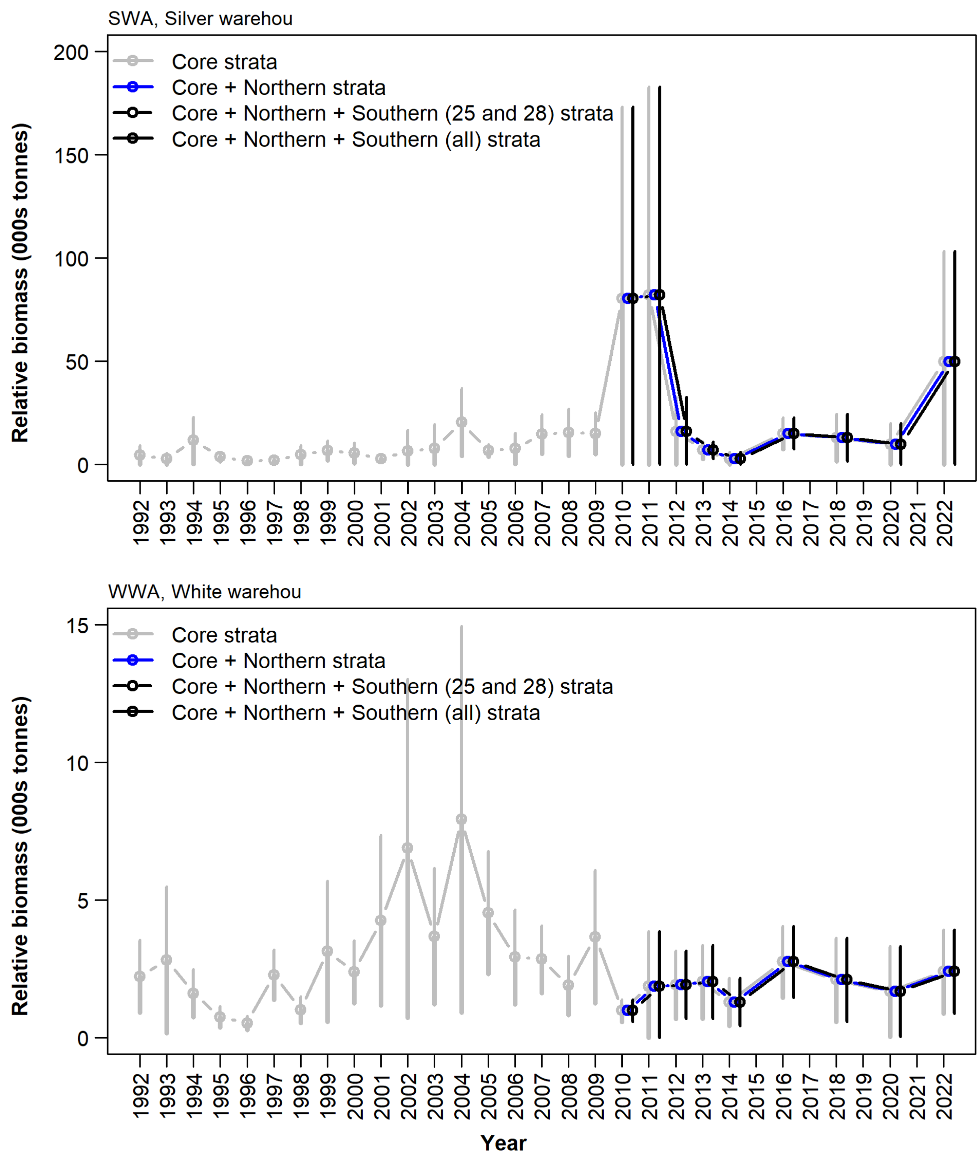

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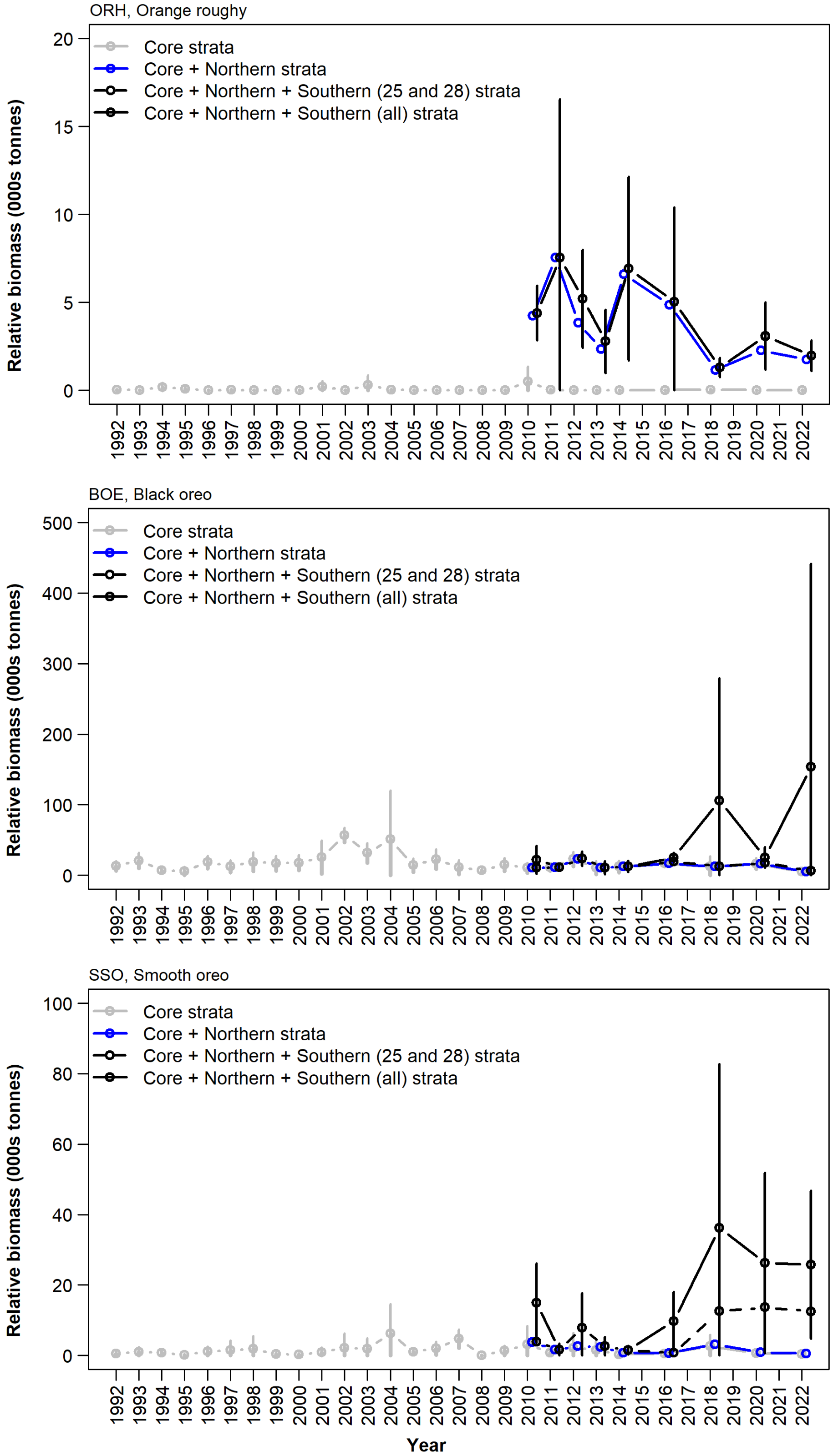
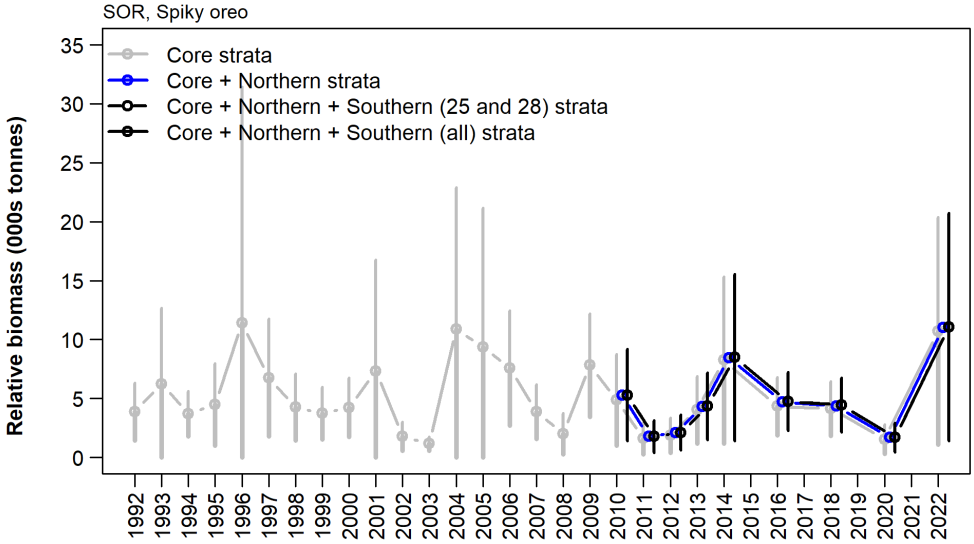
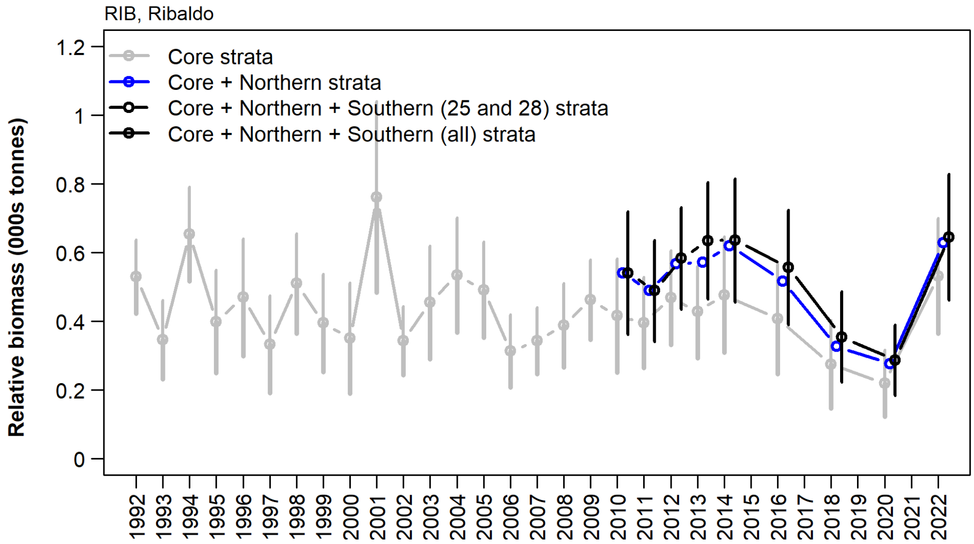
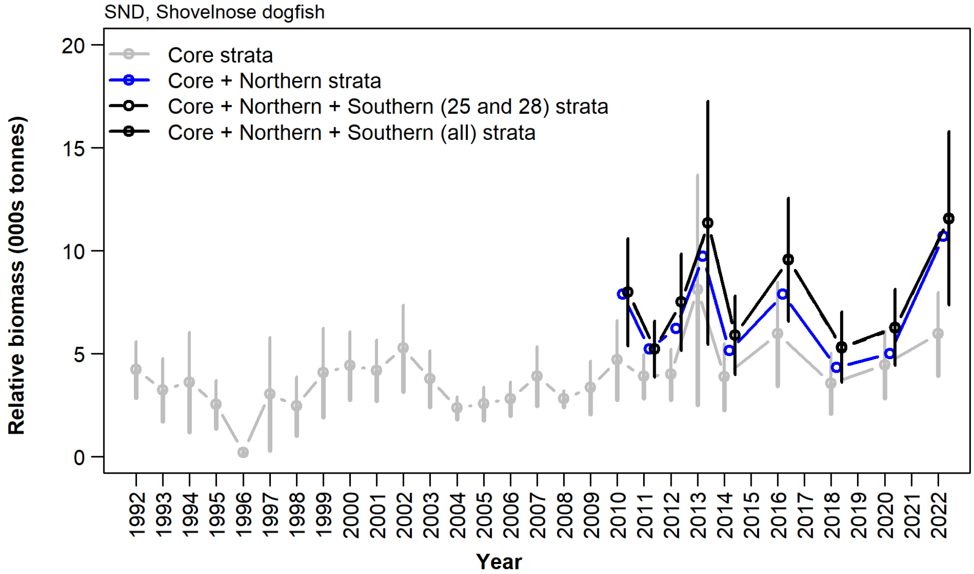


Figure 6b: Relative biomass estimates (thousands of tonnes) of orange roughy, black oreo, smooth oreo, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022. Grey lines show fish from core (200–800 m) strata. Blue lines 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 dotted 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.







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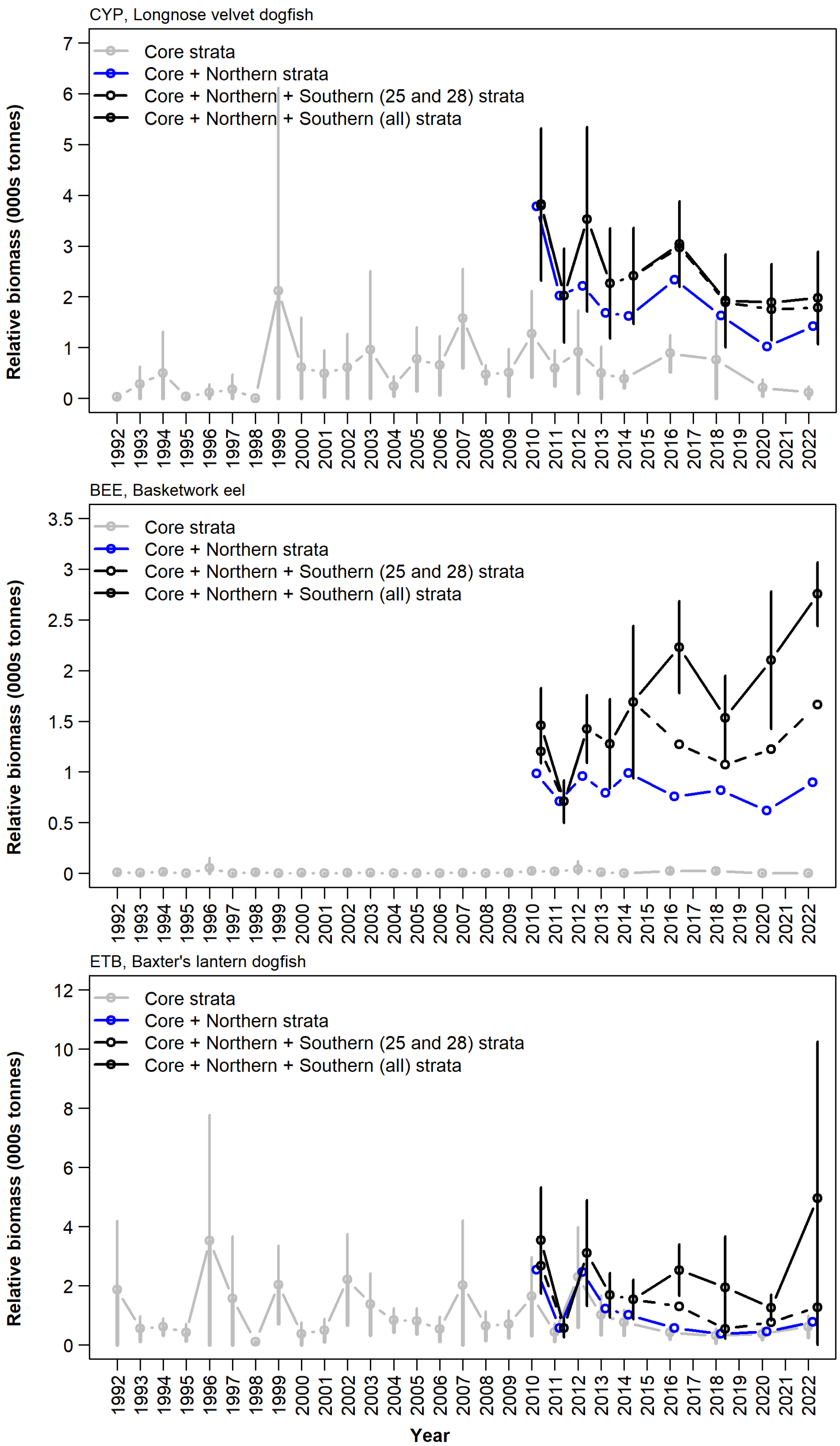

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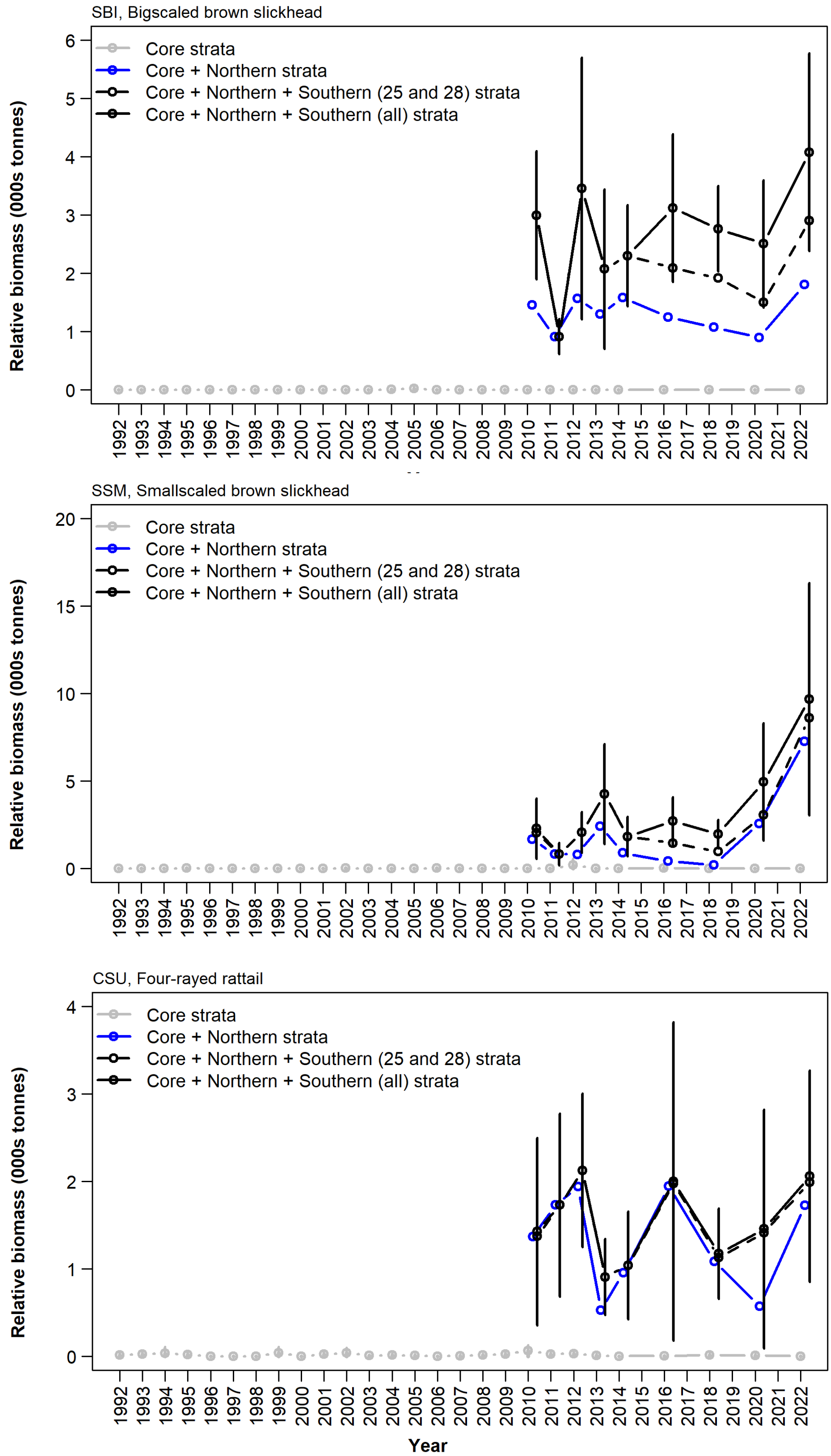

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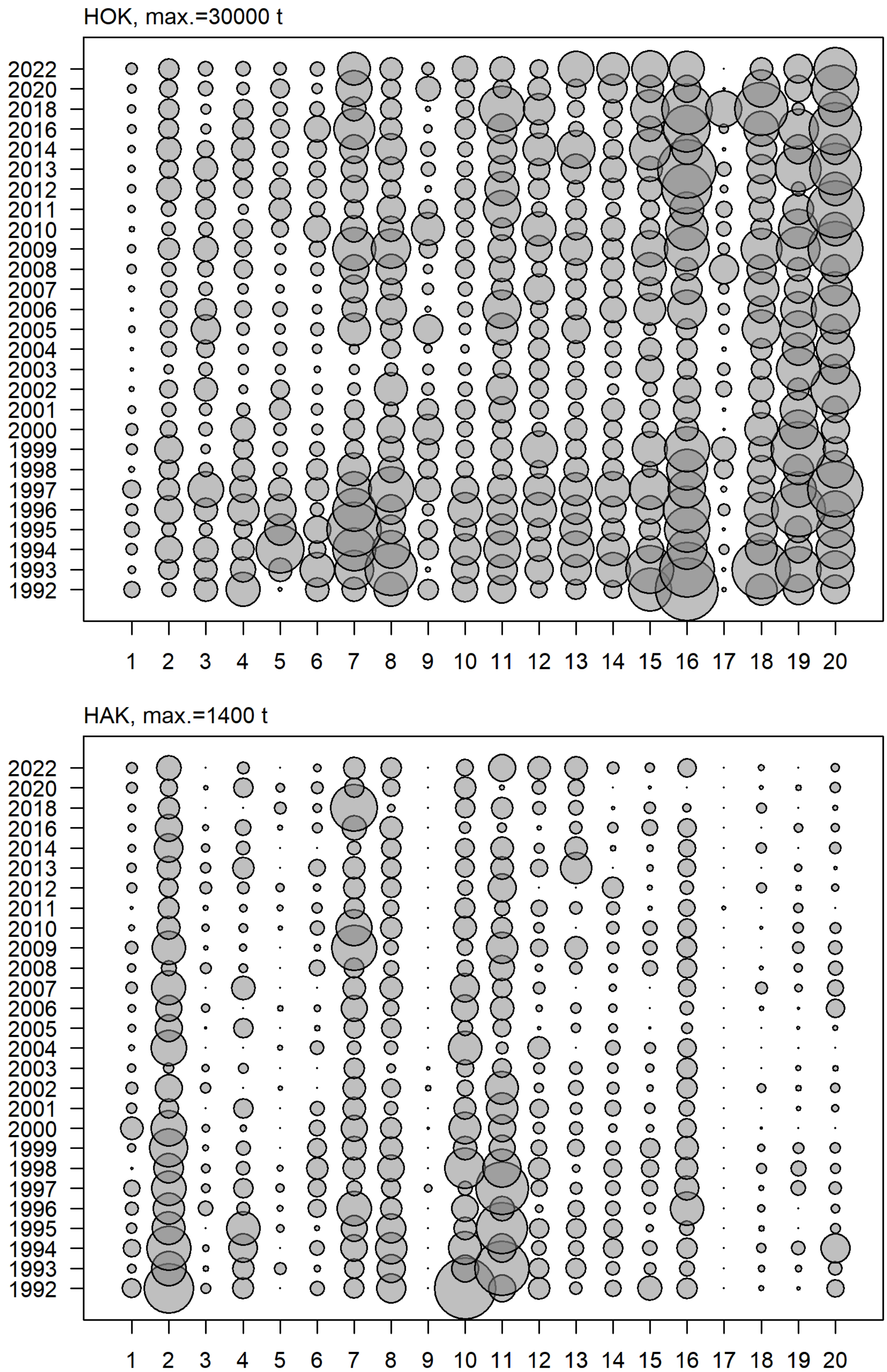
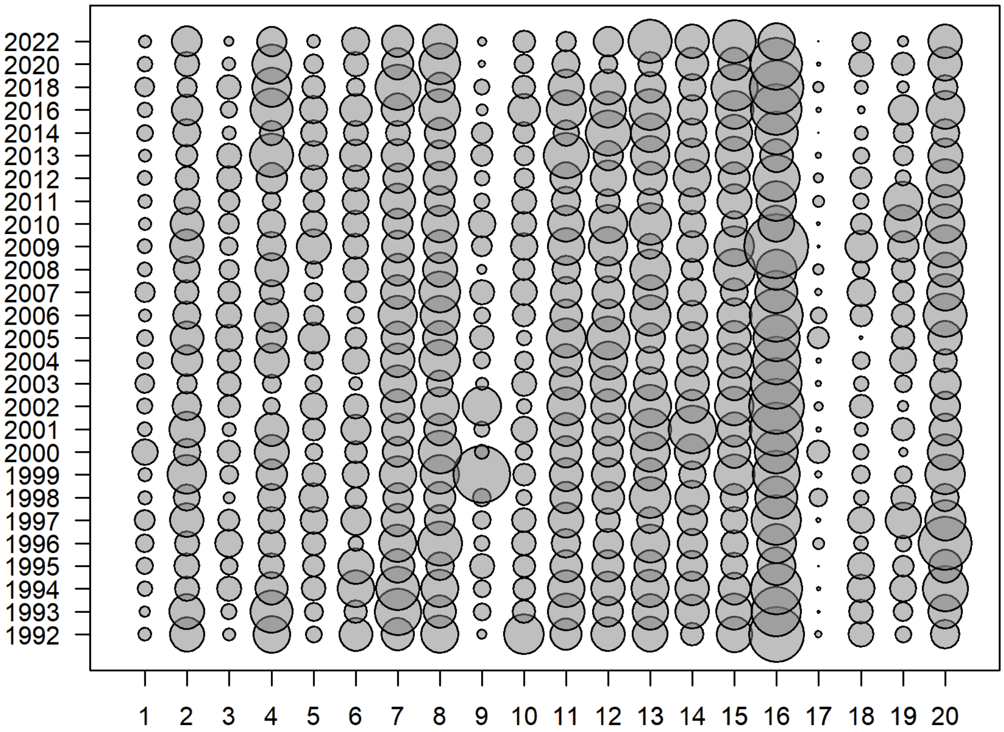
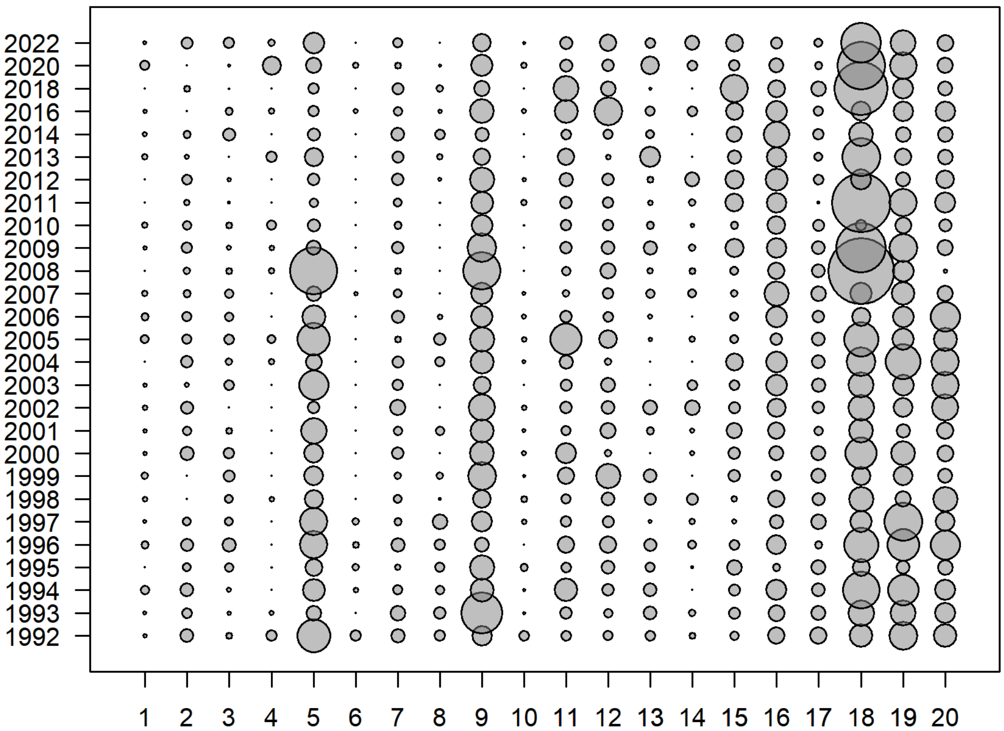


Figure 7a: Relative core (200–800 m) biomass estimates by stratum (1–20, x-axis) for hoki and 10 other selected species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, 2016, 2020, and 2022. Species codes are given in Table 4.

LIN, max.=2500 t



GIZ (combined species), max.=2500 t



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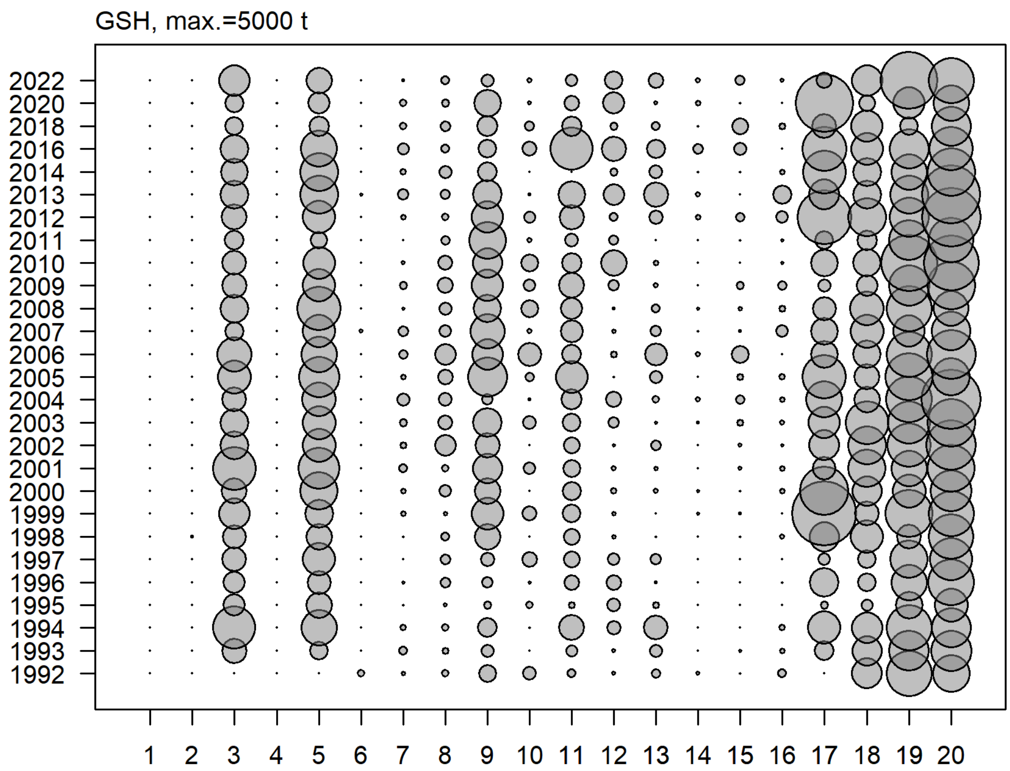

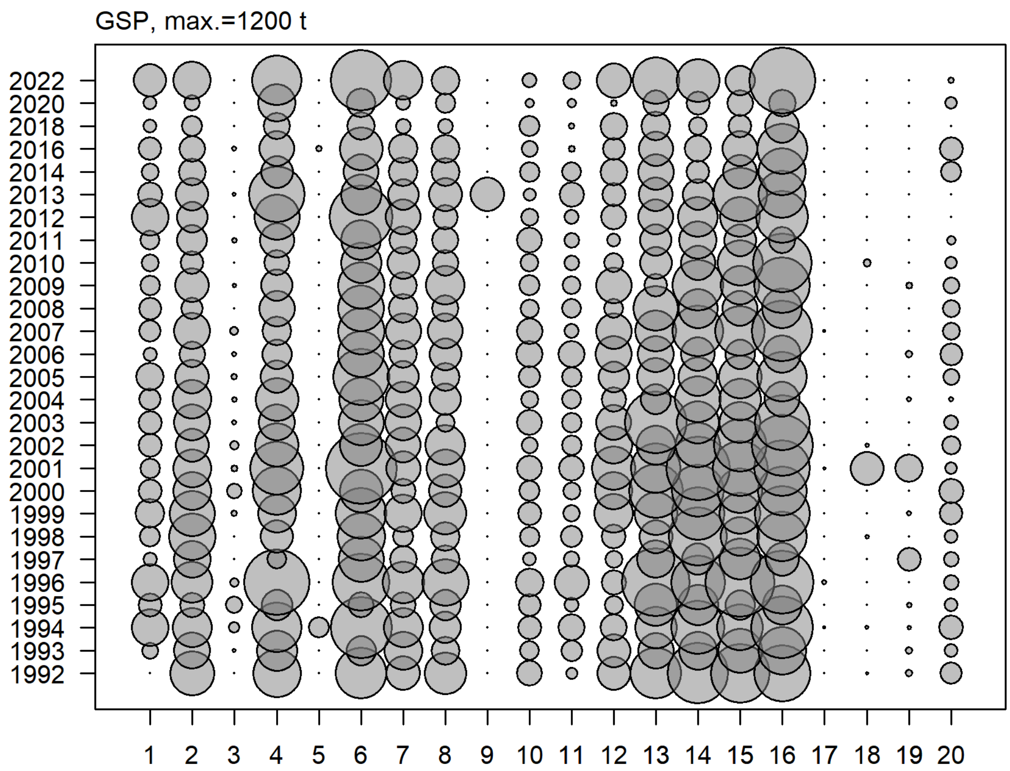

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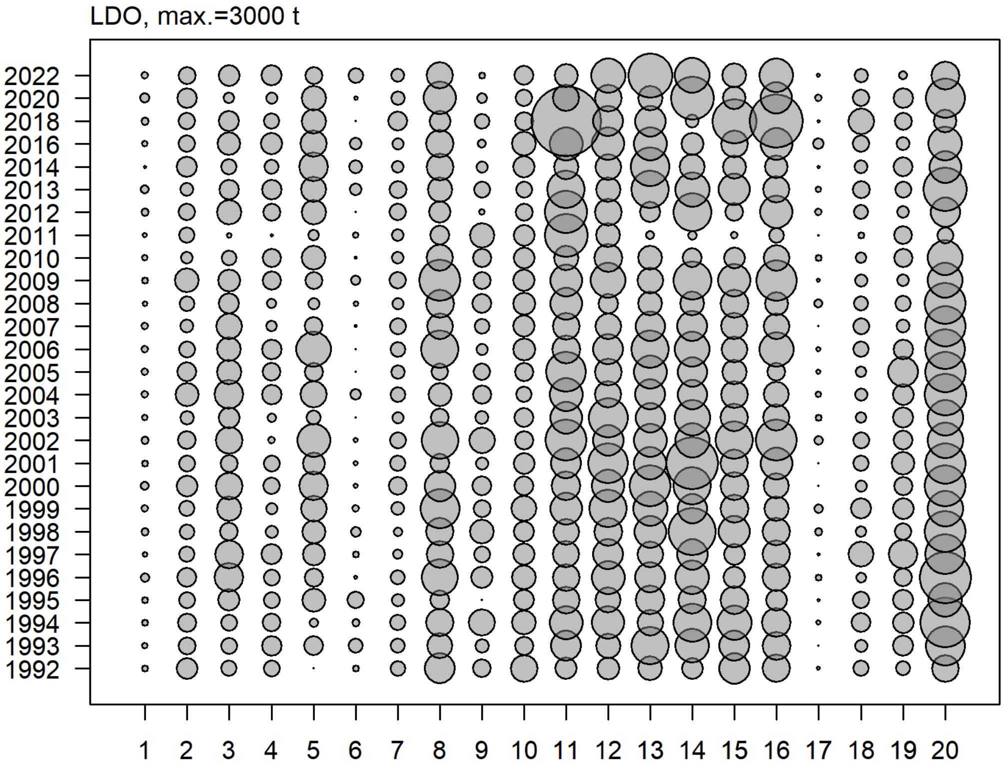

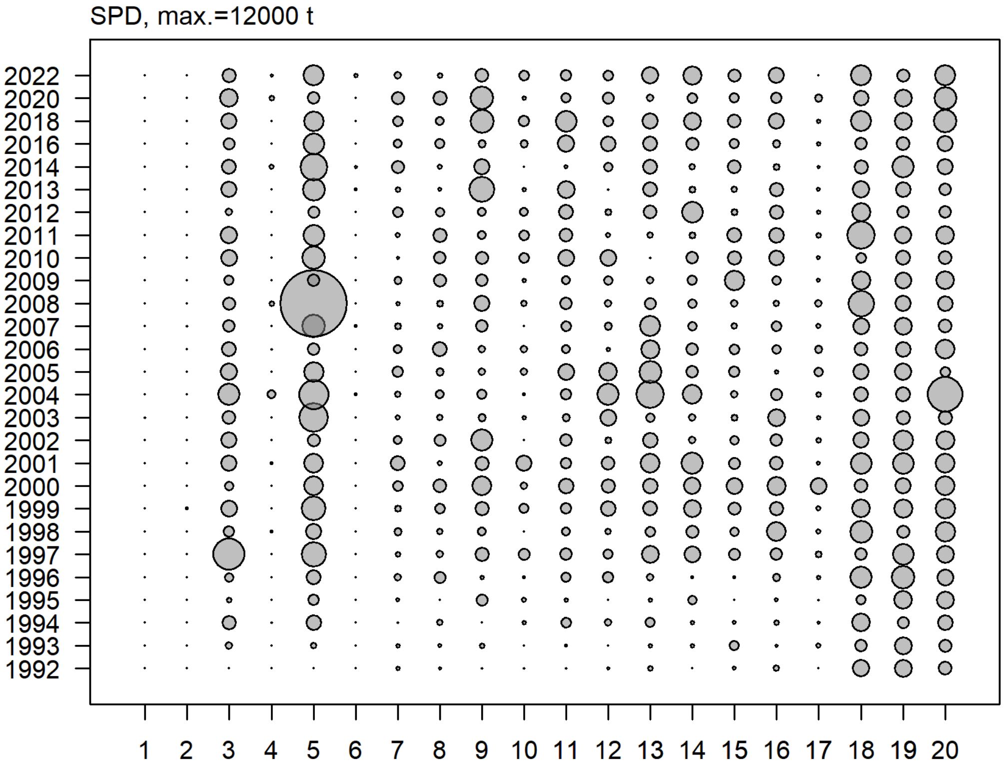

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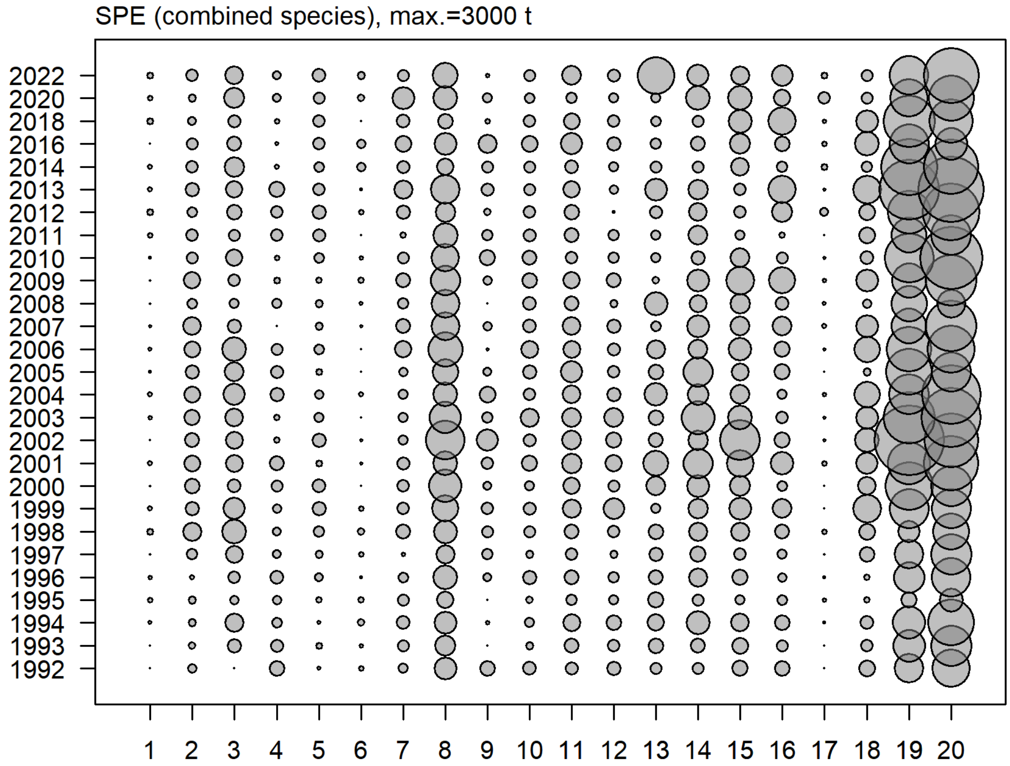

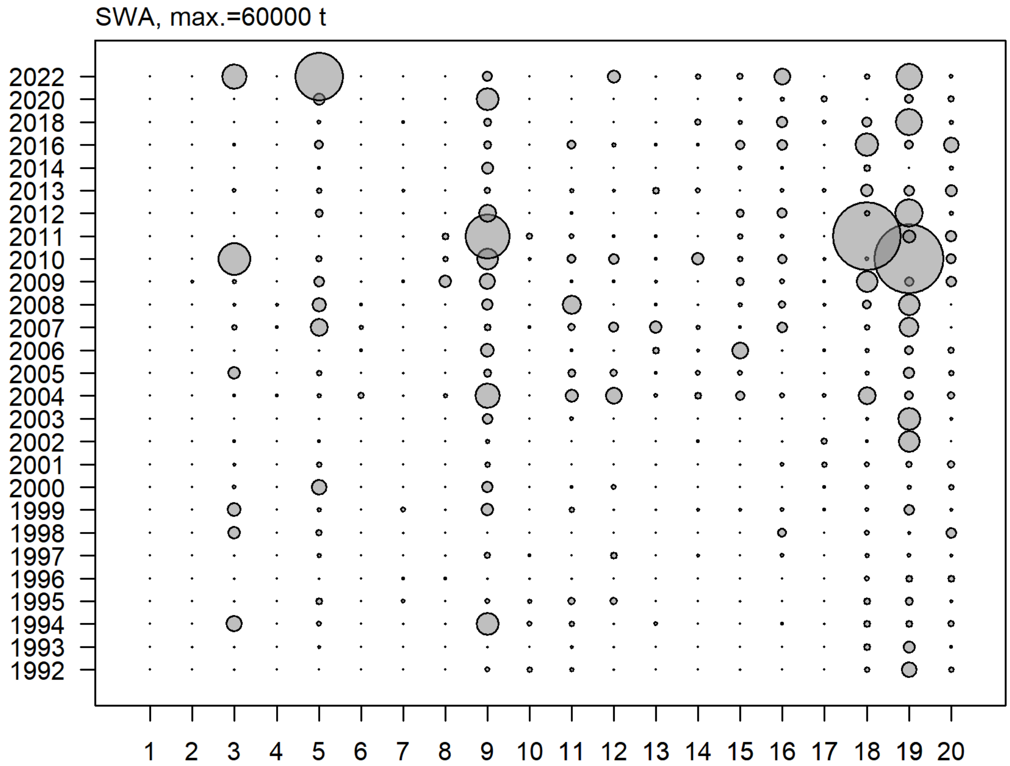

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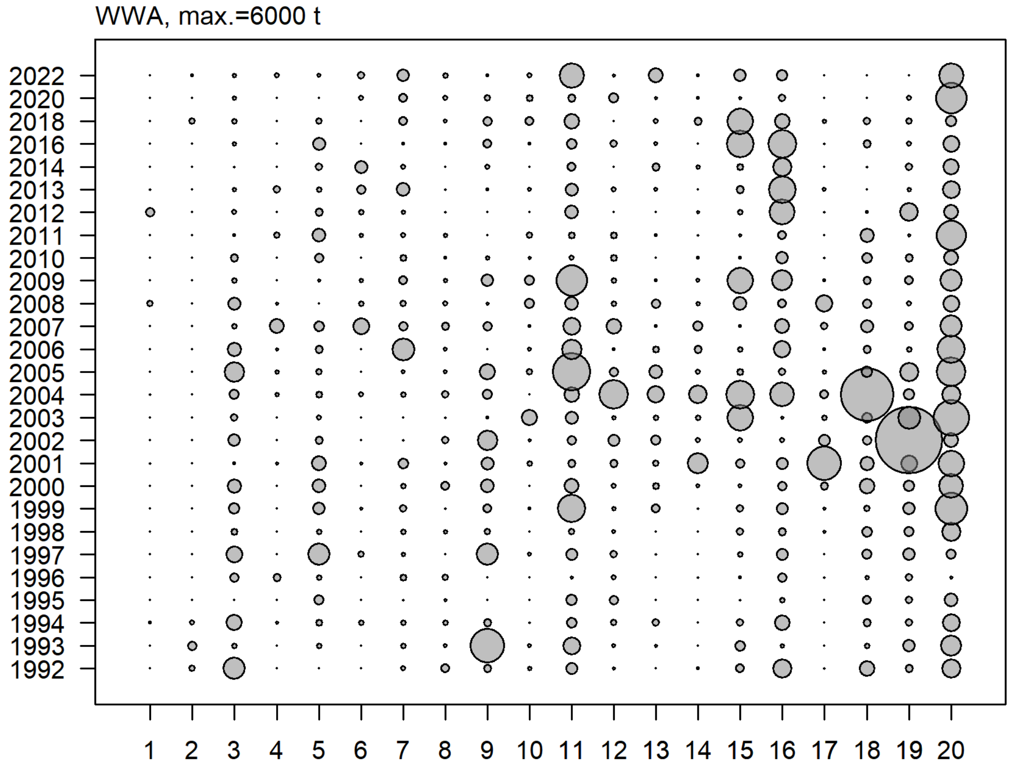

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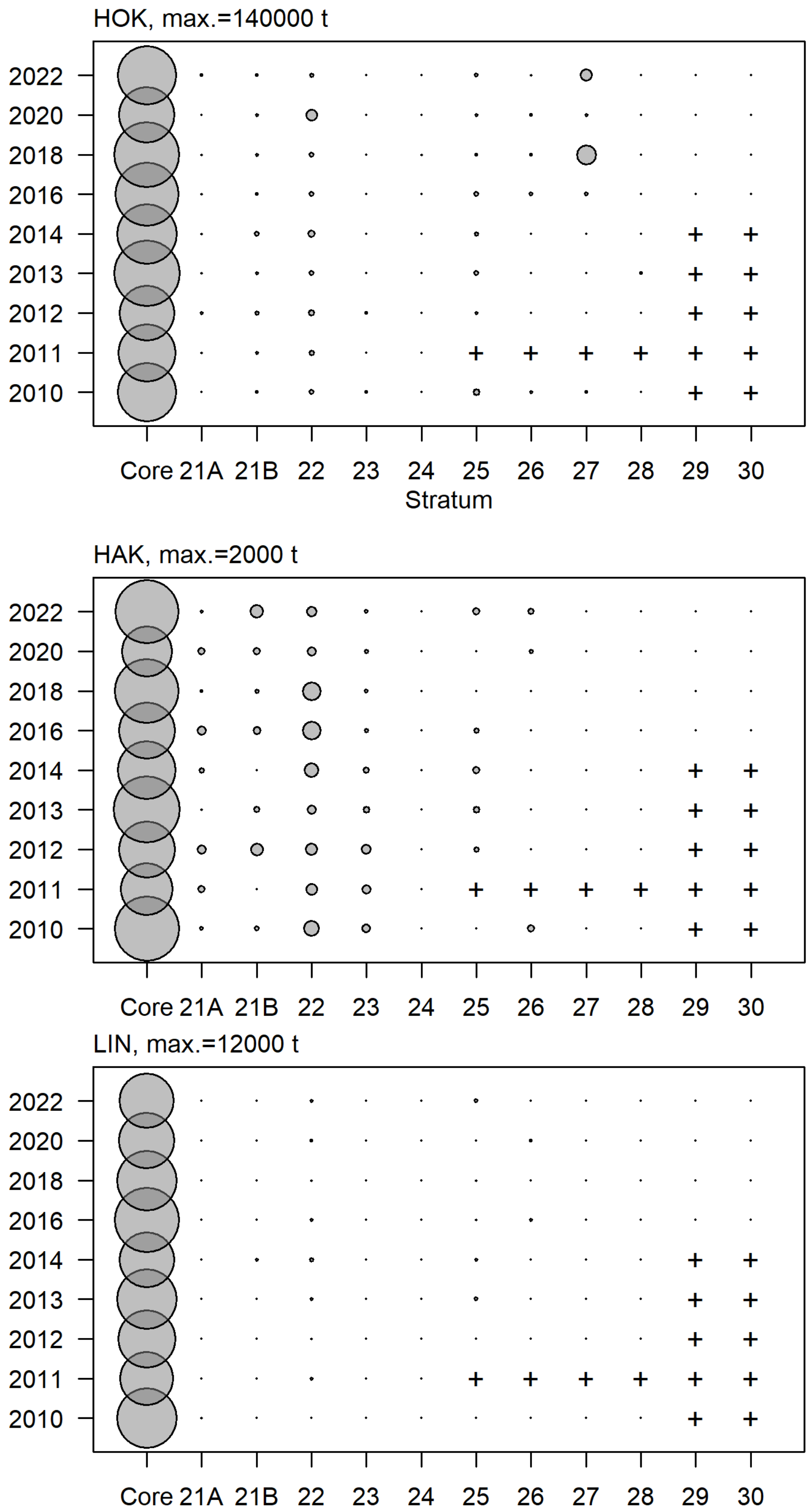
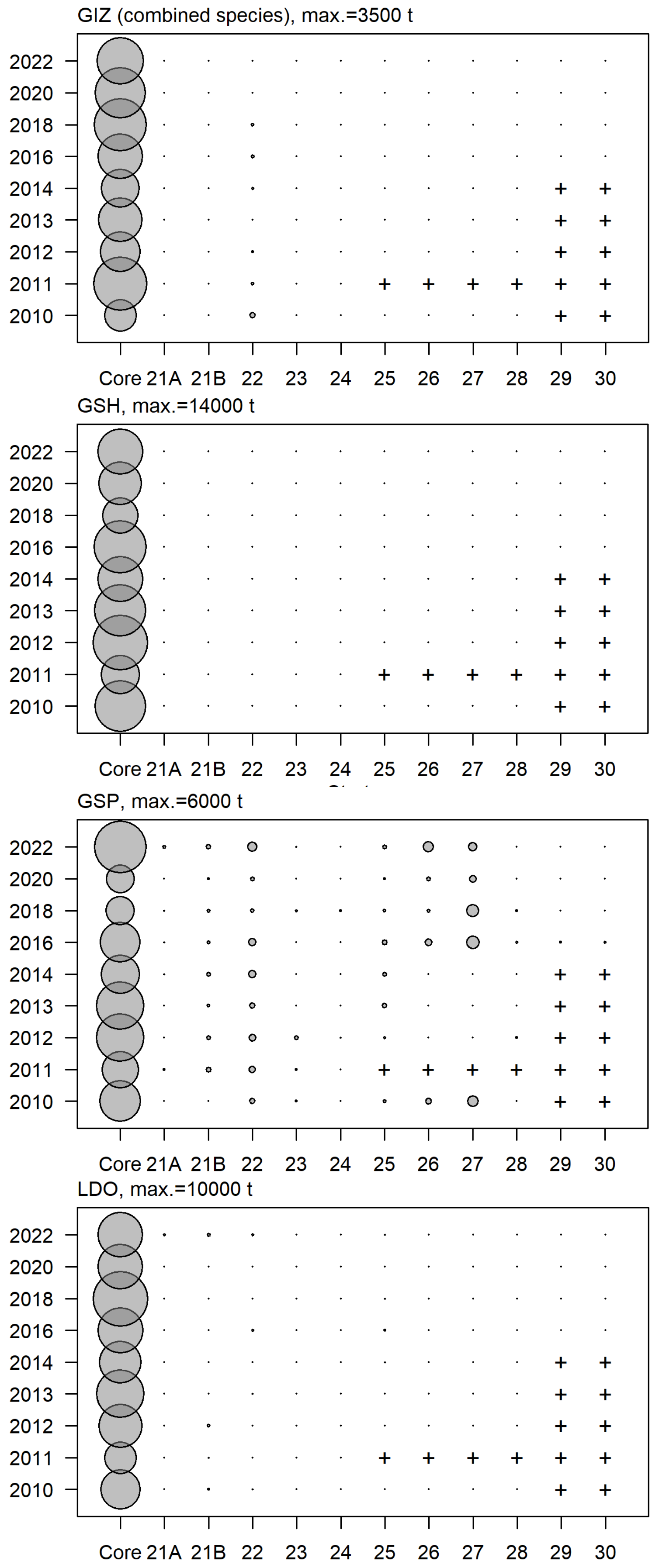


Figure 7b: Total core and deep (800–1300 m) relative biomass estimates by stratum for hoki and 10 other selected species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, 2016, 2018, 2020, and 2022. Cross indicates stratum not sampled. Species codes are given in Table 4.



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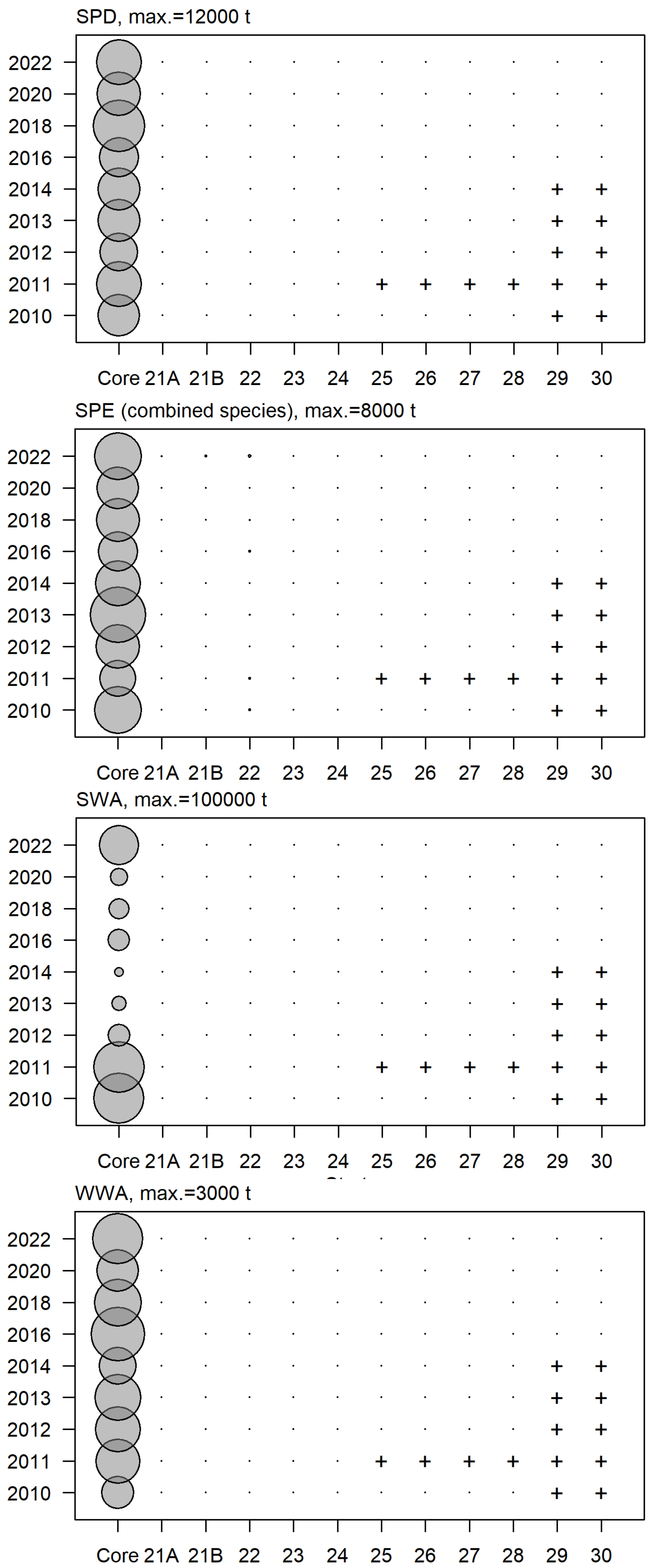

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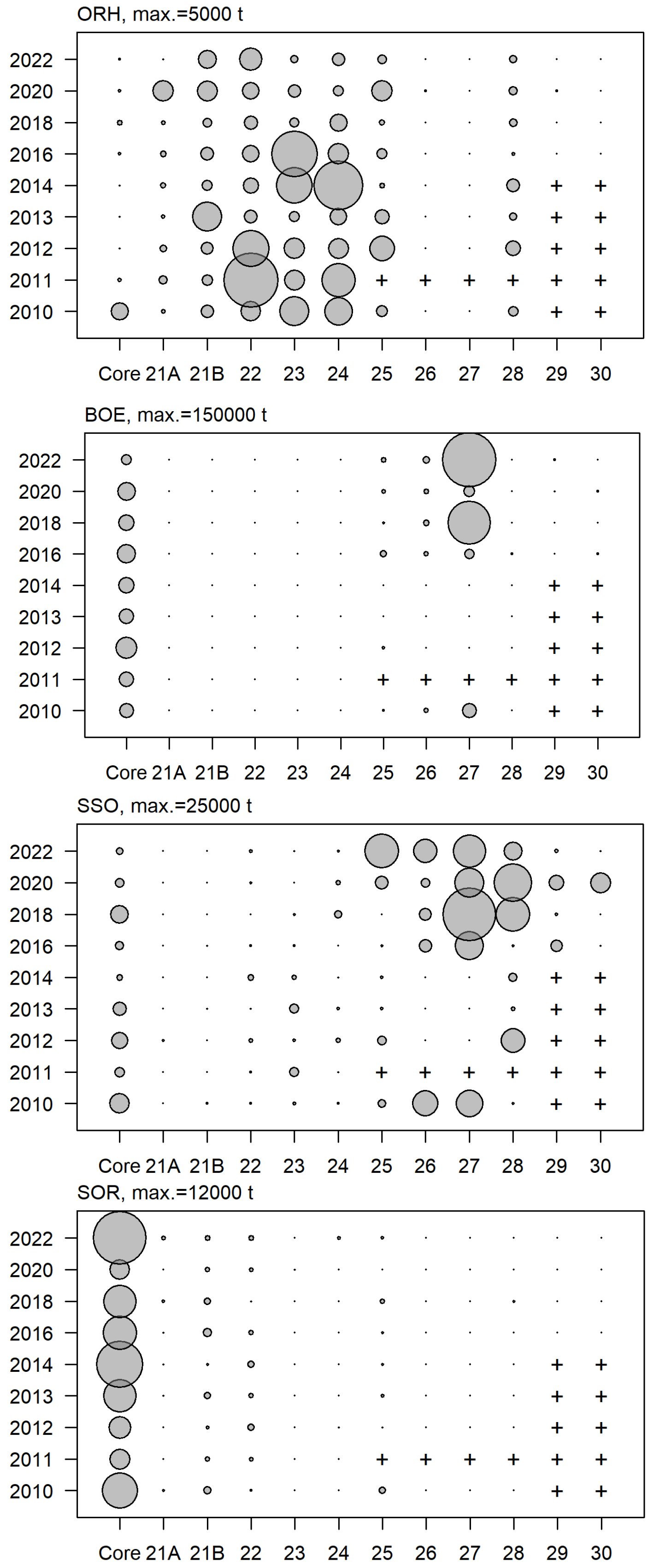
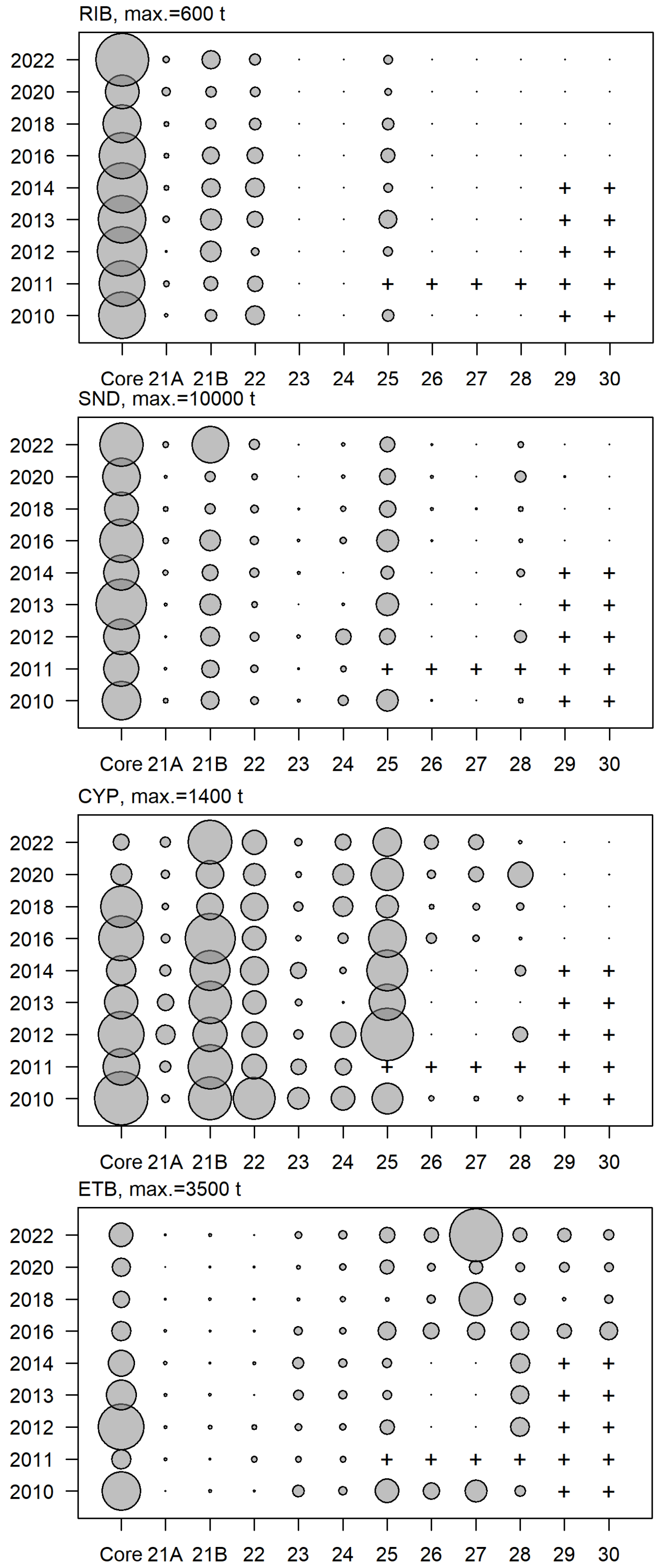


Figure 7c: Relative deep (800–1300 m) biomass estimates by strata for orange roughy, oreo species, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, 2016, 2018, 2020, and 2022. Cross indicates stratum not sampled. Species codes are given in Table 4.



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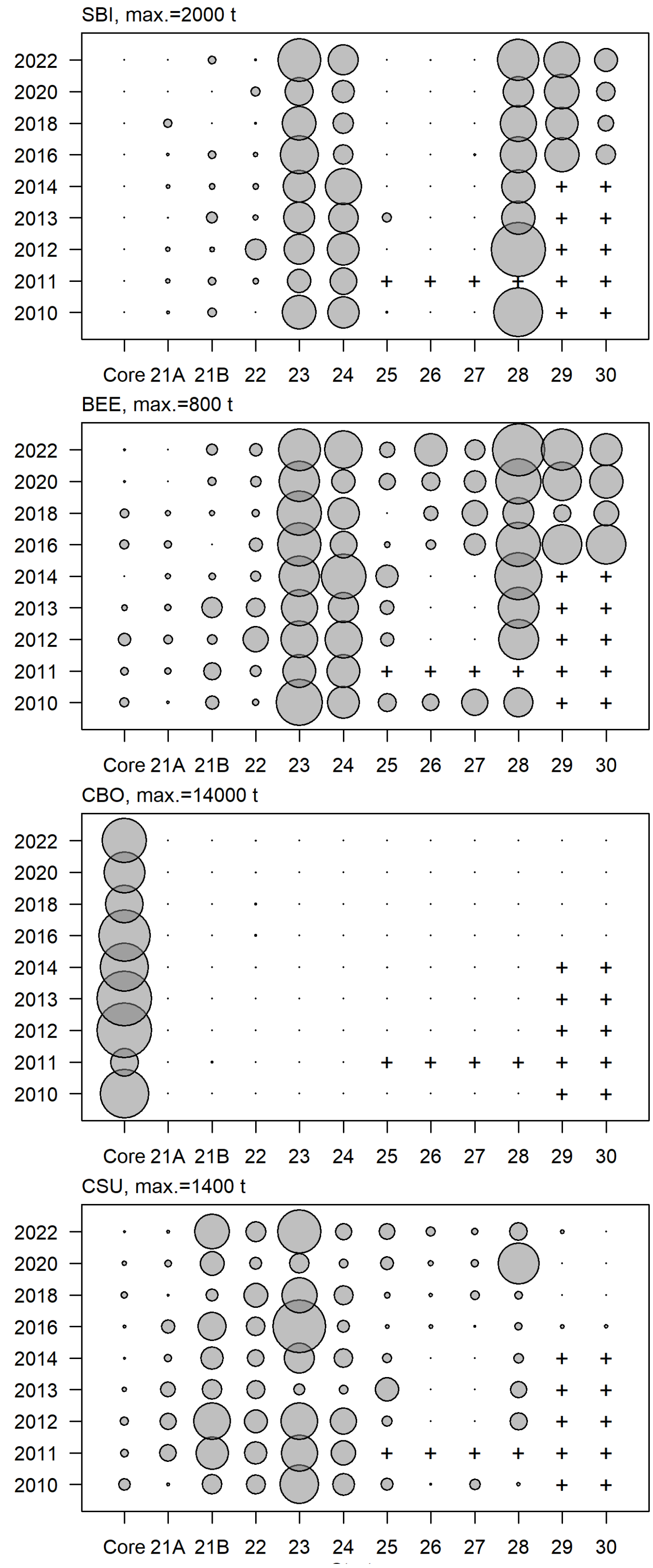

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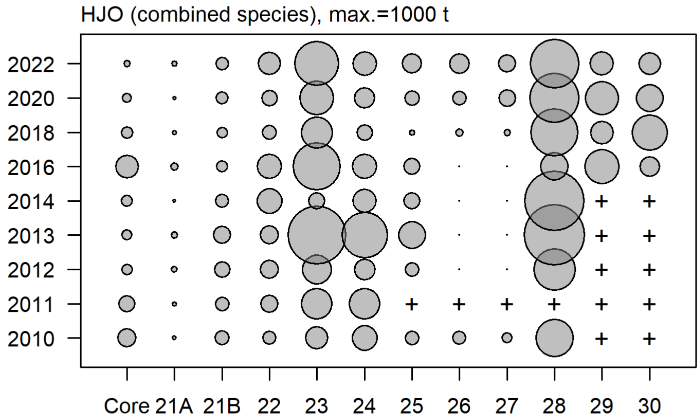

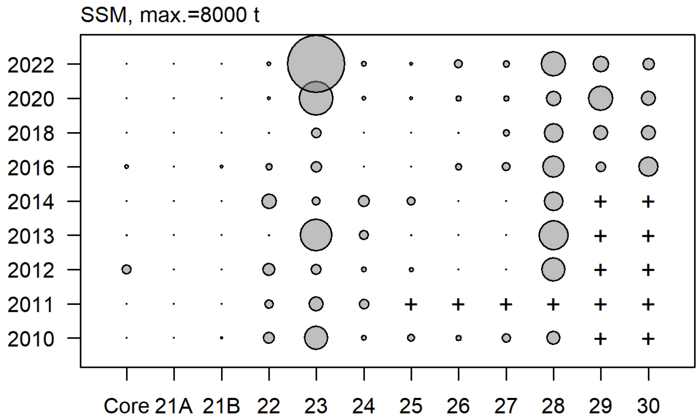

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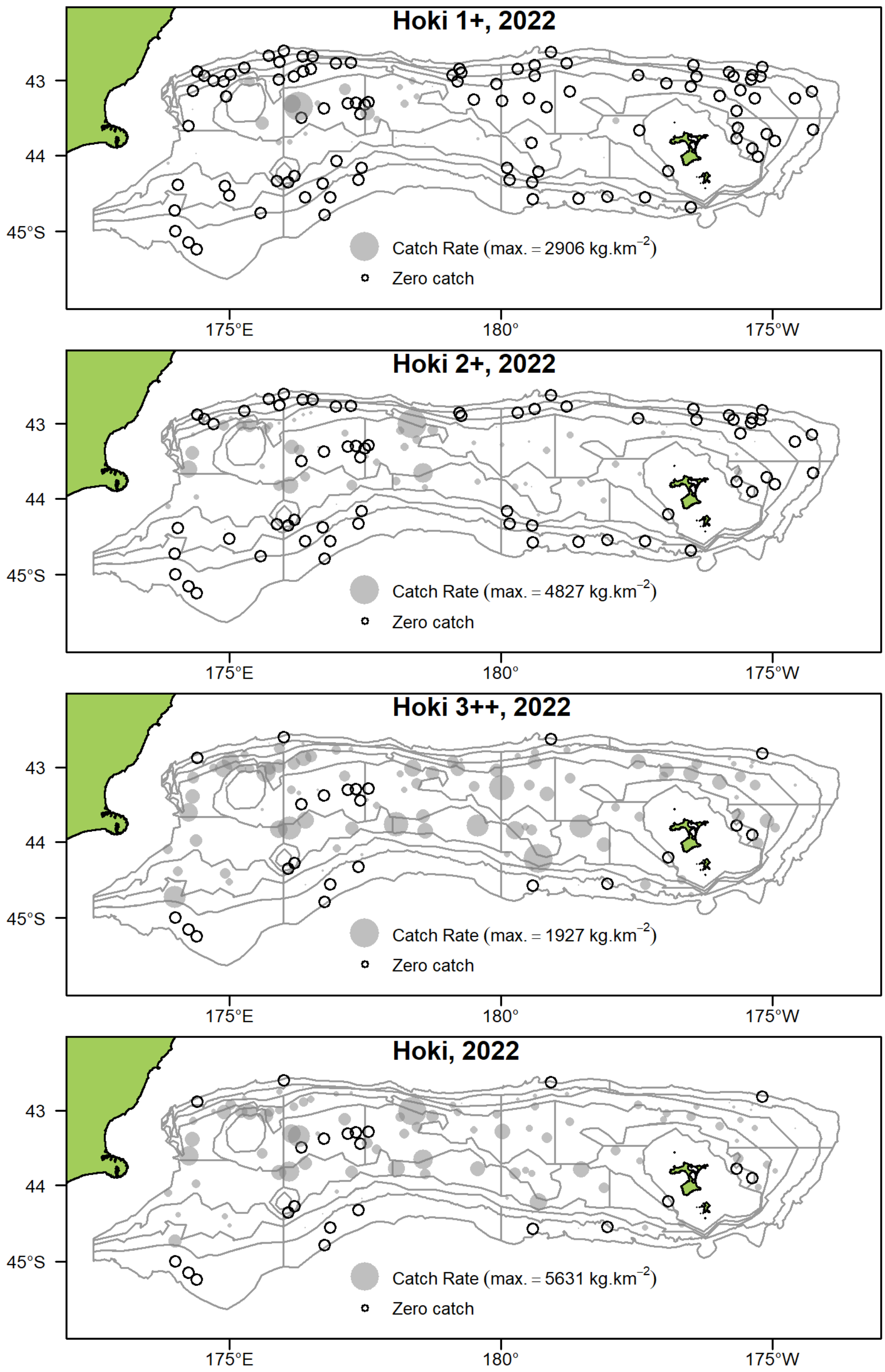


Figure 8: Hoki 1+, 2+, 3++ age class (year) and total catch distribution in 2022. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate (max.) is shown on each plot.

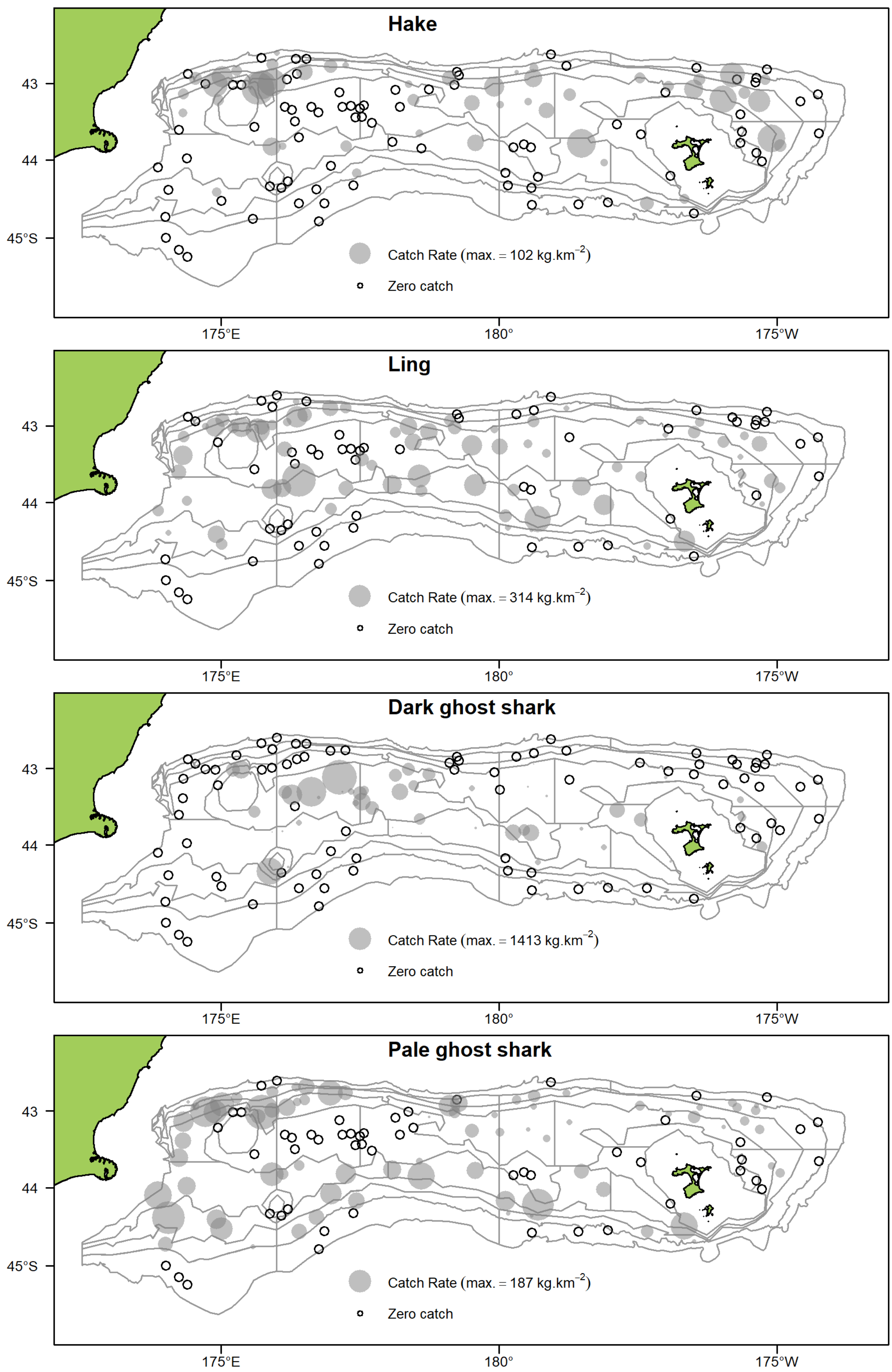
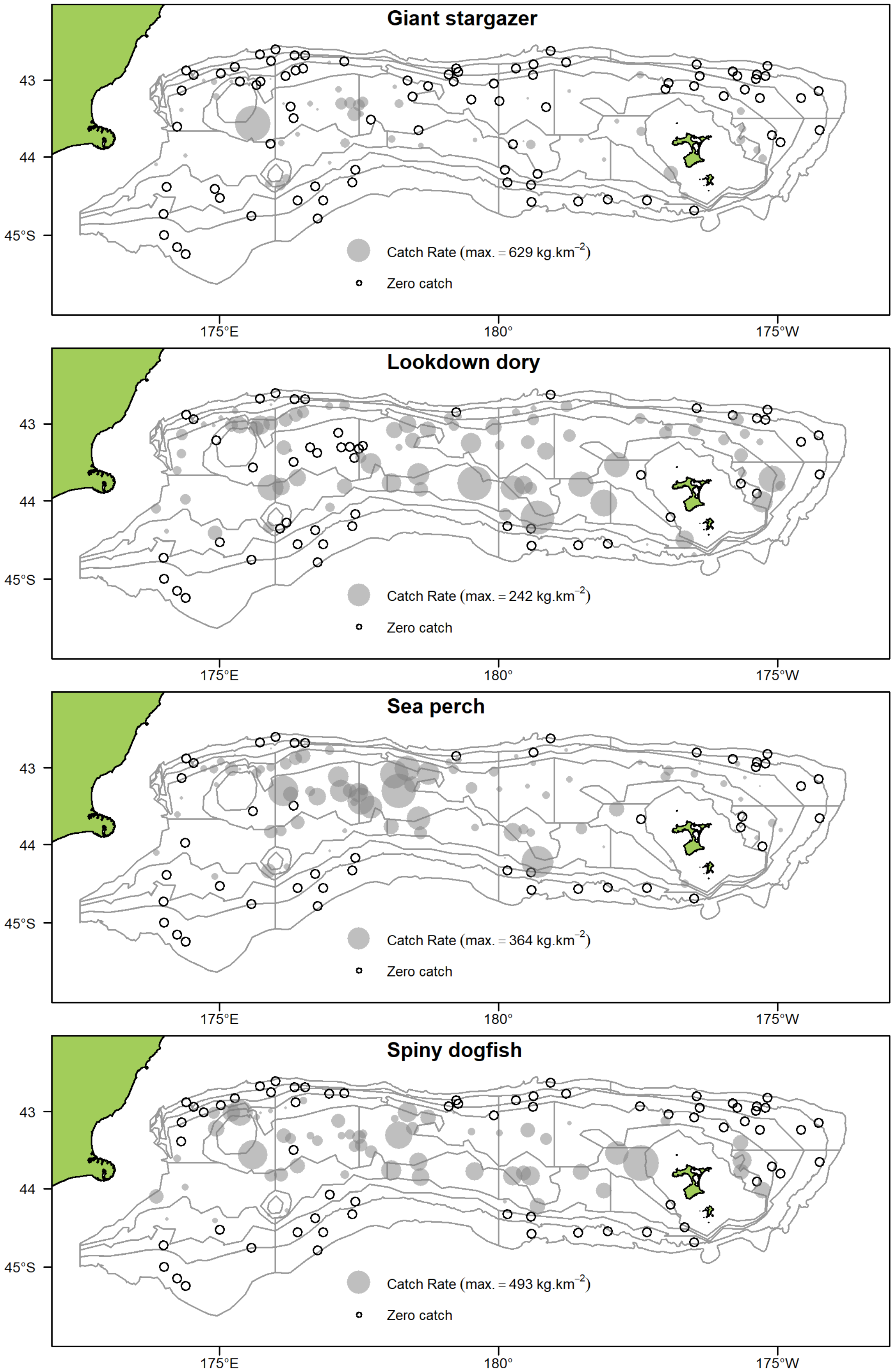


Figure 9: Catch rates (kg km^{-2}) of selected core and deepwater commercial and bycatch species in 2022. Filled circle area is proportional to catch rate. Open circles are zero catch. Maximum catch rate (max.) is shown on each plot.



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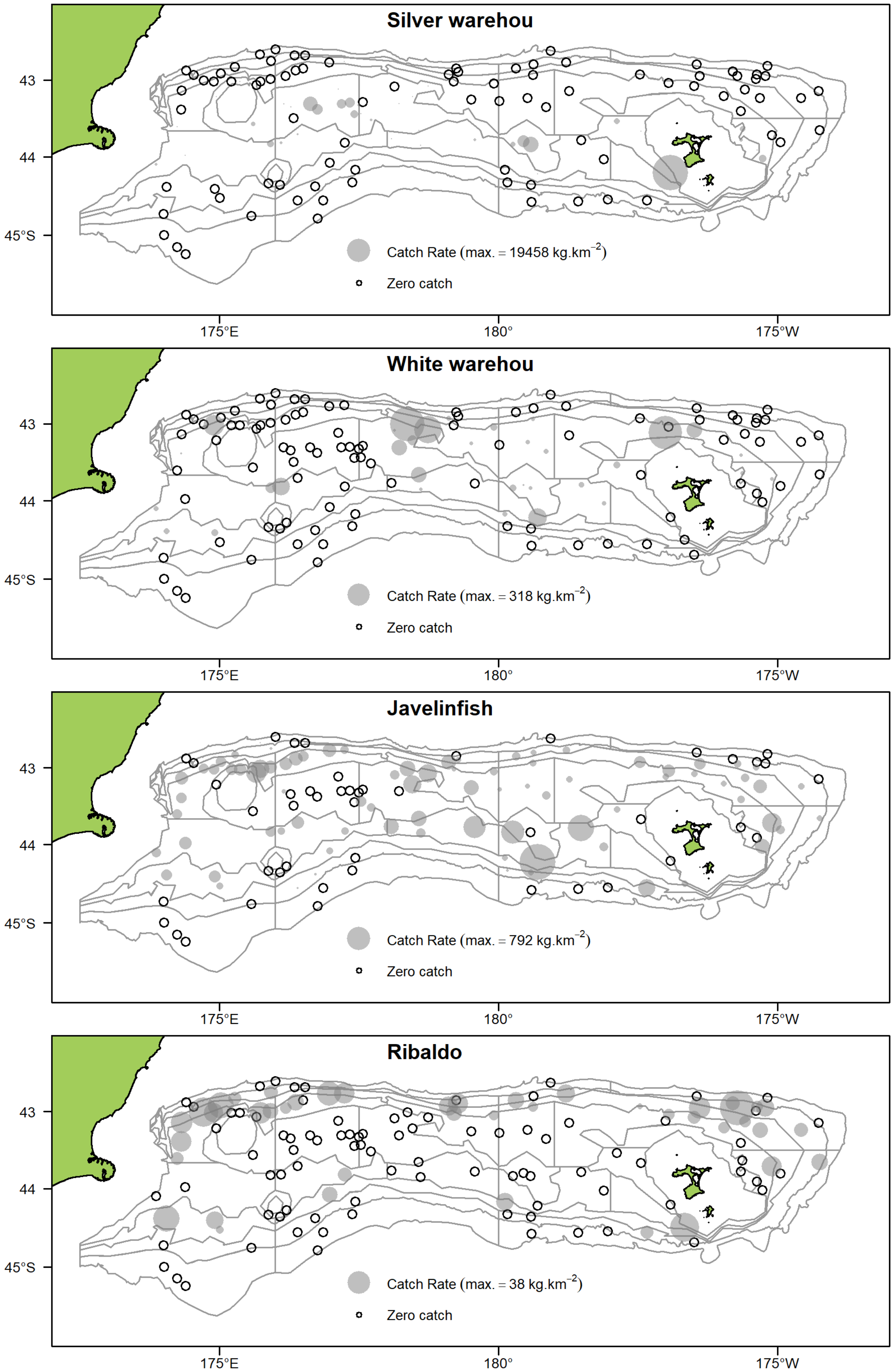

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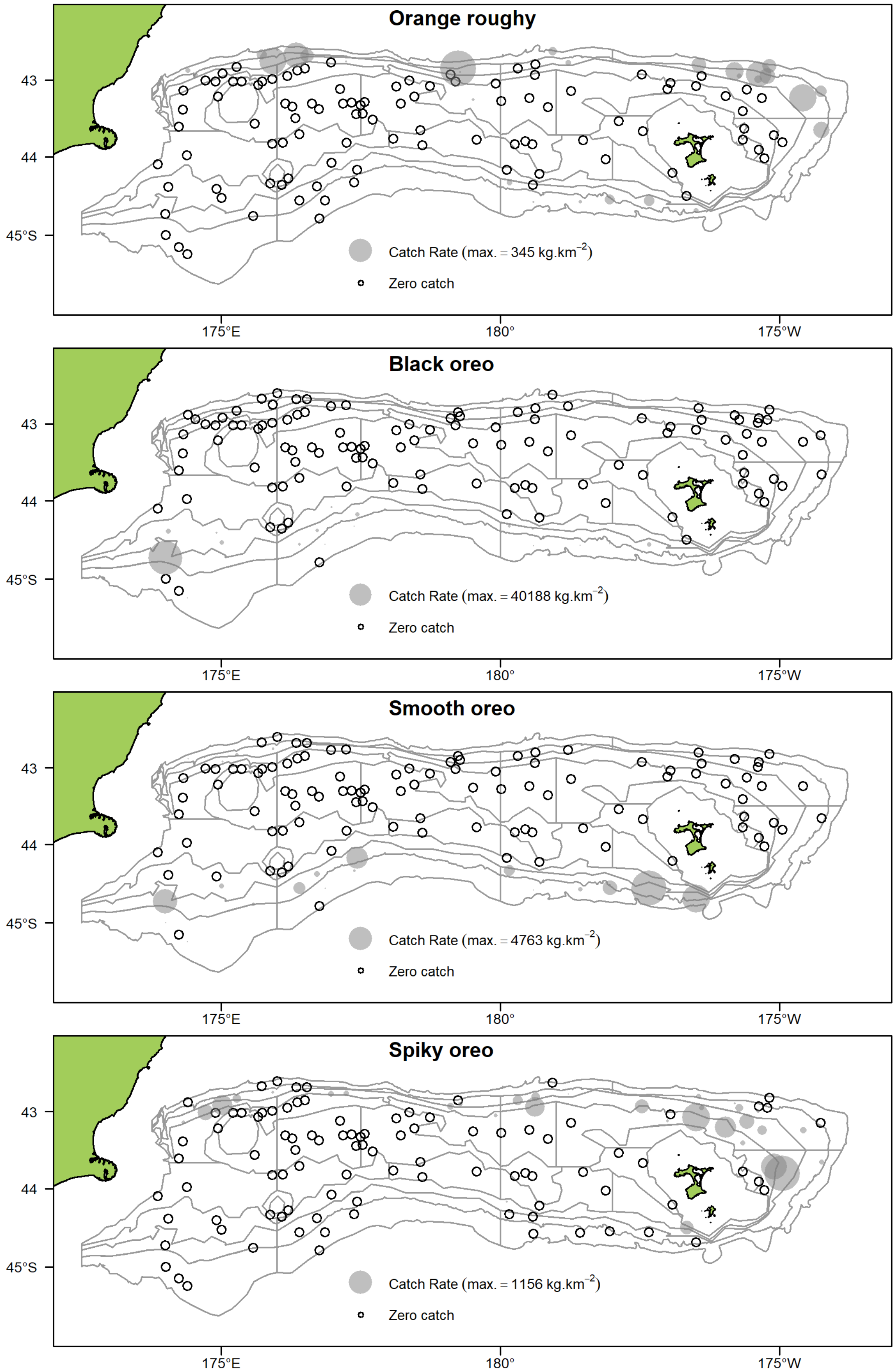

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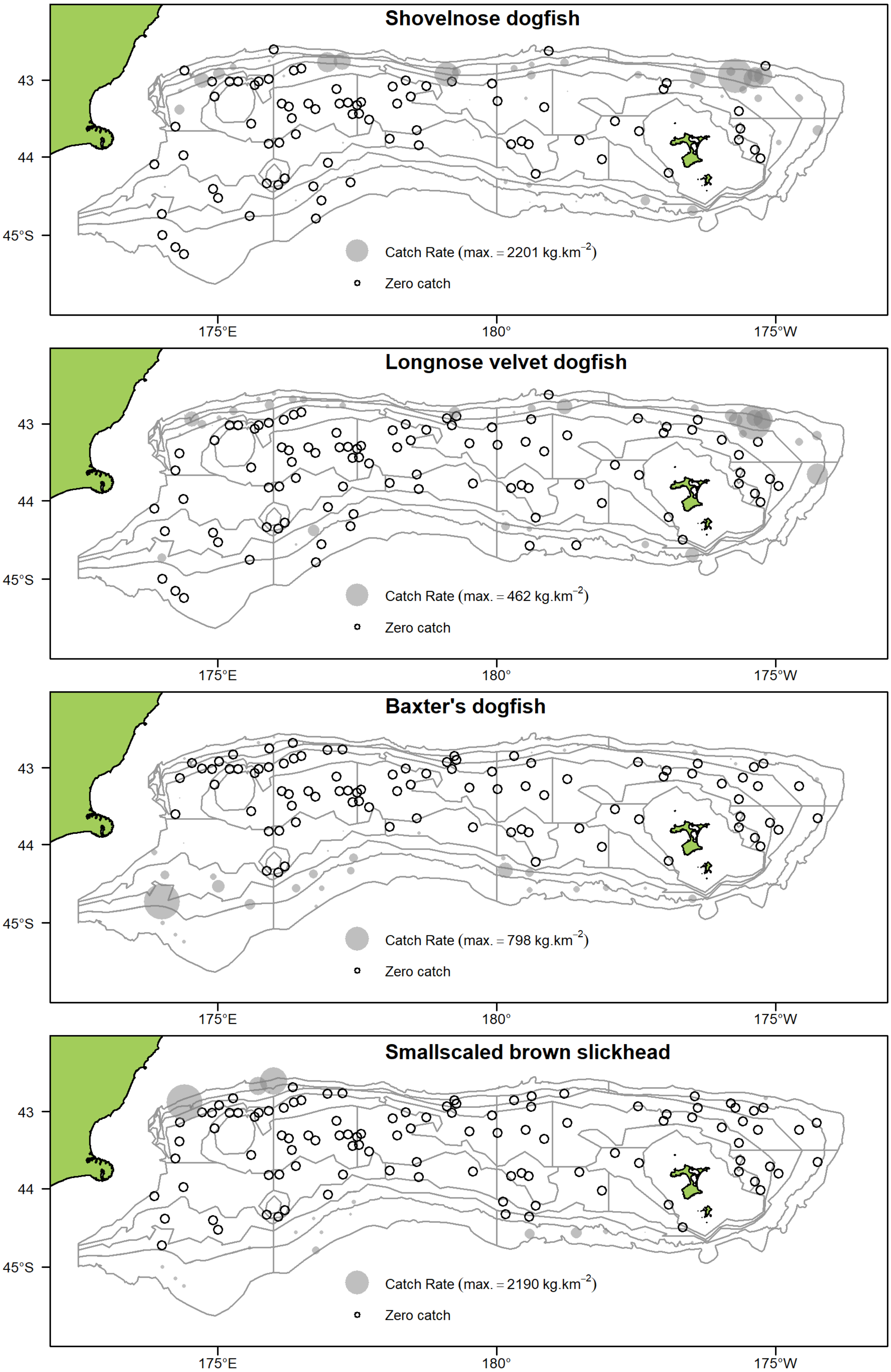

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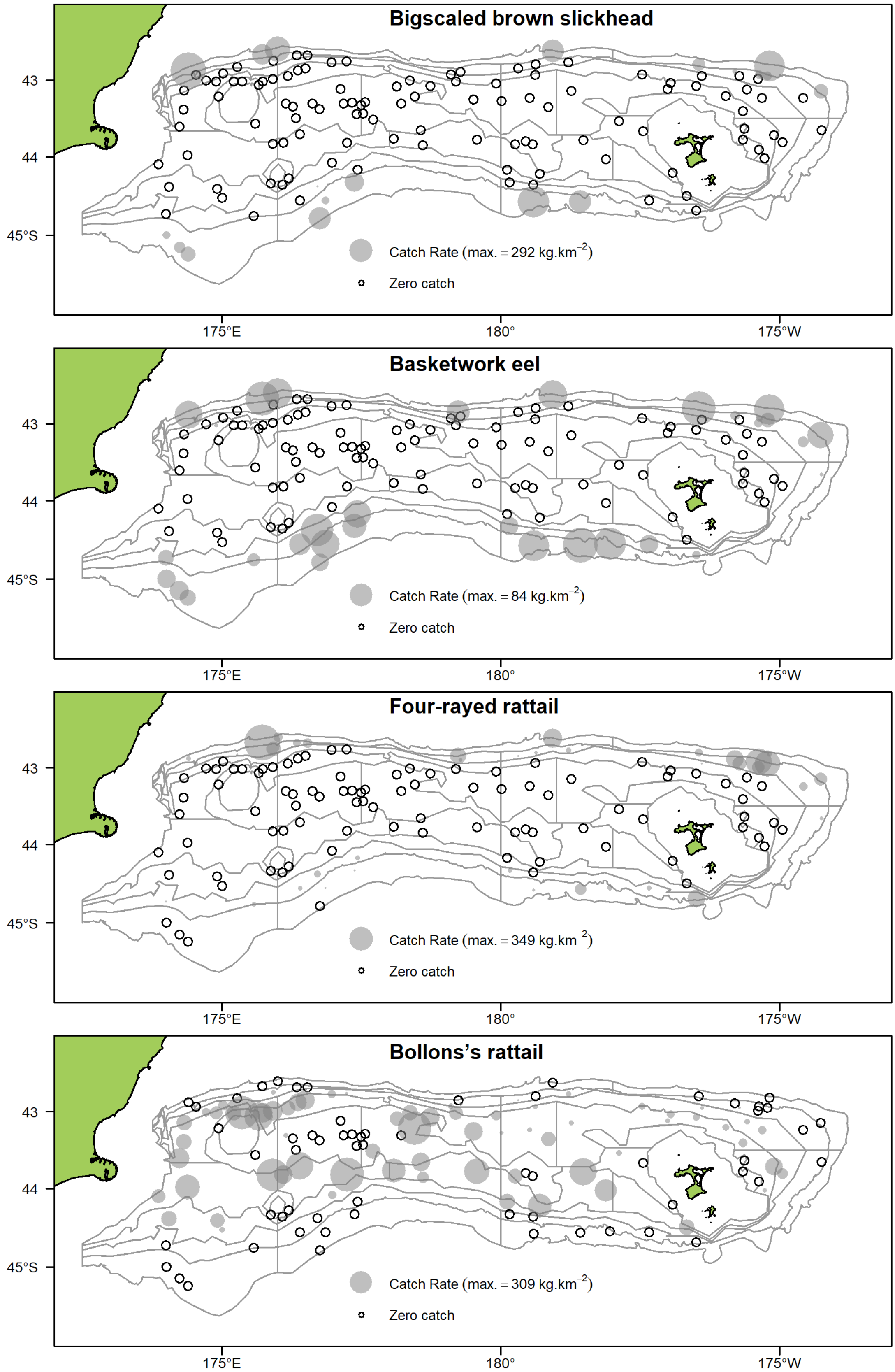

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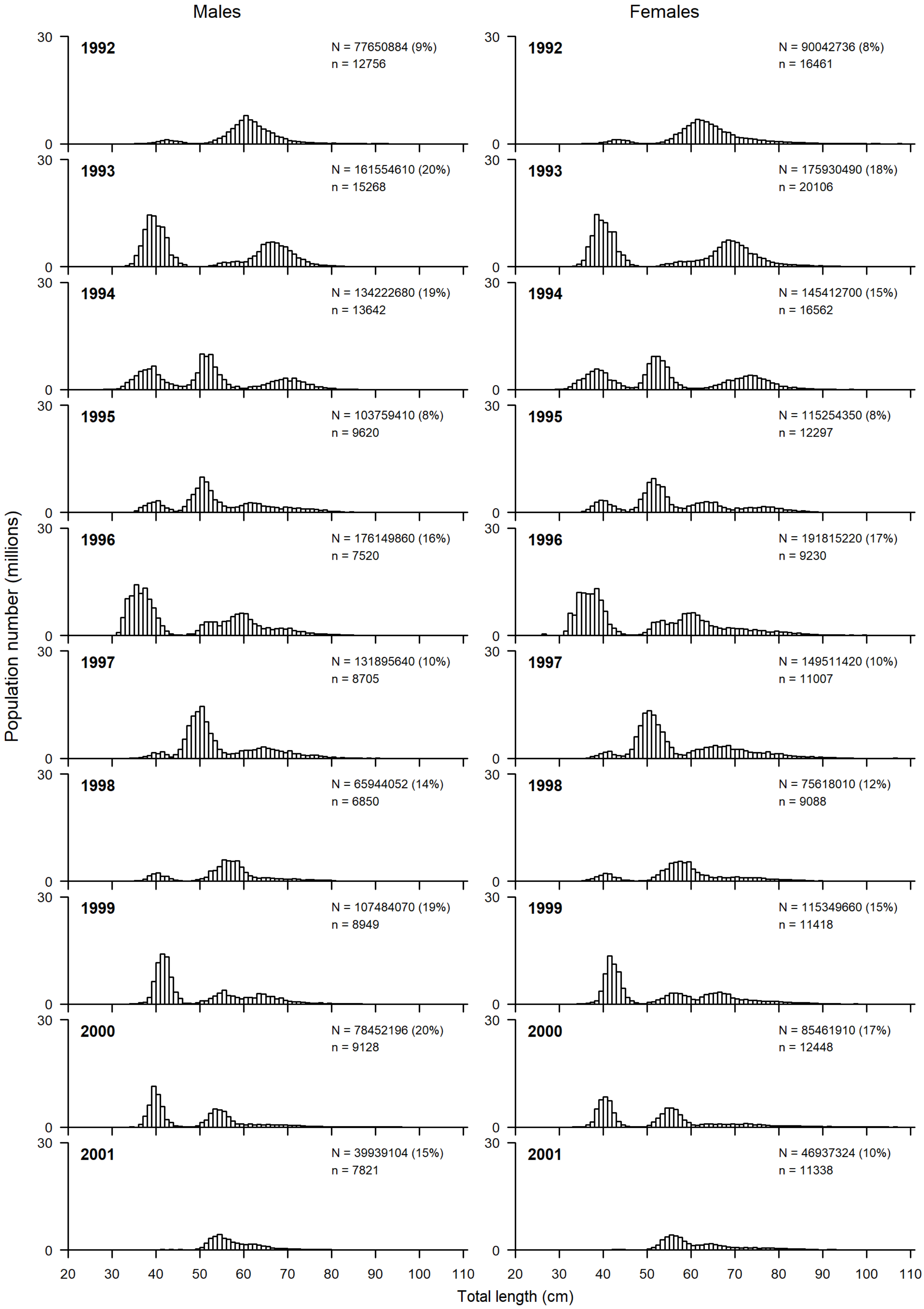
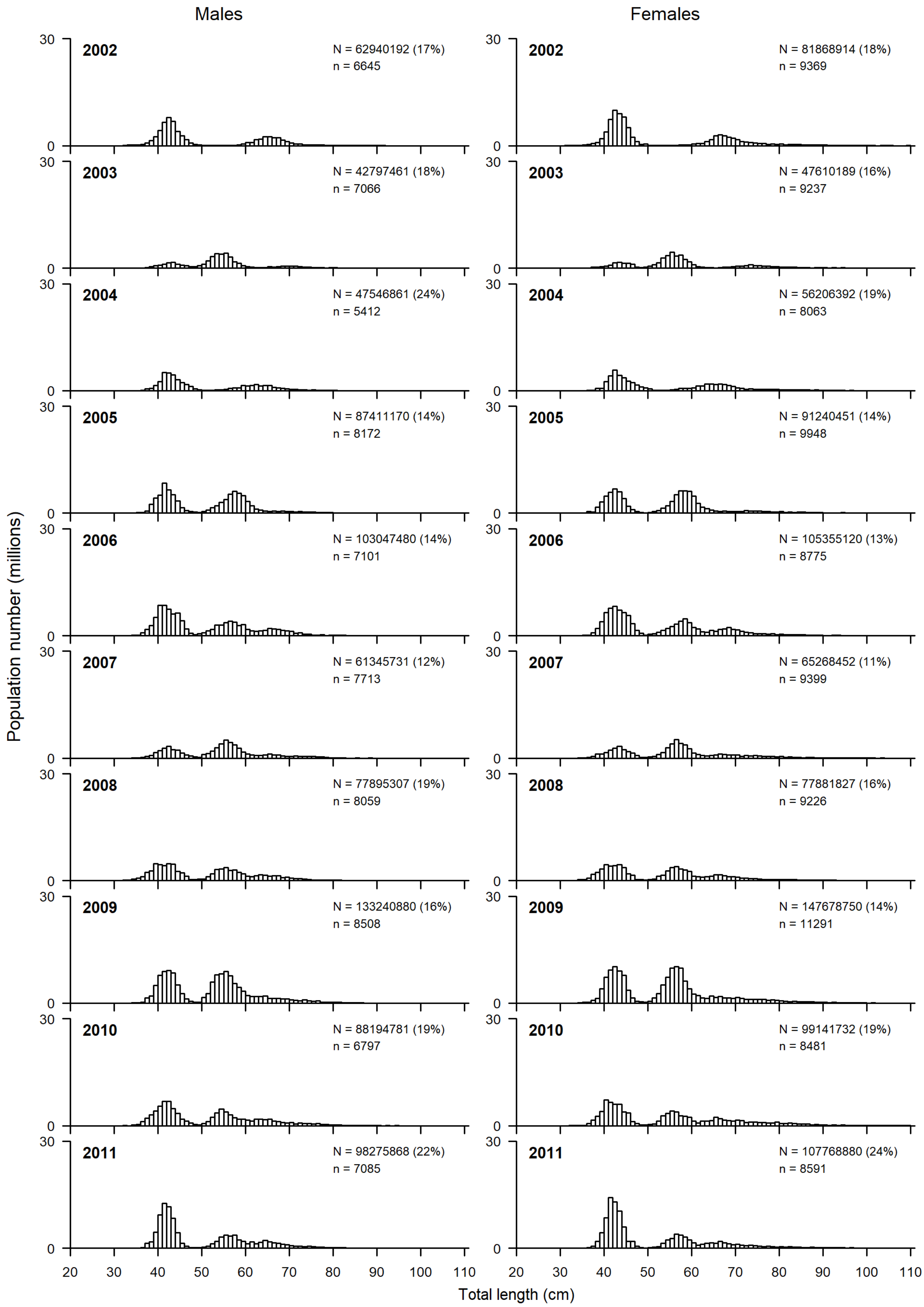


Figure 10: Estimated length frequency distributions of the male and female hoki population from Tangaroa surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022 for core strata. N, estimated population number of male hoki (left panel) and female hoki (right panel); CV (in parentheses), coefficient of variation; n, numbers of fish measured.



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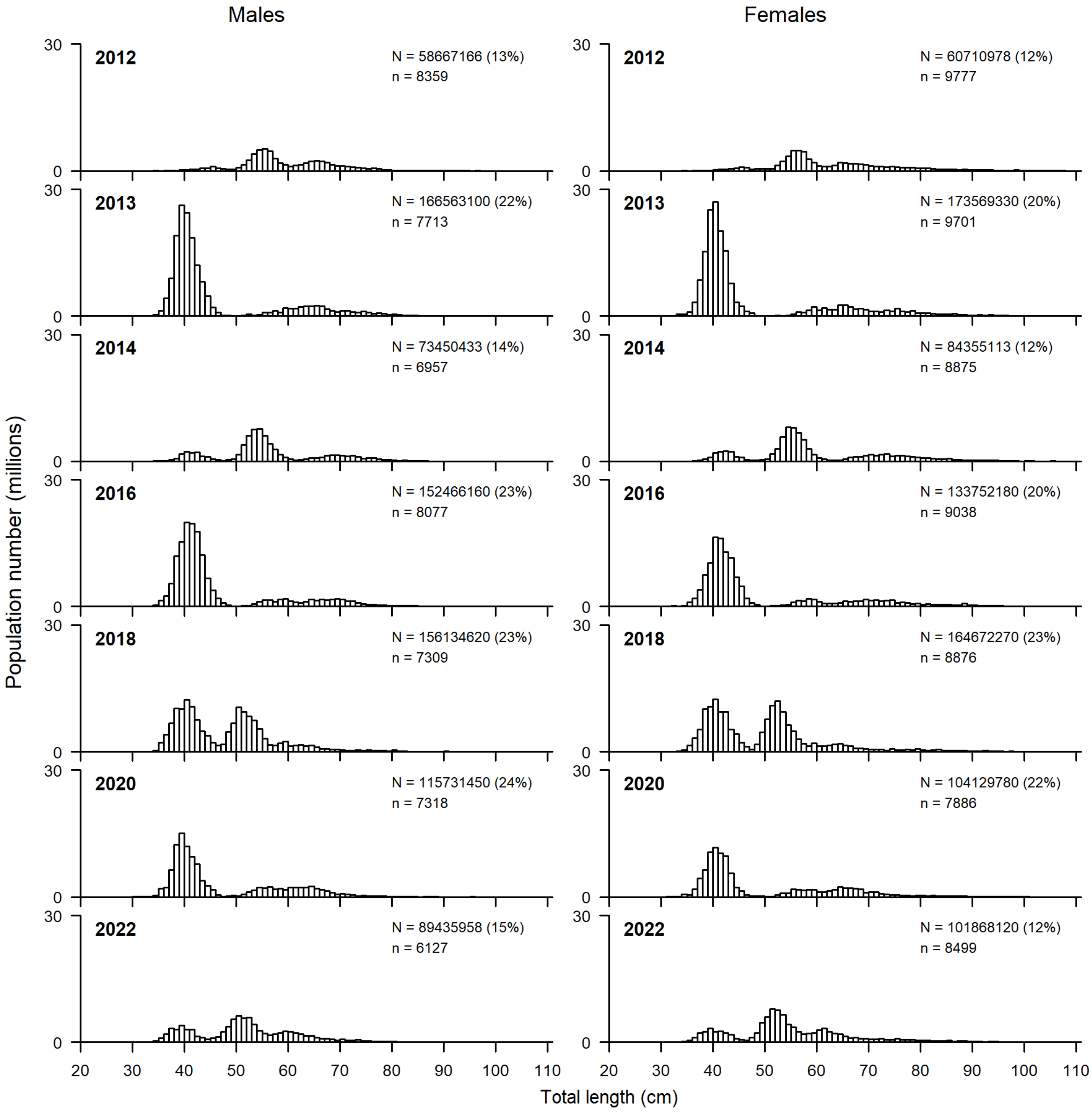

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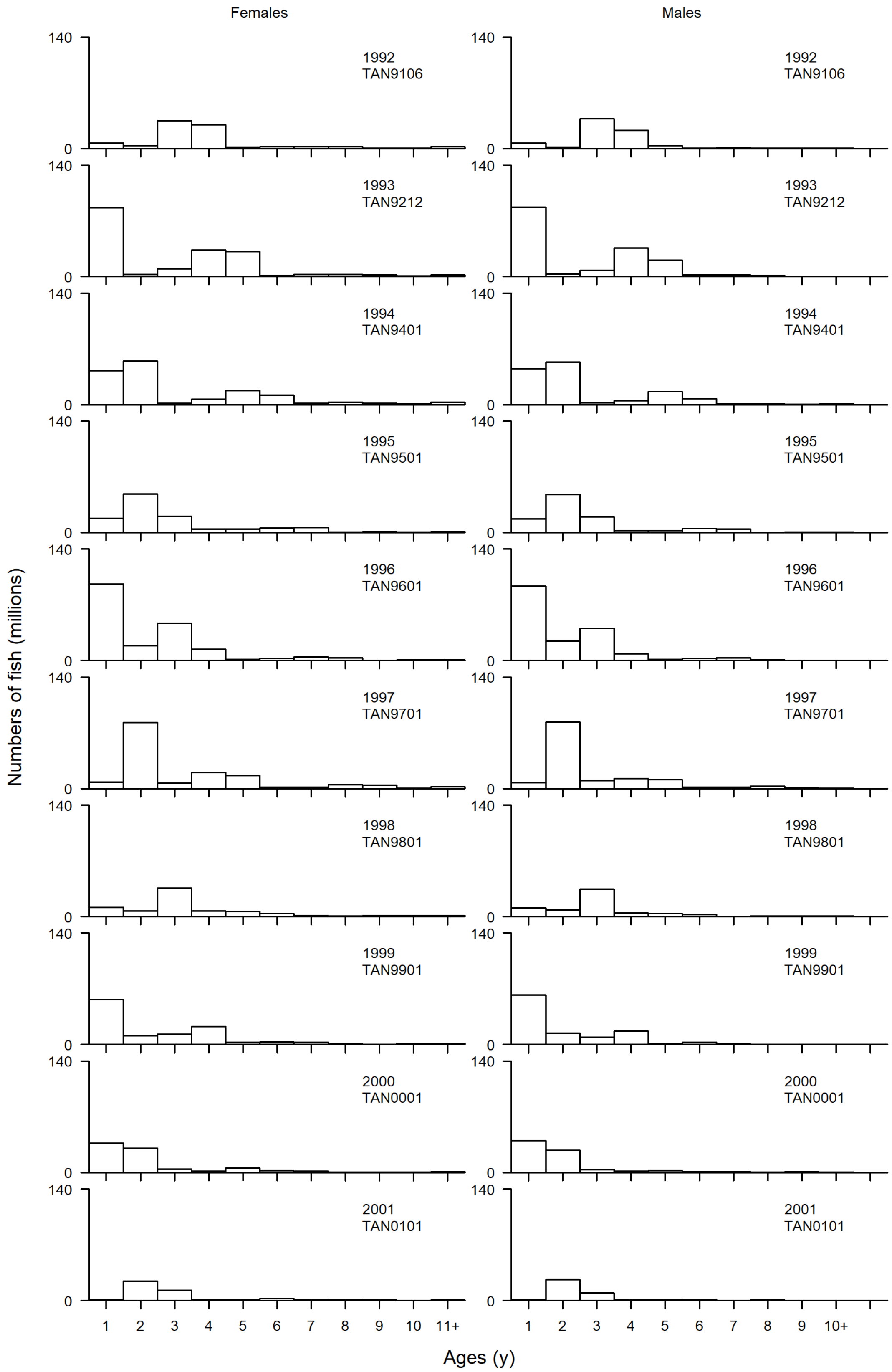

Figure 11: Estimated population numbers-at-age for hoki from Tangaroa surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022. + indicates plus group of combined ages.

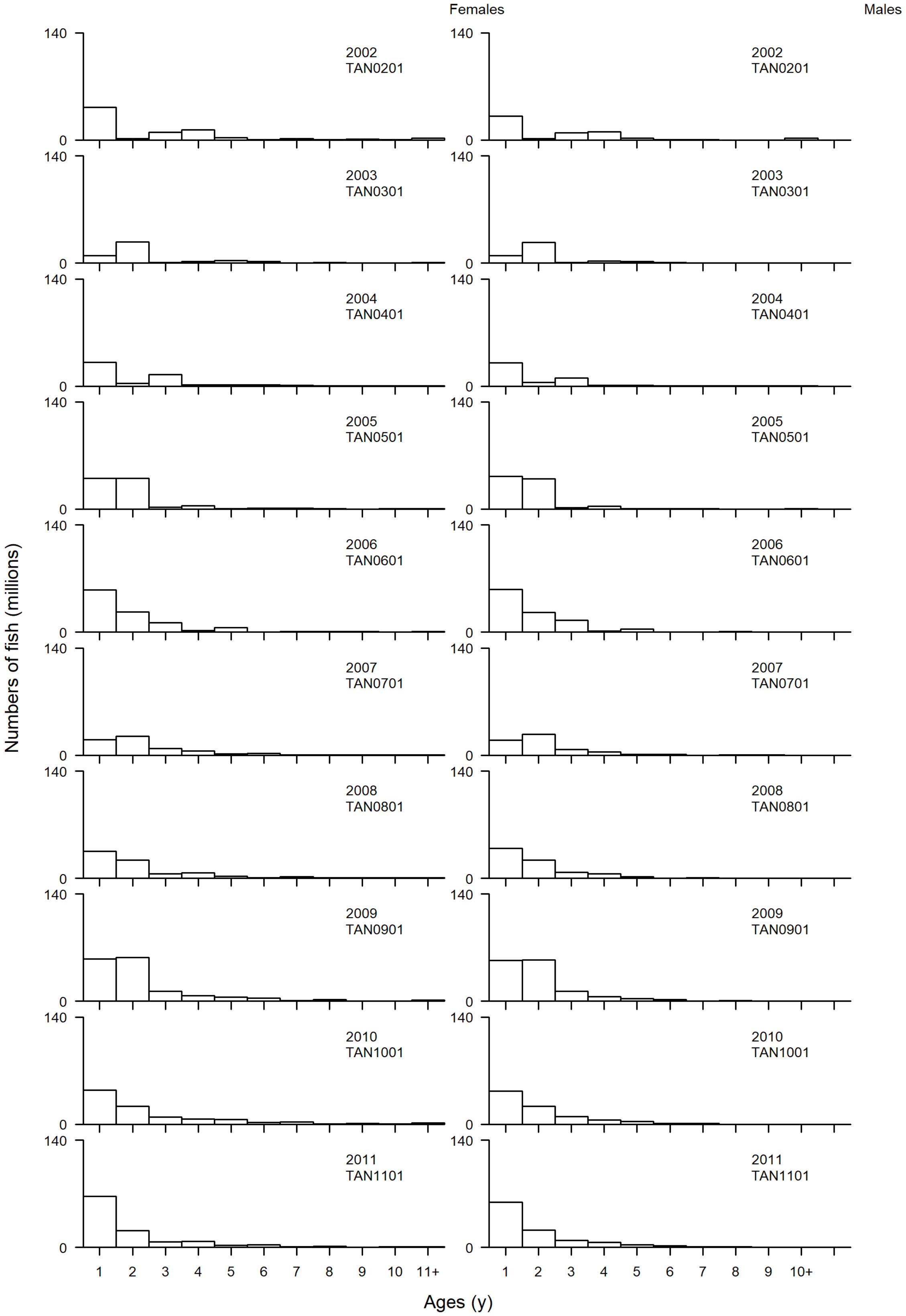

Figure 11 (continued).

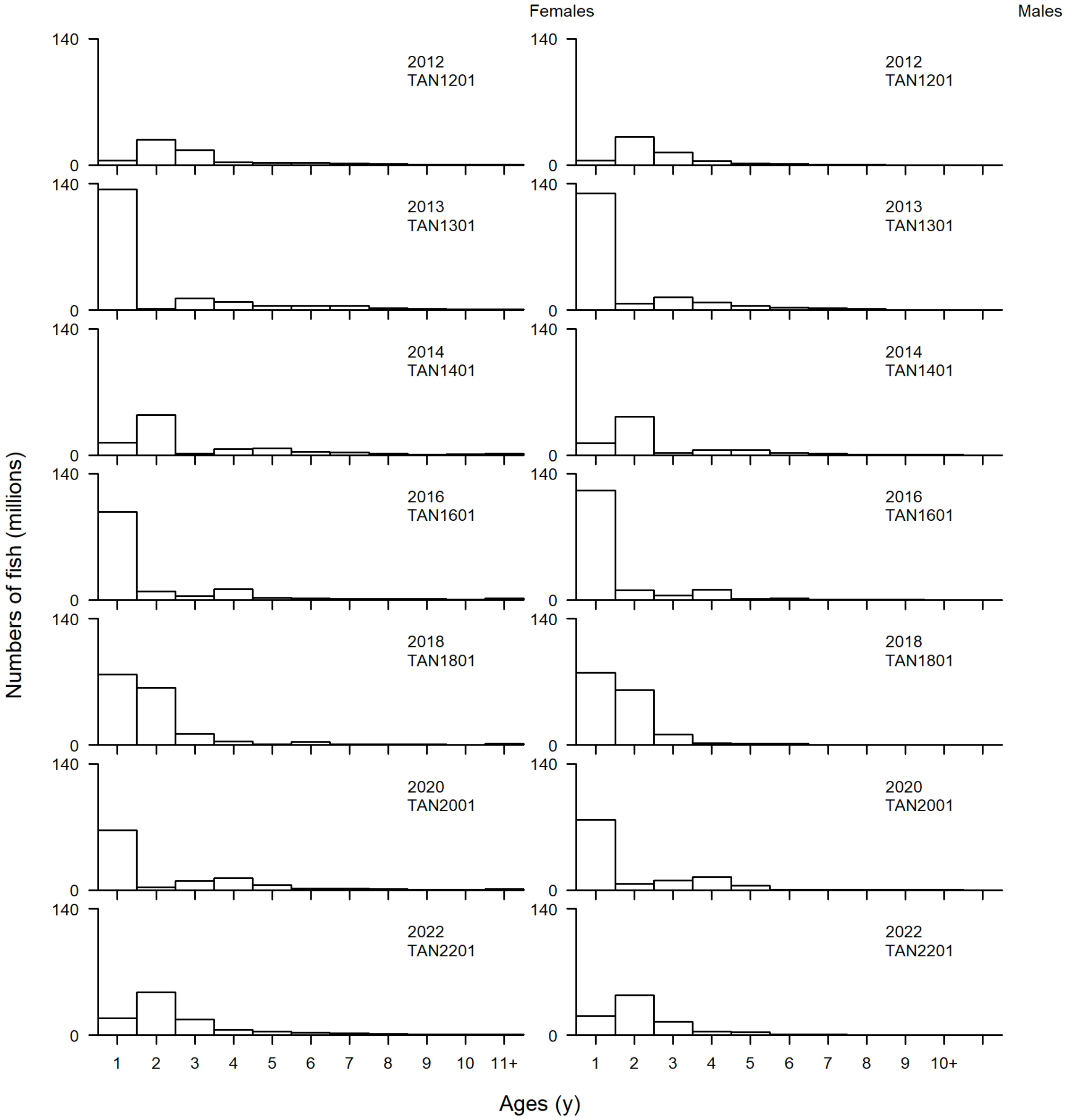

Figure 11 (continued).

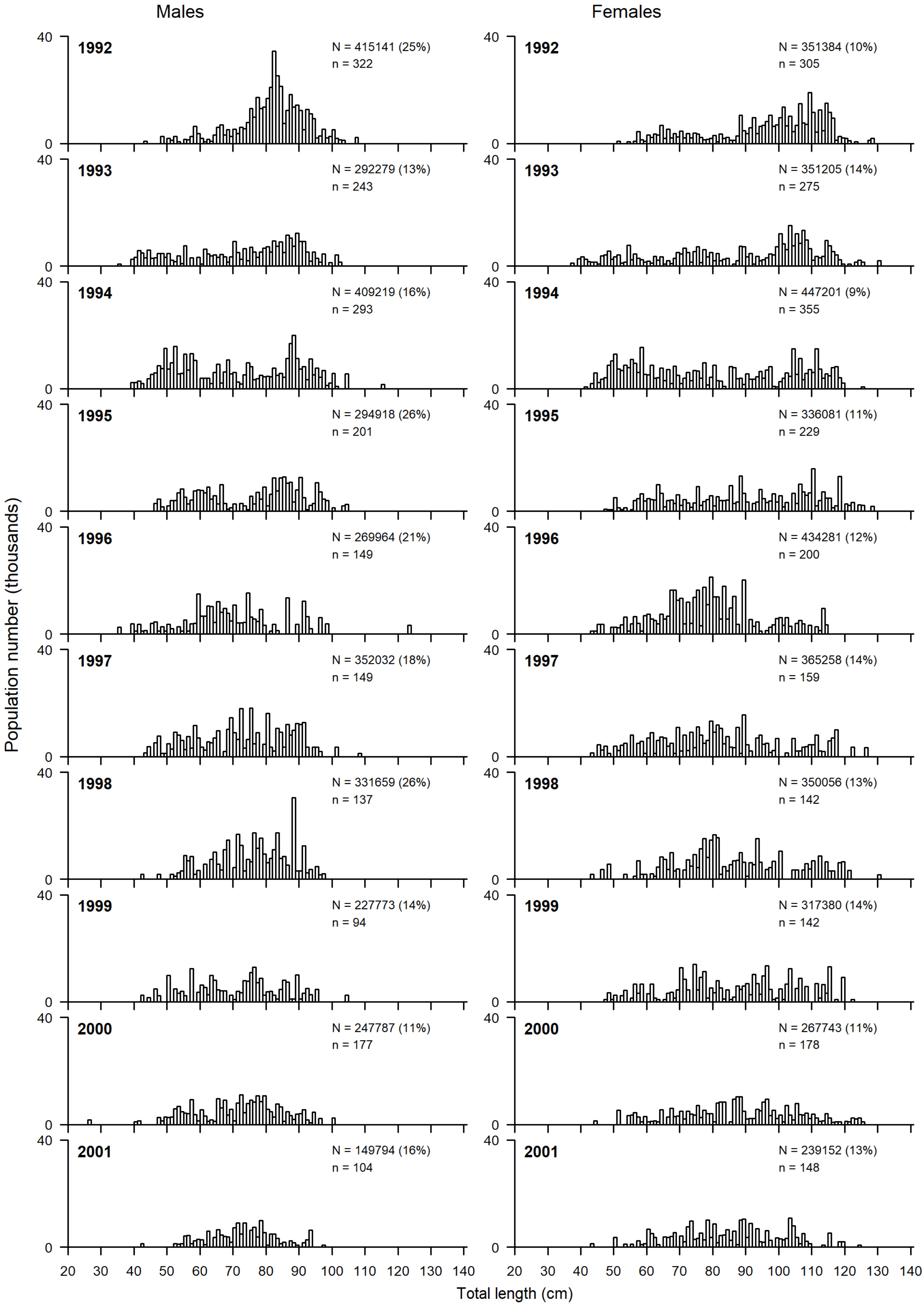

Figure 12: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022 for core strata. N, estimated population number of male hake (left panel) and female hake (right panel); CV (in parentheses), coefficient of variation; n, numbers of fish measured.

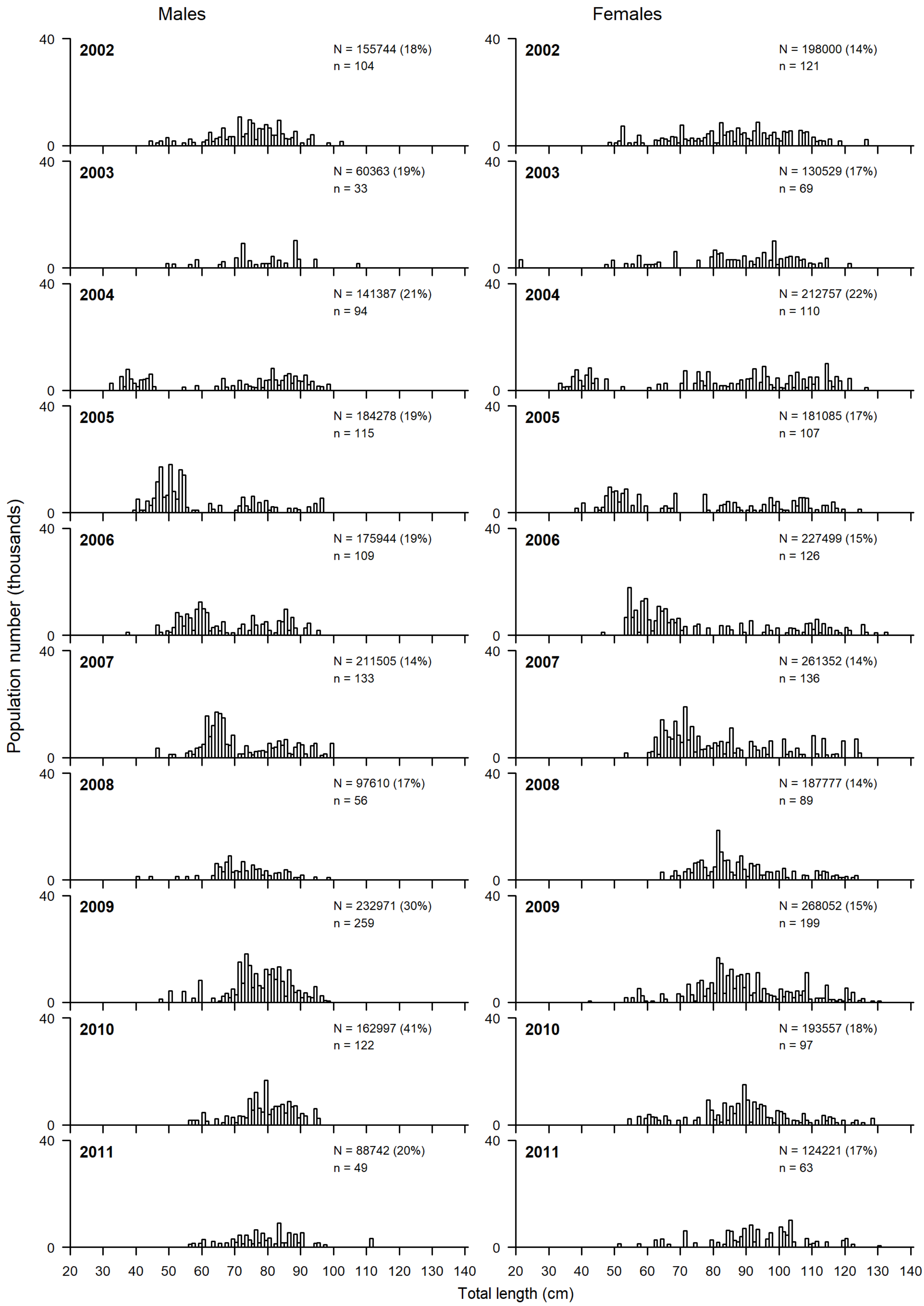

Figure 12 (continued).

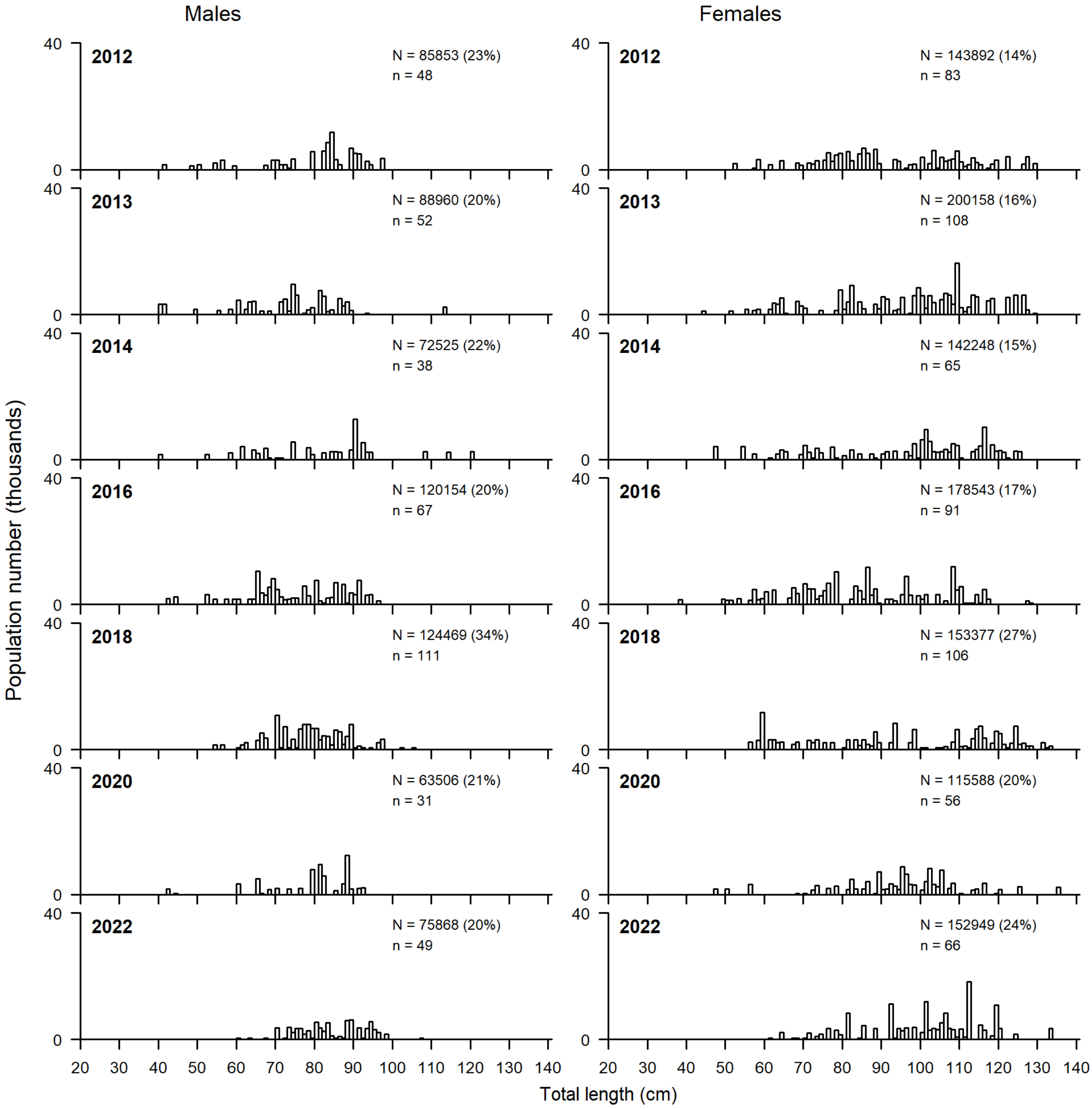

Figure 12 (continued).

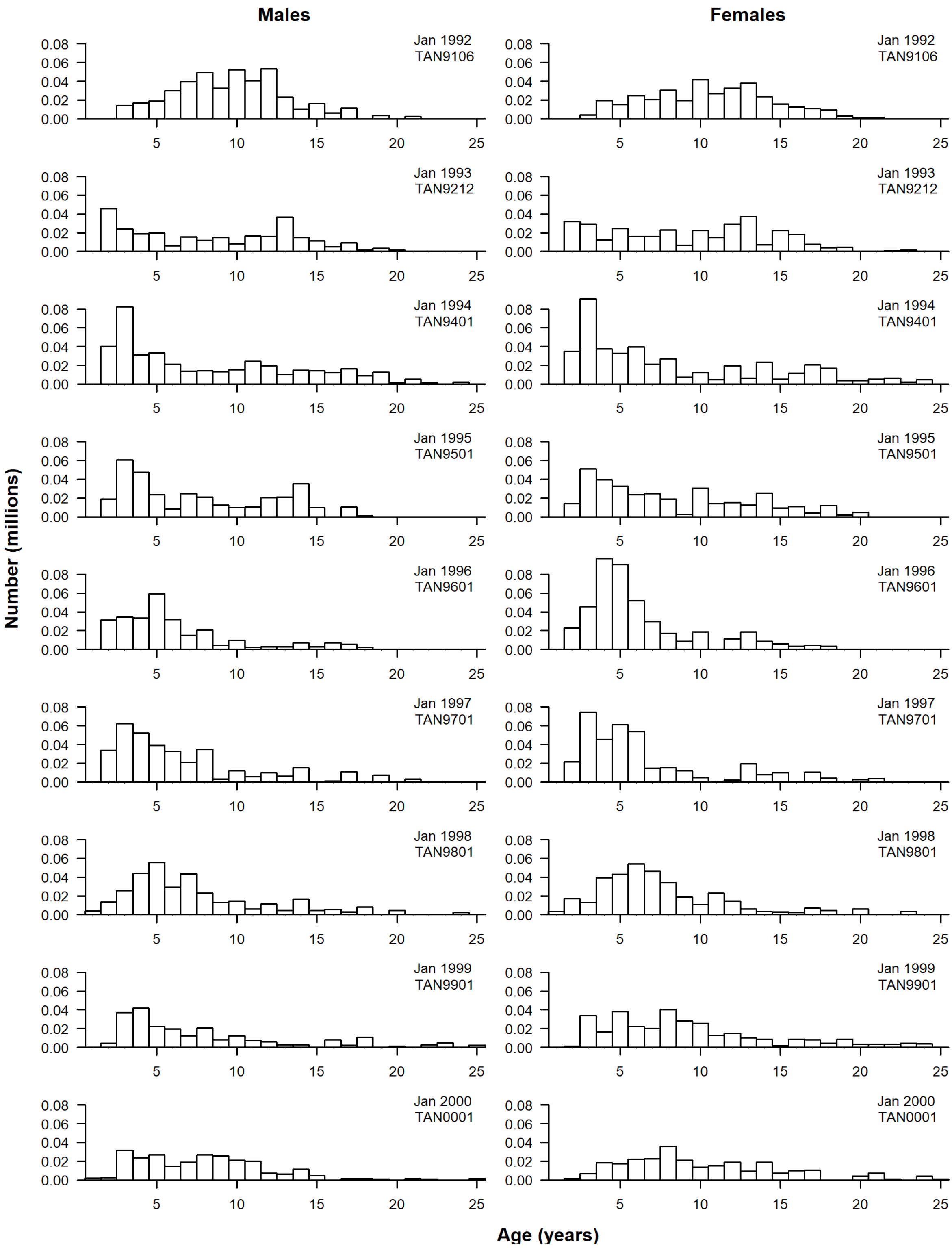

Figure 13: Estimated population numbers-at-age for male and female hake from Tangaroa surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022.

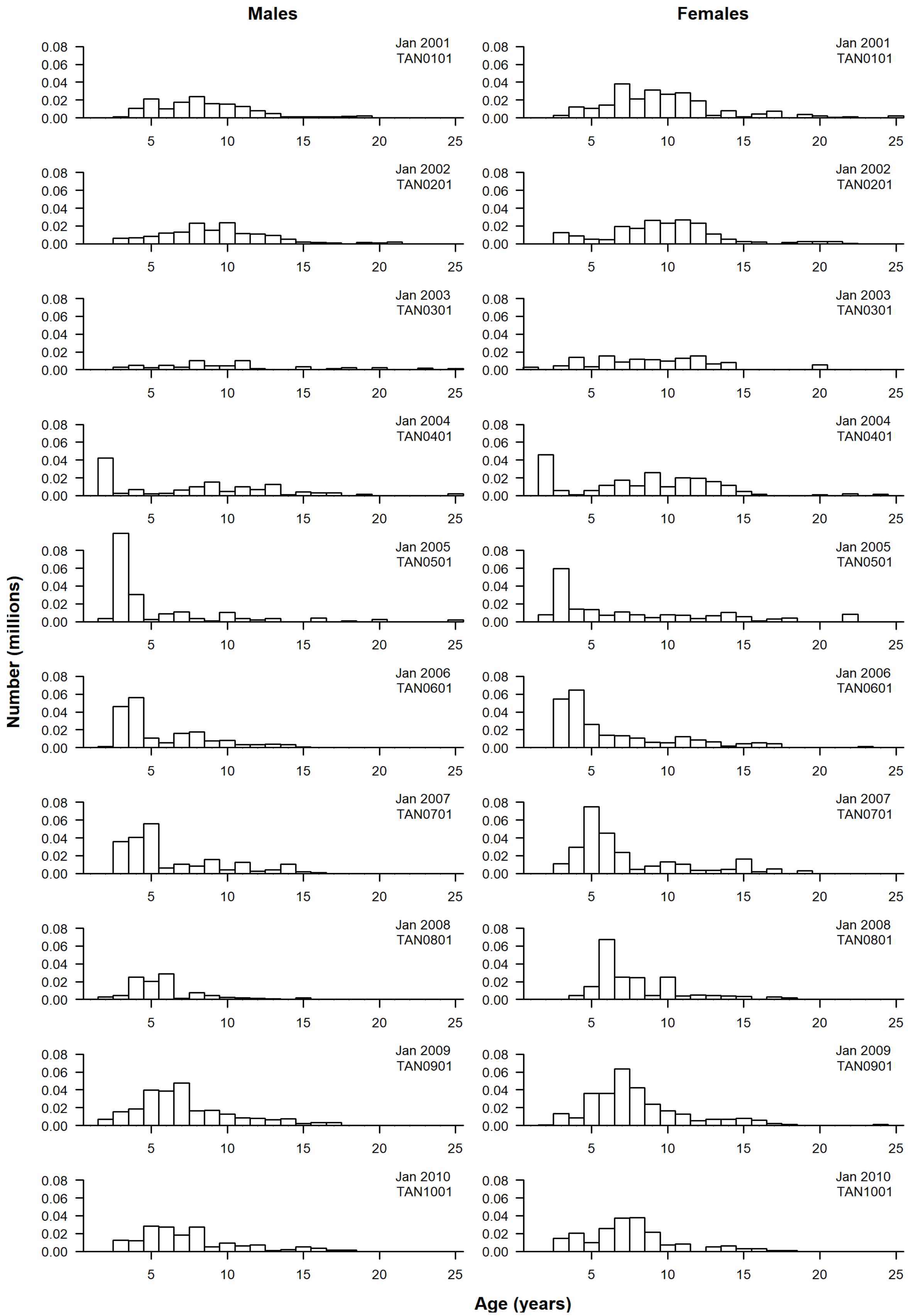

Figure 13 (continued).

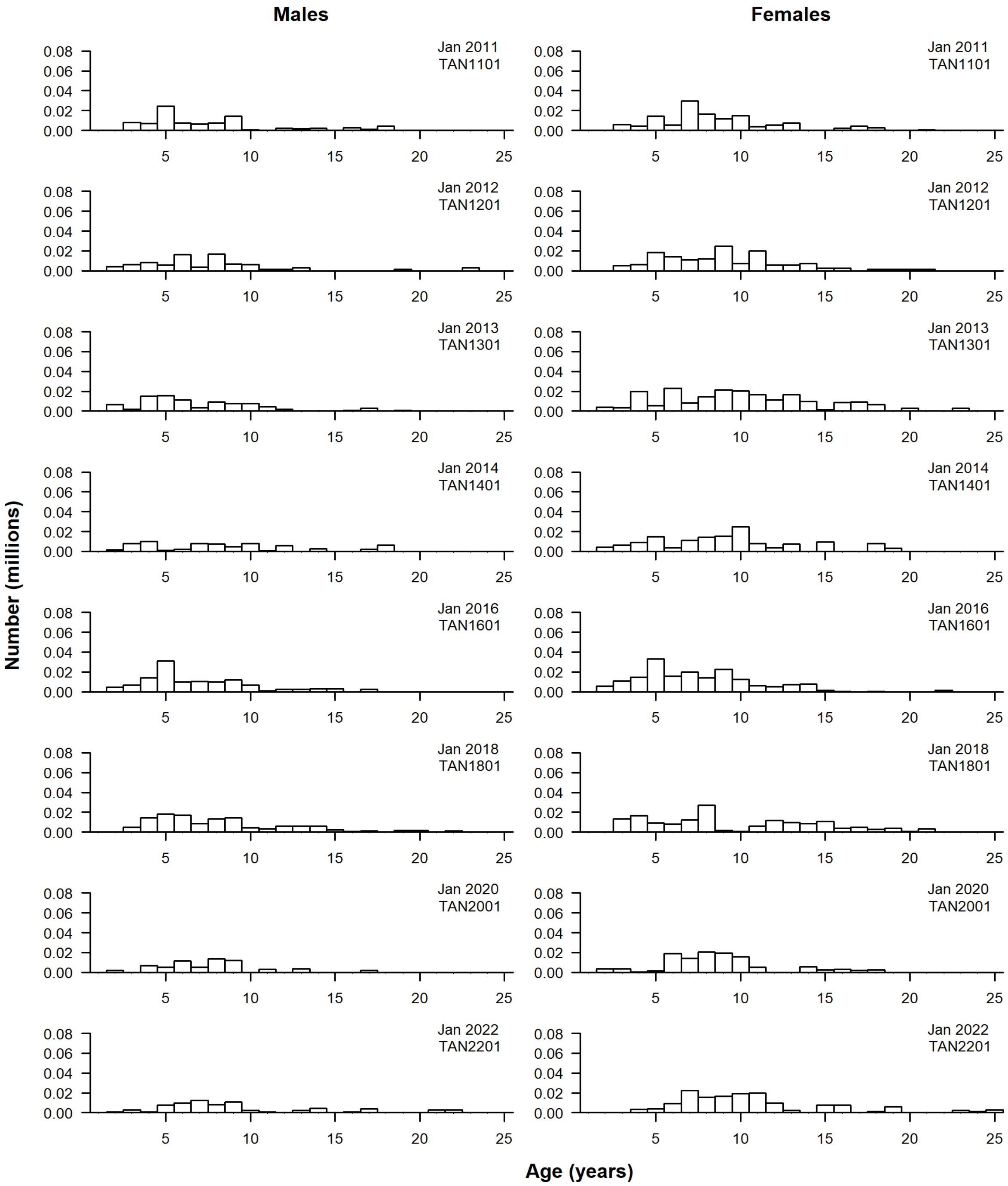

Figure 13 (continued).

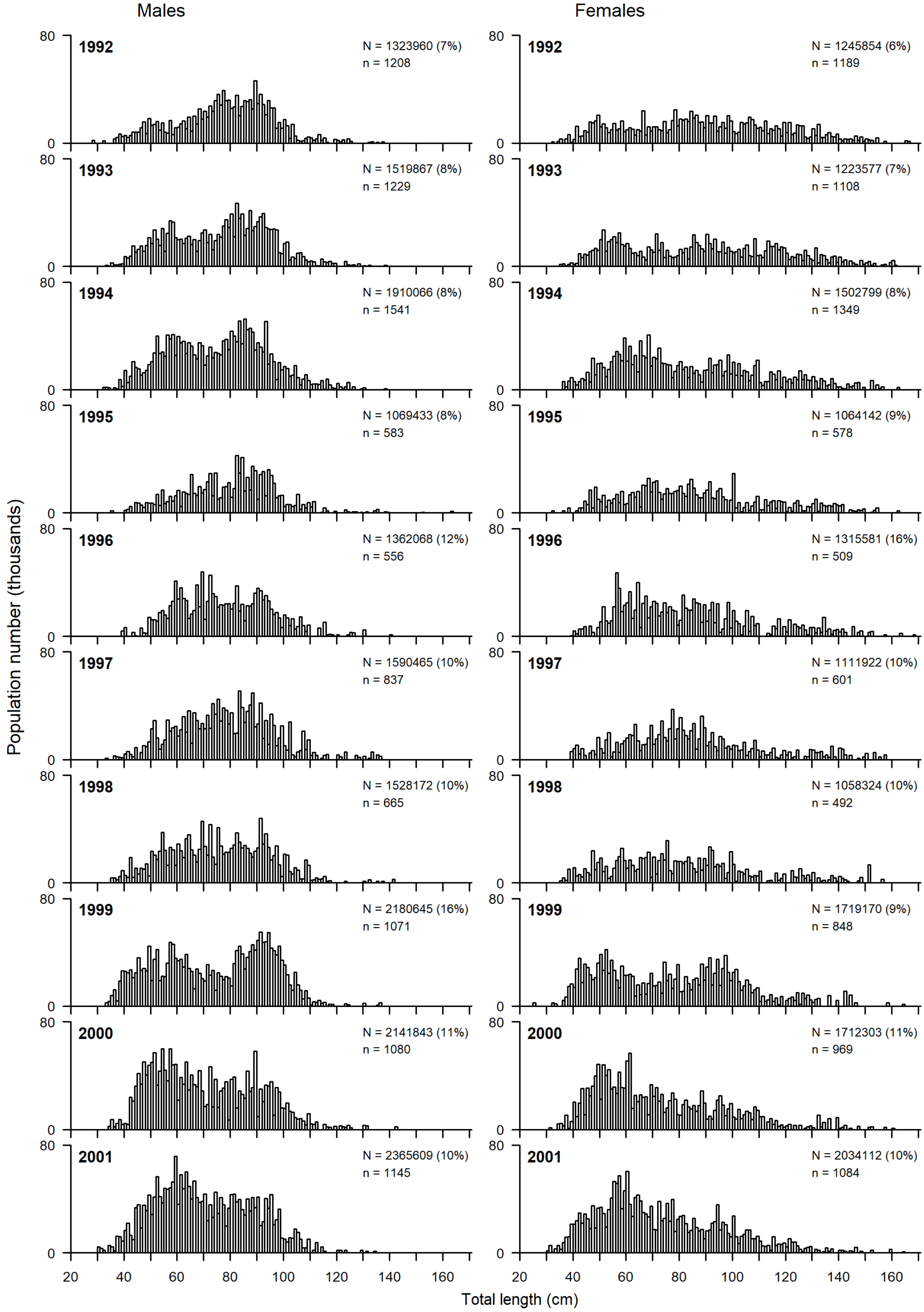

Figure 14: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022 for core strata. N, estimated population number of male ling (left panel) and female ling (right panel); CV (in parentheses), coefficient of variation; n, numbers of fish measured.

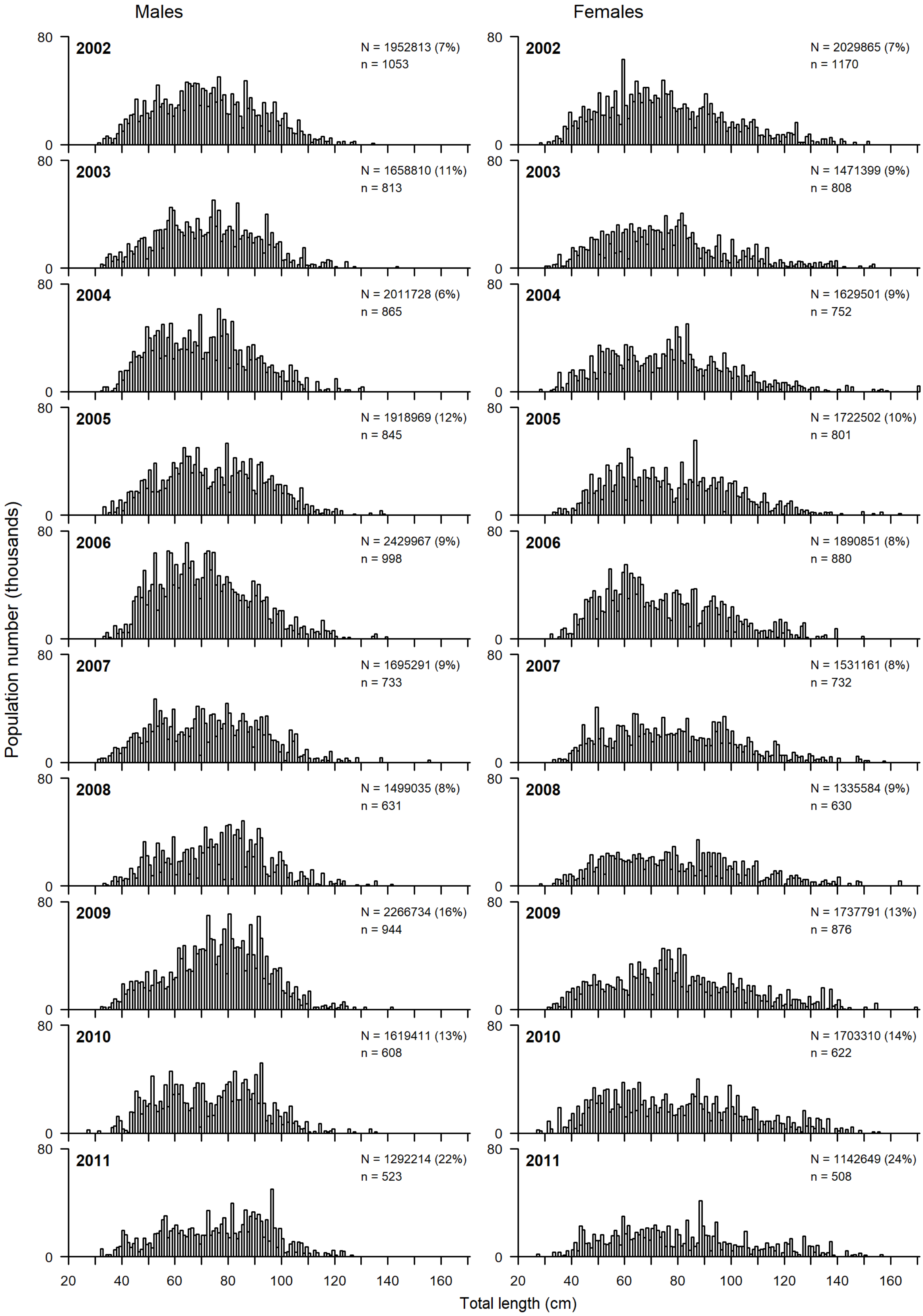

Figure 14 (continued).

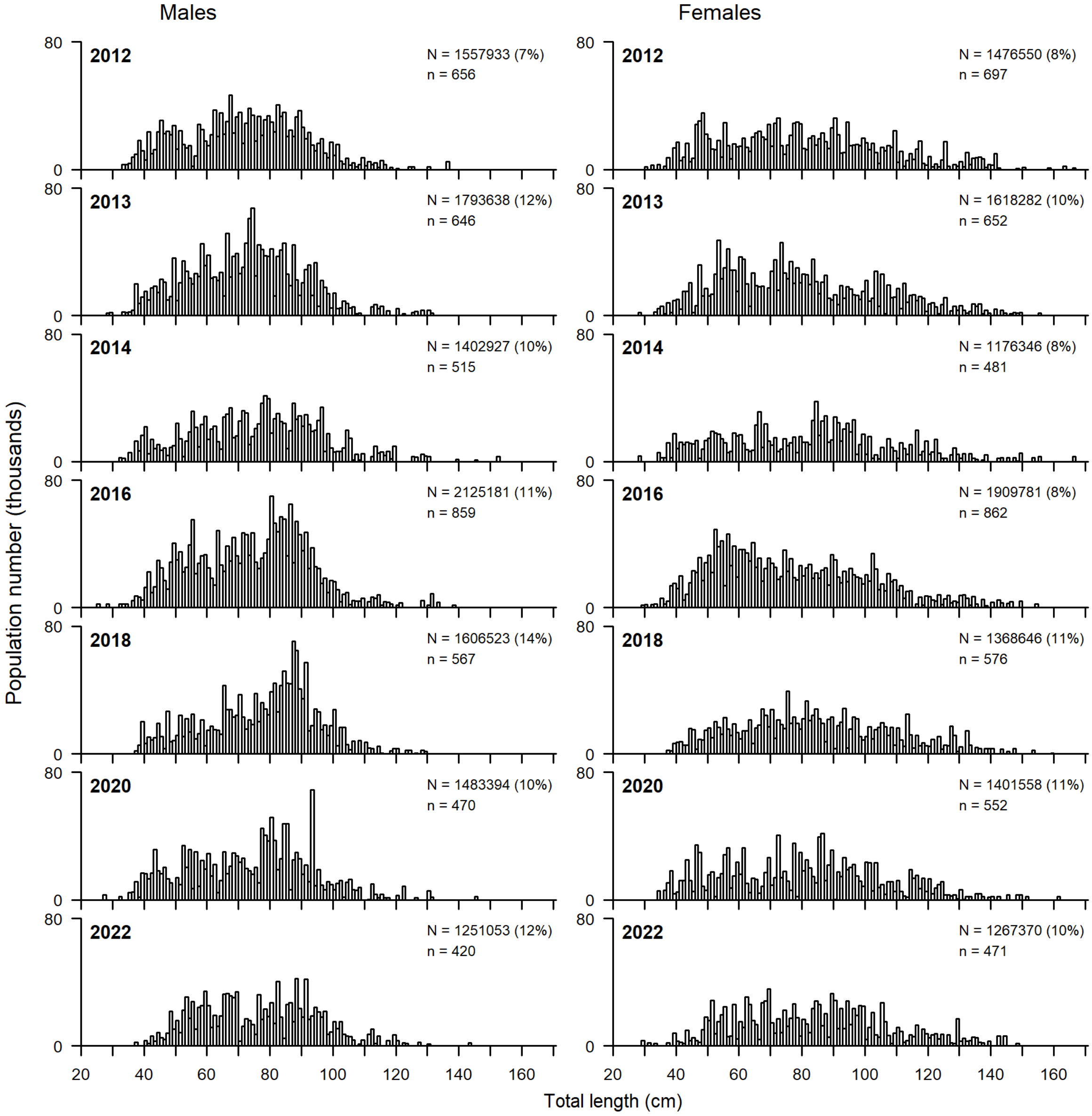

Figure 14 (continued).

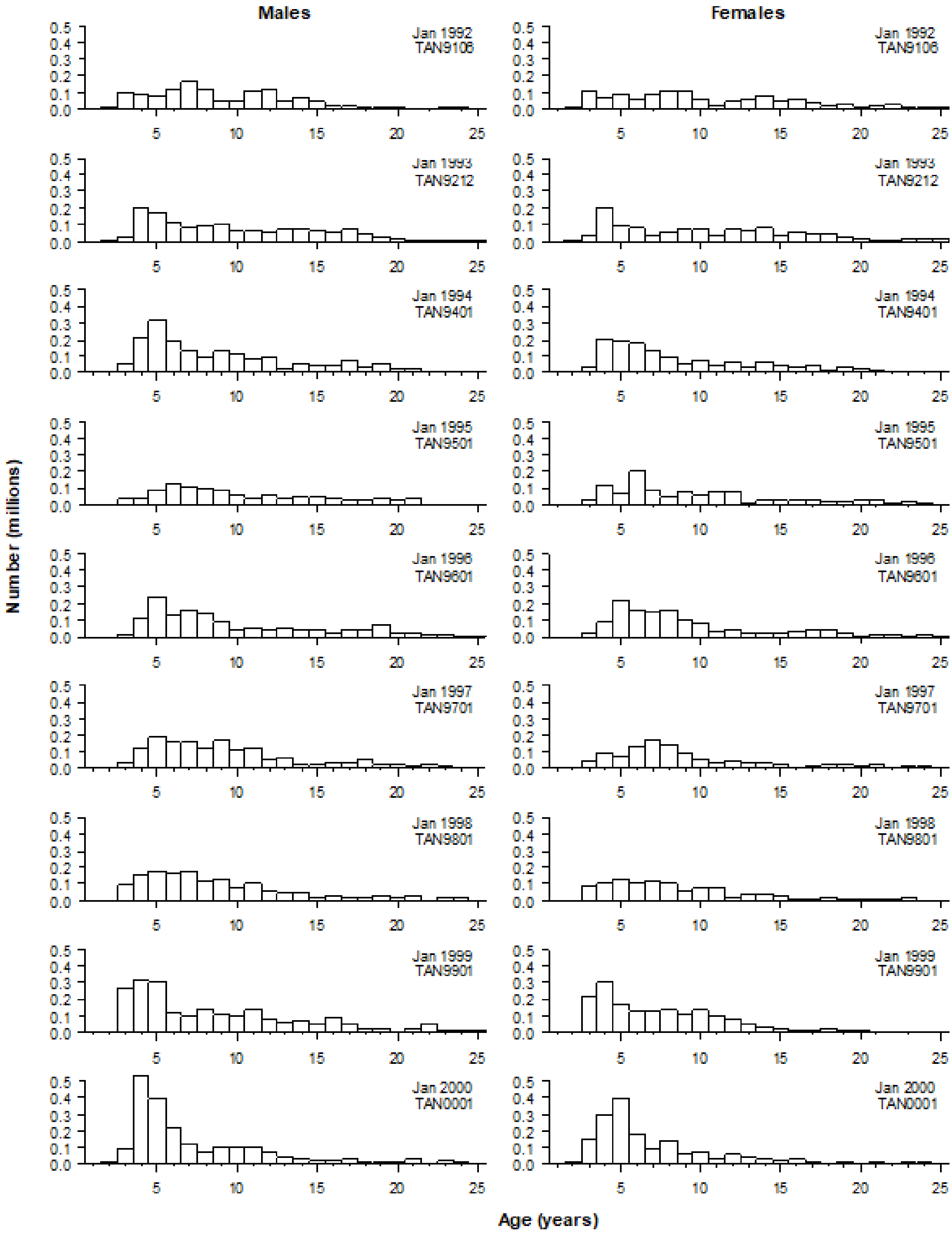

Figure 15: Estimated population numbers-at-age for male and female ling from Tangaroa surveys of the Chatham Rise, January 1992–2014, 2016, 2018, 2020, and 2022.

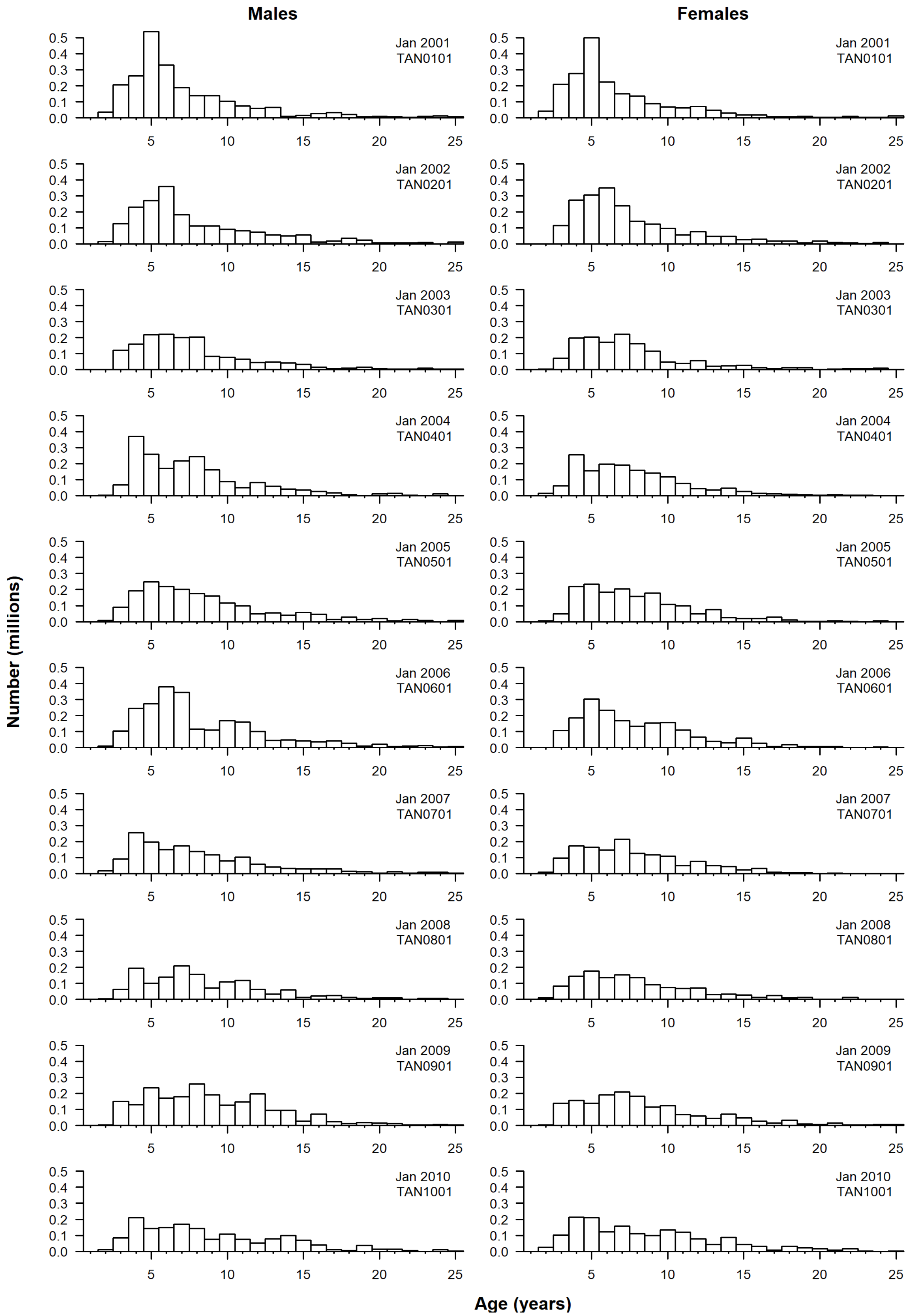

Figure 15 (continued).

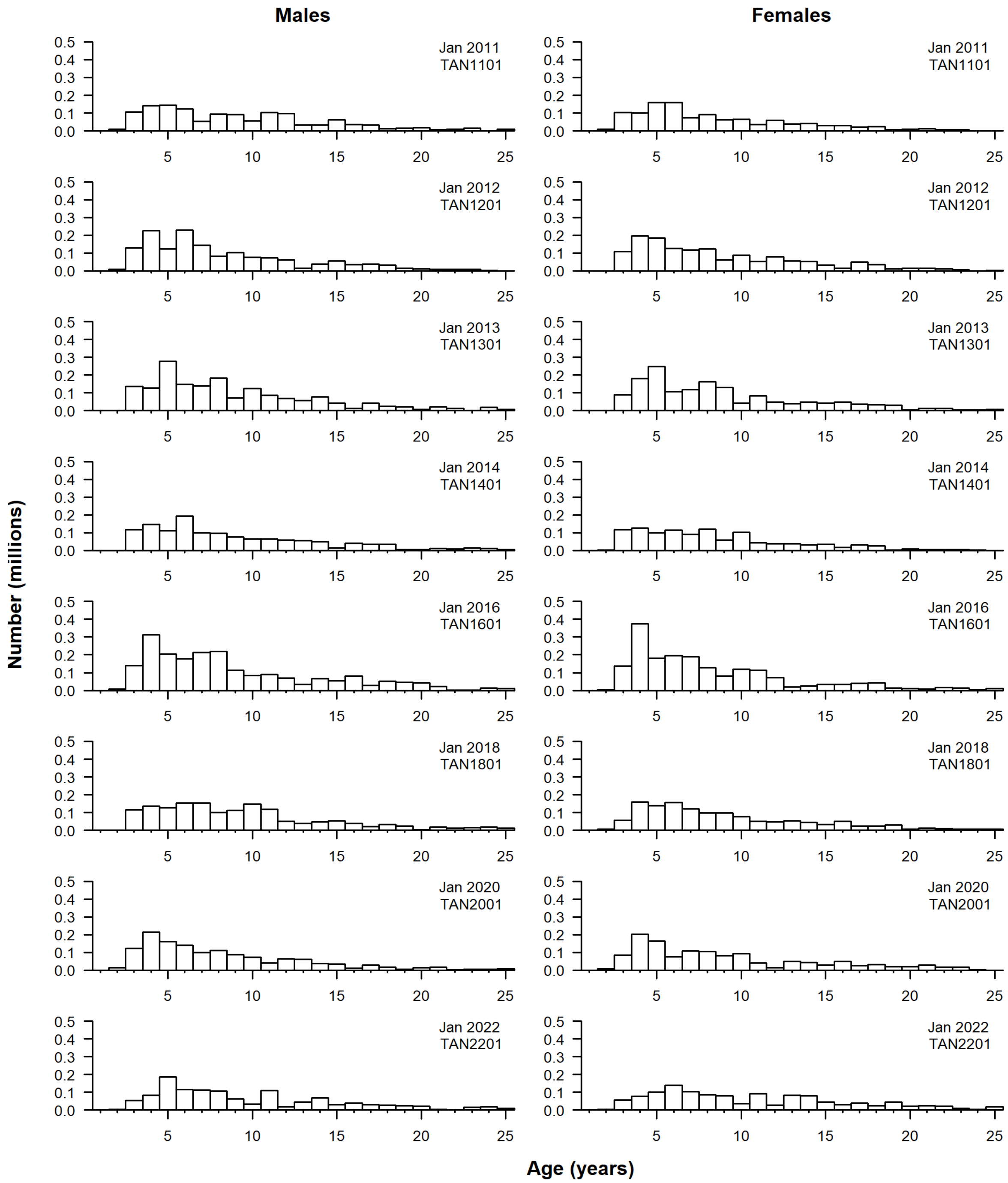

Figure 15 (continued).

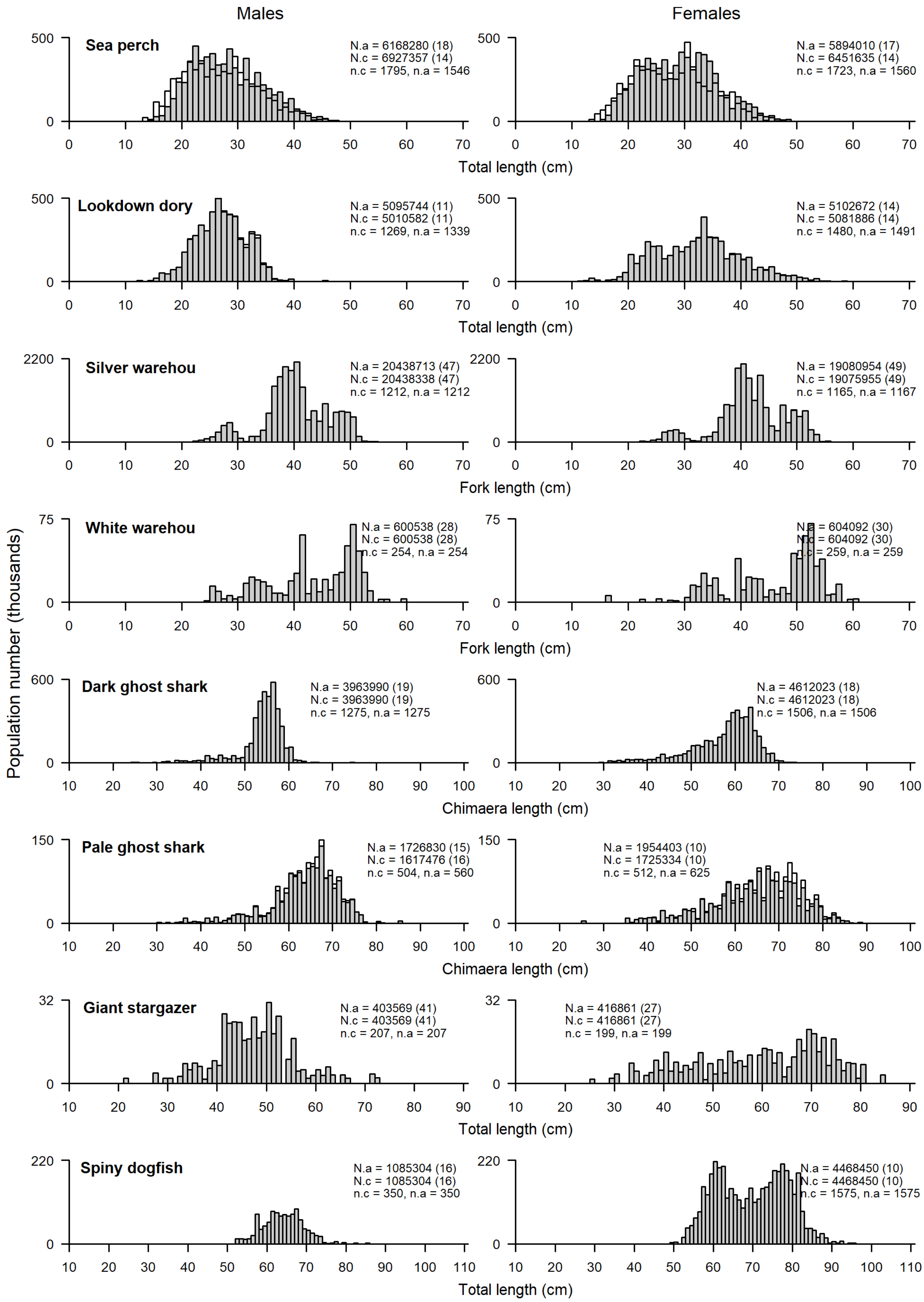

Figure 16a: Length frequency distributions of eight selected commercial species on the Chatham Rise 2022, scaled to population size by sex. N.a, estimated number of male fish (left panel) and female fish (right panel) from all (200–1300 m) strata; N.c, estimated number of male fish (left panel) and female 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.

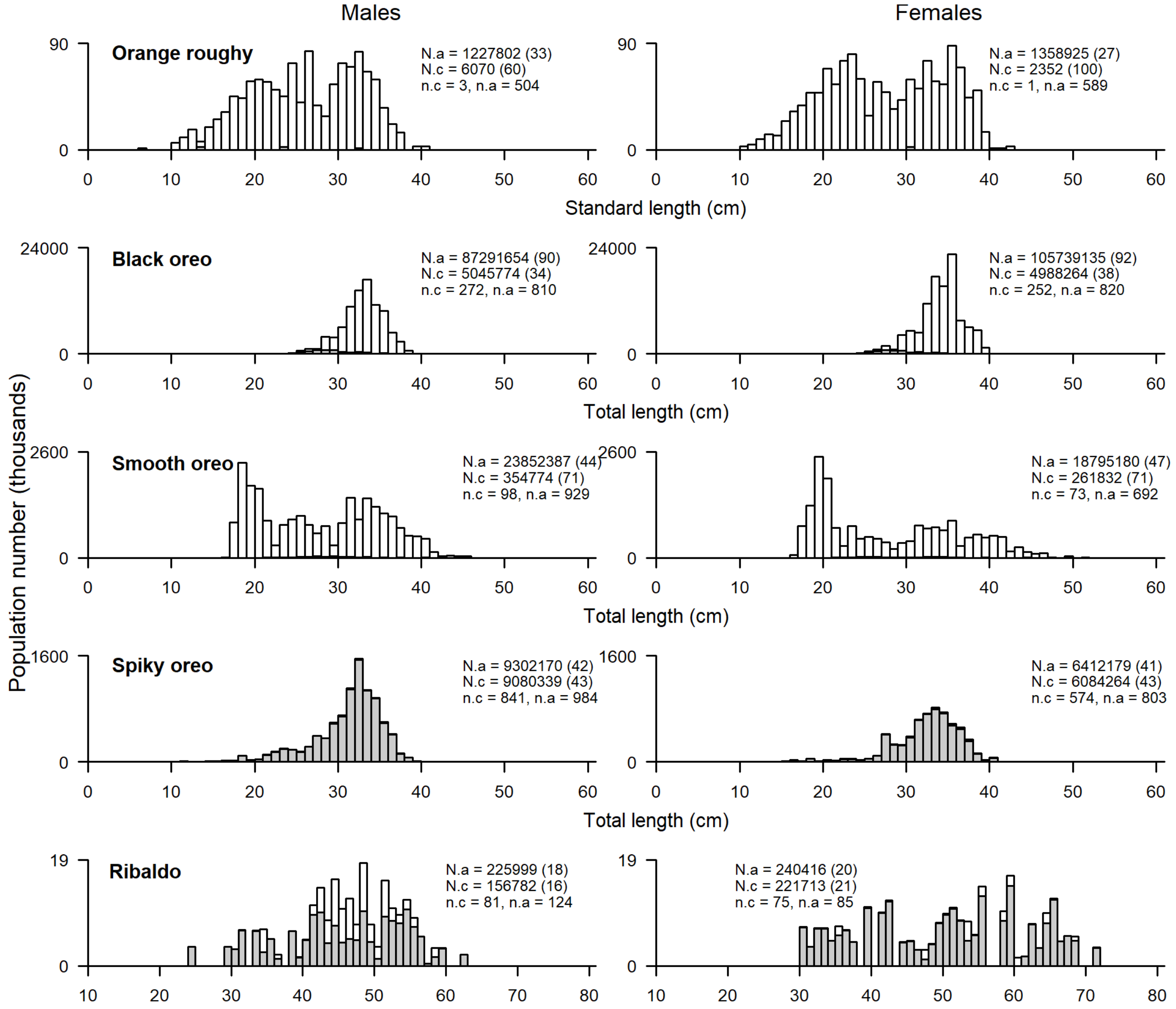

Figure 16b: Length frequency distributions of orange roughy, oreo species, and other selected deepwater species on the Chatham Rise 2022, scaled to population size by sex. N.a, estimated number of male fish (left panel) and female fish (right panel) from all (200–1300 m) strata; N.c, estimated number 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.

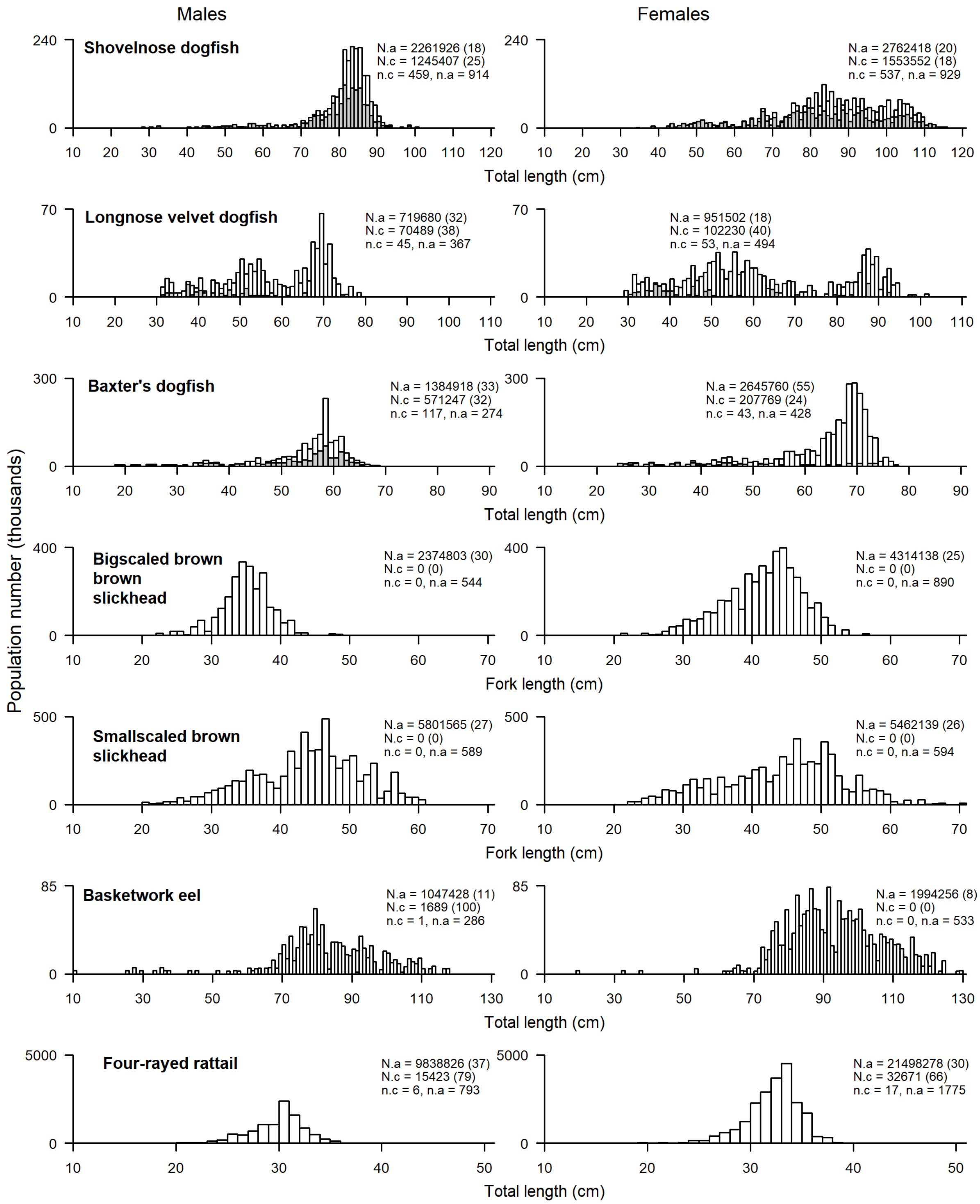

Figure 16b (continued).

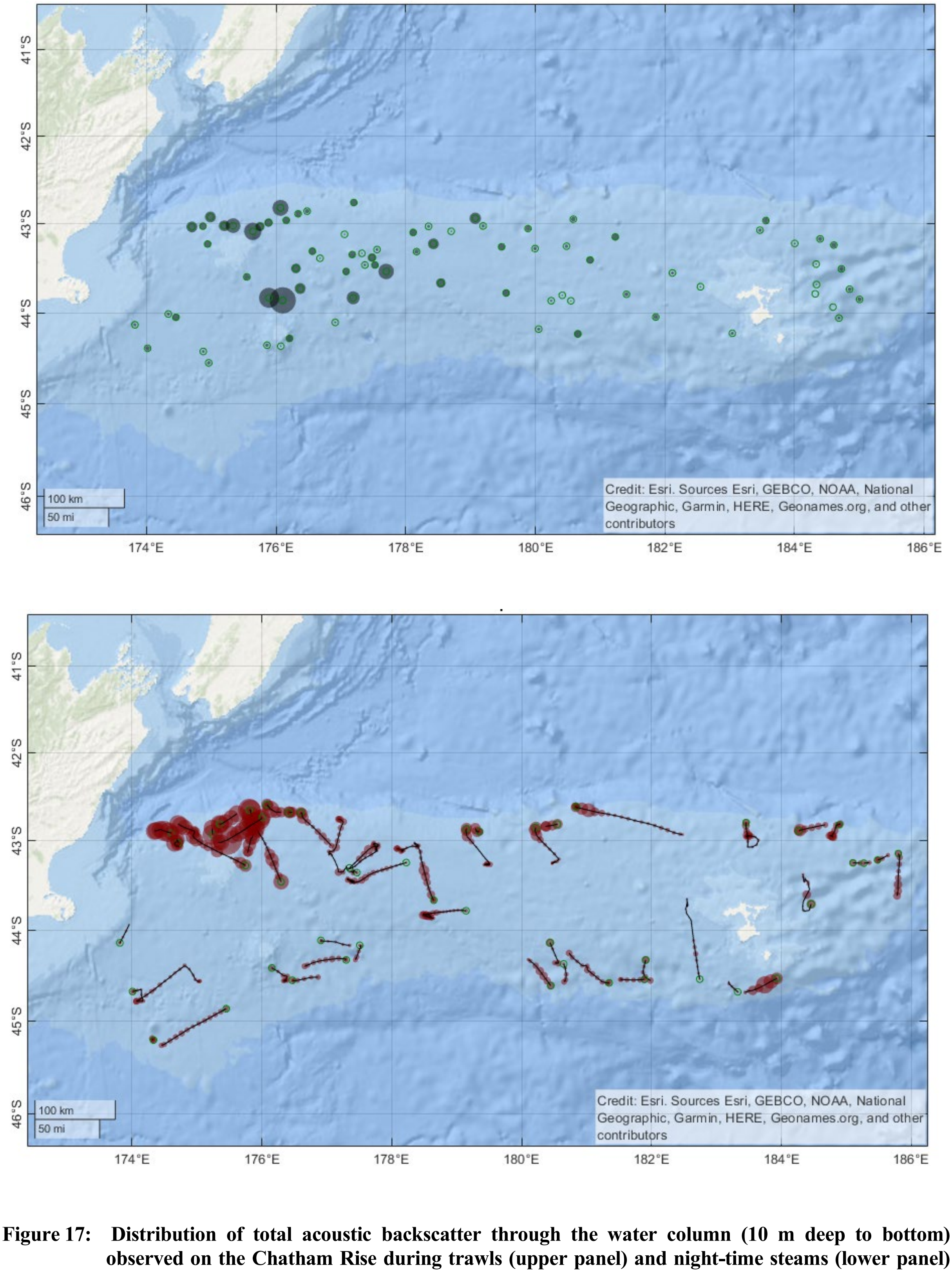

Figure 17: Distribution of total acoustic backscatter through the water column (10 m deep to bottom) observed on the Chatham Rise during trawls (upper panel) and night-time steams (lower panel) throughout the entire survey area in January 2022. Night-time bubbles represent sliced area backscattering coefficient s_a (in m^2 km^{-2}, max. size = 166 m^2 km^{-2}). Daytime bubbles represent day trawl s_a (max. size = 147 m^2 km^{-2}).

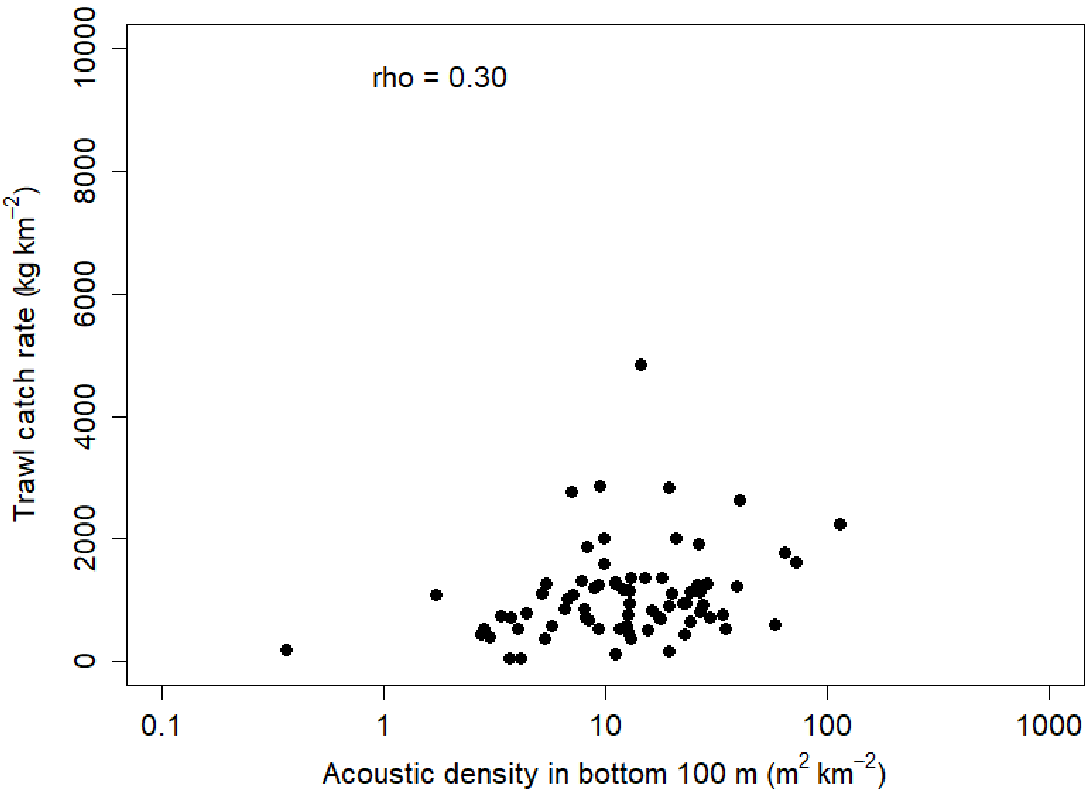

Figure 18: Relationship between total trawl catch rate (all species combined) and bottom-referenced acoustic backscatter recorded during the trawl on the Chatham Rise in 2022. Rho value is Spearman's rank correlation coefficient.

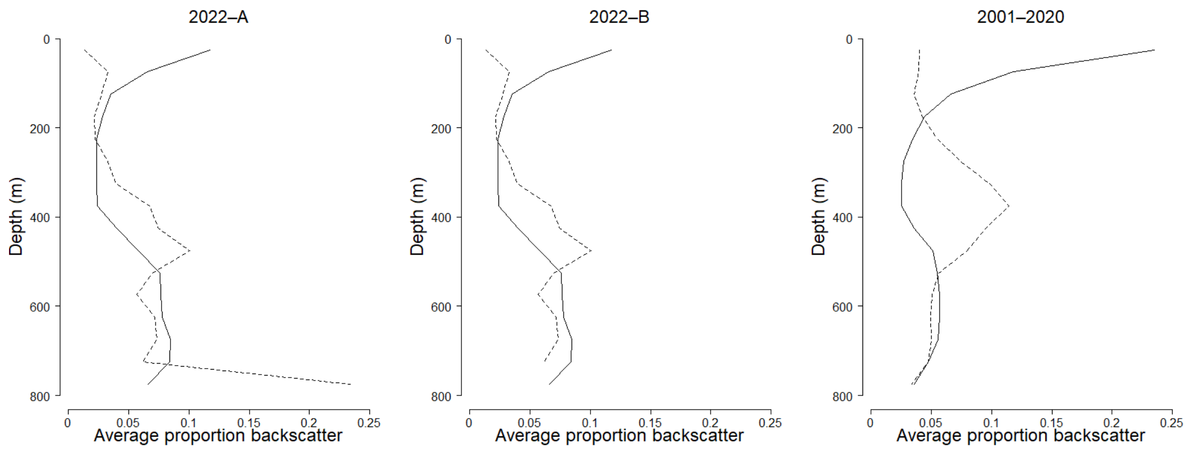

Figure 19: Vertical distribution of the average acoustic backscatter for day (dashed lines) and night (solid lines) for the Chatham Rise surveys in 2022 (left and centre plots) and in 2001–20 (right plot, averaged across all previous surveys).

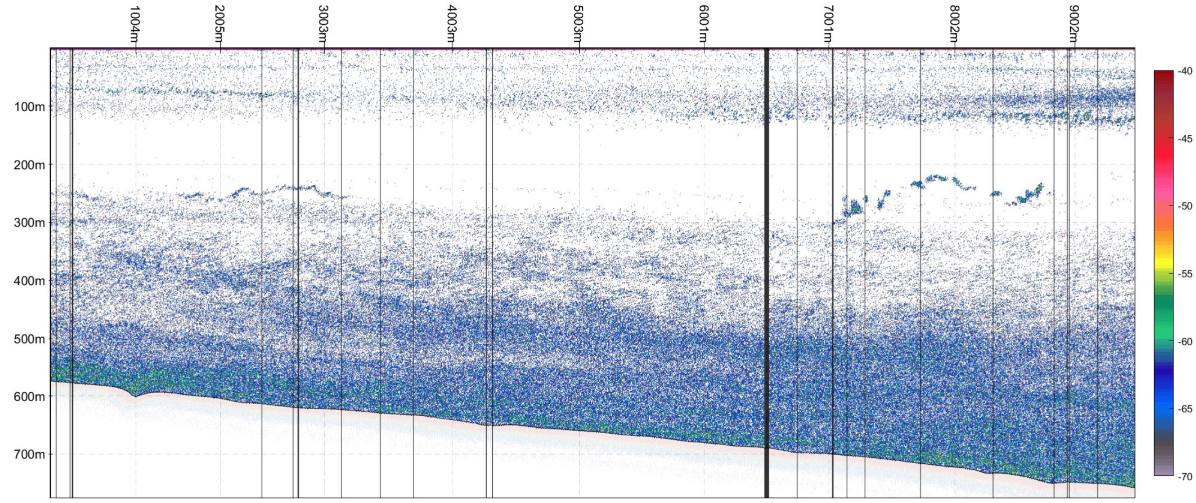

Figure 20: Echogram from core daytime trawl # 111 in stratum 1 (Northwest Chatham Rise) showing dense marks with 100 m off the bottom which were responsible for daytime peak at 750–800 m in vertical distribution of backscatter (see Figure 19). Black vertical lines show transmits where data quality was degraded, which were removed from analysis.

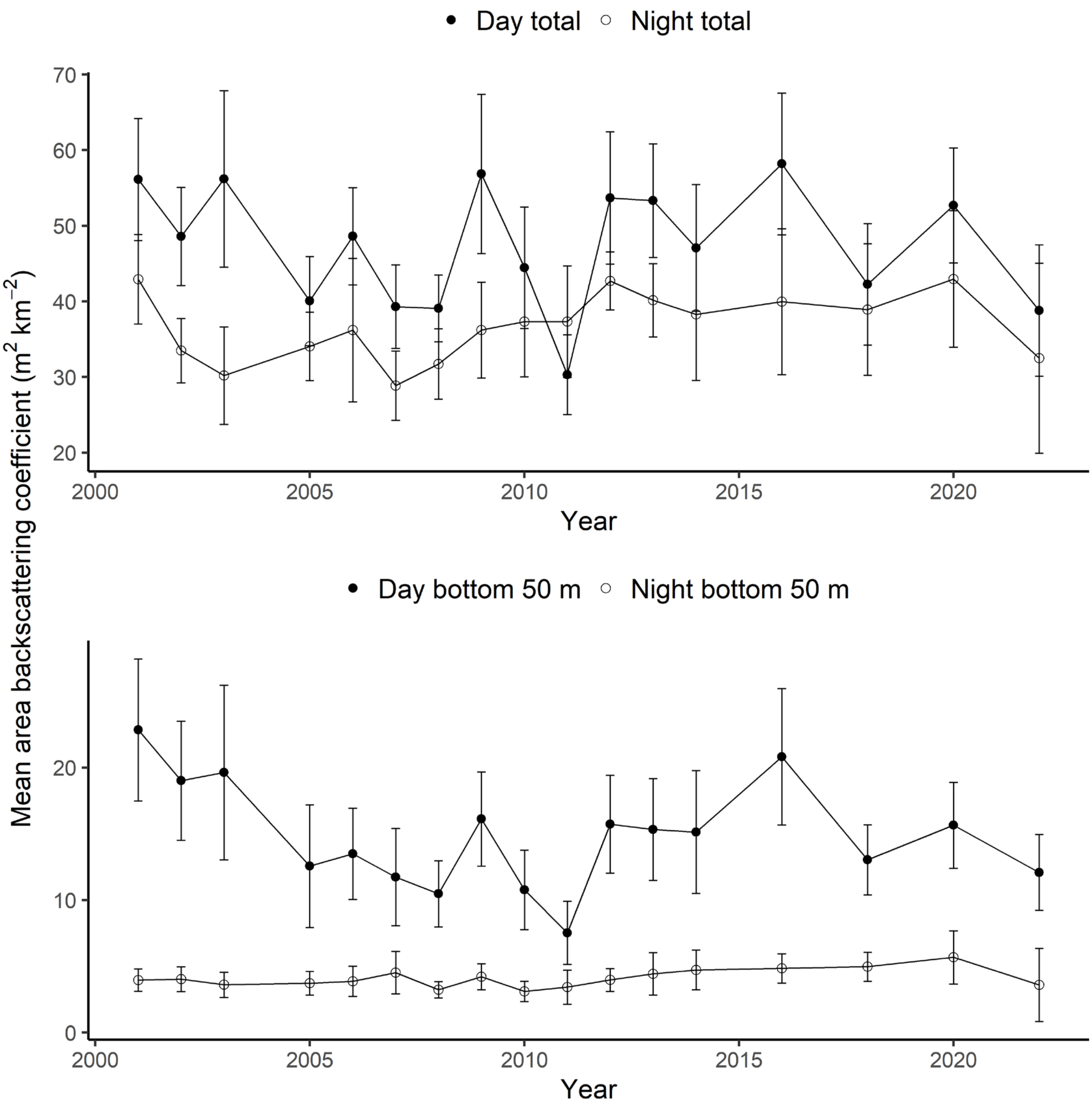

Figure 21: Comparison of relative acoustic abundance indices for the core Chatham Rise area based on (stratum-averaged) mean areal backscatter. Error bars are ± 2 standard errors.

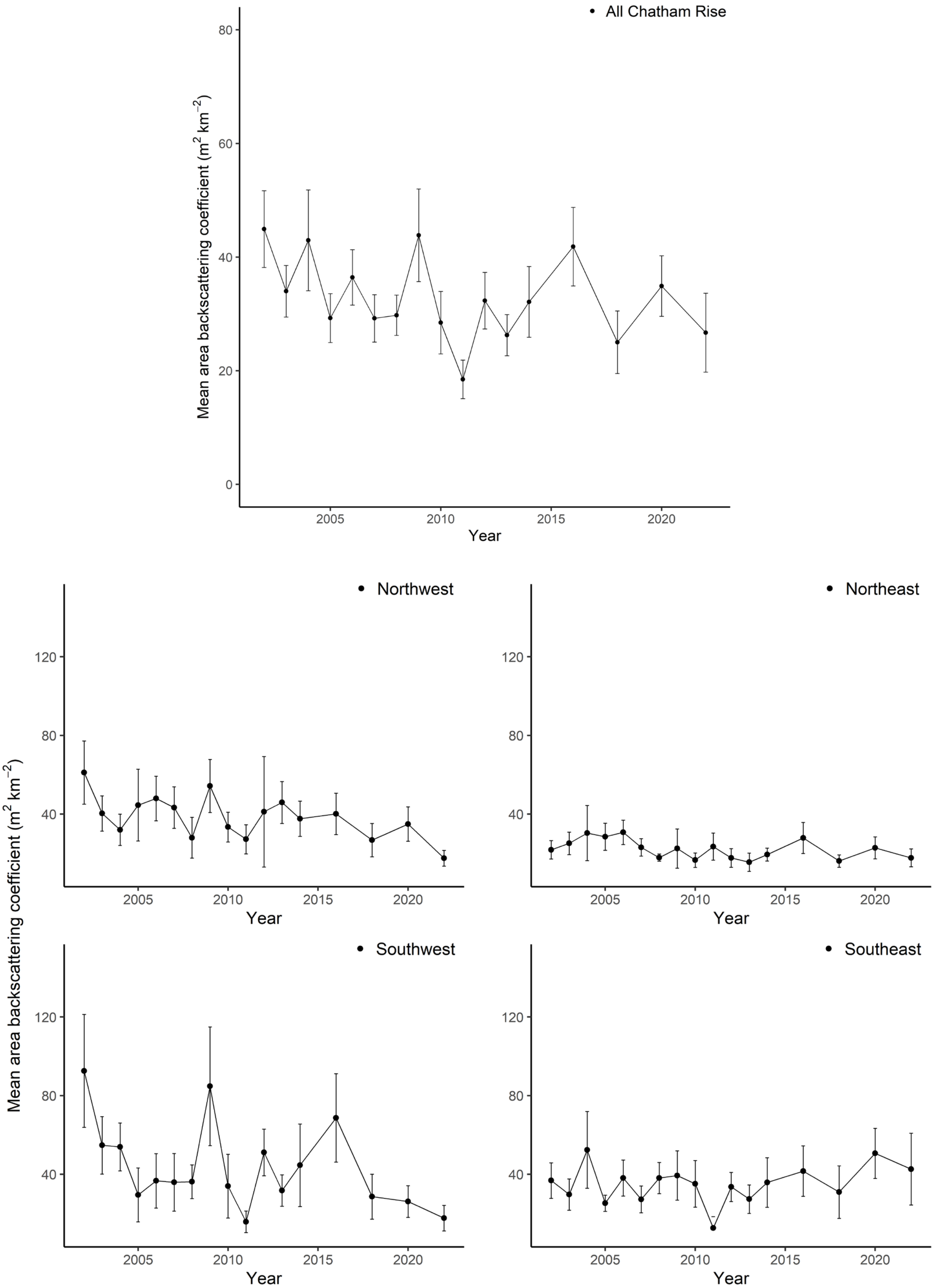

Figure 22: Relative acoustic abundance indices for mesopelagic fish on the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter observed in the upper 200 m corrected in the same sub-area for the estimated proportion in the surface dead zone. Panels show indices for the entire Chatham Rise and the four sub-areas. Error bars are ± 2 standard errors.

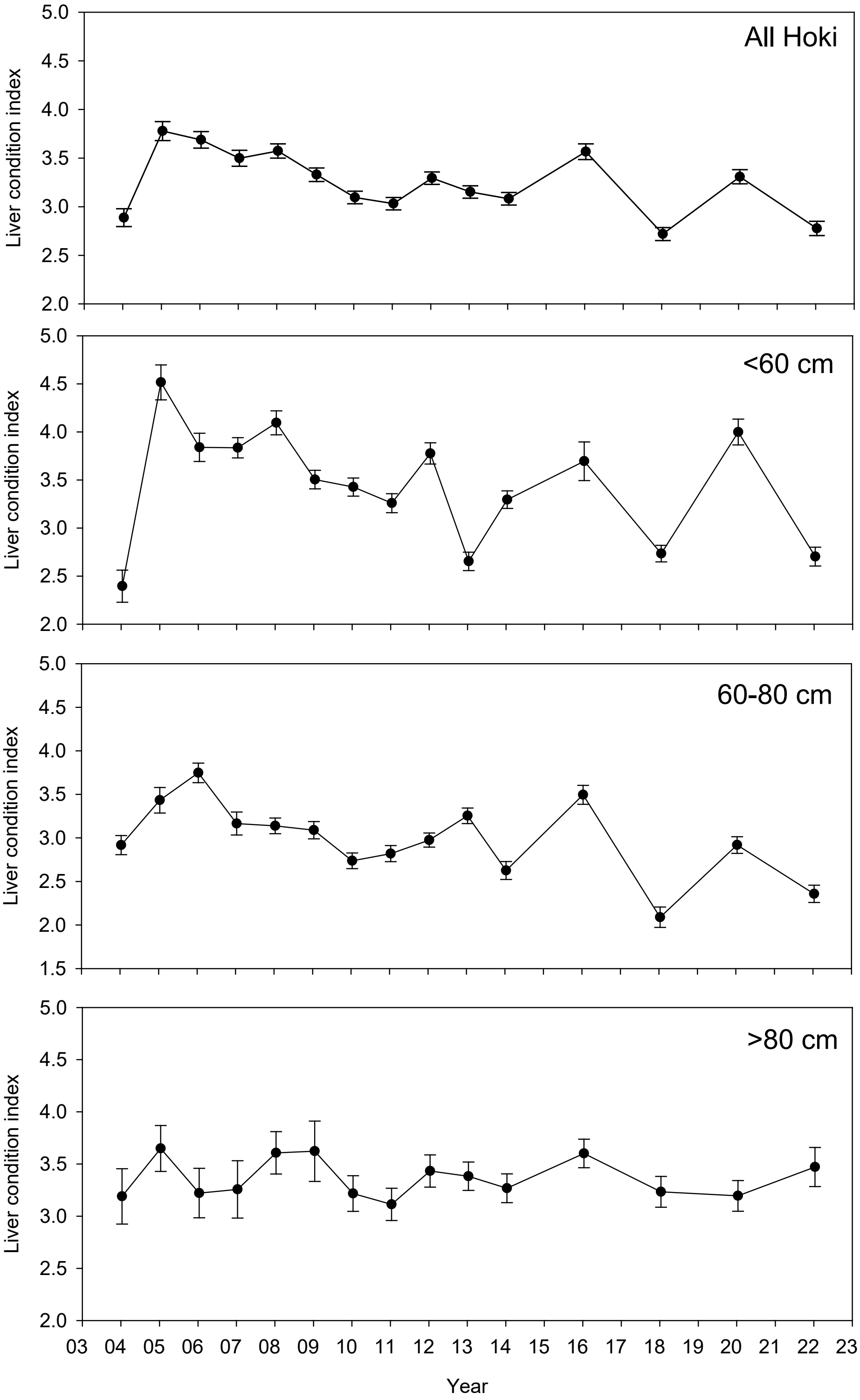

Figure 23: Time series of hoki liver condition indices on the Chatham Rise from 2004 to 22. Data are plotted for all hoki and the three different size classes (<60 cm, 60–80 cm, and >80 cm). Error bars show ± 2 standard errors.

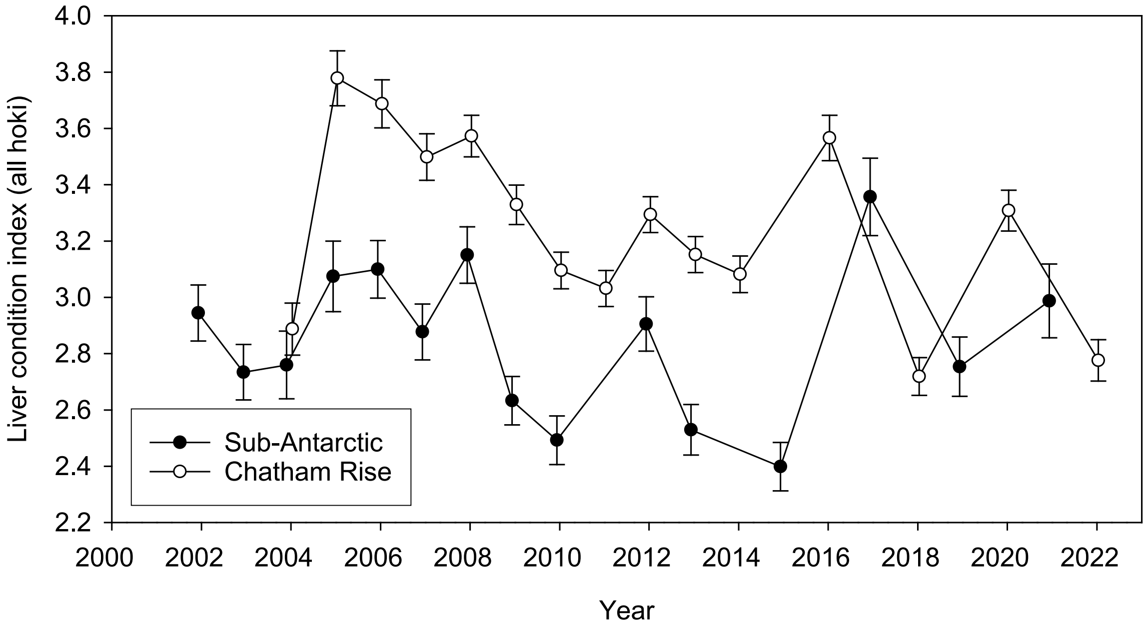

Figure 24: Comparison of time series of hoki liver condition indices (all sizes combined) on the Chatham Rise with indices from the Sub-Antarctic from 2002–22. Error bars show ± 2 standard errors.

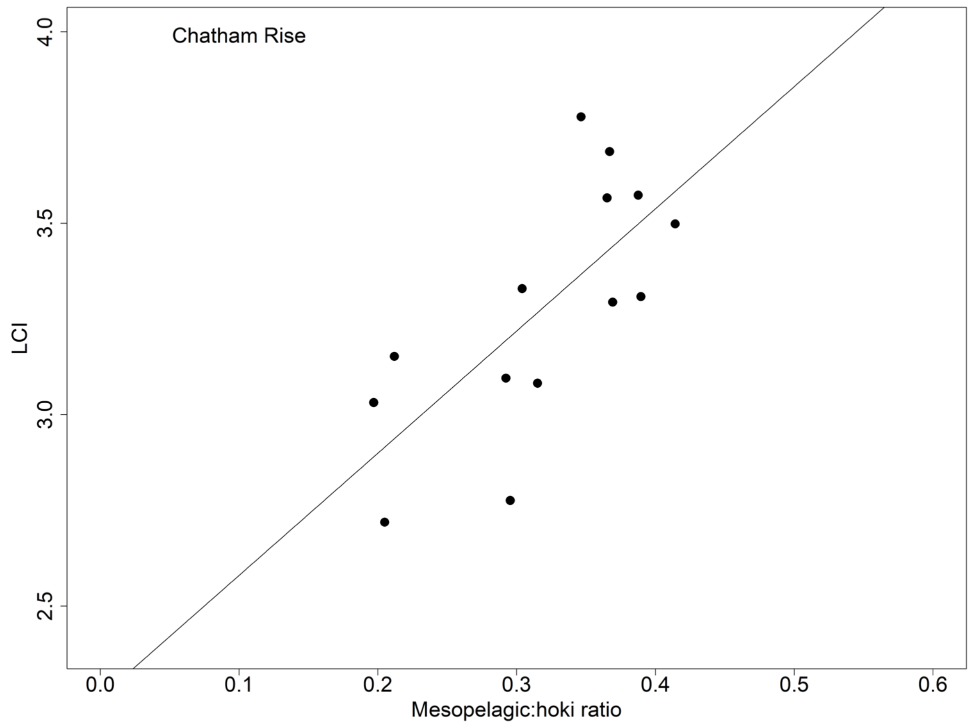

Figure 25: Correlation between hoki liver condition index (LCI) on the Chatham Rise with index of 'food per fish' derived by dividing the mesopelagic acoustic index by the estimated hoki biomass. Pearson correlation coefficient is 0.71.

APPENDIX 1: TAN2201 STATION DATA

Individual station data for all stations conducted during the survey (TAN2201). Latitude and longitude are expressed in degrees and minutes. Dist., distance towed. * indicates tow was not considered suitable for abundance estimation.

Station	Date	Start time (NZST)	Stratum	Start latitude (° ' S)	Start longitude (° ')	E or W	Max. depth (m)	Distance towed (n. mile)	Catch hoki (kg)	Catch hake (kg)	Catch ling (kg)
1 *	6/01/2022	556	002A	42 48.77	176 07.14	E	664	2.88	74.7	5.7	27.2
2	6/01/2022	907	008A	42 57.03	176 11.14	E	537	3.01	328.1	0.0	14.4
3	6/01/2022	1208	008A	42 52.73	176 22.19	E	527	2.92	384.1	0.0	85.4
4	6/01/2022	1428	008A	42 51.02	176 30.30	E	508	3.00	256.1	18.2	37.5
5	6/01/2022	1808	002A	42 46.17	176 58.05	E	657	3.05	137.5	12.2	54.4
6	7/01/2022	536	0019	43 18.86	176 09.19	E	371	3.01	1 503.9	0.0	43.1
7	7/01/2022	807	0019	43 21.17	176 16.84	E	313	3.07	2 394.0	0.0	0.0
8 *	7/01/2022	1323	0019	43 31.47	177 05.95	E	270	2.83	0.0	0.0	0.0
9	7/01/2022	1758	0020	43 26.39	177 32.43	E	313	3.02	532.2	0.0	33.0
10	8/01/2022	544	002A	42 45.67	177 14.57	E	737	3.01	39.8	2.6	25.1
11	8/01/2022	1105	0019	43 07.29	177 07.54	E	290	2.99	648.0	0.0	0.0
12	8/01/2022	1338	0019	43 18.70	176 37.77	E	274	3.02	104.4	0.0	0.0
13	8/01/2022	1756	0019	43 18.78	177 11.39	E	228	3.07	0.0	0.0	0.0
14	9/01/2022	535	0019	43 18.05	177 20.41	E	241	3.01	0.0	0.0	0.0
15	9/01/2022	732	0019	43 20.06	177 29.84	E	268	3.01	1.9	0.0	0.0
16	9/01/2022	1232	0020	43 18.61	178 12.91	E	330	2.09	326.7	0.0	0.0
17	9/01/2022	1808	0020	43 39.77	178 34.26	E	396	3.03	1 994.5	4.1	106.1
18	10/01/2022	545	0020	43 05.68	178 08.70	E	369	3.02	399.0	0.0	21.9
19	10/01/2022	757	0020	43 00.70	178 22.45	E	363	3.01	3 924.1	3.5	61.4
20	10/01/2022	1044	0020	43 04.53	178 44.22	E	395	3.01	709.4	0.0	63.5
21	10/01/2022	1337	002A	42 55.96	179 06.56	E	728	3.02	194.7	14.2	21.1
22	10/01/2022	1621	008B	43 01.50	179 11.81	E	512	2.99	308.0	0.0	31.8
23	10/01/2022	2000	0022	42 53.99	179 16.74	E	821	3.01	21.6	0.0	0.0
24	10/01/2022	2219	0022	42 51.26	179 14.13	E	976	3.02	11.5	0.0	0.0
25	11/01/2022	520	008B	43 15.55	179 30.74	E	437	3.02	253.0	16.1	78.1
26	11/01/2022	831	0010	43 16.85	179 58.60	W	496	3.01	1 129.3	3.7	52.3
27	11/01/2022	1228	008B	43 02.92	179 55.05	E	564	3.02	264.4	26.4	11.1
28	11/01/2022	1644	0010	42 56.55	179 22.69	W	577	3.03	282.9	22.3	26.1
29	11/01/2022	1941	021A	42 47.84	179 22.35	W	864	3.01	92.7	4.4	0.0
30	11/01/2022	2224	021A	42 50.81	179 41.65	W	843	3.04	54.3	1.3	0.0
31	12/01/2022	522	0010	43 14.66	179 29.06	W	514	3.05	196.3	3.6	13.9
32	12/01/2022	807	0010	43 21.64	179 08.86	W	461	3.01	536.8	16.7	15.2
33	12/01/2022	1150	0011	43 08.81	178 43.79	W	504	3.00	365.6	9.8	0.0
34	12/01/2022	1640	021A	42 46.00	178 47.19	W	838	3.01	70.7	0.0	5.9
35	12/01/2022	1953	0023	42 36.98	179 04.44	W	1271	3.01	0.0	0.0	0.0
36	13/01/2022	523	002B	42 55.87	177 28.01	W	629	3.00	325.9	7.4	14.7
37	13/01/2022	912	0011	43 07.06	177 00.56	W	522	3.02	245.8	0.0	6.9
38	13/01/2022	1141	0011	43 02.35	176 56.70	W	550	3.03	342.6	8.3	0.0
39 *	13/01/2022	1442	002B	42 57.77	176 47.62	W	625	3.85	0.0	22.3	0.0
40	13/01/2022	2049	0024	42 48.30	176 27.09	W	1031	3.03	1.9	0.0	0.0
41	14/01/2022	518	002B	42 57.25	176 23.98	W	720	3.01	181.6	9.6	17.1
42	14/01/2022	830	0011	43 04.53	176 30.15	W	541	3.01	379.2	24.9	27.7
43	14/01/2022	1217	0011	43 12.59	175 58.42	W	593	3.04	319.3	47.0	26.2
44	14/01/2022	1630	021B	42 57.09	175 43.20	W	837	3.08	49.0	0.0	0.0
45	14/01/2022	2009	021B	42 53.12	175 48.23	W	933	3.00	14.0	41.2	0.0
46	15/01/2022	0	0024	42 49.18	175 10.92	W	1234	3.01	0.0	0.0	0.0
47	15/01/2022	432	021B	42 56.71	175 13.43	W	979	3.04	1.7	7.2	0.0
48	15/01/2022	706	021B	42 55.67	175 22.20	W	954	3.01	26.2	0.0	0.0
49	15/01/2022	929	021B	42 59.22	175 23.29	W	868	3.00	27.0	0.0	0.0
50	15/01/2022	1301	002B	43 07.87	175 35.31	W	705	3.02	182.7	8.6	14.0

Appendix 1: (continued).

Station	Date	Start time (NZST)	Stratum	Start latitude (° ' S)	Start longitude (° ')	E or W	Max. depth (m)	Distance towed (n. mile)	Catch hoki (kg)	Catch hake (kg)	Catch ling (kg)
51	15/01/2022	1632	002B	43 14.26	175 19.49	W	694	3.01	158.0	32.0	49.7
52	15/01/2022	2152	021B	43 14.21	174 35.08	W	868	3.01	15.4	0.0	0.0
53	16/01/2022	40	0024	43 09.18	174 16.50	W	1042	3.00	3.1	0.0	0.0
54	16/01/2022	536	0025	43 39.73	174 15.04	W	935	3.01	17.0	0.0	0.0
55	16/01/2022	956	0004	43 48.83	174 56.87	W	673	3.01	140.4	9.6	21.4
56	16/01/2022	1230	0012	43 43.38	175 05.74	W	588	3.01	298.3	49.4	39.0
57 *	16/01/2022	1608	0004	43 29.19	175 15.00	W	640	3.04	113.9	0.0	27.2
58	17/01/2022	512	0011	43 24.46	175 39.64	W	498	3.03	94.3	0.0	6.1
59	17/01/2022	750	0009	43 38.38	175 37.93	W	347	3.05	463.4	0.0	12.7
60	17/01/2022	947	0009	43 46.82	175 39.51	W	316	3.01	0.0	0.0	3.3
61	17/01/2022	1240	0009	43 54.35	175 22.43	W	252	2.21	0.0	0.0	0.0
62	17/01/2022	1501	0012	44 01.21	175 16.19	W	499	3.03	186.0	0.0	4.9
63	18/01/2022	148	0025	44 41.64	176 29.74	W	938	2.28	38.1	0.0	0.0
64	18/01/2022	739	0012	44 29.96	176 40.13	W	573	3.02	291.6	6.5	94.2
65	18/01/2022	1227	0005	44 12.46	176 55.26	W	241	2.56	0.0	0.0	0.0
66	18/01/2022	1935	0025	44 33.35	177 20.15	W	816	3.02	172.7	13.4	10.9
67	19/01/2022	512	0005	43 40.36	177 26.96	W	318	2.10	132.4	0.0	14.4
68	19/01/2022	829	0005	43 32.51	177 53.05	W	370	2.07	280.1	0.0	13.1
69	19/01/2022	1237	0013	43 47.58	178 31.42	W	457	3.01	1 135.7	54.0	68.4
70	19/01/2022	1652	0013	44 01.80	178 06.74	W	466	3.02	456.4	3.4	82.1
71	19/01/2022	2203	0028	44 33.08	178 02.52	W	1044	2.14	0.0	0.0	0.0
72	20/01/2022	151	0028	44 33.92	178 34.00	W	1146	3.04	2.1	0.0	0.0
73	20/01/2022	709	0013	44 13.00	179 17.79	W	466	2.74	1 213.1	0.0	115.3
74	20/01/2022	1047	0003	43 50.60	179 26.07	W	304	2.75	162.6	0.0	0.0
75	20/01/2022	1356	0003	43 47.93	179 33.12	W	332	2.09	128.3	0.0	0.0
76	20/01/2022	1655	0003	43 50.25	179 44.18	W	388	2.23	480.3	0.0	21
77	20/01/2022	2222	0025	44 21.89	179 25.45	W	861	2.99	20.7	0.0	3.1
78	21/01/2022	154	0028	44 35.10	179 24.83	W	1218	3.00	0.0	0.0	0.0
79	21/01/2022	649	0025	44 20.09	179 50.18	W	866	3.04	4.3	0.0	6.6
80	21/01/2022	943	0004	44 10.34	179 53.07	W	636	3.01	66.4	0.0	32.4
81	21/01/2022	1443	0014	43 46.78	179 34.59	E	461	3.01	960.5	18.8	91.6
82	22/01/2022	522	0014	43 51.26	178 36.39	E	496	2.43	430.7	0.0	22.4
83	22/01/2022	908	0014	43 45.94	178 04.55	E	486	3.01	1 338.7	0.0	76.0
84	22/01/2022	1430	0015	43 49.26	177 15.10	E	510	3.03	670.7	8.3	40.5
85	22/01/2022	1812	0004	44 05.05	176 58.51	E	656	2.99	96.7	0.0	25.8
86	22/01/2022	2156	0026	44 10.28	177 26.14	E	946	3.01	15.8	5.4	0.0
87	23/01/2022	122	0029	44 19.92	177 22.80	E	1160	3.03	0.0	0.0	0.0
88	23/01/2022	622	0026	44 23.04	176 42.94	E	906	3.05	9.4	0.0	0.0
89	23/01/2022	1148	0017	44 17.02	176 12.40	E	358	2.84	0.0	0.0	0.0
90	23/01/2022	1446	0017	44 21.88	176 05.63	E	341	3.01	0.0	0.0	0.0
91	23/01/2022	1747	0017	44 20.58	175 53.01	E	286	2.47	1.6	0.0	0.0
92	24/01/2022	17	0026	44 33.41	176 23.87	E	976	3.01	4.1	0.0	0.0
93	24/01/2022	421	0029	44 33.60	176 51.69	E	1101	3.05	0.0	0.0	0.0
94	24/01/2022	844	0029	44 47.27	176 45.76	E	1296	3.01	0.0	0.0	0.0
95	24/01/2022	1816	0027	44 45.83	175 34.70	E	961	2.23	2.4	0.0	0.0
96	25/01/2022	140	0030	45 14.43	174 24.10	E	1173	3.03	0.0	0.0	0.0
97	25/01/2022	410	0030	45 09.18	174 15.05	E	1188	3.05	0.0	0.0	0.0
98	25/01/2022	707	0030	45 00.29	174 00.52	E	1201	3.01	0.0	0.0	0.0
99	25/01/2022	1301	0006	44 23.49	174 03.42	E	708	2.93	133.8	0.0	6.1
100	25/01/2022	1805	0027	44 43.99	174 00.10	E	846	2.12	505.5	0.0	0.0
101	26/01/2022	555	0006	44 31.77	175 00.40	E	731	3.07	85.4	0.0	22.9
102	26/01/2022	759	0006	44 24.49	174 55.07	E	651	3.00	156.7	5.4	60.1
103 *	26/01/2022	1200	0016	44 02.74	174 27.47	E	575	0.74	0.0	0.0	0.0
104	26/01/2022	1332	0016	43 59.07	174 23.59	E	571	3.04	335.3	0.0	16.5
105	26/01/2022	1821	0016	44 05.74	173 52.22	E	501	3.06	299.3	0.0	24

Appendix 1: (continued).

Station	Date	Start time (NZST)	Stratum	Start latitude (° ‘ S)	Start longitude (° ‘)	E or W	Max. depth (m)	Distance towed (n. mile)	Catch hoki (kg)	Catch hake (kg)	Catch ling (kg)
106	27/01/2022	556	007A	43 36.69	174 14.77	E	542	3.05	1 661.2	0.0	48.8
107	27/01/2022	836	007A	43 23.58	174 19.42	E	584	3.04	1 097.6	5.1	82.6
108	27/01/2022	1115	0001	43 08.41	174 19.95	E	628	3.03	296.4	7.2	23.6
109	27/01/2022	1951	0022	42 56.59	174 32.43	E	931	3.01	10.1	10.3	0.0
110	27/01/2022	2318	0023	42 52.87	174 24.64	E	1180	3.01	0.0	0.0	0.0
111	28/01/2022	607	0001	43 00.37	174 43.05	E	726	3.01	102.5	0.0	8.2
112	28/01/2022	911	007A	43 01.25	174 53.80	E	546	3.03	918	42.4	72.5
113	28/01/2022	1229	0018	43 13.27	174 57.06	E	231	3.01	15	6.8	0.0
114	28/01/2022	1535	0001	42 55.23	175 01.63	E	651	3.03	511.7	29.9	36.9
115	28/01/2022	1807	0018	43 01.50	175 13.50	E	344	3.10	669.9	0.0	22.4
116	28/01/2022	2055	0022	42 49.64	175 16.91	E	821	3.05	101.8	6.6	3.6
117	29/01/2022	22	0023	42 39.99	175 44.02	E	1144	3.01	5.0	0.0	0.0
118	29/01/2022	811	0018	43 33.96	175 35.85	E	270	3.02	439.7	0.0	0.0
119	29/01/2022	1144	0016	43 50.00	175 55.21	E	467	2.37	817.2	17.2	60.8
120	29/01/2022	1422	0015	43 49.15	176 06.84	E	477	2.60	1 793.1	2.9	57.9
121	29/01/2022	1720	0015	43 42.66	176 23.75	E	425	2.19	636.9	0.0	159.1
122	30/01/2022	155	0022	42 44.90	175 55.98	E	840	3.01	180.5	9.0	0.0
123	30/01/2022	712	0018	43 01.35	175 22.07	E	355	3.01	991.0	0.0	69.5
124	30/01/2022	947	007B	43 01.06	175 44.36	E	508	3.01	371.7	52.7	45.7
125	30/01/2022	1211	007B	43 04.18	175 39.91	E	467	3.01	905.5	69.1	110.3
126	30/01/2022	1500	007B	42 59.28	175 55.04	E	536	3.00	338.6	54.9	21.2
127	30/01/2022	1953	0023	42 36.23	176 00.66	E	1209	3.02	0.0	2.1	0.0
128	30/01/2022	2252	0022	42 40.91	176 20.74	E	892	3.00	12.5	0.0	7.3
129	31/01/2022	110	0022	42 40.84	176 32.21	E	934	2.71	2.3	0.0	0.0
130	31/01/2022	906	0020	43 17.53	177 34.40	E	274	2.32	0.0	0.0	0.0
131	31/01/2022	1234	0020	43 31.12	177 43.05	E	373	2.01	264.1	0.0	14.0
132	31/01/2022	1702	0020	43 13.42	178 27.41	E	392	3.06	496.7	8.2	53.8
133	1/02/2022	545	0019	43 27.29	177 25.48	E	268	3.07	0.0	0.0	0.0
134	1/02/2022	920	0019	43 22.69	176 44.71	E	263	3.03	0.0	0.0	0.0
135	1/02/2022	1420	0019	43 30.30	176 19.78	E	369	3.00	0.0	0.0	0.0

APPENDIX 2: SPECIES CAUGHT DURING TAN2201

Scientific names, common name, and species code of species caught in all core and deep tows (TAN2201). The occurrence (Occ.) of each species (i.e., number of tows caught) in all 130 core and deep 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	6
Phaeophyta	brown seaweed	PHA	3
Porifera	unspecified sponges	ONG	1
Demospongiae (siliceous sponges)			
Astrophorina (sandpaper sponges)			
Ancorinidae			
Ecionemia novaezelandiae	knobbly sandpaper sponge	ANZ	4
Stelletta sp.	orange fat finger sponge	SLT	3
Stryphnus novaezealandiae	sponge	ONG	1
Tethyopsis sp.	sponge	TTH	1
Corallistidae			
Neoschrammeniella fulvodesmus	Smooth white cup sponge	CFU	1
Geodiidae			
Geodia vestigifera	ostrich egg sponge	GVE	1
Hadromerida (woody sponges)			
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	3
Spirophorida (spiral sponges)			
Tetillidae			
Tetilla australe	bristle ball sponge	TTL	1
T. leptoderma	furry oval sponge	TLD	6
Hexactinellida (glass sponges)			
Hexactinosida (lacey honeycomb sponges)			
Lyssacinosida (glass horn sponges)			
Euplectellidae			
Euplectella regalis	basket-weave horn sponge	ERE	3
Hyalascus sp.	floppy tubular sponge	HYA	29
Poecilosclerida (bright sponges)			
Coelosphaeridae			
Lissodendoryx bifacialis	floppy chocolate plate sponge	LBI	3
Crellidae			
Crella incrustans	orange frond sponge	CIC	1
Cnidaria			
Scyphozoa	unspecified jellyfish	JFI	29
Anthozoa			
Octocorallia			
Alcyonacea (soft corals)			
Alcyoniidae			
Anthomastus (*Bathyalcyon*) *robustus*	gigantic coral	ARO	2
Chrysogorgiidae (golden corals)			
Radicipes spp.	whip-like golden coral	RAD	4
Coralliidae			
Corallium spp.	precious corals	CLL	1
Isididae (bamboo corals)		ISI	1
Keratosis spp.	branching bamboo coral	BOO	2
Lepidisis spp.	bamboo coral	LLE	1
Pennatulacea (sea pens)	unspecified sea pens	PTU	11
Funiculinidae			
Funiculina quadrangularis	rope-like sea pen	FQU	3
Hexacorallia			
Actinaria (anemones)	unspecified anemone	ANT	5

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Actiniidae			
Bolocera spp.	deepsea anemone	BOC	5
Liponematidae			
Liponema spp.	deepsea anemone	LIP	2
Actinostolidae (smooth deepsea anemones)		ACS	35
Hormathiidae (warty deepsea anemones)		HMT	31
Corallimorpharia (coral-like anemones)		CLM	2
Scleractinia (stony corals)		SIA	1
Caryophyllidae			
Goniocorella dumosa	bushy hard coral	GDU	9
Stephanocyathus platypus	solitary bowl coral	STP	6
Flabellidae			
Flabellum spp.	flabellum coral	COF	7
Zoantharia (zoanthids)			
Epizoanthidae			
Epizoanthus sp.		EPZ	8
Hydrozoa (hydroids)	unspecified hydroids	HDR	4
Tunicata			
Ascidiacea (sea squirts)		ASC	6
Thaliacea			
Pyrosomida (pyrosomes)			
Pyrosomatidae			
Pyrosoma atlanticum		PYR	29
Salpida (salps)	unspecified salps	SAL	1
Salpidae			
Thetys vagina		ZVA	11
Mollusca			
Bivalvia (bivalves)			
Limidae			
Acesta saginata	lesser giant file shell	ASG	1
Pectinidae (scallops)			
Zygochlamys delicatula	Queen scallop	QSC	1
Gastropoda (gastropods)	unspecified gastropod	GAS	2
Capulidae			
Malluvium calcareum	cap limpet	MCC	1
Buccinidae (whelks)			
Penion chathamensis		PCH	1
Ranellidae (tritons)			
Fusitriton magellanicus		FMA	26
Volutidae (volutes)			
Provocator mirabilis	golden volute	GVO	7
Cephalopoda			
Teuthoidea (squids)			
Oegopsida			
Architeuthidae			
Architeuthis dux	giant squid	GSQ	1
Chiroteuthidae			
Chiroteuthis veryani		CVE	
Cranchiidae	unspecified cranchiid	CHQ	1
Galiteuthis spp.	squid	GAI	1
Teuthowenia pellucida	squid	TPE	8
Histioteuthidae (violet squids)			
Histioteuthis atlantica	violet squid	HAA	1
Histioteuthis spp.	violet squid	VSQ	5

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Octopoteuthidae			
Octopoteuthis spp.	squid	OPO	2
Taningia danae & *T. fimbria*	squid	TDQ	3
Ommastrephidae			
Nototodarus sloanii	Sloan's arrow squid	NOS	52
Todarodes filippovae	Todarodes squid	TSQ	37
Onychoteuthidae			
Moroteuthopsis ingens	warty squid	MIQ	77
Onykia robsoni & *O.* sp. A	warty squid	MRQ	5
Sepioidea			
Sepiolida (bobtail squids)			
Sepiadariidae			
Sepioloidea virgilioi	bobtail squid	SSQ	2
Octopodiformes			
Octopoda	unidentified octopus	OCP	1
Cirrata (cirrate octopus)			
Opisthoteuthidae			
Opisthoteuthis spp.	umbrella octopus	OPI	1
Incirrata (incirrate octopus)			
Octopodidae			
Enteroctopus zealandicus	yellow octopus	EZE	3
Graneledone kubodera & *G. taniwha*	deepwater octopus	DWO	9
Octopus mernoo	octopus	OME	3
O. spp.	octopus	OCO	2
Polychaeta	unspecified polychaete	POL	2
Crustacea			
Malacostraca			
Decapoda			
Dendrobranchiata/Pleocyemata	unspecified natant decapod	NAT	2
Dendrobranchiata			
Aristeidae			
Aristaeomorpha foliacea	royal red prawn	AFO	3
Aristeus spp.	prawn	ARI	1
Austropenaeus nitidus	prawn	ANI	1
Sergestidae			
Sergia potens	prawn	SEP	2
Solenoceridae			
Haliporoides sibogae	jackknife prawn	HSI	2
Pleocyemata			
Caridea			
Campylonotidae			
Campylonotus rathbunae	sabre prawn	CAM	5
Oplophoridae			
Acanthephyra spp.	Sub-Antarctic ruby prawn	ACA	20
Notostomus auriculatus	scarlet prawn	NAU	1
Oplophorus spp.	deepwater prawn	OPP	6
Pasiphaeidae			
Pasiphaea barnardi	deepwater prawn	PBA	19
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	34
Nematocarcinus spp.	spider prawn	NEC	2

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Achelata			
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	30
Palinura			
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	9
Lithodidae (king crabs)			
Lithodes aotearoa	New Zealand king crab	LAO	2
L. robertsoni	Robertson’s king crab	LRO	1
Neolithodes brodiei	Brodie’s king crab	NEB	5
Paralomis zealandica	prickly king crab	PZE	1
Paguroidea (hermit crabs)	unspecified hermit crab	PAG	1
Paguridae (Parapagurid hermit crabs)			
Diacanthurus rubricatus	hermit crab	DIR	9
Porcellanopagurus filholi	hermit crab	PFI	1
Parapaguridae (Parapagurid hermit crabs)			
Sympagurus dimorphus	hermit crab	SDM	9
Lophogastrida			
Gnathophausiidae			
Neognathophausia ingens	giant red mysid	NEI	3
Brachyura (true crabs)			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	11
Goneplacidae			
Pycnoplax victoriensis	two-spined crab	CVI	2
Homolidae			
Dagnaudus petterdi	antlered crab	DAP	11
Inachidae			
Vitjazmaia cf. *latidactyla*	deep-sea spider crab	VIT	2
Majidae (spider crabs)			
Teratomaia richardsoni	spiny masking crab	SMK	9
Portunidae (paddle crabs)			
Nectocarcinus antarcticus	hairy red swimming crab	NCA	1
Ovalipes molleri	swimming crab	OVM	2
Echinodermata			
Asteroidea (starfish)	unspecified starfish	ASR	2
Asteriidae			
Cosmasterias dyscrita	cat’s-foot star	CDY	1
Pseudechinaster rubens	starfish	PRU	10
Sclerasterias mollis	cross-fish	SMO	15
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	30
Plutonaster knoxi	abyssal star	PKN	23
Proserpinaster neozelanicus	starfish	PNE	8
Psilaster acuminatus	geometric star	PSI	29
Benthopectinidae			
Benthopecten spp.	starfish	BES	1
Brisingida	unspecified brisingid	BRG	14
Echinasteridae			
Henricia compacta	starfish	HEC	2
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	1
Hippasteria phrygiana	trojan starfish	HTR	13
Lithosoma novaezelandiae	rock star	LNV	3

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Goniasteridae (cont.)			
Mediaster sladeni	starfish	MSL	16
Pillsburiaster aoteanus	starfish	PAO	8
Solasteridae			
Crossaster multispinus	sun star	CJA	15
Solaster torulatus	chubby sun-star	SOT	2
Odontasteridae			
Odontaster benhami	pentagonal tooth-star	ODT	1
Pterasteridae			
Diplopteraster sp.	starfish	DPP	1
Hymenaster carnosus	starfish	HYC	2
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	39
Ophiuroidea (basket & brittle stars)	unspecified brittle star	OPH	4
Euryalina (basket stars)			
Gorgonocephalidae			
Gorgonocephalus spp.	Gorgon's head basket stars	GOR	4
Echinoidea (sea urchins)	unspecified sea urchin	ECN	1
Regularia			
Cidaridae			
Goniocidaris parasol	parasol urchin	GPA	7
Echinothuriidae/Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	45
Echinothuriidae (Tam O’Shanters)	unspecified Tam O'Shanter urchin	ECT	5
Phormosomatidae			
Phormosoma spp.		PHM	1
Echinidae			
Dermechinus horridus	deepsea urchin	DHO	10
Gracilechinus multidentatus	deepsea kina	GRM	22
Spatangoida (heart urchins)			
Spatangidae			
Spatangus multispinus	purple-heart urchin	SPT	14
Holothuroidea			
Aspidochirotida			
Synallactidae			
Bathyplotes sp.	sea cucumber	BAM	2
Pseudostichopus mollis	sea cucumber	PMO	34
Elasipodida			
Laetmogonidae			
Laetmogone sp.	sea cucumber	LAG	13
Pannychia moseleyi	sea cucumber	PAM	2
Pelagothuridae			
Enypniastes eximia	sea cucumber	EEX	2
Psychropotidae			
Benthodytes sp.	sea cucumber	BTD	2
Pycnogonida	unspecified sea spider	PYC	1
Brachiopoda	unspecified brachiopod	BPD	1
Chondrichthyes (cartilaginous fishes)			
Chimaeridae: chimaeras, ghost sharks			
Chimaera carophila	brown chimaera	CHP	10
Chimaera sp.	unspecified juvenile chimaera	CHI	1
Hydrolagus bemisi	pale ghost shark	GSP	78
H. homonycteris	black ghost shark	HYB	1
H. novaezealandiae	dark ghost shark	GSH	51

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose spookfish	LCH	65
Rhinochimaera pacifica	Pacific spookfish	RCH	23
Scyliorhinidae: cat sharks			
Apristurus ampliceps	roundfin catshark	AAM	6
A. exsanguis	New Zealand catshark	AEX	21
A. garracki	Garrick's catshark	AGK	2
A. melanoasper	fleshynose catshark	AML	3
A. pinguis	bulldog catshark	APN	1
A. cf. *sinensis*	freckled catshark	ASI	2
Bythaelurus dawsoni	Dawson's catshark	DCS	1
Cephaloscyllium isabella	carpet shark	CAR	2
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	15
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	
Squalidae: dogfishes			
Squalus acanthias	spiny dogfish	SPD	64
S. griffini	northern spiny dogfish	NSD	3
Centrophoridae: gulper sharks			
Centrophorus squamosus	leafscale gulper shark	CSQ	27
Deania spp.	shovelnose spiny dogfish	SND	56
Etmopteridae: lantern sharks			
Etmopterus granulosus	Baxter's dogfish	ETB	43
E. lucifer	lucifer dogfish	ETL	58
Dalatiidae: kitefin sharks			
Dalatias licha	seal shark	BSH	27
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	8
Torpedinidae: electric rays			
Tetronarce nobiliana	electric ray	ERA	2
Narkidae: numbfishes, sleeper rays			
Typhlonarke spp.	numbfish	BER	1
Rajidae: skates			
Amblyraja hyperborea	deepwater spiny skate	DSK	4
Dipturus innominatus	smooth skate	SSK	23
Zearaja nasuta	rough skate	RSK	1
Arhynchobatidae: softnose skates			
Bathraja shuntovi	longnosed deepsea skate	PSK	10
Brochiraja asperula	smooth deepsea skate	BTA	14
B. leviveneta	blue skate	BRL	1
B. spinifera	prickly deepsea skate	BTS	8
Osteichthyes (bony fishes)			
Halosauridae: halosaurs			
Halosauropsis macrochir	black halosaur	HAL	1
Halosaurus pectoralis	common halosaur	HPE	3
Notocanthidae: spiny eels			
Notacanthus chemnitzi	giant spineback	NOC	3
N. sexspinis	spineback	SBK	63
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	34
Nemichthyidae: snipe eels			
Nemichthys curvirostris	black spot snipe eel	NCU	1

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Congridae: conger eels	unspecified conger eel	CON	1
Bassanago bulbiceps	swollenhead conger	SCO	48
B. hirsutus	hairy conger	HCO	35
Serrivomeridae: sawtooth eels			
Serrivomer samoensis	common sawtooth eel	SSA	4
Argentinidae: silversides			
Argentina elongata	silverside	SSI	30
Bathylagidae: deepsea smelts			
Bathylagus spp.	deepsea smelts	DSS	1
Bathylagichthys parini	deepsea smelts	BPA	2
Melanolagus bericoides	bigscale deepsea smelt	MEB	12
Platytroctidae: tubeshoulders			
Holtbyrnia laticauda	barlight tubeshoulder	HOL	1
Persparsia kopua	common tubeshoulder	PER	5
Alepocephalidae: slickheads			
Alepocephalus antipodianus	smallscaled brown slickhead	SSM	24
A. australis	bigscaled brown slickhead	SBI	21
Xenodermichthys copei	black slickhead	BSL	17
Diplophidae: portholefishes			
Diplophos rebainsi	Rebain’s portholefish	DRB	1
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	8
Sternoptyx pseudodiaphana	false oblique hatchetfish	SPU	1
Phosichthyidae: lighthouse fishes			
Phosichthys argenteus	lighthouse fish	PHO	39
Stomiidae (dragonfishes)			
Astronesthinae: snaggletooths			
Borostomias antarcticus	southern snaggletooth	BAN	3
B. mononema	snaggletooth	BMO	1
Stomiinae: scaly dragonfishes			
Stomias boa	scaly dragonfish	SBB	3
Chauliodontinae: viperfishes			
Chauliodus sloani	viperfish	CHA	16
Melanostomiinae: barbeled dragonfishes			
Opostomias micripnus	giant black dragonfish	OMI	3
Trigonolampa miriceps	starburst dragonfish	TMI	1
Idiacanthinae: black dragonfishes			
Idiacanthus atlanticus	common black dragonfish	IAT	5
Malacosteinae: loosejaws			
Malacosteus australis	southern loosejaw	MAU	10
Paraulopidae: cucumberfishes			
Paraulopus nigripinnis	cucumberfish	CUC	3
Notosudidae: waryfishes			
Scopelosaurus spp.	unspecified waryfish	SPL	3
Paralepididae: barracudinas	unspecified barracudina	PAL	1
Macroparalepis macrogeneion	headband barracudina	MMA	1
Magnisudis prionosa	giant barracudina	BCA	3
Alepisauridae: lancetfishes			
Alepisaurus brevirostris	shortsnouted lancetfish	ABR	3
Omosudidae: hammerjaw			
Omosudis lowii	hammerjaw	OMO	1
Myctophidae: lanternfishes			
Diaphus danae	Dana lanternfish	DDA	9
Electrona paucirasta	rough lanternfish	EPA	1
Gymnoscopelus bolini	Bolin’s lanternfish	GYB	4
G. microlampas	minispotted lanternfish	GYI	2

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Myctophidae (cont.)			
G. piabilis	southern blacktip lanternfish	GYP	1
Lampanyctodes hectoris	Hector's lanternfish	LHE	2
Lampanyctus achirus	cripplefin lanternfish	LAC	1
L. atrum	dusky lanternfish	LAR	2
L. australis	austral lanternfish	LAU	12
L. intricarius	intricate lanternfish	LIT	14
L. macdonaldi	MacDonald's lanternfish	LMD	1
Symbolophorus boops	bogue lanternfish	SBP	2
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	2
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	5
Ophidiidae: cuskeels			
Brotulotaenia nigra	blue cusk eel	BCR	1
Genypterus blacodes	ling	LIN	74
Macrouridae: rattails			
Coelorinchus acanthiger	spotty faced rattail	CTH	2
C. aspercephalus	oblique banded rattail	CAS	45
C. biclinozonalis	two saddle rattail	CBI	18
C. bollonsi	Bollons' rattail	CBO	71
C. celaenostomus	blacklip rattail	CEX	1
C. fasciatus	banded rattail	CFA	39
C. innotabilis	notable rattail	CIN	38
C. kaiyomaru	Kaiyomaru rattail	CKA	16
C. matamua	Mahia rattail	CMA	21
C. maurofasciatus	darkbanded rattail	CDX	1
C. oliverianus	Oliver's rattail	COL	58
C. parvifasciatus	small banded rattail	CCX	6
C. trachycarus	roughhead rattail	CHY	18
Coryphaenoides dossenus	humpback rattail	CBA	12
C. mcmillani	McMillan's rattail	CMX	1
C. murrayi	Murray's rattail	CMU	9
C. serrulatus	serrulate rattail	CSE	36
Coryphaenoides striaturus	striate rattail	CTR	2
C. subserrulatus	four-rayed rattail	CSU	43
Gadomus aoteanus	filamentous rattail	GAO	1
Kuronezumia leonis	starnose black rat	NPU	2
Lepidorhynchus denticulatus	javelinfish	JAV	89
Nezumia namatahi	squashedfaced rattail	NNA	9
Odontomacrurus murrayi	largefang rattail	OMU	1
Trachonurus gagates	velvet rattail	TRX	1
Lucigadus nigromaculatus	blackspot rattail	VNI	25
Macrourus carinatus	ridge scaled rattail	MCA	27
Mesobius antipodum	black javelinfish	BJA	17
Trachyrincidae: rough rattails			
Trachyrincus aphyodes	white rattail	WHX	41
T. longirostris	unicorn rattail	WHR	2
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	15
Guttigadus globiceps	codling	GGC	1
Halargyreus johnsonii	Johnson's cod	HJO	13
H. sp.	Australasian slender cod	HAS	40
Lepidion inosimae	roundtooth cod	LPI	2
L. microcephalus	small-headed cod	SMC	18
Mora moro	ribaldo	RIB	45

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Moridae (cont.)			
Notophycis marginata	dwarf cod	DCO	4
Pseudophycis bachus	red cod	RCO	21
P. barbata	southern bastard cod	SBR	2
Tripterophycis gilchristi	grenadier cod	GRC	3
Melanonidae: pelagic cods			
Melanonus gracilis	smalltooth pelagic cod	MEL	2
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	109
Merluccius australis	hake	HAK	51
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	1
Ceratiidae: seadevils			
Cryptopsaras couesii	warty seadevil	SDE	4
Scomberesocidae: sauries			
Scomberesox saurus	saury	SAU	3
Melamphaidae: bigscalefishes			
Poromitra atlantica	southern bigscale	CBS	3
Sio nordenskjoldii	black bigscalefish	SNO	1
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	2
Trachichthyidae: roughies, slimeheads			
Hoplostethus atlanticus	orange roughy	ORH	31
H. mediterraneus	silver roughy	SRH	37
Paratrachichthys trailli	common roughy	RHY	8
Berycidae: alfonsinos			
Beryx decadactylus	longfinned beryx	BYD	1
B. splendens	alfonsino	BYS	33
Cyttidae: cyttid dories			
Cyttus novaezealandiae	silver dory	SDO	15
C. traversi	lookdown dory	LDO	83
Zeniontidae: armoureye dories			
Capromimus abbreviatus	capro dory	CDO	13
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	21
A. verrucosus	warty oreo	WOE	5
Neocyttus rhomboidalis	spiky oreo	SOR	41
Pseudocyttus maculatus	smooth oreo	SSO	31
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	69
Notopogon lilliei	crested bellowsfish	CBE	3
Sebastidae: seaperches			
Helicolenus barathri	bigeye sea perch	HBA	81
H. percoides	sea perch	HPC	7
Trachyscorpia eschmeyeri	Cape scorpionfish	TRS	5
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	1
Congiopodus leucopaecilus	pigfish	PIG	2
Triglidae: gurnards			
Chelidonichthys kumu	red gurnard	GUR	1
Lepidotrigla brachyoptera	scaly gurnard	SCG	15
Hoplichthyidae: ghostflatheads			
Hoplichthys cf. *haswelli*	deepsea flathead	FHD	45
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	15
Cottunculus nudus	bonyskull toadfish	COT	2

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Psychrolutidae (cont.)			
Psychrolutes microporos	blobfish	PSY	3
Polyprionidae: wreckfishes			
Polyprion oxygeneios	hāpuku	HAP	10
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	14
Callanthiidae: splendid perches			
Callanthias allporti	southern splendid perch	SDP	1
Epigonidae: deepwater cardinalfishes			
Epigonus denticulatus	white cardinalfish	EPD	6
E. lenimen	bigeye cardinalfish	EPL	11
E. machaera	thin tongue cardinalfish	EPM	24
E. robustus	robust cardinalfish	ERB	7
E. telescopus	deepsea cardinalfish	EPT	21
Howellidae: pelagic basslets			
Rosenblattia robusta	rotund cardinalfish	ROS	4
Carangidae: trevallies, kingfishes			
Trachurus declivis	greenback jack mackerel	JMD	4
T. murphyi	slender jack mackerel	JMM	11
Bramidae: pomfrets			
Brama australis	southern Ray's bream	SRB	16
Pterycombus petersii	fanfish	FAN	2
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	8
Plagiogeneion rubiginosum	rubyfish	RBY	4
Pentacerotidae: boarfishes			
Pentaceros decacanthus	yellow boarfish	YBO	1
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	NMP	7
Zoarcidae: eelpouts			
Melanostigma gelatinosum	limp eelpout	EPO	6
Chiasmodontidae: swallowers			
Chiasmodon microcephalus	black swallower	CML	1
Pinguipedidae: sandperches			
Parapercis gilliesii	yellow cod	YCO	3
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	GIZ	49
Gempylidae: snake mackerels			
Paradiplospinus gracilis	false frostfish	PDS	3
Rexea solandri	gemfish	RSO	4
Thyrsites atun	barracouta	BAR	12
Trichiuridae: cutlassfishes			
Benthodesmus elongatus	bigeye scabbardfish	BNE	1
Lepidopus caudatus	frostfish	FRO	7
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	14
Hyperoglyphe antarctica	bluenose	BNS	4
Schedophilus maculatus	pelagic butterfish	SUM	1
Seriolella caerulea	white warehou	WWA	38
S. punctata	silver warehou	SWA	45
Tubbia tasmanica	Tasmanian ruffe	TUB	2
Nomeidae: eyebrowfishes, driftfishes			
Cubiceps spp.	cubehead	CUB	2
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	18

Appendix 2 (continued).

Scientific name	Common name	Species	Occ.
Achiropsettidae: finless flounders			
Neoachiropsetta milfordi	finless flounder	MAN	10
Rhombosoleidae: southern righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	10

APPENDIX 3: MESOPELAGIC AND BENTHIC INVERTEBRATES

Scientific names of mesopelagic and benthic invertebrates identified after the voyage.

NIWA No.	Cruise/StationNo	Phylum	Class	Order	Family	Genus	Species
158964	TAN2201/117	Arthropoda	Malacostraca	Decapoda	Paguridae	*Porcellanopagurus*	*filholi*
159490	TAN2201/56	Mollusca	Cephalopoda	Oegopsida	Brachioteuthidae	*Brachioteuthis*	
159492	TAN2201/35	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Galiteuthis*	
159491	TAN2201/96	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
159495	TAN2201/117	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
159496	TAN2201/114	Mollusca	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
158970	TAN2201/8	Porifera	Demospongiae	Tetractinellida	Ancorinidae	*Stelletta*	
159455	TAN2201/8	Porifera	Demospongiae	Tetractinellida	Ancorinidae	*Stryphnus*	*novaezealandiae*
158967	TAN2201/114	Porifera	Demospongiae	Tetractinellida	Ancorinidae	*Tethyopsis*	
158966	TAN2201/15	Porifera	Demospongiae	Tetractinellida	Geodiidae	*Geodia*	*vestigifera*

APPENDIX 4: HOKI AGE CLASS LENGTH RANGES

Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomass values given in Figure 8. Length ranges in 1992 and 1993 were revised from those reported by 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
Jan 2020	< 48	48 – 59	≥ 59
Jan 2022	< 46	46 – 56	≥ 56

APPENDIX 5: GONAD STAGING FOR NOTOTODARUS (ARROW SQUID) SPECIES

Marie-Julie Roux and Darren Stevens

No gonad staging standards are currently in place for collecting maturity information on arrow squids, *Nototodarus sloanii* and *Nototodarus gouldi*, in New Zealand.

Uozumi et al. (1995) distinguished four gonad maturity stages for *Nototodarus* (immature, maturing, mature, and spent) based on the appearance of the reproductive and accessory reproductive organs in both *N. gouldi* and *N. sloanii*.

A five-stage gonad maturity scale is proposed here as a standard for collecting maturity information on arrow squids in New Zealand. The scale integrates baseline knowledge developed by Uozumi et al. (1995), with maturity information available for another, similar Ommastrephid squid: *Illex argentinus* (Arkhipkin & Laptikhovsky 1994, FIFD 2007).

The scale includes the four maturity stages described by Uozumi et al. (1995), with the addition of a 'preparatory' early maturation stage. The preparatory stage marks the timing at which energy allocation switches from somatic growth to somatic and reproductive growth or reproductive growth only. A similar scale was applied successfully to assess maturity stages in *N. gouldi* (McGrath & Jackson 2002).

New gonad staging standards for *Nototodarus* will assist with the collection of biological information on arrow squids in New Zealand waters. Such data will serve to improve the understanding of *N. gouldi* and *N. sloanii* life cycles; to identify potential environmental drivers affecting recruitment and maturation; and inform the development and application of stock assessment tools for sustainable management of the squid resources.

Table A5.1: Arrow squid *Nototodarus* (*N. sloanii* and *N. gouldi*) male gonad maturity stages.

Stage		Appearance	Biological activity
Males			
1	Immature	**Spermatophoric gland visible** and internal structure may become apparent as a swirl. Testis small and transparent or slightly opaque*.	Immature
2	Preparatory	**Sperm present** as a white streak in the sperm duct and tentative spermatophores* may be present in spermatophoric sac. **Testis enlarged** and opaque white.	Early maturation
3	Maturing	**True spermatophores present** in spermatophoric sac in **low numbers**. Spermatophores not present in penis or mantle cavity†.	Maturing
4	Mature	**True spermatophores present** in spermatophoric sac in **large numbers**. **Spermatophores present in penis** and may be present in mantle cavity‡.	Mature
5	Spent	**Mantle flaccid** and has lost rigidity. Testis severely degenerated. Spermatophores may or may not remain in spermatophoric sac and penis.	Spent

* In stage 2 males, tentative spermatophores (i.e., spermatophores that contain no sperm) may be present in the form of slightly transparent streaks with uniform colour (as opposed to true spermatophores which are opaque and have the spermatophoric sac full of sperm).

† In samples that have been frozen, the freeze-thaw process can cause spermatophores to be pushed into the penis, in which case distinguishing between maturity stages 3 and 4 can be difficult and maturity assessment should be based on the amount of spermatophores that are present. If spermatophores are present in small amount and only found in the penis, it is a stage 3. If spermatophores are present in large numbers, either in the spermatophoric sac, penis or mantle, it is a stage 4.

‡ Spermatophores may be discharged in panic during hauling or squeezed out by pressure of the overlaying catch in the fish bin, causing the spermatophoric sac to be emptied and the animal to appear as a stage 3. However, large numbers of spermatophores should remain in the penis or mantle cavity in stage 4.

Table A5.2: Arrow squid *Nototodarus* (*N. sloanii* and *N. gouldi*) female gonad maturity stages.

Stage		Appearance	Biological activity
Females			
1	Immature	**Nidamental glands visible** as two thin, translucent longitudinal strips. **Oviducts** and **ovary** are **transparent**.	Immature
2	Preparatory	**Nidamental glands** enlarged and **opaque white**. Oviducal glands visible. Oviducts slightly enlarged with **no eggs** present. **Ovary opaque** and developing granular structure.	Early maturation
3	Maturing	Ovary contains **translucent, yellowish eggs** attached together in glue-like matrix. **Oviducts** not extended and contain **few eggs** (few enough to be counted)§.	Maturing
4	Mature	Ovary filled with individual translucent, shiny eggs. **Oviducal glands enlarged** and opaque white. **Oviducts** are **extended** and **densely packed with eggs** that are far too numerous to count§.	Mature
5	Spent	**Mantle flaccid** and has lost rigidity. Ovary severely degenerated. Eggs may or may not remain in ovary and oviducts.	Spent

§ Females in late maturity stage 3 and maturity stage 4 may have spermatophores present on one or both of the gills or inner side of the mantle.

Glossary

The squid reproductive system consists of a single gonad (testis or ovary) located in the coelom in the posterior part of the body; one or two separate gonoducts (usually a single spermduct in males and a pair of oviducts in females) and a complex of accessory glands (i.e., spermatophoric gland/complex in males; nidamental glands and oviducal glands in females). The primary function of the accessory glands is to produce different secretions to make an egg mass (Arkhipkin 1992).

Spermatophore: a complicated specific capsule containing a mass of spermatozoa, which is transferred during mating in squid.
Spermatophoric gland: Accessory gland in which the spermatophores are formed in male squid.
Spermatophoric (or Needham) sac: Structure of the male squid reproductive system in which the spermatophores accumulate.
Penis (terminal organ): distal muscular part of the spermatophoric sac that elongates during copulation and ejects spermatophores.
Oviducts: Female squid oviducts consisting of strongly curved tubes in which the eggs are accumulated.
Oviducal glands: Accessory glands set on the female oviducts. Oviducal gland secretions serve to protect the individual eggs.
N**idamental glands:** Accessory glands part of the female squid reproductive system. In ommastrephid squid, the nidamental glands serve to secrete a neutrally buoyant mucous mass in which the eggs are suspended at the time of spawning.

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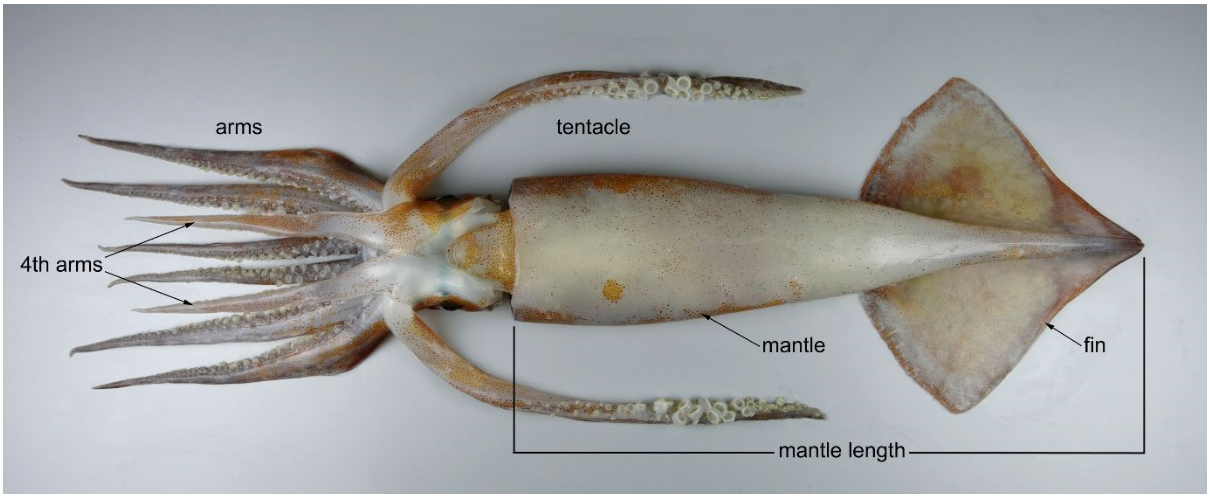

Figure A5.1: External anatomy of the arrow squid (here *N. sloanii* specimen).

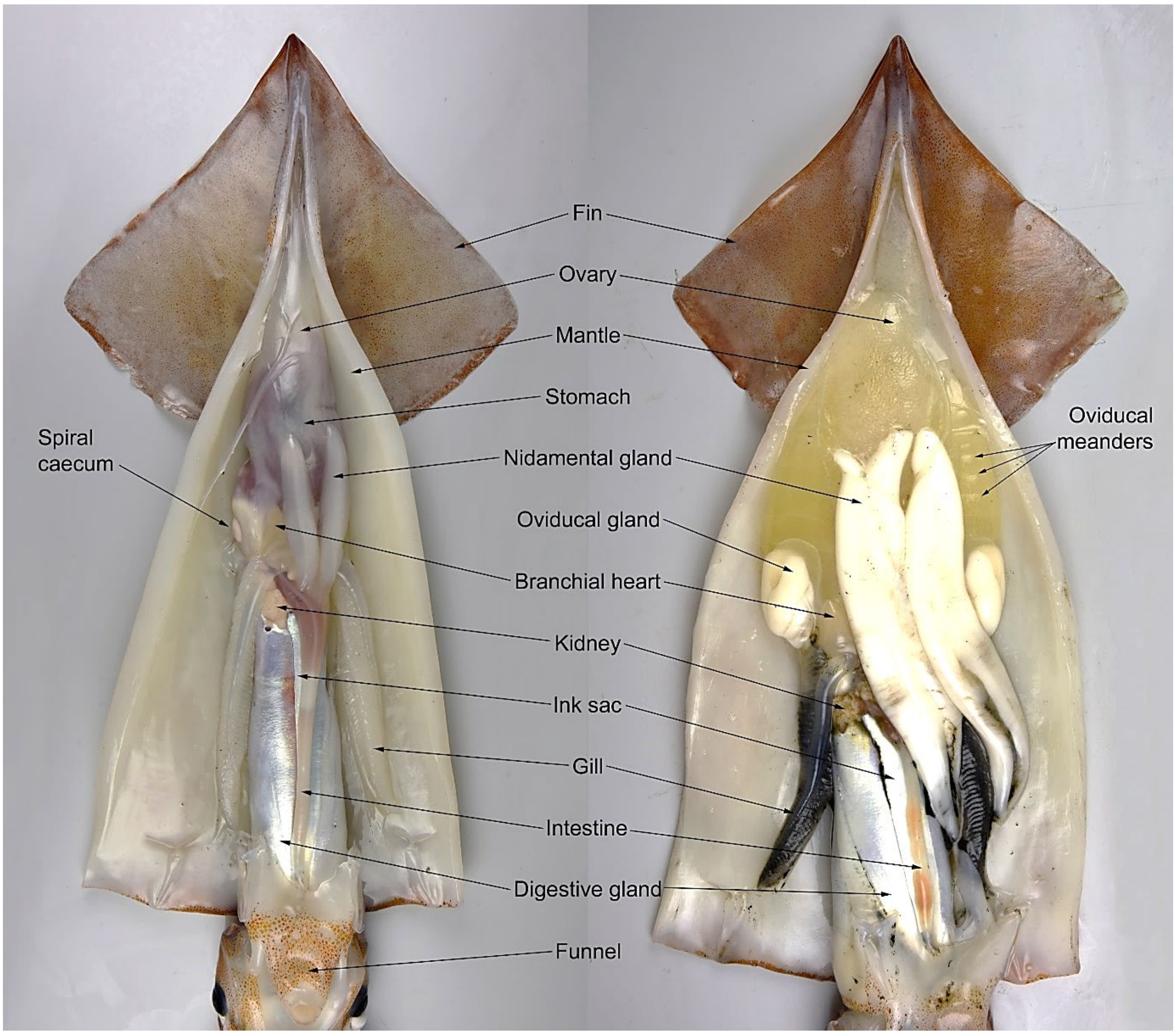

Figure A5.2: Internal anatomy and reproductive system of the female arrow squid. Left: Stage 3 (preparatory) female *N. sloanii*. Right: Stage 5 (mature) female *N. sloanii*.

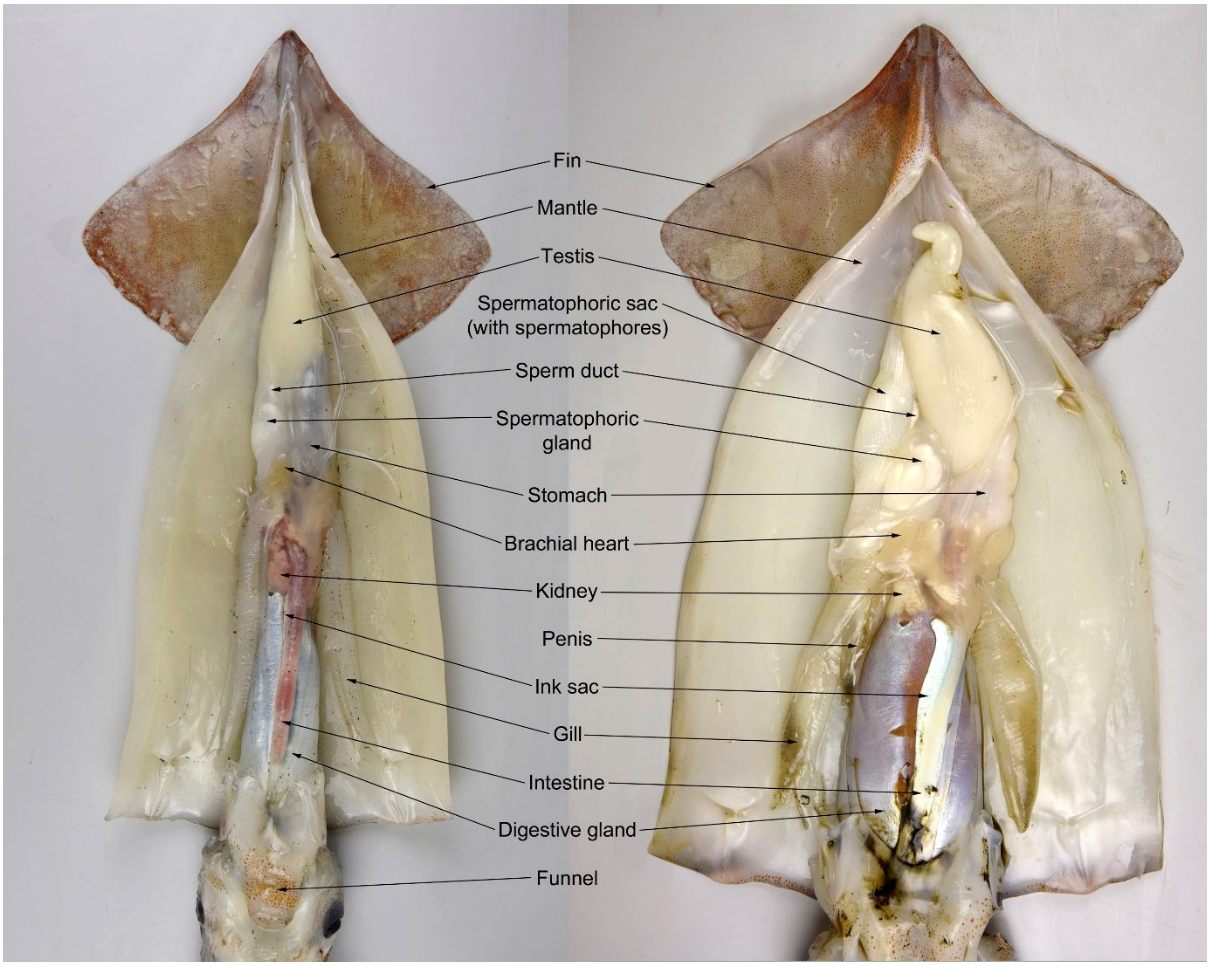

Figure A5.3: Internal anatomy and reproductive system of the male arrow squid. Left: Stage 3 (preparatory) male *N. sloanii*. Right: Stage 4 (mature) male *N. sloanii*.