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Trawl survey of hoki and middle-depth species on the Chatham Rise, January 2020 (TAN2001)

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The 26th 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 2020. A random stratified sampling design was used, and 130 bottom trawls were successfully completed. These comprised 84 core (200–800 m) phase 1 biomass tows, 3 core phase 2 tows, and 43 deep (800–1300 m) tows.

Estimated relative biomass of all hoki in core strata was 89 557 t (CV 14.4%), a decrease of 26.6% from January 2018. This decrease was largely driven by a low biomass estimate for 2+ year old hoki (2017 year-class) of 12 319 t, one of the lowest estimates in the time series. The biomass estimate for 1+ hoki (2018 year-class) of 28 342 t, was the 5th highest in the time series. The relative biomass of recruited hoki (ages 3+ years and older) in core strata was 48 897 t, an increase of 22.5% from that in 2018. Recruited hoki were also observed in deep (800–1300 m) strata in 2020 with an estimated biomass estimate from these deeper strata of 4751 t. The relative biomass of hake in core strata decreased by 37.5% to 1037 t (CV 20.1%) between 2018 and 2020, and the 2020 hake estimate was the second lowest in the time series. The relative biomass of ling was 7557 t (CV 7.9%), 13.5% lower than that in January 2018, but the time series for ling shows no overall trend.

The age frequency distribution for hoki was dominated by 1+ year old fish, with most hoki less than age 5+. The age frequency distribution for hake was broad, with most aged between 4–9 years. The age distribution for ling was also broad, with most aged between 3–21 years.

In 2020 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 = 0.24) between acoustic density from bottom marks and trawl catch rates. The acoustic index of mesopelagic fish abundance in 2020 was 40% higher than that in 2018, and slightly above average for the acoustic time series (since 2001). Hoki liver condition was also higher than that in 2018, and about average in the time series of condition indices (that goes back to 2004). There was a strong positive correlation (r = 0.75) between hoki liver condition and indices of mesopelagic fish scaled by hoki abundance ("food per fish").

Due to generally very good weather, the trawl survey was successfully completed about 36 hours ahead of schedule. In this remaining time, eight additional tows were carried out west of the survey area, in the Canterbury Banks Hoki Management Area (HMA). Hoki were only caught in the two tows within the HMA that were deeper than 200 m.

1. INTRODUCTION

In January 2020, the 26th in a time series of random trawl surveys on the Chatham Rise was completed. This, and all previous surveys in the series, were carried out from RV *Tangaroa* and form the most comprehensive time series of relative species abundance at water depths of 200 to 800 m in New Zealand's 200-mile Exclusive Economic Zone. Previous surveys in this time series were documented by Horn (1994a, 1994b), Schofield & Horn (1994), Schofield & Livingston (1995, 1996, 1997), Bagley & Hurst (1998), Bagley & Livingston (2000), Stevens et al. (2001, 2002, 2008, 2009a, 2009b, 2011, 2012, 2013, 2014, 2015, 2017, 2018), Stevens & Livingston (2003), Livingston et al. (2004), Livingston & Stevens (2005), and Stevens & O'Driscoll (2006, 2007). Trends in relative biomass, and the spatial and depth distributions of 142 species or species groups, were reviewed for the surveys from 1992–2010 by O'Driscoll et al. (2011b).

The main aim of the Chatham Rise surveys is to provide relative biomass estimates of adult and juvenile hoki. Hoki is New Zealand's largest finfish fishery, with an annual catch limit of 115 000 t, reduced from 150 000 t on 1 October 2019. Although managed as a single fishery, hoki is assessed as two stocks, western and eastern. The hypothesis is that juveniles from both stocks mix on the Chatham Rise and recruit to their respective stocks as they approach sexual maturity. The Chatham Rise is also thought to be the principal residence area for the hoki that spawn in Cook Strait and off the east coast South Island in winter (eastern stock). Annual commercial catches of hoki on the Chatham Rise peaked at about 75 000 t in 1997–98 and 1998–99, decreased to a low of 30 700 t in 2004–05, and increased again from 2008–09 to 2011–12 (Ballara & O'Driscoll 2014). The catch from the Chatham Rise in 2018–19 was 40 400 t. The Chatham Rise fishery is ~~–~~ the second largest fishery in the EEZ (behind the west coast South Island) and ~~contributing~~ contributes about 33% of the total New Zealand hoki catch.

To manage the hoki fishery and minimise potential risks, it is important to have some predictive ability about recruitment. 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 and 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 showed that biomass was estimated 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 fisheries-independent estimate of abundance on the Chatham Rise, and the survey time series fulfils an important "ecosystem monitoring" role (e.g., Tuck et al. 2009), as well as providing inputs into single-species stock assessments.

In January 2010, the survey was extended to sample deeper strata (800 to 1300 m) in the north and east of the Chatham Rise. In January 2016, the survey duration was increased by 6 days to also include deeper strata to the south and west of the Chatham Rise. The 2020 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).

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.

1.2 Canterbury Banks Hoki Management Area (stratum 31)

Hoki quota owners, HOK 1 annual catch entitlement (ACE) owners, and Fisheries New Zealand have established Operational Procedures (OPs) that stipulate agreed management measures for the hoki fishery. These OPs include area and seasonal closures. Four hoki management areas (HMAs) have been established, where no hoki target fishing is permitted, to protect small hoki. One of these HMAs is on the Canterbury Banks. Part of the Canterbury Banks HMA is within the core Chatham Rise survey area, but the HMA continues west of the trawl survey area (Figure 1).

There was interest from Deepwater Group (DWG) about how densities of juvenile hoki in the Canterbury HMA compare to those on the rest of the Chatham Rise. The context is to better assess the efficacy of the HMA and to assess, from a management perspective, what (if any) additional management measures may warrant consideration to further reduce fishing mortality on hoki <55 cm.

Due to generally very good weather, the trawl survey was successfully completed about 36 hours ahead of schedule. In this remaining time, eight additional tows were carried out west of the survey area, in the Canterbury Banks HMA. This area was labelled stratum 31. These tows will not be included as part of the survey time series but provide information on distribution of young hoki to inform spatial management.

2. METHODS

2.1 Survey area and design

As in previous years, the survey followed a two-phase random design (after Francis 1984). The main survey area of 200–800 m depth (Figure 1) was divided into 23 strata. Nineteen of these strata are the same as those used in 2003–11 (Livingston et al. 2004, Livingston & Stevens 2005, Stevens & O’Driscoll 2006, 2007, Stevens et al. 2008, 2009a, 2009b, 2011, 2012). In 2012, stratum 7 was divided into strata 7A and 7B at 175° 30'E to more precisely assess the biomass of hake which appeared to be spawning northeast of Mernoo

Bank (in Stratum 7B). In 2013, the survey duration was reduced from 27 to 25 days, removing the contingency for bad weather and reducing the available time for phase 2 stations. To increase the time available for phase 2 stations in 2014, strata 10A and 10B were re-combined into a single stratum 10 and stratum 11A, 11B, 11C, 11D into a single stratum 11. These strata are in the 400–600 m depth range on the northeast Chatham Rise (Figure 1) and were originally split to reduce hake CVs. However, few hake were caught in these strata since 2000 and 18 phase 1 tows (3 in each sub-strata) assigned to this area is no longer justified.

Station allocation for phase 1 was determined from simulations based on catch rates from all previous Chatham Rise trawl surveys (1992–2018), using the 'allocate' procedure of Bull et al. (2000) as modified by Francis (2006). This procedure estimates the optimal number of stations to be allocated in each stratum to achieve the Ministry for Primary Industries target CV of 20% for 2+ hoki, and CVs of 15% for total hoki and 20% for hake. The initial allocation of 84 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+ hoki and hake biomass.

As in 2018, the 2020 survey area included 11 deep strata from 800–1300 m around the entire Chatham Rise (Figure 1). The station allocation for the deep strata was determined based on catch rates of eight bycatch species (basketwork eel, four-rayed rattail, longnose velvet dogfish, Baxter's dogfish, ribaldo, bigscaled brown slickhead, shovelnose dogfish, and smallscaled brown slickhead) in the 2010–18 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 44 phase 1 deep stations (Table 1). There was no allowance for phase 2 trawling in deep strata.

2.2 Vessel and gear specifications

Tangaroa is a purpose-built, research stern trawler of 70 m overall length, a beam of 14 m, 3000 kW (4000 hp) of power, and a gross tonnage of 2282 t.

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

2.3 Trawling procedure

Trawling followed the standardised procedures described by Hurst et al. (1992). Station positions were selected randomly before the voyage using the Random Stations Generation Program (Version 1.6) developed by NIWA. To maximise the amount of time spent trawling in the deep strata (800–1300 m) at night, the time spent searching for suitable core (200–800 m) tows at night was reduced by using the nearest known successful tow position to the random station. Care was taken to ensure that the centre positions of survey tows were at least 3 n. miles apart. For deep strata, there was often insufficient bathymetric data and few known tow positions, so these tows followed the standard survey methodology described by Hurst et al. (1992). If a random station position was found to be on foul ground, a search was made for suitable ground within 3 n. miles of the station position. If no suitable ground could be found, the station was abandoned, and another random position was substituted. Core biomass tows were carried out during daylight hours (as defined by Hurst et al. (1992)), with all trawling between 0502 h and 1845 h NZST. Exemption was received from Fisheries New Zealand on 19 December 2019 to carry out research trawling on known tows in the Mid Chatham Rise and the East Chatham Rise benthic protected area (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 echosounders with hull-mounted transducers. All frequencies are regularly calibrated following standard procedures (Demer et al. 2015), with the most recent calibration being used for any data processing. In the present case, the latest calibration of *Tangaroa* echosounders was 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).

2.5 Hydrology

Temperature and salinity data were collected using a calibrated Seabird SM-37 Microcat CTD datalogger mounted on the headline of the trawl. Data were collected at 5 s intervals throughout the trawl, providing vertical profiles. Surface values were read off the vertical profile at the beginning of each tow at a depth of about 5 m, which corresponded to the depth of the hull temperature sensor used in previous surveys. Bottom values were from about 7.0 m above the seabed (i.e., the height of the trawl headline).

2.6 Catch and biological sampling

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

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

2.7 Estimation of relative biomass and length frequencies

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

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

2.8 Estimation of numbers at age

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

Subsamples of 720 hoki otoliths and 655 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 113 hake otoliths collected were prepared.

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

2.9 Acoustic data analysis

Acoustic data analysis followed the methods applied to recent Chatham Rise trawl surveys (e.g., Stevens et al. 2018), 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 km^2 from bottom-referenced marks were calculated for each recording, based on integration heights of 10 m, 50 m, and 100 m above the bottom. Total acoustic backscatter was also integrated throughout the water column in 50 m depth bins. Acoustic density estimates (m^2 backscatter per km^2) from bottom-referenced marks were compared with trawl catch rates (kg per km^2). No attempt was made to scale acoustic estimates by target strength, correct for differences in catchability, or carry out species decomposition (O'Driscoll 2002, 2003).

O'Driscoll et al. (2009, 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 2020. 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, *psz*. *psz* was estimated as 0.2 by O'Driscoll et al (2009) and was assumed to be the same for all years and strata:

$$p(meso)_s = psz + p(200)_s * (1 - psz)$$

2.10 Canterbury Banks Hoki Management Area (stratum 31)

To investigate the distribution and density of juvenile hoki within the Canterbury Banks Hoki Management Area (HMA), an additional stratum, stratum 31, was created to the west of the survey area (Figure 1). The Canterbury Banks HMA is largely outside of the survey area but there is some overlap on the eastern boundary. Stratum 31 encompasses that portion of the HMA that is outside of the survey area. Station positions were selected randomly before the voyage using the Random Stations Generation Program (Version 1.6) and the trawling procedure and the catch and biological sampling was the same as that used for the survey area. These tows were not included as part of the survey time series.

3. RESULTS

3.1 2020 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 very good, and only about 12 hours were lost due to a strong southwest front on 7 January. Another 9 hours were lost on 17 January when *Tangaroa* transited to Waitangi, Chatham Islands for a medical consultation and to pick up a replacement wetlab parts.

A total of 130 successful trawl survey tows were completed, comprising 84 phase 1 tows and 3 phase 2 tows in core 200–800 m strata, and 43 deep tows (Tables 1 and 2, Figure 2, Appendix 1). Three further tows were considered unsuitable for estimating abundance: station 21 in core stratum 10 came fast; and deep tows 33 and 37 in strata 23 and 24 respectively were rejected because of high headline height suggesting unsatisfactory gear performance. All planned phase 1 tows were carried out in core strata. There was one less deep tow than planned, because the rejected tow in stratum 24 was not substituted. Station details for all tows are given in Appendix 1. Seven 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).

Eight additional tows were carried out west of the survey area, in the Canterbury Banks HMA at the end of the survey period (see Section 3.10). These tows were not included as part of the survey time series.

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 6.6–7.2 m, averaged 6.9 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 115.2–121.0 m, and averaged 119.0 m, and although slightly lower than those in more recent surveys, were within the optimal range (Hurst et al. 1992).

3.3 Hydrology

Surface temperatures in 2020 were 12.2–19.0° C (mean 15.6° C) and bottom temperatures were 3.2–12.2° C (mean 7.6° C) (Figure 3). Surface temperatures within the core survey area were 1.7° C cooler on average compared to the very warm surface temperatures observed in 2018 (Figure 4 top panel). Average bottom temperature in the core area in 2020 was slightly higher than that in 2018 and was the highest observed in the time series, continually the gradually warming trend since 2012 (Figure 4 lower panel).

3.4 Catch composition

The total catch from all 130 valid biomass stations was 122.8 t, of which 44.7 t (36.3%) was hoki, 9.1 t was dark ghost shark (7.4%), 6.4 t (5.2%) was smooth oreo, 5.8 t (4.7%) was black oreo, 4.4 t (3.6%) was silver warehou, 2.9 t (2.4%) was ling, 2.5 t (2.0%) was orange roughy, and 0.6 t (0.5%) was hake (Table 4).

Of the 362 species or species groups identified from valid biomass tows, 173 were teleosts, 39 were elasmobranchs, 1 was an agnathan, 31 were crustaceans, and 20 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. Twenty-six invertebrate taxa were later identified (Appendix 4).

3.5 Relative biomass estimates

3.5.1 Core strata (200–800 m)

Relative biomass in core strata was estimated for 47 species (Table 4). The CVs achieved for hoki, hake, and ling from core strata were 14.4%, 20.1%, and 7.9% respectively. The CV for 2+ hoki (2017 year-class) was 17.4%, below the target CV of 20%. High CVs (over 30%) generally occurred when species were not well sampled by the gear. For example, alfonsino, barracouta, frostfish, and slender mackerel are not strictly demersal and exhibit strong schooling behaviour and consequently catch rates of these are highly variable. Others, such as bluenose, hapuku, rough skate, and tarakihi, have high CVs as they are mainly distributed outside the core survey depth range (O'Driscoll et al. 2011b).

The combined relative biomass for the top 31 species in the core strata that are tracked annually (Livingston et al. 2002, see Table 4) was 23.9% lower than in 2018, 19.6% lower than in 2016, similar to that in 2014, and the 4th lowest in the time series (Figure 5, top panel). As in previous years, hoki was the most abundant species caught (Table 4, Figure 5, lower panel). The relative proportion of hoki in 2020 was about the same as in 2018 and 2016, and one of the higher estimates since 1998. The next most abundant QMS species in core strata were black oreo, silver warehou, dark ghost shark, ling, spiny dogfish, lookdown dory, Sloan's arrow squid, redbait, bigeye sea perch, barracouta, giant stargazer, and alfonsino, each with an estimated relative biomass of over 2000 t (Table 4). The most abundant non-

QMS species were Bollons' rattail, javelinfish, shovelnose dogfish, Oliver's rattail, and oblique banded rattail (Table 4).

Estimated relative biomass of hoki in the core strata in 2020 was 89 557 t, 26.6% lower than the hoki biomass in January 2018 (Table 5, Figures 6a, 7a, 7b). This was largely driven by a low biomass estimate for 2+ hoki (2017-year class) of 12 319 t, one of the lower estimates in the time series. However, the biomass estimate for 1+ hoki (2018-year class) of 28 342 t, was above average for in the time series (Table 6). The relative biomass of recruited hoki (ages 3+ years and older) was 48 897 t, 22.5% higher than in the 2018 survey and one of the higher estimates since 2000.

The relative biomass of hake in core strata was 1037 t, 37.5% lower than that in 2018, 20.2% lower than that in 2016, and the second lowest estimate in the time series (see Table 5, Figures 6a, 7a, 7b).

The relative biomass of ling was 7577 t, 13.4% lower than that in January 2018, and 25.7% lower than that in 2016, although the time series for ling shows no overall trend (Figures 6a, 7a, 7b).

The relative biomass estimates for dark ghost shark was higher than 2018 estimates; silver warehou, giant stargazer, and pale ghost shark, were about the same; and lookdown dory, sea perch, spiny dogfish, and white warehou were lower than the 2018 estimates (Figures 6a, 7a, 7b).

3.5.2 Deep strata (800–1300 m)

Relative biomass and CVs were estimated for 26 deepwater species (Table 4). The relative biomass of orange roughy in all strata in 2020 was 3087 t, compared to 1302 t in 2018 and 6916 t in 2016 (Figures 6b, 7c). Although the survey was not optimised for orange roughy, and there was one large catch in 2020 (1056 kg), the precision was reasonable with a CV of 31.1%.

Deepwater sharks were relatively abundant in deep strata, with 29%, 89%, and 70% of the total survey biomass of shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish occurring in deep strata (Figures 6b, 7c). In 2020, bigscaled and smallscaled brown slickhead were restricted to deep strata, and basketwork eel, and four-rayed rattail were largely restricted to deeper strata. Spiky oreo were mainly caught in core strata (Figures 6b, 7c).

The deep strata contained 5.0% of the total survey hoki biomass, 7.9% of total survey hake biomass, and 0.5% 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 (4751 t) was largely due to a single catch of 2254 kg in stratum 22 and so precision of the estimate was poor with a CV of 66.8%.

3.6 Catch distribution

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

Hoki

In the 2020 survey, hoki were caught in 79 of the 87 core biomass stations. Hoki were not captured in 8 of the 10 shallowest tows (less than 300 m): on the Mernoo and Reserve Banks (strata 18 and 19); Matheson Bank (stratum 3); and east of the Chatham Islands (stratum 9). The highest catch rates were at 300–400 m depths on Reserve Bank (stratum 20) and around the Mernoo Bank (stratum 18), and 400–600 m in strata 7A and 7B (Table 7a, Figure 8a). The highest individual catch of hoki in 2020 was 5424 kg on Reserve Bank in stratum 20, and was mostly 1+ hoki (Figure 8a, Appendix 1). Other high hoki catches were two ~2200 kg catches around the Mernoo Bank in stratum 18 and stratum 7B (Figure 7a), and a further ~2200 kg catch in deep stratum 22 (Figure 7b). The strong year class of hoki aged 1+ (2018 year-class) was largely restricted to western strata around Mernoo and Reserve Banks (strata 18–20) and the adjacent 400-600 m strata (strata 7A, 7B) (Figure 8a). The weak year class of hoki aged 2+

(2017 year-class) were found over much of the Rise at 200–600 m depths but were more abundant on the western Rise, in particular in 400–600 m around Mernoo Bank (strata 7A, 7B) (Figure 8a). Recruited hoki (3+ and older) were widespread but the highest catch rates were on northwest Chatham Rise in stratum 22, south of the Reserve Bank in stratum 14 and 15, and north of Chatham Islands in stratum 9 (Figure 8a).

Hake

There were no large catches of hake in 2020 with consistently low catches throughout the survey area (Figure 9). The highest catches were west of Mernoo Bank in stratum 7A, north of the Matheson Bank in stratum 10, and east of Mernoo Bank in stratum 7B.

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 metres around Mernoo Bank and Reserve Bank (strata 7A,7B, 8A, 8B, 14, 15, 16).

Other species

As with previous surveys, lookdown dory, sea perch and spiny dogfish were widely distributed throughout the survey area at 200–600 m depths. The highest catch rates for sea perch were taken at 200–400 m on Veryan Bank (stratum 17) and Reserve Bank (strata 19, 20), 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, Veryan Bank, Matheson Bank, and north of the Chatham Islands (Figure 9). Dark ghost shark was mainly caught at 200–400 m depths on the western Rise and was particularly abundant on Veryan Bank; while pale ghost shark was mostly caught in deeper water at 400–800 m depth, with higher catch rates to the south. Giant stargazer was mainly caught in shallower strata, with the largest catch taken southwest 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 north of Chatham Islands and white warehou on eastern Reserve Bank (Figure 9). Javelinfish and Bollons' rattail were widely distributed throughout the survey area. The highest catch rate of javelinfish was taken southwest of Mernoo Bank in stratum 16 while the highest catch rates of Bollons' rattail were taken around eastern 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 1055 kg taken on the northeast Rise in 900 m in stratum 21A (Table 7b, Figure 9). As with previous surveys, black oreo was mostly caught on the southwest Rise at 600–1000 m depths. The largest catches of black oreo were 1575 kg from stratum 27 in 835 m and 1078 kg in stratum 6 in 716 m. Smooth oreo were almost entirely taken on the southern Rise at 800–1300 m depths, with the highest catch rates in stratum 28 and 27 (Table 7a, Figure 9). Spiky oreo were widespread and abundant on the northern Rise at 500–850 m, with the highest catch rates taken in stratum 2B (Table 7a, Figure 7). 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 7, 9).

3.7 Biological data

3.7.1 Species sampled

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

3.7.2 Length frequencies and age distributions

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

Hoki

Length and age frequency distributions were dominated by hoki aged 1+ (less than 48 cm) (Figures 10 and 11). There were very few hoki aged 2+ (48–59 cm) and relatively few fish longer than 70 cm (Figure 10) or older than 5+ years (Figure 11). Female hoki were estimated to be slightly less abundant than males (ratio of 0.90 female: 1 male).

Hake

Length frequency and calculated number at age distributions (Figures 12 and 13) were relatively broad, although most male fish were aged 4–9 years and female fish were aged 6–10 years. Female hake were estimated to be more abundant than males (1.82 female: 1 male).

Ling

Length frequency and calculated number-at-age distributions (Figures 14 and 15) indicated a wide range of ages, with most fish aged 3–21. There is evidence of a period of good recruitment from 1999–2006 (Figure 15). Male ling were estimated to be slightly more abundant than females (1 female: 1.06 male).

Other species

Length frequency distributions for other key core and deepwater species are shown in Figures 16. Clear modes are apparent in the size distribution of silver 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 (Figure 16).

The deep strata contained a high proportion of large longnose velvet dogfish, and Baxter’s dogfish, and most, or all, basketwork eel, bigscaled brown slickhead, four-rayed rattail, and smallscaled brown slickhead (Figure 16b).

Length frequency distributions were similar for males and females of sea perch (mainly *Helicolenus barathri*), silver warehou, orange roughy, and black oreo. The length frequency distribution for orange roughy was broad, with most fish between at about 25–40 cm but included fish as small as 7 cm (Figure 16).

The catches of giant stargazer, spiny dogfish, bigscaled brown slickhead, basketwork eels, and four-rayed rattails were dominated by females (greater than 1.5 female: 1 male) while the catch of white warehou was dominated by males (1.42 male: 1 female) (Figure 16).

3.7.3 Reproductive status

Gonad stages of hake, hoki, ling, and several other species are summarised in Table 10. Almost all hoki were recorded as either resting or immature. About 32% of male ling were maturing or ripe, with few females showing signs of spawning. About 40% of male hake were ripe or running ripe, but most females were immature or resting (33%) or maturing (53%) (Table 10). A high proportion of frostfish and orange perch were reproductively active with ripe or running ripe gonads. A high proportion of male barracouta, red cod, and smooth oreo, and female seaperch and spineback eels 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).

3.8 Acoustic data quality

Acoustic data were recorded continuously throughout the survey. Over 109 GB of data were collected during trawling and steaming between stations. Weather and sea conditions during the survey were generally very good, meaning acoustic data quality was high overall. Only 15 out of the 138 successful trawl transects (10.9% of trawls, including tows in the HMA) exceeded the threshold of 30% bad pings and so were not suitable for quantitative analysis. Similarly, only 3 out of the 36 night-time steam transects (8.3% of night steams) were not suitable for analysis.

Expanding symbol plots of the distribution of total acoustic backscatter from daytime trawls and night transects in the overall survey area (200–1300 m) are shown in Figure 17. O'Driscoll et al. (2011a) noted a consistent spatial pattern in total backscatter on the Chatham Rise, with higher backscatter in the west. In 2020, backscatter was more consistent across the Rise, but highest values were in the northwest (Figure 17).

3.8.1 Comparison of acoustics with bottom trawl catches

Acoustic data from 78 core trawl files were integrated and compared with trawl catch rates (Table 11). Data from another 9 recordings during successful core daytime tows were not included in the analysis because the acoustic data were too noisy. Average acoustic backscatter values from the entire water column in 2020 was 25% higher than that in 2018, despite a 26% decrease in average trawl catch rates (Table 11). Average acoustic backscatter in the bottom 10 m, 50 m, and 100 m were also higher than equivalent values in 2018, and about average compared to previous surveys in the time series (Table 11).

There was a positive correlation (Spearman's rank correlation, rho = 0.24, $p < 0.05$) between acoustic backscatter in the bottom 100 m during the day and trawl catch rates (Figure 18). In previous Chatham Rise surveys from 2001–18, rank correlations between trawl catch rates and acoustic density estimates ranged from 0.15 (in 2006) to 0.50 (in 2013). The correlation between acoustic backscatter and trawl catch rates (Figure 18) is not perfect (rho = 1) because the daytime bottom-referenced layers on the Chatham Rise may also contain a high proportion of mesopelagic species, which contribute to the acoustic backscatter, but which are not sampled by the bottom trawl (O'Driscoll 2003, O'Driscoll et al. 2009), and conversely some fish caught by the trawl may not be measured acoustically. For example, there were two tows in 2020 (stations 87 and 88) that high large catches, dominated by dark ghost shark, but low acoustic backscatter. Dark ghost sharks do not have a swimbladder, so are likely to be a weak acoustic target.

3.8.2 Time series of relative mesopelagic fish abundance

In 2020, most acoustic backscatter was between 250 and 500 m depth during the day and migrated into the surface 200 m at night (Figure 19). The daytime vertical distribution was similar to the pattern observed in all previous years except 2011. In 2011, there was a different daytime distribution of backscatter, with a concentration of backscatter between 150 and 350 m, no obvious peak at 350–400 m, and smaller peaks centred at around 550 and 750 m (Stevens et al. 2012). As in 2018 (Stevens et al. 2018), a higher proportion of backscatter remained at depth during the night in 2020 than in some previous years, with an obvious night-time peak at around 500–600 m (Figure 19).

The vertically migrating component of acoustic backscatter is assumed to be dominated by mesopelagic fish (see McClatchie and Dunford, 2003 for rationale and caveats). Figure 20 shows an example echogram with strong daytime mesopelagic layers. In 2020, between 56 and 76% 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 2020 was within the range of other surveys in the time series in all sub-areas (Table 12).

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

Total daytime backscatter in 2020 was 25% higher than that observed in 2018. Backscatter within 50 m of the bottom during the day also increased by 20% from 2018 and was at a similar level to that in 2012 to 2014 (Figure 21). Backscatter close to the bottom at night has been relatively low throughout the time series but shows an increasing trend over the past 10 years (Figure 21).

Acoustic indices of mesopelagic fish abundance are summarised in Table 12 and plotted in Figure 22 for the entire Chatham Rise and for the four sub-areas. The overall mesopelagic estimate for the Chatham Rise increased by 40% from 2018 and was slightly above average for the acoustic time series. The mesopelagic index increased in three of the four sub-areas, with the highest percentage increase (64%) in the southeast. Historically the southeast sub-area usually had lower mesopelagic indices than western areas, but in 2020 this sub-area had the highest estimated average density (followed by the northwest). The southwest sub-area, which has typically been the most variable sub-area over the time series, decreased by 58% from 2016 to 2018, and remained low in 2020 (Table 12, Figure 22).

3.9 Hoki condition

Liver condition (defined as liver weight divided by gutted weight) for all hoki on the Chatham Rise increased by 22% from 2018 to 2020 and was about average in the time series of condition indices that goes back to 2004 (Figure 23). This increase in overall condition was driven by hoki less than 80 cm; condition of fish greater than 80 cm was similar to that in 2018 (Figure 23).

Hoki condition indices on the Chatham Rise were usually 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, but condition indices in both areas was much lower in 2018. Hoki condition in the Sub-Antarctic remained low in November-December 2019 (based on fish from a subset of the trawl survey area from the voyage TAN1908 for FNZ research project ZBD2018/05, NIWA unpublished data), but has increased on the Chatham Rise (Figure 24).

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 (Figure 25) was maintained with the addition of the 2020 data (Pearson's correlation coefficient, $r = 0.75$, $n = 13$, $p < 0.01$).

3.10 Canterbury Banks Hoki Management Area (stratum 31)

A full list of species caught in the Canterbury Banks HMA tows, and the number of stations at which they occurred, is given in Appendix 3. Of the 57 species or species groups identified, 38 were teleosts, 8 were elasmobranchs, 1 was a crustacean, and 2 were cephalopods. The remainder consisted of assorted benthic and pelagic invertebrates. Hoki were caught in only two of the eight trawls in stratum 31 (Appendix 3, Figure 8b). The other 6 tows, which were all shallower than 200 m (see Appendix 1), caught no hoki.

4. CONCLUSIONS

The 2020 survey successfully extended the January Chatham Rise time series to 26 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 27% lower than that in 2018, due to a low biomass estimate of 2+ hoki (2017 year-class), one of the lowest in the time series. The biomass estimate for 1+ hoki (2018 year-class) was the 5th highest in the time series. The estimated biomass of 3++ (recruited) hoki increased by 23% from that in 2018, and, as in 2018, 3++ hoki were also observed in deep (800–1300 m).

The relative biomass of hake in core strata was 38% lower than in 2018, when the largest catch of hake in the time series was taken, and 20% lower than in 2016. The hake estimate is the second lowest in the time series and remains at low levels compared to the early 1990s. The relative biomass of ling in core strata was 13% lower than in 2018, but the time series for ling shows no overall trend.

In 2020 the survey area covered 800–1300 m depths around the entire Rise for only the third 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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Table 1: The number of completed valid biomass tows (200–1300 m) by stratum during the 2020 Chatham Rise trawl survey.

Stratum number	Depth range (m)	Location	Area (km^2)	Phase 1 allocation	Phase 1 stations	Phase 2 stations	Total stations	Station density (1: km^2)
1	600–800	NW Chatham Rise	2 439	3	3		3	1:813
2A	600–800	NW Chatham Rise	3 253	3	3		3	1:1 084
2B	600–800	NE Chatham Rise	8 503	4	4		4	1:2 126
3	200–400	Matheson Bank	3 499	3	3		3	1:1 166
4	600–800	SE Chatham Rise	11 315	3	3		3	1:3 772
5	200–400	SE Chatham Rise	4 078	3	3		3	1:1 359
6	600–800	SW Chatham Rise	8 266	3	3		3	1:2 755
7A	400–600	NW Chatham Rise	4 364	3	3	2	5	1:873
7B	400–600	NW Chatham Rise	869	4	4		4	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		8	1:1 469
12	400–600	SE Chatham Rise	6 578	3	3		3	1:2 193
13	400–600	SE Chatham Rise	6 681	3	3		3	1:2 227
14	400–600	SW Chatham Rise	5 928	3	3		3	1:1 976
15	400–600	SW Chatham Rise	5 842	3	3		3	1:1 947
16	400–600	SW Chatham Rise	11 522	3	3		3	1:3 841
17	200–400	Veryan Bank	865	3	3		3	1:288
18	200–400	Mernoo Bank	4 687	4	4		4	1:1 172
19	200–400	Reserve Bank	9 012	7	7		7	1:1 287
20	200–400	Reserve Bank	9 584	7	7	1	8	1:1 198
Core	200–800		139 492	84	84	3	87	1:1 603
21A	800–1000	NE Chatham Rise	1 249	3	3		3	1:416
21B	800–1000	NE Chatham Rise	5 819	5	5		5	1:1 164
22	800–1000	NW Chatham Rise	7 357	8	8		8	1:920
23	1000–1300	NW Chatham Rise	7 014	5	5		5	1:1 403
24	1000–1300	NE Chatham Rise	5 672	3	2		2	1:2 836
25	800–1000	SE Chatham Rise	5 596	5	5		5	1:1 119
26	800–1000	SW Chatham Rise	5 158	3	3		3	1:1 719
27	800–1000	SW Chatham Rise	7 185	3	3		3	1:2 395
28	1000–1300	SE Chatham Rise	9 494	3	3		3	1:3 165
29	1000–1300	SW Chatham Rise	10 965	3	3		3	1:3 655
30	1000–1300	SW Chatham Rise	10 960	3	3		3	1:3 653
Deep	800–1300		76 469	44	43	0	43	1:1 778
Total	200–1300		215 967	128	127	3	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, and 2020. †, 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

Table 3: Tow and gear parameters by depth range for valid biomass tows (TAN2001). Values shown are sample size (*n*), and for each parameter the mean, standard deviation (s.d.), and range.

	n	Mean	s.d.	Range
Core tow parameters				
Tow length (n. miles)	87	2.9	0.31	2.1–3.1
Tow speed (knots)	87	3.5	0.02	3.4–3.6
All tow parameters				
Tow length (n. miles)	130	2.9	0.27	2.1–3.1
Tow speed (knots)	130	3.5	0.02	3.4–3.6
Headline height (m)				
200–400 m	31	6.9	0.40	6.4–7.6
400–600 m	40	6.6	0.32	6.0–7.2
600–800 m	16	6.7	0.27	6.3–7.3
800–1000 m	27	7.1	0.31	6.6–7.7
1000–1300 m	16	7.2	0.32	6.7–7.9
Core stations 200–800 m	87	6.7	0.37	6.0–7.6
All stations 200–1300 m	130	6.9	0.40	6.0–7.9
Doorspread (m)				
200–400 m	31	115.2	7.28	102.7–127.8
400–600 m	40	121.0	6.02	106.1–131.9
600–800 m	16	119.3	7.40	109.6–132.0
800–1000 m	27	120.4	5.98	108.5–131.5
1000–1300 m	16	118.4	7.58	104.8–129.1
Core stations 200–800 m	87	118.6	7.18	102.7–132.0
All stations 200–1300 m	130	119.0	6.99	102.7–132.0

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 2020 survey core strata (200–800 m); and catch and biomass estimates for deep strata (800–1300 m). Biomass includes unsexed fish. (–, no data.). 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	Common	Catch (kg)					Biomass (t)
Code	name	Core	Deep	Core male	Core female	Core total	Deep
HOK*	Hoki	41 549	3 133	42 545 (15.8)	46 801 (13.4)	89 557 (14.4)	4 751 (66.8)
BOE*	Black oreo	3 190	2 564	8 838 (22.7)	7 627 (27.8)	16 475 (23.6)	8 558 (72.4)
SWA*	Silver warehou	4 411	2	3 814 (43.7)	5 845 (59.0)	9 659 (52.8)	7 (100)
GSH*	Dark ghost shark	9 087	-	3 219 (22.6)	4 874 (19.0)	8 101 (19.6)	-
CBO*	Bollon's rattail	2 710	8	3 418 (10.4)	4 216 (11.1)	7 641 (9.6)	13 (54.9)
LIN*	Ling	2 918	27	3 202 (10.2)	4 374 (10.8)	7 577 (7.9)	40 (49.3)
SPD*	Spiny dogfish	3 307	-	1 213 (29.1)	6 021 (13.7)	7 238 (10.8)	-
JAV*	Javelinfish	2 660	75	673 (20.5)	6 166 (20.5)	7 087 (18.1)	126 (34.9)
LDO*	Lookdown dory	2 565	6	2 209 (10.2)	4 125 (10.2)	6 352 (9.1)	6 (61.8)
NOS*	Sloan’s arrow squid	1 984	-	2 457 (48.5)	2 532 (47.1)	5 032 (47.1)	3 (100.0)
RBT	Redbait	2 216	-	2 344 (99.5)	2 401 (99.7)	4 744 (99.6)	-
SND*	Shovelnose dogfish	2 112	908	2 081 (21.4)	2 384 (16.9)	4 465 (18.2)	1 816 (24.6)
HBA*	Bigeye sea perch	2 034	6	2 118 (11.6)	1 780 (10.3)	3 954 (10.5)	5 (70.8)
BAR*	Barracouta	864	-	1 705 (88.3)	1 499 (82.9)	3 204 (85.7)	-
GIZ*	Giant stargazer	1 211	-	558 (42.8)	2 239 (15.5)	2 797 (18.4)	-
BYS*	Alfonsino	1 224	-	1 333 (63.8)	1 053 (59.2)	2 387 (61.5)	-
WWA*	White warehou	916	-	965 (57.9)	717 (36.9)	1 683 (48.6)	-
SOR*	Spiky oreo	606	102	869 (46.1)	665 (34.1)	1 542 (40.3)	157 (32.4)
GSP*	Pale ghost shark	458	75	705 (26.2)	771 (19.6)	1 476 (22.0)	176 (29.2)
FRO	Frostfish	557	-	499 (67.3)	756 (70.8)	1 255 (56.1)	-
COL*	Oliver's rattail	275	5	428 (68.1)	322 (26.4)	1 170 (35.8)	8 (86.9)
OPE*	Orange perch	547	-	-	-	1 167 (43.1)	-
CAS*	Oblique banded rattail	1 336	-	104 (28.4)	974 (30.5)	1 091 (29.5)	-
HAK*	Hake	506	77	240 (26.2)	797 (21.1)	1 037 (20.1)	89 (29.4)
HAP*	Hapuku	400	-	488 (72.8)	544 (80.7)	1 032 (76.6)	-
SSK	Smooth skate	578	20	136 (50.5)	554 (31.9)	946 (26.5)	58 (58.9)
RCO*	Red cod	440	-	481 (65.9)	290 (49.7)	771 (59.1)	-
SSO*	Smooth oreo	126	6 311	349 (61.8)	260 (54.1)	618 (58.8)	25 637 (50.0)
SCH*	School shark	254	-	384 (37.8)	131 (74.0)	515 (30.7)	-
HPC*	Sea perch	227	-	257 (44.2)	243 (51.0)	501 (47.0)	-
NMP*	Tarakihi	125	-	196 (68.4)	217 (71.9)	413 (69.7)	-
RBM	Ray’s bream	159	-	188 (29.0)	202 (29.6)	391 (29.0)	-
ETB	Baxter's lantern dogfish	70	296	269 (27.1)	109 (28.5)	378 (25.9)	885 (22.6)
SBW	Southern blue whiting	213	-	220 (56.6)	153 (69.5)	373 (60.1)	-
RIB*	Ribaldo	84	55	75 (29.5)	145 (27.6)	220 (22.2)	67 (24.2)
CYP	Longnose velvet dogfish	140	836	93 (49.1)	114 (39.7)	207 (40.1)	1 685 (21.8)
BNS*	Bluenose	76	-	59 (68.8)	45 (60.7)	104 (46.4)	-
RBY	Rubyfish	27	-	9 (91.9)	6 (100)	70 (91.6)	-
EPT	Deepsea cardinalfish	41	4	26 (30.9)	40 (65.7)	66 (43.3)	8 (100.0)
JMM*	Slender jack mackerel	26	-	33 (65.0)	29 (88.0)	63 (73.3)	-
LSO*	Lemon sole	14	-	11 (40.8)	19 (36.6)	33 (32.2)	-
HAS	Australasian slender cod	14	390	11 (32.5)	13 (32.3)	24 (29.4)	1 038 (25.0)
TRU	Trumpeter	8	-	-	22 (100.0)	22 (100.0)	-
SCI	Scampi	9	-	13 (23.6)	4 (33.4)	18 (19.3)	-
ORH	Orange roughy	8	2 429	9 (79.8)	4 (54.5)	13 (59.8)	3 074 (31.2)
CSU	Four-rayed rattail	6	552	3 (92.9)	7 (96.9)	10 (91.9)	1 447 (47.2)
JMD	Jack mackerel	5	-	-	-	9 (56.9)	-
RSO	Gemfish	2	-	-	4 (100.0)	4 (100.0)	-
BYD	Long finned beryx	1	-	3 (71.2)	-	3 (71.2)	-
BEE	Basketwork eel	-	606	-	1 (100.0)	1 (100.0)	2 101 (16.2)
SSM	Smallscaled brown slickhead	-	1 575	-	-	-	4 949 (33.9)
SBI	Bigscaled brown slickhead	-	660	-	-	-	2 508 (21.8)

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, and 2020. 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

Table 6: Relative biomass estimates (t in thousands) for hoki, 200–800 m depths, Chatham Rise trawl surveys January 1992–2014, 2016, 2018, and 2020 (CV, coefficient of variation; 3++, all hoki aged 3 years and older; (see Appendix 5 for length ranges used to define age classes.). See also Figure 6.

		1+ hoki			2+ hoki		3 ++ hoki		Total hoki	
Survey	1+ year class	t	% CV	2+ year class	t	% CV	t	% CV	t	% CV
1992	1990	3.0	(27.8)	1989	23.9	(13.1)	94.7	(7.8)	121.6	(7.7)
1993	1991	33.0	(33.4)	1990	8.8	(18.2)	144.5	(9.0)	186.2	(10.2)
1994	1992	14.7	(20.2)	1991	44.8	(18.4)	87.2	(9.4)	146.7	(9.8)
1995	1993	6.6	(12.9)	1992	42.7	(11.4)	71.8	(8.3)	121.2	(7.4)
1996	1994	27.6	(24.4)	1993	15.0	(13.3)	110.3	(10.3)	152.8	(9.7)
1997	1995	3.2	(40.3)	1994	61.4	(12.0)	93.4	(8.2)	158.0	(8.4)
1998	1996	4.4	(33.0)	1995	15.6	(19.1)	66.7	(10.7)	86.7	(10.9)
1999	1997	25.5	(30.6)	1996	13.8	(19.0)	70.1	(10.2)	109.3	(11.6)
2000	1998	14.4	(32.4)	1997	28.2	(20.7)	29.1	(9.2)	71.7	(12.4)
2001	1999	0.4	(72.9)	1998	26.3	(17.1)	33.7	(8.8)	60.3	(9.7)
2002	2000	22.5	(26.1)	1999	1.2	(21.2)	50.6	(12.7)	74.4	(11.4)
2003	2001	4.9	(46.0)	2000	27.2	(15.1)	20.4	(9.3)	52.5	(11.6)
2004	2002	14.4	(32.5)	2001	5.5	(20.4)	32.8	(12.9)	52.7	(12.6)
2005	2003	17.5	(23.4)	2002	45.8	(16.3)	21.2	(11.4)	84.6	(11.5)
2006	2004	25.9	(21.5)	2003	33.6	(18.8)	39.7	(10.3)	99.2	(10.6)
2007	2005	9.1	(27.5)	2004	32.8	(13.1)	28.8	(8.9)	70.7	(8.5)
2008	2006	15.6	(31.6)	2005	23.8	(15.6)	37.5	(7.8)	76.9	(11.4)
2009	2007	25.2	(28.8)	2006	65.2	(17.2)	53.7	(7.8)	144.1	(10.6)
2010	2008	19.3	(30.7)	2007	28.6	(15.4)	49.6	(16.3)	97.5	(14.6)
2011	2009	26.9	(36.9)	2008	26.3	(14.1)	40.7	(7.8)	93.9	(14.0)
2012	2010	2.6	(30.1)	2009	29.1	(16.6)	55.9	(8.0)	87.5	(9.8)
2013	2011	50.9	(24.5)	2010	1.0	(43.6)	72.1	(12.8)	124.1	(15.3)
2014	2012	5.7	(36.6)	2011	43.3	(14.2)	53.0	(10.9)	101.9	(9.8)
2016	2014	47.6	(27.6)	2013	12.9	(18.6)	54.0	(12.8)	114.5	(14.2)
2018	2016	30.5	(38.8)	2015	51.3	(19.1)	40.3	(14.8)	122.1	(16.0)
2020	2018	28.3	(34.2)	2017	12.3	(17.4)	48.9	(14.7)	89.6	(14.4)

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 2020 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	614 (32.9)	44 (47.1)	115 (39.1)	-	42 (21.3)	53 (25.7)
2A	486 (42.8)	44 (100.0)	41 (63.7)	-	39 (11.0)	31 (24.4)
2B	2 044 (32.4)	66 (64.9)	254 (35.5)	2 (100.0)	18 (42.6)	200 (29.5)
3	1 668 (87.8)	9 (100.0)	84 (100.0)	351 (19.8)	-	73 (66.9)
4	1 261 (26.5)	135 (100.0)	747 (20.2)	4 (100.0)	334 (84.1)	76 (40.3)
5	2 828 (35.4)	29 (54.6)	186 (34.5)	465 (15.1)	-	355 (12.1)
6	861 (28.7)	53 (54.8)	305 (34.2)	-	198 (10.7)	9 (100.0)
7A	8 709 (29.9)	116 (59.3)	385 (17.4)	48 (48.2)	41 (44.1)	79 (37.0)
7B	1 352 (44.5)	24 (40.0)	92 (35.9)	5 (75.4)	7 (70.0)	38 (9.9)
8A	910 (1.6)	82 (29.1)	357 (17.8)	28 (78.9)	40 (70.5)	32 (29.6)
8B	1 911 (33.2)	27 (54.3)	480 (38.2)	29 (17.5)	51 (36.5)	601 (25.9)
9	4 771 (67.0)	-	25 (95.3)	718 (44.9)	-	63 (94.7)
10	2 807 (41.8)	170 (40.6)	184 (20.3)	13 (95.3)	19 (84.7)	174 (25.1)
11	2 568 (12.9)	10 (100.0)	373 (17.7)	222 (65.5)	20 (49.7)	423 (39.6)
12	3 929 (53.7)	66 (100.0)	170 (54.7)	454 (65.1)	11 (63.6)	427 (44.1)
13	2 929 (28.2)	99 (65.5)	296 (64.7)	15 (57.8)	159 (58.9)	368 (53.9)
14	6 174 (67.6)	-	529 (24.2)	28 (50.2)	128 (15.2)	1 096 (31.6)
15	5 560 (72.6)	4 (100.0)	516 (34.6)	3 (100.0)	160 (9.1)	317 (24.8)
16	5 562 (45.4)	-	1 313 (16.9)	-	173 (67.7)	584 (15.5)
17	61 (53.8)	-	10 (66.9)	3 230 (38.2)	-	32 (74.5)
18	10 524 (33.8)	6 (100.0)	298 (88.7)	269 (58.9)	-	165 (52.1)
19	5 390 (60.6)	12 (100.0)	262 (65.0)	979 (81.9)	-	236 (56.7)
20	16 640 (51.8)	42 (70.7)	553 (19.2)	1 237 (25.6)	33 (55.6)	920 (20.2)
Core	89 557 (14.4)	1 037 (20.1)	7 577 (7.9)	8 101 (19.6)	1 476 (22.0)	6 352 (9.1)
21A	33 (30.6)	22 (82.6)	5 (100.0)	-	1 (100.0)	3 (65.1)
21B	251 (19.1)	21 (64.3)	-	-	9 (61.1)	-
22	3 756 (84.4)	33 (29.6)	15 (70.8)	-	35 (26.3)	3 (100.0)
23	18 (63.2)	6 (100.0)	-	-	-	-
24	-	-	-	-	-	-
25	267 (28.0)	-	5 (100.0)	-	7 (63.3)	-
26	140 (59.5)	8 (100.0)	15 (100.0)	-	34 (100.0)	-
27	286 (51.8)	-	-	-	90 (40.9)	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
Deep	4 751 (66.8)	89 (29.4)	40 (49.3)	-	176 (29.2)	6 (61.8)
Total	94 308 (14.1)	1 126 (18.7)	7 617 (7.9)	8 101 (19.6)	1 652 (19.9)	6 358 (9.1)

Table 7a (continued)

Stratum	HBA	HPC	GIZ	SPD	SWA	WWA
						Species code
1	19 (61.8)	-	47 (54.2)	-	-	-
2A	17 (24.3)	-	-	-	-	-
2B	22 (26.2)	-	-	-	-	-
3	183 (50.0)	72 (100.0)	5 (100.0)	759 (34.7)	6 (100.0)	23 (70.0)
4	41 (60.7)	-	176 (100.0)	62 (100.0)	-	-
5	76 (42.1)	-	122 (39.9)	348 (10.8)	1 603 (39.5)	-
6	30 (52.0)	-	16 (100.0)	-	-	28 (100.0)
7A	248 (42.4)	- (100.0)	-	349 (44.6)	1 (100.0)	61 (52.1)
7B	43 (49.4)	-	21 (64.4)	39 (52.2)	-	28 (100.0)
8A	116 (30.8)	-	5 (100.0)	135 (56.7)	-	-
8B	223 (42.2)	-	-	320 (43.9)	-	29 (100.0)
9	53 (67.6)	-	227 (28.0)	1 210 (33.1)	5 958 (84.3)	46 (84.8)
10	64 (61.2)	-	16 (100.0)	45 (100.0)	-	50 (83.2)
11	72 (22.4)	-	81 (100.0)	210 (56.5)	-	71 (53.6)
12	57 (92.9)	-	69 (54.4)	299 (88.7)	15 (50.2)	109 (39.9)
13	53 (50.0)	-	162 (53.0)	126 (43.7)	11 (100.0)	11 (100.0)
14	344 (24.9)	-	54 (57.6)	238 (19.9)	17 (61.0)	7 (100.0)
15	348 (43.5)	-	58 (59.3)	209 (14.2)	95 (36.3)	12 (100.0)
16	164 (52.3)	-	104 (30.3)	268 (11.2)	202 (85.1)	63 (66.8)
17	82 (65.3)	-	31 (9.8)	144 (45.0)	435 (97.7)	-
18	47 (60.2)	29 (100.0)	1 109 (38.8)	541 (25.2)	50 (62.5)	-
19	439 (60.4)	399 (55.6)	370 (36.4)	739 (46.8)	812 (25.1)	27 (74.4)
20	1 212 (12.7)	-	124 (50.2)	1 199 (24.5)	455 (62.3)	1 118 (72.4)
Core	3 954 (10.5)	501 (47.0)	2 797 (18.4)	7 238 (10.8)	9 659 (52.8)	1 683 (48.6)
21A	3 (100.0)	-	-	-	-	-
21B	-	-	-	-	-	-
22	3 (100.0)	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	-
26	-	-	-	-	7 (100.0)	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
Deep	5 (70.8)	-	-	-	7 (100.0)	-
Total	3 959 (10.5)	501 (47.0)	2 797 (18.4)	7 238 (10.8)	9 667 (52.7)	1 683 (48.6)

Table 7a (continued)

Stratum	RIB	BOE	SSO	SOR	CSU	Species code CBO
1	30 (44.0)	-	-	117 (61.0)	- (100.0)	74 (26.4)
2A	14 (61.7)	-	4 (100.0)	82 (97.4)	9 (100.0)	8 (27.1)
2B	41 (59.4)	-	2 (100.0)	1 081 (55.0)	- (100.0)	47 (55.2)
3	-	-	-	-	-	86 (100.0)
4	54 (50.2)	5 069 (49.9)	4 (100.0)	53 (83.2)	-	246 (50.3)
5	-	-	-	-	-	145 (19.7)
6	23 (50.0)	9 487 (24.8)	589 (61.5)	-	-	142 (39.9)
7A	3 (100.0)	-	-	3 (100.0)	-	309 (55.4)
7B	3 (62.0)	-	-	2 (63.0)	-	21 (13.1)
8A	-	-	-	-	-	133 (32.5)
8B	-	-	-	-	-	1 102 (43.1)
9	-	-	-	-	-	-
10	4 (100.0)	-	-	79 (90.6)	- (100.0)	134 (72.8)
11	-	-	-	3 (100.0)	-	236 (37.6)
12	8 (100.0)	-	-	113 (100.0)	-	136 (62.5)
13	10 (100.0)	-	-	8 (72.0)	-	416 (17.6)
14	-	-	-	-	-	1 441 (6.9)
15	16 (100.0)	-	-	-	-	1 064 (30.4)
16	15 (100.0)	1 919 (93.4)	19 (100.0)	-	-	998 (21.4)
17	-	-	-	-	-	-
18	-	-	-	-	-	110 (100.0)
19	-	-	-	-	-	45 (72.9)
20	-	-	-	-	-	748 (30.3)
Core	220 (22.2)	16 475 (23.6)	618 (58.8)	1 542 (40.3)	10 (91.9)	7 641 (9.6)
21A	14 (52.7)	1 (81.3)	2 (75.0)	3 (77.9)	22 (75.5)	-
21B	24 (43.1)	2 (100.0)	4 (55.4)	80 (49.2)	257 (47.9)	2 (100.0)
22	19 (37.5)	- (100.0)	51 (54.5)	67 (47.6)	69 (36.3)	11 (62.3)
23	-	1 (100.0)	5 (100.0)	6 (100.0)	180 (45.5)	-
24	-	-	171 (95.6)	-	37 (93.3)	-
25	10 (71.6)	785 (41.2)	1 367 (45.1)	- (100.0)	78 (56.9)	-
26	-	1 196 (45.2)	656 (20.6)	-	15 (47.7)	-
27	-	6 266 (98.3)	6 872 (68.1)	-	26 (52.3)	-
28	-	18 (86.0)	11 427 (99.1)	1 (100.0)	762 (87.1)	-
29	-	76 (87.8)	1 830 (97.7)	-	1 (100.0)	-
30	-	213 (100.0)	3 250 (100.0)	-	1 (100.0)	-
Deep	67 (24.2)	8 558 (72.4)	25 637 (50.0)	157 (32.4)	1 447 (47.2)	13 (54.9)
Total	287 (17.9)	25 033 (29.2)	26 255 (48.8)	1 699 (36.6)	1 457 (46.9)	7 654 (9.6)

Table 7a (continued)

Stratum						Species code
	BEE	SND	CYP	ETB	SBI	SSM
1	-	1 009 (46.0)	91 (74.5)	1 (100.0)	-	-
2A	-	571 (15.2)	99 (46.7)	-	-	-
2B	1 (100.0)	2 486 (25.9)	-	-	-	-
3	-	-	-	-	-	-
4	-	182 (76.0)	-	9 (89.6)	-	-
5	-	-	-	-	-	-
6	-	-	15 (100.0)	160 (37.6)	-	-
7A	-	23 (100.0)	2 (100.0)	-	-	-
7B	-	6 (100.0)	-	-	-	-
8A	-	-	- (100.0)	-	-	-
8B	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	65 (42.3)	1 (100.0)	-	-	-
11	-	71 (49.0)	-	-	-	-
12	-	14 (100.0)	-	-	-	-
13	-	7 (100.0)	-	14 (100.0)	-	-
14	-	-	-	1 (100.0)	-	-
15	-	30 (100.0)	-	11 (9.0)	-	-
16	-	-	-	183 (41.3)	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
Core	1 (100.0)	4 465 (18.2)	207 (40.1)	378 (25.9)	-	-
21A	-	34 (5.0)	32 (7.5)	1 (100.0)	1 (100.0)	-
21B	18 (60.6)	349 (40.2)	336 (24.1)	4 (100.0)	-	-
22	30 (67.4)	114 (28.8)	221 (27.5)	4 (57.6)	58 (82.1)	20 (44.0)
23	425 (17.2)	-	18 (39.7)	19 (32.9)	515 (47.9)	2 508 (53.5)
24	145 (0.8)	48 (100.0)	203 (100.0)	48 (49.1)	325 (14.8)	39 (65.4)
25	71 (56.1)	823 (44.5)	459 (31.4)	230 (69.0)	-	18 (89.3)
26	88 (20.9)	32 (75.7)	34 (46.8)	70 (31.6)	-	68 (22.7)
27	127 (12.9)	-	103 (100.0)	218 (49.2)	-	65 (63.0)
28	532 (35.8)	406 (50.1)	278 (82.1)	87 (10.4)	605 (77.2)	472 (42.3)
29	381 (58.5)	10 (100.0)	-	112 (26.1)	776 (9.5)	1 296 (76.0)
30	285 (51.1)	-	1 (100.0)	94 (37.7)	228 (43.4)	464 (17.7)
Deep	2 101 (16.2)	1 816 (24.6)	1 685 (21.8)	885 (22.6)	2 508 (21.8)	4 949 (33.9)
Total	2 103 (16.1)	6 281 (14.8)	1 892 (19.9)	1 263 (17.6)	2 508 (21.8)	4 949 (33.9)

Table 7b: Estimated relative biomass (t) and coefficient of variation (% CV) for pre-recruit (nominally < 20 cm SL), 20–30 cm, recruited (nominally > 30 cm SL), and total orange roughy for the 2020 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	1 (100.0)	10 (54.2)	2 (100.0)	13 (62.4)
2B	1 (100.0)	-	-	1 (100.0)
3	-	-	-	-
4	-	-	-	-
5	-	-	-	-
6	-	-	-	-
7A	-	-	-	-
7B	-	-	-	-
8A	-	-	-	-
8B	-	-	-	-
9	-	-	-	-
10	-	-	-	-
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
Core	2 (73.9)	10 (54.2)	2 (100.0)	13 (59.8)
21A	5 (65.4)	264 (92.6)	428 (98.3)	697 (95.1)
21B	34 (55.3)	186 (27.8)	440 (38.8)	660 (34.1)
22	9 (75.8)	70 (34.1)	384 (27.4)	463 (22.9)
23	1 (100.0)	6 (71.7)	250 (35.0)	256 (35.7)
24	- (100.0)	6 (100.0)	165 (28.8)	172 (24.1)
25	15 (61.8)	41 (51.7)	638 (96.9)	694 (91.9)
26	-	-	7 (50.1)	7 (50.1)
27	-	-	-	-
28	22 (53.4)	70 (55.6)	26 (62.2)	118 (50.1)
29	-	-	6 (100.0)	6 (100.0)
30	-	-	-	-
Deep	86 (29.3)	643 (39.6)	2 345 (33.3)	3 074 (31.2)
Total	88 (28.8)	652 (39.1)	2 347 (33.3)	3 087 (31.1)

Table 7c: Estimated relative biomass (t) and coefficient of variation (% CV) for "small" pre-recruit (nominally < 20 cm SL), "medium" 20–30 cm, "large" recruited (nominally > 30 cm SL), and total orange roughy for Chatham Rise trawl surveys January 1992–2014, 2016, 2018, and 2020. Core, total biomass from valid core tows (200–800 m; All, total biomass from all valid tows (200–1300 m).

		Biomass (CV)	
Survey	**Population**	**Core**	**All**
tan1001	Small	6 (59.3)	57 (42.1)
	Medium	29 (71.5)	627 (15.0)
	Large	454 (91.5)	3 701 (19.5)
	Total	489 (88.6)	4 386 (17.7)
tan1101	Small	4 (48.1)	370 (92.1)
	Medium	9 (65.0)	1 857 (75.9)
	Large	11 (50.5)	5 310 (52.1)
	Total	24 (53.5)	7 537 (59.7)
tan1201	Small	1 (100.0)	61 (30.2)
	Medium	2 (100.0)	867 (43.3)
	Large	0 (0.0)	4 278 (27.0)
	Total	3 (100.0)	5 206 (26.7)
tan1301	Small	1 (100.0)	85 (59.0)
	Medium	0 (0.0)	530 (24.5)
	Large	2 (100.0)	2 163 (37.5)
	Total	3 (75.1)	2 778 (32.3)
tan1401	Small	4 (100.0)	6 916 (37.7)
	Medium	0 (100.0)	45 (28.5)
	Large	2 (100.0)	468 (22.2)
	Total	2 (100.0)	6 404 (40.8)
tan1601	Small	2 (100.0)	74 (75.7)
	Medium	4 (100.0)	468 (36.0)
	Large	8 (72.7)	4 495 (55.0)
	Total	14 (54.6)	5 037 (53.3)
tan1801	Small	14 (94.8)	54 (35.0)
	Medium	16 (58.8)	251 (19.2)
	Large	10 (46.3)	997 (24.2)
	Total	40 (59.6)	1 302 (20.8)
tan2001	Small	2 (73.9)	88 (28.8)
	Medium	10 (54.2)	652 (39.1)
	Large	2 (100.0)	2 347 (33.3)
	Total	13 (59.8)	3 087 (31.1)

Table 8: Total numbers of TAN2001 fish, squid and scampi measured for length frequency distributions and biological samples from all tows (including those in Canterbury Banks HMA). The total number of fish measured is sometimes greater than the sum of males and females because some fish were unsexed.

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Alfonsino	BYS	265	213	480	210
Australasian slender cod	HAS	387	466	853	501
Banded bellowsfish	BBE	20	71	1 894	613
Banded rattail	CFA	195	426	637	344
Barracouta	BAR	363	341	704	211
Basketwork eel	BEE	123	549	678	475
Baxter's lantern dogfish	ETB	181	148	329	282
Bigeye cardinalfish	EPL	7	10	19	19
Bigeye sea perch	HBA	1 359	1 387	2 922	995
Bigscaled brown slickhead	SBI	467	813	1 280	392
Black ghost shark	HYB	1	-	1	1
Black javelinfish	BJA	48	30	78	77
Black oreo	BOE	962	873	1 837	384
Black slickhead	BSL	185	232	427	176
Blackspot rattail	VNI	4	8	13	13
Blobfish	PSY	3	-	3	3
Blue cod	BCO	1	3	4	4
Bluenose	BNS	9	6	15	15
Bollon's rattail	CBO	1 636	1 501	3 150	1 133
Brown chimaera	CHP	16	3	19	19
Cape scorpionfish	TRS	2	2	4	4
Capro dory	CDO	-	1	1	1
Carpet shark	CAR	2	2	4	4
Common halosaur	HPE	-	2	4	4
Common roughy	RHY	95	115	211	133
Crested bellowsfish	CBE	-	-	63	26
Cubehead	CUB	1	1	2	2
Cucumber fish	CUC	-	-	3	3
Dark ghost shark	GSH	1 027	1 163	2 195	706
Dawson's catshark	DCS	2	-	2	2
Deepsea cardinalfish	EPT	78	32	121	118
Deepsea flathead	FHD	11	26	40	36
Electric ray	ERA	2	-	2	2
Elephant fish	ELE	2	1	3	3
Finless flounder	MAN	2	2	4	4
Fleshynose catshark	AML	4	6	10	10
Four-rayed rattail	CSU	667	1 318	2 541	516
Freckled catshark	ASI	13	1	15	15
Frill shark	FRS	-	1	1	1
Frostfish	FRO	140	121	262	84
Garrick's catshark	AGK	4	1	5	5
Gemfish	RSO	168	239	407	107
Giant chimaera	CHG	1	1	2	2
Giant hatchetfish	AGI	-	-	1	1
Giant lepidion	LPS	1	-	1	1
Giant stargazer	GIZ	159	274	437	351
Greenback jack mackerel	JMD	28	10	38	38
Hairy conger	HCO	36	47	83	78
Hake	HAK	55	58	114	114
Hapuku	HAP	36	31	67	67
Hoki	HOK	7 628	8 639	16 289	2 110
Humpback rattail	CBA	-	7	7	7
Intricate lanternfish	LIT	-	1	1	1
Javelinfish	JAV	1 043	5 120	6 739	1 439
John dory	JDO	-	1	1	1
Johnsons cod	HJC	202	28	230	123
Kaiyomaru rattail	CKA	72	41	129	98
Leafscale gulper shark	CSQ	22	22	45	45
Lemon sole	LSO	12	21	33	33
Ling	LIN	485	567	1 053	973
Long-nosed chimaera	LCH	130	129	259	244
Longfinned beryx	BYD	3	-	3	3
Longnose velvet dogfish	CYP	277	487	764	500
Longnosed deepsea skate	PSK	2	3	5	5
Lookdown dory	LDO	1 475	1 832	3 344	1 282

Table 8 (continued)

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Lucifer dogfish	ETL	231	182	417	305
Lyconus sp.	LYC	-	1	1	1
Mahia rattail	CMA	35	59	112	95
McMillan's rattail	CMX	-	2	2	2
Mirror dory	MDO	1	2	3	3
Moki	MOK	1	-	1	1
Murray’s rattail	CMU	-	5	5	5
New Zealand catshark	AEX	24	13	37	37
Northern spiny dogfish	NSD	4	-	4	4
Notable rattail	CIN	147	169	520	270
Notal lanternfish	LNT	-	1	1	1
Oblique banded rattail	CAS	336	1 596	1 964	562
Oliver's rattail	COL	610	741	1 887	592
Orange perch	OPE	275	316	592	149
Orange roughy	ORH	651	716	1 422	633
Owston’s dogfish	CYO	44	41	85	85
Pale ghost shark	GSP	150	152	302	289
Pale toadfish	TOP	1	1	3	3
Pigfish	PIG	13	30	43	25
Plunket's shark	PLS	-	2	2	2
Pointynose blue ghost shark	HYP	-	2	2	2
Porbeagle shark	POS	1	-	1	1
Prickly deepsea skate	BTS	2	1	3	3
Prickly dogfish	PDG	2	3	5	5
Ray’s bream	RBM	107	108	215	169
Red cod	RCO	323	180	505	254
Red gurnard	GUR	27	12	39	39
Redbait	RBT	80	68	148	36
Ribaldo	RIB	56	36	92	91
Ridge scaled rattail	MCA	256	165	424	263
Robust cardinalfish	ERB	-	1	1	1
Rough skate	RSK	1	2	3	3
Roughhead rattail	CHY	26	37	65	65
Roundfin catshark	AAM	1	4	5	5
Rubyfish	RBY	19	10	141	40
Rudderfish	RUD	2	2	4	4
Scaly gurnard	SCG	26	23	49	23
Scampi	SCI	54	20	85	77
School shark	SCH	16	7	23	23
Sea perch	HPC	351	346	703	223
Seal shark	BSH	13	25	38	37
Serrulate rattail	CSE	145	119	264	230
Shortsnouted lancetfish	ABR	-	2	3	3
Shovelnose dogfish	SND	576	588	1 164	483
Silver dory	SDO	95	194	522	151
Silver roughy	SRH	62	30	92	77
Silver warehou	SWA	759	807	1 567	444
Silverside	SSI	52	34	277	238
Sixgill shark	HEX	1	1	2	2
Slender jack mackerel	JMM	12	10	22	22
Sloan’s arrow squid	NOS	486	485	1 166	514
Small-headed cod	SMC	12	8	20	17
Small banded rattail	CCX	71	71	154	92
Smallscaled brown slickhead	SSM	415	462	888	383
Smooth deepsea skate	BTA	1	2	3	3
Smooth oreo	SSO	1 010	759	1 774	464
Smooth skate	SSK	6	16	22	19
Southern conger	CVR	-	1	1	1
Spottyface rattail	CTH	5	4	13	13
Southern blue whiting	SBW	224	147	371	90
Southern Ray’s bream	SRB	1	1	2	2
Spiky oreo	SOR	438	390	837	381
Spineback	SBK	53	471	526	291
Spiny dogfish	SPD	537	1 752	2 290	1 026
Spinyfin	SFN	2	-	2	2
Squaretail	TET	-	-	1	1
Squashedface rattail	NNA	2	1	3	3

Table 8 (continued)

Common name	Species code	Number measured Males	Females	Total	Number of biological samples
Striate rattail	CTR	-	2	2	2
Starnose black rat	NPU	-	1	1	1
Swollenhead conger	SCO	26	40	66	55
Tarakihi	NMP	117	132	250	134
Tasmanian ruffe	TUB	1	3	4	4
Thin tongue cardinalfish	EPM	104	68	173	115
Todarodes filippovae	TSQ	1	13	45	45
Trumpeter	TRU	-	2	2	2
Tubeshoulder	HOL	1	1	2	2
Two saddle rattail	CBI	91	224	315	181
Unicorn rattail	WHR	2	4	6	6
Velvet dogfish	ZAS	-	2	2	-
Velvet rattail	TRX	1	-	1	1
Violet cod	VCO	93	88	182	151
Warty oreo	WOE	7	9	16	16
Warty squid (*M. ingens*)	MIQ	5	9	81	81
Warty squid (*Onykia 'robsoni'*)	MRQ	-	-	2	2
White rattail	WHX	198	165	363	363
White warehou	WWA	194	145	339	211
Widenosed chimaera	RCH	54	35	89	88
Witch	WIT	4	-	4	4
Total	-	29 869	39 812	74 773	26 013

Table 9: Length-weight regression parameters* used to scale length frequencies (data from TAN2001). "All CHAT surveys": data from all surveys used as the r^2 value was less than 90% for tan2001 data or n was less than 50.

Common name	Species code	a (intercept)	b (slope)	r^2	n	Length range (cm)	Source
Alfonsino	BYS	0.01607	3.096386	98.19	208	18.2-50.6	tan2001
Australasian slender cod	HAS	0.00183	3.306225	97.97	585	19.7-65.2	tan2001
Banded bellowsfish	BBE	0.003782	3.298888	91.4	3865	13.3-28.5	All CHAT surveys
Banded rattail	CFA	0.000775	3.523038	90.65	302	18.9-37.8	tan2001
Barracouta	BAR	0.004395	3.013689	89.54	1135	47-112.7	All CHAT surveys
Basketwork eel	BEE	0.000383	3.235392	92.49	390	60.4-126.7	tan2001
Baxter's lantern dogfish	ETB	0.002603	3.171962	98.91	272	19.3-75.6	tan2001
Bigeye cardinalfish	EPL	0.028354	2.772618	82.04	202	15-24.5	All CHAT surveys
Bigeye sea perch	HBA	0.008694	3.174278	98.23	1098	13.5-47.7	tan2001
Bigscaled brown slickhead	SBI	0.003588	3.236174	94.75	350	24.9-58.8	tan2001
Black javelinfish	BJA	0.023939	2.510449	90.82	72	22.7-60.7	tan2001
Black oreo	BOE	0.035913	2.818914	90.49	379	22.9-38.7	tan2001
Black slickhead	BSL	0.005191	3.10672	91.51	174	22.7-37.1	tan2001
Blackspot rattail	VNI	0.000341	3.50481	86.67	79	22.7-34.6	All CHAT surveys
Bluenose	BNS	0.005751	3.290932	97.48	250	46.1-94.2	All CHAT surveys
Bollon's rattail	CBO	0.001739	3.29821	93.24	1074	24.3-58.5	tan2001
Bronze bream	BBR	0.025334	2.89714	92.72	129	30.3-50.4	tan2001
Brown chimaera	CHP	0.158188	2.187702	69.97	24	70.4-93	All CHAT surveys
Common roughy	RHY	0.035011	2.815304	90.48	665	11.8-26.4	All CHAT surveys
Crested bellowsfish	CBE	0.010594	2.904466	95.17	111	14.8-30.9	All CHAT surveys
Dark ghost shark	GSH	0.003381	3.13846	95.49	610	21.8-70	tan2001
Deepsea cardinalfish	EPT	0.012204	3.071092	98.87	117	14.2-64.2	tan2001
Deepsea flathead	FHD	0.001018	3.43941	96.04	62	28.6-52.3	All CHAT surveys
Four-rayed rattail	CSU	0.013544	2.454173	74.5	1732	17.9-39	All CHAT surveys
Frostfish	FRO	0.000193	3.347574	96.48	83	53.3-156.1	tan2001
Giant stargazer	GIZ	0.005674	3.268217	98.38	275	26-78	tan2001
Hairy conger	HCO	0.000199	3.530659	97.05	77	49.7-99.9	tan2001
Hake	HAK	0.001902	3.299778	97.55	113	42.5-125.7	tan2001
Hapuku	HAP	0.00278	3.370906	93.71	56	58.6-98.8	tan2001
Hoki	HOK	0.004052	2.92703	98.76	2062	35.5-108.7	tan2001
Humpback rattail	CBA	0.000952	3.380421	94.24	66	39.4-84.5	All CHAT surveys
Javelinfish	JAV	0.00129	3.162158	97.19	1301	15.8-62.1	tan2001
Johnson's cod	HJO	0.00183	3.306225	97.97	585	19.7-65.2	tan2001
Kaiyomaru rattail	CKA	0.009088	2.612086	85.89	222	16.6-39.6	All CHAT surveys
Leafscale gulper shark	CSQ	0.001139	3.353018	99.22	520	36.1-144.9	All CHAT surveys
Lemon sole	LSO	0.00679	3.169418	91.8	506	20.3-40.2	All CHAT surveys
Ling	LIN	0.001512	3.245238	99.36	926	27.6-161.8	tan2001
Long-nosed chimaera	LCH	0.00468	2.900319	98.46	237	19.4-93.3	tan2001
Longnose velvet dogfish	CYP	0.002208	3.165511	98.67	485	30.9-96.4	tan2001
Lookdown dory	LDO	0.022042	2.98222	97.75	1210	12.5-59.3	tan2001
Lucifer dogfish	ETL	0.00202	3.130749	97.53	288	16.2-53.2	tan2001
Mahia rattail	CMA	0.024114	2.600693	95.96	58	21-71.9	tan2001
Notable rattail	CIN	0.019545	2.359365	81.14	792	14.1-40.5	All CHAT surveys
Oblique banded rattail	CAS	0.001568	3.304795	96.81	494	16.9-41.9	tan2001
Oliver's rattail	COL	0.004472	2.851636	90.49	5528	11.8-42.2	All CHAT surveys
Orange perch	OPE	0.018583	3.054993	91.94	142	22.4-36.5	tan2001
Orange roughy	ORH	0.035168	2.985299	98.83	597	8.6-44.2	tan2001
Owston's dogfish	CYO	0.001361	3.335917	96.78	79	30.3-112.7	tan2001
Pale ghost shark	GSP	0.00808	2.911338	95.14	283	28.7-87	tan2001
Ray's bream	RBM	0.025334	2.89714	92.72	129	30.3-50.4	tan2001
Red cod	RCO	0.009769	2.964466	98.71	210	17-62.7	tan2001
Redbait	RBT	0.011439	3.036305	94.33	288	18.6-40.6	All CHAT surveys
Ribaldo	RIB	0.003082	3.313672	98	90	25.9-68.4	tan2001
Ridge scaled rattail	MCA	0.001551	3.291309	98.28	250	24.2-83.7	tan2001
Roughhead rattail	CHY	0.000312	3.6459	94.78	59	25.6-49.9	tan2001
Rubyfish	RBY	0.008749	3.214926	98.36	179	14.1-49	All CHAT surveys
Scaly gurnard	SCG	0.082494	2.346202	76.93	44	12.4-19.9	All CHAT surveys
Scampi	SCI	0.797915	2.761901	88.64	1490	2.7-7.5	All CHAT surveys
School shark	SCH	0.003884	3.050205	92.24	226	90.9-173.5	All CHAT surveys
Sea perch	SPE	0.008694	3.174278	98.23	1098	13.5-47.7	tan2001
Sea perch	HPC	0.008694	3.174278	98.23	1098	13.5-47.7	tan2001
Seal shark	BSH	0.001691	3.253246	99.02	708	35.7-151.2	All CHAT surveys
Serrulate rattail	CSE	0.008519	2.766594	83.81	934	23.9-52	All CHAT surveys
Shovelnose dogfish	SND	0.001773	3.166924	97.7	477	32.8-111.9	tan2001
Sloan's arrow squid	NOS	0.014525	3.14707	91.2	343	10.6-36.7	tan2001

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

Table 9: (continued)

Common name	Species	a	b (slope)	r^2	n	Length range	Source
Spottyface rattail	CTH	0.000229	3.759591	93.36	105	24.6–47.5	All CHAT surveys
Silver dory	SDO	0.017353	2.96373	98.61	119	12.7–32.0	tan2001
Silver roughy	SRH	0.011388	3.26554	90.03	380	9.9–17.8	All CHAT surveys
Silver warehou	SWA	0.014402	3.060352	97.96	379	24.4–53.8	tan2001
Silverside	SSI	0.006635	3.001826	85.3	1591	17.5–31.9	All CHAT surveys
Slender jack mackerel	JMM	0.255066	2.177605	59.99	424	38.3–57.2	All CHAT surveys
Small-headed cod	SMC	0.005053	3.050065	96.32	84	25.1–50.9	All CHAT surveys
Small banded rattail	CCX	0.003281	2.982304	87.75	225	16.1–33.6	All CHAT surveys
Smallscaled brown slickhead	SSM	0.005612	3.112155	97.3	367	20.2–65.4	tan2001
Smooth oreo	SSO	0.015741	3.099116	98.49	446	15.4–47.9	tan2001
Smooth skate	SSK	0.021438	2.973723	98.99	942	29.3–158	All CHAT surveys
Southern blue whiting	SBW	0.002827	3.243359	97.97	792	13.5–56.4	All CHAT surveys
Southern Ray's bream	SRB	0.025334	2.89714	92.72	129	30.3–50.4	tan2001
Spiky oreo	SOR	0.024947	2.951665	98.71	374	11.2–41.8	tan2001
Spineback	SBK	0.000917	3.167531	88.43	1175	32.2–80.4	All CHAT surveys
Spiny dogfish	SPD	0.000927	3.357905	93.34	868	50.4–99.0	tan2001
Swollenhead conger	SCO	0.000338	3.405158	96.89	51	56.2–103.3	tan2001
Tarakihi	NMP	0.023981	2.917622	93.53	59	30.2–46.7	tan2001
Thin tongue cardinalfish	EPM	0.035336	2.628926	71.92	364	14.9–23.8	All CHAT surveys
Todarodes filippovae	TSQ	0.008615	3.237933	98.62	144	18.8–58.2	All CHAT surveys
Two saddle rattail	CBI	0.00124	3.346846	98.81	134	20.0–59.8	tan2001
Unicorn rattail	WHR	0.000876	3.351219	96.71	96	22.8–46.6	All CHAT surveys
Violet cod	VCO	0.002333	3.277342	97.45	148	17.6–56.2	tan2001
Warty squid (*M. ingens*)	MIQ	0.076562	2.735829	97.99	79	11.3–49.3	tan2001
White rattail	WHX	0.001069	3.450206	97.71	340	30.2–96.9	tan2001
White warehou	WWA	0.063818	2.70645	97.17	190	26.9–61.9	tan2001
Widenosed chimaera	RCH	0.001622	3.014258	97.09	80	36.0–152.7	tan2001

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

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

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
AAM	Roundfin catshark	Female	MD	1	-	2	-	-	-	-	3
		Male		-	1	-	-	-	-	-	1
ABR	Shortsnouted lancetfish	Female	MD	-	2	-	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-
AEX	New Zealand catshark	Female	MD	3	1	1	-	-	-	-	5
		Male		-	7	12	-	-	-	-	19
AGK	Garrick's catshark	Female	MD	-	-	-	-	-	-	-	-
		Male		-	-	4	-	-	-	-	4
AML	Fleshynose catshark	Female	MD	-	-	2	-	-	-	-	2
		Male		-	-	4	-	-	-	-	4
ASI	Freckled catshark	Female	MD	-	-	-	-	-	-	-	-
		Male		-	2	2	-	-	-	-	4
BAR	Barracouta	Female	MD	-	46	76	2	6	-	7	137
		Male		-	6	16	46	41	4	5	118
BCO	Blue cod	Female	MD	-	-	2	-	-	-	-	2
		Male		-	-	-	1	-	-	-	1
BEE	Basketwork eel	Female	MD	3	86	16	-	-	-	-	105
		Male		5	14	6	1	-	-	1	27
BJA	Black javelinfish	Female	MD	3	1	-	-	1	-	-	5
		Male		3	1	-	-	-	-	-	4
BNS	Bluenose	Female	MD	3	1	1	1	-	-	-	6
		Male		2	1	-	1	-	-	-	4
BOE	Black oreo	Female	MD	246	293	194	7	4	2	2	748
		Male		477	242	58	21	5	45	4	852
BSH	Seal shark	Female	SS	20	3	1	-	-	-	-	24
		Male		11	1	1	-	-	-	-	13
BSL	Black slickhead	Female	MD	4	4	25	-	-	-	-	33
		Male		2	8	11	1	-	-	-	22
BTA	Smooth deepsea skate	Female	SS	-	-	1	-	-	-	-	1
		Male		-	-	1	-	-	-	-	1
BTS	Prickly deepsea skate	Female	SS	-	-	1	-	-	-	-	1
		Male		2	-	-	-	-	-	-	2
BYD	Longfinned beryx	Female	MD	-	-	-	-	-	-	-	-
		Male		1	1	-	-	-	-	-	2
BYS	Alfonsino	Female	MD	19	27	1	1	-	-	-	48
		Male		21	30	2	-	-	-	-	53
CAR	Carpet shark	Female	SS	-	-	-	-	-	-	-	-
		Male		1	-	1	-	-	-	-	2
CAS	Oblique banded rattail	Female	MD	7	32	-	-	-	-	-	39
		Male		-	1	-	-	-	-	-	1
CBA	Humpback rattail	Female	MD	-	3	1	-	-	-	-	4
		Male		-	-	-	-	-	-	-	-
CBI	Two saddle rattail	Female	MD	-	39	9	7	-	-	-	55
		Male		7	5	4	-	-	-	-	16
CBO	Bollon's rattail	Female	MD	8	76	-	-	-	-	1	85
		Male		7	78	7	-	-	-	-	92
CFA	Banded rattail	Female	MD	-	2	-	-	-	-	-	2
		Male		2	5	-	-	-	-	-	7
CHG	Giant chimaera	Female	MD	1	-	-	-	-	-	-	1
		Male		-	-	1	-	-	-	-	1
CHP	Brown chimaera	Female	SS	-	1	1	-	-	1	-	3
		Male		3	-	13	-	-	-	-	16
CHY	Roughhead rattail	Female	MD	2	4	12	1	-	-	-	19
		Male		2	6	5	-	-	-	-	13
CIN	Notable rattail	Female	MD	1	-	-	-	-	-	-	1
		Male		7	4	-	-	-	-	-	11
CKA	Kaiyomaru rattail	Female	MD	2	1	6	-	-	-	-	9
		Male		1	15	-	-	-	-	-	16
CMA	Mahia rattail	Female	MD	2	11	-	1	-	-	2	16
		Male		-	8	-	-	-	-	-	8
CMU	Murray's rattail	Female	MD	1	2	2	-	-	-	-	5
		Male		-	-	-	-	-	-	-	-
CMX	McMillan's rattail	Female	MD	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
COL	Oliver's rattail	Female	MD	-	14	-	-	-	-	-	14
		Male		-	19	-	-	-	-	-	19
CSE	Serrulate rattail	Female	MD	-	21	7	-	-	-	1	29
		Male		-	33	6	-	-	-	-	39

Table 10 (continued)

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
CSQ	Leafscale gulper shark	Female	SS	6	5	7	2	1	1	-	22
		Male		17	1	3	-	-	-	-	21
CSU	Four-rayed rattail	Female	MD	2	21	24	-	-	-	-	47
		Male		5	14	-	-	-	-	-	19
CTH	Spottyface rattail	Female	MD	-	3	-	-	-	-	-	3
		Male		1	3	1	-	-	-	-	5
CYO	Owston’s dogfish	Female	SS	13	14	6	4	-	2	-	39
		Male		5	1	38	-	-	-	-	44
CYP	Longnose velvet dogfish	Female	SS	232	70	55	6	4	10	-	377
		Male		146	12	79	-	-	-	-	237
DCS	Dawson's catshark	Female	SS	-	-	-	-	-	-	-	-
		Male		-	-	2	-	-	-	-	2
ELE	Elephant fish	Female	MD	1	-	-	-	-	-	-	1
		Male		-	-	2	-	-	-	-	2
EPL	Bigeye cardinalfish	Female	MD	-	2	-	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-
EPT	Deepsea cardinalfish	Female	MD	11	13	1	-	-	-	-	25
		Male		52	1	3	-	-	-	-	56
ERA	Electric ray	Female	MD	-	-	-	-	-	-	-	-
		Male		-	-	2	-	-	-	-	2
ETB	Baxter's lantern dogfish	Female	SS	47	35	27	1	2	8	-	120
		Male		54	23	76	-	-	-	-	153
ETL	Lucifer dogfish	Female	SS	58	33	13	3	6	7	-	120
		Male		56	28	85	-	-	-	-	169
FHD	Deepsea flathead	Female	MD	1	2	-	-	-	-	-	3
		Male		-	-	-	-	-	-	-	-
FRO	Frostfish	Female	MD	-	4	18	3	17	1	-	43
		Male		-	2	1	4	9	-	-	16
FRS	Frill shark	Female	SS	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
GIZ	Giant stargazer	Female	MD	18	76	128	1	3	4	4	234
		Male		15	79	39	-	-	-	1	134
GSH	Dark ghost shark	Female	SS	122	128	108	3	1	20	-	382
		Male		66	39	239	-	-	-	-	344
GSP	Pale ghost shark	Female	SS	32	56	42	3	1	11	-	145
		Male		27	13	100	-	-	-	-	140
GUR	Red gurnard	Female	MD	-	-	7	3	-	-	-	10
		Male		-	14	11	-	-	-	-	25
HAK	Hake	Female	MD	2	17	31	2	1	2	3	58
		Male		5	22	6	13	9	-	-	55
HAP	Hapuku	Female	MD	2	22	2	-	-	-	4	30
		Male		5	22	2	-	-	-	3	32
HAS	Australasian slender cod	Female	MD	7	61	22	1	-	-	1	92
		Male		27	28	14	-	-	-	-	69
HBA	Bigeye sea perch	Female	MD	35	176	11	15	-	-	3	240
		Male		13	80	143	27	2	-	1	266
HCO	Hairy conger	Female	MD	-	-	2	-	1	-	1	4
		Male		2	4	-	-	-	-	-	6
HEX	Sixgill shark	Female	SS	1	-	-	-	-	-	-	1
		Male		1	-	-	-	-	-	-	1
HJC	Johnsons cod	Female	MD	-	2	5	-	-	1	-	8
		Male		1	3	12	23	-	-	-	39
HOK	Hoki	Female	MD	3 423	5 181	6	-	1	-	5	8 616
		Male		3 865	3 717	10	-	-	-	1	7 593
HPC	Sea perch	Female	MD	9	39	10	9	32	-	-	99
		Male		15	18	80	-	2	-	2	117
HYB	Black ghost shark	Female	SS	-	-	-	-	-	-	-	-
		Male		-	-	1	-	-	-	-	1
HYP	Pointynose blue ghost shark	Female	SS	-	1	-	-	-	1	-	2
		Male		-	-	-	-	-	-	-	-
JAV	Javelinfish	Female	MD	3	19	2	-	-	-	-	24
		Male		-	7	-	-	-	-	-	7
JDO	John dory	Female	MD	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
JMD	Jack mackerel	Female	MD	-	1	7	-	-	-	-	8
		Male		-	8	17	-	1	-	-	26
JMM	Slender mackerel	Female	MD	-	-	10	-	-	-	-	10
		Male		-	-	2	1	6	-	-	9

Table 10 (continued)

Species code	Common name	Sex	Staging method	Reproductive stage							
				1	2	3	4	5	6	7	Total
LCH	Long-nosed chimaera	Female	SS	41	26	37	2	-	8	-	114
		Male		44	8	71	-	-	-	-	123
LDO	Lookdown dory	Female	MD	60	261	204	26	4	13	18	586
		Male		68	98	101	187	2	-	-	456
LIN	Ling	Female	MD	214	327	7	8	-	-	-	556
		Male		229	97	27	126	2	1	-	482
LPS	Giant lepidion	Female	MD	-	-	-	-	-	-	-	-
		Male		-	-	1	-	-	-	-	1
LYC	*Lyconus* sp.	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
MAN	Finless flounder	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	1	-	-	-	-	1
MCA	Ridge scaled rattail	Female	MD	13	46	7	-	-	-	-	66
		Male		55	33	10	-	-	-	-	98
MDO	Mirror dory	Female	MD	-	-	2	-	-	-	-	2
		Male		-	-	-	1	-	-	-	1
MOK	Moki	Female	MD	-	-	-	-	-	-	-	-
		Male		-	-	1	-	-	-	-	1
NMP	Tarakihi	Female	MD	4	43	31	2	1	-	-	81
		Male		9	29	30	13	1	1	1	84
NNA	Squashedface rattail	Female	MD	-	-	-	-	-	-	-	-
		Male		-	1	-	-	-	-	-	1
NPU	Starnose black rat	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
NSD	Northern spiny dogfish	Female	SS	-	-	-	-	-	-	-	-
		Male		-	-	4	-	-	-	-	4
OPE	Orange perch	Female	MD	1	1	79	14	22	1	-	118
		Male		4	8	45	51	13	1	1	123
ORH	Orange roughy	Female	MD	105	110	246	6	-	-	-	467
		Male		183	125	117	2	-	-	-	427
PDG	Prickly dogfish	Female	SS	1	-	1	-	-	-	-	2
		Male		-	-	2	-	-	-	-	2
PIG	Pigfish	Female	MD	-	7	1	-	-	-	-	8
		Male		-	4	-	-	-	-	-	4
PLS	Plunket's shark	Female	SS	1	-	1	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-
PSK	Longnosed deepsea skate	Female	SS	-	2	-	1	-	-	-	3
		Male		-	-	2	-	-	-	-	2
RBM	Ray’s bream	Female	MD	1	31	8	-	4	-	-	44
		Male		2	35	8	1	-	1	1	48
RBT	Redbait	Female	MD	-	1	11	-	-	-	1	13
		Male		3	-	2	13	-	-	1	19
RCH	Widenosed chimaera	Female	SS	11	9	11	-	-	4	-	35
		Male		15	14	25	-	-	-	-	54
RCO	Red cod	Female	MD	17	57	16	4	1	1	-	96
		Male		37	11	23	38	13	6	2	130
RHY	Common roughy	Female	MD	-	-	6	17	-	-	-	23
		Male		-	12	6	-	-	-	-	18
RIB	Ribaldo	Female	MD	1	19	1	-	1	1	-	23
		Male		2	16	20	1	-	-	3	42
RSK	Rough skate	Female	MD	-	-	-	-	-	-	-	-
		Male		-	-	1	-	-	-	-	1
RSO	Gemfish	Female	MD	4	44	2	-	-	-	-	50
		Male		16	29	4	1	-	-	-	50
RUD	Rudderfish	Female	MD	-	1	-	-	-	-	-	1
		Male		-	-	2	-	-	-	-	2
SBI	Bigscaled brown slickhead	Female	MD	14	40	48	2	2	-	-	106
		Male		16	16	8	2	-	-	-	42
SBK	Spineback	Female	MD	-	1	38	5	15	4	1	64
		Male		-	-	-	1	2	-	-	3
SBW	Southern blue whiting	Female	MD	-	85	-	-	-	-	-	85
		Male		1	71	-	-	-	-	-	72
SCG	Scaly gurnard	Female	MD	-	2	1	1	-	-	-	4
		Male		-	6	-	-	-	-	-	6
SCH	School shark	Female	SS	4	1	-	-	-	-	-	5
		Male		5	3	8	-	-	-	-	16
SCI	Scampi	Female	MD	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-

Table 10 (continued)

Species code	Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
SCO	Swollenhead conger	Female	MD	3	2	-	1	1	-	-	7
		Male		2	3	2	-	-	-	-	7
SDO	Silver dory	Female	MD	-	9	7	16	2	1	-	35
		Male		-	9	16	-	-	1	-	26
SFN	Spinyfin	Female	MD	-	-	-	-	-	-	-	-
		Male		-	-	2	-	-	-	-	2
SMC	Small-headed cod	Female	MD	-	5	-	-	-	-	-	5
		Male		3	2	-	-	-	-	-	5
SND	Shovelnose dogfish	Female	SS	137	135	20	4	1	11	-	308
		Male		32	66	175	-	-	-	-	273
SOR	Spiky oreo	Female	MD	52	22	94	5	-	1	4	178
		Male		40	20	47	47	-	-	-	154
SPD	Spiny dogfish	Female	SS	100	201	51	175	561	39	-	1 127
		Male		10	17	235	-	-	-	-	262
SRB	Southern Ray's bream	Female	MD	-	-	1	-	-	-	-	1
		Male		-	-	-	-	-	-	-	-
SRH	Silver roughy	Female	MD	2	2	-	-	-	-	-	4
		Male		3	1	-	-	-	-	-	4
SSK	Smooth skate	Female	SS	6	5	1	-	-	1	-	13
		Male		2	1	2	-	-	-	-	5
SSM	Smallscaled brown slickhead	Female	MD	19	46	16	4	-	-	-	85
		Male		28	22	8	5	-	-	-	63
SSO	Smooth oreo	Female	MD	131	147	175	18	5	2	-	478
		Male		185	92	96	134	82	52	-	641
SWA	Silver warehou	Female	MD	40	236	30	11	3	-	2	322
		Male		107	167	29	3	3	-	6	315
TRS	Cape scorpionfish	Female	MD	-	-	-	-	-	-	2	2
		Male		-	1	-	-	-	-	-	1
TRU	Trumpeter	Female	MD	-	2	-	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-
TUB	Tasmanian ruffe	Female	MD	-	-	3	-	-	-	-	3
		Male		-	1	-	-	-	-	-	1
VCO	Violet cod	Female	MD	16	43	-	-	-	-	-	59
		Male		49	8	-	-	-	-	-	57
VNI	Blackspot rattail	Female	MD	-	-	-	1	-	-	-	1
		Male		-	-	-	-	-	-	-	-
WHR	Unicorn rattail	Female	MD	1	1	-	-	-	-	-	2
		Male		-	-	-	-	-	-	-	-
WHX	White rattail	Female	MD	4	49	21	-	-	-	10	84
		Male		23	66	7	-	-	-	-	96
WOE	Warty oreo	Female	MD	1	-	2	-	-	-	-	3
		Male		-	-	-	-	-	-	-	-
WWA	White warehou	Female	MD	6	27	34	-	-	-	1	68
		Male		22	35	6	-	-	-	2	65

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

Table 11: Average trawl catch (excluding benthic organisms) and acoustic backscatter from daytime core tows where acoustic data quality was suitable for echo integration on the Chatham Rise in 2001–20.

			Average acoustic backscatter ($m^2\ km^{-2}$)			
Year	No. of recordings	Average trawl catch (kg km^{-2})	Bottom 10 m	Bottom 50 m	All bottom marks (to 100 m)	Entire echogram
2001	117	1 858	3.63	22.39	31.80	57.60
2002	102	1 849	4.50	18.39	22.60	49.32
2003	117	1 508	3.43	19.56	29.41	53.22
2005	86	1 783	2.78	12.69	15.64	40.24
2006	88	1 782	3.24	13.19	19.46	48.86
2007	100	1 510	2.00	10.83	15.40	41.07
2008	103	2 012	2.03	9.65	13.23	37.98
2009	105	2 480	2.98	15.89	25.01	58.88
2010	90	2 205	1.87	10.80	17.68	44.49
2011	73	1 997	1.79	8.72	12.94	34.79
2012	85	1 793	2.60	15.96	26.36	54.77
2013	76	2 323	3.74	15.87	27.07	56.89
2014	48	1 790	3.15	14.96	24.42	48.45
2016	90	1 890	3.49	20.79	31.81	61.34
2018	85	2 429	2.66	13.88	23.18	42.95
2020	78	1 787	3.52	16.09	26.28	53.59

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

				Stratum
Year	Northeast	Northwest	Southeast	Southwest
2001	0.64	0.83	0.81	0.88
2002	0.58	0.78	0.66	0.86
2003	0.67	0.82	0.81	0.77
2005	0.72	0.83	0.73	0.69
2006	0.69	0.77	0.76	0.80
2007	0.67	0.85	0.73	0.80
2008	0.61	0.64	0.84	0.85
2009	0.58	0.75	0.83	0.86
2010	0.48	0.64	0.76	0.63
2011	0.63	0.49	0.76	0.54
2012	0.40	0.52	0.68	0.79
2013	0.34	0.50	0.54	0.66
2014	0.54	0.62	0.74	0.78
2016	0.69	0.57	0.71	0.84
2018	0.44	0.50	0.75	0.60
2020	0.56	0.57	0.76	0.63

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

		Acoustic index ($m^2 km^{-2}$)											
Survey	Year	Unstratified		Northeast		Northwest		Southeast		Southwest		Stratified	
		Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
tan0101	2002	47.1	8	21.8	11	61.1	13	36.8	12	92.6	16	44.9	8
tan0201	2003	35.8	6	25.1	11	40.3	11	29.6	13	54.7	13	34.0	7
tan0301	2004	40.6	10	30.3	23	32.0	12	52.4	19	53.9	11	42.9	10
tan0501	2005	30.4	7	28.4	12	44.5	21	25.2	8	29.5	23	29.3	7
tan0601	2006	37.0	6	30.7	10	47.9	12	38.1	12	36.7	19	36.4	7
tan0701	2007	32.4	7	23.0	10	43.3	12	27.2	13	35.9	20	29.2	7
tan0801	2008	29.1	6	17.8	5	27.9	19	38.1	10	36.2	12	29.8	6
tan0901	2009	44.7	10	22.4	22	54.3	12	39.3	16	84.8	18	43.8	9
tan1001	2010	27.0	8	16.5	11	33.4	11	35.1	17	34.0	24	28.5	10
tan1101	2011	21.4	9	23.4	15	27.2	14	12.6	23	15.8	17	18.5	9
tan1201	2012	30.8	8	17.6	13	41.1	34	33.5	11	51.1	12	32.3	8
tan1301	2013	28.8	7	15.5	15	45.9	12	27.3	13	31.7	13	26.3	7
tan1401	2014	31.7	9	19.4	8	37.6	12	35.8	18	44.6	24	32.1	10
tan1601	2016	41.7	8	27.8	14	40.1	13	41.6	15	68.7	16	41.8	8
tan1801	2018	24.1	8	16.1	10	26.7	16	30.9	22	28.6	20	25.0	11
tan2001	2020	32.2	7	22.8	12	34.9	13	50.6	13	26.1	15	34.9	8

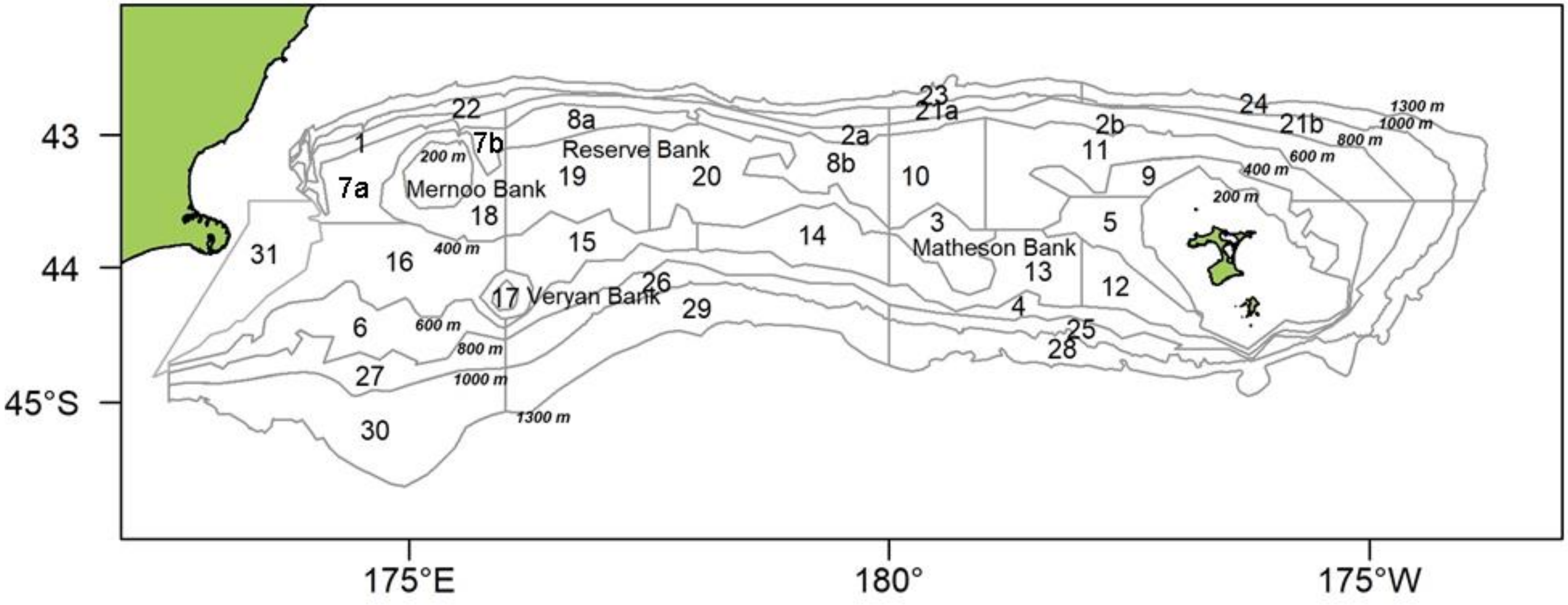


Figure 1: Chatham Rise trawl survey area showing stratum boundaries. Stratum 31 defines most of the Canterbury Banks Hoki Management Area.

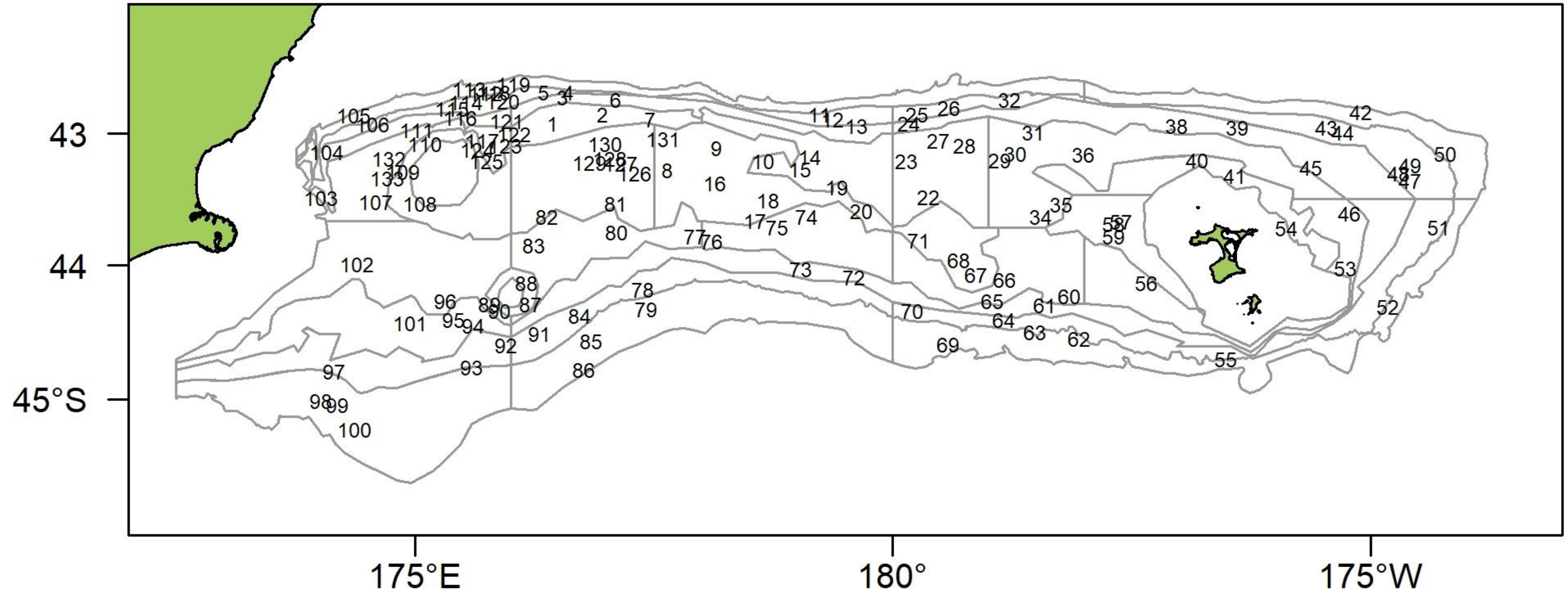


Figure 2: Trawl survey area showing positions of valid biomass stations (n = 130 stations) for TAN2001. In this and subsequent figures actual stratum boundaries are drawn for the deepwater strata.

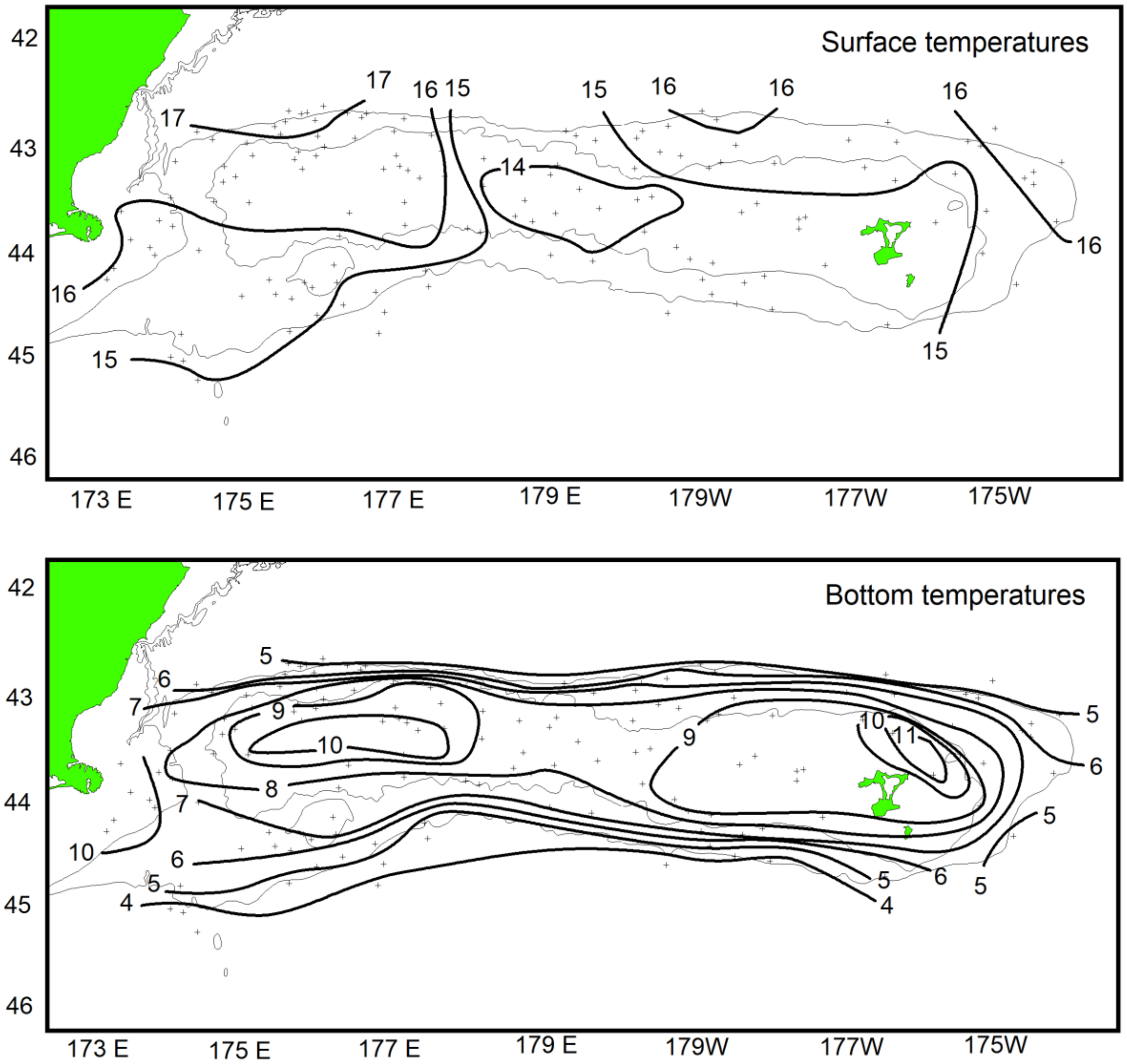


Figure 3: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (ºC) interpolated by eye for TAN2001. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow.

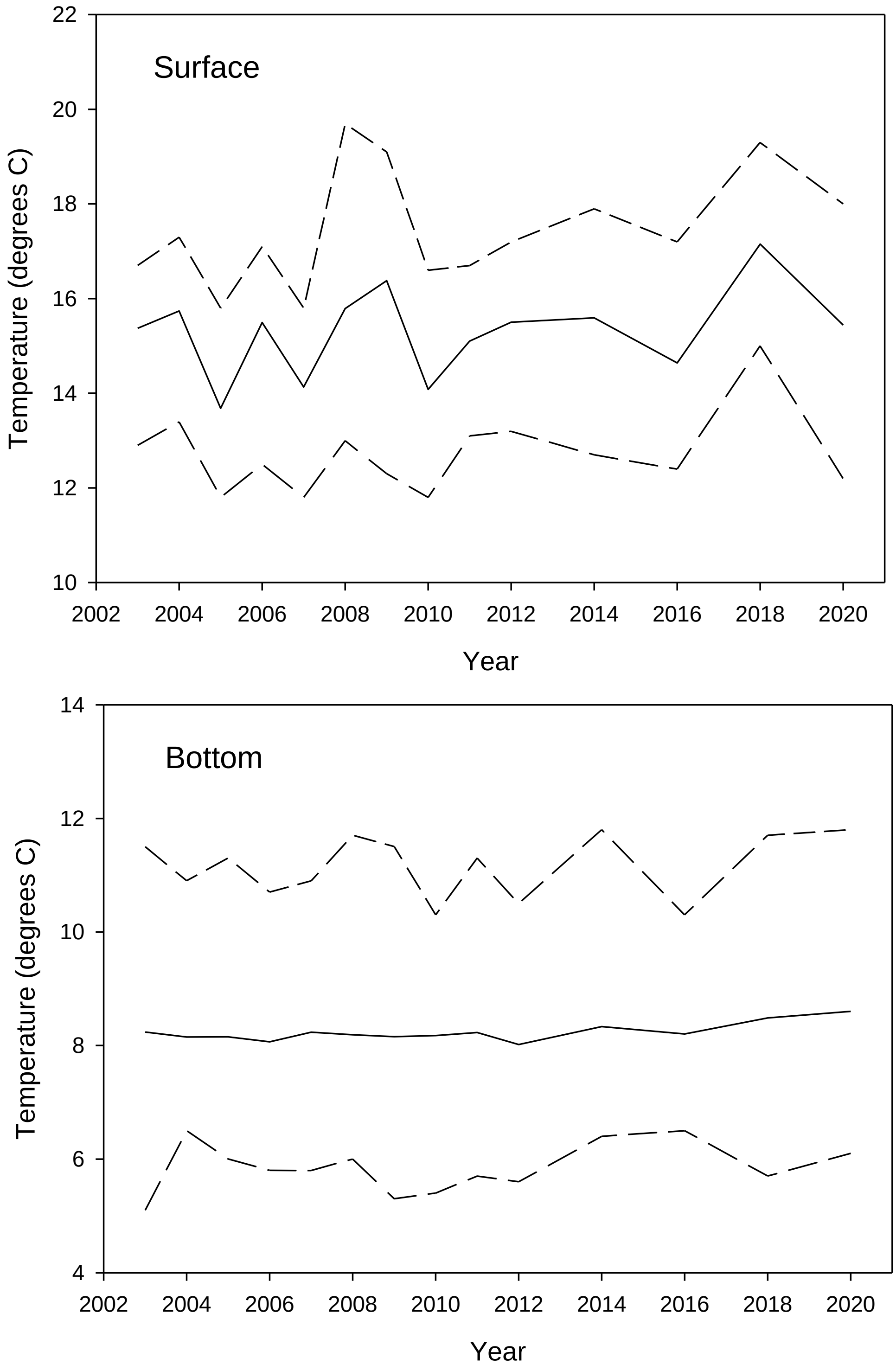


Figure 4: Time series of sea surface (upper panel) and bottom (lower panel) temperature recordings within the core (200–800 m) survey area from the calibrated Seabird CTD recordings made during each tow. Solid line is the mean temperature. Dashed lines are minimum and maximum values in each year.

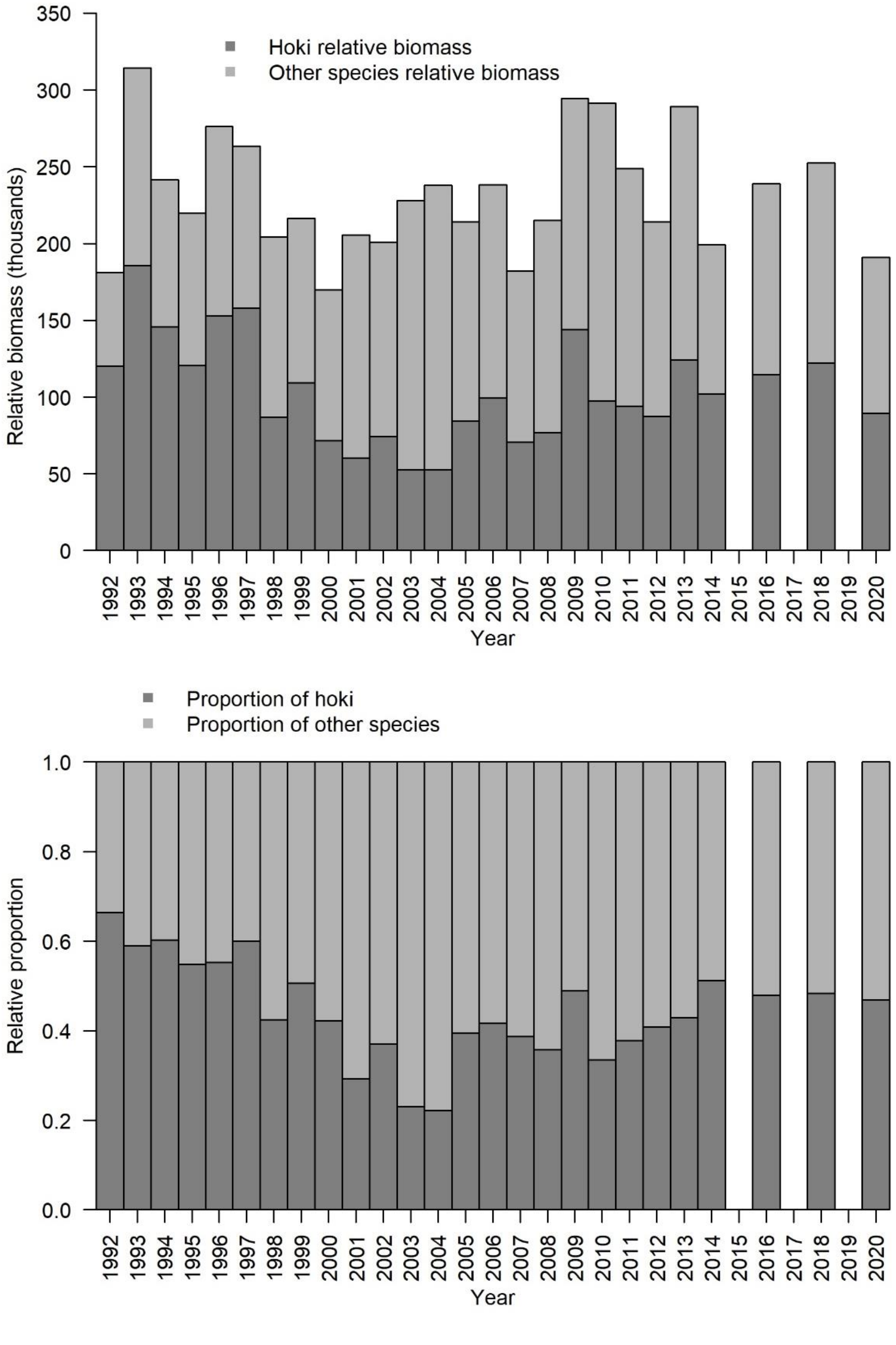


Figure 5: Relative biomass (top panel) and relative proportions of hoki and 30 other key species, as defined by Livingston et al (2002) and indicated in Table 4, (lower panel) from trawl surveys of the Chatham Rise, January 1992–2020 (core strata only).

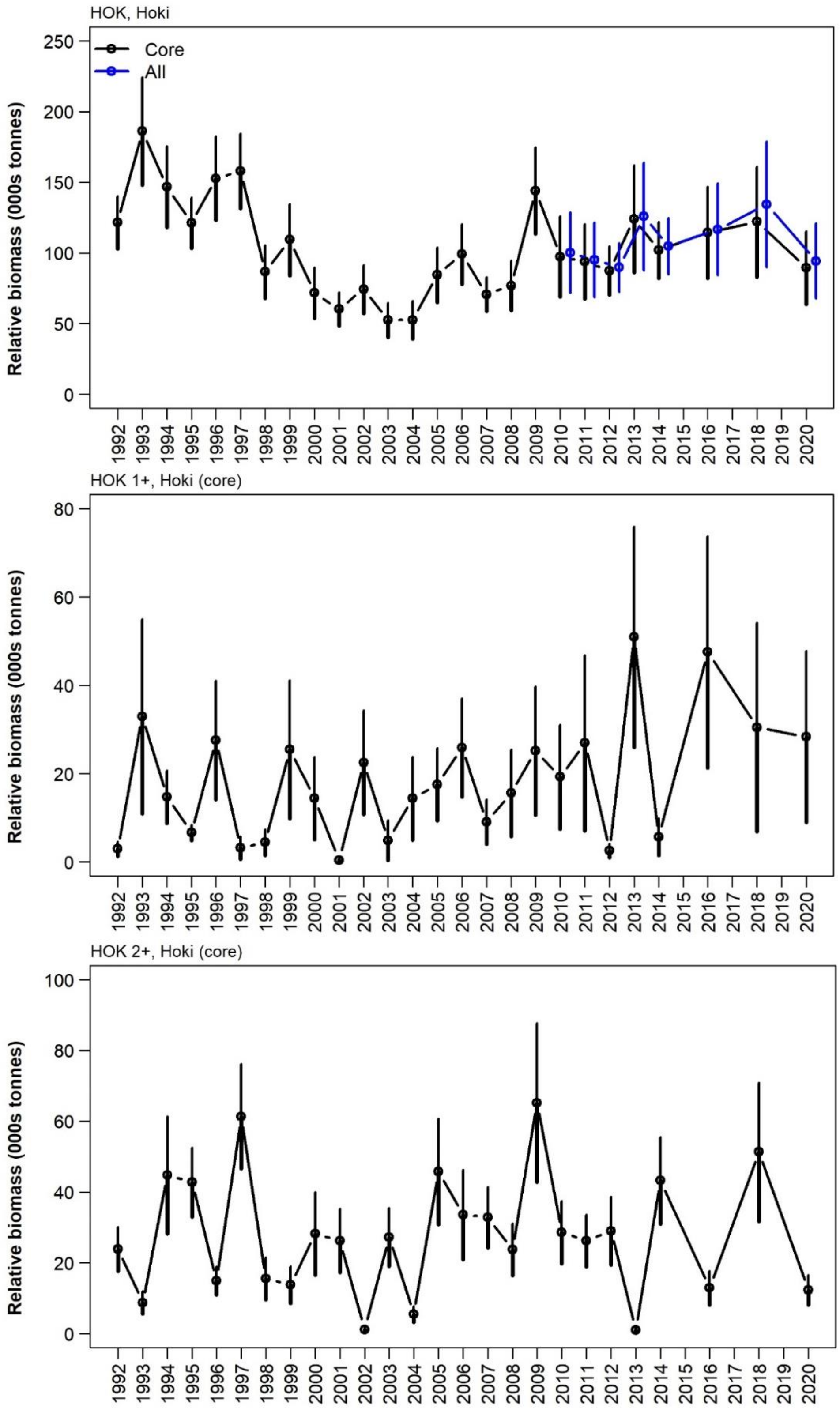


Figure 6a: Relative biomass estimates (thousands of tonnes) of hoki, hake, ling, and 8 other selected commercial species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020 (core and all strata). Error bars show ± 2 standard errors.

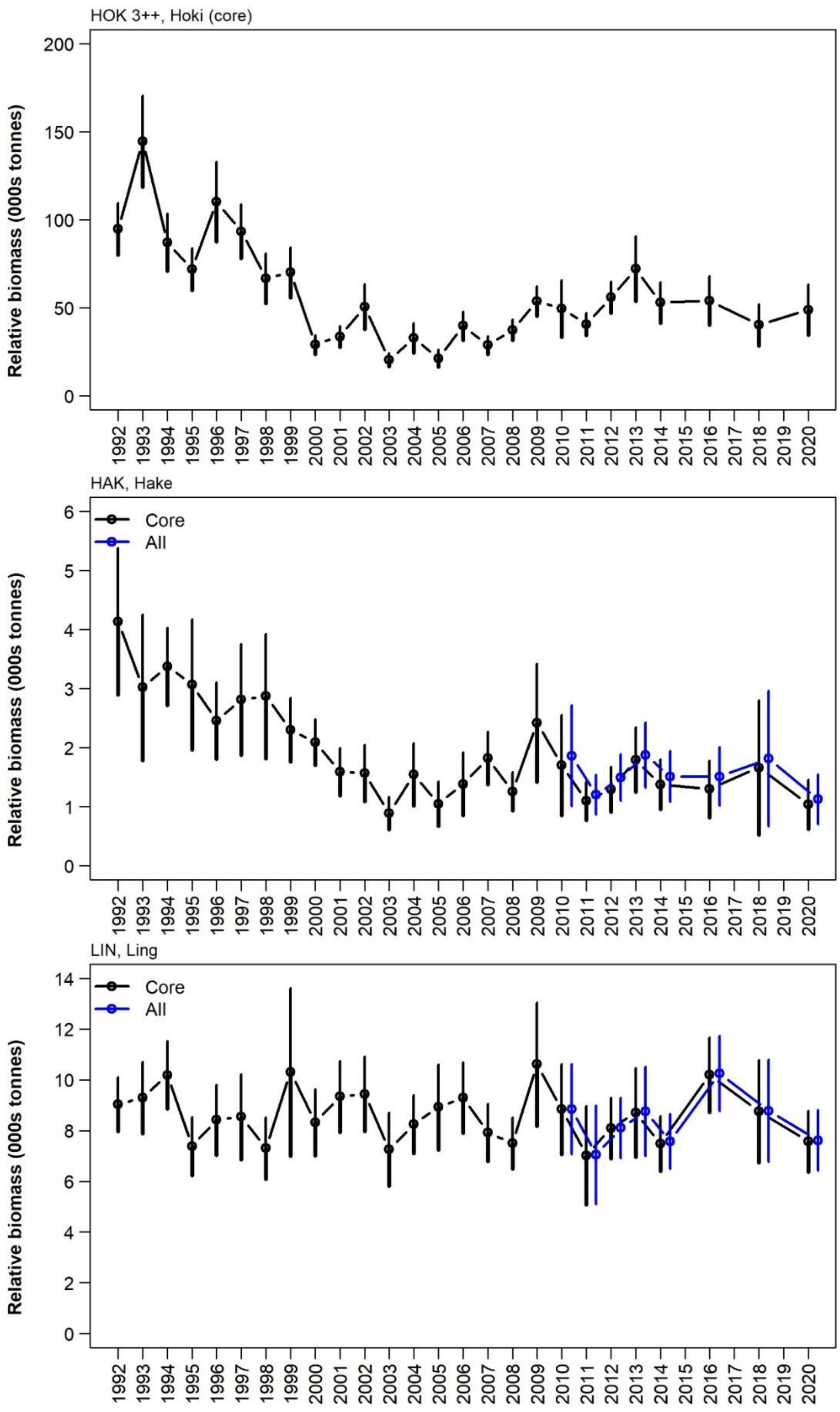


Figure 6a (continued)

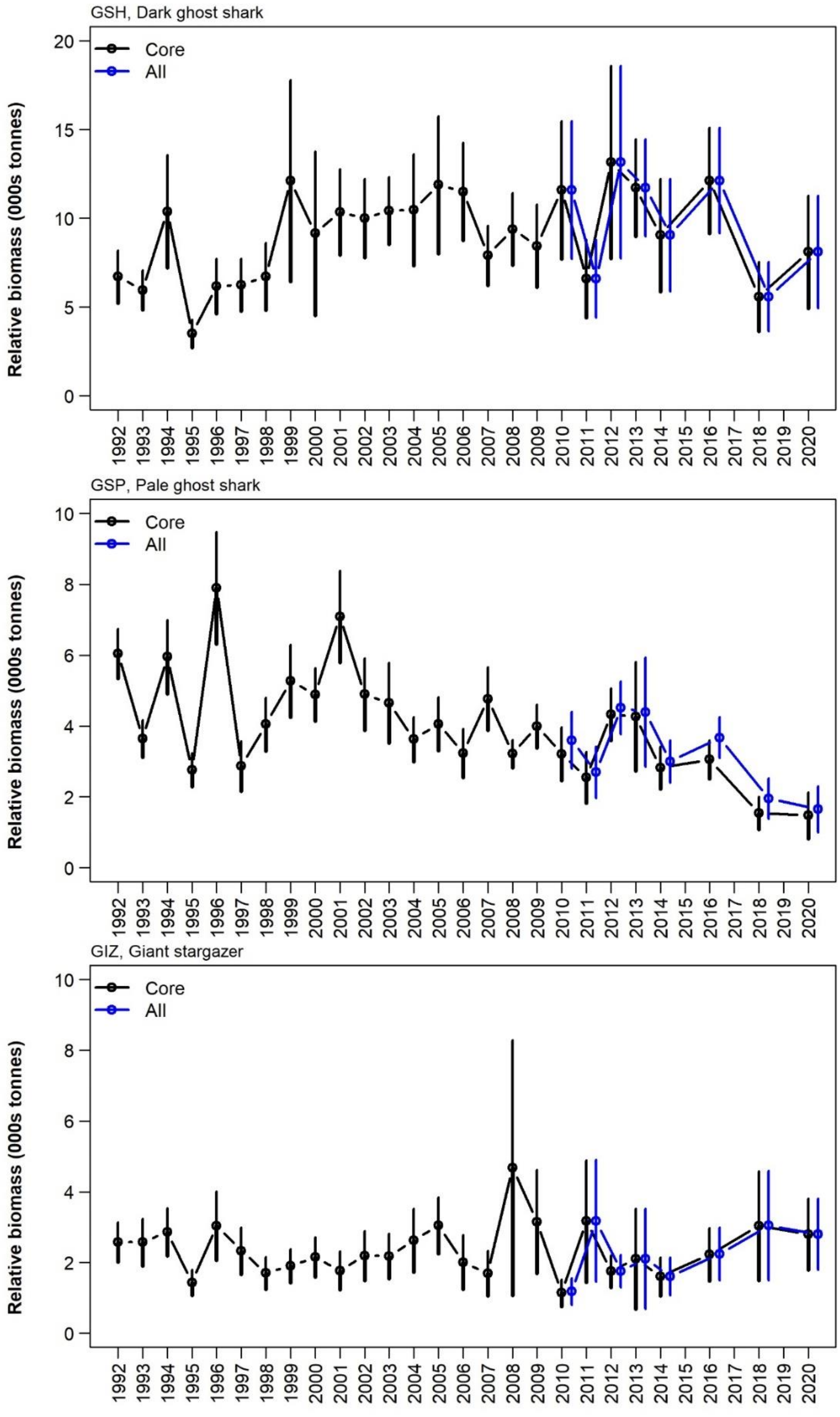


Figure 6a (continued)

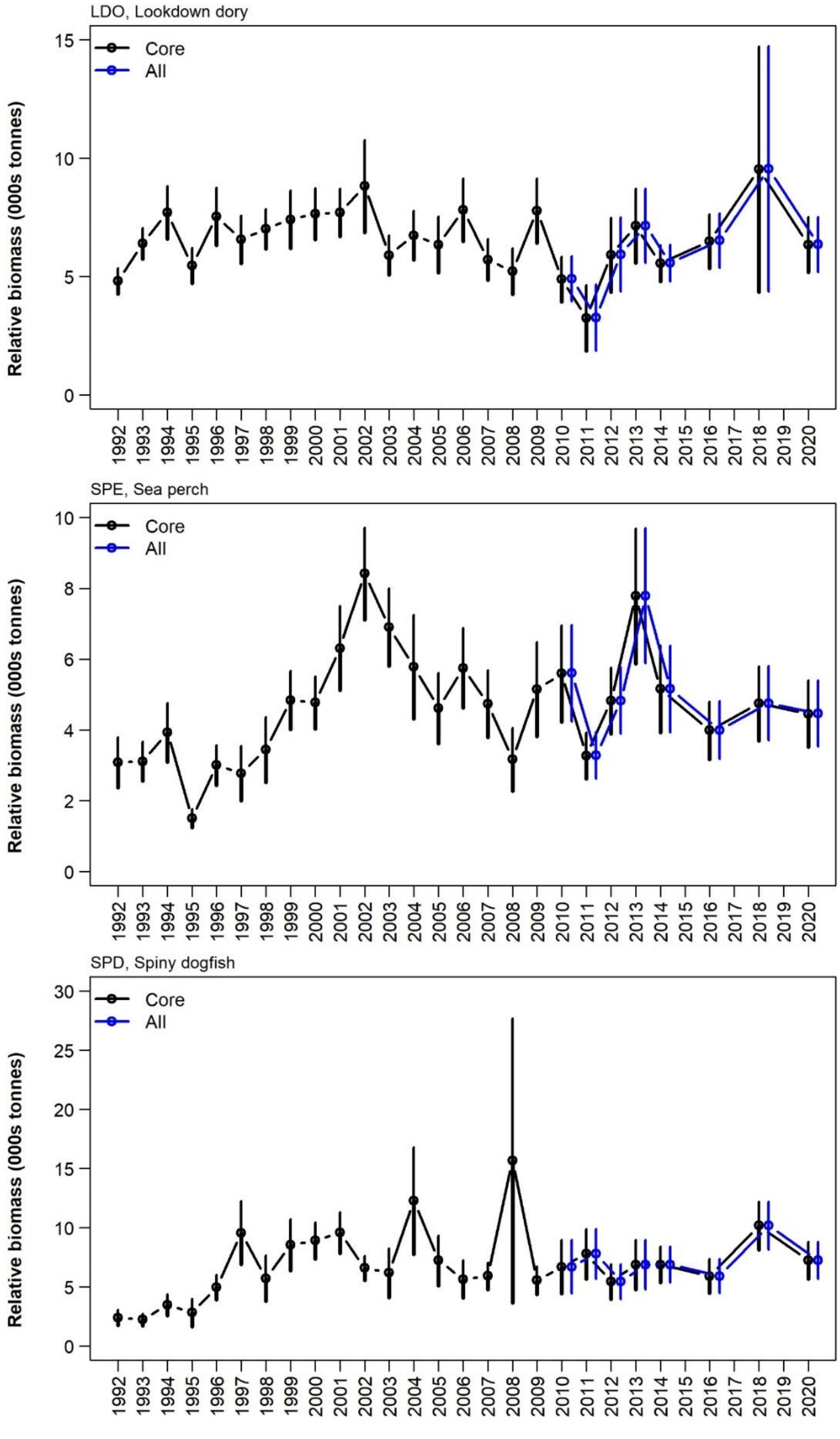


Figure 6a (continued)

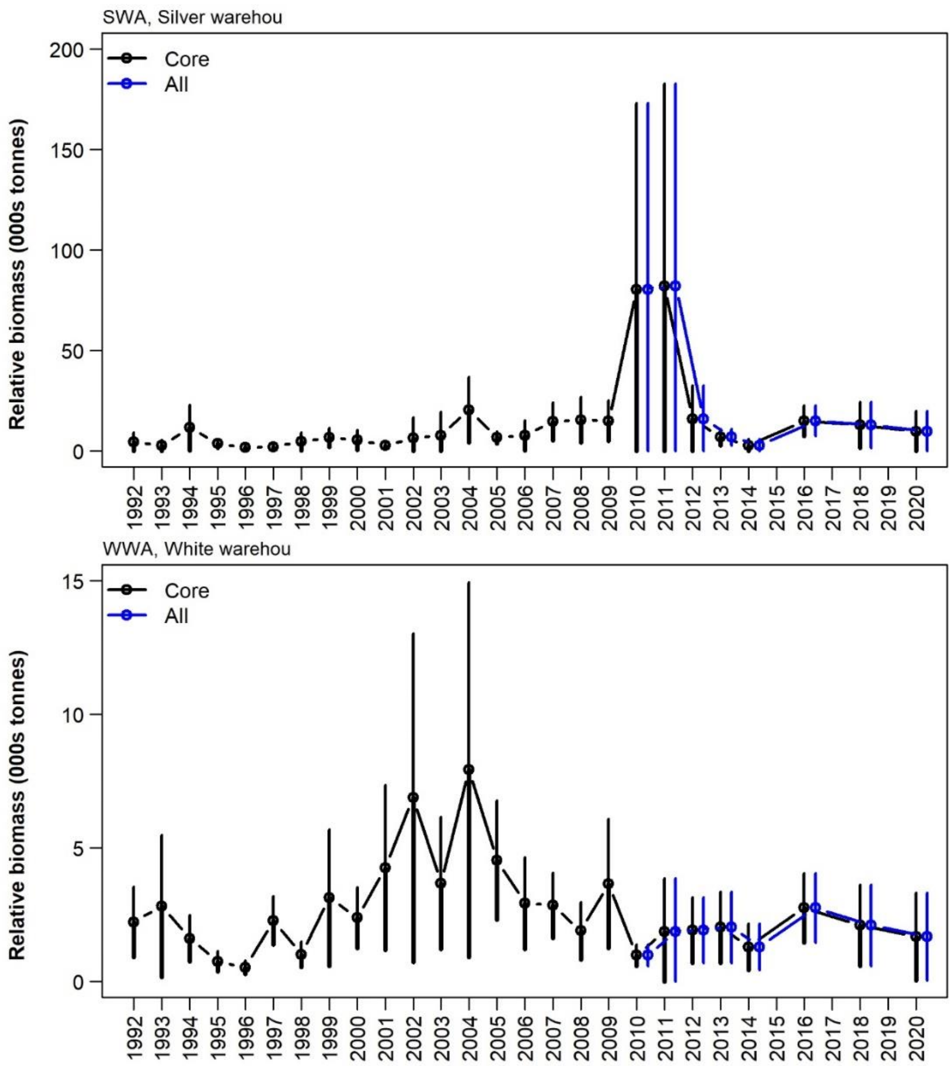


Figure 6a (continued)

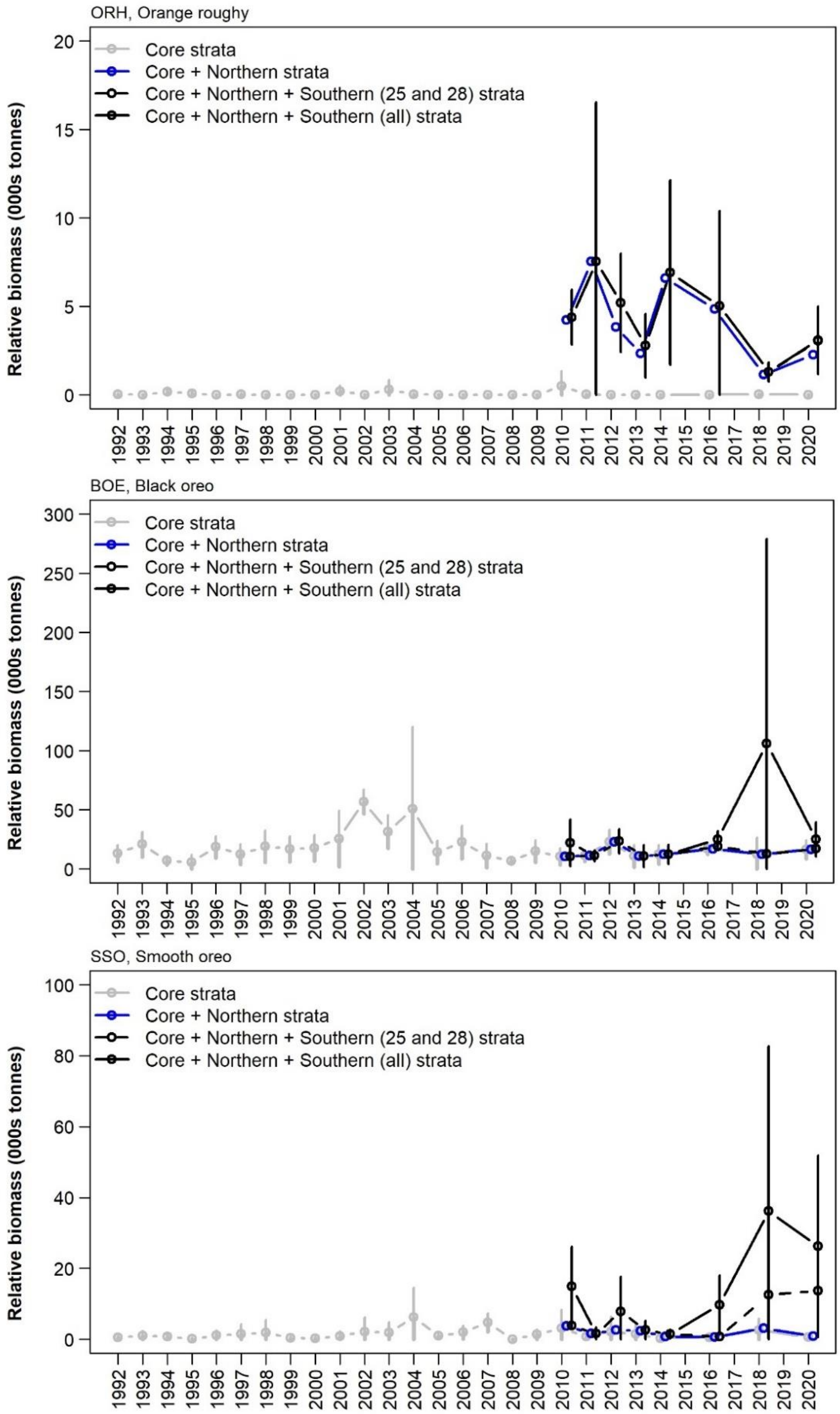


Figure 6b: Relative biomass estimates (thousands of tonnes) of orange roughy, black oreo, smooth oreo, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020. Grey lines show fish from core (200–800 m) strata. Blue lines show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

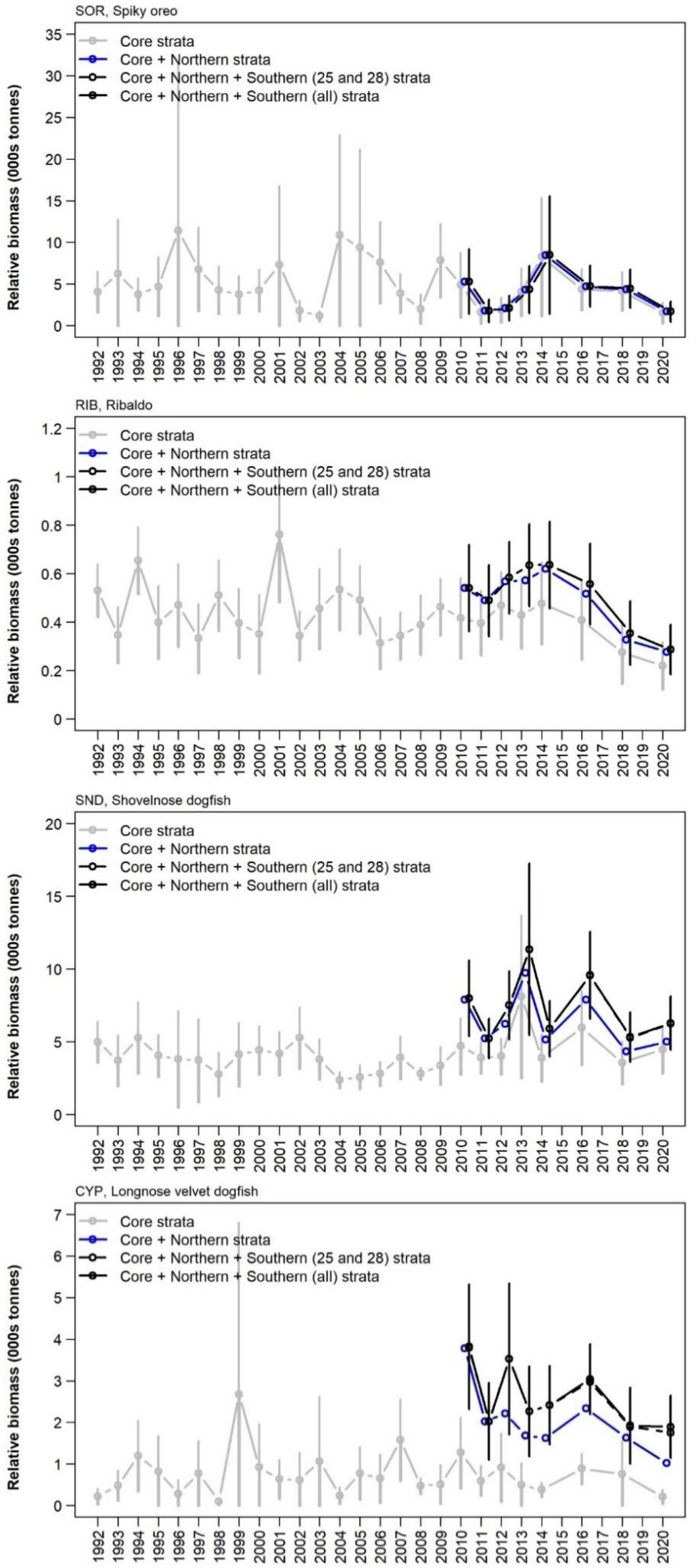
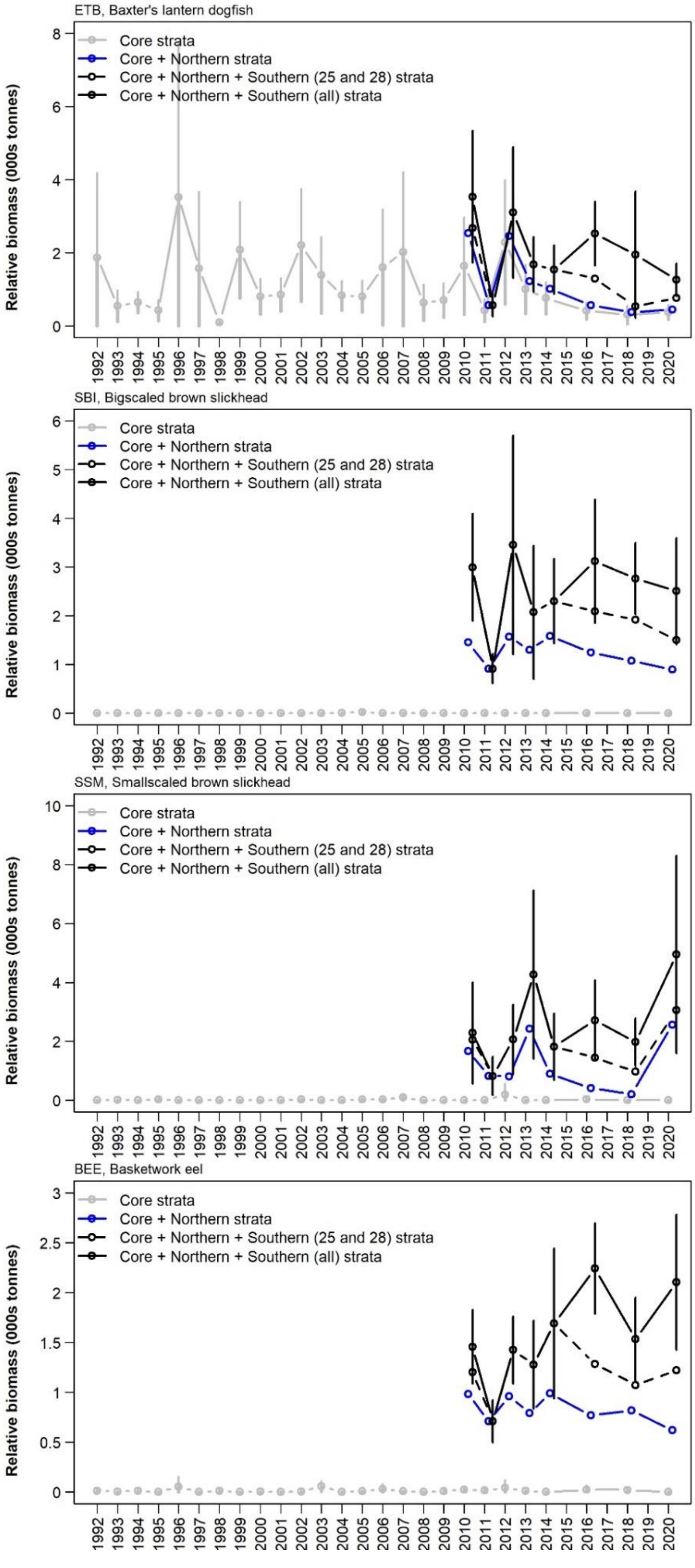


Figure 6b (continued)



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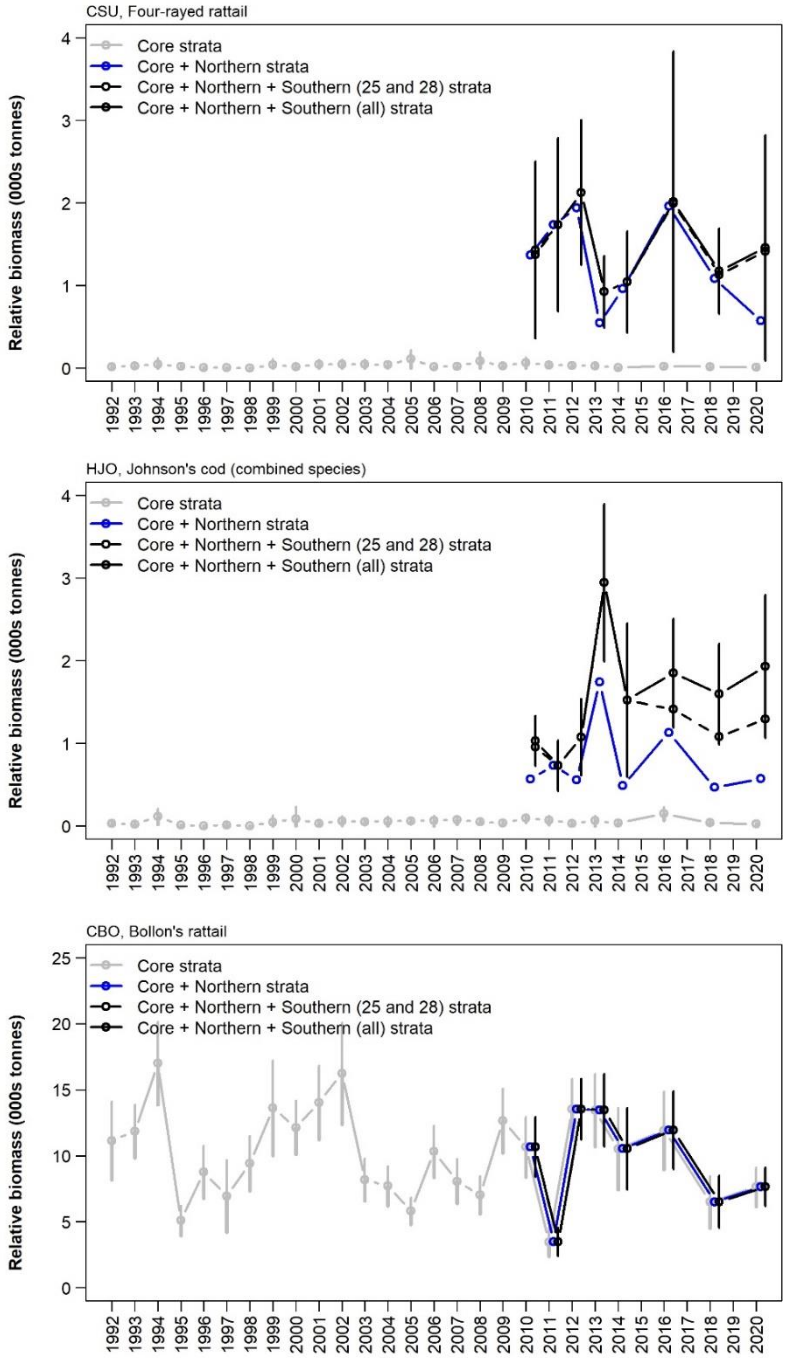

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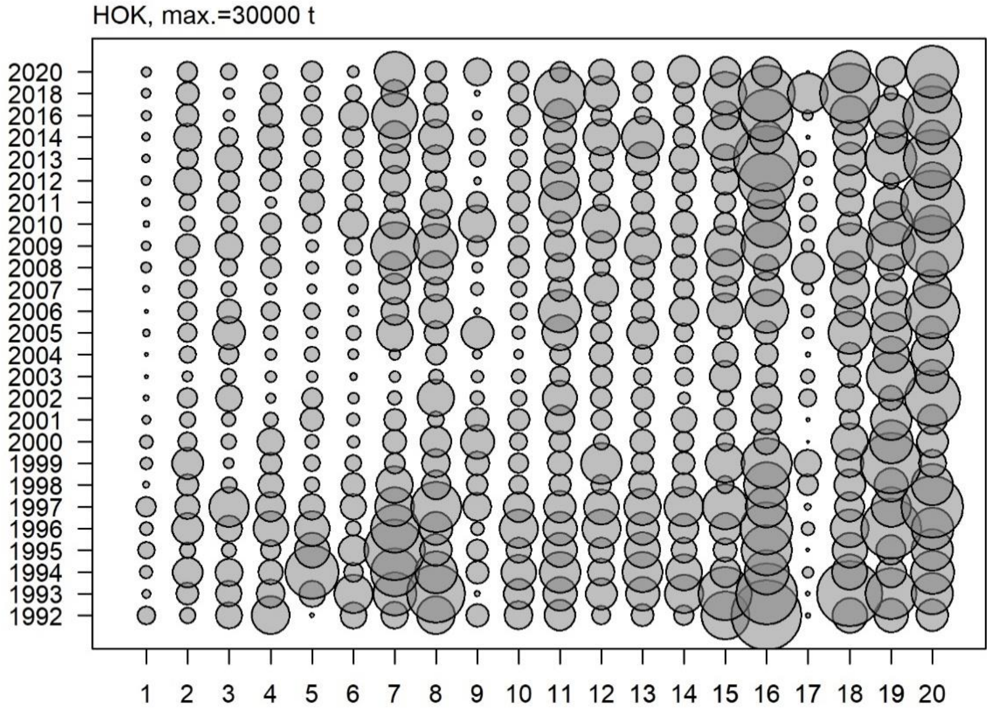


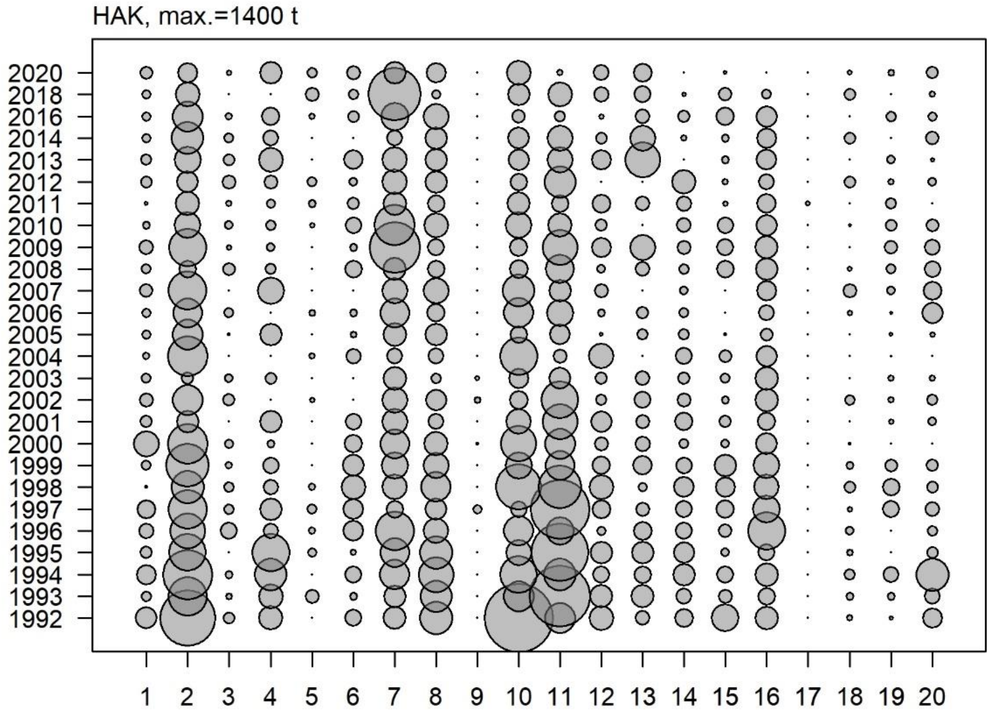
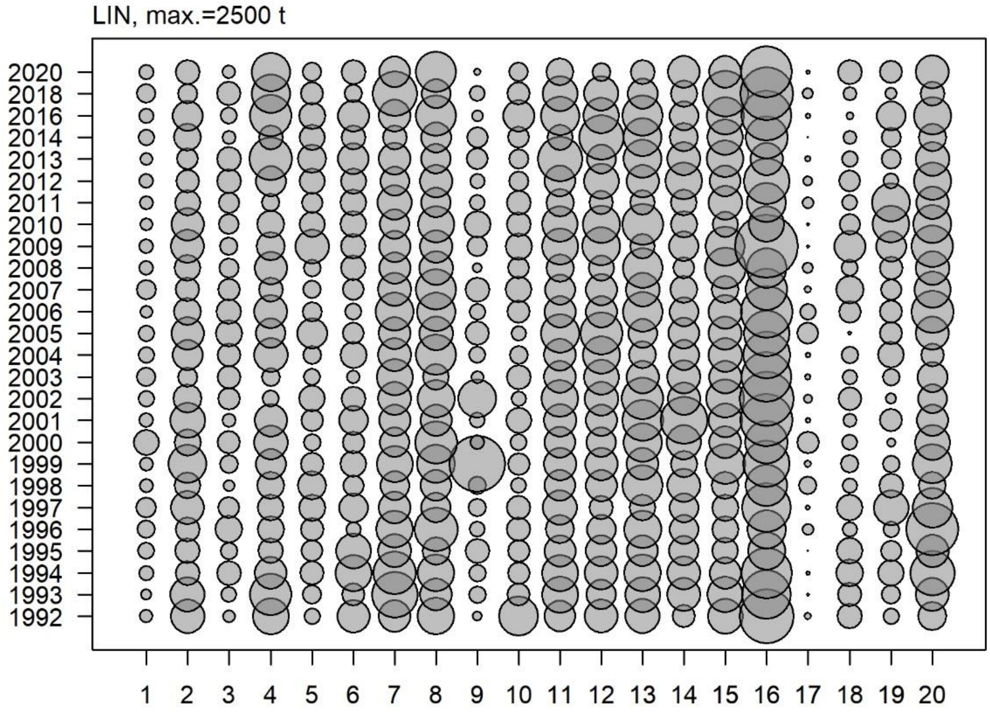
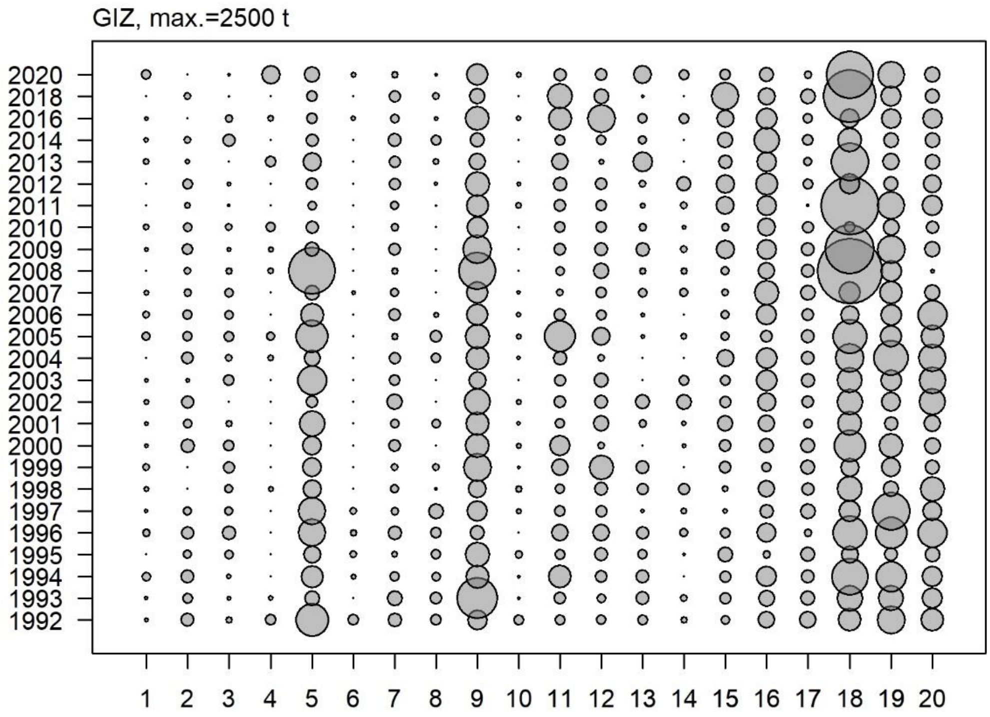


Figure 7a: Relative core (200–800 m) biomass estimates by stratum (1–20, x-axis) for hoki, and 8 other selected species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, 2016, 2016, and 2020.





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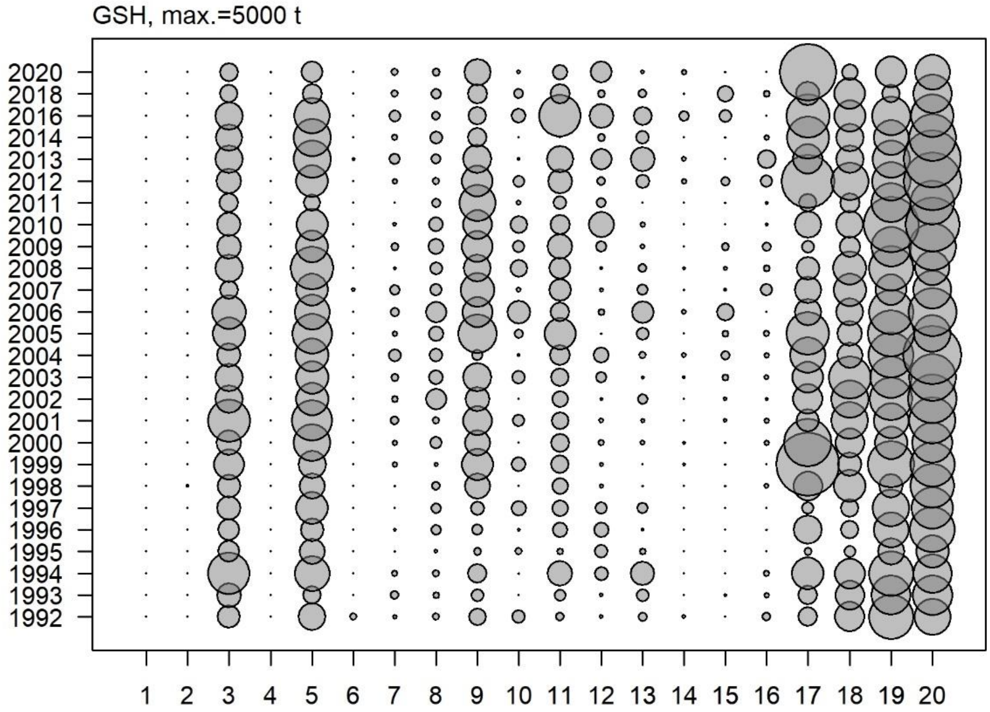

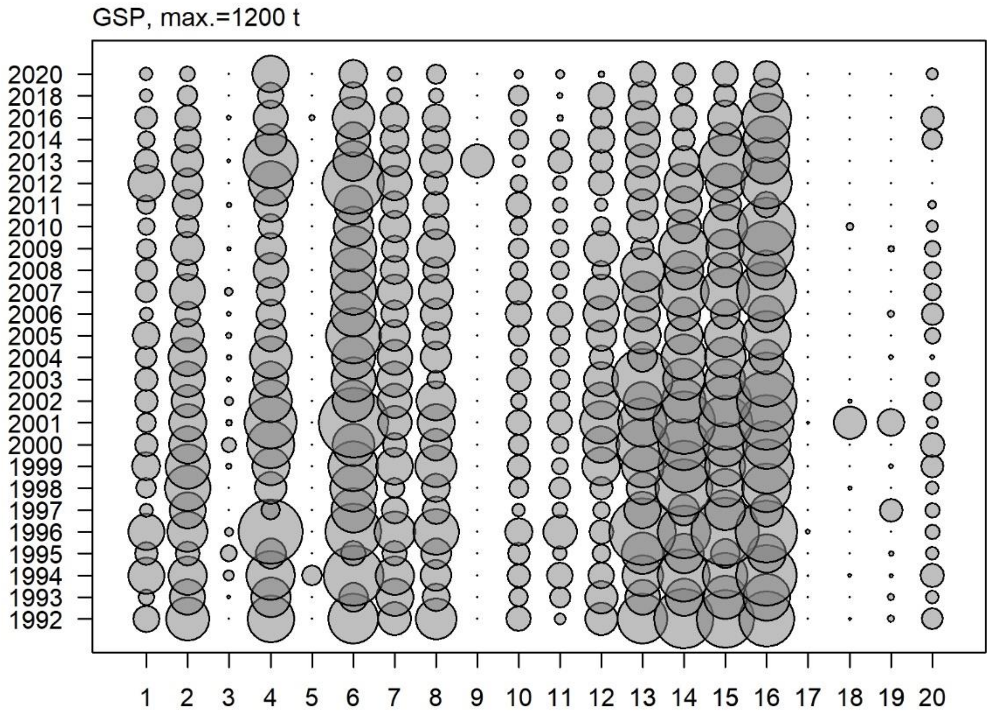

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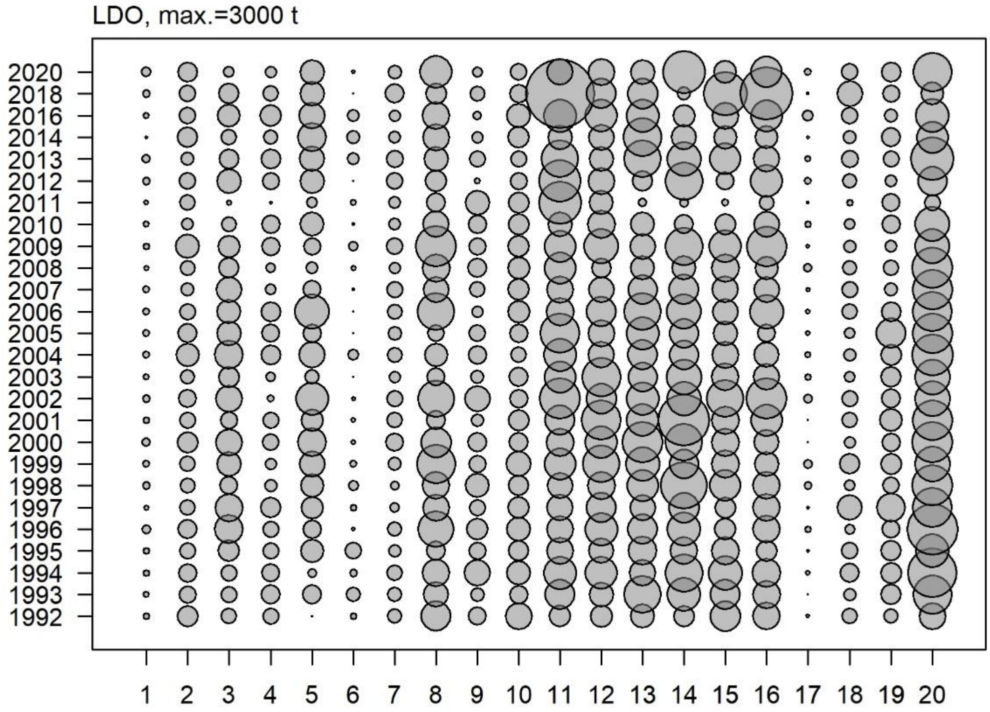

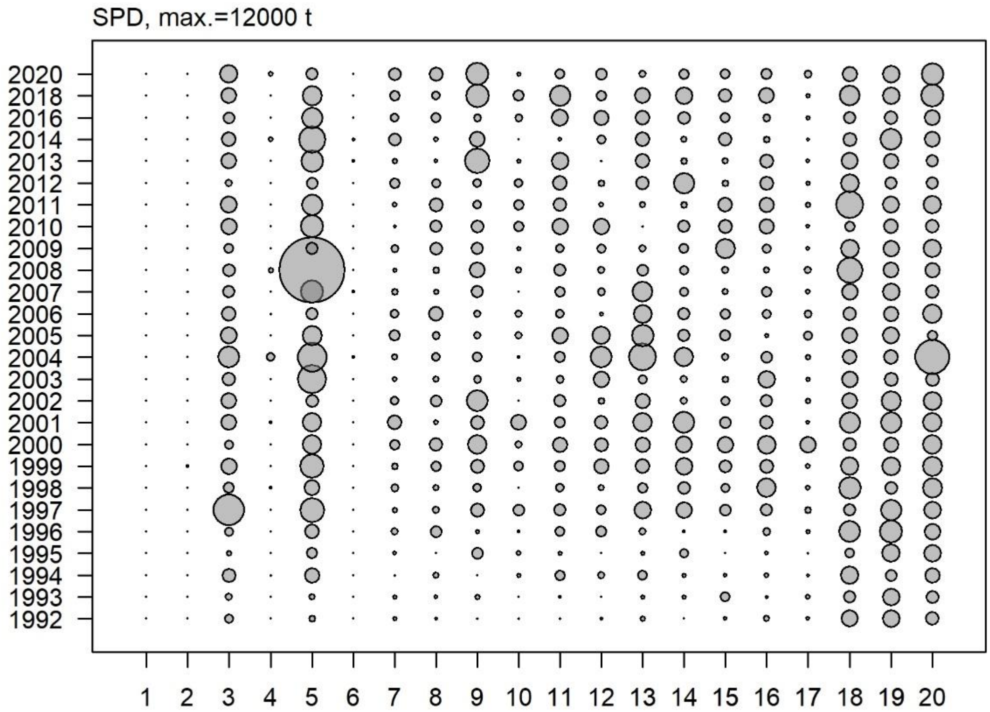

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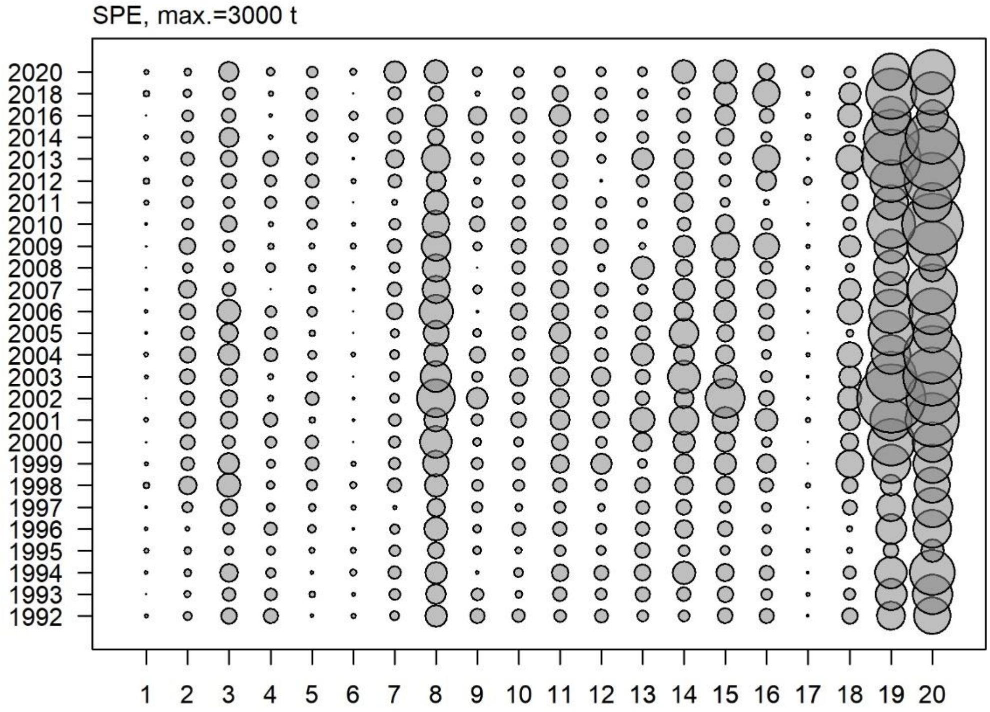

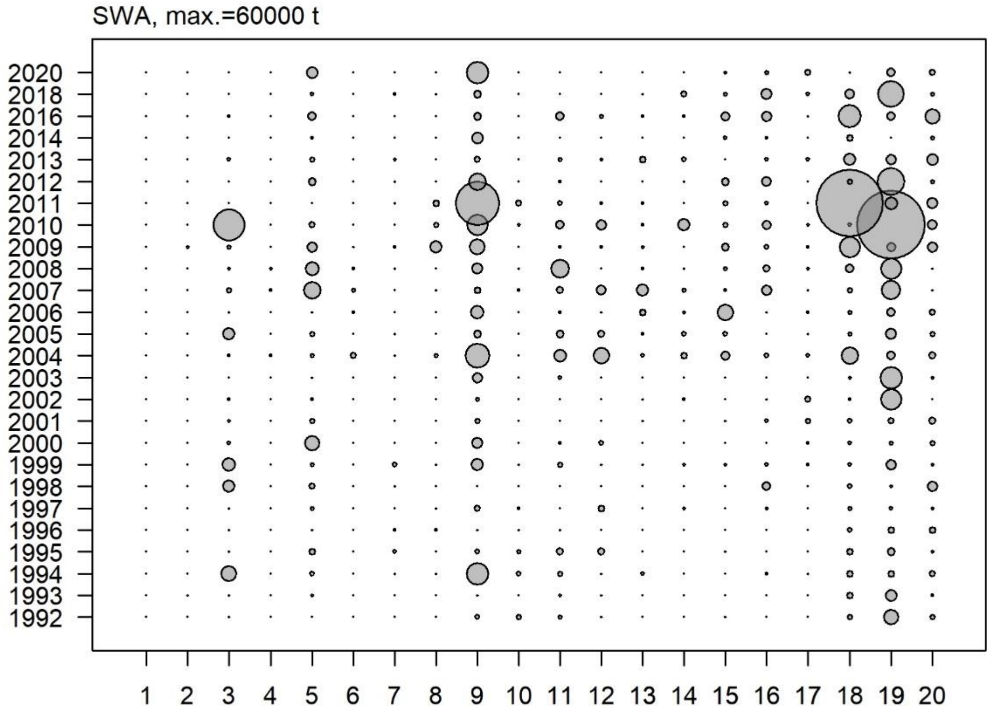

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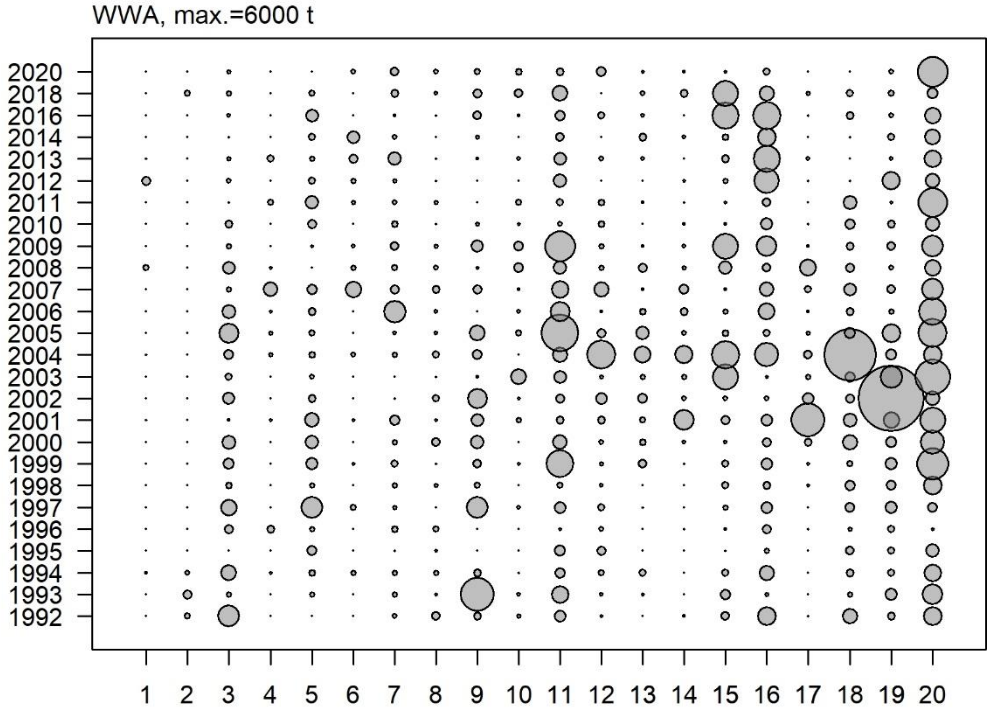

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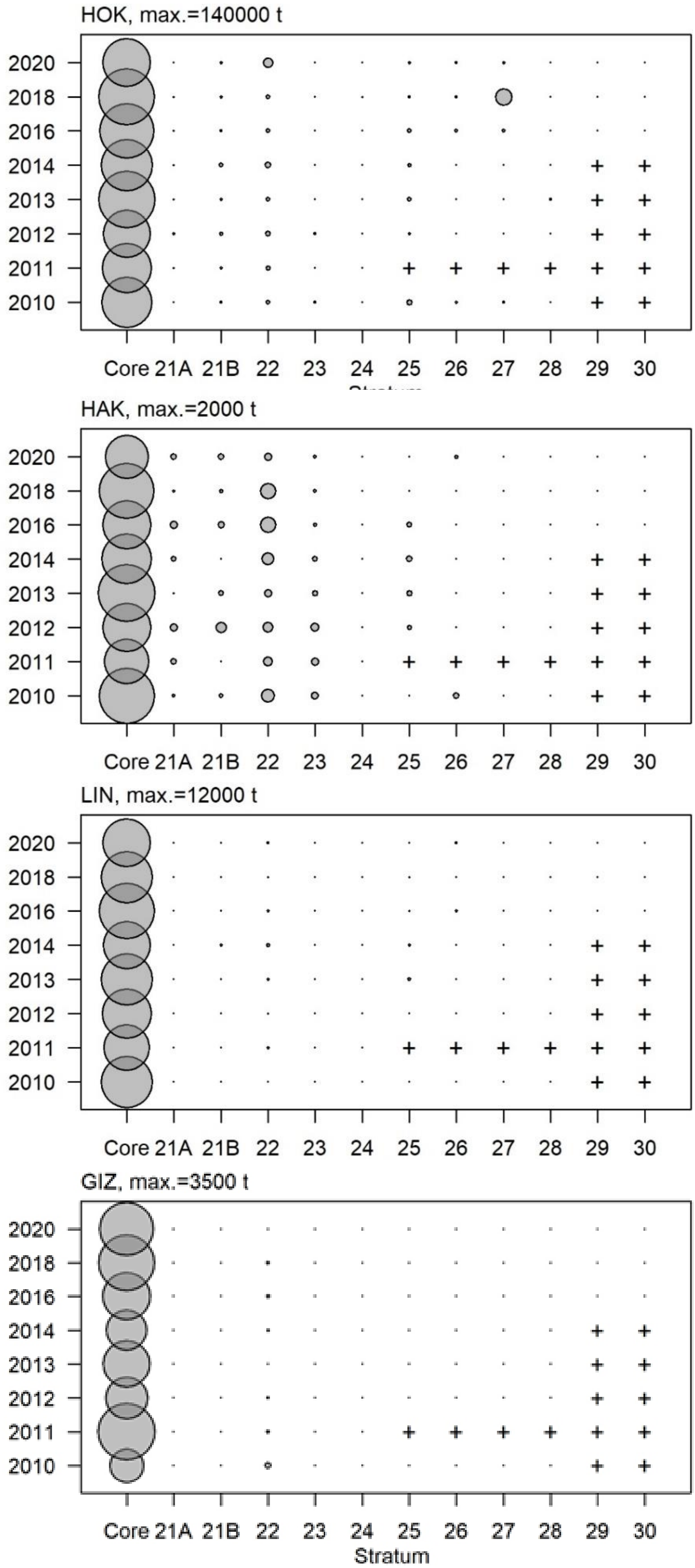
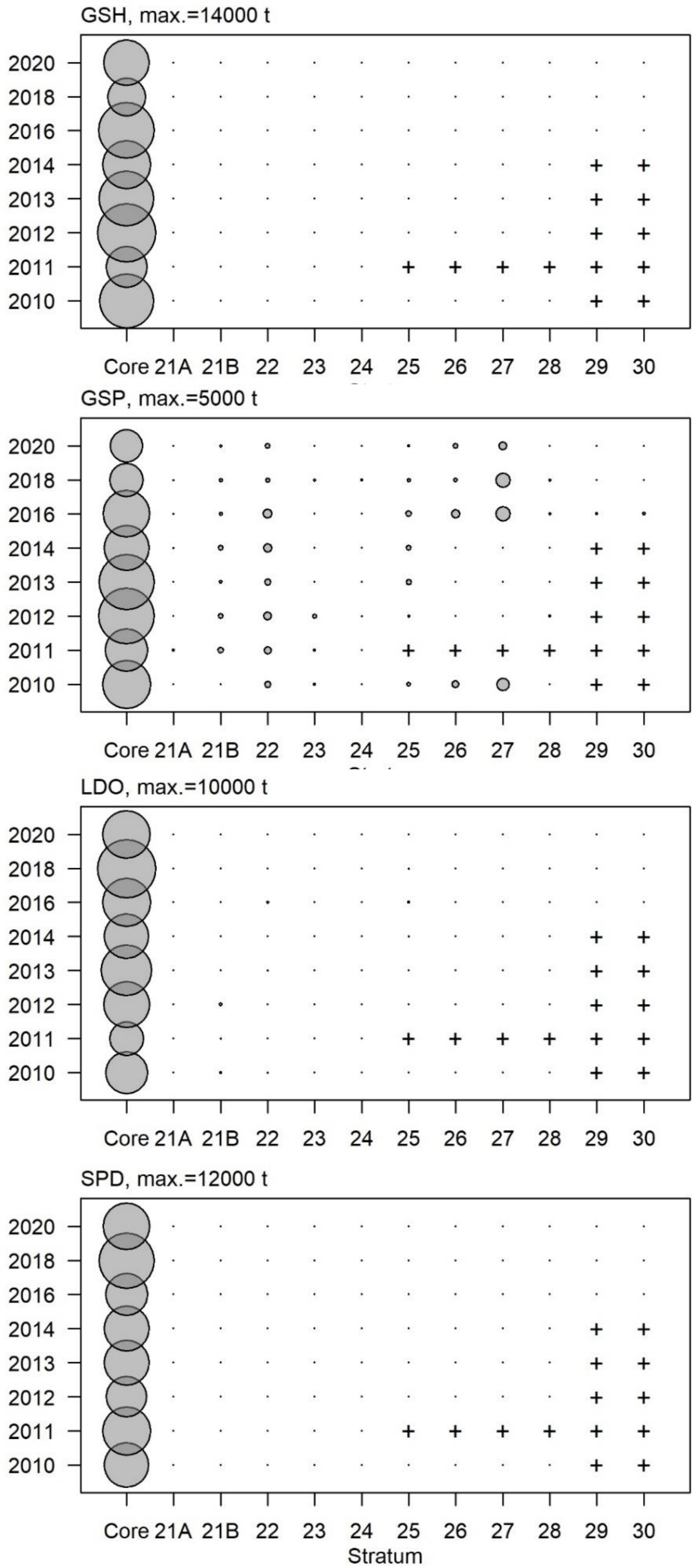


Figure 7b: Total core and deep (800–1300 m) relative biomass estimates by stratum for hoki and 8 other selected species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, 2016, 2018, and 2020. Cross indicates stratum not sampled. Cross indicates stratum not sampled.



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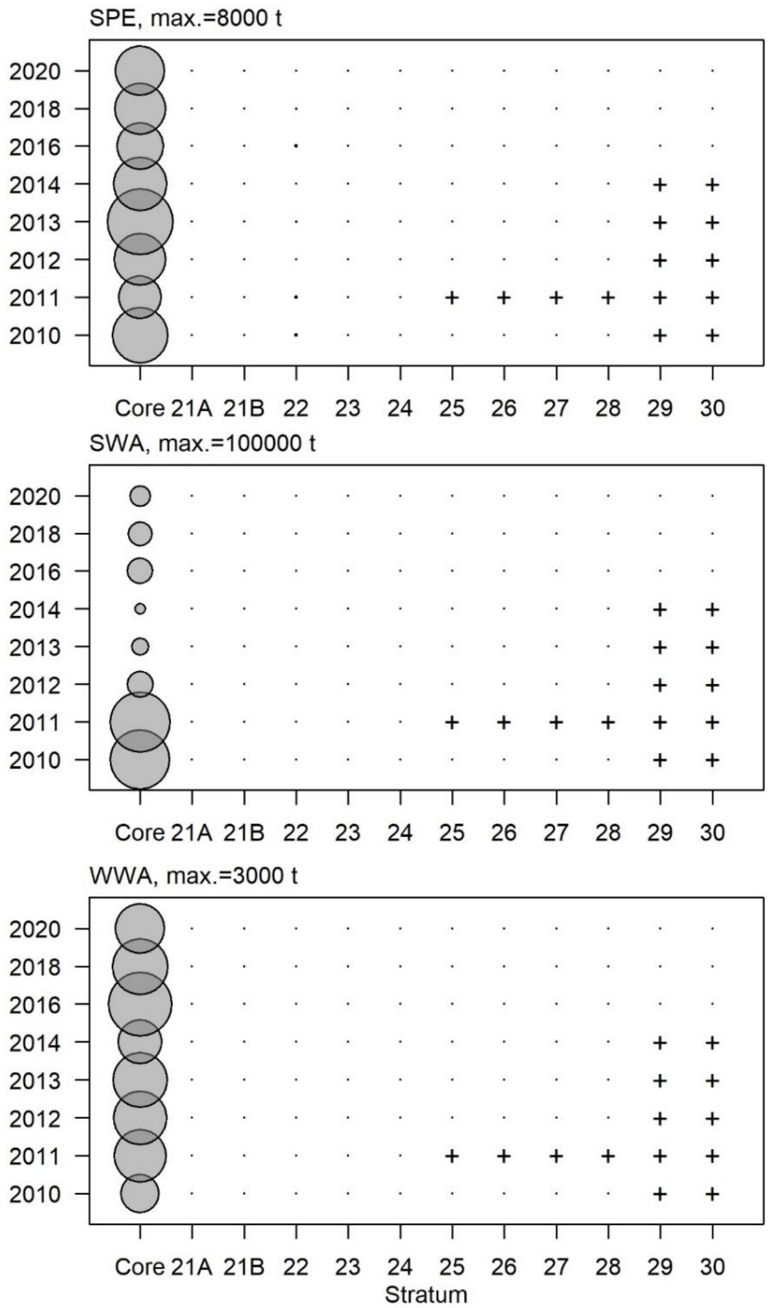

Figure 7b (continued)

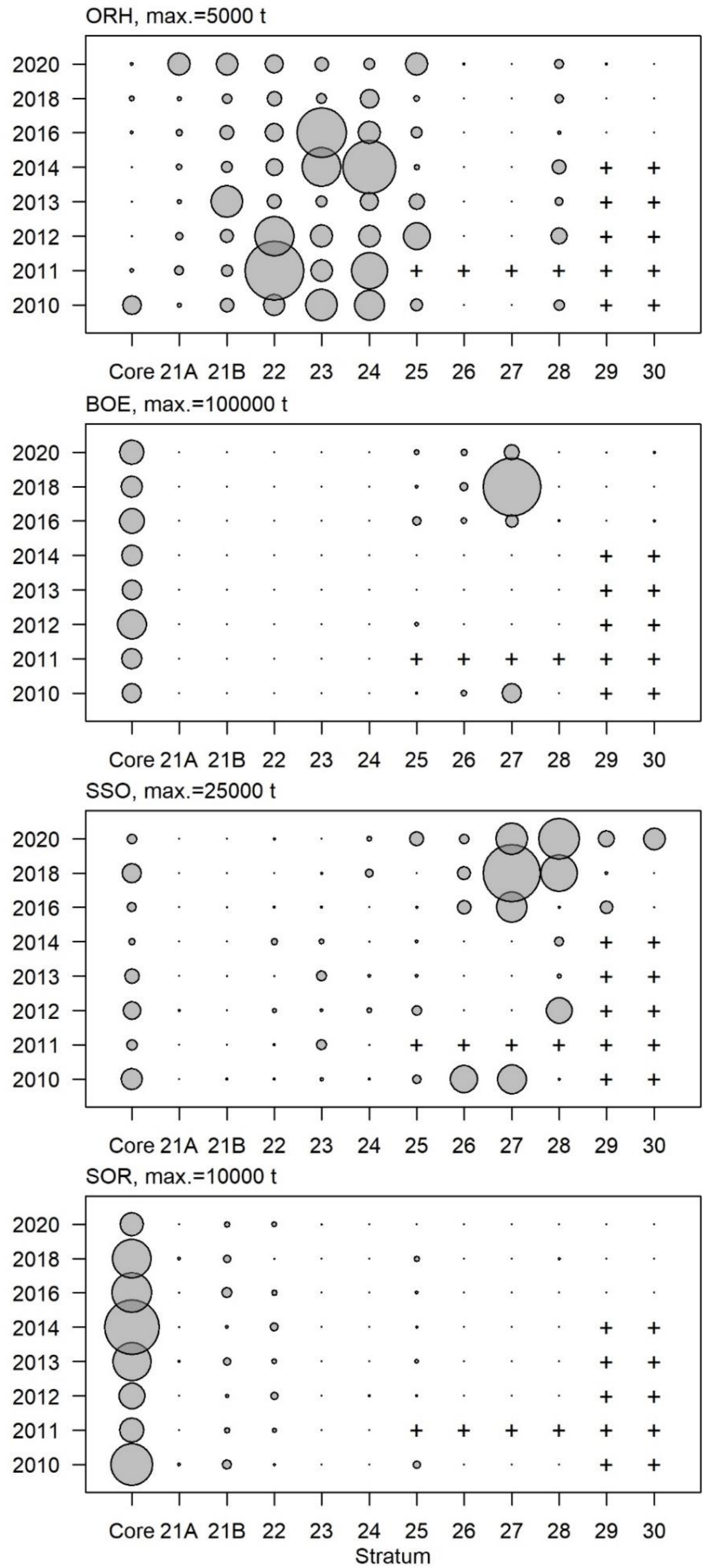

Figure 7c: Relative deep (800–1300 m) biomass estimates by strata for orange roughy, oreo species, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, 2016, 2018, and 2020. Cross indicates stratum not sampled

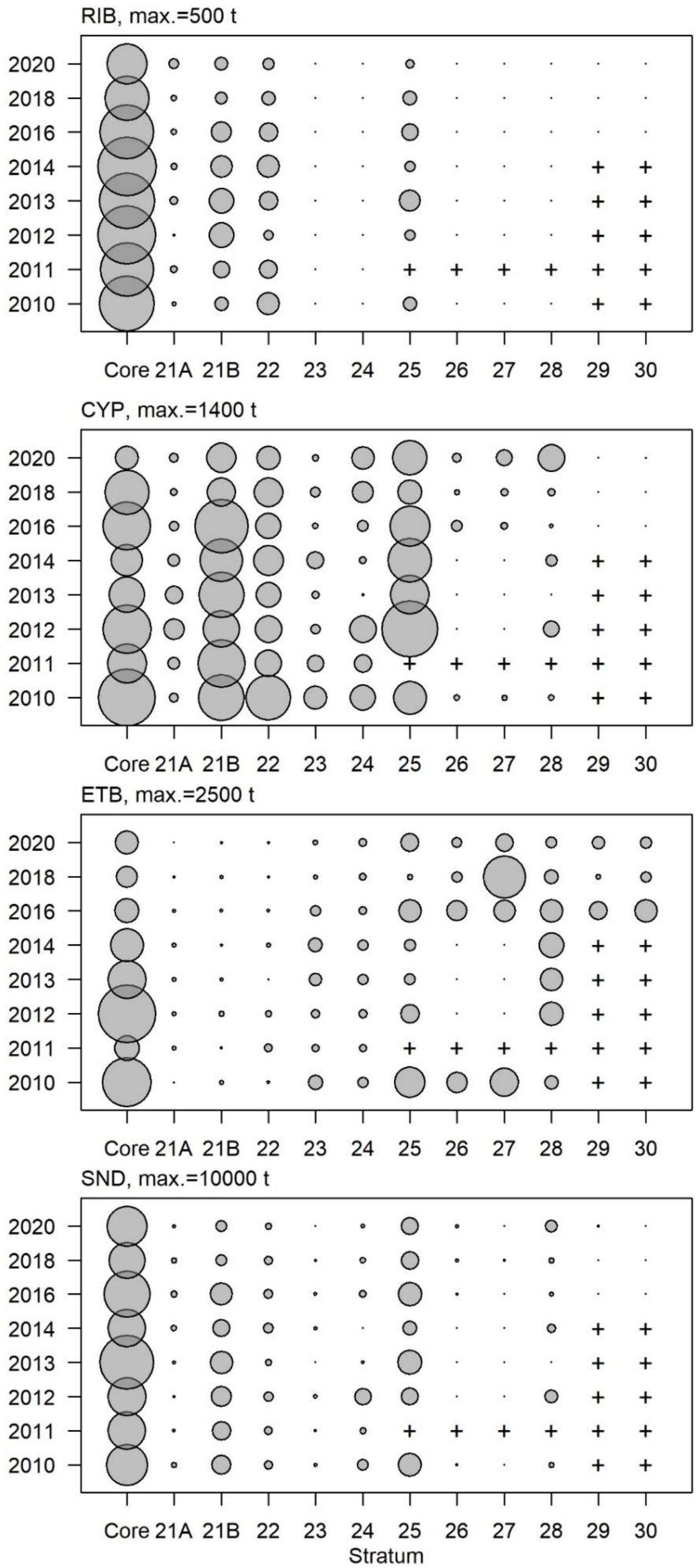

Figure 7c (continued)

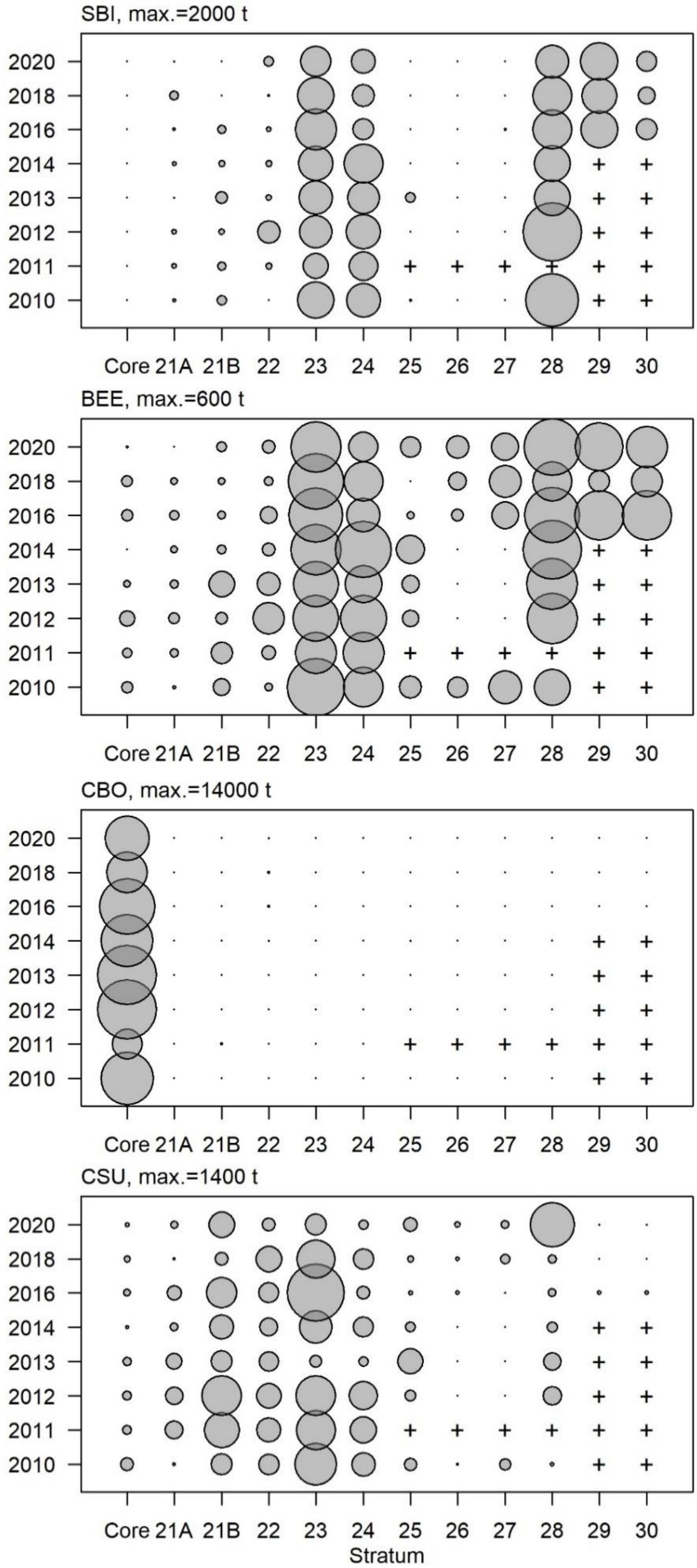

Figure 7c (continued)

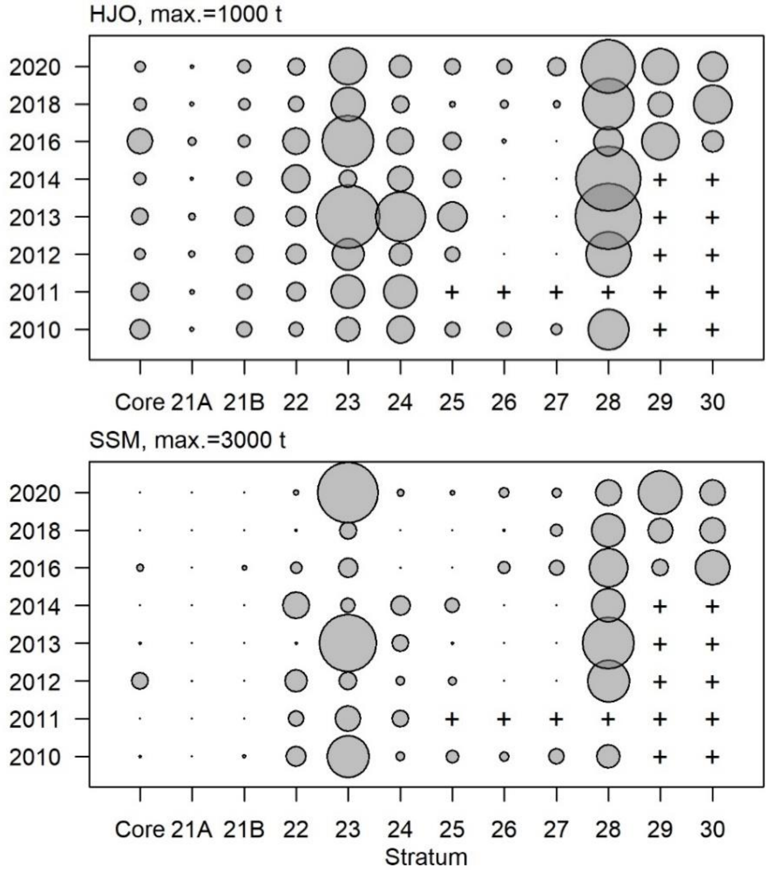

Figure 7c (continued)

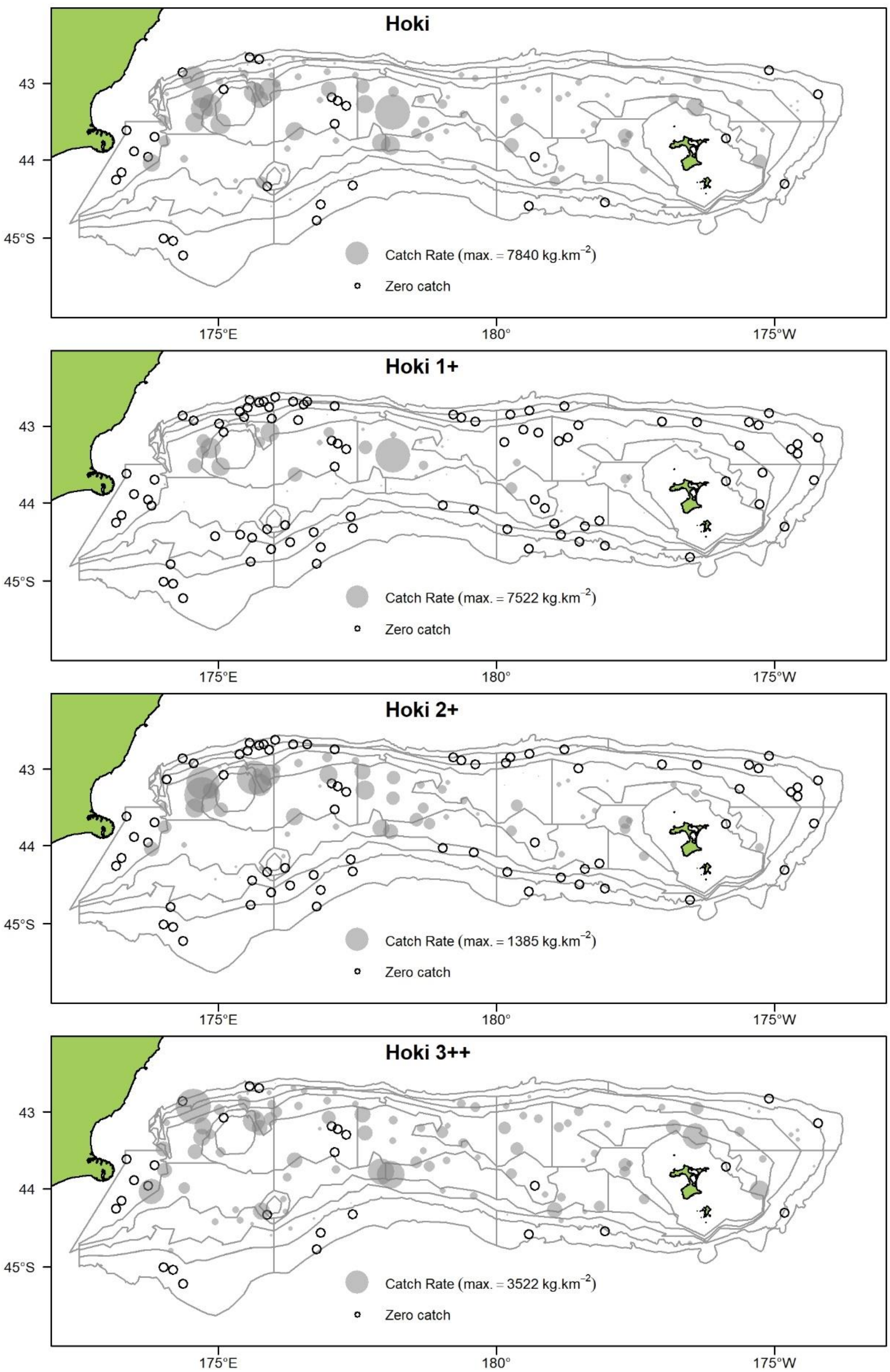

Figure 8a: Hoki 1+, 2+, 3++ age class (year) and total catch distribution in 2020. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate (max.) is shown on each plot.

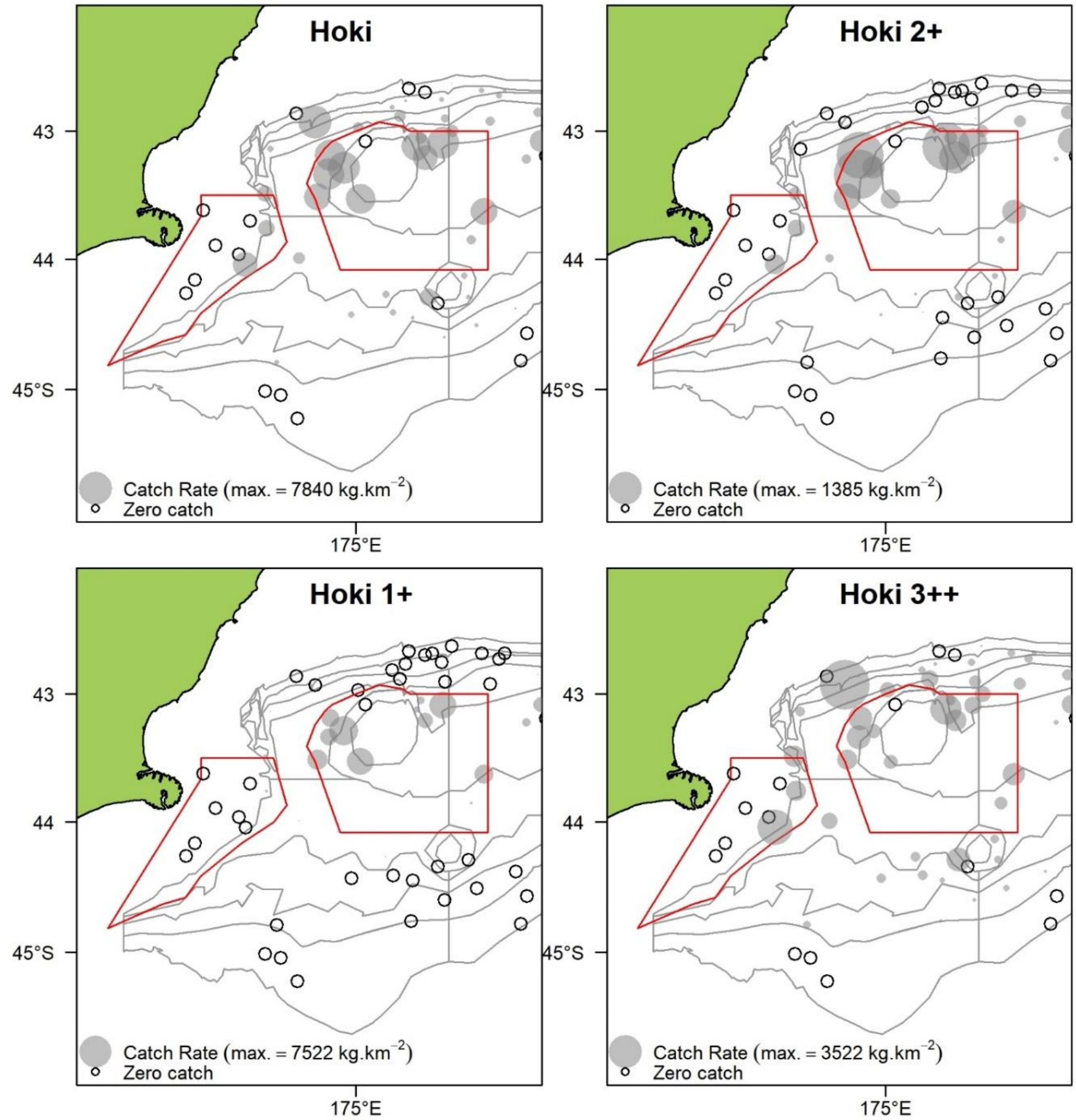

Figure 8b: Catch distribution of 1+, 2+, 3++ age class (year) and all hoki on the western Chatham Rise in 2020. Red polygons are boundary for Canterbury Banks and Mernoo Hoki Management areas (HMA's). The Mernoo HMA is entirely within the core trawl survey area. The Canterbury Banks HMA extends west of the core survey area. 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.

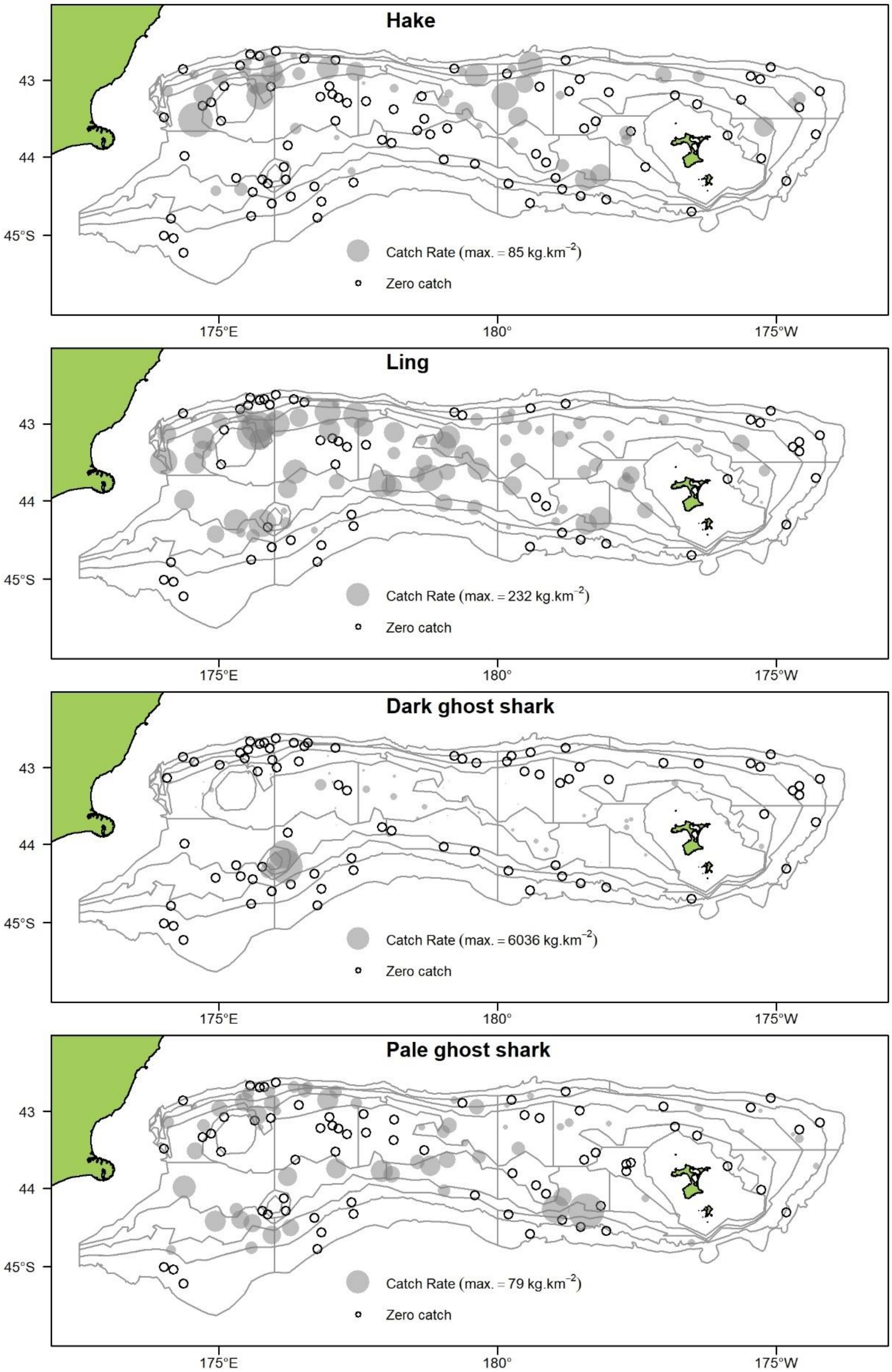

Figure 9: Catch rates (kg km^{-2}) of selected core and deepwater commercial and bycatch species in 2020. Filled circle area is proportional to catch rate. Open circles are zero catch. max., maximum catch rate.

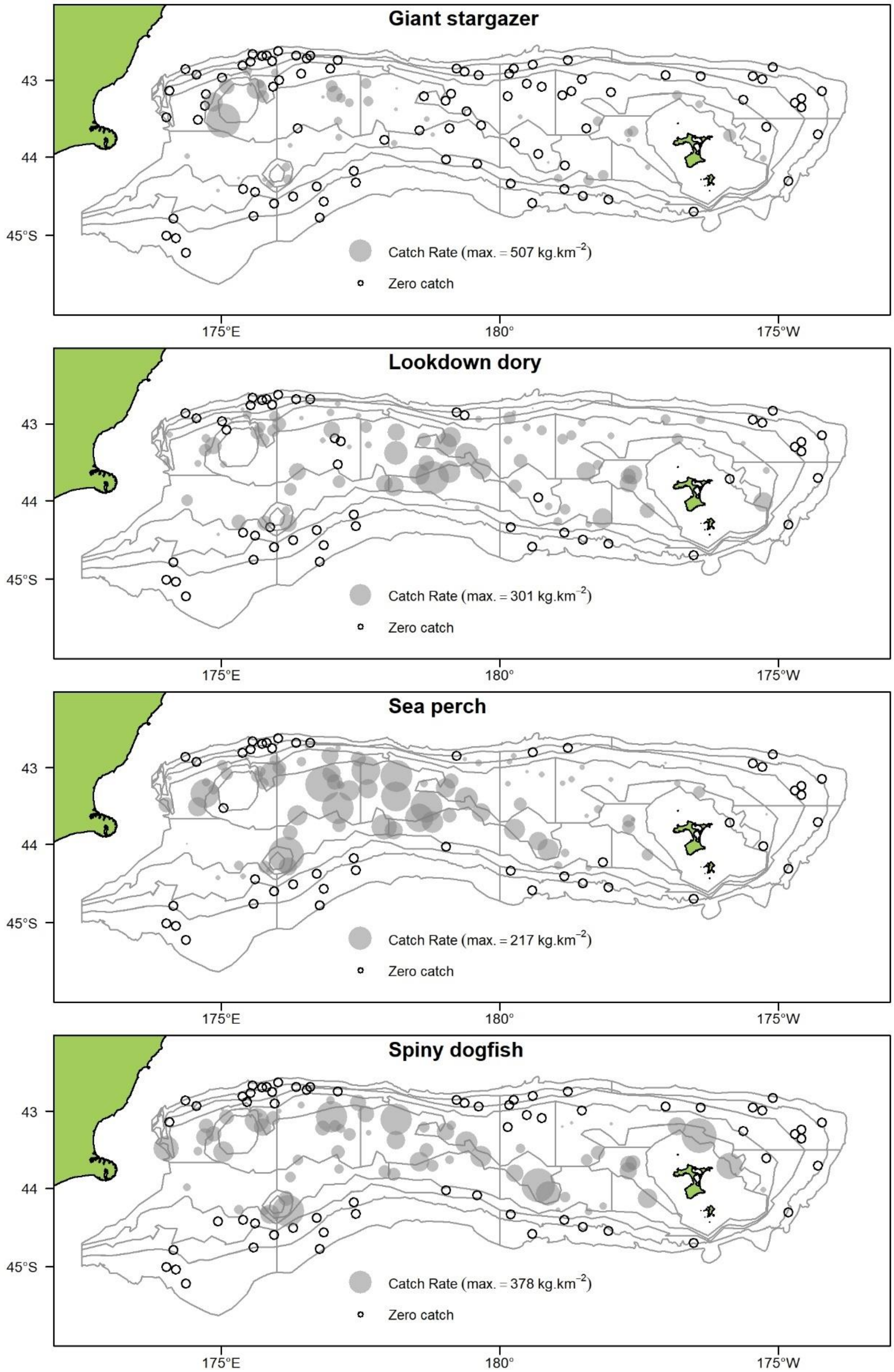

Figure 9 (continued)

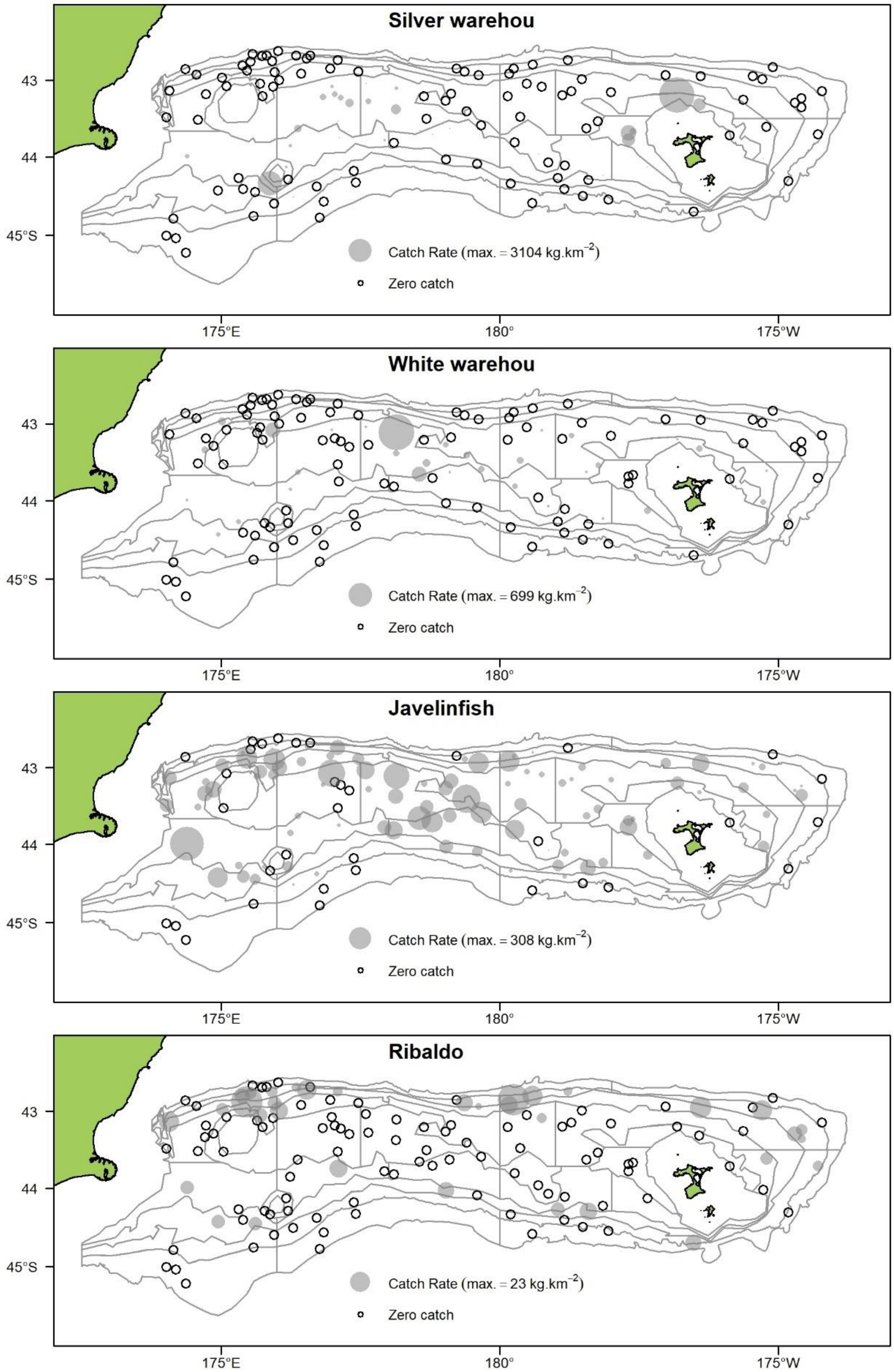

Figure 9 (continued)

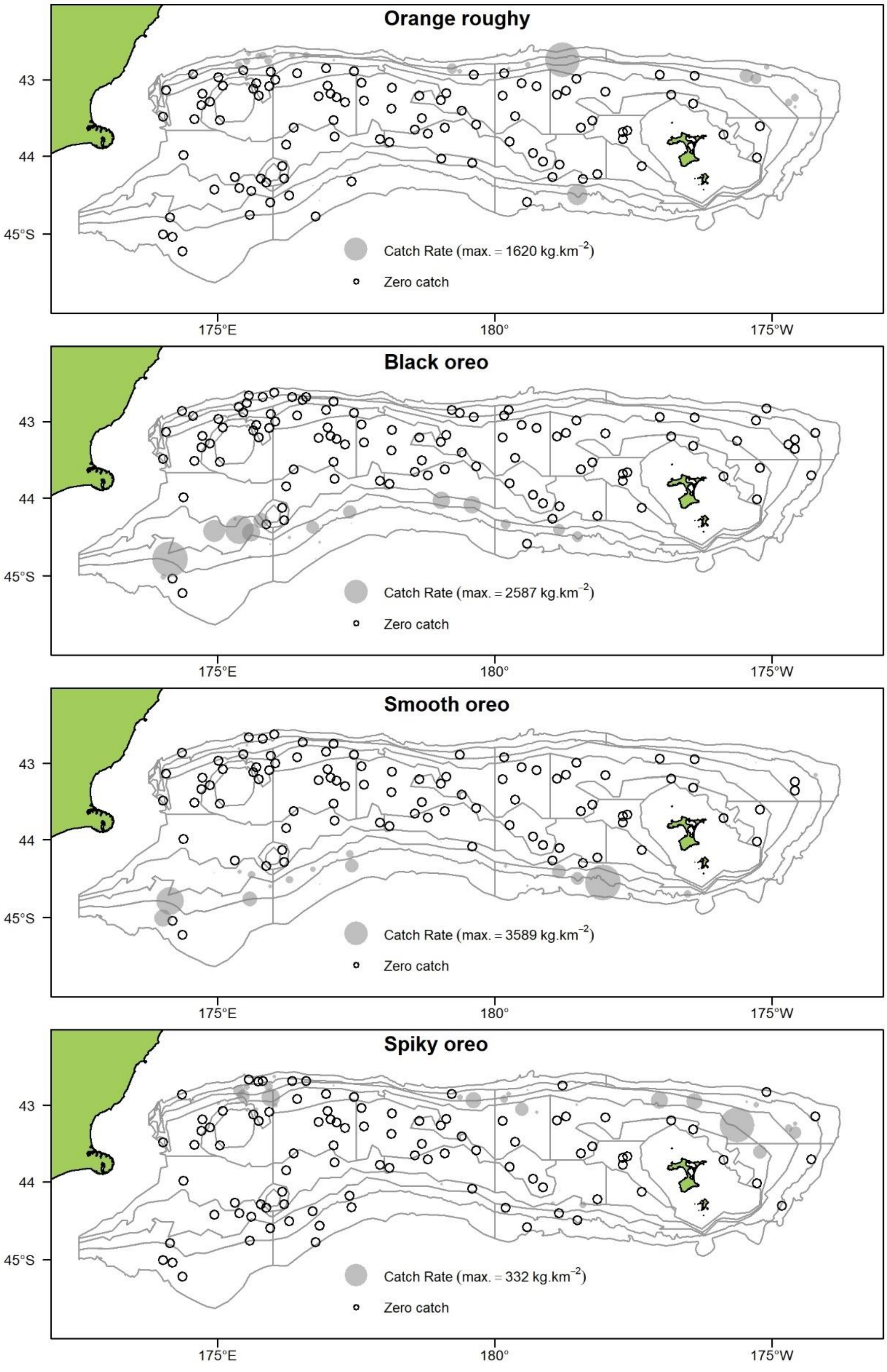

Figure 9 (continued)

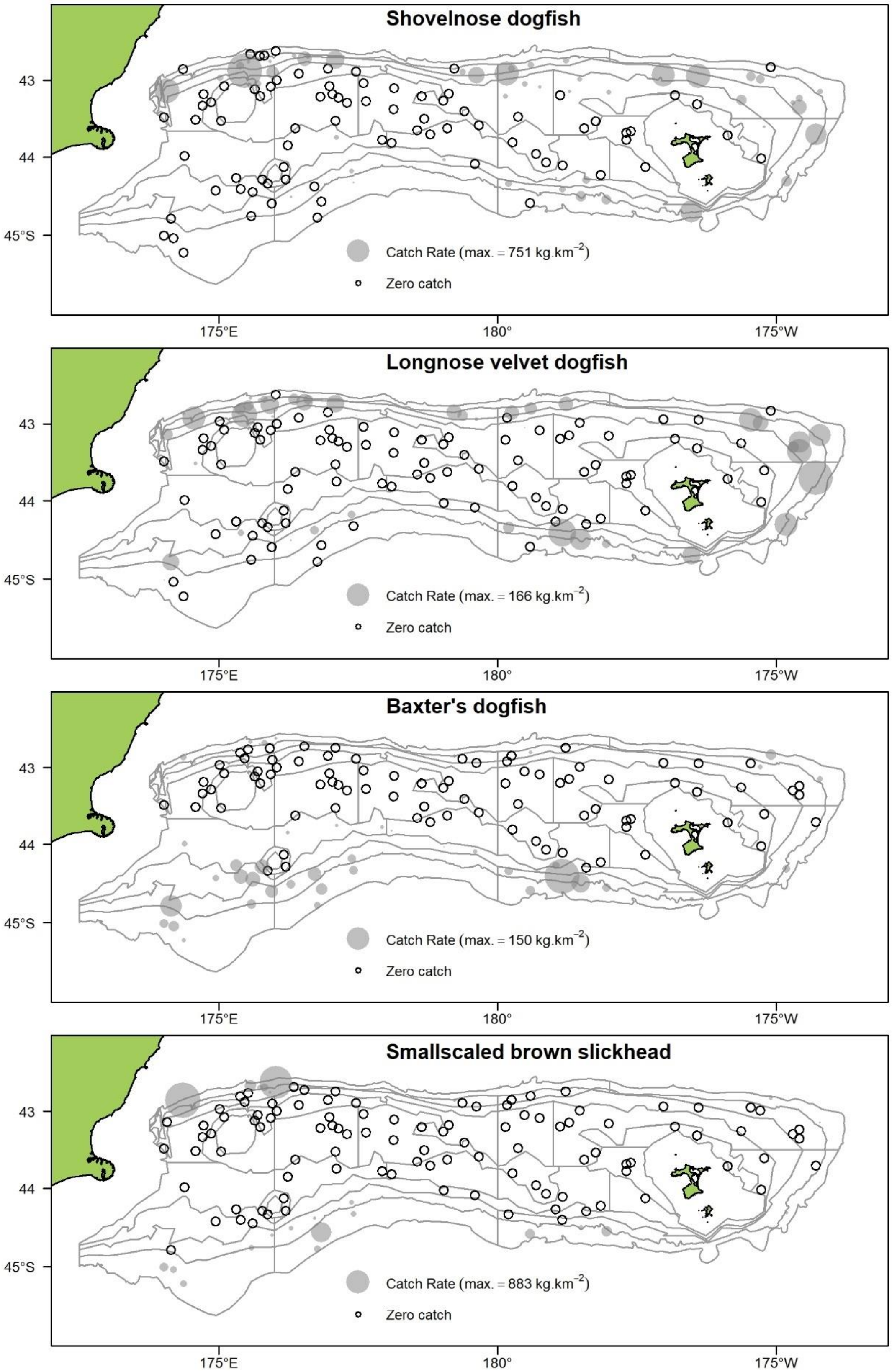

Figure 9 (continued)

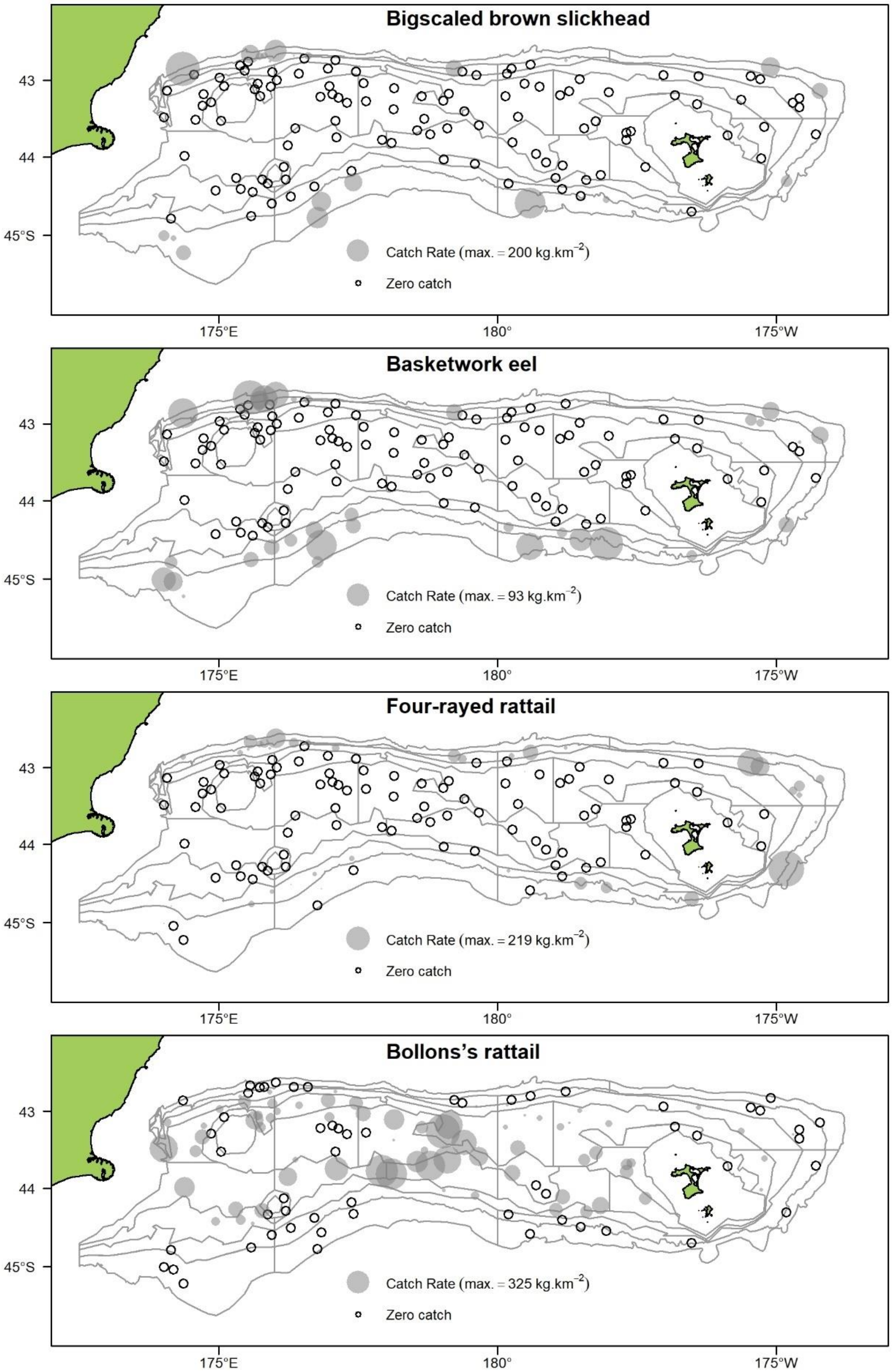

Figure 9 (continued)

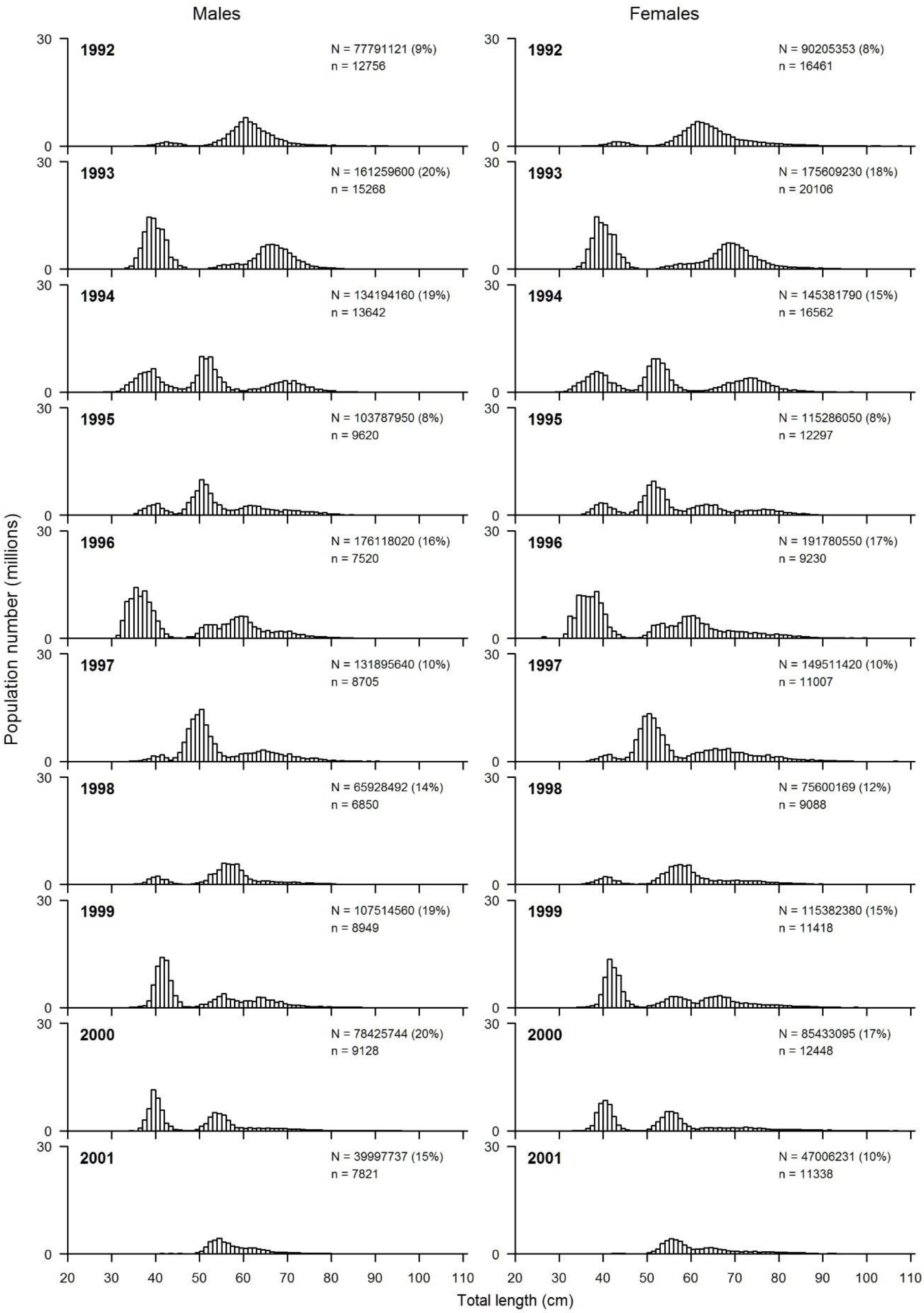

Figure 10: Estimated length frequency distributions of the male and female hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020 for core strata. N, estimated population number of male hoki (left panel) and female hoki (right panel); CV (in parentheses),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

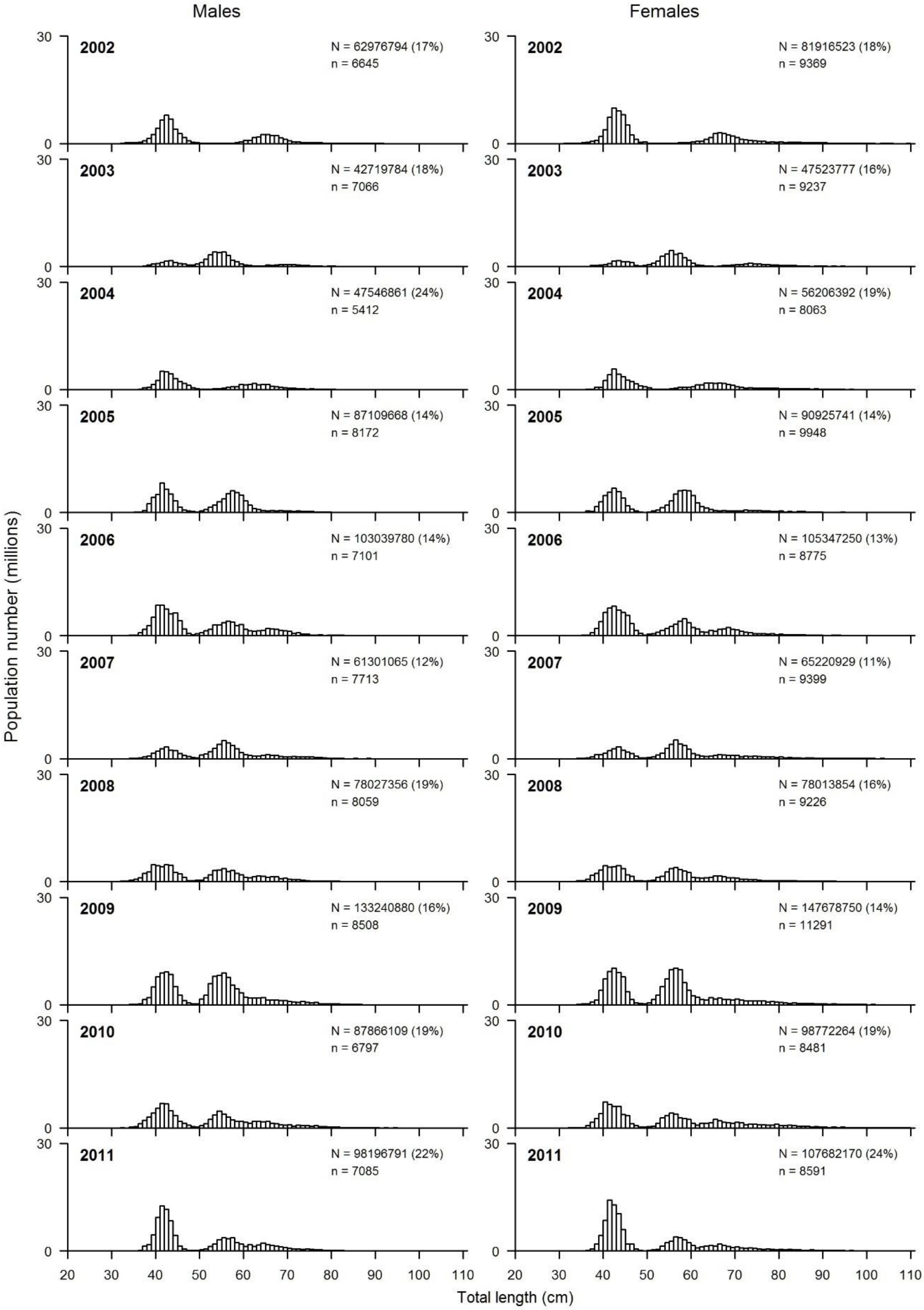

Figure 10 (continued)

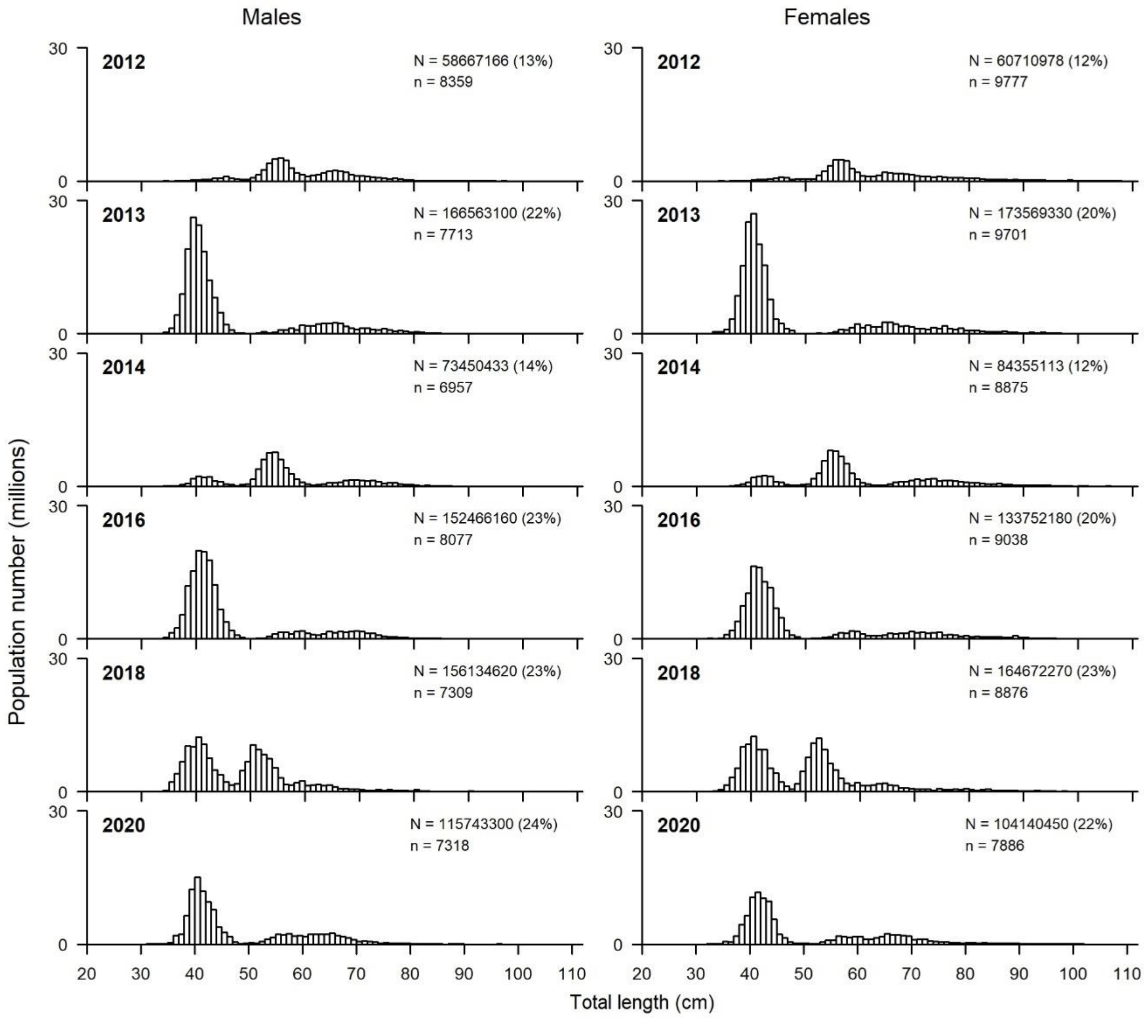

Figure 10 (continued)

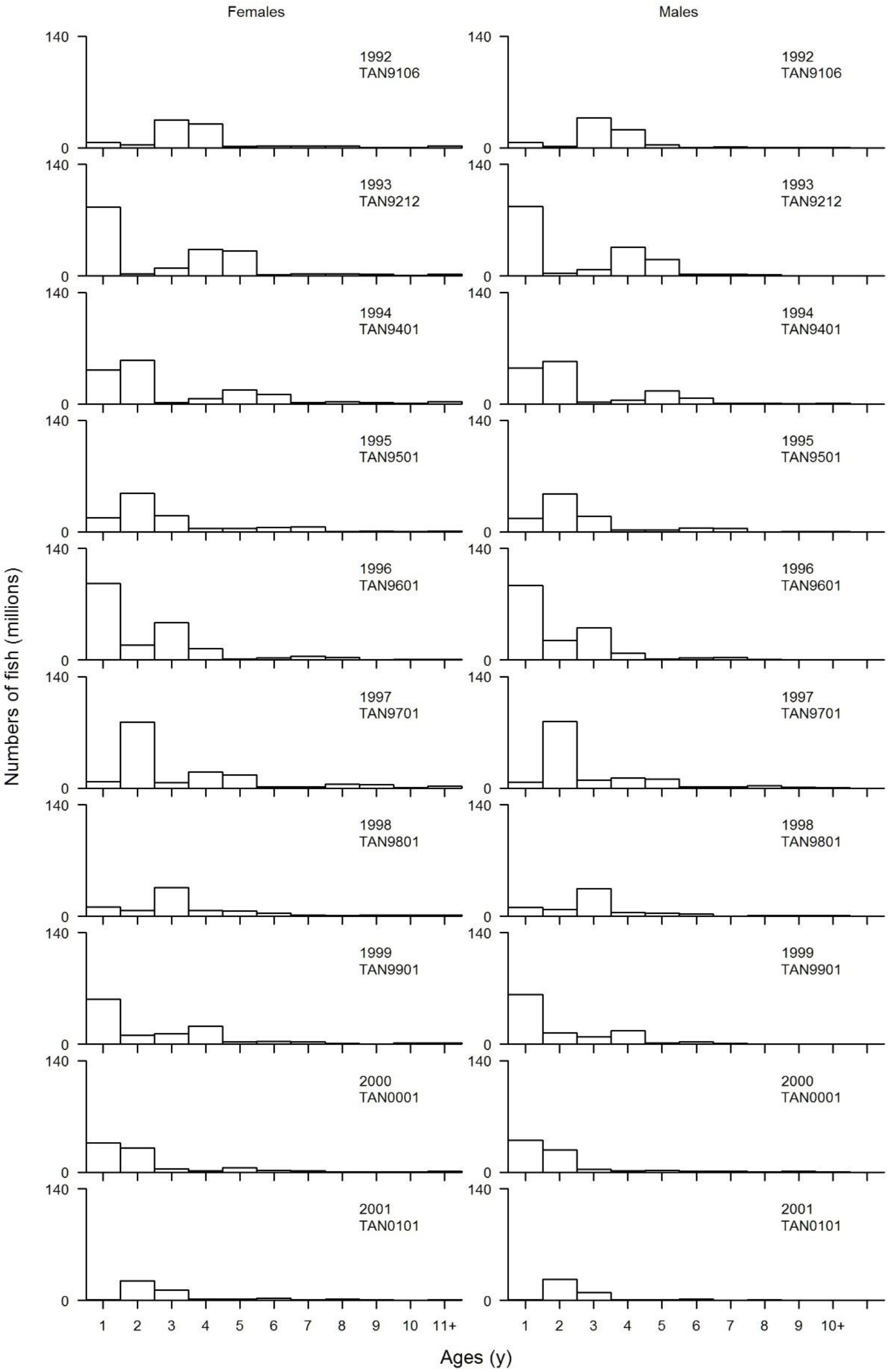

Figure 11: Estimated population numbers-at-age for hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, 2016, 2018, and 2020. +, indicates plus group of combined ages.

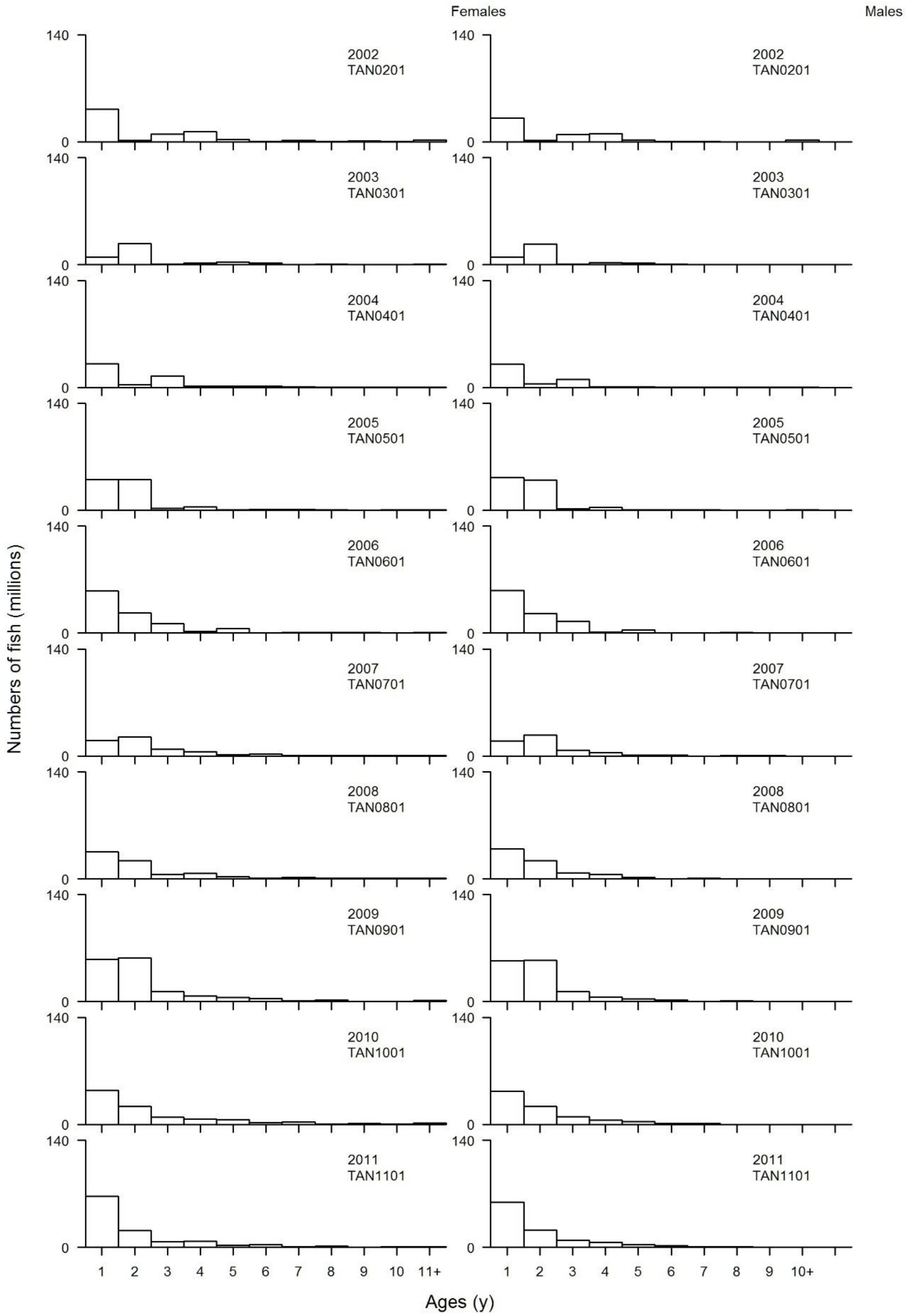

Figure 11 (continued)

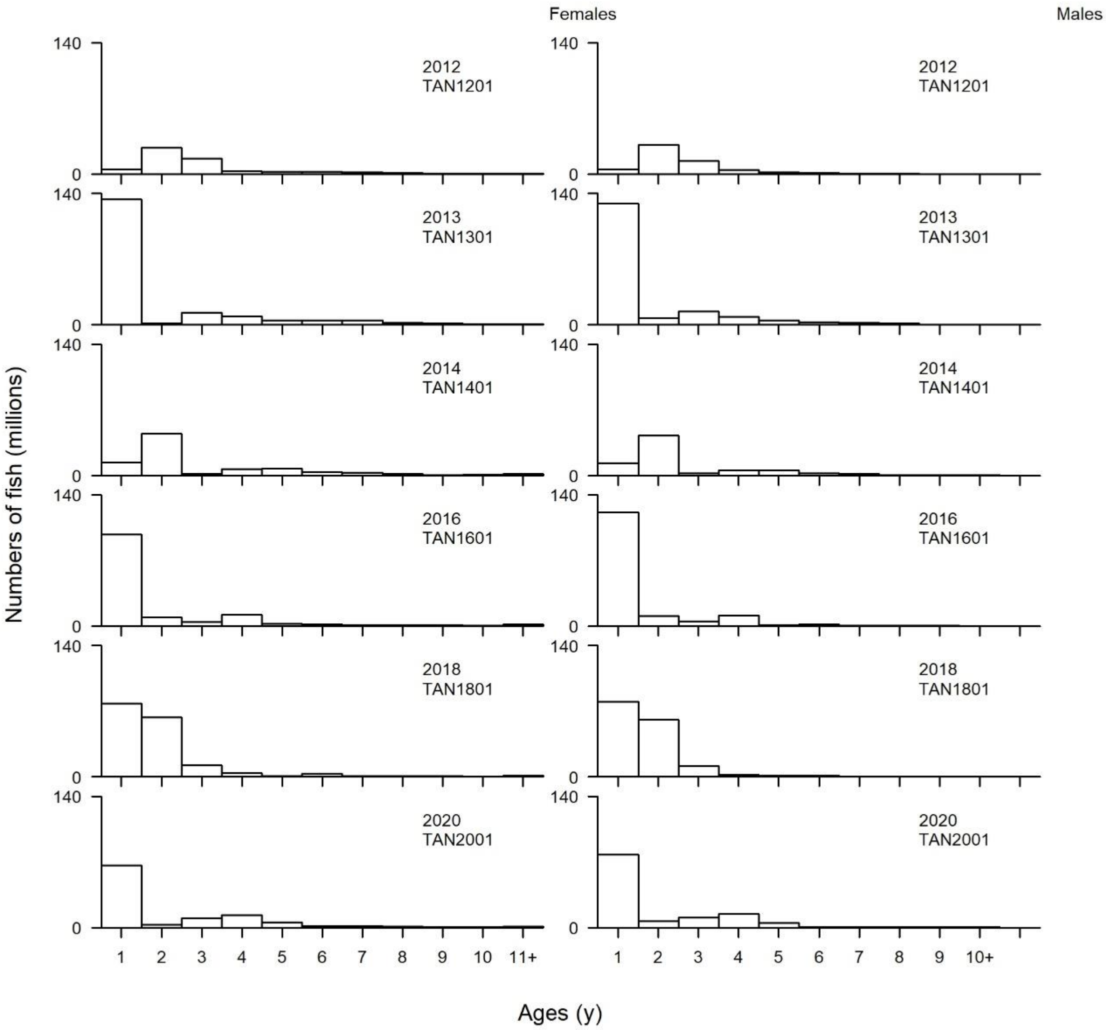

Figure 11 (continued)

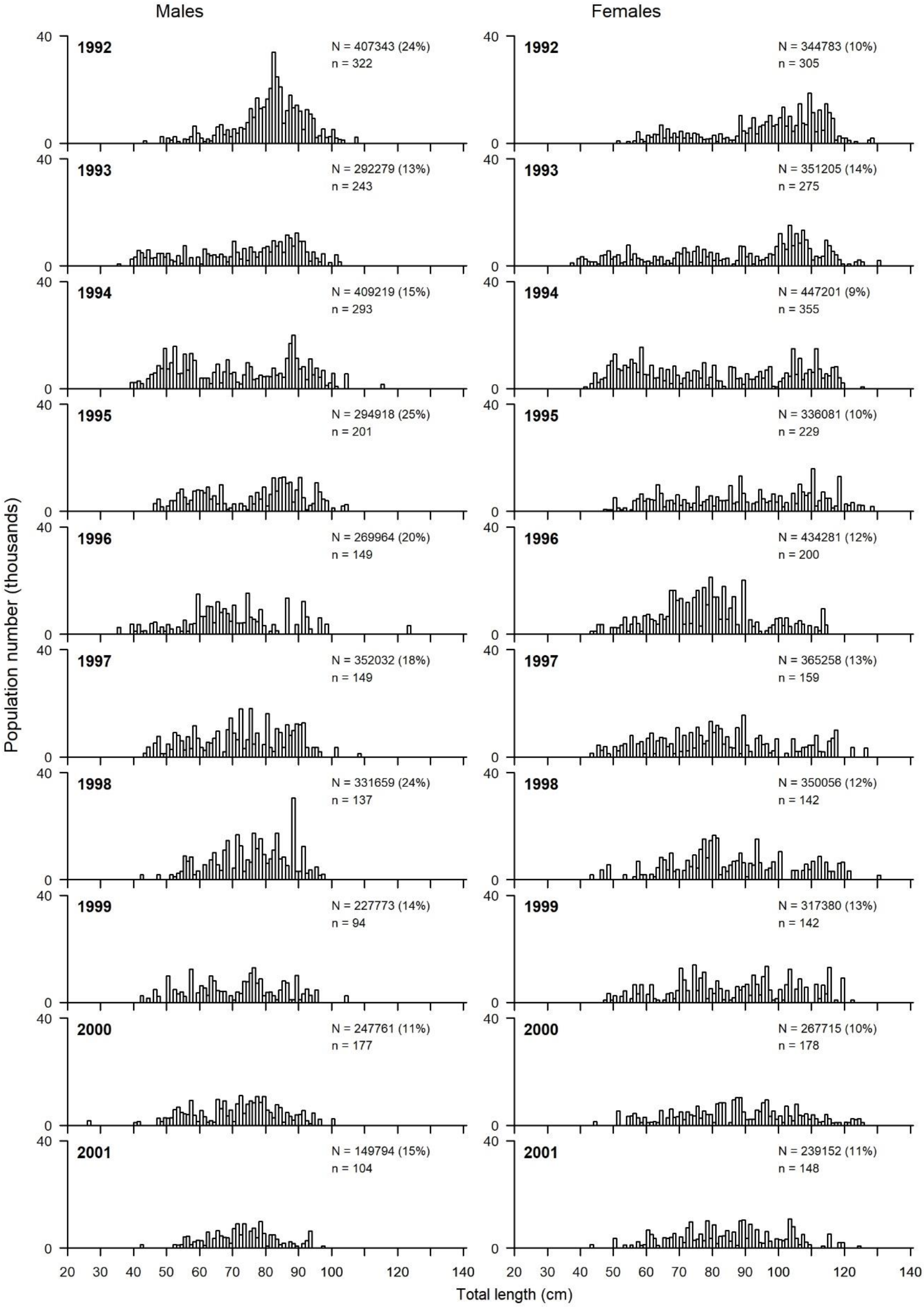

Figure 12: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020 for core strata. N, estimated population number of male hake (left panel) and female hake (right panel); CV (in parentheses),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

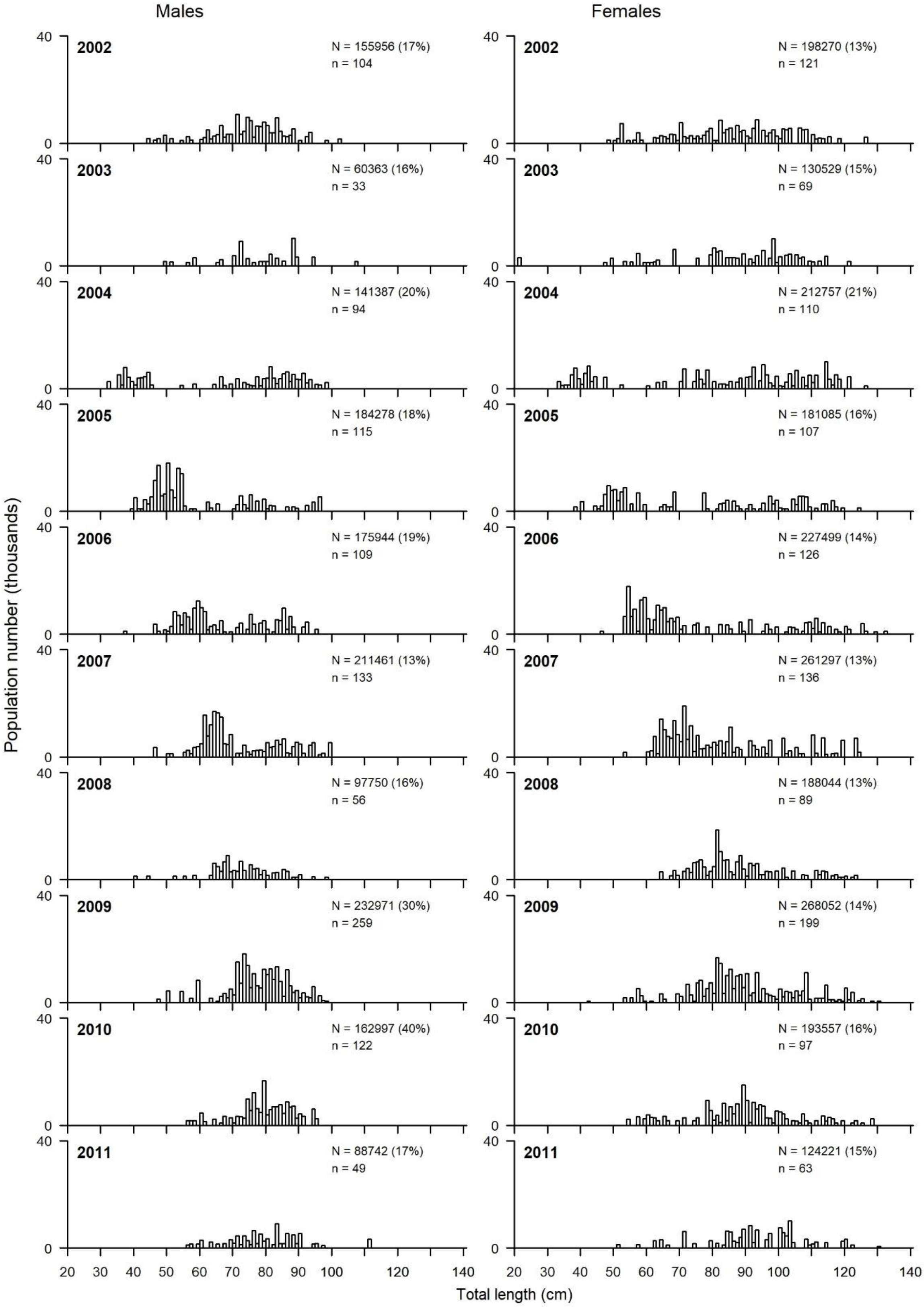

Figure 12 (continued)

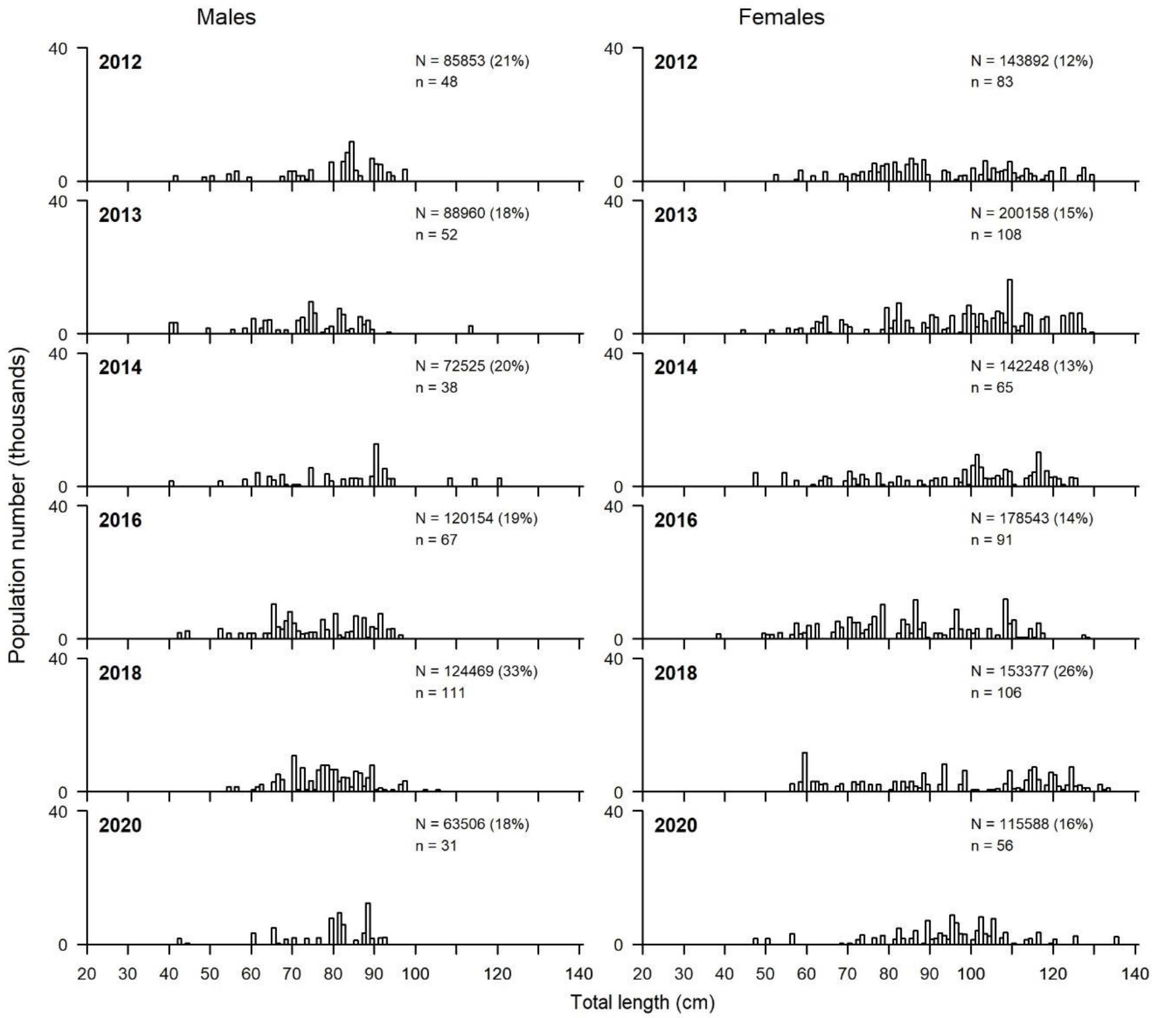

Figure 12 (continued)

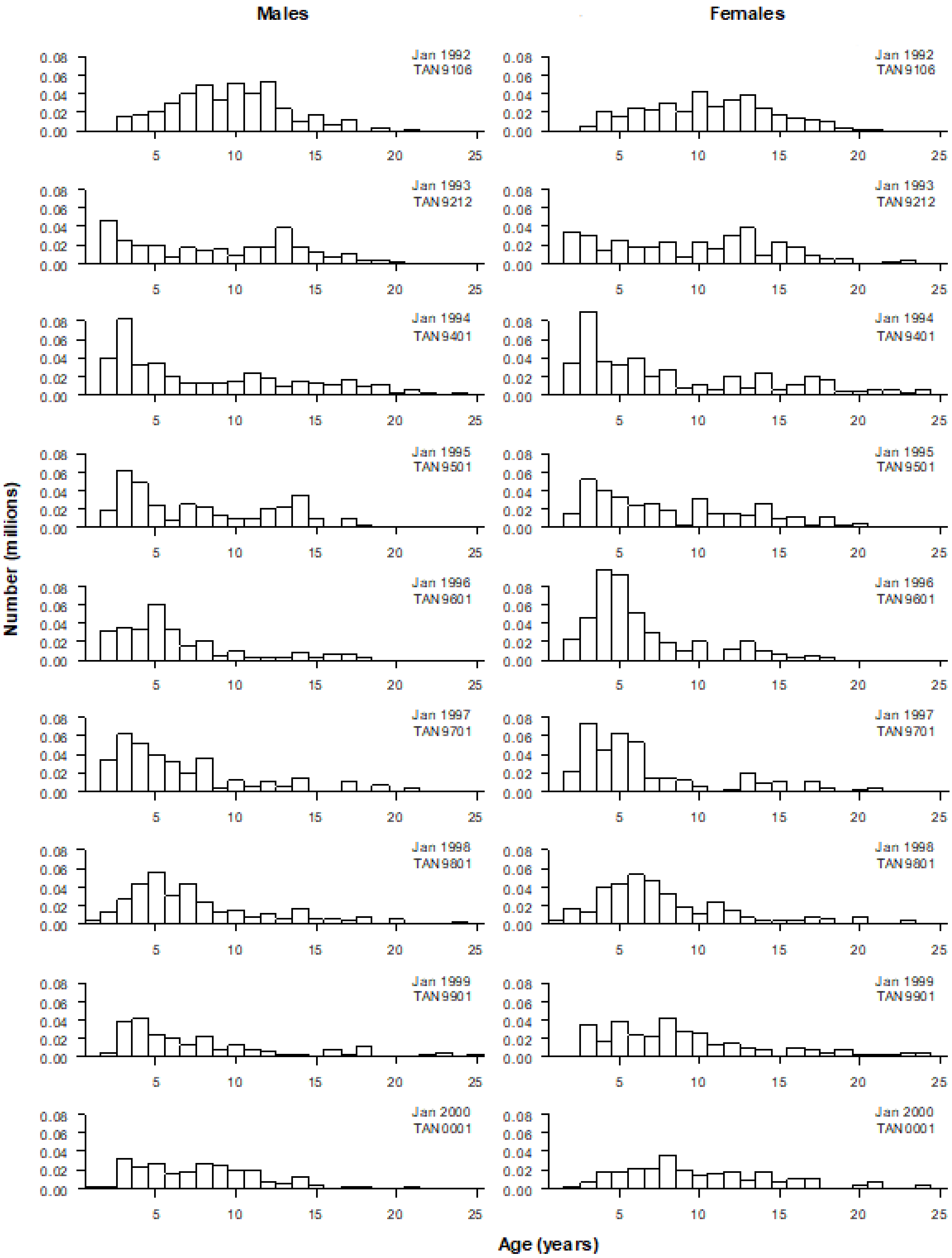

Figure 13: Estimated population numbers-at-age for male and female hake from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020.

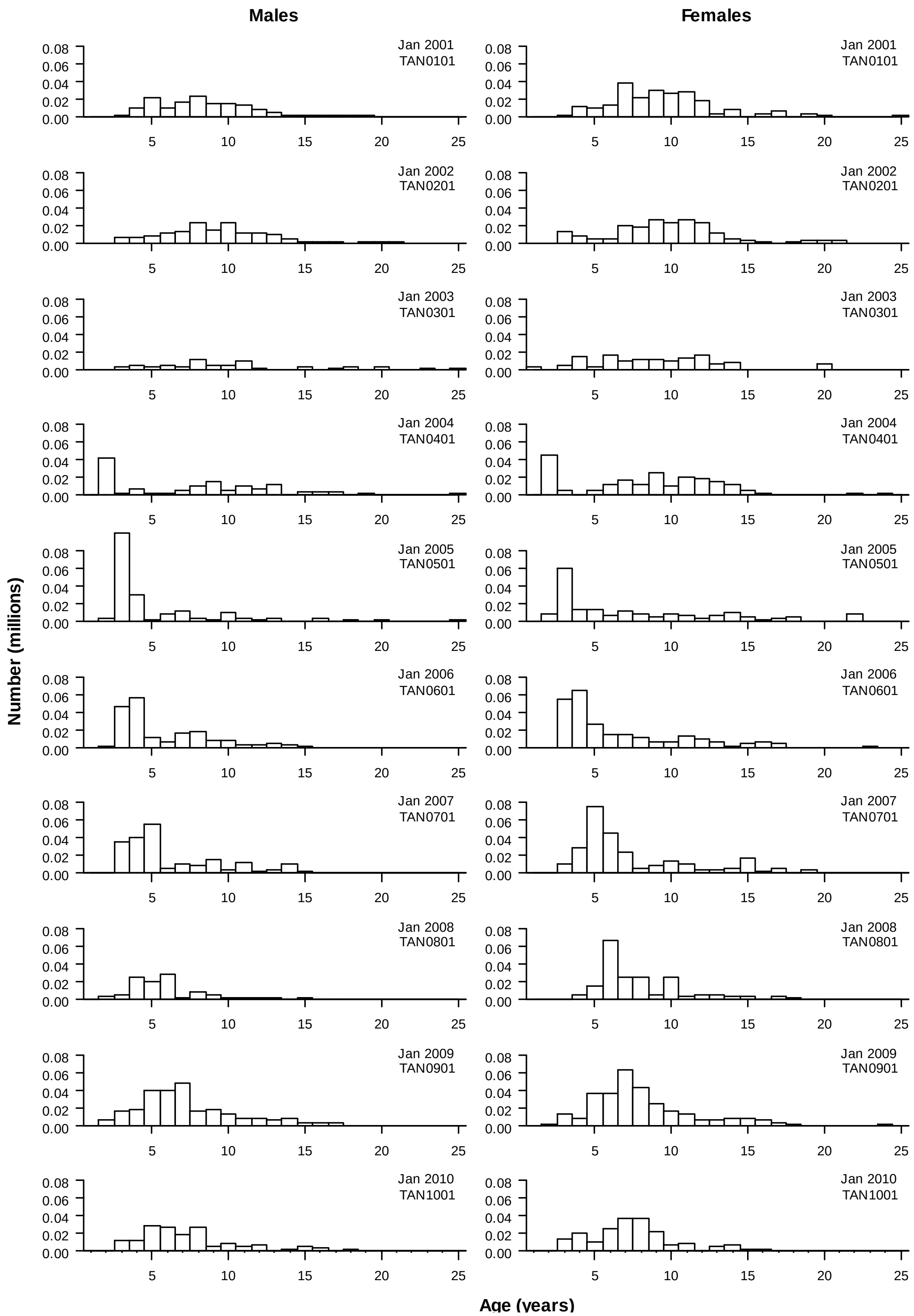

Figure 13 (continued)

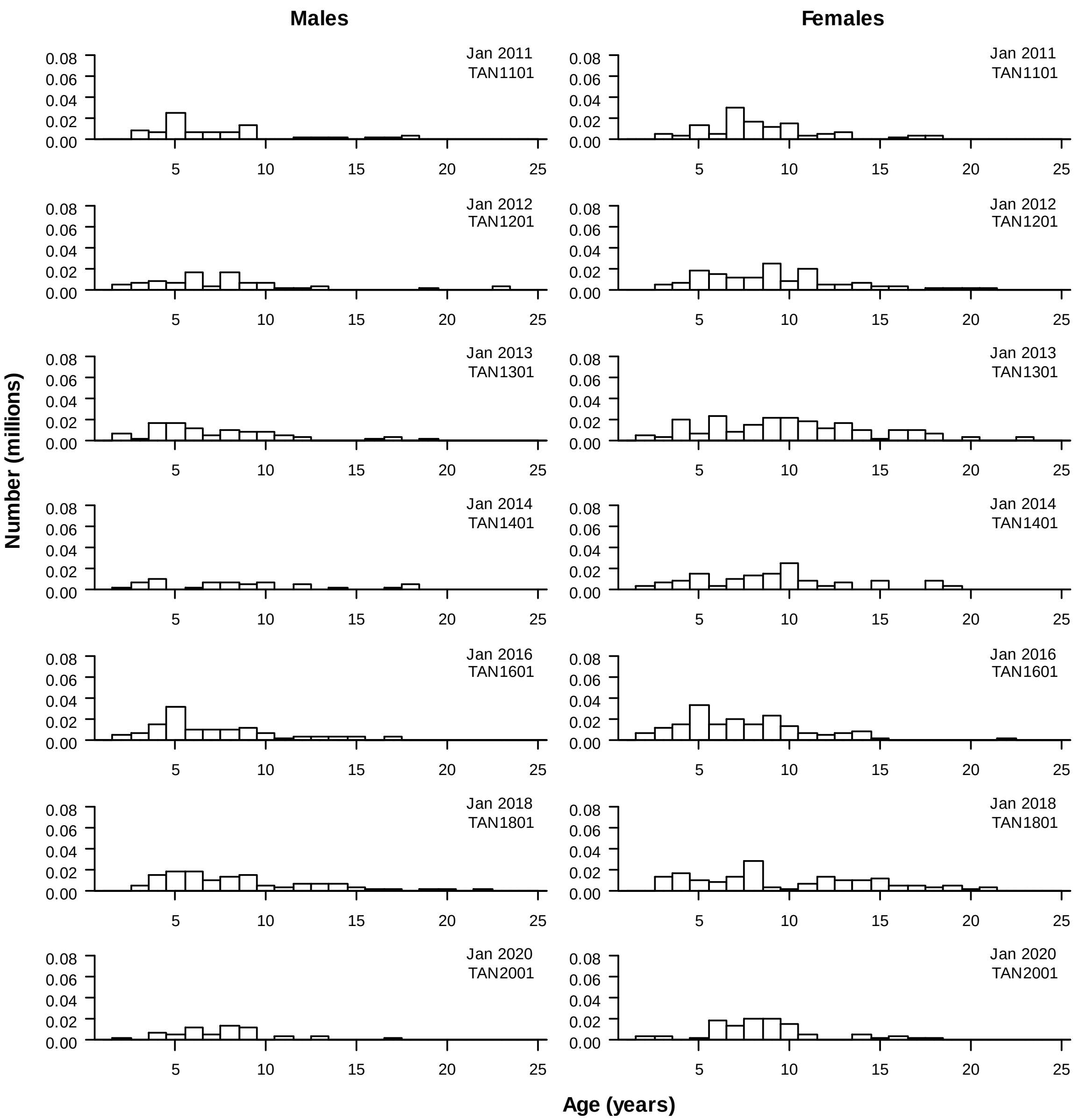

Figure 13 (continued)

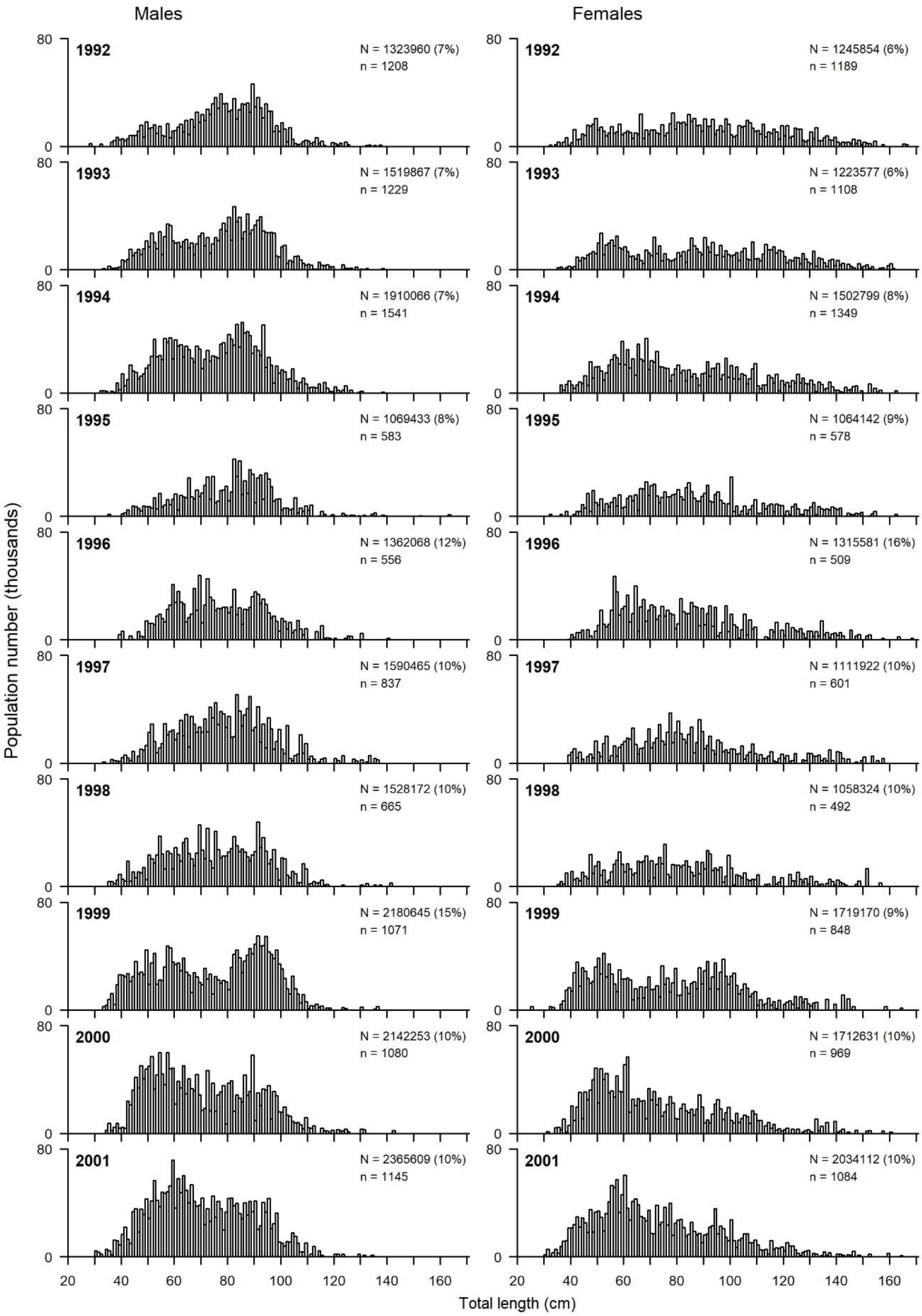

Figure 14: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020 for core strata. N, estimated population number of male ling (left panel) and female ling (right panel); CV (in parentheses), coefficient of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

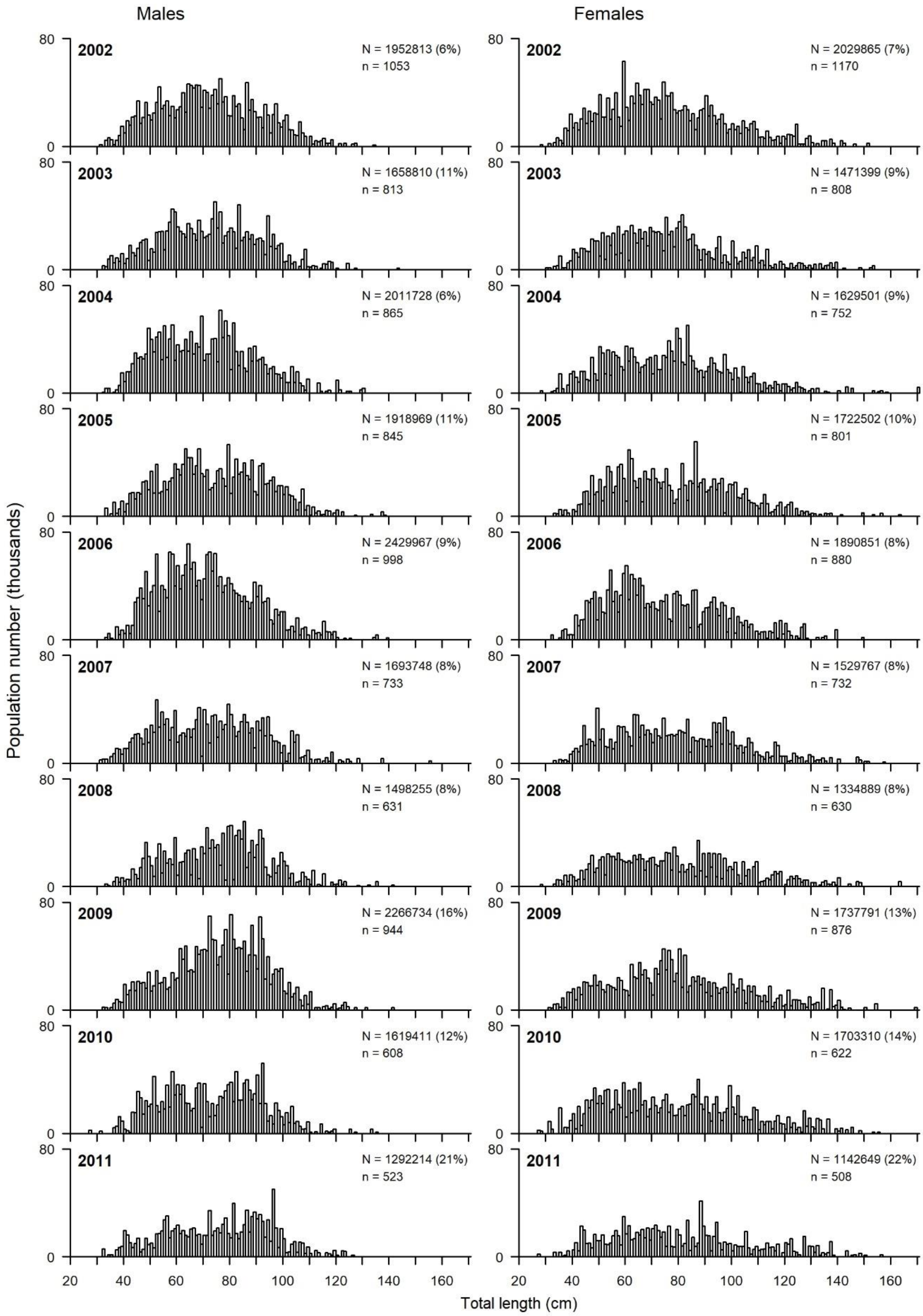

Figure 14 (continued)

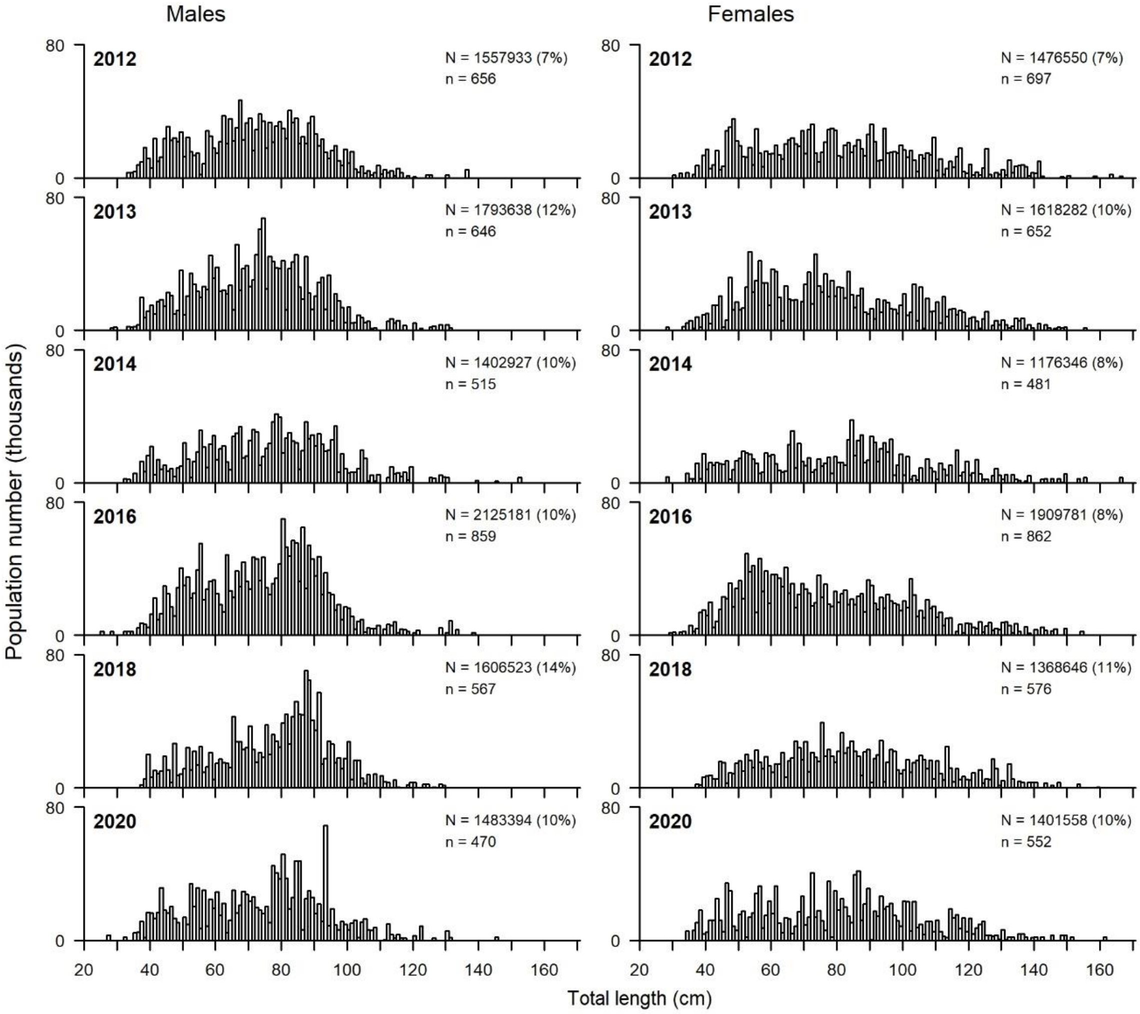

Figure 14 (continued)

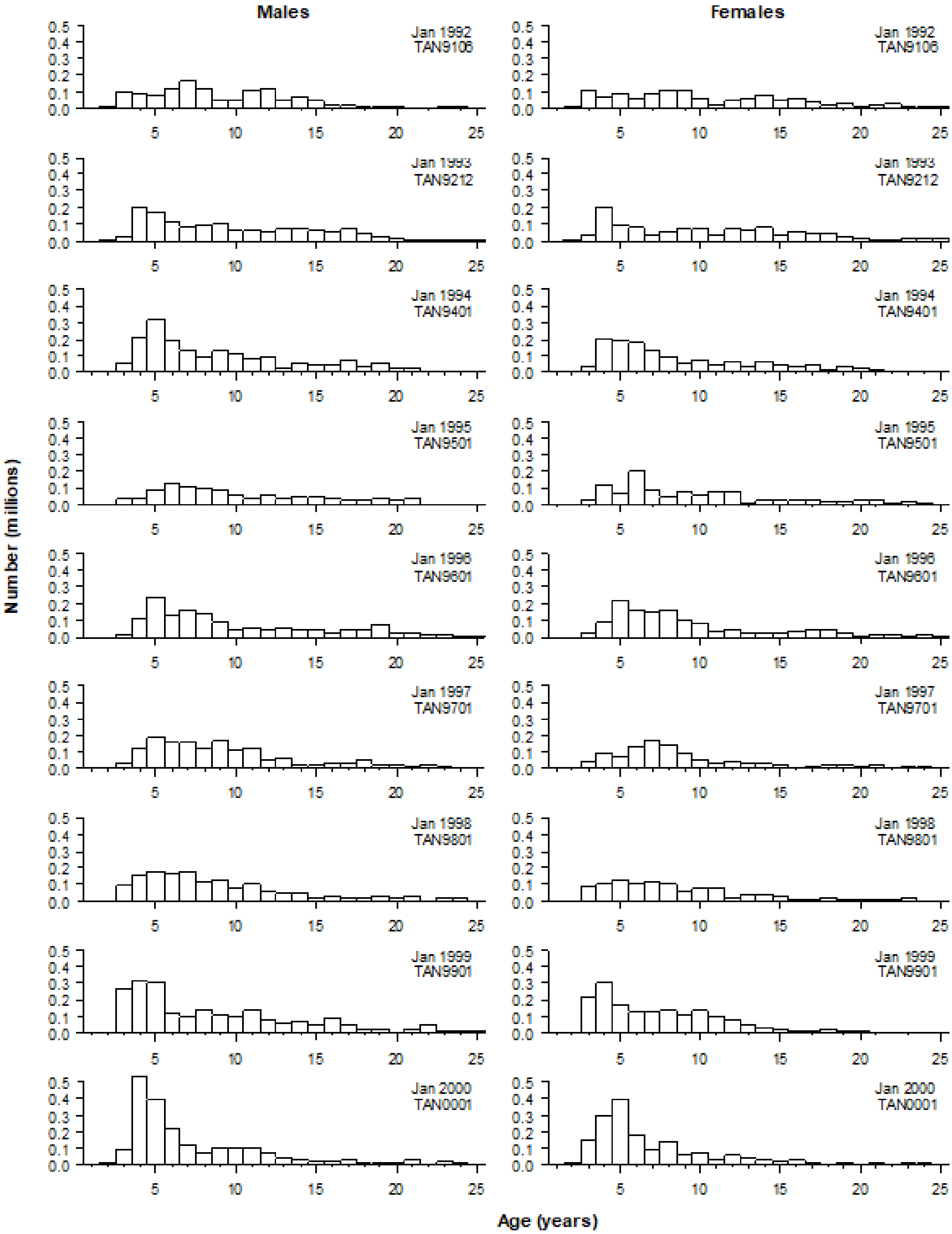

Figure 15: Estimated population numbers-at-age for male and female ling from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, 2016, 2018, and 2020.

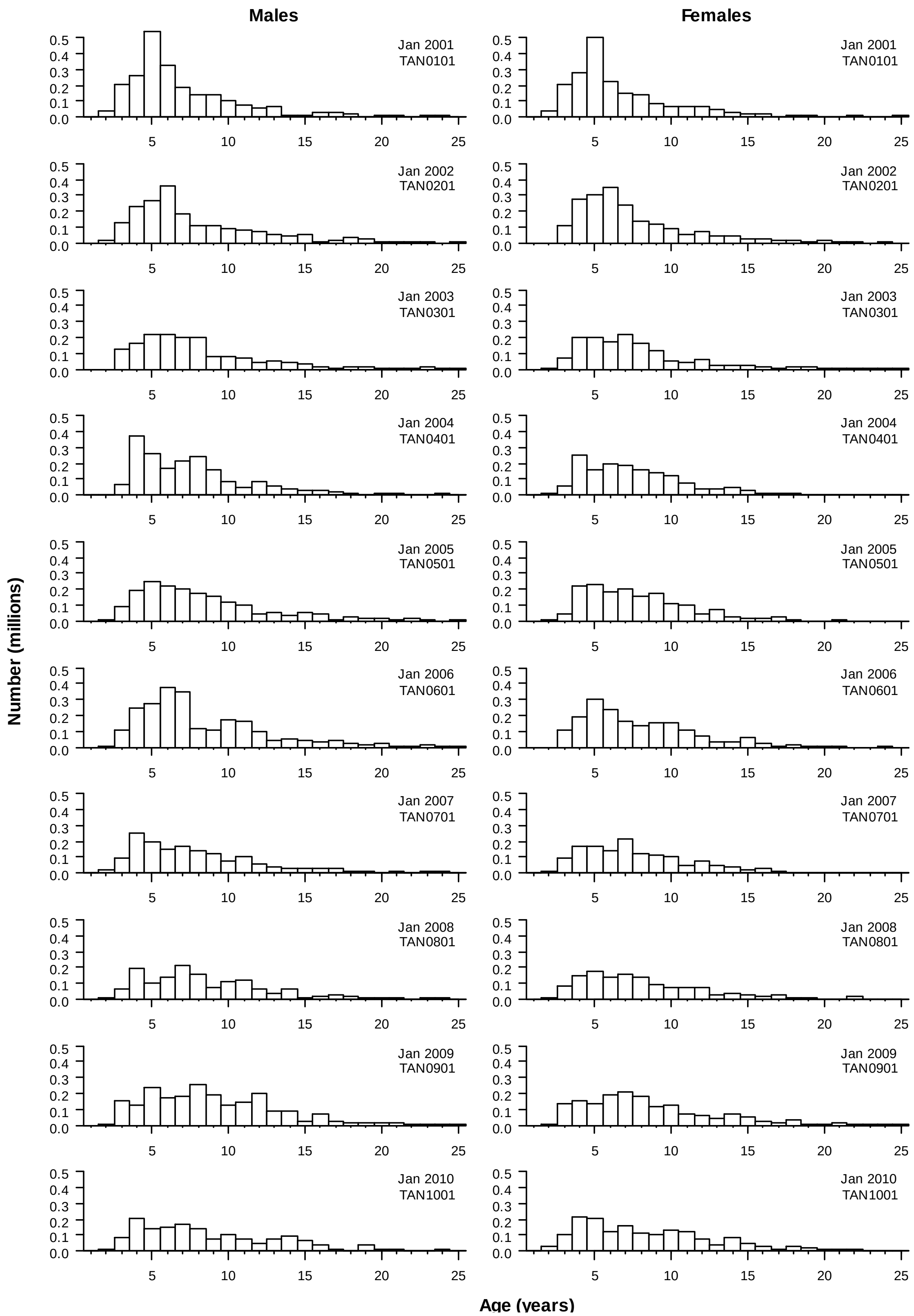

Figure 15 (continued)

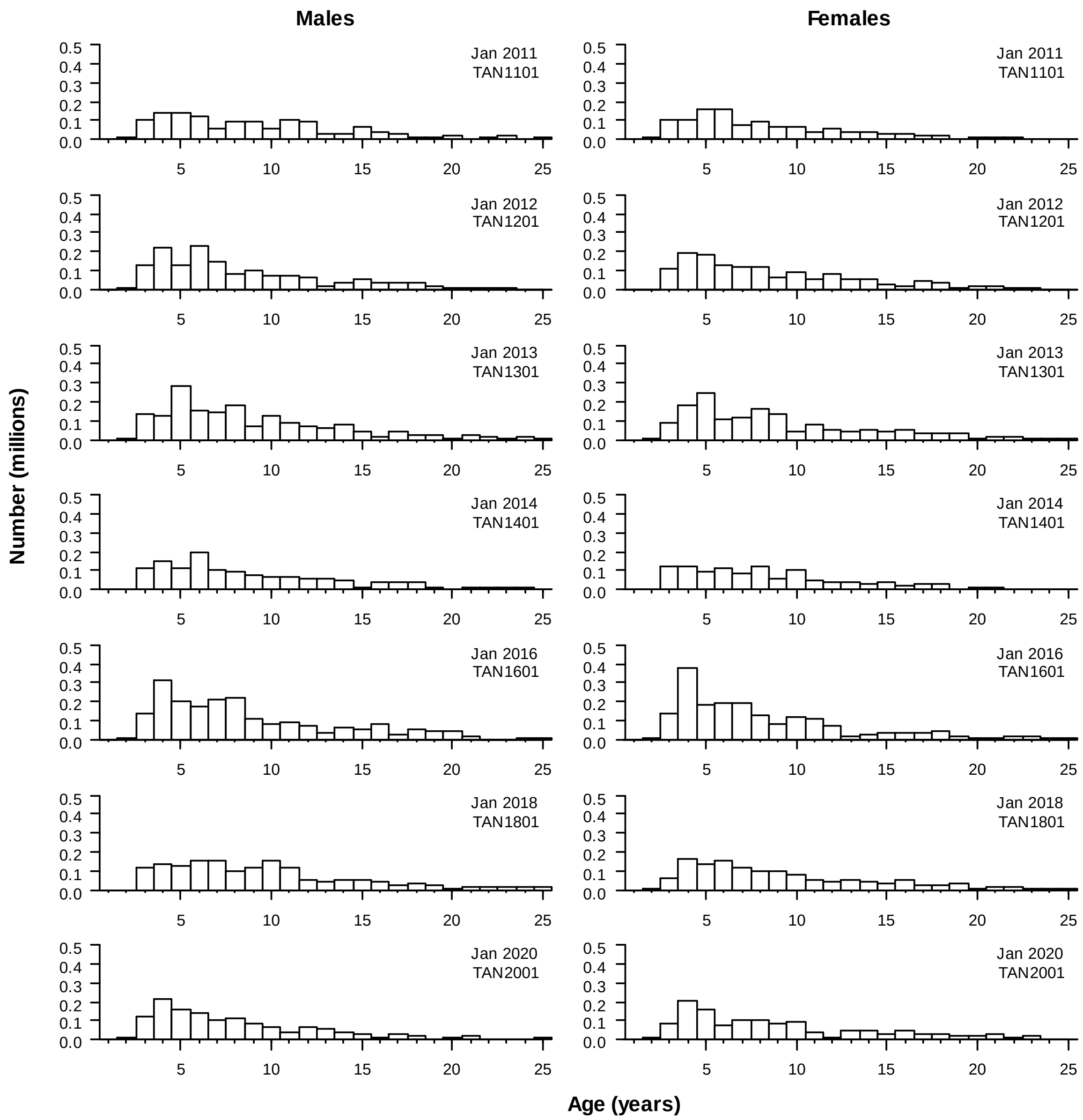

Figure 15 (continued)

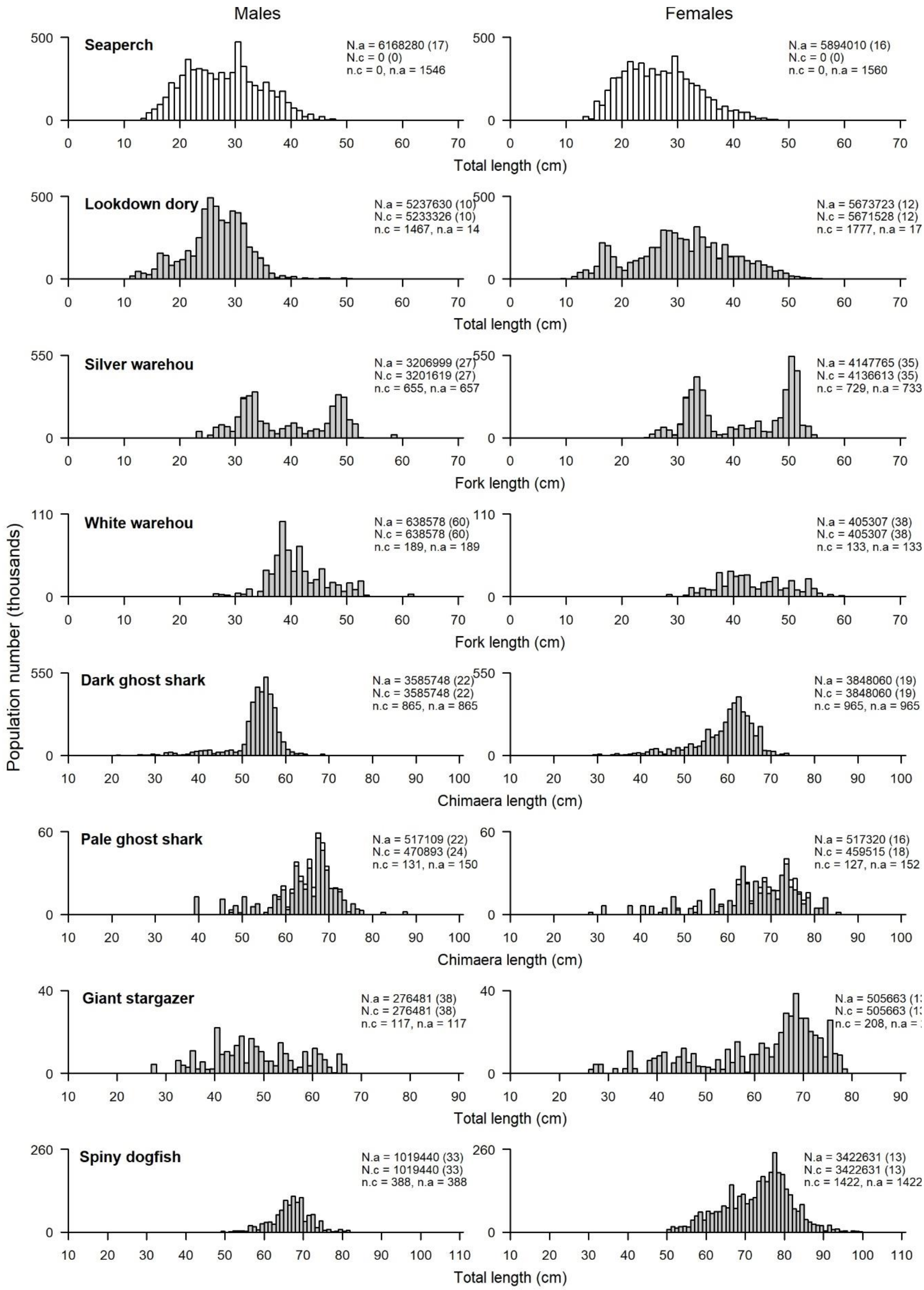

Figure 16a: Length frequency distributions of eight selected commercial species on the Chatham Rise 2020, scaled to population size by sex. N.a, estimated number of male fish (left panel) and female fish (right panel) from all (200–1300 m) strata; N.c, estimated number of male fish (left panel) and female 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.

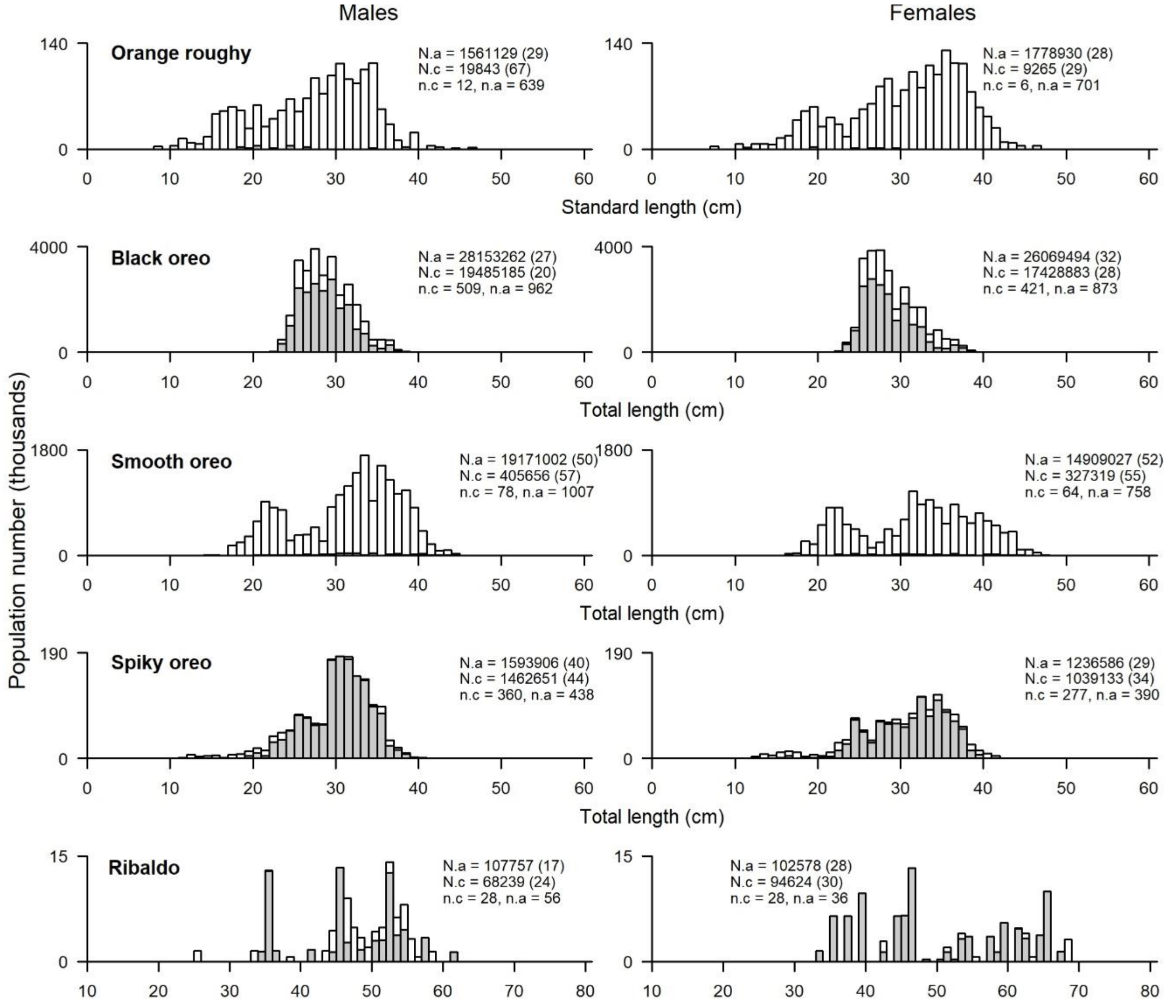

Figure 16b: Length frequencies of orange roughy, oreo species, and other selected deepwater species on the Chatham Rise 2020, scaled to population size by sex. N.a, estimated number of male fish (left panel) and female fish (right panel) from all (200–1300 m) strata; N.c, estimated number of male fish (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.

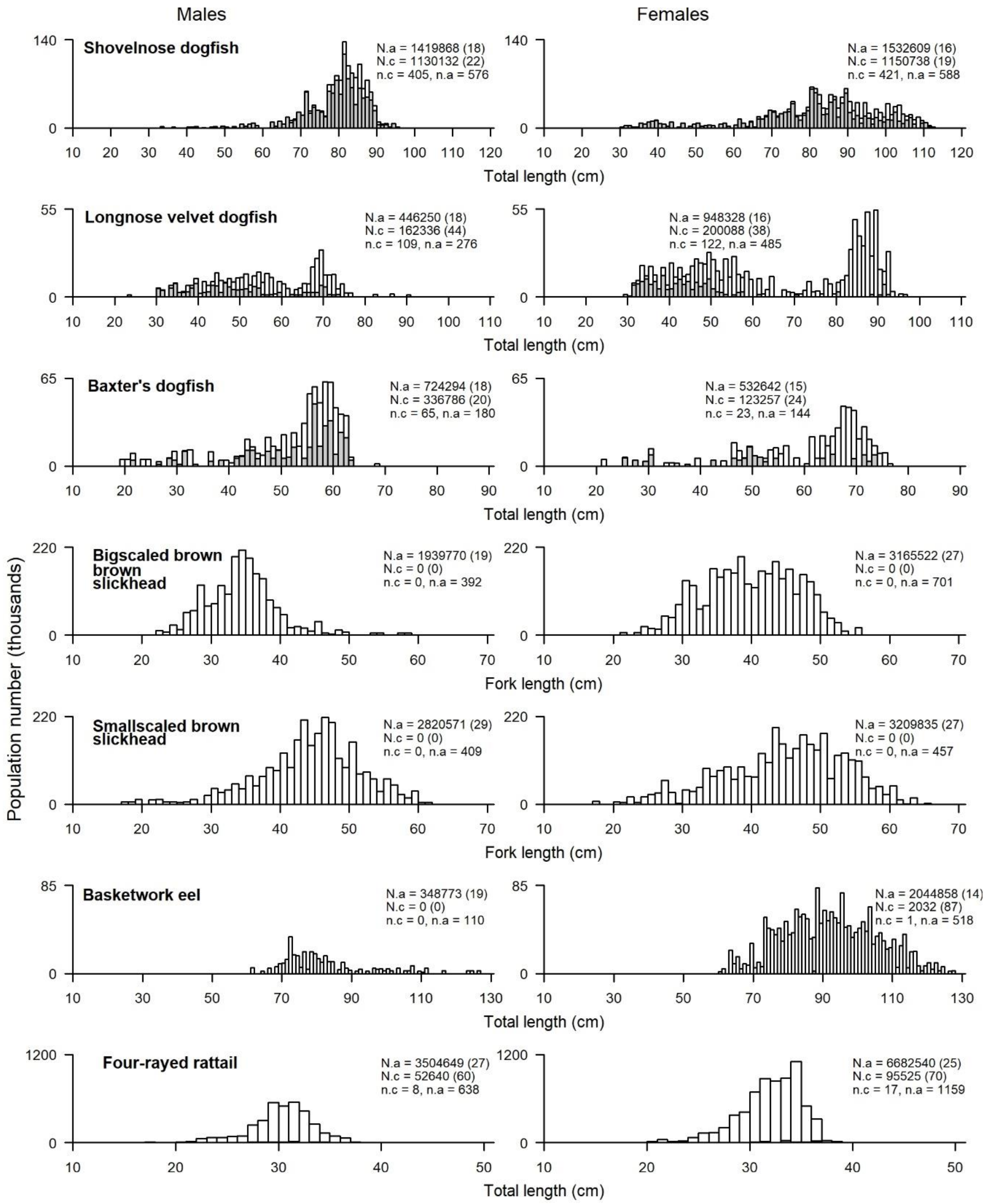

Figure 16b (continued)

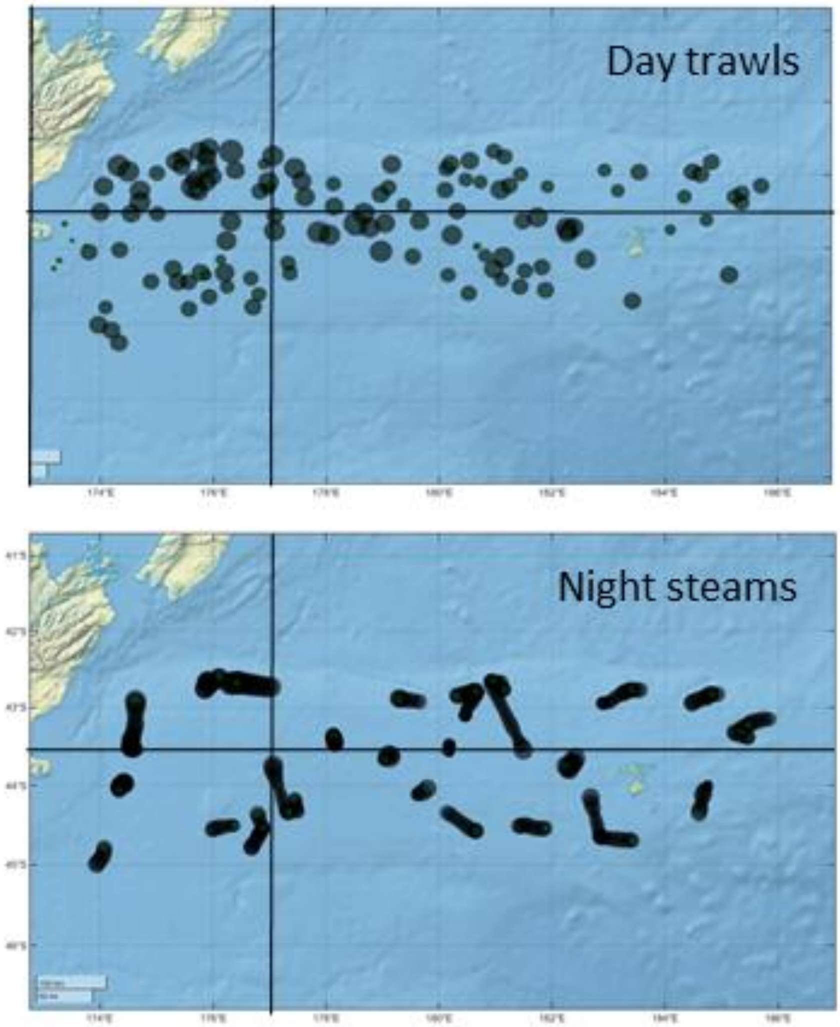

Figure 17: Distribution of total acoustic backscatter through the water column (10 m deep to bottom) (black circles) observed on the Chatham Rise during trawls (upper panel) and night-time steams (lower panel) throughout the entire survey area in January 2020. Horizontal and vertical lines divide the Rise into four subareas (northwest, northeast, southwest, and southeast), Measurement is the (sliced) area backscattering coefficient s_a (in m^2 km^{-2}) represented in logarithmic scale (base 10). A value of 1 m^2 km^{-2} is shown as a circle of 5 km radius.

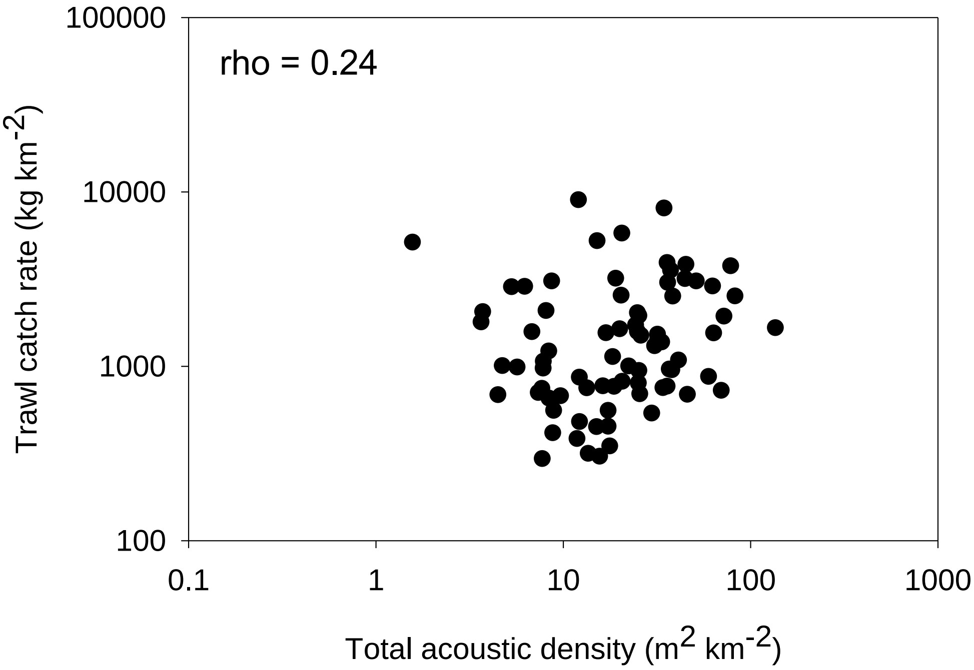

Figure 18: Relationship between total trawl catch rate (all species combined) and bottom-referenced acoustic backscatter recorded during the trawl on the Chatham Rise in 2020. Rho value is Spearman's rank correlation coefficient.

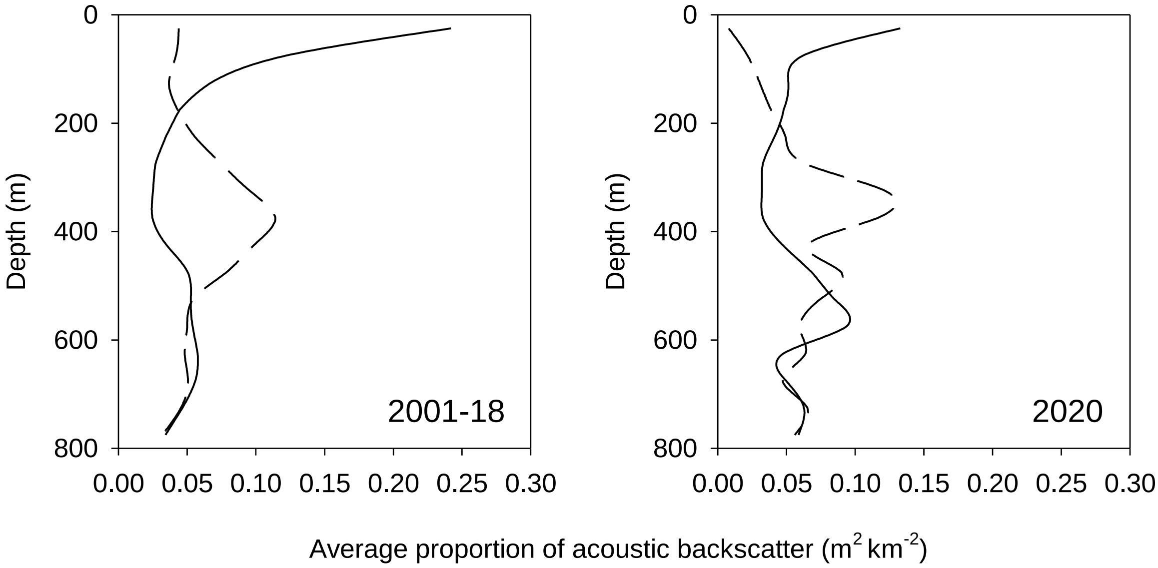

Figure 19: Vertical distribution of the average acoustic backscatter for the day (dashed lines) and at night (solid lines) for the Chatham Rise surveys in 2001-18 (averaged across all previous surveys) and in 2020.

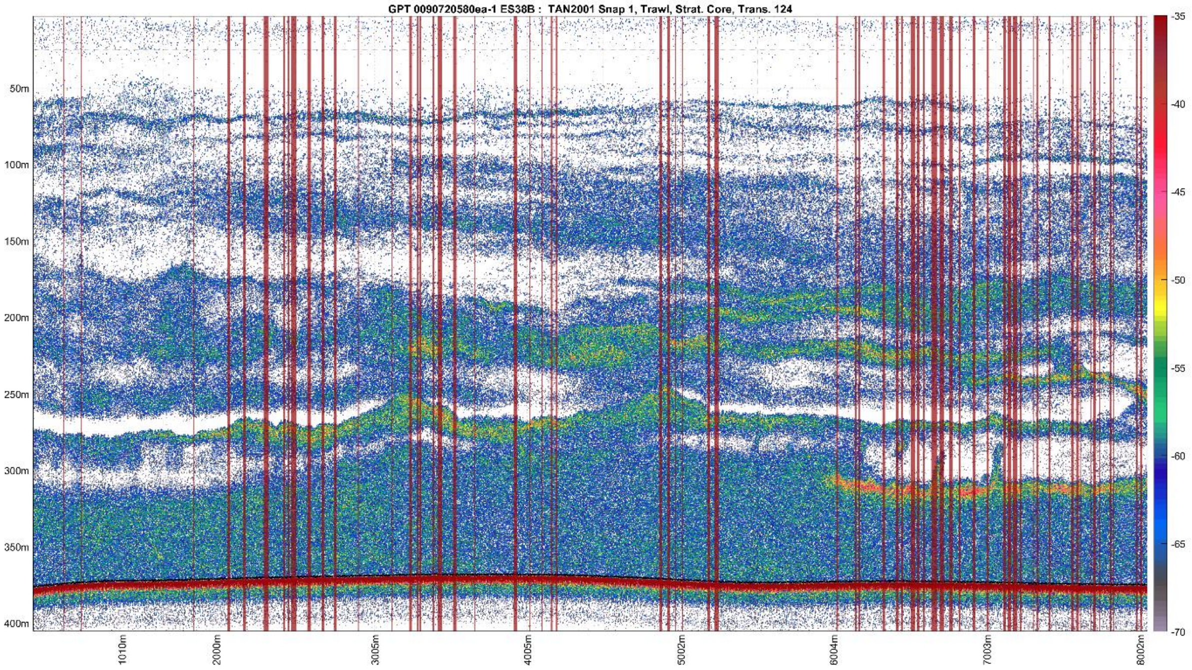

Figure 20: Example echogram from station 124 in stratum 18 (Mernoo Bank) showing strong mesopelagic layers between 200 and 350 m. Red vertical lines show transmits where data quality was degraded which were removed from analysis.

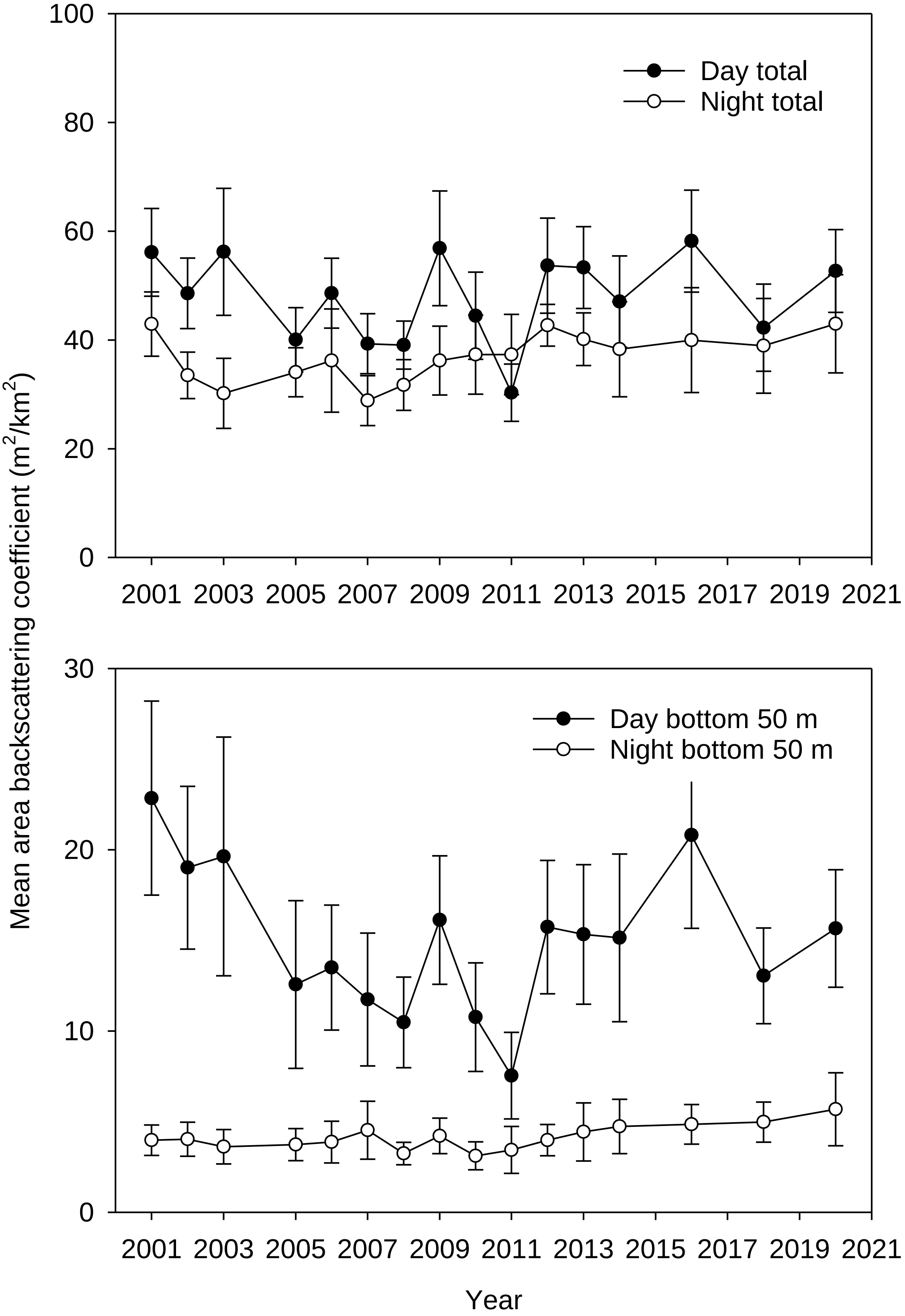

Figure 21: Comparison of relative acoustic abundance indices for the core Chatham Rise area based on (strata-averaged) mean areal backscatter. Error bars are ± 2 standard errors.

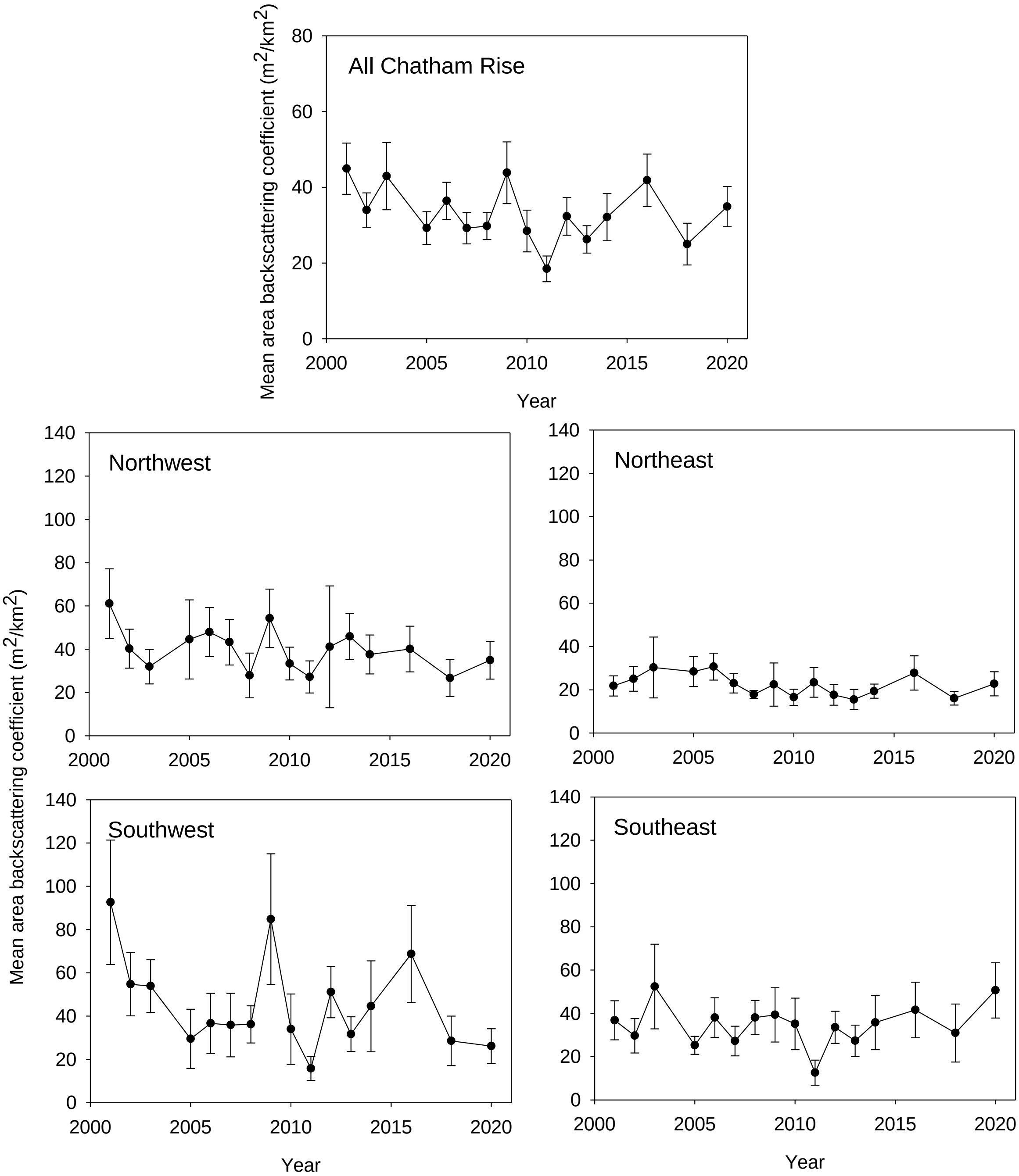

Figure 22: Relative acoustic abundance indices for mesopelagic fish on the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same sub-area observed in the upper 200 m corrected for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

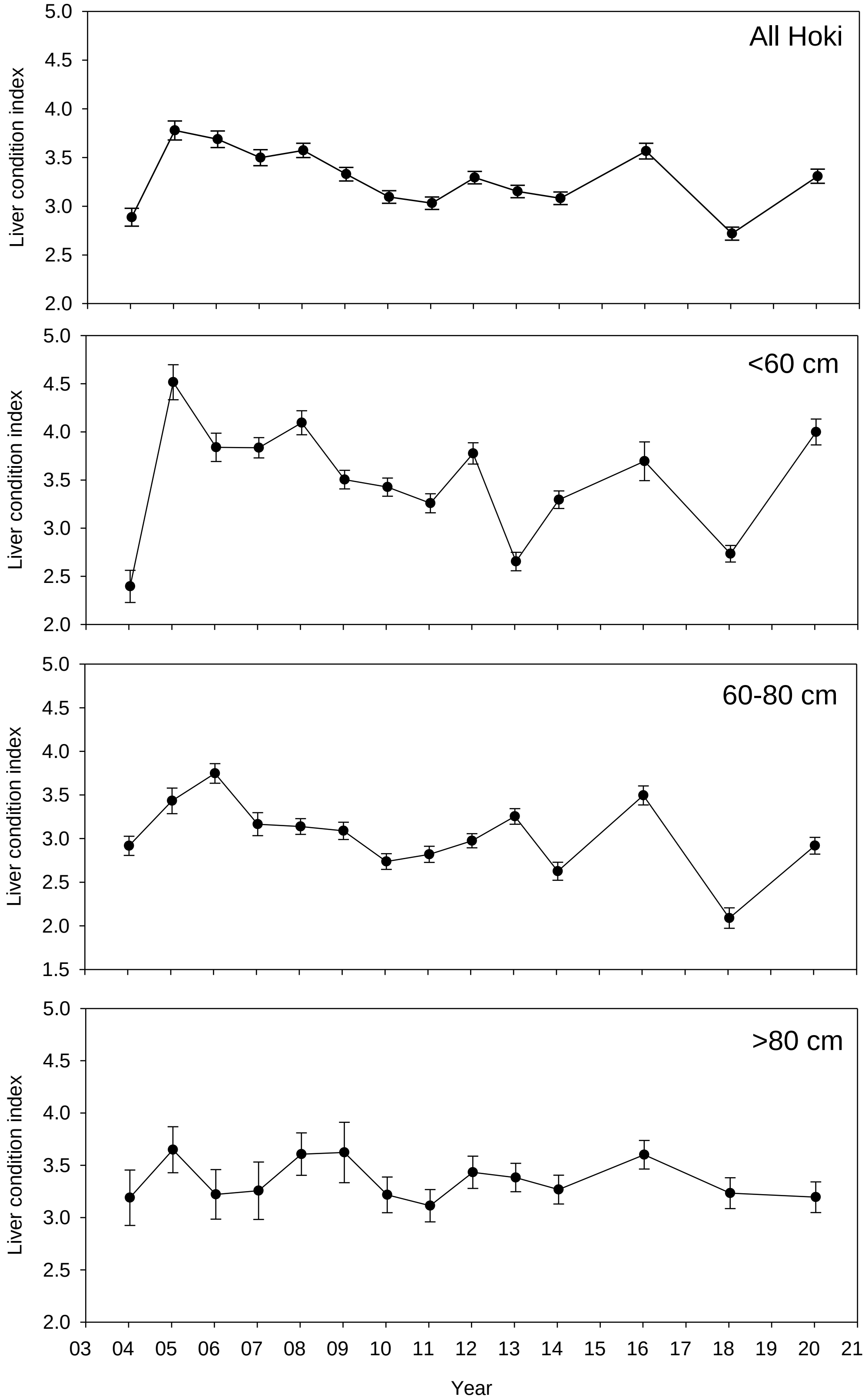

Figure 23: Time series of hoki liver condition indices on the Chatham Rise from 2004–20. Data are plotted for all hoki, then three different size classes (<60 cm, 60–80 cm, and >80 cm). Error bars show ± 2 standard errors.

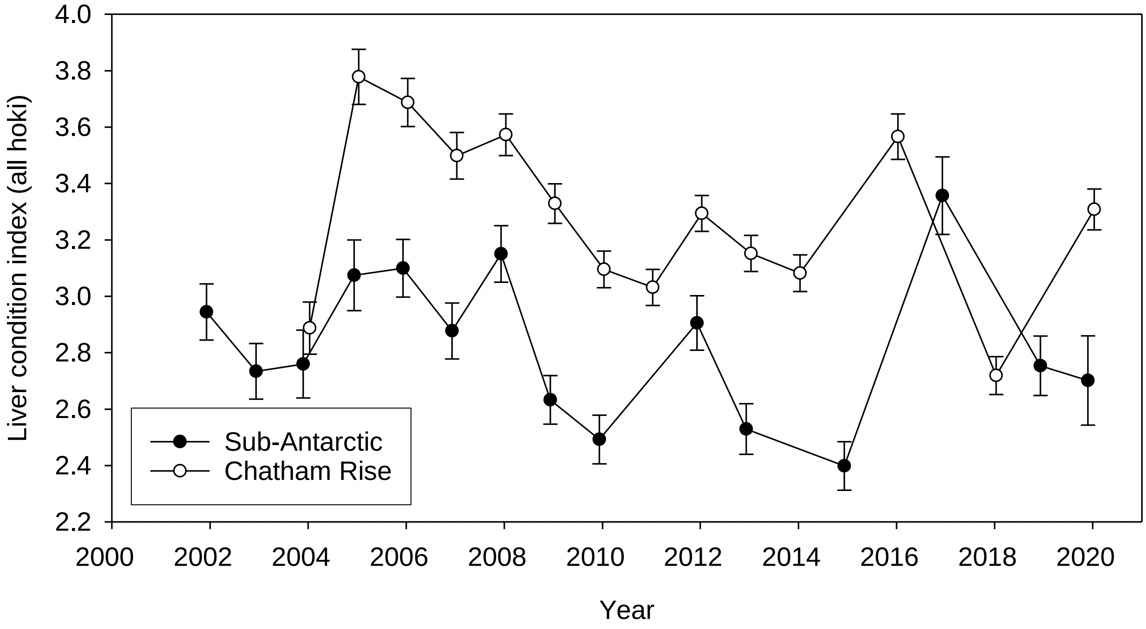

Figure 24: Comparison of time series of hoki liver condition indices (all sizes combined) on the Chatham Rise with indices from the Sub-Antarctic from 2002–20. Error bars show ± 2 standard errors.

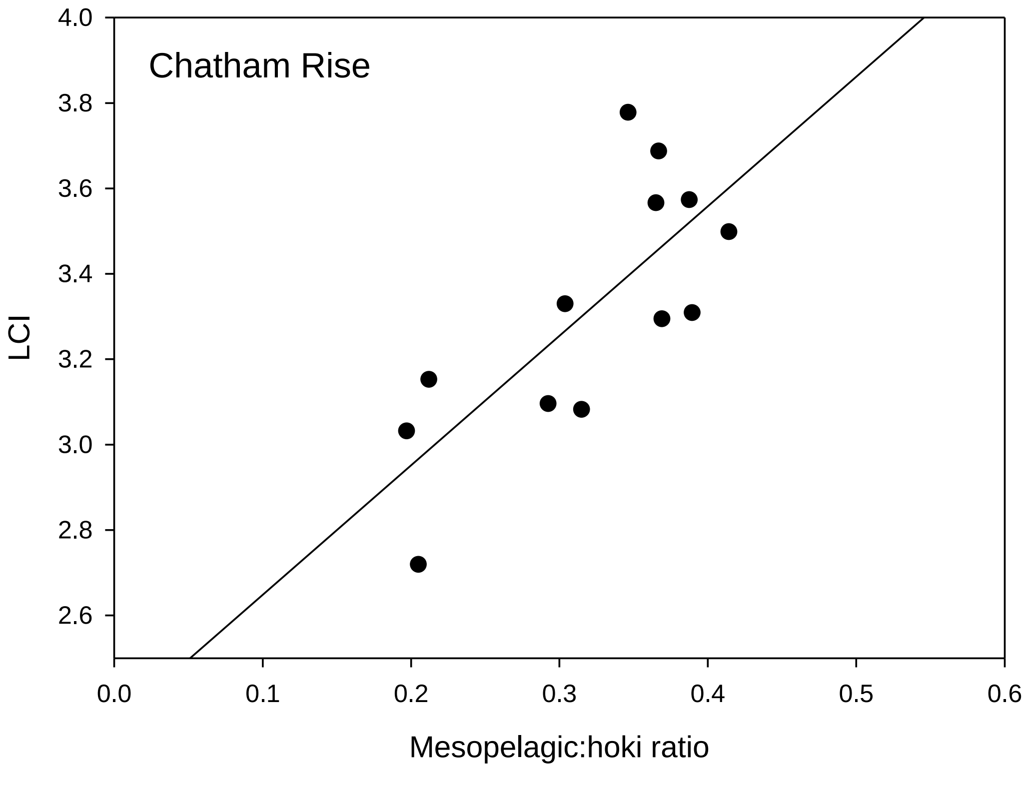

Figure 25: Correlation between hoki liver condition index (LCI) on the Chatham Rise with index of 'food per fish' derived by dividing the mesopelagic acoustic index by the estimated hoki biomass. Pearson correlation coefficient is 0.75.

Appendix 1: Individual station data for all stations conducted during the survey (TAN2001). Stn., station number. Type: P1, phase 1 trawl survey biomass tow; P2, phase 2 trawl survey biomass tow; RS, Canterbury Banks HMA tows. Strat., Stratum number; *, foul trawl stations. Time is NZST, latitude (S), and longitude as degrees and minutes. Dist., distance towed. *, indicates tow was not considered suitable for abundance estimation.

Station	Type	Date	Start time (NZST)	Stratum	Start latitude (° ' S)	Start longitude (° ')	E/W	Max. depth (m)	Distance towed (n. mile)	Catch hoki (kg)	Catch ling (kg)	Catch hake (kg)
1	P1	Jan-05-20	0902	008A	42 55.28	176 26.61	E	512	3.05	202.6	8.3	50.8
2	P1	Jan-05-20	1324	008A	42 51.18	176 57.61	E	462	3.06	196.4	25.2	90.6
3	P1	Jan-05-20	1736	002A	42 43.27	176 32.12	E	796	2.87	76.0	0.0	0.0
4	P1	Jan-05-20	2216	0022	42 41.06	176 35.90	E	942	3.05	33.1	3.3	8.3
5	P1	Jan-06-20	0125	0022	42 40.82	176 21.21	E	906	3.03	62.0	2.3	0.0
6	P1	Jan-06-20	0617	002A	42 44.28	177 05.94	E	798	2.98	43.6	0.0	7.1
7	P1	Jan-06-20	0916	008A	42 53.46	177 27.74	E	448	3.00	184.2	18.4	86.0
8	P1	Jan-06-20	1331	0020	43 16.93	177 38.48	E	291	2.99	1 438.5	0.0	0.0
9	P1	Jan-06-20	1720	0020	43 06.89	178 09.04	E	387	2.97	456.6	3.8	56.4
10	P1	Jan-07-20	1803	008B	43 12.52	178 38.13	E	428	3.01	252.7	0.0	15.1
11	P1	Jan-07-20	2313	0022	42 51.14	179 13.73	E	997	2.99	22.4	0.0	0.0
12	P1	Jan-08-20	0200	0022	42 53.69	179 22.02	E	845	3.07	170.2	4.2	0.0
13	P1	Jan-08-20	0531	002A	42 56.46	179 37.38	E	729	3.06	205.1	30.2	20.6
14	P1	Jan-08-20	1000	008B	43 10.59	179 07.58	E	434	3.09	91.6	3.7	71.6
15	P1	Jan-08-20	1242	008B	43 16.12	179 01.81	E	436	3.06	367.0	6.3	90.3
16	P1	Jan-09-20	0502	0020	43 22.79	178 08.36	E	348	3.03	5 424.4	0.0	19.7
17	P1	Jan-09-20	0846	0020	43 39.75	178 33.73	E	398	2.99	439.3	0.0	32.6
18	P1	Jan-09-20	1116	0020	43 30.69	178 41.44	E	360	3.01	538.4	0.0	36.4
19	P1	Jan-09-20	1523	0020	43 24.38	179 24.58	E	399	3.02	243.3	16.9	52.0
20	P1	Jan-09-20	1808	0020	43 35.50	179 40.28	E	399	3.05	110.9	1.9	61.8
21*	P1	Jan-10-20	0516	0010	43 30.41	179 49.39	W	421	2.21	0.0	0.0	0.0
22	P1	Jan-10-20	0926	0010	43 28.70	179 37.95	W	457	2.96	636.2	18.2	26.1
23	P1	Jan-10-20	1252	0010	43 12.53	179 51.56	W	531	3.05	283.0	36.8	16.1
24	P1	Jan-10-20	1616	002B	42 55.06	179 49.93	W	717	3.05	75.6	0.0	22.0
25	P1	Jan-10-20	2000	021A	42 51.07	179 45.10	W	852	2.97	18.3	3.9	7.6
26	P1	Jan-11-20	0011	021A	42 48.16	179 24.88	W	887	3.10	26.7	31.1	0.0
27	P1	Jan-11-20	0519	0010	43 03.03	179 31.37	W	555	3.02	126.9	19.4	28.0
28	P1	Jan-11-20	0812	0010	43 05.36	179 15.06	W	548	3.00	149.1	0.0	10.6
29	P1	Jan-11-20	1140	0011	43 12.27	178 52.84	W	504	3.00	207.0	3.5	36.4
30	P1	Jan-11-20	1346	0011	43 08.81	178 43.31	W	516	3.11	146.9	0.0	9.4
31	P1	Jan-11-20	1616	0011	42 59.21	178 31.63	W	554	3.00	171.9	0.0	22.8
32	P1	Jan-11-20	2000	021A	42 44.65	178 46.65	W	900	2.99	7.4	0.0	0.0
33*	P1	Jan-12-20	0025	0023	42 39.84	178 58.16	W	1 195	3.01	0.0	0.0	0.0
34	P1	Jan-12-20	0820	0011	43 37.71	178 27.04	W	414	3.00	95.0	0.0	25.0
35	P1	Jan-12-20	1128	0011	43 32.58	178 14.60	W	427	3.01	191.3	0.0	23.1
36	P1	Jan-12-20	1533	0011	43 09.41	178 00.84	W	498	3.00	103.6	0.0	15.8
37*	P1	Jan-13-20	0041	0024	42 46.05	176 30.91	W	1 140	3.00	0.0	0.0	0.0
38	P1	Jan-13-20	0545	002B	42 56.21	177 01.85	W	682	2.98	86.4	14.7	13.8
39	P1	Jan-13-20	0937	002B	42 57.26	176 24.21	W	729	2.96	305.2	6.8	6.1
40	P1	Jan-13-20	1356	0009	43 12.08	176 49.19	W	375	3.04	436.2	0.0	0.3
41	P1	Jan-13-20	1704	0009	43 19.33	176 25.45	W	337	2.27	1 133.6	0.0	7.6
42	P1	Jan-14-20	0146	0024	42 49.53	175 06.08	W	1 240	3.10	0.0	0.0	0.0
43	P1	Jan-14-20	0530	021B	42 57.01	175 27.35	W	913	3.04	11.1	0.0	0.0
44	P1	Jan-14-20	0822	021B	42 59.50	175 17.57	W	908	3.03	21.5	0.0	0.0
45	P1	Jan-14-20	1207	002B	43 15.58	175 37.95	W	652	3.05	204.3	0.0	42.2
46	P1	Jan-14-20	1708	0012	43 36.78	175 13.10	W	592	3.00	116.5	21.8	17.6
47	P1	Jan-14-20	2137	021B	43 21.74	174 35.69	W	845	3.02	39.1	0.0	0.0
48	P1	Jan-15-20	0049	021B	43 17.97	174 42.75	W	849	3.04	43.9	4.7	0.0
49	P1	Jan-15-20	0255	021B	43 14.33	174 35.45	W	883	2.99	32.5	7.5	0.0
50	P1	Jan-15-20	0640	0024	43 08.95	174 13.17	W	1 066	3.02	0.0	0.0	0.0

Appendix 1: (continued)

Station	Type	Date	Start time (NZST)	Stratum	Start latitude (° ‘ S)	Start longitude (° ‘)	E/W	Max. depth (m)	Distance towed (n. mile)	Catch hoki (kg)	Catch hake (kg)	Catch ling (kg)
51	P1	Jan-15-20	1203	0025	43 42.74	174 17.66	W	934	3.03	16.1	0.0	0.0
52	P1	Jan-15-20	1754	0028	44 18.62	174 49.44	W	1 111	3.01	0.0	0.0	0.0
53	P1	Jan-16-20	0510	0012	44 01.12	175 16.12	W	485	3.01	813.2	0.0	1.4
54	P1	Jan-16-20	0939	0009	43 43.46	175 53.07	W	224	2.10	0.0	0.0	0.0
55	P1	Jan-16-20	2120	0025	44 41.74	176 31.48	W	970	2.11	32.6	0.0	0.0
56	P1	Jan-17-20	0523	0012	44 07.92	177 20.79	W	426	3.05	287.0	0.0	36.0
57	P1	Jan-18-20	0526	0005	43 40.44	177 36.34	W	396	3.02	276.3	0.0	42.5
58	P1	Jan-18-20	0740	0005	43 41.35	177 41.49	W	398	3.00	791.7	9.1	9.5
59	P1	Jan-18-20	1029	0005	43 46.87	177 41.48	W	397	3.03	345.2	5.5	42.4
60	P1	Jan-18-20	1521	0013	44 14.04	178 08.91	W	549	3.02	213.7	22.0	67.8
61	P1	Jan-18-20	1813	0004	44 17.70	178 24.71	W	641	3.00	46.1	22.3	56.8
62	P1	Jan-18-20	2256	0028	44 33.02	178 02.79	W	1 059	3.09	0.0	0.0	0.0
63	P1	Jan-19-20	0312	0025	44 30.04	178 30.57	W	998	3.03	35.8	0.0	0.0
64	P1	Jan-19-20	0709	0025	44 24.33	178 50.60	W	876	2.99	53.5	0.0	0.0
65	P1	Jan-19-20	1011	0013	44 15.91	178 57.75	W	592	3.06	438.1	0.0	9.5
66	P1	Jan-19-20	1310	0013	44 06.52	178 49.63	W	468	3.09	206.5	7.6	11.0
67	P1	Jan-19-20	1614	0003	44 04.32	179 07.85	W	318	2.85	64.8	0.0	0.0
68	P1	Jan-19-20	1845	0003	43 57.46	179 18.67	W	234	2.32	0.0	0.0	0.0
69	P1	Jan-20-20	0047	0028	44 35.19	179 25.21	W	1 233	3.03	0.0	0.0	0.0
70	P1	Jan-20-20	0521	0025	44 20.50	179 48.02	W	882	2.99	8.4	0.0	2.7
71	P1	Jan-20-20	1014	0003	43 48.66	179 43.86	W	383	2.10	599.0	3.5	33.1
72	P1	Jan-20-20	1432	0004	44 05.39	179 35.24	E	683	3.00	110.1	0.0	29.4
73	P1	Jan-20-20	1809	0004	44 02.09	179 02.14	E	770	3.00	55.3	0.0	37.6
74	P1	Jan-21-20	0534	0014	43 38.04	179 05.85	E	442	3.02	144.9	0.0	37.1
75	P1	Jan-21-20	0815	0014	43 42.72	178 47.48	E	452	3.02	313.6	0.0	88.0
76	P1	Jan-21-20	1303	0014	43 48.97	178 06.20	E	519	2.24	1 143.8	0.0	38.2
77	P1	Jan-21-20	1446	0015	43 46.69	177 55.72	E	498	3.03	1 474.3	0.0	93.0
78	P1	Jan-21-20	2031	0026	44 11.00	177 22.51	E	929	2.98	4.3	2.9	0.0
79	P1	Jan-21-20	2356	0029	44 19.88	177 25.25	E	1 172	3.04	0.0	0.0	0.0
80	P1	Jan-22-20	0525	0015	43 45.00	177 06.56	E	503	3.02	165.5	1.3	29.0
81	P1	Jan-22-20	0809	0019	43 31.91	177 06.22	E	279	3.01	0.0	0.0	0.0
82	P1	Jan-22-20	1226	0019	43 37.85	176 22.51	E	393	3.00	1 561.1	6.0	74.8
83	P1	Jan-22-20	1527	0015	43 50.97	176 14.70	E	507	3.04	172.3	0.0	47.2
84	P1	Jan-22-20	2042	0026	44 22.96	176 43.38	E	910	2.99	10.2	0.0	5.6
85	P1	Jan-23-20	0026	0029	44 34.48	176 50.59	E	1 116	3.03	0.0	0.0	0.0
86	P1	Jan-23-20	0430	0029	44 46.72	176 45.94	E	1 297	2.99	0.0	0.0	0.0
87	P1	Jan-23-20	1046	0017	44 17.53	176 12.56	E	387	3.04	51.9	0.0	16.0
88	P1	Jan-23-20	1306	0017	44 07.71	176 10.25	E	384	3.05	80.3	0.0	5.0
89	P1	Jan-23-20	1641	0016	44 17.43	175 46.91	E	587	2.10	414.3	0.0	67.5
90	P1	Jan-23-20	1842	0017	44 20.61	175 53.01	E	298	2.19	0.0	0.0	0.0
91	P1	Jan-23-20	2208	0026	44 30.55	176 17.77	E	883	2.99	38.9	0.0	0.0
92	P1	Jan-24-20	0158	0027	44 36.14	175 57.08	E	991	3.01	15.9	0.0	0.0
93	P1	Jan-24-20	0737	0027	44 45.56	175 35.13	E	975	3.01	10.0	0.0	0.0
94	P1	Jan-24-20	1146	0006	44 26.78	175 36.58	E	780	2.46	23.6	0.0	17.9
95	P1	Jan-24-20	1404	0006	44 24.37	175 24.07	E	716	2.98	87.3	7.7	10.8
96	P1	Jan-24-20	1705	0016	44 16.22	175 19.03	E	592	3.00	99.3	0.0	77.8
97	P1	Jan-25-20	0010	0027	44 47.13	174 09.08	E	835	3.03	49.1	0.0	0.0
98	P1	Jan-25-20	0337	0030	45 00.36	174 01.12	E	1 207	3.02	0.0	0.0	0.0
99	P1	Jan-25-20	0642	0030	45 02.31	174 11.17	E	1 170	3.00	0.0	0.0	0.0
100	P1	Jan-25-20	1006	0030	45 13.45	174 22.37	E	1 180	3.02	0.0	0.0	0.0

Appendix 1: (continued)

Station	Type	Date	Start time (NZST)	Stratum	Start latitude (° ‘ S)	Start longitude (° ‘)	E/W	Max. depth (m)	Distance towed (n. mile)	Catch hoki (kg)	Catch hake (kg)	Catch ling (kg)
101	P1	Jan-25-20	1726	0006	44 25.63	174 57.26	E	673	3.05	82.1	4.4	37.6
102	P1	Jan-26-20	0619	0016	43 59.34	174 23.13	E	582	3.01	243.6	0.0	47.8
103	P1	Jan-26-20	1140	007A	43 29.42	174 01.08	E	435	2.08	336.9	0.0	57.0
104	P1	Jan-26-20	1439	0001	43 08.51	174 04.59	E	675	2.99	82.7	5.3	43.9
105	P1	Jan-26-20	1846	0023	42 51.67	174 21.67	E	1 269	3.01	0.0	0.0	0.0
106	P1	Jan-26-20	2200	0022	42 56.03	174 33.79	E	932	3.00	2 254.3	4.3	3.4
107	P1	Jan-27-20	0529	007A	43 31.39	174 35.18	E	520	2.12	1 173.9	41.7	43.3
108	P1	Jan-27-20	0903	0018	43 32.00	175 02.86	E	258	2.10	1 156.7	0.0	0.0
109	P1	Jan-27-20	1155	0018	43 17.17	174 52.18	E	346	3.01	2 290.9	0.0	15.3
110	P1	Jan-27-20	1436	0018	43 05.06	175 05.74	E	278	2.98	0.0	0.0	0.0
111	P1	Jan-27-20	1721	007A	42 57.91	175 01.17	E	589	3.01	260.1	11.9	34.4
112	P1	Jan-28-20	0138	0023	42 41.28	175 44.30	E	1 077	3.03	0.0	0.0	0.0
113	P1	Jan-28-20	0507	0023	42 39.71	175 34.46	E	1 208	3.03	0.0	0.0	0.0
114	P1	Jan-28-20	0748	0022	42 45.69	175 31.75	E	906	3.01	16.5	2.9	0.0
115	P1	Jan-28-20	1005	0022	42 48.48	175 23.50	E	840	3.01	46.6	0.0	0.0
116	P1	Jan-28-20	1235	0001	42 52.91	175 27.90	E	657	3.00	267.5	7.0	38.9
117	P1	Jan-28-20	1529	007B	43 02.95	175 42.05	E	484	3.01	278.7	23.9	124.5
118	P1	Jan-28-20	2049	0023	42 40.62	175 48.94	E	1 078	3.01	3.1	2.7	0.0
119	P1	Jan-28-20	2341	0023	42 37.00	176 02.08	E	1 162	3.03	4.5	0.0	0.0
120	P1	Jan-29-20	0311	0022	42 45.00	175 55.40	E	844	3.01	45.3	7.2	0.0
121	P1	Jan-29-20	0550	0001	42 53.98	175 57.35	E	619	3.04	132.8	22.4	6.9
122	P1	Jan-29-20	0909	007B	43 00.14	176 02.58	E	522	3.02	284.5	14.4	85.3
123	P1	Jan-29-20	1135	007B	43 05.46	175 56.26	E	435	3.00	2 178.3	0.0	8.4
124	P1	Jan-29-20	1407	0018	43 07.30	175 38.99	E	382	2.98	1 782.6	3.5	147.0
125	P1	Jan-29-20	1620	007B	43 12.68	175 45.28	E	443	2.98	1 375.1	35.1	57.7
126	P1	Jan-30-20	0522	0019	43 18.12	177 17.88	E	235	3.04	0.0	0.0	0.0
127	P1	Jan-30-20	0708	0019	43 13.73	177 08.81	E	215	2.97	0.0	0.0	0.0
128	P1	Jan-30-20	0846	0019	43 11.26	177 02.32	E	275	3.01	0.0	0.0	0.0
129	P1	Jan-30-20	1058	0019	43 12.92	176 49.58	E	302	3.03	170.9	0.0	0.0
130	P1	Jan-30-20	1304	0019	43 05.00	176 59.61	E	349	2.19	740.0	0.0	42.7
131	P2	Jan-30-20	1705	0020	43 02.67	177 35.77	E	361	3.02	815.6	0.7	52.7
132	P2	Jan-31-20	0828	007A	43 11.41	174 43.62	E	480	2.10	1545.9	15.1	46.5
133	P2	Jan-31-20	1022	007A	43 20.30	174 42.44	E	413	2.24	1631.7	0.0	35.3
134*	RS	Jan-31-20	1502	0031	43 45.60	174 02.46	E	343	3.04	535.9	0.0	19.8
135*	RS	Jan-31-20	1744	0031	43 42.22	173 51.80	E	102	3.01	0.0	0.0	0.0
136*	RS	Feb-01-20	0525	0031	44 15.86	173 10.46	E	128	3.01	0.0	0.0	0.1
137*	RS	Feb-01-20	0710	0031	44 09.47	173 16.07	E	108	3.01	0.0	0.0	0.0
138*	RS	Feb-01-20	1024	0031	44 02.18	173 48.61	E	397	2.31	985.5	0.0	10.3
139*	RS	Feb-01-20	1220	0031	43 57.82	173 44.48	E	128	3.03	0.0	0.0	0.0
140*	RS	Feb-01-20	1514	0031	43 53.30	173 29.45	E	84	3.02	0.0	0.0	0.0
141*	RS	Feb-02-20	0600	0031	43 37.03	173 21.51	E	72	3.01	0.0	0.0	0.0

Appendix 2: Scientific and common names of species caught from all core and deep tows (TAN2001). The occurrence (Occ.) of each species (number of tows caught) in all 133 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	1
Phaeophyta	brown seaweed	PHA	5
Porifera	unspecified sponges	ONG	3
Demospongiae (siliceous sponges)	unspecified siliceous sponge	DSO	2
Astrophorida (sandpaper sponges)			
Ancorinidae			
Ecionemia novaezelandiae	knobbly sandpaper sponge	ANZ	2
Geodiidae			
Pachymatisma sp.	rocky dumpling sponge	PAZ	2
Hadromerida (woody sponges)			
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	4
Spirophorida (spiral sponges)			
Tetillidae			
Tetilla australe	bristle ball sponge	TTL	1
T. leptoderma	furry oval sponge	TLD	2
Hexactinellida (glass sponges)			
Hexactinosida (lacey honeycomb sponges)			
Lyssacinosida (glass horn sponges)			
Euplectellidae			
Euplectella regalis	basket-weave horn sponge	ERE	4
Hyalascus sp.	floppy tubular sponge	HYA	30
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	18
Anthozoa			
Octocorallia			
Alcyonacea (soft corals)	unspecified soft coral	SOC/GOC	2
Alcyoniidae			
Anthomastus (*Bathyalcyon*) *robustus*	gigantic coral	ARO	1
Chrysogorgiidae (golden corals)			
Radicipes spp.	whip-like golden coral	RAD	9
Clavulariidae			
Telesto spp.	long polyp soft corals	TLO	1
Isididae (bamboo corals)		ISI	1
Antipatharia (black corals)			
Stylopathidae			
Stylopathes spp.		SLP	4
Plexauridae	plexaurid sea fans	PLE	3
Primnoidae	unspecified primnoid	PRI	2
Thourella spp.	bottlebrush coral	THO	3
Pennatulacea (sea pens)	unspecified sea pens	PTU	2
Anthoptilidae			
Anthoptilum grandiflorum	flower sea pen	AGF	1
Funiculinidae			
Funiculina quadrangularis	rope-like sea pen	FQU	5

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Pennatulidae			
Pennatula cf. *phosphorea*	purple sea pen	PPH	2
P. spp.	feathery sea pens	PNN	2
Protoptilidae			
Distichoptilum gracile	two-lined sea pen	DGR	4
Umbellulidae			
Umbellula spp.		UMB	2
Hexacorallia			
Zoanthidea (zoanthids)			
Epizoanthidae			
Epizoanthus sp.		EPZ	1
Actinaria (anemones)	unspecified anemone	ANT	2
Actiniidae			
Bolocera spp.	deepsea anemone	BOC	4
Liponematidae			
Liponema spp.	deepsea anemone	LIP	1
Actinostolidae (smooth deepsea anemones)		ACS	17
Hormathiidae (warty deepsea anemones)		HMT	11
Scleractinia (stony corals)			
Caryophyllidae			
Caryophyllia spp.	cup coral	CAY	2
Desmophyllum dianthus	crested cup coral	DDI	2
Goniocorella dumosa	bushy hard coral	GDU	8
Stephanocyathus platypus	solitary bowl coral	STP	1
Flabellidae			
Flabellum spp.	flabellum coral	COF	5
Hydrozoa (hydroids)	unspecified hydroids	HDR	3
Tunicata			
Ascidiacea (sea squirts)		ASC	3
Thaliacea			
Pyrosomida (pyrosomes)			
Pyrosomatidae			
Pyrosoma atlanticum		PYR	56
Salpida (salps)	unspecified salps	SAL	23
Salpidae			
Soestia zonaria		ZZO	1
Thetys vagina		ZVA	11
Mollusca			
Gastropoda (gastropods)			
Buccinidae (whelks)			
Aeneator recens		AER	2
Ranellidae (tritons)			
Fusitriton magellanicus		FMA	9
Cephalopoda			
Teuthoidea (squids)			
Oegopsida			
Architeuthidae			
Architeuthis dux	giant squid	GSQ	1
Chiroteuthidae			
Chiroteuthis veryani		CVE	1
Cranchiidae	unspecified cranchiid	CHQ	2
Teuthowenia pellucida	squid	TPE	11

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Histioteuthidae (violet squids)			
Histioteuthis macrohista	violet squid	HMC	1
Histioteuthis spp.	violet squid	VSQ	7
Mastigoteuthidae			
Mastigoteuthis spp.		MSQ	1
Octopoteuthidae			
Octopoteuthis spp.	squid	OPO	6
Ommastrephidae	unspecified ommastrephid	OMQ	1
Nototodarus sloanii	Sloan's arrow squid	NOS	49
Todarodes filippovae	Todarodes squid	TSQ	41
Onychoteuthidae			
Moroteuthopsis ingens	warty squid	MIQ	57
Onykia robsoni + *O.* sp. A	warty squid	MRQ	13
Sepioidea			
Sepiolida (bobtail squids)			
Sepiadariidae			
Sepioloidea sp.	bobtail squid	SSQ	1
Sepiolidae			
Stoloteuthis maoria	bobtail squid	IRM	1
Octopodiformes			
Octopoda			
Cirrata (cirrate octopus)			
Opisthoteuthidae			
Opisthoteuthis spp.	umbrella octopus	OPI	4
Incirrata (incirrate octopus)			
Octopodidae			
Graneledone taniwha	deepwater octopus	GTA	3
G. spp.	deepwater octopus	DWO	2
Muusoctopus spp.	octopus	BNO	2
Octopus mernoo	octopus	OME	1
Polychaeta	unspecified polychaete	POL	1
Eunicida			
Onuphidae			
Hyalinoecia tubicola	quill worm	HTU	1
Crustacea			
Cirripedia (barnacles)	unspecified barnacles	BRN	1
Malacostraca			
Decapoda			
Dendrobranchiata/Pleocyemata			
Dendrobranchiata			
Aristeidae			
Aristaeopsis edwardsiana	scarlet prawn	PED	2
Aristeus spp.		ARI	1
Sergestidae			
Sergestes spp.		SER	1
Sergia potens		SEP	4
Solenoceridae			
Haliporoides sibogae	jackknife prawn	HSI	5
Pleocyemata			
Caridea			
Campylonotidae			
Campylonotus rathbunae	sabre prawn	CAM	2

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Oplophoridae			
Acanthephyra spp.	Sub-Antarctic ruby prawn	ACA	16
Notostomus auriculatus	scarlet prawn	NAU	3
Oplophorus novaezeelandiae	deepwater prawn	ONO	2
O. spp.	deepwater prawn	OPP	2
Pandalidae			
Plesionika martia	golden prawn	PLM	1
Pasiphaeidae			
Pasiphaea barnardi	deepwater prawn	PBA	23
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	29
Nematocarcinus spp.	spider prawn	NEC	3
Achelata			
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	27
Palinura			
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	4
Anomura			
Galatheoidea	unspecified squat lobster	GAL	2
Galatheidae (galatheid squat lobsters)			
Munida spp.	squat lobster	MNI	1
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	4
Paralomis zealandica	Prickly king crab	PZE	2
Paguridae (Parapagurid hermit crabs)			
Diacanthurus rubricatus	hermit crab	DIR	1
Parapaguridae (Parapagurid hermit crabs)			
Sympagurus dimorphus	hermit crab	SDM	2
Lophogastrida			
Gnathophausiidae			
Neognathophausia ingens	giant red mysid	NEI	4
Brachyura (true crabs)			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	4
Goneplacidae			
Pycnoplax victoriensis	two-spined crab	CVI	2
Homolidae			
Dagnaudus petterdi	antlered crab	DAP	6
Majidae (spider crabs)			
Teratomaia richardsoni	spiny masking crab	SMK	2
Isopoda (isopods)	unspecified isopod	ISO	1
Echinodermata			
Crinoidea (sea lilies and feather stars)	unspecified crinoid	CRI	2
Comatulida (feather stars)	unspecified feather stars	CMT	2
Asteroidea (starfish)	unspecified starfish	ASR	1
Asteriidae			
Pseudechinaster rubens	starfish	PRU	6
Sclerasterias mollis	cross-fish	SMO	2
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	17
Plutonaster knoxi	abyssal star	PKN	16
Proserpinaster neozelanicus	starfish	PNE	2

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Astropectinidae (cont.)			
Psilaster acuminatus	geometric star	PSI	20
Benthopectinidae			
Benthopecten spp.	starfish	BES	1
Brisingida	unspecified brisingid	BRG	12
Echinasteridae			
Henricia compacta	starfish	HEC	1
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	2
Hippasteria phrygiana	trojan starfish	HTR	3
Lithosoma novaezelandiae	rock star	LNV	2
Mediaster sladeni	starfish	MSL	2
Pillsburiaster aoteanus	starfish	PAO	3
Solasteridae			
Crossaster multispinus	sun star	CJA	5
Solaster torulatus	chubby sun-star	SOT	2
Pterasteridae			
Diplopteraster sp.	starfish	DPP	4
Hymenaster carnosus	starfish	HYC	1
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	25
Ophiuroidea (basket and brittle stars)	unspecified brittle star	OPH	2
Asteroschematidae			
Ophiocreas sibogae	brittle star	OSI	1
Ophiuridae			
Ophiomusium lymani	brittle star	OLY	3
Euryalina (basket stars)			
Gorgonocephalidae			
Gorgonocephalus spp.	Gorgon's head basket stars	GOR	3
Echinoidea (sea urchins)	unspecified sea urchin	ECN	1
Regularia			
Cidaridae			
Goniocidaris parasol	parasol urchin	GPA	2
G. umbraculum	cidarid urchin	GPA	1
Histiocidaridae			
Histiocidaris spp.		HIS	1
Poriocidaris purpurata		PCD	1
Echinothuriidae/Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	36
Echinothuriidae (Tam O’Shanters)	unspecified Tam O'Shanter urchin	ECT	5
Phormosomatidae			
Phormosoma spp.		PHM	3
Echinidae			
Dermechinus horridus	deepsea urchin	DHO	1
Gracilechinus multidentatus	deepsea kina	GRM	19
Spatangoida (heart urchins)			
Spatangidae			
Paramaretia peloria	Microsoft mouse	PMU	3
Spatangus mathesoni	Matheson’s heart urchin	SMT	2
S. multispinus	purple-heart urchin	SPT	7
Holothuroidea	unspecified holothurian	HTH	1
Aspidochirotida			
Synallactidae			
Bathyplotes sp.	sea cucumber	BAM	4
Pseudostichopus mollis	sea cucumber	PMO	28

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Elasipodida			
Laetmogonidae			
Laetmogone sp.	sea cucumber	LAG	7
Pannychia moseleyi	sea cucumber	PAM	5
Pelagothuridae			
Enypniastes eximia	sea cucumber	EEX	7
Psolidae			
Psolus segregatus	sea cucumber	CUC	1
Psychropotidae			
Benthodytes sp.	sea cucumber	BTD	2
Agnatha (jawless fishes)			
Myxinidae: hagfishes			
Eptatretus cirrhatus	hagfish	HAG	1
Chondrichthyes (cartilaginous fishes)			
Chimaeridae: chimaeras, ghost sharks			
Chimaera carophila	brown chimaera	CHP	9
C. lignaria	giant chimaera	CHG	2
Hydrolagus bemisi	pale ghost shark	GSP	62
H. homonycteris	black ghost shark	HYB	1
H. novaezealandiae	dark ghost shark	GSH	53
H. trolli	pointynose blue ghost shark	HYP	1
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose spookfish	LCH	55
Rhinochimaera pacifica	Pacific spookfish	RCH	26
Lamnidae: mackerel sharks			
Lamna nasus	porbeagle	POS	1
Scyliorhinidae: cat sharks			
Apristurus ampliceps	roundfin catshark	AAM	4
A. exsanguis	New Zealand catshark	AEX	16
A. garracki	Garrick’s catshark	AGK	3
A. melanoasper	fleshynose catshark	AML	5
A. cf. *sinensis*	freckled catshark	ASI	6
Bythaelurus dawsoni	Dawson's catshark	DCS	1
Cephaloscyllium isabella	carpet shark	CAR	3
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	9
Chlamydoselachidae: frilled sharks			
Chlamydoselachus anguineus	frill shark	FRS	1
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	2
Squalidae: dogfishes			
Squalus acanthias	spiny dogfish	SPD	67
S. griffini	northern spiny dogfish	NSD	2
Centrophoridae: gulper sharks			
Centrophorus squamosus	leafscale gulper shark	CSQ	19
Deania spp.	shovelnose spiny dogfish	SND	49
Etmopteridae: lantern sharks			
Etmopterus granulosus	Baxter's dogfish	ETB	48
E. lucifer	lucifer dogfish	ETL	51
E. unicolor	shortspine dogfish	ETU	1
Somniosidae: sleeper sharks			
Centroselachus crepidater	longnose velvet dogfish	CYP	45
Centroscymnus owstoni	Owston’s dogfish	CYO	31

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Somniosidae (cont.)			
Proscymnodon plunketi	Plunket's shark	PLS	1
Zameus squamulosus	velvet dogfish	ZAS	2
Dalatiidae: kitefin sharks			
Dalatias licha	seal shark	BSH	28
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	5
Torpedinidae: electric rays			
Tetronarce nobiliana	electric ray	ERA	1
Rajidae: skates			
Dipturus innominatus	smooth skate	SSK	23
Zearaja nasuta	rough skate	RSK	2
Arhynchobatidae: softnose skates			
Bathraja shuntovi	longnosed deepsea skate	PSK	5
Brochiraja asperula	smooth deepsea skate	BTA	7
B. leviveneta	blue skate	BRL	2
B. spinifera	prickly deepsea skate	BTS	3
Osteichthyes (bony fishes)			
Halosauridae: halosaurs			
Halosaurus pectoralis	common halosaur	HPE	2
Notocanthidae: spiny eels			
Notacanthus chemnitzi	giant spineback	NOC	1
N. sexspinis	spineback	SBK	64
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	36
Nemichthyidae: snipe eels			
Avocettina paucipora	fewpore snipe eel	APA	1
Nemichthys curvirostris	black spot snipe eel	NCU	1
N. scolopaceus	slender snipe eel	NEM	1
Congridae: conger eels			
Bassanago bulbiceps	swollenhead conger	SCO	30
B. hirsutus	hairy conger	HCO	27
Serrivomeridae: sawtooth eels			
Serrivomer samoensis	common sawtooth eel	SSA	1
Argentinidae: silversides			
Argentina elongata	silverside	SSI	43
Bathylagidae: deepsea smelts	unspecified deepsea smelt	BLG	1
Bathylagichthys spp.	deepsea smelts	BAH	1
Bathylagus tenuis	black deepsea smelt	BTN	3
Melanolagus bericoides	bigscale deepsea smelt	MEB	10
Platytroctidae: tubeshoulders			
Holtbyrnia laticauda	barlight tubeshoulder	HOL	2
Normichthys yahganorum	cloaked tubeshoulder	NOR	2
Persparsia kopua	common tubeshoulder	PER	10
Alepocephalidae: slickheads			
Alepocephalus antipodianus	smallscaled brown slickhead	SSM	29
A. australis	bigscaled brown slickhead	SBI	23
Xenodermichthys copei	black slickhead	BSL	13
Diplophidae: portholefishes			
Diplophos rebainsi	Rebain’s portholefish	DRB	3
Phosichthyidae: lighthouse fishes			
Phosichthys argenteus	lighthouse fish	PHO	36
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	8
Sternoptyx pseudodiaphana	false oblique hatchetfish	SPU	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Astronesthidae: snaggletooths			
Astronesthes boulengeri	Boulenger's snaggletooth	ASB	1
A. spp.	snaggletooth	ASE	1
Borostomias antarcticus	southern snaggletooth	BAN	4
Stomiinae: scaly dragonfishes			
Stomias boa	scaly dragonfish	SBB	8
Chauliodontinae: viperfishes			
Chauliodus sloani	viperfish	CHA	16
Melanostomiinae: barbeled dragonfishes			
Eustomias trewavasae	Trewavas's dragonfish		1
Flagellostomias boureei	slender dragonfish		1
Melanostomias niger	black dragonfish	MNG	4
Opostomias micripnus	giant black dragonfish	OMI	4
Idiacanthinae: black dragonfishes			
Idiacanthus atlanticus	common black dragonfish	IAT	3
Malacosteinae: loosejaws			
Malacosteus australis	southern loosejaw	MAU	8
Paraulopidae: cucumberfishes			
Paraulopus nigripinnis	cucumberfish	CUC	1
Notosudidae: waryfishes			
Scopelosaurus ahlstromi	Ahlstrom's waryfish	SAH	1
S. spp.		SPL	2
Scopelarchidae: pearleyes			
Benthalbella elongata	Elongate greeneye	BEG	1
Paralepididae: barracudinas			
Macroparalepis macrogeneion	headband barracudina	MMA	3
Evermannellidae: sabretoothfishes			
Evermannella balbo	brown sabretooth	EVB	1
Alepisauridae: lancetfishes			
Alepisaurus brevirostris	shortsnouted lancetfish	ABR	5
Myctophidae: lanternfishes	unspecified lanternfish	LAN	2
Bolinichthys spp.		BOL	1
Diaphus danae	Dana lanternfish	DDA	6
D. hudsoni	Hudson's lanternfish	DHU	1
Electrona subaspera	rough lanternfish	ESU	1
Electrona spp.		ELT	1
Gymnoscopelus bolini	Bolin's lanternfish	GYB	2
G. hintonoides	false-midas lanternfish	GYH	3
G. microlampas	minispotted lanternfish	GYI	4
G. piabilis	southern blacktip lanternfish	GYP	2
G. spp.	lanternfish	GYM	1
Lampadena notialis	notal lanternfish	LNT	1
Lampanyctodes hectoris	Heactor's lanternfish	LHE	1
Lampanyctus australis	austral lanternfish	LAU	15
L. intricarius	intricate lanternfish	LIT	25
L. macdonaldi	MacDonald's lanternfish	LMD	1
Nannobrachium achirus	cripplefin lanternfish	LAC	5
Symbolophorus boops	bogue lanternfish	SBP	6
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	9
Ophidiidae: cuskeels			
Genypterus blacodes	ling	LIN	79
Euclichthyidae: eucla cods			
Euclichthys polynemus	eucla cod	EUC	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Macrouridae: rattails			
Coelorinchus acanthiger	spotty faced rattail	CTH	3
C. aspercephalus	oblique banded rattail	CAS	40
C. biclinozonalis	two saddle rattail	CBI	11
C. bollonsi	Bollons’ rattail	CBO	73
C. fasciatus	banded rattail	CFA	35
C. innotabilis	notable rattail	CIN	45
C. kaiyomaru	Kaiyomaru rattail	CKA	16
C. matamua	Mahia rattail	CMA	16
C. oliverianus	Oliver's rattail	COL	55
C. parvifasciatus	small banded rattail	CCX	18
C. trachycarus	roughhead rattail	CHY	11
Coryphaenoides dossenus	humpback rattail	CBA	7
C. mcmillani	McMillan’s rattail	CMX	2
C. murrayi	Murray’s rattail	CMU	3
C. serrulatus	serrulate rattail	CSE	34
C. striaturus	striate rattail	CTR	2
C. subserrulatus	four-rayed rattail	CSU	43
Kuronezumia leonis	starnose black rat	NPU	1
Lepidorhynchus denticulatus	javelinfish	JAV	96
Nezumia namatahi	squashedfaced rattail	NNA	4
Odontomacrurus murrayi	largefang rattail	OMU	1
Trachonurus gagates	velvet rattail	TRX	1
Lucigadus nigromaculatus	blackspot rattail	VNI	13
Macrourus carinatus	ridge scaled rattail	MCA	25
Mesobius antipodum	black javelinfish	BJA	18
Trachyrincidae: rough rattails			
Trachyrincus aphyodes	white rattail	WHX	36
T. longirostris	unicorn rattail	WHR	4
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	11
Halargyreus johnsonii	Johnson's cod	HJO	11
H. sp.	Australasian slender cod	HAS	42
Lepidion microcephalus	small-headed cod	SMC	14
L. schmidti	Schmidt’s cod	LPS	1
Mora moro	ribaldo	RIB	34
Notophycis marginata	dwarf cod	DCO	3
Pseudophycis bachus	red cod	RCO	23
Tripterophycis gilchristi	grenadier cod	GRC	1
Melanonidae: pelagic cods			
Melanonus gracilis	smalltooth pelagic cod	MEL	1
M. zugmayeri	largetooth pelagic cod	MEZ	1
Merlucciidae: hakes			
Lyconus pinnatus	fangtooth hoki	LYC	1
Macruronus novaezelandiae	hoki	HOK	108
Merluccius australis	hake	HAK	49
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	4
Ceratiidae: seadevils			
Ceratias spp.	seadevils	CER	3
Melamphaidae: bigscalefishes			
Poromitra atlantica	southern bigscale	CBS	4
Sio nordenskjoldii	black bigscalefish	SNO	2
Rondeletiidae: redmouth whalefishes			
Rondeletia loricata	redmouth whalefish	RMW	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Anoplogastridae: fangtooth			
Anoplogaster cornuta	fangtooth	ANO	5
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	5
Diretmichthys parini	spinyfin	SFN	2
Trachichthyidae: roughies, slimeheads			
Hoplostethus atlanticus	orange roughy	ORH	37
H. mediterraneus	silver roughy	SRH	32
Paratrachichthys trailli	common roughy	RHY	9
Berycidae: alfonsinos			
Beryx decadactylus	longfinned beryx	BYD	2
B. splendens	alfonsino	BYS	33
Zeidae: dories			
Zenopsis nebulosa	mirror dory	MDO	1
Cyttidae: cyttid dories			
Cyttus novaezealandiae	silver dory	SDO	15
C. traversi	lookdown dory	LDO	81
Zeniontidae: armoureye dories			
Capromimus abbreviatus	capro dory	CDO	18
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	29
A. verrucosus	warty oreo	WOE	6
Neocyttus rhomboidalis	spiky oreo	SOR	36
Pseudocyttus maculatus	smooth oreo	SSO	43
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	66
Notopogon lilliei	crested bellowsfish	CBE	2
Sebastidae: seaperches			
Helicolenus barathri	bigeye sea perch	HBA	77
H. percoides	sea perch	HPC	7
H. spp.	sea perch	SPE	1
Trachyscorpia eschmeyeri	Cape scorpionfish	TRS	6
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	1
Congiopodus leucopaecilus	pigfish	PIG	4
Triglidae: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	12
Hoplichthyidae: ghostflatheads			
Hoplichthys cf. *haswelli*	deepsea flathead	FHD	33
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	12
Psychrolutes microporos	blobfish	PSY	4
Polyprionidae: wreckfishes			
Polyprion oxygeneios	hapuku	HAP	13
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	12
Epigonidae: deepwater cardinalfishes			
Epigonus denticulatus	white cardinalfish	EPD	4
E. lenimen	bigeye cardinalfish	EPL	6
E. machaera	thin tongue cardinalfish	EPM	27
E. robustus	robust cardinalfish	ERB	2
E. telescopus	deepsea cardinalfish	EPT	18
Howellidae: pelagic basslets			
Rosenblattia robusta	rotund cardinalfish	ROS	7

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Carangidae: trevallies, kingfishes			
Trachurus declivis	greenback jack mackerel	JMD	3
T. murphyi	slender jack mackerel	JMM	4
Bramidae: pomfrets			
Brama australis	southern Ray's bream	SRB	1
B. brama	Ray’s bream	RBM	29
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	12
Plagiogeneion rubiginosum	rubyfish	RBY	2
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	NMP	12
Latridae: trumpeters			
Latris lineata	trumpeter	TRU	1
Chiasmodontidae: swallowers	unspecified swallower	CHM	2
Chiasmodon microcephalus	black swallower	CML	1
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	GIZ	45
Gempylidae: snake mackerels			
Rexea solandri	gemfish	RSO	1
Thyrsites atun	barracouta	BAR	9
Trichiuridae: cutlassfishes			
Benthodesmus spp.	scabbardfish	BEN	3
Lepidopus caudatus	frostfish	FRO	9
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	4
Hyperoglyphe antarctica	bluenose	BNS	6
Pseudoicichthys australis	ragfish	RAG	1
Seriolella caerulea	white warehou	WWA	32
S. punctata	silver warehou	SWA	35
Tubbia tasmanica	Tasmanian ruffe	TUB	3
Nomeidae: eyebrowfishes, driftfishes			
Cubiceps spp.	cubehead	CUB	1
Tetragonuridae: squaretails			
Tetragonurus cuvieri	squaretail	TET	1
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	12
Achiropsettidae: finless flounders			
Neoachiropsetta milfordi	finless flounder	MAN	5
Rhombosoleidae: southern righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	11
Molidae: sunfishes, molas			
Mola alexandrini	bumphead sunfish	MOI	1

Appendix 3: Scientific and common names of species caught from exploratory tows in the Canterbury Banks Hoki Management Area (Stratum 31, TAN2001). The occurrence (Occ.) of each species (number of tows caught) in all 8 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.
Porifera			
Demospongiae (siliceous sponges)			
Haplosclerida (air sponges)			
Callyspongiidae			
Callyspongia sp.	airy finger sponge	CRM	1
Cnidaria			
Anthozoa			
Hexacorallia			
Actinaria (anemones)	unspecified anemone	ANT	1
Hormathiidae (warty deepsea anemones)		HMT	3
Tunicata			
Thaliacea			
Pyrosomida (pyrosomes)			
Pyrosomatidae			
Pyrosoma atlanticum		PYR	4
Salpida (salps)	unspecified salps	SAL	1
Mollusca			
Cephalopoda			
Teuthoidea (squids)			
Oegopsida			
Ommastrephidae			
Nototodarus sloanii	Sloan's arrow squid	NOS	8
Onychoteuthidae			
Moroteuthopsis ingens	warty squid	MIQ	1
Crustacea			
Malacostraca			
Decapoda			
Brachyura (true crabs)			
Majidae (spider crabs)			
Leptomithrax longipes	long-legged masking crab	LLC	3
Echinodermata			
Asteroidea (starfish)			
Asteriidae			
Sclerasterias mollis	cross-fish	SMO	2
Astropectinidae			
Plutonaster knoxi	abyssal star	PKN	1
Holothuroidea			
Synallactida			
Stichopodidae			
Australostichopus mollis	sea cucumber	SCC	2
Chondrichthyes (cartilaginous fishes)			
Callorhinchidae: elephant fishes, ploughnose chimaeras			
Callorhinchus milii	elephantfish	ELE	1
Chimaeridae: chimaeras, ghost sharks			
H. novaezealandiae	dark ghost shark	GSH	6

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Scyliorhinidae: cat sharks			
Cephaloscyllium isabella	carpet shark	CAR	1
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	3
Squalidae: dogfishes			
Squalus acanthias	spiny dogfish	SPD	8
Torpedinidae: electric rays			
Tetronarce nobiliana	electric ray	ERA	1
Rajidae: skates			
Dipturus innominatus	smooth skate	SSK	2
Zearaja nasuta	rough skate	RSK	2
Osteichthyes (bony fishes)			
Congridae: conger eels			
Bassanago bulbiceps	swollenhead conger	SCO	1
Conger verreauxi	southern conger	CVR	1
Argentinidae: silversides			
Argentina elongata	silverside	SSI	4
Myctophidae: lanternfishes			
Symbolophorus boops	bogue lanternfish	SBP	1
Ophidiidae: cuskeels			
Genypterus blacodes	ling	LIN	3
Macrouridae: rattails			
Coelorinchus aspercephalus	oblique banded rattail	CAS	2
C. biclinozonalis	two saddle rattail	CBI	2
C. bollonsi	Bollons' rattail	CBO	2
Lepidorhynchus denticulatus	javelinfish	JAV	2
Moridae: morid cods			
Pseudophycis bachus	red cod	RCO	4
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	2
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	1
Zeidae: dories			
Zeus faber	John dory	JDO	1
Cyttidae: cyttid dories			
Cyttus novaezealandiae	silver dory	SDO	4
C. traversi	lookdown dory	LDO	2
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	1
Notopogon lilliei	crested bellowsfish	CBE	4
Sebastidae: seaperches			
Helicolenus barathri	bigeye sea perch	HBA	1
H. percoides	sea perch	HPC	6
Congiopodidae: pigfishes			
Congiopodus leucopaecilus	pigfish	PIG	2
Triglidae: gurnards			
Chelidonichthys kumu	red gurnard	GUR	5
Lepidotrigla brachyoptera	scaly gurnard	SCG	4
Hoplichthyidae: ghostflatheads			
Hoplichthys cf. *haswelli*	deepsea flathead	FHD	4
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	1
Polyprionidae: wreckfishes			
Polyprion oxygeneios	hapuku	HAP	5

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Carangidae: trevallies, kingfishes			
Trachurus declivis	greenback jack mackerel	JMD	5
T. murphyi	slender jack mackerel	JMM	1
Bramidae: pomfrets			
Brama brama	Ray's bream	RBM	2
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	NMP	5
Latridae: trumpeters			
Latridopsis ciliaris	moki	MOK	1
Pinguipedidae: sandperches			
Parapercis colias	blue cod	BCO	2
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	GIZ	7
Gempylidae: snake mackerels			
Rexea solandri	gemfish	RSO	8
Thyrsites atun	barracouta	BAR	6
Centrolophidae: warehous, medusafishes			
Seriolella caerulea	white warehou	WWA	2
S. punctata	silver warehou	SWA	6
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	1
Rhombosoleidae: southern righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	2

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

NIWA No.	Cruise/StationNo.	Phylum	Class	Order	Family	Genus	Species
145953	TAN2001/43	Mollusca	Cephalopoda	Oegopsida	Octopoteuthidae	*Octopoteuthis*	sp.
145954	TAN2001/26	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
145955	TAN2001/100	Mollusca	Cephalopoda	Oegopsida	Octopoteuthidae	*Octopoteuthis*	sp.
145956	TAN2001/93	Mollusca	Cephalopoda	Oegopsida	Octopoteuthidae	*Octopoteuthis*	sp.
145957	TAN2001/74	Mollusca	Cephalopoda	Oegopsida	Architeuthidae	*Architeuthis*	*dux*
145958	TAN2001/64	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Benthoctopus*	sp.
145959	TAN2001/112	Mollusca	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*macrohista*
145960	TAN2001/105	Mollusca	Cephalopoda	Octopoda	Opisthoteuthidae	*Opisthoteuthis*	sp.
145961	TAN2001/117	Mollusca	Cephalopoda	Oegopsida	Ommastrephidae		
145962	TAN2001/94	Mollusca	Cephalopoda	Octopoda	Amphitretidae	*Amphitretus*	sp.
145963	TAN2001/101	Mollusca	Cephalopoda	Octopoda	Amphitretidae	*Amphitretus*	sp.
145988	TAN2001/118	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
145998	TAN2001/15	Mollusca	Cephalopoda	Sepiida	Sepiolidae		
145999	TAN2001/83	Mollusca	Cephalopoda	Oegopsida	Chiroteuthidae	*Chiroteuthis*	*veranyi*
146000	TAN2001/52	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
141528	TAN2001/25	Mollusca	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
141768	TAN2001/71	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Goniocorella*	*dumosa*
141783	TAN2001/85	Mollusca					
141784	TAN2001/63	Cnidaria	Anthozoa	Alcyonacea	Primnoidae		
141785	TAN2001/110	Cnidaria	Anthozoa	Alcyonacea	Plexauridae		
141786	TAN2001/99	Cnidaria	Anthozoa	Alcyonacea	Isididae		
141791	TAN2001/15	Echinodermata	Holothuroidea	Dendrochirotida	Psolidae	*Psolus*	*squamatus*
141792	TAN2001/64	Arthropoda	Malacostraca	Decapoda	Lithodidae	*Paralomis*	*zealandica*
141793	TAN2001/50	Cnidaria	Hydrozoa				
141794	TAN2001/37	Cnidaria	Hydrozoa				
141795	TAN2001/64	Cnidaria	Anthozoa	Alcyonacea	Primnoidae		

Appendix 5: Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomass values given in Figure 8a. 1992 and 1993 length ranges were revised from those in Stevens et al. (2017).

Survey		Age group	
	1+	2+	3++
Jan 1992	< 50	50 – 60	≥ 60
Jan 1993	< 50	50 – 60	≥ 60
Jan 1994	< 46	46 – 58	≥ 59
Jan 1995	< 46	46 – 58	≥ 59
Jan 1996	< 46	46 – 54	≥ 55
Jan 1997	< 44	44 – 55	≥ 56
Jan 1998	< 47	47 – 55	≥ 53
Jan 1999	< 47	47 – 56	≥ 57
Jan 2000	< 47	47 – 60	≥ 61
Jan 2001	< 49	49 – 59	≥ 60
Jan 2002	< 52	52 – 59	≥ 60
Jan 2003	< 49	49 – 61	≥ 62
Jan 2004	< 51	51 – 60	≥ 61
Jan 2005	< 48	48 – 64	≥ 65
Jan 2006	< 49	49 – 62	≥ 63
Jan 2007	< 48	48 – 62	≥ 63
Jan 2008	< 49	49 – 59	≥ 60
Jan 2009	< 48	48 – 61	≥ 62
Jan 2010	< 48	48 – 61	≥ 62
Jan 2011	< 48	48 – 61	≥ 62
Jan 2012	< 49	49 – 59	≥ 60
Jan 2013	< 47	47 – 54	≥ 55
Jan 2014	< 48	48 – 60	≥ 61
Jan 2016	< 49	49 – 62	≥ 62
Jan 2018	< 48	48 – 59	≥ 59
Jan 2020	< 48	48 – 59	≥ 59