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Trawl survey of hoki and middle-depth species on the Chatham Rise, January 2016 (TAN1601)

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EXECUTIVE SUMMARY

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The twenty-forth 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 3 January to 2 February 2016. A random stratified sampling design was used, and 139 bottom trawls were successfully completed. These comprised 84 core (200–800 m) phase 1 biomass tows, 9 core phase 2 tows, and 46 deep (800–1300 m) tows.

Estimated relative biomass of all hoki in core strata was 114 514 t (CV 14.2%), an increase of 12% from January 2014. This increase was largely driven by the biomass estimate for 1+ year old hoki of 47 566 t, the second highest in the time series for this age class of fish. The biomass estimate for 2+ hoki (2013 year class) was 12 902 t; one of the lower estimates in the time series. The relative biomass of recruited hoki (ages 3+ years and older) of 54 046 t was similar to that in 2014, and about average for the time series. The relative biomass of hake in core strata decreased by 6% to 1299 t (CV 18.5%) between 2014 and 2016. The relative biomass of ling was 10 201 t (CV 7.2%), 36% higher than that in January 2014, but the time-series for ling shows no overall trend.

The age frequency distribution for hoki was dominated by 1+ hoki (2014 year class) and there were relatively few 2+ hoki (2013 year class). The age frequency distribution for hake was broad, with most fish aged between 2 and 10 years. The age distribution for ling was also broad, with most fish aged between 2 and 20 years.

In 2016 the survey area was successfully extended to cover 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 also collected during the trawl survey. As in previous surveys, there was a positive correlation between acoustic density from bottom marks and trawl catch rates. The acoustic index of mesopelagic fish abundance in 2016 was 30% higher than that in 2014, and the highest since 2009. The mesopelagic index increased in all four sub-areas, with the highest percentage increase (54%) in the southwest. Hoki liver condition was also higher in 2016 than that in 2014. There was a moderately strong positive correlation between hoki liver condition and indices of mesopelagic fish scaled by hoki abundance ("food per fish").

1. INTRODUCTION

In January 2016, the twenty-fourth 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), Stevens & Livingston (2003), Livingston et al. (2004), Livingston & Stevens (2005), and Stevens & O'Driscoll (2006, 2007). Trends in relative biomass, and the spatial and depth distributions of 142 species or species groups, were reviewed for the surveys from 1992–2010 by O'Driscoll et al. (2011b).

The main aim of the Chatham Rise surveys is to provide relative biomass estimates of adult and juvenile hoki. Hoki is New Zealand's largest finfish fishery, with an annual total allowable commercial catch (TACC) of 150 000 t from 1 October 2015, down from 160 000 t in 2014–15. Hoki is assessed as two stocks, western and eastern. The current 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, then decreased to a low of 30 700 t in 2004–05, before increasing again from 2008–09 to 2011–12 (Ballara & O'Driscoll 2014). The catch from the Chatham Rise in 2014–15 was 40 100 t, making this the second largest fishery in the EEZ (behind the west coast South island), and contributing about 25% of the total New Zealand hoki catch.

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

Other middle depth species are also monitored by this survey time series (O'Driscoll et al. 2011b). These include important commercial species such as hake and ling, as well as a wide range of non-commercial fish and invertebrate species. For most of these species, the trawl survey is the only fisheries-independent estimate of abundance on the Chatham Rise, and the survey time-series fulfils an important "ecosystem monitoring" role (e.g., Tuck et al. 2009), as well as providing inputs into single-species stock assessment.

In 2010, the Chatham Rise survey was extended to deeper waters (to 1300 m) on the north and southeast Rise, to provide fishery independent relative abundance indices for a wider range of species, including pre-recruit (20–30 cm) and dispersed adult orange roughy, black oreo and smooth oreo, and some common bycatch such as deepwater sharks as well as providing improved information for species like ribaldo and pale ghost shark, which are known to occur deeper than the core survey maximum depth of 800 m. The deeper waters of the southwestern Rise are an important fishing area for oreos and during the 2010 pilot deepwater survey three additional deepwater strata (strata 27–29) were proposed in this area. However, due to time constraints within the 'normal' survey duration only two of these strata were completed (strata 26 and 27) and given that the primary focus of the deepwater survey was to provide data on pre-recruit and recruited orange roughy these southwest strata have not been surveyed since. The survey duration was extended by 6 days (i.e. from 25 to 31 days) in 2016, to provide fishery independent abundance indices for a range of common deepwater bycatch species in the orange roughy and oreo fisheries. The 2016 survey covered depths of 800–1300 m around the whole Chatham Rise, and included strata 27–29 and an additional stratum 30 (1000–1300 m on the southwest Chatham Rise).

Acoustic data have been recorded during trawls and while steaming between stations on all trawl surveys on the Chatham Rise since 1995, except for 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, 2011, Stevens et al. 2009b, 2011, 2012, 2013, 2014, 2015). Acoustic data also provide qualitative information on the amount of backscatter that is not available to the bottom trawl, either through fish 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 HOK2015/01). 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 using trawl surveys and to determine the relative year class strengths of juvenile hoki (1, 2 and 3 year olds), with target coefficient of variation (CV) of 20 % for the number of 2 year olds.

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

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

4. To sample deeper strata for orange roughy using a random trawl survey design.

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

2. METHODS

2.1 Survey area and design

As in previous years, the survey followed a two-phase random design (after Francis 1984). The main survey area of 200–800 m depth (Figure 1) was divided into 23 strata. Nineteen of these strata are the same as those used in 2003–11 (Livingston et al. 2004, Livingston & Stevens 2005, Stevens & O'Driscoll 2006, 2007, Stevens et al. 2008, 2009a, 2009b, 2011, 2012). In 2012, stratum 7 was divided into strata 7A and 7B at 175° 30'E to more precisely assess the biomass of hake which appeared to be spawning northeast of Mernoo Bank (in Stratum 7B). In 2013, the survey duration was reduced from 27 to 25 days, removing the contingency for bad weather and reducing the available time for phase 2 stations. To increase the time available for phase 2 stations in 2014, strata 10A and 10B were re-combined into a single stratum 10 and stratum 11A, 11B, 11C, 11D into a single stratum 11. These strata are in the 400–600 m depth range on the northeast Chatham Rise (Figure 1) and were originally split to reduce hake CVs. However, few hake have been caught in these strata since 2000 and the 18 phase 1 tows (3 in each sub-strata) assigned to this area in recent surveys are not justified by catches.

Station allocation for phase 1 was determined from simulations based on catch rates from all previous Chatham Rise trawl surveys (1992–2014), 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, largely to improve the CV for 2+ hoki and total hoki biomass.

As in the 2010–14 surveys, the 2016 survey area included the deep strata from 800–1300 m on the north and east Chatham Rise, along with equivalent strata on the south west Chatham Rise (strata 26, 27, 29, (Stevens et al. 2011), and an additional stratum 30 (1000–1300 m on the southwest Chatham Rise)).

The station allocation for the deep strata was determined based on catch rates of eight deepwater 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 2010–14 surveys. Orange roughy and oreos were no longer considered target species in 2016. The 'allocate' programme (Francis 2006) was used to estimate the optimal number of stations to be allocated in each of strata 21–28 to achieve a target CV of 25% for these eight bycatch species. A minimum of three stations per stratum was used. Five tows were arbitrarily allocated to each of the two new southwest Chatham Rise strata (strata 29 and 30) based on their survey area. This gave a total of 47 phase 1 deepwater stations (Table 1). There was no allowance for phase 2 trawling in deeper 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 400 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 significantly by using the nearest known successful tow position to the random station. Care had to be taken to ensure that the 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 station was found to be on foul ground, a search was made for suitable ground within 3 n. miles of the station position. If no suitable ground could be found, the station was abandoned and another random position was substituted. Core biomass tows were carried out during daylight hours (as defined by Hurst et al. (1992)), with all trawling between 0457 h and 1903 h NZST.

At each station the trawl was towed for 3 n. miles at a speed over the ground of 3.5 knots. If foul ground was encountered, or the tow hauled early due to reducing daylight, the tow was included as valid only if at least 2 n. miles was covered. If time ran short at the end of the day and it was not possible to reach the last station, the vessel headed towards the next station and the trawl gear was shot in time to ensure completion of the tow by sunset, as long as 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 a calibration immediately after this voyage on 17 February 2016 at the Auckland Islands (O'Driscoll & Roberts 2016).

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 0.04 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, and ling for age determination. Additional data on liver condition were also collected from a subsample of 20 hoki 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). Biomass and coefficient of variation (CV) were calculated by stratum for 1+, 2+, and 3++ (a plus group of hoki aged 3 years or more) age classes of hoki, and for 12 other key species: hake, ling, dark ghost shark, pale ghost shark, giant stargazer, lookdown dory, sea perch, silver warehou, spiny dogfish, white warehou, Bollon's rattail, and javelinfish. These species were selected because they are commercially important, or abundant bycatch species, and the trawl survey samples the main part of their depth distribution (O'Driscoll et al. 2011b). Doorspread swept-area biomass and CVs were also calculated by stratum for a subset of 13 deepwater species: orange roughy (fish less than 20 cm SL, fish less than 30 cm SL, and all fish), black oreo, smooth oreo, spiky oreo, ribaldo, shovelnosed dogfish, Baxter's dogfish, longnosed velvet dogfish, bigscaled brown slickhead, smallscaled brown slickhead, basketwork eel, four-rayed rattails, and Johnson's cod.

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 689 hoki otoliths and 642 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 221 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 ring radii measurements to improve the consistency of age estimation.

2.9 Acoustic data analysis

Acoustic analysis followed the methods applied to recent Chatham Rise trawl surveys (e.g., Stevens et al. 2015), 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 EchoAnalysis which replaces the Echo Sounder Package (ESP2) software (McNeill 2001) used previously. A new algorithm was developed in 2014 that allowed us to quantify the number of 'bad pings' in each acoustic recording. Bad pings were defined as those where values were significantly different from surrounding pings due to bubble aeration or noise spikes. Only acoustic data files where the proportion of bad pings was less than 30% were considered suitable for quantitative analysis.

Estimates of the mean acoustic backscatter per 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 detected acoustic bottom. Total acoustic backscatter was also integrated throughout the water column in 50 m depth bins. Acoustic density estimates (backscatter per km^2) from bottom-referenced marks were compared with trawl catch rates (kg per km^2). No attempt was made to scale acoustic estimates by target strength, correct for differences in catchability, or carry out species decomposition (O'Driscoll 2002, 2003).

O'Driscoll et al. (2009, 2011a) developed a time series of relative abundance estimates for mesopelagic fish on the Chatham Rise based on that component of the acoustic backscatter that migrates into the upper 200 m of the water column at night (nyctoepipelagic backscatter). We updated the mesopelagic time series to include data from 2016. 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 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 deadzone:

$$sa(meso)_i = p(meso)_s \times sa(all)_i$$

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 same stratum *s* as station *i*. $p(meso)_s$ 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 deadzone, p_{sz}. p_{sz} was estimated as 0.2 by O'Driscoll et al. (2009) and was assumed to be the same for all years and strata:

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

3. RESULTS

3.1 2016 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). The weather during the survey was generally favourable. A total of 24 hours were lost due to rough weather, and a further 8 hours were lost due to the vessel responding to a marine emergency (an EPIRB activation).

In total, 139 successful biomass tows were completed, comprising 84 core (200–800 m) phase 1 tows, 9 core phase 2 tows, and 46 deep (800–1300 m) phase 1 tows (Tables 1 and 2, Figure 2, Appendix 1). Six tows were excluded from relative biomass calculations. These included two tows which came fast (stations 37, 62), two tows with gear parameters outside the acceptable range (stations 69, 71), one tow was abandoned due to rough bottom (station 26), and another tow was hauled early due to a large catch of sponge affecting gear performance (station 140). Station details for all tows are given in Appendix 1.

Core station density ranged from 1 per 288 km^2 in stratum 17 (200–400 m, Veryan Bank) to 1 per 3772 km^2 in stratum 4 (600–800 m, south Chatham Rise). Deepwater station density ranged from 1 per 416 km^2 in stratum 21a (800–1000 m, NE Chatham Rise) to 1 per 3165 km^2 in stratum 28 (1000–1300 m, SE Chatham Rise). Mean station density was 1 per 1554 km^2 (see Table 1).

3.2 Gear performance

Gear parameters are summarised in Table 3. A headline height value was obtained for all 139 successful tows, but doorspread readings were not available for 11 tows. Mean headline heights by 200 m depth intervals ranged from 6.7 to 7.1 m, averaged 6.8 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 ranged from 120.9 to 125.5 m, and averaged 123.4 m, and were also consistent with previous surveys.

3.3 Hydrology

The surface temperatures (Figure 3, top panel) ranged from 12.1 to 17.4^{o} C. Bottom temperatures ranged from 3.0 to 10.3^{o} C (Figure 3, bottom panel).

As in previous years, higher surface temperatures were most likely associated with subtropical water to the north. Lower temperatures were associated with Sub-Antarctic water to the south. Higher bottom temperatures were generally associated with shallower depths to the north and west of the Chatham Islands and on and to the east of Mernoo Bank.

3.4 Catch composition

The total catch from all 139 valid biomass stations was 142.4 t, of which 56.6 t (39.7%) was hoki, 4.6 t (3.2%) was ling, and 0.9 t (0.7%) was hake (Table 4).

Of the 321 species or species groups identified from valid biomass tows, 156 were teleosts, 35 were elasmobranchs, 1 was an agnathan, 25 were crustaceans, and 28 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. Of interest was the capture of two pointynose toadfish, *Ebinania* sp. A (from a non-valid tow), a rarely sampled and undescribed species previously known from only 4 specimens.

Fifty six invertebrate taxa (all cephalopods) were later identified (Appendix 3).

3.5 Relative biomass estimates

3.5.1 Core strata (200–800 m)

Relative biomass in core strata was estimated for 47 species (Table 4). The CVs achieved for hoki, hake, and ling from core strata were 14.2%, 18.5%, and 7.2% respectively. The CV for 2+ hoki (2013 year class) was 18.6%, 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, southern Ray's bream, and slender mackerel are not strictly demersal and exhibit strong schooling behaviour and consequently catch rates of these are highly variable. Others, such as bluenose, hapuku, red cod, 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) was higher than in 2012 and 2014, lower than in 2013, and similar to that in 2011, and above average for the time series (Figure 4, top panel). As in previous years, hoki was the most abundant species caught (Table 4, Figure 4, lower panel). The relative proportion of hoki in 2016 was similar to 2009 and 2014, and higher than that in 2010–13. The next most abundant QMS species were black oreo, silver warehou, ling, dark ghost shark, lookdown dory, spiny dogfish, spiky oreo, sea perch, pale ghost shark, white warehou, alfonsino, and giant stargazer, each with an estimated relative biomass of over 2000 t (Table 4). The most abundant non-QMS species were Bollons's rattail, javelinfish, and shovelnose dogfish (Table 4).

Estimated relative biomass of hoki in the core strata in 2016 was 114 514 t, 12% higher than the hoki biomass in January 2014 (Table 5, Figures 5a, 6a, 6b). This was largely driven by a high biomass estimate for 1+ hoki (2014 year-class) of 47 566 t, the second highest in the time series. The biomass of 2+ hoki (2013 year-class) was 12 902 t, one of the lowest in the time series (Table 6). The relative biomass of 3++ (recruited) hoki was 54 046 t, similar estimate to the 2014 survey, and about average for the time series.

The relative biomass of hake in core strata was 1299 t, 6% lower than 2014, and about the same as the 2012 estimate, and still low compared to the early 1990s (see Table 5, Figures 5a, 6a, 6b).

The relative biomass of ling was 10 201 t, 36% higher than in January 2014, and one of the higher estimates in the time series. The time series for ling shows no overall trend (Figures 5a, 6a, 6b).

The relative biomass estimates for most other key core species (dark ghost shark, giant stargazer, lookdown dory, silver warehou, and white warehou) were higher than 2014 estimates, pale ghost shark and spiny dogfish were about the same, and sea perch was lower than the 2014 estimate (Figures 5a, 6a, 6a).

3.5.2 Deep strata (800–1300 m)

Relative biomass and CVs in deep strata were estimated for 21 of 45 core strata species (Table 4). The relative biomass of orange roughy in all strata in 2016 was 5037 t, compared to 6916 t in 2014 (Figures 5b, 6c). However, the precision was poor with a CV of 53.3%; the deepwater survey was not optimised for orange roughy in 2016.

The 2016 survey completed all strata in 800–1300 m depths on the southwest Rise for the first time, an area where black oreo are abundant. As a result, 32% of the relative biomass of black oreo in all strata (25 051 t) was estimated to occur in the deep strata (Table 4, Figures 5b, 6c) compared with 0.6% in the 2014 survey. The estimated relative biomass of smooth oreo in deep strata was 9180 t, but precision was poor with a CV of 45.3%.

Deepwater sharks were relatively abundant in deep strata, with 38%, 71%, and 83% of the total survey biomass of shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish occurring in deep strata (Figures 5b, 6c). Bigscaled brown slickheads, smallscaled brown slickheads, basketwork eels, and four-rayed rattails were largely restricted to deeper strata, while spiky oreo were largely restricted to core strata (Figures 5b, 6c).

The deep strata contained 14% of total survey hake biomass, 1.9% of the total survey hoki biomass, and 0.5% of total survey ling biomass. This indicates that the core survey strata is likely to have sampled most of the hoki and ling biomass available to the trawl survey method on the Chatham Rise, but missed some hake (Table 4).

3.6 Catch distribution

Spatial distribution maps of catches (Figures 7–11) were generally similar to that from previous surveys.

Hoki

In the 2016 survey, hoki were caught in all 93 core biomass stations, with the highest catch rates on the Reserve Bank in 200–400 m depths (strata 19 and 20) and west and south of Mernoo Bank in 400–600 m depths (strata 7a and 16) (Table 7a, Figure 7). The highest individual catch of hoki in 2016 was 4591 kg and it occurred west of Mernoo Bank in stratum 7a, and comprised mainly 1+ hoki (Figure 7a). Other high individual hoki catches of over 3 t were south of Mernoo Bank in stratum 16 and on Reserve Bank in strata 19 and 20). The strong year class of hoki aged 1+ (2014 year-class) was widely distributed but were more abundant close to Mernoo Bank and on Reserve Bank (Figure 7a). Hoki of age 2+ (2013 year-class) were found over much of the Rise at 200–600 m depths but were more abundant in the western strata (Figure 7b). Recruited hoki (3+ and older) were widespread but the highest catch rates were on the southwestern Rise (Figure 7c).

Hake

Catches of hake were consistently low throughout much of the survey area. The highest catch rates were in stratum 7b, northeast of Mernoo Bank, where high catches of hake were observed in 2009 and 2010, and in stratum 7a northwest of Mernoo Bank (Figure 8).

Ling

As in previous years, catches of ling were evenly distributed throughout most strata in the survey area (Figure 9). The highest catch rates were mainly on the south Chatham Rise in 400–600 m (strata 12 to 16). Ling distribution was consistent, and catch rates relatively stable, over the time series (Figure 9).

Other species

As with previous surveys, lookdown dory, sea perch and spiny dogfish were widely distributed throughout the survey area at 200–600 m depths. The largest catch rates for sea perch were taken on the west Rise while the largest catch rates of lookdown dory and spiny dogfish were taken on the east Rise (Figure 10). Dark ghost shark was mainly caught at 200–400 m depths, and was particularly abundant on the Veryan Bank; while pale ghost shark was mostly caught in deeper water at 400–800 m depth, with higher catch rates to the west. Giant stargazer was mainly caught in shallower strata, with the largest catch taken west of the Chatham Islands in stratum 12. Silver warehou and white warehou were patchily distributed at depths of 200–600 m, with the largest catches in the west (Figure 10).

Orange roughy was widespread on the north and east Rise at 800–1300 m depths, with the largest catch of 1068 kg taken on mid-north Rise in 1198 m in stratum 23 (Table 7b, Figure 10), a strata in which large catches have been taken on previous surveys in 2010–2015 (Figure 11). As with previous surveys, black oreo were mostly caught in stratum 6 on the southwest Rise at 600–800 m depths. A number of black oreo were also caught in stratum 27 (800–1000 m), but few fish were caught in the deeper stratum 30 (1000–1300 m), first surveyed in 2016 (Table 7a, Figures 10, 11). Smooth oreo were also mainly caught on the southwest Rise, with the largest catch rate taken in stratum 27 (800–1000 m). Large catches of smooth oreo have generally been taken in this area or on the northwest Rise on previous surveys (Figure 11). Spiky oreo were widespread and abundant on the northeast rise at 500–800 m, with the largest catch-rates taken in stratum 2b (Table 7b, Figure 10). Ribaldo, shovelnose dogfish, longnose velvet dogfish, and four-rayed rattail were more abundant on the north Rise, basketwork eel and bigscaled brown slickhead were abundant on the north Rise and south Rise, and Baxter's dogfish and smallscaled brown slickhead were more abundant on the south Rise (Table 7b, Figure 10).

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 1+ year (less than 49 cm) fish (Figures 12 and 13). There were relatively few 2+ (49–62 cm) fish, and few longer than 80 cm (Figure 12) or older than 6 years (Figure 13). Females were slightly more abundant than males (ratio of 1.12 female: 1 male).

Hake

Length frequency and calculated number at age distributions (Figures 14 and 15) were relatively broad, with most male fish aged between 2 and 10 years and female fish between 2 and 14 years. Females were more abundant than males (1.35 female: 1 male).

Ling

Length frequency and calculated number at age distributions (Figures 16 and 17) indicated a wide range of ages, with most fish aged between 2 and 20. There is evidence of a period of good recruitment from 1999–2006 (Figure 17). The sex ratio was about even.

Other species

Length frequency distributions for key core and deepwater species are shown in Figures 18a, 18b. Clear modes are apparent in the size distribution of white warehou, which may correspond to individual cohorts.

Length frequencies of giant stargazer, lookdown dory, dark and pale ghost sharks, and several shark species (spiny dogfish, Baxter's dogfish, longnose velvet dogfish, and shovelnose dogfish) indicate that females grow larger than males (Figures 18a, 18b).

The deep strata contain a high proportion of large shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish (Figure 18). Bigscaled brown slickheads, smallscaled brown slickheads, basketwork eels, and four-rayed rattail were largely restricted to the deep strata (Figure 18b).

Length frequency distributions were similar for males and females of sea perch, silver warehou, orange roughy, black oreo, smooth oreo, and spiky oreo. The length frequency distribution for orange roughy was broad, with a mode at 30–37 cm, but included fish as small as 7 cm (Figures 18a, 18b).

The catch of 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 ribaldo was dominated by males (1.8 male: 1 female) (Figures 18a, 18b).

3.7.3 Reproductive status

Gonad stages of hake, hoki, ling, and a number of other species are summarised in Table 10. Almost all hoki were recorded as either resting or immature. About 31% of male ling were maturing or ripe, with few females showing signs of spawning. About 58% of male hake were ripe, running ripe, partially spent, or spent, but most females were immature or resting (65%) or maturing (29%) (Table 10). Most other species for which reproductive state was recorded did not appear to be reproductively active, except spiny dogfish and some deepwater sharks (Table 10).

3.8 Acoustic data quality

Over 91 GB of acoustic data were collected with the multi-frequency (18, 38, 70, 120, and 200 kHz) hull- mounted EK60 systems on each trawl station and while steaming between stations. Weather and sea conditions during the survey were generally very good meaning that acoustic data quality was high. Only 4% of acoustic files from the 2016 survey exceeded the threshold of 30% bad pings, and so were not suitable for quantitative analysis (Figure 19).

Expanding symbol plots of the distribution of total acoustic backscatter from daytime trawls and night transects in the core survey area are shown in Figure 20. As noted by O'Driscoll et al. (2011a), there is a consistent spatial pattern in total backscatter on the Chatham Rise, with higher backscatter in the west.

3.8.1 Comparison of acoustics with bottom trawl catches

Acoustic data from 90 trawl files were integrated and compared with trawl catch rates (Table 11). Data from the other three recordings during core daytime tows were not included in the analysis because the acoustic data were too noisy. Average acoustic backscatter values from the entire water column in 2016 was the highest in the time series (Table 11). Average acoustic backscatter in the bottom 10 m and 50 m were also relatively high (Table 11).

There was a positive correlation (Spearman's rank correlation, rho = 0.35, $p < 0.01$) between acoustic backscatter in the bottom 100 m during the day and trawl catch rates (Figure 21). In previous Chatham Rise surveys from 2001–14, 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 21) is not perfect (rho = 1) because the daytime bottom-referenced layers on the Chatham Rise may also contain a high proportion of mesopelagic species, which contribute to the acoustic backscatter, but which are not sampled by the bottom trawl (O'Driscoll 2003, O'Driscoll et al.

2009), and conversely some fish caught by the trawl may not be measured acoustically (e.g., close to bottom in acoustic deadzone). This, combined with the diverse composition of demersal species present, means that it is unlikely that acoustics will provide an alternative biomass estimate for hoki on the Chatham Rise.

3.8.2 Time-series of relative mesopelagic fish abundance

In 2016, most acoustic backscatter was between 200 and 500 m depth during the day, and migrated into the surface 200 m at night (Figure 22). The vertical distribution was similar to the pattern observed in all previous years except 2011 (O'Driscoll et al. 2011a, Stevens et al. 2013, 2014, 2015). 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).

The vertically migrating component of acoustic backscatter is assumed to be dominated by mesopelagic fish (see McClatchie & Dunford, 2003 for rationale and caveats). In 2016, between 57 and 84% of the total backscatter in each of the four sub-areas was in the upper 200 m at night and was estimated to be from vertically migrating mesopelagic fish (Table 12). The proportion of backscatter attributed to mesopelagic fish in 2016 was similar to other surveys in the time-series, and lowest in the northwest where there were higher densities of demersal fish (Table 12).

Day estimates of total acoustic backscatter over the Chatham Rise were consistently higher than night estimates (Figure 23) because of the movement of fish into the surface deadzone (shallower than 14 m) at night (O'Driscoll et al. 2009). The only exception to this was in 2011, when night estimates were higher than day estimates (Figure 23). 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 2016 was 24% higher than that observed in 2014. Backscatter within 50 m of the bottom during the day generally decreased from 2001 to 2011, but has subsequently increased (Figure 23). Backscatter close to the bottom at night has been relatively low throughout the time-series, but shows an increasing trend over the past seven years (Figure 23).

Acoustic indices of mesopelagic fish abundance are summarised in Table 13 and plotted in Figure 24 for the entire Chatham Rise and for the four sub-areas. The overall mesopelagic estimate for the Chatham Rise increased by 30% from 2014 and was the highest since 2009. The mesopelagic index increased in all four sub-areas, with the highest percentage increase (54%) in the southwest (Table 13, Figure 24).

3.9 Hoki condition

Liver condition (defined as liver weight divided by gutted weight) for all hoki on the Chatham Rise increased from 2014 to 2016 (Figure 25). This increase in overall condition occurred across all length classes (Figure 25). Stevens et al. (2014) suggested that hoki condition may be related to both food availability and hoki density, and estimated an index of "food per fish" from the ratio of the acoustic estimate of mesopelagic fish abundance divided by the trawl estimate of hoki abundance. The significant positive correlation between liver condition and the food per fish index reported in 2013 (Stevens et al. 2014) and 2014 (Stevens et al. 2015) was maintained with the addition of the 2016 data (Figure 26, Pearson's correlation coefficient, $r = 0.72$, $n = 11$, $p < 0.02$).

4. CONCLUSIONS

The 2016 survey successfully extended the January Chatham Rise time series to 24 points (annual from 1992–2014, then 2016), 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 12% higher than that in 2014, largely due to a high relative biomass estimate of 1+ hoki, the second highest in the time series. The relative biomass of 2+ hoki (2013 year class) was one of the lowest estimates in the time series. The estimated biomass of 3++ (recruited) hoki was similar to the 2014 survey and about average for the time series.

The relative biomass of hake in core strata was 6% lower than in 2014, and remains at historically low levels compared to the early 1990s. The relative biomass of ling in core strata was 36% higher than in 2014, but the time series for ling shows no overall trend.

In 2016 the survey area was successfully extended to cover 800–1300 m depths around the entire Rise. The deep strata provide relative biomass indices for a range of deepwater species associated with orange roughy and oreo fisheries. A high proportion of the estimated biomass of deepwater sharks (shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish) occurred in deep strata, and bigscaled brown slickheads, smallscaled brown slickheads, basketwork eels, and four-rayed rattails were largely restricted to deeper strata.

The deep strata contained only a small proportion of the total survey relative biomass for hake, hoki, and ling, confirming that the core survey area is appropriate for these species.

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Table 1: The number of completed valid biomass tows (200–1300 m) by stratum during the 2016 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	4	4	1	5	1: 1 091
7B	400–600	NW Chatham Rise	869	3	3		3	1: 290
8A	400–600	NW Chatham Rise	3 286	3	3		3	1: 1 095
8B	400–600	NW Chatham Rise	5 722	3	3		3	1: 1 907
9	200–400	NE Chatham Rise	5 136	3	3		3	1: 1 712
10	400–600	NE Chatham Rise	6 321	4	4		4	1: 1 580
11	400–600	NE Chatham Rise	11 748	7	7		7	1: 1 678
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		5	1: 1 168
16	400–600	SW Chatham Rise	11 522	3	3	8	11	1: 1 047
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	6	6		6	1: 1 597
Core	200–800		139 492	84	84	9	93	1: 1 500
21A	800–1000	NE Chatham Rise	1 249	3	3		3	1: 416
21B	800–1000	NE Chatham Rise	5 819	3	3		3	1: 1 940
22	800–1000	NW Chatham Rise	7 357	11	11		11	1: 669
23	1000–1300	NW Chatham Rise	7 014	4	4		4	1: 1 754
24	1000–1300	NE Chatham Rise	5 672	3	3		3	1: 1 891
25	800–1000	SE Chatham Rise	5 596	4	4		4	1: 1 399
26	800–1000	SW Chatham Rise	5 158	4	3		3	1: 1 719
27	800–1000	SW Chatham Rise	7 185	4	4		4	1: 1 796
28	1000–1300	SE Chatham Rise	9 494	3	3		3	1: 3 165
29	1000–1300	SW Chatham Rise	10 965	4	4		4	1: 2 741
30	1000–1300	SW Chatham Rise	10 960	4	4		4	1: 2 740
Deep	800–1300		76 469	47	46	0	46	1: 1 662
Total	200–1300		215 967	131	130	9	139	1: 1 554

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

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

Table 3: Tow and gear parameters by depth range for valid biomass tows (TAN1601). 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)	93	2.9	0.28	2.1–3.1
Tow speed (knots)	93	3.5	0.03	3.4–3.5
All tow parameters				
Tow length (n. miles)	139	2.9	0.23	2.1–3.1
Tow speed (knots)	19	3.5	0.02	3.4–3.5
Gear parameters				
200–400 m				
Headline height (m)	29	6.8	0.25	6.3–7.6
Doorspread (m)	28	120.9	5.13	110.0–128.5
400–600 m				
Headline height (m)	48	6.7	0.23	6.2–7.2
Doorspread (m)	47	124.5	4.41	115.8–134.6
600–800 m				
Headline height (m)	16	6.7	0.21	6.4–7.0
Doorspread (m)	16	125.5	4.54	118.8–133.4
800–1000 m				
Headline height (m)	28	6.8	0.15	6.5–7.2
Doorspread (m)	26	123.1	4.59	112.8–133.3
1000–1300 m				
Headline height (m)	18	7.1	0.26	6.7–7.7
Doorspread (m)	11	122.8	5.65	113.2–129.5
Core stations 200–800 m				
Headline height (m)	93	6.7	0.23	6.2–7.6
Doorspread (m)	91	123.6	4.96	110.0–134.6
All stations 200–1300 m				
Headline height (m)	139	6.8	0.26	6.2–7.7
Doorspread (m)	128	123.4	4.91	110.0–134.6

Table 4: Catch (kg) and total relative biomass (t) estimates (also by sex) with coefficient of variation (CV) for QMS species, other commercial species, and key non-commercial species for valid biomass tows in the 2016 survey core strata (200–800 m); and biomass estimates (not catch) for deep strata (800–1300 m). Total biomass includes unsexed fish. (–, no data.). Arranged in descending relative biomass estimates for the core strata. –, no data.

		Core strata 200–800m							800–1300 m	
Common name	Code	Catch	Biomass males		Biomass females		Total biomass		Deep biomass	
		kg	t	% CV	t	% CV	t	% CV	t	% CV
QMS species										
Hoki	HOK	55 190	53 388	16.1	60 825	12.8	114 514	14.2	2 218	14.8
Black oreo	BOE	4 186	8 340	12.2	8 603	14.4	16 981	13.1	8 070	33.5
Silver warehou	SWA	6 850	8 494	26.6	6 479	26.3	14 983	25.3	–	
Ling	LIN	4 543	4 719	11.6	5 475	7.5	10 201	7.2	53	47.1
Dark ghost shark	GSH	8 212	5 450	12.1	6 449	12.8	11 925	11.7	–	
Lookdown dory	LDO	2 851	2 188	9.8	4 281	9.5	6 494	8.8	30	43.2
Spiny dogfish	SPD	2 677	1 112	22.2	4 782	11.6	5 908	12.1	–	
Spiky oreo	SOR	1 326	2 298	29.2	2 038	28.1	4 339	28.3	402	39.6
Sea perch	SPE	1 834	2 159	10.8	1 800	10.7	3 989	10.4	8	93.5
Pale ghost shark	GSP	1 811	1 532	9.7	1 516	10.4	3 259	10.4	618	17.1
White warehou	WWA	1 284	1 503	27.6	1 251	20.0	2 760	23.5	–	
Alfonsino	BYS	1 166	1 343	43.6	1 188	40.3	2 565	41.4	–	
Giant stargazer	GIZ	1 026	471	15.4	1 757	20.7	2 228	17.2	11	100
Smooth skate	SSK	734	581	26.9	1 081	27.6	1 662	22.3		
Hake	HAK	739	380	23.5	919	20.3	1 299	18.5	213	28.6
Southern Ray's bream	SRB	305	279	29.4	284	29.2	566	28.6	–	
Smooth oreo	SSO	145	257	93.8	298	95.6	555	94.7	9 180	45.3
School shark	SCH	231	285	41.4	244	40.8	529	31.3	–	
Arrow squid	NOS	224	211	23.3	267	32.2	483	27.0	–	
Red cod	RCO	400	256	30.7	165	33.1	422	29.4	–	
Ribaldo	RIB	192	136	14.2	271	27.5	407	19.7	150	16.5
Barracouta	BAR	124	240	53.9	141	62.7	381	56.9	–	
Bluenose	BNS	120	77	50.7	140	52.9	217	50.0	–	
Slender mackerel	JMM	70	104	59.8	86	52.6	190	55.9	–	
Deepsea cardinalfish	EPT	103	97	46.7	64	45.9	166	43.2		
Hapuku	HAP	60	70	45.2	77	52.2	147	38.9	–	
Tarakihi	NMP	30	43	21.4	50	77.7	93	49.7	–	
Lemon sole	LSO	41	38	28.4	50	35.3	89	28.8	–	
Banded stargazer	BGZ	20	19	100	30	100	49	100	–	
Rough skate	RSK	30	15	85.6	32	66.5	47	64.7	–	
Scampi	SCI	8	9	25.9	7	17.6	16	19.2	–	
Orange roughy	ORH	8	3	50.4	11	64.2	14	54.6	5 023	53.5
Redbait	RBT	4	7	56.7	3	100	10	50.3	–	
Frostfish	FRO	3	8	100	–		8	100	–	
Rubyfish	RBY	2	5	100	2	100	6	79.1	–	
Ray's bream	RBM	2	5	100	–		5	100	–	
Jack mackerel	JMD	1	2	100	–		2	100	–	
Commercial non-QMS species										
Shovelnose dogfish	SND	2 746	1 836	22.8	3 943	24.5	5 962	21.2	3 605	22.2
Southern blue whiting	SBW	35	43	33.4	26	31.0	69	29.7	–	

Table 4 (continued)

Common name	Code	Catch	Biomass males		Biomass females		Total biomass		Deep biomass	
			Core strata 200–800m						800–1300 m	
		kg	t	% CV	t	% CV	t	% CV	t	% CV
Non-commercial species										
Bollons's rattail	CBO	5 222	3 700	14.8	5 744	18.3	11 924	12.4	24	38.4
Javelinfish	JAV	5 488	1 652	27.1	9 615	12.8	11 340	13.3	675	17.1
Longnose velvet dogfish	CYP	580	454	10.0	426	38.1	886	20.6	2 154	17.7
Baxters lantern dogfish	ETB	136	197	28.2	118	32.3	420	26.9	2 107	20.1
Smallscaled brown slickhead	SSM	24	28	100	5	100	36	92.9	2 681	25.5
Basketwork eel	BEE	6	3	100	20	100	22	27.1	2 220	10.2
Four-rayed rattail	CSU	14	–		5	81.9	22	27.1	1 995	45.7
Bigscaled brown slickhead	SBI	–	–		–		–		3 121	20.3
Total (above)		110 803								
Grand total (all species)		118 638								

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

			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

Table 6: Relative biomass estimates (t in thousands) for hoki, 200–800 m depths, Chatham Rise trawl surveys January 1992–2014, and 2016 (CV, coefficient of variation; 3++, all hoki aged 3 years and older; (see Appendix 4 for length ranges used to define age classes.). See also Figure 5.

		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	2.8	(27.9)	1989	1.2	(18.1)	116.1	(7.8)	120.2	(9.7)
1993	1991	32.9	(33.4)	1990	2.6	(25.1)	150.1	(8.9)	185.6	(10.3)
1994	1992	14.6	(20.0)	1991	44.7	(18.0)	86.2	(9.0)	145.6	(9.8)
1995	1993	6.6	(13.0)	1992	44.9	(11.0)	69.0	(9.0)	120.4	(7.6)
1996	1994	27.6	(24.0)	1993	15.0	(13.0)	106.6	(10.0)	152.8	(9.8)
1997	1995	3.2	(40.0)	1994	62.7	(12.0)	92.1	(8.0)	158.0	(8.4)
1998	1996	4.5	(33.0)	1995	6.9	(18.0)	75.6	(11.0)	86.7	(10.9)
1999	1997	25.6	(30.4)	1996	16.5	(18.9)	67.0	(9.9)	109.3	(11.6)
2000	1998	14.4	(32.4)	1997	28.2	(20.7)	29.5	(9.3)	71.7	(12.3)
2001	1999	0.4	(74.6)	1998	24.2	(17.8)	35.7	(9.2)	60.3	(9.7)
2002	2000	22.4	(25.9)	1999	1.2	(21.2)	50.7	(12.3)	74.4	(11.4)
2003	2001	5.0	(46.0)	2000	27.2	(15.1)	20.4	(9.3)	52.6	(8.7)
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	32.6	(12.8)	28.8	(8.9)	70.5	(8.4)
2008	2006	15.6	(31.6)	2005	23.8	(15.5)	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)

Table 7a: Estimated relative biomass (t) and coefficient of variation (% CV) for hoki, hake, ling, other key core strata species, and key deepwater species by stratum for the 2016 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	608 (46.1)	22 (100.0)	112 (20.6)	-	124 (48.3)	23 (75.9)
2A	660 (17.1)	27 (66.7)	162 (65.1)	-	80 (17.6)	29 (23.7)
2B	2 451 (19.4)	234 (41.9)	300 (24.1)	-	82 (17.5)	143 (22.2)
3	790 (26.4)	15 (100.0)	141 (30.5)	804 (9.8)	6 (100.0)	314 (22.1)
4	3 408 (6.9)	90 (100.0)	880 (34.5)	-	293 (34.0)	279 (38.6)
5	2 863 (62.4)	10 (52.5)	371 (21.3)	1 287 (9.8)	9 (51.4)	414 (25.1)
6	5 067 (70.3)	38 (100.0)	506 (59.4)	-	433 (17.2)	90 (62.4)
7A	12 280 (55.8)	158 (81.6)	437 (23.7)	128 (86.9)	180 (48.6)	63 (21.2)
7B	589 (60.9)	67 (87.7)	91 (3.7)	4 (38.5)	18 (47.6)	15 (8.7)
8A	1 038 (22.9)	90 (41.4)	165 (26.7)	-	42 (66.8)	62 (20.9)
8B	2 728 (34.3)	96 (55.0)	671 (4.7)	70 (100.0)	151 (32.1)	388 (29.4)
9	558 (53.6)	-	62 (22.0)	312 (84.1)	-	42 (69.2)
10	3 337 (52.2)	50 (60.2)	502 (39.0)	210 (100.0)	64 (18.1)	346 (33.5)
11	6 827 (32.0)	31 (51.6)	753 (21.8)	1 775 (37.0)	10 (100.0)	653 (33.6)
12	2 707 (12.9)	9 (100.0)	635 (31.8)	602 (92.7)	115 (79.8)	635 (33.3)
13	1 853 (41.0)	56 (100.0)	828 (35.8)	355 (83.8)	276 (41.0)	652 (54.7)
14	2 487 (49.9)	40 (100.0)	431 (5.9)	105 (91.9)	167 (3.8)	289 (18.0)
15	4 862 (48.0)	90 (76.7)	708 (17.5)	162 (50.3)	287 (21.0)	444 (20.1)
16	16 574 (27.4)	124 (33.3)	1 264 (12.3)	2 (100.0)	593 (18.4)	597 (18.7)
17	714 (71.1)	-	14 (56.5)	1 933 (48.0)	-	72 (48.7)
18	9 387 (26.7)	-	32 (60.0)	997 (17.6)	-	170 (38.3)
19	12 153 (61.6)	29 (67.5)	426 (49.9)	1 521 (29.7)	-	101 (39.2)
20	20 575 (48.5)	24 (100.0)	712 (29.2)	1 863 (16.8)	128 (54.2)	670 (19.6)
Core	114 514 (14.2)	1 299 (18.5)	10 201 (7.2)	12 129 (12.2)	3 055 (8.8)	6 494 (8.8)
21A	92 (17.7)	34 (93.9)	1 (100.0)	-	4 (52.3)	- (100.0)
21B	141 (38.6)	23 (62.5)	-	-	19 (55.3)	3 (100.0)
22	597 (24.4)	136 (35.1)	23 (57.1)	-	113 (22.3)	18 (62.8)
23	15 (100.0)	8 (100.0)	-	-	-	-
24	29 (50.1)	-	-	-	-	-
25	574 (47.8)	13 (100.0)	10 (100.0)	-	48 (48.3)	10 (66.1)
26	324 (20.6)	-	19 (100.0)	-	101 (44.3)	-
27	397 (12.0)	-	-	-	306 (28.8)	-
28	35 (70.5)	-	-	-	9 (100.0)	-
29	-	-	-	-	6 (100.0)	-
30	15 (100.0)	-	-	-	12 (57.8)	-
Deep	2 218 (13.9)	213 (16.4)	53 (7.2)	- (12.2)	618 (7.9)	30 (8.8)
Total	116 732 (13.9)	1 512 (16.4)	10 254 (7.2)	12 129 (12.2)	3 673 (7.9)	6 524 (8.8)

Table 7a (continued)

Stratum	SPE	SPD	SWA	WWA	GIZ	RIB
						Species code
1	1 (100.0)	4 (100.0)	-	-	8 (100.0)	50 (29.1)
2A	18 (58.4)	-	-	-	-	75 (4.6)
2B	58 (11.4)	-	-	-	-	21 (23.8)
3	129 (34.0)	312 (35.3)	79 (19.3)	18 (80.8)	32 (100.0)	-
4	8 (100.0)	-	-	-	19 (100.0)	117 (58.4)
5	86 (31.6)	1 072 (18.1)	865 (42.6)	197 (29.1)	58 (91.0)	-
6	47 (61.1)	-	9 (100.0)	-	12 (100.0)	29 (51.0)
7A	139 (47.0)	158 (70.9)	9 (55.7)	7 (50.1)	19 (43.5)	28 (45.4)
7B	20 (36.0)	14 (53.3)	-	1 (100.0)	19 (81.7)	1 (100.0)
8A	116 (30.7)	82 (51.7)	-	5 (87.5)	1 (100.0)	-
8B	182 (64.0)	135 (71.7)	-	-	7 (100.0)	-
9	202 (47.1)	152 (82.3)	764 (68.0)	89 (51.6)	293 (34.8)	-
10	158 (65.2)	146 (100.0)	7 (100.0)	7 (100.0)	12 (100.0)	25 (71.9)
11	286 (32.0)	663 (52.4)	836 (67.2)	120 (49.2)	277 (33.7)	3 (100.0)
12	116 (80.4)	548 (51.3)	232 (20.3)	62 (75.5)	394 (74.5)	-
13	71 (32.7)	497 (70.5)	80 (85.4)	18 (100.0)	45 (100.0)	9 (100.0)
14	126 (20.0)	393 (54.4)	56 (100.0)	- (100.0)	50 (52.7)	23 (100.0)
15	247 (58.6)	228 (25.8)	971 (80.8)	876 (56.8)	146 (36.5)	-
16	136 (29.8)	153 (25.5)	1 180 (28.4)	941 (41.0)	221 (20.6)	25 (52.0)
17	16 (21.5)	42 (30.9)	29 (74.0)	3 (83.8)	45 (11.3)	-
18	336 (23.4)	332 (23.7)	6 239 (42.2)	68 (51.3)	182 (46.9)	-
19	897 (28.0)	402 (13.5)	833 (60.3)	27 (43.8)	194 (33.9)	-
20	593 (23.4)	575 (23.2)	2 795 (85.3)	321 (33.0)	194 (68.0)	-
Core	3 989 (10.4)	5 908 (12.1)	14 983 (25.3)	2 760 (23.5)	2 228 (17.2)	407 (19.7)
21A	1 (100.0)	-	-	-	-	5 (34.1)
21B	-	-	-	-	-	57 (18.7)
22	8 (100.0)	-	-	-	11 (100.0)	49 (31.4)
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	-	-	39 (41.1)
26	-	-	-	-	-	-
27	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
30	-	-	-	-	-	-
Deep	8 (10.4)	- (12.1)	- (25.3)	- (23.5)	11 (17.1)	150 (15.1)
Total	3 997 (10.4)	5 908 (12.1)	14 983 (25.3)	2 760 (23.5)	2 240 (17.1)	557 (15.1)

Table 7a (continued)

	Species code					
Stratum	**BOE**	**SSO**	**SOR**	**SND**	**CYP**	**ETB**
1	-	-	29 (51.7)	633 (61.9)	106 (50.2)	4 (82.2)
2A	-	2 (100.0)	84 (16.4)	1 652 (59.4)	706 (24.0)	-
2B	-	9 (100.0)	2 925 (38.8)	2 113 (30.6)	67 (58.2)	-
3	-	-	-	-	-	-
4	1 391 (93.2)	4 (100.0)	1 236 (37.9)	1 128 (17.0)	-	4 (62.1)
5	-	-	-	-	-	-
6	15 587 (11.6)	539 (97.5)	-	-	-	258 (31.6)
7A	-	-	1 (100.0)	177 (81.6)	6 (90.8)	1 (100.0)
7B	-	-	-	2 (100.0)	-	-
8A	-	-	-	36 (100.0)	-	-
8B	-	-	-	21 (100.0)	-	-
9	-	-	-	-	-	-
10	-	-	62 (100.0)	110 (68.5)	-	-
11	-	-	2 (100.0)	7 (100.0)	-	-
12	-	-	-	15 (100.0)	-	-
13	-	-	-	-	-	45 (100.0)
14	-	-	-	-	-	3 (74.9)
15	-	-	-	32 (100.0)	-	56 (100.0)
16	3 (57.6)	-	-	36 (51.9)	-	49 (63.6)
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	-	-	-	-
Core	16 981 (13.1)	555 (94.7)	4 339 (28.3)	5 962 (21.2)	886 (20.6)	420 (26.9)
21A	-	3 (71.5)	8 (16.1)	116 (31.7)	36 (14.7)	8 (100.0)
21B	-	20 (36.1)	275 (56.6)	1 414 (36.3)	1 103 (27.1)	6 (100.0)
22	1 (67.1)	28 (47.5)	87 (36.9)	230 (23.0)	247 (13.0)	6 (40.6)
23	2 (100.0)	31 (40.0)	2 (100.0)	26 (68.7)	14 (62.5)	79 (33.3)
24	-	2 (28.7)	4 (100.0)	134 (40.2)	48 (57.7)	48 (35.1)
25	2 040 (100.0)	40 (67.7)	25 (45.2)	1 612 (37.6)	634 (36.7)	371 (100.0)
26	1 109 (37.3)	1 329 (44.7)	-	18 (69.7)	47 (14.2)	292 (31.2)
27	4 574 (37.6)	6 538 (60.6)	-	-	20 (60.3)	335 (45.4)
28	136 (100.0)	42 (50.1)	1 (100.0)	55 (100.0)	6 (100.0)	358 (10.0)
29	40 (60.0)	1 131 (97.3)	-	-	-	238 (21.4)
30	170 (60.5)	17 (33.8)	-	-	-	365 (19.2)
Deep	8 070 (14.0)	9 180 (43.0)	402 (26.2)	3 605 (15.7)	2 154 (13.9)	2 107 (17.3)
Total	25 052 (14.0)	9 735 (43.0)	4 742 (26.2)	9 568 (15.7)	3 040 (13.9)	2 527 (17.3)

Table 7a (continued)

						Species code
Stratum	**SBI**	**SSM**	**BEE**	**CSU**	**CBO**	**JAV**
1	-	33 (100.0)	-	4 (96.2)	147 (42.4)	129 (48.6)
2A	-	3 (100.0)	-	-	-	811 (50.7)
2B	-	-	-	1 (100.0)	122 (42.2)	960 (44.2)
3	-	-	-	-	571 (40.0)	493 (40.5)
4	-	-	-	-	597 (25.7)	555 (16.0)
5	-	-	-	-	288 (16.8)	496 (39.7)
6	-	-	22 (100.0)	-	634 (68.0)	1 056 (64.2)
7A	-	-	-	-	412 (20.9)	390 (24.8)
7B	-	-	-	-	49 (12.4)	37 (64.1)
8A	-	-	-	-	46 (22.3)	245 (45.7)
8B	-	-	-	-	342 (45.4)	300 (26.3)
9	-	-	-	-	-	39 (96.2)
10	-	-	-	-	278 (67.5)	1 019 (79.8)
11	-	-	-	-	1 033 (28.1)	754 (34.1)
12	-	-	-	-	1 478 (66.7)	712 (43.3)
13	-	-	-	-	1 068 (74.0)	712 (84.8)
14	-	-	-	-	495 (15.4)	503 (32.9)
15	-	-	-	-	1 165 (20.5)	330 (48.4)
16	-	-	-	-	2 159 (8.5)	1 040 (29.9)
17	-	-	-	-	8 (95.9)	88 (62.7)
18	-	-	-	-	46 (58.6)	106 (36.5)
19	-	-	-	-	340 (54.2)	127 (38.5)
20	-	-	-	-	631 (29.1)	439 (28.7)
Core	-	36 (92.9)	22 (100.0)	5 (82.3)	11 909 (12.4)	11 340 (13.3)
21A	6 (100.0)	-	15 (83.5)	85 (96.0)	-	12 (70.3)
21B	40 (100.0)	19 (100.0)	-	362 (38.9)	-	57 (61.7)
22	15 (60.0)	99 (84.7)	49 (51.7)	164 (54.0)	17 (48.8)	37 (59.1)
23	931 (15.0)	262 (17.8)	484 (12.4)	1 261 (70.6)	-	1 (100.0)
24	258 (39.0)	2 (100.0)	187 (33.7)	67 (36.1)	-	-
25	-	-	10 (100.0)	9 (37.2)	2 (100.0)	298 (19.4)
26	-	101 (43.1)	24 (74.8)	7 (85.2)	-	224 (39.1)
27	4 (100.0)	155 (48.6)	123 (59.5)	1 (60.8)	-	43 (50.1)
28	841 (71.5)	1 029 (52.5)	505 (35.6)	26 (94.7)	3 (100.0)	2 (100.0)
29	770 (4.7)	200 (33.3)	406 (6.1)	7 (100.0)	-	-
30	257 (33.6)	814 (48.1)	406 (15.6)	-	2 (100.0)	- (100.0)
Deep	3 121 (20.3)	2 681 (25.2)	2 220 (10.2)	1 995 (45.7)	24 (12.4)	675 (12.6)
Total	3 121 (20.3)	2 716 (25.2)	2 231 (10.2)	1 994 (45.7)	11 933 (12.4)	12 014 (12.6)

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

Stratum	< 20 cm	20–30 cm	≥30 cm	Total
1	-	-	-	-
2A	2 (100.0)	4 (100.0)	3 (100.0)	9 (65.0)
2B	-	-	-	-
3	-	-	-	-
4	-	-	-	-
5	-	-	-	-
6	-	-	-	-
7A	-	-	-	-
7B	-	-	-	-
8A	-	-	-	-
8B	-	-	5 (100.0)	5 (100.0)
9	-	-	-	-
10	-	-	-	-
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
Core	2 (100.0)	4 (100.0)	8 (72.7)	14 (54.6)
21A	1 (100.0)	34 (97.3)	29 (100.0)	64 (98.6)
21B	3 (74.4)	78 (18.2)	203 (7.6)	285 (7.6)
22	2 (64.6)	48 (38.9)	403 (39.5)	453 (37.5)
23	56 (100.0)	169 (91.3)	3 123 (78.8)	3 348 (79.7)
24	1 (100.0)	53 (57.6)	636 (31.1)	689 (31.7)
25	9 (51.9)	74 (61.5)	84 (49.7)	168 (54.3)
26	-	-	-	-
27	-	-	-	-
28	-	8 (59.8)	8 (100.0)	16 (58.1)
29	-	-	-	-
30	-	-	-	-
Deep	71 (78.3)	464 (36.4)	4 487 (55.1)	5 023 (53.5)
Total	74 (75.7)	468 (36.0)	4 495 (55.0)	5 037 (53.3)

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

	Species code	Number measured Males	Number measured Females	Number measured Total	Number of biological samples
Alfonsino	BYS	458	402	886	411
Banded bellowsfish	BBE	1	21	2 195	405
Banded rattail	CFA	333	936	1 295	516
Banded stargazer	BGZ	1	1	2	2
Barracouta	BAR	50	28	78	53
Basketwork eel	BEE	194	486	823	348
Baxter’s lantern dogfish	ETB	340	337	679	546
Bigeye cardinalfish	EPL	32	15	61	27
Big-scale pomfret	BSP	0	2	2	2
Bigscaled brown slickhead	SBI	423	797	1 222	754
Black ghost shark	HYB	2	0	2	2
Black oreo	BOE	1 133	1 199	2 335	396
Black javelinfish	BJA	56	51	111	40
Black slickhead	BSL	189	235	441	232
Blackspot rattail	VNI	0	0	6	6
Blue mackerel	EMA	0	1	1	1
Bluenose	BNS	9	14	23	23
Bollons's rattail	CBO	1 760	1 803	3 781	1 903
Brown chimaera	CHP	1	2	3	3
Cape scorpionfish	TRS	6	16	22	22
Capro dory	CDO	0	0	139	43
Catshark (*Apristurus* spp.)	APR	47	17	64	64
Common roughy	RHY	117	158	275	123
Deepsea cardinalfish	EPT	132	57	199	135
Deepsea spiny (Arctic) skate	DSK	0	1	1	1
Four-rayed rattail	CSU	423	761	1 989	608
Frill shark	FRS	0	2	2	2
Frostfish	FRO	2	0	2	2
Gemfish	RSO	0	1	1	1
Ghost shark	GSH	1 820	1 658	3 483	1 171
Giant stargazer	GIZ	150	178	329	307
Greenback jack mackerel	JMD	1	0	1	1
Hairy conger	HCO	2	2	17	4
Hake	HAK	115	106	221	221
Hapuku	HAP	5	6	11	11
Hoki	HOK	8 289	9 901	18 358	2 536
Humpback rattail (slender rattail)	CBA	0	8	8	8
Javelin fish	JAV	1 373	5 773	7 305	2 476
Johnson's cod	HJO	763	771	1 537	816
Kaiyomaru rattail	CKA	47	28	127	98
Leafscale gulper shark	CSQ	11	35	46	44
Lemon sole	LSO	39	49	89	89
Ling	LIN	893	884	1 779	1 469
Longfinned beryx	BYD	4	1	5	5
Longnose velvet dogfish	CYP	605	559	1 164	804
Long-nosed chimaera	LCH	273	234	508	428
Longnosed deepsea skate	PSK	1	0	1	1
Lookdown dory	LDO	1 766	2 232	4 117	2 121

Table 8 (continued)

	Species code	Number measured Males	Number measured Females	Number measured Total	Number of biological samples
Lucifer dogfish	ETL	222	270	503	359
Mahia rattail	CMA	13	18	31	31
Mirror dory	MDO	1	7	8	8
Murray's rattail	CMU	0	5	5	5
Nezumia namatahi	NNA	1	3	4	4
Northern spiny dogfish	NSD	13	3	16	16
Notable rattail	CIN	132	245	697	296
NZ southern arrow squid	NOS	268	307	583	366
Oblique banded rattail	CAS	304	1 220	1 600	573
Oliver's rattail	COL	637	983	2 104	1 036
Orange perch	OPE	111	229	340	86
Orange roughy	ORH	672	727	1 423	873
Owston's dogfish	CYO	92	44	136	136
Pale ghost shark	GSP	552	559	1 114	842
Plunket’s shark	PLS	4	5	9	9
Pointynose blue ghost shark	HYP	3	0	3	3
Prickly dogfish	PDG	7	4	11	10
Ray’s bream	RBM	1	0	1	1
Red cod	RCO	307	156	465	264
Redbait	RBT	3	2	5	5
Ribaldo	RIB	115	66	181	169
Ridge scaled rattail	MCA	493	277	785	584
Roughhead rattail	CHY	9	30	40	40
Rough skate	RSK	2	3	5	5
Ruby fish	RBY	1	1	2	2
Rudderfish	RUD	26	12	38	38
Scampi	SCI	53	41	95	95
School shark	SCH	10	8	18	18
Sea perch	SPE	1 801	1 654	3 537	1 467
Seal shark	BSH	26	31	57	57
Serrulate rattail	CSE	141	114	277	234
Shovelnose spiny dogfish	SND	815	787	1 605	766
Silver dory	SDO	158	88	248	61
Silver roughy	SRH	30	31	211	89
Silver warehou	SWA	1 150	915	2 068	731
Silverside	SSI	104	61	1 020	181
Sixgill shark	HEX	1	1	2	2
Slender jack mackerel	JMM	32	27	59	59
Small banded rattail	CCX	41	25	173	94
Small-headed cod	SMC	18	14	32	32
Smallscaled brown slickhead	SSM	377	506	886	623
Smooth deepsea skate	BTA	1	0	1	1
Smooth oreo	SSO	836	643	1 481	429
Smooth skate	SSK	24	30	54	48
Southern blue whiting	SBW	57	34	91	75
Southern rays bream	SRB	105	101	207	177
Spiky oreo	SOR	625	639	1 272	534
Spineback	SBK	41	592	661	479
Spiny dogfish	SPD	381	1 117	1 499	944
Spotty faced rattail	CTH	3	12	15	15

Table 8 (continued)

	Species code	Number measured Males	Number measured Females	Number measured Total	Number of biological samples
Striate rattail	CTR	1	3	4	4
Swollenhead conger	SCO	1	4	14	8
Taningia spp. (squid)	TDQ	0	0	2	2
Tarakihi	NMP	11	10	21	21
Thin tongue cardinalfish	EPM	24	7	61	61
Two saddle rattail	CBI	207	146	354	211
Unicorn rattail	WHR	6	15	22	22
Velvet rattail	TRX	0	1	1	1
Violet cod	VCO	144	104	248	163
Warty oreo	WOE	33	29	62	62
White rattail	WHX	220	188	408	361
White warehou	WWA	429	349	798	449
Widenosed chimaera	RCH	80	84	165	142
Total		33 839	43 354	83 584	33 760

Table 9: Length-weight regression parameters* used to scale length frequencies (all data from TAN1601). Length measurement method: TL, total length; FL, fork length, CL, chimaera length; SL, standard length.

Species	*a* (intercept)	*b* (slope)	r^2	*n*	Length range (cm)	Length measurement
Baxter's dogfish	0.003310	3.109395	0.99	508	20–78	TL
Basketwork eel	0.000651	3.120626	0.92	255	59–126	TL
Bigscaled brown slickhead	0.004124	3.213271	0.96	361	26–58	FL
Black oreo	0.029557	2.895911	0.89	395	23–39	TL
Bollons's rattail	0.001570	3.325815	0.95	1 275	23–61	TL
Dark ghost shark	0.003607	3.126585	0.95	825	28–73	CL
Four-rayed rattail	0.024715	2.283233	0.67	311	23–39	TL
Giant stargazer	0.006519	3.232007	0.99	303	15–82	TL
Hake	0.002120	3.273983	0.98	218	38–128	TL
Hoki	0.004294	2.915508	0.99	2 241	36–111	TL
Javelinfish	0.001068	3.211086	0.97	1 402	19–65	TL
Ling	0.001596	3.242461	0.99	1 356	26–154	TL
Longnose velvet dogfish	0.002322	3.149649	0.98	553	30–97	TL
Lookdown dory	0.029584	2.911942	0.98	1 479	12–55	TL
Orange roughy	0.045577	2.912915	0.99	509	8–41	SL
Pale ghost shark	0.008473	2.907834	0.96	779	34–90	CL
Ribaldo	0.004551	3.219431	0.97	147	25–71	TL
Sea perch	0.009084	3.167219	0.99	1 199	14–50	TL
Silver warehou	0.015135	3.066795	0.97	674	16–56	FL
Shovelnose dogfish	0.001848	3.154963	0.97	737	31–114	TL
Smallscaled brown slickhead	0.008002	3.028016	0.98	438	22–69	FL
Smooth oreo	0.018479	3.067592	0.98	361	17–51	TL
Spiny dogfish	0.000848	3.392260	0.94	768	50–102	TL
Spiky oreo	0.025901	2.962600	0.99	478	10–43	TL
White warehou	0.012580	3.165014	0.99	433	14–60	FL

* $W = aL^b$ 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.

Common name	Sex	Staging	Reproductive stage							
		method	1	2	3	4	5	6	7	Total
Alfonsino	Male	MD	106	46	12	–	–	–	–	164
	Female		79	49	1	–	–	–	–	129
Banded rattail	Male	MD	9	16	1	–	–	–	–	26
	Female		12	35	–	–	–	–	–	47
Banded stargazer	Male	MD	–	1	–	–	–	–	–	1
	Female		–	1	–	–	–	–	–	1
Barracouta	Male	MD	–	7	1	7	14	2	1	38
	Female		–	5	16	–	–	–	–	21
Basketwork eel	Male	MD	11	12	1	–	–	–	–	24
	Female		3	37	10	–	–	–	–	50
Baxter's dogfish	Male	SS	71	86	96	–	–	–	–	253
	Female		139	99	42	2	6	1	–	289
Bigscaled brown	Male	MD	13	16	13	1	–	–	3	46
slickhead	Female		18	20	53	8	2	1	3	105
Black javelinfish	Male	MD	4	13	–	1	–	–	–	18
	Female		1	14	–	–	–	–	–	15
Black slickhead	Male	MD	–	–	10	5	–	–	2	17
	Female		–	–	16	8	–	–	–	24
Black oreo	Male	MD	107	81	12	10	–	–	2	212
	Female		67	50	63	1	–	–	–	181
Blue mackerel	Male	MD	–	–	–	–	–	–	–	–
	Female		–	–	1	–	–	–	–	1
Bluenose	Male	MD	4	5	–	–	–	–	–	9
	Female		9	3	2	–	–	–	–	14
Bollons's rattail	Male	MD	13	119	16	–	–	–	–	148
	Female		21	110	11	–	–	–	2	142
Cape scorpionfish	Male	MD	2	2	–	–	–	–	–	4
	Female		5	8	–	–	–	–	–	13
Catshark	Male	SS	2	9	5	–	–	–	–	16
(*Apristurus* spp.)	Female		1	–	2	–	–	–	–	3
Common roughy	Male	SS	–	9	11	1	–	–	–	21
	Female		1	–	1	17	–	–	–	19
Dark ghost shark	Male	SS	99	97	262	–	–	–	–	458
	Female		184	188	46	6	–	–	–	424
Deepsea cardinalfish	Male	MD	24	–	–	–	–	–	–	24
	Female		14	4	–	–	–	–	–	18
Four-rayed rattail	Male	MD	4	7	–	–	–	–	–	11
	Female		1	13	9	–	–	–	–	23
Frostfish	Male	MD	–	1	–	1	–	–	–	2
	Female		–	–	–	–	–	–	–	–
Gemfish	Male	MD	–	–	–	–	–	–	–	–
	Female		–	1	–	–	–	–	–	1
Giant stargazer	Male	MD	45	100	–	–	–	–	1	146
	Female		37	55	61	–	–	1	3	157
Greenback jack	Male	MD	–	–	1	–	–	–	–	1
mackerel	Female		–	–	–	–	–	–	–	–
Hake	Male	MD	18	24	6	15	31	8	13	115
	Female		31	37	30	1	1	–	4	104
Hapuku	Male	MD	2	3	–	–	–	–	–	5
	Female		3	3	–	–	–	–	–	6
Hoki	Male	MD	456	319	–	–	–	2	1	778
	Female		610	1113	5	–	1	–	9	1 738
Humpback rattail	Male	MD	–	–	–	–	–	–	–	–
	Female		–	1	–	–	–	–	–	1
Javelinfish	Male	MD	30	57	–	–	–	2	–	89
	Female		63	319	58	–	–	–	14	454

Table 10 (continued)

Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
Johnson's cod	Male	MD	34	43	42	18	–	1	–	138
(*Halargyreus* spp.)	Female		29	80	172	–	–	–	–	281
Kaiyomaru rattail	Male	MD	–	2	–	–	–	–	–	2
	Female		–	2	2	–	–	–	–	4
Leafscale gulper shark	Male	SS	7	–	4	–	–	–	–	11
	Female		5	8	15	3	–	–	–	31
Lemon sole	Male	MD	2	1	–	–	–	–	–	3
	Female		–	2	–	–	–	–	–	2
Ling	Male	MD	306	180	100	124	7	–	–	717
	Female		396	332	10	2	–	–	–	740
Longfinned beryx	Male	MD	3	–	1	–	–	–	–	4
	Female		–	1	–	–	–	–	–	1
Longnose spookfish	Male	SS	52	29	130	–	–	–	–	211
	Female		76	51	52	–	–	–	–	179
Longnose velvet dogfish	Male	SS	152	51	157	–	–	–	–	360
	Female		146	84	41	21	9	1	–	302
Longnosed deepsea skate	Male	MD	1	–	–	–	–	–	–	1
	Female		–	–	–	–	–	–	–	–
Lookdown dory	Male	MD	204	317	80	26	1	–	–	628
	Female		247	209	270	1	–	215	–	744
Lucifer dogfish	Male	SS	13	28	70	–	–	–	–	111
	Female		31	50	21	4	2	3	–	111
Mirror dory	Male	MD	–	–	–	1	–	–	–	1
	Female		–	–	7	–	–	–	–	7
Nezumia namatahi	Male	MD	–	1	–	–	–	–	–	1
	Female		–	–	–	–	–	–	–	–
Northern spiny dogfish	Male	SS	–	3	10	–	–	–	–	13
	Female		2	1	–	–	–	–	–	3
Notable rattail	Male	MD	–	5	4	–	–	–	–	9
	Female		5	8	14	–	–	–	–	27
Oblique banded rattail	Male	MD	3	7	1	–	–	–	–	11
	Female		5	79	–	–	–	–	–	84
Oliver's rattail	Male	MD	1	29	5	–	–	–	–	35
	Female		13	67	2	–	–	–	–	82
Orange perch	Male	MD	–	4	13	1	1	–	–	19
	Female		2	10	12	5	–	–	–	29
Orange roughy	Male	MD	104	110	140	–	–	–	–	354
	Female		78	25	268	2	–	2	–	375
Pacific spookfish	Male	SS	23	15	21	–	–	–	–	59
	Female		28	–	5	–	–	–	–	33
Pale ghost shark	Male	SS	131	37	194	–	–	–	–	362
	Female		173	163	70	3	2	–	–	406
Plunket's shark	Male	SS	–	2	1	–	–	–	–	3
	Female		2	2	1	–	–	–	–	5
Ray's bream	Male	MD	–	1	–	–	–	–	–	1
	Female		–	–	–	–	–	–	–	–
Redbait	Male	MD	–	–	1	–	–	–	–	1
	Female		–	–	2	–	–	–	–	2
Red cod	Male	MD	49	20	18	32	6	5	6	136
	Female		34	43	5	2	–	–	–	84
Ribaldo	Male	MD	6	61	36	–	–	–	–	103
	Female		7	35	–	–	–	–	4	46
Ridge scaled rattail	Male	MD	134	74	13	1	–	–	–	222
	Female		55	88	16	–	–	–	–	159
Roughhead rattail	Male	MD	–	1	4	–	–	–	–	5
	Female		2	–	6	2	–	–	–	10

Table 10 (continued)

Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
Rough skate	Male	SS	–	–	1	–	–	–	–	1
	Female		–	1	–	–	1	–	–	2
Rubyfish	Male	MD	–	–	–	1	–	–	–	1
	Female		–	–	1	–	–	–	–	1
Rudderfish	Male	MD	–	4	4	5	–	–	–	13
	Female		–	2	3	–	1	–	–	6
School shark	Male	SS	–	2	4	–	–	–	–	6
	Female		2	–	–	–	–	–	–	2
Sea perch	Male	MD	91	353	64	1	–	–	–	509
	Female		129	291	11	1	6	2	2	442
Seal Shark	Male	SS	25	–	1	–	–	–	–	26
	Female		25	2	2	–	–	–	–	29
Serrulate rattail	Male	MD	3	11	8	–	–	–	–	22
	Female		3	30	12	–	–	–	–	45
Shovelnose dogfish	Male	SS	27	46	346	–	–	–	–	419
	Female		132	161	39	7	1	1	–	341
Silver dory	Male	MD	7	5	4	–	–	–	–	16
	Female		12	5	2	3	1	–	–	23
Silver warehou	Male	MD	56	299	7	–	–	1	–	363
	Female		35	253	17	–	–	1	–	306
Sixgill shark	Male	SS	1	–	–	–	–	–	–	1
	Female		–	–	–	–	–	–	–	–
Slender jack	Male	MD	1	5	9	4	9	–	–	28
mackerel	Female		–	2	17	2	–	–	–	21
Sloan's arrow squid	Male	SQ	1	23	–	11	21	–	–	56
	Female		1	18	2	2	16	–	–	39
Small-headed cod	Male	MD	–	1	–	–	–	–	–	1
	Female		–	2	–	–	–	–	–	2
Smallscaled brown	Male	MD	27	62	29	2	–	–	–	120
slickhead	Female		18	102	13	–	–	–	–	133
Smooth deepsea	Male	SS	–	–	1	–	–	–	–	1
skate	Female		–	–	–	–	–	–	–	–
Smooth oreo	Male	MD	76	33	36	21	21	6	–	196
	Female		81	30	65	1	–	–	–	177
Smooth skate	Male	SS	12	10	1	–	–	–	–	33
	Female		12	6	2	–	–	–	–	20
Smooth skin dogfish	Male	SS	12	6	71	–	–	–	–	99
	Female		22	15	7	–	–	–	–	44
Southern blue	Male	MD	6	40	–	–	–	–	–	46
whiting	Female		1	26	–	–	–	–	–	27
Southern Ray's	Male	MD	4	48	4	–	–	–	–	56
bream	Female		1	29	15	–	–	–	–	45
Spiky oreo	Male	MD	95	90	28	4	–	2	16	235
	Female		86	26	132	4	1	1	29	279
Spineback	Male	SS	–	3	–	–	2	–	–	5
	Female		2	8	57	9	18	–	2	96
Spiny dogfish	Male	SS	5	29	134	–	–	–	–	168
	Female		77	116	65	73	317	4	–	652
Spotty faced rattail	Male	MD	–	–	–	–	–	–	–	–
	Female		1	1	–	1	–	–	–	3
Striate rattail	Male	MD	1	–	–	–	–	–	–	1
	Female		2	1	–	–	–	–	–	3
Swollenhead conger	Male	MD	–	1	–	–	–	–	–	1
	Female		–	1	1	–	–	–	–	2
Tarakihi	Male	MD	–	6	3	–	–	–	2	11
	Female		–	9	1	–	–	–	–	10

Table 10 (continued)

Common name	Sex	Staging method	Reproductive stage 1	2	3	4	5	6	7	Total
Two saddle rattail	Male	MD	1	3	15	1	–	–	–	20
	Female		3	10	6	1	–	–	2	22
Unicorn rattail	Male	MD	3	–	–	–	–	–	–	3
	Female		4	5	–	–	–	–	–	9
Velvet rattail	Male	MD	–	–	–	–	–	–	–	–
	Female		–	–	1	–	–	–	–	1
Violet rattail	Male	MD	44	9	1	–	1	–	–	55
	Female		27	27	–	–	–	–	–	54
Warty oreo	Male	MD	28	4	–	–	–	–	–	32
	Female		21	7	1	–	–	–	–	29
White rattail	Male	MD	31	43	10	–	–	–	2	86
	Female		10	58	14	–	–	–	–	82
White warehou	Male	MD	109	104	2	–	–	–	–	215
	Female		97	56	20	–	–	–	–	173

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).
Arrow squid (SQ) gonad stages: 1, immature unsexed; 2, immature sexed; 3, developing; 4, maturing; 5, mature; 6, spent.
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 2001–16.

			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

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

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

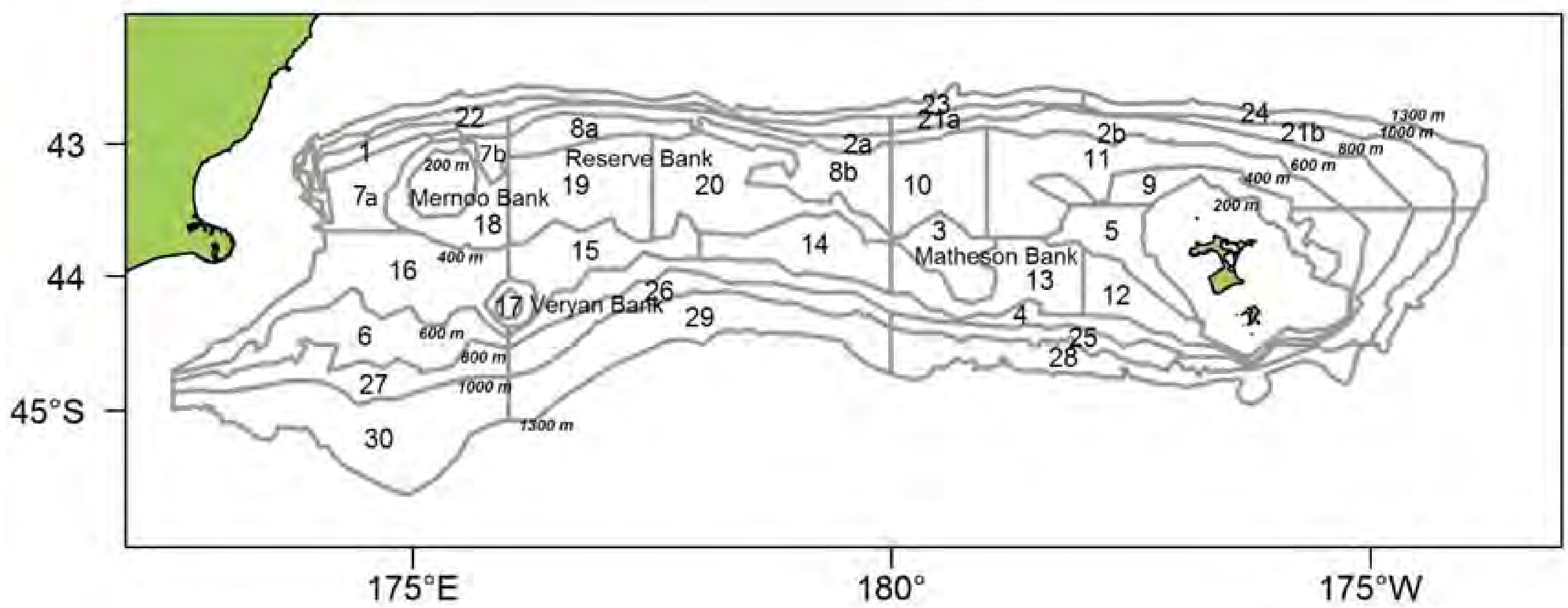


Figure 1: Chatham Rise trawl survey area showing stratum boundaries.

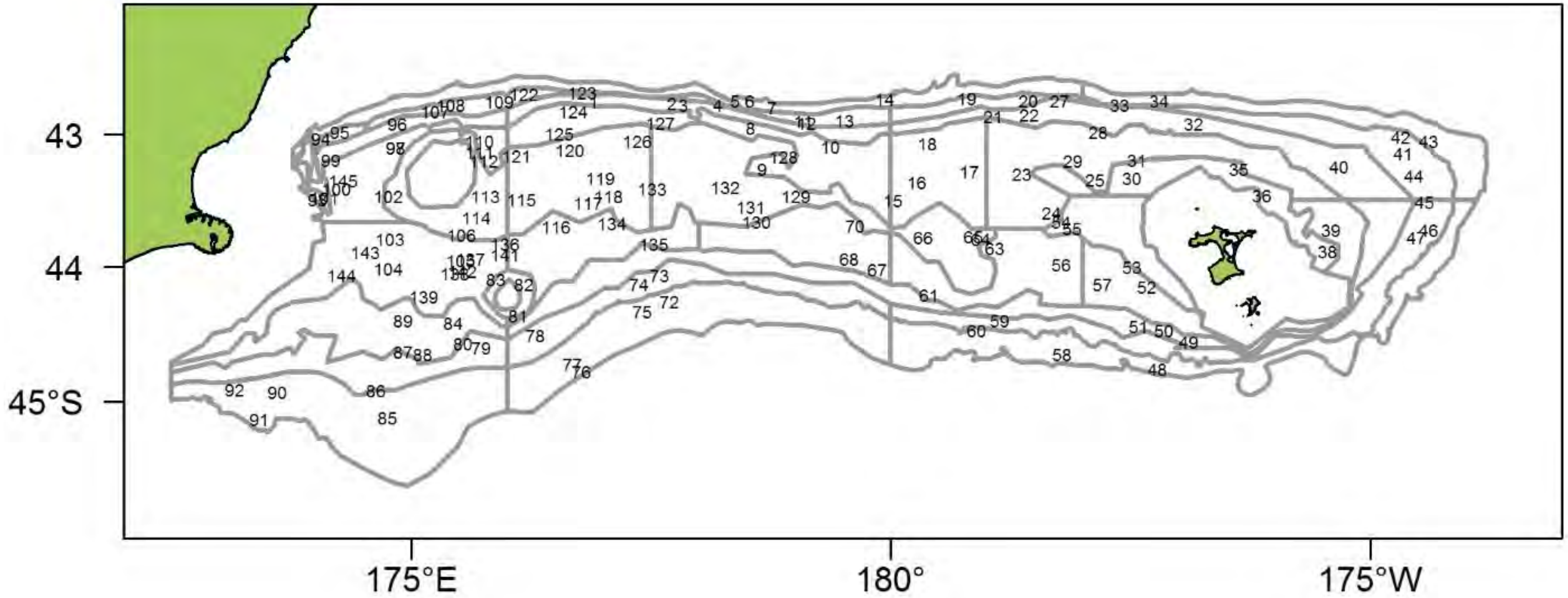


Figure 2: Trawl survey area showing positions of valid biomass stations (n = 139 stations) for TAN1601. In this and subsequent figures actual stratum boundaries are drawn for the deepwater strata. These boundaries sometimes overlap with existing core survey stratum boundaries.

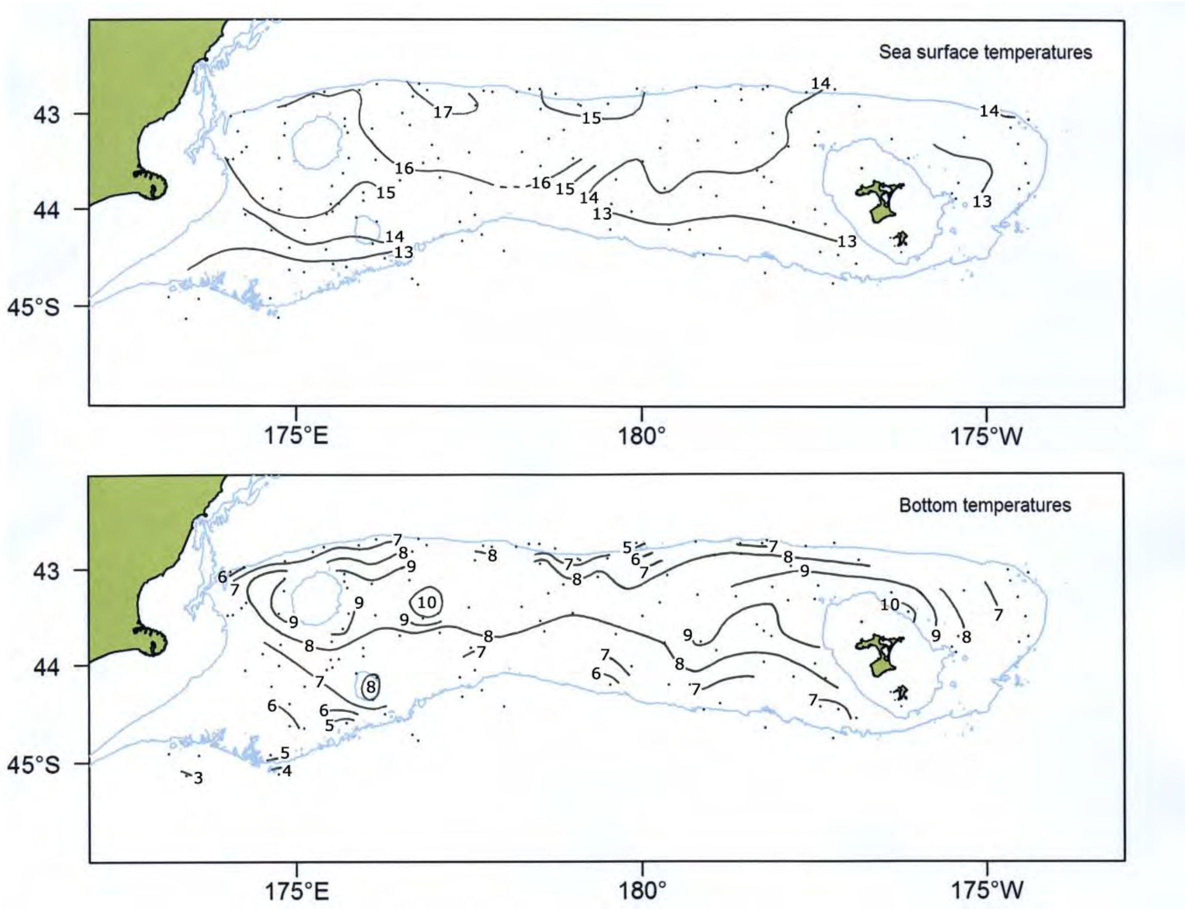


Figure 3: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (°C) interpolated by eye for TAN1601. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow.

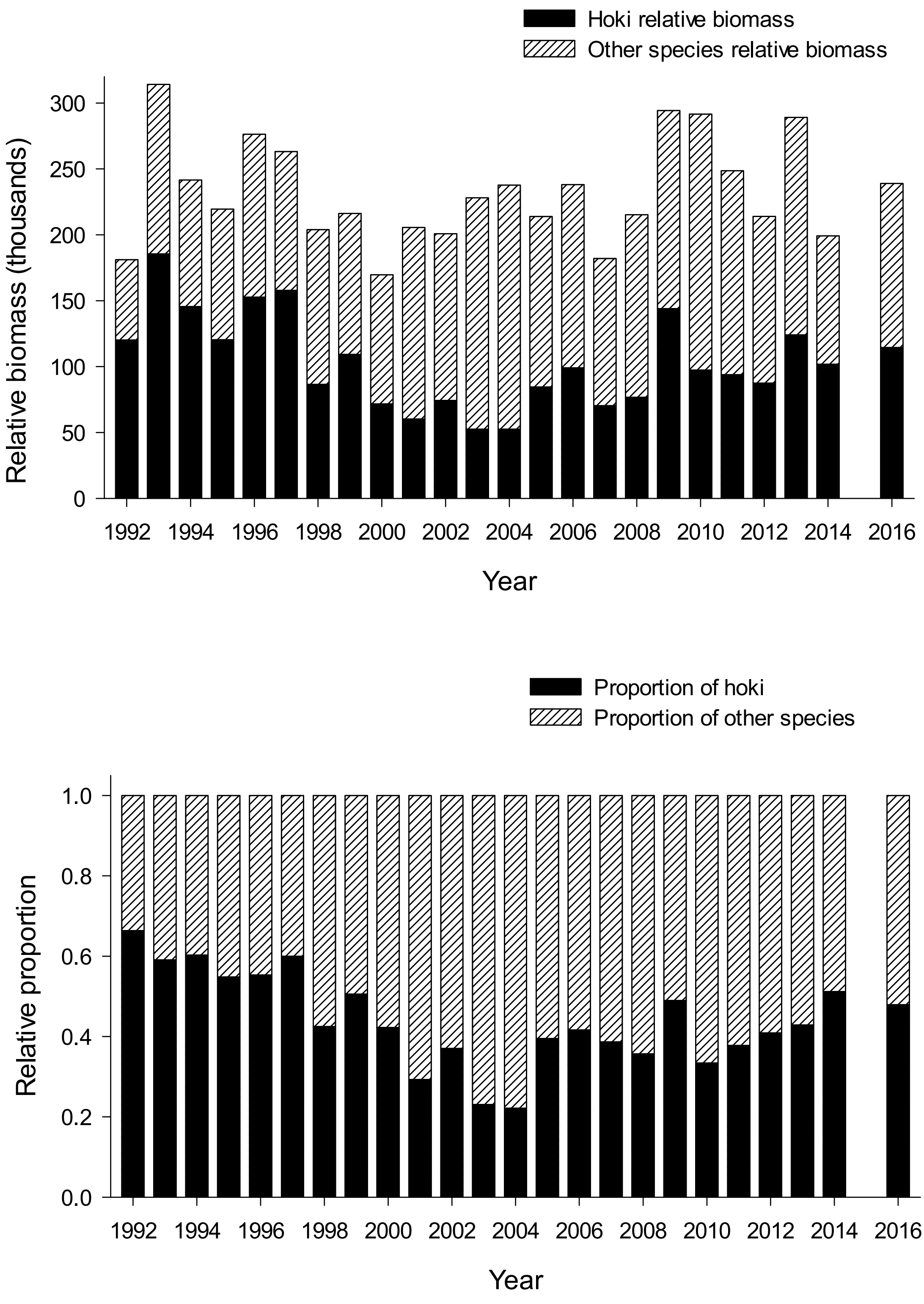


Figure 4: Relative biomass (top panel) and relative proportions of hoki and 30 other key species (lower panel) from trawl surveys of the Chatham Rise, January 1992–2016 (core strata only).

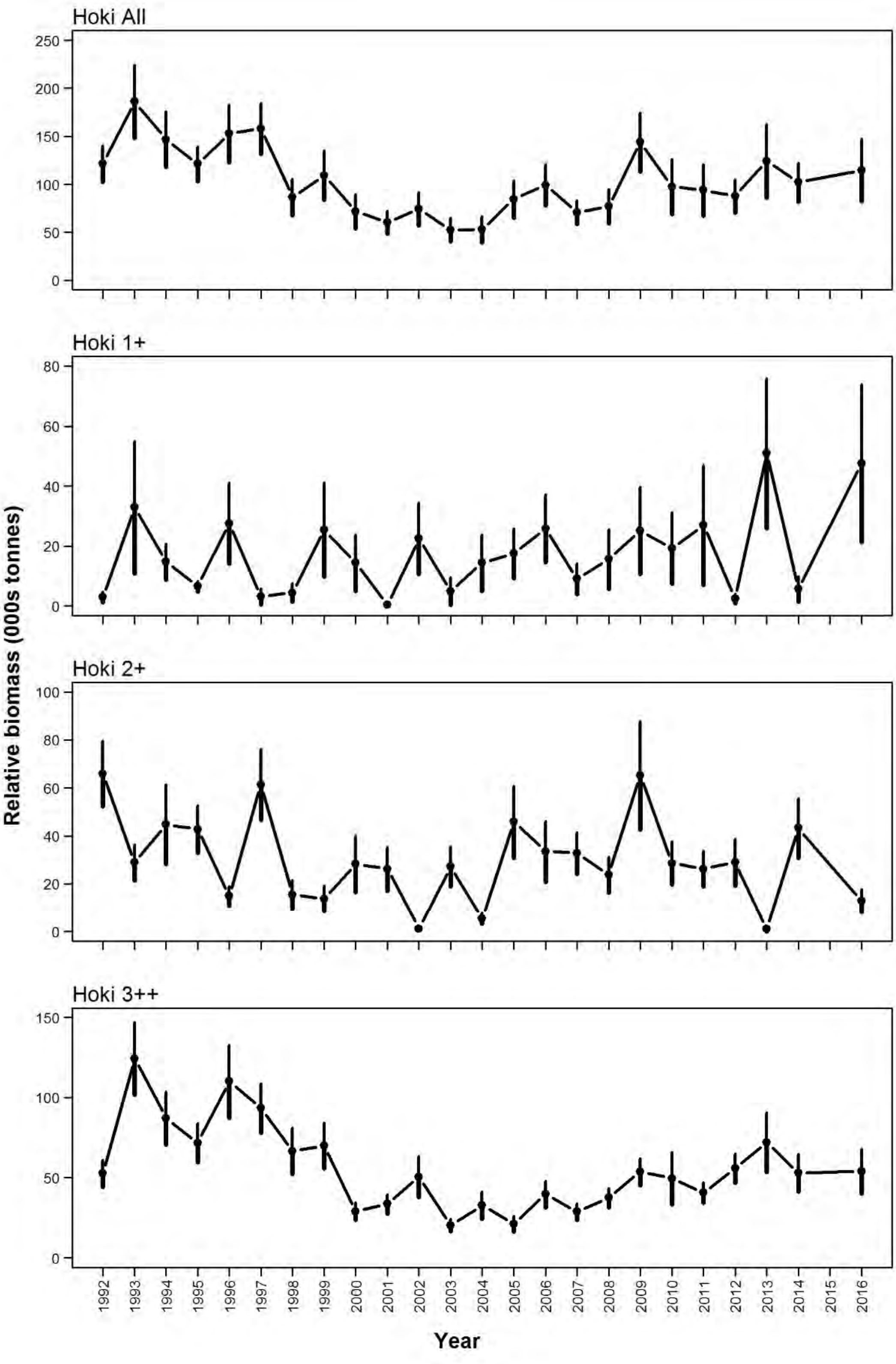


Figure 5a: Relative biomass estimates (thousands of tonnes) of hoki, hake, ling, and other selected commercial species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, and 2016 (core strata only). Error bars show ± 2 standard errors.

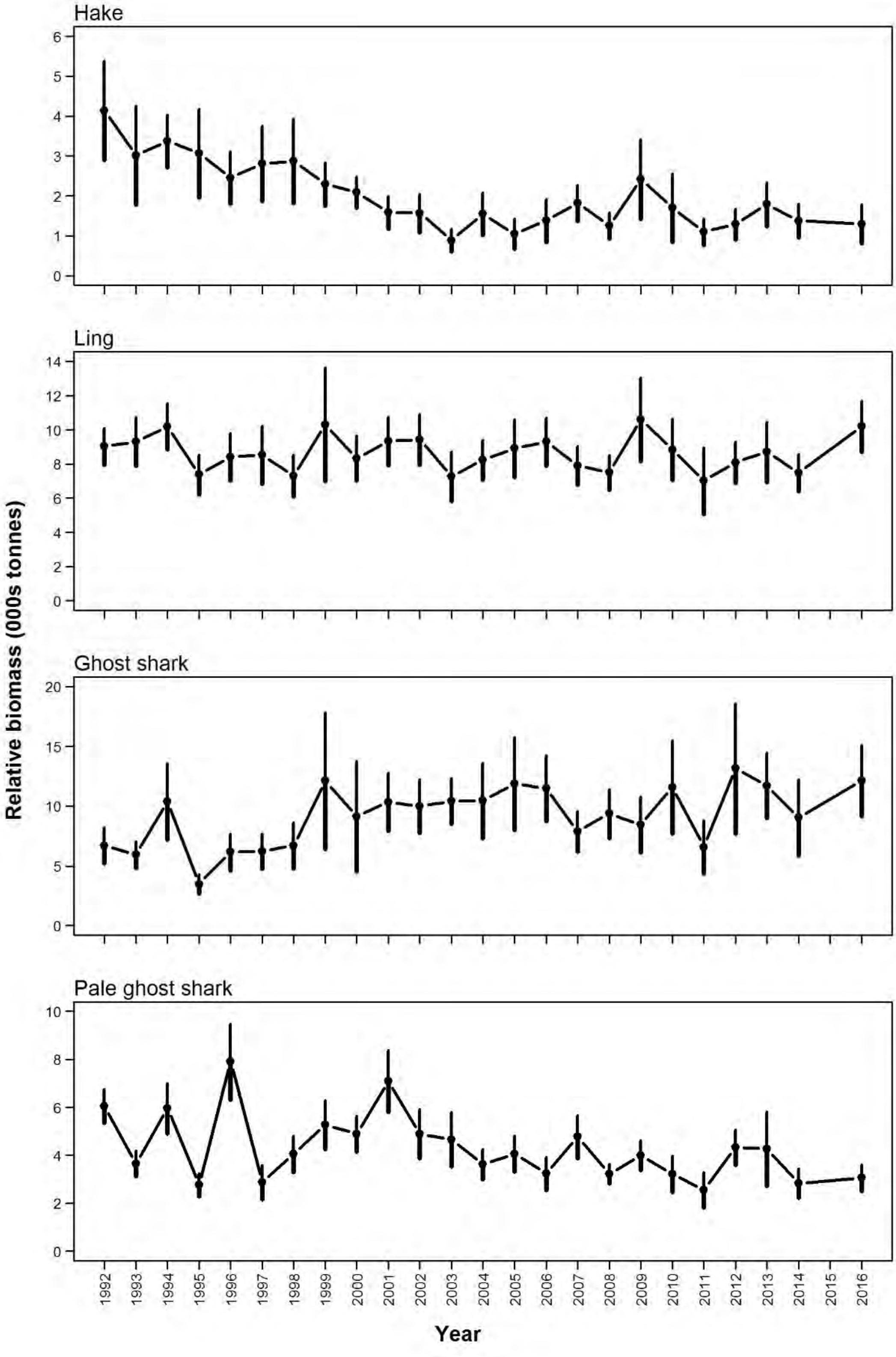


Figure 5a (continued)

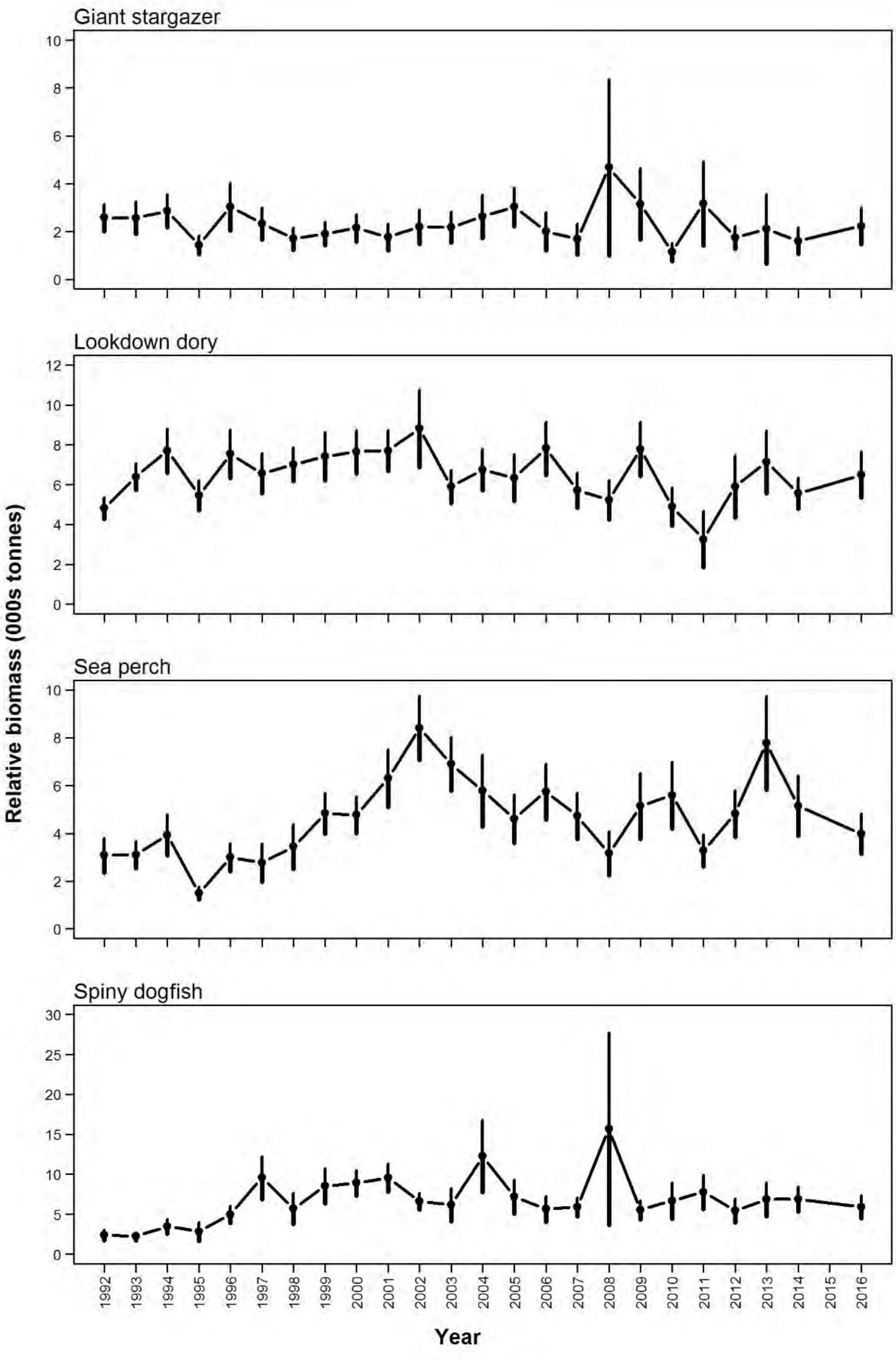


Figure 5a (continued)

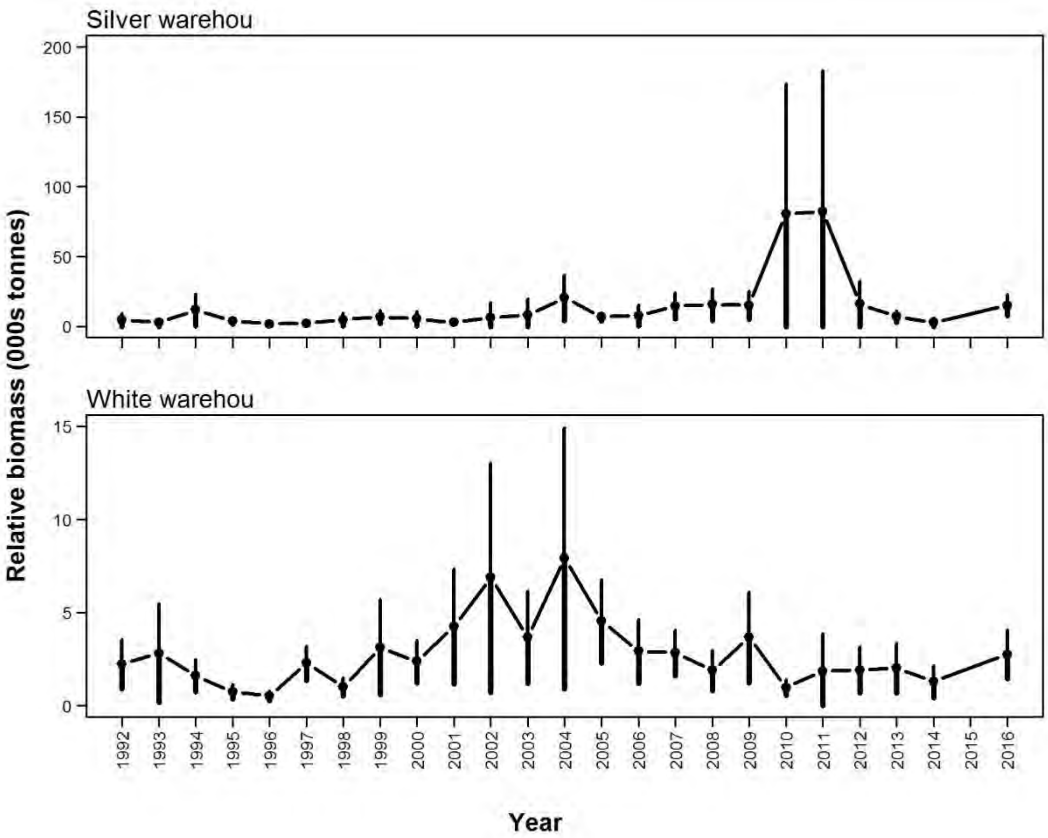


Figure 5a (continued)

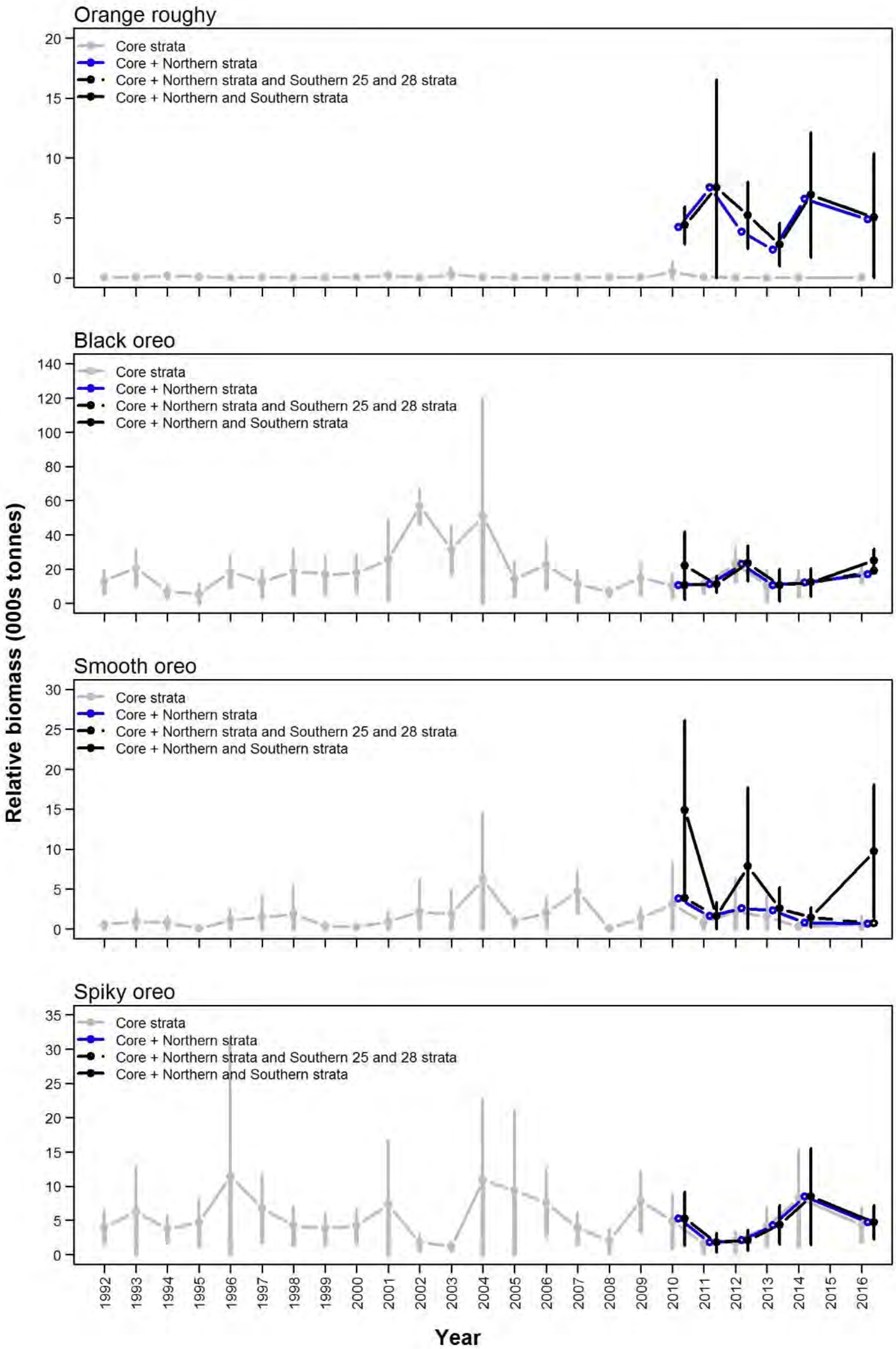
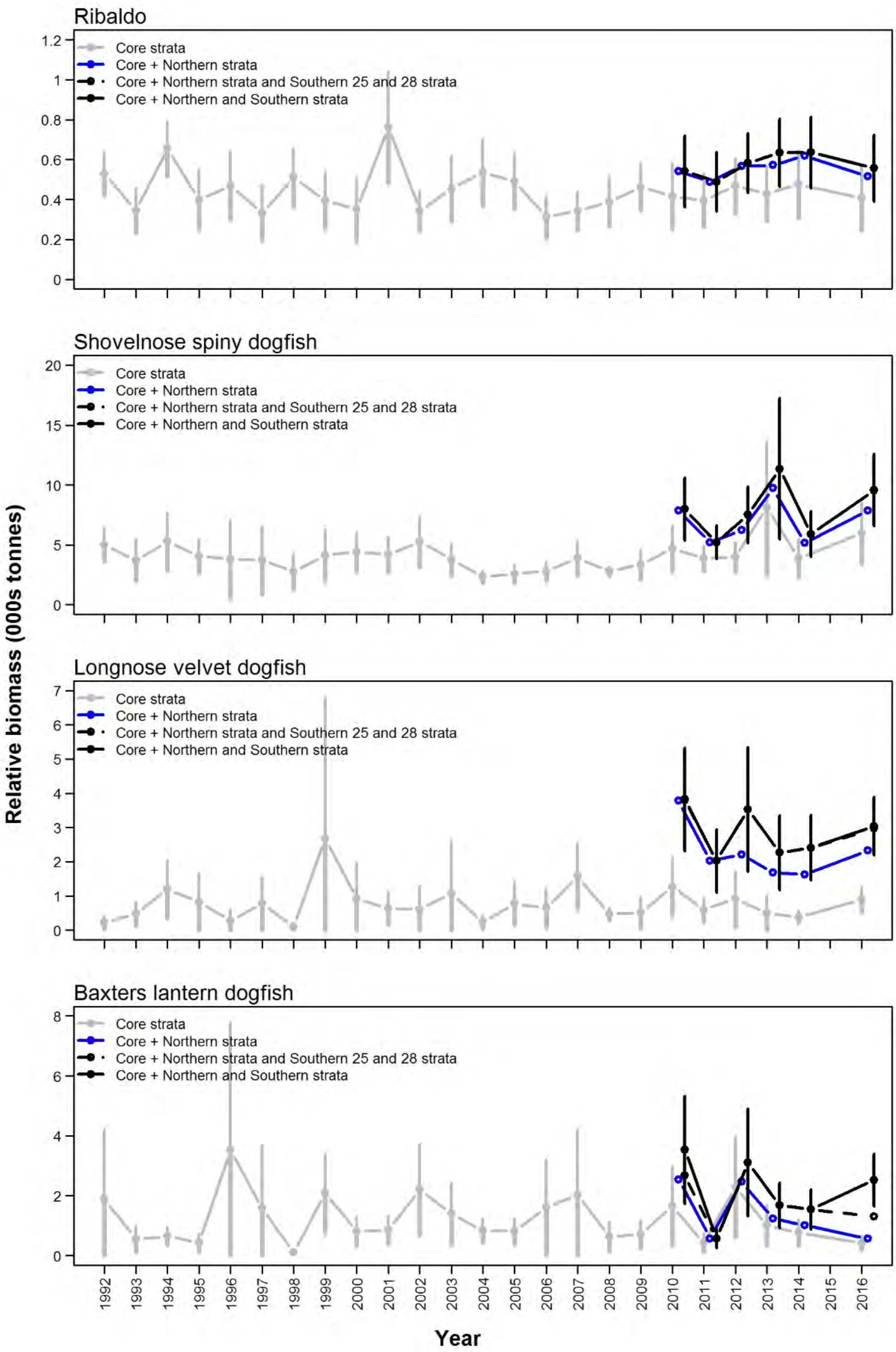


Figure 5b: Relative biomass estimates (thousands of tonnes) of orange roughy, oreo species, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, and 2016. Grey lines show fish from core (200–800 m) strata. Blue lines show fish from core strata plus the northern deep (800–1300 m) strata. Black solid lines show fish from core strata plus the northern and southern deep (800–1300 m) strata, and black dotted lines show fish from core strata plus the northern and southern 25 and 28 deep strata (800–1300 m). Error bars show ± 2 standard errors.



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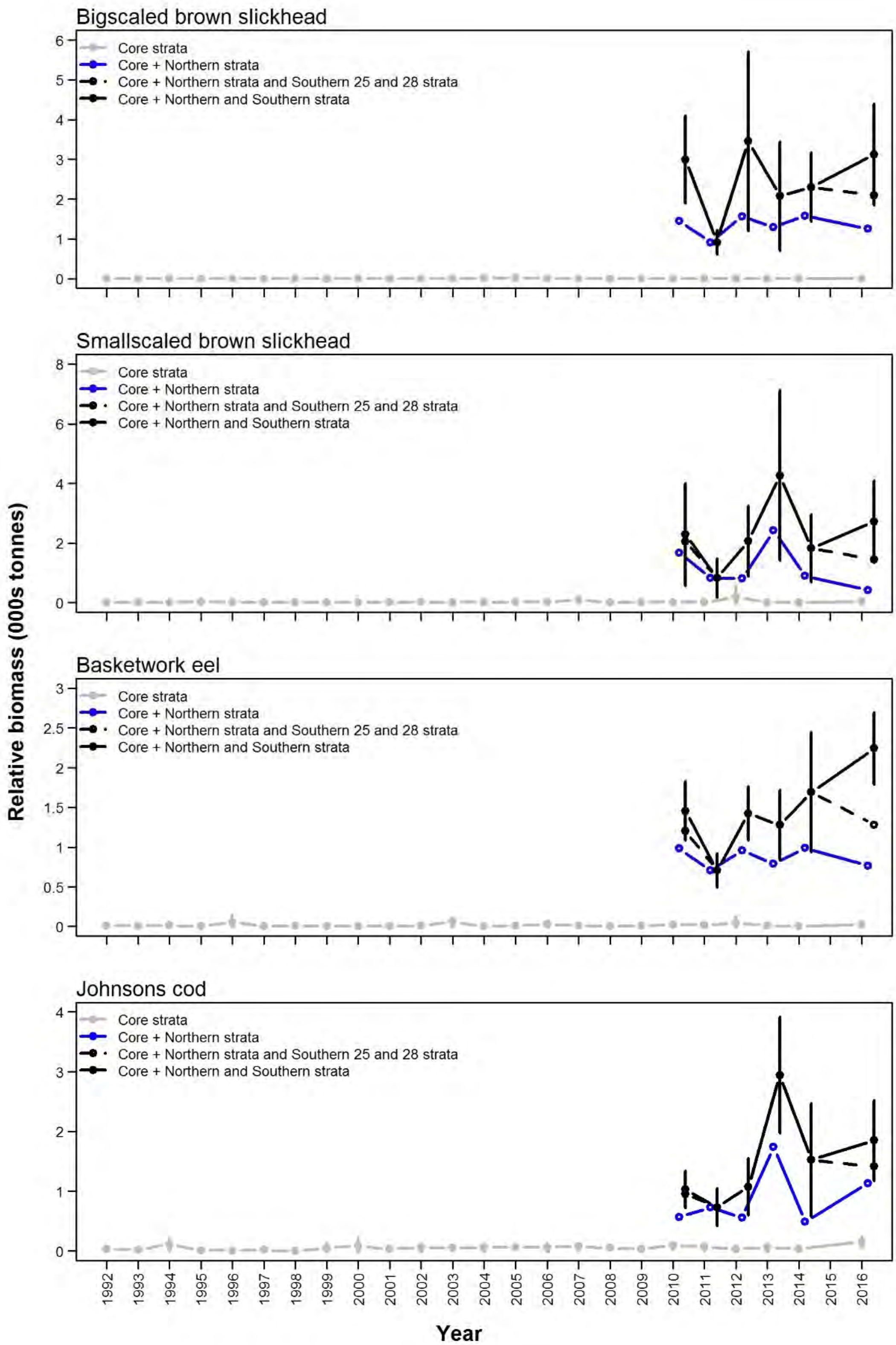

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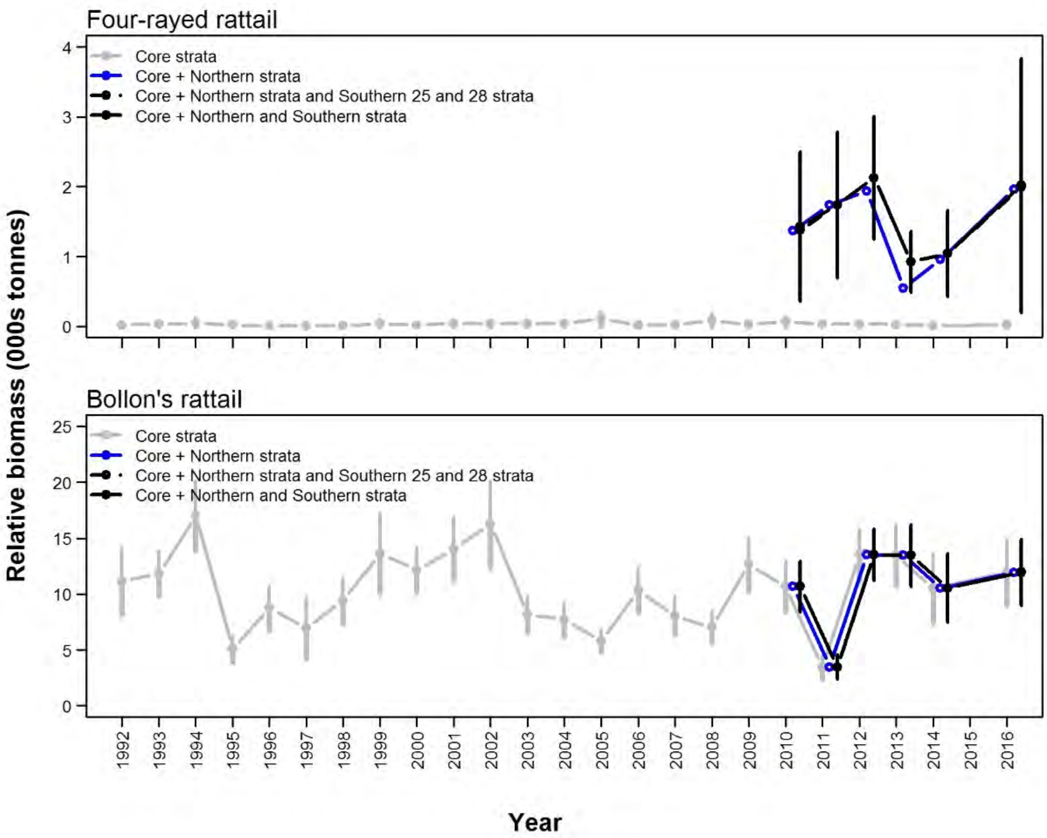


Figure 5b (continued)

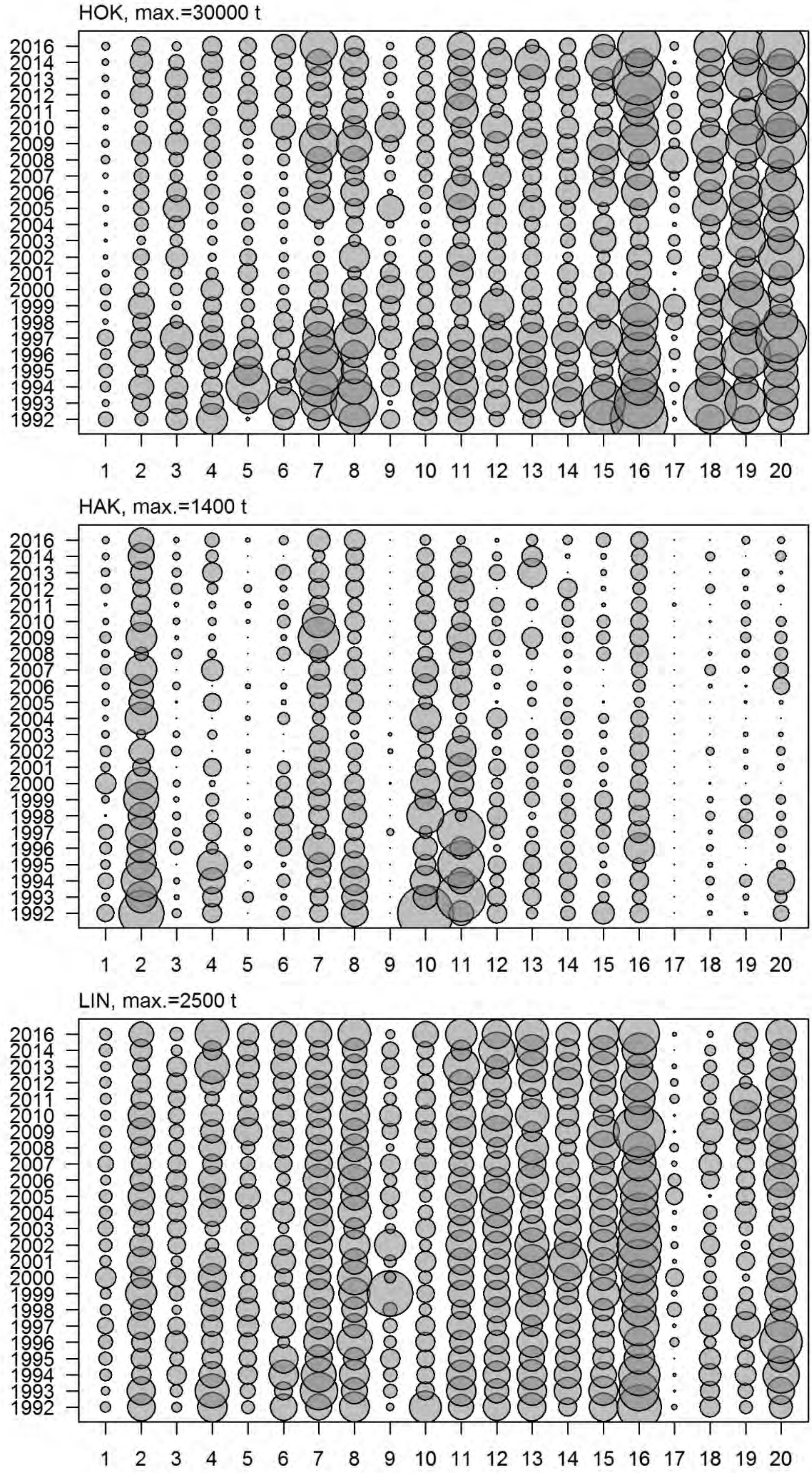
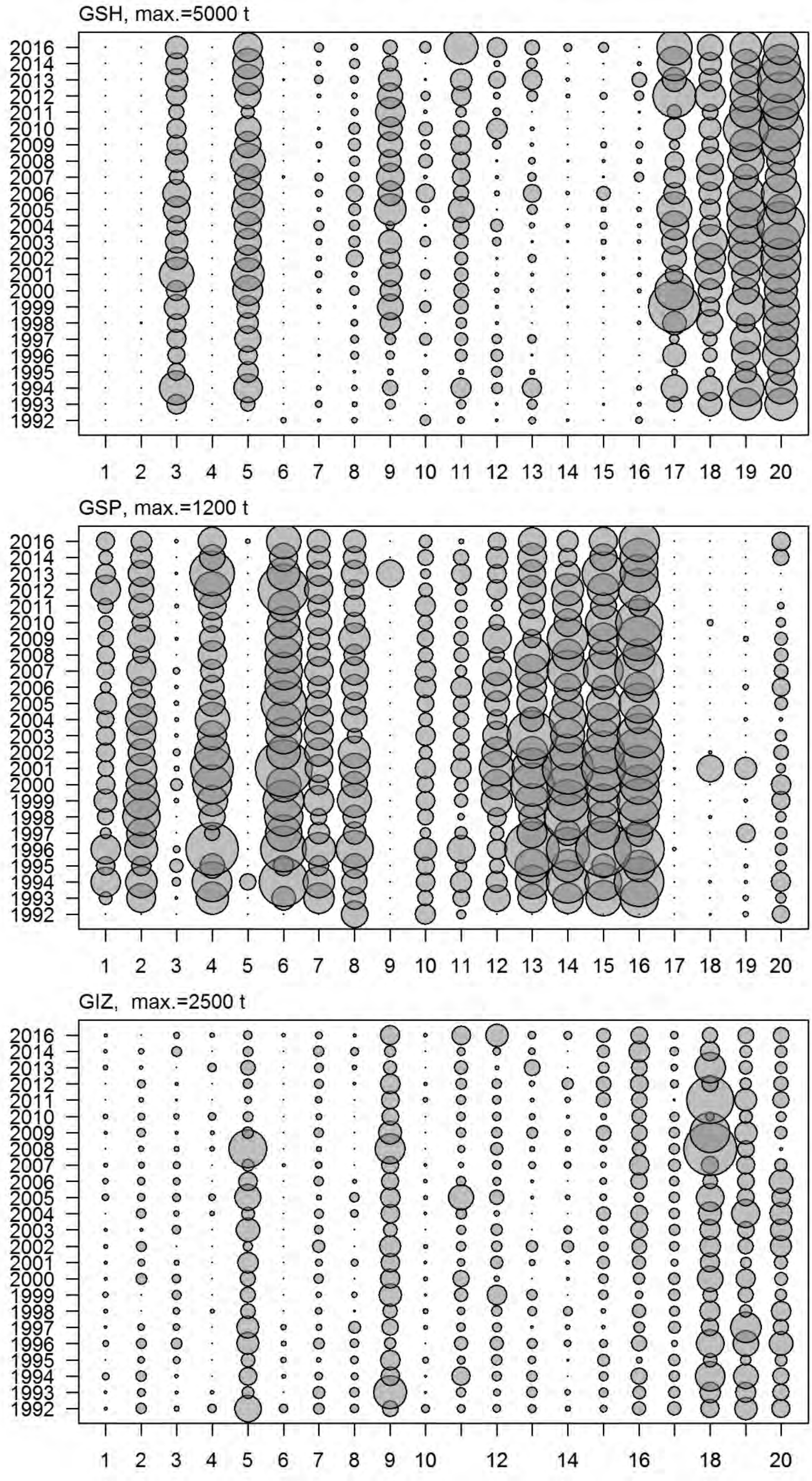


Figure 6a: Relative core (200–800 m) biomass estimates by strata for hoki, and other selected midwater species sampled by annual trawl surveys of the Chatham Rise, January 1992–2014, and 2016.



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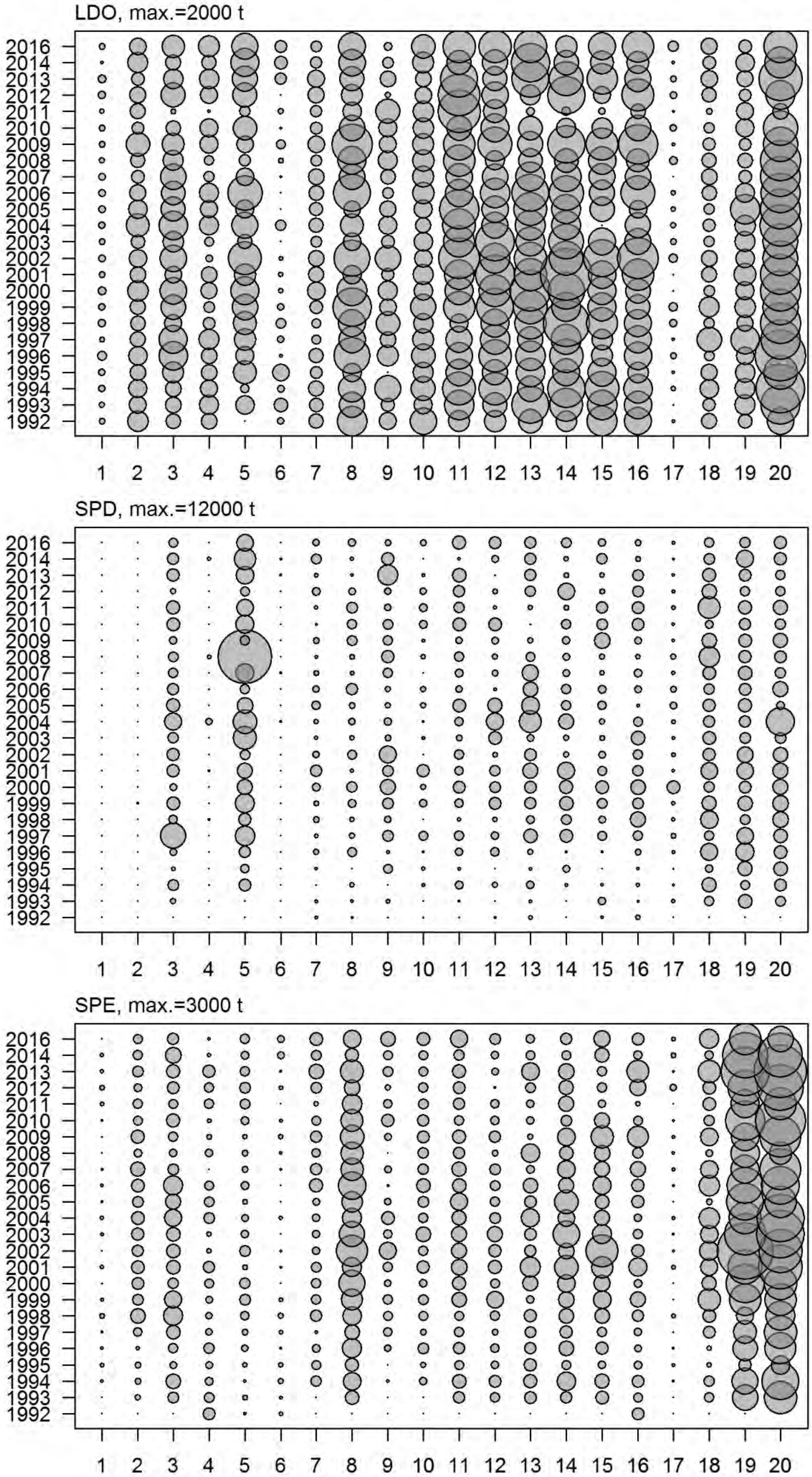


Figure 6a (continued)

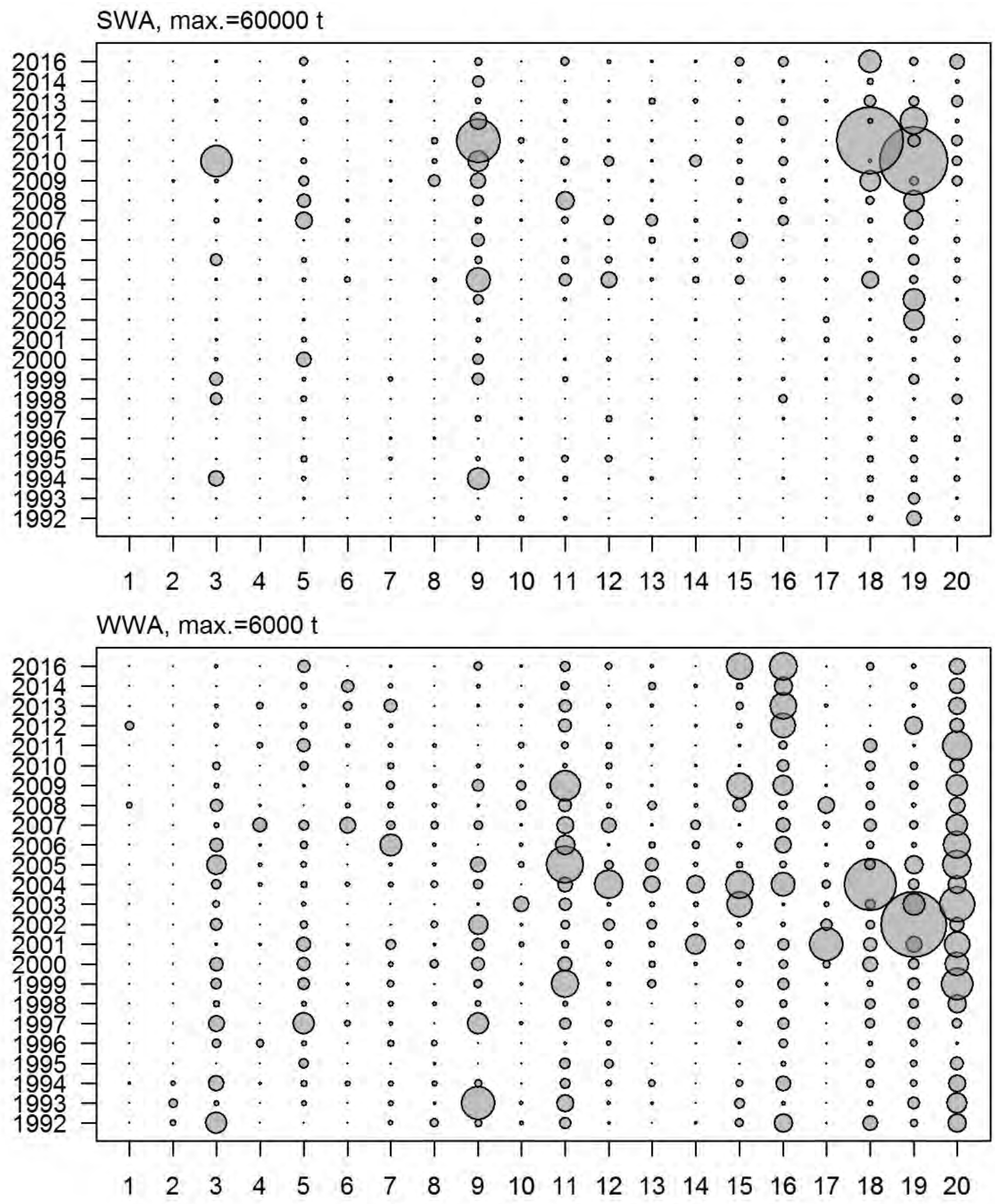


Figure 6a (continued)

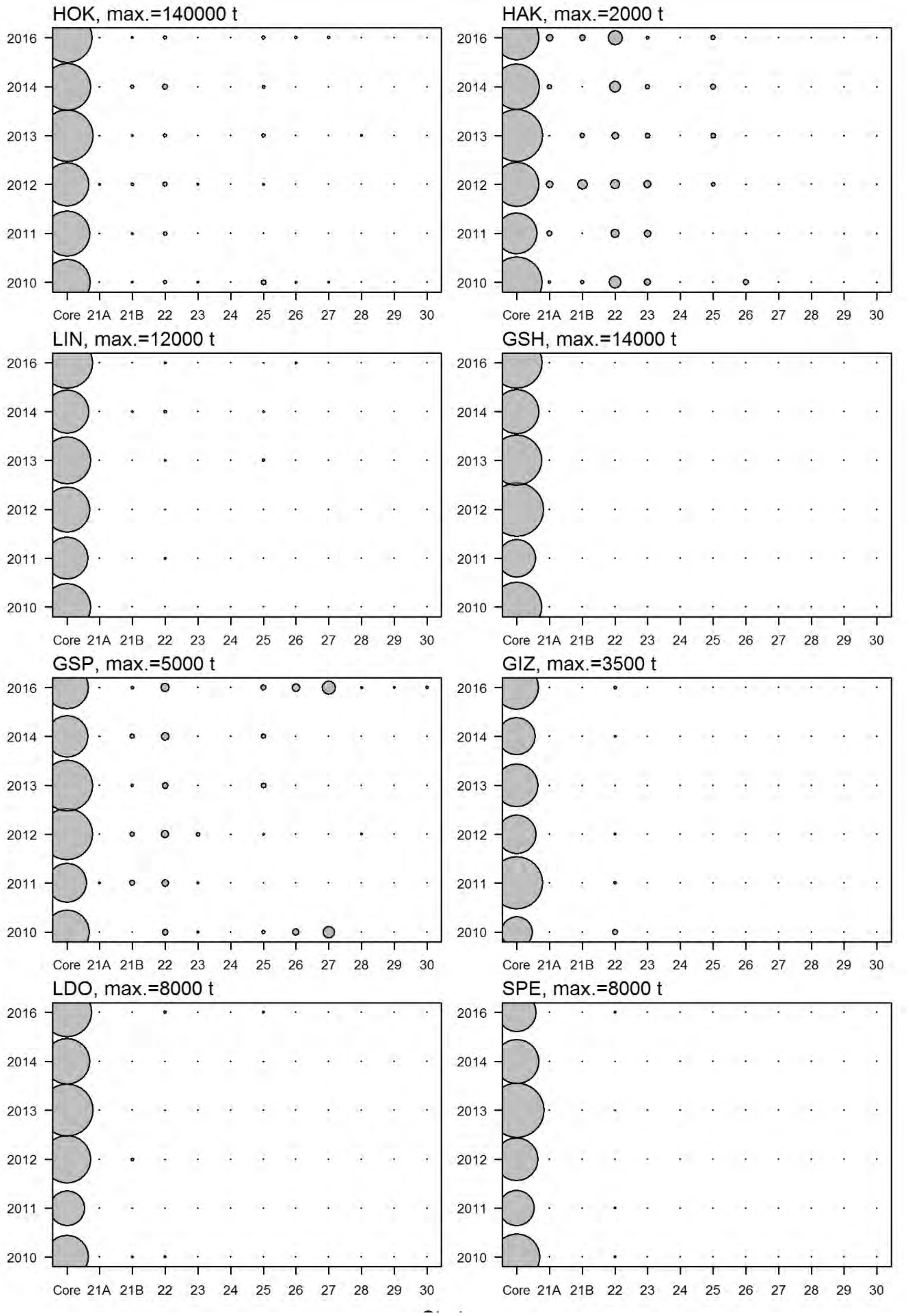


Figure 6b: Relative deep (800–1300 m) biomass estimates by strata for hoki and other selected middle depth species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, and 2016.

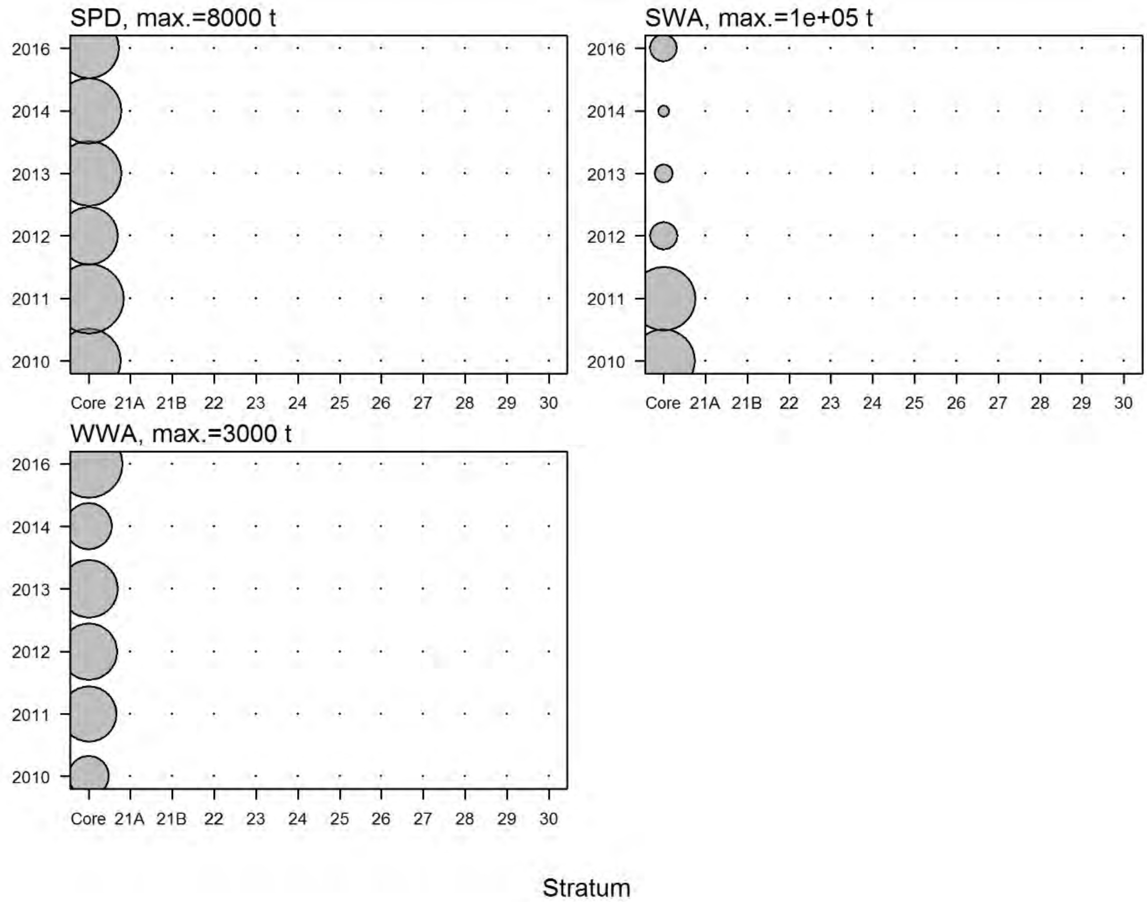


Figure 6b (continued)

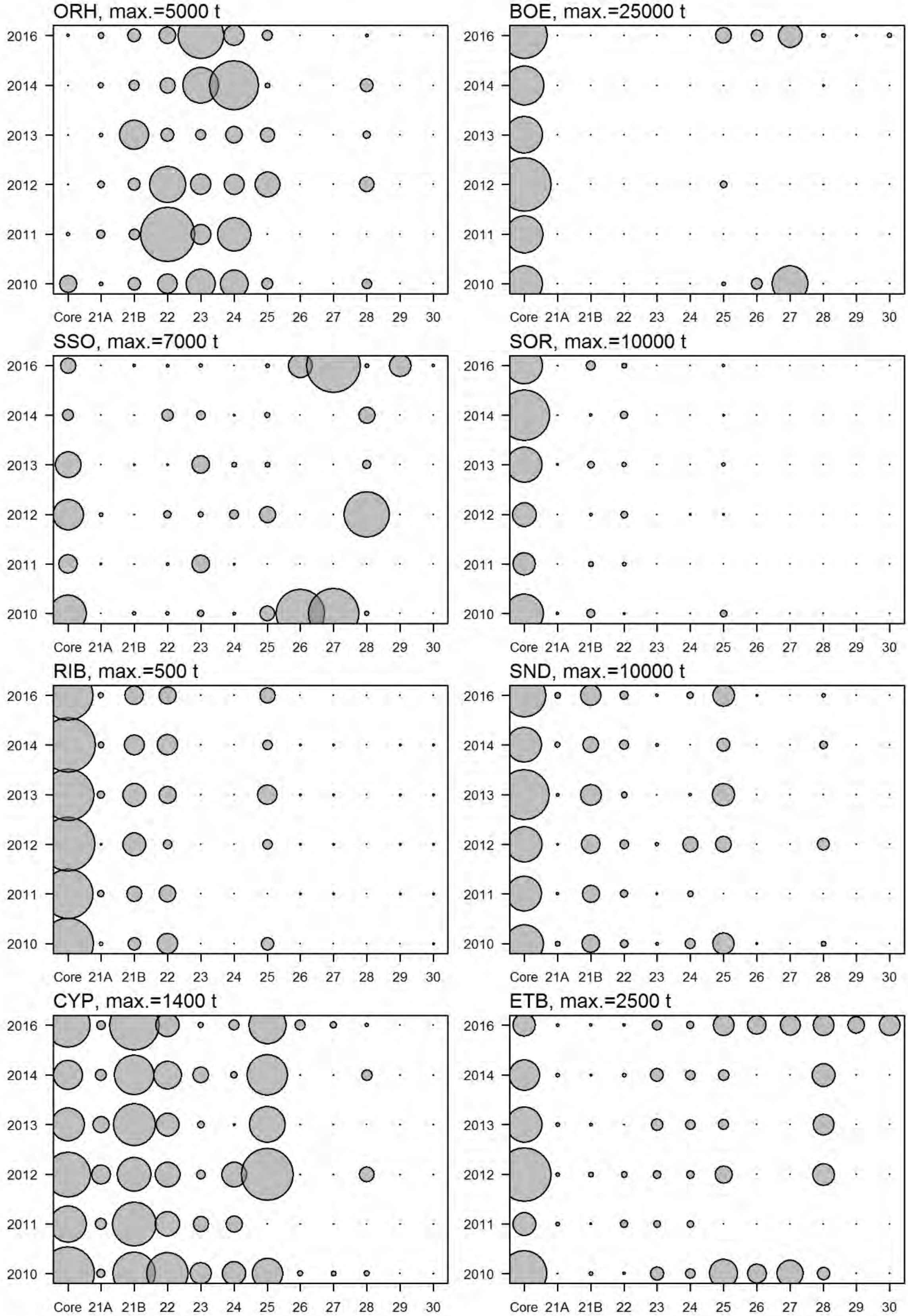


Figure 6c: Relative deep (800–1300 m) biomass estimates by strata for orange roughy, oreo species, and other selected deepwater species sampled by annual trawl surveys of the Chatham Rise, January 2010–2014, and 2016.

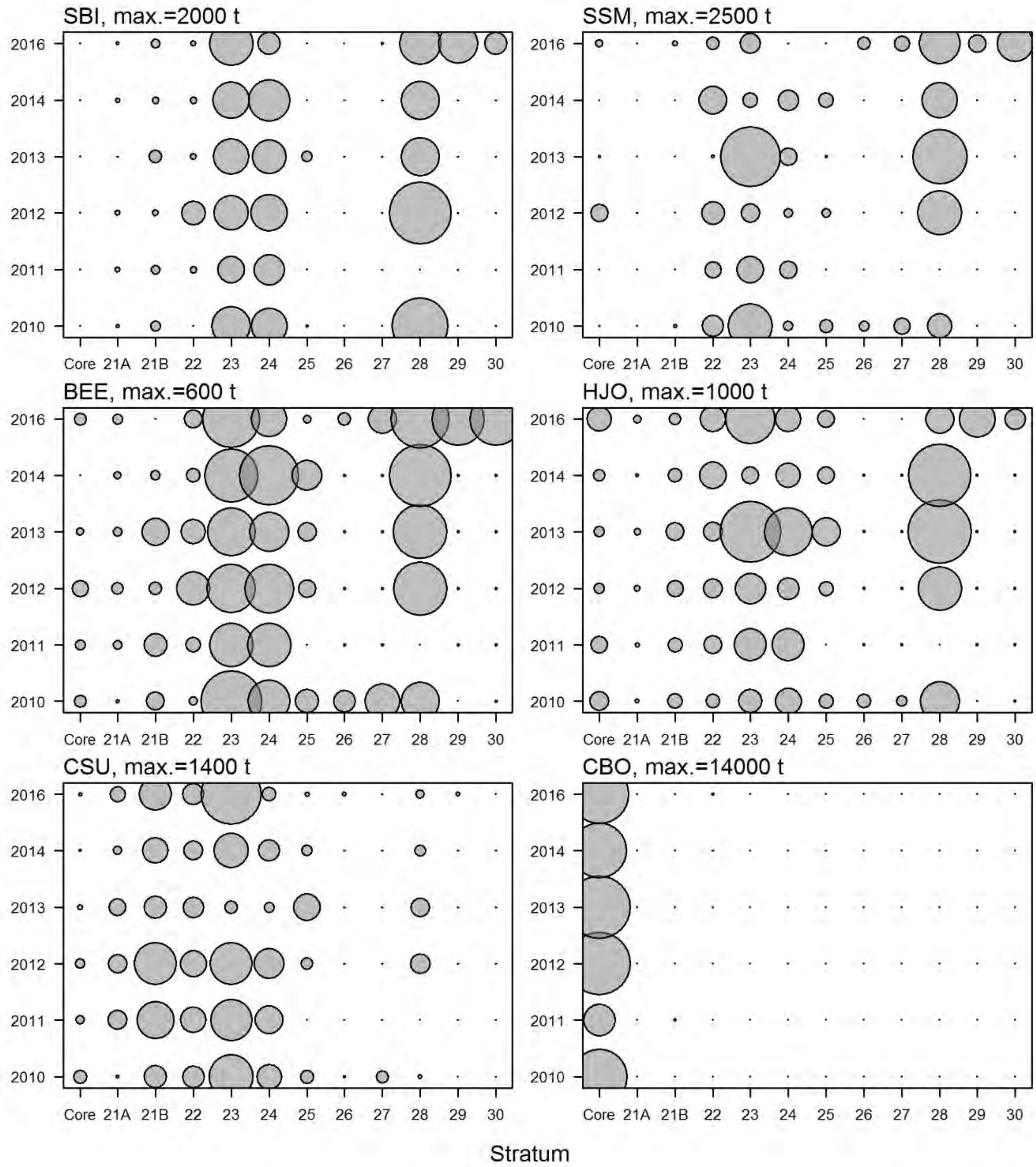


Figure 6c (continued)

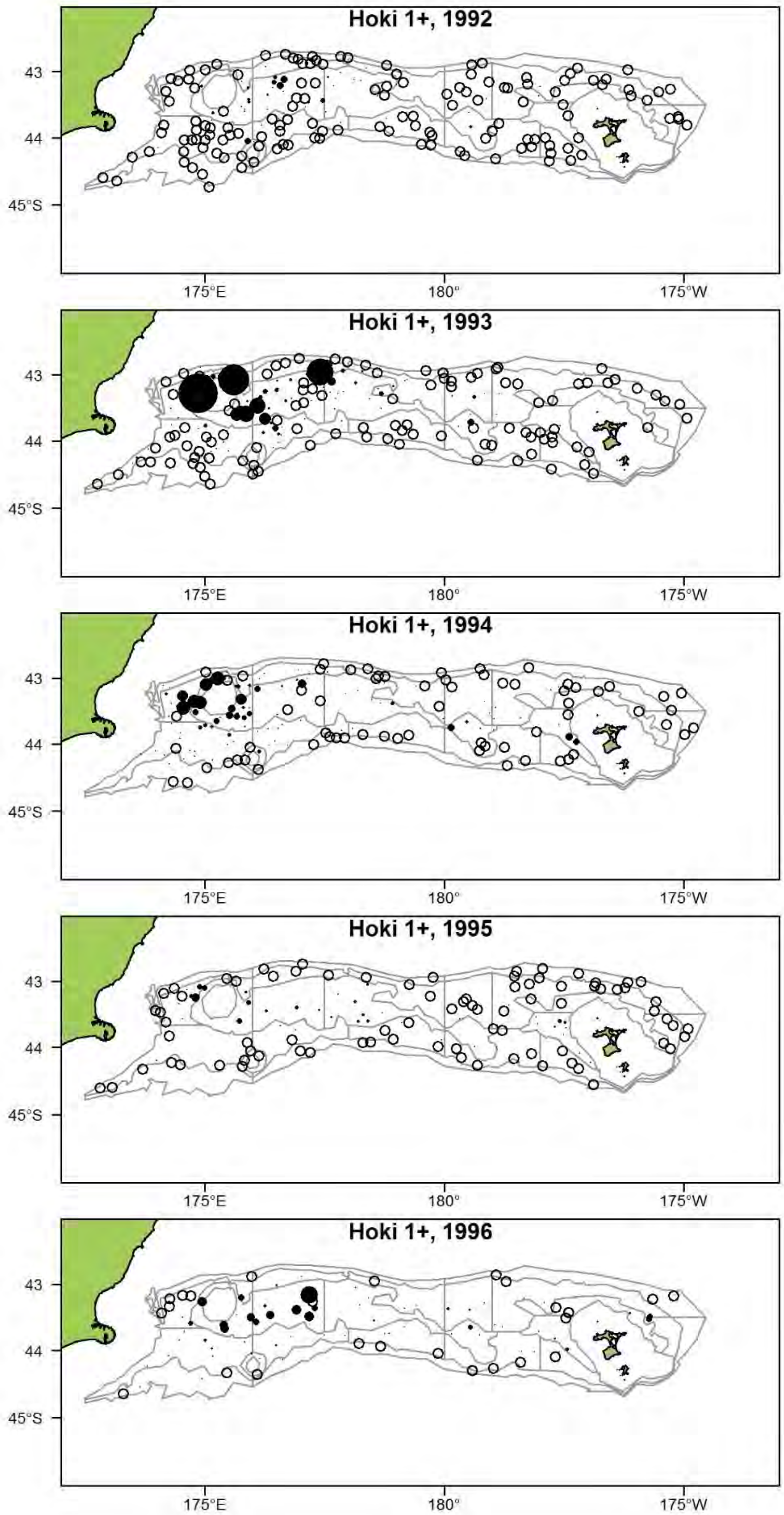


Figure 7a: Hoki 1+ catch distribution 1992–2014, and 2016. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 30 850 kg km^{-2}.

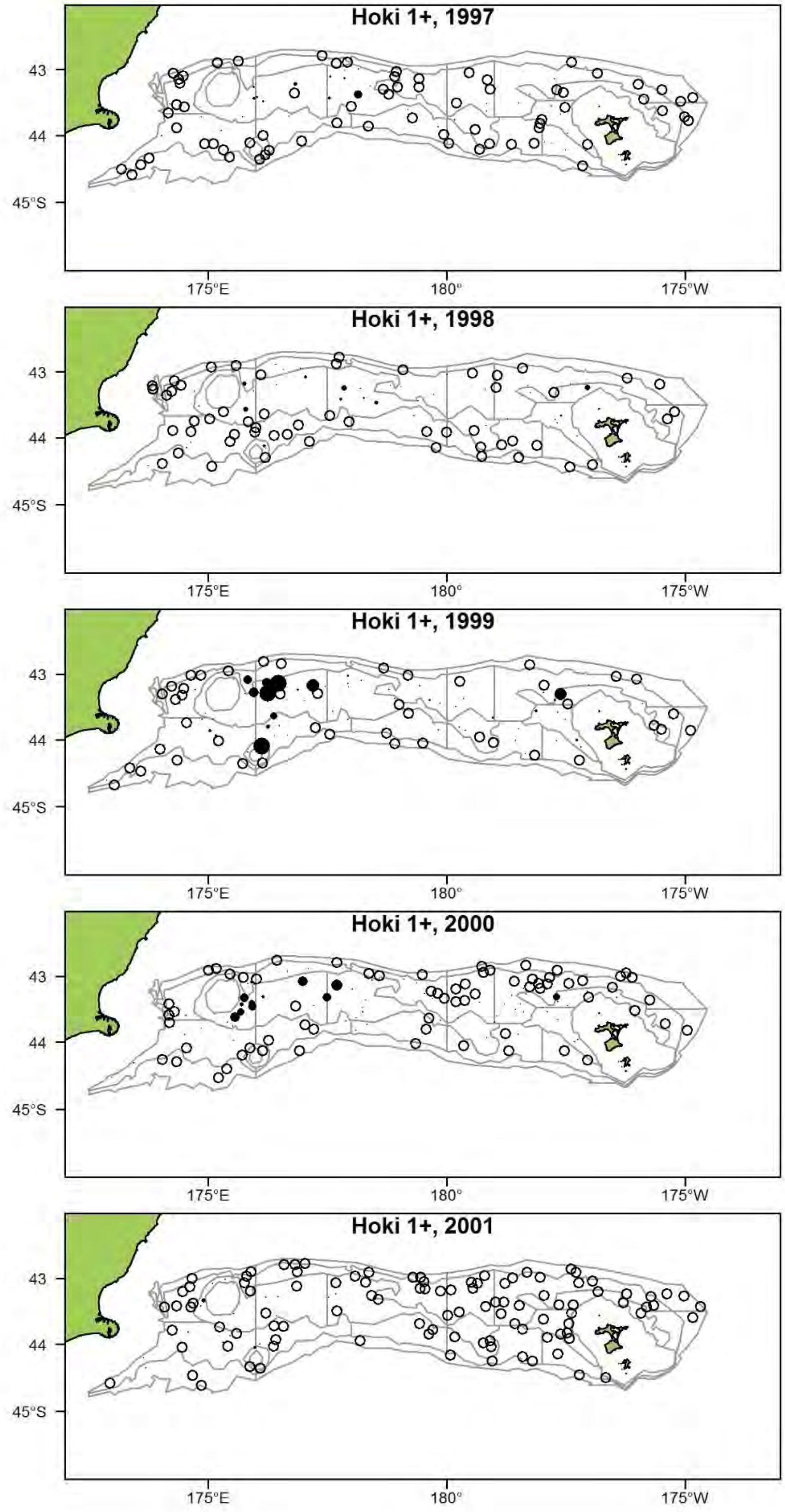
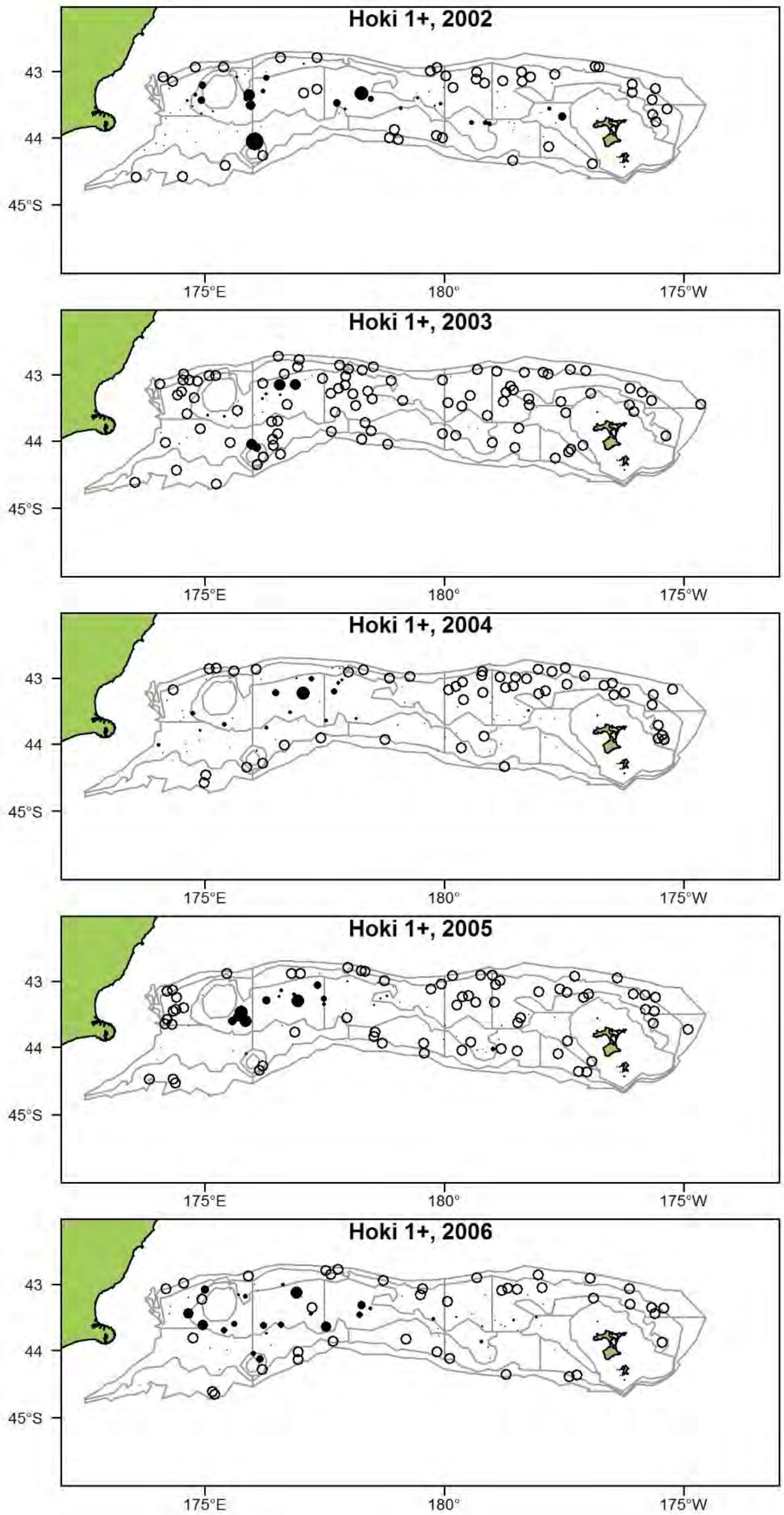


Figure 7a (continued)



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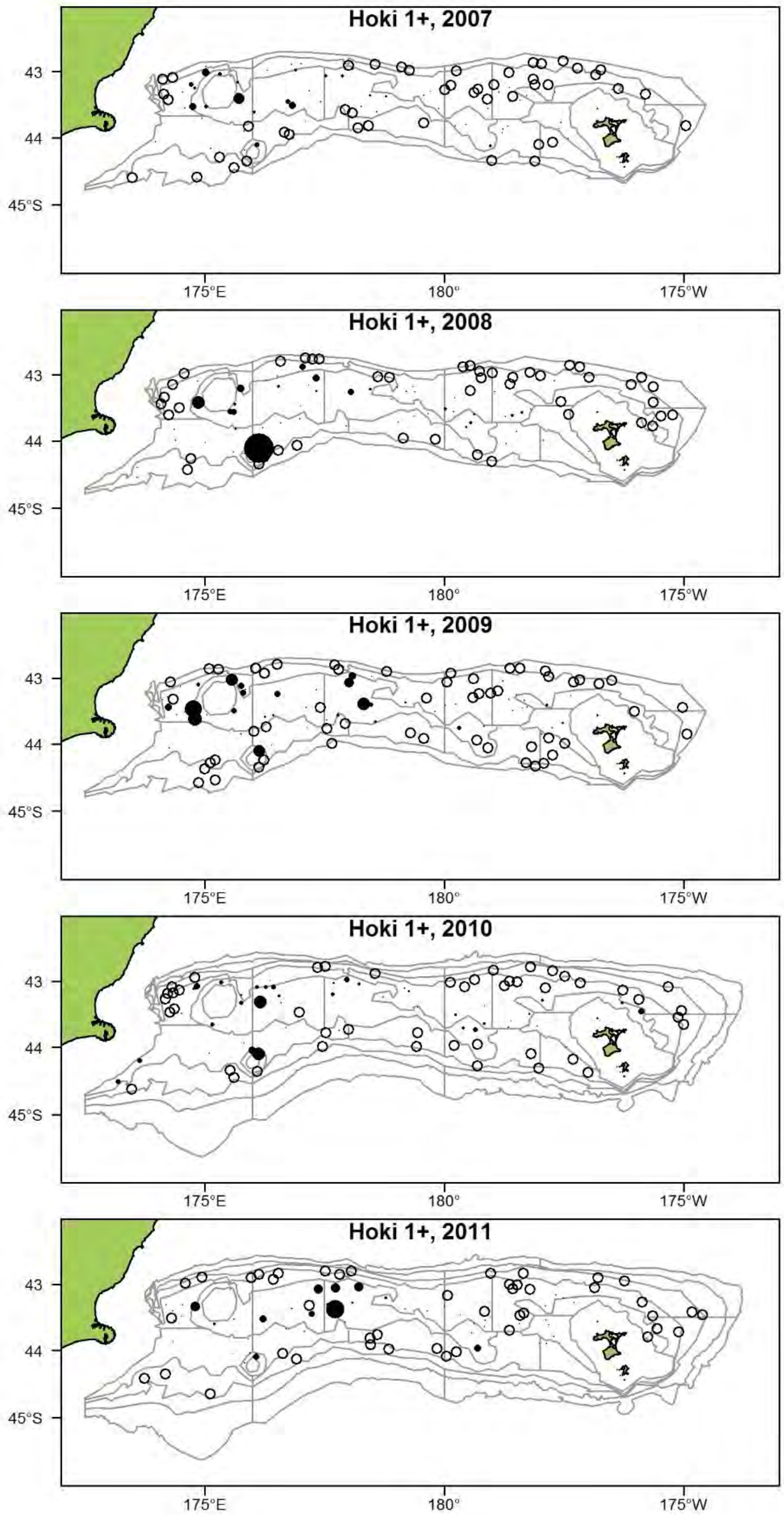


Figure 7a (continued)

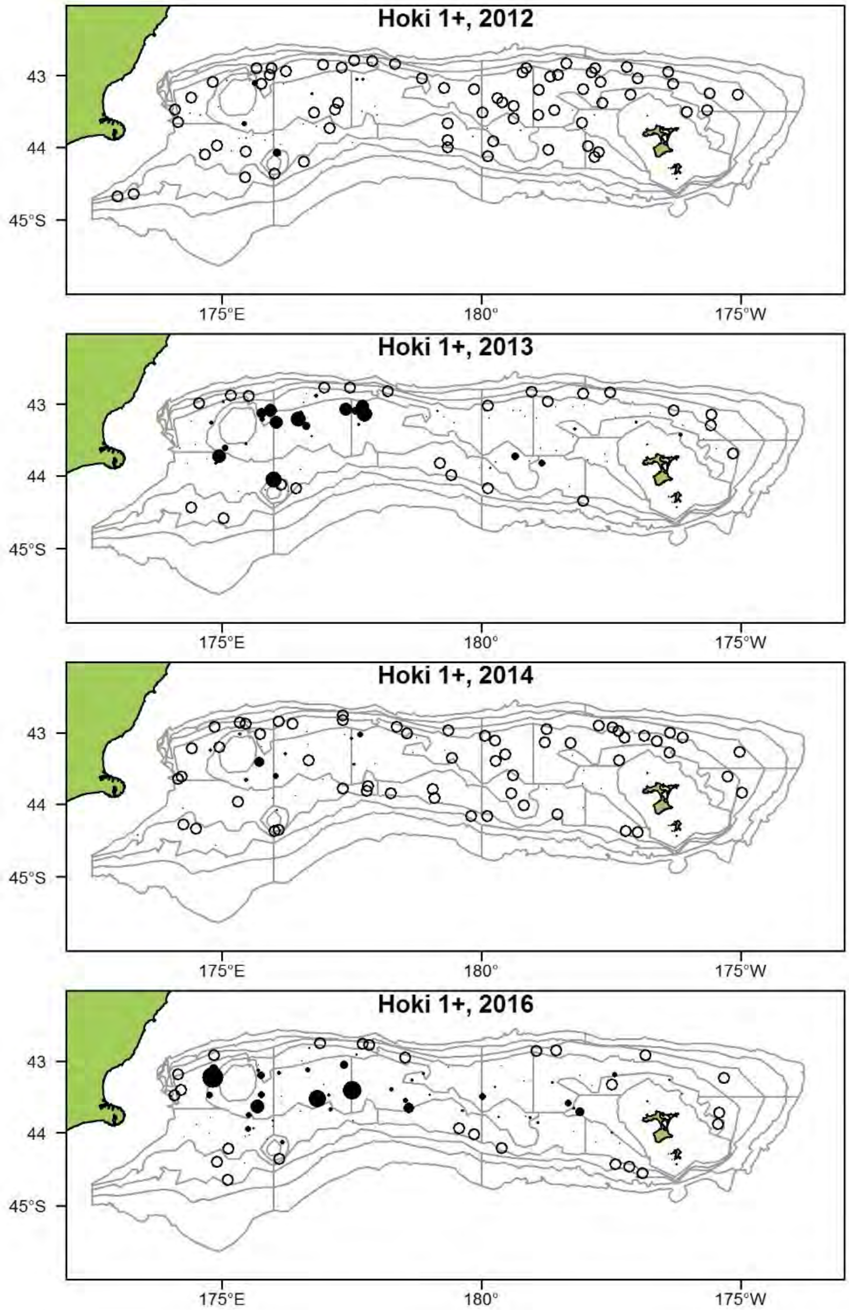


Figure 7a (continued)

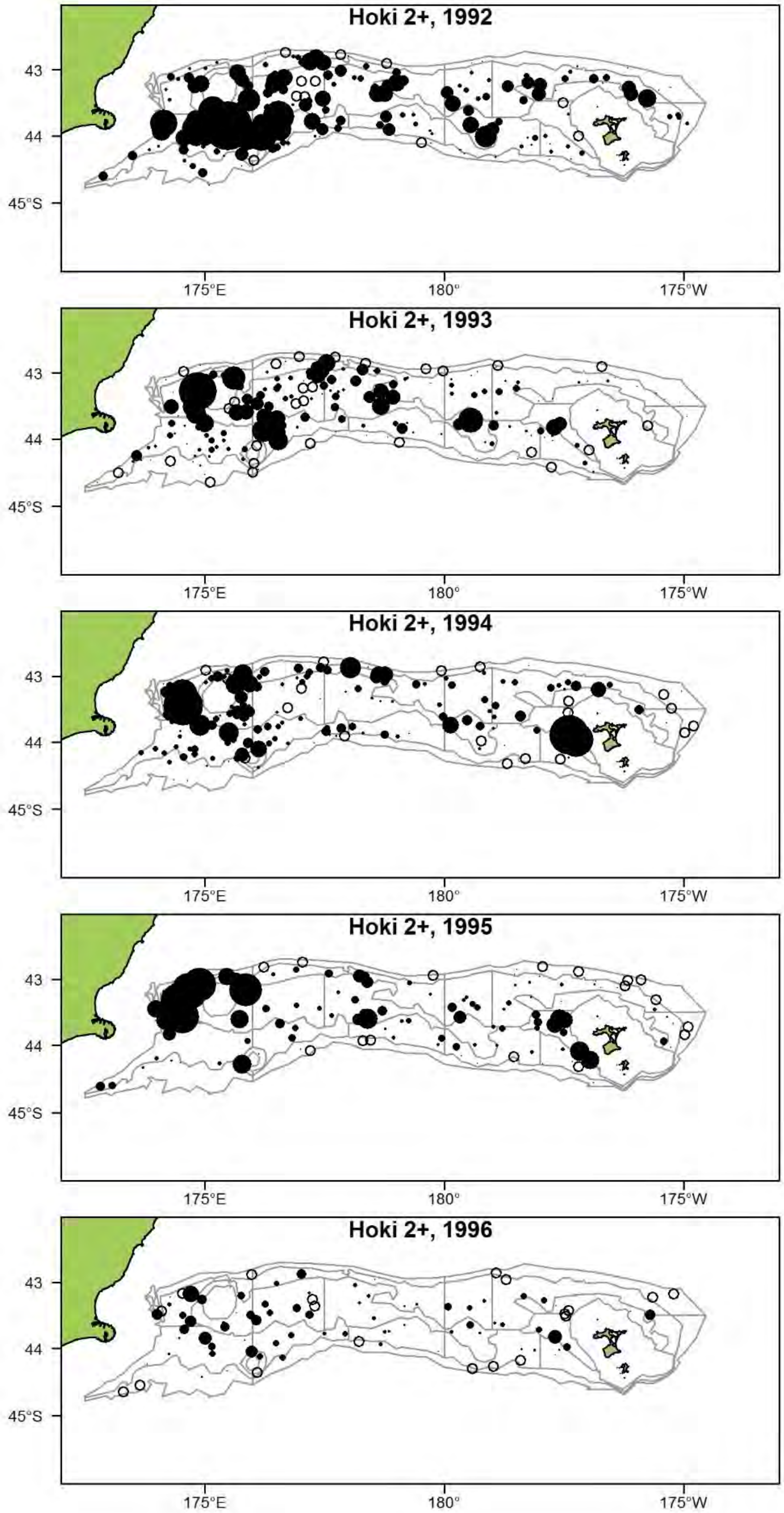


Figure 7b: Hoki 2+ catch distribution 1992–2014, and 2016. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 6791 kg km^{-2}.

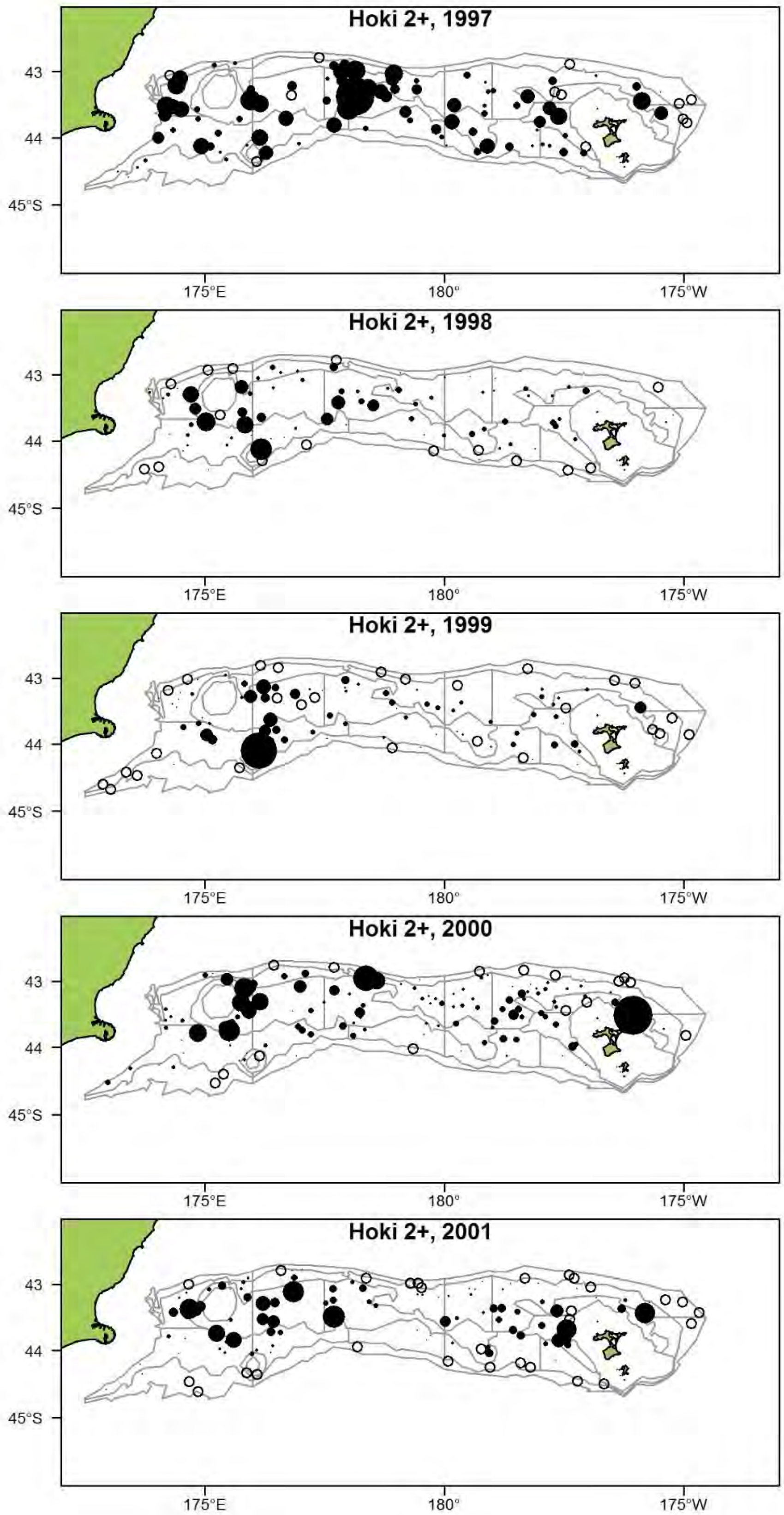


Figure 7b (continued)

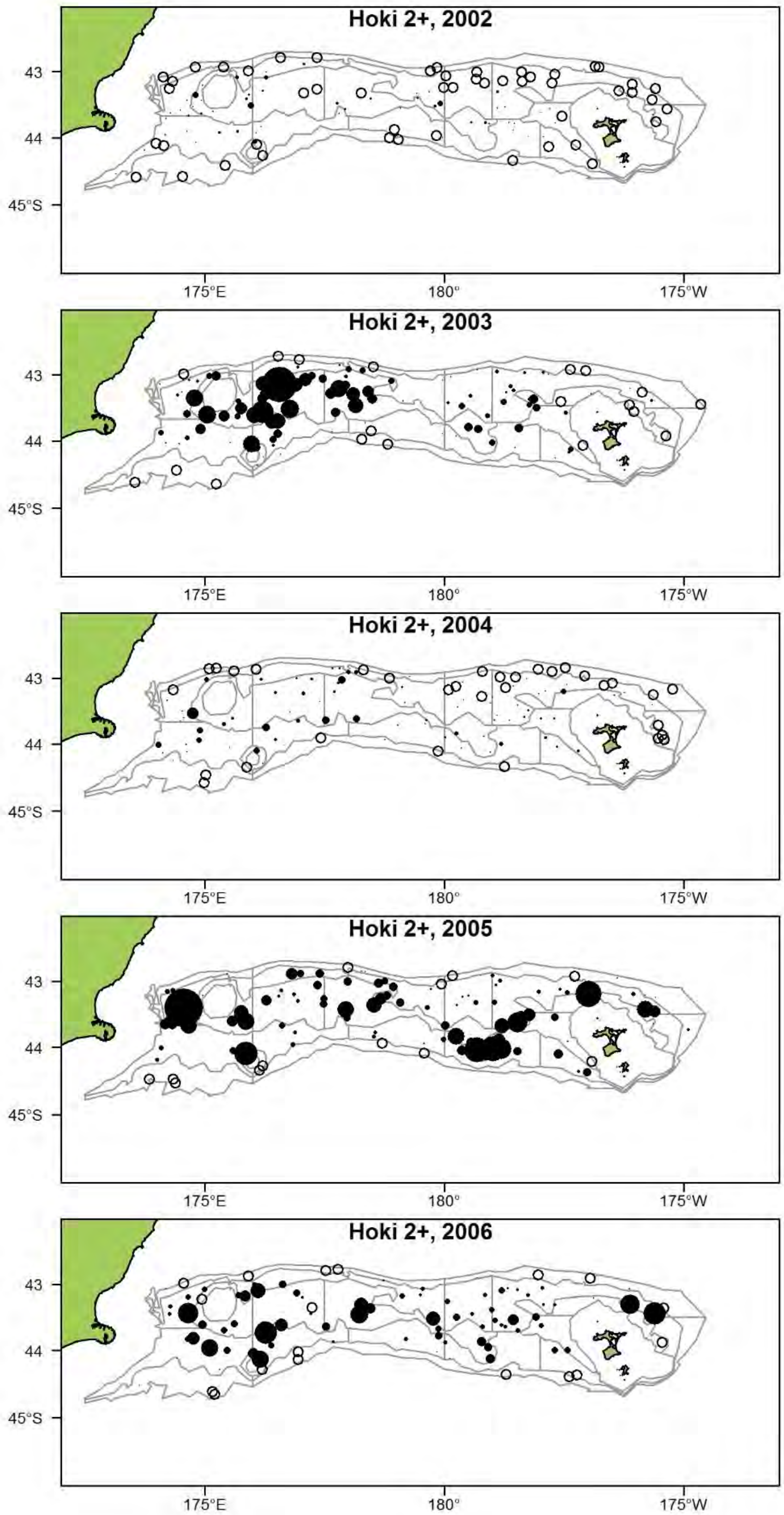


Figure 7b (continued)

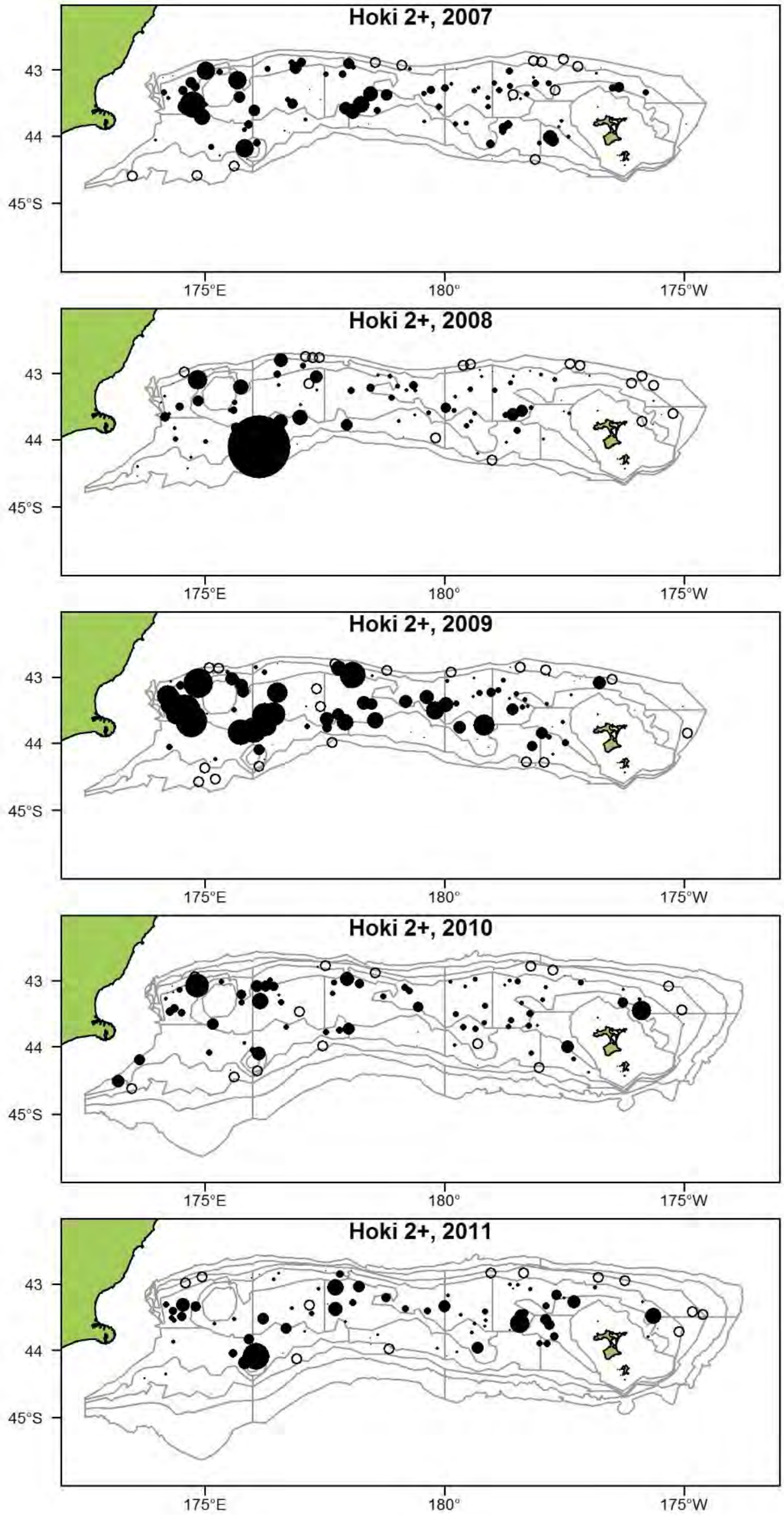


Figure 7b (continued)

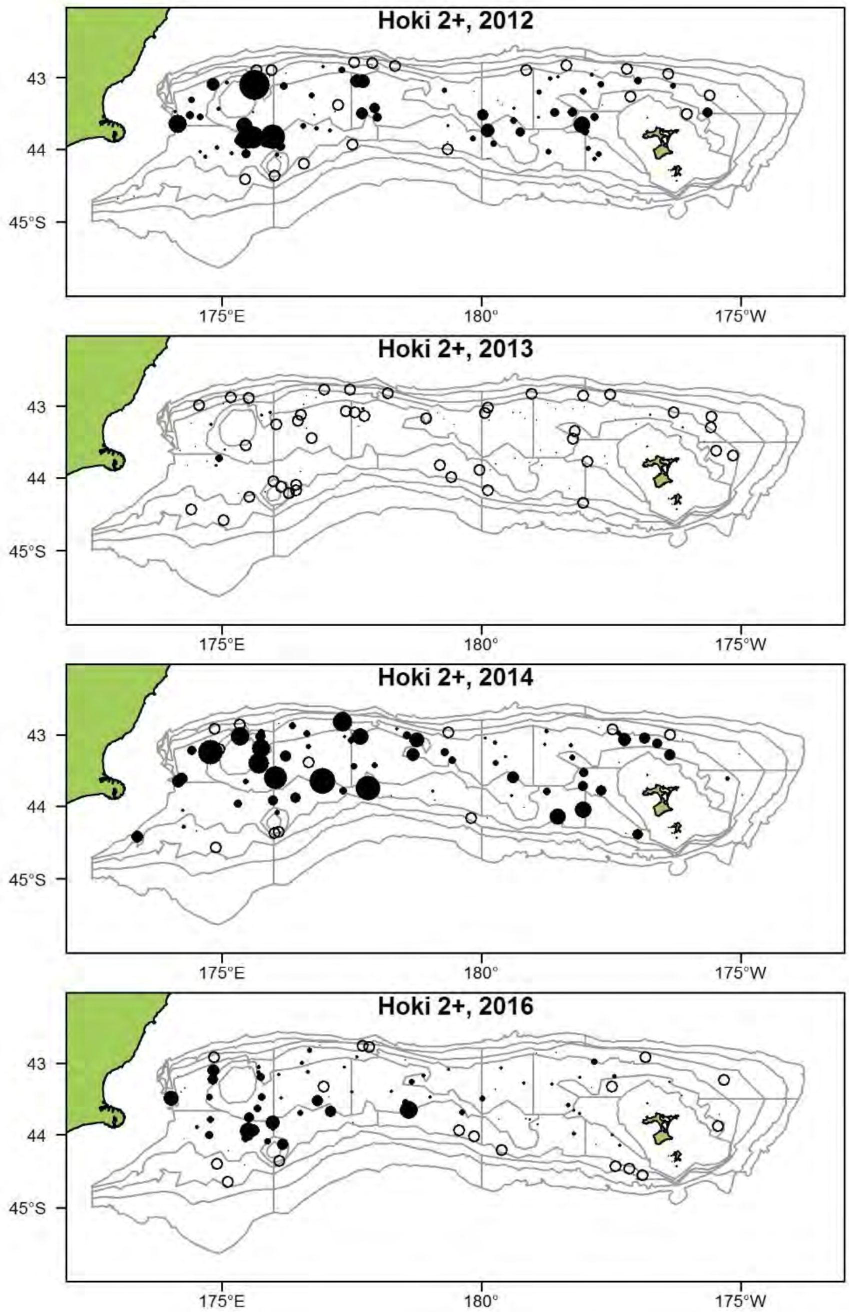


Figure 7b (continued)

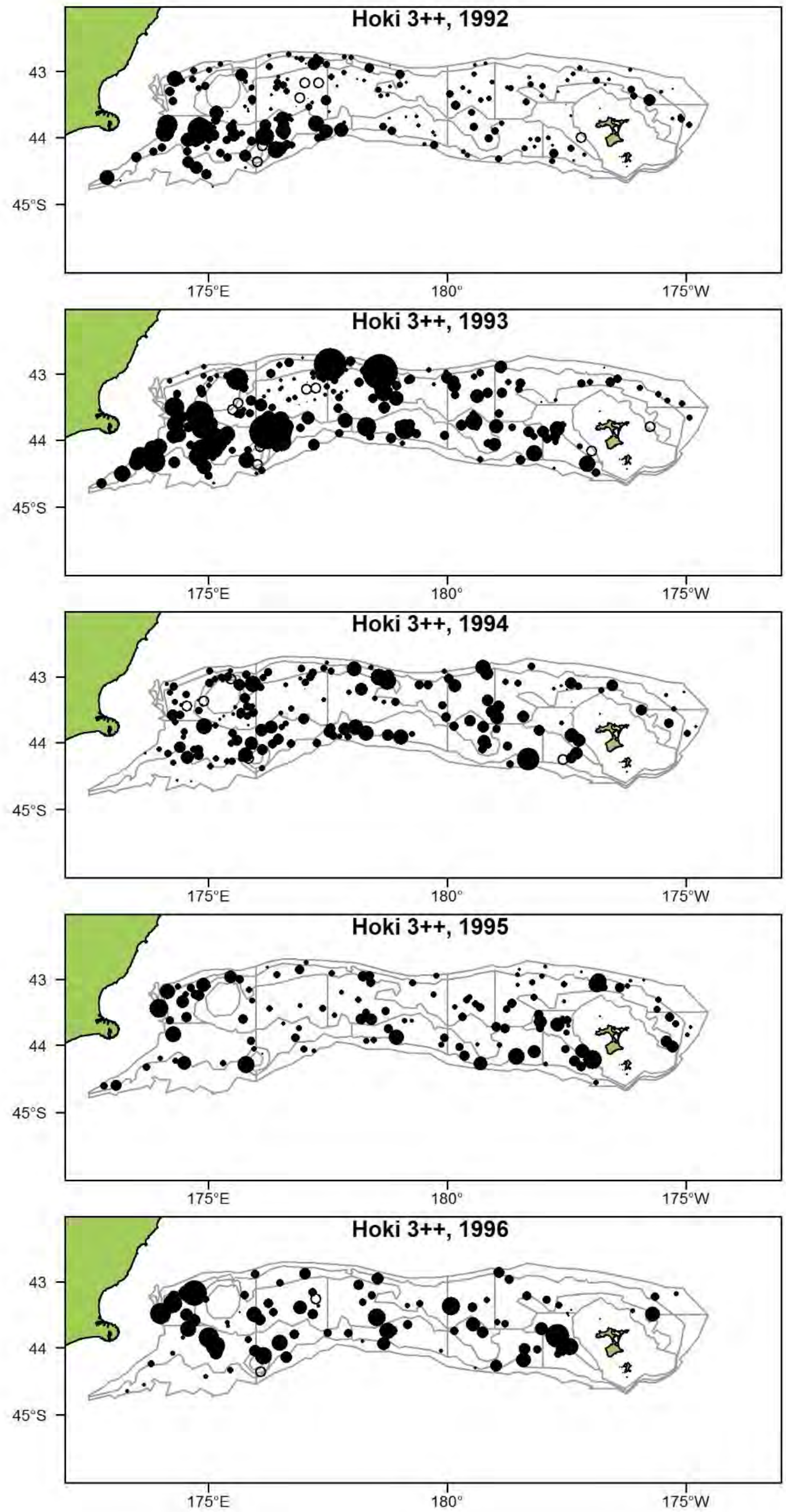


Figure 7c: Hoki 3++ catch distribution. 1992–2014, and 2016. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 11 177 kg km^{-2}.

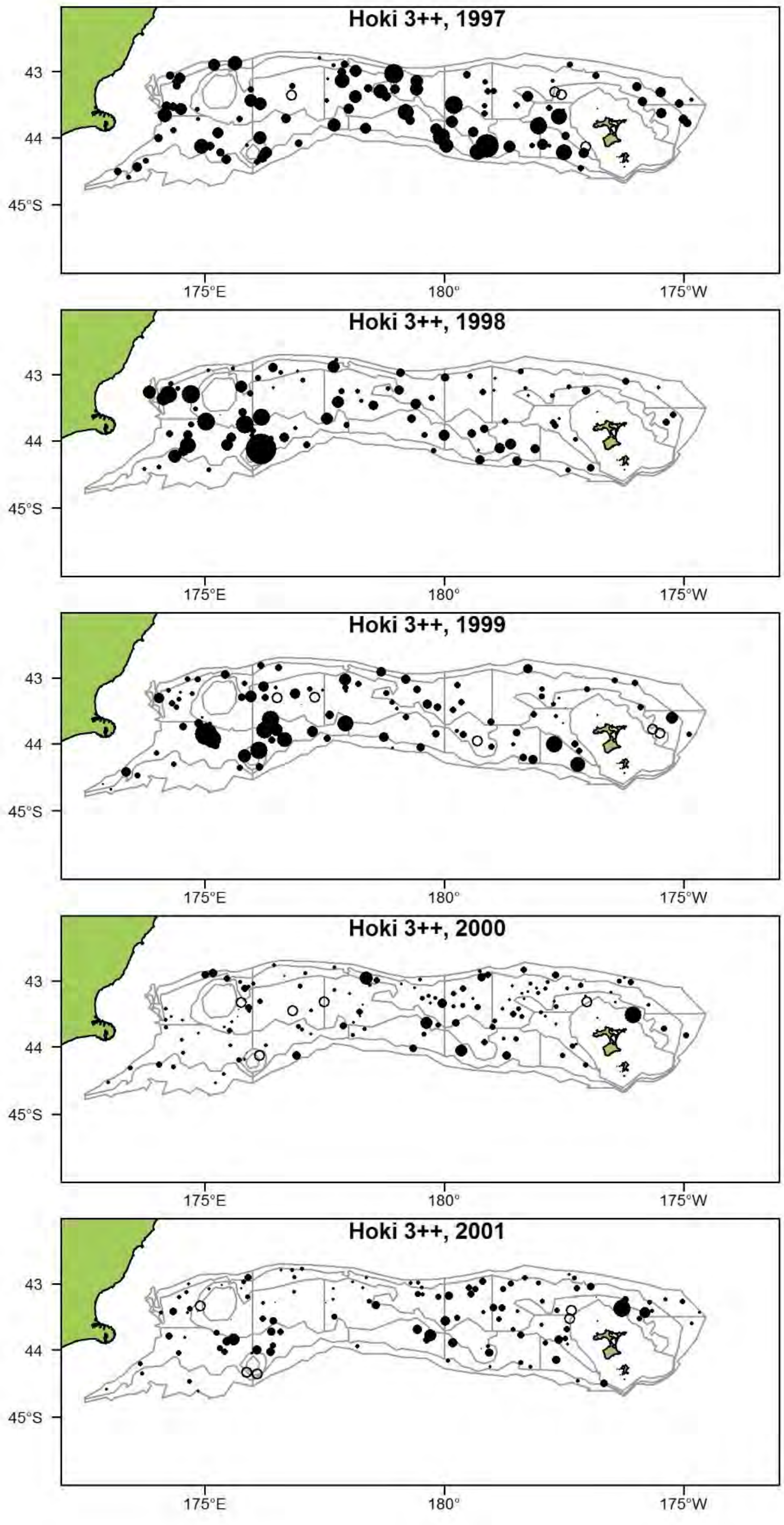
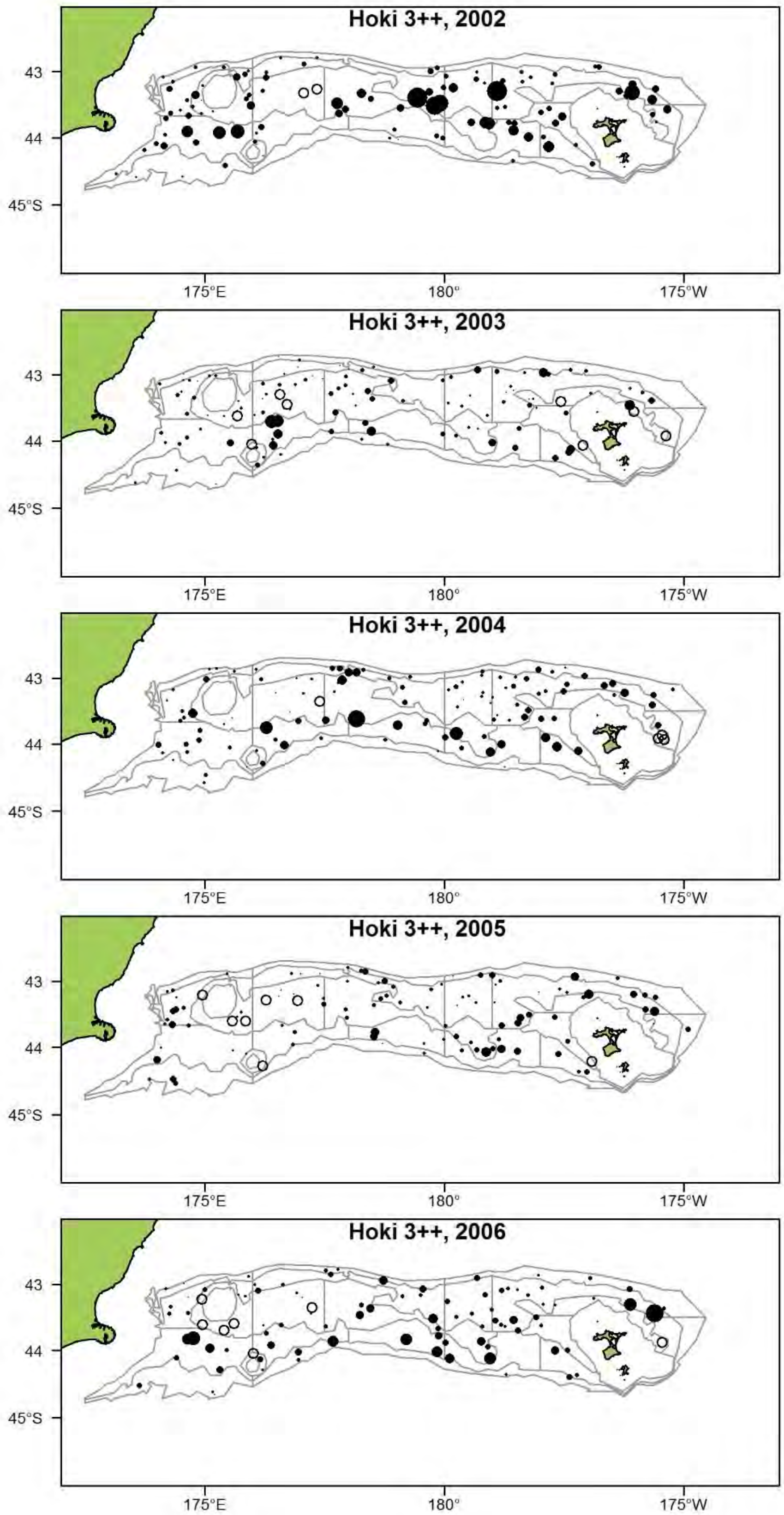


Figure 7c (continued)



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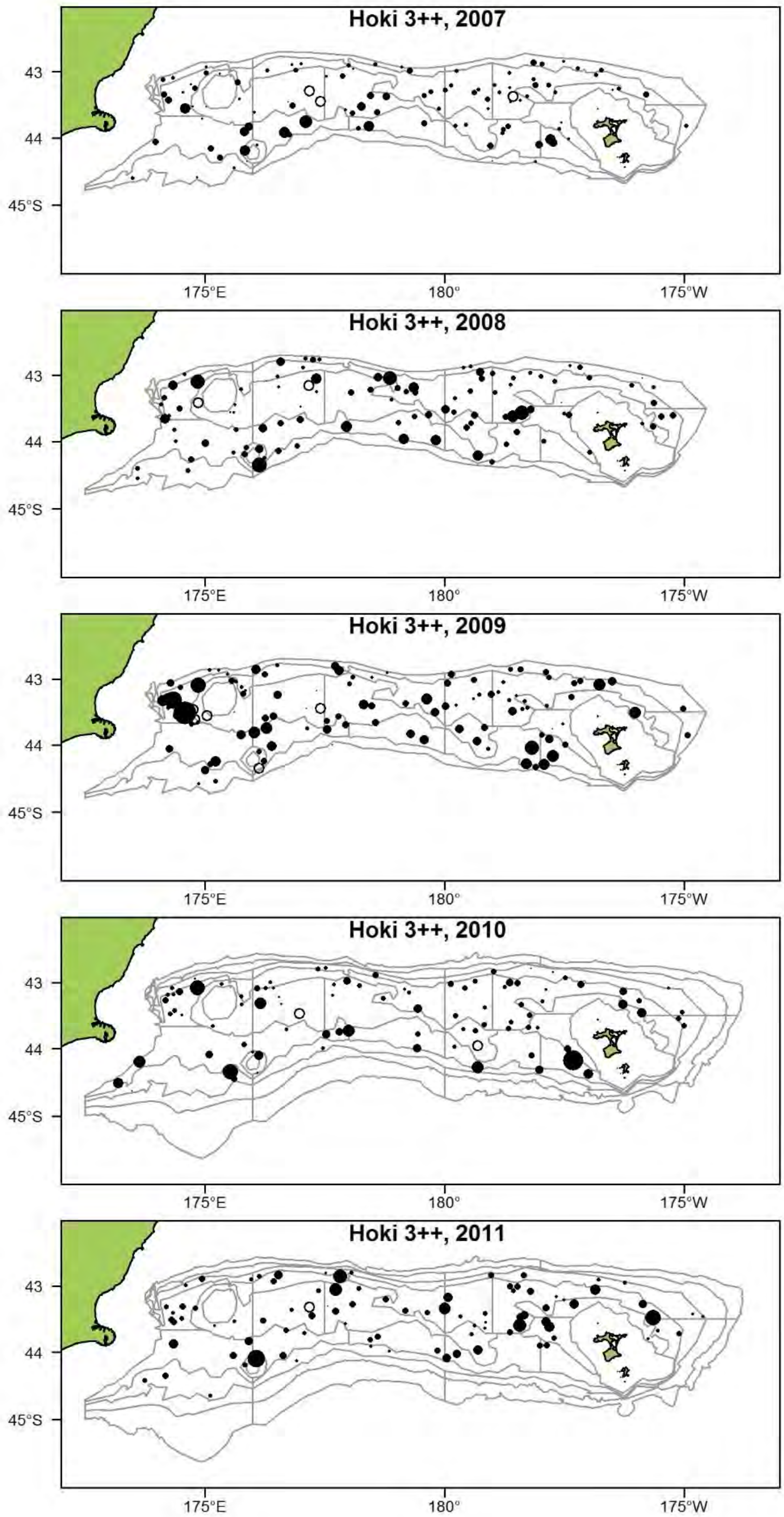


Figure 7c (continued)

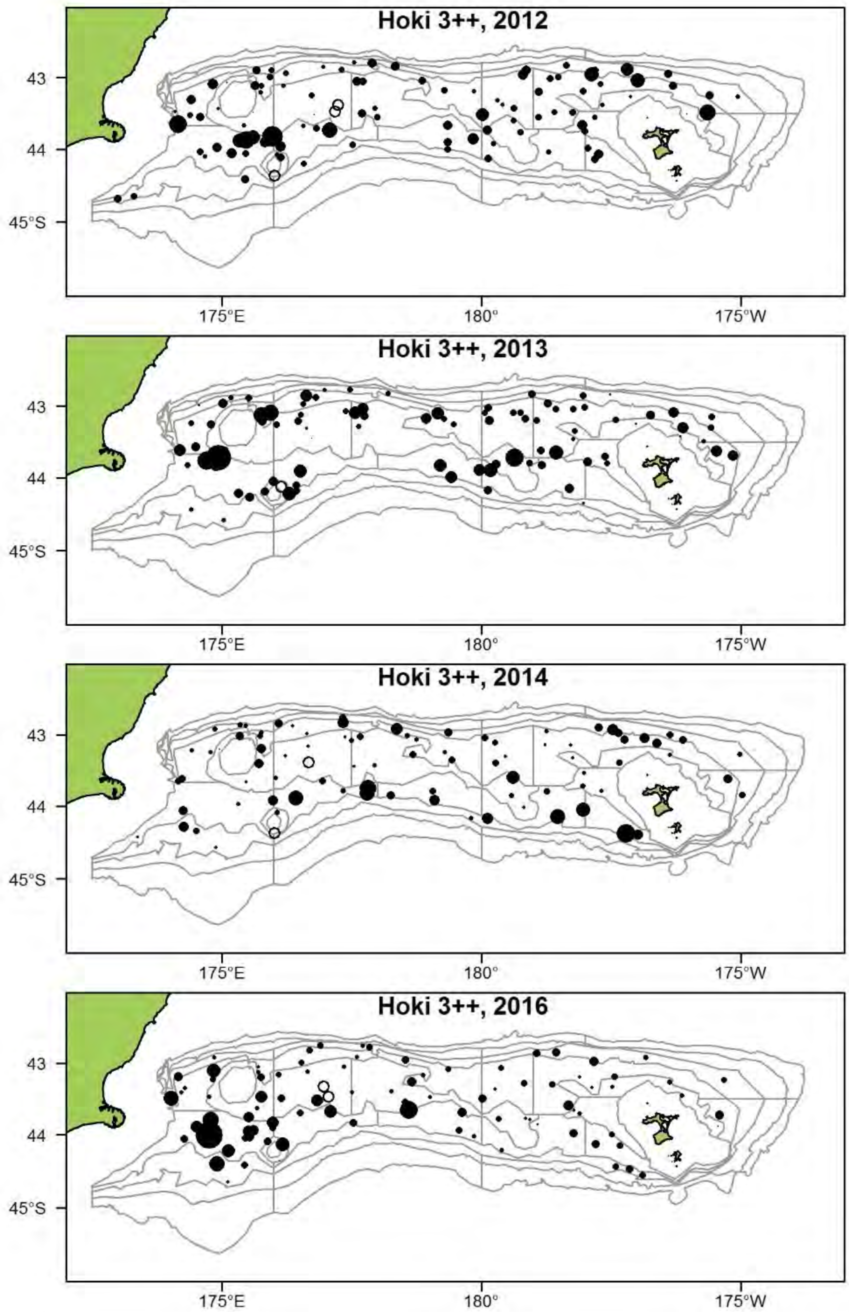


Figure 7c (continued)

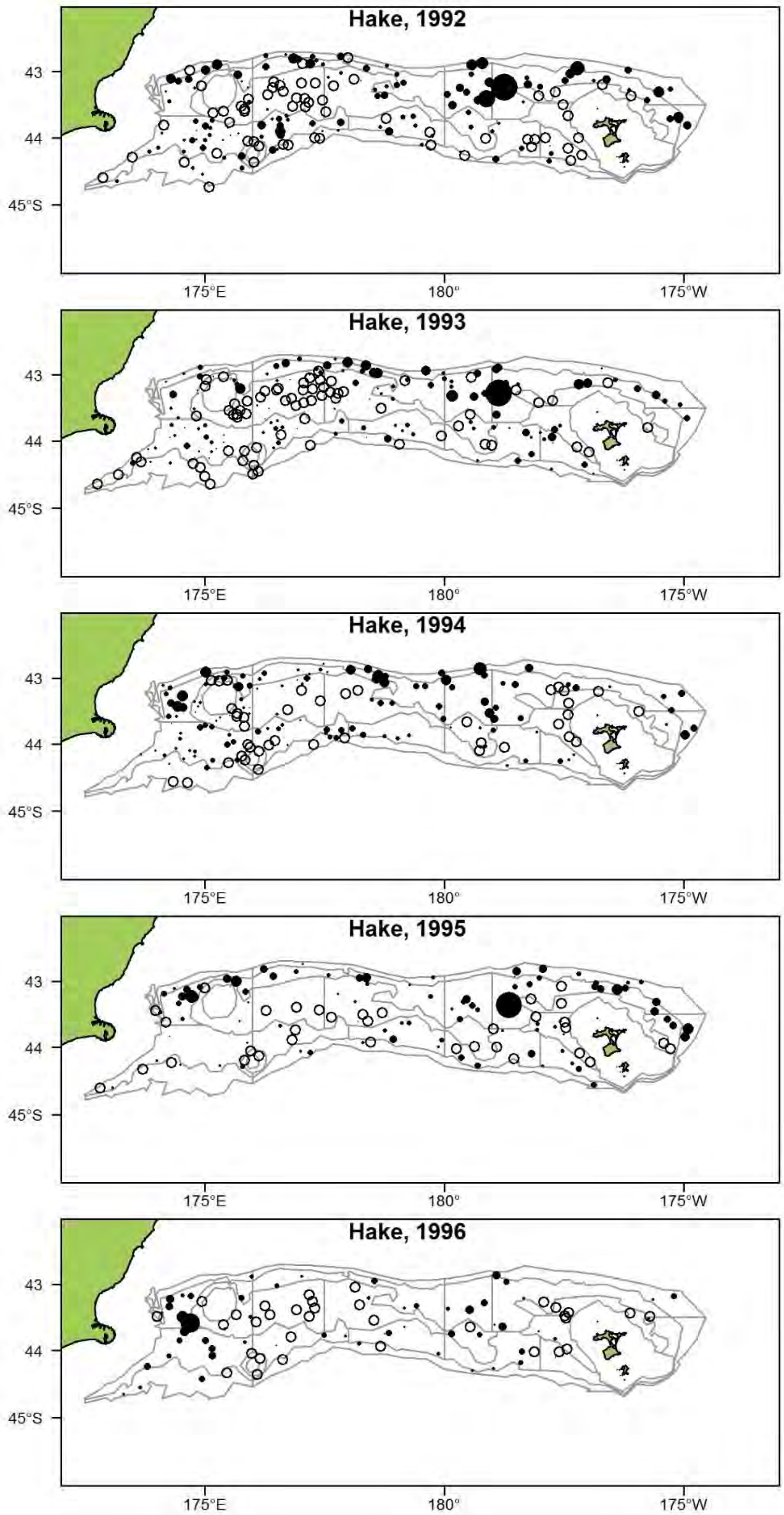


Figure 8: Hake catch distribution 1992–2014, and 2016. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 1320 kg km^{-2}.

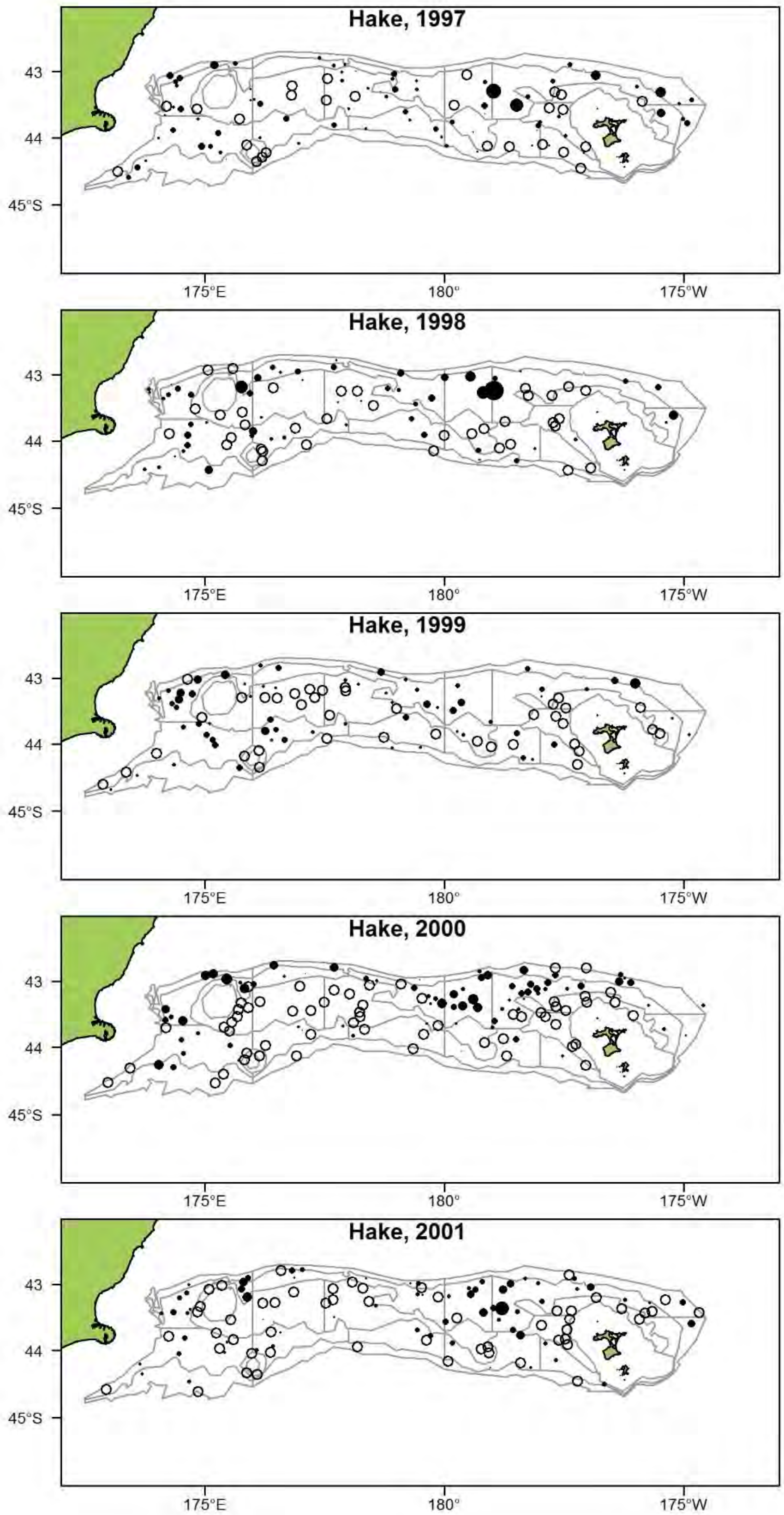


Figure 8 (continued)

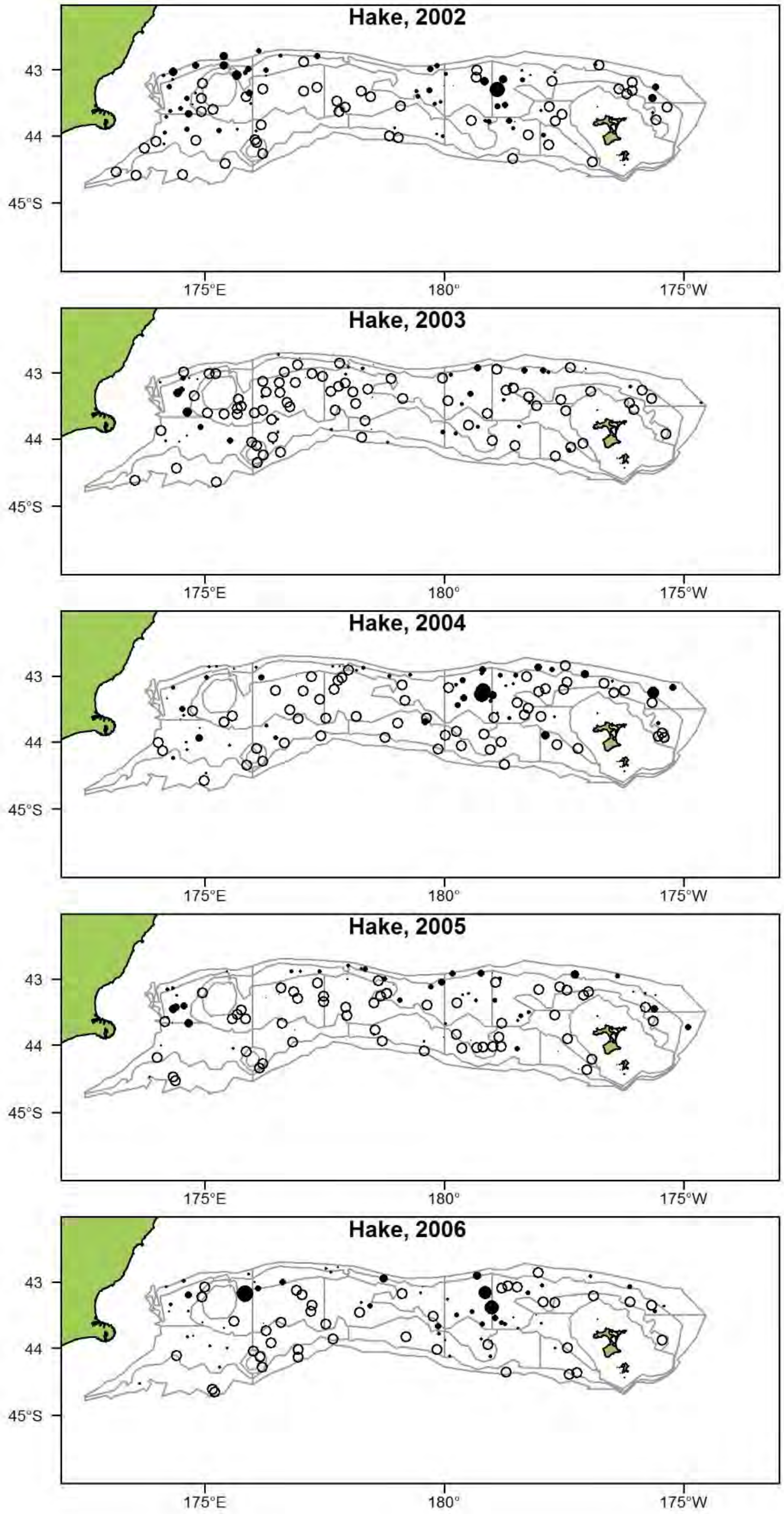


Figure 8 (continued)

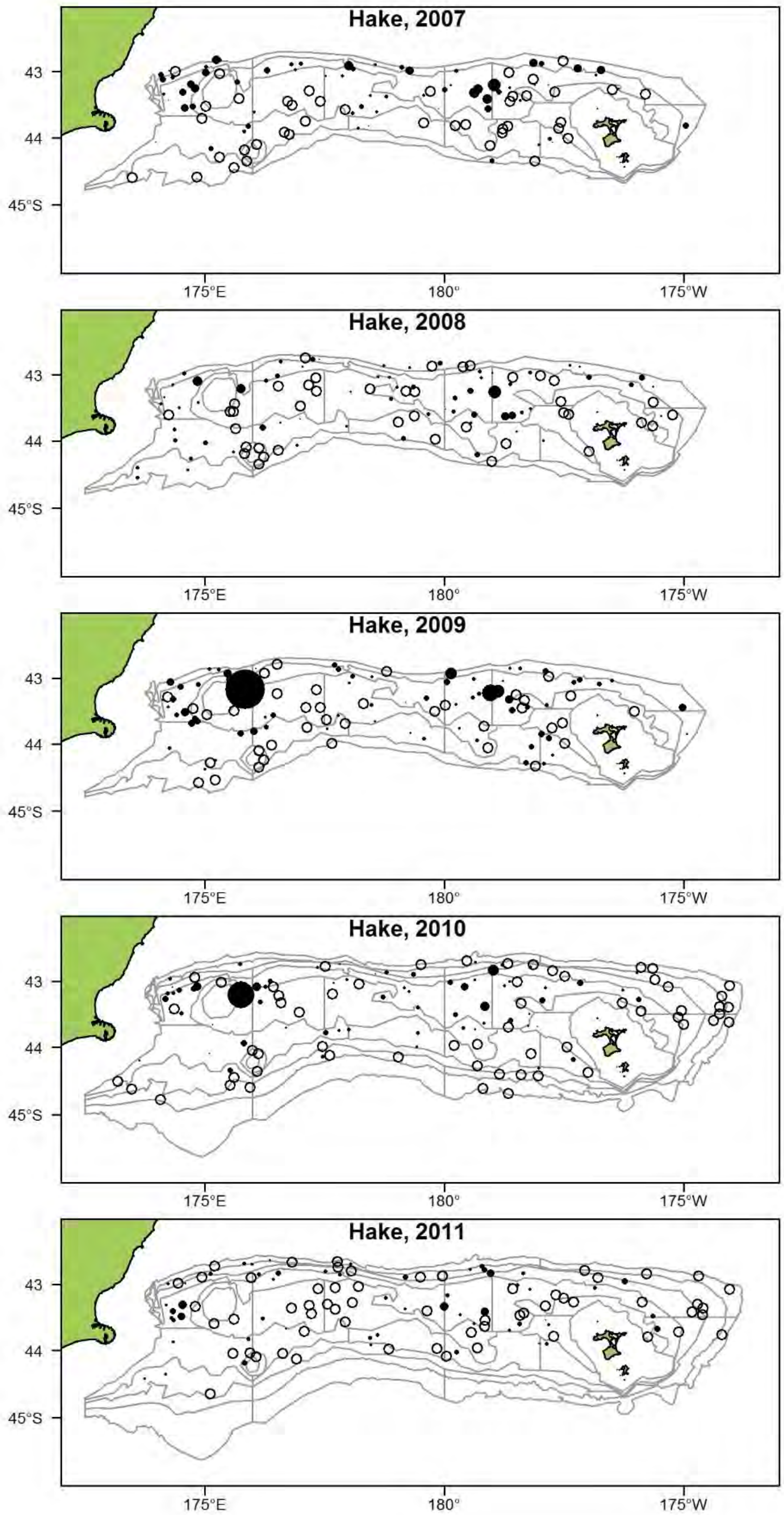


Figure 8 (continued)

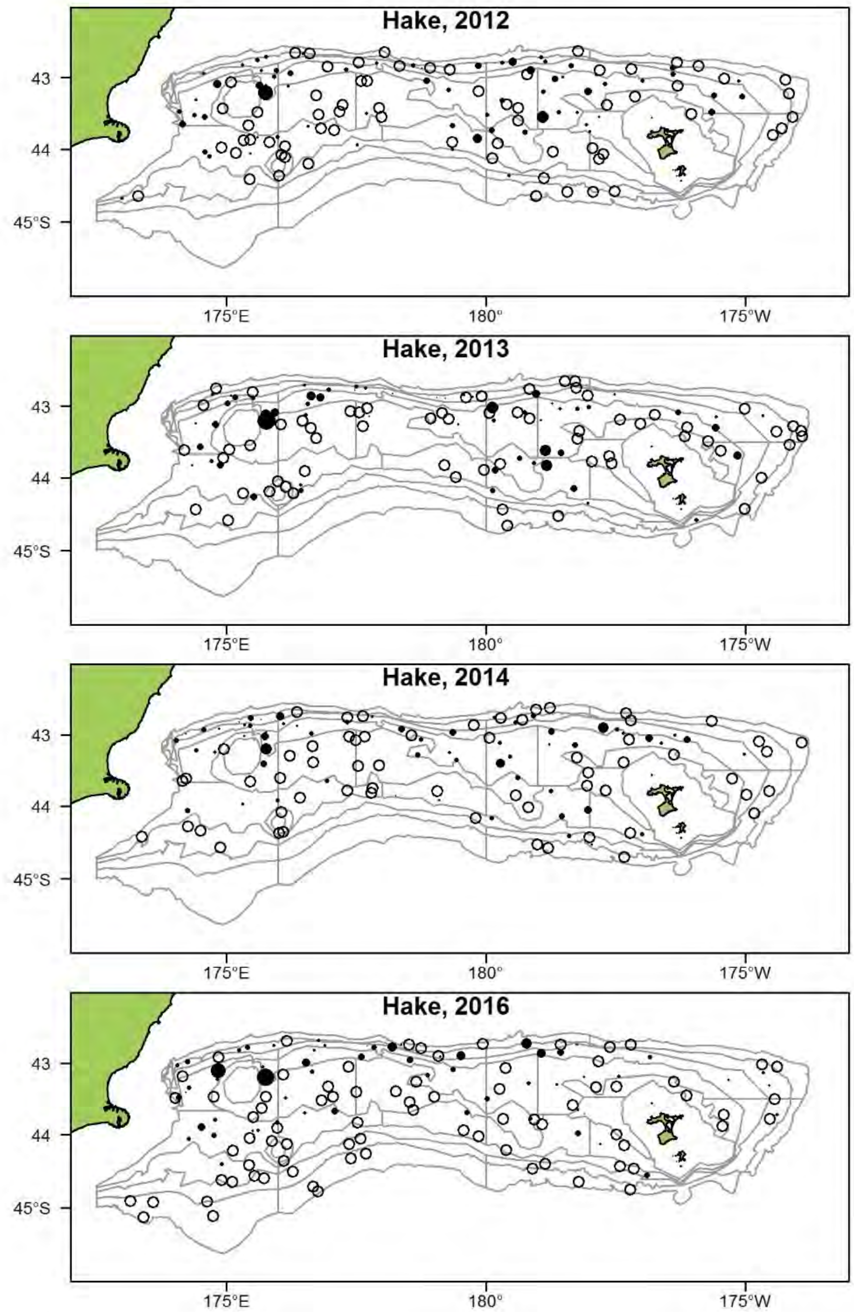


Figure 8 (continued)

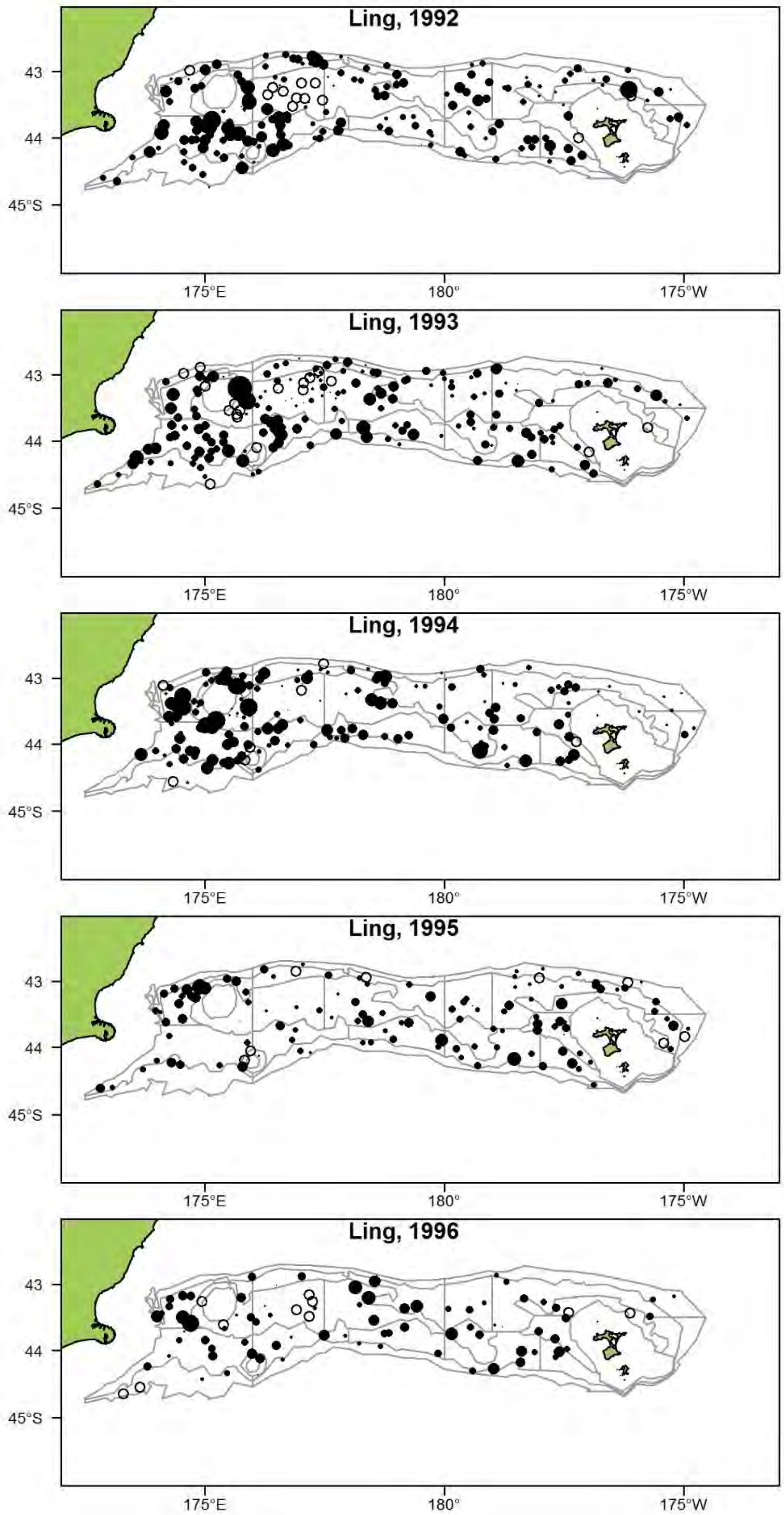


Figure 9: Ling catch distribution 1992–2014, and 2016. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 1786 kg km^{-2}.

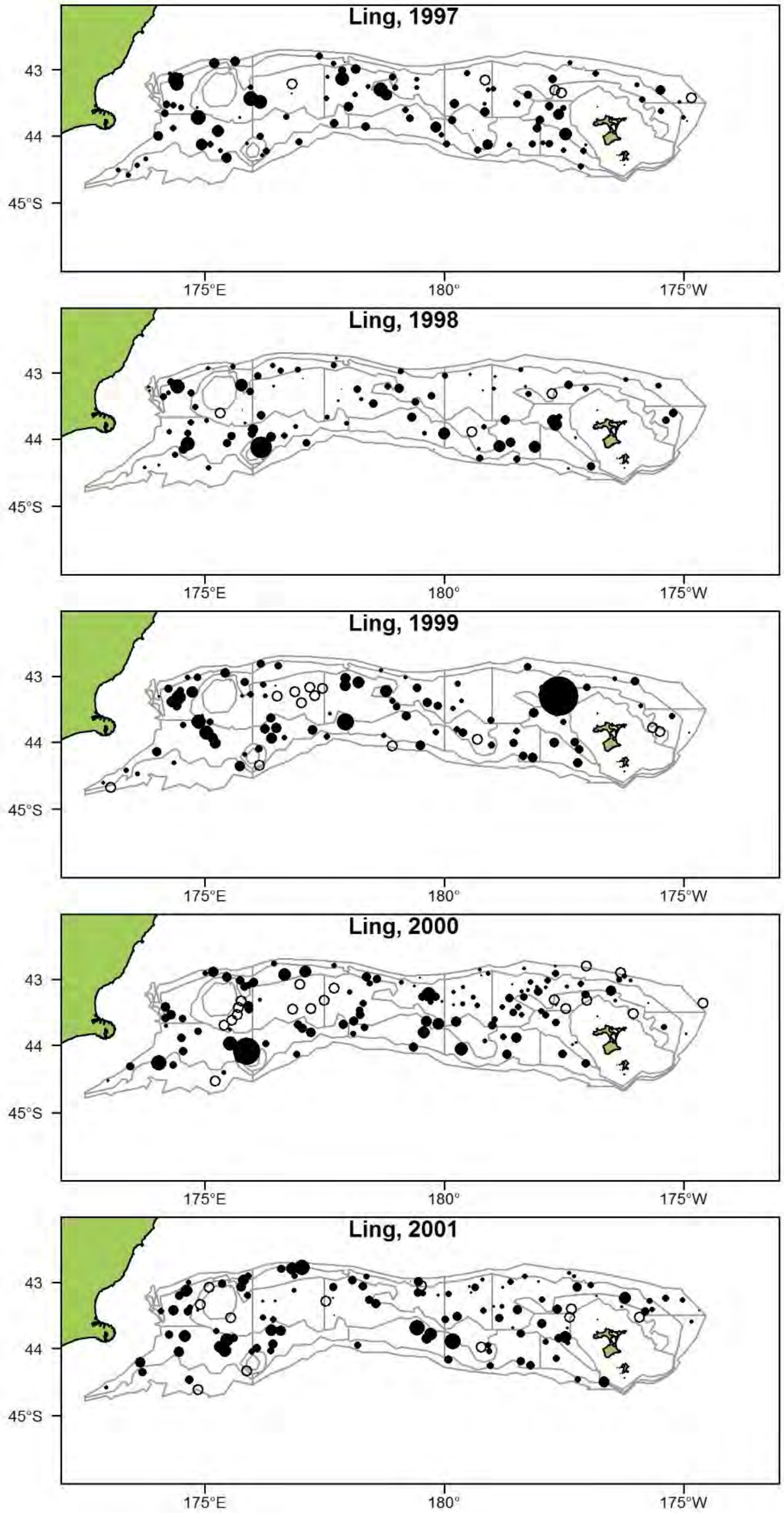


Figure 9 (continued)

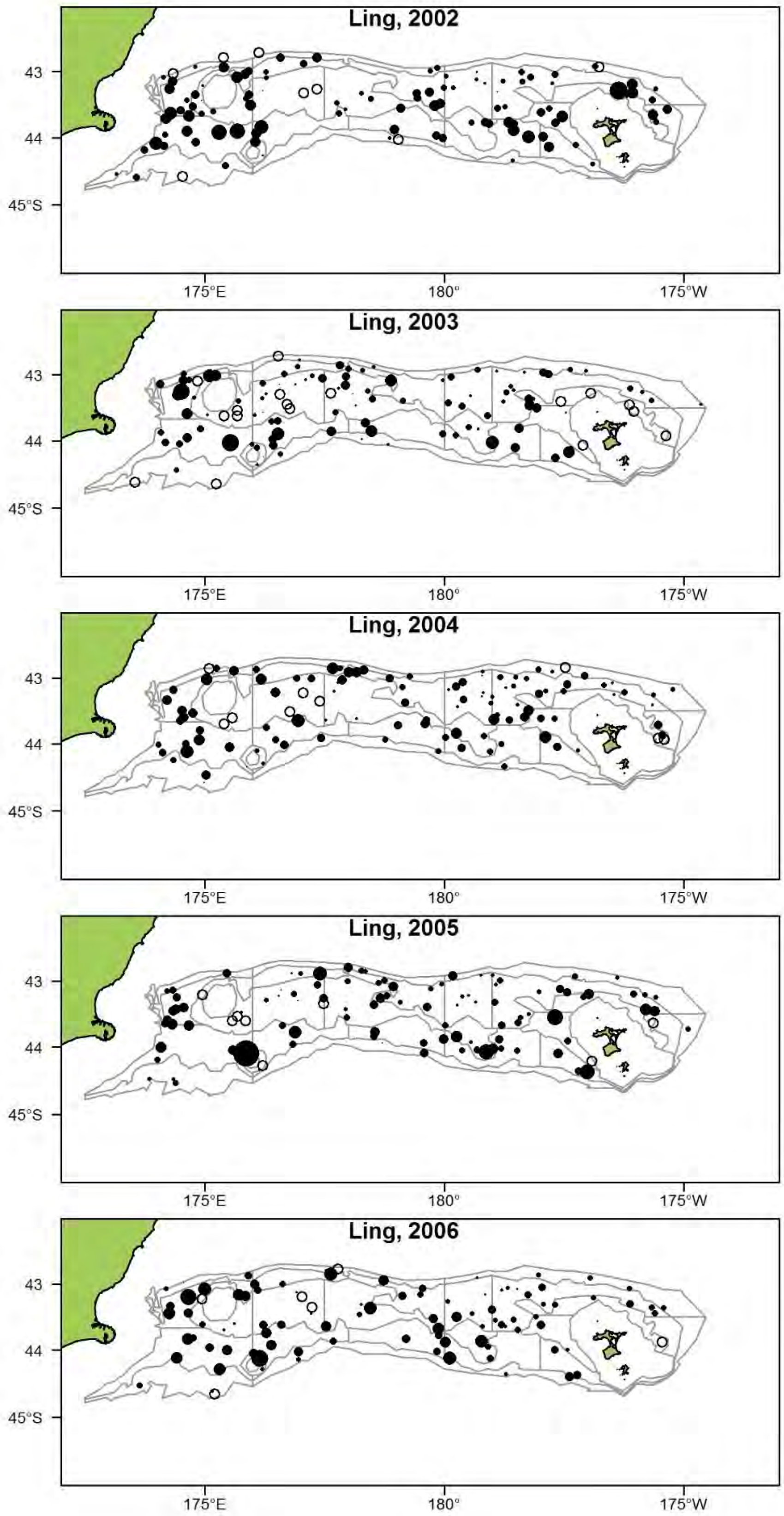


Figure 9 (continued)

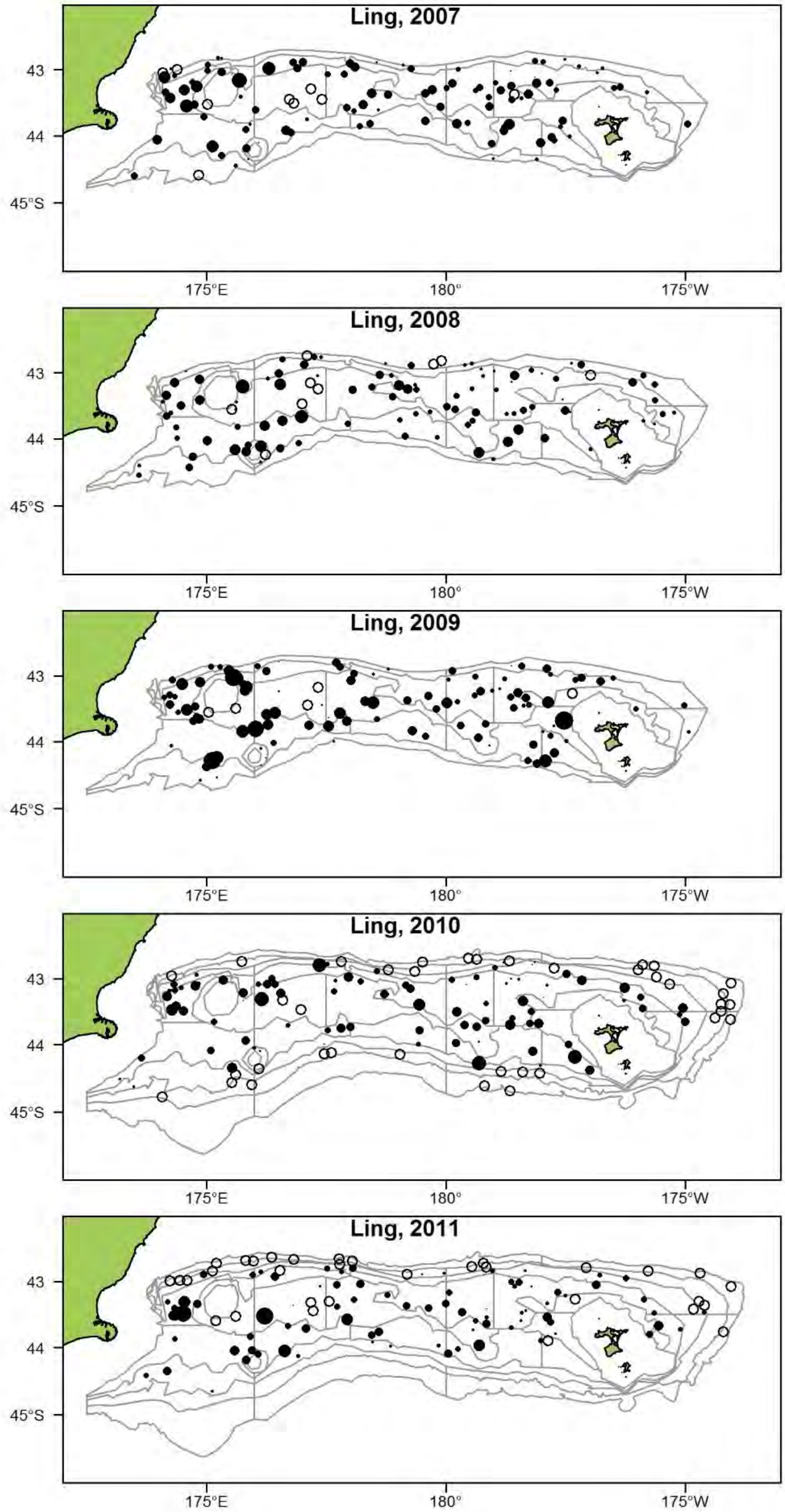


Figure 9 (continued)

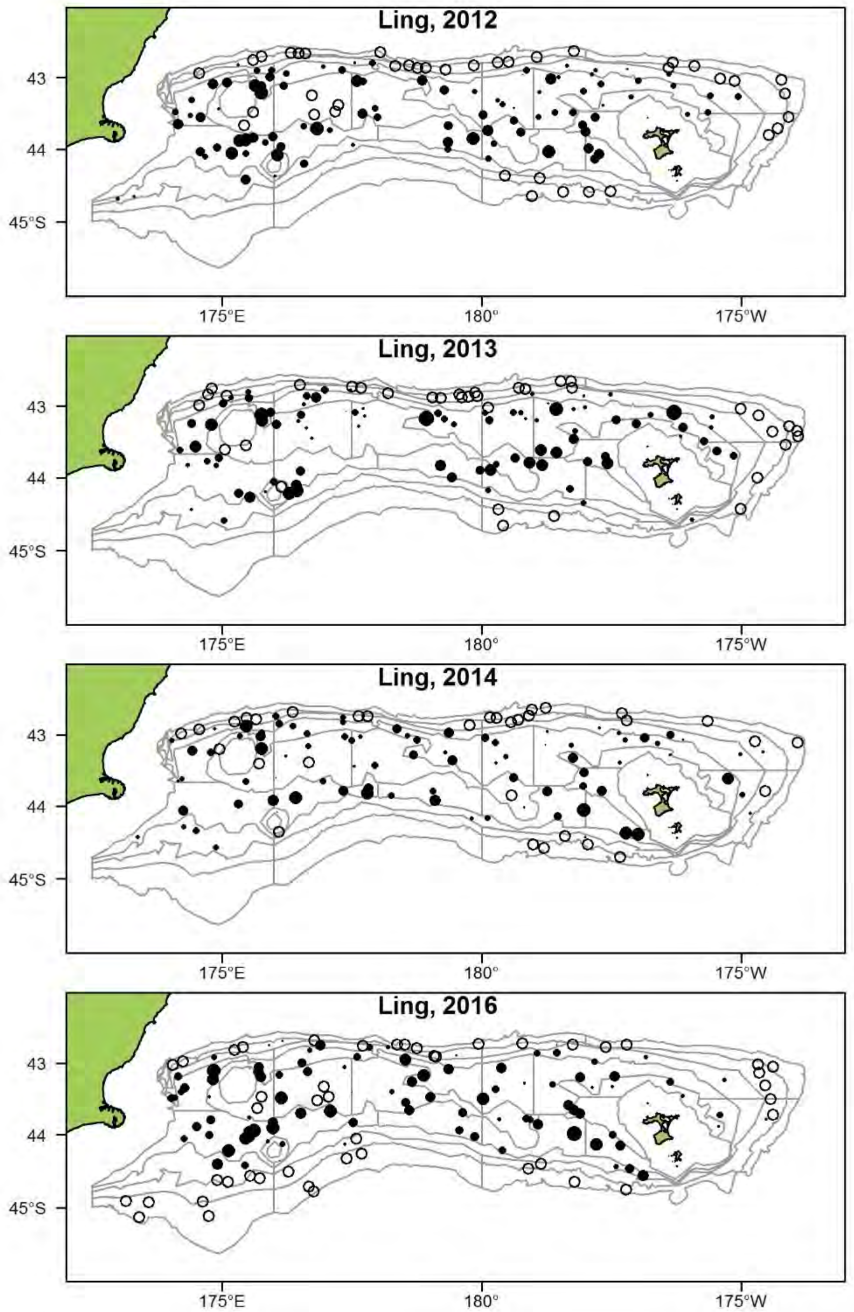


Figure 9 (continued)

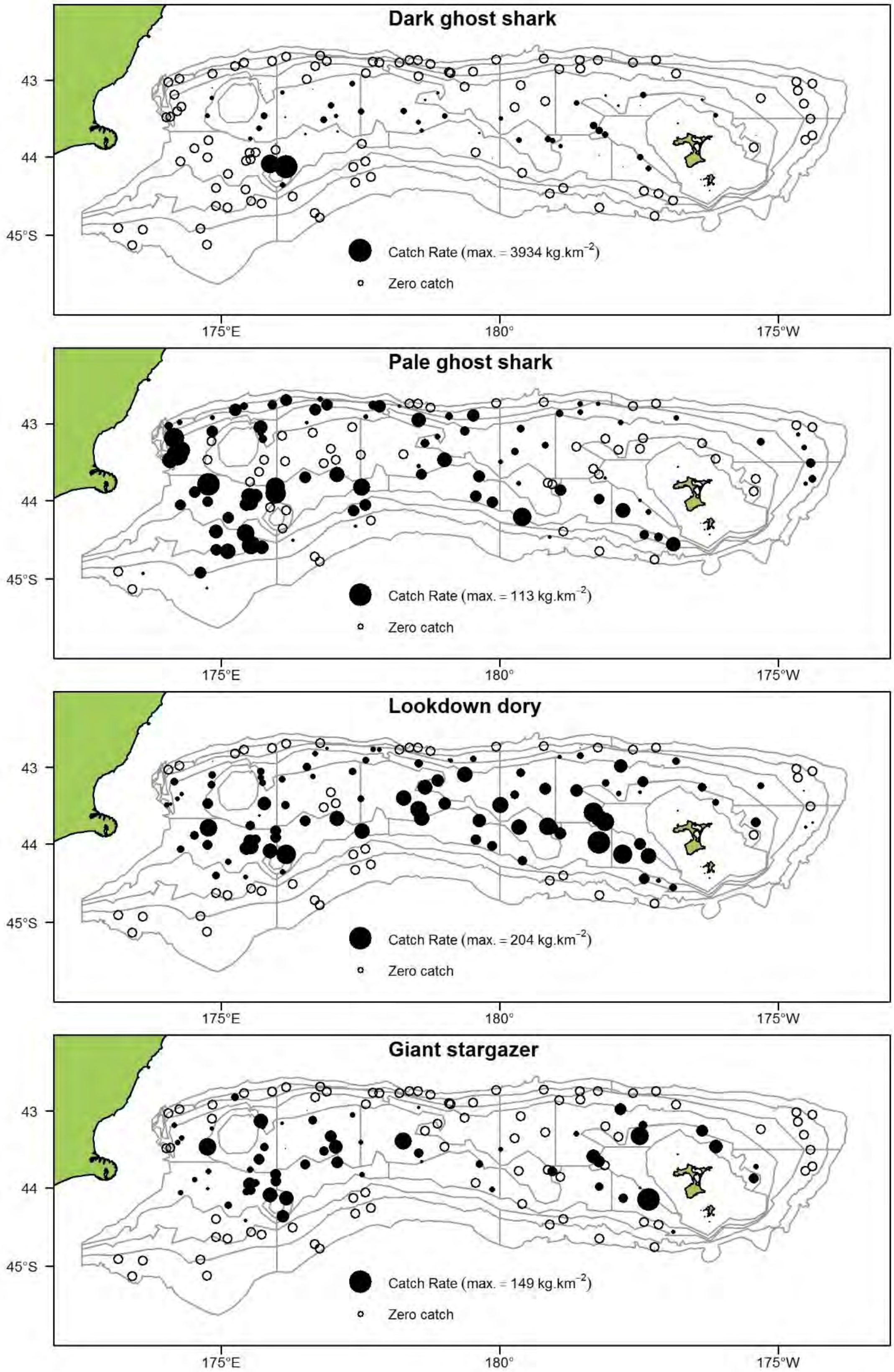


Figure 10: Catch rates (kg km^{-2}) of selected core and deepwater commercial and bycatch species in 2016. Filled circle area is proportional to catch rate. Open circles are zero catch. (max., maximum catch rate).

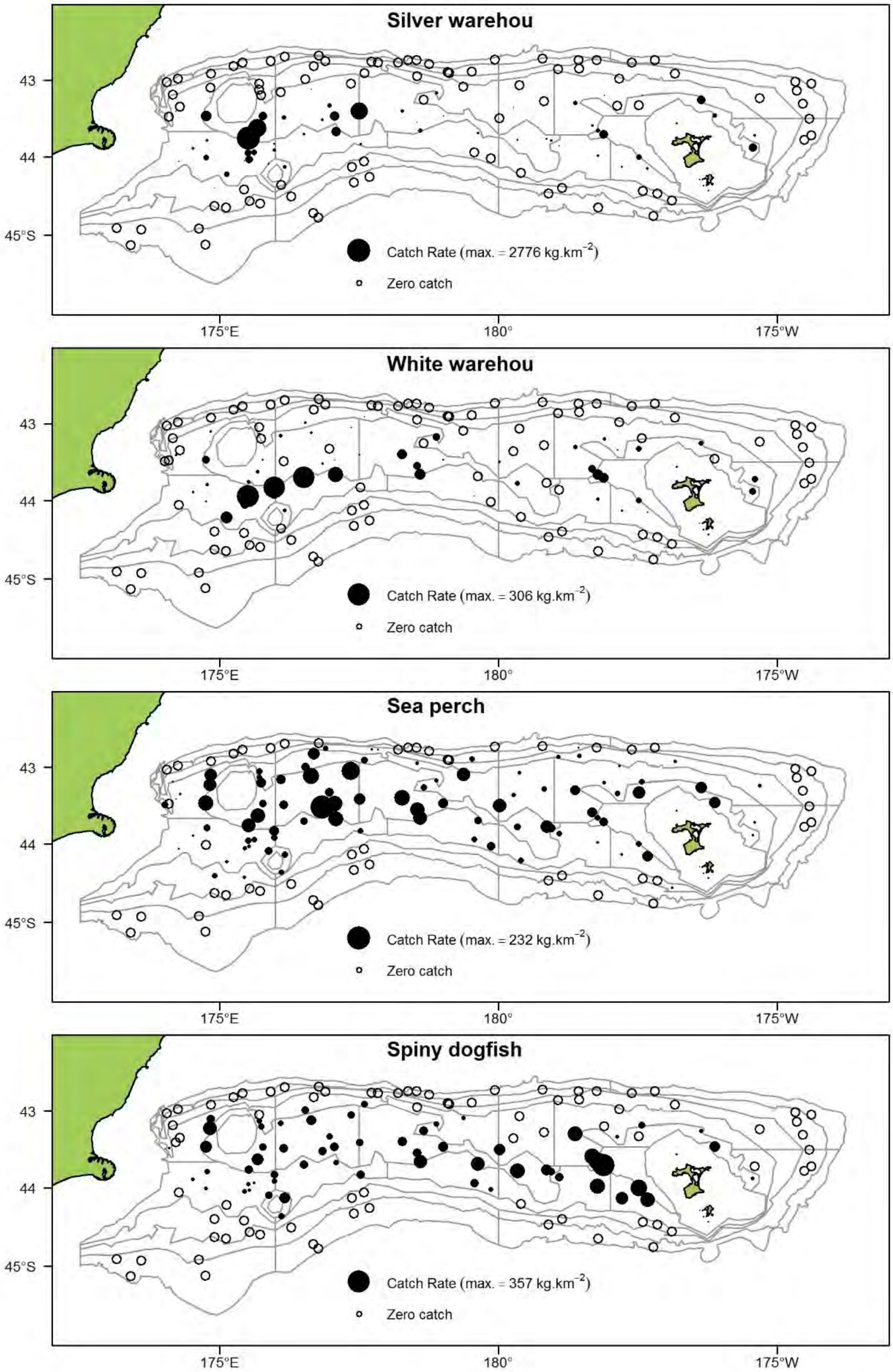


Figure 10 (continued)

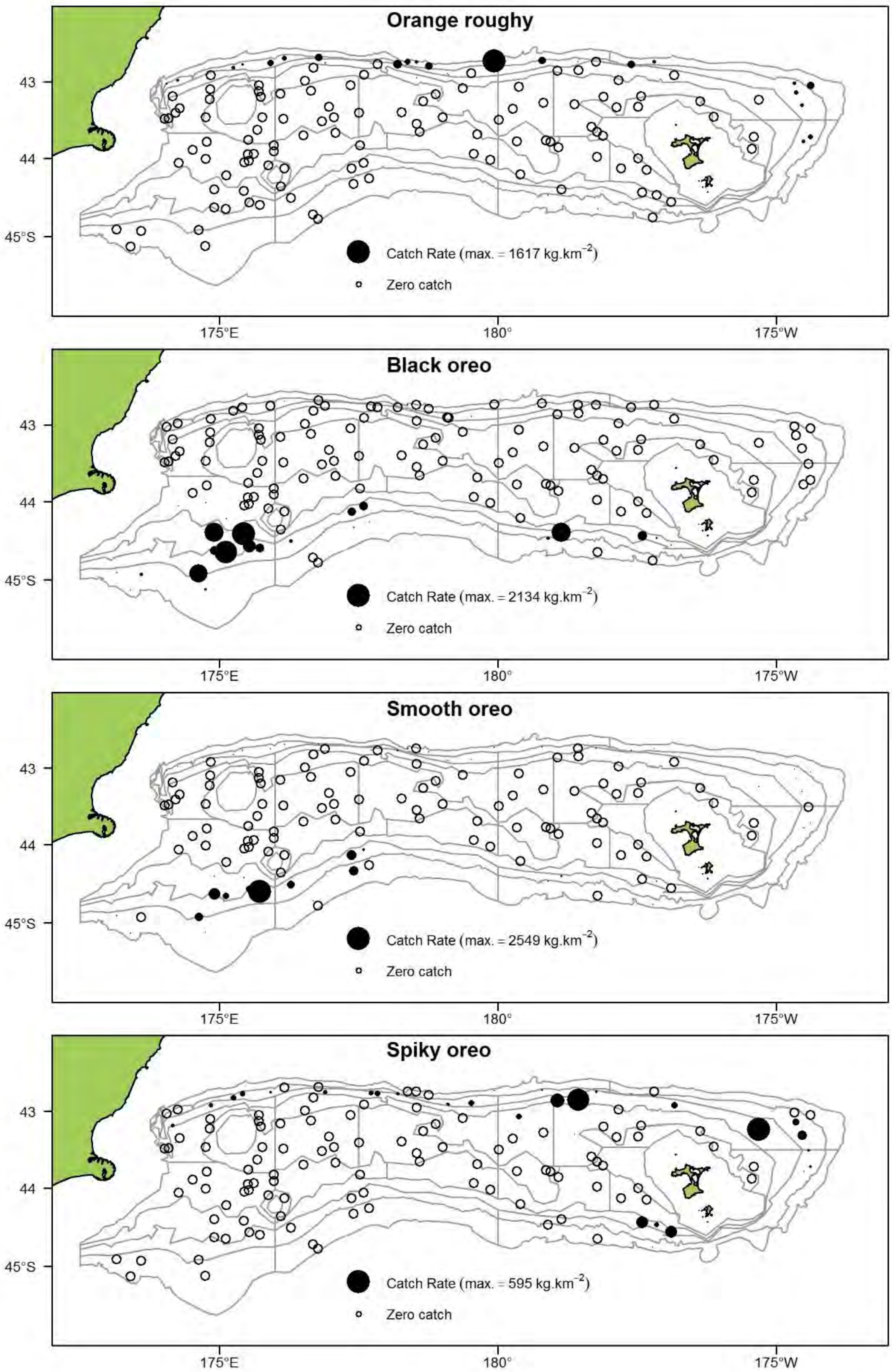


Figure 10 (continued)

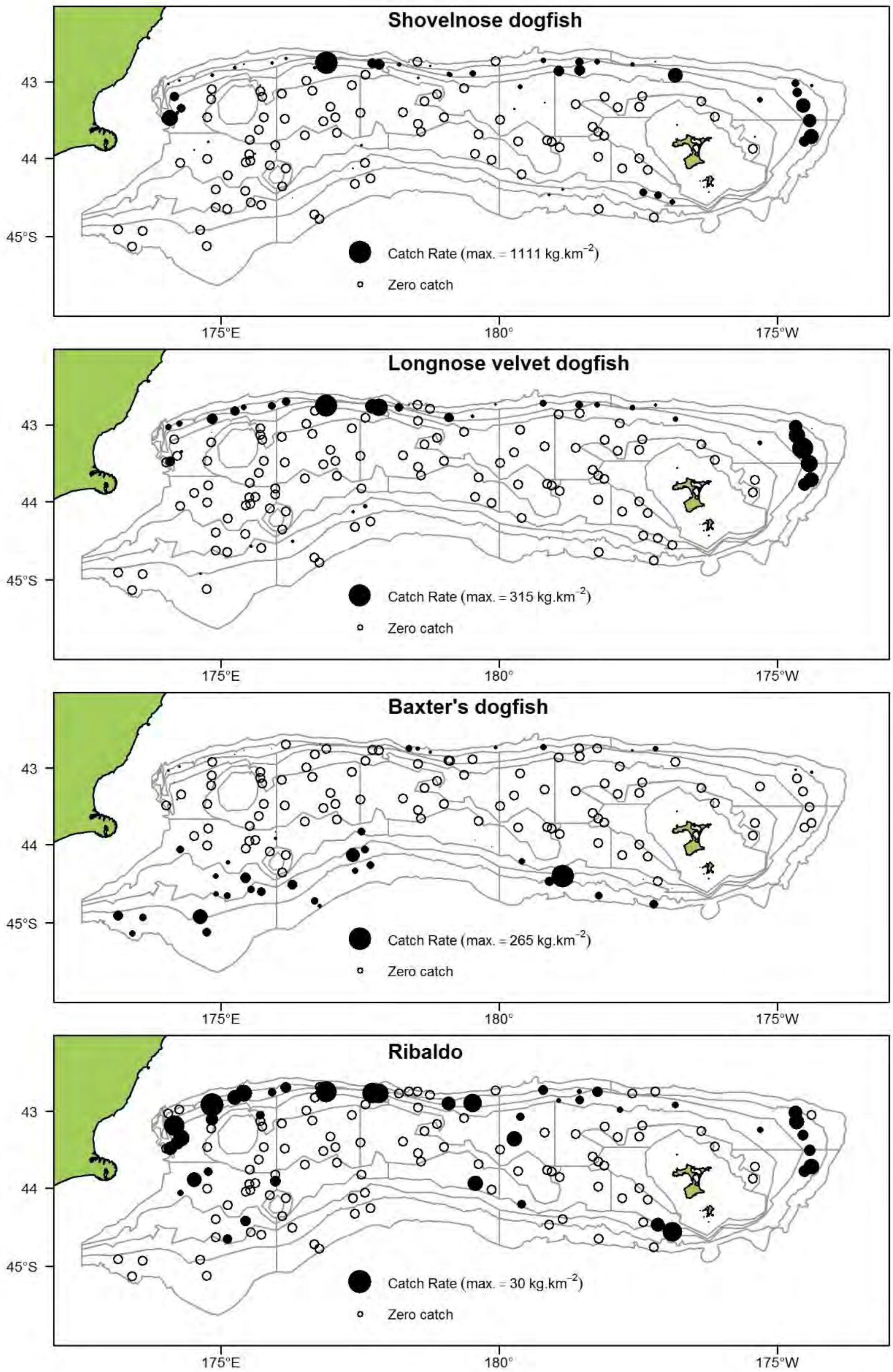


Figure 10 (continued)

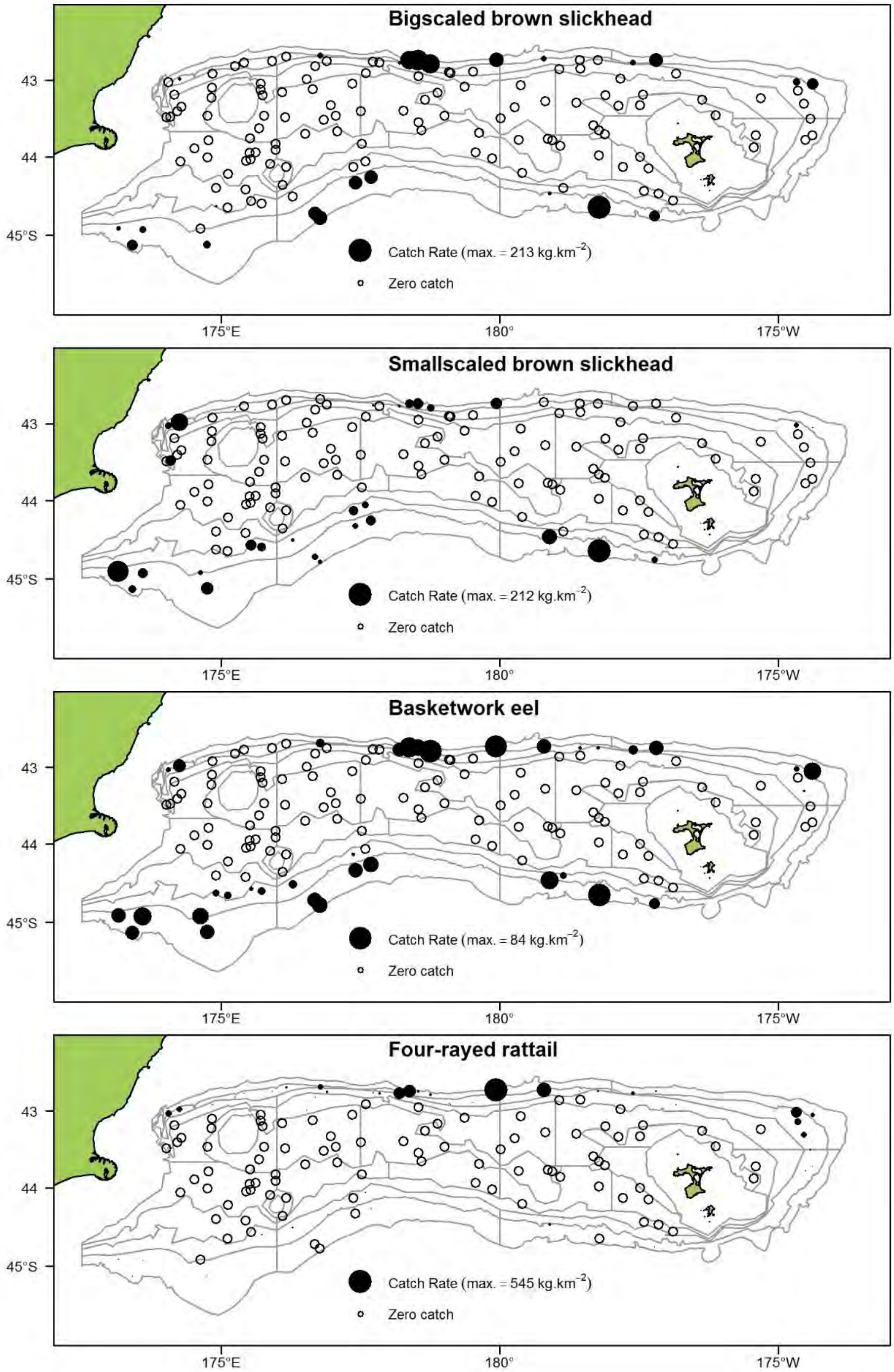
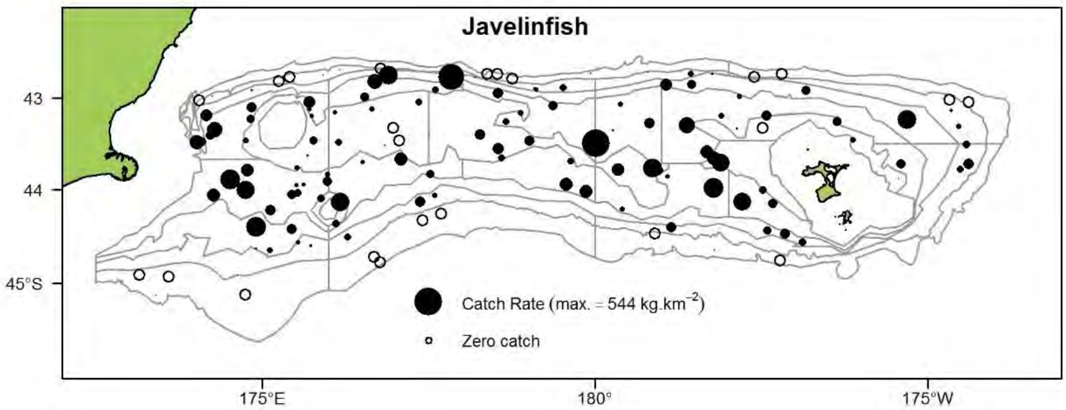


Figure 10 (continued)



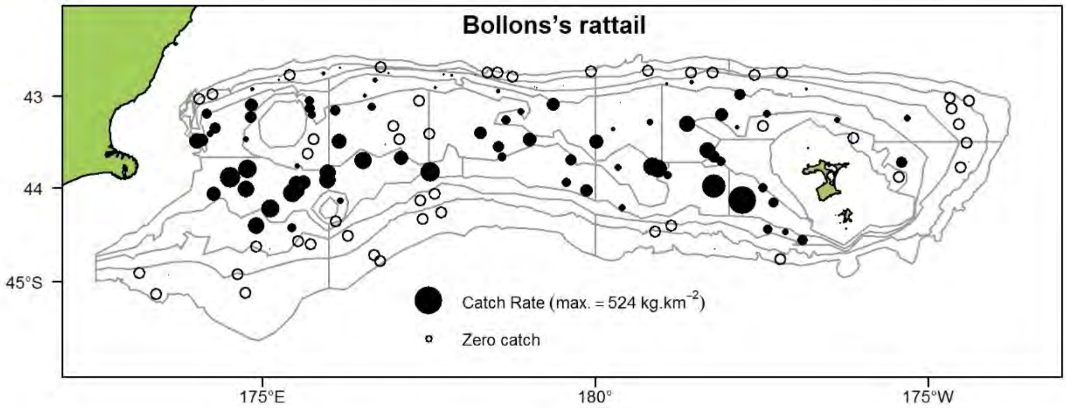


Figure 10 (continued)

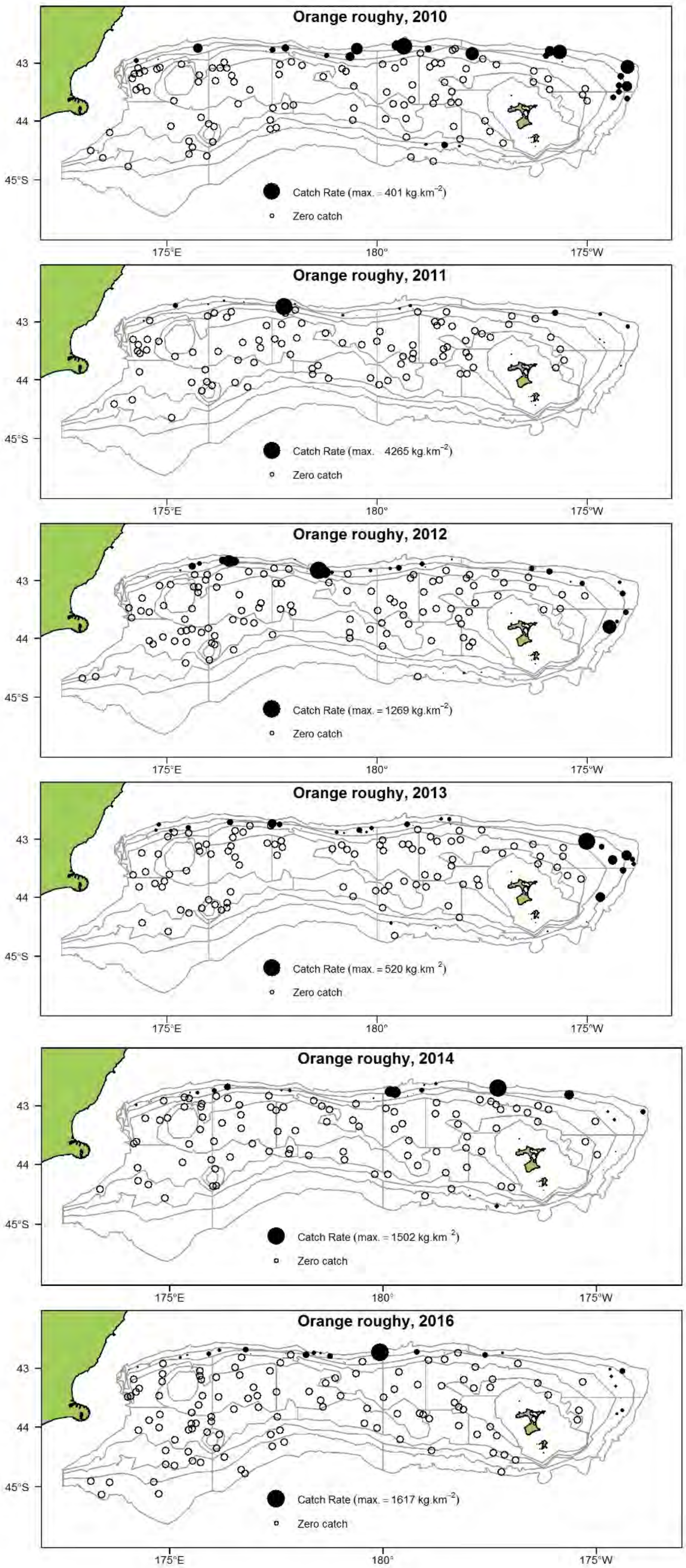


Figure 11: Orange roughy, black oreo, and smooth oreo catch distribution 1992-2014, and 2016. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch.

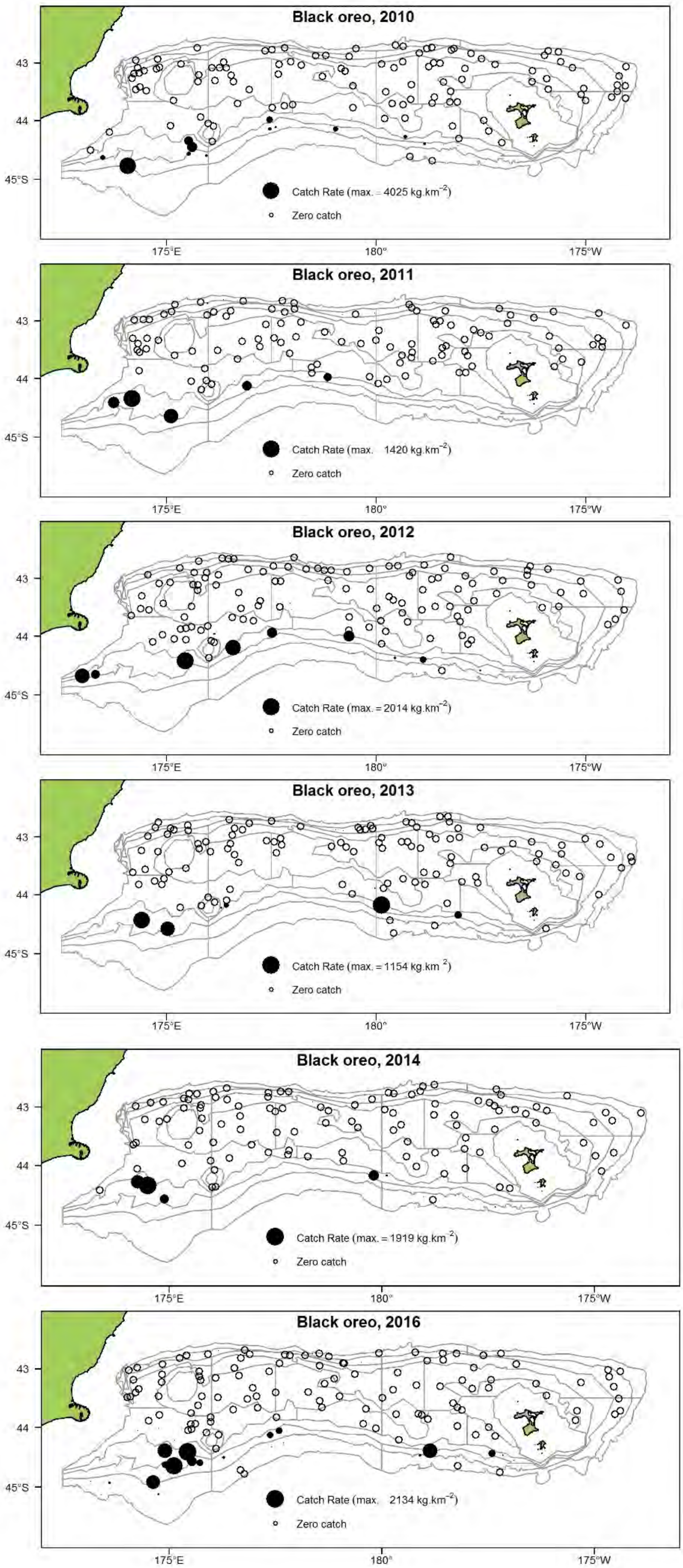


Figure 11 (continued)

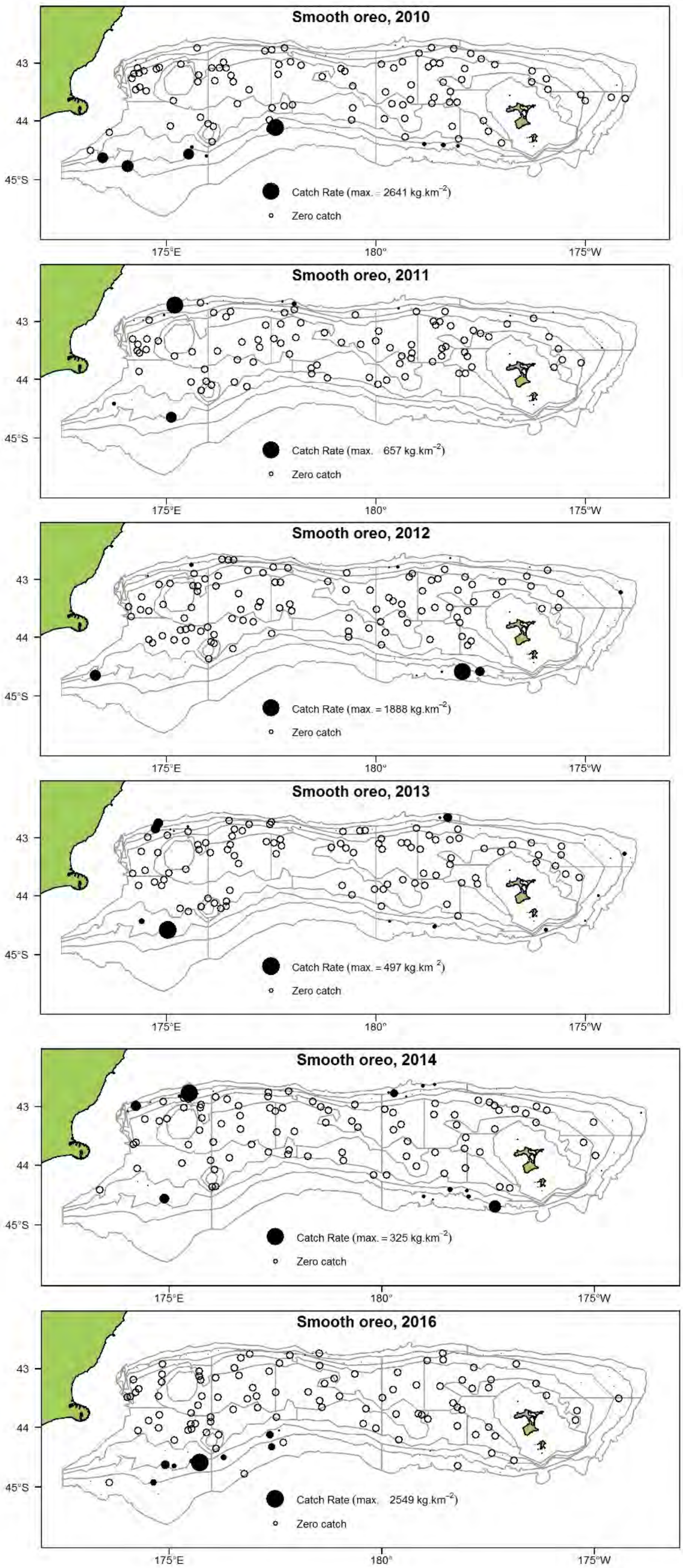


Figure 11 (continued)

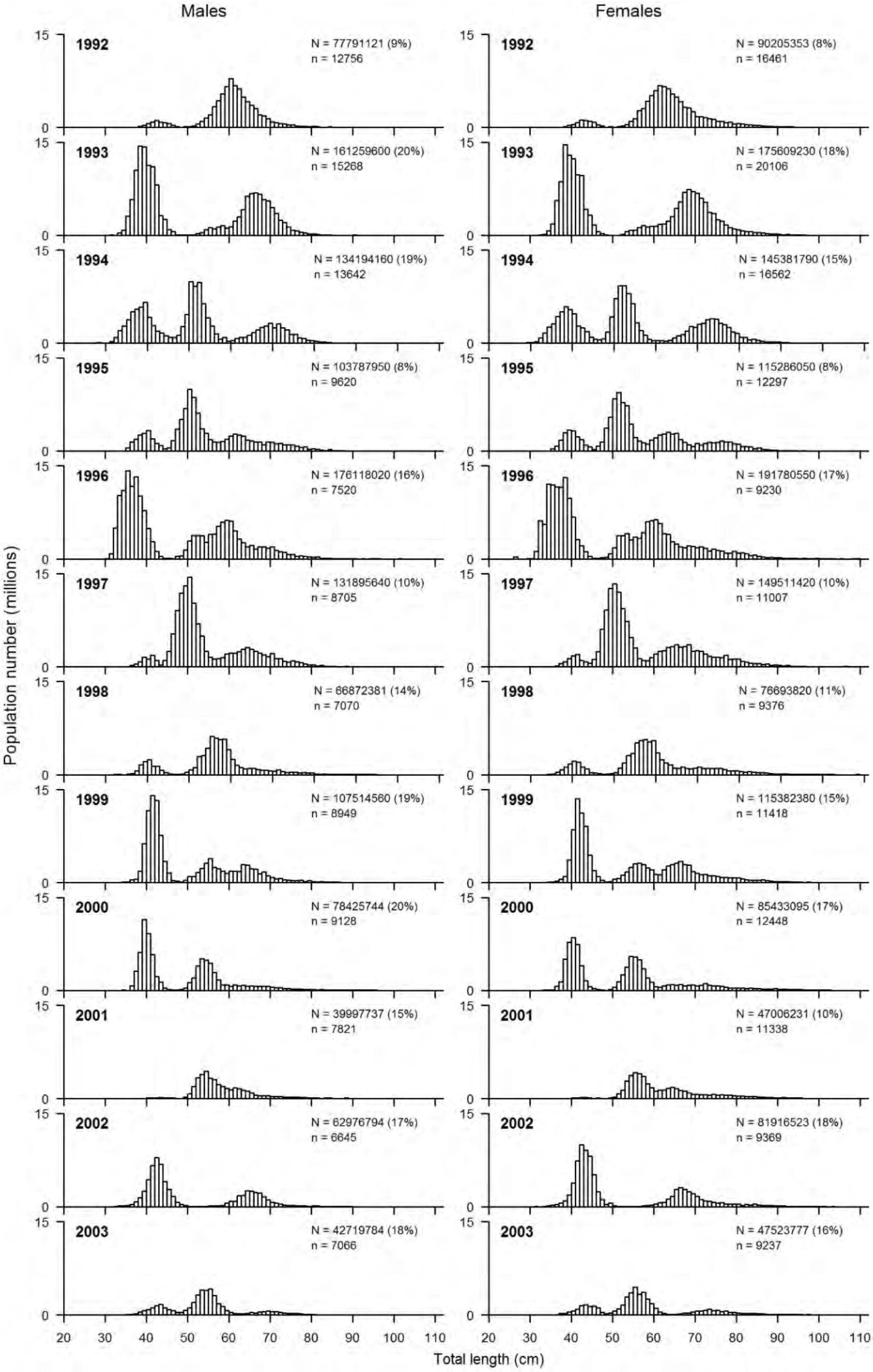


Figure 12: Estimated length frequency distributions of the male and female hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, and 2016 for core strata. CV, coefficient of variation; n, estimated population number of male hoki (left panel) and female hoki (right panel); no., numbers of fish measured.

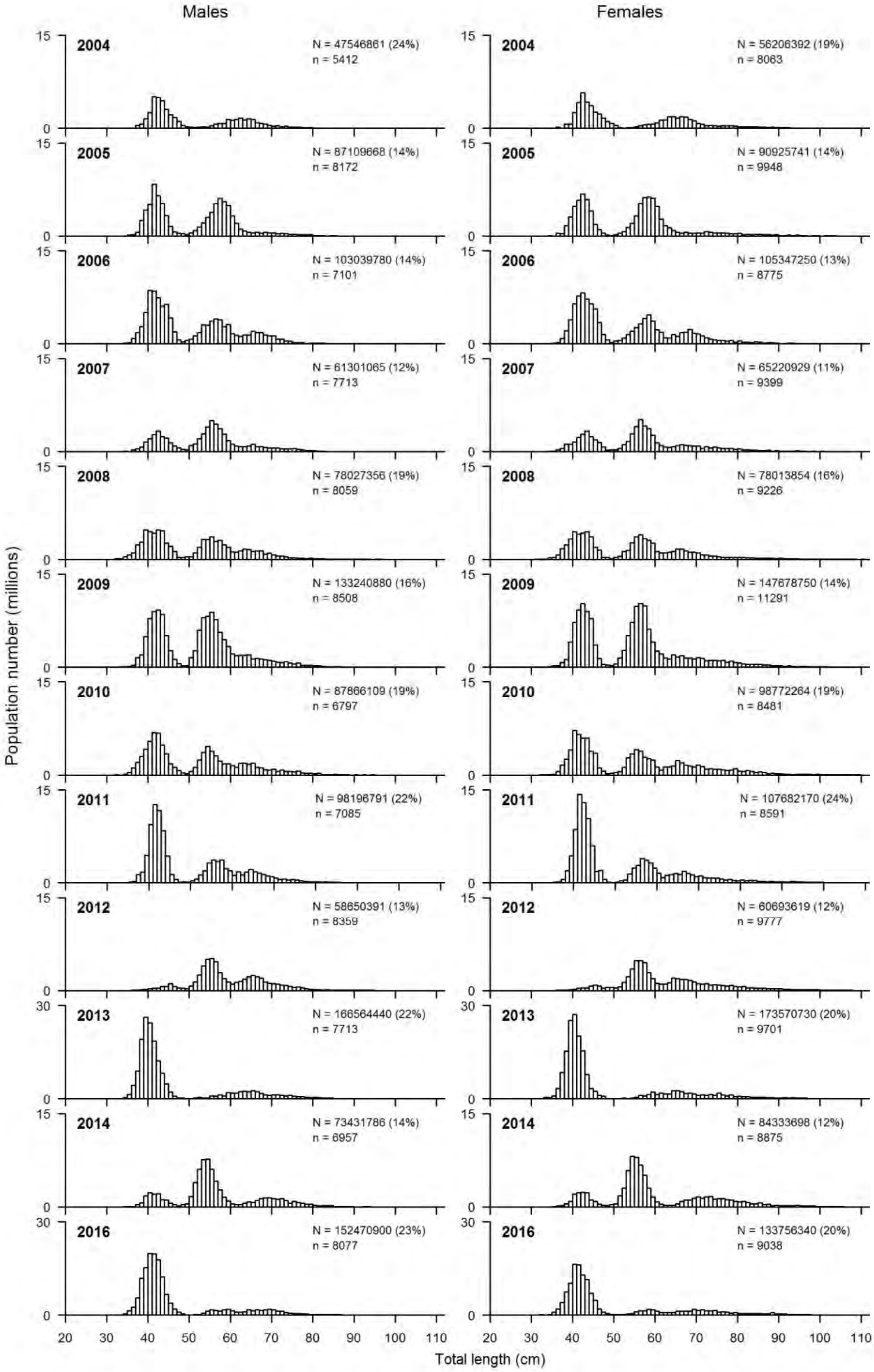


Figure 12 (continued). Note scale change for 2013 and 2016.

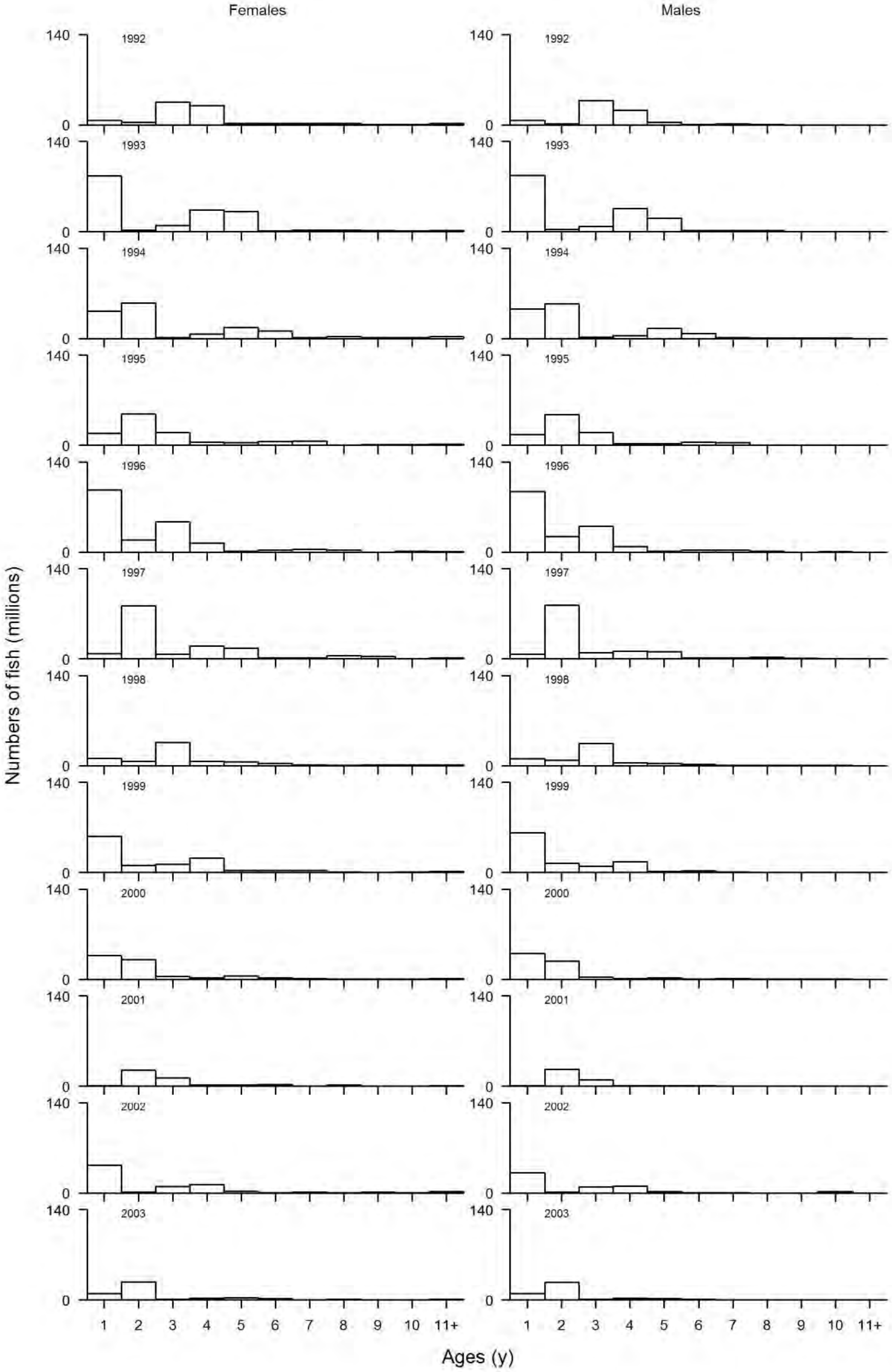


Figure 13: Estimated population numbers at age for hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, and 2016. +, indicates plus group of combined ages.

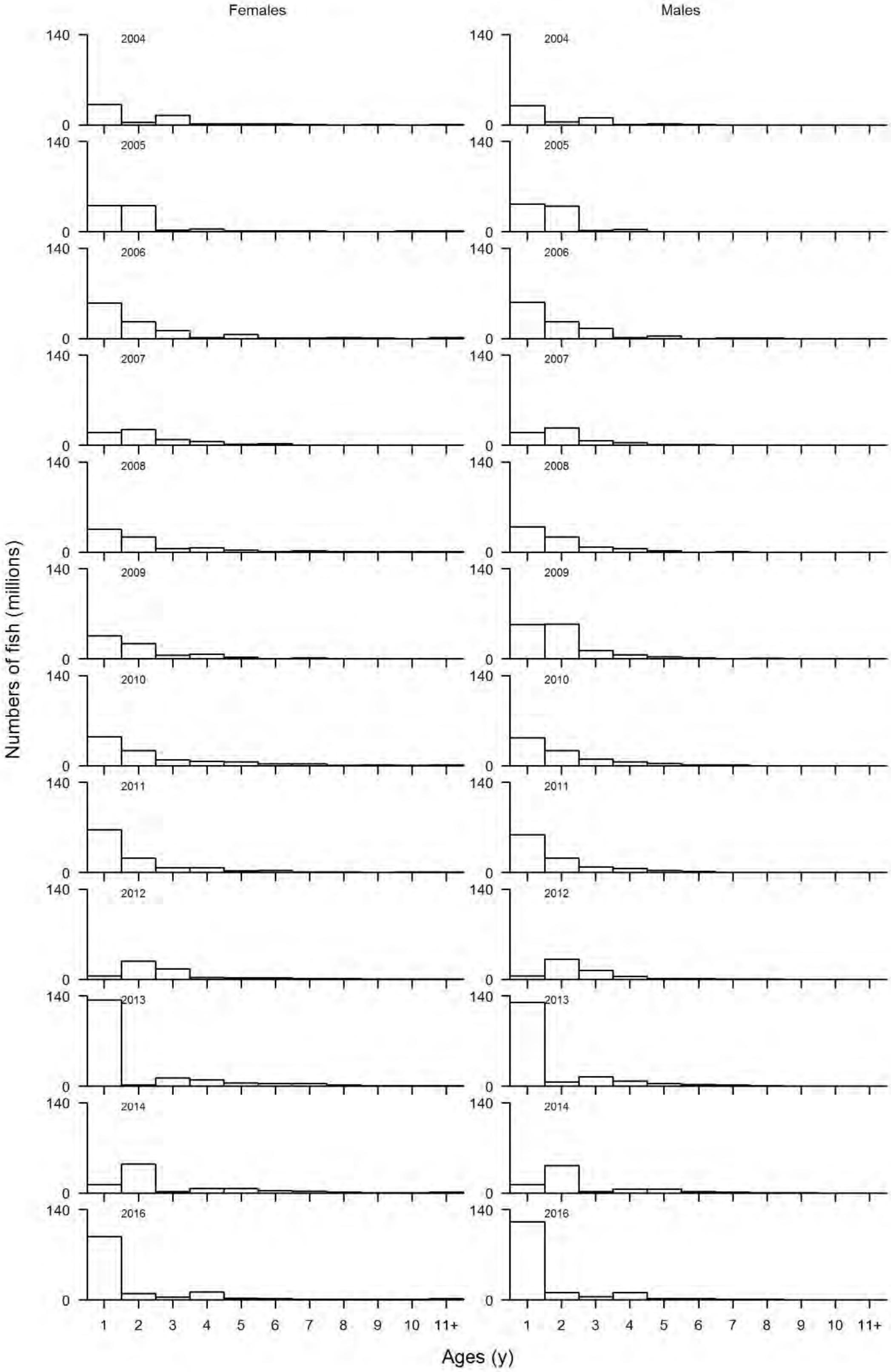


Figure 13 (continued)

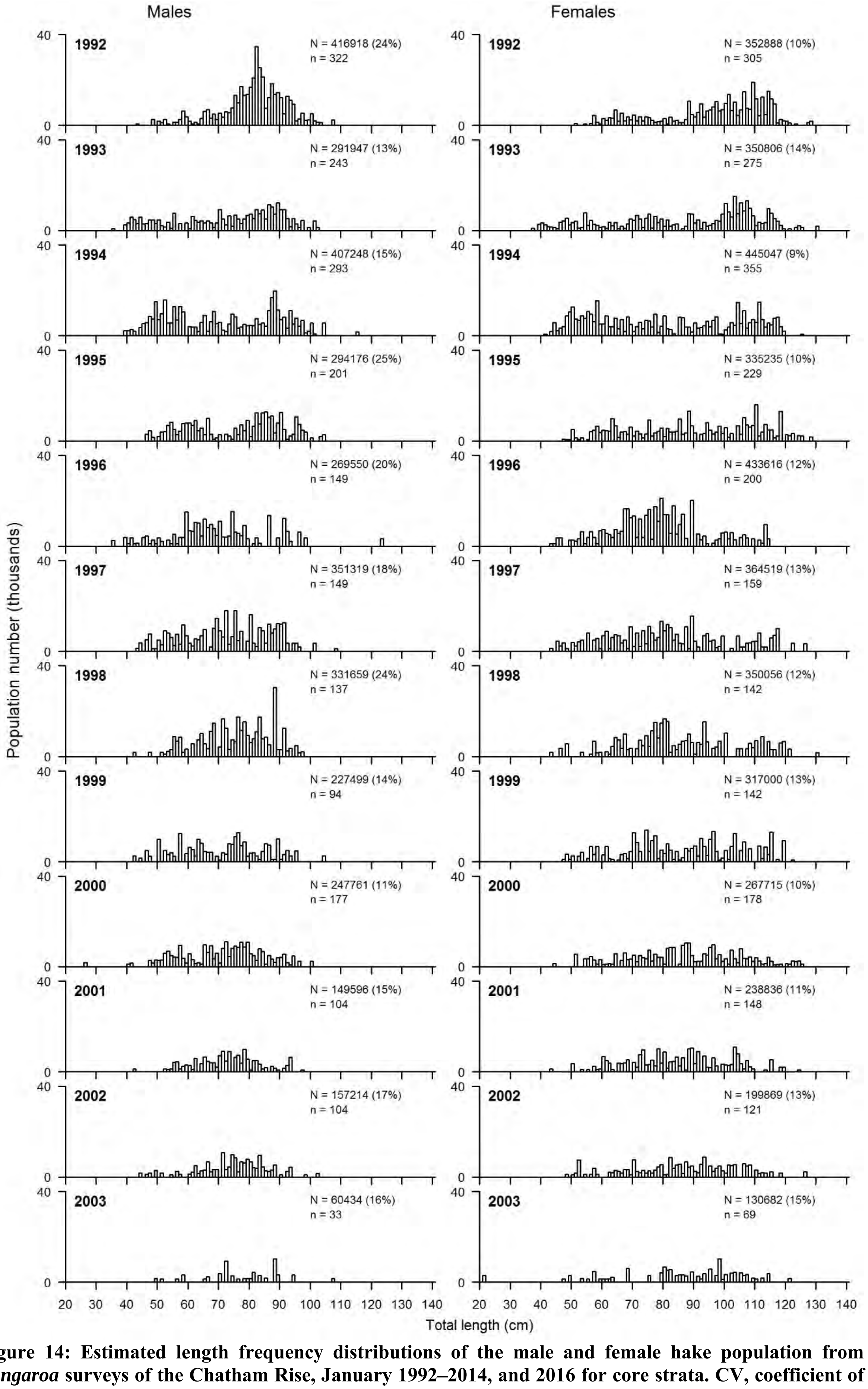


Figure 14: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, and 2016 for core strata. CV, coefficient of variation; *n*, estimated population number of hake; no., numbers of fish measured.

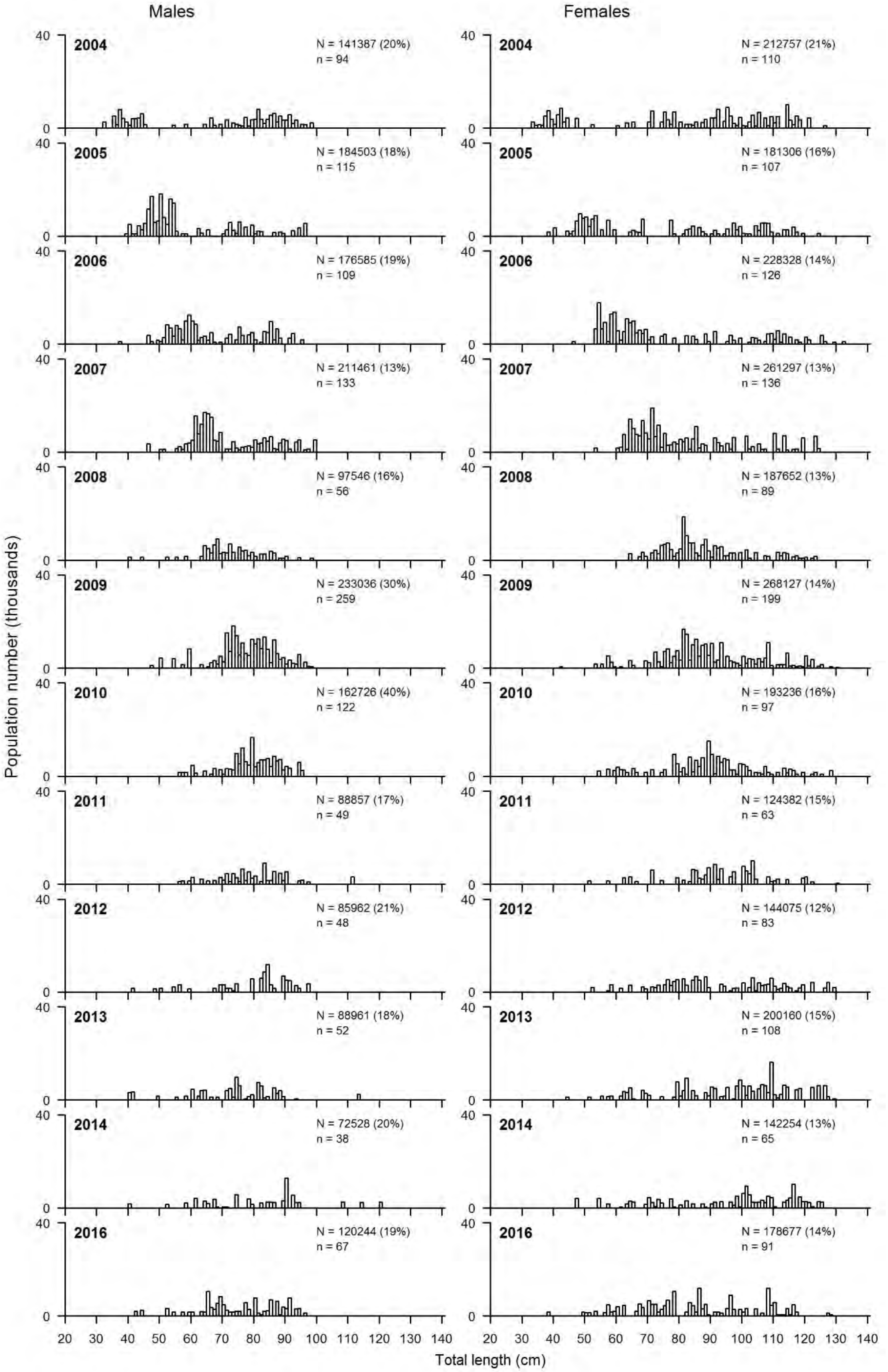


Figure 14 (continued)

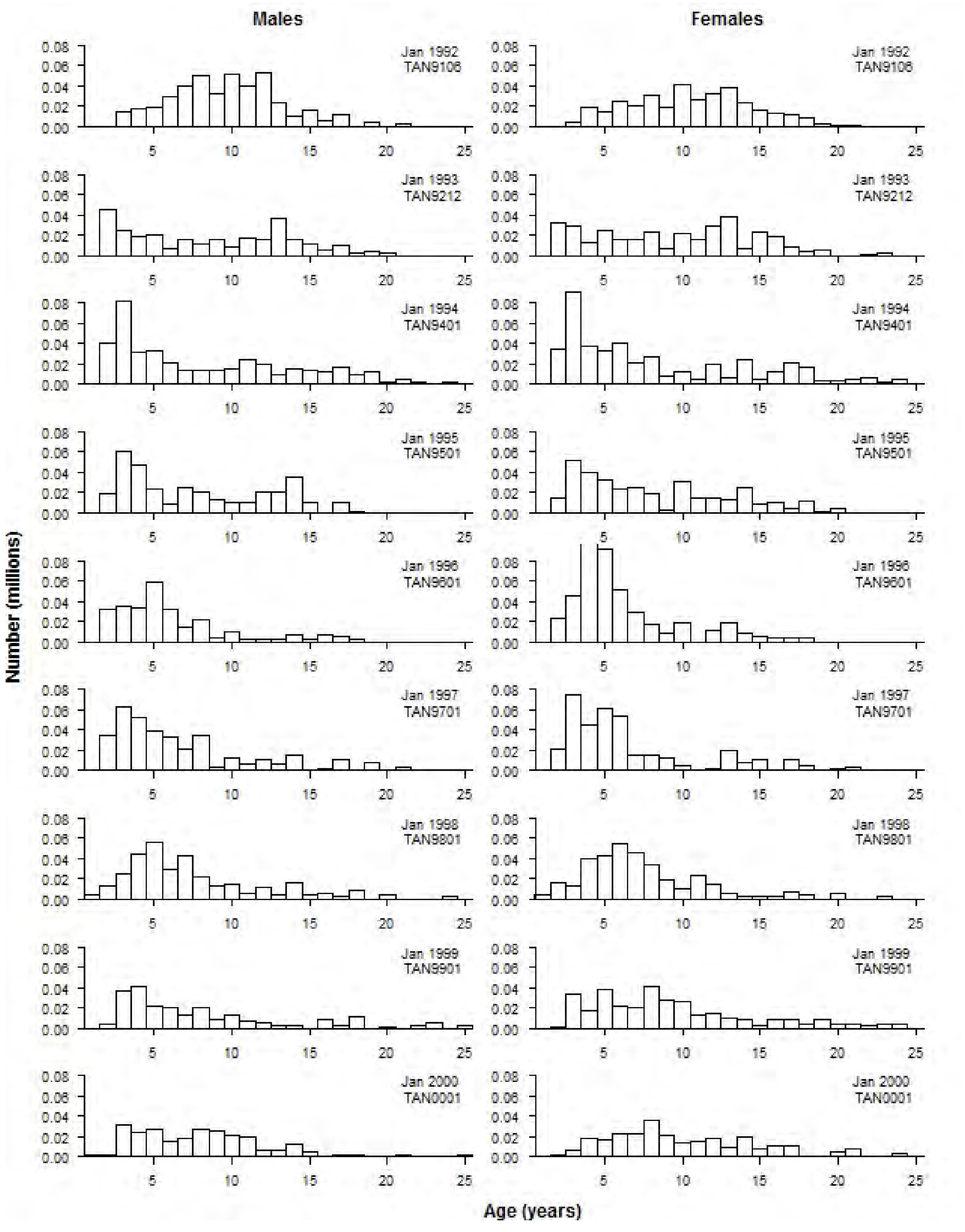


Figure 15: Estimated proportion at age for male and female hake from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, and 2016.

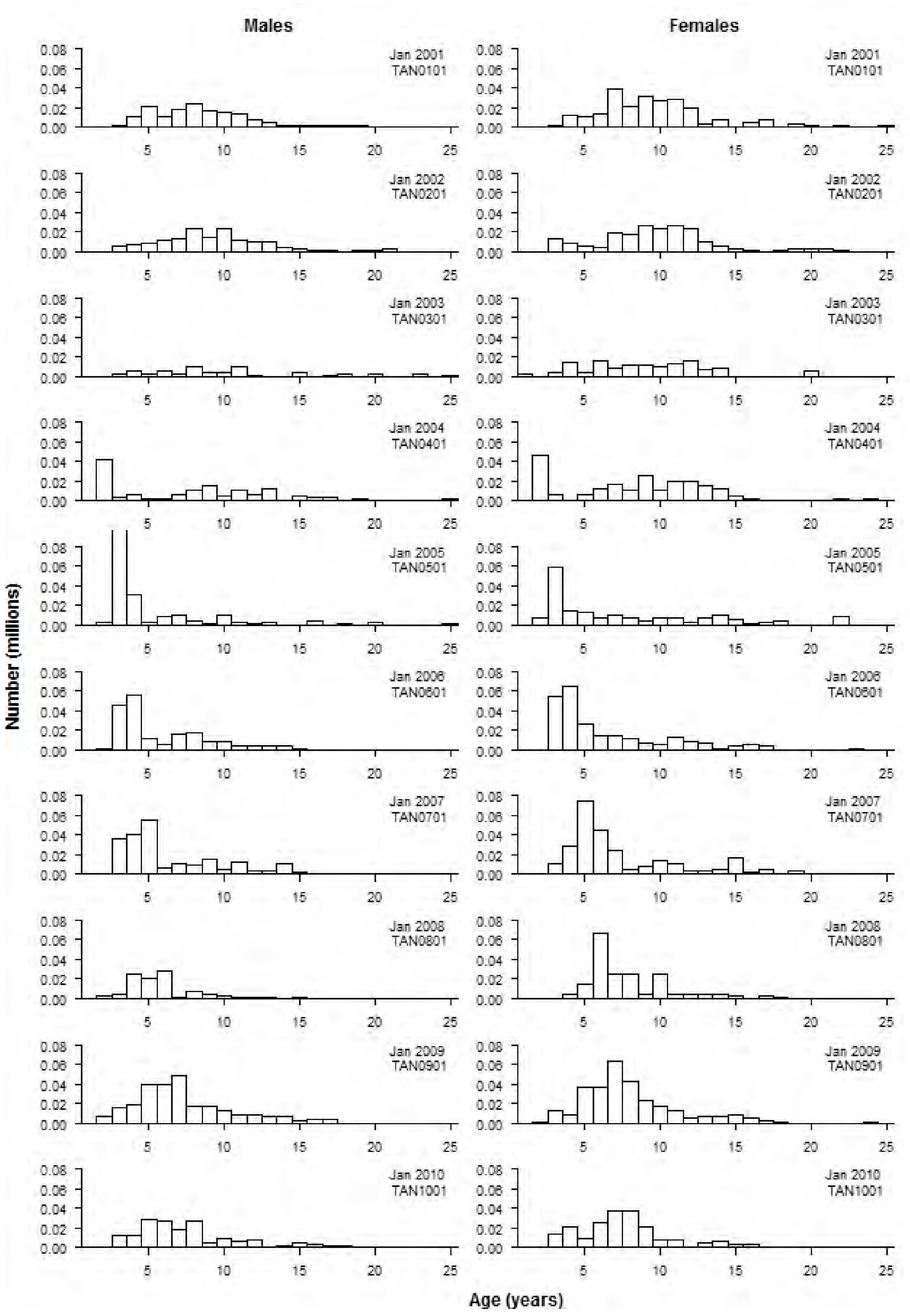


Figure 15 (continued)

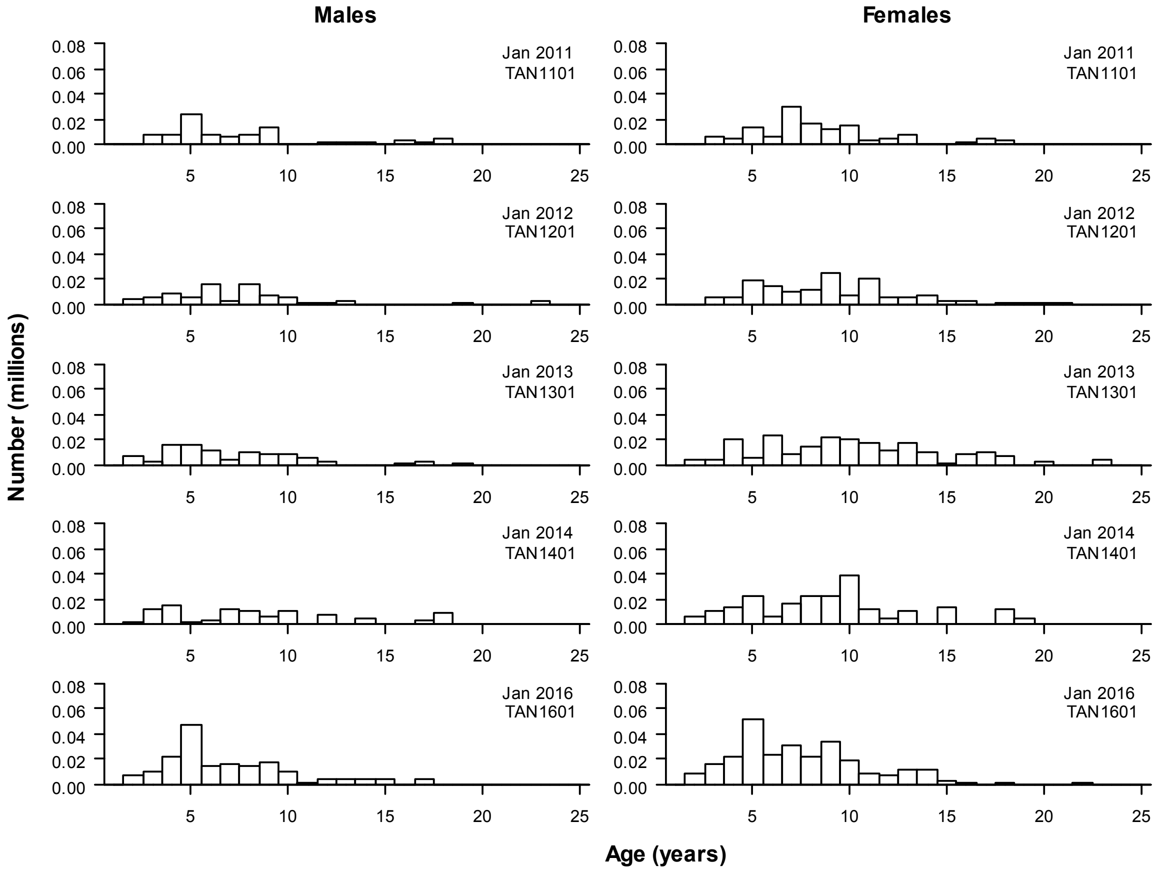


Figure 15 (continued)

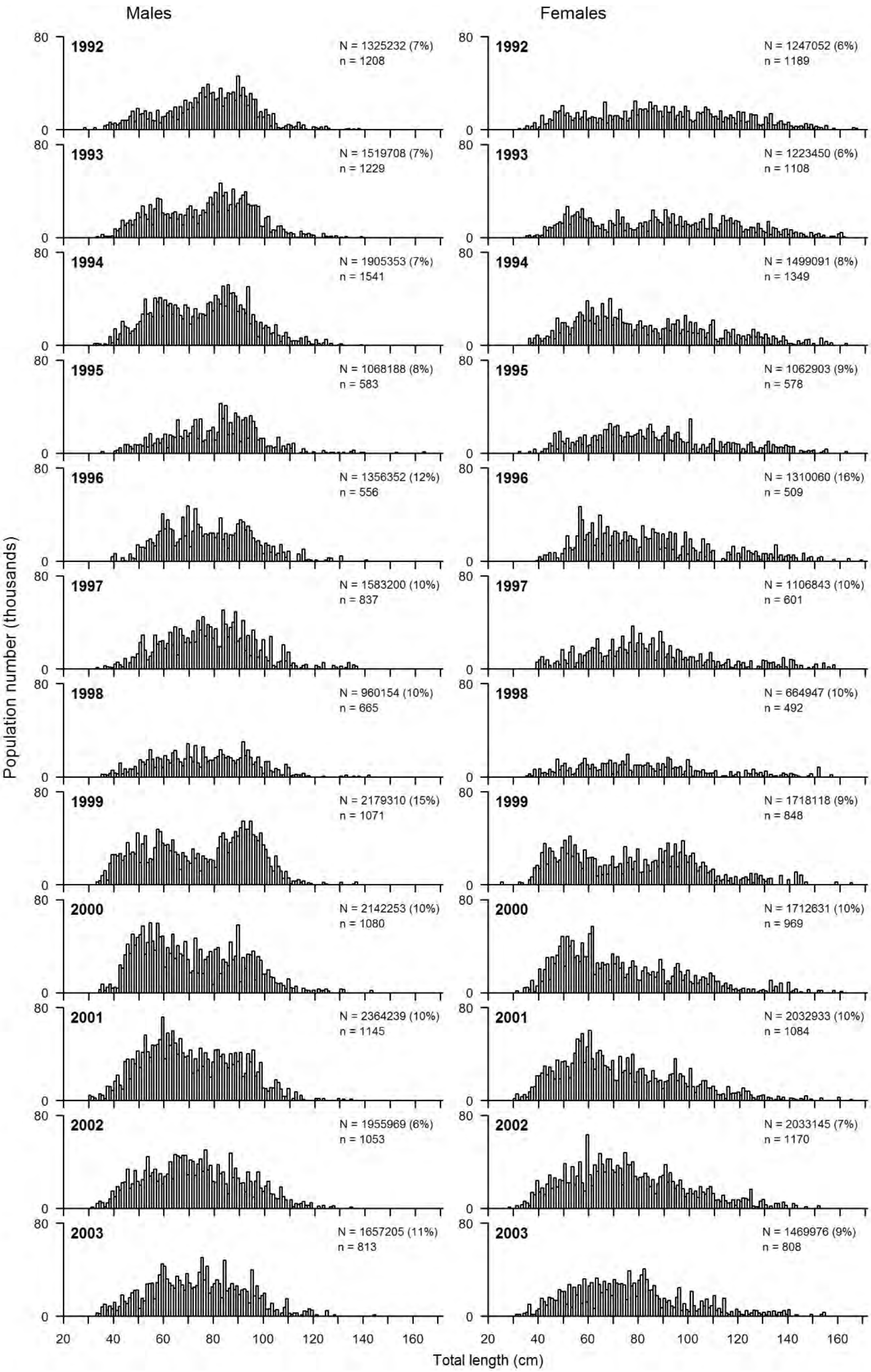


Figure 16: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2014, and 2016 for core strata. CV, coefficient of variation; n, estimated population number of ling; no., numbers of fish measured.

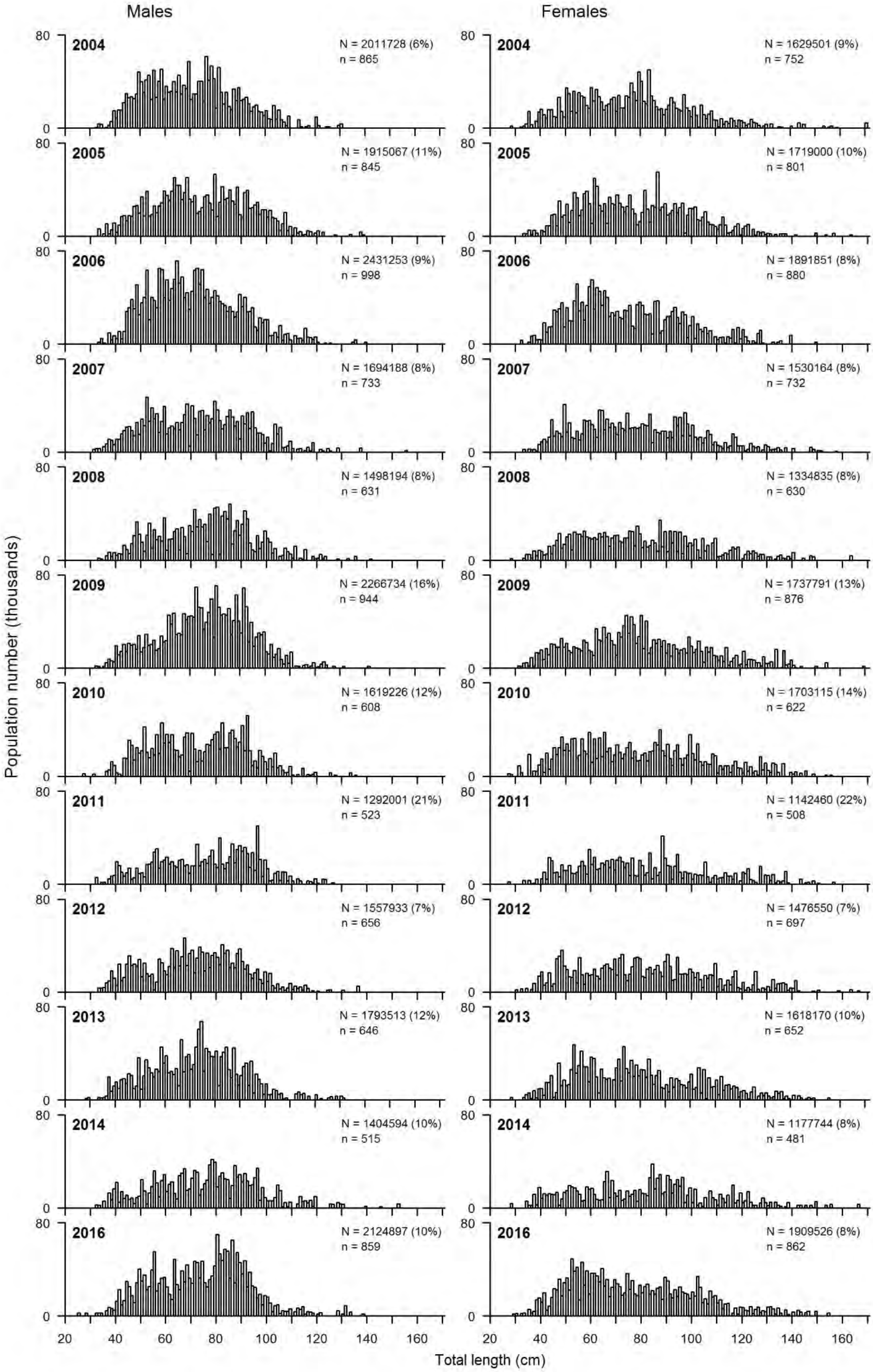


Figure 16 (continued)

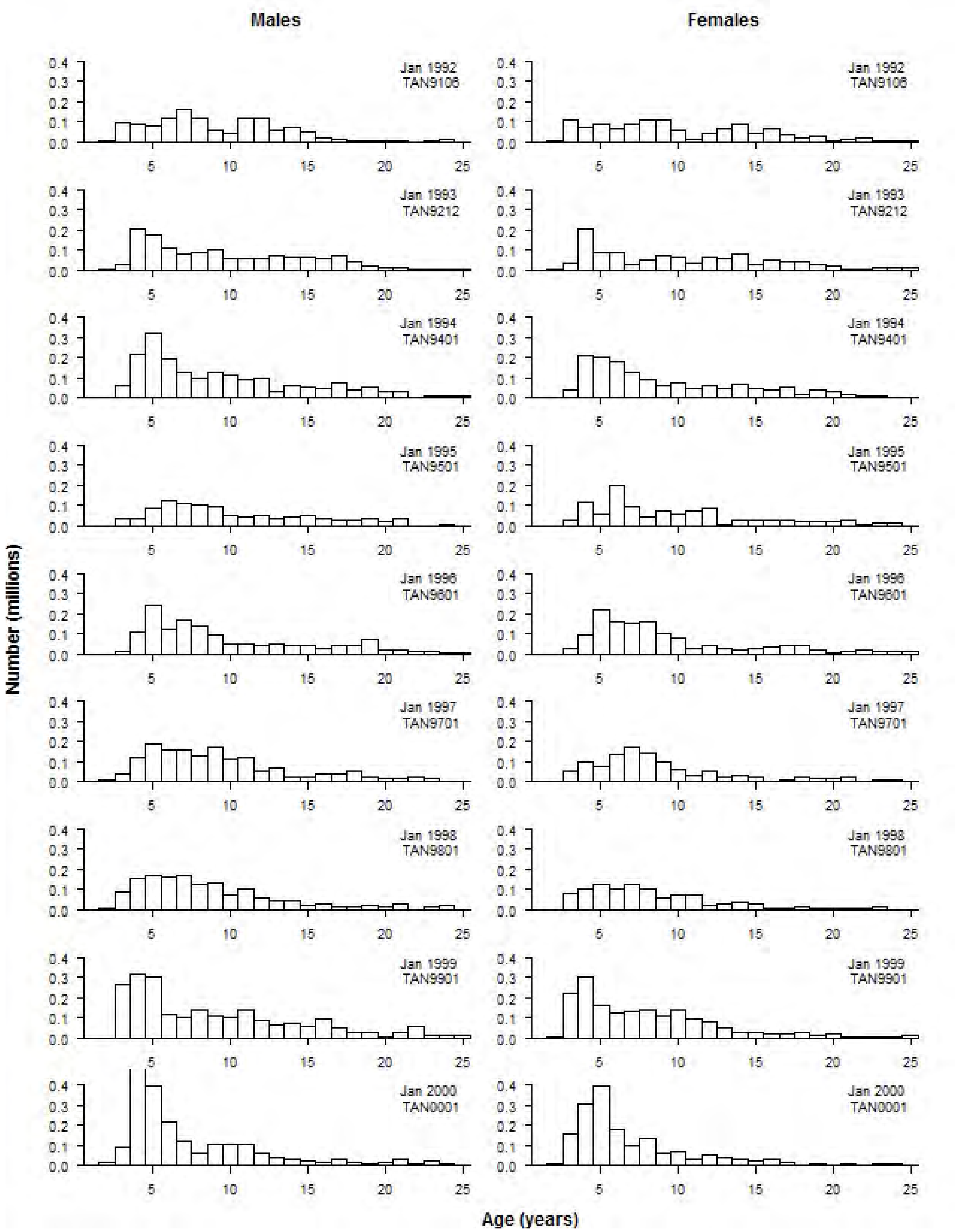


Figure 17: Estimated population numbers at age for male and female ling from *Tangaroa* surveys of the Chatham Rise, January, 1992–2014, and 2016.

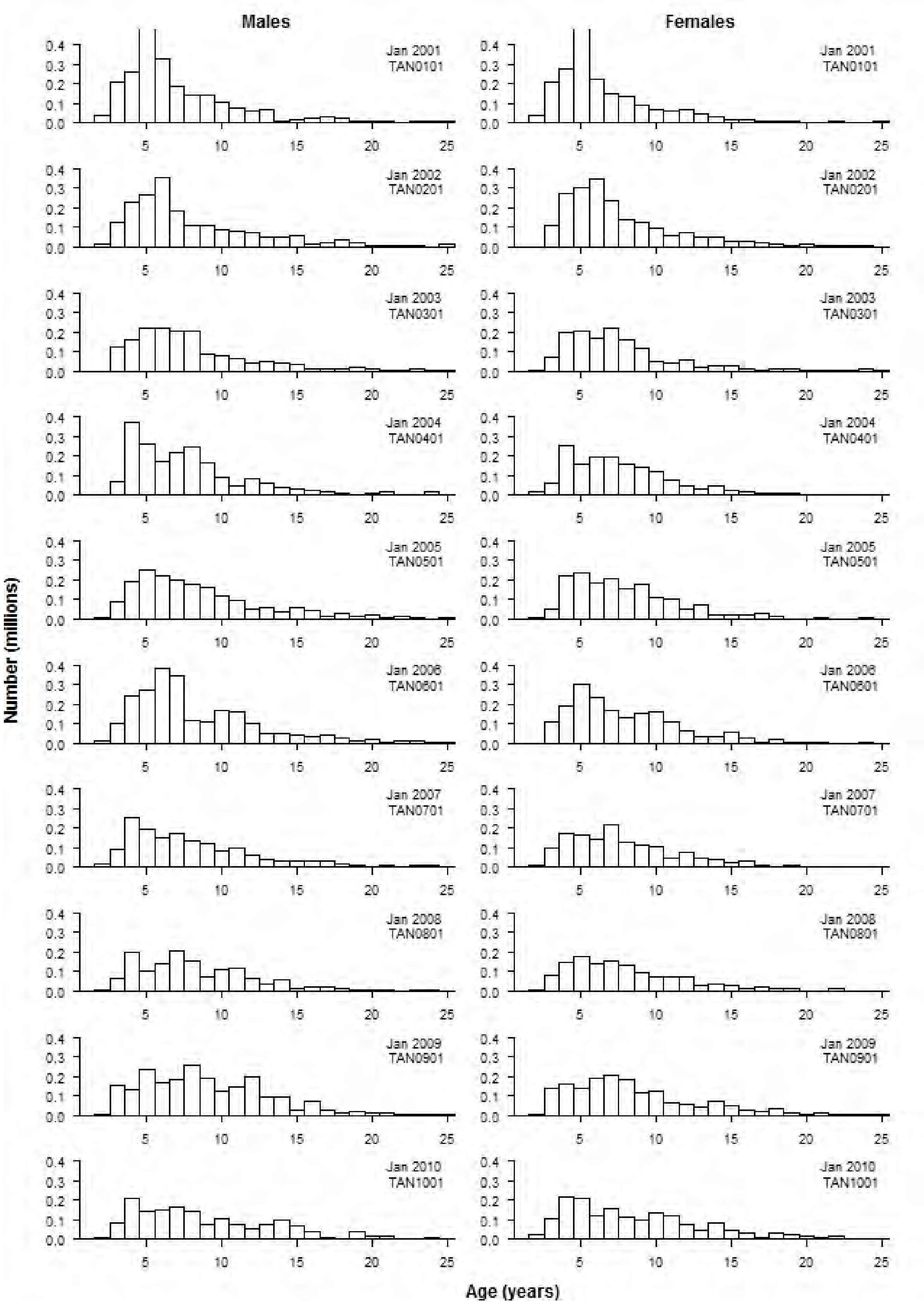


Figure 17 (continued)

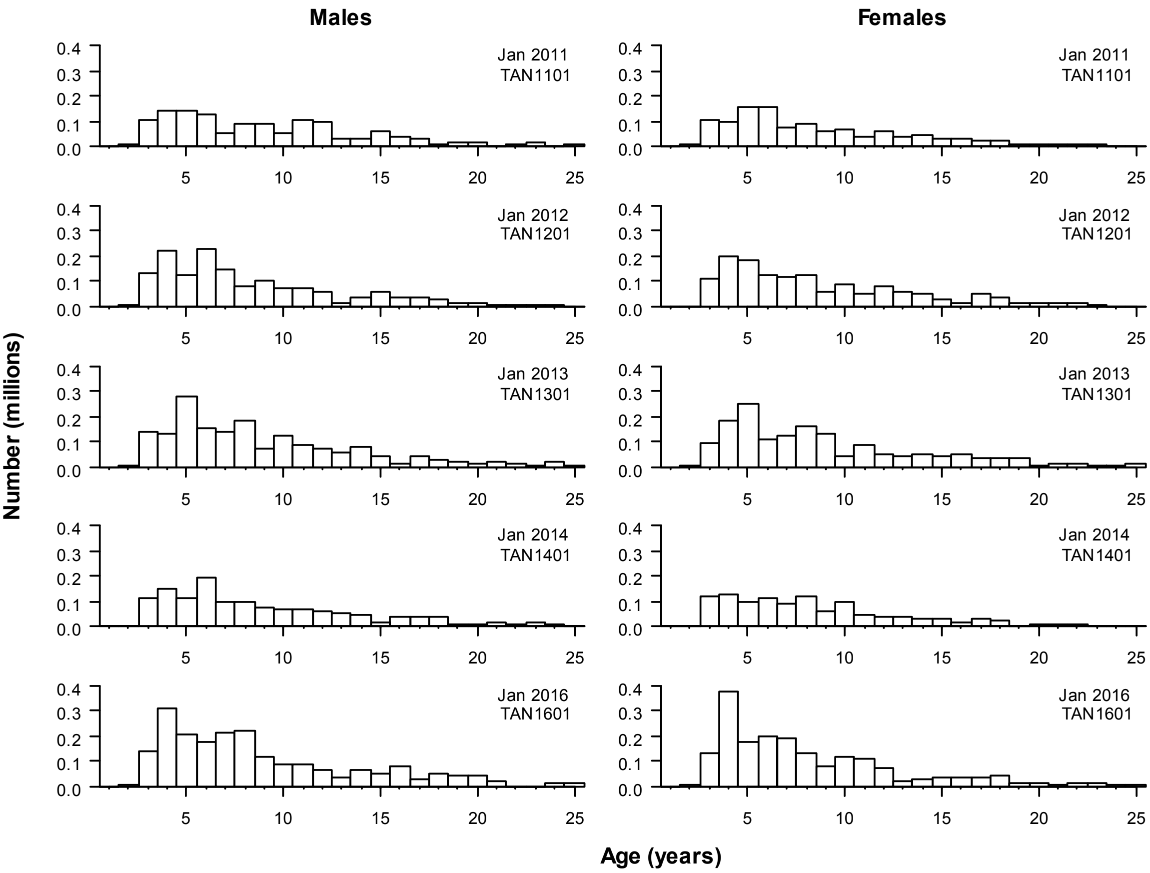


Figure 17 (continued)

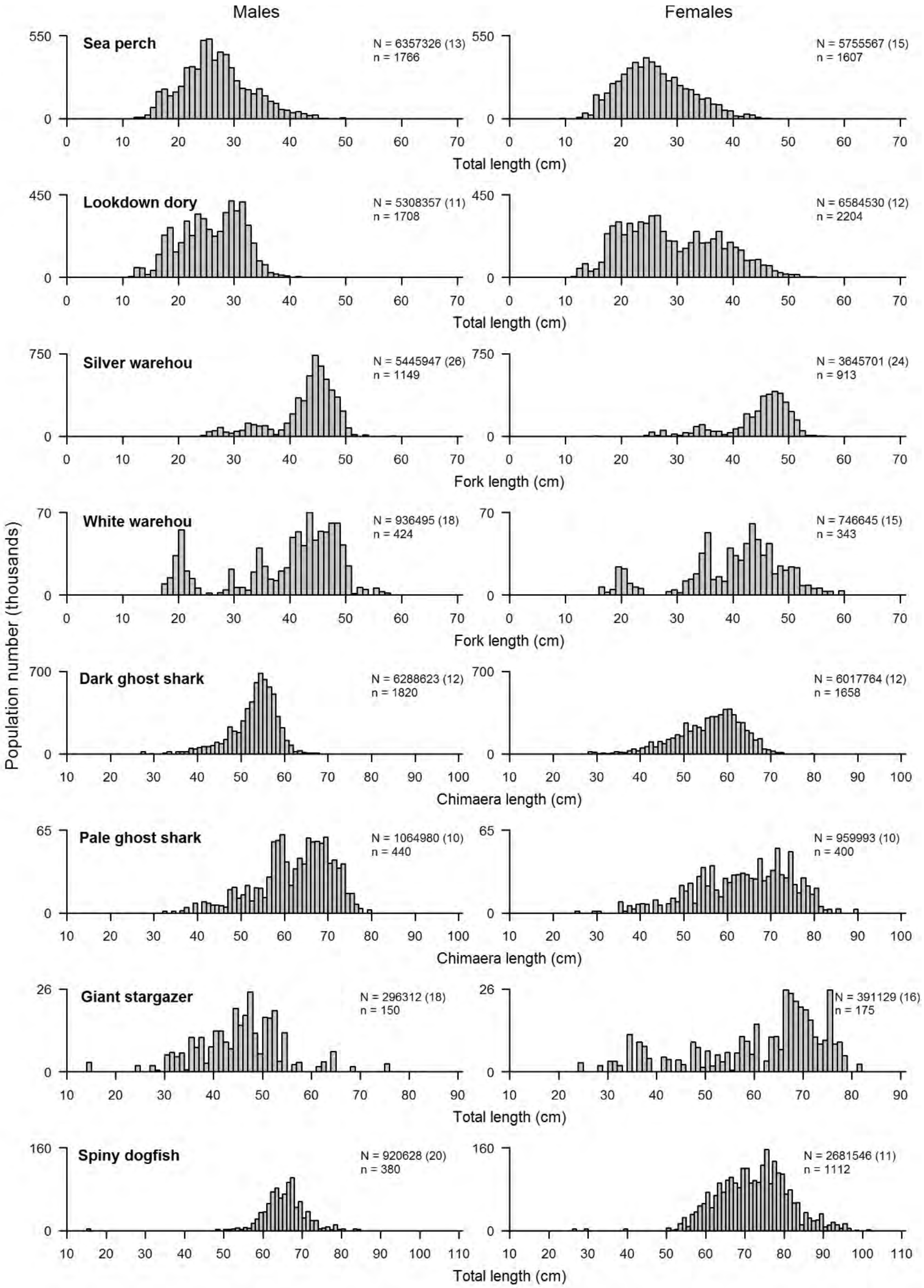


Figure 18a: Length frequency distributions of selected commercial species on the Chatham Rise 2016, scaled to population size by sex. M, estimated male population; F, estimated female population; U, estimated unsexed population (hatched bars); CV, coefficient of variation for the estimated numbers of fish; n, number of fish measured.

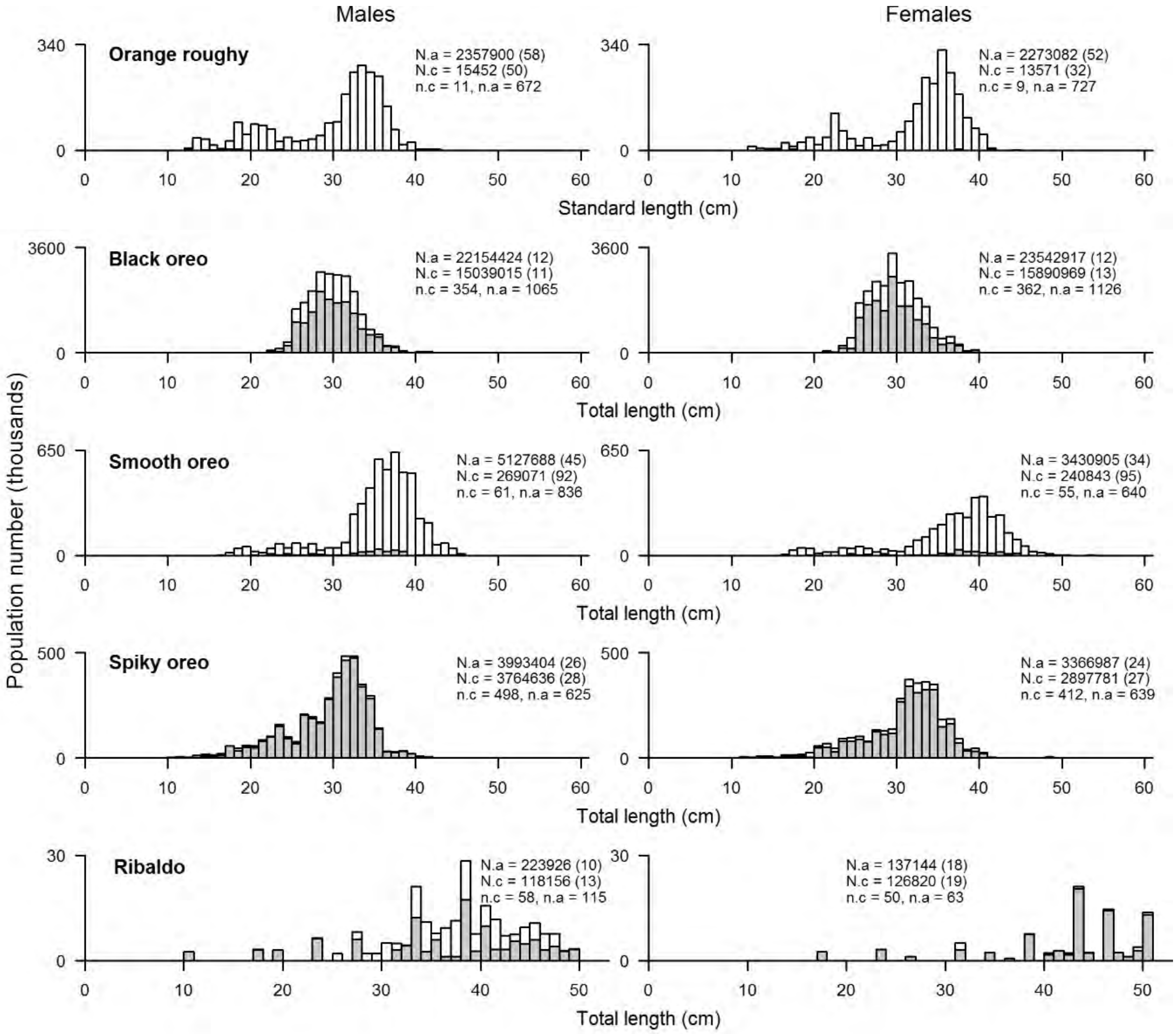


Figure 18b: Length frequencies of orange roughy, oreo species, and other selected deepwater species on the Chatham Rise 2016, scaled to population size by sex. M, estimated male population; F, estimated female population; CV, coefficient of variation of the estimated numbers of fish; n, number of fish measured. White bars show fish from all (200–1300 m) strata. Black bars show fish from core (200–800 m) strata.

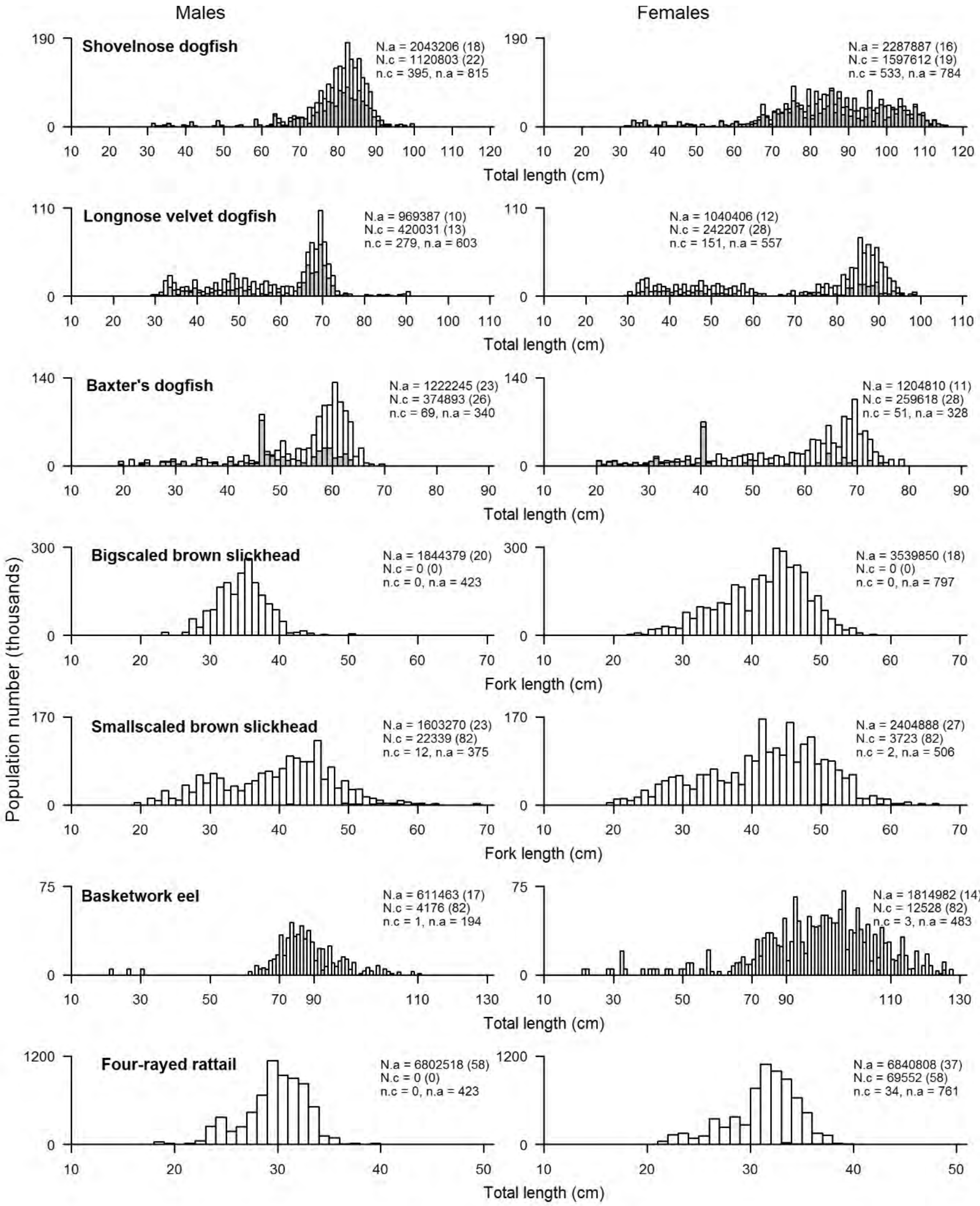


Figure 18b (continued)

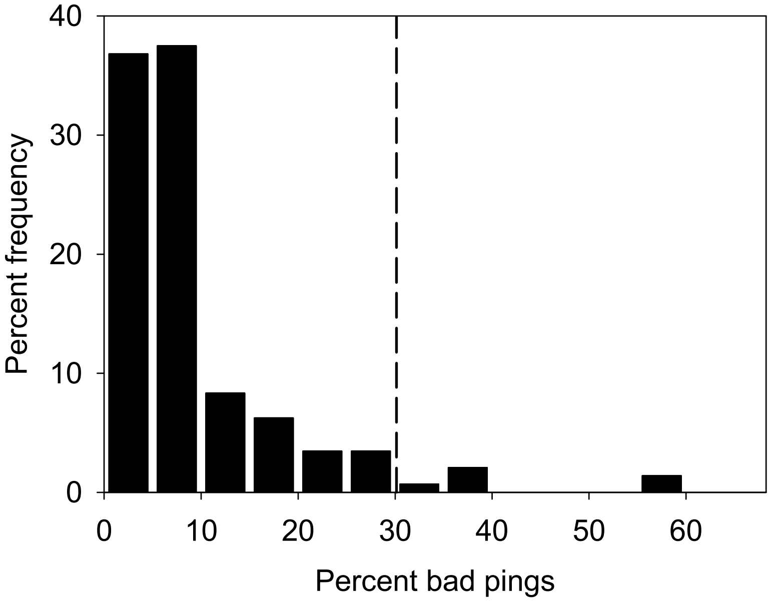


Figure 19: Percentage of bad pings in acoustic data from 2016 trawl survey. Only data with fewer than 30% bad pings (vertical dashed line) were analysed quantitatively.

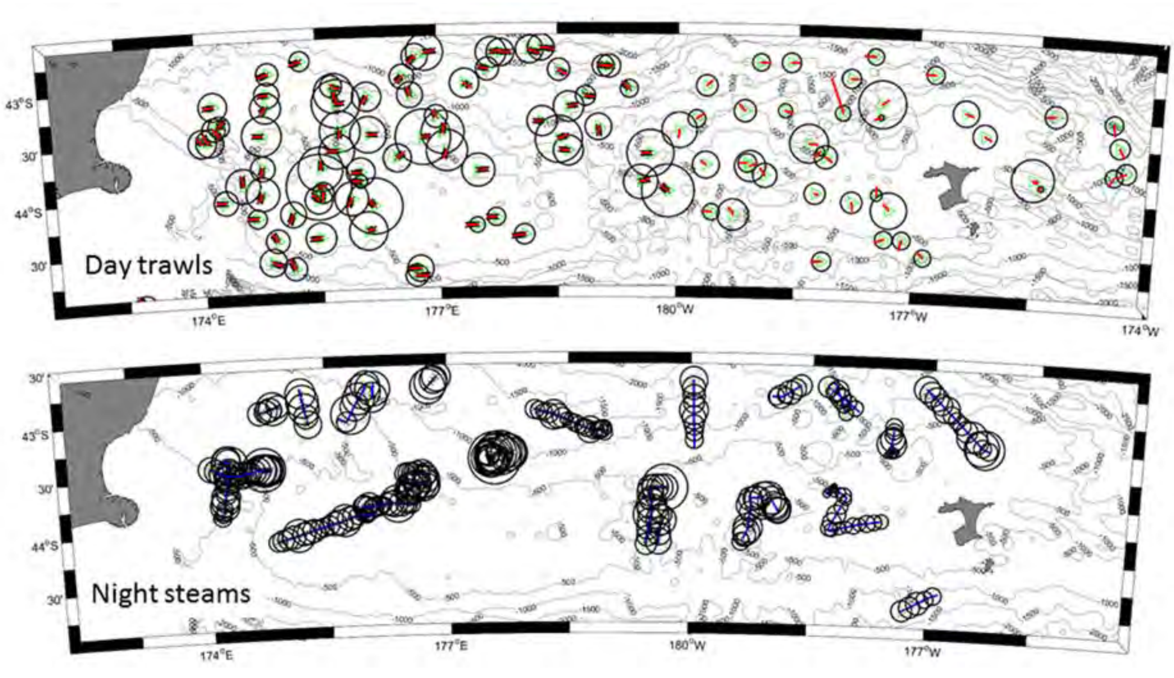


Figure 20: Distribution of total acoustic backscatter (open circles) observed on the Chatham Rise during daytime trawls (upper panel) and night-time steams (lower panel) throughout the entire survey area in January 2016. Circle area is proportional to the acoustic backscatter.

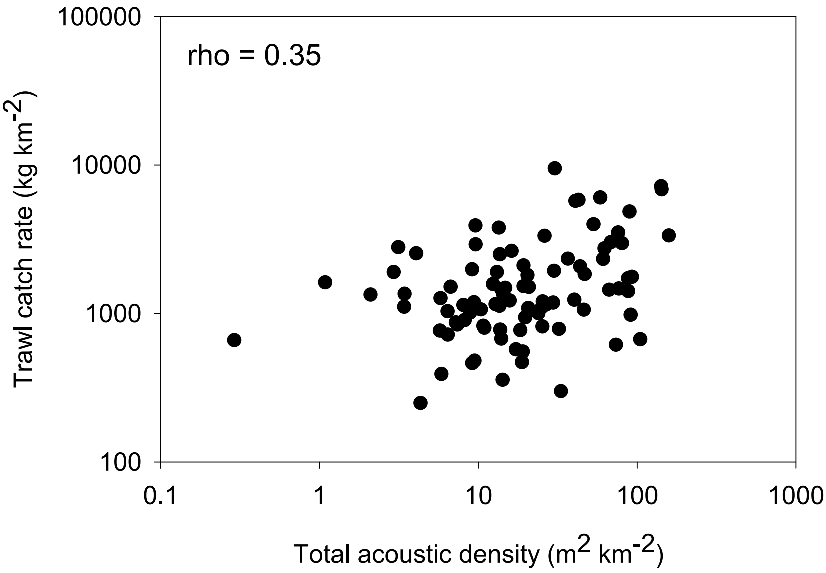


Figure 21: Relationship between total trawl catch rate (all species combined) and bottom-referenced acoustic backscatter recorded during the trawl on the Chatham Rise in 2016. Rho value is Spearman's rank correlation coefficient.

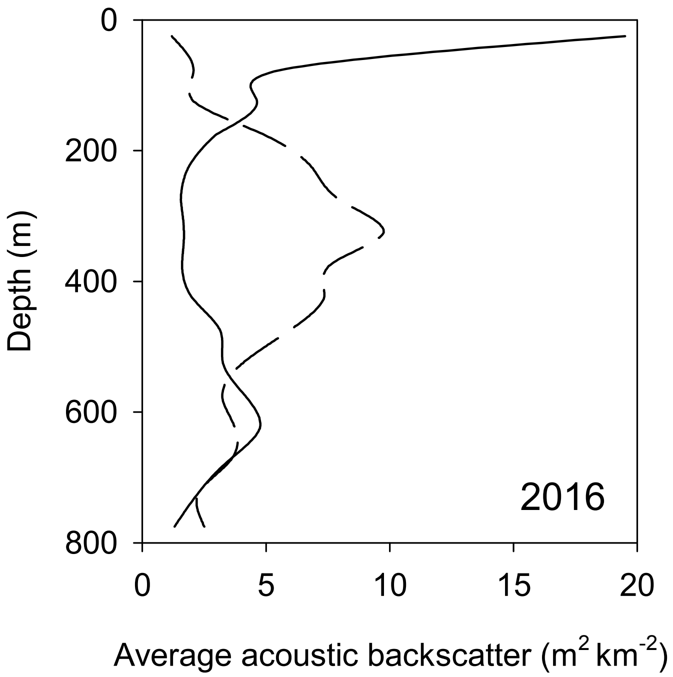


Figure 22: Vertical distribution of the average acoustic backscatter for the day (dashed lines) and at night (solid lines) for the Chatham Rise survey in 2016.

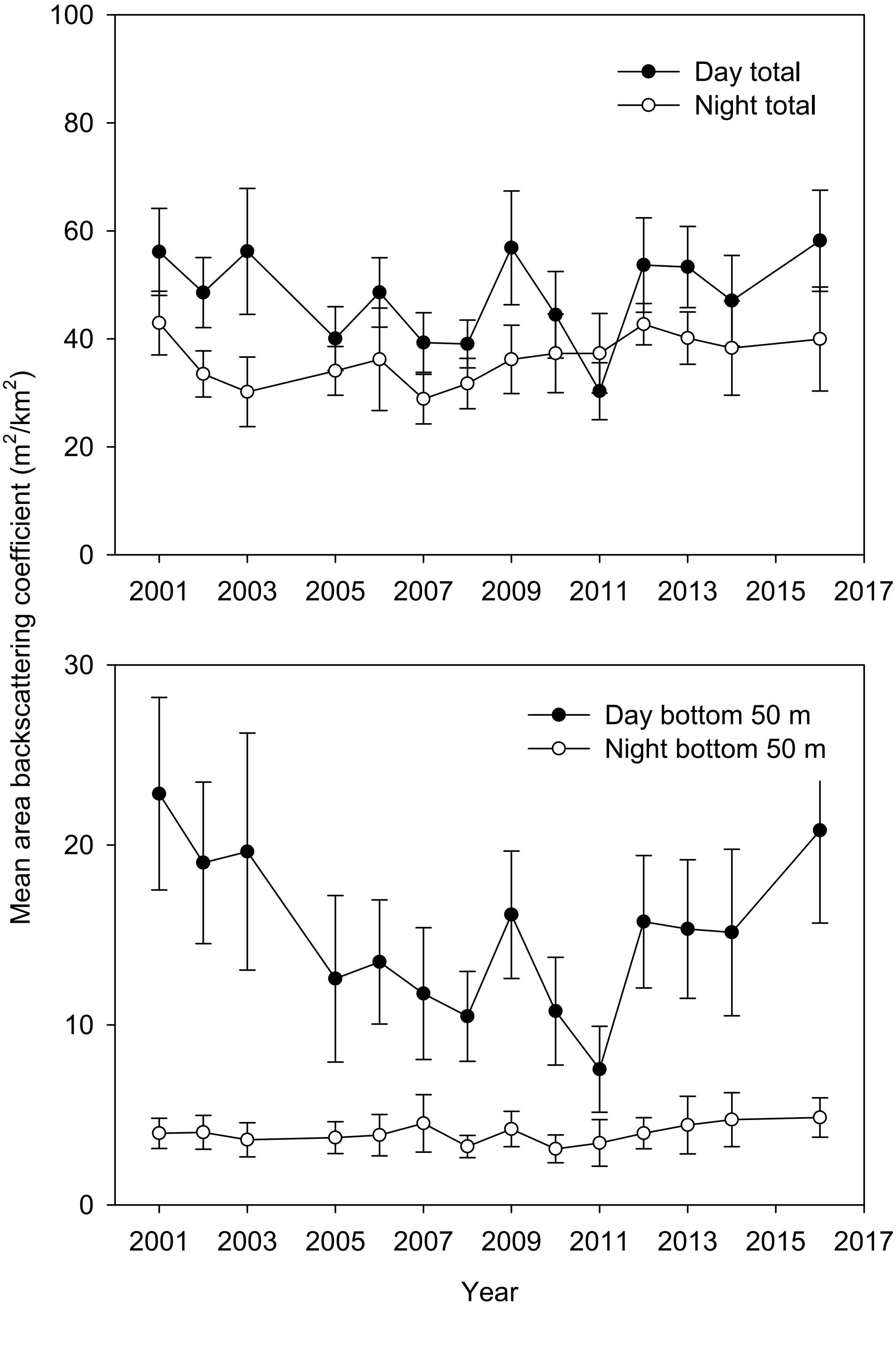


Figure 23: Comparison of relative acoustic abundance indices for the core Chatham Rise area based on (strata-averaged) mean areal backscatter. Error bars are ± 2 standard errors.

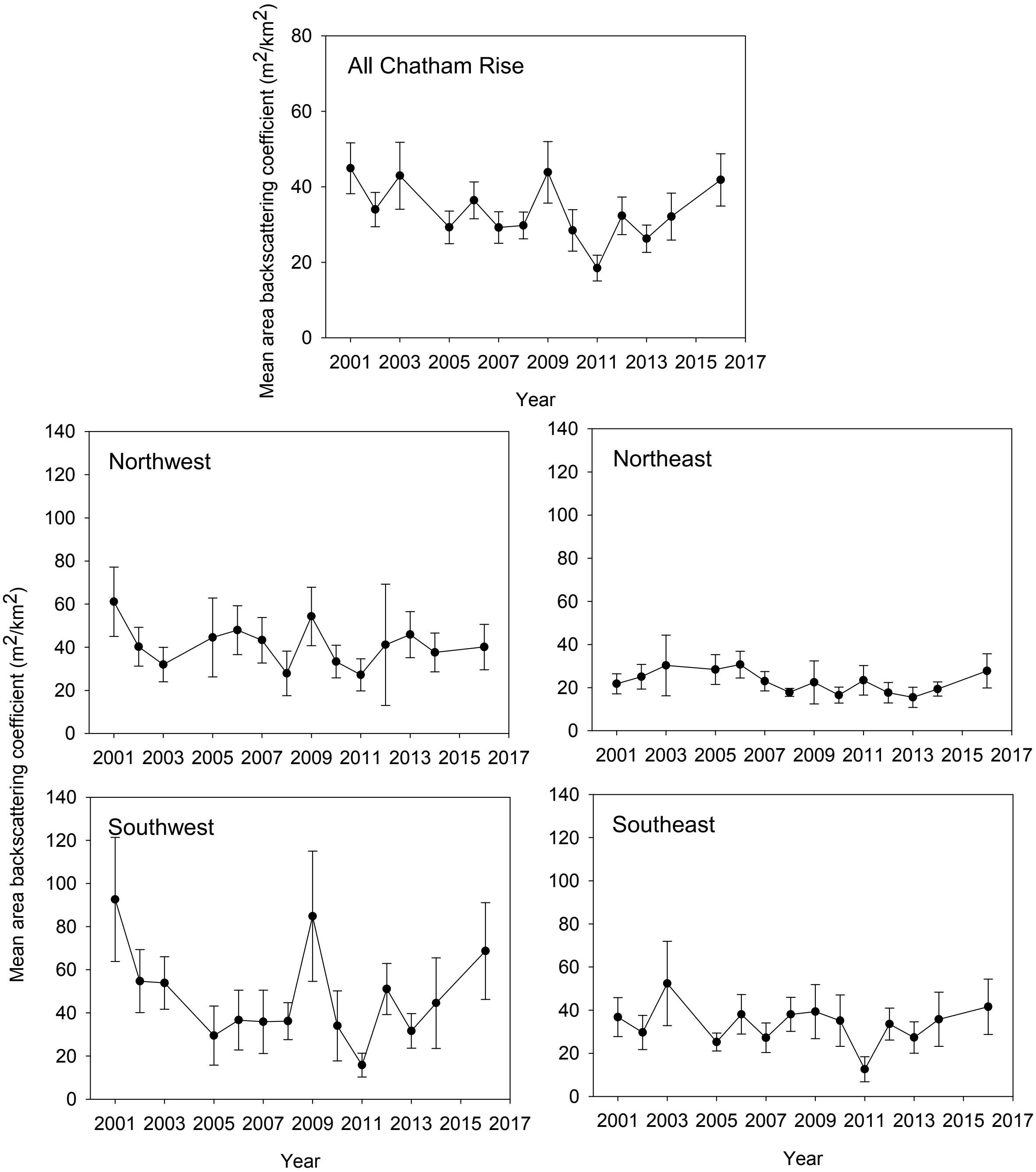


Figure 24: Relative acoustic abundance indices for mesopelagic fish on the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same sub-area observed in the upper 200 m corrected for 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.

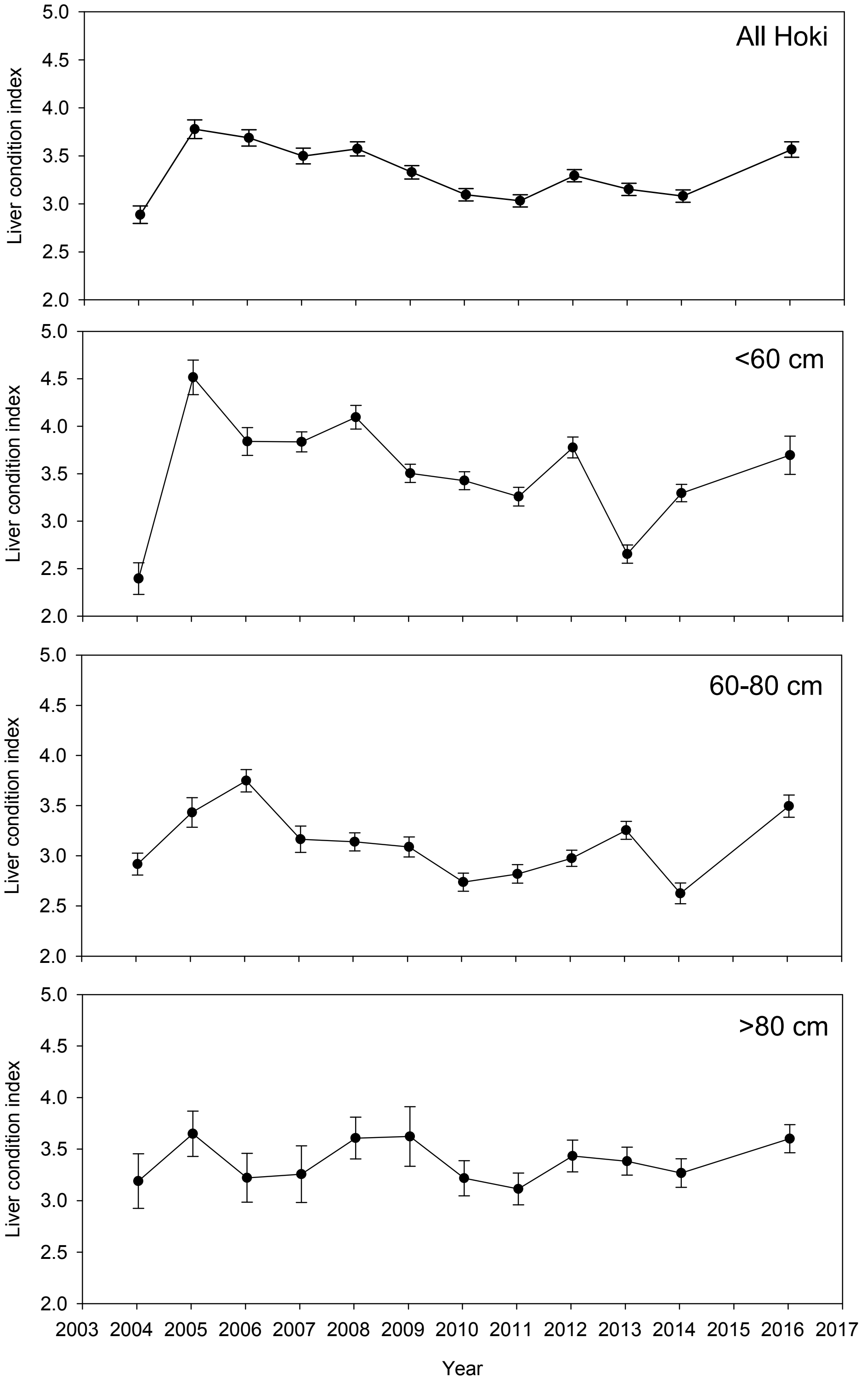


Figure 25: Time-series of hoki liver condition indices on the Chatham Rise from 2004–16. Data are plotted for all hoki, then three different size classes (<60 cm, 60–80 cm, and >80 cm). Error bars show ± 2 standard errors.

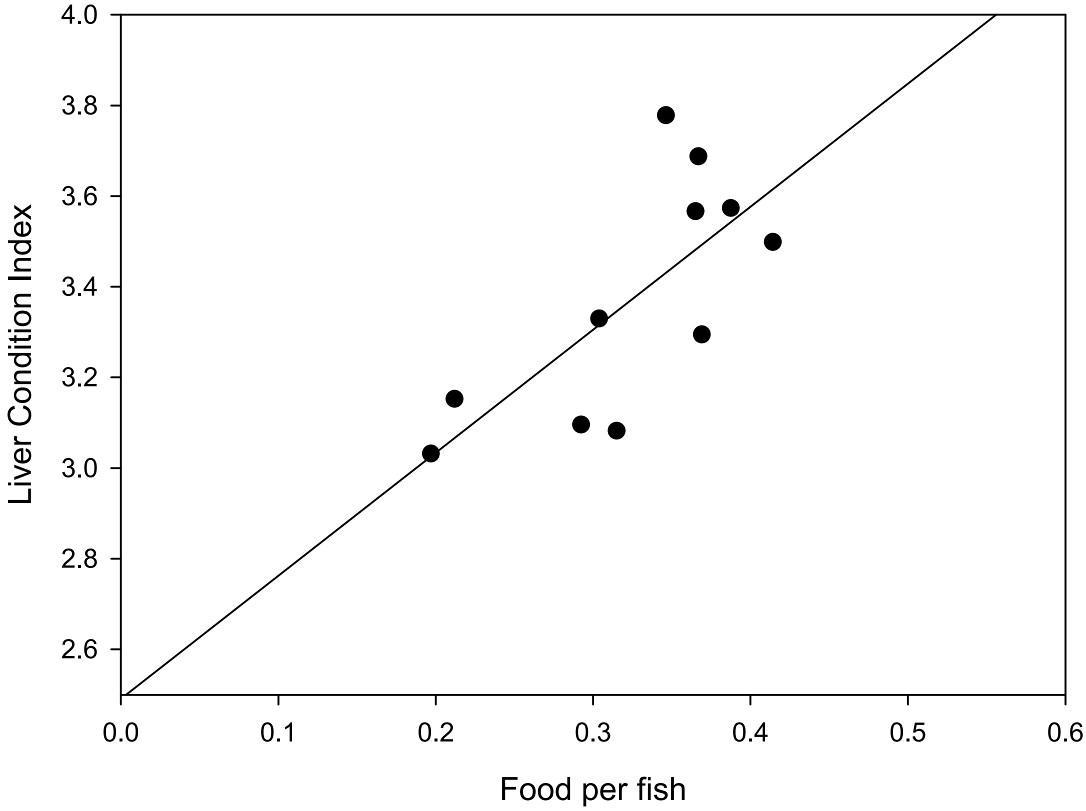


Figure 26: Correlation between hoki liver condition and the ratio between the acoustic estimate of mesopelagic fish abundance divided by the trawl estimate of hoki abundance (food per fish) for Chatham Rise surveys 2004–2016.

Appendix 1: Individual station data for all stations conducted during the survey (TAN1601). Stn., station number; P1, phase 1 trawl survey biomass tow; P2, phase 2 trawl survey biomass tow; Strat., Stratum number; *, foul trawl stations.

						Start tow		Gear	depth	Dist.			Catch
Stn.	Type	Strat.	Date	Time	Latitude	Longitude			m	Towed			kg
				NZST	° ' S	° '	E/W	min.	max.	n. mile	hoki	hake	ling
1	P1	2A	4-Jan-16	638	42 45.19	176 54.01	E	685	715	3.01	236.9	5.4	110.4
2	P1	2A	4-Jan-16	1206	42 45.84	177 43.48	E	766	791	3.03	133.5	0.4	0
3	P1	2A	4-Jan-16	1430	42 46.26	177 50.50	E	722	735	2.99	238.2	18.6	38.7
4	P1	22	4-Jan-16	1733	42 45.92	178 12.09	E	965	973	3.00	45.4	61.8	19.7
5	P1	23	4-Jan-16	2014	42 44.51	178 23.05	E	1169	1172	3.03	0	4.4	0
6	P1	23	4-Jan-16	2236	42 44.64	178 31.92	E	1240	1243	3.00	0	0	0
7	P1	23	5-Jan-16	128	42 47.31	178 45.80	E	1165	1173	3.03	0	0	0
8	P1	8B	5-Jan-16	506	42 56.97	178 32.68	E	489	530	3.02	375.1	32	128.4
9	P1	8B	5-Jan-16	827	43 15.87	178 39.82	E	413	414	3.01	796.3	0	111.3
10	P1	8B	5-Jan-16	1240	43 05.67	179 22.49	E	449	459	3.05	258.6	18.5	112.4
11	P1	22	5-Jan-16	1533	42 53.83	179 05.35	E	838	844	3.01	26.5	0	0
12	P1	22	5-Jan-16	1740	42 54.37	179 07.01	E	814	814	3.01	31.3	3.3	0
13	P1	22	5-Jan-16	2032	42 53.37	179 31.24	E	812	817	3.00	225.0	57.4	4.1
14	P1	23	5-Jan-16	2348	42 43.88	179 56.53	E	1197	1198	2.99	8.5	0	0
15	P1	10	6-Jan-16	620	43 30.02	179 58.52	W	400	405	3.01	1 350.8	19.0	152.2
16	P1	10	6-Jan-16	916	43 21.69	179 43.94	W	480	480	3.01	179.7	0	54.3
17	P1	10	6-Jan-16	1311	43 16.79	179 10.68	W	485	505	3.01	307.0	12.4	8.6
18	P1	10	6-Jan-16	1639	43 03.91	179 37.42	W	527	534	3.04	274.3	0	102.7
19	P1	21A	6-Jan-16	2028	42 43.29	179 12.74	W	954	964	3.00	53.6	78.1	0
20	P1	21A	7-Jan-16	55	42 44.67	178 33.40	W	836	846	3.08	97.7	0	3.1
21	P1	2B	7-Jan-16	509	42 51.46	178 55.65	W	627	644	3.02	348.2	56.1	37.2
22	P1	2B	7-Jan-16	748	42 51.23	178 33.29	W	605	606	3.01	415.7	35.4	58.7
23	P1	11	7-Jan-16	1158	43 17.70	178 37.76	W	344	436	3.03	467.5	5.8	38.3
24	P1	11	7-Jan-16	1509	43 35.14	178 19.14	W	400	405	3.01	1 503.8	0	103.7
25	P1	11	7-Jan-16	1839	43 20.42	177 52.41	W	433	438	3.00	99.4	0	7.8
*26	P1	21A	8-Jan-16	16	42 42.36	178 10.03	W	932	962	1.13	-	-	-
27	P1	21A	8-Jan-16	257	42 44.29	178 14.36	W	853	859	3.00	68.6	3.3	0
28	P1	11	8-Jan-16	655	42 58.95	177 49.51	W	520	522	2.96	678.2	0	43.1
29	P1	11	8-Jan-16	1028	43 12.22	178 05.78	W	445	450	3.00	150.3	3.9	93.3
30	P1	9	9-Jan-16	500	43 19.94	177 29.02	W	319	326	2.13	112.6	0	12.1
31	P1	11	9-Jan-16	710	43 11.70	177 25.70	W	400	425	3.01	871.5	9.0	102.6
32	P1	2B	9-Jan-16	1143	42 54.97	176 50.35	W	706	708	3.02	184.1	14.2	21.8
33	P1	24	9-Jan-16	1704	42 46.41	177 36.34	W	1011	1015	3.03	7.9	0	0
34	P1	24	9-Jan-16	2054	42 44.51	177 11.80	W	1102	1108	3.01	7.2	0	0
35	P1	11	10-Jan-16	457	43 15.72	176 22.05	W	408	410	3.01	297.2	0	59.9
36	P1	9	10-Jan-16	727	43 27.65	176 07.76	W	302	311	3.00	207.3	0	16.6
*37	P1	9	10-Jan-16	1139	43 50.09	175 29.87	W	313	319	0.50	-	-	-
38	P1	9	10-Jan-16	1642	43 52.83	175 26.53	W	226	291	3.02	5.8	0	7.4
39	P1	12	11-Jan-16	1029	43 43.29	175 24.59	W	487	527	3.01	482.1	0	42.2
40	P1	2B	11-Jan-16	1527	43 14.27	175 19.09	W	682	694	3.03	204.9	4.3	23.6
41	P1	21B	11-Jan-16	2033	43 08.15	174 38.90	W	870	875	3.01	36.0	8.4	0
42	P1	21B	11-Jan-16	2259	43 01.50	174 40.67	W	924	933	3.03	5.7	0	0
43	P1	24	12-Jan-16	135	43 02.89	174 23.11	W	1054	1090	3.01	0	0	0
44	P1	21B	12-Jan-16	525	43 18.84	174 32.22	W	844	848	3.02	31.2	3.3	0

Appendix 1: (continued)

			Start tow					Gear depth		Dist.	Catch		
Stn.	Type	Strat.	Date	Time	Latitude	Longitude			m	towed			kg
				NZST	° ' S	° '	E/W	min.	max.	n. mile	hoki	hake	ling
45	P1	25	12-Jan-16	756	43 30.81	174 25.56	W	830	834	3.00	58.5	0	0
46	P1	25	12-Jan-16	1034	43 43.13	174 23.59	W	828	843	3.05	57.1	8.9	0
47	P1	25	12-Jan-16	1238	43 46.72	174 31.47	W	823	831	3.05	45.5	0	7.3
48	P1	28	13-Jan-16	251	44 45.31	177 13.45	W	1199	1217	3.03	0	0	0
49	P1	4	13-Jan-16	650	44 33.62	176 53.20	W	648	682	3.01	315.5	23.8	117.3
50	P1	4	13-Jan-16	935	44 27.95	177 09.11	W	673	733	3.01	327.5	0	89.2
51	P1	4	13-Jan-16	1227	44 26.28	177 24.62	W	664	6979	3.07	260.4	0	26.6
52	P1	12	13-Jan-16	1558	44 08.82	177 19.84	W	408	414	3.02	307.6	0	98.7
53	P1	5	13-Jan-16	1810	44 00.24	177 28.91	W	363	377	3.01	318.7	0	52.4
54	P1	5	14-Jan-16	500	43 39.80	178 13.16	W	370	373	2.99	211.2	4.2	112.5
55	P1	5	14-Jan-16	704	43 42.64	178 06.61	W	374	378	3.02	1 576.2	2.9	108.1
56	P1	13	14-Jan-16	1007	43 59.08	178 13.48	W	443	460	3.03	500.2	25.4	208.9
57	P1	12	14-Jan-16	1333	44 07.58	177 47.12	W	483	493	3.00	444.8	3.9	148.5
58	P1	28	14-Jan-16	1924	44 38.87	178 12.37	W	1211	1214	3.01	2.3	0	0
59	P1	25	15-Jan-16	37	44 24.20	178 51.34	W	856	873	3.02	249.3	0	0
60	P1	28	15-Jan-16	448	44 28.05	179 05.86	W	1017	1028	3.04	8.6	0	0
61	P1	13	15-Jan-16	1544	44 12.87	179 36.24	W	551	598	2.97	126.6	0	59.2
*62	P1	13	15-Jan-16	1903	44 12.61	179 18.27	W	416	443	2.30	-	-	-
63	P1	13	16-Jan-16	502	43 51.68	178 54.76	W	405	413	3.02	205.0	0	103.7
64	P1	3	16-Jan-16	706	43 47.55	179 03.80	W	391	395	2.06	267.1	0	46.6
65	P1	3	16-Jan-16	901	43 46.32	179 08.41	W	369	385	3.00	108.1	13.2	57.8
66	P1	3	16-Jan-16	1208	43 46.92	179 39.55	W	356	362	2.13	302.0	0	16.6
67	P1	14	16-Jan-16	1541	44 01.12	179 51.31	E	492	507	3.02	135.4	0	78.1
68	P1	14	16-Jan-16	1823	43 56.65	179 34.44	E	509	516	3.00	294.9	0	64.2
*69	P1	26	16-Jan-16	2312	44 12.47	179 32.84	E	873	893	3.05	-	-	-
70	P1	14	17-Jan-16	502	43 41.44	179 38.10	E	413	418	3.02	828.5	20.3	75.7
*71	P1	29	17-Jan-16	1455	44 25.95	178 00.75	E	1198	1207	3.02	-	-	-
72	P1	29	17-Jan-16	1833	44 15.72	177 41.27	E	1055	1057	3.01	0	0	0
73	P1	26	17-Jan-16	2222	44 03.31	177 35.69	E	800	840	3.04	52.6	0	0
74	P1	26	18-Jan-16	222	44 08.00	177 22.41	E	841	884	3.03	88.5	0	10.9
75	P1	29	18-Jan-16	604	44 19.93	177 24.85	E	1155	1156	3.03	0	0	0
76	P1	29	18-Jan-16	1213	44 46.76	176 45.96	E	1261	1274	3.00	0	0	0
77	P1	29	18-Jan-16	1526	44 42.96	176 40.79	E	1200	1208	3.04	0	0	0
78	P1	26	18-Jan-16	2045	44 30.58	176 17.62	E	845	875	3.01	47.2	0	0
79	P1	27	19-Jan-16	210	44 35.92	175 43.82	E	809	833	3.02	44.1	0	0
80	P1	27	19-Jan-16	440	44 33.97	175 32.36	E	809	812	3.02	43.9	0	0
81	P1	17	19-Jan-16	827	44 21.55	176 06.78	E	317	347	2.22	5.6	0	1
82	P1	17	19-Jan-16	1102	44 07.82	176 09.99	E	341	350	3.02	1 962.1	0	31.5
83	P1	17	19-Jan-16	1326	44 05.24	175 52.71	E	324	334	2.99	507.0	0	14.3
84	P1	6	19-Jan-16	1708	44 25.07	175 26.67	E	672	683	3.02	310.7	0	57.8
85	P1	30	19-Jan-16	2357	45 07.25	174 44.95	E	1038	1070	3.02	0	0	0
86	P1	27	20-Jan-16	305	44 55.36	174 38.03	E	873	873	3.03	69.3	0	0
87	P1	27	20-Jan-16	902	44 38.04	174 54.56	E	800	834	3.00	64.0	0	0
88	P1	6	20-Jan-16	1141	44 39.24	175 07.36	E	759	785	3.00	64.7	0	0
89	P1	6	20-Jan-16	1445	44 24.28	174 54.79	E	612	642	3.05	1 463.6	13.8	125.9
90	P1	30	20-Jan-16	2326	44 55.93	173 36.09	E	1159	1170	2.99	5.6	0	0
91	P1	30	21-Jan-16	328	45 07.97	173 24.43	E	1272	1279	3.02	0	0	0

Appendix 1: (continued)

					Start tow			Gear	depth	Dist.			Catch
Stn.	Type	Strat.	Date	Time	Latitude	Longitude			m	towed			kg
				NZST	° ' S	° '	E/W	min.	max.	n. mile	hoki	hake	ling
92	P1	30	21-Jan-16	654	44 54.37	173 09.48	E	1123	1153	2.52	0	0	0
93	P1	7A	21-Jan-16	1640	43 29.54	174 01.25	E	415	427	2.22	2 209.9	0	56.0
94	P1	22	21-Jan-16	2036	43 02.06	174 03.85	E	908	969	3.02	37.9	12.0	0
95	P1	22	21-Jan-16	2254	42 58.95	174 15.07	E	977	984	2.99	76.7	19.9	0
96	P1	1	22-Jan-16	509	42 55.37	174 50.98	E	733	743	3.03	112.6	0	33.0
97	P1	7A	22-Jan-16	743	43 06.16	174 50.67	E	447	480	3.01	2 925.1	153.7	177.1
98	P1	7A	22-Jan-16	743	43 06.16	174 50.67	E	447	480	3.01	6 243.9	5.6	92.1
99	P1	1	22-Jan-16	1349	43 11.30	174 09.36	E	606	612	3.01	478.2	0	64.3
100	P1	7A	22-Jan-16	1628	43 24.71	174 13.10	E	558	566	3.01	118.8	2.6	50.9
101	P1	1	22-Jan-16	1857	43 28.68	174 05.46	E	690	701	2.36	157.6	26.7	40.4
102	P1	18	23-Jan-16	503	43 28.15	174 45.38	E	349	372	3.02	960.0	0	10.9
103	P1	16	23-Jan-16	803	43 47.16	174 46.60	E	477	482	3.01	1 672.2	13.0	73.5
104	P1	16	23-Jan-16	1024	44 00.79	174 45.40	E	493	510	3.01	4 947.5	21.9	66.0
105	P1	16	23-Jan-16	1515	43 57.06	175 30.49	E	472	480	2.49	2 280.5	4.7	84.1
106	P1	18	23-Jan-16	1734	43 45.89	175 30.92	E	353	377	2.24	1 658.2	0	16.3
107	P1	22	24-Jan-16	1842	42 49.32	175 15.14	E	835	840	3.01	118.4	12.4	0
108	P1	22	24-Jan-16	2128	42 46.47	175 24.67	E	895	903	3.01	49.4	21.2	0
109	P1	22	25-Jan-16	43	42 45.00	175 55.13	E	830	835	3.01	150.9	6.1	4.3
110	P1	7B	25-Jan-16	502	43 03.08	175 42.55	E	477	479	3.02	146.8	8.6	96.6
111	P1	7B	25-Jan-16	656	43 07.71	175 42.54	E	442	450	3.02	395.6	10.3	106.5
112	P1	7B	25-Jan-16	845	43 12.06	175 45.02	E	425	445	3.02	1 489.7	212.0	109.5
113	P1	18	25-Jan-16	1138	43 28.33	175 46.07	E	280	307	2.20	1 902.6	0	0
114	P1	18	25-Jan-16	1342	43 38.00	175 41.02	E	280	295	3.01	3 490.1	0	0
115	P1	19	25-Jan-16	1721	43 29.55	176 09.02	E	369	381	3.04	440.6	8.5	165.1
116	P1	15	26-Jan-16	502	43 41.78	176 30.57	E	405	406	2.66	511.8	7.6	114.6
117	P1	19	26-Jan-16	734	43 31.45	176 50.19	E	265	276	2.26	6 240.0	0	0
118	P1	19	26-Jan-16	930	43 28.20	177 03.79	E	243	255	3.00	179.2	0	0
119	P1	19	26-Jan-16	1133	43 19.65	176 58.07	E	245	247	2.06	5.0	0	0
120	P1	19	26-Jan-16	1407	43 07.45	176 38.80	E	319	357	3.00	698.9	14.4	90.1
121	P1	19	26-Jan-16	1737	43 09.85	176 05.87	E	379	392	3.00	563.8	0	57.9
122	P1	22	26-Jan-16	2205	42 41.49	176 10.26	E	872	884	3.02	120.2	0	6.7
123	P1	22	27-Jan-16	148	42 41.03	176 47.01	E	954	956	3.03	10.2	9.2	0
124	P1	8A	27-Jan-16	517	42 49.00	176 41.40	E	467	514	3.05	453.2	6.6	25.7
125	P1	8A	27-Jan-16	732	42 59.25	176 32.70	E	428	438	3.01	286.7	45.7	71.8
126	P1	19	27-Jan-16	1235	43 03.20	177 21.50	E	299	306	3.00	1 312.4	0	17.8
127	P1	8A	27-Jan-16	1522	42 54.81	177 35.92	E	405	423	3.04	207.6	30.1	52.7
128	P1	20	28-Jan-16	501	43 10.50	178 52.71	E	372	392	3.04	336.7	15.3	151.2
129	P1	20	28-Jan-16	756	43 28.34	179 00.79	E	365	375	3.01	214.7	0	100.1
130	P1	20	28-Jan-16	1110	43 39.90	178 36.17	E	388	396	3.03	4 906.1	0	92.4
131	P1	20	28-Jan-16	1313	43 33.22	178 32.44	E	348	362	3.00	946.8	0	70.4
132	P1	20	28-Jan-16	1614	43 23.88	178 16.03	E	335	344	2.47	588.3	0	30.0
133	P1	20	29-Jan-16	502	43 24.40	177 30.51	E	283	303	2.56	5 888.2	0	1.9
134	P1	15	29-Jan-16	859	43 40.23	177 05.69	E	411	475	3.02	1 626.9	38.5	160.7
135	P1	15	29-Jan-16	1226	43 50.08	177 31.99	E	557	563	3.00	357.8	0	88.3
136	P2	16	30-Jan-16	505	43 49.81	175 59.07	E	454	462	3.01	1 670.7	14.7	112.5
137	P2	16	30-Jan-16	757	43 56.48	175 37.44	E	486	493	3.02	1 315.0	9.8	175.8

Appendix 1: (continued)

Stn.	Type	Strat.	Start tow Date	Time NZST	Latitude ° ' S	Longitude ° '	E/W	Gear depth (m) min.	max.	Dist. Towed n. mile	Catch (kg) hoki	hake	ling
138	P2	16	30-Jan-16	1015	44 03.18	175 27.11	E	495	512	3.04	545.2	0	150.5
139	P2	16	30-Jan-16	1324	44 13.00	175 07.70	E	534	559	2.99	987.4	0	155.8
*140	P2	16	30-Jan-16	1646	44 12.94	174 38.80	E	569	578	2.92	-	-	-
141	P2	16	31-Jan-16	503	43 54.89	175 59.03	E	514	546	3.04	465.2	0	163.5
142	P2	16	31-Jan-16	814	44 01.62	175 31.85	E	502	524	2.74	694.6	3.6	94.4
143	P2	16	31-Jan-16	1342	43 53.19	174 31.40	E	546	548	3.04	890.1	39.4	86.4
144	P2	16	31-Jan-16	1649	44 03.71	174 16.06	E	552	566	3.01	355.0	10.9	44.1
145	P2	7A	1-Feb-16	516	43 20.87	174 17.24	E	576	584	3.02	130.5	16.9	88.0

Appendix 2: Scientific and common names of species caught from all valid biomass tows (TAN1601). The occurrence (Occ.) of each species (number of tows caught) in the 139 valid biomass 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	5
Porifera	unspecified sponges	ONG	1
Demospongiae (siliceous sponges)			
Astrophorida (sandpaper sponges)			
Ancorinidae			
Ecionemia novaezelandiae	knobbly sandpaper sponge	ANZ	1
Pachastrellidae			
Poecillastra laminaris	chipped fibreglass matt sponge	PLN	
Hadromerida (woody sponges)			
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	8
Haplosclerida (air sponges)			
Callyspongiidae			
Callyspongia cf. *ramosa*	airy finger sponge	CRM	1
Spirophorida (spiral sponges)			
Tetillidae			
Tetilla australe	bristle ball sponge	TTL	5
T. leptoderma	furry oval sponge	TLD	1
Hexactinellida (glass sponges)	unspecified glass sponge	GLS	1
Lyssacinosida (tubular sponges)			
Euplectellidae			
Euplectella regalis	Basket-weave horn sponge	ERE	6
Rossellidae			
Hyalascus sp.	floppy tubular sponge	HYA	32
Poecilosclerida (bright sponges)			
Coelosphaeridae			
Lissodendoryx bifacialis	floppy chocolate plate sponge	LBI	1
Cnidaria			
Scyphozoa	unspecified jellyfish	JFI	40
Anthozoa			
Octocorallia			
Alcyonacea (soft corals)	unspecified soft coral	SOC	5
Isididae			
Keratoisis spp.	branching bamboo coral	BOO	1
Lepidisis spp.	bamboo coral	LLE	2
Pennatulacea (sea pens)	unspecified sea pens	PTU	5
Umbellulidae			
Umbellula spp.	sea pens	UMB	1
Hexacorallia			
Zoanthidea (zoanthids)			
Epizoanthidae			
Epizoanthus sp.		EPZ	6
Corallimorpharia (coral-like anemones)			
Corallimorphidae			
Corallimorphus spp.	coral-like anemone	CLM	1
Actinaria (anemones)	unspecified anemone	ANT	8
Actiniidae			
Bolocera spp.	deepsea anemone	BOC	3
Actinostolidae (smooth deepsea anemones)		ACS	28
Hormathiidae (warty deepsea anemones)		HMT	20
Liponematidae			
Liponema spp.	deepsea anemone	LIP	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Scleractinia (stony corals)			
Caryophyllidae			
Goniocorella dumosa	bushy hard coral	GDU	2
Stephanocyathus platypus	solitary bowl coral	STP	1
Flabellidae			
Flabellum spp.	flabellum coral	COF	12
Hydrozoa			
Anthoathecata (hydroids)	unspecified hydroids	HDR	1
Stylasteridae			
Lepidotheca spp.		LPT	1
Ascidiacea	unspecified sea squirt	ASC	1
Tunicata			
Thaliacea (salps)	unspecified salps	SAL	2
Salpidae			
Pyrosoma atlanticum		PYR	43
Soestia zonaria		ZZO	1
Mollusca			
Gastropoda (gastropods)	unspecified gastropods	GAS	3
Ranellidae (tritons)			
Fusitriton magellanicus		FMA	27
Volutidae (volutes)			
Provocator mirabilis	golden volute	GVO	7
Cephalopoda			
Sepiolida (bobtail squids)			
Sepiadariidae			
Sepioloidea spp.	bobtail squid	SSQ	3
Teuthoidea (squids)			
Octopoteuthidae			
Octopoteuthis sp. 1 NZ		OPO	2
Taningia spp.		TDQ	1
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	69
O. robsoni	warty squid	MRQ	8
Pholidoteuthidae			
Pholidoteuthis sp. 1 NZ	large red scaly squid	PSQ	1
Histioteuthidae (violet squids)			
Histioteuthis atlantica	violet squid	HAA	4
Histioteuthis spp.	violet squid	VSQ	8
Ommastrephidae	unspecified ommastrephid	OMQ	1
Nototodarus sloanii	Sloan's arrow squid	NOS	56
Todarodes filippovae	Todarodes squid	TSQ	60
Chiroteuthidae			
Chiroteuthis veryani	squid	CVE	2
Mastigoteuthidae			
Idioteuthis cordiformis	whip-lash squid	ICQ	1
Mastigoteuthis agassizzi	whip-lash squid	MAG	1
Mastigoteuthis spp.	whip-lash squid	MSQ	1
Cranchiidae	unspecified cranchiid	CHQ	1
Galiteuthis suhmi	squid	GAI	2
Galiteuthis spp.	squid	GAI	6
Teuthowenia pellucida	squid	TPE	10

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Incirrata (incirrate octopus)			
Amphitretidae			
Amphitretis spp.	deepwater octopus	AMP	1
Vitreledonella richardi	glass octopus	VRI	1
Octopodidae			
Benthoctopus tangaroa	octopus	BNO	1
Enteroctopus zealandicus	yellow octopus	EZE	1
Graneledone taniwha taniwha	deepwater octopus	GTA	4
Octopus mernoo	octopus	OME	1
Thaumeledone zeiss	deepwater octopus	TZE	2
Polychaeta			
Eunicida			
Eunicidae			
Eunice spp.	Eunice sea worm	EUN	1
Phyllodocida			
Aphroditidae			
Aphrodita spp.	sea mouse	ADT	1
Pycnogonida	unspecified sea spider	PYC	1
Crustacea			
Malacostraca			
Dendrobranchiata			
Aristeidae			
Aristaeomorpha foliacea	royal red prawn	AFO	1
Aristeus sp.	deepwater prawn	ARI	2
Sergestidae			
Sergia potens	deepwater prawn	SEP	2
Pleocyemata			
Caridea			
Oplophoridae			
Acanthephyra spp.	SubAntarctic ruby prawn	ACA	8
Oplophorus novaezeelandiae	deepwater prawn	ONO	1
Pasiphaeidae			
Pasiphaea barnardi	deepwater prawn	PBA	19
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	33
Achelata			
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	32
Palinura			
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	3
Crab (unspecified anomuran + brachyuran crab)		CRB	1
Anomura			
Galatheoidea			
Galatheidae (galatheid squat lobsters)			
Munida gracilis	squat lobster	MGA	1
Lithodidae (king crabs)			
Lithodes aotearoa	New Zealand king crab	LAO	2
L. robertsoni	Robertson's king crab	LRO	2
Neolithodes brodiei	Brodie's king crab	NEB	2
Paralomis zealandica	Prickly king crab	PZE	2

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Paguroidea (unspecified hermit crabs)		PAG	6
Paguridae (Pagurid hermit crabs)			
Diacanthurus rubricatus	hermit crab	DIR	6
Parapaguridae (Parapagurid hermit crabs)			
Sympagurus dimorphus	hermit crab	SDM	9
Brachyura (true crabs)			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	14
Homolidae			
Dagnaudus petterdi	antlered crab	DAP	4
Inachidae			
Vitjazmaia latidactyla	deepsea spider crab	VIT	4
Majidae (spider crabs)			
Leptomithrax garricki	Garrick's masking crab	GMC	1
Teratomaia richardsoni	spiny masking crab	SMK	8
Portunidae (swimming crabs)			
Nectocarcinus bennetti	smooth red swimming crab	NCB	1
Ovalipes molleri	swimming crab	OVM	1
Echinodermata			
Asteroidea (starfish)	unspecified starfish	ASR	2
Asteriidae			
Cosmasterias dyscrita	cat's-foot star	CDY	1
Pseudechinaster rubens	starfish	PRU	2
Sclerasterias mollis	cross-fish	SMO	4
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	13
Plutonaster knoxi	abyssal star	PKN	23
Proserpinaster neozelanicus	starfish	PNE	10
Psilaster acuminatus	geometric star	PSI	33
Benthopectinidae			
Benthopecten spp.	starfish	BES	3
Brisingida	unspecified Brisingid	BRG	14
Echinasteridae			
Henricia compacta	starfish	HEC	3
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	4
Hippasteria phrygiana	trojan starfish	HTR	8
Lithosoma novaezelandiae	rock star	LNV	8
Mediaster sladeni	starfish	MSL	10
Pillsburiaster aoteanus	starfish	PAO	4
Solasteridae			
Crossaster multispinus	sun star	CJA	12
Solaster torulatus	chubby sun-star	SOT	5
Pterasteridae			
Diplopteraster sp.	starfish	DPP	2
Hymenaster carnosus	starfish	HYC	1
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	43
Ophiuroidea (basket and brittle stars)	unspecified brittle star	OPH	3
Ophiodermatiae			
Bathypectinura heros	deepsea brittle star	BHE	1
Ophiuridae			
Ophiomusium lymani	brittle star	OLY	4
Euryalina (basket stars)			
Gorgonocephalidae			
Gorgonocephalus spp.	Gorgon's head basket stars	GOR	2

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Echinoidea (sea urchins)			
Regularia			
Cidaridae (cidarid urchins)			
Goniocidaris parasol	parasol urchin	GPA	8
Echinothuriidae/Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	49
Phormosomatidae			
Phormosoma spp.		PHM	8
Echinidae			
Gracilechinus multidentatus	deepsea kina	GRM	16
Spatangoida (heart urchins)			
Spatangidae			
Paramaretia peloria	Microsoft mouse	PMU	5
Spatangus multispinus	purple-heart urchin	SPT	13
Holothuroidea	unspecified holothurian	HTH	4
Aspidochirotida			
Synallactidae			
Bathyplotes sp.	sea cucumber	BAM	5
Pseudostichopus mollis	sea cucumber	PMO	30
Elasipodida			
Laetmogonidae			
Laetmogone sp.	sea cucumber	LAG	9
Pannychia moseleyi	sea cucumber	PAM	7
Pelagothuridae			
Enypniastes exima	sea cucumber	EEX	8
Psychropotidae			
Benthodytes sp.	sea cucumber	BTD	5
Brachiopoda (lamp shells)	unspecified lamp shell	BPD	1
Agnatha (jawless fishes)			
Myxinidae: hagfishes			
Eptatretus cirrhatus	hagfish	HAG	4
Chondrichthyes (cartilaginous fishes)			
Chlamydoselachidae: frilled sharks			
Chlamydoselachus anguineus	frill shark	FRS	2
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	2
Squalidae: dogfishes			
Squalus acanthias	spiny dogfish	SPD	63
S. griffini	northern spiny dogfish	NSD	7
Centrophoridae: gulper sharks			
Centrophorus squamosus	leafscale gulper shark	CSQ	27
Deania calcea	shovelnose spiny dogfish	SND	57
Etmopteridae: lantern sharks			
Etmopterus baxteri	Baxter's dogfish	ETB	52
E. lucifer	lucifer dogfish	ETL	61
Somniosidae: sleeper sharks			
Centroscymnus crepidater	longnose velvet dogfish	CYP	41
C. owstoni	smooth skin dogfish	CYO	28
Proscymnodon plunketi	Plunket's shark	PLS	8
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	15
Dalatiidae: kitefin sharks			
Dalatias licha	seal shark	BSH	30

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Scyliorhinidae: cat sharks			
Apristurus spp.	catshark	APR	32
Bythaelurus dawsoni	Dawson's catshark	DCS	1
Cephaloscyllium isabellum	carpet shark	CAR	2
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	11
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	2
Narkidae: blind electric rays			
Typhlonarke aysoni	blind electric ray	TAY	1
T. tarakea	oval electric ray	TTA	1
T. spp.	numbfish	BER	6
Rajidae: skates			
Amblyraja hyperborea	deepwater spiny (Arctic) skate	DSK	3
Bathraja shuntovi	longnosed deepsea skate	PSK	8
Brochiraja asperula	smooth deepsea skate	BTA	18
B. spinifera	prickly deepsea skate	BTS	3
Dipturus innominatus	smooth skate	SSK	38
Zearaja nasuta	rough skate	RSK	4
Chimaeridae: chimaeras, ghost sharks			
Chimaera carophila	brown chimaera	CHP	8
Hydrolagus bemisi	pale ghost shark	GSP	93
H. homonycteris	black ghost shark	HYB	1
H. novaezealandiae	dark ghost shark	GSH	52
H. trolli	pointynose blue ghost shark	HYP	1
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	longnose spookfish	LCH	66
Rhinochimaera pacifica	Pacific spookfish	RCH	27
Osteichthyes (bony fishes)			
Halosauridae: halosaurs			
Halosaurus pectoralis	common halosaur	HPE	3
Notocanthidae: spiny eels			
Notacanthus chemnitzi	giant spineback	NOC	2
N. sexspinis	spineback	SBK	74
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	35
Simenchelys parasitica	snubnosed eel	SNE	1
Synaphobranchus affinis	grey cutthroat eel	SAF	1
Nemichthyidae: snipe eels			
Avocettina spp.	black snipe eel	AVO	1
Congridae: conger eels			
Bassanago bulbiceps	swollenhead conger	SCO	48
B. hirsutus	hairy conger	HCO	44
Serrivomeridae: sawtooth eels			
Serrivomer spp.	sawtooth eel	SAW	2
Gonorynchidae: sandfish			
Gonorynchus forsteri & *G. greyi*	sandfishes	GON	3
Argentinidae: silversides			
Argentina elongata	silverside	SSI	61
Bathylagidae: deepsea smelts			
Bathylagichthys spp.	grey pencilsmelts	BAH	3
Melanolagus bericoides	bigscale blacksmelt	MEB	6
Platytroctidae: tubeshoulders			
Persparsia kopua	tubeshoulder	PER	3

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Alepocephalidae: slickheads			
Alepocephalus antipodianus	smallscaled brown slickhead	SSM	29
A. australis	bigscaled brown slickhead	SBI	24
Talismania longifilis	slickhead	TAL	1
Xenodermichthys spp.	black slickhead	BSL	18
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	4
Photichthyidae: lighthouse fishes			
Phosichthys argenteus	lighthouse fish	PHO	25
Stomiidae: barbeled dragonfishes			
Chauliodus sloani	viperfish	CHA	15
Idiacanthus spp.	black dragonfish	IDI	5
Malacosteus australis	southern loosejaw	MAU	3
Melanostomias spp.	scaleless black dragonfishes	MEN	3
Opostomias micripnus	giant black dragonfish	OMI	3
Stomias spp.		STO	5
Astronesthidae: snaggletooths	unspecified snaggletooth	AST	2
Astronesthes spp.		ASE	1
Borostomias antarcticus		BAN	5
B. mononema		BMO	1
Neonesthes microcephalus		NMI	1
Chlorophthalmidae: cucumberfishes, tripodfishes			
Paraulopus nigripinnis	cucumber fish	CUC	1
Scopelarchidae: pearleyes			
Scopelarchoides kreffti	Krefft's pearleye	SKR	1
Notosudidae: waryfishes			
Scopelosaurus spp.		SPL	3
Paralepididae: barracudinas			
Macroparalepis macrugeneion		MMA	1
Magnisudis prionosa	giant barracudina	BCA	1
Myctophidae: lanternfishes	unspecified lanternfish	LAN	9
Diaphus danae	dana lanternfish	DDA	5
Electrona paucirastra	belted lanternfish	EPA	1
Gymnoscopelus hintonoides	false-midas lanternfish	GYH	1
G. piabilis	southern blacktip lanternfish	GYP	3
Lampadena notialis	notal lanternfish	LNT	1
L. speculigera	mirror lanternfish	LSP	1
Lampanyctus australis	austral lanternfish	LAU	4
L. intricarius	intricate lanternfish	LIT	16
Nannobrachium achirus	cripplefin lanternfish	LAC	3
Symbolophorus boops	bogue lanternfish	SBP	3
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	11
Halargyreus spp.	'Johnson's' cod	HJO	49
Lepidion microcephalus	small-headed cod	SMC	31
Mora moro	ribaldo	RIB	43
Notophycis marginata	dwarf cod	DCO	8
Pseudophycis bachus	red cod	RCO	28
P. barbata	southern bastard cod	SBR	1
Moridae: morid cods (cont)			
Tripterophycis gilchristi	grenadier cod	GRC	2
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	19
Merlucciidae: hakes			
Lyconus spp.	lyconus	LYC	2
Macruronus novaezelandiae	hoki	HOK	127
Merluccius australis	hake	HAK	61

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Macrouridae: rattails, grenadiers			
Coelorinchus acanthiger	spotty faced rattail	CTH	4
C. aspercephalus	oblique banded rattail	CAS	46
C. biclinozonalis	two saddle rattail	CBI	10
C. bollonsi	Bollons’s rattail	CBO	93
C. fasciatus	banded rattail	CFA	45
C. innotabilis	notable rattail	CIN	52
C. kaiyomaru	Kaiyomaru rattail	CKA	13
C. matamua	Mahia rattail	CMA	19
C. oliverianus	Oliver's rattail	COL	64
C. parvifasciatus	small banded rattail	CCX	17
C. trachycarus	roughhead rattail	CHY	11
Coryphaenoides dossenus	humpback rattail	CBA	8
C. murrayi	Murray’s rattail	CMU	6
C. serrulatus	serrulate rattail	CSE	37
C. striaturus	striate rattail	CTR	2
C. subserrulatus	four-rayed rattail	CSU	47
Gadomus aoteanus	filamentous rattail	GAO	3
Lepidorhynchus denticulatus	javelinfish	JAV	116
Lucigadus nigromaculatus	blackspot rattail	VNI	32
Macrourus carinatus	ridge scaled rattail	MCA	28
Mesobius antipodum	black javelinfish	BJA	15
Nezumia namatahi		NNA	5
Trachonurus gagates	velvet rattail	TRX	2
Trachonurus villosus		TVI	1
Trachyrincus aphyodes	white rattail	WHX	36
T. longirostris	unicorn rattail	WHR	4
Ophidiidae: cuskeels			
Genypterus blacodes	ling	LIN	93
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	7
Regalecidae: oarfishes			
Agrostichthys parkeri	ribbonfish	AGR	2
Trachichthyidae: roughies, slimeheads			
Hoplostethus atlanticus	orange roughy	ORH	30
H. mediterraneus	silver roughy	SRH	43
Paratrachichthys trailli	common roughy	RHY	9
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	4
Diretmichthys parini	spinyfin	SFN	1
Anoplogastridae: fangtooth			
Anoplogaster cornuta	fangtooth	ANO	3
Berycidae: alfonsinos			
Beryx decadactylus	longfinned beryx	BYD	2
B. splendens	alfonsino	BYS	34
Melamphaidae: bigscalefishes	unspecified bigscalefish	MPH	8
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	16
Cyttus novaezealandiae	silver dory	SDO	13
C. traversi	lookdown dory	LDO	95
Zenopsis nebulosa	mirror dory	MDO	2
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	27
A. verrucosus	warty oreo	WOE	6
Neocyttus rhomboidalis	spiky oreo	SOR	33
Pseudocyttus maculatus	smooth oreo	SSO	45

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	66
Notopogon lilliei	crested bellowsfish	CBE	2
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	89
Trachyscorpia eschmeyeri	Cape scorpionfish	TRS	6
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	3
Congiopodus leucopaecilus	pigfish	PIG	2
Triglidae: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	10
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	44
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	23
Cottunculus nudus	bonyskull toadfish	COT	1
Neophrynichthys latus	dark toadfish	TOD	1
Psychrolutes microporos	blobfish	PSY	5
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	7
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	13
Epigonidae: deepwater cardinalfishes	unspecified cardinalfish	CDL	1
Epigonus denticulatus	white cardinalfish	EPD	12
E. lenimen	bigeye cardinalfish	EPL	7
E. machaera	thin tongue cardinalfish	EPM	22
E. robustus	robust cardinalfish	EPR	4
E. telescopus	deepsea cardinalfish	EPT	20
Rosenblattia robusta	rotund cardinalfish	ROS	1
Carangidae: trevallies, kingfishes			
Trachurus declivis	greenback jack mackerel	JMD	1
T. murphyi	slender jack mackerel	JMM	8
Bramidae: pomfrets			
Brama australis	southern Ray's bream	SRB	35
B. brama	Ray’s bream	RBM	1
Taractichthys longipinnis	big-scale pomfret	BSP	1
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	4
Plagiogeneion rubiginosum	rubyfish	RBY	2
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	NMP	6
Zoarcidae: eelpouts			
Melanostigma gelatinosum	limp eel pout	EPO	1
Uranoscopidae: armourhead stargazers			
Kathetostoma binigrasella	banded stargazer	BGZ	1
K. giganteum	giant stargazer	GIZ	62
Pinguipedidae: sandperches, weevers			
Parapercis gilliesi	yellow cod	YCO	2
Percophidae: opalfishes			
Hemerocoetes spp.	opalfish	OPA	2
Gempylidae: snake mackerels			
Paradiplospinus gracilis	false frostfish	PDS	1
Rexea solandri	gemfish	RSO	1
Thyrsites atun	barracouta	BAR	8
Trichiuridae: cutlassfishes			
Benthodesmus spp.	scabbardfish	BEN	1
Lepidopus caudatus	frostfish	FRO	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Scombridae: mackerels, tunas			
Scomber australasicus	blue mackerel	EMA	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	13
Hyperoglyphe antarctica	bluenose	BNS	6
Seriolella caerulea	white warehou	WWA	53
S. punctata	silver warehou	SWA	55
Nomeidae: eyebrowfishes, driftfishes			
Cubiceps spp.	cubehead	CUB	2
Tetragonuridae: squaretails			
Tetragonurus cuvieri	squaretail	TET	1
Achiropsettidae: southern flounders			
Neoachiropsetta milfordi	finless flounder	MAN	10
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	17
Pleuronectidae: righteyed flounders			
Azygopus pinnifasciatus	spotted flounder	SDF	1
Pelotretis flavilatus	lemon sole	LSO	13

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

NIWA No.	Cruise/station_no.	Class	Order	Family	Genus	Species
105444	TAN1601/128	Cephalopoda	Octopoda			
105440	TAN1601/88	Cephalopoda	Octopoda	Amphitretidae	*Amphitretus*	*pelagicus*
105582	TAN1601/140	Cephalopoda	Octopoda	Octopodidae	*Benthoctopus*	cf. *tangaroa*
105583	TAN1601/94	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*taniwha*
105584	TAN1601/75	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*taniwha*
105581	TAN1601/87	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*taniwha*
105197	TAN1601/79	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*taniwha*
105436	TAN1601/69	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*taniwha*
105438	TAN1601/64	Cephalopoda	Octopoda	Octopodidae	*Octopus*	*mernoo*
105439	TAN1601/132	Cephalopoda	Octopoda	Octopodidae	*Octopus*	*mernoo*
105443	TAN1601/115	Cephalopoda	Octopoda	Octopodidae	*Octopus*	?*mernoo*
105434	TAN1601/92	Cephalopoda	Octopoda	Octopodidae	*Thaumeledone*	cf. *zeiss*
105435	TAN1601/77	Cephalopoda	Octopoda	Octopodidae	*Thaumeledone*	*zeiss*
105441	TAN1601/59	Cephalopoda	Octopoda	Vitreledonellidae	*Vitreledonella*	*richardi*
105548	TAN1601/97	Cephalopoda	Oegopsida	Chiroteuthidae	cf. Chiroteuthis	
105589	TAN1601/40	Cephalopoda	Oegopsida	Chiroteuthidae	*Chiroteuthis*	*veranyi*
105586	TAN1601/19	Cephalopoda	Oegopsida	Chiroteuthidae	*Chiroteuthis*	*veranyi*
105564	TAN1601/46	Cephalopoda	Oegopsida	Chiroteuthidae	*Chiroteuthis*	*veranyi*
105543	TAN1601/125	Cephalopoda	Oegopsida	Cranchiidae	cf. *Teuthowenia*	
105576	TAN1601/71	Cephalopoda	Oegopsida	Cranchiidae	*Galiteuthis*	
105572	TAN1601/80	Cephalopoda	Oegopsida	Cranchiidae	*Galiteuthis*	
105558	TAN1601/76	Cephalopoda	Oegopsida	Cranchiidae	*Galiteuthis*	*suhmi*
105550	TAN1601/92	Cephalopoda	Oegopsida	Cranchiidae	*Galiteuthis*	*suhmi*
105559	TAN1601/74	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
105551	TAN1601/95	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
105549	TAN1601/97	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
105555	TAN1601/95	Cephalopoda	Oegopsida	Cranchiidae	*Teuthowenia*	*pellucida*
105569	TAN1601/45	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	
105542	TAN1601/92	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	
105560	TAN1601/69	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	
105580	TAN1601/88	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
105591	TAN1601/27	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
105590	TAN1601/7	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
105575	TAN1601/40	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
105552	TAN1601/90	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
105553	TAN1601/107	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	*atlantica*
105579	TAN1601/86	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	cf. *atlantica*
105577	TAN1601/87	Cephalopoda	Oegopsida	Histioteuthidae	*Histioteuthis*	cf. *atlantica*
105546	TAN1601/129	Cephalopoda	Oegopsida	Mastigoteuthidae	*Idioteuthis*	cf. *cordiformis*
105578	TAN1601/19	Cephalopoda	Oegopsida	Mastigoteuthidae	*Idioteuthis*	*cordiformis*
105566	TAN1601/71	Cephalopoda	Oegopsida	Mastigoteuthidae	*Mastigoteuthis*	
105573	TAN1601/76	Cephalopoda	Oegopsida	Mastigoteuthidae	*Mastigoteuthis*	
105587	TAN1601/76	Cephalopoda	Oegopsida	Mastigoteuthidae	*Mastigoteuthis*	*agassizii*
105574	TAN1601/6	Cephalopoda	Oegopsida	Octopoteuthidae	*Octopoteuthis*	sp. I NZ
105556	TAN1601/91	Cephalopoda	Oegopsida	Octopoteuthidae	*Octopoteuthis*	sp. I NZ
105561	TAN1601/69	Cephalopoda	Oegopsida	Onychoteuthidae	*Onykia*	
105571	TAN1601/47	Cephalopoda	Oegopsida	Onychoteuthidae	*Onykia*	
105568	TAN1601/88	Cephalopoda	Oegopsida	Onychoteuthidae	*Onykia*	cf. *ingens*
105585	TAN1601/43	Cephalopoda	Oegopsida	Pholidoteuthidae	*Pholidoteuthis*	sp. I NZ
105544	TAN1601/112	Cephalopoda	Sepiida	Sepiadariidae	*Sepioloidea*	spp.
105547	TAN1601/98	Cephalopoda	Sepiida	Sepiadariidae	*Sepioloidea*	spp.
105545	TAN1601/102	Cephalopoda	Sepiida	Sepiadariidae	*Sepioloidea*	spp.

Appendix 3 (continued)

NIWA No.	Cruise/station_no.	Class	Order	Family	Genus	Species
105437	TAN1601/88	Cephalopoda	Teuthida			
105567	TAN1601/87	Cephalopoda	Teuthida			
105563	TAN1601/87	Cephalopoda	Teuthida			
105565	TAN1601/48	Cephalopoda	Teuthida			

Appendix 4: Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomass values given in Figure 7a.

Survey	Age group		
	1+	2+	3++
Jan 1992	< 50	50 – 64	≥ 65
Jan 1993	< 50	50 – 64	≥ 65
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