Trawl survey of hoki and middle-depth species on the Chatham Rise, January 2011 (TAN1101)

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EXECUTIVE SUMMARY

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The twentieth 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 2 to 28 January 2011. A random stratified sampling design was used, and 114 bottom trawl stations were successfully completed comprising of 88 core (200–800 m) phase one biomass stations, 2 core phase two stations, 23 deep (800–1300 m) stations, and 1 deep phase two station.

The estimate of relative core biomass of all hoki was 93 904 t (c.v. 14.0%), a decrease of 3.7% from January 2010. This was largely driven by a decrease in recuited hoki (3+ and older) from 49 585 t in 2010 to 40 697 t in 2011. The relative biomass of hake decreased by 35.4% to 1099 t (c.v. 14.9%) in 2011. The relative biomass of ling was 7027 t (c.v. 13.8%), 21% lower than in January 2010, but the time-series for ling shows no overall trend.

The 2009 hoki year-class at age 1+ appears to be above average in biomass while the 2008 year-class at age 2+ looks to be average in the trawl time series. The age frequency distribution for hake was broad, with a peak of younger fish from ages 5–8 years, suggesting a pulse of recent recruitment. The age distribution for ling was broad, with most fish aged between 3 and 16 years.

Due to loss of time early in the survey, the southern deep strata (strata 25 and 28) were dropped. The estimated relative biomass of orange roughy in core strata and northern deep strata was 7537 t, a 72% increase from 2010. However, precision was poor (c.v. 60.0%), and the increase was largely due to a 3 t catch on the northwest Chatham Rise.

Acoustic data were also collected during the trawl survey. Acoustic indices of mesopelagic fish abundance on the Chatham Rise in 2011 were the lowest in the time-series going back to 2001. The low acoustic estimate in 2011 was due to the absence of strong daytime mesopelagic marks between 300 and 500 m, particularly on the south Chatham Rise. Total acoustic backscatter observed at night did not show the same decline. Comparison with results from earlier surveys is confounded because there was relatively little good quality acoustic data available from the southeast Chatham Rise in 2011 due to poor weather conditions. Therefore it is uncertain whether the apparent decline in mesopelagic indices in 2011 was related to sample availability (i.e., station locations), or to changes in the species composition, distribution, or abundance of key mesopelagic species. As in previous surveys, there was a weak positive correlation between acoustic density from bottom marks and trawl catch rates in 2011.

1. INTRODUCTION

In January 2011, the twentieth in a time series of annual random trawl surveys to estimate relative abundance indices for hoki and a range of other middle depth species 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. The surveys follow a random stratified design, with stratification by depth, longitude, and latitude across the Chatham Rise to ensure full coverage of the area.

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), Stevens & Livingston (2003), Livingston et al. (2004), Livingston & Stevens (2005), and Stevens & O'Driscoll (2006, 2007). Trends in relative biomass and changes in catch and age distribution of 31 species from surveys 1992–2001 were reviewed by Livingston et al. (2002). Relative biomass trends and spatial and depth distributions of 142 species or groups from surveys 2002–2010 were reviewed by O'Driscoll et al. (2011b). Of the priority species, the relative biomass of hoki decreased in the middle part of the time series but subsequently increased, hake showed a significant decrease over the time series, and ling showed no clear trend over the time series.

The 2011 survey results presented here continue the Chatham Rise trawl survey series as part of a long-term research programme to estimate the relative abundance of hoki and other middle depth species for stock assessment. The survey covers the principal juvenile stocks of hoki, believed to derive from both western and eastern spawning stocks. It also surveys older hoki that form part of the eastern stock spawning in Cook Strait and off the east coast South Island. Although older hoki also occur over deepwater and in association with hills, such as the Andes complex east of the Chatham Rise (Livingston et al. 2004), the survey is treated as representative of the eastern adult stock. As well as relative abundance, the survey provided fishery-independent data on the population size structure of middle depth species and their catch distribution across the Chatham Rise. Otoliths from a range of Quota Management System (QMS) species were collected for ageing and use in stock assessments.

Since 2010, the Chatham Rise survey has been extended to deeper waters (to 1300 metres) to provide fishery independent relative abundance indices for a wider range of species, including pre-recruit (20–30 cm) and dispersed adult orange roughy, and black and smooth oreos, as well as providing improved information for species like ribaldo and pale ghostshark, which are known to occur deeper than the historic survey depth boundary (800 m).

Acoustic data were recorded during trawls and while steaming between stations on all trawl surveys on the Chatham Rise since 1995, except for 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), 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, Stevens et al. 2009b, 2011). Acoustic data also provide qualitative information on the amount of backscatter that is not available to the bottom trawl, either off the bottom, or over areas of foul ground.

Other work carried out concurrently with the trawl survey included sampling and preservation of unidentified organisms caught in the trawl.

1.1 Project objectives

The trawl survey was carried out under contract to the Ministry of Fisheries (project HOK2007/02C). 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 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 c.v. of 20 % for the number of 2 year olds.

2. To determine the population proportions at age for hoki 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 the same 26 strata used in 2003–10 (Livingston et al. 2004, Livingston & Stevens 2005, Stevens & O'Driscoll 2006, 2007, Stevens et al. 2008, 2009a, b, 2011). Station allocation for phase 1 was determined from simulations based on catch rates from all previous Chatham Rise trawl surveys (1992–2010), 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 of Fisheries target c.v. of 20% for 2+ hoki, and c.v.s of 15% for total hoki and 20% for hake. The initial allocation of 88 stations in phase 1 (Table 1) was the same as that used in the 2010 survey, when the c.v. for 2+ hoki was 15.4% (Stevens et al. 2011). Phase 2 stations were allocated at sea, largely to improve the c.v. for 1+ hoki.

As in 2010, the survey area was extended to 1300 m. Strata on the southwest Chatham Rise (strata 26, 27, and 29), were excluded due to limited time and large steaming distances. The station allocation for the deep strata was determined based on catch rates of orange roughy from the 2010 pilot survey, using the 'allocate' programme (Francis 2006) to estimate the optimal number of stations per stratum to achieve a target c.v. of 15% for both total orange roughy and orange roughy less than 30 cm. There was no allowance for phase 2 trawling in deeper strata. Nine of the planned 32 deep tows were not completed because strata 25 and 28 were dropped due to lack of time.

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 5 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 at NIWA, Wellington. 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 0512 h and 1833 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 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 5 min 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 were regularly calibrated following standard procedures (Foote et al. 1987), with the most recent calibration on 27 January 2010 in Palliser Bay. The system and calibration parameters are given in table 2 of Stevens et al. (2011).

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 second 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 about 7.0 m above the seabed (i.e., the height of the headline).

2.6 Catch and biological sampling

At each station all items in the catch were sorted into species and weighed on Seaway motion-compensating electronic scales accurate to about 0.2 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. Specimens were stored at 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, sex, 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 (c.v.) 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 10 other key species: hake, ling, dark ghostshark, pale ghostshark, giant stargazer, lookdown dory, sea perch, silver warehou, spiny dogfish, and white warehou. These species were selected because they are commercially important, and the trawl survey samples the main part of their depth distribution. Doorspread swept-area biomass and c.v.s were also calculated by stratum for a subset of 8 abundant deepwater species: orange roughy (fish less than 20 cm, fish less than 30 cm, and all fish), black, smooth, and spiky oreos, ribaldo, shovelnosed dogfish, Baxter's dogfish, and longnosed velvet dogfish.

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, the assumptions being that fish were randomly distributed over the bottom, that no fish were present above the height of the headline, and that all fish within the path of the trawl doors were caught.

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 647 hoki otoliths and 647 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 the tails of the length distributions were represented. The numbers aged approximated the sample size necessary to produce mean weighted c.v.s of less than 20% for hoki and 30% for ling across all age classes. All 139 hake otoliths collected were read.

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 generally followed the methods applied to recent Chatham Rise trawl surveys (e.g., Stevens & O'Driscoll 2007, Stevens et al. 2008, 2009a, 2009b, 2011) and generalised by O'Driscoll et al. (2011a).

All acoustic recordings made during the trawl survey were visually examined. Marks were classified into seven main categories based on the relative depth of the mark in the water column, mark orientation (surface- or bottom-referenced), mark structure (layers or schools) and the relative strength of the mark at the five frequencies. Most of the analyses in this report are based on the 38 kHz data as this frequency was the only one available (along with uncalibrated 12 kHz data) for all previous surveys that used the old CREST acoustic system (Coombs et al. 2003). We did not attempt to do a full multifrequency analysis of mark types for this report. A more extensive analysis of these and other acoustic data from the Chatham Rise is being carried out as part of a FRST programme (CO1X0501).

Descriptive statistics were produced on the frequency of occurrence of the seven different mark types: surface layers, pelagic layers, pelagic schools, pelagic clouds, bottom layers, bottom clouds, and bottom schools. Brief descriptions of the mark types are provided in previous reports (e.g., Stevens et al. 2008, 2009a, 2009b, 2011), and an example multifrequency echogram is shown in Stevens et al. (2009b). Other example (38 kHz) echograms may be found in Cordue et al. (1998), Bull (2000), O'Driscoll (2001a, 2001b), and Stevens et al. (2008, 2011a).

As part of the qualitative description, the quality of acoustic data recordings was subjectively classified as 'good', 'marginal', or 'poor' (see appendix 2 of O'Driscoll & Bagley (2004) for examples). Only good or marginal quality recordings were considered suitable for quantitative analysis.

2.9.1 Comparison of acoustics with bottom trawl catches

A quantitative analysis was carried out on daytime trawl and night steam recordings using custom Echo Sounder Package (ESP2) software (McNeill 2001). Estimates of the mean acoustic backscatter per km^2 from bottom referenced marks (bottom layers, clouds, and schools) 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).

2.9.2 Time-series of relative mesopelagic fish abundance

O'Driscoll et al. (2011a) developed a time series of relative abundance estimates for mesopelagic fish on the Chatham Rise based on that component of the acoustic backscatter that migrates into the upper 200 m of the water column at night. Because some of the mesopelagic fish migrate very close to the surface at night, they move into the surface 'deadzone' (shallower than 14 m) where they are not detectable by the vessel's downward looking hull-mounted transducer. Consequently, there is a substantial negative bias in night-time acoustic estimates. To correct for this bias, O'Driscoll et al. (2009) used night estimates of demersal backscatter (which remains deeper than 200 m at night) to correct daytime estimates of total backscatter.

We updated the mesopelagic time series to include data from 2011. The methods were the same as those used by O'Driscoll et al. (2011a) and Stevens et al. (2011). 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:

$$sa(meso)i = p(meso)s * sa(all)i$$

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

p(meso)s = psz + p(200)s * (1 - psz)

3. RESULTS

3.1 2011 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 location of deepwater strata required some long steams between trawls and reduced time available to survey the ground before trawling. Therefore known successful tow positions were used for all core biomass tows.

This was the first *Tangaroa* voyage after an extensive re-fit in Singapore from July–Nov 2010 and considerable effort was put into making sure ship's systems and equipment (especially winches and trawl gear) were consistent with those used for previous surveys. Time was lost early in the voyage due to operational problems with ship electrical systems (a breaker was tripping during trawling). There was also loss of time on 9 January due to broken winding-on gear on the port trawl winch. The net monitor paravane flooded on 11 January and was replaced. The replacement unit was faulty and was not suitable for trawling in deep water, so two new units were picked up south of Cape Palliser from RV *Ikatere* on the night 17 January with no significant loss of survey time. Fishing operations only had to be suspended once (for 6 hours on the night of 18 January), by rough conditions (20–35 knot winds and 2–4 m swells) and for much of the survey poor weather reduced vessel speed between trawl survey stations.

Because of the cumulative loss of time during the first two weeks of the voyage there was concern that core survey objectives might not be met. After discussions with MFish, the two deep strata on the southeast Chatham Rise (strata 25 and 28) were dropped. This decision ensured that all phase 1 tows within the core (200–800 m) survey area were completed. Strata 25 and 28 have been less important for orange roughy, with only 8% of the estimated relative orange biomass in these two strata in 2010.

In total 114 successful biomass tows were completed, comprising 88 core (200–800 m) phase 1 tows, 2 core phase 2 stations, 23 deep (800–1300 m) phase 1 tows, and one deep phase 2 tow (Tables 1 and 2, Figure 2, Appendix 1). All 88 of the planned core phase 1 stations were completed. Eight core bottom trawls were excluded from relative biomass calculations: 4 tows came fast, another tow was hauled early due to very high headline height and doorspread readings, and 3 tows were excluded due to equipment failure (the net monitor and the starboard winch cable feeder failed). All deep tows were successful, however, nine of the planned 32 deep tows were not completed, as a result of strata 25 and 28 being dropped due to lack of time.

Core station density ranged from 1:288 km^2 in stratum 17 (200–400 m, Veryan Bank) to 1:3722 km^2 in stratum 4 (600–800 m, south Chatham Rise). Deep station density ranged from 1:416 km^2 in stratum 21a (800–1000 m, NE Chatham Rise) to 1:1940 km^2 in stratum 21b (800–1000 m, NE Chatham Rise). Mean station density was 1:1594 km^2 (see Table 1).

3.2 Gear performance

Gear parameters are summarised in Table 3. A headline height value was obtained for all 114 successful tows, but doorspread readings were not available for 19 tows, due to a combination of the Scanmar door sensors not working and the net monitor not being used on tows greater than 1000 m depth. Mean headline heights ranged from 6.0 to 7.9 m, averaged 6.9 m, and were consistent with previous surveys and within the optimal range (Hurst et al. 1992) (Table 3). Mean doorspread measurements by 200 m depth intervals ranged from 104.5 to 139.8 m, and averaged 125.9 m. This is the highest average doorspread in the time series by 4 m (O'Driscoll et al. 2011b), and reflects the higher overall doorspreads on this survey including

33 over 130 metres (Table 3), and outside the optimal range (Hurst et al. 1992). The reason for these higher doorspread readings is unknown.

3.3 Hydrology

Surface and bottom temperatures were recorded throughout the survey from the Seabird CTD. The surface temperatures (Figure 3, top panel) ranged from 13.1 to 17.9 ^{o}C. Bottom temperatures ranged from 3.2 to 11.3 ^{o}C (Figure 3, bottom panel).

As in previous years, higher surface temperatures were 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 of the Chatham Islands and on and to the east of the Mernoo Bank.

3.4 Catch composition

The total catch from all 114 valid biomass stations was 130 t, of which 48.3 t (37.3%) was hoki, 3.2 t (2.5%) was ling, and 0.7 t (0.5%) was hake (Table 4). Silver warehou were caught in good numbers with 28.2 t (21.8%), including an 18 t catch. Of the 274 species or species groups identified at sea, 128 were teleosts, 35 were elasmobranchs, 1 was an agnathan, 26 were crustaceans, and 15 were cephalopods. The remainder consisted of assorted benthic and pelagic invertebrates. A full list of species caught, and the number of core stations at which they occurred, is given in Appendix 2. Eighteen benthic invertebrates were formally identified after the voyage (Appendix 3).

3.5 Relative biomass estimates

Core strata (200–800 m)

Relative core biomass was estimated for 41 species (Table 4). The c.v.s achieved for hoki, hake, and ling from core strata were 14.0%, 14.9%, and 13.8% respectively. The c.v. for 2+ hoki (2008 year class) was 14.1%, below the target c.v. of 20%. High c.v.s (over 30%) generally occurred when species were not well sampled by the gear. For example, alfonsino, silver warehou, slender mackerel, and arrow squid are not strictly demersal and exhibit strong schooling behaviour. Others, such as hapuku, tarakihi, and red cod, have high c.v.s because they are mainly distributed outside the core survey depth range.

The combined relative biomass for the top 31 species in the core strata that are tracked from year to year was lower than in 2009 and 2010, but still relatively high (Figure 4, top panel). As in previous years, hoki was the most abundant species caught (Table 4, Figure 4, lower panel), with a similar relative biomass to 2010. The relative biomass for the 30 other key species was 20% lower than in 2010. Silver warehou was a notable exception with a second successive record relative biomass estimate, largely due to an18 t catch in stratum 18, southeast of the Mernoo Bank (Figure 5). The next most abundant QMS species were black oreo, spiny dogfish, ling, dark ghost shark, sea perch, lookdown dory, giant stargazer, and pale ghost shark each with an estimated relative biomass of over 2000 t (Table 4). The most abundant non-QMS species were common roughy, javelinfish, big-eye rattail, banded bellowsfish, orange perch, and two saddle rattail (Table 4).

The estimate of relative biomass of hoki in the core strata was 93 904 t, a 3.7% decease from January 2010 (Table 5, Figure 5). This was largely driven by a 17.9% decrease in recruited hoki (3+ and older) from 49 585 t in 2010 to 40 697 t in 2011 (Table 6). However, the relative biomass of 1+ hoki (2009 year-class) was higher than in 2010 and appears to be one of the stronger year classes in the time series. The number of 2+ hoki (2008 year-class) was similar to last year (Table 6).

The relative biomass of hake in core strata decreased by 35.4% in 2011 to 1099 t, one of the lowest estimates in the time series (see Table 5, Figure 5). There were no core tows to the northeast of Mernoo Bank (stratum 18), where good catches of hake were observed on the previous two surveys.

The relative biomass of ling was 7 027 t, 20.6% lower than in January 2010. The time series for ling shows no overall trend (Figure 5).

The relative biomass of giant stargazer, spiny dogfish, and white warehou increased from 2010, while the relative biomass of dark ghost shark, lookdown dory, pale ghost shark, sea perch, and white warehou decreased (Figure 5). The relative biomass estimate for silver warehou is high but precision is low (c.v. 61.5%) due to one large catch of 18.3 t in stratum 18 (Figure 5).

Deep strata (800–1300 m)
Relative biomass and c.v.s were estimated for 19 of 41 core strata species that were also captured in deep survey strata on the northern Chatham Rise (Table 4). The deep strata were included into the survey design primarily to estimate the relative biomass of juvenile and recruited orange roughy. The estimated relative biomass of orange roughy was 7 513 t (c.v. 59.9%), which was 65.0% of the total biomass for core species in deep strata (Table 4). The c.v. for the relative biomass of orange roughy in all strata in 2011 was large compared to 2010, when the c.v. was 16.6%, because of a single large catch (3 t) taken in stratum 22. There was only enough time to complete a single phase 2 tow in stratum 22, and this was insufficient to reduce the c.v. to target levels.

The estimated relative biomass of smooth oreo in deep strata was 783 t (but precision was poor with a c.v. of 82.8%). Only 8% of the relative biomass of spiky oreo in all strata and 0.1% of the relative biomass of black oreo in all strata were estimated to occur in the deep strata (Table 4). However, in the 2010 survey, 47% of the relative biomass of black oreo was from stratum 27, an area which was not fished during this year's survey. Shovelnose dogfish were abundant in the deep strata, with 25% of their total survey relative biomass found in these strata (Table 4).

The deep strata contained 8.6% of total survey hake biomass, 1.3% of total survey hoki biomass, and 0.3% of total survey ling biomass indicating that the core survey strata are likely to encompass the majority of the population (Table 4).

3.6 Catch distribution

Hoki
In the 2011 survey, hoki were caught at 89 of 90 core biomass stations, with the highest catch rates mainly in shallow strata (200–400 m) on the western Chatham Rise (Table 7, Figure 6). The highest individual catch rates of hoki in 2009 occurred on the Reserve Bank in stratum 20, and comprised mainly 1+ (2009 year class) hoki (Figure 6). As in previous surveys, 1+ hoki were largely confined to the Mernoo, Veryan, and Reserve Banks (Figure 6a), while 2+ hoki were found throughout much of the Rise, in particular the northern strata in 200–600 m depth (Figure 6b). The distribution of 3++ hoki was similar to that of 2+ fish (Figure 6c).

Hake
Catches of hake were consistently low throughout much of the survey area. The highest catch rates were west of the Mernoo Bank in stratum 7, and in the known hake spawning area in strata 10A and 10B. Unlike 2009 and 2010, no random stations fell east of the Mernoo Bank in stratum 7 (Table 7, Figure 7) where hake appear to spawn.

Ling
As in previous years, catches of ling were evenly distributed throughout most strata in the survey area (Table 7, Figure 8). The highest catch rates were on the Reserve Bank (stratum 19) and NW Chatham Rise

(stratum 7). Ling distribution was reasonably consistent, and catch rates have been relatively stable over the time series (Figure 8).

Other species

As with previous surveys, spiny dogfish were widely distributed throughout the survey area at 200–600 m depths (Table 7, Figure 9). Lookdown dory and sea perch were also widespread but were most abundant in the east of the survey area, and Reserve Bank (strata 19 and 20) respectively. Dark ghost shark were mainly caught in 200–400 m depths, while pale ghost shark were mostly caught in deeper water at 400–800 m depth. Giant stargazer were abundant in the shallower strata of the survey area, with the largest catches taken in stratum 18 (Mernoo Bank) (Table 7). Silver warehou and white warehou were patchily distributed at depths of 200–600 m. In 2011, there was a large catch of 18 t of silver warehou in stratum 18 (Mernoo Bank) (Figure 9).

Orange roughy were widespread on the northern Rise at 800–1300 m depths, with the largest catch of 3 t taken in on the north-western Rise in stratum 22 (Figure 9). The 3 t catch consisted of both juvenile and adult orange roughy (Table 7). The spatial distribution of black and smooth oreos was relatively patchy compared to orange roughy, although the distribution of the former two species was incompletely sampled because strata 25 and 28 were dropped (Figure 9). Black oreo, predominantly juveniles, were almost entirely caught on the south-western rise at 600–800 m depths, in strata 4 and 6 (Table 7), while smooth oreo were mainly caught in the same area (stratum 6) and on the north-western rise at 800–1300 m depths (stratum 23). Spiky oreo were more widespread and most abundant on the northern rise in 600–800 m depths (strata 2 and 12) (Table 7, Figure 9).

3.7 Biological data

3.7.1 Species sampled

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

3.7.2 Length frequencies and age distributions

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

Hoki

The hoki length frequency (Figure 10) was dominated by 1+ (less than 48 cm) and 2+ (48–62 cm) fish (Figure 11). There were few hoki longer than 80 cm (Figure 10) or older than age 6 (Figure 11). Female hoki were slightly more abundant than males (ratio of 1.10 female : 1 male).

Hake

Hake scaled length frequencies and calculated numbers at age (Figures 12 and 13) were relatively broad, with most male fish aged between 3 and 9 years and female fish between 3 and 13 years. Since 2004 a cohort of small fish have moved through, which would be 9+ (2001 year-class) in 2011. This year-class was not abundant in 2011. It is uncertain whether this is due to a real decline in the abundance of this cohort, ageing error, or the population not being well sampled in 2011. Female hake were as abundant as males (1.02 female: male).

Ling

Ling scaled length frequencies and calculated numbers at age (Figures 14 and 15) were broad, with most fish aged between 3 and 17. There was a period of good recruitment during the 1990s (Figure 15). Female ling were slightly less abundant than males (0.9 female: male).

Other species

Length frequency distributions for key core and deepwater commercial species are shown in Figure 16. Clear modes are apparent in the size distribution of silver warehou and white warehou, which may correspond to yearly cohorts. Length frequencies of lookdown dory, giant stargazer, spiny dogfish, and dark and pale ghost sharks indicate that females grow larger than males. Length frequencies of sea perch, orange roughy, black oreo, smooth oreo, and spiky oreo indicate that males and females grow to a similar size. Because larger orange roughy are more abundant in deeper water, the inclusion of the deep-water strata allowed the main depth distribution of orange roughy to be sampled. Length frequency modes were apparent in the length distribution for orange roughy, and possibly also smooth oreo, but are unlikely to represent distinct year classes given the high longevity of these species. In contrast, the length frequency distribution of black oreo was unimodal. As with previous years, the catch of spiny dogfish was dominated by females (3.8 female: male). Sex ratios were about even for most other species (Figure 16).

3.7.3 Reproductive status

Gonad stages of hake, hoki, ling, and a number of other species are summarised in Table 10. All hoki were recorded as either resting or immature. About 35% of male ling were maturing or ripe, but few females were showing signs of reproductive activity. Similarly 39% of male hake were ripe or running ripe, but most females were resting (51%) or maturing (35%) (Table 10). The majority of the other species for which reproductive state was recorded showed no sign of reproductive activity, the exceptions being two saddle rattails and the occasional deepwater shark (Table 10).

3.8 Acoustic results

Over 78 GB of acoustic data were collected with the multi-frequency (18, 38, 70, 120 and 200 kHz) hull-mounted EK60 systems during the trawl survey. Moderate to rough weather and sea conditions for much of the survey meant that the quality of acoustic recordings was not as good as in some previous surveys, but 77% of the 327 files collected were still suitable for quantitative analysis. Twenty three of the 102 daytime trawl files were considered too poor to be analysed quantitatively.

Expanding symbol plots of the distribution of total acoustic backscatter from good and adequate quality recordings observed during daytime trawls and night transects are shown in Figure 17. As noted by O'Driscoll et al. (2011b), there is a consistent spatial pattern in total backscatter, with higher backscatter in the west. There were relatively few trawl stations with acoustic data from the southeast Chatham Rise in 2011 (see Figure 17 – only 13 acoustic data-points in this stratum in 2011 compared to 22–30 points from each of the surveys from 2001–10) because of poor weather conditions while the survey was in this region.

3.8.1 Description of acoustic mark types

The frequency of occurrence of each of the seven mark categories is given in Table 11. Often several types of mark were present in the same echogram. The percent occurrence of acoustic mark types on the Chatham Rise in 2011 was generally similar to that observed in previous surveys, but a lower percentage of bottom schools and layers and a higher percentage of bottom clouds were observed during the day in 2011 (Table 11). Bottom clouds are more diffuse and dispersed than bottom layers and the increase in this mark type, along with a concurrent reduction in occurrence of bottom layers, may have been due to the reduced acoustic density in bottom-referenced layers (see Section 3.8.2 below).

Pelagic layers were the most common daytime mark type, occurring in 79% of day steam files and 71% of day trawl files in 2011 (Table 11). Midwater trawling on previous Chatham Rise surveys suggests that pelagic layers contain mesopelagic fish species, such as pearlsides (*Maurolicus australis*) and lanternfishes (myctophids) (McClatchie & Dunford 2003, Stevens et al. 2009a). These mesopelagic species vertically migrate, rising in the water column and dispersing during the night, turning into pelagic clouds and surface layers. Surface layers were observed in almost all (97%) night recordings and most (70%) day echograms. Pelagic schools were observed in 32% of day steam files, 37% of day trawl files, and 6% of night files (Table 11). Cordue et al. (1998) suggested that pelagic schools or "bullets" were associated with Ray's bream, but it is likely that the schools are aggregations of mesopelagic fish, on which Ray's bream feed. Trawling on a voyage carried out by the FRST programme in May–June 2008 found that small pelagic schools were often dominated by the myctophid *Symbolophorus* spp. (Stéphane Gauthier, NIWA, pers. comm.)

Bottom layers were observed in 59% of day steam files, 50% of day trawl files, and 26% of night files (Table 11). Like pelagic layers, bottom layers tended to disperse at night, to form bottom clouds. Bottom layers and clouds were usually associated with a mix of demersal fish species, but probably also contain mesopelagic species when these occur close to the bottom (O'Driscoll 2003). There was often mixing of bottom layers and pelagic layers. Bottom-referenced schools were present in only 5% of daytime (trawl and steam) recordings in 2011, and were most abundant in 200–400 m water depth. Bottom schools and layers 10–70 m off the bottom are sometimes associated with catches of 1+ and 2+ hoki, but also with other species such as alfonsino and silver warehou (Stevens et al. 2008, 2009a, 2009b, 2011).

3.8.2 Comparison of acoustics with bottom trawl catches

Acoustic data from 73 trawl files were integrated and compared with trawl catch rates (Table 12). Data from the other 29 daytime trawl recordings were not included in the analysis because the acoustic data were too noisy (23 files) or because the trawl was outside the 200–800 m core survey area (6 files). Average acoustic backscatter values from bottom-referenced marks and from the entire water column in 2011 were the lowest in the time-series stretching back to 2001 (Table 12). Average trawl catch from the comparable tows in 2011 was also lower than that in 2007–10, but higher than the average catch rates in 2001–06 (Table 12). However the trawl catch in 2011 was driven up by two large catches of silver warehou (tows 53 and 112), and the median trawl catch in 2011 was the second lowest (after 2008) in the time-series.

There was a weak positive correlation (Spearman's rank correlation, rho = 0.32) between acoustic backscatter in the bottom 100 m during the day and trawl catch rates (Figure 18). In previous Chatham Rise surveys from 2001–10, rank correlations between trawl catch rates and acoustic density estimates ranged from 0.15 (in 2006) to 0.46 (in 2001). The weak correlation between acoustic backscatter and trawl catch rates (Figure 18) arises because large catches are sometimes made when there are only weak marks observed acoustically, and conversely, relatively little is caught in some trawls where dense marks are present. O'Driscoll (2003) suggested that bottom-referenced layers on the Chatham Rise may also contain a high proportion of mesopelagic "feed" species, which contribute to the acoustic backscatter, but which are not sampled by the bottom trawl. Comparison of paired day and night acoustic recordings from the same location indicates that, on average, 35–50% of the bottom-referenced backscatter observed during the day migrates more than 50 m away from the bottom at night, suggesting that this component is not demersal fish (O'Driscoll et al. 2009). This, combined with the diverse composition of demersal species present, means that it is unlikely that acoustics will provide an alternative relative biomass estimate for hoki on the Chatham Rise.

3.8.3 Time-series of relative mesopelagic fish abundance

In surveys from 2001–10, most acoustic backscatter was between 300 and 500 m depth during the day, and migrated into the surface 200 m at night (e.g., pattern for 2010 in Figure 19). In 2011, there was no strong daytime peak centred around 350 m, but there was a concentration of backscatter between

150 and 350 m, and smaller peaks centred at around 550 and 750 m (Figure 19). The distribution of backscatter at night in 2011 was similar to the pattern observed in previous surveys, with most backscatter in the upper 200 m (Figure 19).

The vertically migrating component of acoustic backscatter is assumed to be dominated by mesopelagic fish (see McClatchie & Dunford, 2003 for rationale and caveats). In 2011, between 49 and 76% of the total backscatter in each of the four sub-areas was in the upper 200 m at night and was estimated to be from vertically migrating mesopelagic fish (Table 13). These percentages were similar to those observed in 2010, but lower than in previous years, when up to 88% of the backscatter in some areas was estimated to be from mesopelagic fish (Table 13).

From 2001 to 2010, day estimates of total acoustic backscatter over the Chatham Rise were consistently higher than night estimates (Figure 20) because of the movement of fish into the surface deadzone (shallower than 14 m) at night (O'Driscoll et al. 2009). In 2011, for the first time, night estimates were higher than day estimates (Figure 20). Day estimates of total backscatter have declined since 2009, but night estimates have been relatively consistent over the same period (Figure 20). O'Driscoll et al. (2011b) concluded that changes in total backscatter are probably related to patterns in mesopelagic fish abundance, rather than demersal fish abundance, but it is difficult to explain why day estimates have declined in the last two years and night estimates have not unless there has been a change in species composition and/or diel behaviour. Similarly, backscatter within 50 m of the bottom during the day has decreased since the start of the time series, but backscatter close to the bottom at night was about the same throughout (Figure 20).

The 'best' estimate of mesopelagic fish abundance was calculated by multiplying estimates of the total daytime backscatter 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. This effectively subtracts backscatter which remains deeper than 200 m at night (i.e., the bathypelagic and demersal components) from day estimates of total backscatter (O'Driscoll et al. 2011b). The estimated acoustic indices calculated using this method are summarised in Table 14 and plotted in Figure 21 for the entire Chatham Rise and for the four sub-areas. Mesopelagic estimates from 2011 were the lowest in the time-series for the overall Chatham Rise and for three of the four subareas (Table 14). There were particularly large declines in daytime backscatter observed in the two southern strata in 2011 (Table 14, Figure 21).

Decreases in total acoustic backscatter during the day (see Table 12) and the derived mesopelagic estimates (Figure 21) in 2011 were due to the absence of strong daytime mesopelagic marks between 300 and 500 m (see Figure 19), particularly on the southern Chatham Rise. When combined with the relative lack of both daytime bottom layers and pelagic schools in 2011 (see Table 11), this suggests a change in mesopelagic species composition on the south Chatham Rise compared to previous surveys. However, comparison with results from earlier surveys is confounded because there was relatively little good quality acoustic data available from the southeast Chatham Rise in 2011 due to poor weather (see Figure 17). Therefore it is uncertain whether the apparent change in mesopelagic indices in 2011 was related to sample availability (i.e., station locations), or to environmental conditions, a change in seasonal patterns of distribution, or an actual change in abundance of key mesopelagic species.

4. CONCLUSIONS

The 2011 survey successfully extended the January Chatham Rise time series into its twentieth year and provided abundance indices for hoki, hake, and ling. The survey c.v. of 14.1% achieved for 2+ hoki was well below the target level of 20%. The estimated relative biomass of hoki in all strata was 3.7% lower than in 2010, largely due to a decrease in the relative biomass of recruited hoki. However, the 1+ year-class (2009 year-class) was higher than in 2010 and appears to be one of the stronger cohorts in the time series. The 2+ year-class (2008 year-class) is similar to last year and about average in the time series.

The relative biomass of hake in core strata decreased by 35% in 2011 to 1099 t, which is one of the lowest estimates in the time series. However there were no core tows to the northeast of Mernoo Bank (stratum 18), where good catches of hake have been observed on the previous two surveys. The relative biomass of ling in core strata also decreased in 2011, but the time series for ling shows no overall trend.

Due to loss of time early in the survey, the southern deep strata (strata 25 and 28) were dropped. However, the northern deep strata were successfully completed providing abundance indices for pre-recruit and recruited orange roughy. The estimated relative biomass of orange roughy in all strata increased by 72% in 2011 to 7537 t, but precision was poor (c.v. 60.0%), and the increase was largely due to a 3 t catch of orange roughy in stratum 22 on the northwest Chatham Rise. The 2010 and 2011 orange roughy relative biomass estimates are the first in a time series. Additional estimates are required before biomass trends can be investigated.

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Table 1: The number of completed valid biomass stations (200–1300m) by stratum during the 2011 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	6	6		6	1: 1 417
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
7	400–600	NW Chatham Rise	5 233	6	6		6	1: 872
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
10A	400–600	NE Chatham Rise	2 958	3	3		3	1: 986
10B	400–600	NE Chatham Rise	3 363	3	3		3	1: 1 121
11A	400–600	NE Chatham Rise	2 966	4	4		4	1: 742
11B	400–600	NE Chatham Rise	2 072	3	3		3	1: 691
11C	400–600	NE Chatham Rise	3 342	3	3		3	1: 1 114
11D	400–600	NE Chatham Rise	3 368	3	3		3	1: 1 123
12	400–600	SE Chatham Rise	6 578	3	3		3	1: 2 193
13	400–600	SE Chatham Rise	6 681	3	3		3	1: 2 227
14	400–600	SW Chatham Rise	5 928	3	3		3	1: 1 976
15	400–600	SW Chatham Rise	5 842	3	3		3	1: 1 947
16	400–600	SW Chatham Rise	11 522	3	3		3	1: 3 841
17	200–400	Veryan Bank	865	3	3		3	1: 288
18	200–400	Mernoo Bank	4 687	3	3		3	1: 1 562
19	200–400	Reserve Bank	9 012	4	4		4	1: 2 253
20	200–400	Reserve Bank	9 584	5	5	2	7	1: 1 369
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	6	6	1	7	1: 1 051
23	1000–1300	NW Chatham Rise	7 014	7	7		7	1: 1 002
24	1000–1300	NE Chatham Rise	5 672	4	3		3	1: 1 891
25	800–1000	SE Chatham Rise	5 596	5	0		0	
28	1000–1300	SE Chatham Rise	9 494	4	1		1	
Total			181 699	120	111	3	114	1: 1 594

Table 2: Survey dates and number of valid 200–800 m depth biomass stations in surveys of the Chatham Rise, January 1992–2011.

Trip_code	Start date	End date	No. of valid core biomass stations
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

Table 3: Tow and gear parameters by depth range for valid biomass stations (TAN1101). Values shown are sample size (n), and for each parameter the mean, standard deviation (s.d.), and range.

	n	Mean (m)	s.d.	Range
Core tow parameters				
Tow length (n. miles)	90	2.9	0.25	2.0–3.2
Tow speed (knots)	90	3.5	0.06	3.3−3.7
All tow parameters				
Tow length (n. miles)	114	2.9	0.24	2.0–3.2
Tow speed (knots)	114	3.5	0.06	3.3−3.7
Gear parameters				
200–400 m				
Headline height	26	7.0	0.34	6.2−7.6
Doorspread	25	119.6	7.80	104.5–132.6
400–600 m				
Headline height	46	6.7	0.32	6.0−7.7
Doorspread	39	129.1	4.48	118.8–139.8
600–800 m				
Headline height	18	6.8	0.23	6.5−7.2
Doorspread	18	127.3	6.62	113.0–136.3
800–1000 m				
Headline height	13	7.0	0.30	6.6−7.6
Doorspread	11	126.0	4.75	119.9–133.0
1000–1300 m				
Headline height	11	7.3	0.33	6.9−7.9
Doorspread	2	127.3	8.84	121.0–133.5
Core stations 200–800 m				
Headline height	90	6.8	0.33	6.0−7.7
Doorspread	82	125.8	7.36	104.5–139.8
All stations 200–1300 m				
Headline height	114	6.9	0.36	6.0−7.9
Doorspread	95	125.9	7.07	104.5–139.8

Table 4: Catch (kg) and total biomass (t) estimates (also by sex) with coefficient of variation (c.v.) of QMS species, other commercial species, and major non-commercial species for valid biomass stations in core strata (200–800 m depths); and biomass estimates for deep strata (800-1300 m depths). Total biomass includes unsexed fish. (-, no data.).

	Core strata 200–800m								800–1300 m	
Common name	Code	Catch	Biomass males		Biomass females		Total biomass		Deep biomass	
		kg	t	% c.v.	t	% c.v.	t	% c.v.	t	% c.v.
QMS species										
Hoki	HOK	47 339	42 016	14.4	51 796	14.0	93 904	14.0	1 223	11.2
Silver warehou	SWA	28 221	46 181	63.1	35 894	59.5	82 075	61.5	-	
Black oreo	BOE	2 764	5 478	21.3	5 676	21.1	11 195	21.0	16	60
Spiny dogfish	SPD	3 290	1 384	27.4	6 410	12.1	7 794	13.6	-	
Ling	LIN	3 210	3 169	17.2	3 858	12.5	7 027	13.8	19	73.1
Dark ghostshark	GSH	3 195	2 546	16.5	4 041	18.0	6 588	16.6	-	
Sea perch	SPE	1 379	1 660	10.7	1 614	10.6	3 278	10.2	8	61.2
Lookdown dory	LDO	1 670	1 294	34.7	1 960	16.2	3 257	21.4	8	44.6
Giant stargazer	STA	1 074	1 047	31.2	2 121	26.7	3 169	27.7	8	100
Pale ghostshark	GSP	1 053	1 250	14.9	1 300	14.1	2 550	14.2	145	21.2
White warehou	WWA	918	1 032	55.5	828	52.2	1 861	53.9	-	
Spiky oreo	SOR	741	798	47.3	812	37.9	1 619	41.9	154	42.3
Arrow squid	NOS	449	615	63.9	894	66.7	1 511	65.3	1	100
Hake	HAK	581	321	22.9	778	16.9	1 099	14.9	103	28.8
Alfonsino	BYS	552	571	56.4	465	44.1	1 038	50.4	4	100
Smooth skate	SSK	498	314	38.3	600	40.0	1 009	32.0	8	100
Smooth oreo	SSO	233	413	79.2	390	73.3	808	76.4	783	82.8
Hapuku	HAP	138	258	48.2	181	33.0	438	38.1	-	
Ribaldo	RIB	229	204	15.9	192	25.6	396	16.7	93	34.7
Red cod	RCO	166	192	64.6	161	57.9	357	61.6	-	
Southern Ray's bream	SRB	100	185	78.8	171	52.1	355	65.8	-	
School shark	SCH	113	275	72.9	51	100	325	62.8	-	
Barracouta	BAR	48	77	56.6	92	62.5	169	58.2	-	
Rough skate	RSK	94	28	60.9	126	65.5	154	54.9	-	
Tarakihi	TAR	43	103	59.4	47	39.8	150	49.6	-	
Slender mackerel	JMM	48	91	82.3	46	72.1	137	78.5	-	
Deepsea cardinalfish	EPT	42	33	42.6	28	44.1	62	41.9	-	
Bluenose	BNS	33	23	70.9	28	63.1	51	48.0	-	
Orange roughy	ORH	13	14	52.2	11	56.6	24	53.5	7 513	59.9
Lemon sole	LSO	10	11	41.2	10	44.0	21	40.5	-	
Rubyfish	RBY	6	5	75.9	4	100	12	87.7	-	
Scampi	SCI	4	3	25.5	5	26.3	9	18.8	-	
Frostfish	FRO	2	8	100	0		8	100	-	
Jack mackerel	JMD	3	1	100	6	100	7	82.8	-	
Commercial non-QMS species (where biomass > 30 t)										
Shovelnose dogfish	SND	2 198	2 140	16.2	1 756	14.4	3 897	13.7	1 329	32.6
Non-commercial species (where biomass > 800 t)										
Common roughy	RHY	3 028	-	-	-	-	11 604	98.0	-	
Javelinfish	JAV	3 349	-	-	-	-	7 849	12.3	109	46.2
Big-eye rattail	CBO	1 556	-	-	-	-	3 455	15.7	19	39.6
Banded bellowsfish	BBE	776	-	-	-	-	1 314	11.9	10	100
Orange perch	OPE	372	-	-	-	-	1 164	42.6	-	
Two saddle rattail	CBI	247	-	-	-	-	853	29.2	-	
Total (above)		109 785								
Grand total (all species)		115 434								

Table 5: Estimated biomass (t) with coefficient of variation below (%) of hoki, hake, and ling sampled by annual trawl surveys of the Chatham Rise, January 1992–2011. stns, stations (-, no data; c.v., coefficient of variation.).

		Core strata 200–800 m			
Year	Survey	No. stns	Hoki	Hake	Ling
1992	TAN9106	184	120 190	4 180	8 930
	c.v.		7.7	14.9	5.8
1993	TAN9212	194	185 570	2 950	9 360
	c.v.		10.3	17.2	7.9
1994	TAN9401	165	145 633	3 353	10 129
	c.v.		9.8	9.6	6.5
1995	TAN9501	122	120 441	3 303	7 363
	c.v.		7.6	22.7	7.9
1996	TAN9601	89	152 813	2 457	8 424
	c.v.		9.8	13.3	8.2
1997	TAN9701	103	157 974	2 811	8 543
	c.v.		8.4	16.7	9.8
1998	TAN9801	91	86 678	2 873	7 313
	c.v.		10.9	18.4	8.3
1999	TAN9901	100	109 336	2 302	10 309
	c.v.		11.6	11.8	16.1
2000	TAN0001	128	72 151	2 152	8 348
	c.v.		12.3	9.2	7.8
2001	TAN0101	119	60 330	1 589	9 352
	c.v.		9.7	12.7	7.5
2002	TAN0201	107	74 351	1 567	9 442
	c.v.		11.4	15.3	7.8
2003	TAN0301	115	52 531	888	7 261
	c.v.		11.6	15.5	9.9
2004	TAN0401	110	52 687	1 547	8 248
	c.v.		12.6	17.1	7.0
2005	TAN0501	106	84 594	1 048	8 929
	c.v.		11.5	18.0	9.4
2006	TAN0601	96	99 208	1 384	9 301
	c.v.		10.6	19.3	7.4
2007	TAN0701	101	70 479	1 824	7 907
	c.v.		8.4	12.2	7.2
2008	TAN0801	101	76 859	1 257	7 504
	c.v.		11.4	12.9	6.7
2009	TAN0901	108	144 088	2 419	10 615
	c.v.		10.6	20.7	11.5
2010	TAN1001	91	97 503	1 701	8 846
	c.v.		14.6	25.1	10.0
2011	TAN1101	90	93 904	1 099	7 027
	c.v.		14.0	14.9	13.8

Table 6: Relative biomass estimates (t in thousands) of hoki, 200–800 m depths, Chatham Rise trawl surveys January 1992–2011 (c.v. coefficient of variation; 3++ all hoki aged 3 years and older; (see Appendix 4 for length ranges of age classes).

		1+ hoki			2+ hoki		3 ++ hoki		Total hoki	
Survey	1+ year class	t	% c.v	2+ year class	t	% c.v	t	% c.v	t	% c.v
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	0.5	(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)

Table 7: Estimated biomass (t) and coefficient of variation (% c.v.) of hoki, hake, ling, orange roughy, and 15 other key species by stratum (See Table 4 for species common names.) (Core, total biomass from valid core tows (200–800 m); Total, total biomass from all valid tows (200–1300 m); -, not calculated.).

	Species code											
	HOK		SWA		SPD		LIN		GSH		SPE	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.
1	435	33	0	0	0	0	92	51	0	0	18	100
2a	440	30	0	0	0	0	137	25	0	0	49	37
2b	1 210	24	0	0	0	0	187	30	0	0	33	22
3	3 137	78	15	53	686	47	221	66	372	90	77	29
4	815	11	0	0	0	0	160	23	0	0	83	61
5	3 803	24	22	34	1 066	10	220	45	284	42	91	75
6	1 786	27	0	0	0	0	347	57	0	0	0	0
7	2 818	22	36	93	51	46	612	35	1	100	22	49
8a	2 700	49	0	0	0	0	128	68	0	0	97	28
8b	3 397	18	533	61	448	16	317	16	77	50	260	28
9	2 808	76	22 753	91	178	52	120	71	1 336	33	69	98
10a	2 430	50	366	47	53	82	184	13	6	53	64	35
10b	672	37	31	34	205	35	113	63	19	100	29	60
11a	3 709	48	145	15	150	28	51	26	54	58	33	53
11b	622	17	5	100	0	0	83	20	0	0	27	21
11c	1 763	6	19	26	229	51	89	61	37	55	12	42
11d	4 492	52	82	100	32	100	181	29	79	100	50	17
12	1 831	46	60	100	49	100	290	69	97	93	69	56
13	3 327	9	74	89	94	53	311	29	0	0	57	44
14	1 600	7	11	54	108	35	348	32	0	0	224	60
15	2 594	40	355	50	501	84	590	39	3	100	58	15
16	8 927	12	148	100	537	57	778	35	8	100	20	100
17	2 108	79	9	55	64	46	62	13	325	37	1	100
18	4 730	76	54 228	85	1 857	43	124	100	388	47	162	99
19	7 338	52	1 853	60	688	26	745	100	1 561	29	729	21
20	24 410	44	1 330	48	798	20	536	34	1 940	41	942	16
21a	118	61	0	0	0	0	0	0	0	0	1	100
21b	262	1	0	0	0	0	0	0	0	0	0	0
22	836	14	0	0	0	0	19	73	0	0	8	65
23	3	100	0	0	0	0	0	0	0	0	0	0
24	4	100	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0
Core	93 904	14	82 075	62	7 794	14	7 027	14	6 588	17	3 278	10
Total	95 127	14	82 075	62	7 794	14	7 046	14	6 588	17	3 286	10

Table 7 (continued)

	Species code									
	LDO		STA		GSP		WWA		HAK	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.
1	14	64	0	0	87	71	0	0	4	100
2a	62	11	17	100	116	17	0	0	31	54
2b	88	21	0	0	101	20	0	0	132	52
3	16	52	3	90	7	100	5	65	11	100
4	5	100	0	0	282	34	40	100	24	100
5	71	40	41	55	0	0	203	38	16	71
6	21	84	0	0	369	10	24	55	41	50
7	82	15	35	57	180	34	27	53	155	30
8a	86	15	2	100	50	79	17	75	54	29
8b	135	29	0	0	120	75	2	100	33	55
9	362	52	251	46	0	0	0	0	0	0
10a	245	53	5	100	146	52	16	46	89	56
10b	20	29	12	58	7	100	24	89	59	100
11a	254	44	27	51	0	0	16	85	22	68
11b	37	51	0	0	9	57	7	59	14	60
11c	35	24	42	47	25	100	0	0	11	100
11d	761	80	0	0	19	25	34	85	38	56
12	337	15	57	52	42	52	53	38	95	62
13	40	75	16	81	230	78	8	100	57	80
14	48	30	25	61	334	35	5	100	61	51
15	29	30	159	89	238	88	13	100	8	100
16	136	54	190	46	170	45	82	80	105	55
17	3	61	3	50	0	0	0	0	7	100
18	25	100	1699	48	0	0	226	100	0	0
19	188	100	381	51	0	0	9	95	33	100
20	157	47	203	61	18	100	1050	92	0	0
21a	1	100	0	0	5	37	0	0	22	29
21b	5	50	0	0	51	40	0	0	0	0
22	3	100	8	100	81	28	0	0	49	53
23	0	0	0	0	7	53	0	0	31	39
24	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
Core	3 257	21	3 169	28	2 550	14	1 861	54	1 099	15
Total	3 266	21	3 177	28	2 695	14	1 861	54	1 201	14

Table 7 (continued)

									Species code	
	<20 cm ORH		<30 cm ORH		total ORH		BOE		SOR	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.
1	0	0	0	0	1	100	0	0	80	58
2a	1	100	2	100	5	100	0	0	229	44
2b	2	65	10	72	17	70	0	0	623	30
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	2 740	52	38	44
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	8 452	22	2	100
7	0	0	0	0	0	0	0	0	0	0
8a	0	0	0	0	0	0	0	0	2	100
8b	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10a	0	0	0	0	0	0	0	0	0	0
10b	0	0	0	0	0	0	0	0	0	0
11a	0	0	0	0	0	0	0	0	0	0
11b	0	0	0	0	0	0	0	0	2	100
11c	0	0	0	0	0	0	0	0	0	0
11d	0	0	0	0	0	0	0	0	0	0
12	1	100	1	100	1	100	0	0	643	100
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	3	62	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	100
21a	2	52	28	42	111	49	0	100	1	100
21b	3	83	80	25	190	29	0	0	87	39
22	344	97	1 834	94	4 726	94	6	75	62	89
23	7	51	54	37	666	48	10	86	3	100
24	2	100	199	46	1 819	34	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
Core	4	48	13	57	24	54	11 195	21	1619	42
Total	362	92	2 208	79	7 537	60	11 211	21	1 772	39

Table 7 (continued)

	Species code									
	SND		SSO		ETB		CYP		RIB	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.
1	308	39	11	92	0	100	183	51	27	29
2a	1 028	14	4	100	4	100	88	100	95	33
2b	2 279	22	27	62	47	100	317	38	69	32
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	132	91	2	100	5	100
5	0	0	0	0	0	0	0	0	0	0
6	68	89	766	81	237	34	0	0	35	52
7	81	46	0	0	3	60	6	89	48	36
8a	6	100	0	0	0	0	0	0	22	80
8b	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10a	17	100	0	0	0	0	0	0	3	100
10b	0	0	0	0	0	0	0	0	3	100
11a	0	0	0	0	0	0	0	0	0	0
11b	37	24	0	0	3	100	0	100	17	70
11c	0	0	0	0	0	0	0	0	4	100
11d	0	0	0	0	0	0	0	0	4	100
12	65	100	0	0	0	0	0	0	9	100
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	39	100
15	0	0	0	0	0	0	0	0	17	60
16	7	100	0	0	3	100	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21a	24	33	7	67	13	85	58	8	7	18
21b	994	42	6	78	3	100	871	47	39	64
22	186	23	28	40	44	49	270	9	47	43
23	11	72	728	89	41	46	108	29	0	0
24	114	78	15	52	43	55	121	100	0	0
25	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
Core	3 897	14	808	76	430	36	596	29	396	17
Total	5 226	13	1 592	56	573	27	2 024	23	489	15

Table 8: Total numbers of fish, squid and scampi measured for length frequency distributions and biological samples (TAN1101). The total number of fish measured is sometimes greater than the sum of males and females because some fish were unsexed.

Species	Species code	Number measured Males	Number measured Females	Number measured Total
Abyssal rattail	CTR	0	2	2
Alfonsino	BYS	381	325	710
Banded bellowsfish	BBE	306	253	2 894
Banded rattail	CFA	38	18	258
Barracouta	BAR	12	16	28
Basketwork eel	BEE	159	292	461
Baxter's dogfish	ETB	116	111	227
Bigeye cardinalfish	EPL	187	145	334
Bigscaled brown slickhead	SBI	416	630	1 049
Black javelinfish	BJA	1	5	6
Black oreo	BOE	536	522	1 062
Black slickhead	BSL	171	102	273
Blackspot rattail	VNI	15	19	37
Bluenose	BNS	6	3	9
Bollons rattail	CBO	1 454	912	2 376
Brown chimaera	CHP	5	3	8
Carpet shark	CAR	1	0	1
Catshark	APR	10	5	15
Common roughy	RHY	193	207	401
Crested bellowsfish	CBE	1	5	142
Dark ghostshark	GSH	956	1 002	1 958
Dawson’s catshark	DCS	1	2	3
Deepsea cardinalfish	EPT	68	45	115
Deepsea flathead	FHD	6	12	18
Deepwater spiny skate	DSK	1	0	1
Finless flounder	MAN	2	1	3
Four-rayed rattail	CSU	975	795	2 313
Frill shark	FRS	0	2	2
Frostfish	FRO	1	0	1
Giant stargazer	STA	186	193	381
Greenback jack mackerel	JMD	1	2	3
Hairy conger	HCO	1	6	7
Hake	HAK	76	65	141
Hapuku	HAP	18	10	28
Hoki	HOK	7 236	9 087	16 340
Humpback rattail	CBA	1	19	20
Javelin fish	JAV	1 103	5 387	6 579
Johnson's cod	HJO	322	534	873
Leafscale gulper shark	CSQ	24	45	69
Lemon sole	LSO	14	11	25
Ling	LIN	524	514	1 039
Longnose velvet dogfish	CYP	312	430	742
Long-nosed chimaera	LCH	155	127	282
Longnosed deepsea skate	PSK	5	2	7
Lookdown dory	LDO	1 041	848	1 902
Lucifer dogfish	ETL	192	215	408
Mahia rattail	CMA	59	72	131
Nezumia namatahi	NNA	0	1	1
Northern spiny dogfish	NSD	3	1	4
Notable rattail	CIN	231	291	596
Notocanthus chemnitzi	NOC	1	0	1

Table 8 (continued)

Species	Species code	Number measured Males	Number measured Females	Number measured Total
NZ southern arrow squid	NOS	278	327	608
Oblique banded rattail	CAS	168	931	1 178
Oliver's rattail	COL	751	1 046	1 967
Orange perch	OPE	185	247	433
Orange roughy	ORH	771	906	1 688
Pale ghostshark	GSP	354	358	712
Plunket's shark	PLS	7	6	13
Prickly deepsea skate	BTS	0	2	2
Prickly dogfish	PDG	3	8	11
Red cod	RCO	98	74	188
Redbait	RBT	12	7	19
Ribaldo	RIB	125	55	180
Ridge scaled rattail	MCA	11	30	41
Robust cardinalfish	EPR	68	71	140
Rough skate	RSK	6	9	15
Roughhead rattail	CHY	11	5	16
Roughhead rattail	CTH	2	4	6
Ruby fish	RBY	7	5	20
Rudderfish	RUD	11	3	14
Sandfish	GON	0	2	2
Scampi	SCI	16	22	40
School shark	SCH	7	1	8
Sea perch	SPE	1 287	1 387	2 687
Seal shark	BSH	26	41	67
Serrulate rattail	CSE	265	126	394
Shovelnose dogfish	SND	778	553	1 337
Silver dory	SDO	133	100	234
Silver roughy	SRH	131	110	251
Silver warehou	SWA	1 160	975	2 136
Silverside	SSI	480	328	974
Sixgill shark	HEX	1	1	2
Slender mackerel	JMM	25	13	38
Small banded rattail	CCX	0	4	4
Small-headed cod	SMC	2	4	6
Smallscaled brown slickhead	SSM	257	163	420
Smooth oreo	SSO	326	300	628
Smooth skate	SSK	19	21	40
Smoothskin dogfish	CYO	98	54	152
Southern blue whiting	SBW	5	3	8
Southern Ray’s bream	SRB	40	42	82
Spiky oreo	SOR	593	588	1 232
Spineback	SBK	13	90	104
Spiny dogfish	SPD	395	1 470	1 865
Swollenhead conger	SCO	8	6	14
Tarakihi	TAR	23	10	33
Trachyscorpia capensis	TRS	0	4	4
Tubbia tasmanica	TUB	0	3	3
Two saddle rattail	CBI	29	113	142
Unicorn rattail	WHR	1	1	2
Velvet rattail	TRX	0	1	1
Viperfish	CHA	0	1	1
Warty oreo	WOE	22	16	38

Table 8 (continued)

Species	Species code	Number measured Males	Number measured Females	Number measured Total
Warty squid (*O. robsoni*)	MRQ	4	1	5
White cardinalfish	EPD	0	2	116
White rattail	WHX	150	107	257
White warehou	WWA	292	228	521
Wide-nosed chimaera	RCH	62	58	120
Witch	WIT	16	15	31
Total		27 055	34 352	65 536

Table 9: Length-weight regression parameters* used to scale length frequencies (all data from TAN1101).

Species	*a* (intercept)	*b* (slope)	r^2	*n*	Length range (cm)
Black oreo	0.016020	3.070446	0.86	168	24–39
Dark ghostshark	0.002705	3.197002	0.96	699	34–75
Giant stargazer	0.008261	3.161064	0.98	377	27–81
Hake	0.002783	3.210539	0.98	137	42–131
Hoki	0.003737	2.948525	0.99	2 071	37–109
Ling	0.001272	3.295430	0.99	886	28–156
Lookdown dory	0.025799	2.950263	0.99	1 124	11–56
Orange roughy	0.039710	2.944295	0.99	496	7–41
Pale ghostshark	0.006639	2.968266	0.97	620	23–87
Sea perch	0.012641	3.063978	0.99	1 133	12–49
Silver warehou	0.009822	3.151097	0.98	755	15–55
Smooth oreo	0.022146	2.997321	0.99	270	17–51
Spiny dogfish	0.001138	3.321544	0.94	995	52–106
White warehou	0.019184	3.025823	0.99	261	16–60

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

Table 10: Numbers of fish measured at each reproductive stage (Bony and cartilaginous fish were staged using different methods – see footnote below table).

		Reproductive stage								
Common name	Sex	1	2	3	4	5	6	7	8	Total
Alfonsino	Male	1	-	-	-	-	-	-	-	1
	Female	2	-	-	-	-	-	-	-	2
Banded rattail	Male	-	1	-	-	-	-	-	-	1
	Female	-	4	-	-	-	-	-	-	4
Baxter’s dogfish	Male	42	8	61	-	-	-	-	-	111
	Female	51	23	7	9	13	2	-	-	105
Bigeye rattail	Male	-	48	-	-	-	-	-	-	48
	Female	2	26	-	-	-	-	-	-	28
Blackjavelinfish	Male	1	-	-	-	-	-	-	-	1
	Female	2	1	1	-	1	-	-	-	5
Black oreo	Male	85	74	5	-	-	-	-	-	164
	Female	56	108	12	-	-	-	-	-	176
Black slickhead	Male	15	62	-	-	-	-	-	-	77
	Female	6	-	19	-	-	-	-	-	25
Carpet shark	Male	1	-	-	-	-	-	-	-	1
	Female	-	-	-	-	-	-	-	-	-
Catshark	Male	3	2	5	-	-	-	-	-	10
(*Apristurus* spp.)	Female	3	-	-	-	1	-	-	-	4
Dark ghostshark	Male	40	43	172	-	-	-	-	-	255
	Female	74	105	43	-	-	-	-	-	222
Dawson’s catshark	Male	-	-	1	-	-	-	-	-	1
	Female	-	1	1	-	-	-	-	-	2
Deepsea cardinalfish	Male	15	-	-	-	-	-	-	-	15
	Female	7	-	-	-	-	-	-	-	7
Frill shark	Male	-	-	-	-	-	-	-	-	-
	Female	-	1	-	-	-	-	-	-	1
Giant stargazer	Male	1	-	-	-	-	-	-	-	1
	Female	-	-	-	-	-	-	-	-	-
Hake	Male	16	13	10	14	15	6	1	-	75
	Female	7	32	22	-	-	-	2	-	63
Hoki	Male	481	319	-	-	-	-	-	-	800
	Female	678	662	-	-	-	-	-	-	1340
Humpback (slender)	Male	-	-	-	-	-	-	-	-	-
rattail	Female	1	8	2	-	-	-	-	-	11
Javelinfish	Male	3	16	11	-	-	-	-	-	30
	Female	23	8	4	-	-	-	-	-	35
Leafscale gulper shark	Male	19	-	2	-	-	-	-	-	21
	Female	31	3	7	1	-	1	-	-	43
Ling	Male	186	108	118	40	-	-	-	-	452
	Female	171	270	2	2	-	-	-	-	445
Long-nosed chimaera	Male	28	3	51	-	-	-	-	-	82
	Female	34	14	20	3	-	-	-	-	71
Longnosed deepsea skate	Male	1	2	-	-	-	-	-	-	3
	Female	-	1	-	-	-	-	-	-	1
Longnose velvet dogfish	Male	140	13	82	-	-	-	-	-	235
	Female	177	87	41	31	1	1	-	-	338
Lookdown dory	Male	4	3	-	-	-	-	-	-	7
	Female	2	-	-	-	-	-	-	-	2
Lucifer dogfish	Male	4	12	51	-	-	-	-	-	67
	Female	24	30	10	7	-	1	-	-	72
Mahia rattail	Male	6	19	-	-	-	-	-	-	25
	Female	2	20	-	-	-	-	-	-	22

Table 10 (continued)

Common name	Sex	Reproductive stage 1	2	3	4	5	6	7	8	Total
Northern spiny dogfish	Male	1	-	2	-	-	-	-	-	3
	Female	-	-	1	-	-	-	-	-	1
Oblique banded rattail	Male	3	9	1	-	-	-	-	-	13
	Female	8	52	-	-	-	-	-	-	60
Oliver's rattail	Male	-	3	-	-	-	-	-	-	3
	Female	-	2	-	-	-	-	-	-	2
Orange Roughy	Male	126	108	2	-	-	-	-	-	236
	Female	107	96	108	-	-	-	-	1	312
Pale ghostshark	Male	81	12	135	-	-	-	-	-	228
	Female	98	51	46	6	1	-	-	-	202
Plunket's shark	Male	3	2	-	-	-	-	-	-	5
	Female	1	3	-	-	-	-	-	-	4
Prickly deepsea skate	Male	-	-	-	-	-	-	-	-	-
	Female	2	-	-	-	-	-	-	-	2
Prickly dogfish	Male	-	1	2	-	-	-	-	-	3
	Female	1	2	2	-	-	1	-	-	6
Ribaldo	Male	-	21	-	-	-	-	-	-	21
	Female	-	6	-	-	-	-	-	-	6
Ridge scaled rattail	Male	-	-	-	-	-	-	-	-	-
	Female	1	-	-	-	-	-	-	-	1
Roughhead rattail	Male	-	7	4	-	-	-	-	-	11
(*C. trachycarus*)	Female	-	-	4	1	-	-	-	-	5
Rough skate	Male	-	-	5	-	-	-	-	-	5
	Female	3	1	1	-	-	1	-	-	6
Rudderfish	Male	-	-	-	-	-	-	-	-	-
	Female	-	-	1	-	-	-	-	-	1
School shark	Male	-	1	5	-	-	-	-	-	6
	Female	-	-	-	-	-	-	-	-	-
Sea Perch	Male	1	7	-	-	-	-	-	-	8
	Female	9	6	-	-	2	-	-	-	17
Seal Shark	Male	24	-	1	-	-	-	-	-	25
	Female	31	3	1	1	-	-	-	-	36
Shovelnose dogfish	Male	73	66	236	-	-	-	-	-	375
	Female	161	103	18	7	1	2	-	-	292
Silver warehou	Male	-	33	-	-	-	-	-	-	33
	Female	-	19	-	-	-	-	-	-	19
Small banded rattail	Male	-	-	-	-	-	-	-	-	-
	Female	-	-	-	1	-	-	-	-	1
Smooth oreo	Male	115	35	23	5	-	-	-	-	178
	Female	88	34	14	-	2	-	-	-	138
Smooth skate	Male	10	1	1	-	-	-	-	-	12
	Female	11	6	-	-	-	-	-	-	17
Smooth skin dogfish	Male	12	2	73	-	-	-	-	-	87
	Female	17	20	6	3	-	-	-	-	46
Southern Ray's bream	Male	1	-	-	-	-	-	-	-	1
	Female	-	-	-	-	-	-	-	-	-
Spiky oreo	Male	101	85	16	-	-	-	-	-	202
	Female	89	91	27	1	2	1	-	-	211
Spiny dogfish	Male	6	23	234	-	-	-	-	-	263
	Female	223	281	85	121	277	7	-	-	994
Spotty faced rattail	Male	-	1	1	-	-	-	-	-	2
(*C. acanthiger*)	Female	-	4	-	-	-	-	-	-	4
Squashed face rattail	Male	-	-	-	-	-	-	-	-	-
	Female	-	-	1	-	-	-	-	-	1

Table 10 (continued)

		Reproductive stage								
Common name	Sex	1	2	3	4	5	6	7	8	Total
									-	
Striate rattail	Male	-	-	-	-	-	-	-	-	-
	Female	-	2	-	-	-	-	-	-	2
Tarakihi	Male	1	12	2	-	-	-	-	-	15
	Female	-	4	-	-	-	-	-	-	4
Trachyscorpia capensis	Male	-	-	-	-	-	-	-	-	-
	Female	-	1	-	-	-	-	-	-	1
Two saddle rattail	Male	-	25	3	-	-	1	-	-	29
	Female	14	64	14	4	-	5	11	-	112
Unicorn rattail	Male	-	1	-	-	-	-	-	-	1
	Female	-	1	-	-	-	-	-	-	1
Velvet rattail	Male	-	-	-	-	-	-	-	-	-
	Female	-	-	-	1	-	-	-	-	1
Warty oreo	Male	-	5	-	-	-	-	-	-	5
	Female	-	-	1	-	-	-	-	-	1
White warehou	Male	5	1	-	-	-	-	-	-	6
	Female	3	1	-	-	-	-	-	-	4
White rattail	Male	9	7	-	-	-	-	-	-	16
	Female	5	16	-	-	-	-	-	-	21
Widenosed chimaera	Male	-	-	14	-	-	-	-	-	14
	Female	4	6	4	-	-	-	-	-	14

Middle depths gonad stages: 1, immature; 2, resting; 3, ripening; 4, ripe; 5, running ripe; 6, partially spent; 7, spent. (after Hurst et al. 1992)

Deepwater gonad stages (excluding oreos): male: 1, immature/resting; 2, early maturation; 3, mature; 4, ripe; 5, spent; 8, partially spent: female: 1, immature/resting; 2, early maturation; 3, mature; 4, ripe; 5, running ripe; 6, spent; 7, atretic; 8, partially spent

Oreo gonad stages: male: 1, immature; 2, resting/early maturation; 3, mature; 4, ripe; 5, spent; 8, partially spent: female: 1, immature; 2, resting/early maturation; 3, mature; 4, ripe; 5, running ripe; 6, spent; 7, atretic; 8, partially spent

Cartilaginous fish 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: Percent occurrence of seven mark types during the 2011 Chatham Rise trawl survey compared to results from previous surveys (from Stevens et al. 2011).

				Pelagic marks			Bottom marks		
Acoustic file	Survey	*n*	Surface Layer	School	Layer	Cloud	Layer	Cloud	School
Day trawl	2011	102	61	37	71	61	50	50	6
	2010	111	59	32	73	59	73	41	6
	2009	110	63	40	78	53	75	33	13
	2008	110	63	39	83	56	58	41	9
	2007	112	71	42	77	45	46	46	8
	2006	102	59	40	88	44	67	36	16
	2005	111	57	37	93	31	60	42	23
	2003	123	64	41	85	55	47	47	22
Day steam	2011	100	80	32	79	76	59	60	4
	2010	109	71	50	79	63	82	37	8
	2009	99	63	56	80	45	81	42	21
	2008	82	67	46	91	48	77	28	20
	2007	81	78	44	91	40	69	43	15
	2006	79	76	47	95	42	87	37	16
	2005	78	71	45	95	37	76	45	35
	2003	66	80	55	97	49	83	35	24
Night steam and trawl	2011	125	97	6	26	90	26	74	2
	2010	117	97	6	19	86	43	77	5
	2009	93	96	11	18	78	40	68	4
	2008	46	100	2	20	83	24	87	2
	2007	51	100	10	25	92	20	80	4
	2006	33	94	15	48	88	45	85	6
	2005	30	100	33	53	77	57	83	7
	2003	44	100	14	18	93	30	96	2

Table 12: 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 2001–11.

			Average acoustic backscatter (m^2 km^{-2})			
Year (Survey)	No. of recordings	Average trawl catch (kg km^{-2})	Bottom 10 m	Bottom 50 m	All bottom marks (to 100 m)	Entire echogram
2001 (TAN0101)	117	1 858	3.63	22.39	31.80	57.60
2002 (TAN0201)	102	1 849	4.50	18.39	22.60	49.32
2003 (TAN0301)	117	1 508	3.43	19.56	29.41	53.22
2005 (TAN0501)	86	1 783	2.78	12.69	15.64	40.24
2006 (TAN0601)	88	1 782	3.24	13.19	19.46	48.86
2007 (TAN0701)	100	1 510	2.00	10.83	15.40	41.07
2008 (TAN0801)	103	2 012	2.03	9.65	13.23	37.98
2009 (TAN0901)	105	2 480	2.98	15.89	25.01	58.88
2010 (TAN1001)	90	2 205	1.87	10.80	17.68	44.49
2011 (TAN1101)	73	1 997	1.79	8.72	12.94	34.79

Table 13: 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 (updated from Stevens et al. 2011).

	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

Table 14: 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 13) 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)											
		Unstratified		Northeast		Northwest		Southeast		Southwest		Stratified	
Survey	Year	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.	Mean	c.v.
TAN0101	2001	47.1	8	21.8	11	61.1	13	36.8	12	92.6	16	44.9	8
TAN0201	2002	35.8	6	25.1	11	40.3	11	29.6	13	54.7	13	34.0	7
TAN0301	2003	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

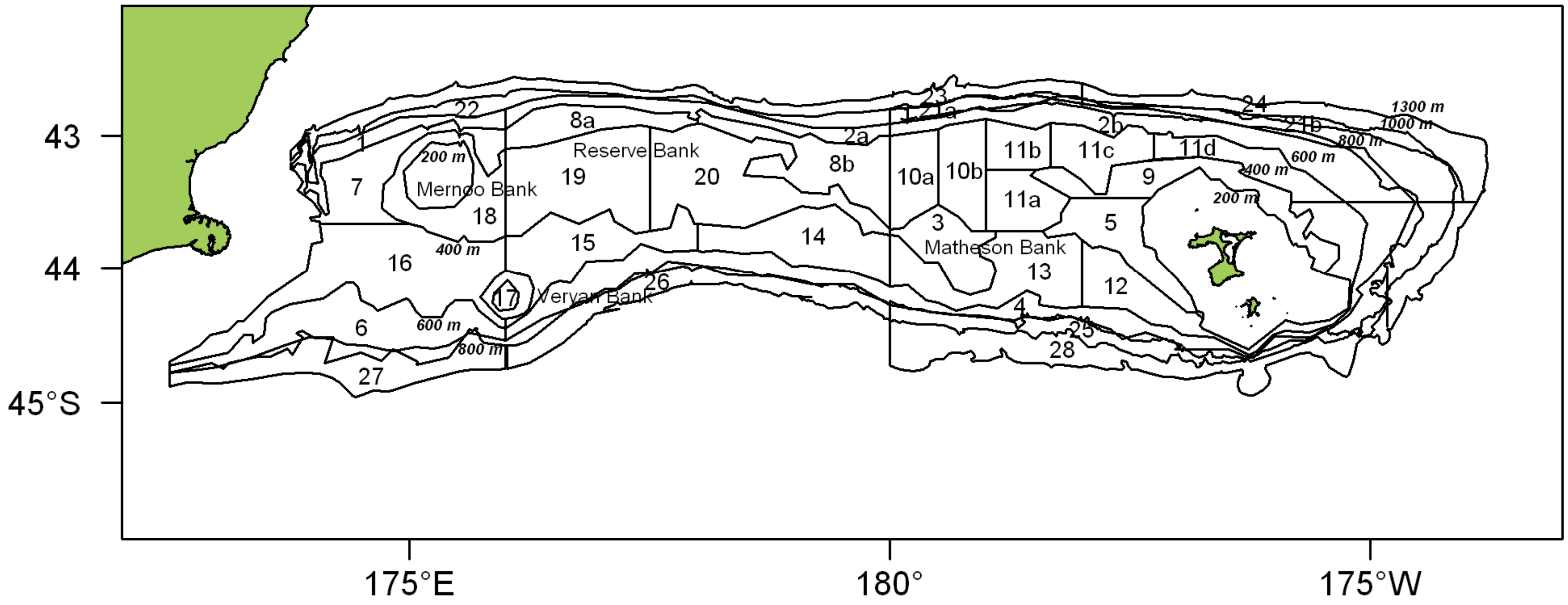


Figure 1: Trawl survey area showing stratum boundaries. Strata 25–28 were not surveyed in 2011.

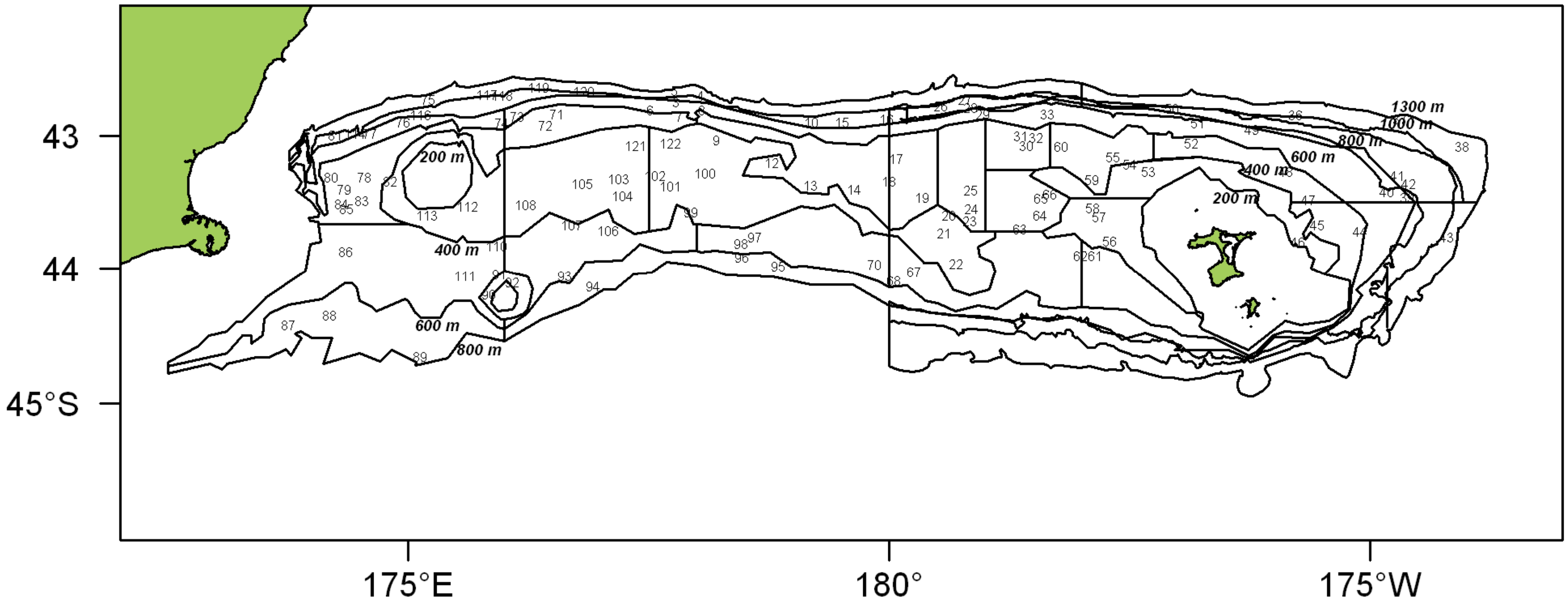


Figure 2: Trawl survey area showing positions of valid biomass stations (n = 114 stations) for TAN1101. In this and subsequent figures actual stratum boundaries are drawn for the new deepwater strata. These boundaries sometimes overlap with existing core survey stratum boundaries.

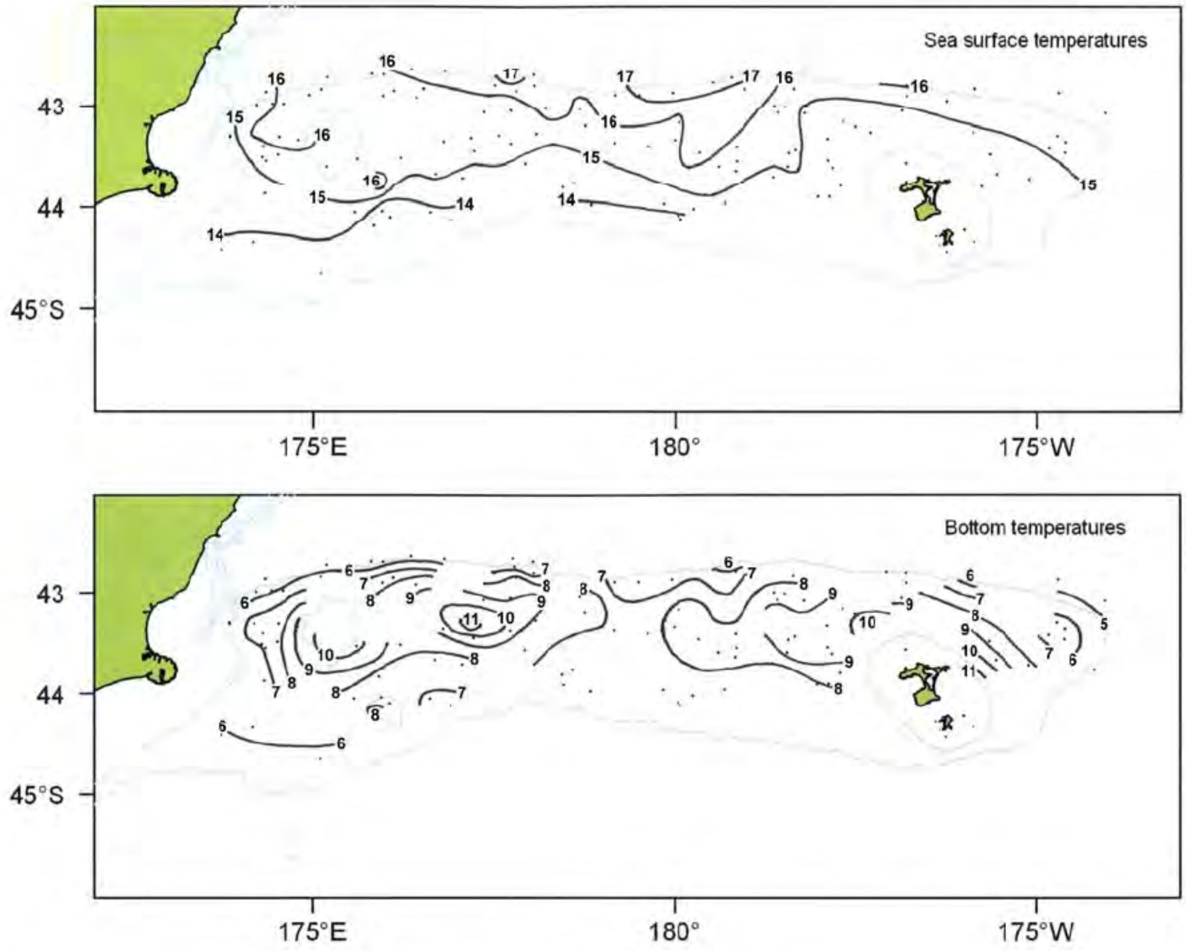
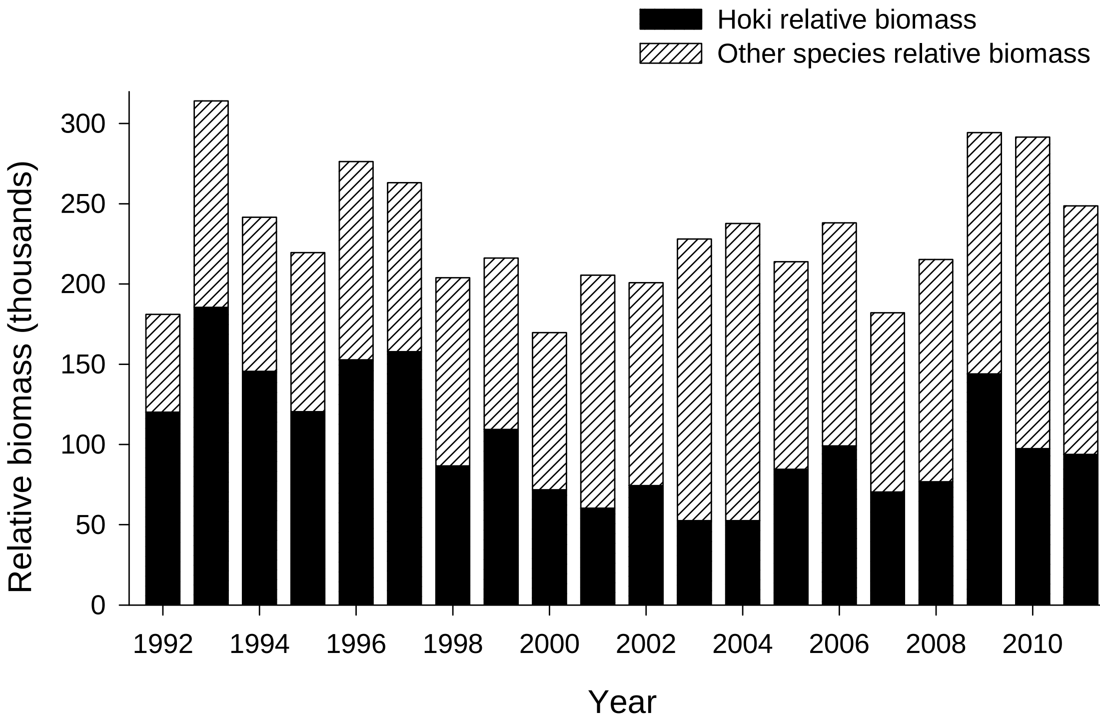


Figure 3: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (°C) interpolated by eye. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow.



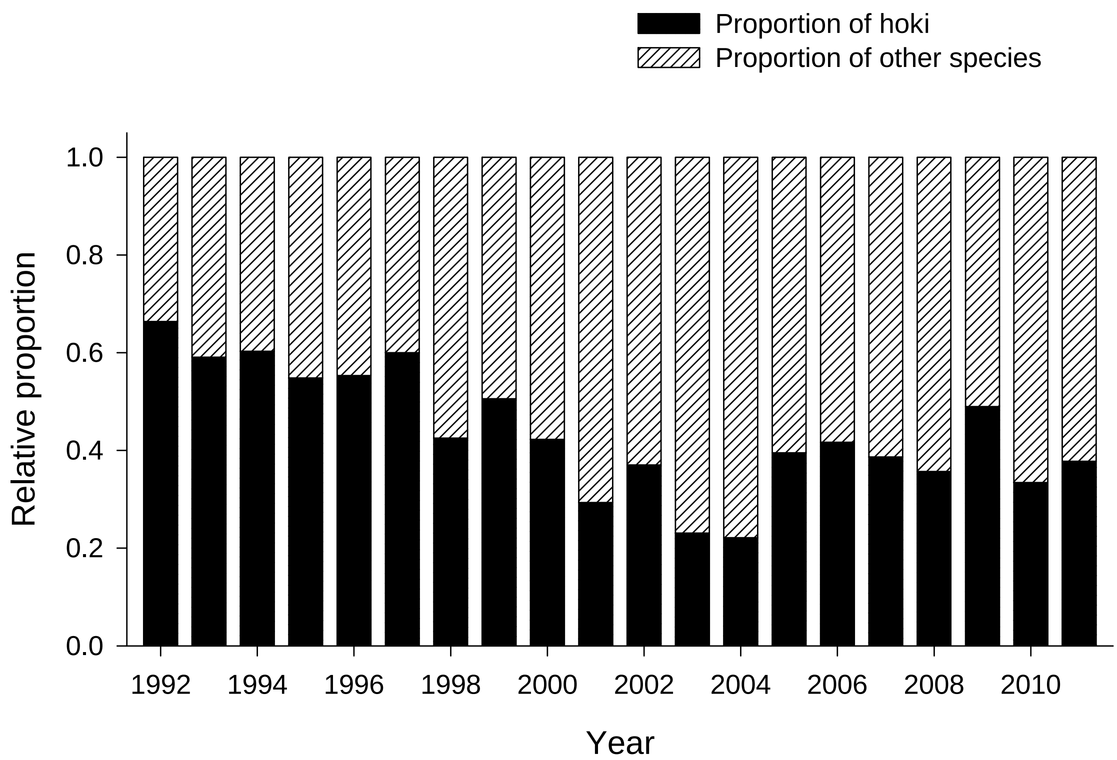


Figure 4: Relative biomass (top panel) and relative proportions of hoki and 30 other key species (lower panel) from trawl surveys of the Chatham Rise, January 1992–2011.

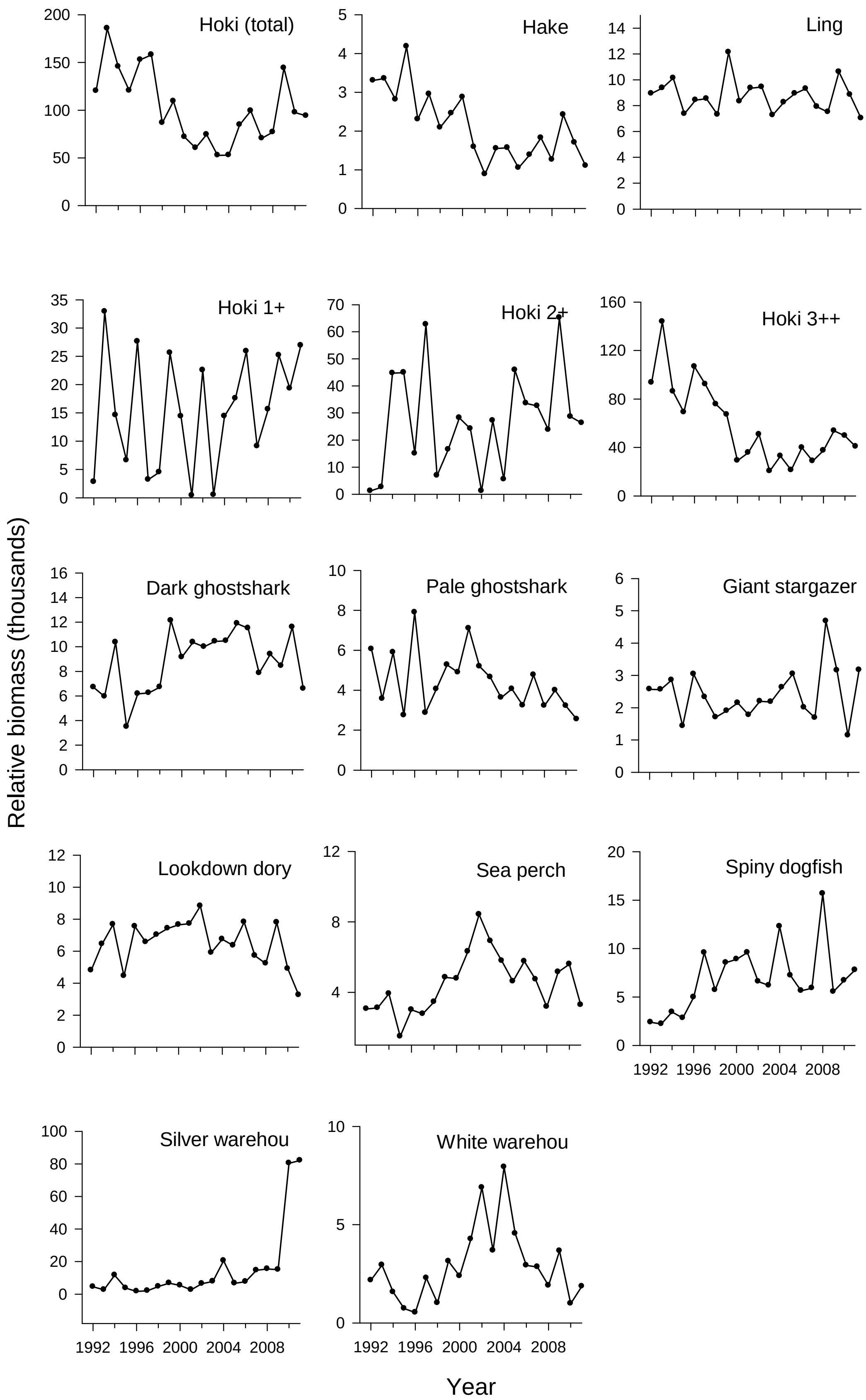


Figure 5: Relative biomass estimates (thousands) of important species sampled by annual trawl surveys of the Chatham Rise, January 1992–2011.

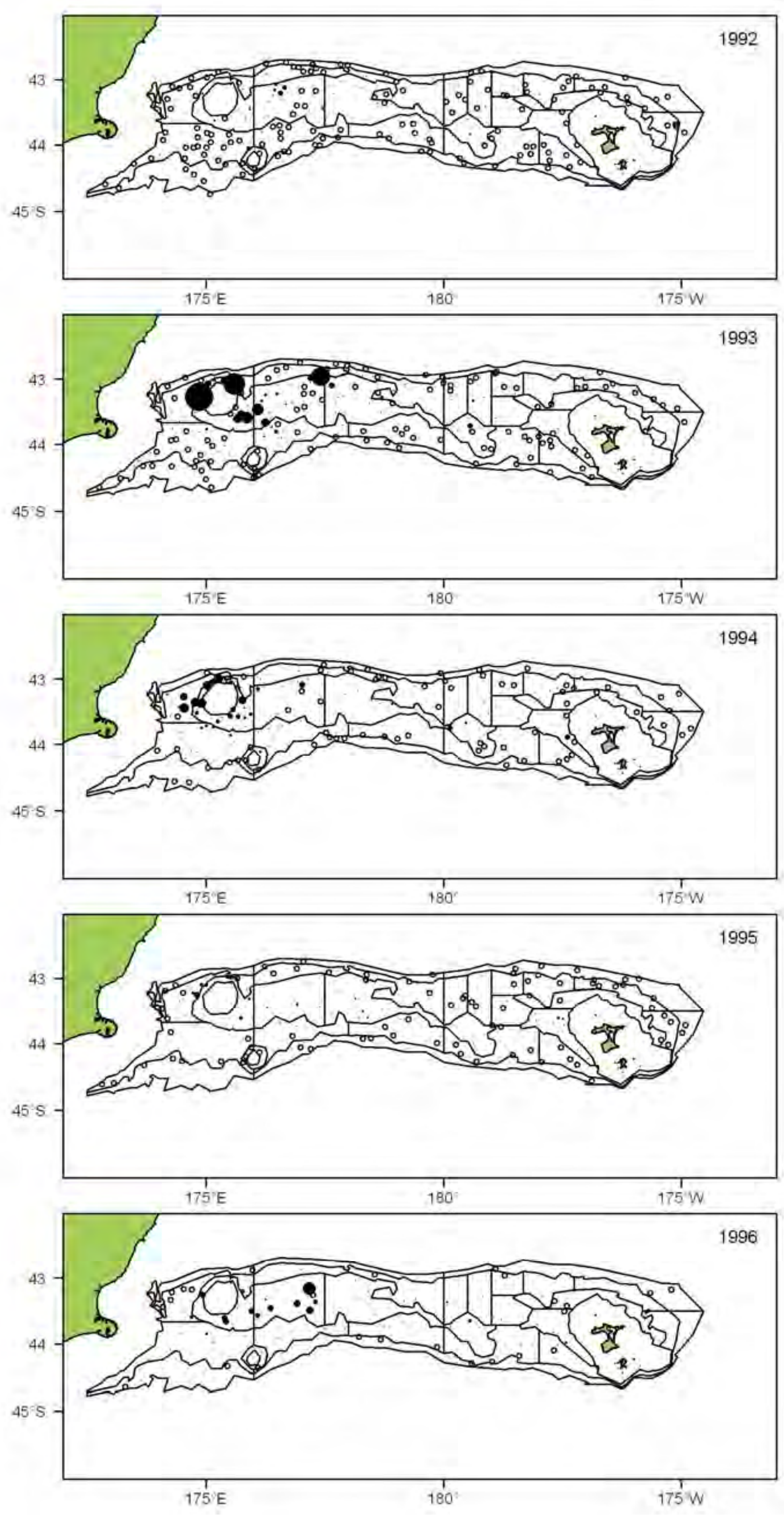


Figure 6a: Hoki 1+ catch distribution 1992–2011. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 30 850 kg.km^{-2}.

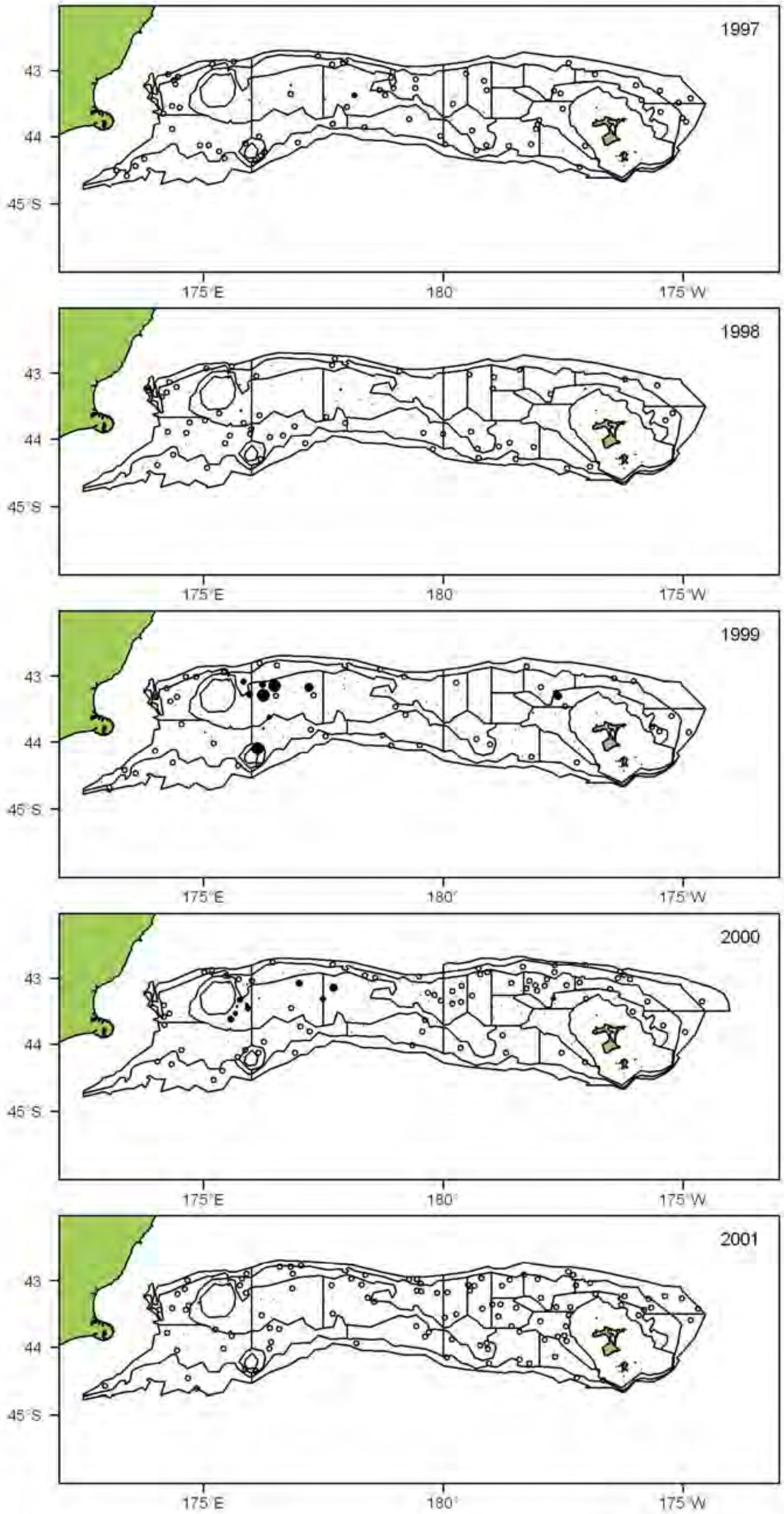


Figure 6a (continued)

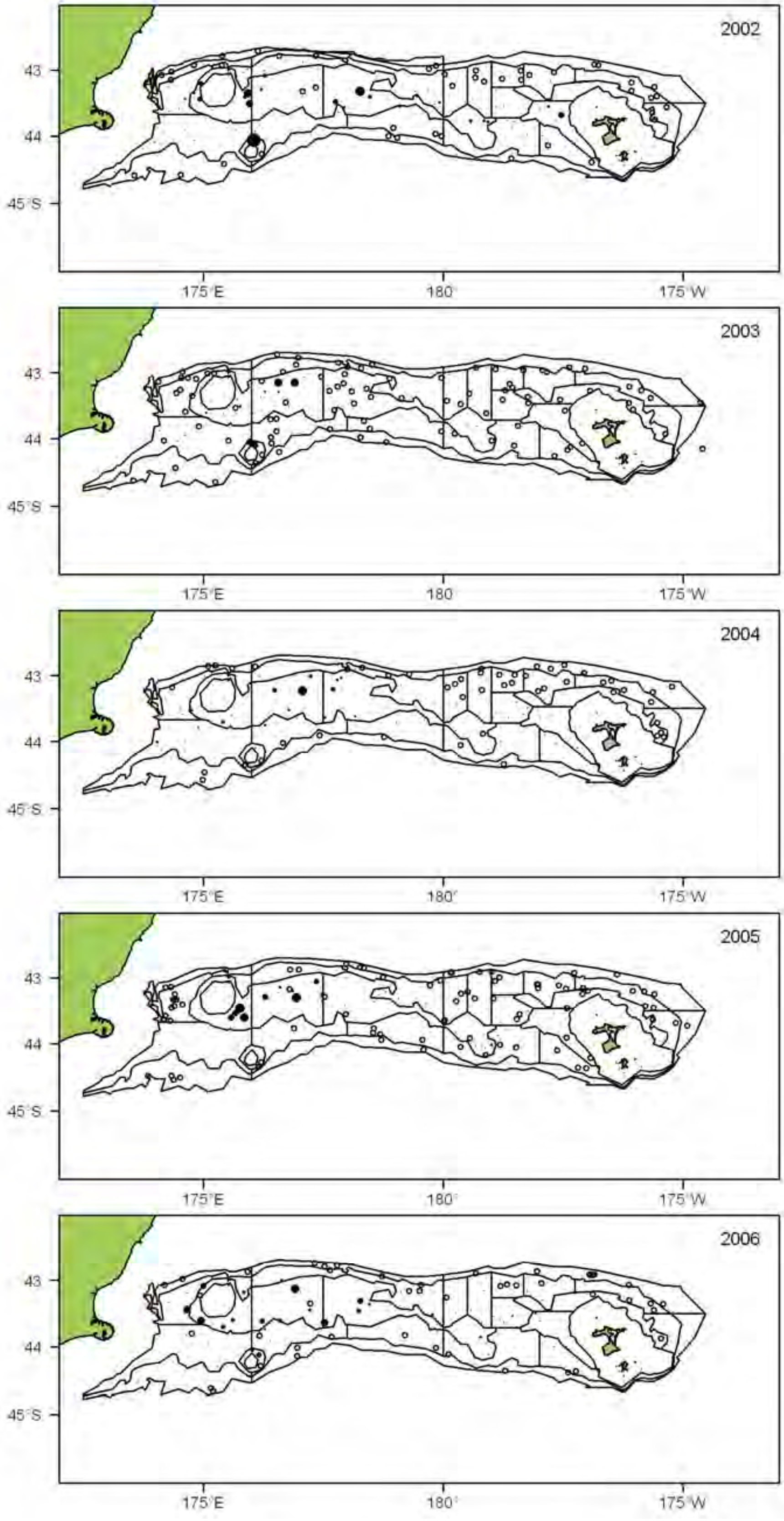


Figure 6a (continued)

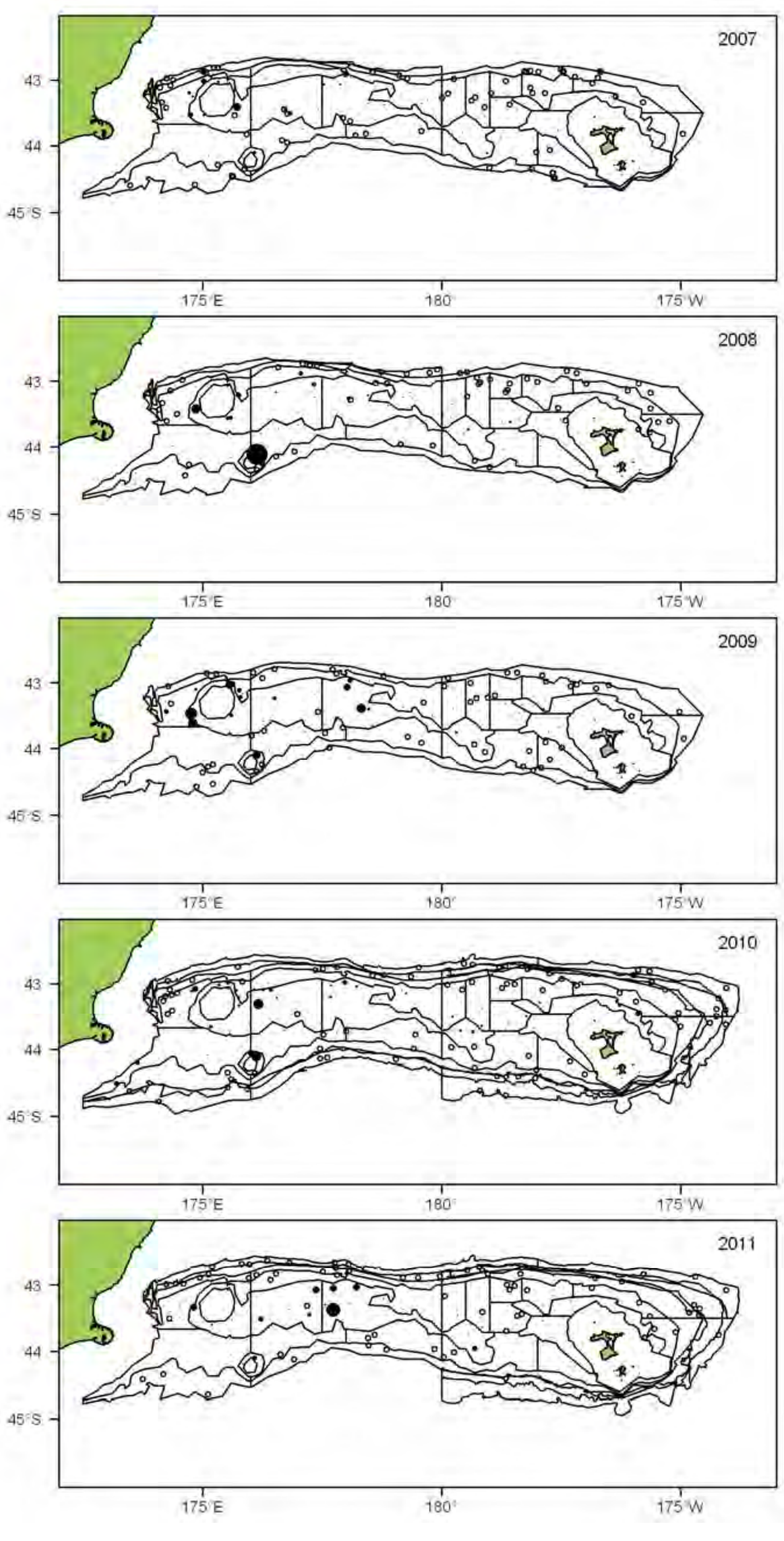


Figure 6a (continued)

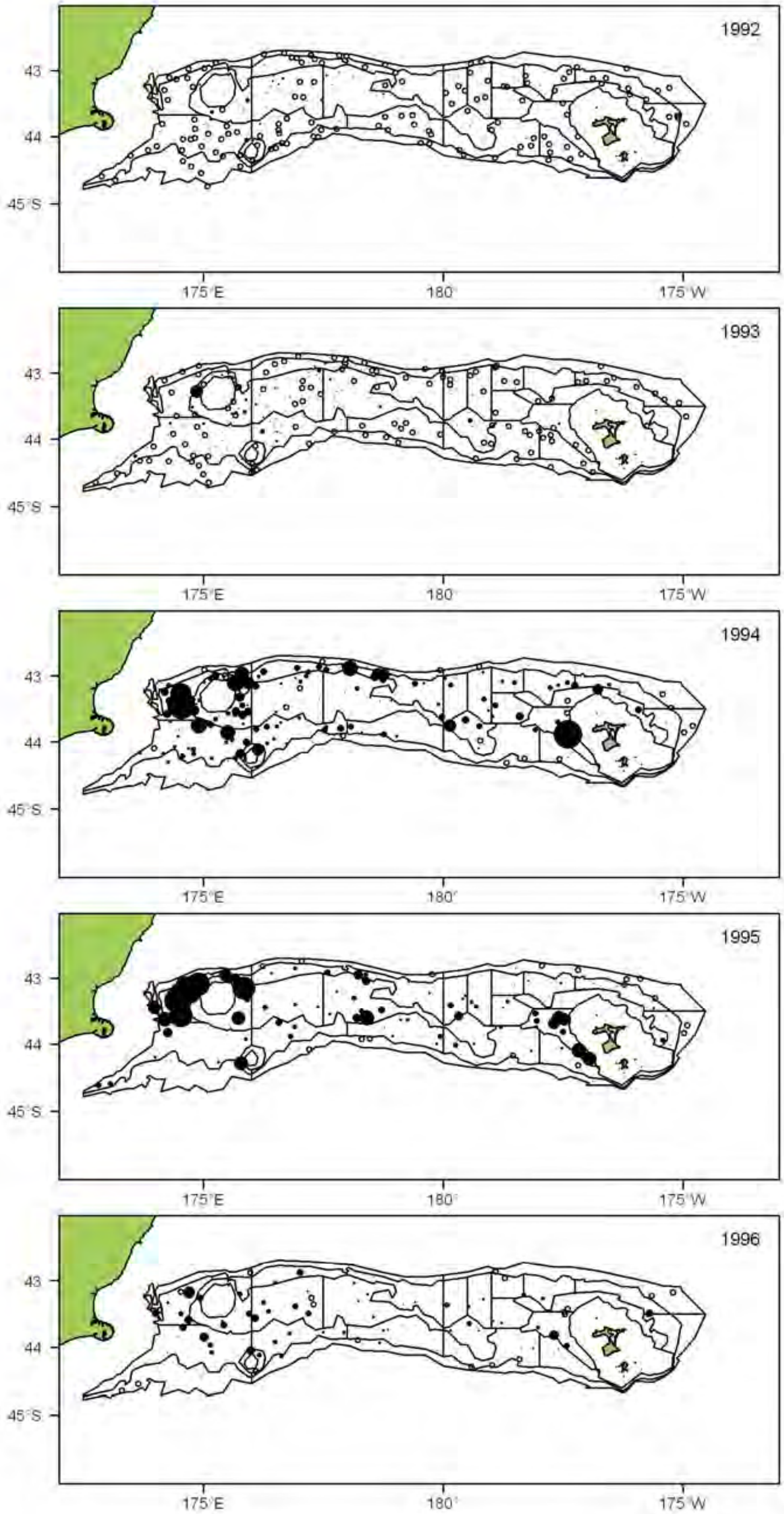


Figure 6b: Hoki 2+ catch distribution 1992–2011. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 6791 kg.km^{-2}.

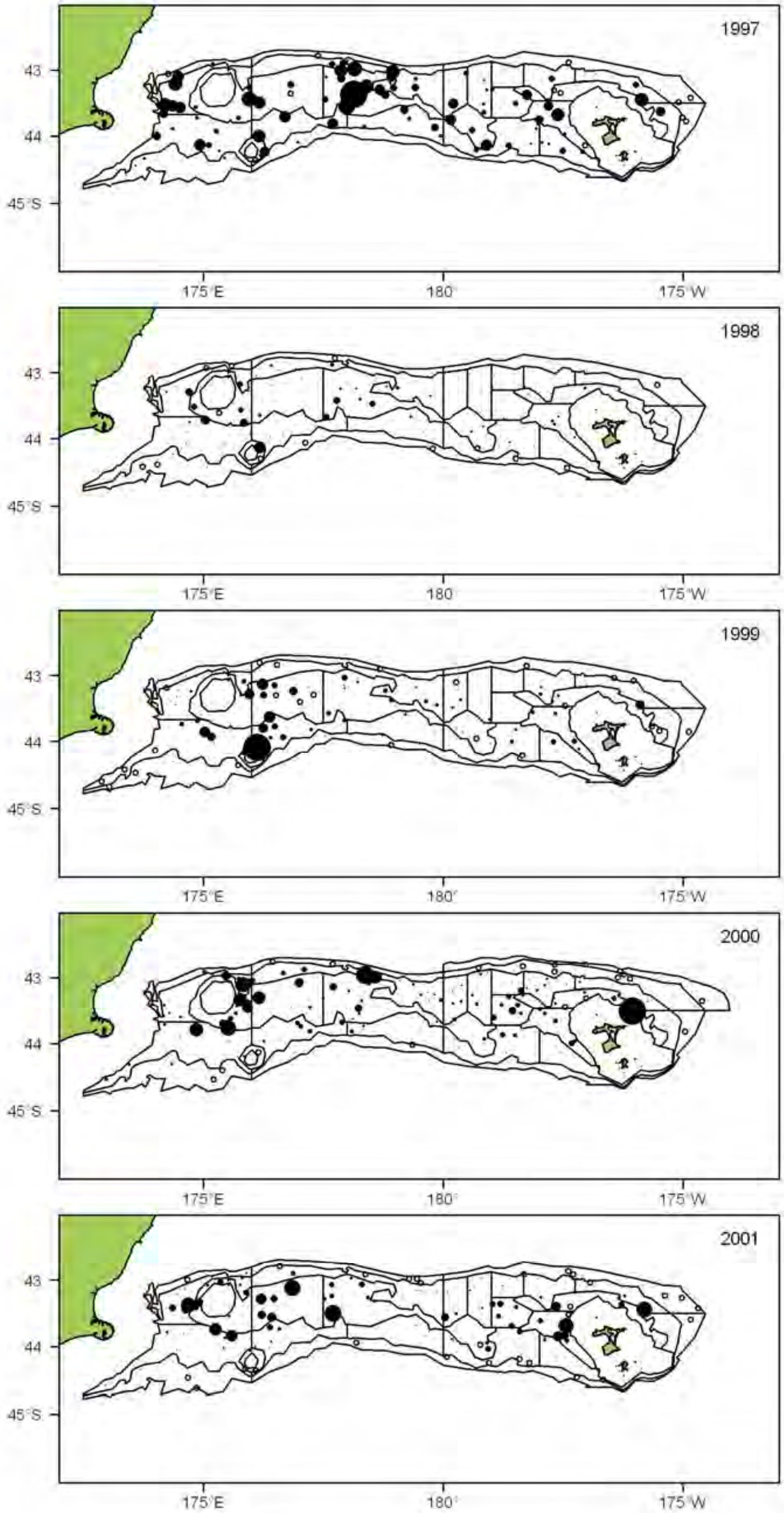


Figure 6b (continued)

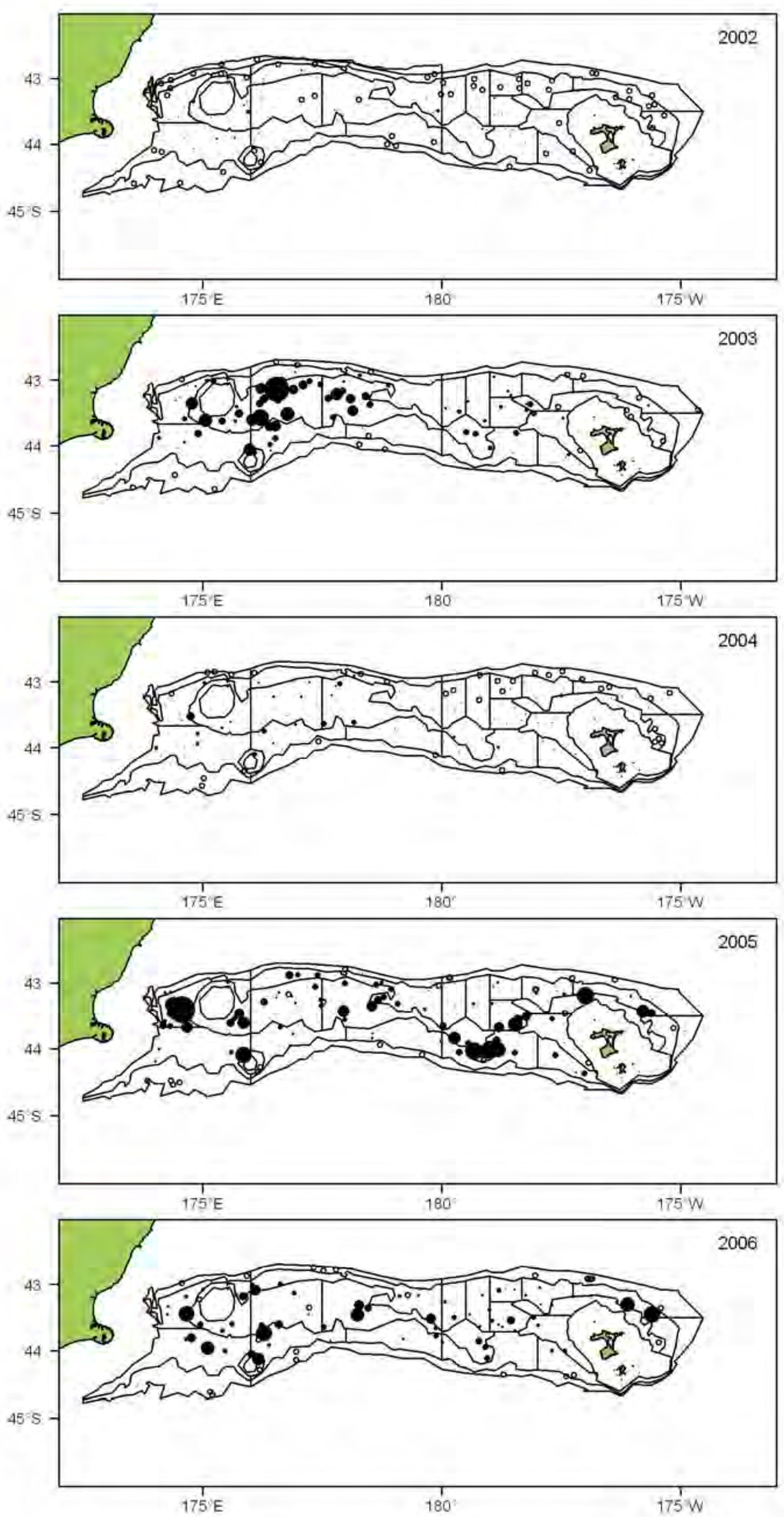


Figure 6b (continued)

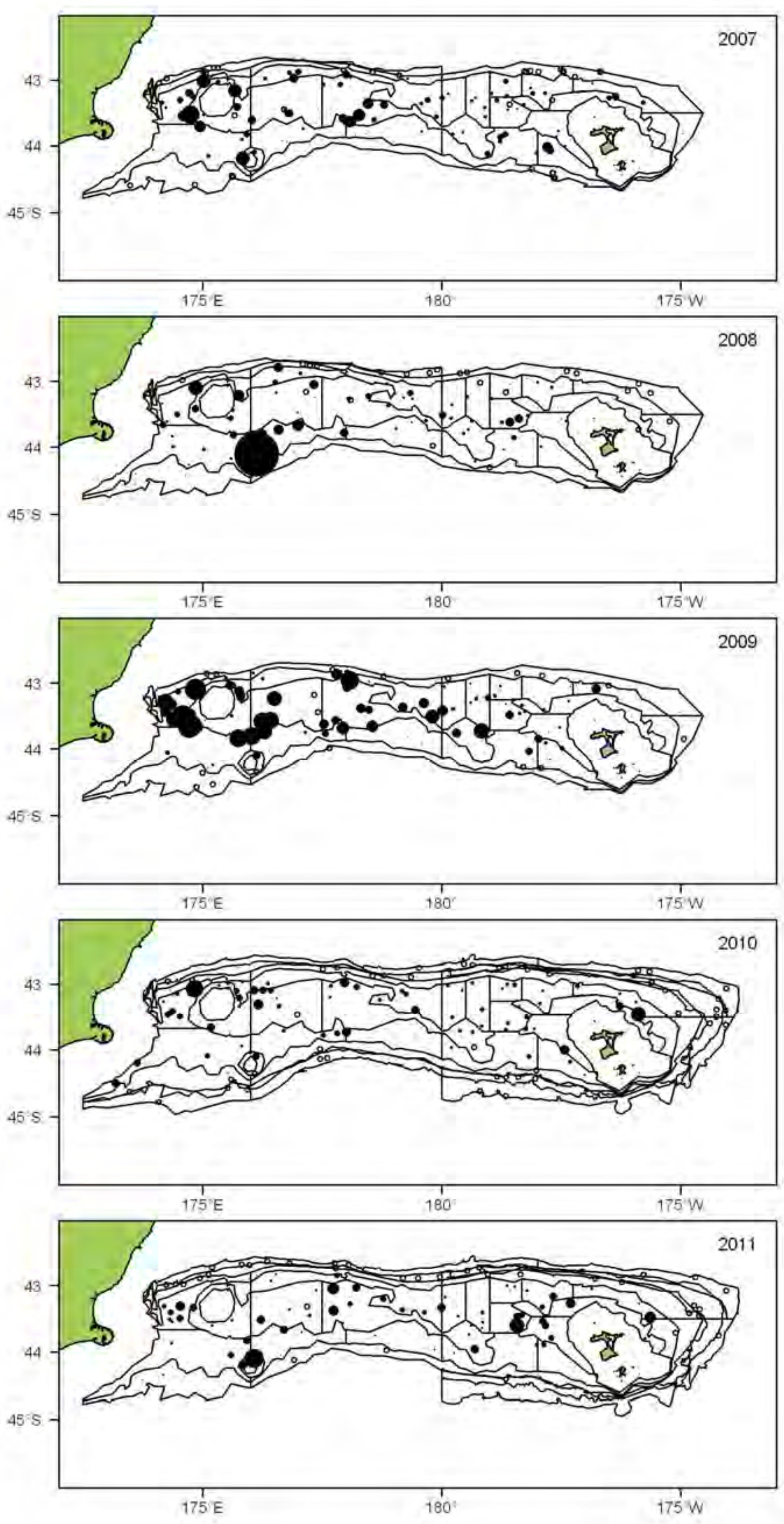


Figure 6b (continued)

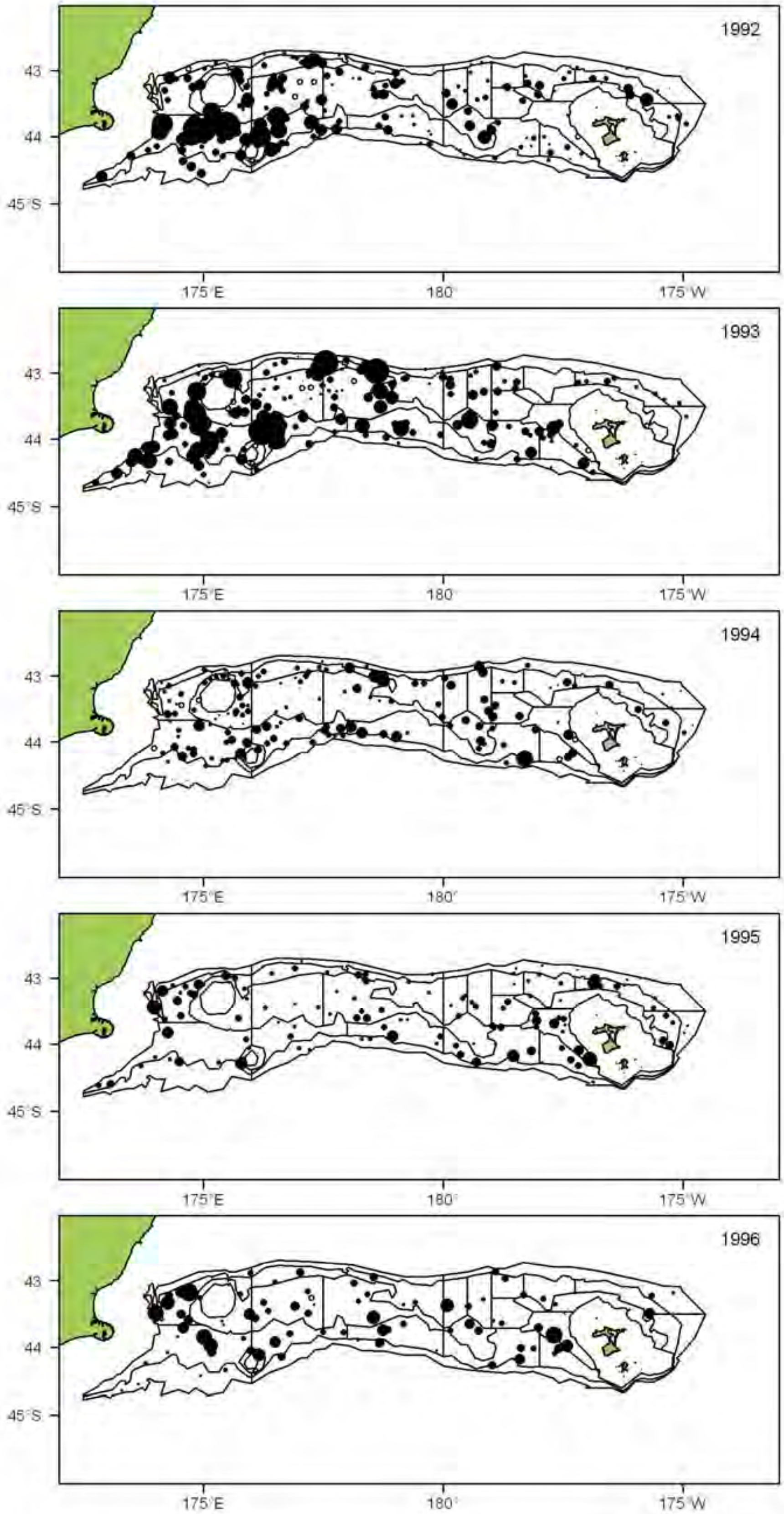


Figure 6c: Hoki 3++ catch distribution. 1992–2011. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 11 177 kg.km^{-2}.

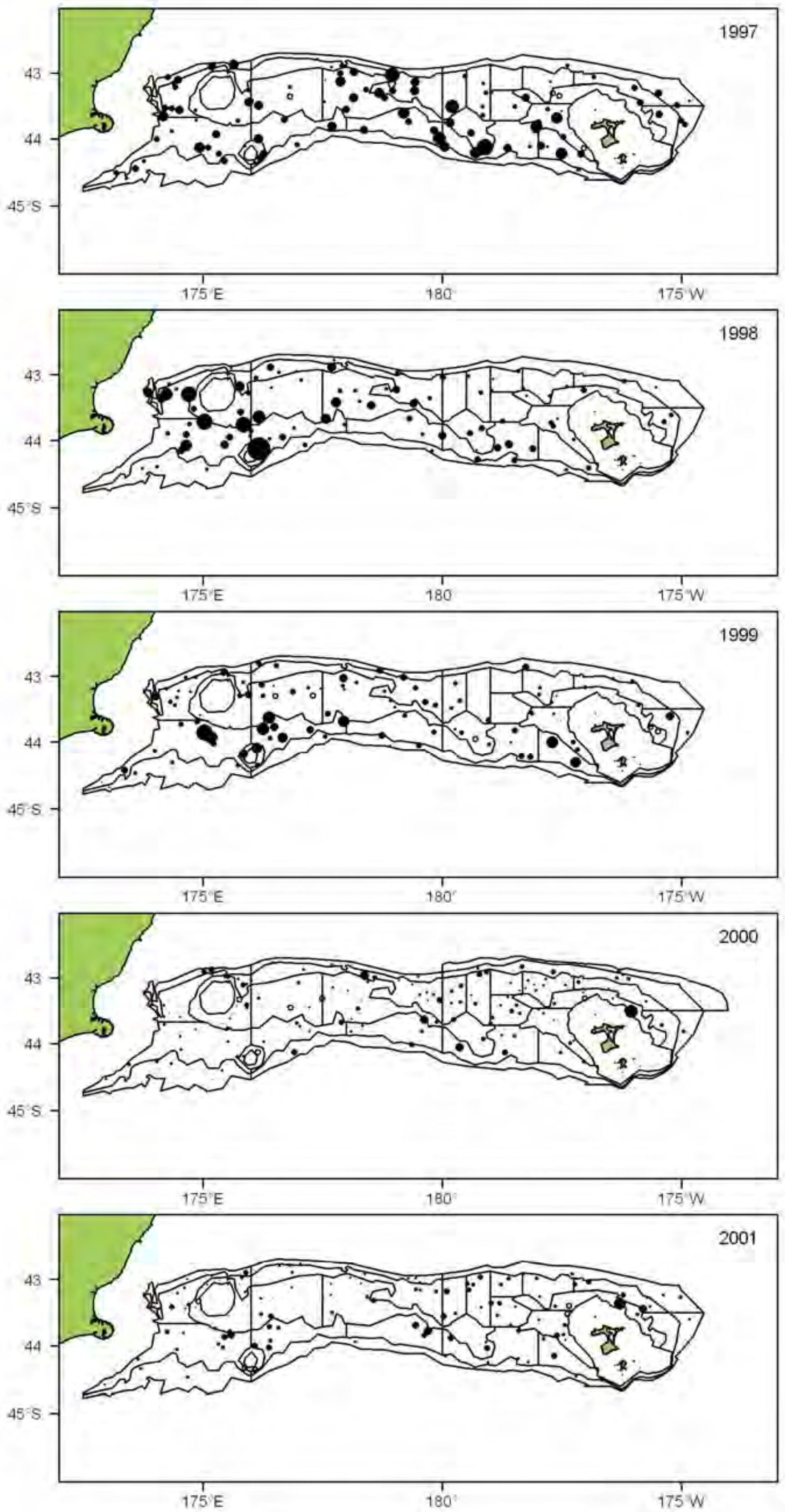


Figure 6c (continued)

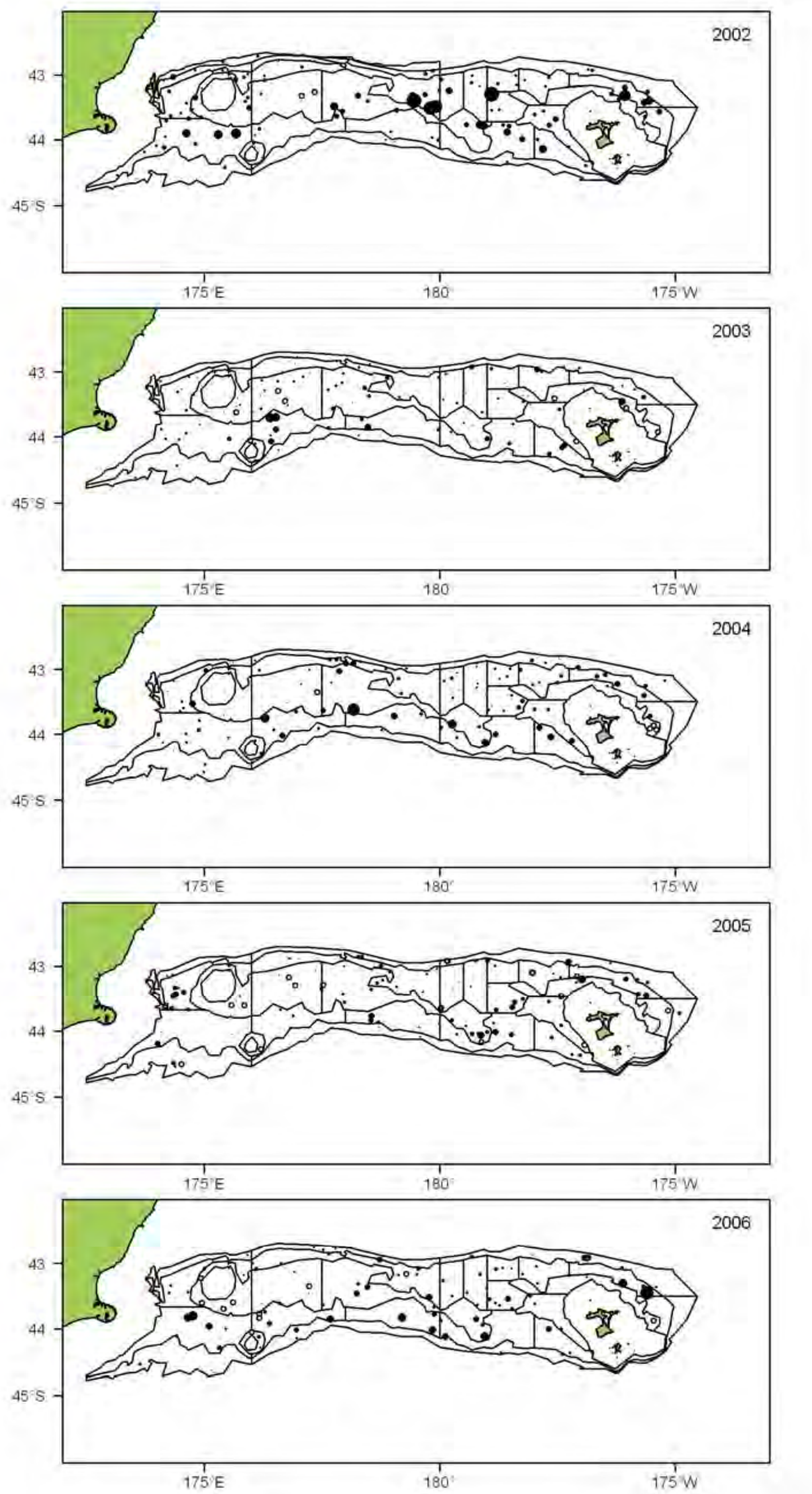


Figure 6c (continued)

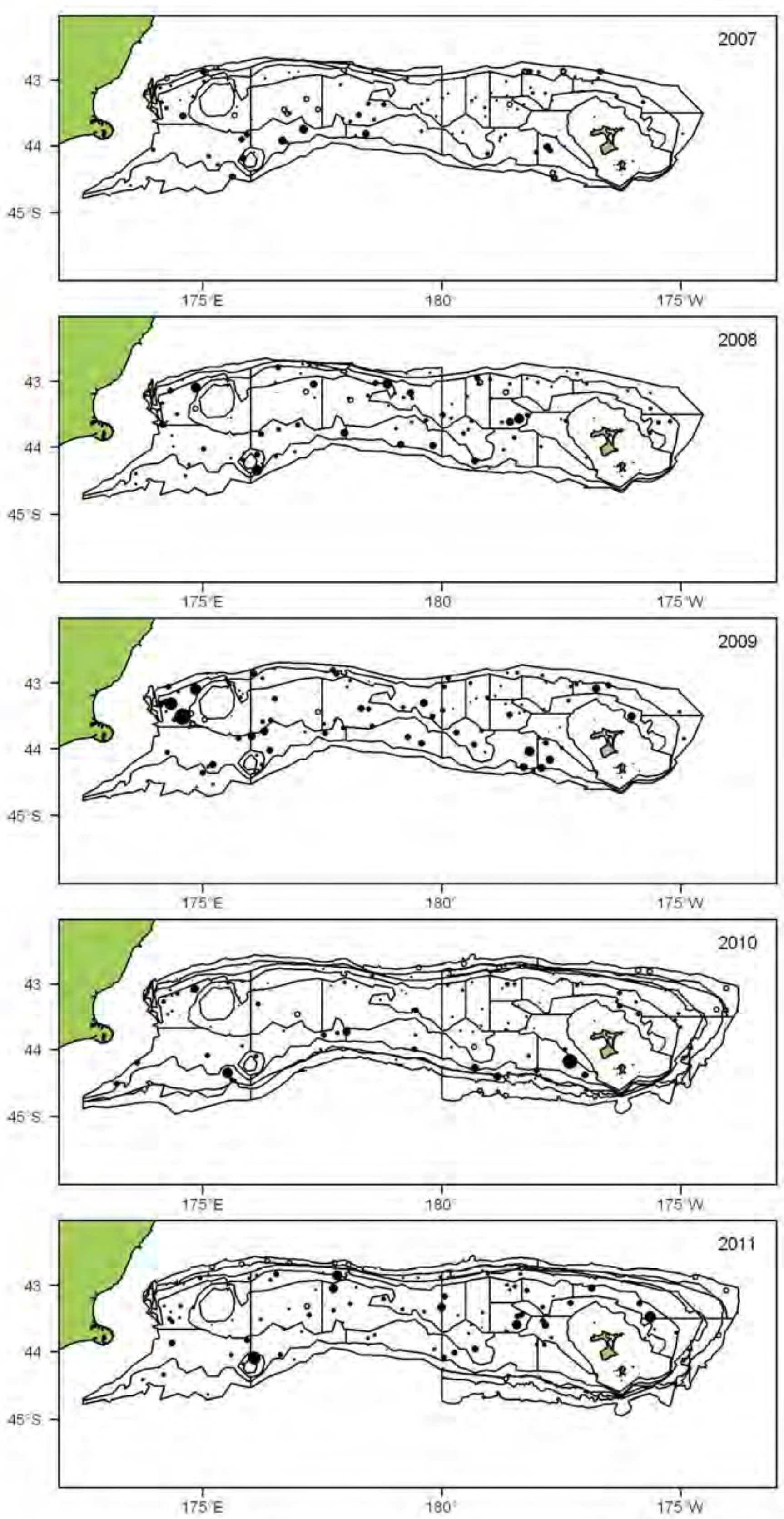


Figure 6c (continued)

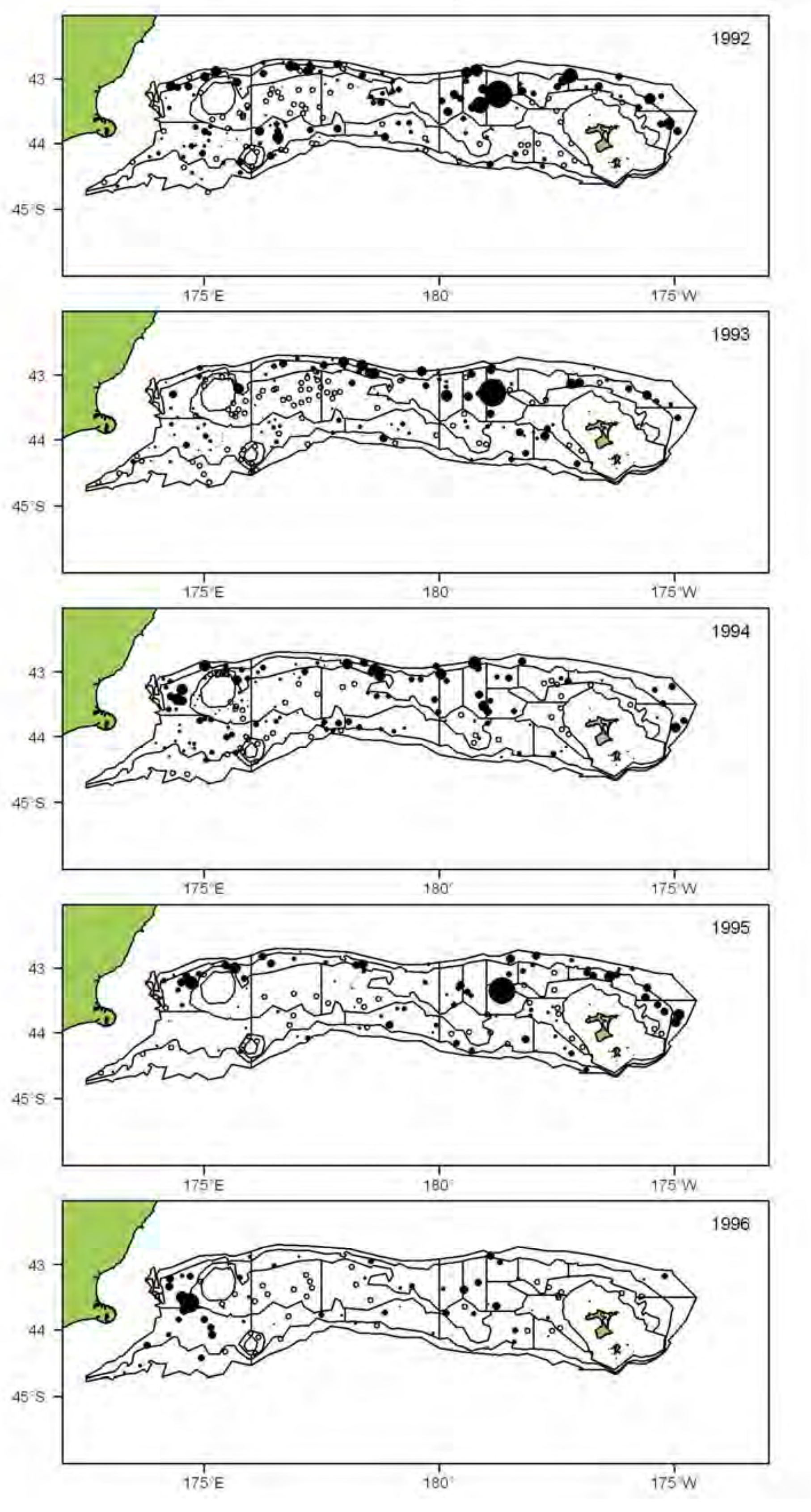


Figure 7: Hake catch distribution 1992–2011. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 620 kg.km^{-2}.

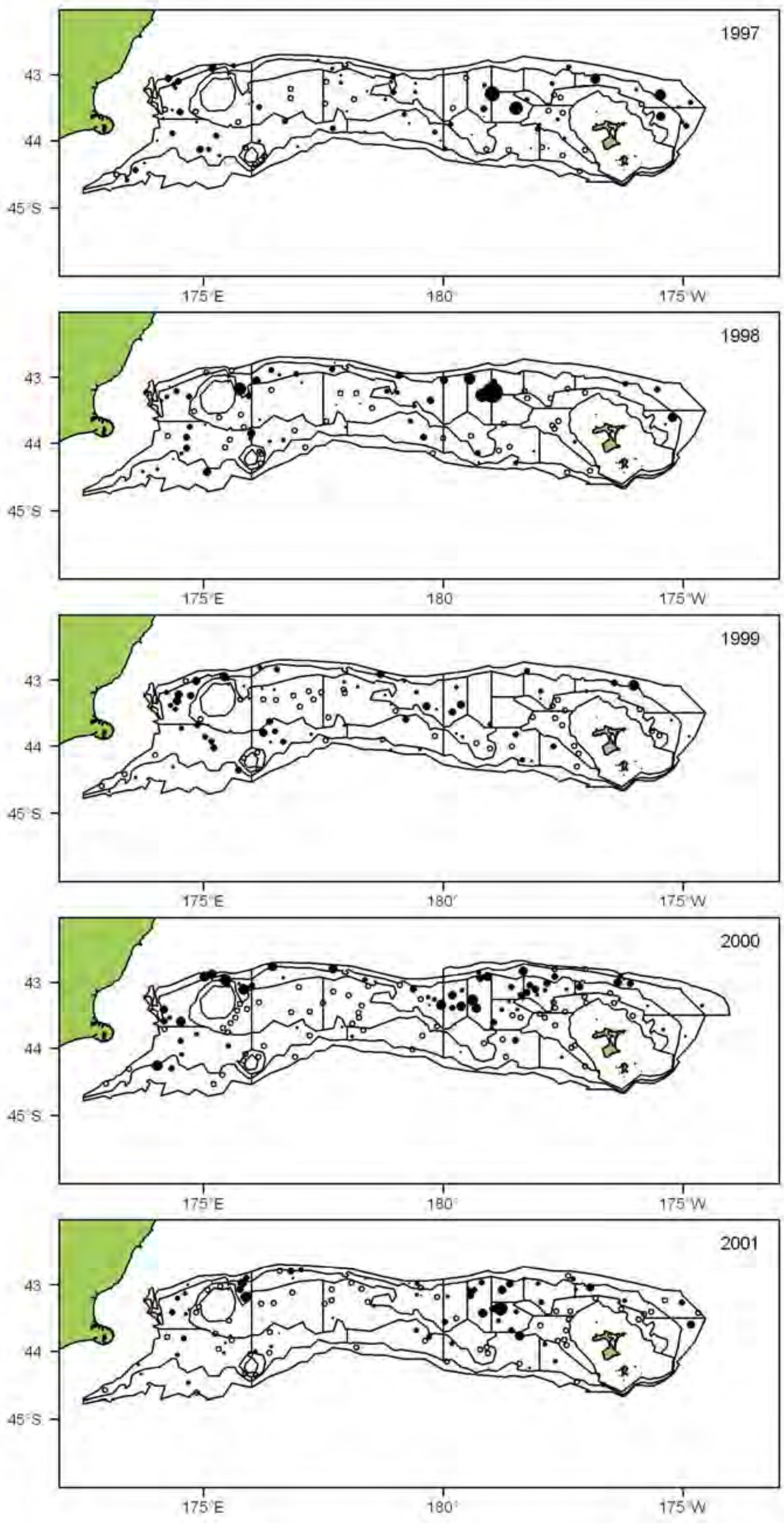


Figure 7 (continued)

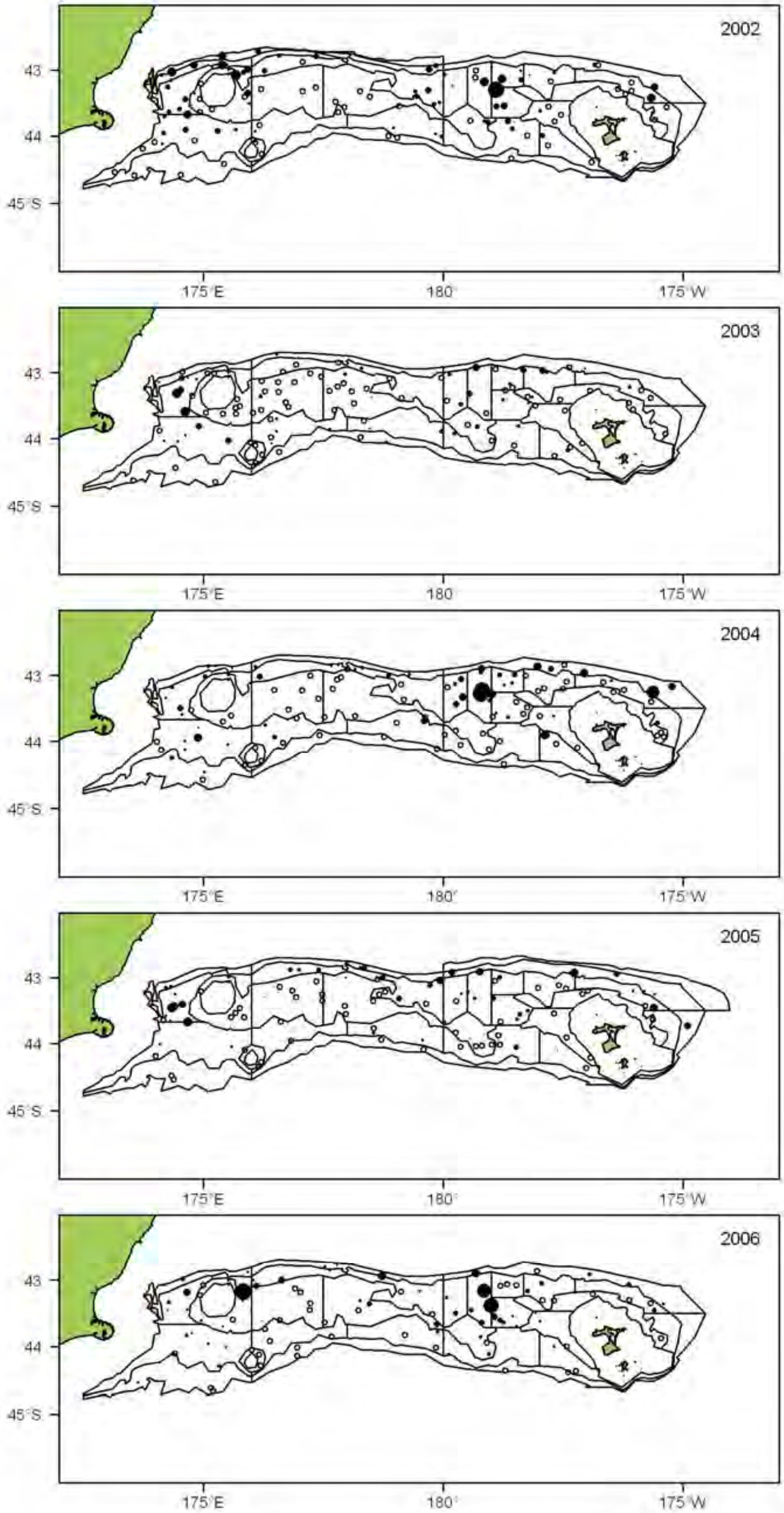


Figure 7 (continued)

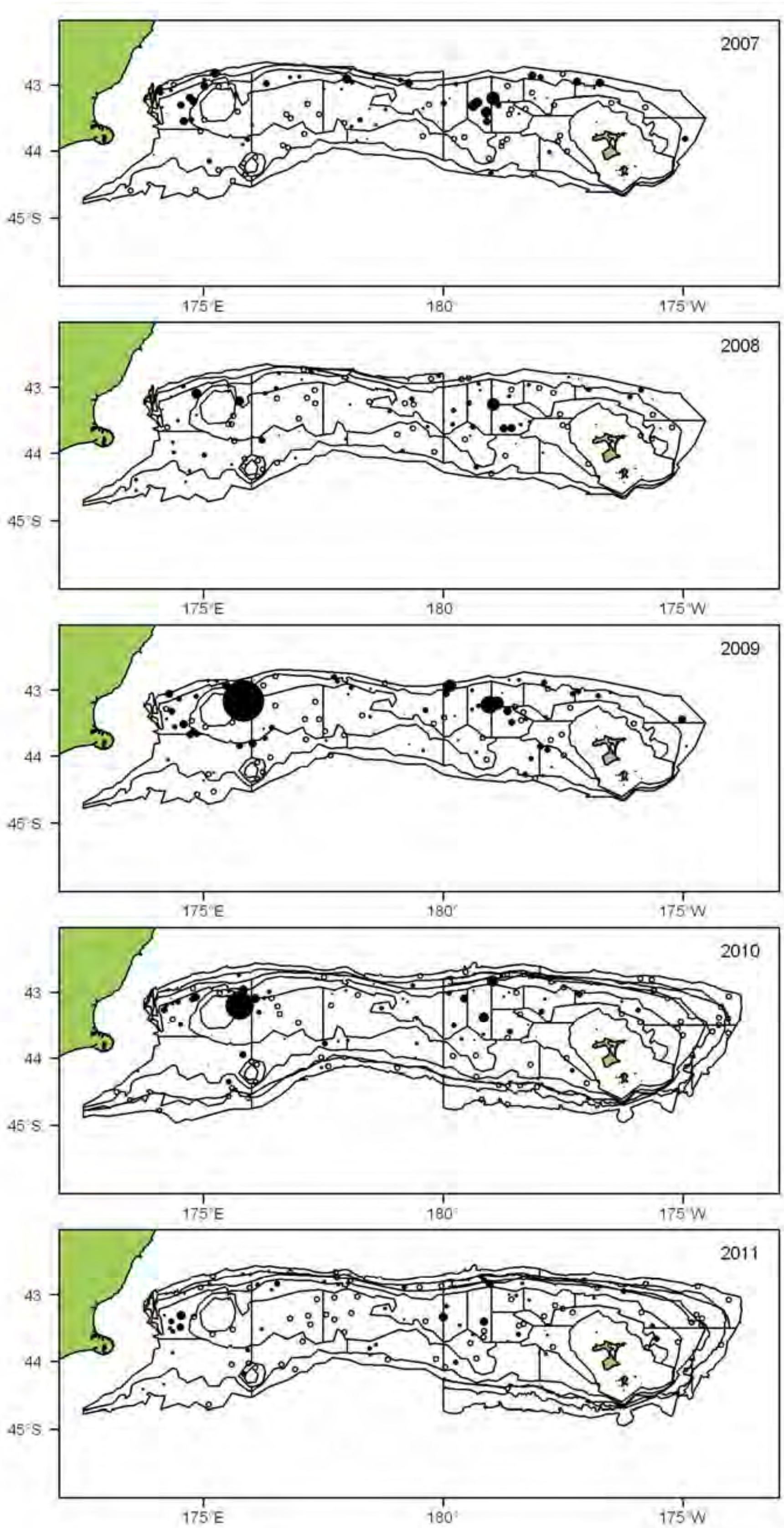


Figure 7 (continued)

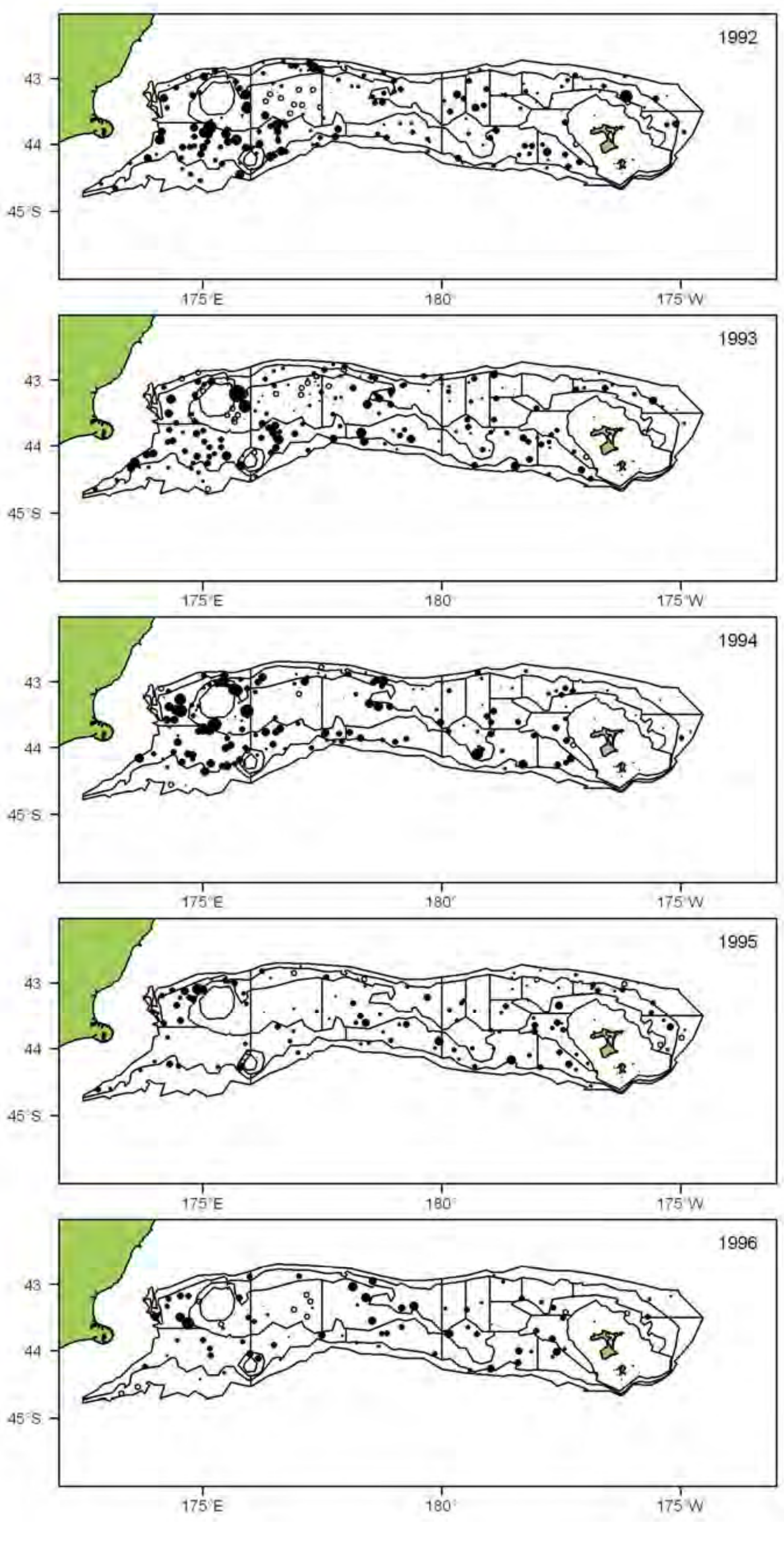


Figure 8: Ling catch distribution 1992–2011. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 1786 kg.km^{-2}.

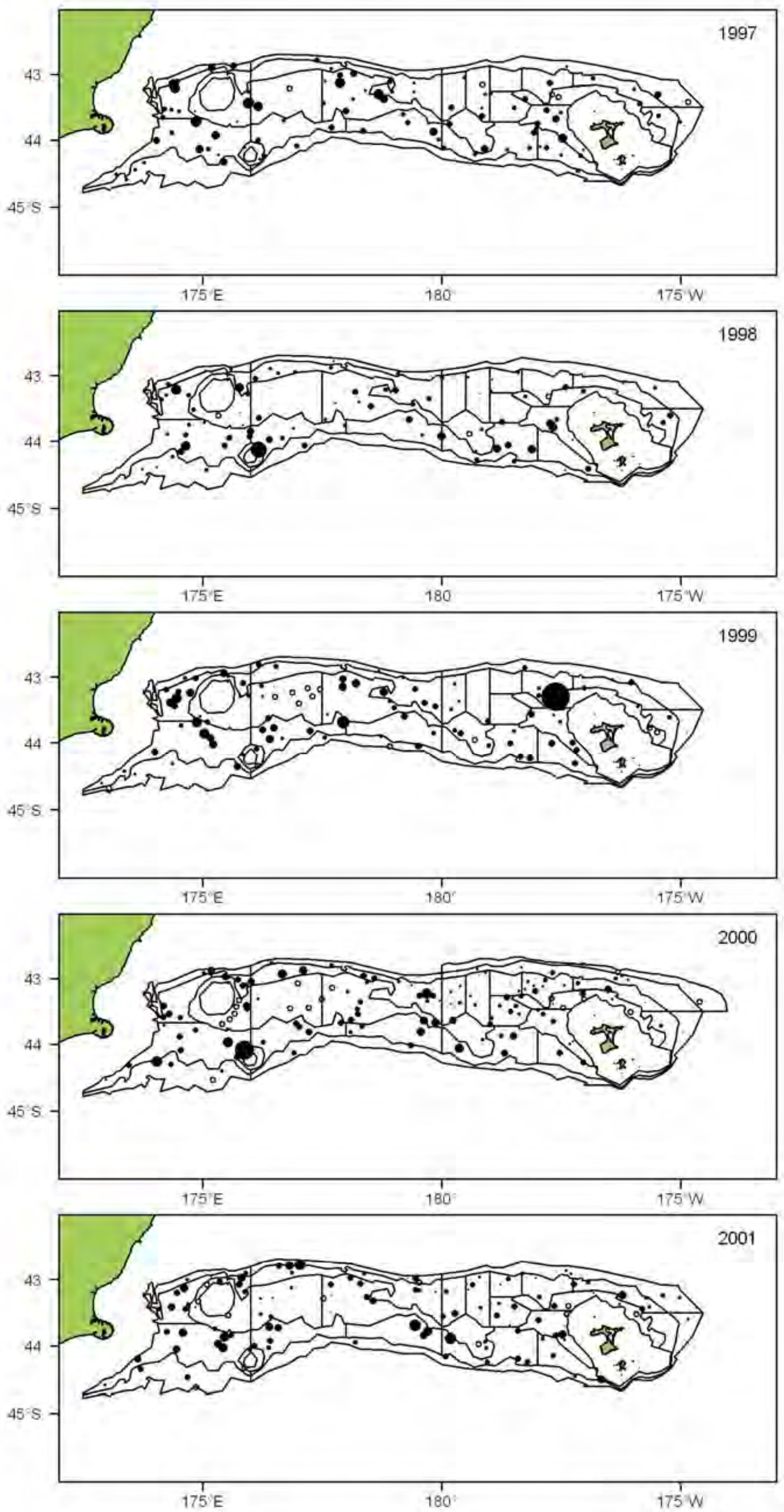


Figure 8 (continued)

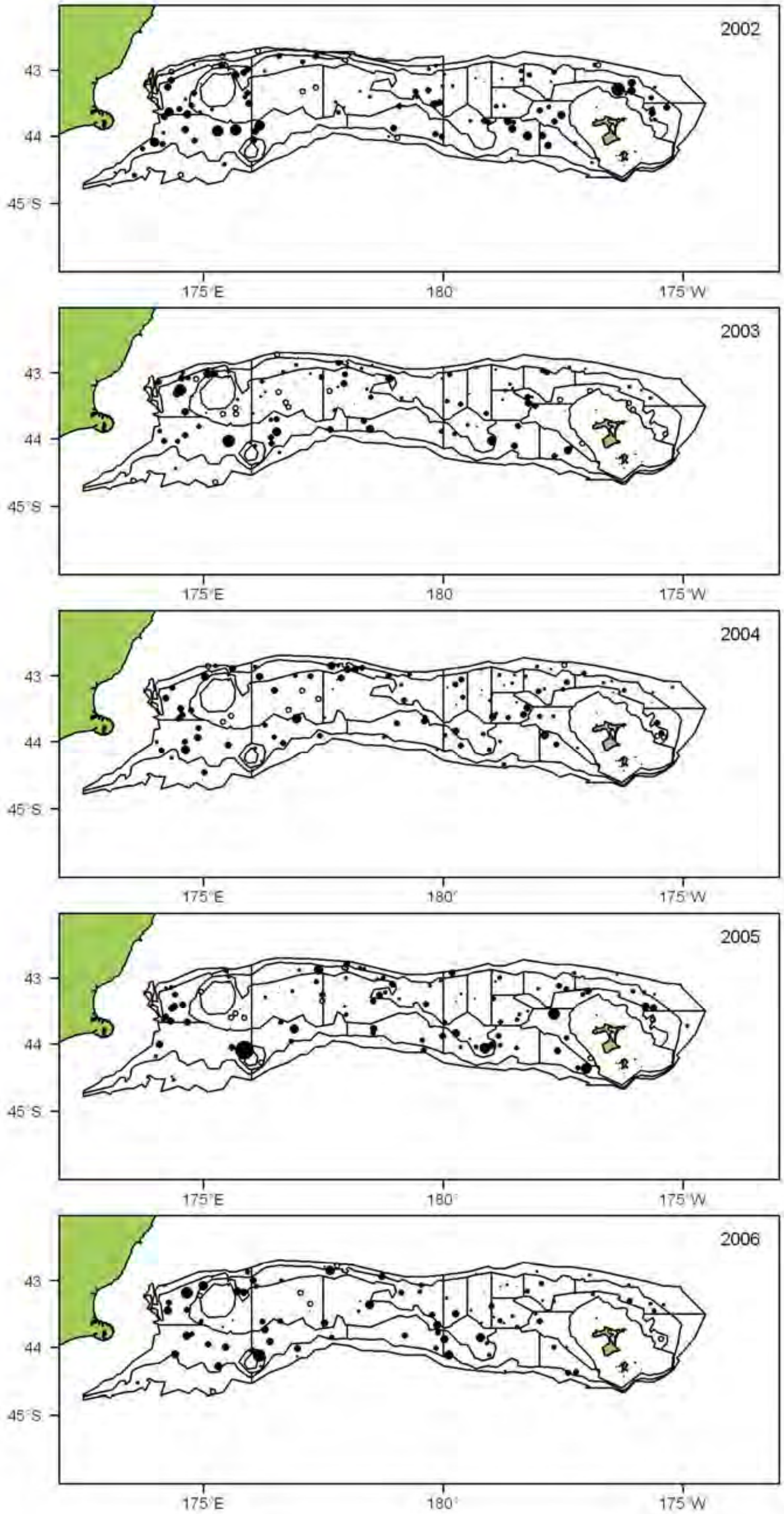


Figure 8 (continued)

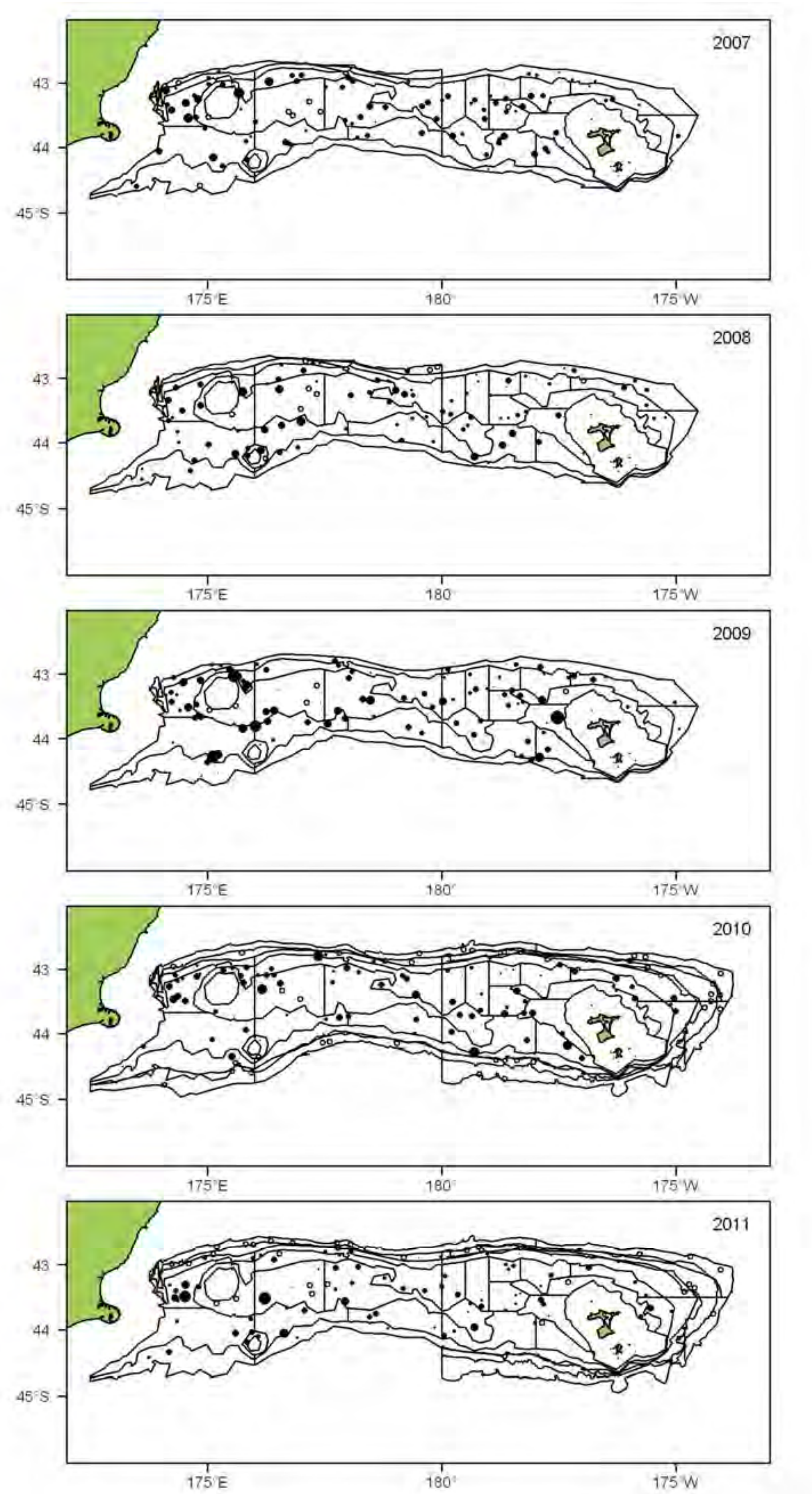


Figure 8 (continued)

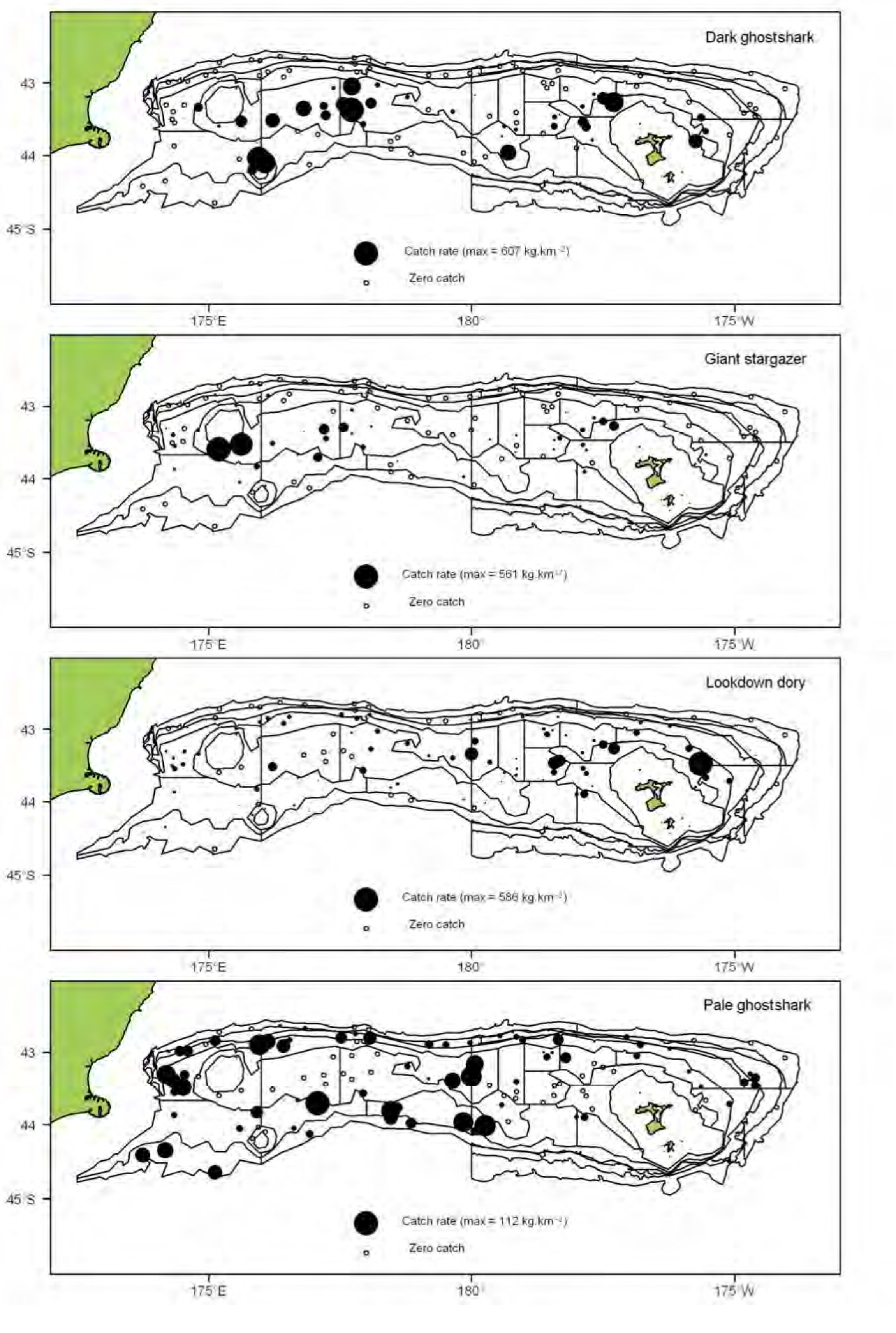


Figure 9: Catch rates (kg.km^{-2}) of selected commercial species in 2011. Filled circle area is proportional to catch rate. Open circles are zero catch. (max., maximum catch rate).

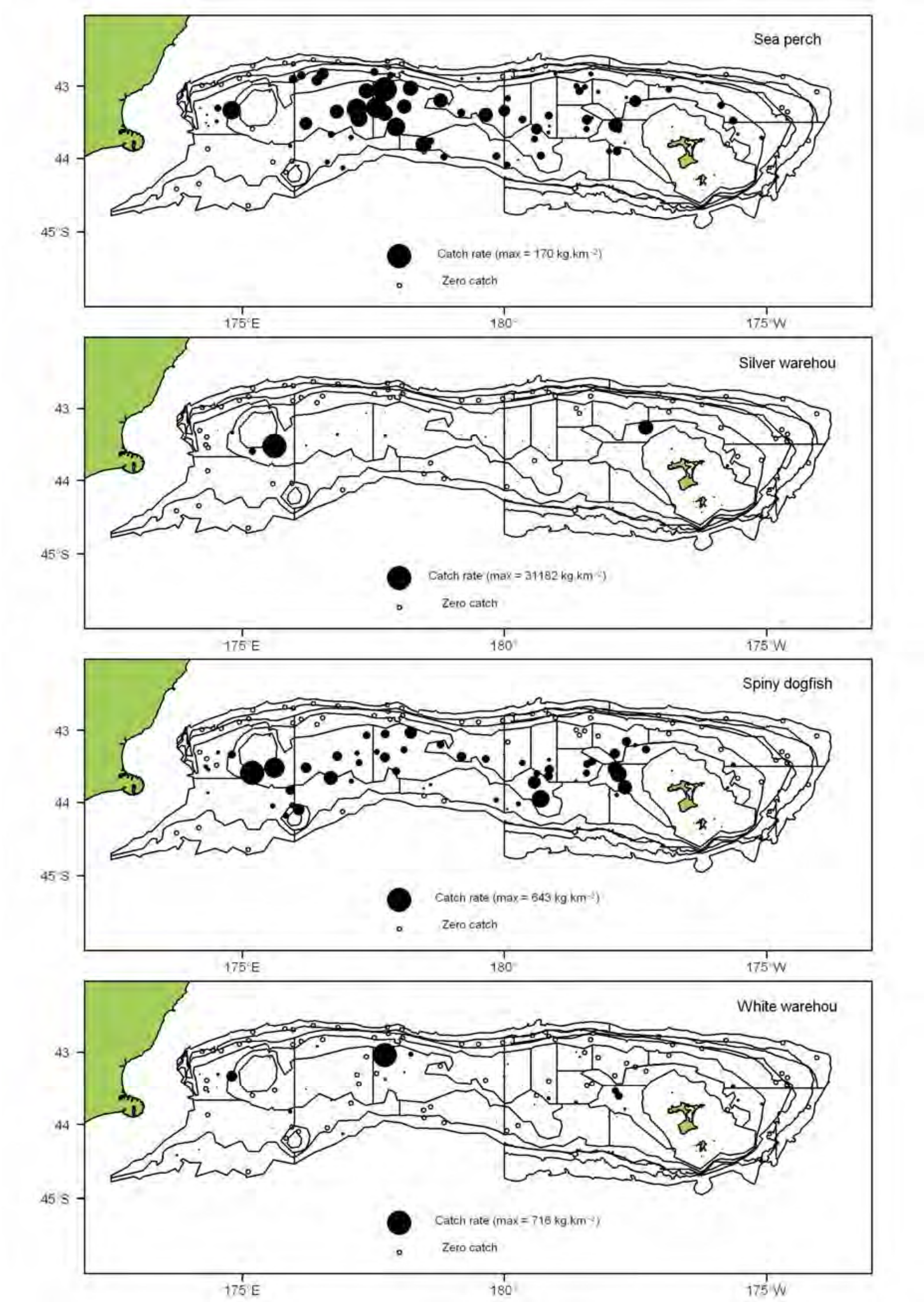


Figure 9 (continued)

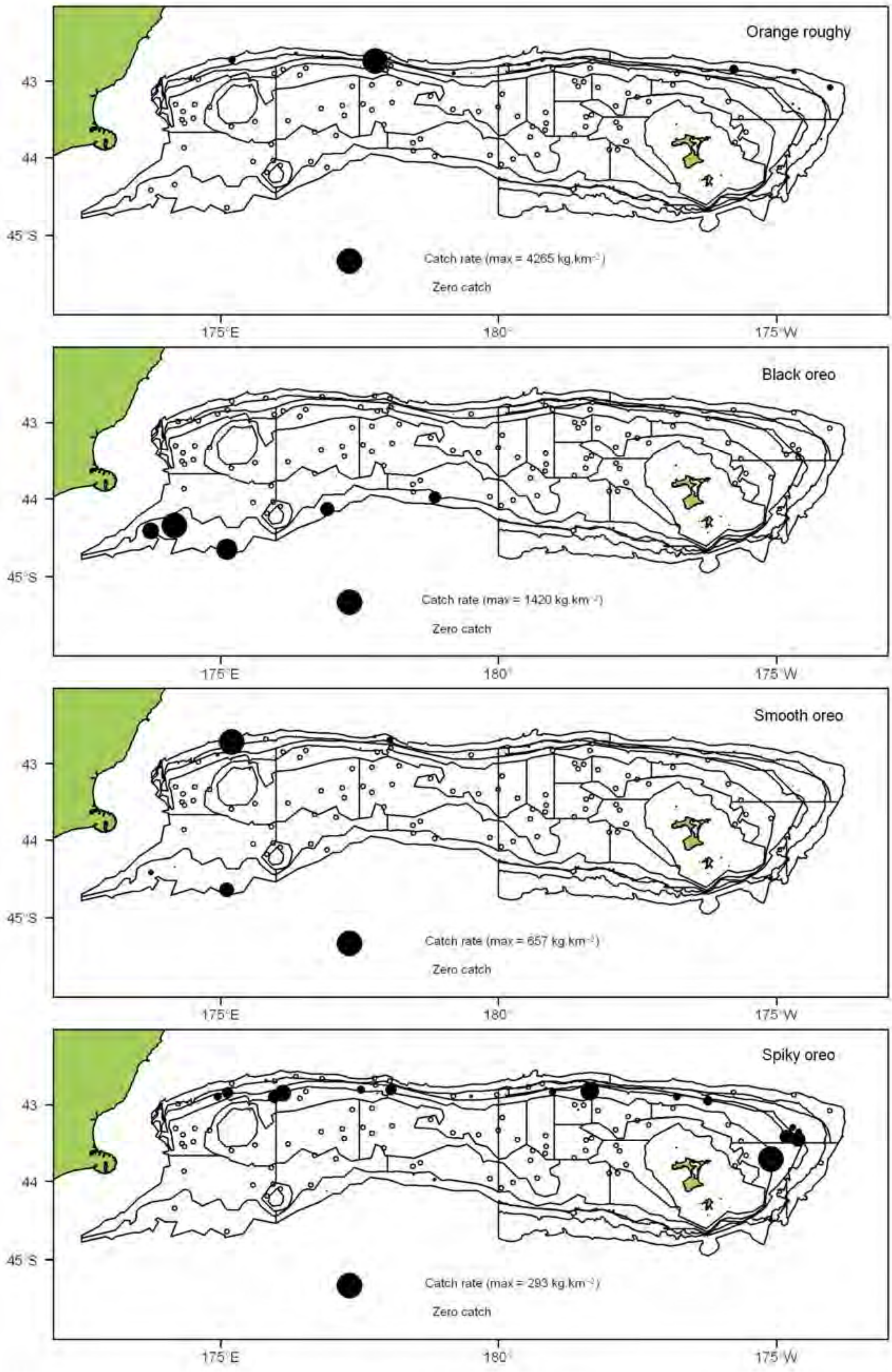


Figure 9 (continued)

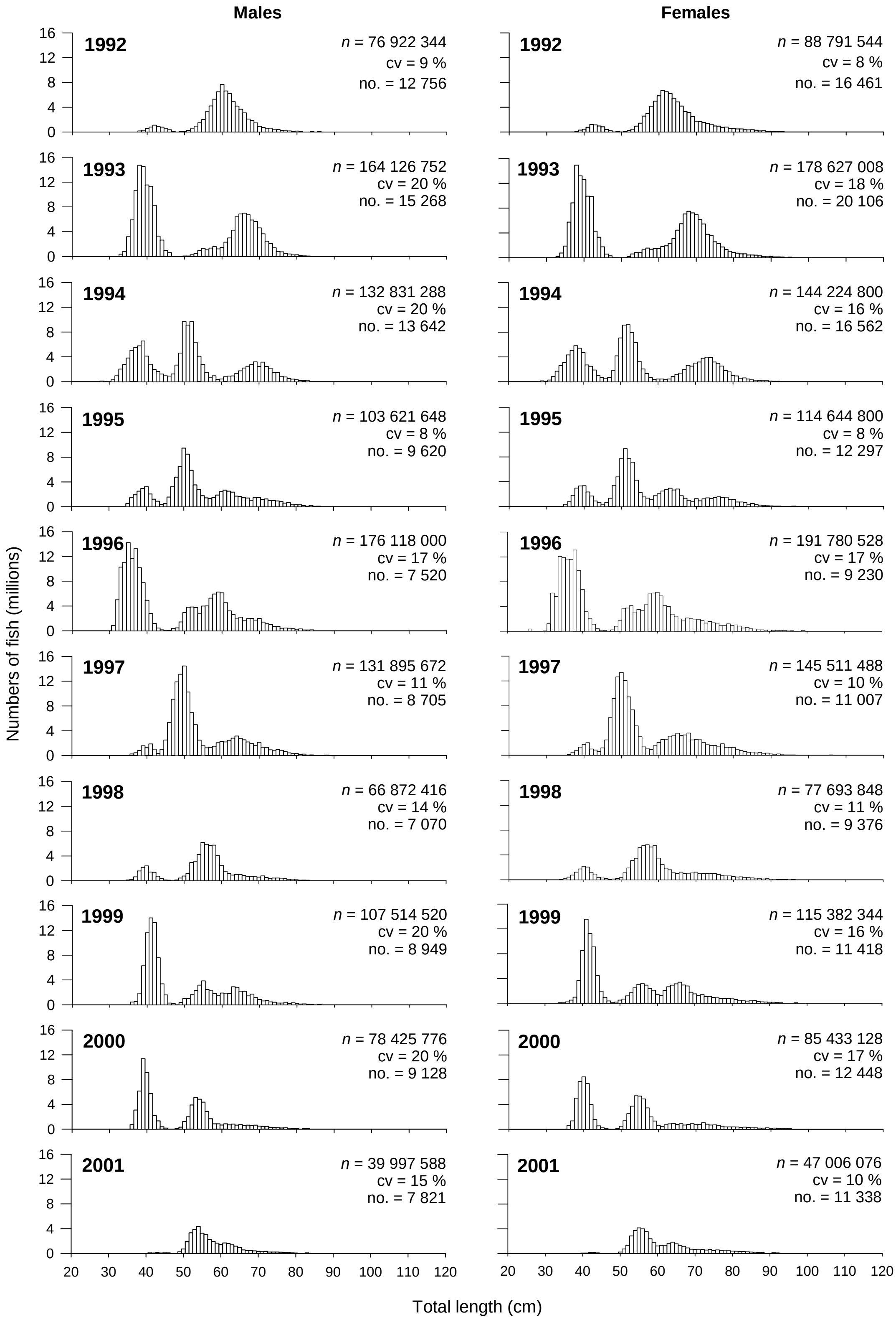


Figure 10: Estimated length frequency distributions of the male and female hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2011. (c.v., coefficient of variation; *n*, estimated population number of male hoki (left panel) and female hoki (right panel); no., numbers of fish measured.).

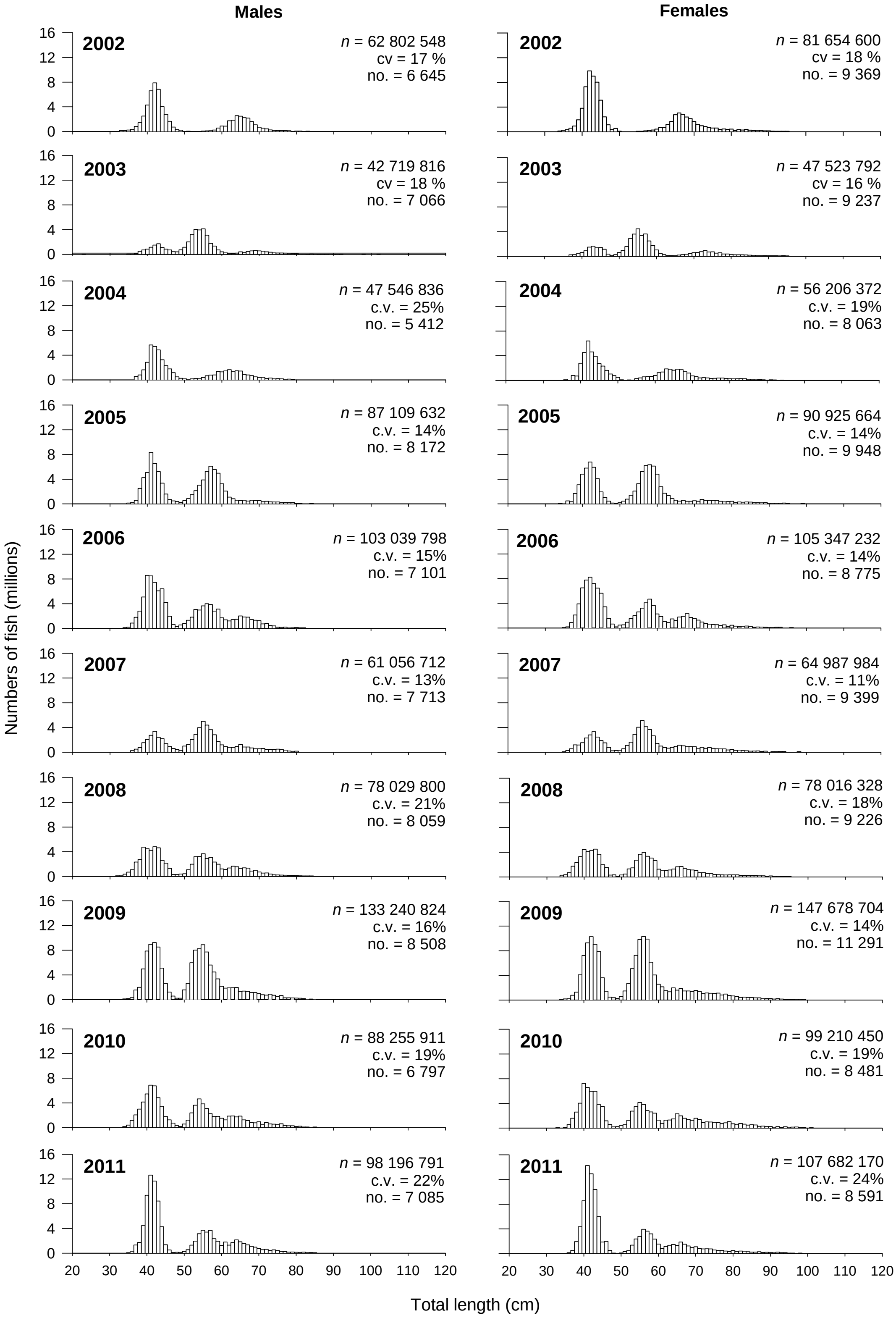


Figure 10 (continued)

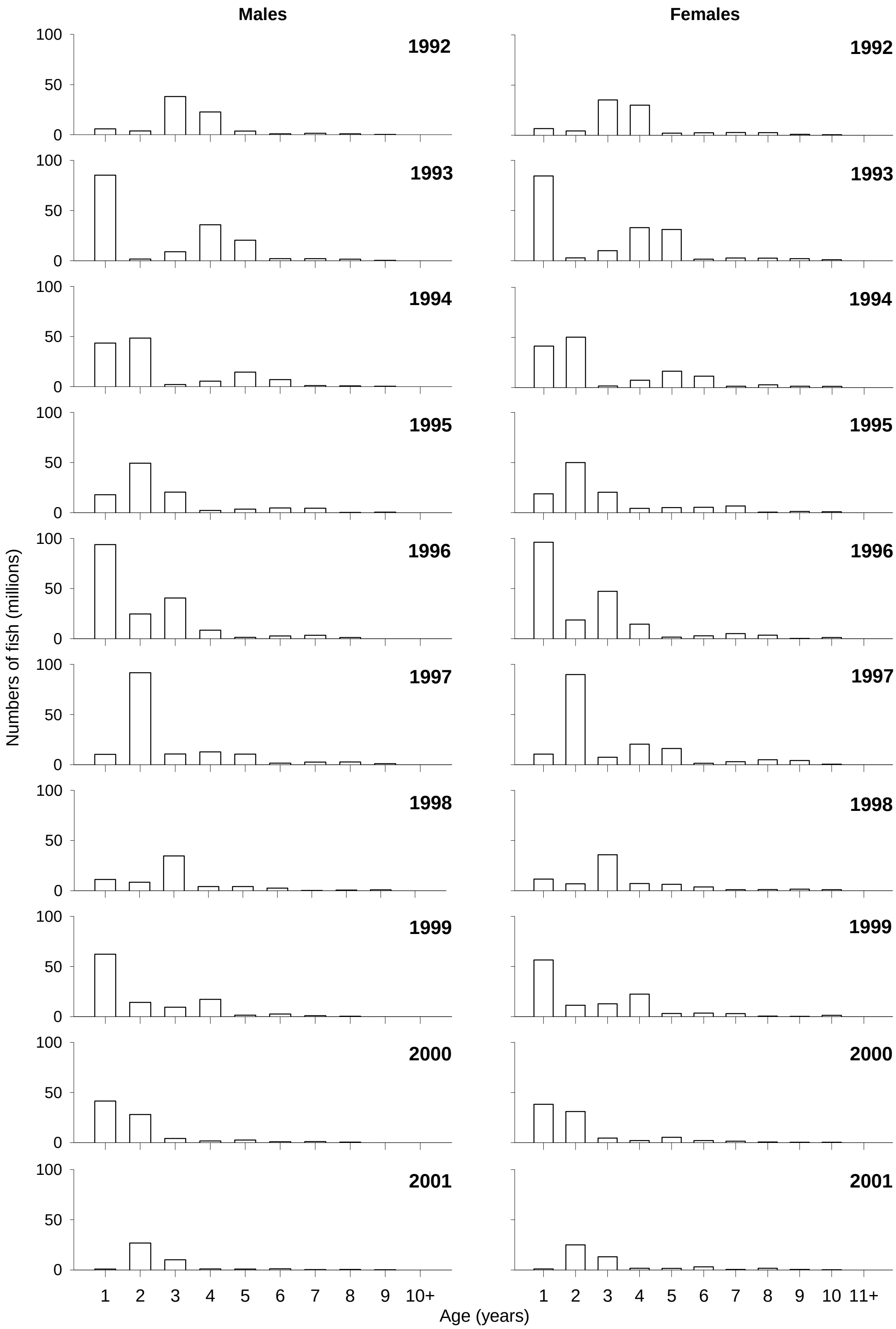


Figure 11: Estimated population numbers at age of hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2011. (+, indicates plus group of combined ages.).

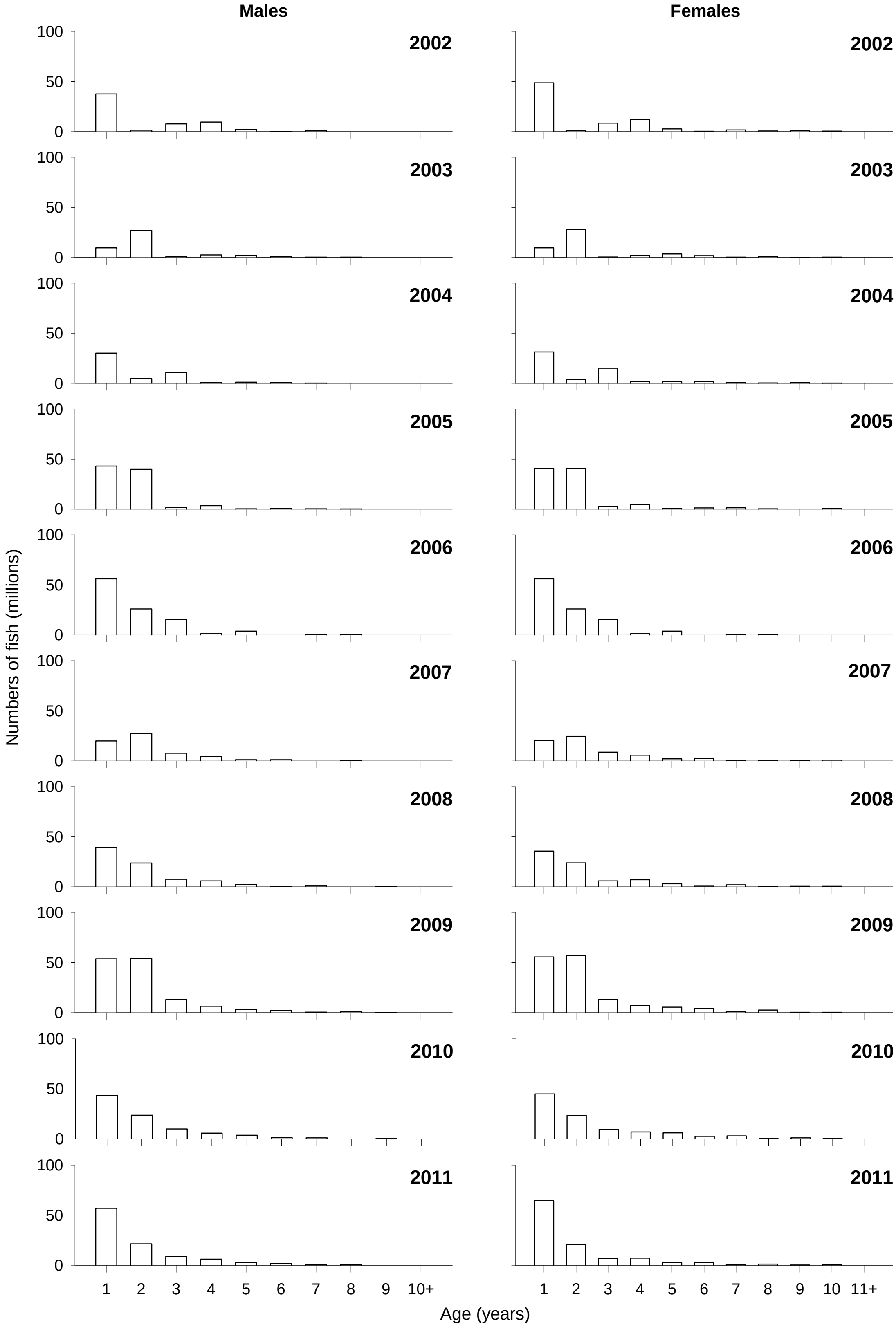


Figure 11 (continued)

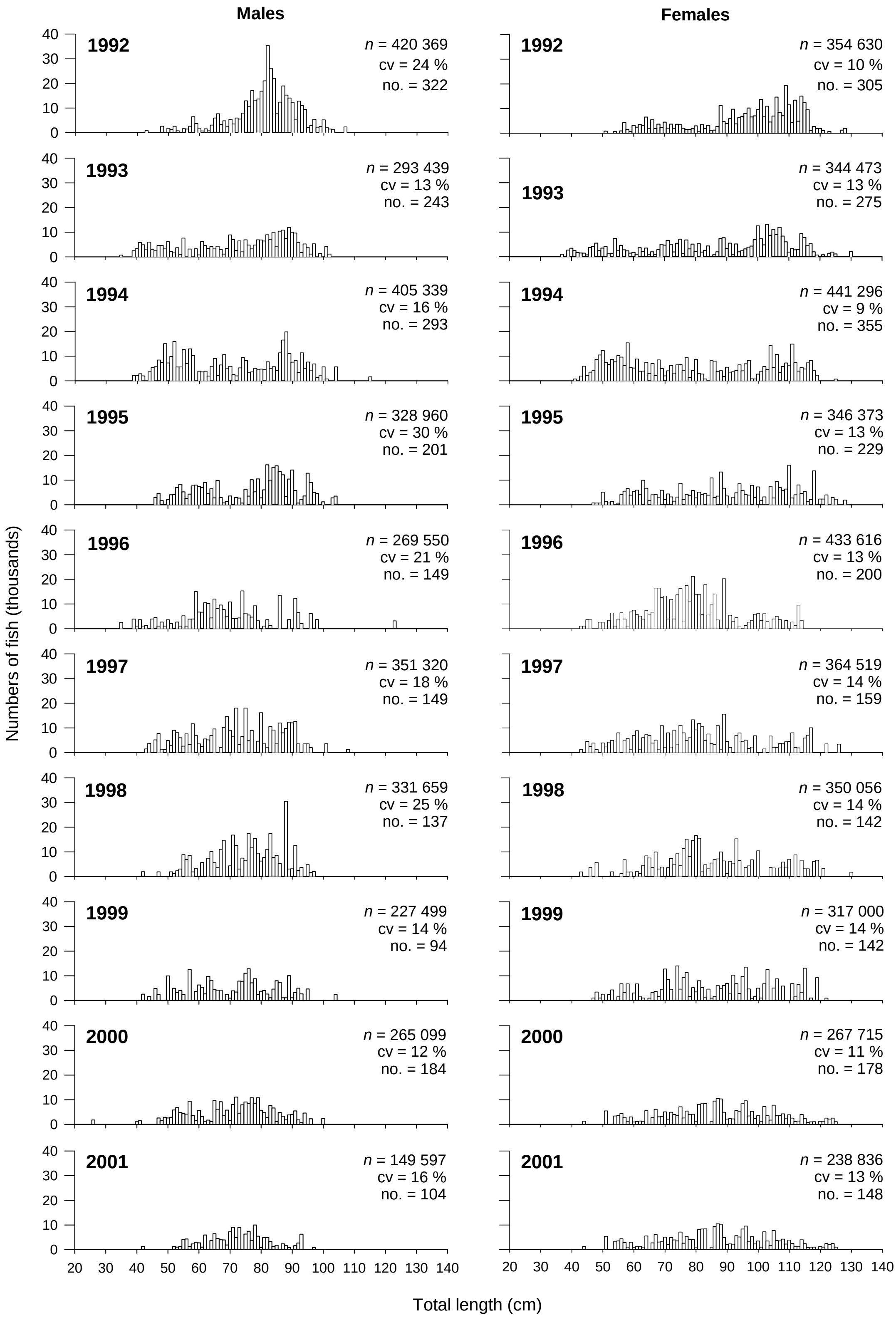


Figure 12: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2011. (c.v., coefficient of variation; *n*, estimated population number of hake; no., numbers of fish measured.).

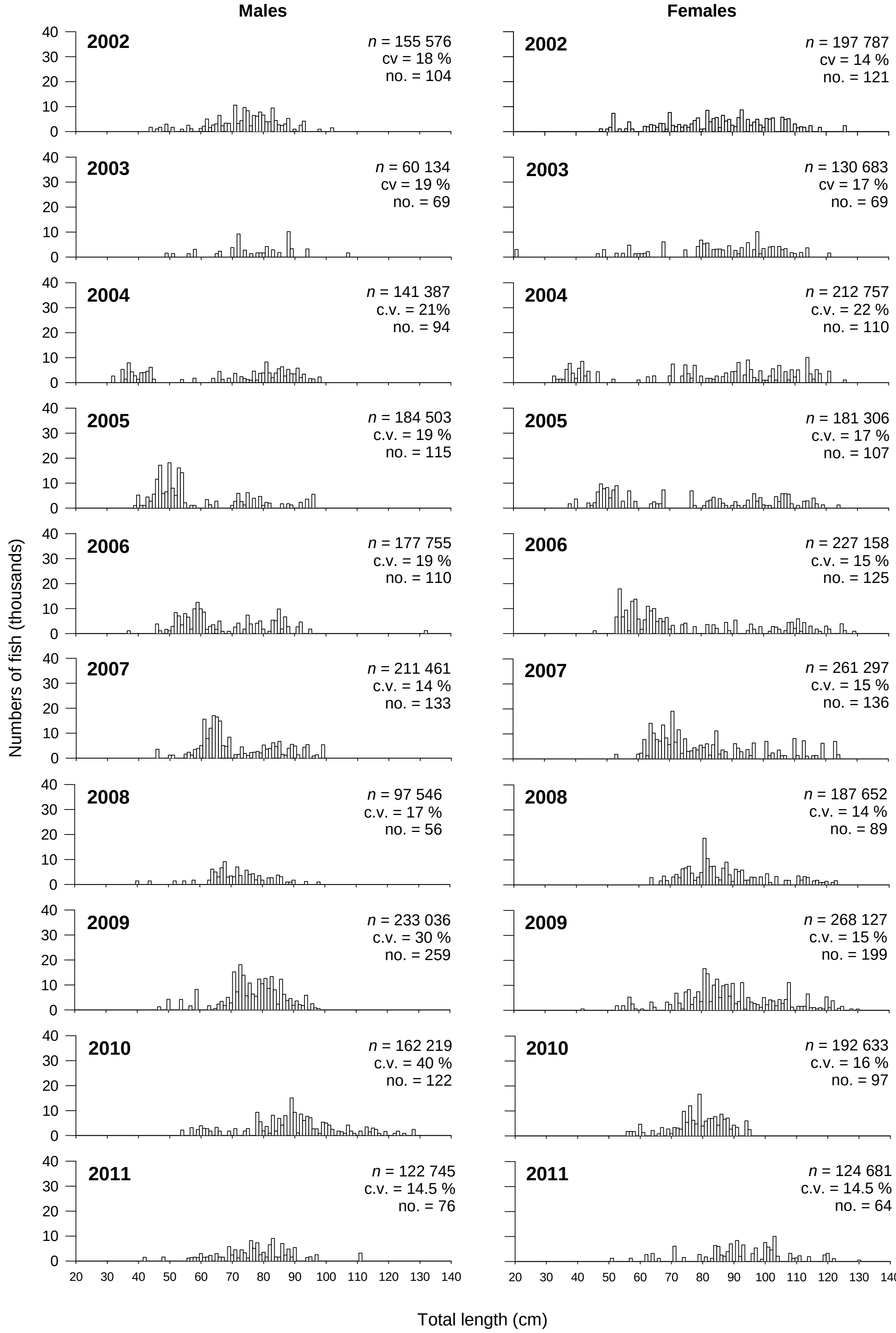


Figure 12 (continued)

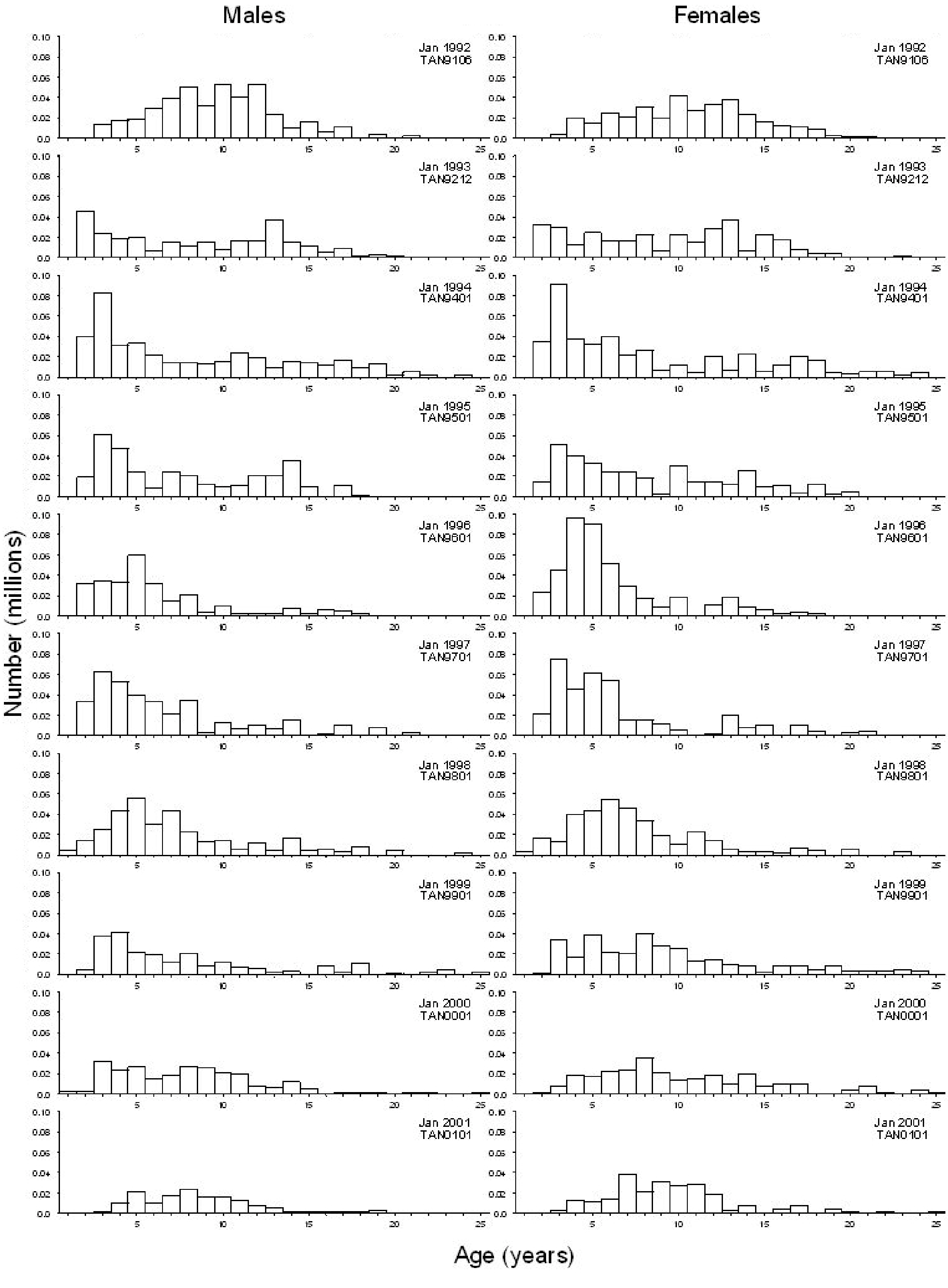


Figure 13: Estimated proportion at age of male and female hake from *Tangaroa* surveys of the Chatham Rise, January, 1992–2011.

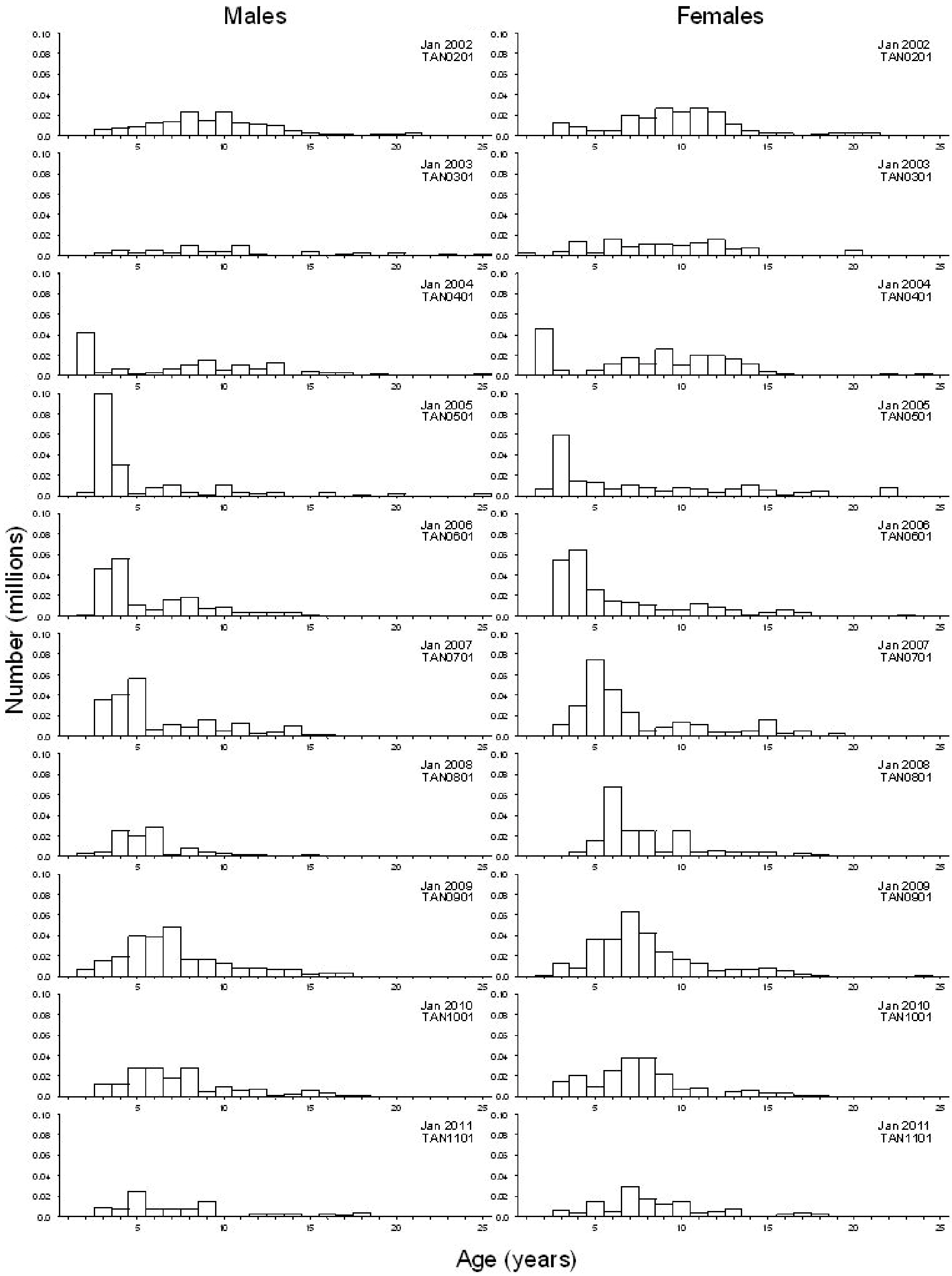


Figure 13 (continued)

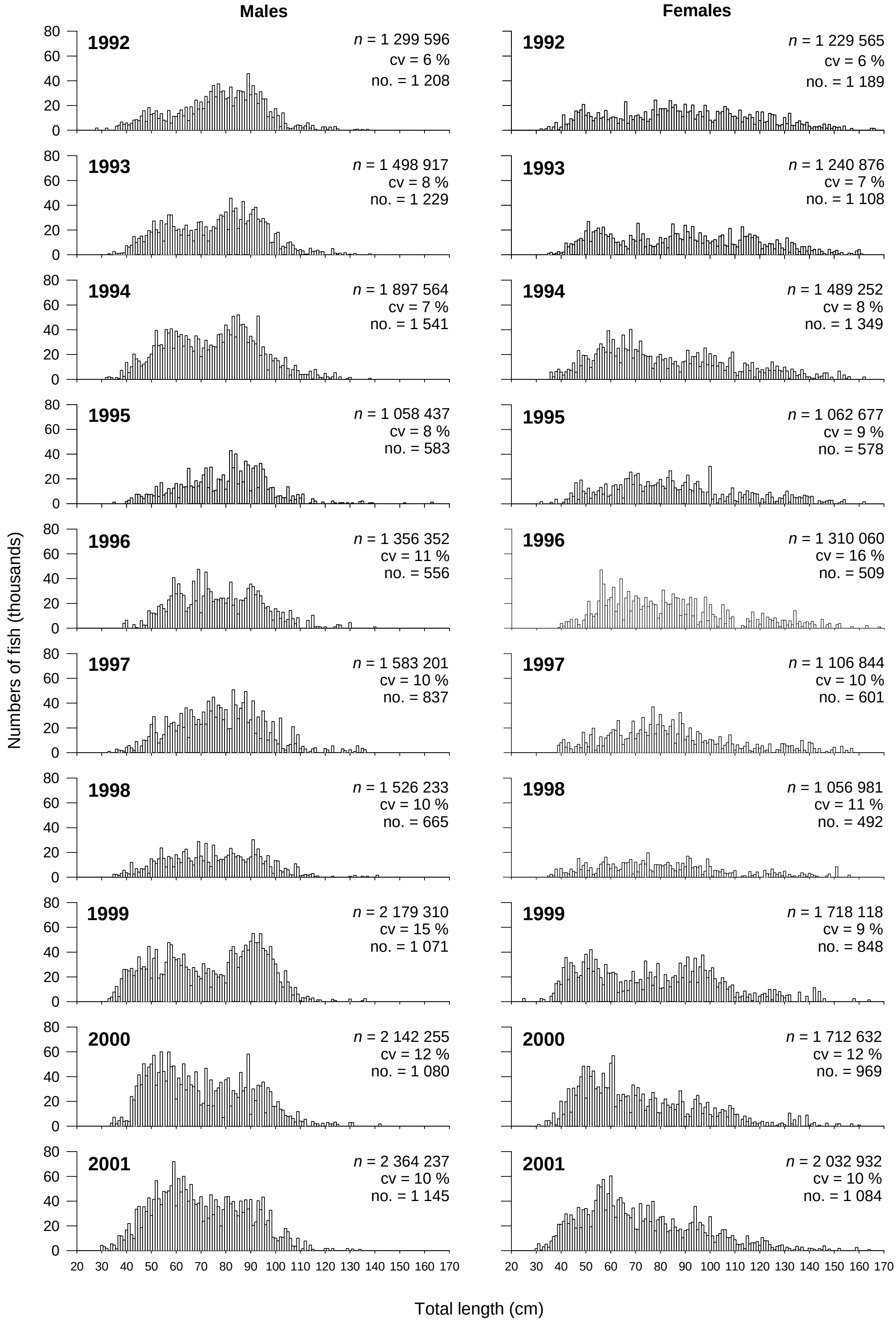


Figure 14: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2011. (c.v., coefficient of variation; *n*, estimated population number of ling; no., numbers of fish measured.).

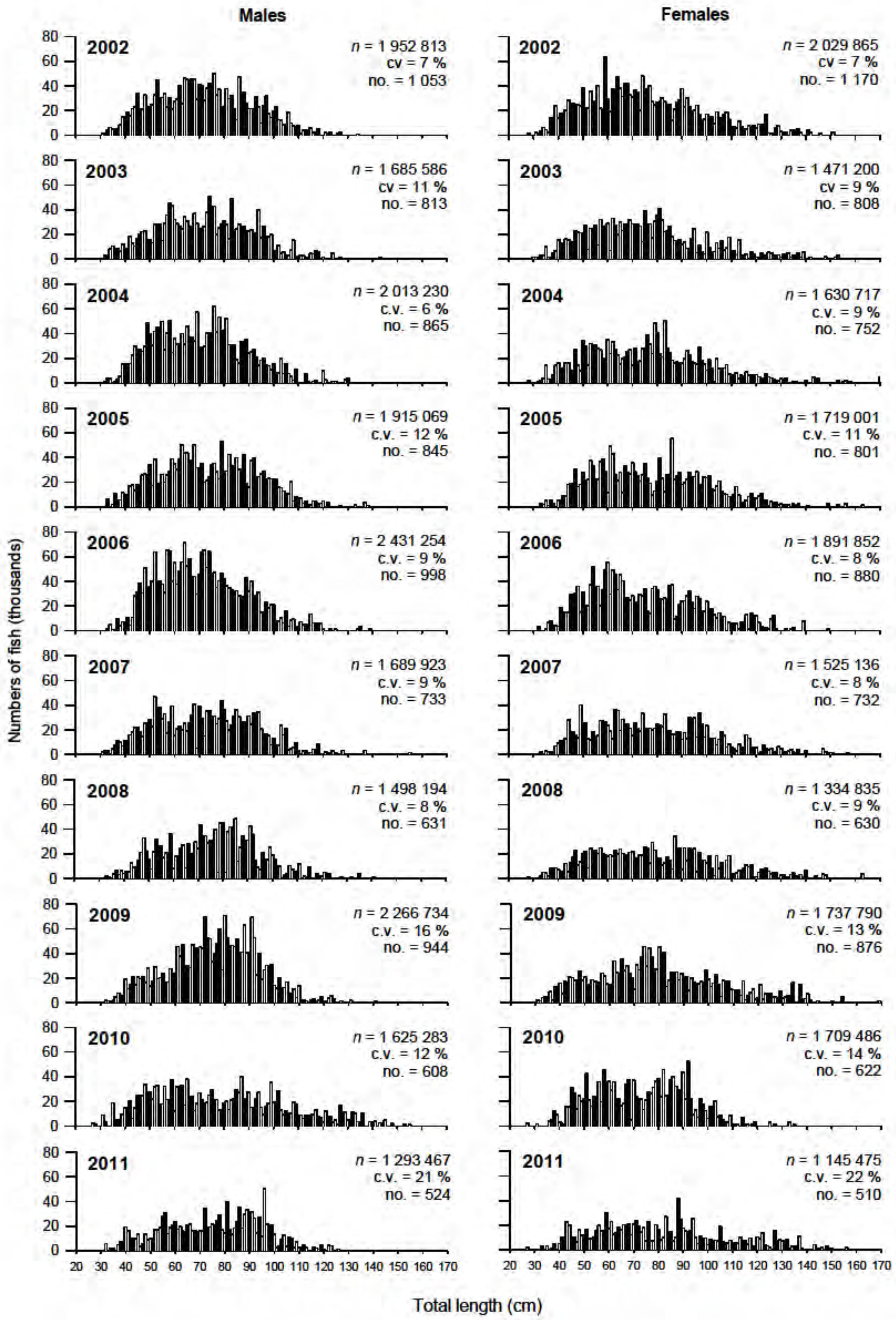


Figure 14 (continued)

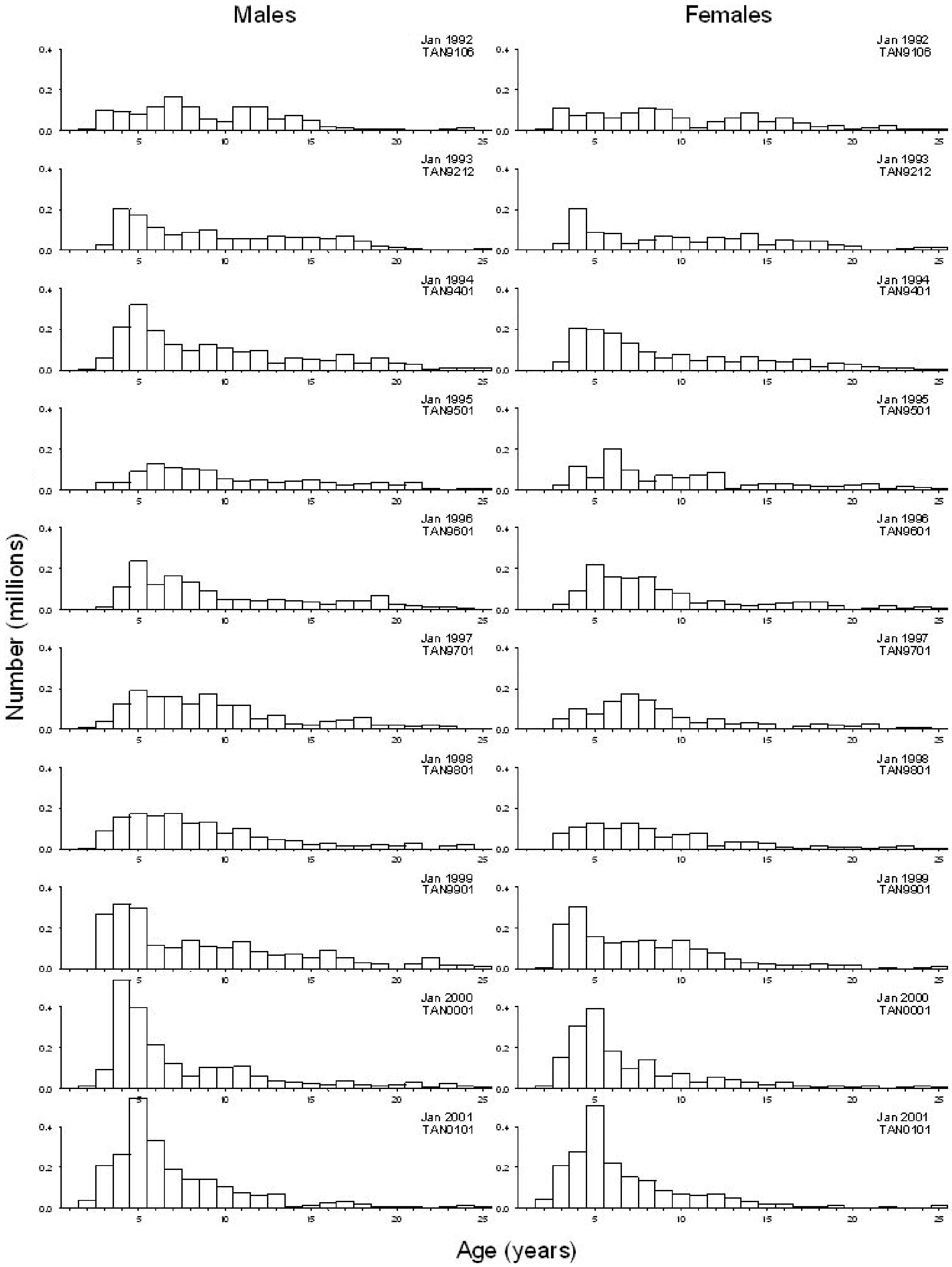


Figure 15: Estimated population numbers at age of male and female ling from *Tangaroa* surveys of the Chatham Rise, January, 1992–2011.

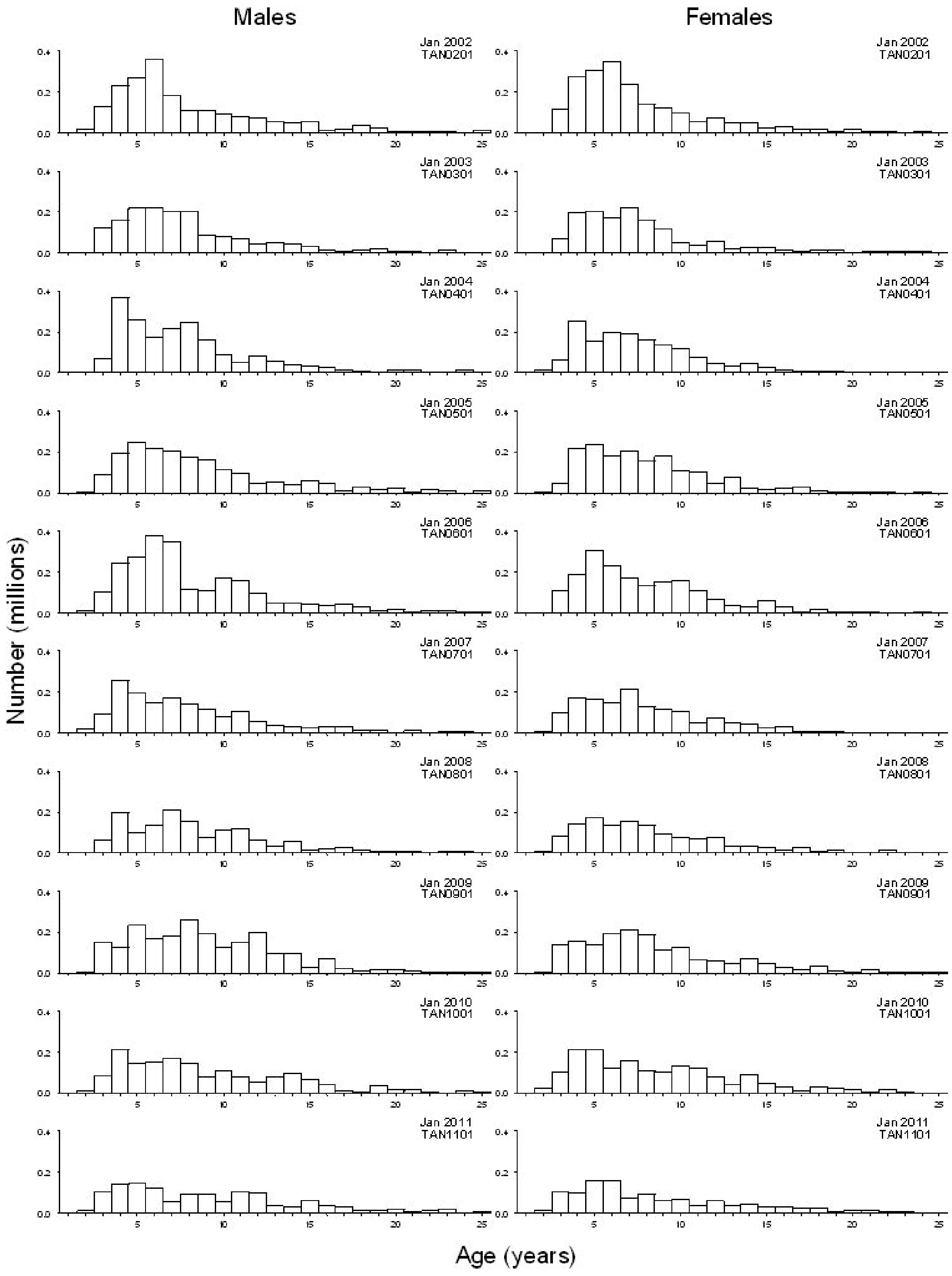


Figure 15 (continued)

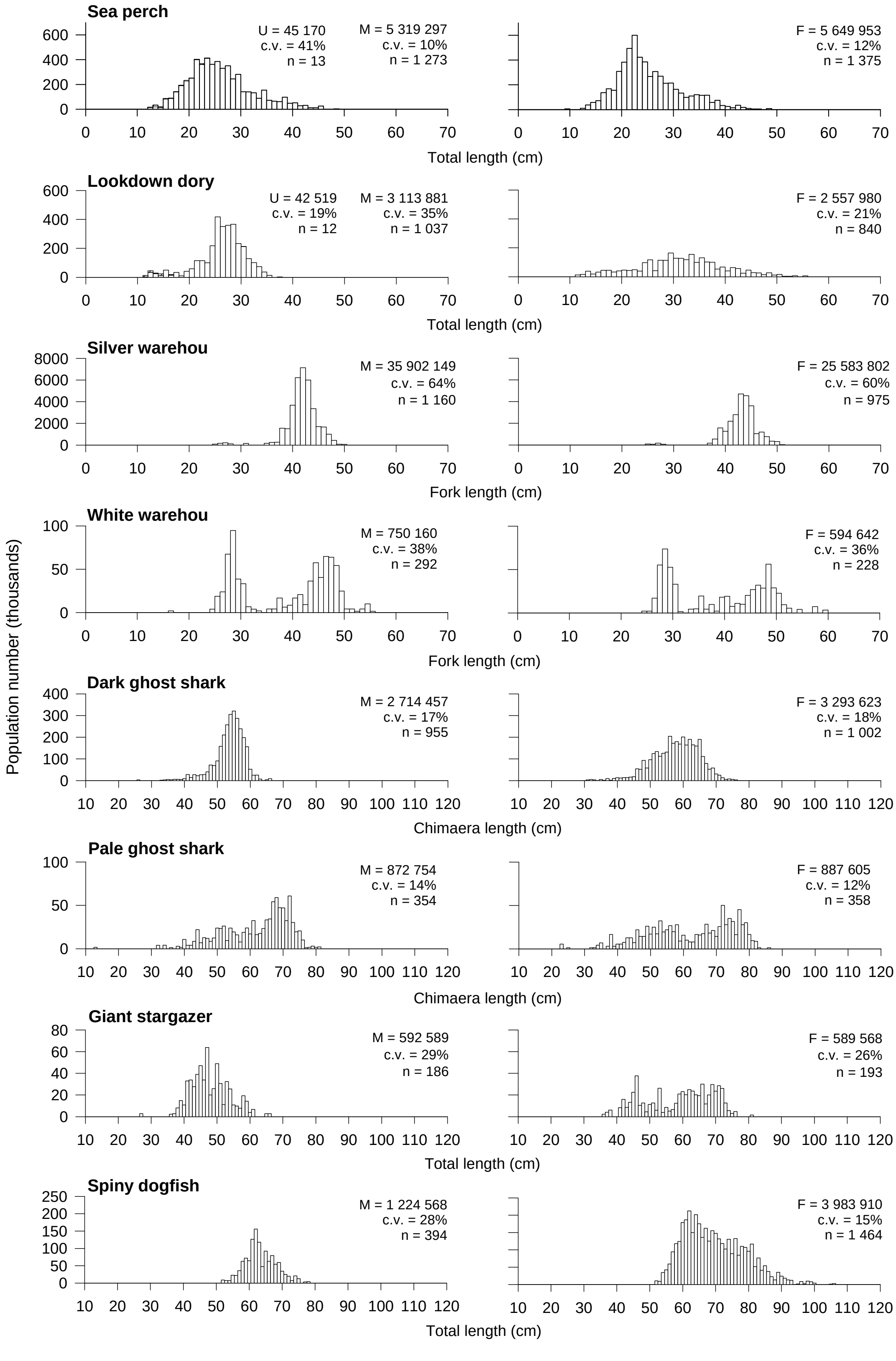


Figure 16a: Length frequencies of selected commercial species on the Chatham Rise 2011, scaled to population size by sex (M, estimated male population; F, estimated female population; U, estimated unsexed population (hatched bars); c.v. coefficient of variation of the estimated numbers of fish; n, number of fish measured).

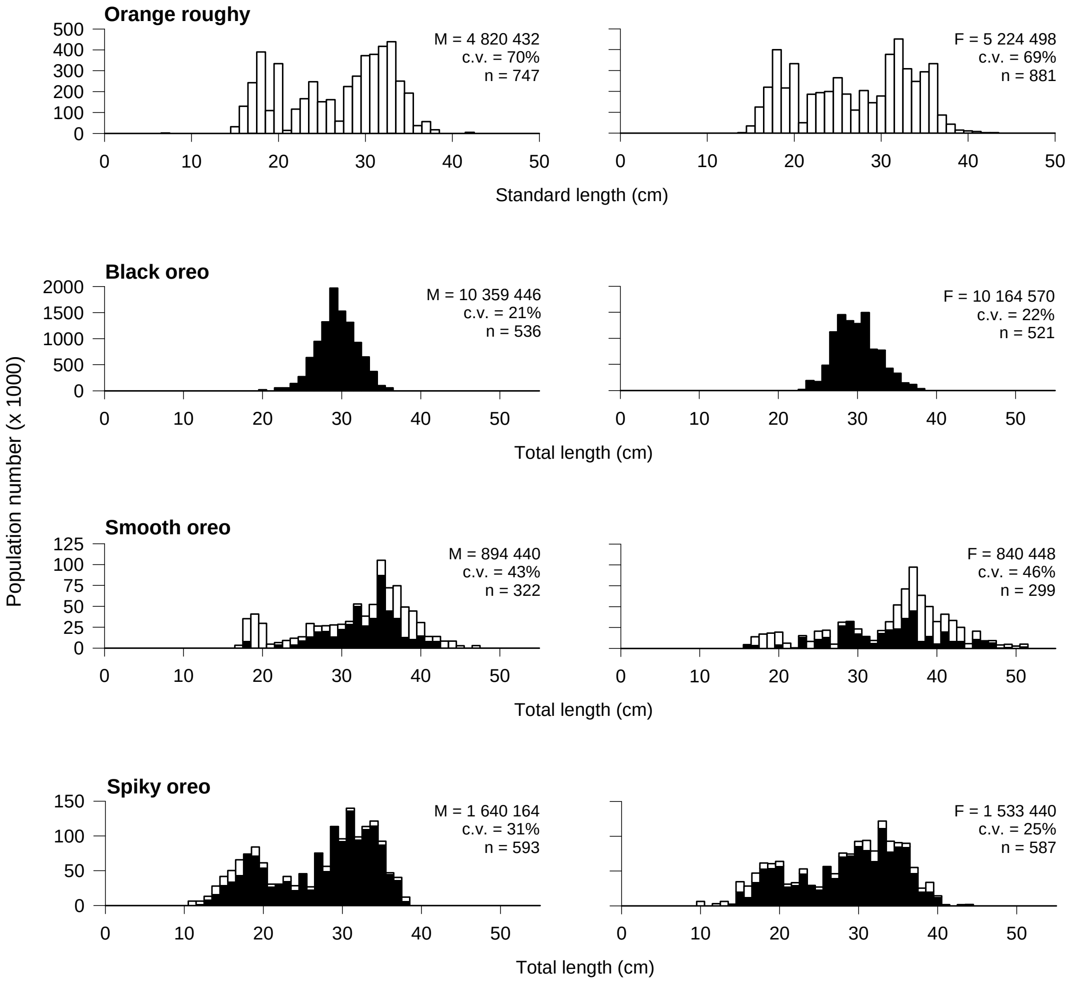


Figure 16b: Length frequencies of orange roughy and oreo species on the Chatham Rise 2011, scaled to population size by sex (M, estimated male population; F, estimated female population; U, estimated unsexed population (hatched bars); c.v. coefficient of variation of the estimated numbers of fish; n, number of fish measured). White bars show fish from all (200-1300 m) strata. Black bars show fish from core (200-800 m) strata only.

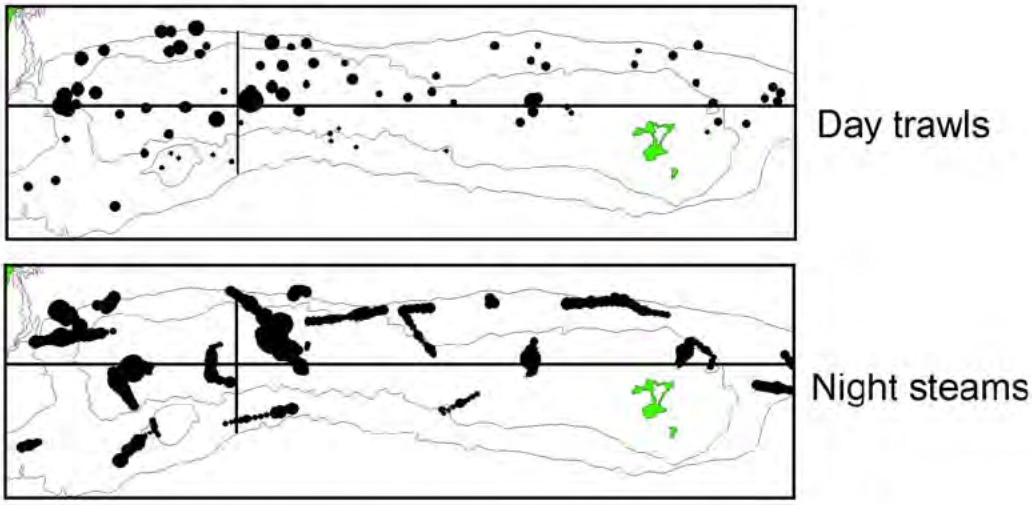


Figure 17: Distribution of total acoustic backscatter observed on the Chatham Rise during daytime trawls and night-time steams in January 2011. Circle area is proportional to the acoustic backscatter (maximum symbol size = 500 m^2 km^{-2}). Lines separate the four acoustic strata.

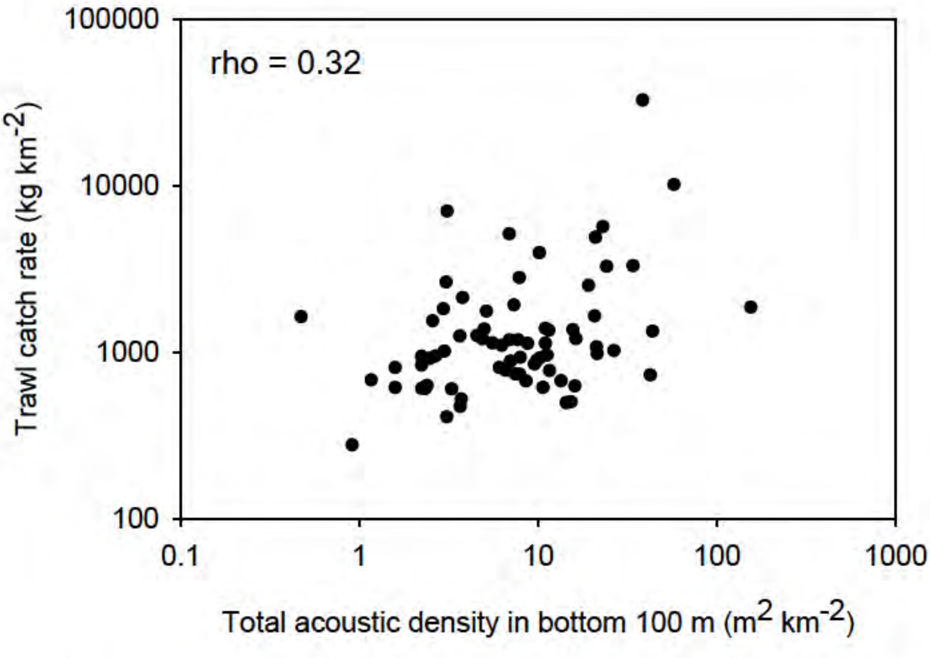


Figure 18: Relationship between total trawl catch rate (all species combined) and bottom-referenced acoustic backscatter recorded during the trawl on the Chatham Rise in 2011. Rho value is Spearman's rank correlation coefficients.

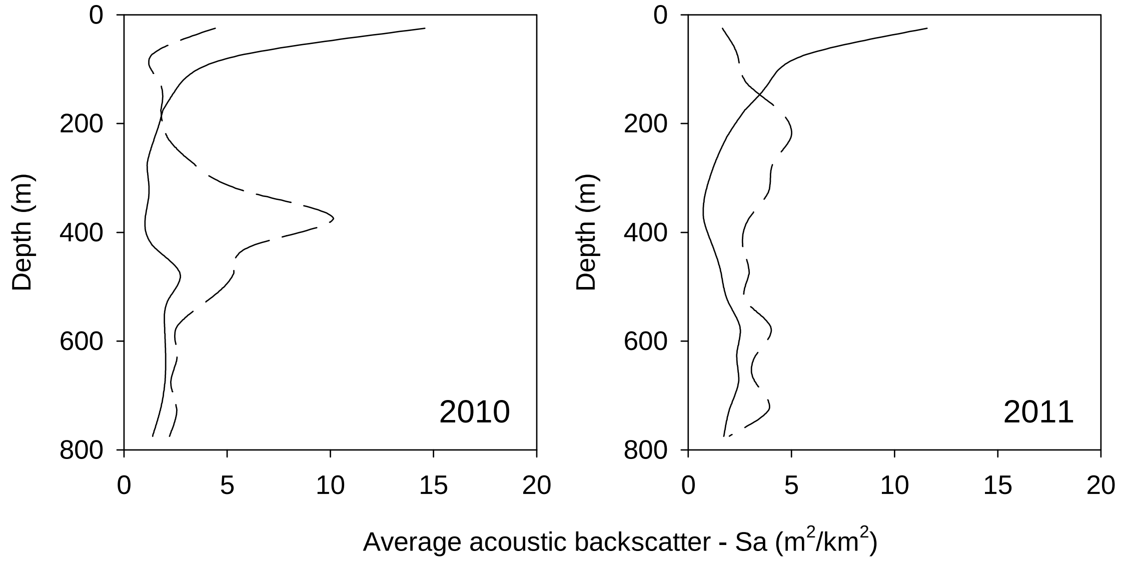


Figure 19. Comparison of distribution of total acoustic backscatter integrated in 50 m depth bins on the Chatham Rise observed during the day (dashed lines) and at night (solid lines) in 2010 and 2011.

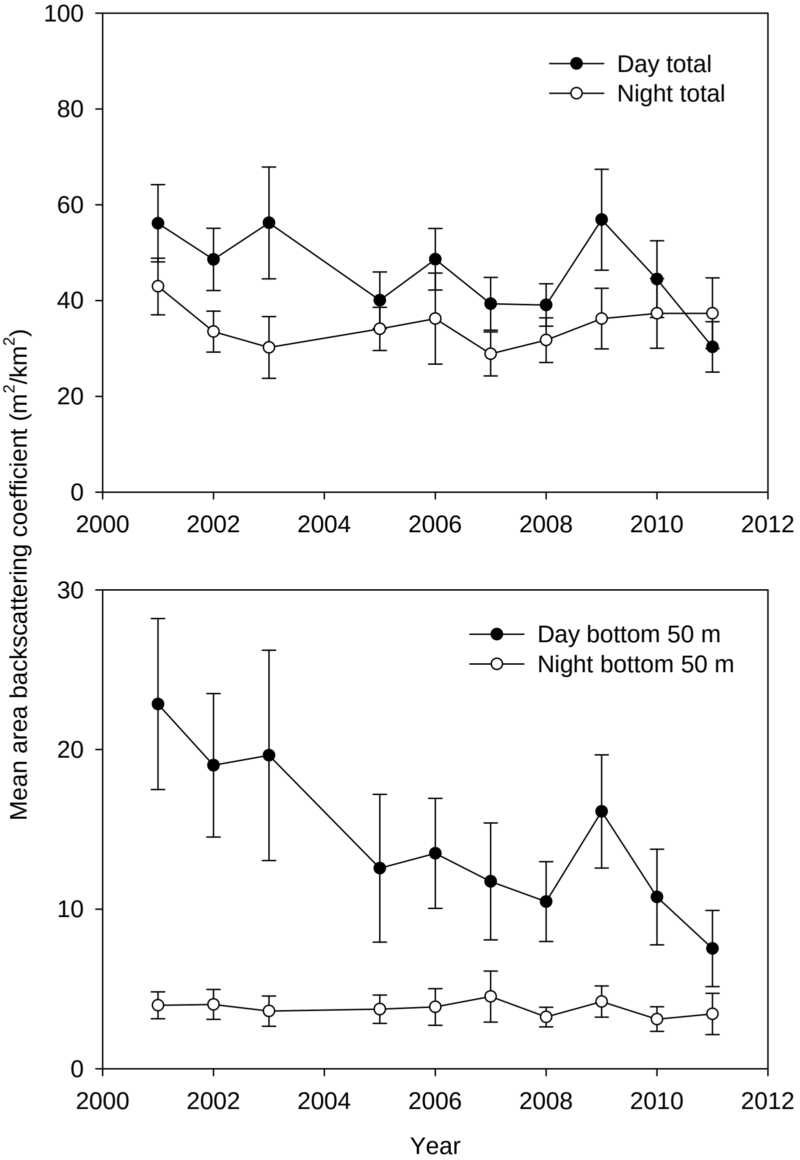


Figure 20: Comparison of relative acoustic abundance indices for the Chatham Rise based on (strata-averaged) mean areal backscatter (s_a). Error bars are ± 2 standard errors.

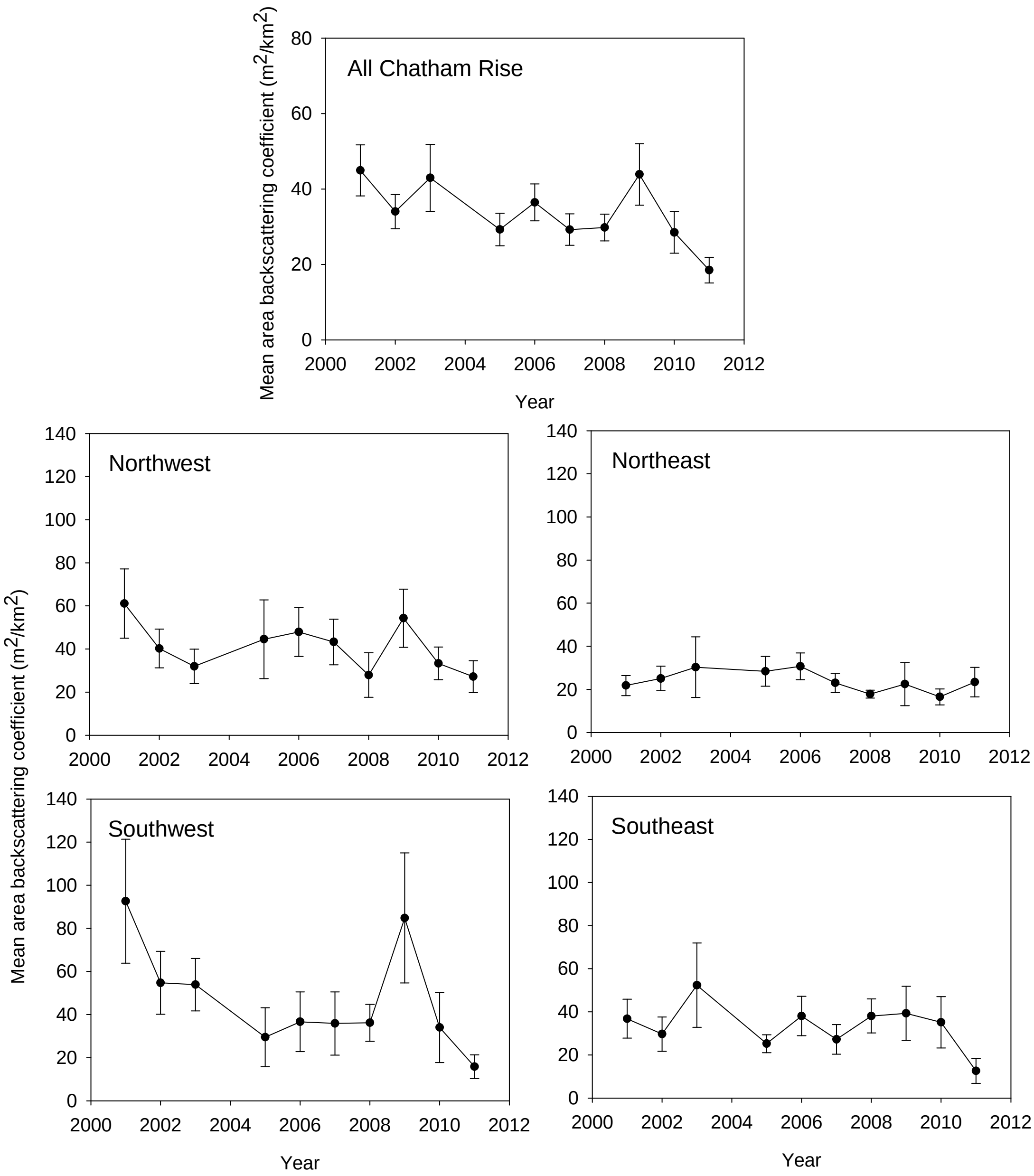


Figure 21: Relative acoustic abundance indices for mesopelagic fish on the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same sub-area observed in the upper 200 m corrected for the estimated proportion in the surface deadzone (see Table 20). Panels show indices for the entire Chatham Rise and for four sub-areas. Error bars are approximate 95% confidence intervals from bootstrapping.

Appendix 1: Individual station data for all stations conducted during the survey (TAN1101). RD, daytime research trawl survey biomass station; P2, phase 2 trawl survey biomass stations; RN, night-time research trawl survey station; Strat., Stratum number; –, catch not recorded; *, 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	7	2-Jan-11	1508	43 18.52	173 52.33	E	456	459	0.48	-	-	-
*2	P1	7	2-Jan-11	1541	43 18.27	173 52.31	E	454	462	0.61	-	-	-
3	P1	22	3-Jan-11	2113	42 44.44	177 47.50	E	846	858	3.01	69	0	0
4	P1	23	4-Jan-11	0102	42 41.20	178 03.23	E	1068	1080	2.95	0	6	0
5	P1	23	4-Jan-11	0442	42 39.05	177 46.03	E	1176	1246	3.00	0	0	0
6	P1	2A	4-Jan-11	0942	42 47.78	177 31.36	E	654	6702	3.00	36	7	24
7	P1	8A	4-Jan-11	1221	42 50.84	177 49.09	E	487	496	3.04	1 187	10	20
8	P1	2A	4-Jan-11	1449	42 48.15	178 03.62	E	679	685	3.03	107	0	43
9	P1	20	4-Jan-11	1810	43 01.94	178 12.65	E	345	354	3.03	1 645	0	49
10	P1	22	5-Jan-11	0054	42 53.52	179 11.61	E	851	855	3.02	76	16	0
*11	P1	20	5-Jan-11	0543	43 02.26	178 41.30	E	383	390	2.46	175	7	10
12	P1	8B	5-Jan-11	0833	43 12.10	178 46.62	E	410	414	2.87	548	8	26
13	P1	8B	5-Jan-11	1157	43 22.29	179 11.03	E	410	412	2.64	337	4	39
14	P1	8B	5-Jan-11	1513	43 24.03	179 38.52	E	418	436	2.75	273	0	40
15	P1	22	6-Jan-11	0023	42 53.28	179 30.52	E	819	825	3.01	99	0	4
16	P1	22	6-Jan-11	0418	42 52.47	179 58.36	E	826	840	3.01	133	0	10
17	P1	10A	6-Jan-11	0759	43 10.32	179 55.95	W	513	517	3.02	467	13	33
18	P1	10A	6-Jan-11	1037	43 20.37	179 59.84	W	426	444	3.02	1 161	46	49
19	P1	10A	6-Jan-11	1327	43 27.57	179 39.57	W	438	447	2.54	127	6	44
20	P1	3	6-Jan-11	1615	43 35.90	179 22.69	W	386	396	2.83	105	6	22
21	P1	3	6-Jan-11	1833	43 43.88	179 25.54	W	363	375	2.36	128	0	5
22	P1	3	7-Jan-11	0514	43 57.47	179 18.14	W	203	224	3.00	1 358	0	86
23	P1	10B	7-Jan-11	0918	43 38.13	179 09.68	W	40	413	3.01	88	0	54
24	P1	10B	7-Jan-11	1133	43 32.95	179 08.34	W	449	450	3.04	97	0	17
25	P1	10B	7-Jan-11	1407	43 24.50	179 09.21	W	450	458	3.02	253	38	3
26	P1	21A	7-Jan-11	2036	42 46.26	179 27.54	W	927	959	3.01	16	5	0
27	P1	21A	7-Jan-11	2314	42 43.28	179 12.57	W	951	954	3.00	37	16	0
28	P1	21A	8-Jan-11	0212	42 46.80	179 08.93	W	816	820	2.06	103	12	0
29	P1	2B	8-Jan-11	0516	42 49.93	179 01.58	W	689	702	3.00	167	33	20
30	P1	11B	8-Jan-11	0937	43 04.12	178 34.44	W	510	524	2.93	141	0	19
31	P1	11B	8-Jan-11	1215	43 00.12	178 37.73	W	528	531	3.03	238	4	29
32	P1	11B	8-Jan-11	1409	43 00.46	178 28.49	W	533	537	3.01	274	10	40
33	P1	2B	8-Jan-11	1706	42 49.95	178 20.93	W	644	652	2.99	188	11	5
*34	P1	21B	9-Jan-11	0151	42 47.86	176 48.21	W	975	977	3.04	-	-	-
*35	P1	24	9-Jan-11	1528	42 49.63	175 50.10	W	1050	1063	0.41	-	-	-
36	P1	24	9-Jan-11	1717	42 50.31	175 46.26	W	1010	1033	2.97	2	0	0
37	P1	24	10-Jan-11	0005	42 52.40	174 41.56	W	1182	1197	2.98	0	0	0
38	P1	24	10-Jan-11	0510	43 04.72	174 02.23	W	1157	1203	2.98	0	0	0
39	P1	2B	10-Jan-11	1021	43 27.32	174 36.63	W	775	777	3.02	48	0	18
40	P1	2B	10-Jan-11	1235	43 25.03	174 48.98	W	765	792	3.01	38	0	0
41	P1	21B	10-Jan-11	1541	43 18.02	174 42.77	W	827	831	3.01	31	0	0
42	P1	21B	10-Jan-11	1753	43 21.75	174 35.72	W	820	835	3.00	29	0	0
43	P1	28	10-Jan-11	2232	43 45.78	174 11.84	W	1126	1150	2.99	0	0	0
44	P1	12	11-Jan-11	0512	43 43.11	175 06.16	W	572	587	3.00	146	0	21

Appendix 1: *continued*

Stn.	Type	Strat.	Date	Time NZST	Start tow Latitude ° ' S	Start tow Longitude ° '	E/W	Gear depth m min.	Gear depth m max.	Dist. towed n. mile	Catch kg hoki	Catch kg hake	Catch kg ling
45	P1	12	11-Jan-11	1337	43 40.26	175 33.19	W	408	427	3.01	71	22	73
46	P1	9	11-Jan-11	1619	43 48.15	175 44.85	W	224	272	2.99	81	0	33
47	P1	11D	12-Jan-11	1020	43 29.04	175 38.24	W	450	496	3.00	1 785	15	23
48	P1	11D	12-Jan-11	1332	43 16.24	175 52.26	W	532	542	3.02	355	0	30
49	P1	2B	12-Jan-11	1718	42 56.94	176 13.86	W	749	756	2.99	90	20	29
50	PI	21B	12-Jan-11	2249	42 47.29	177 03.66	W	977	990	3.00	31	0	0
51	P1	2B	13-Jan-11	0522	42 53.81	176 47.39	W	757	778	3.00	84	0	19
52	P1	11D	13-Jan-11	0846	43 02.75	176 51.72	W	508	531	2.98	574	9	60
53	P1	9	13-Jan-11	1333	43 16.19	177 18.17	W	308	339	2.02	615	0	0
54	P1	9	13-Jan-11	1535	43 12.77	177 29.89	W	365	374	2.16	64	0	8
55	P1	11C	13-Jan-11	1743	43 09.60	177 40.32	W	408	410	2.99	395	0	43
56	P1	5	14-Jan-11	0518	43 47.18	177 42.55	W	375	390	3.01	340	0	7
57	P1	5	14-Jan-11	0833	43 36.45	177 49.21	W	367	379	3.02	832	6	41
58	P1	5	14-Jan-11	1118	43 32.42	177 52.89	W	360	366	3.02	783	2	66
59	P1	11C	14-Jan-11	1339	43 19.68	177 53.36	W	433	439	3.01	424	0	13
60	P1	11C	14-Jan-11	1704	43 04.61	178 12.33	W	519	528	2.99	352	7	4
61	P1	12	15-Jan-11	0522	43 53.76	177 51.56	W	407	432	2.99	369	9	0
62	PI	13	15-Jan-11	0711	43 53.95	178 00.80	W	440	440	3.04	304	3	26
63	P1	11A	15-Jan-11	1137	43 41.87	178 38.14	W	436	448	3.01	203	6	21
64	P1	11A	15-Jan-11	1343	43 35.76	178 25.66	W	412	417	3.01	2 119	16	10
65	P1	11A	15-Jan-11	1547	43 28.08	178 25.27	W	427	430	3.00	701	0	12
66	P1	11A	15-Jan-11	1802	43 26.18	178 19.80	W	424	424	2.52	444	0	6
67	PI	13	16-Jan-11	0522	44 01.24	179 44.21	W	440	451	3.01	371	16	22
68	P1	13	16-Jan-11	0750	44 05.14	179 57.14	W	500	575	3.02	418	0	54
*69	PI	4	16-Jan-11	1120	44 07.26	179 54.72	W	618	624	0.87	-	-	-
70	P1	14	16-Jan-11	1307	43 58.12	179 50.85	E	464	485	3.05	233	0	19
71	P1	8A	17-Jan-11	0805	42 50.00	176 32.55	E	497	511	3.01	399	19	0
72	P1	8A	17-Jan-11	1005	42 55.46	176 26.06	E	482	493	3.04	216	7	64
73	P1	2A	17-Jan-11	1245	42 50.98	176 07.80	E	607	612	3.01	136	12	19
74	P1	1	17-Jan-11	1443	42 53.95	175 58.29	E	602	609	3.02	92	0	31
75	P1	23	18-Jan-11	0149	42 42.94	175 12.81	E	1179	1187	3.02	0	0	0
76	P1	1	18-Jan-11	0538	42 53.21	174 56.86	E	766	780	2.92	207	0	46
77	P1	1	18-Jan-11	0830	42 58.90	174 35.72	E	752	782	3.03	74	4	0
78	P1	7	18-Jan-11	1155	43 18.64	174 32.45	E	496	498	3.15	853	50	122
79	P1	7	18-Jan-11	1423	43 24.07	174 19.61	E	575	579	3.02	274	21	44
80	P1	7	18-Jan-11	1626	43 18.55	174 11.81	E	575	577	2.61	222	5	20
81	P1	22	18-Jan-11	2026	42 59.11	174 14.37	E	978	984	2.94	57	6	0
82	P1	18	19-Jan-11	0541	43 20.68	174 48.71	E	353	384	2.99	1 780	0	56
83	P1	7	19-Jan-11	0846	43 29.68	174 31.25	E	513	535	2.82	386	32	203
84	P1	7	19-Jan-11	1105	43 30.88	174 18.68	E	543	558	3.01	317	11	86
85	P1	7	19-Jan-11	1317	43 32.83	174 21.47	E	556	560	2.75	264	11	25
86	P1	16	19-Jan-11	1658	43 52.32	174 20.78	E	534	545	2.99	525	7	26
87	P1	6	20-Jan-11	0544	44 25.16	173 45.16	E	703	708	3.00	143	5	23
88	P1	6	20-Jan-11	0907	44 21.18	174 10.54	E	674	676	2.99	233	5	63
89	P1	6	20-Jan-11	1534	44 39.26	175 07.47	E	761	787	3.02	95	0	5
90	P1	17	21-Jan-11	0537	44 11.43	175 50.11	E	275	323	2.99	549	15	50

Appendix 1: *continued*

			Start tow					Gear depth		Dist.	Catch		
Stn.	Type	Strat.	Date	Time	Latitude	Longitude			m	towed			Kg
				NZST	º ' S	º '	E/W	min.	max.	n. mile	hoki	hake	Ling
91	P1	17	21-Jan-11	0831	44 02.69	175 57.08	E	348	366	2.99	104	0	50
92	P1	17	21-Jan-11	1022	44 05.81	176 04.81	E	266	342	2.99	4 046	0	34
93	P1	15	21-Jan-11	1418	44 02.95	176 38.00	E	546	584	3.01	269	0	132
94	P1	4	21-Jan-11	1749	44 07.75	176 55.15	E	668	687	3.01	66	0	15
95	P1	4	22-Jan-11	0548	43 59.10	178 51.21	E	632	672	3.01	44	0	10
96	P1	4	22-Jan-11	0845	43 54.82	178 27.92	E	611	645	3.02	47	5	6
97	P1	14	22-Jan-11	1202	43 45.38	178 36.03	E	423	427	3.06	205	10	65
98	P1	14	22-Jan-11	1354	43 48.77	178 27.56	E	450	490	3.02	163	12	44
99	P1	20	22-Jan-11	1745	43 34.42	177 56.43	E	347	354	3.01	95	0	101
100	P1	20	23-Jan-11	0537	43 16.93	178 05.13	E	321	333	2.15	305	0	25
101	P1	20	23-Jan-11	0820	43 22.93	177 43.86	E	315	347	3.01	6 002	0	27
102	P1	20	22-Jan-11	1028	43 17.89	177 34.05	E	253	261	2.99	108	0	0
103	P1	19	23-Jan-11	1307	43 19.47	177 11.70	E	215	230	3.00	0	0	0
104	P1	19	23-Jan-11	1457	43 27.18	177 13.59	E	245	259	2.12	516	0	0
105	P1	19	23-Jan-11	1747	43 21.47	176 48.76	E	270	273	3.01	163	0	0
106	P1	15	24-Jan-11	0539	43 42.60	177 04.86	E	465	478	3.03	129	0	58
107	P1	15	24-Jan-11	0836	43 40.43	176 41.96	E	423	444	3.04	551	3	30
108	P1	19	24-Jan-11	1156	43 31.48	176 13.45	E	373	378	3.01	1 327	10	237
*109	P1	18	24-Jan-11	1514	43 41.44	175 50.12	E	312	322	0.63	-	-	-
110	P1	16	24-Jan-11	1659	43 50.00	175 55.17	E	457	460	3.01	703	13	40
111	P1	16	25-Jan-11	0544	44 02.72	175 35.32	E	514	536	3.01	441	0	76
112	P1	18	25-Jan-11	1010	43 31.69	175 37.26	E	242	254	3.04	123	0	0
113	P1	18	25-Jan-11	1312	43 36.29	175 11.85	E	244	281	2.01	117	0	0
114	P1	22	25-Jan-11	2038	42 58.53	174 26.91	E	878	898	2.89	37	0	0
*115	P1	23	25-Jan-11	2307	42 51.82	174 21.32	E	1245	1250	1.36	0	0	0
116	P2	22	26-Jan-11	0352	42 50.21	175 07.59	E	839	866	2.99	93	10	0
117	P1	23	26-Jan-11	0819	42 40.62	175 49.15	E	1055	1074	3.00	0	8	0
118	P1	23	26-Jan-11	1212	42 41.18	175 58.93	E	1012	1169	3.01	2	5	0
119	P1	23	26-Jan-11	1615	42 38.02	176 21.53	E	1020	1040	3.01	0	3	0
120	P1	23	26-Jan-11	1955	42 39.89	176 49.69	E	1024	1045	2.99	0	0	0
121	P2	20	27-Jan-11	0538	43 03.91	177 22.35	E	292	300	2.15	1 028	0	5
122	P2	20	27-Jan-11	0906	43 02.94	177 43.57	E	317	323	2.96	2 864	0	49

Appendix 2: Scientific and common names of species caught from all valid biomass tows (TAN1101). The occurrence (Occ.) of each species (number of tows caught) in the 114 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	4
Porifera	unspecified sponges	ONG	8
Demospongiae (siliceous sponges)			
Astrophorida (sandpaper sponges)			
Ancorinidae			
Ancorina novaezelandiae	knobbly sandpaper sponge	ANZ	3
Geodiidae			
Geodinela vestigifera	ostrich egg sponge	GVE	4
Hadromerida (woody sponges)			
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	13
Poecilosclerida (bright sponges)			
Crellidae			
Crella incrustans	orange frond sponge	CIC	1
Hymedesmiidae			
Phorbas spp.	grey fibrous massive sponge	PHB	1
Hexactinellida (glass sponges)			
Lyssacinosida (tubular sponges)			
Rossellidae			
Hyalascus sp.	floppy tubular sponge	HYA	23
Cnidaria			
Coral (Hydrozoan + Anthozoan corals)	unspecified coral	COU	1
Anthoathecata (hydroids)			
Stylasteridae			
Calyptopora reticulata	white hydrocoral	CRE	1
Scyphozoa	unspecified jellyfish	JFI	16
Anthozoa			
Octocorallia			
Alcyonacea (soft corals)	unspecified soft coral	SOC	1
Gorgonacea (gorgonian corals)			
Primnoidae			
Primnoa spp.		PMN	1
Pennatulacea (sea pens)	unspecified sea pens	PTU	9
Pennatulidae			
Pennatula spp.	purple sea pens	PNN	1
Hexacorallia			
Zoanthidea (zoanthids)			
Epizoanthidae			
Epizoanthus sp.		EPZ	3
Actinaria (anemones)	unspecified anemones	ANT	5
Actiniidae (deepsea anemones)		BOC	3
Actinostolidae (smooth deepsea anemones)		ACS	24
Hormathiidae (warty deepsea anemones)		HMT	15
Scleractinia (stony corals)			
Caryophyllidae			
Desmophyllum dianthus	crested cup coral	DDI	4
Goniocorella dumosa	bushy hard coral	GDU	10

Stephanocyathus platypus	solitary bowl coral	STP	1

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Flabellidae			
Flabellum spp.	flabellum coral	COF	8
Ascidiacea	unspecified sea squirt	ASC	1
Tunicata			
Thaliacea (salps)	unspecified salps	SAL	9
Salpidae			
Pyrosoma atlanticum		PYR	3
Mollusca			
Gastropoda (gastropods)			
Nudibranchia (sea slugs)		NUD	1
Buccinidae (whelks)			
Penion chathamensis		PCH	1
Ranellidae (tritons)			
Fusitriton magellanicus		FMA	28
Volutidae (volutes)			
Provocator mirabilis	golden volute	GVO	3
Bivalvia (bivalves)			
Limidae			
Acesta maui	giant file shell	AMA	
Cephalopoda			
Teuthoidea (squids)	unspecified squid	SQX	1
Lycoteuthidae			
Lycoteuthis lorigera	crowned firefly squid	LSQ	1
Octopoteuthididae			
Octopoteuthis megaptera		OCM	1
Onychoteuthidae			
Onykia ingens	warty squid	MIQ	49
O. robsoni	warty squid	MRQ	5
Pholidoteuthis boschmai	scaly squid	PSQ	1
Histioteuthidae (violet squids)			
Histioteuthis spp.	violet squid	VSQ	1
Ommastrephidae			
Nototodarus sloanii	Sloan's arrow squid	NOS	37
Todarodes filippovae	Todarodes squid	TSQ	27
Mastigoteuthidae			
Mastigoteuthis sp.	squid	MSQ	1
Cranchiidae			
Teuthowenia pellucida		TPE	4
Cirrata (cirrate octopus)			
Opisthoteuthididae			
Opisthoteuthis spp.	umbrella octopus	OPI	6
Incirrata (incirrate octopus)			
Octopodidae			
Enteroctopus zealandicus	yellow octopus	EZE	2
Graneledone taniwha taniwha	deepwater octopus	GTA	4
Octopus mernoo	octopus	OME	6

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Polychaeta	unspecified polychaete	POL	1
Phyllodocida			
Aphroditidae			
Aphrodita spp.	sea mouse	ADT	2
Eunicidae			
Eunice spp.	Eunice sea worm	EUN	1
Crustacea			
Malacostraca			
Dendrobranchiata/Pleocyemata (prawns)			
Dendrobranchiata			
Aristeidae			
Aristaeomorpha foliacea	royal red prawn	AFO	2
Austropenaeus nitidus	prawn	NAT	1
Solenoceridae			
Haliporoides sibogae	jack-knife prawn	HSI	1
Pleocyemata			
Caridea			
Oplophoridae			
Acanthephyra pelagica			
A. spp.	ruby prawn	ACA	1
Notostomus auriculatus	scarlet prawn	NAU	1
Oplophorus novaezeelandiae	deepwater prawn	ONO	1
O. spp.	deepwater prawn	OPP	1
Pasiphaeidae			
Pasiphaea aff. *tarda*	deepwater prawn	PTA	14
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	20
Nematocarcinus spp.	spider prawn	NEC	1
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	21
Palinura			
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	10
Anomura			
Galatheidae (squat lobsters)			
Galatheoidea			
Munida gracilis	squat lobster	MGA	2
Inachidae			
Vitjazmaia latidactyla	deepsea spider crab	VIT	4
Lithodidae (king crabs)			
Lithodes aotearoa	New Zealand king crab	LMU	3
Neolithodes brodiei	Brodie's king crab	NEB	2
Paralomis zealandica	prickly king crab	PZE	1
Paguroidea (unspecified pagurid & parapagurid hermit crabs)		PAG	20
Paguridae (Pagurid hermit crabs)			
Diacanthurus rubricatus	hermit crab	DIR	1
Parapaguridae (Parapagurid hermit crabs)			
Sympagurus dimorphus	hermit crab	SDM	8

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Brachyura (true crabs)			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	21
Goneplacidae			
Pycnoplax victoriensis	two-spined crab	CVI	4
Homolidae			
Dagnaudus petterdi	antlered crab	DAP	5
Majidae (spider crabs)			
Leptomithrax garricki	Garrick’s masking crab	GMC	1
Teratomaia richardsoni	spiny masking crab	SMK	14
Portunidae (swimming crabs)			
Ovalipes molleri	Swimming crab	OVM	1
Echinodermata			
Asteroidea (starfish)	unspecified starfish	ASR	3
Asteriidae			
Pseudechinaster rubens	starfish	PRU	9
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	19
Plutonaster knoxi	abyssal star	PKN	19
Proserpinaster neozelanicus	starfish	PNE	19
Psilaster acuminatus	geometric star	PSI	35
Sclerasterias mollis	cross-fish	SMO	16
Benthopectinidae			
Benthopecten spp.	starfish	BES	4
Brisingida		BRG	16
Goniasteridae			
Hippasteria phrygiana	trojan starfish	HTR	8
Lithosoma novaezelandiae	rock star	LNV	1
Mediaster sladeni	starfish	MSL	11
Pillsburiaster aoteanus	starfish	PAO	6
Odontasteridae			
Odontaster spp.	pentagonal tooth-star	ODT	2
Solasteridae			
Crossaster multispinus	sun star	CJA	14
Solaster torulatus	chubby sun-star	SOT	5
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	37
Ophiuroidea (basket and brittle stars)	unspecified brittle star	OPH	1
Euryalina (basket stars)			
Gorgonocephalidae			
Gorgonocephalus spp.	Gorgon's head basket stars	GOR	5
Echinoidea (sea urchins)			
Regularia			
Cidaridae (cidarid urchins)			
Goniocidaris parasol	parasol urchin	GPA	5
Histiocidaridae (cidarid urchins)			
Poriocidaris purpurata		PCD	1
Echinothuriidae/Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	51
Echinidae			
Gracilechinus multidentatus	deepsea kina	GRM	15
Dermechinus horridus	deepsea urchin	DHO	1

Appendix 2 (continued)

Scientific name	Common name	Specie s	Occ.
Pedinidae			
Caenopedina sp.	giant purple pedinid	CAL	1
Spatangidae (heart urchins)			
Spatangus multispinus	purple-heart urchin	SPT	19
Holothuroidea	unspecified sea cucumber	HTH	8
Aspidochirotida			
Synallactidae			
Bathyplotes moseleyi	sea cucumber	BAM	9
Pseudostichopus mollis	sea cucumber	PMO	17
Elasipodida			
Laetmogonidae			
Laetmogone sp.	sea cucumber	LAG	9
Pannychia moseleyi	sea cucumber	PAM	6
Pelagothuridae			
Enypniastes exima	sea cucumber	EEX	6
Psychropotidae			
Benthodytes sp.	sea cucumber	BTD	2
Brachiopoda	unspecified lamp shell	BPD	2
Agnatha (jawless fishes)			
Eptatretus cirrhatus	hagfish	HAG	1
Chondrichthyes (cartilagenous fishes)			
Chlamydoselachidae: frill shark			
Chlamydoselachus anguineus	frill shark	FRS	2
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	2
Chlamydoselachidae: frill shark			
Chlamydoselachus anguineus	frill shark	FRS	2
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	2
Squalidae: dogfishes			
Centrophorus squamosus	leafscale gulper shark	CSQ	21
Centroscymnus crepidater	longnose velvet dogfish	CYP	34
C. owstoni	smooth skin dogfish	CYO	28
Deania calcea	shovelnose dogfish	SND	44
Etmopterus baxteri	Baxter's dogfish	ETB	30
E. lucifer	Lucifer dogfish	ETL	49
Proscymnodon plunketi	Plunket's shark	PLS	10
Scymnorhinus licha	seal shark	BSH	33
Squalus acanthias	spiny dogfish	SPD	57
S. griffini	northern spiny dogfish	NSD	4
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	9
Scyliorhinidae: cat sharks			
Apristurus spp.	catshark	APR	18
Cephaloscyllium isabellum	carpet shark	CAR	1
Halaelurus dawsoni	Dawson's catshark	DCS	9
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	4

Appendix 2 (continued)

Scientific name	Common name	Specie s	Occ.
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	1
Narkidae: blind electric rays			
Typhlonarke aysoni	blind electric ray	TAY	1
T. tarakea	oval electric ray	TTA	1
T. spp.	numbfish	BER	3
Rajidae: skates			
Amblyraja hyperborea	deepwater spiny (Arctic) skate	DSK	1
Bathraja shuntovi	longnosed deepsea skate	PSK	5
Brochiraja asperula	smooth deepsea skate	BTA	25
B. leviveneta	blue skate	BTH	1
B. spinifera	prickly deepsea skate	BTS	6
Dipturus innominatus	smooth skate	SSK	25
Zearaja nasuta	rough skate	RSK	7
Chimaeridae: chimaeras, ghostsharks			
Chimaera sp.	brown chimaera	CHP	6
Hydrolagus bemisi	pale ghostshark	GSP	70
H. novaezealandiae	dark ghostshark	GSH	42
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	long-nosed chimaera	LCH	51
Rhinochimaera pacifica	widenosed chimaera	RCH	20
Osteichthyes (bony fishes)			
Halosauridae: halosaurs			
Halosaurus pectoralis	common halosaur	HPE	6
Notocanthidae: spiny eels			
Notacanthus chemnitzi	giant spineback	NOC	1
N. sexspinis	spineback	SBK	50
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	22
Congridae: conger eels			
Bassanago bulbiceps	swollenhead conger	SCO	27
B. hirsutus	hairy conger	HCO	30
Serrivomeridae: sawtooth eels			
Serrivomer sp.	sawtooth eel	SAW	
Gonorynchidae: sandfish			
Gonorynchus forsteri & *G. greyi*	sandfishes	GON	2
Argentinidae: silversides			
Argentina elongata	silverside	SSI	51
Bathylagidae: deepsea smelts			
Melanolagus bericoides	bigscale blacksmelt	MEB	7
Nansenia sp.	deepsea smelt	DSS	1
Alepocephalidae: slickheads			
Alepocephalus antipodianus	smallscaled brown slickhead	SSM	14
A. australis	bigscaled brown slickhead	SBI	16
Xenodermichthys copei	black slickhead	BSL	14
Platytroctidae: tubeshoulders			
Persparsia kopua		PER	1
Gonostomatidae: lightfishes	unspecified lightfish	GST	1
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	4

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	23
Chauliodontidae: viperfishes			
Chauliodus sloani	viperfish	CHA	10
Astronesthidae: snaggletooths	unspecified snaggletooth	AST	1
Melanostomiidae: scaleless black dragonfishes			
Melanostomias spp.	scaleless black dragonfishes	MEN	1
Malacosteidae: loosejaws			
Malacosteus spp.	loosejaw	MAL	7
Idiacanthidae: black dragonfishes			
Idiacanthus spp.	black dragonfish	IDI	2
Chlorophthalmidae: cucumberfishes, tripodfishes			
Chlorophthalmus nigripinnis	cucumberfish	CUC	1
Scopelarchidae: pearleyes	unspecified pearleye	PEY	1
Scopelarchoides kreffti	Krefft's pearleye	SKR	1
Notosudidae: waryfishes			
Scopelosaurus spp.		SPL	2
Paralepididae: barracudinas	unspecified barracudina	PAL	1
Macroparalepis macrugeneion		MMA	2
Evermannellidae: sabretooth fishes			
Evermanella balbo	brown sabretooth	EVB	1
Myctophidae: lanternfishes	unspecified lanternfish	LAN	16
Gymnoscopelus spp.		GYM	1
Lampadena notialis		LPD	2
Lampanyctodes hectoris	Hector's lanternfish	LHE	2
Lampanyctus spp.		LPA	15
Symbolophorus spp.		SYM	1
Moridae: morid cods			
Halargyreus johnsonii	Johnson's cod	HJO	35
Lepidion microcephalus	small-headed cod	SMC	13
Mora moro	ribaldo	RIB	40
Notophycis marginata	dwarf cod	DCO	3
Pseudophycis bachus	red cod	RCO	14
Tripterophycis gilchristi	grenadier cod	GRC	3
Melanonidae: pelagic cods			
Melanonus gracilis	small toothed pelagic cod	MEL	1
M. zugmayeri	large toothed pelagic cod	MEZ	3
Euclichthyidae: eucla cods			
Euclichthys polynemus	eucla cod	EUC	1
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	3
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	104
Merluccius australis	hake	HAK	55
Macrouridae: rattails, grenadiers			
Coelorinchus acanthiger	spotty faced rattail	CTH	2
C. aspercephalus	oblique banded rattail	CAS	48
C. biclinozonalis	two saddle rattail	CBI	9
C. bollonsi	bigeye rattail	CBO	82
C. fasciatus	banded rattail	CFA	32
C. innotabilis	notable rattail	CIN	32

C. matamua	Mahia rattail	CMA	17

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
C. maurofasciatus	dark banded rattail	CDX	1
C. oliverianus	Oliver's rattail	COL	69
C. parvifasciatus	small banded rattail	CCX	10
C. trachycarus	roughhead rattail	CHY	8
Coryphaenoides dossenus	humpback (slender) rattail	CBA	16
C. serrulatus	serrulate rattail	CSE	29
C. striaturus	striate rattail	CTR	2
C. subserrulatus	four-rayed rattail	CSU	37
Lepidorhynchus denticulatus	javelinfish	JAV	94
Lucigadus nigromaculatus	blackspot rattail	VNI	29
Macrourus carinatus	ridge scaled rattail	MCA	11
Mesobius antipodum	black javelinfish	BJA	4
Nezumia namatahi	squashed face rattail	NNA	3
Trachonurus gagates	velvet rattail	TRX	2
Trachyrincus aphyodes	white rattail	WHX	26
T. longirostris	unicorn rattail	WHR	3
Ophidiidae: cuskeels			
Genypterus blacodes	ling	LIN	82
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	3
Ceratiidae: seadevils			
Cryptopsaras couesi	seadevil	SDE	2
Himantolophidae: prickly anglerfishes			
Himantolophus appelii	prickly anglerfish	HIA	1
Linophrynidae: linophrynids			
Haplophryne mollis	phantom angler	LPH	1
Trachichthyidae: roughies, slimeheads			
Hoplostethus atlanticus	orange roughy	ORH	29
H. mediterraneus	silver roughy	SRH	48
Paratrachichthys trailli	common roughy	RHY	8
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	2
Anoplogastridae: fangtooth			
Anoplogaster cornuta	fangtooth	ANO	2
Berycidae: alfonsinos			
Beryx splendens	alfonsino	BYS	34
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	13
Cyttus novaezealandiae	silver dory	SDO	14
C. traversi	lookdown dory	LDO	81
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	14
A. verrucosus	warty oreo	WOE	6
Neocyttus rhomboidalis	spiky oreo	SOR	27
Pseudocyttus maculatus	smooth oreo	SSO	31
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	68
Notopogon lilliei	crested bellowsfish	CBE	6
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	81
Trachyscorpia capensis		TRS	2

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	4
Congiopodus leucopaecilus	pigfish	PIG	2
Triglidae: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	8
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	34
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	11
Psychrolutes microporos	blobfish	PSY	3
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	11
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	11
Apogonidae: cardinalfishes			
Epigonus denticulatus	white cardinalfish	EPD	10
E. lenimen	bigeye cardinalfish	EPL	11
E. robustus	robust cardinalfish	EPR	21
E. telescopus	deepsea cardinalfish	EPT	14
Rosenblattia robusta	rotund cardinalfish	ROS	5
Carangidae: trevallies, kingfishes			
Trachurus declivis	greenback jack mackerel	JMD	2
T. symmetricus murphyi	slender jack mackerel	JMM	5
Bramidae: pomfrets			
Brama australis & *B. brama*	southern Ray's bream & Ray’s bream	SRB & RBM	19
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	6
Plagiogeneion rubiginosum	rubyfish	RBY	3
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	TAR	6
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	47
Percophidae: opalfishes			
Hemerocoetes spp.	opalfish	OPA	1
Pinguipedidae: sandperches, weevers			
Parapercis gilliesi	yellow cod	YCO	1
Gempylidae: snake mackerels			
Nesiarchus nasutus	black baracouta	BBA	2
Thyrsites atun	barracouta	BAR	6
Trichiuridae: cutlassfishes			
Benthodesmus spp.	scabbardfish	BEN	1
Lepidopus caudatus	frostfish	FRO	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	10
Hyperoglyphe antarctica	bluenose	BNS	5
Schedophilus huttoni	slender ragfish	SUH	1
S. maculatus	pelagic butterfish	SUM	1
Seriolella caerulea	white warehou	WWA	42
S. punctata	silver warehou	SWA	53
Tubbia tasmanica	Tasmanian ruffe	TUB	3

Appendix 2 (continued)

Scientific name	Common name	Species	Occ.
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	10
Neoachiropsetta milfordi	finless flounder	MAN	5
Pleuronectidae: righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	9

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

NIWA No.	Cruise/Station_no	Phylum	Class	Subclass	Order	Family	Genus	Species
70541	TAN1101/54	Arthropoda	Malacostraca		Decapoda	Homolidae	*Dagnaudus*	*petterdi*
70521	TAN1101/74	Cnidaria	Anthozoa	Hexacorallia	Actiniaria	Actiniidae		
70529	TAN1101/14	Cnidaria	Anthozoa	Hexacorallia	Corallimorpharia			
70523	TAN1101/98	Cnidaria	Anthozoa	Octocorallia	Gorgonacea	Primnoidae		
70530	TAN1101/98	Cnidaria	Anthozoa	Hexacorallia	Scleractinia	Caryophylliidae	*Desmophyllum*	*dianthus*
70531	TAN1101/20	Cnidaria	Anthozoa	Hexacorallia	Scleractinia	Caryophylliidae	*Goniocorella*	*dumosa*
70527	TAN1101/36	Cnidaria	Hydrozoa	Siphonophora				
70520	TAN1101/47	Echinodermata	Asteroidea		Valvatida	Goniasteridae	*Mediaster*	*sladeni*
70524	TAN1101/99	Echinodermata	Asteroidea		Velatida	Pterasteridae	*Pteraster*	(*Apterodon*) *bathamae*
70526	TAN1101/92	Echinodermata	Asteroidea		Velatida	Pterasteridae	*Pteraster*	(*Apterodon*) *bathamae*
70528	TAN1101/8	Echinodermata	Holothuroidea (Class)		Molpadiida	Molpadiidae	*Heteromolpadia*	*pikei*
70539	TAN1101/9	Echinodermata	Holothuroidea (Class)		Molpadiida	Molpadiidae	*Heteromolpadia*	*pikei*
70525	TAN1101/54	Echinodermata	Ophiuroidea		Euryalinida [aka Phyrynophiurida]	Gorgonocephalidae	*Astrothorax*	*waitei*
70522	TAN1101/18	Mollusca	Cephalopoda	Coleoidea	Octopoda	Octopodidae	*Octopus*	*mernoo*
70540	TAN1101/9	Mollusca	Cephalopoda	Coleoidea	Octopoda	Octopodidae	*Octopus*	*mernoo*
70532	TAN1101/54	Porifera	Demospongiae		Astrophorida	Ancorinidae	*Ecionemia*	*novaezealandiae*
70533	TAN1101/49	Porifera	Demospongiae		Astrophorida	Ancorinidae	*Tethyopsis*	n. sp. 1
62167	TAN1101/54	Porifera	Demospongiae		Astrophorida	Geodiidae	*Geodia*	*vestigifera*

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

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