Trawl survey of hoki and middle depth species on the Chatham Rise, January 2010 (TAN1001)

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EXECUTIVE SUMMARY

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The nineteenth 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 2010. A random stratified sampling design was used and 91 bottom trawl stations were successfully completed in the core (200–800 m) survey area, comprising 87 phase 1 biomass stations and 4 phase 2 stations. For the first time a deepwater objective to estimate the relative biomass of orange roughy and other deepwater species was added to the survey, and 33 stations were successfully completed in deep (800–1300 m) strata.

The estimate of relative biomass of all hoki in the core survey area was 97 503 t, a decrease of 32% from January 2009. This was largely driven by a decrease in the abundance of 2+ hoki from 65 218 t (2006 year-class) in 2009 to 28 648 t (2007 year-class) in 2010; although the number of 1+ and recruited hoki (3+ and older) hoki were also lower in 2010. The biomass of hake in the core area decreased by 30% to 1701 t in 2010. The biomass of ling was 8846 t, 17% lower than in January 2009, but the time-series for ling shows no overall trend. Coefficients of variation (c.v.s) of biomass estimates were 14.6% for total hoki, 25.1% for hake, and 10.0% for ling. The c.v. for age 2+ hoki was 15.9%, which was below the Ministry of Fisheries target c.v. of 20%.

The 2007 hoki year-class at age 2+ was about average in the trawl time series. The 2008 hoki year-class at age 1+ was also about average. The age frequency distribution for hake was broad, with a peak of younger fish from ages 5–8, suggesting a pulse of recent recruitment. The age distribution for ling was broad, with most fish aged between 3 and 16.

Only 9 of the 10 deeper strata were surveyed in 2010 because of time constraints.The biomass estimate for orange roughy from all strata was 4386 t, with a c.v. of 17.7%. Most (89%) of the orange roughy biomass was from the additional deep strata. The deepwater survey appeared to be useful for measuring abundance of orange roughy in both the Northwest and East and South Rise stocks but less useful for oreos, which are more widespread over the South Rise.

Acoustic data were also collected during the trawl survey. Acoustic indices of mesopelagic fish abundance on the northeast Chatham Rise in 2010 were the lowest in the time-series, but there has been no clear trend in mesopelagic biomass on the Chatham Rise over the last 10 years. There was a weak positive correlation between acoustic density from bottom marks and trawl catch rates in 2010.

1. INTRODUCTION

In January 2010, the nineteenth 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 species abundance in 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 have been 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), Stevens & Livingston (2003), Livingston et al. (2004), Livingston & Stevens (2005), and Stevens & O’Driscoll (2006, 2007). Trends in biomass and changes in catch and age distribution of 31 species from surveys 1992–2001 were reviewed by Livingston et al. (2002) and another comprehensive review of surveys from 1992–2010 is currently being carried out as part of Ministry of Fisheries Research Project HOK2007/02C.

Chatham Rise surveys provide relative biomass estimates of adult and juvenile hoki. Hoki is New Zealand's largest fishery with a current TACC of 120 000 t. Although managed as a single stock, hoki is assessed as two stocks, western and eastern. The current hypothesis is that juveniles from both stocks mix on the Chatham Rise and recruit to their respective stocks as they approach sexual maturity. The Chatham Rise is also the principal residence area for the hoki that spawn in Cook Strait and off the east coast South Island in winter (eastern stock). The hoki fishery is now strongly recruitment driven and therefore subject to large fluctuations in stock size. To manage the fishery and minimise potential risks, it is important to have some predictive ability concerning recruitment into the fishery. Current information on juvenile hoki behaviour suggests that the Chatham Rise 2+ index provides the best estimate of relative year class strength. There is a time lag of about 1–3 years between surveys of the 2 year olds and their full recruitment into the fisheries. The survey data from both juvenile and adult abundance are input to the model directly to estimate recruitment parameters and determine current stock status.

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

As a pilot study in 2010, the Chatham Rise trawl survey was extended to sample deeper strata (800 to 1300 m). It was hoped that this extension would allow the survey to provide fishery independent abundance indices for a range of deepwater 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 ghost shark, which are known to occur deeper than the current survey depth boundary (800 m).

Acoustic data have been recorded during trawls and while steaming between stations on all trawl surveys on the Chatham Rise since 1995, except in 2004. Data from previous surveys were analysed to describe mark types (Cordue et al. 1998, Bull 2000, O’Driscoll 2001a, Livingston et al. 2004, Stevens & O’Driscoll 2006, 2007, Stevens et al. 2008, 2009a, 2009b), 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, 2010, Stevens et al. 2009b). Acoustic data also provide qualitative information on the amount of backscatter that is not available to the bottom trawl, either through being off the bottom, or over areas of foul ground.

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

The continuation of the time series of trawl surveys on the Chatham Rise is a high priority to provide information required to update the assessment of hoki and other middle depth species. In the 10-year Deepwater Research Plan it is proposed to carry out the survey in 8 of the next 10 years.

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 using otolith samples from the trawl survey.

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

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

5. To carry out a pilot survey of deepwater strata (800–1300 m).

2. METHODS

2.1 Survey area and design

As in previous years, the survey followed a two-phase random design (after Francis 1984). The core survey area of 200–800 m depth (Figure 1) was divided into the same 26 strata used in 2003–09 (Livingston et al. 2004, Livingston & Stevens 2005, Stevens & O'Driscoll 2006, 2007, Stevens et al. 2008, 2009a, 2009b). Station allocation for phase 1 was determined from simulations based on catch rates from all previous Chatham Rise trawl surveys (1992–2009), 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 core stations in phase 1 (Table 1) was similar to that used in the 2009 survey, when the c.v. for 2+ hoki was 17.2% (Stevens et al. 2009b). Phase 2 stations were allocated at sea, largely to improve the c.v. for hake.

There were 10 proposed deepwater strata (Figure 1, Table 1). Stratification was based on bathymetry, current orange roughy and oreo stock management boundaries, the observed distribution of pre-recruit orange roughy (Dunn et al. 2009), and likely steaming distances. Strata 21 and 22 on the northern Chatham Rise are existing 800–1000 m trawl strata, which have been previously surveyed for hake (stratum 21 was surveyed in 2000, and stratum 22 was surveyed in 2002, 2007, and 2008). Stratum 21 was split into two (strata 21a and 21b) at 178º W, because 178º W is the designated ORH 3B subarea boundary between the Northwest Rise and East and South Rise stocks. Strata 23 and 24 are 1000–1300 m strata on the north Rise. Again these two strata were separated by the subarea boundary at 178º W. Because of logistical considerations related to steaming distance, the eastern boundary of the deeper strata was arbitrarily defined as 174º W. It was considered extremely unlikely there would be time to trawl on stations further east than this during the time available. The North and South Rise were separated at 43º 30' S, in keeping with the boundary between existing shallower trawl survey strata. On the south Rise there were three 800–1000 m strata (25, 26, and 27) divided at 180º and 176º E. The boundary at 180º was related to observed density of 22–27 cm orange roughy, which tends to be higher east of 180º (figure 5 in Dunn et al. 2009). The boundary at 176º E is the QMA boundary between OEO 3A and OEO 4. Two

1000–1300 m strata (28 and 29) were proposed on the South Rise, from 176º E to 180º and from 180º to 174º W. We did not propose surveying the 1000–1300 m area west of 176º E (i.e., OEO 3A) because this area is very large, and could not be covered in the time available.

The proposed allocation of deepwater stations (Table 1) was based on spreading 40 stations (estimated to be the maximum number achievable without extending the survey period) across all 10 deep strata, strata area and expected densities of 22–27 cm orange roughy. More stations were provisionally allocated to 800–1000 m strata because density of pre-recruit orange roughy probably peaks at about 900 m (Dunn et al. 2009). There was no allowance for phase 2 trawling in deeper strata.

2.2 Vessel and gear specifications

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

The bottom trawl was the same as that used on previous surveys of middle depth species by *Tangaroa.* The net is an eight-seam hoki bottom trawl with 100 m sweeps, 50 m bridles, 12 m backstrops, 58.8 m groundrope, 45 m headline, and 60 mm codend mesh (see Hurst & Bagley (1994) for net plan and rigging details). The trawl doors were Super Vee type with an area of 6.1 m^2. Measurements of doorspread (from a Scanmar 400 system) and headline height (from a Furuno net monitor) were recorded every 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. A minimum distance between stations of 3 n. miles was used. 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 0453 h and 1845 h NZST. Trawls in deepwater strata were carried out primarily at night, but some deep tows were carried out during the day to minimise steaming distances. Deepwater surveys use both day and night trawls to estimate biomass (e.g., Doonan et al. 2009), so doing deeper tows at night is unlikely to bias results for these species.

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 had been covered in core strata (or 1.5 n. mile in deepwater strata). If time ran short at the end of the day and it was not possible to reach the last core 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 calibrated following standard procedures (Foote et al. 1987) on 27 January 2010 in Palliser Bay, at the end of the trawl survey (Appendix 1). The system and calibration parameters are given in Table 2.

2.5 Hydrology

Temperature and salinity data were collected using a calibrated Seabird SM-37 Microcat CTD datalogger mounted on the headline of the trawl. Data were collected at 5 s intervals throughout the trawl, providing vertical profiles. Surface values were read off the vertical profile at the beginning of each tow at a depth of about 5 m, which corresponded to the depth of the hull temperature sensor used in previous surveys. Bottom values were 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 0.3 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 are being stored at NIWA for subsequent 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 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, ling, orange roughy, and oreos for age determination. Additional data on liver condition were also collected from a subsample of 20 hoki per tow by recording gutted and liver weights.

2.7 Estimation of 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 middle depth species: hake, ling, dark ghost shark, pale ghost shark, giant stargazer, lookdown dory, sea perch, silver warehou, spiny dogfish, and white warehou. These species were selected because they are commercially important, and the core 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 the 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 680 hoki otoliths and 636 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 251 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 measurents 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) and generalised by O'Driscoll et al. (2010).

2.9.1 Description of acoustic mark types

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 on 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 Foundation for Research Science & Technology (FRST) programme (CO1X0501).

Descriptive statistics were produced on the frequency of occurrence of different marks. Brief descriptions of the mark types are given below, and an example multifrequency echogram was 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).

1. Surface layers

These occurred within the upper 100 m of the water column and tended to be stronger on 18 kHz (previously 12 kHz) than on other frequencies.

2. Pelagic layers

Surface-referenced midwater layers which were typically continuous for more than 1 km. Like surface layers these were typically strongest on 18 kHz. This category is equivalent to "Type A" marks of Bull (2000).

3. Pelagic schools

Well-defined schools in midwater which are generally similar on all frequencies. Equivalent to "bullet" marks of Cordue et al. (1998) and Bull (2000). In 2007, pelagic schools were further subdivided into three categories (Stevens et al. 2008):

a) Type A schools: dense well defined schools with a clear nucleus which occur in the upper 250 m.
b) Type B schools: schools or shoals which are not as discrete or strong as type A schools, with little evidence of a nucleus. Often occur in patches, creating a semi-continuous layer. Usually at 100–400 m depth.
c) Type C schools: dense schools similar to type A, but occurring deeper than 250 m .

4. Pelagic clouds

Surface-referenced midwater marks which were more diffuse and dispersed than pelagic layers, typically over 100 m thick with no clear boundaries.

5. Bottom layers
Bottom-referenced layers which were continuous for more than 1 km and were generally stronger on 38 kHz and 70 kHz than on 18 kHz. Equivalent to "Type B" marks of Bull (2000) and "Type 1" marks of Cordue et al. (1998).

6. Bottom clouds
Bottom-referenced marks which were more diffuse and dispersed than bottom layers with no clear upper boundary.

7. Bottom schools
Distinct schools close to the bottom. These are equivalent to "Type C" marks of Bull (2000).

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.

2.9.2 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).

2.9.3 Time-series of relative mesopelagic fish abundance

O'Driscoll et al. (2009, 2010) developed a time series of relative abundance estimates for mesopelagic fish on the Chatham Rise based on that component of the acoustic backscatter that migrates into the upper 200 m of the water column at night (nyctoepipelagic backscatter). Because some of the mesopelagic fish migrate very close to the surface at night, they move into the surface '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 2010. The methods were the same as those used by O'Driscoll et al. (2010). 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 from were stratified into four broad sub-areas (O'Driscoll et al. 2010). Sub-area 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 sub-area s as station i. $p(meso)_s$ was calculated from the observed proportion of night-time backscatter observed in the upper 200 m in sub-area s ($p(200)_s$) and the estimated proportion of the total backscatter in the surface deadzone, p_{sz}. p_{sz} was estimated as 0.2 by O'Driscoll et al (2009) and was assumed to be the same for all years and sub-areas:

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

3. RESULTS

3.1 2010 survey coverage

The trawl survey was successfully completed. The addition of 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. However, having two shifts of scientific staff to cover 24-hour operations worked well and staff workload was manageable. Although fishing operations were never suspended, some time was lost in the first week of the survey when bad weather meant that vessel speed between trawl survey stations had to be reduced. Another 6 hours were required to repair a damaged trawl and 5 hours were lost due to a Chatham Island pickup to replace a net monitor.

A total of 124 successful biomass tows was completed, comprising 87 core (200–800 m) phase 1 tows, 4 core phase 2 stations, and 33 deep (800–1300 m) tows (Tables 1 and 3, Figure 2, Appendix 2). All but one of the 88 planned core phase on stations were completed – one station in stratum 11A was dropped after the net came fast and substitute stations in this stratum required considerable back-tracking. Ten other trawl stations were excluded from the biomass calculations: 5 tows came fast, another tow was hauled early due to rough bottom, 2 tows were excluded due to equipment failure (the net monitor and the port winch cable feeder failed), and there were 2 non-random tows in stratum 7 to collect additional hake otoliths. Phase two trawl stations were in strata 7 (3 stations) to improve the c.v. for hake, and stratum 16 (1 station) for hoki.

The pilot study achieved 33 of 40 planned deepwater tows within the 'normal' 27 day survey duration. These covered 9 of the 10 deeper strata. The remaining 7 deepwater tows were not completed because of time constraints. This was a particular issue for deepwater strata on the southwest Chatham Rise (strata 26, 27, and 29), where the stratum areas were large and longer steams were required.

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 1:3165 km^2 in stratum 28 (1000–1300 m, SE Chatham Rise). Mean station density was 1:1653 km^2 (see Table 1).

3.2 Gear performance

Gear parameters are summarised in Table 4. The headline height was obtained for all 124 successful tows, but doorspread readings were not available for 40 tows, due to a combination of a faulty deck unit (replaced during the survey) and the doorspread sensors not being used on tows greater than 1100 m depth. Gear configuration was relatively consistent over the depth range of the survey. Mean doorspread measurements by 200 m depth intervals ranged from 115.6 to 121.6 m and mean headline height ranged from 6.8 to 7.3 m (Table 4). Measured gear parameters in 2010 were similar to those obtained on other voyages of *Tangaroa* in this area when the same gear was used, and were all within the optimal range (Hurst et al. 1992).

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 11.4 to 16.6 ^{o}C. Bottom temperatures ranged from 2.9 to 10.3 ^{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 and to the west of the Chatham Islands and on and to the east of the Mernoo Bank. Lower bottom temperatures were in the deepest strata in the survey area.

3.4 Catch composition

The total catch from the 124 valid biomass stations was 146 t, of which 126 t were from core strata (Table 5). Of the total catch, 42.9 t (29.1%) was hoki, 3.7 t (2.5%) was ling, and 1.2 t (0.8%) was hake. Silver warehou made up a high proportion (21.3%) of the overall catch with 31.5 t taken, including one 17 t catch.

Of the 282 species or species groups identified at sea, 128 were teleosts, 32 were elasmobranches, 1 was an agnathan, 28 were crustaceans, and 16 were cephalopods, the remainder consisting 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 3. Thirty benthic invertebrates were formally identified after the voyage (Appendix 4).

3.5 Biomass estimates

Biomass was estimated for 44 species for both core and deep strata (Table 5).

3.5.1 Core strata (200–800 m)

The c.v.s achieved for hoki, hake, and ling from core strata were 14.6%, 25.1%, and 10.0% respectively. The c.v. for 2+ hoki (2007 year class) was 15.9%, 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, slender mackerel, and silver warehou are not strictly demersal and exhibit strong schooling behaviour. Others, such as hapuku and red cod, have high c.v.s as they are mainly distributed outside the core survey depth range.

The combined biomass for the top 31 species in the core strata that are tracked from year to year was very similar to 2009 but less as a relative proportion of the total (Figure 4). As in previous years, hoki was the most abundant species caught (Table 5, Figure 4). A decrease in hoki biomass in 2010 was compensated by a strong biomass estimate for silver warehou, only 17% lower than the estimate for hoki, and the highest in the time series but with a large c.v. (Table 5, Figure 5). The high silver warehou biomass estimate was largely due to a 17 t catch in stratum 19, east of the Mernoo Bank. The next most abundant QMS species were alfonsino, dark ghost shark, black oreo, ling, spiny dogfish, sea perch, lookdown dory, spiky oreo, pale ghost shark, and smooth oreo, each with an estimated biomass of over 2000 t (Table 5). The most abundant non-QMS species were javelinfish, big-eye rattail, shovelnose dogfish, Baxter's dogfish, and oblique-banded rattail (Table 5).

The estimate of relative biomass of all hoki was 97 503 t, a 32% decease from January 2009 (Table 6, Figure 5). This was largely driven by a decrease in the abundance of 2+ hoki from 65 218 t (2006 year-class) in 2009 to 28 648 t (2007 year-class) in 2010; although the number of 1+ and recruited hoki (3+ and older) hoki were also lower in 2010 (Table 7). At 2+, the 2006 year-class was one of the strongest in the time series (Stevens et al. 2009b), but they did not appear to be as strong at 3+ and the number of recruited hoki were down slightly in 2010 (Table 7).

The biomass of hake in core strata decreased by 30% in 2010 to 1701 t, a similar level to surveys since 2001 (see Table 6, Figure 5). The biomass of ling was 8846 t, which was 17% lower than in January 2009, but the time series for ling shows no overall trend (Figure 5).

The relative biomass of dark ghost shark increased from 2009, while the biomass of giant stargazer, lookdown dory, and white warehou decreased (Figure 5). Biomass estimates for pale ghost shark, sea perch, and spiny dogfish were similar in 2009 and 2010 (Figure 5).

3.5.2 Deep strata (800–1300 m)

Relative biomass and c.v.s were estimated for 23 of 44 core strata species that were also captured in deep survey strata (800–1300 m) (Table 5). The deep strata were included into the survey design to estimate the abundance of juvenile and recruited orange roughy. The estimated abundance of orange roughy in the deep strata was 3897 t, which was 89% of the total orange roughy biomass in the overall survey area (200–1300 m).

Smooth and black oreo were estimated to be the most abundant species in the deep strata, with 79% and 52% respectively of the total survey biomass for these species found in the deep strata. Conversely, only 8% of the total spiky oreo biomass was estimated to occur in the deep strata (Table 5). Shovelnose dogfish, longnose velvet dogfish, and Baxter's dogfish were also abundant in the deep strata, and 41%, 67%, and 54% respectively of their total survey biomass was found in these strata (Table 5).

The deep strata contained 8.7% of total hake biomass, 2.8% of total hoki biomass, and 0.1% of total ling biomass indicating that the core survey strata likely encompass the majority of the distributions of these three species (Table 5).

3.6 Catch distribution

Hoki

In the 2010 survey, hoki were caught at 89 of 91 core biomass stations, but the highest catch rates were mainly in shallow strata (200–400 m) on the western Chatham Rise, reflecting reasonable numbers of smaller hoki (Table 8, Figure 6). The highest individual catch rates of hoki in 2009 occurred in stratum 7, west of the Mernoo Bank, and comprised mainly 2+ (2007 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, although the highest catches were on the southern rise (Figure 6c).

Hake

As in 2009, the highest catch rate of hake in 2010 was east of the Mernoo Bank in stratum 7 (Figure 7) where male hake were mainly running ripe but few female hake were ready to spawn. Catches of hake were consistently low throughout much of the rest of the Rise.

Ling

As in previous years, catches of ling were evenly distributed throughout most strata in the survey area (Table 8, Figure 8). The highest catch rates were on the Reserve Bank (stratum 19), northwest Chatham Rise (stratum 2A), and west of the Chatham Islands in strata 12 and 13. Ling distribution has been reasonably consistent, and catch rates have remained relatively stable over the time series (Figure 8).

Other species

As with previous surveys, lookdown dory and spiny dogfish were widely distributed throughout the survey area in 200–600 m depths (Table 8, Figure 9). Sea perch were also widespread but were most abundant on the Reserve Bank (strata 19 and 20). 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 most abundant in shallower strata in the west of the survey area (Table 8), with the largest catch taken in stratum 18 (Mernoo Bank) (Figure 9). Silver warehou and white warehou were patchily distributed at depths of 200–600 m. As noted above, in 2010, there was a very large catch of silver warehou in stratum 19 (Reserve Bank) (Figure 9). Orange roughy were mainly caught on the north and east Chatham Rise, with black and smooth oreos most abundant in the southwest (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 9.

3.7.2 Length frequencies and age distributions

Length-weight relationships used in SurvCalc to scale length frequencies and calculate biomass and catch rates are given in Table 10.

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). As noted above, the 2006 year-class (which was one of the strongest in the time-series at age 2+ in 2009) did not appear to be particularly strong at age 3+ in 2010 (Figure 11). Female hoki were slightly more abundant than males (ratio of 1.12 females : 1 male).

Hake

Hake scaled length frequencies and calculated numbers at age (Figures 12 and 13) show a mode of small fish moving through since 2004, which in 2010 would be 8+ (2001 year-class). However, this year-class does not appear to be any more abundant than 5 and 6 year old males or 7 year old females possibly indicating a reduction in year-class strength or ageing error. Female hake were slightly more abundant than males (1.19 females : 1 male).

Ling

Ling scaled length frequencies and calculated numbers at age (Figures 14 and 15) were broad, with most fish aged between 3 and 16. Based on catches of young ling (ages 3–5), there appears to have been a period of good recruitment during the 1990s (Figure 15). Female ling were slightly more abundant than males (1.1 female to every male).

Other species

Length frequency distributions for other species are shown in Figure 16. Clear modes are apparent in the size distribution of silver 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 or are distributed differently. As with previous years, the catch of spiny dogfish and giant stargazer was dominated by females (2.8 females and 1.7 females to every male respectively). Sex ratios were about even for most other species (Figure 16).

A mixture of adult and juvenile black and smooth oreo and orange roughy was caught (Figure 16). Small black and smooth oreo were caught shallower than 800 m with larger fish in deeper water (Figure 16). It was notable that the survey caught small (less than 20 cm) orange roughy in both core and deep strata (Figure 16). Small orange roughy were mostly caught in strata 2a and 22 on the Northwest Chatham Rise (see Table 8). Pre-recruit orange roughy (less than 30 cm) made up about 17% of the orange roughy biomass (see Table 8).

3.7.3 Reproductive status

Gonad stages of hake, hoki, ling, and a number of other species are summarised in Table 11. Almost all hoki (99%) were either resting or immature. About 32% of male ling were maturing or ripe, but few females were showing signs of reproductive activity. Similarly 46% of male hake were ripe or running ripe, but most females were resting (34%) or maturing (41%) (Table 11).

3.8 Acoustic results

A total of 336 acoustic data files (133 “trawl” files and 203 “steam” files) was recorded during the trawl survey. The number of acoustic files while steaming was higher than in previous surveys because the file size was restricted to a maximum of 200 MB in 2010 (i.e., multiple smaller files were created during a steam rather than a single large file). Good weather conditions for much of the voyage meant that the quality of acoustic recordings was generally good (71% of all echograms). Only 3 of the 111 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. (2010), there is a consistent spatial pattern in total backscatter, with a trend of increasing backscatter towards the west.

3.8.1 Description of acoustic mark types

The frequency of occurrence of each of the seven mark categories is given in Table 12. Often several types of mark were present in the same echogram. The percent occurrence of acoustic mark types on the Chatham Rise in 2010 was generally similar to that observed in previous surveys, although a lower percentage of bottom schools was observed in 2010 during the daytime (Table 12).

Pelagic layers were the most common daytime mark type, occurring in 79% of day steam files and 73% of day trawl files in 2010 (Table 12). Midwater trawling on previous Chatham Rise surveys suggests that pelagic layers contain mesopelagic fish species, such as pearlsides (*Maurolicus australis*) and 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 (e.g., Figure 18). Surface layers were observed in almost all (97%) night recordings and most (65%) day echograms. Pelagic schools were observed in 50% of day steam files, 32% of day trawl files, and 6% of night files (Table 12). 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.

Bottom layers were observed in 82% of day steam files, 73% of day trawl files, and 43% of night files (Table 12). 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 7% of daytime (trawl and steam) recordings in 2010, and were most abundant in 200–400 m water depth. Bottom schools and layers 10–70 m off the bottom were sometimes associated with catches of 1+ and 2+ hoki, but also with other species such as alfonsino and silver warehou (e.g., Figure 19).

3.8.2 Comparison of acoustics with bottom trawl catches

Acoustic data from 100 trawl files were integrated and compared with trawl catch rates (Table 13). Data from the other 11 daytime trawl recordings were not included in the analysis because the acoustic data were too noisy (3 files) or because the associated trawl was not considered suitable for biomass estimation (8 files). Average acoustic backscatter from the bottom 10 m in 2010 was the lowest in the time-series, even though average trawl catches were relatively high (Table 13). Backscatter from all bottom-referenced marks was also below average, but was higher than in 2005, 2007, and 2008 (Table 13).

There was a weak positive correlation (Spearman's rank correlation, rho = 0.28) between acoustic backscatter in the bottom 100 m during the day and trawl catch rates (Figure 20). In previous Chatham Rise surveys from 2001–09, 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 20) 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. Ongoing research as part of the FRST project C01X0501 supports this hypothesis. 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 biomass estimate for hoki on the Chatham Rise.

3.8.3 Time-series of relative mesopelagic fish abundance

Most acoustic backscatter observed in 2010 was concentrated between 300 and 500 m depth during the day, and migrated into the surface 200 m at night (Figure 21). This was very similar to the pattern observed in previous surveys (Figure 21). The vertically migrating component was assumed to be dominated by mesopelagic fish (see McClatchie and Dunford (2003) for rationale and caveats). In 2010, between 48 and 76% of the total backscatter in each of the four sub-areas was estimated to be from vertically migrating mesopelagic fish (Table 14). This percentage was slightly lower than in previous years, when up to 88% of the backscatter in some areas was estimated to be from mesopelagic fish (Table 14).

Day estimates of total acoustic backscatter over the Chatham Rise were consistently higher than night estimates (Figure 22) because of the movement of fish into the surface deadzone (shallower than 14 m) at night (O'Driscoll et al. 2009). Daytime estimates in the bottom 50 m were also higher than night estimates (Figure 22) because mesopelagic schools and layers often occur close to the bottom during the day. Backscatter within 50 m of the bottom during the day has decreased since the start of the time series (see Table 13), but backscatter close to the bottom at night did not show the same pattern (Figure 22). We conclude that changes in total backscatter are probably related to patterns in mesopelagic fish abundance, rather than demersal fish abundance (O'Driscoll et al. 2010).

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. 2010). The estimated acoustic indices calculated using this method are summarised in Table 15 and plotted in Figure 23 for the entire Chatham Rise and for the four sub-areas. Mesopelagic estimates from 2010 were the lowest in the time-series in the northeast sub-area and overall Chatham Rise (Table 15), but there has been no clear trend in mesopelagic fish biomass on the Chatham Rise over the last 10 years (Figure 23).

4. CONCLUSIONS

The 2010 survey successfully extended the January Chatham Rise time series into its nineteenth year and provided abundance indices for hoki, hake, ling, and other middle depth species. The survey c.v. of 15.4% achieved for 2+ hoki was well below the target level of 20%. The estimated total biomass of hoki was 32% lower than in 2009, largely due to an average 2+ cohort (2007 year-class). In the previous survey, the 2006 year-class was one of the strongest in the time series at age 2+. However, this year class was much weaker at 3+ and the number of recruited hoki (3+ and older) was down slightly from last year.

The biomass of hake in core strata decreased by 30% in 2010 to 1701 t, largely due to the random trawl stations not catching aggregations of spawning hake, and remains at historically low levels. The biomass of ling was also lower than last year, but the time series for ling shows no overall trend.

The pilot extension of the survey area to 1300 m was successful. The pilot study achieved 33 of 40 planned deepwater tows within the 'normal' 27 day survey duration. The full set of deepwater tows was not completed because of time constraints. This was a particular issue for deepwater strata on the Southwest Chatham Rise (strata 26, 27, and 29), where the stratum areas were large and longer steams were required The deepwater survey appeared to be useful for measuring abundance of orange roughy in both the Northwest and East and South Rise stocks but less useful for oreos, which are more widespread over the South Rise. Following a presentation of survey results on 23 April, the Deepwater Fisheries Assessment Working Group suggested that a survey for orange roughy could be restricted to the North and East Rise (strata 21–25, and 28 of the 2010 survey), and this is what has been proposed for 2011.

5. ACKNOWLEDGMENTS

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Table 1: The number of completed valid biomass stations (200–1300m) by stratum during the 2010 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	5	5		5	1: 1 701
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	3	9	1: 581
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	3		3	1: 989
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	1	4	1: 2 881
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	5	5		3	1: 1 802
20	200–400	Reserve Bank	9 584	5	5		5	1: 1 917
21a	800–1000	NE Chatham Rise	1 249	3	3		3	1: 416
21b	800–1000	NE Chatham Rise	5 819	5	4		4	1: 1 455
22	800–1000	NW Chatham Rise	7 357	4	4		4	1: 1 839
23	1000–1300	NW Chatham Rise	7 014	4	4		4	1: 1 754
24	1000–1300	NE Chatham Rise	5 672	4	4		4	1: 1 418
25	800–1000	SE Chatham Rise	5 596	5	5		5	1: 1 119
26	800–1000	SW Chatham Rise	5 158	3	3		3	1: 1 719
27	800–1000	SW Chatham Rise	7 185	5	3		3	1: 2 395
28	1000–1300	SE Chatham Rise	9 494	4	3		3	1: 3 165
29	1000–1300	SW Chatham Rise	10 965	3	0		0	1: 813
Total			205 007	128	120	4	124	1: 1 653

Table 2: EK60 transceiver settings and other relevant parameters. Values in bold were calculated from the calibration on 27 January 2010 (see Appendix 1).

Parameter					
Frequency (kHz)	18	38	70	120	200
GPT model	GPT-Q18(2)-S 1.0 00907205c476	GPT-Q38(4)-S 1.0 00907205c463	GPT-Q70(1)-S 1.0 00907205ca98	GPT-Q120(1)-S 1.0 009072058148	GPT-Q120(1)-S 1.0 009072058148
GPT serial number	652	650	674	668	692
GPT software version	050112	050112	050112	050112	050112
ER60 software version	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
Transducer model	Simrad ES18-11	Simrad ES38	Simrad ES70-7C	Simrad ES120-7C	Simrad ES200-7C
Transducer serial number	2080	23083	158	477	364
Transmit power (W)	2000	2000	1000	500	300
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Transducer peak gain (dB)	**23.00**	**25.95**	**26.72**	**26.74**	**25.03**
Sa correction (dB)	**-0.76**	**-0.59**	**-0.30**	**-0.35**	**-0.36**
Bandwidth (Hz)	1570	2430	2860	3030	3090
Sample interval (m)	0.191	0.191	0.191	0.191	0.191
Two-way beam angle (dB)	–17.0	–20.60	–21.0	–21.0	–20.70
Absorption coefficient (dB/km)	2.67	9.79*	22.79	37.44	52.69
Speed of sound (m/s)	1494	1494	1494	1494	1494
Angle sensitivity (dB) alongship/athwartship	13.90/13.90	21.90/21.90	23.0/23.0	23.0/23.0	23.0/23.0
3 dB beamwidth (º) alongship/athwartship	**11.0/11.3**	**6.9/6.9**	**6.3/6.4**	**6.1/6.4**	**6.7/6.7**
Angle offset (º) alongship/athwartship	**0.0/0.0**	**0.0/0.0**	**0.0/0.0**	**0.0/0.0**	**0.0/0.0**
Calibration RMS deviation (dB)	**0.14**	**0.11**	**0.14**	**0.16**	**0.18**

* Acoustic densities were calculated with an absorption coefficient of 8.0 dB km^{-1} so that these would be comparable to earlier results from the CREST acoustic system.

Table 3: Survey dates and number of valid 200–800 m depth biomass stations in surveys of the Chatham Rise, January 1992–2010

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

Table 4: Tow and gear parameters by depth range for valid biomass stations (TAN1001). 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)	91	3.0	0.18	2.0–3.1
Tow speed (knots)	91	3.5	0.07	3.3–3.8
All tow parameters				
Tow length (n. miles)	124	2.9	0.23	1.6–3.1
Tow speed (knots)	124	3.5	0.06	3.3–3.8
Gear parameters				
200–400 m				
Headline height	25	6.9	0.33	6.0–7.4
Doorspread	21	115.6	6.56	101.7–125.0
400–600 m				
Headline height	49	6.8	0.35	6.1–7.4
Doorspread	36	118.7	4.74	109.4–130.1
600–800 m				
Headline height	18	6.9	0.36	6.3–7.6
Doorspread	14	119.1	5.23	110.4–126.4
800–1000 m				
Headline height	22	7.1	0.24	6.5–7.4
Doorspread	11	121.5	3.62	116.2–128.4
1000–1300 m				
Headline height	11	7.3	0.42	6.9–8.1
Doorspread	3	121.6	4.38	118.3–126.6
Core stations 200–800 m				
Headline height	91	6.9	0.35	6.0–7.6
Doorspread	70	117.9	5.56	101.7–130.1
All stations 200–1300 m				
Headline height	124	6.9	0.36	6.0–8.0
Doorspread	84	118.5	5.44	101.7–130.1

Table 5: 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	41 003	40 364	15.2	57 020	14.7	97 503	14.6	2 770	37.6
Silver warehou	SWA	31 473	40 017	57.7	40 432	57.0	80 469	57.7	-	
Alfonsino	BYS	5 977	6 067	63.4	8 453	65.6	14 533	64.6	-	
Dark ghost shark	GSH	5 754	5 436	14.8	6 132	19.0	11 596	16.8	-	
Black oreo	BOE	2 234	5 172	31.9	5 238	35.2	10 510	33.6	11 532	80.7
Ling	LIN	3 628	3 550	12.7	5 296	11.7	8 846	10.0	5	50.3
Spiny dogfish	SPD	2 875	1 541	28.0	5 152	15.5	6 698	16.9	-	
Sea perch	SPE	2 103	2 692	11.3	2 866	14.9	5 594	12.4	12	49.4
Lookdown dory	LDO	1 968	1 618	11.8	3 268	9.8	4 896	9.7	20	64.4
Spiky oreo	SOR	1 721	2 904	42.0	1 955	37.3	4 870	39.9	418	46
Pale ghost shark	GSP	1 186	1 721	13.0	1 495	12.3	3 216	11.7	384	34.5
Smooth oreo	SSO	760	1 647	83.9	1 440	84.8	3 087	84.3	11 801	42.2
Hake	HAK	1 084	588	42.9	1 113	19.7	1 701	25.1	161	22.9
Smooth skate	SSK	654	480	34.5	1 096	27.7	1 576	21.1	86	83.9
Rubyfish	RBY	652	587	100	478	99.3	1 260	99.7	-	
Hapuku	HAP	584	642	84.8	519	91.9	1 162	88	-	
Giant stargazer	STA	542	229	29.0	911	18.0	1 140	16.8	38	100
Arrow squid	NOS	493	444	52.0	664	53.3	1 112	52.6	-	
White warehou	WW A	411	527	21.8	449	23.0	983	20.9	-	
Southern Ray's bream	SRB	183	204	38.1	278	33.6	495	33.7	4	70.8
Orange roughy	ORH	205	272	90.3	217	86.6	489	88.6	3 897	16.6
Ribaldo	RIB	231	175	30.2	241	24.2	416	19.9	125	27.1
School shark	SCH	118	227	38.5	91	72.7	317	36.3	-	
Barracouta	BAR	58	81	63.3	52	71.4	133	64.9	-	
Deepsea cardinalfish	EPT	89	65	29.5	63	18.4	132	20	-	
Bluenose	BNS	57	46	57.0	82	57.9	128	38.3	-	
Slender mackerel	JMM	19	31	86.4	28	53.3	59	69.5	-	
Lemon sole	LSO	25	20	23.5	32	37.2	52	29.3	-	
Red cod	RCO	23	19	53.6	28	42.4	47	44.1	-	
Blue mackerel	EMA	14	18	100	11	100	29	100	-	
Scampi	SCI	8	16	28.6	4	28.8	20	25.1	-	
Jack mackerel	JMD	4	6	100	5	100	11	100	-	
Tarakihi	TAR	4	3	100	6	71.6	9	58.3	-	
Commercial non-QMS species (where biomass > 30 t)										
Shovelnose dogfish	SND	2 583	1 866	15.5	2 808	25.5	4 700	20.6	3 288	26.6
Redbait	RBT	40	62	69.6	57	66.6	119	67.7	-	
Non-commercial species (where biomass > 800 t)										
Javelinfish	JAV	5 147	-	-	-	-	13 925	14.2	512	37.7
Big-eye rattail	CBO	3 929	-	-	-	-	10 669	10.6	6	77
Baxter's dogfish	ETB	393	-	-	-	-	1 647	40.3	1 892	32.3
Oblique-banded rattail	CAS	564	-	-	-	-	1 447	16.6	-	
Longnose velvet dogfish	CYP	752	-	-	-	-	1 268	33.5	2 554	24.3
Oliver's rattail	COL	401	-	-	-	-	1 242	27.3	2	65.9
Long-nosed chimaera	LCH	315	-	-	-	-	1 004	20.8	234	25
Banded bellowsfish	BBE	514	-	-	-	-	1 014	13.4	5	62.3
Leafscale gulper shark	CSQ	370	-	-	-	-	915	30.6	180	38.4
Total (above)		121 148								

Grand total (all species)	125 836

Table 6: Estimated biomass (t) with coefficient of variation below (%) of hoki, hake, and ling sampled by annual trawl surveys of the Chatham Rise, January 1992–2010. 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

Table 7: Relative biomass estimates (t in thousands) of hoki, 200–800 m depths, Chatham Rise trawl surveys January 1992–2010 (c.v. coefficient of variation; 3++ all hoki aged 3 years and older; (see Appendix 5 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)

Table 8: 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		GSH		LIN		SPD		SPE	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.
1	241	29	0	-	0	-	81	35	0	-	4	100
2a	567	25	0	-	0	-	302	65	0	-	30	55
2b	930	36	0	-	0	-	239	71	0	-	46	47
3	1 573	54	12 127	92	560	34	209	45	646	36	172	50
4	2 779	42	0	-	0	-	376	77	0	-	16	100
5	2 145	51	449	21	1 000	33	326	16	1 216	43	64	60
6	5 345	77	0	-	0	-	346	91	0	-	12	100
7	5 350	50	9	100	12	54	443	17	18	60	74	34
8a	2 578	38	307	59	63	39	192	23	78	30	135	21
8b	2 298	9	17	53	142	89	465	9	263	53	314	36
9	8 286	50	5 212	59	865	13	356	43	386	83	148	57
10a	1 076	18	50	77	0	-	156	59	55	92	98	64
10b	1 194	21	68	85	294	99	150	21	206	98	31	13
11a	1 222	12	325	92	230	76	214	35	530	18	17	40
11b	761	28	19	76	0	-	19	23	9	100	21	21
11c	738	30	178	100	161	55	94	76	102	58	17	28
11d	1 342	17	262	87	0	-	325	19	0	-	35	26
12	8 892	67	1 275	85	649	86	720	44	625	99	70	57
13	3 571	45	55	100	27	100	863	35	10	100	53	26
14	4 440	56	1 713	70	0	-	366	26	330	63	110	36
15	3 044	26	318	70	0	-	324	40	470	52	225	24
16	13 717	37	961	58	8	61	635	30	543	90	79	44
17	1 712	68	103	32	742	62	5	66	36	69	5	18
18	3 470	22	143	43	766	37	223	54	253	57	105	68
19	11 742	75	55 737	81	3 079	50	681	54	495	22	1 426	34
20	8 490	30	1 141	71	2 997	25	735	35	429	32	2 291	19
21a	51	50	0	0	0	0	5	50	0	0	1	77
21b	157	83	0	0	0	0	0	0	0	0	2	100
22	683	38	0	0	0	0	0	0	0	0	9	61
23	142	93	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0
25	1 313	75	0	0	0	0	0	0	0	0	0	0
26	229	61	0	0	0	0	0	0	0	0	0	0
27	181	33	0	0	0	0	0	0	0	0	0	0
28	15	100	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0
Core	97 503	15	80 469	58	11 596	17	8 846	10	6 698	17	5 594	12
Total	100 273	14	80 469	58	11 596	17	8 852	10	6 698	17	5 606	12

Table 8 (continued)

	Species code									
	LDO		GSP		HAK		STA		WWA	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.
1	23	43	72	16	16	85	17	51	0	-
2a	24	11	67	21	14	70	26	17	0	-
2b	64	33	56	30	184	90	15	100	0	-
3	139	55	0	-	20	72	24	51	74	72
4	211	48	154	37	28	100	47	100	0	-
5	338	22	0	-	9	58	81	30	96	27
6	3	100	387	21	71	100	0	-	0	-
7	89	16	240	20	465	75	31	100	51	63
8a	74	39	15	58	103	47	0	-	5	95
8b	336	31	147	22	64	32	0	-	0	-
9	205	46	0	-	0	-	219	40	20	68
10a	161	36	46	70	91	29	0	-	8	100
10b	109	58	29	40	104	72	2	100	3	100
11a	232	5	34	100	30	83	0	-	17	68
11b	39	24	5	100	10	54	0	-	0	-
11c	63	41	6	83	42	64	46	72	4	100
11d	33	16	9	37	75	34	9	100	4	100
12	476	59	90	78	41	100	56	62	56	100
13	345	54	245	41	0	-	32	100	0	-
14	224	30	277	33	56	21	8	100	8	100
15	267	28	485	36	71	54	30	55	7	100
16	405	22	803	33	122	78	166	65	172	44
17	27	58	0	-	0	-	66	39	4	100
18	72	39	14	100	3	100	59	77	123	90
19	204	61	0	-	38	100	126	59	74	84
20	731	22	34	100	43	50	80	42	256	42
21a	0	0	1	63	5	100	0	0	0	0
21b	12	100	2	66	10	100	0	0	0	0
22	8	58	59	34	97	23	38	100	0	0
23	0	0	6	100	29	64	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0
25	0	0	21	42	0	0	0	0	0	0
26	0	0	70	55	20	100	0	0	0	0
27	0	0	224	56	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
Core	4 896	10	3 216	12	1 701	25	1 140	17	983	21
Total	4 915	10	3 600	11	1 861	23	1 178	17	983	21

Table 8 (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	2	100	0	0	38	13
2a	5	64	18	89	56	97	0	0	78	33
2b	1	100	17	96	431	100	0	0	1 462	81
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	2 419	100	1 574	75
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	7 695	33	0	0
7	0	0	0	0	0	0	0	0	28	56
8a	0	0	0	0	0	0	0	0	0	0
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	322	99
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	0	0
11c	0	0	0	0	0	0	0	0	506	100
11d	0	0	0	0	0	0	0	0	8	100
12	0	0	0	0	0	0	0	0	785	100
13	0	0	0	0	0	0	395	100	70	80
14	0	0	0	0	0	0	1	100	0	0
15	0	0	0	0	0	0	0	0	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	0
21a	1	54	15	91	29	96	0	0	25	97
21b	3	100	82	28	253	32	0	0	220	74
22	37	62	150	34	633	22	0	0	15	59
23	5	58	137	38	1 374	40	0	0	0	0
24	1	100	154	18	1 249	21	0	0	0	0
25	1	76	63	36	207	27	133	88	158	63
26	0	0	1	100	1	100	1 050	49	0	0
27	0	0	0	0	0	0	10 349	90	0	0
28	3	100	48	100	152	100	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
Core	6	60	35	66	489	89	10 510	34	4 870	40
Total	58	42	689	15	4 386	18	22 041	45	5 287	37

Table 8 (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	560	39	1	100	6	97	234	52	89	51
2a	1 112	47	3	100	6	50	722	46	58	38
2b	1 668	43	9	48	3	100	281	83	37	46
3	0	0	0	0	0	0	0	0	0	0
4	288	44	0	0	121	100	0	0	36	100
5	0	0	0	0	0	0	0	0	0	0
6	0	0	3 074	85	1 227	51	24	100	0	0
7	312	48	0	0	7	67	6	66	44	35
8a	0	0	0	0	0	0	0	0	0	0
8b	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10a	95	84	0	0	0	0	0	0	0	0
10b	29	100	0	0	0	0	0	0	2	100
11a	0	0	0	0	0	0	0	0	1	100
11b	31	17	0	0	0	0	0	0	4	100
11c	147	100	0	0	0	0	0	0	2	100
11d	151	30	0	0	0	0	0	0	20	8
12	173	100	0	0	0	0	0	0	0	0
13	0	0	0	0	56	100	0	0	30	100
14	31	100	0	0	24	100	0	0	67	50
15	40	74	0	0	11	100	0	0	16	100
16	62	65	0	0	185	82	0	0	11	100
17	0	0	0	0	0	0	0	0	0	0
18	1	100	0	0	0	0	1	100	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	92	33	0	100	2	100	31	33	3	58
21b	1 041	6	29	69	14	62	813	28	27	58
22	197	50	29	80	7	89	782	64	68	36
23	32	58	98	30	155	38	208	79	0	0
24	332	71	27	42	82	22	251	56	0	0
25	1 491	56	526	43	636	90	427	44	27	65
26	10	50	5 308	79	304	23	15	44	0	0
27	0	0	5 732	46	561	34	12	53	0	0
28	93	100	52	51	131	18	14	100	0	0
29	0	0	0	0	0	0	0	0	0	0
Core	4 700	21	3 087	84	1 647	40	1 268	34	416	20
Total	7 988	16	14 888	38	3 538	26	3 822	20	541	17

Table 9: Total numbers of fish, squid, and scampi measured for length frequency distributions and biological samples (TAN1001). The total number of fish measured is sometimes greater than the sum of males and females because some fish were unsexed.

Species	Number measured Males	Number measured Females	Number measured Total	Number of biological samples
Abyssal rattail *(C. murrayi)*	0	1	1	1
Abyssal rattail *(C. striaturus)*	0	1	1	1
Alfonsino	670	670	1 366	631
Banded bellowsfish	403	483	2 656	530
Banded rattail	195	293	516	177
Barracouta	21	10	31	31
Basketwork eel	165	403	573	282
Baxter's dogfish	330	375	705	552
Big-scale pomfret	0	1	1	1
Bigscaled brown slickhead	333	745	1 082	353
Bigeye cardinalfish	13	9	45	45
Black ghost shark	0	1	1	1
Black javelinfish	100	79	188	101
Black oreo	1 074	1 061	2 146	405
Black slickhead	200	417	666	258
Blackspot rattail	5	10	16	16
Blue cuskeel	1	0	1	1
Blue mackerel	7	4	11	11
Bluenose	9	5	14	14
Bollon’s rattail	1 809	1 722	3 580	919
Brown chimaera	5	4	9	9
Bulbous rattail	0	0	1	1
Capro dory	2	7	9	9
Catshark	33	21	54	54
Dark ghost shark	1 890	1 624	3 525	1 466
Dawson’s catshark	0	1	1	1
Deepsea cardinalfish	170	129	309	303
Deepsea flathead	2	3	5	5
Deepwater spiny skate	1	1	2	2
Electric ray	1	1	2	2
Filamentous rattail	2	0	2	2
Finless flounder	1	2	3	3
Four-rayed rattail	230	950	2 339	271
Giant chimaera	0	2	2	2
Giant squid	1	0	1	1
Giant stargazer	67	111	179	179
Greenback jack mackerel	2	2	4	3
Hairy conger	2	2	4	4
Hake	144	107	251	251
Hapuku	53	42	95	95
Hoki	7 022	9 178	16 237	2 254
Humpback rattail	1	9	10	7
Javelinfish	1 001	5 795	7 215	1 306
Johnson's cod	357	329	817	542
Kaiyomaru rattail	10	17	28	28
Large headed slickhead	0	2	3	3
Leafscale gulper shark	23	44	67	67
Lemon sole	25	29	54	49
Ling	619	633	1 252	1 111
Longnose velvet dogfish	488	545	1 042	701
Long-nosed chimaera	191	183	374	330

Table 9 (continued)

Species	Number measured Males	Number measured Females	Number measured Total	Number of biological samples
Longnosed deepsea skate	2	5	7	7
Lookdown dory	1 393	1 545	2 970	1 498
Lucifer dogfish	156	174	330	237
Mahia rattail	23	32	55	54
McMillan’s rattail	0	0	2	2
Nezumia namatahi	0	1	1	1
Northern spiny dogfish	2	0	2	2
Notable rattail	94	125	333	153
Numbfish	1	4	5	5
NZ southern arrow squid	250	309	576	329
Oblique banded rattail	290	1 780	2 103	453
Oliver's rattail	494	1 169	2 103	438
Orange perch	59	69	129	45
Orange roughy	864	849	1 722	621
Pale ghost shark	431	398	829	731
Plunket's shark	6	12	18	17
Pointynose blue ghost shark	1	0	1	1
Prickly deepsea skate	4	0	4	4
Prickly dogfish	6	4	10	10
Psychrolutes	1	0	6	6
Redbait	45	34	79	79
Red cod	17	22	39	39
Ribaldo	116	68	184	125
Ridge scaled rattail	73	96	172	102
Robust cardinalfish	79	135	217	90
Rotund cardinalfish	1	0	1	1
Roughhead rattail	17	18	35	35
Ruby fish	51	38	134	43
Rudderfish	17	6	23	23
Scampi	47	20	71	71
Schedophilus huttoni	0	1	1	1
School shark	6	2	8	8
Sea perch	1 439	1 527	3 011	973
Seal shark	31	33	64	62
Serrulate rattail	206	114	355	292
Shortsnouted lancetfish	0	0	2	2
Shovelnose dogfish	818	918	1 742	1 096
Silver dory	50	40	114	43
Silver roughy	24	49	186	123
Silver warehou	1 198	1 308	2 509	1 125
Silverside	337	155	708	286
Slender mackerel	8	8	16	16
Small banded rattail	10	5	62	16
Small-headed cod	27	14	43	40
Smallscaled brown slickhead	253	356	613	330
Smooth deepsea skate	0	1	1	1
Smooth oreo	894	699	1 599	484
Smooth skate	19	32	51	51
Smoothskin dogfish	93	56	150	132
Snubnosed eel	0	0	1	1
Southern blue whiting	44	26	70	70
Southern Ray’s bream	52	79	136	114

Table 9 (continued)

Species	Number measured Males	Number measured Females	Number measured Total	Number of biological samples
Spiky oreo	885	743	1 661	651
Spineback	8	113	123	103
Spiny dogfish	420	1 222	1 644	990
Squaretail	1	0	1	1
Swollenhead conger	3	8	11	11
Tarakihi	1	2	3	3
Todarodes filippovae	1	14	16	16
Trachyscorpia capensis	3	3	8	8
Two saddle rattail	94	163	257	174
Unicorn rattail	0	1	1	1
Violet cod	17	11	28	28
Warty oreo	16	21	38	38
Warty squid (*Onykia ingens*)	7	9	33	33
Warty squid (*O. robsoni*)	0	2	2	2
White cardinalfish	2	0	2	2
White rattail	120	116	238	198
White warehou	129	102	245	221
Wide-nosed chimaera	51	20	71	70
Witch	2	5	12	12
Total			75 493	26 441

Table 10: Length-weight regression parameters* used to scale length frequencies (all data from TAN1001).

Species	*a* (intercept)	*b* (slope)	r^2	*n*	Length range (cm)
Dark ghost shark	0.004294	3.083776	0.97	1226	29–73
Giant stargazer	0.005419	0.982627	0.98	172	32–79
Hake	0.002357	3.250868	0.97	249	54–128
Hoki	0.004210	2.916284	0.99	1 974	36–112
Ling	0.002157	3.176581	0.99	1 100	27–155
Lookdown dory	0.033734	2.87935	0.98	1 324	11–54
Pale ghost shark	0.007640	2.932888	0.97	723	29–87
Sea perch	0.014173	3.039696	0.99	944	12–48
Silver warehou	0.023642	2.956380	0.93	844	31–57
Spiny dogfish	0.001504	3.257308	0.94	874	52–103
White warehou	0.019835	3.046067	0.99	223	15–56

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

Table 11: Numbers of fish measured at each reproductive stage (bony and cartilaginous fish were staged using different methods– see footnote below table).

Common name	Sex	Reproductive stage 1	2	3	4	5	6	7	8	Total
Alfonsino	Male	41	24	0	0	0	0	0	-	65
	Female	35	48	0	0	0	0	0	-	83
Barracouta	Male	0	0	0	4	3	0	0	-	7
	Female	0	0	3	0	0	0	0	-	3
Basketwork eel	Male	1	1	1	1	0	0	0	-	4
	Female	2	18	6	0	0	0	0	-	26
Baxter’s dogfish **	Male	70	25	139	-	-	-	-	-	234
	Female	81	132	66	13	9	1	-	-	302
Bigeye rattail	Male	4	8	0	0	0	0	0	-	12
	Female	1	9	0	0	0	0	0	-	10
Bigscale pomfret	Male	0	0	0	0	0	0	0	-	0
	Female	0	0	1	0	0	0	0	-	1
Bigscaled brown	Male	0	4	0	0	0	0	0	-	4
slickhead	Female	0	25	18	0	0	0	0	-	43
Black javelinfish	Male	1	4	6	0	0	0	0	-	11
	Female	0	2	5	0	0	0	0	-	7
Black oreo *	Male	124	60	17	0	1	0	0	1	203
	Female	79	112	10	0	0	0	0	0	201
Blackspot rattail	Male	0	2	0	0	0	0	0	-	2
	Female	0	0	0	5	0	0	0	-	5
Bluenose	Male	1	3	0	0	0	0	0	-	4
	Female	3	0	1	0	0	0	0	-	4
Brown chimaera **	Male	0	0	5	-	-	-	-	-	5
	Female	0	1	1	1	0	0	-	-	3
Capro dory	Male	0	0	0	0	0	0	0	-	0
	Female	0	0	7	0	0	0	0	-	7
Catshark **	Male	6	6	21	-	-	-	-	-	33
(*Apristurus* spp.)	Female	7	0	7	2	4	1	-	-	21
Dark ghost shark **	Male	208	107	207	-	-	-	-	-	522
	Female	217	143	91	36	0	0	0	-	487
Dawson’s catshark **	Male	0	0	0	-	-	-	-	-	0
	Female	0	1	0	0	0	0	-	-	1
Deepsea cardinalfish	Male	37	0	0	0	0	0	0	-	37
	Female	31	0	0	0	0	0	0	-	31
Electric ray **	Male	0	0	1	-	-	-	-	-	1
	Female	0	0	0	0	0	0	-	-	0
Four-rayed rattail	Male	0	7	7	0	0	0	0	-	14
	Female	0	2	4	0	0	0	0	-	6
Giant stargazer	Male	3	4	0	0	0	0	0	-	7
	Female	7	9	7	0	0	1	3	-	20
Hake	Male	12	8	5	26	40	40	13	-	144
	Female	10	36	44	4	1	6	6	-	107
Hapuku	Male	5	43	1	0	0	0	0	-	49
	Female	20	22	0	0	0	0	0	-	42
Hoki	Male	495	303	0	1	0	5	0	-	804
	Female	773	632	1	0	0	1	16	-	1423
Jack mackerel	Male	0	0	0	1	1	0	0	-	2
(Trachurus declivis)	Female	0	0	1	0	0	0	0	-	1
Leafscale gulper	Male	16	4	3	-	-	-	-	-	23
Shark **	Female	18	10	11	4	0	0	-	-	43
Ling	Male	197	175	116	65	4	0	0	-	557
	Female	202	345	3	0	0	0	0	-	550

Table 11 (continued)

Common name	Sex	Reproductive stage								Total
		1	2	3	4	5	6	7	8	
									-	
Long-nosed chimaera	Male	35	14	54	-	-	-	-	-	103
**	Female	48	21	26	11	0	0	-	-	106
Longnose velvet	Male	120	32	138	-	-	-	-	-	290
Dogfish **	Female	161	91	40	59	3	1	-	-	355
Longnosed deepsea	Male	0	0	2	-	-	-	-	-	2
Skate **	Female	1	0	1	0	0	0	-	-	2
Lookdown dory	Male	26	51	28	38	0	0	0	-	143
	Female	36	42	38	2	0	0	3	-	121
Lucifer dogfish **	Male	3	8	25	-	-	-	-	-	36
	Female	9	15	6	2	0	0	-	-	32
Mahia rattail	Male	0	0	0	0	0	0	0	-	0
	Female	0	4	0	0	0	0	0	-	4
Northern spiny	Male	0	1	1	-	-	-	-	-	2
Dogfish **	Female	0	0	0	0	0	0	-	-	0
Orange roughy *	Male	109	186	17	0	1	0	0	0	313
	Female	64	123	118	1	0	0	1	0	307
Pale ghost shark **	Male	84	24	204	-	-	-	-	-	312
	Female	119	51	108	6	1	0	-	-	285
Plunket’s shark **	Male	4	1	1	-	-	-	-	-	6
	Female	10	1	0	0	0	0	-	-	11
Pointynose blue ghost	Male	0	0	1	-	-	-	-	-	1
Shark **	Female	0	0	0	0	0	0	-	-	0
Prickly deepsea skate	Male	1	0	1	-	-	-	-	-	2
**	Female	0	0	0	0	0	0	-	-	0
Prickly dogfish **	Male	0	0	5	-	-	-	-	-	5
	Female	0	0	0	1	0	0	-	-	1
Redbait	Male	0	0	4	0	0	0	0	-	4
	Female	0	0	1	2	0	0	0	-	3
Red cod	Male	0	0	2	0	0	0	0	-	2
	Female	1	1	0	0	0	0	0	-	2
Ribaldo	Male	0	41	0	0	0	0	0	-	41
	Female	6	24	0	0	0	0	1	-	31
Ridge scaled rattail	Male	0	0	0	0	0	0	0	-	0
	Female	0	1	0	0	0	0	0	-	1
Robust cardinalfish	Male	0	1	5	6	0	0	0	-	12
	Female	0	0	0	0	23	0	0	-	23
Rubyfish	Male	13	0	0	0	0	0	0	-	13
	Female	12	1	0	0	0	0	0	-	13
Rudderfish	Male	0	0	2	1	0	0	0	-	3
	Female	0	2	1	0	0	0	0	-	3
Schedophilus huttoni	Male	0	0	0	0	0	0	0	-	0
	Female	0	0	1	0	0	0	0	-	1
School shark **	Male	0	1	3	-	-	-	-	-	4
	Female	0	0	0	0	0	0	-	-	0
Sea perch	Male	3	9	2	0	0	0	0	-	14
	Female	1	15	0	0	0	0	0	-	16
Seal shark **	Male	25	2	0	-	-	-	-	-	27
	Female	21	3	3	0	0	0	-	-	27
Shovelnose dogfish	Male	117	91	280	-	-	-	-	-	488
**	Female	263	275	35	7	0	0	-	-	580
Silver roughy	Male	1	1	0	0	0	0	0	-	2
	Female	2	3	0	0	0	0	0	-	5
Slender mackerel	Male	0	0	0	0	0	0	0	-	0
(T. s. murphyi)	Female	0	0	1	0	0	0	0	-	1

Table 11 (continued)

Common name	Sex	Reproductive stage 1	2	3	4	5	6	7	8	Total
									-	
Silver warehou	Male	1	226	0	0	0	0	5	-	232
	Female	1	386	1	0	0	0	5	-	393
Small banded rattail	Male	0	9	1	0	0	0	0	-	10
	Female	0	4	1	0	0	0	0	-	5
Smallscaled brown	Male	2	7	5	0	0	0	0	-	14
slickhead	Female	1	23	6	0	0	0	0	-	30
Smooth oreo *	Male	107	84	43	23	4	0	0	12	273
	Female	102	84	16	1	0	0	0	0	203
Smooth skate **	Male	13	1	4	-	-	-	-	-	18
	Female	11	9	1	0	0	0	-	-	21
Smooth skin dogfish	Male	29	2	44	-	-	-	-	-	75
**	Female	34	11	5	3	0	0	-	-	53
Southern Ray's bream	Male	1	6	1	0	0	0	1	-	9
	Female	1	3	4	0	0	0	0	-	8
Spiky oreo	Male	145	118	29	10	0	0	0	-	282
	Female	92	127	75	2	1	2	0	-	299
Spineback	Male	0	0	0	0	0	0	0	-	0
	Female	0	0	1	0	0	0	0	-	1
Spiny dogfish **	Male	2	38	165	-	-	-	-	-	205
	Female	146	216	77	120	104	9	-	-	672
Swollenhead conger	Male	0	0	0	0	0	0	0	-	0
	Female	0	0	2	0	0	0	0	-	2
Tarakihi	Male	0	0	0	0	0	0	0	-	0
	Female	0	1	0	0	0	0	0	-	1
Two saddle rattail	Male	0	3	26	0	0	0	0	-	29
	Female	3	6	2	26	0	0	0	-	37
Violet cod	Male	16	0	0	0	0	0	0	-	16
	Female	10	0	0	0	0	0	0	-	10
Warty oreo	Male	12	3	0	0	0	0	0	0	15
	Female	11	4	0	0	0	0	0	0	15
White warehou	Male	14	11	0	0	0	0	0	-	25
	Female	8	11	2	0	0	0	0	-	21
White rattail	Male	0	1	0	0	0	0	0	-	1
	Female	6	1	0	0	0	0	0	-	7
Widenosed chimaera	Male	8	11	12	-	-	-	-	-	31
**	Female	4	2	5	0	5	0	-	-	16

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: 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

** 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 12: Percent occurrence of seven mark types during the 2010 Chatham Rise trawl survey compared to results from previous surveys (Stevens et al. 2009b).

				Pelagic marks			Bottom marks		
Acoustic file	Survey	*n*	Surface Layer	School	Layer	Cloud	Layer	Cloud	School
Day trawl	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	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	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 13: Average trawl catch (excluding benthic organisms) and acoustic backscatter from daytime tows where acoustic data quality was suitable for echo integration on the Chatham Rise in 2001–10.

				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	3.43	21.12	30.00	54.34
2002 (TAN0201)	105	1 844	4.25	17.35	21.32	46.53
2003 (TAN0301)	117	1 508	3.23	18.46	27.75	50.21
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)	100	2 070	1.76	9.97	16.27	42.82

Table 14: 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 O'Driscoll et al. 2010).

	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

Table 15: 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 14) 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%). Note that these values are calculated using the "alternative method" of O'Driscoll et al. (2010) and therefore values for 2001–09 are not the same as those in table 3 of O'Driscoll et al. (2010), which were estimated using the method of O'Driscoll et al. (2009).

		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	25.9	7	15.9	9	33.4	11	34.1	16	34.0	24	27.9	9

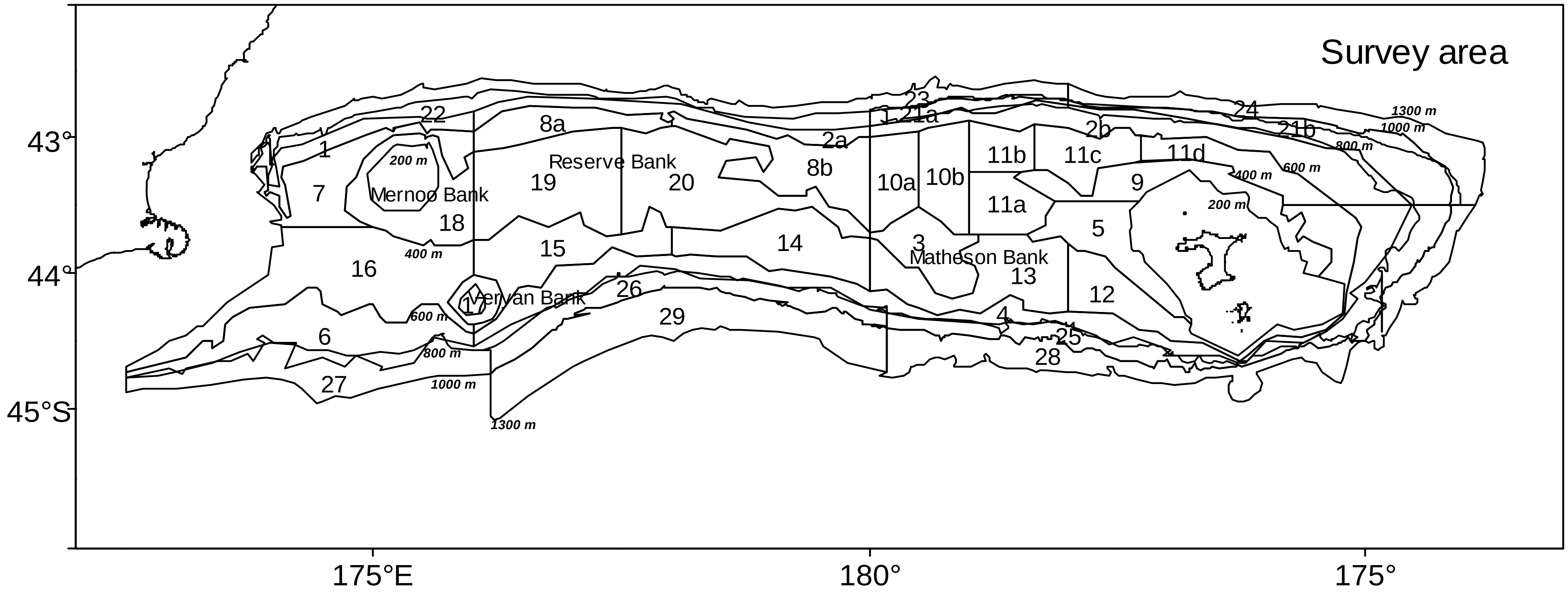


Figure 1: Trawl survey area showing stratum boundaries for TAN1001.

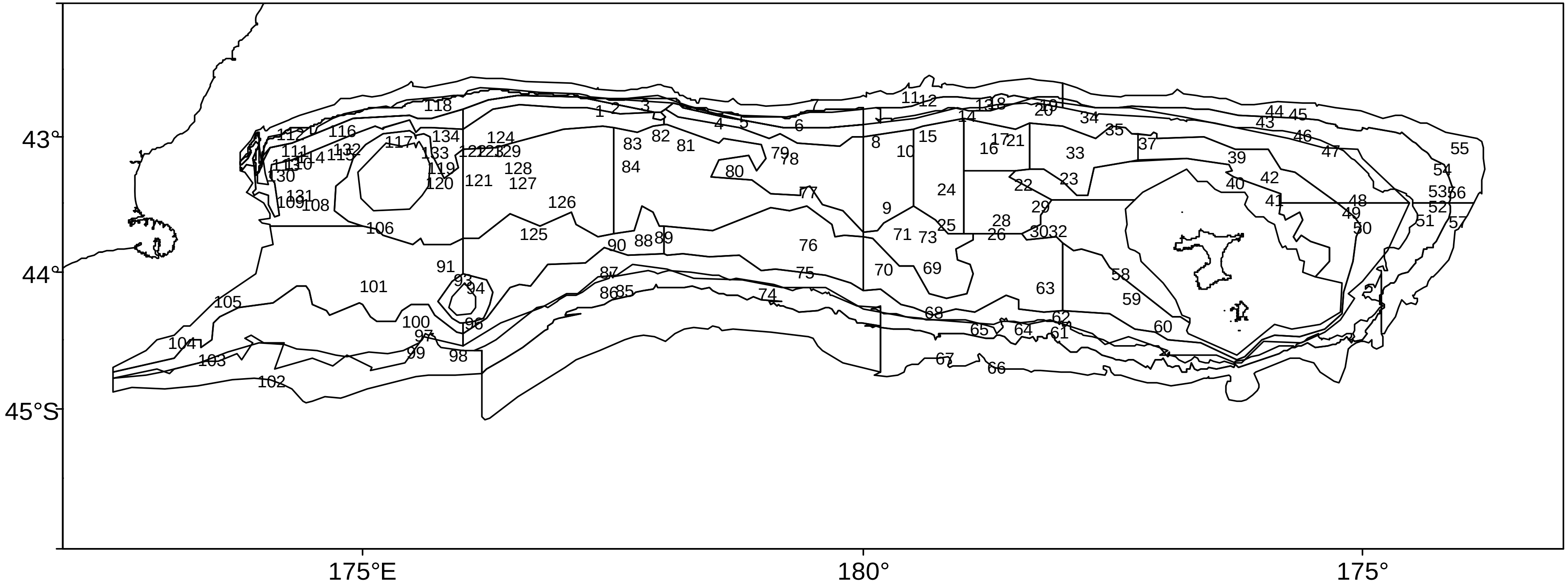


Figure 2: Trawl survey area showing positions of valid biomass stations (n = 124 stations) for TAN1001. In this and subsequent figures actual stratum boundaries are drawn for the new deepwater strata. These boundaries sometimes overlap with existing core survey stratum boundaries. This issue will be resolved as part of the review of the trawl survey series currently being carried out for Ministry of Fisheries Research Project HOK2007/02C.

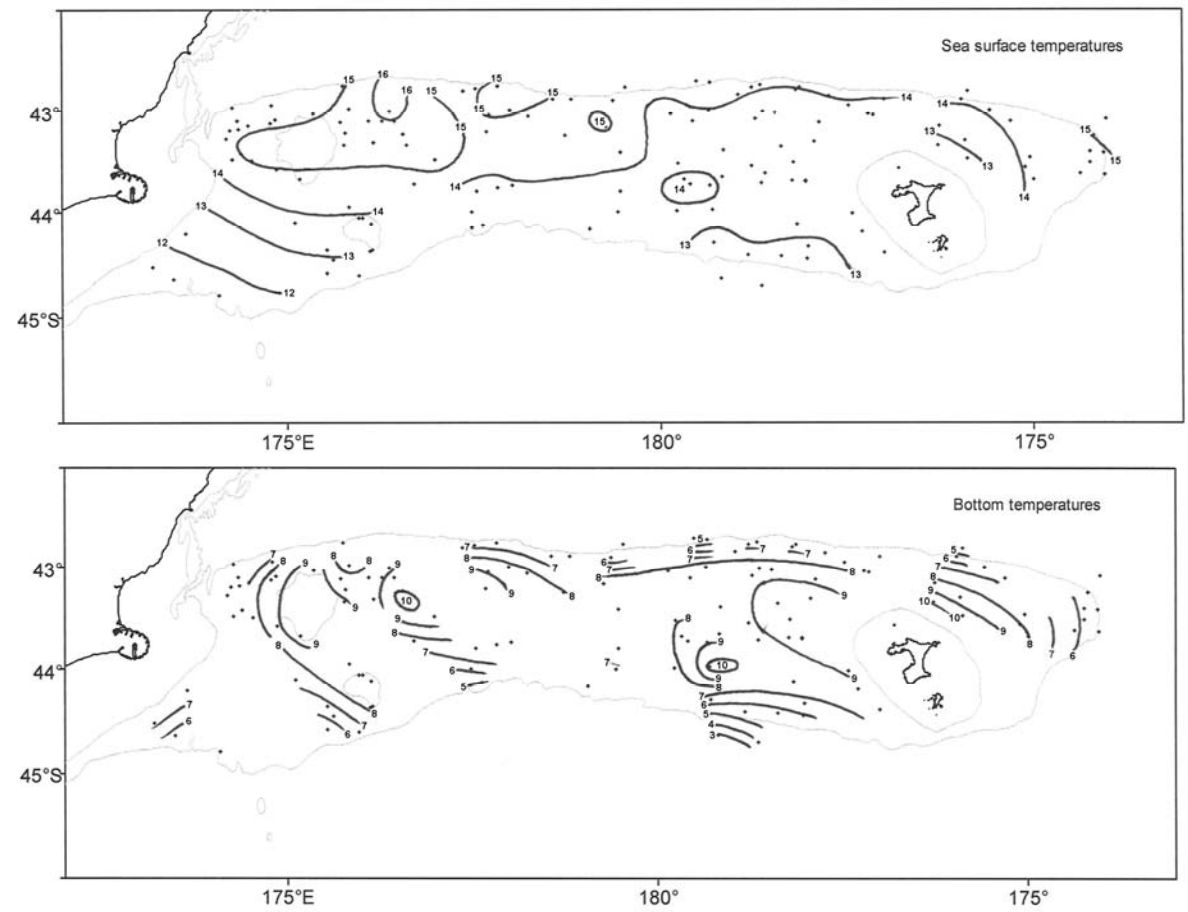


Figure 3: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (°C) interpolated by eye. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow

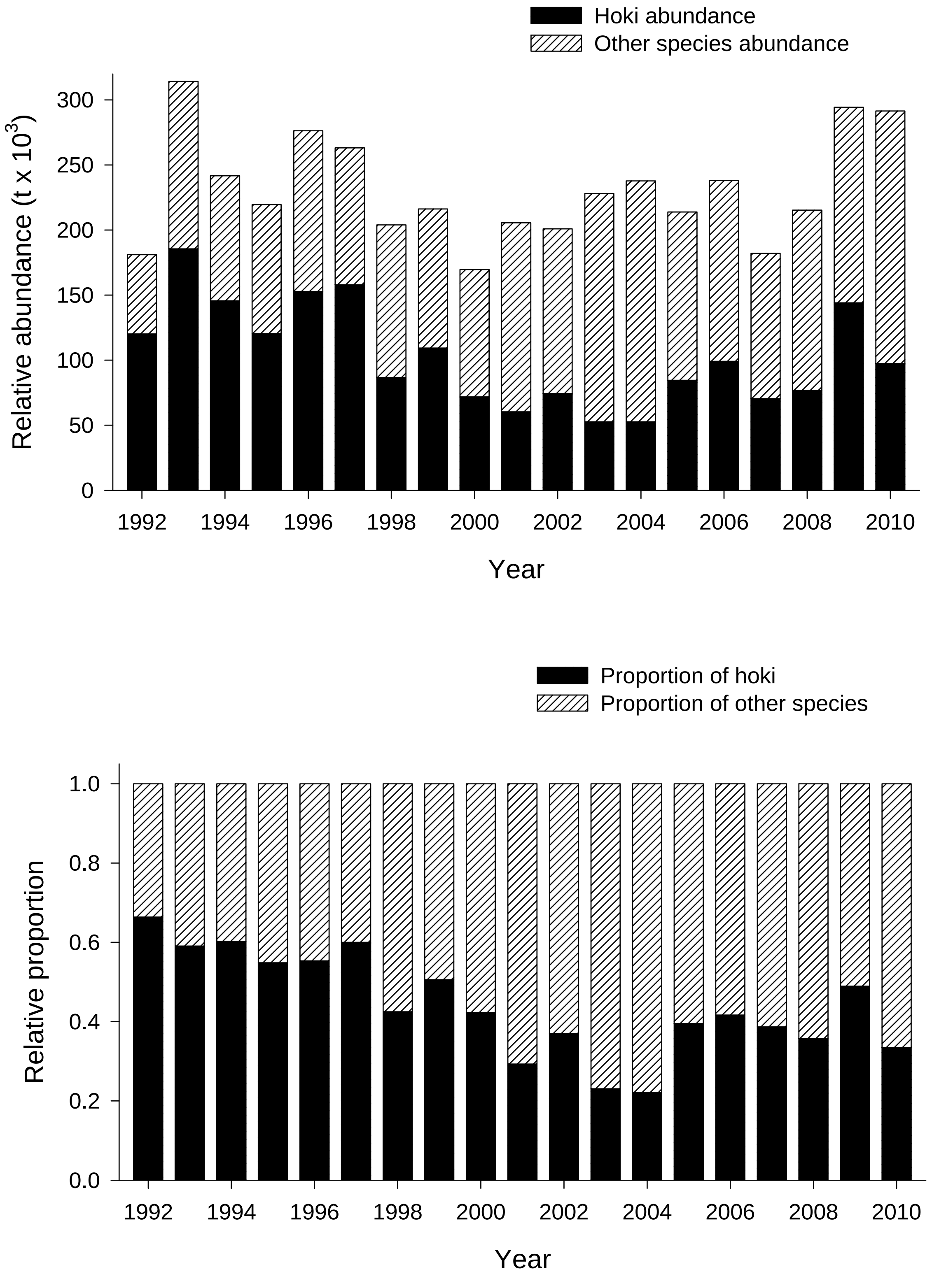


Figure 4: Relative biomass (top panel) and relative proportions of hoki and 30 other key species (lower `panel) from trawl surveys of the Chatham Rise, January 1992–2010

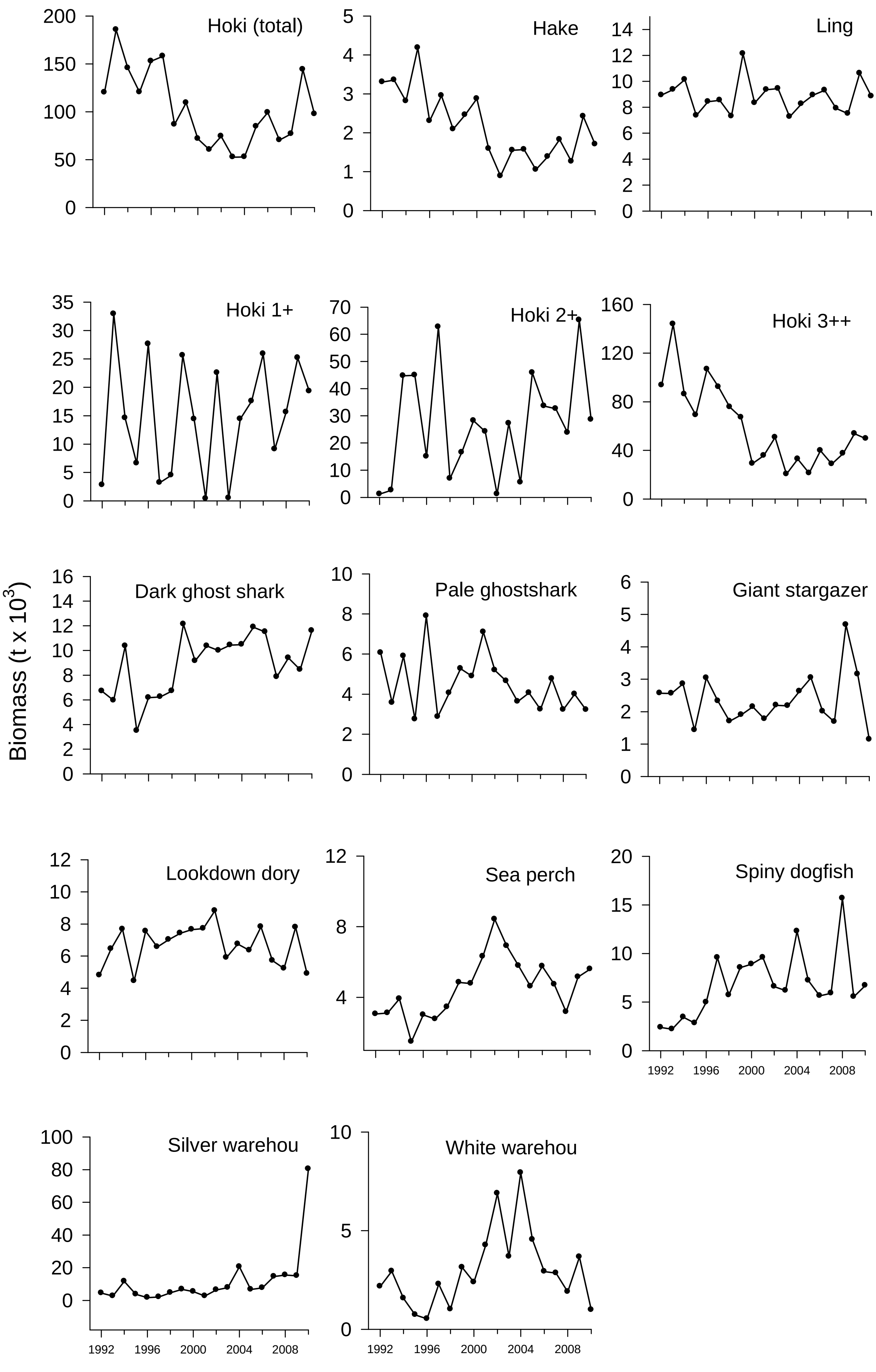


Figure 5: Relative biomass estimates (t x 10^3) of important species sampled by annual trawl surveys of the Chatham Rise, January 1992–2010

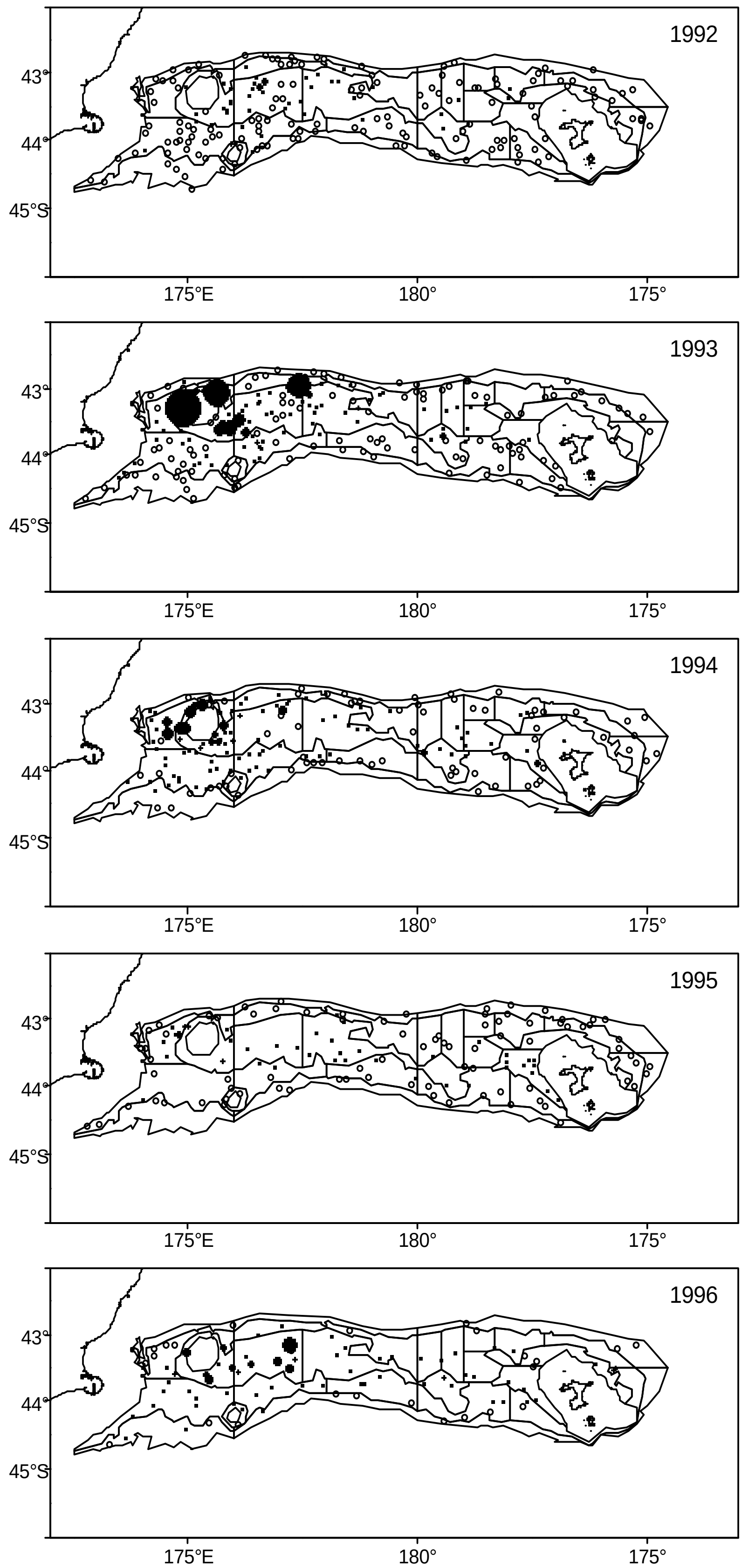


Figure 6a: Hoki 1+ catch distribution 1992–2010. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 30 850 kg km^{-2}

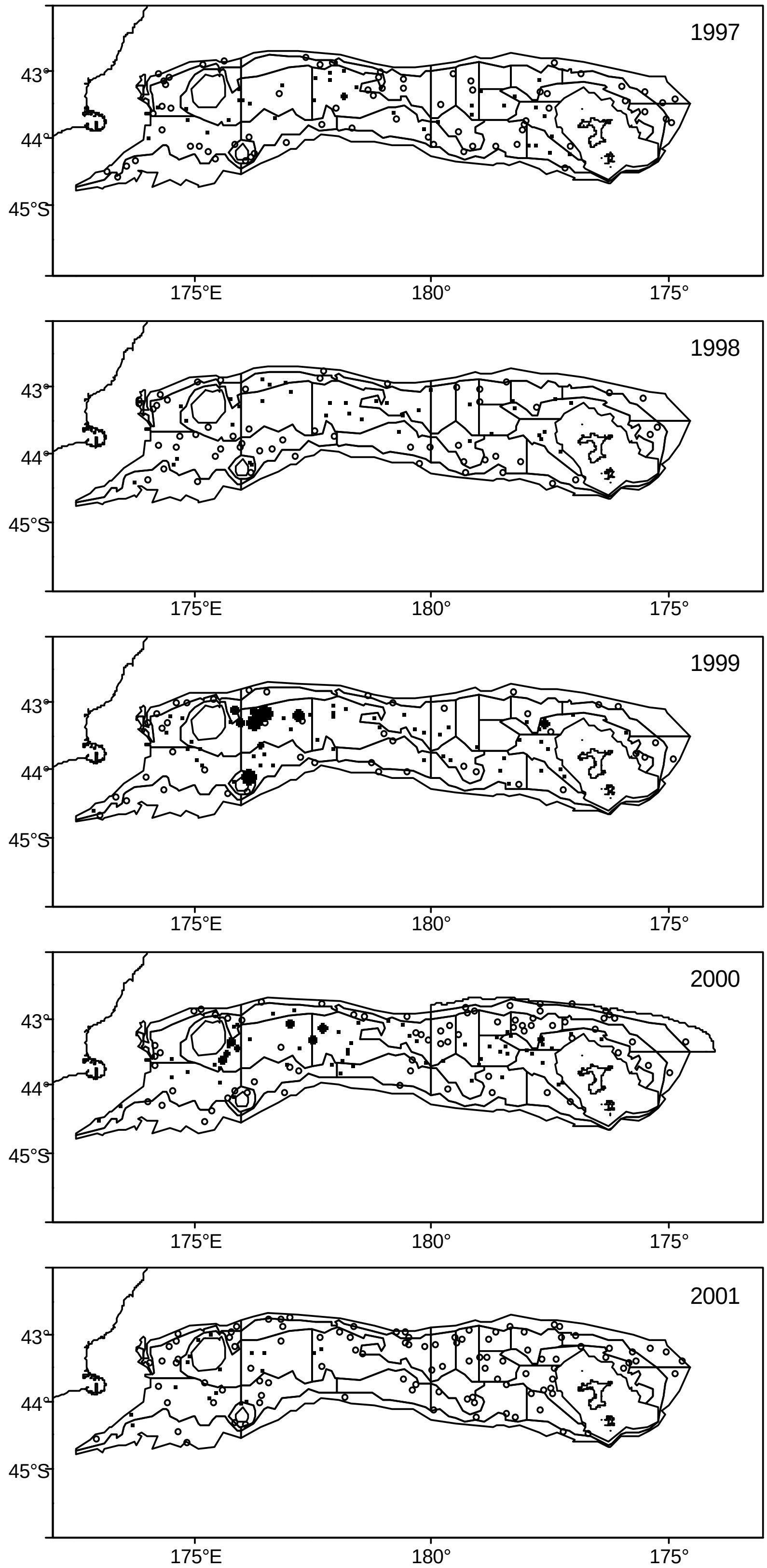


Figure 6a (continued)

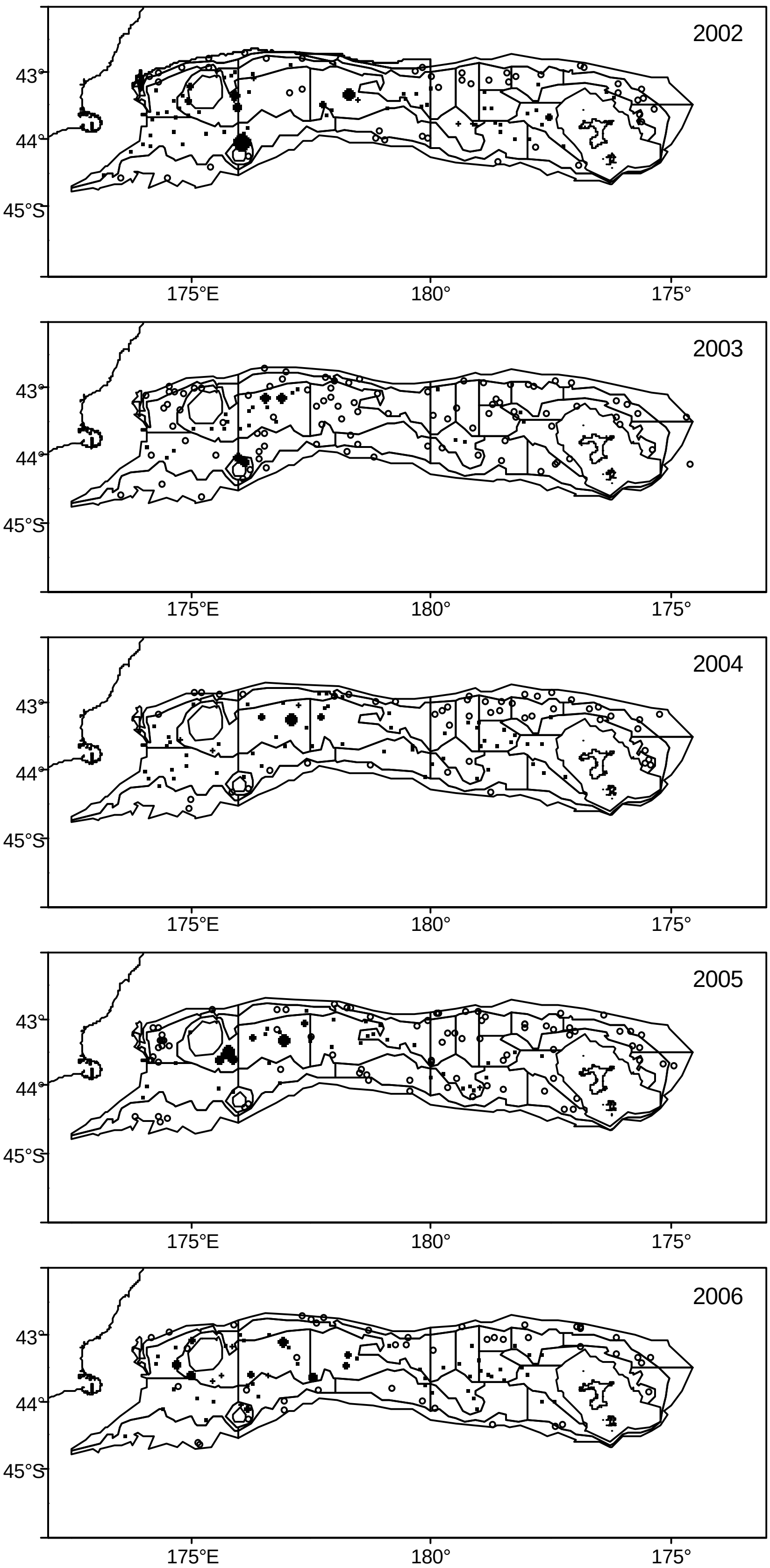


Figure 6a (continued)

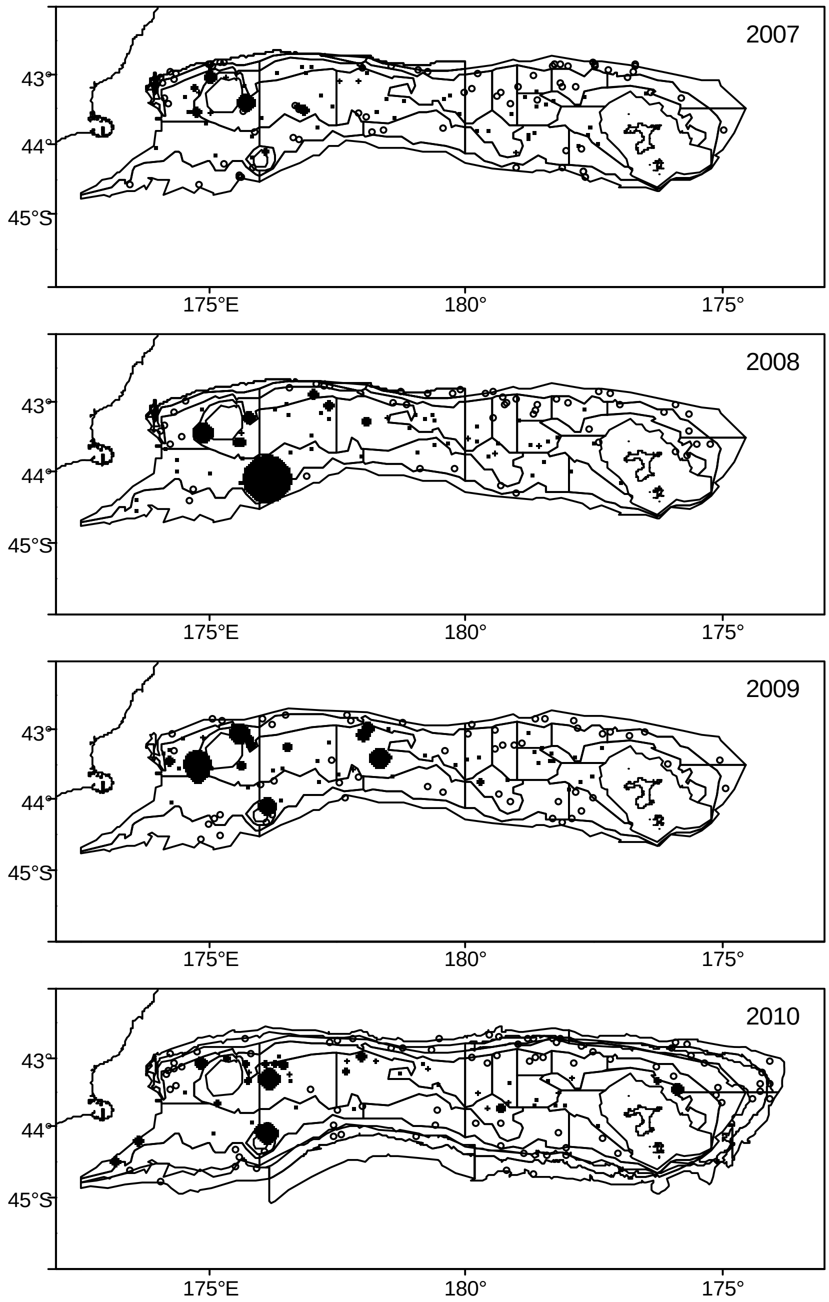


Figure 6a (continued)

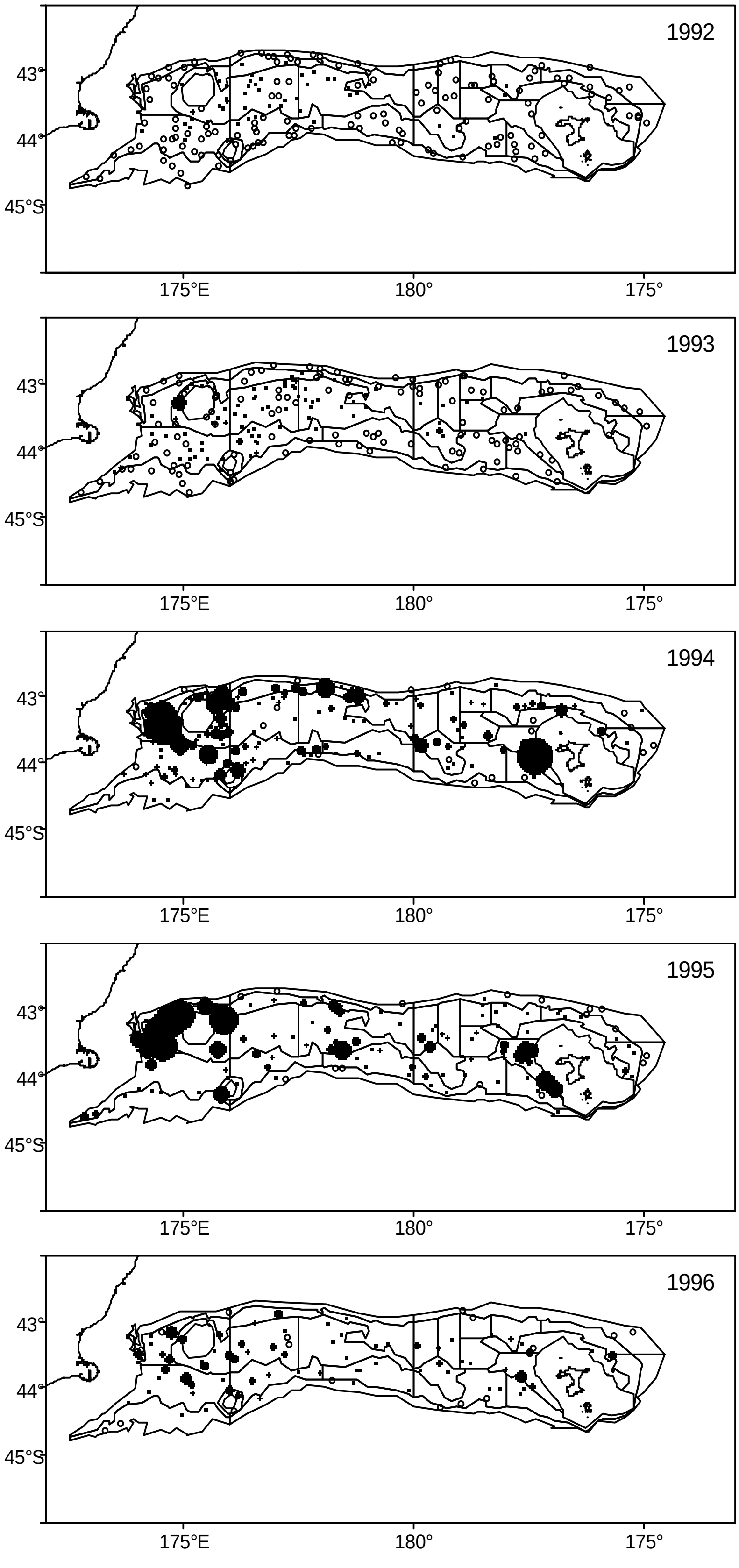


Figure 6b: Hoki 2+ catch distribution 1992–2010. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 6791 kg km^{-2}

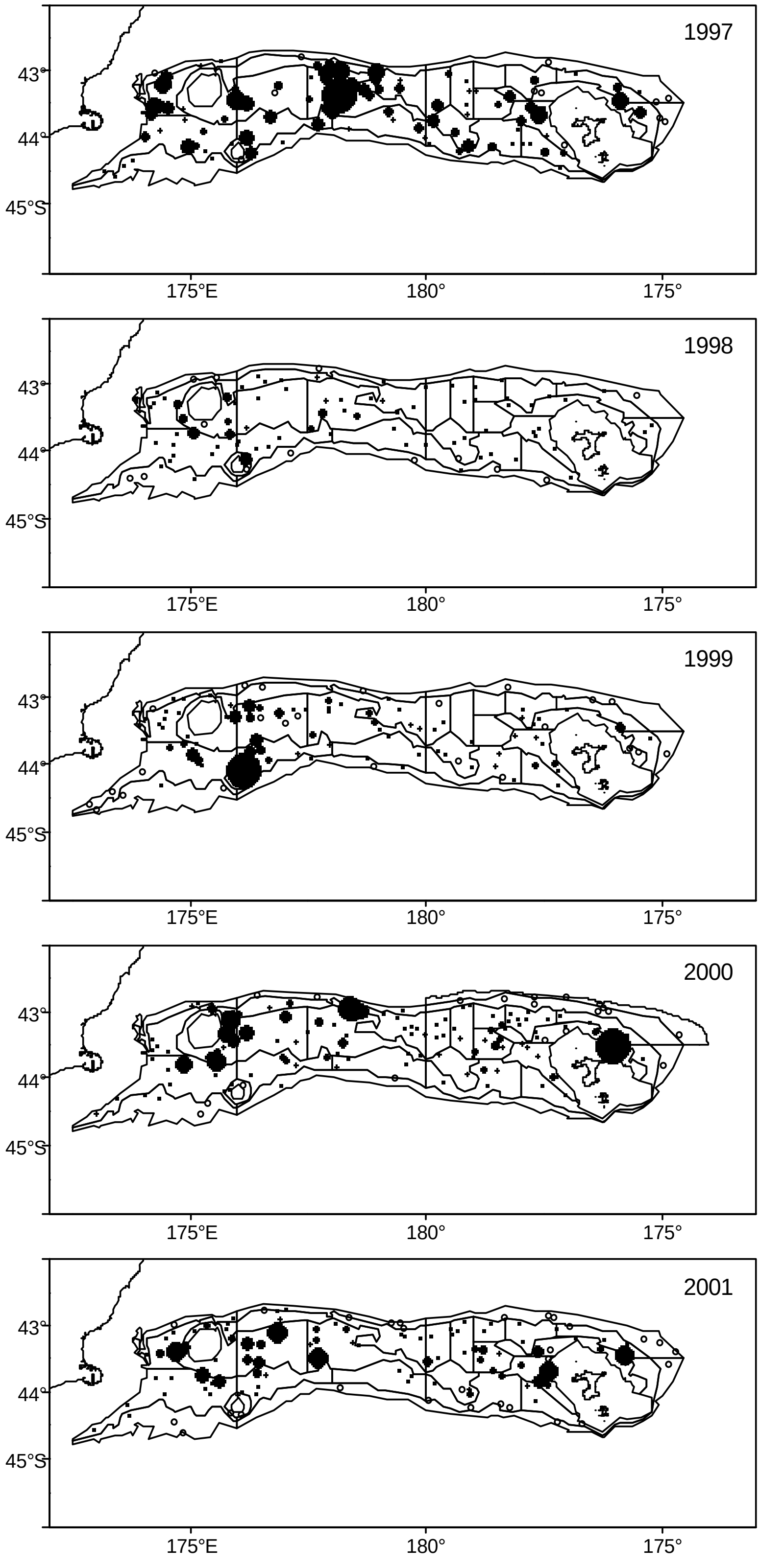


Figure 6b (continued)

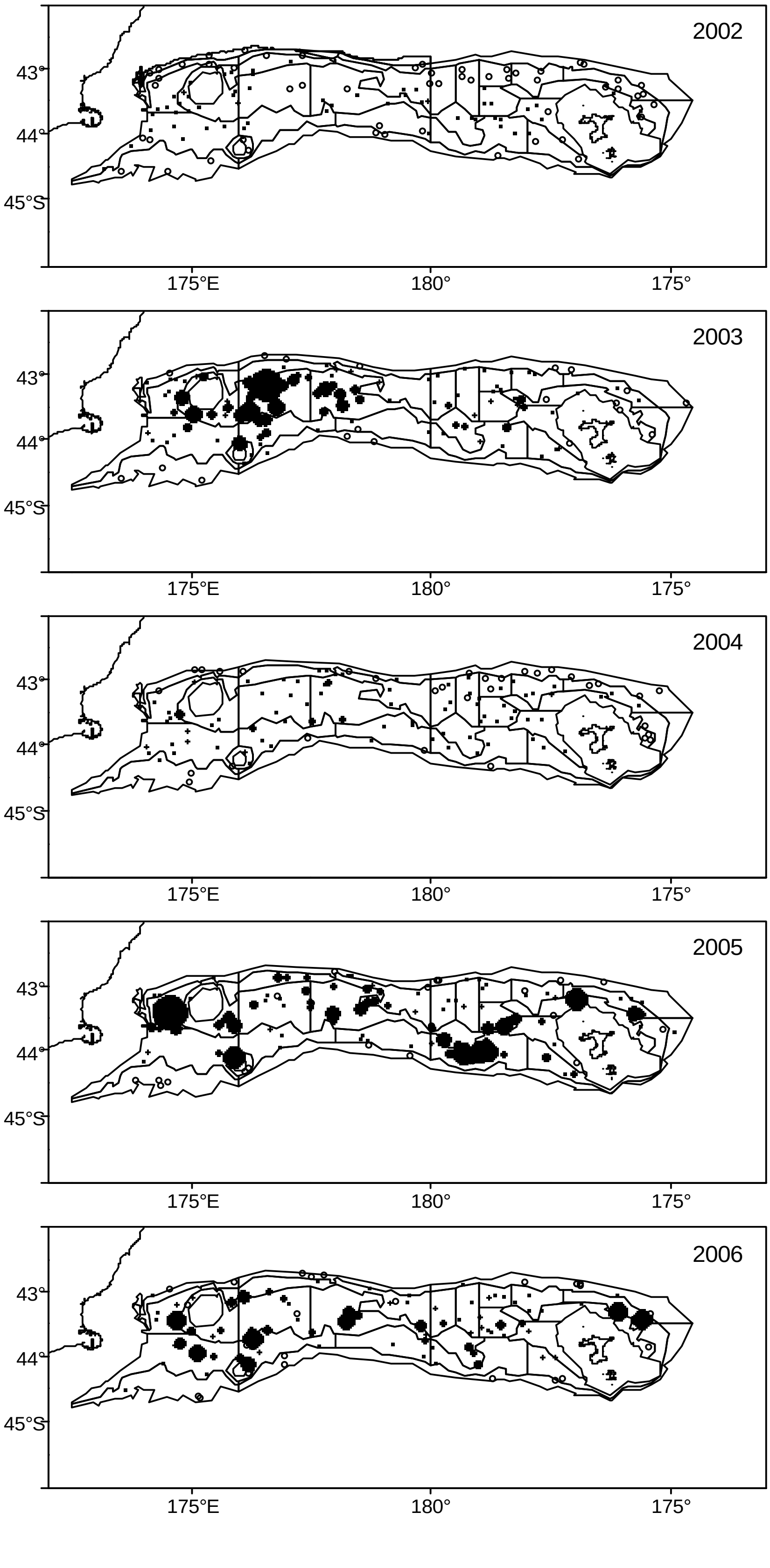


Figure 6b (continued)

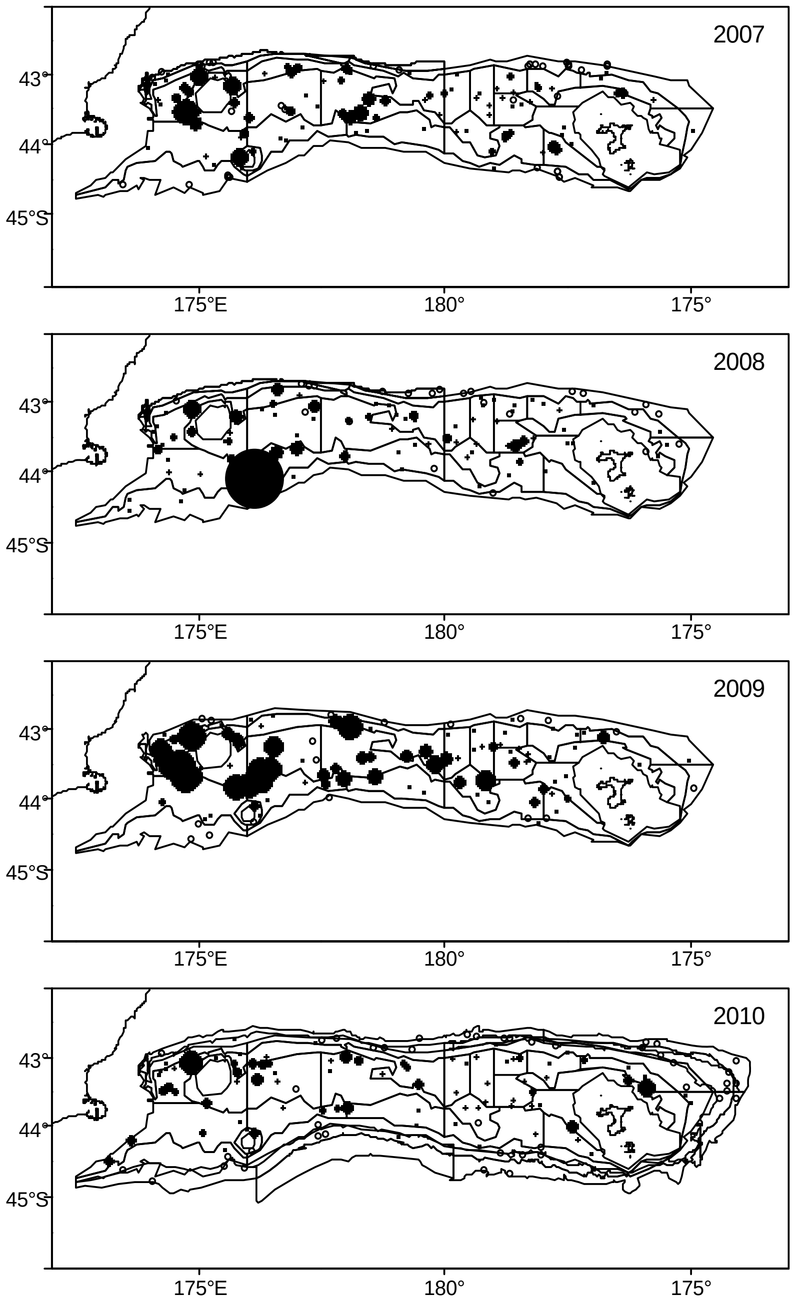


Figure 6b (continued)

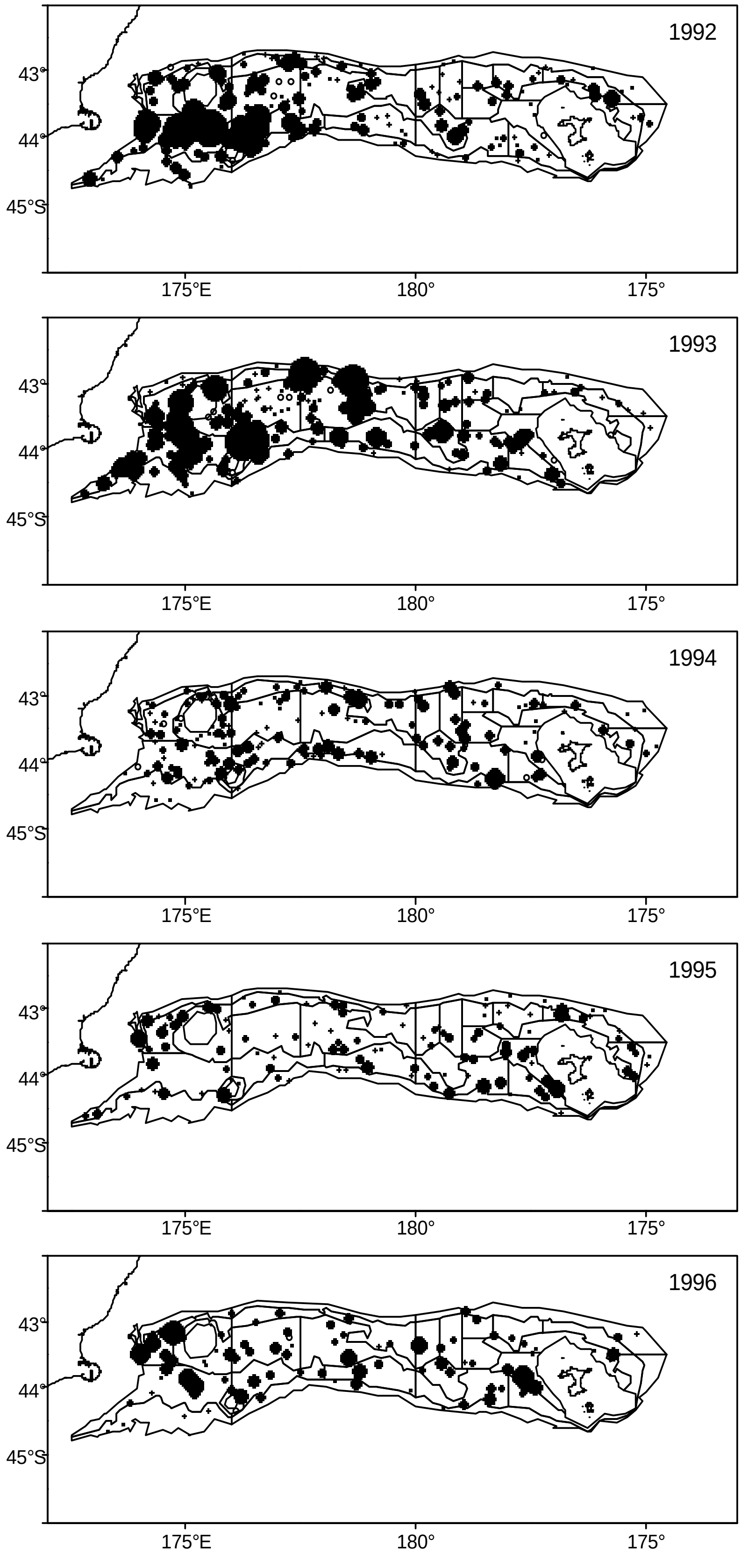


Figure 6c: Hoki 3++ catch distribution. 1992–2010. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 11 177 kg km^{-2}

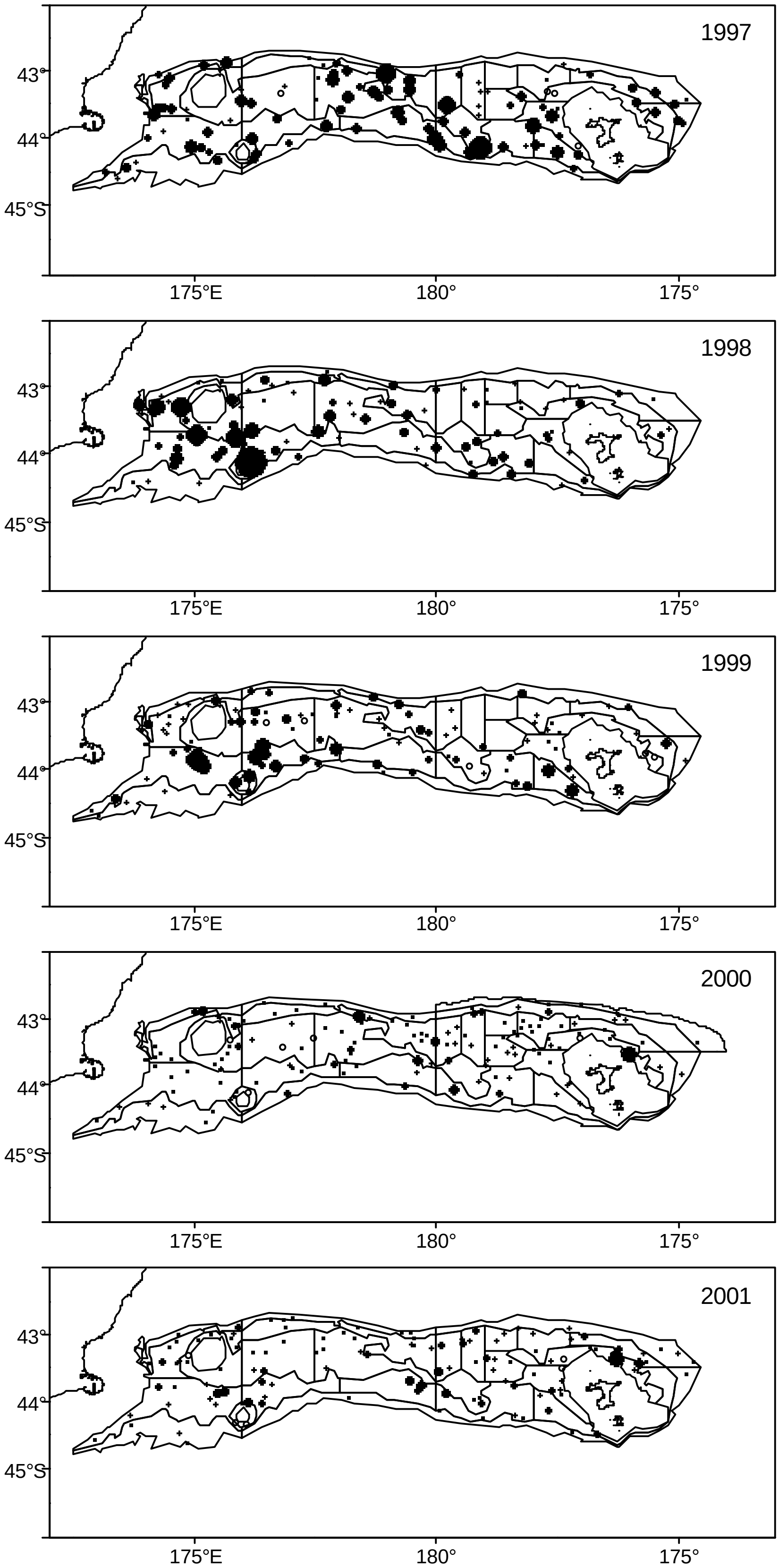


Figure 6c (continued)

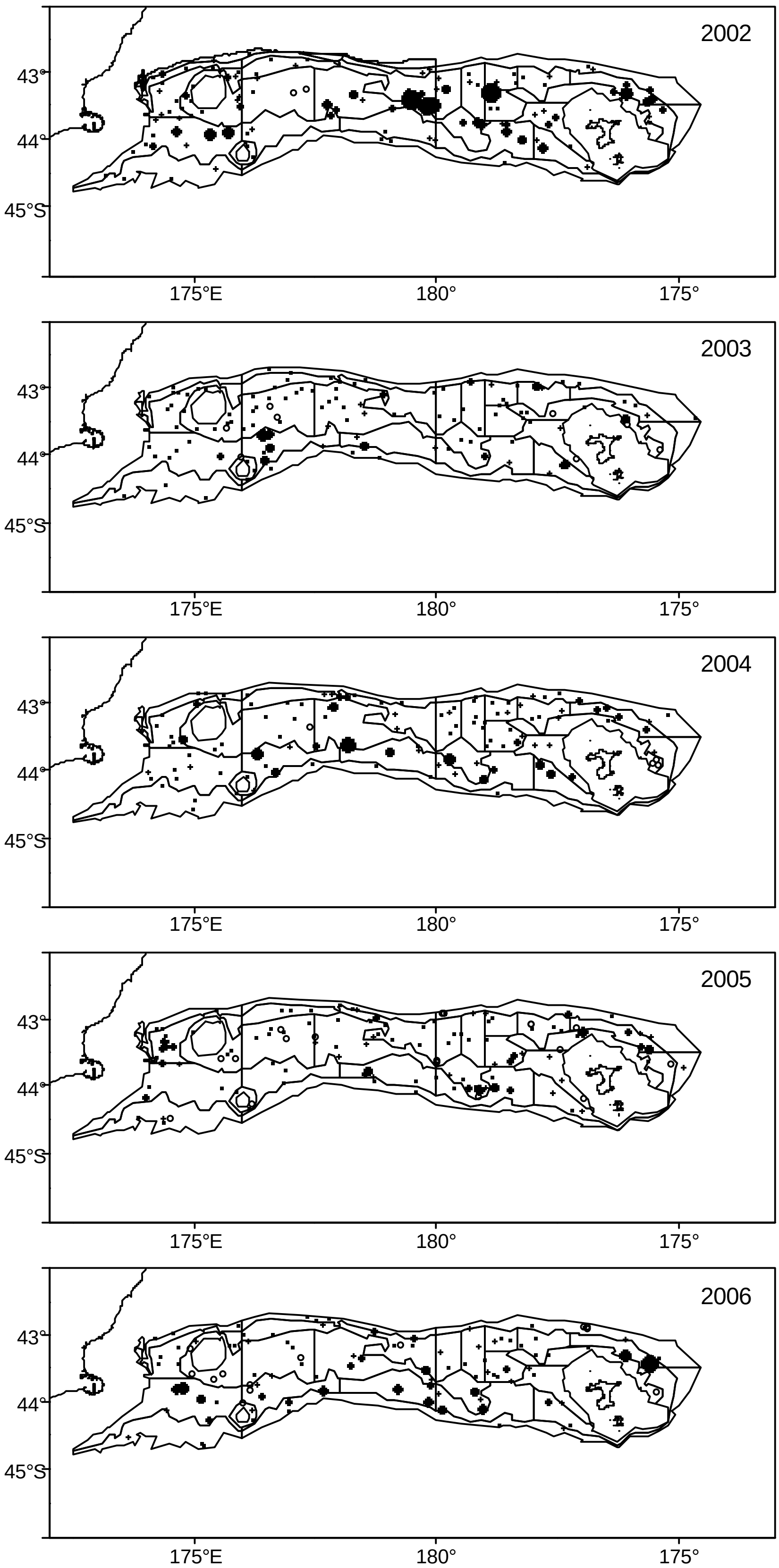


Figure 6c (continued)

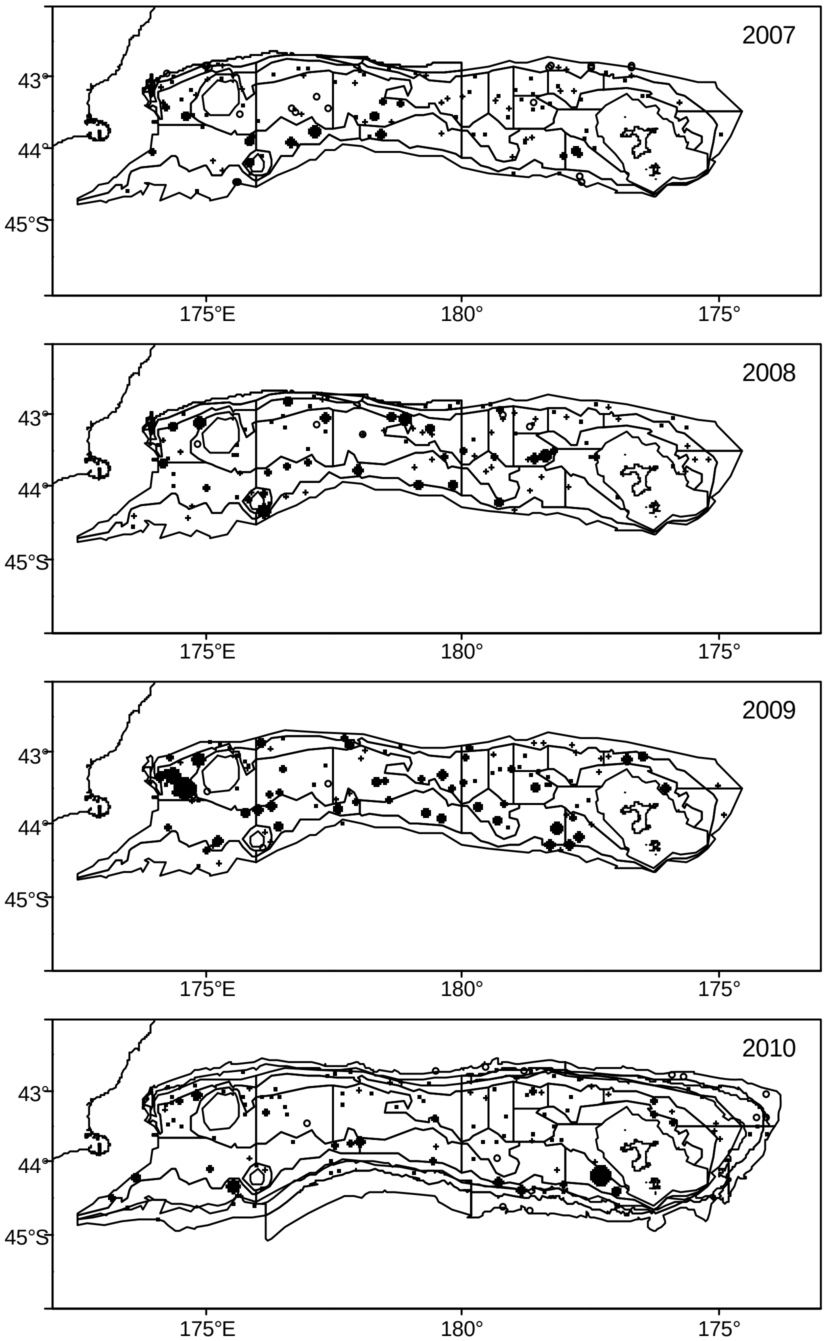


Figure 6c (continued)

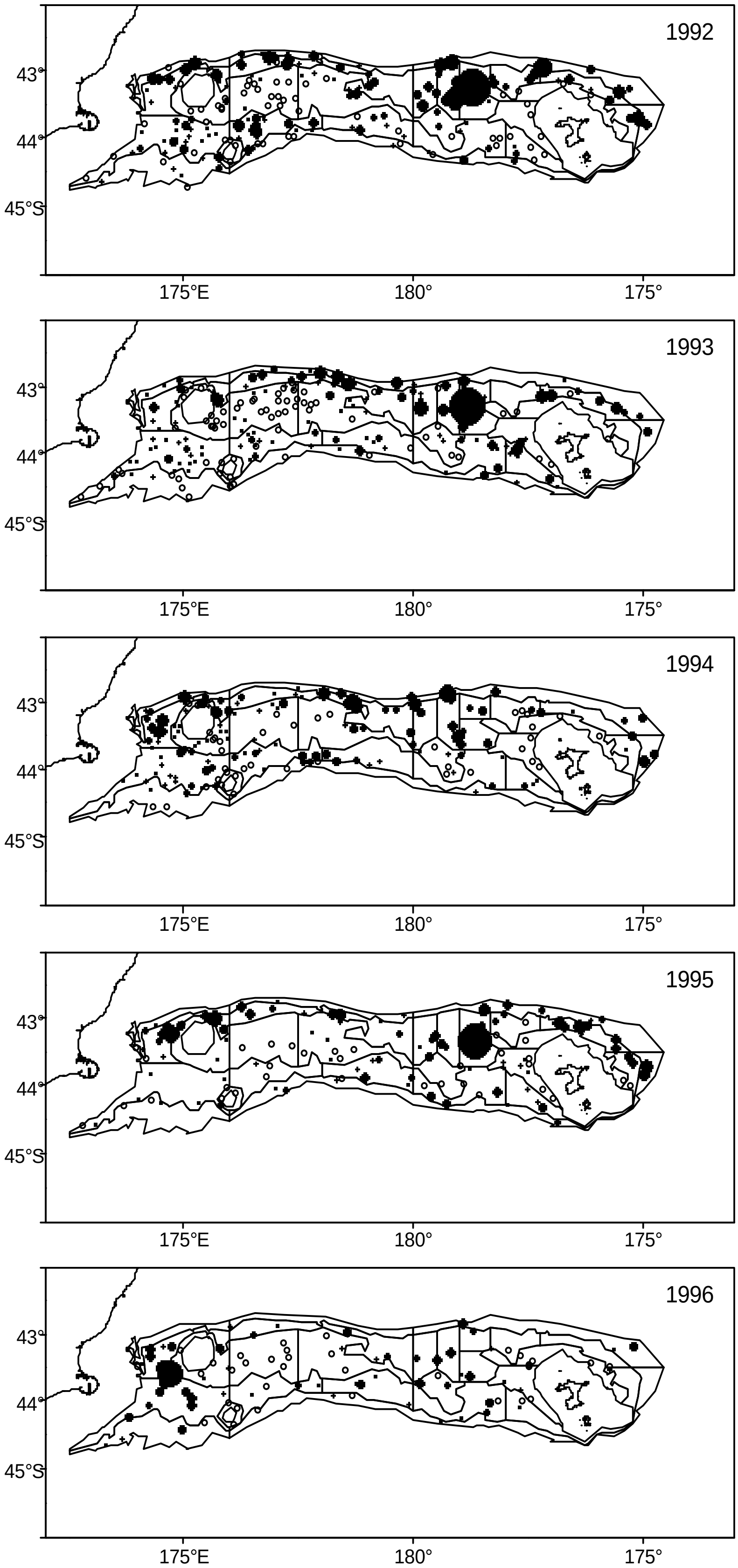
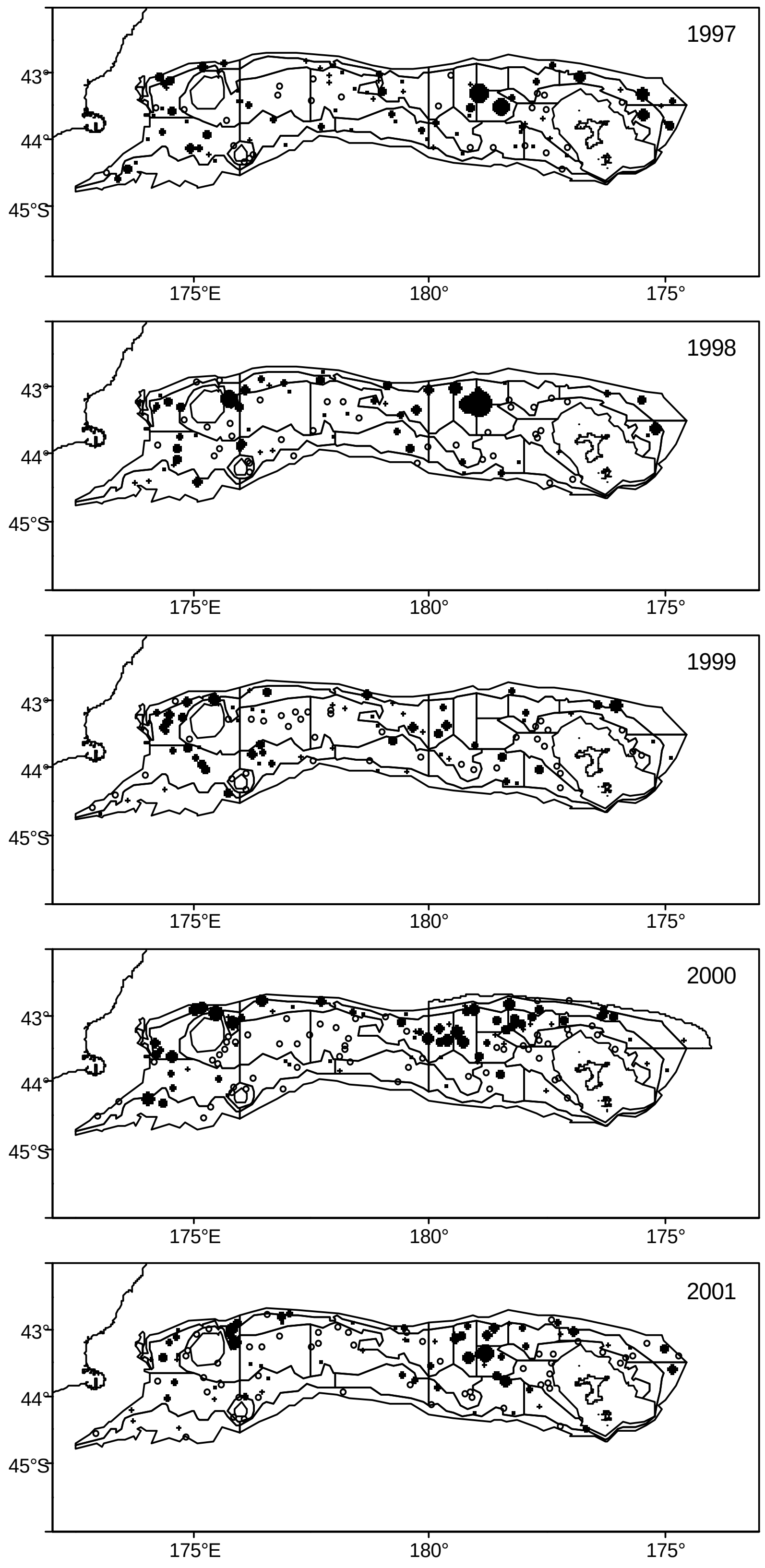


Figure 7: Hake catch distribution 1992–2010. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 620 kg km^{-2}



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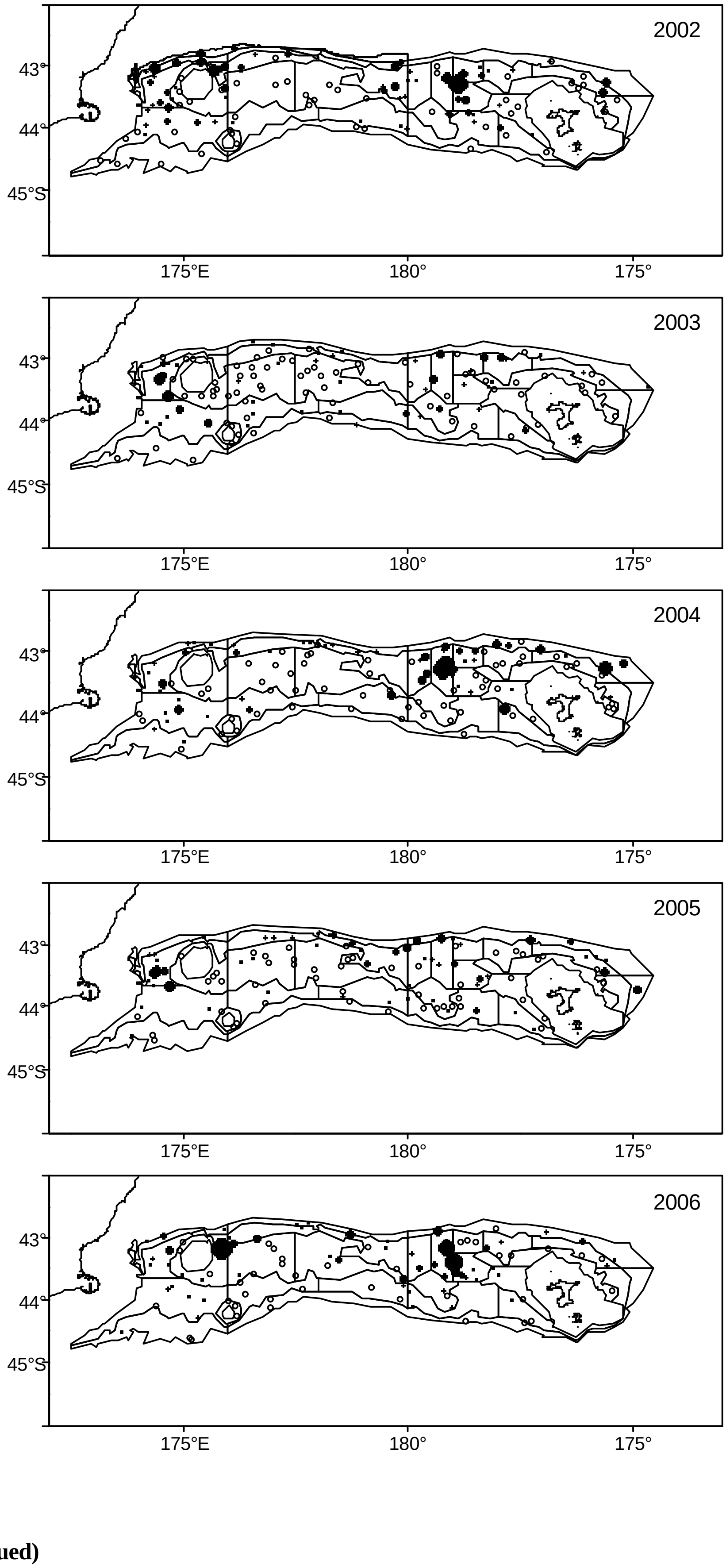

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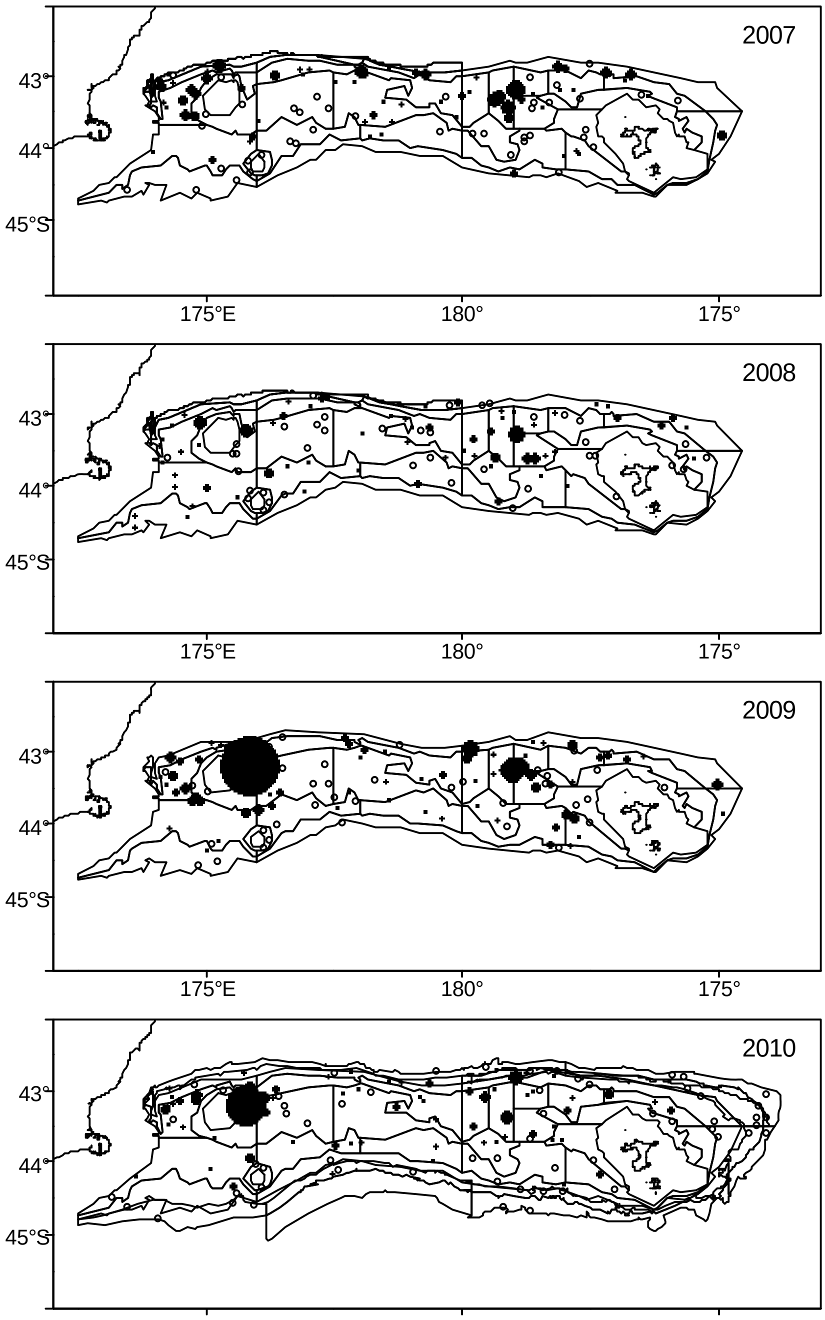

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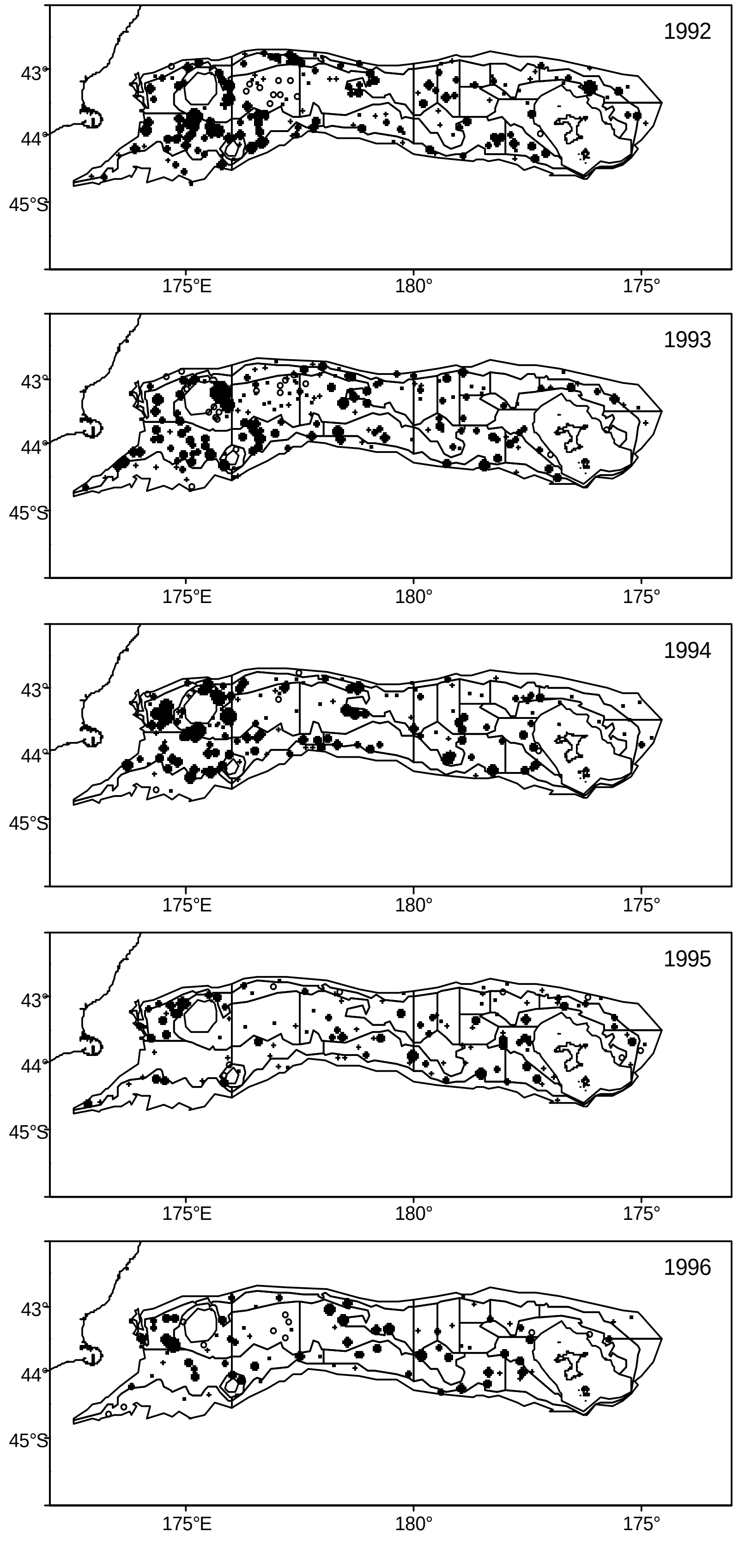
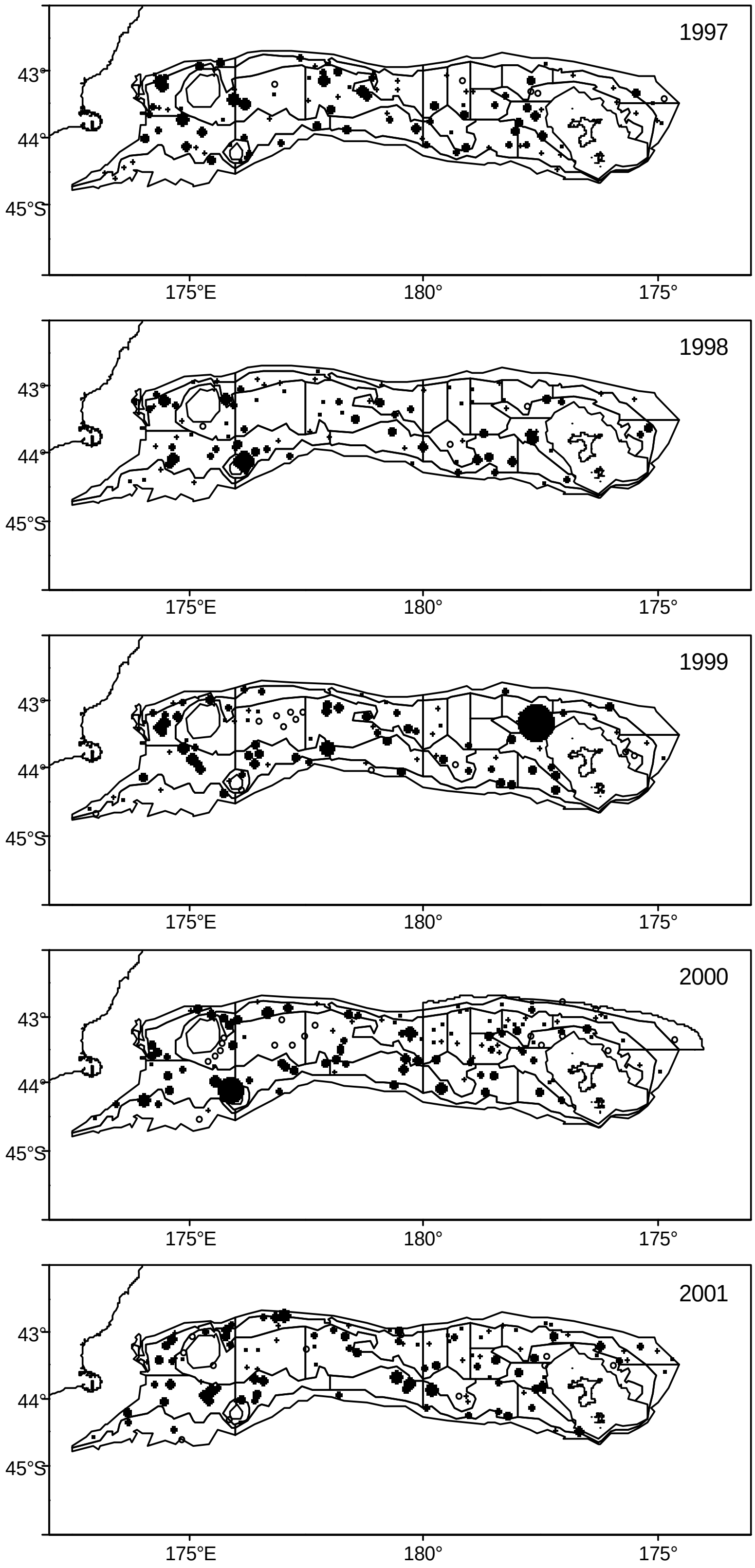


Figure 8: Ling catch distribution 1992–2010. Filled circle area is proportional to catch rate (kg km^{-2}). Open circles are zero catch. Maximum catch rate in series is 1786 kg km^{-2}



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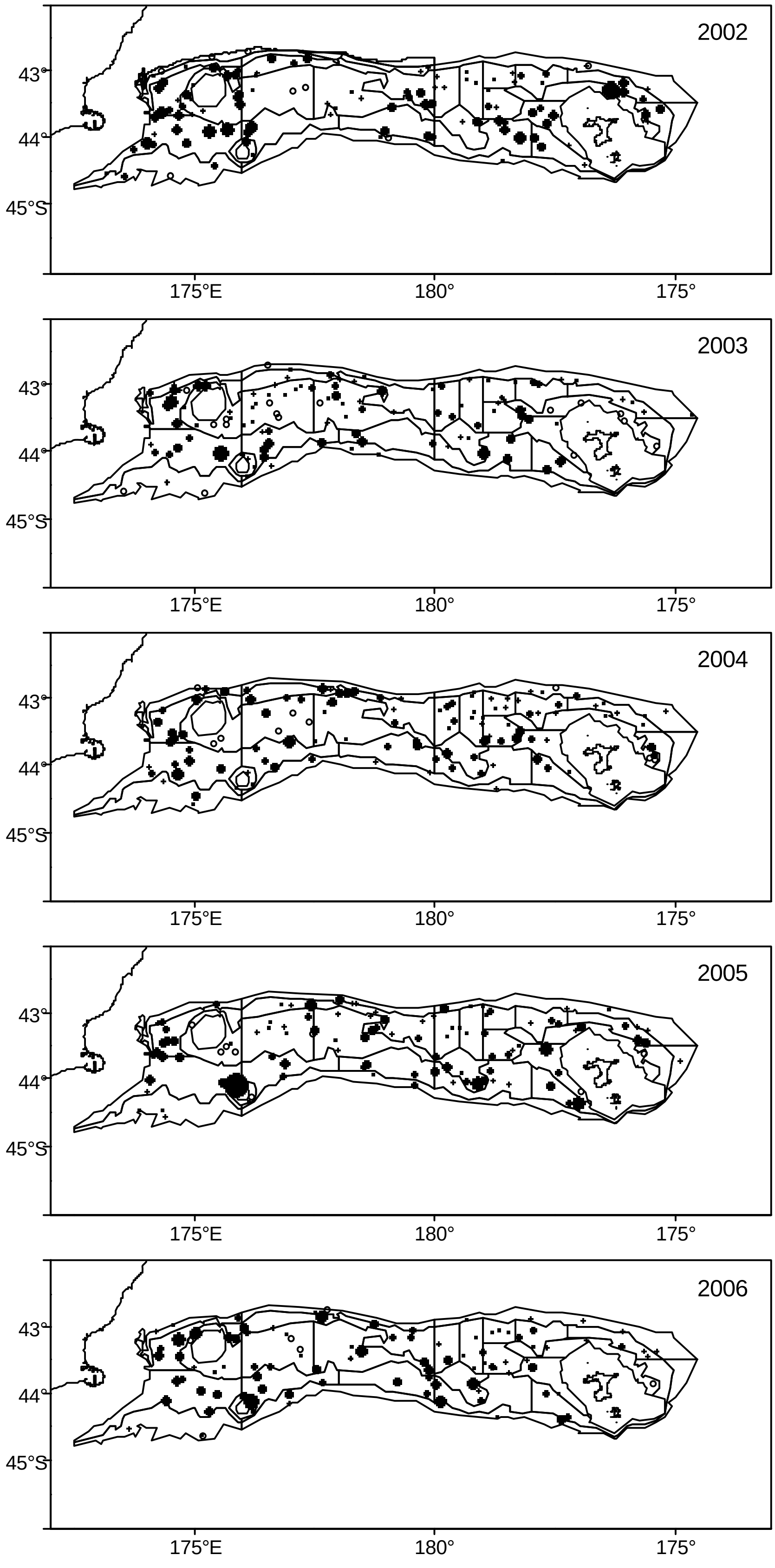

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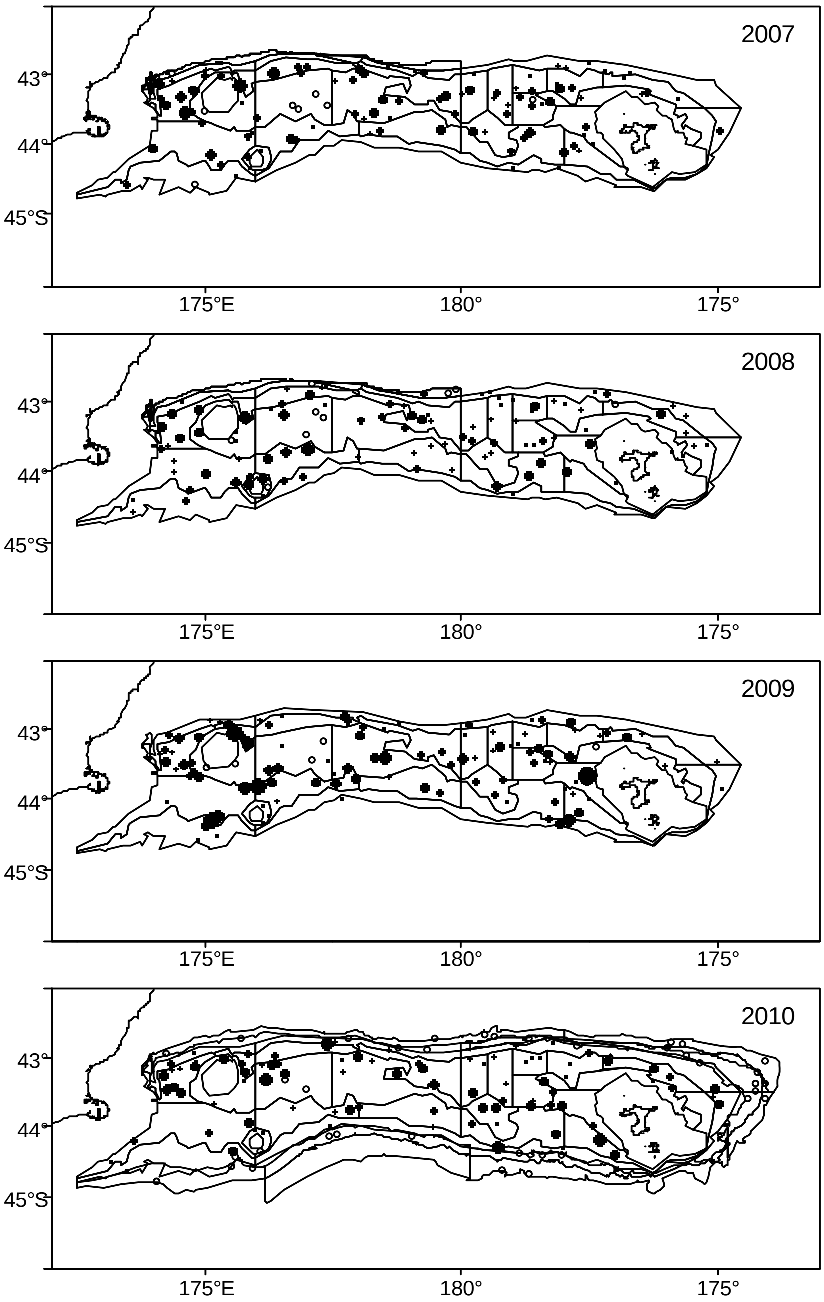

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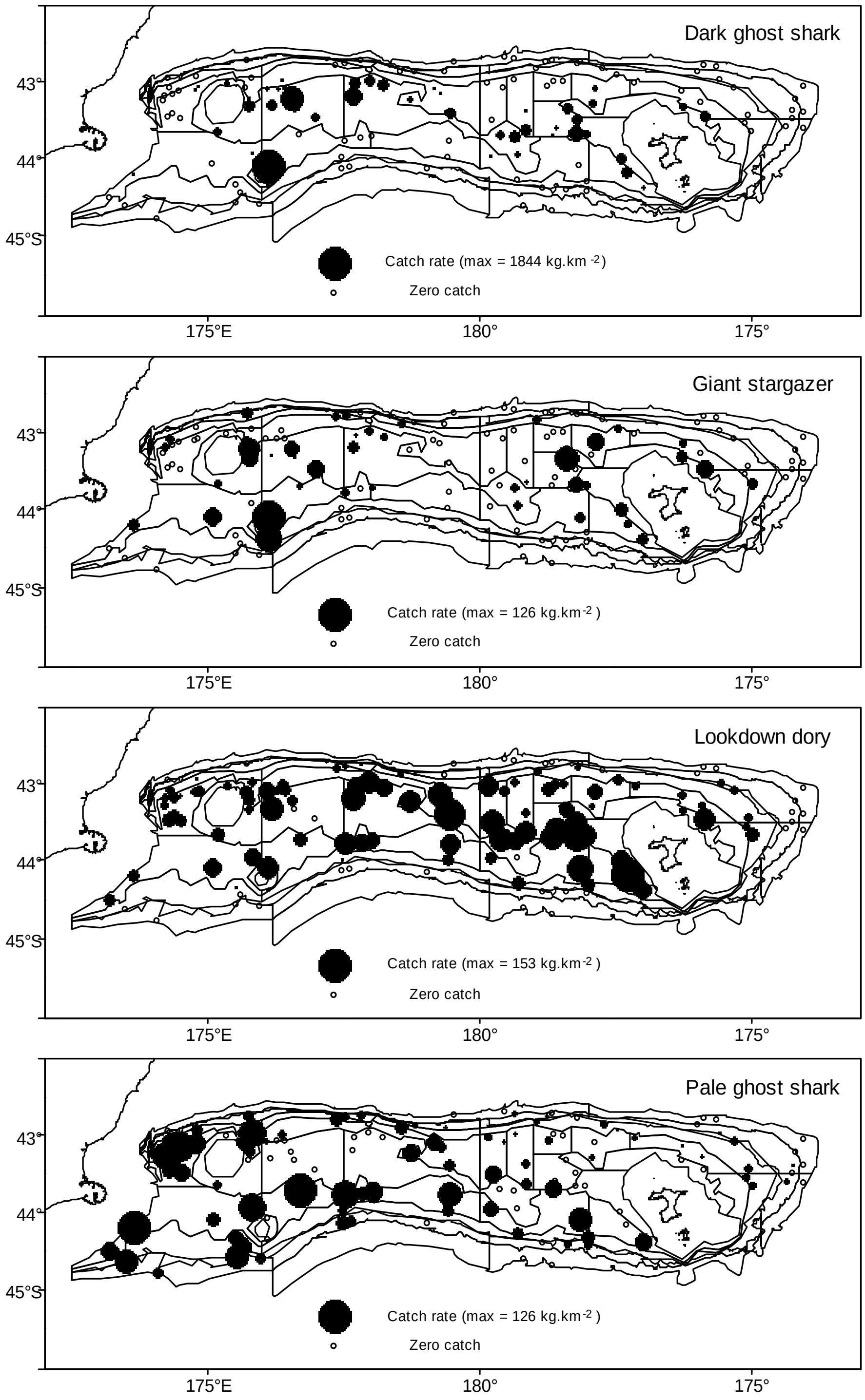

Figure 9: Catch rates (kg km^{-2}) of selected commercial species in 2010. Filled circle area is proportional to catch rate. Open circles are zero catch. (max., maximum catch rate)

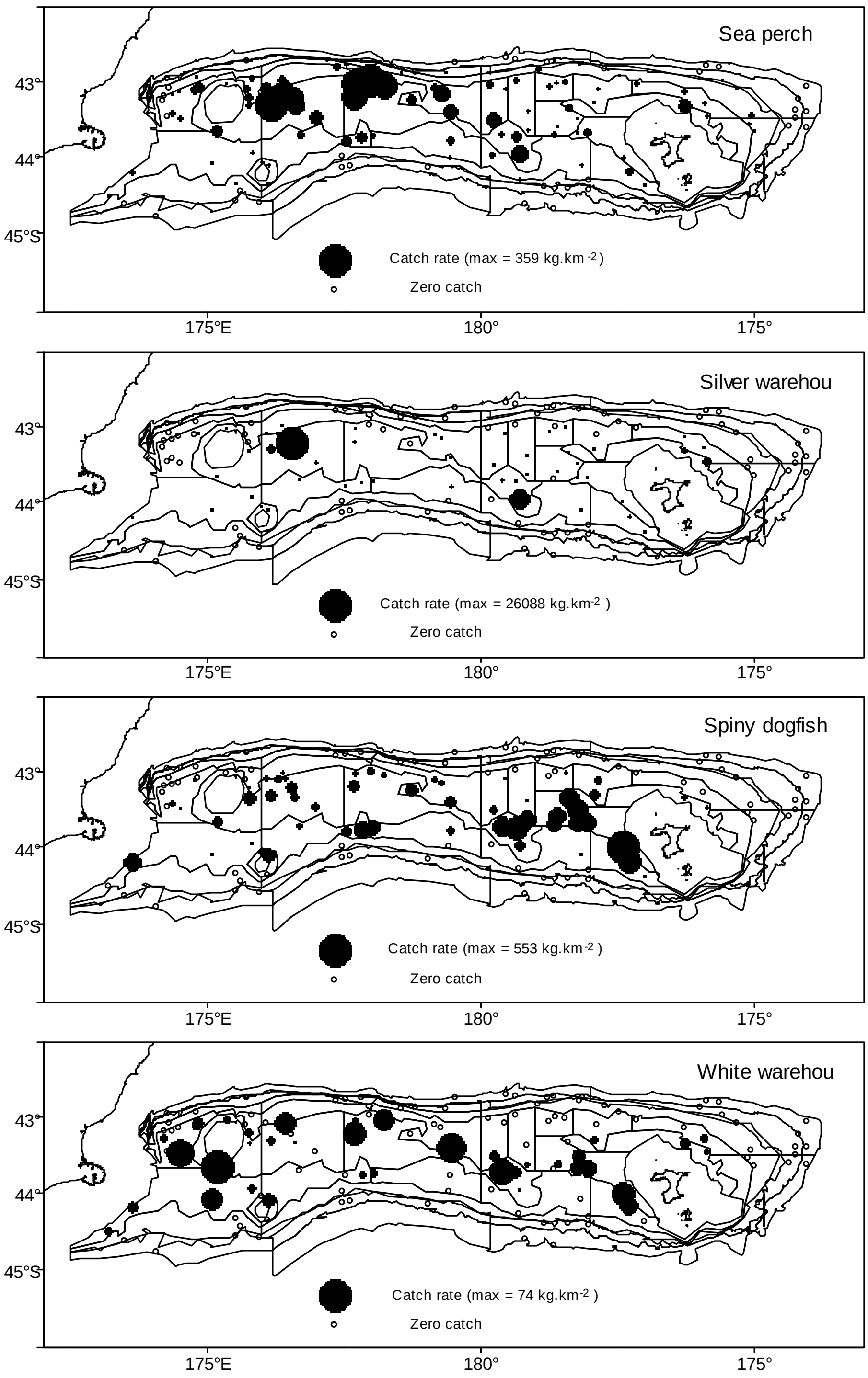

Figure 9 (continued)

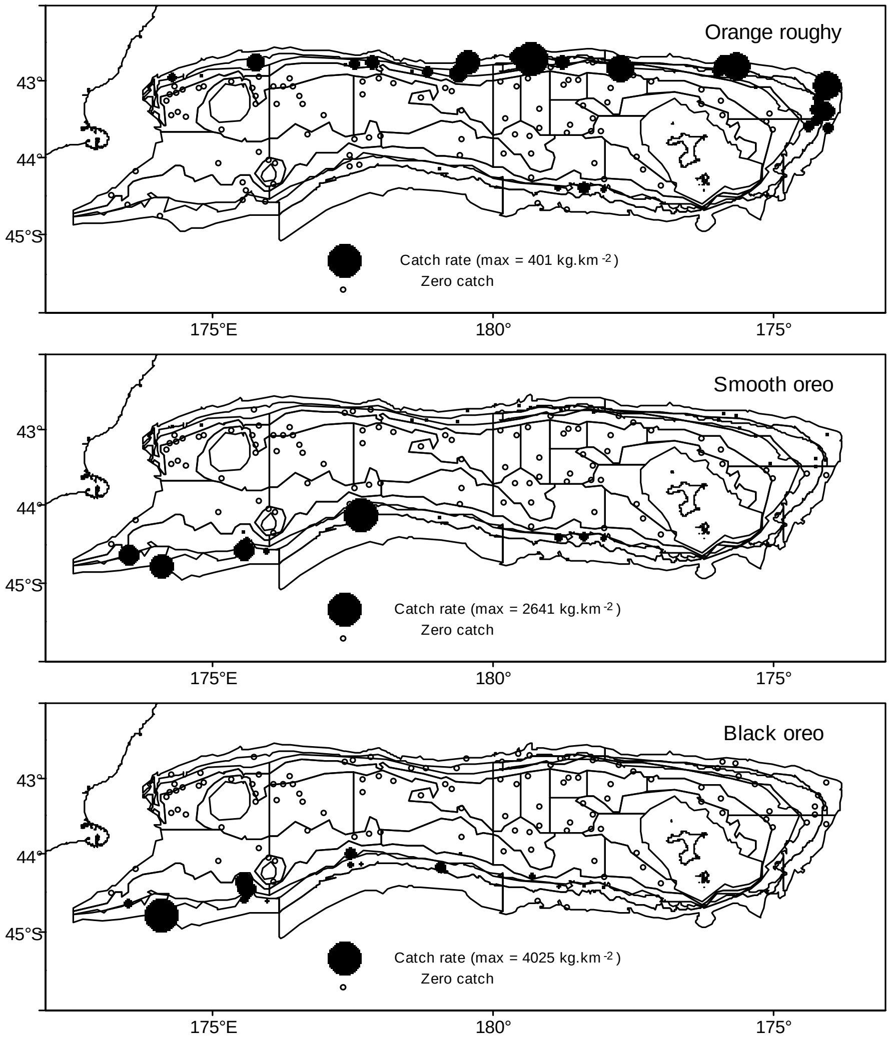

Figure 9 (continued)

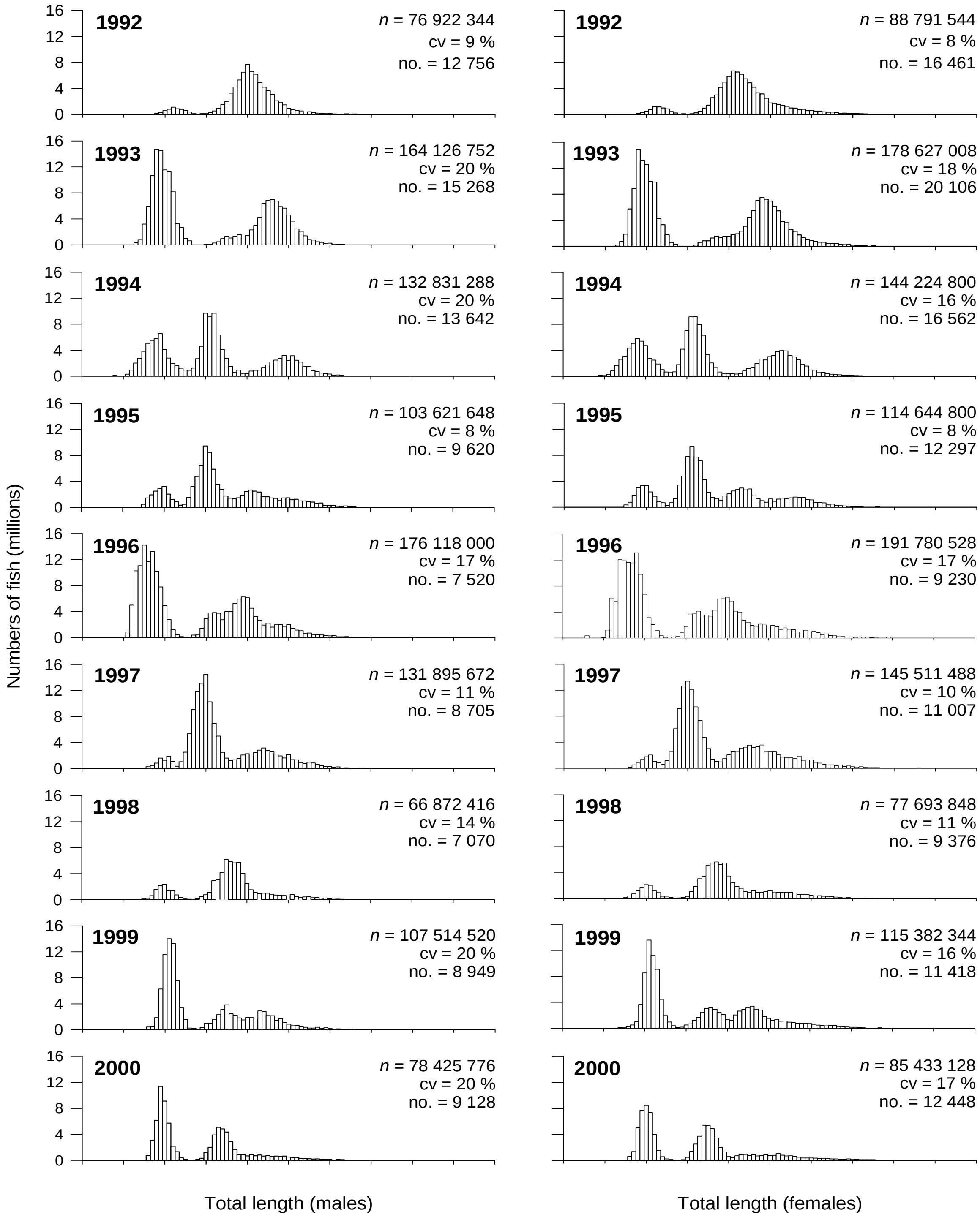

Figure 10: Estimated length frequency distributions of the male and female hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2010. (c.v., coefficient of variation; *n*, estimated population number of male hoki (left panel) and female hoki (right panel); no., numbers of fish measured.)

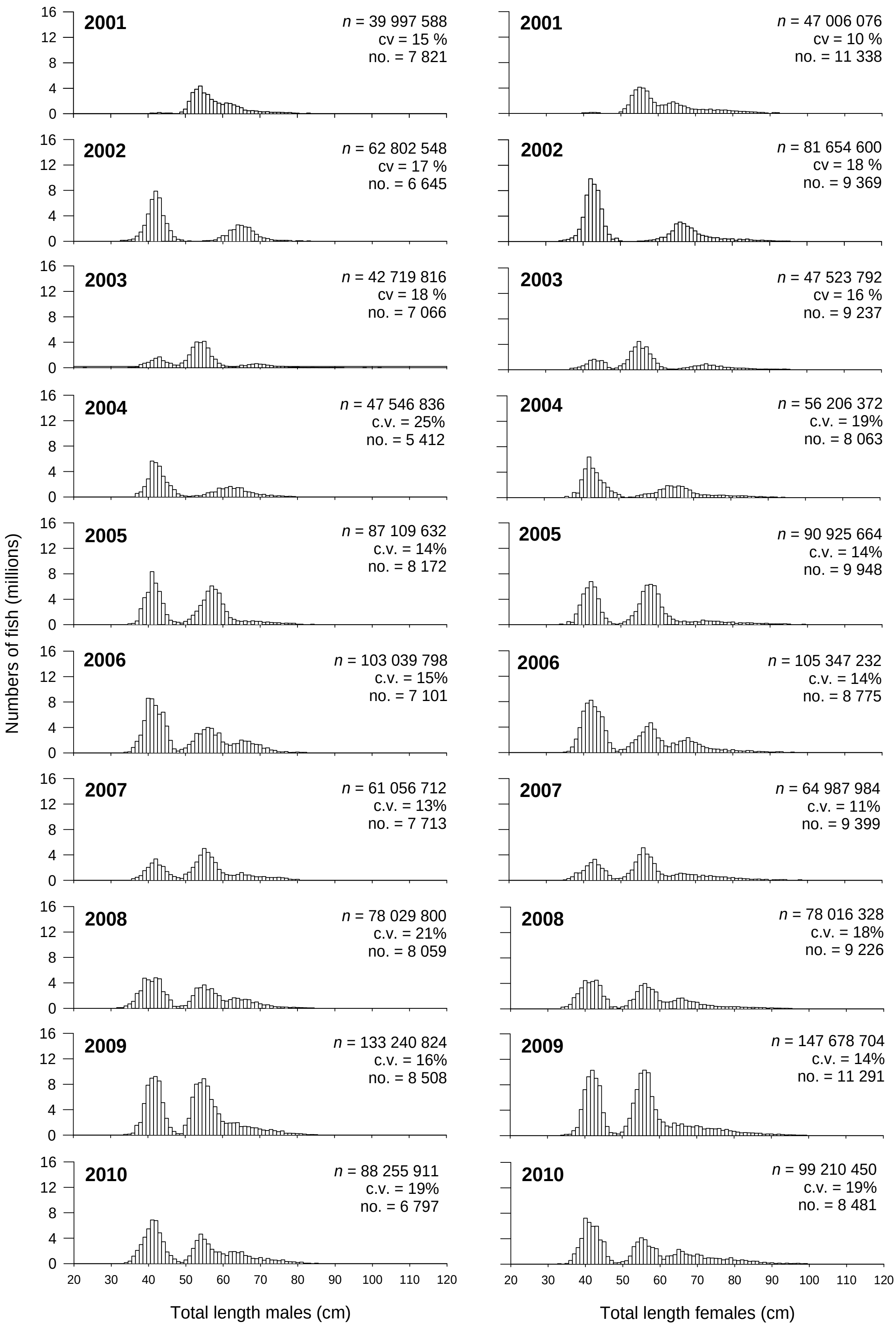

Figure 10 (continued)

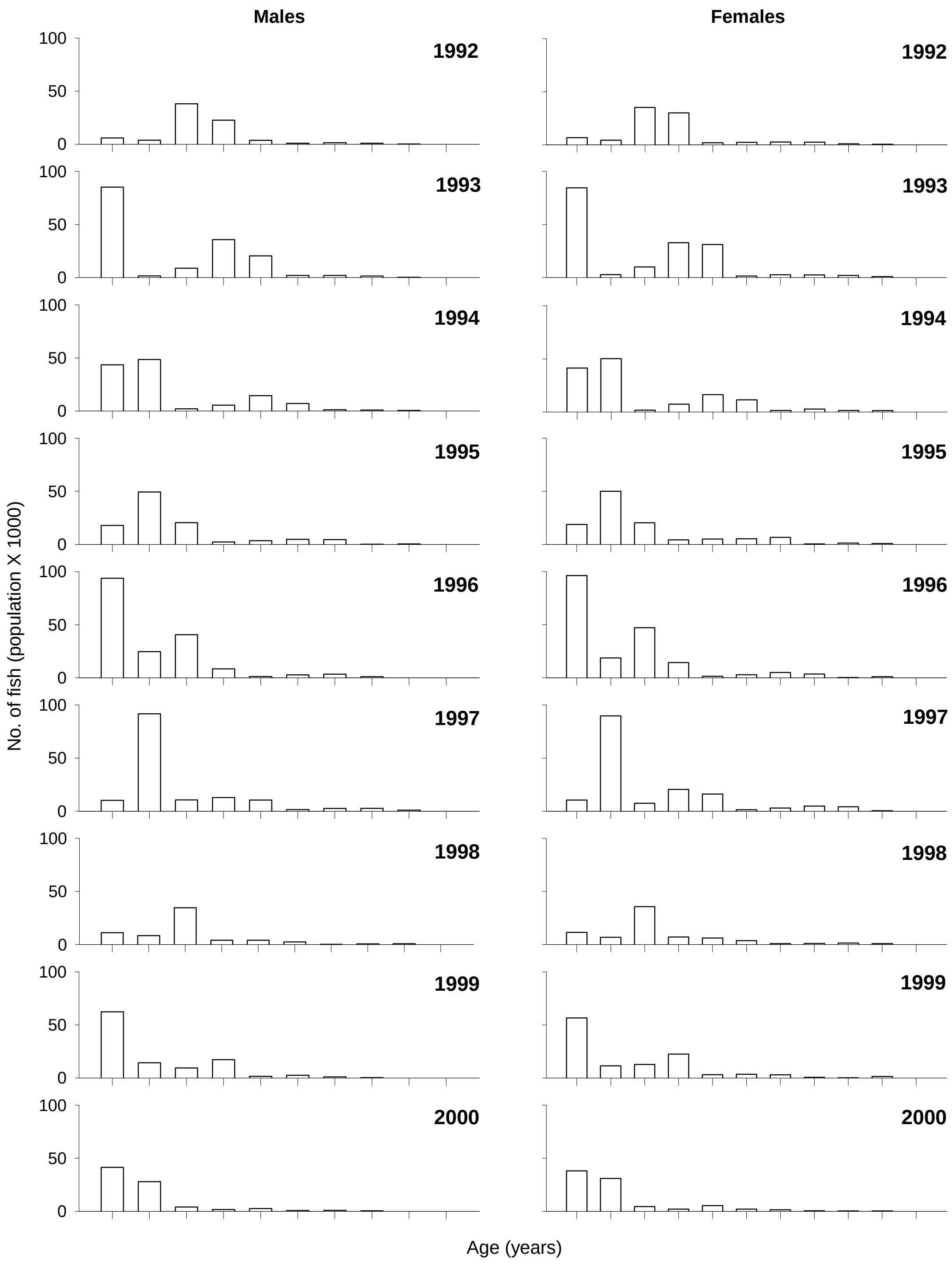

Figure 11: Estimated population numbers at age of hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2010. (+, indicates plus group of combined ages.)

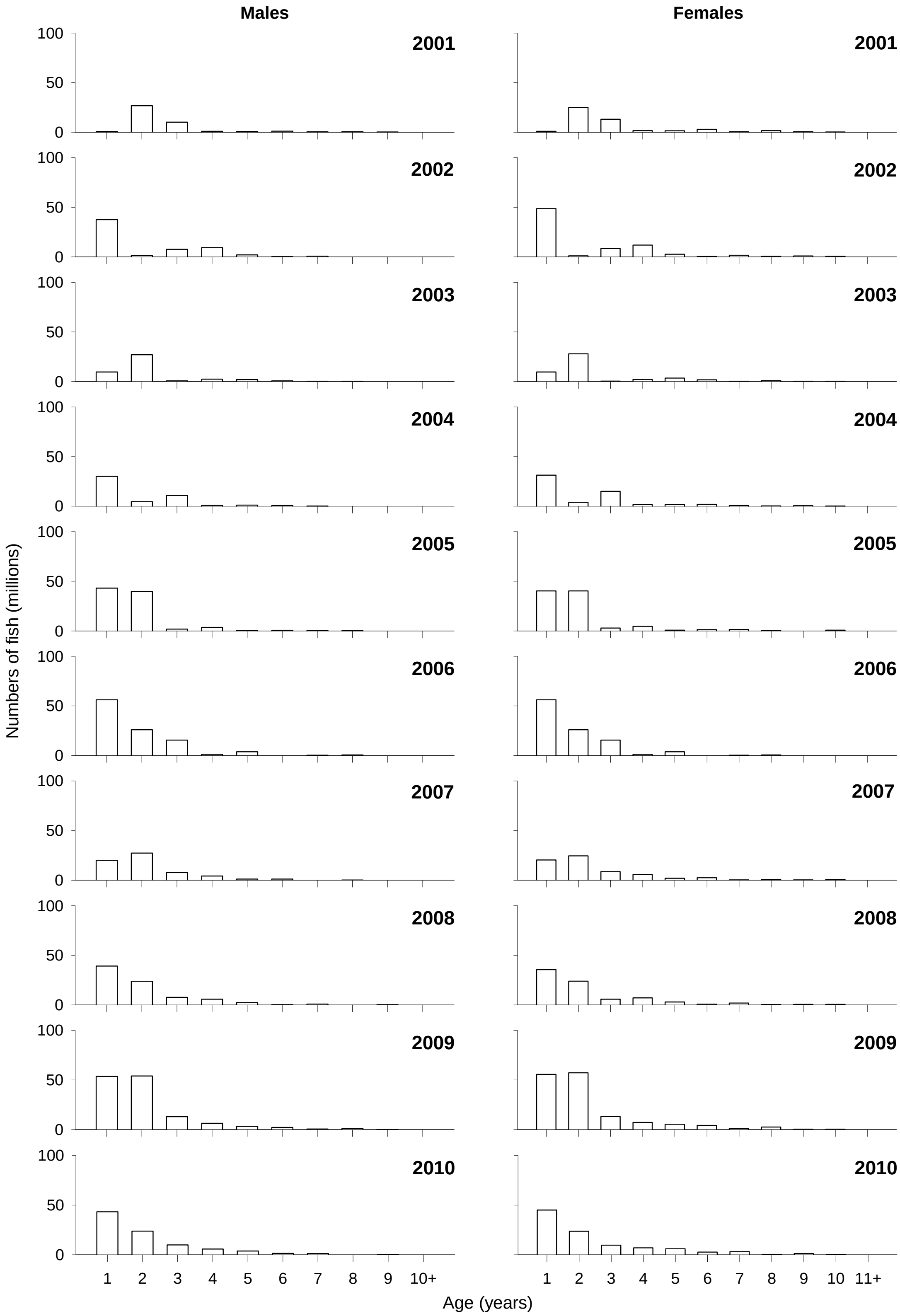

Figure 11 (continued)

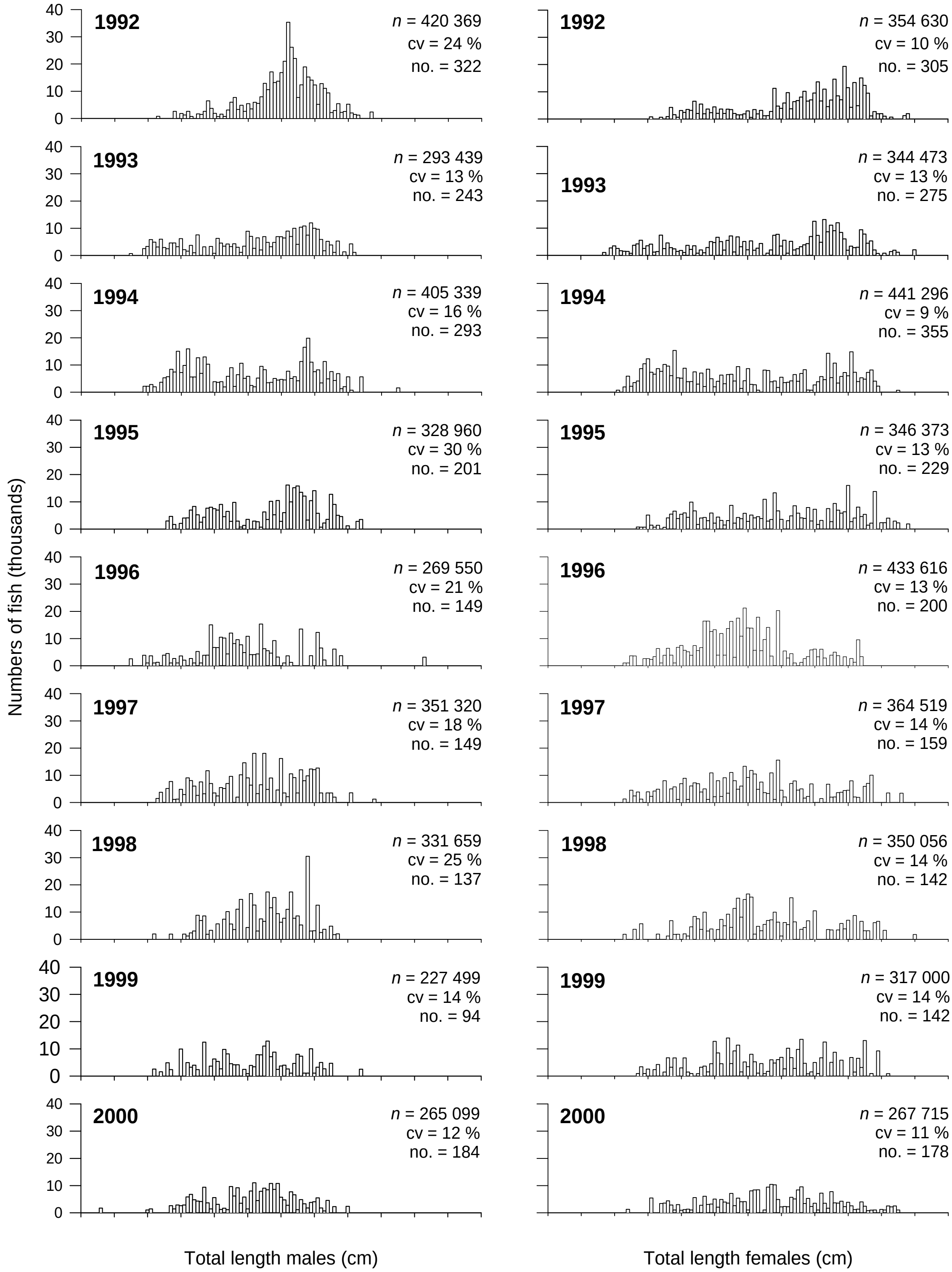

Figure 12: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2010. (c.v., coefficient of variation; *n,* estimated population number of hake; no., numbers of fish measured.)

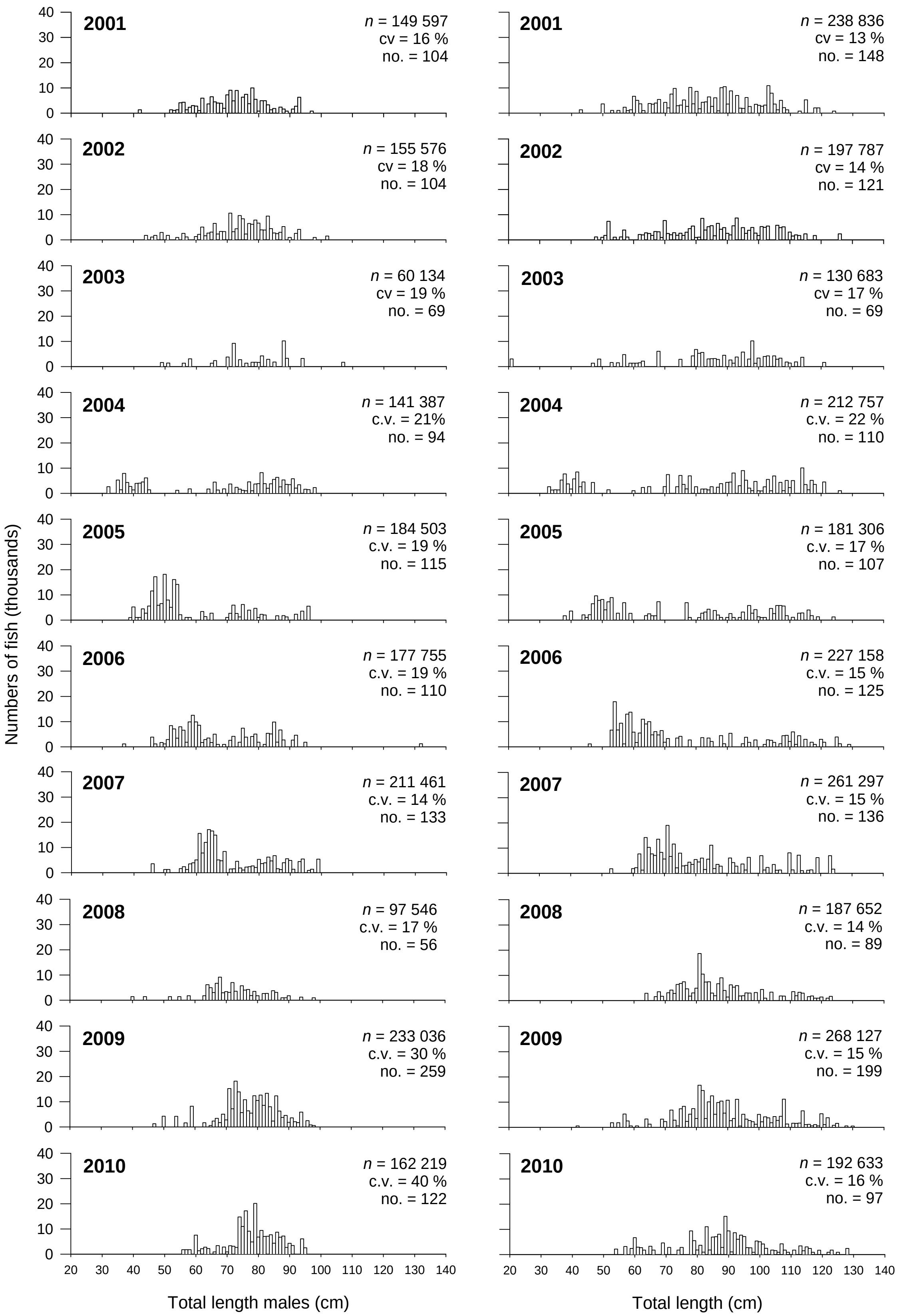

Figure 12 (continued)

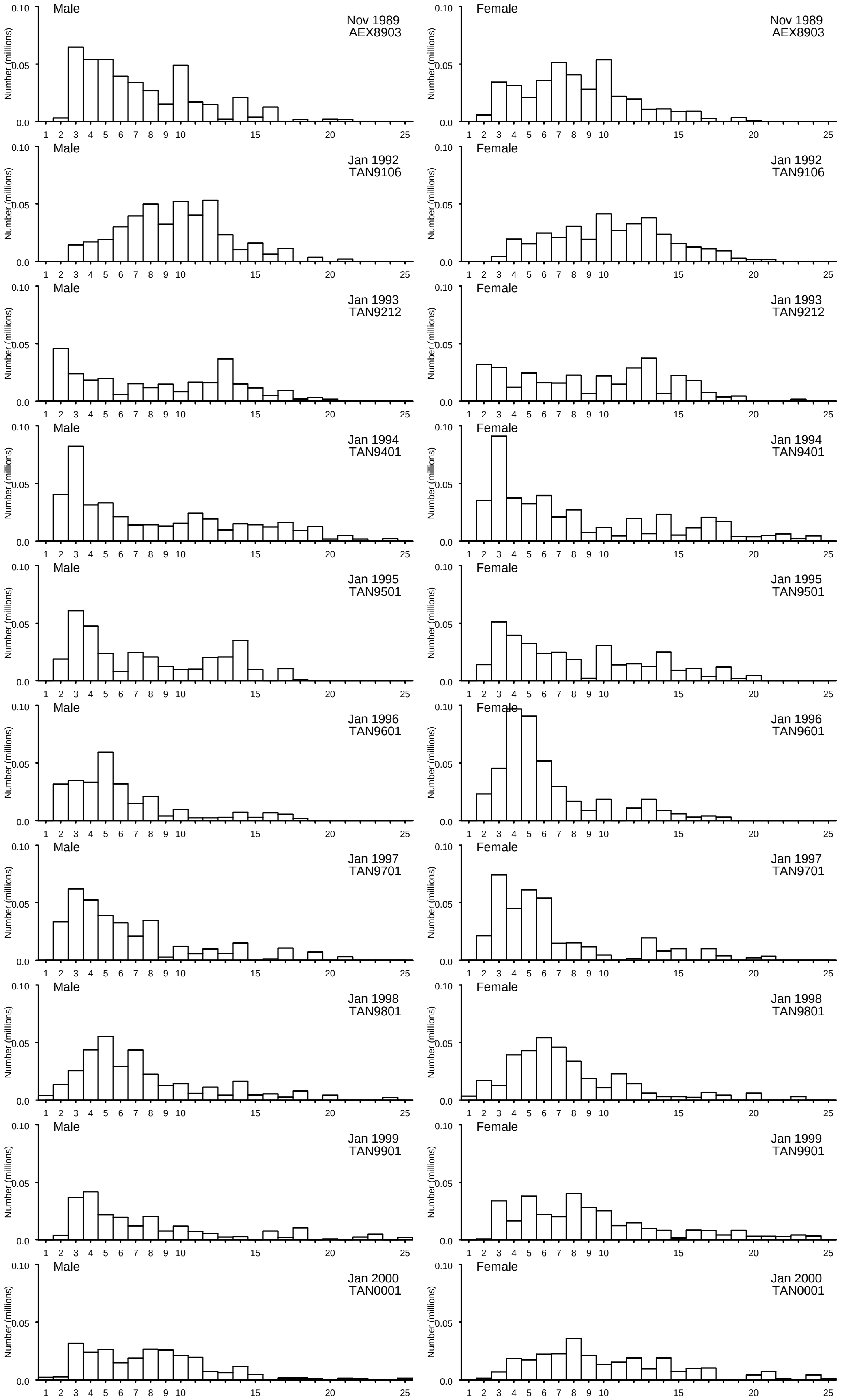

Figure 13: Estimated proportion at age of male and female hake from *Tangaroa* surveys of the Chatham Rise, January, 1992–2010

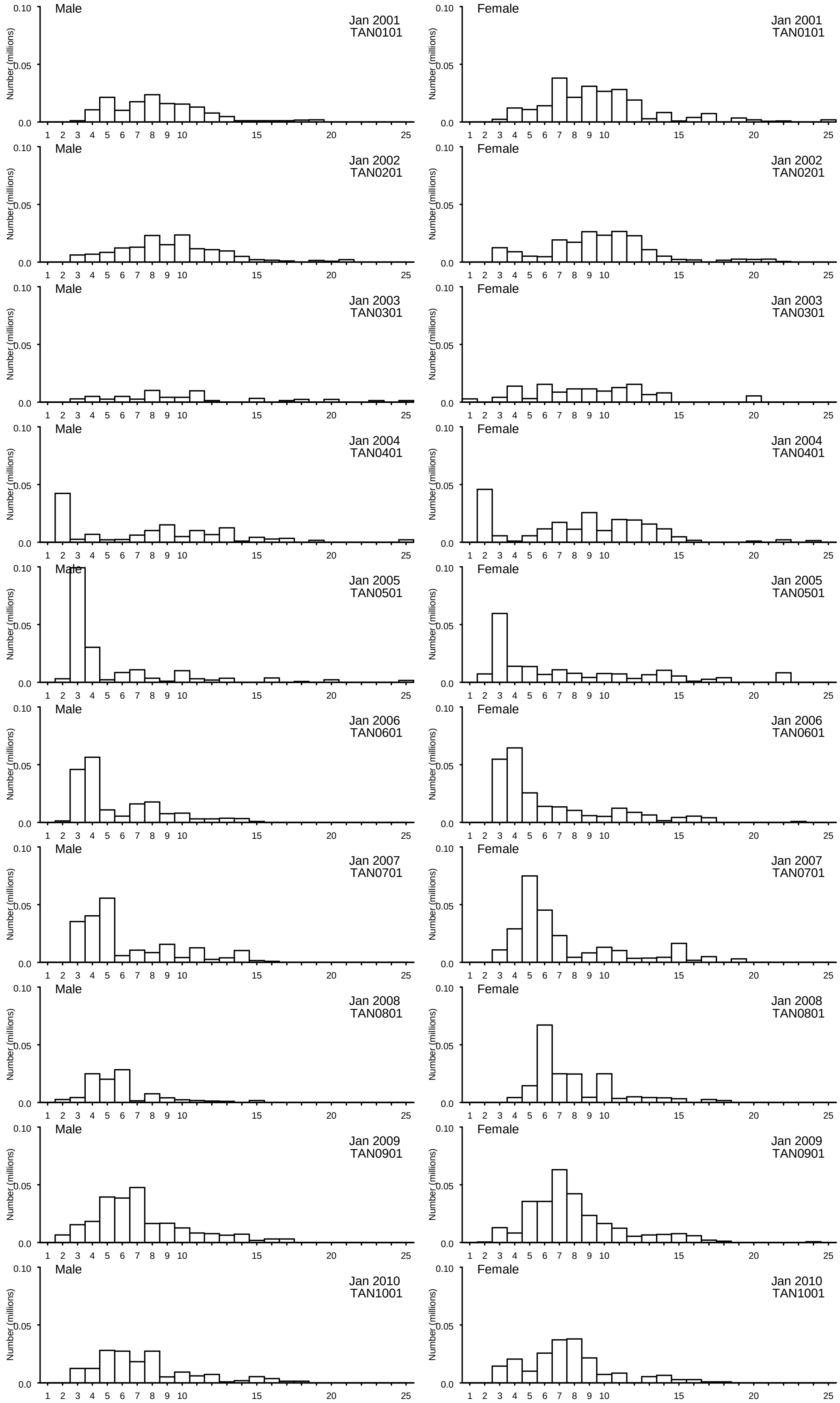

Figure 13 (continued)

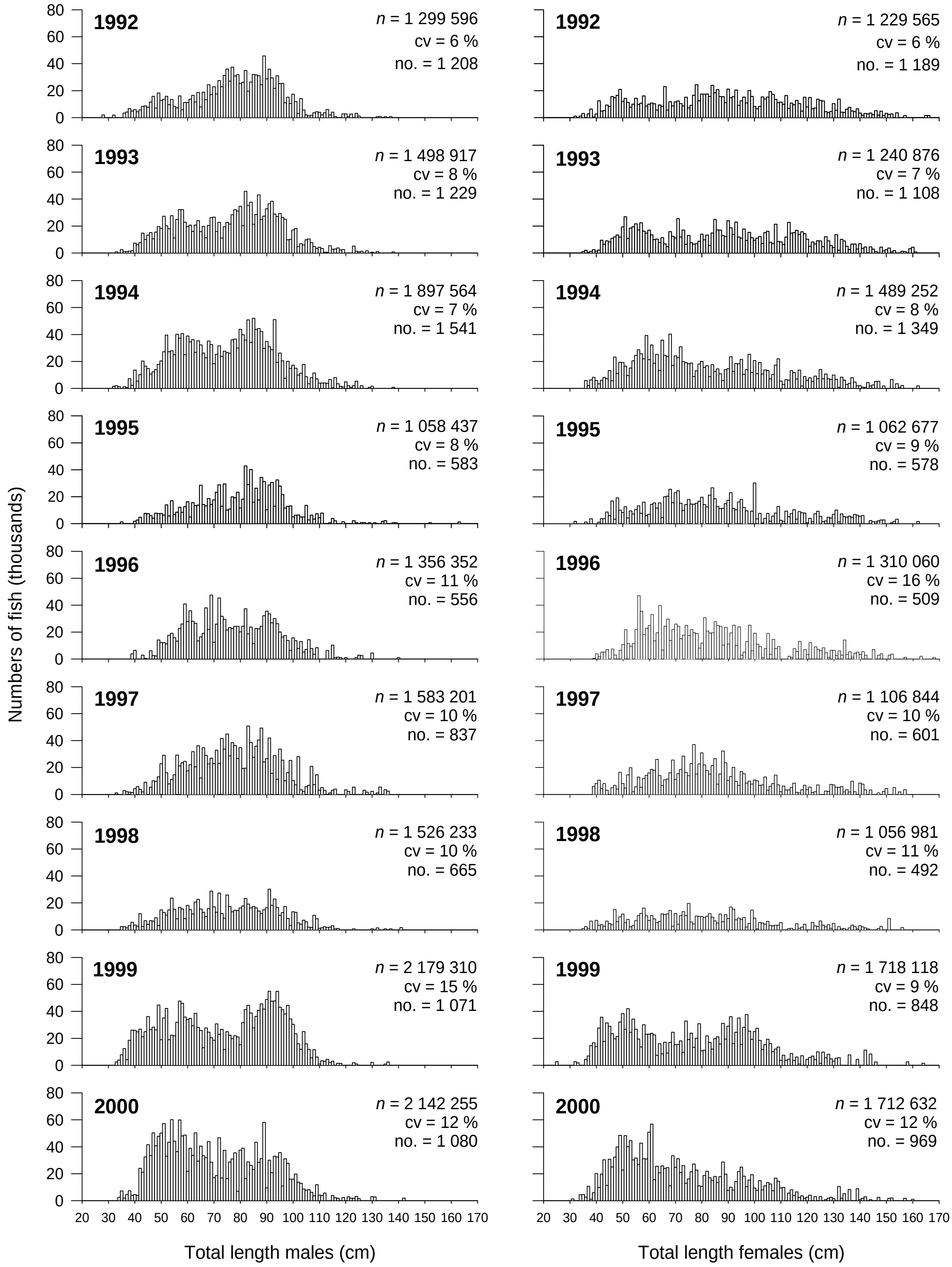

Figure 14: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2010. (c.v., coefficient of variation; *n*, estimated population number of ling; no., numbers of fish measured.)

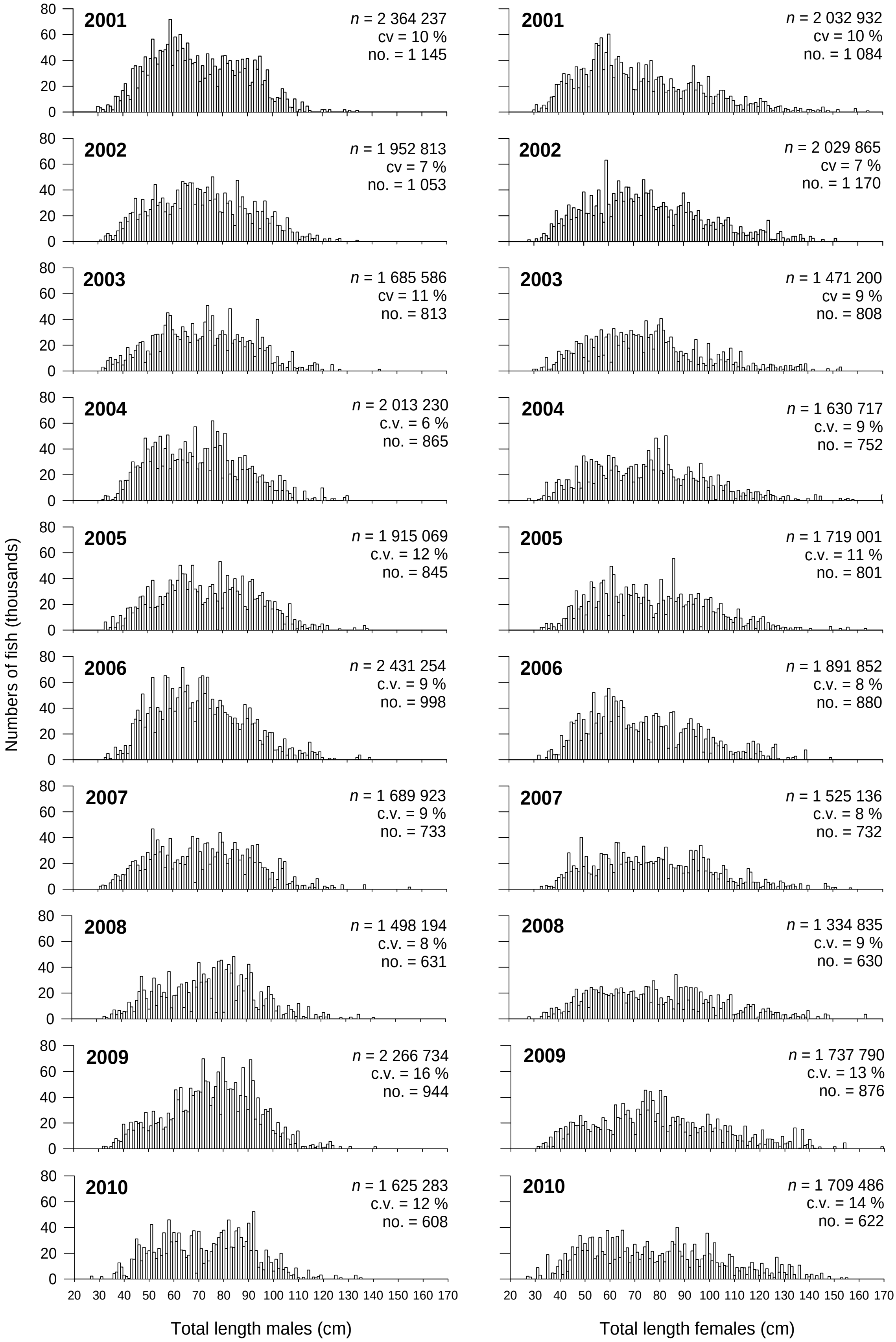

Figure 14 (continued)

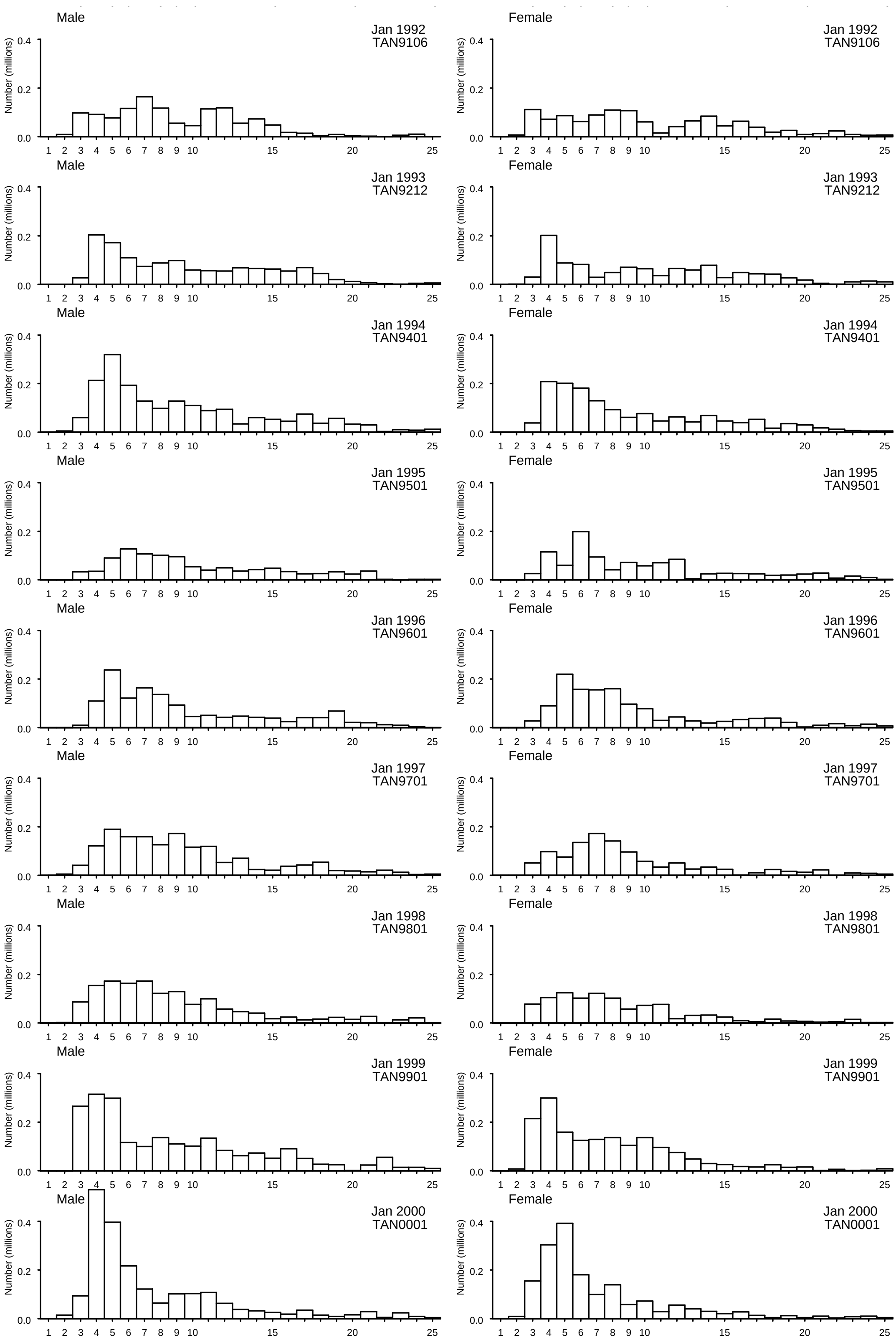

Figure 15: Estimated population numbers at age of male and female ling from *Tangaroa* surveys of the Chatham Rise, January, 1992–2010.

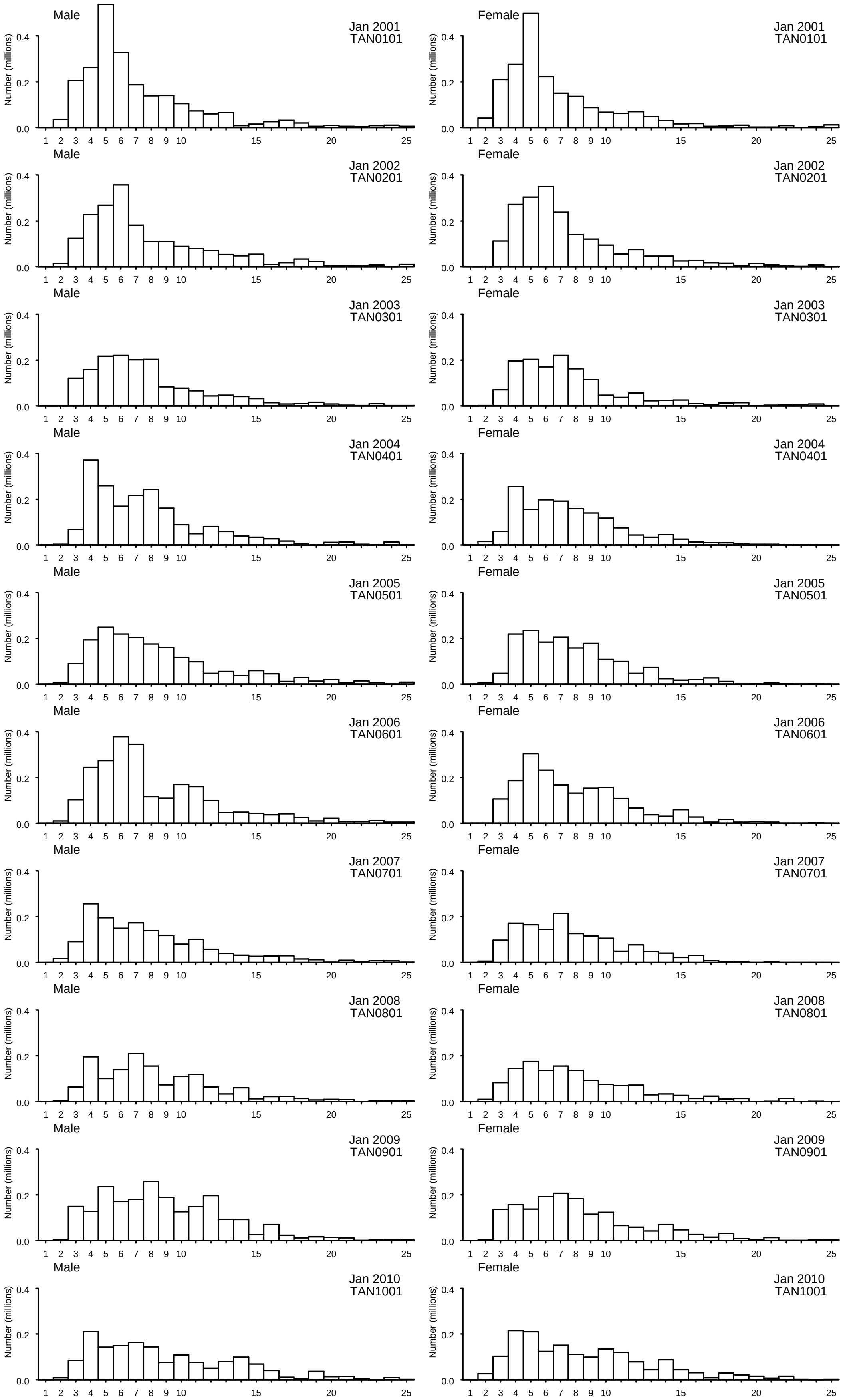

Figure 15 (continued)

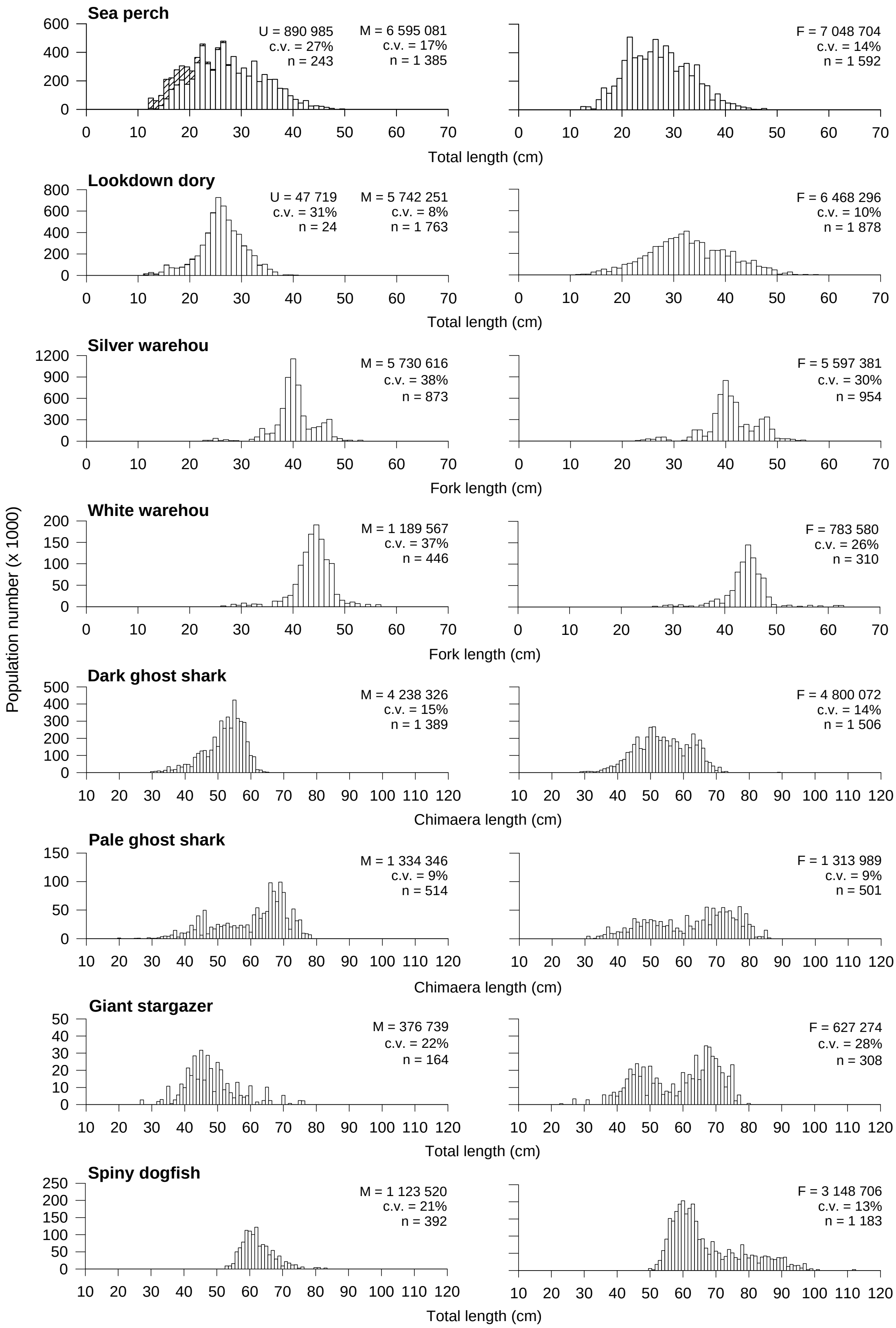

Figure 16: Length frequencies of selected commercial species on the Chatham Rise 2010, scaled to population size by sex (M, estimated male population; F, estimated female population; U, estimated unsexed population (hatched bars); c.v. coefficient of variation of the estimated numbers of fish; n, number of fish measured).

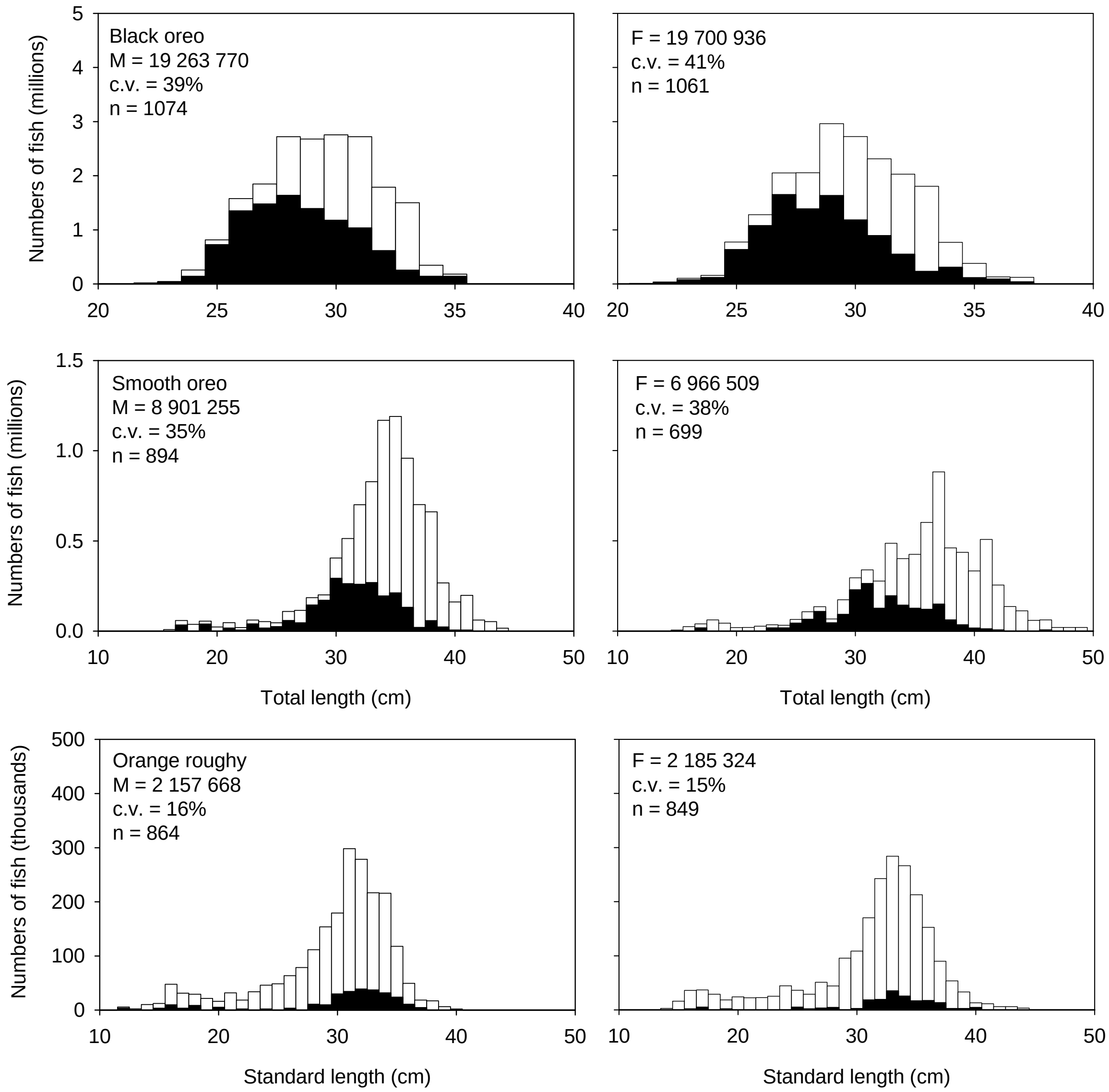

Figure 16 (continued): Length frequencies of selected deepwater species on the Chatham Rise 2010, scaled to population size by sex (M, estimated male population; F, estimated female population; c.v. coefficient of variation of the estimated numbers of fish; n, number of fish measured). White bars show fish from all (200–1300 m) strata. Black bars show fish from core (200–800 m) strata only.

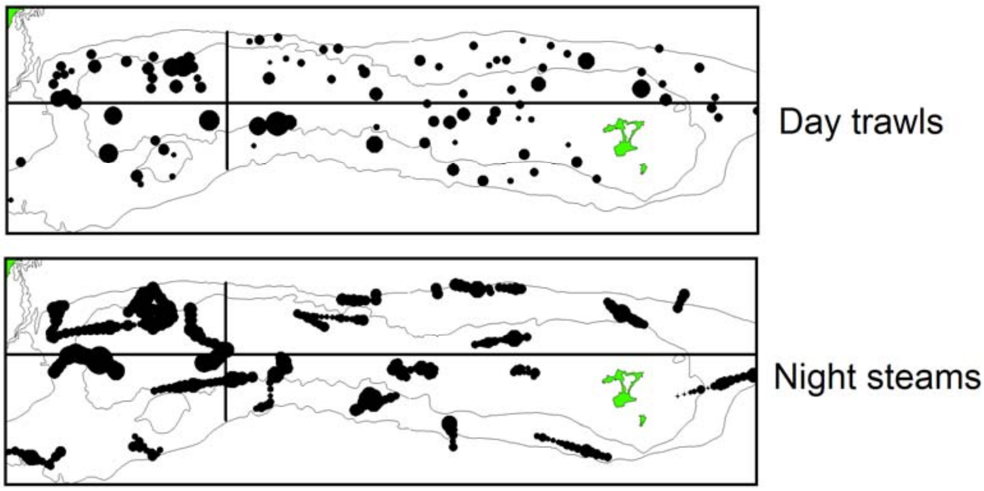

Figure 17: Distribution of total acoustic backscatter observed on the Chatham Rise during daytime trawls and night-time steams in January 2010. Circle area is proportional to the acoustic backscatter (maximum symbol size = 500 m^2/km^2). Lines separate the four acoustic strata.

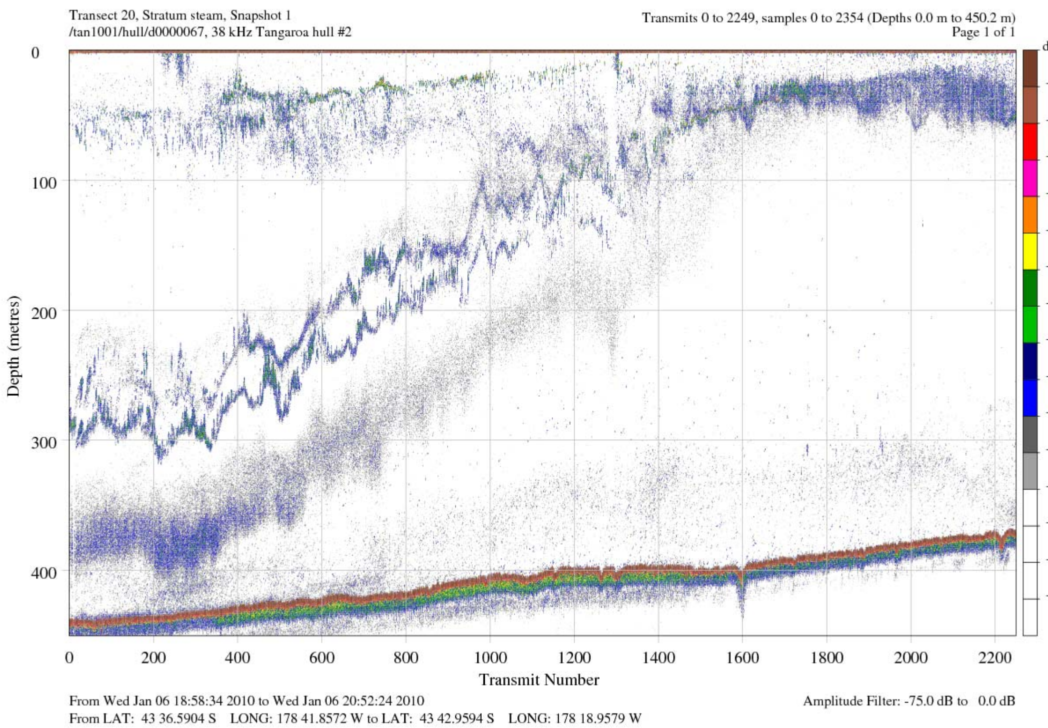

Figure 18: Example of 38 kHz acoustic echogram showing vertical migration of pelagic layers between 19:00 and 21:00 NZDT.

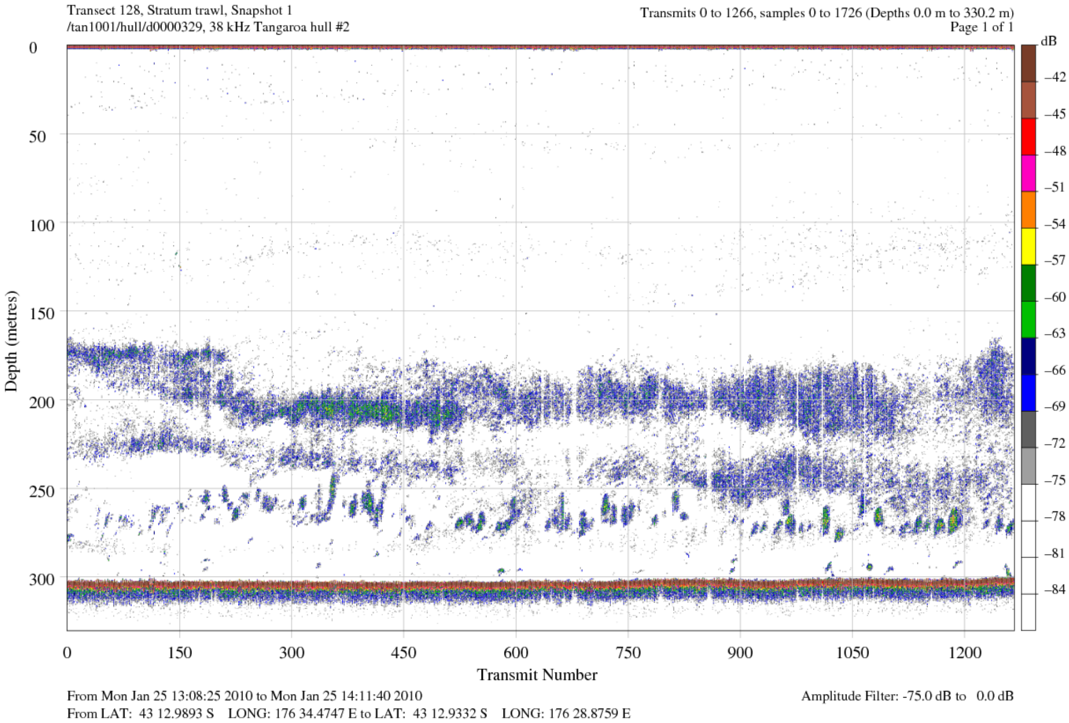

Figure 19: Example of 38 kHz acoustic echogram showing bottom schools between 250 and 270 m. This recording was made during trawl 128 which caught 17 t of silver warehou. There are pelagic layers above at 160–250 m depth.

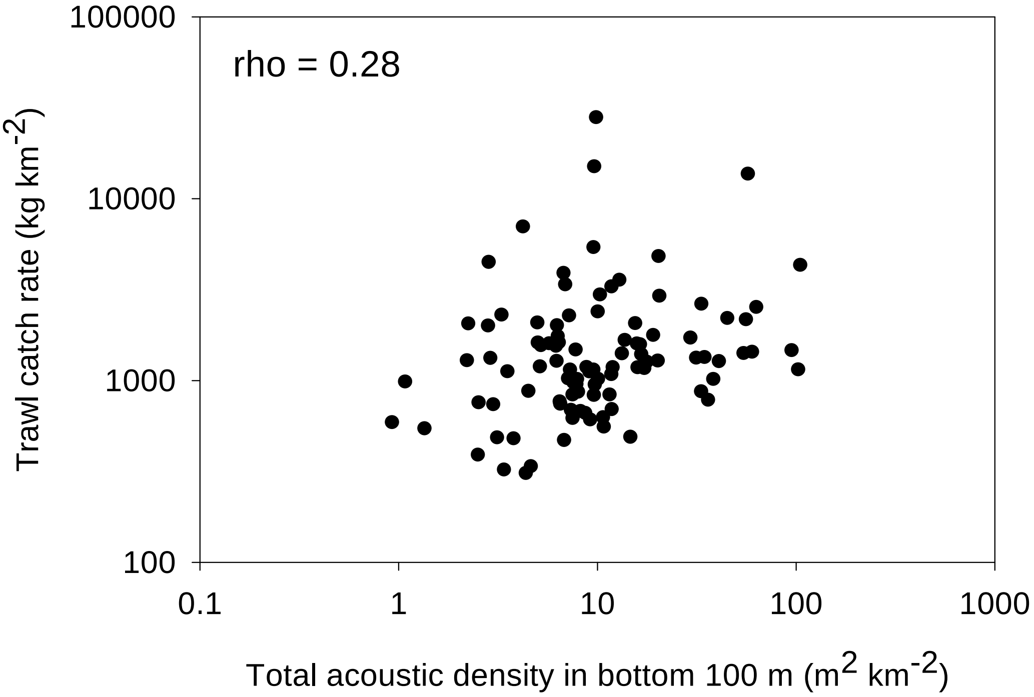

Figure 20: Relationship between total trawl catch rate (all species combined) and bottom-referenced acoustic backscatter recorded during the trawl on the Chatham Rise in 2010. Rho value is Spearman's rank correlation coefficients.

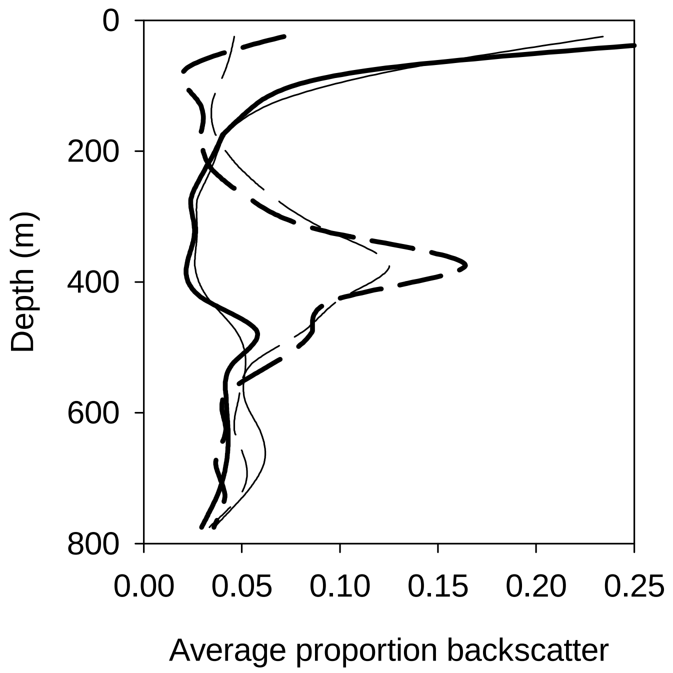

Figure 21. Distribution of total acoustic backscatter integrated in 50 m depth bins on the Chatham Rise observed during the day (dashed lines) and at night (solid lines) in 2010 (bold lines) and average distribution from 2001–10 (thin lines).

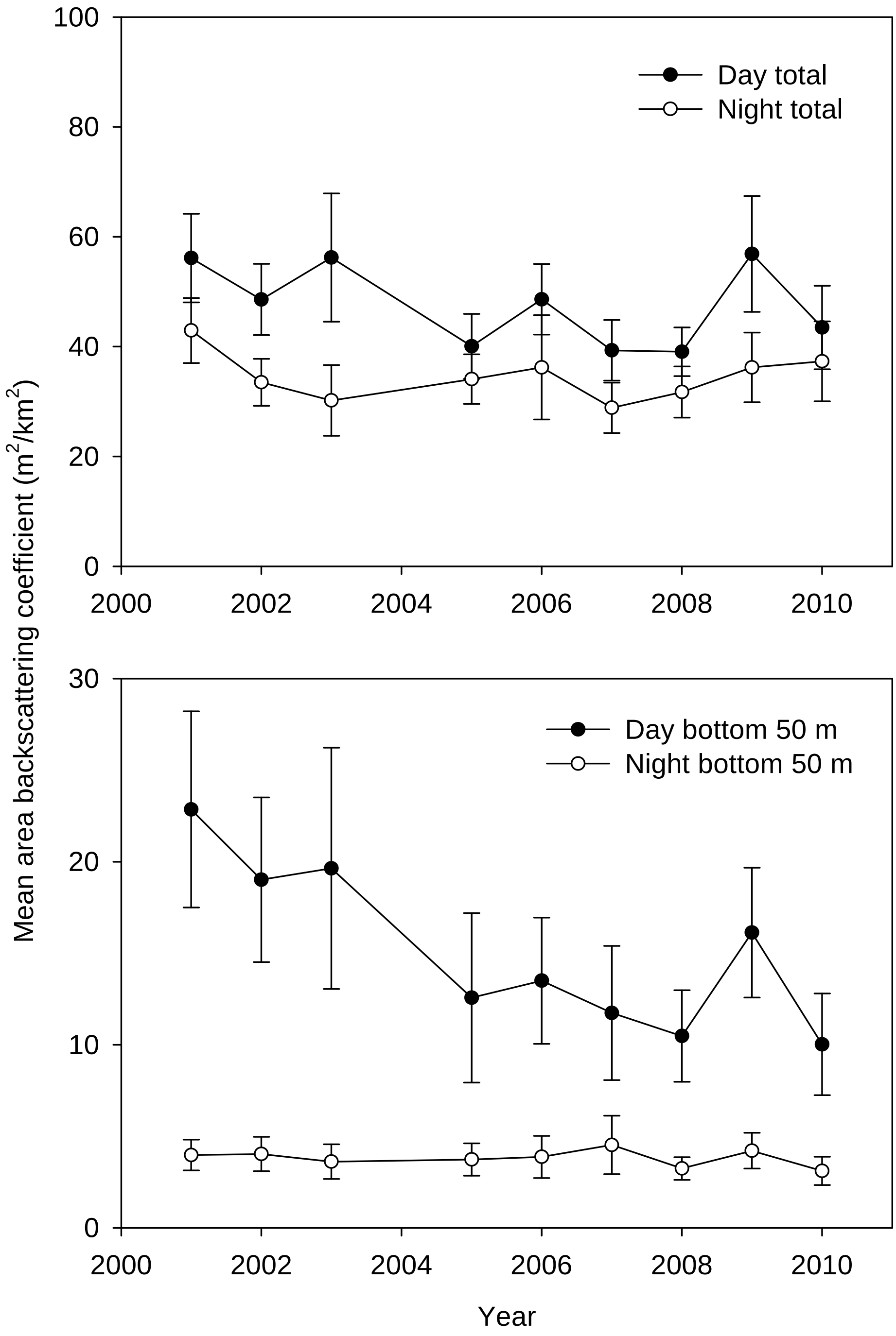

Figure 22: Comparison of relative acoustic abundance indices for the Chatham Rise based on (strata-averaged) mean areal backscatter (s_a). Error bars are ± 2 standard errors.

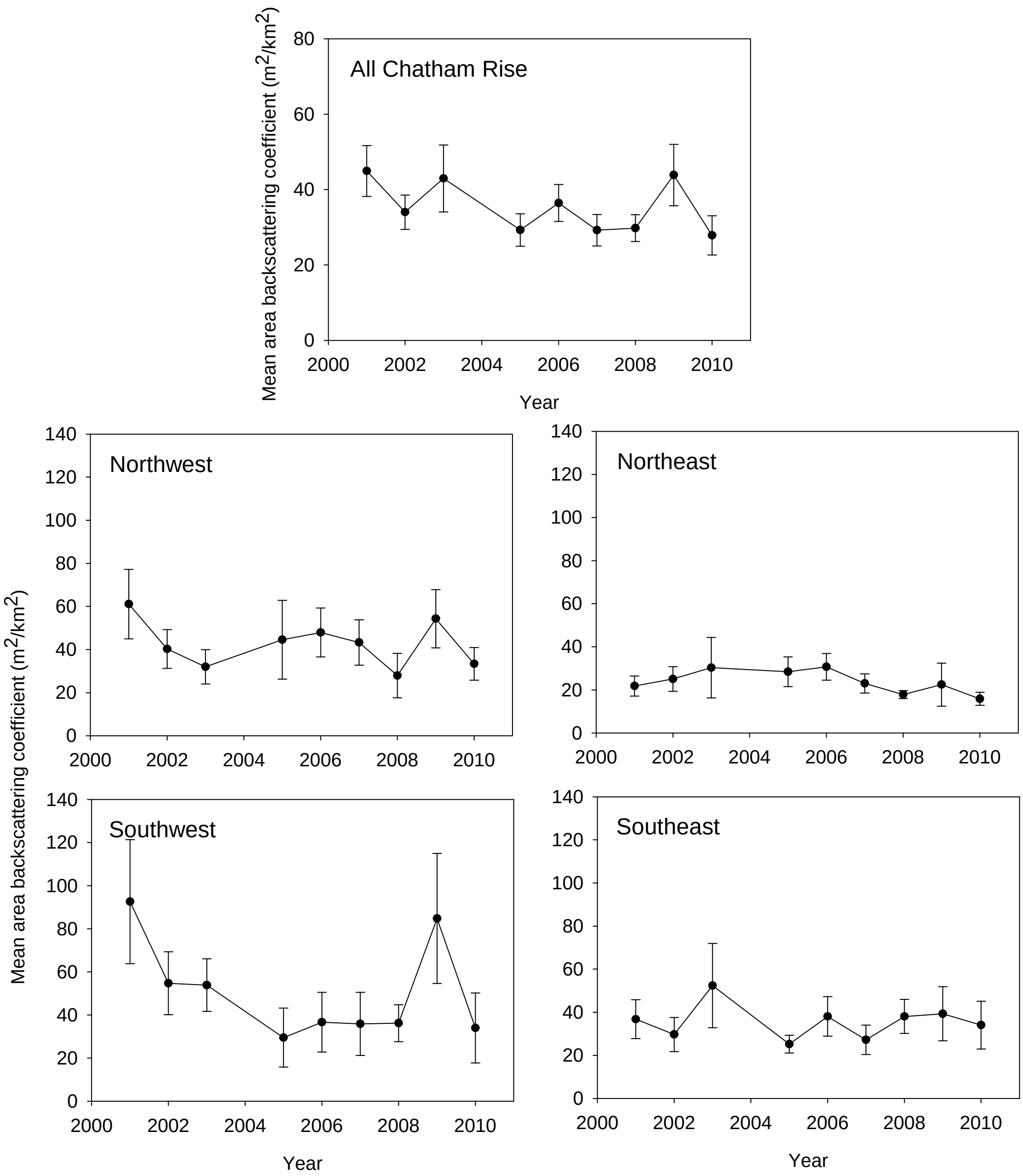

Figure 23: Relative acoustic abundance indices for mesopelagic fish on the Chatham Rise. Indices were derived by multiplying the total backscatter observed at each daytime trawl station by the estimated proportion of night-time backscatter in the same sub-area observed in the upper 200 m corrected for the estimated proportion in the surface deadzone (see Table 15). Panels show indices for the entire Chatham Rise and for four sub-areas. Error bars are approximate 95% confidence intervals from bootstrapping.

Appendix 1: TAN1001 EK60 calibration

A1.1 Methods

Calibration of the 18, 38, 70, 120, and 200 kHz EK60 echosounders on *Tangaroa* was performed on 27 January 2010 in Palliser Bay, at the end of the Chatham Rise trawl survey. The calibration was conducted broadly as per the procedures of MacLennan & Simmonds (1992).

The calibration data were recorded in EK60 raw format files. These data are stored in the NIWA Fisheries Acoustics Database. The EK60 transceiver settings in effect during the calibration are given in Table A1.1.

The vessel drifted in about 50 m of water in Palliser Bay (41˚ 29.62 S, 175˚ 07.32 W) and a weighted line was passed under the keel to facilitate setting up the three calibration lines and calibration sphere. A lead weight was deployed 2 m below the sphere to steady the arrangement of lines. The sphere and associated lines were immersed in a soap solution before entering the water, and the sphere centred in the beam of the 38 kHz transducers to obtain data for the on-axis calibration. It was then moved around to obtain data for the beam shape calibration. There was not enough time to completely cover the beam of all transducers because of impending sunset. However, the close proximity of all five transducers meant that a fair amount of echoes were recorded across all frequencies.

The weather during the calibration was good, with 10 knots of wind and no swell. There was a noticeable current that dragged the lines away from their intended positions.

A temperature/salinity/depth profile was taken using a Seabird SBE21 conductivity, temperature, and depth probe (CTD). Estimates of acoustic absorption were calculated using the formulae in Doonan et al. (2003). The formula from Francois & Garrison (1982) was used at 200 kHz. Estimates of seawater sound speed and density were calculated using the formulae of Fofonoff & Millard (1983). The sphere target strength was calculated as per equations 6 to 9 in MacLennan (1981), using longitudinal and transverse sphere sound velocities of 6853 and 4171 m/s respectively and a sphere density of 14 900 kg/m^3.

A1.2 Analysis

The data in the .raw EK60 files were extracted using custom-written software. The amplitude of the sphere echoes was obtained by filtering on range, and choosing the sample with the highest amplitude. Instances where the sphere echo was disturbed by fish echoes were discarded. The alongship and athwartship beam widths and offsets were calculated by fitting the sphere echo amplitudes to the Simrad theoretical beam pattern:

$$compensation = 6.0206\left(\left(\frac{2\theta_{fa}}{BW_{fa}}\right)^2 + \left(\frac{2\theta_{ps}}{BW_{pw}}\right)^2 - 0.18\left(\frac{2\theta_{fa}}{BW_{fa}}\right)^2\left(\frac{2\theta_{ps}}{BW_{pw}}\right)^2\right),$$

where θ_{ps} is the port/starboard echo angle, θ_{fa} the fore/aft echo angle, BW_{ps} the port/starboard beamwidth, BW_{fa} the fore/aft beamwidth, and *compensation* the value, in dB, to add to an uncompensated echo to yield the compensated echo value. The fitting was done using an unconstrained nonlinear optimisation (as implemented by the Matlab `fminsearch` function). The S_a correction was calculated from:

$$Sa, corr = 5\log10\left(\frac{\sum P_i}{4P_{\max}}\right),$$

where P_i is sphere echo power measurements and P_{max} the maximum sphere echo power measurement. A value for $S_{a,corr}$ is calculated for all valid sphere echoes and the mean over all sphere echoes is used to determine the final $S_{a,corr}$.

A1.3 Discussion

The results from the temperature/depth cast are given in Table A1.2, along with estimates of the sphere target strength, sound speed, and acoustic absorption for 18, 38, 70, 120, and 200 kHz.

The calibration parameters resulting from the calibration are given in Table A1.3 along with results from previous calibrations. It is important to note that the 38 kHz and 70 kHz systems were calibrated in the Ross Sea in February 2008, where the water temperature was -1.44 °C, considerably lower than during the following calibrations. The effect of water temperature on transducer parameters and performance is not precisely known, but has been reported to have a significant effect at some frequencies (Demer & Renfree 2008) and any large differences between the two sets of results should not be taken as a permanent shift in system performance. Also, the 70 kHz transducer was in a different location during the voyage to the Ross Sea and this can also affect transducer performance. Despite this, results for the 38 kHz are fairly consistent across all three calibrations. The transducer peak gain for the 70 kHz is also similar across all three calibrations; however, the Sa corrections differ significantly. Sa correction values between tan0802 and tan1001 differ by only 0.02 dB, but there's a change of more than 0.05 dB with the tan0806 calibration.

For the other three frequencies (18, 120, and 200 kHz) there was only one other calibration (tan0806) for comparison. Despite less than ideal beam coverage, parameter values did not differ much from the previous calibration, with the exception of the Sa correction value on the 200 kHz, which shows a 30% increase (0.11 dB).

The estimated beam patterns, as well as the coverage of the beam by the calibration sphere, are given in Figures A1.1–A1.10. The symmetrical nature of the beam patterns and the centering on zero indicates that the transducers and EK60 transceivers were operating correctly. The RMS of the difference between the Simrad beam model and the sphere echoes out to the 3dB beamwidth was always less than 0.2 dB (Table A1.3), indicating excellent quality calibrations (<0.4 dB is acceptable, <0.3 dB good, and <0.2 dB excellent). This is, however, confounded by the fact that the beam coverage was not complete, particularly on the 18, 120, and 200 kHz.

Table A1.1. EK60 transceiver settings and other relevant parameters in effect during the calibration.

Parameter					
Frequency (kHz)	18	38	70	120	200
GPT model	GPT-Q18(2)-S 1.0 00907205c476	GPT-Q38(4)-S 1.0 00907205c463	GPT-Q70(1)-S 1.0 00907205ca98	GPT-Q120(1)-S 1.0 009072058148	GPT-Q120(1)-S 1.0 009072058148
GPT serial number	652	650	674	668	692
GPT software version	050112	050112	050112	050112	050112
ER60 software version	2.1.2	2.1.2	2.1.2	2.1.2	2.1.2
Transducer model	Simrad ES18-11	Simrad ES38	Simrad ES70-7C	Simrad ES120-7C	Simrad ES200-7C
Transducer serial number	2080	23083	158	477	364
Sphere type/size	tungsten carbide/38.1 mm diameter (same for all frequencies)				
Transducer draft setting (m)	0.0	0.0	0.0	0.0	0.0
Transmit power (W)	2000	2000	1000	500	300
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Transducer peak gain (dB)	22.4	26.5	27.0	27.0	27.0
Sa correction (dB)	0.0	0.0	0.0	0.0	0.0
Bandwidth (Hz)	1570	2430	2860	3030	3090
Sample interval (m)	0.191	0.191	0.191	0.191	0.191
Two-way beam angle (dB)	–17.0	–20.60	–21.0	–21.0	–20.70
Absorption coefficient (dB/km)	2.67	9.79	22.79	37.44	52.69
Speed of sound (m/s)	1494	1494	1494	1494	1494
Angle sensitivity (dB) alongship/athwartship	13.90/13.90	21.90/21.90	23.0/23.0	23.0/23.0	23.0/23.0
3 dB beamwidth (º) alongship/athwartship	11.0/11.0	7.10/7.10	7.0/7.0	7.0/7.0	7.0/7.0
Angle offset (º) alongship/athwartship	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0

Table A1.2. CTD cast details and derived water properties. The values for sound speed, salinity and absorption are the mean over water depths 4 to 20 m.

Parameter	
Date/time (NZST, start)	27 January 2010 18:40
Position	41˚ 29.62 S 175˚ 07.32 W
Mean sphere range (m)	18.7 (18 kHz), 17.9 (38), 18.7 (70), 18.7 (120), 18.7 (200)
Mean temperature (ºC)	15.1
Mean salinity (psu)	34.7
Sound speed (m/s)	1506.8
Water density (kg/m^3)	1025.8
Sound absorption (dB/km)	2.16 (18 kHz) 8.68 (38 kHz) 22.63 (70 kHz) 41.43 (120 kHz) 65.36 (200 kHz)
Sphere target strength (dB re 1m^2)	–42.56 (18 kHz) –42.42 (38 kHz) –41.52 (70 kHz) –39.58 (120 kHz) –38.94 (200 kHz)

Table A1.3. Calibration results, past and present. Note that the February 2008 measurements were conducted in –1.4 °C seawater and the 70 kHz was at a different location. For the 2010 calibration, percent difference from the May 2008 calibration values are shown in parentheses.

		January 2010	May 2008	February 2008
18 kHz				
	Transducer peak gain (dB)	23.00 (0.2%)	22.96	
	Sa correction (dB)	-0.76 (6.6 %)	–0.81	
	Beamwidth (º) alongship/athwartship	11.0/11.3	10.8/10.8	
	Beam offset (º) alongship/athwartship	0.00/0.00	0.00/0.00	
	RMS deviation (dB)	0.14	0.26	
38 kHz				
	Transducer peak gain (dB)	25.95 (0.5%)	25.81	25.85
	Sa correction (dB)	-0.59 (3.4%)	–0.57	–0.53
	Beamwidth (º) alongship/athwartship	6.9/6.9	7.0/7.0	7.0/7.0
	Beam offset (º) alongship/athwartship	0.00/0.00	0.00/0.00	–0.04/0.04
	RMS deviation (dB)	0.11	0.16	0.13
70 kHz				
	Transducer peak gain (dB)	26.72 (1.2%)	26.43	26.58
	Sa correction (dB)	-0.30 (16.7%)	–0.35	–0.28
	Beamwidth (º) alongship/athwartship	6.3/6.4	6.6/6.6	6.7/6.6
	Beam offset (º) alongship/athwartship	0.00/0.00	0.00/0.00	–0.03/0.00
	RMS deviation (dB)	0.14	0.25	0.15
120 kHz				
	Transducer peak gain (dB)	26.74 (2.1%)	26.17	
	Sa correction (dB)	-0.35 (2.8%)	–0.36	
	Beamwidth (º) alongship/athwartship	6.1/6.4	6.5/6.6	
	Beam offset (º) alongship/athwartship	0.00/0.00	0.00/0.00	
	RMS deviation (dB)	0.16	0.35	
200 kHz				
	Transducer peak gain (dB)	25.03 (0.3%)	24.96	
	Sa correction (dB)	-0.36 (30.6%)	–0.25	
	Beamwidth (º) alongship/athwartship	6.7/6.7	6.8/6.9	
	Beam offset (º) alongship/athwartship	0.00/0.00	0.00/0.00	
	RMS deviation (dB)	0.18	0.39	

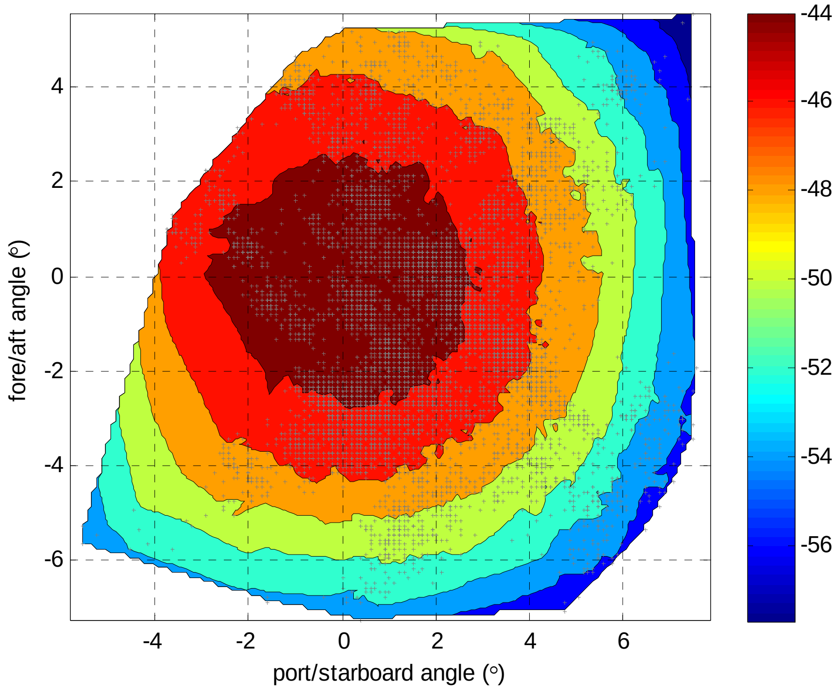

Figure A1.1. The 18 kHz estimated beam pattern from the sphere echo strength and position. The '+' symbols indicate where sphere echoes were received. The colours indicate the received sphere echo strength in dB re 1 m^2.

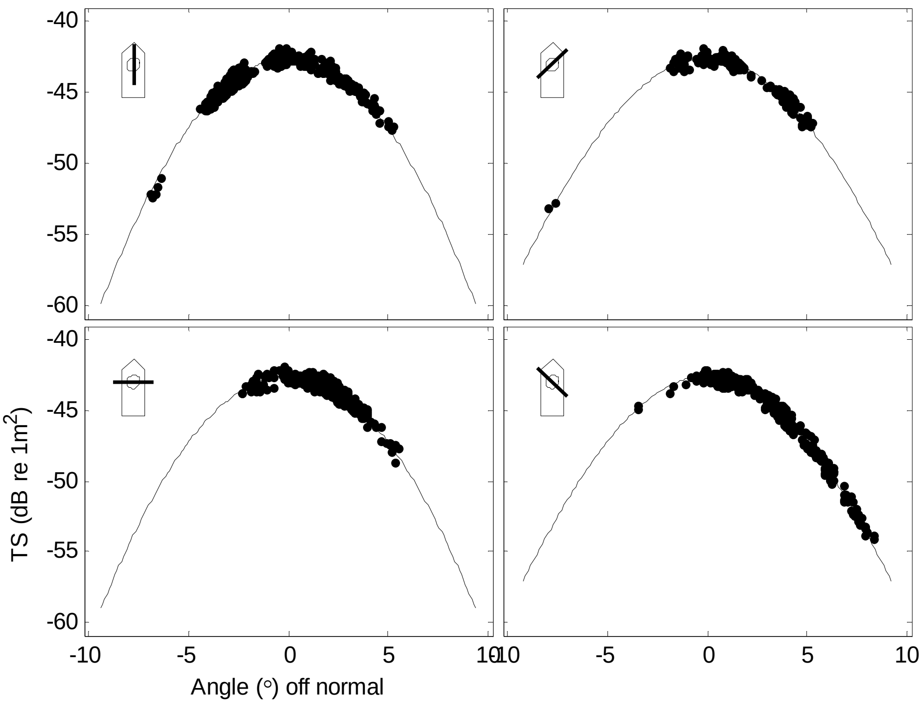

Figure A1.2. Beam pattern results from the 18 kHz analysis. The solid line is the ideal beam pattern fit to the sphere echoes for four slices through the beam.

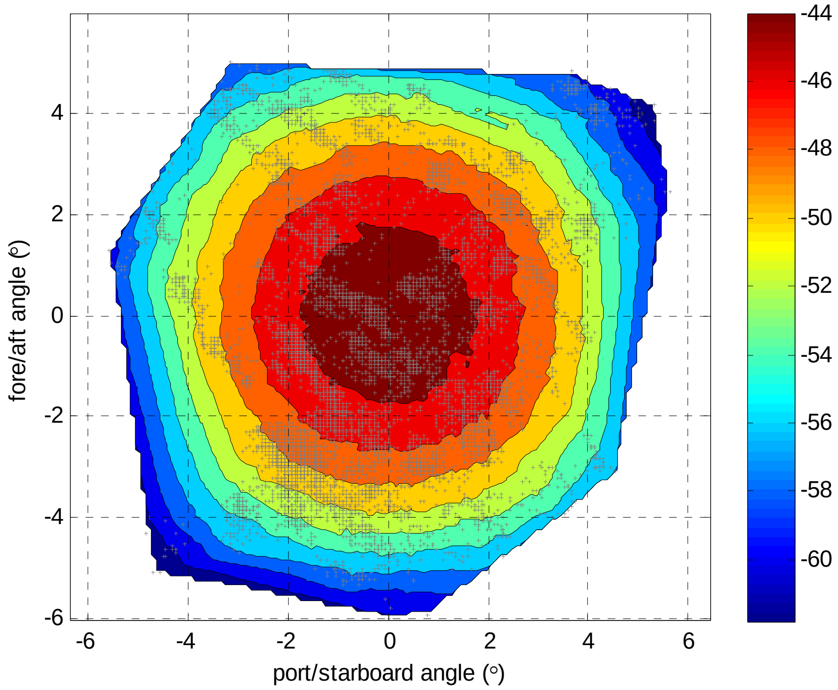

Figure A1.3. The 38 kHz estimated beam pattern from the sphere echo strength and position. The '+' symbols indicate where sphere echoes were received. The colours indicate the received sphere echo strength in dB re 1 m^2.

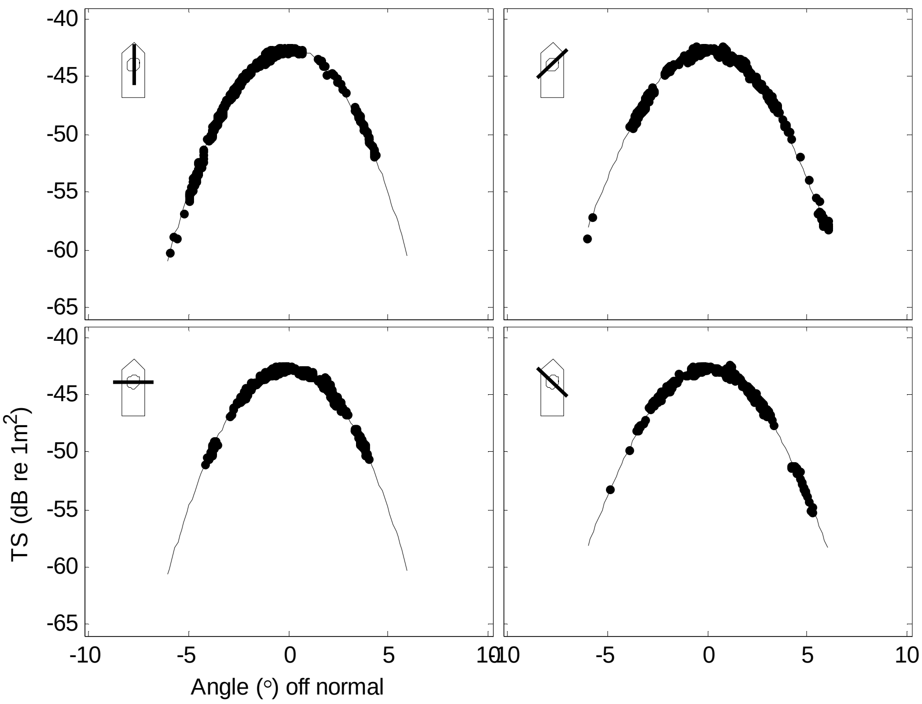

Figure A1.4. Beam pattern results from the 38 kHz analysis. The solid line is the ideal beam pattern fit to the sphere echoes for four slices through the beam.

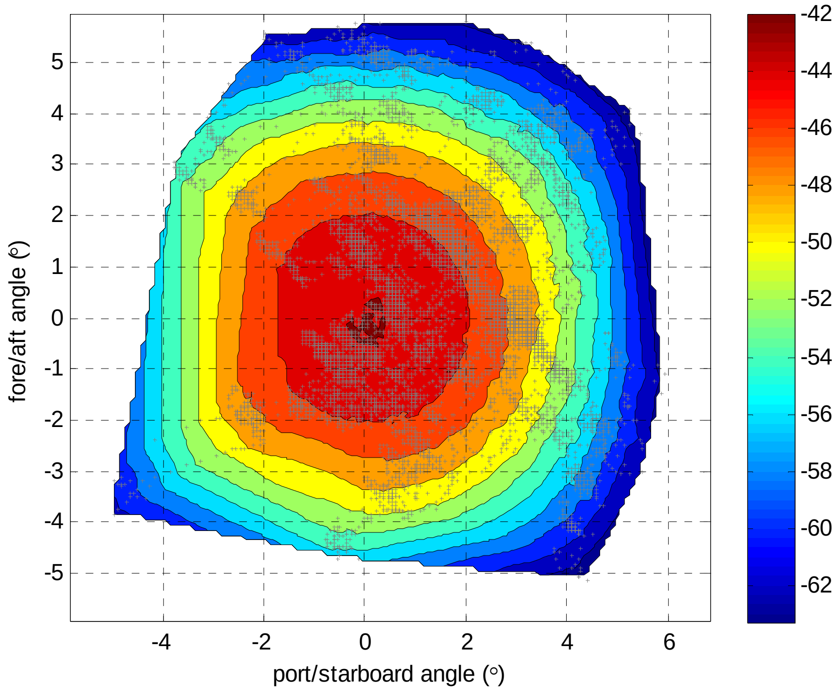

Figure A1.5. The 70 kHz estimated beam pattern from the sphere echo strength and position. The '+' symbols indicate where sphere echoes were received. The colours indicate the received sphere echo strength in dB re 1 m^2.

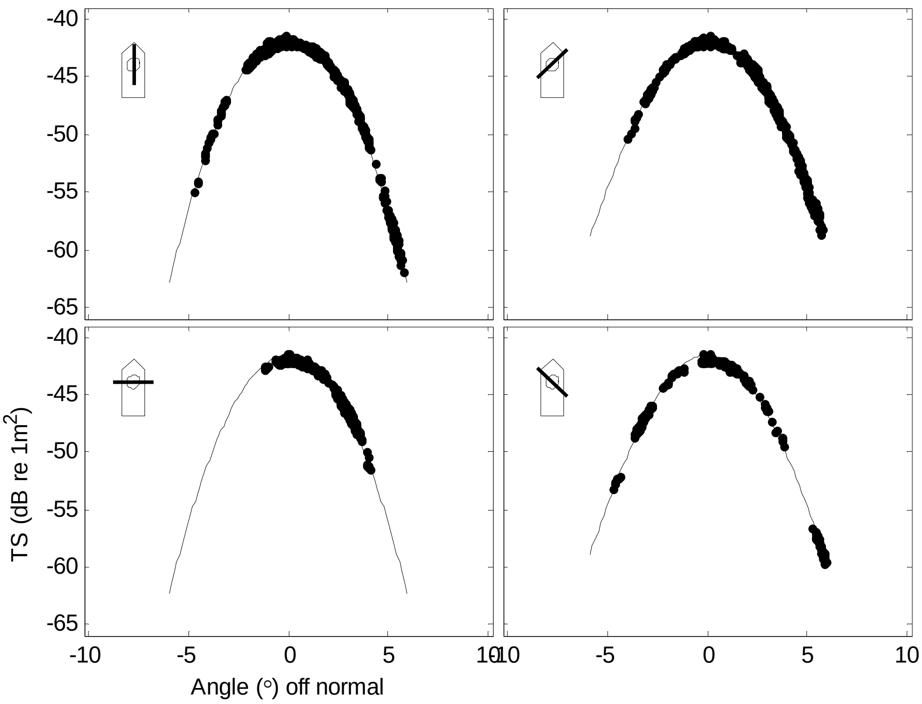

Figure A1.6. Beam pattern results from the 70 kHz analysis. The solid line is the ideal beam pattern fit to the sphere echoes for four slices through the beam.

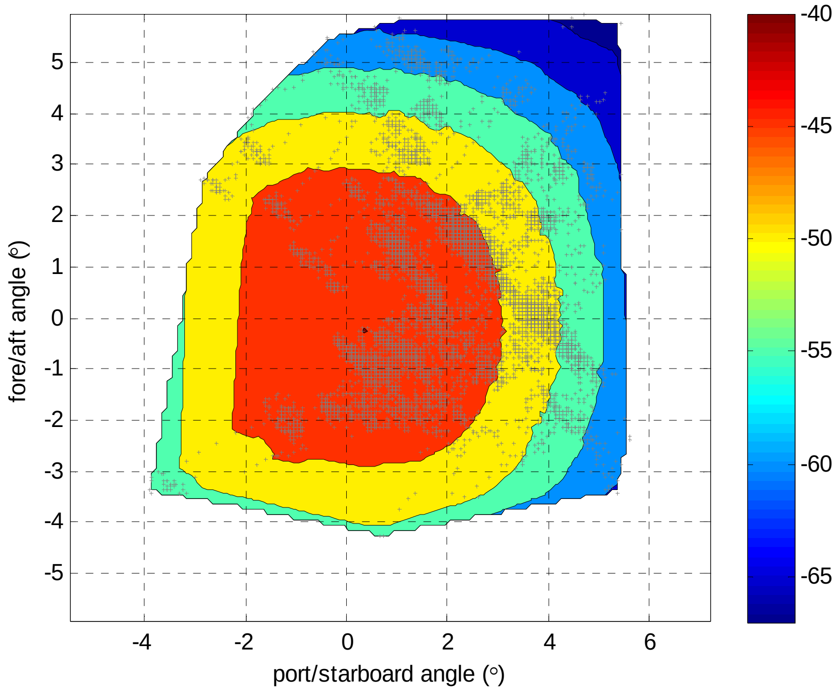

Figure A1.7. The 120 kHz estimated beam pattern from the sphere echo strength and position. The '+' symbols indicate where sphere echoes were received. The colours indicate the received sphere echo strength in dB re 1 m^2.

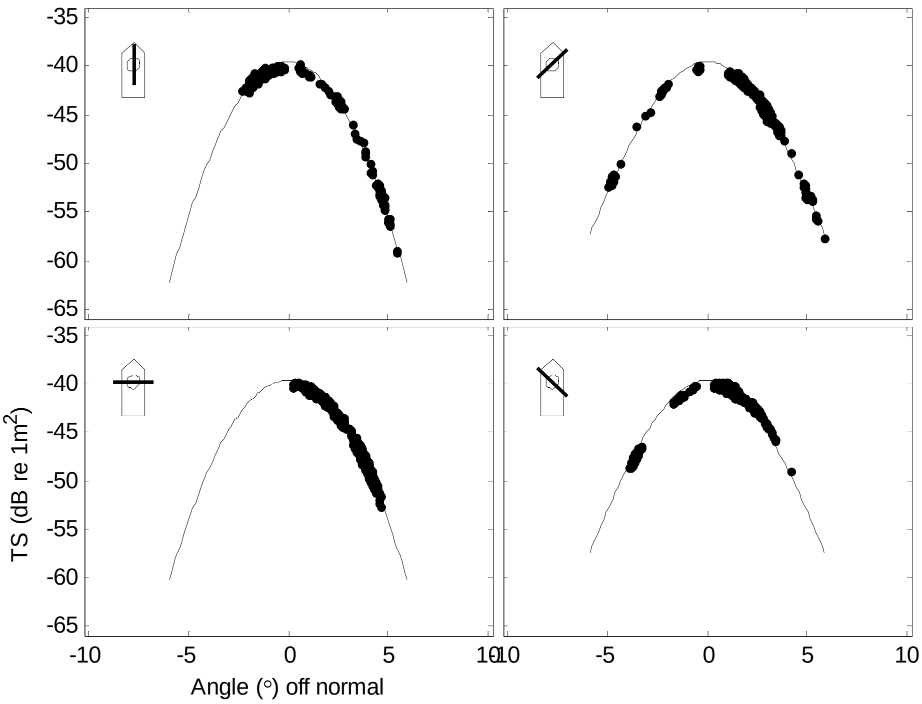

Figure A1.8. Beam pattern results from the 120 kHz analysis. The solid line is the ideal beam pattern fit to the sphere echoes for four slices through the beam.

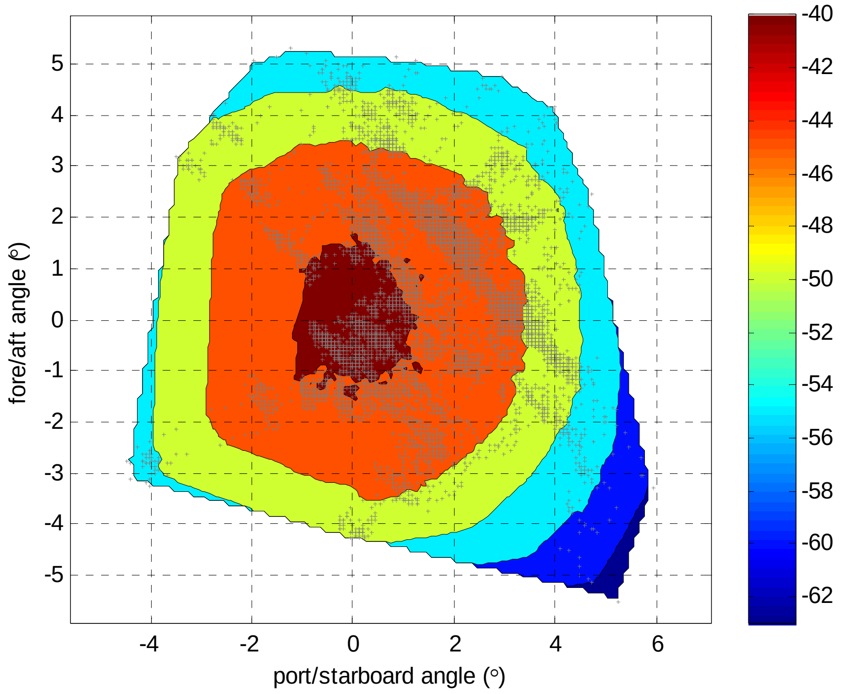

Figure A1.9. The 200 kHz estimated beam pattern from the sphere echo strength and position. The '+' symbols indicate where sphere echoes were received. The colours indicate the received sphere echo strength in dB re 1 m².

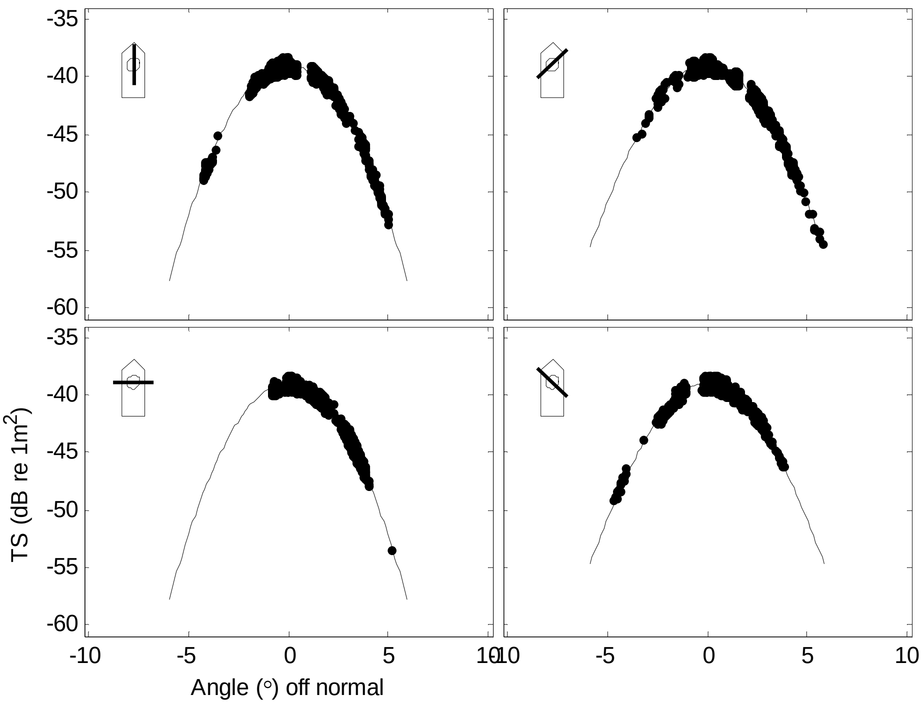

Figure A1.10. Beam pattern results from the 200 kHz analysis. The solid line is the ideal beam pattern fit to the sphere echoes for four slices through the beam.

Appendix 2: Individual station data for all stations conducted during the survey (TAN1001). 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	RD	2A	2-Jan-10	824	42 47.38	177 21.51	E	654	672	3	115.4	6.4	137.4
2	RD	2A	2-Jan-10	1056	42 46.25	177 31.00	E	761	772	3	64.4	0	18.9
3	RD	22	2-Jan-10	1335	42 44.63	177 49.43	E	832	844	2.99	34.6	3.1	0
4	RD	2A	2-Jan-10	1816	42 52.77	178 33.56	E	775	785	3	171.8	1.9	25.6
5	RN	22	2-Jan-10	2035	42 52.19	178 48.03	E	900	900	3.01	126.4	10	0
6	RN	22	3-Jan-10	25	42 53.27	179 21.59	E	822	838	3	69.4	12.1	0
7	RN	23	3-Jan-10	312	42 45.23	179 31.26	E	1221	1225	3	0	0	0
8	RD	10A	3-Jan-10	751	43 01.00	179 52.38	W	570	576	3.06	235.3	15.7	31.1
9	RD	10A	3-Jan-10	1234	43 30.86	179 45.94	W	416	424	3.01	322.9	13.9	72.5
10	RD	10A	3-Jan-10	1658	43 05.22	179 34.26	W	520	522	3	173.6	32	2.3
11	RN	23	3-Jan-10	2151	42 41.10	179 31.60	W	1180	1197	3.13	0	0	0
12	RN	23	4-Jan-10	25	42 42.40	179 21.02	W	1049	1068	3	3.1	3.8	0
13	RD	21A	4-Jan-10	453	42 44.75	178 47.15	W	875	920	3.01	0	7.4	4.7
14	RD	2B	4-Jan-10	716	42 50.07	178 58.10	W	655	700	3.01	160.3	69.8	23.8
15	RD	10B	4-Jan-10	1044	42 59.04	179 21.49	W	537	550	3	194	5.1	26.4
16	RD	11B	4-Jan-10	1512	43 03.99	178 44.68	W	511	514	2.99	115.8	6.1	7.1
17	RD	11B	4-Jan-10	1726	43 00.11	178 37.64	W	530	531	2.99	339.6	3.8	3.7
18	RN	21A	4-Jan-10	2131	42 44.07	178 39.94	W	857	882	3.01	40.3	0	0
19	RN	21A	5-Jan-10	110	42 45.15	178 08.14	W	822	840	2.84	40	0	3.9
20	RD	2B	5-Jan-10	526	42 46.66	178 11.71	W	750	759	3	16	6.2	1.9
21	RD	11B	5-Jan-10	1046	43 00.38	178 28.46	W	534	535	3	323	0	8.5
22	RD	9	5-Jan-10	1443	43 20.51	178 23.50	W	392	400	3	241	0	79.2
23	RD	11C	5-Jan-10	1746	43 17.43	177 57.24	W	424	444	3.01	231.6	18.3	1.1
24	RD	10B	6-Jan-10	520	43 22.95	179 09.58	W	450	452	2.99	189.7	49.5	21.9
25	RD	10B	6-Jan-10	815	43 38.31	179 10.29	W	407	408	3.03	335.8	6.6	42.2
26	RD	11A	6-Jan-10	1153	43 42.18	178 39.73	W	438	465	3.05	235.2	0	82.2
*27	RD	11A	6-Jan-10	1508	43 32.26	178 46.54	W	430	432	1.3	–	8.1	–
28	RD	11A	6-Jan-10	1738	43 36.27	178 36.75	W	417	429	3.02	251.9	17.9	27.4
29	RD	11A	7-Jan-10	531	43 30.03	178 13.31	W	409	411	2.99	332.6	2.4	34.6
30	RD	5	7-Jan-10	743	43 40.58	178 14.16	W	369	375	2.98	247.3	2.8	44.5
*31	RD	5	7-Jan-10	1015	43 41.42	178 03.36	W	374	374	1.11	–	–	–
32	RD	5	7-Jan-10	1145	43 40.96	178 03.80	W	371	380	3	95.9	1.4	67.8
33	RD	11C	8-Jan-10	516	43 05.84	177 52.69	W	474	475	2.9	84.4	6.4	8
34	RD	2B	8-Jan-10	852	42 50.39	177 44.61	W	752	757	3.02	25.3	0	0
35	RD	11C	8-Jan-10	1132	42 55.86	177 28.71	W	618	623	3	116.1	0	45.4
*36	RD	11D	8-Jan-10	1401	43 01.22	177 13.16	W	538	575	1.19	–	–	–
37	RD	11D	8-Jan-10	1511	43 01.81	177 09.89	W	527	583	3.03	349.2	24.8	77.1
*38	RD	2B	8-Jan-10	1826	42 52.22	177 00.76	W	776	785	2.84	–	–	–
39	RD	11D	9-Jan-10	502	43 08.52	176 16.50	W	514	517	3	274.4	5.8	76.6
40	RD	9	9-Jan-10	756	43 19.88	176 16.90	W	370	370	3	898.1	0	11.5
41	RD	9	9-Jan-10	1059	43 27.81	175 53.14	W	368	397	3	2072.6	0	46.1
42	RD	11D	9-Jan-10	1406	43 17.01	175 55.87	W	505	516	3.01	191.2	16	42.6
43	RD	21B	9-Jan-10	1840	42 52.32	175 58.66	W	945	947	3.01	7.4	4.9	0
44	RN	24	9-Jan-10	2136	42 47.61	175 53.50	W	1148	1157	3.02	0	0	0

Appendix 2 (continued)

Stn.	Type	Strat.	Start tow Date	Time NZST	Latitude ° ' S	Longitude ° '	E/W	Gear depth m min.	max.	Dist. towed n. mile	Catch kg hoki	hake	ling
45	RN	24	10-Jan-10	17	42 48.49	175 38.74	W	1115	1118	3	0	0	0
46	RN	21B	10-Jan-10	327	42 58.96	175 36.21	W	811	812	3	63	0	0
47	RD	2B	10-Jan-10	604	43 05.47	175 19.33	W	763	767	3.01	53.3	0	0
48	RD	2B	10-Jan-10	1012	43 27.04	175 03.14	W	632	634	3.01	114.5	0	69.5
49	RD	12	10-Jan-10	1236	43 32.98	175 06.70	W	583	592	3.01	137.5	0	23.2
50	RD	4	10-Jan-10	1445	43 39.69	175 00.02	W	614	615	3.02	122.8	0	52.8
51	RN	25	10-Jan-10	1937	43 35.74	174 22.78	W	827	865	2.98	22.1	0	0
52	RN	25	10-Jan-10	2244	43 30.18	174 14.96	W	910	922	3	8.4	0	0
53	RN	21B	11-Jan-10	223	43 23.57	174 15.05	W	913	930	3.02	0	0	0
54	RD	21B	11-Jan-10	700	43 13.73	174 12.15	W	987	993	3.02	2.7	0	0
55	RD	24	11-Jan-10	1331	43 03.94	174 02.28	W	1155	1209	3.01	0	0	0
56	RD	24	11-Jan-10	1709	43 23.96	174 03.47	W	1040	1053	1.73	0	0	0
57	RN	28	11-Jan-10	1954	43 36.93	174 03.05	W	1154	1192	3	3.2	0	0
58	RD	5	12-Jan-10	1114	44 00.23	177 25.67	W	361	364	3.03	705.6	0	43.8
59	RD	12	12-Jan-10	1406	44 10.92	177 18.82	W	418	436	2.56	1724.1	10.4	110.2
60	RD	12	12-Jan-10	1657	44 22.79	177 00.20	W	469	488	3	463.5	0	60.4
61	RN	25	12-Jan-10	253	44 25.76	178 02.51	W	855	862	3.04	99.2	0	0
62	RD	4	13-Jan-10	546	44 18.36	178 01.02	W	612	613	2.99	288.9	4.9	7.9
63	RD	13	13-Jan-10	922	44 06.08	178 10.69	W	480	481	3.01	260.1	0	59
64	RD	25	13-Jan-10	1314	44 24.55	178 23.44	W	900	935	2.39	28.1	0	0
65	RD	25	13-Jan-10	1658	44 24.29	178 50.64	W	848	865	3	599.9	0	0
66	RN	28	13-Jan-10	2136	44 41.33	178 39.82	W	1291	1300	3.03	0	0	0
67	RN	28	14-Jan-10	142	44 37.33	179 11.58	W	1270	1276	3.01	0	0	0
68	RD	13	14-Jan-10	609	44 16.98	179 18.24	W	578	580	2.07	454.8	0	100.2
69	RD	3	14-Jan-10	1242	43 57.55	179 18.58	W	219	224	3	0	0	3.7
70	RD	13	14-Jan-10	1652	43 57.94	179 47.47	W	427	431	2.04	92.2	0	34.8
71	RD	3	15-Jan-10	512	43 42.83	179 36.88	W	337	357	3.01	327.5	8.7	55.8
*72	RD	3	15-Jan-10	720	43 39.36	179 40.99	W	365	370	2.94	–	6.6	–
73	RD	3	15-Jan-10	1527	43 43.59	179 21.25	W	369	388	3.01	583.2	2.4	59.7
74	RN	26	16-Jan-10	46	44 09.13	179 02.47	E	868	876	3	66.3	0	0
75	RD	14	16-Jan-10	518	43 59.46	179 25.29	E	574	576	3.03	316.5	3.7	19.6
76	RD	14	16-Jan-10	846	43 46.97	179 27.13	E	476	488	2.91	127.3	7.9	50.3
77	RD	20	16-Jan-10	1330	43 23.85	179 26.71	E	388	398	3	684.9	7.2	107
78	RD	8B	16-Jan-10	1649	43 08.96	179 15.78	E	427	433	3.02	322.4	5.1	61.2
79	RD	8B	16-Jan-10	1841	43 06.11	179 10.28	E	423	426	2.94	227.7	5.2	44.7
80	RD	8B	17-Jan-10	529	43 14.27	178 43.32	E	414	415	2.99	258.5	12	57.6
81	RD	20	17-Jan-10	929	43 02.22	178 13.21	E	347	353	3.01	448.4	0	31.4
82	RD	20	17-Jan-10	1247	42 58.92	177 58.39	E	353	359	2.28	977.4	4.3	56.6
83	RD	20	17-Jan-10	1530	43 01.94	177 41.12	E	312	325	3	264.3	2.1	10.7
84	RD	20	17-Jan-10	1810	43 12.19	177 40.03	E	296	309	2.84	263.9	0	28.2
85	RN	26	18-Jan-10	228	44 07.40	177 36.57	E	905	920	3.01	8.1	0	0
86	RN	26	18-Jan-10	511	44 08.66	177 27.89	E	909	925	1.64	8.6	4.3	0
87	RD	4	18-Jan-10	748	43 59.44	177 27.39	E	720	752	3.06	66.8	0	2.4
88	RD	15	18-Jan-10	1130	43 45.06	177 48.54	E	469	479	3	406.5	5.4	64.5
89	RD	14	18-Jan-10	1505	43 43.78	178 00.42	E	463	471	2.83	988.8	6.6	48.1
90	RD	15	18-Jan-10	1834	43 46.53	177 32.00	E	470	507	3.03	425.3	15.3	25.8

Appendix 2 (continued)

Stn.	Type	Strat.	Date	Time NZST	Start tow Latitude ° ' S	Longitude ° '	E/W	Gear depth m min.	max.	Dist. towed n. mile	Catch Kg hoki	hake	Ling
91	RD	16	19-Jan-10	516	43 56.12	175 49.36	E	493	521	2.99	186.3	22.8	56.9
*92	RD	17	19-Jan-10	730	44 02.69	175 57.50	E	347	351	1.6	–	–	–
93	RD	17	19-Jan-10	854	44 02.82	176 00.03	E	356	382	3.02	809.4	0	8.4
94	RD	17	19-Jan-10	1123	44 05.93	176 07.49	E	347	354	3	2782.6	0	2.9
*95	RD	17	19-Jan-10	1401	44 21.05	176 08.63	E	327	338	0.85	–	–	–
96	RD	17	19-Jan-10	1517	44 21.74	176 06.20	E	322	360	2.53	20.6	0	0
97	RD	6	19-Jan-10	1845	44 26.75	175 36.87	E	746	775	2.53	160.2	0	0
98	RN	27	19-Jan-10	2341	44 35.97	175 57.28	E	919	953	3.01	9.1	0	0
99	RN	27	20-Jan-10	403	44 34.15	175 32.10	E	806	812	3.01	13.8	0	0
100	RD	6	20-Jan-10	1121	44 21.10	175 31.63	E	685	704	3	1088.1	17.3	78.5
101	P2	16	20-Jan-10	1540	44 05.54	175 05.97	E	494	495	3.02	390.4	1.5	42.7
102	RN	27	20-Jan-10	2304	44 47.02	174 04.96	E	821	845	3	27.3	0	0
103	RD	6	21-Jan-10	524	44 37.92	173 29.02	E	781	794	3	14.2	0	5.3
104	RD	16	21-Jan-10	1119	44 30.68	173 11.32	E	490	514	3	1214.2	0	5.7
105	RD	16	21-Jan-10	1541	44 12.15	173 38.53	E	453	462	3	1280	3.1	36.7
106	RD	18	22-Jan-10	519	43 39.67	175 10.50	E	348	371	3.03	713.6	1.5	31.6
*107	RD	18	22-Jan-10	805	43 34.18	174 51.06	E	365	380	2.72	–	–	–
108	RD	7	22-Jan-10	1046	43 29.69	174 31.16	E	523	534	3	197.4	10.5	66.2
109	RD	7	22-Jan-10	1259	43 28.13	174 16.47	E	552	558	3	322	1.7	93.7
110	RD	7	22-Jan-10	1609	43 10.92	174 20.89	E	581	594	3	72.2	7.3	32.7
111	RD	1	22-Jan-10	1817	43 05.13	174 19.43	E	633	766	3.04	81.8	1.3	36.4
112	RN	23	22-Jan-10	2334	42 57.77	174 16.45	E	1027	1035	3.01	50.3	7.3	0
113	RD	1	23-Jan-10	535	43 11.59	174 13.87	E	602	615	3	84.6	11.4	15.9
114	RD	7	23-Jan-10	805	43 08.16	174 27.90	E	552	572	3.03	355	16.7	18.2
115	RD	7	23-Jan-10	1039	43 06.57	174 45.95	E	464	490	3.02	799.9	20.4	70.3
116	RD	1	23-Jan-10	1424	42 56.43	174 47.20	E	734	739	3.03	26.6	0	12.7
117	RD	18	23-Jan-10	1809	43 01.42	175 21.02	E	324	350	3.03	357.4	0	59.9
118	RN	22	23-Jan-10	2312	42 44.68	175 44.23	E	893	902	3	19.8	10.2	0
119	RD	7	24-Jan-10	526	43 12.74	175 46.47	E	405	430	3	454.2	419	65.7
120	RD	18	24-Jan-10	910	43 19.63	175 45.36	E	295	296	2.66	322.2	0	1.9
121	RD	19	24-Jan-10	1146	43 18.89	176 09.41	E	340	365	3.01	3442.8	14.1	145.2
122	RD	8A	24-Jan-10	1433	43 05.33	176 05.51	E	433	438	3.01	766.6	38.9	23.2
123	RD	8A	24-Jan-10	1641	43 05.24	176 16.40	E	401	408	3.01	609.5	9.6	53.4
124	RD	8A	24-Jan-10	1838	42 59.57	176 22.23	E	457	465	3.02	133.4	11.9	36.2
125	RD	15	25-Jan-10	528	43 42.71	176 41.98	E	454	459	3	159.9	2.1	16.7
126	RD	19	25-Jan-10	818	43 28.35	176 58.99	E	240	249	3	0	0	0
127	RD	19	25-Jan-10	1123	43 19.71	176 36.25	E	258	272	3	136.7	0	0
128	RD	19	25-Jan-10	1319	43 12.97	176 33.02	E	303	304	3	151.8	0	64.6
129	RD	19	25-Jan-10	1657	43 05.33	176 25.77	E	366	376	3.01	582.5	0	40.9
130	P2	7	26-Jan-10	531	43 16.41	174 10.94	E	569	577	3	226.1	21.8	68.9
131	P2	7	26-Jan-10	757	43 25.17	174 22.00	E	530	547	2.99	314.8	0	66.7
132	P2	7	26-Jan-10	1214	43 04.91	174 50.49	E	477	478	2.99	3235	37.5	13
133	P2	HAK	26-Jan-10	1649	43 06.13	175 42.51	E	445	462	3.01	415.5	16.1	49.1
134	P2	HAK	27-Jan-10	534	42 57.96	175 49.59	E	552	554	3.01	131.9	43.5	45.9

Appendix 3: Scientific and common names of species caught from all valid biomass tows (TAN1001). The occurrence (Occ.) of each species (number of tows caught) in the 124 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	3
Porifera	unspecified sponges	ONG	11
Hexactinellida (glass sponges)			
Lyssacinosida (glass horn sponges)			
Euplectellidae			
Euplectella regalis	basket-weave horn sponge	ERE	1
Rossellidae			
Hyalascus sp.	floppy tubular sponge	HYA	18
Demospongiae (siliceous sponges)			
Astrophorida (sandpaper sponges)			
Ancorinidae			
Ancorina novaezelandiae	knobbly sandpaper sponge	ANZ	1
Geodiidae			
Geodinela vestigifera	ostrich egg sponge	GVE	1
Pachastrellidae			
Thenea novaezelandiae	yoyo sponge	THN	1
Hadromerida (woody sponges)			
Suberitidae			
Suberites affinis	fleshy club sponge	SUA	7
Spirophorida (spiral sponges)			
Tetillidae			
Tetilla leptoderma	furry oval sponge	TLD	2
Cnidaria			
Coral (Hydrozoan + Anthozoan corals)			
Scyphozoa	unspecified jellyfish	JFI	23
Anthozoa			
Octocorallia			
Alcyonacea (soft corals)			
Gorgonacea (gorgonian corals)		GOC	1
Chrysogorgiidae			
Chrysogorgia spp.	golden coral	CHR	1
Isididae			
Keratoisis spp.	branching bamboo coral	BOO	3
Lepidsis spp.	bamboo coral	LLE	1
Primnoidae			
Thouarella spp.	bottlebrush coral	THO	2
Pennatulacea (sea pens)	unspecified sea pens	PTU	16
Pennatulidae			
Pennatula spp.	purple sea pens	PNN	2
Hexacorallia			
Zoanthidea (zoanthids)			
Epizoanthidae			
Epizoanthus sp.		EPZ	7
Actinaria (anemones)	unspecified anemones	ANT	2
Actiniidae (deepsea anemones)		BOC	2
Actinostolidae (smooth deepsea anemones)		ACS	23
Hormathiidae (warty deepsea anemones)		HMT	12

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Scleractinia (stony corals)			
Caryophyllidae			
Caryophyllia spp.	carnation cup coral	CAY	1
Desmophyllum dianthus	crested cup coral	DDI	1
Goniocorella dumosa	bushy hard coral	GDU	4
Stephanocyathus platypus	solitary bowl coral	STP	1
Flabellidae			
Flabellum spp.	flabellum coral	COF	7
Ascidiacea	unspecified sea squirt	ASC	5
Tunicata			
Thaliacea (salps)	unspecified salps	SAL	11
Salpidae			
Pyrosoma atlanticum		PYR	2
Sipuncula	unspecified peanut worm	SIP	1
Mollusca			
Gastropoda (gastropods)			
Nudibranchia (sea slugs)	Unspecified sea slug	NUD	1
Buccinidae (whelks)			
Penion chathamensis		PCH	3
Ranellidae (tritons)			
Fusitriton magellanicus		FMA	34
Volutidae (volutes)			
Provocator mirabilis	golden volute	GVO	2
Cephalopoda			
Teuthoidea (squids)			
Octopoteuthididae			
Octopoteuthis megaptera		OSQ	1
Taningia danae		TDQ	1
Onychoteuthidae			
Onykia (Moroteuthis) ingens	warty squid	MIQ	55
O (M). robsoni	warty squid	MRQ	4
Lepidoteuthidae			
Lepidoteuthis grimaldii	scaly squid	SQX	1
Architeuthidae (giant squids)			
Architeuthis spp.	giant squid	GSQ	1
Histioteuthidae (violet squids)			
Histioteuthis (Stigmatoteuthis) hoylei	violet squid	VSQ	5
Ommastrephidae			
Nototodarus sloanii	Sloan's arrow squid	NOS	41
Ommastrephes bartrami	squid	RSQ	1
Todarodes filippovae	Todarodes squid	TSQ	27
Chiroteuthidae			
Chiroteuthis mega	squid	CVE	1
Mastigoteuthidae			
Mastigoteuthis sp.	squid	MSQ	1
Cranchiidae			
Teuthowenia pellucida		TPE	7

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Vampyromorpha (vampire squid)			
Vampyroteuthidae			
Vampyroteuthis infernalis	vampire squid		1
Octopoda (octopods)			
Cirrata (cirrate octopus)			
Opisthoteuthididae			
Opisthoteuthis mero	umbrella octopus	OPI	3
Incirrata (incirrate octopus)			
Octopodidae			
Benthoctopus sp.	deepwater octopus	BNO	1
Graneledone challengeri	deepwater octopus	DWO	1
G. taniwha taniwha	deepwater octopus	DWO	6
Octopus mernoo	octopus	OCP	2
Polychaeta	unspecified polychaete	POL	1
Phyllodocida			
Aphroditidae			
Aphrodita spp.	sea mouse	ADT	1
Onuphidae			
Hyalinoecia tubicola	quill worm	HTU	1
Crustacea			
Malacostraca			
Dendrobranchiata/Pleocyemata (prawns)			
Dendrobranchiata			
Aristeidae			
Aristaeomorpha foliacea	royal red prawn	AFO	1
Aristaeopsis edwardsiana	scarlet prawn	PED	1
Solenoceridae			
Haliporoides sibogae	jack-knife prawn	HSI	2
Pleocyemata			
Caridea			
Camplyonotidae			
Camplyonotus rathbunae	sabre prawn	CAM	2
Oplophoridae			
Acanthephyra spp.	ruby prawn	ACA	7
Pasiphaeidae			
Pasiphaea aff. *tarda*	deepwater prawn	PTA	14
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	29
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	31
Palinura			
Polychelidae			
Polycheles spp.	deepsea blind lobster	PLY	5
Crab (Anomuran + Brachyuran crabs)	unspecified crabs	CRB	2
Anomura			
Galatheoidea			
Chirostylidae (squat lobsters)			
Gastroptychus novaezelandiae	squat lobster	GAT	1

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Galatheidae (squat lobsters)			
Munida gracilis	squat lobster	MGA	1
Phylladiorhynchus pusillus	squat lobster	GAL	1
Inachidae			
Platymaia maoria	Dell's spider crab	PTM	2
Vitjazmaia latidactyla	deepsea spider crab	VIT	5
Lithodidae (king crabs)			
Lithodes cf. *longispinus*	long-spined king crab	LLT	1
L. murrayi	Murray's king crab	LMU	3
Neolithodes brodiei	Brodie's king crab	NEB	6
Paralomis zealandica	prickly king crab	PZE	1
Paguroidea (unspecified pagurid & parapagurid hermit crabs)		PAG	4
Parapaguridae (Parapagurid hermit crabs)			
Sympagurus dimorphus	hermit crab	SDM	16
Brachyura (true crabs)			
Atelecyclidae			
Trichopeltarion fantasticum	frilled crab	TFA	12
Goneplacidae			
Pycnoplax victoriensis	two-spined crab	CVI	1
Homolidae			
Dagnaudus petterdi	antlered crab	DAP	8
Majidae (spider crabs)			
Teratomaia richardsoni	spiny masking crab	SMK	8
Mysidacea (mysids)			
Gnathophausiidae			
Neognathophausia ingens	giant red mysid	NEI	1
Isopoda			
Aegidae			
Aega monophthalma	fish biter	AMO	1
Serolidae			
Acutiserolis spp.	spiny serolid isopod	ACU	1
Echinodermata			
Asteroidea (starfish)	unspecified starfish	ASR	3
Asteriidae			
Pseudechinaster rubens	starfish	PRU	13
Astropectinidae			
Dipsacaster magnificus	magnificent sea-star	DMG	23
Plutonaster knoxi	abyssal star	PKN	20
Proserpinaster neozelanicus	starfish	PNE	4
Psilaster acuminatus	geometric star	PSI	33
Sclerasterias mollis	cross-fish	SMO	5
Benthopectinidae			
Benthopecten spp.	starfish	BES	3
Brisingidae, Hymenodiscidae, Novodiniidae, Freyellidae			
Benthopecten spp.	armless stars	BRG	13
Goniasteridae			
Ceramaster patagonicus	pentagon star	CPA	1
Hippasteria phrygiana	trojan starfish	HTR	9
Lithosoma novaezelandiae	rock star	LNV	1
Mediaster sladeni	starfish	MSL	8
Pillsburiaster aoteanus	starfish	PAO	2

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Odontasteridae			
Odontaster spp.	pentagonal tooth-star	ODT	1
Pterasteridae			
Diplopteraster sp.	starfish	DPP	1
Radiasteridae			
Radiaster gracilis	starfish	RGR	1
Solasteridae			
Crossaster multispinus	sun star	CJA	6
Solaster torulatus	chubby sun-star	SOT	4
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	40
Ophiuroidea (basket and brittle stars)	unspecified brittle star	OPH	3
Ophiodermatidae			
Bathypectinura heros	deepsea brittle star	BHE	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	13
G. umbraculum	umbrella urchin	GOU	1
Echinothuriidae/Phormosomatidae	unspecified Tam O'Shanter urchin	TAM	39
Echinidae			
Gracilechinus multidentatus	deepsea kina	GRM	17
Spatangidae (heart urchins)			
Paramaretia peloria	Microsoft mouse	PMU	1
Spatangus mathesoni	Matheson's heart urchin	SMT	1
S. multispinus	purple-heart urchin	SPT	15
Holothuroidea	unspecified sea cucumber	HTH	11
Aspidochirotida			
Synallactidae			
Bathyplotes moseleyi	sea cucumber	BAM	18
Pseudostichopus mollis	sea cucumber	PMO	30
Elasipodida			
Laetmogonidae			
Laetmogone sp.	sea cucumber	LAG	9
Pannychia moseleyi	sea cucumber	PAM	3
Pelagothuridae			
Enypniastes exima	sea cucumber	EEX	7
Bryozoan	unspecified bryozoan	COZ	1
Brachiopoda	unspecified lamp shell	BPD	4
Agnatha (jawless fishes)			
Eptatretus cirrhatus	hagfish	HAG	1
Chondrichthyes (cartilagenous fishes)			
Chlamydoselachidae: frill shark			
Chlamydoselachus anguineus	frill shark	FRS	1

Appendix 3 (continued)

Scientific name	Common name	Specie s	Occ.
Hexanchidae: cow sharks			
Hexanchus griseus	sixgill shark	HEX	2
Squalidae: dogfishes			
Centrophorus squamosus	leafscale gulper shark	CSQ	26
Centroscymnus crepidater	longnose velvet dogfish	CYP	44
C. owstoni	smooth skin dogfish	CYO	25
C. plunketi	Plunket's shark	PLS	12
Deania calcea	shovelnose dogfish	SND	64
Etmopterus baxteri	Baxter's dogfish	ETB	47
E. lucifer	Lucifer dogfish	ETL	55
Scymnorhinus licha	seal shark	BSH	35
Squalus acanthias	spiny dogfish	SPD	54
S. griffini	northern spiny dogfish	NSD	2
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	9
Scyliorhinidae: cat sharks			
Apristurus spp.	catshark	APR	23
Halaelurus dawsoni	Dawson's catshark	DCS	2
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	7
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	4
Narkidae: blind electric rays			
Typhlonarke spp.	numbfish	BER	4
Rajidae: skates			
Amblyraja hyperborea	deepwater spiny (Arctic) skate	DSK	2
Bathraja shuntovi	longnosed deepsea skate	PSK	5
Dipturus innominatus	smooth skate	SSK	35
Notoraja asperula	smooth deepsea skate	BTA	18
N. spinifera	prickly deepsea skate	BTS	9
Chimaeridae: chimaeras, ghostsharks			
Chimaera lignaria	giant chimaera	CHG	1
Chimaera sp.	brown chimaera	CHP	4
Hydrolagus bemisi	pale ghost shark	GSP	79
H. novaezealandiae	dark ghost shark	GSH	46
H. trolli	pointynose blue ghost shark	HYP	1
H. sp. A	black ghost shark	HYB	1
H. spp.	unspecified ghost shark	HYD	1
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	long-nosed chimaera	LCH	57
Rhinochimaera pacifica	widenosed chimaera	RCH	23
Osteichthyes (bony fishes)			
Halosauridae: halosaurs			
Halosaurus pectoralis	common halosaur	HPE	2
H. macrochir	abyssal halosaur	HAL	1
Notocanthidae: spiny eels			
Notacanthus sexspinis	spineback	SBK	69
Synaphobranchidae: cutthroat eels			
Diastobranchus capensis	basketwork eel	BEE	28
Simenchelys parasiticus	snubnosed eel	SNE	2

Appendix 3 (continued)

Scientific name	Common name	Specie s	Occ.
Congridae: conger eels			
Bassanago bulbiceps	swollenhead conger	SCO	36
B. hirsutus	hairy conger	HCO	28
Gonorynchidae: sandfish			
Gonorynchus forsteri & *G. greyi*	sandfishes	GON	1
Argentinidae: silversides			
Argentina elongata	silverside	SSI	48
Bathylagidae: deepsea smelts			
Bathylagus spp.	deepsea smelt	DSS	6
Alepocephalidae: slickheads			
Alepocephalus australis	smallscaled brown slickhead	SSM	28
A. sp.	bigscaled brown slickhead	SBI	15
Roulenia sp.	large headed slickhead	BAT	1
Xenodermichthys spp.	black slickhead	BSL	15
Platytroctidae: tubeshoulders			
Persparsia kopua		PER	4
Gonostomidae: lightfishes			
Diplophos spp.		DIP	3
Sternoptychidae: hatchetfishes			
Argyropelecus gigas	giant hatchetfish	AGI	4
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	20
Chauliodontidae: viperfishes			
Chauliodus sloani	viperfish	CHA	4
Stomiidae: scaly dragonfishes			
Stomias spp.	scaly dragonfish	STO	1
Astronesthidae: snaggletooths	unspecified snaggletooth	AST	1
Melanostomiidae: scaleless black dragonfishes			
Melanostomias spp.		MEN	2
Notosudidae: waryfishes			
Scopelosaurus spp.		SPL	6
Paralepididae: barracudinas			
Macroparalepis macrugeneion		MMA	1
Alepisauridae: lancetfishes			
Alepisaurus brevirostris	shortsnouted lancetfish	ABR	2
Myctophidae: lanternfishes	unspecified lanternfish	LAN	15
Gymnoscopelus spp.		GYM	2
Lampanyctodes hectoris		LHE	1
Lampanyctus spp.		LPA	4
Moridae: morid cods			
Antimora rostratai	violet cod	VCO	4
Halargyreus johnsonii	Johnson's cod	HJO	39
Lepidion microcephalus	small-headed cod	SMC	21
Mora moro	ribaldo	RIB	42
Notophycis marginata	dwarf cod	DCO	2
Pseudophycis bachus	red cod	RCO	11
Tripterophycis gilchristi	grenadier cod	GRC	1
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	4

Appendix 3 (continued)

Scientific name	Common name	Specie s	Occ.
Merlucciidae: hakes			
Lyconus sp.		LYC	1
Macruronus novaezelandiae	hoki	HOK	114
Merluccius australis	hake	HAK	67
Macrouridae: rattails, grenadiers			
Caelorinchus acanthiger	roughhead rattail	CTH	3
C. aspercephalus	oblique banded rattail	CAS	51
C. biclinozonalis	two saddle rattail	CBI	8
C. bollonsi	bigeye rattail	CBO	86
C. celaenostomus	black lip rattail	CEX	1
C. fasciatus	banded rattail	CFA	32
C. innotabilis	notable rattail	CIN	43
C. kaiyomaru	Kaiyomaru rattail	CKA	8
C. matamua	Mahia rattail	CMA	22
C. mycterismus	upturned snout rattail	CJX	1
C. parvifasciatus	small banded rattail	CCX	17
C. oliverianus	Oliver's rattail	COL	71
C. trachycarus	roughhead rattail	CHY	9
Coryphaenoides dossenus	humpback (slender) rattail	CBA	10
C. mcmillani	McMillan’s rattail	CMX	3
C. murrayi	abyssal rattail	CMU	1
C. serrulatus	serrulate rattail	CSE	32
C. striaturus	abyssal rattail	CTR	1
C. subserrulatus	four-rayed rattail	CSU	39
Gadomus aoteanus	filamentous rattail	GAO	4
Kuronezumia bubonis	bulbous rattail	NBU	1
Lepidorhynchus denticulatus	javelinfish	JAV	100
Lucigadus nigromaculata	blackspot rattail	VNI	25
Macrourus carinatus	ridge scaled rattail	MCA	21
Mesobius antipodum	blackjavelinfish	BJA	11
Nezumia namatahi	squashed face rattail	NNA	3
Trachyrincus aphyodes	white rattail	WHX	26
T. longirostris	unicorn rattail	WHR	1
Ophidiidae: cuskeels			
Brotulotaenia crassa	blue cuck eel	BCR	1
Genypterus blacodes	ling	LIN	89
Carapidae: pearlfishes			
Echiodon cryomargarites	messmate fish	ECR	5
Chaunacidae: seatoads			
Chaunax pictus	pink frogmouth	CHX	1
Ceratiidae: seadevils			
Cryptopsaras couesi	seadevil	SDE	2
Linophrynidae: linophrynids			
Haplophryne mollis		LPH	1
Scomberesocidae: sauries			
Scomberesox saurus	saury	SAU	1
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	1
Trachichthyidae: roughies, slimeheads			
Hoplostethus atlanticus	orange roughy	ORH	31
H. mediterraneus	silver roughy	SRH	53

Paratrachichthys trailli	common roughy	RHY	4

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Diretmidae: discfishes			
Diretmus argenteus	discfish	DIS	1
Anoplogastridae: fangtooth			
Anoplogaster cornuta	fangtooth	ANO	1
Berycidae: alfonsinos			
Beryx splendens	alfonsino	BYS	39
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	10
Cyttus novaezealandiae	silver dory	SDO	15
C. traversi	lookdown dory	LDO	90
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	15
A. verrucosus	warty oreo	WOE	8
Neocyttus rhomboidalis	spiky oreo	SOR	37
Pseudocyttus maculatus	smooth oreo	SSO	35
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	67
Notopogon lilliei	crested bellowsfish	CBE	1
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	89
Trachyscorpia capensis		TRS	5
Congiopodidae: pigfishes			
Alertichthys blacki	alert pigfish	API	1
Congiopodus coriaceus	deepsea pigfish	DSP	2
Triglidae: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	5
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	33
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	16
Cottunculus nudus	bonyskull toadfish	COT	1
Psychrolutes microporos	blobfish	PSY	9
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	8
Serranidae: sea perches, gropers			
Lepidoperca aurantia	orange perch	OPE	7
Apogonidae: cardinalfishes			
Epigonus denticulatus	white cardinalfish	EPD	8
E. lenimen	bigeye cardinalfish	EPL	10
E. robustus	robust cardinalfish	EPR	24
E. telescopus	deepsea cardinalfish	EPT	23
Rosenblattia robusta	rotund cardinalfish	ROS	5
Carangidae: trevallies, kingfishes			
Trachurus declivis	jack mackerel	JMD	1
T. symmetricus murphyi	slender mackerel	JMM	5
Bramidae: pomfrets			
Brama australis & *B. brama*	southern Ray's bream & Ray’s bream	SRB & RBM	34
Taratichthys longipinnis	big-scale pomfret	BSP	1
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	6
Plagiogeneion rubiginosum	rubyfish	RBY	3

Appendix 3 (continued)

Scientific name	Common name	Species	Occ.
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	TAR	3
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	43
Pinguipedidae: sandperches, weevers			
Parapercis gilliesi	yellow cod	YCO	1
Gempylidae: snake mackerels			
Thyrsites atun	barracouta	BAR	3
Scombridae: mackerels, tunas			
Scomber australasicus	blue mackerel	EMA	1
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	25
Hyperoglyphe antarctica	bluenose	BNS	8
Schedophilus huttoni		SUH	1
Seriolella caerulea	white warehou	WWA	40
S. punctata	silver warehou	SWA	52
Tubbia tasmanica		TUB	2
Tetragonuridae: squaretails			
Tetragonurus cuvieri	squaretail	TET	2
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	9
Neoachiropsetta milfordi	finless flounder	MAN	5
Pleuronectidae: righteyed flounders			
Pelotretis flavilatus	lemon sole	LSO	8

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

NIWA No.	Cruise/Station No	Phylum	Class	Order	Family	Genus	Species
61547	TAN1001/5	Annelida	Polychaeta	Phyllodocida	Polynoidae	*Harmothoe*	*crosetensis*
61564	TAN1001/43	Arthropoda	Malacostraca	Decapoda	Majidae	*Vitjazmaia*	*latidactyla*
61565	TAN1001/84	Arthropoda	Malacostraca	Decapoda	Majidae	*Leptomithrax*	*garricki*
61540	TAN1001/112	Arthropoda	Maxillopoda	Pedunculata	Lepadidae	*Lepas*	*australis*
61552	TAN1001/117	Cnidaria	Anthozoa	Actiniaria	Actinostolidae		
61561	TAN1001/19	Cnidaria	Anthozoa	Gorgonacea	Chrysogorgiidae	*Radicipes*	
61562	TAN1001/39	Cnidaria	Anthozoa	Pennatulacea	Anthoptilidae	*Anthoptilum*	*grandiflorum*
61563	TAN1001/125	Cnidaria	Anthozoa	Pennatulacea			
68826	TAN1001/39	Cnidaria	Anthozoa	Pennatulacea	Funiculinidae	*Funiculina*	*quadriangularis*
61542	TAN1001/8	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Stephanocyathus*	*platypus*
61559	TAN1001/39	Echinodermata	Asteroidea	Notomyotida	Benthopectinidae	*Benthopecten*	*munidae*
68259	TAN1001/66	Echinodermata	Asteroidea	Paxillosida	Astropectinidae	*Psilaster*	*acuminatus*
61555	TAN1001/34	Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Mediaster*	*sladeni*
61556	TAN1001/67	Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Pseudarchaster*	*macdougalli*
61557	TAN1001/66	Echinodermata	Asteroidea	Valvatida	Goniasteridae	*Pseudarchaster*	*macdougalli*
61560	TAN1001/9	Echinodermata	Echinoidea	Spatangoida	Spatangidae	*Paramaretia*	*peloria*
61543	TAN1001/118	Echinodermata	Holothuroidea	Aspidochirotida	Synallactidae	*Bathyplotes*	cf. *moseleyi*
61548	TAN1001/124	Echinodermata	Holothuroidea	Elasipodida	Laetmogonidae	*Laetmogone*	*violacea*
61549	TAN1001/97	Echinodermata	Holothuroidea	Elasipodida	Laetmogonidae	*Pannychia*	cf. *moseleyi*
61558	TAN1001/66	Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	*Ophiomusium*	*lymani*
61550	TAN1001/23	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Benthoctopus*	sp.
61551	TAN1001/2	Mollusca	Cephalopoda	Octopoda	Octopodidae	*Graneledone*	*taniwha*
60583	TAN1001/7	Mollusca	Cephalopoda	Teuthida	Architeuthidae	*Architeuthis*	*dux*
61553	TAN1001/129	Mollusca	Gastropoda	Neogastropoda	Buccinidae	*Penion*	*chathamensis*
61554a	TAN1001/22	Mollusca	Gastropoda	Neogastropoda	Volutidae	*Provocator*	*mirabilis*
61554b	TAN1001/22	Mollusca	Gastropoda	Neotaenioglossa	Capulidae	*Malluvium*	*calcareum*
61541	TAN1001/2	Porifera	Demospongiae	Astrophorida	Ancorinidae	*Tethyopsis*	n. sp. 1
61545b	TAN1001/97	Porifera	Demospongiae	Astrophorida	Ancorinidae	*Stelletta*	n. sp. 7
61545a	TAN1001/97	Porifera	Demospongiae	Poecilosclerida	Coelosphaeridae	*Lissodendoryx*	*bifacialis*
61539	TAN1001/66	Porifera	Demospongiae	Spirophorida	Tetillidae	*Craniella*	cf. *metaclada*
61544	TAN1001/76	Porifera	Hexactinellida	Lyssacinosida	Rossellidae	*Hyalascus*	n. sp. 1

Appendix 5: Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomasses given in Table 7.

				Age group
Survey	0+	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