MINISTRY OF FISHERIES
Te Tautiaki i nga tini a Tangaroa

ISSN 1175-1584

Trawl survey of hoki and middle depth species on the Chatham Rise, January 2004 (TAN0401)

M. E. Livingston
D. W. Stevens

New Zealand Fisheries Assessment Report 2005/21
March 2005

Trawl survey of hoki and middle depth species on the Chatham Rise, January 2004 (TAN0401)

M. E. Livingston
D. W. Stevens

NIWA
Private Bag 14901
Wellington

New Zealand Fisheries Assessment Report 2005/21
March 2005

Published by Ministry of Fisheries
Wellington
2005

ISSN 1175-1584

Citation:
Livingston, M.E.; Stevens, D.W. (2005).
Trawl survey of hoki and middle depth species on the Chatham Rise,
January 2004 (TAN0401).
New Zealand Fisheries Assessment Report 2005/21. 62 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

Livingston, M.E.; Stevens, D.W. (2005). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2004 (TAN0401).

New Zealand Fisheries Assessment Report 2005/21. **62 p.**

The thirteenth trawl survey in a time series to estimate the relative biomass of hoki and other middle depth species on the Chatham Rise was completed in January 2004. Using a random stratified sampling design, 107 phase 1 stations, and 3 phase 2 stations in core depths of 200–800 m were successfully completed. The estimate of relative biomass of hoki at 52 700 t was almost identical to the estimate in January 2003, the lowest in the time series. The biomass of hoki 3 years and older was a little higher than in 2003 due to the movement of the stronger 2000 year class into the plus group. It seems that although the biomasses of the 1997, 1998, and 2000 year classes lie in the middle range observed within the time series, recruitment since 1995 has generally been lower than in the earlier part of the series, contributing to the downward trend in biomass. The 2002 year class does not appear to be particularly strong at the 1+ age group.

The biomass of hake in core strata was back up to that recorded in January 2002, and the biomass of ling was also slightly higher but showed no overall trend.

Coefficients of variation (c.v.s) achieved for total hoki and hake were 12.7% and 17.1% respectively. Phase 2 stations to reduce the c.v. for 2+ hoki achieved a final c.v. of 20.4%.

Age frequency distributions of hake suggest some new recruitment with relatively high estimates of 2 year olds, and those of ling indicate moderate recruitment during the late 1990's.

Although the biomasses of hoki and hake have not declined further since 2003, it is unclear from this year's survey if the downward trends have slowed as yet. Sea perch and pale ghost shark biomass estimates were lower than in 2003, while giant stargazers, spiny dogfish, silver warehou and white warehou, biomasses have increased since 2003.

1. INTRODUCTION

In January 2004, the thirteenth survey 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 R.V. *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 and longitude across the Chatham Rise to ensure full coverage of the area. In 2004, the stratification in core depths of 200–800 m was the same as in 2003 (Livingston et al. 2004).

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), Stevens & Livingston (2003), and Livingston et al. (2004). Trends in biomass and changes in catch and age distribution of 31 species from surveys in 1992–2001 were reviewed by Livingston et al. (2002). Hoki dominated the catches in every survey, and formed 53 to 66% of the total biomass from 1992 to 1997. By 2001, however, the proportion of hoki had decreased to 29% as the biomass estimate dropped steadily from about 160 000 t in 1997 to 60 300 t in 2001 (Livingston et al. 2002). Hake, another priority species in this research programme, also showed a steady decline in biomass within the time series, while ling biomass was variable, showing no trend (Livingston et al. 2002).

The 2004 survey results presented here continue the Chatham Rise trawl survey series as part of a long-term research programme to estimate the abundance of hoki and other middle depth species for stock assessment. The survey covers the principal juvenile stocks of hoki, believed to derive from both western and eastern spawning stocks. It also surveys older hoki that form part of the eastern stock spawning in Cook Strait and off the east coast South Island. Although older hoki also occur in deepwater and in association with seamounts such as the Andes complex east of the Chatham Rise (Livingston et al. 2004), the survey is treated as representative of the eastern adult stock. As well as abundance, the survey provided fishery independent data on the population size structure of these species, and their catch distribution across the Chatham Rise. Otoliths from a range of QMS species were collected for ageing and use in stock assessments (Annala et al. 2004). Other work carried out concurrently with the survey included increased effort to collect adequate samples for identification of all organisms caught by the trawl (Objective 4 below).

1.1 Project objectives

The specific objectives for the project during 2003–04 were as follows.

1. To continue the time series of relative abundance indices of recruited hoki (eastern stock), hake (HAK 4), and other middle depth species on the Chatham Rise using trawl surveys.

2. To determine the relative year class strengths of juvenile hoki (1, 2, and 3 year olds) on the Chatham Rise, with target c.v. of 20% for the number of 2 year olds.

3. To determine the population proportions at age for hoki and hake on the Chatham Rise using otolith samples from the trawl survey.

4. To collect and preserve specimens of unidentified organisms taken during the trawl

Acoustic data were collected using the ES60, and have been archived for future reference.

2. METHODS

2.1 Survey area and design

As in previous years, the survey followed a two-phase random design (after Francis 1984). The main survey area, 200–800 m depths (Figure 1, top panel) was divided into the same strata used in 2003 (Livingston et al. 2004). Phase 1 station allocation was optimised to achieve a target c.v. of 20% for hake, with target c.v.s for 2+ hoki of 20% and recruited hoki of 15%. Stratum areas and catch rates from previous surveys in the series were used in a bootstrap simulation to allocate phase 1 stations to strata with high catch rates of key species, based on the same principle as the phase 2 station allocation of Francis (1984). We also compared allocation results from runs including all surveys to runs with selected surveys with strong year classes at 2 years old. Surprisingly, there was little change in the station allocation among strata, and little gain in terms of numbers of stations required to meet target c.v.s. We had, however, noticed that in recent years there has been a decline in the relative importance of western strata, and that phase 2 stations have been increasingly required in eastern strata. We therefore did a run on these surveys only and found that the optimal allocation under this scenario reduced the number of stations required in western strata, in particular, strata 16 and 17 (Figure 2). A minimum of 106 random stations was planned for phase 1, allowing for a higher number of phase 2 stations than in previous years. Time for a further 15 stations for phase 2 was retained to improve the c.v. for key species or hoki age classes if required.

All station positions were determined using the NIWA Random Stations Generation Program (version 1.6). Mid-tow positions were always separated by a minimum of 3 n. miles.

2.2 Vessel specifications

RV *Tangaroa* is a purpose-built research stern trawler with the following specifications: length overall, 70 m; beam, 14 m; gross tonnage, 2282 t; power, 3000 kW (4000 hp).

2.3 Gear specifications

The trawl gear was the same as that used on previous *Tangaroa* surveys in this series, i.e., an eight-seam hoki bottom trawl with a 58.8 m groundrope, 45 m headrope (see Hurst & Bagley (1994) for the net plan and rigging details), and a codend inside-mesh size of 60 mm. It was rigged with 100 m long sweeps, 50 m bridles, and 12 m backstrops. The trawl doors were Super Vee type with an area of 6.1 m^2.

2.4 Trawling procedure

Stations were carried out during daylight, i.e., between sunrise and sunset (earliest start time, 0509 h, latest finish time, 1815 h NZST). The gear was not shot until downward plankton movements had stabilised at the beginning of the day, since there is evidence that the catchability of hoki is low before 0600 (Livingston et al. 2002). When time was running short at the end of the day, the vessel steamed towards the last station and the trawl gear was shot in time to ensure completion of the tow by sunset, as long as 5 n. miles or more of the distance between stations had been completed. At each station it was planned to tow for 3 n. miles at a speed of 3.5 knots over the ground. If a station occurred in an area of foul ground, then the area within 3 n. miles of that position was searched for suitable bottom. If suitable ground was not found, the station was abandoned and another random position chosen. If foul ground was encountered during trawling, the station was considered unsuitable for biomass estimation if less than 2 n. miles of the tow had been covered during the tow. Tows less than 2 n. miles long were replaced with another random station in the same stratum. The average speed over the ground was calculated at the end of each tow.

The doorspread and headline height were recorded every 5 minutes during each tow (from the Scanmar system and either the Furuno or Kaijo Denki net monitor, respectively) and an average was calculated. Gear configuration was maintained as consistently as possible during the survey and within the ranges described as optimal by Hurst et al. (1992). Gear configurations outside this range were identified by a gear performance code of 3, but these tows were considered for inclusion in the biomass analysis if, for example, the violation was less than 10%, or if the number of stations in a stratum was at the minimum.

2.5 Hydrology

Chatham Rise waters are characterised by the Subtropical Front (STF) that lies more or less west to east along the crest of the Rise. The precise location of the STF can be difficult to ascertain, although Subtropical Water to the north is typically warmer than the Subantarctic Water which lies south of the STF. In this study, water temperature data collected from the surface and bottom were used to determine the location of these water masses during the survey. Surface temperatures were obtained at 5 m depth from the calibrated Seabird CTD, before the gear moved down to the seabed. Bottom temperatures were obtained from the Seabird CTD mounted on the trawl headline about 6.5 m above the seabed during trawling. Surface and bottom temperatures were plotted to estimate isotherm characteristics of the Chatham Rise and ascertain which water masses were characterising the area during the survey. We also checked the Satellite Sea-surface Temperature (SST) chart for January on the NIWA SST Climate Database for comparison, and temperature anomalies for January.

2.6 Catch sampling and modified species selection

The catch at each station was sorted into species and weighed on motion-compensating electronic scales accurate to within ± 0.3 kg. For large catches of mixed rattails, the weights of individual species were estimated by subsampling, i.e., a subsample was sorted and weighed by species and the total catch was scaled according to the percentage weight of each species in the subsample.

From each tow, samples of up to 200 hoki and 50–200 of other commercial species were randomly selected from the catch to measure length (to the nearest centimetre) and determine sex. Up to 20 specimens of hoki, hake, and ling were selected from the length frequency sample for detailed biological analysis and otolith removal. Data collected included length (to the nearest millimetre), weight, sex, gonad stage (if in maturing or spawning condition), and weight. As a result of work to examine annual variation in length-weight relationships (Livingston et al. 2004), sampling for other species focused on obtaining length frequencies for a wide range of species (i.e., not only QMS), while biological data collection was focused on species for which there were few data.

Length-weight data were collected from hoki, hake, ling, dark ghost shark, giant stargazer, lookdown dory, and pale ghost shark. Other species targeted for length-weight data included those for which there are fewer than 500 length-weight records on the Trawlsurvey database. Length-weight relationships of species not weighed were obtained as a mean from all surveys combined.

Data were entered using the electronic data capture system aboard *Tangaroa* and were error checked at sea. Coefficients of variation (c.v.s) and biomass estimates were monitored for hoki, hake, ling, and individual size classes of hoki as the survey progressed.

2.7 Otolith collection and ageing

Otoliths from hoki and other middle depth species were routinely collected for other studies on age and growth. Hoki, hake, and ling otoliths were aged using the validated methodology of Horn & Sullivan (1996), as modified by Cordue et al. (2000). Population estimates of numbers of fish at age were calculated by applying proportions at age in each 1 cm length class to the length frequency using software developed by NIWA (Wellington).

2.8 Trawl survey data analysis

Relative abundance (i.e., biomass expressed as tonnes) was estimated by the area-swept method of Francis (1984, 1989) using valid stations only (i.e., gear performance of 1 or 2 only, except in unique circumstances such as that described at the end of Section 2.4). Coefficients of variation were calculated as a measure of the precision of the biomass estimates, as follows:

$$\text{c.v.}\ (\%) = S_B / B \times 100$$

where S_B is the standard error of the biomass (B).

The catchability coefficient (an estimate of the proportion of fish in the survey area available to be caught in the net) is the product of vulnerability (v), vertical availability (u_v), and areal availability (u_a) as defined by Francis (1989). These factors were all set to 1 in these analyses, assuming that fish were randomly distributed over the bottom within a stratum; fish distribution did not extend above the headline height of the net; all fish in the path of the doors were caught; and the herding effect of the doors, sweeps, and bridles was constant.

Length frequencies scaled to population estimates and biomass estimates were calculated using the Trawlsurvey Analysis Program, version 3.2 (Vignaux 1994). The data from each station were scaled by the percentage of the catch sampled (to represent each catch) and by the ratio of the area swept to stratum area (to represent the total population). A further correction (usually minor) was made to ensure that the biomass calculated from the scaled length frequencies equated to the biomass calculated from catch data. Total biomass and biomass by stratum for 1+, 2+, and 3++ (a plus group of hoki aged 3 years or more) age classes of hoki were also calculated using the Trawlsurvey Analysis Programme using length frequency data to estimate appropriate length ranges of each age class.

Catch rate distributions, length frequencies, and numbers at age of hoki, hake, and ling were plotted as a full time series. Catch distributions and length frequencies for eight other key species (dark ghost shark, pale ghost shark, giant stargazer, lookdown dory, sea perch, silver warehou, spiny dogfish, white warehou) were plotted for this survey only. These species were selected because they are commercially important, and the trawl survey samples the main part of their depth distribution. Other species, such as black oreo, are also commercial and relatively abundant on these surveys, but their depth distribution extends well beyond that sampled by the survey and the data are not representative of the full population.

The relative biomass estimates from the entire time series were plotted for hoki, hake, ling, and the other eight key species listed above, to indicate trends and variability in the abundance indices.

3. RESULTS

3.1 2004 survey coverage

The survey successfully sampled all strata, with 110 stations completed, all of which were deemed valid for biomass estimation. Of the 110 stations, 107 were from phase 1 of the survey and 3 were from phase 2. Two phase 2 stations were allocated to stratum 19 and one to stratum 20 to improve the c.v. for 2+ hoki. The station distribution is shown in Figure 1 (lower panel), and the final tally of valid stations is given in Table 1.

The dates of the trawl survey were within the time frame covered in previous years (Table 2). Doorspread readings were recorded from 87 of the 110 valid biomass stations (Table 3). The missing readings were substituted with mean values from the appropriate depth zones obtained during the survey.

Station density ranged from 1:288 km^2 in stratum 17 (200–400 m, Veryan Bank) to 1:2829 km^2 in stratum 4 (600–800 m, south Chatham Rise). Mean station density was 1:1268 km^2.

3.2 Gear performance

Gear configuration for valid biomass tows was relatively constant over the 200–800 m depth range. Mean doorspread measurements by 200 m depth intervals ranged from 113.0 to 118.0 m and mean headline height ranged from 6.8 to 6.9 m; all were within the optimal range (Hurst et al. 1992) (Table 3).

3.3 Hydrology

Surface and bottom temperatures were recorded throughout the survey from the seabird CTD. The surface temperatures (Figure 2, top panel) ranged from 13.4 to 17.3 °C. Bottom temperatures ranged from 6.5 to 10.9 °C (Figure 2, bottom panel).

As in previous years, higher surface temperatures were associated with Subtropical Water to the north. Lower temperatures were associated with Subantarctic Water to the south. Higher bottom temperatures were generally associated with shallower depths to the north of the Chatham Islands and to the east of the Mernoo Bank. The location of the STF is typically determined by close isotherms at the surface. Although not well defined during this survey, the closest isotherms of 15–16 °C lay over the southern slopes of the Rise (Figure 2, upper panel). Our interpretation is that a tongue of cool water projected north in the Mernoo Gap, with the edge of the STF passing south of Mernoo Bank.

3.4 Catch composition

One hundred and seventy-four species or species groups were recorded from the 110 valid biomass tows. The total catch was 103 t, of which 23.0 t (22.4%) was hoki, 12.1 t (11.7%) was black oreo, 8.9 t (8.6%) was silver warehou, 5.1 t (4.9%) was spiny dogfish, 5.0 t (4.8%) was javelinfish, and 4.6 t (4.5%) was spiky oreo (Table 4).

Of the 174 species or species groups identified, there were 93 teleosts, 26 elasmobranchs, 17 crustaceans, and 10 cephalopods, the remainder consisting of assorted benthic and pelagic organisms. A full list of species caught, and the number of stations at which they occurred, is given in Appendix 2. A number of benthic invertebrates are awaiting formal identification.

3.5 Biomass estimates

Relative biomasses, were estimated for 46 species (Table 4). The c.v.s estimated for hoki, hake, and ling were close to target levels. Phase 2 stations resulted in a c.v. of 20.4% for 2+ hoki (2001 year class). High c.vs (over 30%) generally occurred when species were not well sampled by the gear. For example, silver warehou and alfonsino are not demersal and exhibit strong schooling behaviour. Others, such as smooth oreo and barracouta, have high c.vs as they are mainly distributed outside the survey depth range.

The combined biomass for the top 31 species in the core strata that are tracked from year to year was higher than in 2003 (Figure 3, top panel). Although at historically low levels, hoki biomass was similar to 2003. As in previous years, hoki was still the most abundant species caught (Table 4), but formed a lower proportion of the total biomass than last year (Figure 3, lower panel). Overall, the proportion of hoki has dropped from over 50% of the biomass to at the beginning of the time series to about 20% (Figure 3, lower panel). Black oreo, silver warehou, spiky oreo, dark ghost shark, ling, white warehou, smooth oreo, sea perch, pale ghost shark, giant stargazer, and hake were the next most abundant QMS species after hoki, each with an estimated biomass over 1500 t. The most abundant commercial non-QMS species were spiny dogfish, lookdown dory, shovelnose dogfish, and smooth skate (all biomass over 1 500 t). A substantial biomass of non-commercial species, primarily javelinfish and other rattails, was also estimated (Table 4).

The relative hoki biomass, estimated at 52 600 t, was very close to that of 2003 (Table 5). There was average recruitment of 1+ fish (2002 year class), and an increase in the biomass of fish aged 3 years and over (3++) due to recruitment of the 2+ year class into the plus group (Table 6). The hake biomass estimate was almost double that of 2003, and almost identical to that recorded in 2001 and 2002. Ling biomass was up slightly from 2003.

Pale ghost shark and sea perch biomass estimates were lower than in 2003, continuing a downward trend since 2001 and 2002 respectively. Dark ghost shark showed little change from 2003, while lookdown dory, giant stargazer silver warehou, spiny dogfish, and white warehou biomasses have increased since 2001 (Figure 4).

3.6 Catch distribution

Hoki

In the 2004 survey, hoki were caught at 107 of the 110 biomass stations, but the highest catch rates were in shallow strata (200–400 m) along the crest of the Rise (Figure 5a), reflecting the abundance of 1+ hoki, the 2002 year class of a similar order of magnitude to the 1998 year class measured at age 1+(Table 6). Two-year-old hoki were relatively scarce, with low catch rates throughout the survey area (Figure 5b). The older fish, three years and over, showed the greatest catch rates along the southern 400 m boundary of the survey area, reflecting the distribution of the moderately strong 2000 year class (Figure 5c). The highest individual 2004 station catch rate of hoki occurred on the Reserve Bank (stratum 19) and consisted of mainly 1+ fish. The distribution of this age class was mainly on western strata, particularly the Reserve Bank (strata 19 and 20) as seen in previous years (Figure 5a).

As hoki catch rates have declined, catch distribution patterns have changed. In early years, catch rates of hoki were higher in western strata, particularly the 1+ and 2+ age classes. Older fish were generally more evenly distributed, although during the 1992 and 1993 surveys, large catches of 3++ hoki were also taken in the western strata (Livingston et al. 2002). From 2000 to 2002, catches of older hoki have were skewed more to the east, but in 2003 and 2004 the distribution became more even again (Figure 5c).

Hake

In 2004, catch rates of hake were higher than in 2003, with the highest catch rates northwest of the Chatham Islands where hake spawn at this time of year (Figure 6). Strata 10a, 10b, 11a, 11b, 11c, 11d, and 2b near the Chatham Islands contributed 56% of hake biomass (Tables 7 and 8). The highest stratum catch rates of hake were from stratum 10b in the hake spawning area. Few hake were taken at depths of 200–400 m. The decline in hake catch rates over the time series is seen in Figure 6, and since 2000 very few hake have been caught along the south side of the survey area.

Ling

Catches of ling were evenly distributed throughout most strata in the survey area (Figure 7). The largest catch was taken in stratum 20, on the southern edge of the Reserve Bank. Ling distribution has been reasonably consistent, and catch rates have remained relatively stable over the time series.

Other species

As with previous surveys, giant stargazer (200–400 m), lookdown dory(200–600 m), and pale ghost shark (400–800 m) were widely distributed across the survey area and taken in large quantities within their depth zones (Figure 8). Spiny dogfish were also widely distributed, although larger catches were taken from the southern rise in 200–600 m depths. Sea perch were more concentrated in strata east of Mernoo Bank. Dark ghost shark occurred mainly in 200–400 m depths, with the largest catch again taken in stratum 17 on Veryan Bank. Silver warehou and white warehou were patchily distributed and predominantly taken at depths of 200–600 m, with occasional large catches taken from stratum 9, north of the Chatham Islands, and stratum 18, west of the Mernoo Bank (Figure 8, Tables 7 and 8).

3.7 Biological data

3.7.1 Species sampled

The number of species and the number of samples for which length-weight data were collected is given in Table 9.

3.7.2 Length frequencies and age distributions

Length-weight relationships used in the Trawlsurvey Analysis Program to scale length frequencies and calculate biomass and catch rates of 1+, 2+ and 3++ hoki, are given in Table 10.

Hoki

The 1+ age class of hoki (less than 51 cm total length) dominated scaled length frequencies and age frequencies in the 2004 survey (Figures 9 and 10). Numbers of 2+ hoki (51–61 cm) were very low.

The decline in biomass over time is reflected in the decline of the number of older hoki within the time series. Intermittent recruitment pulses dominate length frequencies and numbers at age over the time series (Figures 9 and 10). Although recruitment was above average in 1997, 1998, and 2000, the numbers of fish at age in these year classes are considerably lower than observed in the pulse of strong recruitment observed in 1991–94 (Figures 9 and 10, and see Figure 4). The 2000 year class was about average year class strength.

Hake

Hake scaled length frequencies and calculated numbers at age (Figures 11 and 12) comprise mainly medium to large individuals of at least 7 years of age corresponding to juvenile recruitment to the survey area during the mid 1990s. The time series does not appear to be a particularly good indicator of 1+ and 2+ age class strength and may be indicative of reduced selectivity or later recruitment from outside the survey area. Juvenile recruitment to the survey area has been very poor for the previous 3 years, although there is some indication of a strong 2+ age class in 2004. If recruitment is strong then these fish will show strongly as 3+ year old fish in the 2005 survey.

Ling

In contrast to hake, ling scaled length frequencies and calculated numbers at age comprise mainly medium sized individuals of 4–8 years, which corresponds to several years of strong recruitment during the late 1990s (Figures 13 and 14). The time series is a poor indicator of 1+ and 2+ age class strength and, like hake, may be indicative of reduced selectivity or availability in the survey area.

Other species

Length frequency distributions for sea perch, silver warehou, and white warehou indicate that males grow to a similar maximum size, and have a similar distribution to females (Figure 15). In 2004, 1+ silver and white warehou (about 30 cm) were relatively weak compared with the 2+ cohort (about 40 cm) (Figure 15). It is not clear whether the modal groups in the length frequencies of sea perch represent distinct year classes. Most of the alfonsino and oreos caught (not shown) were pre-recruits.

Length frequencies of lookdown dory, giant stargazer, spiny dogfish, dark ghost shark and pale ghost shark indicate that females grow larger than males. It is unclear if modal peaks correspond to individual year classes in the length frequencies of these species (Figure 15).

3.7.3 Reproductive status

Gonad stages of hake, hoki, ling, sea perch, and small numbers of other species are summarised in Table 11. Hoki and ling were either resting or immature; 57% of male adult hake were running ripe, but few females were showing signs of reproductive activity this year. A small number (6%) of female lookdown dory showed signs of reproductive activity (Table 11). Gonad stages of adult fish from most other species were resting.

3.7.4 Sex ratios

Overall sex ratios calculated from male and female population numbers given on length frequency histograms (Figures 9a, 9b, 11a, 11b, 13a, 13b, 15) were 1:1.2 (males to females) for hoki, with more females 1:1.5 at 400–600 m, increasing to 1:4.6 in 600–800 m. Female hake are also found in greater numbers than males, whereas male ling tend to be more abundant than females. Sex ratios were about even for most other species, except spiny dogfish that were also predominantly female (sex ratios exceeded 1:1.5).

4. DISCUSSION

The 2004 survey successfully continued the January *Tangaroa* time series with a total of 110 valid biomass tows. Weather conditions were generally favourable, with only two days lost to bad weather.

The survey c.v. of 12.6% achieved for adult hoki was well within the target precision level of 15%. The c.v. of 17.1% for hake was also within the target c.v. of 20%. The c.v. for 2 year old hoki was 20.4% and was just over the target c.v. of 20% due to the patchy distribution of this weak year class.

The estimated total biomass of hoki was essentially the same as in the previous survey, mainly as a result of reasonable recruitment in the 1+ cohort. The total hoki biomass continues to remain at the lowest level within the overall time series.

The biomass of hake in core strata was significantly higher than in the 2003 survey, and is at similar low levels to those estimated from the 2001 and 2002 surveys. Although the trawl survey does not appear to sample 1–2 year old hake well, there is a suggestion of relatively strong 2+ recruitment from the 2004 survey. This may be confirmed in the 2005 survey when these fish are 3+ years old and better sampled by the gear.

The biomass of ling in core strata was slightly higher compared with 2003 but there is no obvious trend within the time series. Although the trawl survey does not sample 1–3 year old ling well, a peak at age 4–7 years shows that there has been good recruitment in recent years.

5. CONCLUSIONS

The survey in 2004 extended the time series into its 13th year and provided comparable abundance indices for hoki, hake, and ling that have been used for stock assessment. The estimated biomass of hoki and hake remains at very low levels, although there appears to be some recruitment of 1+ fish in both species.

6. ACKNOWLEDGMENTS

We wish to thank the scientific staff and the Master, officers, and crew of *Tangaroa* who contributed to the success of this voyage. Thanks also to our internal reviewer, Neil Bagley, for providing constructive comments on this manuscript, and to the scientific staff involved with the preparation, reading, and calculation of catch at age data for hoki, hake, and ling otoliths from this survey. This work was carried out by NIWA under contract to the Ministry of Fisheries (Project HOK2003/02).

7. REFERENCES

Annala, J.H.; Sullivan, K.J.; O'Brien, C.J.; Smith, N.W.McL.; Grayling, S.M. (Comps.) (2003). Report from the Fishery Assessment Plenary, May 2003: stock assessments and yield estimates: 616 p. (Unpublished report held in NIWA library, Wellington.)

Annala, J.H.; Sullivan, K.J.; Smith, N.W.McL.; Griffiths, M.H., Todd, P.R., Mace, P.M., Connell, A.M. Comps. (2004). Report from the Fishery Assessment Plenary, May 2004: stock assessment and yield estimates. 690 p. (Unpublished report held in NIWA library, Wellington.)

Annala, J.H.; Wood, B.A.; Smith, D.W. (1989). Age, growth, mortality and yield-per-recruit estimates of tarakihi from the Chatham Islands during 1984 and 1985. Fisheries Research Centre Internal Report 119. 23 p. (Unpublished report held in NIWA library, Wellington.)

Bagley, N.W.; Hurst, R.J. (1998). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1998 (TAN9801). *NIWA Technical Report 44*. 54 p.

Bagley, N.W.; Livingston, M.E. (2000). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1999 (TAN9901). *NIWA Technical Report 81.* 52 p.

Beentjes, M.P. (1992). Assessment of red cod based on recent trawl survey and catch sampling data. *New Zealand Fisheries Assessment Research Document 92/16.* 41 p.

Cordue, P.L.; Ballara, S.L.; Horn, P.L. (2000). Hoki ageing: recommendation of which data to routinely record for hoki otoliths. Final Research Report to the Ministry of Fisheries for Project MOF1999/01 (Hoki ageing). 24 p. (Unpublished report held by Ministry of Fisheries, Wellington.)

Francis, R.I.C.C. (1984). An adaptive strategy for stratified random trawl surveys. *New Zealand Journal of Marine and Freshwater Research 18*: 59–71.

Francis, R.I.C.C. (1989). A standard approach to biomass estimation from bottom trawl surveys. New Zealand Fisheries Assessment Research Document 89/3. 3 p. (Draft report held in NIWA library, Wellington.)

Hatanaka, H.; Uozumi, Y.; Fukui, J.; Aizawa, M.; Hurst, R.J. (1989). Japan-New Zealand trawl survey off southern New Zealand, October–November 1983. *New Zealand Fisheries Technical Report No. 9.* 52 p.

Horn, P.L. (1988). Age and growth of bluenose, *Hyperoglyphe Antarctica* (Pisces: Stromateoidei) from the lower east coast, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 22: 369–378.

Horn, P.L. (1994a). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1991-January 1992 (TAN9106). *New Zealand Fisheries Data Report No. 43.* 38 p.

Horn, P.L. (1994b). Trawl survey of hoki and middle depth species on the Chatham Rise, December 1992-January 1993 (TAN9212). *New Zealand Fisheries Data Report No. 44.* 43 p.

Horn, P.L.; Sullivan, K.J. (1996). Validated aging methodology using otoliths, and growth parameters for hoki (*Macruronus novaezeelandiae*) in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 30:* 161–174.

Hurst, R.J.; Bagley, N.W. (1994). Trawl survey of middle depth and inshore bottom species off Southland, February-March 1993 (TAN9301). *New Zealand Fisheries Data Report No. 52.* 58 p.

Hurst, R.J.; Bagley, N.; Chatterton, T.; Hanchet, S.; Schofield, K.; Vignaux, M. (1992). Standardisation of hoki/middle depth time series trawl surveys. MAF Fisheries Greta Point Internal Report No. 194. 89 p. (Draft report held in NIWA library, Wellington.)

Johnston, A.D. (1983). The southern Cook Strait groper fishery. *Fisheries Technical Report No. 159.* 33 p.

Livingston, M.E.; Bull, B.; Stevens, D.W.; Bagley, N.W. (2002). A review of hoki and middle depth trawl surveys of the Chatham Rise, January 1992–2001. *NIWA Technical Report 113.* 146 p.

Livingston, M.E.; Stevens, D.; O'Driscoll, R.L.; Francis, R.I.C.C. (2004). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2003 (TAN0301). *New Zealand Fisheries Assessment Report 2004/16.* 71 p.

Schofield, K.A.; Horn, P.L. (1994). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1994 (TAN9401). *New Zealand Fisheries Data Report No. 53.* 54 p.

Schofield, K.A.; Livingston, M.E. (1995). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1995 (TAN9501). *New Zealand Fisheries Data Report No. 59.* 53 p.

Schofield, K.A.; Livingston, M.E. (1996). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1996 (TAN9601). *New Zealand Fisheries Data Report No. 71.* 50 p.

Schofield, K.A.; Livingston, M.E. (1997). Trawl survey of hoki and middle depth species on the Chatham Rise, January 1997 (TAN9701). *NIWA Technical Report 6.* 51 p.

Stevens, D.W.; Livingston, M.E.; Bagley, N.W. (2001). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2000 (TAN0001). *NIWA Technical Report 104.* 55 p.

Stevens, D.W.; Livingston, M.E.; Bagley, N.W. (2002). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2001 (TAN0101). *NIWA Technical Report 116.* 61 p.

Stevens, D.W.; Livingston, M.E. (2003). Trawl survey of hoki and middle depth species on the Chatham Rise, January 2002 (TAN0201). *New Zealand Fisheries Assessment Report 2003/19.* 57 p.

Stevenson, M.L.; Beentjes, M.P. (1999). Inshore trawl survey of the Canterbury Bight and Pegasus Bay, December 1998–January 1999 (KAH9809). *NIWA Technical Report 63.* 66 p.

Tracey, D.M.; George, K.; Gilbert, D.J. (2000). Estimation of age, growth, and mortality parameters of black cardinalfish (*Epigonus telescopus*). *New Zealand Fisheries Assessment Report 2000/27.* 21 p.
Vignaux, M. (1994). Documentation of Trawlsurvey Analysis Program. MAF Fisheries Greta Point Internal Report No. 225. 44 p. (Draft report held in NIWA library, Wellington.)

Table 1: Stratum description and valid stations completed. (-, no stations.)

Stratum	Depth (m)	Location	Area (km^2)	Number of stations Phase 1	Phase 2	Total	Station density (km^2)
1	600–800	NW Chatham Rise	2 439	3	-	3	1:813
2a	600–800	NW Chatham Rise	3 253	3	-	3	1:1 084
2b	600–800	NE Chatham Rise	8 503	6	-	6	1:1 417
3	200–400	Matheson Bank	3 499	3	-	3	1:1 166
4	600–800	SE Chatham Rise	11 315	4	-	4	1:2 829
5	200–400	SE Chatham Rise	4 078	3	-	3	1:1 359
6	600–800	SW Chatham Rise	8 266	3	-	3	1:2 755
7	400–600	NW Chatham Rise	5 233	6	-	6	1:872
8a	400–600	NW Chatham Rise	3 286	3	-	3	1:1 095
8b	400–600	NW Chatham Rise	5 722	5	-	5	1:1 144
9	200–400	NE Chatham Rise	5 136	5	-	5	1:1 027
10a	400–600	NE Chatham Rise	2 958	5	-	5	1:592
10b	400–600	NE Chatham Rise	3 363	5	-	5	1:673
11a	400–600	NE Chatham Rise	2 966	7	-	7	1:424
11b	400–600	NE Chatham Rise	2 072	4	-	4	1:518
11c	400–600	NE Chatham Rise	3 342	4	-	4	1:836
11d	400–600	NE Chatham Rise	3 368	4	-	4	1:842
12	400–600	SE Chatham Rise	6 578	3	-	3	1:2 193
13	400–600	SE Chatham Rise	6 681	3	-	3	1:2 227
14	400–600	SW Chatham Rise	5 928	3	-	3	1:1 976
15	400–600	SW Chatham Rise	5 842	4	-	4	1:1 461
16	400–600	SW Chatham Rise	11 522	7	-	7	1:1 646
17	200–400	Veryan Bank	865	3	-	3	1:288
18	200–400	Mernoo Bank	4 687	3	-	3	1:1 562
19	200–400	Reserve Bank	9 012	4	2	6	1:1 502
20	200–400	Reserve Bank	9 584	4	1	5	1:1 917
Total			139 498	107	3	110	1:1 268

Table 2. Survey dates and number of valid stations in surveys of the Chatham Rise, January 1992–2004.

Start date	End date	No. of valid stations
28 Dec 1991	1 Feb 1992	184
30 Dec 1992	6 Feb 1993	194
2 Jan 1994	31 Jan 1994	162
4 Jan 1995	27 Jan 1995	122
27 Dec 1995	14 Jan 1996	89
2 Jan 1997	24 Jan 1997	103
3 Jan 1998	21 Jan 1998	91
3 Jan 1999	26 Jan 1999	100
27 Dec 1999	22 Jan 2000	128
28 Dec 2000	25 Jan 2001	119
5 Jan 2002	25 Jan 2002	107
29 Dec 2002	21 Jan 2003	115
27 Dec 2003	23 Jan 2004	110

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

	n	Mean (m)	s.d.	Range
Tow parameters				
Tow length (n. miles)	110	3.0	0.19	2.0–3.05
Tow speed (knots)	110	3.5	0.05	3.3–3.7
Gear parameters				
200–400 m				
Headline height	28	6.9	0.24	6.4–7.4
Doorspread	23	113.0	6.62	98.7–121.2
400–600 m				
Headline height	63	6.8	0.19	6.5–7.3
Doorspread	48	118.0	5.03	106.2–127.0
600–800 m				
Headline height	19	6.9	0.25	6.6–7.5
Doorspread	16	116.9	6.89	103.6–129.0
All stations 200–800 m				
Headline height	110	6.9	0.21	6.4–7.5
Doorspread	87	116.5	6.15	98.7–129.0

Table 4: Catch (kg) and total biomass (t) estimates (also by sex) with coefficient of variation (c.v.), of ITQ species, other commercial species, and major non-commercial species 200–800 m depths. Total biomass includes unsexed fish. (-, no data.)

Common name	Code	Catch	Biomass males		Biomass females		Total biomass	
		kg	t	% c.v.	t	% c.v.	t	% c.v.
ITQ species								
Hoki	HOK	23 048	20 961	15.7	31 680	10.9	52 687	12.6
Black oreo	BOE	12 111	26 396	68.4	24 492	67.7	50 888	68.1
Silver warehou	SWA	8 865	8 650	41.7	11 882	39.3	20 548	39.5
Spiky oreo	SOR	4 630	6 855	56.0	4 025	54.4	10 881	55.3
Dark ghost shark	GSH	6 793	4 443	15.1	5 947	15.0	10 471	15.0
Ling	LIN	4 032	3 871	7.3	4 374	8.6	8 248	7.0
White warehou	WWA	3 336	4 494	48.7	3 431	39.2	7 932	44.2
Smooth oreo	SSO	1 490	3 532	64.5	2 726	69.6	6 258	66.4
Sea perch	SPE	2 493	2 731	13.4	2 741	14.0	5 786	13.0
Pale ghost shark	GSP	1 563	1 811	7.7	1 810	10.9	3 627	8.6
Giant stargazer	STA	1 335	614	20.9	1 987	18.8	2 625	17.2
Hake	HAK	949	394	20.6	1 154	21.4	1 547	17.1
Red cod	RCO	521	427	42.4	235	39.9	662	41.3
Alfonsino	BYS	366	330	38.4	230	28.3	594	31.3
Ribaldo	RIB	258	164	22.7	371	19.2	535	15.6
Arrow squid	NOS	232	212	31.9	199	30.0	420	29.8
Tarakihi	TAR	125	118	53.9	132	58.2	252	50.7
School shark	SCH	133	140	55.6	88	41.2	228	42.9
Banded giant stargazer	BGZ	94	87	83.9	114	69.7	202	75.4
Barracouta	BAR	79	87	43.9	101	45.6	188	37.0
Frostfish	FRO	67	118	92.9	50	89.3	172	91.9
Slender mackerel	JMM	52	70	51.0	58	45.8	128	47.5
Hapuku	HAP	34	9	100	88	53.7	97	48.8
Lemon sole	LSO	39	11	46.3	13	37.5	59	27.0
Rubyfish	RBY	22	22	85.0	17	80.7	39	83.1
Orange roughy	ORH	19	17	82.9	17	67.0	34	73.5
Bluenose	BNS	19	4	100	28	59.0	32	53.6
Rough skate	RSK	16	6	100	11	100.0	22	60.4
Black cardinalfish	EPT	9	11	60.6	4	48.6	16	51.1
Jack mackerel	JMD	3	7	50.1	0	-	7	50.1
Long-finned beryx	BYD	0.1	0.1	100	0	-	0.1	100

Table 4. *Continued*

Common name	Code	Catch	Biomass males		Biomass females		Total biomass	
		kg	t	% c.v.	t	% c.v.	t	% c.v.
Commercial non-ITQ species (where biomass > 30 t)								
Spiny dogfish	SPD	5 078	1 425	23.2	10 848	18.4	12 289	18.4
Lookdown dory	LDO	3 300	2 056	9.1	4 687	8.1	6 746	7.7
Shovelnose dogfish	SND	1 353	950	17.5	1 410	12.1	2 363	11.5
Smooth skate	SSK	988	900	31.9	1 106	25.2	2 006	21.0
Ray's bream	RBM	115	145	25.4	128	25.6	273	24.0
Northern spiny dogfish	NSD	36	33	32.1	52	45.0	85	28.9
Scampi	SCI	18	22	22.6	10	20.8	35	19.2
Southern blue whiting	SBW	64	16	50.0	14	50.0	30	50.0
Non-commercial species (where biomass > 800 t)								
Javelinfish	JAV	4 998	-	-	-	-	10 954	10.1
Big-eye rattail	CBO	3 897	-	-	-	-	7 705	9.8
Oliver's rattail	COL	715	-	-	-	-	1 938	29.9
Longnose chimaera	LCH	489	-	-	-	-	1 554	13.0
Banded bellowsfish	BBE	868	-	-	-	-	1 319	15.6
Oblique-banded ratt.	CAS	575	-	-	-	-	841	17.6
Baxter's dogfish	ETB	201	-	-	-	-	835	24.2
Total (above)		95 428	-	-	-	-	234 158	-
Grand total (all species)		103 052	-	-	-	-	-	-

Table 5: Estimated biomass (t) with coefficient of variation below (%) of hoki, hake, and ling sampled by annual trawl surveys of the Chatham Rise, January 1992–2004. stns, stations. (-, no data; c.v., coefficient of variation.)

		Core strata 200–800 m				800–1000 m			
Year	Survey	No. stns	Hoki	Hake	Ling	No. stns	Hoki	Hake	Ling
1992	TAN9106	184	120 190	4 180	8 930	0	-	-	-
	c.v.		7.7	14.9	5.8				
1993	TAN9212	194	185 570	2 950	9 360	0	-	-	-
	c.v.		10.3	17.2	7.9				
1994	TAN9401	165	145 633	3 353	10 129	0	-	-	-
	c.v.		9.8	9.6	6.5				
1995	TAN9501	122	120 441	3 303	7 363	0	-	-	-
	c.v.		7.6	22.7	7.9				
1996	TAN9601	89	152 813	2 457	8 424	0	-	-	-
	c.v.		9.8	13.3	8.2				
1997	TAN9701	103	157 974	2 811	8 543	0	-	-	-
	c.v.		8.4	16.7	9.8				
1998	TAN9801	91	86 678	2 873	7 313	0	-	-	-
	c.v.		10.9	18.4	8.3				
1999	TAN9901	100	109 336	2 302	10 309	0	-	-	-
	c.v.		11.6	11.8	16.1				
2000	TAN0001	128	72 151	2 152	8 348	4	411	62	18
	c.v.		12.3	9.2	7.8		56	64	100
2001	TAN0101	119	60 330	1 589	9 352	0	-	-	-
	c.v.		9.7	12.7	7.5				
2002	TAN0201	107	74 351	1 567	9 442	3	1 955	338	0
	c.v.		11.4	15.3	7.8		39	23	
2003	TAN0301	115	52 531	888	7 261	0	-	-	-
	c.v.		11.6	15.5	9.9				
2004	TAN0401	110	52 687	1 547	8 248	0	-	-	-
	c.v.		12.6	17.1	7.0				

Table 6: Relative biomass estimates (t in thousands) of hoki 200–800 m depths, Chatham Rise trawl surveys January 1992–2004. (c.v. coefficient of variation; 3++ all hoki aged 3 years and older; (see Appendix 3 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)

Table 7: Estimated biomass (t) and coefficient of variation (% c.v.) of hoki, hake, ling, and 8 other species by stratum. (See Table 4 for species codes.) (-, not calculated.)

Species code

	HOK		SWA		SPD		GSH		LIN		WWA		LDO		SPE		GSP		STA		HAK	
Stratum	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	t	c.v.	T	c.v.	t	c.v.
1	115	5	0	-	0	-	0	-	132	58	5	100	30	13	14	82	111	56	0	-	15	28
2a	341	22	0	-	0	-	3	100	210	22	0	-	82	31	60	26	117	50	17	59	39	11
2b	1 528	24	0	-	0	-	0	-	252	31	0	-	242	33	95	52	232	25	55	76	414	35
3	2 449	45	68	39	1 126	38	578	17	272	34	109	53	491	44	276	14	7	100	26	53	0	-
4	747	31	80	100	161	67	0	-	578	17	21	60	229	22	117	52	437	36	18	100	0	-
5	1 450	24	233	30	2 026	66	1 132	22	167	28	55	32	418	18	49	56	0	-	128	53	9	100
6	708	31	401	95	16	100	0	-	364	62	28	59	70	100	13	100	462	31	0	-	65	61
7	776	39	32	69	88	54	158	99	558	9	38	78	130	16	55	60	302	27	68	43	66	32
8a	762	12	0	-	0	-	0	-	341	31	12	52	90	35	96	27	56	15	28	54	42	61
8b	1 907	27	222	69	160	73	168	57	491	18	46	91	234	32	251	15	175	45	19	61	27	70
9	531	78	7 104	99	233	54	114	81	140	57	106	98	205	62	153	56	0	-	269	53	0	-
10a	248	30	2	100	0	-	0	-	139	32	0.9	100	74	21	40	28	28	41	0	-	70	32
10b	271	16	0	-	13	100	7	100	37	30	0	-	72	16	46	12	42	16	7	100	324	38
11a	589	33	96	34	176	23	311	32	205	25	38	49	257	29	45	25	16	57	51	68	16	50
11b	209	24	11	100	0	-	0.2	100	54	26	7	38	51	12	26	25	27	39	6	100	29	23
11c	596	15	21	85	42	52	74	50	175	24	42	100	166	19	47	31	11	60	36	55	0	-
11d	1 297	10	1 795	59	48	39	22	79	86	37	185	55	184	26	70	11	32	35	3	100	7	100
12	3 497	24	3 238	100	1 090	49	241	34	720	26	1 003	96	412	23	110	67	145	62	28	100	180	72
13	2 309	34	157	57	1 856	6	53	91	383	20	344	39	546	52	317	50	214	11	0	-	0	-
14	2 072	45	491	58	855	6	24	100	469	14	394	31	517	16	266	22	503	19	0	-	78	100
15	3 940	47	950	54	124	56	79	58	576	33	931	87	443	24	216	38	408	20	153	58	45	61
16	3 331	31	289	61	307	40	31	91	1 112	20	675	53	382	18	58	32	287	22	222	22	121	60
17	170	55	179	79	70	31	1 310	25	13	50	80	59	21	77	11	90	0	-	89	17	0	-
18	3 680	60	3 734	53	510	10	663	14	147	100	3 264	99	98	56	390	42	0	-	421	48	0	-
19	8 121	56	871	69	504	20	2 046	28	347	49	142	87	270	56	948	41	6	100	610	45	0.9	100
20	11 043	28	574	39	2 883	58	3 454	40	274	62	405	33	1 030	16	2 015	28	6	100	372	60	0	-
Total	52 687	13	20 548	40	12 289	18	10 471	15	8 248	7	7 932	44	6 746	8	5 786	13	3 627	9	2 625	17	1 547	17

Table 8: Catch rate (kg.km^{-2}) and standard deviations (s.d.) of hoki, hake, ling, and 8 other species by stratum. (See Table 4 for species codes.) (-, not calculated.)

Stratum	HOK		SWA		SPD		GSH		LIN		WWA		LDO		SPE		GSP		STA		HAK (Species code)	
	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.	kg.km^{-2}	s.d.
1	47	4	0	-	0	-	0	-	54	55	2	4	12	3	6	8	45	44	0	-	6	3
2a	105	40	0	-	0	-	1	2	65	25	0	-	25	14	18	8	36	31	5	5	12	2
2b	180	107	0	-	0	-	0	-	30	22	0	-	28	23	11	14	27	17	6	12	49	42
3	700	548	19	22	322	209	165	49	78	45	31	29	140	108	79	20	2	4	7	7	0	-
4	66	40	7	14	14	19	0	0	51	17	2	2	20	9	10	11	39	28	2	3	0	-
5	355	148	57	29	497	566	278	105	41	20	14	7	102	32	12	12	0	0	31	29	2	4
6	86	46	48	80	2	3	0	-	44	48	3	3	8	15	2	3	56	30	0	-	8	8
7	148	143	6	10	17	22	30	74	107	25	7	14	25	10	10	15	58	38	13	13	13	10
8a	232	49	0	-	0	-	0	-	104	56	4	3	27	17	29	14	17	4	9	8	13	13
8b	333	204	39	59	28	46	29	38	86	34	8	16	41	30	44	15	30	30	3	4	5	7
9	103	181	1 383	3 054	45	54	22	40	27	35	21	45	40	55	30	37	0	-	52	62	0	-
10a	84	57	0.6	1	0	-	0	-	47	34	0.3	0.7	25	12	14	9	9	9	0	-	24	17
10b	80	28	0	-	4	9	2	4	11	7	0	-	21	8	14	4	12	4	2	5	96	82
11a	199	171	32	29	59	37	105	88	69	46	13	17	87	67	15	10	5	8	17	31	5	7
11b	101	48	5	11	0	-	0.1	0.2	26	14	3	3	24	6	13	6	13	10	3	6	14	7
11c	178	54	6	11	13	13	22	22	52	25	13	25	50	17	14	9	3	4	11	12	0	-
11d	385	79	533	631	14	11	7	10	26	19	55	60	55	29	21	5	10	7	1	2	2	4
12	532	217	492	853	166	141	37	22	109	50	153	254	63	25	17	19	22	24	4	7	27	34
13	346	204	23	23	278	29	8	12	57	20	51	35	82	74	47	41	32	6	0	-	0	-
14	350	271	83	83	144	16	4	7	79	20	66	36	87	25	45	17	85	28	0	-	13	23
15	674	639	163	177	21	24	13	16	99	65	159	278	76	34	37	28	70	28	26	30	8	9
16	289	241	25	40	27	28	3	6	97	50	59	83	33	15	5	4	25	14	19	11	10	17
17	196	186	207	282	81	43	1 515	654	15	13	92	94	25	33	12	19	0	-	103	30	0	-
18	785	809	797	728	109	19	141	34	31	54	696	1 197	21	20	83	60	0	-	90	74	0	-
19	901	1 240	97	164	56	28	227	156	39	46	16	33	30	41	105	106	0.7	2	68	74	0.1	0.2
20	1 152	731	60	52	301	388	360	320	29	40	42	31	107	39	210	132	0.6	1	39	52	0	-

Table 9: Species and numbers of fish for which length, sex, and length-weight (L-Wt) data were collected. -, unsexed fish. (See Table 4 for species codes.)

	Length frequency samples			L-Wt		Length frequency samples			L-Wt
Species Code	males	females	total	total	Species code	males	females	total	total
APR	0	1	1		LDO	2 061	1 923	3 993	992
BAR	21	18	39		LIN	865	752	1 619	1 618
BBE	0	1	2 159		LSO	10	10	20	
BBR	1	1	2	2	MRQ	0	0	11	
BGZ	12	10	22	22	NOS	235	232	477	1
BNS	1	3	4	4	NSD	7	8	15	6
BOE	325	293	618		OPE	156	183	339	
BSH	20	46	66	58	ORH	11	11	22	12
BYD	1	0	1		PLS	1	3	4	4
BYS	283	182	480	1	RBM	42	33	75	38
CAS	0	0	103	103	RBT	7	4	11	
CBO	16	15	1 518		RBY	30	21	51	51
COL	0	2	849	297	RCO	271	120	391	
CSQ	2	12	14	11	RIB	83	75	158	155
CYO	16	9	28	10	RSK	1	1	2	2
CYP	93	84	177	77	SBW	15	9	24	
EPL	2	1	3	3	SCH	5	4	9	9
EPT	14	8	22	21	SCI	100	58	161	161
ETB	97	53	150	87	SND	321	383	713	6
ETL	125	116	244	233	SOR	621	408	1 033	6
FRO	48	14	65		SPD	240	1 471	1 711	8
GSH	1 247	1 312	2 561	616	SPE	950	1 061	2 200	
GSP	443	391	834	622	SSK	22	28	50	50
HAK	94	110	204	204	SSO	222	158	380	5
HAP	1	4	5	2	STA	163	246	411	330
HOK	5 412	8 063	13 482	1 264	SWA	704	889	1 598	
JAV	0	2	3 414		TAR	48	49	98	
JMD	2	0	2		WHX	9	4	13	13
JMM	22	19	41		WWA	608	511	1 125	
LCH	198	165	363	271					

Note. Total sometimes exceeds sum of male+female fish due to the presence of some fish that are recorded unsexed.

Table 10: Length-weight regression parameters* used to scale length frequencies.

Species	*a* (intercept)	*b* (slope)	r^2	*n*	Length range (cm)	Data source
Dark ghost shark	0.002295	3.234432	0.99	616	25–77	TAN0401
Giant stargazer	0.005160	3.283951	0.97	314	29–80	TAN0401
Hake	0.002759	3.216404	0.99	201	32–126	TAN0401
Hoki	0.002895	3.003977	0.98	1 248	37–113	TAN0401
Ling	0.001341	3.278554	0.99	1 603	26–170	TAN0401
Lookdown dory	0.022253	2.986095	0.99	872	11–58	TAN0401
Pale ghost shark	0.006206	2.982278	0.98	621	31–88	TAN0401
Alfonsino	0.018975	3.057496	0.99	2 301	17–54	TAN9106-TAN0201
Barracouta	0.003590	3.056385	0.91	309	50–112	TAN9106-TAN0201
Lemon sole	0.006492	3.170475	0.92	125	24–39	TAN9106-TAN0201
Shovelnose dogfish	0.001815	3.158984	0.99	1 885	29–126	TAN9106-TAN0201
Silver warehou	0.007688	3.233235	0.99	2 915	19–57	TAN9106-TAN0201
Slender mackerel	0.441049	2.022669	0.66	83	42–55	TAN9106-TAN0201
Spiny dogfish	0.001887	3.193811	0.96	2 651	48–106	TAN9106-TAN0201
White warehou	0.012109	3.164962	0.99	2 382	12–65	TAN9106-TAN0201
Scampi	0.819172	2.746626	0.88	1 032	2.7–7.2	TAN9106-TAN0301
Sea perch	0.008469	3.194447	0.99	4 384	10–53	TAN9106-TAN0301
Smooth skate	0.023067	2.959919	0.99	389	33–158	TAN9106-TAN0401
Ribaldo	0.003224	3.321869	0.98	879	21–78	TAN9106-TAN0401
Arrow squid	0.0290	3.00	-	-	-	Annala et al. (2003)
Banded giant stargazer	0.009591	3.262359	566	0.96	16–69	All records on DB
Black cardinalfish	0.0269	2.870105	213	0.96	33–75	Tracey et al. (2000)
Black oreo	0.0248	2.950	9 790	0.98	11–44	DB, Chat. Rise, Nov-Mar
Bluenose	0.00963	3.173	-	-	-	Horn (1988)
Hapuku	0.014230	2.998	1 644	-	50–130	Johnston (1983)
Northern spiny dogfish	0.002215	3.172480	235	0.97	36–90	All records on DB
Orange roughy	0.0687	2.792	7 880	0.99	9–44	DB, Chat. Rise, Nov-Mar
Ray's bream	0.005616	3.305003	929	0.96	28–56	All records on DB
Red cod	0.0092	3.003	923	0.98	13–72	Beentjes (1992)
Rubyfish	0.014666	3.053829	334	1.0	15-53	All records on DB
Rough skate	0.033966	2.876666	336	-	14–70	Stevenson & Beentjes (1999)
Smooth oreo	0.0309	2.895	9 147	0.98	10–57	DB, Chat. Rise, Nov-Mar
Southern blue whiting	0.003	3.2	444	-	19–55	Hatanaka et al. (1989)
Spiky oreo	0.025360	2.964571	420	0.97	18–43	TAN0101
Tarakihi	0.02	2.98	-	-	-	Annala et al. (1989)

* $W = aL^b$ 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*

Common name	Sex	Reproductive stage							Total
		1	2	3	4	5	6	7	
Banded giant stargazer	Male	0	12	0	0	0	0	0	12
	Female	0	9	1	0	0	0	0	10
Bigeye cardinalfish	Male	1	0	0	0	0	0	0	1
	Female	1	0	0	0	0	0	0	1
Black cardinalfish	Male	2	0	0	1	0	0	0	3
	Female	4	0	0	0	0	0	0	4
Bluenose	Male	1	0	0	0	0	0	0	1
	Female	0	0	0	0	0	0	0	0
Giant stargazer	Male	0	19	2	0	0	0	0	21
	Female	1	19	9	0	0	0	0	29
Hake	Male	15	7	3	9	48	2	0	84
	Female	16	27	46	3	0	0	2	94
Hapuku	Male	0	0	0	0	0	0	0	0
	Female	0	1	0	0	0	0	0	1
Hoki	Male	110	300	2	6	0	0	1	419
	Female	89	711	2	0	0	0	1	803
Lookdown dory	Male	47	77	13	33	0	0	0	170
	Female	19	44	22	1	0	6	3	95
Ling	Male	282	299	24	223	7	0	0	835
	Female	197	508	13	3	0	0	0	721
Ribaldo	Male	2	13	10	0	0	0	0	25
	Female	3	27	0	0	0	2	1	33

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

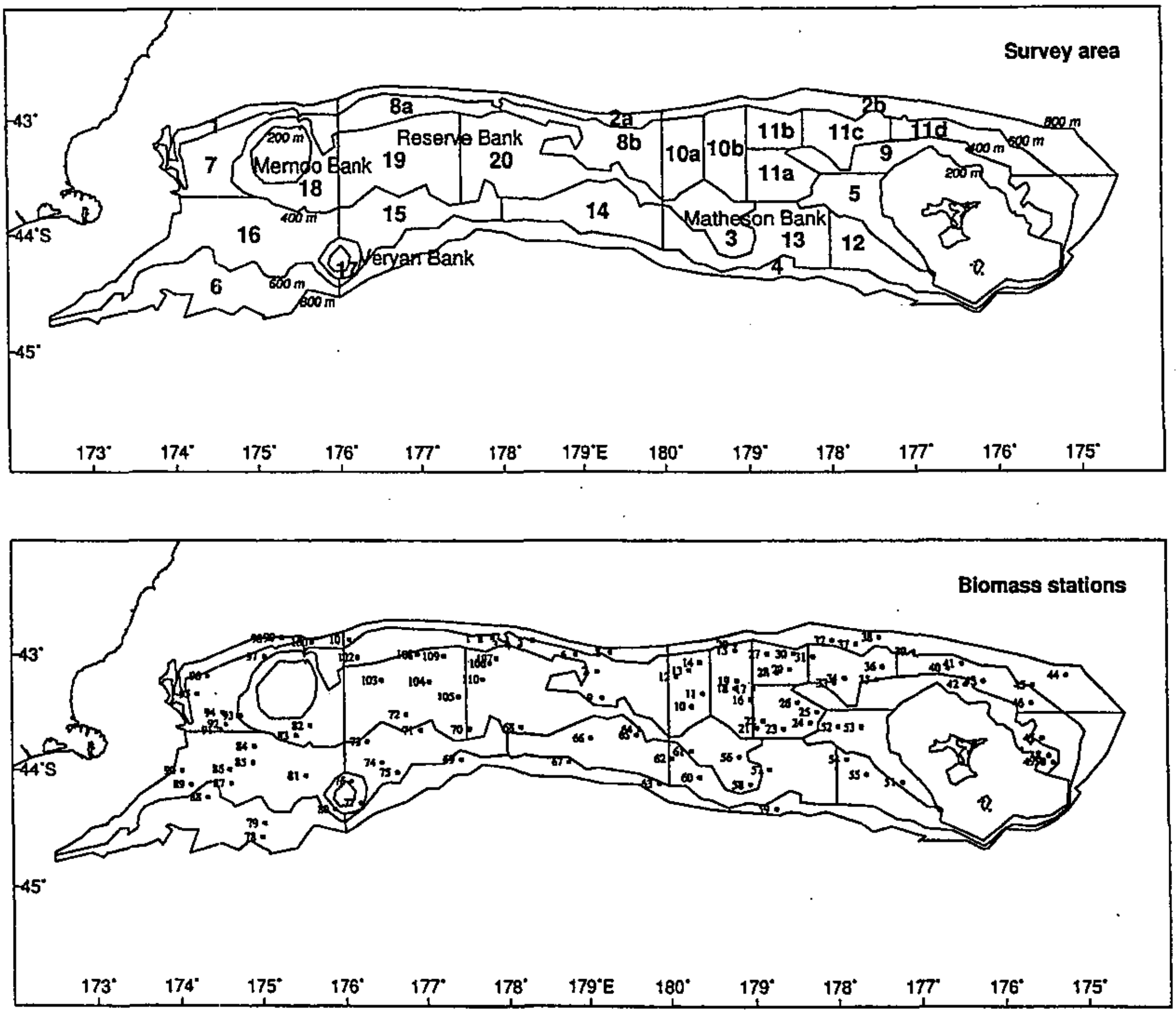


Figure 1: Trawl survey area showing stratum boundaries, and valid biomass station positions for TAN0401 (n = 110).

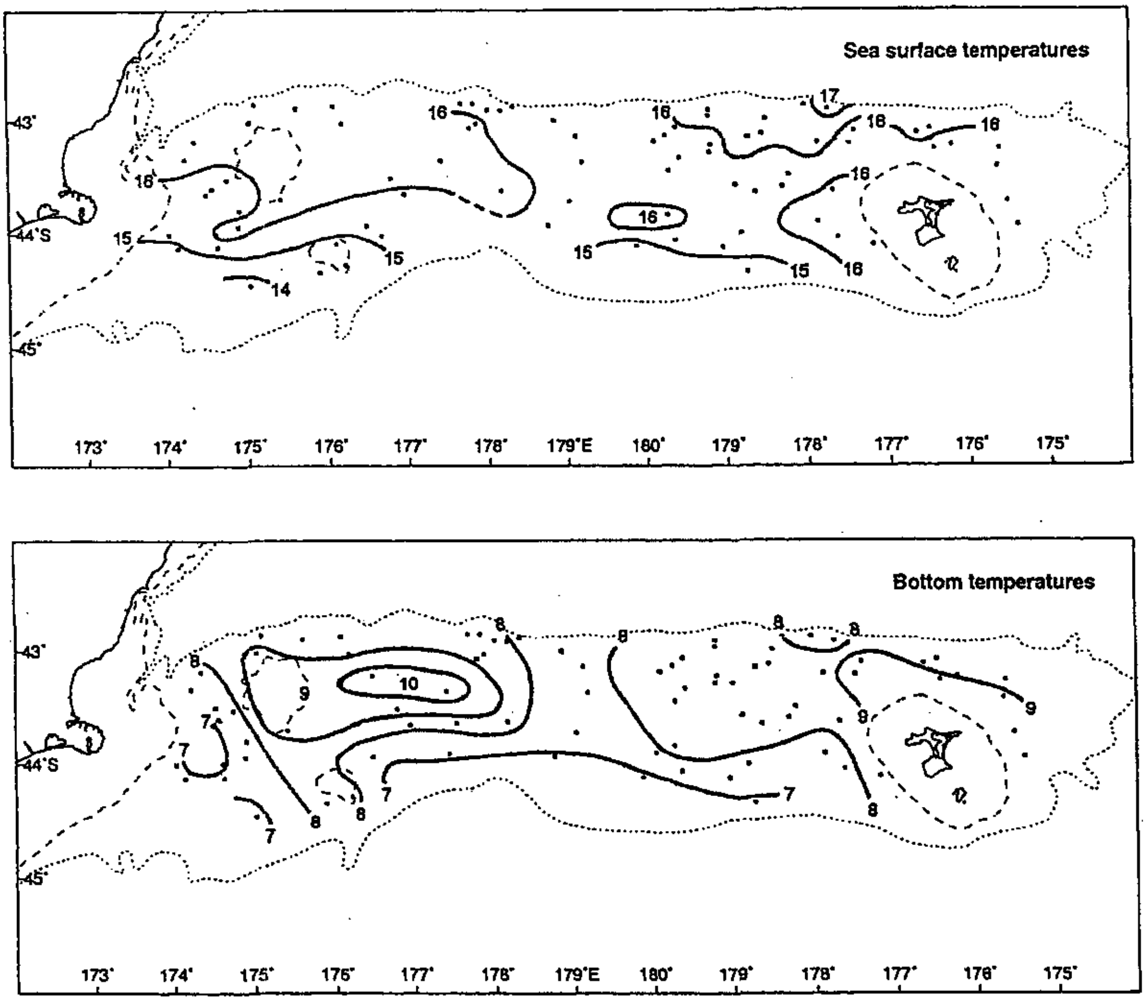
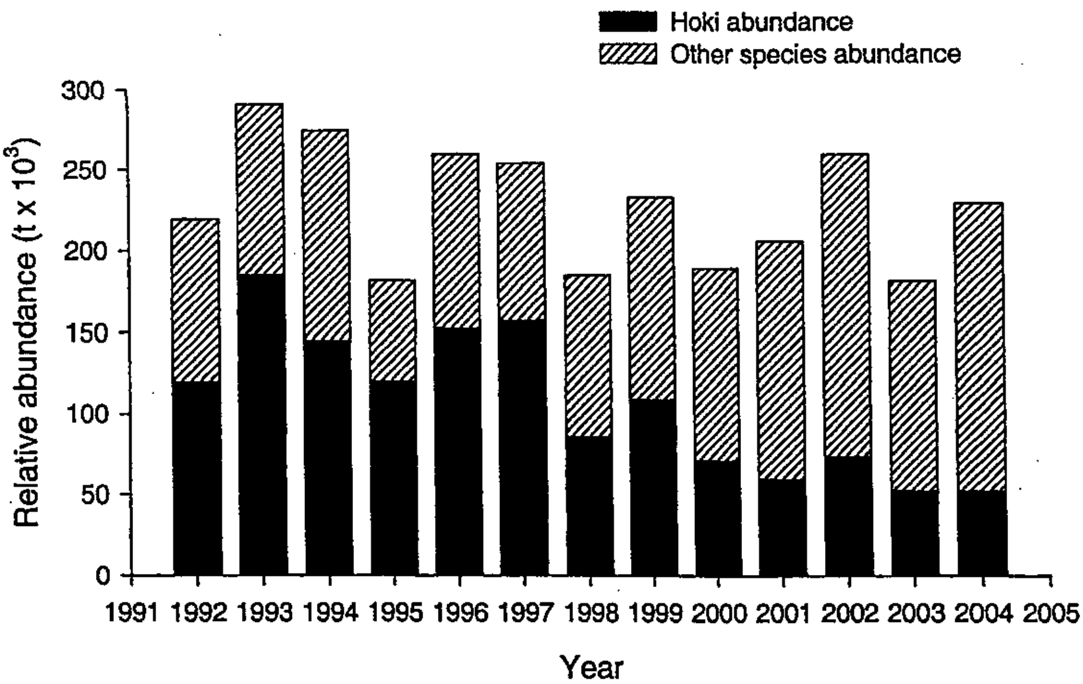


Figure 2: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (°C) interpolated by eye. The temperatures shown are from the calibrated Seabird CTD recordings made during each tow.



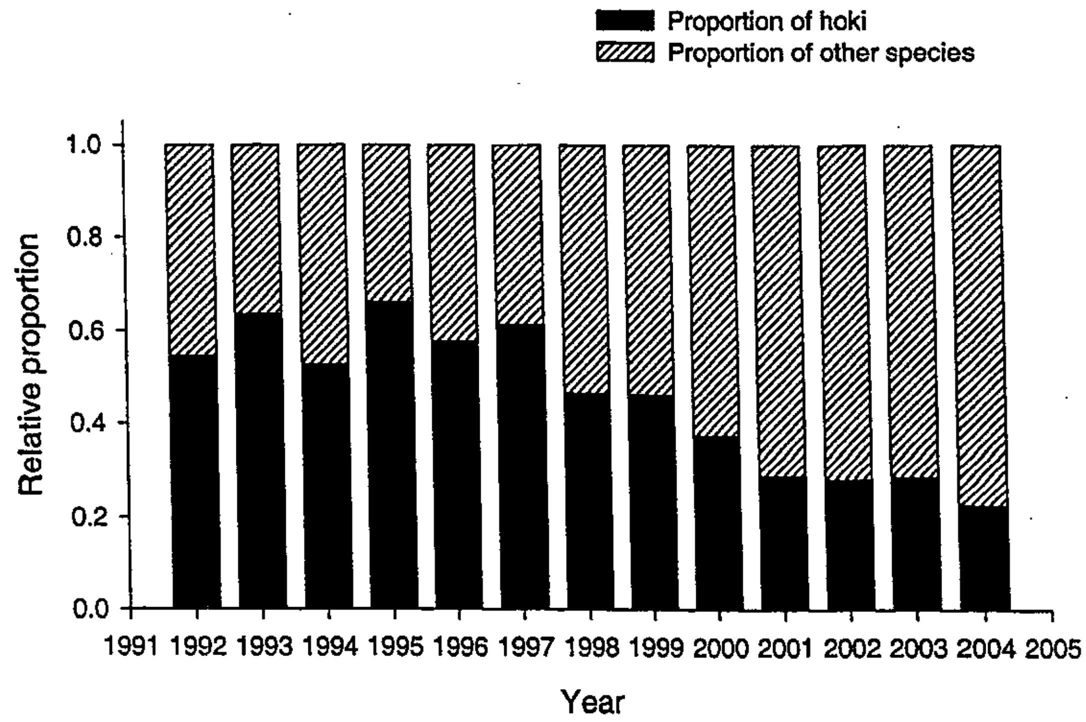


Figure 3: Relative biomass (top panel) and relative proportions of hoki and other species (lower panel) from trawl surveys of the Chatham Rise, January 1992–2004.

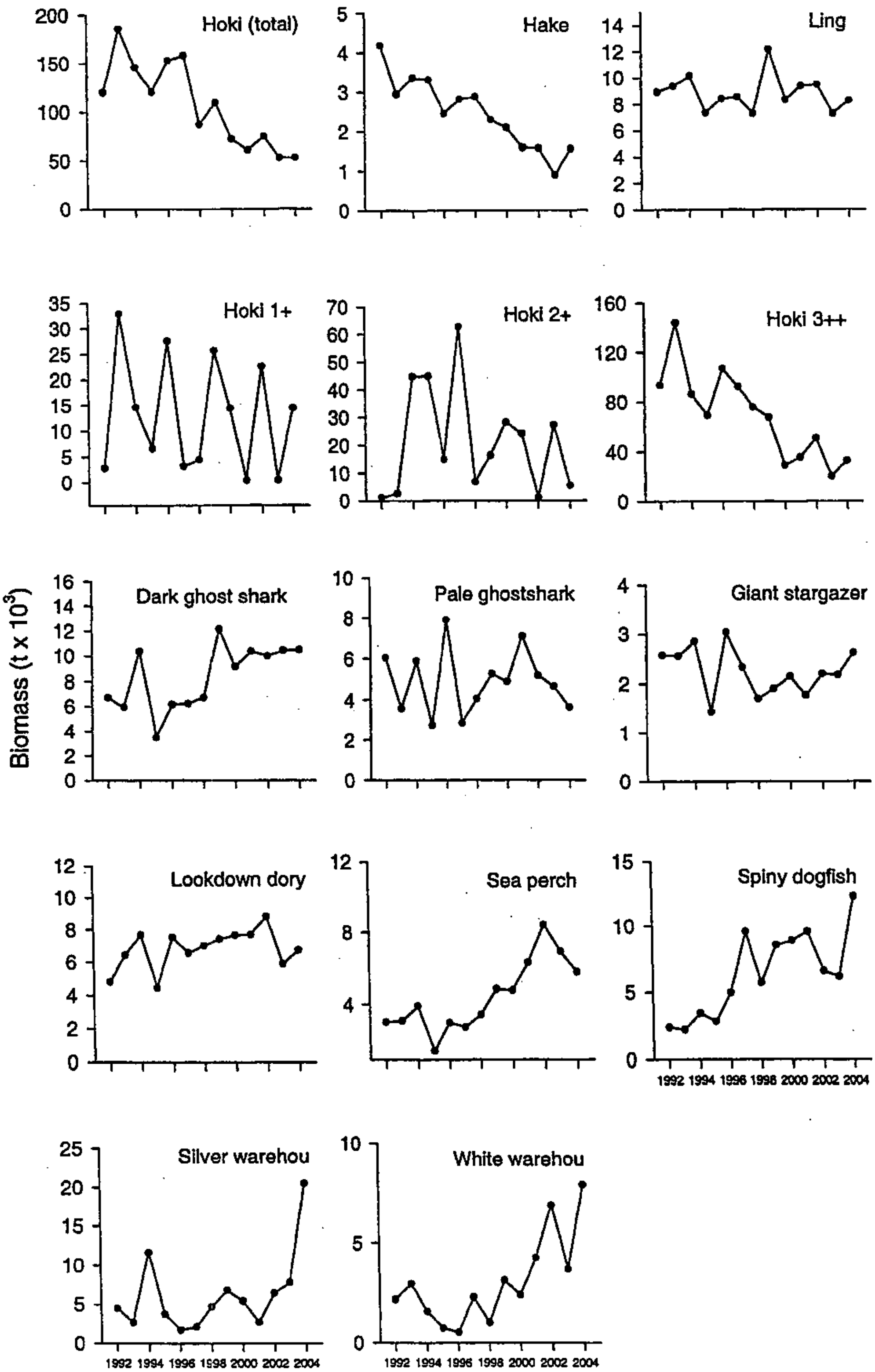


Figure 4: Relative biomass estimates of important species sampled by annual trawl surveys of the Chatham Rise, January 1992–2004.

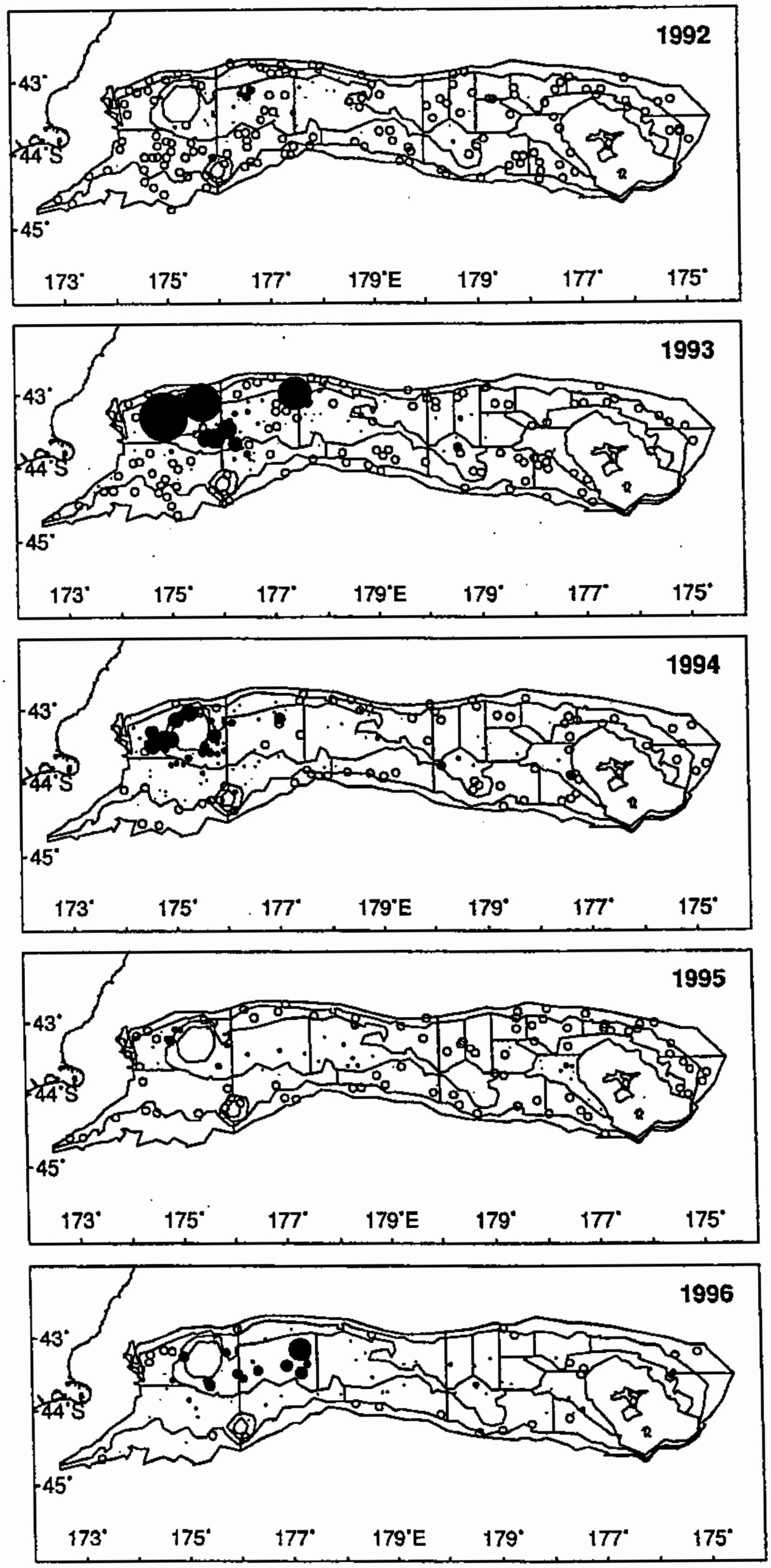


Figure 5a. Hoki 1+ catch distribution 1992–2004. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 30 850 kg.km^{-2}.

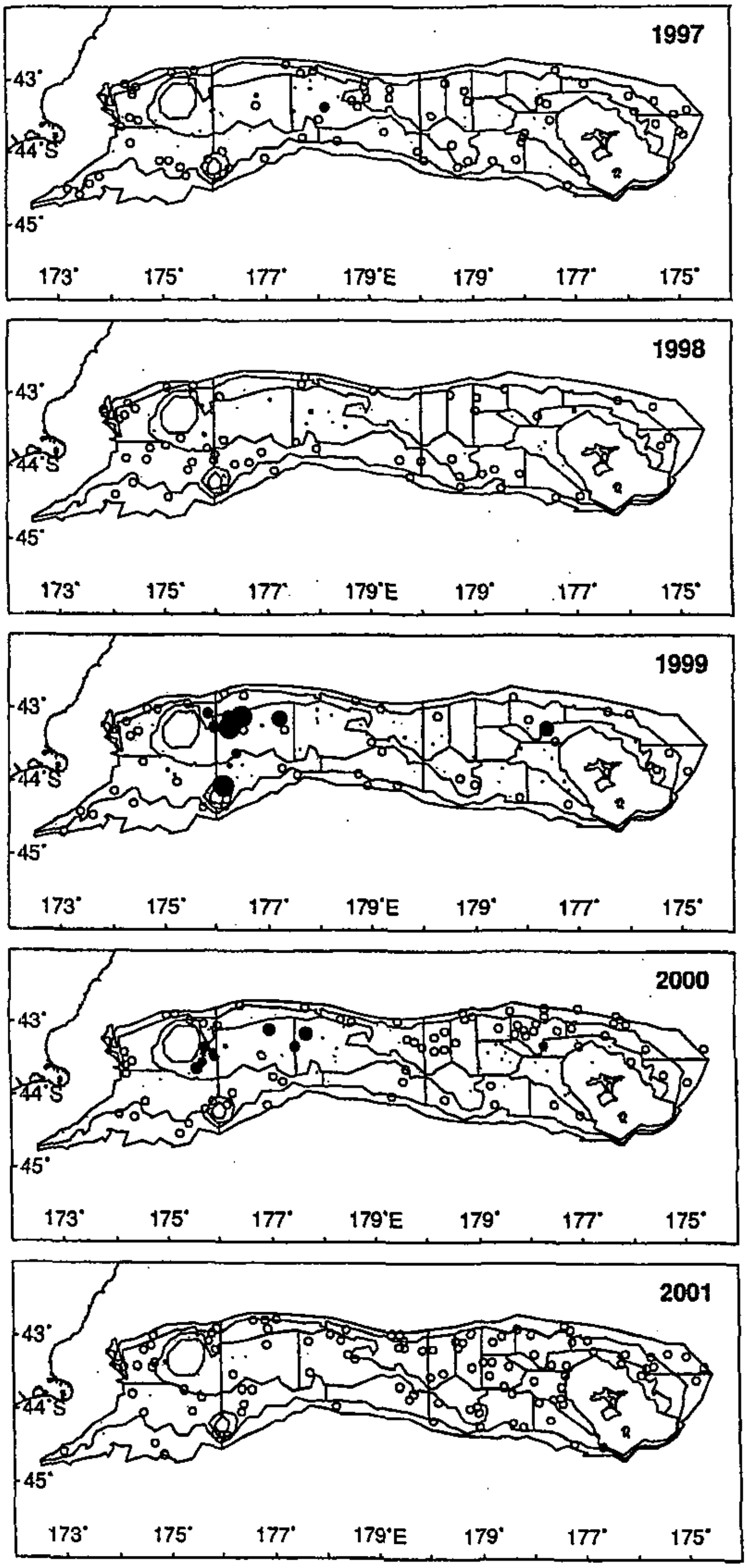


Figure 5a (continued)

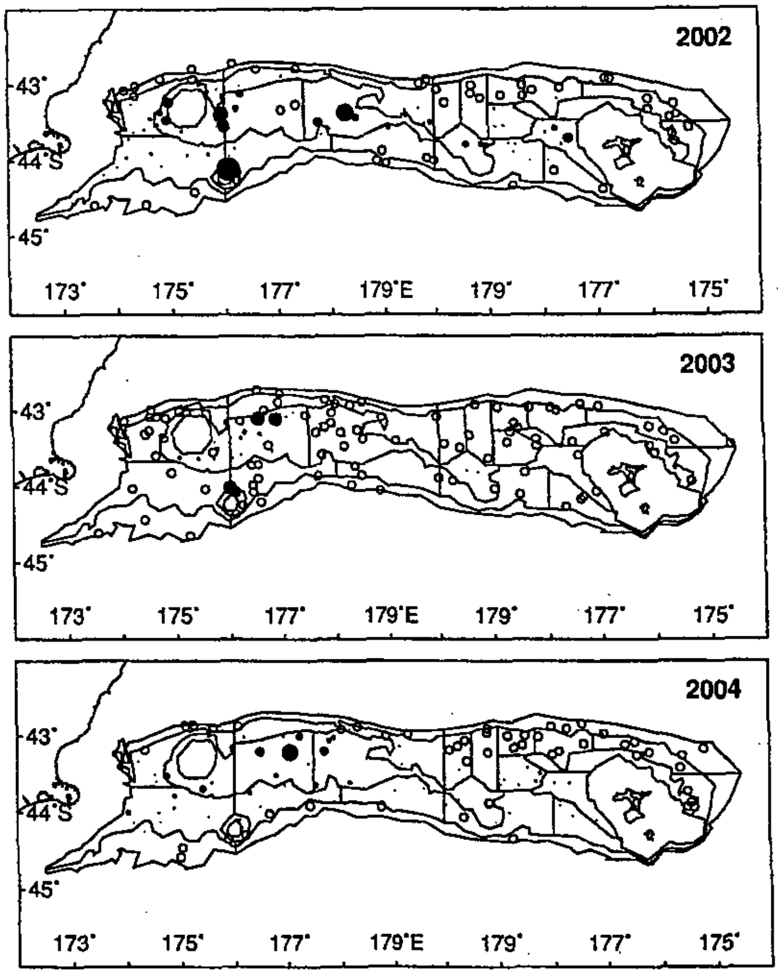


Figure 5a (continued)

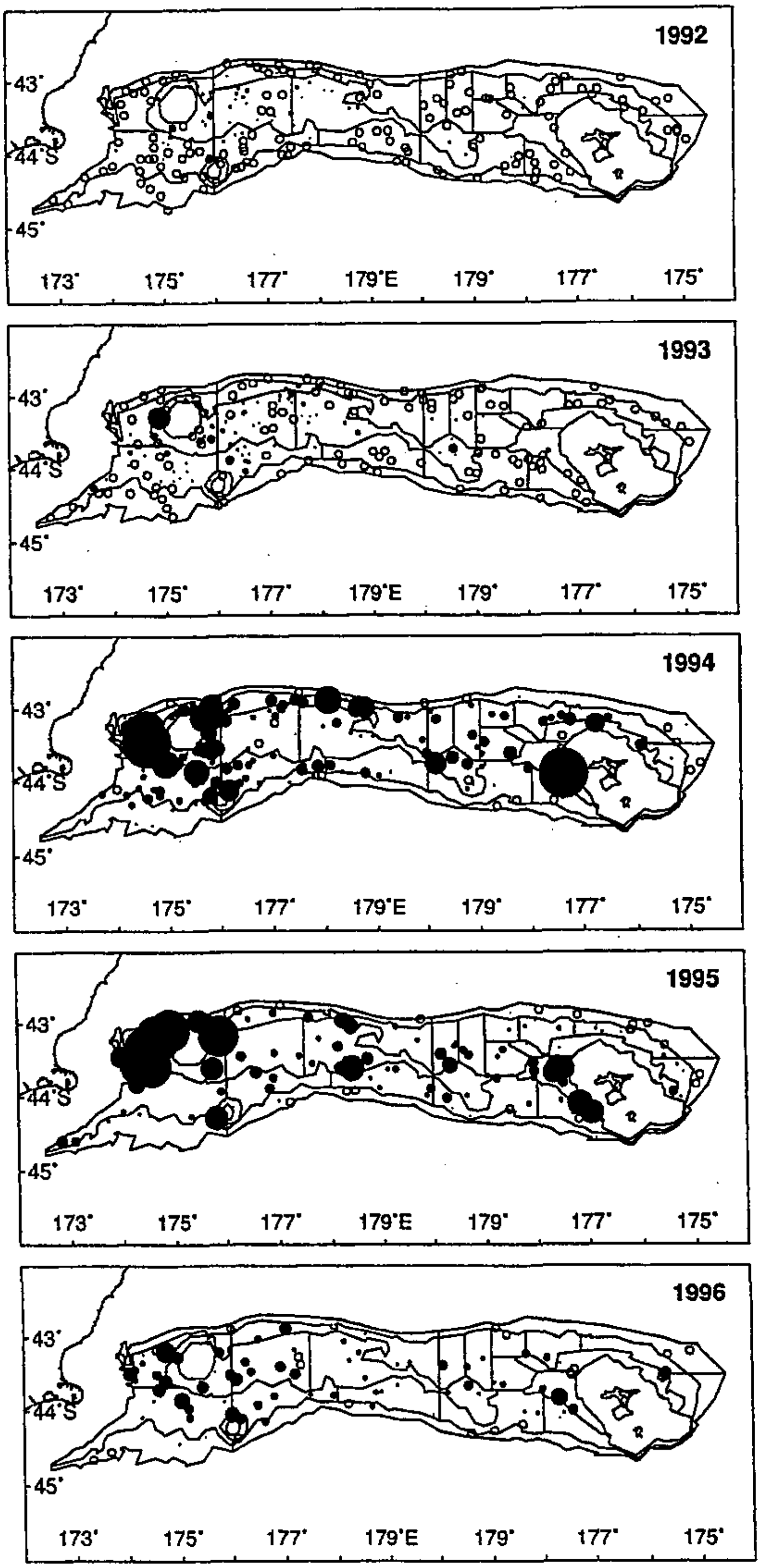


Figure 5b. Hoki 2+ catch distribution 1992–2004. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 6791 kg.km^{-2}.

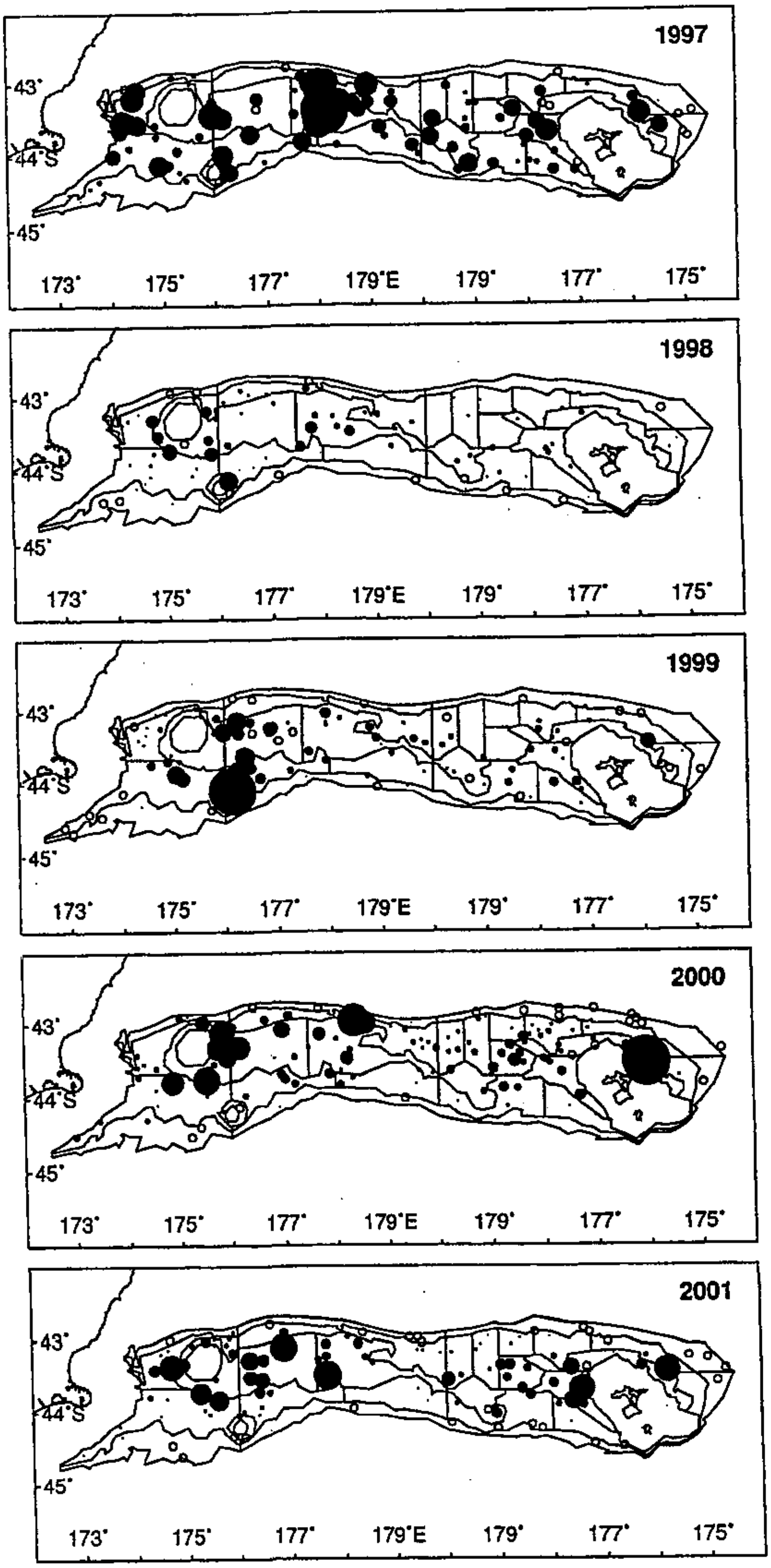


Figure 5b (continued)

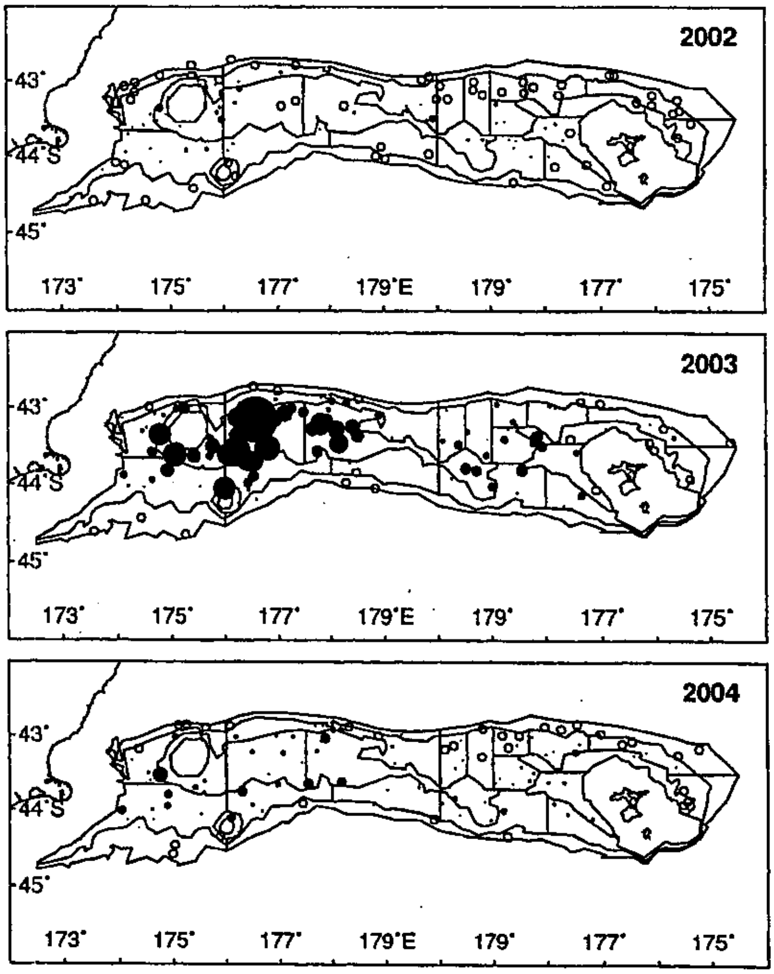


Figure 5b (continued)

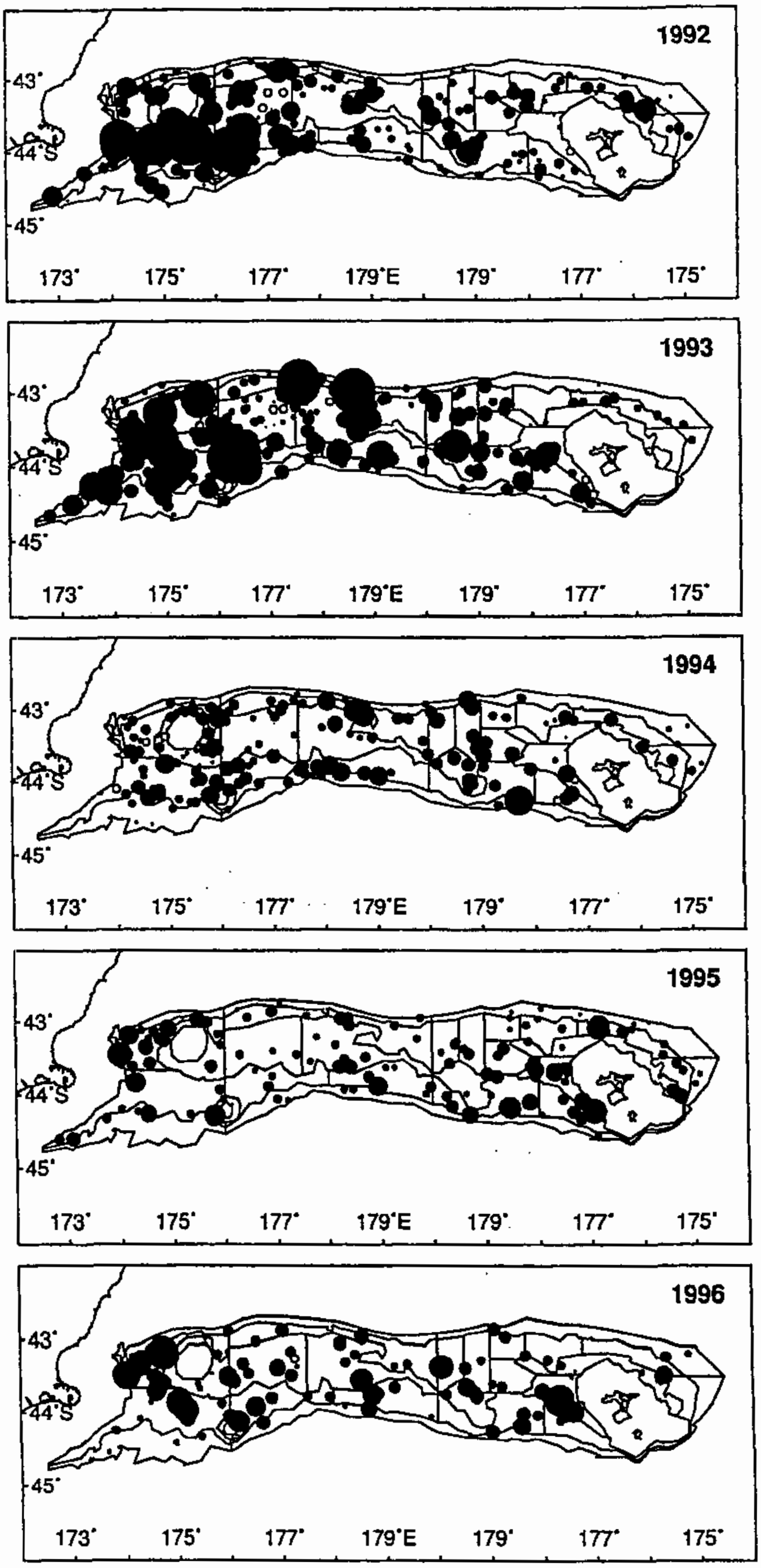


Figure 5c. Hoki 3++ catch distribution. 1992–2004. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 11 177 kg.km^{-2}.

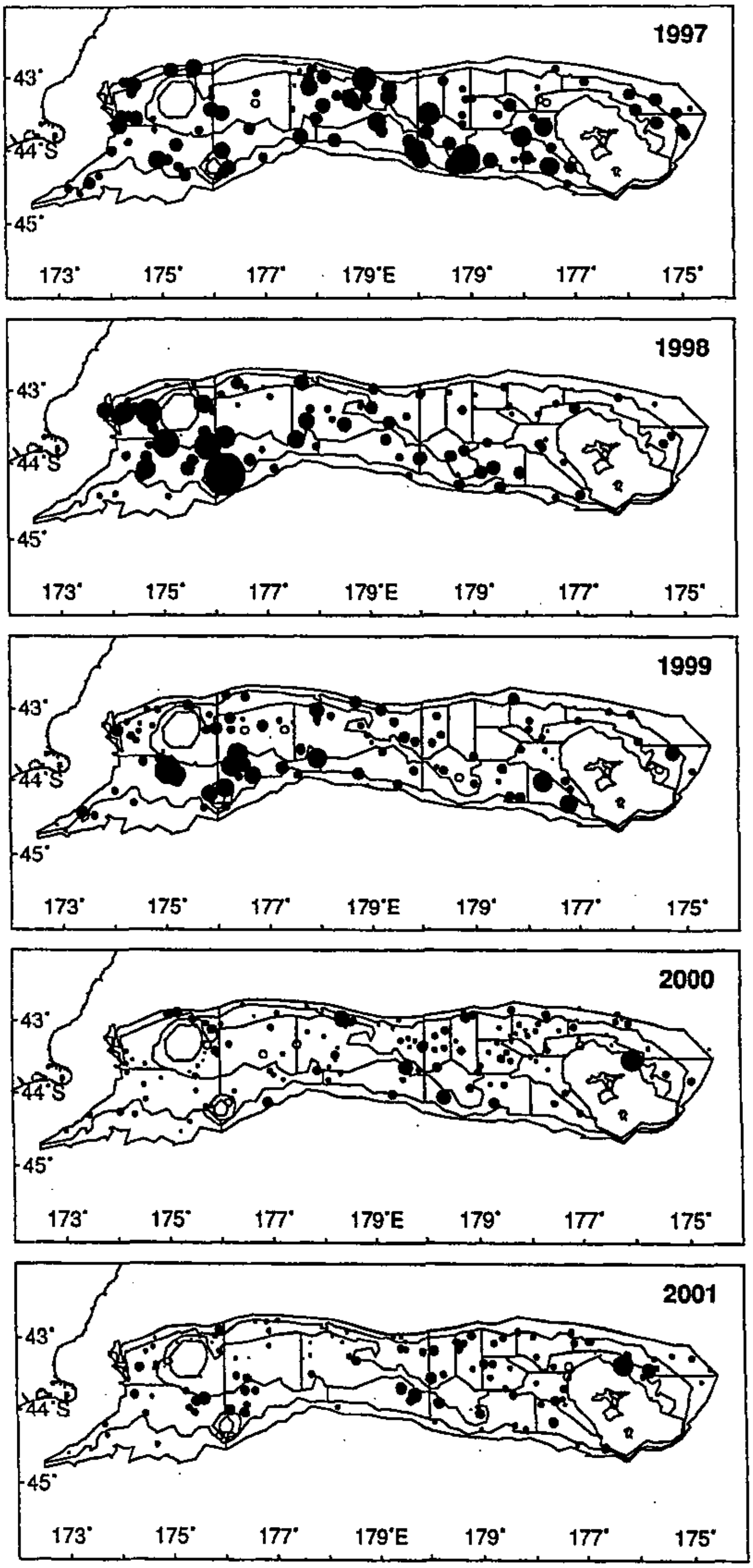


Figure 5c (continued)

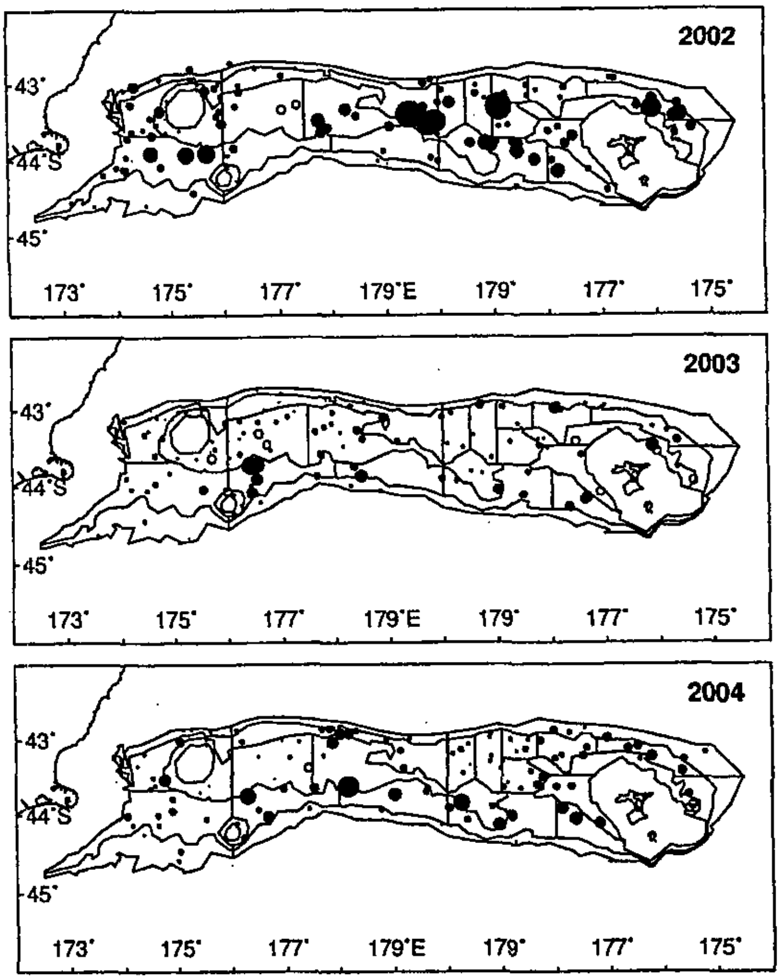


Figure 5c (continued)

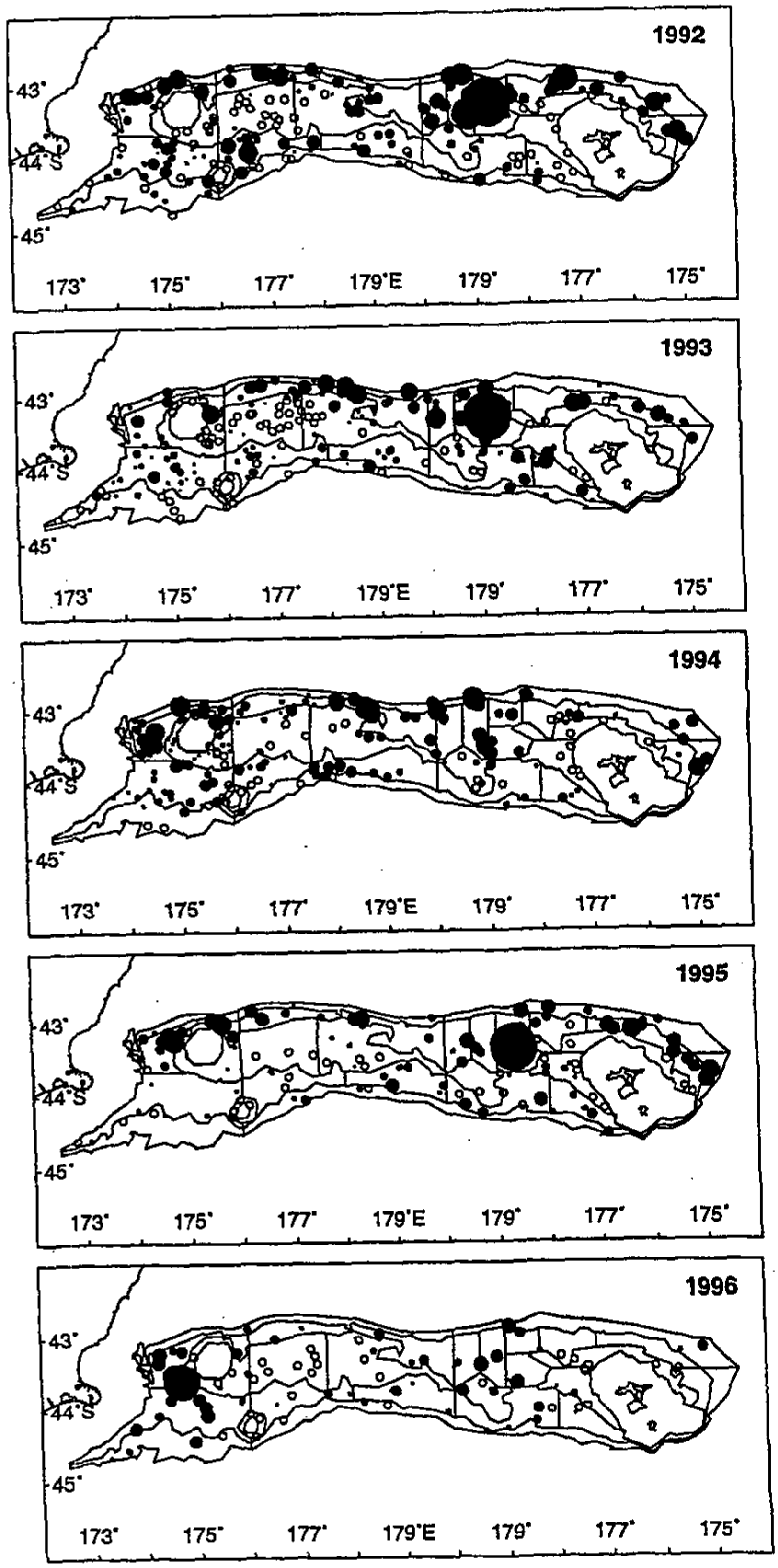


Figure 6. Hake catch distribution 1992–2004. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 70 kg.km^{-2}.

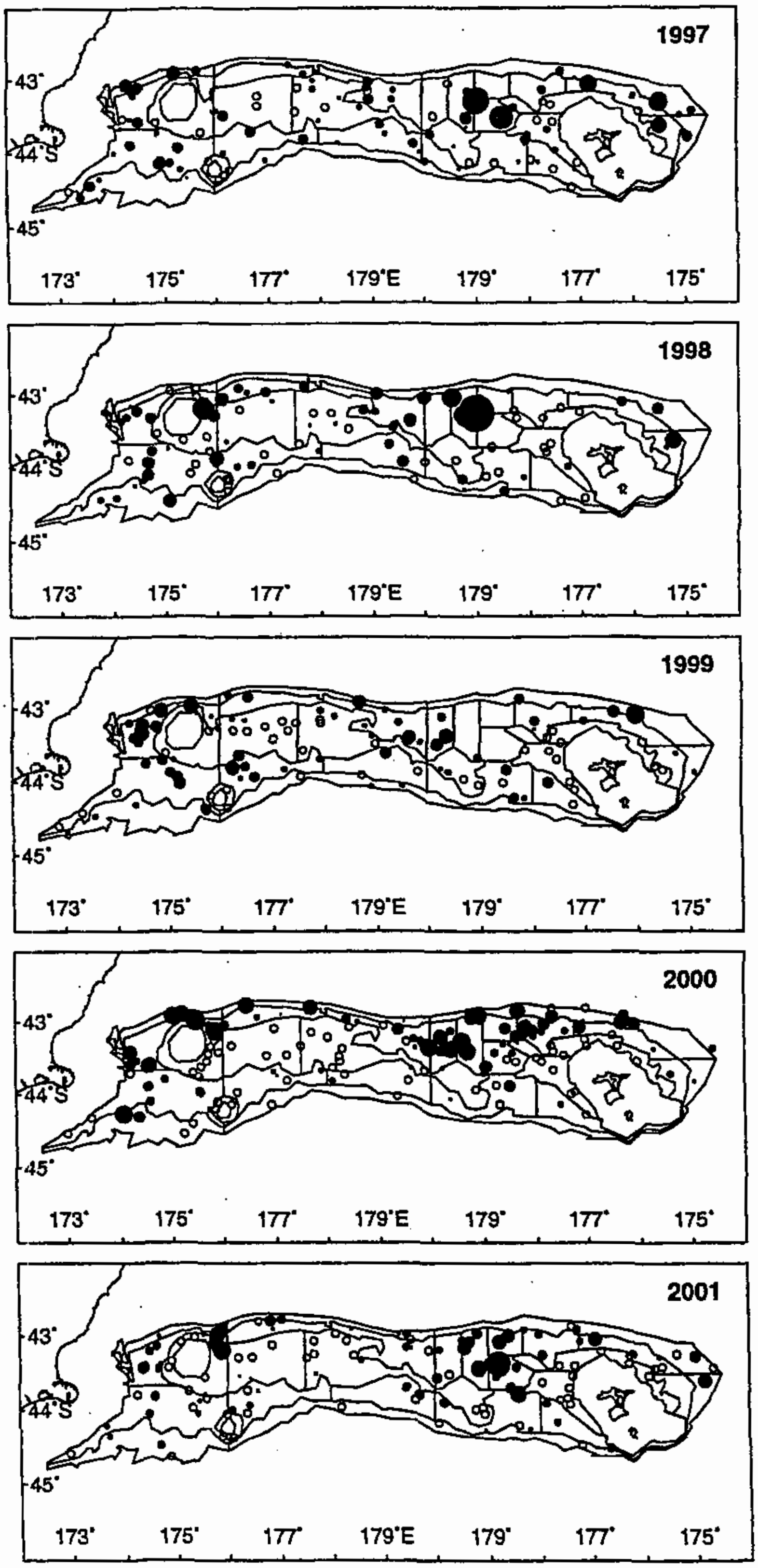


Figure 6 (continued)

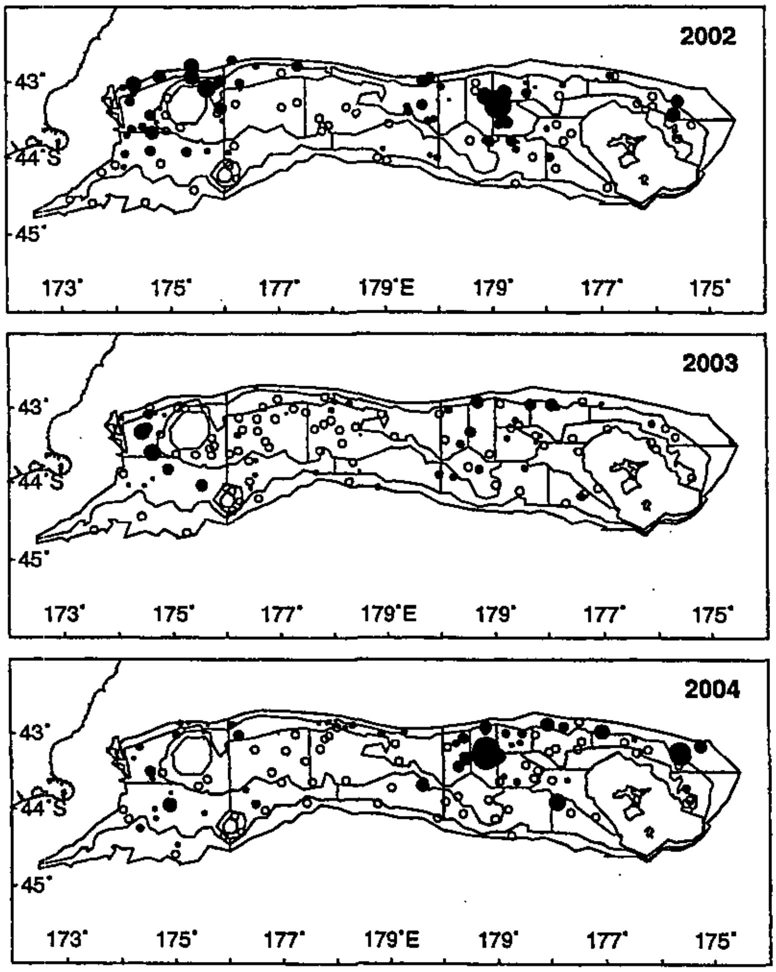


Figure 6 (continued)

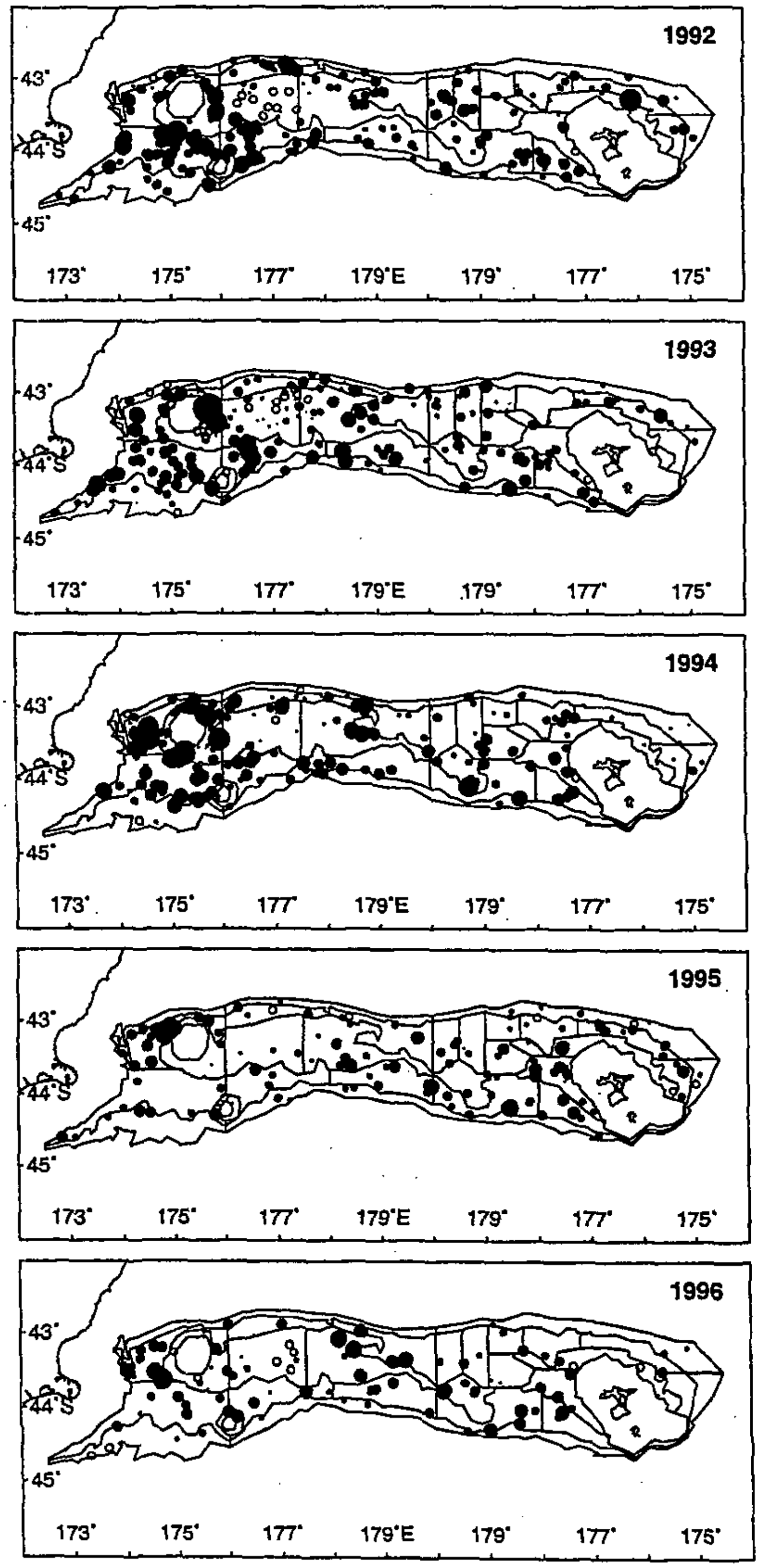


Figure 7. Ling catch distribution 1992–2004. Filled circle area is proportional to catch rate (kg.km^{-2}). Open circles are zero catch. Maximum catch rate in series is 1786 kg.km^{-2}.

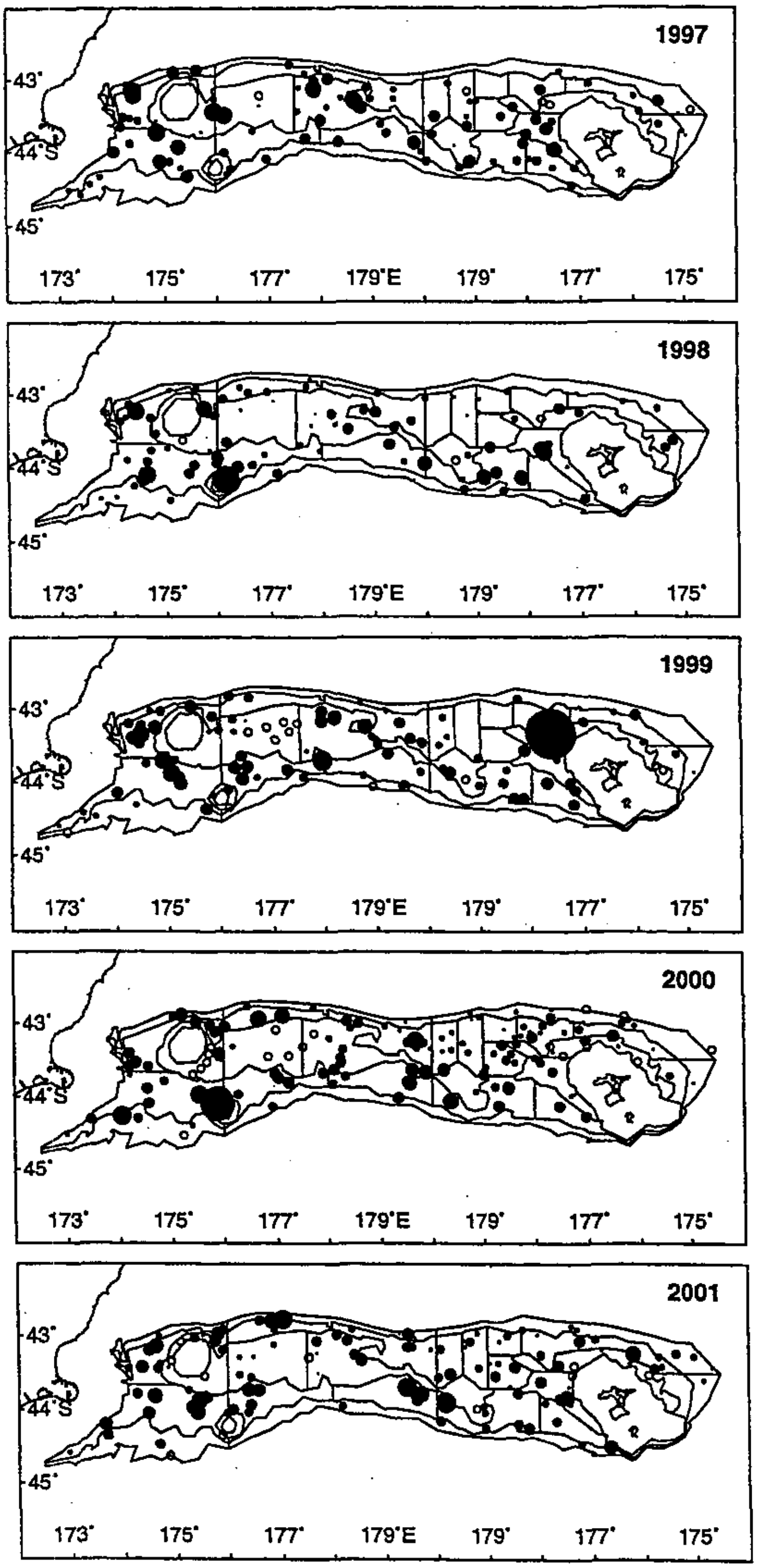


Figure 7 (continued)

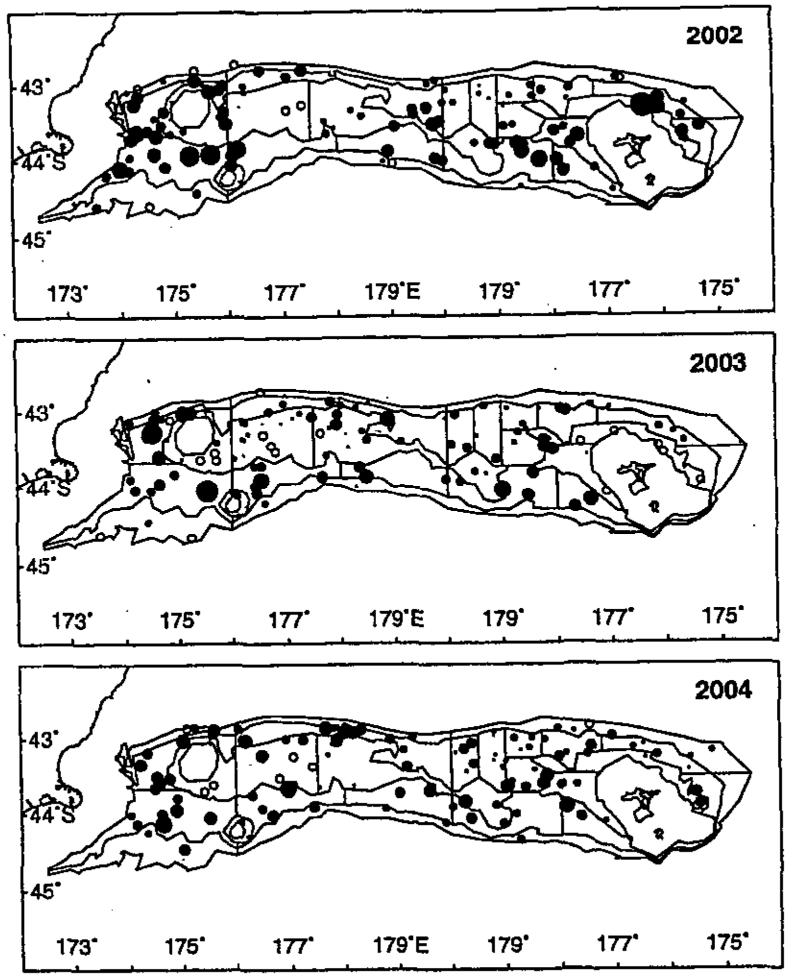


Figure 7 (continued)

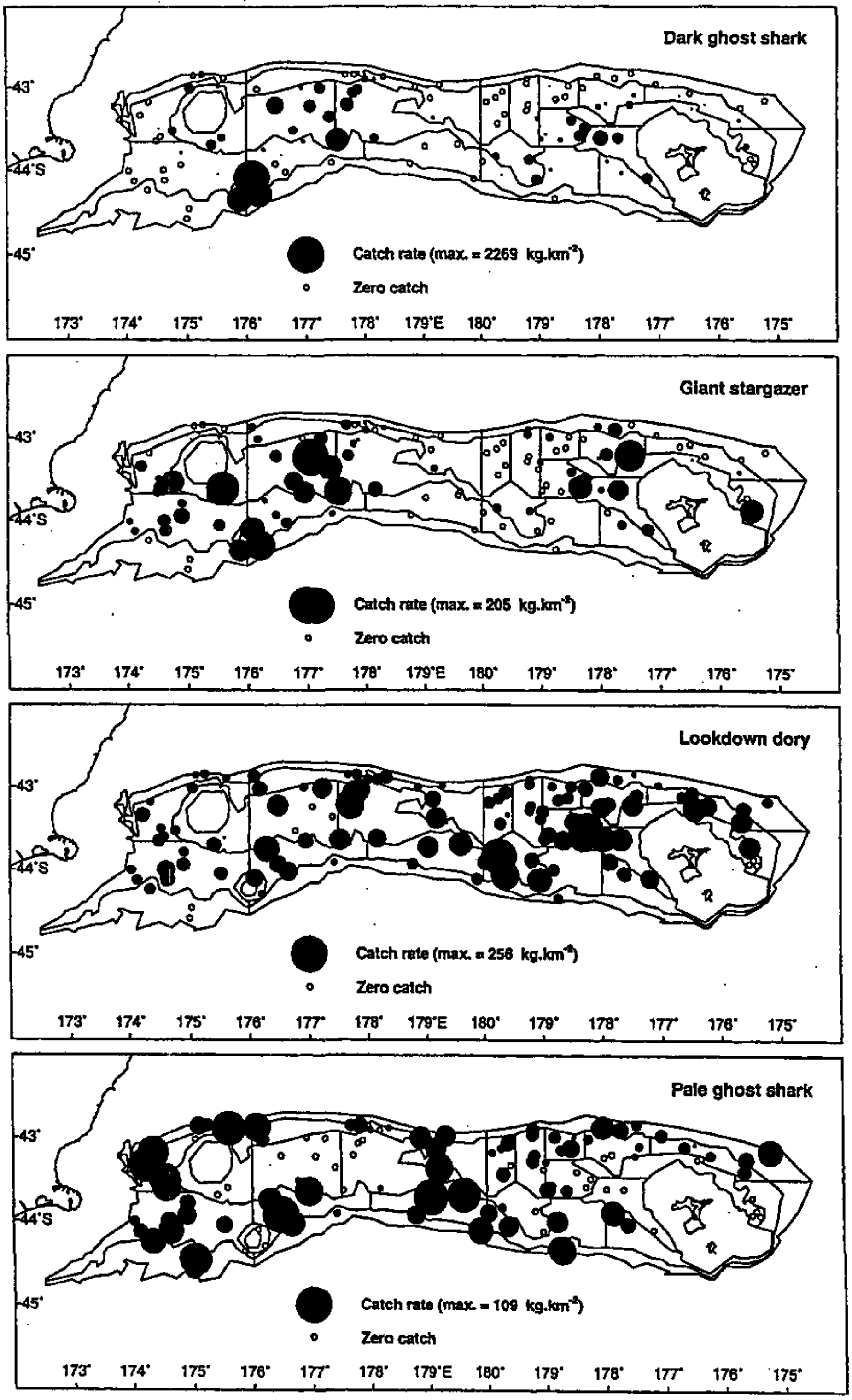


Figure 8: Catch rates (kg.km^{-2}) of selected commercial species in 2004. Filled circle area is proportional to catch rate. Open circles are zero catch. (max., maximum catch rate)

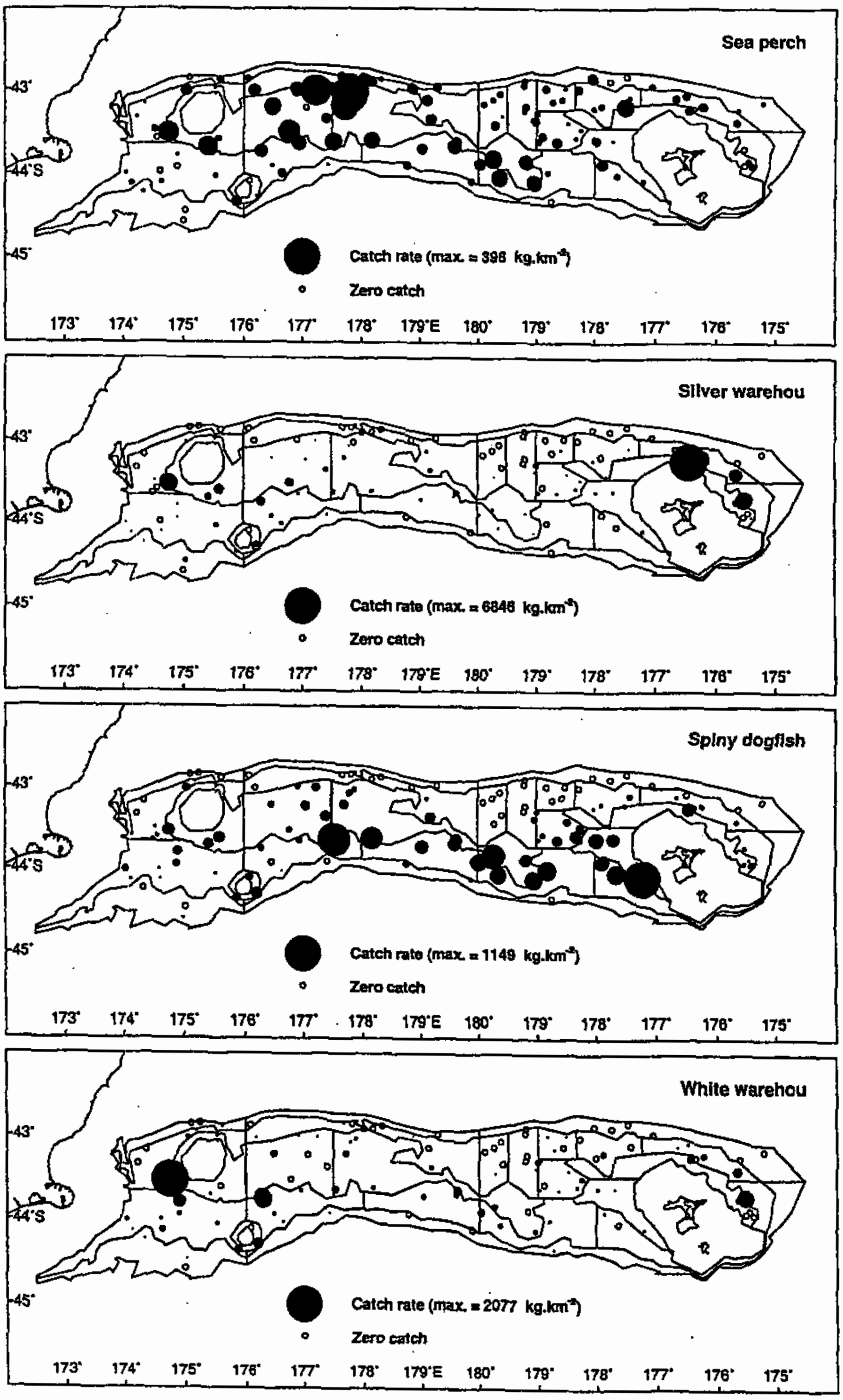


Figure 8 (continued)

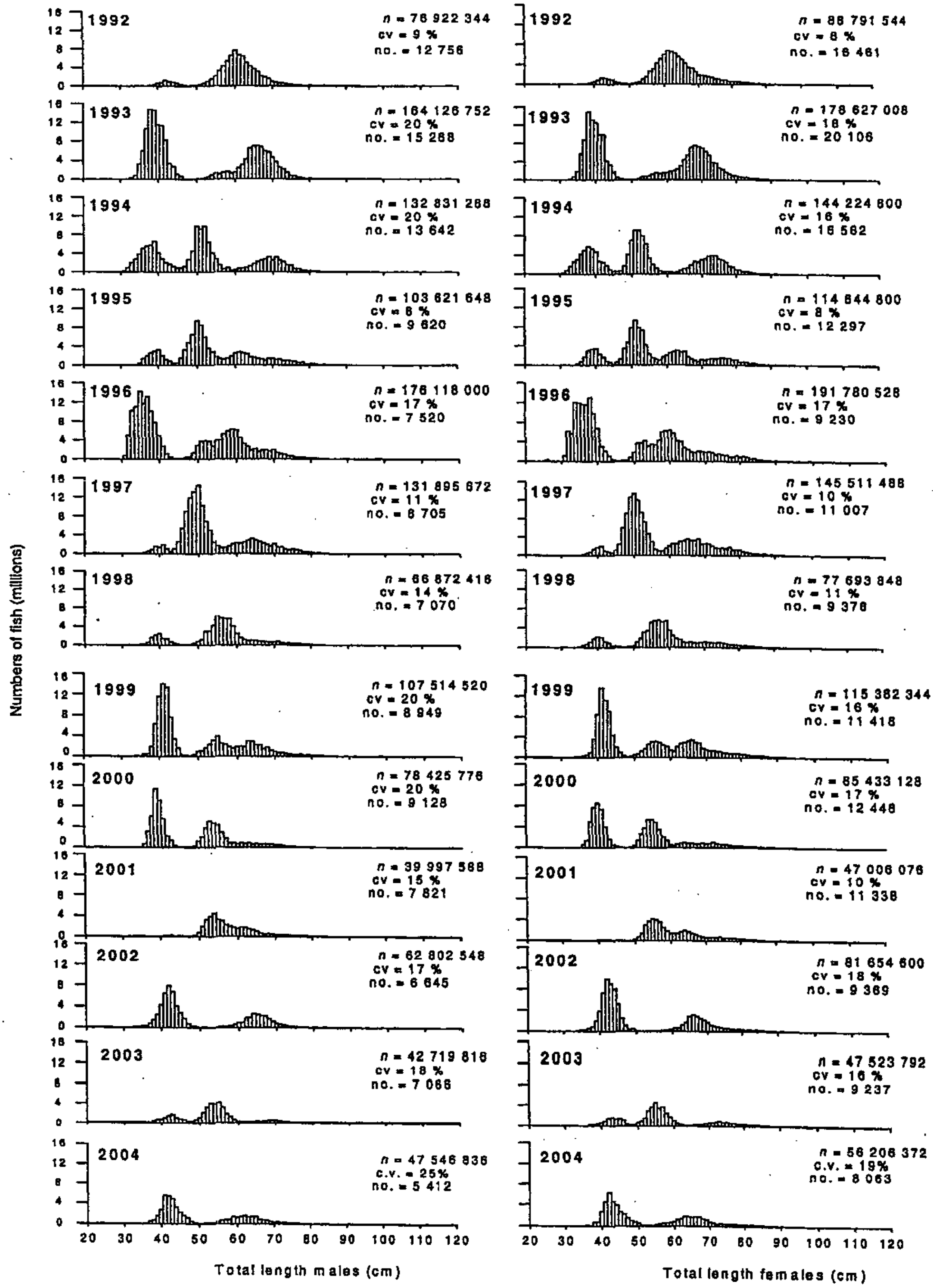


Figure 9: Estimated length frequency distributions of the male and female hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2004. (c.v., coefficient of variation; n, estimated population number of male hoki (left panel) and female hoki (right panel); no., numbers of fish measured.)

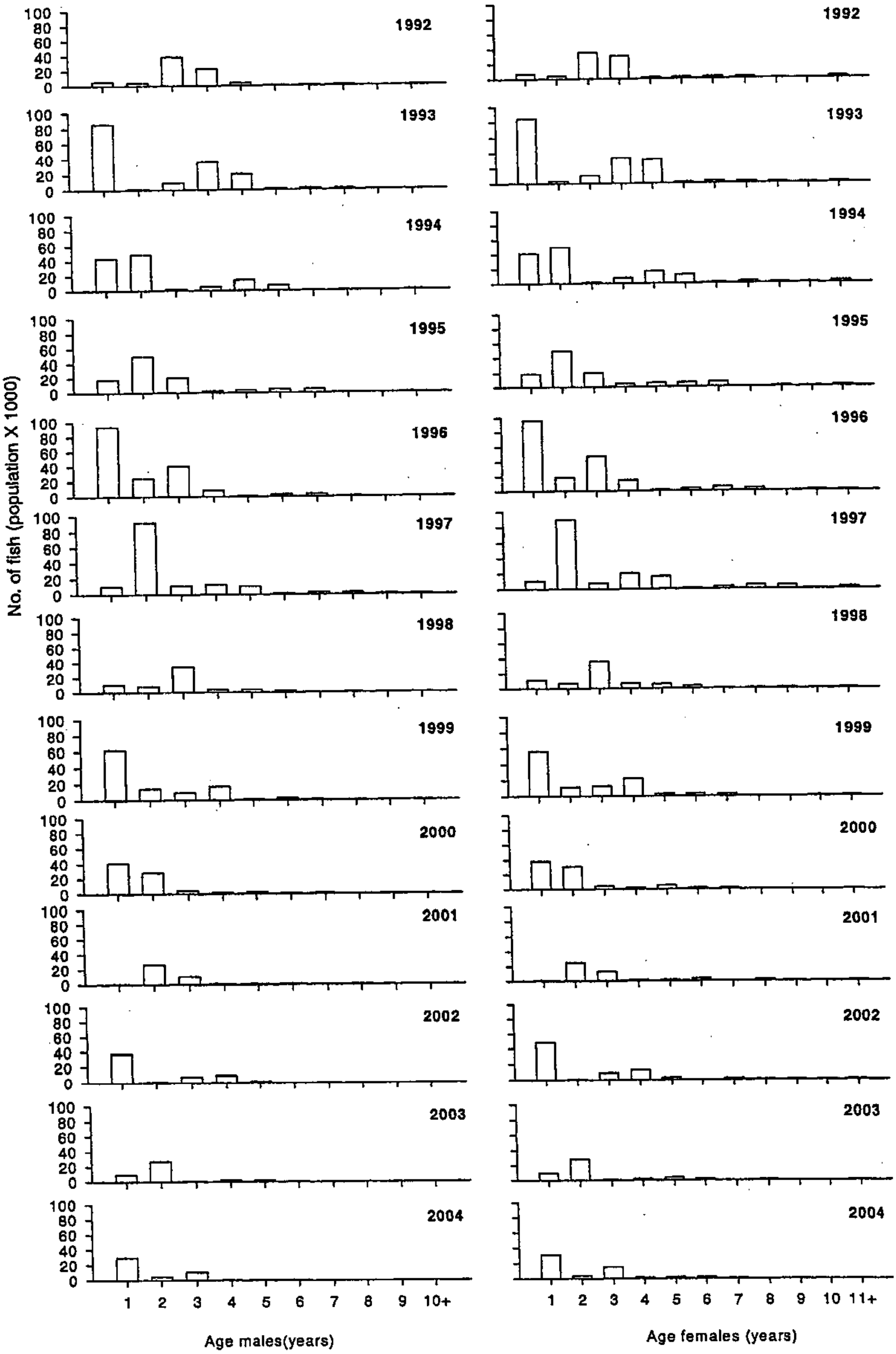


Figure 10: Estimated population numbers at age of hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2004. (+, indicates plus group of combined ages.)

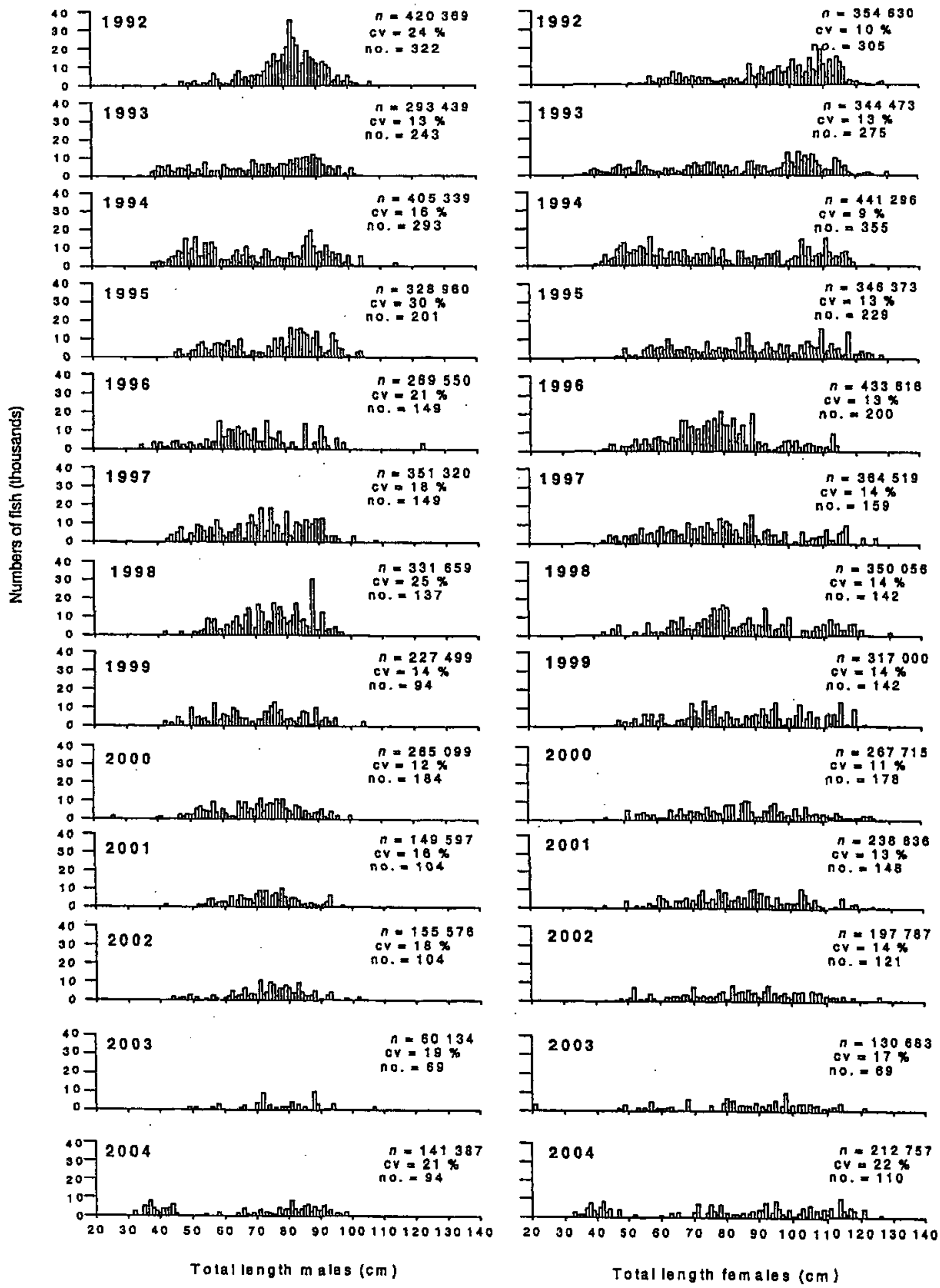


Figure 11: Estimated length frequency distributions of the male and female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2004. (c.v., coefficient of variation; n, estimated population number of hake; no., numbers of fish measured.)

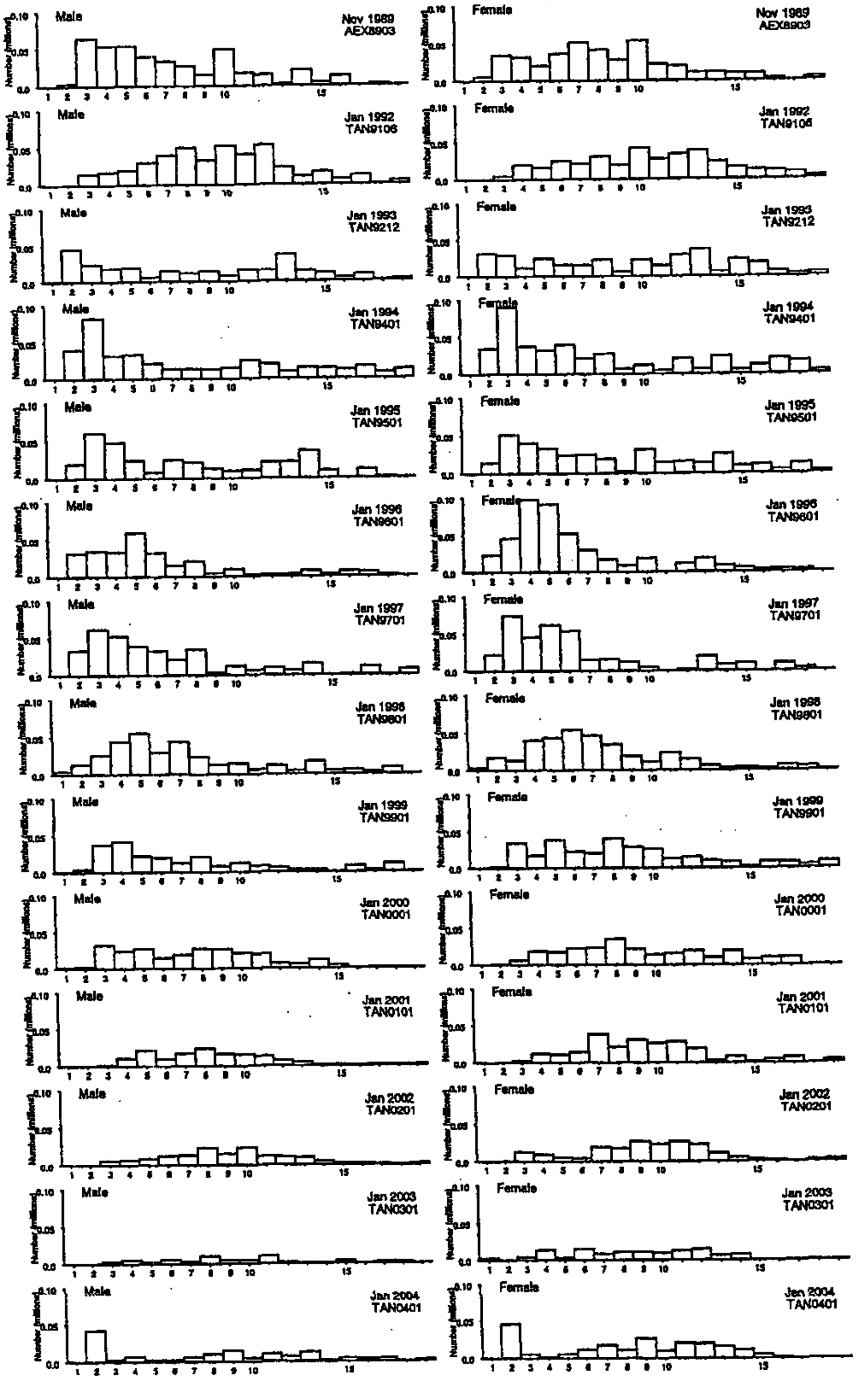


Figure 12: Estimated proportion at age of male and female hake from *Tangaroa* surveys of the Chatham Rise, January, 1992–2004.

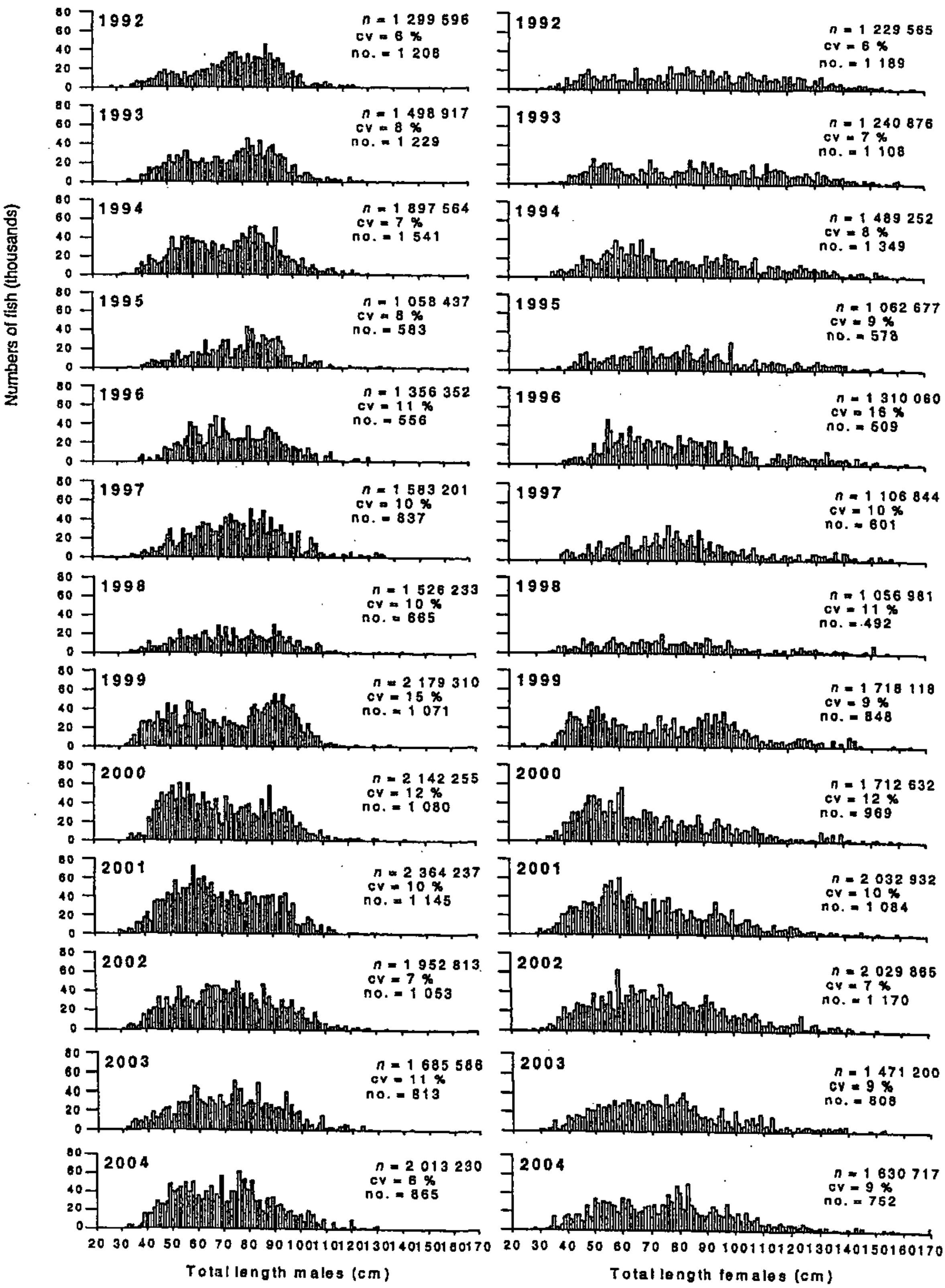


Figure 13: Estimated length frequency distributions of the ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2004. (c.v., coefficient of variation; n, estimated population number of ling; no., numbers of fish measured.)

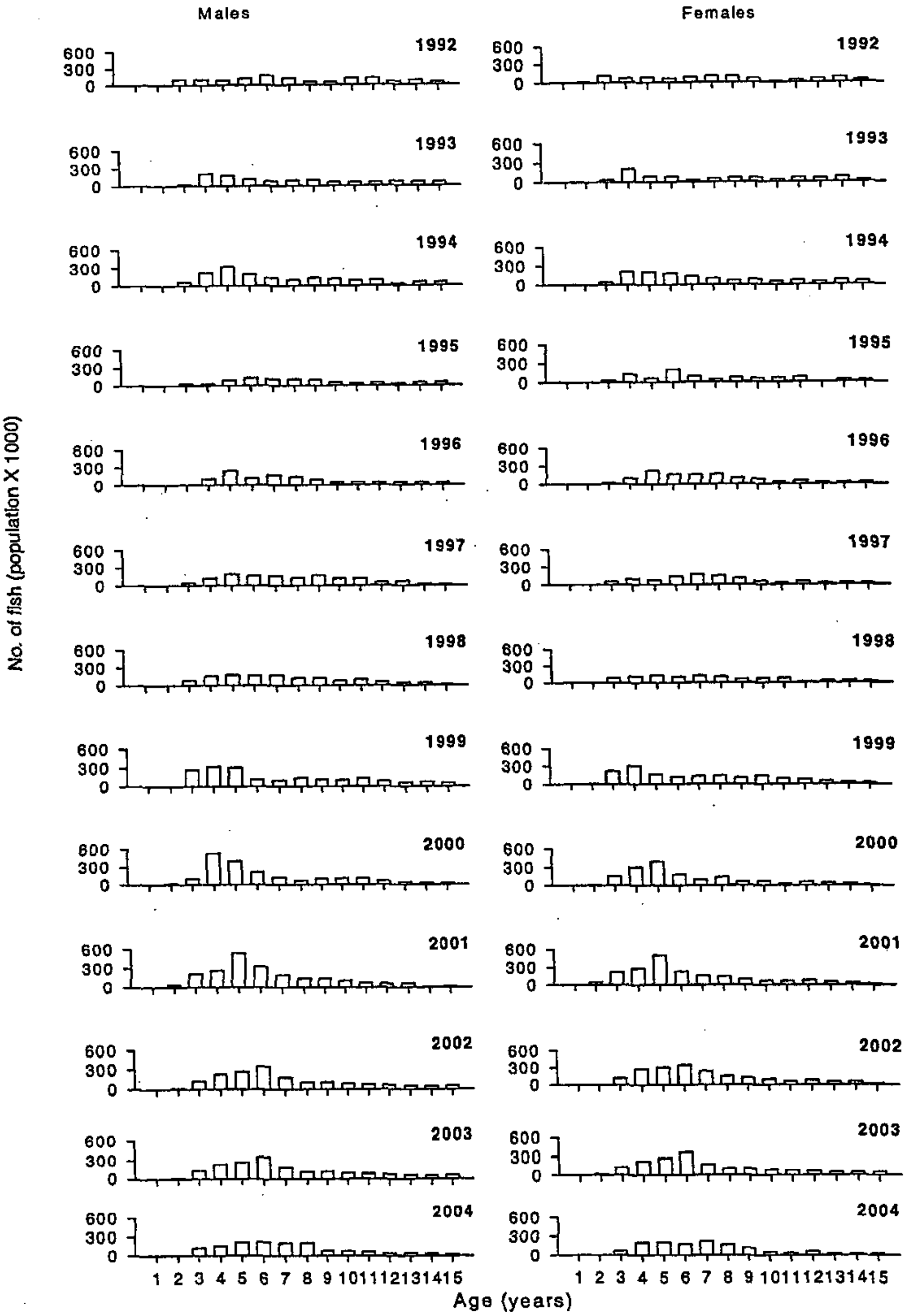


Figure 14: Estimated population numbers at age of male and female ling (age 1–15 years) from *Tangaroa* surveys of the Chatham Rise, January, 1992–2003. (Note: the age class of 15 years is not a plus group.)

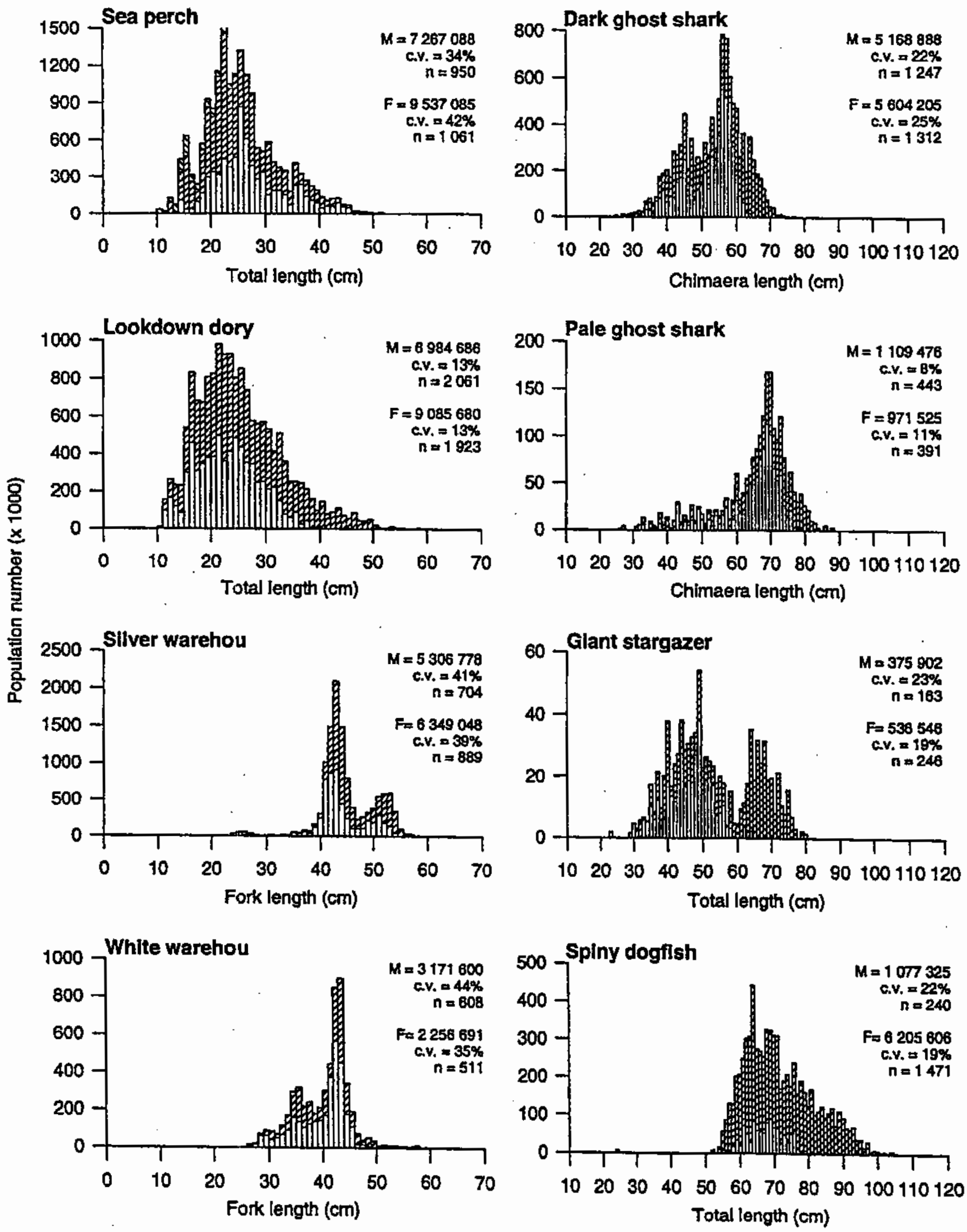


Figure 15: Length frequencies of selected commercial species on the Chatham Rise, 2004, scaled to population size by sex (M, estimated male population; F, estimated female population (hatched bars); c.v. coefficient of variation of the estimated numbers of fish; n, number of fish measured.) Note: unsexed fish are only shown for sea perch with cross hatching angled down to the right.

Appendix 1: Individual station data for all stations conducted during the survey. P1, phase 1 trawl survey biomass stations; P2, phase 2 trawl survey biomass stations; Strat., Stratum number.

					Start of tow			Depth (m)		Dist.			Catch (kg)
Stn.	Type	Strat.	Date	Time	Latitude	Longitude				towed	hoki	hake	ling
				NZST	° ' S	° '	E/W	min.	max.	(n. mile)			
1	P1	8A	28-Dec-03	637	42 50.84	177 40.29	E	504	519	3	153.4	3.8	93.7
2	P1	8A	28-Dec-03	834	42 50.86	177 49.42	E	489	500	3	183.2	2.7	25.6
3	P1	8B	28-Dec-03	1047	42 54.31	178 00.50	E	413	418	3	384.3	0	79.6
4	P1	8B	28-Dec-03	1232	42 54.71	178 10.14	E	446	454	3	340.2	4.4	76.8
5	P1	2A	28-Dec-03	1450	42 52.58	178 19.25	E	636	641	3	97.3	9.2	60.7
6	P1	8B	29-Dec-03	511	43 00.01	178 51.65	E	483	499	3.01	86.5	11.2	46.4
7	P1	8B	29-Dec-03	739	43 08.42	179 07.45	E	425	426	3	142.6	0	27.4
8	P1	2A	29-Dec-03	1007	42 58.59	179 17.60	E	602	603	3.01	61.7	8	32.1
9	P1	8B	29-Dec-03	1400	43 22.24	179 11.10	E	411	414	3	133.4	0	48.3
10	P1	10A	30-Dec-03	537	43 26.57	179 43.29	W	448	459	3.02	59.5	22.3	7.8
11	P1	10A	30-Dec-03	745	43 19.91	179 35.27	W	476	486	2.99	7.9	27.3	41.3
12	P1	10A	30-Dec-03	1012	43 11.10	179 54.37	W	514	518	3.02	55.3	0	6.9
13	P1	10A	30-Dec-03	1233	43 07.95	179 45.13	W	525	526	2.99	109.6	8.7	47.8
14	P1	10A	30-Dec-03	1423	43 03.75	179 37.23	W	527	536	3.01	47	20.7	52.2
15	P1	10B	30-Dec-03	1733	42 57.42	179 12.61	W	547	550	3.01	52.6	10.3	2.7
16	P1	11A	31-Dec-03	529	43 22.97	179 01.88	W	436	442	3	28.2	10.2	17.6
17	P1	10B	31-Dec-03	739	43 17.19	178 59.68	W	447	457	3.01	38.9	39.4	14.6
18	P1	10B	31-Dec-03	941	43 17.07	179 12.47	W	490	499	3	48.4	131	3.2
19	P1	10B	31-Dec-03	1140	43 13.10	179 11.48	W	509	515	3	48.3	126.6	6.7
20	P1	10B	31-Dec-03	1455	42 54.29	179 12.23	W	583	585	3.01	88.6	27.2	10.6
21	P1	11A	1-Jan-04	525	43 37.91	178 57.73	W	426	446	3	98.1	0	83.4
22	P1	11A	1-Jan-04	734	43 34.12	178 53.11	W	450	450	2.32	22.5	4.1	16.9
23	P1	11A	1-Jan-04	943	43 38.27	178 38.55	W	422	440	3.01	68.8	9.9	45.7
24	P1	11A	1-Jan-04	1324	43 35.15	178 19.15	W	402	406	2.81	245.5	0	56.8
25	P1	11A	1-Jan-04	1517	43 29.24	178 14.24	W	412	417	3.01	294.5	0	76.2
26	P1	11A	1-Jan-04	1731	43 24.62	178 28.06	W	426	426	3.02	118.7	0	11.9
27	P1	11B	2-Jan-04	528	42 59.35	178 49.62	W	525	525	2.99	66.8	11.9	27.6
28	P1	11B	2-Jan-04	752	43 08.77	178 43.40	W	497	499	3	33.3	4.8	5.7
29	P1	11B	2-Jan-04	937	43 07.08	178 33.56	W	505	511	3	109.5	6.6	17.9
30	P1	11B	2-Jan-04	1200	42 59.13	178 30.76	W	531	538	3.01	56.5	14.2	17.3
31	P1	11C	2-Jan-04	1407	43 00.85	178 16.54	W	535	536	3	151.9	0	21.8
32	P1	2B	2-Jan-04	1718	42 52.07	178 02.48	W	607	616	2.98	156.2	28.5	25.8
33	P1	11C	3-Jan-04	516	43 14.18	178 01.13	W	423	453	3.01	91.6	0	42.9
34	P1	11C	3-Jan-04	705	43 11.88	177 53.49	W	453	463	3	76.2	0	18.4
35	P1	9	3-Jan-04	953	43 12.54	177 29.92	W	364	376	3	247.7	0	27.3
36	P1	11C	3-Jan-04	1212	43 05.92	177 25.60	W	467	479	3.03	126.8	0	45.6
37	P1	2B	3-Jan-04	1510	42 54.16	177 45.08	W	608	614	3	67	14.1	9.4
38	P1	2B	3-Jan-04	1808	42 50.69	177 27.91	W	782	790	3.01	24.7	0	0
39	P1	2B	4-Jan-04	638	42 58.23	177 03.40	W	602	626	3	209.5	36	42.9
40	P1	11D	4-Jan-04	938	43 06.77	176 39.39	W	460	478	3	206.4	0	19.6
41	P1	11D	4-Jan-04	1129	43 04.53	176 29.32	W	534	542	3.03	221.1	5.3	9.2
42	P1	9	4-Jan-04	1427	43 15.35	176 26.80	W	391	394	2.03	44.2	0	4.9
43	P1	11D	4-Jan-04	1612	43 13.48	176 14.04	W	466	472	3.01	316	0	31.1
44	P1	2B	5-Jan-04	524	43 10.44	175 14.08	W	732	732	3.01	70.1	25.3	18.5

Appendix 1 (continued)

Stn.	Type	Strat.	Date	Time NZST	Start of tow Latitude ° ' S	Longitude ° '	E/W	Depth (m) min.	max.	Dist. towed (n. mile)	Catch (kg) hoki	hake	ling
45	P1	2B	5-Jan-04	903	43 15.54	175 37.98	W	622	634	3	137.3	73.8	14.3
47	P1	11D	5-Jan-04	1120	43 24.89	175 39.44	W	470	487	3.02	234.7	0	4.4
48	P1	12	5-Jan-04	1400	43 43.17	175 31.78	W	420	445	2.19	125.1	7.2	40
49	P1	9	5-Jan-04	1558	43 52.33	175 27.30	W	241	298	2.85	0	0	45
50	P1	9	6-Jan-04	509	43 55.40	175 31.98	W	226	245	2.48	0	0	0
51	P1	9	6-Jan-04	718	43 55.88	175 24.04	W	232	247	3	0	0	0
52	P1	5	6-Jan-04	1559	44 06.20	177 11.99	W	372	377	3.01	346	0	15.2
53	P1	5	7-Jan-04	516	43 37.11	177 58.66	W	374	381	3.03	179.8	0	41.8
54	P1	5	7-Jan-04	807	43 37.27	177 41.87	W	374	380	3	171.2	4.4	23.8
55	P1	12	7-Jan-04	1129	43 53.95	177 52.90	W	413	427	3.01	415.8	43.4	109.2
56	P1	12	7-Jan-04	1350	44 02.18	177 38.34	W	440	445	3.01	442.9	0	46.9
57	P1	3	8-Jan-04	523	43 52.87	179 10.42	W	260	308	2.99	118.9	0	32.1
58	P1	13	8-Jan-04	809	43 59.70	178 48.87	W	417	427	2.99	361.4	0	24.9
59	P1	3	8-Jan-04	1024	44 07.37	179 02.56	W	357	365	3.01	413.1	0	33.8
60	P1	4	8-Jan-04	1414	44 20.31	178 44.33	W	675	676	3.03	16.7	0	31
61	P1	13	11-Jan-04	741	44 03.72	179 38.36	W	423	429	3.04	109.1	0	51.5
62	P1	3	11-Jan-04	1023	43 50.15	179 44.10	W	377	385	3.01	828.4	0	84.3
63	P1	13	11-Jan-04	1345	43 53.84	179 57.96	W	410	428	3.05	200.2	0	36.2
64	P1	4	11-Jan-04	1721	44 06.89	179 52.54	E	614	628	3	26.4	0	27.8
65	P1	14	12-Jan-04	513	43 38.57	179 38.04	E	402	418	3.01	122	0	42.2
66	P1	14	12-Jan-04	724	43 41.44	179 36.14	E	422	429	3	131.6	25.2	64.6
67	P1	14	12-Jan-04	1052	43 43.25	179 02.09	E	435	442	2.85	399.4	0	44.7
68	P1	4	12-Jan-04	1400	43 55.81	178 45.96	E	600	613	2.99	69.8	0	25.9
69	P1	20	12-Jan-04	1815	43 37.44	178 09.93	E	370	383	3	1514.3	0	4.5
70	P1	4	13-Jan-04	527	43 54.30	177 25.75	E	611	612	3	58.6	0	49.5
71	P1	20	13-Jan-04	902	43 38.29	177 31.59	E	311	327	3.01	609.7	0	8.5
72	P1	15	13-Jan-04	1248	43 39.11	176 56.86	E	435	437	3.01	244.4	0	128
73	P1	19	13-Jan-04	1648	43 30.96	176 46.89	E	246	261	3	173.2	0	0
74	P1	15	14-Jan-04	524	43 45.15	176 17.29	E	409	420	3	1046.8	7.5	38.3
75	P1	15	14-Jan-04	802	43 55.98	176 28.53	E	499	506	3	113.8	12.2	36.1
76	P1	15	14-Jan-04	1004	44 01.32	176 39.84	E	539	552	3	343.7	0	53.6
77	P1	17	14-Jan-04	1410	44 05.84	176 05.16	E	313	345	3.01	227.6	0	17.1
78	P1	17	11-Jan-04	1650	44 17.11	176 12.48	E	245	356	3.01	129.9	0	10
79	P1	6	15-Jan-04	537	44 34.91	174 59.61	E	759	759	2.99	53	0	0.3
80	P1	6	15-Jan-04	922	44 27.59	175 01.58	E	700	706	2	62.5	3.3	44.1
81	P1	17	15-Jan-04	1410	44 20.73	175 53.00	E	220	296	3.01	2.5	0	1.1
82	P1	16	15-Jan-04	1739	44 02.94	175 31.48	E	516	525	2.99	72.9	5.3	73.4
83	P1	18	16-Jan-04	527	43 36.89	175 34.67	E	273	288	3.01	63.9	0	0
84	P1	18	16-Jan-04	722	43 41.97	175 24.44	E	330	358	3	361.6	0	0
85	P1	16	16-Jan-04	1021	43 47.65	174 54.25	E	452	465	3.02	299.3	2.2	45.7
86	P1	16	16-Jan-04	1224	43 56.15	174 53.33	E	465	468	3.01	239.9	31.3	85.8
87	P1	16	16-Jan-04	1451	43 59.77	174 36.75	E	524	548	3.01	118.8	4.7	46.1
88	P1	16	16-Jan-04	1732	44 07.18	174 37.69	E	542	559	3.02	66.7	5	124.2
89	P1	6	17-Jan-04	533	44 14.36	174 20.28	E	608	608	3	28.3	10.8	24.1
90	P1	16	17-Jan-04	813	44 07.75	174 08.05	E	550	564	3	54.8	0	45.4

Appendix 1 (continued)

					Start of tow			Depth (m)		Dist.			Catch (kg)
Stn.	Type	Strat.	Date	Time	Latitude	Longitude				towed	hoki	hake	ling
				NZST	° ' S	° '	E/W	min.	max.	(n. mile)			
91	P1	7	17-Jan-04	1425	43 39.08	174 29.51	E	536	542	3.02	84.3	1.2	58
92	P1	7	17-Jan-04	1717	43 36.14	174 33.57	E	533	542	3.01	71.9	6.2	75.9
93	P1	18	18-Jan-04	1250	43 31.61	174 44.82	E	379	396	2.99	1126.4	0	63.3
94	P1	7	19-Jan-04	534	43 29.99	174 31.56	E	504	538	3.03	73.3	18.8	71.1
95	P1	7	19-Jan-04	826	43 20.47	174 13.03	E	571	576	3.01	30.1	2.9	73.5
96	P1	7	19-Jan-04	1048	43 10.98	174 20.71	E	584	597	3.01	47.2	9.5	51.8
97	P1	7	19-Jan-04	1503	43 00.92	175 02.34	E	429	442	3	280.3	11.6	95.9
98	P1	1	19-Jan-04	1722	42 51.51	175 05.82	E	790	793	3.01	32.8	6	0
99	P1	1	20-Jan-04	538	42 51.01	175 15.09	E	747	751	3	34.5	4	38.6
100	P1	1	20-Jan-04	835	42 53.45	175 36.53	E	614	622	3	28.9	2.3	74.3
101	P1	2A	20-Jan-04	1145	42 52.21	176 04.52	E	603	608	3.01	47.6	6.2	34.4
102	P1	8A	20-Jan-04	1502	43 01.46	176 10.63	E	477	484	3	125.7	19.4	89.4
103	P1	19	21-Jan-04	526	43 13.20	176 28.68	E	294	300	3	657.8	0	71.6
104	P1	19	21-Jan-04	923	43 13.75	177 03.38	E	207	224	3	1881.7	0	0
105	P1	19	21-Jan-04	1220	43 21.61	177 24.15	E	239	251	2.12	9.8	0	0
106	P1	20	21-Jan-04	1552	43 04.07	177 47.13	E	317	322	3.02	246.7	0	7.3
107	P1	20	21-Jan-04	1801	43 01.68	177 52.13	E	338	377	2.62	630.2	0	57.7
108	P2	19	22-Jan-04	527	42 59.76	176 55.25	E	375	393	2.99	81	0.4	35.1
109	P2	19	22-Jan-04	754	43 00.59	177 13.91	E	310	338	3	437.8	0	45.9
110	P2	20	22-Jan-04	1132	43 12.38	177 41.75	E	298	309	3	611.1	0	7.4

Appendix 2: Scientific and common names of species caught in valid biomass tows. The occurrence (Occ.) of each species (number of tows caught) in the 110 valid biomass tows is also shown. (Note that codes are continually updated on the database following this and other surveys.)

Scientific name	Common name	Code	Occ.
Porifera	unspecified sponges	ONG	35
Cnidaria			
Scyphozoa (jellyfish)	unspecified jellyfish	JFI	13
Hydrozoa			
Coral (Hydrozoan + Anthozoan corals)	unspecified coral	COU	22
Anthozoa			
Pennatulacea (sea pens)	unspecified sea pens	SPN	22
Actinaria (sea anemones)	unspecified sea anemones	ANT	39
Tunicata			
Thaliacea (salps)	unspecified salps	SAL	5
Pyrosoma atlanticum		PYR	41
Mollusca			
Gastropoda (gastropods)	unspecified gastropods	GAS	1
Cymatiidae			
Fusitriton magellanicus		FMA	37
Volutidae			
Provocator mirabilis	golden volute	GVO	2
Cephalopoda			
Teuthoidea (squids)	unspecified squids	SQX	2
Ommastrephidae			
Nototodarus sloanii	arrow squid	NOS	64
Ommastrephes bartrami	red squid	RSQ	4
Todarodes filippovae	Antarctic flying squid	TSQ	18
Onchoteuthidae			
Moroteuthis ingens	warty squid	MIQ	37
M. robsoni	warty squid	MRQ	5
Chranchiidae (cranchiid squids)		CHQ	1
Octopoda (octopods)		OCP	1
Octopodidae			
Enteroctopus zealandicus	yellow octopus	EZE	7
Graneledone spp.	deepwater octopus	DWO	6
Crustacea			
Dendrobranchiata/Pleocyemata (prawns)			
Caridea			
Campylonotidae			
Campylonotus rathbunae	sabre prawn	CAM	5
Nematocarcinidae			
Lipkius holthuisi	omega prawn	LHO	9
Oplophoridae			
Oplophorus novaezeelandiae	prawn	ONO	2

Appendix 2 (continued)

Scientific name	Common name	Code	Occ.
Pasiphaeidae			
Pasiphaea barnardi	prawn	PBA	1
Astacidea			
Nephropidae (clawed lobsters)			
Metanephrops challengeri	scampi	SCI	47
Palinura			
Polychelidae			
Polycheles suhmi	polychelid	PLY	4
Crab (anomuran + brachyuran crabs)	unspecified crabs	CRB	25
Anomura			
Galatheidae (squat lobsters)			
Munida sp.		MUN	5
Lithodidae (king crabs)			
Lithodes murrayi	southern stone crab	LMU	2
Neolithodes brodiei		NEB	2
Paralomis hystrix		PHS	1
Parapaguridae (parapagurid hermit crabs)			
Parapagurus dimorphus	hermit crab	PAG	5
Brachyura			
Homolidae			
Paromola petterdi	antlered crab	ATC	13
Portunidae (swimming crabs)			
Ovalipes molleri	swimming crab	OVM	1
Majidae (spider crabs)			
Leptomithrax sp.	masking crab	SSC	13
Bryozoa (bryozoans)		COZ	2
Echinodermata			
Asteroidea (starfish)	unspecified asteroid	ASR	39
Astropectinidae			
Dipsachaster magnificus	starfish	DMG	17
Plutonaster spp.	starfish	PLT	24
Psilaster acuminatus	geometric star	PSI	44
Goniasteridae			
Hippasteria trojana	trojan star	HTR	9
Mediaster sladeni	starfish	MSL	20
Solasteridae			
Crossaster japonicus	sun star	CJA	29
Solaster torulatus	starfish	SOT	12
Zoroasteridae			
Zoroaster spp.	rat-tail star	ZOR	27
Holothuroidea (sea cucumbers)	unspecified holothruian	HTH	29
Ophiuroidea (basket and brittle stars)	unspecified ophiuroid	OPH	4
Euryalina (basket stars)			
Gorgonocephalidae			
Gorgonocephalus sp.	basket star	GOR	15

Appendix 2 (continued)

Scientific name	Common name	Code	Occ.
Echinoidea (sea urchins)			
Regularia			
Cidaridae (cidarid urchins)			
Goniocidaris parasol	cidarid urchin	GPA	14
Echinothuriidae (Tam-o-shanter urchins)		TAM	31
Araeosoma spp.	Tam o shanter urchin	ARA	2
Echinidae			
Dermechinus horridus	sea urchin	DHO	2
Gracilechinus multidentatus	sea urchin	GRM	6
Spatangidae (heart urchins)			
Paramaretia multituberculata	heart urchin	PMU	18
Chondrichthyes (cartilagenous fishes)			
Hexanchidae: cowsharks			
Hexanchus griseus	sixgill shark	HEX	2
Squalidae: dogfishes			
Centrophorus squamosus	leafscale gulper shark	CSQ	7
Centroscymnus crepidater	longnose velvet dogfish	CYP	9
C. owstoni	smoothskin dogfish	CYO	2
C. plunketi	Plunket's shark	PLS	15
Deania calcea	shovelnose dogfish	SND	39
Etmopterus baxteri	Baxter's dogfish	ETB	18
E. lucifer	Lucifer dogfish	ETL	80
Scymnorhinus licha	seal shark	BSH	28
Squalus acanthias	spiny dogfish	SPD	71
S. mitsukurii	northern spiny dogfish	NSD	8
Oxynotidae: rough sharks			
Oxynotus bruniensis	prickly dogfish	PDG	9
Scyliorhinidae: cat sharks			
Apristurus spp.	deepsea catsharks	APR	7
Cephaloscyllium isabellum	carpet shark	CAR	1
Halaelurus dawsoni	Dawson's catshark	DCS	1
Triakidae: smoothhounds			
Galeorhinus galeus	school shark	SCH	7
Torpedinidae: electric rays			
Torpedo fairchildi	electric ray	ERA	1
Narkidae: blind electric rays			
Typhlonarke spp.	numbfish	BER	4
Rajidae: skates			
Bathyraja shuntovi	longnosed deepsea skate	PSK	1
Dipturus innominatus	smooth skate	SSK	33
D. nasutus	rough skate	RSK	3
Notoraja spp.		BTA	29
Chimaeridae: chimaeras, ghost sharks			
Hydrolagus novaezealandiae	ghost shark	GSH	57
H. bemisi	pale ghost shark	GSP	74
Rhinochimaeridae: longnosed chimaeras			
Harriotta raleighana	long-nosed chimaera	LCH	45
Rhinochimaera pacifica	wide-nosed chimaera	RCH	3

Appendix 2 (continued)

Scientific name	Common name	Code	Occ.
Osteichthyes (bony fishes)			
Notocanthidae: spiny eels			
Notacanthus sexspinis	spineback	SBK	51
Congridae: conger eels			
Bassanago bulbiceps	swollenhead conger	SCO	35
B. hirsutus	hairy conger	HCO	21
Gonorynchidae: sandfish			
Gonorynchus forsteri	sandfish	GON	2
Argentinidae: silversides			
Argentina elongata	silverside	SSI	58
Alepocephalidae: slickheads			
Alepocephalus sp.	bigscaled brown slickhead	SBI	1
Xenodermichthys spp.	black slickhead	BSL	1
Platytroctidae: tubeshoulders			
Persparsia kopua		PER	1
Sternoptychidae: hatchetfishes		HAT	1
Photichthyidae: lighthouse fishes			
Photichthys argenteus	lighthouse fish	PHO	16
Stomiidae: scaly dragonfishes			
Stomias sp.		STO	1
Paralepididae: barracudinas		PAL	1
Myctophidae: lanternfishes		LAN	5
Moridae: morid cods			
Antimora rostrata	violet cod	VCO	1
Halargyreus johnsonii	slender cod	HJO	10
Lepidion microcephalus	small-headed cod	SMC	4
Mora moro	ribaldo	RIB	40
Notophycis marginata	dwarf cod	DCO	2
Pseudophycis bachus	red cod	RCO	22
Tripterophycis gilchristi	grenadier cod	GRC	4
Gadidae: true cods			
Micromesistius australis	southern blue whiting	SBW	2
Merlucciidae: hakes			
Macruronus novaezelandiae	hoki	HOK	107
Merluccius australis	hake	HAK	53
Macrouridae: rattails, grenadiers			
Caelorinchus aspercephalus	oblique banded rattail	CAS	50
C. biclinozonalis	two saddle rattail	CBI	8
C. bollonsi	bigeye rattail	CBO	100
C. fasciatus	banded rattail	CFA	25
C. innotabilis	notable rattail	CIN	7
C. matamua	Mahia rattail	CMA	7
C. oliverianus	Oliver's rattail	COL	74
C. parvifasciatus	small banded rattail	CCX	26
Coryphaenoides dossenus	long barbel rattail	CBA	1
C. serrulatus	serrulate rattail	CSE	4
C. subserrulatus	four-rayed rattail	CSU	7

Appendix 2 (continued)

Scientific name	Common name	Code	Occ.
Lepidorhynchus denticulatus	javelinfish	JAV	105
Lucigadus nigromaculatus	blackspot rattail	VNI	25
Macrourus carinatus	ridge-scaled rattail	MCA	1
Nezumia namatahi	squashed face rattail	NNA	2
Trachyrincus aphyodes	white rattail	WHX	3
Ophidiidae: cusk eels			
Genypterus blacodes	ling	LIN	101
Trachipteridae: dealfishes			
Trachipterus trachypterus	dealfish	DEA	1
Trachichthyidae: roughies			
Hoplostethus atlanticus	orange roughy	ORH	3
H. mediterraneus	silver roughy	SRH	41
Paratrachichthys trailli	common roughy	RHY	7
Berycidae: alfonsinos			
Beryx decadactylus	longfinned beryx	BYD	1
B. splendens	alfonsino	BYS	38
Zeidae: dories			
Capromimus abbreviatus	capro dory	CDO	19
Cyttus novaezealandiae	silver dory	SDO	21
C. traversi	lookdown dory	LDO	102
Zenopsis nebulosus	mirror dory	MDO	2
Oreosomatidae: oreos			
Allocyttus niger	black oreo	BOE	8
Neocyttus rhomboidalis	spiky oreo	SOR	21
Pseudocyttus maculatus	smooth oreo	SSO	7
Macrorhamphosidae: snipefishes			
Centriscops humerosus	banded bellowsfish	BBE	82
Notopogon lilliei	crested bellowsfish	CBE	4
Scorpaenidae: scorpionfishes			
Helicolenus spp.	sea perch	SPE	97
Congiopoidae: pigfishes			
Alertichthys blacki	alert pigfish	API	2
Congiopodus coriaceus	deepsea pigfish	DSP	1
C. leucopaecilus	pigfish	PIG	3
Triglidae: gurnards			
Lepidotrigla brachyoptera	scaly gurnard	SCG	8
Hoplichthyidae: ghostflatheads			
Hoplichthys haswelli	deepsea flathead	FHD	55
Psychrolutidae: toadfishes			
Ambophthalmos angustus	pale toadfish	TOP	37
Percichthyidae: temperate basses			
Polyprion oxygeneios	hapuku	HAP	6
Serranidae: sea perches			
Lepidoperca aurantia	orange perch	OPE	10
Apogonidae: cardinalfishes			
Epigonus lenimen	bigeye cardinalfish	EPL	20
E. robustus	robust cardinalfish	EPR	13
E. telescopus	deepsea cardinalfish	EPT	9

Appendix 2 (continued)

Scientific name	Common name	Code	Occ.
Carangidae: jacks, trevallies, kingfishes			
Trachurus declivis	jack mackerel	JMD	2
T. symmetricus murphyi	slender mackerel	JMM	6
Bramidae: pomfrets			
Brama brama &	Ray's bream &	RBM &	25
B. australis	southern Ray's bream	SRB	
Xenobrama microlepis	bronze bream	BBR	2
Emmelichthyidae: bonnetmouths, rovers			
Emmelichthys nitidus	redbait	RBT	6
Plagiogeneion rubiginosus	ruby fish	RBY	2
Cheilodactylidae: tarakihi, morwongs			
Nemadactylus macropterus	tarakihi	TAR	7
Uranoscopidae: armourhead stargazers			
Kathetostoma giganteum	giant stargazer	STA	61
Kathetostoma sp.	banded giant stargazer	BGZ	3
Percophidae: opalfishes			
Hemerocoetes spp.	opalfish	OPA	1
Pinguipedidae: weavers			
Parapercis gilliesi	yellow cod	YCO	2
Gemplylidae: snake mackerels			
Ruvettus pretiosus	oilfish	OFH	1
Thyrsites atun	barracouta	BAR	10
Trichiuridae: cutlassfishes			
Lepidopus caudatus	frostfish	FRO	4
Centrolophidae: raftfishes, medusafishes			
Centrolophus niger	rudderfish	RUD	22
Hyperoglyphe antarctica	bluenose	BNS	4
Icichthys australis	ragfish	RAG	2
Schedophilus huttoni		SUH	3
S. maculatus	pelagic butterfish	SUM	1
Seriolella caerulea	white warehou	WWA	65
S. punctata	silver warehou	SWA	58
Bothidae: lefteyed flounders			
Arnoglossus scapha	witch	WIT	14
Neoachiropsetta milfordi	finless flounder	MAN	1
Pleuronectidae: righteyed flounders			
Azygopus pinnifasciatus	spotted flounder	SDF	2
Pelotretis flavilatus	lemon sole	LSO	18

Appendix 3: Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomasses given in Table 6.

Survey	Age group			
	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