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## EXECUTIVE SUMMARY


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The twelfth 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 2003. Using a random stratified sampling design, 106 phase 1 stations and 9 phase 2 stations in core depths of 200–800 m were successfully completed. In addition 2 mid-water tows were carried out over a deepwater hill complex (the Andes) to the east of the survey area. The estimate of relative biomass of hoki in core depths was the lowest in the time series at 52 500 t, continuing the downward trend observed since 1996. The biomass of hoki 3 years and older was also very low. 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 biomass of hake in core strata was also at the lowest in the survey series, continuing a downward trend observed since the surveys began, while the biomass of ling, although slightly lower, showed no overall trend.

Coefficients of variation (c.v.s) achieved for total hoki and hake were 8.7% and 15.5% respectively, considerably lower than the target c.v.s. Phase 2 stations to reduce the c.v. for 2+ hoki achieved a final c.v. of 15.1%, also lower than the target c.v.

Age frequency distributions of hake suggest low recruitment since the mid 1990s, while those of ling indicate moderate recruitment during the late 1990s.

It is clear from this year's survey that the downward trends in hoki and hake biomass have not slowed as yet. Lookdown dory, sea perch, and white warehou biomass estimates were lower than in 2002, breaking their upward trend. Spiny dogfish, and dark and pale ghost shark species showed little change from 2002, but silver warehou biomass has increased since 2001.

## 1. INTRODUCTION

In January 2003, the twelfth in a time series of annual random trawl surveys on the Chatham Rise to estimate relative abundance indices for hoki and a range of other middle depth species was completed. This and all previous surveys in the series were carried out from the research vessel *Tangaroa* and form the most comprehensive time series of species abundance in water depths of 200–800 m in New Zealand's 200 mile Exclusive Economic Zone. The surveys followed a random stratified design, with stratification by depth and longitude across the Chatham Rise to ensure full coverage of the area. In 2003, the stratification used was the same as that in 2002 (Stevens & Livingston. 2003) in core depths of 200–800 m. Two additional tows were carried out on the Andes Hill complex to the east of the Chatham Rise to investigate reports of large hoki in midwater over bottom depths of 1000 m or more.

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), and Stevens et al. (2001, 2002), Stevens & Livingston 2003). Trends in biomass and changes in catch and age distribution of 31 species from surveys between 1992 and 2001 were reviewed by Livingston et al. (2002). Hoki dominated the catches in every survey, and formed 53–66% of the total biomass from 1992 to 1997. By 2001, however, the proportion of hoki 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).

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 Individual Transferable Quota (ITQ) species were collected for ageing and use in stock assessments (Annala et al. 2003). Other work carried out concurrently with the survey included acoustic data collection (Objective 3, below) and increased effort to collect adequate samples for identification of all organisms caught by the trawl (Objective 4, below). This year, we also piloted a change to the sampling of the catch protocol, partly as a result of a study that found length-weight relationships of 13 species in the survey series varied less than 10% from year to year (Appendix 1), and partly to improve work efficiency at sea. *Details of the* revised sampling protocol are given in the Methods section.

### 1.1 Project Objectives

The specific objectives for the project during 2002–2003 were as follows.

1. To continue the time series of relative abundance indices of recruited hoki (eastern stock), juvenile hoki (western and eastern stocks), hake (HAK 4), and other middle depth species on the Chatham Rise using trawl surveys. The survey design will be optimised for 2 year old hoki (target c.v. of 20 %) and recruited hoki (target c.v. of 20 %).

2. To determine the population proportions at age for hoki and hake 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.

## 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 2002 (Stevens & Livingston 2003). 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 the last three 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 more phase 2 stations than previously. 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 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 for the biomass survey were carried out during daylight, i.e., between sunrise and sunset (earliest start time, 0435 h, latest finish time, 1849 h NZST). The gear did not get shot until downward micronekton and fish movements had stabilised at the beginning of the day, because 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 invalid 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 Kaijo Denki or Furuno net monitor, respectively) and an average 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 the start of each tow from a temperature sensor mounted on the hull at a depth of about 5 m. Temperatures at 5 m depth were also recorded from the Seabird CTD, before the gear moved down to the seabed. Bottom temperatures were obtained from the average of recordings taken every 5 minutes 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. The Seabird CTD generated temperature and salinity depth profiles for acoustic analysis.

## 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 (in Appendix 1), sampling for other species focused on obtaining length frequencies for a wide range of species (i.e., not only ITQ), while biological data collection was focused on species for which we had few data, or species that were relatively abundant in a given tow and would assist with the interpretation of acoustic data collected during the tow.

Length, weight, and sex data were collected from hoki, hake, and ling, and species for which there exist fewer than 500 specimens on the Trawl database. Species which are not well sampled within the depth range of the survey (e.g., shallow water species such as tarakihi, barracouta, mackerels, or deepwater species such as orange roughy and the oreos) were not weighed individually unless specifically requested by other research programmes. Mean length-weight relationships from all surveys combined were used to scale length frequency histograms by population number. Since there appears to be little annual variation in length-weight relationships (Appendix 1), we decided that a useful approach would be to rotate the collection of length and weight data so that this is monitored every second or third year for each species. Continued effort was put into collecting these data for non-commercial species to facilitate interpretation of acoustic recordings collected during and between tows (O'Driscoll 2002).

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 break and burn method of Horn & Sullivan (1996). 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).

Data were entered in real time 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 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 those 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.

## 2.8 Midwater sampling

During the course of the survey, we sampled the Andes hill complex lying east of the Chatham Rise in deepwater just outside the survey area (Figure 2) using a Spaghetti Midwater Trawl (NIWA Net Reference No. 119; net plan available from NIWA Vessel Company on request). Anecdotal reports from fishing industry personnel have indicated that, at times, large hoki can be caught in commercial quantities in mid-water near these hills. Two tows were carried out 'blind' (i.e., without predetermining the presence or otherwise of suitable marks). As the tows progressed, trawl position in the water column was adjusted to ensure that marks at 500–700 m were sampled. The first tow (station 049) was about 45 minutes duration, and the second (station 050) just 30 minutes. The catch was identified and weighed. All hoki were sexed, measured, and weighed, had the otoliths removed for ageing and the stomach contents recorded.

## 2.9 Acoustics

### 2.9.1 Acoustic data collection

Acoustic data were collected during trawling and while steaming between trawl stations (both day and night) using a custom-built *CREST* system (Coombs et al. 2003) with hull-mounted Simrad single-beam 12 and 38-kHz transducers. *CREST* is a computer-based "software echo-sounder" which supports multiple channels. The transmitter was a switching type with a nominal power output of 2 kW rms. Transmitted pulse length was 1 ms with 3 s between transmits. The *CREST* receiver has a broadband, wide dynamic range pre-amplifier and serial analog-to-digital converters (ADCs), which feed a digital signal processor (DSP56002). Data from the ADCs were complex demodulated, filtered, and a 20 log *R* time-varied gain was applied. The results were then shifted to give 16-bit resolution in both the real and imaginary terms and the complex data stored for later processing. The 38-kHz transducer was calibrated before the survey following standard procedures (Foote et al. 1987). The 12-kHz transducer was not calibrated. Data collected on 12 kHz were used only to make visual comparisons with 38-kHz data and were not analysed quantitatively.

### 2.9.2 Acoustic data analysis

All acoustic recordings made during the trawl survey were visually examined. Marks were classified into eight categories based on the relative depth of the mark in the water column, mark orientation (surface- or bottom-referenced), mark structure (layers, schools, or single targets), and the relative strength of the mark on 38 kHz and 12 kHz. Descriptive statistics were produced on the frequency of occurrence of different marks. Brief descriptions of the eight marks types are given below. Example echograms were produced by Cordue et al. (1998), Bull (2000), and O'Driscoll (2001a, 2001b).

1. Surface layers

   These occurred within the upper 100 m of the water column and tended to be stronger on 12 kHz than on 38 kHz.

2. Pelagic layers

   Surface-referenced midwater layers which were typically continuous for more than 1 km and much stronger on 12 kHz than on 38 kHz. This category is equivalent to "Type A" marks of Bull (2000).

3. Pelagic schools

   Well defined schools in midwater which appear as crescents on 12 kHz. Equivalent to "bullet" marks of Cordue et al. (1998) and Bull (2000).

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 than on 12 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 appear as crescents on 12 kHz and are equivalent to "Type C" marks of Bull (2000).

8. Single targets
   Inverted U-shaped single targets visible on 38 kHz close to the bottom.

A quantitative analysis was also carried out to compare acoustic backscatter from bottom-referenced marks with trawl catch rates. Acoustic data collected on 38-kHz during each tow (corrected for the lag of the trawl behind the vessel based on warp length and water depth) were integrated using custom Echo Sounder Package (ESP2) software (McNeill 2001) to calculate the mean acoustic backscatter per kilometre squared. Two values of acoustic backscatter were calculated for each trawl. The first estimate was based an integration height of 10 m above the acoustic bottom, which was similar to the measured headline height of the trawl (average 7.0 m). The second acoustic estimate integrated all backscatter from the bottom up to the maximum height of the bottom referenced mark or 100 m, but excluded all other mark types. Raw acoustic density estimates (backscatter per km$^2$) were then 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, as was done for the 2001 and 2002 surveys (O'Driscoll 2002).

## 3. RESULTS

### 3.1 2003 survey coverage

The survey successfully sampled all strata, with a total of 115 used for biomass estimation out of 120 bottom stations completed (4 stations were deemed non-valid because headline parameters were outside the normal range, and 1 station came fast). Of the115 valid biomass stations, 106 were from phase 1 of the survey and 9 were from phase 2. Three phase 2 stations were allocated to each of strata 15, 16, and 19 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 completed versus those originally planned per stratum is given in Table 1. An additional two exploratory midwater tows were carried out outside the survey area. Individual station data, including non-valid tows, foul tows, and midwater tows are given in Appendix 2.

The dates of the trawl survey were within the time frame covered in previous years (Table 2). Doorspread readings were recorded from 102 of the 115 valid biomass stations (Table 3). The missing readings were filled with mean values from the appropriate depth zones obtained during the survey.

Station density ranged from 1:288 in stratum 17 (200–400 m, Veryan Bank) to 1:3772 km$^2$ in stratum 4 (600–800 m, south Chatham Rise). Mean station density for core strata was 1:1303, and over the full survey area was 1:1335 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 115.2 to 122.7 m and mean headline height ranged from 6.4 to 6.7 m, and were all within the optimal range (Hurst et al. 1992) (Table 3).

### 3.3 Hydrology

Surface and bottom temperatures were recorded throughout the survey. The results indicated that the hull-mounted sensor was reading about 0.5–1.0 °C above the CTD temperatures near the surface. The surface temperatures plotted (Figure 2 top panel) are those from the CTD (as these recordings were considered more reliable) and ranged from 13.0 to 16.5 °C. Bottom temperatures, also from the CTD, ranged from 5.3 to 11.1 °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 Sub-Antarctic 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, typically determined by close isotherms at the surface, was ill defined during this survey (Figure 2). 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 ninety-four species or species groups were recorded from the 115 valid biomass tows. The total catch was 116.2 t, of which 38.2 t (32.9%) was hoki, 6.9 t (5.9%) was black oreo, 6.5 t (5.6%) was javelinfish, 4.4 t (3.8%) was big-eye rattail, 9.9 t (8.5%) was dark ghost shark, and 3.7 t (3.1%) was ling (Table 4).

Of the 194 species or species groups identified, there were 104 teleosts, 27 elasmobranchs, 17 crustaceans, and 8 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 3. A number of benthic invertebrates are awaiting formal identification.

### 3.5 Biomass estimates

Relative biomasses, with c.v.s for hoki, hake, and ling well within target levels, were estimated for 52 species (Table 4). Phase 2 stations resulted in a c.v. of 15.5% for 2+ hoki (2000 year class). High c.v.s (over 20%) occurred when species were not well sampled by the gear, for example, silver warehou and alfonsino are pelagic and exhibit strong schooling behaviour. Others, such as smooth oreo and barracouta, have high c.v.s as they are mainly distributed outside the survey depth range.

The combined biomass for 52 species in core strata (Table 4) in 2003 was lower than in 2002, and close to that of 2000 (Figure 3, top panel). Hoki biomass was lower than in 2002, but as in previous years, it was the most abundant species caught (Table 4). As a proportion of the total biomass, hoki remained at a similar level to 2001 and 2002 (Figure 3, lower panel). Black oreo, dark ghost shark, silver warehou, ling, sea perch, pale ghost shark, barracouta, white warehou, giant stargazer, and smooth oreo were the next most abundant species after hoki, each with an estimated biomass over 1500 t. The most abundant commercial non-ITQ species were spiny dogfish, lookdown dory, shovelnose dogfish, and Ray's bream (all biomasses greater than 1500 t). A substantial biomass of non-commercial species, primarily javelinfish and other rattails, was also estimated (Table 4).

The downward trend in hoki biomass continued in 2003, with an estimated value of 52 500 t (Table 5). The decrease in hoki biomass was due to below average recruitment of 1+ fish (2001 year class), and a substantial drop in the biomass of fish aged 3 years and over (3++) (Table 6). The weak 199 year class moving into the plus group would have added little to the already relatively weak recruitment observed in preceding years. Hake and ling biomass were also lower than in 2002 (see Table 4).

It is clear from this year's survey that the downward trends in hoki and hake biomass have not slowed as yet. Lookdown dory, sea perch, and white warehou biomass estimates were lower than in 2002, breaking their upward trend. Spiny dogfish, dark and pale ghost shark species showed little change from 2002, while silver warehou biomass has increased since 2001 (Figure 4).

### 3.6 Catch distribution

#### Hoki

In the 2003 survey, hoki were caught at 111 of the 115 valid biomass stations, but the highest catch rates were in shallow strata (200–400 m) along the crest of the Rise, reflecting the relatively high proportion of 2+ fish this year (compare Figures 5a and 5b). The highest individual station catch rate of hoki in 2003 occurred on the Reserve Bank (stratum 19) and comprised mainly 2+ fish. The distribution of this age class was skewed towards western strata (Figure 5b). The weak 1+ year class was more abundant in the shallow strata (200–400 m) and most of the 1+ biomass occurred in strata 17 and 19 (Figure 5a, Tables 7 and 8). Relatively large numbers of 2+ hoki were caught, mixed in with schools of a few 1+ hoki, in strata 17–20 (Figure 5c). Older hoki in the 3++ plus group were distributed in 400–800 m depths throughout the survey area, but catch rates were higher in the west in stratum 15 (Figure 5c).

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 were skewed more to the east, but in 2003, the distribution was more even again (Figure 5c).

#### Hake

In 2003 catch rates of hake were low, with the highest catch rates northwest of the Chatham Islands where hake spawn at this time of year, and strata at the west of Mernoo Bank (Figure 6). Strata 10a, 10b, 11a, 11b, 11c, and 11d near the Chatham Islands contributed 27% of hake biomass, and strata 7 and 16, west of Mernoo Bank, contributed 34% (Tables 7 and 8). The highest catch rates of hake were from stratum 7 at Mernoo Bank and stratum 11c 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, almost no hake have been caught along the south side of the survey area.

#### Ling

Catches of ling were caught fairly evenly in most strata over the Chatham Rise between 200 and 600 m in the 2003 survey, with the exception of strata 18, 19, 20, and 9 which had very low catches of ling (Figure 7). The largest catch was taken in stratum 16, southwest of Mernoo Bank. Ling distribution has been reasonably consistent, and catch rates have remained relatively stable over the time series.

#### Other species

As with previous surveys, lookdown dory, spiny dogfish, pale ghost shark, and giant stargazer were widely distributed across the survey area and taken in large quantities at depths of 200–600 m (Figure 8). Big-eye rattail, Oliver's rattail, and javelinfish (not shown) were also widely distributed but generally taken in water deeper than 400 m. Sea perch were more concentrated in strata east of Mernoo Bank than usual. 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 200–400 m, with occasional large catches taken from stratum 19, east of the Mernoo Bank (Figure 8 and Tables 8, 9).

## 3.7 Biological data

### 3.7.1 Species sampled

The number of species and the number of samples for which length and detailed biological data were collected are given in Table 9. This was largely due to the additional data required to interpret acoustic recordings.

### 3.7.2 Length frequencies and age distributions

Length-weight relationships used in the Trawlsurvey Analysis Program to scale length frequencies are given in Table 10. The length and age frequencies shown represent the population structure, as sampled by the bottom trawl, for the survey area in 2003.

#### Hoki

The 2+ age class of hoki (48–60 cm TL) dominated scaled length frequencies and age frequencies in the 2003 survey (Figures 9 and 10). Numbers of 1+ hoki (less than 52 cm TL) 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 & 10). Although recruitment was above average in the 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 & 10). Recruitment of the 2001 year class was below average.

#### 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 last 3 years.

#### 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 2003, 1+ silver warehou (about 30 cm) were relatively weak compared with the 2+ cohort (40 cm), while white warehou length frequencies showed the reverse distribution (Figure 15). The length frequency distribution of sea perch was bimodal, with peaks at about 23 and 30 cm corresponding to fish aged about 5 and 10 years respectively (Paul & Francis 2002). Most of the alfonsino and oreos caught (not shown) were also 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 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 were either resting or immature; 43% of male adult hake were running ripe, but few females were showing signs of reproductive activity this year. Adult ling showed a few males (6%) and females (less than 1%) had developed gonads, and also in contrast with 2002, very few sea perch were spawning in 2003 (Table 11). Adults of 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 1:1.3 (males to females) for hoki, with more females 1:1.5 at 400–600 m, increasing to 1:4.2 at 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, which were also predominantly female (sex ratios exceeded 1:1.5).

## 3.8 Midwater tows

Both tows caught almost clean catches of large hoki, with a few Ray's bream and todarodes squid. The length frequencies (unscaled) and age composition of the midwater samples show that these hoki were relatively large (most over 85 cm TL, Figure 16) and were mostly from the relatively strong 1991–94 year classes and 1987–88 year classes (Figure 17).

## 3.9 Description of acoustic mark types

A total of 233 acoustic data files (123 "trawl" files and 110 "steam" files) were recorded during the trawl survey. The frequency of occurrence of each of the eight mark categories is given in Table 12. Often several types of mark were present in the same echogram. Data were subdivided into three depth ranges (200–400 m, 401–600 m, 601–1000 m) based on the maximum depth observed during the acoustic file.

Pelagic layers were the most common daytime mark type, occurring in 97% of day steam files and 85% of trawl files (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). These mesopelagic species migrate vertically, rising in the water column and dispersing during the night, turning into pelagic clouds and surface layers. Surface layers were observed in all night recordings and most day echograms. The identity of organisms in surface layers is unknown, because few trawls have been carried out close to the surface on the Chatham Rise. Acoustic scattering is probably contributed by a number of pelagic zooplankton (including gelatinous organisms such as salps) as well as mesopelagic fish. Pelagic schools were observed in 55% of day steam files and 85% of trawl 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 themselves are mesopelagic fish, on which Ray's bream feed.

Bottom layers were observed in 83% of day steam files, 47% of trawl files, and 30% of night steam 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 2002). There was often mixing of bottom layers and pelagic layers, particularly when the seabed rose or fell. Bottom-referenced schools were present in 22–24% of daytime (trawl and steam) recordings, and were most abundant in 200–400 m water depth (Table 12). Bottom schools 10–40 m off the bottom were sometimes associated with large catches of 1+ and 2+ hoki (e.g., trawls 107 and 108). Single target echoes close to the bottom were observed in almost all (74–96%) files, regardless of depth or time of day (Table 12). Single targets usually occurred in the same echogram as other mark types, making identification of the species responsible for the single target echoes difficult, and probably consist of low densities of demersal fish.

A comparable summary, using the same mark categories, was given by O'Driscoll & Bagley (2003) for the 2002 Sub-Antarctic trawl survey. Pelagic layers and clouds were observed less frequently, and were less dense, in the Sub-Antarctic than on the Chatham Rise, but pelagic schools were more common in the Sub-Antarctic. This may reflect differences in the mesopelagic fish fauna between the two areas. The frequency of occurrence of bottom-referenced marks was similar in the Sub-Antarctic and Chatham Rise, although the species composition varied. For example, bottom-referenced schools were often associated with southern blue whiting in the Sub-Antarctic, whereas on the Chatham Rise bottom schools appeared to contain mainly juvenile hoki and silver warehou.

### 3.9.1 Comparison of acoustics with bottom trawl catches

Acoustic data from 117 trawl files were integrated and compared with trawl catch rates. Data from the other six trawl recordings were not included in the analysis because the acoustic data were too noisy or because the trawl was not considered suitable for biomass estimation. Average acoustic backscatter from bottom-referenced regions and trawl catch rates (for all species combined) in 2003 were similar to 2001 and 2002 (Table 13). There was a very weak (rho = 0.16–0.18), but statistically significant, positive correlation between acoustic backscatter and trawl catch rates (Figure 18). However, the observed acoustic backscatter in the bottom 10 m was 15.3 times higher on average than predicted from trawl catches, where predicted values were based on measured trawl densities and estimated acoustic target strength. The ratio of trawl:acoustic vulnerability is probably high because of low trawl catchability and the acoustic contribution of small mesopelagic species which are not caught by the trawl (O'Driscoll 2002, 2003).

### 3.9.2 *Acoustic recordings during exploratory midwater trawls*

Acoustic data were recorded during the two exploratory midwater trawls on the Andes hill complex. Data quality was poor because the acoustic system was not set up to record to depths greater than 1000 m and the bottom tracking function failed. However, it was possible to see the hoki layer at 550–650 m depth (Figure 19). Densities in this layer were very low. Assuming all acoustic backscatter was from hoki, and with an average hoki length of 91 cm, the peak density of hoki in the layer estimated from acoustics was 0.000805 fish $m^{-3}$, which is equivalent to one hoki every 1240 $m^3$ of water. This compares to peak acoustic densities of up to 0.25 hoki $m^{-3}$ (one fish every 4 $m^3$) in spawning schools.

## 4. DISCUSSION

The 2003 survey successfully continued the January *Tangaroa* time series with a total of 115 valid biomass tows, and 2 exploratory midwater tows completed. No days were lost to bad weather.

The survey c.v. of 11.6% achieved for adult hoki was below the target level of 15%. The c.v. of 15.5% for hake and of 15.1% for 2 year old hoki were both below the target of 20%.

The estimated total biomass of hoki was 30% lower than on the previous survey, mainly as a result of weak recruitment in the 1+ cohort, and weak year classes now dominating the 3++ group. Further, as the midwater tows have shown, fish older than about 7 years are not necessarily found within the core survey area. Two samples do not provide a robust indication of hoki occurrence in midwater generally, but they nevertheless confirm anecdotal industry reports that hoki can be caught over deepwater at times, and may have some implications in estimating priors on the availability of hoki within the survey area for the stock assessment model (Annala et al. 2003). The total hoki biomass was at its lowest level within the overall time series.

The biomass of hake in core strata was also lower than on the 2002 survey and remains at the lowest level since the time series began in 1992. Although the trawl survey does not appear to sample 1–2 year old hake well, recruitment since 1998 has been poor compared with 1993–97.

The biomass of ling in core strata was also low compared with 2002, 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.

Although overall biomass was down compared with 2002, it was within the previously observed range, and was close to that estimated in 1995, 1998, 2000, and 2001.

## 5. CONCLUSIONS

The survey in 2003 extended the time series into its twelfth year and provided comparable abundance indices for hoki, hake, and ling that have been used for stock assessment. The continued decline in biomass trends for both hoki and hake was disappointing, but unless stronger recruitment is seen in the next few years, the biomass of these species may decline further at current rates of exploitation.

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**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 | 3 | - | 3 | 1:2 834 |
| 3 | 200–400 | Matheson Bank | 3 499 | 3 | - | 3 | 1:1 166 |
| 4 | 600–800 | SE Chatham Rise | 11 315 | 3 | - | 3 | 1:3 772 |
| 5 | 200–400 | SE Chatham Rise | 4 078 | 3 | - | 3 | 1:816 |
| 6 | 600–800 | SW Chatham Rise | 8 266 | 3 | - | 3 | 1:2 755 |
| 7 | 400–600 | NW Chatham Rise | 5 233 | 6 | - | 6 | 1:654 |
| 8a | 400–600 | NW Chatham Rise | 3 286 | 3 | - | 3 | 1:1 095 |
| 8b | 400–600 | NW Chatham Rise | 5 722 | 4 | - | 4 | 1:1 144 |
| 9 | 200–400 | NE Chatham Rise | 5 136 | 7 | - | 7 | 1:1 284 |
| 10a | 400–600 | NE Chatham Rise | 2 958 | 3 | - | 3 | 1:1 479 |
| 10b | 400–600 | NE Chatham Rise | 3 363 | 3 | - | 3 | 1:1 121 |
| 11a | 400–600 | NE Chatham Rise | 2 966 | 3 | - | 3 | 1:989 |
| 11b | 400–600 | NE Chatham Rise | 2 072 | 3 | - | 3 | 1:691 |
| 11c | 400–600 | NE Chatham Rise | 3 342 | 3 | - | 3 | 1:1 114 |
| 11d | 400–600 | NE Chatham Rise | 3 368 | 3 | - | 3 | 1:1 123 |
| 12 | 400–600 | SE Chatham Rise | 6 578 | 3 | - | 3 | 1:1 645 |
| 13 | 400–600 | SE Chatham Rise | 6 681 | 3 | - | 3 | 1:1 670 |
| 14 | 400–600 | SW Chatham Rise | 5 928 | 3 | - | 3 | 1:1 976 |
| 15 | 400–600 | SW Chatham Rise | 5 842 | 3 | 3 | 6 | 1:1 168 |
| 16 | 400–600 | SW Chatham Rise | 11 522 | 3 | 3 | 6 | 1:1 047 |
| 17 | 200–400 | Veryan Bank | 865 | 4 | - | 4 | 1:288 |
| 18 | 200–400 | Mernoo Bank | 4 687 | 8 | - | 8 | 1:521 |
| 19 | 200–400 | Reserve Bank | 9 012 | 10 | 3 | 13 | 1:2 253 |
| 20 | 200–400 | Reserve Bank | 9 584 | 10 | - | 10 | 1:1 597 |
| Total | 200–1000 | | 139 498 | 106 | 9 | 115 | 1:1 213 |

**Table 2. Survey dates and number of valid stations in surveys of the Chatham Rise, January 1992–2003.**

| 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 |

**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) | 115 | 3.0 | 0.19 | 2.01–3.24 |
| Tow speed (knots) | 115 | 3.5 | 0.10 | 3.2–3.8 |
| **Gear parameters** | | | | |
| 200–400 m | | | | |
| Headline height | 48 | 6.5 | 0.37 | 5.8–7.4 |
| Doorspread | 45 | 115.2 | 5.42 | 104.0–124.9 |
| 400–600 m | | | | |
| Headline height | 52 | 6.4 | 0.33 | 5.7–7.0 |
| Doorspread | 44 | 120.1 | 4.82 | 108.7–129.4 |
| 600–800 m | | | | |
| Headline height | 15 | 6.7 | 0.40 | 6.0–7.5 |
| Doorspread | 13 | 122.7 | 5.95 | 108.1–128.2 |
| All stations 200–800 m | | | | |
| Headline height | 115 | 6.5 | 0.37 | 5.7–7.5 |
| Doorspread | 102 | 118.3 | 5.94 | 104.0–129.4 |
| Midwater stations | | | | |
| Headline height | | | | |
| Doorspread | 3 | 115.0 | 0.19 | 2.01–3.24 |

**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 depth. Total biomass includes unsexed fish. (-, no data.)**

| | | | Biomass | | | | | |
|---|---|---|---|---|---|---|---|---|
| Common name | Code | Catch | Male | | Female | | Total | |
| | | kg | t | c.v. (%) | t | c.v. (%) | t | c.v. (%) |
| **ITQ species** | | | | | | | | |
| Hoki | HOK | 38 207 | 21 853 | 13.7 | 30 643 | 10.5 | 52 531 | 11.6 |
| Black oreo | BOE | 6 855 | 15 485 | 21.2 | 16 004 | 23.4 | 31 489 | 22.3 |
| Dark ghost shark | GSH | 9 866 | 4 529 | 10.3 | 5 903 | 8.7 | 10 431 | 9.1 |
| Silver warehou | SWA | 6 642 | 4 115 | 77.3 | 3 699 | 71.2 | 7 815 | 74.3 |
| Ling | LIN | 3 747 | 3 427 | 13.1 | 3 834 | 9.6 | 7 261 | 9.9 |
| Sea perch | SPE | 4 623 | 3 886 | 9.4 | 2 928 | 8.7 | 6 904 | 8.1 |
| Pale ghost shark | GSP | 1 919 | 2 297 | 14.4 | 2 352 | 13.4 | 4 653 | 12.1 |
| Barracouta | BAR | 1 845 | 2 154 | 53.3 | 1 533 | 43.2 | 3 696 | 47.1 |
| White warehou | WWA | 2 741 | 2 063 | 33.9 | 1 621 | 33.4 | 3 685 | 33.5 |
| Giant stargazer | STA | 1 583 | 735 | 24.6 | 1 443 | 14.2 | 2 178 | 14.8 |
| Smooth oreo | SSO | 476 | 989 | 79.1 | 865 | 83.8 | 1 853 | 81.3 |
| Spiky oreo | SOR | 374 | 596 | 25.1 | 579 | 25.1 | 1 180 | 24.9 |
| Alfonsino | BYS | 883 | 579 | 36.5 | 568 | 42.5 | 1 151 | 38.7 |
| Hake | HAK | 470 | 207 | 19.0 | 681 | 17.8 | 888 | 15.5 |
| Red cod | RCO | 737 | 332 | 57.4 | 475 | 58.5 | 809 | 57.6 |
| Tarakihi | TAR | 423 | 415 | 45.3 | 218 | 49.1 | 633 | 36.1 |
| Ribaldo | RIB | 208 | 254 | 21.2 | 201 | 26.7 | 455 | 18.1 |
| Hapuku | HAP | 280 | 186 | 55.6 | 153 | 56.4 | 340 | 54.1 |
| Orange roughy | ORH | 74 | 130 | 99.3 | 161 | 94.8 | 292 | 96.6 |
| Arrow squid | NOS | 192 | 112 | 19.7 | 123 | 30.9 | 245 | 23.9 |
| School shark | SCH | 107 | 58 | 48.3 | 63 | 71.9 | 121 | 43.4 |
| Banded giant stargazer | BGZ | 89 | 46 | 88.8 | 50 | 64.6 | 96 | 70.0 |
| Slender mackerel | JMM | 83 | 66 | 33.8 | 24 | 35.7 | 94 | 30.9 |
| Lemon sole | LSO | 38 | 19 | 38.6 | 29 | 27.4 | 56 | 24.5 |
| Bluenose | BNS | 41 | 27 | 100 | 17 | 100 | 44 | 100 |
| Black cardinalfish | EPT | 14 | 18 | 81.5 | 8 | 57.7 | 29 | 53.5 |
| Blue mackerel | EMA | 18 | 10 | 71.9 | 7 | 76.4 | 17 | 65.5 |
| Frostfish | FRO | 5 | 0 | - | 1 | 100 | 10 | 63.8 |
| Bass groper | BAS | 6 | 6 | 100 | 0 | - | 6 | 100 |
| Long finned beryx | BYD | 2 | 1 | 100 | 0 | - | 3 | 82.5 |
| Jack mackerel | JMD | 1 | 0 | - | 2 | 100 | 2 | 100 |
| Rubyfish | RBY | 1 | 1 | 71.2 | 0 | - | 1 | 71.2 |

Table 4. *Continued*

| Common name | Code | Catch kg | Biomass males t | Biomass males % c.v. | Biomass females t | Biomass females % c.v. | Total biomass t | Total biomass % c.v. |
|---|---|---|---|---|---|---|---|---|
| **Commercial non-ITQ species (where biomass > 30 t)** | | | | | | | | |
| Spiny dogfish | SPD | 3 410 | 726 | 41.3 | 5 465 | 17.3 | 6 191 | 16.7 |
| Lookdown dory | LDO | 3 078 | 1 758 | 7.5 | 4 089 | 8.3 | 5 904 | 7.0 |
| Shovelnose dogfish | SND | 1 661 | 1 549 | 19.0 | 2 225 | 20.4 | 3 781 | 18.0 |
| Smooth skate | SSK | 803 | 499 | 25.1 | 824 | 27.9 | 1 355 | 21.0 |
| Ray's bream | RBM | 1 375 | 729 | 28.5 | 839 | 29.2 | 1 746 | 27.5 |
| Redbait | RBT | 263 | 249 | 90.8 | 158 | 86.4 | 408 | 88.9 |
| Scampi | SCI | 41 | 38 | 13.8 | 20 | 15.7 | 62 | 12.8 |
| Northern spiny dogfish | NSD | 38 | 45 | 50.3 | 8 | 60.1 | 53 | 45.0 |
| Southern Blue Whiting | SBW | 117 | 23 | 49.0 | 17 | 66.9 | 40 | 55.7 |
| Rough skate | RSK | 22 | 8 | 70.7 | 23 | 76.2 | 32 | 63.9 |
| **Non-commercial species (where biomass > 800 t)** | | | | | | | | |
| Javelinfish | JAV | 6 485 | - | - | - | - | 13 175 | 11.5 |
| Big-eye rattail | CBO | 4 367 | - | - | - | - | 8 186 | 9.8 |
| Baxter's dogfish | ETB | 347 | - | - | - | - | 1 398 | 37.4 |
| Orange perch | OPE | 1 227 | - | - | - | - | 1 313 | 55.8 |
| Oliver's rattail | COL | 499 | - | - | - | - | 1 187 | 34.2 |
| Banded bellowsfish | BBE | 642 | - | - | - | - | 1 148 | 10.7 |
| Longnose velvet dogfish | CYP | 346 | - | - | - | - | 1 065 | 72.8 |
| Longnose chimaera | LCH | 385 | - | - | - | - | 937 | 11.6 |
| Oblique-banded ratt. | CAS | 870 | - | - | - | - | 857 | 11.0 |
| Common roughy | RHY | 771 | - | - | - | - | 824 | 63.7 |
| Total catch (above) | | 109 297 | | | | | | |
| Grand total catch (all species) | | 116 217 | | | | | | |

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 1992–2003. stns, stations. (-, no data.)**

| | | 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 | | | | |

**Table 6: Relative biomass estimates (t in thousands) of hoki, 200–800 m depths, Chatham Rise trawl surveys January *1992–2003*. (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) |

Table 7: Estimated biomass (t) and coefficient of variation (%) of hoki, hake, ling, and 8 other species by stratum. (See Table 3 for species codes.) (-, not calculated.)

| | Species code | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HOK | | GSH | | GSP | | HAK | | LDO | | LIN | | SPD | | SPE | | STA | | SWA | | WWA | |
| 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 | 105 | 53 | 0 | - | 129 | 64 | 25 | 75 | 23 | 26 | 183 | 20 | 5 | 100 | 11 | 54 | 9 | 100 | 0 | - | 0 | - |
| 2a | 137 | 28 | 0 | - | 164 | 70 | 12 | 47 | 22 | 8 | 24 | 55 | 0 | - | 42 | 57 | 10 | 100 | 0 | - | 0 | - |
| 2b | 578 | 39 | 0 | - | 150 | 23 | 29 | 53 | 97 | 31 | 177 | 38 | 0 | - | 108 | 44 | 0 | - | 0 | - | 0 | - |
| 3 | 1 508 | 19 | 781 | 5 | 5 | 100 | 20 | 100 | 262 | 30 | 278 | 71 | 422 | 24 | 187 | 77 | 55 | 89 | 11 | 58 | 57 | 82 |
| 4 | 800 | 13 | 0 | - | 312 | 28 | 35 | 100 | 52 | 83 | 171 | 55 | 0 | - | 22 | 100 | 0 | - | 0 | - | 0 | - |
| 5 | 769 | 50 | 1 081 | 23 | 0 | - | 0 | - | 128 | 95 | 137 | 91 | 1 953 | 44 | 55 | 60 | 422 | 51 | 52 | 18 | 28 | 100 |
| 6 | 380 | 49 | 0 | - | 482 | 51 | 0 | - | 0 | - | 83 | 100 | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - |
| 7 | 812 | 34 | 58 | 90 | 311 | 48 | 152 | 44 | 74 | 26 | 672 | 33 | 55 | 84 | 54 | 65 | 59 | 40 | 0 | - | 0 | - |
| 8a | 367 | 60 | 106 | 50 | 17 | 51 | 0 | - | 40 | 16 | 170 | 21 | 73 | 64 | 273 | 38 | 0 | - | 0 | - | 0 | - |
| 8b | 978 | 22 | 101 | 94 | 68 | 40 | 29 | 59 | 159 | 36 | 184 | 21 | 13 | 100 | 300 | 31 | 0 | - | 0 | - | 4 | 100 |
| 9 | 946 | 59 | 834 | 27 | 0 | - | 6 | 100 | 106 | 56 | 76 | 80 | 142 | 31 | 67 | 57 | 154 | 28 | 1 283 | 98 | 8 | 55 |
| 10a | 481 | 34 | 110 | 98 | 79 | 37 | 31 | 50 | 132 | 41 | 171 | 3 | 0 | - | 136 | 50 | 0 | - | 0 | - | 275 | 99 |
| 10b | 756 | 37 | 63 | 98 | 69 | 16 | 79 | 53 | 86 | 21 | 125 | 39 | 41 | 100 | 70 | 16 | 0 | - | 0 | - | 5 | 100 |
| 11a | 556 | 42 | 228 | 28 | 10 | 100 | 16 | 56 | 338 | 34 | 174 | 51 | 75 | 12 | 106 | 44 | 53 | 72 | 77 | 47 | 130 | 55 |
| 11b | 303 | 31 | 78 | 100 | 14 | 61 | 8 | 100 | 76 | 28 | 42 | 23 | 51 | 76 | 11 | 43 | 5 | 100 | 94 | 54 | 17 | 100 |
| 11c | 1 003 | 56 | 0 | - | 58 | 27 | 93 | 30 | 111 | 35 | 186 | 39 | 0 | - | 53 | 20 | 8 | 100 | 0 | - | 2 | 100 |
| 11d | 598 | 51 | 11 | 94 | 12 | 70 | 14 | 100 | 71 | 32 | 112 | 18 | 12 | 100 | 55 | 4 | 1 | 100 | 0 | - | 34 | 50 |
| 12 | 3 015 | 23 | 114 | 76 | 288 | 34 | 42 | 100 | 910 | 11 | 616 | 28 | 616 | 34 | 218 | 48 | 101 | 100 | 0 | - | 19 | 55 |
| 13 | 1 904 | 38 | 8 | 100 | 902 | 34 | 58 | 51 | 515 | 29 | 550 | 20 | 188 | 40 | 135 | 14 | 0 | - | 9 | 100 | 34 | 50 |
| 14 | 2 120 | 38 | 6 | 100 | 424 | 52 | 41 | 80 | 740 | 17 | 571 | 25 | 127 | 73 | 651 | 28 | 51 | 100 | 25 | 100 | 32 | 52 |
| 15 | 5 839 | 33 | 43 | 63 | 399 | 18 | 25 | 34 | 454 | 28 | 547 | 19 | 109 | 52 | 344 | 28 | 54 | 49 | 23 | 100 | 785 | 98 |
| 16 | 2 910 | 26 | 23 | 93 | 711 | 30 | 149 | 46 | 411 | 51 | 1 262 | 41 | 729 | 65 | 84 | 54 | 220 | 28 | 7 | 100 | 12 | 49 |
| 17 | 1 199 | 59 | 966 | 59 | 0 | - | 0 | - | 26 | 46 | 19 | 43 | 40 | 32 | 4 | 58 | 93 | 23 | 6 | 84 | 37 | 90 |
| 18 | 3 147 | 31 | 1 810 | 20 | 0 | - | 0 | - | 67 | 36 | 114 | 64 | 610 | 15 | 287 | 36 | 310 | 40 | 93 | 32 | 118 | 38 |
| 19 | 14 511 | 36 | 1 780 | 19 | 0 | - | 11 | 84 | 254 | 23 | 153 | 38 | 471 | 23 | 1 568 | 13 | 214 | 34 | 6 048 | 94 | 593 | 41 |
| 20 | 6 811 | 15 | 2 230 | 18 | 48 | 69 | 11 | 84 | 752 | 13 | 464 | 34 | 459 | 23 | 2 063 | 16 | 359 | 31 | 88 | 72 | 1 493 | 60 |
| Total | 52 531 | 12 | 10 431 | 9 | 4 653 | 12 | 888 | 15 | 5 904 | 7 | 7 261 | 10 | 6 191 | 17 | 6 904 | 8 | 2 178 | 15 | 7 815 | 74 | 3 685 | 34 |

Table 8: Catch rate (kg.km$^{-2}$) and standard deviations (s.d.) of hoki, hake, ling, and 8 other species by stratum. (See Table 3 for species codes.) (-, not calculated.)

| Stratum | Species code | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HOK | | GSH | | GSP | | HAK | | LDO | | LIN | | SPD | | SPE | | STA | | SWA | | WWA | |
| | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. | kg | s.d. |
| 1 | 43 | 40 | 0 | - | 53 | 58 | 10 | 13 | 9 | 4 | 75 | 26 | 2 | 4 | 4 | 4 | 4 | 7 | 0 | - | 0 | - |
| 2a | 42 | 20 | 0 | - | 50 | 62 | 4 | 3 | 7 | 1 | 7 | 7 | 0 | - | 13 | 13 | 3 | 6 | 0 | - | 0 | - |
| 2b | 68 | 46 | 0 | - | 18 | 7 | 3 | 3 | 11 | 6 | 21 | 14 | 0 | - | 13 | 10 | 0 | - | 0 | - | 0 | - |
| 3 | 431 | 143 | 223 | 18 | 1 | 3 | 6 | 10 | 39 | 6 | 79 | 98 | 121 | 50 | 53 | 71 | 16 | 24 | 3 | 3 | 16 | 23 |
| 4 | 71 | 15 | 0 | - | 28 | 13 | 3 | 5 | 5 | 7 | 15 | 14 | 0 | - | 2 | 3 | 0 | - | 0 | - | 0 | - |
| 5 | 189 | 165 | 265 | 107 | 0 | - | 0 | - | 31 | 52 | 34 | 53 | 479 | 365 | 13 | 14 | 103 | 92 | 13 | 4 | 7 | 12 |
| 6 | 46 | 39 | 0 | - | 58 | 51 | 0 | - | 0 | - | 10 | 17 | 0 | - | 0 | - | 0 | - | 0 | - | 0 | - |
| 7 | 155 | 129 | 11 | 25 | 59 | 71 | 29 | 31 | 14 | 9 | 128 | 103 | 10 | 22 | 10 | 17 | 11 | 11 | 0 | - | 0 | - |
| 8a | 112 | 116 | 32 | 28 | 5 | 5 | 0 | - | 12 | 3 | 52 | 19 | 22 | 24 | 83 | 54 | 0 | - | 0 | - | 0 | - |
| 8b | 171 | 77 | 18 | 33 | 12 | 9 | 5 | 6 | 28 | 20 | 32 | 13 | 2 | 5 | 52 | 32 | 0 | - | 0 | - | 0.7 | 1 |
| 9 | 184 | 290 | 162 | 116 | 0 | - | 1 | 3 | 21 | 30 | 15 | 31 | 28 | 23 | 13 | 20 | 30 | 22 | 250 | 646 | 2 | 2 |
| 10a | 163 | 95 | 37 | 63 | 27 | 17 | 11 | 9 | 45 | 31 | 58 | 3 | 0 | - | 46 | 40 | 0 | - | 0 | - | 93 | 160 |
| 10b | 225 | 146 | 19 | 32 | 21 | 6 | 24 | 22 | 26 | 9 | 37 | 25 | 12 | 21 | 21 | 6 | 0 | - | 0 | - | 2 | 3 |
| 11a | 187 | 136 | 77 | 37 | 3 | 6 | 6 | 5 | 114 | 67 | 59 | 52 | 25 | 5 | 36 | 27 | 18 | 22 | 26 | 21 | 44 | 42 |
| 11b | 146 | 78 | 38 | 65 | 7 | 7 | 4 | 6 | 37 | 18 | 20 | 8 | 25 | 32 | 5 | 4 | 2 | 4 | 45 | 42 | 8 | 14 |
| 11c | 300 | 291 | 0 | - | 17 | 8 | 28 | 14 | 33 | 20 | 56 | 38 | 0 | - | 16 | 6 | 2 | 4 | 0 | - | 0.7 | 1 |
| 11d | 178 | 156 | 3 | 5 | 4 | 4 | 4 | 7 | 21 | 12 | 33 | 10 | 4 | 6 | 16 | 1 | 0.4 | 0.7 | 0 | - | 10 | 9 |
| 12 | 458 | 182 | 17 | 23 | 44 | 26 | 6 | 11 | 138 | 26 | 94 | 45 | 94 | 55 | 33 | 28 | 15 | 27 | 0 | - | 3 | 3 |
| 13 | 285 | 188 | 1 | 2 | 135 | 80 | 9 | 8 | 77 | 38 | 82 | 29 | 28 | 20 | 20 | 5 | 0 | - | 1 | 2 | 5 | 4 |
| 14 | 358 | 234 | 1 | 2 | 71 | 64 | 7 | 10 | 125 | 37 | 96 | 43 | 21 | 27 | 110 | 53 | 9 | 15 | 4 | 7 | 5 | 5 |
| 15 | 999 | 809 | 7 | 11 | 68 | 30 | 4 | 4 | 78 | 53 | 94 | 43 | 19 | 24 | 59 | 41 | 9 | 11 | 4 | 10 | 134 | 322 |
| 16 | 253 | 160 | 2 | 4 | 62 | 46 | 13 | 15 | 36 | 44 | 110 | 109 | 63 | 100 | 7 | 10 | 19 | 13 | 0.6 | 2 | 1 | 1 |
| 17 | 1 385 | 1 633 | 1 117 | 1 316 | 0 | - | 0 | - | 30 | 28 | 21 | 19 | 46 | 30 | 5 | 6 | 107 | 49 | 7 | 12 | 42 | 76 |
| 18 | 672 | 591 | 386 | 216 | 0 | - | 0 | - | 14 | 14 | 24 | 44 | 130 | 56 | 61 | 62 | 66 | 75 | 20 | 18 | 25 | 27 |
| 19 | 1 610 | 2 087 | 198 | 133 | 0 | - | 1 | 4 | 28 | 24 | 17 | 23 | 52 | 43 | 174 | 118 | 24 | 29 | 671 | 2 268 | 66 | 97 |
| 20 | 711 | 340 | 233 | 135 | 5 | 11 | 1 | 3 | 78 | 32 | 48 | 53 | 48 | 35 | 215 | 108 | 37 | 37 | 9 | 21 | 156 | 293 |

Table 9: Species and numbers of fish for which length, sex, and length-weight (L-Wt) data were collected. -, unsexed fish. (See Table 3 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 |
| BAR | 297 | 188 | 486 | | LDO | 1 914 | 2 379 | 4 321 | - |
| BAS | 1 | 0 | 1 | 1 | LIN | 838 | 848 | 1 690 | 1 495 |
| BBE | 1 | 0 | 2 921 | 366 | LSO | 29 | 39 | 77 | - |
| BGZ | 10 | 8 | 21 | - | MCA | 0 | 0 | 8 | - |
| BNS | 6 | 4 | 10 | 10 | NOS | 184 | 165 | 350 | - |
| BOE | 388 | 372 | 760 | - | NSD | 23 | 10 | 33 | 22 |
| BSH | 23 | 32 | 55 | 29 | OPE | 271 | 313 | 600 | 101 |
| BYD | 1 | 0 | 2 | - | ORH | 41 | 45 | 88 | - |
| BYS | 496 | 362 | 862 | - | PLS | 4 | 6 | 10 | 6 |
| CAR | 0 | 1 | 1 | - | RBM | 384 | 446 | 863 | 394 |
| CAS | 9 | 119 | 989 | 45 | RBT | 66 | 45 | 111 | 2 |
| CBO | 1 294 | 1 362 | 2 811 | 462 | RBY | 2 | 0 | 2 | - |
| CFA | 0 | 0 | 164 | - | RCO | 309 | 295 | 607 | - |
| COL | 6 | 24 | 691 | 151 | RHY | 8 | 18 | 468 | - |
| CSQ | 7 | 8 | 15 | 11 | RIB | 105 | 44 | 149 | 148 |
| CYO | 18 | 5 | 23 | 20 | RSK | 2 | 2 | 4 | 4 |
| CYP | 124 | 208 | 332 | 53 | SBW | 102 | 61 | 163 | 103 |
| EMA | 8 | 4 | 12 | - | SCH | 4 | 3 | 7 | 7 |
| EPL | 2 | 5 | 56 | - | SCI | 245 | 169 | 425 | 425 |
| EPR | 0 | 0 | 11 | - | SDO | 0 | 0 | 127 | - |
| EPT | 15 | 13 | 38 | 36 | SND | 354 | 509 | 865 | - |
| ETB | 123 | 115 | 238 | 124 | SOR | 299 | 240 | 544 | - |
| ETL | 201 | 146 | 348 | - | SPD | 203 | 1 158 | 1 361 | - |
| FRO | 0 | 1 | 1 | - | SPE | 2 523 | 2 060 | 4 845 | 680 |
| GSH | 2 750 | 2 763 | 5513 | - | SSI | 2 | 38 | 808 | - |
| GSP | 570 | 527 | 1 098 | 32 | SSK | 26 | 36 | 64 | 64 |
| HAK | 34 | 72 | 106 | 105 | SSO | 110 | 92 | 202 | - |
| HAP | 28 | 22 | 50 | 46 | STA | 302 | 274 | 577 | - |
| HJO | 0 | 0 | 16 | - | SWA | 360 | 361 | 722 | - |
| HOK | 7 291 | 9 708 | 17 016 | 1511 | TAR | 231 | 113 | 344 | 1 |
| JAV | 15 | 118 | 8471 | - | WHX | 3 | 2 | 5 | - |
| JMD | 0 | 1 | 1 | - | WWA | 813 | 553 | 1 369 | - |
| JMM | 43 | 17 | 60 | - | YCO | 1 | 1 | 2 | 1 |
| LCH | 160 | 146 | 307 | 259 | | | | | |

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

| Species | $a$ (intercept) | $b$ (slope) | $r^2$ | $n$ | Length range (cm) | Data source |
|---|---|---|---|---|---|---|
| Hake | 0.002387 | 3.243991 | 0.99 | 105 | 21–121 | TAN0301 |
| Hoki | 0.003463 | 2.967778 | 0.98 | 1 506 | 37–118 | TAN0301 |
| Ling | 0.001201 | 3.303530 | 0.99 | 1 452 | 30–153 | TAN0301 |
| Ribaldo | 0.003493 | 3.297659 | 0.97 | 148 | 32–71 | TAN0301 |
| Sea perch | 0.009077 | 3.180683 | 0.99 | 557 | 10–50 | TAN0301 |
| 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 |
| Dark ghost shark | 0.002201 | 3.250992 | 0.98 | 3 990 | 23–81 | TAN9106-TAN0201 |
| Giant stargazer | 0.007954 | 3.180478 | 0.98 | 2 139 | 19–85 | TAN9106-TAN0201 |
| Lemon sole | 0.006492 | 3.170475 | 0.92 | 125 | 24–39 | TAN9106-TAN0201 |
| Lookdown dory | 0.024380 | 2.966815 | 0.99 | 4 666 | 10–58 | TAN9106-TAN0201 |
| Pale ghost shark | 0.005563 | 3.010078 | 0.97 | 2 936 | 18–90 | 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 |
| Smooth skate | 0.022969 | 2.961655 | 0.99 | 326 | 33–158 | TAN9106-TAN0201 |
| Spiny dogfish | 0.001887 | 3.193811 | 0.96 | 2 651 | 48–106 | TAN9106-TAN0201 |
| White warehou | 0.011444 | 3.182711 | 0.98 | 479 | 12–62 | TAN9106-TAN0201 |
| Scampi | 0.819172 | 2.746626 | 0.88 | 1 032 | 2.7–7.2 | TAN9106-TAN0301 |
| Arrow squid | 0.0290 | 3.00 | - | - | - | Annala et al. (2003) |
| Banded giant stargazer | 0.009831 | 3.255745 | 548 | 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 |
| Blue mackerel | 0.001741 | 3.536956 | 44 | 1.0 | 16–53 | All records on DB |
| Hapuku | 0.014230 | 2.998 | 1 644 | - | 50–130 | Johnston (1983) |
| Northern spiny dogfish | 0.002177 | 3.176741 | 231 | 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 | 0.005308 | 3.320126 | 891 | 0.96 | 28–56 | All records on DB |
| Redbait | 0.004191 | 3.321901 | 189 | 1.0 | 12–40 | All records on DB |
| Red cod | 0.0092 | 3.003 | 923 | 0.98 | 13–72 | Beentjes (1992) |
| 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 | 2.94 | - | - | - | 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. DB, trawlsurvey database held at NIWA, Wellington

**Table 11: Numbers of fish measured at each reproductive stage***

| Common name | Sex | Reproductive stage 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Black cardinalfish | Male | 7 | 1 | 1 | 0 | 0 | 0 | 0 | 9 |
| | Female | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Hake | Male | 5 | 6 | 1 | 4 | 13 | 1 | 0 | 30 |
| | Female | 8 | 27 | 22 | 3 | 1 | 2 | 2 | 65 |
| Hapuku | Male | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| | Female | 1 | 7 | 0 | 1 | 0 | 0 | 0 | 9 |
| Hoki | Male | 204 | 147 | 2 | 0 | 0 | 3 | 2 | 358 |
| | Female | 165 | 547 | 0 | 0 | 0 | 0 | 4 | 716 |
| Ling | Male | 236 | 173 | 37 | 164 | 7 | 43 | 0 | 660 |
| | Female | 178 | 452 | 2 | 2 | 0 | 3 | 1 | 638 |
| Orange perch | Male | 0 | 0 | 31 | 13 | 2 | 0 | 0 | 46 |
| | Female | 1 | 0 | 38 | 13 | 0 | 0 | 0 | 52 |
| Ray's bream | Male | 0 | 35 | 5 | 0 | 0 | 0 | 0 | 40 |
| | Female | 0 | 15 | 22 | 0 | 0 | 0 | 0 | 37 |
| Ribaldo | Male | 3 | 33 | 5 | 0 | 0 | 0 | 10 | 51 |
| | Female | 2 | 5 | 1 | 0 | 0 | 0 | 5 | 13 |
| School shark | Male | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | Female | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sea perch | Male | 36 | 45 | 20 | 2 | 0 | 0 | 1 | 104 |
| | Female | 43 | 21 | 0 | 3 | 4 | 0 | 0 | 71 |
| Tarakihi | Male | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| | Female | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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

**Table 12: Frequency of occurrence of eight acoustic mark types (see text for definitions) during the 2003 Chatham Rise trawl survey. Several mark types were usually present in the same echogram. *n* is the number of acoustic files examined.**

| | | | Pelagic marks | | | | Bottom marks | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Acoustic file | Max. depth (m) | *n* | Surface Layer | School | Layer | Cloud | Layer | Cloud | School | Single target |
| Day steam | 200–400 | 20 | 13 | 9 | 20 | 10 | 13 | 7 | 8 | 16 |
| | 400–600 | 31 | 26 | 18 | 30 | 9 | 30 | 6 | 5 | 23 |
| | 600–800 | 15 | 14 | 9 | 14 | 13 | 12 | 10 | 3 | 12 |
| | Total | 66 | 53 | 36 | 64 | 32 | 55 | 23 | 16 | 51 |
| | % occurrence | | 80 | 55 | 97 | 49 | 83 | 35 | 24 | 77 |
| Night steam | 200–400 | 10 | 10 | 0 | 0 | 9 | 0 | 8 | 1 | 9 |
| | 400–600 | 26 | 26 | 5 | 7 | 25 | 8 | 26 | 0 | 25 |
| | 600–800 | 8 | 8 | 1 | 1 | 7 | 5 | 8 | 0 | 8 |
| | Total | 44 | 44 | 6 | 8 | 41 | 13 | 42 | 1 | 42 |
| | % occurrence | | 100 | 14 | 18 | 93 | 30 | 96 | 2 | 96 |
| Trawl | 200–400 | 51 | 30 | 18 | 45 | 32 | 20 | 15 | 24 | 41 |
| | 400–600 | 57 | 40 | 26 | 51 | 22 | 34 | 32 | 3 | 36 |
| | 600–800 | 15 | 9 | 6 | 9 | 14 | 4 | 11 | 0 | 14 |
| | Total | 123 | 79 | 50 | 105 | 68 | 58 | 58 | 27 | 91 |
| | % occurrence | | 64 | 41 | 85 | 55 | 47 | 47 | 22 | 74 |

**Table 13. Average trawl catch and acoustic backscatter from bottom-referenced marks during tows where acoustic data quality was suitable for echo integration on the Chatham Rise in 2001–03. All tows were conducted during daylight. Data for 2001 and 2002 are from O'Driscoll (2002).**

| Survey | Number of recordings | Average trawl catch (kg km$^{-2}$) | Average acoustic backscatter (m$^2$ km$^{-2}$) | |
|---|---|---|---|---|
| | | | Bottom 10 m | Entire layer |
| 2001 (TAN0101) | 115 | 1 447 | 2.499 | 26.06 |
| 2002 (TAN0201) | 105 | 1 844 | 4.006 | 20.13 |
| 2003 (TAN0301) | 117 | 1 507 | 3.208 | 27.41 |

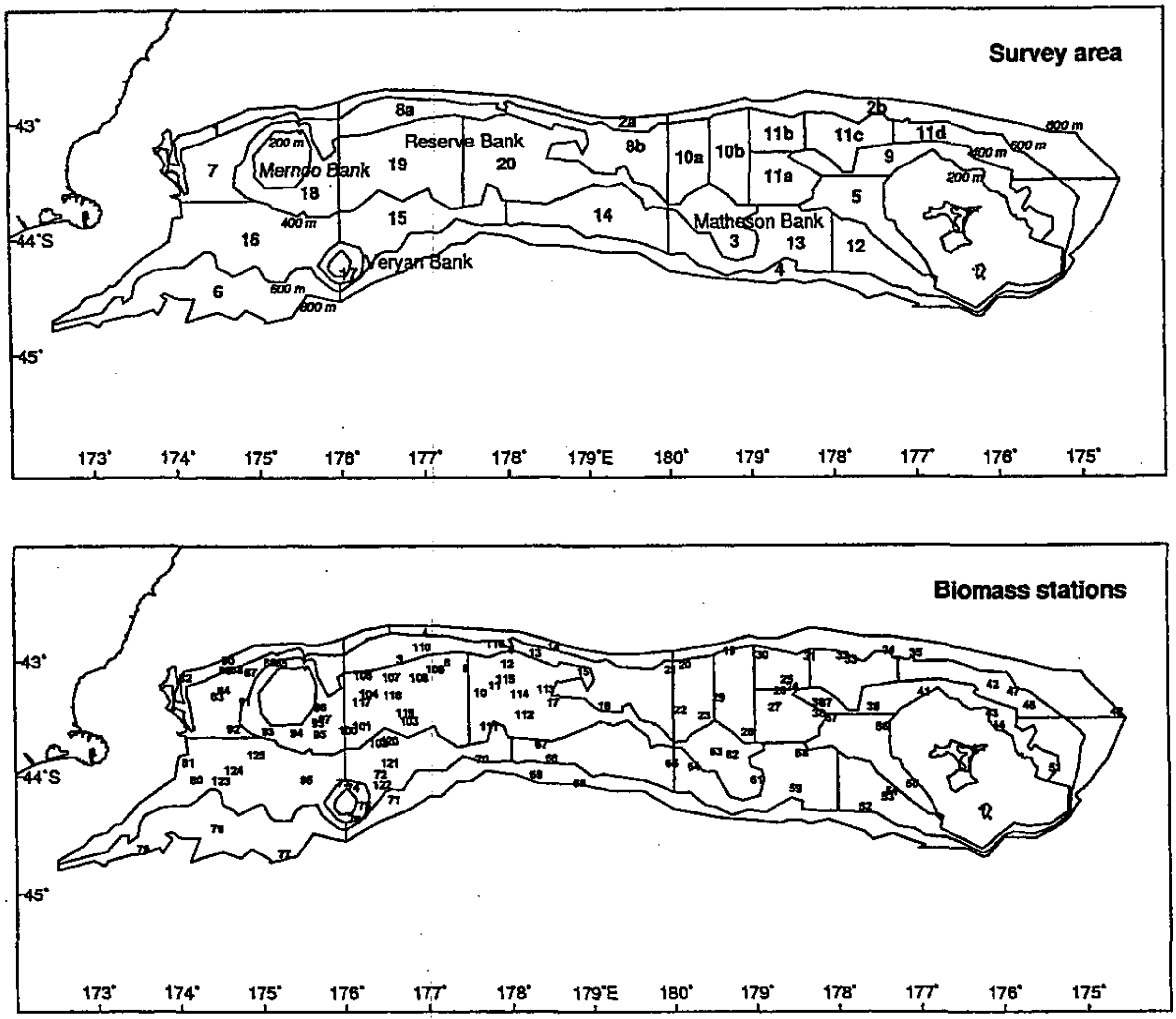



**Figure 1: Chatham Rise trawl survey area showing stratum boundaries and valid biomass station positions (n = 115).**

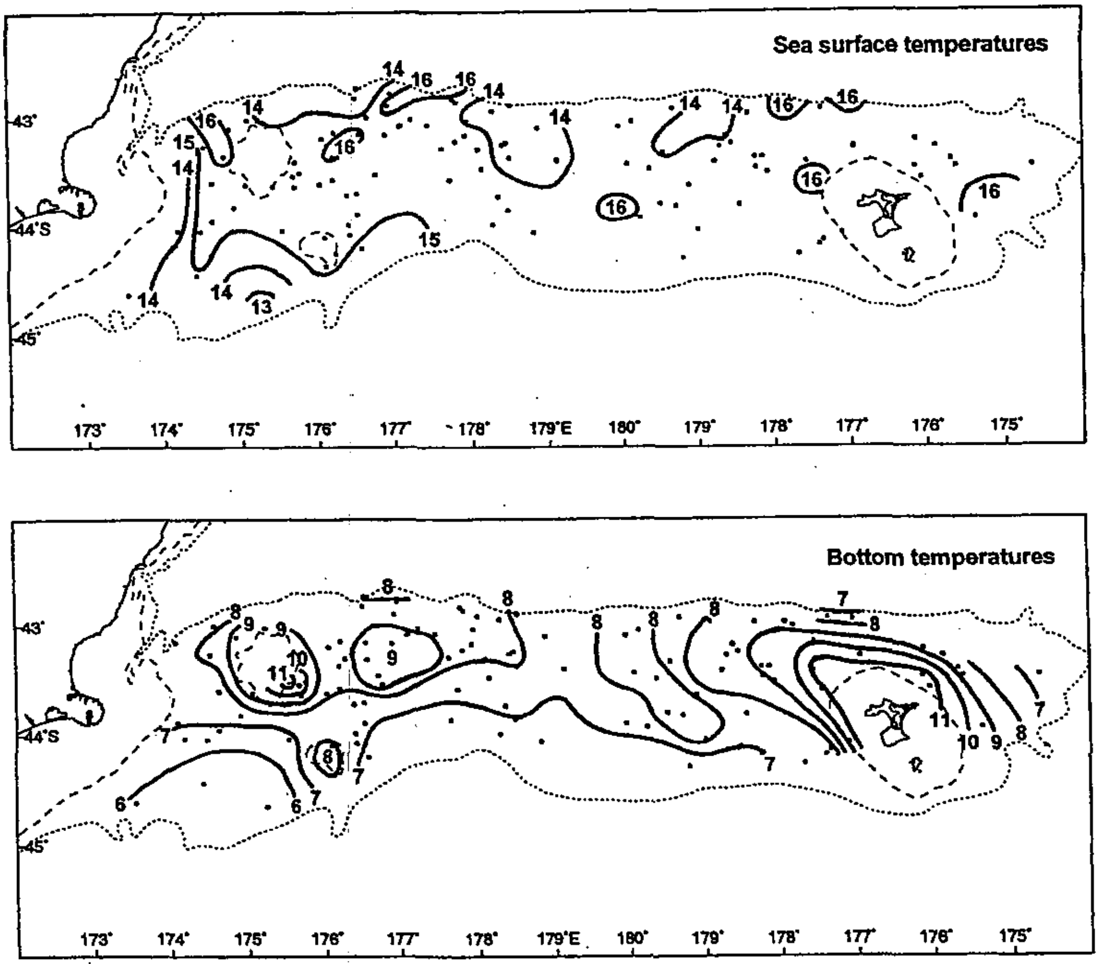



**Figure 2: Positions of sea surface and bottom temperature recordings and approximate location of isotherms (°C) interpolated by eye. The temperatures are from the Seabird CTD recordings made during each tow.**

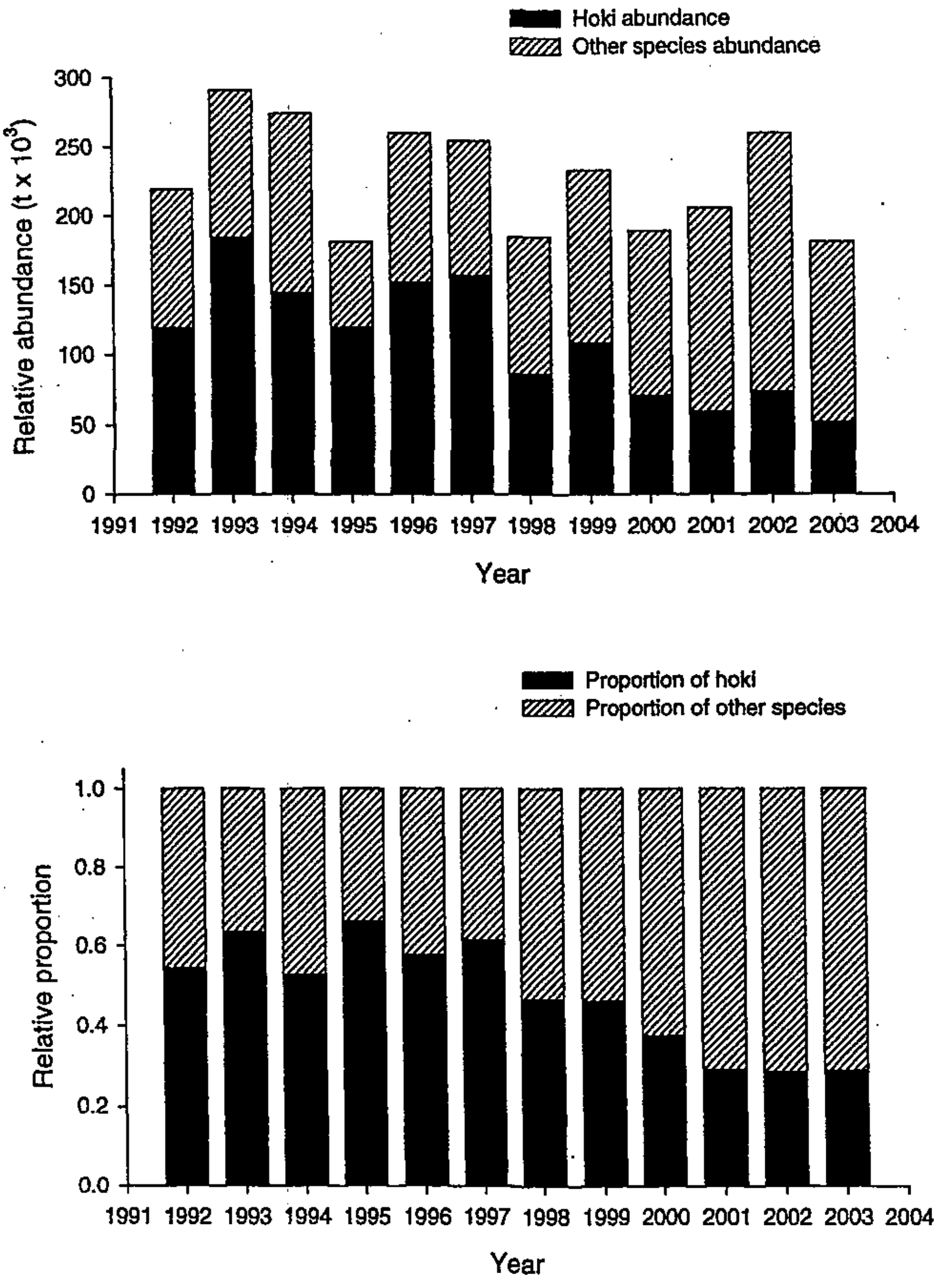



**Figure 3: Relative biomass (top panel) and relative proportions of hoki and other species (lower panel) from trawl surveys of the Chatham Rise, January 1992–2003.**

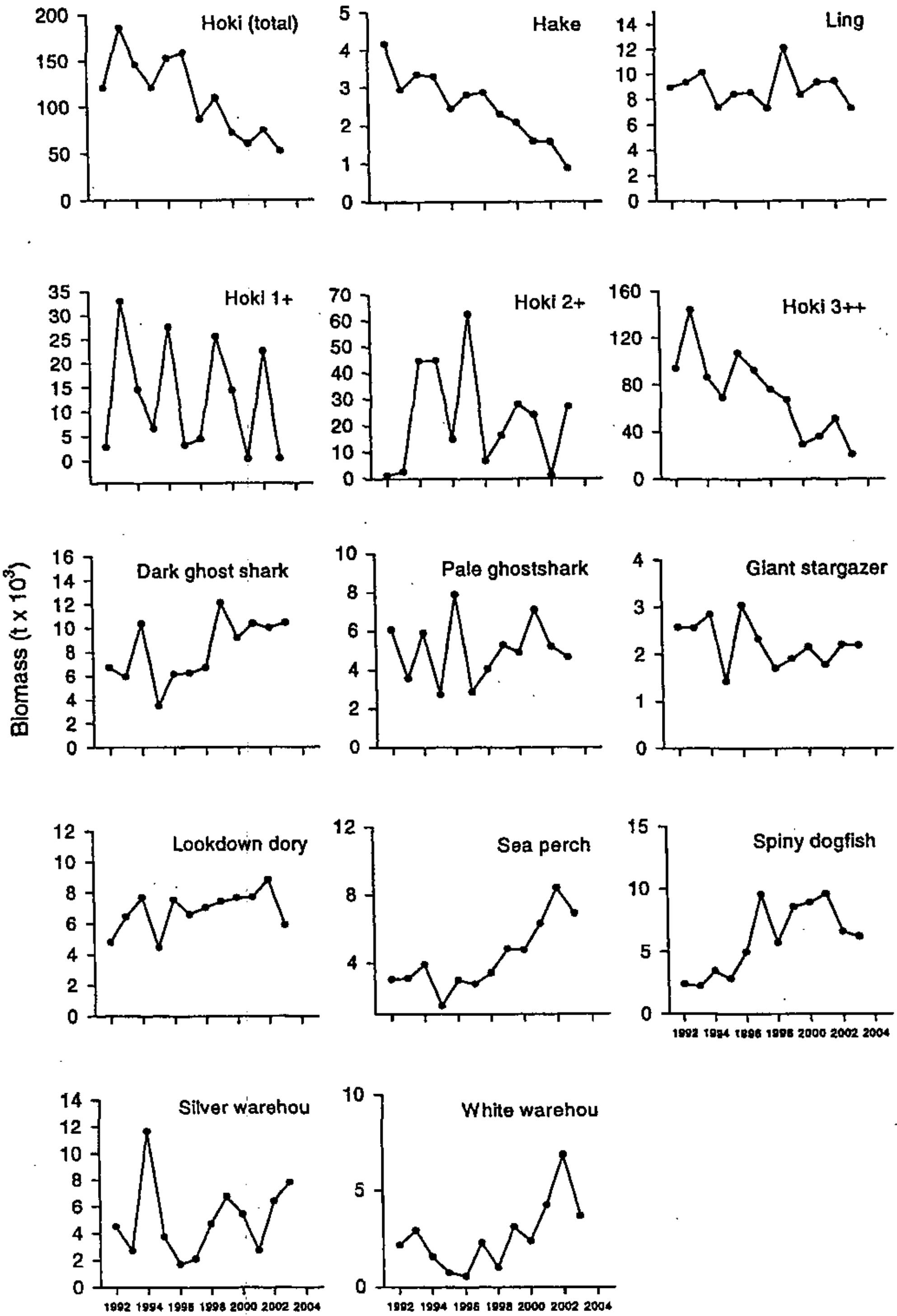



**Figure 4: Relative biomass estimates (t x $10^3$) of important species sampled by annual trawl surveys of the Chatham Rise, January 1992–2003.**

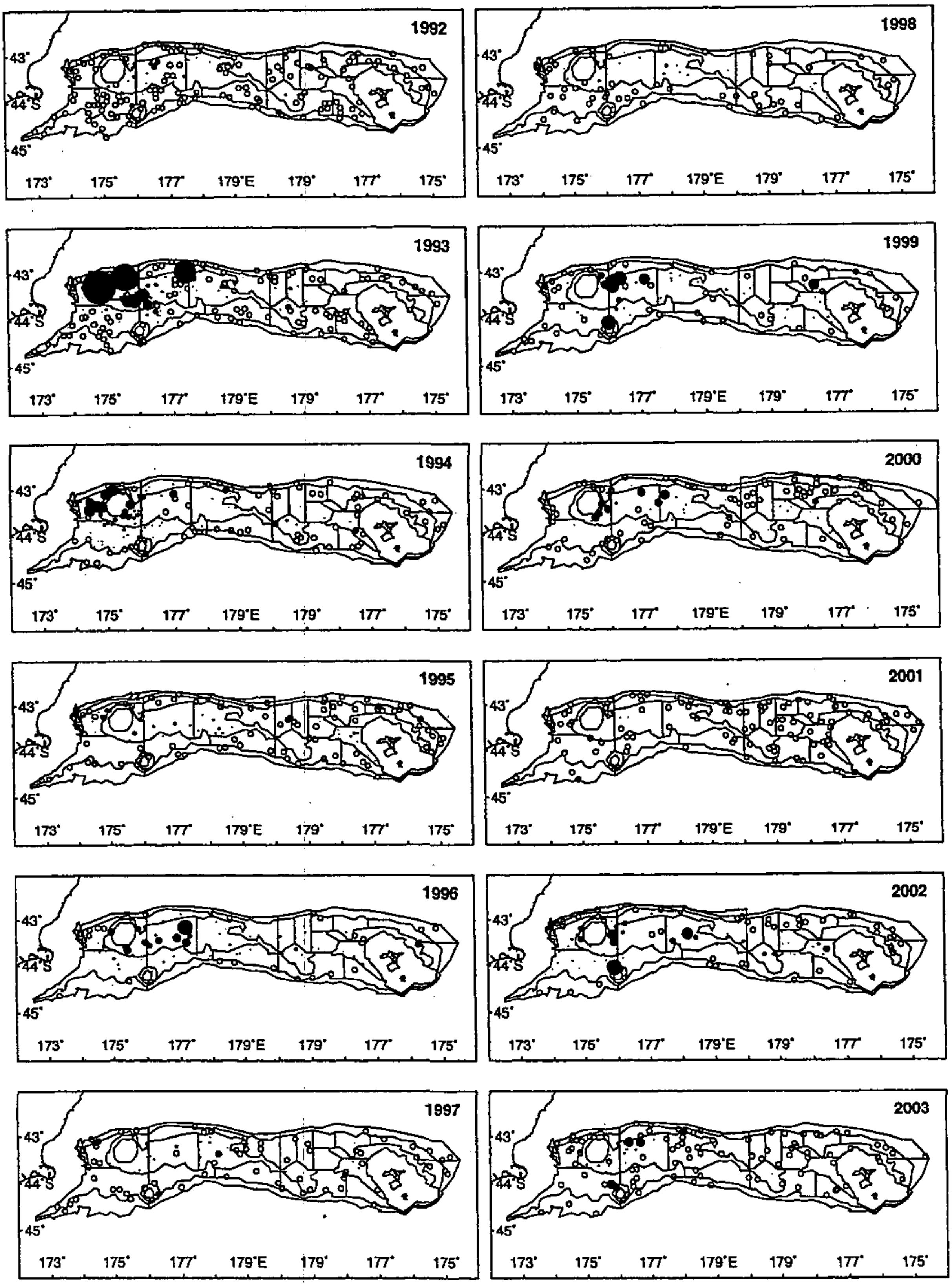



**Figure 5a. Hoki 1+ catch distribution 1992–2003. Filled circle area is proportional to catch rate (kg.km$^{-2}$). Open circles are zero catch. Maximum catch rate in series is 30 850 kg.km$^{-2}$.**

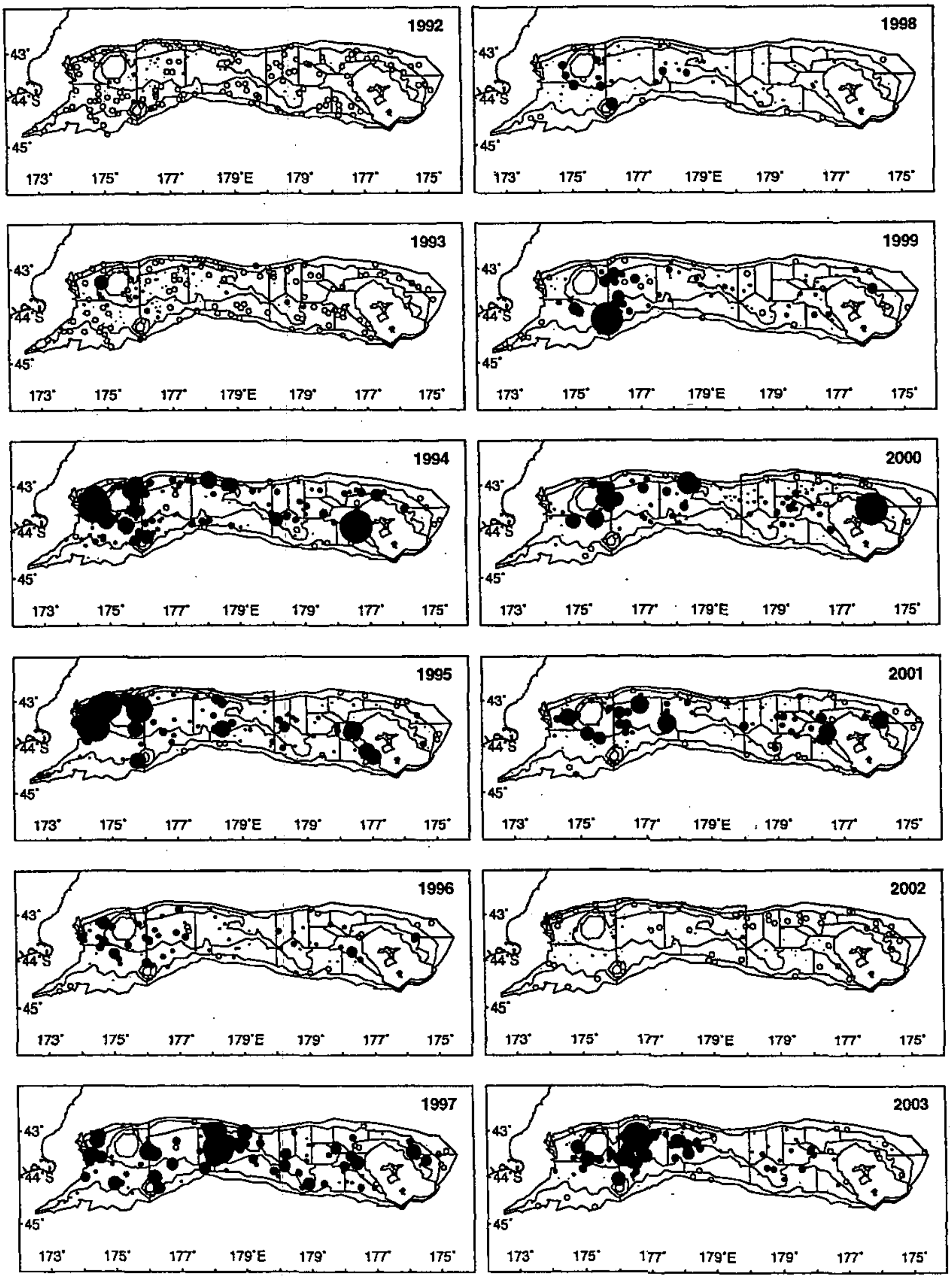



**Figure 5b. Hoki 2+ catch distribution 1992–2003. Filled circle area is proportional to catch rate (kg.km$^{-2}$). Open circles are zero catch. Maximum catch rate in series is 6791 kg.km$^{-2}$.**

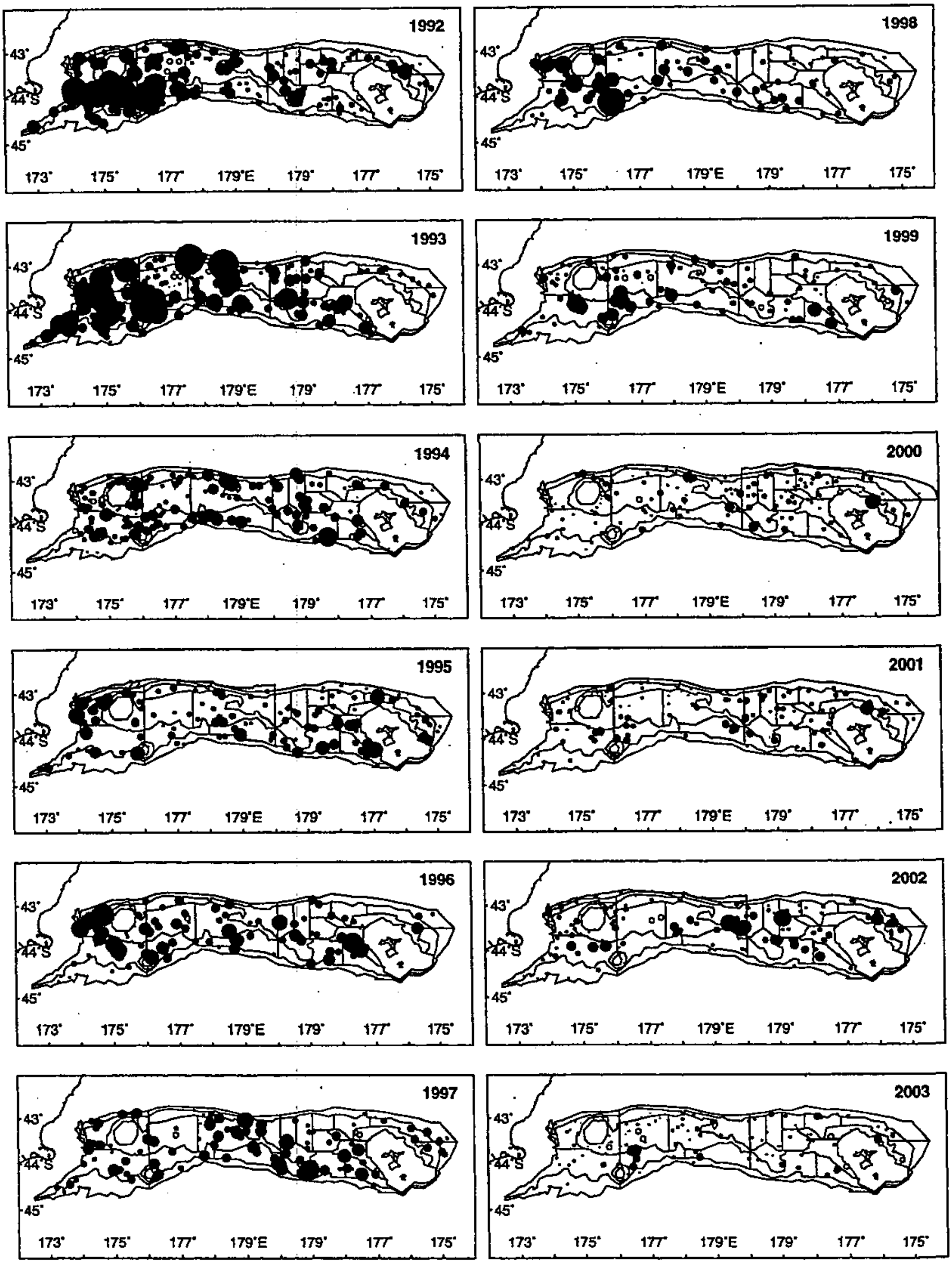



Figure 5c. Hoki 3++ catch distribution. Filled circle area is proportional to catch rate (kg.km$^{-2}$). Open circles are zero catch. Maximum catch rate in series is 11 177 kg.km$^{-2}$.

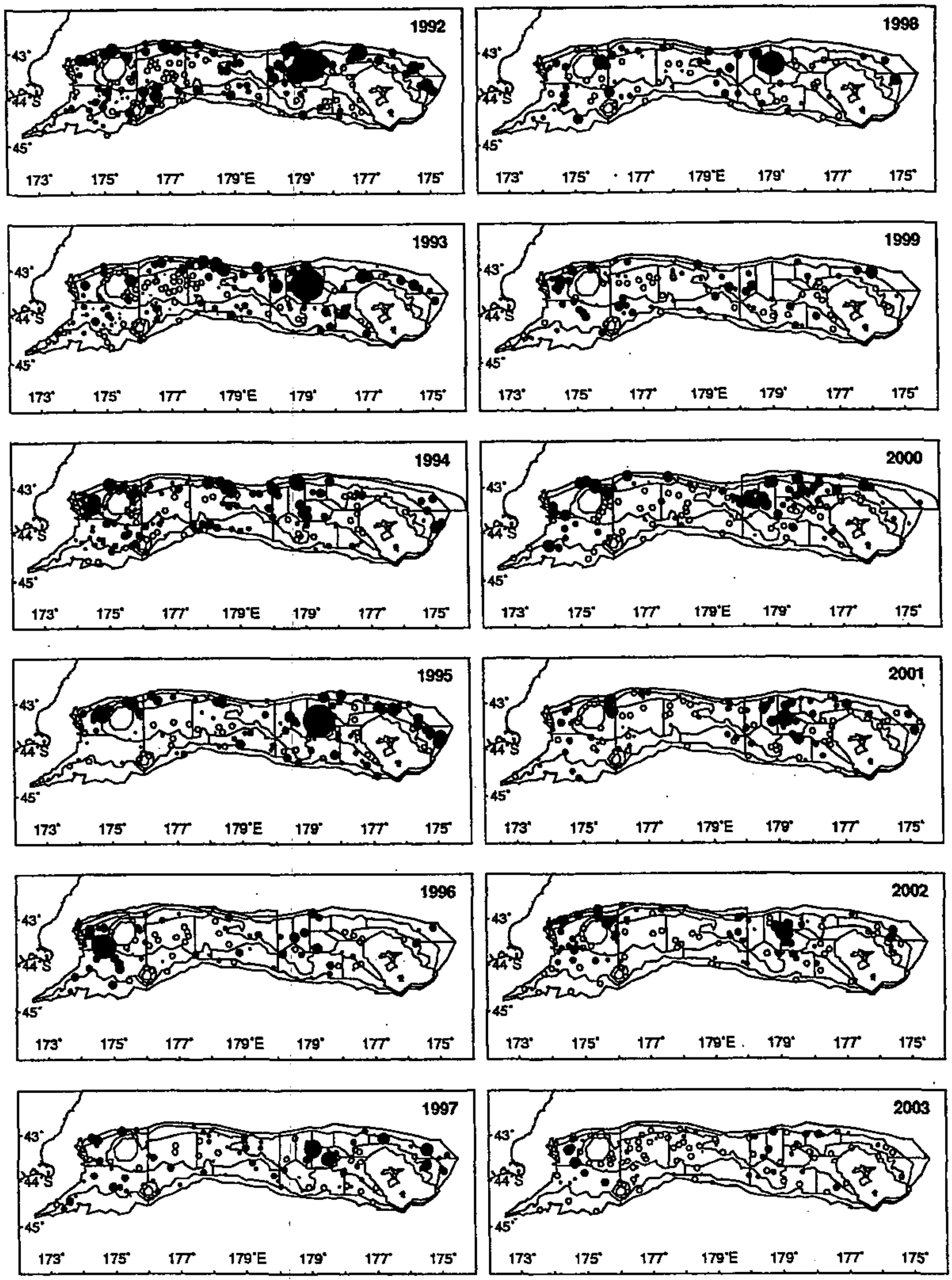



**Figure 6. Hake catch distribution 1992–2003. Filled circle area is proportional to catch rate (kg.km$^{-2}$). Open circles are zero catch. Maximum catch rate in series is 70 kg.km$^{-2}$.**

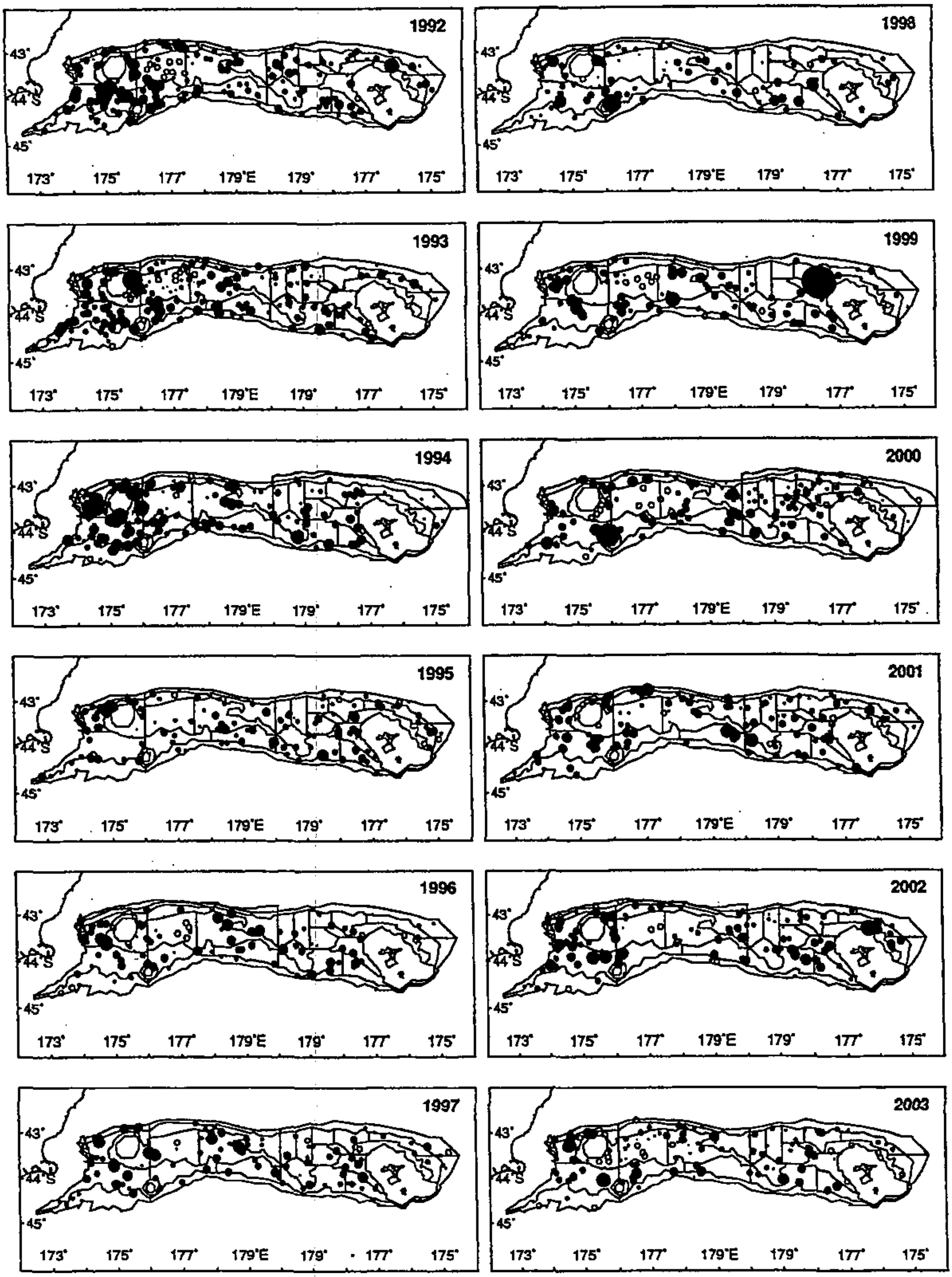



**Figure 7. Ling catch distribution 1992–2003. Filled circle area is proportional to catch rate (kg.km$^{-2}$). Open circles are zero catch. Maximum catch rate in series is 330 kg.km$^{-2}$.**

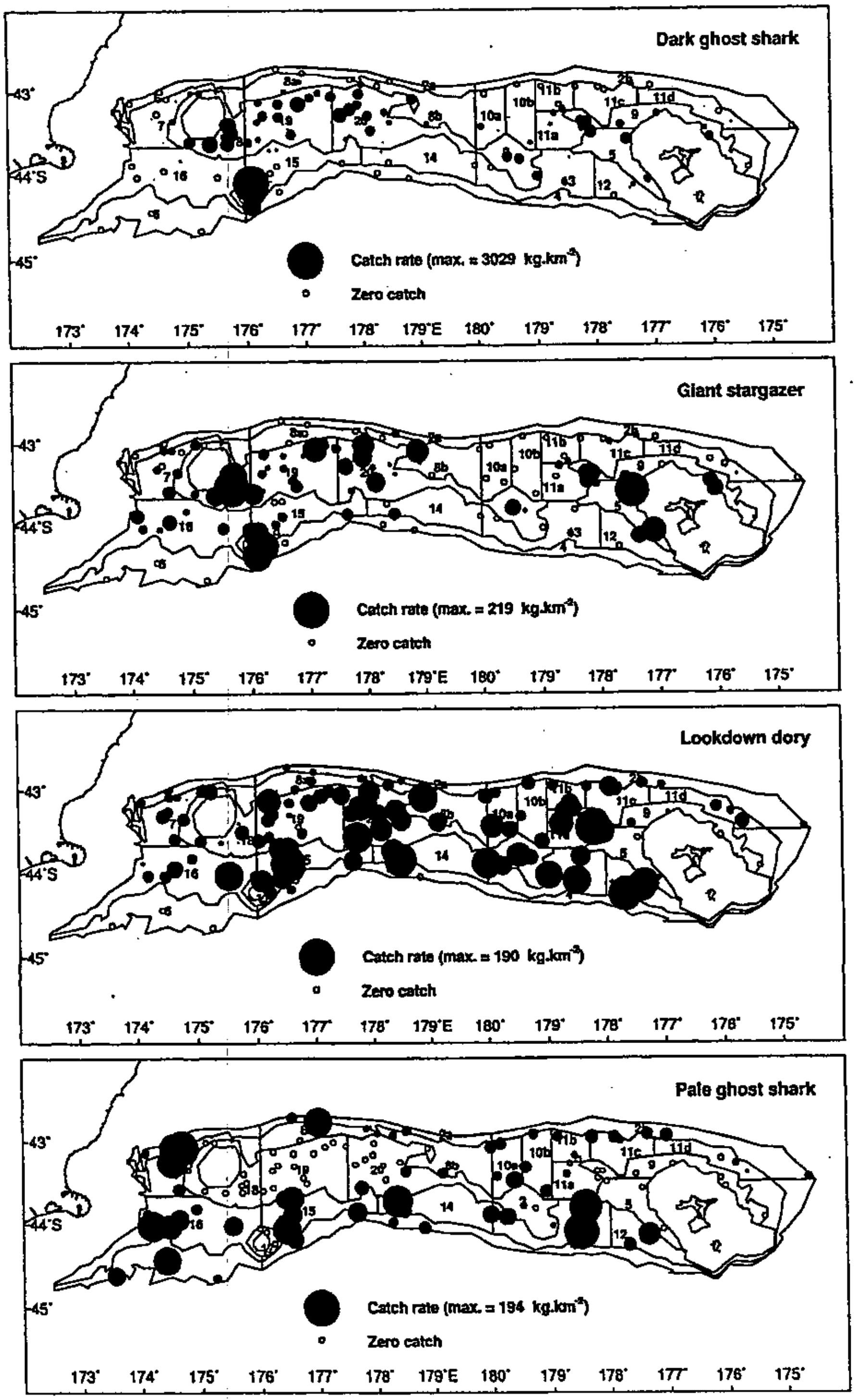



**Figure 8: Catch rates (kg.km$^{-2}$) of selected commercial species in 2003. Filled circle area is proportional to catch rate. Open circles are zero catch. (max., maximum catch rate)**

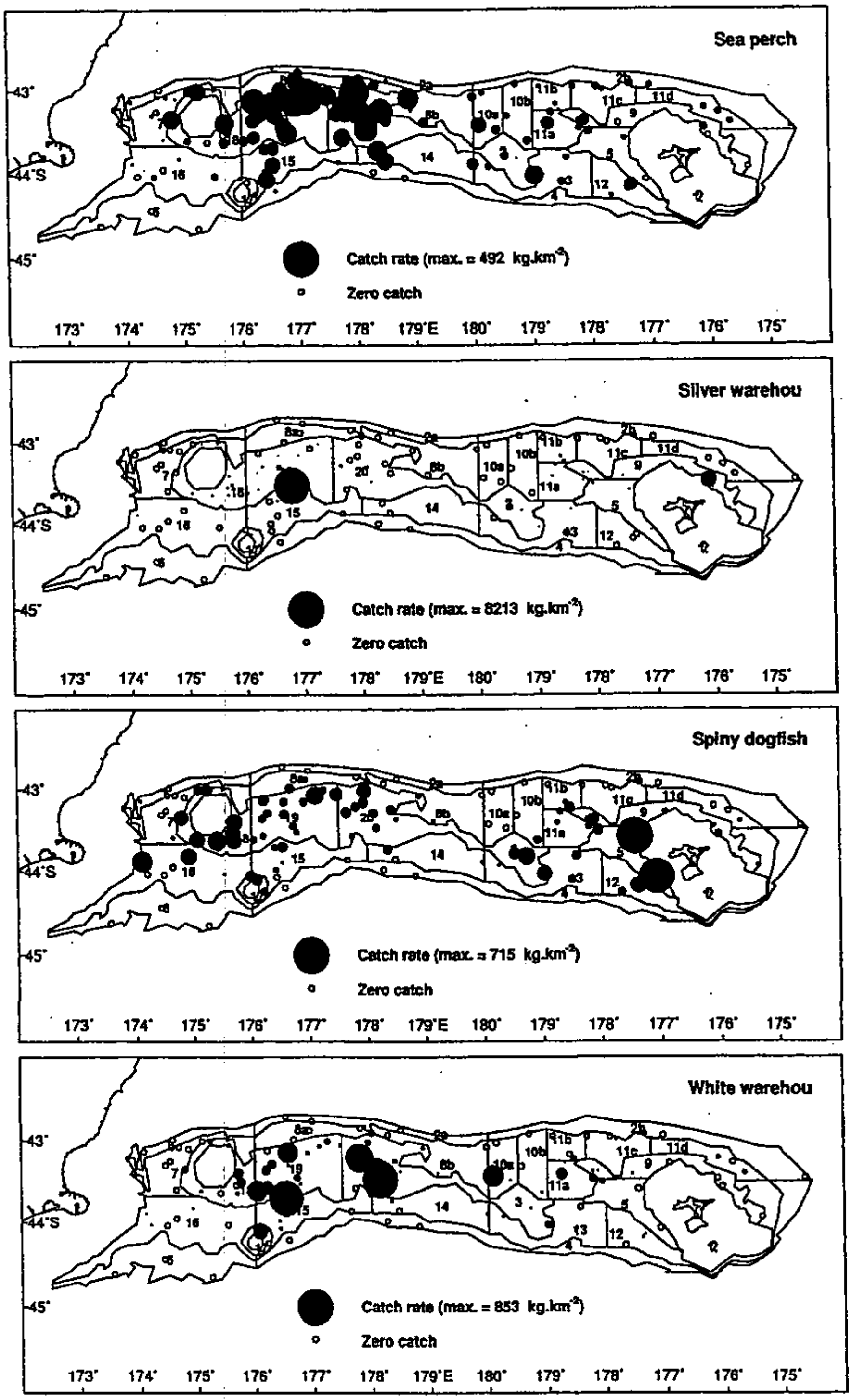



**Figure 8: (continued)**

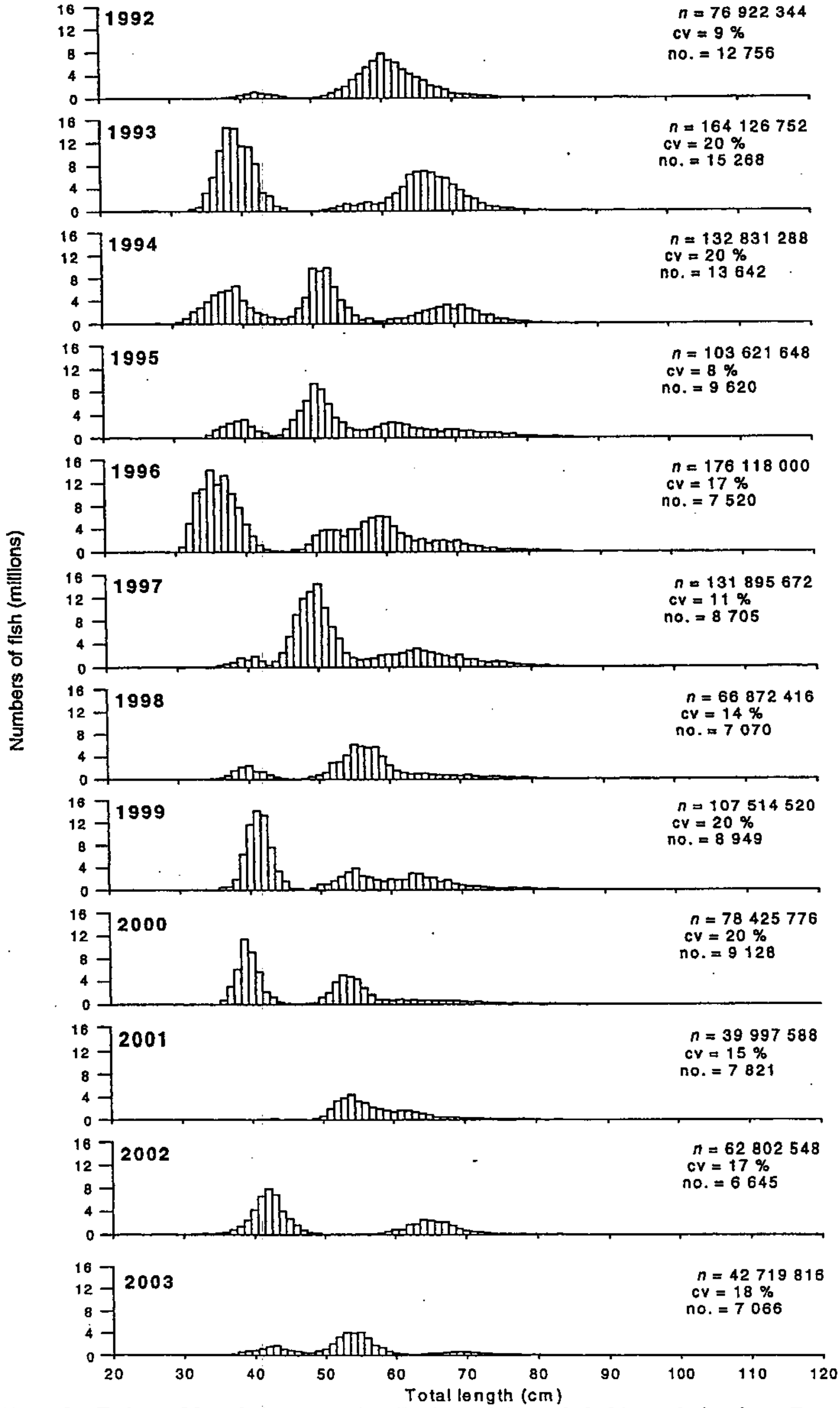



**Figure 9a: Estimated length frequency distributions of the male hoki population from *Tangaroa* surveys of the Chatham Rise, January 1992–2003. (c.v., coefficient of variation; n, estimated population number of male hoki; no., numbers of fish measured.)**

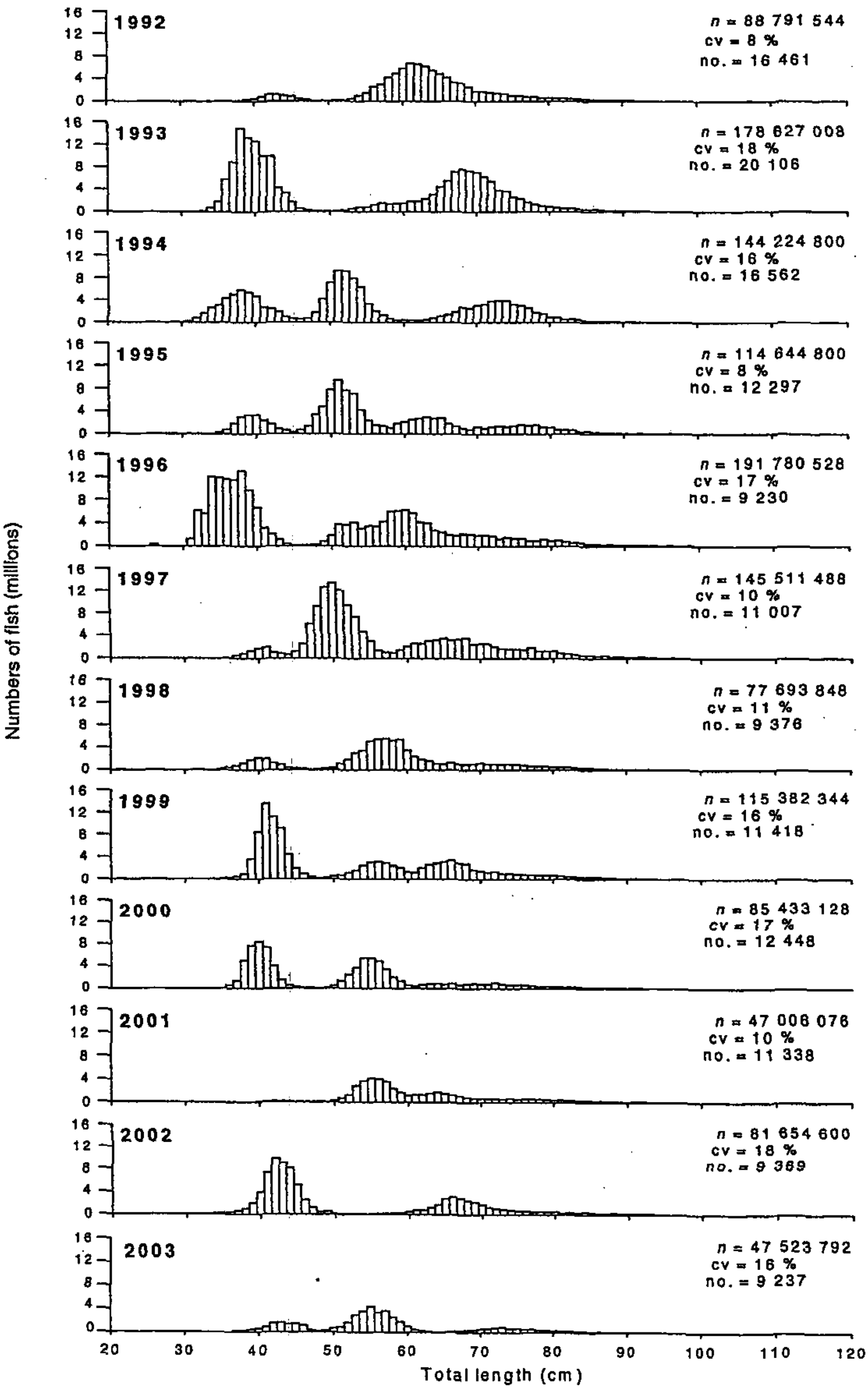



**Figure 9b: Estimated length frequency distributions of the female hoki population from Tangaroa surveys of the Chatham Rise, January 1992–2003. (c.v., coefficient of variation; n, estimated population number of female hoki; no., numbers of fish measured.)**

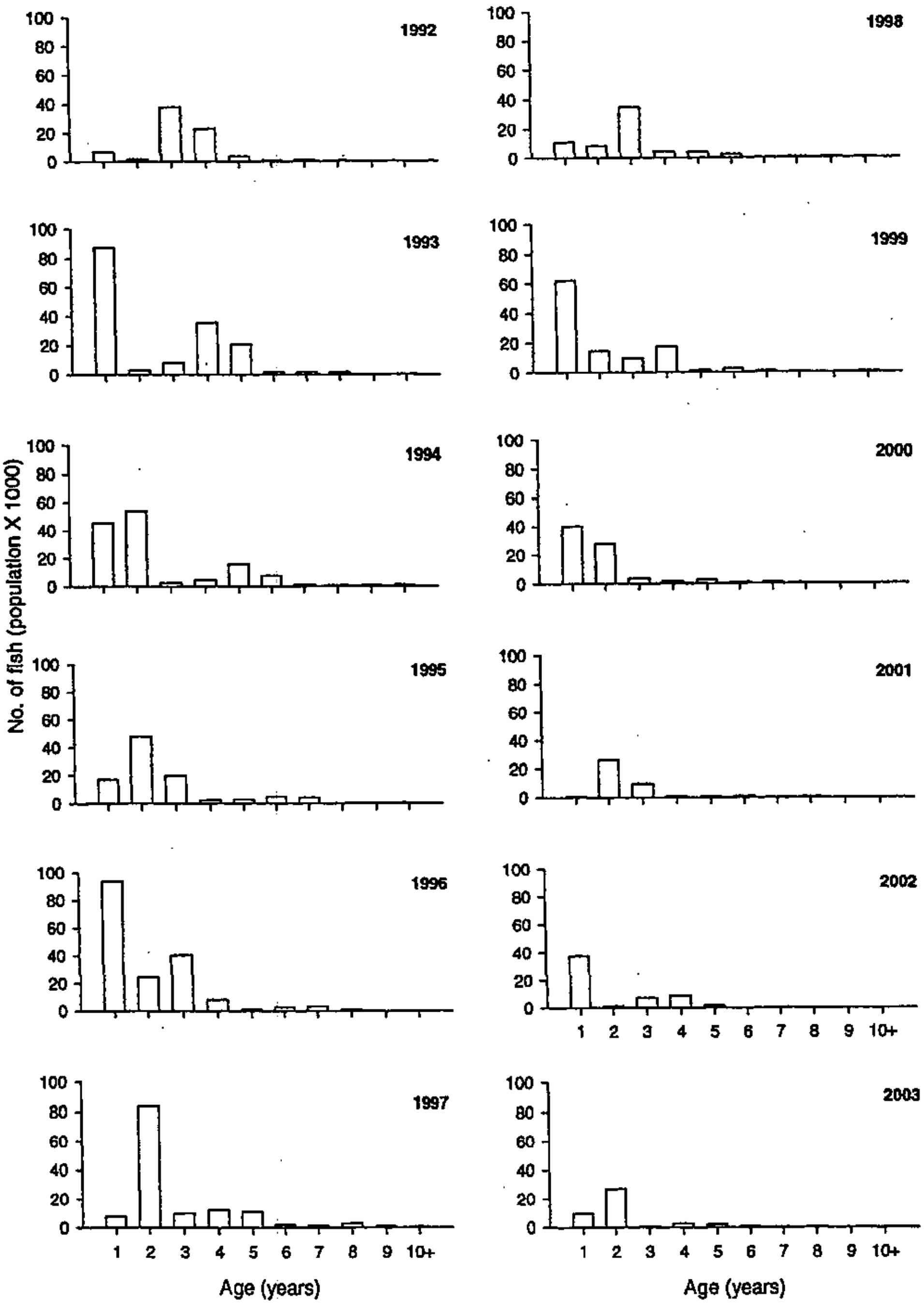



**Figure 10a: Estimated population numbers at age of male hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2003. (+, indicates plus group of combined ages.) Note: numbers at age revised for full series to accommodate multi sub-sampling in the catch.**

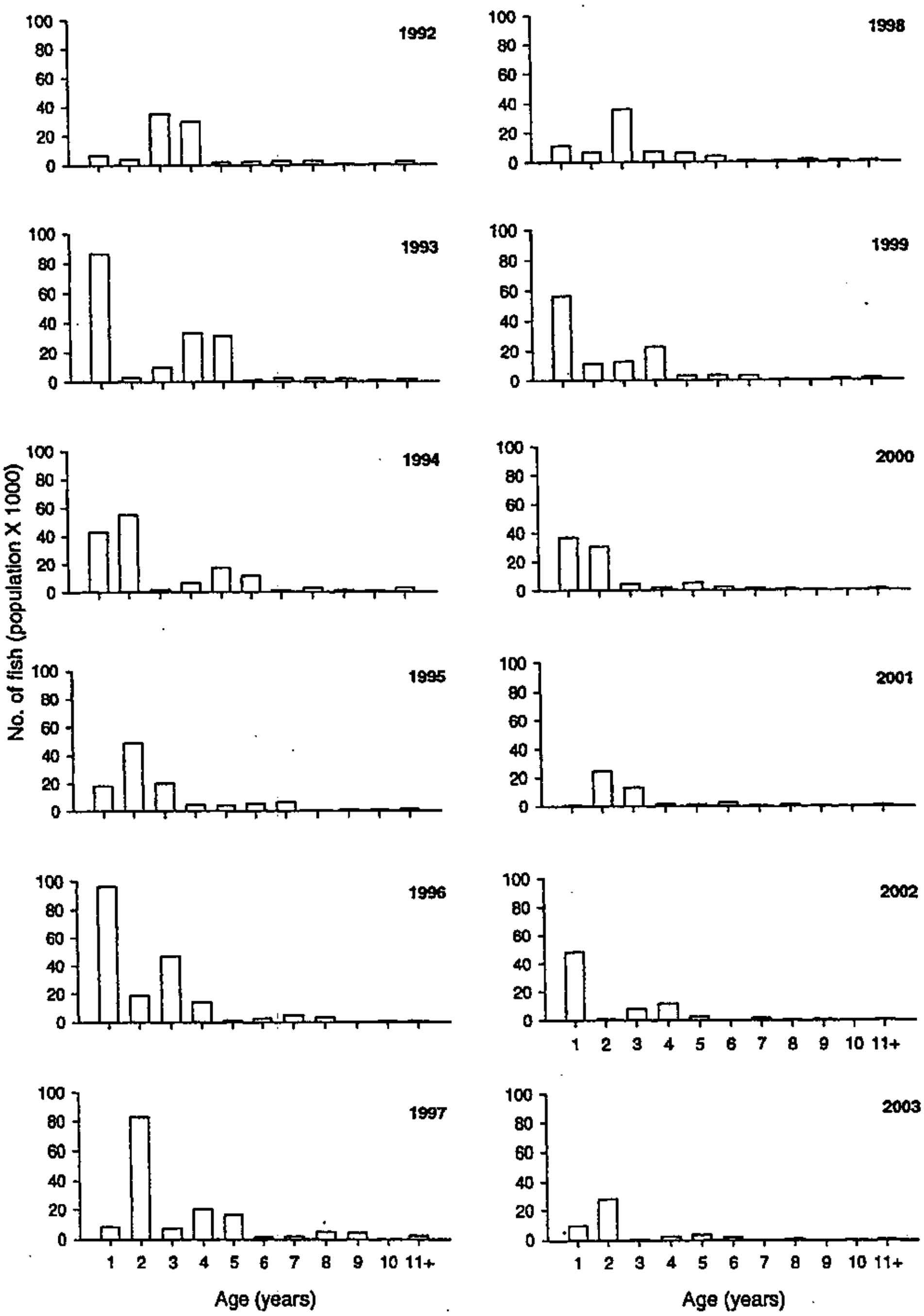



**Figure 10b: Estimated population numbers at age of female hoki from *Tangaroa* surveys of the Chatham Rise, January, 1992–2003. (+, indicates plus group of combined ages.) Note: numbers at age revised for full series to accommodate multi sub-sampling in the catch.**

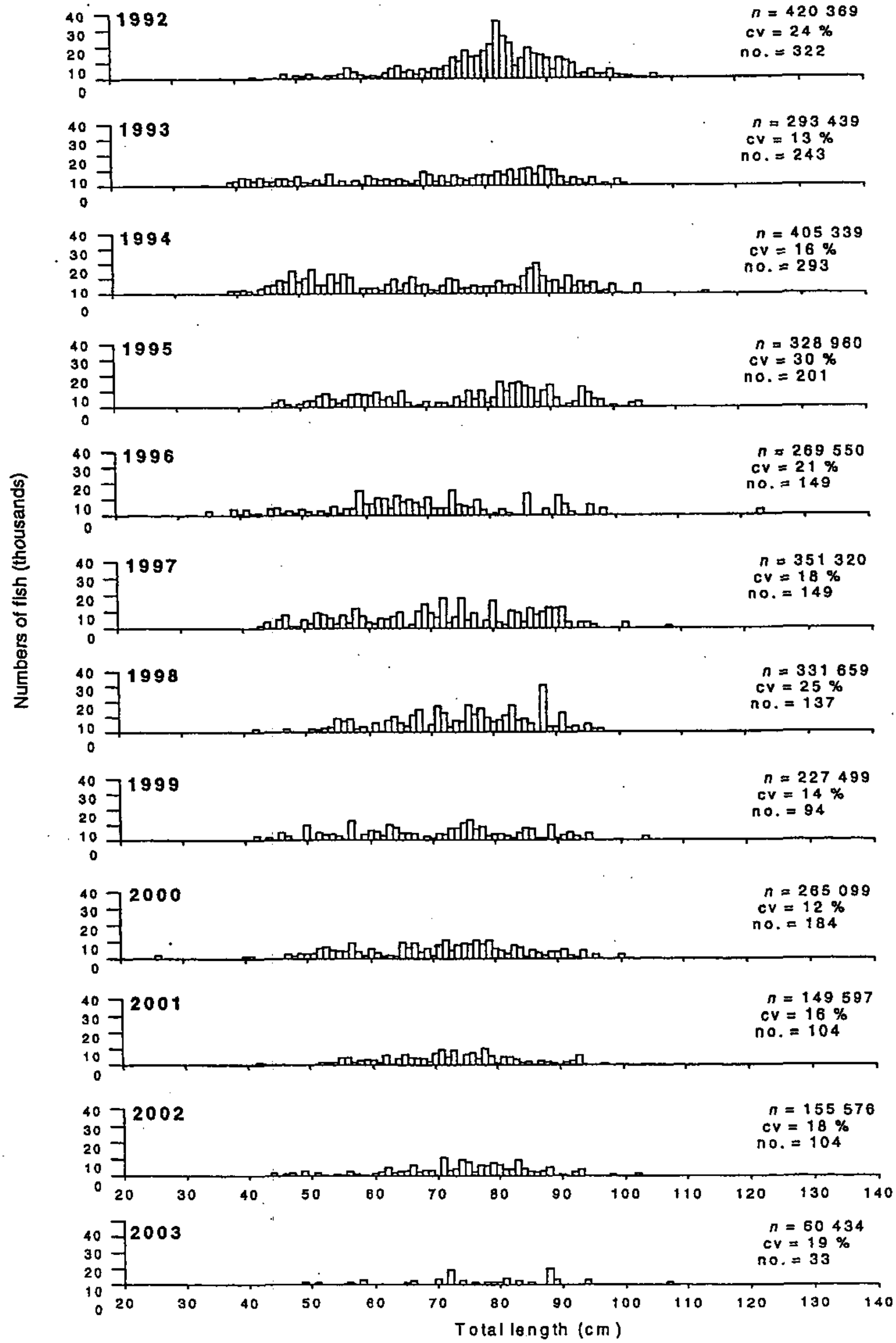



**Figure 11a: Estimated length frequency distributions of the male hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2003. (c.v., coefficient of variation; n, estimated population number of male hake; no., numbers of fish measured.)**

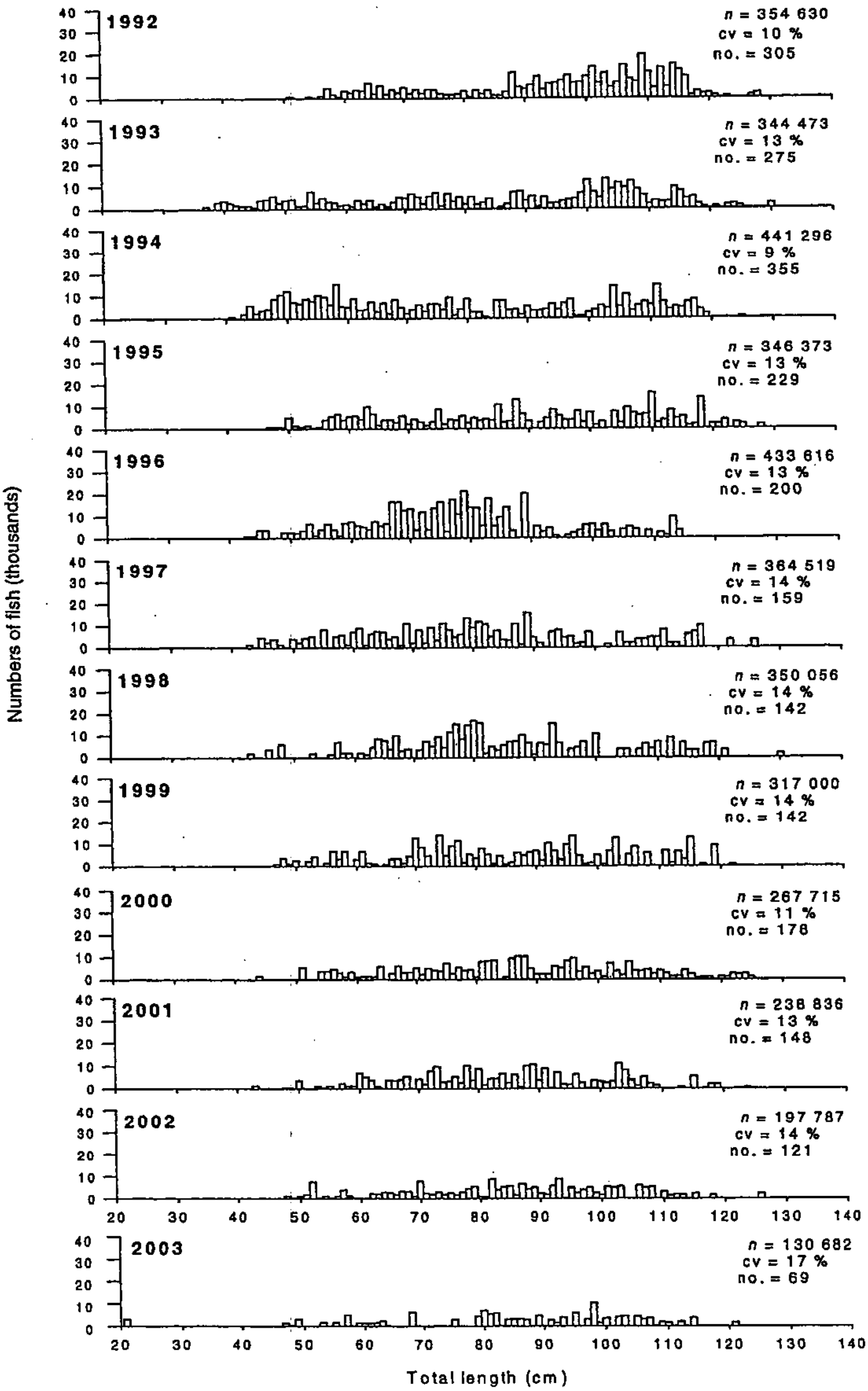



**Figure 11b: Estimated length frequency distributions of the female hake population from *Tangaroa* surveys of the Chatham Rise, January 1992–2003. (c.v., coefficient of variation; n, estimated population number of female hake; no., numbers of fish measured.)**

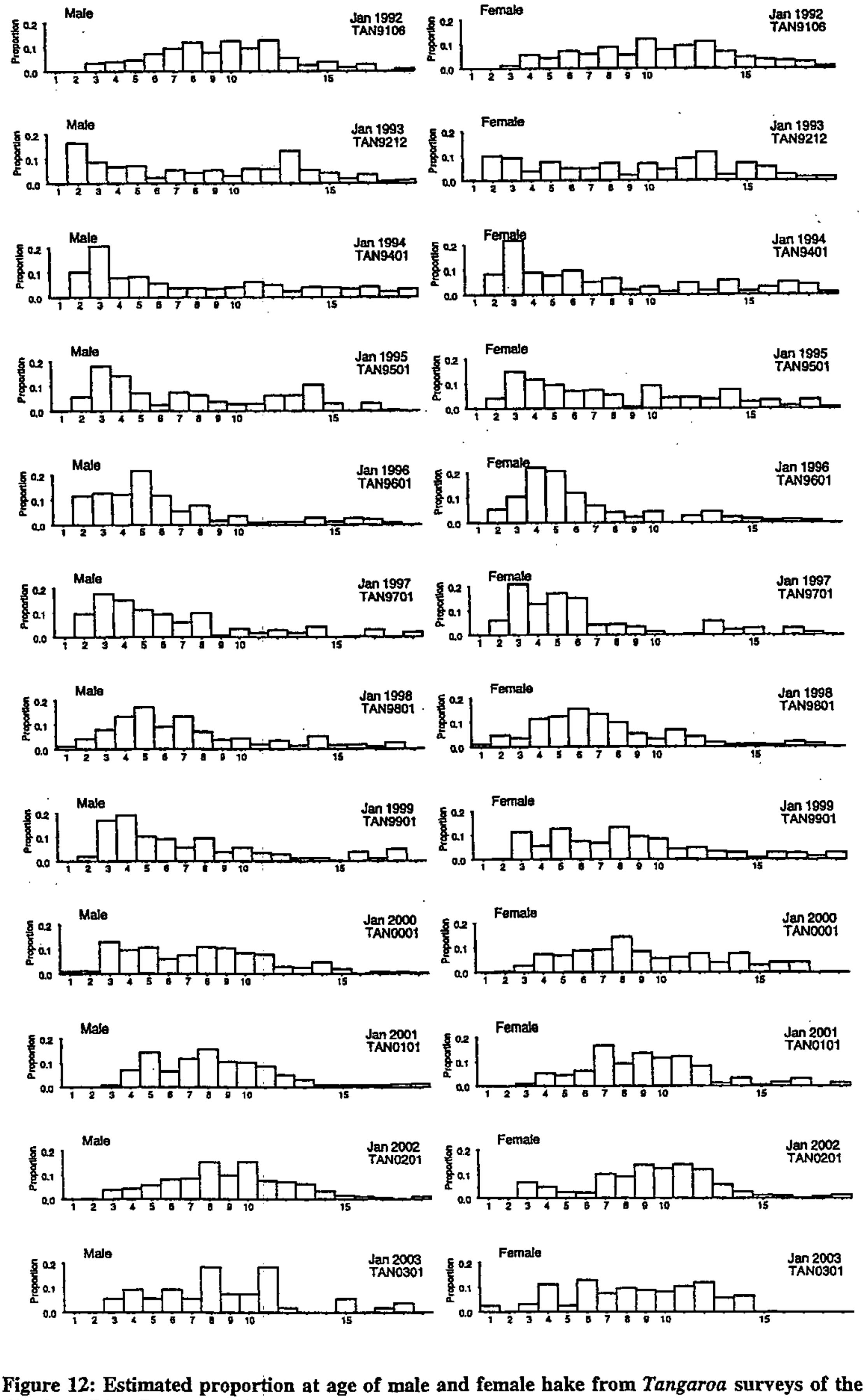



**Figure 12: Estimated proportion at age of male and female hake from *Tangaroa* surveys of the Chatham Rise, January, 1992–2003.**

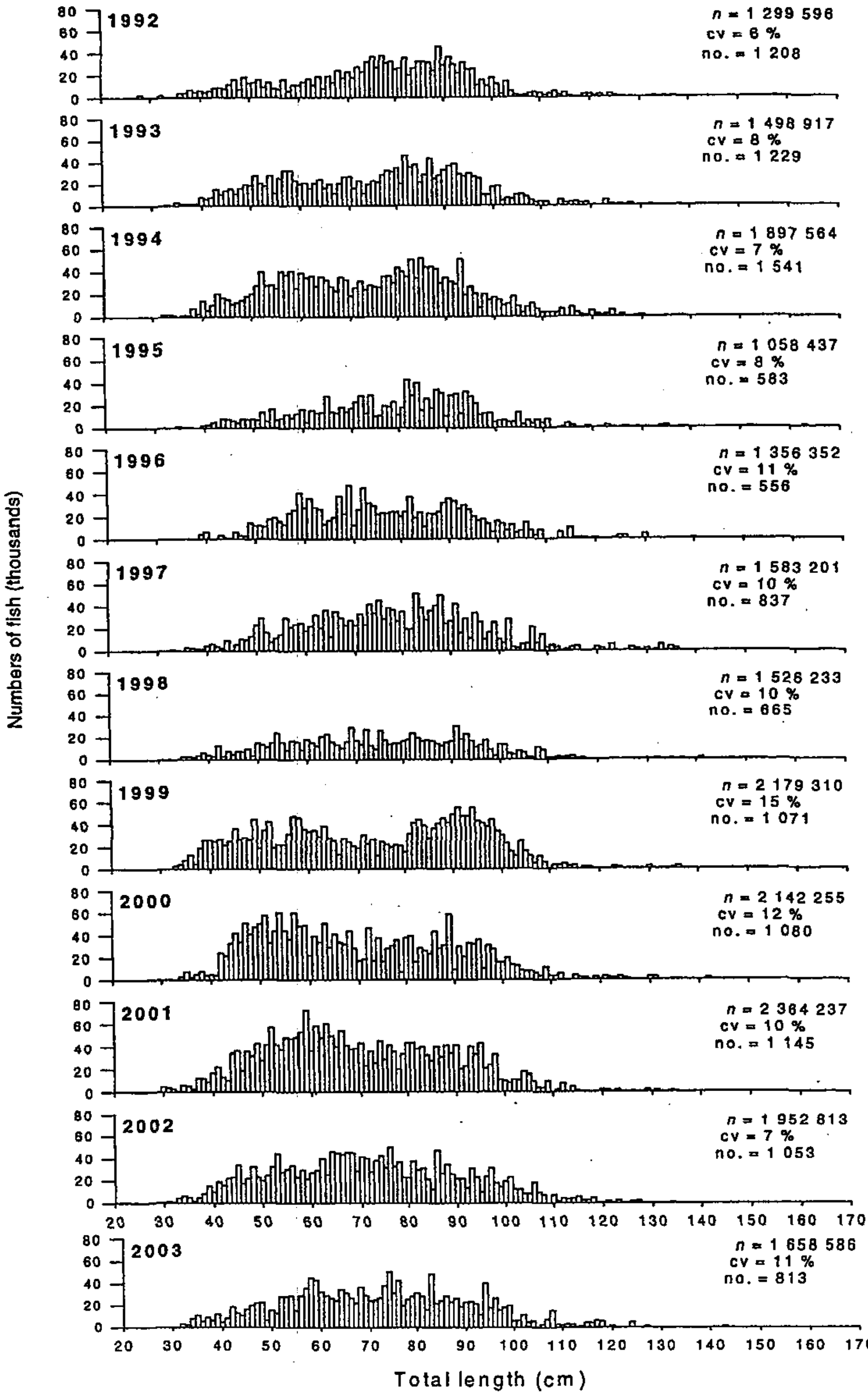



**Figure 13a: Estimated length frequency distributions of the male ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2003. (c.v., coefficient of variation; n, estimated population number of male ling; no., numbers of fish measured.)**

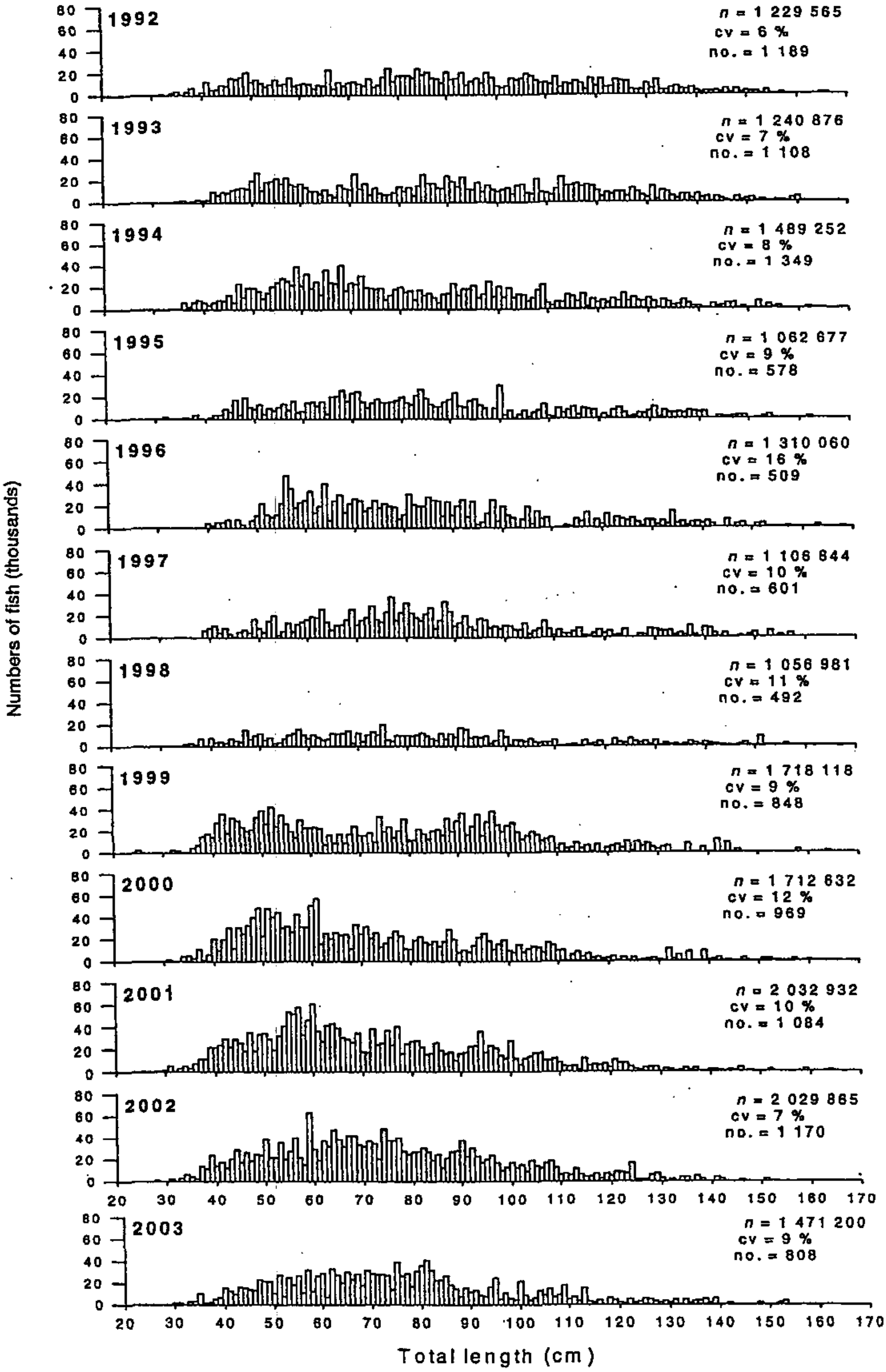



**Figure 13b: Estimated length frequency distributions of the female ling population from *Tangaroa* surveys of the Chatham Rise, January 1992–2003. (c.v., coefficient of variation; n, estimated population number of female ling; no., numbers of fish measured.)**

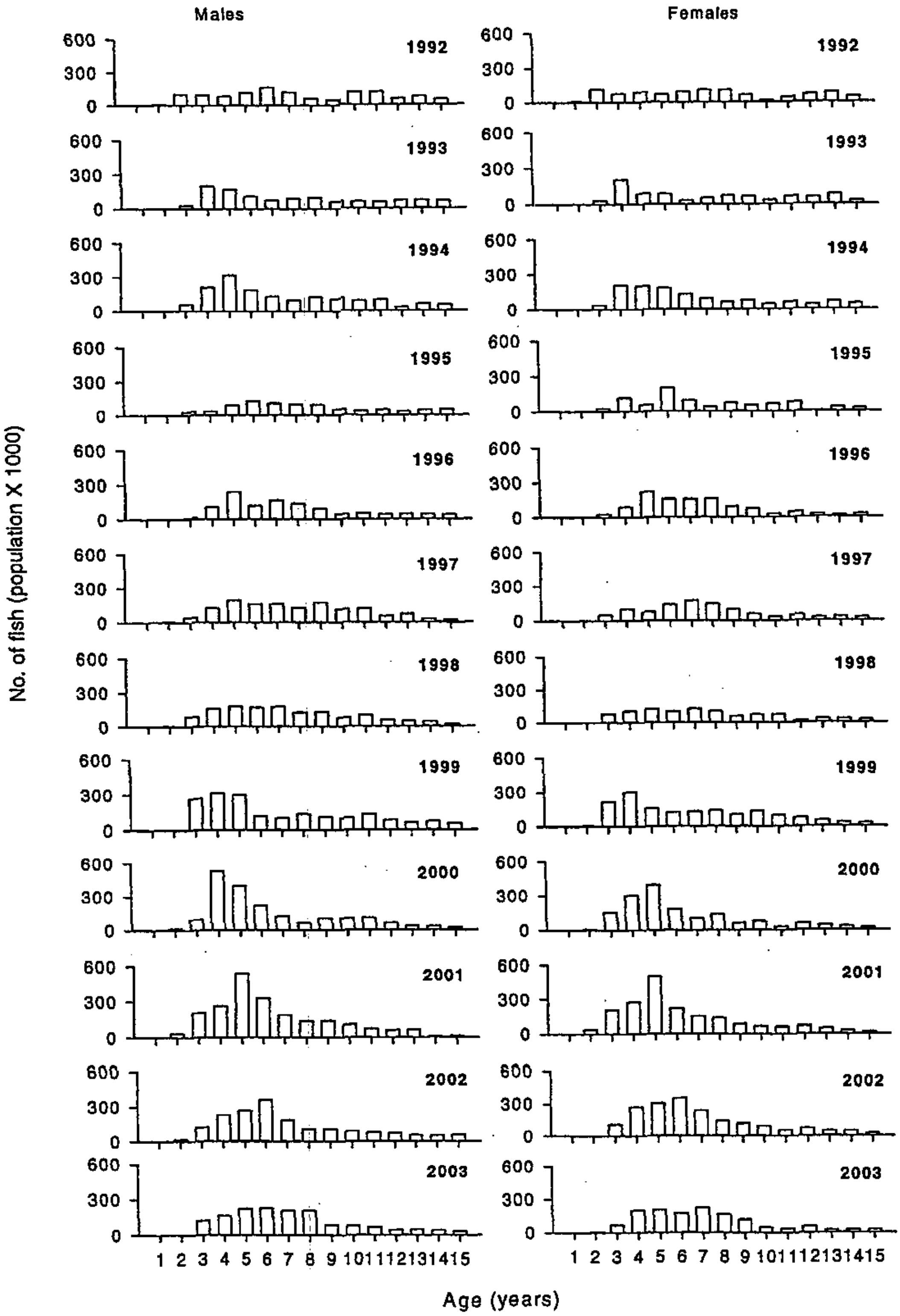



**Figure 14: Estimated population numbers at age of male and female ling (age 1–15 years) from *Tangaroa* surveys of the Chatham Rise, January, 1992–2003. (Note: the age class of 15 years is not a plus group.)**

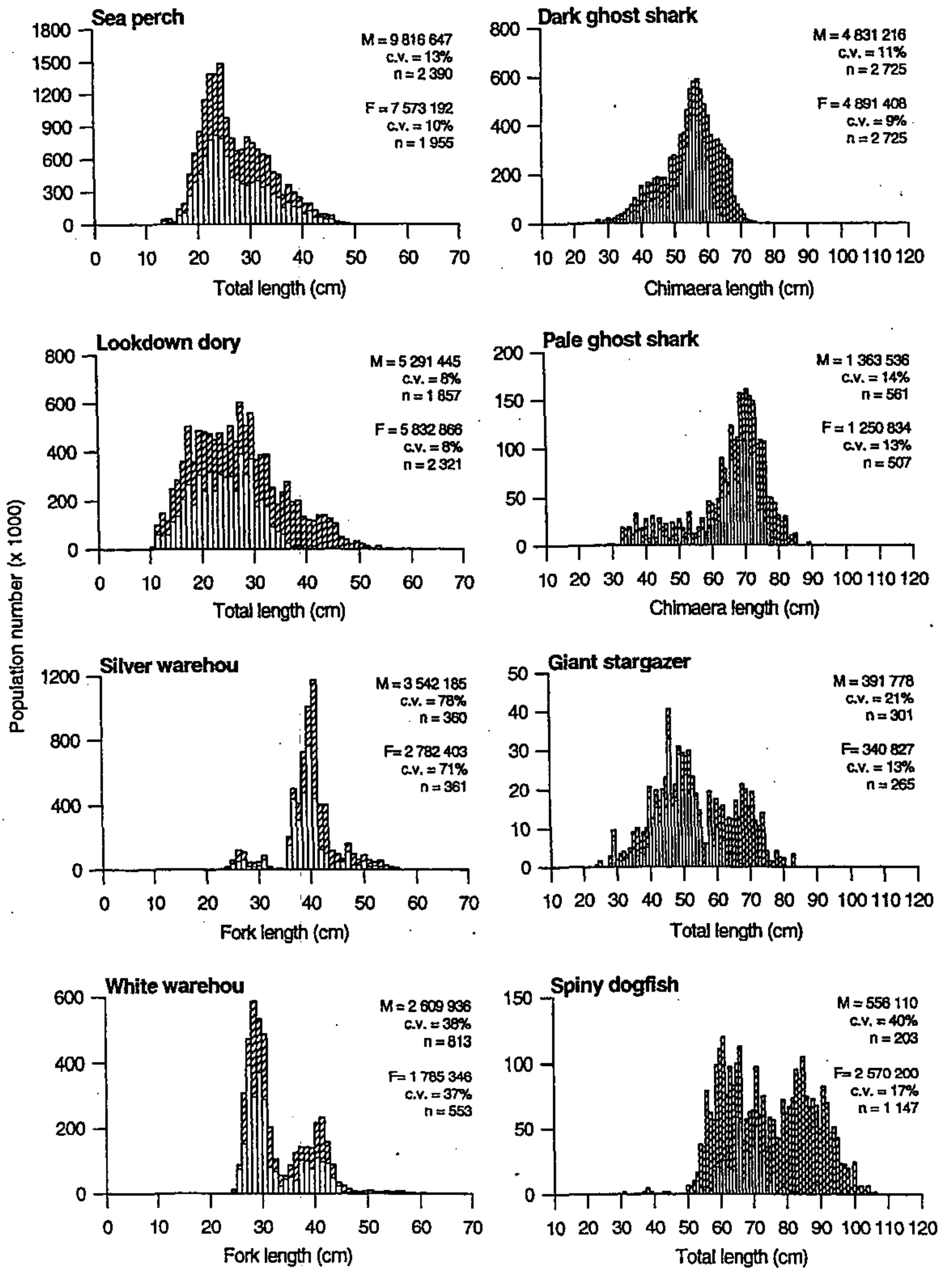



**Figure 15: Length frequencies of selected commercial species on the Chatham Rise 2003, scaled to population size by sex (M, estimated male population; F, estimated female population (hatched bars); c.v. coefficient of variation of the estimated numbers of fish; n, number of fish measured.)**

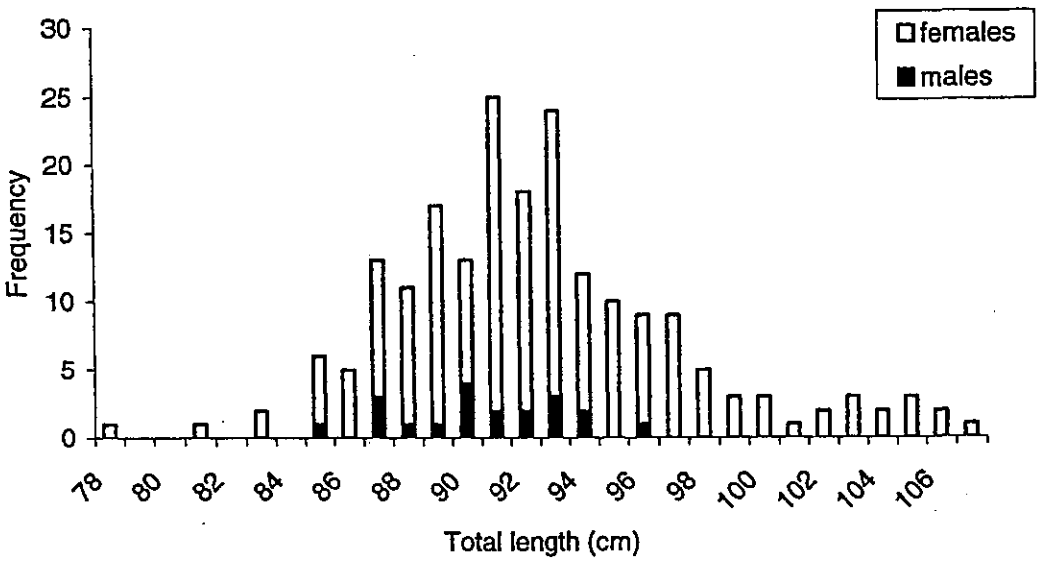



**Figure 16: Unscaled length frequency of hoki caught from midwater tows on the Andes hill complex, east of the Chatham Rise.**

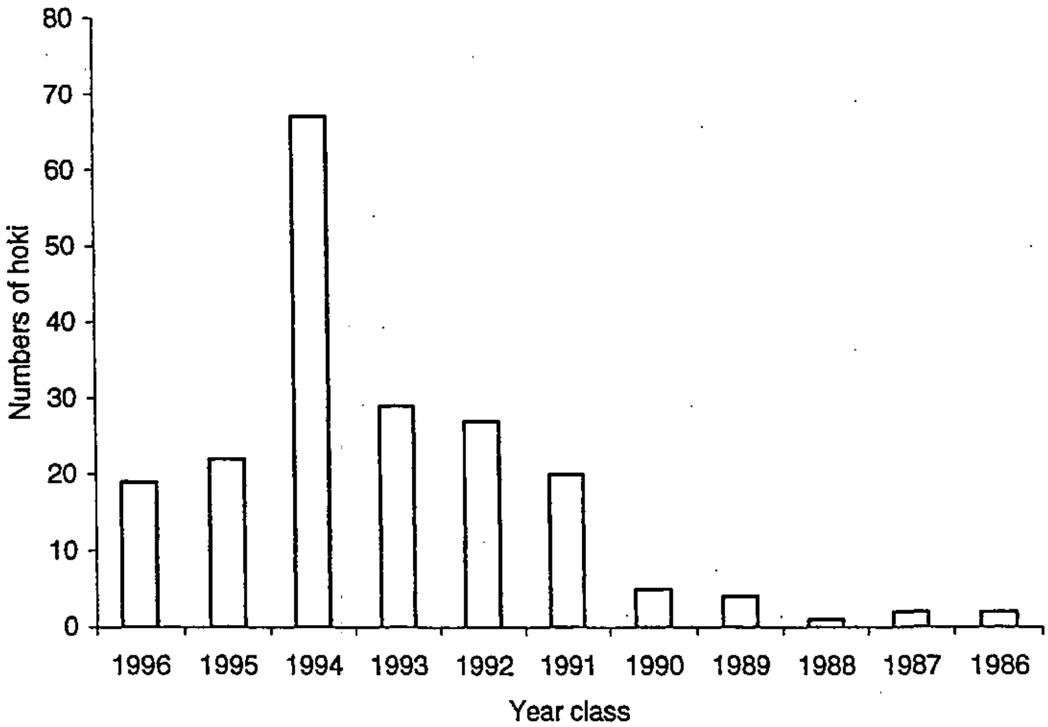
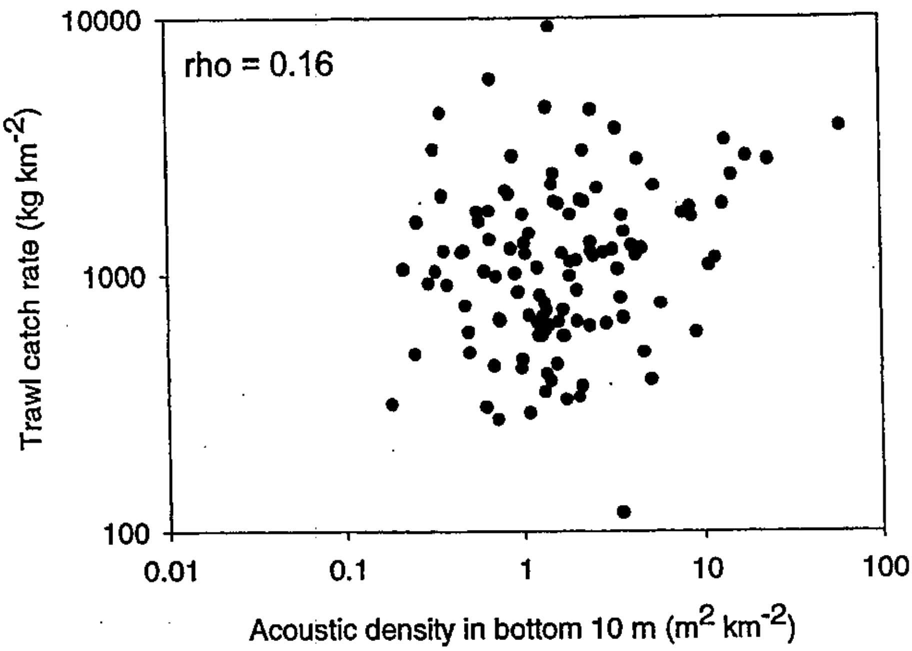



**Figure 17. Numbers of hoki aged from otoliths in each year class from midwater tows on the Andes hill complex, east of the Chatham Rise.**



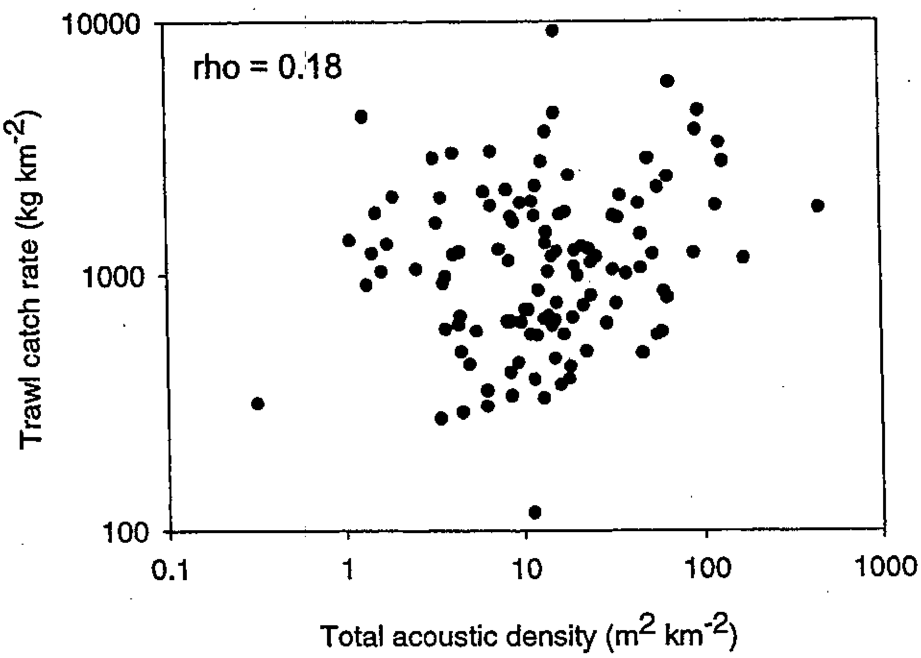




**Figure 18: Relationship between total trawl catch rate (all species combined) and acoustic backscatter recorded during the trawl on the Chatham Rise in 2003. Rho values are Spearman's rank correlation coefficients.**

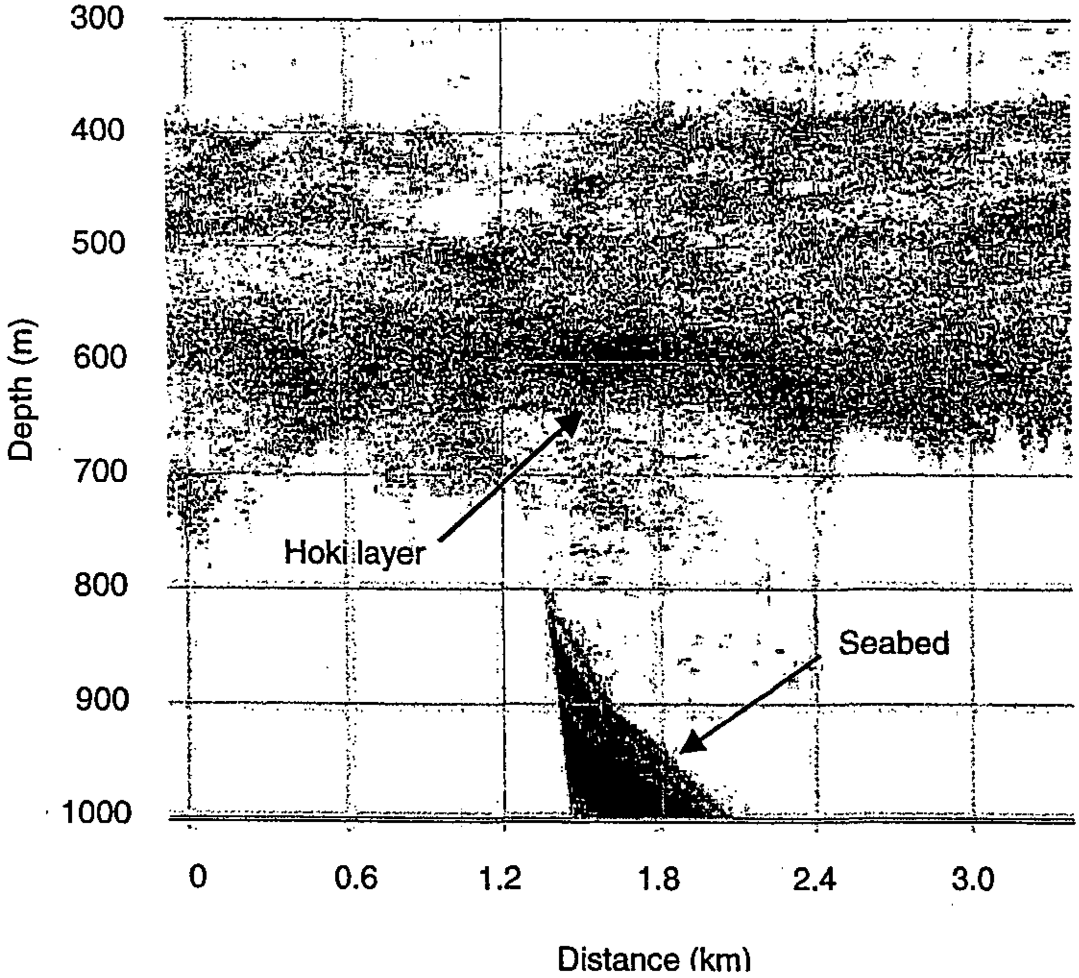



**Figure 19: Acoustic echogram collected during exploratory midwater tow (station 49). The midwater trawl was towed at depths of 585–645 m and caught 353 kg of large hoki in 45 min. The seabed echo is missing in much of the echogram because bottom tracking failed.**

## Appendix 1. The utility in stock assessments of biological samples from the summer Chatham Rise trawl surveys. Note to the Hoki Working Group, 4 December 2002, by Chris Francis, NIWA (Report Number WG-HOK-2002/45)


### Summary

There had been 11 *Tangaroa* surveys of the Chatham Rise in summer (from the summers of 1991–92 to 2001–02, inclusive) at the time of this study. In stock assessments, the only current use of biological data from these surveys is for calculating LFs (length frequency distributions), which are converted, via age-length keys, to AFs (age frequency distributions).

Data for the main 13 middle-depth species from these surveys were analysed by sex. In any year the predicted weight of a species at a given length is usually within 10% of the value obtained by using data from all years combined. Also the uncertainty in estimated LFs that is caused by sampling variation in biological data (length-weight samples) is much less than that arising from the non-biological data.

It was concluded that there is no need, for current stock assessment purposes, to collect any biological data from these species in future Chatham Rise surveys. Therefore, there may be scope for reducing target sample sizes for biological data in future surveys. The decision about these targets should be based on other possible uses of these data.


### Introduction

At the time of this study, there had been 11 *Tangaroa* surveys of the Chatham Rise in summer. The number of length-weight observations collected in these surveys has increased in recent years, averaging about 10 000 over the last three surveys (Appendix 1, Table 1). It is time-consuming (and thus costly) to collect these data and so it is worthwhile to ask whether this time is well spent.

**Appendix 1, Table 1: Number of sexed length-weight observations, by species and overall, from each survey. 'OTH' = species other than those named; 'ALL' = all species. Only samples from stations used in biomass estimates for the core strata are included.**

| Voyage | HOK | HAK | LIN | SWA | SPE | WWA | STA | LDO | BYS | RIB | GSP | GSH | SPD | OTH | ALL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TAN9106 | 1333 | 506 | 1042 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2881 |
| TAN9212 | 1204 | 420 | 882 | 170 | 207 | 78 | 90 | 176 | 0 | 20 | 106 | 171 | 0 | 95 | 3619 |
| TAN9401 | 1002 | 444 | 896 | 160 | 193 | 52 | 97 | 216 | 117 | 116 | 79 | 50 | 0 | 23 | 3445 |
| TAN9501 | 881 | 364 | 469 | 283 | 229 | 188 | 190 | 290 | 167 | 55 | 237 | 262 | 200 | 113 | 3928 |
| TAN9601 | 1511 | 333 | 756 | 268 | 444 | 94 | 350 | 357 | 181 | 52 | 341 | 525 | 170 | 40 | 5422 |
| TAN9701 | 793 | 295 | 583 | 144 | 100 | 127 | 18 | 39 | 0 | 0 | 24 | 114 | 0 | 192 | 2429 |
| TAN9801 | 981 | 279 | 673 | 279 | 232 | 258 | 208 | 477 | 357 | 79 | 284 | 355 | 0 | 334 | 4796 |
| TAN9901 | 1776 | 235 | 1003 | 632 | 519 | 398 | 267 | 553 | 516 | 58 | 259 | 431 | 369 | 1654 | 8670 |
| TAN0001 | 2231 | 354 | 1852 | 199 | 171 | 186 | 322 | 351 | 144 | 11 | 167 | 290 | 258 | 843 | 7379 |
| TAN0101 | 2064 | 251 | 1750 | 625 | 800 | 515 | 213 | 1081 | 281 | 188 | 856 | 1117 | 966 | 2829 | 13536 |
| TAN0201 | 2132 | 225 | 1513 | 56 | 456 | 323 | 315 | 429 | 131 | 105 | 445 | 513 | 543 | 1887 | 9073 |

The only current stock-assessment use of these data is for calculating LFs (length frequency distributions), which are converted, via age-length keys, to AFs (age frequency distributions).

In this note I ask two questions for the 13 main middle-depth species (as given in Appendix 1, Table 1):

1. How much do weights predicted from length-weight data typically vary from year to year?
2. What would be the effect of using the combined length-weight data (from all trips) in each assessment, rather than using trip-by-trip data?

In addressing these questions, samples from stations not used for estimating the biomass for the core strata were ignored. Also, all analyses were done separately by sex for each species, without any consideration of the question as to whether there are consistent between-sex differences (e.g., Francis (2003) found no consistent differences in mean weight at length for hoki).

### Year-to-year variation

For hoki, year-to-year variation in the length-weight relationships estimated from biological samples is so slight it is hard to see on a conventional plot (Appendix 1, Figure 1, upper panels). When the curves are plotted relative to combined relationships (calculated using data from all trips) it is apparent that the year-to-year variation is always less than 10%, and usually less than 5% (Appendix 1. Figure 1, lower panels).

Similar plots for the other main species show more variation, but this is still usually less than 10% (Appendix 2. Figure 2).

### Effect of using combined data

To examine the effect of using combined data I first calculated, for each of the 13 main species, a series of twelve estimated LFs. All of the LFs used catch and length data from the 2002 survey; they differed only in the length-weight parameters that were used. Eleven of the LFs used length-weight parameters from single trips; the twelfth LF used length-weight parameters from all trips combined. NIWA's catch-at-age software was used to generate 95% confidence intervals for this last LF using a bootstrap procedure.

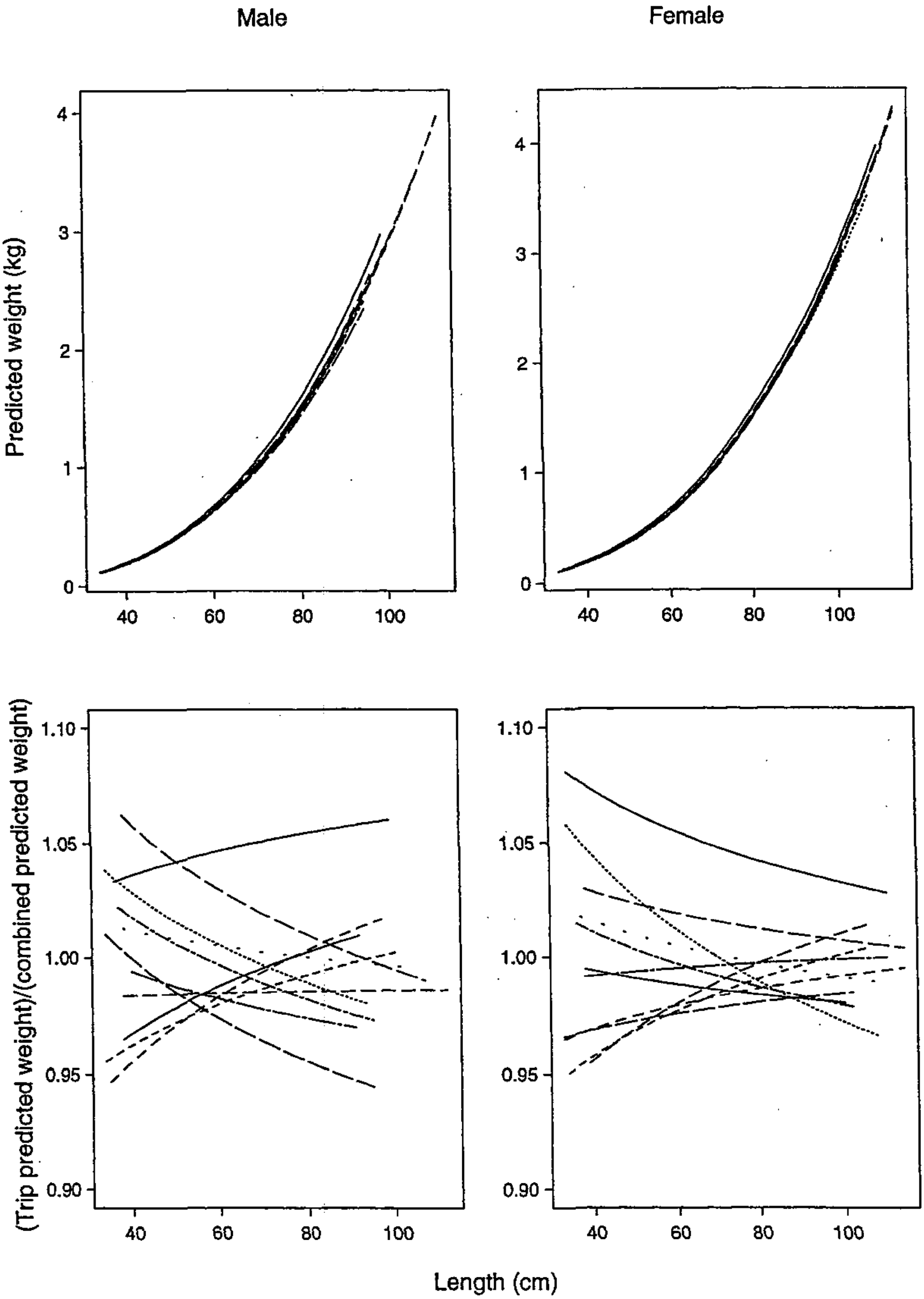
For hoki, all the single-trip LFs lay well within the 95% confidence intervals for the combined LFs (Figure 3, upper panels). In fact, all the single-trip LFs lay between the 30th and 70th percentile of the bootstrap distribution (Appendix 1, Figure 3, lower panels). This means that the uncertainty in the LFs that is associated with the biological data (the length-weight parameters) is small compared to that arising from the non-biological data (the catches and lengths). Therefore the effect of using combined length-weight parameters would be slight.

The same is true for the other 12 species (Appendix 1, Figure 4).

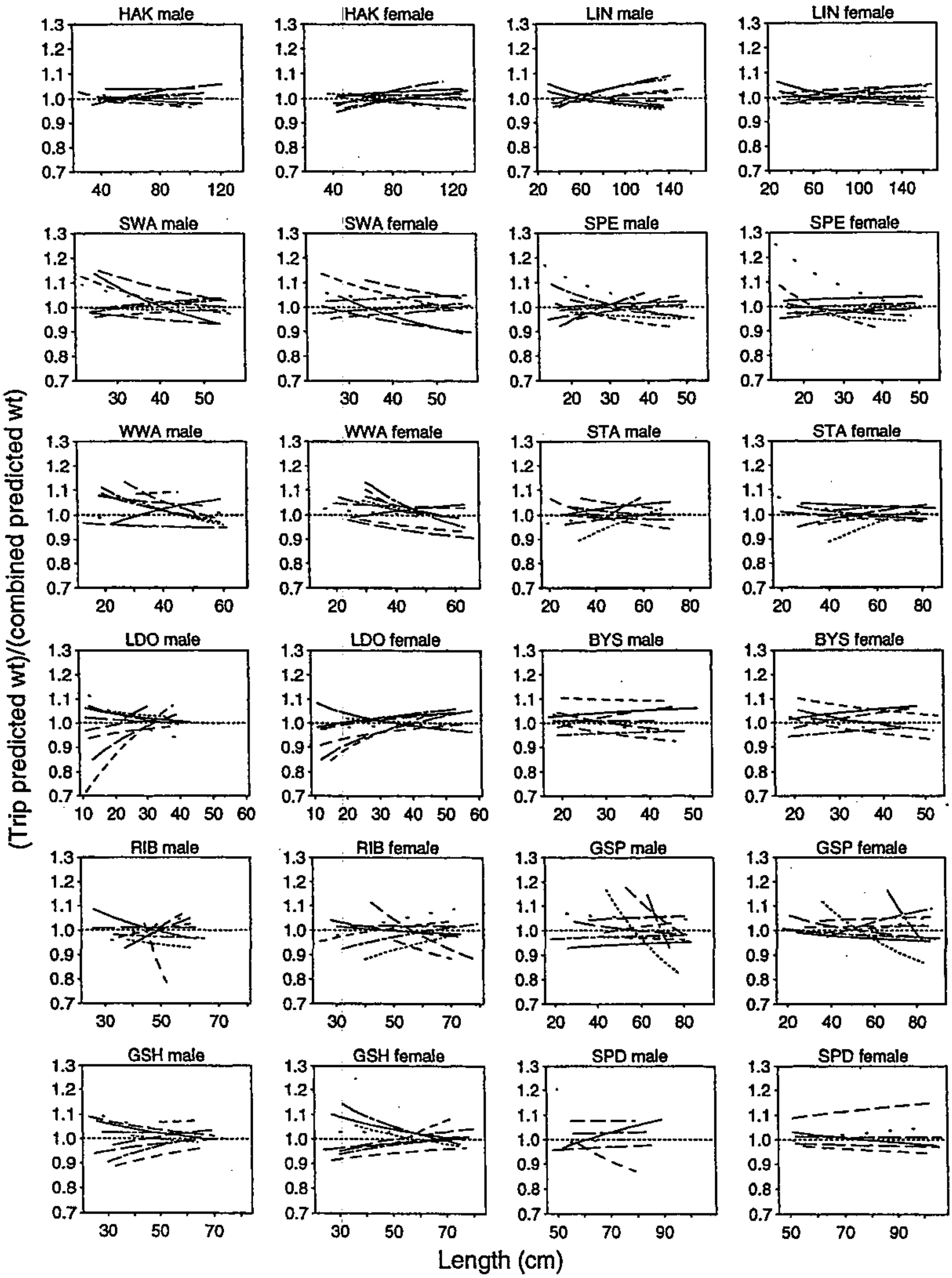
### Discussion

It was concluded that there would be no significant loss to current stock assessments if no biological data were collected in future surveys.

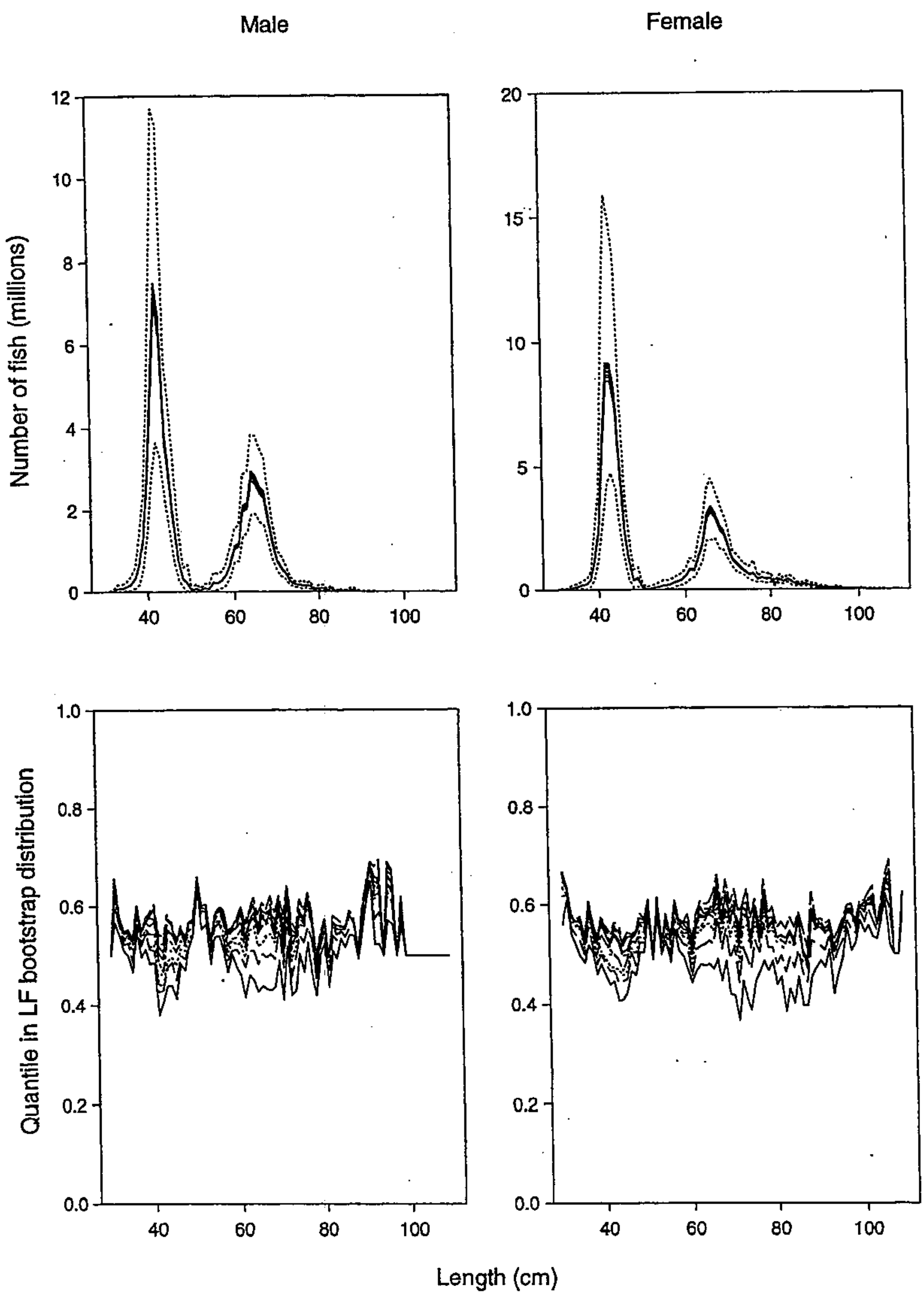
Because other projects may use these data, and because the needs of stock assessment models may change in the future, it would be a mistake to completely stop the collection of biological data. However, there is likely to be some scope for reducing target sample sizes.



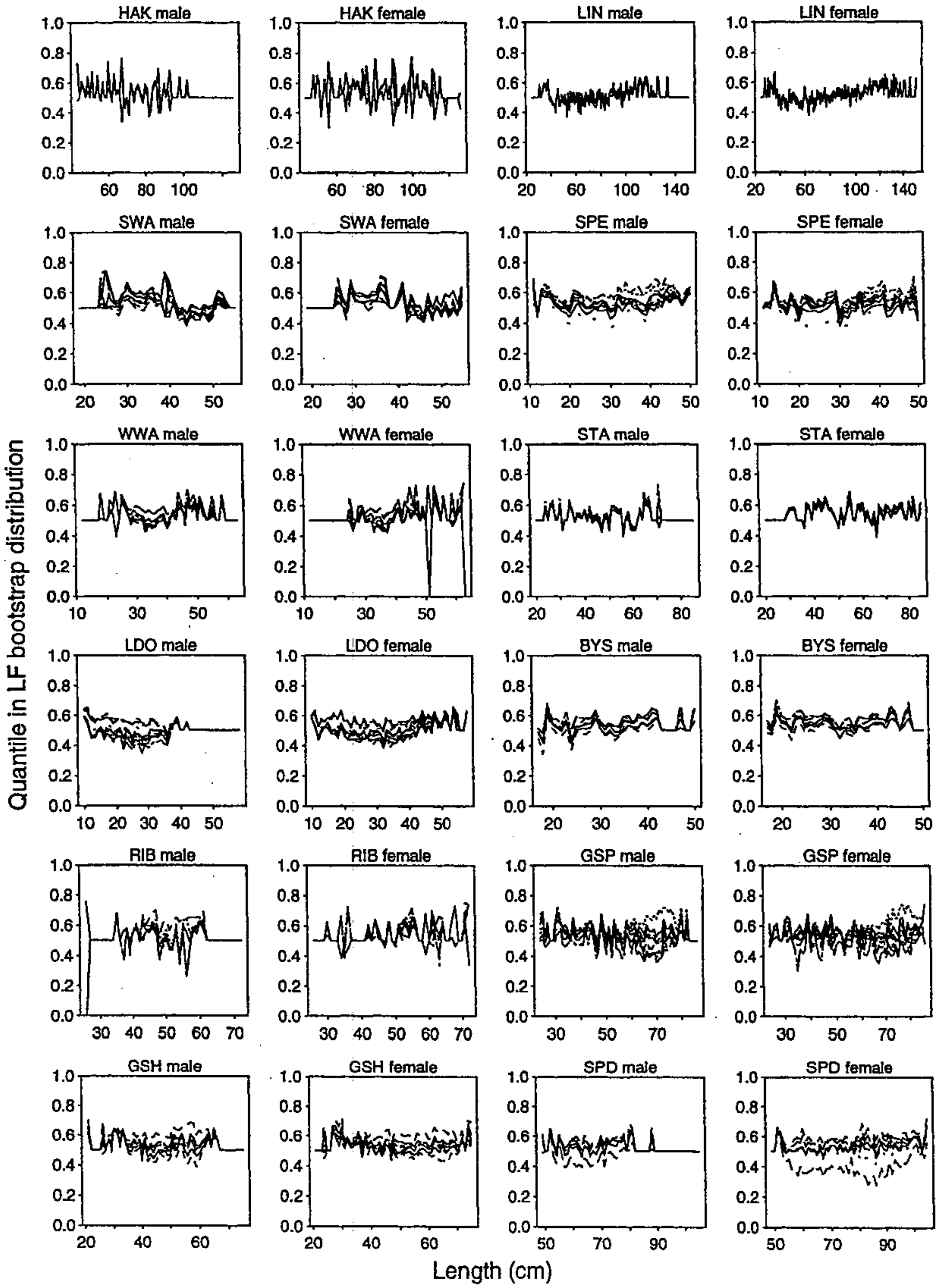

**Appendix 1, Figure 1: Year-to-year variation in the estimated length-weight relationships for hoki by sex: upper panels, conventional plots of predicted weight against length; lower panels, predicted weight at length from an individual trip divided by that from all trips combined (in all panels each line represents one trip).**




**Appendix 1, Figure 2: Year-to-year variation in the estimated length-weight relationships for twelve species by sex. In each panel each line represents the predicted weight at length from an individual trip divided by that from all trips combined (these plots are directly comparable with the lower panels in Appendix 1, Figure 1).**




**Appendix 1, Figure 3: Illustration, for hoki, of the effect of using different length-weight parameters in the calculation of LFs by sex for the 2002 survey. In the upper panels solid lines are LFs using length-weight parameters from individual trips; broken lines are 95% confidence intervals for LFs using length-weight parameters from all trips combined. Lower panels show the 11 individual-trip LFs expressed as quantiles of the bootstrap distribution for the combined-data LF.**




**Appendix 1, Figure 4: The effect of using different length-weight parameters in the calculation of LFs by sex for the 2002 survey. In each panel the 11 individual-trip LFs are plotted as quantiles of the bootstrap distribution for the combined-data LF (as in the lower panels of Figure 3). Species codes are given in Table 4.**

**Appendix 2: Individual station data for all stations conducted during the survey. P1, phase 1 trawl survey biomass stations; P2, phase 2 trawl survey biomass stations; AS, acoustic stations; NV, non-valid biomass stations; EX, an additional phase 1 trawl survey station; 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 | 2A | 29-Dec-02 | 0528 | 42 43.12 | 176 32.40 | E | 773 | 783 | 2.94 | 13.5 | 4.8 | 0 |
| 2 | NV | 8A | 29-Dec-02 | 0740 | 42 48.68 | 176 31.26 | E | 523 | 555 | 3.01 | 28.9 | 0 | 68.9 |
| 3 | P1 | 8A | 29-Dec-02 | 1019 | 42 59.19 | 176 40.02 | E | 406 | 410 | 3.05 | 169.2 | 0 | 32.2 |
| 4 | P1 | 2A | 29-Dec-02 | 1311 | 42 45.93 | 176 58.76 | E | 648 | 655 | 3 | 40.8 | 1.9 | 5.7 |
| 5 | NV | 8A | 29-Dec-02 | 1719 | 42 49.38 | 177 46.61 | E | 534 | 564 | 2.98 | 69 | 8.2 | 17.3 |
| 6 | P1 | 8B | 29-Dec-02 | 1819 | 42 54.37 | 178 00.40 | E | 413 | 416 | 2.01 | 83.7 | 4 | 21.1 |
| 7 | NV | 19 | 30-Dec-02 | 0444 | 43 03.97 | 177 06.99 | E | 330 | 341 | 3.01 | 169.4 | 0 | 23.7 |
| 8 | P1 | 19 | 30-Dec-02 | 0622 | 43 00.69 | 177 14.50 | E | 305 | 330 | 2.96 | 180.1 | 0 | 16.3 |
| 9 | P1 | 19 | 30-Dec-02 | 0818 | 43 03.81 | 177 27.77 | E | 319 | 325 | 3.05 | 189.5 | 0 | 52.3 |
| 10 | P1 | 20 | 30-Dec-02 | 1038 | 43 16.74 | 177 37.96 | E | 265 | 276 | 3 | 386.7 | 0 | 0 |
| 11 | P1 | 20 | 30-Dec-02 | 1246 | 43 12.74 | 177 48.13 | E | 293 | 328 | 3 | 883.9 | 0 | 8 |
| 12 | P1 | 20 | 30-Dec-02 | 1454 | 43 01.47 | 177 57.08 | E | 343 | 361 | 3.03 | 111.8 | 6.5 | 46.8 |
| 13 | P1 | 8B | 30-Dec-02 | 1724 | 42 56.00 | 178 17.37 | E | 457 | 486 | 3.02 | 192.1 | 8.2 | 20.5 |
| 14 | P1 | 2A | 31-Dec-02 | 0500 | 42 52.83 | 178 31.20 | E | 722 | 760 | 3 | 32.6 | 0.8 | 9.5 |
| 15 | P1 | 20 | 31-Dec-02 | 0752 | 43 05.58 | 178 53.11 | E | 372 | 378 | 3.01 | 314.5 | 0 | 107.5 |
| 16 | NV | 20 | 31-Dec-02 | 1122 | 43 13.72 | 178 27.50 | E | 371 | 390 | 2.99 | 149.5 | 6.7 | 46.6 |
| 17 | P1 | 20 | 31-Dec-02 | 1351 | 43 22.03 | 178 30.15 | E | 344 | 376 | 3 | 399.1 | 1.2 | 36.8 |
| 18 | P1 | 8B | 31-Dec-02 | 1730 | 43 23.51 | 179 08.45 | E | 400 | 409 | 3.01 | 72.9 | 0 | 25.4 |
| 19 | P1 | 10B | 1-Jan-03 | 0435 | 42 55.00 | 179 18.80 | W | 583 | 592 | 3.02 | 262 | 28.7 | 29.7 |
| 20 | P1 | 10A | 1-Jan-03 | 0917 | 43 02.01 | 179 51.41 | W | 555 | 559 | 3.01 | 78.4 | 10.9 | 42.8 |
| 21 | P1 | 8B | 1-Jan-03 | 1109 | 43 04.83 | 179 58.02 | E | 518 | 529 | 3.01 | 80.2 | 0 | 10.1 |
| 22 | P1 | 10A | 1-Jan-03 | 1458 | 43 25.73 | 179 55.36 | W | 400 | 429 | 3.04 | 69.6 | 0 | 35.1 |
| 23 | P1 | 10A | 1-Jan-03 | 1754 | 43 28.66 | 179 37.87 | W | 428 | 451 | 3.01 | 181.9 | 11 | 40.5 |
| 24 | P1 | 11B | 2-Jan-03 | 0438 | 43 14.01 | 178 32.78 | W | 429 | 463 | 3.13 | 55.5 | 0 | 12.7 |
| 25 | P1 | 11B | 2-Jan-03 | 0648 | 43 10.11 | 178 36.83 | W | 470 | 489 | 3.01 | 85.3 | 7.3 | 19.3 |
| 26 | P1 | 11A | 2-Jan-03 | 0832 | 43 16.02 | 178 41.86 | W | 440 | 452 | 3.01 | 23 | 0 | 26.2 |
| 27 | P1 | 11A | 2-Jan-03 | 1024 | 43 24.43 | 178 45.61 | W | 429 | 445 | 3 | 155.4 | 7.2 | 12.9 |
| 28 | P1 | 10B | 2-Jan-03 | 1320 | 43 37.32 | 179 05.87 | W | 400 | 407 | 3 | 124.8 | 0 | 37.7 |
| 29 | P1 | 10B | 2-Jan-03 | 1635 | 43 19.29 | 179 26.88 | W | 483 | 492 | 2.97 | 66.9 | 19.8 | 6.5 |
| 30 | P1 | 11B | 3-Jan-03 | 0450 | 42 57.21 | 178 54.27 | W | 533 | 537 | 3 | 158.1 | 0 | 9 |
| 31 | P1 | 11C | 3-Jan-03 | 0821 | 42 57.87 | 178 19.38 | W | 545 | 546 | 3.01 | 62.2 | 23.5 | 8.6 |
| 32 | P1 | 11C | 3-Jan-03 | 1103 | 42 57.65 | 177 55.69 | W | 532 | 560 | 2.99 | 407.5 | 24.9 | 49.1 |
| 33 | P1 | 11C | 3-Jan-03 | 1302 | 42 59.63 | 177 49.77 | W | 500 | 522 | 2.99 | 121.8 | 7.9 | 53.2 |
| 34 | P1 | 2B | 3-Jan-03 | 1610 | 42 55.13 | 177 22.02 | W | 646 | 660 | 2.98 | 59.3 | 0 | 21.6 |
| 35 | P1 | 2B | 3-Jan-03 | 1838 | 42 56.22 | 177 02.31 | W | 657 | 666 | 2.92 | 56.6 | 2.6 | 9.8 |
| 36 | P1 | 9 | 4-Jan-03 | 0440 | 43 21.97 | 178 13.92 | W | 372 | 392 | 2.99 | 40.7 | 0 | 55.7 |
| 37 | P1 | 9 | 4-Jan-03 | 0632 | 43 22.19 | 178 08.32 | W | 369 | 374 | 2.52 | 213.3 | 4.2 | 10.9 |
| 38 | P1 | 11A | 4-Jan-03 | 1011 | 43 27.86 | 178 13.30 | W | 405 | 422 | 3.04 | 197.6 | 3.9 | 78.9 |
| 39 | P1 | 9 | 4-Jan-03 | 1426 | 43 24.40 | 177 33.56 | W | 300 | 323 | 3.24 | 0 | 0 | 0 |
| 40* | P1 | 9 | 4-Jan-03 | 1748 | 43 16.13 | 176 56.35 | W | 270 | 330 | 1.45 | NR | NR | NR |
| 41 | P1 | 9 | 4-Jan-03 | 1849 | 43 16.72 | 176 56.51 | W | 273 | 285 | 2.01 | 31.2 | 0 | 0 |
| 42 | P1 | 11D | 5-Jan-03 | 0430 | 43 12.58 | 176 07.08 | W | 482 | 514 | 3.06 | 53.4 | 8.4 | 29.4 |
| 43 | P1 | 9 | 5-Jan-03 | 0703 | 43 27.62 | 176 07.71 | W | 302 | 312 | 3.03 | 481.7 | 0 | 0 |
| 44 | P1 | 9 | 5-Jan-03 | 0901 | 43 33.86 | 176 02.70 | W | 215 | 222 | 3.01 | 0 | 0 | 0 |

## Appendix 2 (continued)

| Stn. | Type | Strat. | Date | Time NZST | Start of tow Latitude ° ' S | Start of tow Longitude ° ' | E/W | Depth (m) min. | Depth (m) max. | Dist. towed (n. mile) | Catch (kg) hoki | Catch (kg) hake | Catch (kg) ling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | P1 | 11D | 5-Jan-03 | 1225 | 43 23.53 | 175 40.35 | W | 464 | 505 | 2.99 | 254.2 | 0 | 25.1 |
| 47 | P1 | 11D | 5-Jan-03 | 1736 | 43 16.22 | 175 52.07 | W | 533 | 540 | 2.92 | 63.8 | 0 | 14.4 |
| 48 | P1 | 2B | 6-Jan-03 | 0443 | 43 27.15 | 174 38.43 | W | 773 | 782 | 3 | 10.6 | 4.3 | 7.3 |
| 49 | MW | | 6-Jan-03 | 1002 | 44 07.02 | 174 34.04 | W | 600 | 667 | 4.35 | 353.1 | 0 | 0 |
| 50 | MW | | 6-Jan-03 | 1242 | 44 09.01 | 174 35.52 | W | 515 | 735 | 2.54 | 160.3 | 0 | 0 |
| 51 | P1 | 9 | 6-Jan-03 | 1757 | 43 56.01 | 175 22.49 | W | 205 | 238 | 3.01 | 0 | 0 | 0 |
| 52 | P1 | 12 | 7-Jan-03 | 0453 | 44 15.58 | 177 40.55 | W | 511 | 514 | 3.01 | 189.9 | 0 | 54.7 |
| 53 | P1 | 12 | 7-Jan-03 | 0737 | 44 10.46 | 177 23.97 | W | 444 | 455 | 3 | 244.2 | 11.7 | 84.9 |
| 54 | P1 | 12 | 7-Jan-03 | 0938 | 44 07.83 | 177 20.93 | W | 407 | 415 | 3 | 440.9 | 0 | 34.1 |
| 55 | P1 | 5 | 7-Jan-03 | 1223 | 44 03.97 | 177 05.96 | W | 235 | 247 | 3.01 | 0 | 0 | 0 |
| 56 | P1 | 5 | 7-Jan-03 | 1628 | 43 34.89 | 177 27.39 | W | 275 | 287 | 2.03 | 108.2 | 0 | 2.5 |
| 57 | P1 | 5 | 9-Jan-03 | 0432 | 43 30.25 | 178 04.41 | W | 366 | 379 | 3 | 197.6 | 0 | 61.7 |
| 58 | P1 | 13 | 9-Jan-03 | 0809 | 43 48.39 | 178 26.52 | W | 431 | 446 | 3 | 329.8 | 8 | 64.6 |
| 59 | P1 | 13 | 9-Jan-03 | 1050 | 44 06.25 | 178 31.28 | W | 452 | 469 | 3.01 | 159.7 | 0 | 68.2 |
| 60* | P1 | 13 | 9-Jan-03 | 1457 | 44 17.33 | 179 11.62 | W | 584 | 594 | 0.87 | NR | NR | NR |
| 61 | P1 | 3 | 9-Jan-03 | 1805 | 44 01.94 | 178 59.30 | W | 328 | 368 | 3.06 | 410.3 | 0 | 131.6 |
| 62 | P1 | 3 | 10-Jan-03 | 0436 | 43 48.98 | 179 17.18 | W | 324 | 344 | 3.04 | 218 | 11.3 | 6.2 |
| 63 | P1 | 3 | 10-Jan-03 | 0636 | 43 47.46 | 179 29.24 | W | 324 | 331 | 3 | 234.9 | 0 | 24.4 |
| 64 | P1 | 13 | 10-Jan-03 | 0907 | 43 55.37 | 179 45.53 | W | 405 | 420 | 3 | 84.4 | 9.5 | 33.1 |
| 65 | P1 | 14 | 10-Jan-03 | 1115 | 43 53.51 | 179 58.26 | E | 430 | 450 | 3 | 120.1 | 11.9 | 37.5 |
| 66 | P1 | 4 | 10-Jan-03 | 1726 | 44 03.20 | 178 49.11 | E | 771 | 789 | 2.98 | 60.9 | 6.5 | 5.1 |
| 67 | P1 | 14 | 11-Jan-03 | 0720 | 43 43.57 | 178 21.26 | E | 407 | 423 | 3.01 | 182.1 | 0 | 62 |
| 68 | P1 | 14 | 11-Jan-03 | 0934 | 43 50.80 | 178 28.77 | E | 479 | 529 | 3 | 422.5 | 2 | 95.7 |
| 69 | P1 | 4 | 11-Jan-03 | 1158 | 43 59.08 | 178 16.79 | E | 760 | 777 | 3 | 45.1 | 0 | 4.2 |
| 70 | P1 | 15 | 11-Jan-03 | 1547 | 43 51.33 | 177 38.98 | E | 580 | 592 | 2.98 | 141.3 | 5 | 65.3 |
| 71 | P1 | 4 | 12-Jan-03 | 0454 | 44 11.86 | 176 35.08 | E | 650 | 653 | 3.02 | 37.4 | 0 | 20.6 |
| 72 | P1 | 15 | 12-Jan-03 | 0754 | 43 58.94 | 176 25.03 | E | 502 | 540 | 3 | 177.5 | 0 | 54.7 |
| 73 | P1 | 17 | 12-Jan-03 | 1057 | 44 03.21 | 175 58.77 | E | 300 | 386 | 3 | 2241.9 | 0 | 18.6 |
| 74 | P1 | 17 | 12-Jan-03 | 1256 | 44 05.82 | 176 05.49 | E | 310 | 343 | 3 | 1145.7 | 0 | 27.1 |
| 75 | P1 | 17 | 12-Jan-03 | 1523 | 44 14.52 | 176 13.91 | E | 275 | 357 | 3 | 29.1 | 0 | 0.5 |
| 76 | P1 | 17 | 12-Jan-03 | 1746 | 44 21.65 | 176 06.23 | E | 299 | 346 | 2.51 | 73.9 | 0 | 6.1 |
| 77 | P1 | 6 | 13-Jan-03 | 0449 | 44 39.18 | 175 14.85 | E | 771 | 791 | 3.04 | 2 | 0 | 0 |
| 78 | P1 | 6 | 13-Jan-03 | 0921 | 44 26.33 | 174 25.47 | E | 712 | 720 | 3.01 | 54.3 | 0 | 20.6 |
| 79 | P1 | 6 | 13-Jan-03 | 1424 | 44 37.00 | 173 32.75 | E | 750 | 776 | 3.01 | 39.6 | 0 | 0 |
| 80 | P1 | 16 | 14-Jan-03 | 0448 | 44 01.72 | 174 10.82 | E | 522 | 537 | 3 | 66.6 | 3.4 | 46.5 |
| 81 | P1 | 16 | 14-Jan-03 | 0706 | 43 52.87 | 174 05.62 | E | 418 | 427 | 3.01 | 157 | 0 | 32.7 |
| 82 | P1 | 1 | 14-Jan-03 | 1252 | 43 08.62 | 174 04.37 | E | 666 | 673 | 3 | 56.4 | 3.7 | 52.6 |
| 83 | P1 | 7 | 14-Jan-03 | 1607 | 43 18.62 | 174 26.53 | E | 532 | 548 | 2.99 | 112.6 | 43.1 | 90.8 |
| 84 | P1 | 7 | 14-Jan-03 | 1812 | 43 15.43 | 174 31.29 | E | 520 | 527 | 3 | 34.5 | 22.9 | 199.2 |
| 85 | P1 | 18 | 15-Jan-03 | 0503 | 43 00.76 | 175 14.06 | E | 310 | 370 | 2.51 | 237.4 | 0 | 72.6 |
| 86 | P1 | 7 | 15-Jan-03 | 0642 | 43 00.51 | 175 05.50 | E | 424 | 442 | 3 | 134.2 | 0 | 115.9 |
| 87 | P1 | 7 | 15-Jan-03 | 0905 | 43 06.09 | 174 51.26 | E | 438 | 469 | 3.01 | 37.1 | 3.5 | 0 |
| 88 | P1 | 7 | 15-Jan-03 | 1055 | 43 04.54 | 174 40.98 | E | 537 | 574 | 3.01 | 52.6 | 2.1 | 31.6 |
| 89 | P1 | 1 | 15-Jan-03 | 1246 | 43 04.83 | 174 32.72 | E | 600 | 629 | 3.01 | 30.7 | 17.5 | 70 |
| 90 | P1 | 1 | 15-Jan-03 | 1456 | 42 59.58 | 174 34.40 | E | 750 | 778 | 2.96 | 2 | 0 | 33.3 |

## Appendix 2 (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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | P1 | 18 | 15-Jan-03 | 1815 | 43 21.15 | 174 46.61 | E | 358 | 372 | 2.34 | 757.5 | 0 | 11.4 |
| 92 | P1 | 7 | 16-Jan-03 | 0457 | 43 35.50 | 174 37.66 | E | 477 | 503 | 2.99 | 262.5 | 47.5 | 86.3 |
| 93 | P1 | 18 | 16-Jan-03 | 0746 | 43 36.77 | 175 03.61 | E | 315 | 333 | 3.02 | 1034.4 | 0 | 6.4 |
| 94 | P1 | 18 | 16-Jan-03 | 1000 | 43 37.51 | 175 24.85 | E | 269 | 282 | 3 | 374.5 | 0 | 0 |
| 95 | P1 | 18 | 16-Jan-03 | 1222 | 43 38.04 | 175 41.70 | E | 270 | 285 | 3 | 137.1 | 0 | 0 |
| 96 | P1 | 16 | 16-Jan-03 | 1610 | 44 01.83 | 175 31.81 | E | 508 | 532 | 3.02 | 230.7 | 21.9 | 216.8 |
| 97 | P1 | 18 | 17-Jan-03 | 0454 | 43 30.32 | 175 45.74 | E | 274 | 309 | 3.01 | 554.2 | 0 | 0.1 |
| 98 | P1 | 18 | 17-Jan-03 | 0640 | 43 24.11 | 175 42.48 | E | 240 | 283 | 3 | 93.3 | 0 | 20.2 |
| 99 | P1 | 18 | 17-Jan-03 | 0822 | 43 32.11 | 175 40.69 | E | 258 | 265 | 3.01 | 16.3 | 0 | 0 |
| 100 | P1 | 19 | 17-Jan-03 | 1104 | 43 36.44 | 176 02.15 | E | 330 | 341 | 3.01 | 796.4 | 0 | 10.5 |
| 101 | P1 | 19 | 17-Jan-03 | 1254 | 43 33.91 | 176 12.36 | E | 339 | 362 | 2.99 | 1575.3 | 0 | 2.5 |
| 102 | P1 | 15 | 17-Jan-03 | 1505 | 43 42.75 | 176 23.99 | E | 404 | 427 | 3.03 | 1347.1 | 0 | 30.7 |
| 103 | P1 | 19 | 17-Jan-03 | 1802 | 43 31.44 | 176 46.59 | E | 246 | 262 | 3 | 1036.1 | 0 | 0 |
| 104 | P1 | 19 | 18-Jan-03 | 0447 | 43 17.30 | 176 17.24 | E | 319 | 339 | 3.08 | 591.9 | 0 | 9.7 |
| 105* | P1 | 19 | 18-Jan-03 | 0702 | 43 11.29 | 176 04.08 | E | 386 | 388 | 2.8 | NR | NR | NR |
| 106 | P1 | 19 | 18-Jan-03 | 0852 | 43 07.72 | 176 13.37 | E | 368 | 374 | 3.01 | 664.2 | 0 | 31 |
| 107 | P1 | 19 | 18-Jan-03 | 1112 | 43 08.77 | 176 33.42 | E | 300 | 311 | 3 | 5116.5 | 0 | 0.6 |
| 108 | P1 | 19 | 18-Jan-03 | 1328 | 43 09.00 | 176 54.14 | E | 279 | 291 | 2.99 | 2110.7 | 0 | 3 |
| 109 | P1 | 19 | 18-Jan-03 | 1520 | 43 04.43 | 177 06.02 | E | 319 | 344 | 2.98 | 556 | 1.6 | 4.8 |
| 110 | P1 | 8A | 18-Jan-03 | 1752 | 42 52.95 | 176 56.25 | E | 408 | 422 | 3.06 | 33.5 | 0 | 23.9 |
| 111 | P1 | 20 | 19-Jan-03 | 0457 | 43 34.38 | 177 43.97 | E | 377 | 394 | 3 | 410.3 | 0 | 26.3 |
| 112 | P1 | 20 | 19-Jan-03 | 0735 | 43 28.36 | 178 08.99 | E | 334 | 343 | 3.01 | 697.1 | 0 | 4.4 |
| 113 | P1 | 20 | 19-Jan-03 | 1016 | 43 14.85 | 178 24.67 | E | 369 | 382 | 3 | 539.6 | 0 | 19.6 |
| 114 | P1 | 20 | 19-Jan-03 | 1310 | 43 17.45 | 178 05.84 | E | 314 | 328 | 3.02 | 556.3 | 0 | 1.1 |
| 115 | P1 | 20 | 19-Jan-03 | 1509 | 43 09.67 | 177 55.58 | E | 351 | 387 | 2.99 | 309.5 | 0 | 66.4 |
| 116 | P1 | 8A | 19-Jan-03 | 1757 | 42 51.08 | 177 49.02 | E | 471 | 568 | 3 | 27.1 | 0 | 50.6 |
| 117 | P2 | 19 | 20-Jan-03 | 0453 | 43 21.52 | 176 12.20 | E | 313 | 353 | 2.99 | 401 | 8.8 | 15.3 |
| 118 | P2 | 19 | 20-Jan-03 | 0715 | 43 18.01 | 176 34.35 | E | 259 | 265 | 3.01 | 410.9 | 0 | 0 |
| 119 | P2 | 19 | 20-Jan-03 | 0934 | 43 27.17 | 176 43.49 | E | 249 | 262 | 3 | 0.6 | 0 | 0 |
| 120 | P2 | 15 | 20-Jan-03 | 1204 | 43 41.73 | 176 31.69 | E | 404 | 429 | 3.01 | 1290.9 | 4.4 | 44.8 |
| 121 | P2 | 15 | 20-Jan-03 | 1411 | 43 53.29 | 176 31.98 | E | 478 | 497 | 3.02 | 586.8 | 4.5 | 111.9 |
| 122 | P2 | 15 | 20-Jan-03 | 1613 | 44 04.29 | 176 25.90 | E | 535 | 598 | 3.03 | 379.3 | 2.6 | 53.5 |
| 123 | P2 | 16 | 21-Jan-03 | 0456 | 44 02.29 | 174 28.27 | E | 558 | 574 | 3.04 | 64.1 | 3.1 | 38.5 |
| 124 | P2 | 16 | 21-Jan-03 | 0656 | 43 56.77 | 174 37.68 | E | 509 | 529 | 2.99 | 148 | 3.3 | 63 |
| 125 | P2 | 16 | 21-Jan-03 | 0914 | 43 49.16 | 174 54.32 | E | 450 | 460 | 3 | 319.3 | 18.5 | 36 |

* Foul trawl stations

NR Catch not recorded on foul trawl stations

**Appendix 3: Scientific and common names of species caught from valid biomass tows. Occurrence of each species (number of tows in which caught) in the 115 valid biomass tows. (Note that codes are continually updated on the database following this and other surveys.)**

| Scientific name | Common name | Code | Occ. |
|---|---|---|---|
| **Algae** | unspecified seaweed | SEO | 5 |
| | | | |
| **Porifera** | sponges | ONG | 47 |
| | | | |
| **Cnidaria** | | | |
| Scyphozoa (jellyfish) | unspecified jellyfish | JFI | 16 |
| | | | |
| **Hydrozoa** | | | |
| Coral (Hydrozoan + Anthozoan corals) | unspecified coral | COU | 31 |
| | | | |
| **Anthozoa** | | | |
| Pennatulacea (sea pens) | unspecified sea pens | SPN | 18 |
| Actinaria (sea anemones) | unspecified sea anemones | ANT | 47 |
| | | | |
| **Tunicata** | | | |
| Thaliacea (salps) | unspecified salps | SAL | 1 |
| *Pyrosoma atlanticum* | | PYR | 80 |
| | | | |
| **Annelida** | | | |
| Polychaeta | unspecified polychaete | POL | 1 |
| | | | |
| **Mollusca** | | | |
| Gastropoda (gastropods) | unspecified gastropods | GAS | 4 |
| Cymatiidae | | | |
| *Fusitriton magellanicus* | | FMA | 34 |
| Volutidae | | | |
| *Provocator mirabilis* | golden volute | GVO | 2 |
| Buccinidae | | | |
| *Penion* sp. | | | 2 |
| | | | |
| Bivalvia (bivalves) | unspecified bivalves | BIV | 4 |
| | | | |
| Cephalopoda | | | |
| Teuthoidea (squids) | | | |
| Ommastrephidae | | | |
| *Nototodarus sloanii* | arrow squid | NOS | 65 |
| *Todarodes filippovae* | Antarctic flying squid | TSQ | 20 |
| Onchoteuthidae | | | |
| *Moroteuthis ingens* | warty squid | MIQ | 40 |
| *M. robsoni* | warty squid | MRQ | 1 |
| Octopoda (octopods) | | OCP | 4 |
| Octopodidae | | | |
| *Enteroctopus zealandicus* | yellow octopus | EZE | 2 |
| *Graneledone* spp. | deepwater octopus | DWO | 8 |
| Opisthoteuthididae | | | |
| *Opisthoteuthis* spp. | umbrella octopus | OPI | 2 |

## Appendix 3 (continued)

| Scientific name | Common name | Code | Occ. |
|---|---|---|---|
| **Crustacea** | | | |
| Dendrobranchiata/Pleocyemata (prawns) | | | |
| Caridea | | | |
| Alpheidae (snapping shrimps) | | | |
| *Alpheus socialis* | snapping shrimp | | 1 |
| Nematocarcinidae | | | |
| *Lipkius holthuisi* | omega prawn | LHO | 16 |
| Oplophoridae | | | |
| *Oplophorus novaezeelandiae* | prawn | ONO | 2 |
| Pasiphaeidae | | | |
| *Pasiphaea* spp. | prawn | PAS | 4 |
| Penaeidea | | | |
| Sergestidae | | | |
| *Sergia potens* | prawn | SEP | 1 |
| Astacidea | | | |
| Nephropidae (clawed lobsters) | | | |
| *Metanephrops challengeri* | scampi | SCI | 61 |
| Palinura | | | |
| Polychelidae | | | |
| *Polycheles suhmi* | polychelid | PLY | 4 |
| Crab (Anomuran + Brachyuran crabs) | unspecified crabs | CRB | 15 |
| Anomura | | | |
| Galatheidae (squat lobsters) | | | |
| *Munida* sp. | | MUN | 6 |
| Lithodidae (king crabs) | | | |
| *Lithodes murrayi* | southern stone crab | LMU | 1 |
| *Neolithodes brodiei* | | NEB | 2 |
| *Paralomis hystrix* | | PHS | 2 |
| Parapaguridae (Parapagurid hermit crabs) | | | |
| *Parapagurus dimorphus* | hermit crab | PAG | 31 |
| Axiidae | | | |
| *Spongaxius novaezelandiae* | | | 1 |
| Brachyura | | | |
| Homolidae | | | |
| *Paromola petterdi* | antlered crab | ATC | 18 |
| Portunidae (swimming crabs) | | | |
| *Ovalipes molleri* | swimming crab | OVM | 2 |
| Majidae (spider crabs) | | | |
| *Leptomithrax* sp. | masking crab | SSC | 7 |
| **Bryozoa** (bryozoans) | | COZ | 2 |
| **Brachiopoda** (lamp shells) | | BPD | 1 |
| **Echinodermata** | | | |
| Asteroidea (starfish) | unspecified asteroid | ASR | 58 |
| Astropectinidae | | | |
| *Plutonaster* spp. | starfish | PLT | 19 |
| *Psilaster acuminatus* | geometric star | PSI | 58 |

## Appendix 3 (continued)

| Scientific name | Common name | Code | Occ. |
|---|---|---|---|
| Goniasteridae | | | |
| *Hippasteria trojana* | trojan star | HTR | 7 |
| *Mediaster sladeni* | starfish | MSL | 15 |
| Odontasteridae | | | |
| *Odontaster* spp. | pentagonal tooth-star | ODT | 3 |
| Solasteridae | | | |
| *Crossaster japonicus* | sun star | CJA | 27 |
| *Solaster torulatus* | starfish | SOT | 9 |
| Velatida | | | |
| *Peribolaster lictor* | starfish | PLI | 3 |
| Zoroasteridae | | | |
| *Zoroaster* spp. | rat-tail star | ZOR | 35 |
| Holothuroidea (sea cucumbers) | unspecified holothruian | HTH | 31 |
| holothurian sp.1 | sea cucumber | SCC | 11 |
| Ophiuroidea (basket and brittle stars) | unspecified ophiuroid | OPH | 3 |
| Euryalina (basket stars) | | | |
| Gorgonocephalidae | | | |
| *Gorgonocephalus* sp. | basket star | GOR | 13 |
| Echinoidea (sea urchins) | | | |
| Regularia | | | |
| Cidaridae (cidarid urchins) | | | |
| *Goniocidaris parasol* | cidarid urchin | GPA | 11 |
| *G. umbraculum* | cidarid urchin | GOU | 2 |
| Echinothuriidae (Tam-o-shanter urchins) | | TAM | 24 |
| *Araeosoma* spp. | Tam o'shanter urchin | ARA | 11 |
| Echinidae | | | |
| *Gracilechinus multidentatus* | sea urchin | GRM | 11 |
| *Dermechinus horridus* | sea urchin | DHO | 7 |
| Spatangidae (heart urchins) | | | |
| *Paramaretia multituberculata* | heart urchin | PMU | 22 |
| **Agnatha** (jawless fishes) | | | |
| Myxinidae: hagfishes | | | |
| *Eptatretus cirrhatus* | hagfish | HAG | 1 |
| **Chondrichthyes** (cartilagenous fishes) | | | |
| Chlamydoselachidae: frill shark | | | |
| *Chlamydoselachus anguineus* | frill shark | FRS | 1 |
| Squalidae: dogfishes | | | |
| *Centrophorus squamosus* | leafscale gulper shark | CSQ | 8 |
| *Centroscymnus crepidater* | longnose velvet dogfish | CYP | 14 |
| *C. owstoni* | smoothskin dogfish | CYO | 2 |
| *C. plunketi* | Plunket's shark | PLS | 7 |
| *Deania calcea* | shovelnose dogfish | SND | 31 |
| *Etmopterus baxteri* | Baxter's dogfish | ETB | 19 |
| *E. lucifer* | Lucifer dogfish | ETL | 58 |
| *Scymnorhinus licha* | seal shark | BSH | 25 |
| *Squalus acanthias* | spiny dogfish | SPD | 76 |
| *S. mitsukurii* | northern spiny dogfish | NSD | 7 |

## Appendix 3 (continued)

| Scientific name | Common name | Code | Occ. |
|---|---|---|---|
| Oxynotidae: rough sharks | | | |
| *Oxynotus bruniensis* | prickly dogfish | PDG | 10 |
| Scyliorhinidae: cat sharks | | | |
| *Apristurus* spp. | deepsea catsharks | APR | 5 |
| *Cephaloscyllium isabellum* | carpet shark | CAR | 4 |
| *Halaelurus dawsoni* | Dawson's catshark | DCS | 4 |
| Triakidae: smoothhounds | | | |
| *Galeorhinus galeus* | school shark | SCH | 6 |
| Torpedinidae: electric rays | | | |
| *Torpedo fairchildi* | electric ray | ERA | 3 |
| Narkidae: blind electric rays | | | |
| *Typhlonarke* spp. | numbfish | BER | 4 |
| Rajidae: skates | | | |
| *Amblyraja georgiana* | Antarctic starry skate | SRR | 1 |
| *Dipturus innominatus* | smooth skate | SSK | 43 |
| *D. nasutus* | rough skate | RSK | 3 |
| *Notoraja asperula* | | BTA | 26 |
| *N. spinifera* | | BTS | 19 |
| Chimaeridae: chimaeras, ghost sharks | | | |
| *Hydrolagus novaezealandiae* | ghost shark | GSH | 74 |
| *Hydrolagus* sp. B | pale ghost shark | GSP | 63 |
| Rhinochimaeridae: longnosed chimaeras | | | |
| *Harriotta raleighana* | long-nosed chimaera | LCH | 42 |
| *Rhinochimaera pacifica* | widenosed chimaera | RCH | 6 |
| | | | |
| **Osteichthyes (bony fishes)** | | | |
| Halosauridae: halosaurs | | | |
| *Halosaurus pectoralis* | common halosaur | HPE | 1 |
| Notocanthidae: spiny eels | | | |
| *Notacanthus sexspinis* | spineback | SBK | 44 |
| Synaphobranchidae: cutthroat eels | | | |
| *Diastobranchus capensis* | basketwork eel | BEE | 4 |
| Congridae: conger eels | | | |
| *Bassanago bulbiceps* | swollenhead conger | SCO | 38 |
| *B. hirsutus* | hairy conger | HCO | 25 |
| Gonorynchidae: sandfish | | | |
| *Gonorynchus forsteri* | sandfish | GON | 1 |
| Argentinidae: silversides | | | |
| *Argentina elongata* | silverside | SSI | 71 |
| Bathylagidae: deepsea smelts | | | |
| *Bathylagus* spp. | deepsea smelt | DSS | 1 |
| Alepocephalidae: slickheads | | | |
| *Xenodermichthys* spp. | black slickhead | BSL | 4 |
| Sternoptychidae: hatchetfishes | | | |
| *Argyropelecus gigas* | giant hatchetfish | AGI | 2 |
| Photichthyidae: lighthouse fishes | | | |
| *Photichthys argenteus* | lighthouse fish | PHO | 17 |
| Chauliodontidae: viperfishes | | | |
| *Chauliodus sloani* | viper fish | CHA | 3 |

## Appendix 3 (continued)

| Scientific name | Common name | Code | Occ. |
|---|---|---|---|
| Melanostomiidae: scaleless black dragonfishes | | MST | 1 |
| Chlorophthalmidae: cucumberfishes, tripodfishes | | | |
| *Chlorophthalmus nigripinnis* | cucumberfish | CUC | 2 |
| Notosudidae: waryfishes | | | |
| *Scopelosaurus* sp. | | SPL | 2 |
| Paralepididae: barracudinas | | PAL | 1 |
| Myctophidae: lanternfishes | | LAN | 6 |
| *Lampanyctus* spp. | lanternfish | LPA | 1 |
| Moridae: morid cods | morid cods | MOD | 1 |
| *Antimora rostrata* | violet cod | VCO | 1 |
| *Austrophycis marginata* | dwarf cod | DCO | 2 |
| *Halargyreus johnsonii* | slender cod | HJO | 11 |
| *Laemonema* sp. | | LAE | 1 |
| *Lepidion microcephalus* | small-headed cod | SMC | 4 |
| *Mora moro* | ribaldo | RIB | 33 |
| *Physiculus luminosa* | luminescent cod | PLU | 1 |
| *Pseudophycis bachus* | red cod | RCO | 32 |
| *Tripterophycis gilchristi* | grenadier cod | GRC | 6 |
| Gadidae: true cods | | | |
| *Micromesistius australis* | southern blue whiting | SBW | 3 |
| Merlucciidae: hakes | | | |
| *Macruronus novaezelandiae* | hoki | HOK | 111 |
| *Merluccius australis* | hake | HAK | 46 |
| Macrouridae: rattails, grenadiers | | | |
| *Caelorinchus aspercephalus* | oblique banded rattail | CAS | 67 |
| *C. biclinozonalis* | two saddle rattail | CBI | 18 |
| *C. bollonsi* | bigeye rattail | CBO | 95 |
| *C. fasciatus* | banded rattail | CFA | 28 |
| *C. innotabilis* | notable rattail | CIN | 8 |
| *C. matamua* | Mahia rattail | CMA | 6 |
| *C. maurofasciatus* | dark banded rattail | CDX | 1 |
| *C. oliverianus* | Oliver's rattail | COL | 60 |
| *C. parvifasciatus* | small banded rattail | CCX | 33 |
| *Coryphaenoides dossenus* | long barbel rattail | CBA | 6 |
| *C serrulatus* | serrulate rattail | CSE | 8 |
| *C subserrulatus* | four-rayed rattail | CSU | 8 |
| *Lepidorhynchus denticulatus* | javelinfish | JAV | 108 |
| *Macrourus carinatus* | ridge scaled rattail | MCA | 4 |
| *Trachyrincus aphyodes* | white rattail | WHX | 5 |
| *Ventrifossa nigromaculata* | blackspot rattail | VNI | 29 |
| Ophidiidae: cusk eels | | | |
| *Genypterus blacodes* | ling | LIN | 98 |
| Trachipteridae: dealfishes | | | |
| *Trachipterus trachypterus* | dealfish | DEA | 4 |
| Trachichthyidae: roughies | | | |
| *Hoplostethus atlanticus* | orange roughy | ORH | 3 |
| *H. mediterraneus* | silver roughy | SRH | 38 |
| *Paratrachichthys trailli* | common roughy | RHY | 14 |

## Appendix 3 (continued)

| Scientific name | Common name | Code | Occ. |
| --- | --- | --- | --- |
| Diretmidae: discfishes | | | |
| *Diretmus argenteus* | discfish | DIS | 1 |
| Berycidae: alfonsinos | | | |
| *Beryx decadactylus* | longfinned beryx | BYD | 2 |
| *B splendens* | alfonsino | BYS | 40 |
| Zeidae: dories | | | |
| *Capromimus abbreviatus* | capro dory | CDO | 25 |
| *Cyttus novaezealandiae* | silver dory | SDO | 29 |
| *C. traversi* | lookdown dory | LDO | 107 |
| *Zenopsis nebulosus* | mirror dory | MDO | 2 |
| Oreosomatidae: oreos | | | |
| *Allocyttus niger* | black oreo | BOE | 7 |
| *Neocyttus rhomboidalis* | spiky oreo | SOR | 13 |
| *Pseudocyttus maculatus* | smooth oreo | SSO | 7 |
| Macrorhamphosidae: snipefishes | | | |
| *Centriscops humerosus* | banded bellowsfish | BBE | 84 |
| *Notopogon lilliei* | crested bellowsfish | CBE | 5 |
| Scorpaenidae: scorpionfishes | | | |
| *Helicolenus* spp. | sea perch | SPE | 98 |
| Congiopoidae: pigfishes | | | |
| *Alertichthys blacki* | alert pigfish | API | 5 |
| *Congiopodus coriaceus* | deepsea pigfish | DSP | 2 |
| Triglidae: gurnards | | | |
| *Lepidotrigla brachyoptera* | scaly gurnard | SCG | 18 |
| Hoplichthyidae: ghostflatheads | | | |
| *Hoplichthys haswelli* | deepsea flathead | FHD | 52 |
| Psychrolutidae: toadfishes | | | |
| *Ambophthalmos angustus* | pale toadfish | TOP | 41 |
| *Cottunculus nudus* | bonyskull toadfish | COT | 2 |
| Percichthyidae: temperate basses | | | |
| *Polyprion americanus* | bass | BAS | 1 |
| *P. oxygeneios* | hapuku | HAP | 18 |
| Serranidae: sea perches | | | |
| Lepidoperca aurantia | orange perch | OPE | 19 |
| Apogonidae: cardinalfishes | | | |
| *Epigonus lenimen* | bigeye cardinalfish | EPL | 13 |
| *E. robustus* | robust cardinalfish | EPR | 11 |
| *E. telescopus* | deepsea cardinalfish | EPT | 21 |
| Carangidae: jacks, trevallies, kingfishes | | | |
| *Trachurus declivis* | jack mackerel | JMD | 1 |
| *T. symmetricus murphyi* | slender mackerel | JMM | 16 |
| Bramidae: pomfrets | | | |
| *Brama brama* & | Ray's bream & | RBM & | 49 |
| *B. australis* | southern Ray's bream | SRB | |
| *Xenobrama microlepis* | bronze bream | BBR | 1 |
| Emmelichthyidae: bonnetmouths, rovers | | | |
| *Emmelichthys nitidus* | redbait | RBT | 18 |
| *Plagiogeneion rubiginosus* | ruby fish | RBY | 2 |

## Appendix 3 (continued)

| Scientific name | Common name | Code | Occ. |
|---|---|---|---|
| Pentacerotidae: boarfishes, armourfishes | | | |
| *Pentaceros decacanthus* | yellow boarfish | YBO | 2 |
| Cheilodactylidae: tarakihi, morwongs | | | |
| *Nemadactylus macropterus* | tarakihi | TAR | 12 |
| Uranoscopidae: armourhead stargazers | | | |
| *Kathetostoma giganteum* | giant stargazer | STA | 67 |
| *Kathetostoma* sp. | banded giant stargazer | BGZ | 2 |
| Percophidae: opalfishes | | | |
| *Hemerocoetes* spp. | opalfish | OPA | 3 |
| Pinguipedidae: weavers | | | |
| *Parapercis gilliesi* | yellow cod | YCO | 3 |
| Gemplylidae: snake mackerels | | | |
| *Ruvettus pretiosus* | oilfish | OFH | 1 |
| *Thyrsites atun* | barracouta | BAR | 18 |
| Trichiuridae: cutlassfishes | | | |
| *Lepidopus caudatus* | frostfish | FRO | 3 |
| Scombridae: mackerels, tunas | | | |
| *Scomber australasicus* | blue mackerel | EMA | 2 |
| Centrolophidae: raftfishes, medusafishes | | | |
| *Centrolophus niger* | rudderfish | RUD | 18 |
| *Hyperoglyphe antarctica* | bluenose | BNS | 1 |
| *Icichthys australis* | ragfish | RAG | 1 |
| *Seriolella caerulea* | white warehou | WWA | 59 |
| *S. punctata* | silver warehou | SWA | 44 |
| *Tubbia tasmanica* | | TUB | 4 |
| Bothidae: lefteyed flounders | | | |
| *Arnoglossus scapha* | witch | WIT | 24 |
| *Neoachiropsetta milfordi* | finless flounder | MAN | 5 |
| Pleuronectidae: righteyed flounders | | | |
| *Azygopus pinnifasciatus* | spotted flounder | SDF | 1 |
| *Pelotretis flavilatus* | lemon sole | LSO | 18 |

**Appendix 4: Length ranges (cm) used to identify 1+, 2+ and 3++ hoki age classes to estimate relative biomasses given in Table 5.**

| | | | | 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 |