# Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2008–09 fishing year and from trawl surveys in summer 2009–10, with a summary of all available data sets

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# EXECUTIVE SUMMARY

**Horn, P.L.; Sutton, C.P. (2010). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2008–09 fishing year and from trawl surveys in summer 2009–10, with a summary of all available data sets.**

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This report describes catch-at-age distributions for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) estimated from commercial fisheries for these species in the 2008–09 fishing year (using data and otoliths collected at sea by observers), and from trawl surveys of hoki and middle depth species on the Campbell Plateau in December 2009 (TAN0911) and the Chatham Rise in January 2010 (TAN1001). For each estimated catch-at-age distribution there is a target coefficient of variation (c.v.) of 30% (mean weighted c.v. across all age classes).

For hake, the mean weighted c.v. targets were met for the three commercial fishery samples (WCSI, Sub-Antarctic, and Chatham west), but not met for the two trawl surveys. It appears likely that three relatively strong year classes were produced on the Chatham Rise in 2001, 2002, and 2003.

For ling, the mean weighted c.v. targets were met for both trawl survey samples and for the commercial trawl fishery in the Sub-Antarctic. Targets were almost met for the Chatham Rise and Cook Strait trawl fisheries. There were insufficient data collected to estimate catch-at-age for the 2009 WCSI trawl fishery. Of the three ling longline fisheries for which catch-at-age distributions were produced for 2008–09, the c.v. targets were met for the Chatham Rise and Sub-Antarctic non-spawning fisheries, but not for the Bounty Plateau fishery.

In all distributions for both species where the target c.v. was not met it was not possible to improve the precision as all available data and otoliths had been used in the analyses.

This report also provides summaries of all catch-at-age distributions available for hake and ling from the various trawl survey and fisheries series.

# 1. INTRODUCTION

The work presented here aimed to determine catch-at-age from the main fisheries for hake and ling in the 2008–09 fishing year, and for hake and ling from trawl surveys conducted during the summer of 2009–10. Catch-at-age data are a vital input to the stock assessment process as they provide important information on the year class strength of recruited cohorts, and enable calculation of selectivity ogives for the trawl surveys and commercial fisheries for these species. This report describes the resulting catch-at-age distributions for hake and ling; the new data extend existing series of catch-at-age data in all cases. It fulfils the third year's reporting requirements for Objectives 4 and 5 and the second year's reporting requirements for Objective 6 of Project MID2007-01 "Determination of catch-at-age in hoki, hake and ling fisheries", funded by the Ministry of Fisheries. Those objectives are as follows.

4. To determine the catch-at-age from hake fisheries in HAK 1, 4 and 7 from samples collected at sea by the Observer Programme, by trawl surveys and from other sources in 2008/09, with a target coefficient of variation (c.v.) of 30% for each fishstock (mean weighted c.v. across all age classes).

5. To determine the catch-at-age from ling fisheries in LIN 3 & 4, 5 & 6 and 7 in 2008/09 from samples collected at sea by the Observer Programme, by trawl surveys and from other sources, with a target coefficient of variation (c.v.) of 30% for each fishstock (mean weighted c.v. across all age classes).

6. To collect the otoliths required for determining the catch-at-age from the Cook Strait ling fishery in winter 2009 and determine the length frequency distribution of this catch (LIN 2 & 7).

The report also summarises all the available catch-at-age data sets for hake and ling from trawl surveys and commercial fisheries, and describes the strata used in the analyses of data from the commercial trawl fisheries. The derivation of the strata was presented by Horn & Sutton (2008), although the Chatham Rise hake strata have been modified recently (Horn & Francis 2010).

# 2. METHODS

For hake, it was proposed to age the following samples under this project (with the number of aged otoliths in square brackets):

HAK 1 — trawl survey, Dec 2009 (project MDT2007-01C) [600]
HAK 1 — commercial trawl fishery, Sep 2008–May 2009 [600]
HAK 4 — trawl survey, Jan 2010 (project HOK2007-02C) [all available]
HAK 4 — commercial trawl fishery, Oct 2008–April 2009 [500]
HAK 7 — commercial trawl fishery, Jun–Sep 2009 [500]

For ling, it was proposed to age the following samples under this project (with the number of aged otoliths in square brackets):

LIN 3&4 — trawl survey, Jan 2010 (project HOK2007-02C) [640]
LIN 3&4 — commercial longline fishery, Jun–Oct 2009 [580]
LIN 5&6 — trawl survey, Dec 2009 (project MDT2007-01C) [570]
LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2008 [500]
LIN 5&6 — commercial longline fishery, non-spawning, Campbell, Feb–Jul 2009 [500]
LIN 7 — commercial trawl fishery, west coast South Island, Jun–Sep 2009 [600]
LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2009 [500]

As no observer otoliths were available from the spawning Puysegur ling line fishery, resources were transferred to processing and reading a sample from the Bounty Plateau line fishery. Samples from this fishery had been analysed previously. Also, only 95 ling otoliths had been collected by observers from the winter 2009 west coast South Island trawl fishery. This sample size was considered to be insufficient to define the age distribution of the catch, so none were read.

The following additional commercial fishery catch-at-age distributions for ling were estimated using age-length keys derived previously from the January 2009 Chatham Rise trawl survey (LIN 3&4) and the December 2008 Sub-Antarctic trawl survey (LIN 5&6).

LIN 3&4 — commercial trawl fishery, Oct 2008–May 2009
LIN 5&6 — commercial trawl fishery, Sep 2008–Apr 2009

A catch-at-age model describing the age structure of each of the commercial fisheries and surveyed areas was developed as in previous years for both species. For each of the samples, otoliths (for each sex separately) from each 1 cm length class were selected in proportion to their occurrence in the scaled length frequency, with the constraint that the number of otoliths in each length class (where available) was at least one. In addition, all otoliths from fish in the extreme right hand tail of the scaled length frequency (constituting about 2% of that length frequency) were fully sampled. This provides a sample with a mean weighted c.v. similar to that from proportional sampling, but does better than uniform sampling for the older age classes (A. Dunn, NIWA, pers. comm.). Otoliths were prepared and read using the validated ageing technique for hake (Horn 1997) or ling (Horn 1993). Catch-at-age was calculated by constructing age-length keys separately for each sex and applying them to the scaled length frequency data derived from each fishery or survey separately using software developed specifically for this task by NIWA (Bull & Dunn 2002).

Observer sampling of the HAK 1 and HAK 4 commercial trawl fisheries sometimes provides only small numbers of otoliths. Consequently, catch-at-age distributions for these fisheries are estimated using age-length keys combining commercial fishery and trawl survey age data. For example, the age-length key for the 2008–09 HAK 1 fishery includes otoliths from observer sampling from September 2008 to May 2009 plus age data from the TAN0813 trawl survey in December 2008.

The mean weighted c.v. targets for hake from trawl surveys have often not been met. To maximise the chances of meeting the target, all hake from the trawl shots used in the biomass (and scaled length-frequency) calculations were measured and had their otoliths collected. Also, any additional hake caught in survey tows not used for biomass calculations (i.e., foul shots, midwater tows, or night tows) were measured, sexed, and had their otoliths removed. These extra fish were aged, and the data incorporated into the age-length key. Consequently, in the data summaries shown below, the number of aged hake from the trawl surveys is often greater than the number of measured fish (i.e., the fish used to calculate the catch-at-length and catch-at-age).


## 3.    RESULTS

### 3.1    Observer catch-at-age data from hake trawl fisheries

#### 3.1.1    Chatham Rise

Data from the Chatham Rise had previously been analysed as four separate fisheries (e.g., Horn & Sutton 2009) as shown in Figure 1, and defined as follows:

1.    West shallow (longitude ≤ 178.1° E, and bottom depth ≤ 530 m)
2.    West deep (longitude ≤ 178.1° E, and bottom depth > 530 m)
3.    East excl. area 404 (longitude > 178.1° E, and excluding Statistical Area 404)
4.    Area 404 (178° W ≤ longitude ≤ 179.5° W, 42° S ≤ latitude ≤ 43.75° S)

However, following the recent assessment of the Chatham Rise hake stock (Horn & Francis 2010) it was concluded that splitting the data into two fisheries (i.e., west and east) was satisfactory. Consequently, two commercial age frequencies are developed for each year (whenever sufficient data are available) using a single age-length key and two strata separated at longitude 178.1° E. The raw data are still stratified as shown in Figure 2, so each fishery comprises two strata. A single age-length key for each year is considered to be acceptable as Horn & Dunn (2007) showed that mean age at length did not differ between fisheries.

A tow was included in the catch-at-age analysis if it occurred between 1 October and 30 April, and if at least five hake had been measured from it.
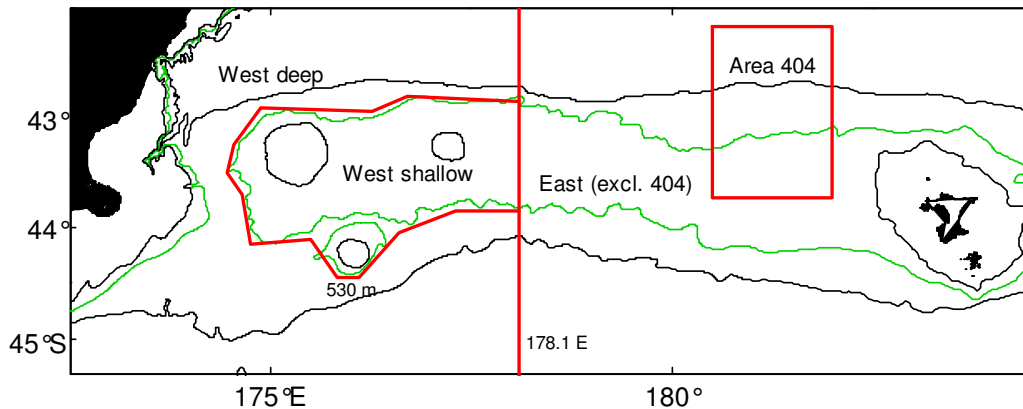


**Figure 1: Fishery strata defined for the Chatham Rise hake fishery. The stratum boundary defined by depth (530 m) is shown only approximately. Isobaths at 1000, 500, and 250 m are also shown.**

Observer data from each fishery were converted into catch-at-age distributions if there were at least 400 length measurements (west fishery) or 300 length measurements (east fishery). Table 1 summarises the quantities of useful data.

**Table 1: Numbers of measured and aged male (Mal) and female (Fem) hake contributing to samples of proportion at age from the two commercial trawl fisheries on the Chatham Rise. The number of tows sampled by observers and the estimated mean weighted c.v. (%) by age are also listed.**

| Fishing year | | | | | | | | | Measured | . | | Aged |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | West | | | | East | | | | | |
| | Mal | Fem | Tows | c.v. | Mal | Fem | Tows | c.v. | | | Mal | Fem |
| 1991–92 | 2 112 | 2636 | 163 | 21.9 | 170 | 247 | 25 | 43.2 | | | 233 | 230 |
| 1992–93 | | | | | | | | | | | | |
| 1993–94 | 355 | 452 | 90 | 36.7 | | | | | | | 181 | 217 |
| 1994–95 | 318 | 603 | 69 | 32.8 | 234 | 88 | 14 | 43.1 | | | 170 | 191 |
| 1995–96 | 802 | 917 | 103 | 28.2 | | | | | | | 113 | 165 |
| 1996–97 | 354 | 233 | 28 | 39.6 | 335 | 75 | 28 | 48.6 | | | 145 | 149 |
| 1997–98 | 3 161 | 3 046 | 390 | 14.9 | 224 | 140 | 44 | 41.0 | | | 393 | 393 |
| 1998–99 | 712 | 1 279 | 171 | 19.4 | | | | | | | 290 | 440 |
| 1999–2000 | 807 | 901 | 168 | 19.0 | | | | | | | 442 | 499 |
| 2000–01 | 830 | 1 135 | 185 | 17.6 | 1 017 | 283 | 47 | 24.7 | | | 317 | 426 |
| 2001–02 | 386 | 492 | 89 | 20.6 | | | | | | | 455 | 419 |
| 2002–03 | 176 | 272 | 61 | 25.4 | | | | | | | 256 | 345 |
| 2003–04 | 597 | 438 | 101 | 26.8 | 378 | 92 | 38 | 26.6 | | | 364 | 304 |
| 2004–05 | 896 | 437 | 82 | 24.2 | | | | | | | 391 | 343 |
| 2005–06 | 234 | 330 | 69 | 39.1 | | | | | | | 189 | 255 |
| 2006–07 | | | | | 409 | 278 | 47 | 27.6 | | | 368 | 388 |
| 2007–08 | 286 | 270 | 53 | 20.6 | | | | | | | 350 | 335 |
| 2008–09 | 257 | 162 | 43 | 24.3 | | | | | | | 237 | 185 |

In the 2008–09 fishing year, sufficient length data and otoliths were available to calculate a catch-at-age distribution for the west fishery only (see Table 1). Details of that estimated distribution are given in Table 2. Although the sample size of measured fish just met the threshold of 400, the mean weighted c.v. of 24% was within the 30% target.

All estimated proportion at age distributions from the two Chatham Rise trawl fisheries are presented in Appendix A (Figures A1 and A2).

**Table 2: Calculated numbers at age, separately by sex, with c.v.s, for hake caught during commercial trawl operations on the Chatham Rise (west) during October 2008–April 2009, and in the Sub-Antarctic during September 2008–May 2009. Summary statistics for the samples are also presented.**

| | Chatham Rise (west) | | | | | Sub-Antarctic | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. | Age | Male | c.v. | Female | c.v. |
| 3 | 1 878 | 0.970 | 911 | 1.115 | 3 | 487 | 1.334 | 259 | 0.961 |
| 4 | 17 669 | 0.344 | 2 250 | 0.979 | 4 | 22 430 | 0.309 | 2 614 | 0.413 |
| 5 | 32 094 | 0.265 | 18 909 | 0.397 | 5 | 58 626 | 0.215 | 1 535 | 0.436 |
| 6 | 38 445 | 0.199 | 26 578 | 0.317 | 6 | 57 543 | 0.196 | 4 429 | 0.371 |
| 7 | 47 326 | 0.197 | 35 553 | 0.244 | 7 | 57 694 | 0.166 | 10 359 | 0.259 |
| 8 | 12 230 | 0.390 | 17 360 | 0.343 | 8 | 29 013 | 0.232 | 19 389 | 0.219 |
| 9 | 14 233 | 0.384 | 7 453 | 0.448 | 9 | 25 143 | 0.274 | 13 945 | 0.273 |
| 10 | 7 527 | 0.453 | 1 140 | 1.524 | 10 | 23 666 | 0.318 | 15 766 | 0.224 |
| 11 | 6 473 | 0.509 | 282 | 1.643 | 11 | 16 940 | 0.345 | 13 524 | 0.286 |
| 12 | 2 797 | 0.630 | 606 | 1.339 | 12 | 19 476 | 0.330 | 10 584 | 0.290 |
| 13 | 1 678 | 0.934 | 44 | 2.275 | 13 | 11 374 | 0.445 | 8 787 | 0.372 |
| 14 | 2 880 | 0.684 | 0 | – | 14 | 21 050 | 0.316 | 10 517 | 0.351 |
| 15 | 0 | – | 0 | – | 15 | 11 100 | 0.437 | 9 029 | 0.372 |
| 16 | 1 028 | 1.080 | 915 | 1.375 | 16 | 4 346 | 0.567 | 3 865 | 0.527 |
| 17 | 810 | 2.036 | 0 | – | 17 | 4 783 | 0.611 | 3 015 | 0.488 |
| | | | | | 18 | 3 622 | 1.032 | 1 886 | 0.566 |
| | | | | | 19 | 6 543 | 0.748 | 0 | – |
| | | | | | 20 | 0 | – | 206 | 1.207 |
| | | | | | 21 | 0 | – | 303 | 1.129 |
| | | | | | 22 | 3 082 | 0.747 | 0 | – |
| | | | | | 23 | 0 | – | 625 | 1.295 |
| | | | | | 24 | 1 542 | 1.100 | 0 | – |
| | | | | | 25 | 2 094 | 1.263 | 0 | – |

| | | |
|---|---|---|
| Measured males | 257 | 1 221 |
| Measured females | 162 | 893 |
| Aged males | 237 | 311 |
| Aged females | 185 | 498 |
| No. of tows sampled | 43 | 109 |
| Mean weighted c.v. (sexes pooled) | 24.3 | 23.9 |

## 3.1.2 Sub-Antarctic

There are one major and three very minor hake fisheries in the Sub-Antarctic area, so a single fishery ogive is considered suitable for this stock. Consequently, a commercial age frequency is developed using a single age-length key and the four fishery strata shown in Figure 2, and defined as follows:

1.   Puysegur Bank (165° E ≤ longitude ≤ 168° E, 46° S ≤ latitude ≤ 48° S)
2.   Snares-Pukaki (165° E ≤ longitude ≤ 175° E, 46° S ≤ latitude ≤ 50.25° S, but excluding the Puysegur Bank stratum)
3.   Auckland Island (165° E ≤ longitude ≤ 169° E, 50.25° S < latitude ≤ 54° S)
4.   Campbell Island (169° E < longitude ≤ 174° E, 50.25° S < latitude ≤ 54° S)

A tow was included in the catch-at-age analysis if it occurred between 1 September and 31 May, and if at least five hake had been measured from it. The start of the fishing year was not used as the start of the time stratum because a descriptive analysis of this fishery indicated a landings peak from September to February (Devine 2008), so it is logical to include the September catch with landings from the five months immediately following it, rather than with catches taken about seven months previously.
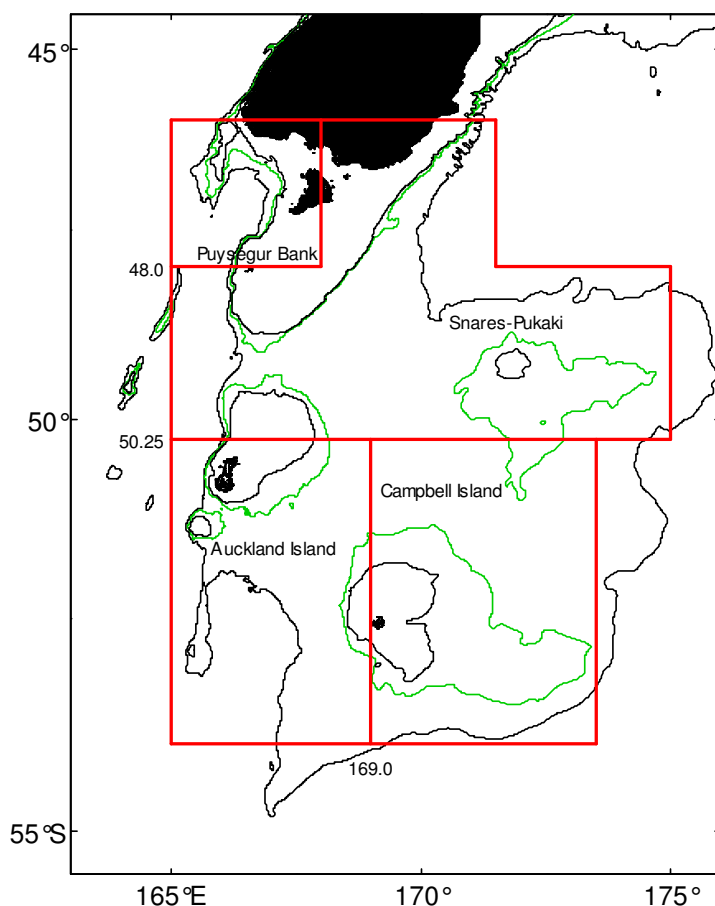


**Figure 2: Fishery strata defined for the Sub-Antarctic hake fishery. Numbers show latitudes/longitudes of fishery boundaries. Isobaths at 1000, 500, and 250 m are also shown.**

Table 3 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for trawl-caught hake in the 2008–09 fishing year are given in Table 2. The mean weighted c.v. of 23.9% was well within the target of 30%.

All estimated proportion at age distributions from the Sub-Antarctic trawl fishery are presented in Appendix A (Figure A3).

**Table 3: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic trawl fishery.**

| Year | Males Measured | Aged | Females Measured | Aged | Tows | Mean c.v. |
|------|---------------|------|-----------------|------|------|-----------|
| 1989–90 | 269 | 47 | 548 | 71 | 74 | 42.0 |
| 1990–91 | 175 | – | 588 | – | 64 | – |
| 1991–92 | 557 | 215 | 1 363 | 409 | 151 | 24.9 |
| 1992–93 | 833 | 183 | 1 218 | 518 | 171 | 27.6 |
| 1993–94 | 512 | 87 | 609 | 173 | 119 | 47.8 |
| 1994–95 | 167 | – | 597 | – | 92 | – |
| 1995–96 | 289 | 65 | 435 | 110 | 75 | 50.0 |
| 1996–97 | 84 | – | 219 | – | 54 | – |
| 1997–98 | 390 | 82 | 1 018 | 193 | 154 | 37.7 |
| 1998–99 | 463 | 174 | 1 077 | 322 | 199 | 27.4 |
| 1999–2000 | 3 007 | 259 | 2 526 | 421 | 307 | 22.5 |
| 2000–01 | 527 | 388 | 1 648 | 698 | 216 | 29.6 |
| 2001–02 | 921 | 333 | 2 026 | 874 | 320 | 23.4 |
| 2002–03 | 271 | 258 | 908 | 739 | 197 | 40.4 |
| 2003–04 | 1 309 | 350 | 969 | 518 | 165 | 24.7 |
| 2004–05 | 179 | 185 | 424 | 305 | 82 | 40.1 |
| 2005–06 | 1 906 | 218 | 1 094 | 506 | 153 | 23.2 |
| 2006–07 | 547 | 224 | 666 | 351 | 73 | 38.5 |
| 2007–08 | 891 | 325 | 592 | 682 | 89 | 23.2 |
| 2008–09 | 1 221 | 311 | 893 | 498 | 109 | 23.9 |

### 3.1.3   West coast South Island

The fishery off WCSI was stratified as follows:

1.      Deep (bottom depth ≥ 629 m)
2.      North shallow (latitude < 42.55° S)
3.      South shallow (latitude ≥ 42.55° S)

A tow was included in the catch-at-age analysis if it occurred between 1 June and 30 September, and if at least five hake had been measured from it.

Table 4 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for trawl-caught hake in the 2008–09 fishing year are given in Table 5. The measured sample size was large, and the mean weighted c.v. of 18.5% was well within the target of 30%.

All estimated proportion at age distributions from the WCSI trawl fishery are presented in Appendix A (Figure A4).

**Table 4: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the WCSI trawl fishery.**

|  | Males | | Females | | Tows | Mean c.v. |
|---|---|---|---|---|---|---|
| Year | Measured | Aged | Measured | Aged | | |
| 1989–90 | 578 | 210 | 567 | 261 | 57 | 23.1 |
| 1990–91 | 2 288 | 286 | 1 653 | 358 | 146 | 18.4 |
| 1991–92 | 2 592 | 196 | 1 193 | 261 | 121 | 22.5 |
| 1992–93 | 2 129 | 188 | 979 | 163 | 93 | 29.1 |
| 1993–94 | 1 598 | 151 | 1 643 | 272 | 174 | 32.5 |
| 1994–95 | 2 528 | 271 | 2 769 | 342 | 152 | 29.2 |
| 1995–96 | 2 862 | 287 | 1 753 | 326 | 193 | 28.9 |
| 1996–97 | 3 286 | 262 | 1 720 | 198 | 234 | 21.3 |
| 1997–98 | 2 339 | 257 | 1 497 | 253 | 237 | 21.4 |
| 1998–99 | 4 186 | 270 | 3 744 | 240 | 307 | 18.3 |
| 1999–2000 | 2 705 | 258 | 2 330 | 269 | 285 | 18.9 |
| 2000–01 | 1 529 | 176 | 1 723 | 280 | 192 | 23.9 |
| 2001–02 | 2 281 | 93 | 2 434 | 385 | 380 | 33.8 |
| 2002–03 | 1 917 | 227 | 2 063 | 234 | 296 | 20.0 |
| 2003–04 | 2 702 | 303 | 2 181 | 193 | 353 | 16.5 |
| 2004–05 | 2 305 | 238 | 2 324 | 280 | 217 | 23.8 |
| 2005–06 | 5 502 | 276 | 4 231 | 298 | 395 | 16.3 |
| 2006–07 | 3 385 | 248 | 3 258 | 257 | 132 | 16.7 |
| 2007–08 | 4 682 | 321 | 2 416 | 266 | 147 | 17.7 |
| 2008–09 | 5 773 | 301 | 3 610 | 301 | 178 | 18.5 |

**Table 5: Calculated numbers at age, separately by sex, with c.v.s, for hake caught during commercial trawl operations off the west coast of South Island (WCSI) during June–September 2009. Summary statistics for the samples are also presented.**

|  |  |  | WCSI | |
|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. |
| 2 | 43 589 | 0.293 | 30 502 | 0.359 |
| 3 | 43 105 | 0.262 | 34 610 | 0.277 |
| 4 | 74 777 | 0.222 | 11 224 | 0.481 |
| 5 | 127 908 | 0.152 | 53 353 | 0.206 |
| 6 | 144 944 | 0.139 | 70 302 | 0.175 |
| 7 | 111 136 | 0.177 | 87 732 | 0.163 |
| 8 | 86 723 | 0.207 | 79 611 | 0.186 |
| 9 | 51 396 | 0.281 | 53 405 | 0.196 |
| 10 | 53 100 | 0.315 | 33 793 | 0.271 |
| 11 | 52 627 | 0.286 | 21 487 | 0.280 |
| 12 | 36 154 | 0.315 | 25 498 | 0.306 |
| 13 | 60 781 | 0.246 | 15 329 | 0.333 |
| 14 | 41 125 | 0.312 | 18 262 | 0.351 |
| 15 | 31 519 | 0.325 | 5 123 | 0.556 |
| 16 | 27 175 | 0.411 | 2 433 | 1.074 |
| 17 | 16 307 | 0.451 | 0 | – |
| 18 | 5 167 | 1.090 | 1 772 | 1.064 |
| 19 | 3 378 | 0.969 | 0 | – |
| 20 | 0 | – | 0 | – |
| 21 | 0 | – | 0 | – |
| 22 | 0 | – | 0 | – |
| 23 | 3 286 | 0.955 | 0 | – |

| | |
|---|---|
| Measured males | 5 773 |
| Measured females | 3 610 |
| Aged males | 301 |
| Aged females | 301 |
| No. of tows sampled | 178 |
| Mean weighted c.v. (sexes pooled) | 18.5 |

## 3.2 Trawl survey catch-at-age data for hake

### 3.2.1 Chatham Rise

Trawl survey catch-at-age distributions are estimates of the numbers of hake, by sex and age, available to the trawl in the survey area between 200 and 800 m. In some years an additional deeper stratum (800–1000 m) on the north Rise is surveyed. However, to ensure comparability, the distributions presented here are for the 'core' strata only, i.e., 200–800 m.

Table 6 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for hake caught in the January 2010 trawl survey are given in Table 7. The mean weighted c.v. of 39.7% did not meet the target of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis. The 30% target has been met in only one of the 19 surveys (TAN9106, see Table 6).

All estimated proportion at age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A5). It appears likely that a very strong year class was produced in 2001 (i.e., aged 2 in January 2004), and that it was followed by two further relatively strong year classes in 2002 and 2003. The progression of these year classes is apparent in the survey distributions since TAN0401.

**Table 6: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Chatham Rise resource surveys.**

|  | Males | | Females | | | Mean c.v. |
|---|---|---|---|---|---|---|
| Source | Measured | Aged | Measured | Aged | Tows | |
| AEX8903 | 220 | 154 | 212 | 179 | 63 | 39.5 |
| TAN9106 | 322 | 233 | 305 | 230 | 122 | 30.0 |
| TAN9212 | 243 | 200 | 275 | 225 | 121 | 32.7 |
| TAN9401 | 293 | 181 | 355 | 217 | 123 | 33.1 |
| TAN9501 | 201 | 170 | 229 | 191 | 87 | 38.7 |
| TAN9601 | 149 | 113 | 200 | 165 | 56 | 36.4 |
| TAN9701 | 149 | 145 | 159 | 149 | 77 | 36.1 |
| TAN9801 | 137 | 135 | 142 | 139 | 55 | 39.0 |
| TAN9901 | 94 | 103 | 142 | 157 | 62 | 44.1 |
| TAN0001 | 177 | 177 | 178 | 177 | 72 | 35.9 |
| TAN0101 | 104 | 112 | 148 | 150 | 66 | 37.3 |
| TAN0201 | 104 | 177 | 121 | 172 | 61 | 36.4 |
| TAN0301 | 33 | 34 | 69 | 71 | 46 | 61.4 |
| TAN0401 | 94 | 82 | 110 | 105 | 53 | 49.4 |
| TAN0501 | 115 | 134 | 107 | 113 | 55 | 45.3 |
| TAN0601 | 109 | 123 | 126 | 138 | 56 | 33.8 |
| TAN0701 | 133 | 158 | 136 | 142 | 61 | 32.6 |
| TAN0801 | 55 | 65 | 87 | 99 | 60 | 38.0 |
| TAN0901 | 259 | 238 | 201 | 191 | 70 | 32.5 |
| TAN1001 | 122 | 142 | 97 | 107 | 56 | 39.7 |

**Table 7: Calculated numbers at age in the survey area, separately by sex, with c.v.s, for hake caught during trawl surveys of the Chatham Rise in January 2010 (survey TAN1001) and the Sub-Antarctic in November-December 2009 (survey TAN0911). Summary statistics for the samples are also presented.**

| | | | TAN1001 | | | | | TAN0911 | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. | Age | Male | c.v. | Female | c.v. |
| 2 | 0 | – | 0 | – | 2 | 0 | – | 1 359 | 0.899 |
| 3 | 12 224 | 0.520 | 14 361 | 0.558 | 3 | 38 566 | 0.264 | 70 173 | 0.294 |
| 4 | 12 220 | 0.489 | 20 563 | 0.413 | 4 | 43 914 | 0.229 | 113 574 | 0.315 |
| 5 | 28 112 | 0.487 | 9 881 | 0.558 | 5 | 21 924 | 0.366 | 48 097 | 0.280 |
| 6 | 27 448 | 0.533 | 25 621 | 0.431 | 6 | 4 720 | 0.660 | 15 403 | 0.431 |
| 7 | 18 185 | 0.522 | 37 142 | 0.358 | 7 | 2 638 | 0.860 | 6 503 | 0.467 |
| 8 | 27 294 | 0.490 | 37 931 | 0.348 | 8 | 3 072 | 0.910 | 10 094 | 0.585 |
| 9 | 5 101 | 0.864 | 21 428 | 0.431 | 9 | 528 | 1.893 | 15 258 | 0.582 |
| 10 | 9 317 | 0.686 | 7 089 | 0.776 | 10 | 0 | – | 9 102 | 0.817 |
| 11 | 5 903 | 0.908 | 8 349 | 0.660 | 11 | 2 612 | 1.586 | 9 571 | 0.615 |
| 12 | 7 095 | 0.763 | 0 | – | 12 | 0 | – | 8 220 | 0.499 |
| 13 | 798 | 1.580 | 5 219 | 0.767 | 13 | 1 222 | 1.392 | 3 846 | 0.938 |
| 14 | 1 794 | 1.212 | 6 349 | 0.734 | 14 | 1 042 | 1.672 | 8 838 | 0.696 |
| 15 | 5 323 | 0.791 | 2 729 | 0.949 | 15 | 0 | – | 3 484 | 0.852 |
| 16 | 3 612 | 0.978 | 2 758 | 1.006 | 16 | 7 992 | 1.704 | 2 721 | 0.951 |
| 17 | 1 234 | 1.585 | 915 | 1.662 | 17 | 0 | – | 0 | – |
| 18 | 1 366 | 1.444 | 878 | 1.414 | 18 | 0 | – | 1 543 | 1.573 |
| | | | | | 19 | 0 | – | 0 | – |
| | | | | | 20 | 0 | – | 0 | – |
| | | | | | 21 | 0 | – | 3 168 | 1.565 |

| | | |
|---|---|---|
| Measured males | 122 | 152 |
| Measured females | 97 | 382 |
| Aged males | 142 | 164 |
| Aged females | 107 | 436 |
| No. of tows sampled | 56 | 37 |
| Mean weighted c.v. (sexes pooled) | 39.7 | 36.3 |

### 3.2.2 Sub-Antarctic

Trawl survey catch-at-age distributions are estimates of the numbers of hake, by sex and age, available to the trawl in the survey. The main survey series has been conducted in summer. Those surveys have sampled depths from 300 to 800 m, plus an 800–1000 m stratum at Puysegur, and, in some years, other 800–1000 m strata off the Campbell Plateau. However, to ensure comparability, the distributions presented here are for the 'core' 300–800 m strata plus the deep Puysegur stratum only. The catch-at-age distributions from the spring and autumn surveys are derived from the 'core' 300–800 m strata only.

Table 8 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for hake caught in the November–December 2009 trawl survey are given in Table 7. The mean weighted c.v. of 36% did not meet the target of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis. The 30% target has never been met in any of the Sub-Antarctic surveys (see Table 8).

All estimated proportion at age distributions from the Sub-Antarctic trawl surveys are presented in Appendix A (Figure A6).

**Table 8: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age for the Sub-Antarctic resource surveys.**

| Survey | Males Measured | Aged | Females Measured | Aged | Tows | Mean c.v. |
|---|---|---|---|---|---|---|
| Summer surveys | | | | | | |
| AEX8902 | 45 | 43 | 76 | 66 | 34 | 52.7 |
| TAN9105 | 337 | 117 | 332 | 217 | 61 | 65.1 |
| TAN9211 | 14 | 46 | 133 | 168 | 48 | 48.6 |
| TAN9310 | 57 | 93 | 181 | 182 | 59 | 47.2 |
| TAN0012 | 348 | 239 | 392 | 352 | 56 | 37.3 |
| TAN0118 | 219 | 212 | 351 | 349 | 44 | 35.6 |
| TAN0219 | 331 | 191 | 490 | 377 | 38 | 36.1 |
| TAN0317 | 126 | 186 | 175 | 220 | 30 | 41.0 |
| TAN0414 | 178 | 245 | 225 | 283 | 39 | 42.8 |
| TAN0515 | 88 | 146 | 265 | 274 | 39 | 39.9 |
| TAN0617 | 188 | 190 | 487 | 460 | 39 | 33.6 |
| TAN0714 | 166 | 217 | 352 | 423 | 47 | 35.4 |
| TAN0813 | 289 | 188 | 808 | 412 | 39 | 30.9 |
| TAN0911 | 152 | 164 | 382 | 436 | 37 | 36.3 |
| Autumn surveys | | | | | | |
| TAN9204 | 60 | 58 | 113 | 107 | 48 | 46.8 |
| TAN9304 | 36 | 36 | 124 | 122 | 54 | 49.5 |
| TAN9605 | 32 | 86 | 93 | 137 | 45 | 61.9 |
| TAN9805 | 49 | 94 | 146 | 189 | 31 | 52.0 |
| Spring surveys | | | | | | |
| TAN9209 | 76 | 68 | 141 | 113 | 44 | 43.8 |

## 3.3 Observer catch-at-age data from ling longline fisheries

### 3.3.1 Chatham Rise

The line fishery data from the Chatham Rise are analysed using a single area stratum (i.e., FMAs 3 and 4 between 42° and 46° S), and a time stratum of 1 June to 31 October.

Table 9 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for Chatham Rise line-caught ling in the 2008–09 fishing year are given in Table 10. The mean weighted c.v. of 21.5% was well within the target value of 30%.

**Table 9: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Chatham Rise longline fishery.**

| Year | Males Measured | Aged | Females Measured | Aged | Sets | Mean c.v. |
|---|---|---|---|---|---|---|
| 2002 | 4 966 | 284 | 2 998 | 309 | 538 | 20.4 |
| 2003 | 3 038 | 337 | 2 071 | 289 | 429 | 19.1 |
| 2004 | 1 066 | 302 | 747 | 293 | 139 | 21.8 |
| 2005 | 889 | 356 | 479 | 234 | 137 | 21.6 |
| 2006 | 266 | 95 | 294 | 141 | 48 | 36.6 |
| 2007 | 351 | 174 | 268 | 139 | 62 | 31.1 |
| 2008 | 574 | 216 | 570 | 262 | 84 | 25.9 |
| 2009 | 619 | 283 | 798 | 413 | 147 | 21.5 |

**Table 10: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial longline operations on the Chatham Rise (LIN 3&4) in June–October 2009, and in the Sub-Antarctic non-spawning fishery (LIN 5&6) in February–July 2009. Summary statistics for the samples are also presented.**

| | Chatham Rise | | | | | Sub-Antarctic non-spawning | | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. | Age | Male | c.v. | Female | c.v. |
| 4 | 99 | 1.936 | 0 | – | 4 | 0 | – | 0 | – |
| 5 | 47 | 1.933 | 255 | 1.084 | 5 | 1 336 | 0.674 | 0 | – |
| 6 | 160 | 1.006 | 200 | 1.051 | 6 | 1 874 | 0.597 | 2 565 | 0.542 |
| 7 | 466 | 0.994 | 1 087 | 0.427 | 7 | 4 584 | 0.418 | 3 185 | 0.477 |
| 8 | 2 024 | 0.483 | 2 123 | 0.423 | 8 | 6 008 | 0.409 | 8 705 | 0.277 |
| 9 | 5 743 | 0.280 | 3 337 | 0.346 | 9 | 2 283 | 0.493 | 9 100 | 0.300 |
| 10 | 7 049 | 0.317 | 3 890 | 0.275 | 10 | 3 203 | 0.392 | 7 790 | 0.259 |
| 11 | 7 391 | 0.277 | 4 120 | 0.263 | 11 | 731 | 0.735 | 11 838 | 0.194 |
| 12 | 10 338 | 0.200 | 6 431 | 0.245 | 12 | 825 | 0.876 | 6 642 | 0.284 |
| 13 | 11 455 | 0.211 | 11 901 | 0.163 | 13 | 1 075 | 0.642 | 6 005 | 0.280 |
| 14 | 9 517 | 0.210 | 15 286 | 0.140 | 14 | 711 | 0.845 | 5 459 | 0.302 |
| 15 | 2 606 | 0.354 | 5 081 | 0.247 | 15 | 819 | 0.769 | 4 410 | 0.326 |
| 16 | 4 231 | 0.354 | 9 260 | 0.170 | 16 | 247 | 1.239 | 4 812 | 0.311 |
| 17 | 2 672 | 0.374 | 5 143 | 0.275 | 17 | 642 | 1.001 | 877 | 0.622 |
| 18 | 2 306 | 0.413 | 3 116 | 0.334 | 18 | 345 | 1.152 | 1 163 | 0.631 |
| 19 | 887 | 0.569 | 2 202 | 0.358 | 19 | 637 | 0.840 | 1 595 | 0.638 |
| 20 | 584 | 0.687 | 615 | 0.577 | 20 | 0 | – | 0 | – |
| 21 | 1 115 | 0.624 | 2 444 | 0.409 | 21 | 0 | – | 0 | – |
| 22 | 291 | 0.828 | 1 253 | 0.554 | 22 | 0 | – | 0 | – |
| 23 | 1 541 | 0.579 | 759 | 0.634 | 23 | 220 | 1.330 | 393 | 1.165 |
| 24 | 1 097 | 0.661 | 794 | 0.677 | 24 | 0 | – | 171 | 1.325 |
| 25 | 1 192 | 0.736 | 596 | 0.826 | 25 | 247 | 1.360 | 0 | – |
| 26 | 649 | 0.750 | 0 | – | 26 | 0 | – | 166 | 1.182 |
| 27 | 205 | 1.331 | 320 | 0.784 | | | | | |
| 28 | 71 | 1.750 | 0 | – | | | | | |
| 29 | 0 | – | 100 | 1.556 | | | | | |
| 30 | 453 | 0.857 | 91 | 1.589 | | | | | |
| 31 | 0 | – | 0 | – | | | | | |
| 32 | 129 | 1.367 | 0 | – | | | | | |
| 33 | 474 | 1.094 | 162 | 1.730 | | | | | |
| 34 | 241 | 1.354 | 0 | – | | | | | |
| 35 | 0 | – | 0 | – | | | | | |
| 36 | 86 | 1.285 | 0 | – | | | | | |
| | | | | | | | | | |
| Measured males | | | 619 | | | | | 165 | |
| Measured females | | | 798 | | | | | 454 | |
| Aged males | | | 283 | | | | | 61 | |
| Aged females | | | 413 | | | | | 196 | |
| No. of sets sampled | | | 147 | | | | | 49 | |
| Meanweighted c.v. (sexes pooled) | | | 21.5 | | | | | 28.0 | |

All estimated proportion at age distributions from the Chatham Rise longline fishery are presented in Appendix B (Figure B1).

## 3.3.2 Sub-Antarctic

The line fishery data from the Sub-Antarctic stock are analysed as two separate fisheries, one spawning and one non-spawning. The spawning fishery was defined as a single stratum comprising the Puysegur Bank and Solander Corridor (i.e., Statistical Area 30), with a time stratum of October to

December. The non-spawning fishery was defined as a single stratum comprising all of FMAs 5 and 6, excluding Statistical Area 30 and the Bounty Plateau, with a time stratum of 1 February to 31 July.

Table 11 summarises the quantities of data used each year to produce the catch-at-age distributions for the two Sub-Antarctic longline fisheries, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for non-spawning Sub-Antarctic line-caught ling in the 2008–09 fishing year are given in Table 10. The sample size was relatively small, but the mean weighted c.v. of 28% did meet the target value of 30%. There was no observer sampling of spawning Sub-Antarctic line-caught ling in the 2008–09 fishing year.

**Table 11: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic spawning and non-spawning longline fisheries.**

| | Males | | Females | | | Mean c.v. |
|---|---|---|---|---|---|---|
| Fishery & year | Measured | Aged | Measured | Aged | Sets | |
| Spawning line fishery | | | | | | |
| 2000 | 4 044 | 242 | 4 231 | 278 | 83 | 20.6 |
| 2001 | 2 084 | 131 | 1 962 | 143 | 55 | 28.7 |
| 2002 | 670 | 197 | 898 | 284 | 157 | 22.6 |
| 2003 | 1 250 | 211 | 1 687 | 307 | 214 | 20.0 |
| 2004 | 887 | 208 | 1 129 | 289 | 168 | 22.5 |
| 2005 | 193 | 88 | 362 | 179 | 54 | 28.6 |
| 2006 | 233 | 108 | 707 | 345 | 94 | 23.3 |
| 2007 | 412 | 191 | 418 | 217 | 82 | 25.1 |
| 2008 | 227 | 68 | 198 | 62 | 24 | 44.3 |
| Non-spawning line fishery | | | | | | |
| 1998 | 608 | 73 | 2 763 | 395 | 34 | 23.1 |
| 1999 | 3 316 | 214 | 7 535 | 428 | 136 | 18.3 |
| 2001 | 674 | 103 | 2 040 | 235 | 58 | 25.3 |
| 2003 | 304 | 128 | 611 | 273 | 43 | 29.3 |
| 2005 | 413 | 114 | 716 | 307 | 113 | 25.9 |
| 2009 | 165 | 61 | 454 | 196 | 49 | 28.0 |

All estimated proportion at age distributions from the spawning and non-spawning Sub-Antarctic longline fisheries are presented in Appendix B (Figures B2 and B3).

### 3.3.3 Cook Strait

The line fishery data from Cook Strait are analysed using a single area stratum (i.e., those parts of FMAs 2, 7, and 8 between 41° and 42° S and 174° and 175.4° E, equating approximately to Statistical Areas 16 and 17), and a time stratum of 1 June to 30 September.

Table 12 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. There was no observer sampling of Cook Strait line-caught ling in the 2008–09 fishing year. All estimated proportion at age distributions from the Cook Strait longline fishery are presented in Appendix B (Figure B4).

**Table 12: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Cook Strait longline fishery.**

| | Males | | Females | | | Mean c.v. |
|---|---|---|---|---|---|---|
| Year | Measured | Aged | Measured | Aged | Sets | |
| 2006 | 607 | 319 | 538 | 275 | 116 | 19.3 |
| 2007 | 238 | 125 | 180 | 92 | 43 | 33.8 |

### 3.3.4  Bounty Plateau

The line fishery data from the Bounty Plateau are analysed using a single area stratum (i.e., that part of FMA 6 east of 176° E), and a time stratum of 1 November to 31 March.

Table 13 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s.  The details of the estimated catch-at-age distribution for Bounty Plateau line-caught ling in the 2008–09 fishing year are given in Table 14. The mean weighted c.v. of 37.3% did not meet the target value of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis. All estimated proportion at age distributions from the Bounty Plateau longline fishery are presented in Appendix B (Figure B5).

**Table 13: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Bounty Plateau longline fishery.**

| Year | Males Measured | Aged | Females Measured | Aged | Sets | Mean c.v. |
|---|---|---|---|---|---|---|
| 1993 | 201 | 52 | 237 | 69 | 24 | 50.4 |
| 2000 | 1 102 | 106 | 2 184 | 185 | 41 | 26.9 |
| 2001 | 405 | 50 | 713 | 66 | 20 | 43.6 |
| 2004 | 1 155 | 200 | 1 628 | 300 | 272 | 20.0 |
| 2008 | 308 | 156 | 562 | 271 | 86 | 25.3 |
| 2009 | 262 | 116 | 213 | 88 | 42 | 37.3 |

**Table 14: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial longline operations on the Bounty Plateau during November 2008–March 2009. Summary statistics for the sample are also presented.**

| | | | Bounty Plateau | |
|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. |
| 10 | 87 | 1.724 | 0 | – |
| 11 | 311 | 0.903 | 0 | – |
| 12 | 0 | – | 454 | 0.877 |
| 13 | 407 | 0.752 | 727 | 0.472 |
| 14 | 1 283 | 0.427 | 834 | 0.597 |
| 15 | 1 437 | 0.422 | 2 203 | 0.304 |
| 16 | 2 664 | 0.301 | 1 014 | 0.473 |
| 17 | 1 919 | 0.351 | 1 898 | 0.404 |
| 18 | 1 587 | 0.365 | 853 | 0.470 |
| 19 | 2 232 | 0.342 | 1 303 | 0.436 |
| 20 | 1 445 | 0.387 | 383 | 0.634 |
| 21 | 838 | 0.585 | 277 | 1.023 |
| 22 | 489 | 0.624 | 264 | 1.077 |
| 23 | 769 | 0.598 | 836 | 0.497 |
| 24 | 1 089 | 0.518 | 203 | 0.905 |
| 25 | 310 | 0.913 | 325 | 0.827 |
| 26 | 219 | 0.933 | 115 | 1.572 |
| 37 | 102 | 1.276 | 0 | – |
| 38 | 0 | – | 732 | 0.689 |
| 39 | 252 | 1.147 | 256 | 1.435 |

| | |
|---|---|
| Measured males | 262 |
| Measured females | 213 |
| Aged males | 116 |
| Aged females | 88 |
| No. of sets sampled | 42 |
| Mean weighted c.v. (sexes pooled) | 37.3 |

### 3.4　Observer catch-at-age data from ling trawl fisheries

### 3.4.1　Chatham Rise

Trawl fishery data from the Chatham Rise were used if they were collected between 1 October and 31 May in each fishing year, and were stratified using the following four strata:

- Coast (longitude ≤ 174° E, target not scampi)
- Scampi (all tows targeting scampi)
- North Rise (latitude < 43.55° S, longitude > 174° E, target not scampi)
- South Rise (latitude ≥ 43.55° S, longitude > 174° E, target not scampi)

Table 15 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for trawl-caught ling in the 2008–09 fishing year are given in Table 16. The mean weighted c.v. of 32% was just higher than the value of 30% that is usually used as a target for ling catch-at-age distributions.

All estimated proportion at age distributions from the Chatham Rise trawl fishery are presented in Appendix B (Figure B6).

**Table 15: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Chatham Rise trawl fishery.**

| Source | Males | | Females | | | Mean c.v. |
|---|---|---|---|---|---|---|
| | Measured | Aged | Measured | Aged | Tows | |
| 1991–92 | 2 151 | 252 | 2 653 | 281 | 143 | 27.0 |
| 1993–94 | 1 127 | 302 | 768 | 302 | 126 | 32.9 |
| 1994–95 | 359 | 236 | 302 | 201 | 59 | 45.1 |
| 1995–96 | 453 | 306 | 399 | 284 | 87 | 30.0 |
| 1996–97 | 162 | 317 | 240 | 242 | 31 | 41.1 |
| 1997–98 | 3 463 | 348 | 3 117 | 280 | 497 | 18.7 |
| 1998–99 | 3 306 | 336 | 2 469 | 318 | 312 | 20.0 |
| 1999–2000 | 887 | 322 | 1 013 | 326 | 161 | 24.8 |
| 2000–01 | 1 000 | 312 | 988 | 341 | 188 | 21.0 |
| 2001–02 | 642 | 294 | 708 | 334 | 129 | 23.8 |
| 2002–03 | 694 | 317 | 764 | 347 | 114 | 24.3 |
| 2003–04 | 356 | 303 | 600 | 302 | 99 | 30.1 |
| 2004–05 | 869 | 310 | 666 | 326 | 194 | 27.9 |
| 2005–06 | 251 | 328 | 291 | 330 | 54 | 34.5 |
| 2006–07 | 699 | 310 | 687 | 330 | 135 | 22.9 |
| 2007–08 | 2 755 | 317 | 2 070 | 325 | 276 | 20.9 |
| 2008–09 | 1 034 | 323 | 1 120 | 298 | 141 | 32.4 |

**Table 16: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial trawl operations on the Chatham Rise during October 2008–May 2009, and in the Sub-Antarctic during September 2008–April 2009. Summary statistics for the samples are also presented.**

| | | | Chatham Rise | | | | | Sub-Antarctic | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. | Age | Male | c.v. | Female | c.v. |
| 2 | 0 | – | 0 | – | 2 | 1 171 | 1.500 | 120 | 2.828 |
| 3 | 3 755 | 1.136 | 11 107 | 0.839 | 3 | 7 932 | 0.547 | 11 654 | 0.458 |
| 4 | 7 334 | 1.016 | 3 934 | 0.864 | 4 | 30 878 | 0.370 | 19 692 | 0.398 |
| 5 | 18 245 | 0.417 | 7 353 | 0.565 | 5 | 66 737 | 0.319 | 44 082 | 0.271 |
| 6 | 16 315 | 0.502 | 15 569 | 0.400 | 6 | 117 225 | 0.201 | 76 309 | 0.251 |
| 7 | 18 597 | 0.523 | 24 044 | 0.289 | 7 | 77 540 | 0.245 | 109 741 | 0.191 |
| 8 | 21 708 | 0.311 | 20 207 | 0.280 | 8 | 68 609 | 0.249 | 113 223 | 0.181 |
| 9 | 15 756 | 0.348 | 15 623 | 0.292 | 9 | 79 547 | 0.216 | 83 763 | 0.220 |
| 10 | 9 444 | 0.363 | 23 359 | 0.267 | 10 | 34 512 | 0.332 | 76 526 | 0.225 |
| 11 | 12 090 | 0.288 | 12 284 | 0.357 | 11 | 56 249 | 0.249 | 44 744 | 0.249 |
| 12 | 13 555 | 0.221 | 8 886 | 0.403 | 12 | 34 597 | 0.340 | 66 509 | 0.210 |
| 13 | 7 337 | 0.309 | 7 883 | 0.420 | 13 | 64 479 | 0.229 | 36 846 | 0.301 |
| 14 | 5 993 | 0.322 | 11 809 | 0.358 | 14 | 43 677 | 0.280 | 32 406 | 0.272 |
| 15 | 2 028 | 0.579 | 10 613 | 0.390 | 15 | 22 551 | 0.377 | 29 402 | 0.265 |
| 16 | 5 588 | 0.394 | 3 957 | 0.560 | 16 | 12 080 | 0.460 | 15 625 | 0.408 |
| 17 | 2 247 | 0.468 | 2 127 | 0.822 | 17 | 3 478 | 0.925 | 6 845 | 0.498 |
| 18 | 1 561 | 0.703 | 2 787 | 0.633 | 18 | 16 273 | 0.422 | 10 337 | 0.400 |
| 19 | 1 442 | 0.674 | 431 | 0.814 | 19 | 4 090 | 0.797 | 8 105 | 0.643 |
| 20 | 1 615 | 0.887 | 121 | 1.266 | 20 | 0 | – | 1 106 | 1.219 |
| 21 | 821 | 0.937 | 1 438 | 0.732 | 21 | 1 481 | 1.346 | 12 401 | 0.346 |
| 22 | 544 | 1.170 | 344 | 0.750 | 22 | 6 191 | 0.691 | 1 943 | 0.918 |
| 23 | 50 | 1.500 | 24 | 2.158 | 23 | 169 | 2.100 | 0 | – |
| 24 | 513 | 0.954 | 19 | 2.081 | 24 | 0 | – | 0 | – |
| 25 | 1 947 | 1.257 | 19 | 2.044 | 25 | 0 | – | 321 | 1.096 |
| 26 | 1 096 | 0.772 | 0 | – | 26 | 0 | – | 459 | 1.338 |
| 27 | 0 | – | 0 | – | 27 | 0 | – | 303 | 1.308 |
| 28 | 0 | – | 0 | – | | | | | |
| 29 | 0 | – | 196 | 1.163 | | | | | |
| 30 | 0 | – | 0 | – | | | | | |
| 31 | 702 | 0.943 | 91 | 1.630 | | | | | |

| | | | | |
|---|---|---|---|---|
| Measured males | | 1 034 | | 2 877 |
| Measured females | | 1 120 | | 3 803 |
| Aged males | | 323 | | 245 |
| Aged females | | 298 | | 324 |
| No. of tows sampled | | 141 | | 184 |
| Mean weighted c.v. (sexes pooled) | | 32.4 | | 19.4 |

### 3.4.2 Sub-Antarctic

Trawl fishery data from the Sub-Antarctic were used if they were collected between 1 September and 30 April in each fishing year, and were stratified using the following three strata:

1. Scampi (all tows targeting scampi)
2. Shallow (bottom depth ≤ 450 m, and target not scampi)
3. Deep (bottom depth > 450 m, and target not scampi)

Table 17 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for trawl-caught ling in the 2008–09 fishing year are given in Table 16. The mean weighted c.v. of

19% was better then the value of 30% that is usually used as a target for ling catch-at-age distributions.

All estimated proportion at age distributions from the Sub-Antarctic trawl fishery are presented in Appendix B (Figure B7).

**Table 17: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic trawl fishery.**

| Source | Males | | Females | | Tows | Mean c.v. |
|---|---|---|---|---|---|---|
| | Measured | Aged | Measured | Aged | | |
| 1991–92 | 1 466 | 437 | 1 652 | 667 | 141 | 22.0 |
| 1992–93 | 1 337 | 235 | 1 615 | 363 | 164 | 28.3 |
| 1993–94 | 686 | 256 | 1 059 | 357 | 129 | 29.2 |
| 1995–96 | 881 | 366 | 779 | 297 | 83 | 24.5 |
| 1997–98 | 1 408 | 274 | 1 717 | 302 | 218 | 29.0 |
| 2000–01 | 2 192 | 247 | 1 947 | 351 | 267 | 28.1 |
| 2001–02 | 1 887 | 264 | 2 579 | 327 | 424 | 24.8 |
| 2002–03 | 1 164 | 434 | 1 828 | 625 | 263 | 20.9 |
| 2003–04 | 853 | 246 | 1 397 | 337 | 202 | 22.9 |
| 2004–05 | 2 324 | 254 | 2 415 | 339 | 218 | 21.5 |
| 2005–06 | 2 739 | 288 | 2 618 | 305 | 252 | 20.4 |
| 2006–07 | 1 644 | 225 | 1 446 | 382 | 191 | 24.3 |
| 2007–08 | 4 104 | 229 | 3 258 | 353 | 183 | 23.3 |
| 2008–09 | 2 877 | 245 | 3 803 | 324 | 184 | 19.4 |

### 3.4.3   West coast South Island

Trawl fishery data off WCSI were used if they were collected between 1 June and 30 September each year, and were stratified using the following three strata:

- Deep (bottom depth ≥ 498 m)
- North shallow (bottom depth < 498 m, latitude < 42.42° S)
- South shallow (bottom depth < 498 m, latitude ≥ 42.42° S)

Table 18 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s.  There were insufficient data collected to estimate the catch-at-age distribution for trawl-caught ling in the 2008–09 fishing year (i.e., 311 length measurements and 95 otoliths).

All estimated proportion at age distributions from the WCSI trawl fishery are presented in Appendix B (Figure B8).

**Table 18: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the WCSI trawl fishery.**

| Year | Males Measured | Aged | Females Measured | Aged | Tows | Mean c.v. |
|---|---|---|---|---|---|---|
| 1991 | 563 | 176 | 440 | 220 | 65 | 34.8 |
| 1994 | 873 | 172 | 1 096 | 221 | 141 | 27.9 |
| 1995 | 1 051 | 238 | 794 | 268 | 111 | 24.3 |
| 1996 | 485 | 247 | 448 | 201 | 83 | 28.0 |
| 1997 | 1 532 | 442 | 901 | 399 | 173 | 19.5 |
| 1998 | 1 063 | 349 | 700 | 279 | 155 | 23.6 |
| 1999 | 1 862 | 285 | 1 126 | 263 | 221 | 23.7 |
| 2000 | 829 | 269 | 783 | 264 | 168 | 26.8 |
| 2001 | 1 106 | 256 | 924 | 307 | 178 | 29.6 |
| 2002 | 1 401 | 283 | 1 405 | 321 | 332 | 21.4 |
| 2003 | 1 157 | 293 | 1 290 | 302 | 286 | 23.3 |
| 2004 | 1 003 | 243 | 1 540 | 352 | 334 | 21.4 |
| 2005 | 908 | 282 | 899 | 355 | 184 | 24.9 |
| 2006 | 763 | 276 | 844 | 361 | 154 | 29.0 |
| 2007 | 228 | 148 | 258 | 158 | 65 | 38.7 |
| 2008 | 805 | 209 | 824 | 251 | 98 | 24.1 |

## 3.4.4 Cook Strait

The trawl fishery in Cook Strait is analysed using a single area stratum (i.e., those parts of FMAs 2, 7, and 8 between 41° and 42° S and 174° and 175.4° E, equating approximately to Statistical Areas 16 and 17), and a time stratum of 1 June to 30 September.

Table 19 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for Cook Strait trawl-caught ling in the 2008–09 fishing year are given in Table 20. The mean weighted c.v. of 33.4% was higher than the target value of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis.

All estimated proportion at age distributions from the Cook Strait trawl fishery are presented in Appendix B (Figure B9).

**Table 19: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Cook Strait trawl fishery.**

| Year | Males Measured | Aged | Females Measured | Aged | Tows | Mean c.v. |
|---|---|---|---|---|---|---|
| 1999 | 226 | 75 | 189 | 54 | 59 | 47.9 |
| 2000 | 197 | 95 | 191 | 93 | 62 | 40.9 |
| 2001 | 610 | 205 | 550 | 208 | 72 | 24.5 |
| 2002 | 583 | 219 | 644 | 241 | 58 | 27.9 |
| 2003 | 430 | 282 | 437 | 308 | 56 | 24.2 |
| 2004 | 609 | 269 | 645 | 241 | 48 | 27.2 |
| 2005 | 617 | 272 | 561 | 264 | 75 | 26.4 |
| 2006 | 729 | 248 | 539 | 226 | 26 | 26.4 |
| 2007 | 327 | 143 | 300 | 137 | 19 | 42.0 |
| 2008 | 569 | 280 | 470 | 226 | 44 | 27.0 |
| 2009 | 241 | 180 | 219 | 164 | 62 | 33.4 |

**Table 20: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial trawl operations in Cook Strait during June–September 2009. Summary statistics for the sample are also presented.**

| | | | Cook Strait | |
|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. |
| 3 | 67 | 1.915 | 61 | 1.814 |
| 4 | 1 056 | 0.544 | 1 148 | 0.377 |
| 5 | 1 517 | 0.350 | 1 085 | 0.381 |
| 6 | 1 079 | 0.397 | 1 602 | 0.331 |
| 7 | 857 | 0.447 | 1 516 | 0.302 |
| 8 | 1 485 | 0.301 | 1 784 | 0.274 |
| 9 | 1 738 | 0.288 | 667 | 0.518 |
| 10 | 856 | 0.425 | 823 | 0.427 |
| 11 | 535 | 0.499 | 970 | 0.428 |
| 12 | 638 | 0.616 | 697 | 0.429 |
| 13 | 665 | 0.479 | 482 | 0.565 |
| 14 | 655 | 0.530 | 383 | 0.537 |
| 15 | 692 | 0.435 | 309 | 0.675 |
| 16 | 587 | 0.505 | 305 | 0.660 |
| 17 | 241 | 0.684 | 82 | 1.257 |
| 18 | 350 | 0.539 | 124 | 1.021 |
| 19 | 294 | 0.623 | 273 | 0.747 |
| 20 | 178 | 0.892 | 0 | – |
| 21 | 162 | 0.954 | 63 | 1.559 |
| 22 | 0 | – | 0 | – |
| 23 | 97 | 0.951 | 0 | – |
| 24 | 0 | – | 0 | – |
| 25 | 63 | 1.447 | 0 | – |
| 31 | 63 | 1.549 | 0 | – |

| | |
|---|---|
| Measured males | 241 |
| Measured females | 219 |
| Aged males | 180 |
| Aged females | 164 |
| No. of tows sampled | 62 |
| Mean weighted c.v. (sexes pooled) | 33.4 |

## 3.5 Trawl survey catch-at-age data for ling

### 3.5.1 Chatham Rise

Trawl survey catch-at-age distributions are estimates of the numbers of ling, by sex and age, available to the trawl in the survey area between 200 and 800 m. In some years an additional deeper stratum (800–1000 m) on the north Rise is surveyed. However, to ensure comparability, the distributions presented here are for the 'core' strata only, i.e., 200–800 m.

Table 21 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for ling caught in the January 2010 trawl survey are given in Table 22. The mean weighted c.v. of 25% was well within the target of 30%, as it has been in all surveys in this series.

All estimated proportion at age distributions from the Chatham Rise trawl surveys are presented in Appendix B (Figure B10).

**Table 21: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Chatham Rise trawl surveys.**

| Survey | Males | | Females | | | Mean c.v. |
|---|---|---|---|---|---|---|
| | Measured | Aged | Measured | Aged | Tows | |
| AEX8903 | 743 | 303 | 613 | 296 | 130 | 26.0 |
| TAN9106 | 1 208 | 252 | 1 189 | 281 | 174 | 22.4 |
| TAN9212 | 1 229 | 286 | 1 108 | 313 | 177 | 21.7 |
| TAN9401 | 1 541 | 302 | 1 349 | 302 | 157 | 21.5 |
| TAN9501 | 583 | 236 | 578 | 201 | 114 | 28.1 |
| TAN9601 | 556 | 306 | 509 | 284 | 79 | 27.7 |
| TAN9701 | 837 | 317 | 601 | 242 | 98 | 24.3 |
| TAN9801 | 665 | 348 | 492 | 280 | 88 | 24.5 |
| TAN9901 | 1 071 | 336 | 848 | 318 | 111 | 23.8 |
| TAN0001 | 1 080 | 322 | 969 | 326 | 113 | 22.0 |
| TAN0101 | 1 145 | 312 | 1 084 | 341 | 108 | 20.5 |
| TAN0201 | 1 053 | 294 | 1 170 | 334 | 102 | 19.7 |
| TAN0301 | 813 | 317 | 808 | 347 | 98 | 20.6 |
| TAN0401 | 865 | 303 | 752 | 302 | 101 | 20.2 |
| TAN0501 | 845 | 310 | 801 | 326 | 98 | 22.5 |
| TAN0601 | 1 007 | 328 | 880 | 330 | 90 | 21.0 |
| TAN0701 | 733 | 310 | 732 | 330 | 94 | 21.0 |
| TAN0801 | 610 | 317 | 623 | 325 | 92 | 22.3 |
| TAN0901 | 946 | 338 | 880 | 312 | 103 | 24.3 |
| TAN1001 | 608 | 322 | 882 | 339 | 70 | 25.0 |

**Table 22: Calculated numbers at age in the survey area, separately by sex, with c.v.s, for ling caught during trawl surveys of the Chatham Rise in January 2010 (survey TAN1001) and the Sub-Antarctic in November–December 2009 (survey TAN0911). Summary statistics for the samples are also presented.**

| | | TAN1001 | | | | | TAN0911 | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | Male | c.v. | Female | c.v. | Age | Male | c.v. | Female | c.v. |
| 2 | 9 343 | 0.946 | 25 955 | 0.722 | 2 | 0 | – | 0 | – |
| 3 | 84 921 | 0.561 | 102 940 | 0.383 | 3 | 137 926 | 0.364 | 98 388 | 0.703 |
| 4 | 210 732 | 0.326 | 214 498 | 0.307 | 4 | 213 323 | 0.399 | 282 944 | 0.363 |
| 5 | 142 037 | 0.299 | 209 831 | 0.249 | 5 | 440 337 | 0.267 | 362 496 | 0.311 |
| 6 | 148 710 | 0.258 | 123 312 | 0.301 | 6 | 445 626 | 0.230 | 568 901 | 0.218 |
| 7 | 168 208 | 0.226 | 156 331 | 0.242 | 7 | 452 412 | 0.230 | 518 596 | 0.231 |
| 8 | 143 496 | 0.221 | 110 852 | 0.271 | 8 | 363 463 | 0.243 | 448 958 | 0.236 |
| 9 | 76 176 | 0.315 | 99 706 | 0.301 | 9 | 264 343 | 0.258 | 448 433 | 0.238 |
| 10 | 107 978 | 0.259 | 134 894 | 0.236 | 10 | 153 241 | 0.361 | 565 333 | 0.233 |
| 11 | 75 382 | 0.295 | 119 563 | 0.270 | 11 | 120 854 | 0.406 | 291 116 | 0.275 |
| 12 | 51 517 | 0.341 | 77 585 | 0.290 | 12 | 154 734 | 0.362 | 558 614 | 0.200 |
| 13 | 78 844 | 0.315 | 43 521 | 0.406 | 13 | 215 383 | 0.298 | 338 751 | 0.267 |
| 14 | 98 597 | 0.267 | 87 071 | 0.278 | 14 | 150 033 | 0.362 | 134 967 | 0.352 |
| 15 | 68 280 | 0.297 | 44 268 | 0.399 | 15 | 165 414 | 0.341 | 223 340 | 0.331 |
| 16 | 40 148 | 0.401 | 30 516 | 0.474 | 16 | 117 760 | 0.418 | 135 656 | 0.374 |
| 17 | 10 887 | 0.844 | 8 293 | 0.812 | 17 | 31 195 | 0.694 | 79 510 | 0.507 |
| 18 | 5 280 | 1.028 | 29 894 | 0.456 | 18 | 19 785 | 0.927 | 130 792 | 0.402 |
| 19 | 37 175 | 0.430 | 21 859 | 0.600 | 19 | 11 850 | 1.493 | 73 819 | 0.573 |
| 20 | 13 941 | 0.587 | 16 027 | 0.640 | 20 | 6 074 | 1.303 | 71 916 | 0.498 |
| 21 | 14 930 | 0.819 | 7 995 | 1.028 | 21 | 0 | – | 8 182 | 1.469 |
| 22 | 4 457 | 1.233 | 15 714 | 0.741 | 22 | 37 884 | 0.690 | 17 631 | 1.555 |
| 23 | 0 | – | 1 792 | 1.470 | 23 | 25 231 | 0.915 | 15 007 | 1.056 |
| 24 | 9 614 | 0.791 | 0 | – | 24 | 0 | – | 643 | 2.593 |
| 25 | 1 861 | 1.308 | 1 741 | 1.540 | 25 | 31 427 | 0.770 | 0 | – |
| 26 | 2 651 | 1.647 | 0 | – | 26 | 865 | 2.034 | 0 | – |
| 27 | 1 552 | 1.300 | 0 | – | 27 | 11 850 | 1.442 | 13 005 | 1.118 |
| 28 | 0 | – | 0 | – | 28 | 941 | 2.099 | 0 | – |
| 29 | 1 609 | 1.433 | 0 | – | | | | | |
| 30 | 3 057 | 1.548 | 0 | – | | | | | |
| 31 | 1 552 | 1.310 | 0 | – | | | | | |

| | | | |
|---|---|---|---|
| Measured males | | 608 | 830 |
| Measured females | | 622 | 882 |
| Aged males | | 322 | 232 |
| Aged females | | 320 | 339 |
| No. of tows sampled | | 84 | 70 |
| Mean weighted c.v. (sexes pooled) | | 25.0 | 22.8 |

### 3.5.2 Sub-Antarctic

Trawl survey catch-at-age distributions are estimates of the numbers of ling, by sex and age, available to the trawl in the survey. The main survey series has been conducted in summer. Those surveys have sampled depths from 300 to 800 m, plus an 800–1000 m stratum at Puysegur, and, in some years, other 800–1000 m strata off the Campbell Plateau. However, to ensure comparability, the distributions presented here are for the 'core' 300–800 m strata plus the deep Puysegur stratum only. The catch-at-age distributions from the autumn surveys are derived from the 'core' 300–800 m strata only.

Table 23 summarises the quantities of data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch-at-age distribution for ling caught in the November–December 2009 trawl survey are given in Table 22. The mean weighted c.v. of 22.8% was well within the target of 30%, as it has been in all surveys in this series.

23

All estimated proportion at age distributions from the Sub-Antarctic trawl surveys are presented in Appendix B (Figure B12).

**Table 23: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic trawl surveys.**

|  | Males | | Females | | | Mean c.v. |
| --- | --- | --- | --- | --- | --- | --- |
| Survey | Measured | Aged | Measured | Aged | Tows | |
| Summer surveys | | | | | | |
| AEX8902 | 760 | 160 | 1 067 | 234 | 133 | 29.0 |
| TAN9105 | 1 563 | 213 | 2 079 | 348 | 151 | 19.6 |
| TAN9211 | 1 249 | 227 | 1 668 | 354 | 146 | 21.1 |
| TAN9310 | 1 520 | 254 | 1 894 | 351 | 127 | 22.3 |
| TAN0012 | 1 761 | 244 | 1 696 | 351 | 85 | 18.8 |
| TAN0118 | 1 316 | 268 | 1 290 | 326 | 95 | 19.6 |
| TAN0219 | 1 661 | 224 | 1 606 | 350 | 88 | 20.6 |
| TAN0317 | 1 270 | 243 | 1 156 | 333 | 70 | 22.1 |
| TAN0414 | 1 433 | 256 | 1 146 | 339 | 79 | 27.0 |
| TAN0515 | 1 095 | 279 | 988 | 300 | 82 | 22.0 |
| TAN0617 | 969 | 250 | 1 011 | 355 | 80 | 23.1 |
| TAN0714 | 1 014 | 229 | 1 288 | 353 | 79 | 21.7 |
| TAN0813 | 1 162 | 250 | 994 | 327 | 80 | 26.8 |
| TAN0911 | 830 | 232 | 882 | 339 | 70 | 22.8 |
| Autumn surveys | | | | | | |
| TAN9204 | 1 570 | 221 | 1 498 | 310 | 90 | 21.5 |
| TAN9304 | 1 353 | 261 | 1 344 | 373 | 97 | 21.1 |
| TAN9605 | 1 129 | 325 | 902 | 303 | 88 | 21.9 |
| TAN9805 | 809 | 271 | 765 | 296 | 64 | 22.9 |

## 4. DISCUSSION

### 4.1 Hake

For hake, sufficient otoliths and length-frequency data to produce catch-at-age distributions that met the target mean weighted c.v.s were available from the HAK 7 fishery off WCSI, the HAK 1 fishery in the Sub-Antarctic, and the 'western' section of the HAK 1 and 4 fishery on the Chatham Rise. The target has almost always been met for samples in the WCSI fishery (see Table 4). The sampling intensity in the HAK 1 (Sub-Antarctic) commercial trawl fishery was good in 2008–09. Sampling intensity in the Sub-Antarctic has varied considerably between years, with consequent wide variation in the mean weighted c.v.s (see Table 3). Data from the Chatham Rise are analysed as two separate fisheries (see Table 1), but a catch-at-age distribution was able to be derived only for the 'western' fishery in 2008–09.

The Sub-Antarctic trawl survey produced a good sample of aged fish (600), but the Chatham Rise survey was less productive (249 age estimates). Catch-at-age distributions were produced for both the trawl surveys, and both of the estimated mean weighted c.v.s were above the target of 30% (36.3% for Sub-Antarctic, 39.7% for Chatham Rise). However, no improvements in the precision can be achieved, as all available data were included in the analyses.

On the Chatham Rise, younger hake tend to be concentrated in the west, with the population dominated by fish aged 2–10 years (see Appendix A, Figure A1). Middle-aged and older hake (i.e., 5–15 years old) tend to dominate catches in the eastern Rise (see Figure A2). Males and females appear to be about evenly abundant in all areas except Statistical Area 404, where males clearly dominate the catch (Horn & Sutton 2009). There is a clear year class progression apparent in the seven most recent Chatham Rise survey distributions (Figure A5). The 2001 year class (aged 2+ in January 2004) clearly progresses through to

age 7+ in 2009, for both males and females. It also appears likely that the two following year classes (2002 and 2003) are moderately strong.

In the Sub-Antarctic, there are some clear year class progressions, particularly in the male distributions. Figure A3 shows the progressions of hake aged 10 in 1990 through to age 16 in 1996, and aged 6 in 1998 through to age 12 in 2004. The two most recent trawl surveys indicate the possibility of some recent moderately strong recruitment (Figure A6).

The WCSI trawl catch is dominated by hake aged 6–12 years, with no clearly apparent year class progressions (see Figure A4). In some years, large numbers of 1- or 2-year-old fish are taken by the fishery, but these do not manifest as strong cohorts in later years. A characteristic of most of the WCSI distributions is that numbers of fish aged 3 and 4 are generally very low. It seems likely that fish of this age are much less vulnerable or available to the trawl during the winter months of the fishery than younger or older hake.

## 4.2    Ling

Catch-at-age distributions were produced for three commercial longline fisheries in 2008–09, and the target c.v.s were met for two of these (Chatham Rise and Sub-Antarctic non-spawning). The target was not met for the Bounty Plateau fishery owing to relatively light sampling; only part of one trip was observed in this fishery. A catch-at-age distribution was scheduled to be produced for the Sub-Antarctic spawning fishery, but it was not sampled by observers in 2008–09. The resources intended to be used to analyse the Sub-Antarctic spawning fishery were transferred to the Bounty Plateau fishery. Only three years of comprehensive sampling for catch-at-age were previously available for that fishery (see Table 13), so it was considered desirable to add to that series.

Catch-at-age distributions were produced for trawl fisheries catching ling in four areas. The Chatham Rise and Sub-Antarctic distributions used observer length data applied to age-length keys obtained from trawl surveys, e.g., Chatham Rise length data collected from October 2008 to May 2009 were applied to the age-length key from the January 2009 (TAN0901) trawl survey of the Chatham Rise. The estimated catch-at-age distributions from the Sub-Antarctic had a mean weighted c.v. well within the usual target of 30%, but the Chatham Rise c.v. was above the target despite being based on relatively large sample sizes. Most distributions calculated for both these fisheries in previous years had been within the target. An estimate of catch-at-age was also produced for the ling taken as bycatch in the Cook Strait hoki spawning fisheries; it was outside the target c.v. of 30% owing to sampling being at its lowest level since 2000 (see Table 19). An estimate of catch-at-age for the ling bycatch from the WCSI hoki spawning fishery could not be produced for 2009 as only 311 fish were measured, despite the total ling catch being in excess of 800 t. This was the lowest level of sampling in this fishery since 1990 (see Tables 18).

Sufficient ling otoliths and length-frequency data were available from the Sub-Antarctic and Chatham Rise trawl surveys to easily meet the mean weighted c.v. target. The target has been met in all surveys from these two areas.

The ling longline fisheries catch few fish younger than 7 years, and much of the catch is older than 12 years. Sex ratios of the longline catch are about 1:1 on the Chatham Rise and in Cook Strait, but tend to be biased towards females in the other fisheries. This is particularly apparent in the Sub-Antarctic non-spawning fishery (see Figure B3). No clear year class progressions are apparent in any of the longline series.

Recruitment to the trawl fisheries is generally about two years earlier than to the line fisheries (i.e., at about 5 years), and most of the catch is 13 years or younger. No clear year class progressions are apparent in any of the trawl series. The ling trawl catch-at-age distributions from the WCSI fishery often exhibit a trough at about age 6 or 7. This is consistent with an inflexion point in the length-frequency distributions at lengths of about 72 cm for males and 77 cm for females (see figure 3 of

Horn 2008). It seems likely that fish of this size are less vulnerable or available to the trawl during the winter months of the fishery.

## 5.    ACKNOWLEDGMENTS

## 6.    REFERENCES

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# Appendix A: Summaries of the proportions-at-age data for hake from resource surveys and trawl fishery observer sampling
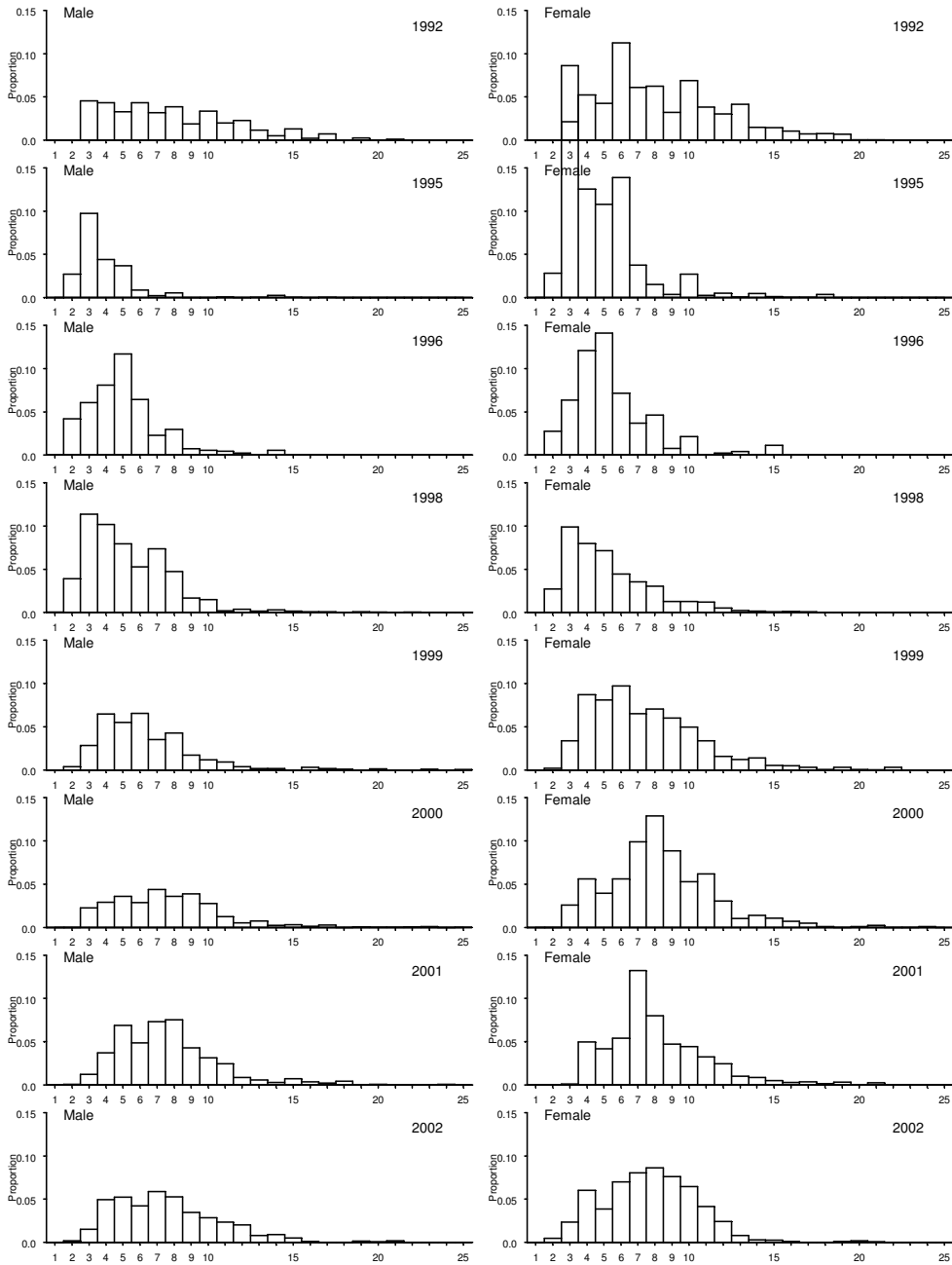


**Figure A1: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2009.**
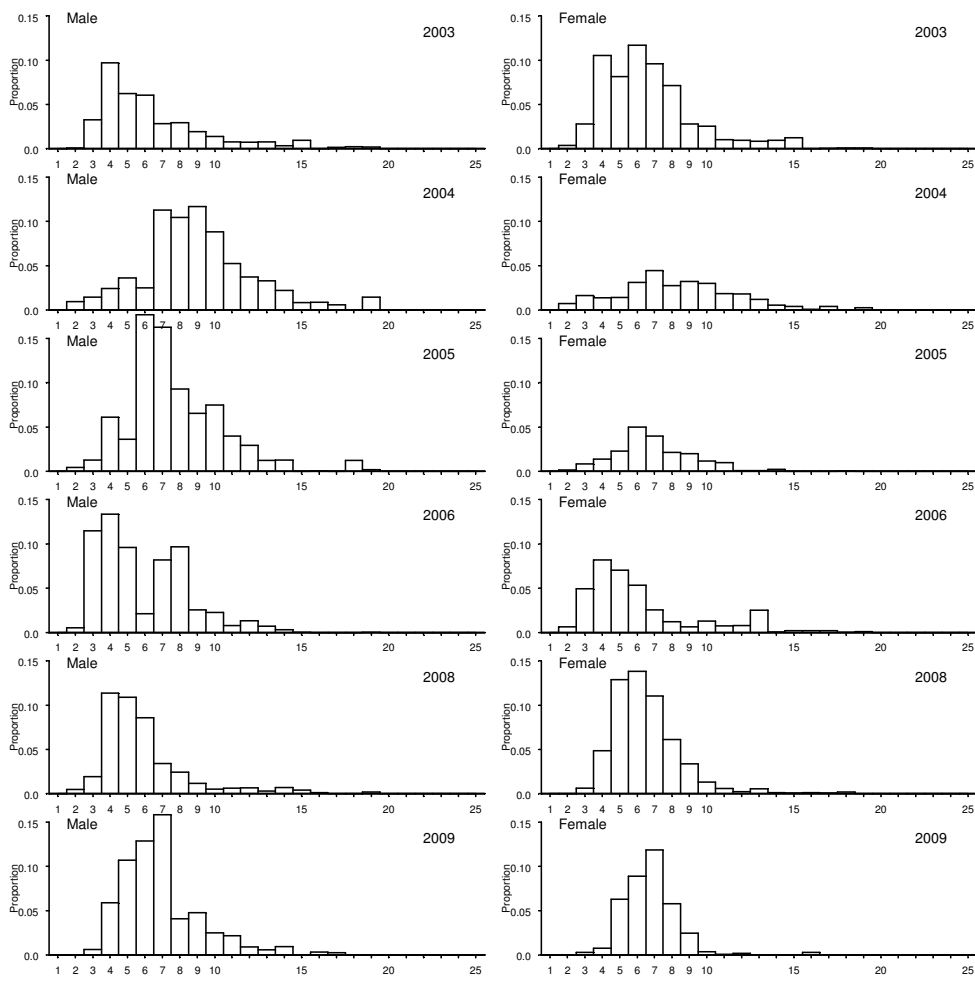
**Figure A1 ctd.: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2009.**
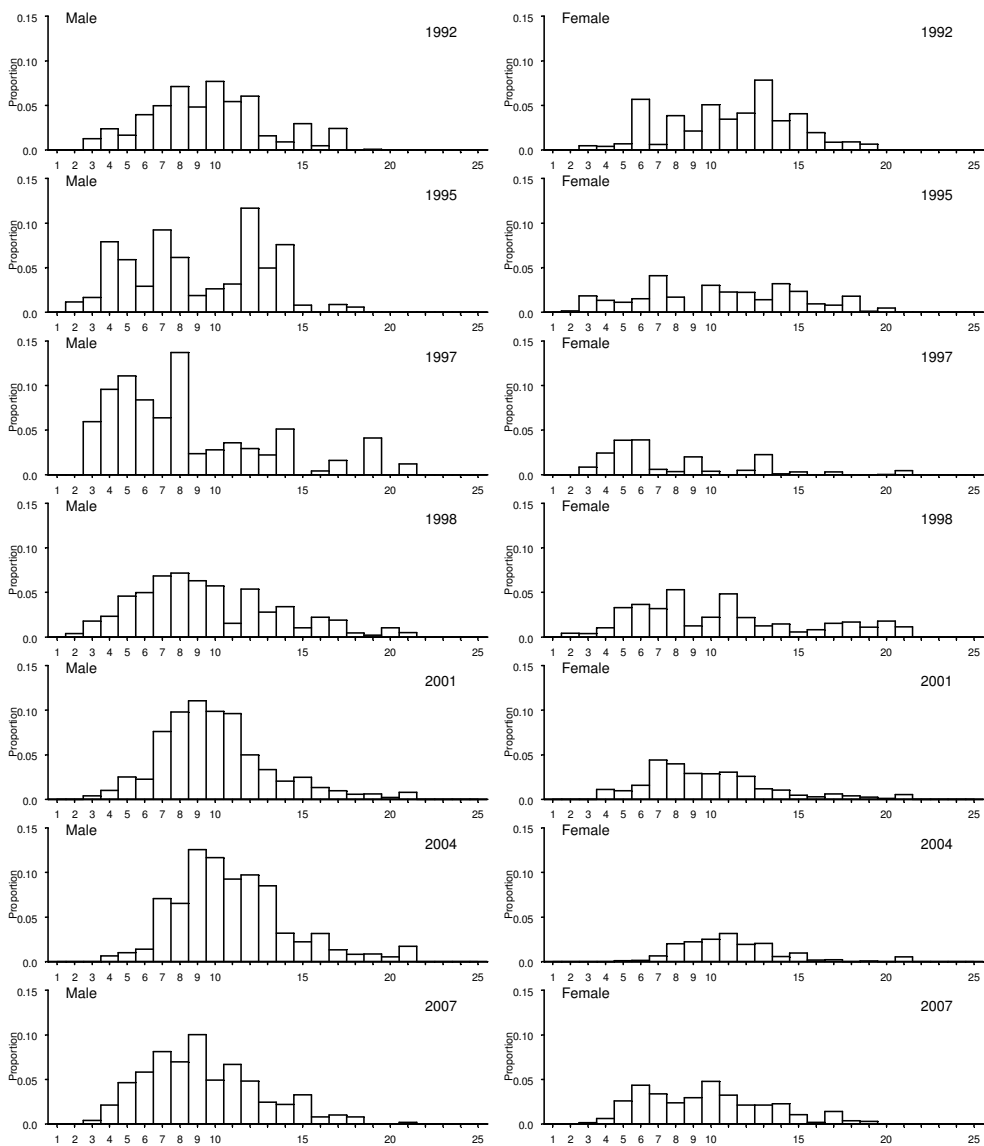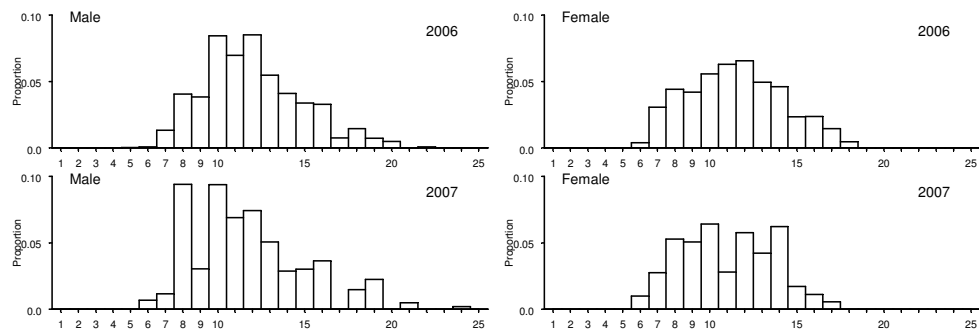
**Figure A2: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2009.**
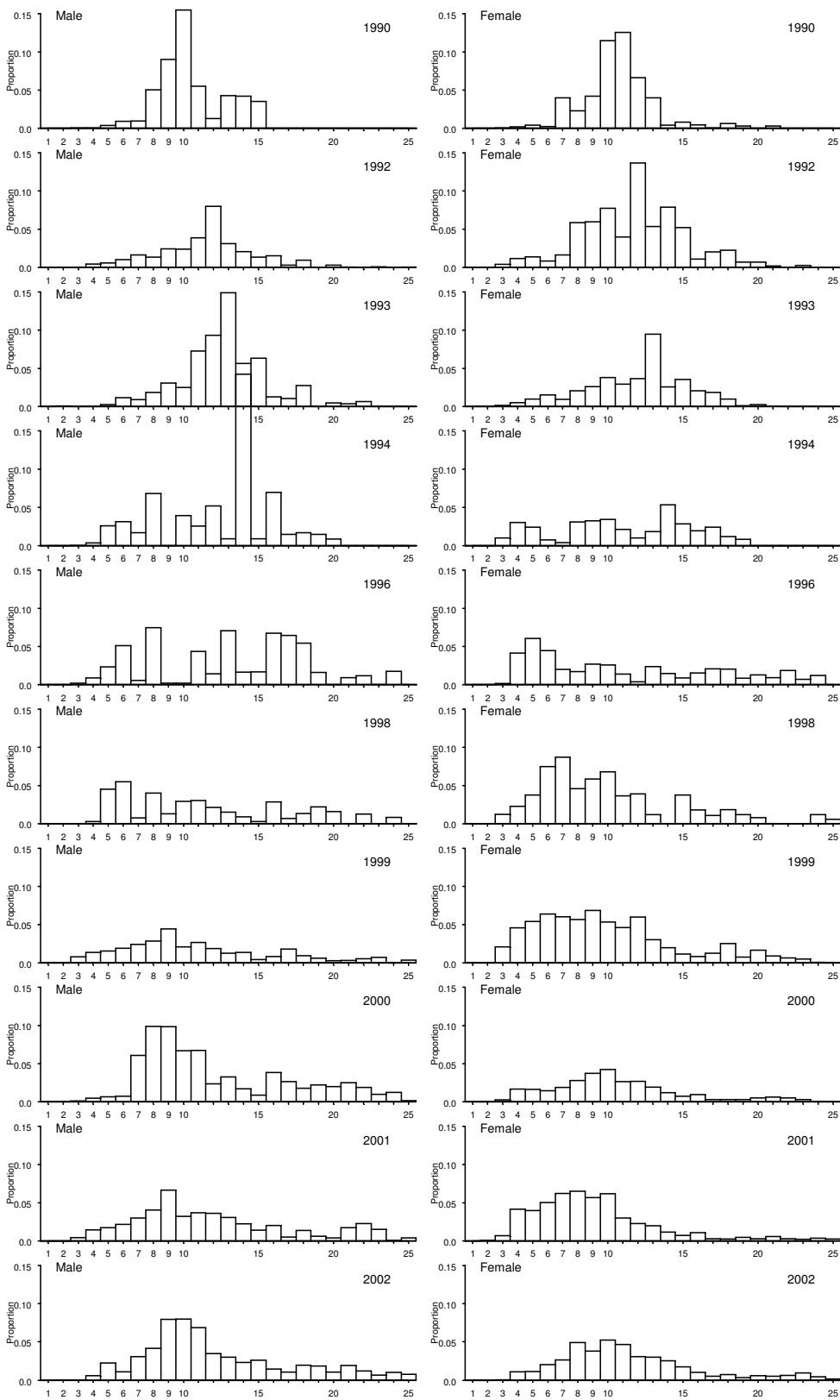
**Figure A3: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2009.**
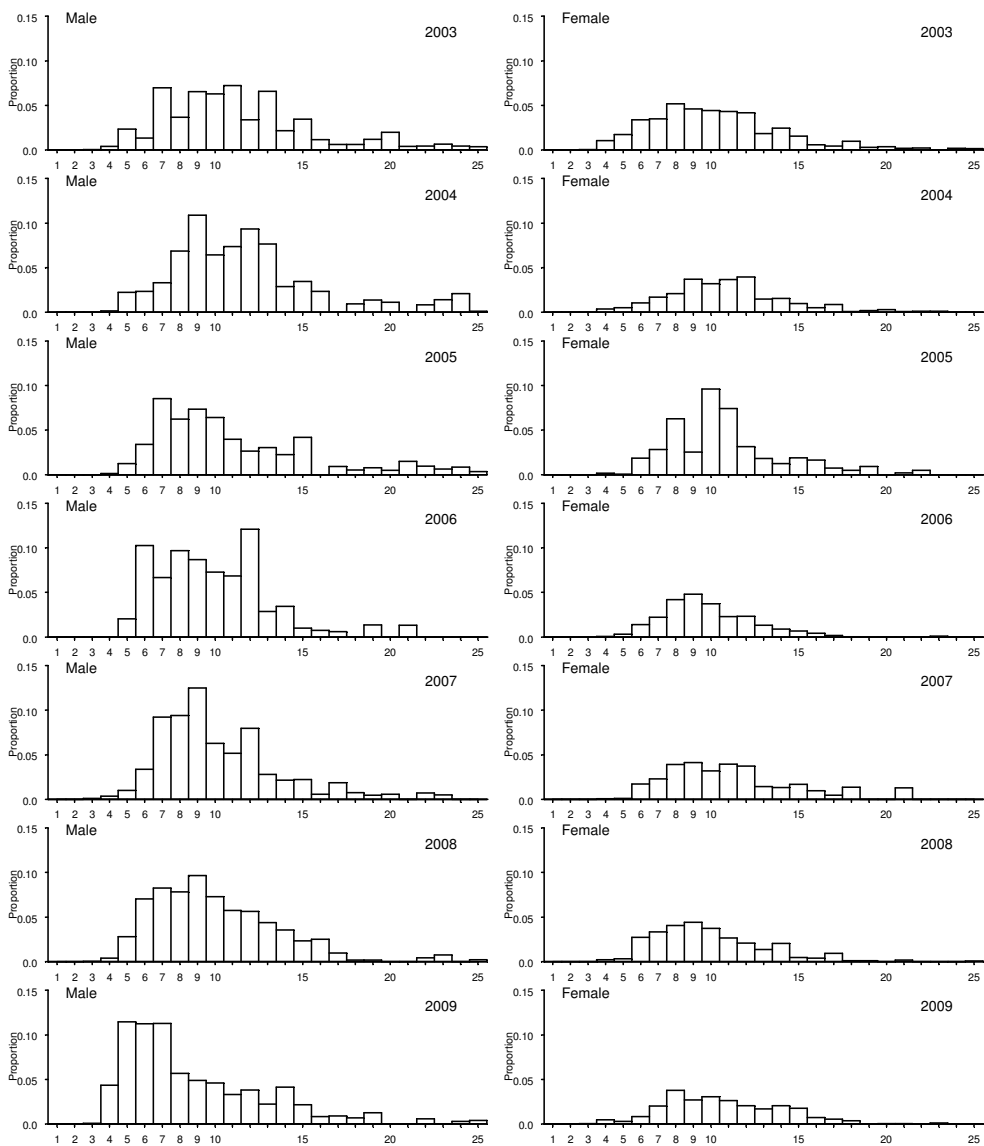
**Figure A3 ctd.: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2009.**
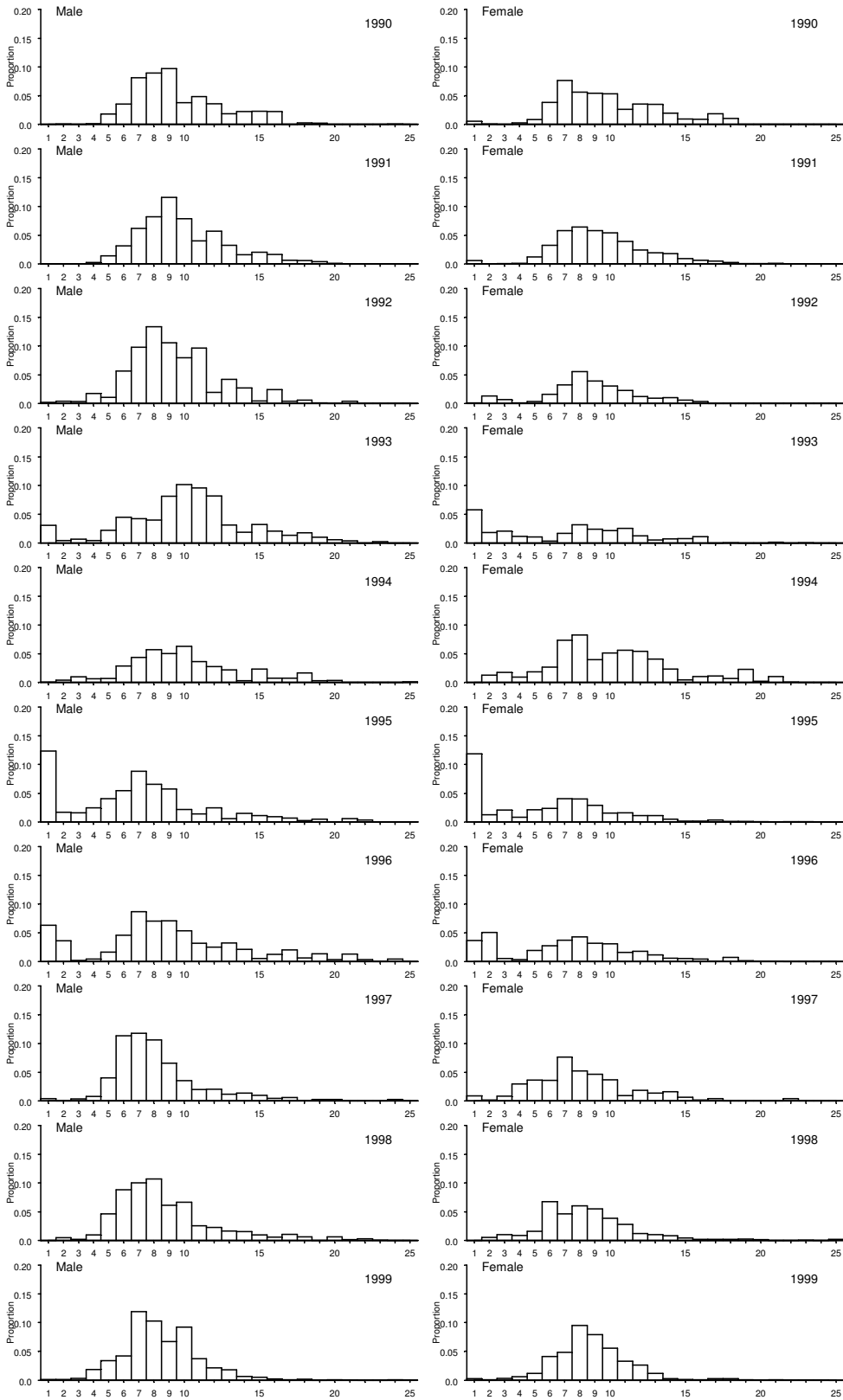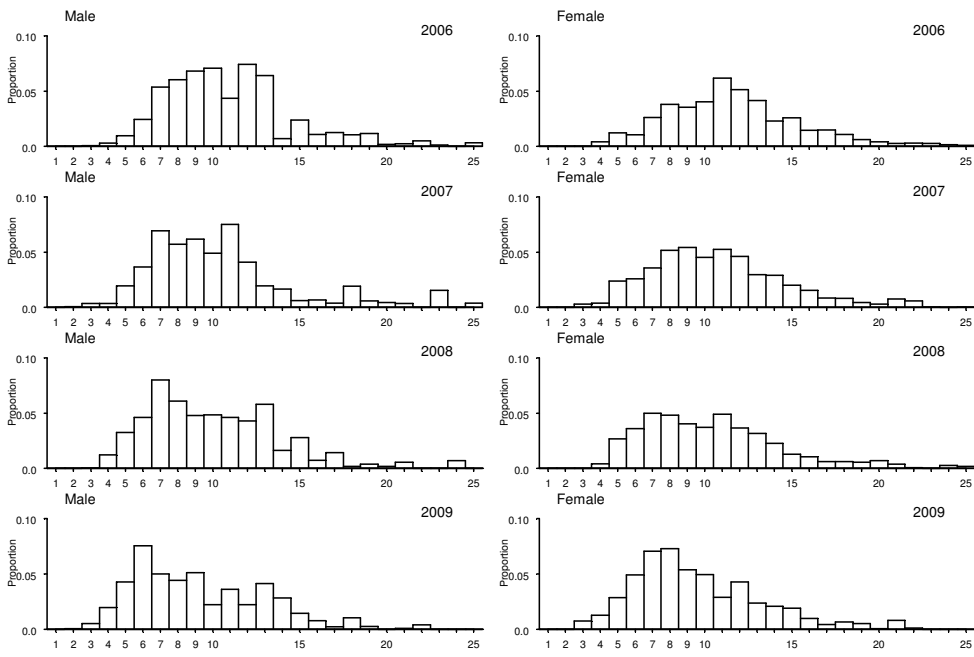
**Figure A4: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2010.**
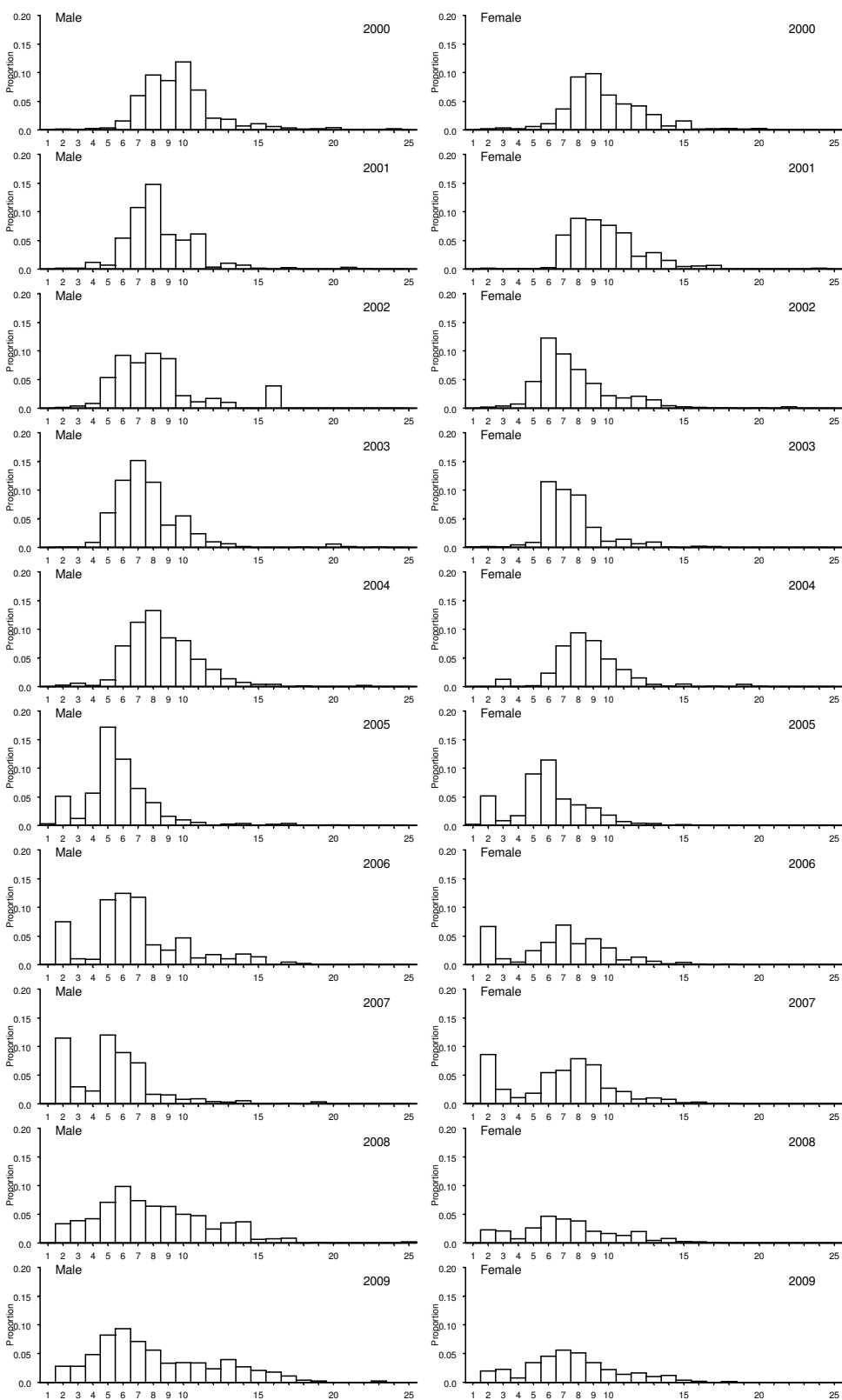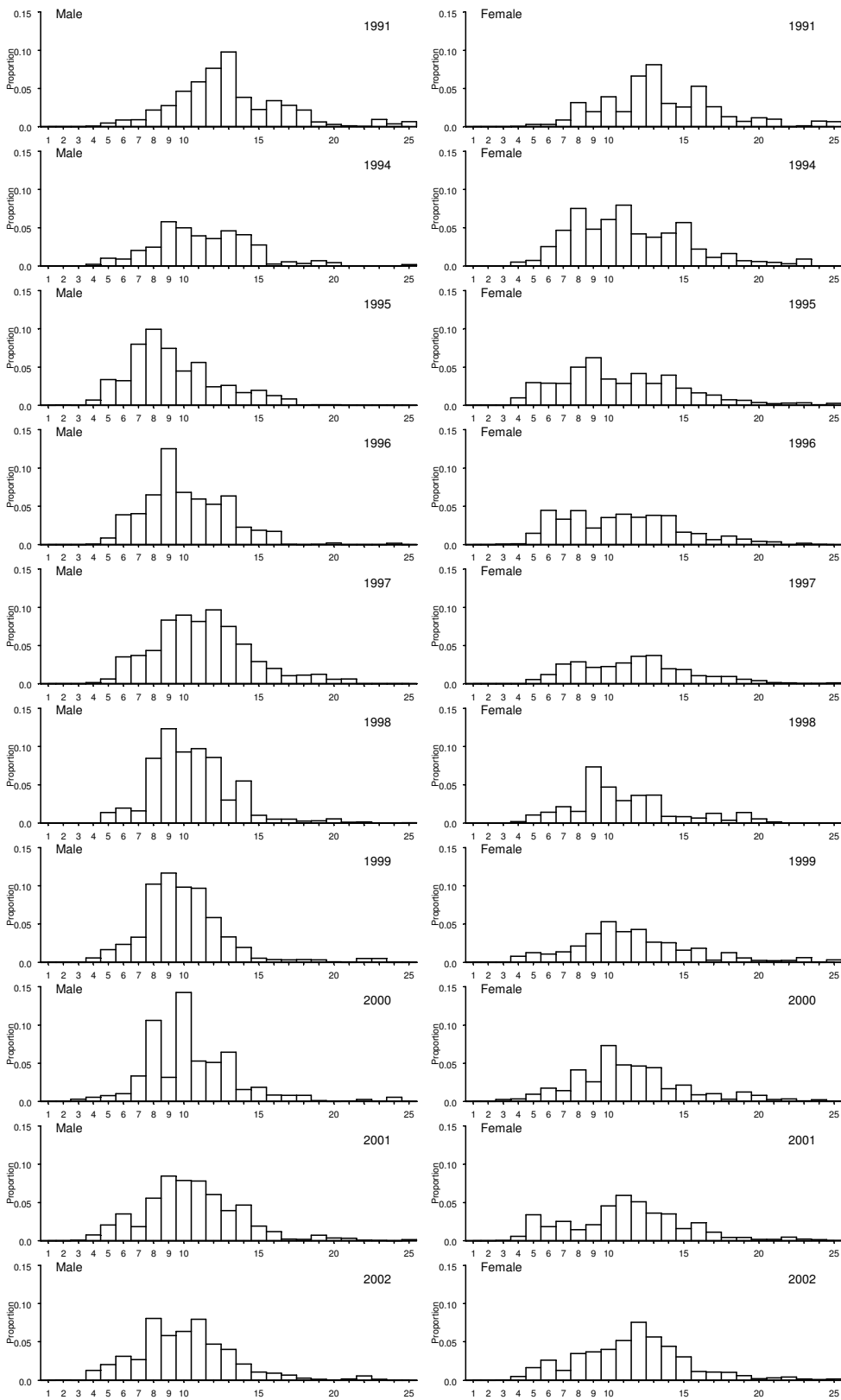
**Figure A4 ctd.: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2010.**
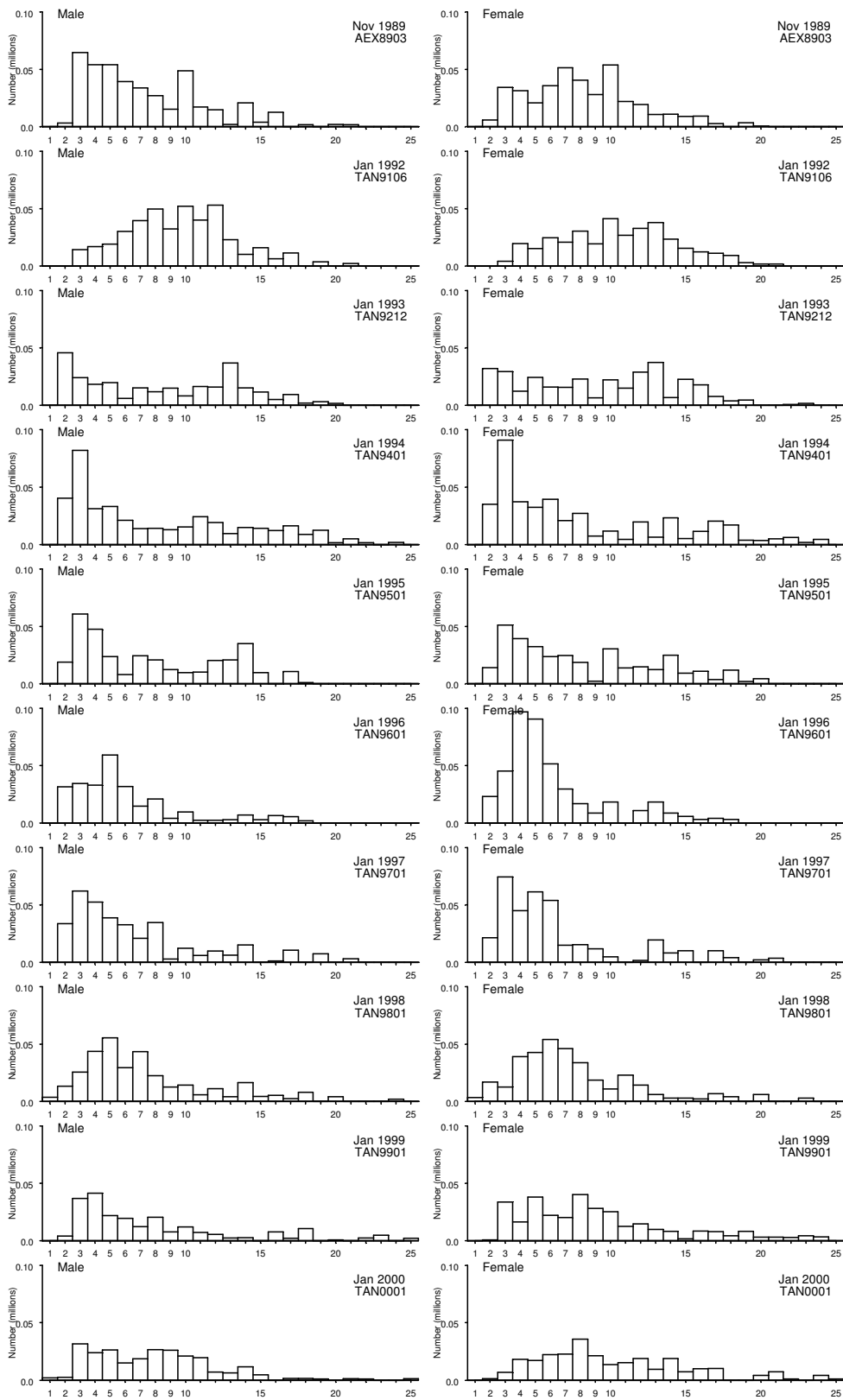
**Figure A5: Available age frequencies of hake (ages 1 to 25) from resource surveys on the Chatham Rise, 1989–90 to 2009–10.**

34
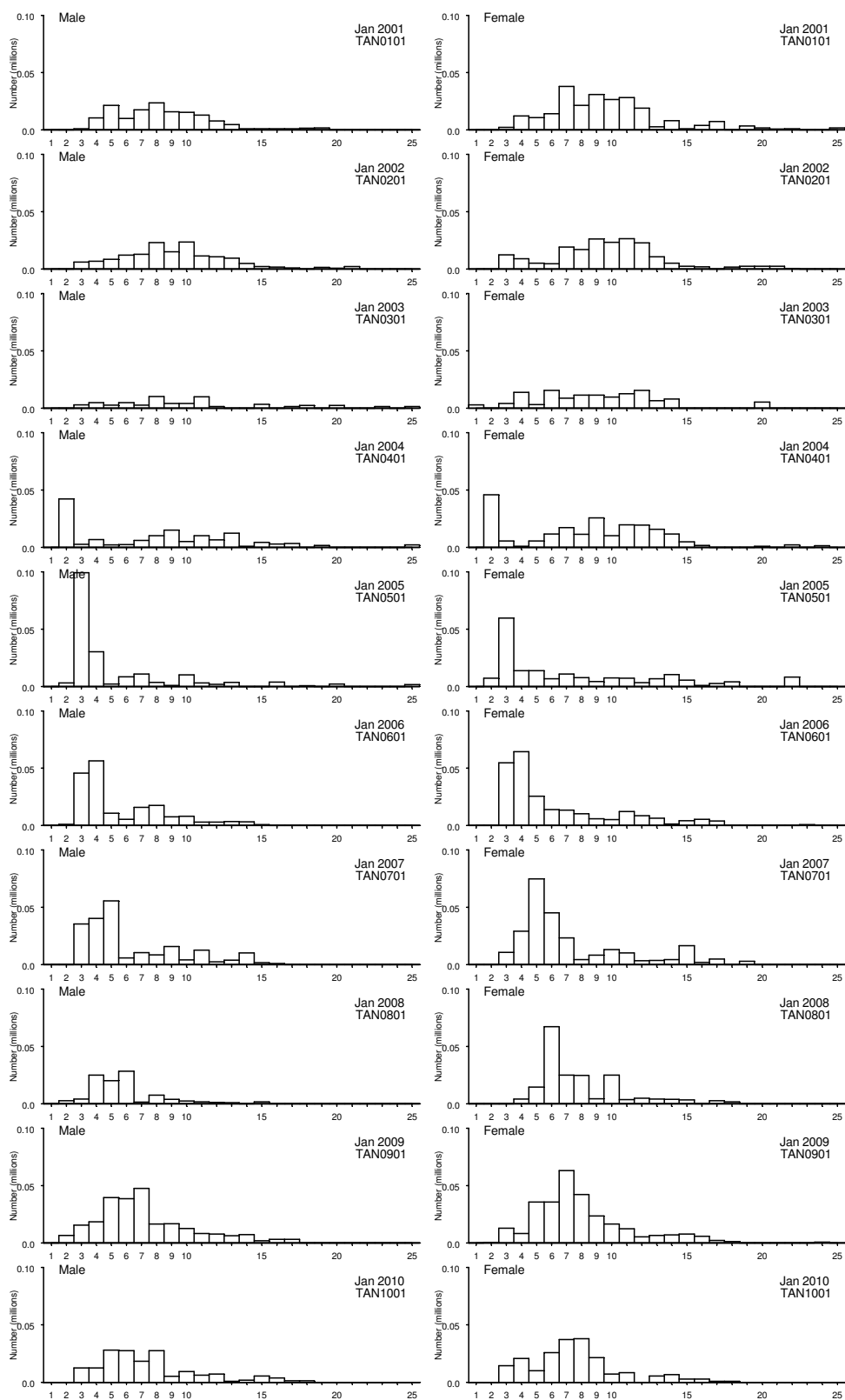
**Figure A5 ctd.: Available age frequencies of hake (ages 1 to 25) from resource surveys on the Chatham Rise, 1989–90 to 2009–10.**
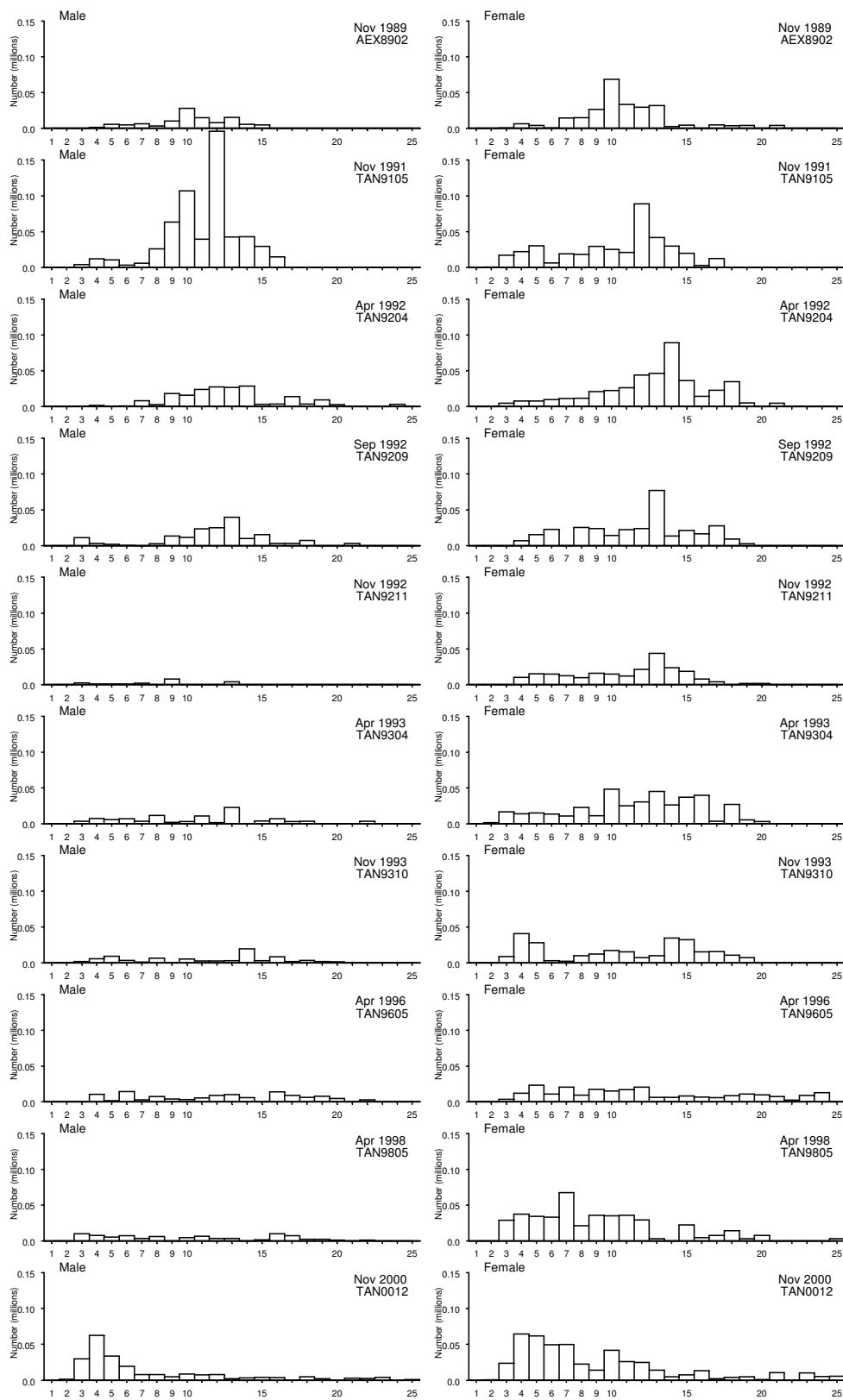
**Figure A6: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Sub-Antarctic, 1989 to 2010.**
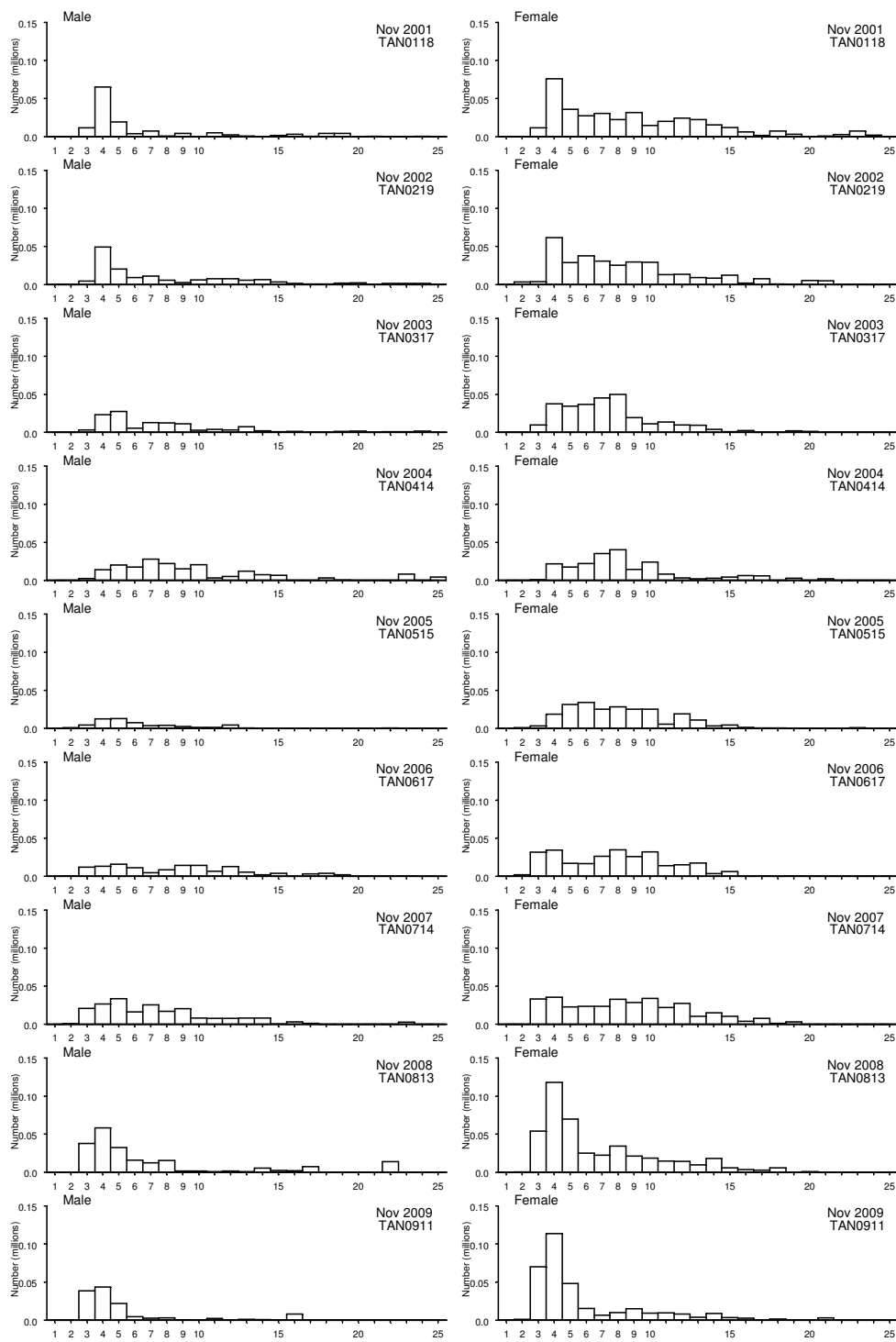
**Figure A6 ctd.: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Sub-Antarctic, 1989 to 2010.**

**Appendix B: Summaries of the proportions-at-age data for ling from resource surveys and observer sampling of line and trawl fisheries**
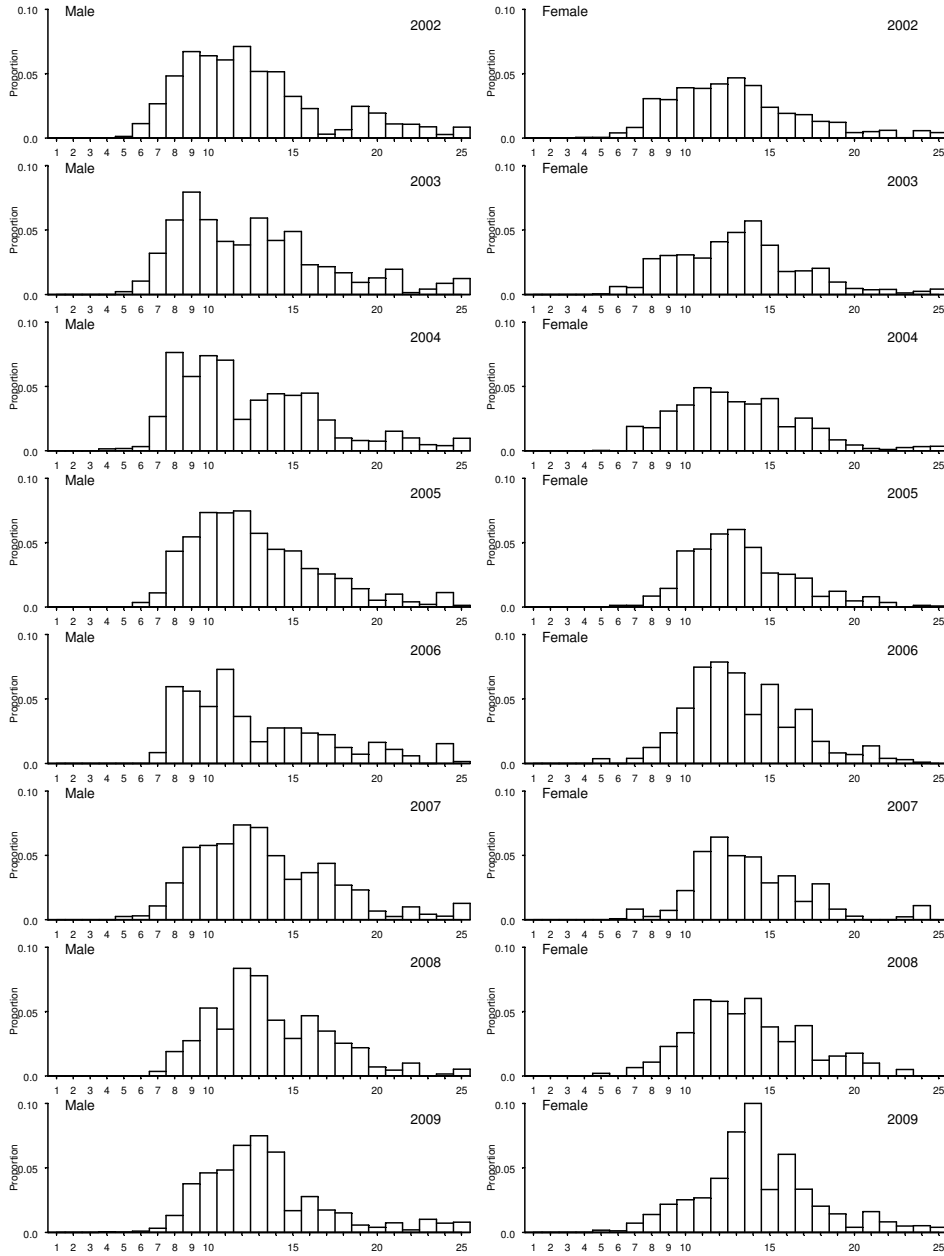


**Figure B1: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2009.**
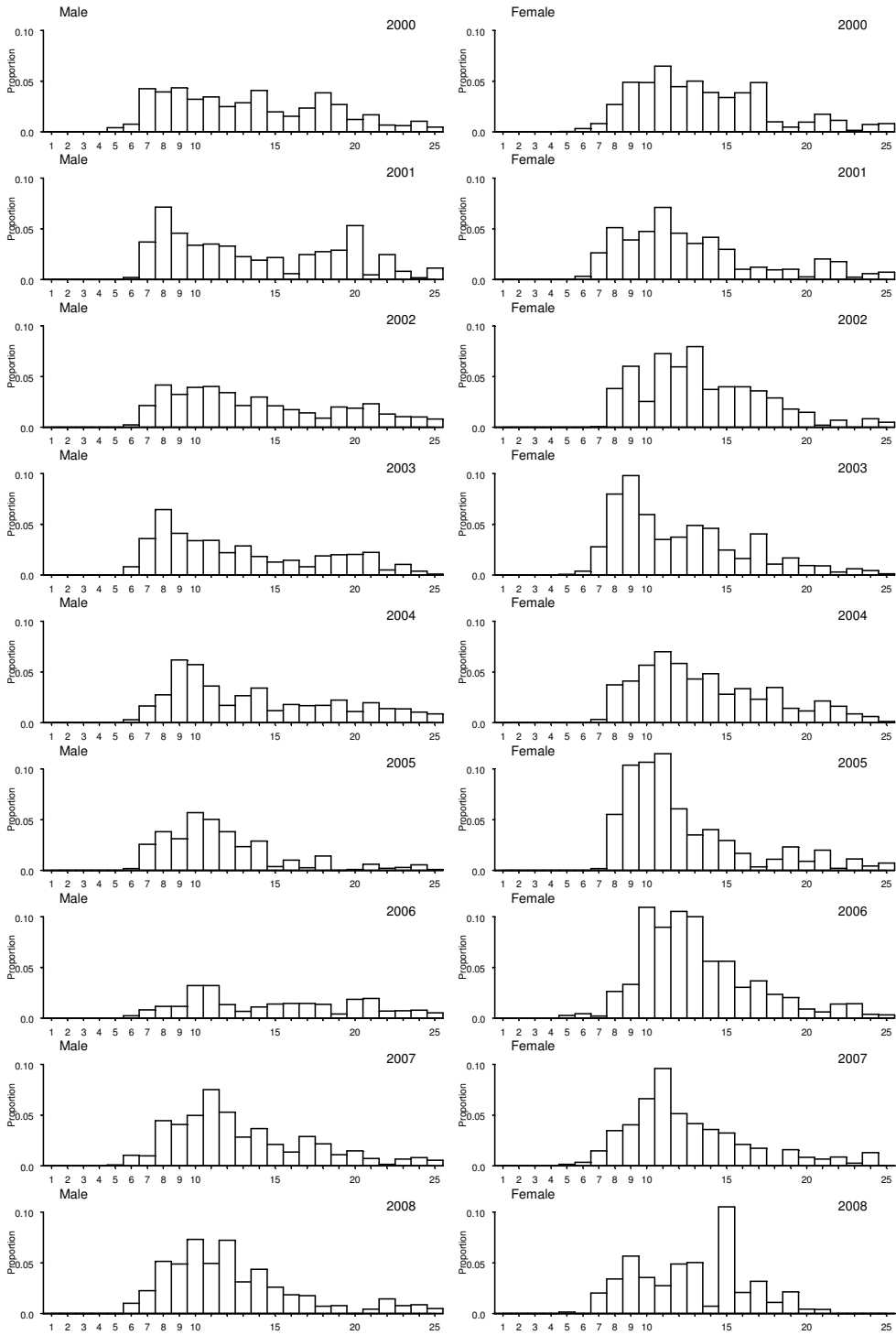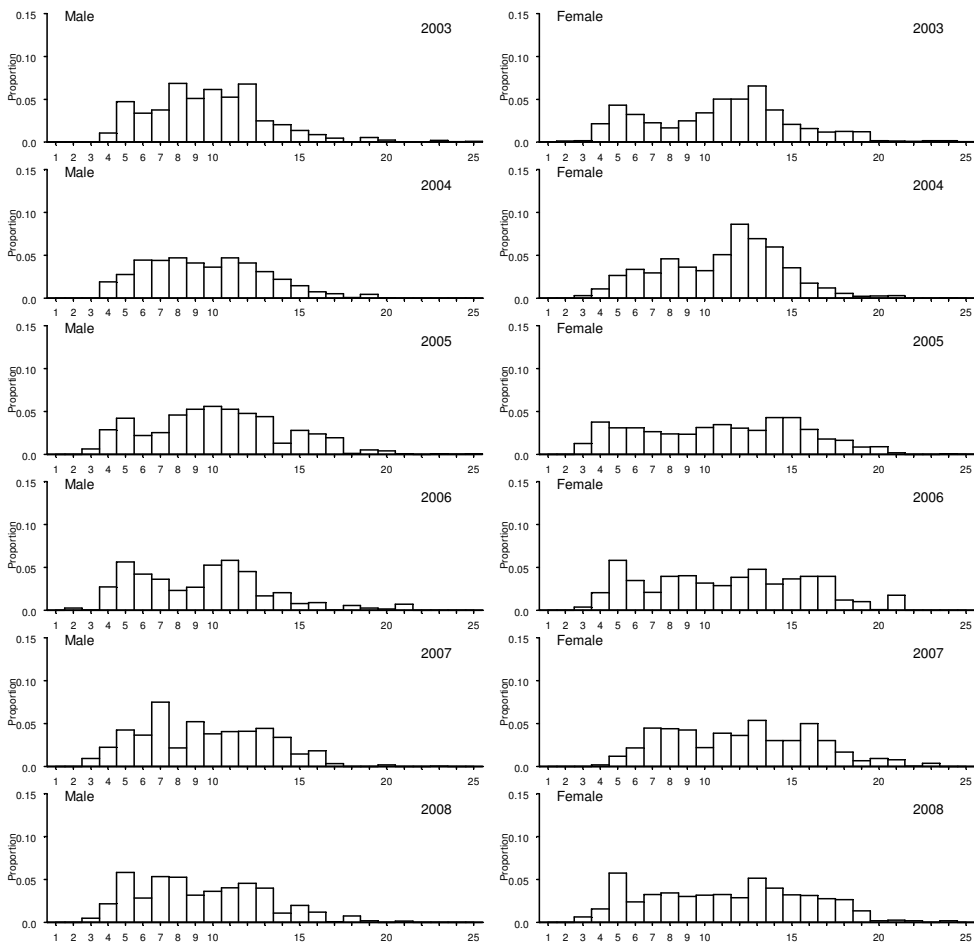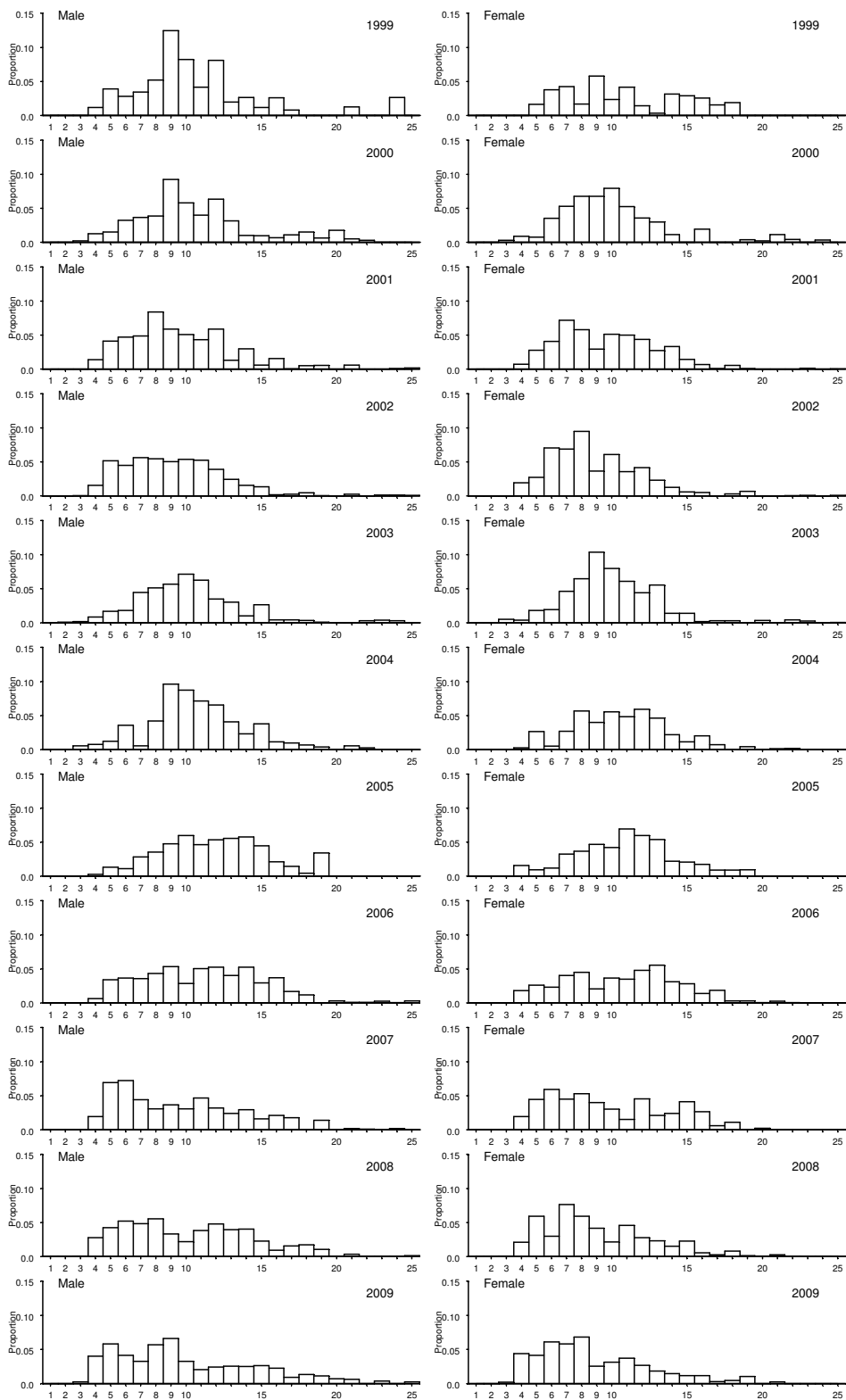
**Figure B2: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2009.**
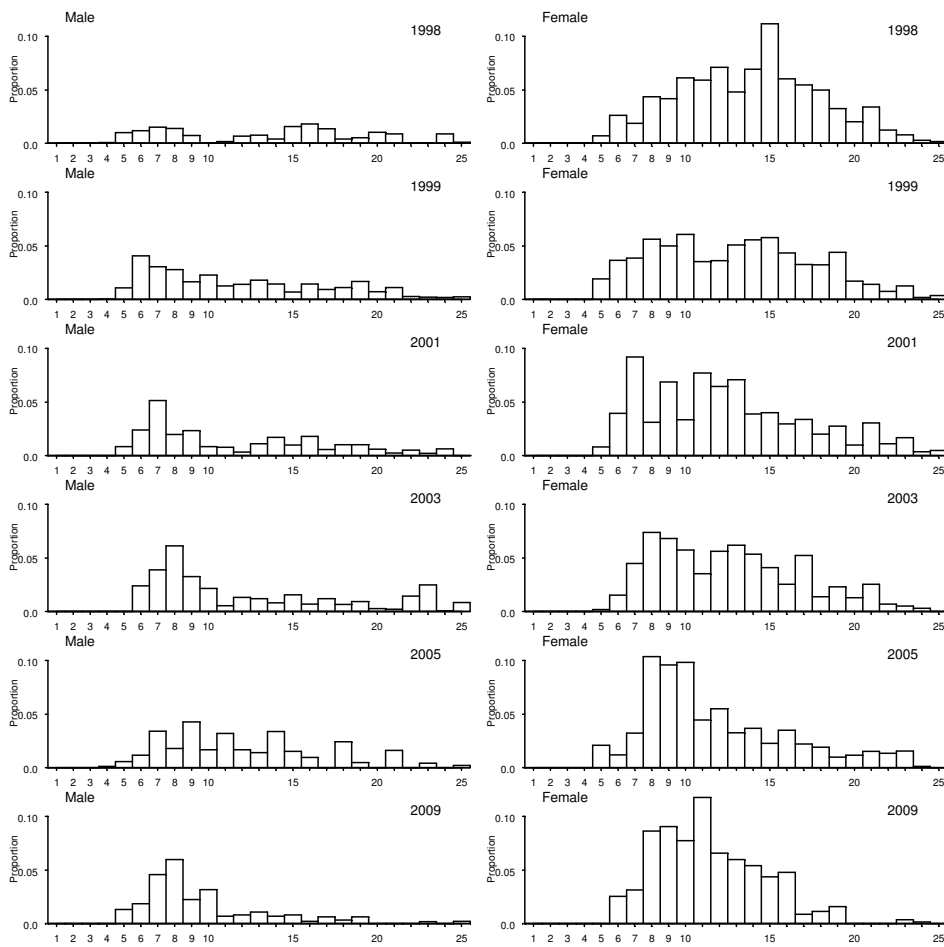
**Figure B3: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2009.**



**Figure B4: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2006 to 2009.**
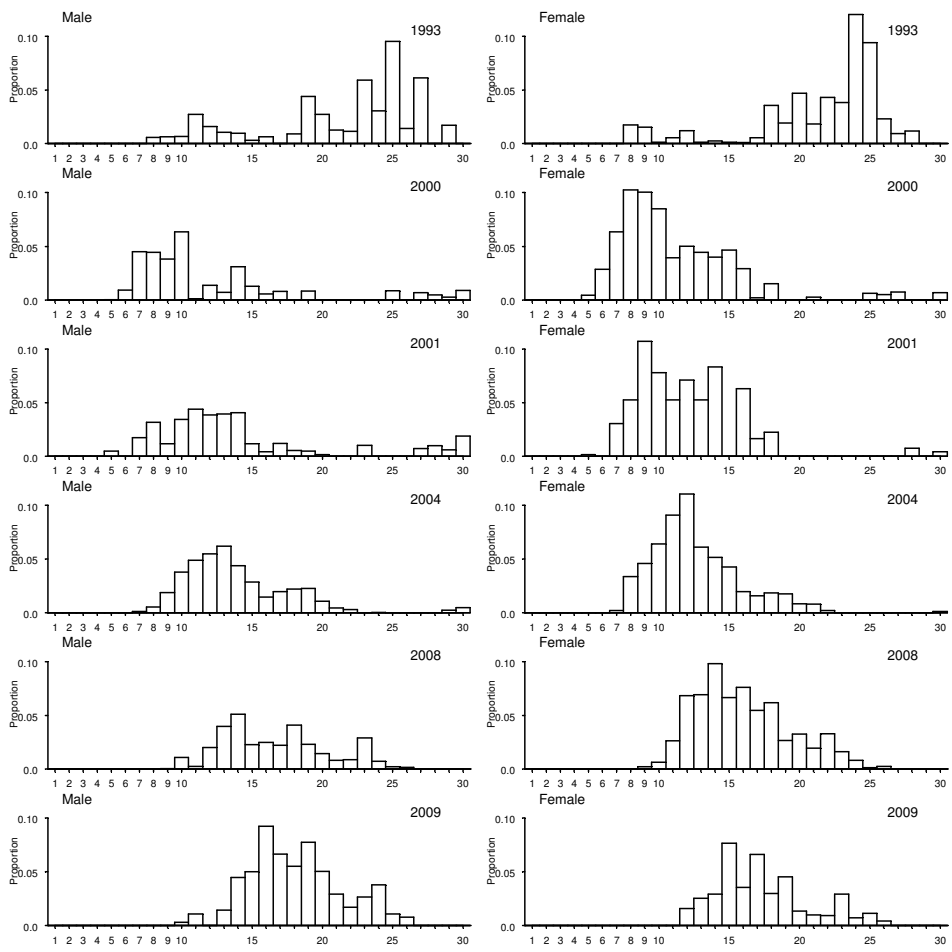
**Figure B5: Available age frequencies of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2009.**
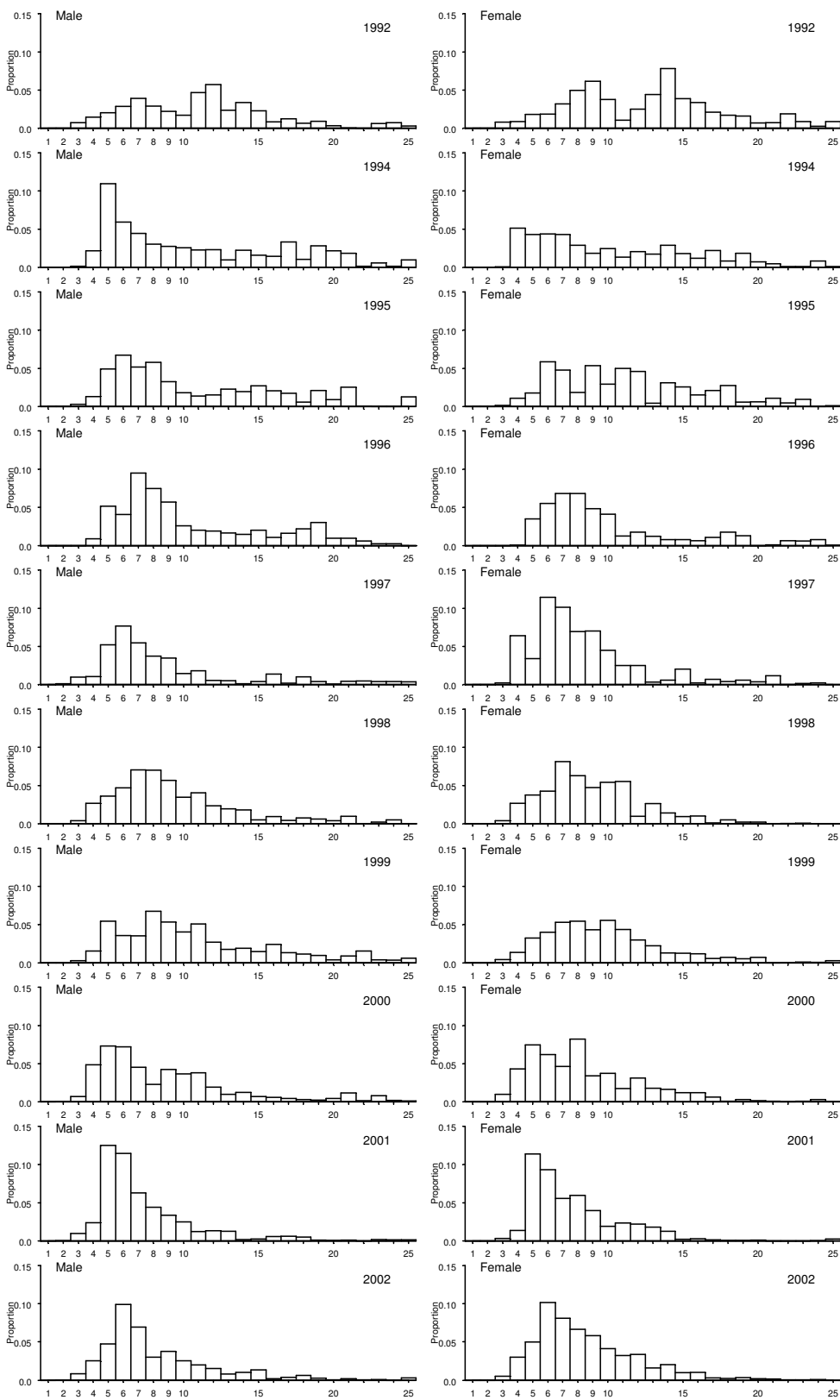
**Figure B6: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2009.**

42
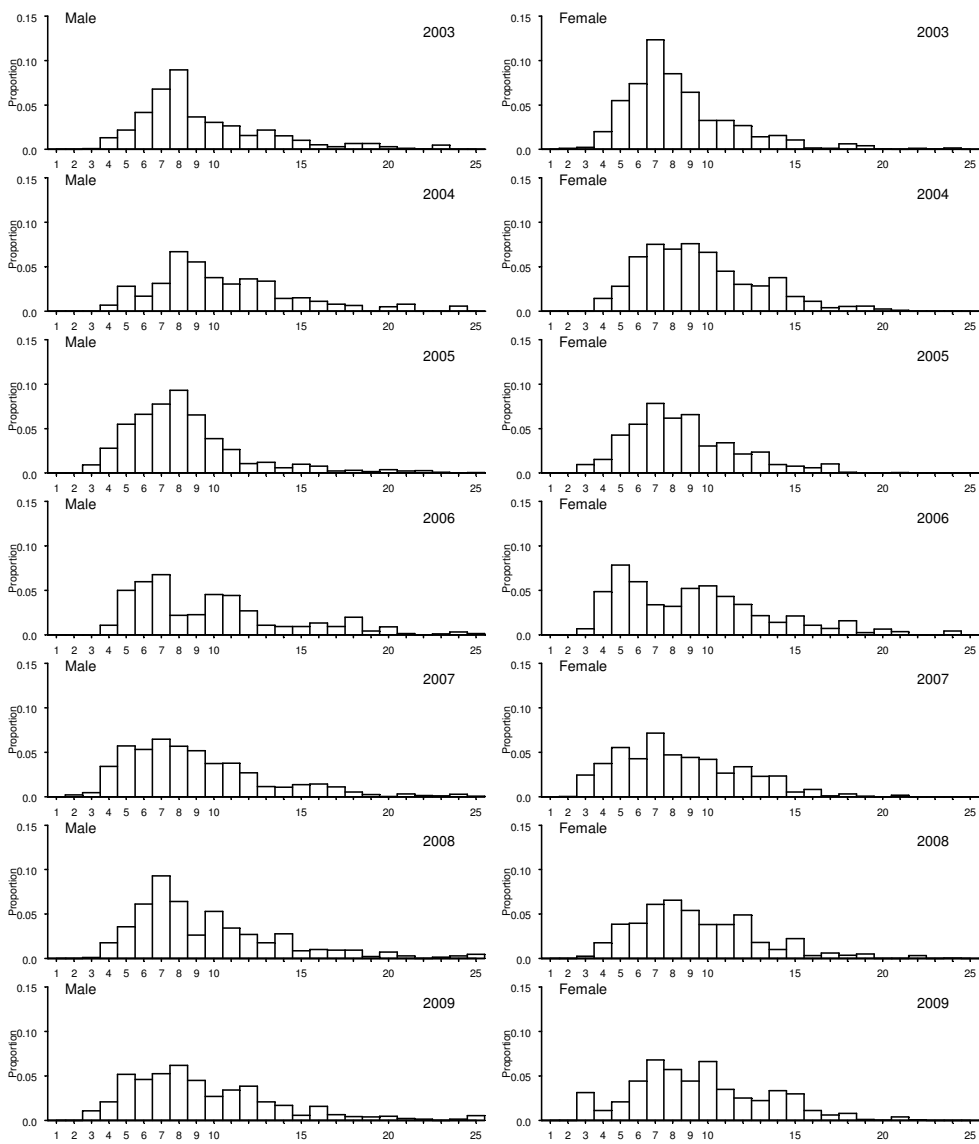
**Figure B6 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2009.**
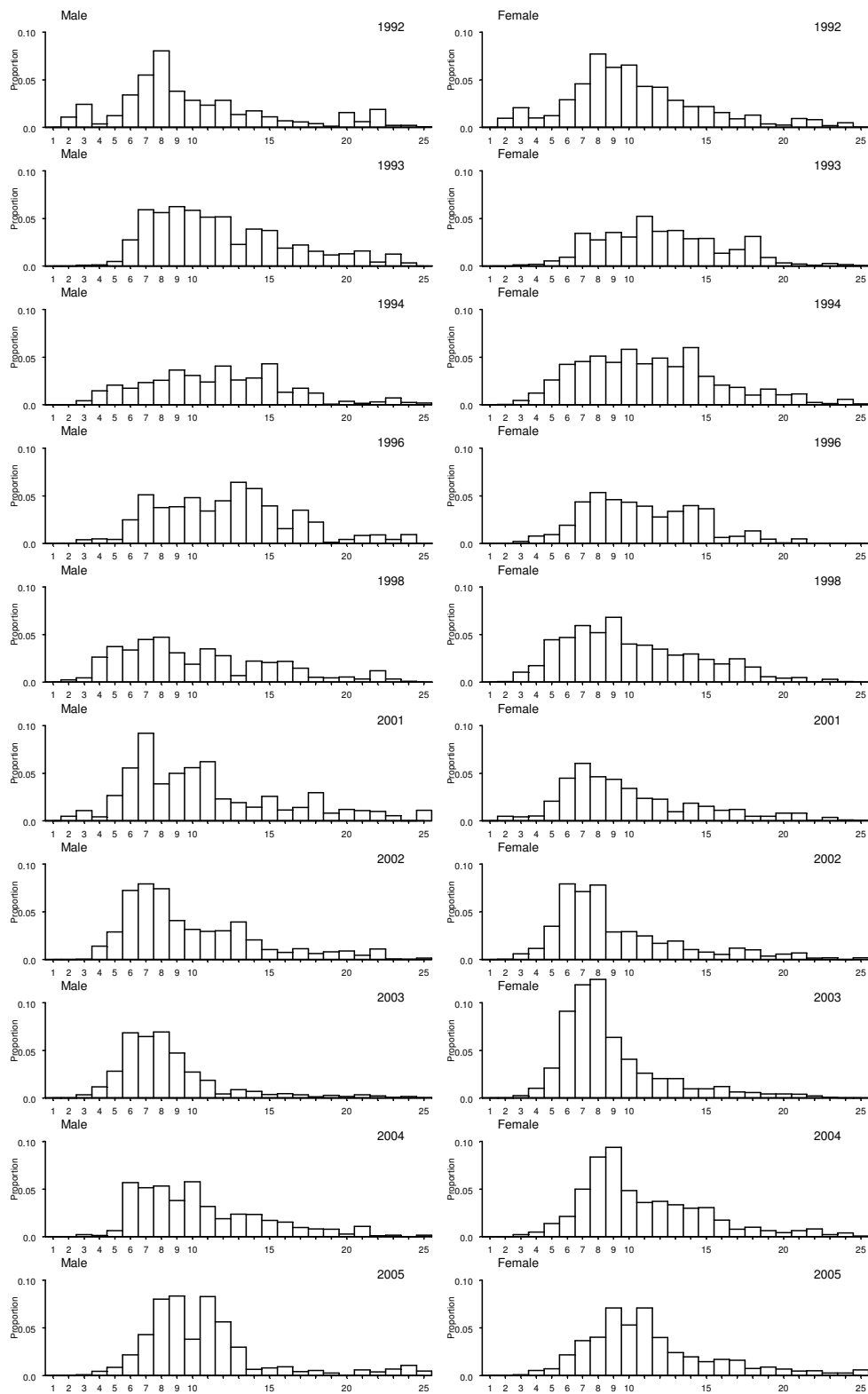
**Figure B7: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2009.**
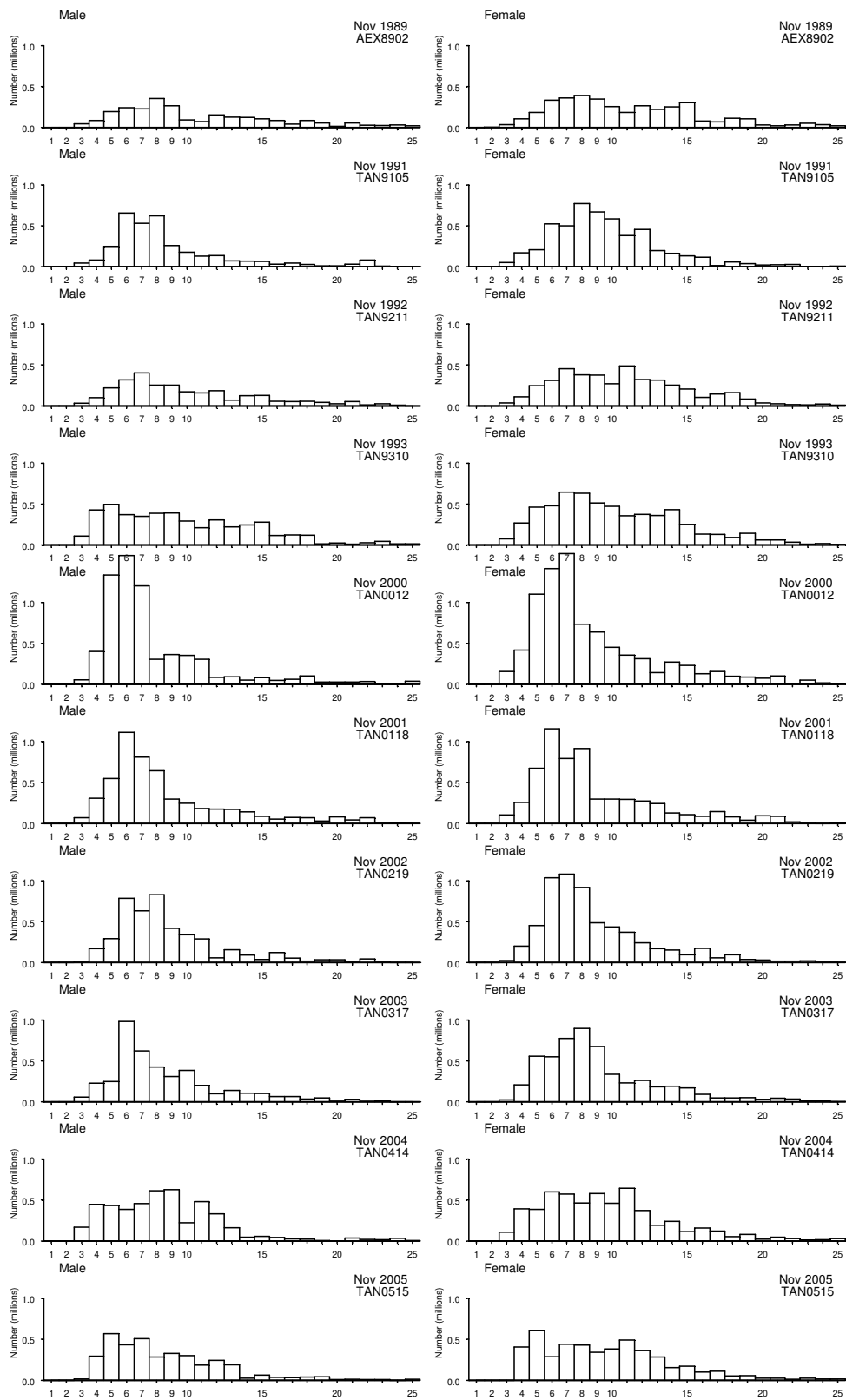
**Figure B7 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2009.**

**Figure B8: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2009.**

**Figure B8 ctd.: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2009.**

**Figure B9: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2009.**
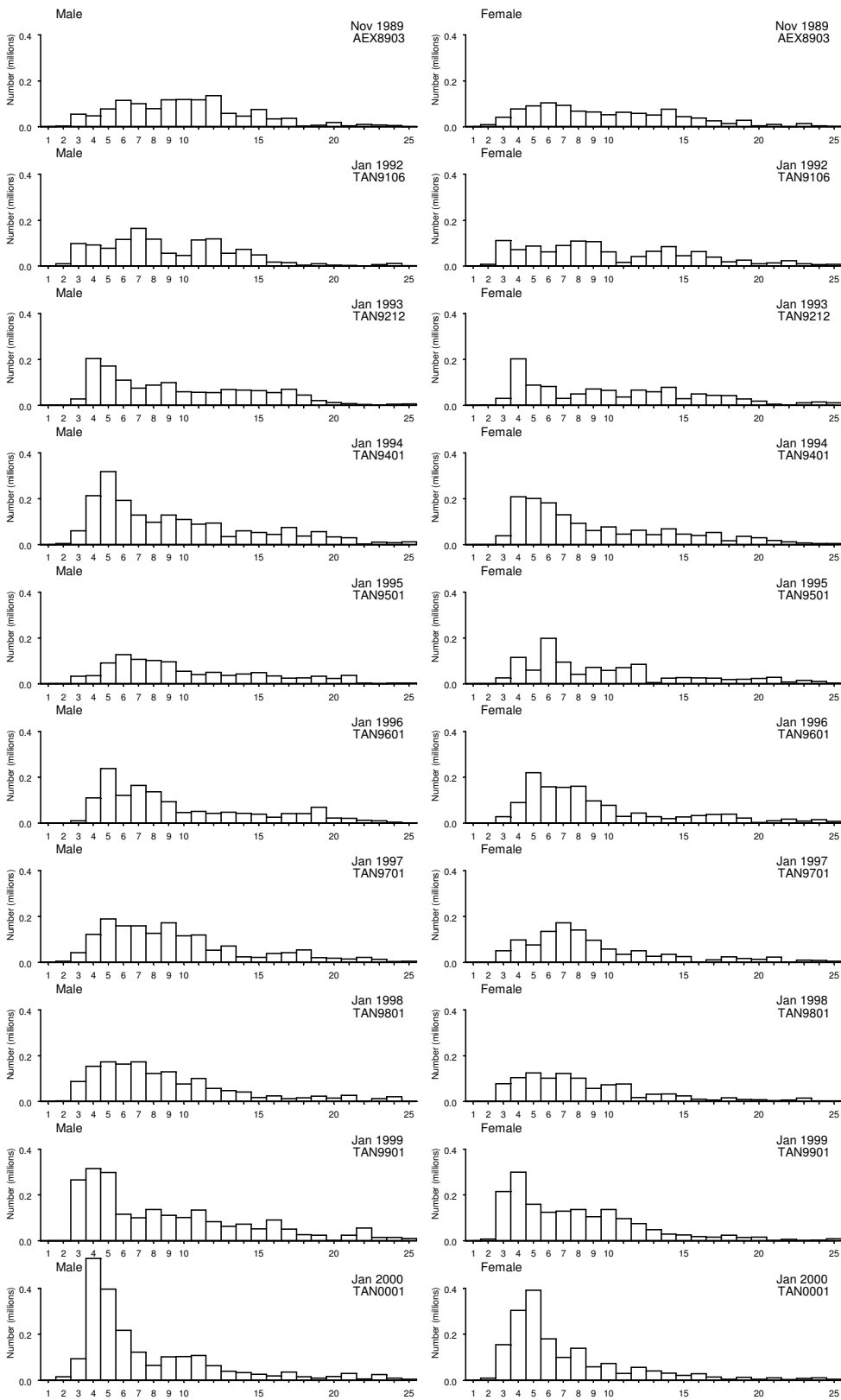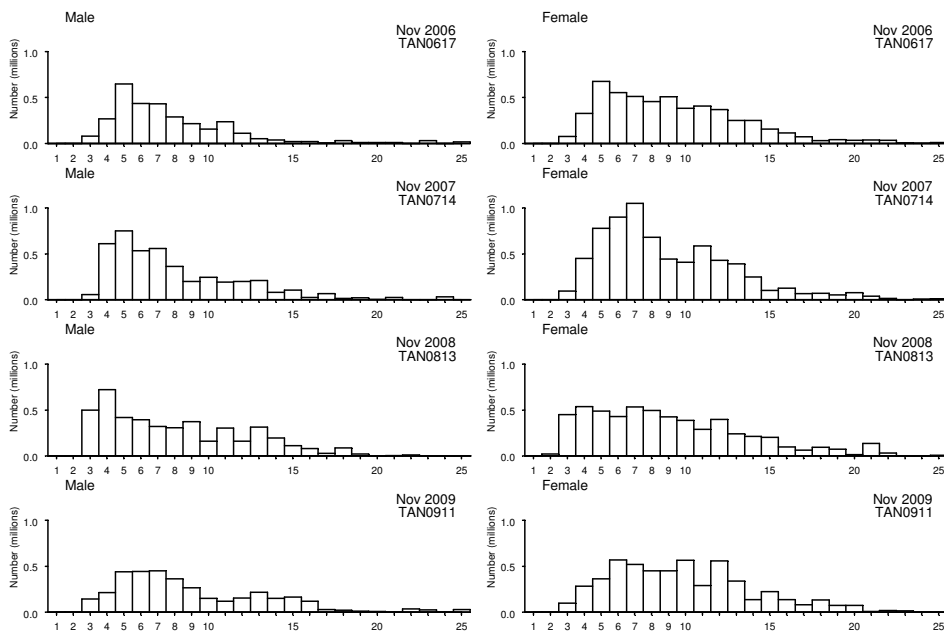
**Figure B10: Available age frequencies of ling (ages 1 to 25) from resource surveys on the Chatham Rise, 1989–90 to 2009–10.**
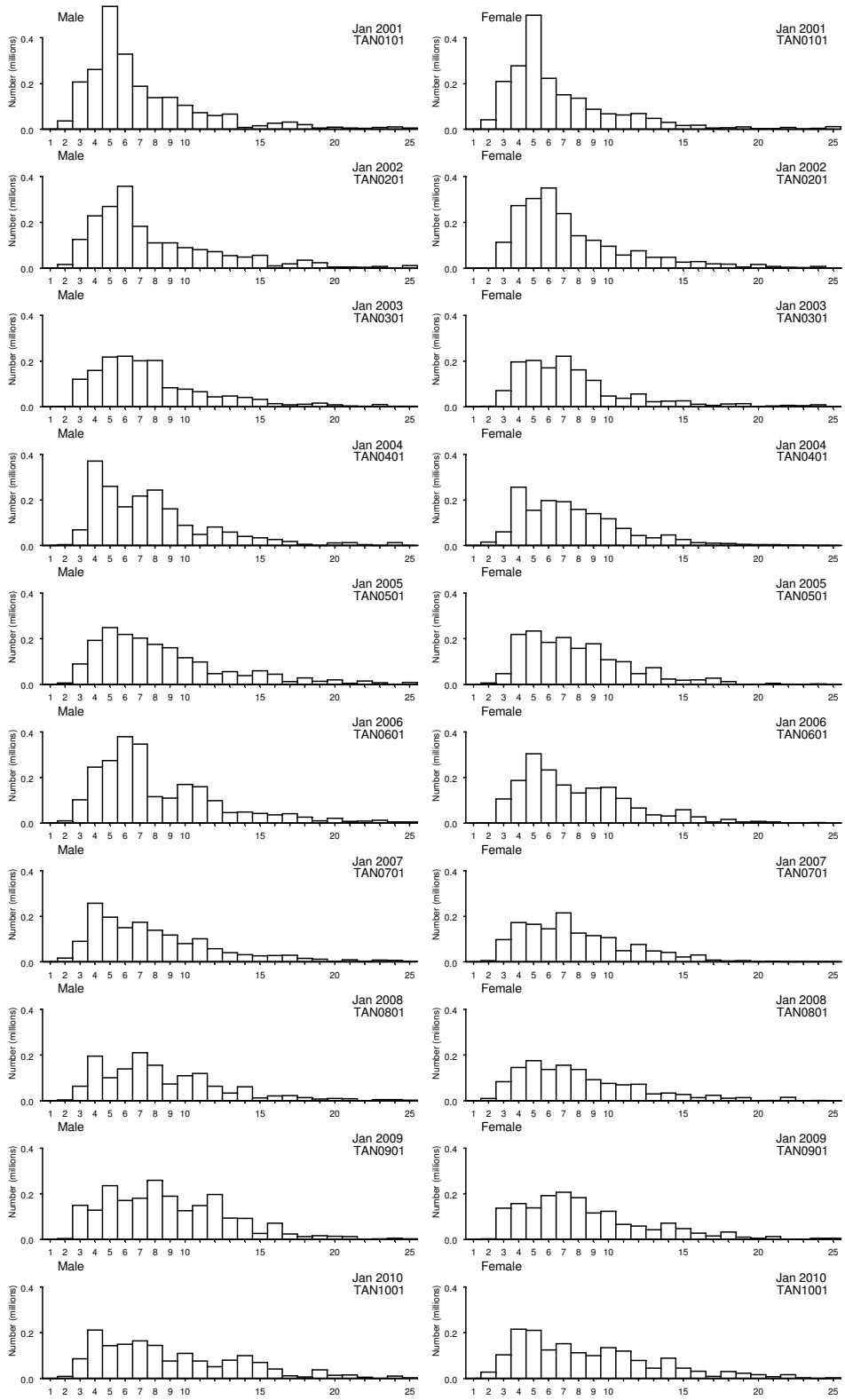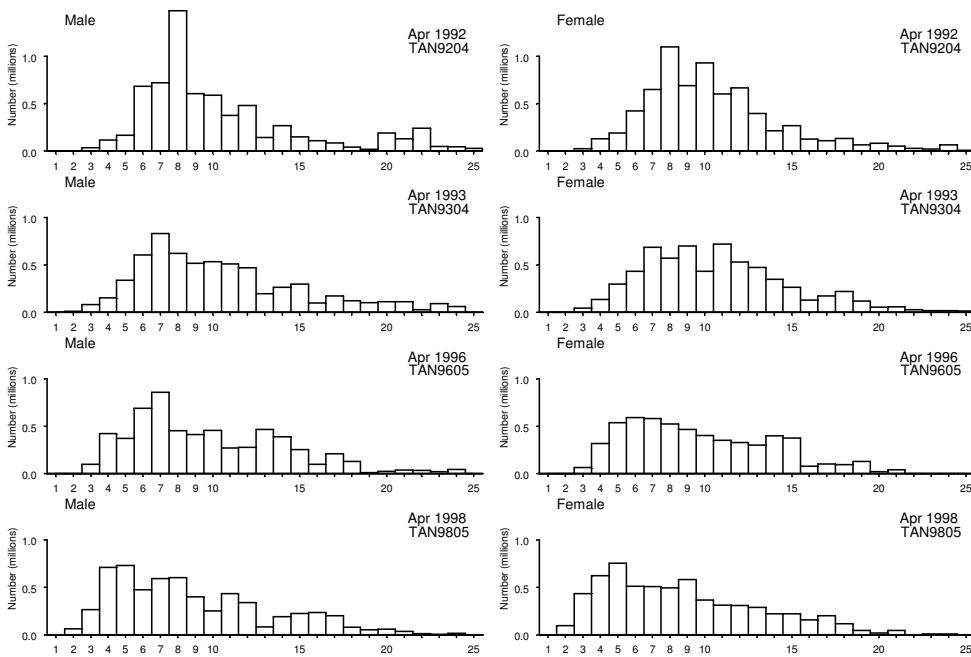
**Figure B10 ctd.: Available age frequencies of ling (ages 1 to 25) from resource surveys on the Chatham Rise, 1989–90 to 2009–10.**

**Figure B11: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2009.**

51

**Figure B11 ctd.: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2009.**



**Figure B12: Available age frequencies of ling (ages 1 to 25) from autumn resource surveys in the Sub-Antarctic, 1992 to 1998.**