



Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2014–15 fishing year and from a trawl survey in 2016, with a summary of all available data sets from the New Zealand EEZ

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## EXECUTIVE SUMMARY

**Horn, P.L.; Sutton, C.P. (2017). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2014–15 fishing year and from a trawl survey in 2016, with a summary of all available data sets from the New Zealand EEZ.**

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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 2014–15 fishing year (using data and otoliths collected at sea by observers), and from a trawl survey of hoki and middle depth species on the Chatham Rise in January 2016 (TAN1601). The target coefficient of variation (CV) for each estimated catch-at-age distribution from the observer samples and the trawl survey was 30% (mean weighted CV across all age classes).

For hake, the target CV was met for the three commercial fisheries (west Chatham Rise, west coast South Island, and Sub-Antarctic), but was not met for the trawl survey. There were insufficient data to estimate catch-at-age for the east Chatham Rise commercial trawl fishery.

For ling, the target CV was met for the commercial trawl fisheries from west coast South Island and the Sub-Antarctic, and the trawl survey. It was nearly met for the Chatham Rise trawl fishery. There were insufficient data collected to estimate catch-at-age for the 2013 Cook Strait commercial trawl fishery. Catch-at-age was also estimated and the target CV was met for the ling longline fisheries on Chatham Rise in 2013–14 and west coast South Island in 2014–15. No samples from other longline fisheries were available.

Where the target CV was not met, it was not possible to improve the precision for either fishery by reading more otoliths (i.e., increasing the sample size), because all available data and otoliths were used in the analyses. It would be desirable to ensure that, for all fisheries where catch-at-age estimates are produced, sampled (observed) trips occur in the areas and months that were used to produce the time series reported here. Those areas and months are listed in this document. Summaries of all previous catch-at-age distributions made for hake and ling from trawl surveys and commercial fisheries are also provided.

## 1. INTRODUCTION

This work aimed to determine catch-at-age from the main fisheries for hake and ling in the 2014–15 fishing year, and for hake and ling from a trawl survey conducted in January 2016. Catch-at-age data are a vital input into 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 reporting requirements for hake and ling in Objective 1 of Project MID201501 “Routine age determination of hoki and middle depth species from commercial fisheries and trawl surveys”, funded by the Ministry for Primary Industries. That objective is:

1. To determine catch-at-age for commercial catches and resource surveys of specified middle depth and deepwater fishstocks.

The report also summarises all historic 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 were modified in 2010 (Horn & Francis 2010).

## 2. METHODS

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

- HAK 1 — commercial trawl fishery, Sep 2014–May 2015 [600].
- HAK 4 — trawl survey, Jan 2016 (project HOK2015-01) [600].
- HAK 4 — commercial trawl fishery, Oct 2014–Apr 2015 [600].
- HAK 7 — commercial trawl fishery, Jun–Sep 2015 [600].

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

- LIN 3&4 — commercial longline fishery, Chatham Rise, Jun–Oct 2015 [580].
- LIN 3&4 — trawl survey, Chatham Rise, Jan 2016 (project HOK2015-01) [600].
- LIN 3&4 — commercial trawl fishery, Chatham Rise, Oct 2014–May 2015 [600].
- LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2014 [500].
- LIN 5&6 — commercial longline fishery, non-spawning, Campbell, Feb–Jul 2015 [500].
- LIN 6B — commercial longline fishery, Bounty, Nov 2014–Mar 2015 [500].
- LIN 7 — commercial trawl fishery, west coast South Island, Jun–Sep 2015 [600].
- LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2015 [500].

Insufficient or no observer otoliths were available from the ling longline fisheries on Chatham Rise (LIN 3&4), Sub-Antarctic (LIN 5&6), and Bounty Plateau (LIN 6B), and also from the winter 2015 Cook Strait trawl fishery (LIN 7&2). Consequently, catch-at-age distributions were not able to be produced for those fisheries. However, a suitable sample was available from the longline fishery off west coast South Island (LIN 7) in winter 2015, enabling a catch-at-age distribution to be produced for this relatively infrequently sampled fishery.

The following additional commercial fishery catch-at-age distribution for ling was estimated using an age-length key derived previously from the December 2014 Sub-Antarctic trawl survey (LIN 5&6).

- LIN 5&6 — commercial trawl fishery, Sub-Antarctic, Sep 2014–Apr 2015.

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 provided a sample with a mean weighted CV similar to that from proportional sampling, but smaller than from 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).

Fishery catch-at-age distributions were scaled to the total estimated catch from each fishery in the time period sampled. For fisheries with multiple strata, length frequency data from each stratum were first scaled to the estimated catch from that stratum, and then the length frequencies from all strata were summed, and the resulting age-length key was applied to the total length frequency. Survey catch-at-age distributions were scaled to total estimated biomass available to the trawl in the survey area.

Observer sampling of the HAK 1 and HAK 4 commercial trawl fisheries have sometimes provided only small numbers of otoliths. Consequently, catch-at-age distributions for these fisheries were 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 included otoliths from observer sampling from September 2008 to May 2009 plus age data from the TAN0813 trawl survey in December 2008.

The target mean weighted CV for hake from trawl surveys has often not been met. To maximise the chances of meeting the target, all hake from the trawl shots used in the survey biomass and scaled length-frequency calculations were measured and their otoliths were collected. Any hake caught in survey tows not used for biomass calculations (i.e., foul shots, midwater tows, or night tows) were also sampled. 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

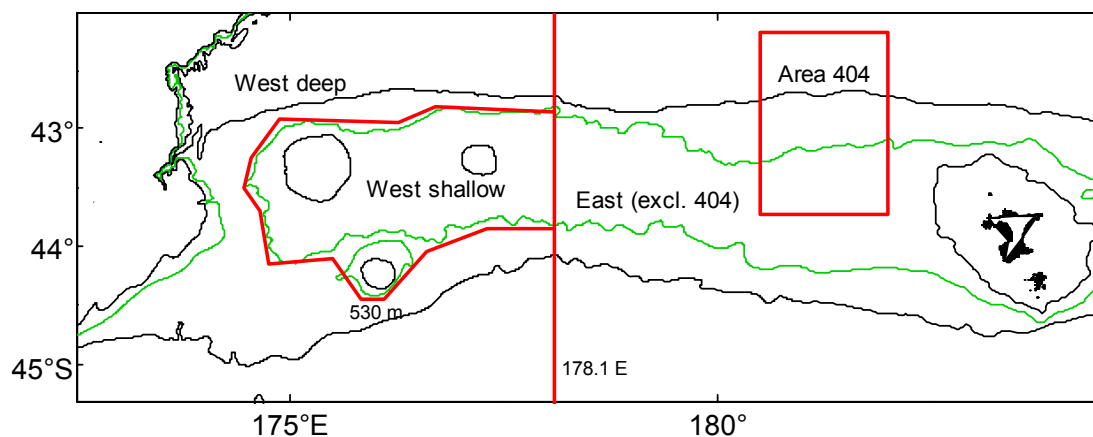
##### 3.1.1 Chatham Rise

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

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

An assessment of the Chatham Rise hake stock (Horn & Francis 2010) concluded that splitting the data into two fisheries (i.e., west and east), rather than four was statistically satisfactory. Consequently, two commercial age frequencies were developed for each year (whenever sufficient data were available) using a single age-length key and two strata separated at longitude  $178.1^\circ$  E. The raw data were still stratified as shown in Figure 1, so each fishery comprised two strata. A single age-length key for each year was used as Horn & Dunn (2007) showed that mean age at length did not differ between fisheries (i.e., in years when there were sufficient data to estimate catch-at-age for both fisheries, the same age-length key was used for both).

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 were measured from it.



**Figure 1: Strata defined for the Chatham Rise hake fishery. The west stratum boundary defined by depth (530 m) is shown only approximately (red). Isobaths at 1000, 500 (green), 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. In the 2014–15 fishing year, sufficient length data ( $n = 522$ ) were available from the east strata to calculate a catch-at-age distribution, but not for the west strata ( $n = 124$ ). Details of the estimated catch-at-age distribution for east trawl-caught hake in the 2014–15 fishing year are in Table 2. The mean weighted CV of 29% just met the target of 30%.

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



**Table 1: Numbers of measured (by fishery) and aged (fisheries combined) male (M) and female (F) 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 CV (%) by age are also listed. Blank cells in the table indicate that insufficient data were available to allow estimation of catch-at-age.**

| Fishing year | Measured |       |      |      |       |     |      |      | Aged |     |
|--------------|----------|-------|------|------|-------|-----|------|------|------|-----|
|              | West     |       |      |      | East  |     |      |      | M    | F   |
|              | M        | F     | Tows | CV   | M     | F   | Tows | CV   |      |     |
| 1991–92      | 2 112    | 2 636 | 163  | 21.9 | 170   | 247 | 25   | 43.2 | 233  | 230 |
| 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 |
| 2009–10      | 147      | 259   | 38   | 25.6 |       |     |      |      | 228  | 244 |
| 2010–11      | 202      | 249   | 46   | 34.3 |       |     |      |      | 199  | 251 |
| 2011–12      |          |       |      |      |       |     |      |      | 0    | 0   |
| 2012–13      |          |       |      |      |       |     |      |      | 0    | 0   |
| 2013–14      | 213      | 221   | 37   | 29.5 |       |     |      |      | 150  | 145 |
| 2014–15      |          |       |      |      | 249   | 273 | 33   | 28.6 | 91   | 132 |

**Table 2: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations in the east Chatham Rise during October 2014–April 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male  | CV    | Female | CV    |
|-------------------------------------|-------|-------|--------|-------|
| 2                                   | 19    | 1.716 | 5      | 2.869 |
| 3                                   | 368   | 0.586 | 350    | 0.449 |
| 4                                   | 1 051 | 0.294 | 1 081  | 0.389 |
| 5                                   | 1 671 | 0.227 | 2 140  | 0.256 |
| 6                                   | 721   | 0.375 | 748    | 0.343 |
| 7                                   | 682   | 0.328 | 925    | 0.307 |
| 8                                   | 1 037 | 0.332 | 449    | 0.373 |
| 9                                   | 222   | 0.768 | 349    | 0.385 |
| 10                                  | 102   | 0.955 | 159    | 0.691 |
| 11                                  | 0     | –     | 105    | 0.652 |
| 12                                  | 102   | 0.924 | 73     | 0.806 |
| 13                                  | 0     | –     | 155    | 0.739 |
| 14                                  | 0     | –     | 74     | 0.953 |
| 15                                  | 0     | –     | 14     | 1.693 |
| 16                                  | 127   | 1.207 | 0      | –     |
| 17                                  | 59    | 1.169 | 0      | –     |
| Measured males                      |       |       | 249    |       |
| Measured females                    |       |       | 273    |       |
| Aged males                          |       |       | 91     |       |
| Aged females                        |       |       | 132    |       |
| No. of tows sampled                 |       |       | 33     |       |
| Mean weighted CV (% , sexes pooled) |       |       | 28.6   |       |

### 3.1.2 Sub-Antarctic

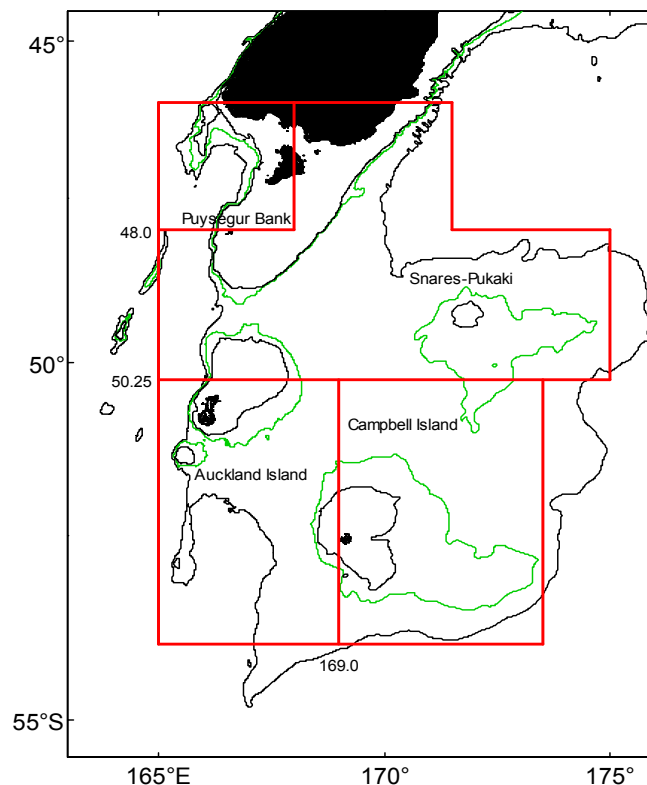
There was one major and three very minor hake fisheries in the Sub-Antarctic area, so a single fishery ogive was used for this stock. A commercial age frequency was developed using a single age-length key and the four fishery strata shown in Figure 2 (determined by Horn (2008b)), and defined as follows:

1. Puysegur Bank ( $165^{\circ} \text{ E} \leq \text{longitude} \leq 168^{\circ} \text{ E}$ ,  $46^{\circ} \text{ S} \leq \text{latitude} \leq 48^{\circ} \text{ S}$ ).
2. Snares-Pukaki ( $165^{\circ} \text{ E} \leq \text{longitude} \leq 175^{\circ} \text{ E}$ ,  $46^{\circ} \text{ S} \leq \text{latitude} \leq 50.25^{\circ} \text{ S}$ , but excluding the Puysegur Bank stratum and the area north of  $48^{\circ} \text{ S}$  and east of  $171.6^{\circ}$ ).
3. Auckland Island ( $165^{\circ} \text{ E} \leq \text{longitude} \leq 169^{\circ} \text{ E}$ ,  $50.25^{\circ} \text{ S} < \text{latitude} \leq 54^{\circ} \text{ S}$ ).
4. Campbell Island ( $169^{\circ} \text{ E} < \text{longitude} \leq 174^{\circ} \text{ E}$ ,  $50.25^{\circ} \text{ S} < \text{latitude} \leq 54^{\circ} \text{ S}$ ).

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 were measured from that tow. The time stratum was based on a descriptive analysis indicating a landings peak from September to February (Devine 2008), so it is not logical to use the administrative fishing year (1 October to 30 September) which bisects the fishery timing. Observer data were converted into catch-at-age distributions if there were at least 700 length measurements, and if sufficient otoliths had been collected to produce a comprehensive age-length key.

Table 3 summarises the data used each year to produce the catch-at-age distributions, and the resulting mean weighted CVs. Details of the estimated catch-at-age distribution for trawl-caught hake in the 2014–15 fishing year are in Table 4. The mean weighted CV of 23% was within the target of 30%.

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



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

**Table 3: Numbers of measured male and female hake, age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic trawl fishery.**

| Year      | Males    |      | Females  |      | Tows | Mean CV |
|-----------|----------|------|----------|------|------|---------|
|           | Measured | Aged | Measured | Aged |      |         |
| 1989–90   | 269      | 47   | 548      | 71   | 74   | 42.0    |
| 1990–91   | 175      | 0    | 588      | 0    | 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      | 0    | 597      | 0    | 92   | –       |
| 1995–96   | 289      | 65   | 435      | 110  | 75   | 50.0    |
| 1996–97   | 84       | 0    | 219      | 0    | 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    |
| 2009–10   | 1 879    | 418  | 1 029    | 611  | 91   | 18.2    |
| 2010–11   | 3 738    | 296  | 1 212    | 282  | 117  | 20.2    |
| 2011–12   | 4 098    | 581  | 1 597    | 605  | 109  | 15.0    |
| 2012–13   | 2 555    | 412  | 1 306    | 666  | 100  | 19.5    |
| 2013–14   | 4 027    | 316  | 1 443    | 146  | 90   | 19.4    |
| 2014–15   | 2 907    | 256  | 800      | 210  | 94   | 22.9    |

**Table 4: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations in the Sub-Antarctic during September 2014–May 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male   | CV     | Female | CV    |
|-------------------------------------|--------|--------|--------|-------|
| 4                                   | 0      | –      | 4      | 2.071 |
| 5                                   | 2 517  | 0.553  | 103    | 0.931 |
| 6                                   | 8 997  | 0.305  | 1 246  | 0.689 |
| 7                                   | 20 693 | 0.198  | 1 842  | 0.382 |
| 8                                   | 23 874 | 0.174  | 6 133  | 0.284 |
| 9                                   | 29 117 | 0.164  | 6 557  | 0.245 |
| 10                                  | 17 865 | 0.213  | 6 218  | 0.263 |
| 11                                  | 11 848 | 0.261  | 8 104  | 0.300 |
| 12                                  | 13 143 | 0.246  | 7 379  | 0.318 |
| 13                                  | 7 912  | 0.327  | 4 127  | 0.320 |
| 14                                  | 3 319  | 0.460  | 2 370  | 0.669 |
| 15                                  | 4 178  | 0.446  | 1 534  | 0.653 |
| 16                                  | 2 647  | 0.473  | 2 321  | 0.426 |
| 17                                  | 7 967  | 0.274  | 873    | 0.637 |
| 18                                  | 3 820  | 0.538  | 612    | 0.930 |
| 19                                  | 4 138  | 0.442  | 214    | 1.050 |
| 20                                  | 3 074  | 0.483  | 1 293  | 0.772 |
| 21                                  | 3 590  | 0.463  | 527    | 0.874 |
| 22                                  | 3 402  | 0.449  | 841    | 0.746 |
| 23                                  | 1 894  | 0.569  | 0      | –     |
| 24                                  | 733    | 1.086  | 0      | –     |
| 25                                  | 0      | –      | 0      | –     |
| 26                                  | 0      | –      | 0      | –     |
| 27                                  | 281    | 1.2972 | 0      | –     |
| Measured males                      |        |        | 2 907  |       |
| Measured females                    |        |        | 800    |       |
| Aged males                          |        |        | 256    |       |
| Aged females                        |        |        | 210    |       |
| No. of tows sampled                 |        |        | 94     |       |
| Mean weighted CV (% , sexes pooled) |        |        | 22.9   |       |

### 3.1.3 West coast South Island (WCSI)

The fishery off WCSI was stratified (by Horn & Sutton (2008)) as follows:

1. Deep (bottom depth  $\geq 629$  m).
2. North shallow (bottom depth  $< 629$  m, latitude  $< 42.55^\circ$  S).
3. South shallow (bottom depth  $< 629$  m, latitude  $\geq 42.55^\circ$  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 were measured from that tow.

Table 5 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. Details of the estimated catch-at-age distribution for trawl-caught hake in the 2014–15 fishing year are in Table 6. The measured sample size was larger than in all previous years, although similar to the 2012–13 sample. The mean weighted CV of 14% was much less than the target of 30%.

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

**Table 5: Numbers of measured male and female hake, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the WCSI trawl fishery.**

| Year      | Males    |      | Females  |      | Tows | Mean CV |
|-----------|----------|------|----------|------|------|---------|
|           | 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  | 18.8    |
| 2009–10   | 2 454    | 130  | 1 877    | 134  | 76   | 25.4    |
| 2010–11   | 2 489    | 260  | 2 489    | 353  | 104  | 16.8    |
| 2011–12   | 2 535    | 357  | 2 061    | 381  | 140  | 14.4    |
| 2012–13   | 12 352   | 325  | 8 417    | 443  | 493  | 14.3    |
| 2013–14   | 8 128    | 320  | 7 242    | 384  | 360  | 13.1    |
| 2014–15   | 12 334   | 329  | 10 173   | 363  | 498  | 13.6    |

**Table 6: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations off the WCSI during June–September 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male    | CV    | Female  | CV    |
|-------------------------------------|---------|-------|---------|-------|
| 0                                   | 7       | 2.536 | 0       | –     |
| 1                                   | 896     | 0.698 | 662     | 0.742 |
| 2                                   | 11 718  | 0.175 | 10 610  | 0.168 |
| 3                                   | 2 636   | 0.279 | 1 530   | 0.285 |
| 4                                   | 20 622  | 0.250 | 4 257   | 0.298 |
| 5                                   | 221 493 | 0.085 | 25 144  | 0.215 |
| 6                                   | 202 034 | 0.109 | 68 133  | 0.141 |
| 7                                   | 149 914 | 0.128 | 111 032 | 0.126 |
| 8                                   | 78 152  | 0.175 | 140 737 | 0.104 |
| 9                                   | 33 565  | 0.274 | 68 933  | 0.155 |
| 10                                  | 9 764   | 0.503 | 28 653  | 0.222 |
| 11                                  | 28 652  | 0.306 | 18 882  | 0.279 |
| 12                                  | 3 997   | 0.761 | 12 541  | 0.348 |
| 13                                  | 6 699   | 0.654 | 6 388   | 0.523 |
| 14                                  | 7 652   | 0.620 | 1 961   | 0.811 |
| 15                                  | 4 722   | 0.808 | 20      | 1.618 |
| 16                                  | 11 974  | 0.458 | 2 088   | 0.817 |
| 17                                  | 6 383   | 0.510 | 3 405   | 0.711 |
| 18                                  | 4 291   | 0.742 | 3 089   | 0.647 |
| 19                                  | 2 762   | 1.044 | 1 934   | 1.042 |
| 20                                  | 11 601  | 0.446 | 1 170   | 1.024 |
| 21                                  | 3 672   | 0.948 | 1 170   | 1.047 |
| 22                                  | 1 121   | 1.133 | 0       | –     |
| 23                                  | 2 762   | 1.034 | 0       | –     |
| 24                                  | 2 775   | 1.056 | 0       | –     |
| Measured males                      |         |       | 12 334  |       |
| Measured females                    |         |       | 10 174  |       |
| Aged males                          |         |       | 329     |       |
| Aged females                        |         |       | 363     |       |
| No. of tows sampled                 |         |       | 498     |       |
| Mean weighted CV (% , sexes pooled) |         |       | 13.6    |       |

## 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 Chatham Rise was surveyed. However, to ensure comparability, the distributions presented here are for the core strata only, i.e., 200–800 m.

Table 7 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The 30% target was met in only one of the 20 surveys (TAN9106, see Table 7). The details of the estimated catch-at-age distribution for hake caught in the January 2016 trawl survey are given in Table 8. The mean weighted CV of 41% was greater than the target of 30%.

All estimated proportion-at-age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A5). It is likely that a strong year class was produced in 2002 (i.e., spawned at the start of the 2001–02 fishing year, and aged 2 years in January 2004), and that it was followed by two further relatively strong year classes in 2003 and 2004. The progression of these year classes, but particularly that from 2002, is apparent in the survey size distributions since TAN0401. A relatively

strong year class spawned at the start of the 1990–91 fishing year (age 3 in January 1994) is also apparent.

**Table 7: Numbers of measured male and female hake, age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age, for the Chatham Rise trawl surveys.**

| Source  | Males    |      | Females  |      | Tows | Mean CV |
|---------|----------|------|----------|------|------|---------|
|         | Measured | Aged | Measured | Aged |      |         |
| 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    |
| TAN1101 | 49       | 74   | 63       | 65   | 45   | 44.5    |
| TAN1201 | 48       | 78   | 83       | 98   | 54   | 49.5    |
| TAN1301 | 51       | 73   | 109      | 112  | 47   | 48.4    |
| TAN1401 | 38       | 88   | 65       | 91   | 46   | 55.4    |
| TAN1601 | 67       | 115  | 91       | 106  | 46   | 40.8    |

**Table 8: Calculated numbers at age in the survey area, separately by sex, with CVs, for hake caught during a trawl survey of the Chatham Rise in January 2016 (survey TAN1601). Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male   | CV    | Female | CV    |
|-------------------------------------|--------|-------|--------|-------|
| 2                                   | 6 848  | 1.017 | 9 035  | 0.656 |
| 3                                   | 9 877  | 0.948 | 16 569 | 0.548 |
| 4                                   | 21 820 | 0.526 | 21 988 | 0.486 |
| 5                                   | 47 542 | 0.348 | 50 970 | 0.308 |
| 6                                   | 14 575 | 0.460 | 23 580 | 0.510 |
| 7                                   | 15 469 | 0.539 | 30 273 | 0.453 |
| 8                                   | 14 656 | 0.543 | 21 906 | 0.469 |
| 9                                   | 17 892 | 0.614 | 34 406 | 0.430 |
| 10                                  | 10 261 | 0.783 | 19 404 | 0.537 |
| 11                                  | 1 492  | 1.412 | 9 140  | 0.701 |
| 12                                  | 3 685  | 0.889 | 7 569  | 0.638 |
| 13                                  | 3 934  | 0.884 | 11 311 | 0.868 |
| 14                                  | 4 585  | 1.315 | 12 030 | 0.645 |
| 15                                  | 4 679  | 1.619 | 2 492  | 1.344 |
| 16                                  | 0      | –     | 665    | 1.777 |
| 17                                  | 3 785  | 1.337 | 0      | –     |
| 18                                  | 0      | –     | 665    | 1.699 |
| 19                                  | 0      | –     | 0      | –     |
| 20                                  | 0      | –     | 0      | –     |
| 21                                  | 0      | –     | 0      | –     |
| 22                                  | 0      | –     | 1 962  | 1.324 |
| Measured males                      |        |       |        | 67    |
| Measured females                    |        |       |        | 91    |
| Aged males                          |        |       |        | 115   |
| Aged females                        |        |       |        | 106   |
| No. of tows sampled                 |        |       |        | 46    |
| Mean weighted CV (% , sexes pooled) |        |       |        | 40.8  |

### 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 was conducted in summer. Those surveys 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. For 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 9 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. No survey in this series was conducted in December 2015.

All estimated proportion-at-age distributions from the Sub-Antarctic trawl surveys are presented in Appendix A; Figure A6 shows the summer survey distributions and Figure A7 shows the spring and autumn survey distributions.



**Table 9: Numbers of measured male and female hake, age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age for the Sub-Antarctic resource surveys.**

| Survey         | Males    |      | Females  |      | Tows | Mean CV |
|----------------|----------|------|----------|------|------|---------|
|                | Measured | Aged | Measured | Aged |      |         |
| 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    |
| TAN1117        | 405      | 238  | 423      | 357  | 37   | 37.3    |
| TAN1215        | 155      | 222  | 359      | 537  | 36   | 39.1    |
| TAN1412        | 41       | 41   | 169      | 176  | 29   | 47.7    |
| 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    |

### 3.2.3 West coast South Island

Trawl survey catch-at-age distributions are estimates of the numbers of hake, by sex and age, available to the trawl in the survey. A combined trawl and acoustic survey by *Tangaroa* in 2000 (O’Driscoll et al. 2004) was replicated (with some modifications) in winter 2012 (O’Driscoll et al. 2014) and winter 2013 (O’Driscoll et al. 2015), so a three survey comparable time series is available. The biomass estimates from the three surveys were standardised using random day-time bottom trawl stations in strata 1&2A, B, and C, and 4A, B, and C (depth 300–650 m), with stratum areas from the 2012 survey (O’Driscoll et al. 2014).

Table 10 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. Because no otoliths from the 2000 survey were aged, the scaled length-frequency distribution from that survey was applied to the WCSI commercial fishery age-length key for 2000. The age-length keys for the 2012 and 2013 surveys were derived using otoliths collected during the surveys. There was no survey in this series conducted in winter 2015.

All estimated proportion-at-age distributions from the WCSI trawl surveys are presented in Appendix A (Figure A8).

**Table 10: Numbers of measured male and female hake, age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age for the west coast South Island trawl surveys.**

| Survey  | Males    |      | Females  |      | Tows | Mean CV |
|---------|----------|------|----------|------|------|---------|
|         | Measured | Aged | Measured | Aged |      |         |
| TAN0007 | 331      | 230  | 407      | 255  | 36   | 26.4    |
| TAN1210 | 211      | 330  | 228      | 332  | 36   | 26.6    |
| TAN1308 | 94       | 255  | 213      | 371  | 34   | 33.7    |

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

#### 3.3.1 Chatham Rise

The longline fishery data from the Chatham Rise were 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 11 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were no or insufficient data collected from the Chatham Rise ling longline fishery in 2010–12 and 2015.

**Table 11: Numbers of measured male and female ling, age data used in the age-length key, trips and sets sampled, and estimated mean weighted CV (%) by age, for the Chatham Rise longline fishery.**

| Year | Males    |      | Females  |      | Trips | Sets | Mean CV |
|------|----------|------|----------|------|-------|------|---------|
|      | Measured | Aged | Measured | Aged |       |      |         |
| 2002 | 4 966    | 284  | 2 998    | 309  | 5     | 538  | 20.4    |
| 2003 | 3 038    | 337  | 2 071    | 289  | 5     | 429  | 19.1    |
| 2004 | 1 066    | 302  | 747      | 293  | 2     | 139  | 21.8    |
| 2005 | 889      | 356  | 479      | 234  | 1     | 137  | 21.6    |
| 2006 | 266      | 95   | 294      | 141  | 1     | 48   | 36.6    |
| 2007 | 351      | 174  | 268      | 139  | 4     | 62   | 31.1    |
| 2008 | 574      | 216  | 570      | 262  | 4     | 84   | 25.9    |
| 2009 | 619      | 283  | 798      | 413  | 3     | 147  | 21.5    |
| 2013 | 314      | 112  | 655      | 252  | 1     | 50   | 25.9    |
| 2014 | 789      | 288  | 801      | 284  | 3     | 156  | 21.9    |

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 longline fishery data from the Sub-Antarctic stock were 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 030), with a time stratum of 1 October to 31 December. The non-spawning fishery was defined as a single stratum comprising all of FMAs 5 and 6, excluding Statistical Area 030 and the Bounty Plateau, with a time stratum of 1 February to 31 July. Ling on the Bounty Plateau were analysed separately from Sub-Antarctic ling because they are believed to comprise a distinct biological stock (Horn 2005).

Table 12 summarises the 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 CVs. No observer sampling of either the spawning or non-spawning fisheries occurred in the 2014–15 fishing year.

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).

**Table 12: Numbers of measured male and female ling, age data used in the age-length key, trips and sets sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic spawning and non-spawning longline fisheries.**

| Fishery and year          | Males    |      | Females  |      | Trips | Sets | Mean CV |
|---------------------------|----------|------|----------|------|-------|------|---------|
|                           | Measured | Aged | Measured | Aged |       |      |         |
| Spawning line fishery     |          |      |          |      |       |      |         |
| 2000                      | 4 044    | 242  | 4 231    | 278  | 1     | 83   | 20.6    |
| 2001                      | 2 084    | 131  | 1 962    | 143  | 2     | 55   | 28.7    |
| 2002                      | 670      | 197  | 898      | 284  | 1     | 157  | 22.6    |
| 2003                      | 1 250    | 211  | 1 687    | 307  | 2     | 214  | 20.0    |
| 2004                      | 887      | 208  | 1 129    | 289  | 2     | 168  | 22.5    |
| 2005                      | 193      | 88   | 362      | 179  | 1     | 54   | 28.6    |
| 2006                      | 233      | 108  | 707      | 345  | 1     | 94   | 23.3    |
| 2007                      | 412      | 191  | 418      | 217  | 1     | 82   | 25.1    |
| 2008                      | 227      | 68   | 198      | 62   | 1     | 24   | 44.3    |
| 2010                      | 89       | 51   | 361      | 177  | 1     | 45   | 34.0    |
| Non-spawning line fishery |          |      |          |      |       |      |         |
| 1998                      | 608      | 73   | 2 763    | 395  | 1     | 34   | 23.1    |
| 1999                      | 3 316    | 214  | 7 535    | 428  | 2     | 136  | 18.3    |
| 2001                      | 674      | 103  | 2 040    | 235  | 2     | 58   | 25.3    |
| 2003                      | 304      | 128  | 611      | 273  | 2     | 43   | 29.3    |
| 2005                      | 413      | 114  | 716      | 307  | 2     | 113  | 25.9    |
| 2009                      | 165      | 61   | 454      | 196  | 1     | 49   | 28.0    |
| 2010                      | 151      | 78   | 424      | 214  | 1     | 49   | 29.0    |
| 2011                      | 180      | 60   | 823      | 267  | 1     | 64   | 27.3    |
| 2012                      | 316      | 109  | 979      | 320  | 2     | 91   | 23.7    |
| 2014                      | 156      | 57   | 782      | 258  | 2     | 59   | 29.8    |

### 3.3.3 West coast South Island

The line fishery data from west coast South Island were analysed using a single area stratum and a time stratum of 1 May to 31 August.

Table 13 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The 2003, 2006 and 2007 age-length keys were developed using age data from the trawl fisheries in the same years, as no otoliths were sampled from longline trips. The 2006 and 2007 data were collected under the SeaFIC ling longline logbook programme (Langley 2001). The 2012 age-length key was developed using 129 otoliths sampled from a longline trip, plus additional age data from the July 2012 research trawl survey off WCSI. Two longline trips targeting ling off WCSI were sampled in the 2014–15 fishing year; the resulting estimated catch-at-age distribution is given in Table 14. The mean weighted CV of 29.5% just met the target value of 30%. All estimated proportion-at-age distributions from the WCSI longline fishery are presented in Appendix B (Figure B4).

**Table 13: Numbers of measured male and female ling, age data used in the age-length key, trips and sets sampled, and estimated mean weighted CV (%) by age, for the west coast South Island longline fishery.**

| Year | Males    |      | Females  |      | Trips | Sets | Mean CV |
|------|----------|------|----------|------|-------|------|---------|
|      | Measured | Aged | Measured | Aged |       |      |         |
| 2003 | 123      | 215  | 148      | 246  | 3     | 24   | 37.9    |
| 2006 | 104      | 191  | 301      | 329  | 7     | 24   | 35.0    |
| 2007 | 109      | 119  | 192      | 169  | 7     | 28   | 42.2    |
| 2012 | 190      | 246  | 379      | 311  | 1     | 31   | 29.3    |
| 2015 | 296      | 144  | 188      | 97   | 2     | 49   | 29.5    |

**Table 14: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial longline operations off WCSI (LIN 7) in May–August 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male  | CV    | Female | CV    |
|-------------------------------------|-------|-------|--------|-------|
| 7                                   | 685   | 0.991 | 0      | –     |
| 8                                   | 2 740 | 0.453 | 467    | 1.572 |
| 9                                   | 6 720 | 0.284 | 1 580  | 0.538 |
| 10                                  | 5 406 | 0.323 | 4 125  | 0.386 |
| 11                                  | 8 124 | 0.252 | 4 811  | 0.404 |
| 12                                  | 8 193 | 0.265 | 6 781  | 0.303 |
| 13                                  | 5 615 | 0.297 | 5 101  | 0.312 |
| 14                                  | 3 683 | 0.410 | 3 398  | 0.413 |
| 15                                  | 1 568 | 0.572 | 1 974  | 0.514 |
| 16                                  | 1 245 | 0.606 | 1 164  | 0.642 |
| 17                                  | 2 032 | 0.591 | 321    | 1.230 |
| 18                                  | 1 451 | 0.705 | 200    | 1.455 |
| 19                                  | 773   | 0.896 | 0      | –     |
| 20                                  | 462   | 1.036 | 367    | 1.067 |
| 21                                  | 567   | 1.047 | 96     | 1.547 |
| 22                                  | 0     | –     | 13     | 2.521 |
| 23                                  | 317   | 1.311 | 0      | –     |
| Measured males                      |       |       |        | 296   |
| Measured females                    |       |       |        | 188   |
| Aged males                          |       |       |        | 144   |
| Aged females                        |       |       |        | 97    |
| No. of sets sampled                 |       |       |        | 49    |
| Mean weighted CV (% , sexes pooled) |       |       |        | 29.5  |

### 3.3.4 Cook Strait

The line fishery data from Cook Strait were 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 016 and 017), and a time stratum of 1 June to 30 September.

Table 15 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The 2001 age-length key used 57 otoliths collected from the longline fishery (i.e., all that were collected), plus 316 otoliths collected from the trawl fishery in the same area and year. There was no observer sampling of Cook Strait longline-caught ling in the 2014–15 fishing year. All estimated proportion-at-age distributions from the Cook Strait longline fishery are presented in Appendix B (Figure B5).

**Table 15: Numbers of measured male and female ling, age data used in the age-length key, trips and sets sampled, and estimated mean weighted CV (%) by age, for the Cook Strait longline fishery.**

| Year | Males    |      | Females  |      | Trips | Sets | Mean CV |
|------|----------|------|----------|------|-------|------|---------|
|      | Measured | Aged | Measured | Aged |       |      |         |
| 2001 | 315      | 179  | 356      | 194  | 1     | 17   | 29.8    |
| 2003 | 165      | 164  | 145      | 142  | 1     | 31   | 33.1    |
| 2006 | 607      | 319  | 538      | 275  | 1     | 116  | 19.3    |
| 2007 | 238      | 125  | 180      | 92   | 1     | 43   | 33.8    |

### 3.3.5 Bounty Plateau

The longline fishery data from the Bounty Plateau were 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 16 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were no data collected from the Bounty Plateau ling longline fishery in the 2014–15 fishing year. All estimated proportion-at-age distributions from the Bounty Plateau longline fishery are presented in Appendix B (Figure B6).

**Table 16: Numbers of measured male and female ling, age data used in the age-length key, trips and sets sampled, and estimated mean weighted CV (%) by age, for the Bounty Plateau longline fishery.**

| Year      | Males    |      | Females  |      | Trips | Sets | Mean CV |
|-----------|----------|------|----------|------|-------|------|---------|
|           | Measured | Aged | Measured | Aged |       |      |         |
| 1992–93   | 201      | 52   | 237      | 69   | 1     | 24   | 50.4    |
| 1999–2000 | 1 102    | 106  | 2 184    | 185  | 1     | 41   | 26.9    |
| 2000–01   | 405      | 50   | 713      | 66   | 1     | 20   | 43.6    |
| 2003–04   | 1 155    | 200  | 1 628    | 300  | 3     | 272  | 20.0    |
| 2007–08   | 308      | 156  | 562      | 271  | 1     | 86   | 25.3    |
| 2008–09   | 262      | 116  | 213      | 88   | 1     | 42   | 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:

1. Coast (longitude  $\leq 174^\circ$  E, target not scampi).
2. Scampi (all tows targeting scampi).
3. North Rise (latitude  $< 43.55^\circ$  S, longitude  $> 174^\circ$  E, target not scampi).
4. South Rise (latitude  $\geq 43.55^\circ$  S, longitude  $> 174^\circ$  E, target not scampi).

Scampi target tows comprise a separate stratum because the gear used in this fishery usually retains ling of a smaller average size than the trawls used to target fishes.

Table 17 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The estimated catch-at-age distribution for trawl-caught ling in the 2014–15 fishing year is given in Table 18. The observer sampling in 2014–15 was at a lower level than in all but one year since 1997–98; all available otoliths were aged. The mean weighted CV of 33% almost met the target value of 30%.

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

**Table 17: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the Chatham Rise trawl fishery.**

| Source    | Males    |      | Females  |      | Tows | Mean CV |
|-----------|----------|------|----------|------|------|---------|
|           | Measured | Aged | Measured | Aged |      |         |
| 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    |
| 2009–10   | 526      | 318  | 571      | 309  | 87   | 28.9    |
| 2010–11   | 492      | 308  | 521      | 293  | 74   | 27.3    |
| 2011–12   | 739      | 257  | 767      | 297  | 82   | 26.4    |
| 2012–13   | 981      | 278  | 1 083    | 315  | 130  | 24.1    |
| 2013–14   | 1 385    | 314  | 1 674    | 258  | 164  | 29.7    |
| 2014–15   | 330      | 102  | 499      | 176  | 47   | 33.4    |

**Table 18: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial trawl operations on the Chatham Rise during October 2014–May 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male   | CV    | Female | CV    |
|-------------------------------------|--------|-------|--------|-------|
| 3                                   | 270    | 2.095 | 0      | –     |
| 4                                   | 2 140  | 0.756 | 1 970  | 0.813 |
| 5                                   | 17 256 | 0.455 | 21 983 | 0.497 |
| 6                                   | 19 294 | 0.466 | 31 617 | 0.335 |
| 7                                   | 26 228 | 0.362 | 23 274 | 0.367 |
| 8                                   | 13 273 | 0.434 | 30 421 | 0.387 |
| 9                                   | 10 894 | 0.628 | 18 994 | 0.325 |
| 10                                  | 5 691  | 0.617 | 20 537 | 0.254 |
| 11                                  | 2 078  | 0.791 | 9 078  | 0.458 |
| 12                                  | 553    | 1.166 | 1 516  | 0.687 |
| 13                                  | 7 986  | 1.037 | 2 998  | 0.577 |
| 14                                  | 76     | 1.958 | 6 286  | 0.462 |
| 15                                  | 886    | 0.894 | 1 845  | 0.590 |
| 16                                  | 0      | –     | 206    | 1.414 |
| 17                                  | 1 173  | 1.026 | 247    | 1.343 |
| 18                                  | 393    | 1.216 | 0      | –     |
| 19                                  | 1 734  | 0.625 | 255    | 1.393 |
| 20                                  | 0      | –     | 808    | 1.076 |
| 21                                  | 0      | –     | 421    | 1.228 |
| 22                                  | 0      | –     | 0      | –     |
| 23                                  | 0      | –     | 0      | –     |
| 24                                  | 0      | –     | 0      | –     |
| 25                                  | 1 609  | 1.540 | 0      | –     |
| 26                                  | 0      | –     | 421    | 1.209 |
| Measured males                      |        |       |        | 330   |
| Measured females                    |        |       |        | 499   |
| Aged males                          |        |       |        | 102   |
| Aged females                        |        |       |        | 176   |
| No. of tows sampled                 |        |       |        | 47    |
| Mean weighted CV (% , sexes pooled) |        |       |        | 33.4  |

### 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  $\leq$  450 m, and target not scampi).
3. Deep (bottom depth  $>$  450 m, and target not scampi).

Table 19 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The estimated catch-at-age distribution for trawl-caught ling in the 2014–15 fishing year are given in Table 20. The mean weighted CV of 19% was less than the target value of 30%.

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

**Table 19: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic trawl fishery.**

| Source  | Males    |      | Females  |      | Tows | Mean CV |
|---------|----------|------|----------|------|------|---------|
|         | 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    |
| 2009–10 | 2 899    | 226  | 3 266    | 336  | 121  | 21.7    |
| 2010–11 | 2 212    | 236  | 2 630    | 279  | 215  | 21.4    |
| 2011–12 | 2 826    | 260  | 2 398    | 316  | 131  | 21.9    |
| 2012–13 | 4 565    | 286  | 5 542    | 317  | 275  | 21.6    |
| 2013–14 | 2 236    | 232  | 2 716    | 311  | 147  | 20.3    |
| 2014–15 | 3 920    | 264  | 3 274    | 363  | 229  | 19.2    |



**Table 20: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial trawl operations in the Sub-Antarctic during September 2014–April 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male    | CV    | Female  | CV    |
|-------------------------------------|---------|-------|---------|-------|
| 3                                   | 509     | 1.268 | 528     | 0.853 |
| 4                                   | 4 705   | 0.526 | 10 157  | 0.381 |
| 5                                   | 53 056  | 0.225 | 46 692  | 0.301 |
| 6                                   | 124 716 | 0.186 | 95 923  | 0.225 |
| 7                                   | 247 240 | 0.159 | 147 380 | 0.167 |
| 8                                   | 202 318 | 0.193 | 140 214 | 0.165 |
| 9                                   | 105 226 | 0.277 | 98 899  | 0.199 |
| 10                                  | 117 553 | 0.250 | 67 462  | 0.220 |
| 11                                  | 67 600  | 0.323 | 33 255  | 0.313 |
| 12                                  | 45 106  | 0.404 | 46 342  | 0.250 |
| 13                                  | 36 604  | 0.366 | 25 786  | 0.336 |
| 14                                  | 29 739  | 0.486 | 22 188  | 0.314 |
| 15                                  | 20 559  | 0.705 | 15 363  | 0.361 |
| 16                                  | 14 147  | 0.797 | 8 891   | 0.467 |
| 17                                  | 34 124  | 0.487 | 21 810  | 0.279 |
| 18                                  | 61 999  | 0.326 | 9 865   | 0.366 |
| 19                                  | 18 589  | 0.745 | 10 346  | 0.536 |
| 20                                  | 2 671   | 0.712 | 3 242   | 0.646 |
| 21                                  | 6 753   | 0.628 | 2 859   | 0.574 |
| 22                                  | 10 247  | 0.636 | 2 299   | 0.732 |
| 23                                  | 2 030   | 1.149 | 1 828   | 0.827 |
| 24                                  | 840     | 1.132 | 0       | –     |
| 25                                  | 2 482   | 1.054 | 0       | –     |
| 26                                  | 0       | –     | 1 103   | 1.278 |
| 27                                  | 0       | –     | 0       | –     |
| 28                                  | 0       | –     | 0       | –     |
| 29                                  | 1 805   | 1.092 | 0       | –     |
| Measured males                      |         |       | 3 920   |       |
| Measured females                    |         |       | 3 274   |       |
| Aged males                          |         |       | 264     |       |
| Aged females                        |         |       | 363     |       |
| No. of tows sampled                 |         |       | 229     |       |
| Mean weighted CV (% , sexes pooled) |         |       | 19.2    |       |

### 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:

1. Deep (bottom depth  $\geq$  498 m).
2. North shallow (bottom depth  $<$  498 m, latitude  $<$  42.42° S).
3. South shallow (bottom depth  $<$  498 m, latitude  $\geq$  42.42° S).

Table 21 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were insufficient data (particularly otoliths) collected to estimate the catch-at-age distribution for trawl-caught ling from 2008–09 to 2010–11. The details of the estimated catch-at-age distribution for trawl-caught ling in the 2014–15 fishing year are given in Table 22, where the amount of length data and otoliths was higher than in all other sampled years. The mean weighted CV of 21% was less than the target value of 30%.

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

**Table 21: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the WCSI trawl fishery.**

| Year | Males    |      | Females  |      | Tows | Mean CV |
|------|----------|------|----------|------|------|---------|
|      | Measured | Aged | Measured | Aged |      |         |
| 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    |
| 2012 | 686      | 321  | 576      | 345  | 83   | 31.8    |
| 2013 | 1 270    | 283  | 1 302    | 376  | 153  | 23.9    |
| 2014 | 619      | 183  | 692      | 202  | 95   | 31.6    |
| 2015 | 3 684    | 292  | 3 822    | 363  | 417  | 21.2    |

**Table 22: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial trawl operations off WCSI during June–September 2015. Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male   | CV    | Female | CV    |
|-------------------------------------|--------|-------|--------|-------|
| 2                                   | 73     | 1.231 | 144    | 0.948 |
| 3                                   | 1 576  | 0.894 | 3 117  | 0.333 |
| 4                                   | 10 071 | 0.257 | 12 068 | 0.237 |
| 5                                   | 17 038 | 0.209 | 15 503 | 0.233 |
| 6                                   | 9 394  | 0.297 | 4 027  | 0.461 |
| 7                                   | 7 054  | 0.404 | 6 817  | 0.323 |
| 8                                   | 14 287 | 0.293 | 4 539  | 0.397 |
| 9                                   | 20 061 | 0.195 | 10 251 | 0.247 |
| 10                                  | 20 632 | 0.226 | 10 116 | 0.254 |
| 11                                  | 11 661 | 0.264 | 12 632 | 0.233 |
| 12                                  | 19 530 | 0.216 | 12 162 | 0.217 |
| 13                                  | 12 676 | 0.255 | 11 133 | 0.227 |
| 14                                  | 5 552  | 0.511 | 11 370 | 0.238 |
| 15                                  | 5 969  | 0.415 | 14 263 | 0.209 |
| 16                                  | 4 004  | 0.476 | 5 546  | 0.342 |
| 17                                  | 929    | 0.670 | 3 720  | 0.408 |
| 18                                  | 1 732  | 0.722 | 3 040  | 0.503 |
| 19                                  | 334    | 0.931 | 1 219  | 0.430 |
| 20                                  | 112    | 1.133 | 3 109  | 0.429 |
| 21                                  | 610    | 0.978 | 506    | 0.534 |
| 22                                  | 672    | 0.989 | 1 205  | 0.818 |
| 23                                  | 235    | 0.938 | 764    | 0.847 |
| 24                                  | 206    | 1.210 | 483    | 0.673 |
| 25                                  | 75     | 0.923 | 398    | 0.804 |
| 26                                  | 241    | 0.774 | 0      | –     |
| 27                                  | 31     | 1.478 | 83     | 0.984 |
| 28                                  | 0      | –     | 31     | 1.153 |
| 29                                  | 0      | –     | 32     | 1.419 |
| 30                                  | 0      | –     | 0      | –     |
| 31                                  | 39     | 1.327 | 0      | –     |
| Measured males                      |        |       | 3 684  |       |
| Measured females                    |        |       | 3 822  |       |
| Aged males                          |        |       | 292    |       |
| Aged females                        |        |       | 363    |       |
| No. of tows sampled                 |        |       | 417    |       |
| Mean weighted CV (% , sexes pooled) |        |       | 21.2   |       |

### 3.4.4 Cook Strait

The trawl fishery in Cook Strait was 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 016 and 017), and a time stratum of 1 June to 30 September.

Table 23 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were insufficient data collected to estimate the catch-at-age distribution for trawl-caught ling in 2015 (164 length measurements).

All estimated proportion-at-age distributions from the Cook Strait trawl fishery are presented in Appendix B (Figure B10).

**Table 23: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the Cook Strait trawl fishery.**

| Year | Males    |      | Females  |      | Tows | Mean CV |
|------|----------|------|----------|------|------|---------|
|      | Measured | Aged | Measured | Aged |      |         |
| 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    |
| 2010 | 274      | 195  | 250      | 196  | 41   | 36.2    |

### 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 was surveyed. However, to ensure comparability, the distributions presented here are for the core strata only, i.e., 200–800 m.

Table 24 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The details of the estimated catch-at-age distribution for ling caught in the January 2016 trawl survey are given in Table 25. The mean weighted CV of 22% was less than the target of 30%.

All estimated proportion-at-age distributions from the Chatham Rise trawl surveys are presented in Appendix B (Figure B11).

**Table 24: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the Chatham Rise trawl surveys.**

| Survey  | Males    |      | Females  |      | Tows | Mean CV |
|---------|----------|------|----------|------|------|---------|
|         | Measured | Aged | Measured | Aged |      |         |
| 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    |
| TAN1101 | 523      | 334  | 508      | 313  | 80   | 30.6    |
| TAN1201 | 656      | 273  | 697      | 313  | 93   | 23.0    |
| TAN1301 | 646      | 287  | 652      | 324  | 83   | 24.9    |
| TAN1401 | 515      | 322  | 482      | 275  | 82   | 26.4    |
| TAN1601 | 860      | 317  | 863      | 325  | 86   | 21.8    |

**Table 25: Calculated numbers at age in the survey area, separately by sex, with CVs, for ling caught during a trawl survey of the Chatham Rise in January 2016 (survey TAN1601). Summary statistics for the samples are also presented. Age in years.**

| Age                                 | Male    | CV    | Female  | CV    |
|-------------------------------------|---------|-------|---------|-------|
| 2                                   | 7 361   | 1.284 | 5 684   | 1.042 |
| 3                                   | 138 963 | 0.296 | 135 325 | 0.245 |
| 4                                   | 312 820 | 0.201 | 375 478 | 0.186 |
| 5                                   | 205 769 | 0.233 | 180 597 | 0.228 |
| 6                                   | 178 643 | 0.242 | 195 548 | 0.194 |
| 7                                   | 212 930 | 0.228 | 189 385 | 0.211 |
| 8                                   | 218 213 | 0.208 | 128 910 | 0.255 |
| 9                                   | 114 046 | 0.292 | 81 270  | 0.319 |
| 10                                  | 84 310  | 0.344 | 118 809 | 0.262 |
| 11                                  | 91 147  | 0.314 | 112 983 | 0.253 |
| 12                                  | 68 525  | 0.354 | 72 521  | 0.299 |
| 13                                  | 32 918  | 0.534 | 20 654  | 0.557 |
| 14                                  | 67 721  | 0.362 | 25 729  | 0.518 |
| 15                                  | 54 234  | 0.394 | 35 015  | 0.424 |
| 16                                  | 79 636  | 0.343 | 33 950  | 0.422 |
| 17                                  | 27 491  | 0.496 | 39 493  | 0.365 |
| 18                                  | 52 299  | 0.374 | 42 460  | 0.357 |
| 19                                  | 44 734  | 0.408 | 13 694  | 0.669 |
| 20                                  | 42 893  | 0.447 | 11 693  | 0.767 |
| 21                                  | 20 863  | 0.500 | 6 818   | 0.751 |
| 22                                  | 1 679   | 1.645 | 15 125  | 0.655 |
| 23                                  | 2 015   | 1.324 | 13 692  | 0.582 |
| 24                                  | 12 183  | 0.609 | 4 609   | 0.992 |
| 25                                  | 11 730  | 0.968 | 9 152   | 0.938 |
| 26                                  | 1 389   | 1.540 | 3 972   | 1.517 |
| 27                                  | 3 467   | 1.494 | 7 430   | 1.016 |
| 28                                  | 2 910   | 1.484 | 0       | –     |
| 29                                  | 3 428   | 1.605 | 0       | –     |
| 30                                  | 3 428   | 1.329 | 0       | –     |
| 31                                  | 0       | –     | 0       | –     |
| 32                                  | 2 667   | 1.404 | 0       | –     |
| Measured males                      |         |       |         | 860   |
| Measured females                    |         |       |         | 863   |
| Aged males                          |         |       |         | 317   |
| Aged females                        |         |       |         | 325   |
| No. of tows sampled                 |         |       |         | 86    |
| Mean weighted CV (% , sexes pooled) |         |       |         | 21.8  |

### 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 was conducted in summer. Those surveys 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. 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 26 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There was no survey in this series conducted in December 2015.

All estimated proportion-at-age distributions from the Sub-Antarctic trawl surveys are presented in Appendix B; Figure B12 shows the summer survey distributions and Figure B13 shows the autumn survey distributions.

**Table 26: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic trawl surveys.**

| Survey         | Males    |      | Females  |      | Tows | Mean CV |
|----------------|----------|------|----------|------|------|---------|
|                | Measured | Aged | Measured | Aged |      |         |
| Summer surveys |          |      |          |      |      |         |
| AEX8902        | 760      | 160  | 1 067    | 234  | 133  | 28.8    |
| TAN9105        | 1 563    | 213  | 2 079    | 348  | 151  | 19.8    |
| TAN9211        | 1 249    | 227  | 1 668    | 354  | 146  | 20.7    |
| TAN9310        | 1 520    | 254  | 1 894    | 351  | 127  | 22.2    |
| TAN0012        | 1 761    | 244  | 1 696    | 351  | 85   | 19.2    |
| TAN0118        | 1 316    | 268  | 1 290    | 326  | 95   | 19.8    |
| TAN0219        | 1 661    | 224  | 1 606    | 350  | 88   | 20.8    |
| TAN0317        | 1 270    | 243  | 1 156    | 333  | 70   | 22.1    |
| TAN0414        | 1 433    | 256  | 1 146    | 339  | 79   | 26.7    |
| TAN0515        | 1 095    | 279  | 988      | 300  | 82   | 22.4    |
| TAN0617        | 969      | 250  | 1 011    | 355  | 80   | 22.6    |
| TAN0714        | 1 014    | 229  | 1 288    | 353  | 79   | 21.4    |
| TAN0813        | 1 162    | 250  | 994      | 327  | 80   | 26.6    |
| TAN0911        | 830      | 232  | 882      | 339  | 70   | 22.8    |
| TAN1117        | 1 264    | 266  | 1 321    | 322  | 80   | 23.6    |
| TAN1215        | 1 391    | 289  | 1 555    | 316  | 80   | 25.5    |
| TAN1412        | 1 175    | 262  | 1 261    | 365  | 76   | 21.1    |
| 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    |

### 3.5.3 West coast South Island

Trawl survey catch-at-age distributions are estimates of the numbers of ling, by sex and age, available to the trawl in the survey. A combined trawl and acoustic survey by *Tangaroa* in 2000 (O’Driscoll et al. 2004) was replicated (with some modifications) in winter 2012 (O’Driscoll et al. 2014) and winter 2013 (O’Driscoll et al. 2015), so a three year comparable time series is available. The biomass estimates from the three surveys were standardised using random daytime bottom trawl stations in strata 1&2A, B, and C, and 4A, B, and C (depth 300–650 m), with stratum areas from the 2012 survey (O’Driscoll et al. 2014).

Table 27 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. Because no otoliths from the 2000 survey were aged, the scaled length-frequency distribution from that survey was applied to the WCSI commercial fishery age-length key for 2000. The age-length keys for the 2012 and 2013 surveys were derived using otoliths collected during the surveys. No survey in this series was conducted in 2015.

All estimated proportion-at-age distributions from the west coast South Island trawl surveys are presented in Appendix B (Figure B14).

**Table 27: Numbers of measured male and female ling, age data used in the age-length key, tows sampled, and estimated mean weighted CV (%) by age for the west coast South Island resource surveys.**

| Survey  | Males    |      | Females  |      | Tows | Mean CV |
|---------|----------|------|----------|------|------|---------|
|         | Measured | Aged | Measured | Aged |      |         |
| TAN0007 | 784      | 284  | 637      | 276  | 45   | 29.5    |
| TAN1210 | 962      | 305  | 722      | 308  | 48   | 26.7    |
| TAN1308 | 1 026    | 224  | 768      | 298  | 53   | 30.1    |

## 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 CV were available from the HAK 7 fishery off WCSI, the HAK 1 fishery in the Sub-Antarctic, and the HAK 4 fishery on the east Chatham Rise. The target was almost always met for samples from the WCSI fishery (see Table 5). The sampling intensity in the HAK 7 (WCSI) commercial trawl fishery was higher in 2014–15 than in any previous year. Sampling intensity in the Sub-Antarctic varied considerably between years, with consequent wide variation in the mean weighted CVs (see Table 3) and the sampling intensity of this fishery in 2014–15 was moderate. Hake on Chatham Rise were analysed as two separate fisheries (see Table 1), and although sampling intensity was low in 2014–15 there were sufficient data to produce a reasonable catch-at-age distribution for the east fishery; a distribution for this fishery was last produced in 2006–07. Sampling of the west Chatham Rise fishery resulted in catch-at-age distributions in all but one year from 1991–92 to 2010–11, but sampling intensity was low since then and only one distribution was produced.

The January 2016 Chatham Rise survey produced low numbers of hake (158 measured fish in the analysed strata), and consequently the catch-at-age distribution for the trawl survey had a mean weighted CV much higher than the target of 30% (41%). No improvements in the precision can be achieved, however, as all available data were included in the analysis. The target of 30% was met only once in this survey series, although the values were often between 30 and 40% (see Table 7). There was no survey of the Sub-Antarctic in December 2015.

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 east (see Figure A2). Previous analyses showed that males and females appeared to be about evenly abundant in all areas except Statistical Area 404, where males dominated the catch (Horn & Sutton 2009). Some year class progressions were apparent. The year class that spawned at the start of the 1990–91 fishing year (age 3 years in January 1994) appears relatively strong, and can be tracked in some subsequent distributions through to about 2003. There was a clear year class progression apparent in the Chatham Rise survey distributions from 2004 to 2011 (Figure A5). The year class that spawned in late 2001 (aged 2+ years in January 2004) clearly progressed through to age 9+ years in 2011, for both males and females. It also appears likely that the two following year classes (2002 and 2003) were moderately strong.

In the Sub-Antarctic, there were 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, aged 6 in 1998 through to age 12 years in 2004, and age 5 in 2009 through to age 11 years in 2015.

The WCSI trawl catch was dominated by hake aged 5–12 years, with no clearly apparent year class progressions (see Figure A4). In some years, large numbers of 1- or 2-year-old fish were taken by the fishery, but these did not always manifest as strong cohorts in later years. The relatively abundant 2-year-old fish in catches from 2005, 2006, and 2007 progressed to comprise a high proportion of the catch from 2010 to 2012. Since 2011, fish older than 10 years appear to have been less abundant in the catch than



in most previous years. A characteristic of most of the WCSI distributions was that numbers of fish aged 3 and 4 years were generally very low. Fish of this age may be 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 one commercial longline fishery in 2014–15 (west coast South Island), and the target CV was met. Catch-at-age distributions were scheduled to be produced for the Chatham Rise, Sub-Antarctic and Bounty Plateau fisheries, but they were either not sampled by observers in 2014–15, or the sample size was insufficient to analyse (i.e., Chatham Rise). The west coast South Island longline fishery is not scheduled for regular analysis because it is predominantly conducted from small vessels and is rarely sampled by observers. However, a reasonable sample from two trips in 2014–15 was used to produce the fifth catch-at-age distribution for this fishery. Observer sampling on ling longline vessels declined in recent years in tandem with a reduction in effort by this fleet. It would be desirable to ensure that trips that are observed in the various areas occur during the months chosen for analysis of the particular fisheries (see Section 2).

Catch-at-age distributions were produced for trawl fisheries catching ling in three areas. The Sub-Antarctic distribution used observer length data applied to age-length keys obtained from a trawl survey, i.e., Sub-Antarctic length data collected from September 2014 to April 2015 were applied to the age-length key from the December 2014 (TAN1412) trawl survey of the Sub-Antarctic. The estimated CV was below the target value, as it was for all distributions in this series. The Chatham Rise and WCSI distributions relied entirely on observer length data and otoliths. The Chatham Rise catch-at-age distribution had a mean weighted CV just above the target of 30%. Most samples in this series were close to the target, but the level of observer sampling was relatively low in this fishery in 2014–15 (see Table 17). The WCSI commercial fishery was more extensively sampled in 2014–15 than in any previous year (see Table 21). Consequently, the estimated catch-at-age distribution had one of the lowest mean weighted CVs of the series. An estimate of catch-at-age for the ling bycatch from the Cook Strait hoki spawning fisheries was not able to be produced for 2014 as insufficient fish were sampled. No age structure for the Cook Strait fishery has been produced since 2010.

Sufficient ling otoliths and length-frequency data were available from a trawl survey of the Chatham Rise (January 2016) to meet the mean weighted CV target. The target was met in all but one of the previous surveys of this area (see Table 24).

The ling longline fisheries caught few fish younger than 7 years, and much of the catch was older than 12 years. Sex ratios of the longline catch were about 1:1 on the Chatham Rise and in Cook Strait, but were biased towards females in the other fisheries, particularly the Sub-Antarctic non-spawning fishery (see Figure B3). Year class progressions were not apparent in the longline series, although in the Chatham Rise fishery, females at age 13 in 2002 can be observed progressing to age 18 in 2007.

Recruitment to the trawl fisheries was generally about two years earlier than to the longline fisheries (i.e., at about 5 years), and most of the catch was 13 years or younger. Some year class progressions were apparent in some of the trawl series, particularly for female fish. On the Chatham Rise, a relatively strong year class of fish aged 5 in 2001 can be followed through to 2008 when they are 12 years old. Ling in the Sub-Antarctic aged 6 and 8 in 2002 are still relatively strong in 2006 at ages 10 and 12 years. Some similar patterns in Chatham Rise and Sub-Antarctic trawl survey catch-at-age are also apparent, as would be expected given that the same age-length key is applied to trawl fisheries and trawl surveys from a particular area. In the Cook Strait trawl fishery, female ling exhibit a relatively strong year class aged 7 in 2001 through to age 11 in 2005.

The ling trawl catch-at-age distributions from the WCSI fishery often exhibited 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 2008a). Fish of this size may be less vulnerable or available to the trawl during the winter months of the fishery.

### 4.3 Observer sampling

All the commercial fishery catch-at-age distributions reported here were reliant on the collection by observers of length data and otoliths. It was noted above that some planned catch-at-age distributions could not be estimated owing to insufficient data being collected. In some situations this has resulted from a marked reduction in effort in a fishery, e.g., the hake trawl fishery on the eastern Chatham Rise has produced relatively small catches since 2009–10 (Horn 2013). But for some fisheries, there was either insufficient or no observer sampling, or the observed trips occurred at times outside the ‘main’ fishery period used to estimate commercial catch-at-age, e.g., the Chatham Rise longline fishery. Sampling levels of trawl-caught ling off WCSI were low or inadequate in most years from 2006 to 2014, despite the presence of observers who comprehensively sampled hoki and hake from the same fishery that produces most of the ling catch. It appears likely that most observers were not aware of the need to comprehensively sample ling from the WCSI hoki target fishery (although this may have been rectified in 2015). If possible, it would be desirable to ensure that, for all fisheries where catch-at-age estimates are produced, sampled (observed) trips occur in the areas and months used to produce the time series reported here, and observers are adequately briefed on the sampling requirements. The areas and months for each fishery are listed in this document in the sections above, e.g., for the Chatham Rise ling longline fishery the chosen season is from June to October.

## 5. ACKNOWLEDGMENTS

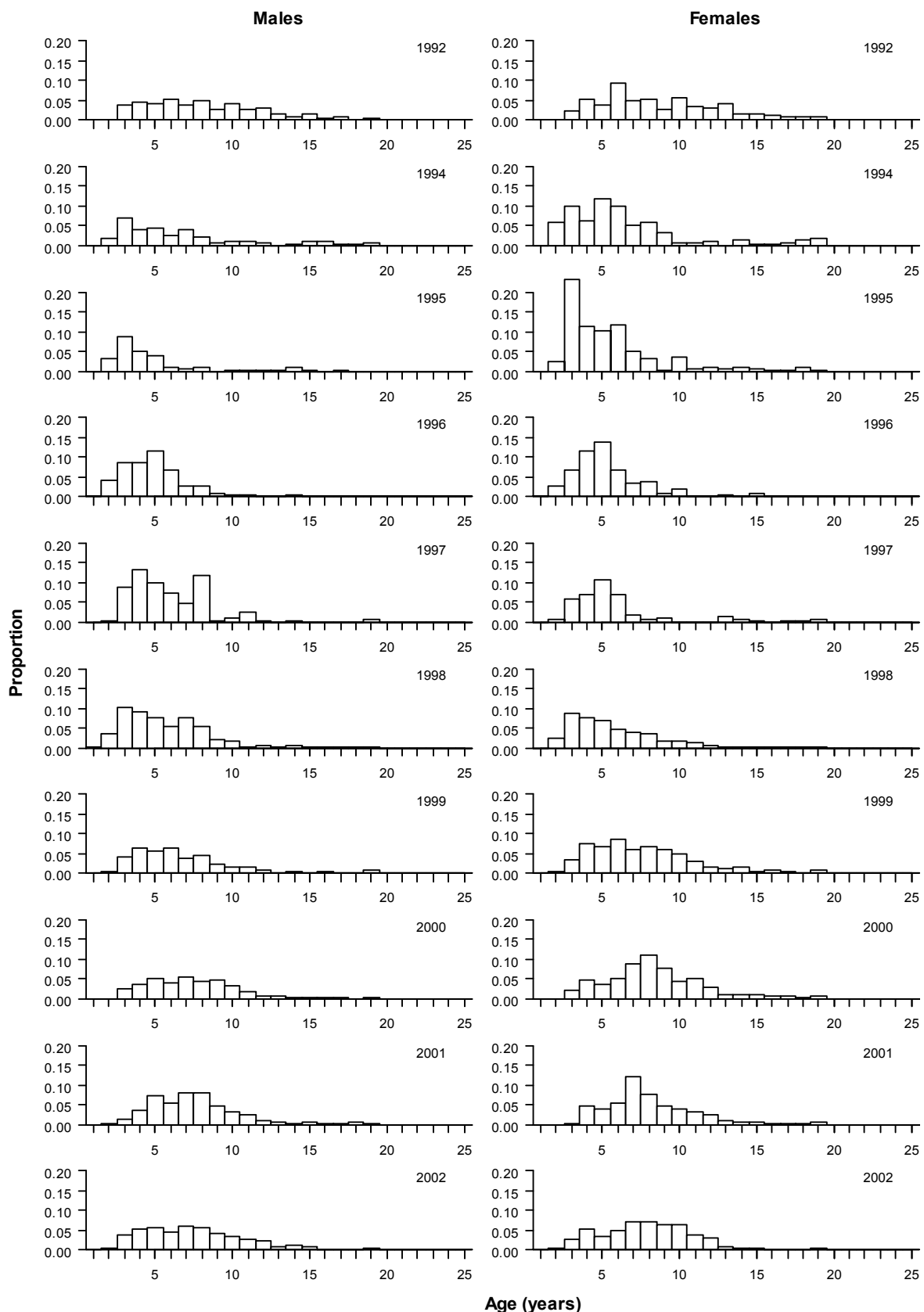
This work was funded by the Ministry for Primary Industries under Project MID201501. We thank Sira Ballara for assistance in creating the figures in Appendices A and B, and Peter McMillan for reviewing the manuscript.

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## Appendix A: Summaries of the proportions-at-age data for hake



**Figure A1: Age frequency distributions of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2015. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–April 2002 sample.**

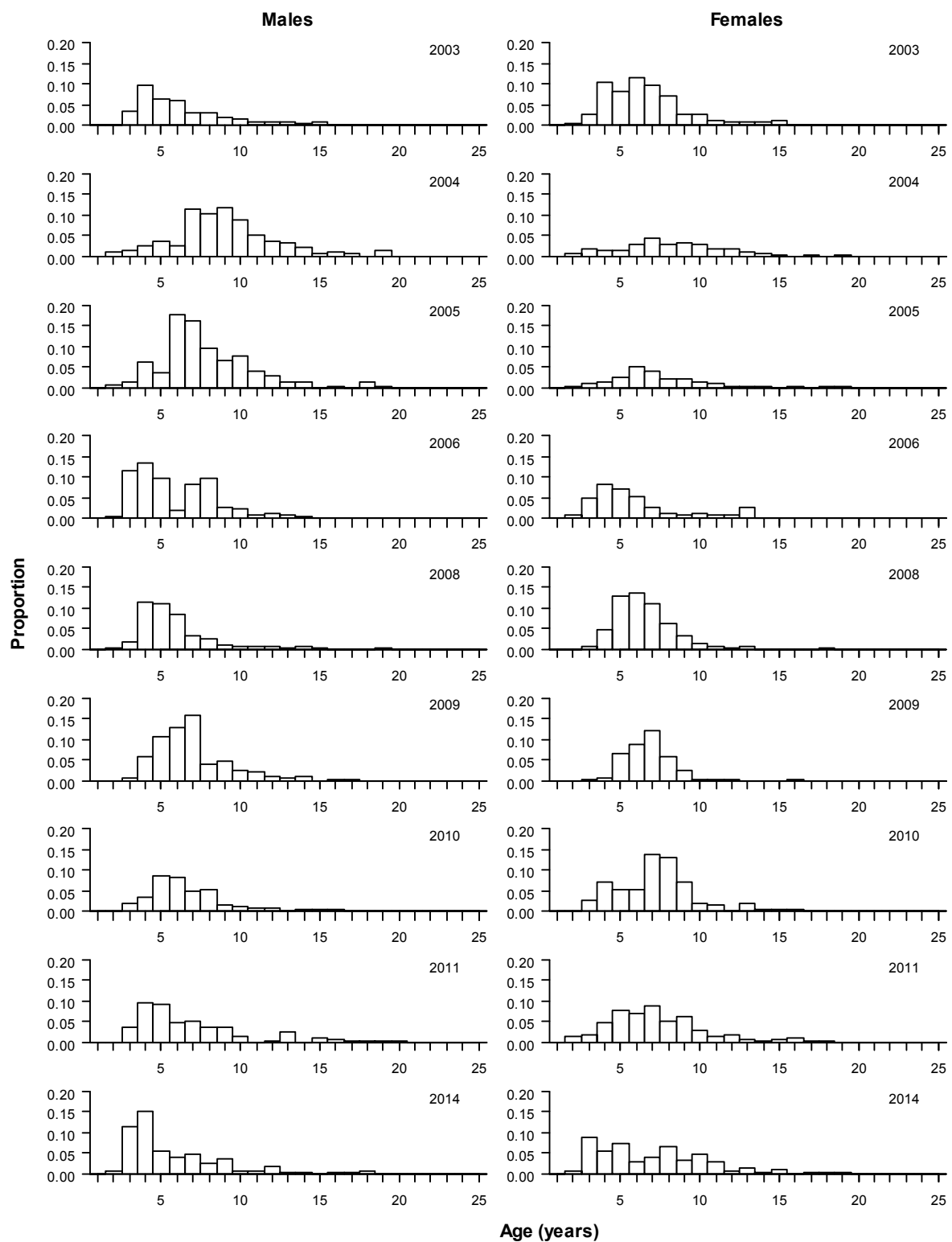
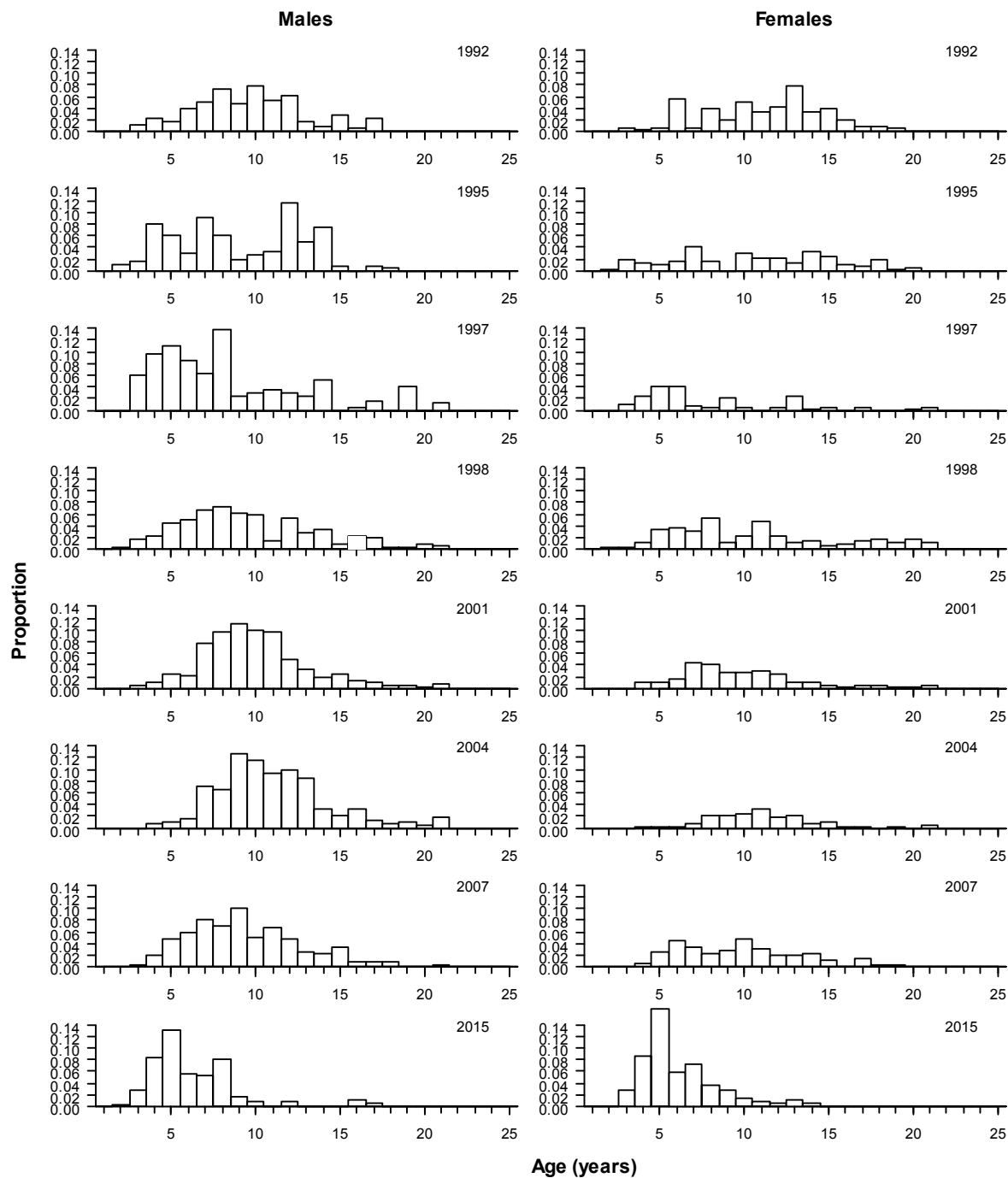
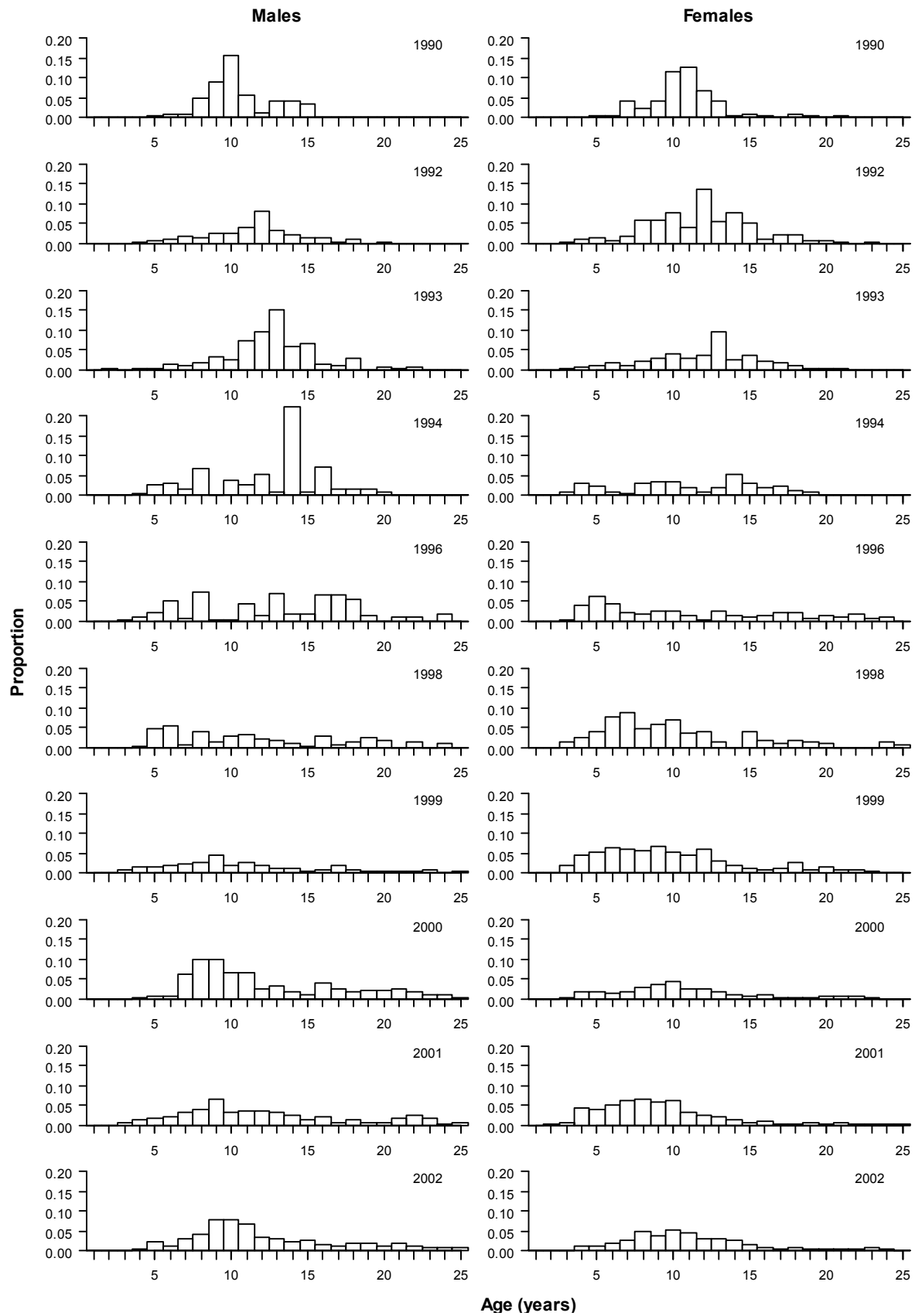


Figure A1 ctd.



**Figure A2: Age frequency distributions of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2015. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “1992” denotes the October 1991–April 1992 sample.**



**Figure A3: Age frequency distributions of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2015. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the September 2001–May 2002 sample.**

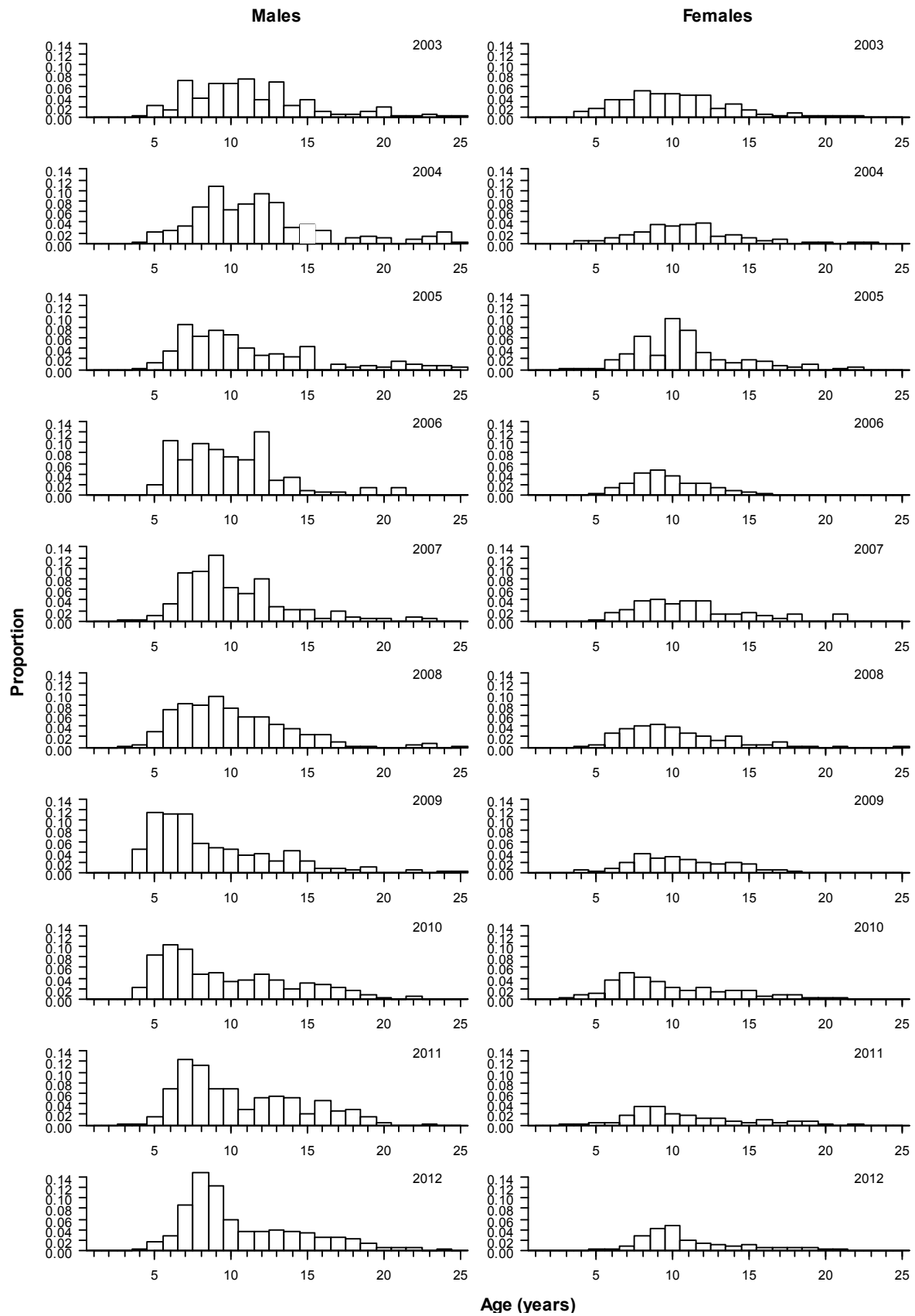


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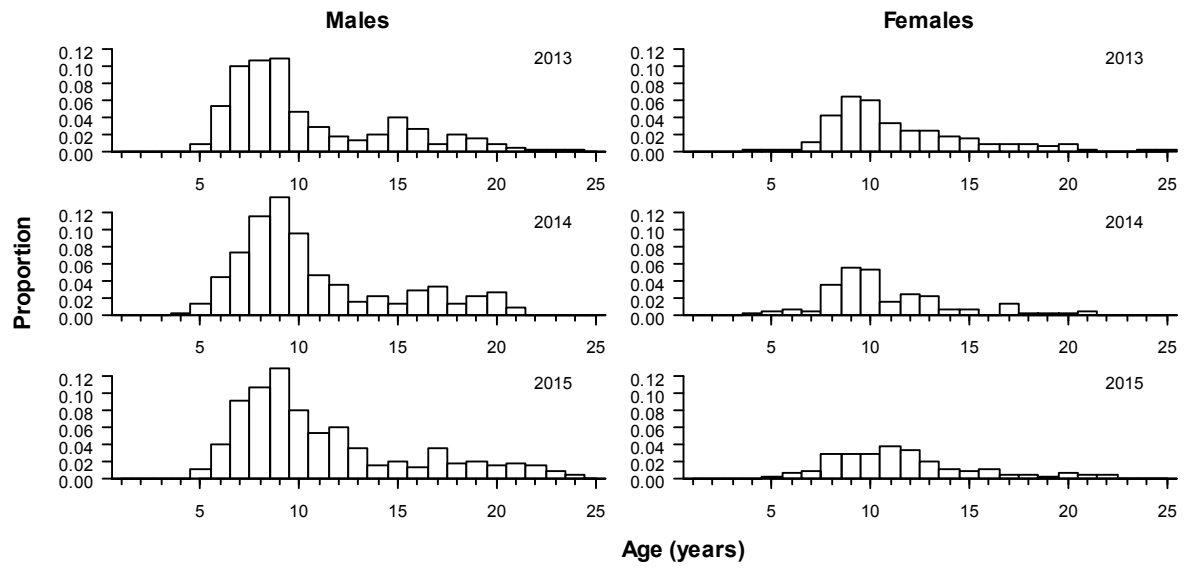
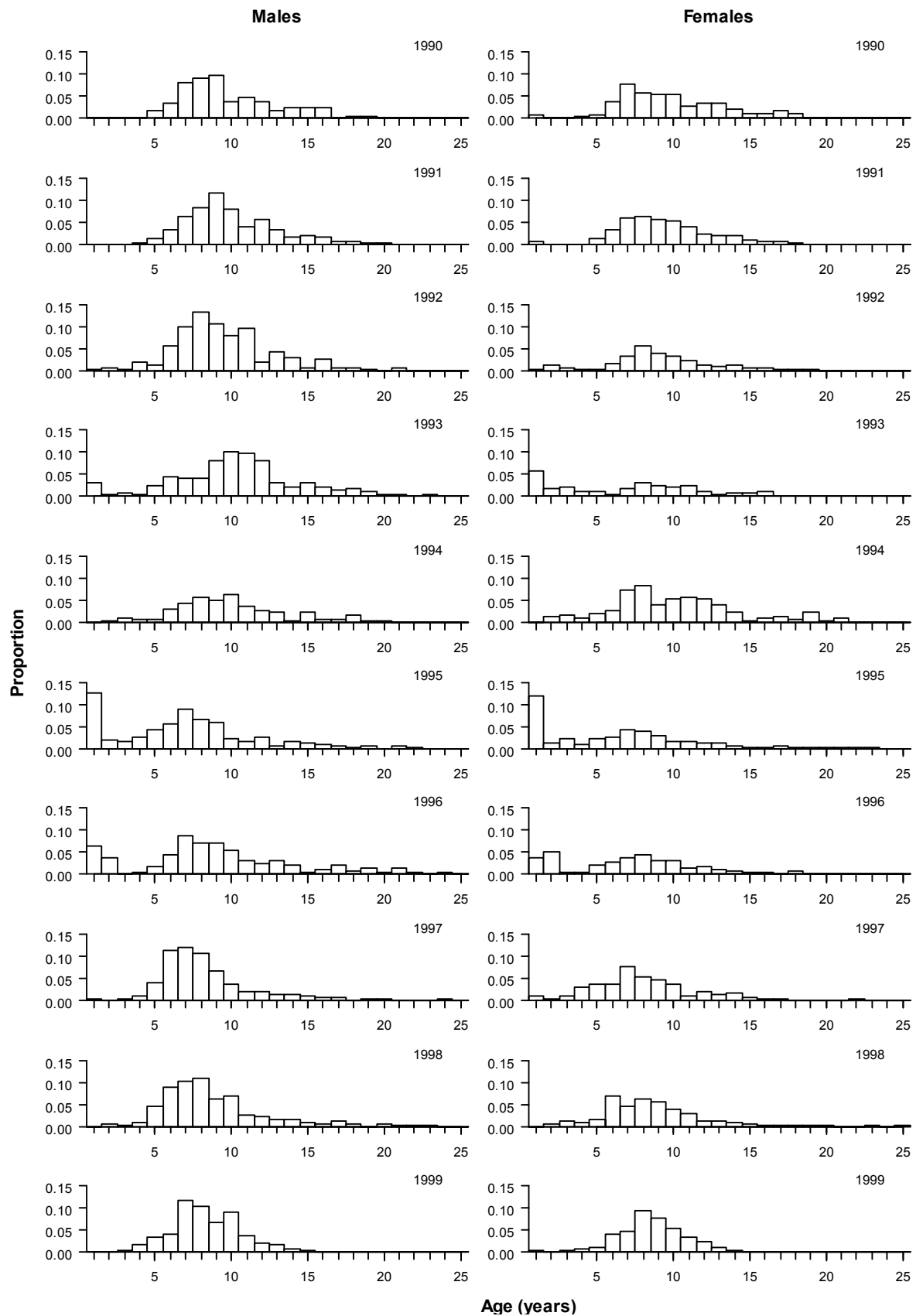


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**Figure A4: Age frequency distributions of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2015.**

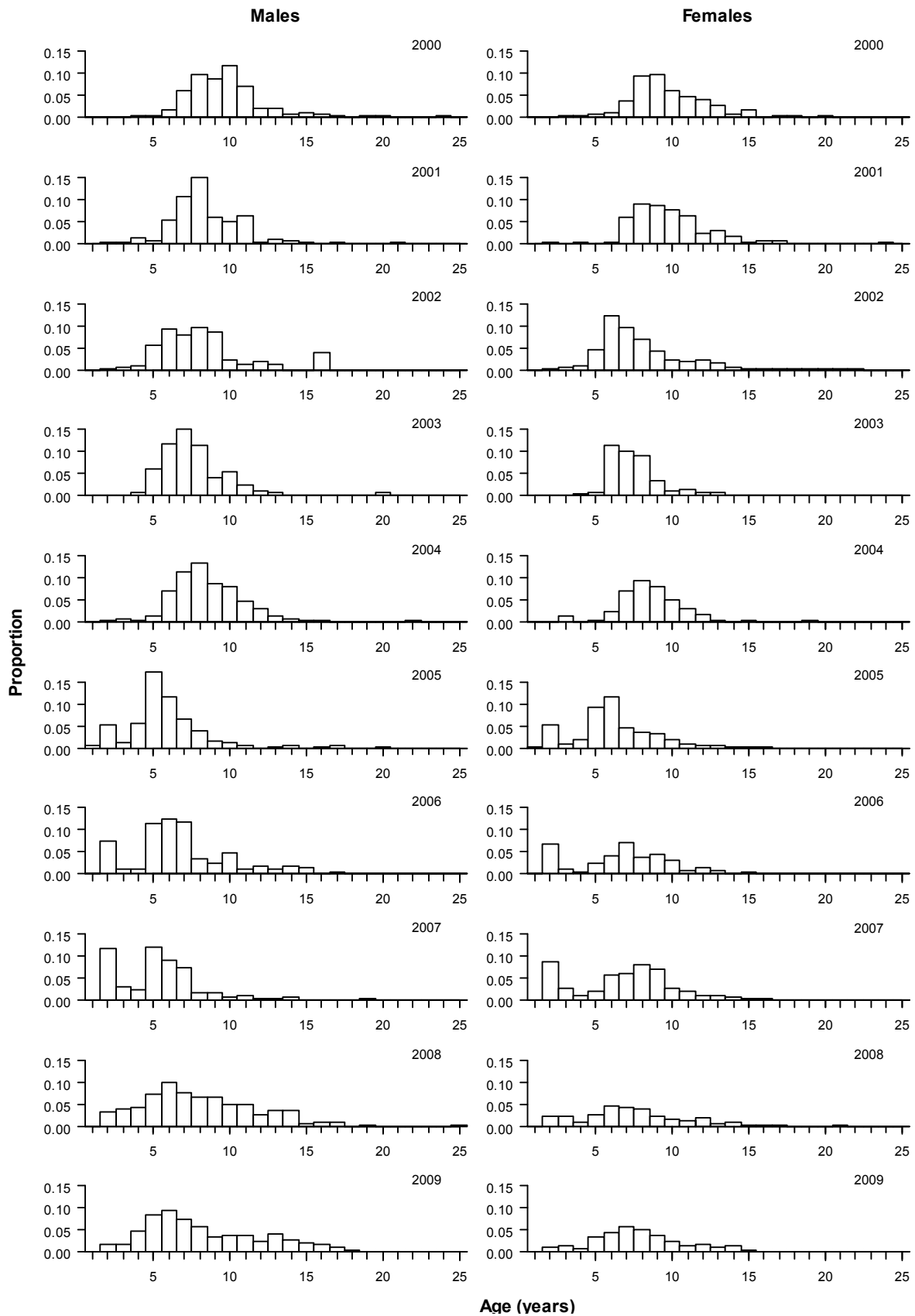


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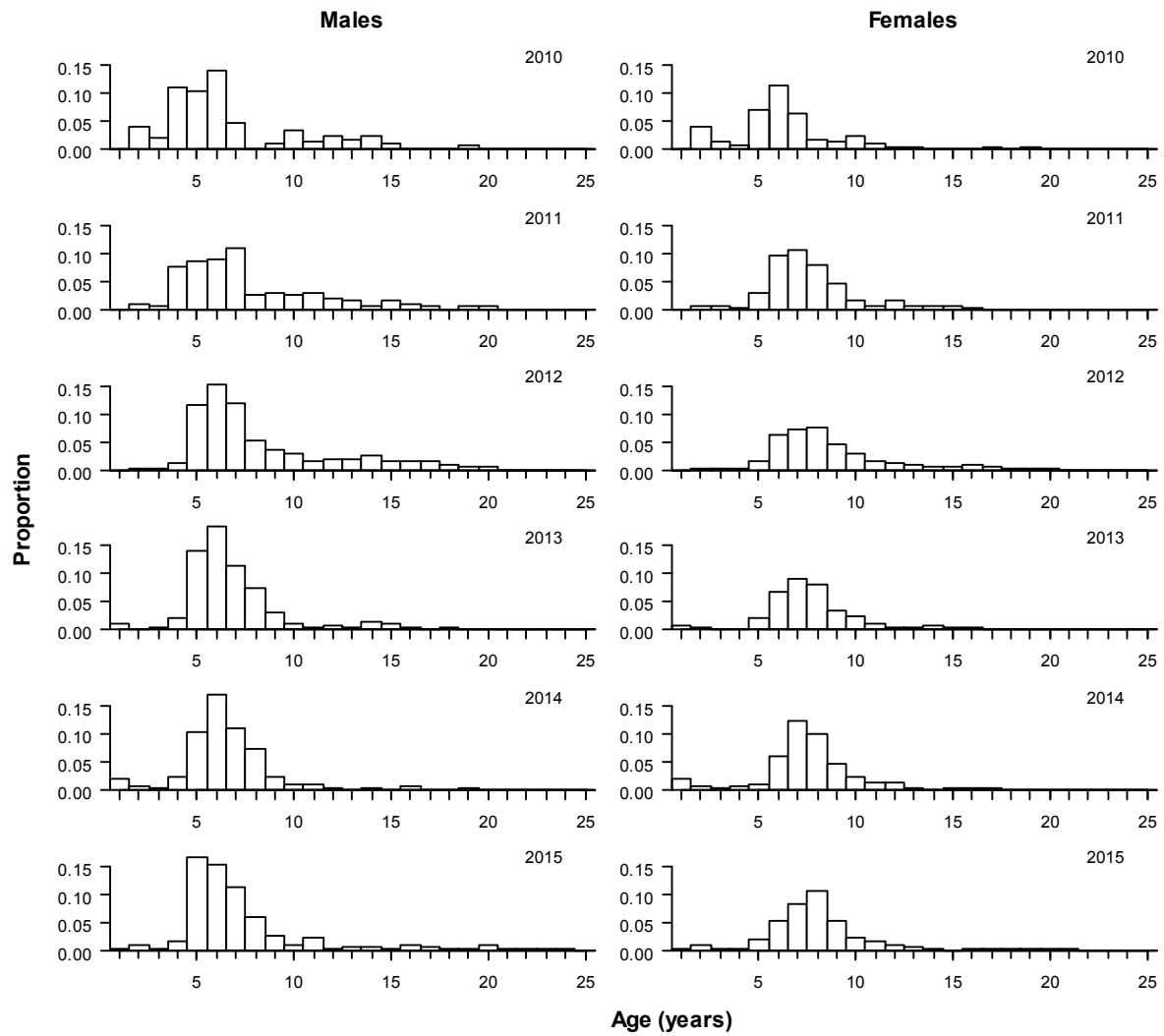
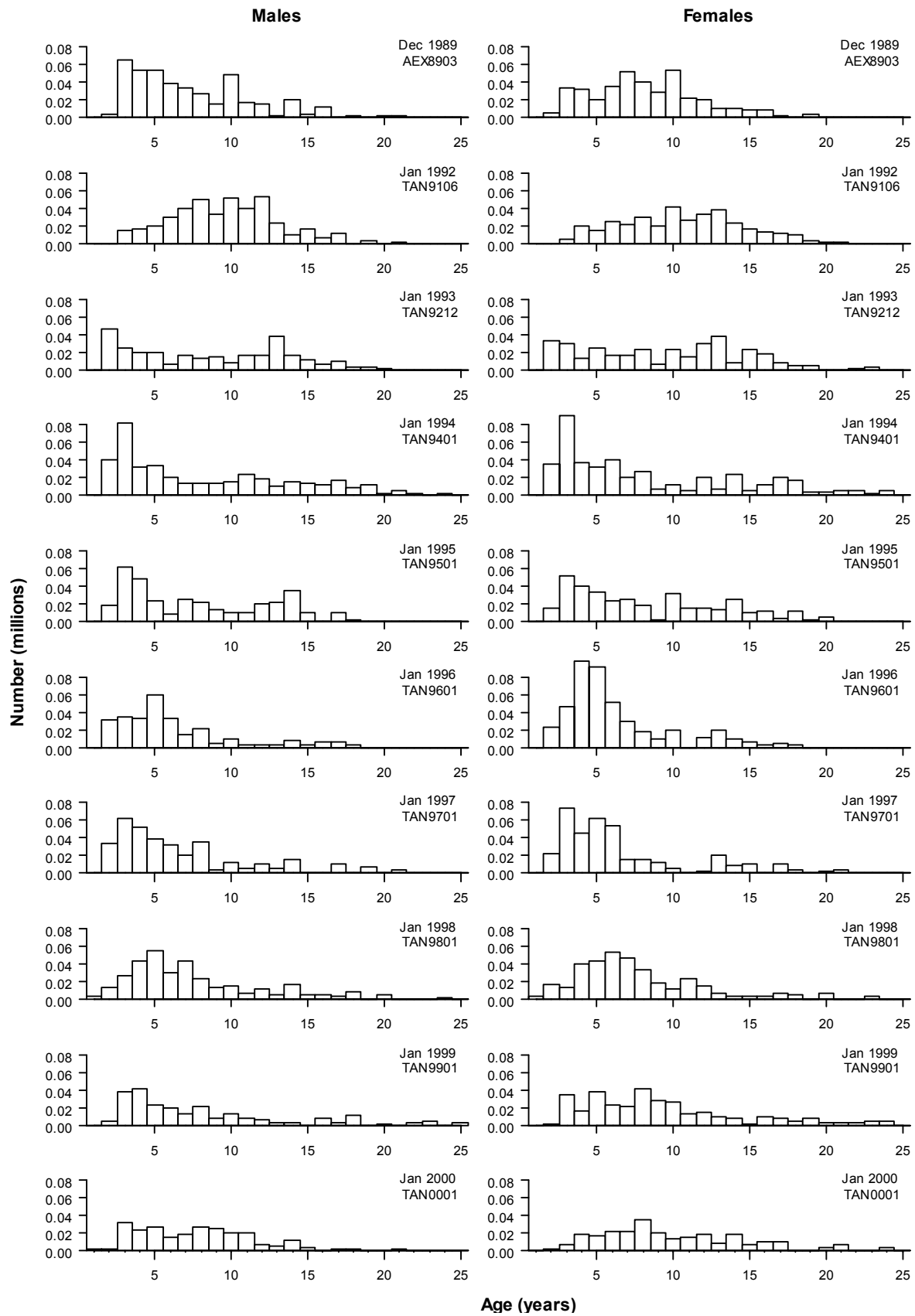


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**Figure A5: Age frequency distributions of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2015–16.**

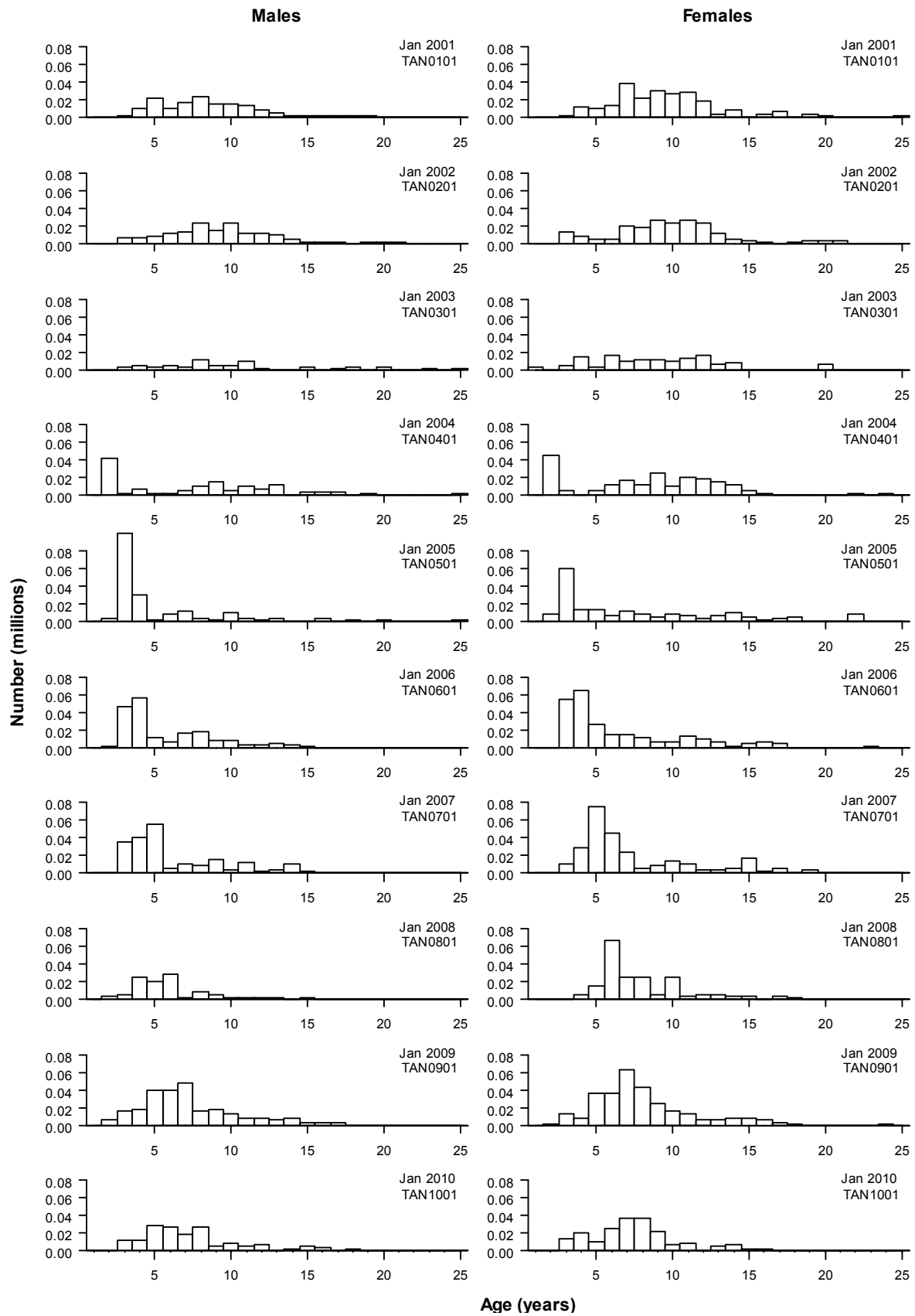


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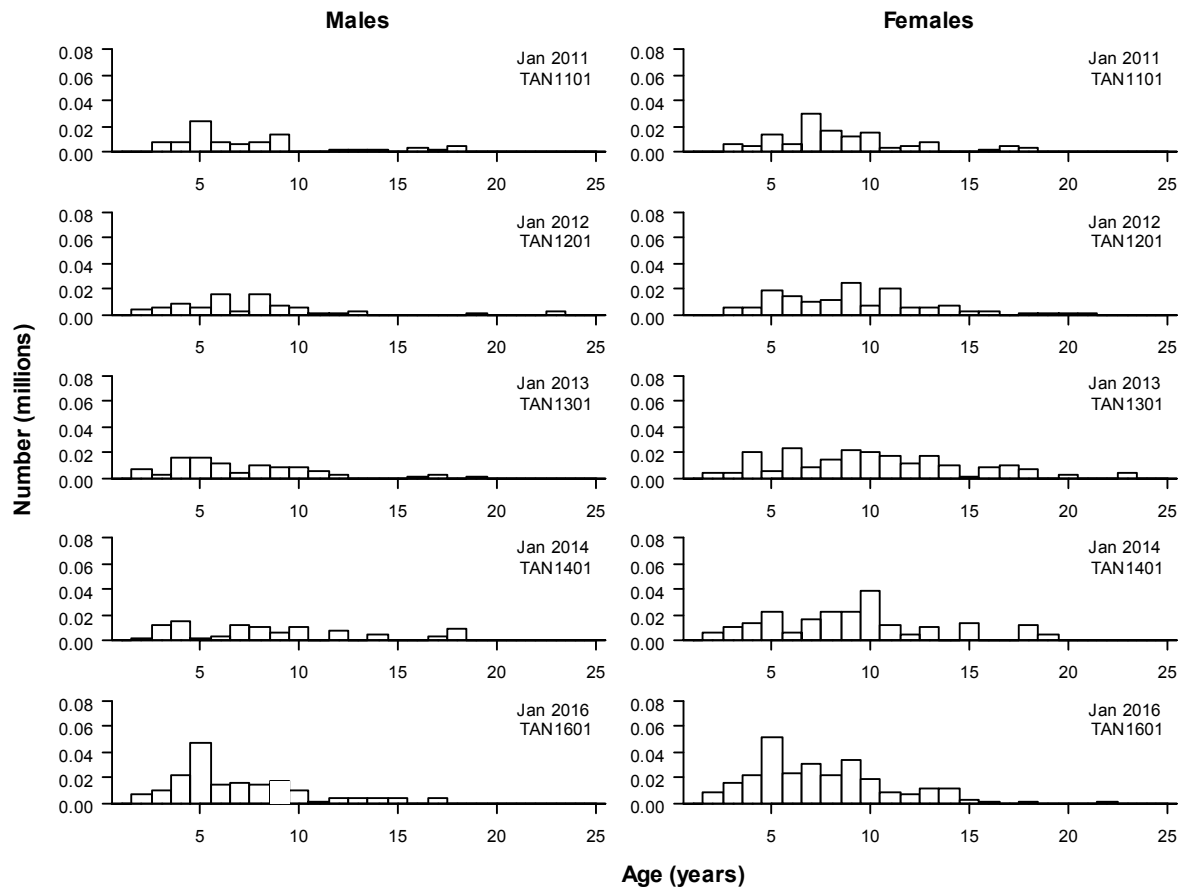
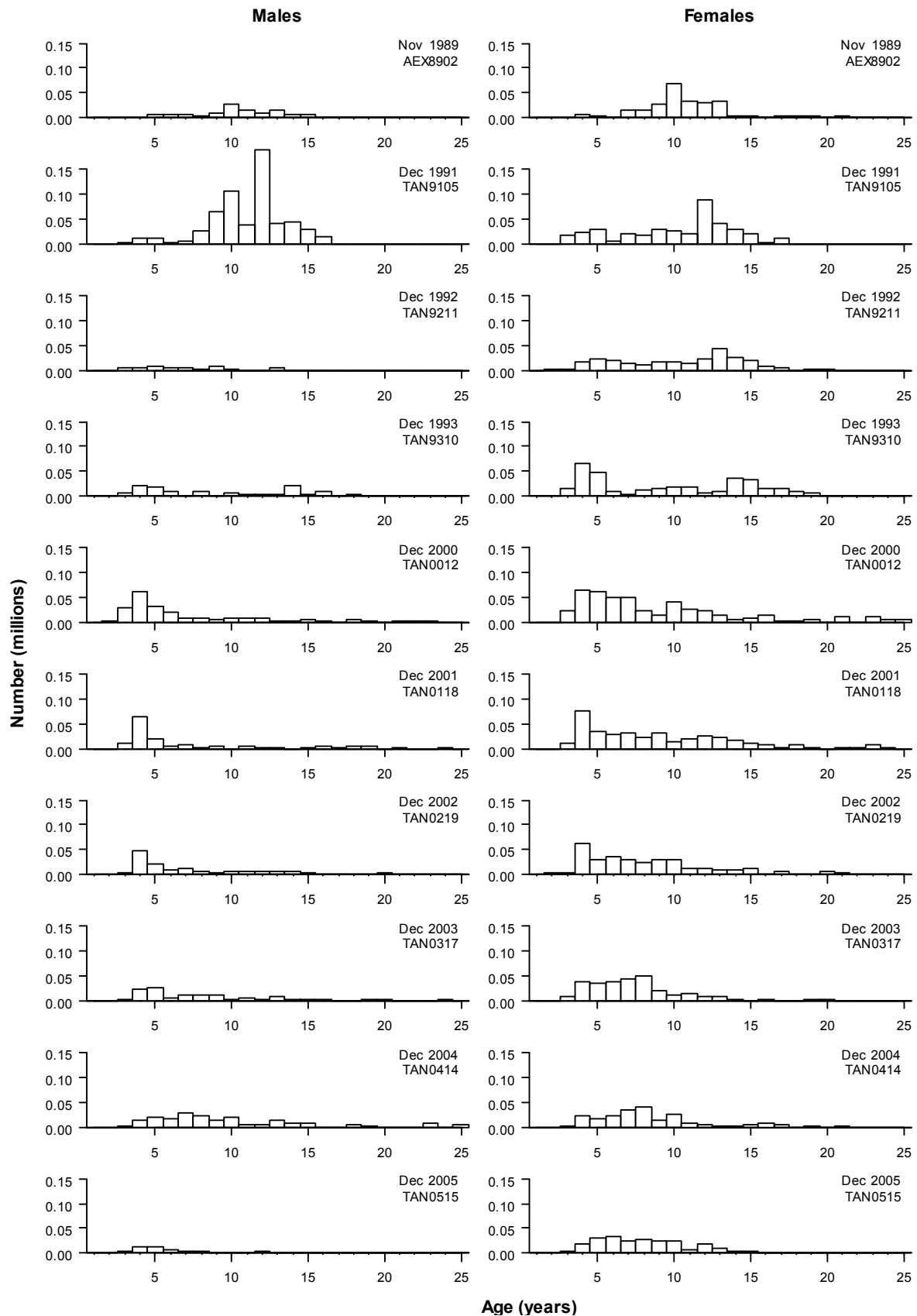


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**Figure A6: Age frequency distributions of hake (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2015.**



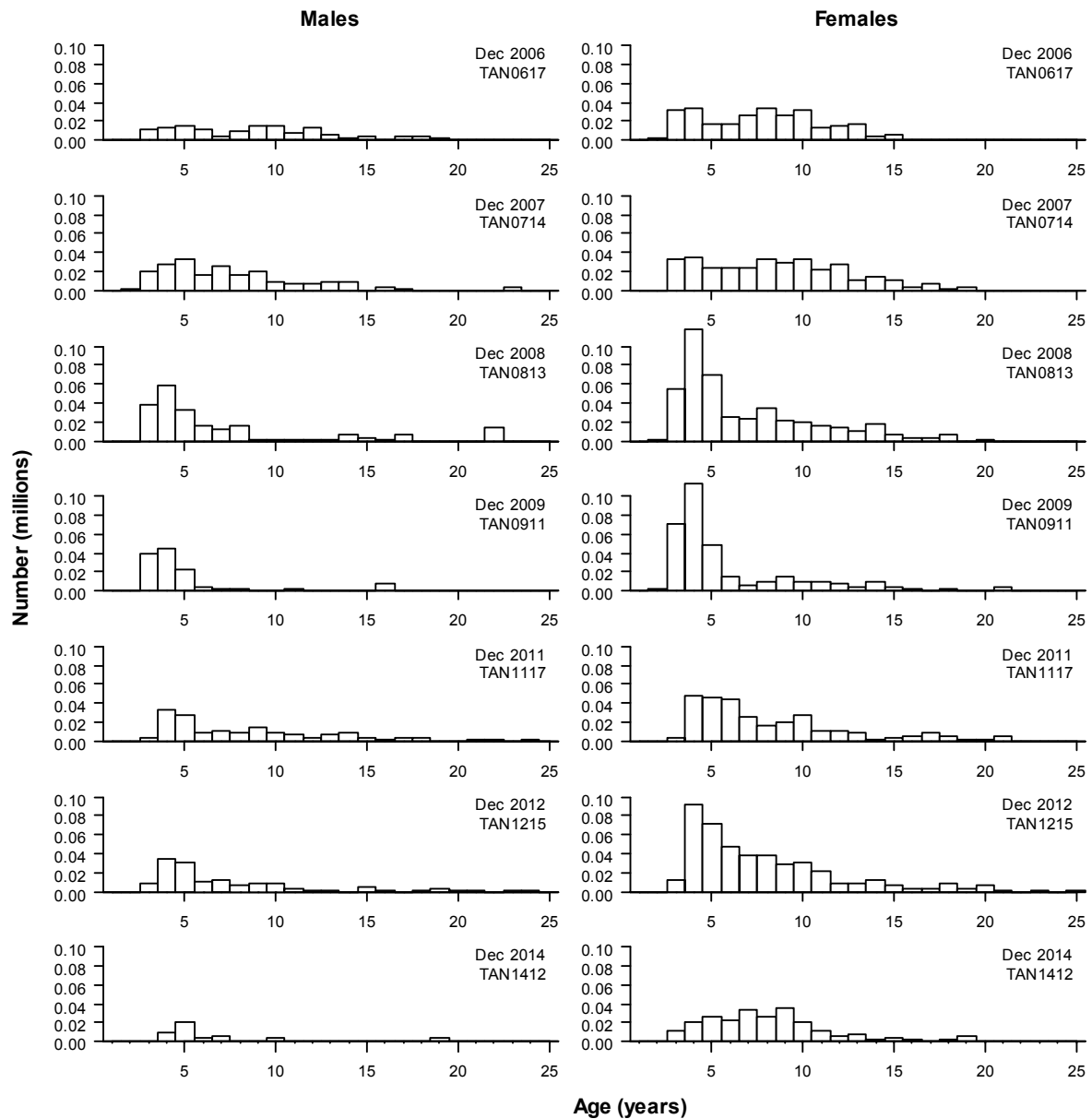
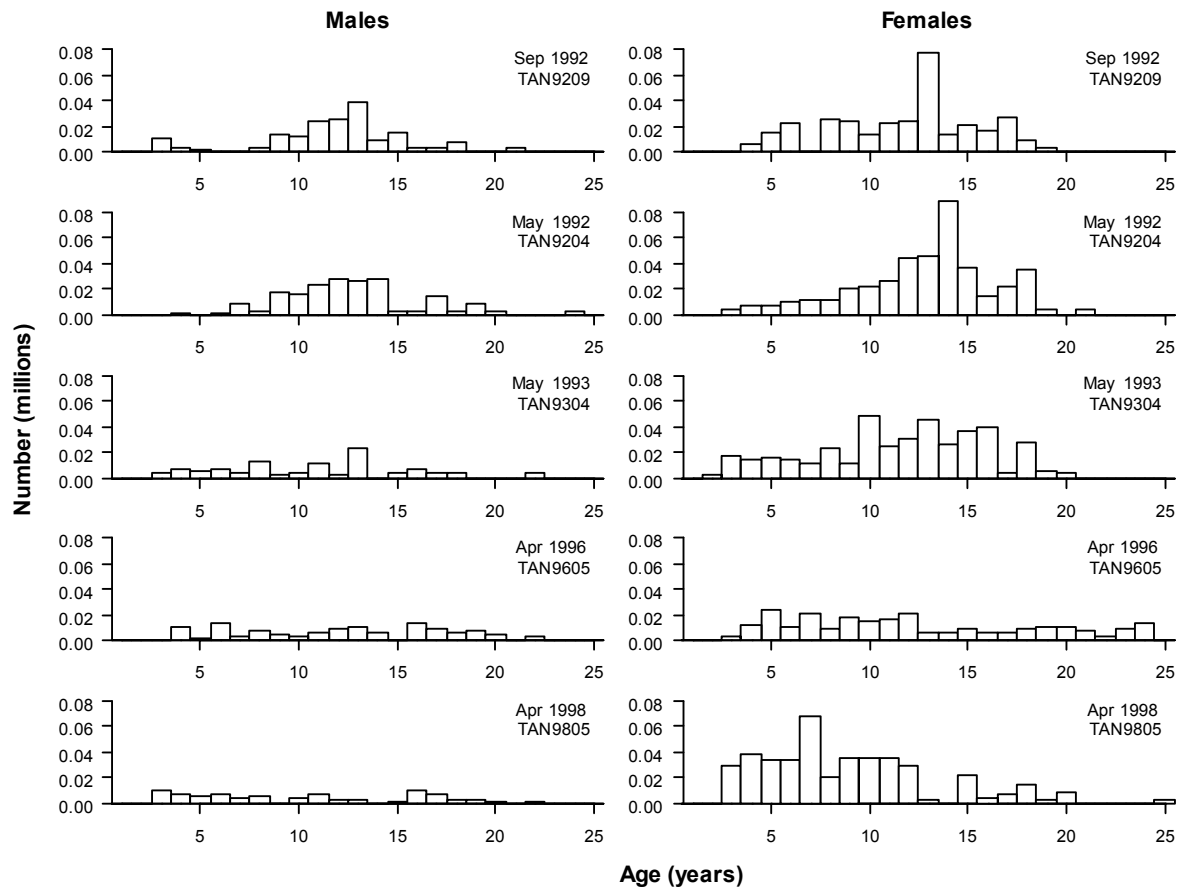
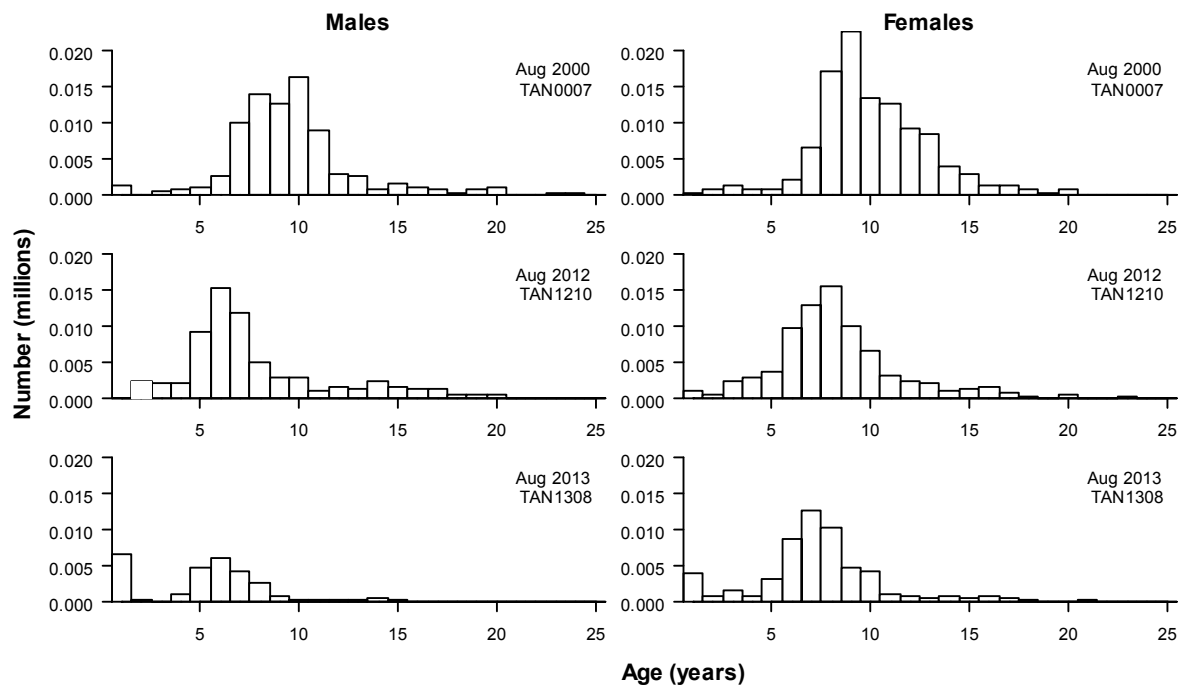


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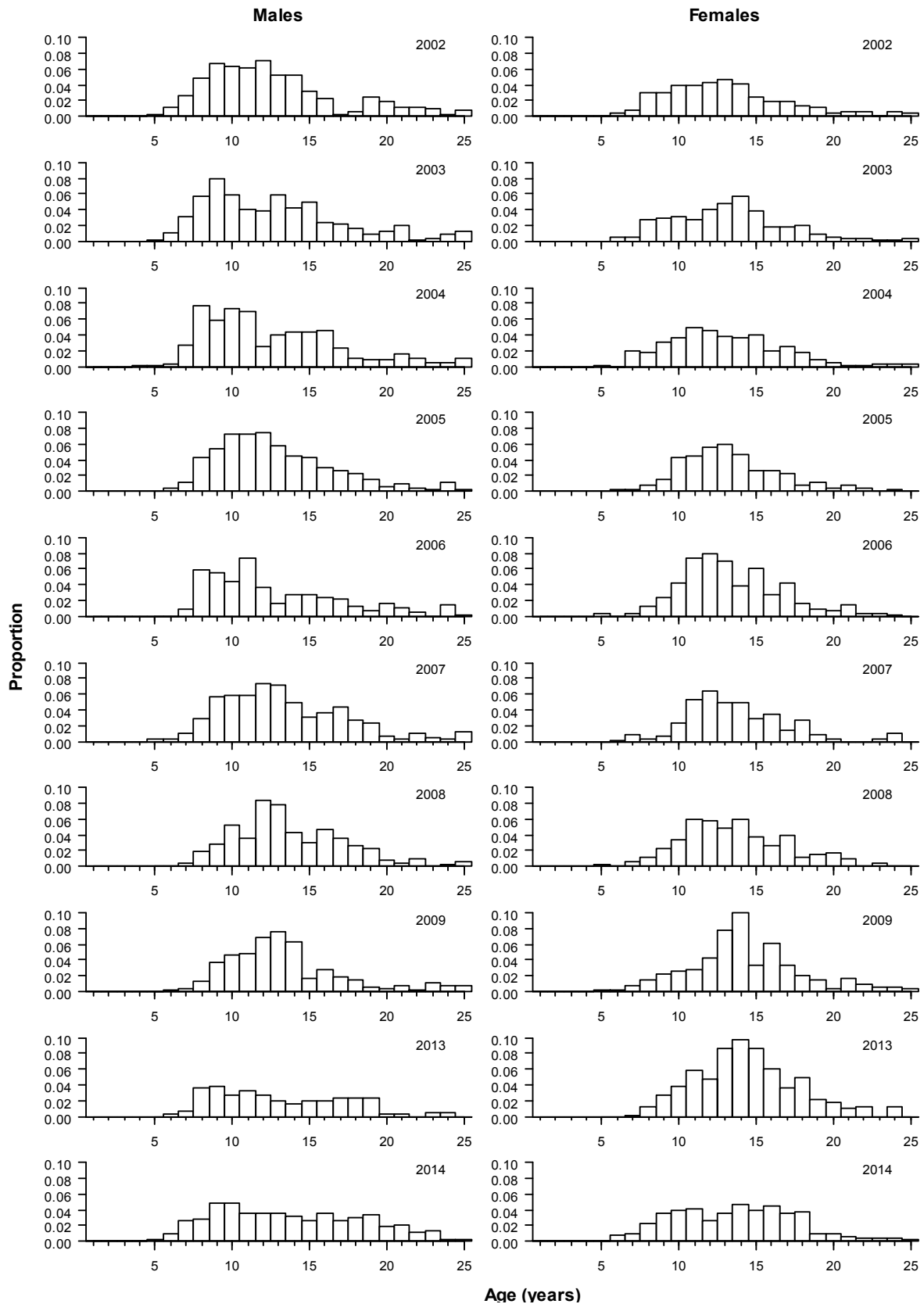


**Figure A7: Age frequency distributions of hake (ages 1 to 25) from spring (September) and autumn (April–May) resource surveys in the Sub-Antarctic, 1992 to 1998.**

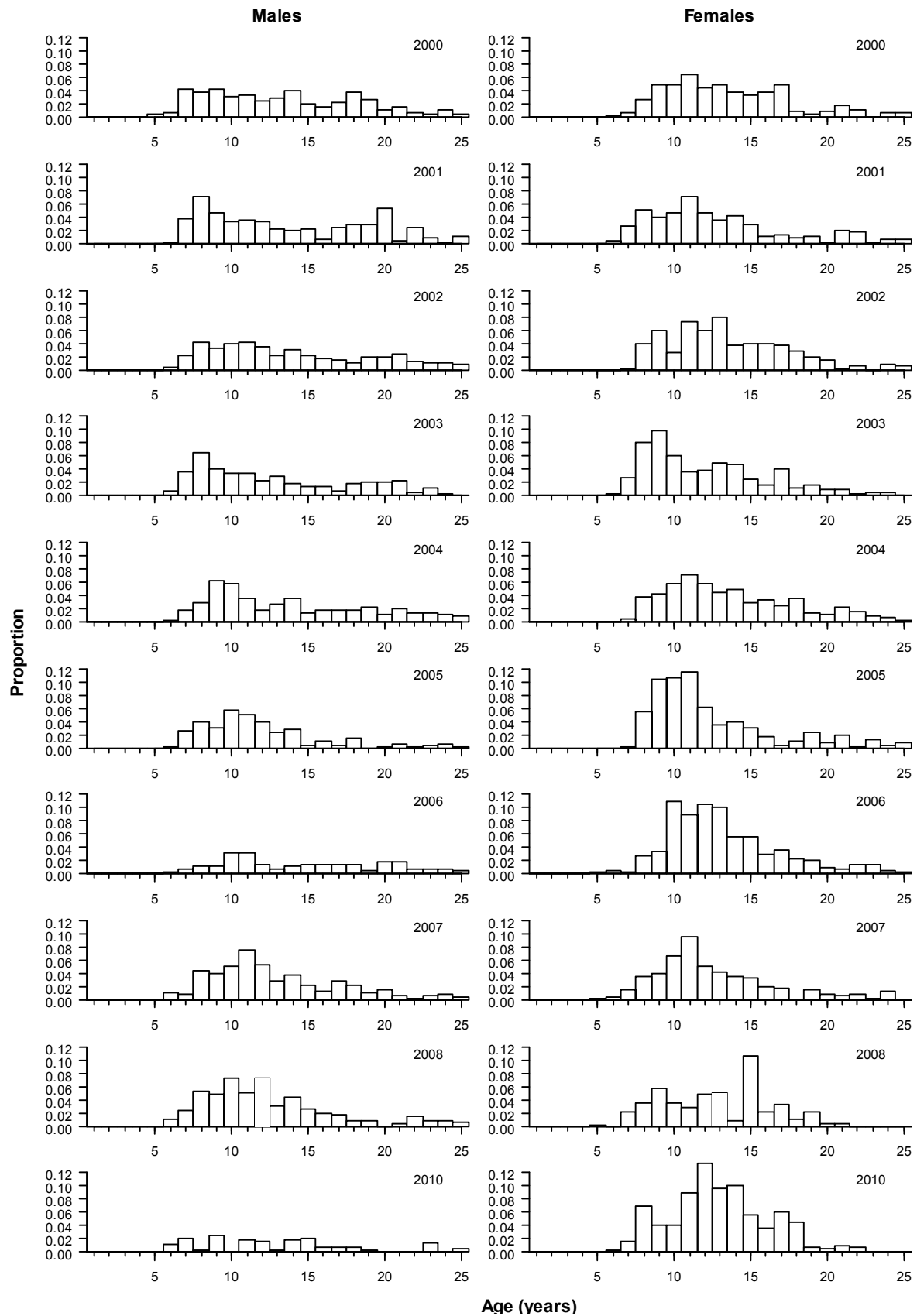


**Figure A8: Age frequency distributions of hake (ages 1 to 25) from resource surveys off WCSI, from 2000 to 2014.**

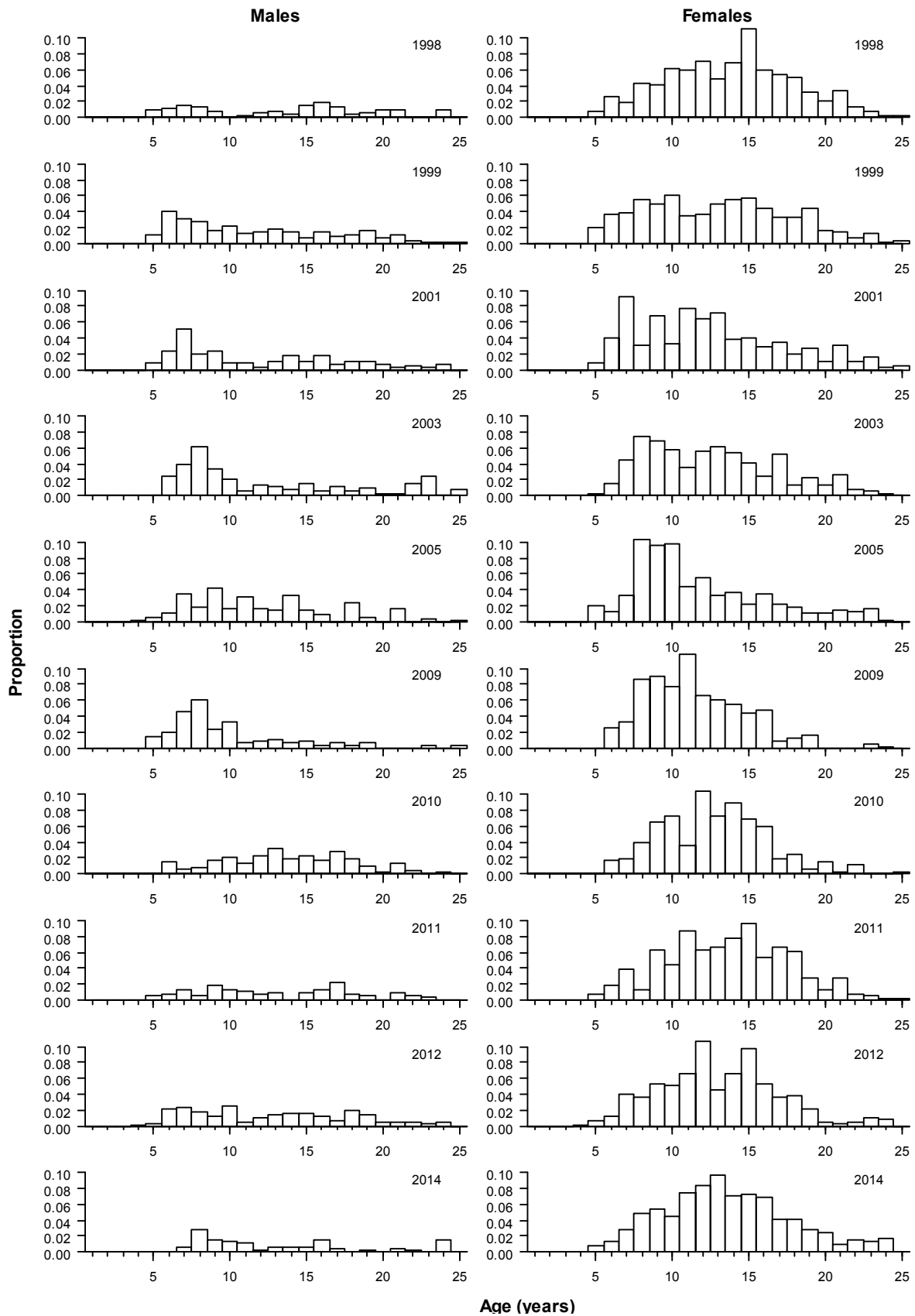
## Appendix B: Summaries of the proportions-at-age data for ling



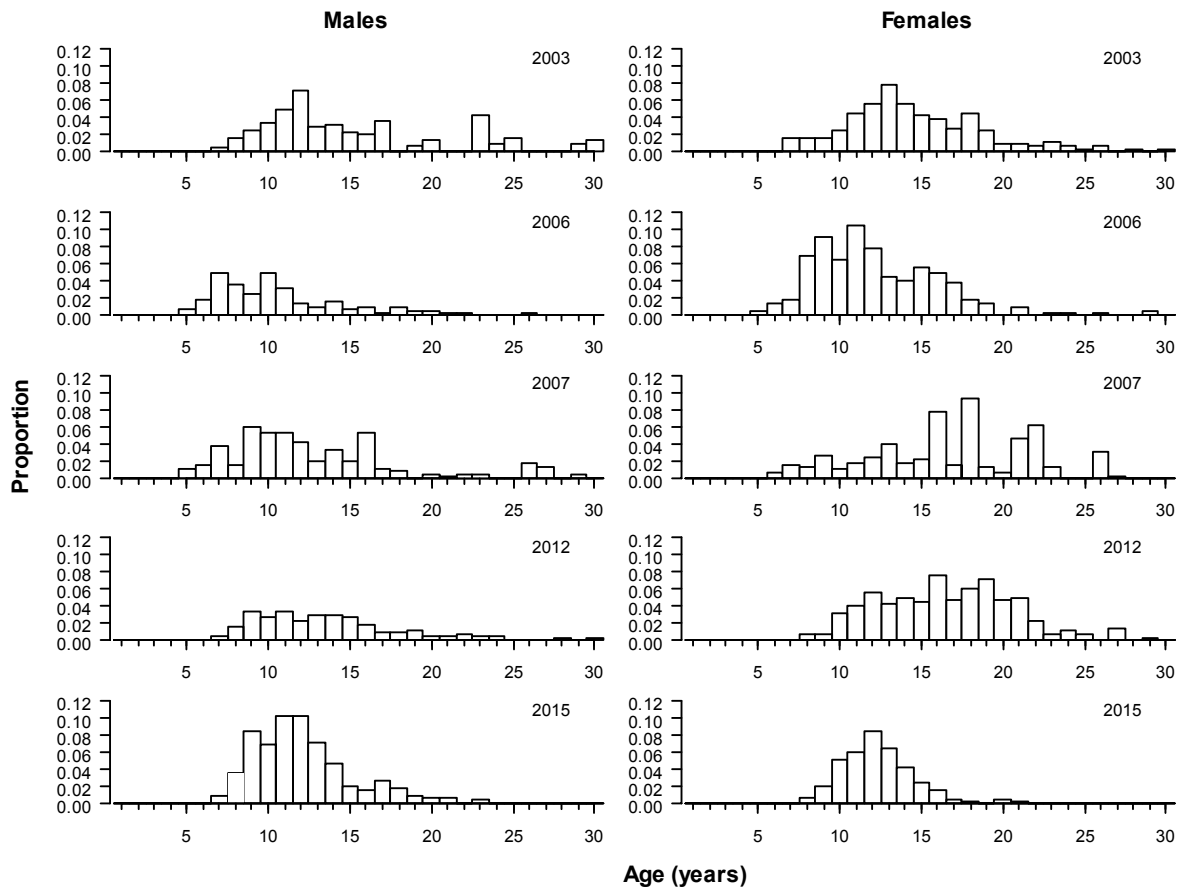
**Figure B1: Age frequency distributions of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2015.**



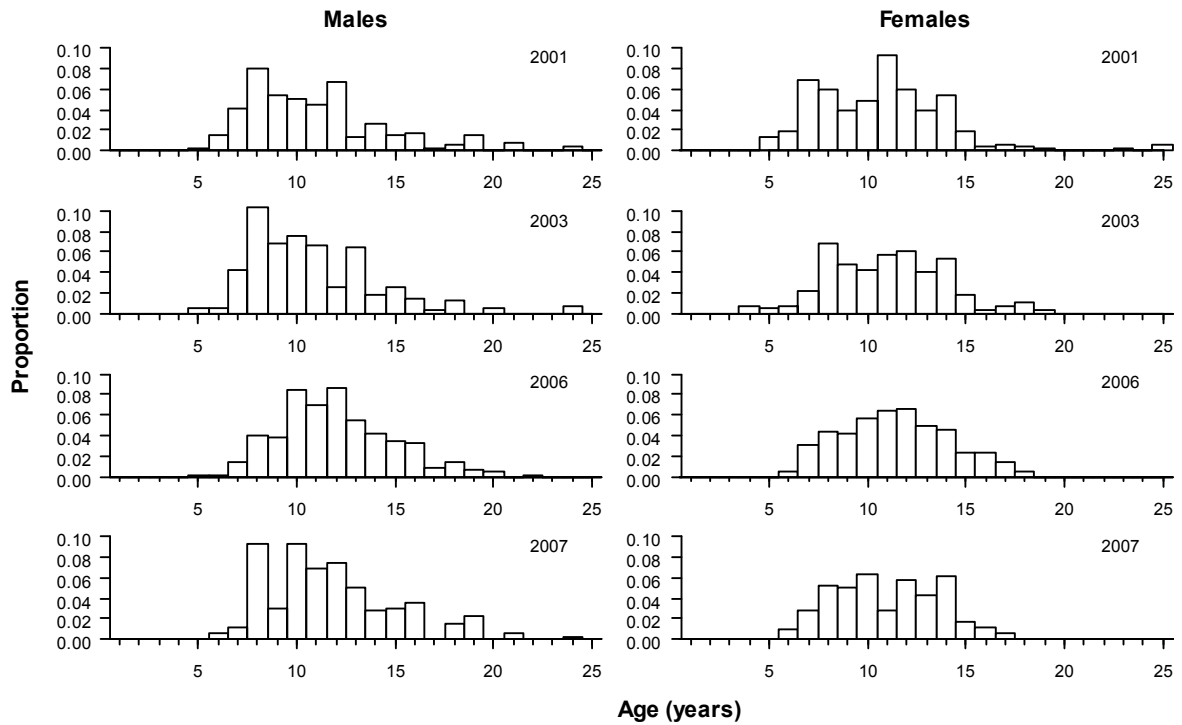
**Figure B2: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2015.**



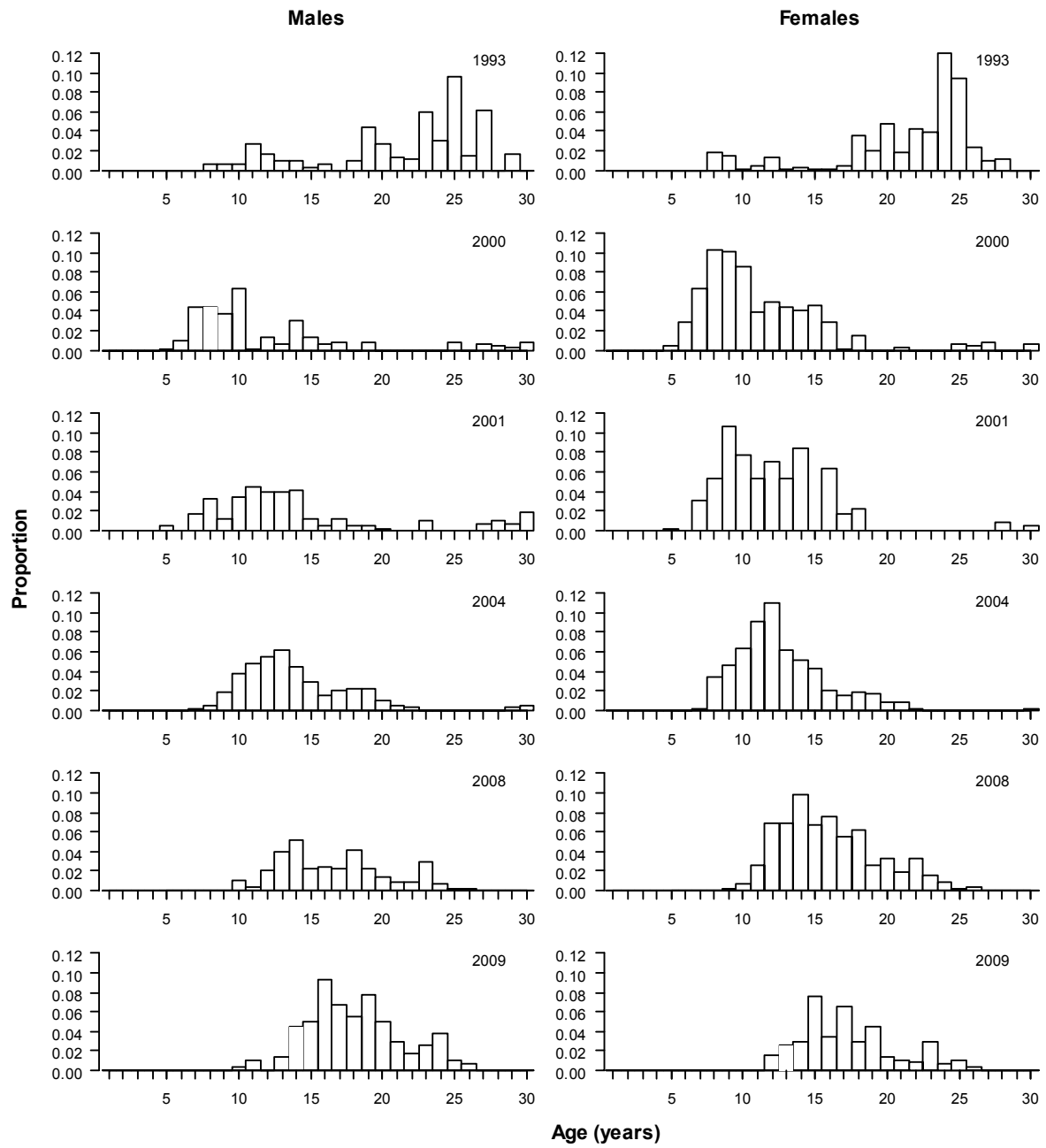
**Figure B3: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2015.**



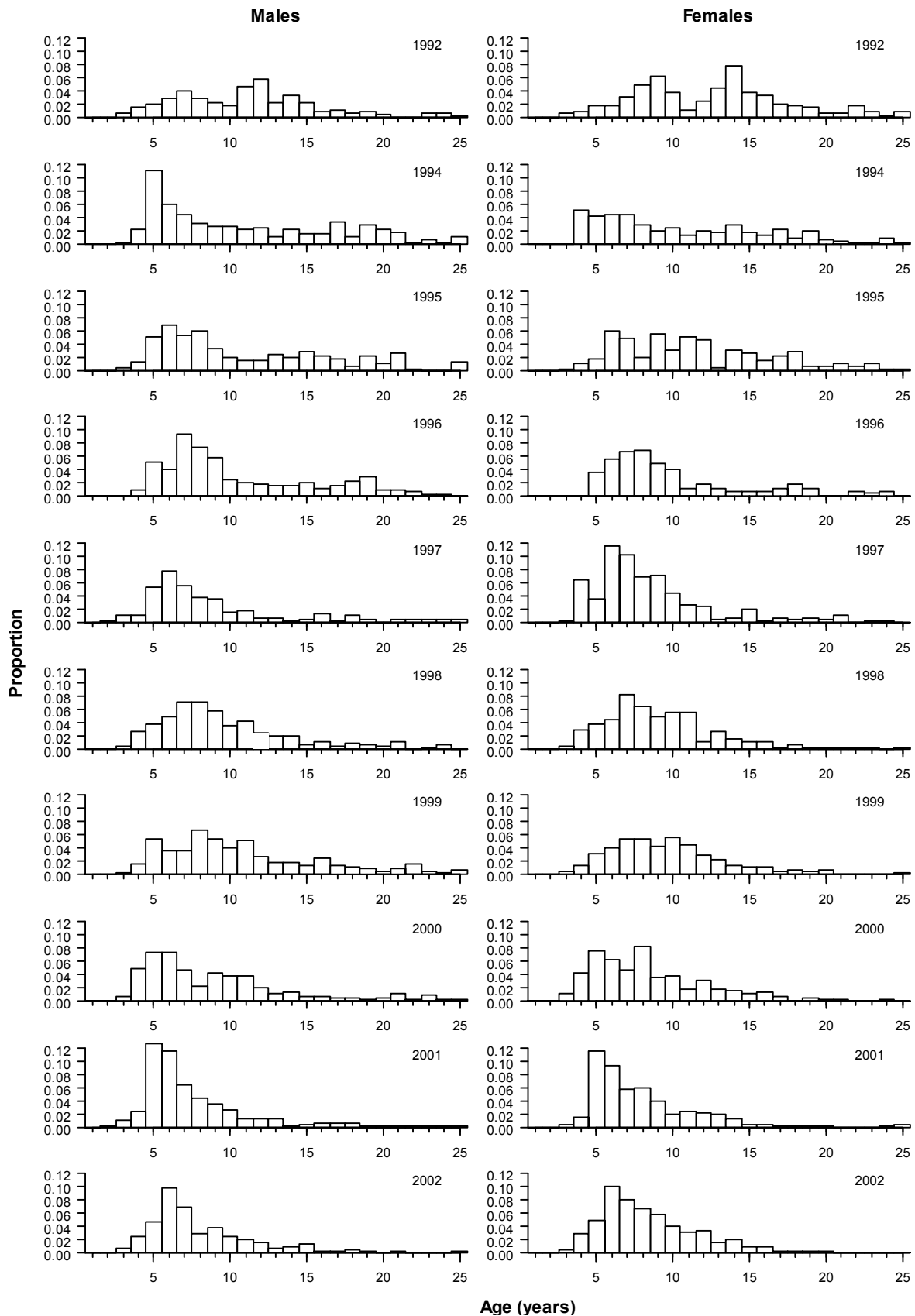
**Figure B4: Age frequency distributions of ling from commercial catch-at-age data in the west coast South Island line fishery, 2003 to 2015.**



**Figure B5: Age frequency distributions of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2001 to 2015.**



**Figure B6: Age frequency distributions of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2015.**



**Figure B7: Age frequency distributions of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2015. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–May 2002 sample.**



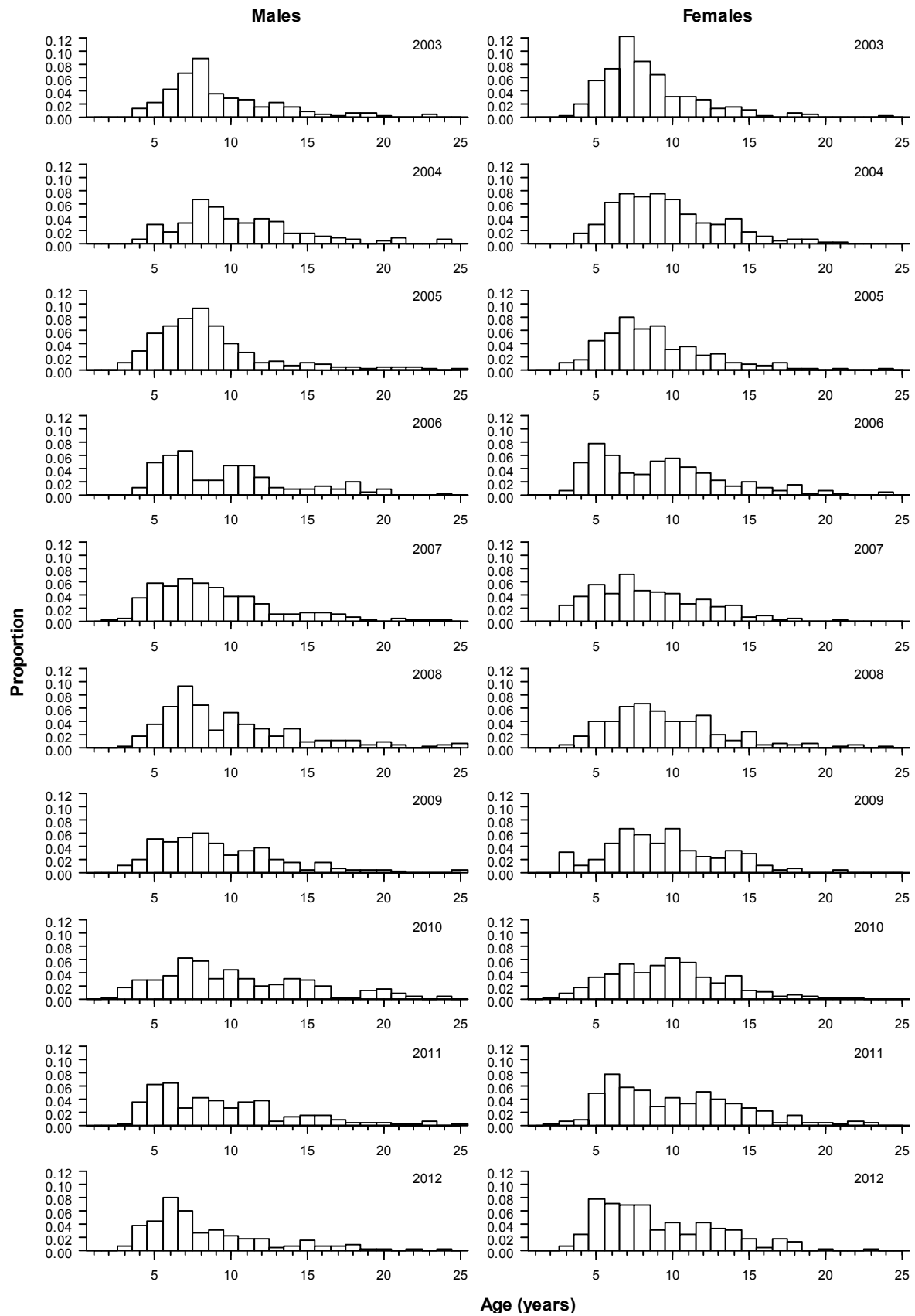


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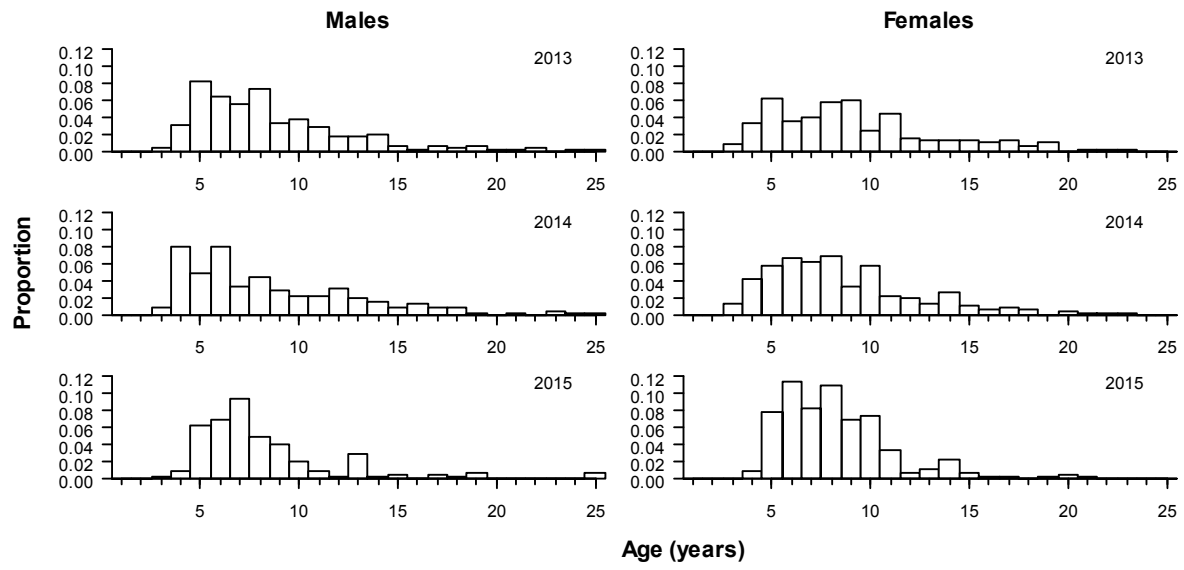
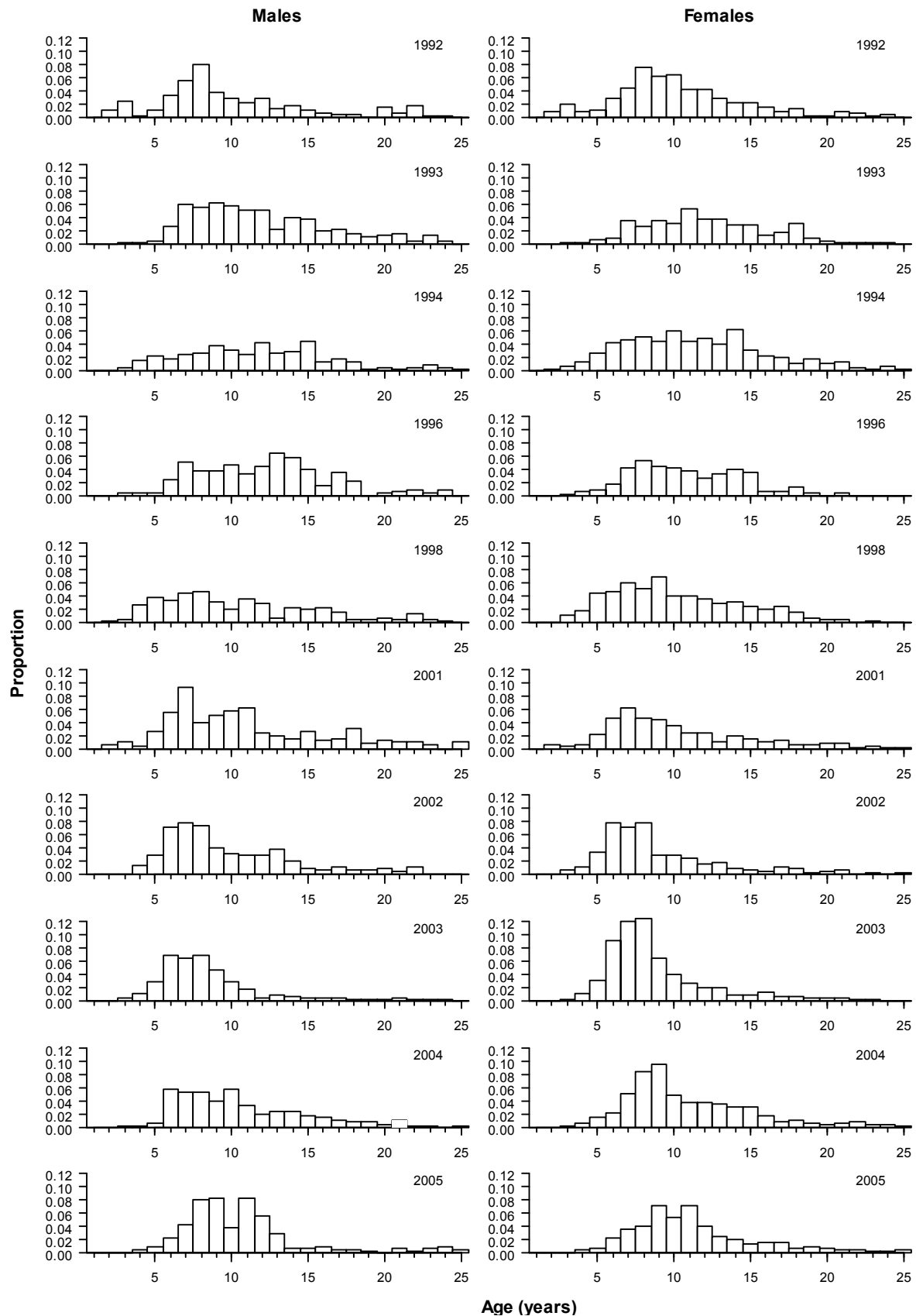


Figure B7 ctd.



**Figure B8: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2015. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2005” denotes the September 2004–April 2005 sample.**

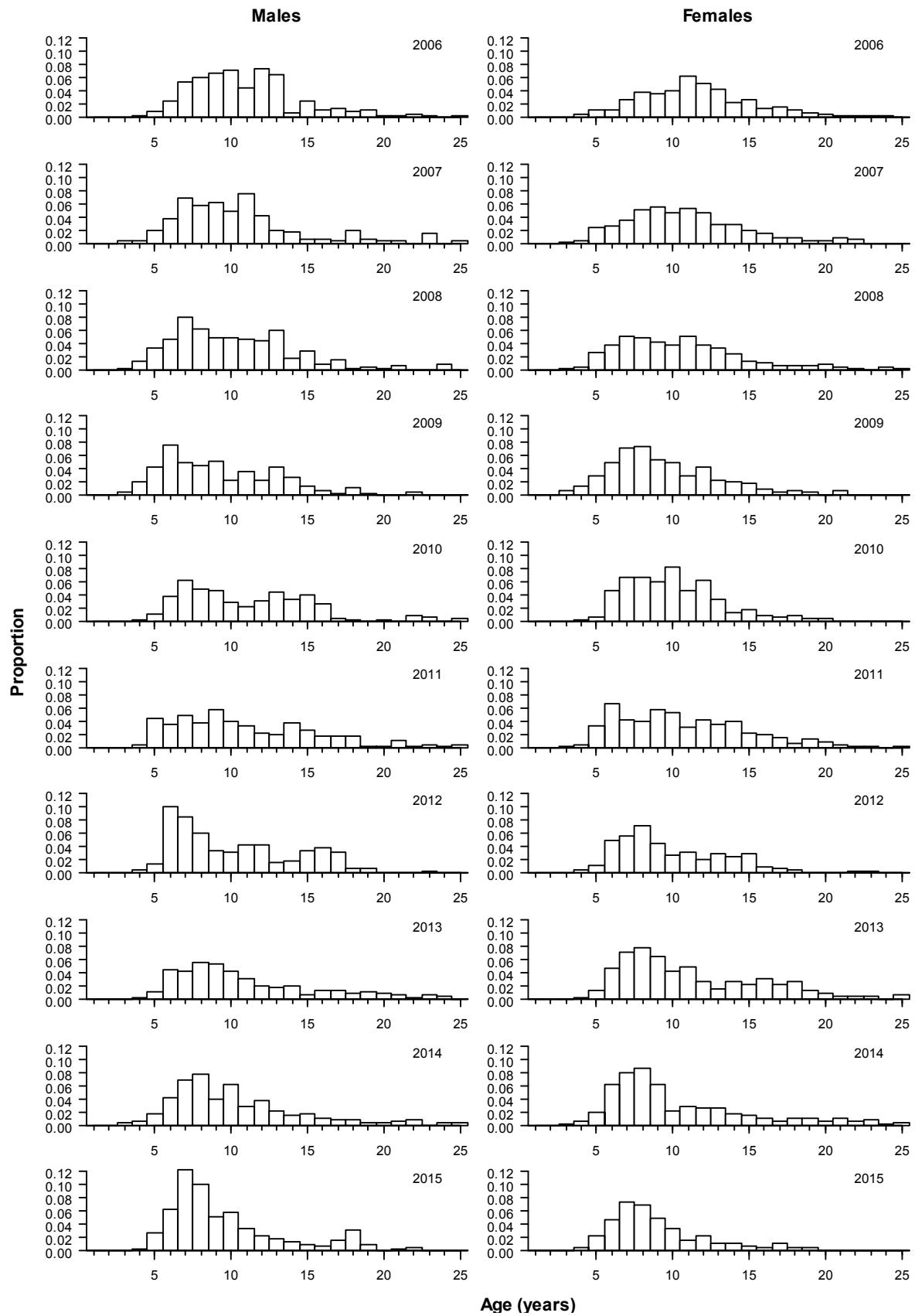
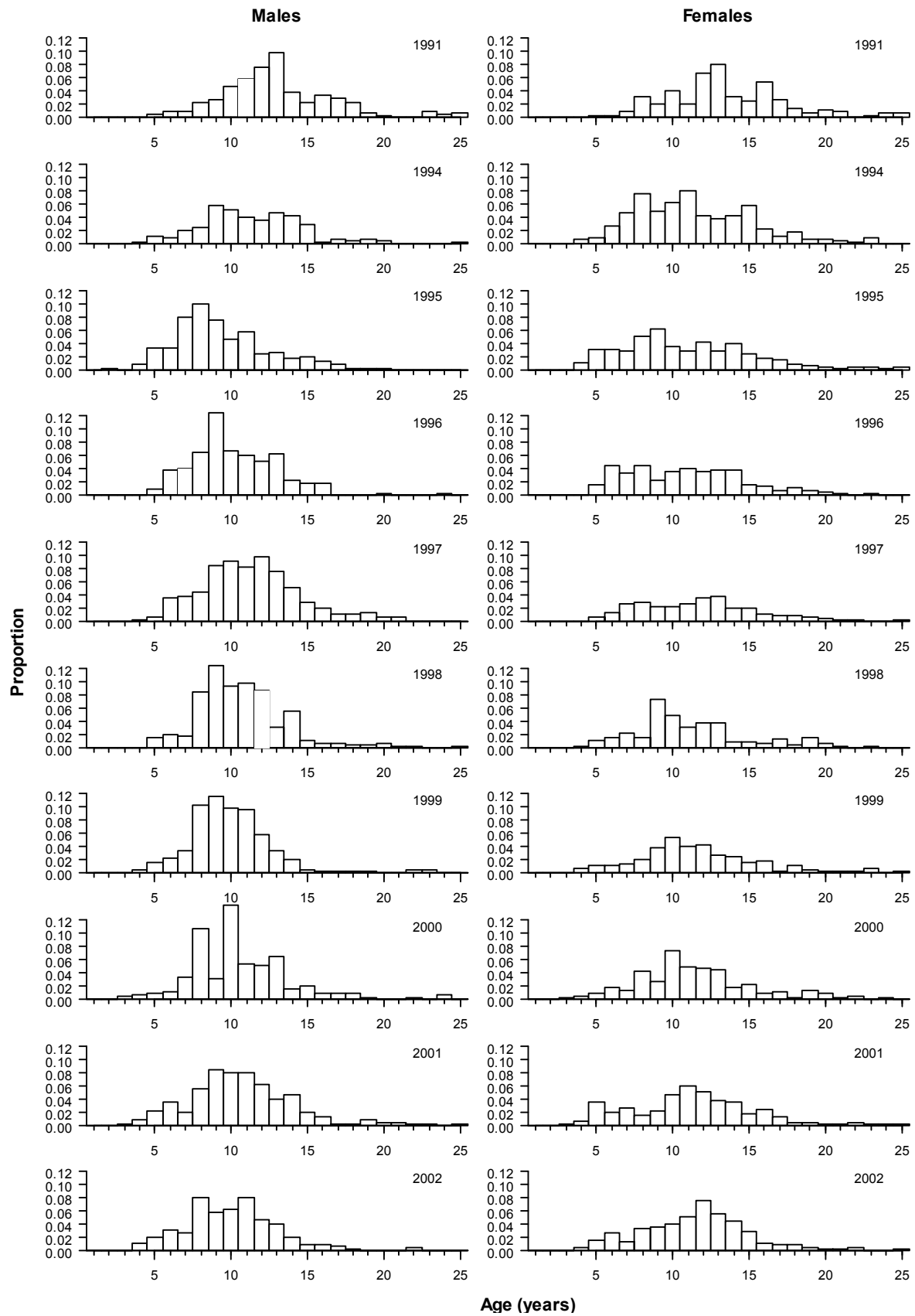


Figure B8 ctd.



**Figure B9: Age frequency distributions of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2015.**

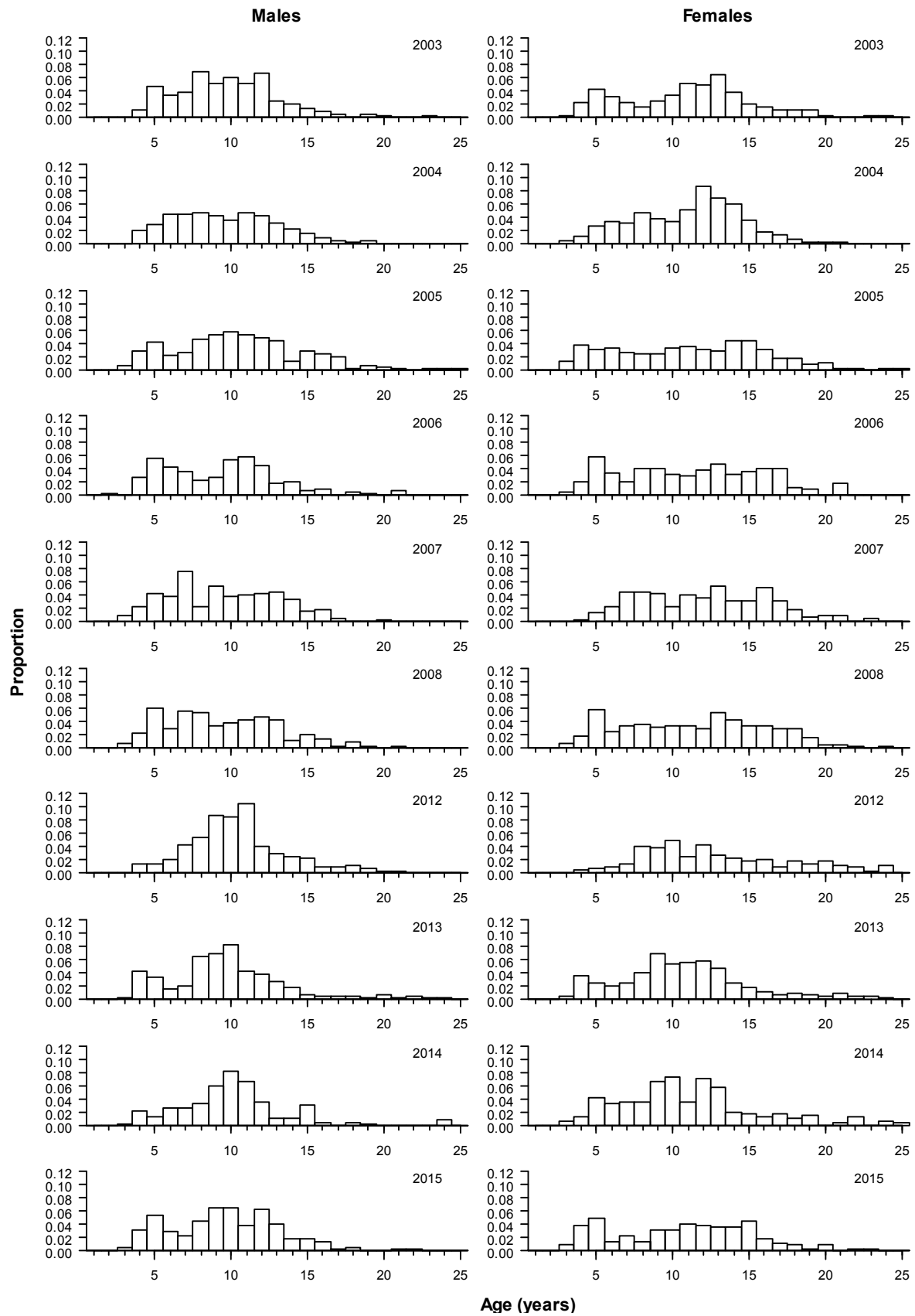
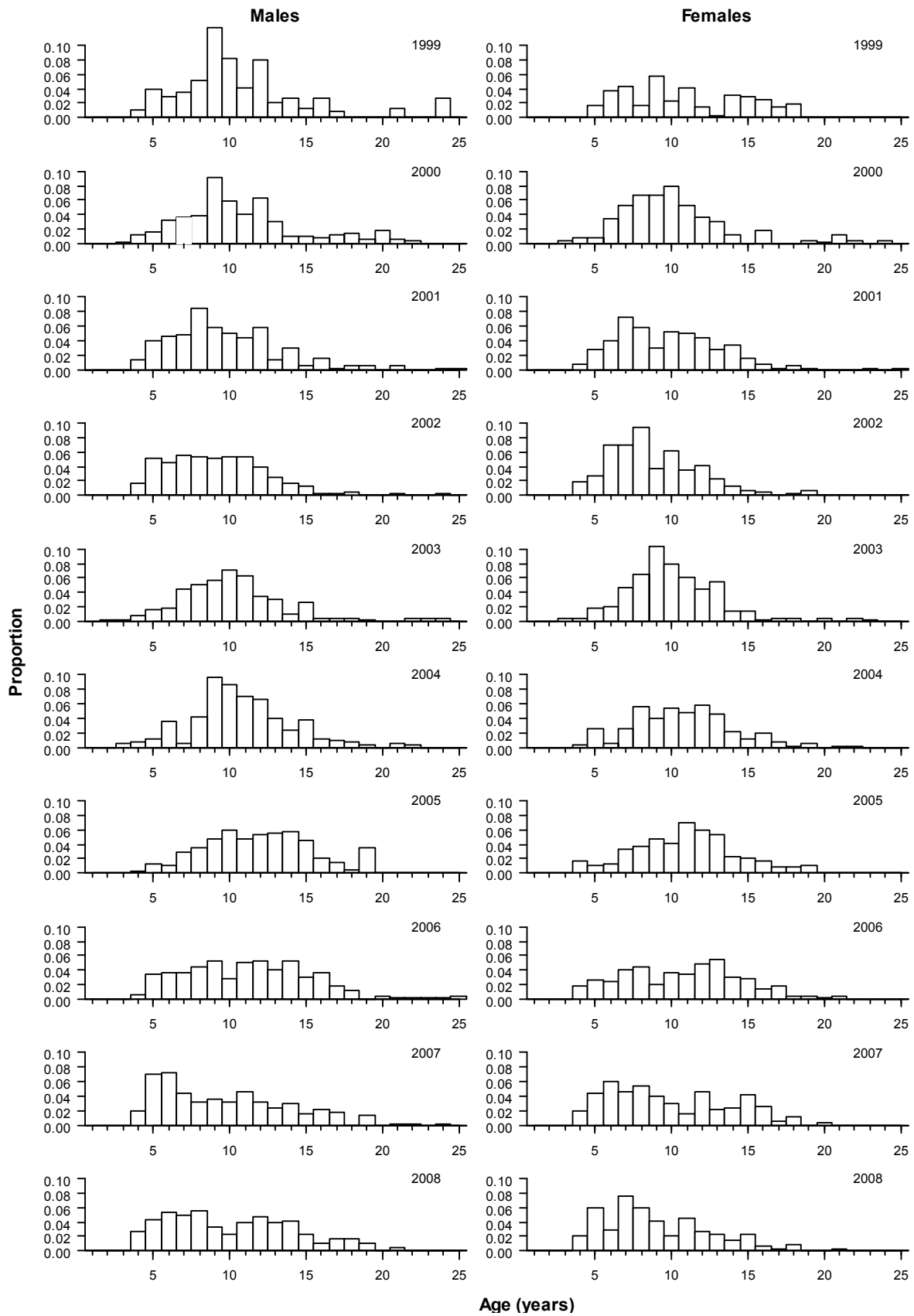


Figure B9 ctd.



**Figure B10: Age frequency distributions of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2015.**

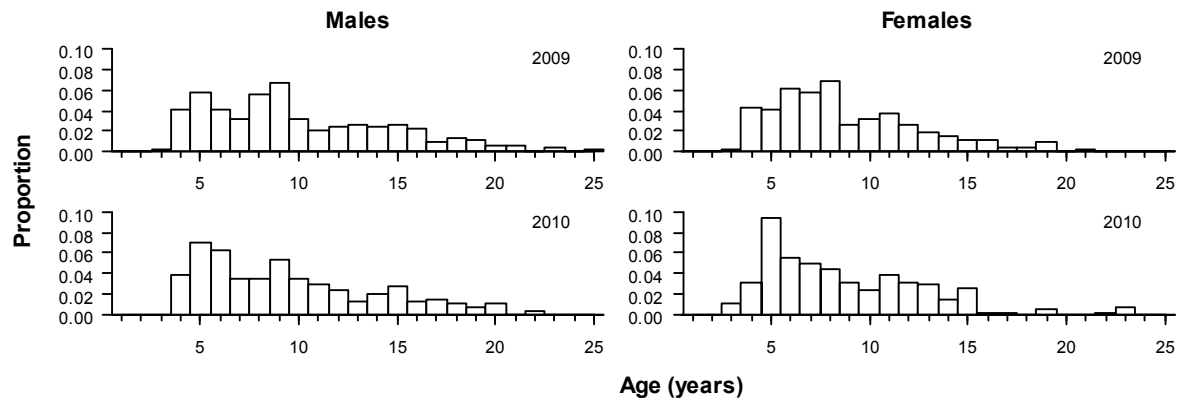
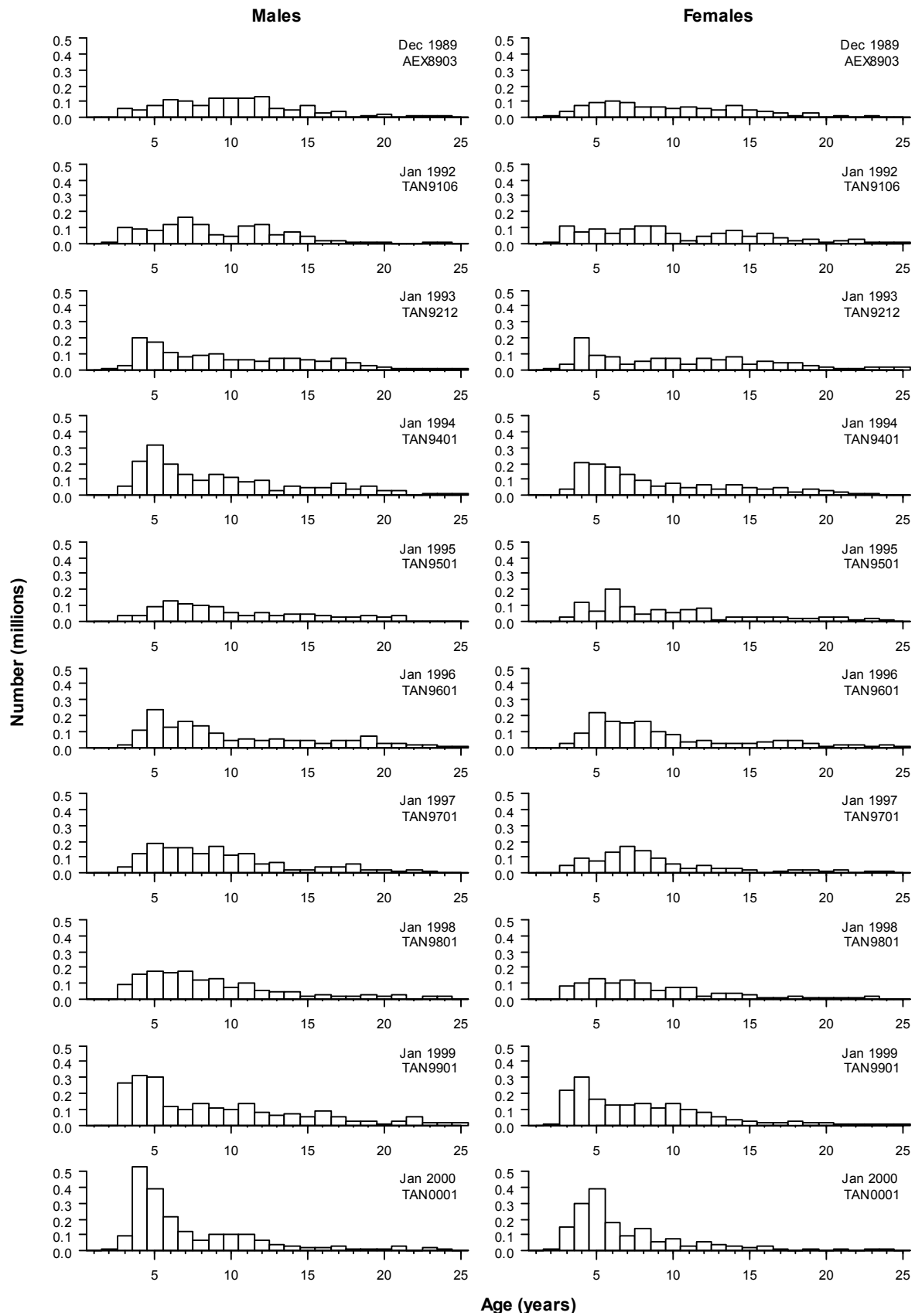


Figure B10 ctd.





**Figure B11: Age frequency distributions of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2015–16.**

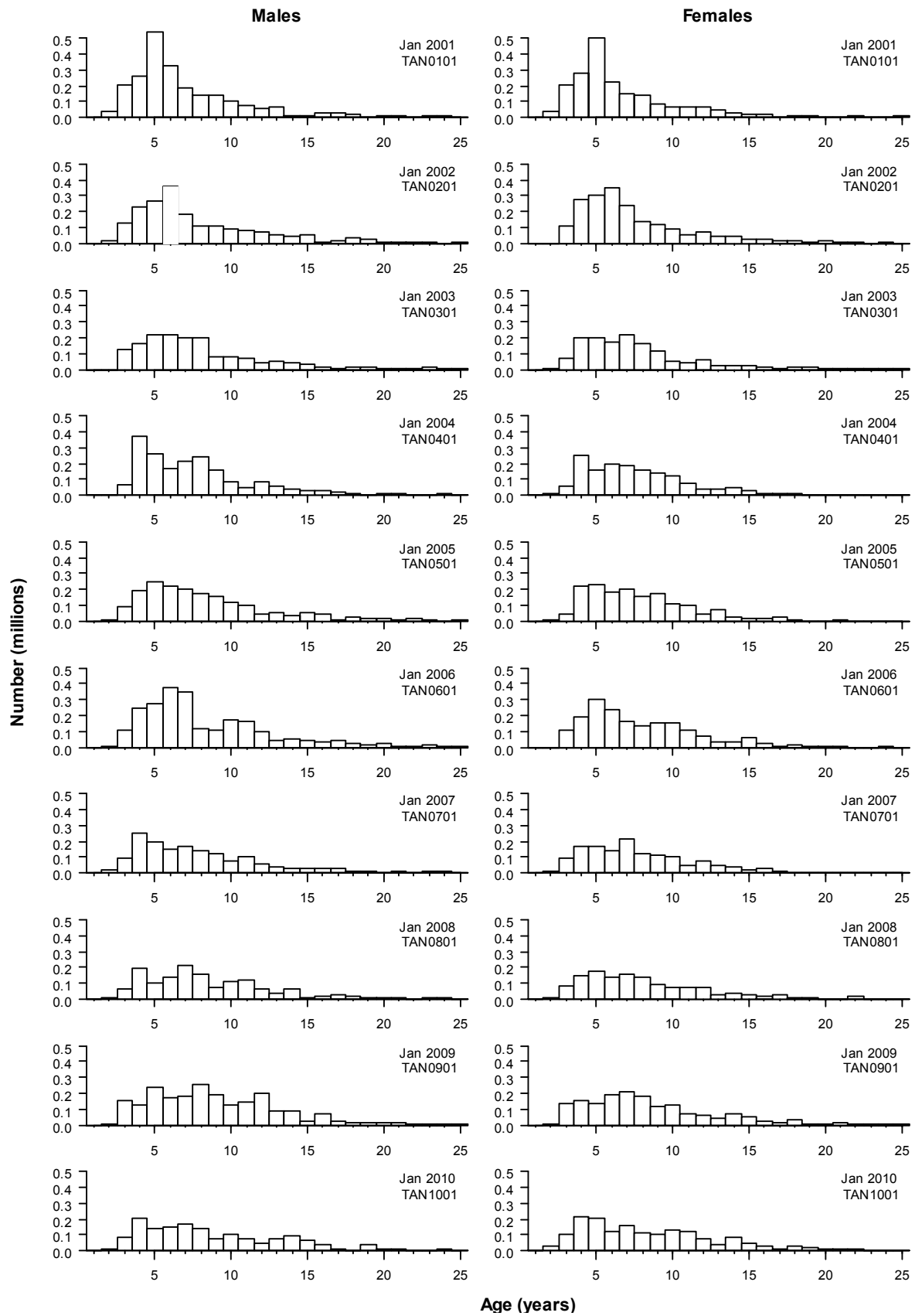


Figure B11 ctd.

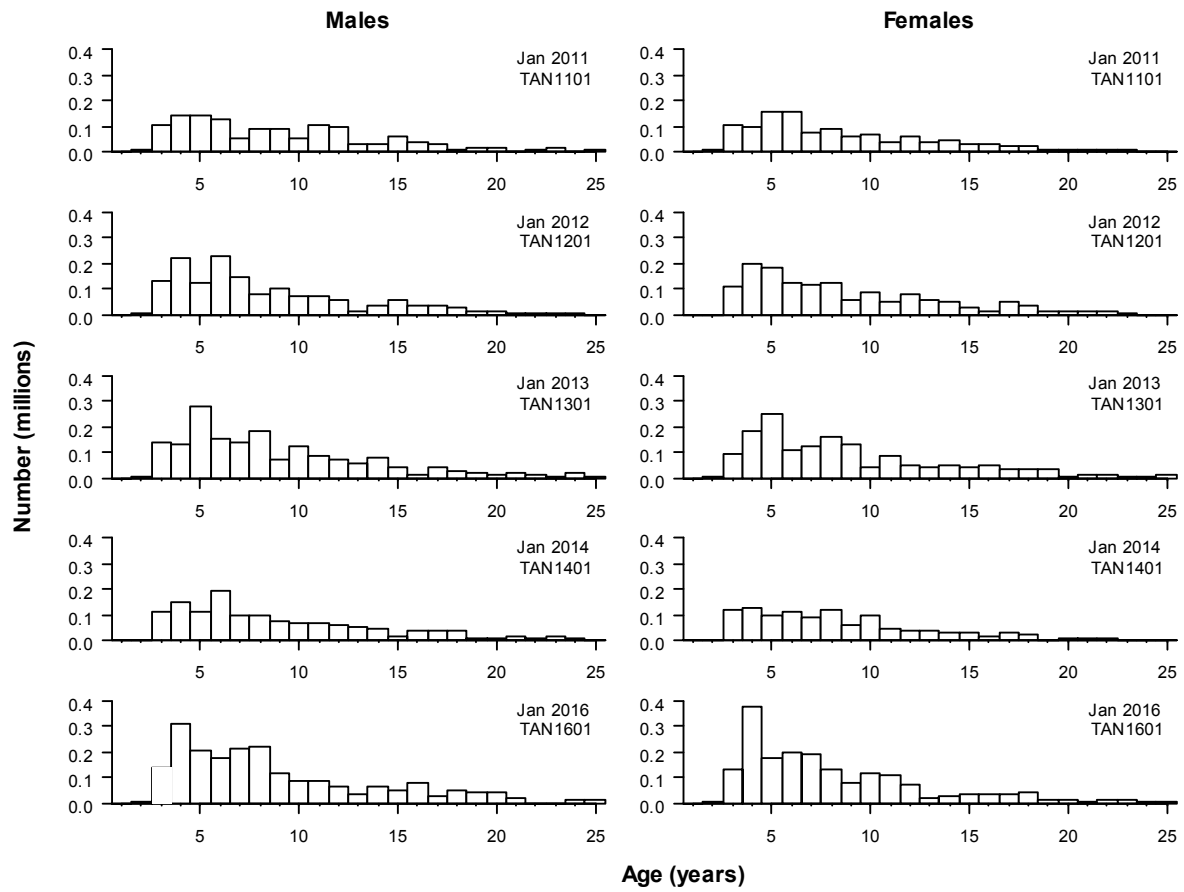


Figure B11 ctd.

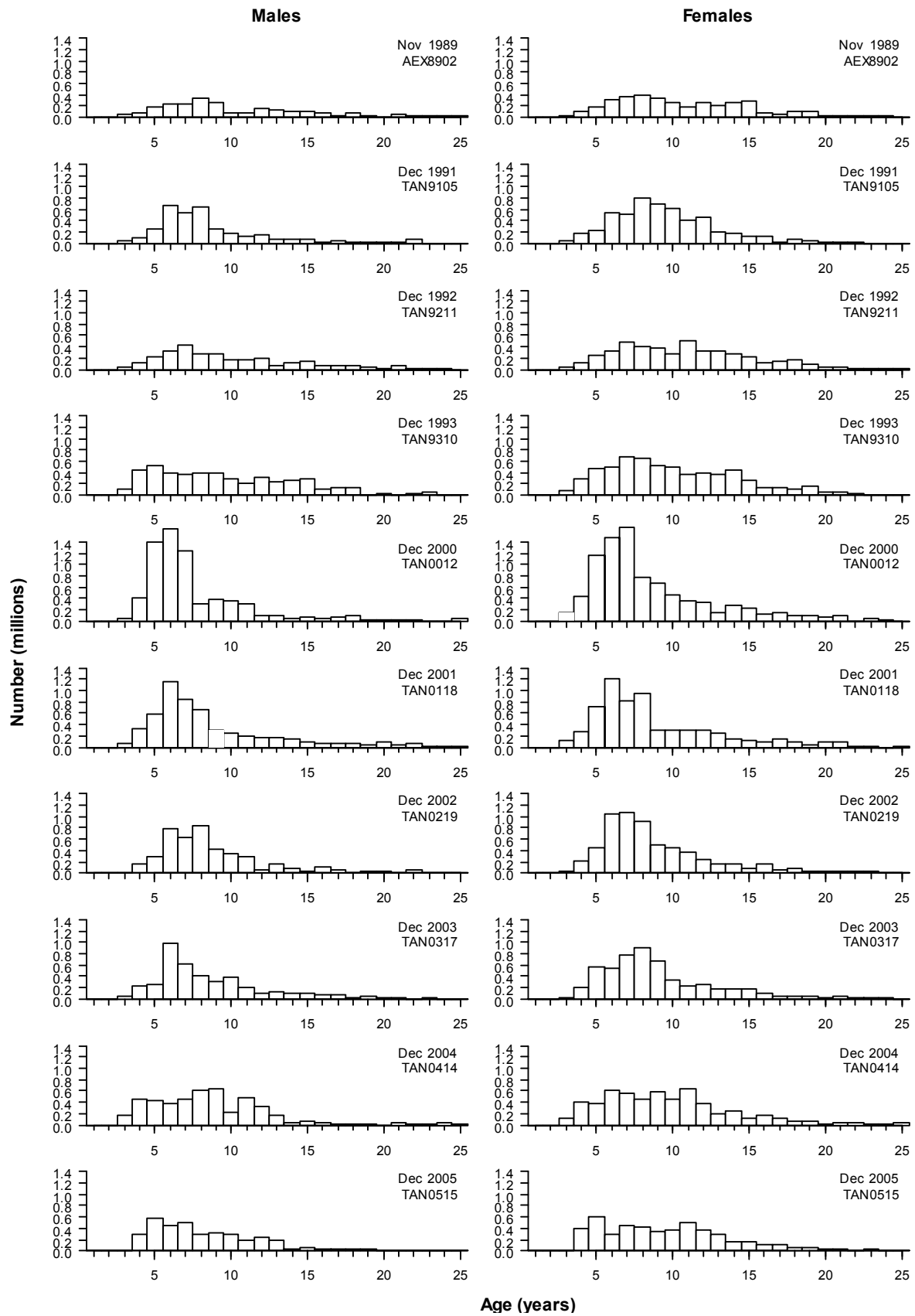


Figure B12: Age frequency distributions of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2015.

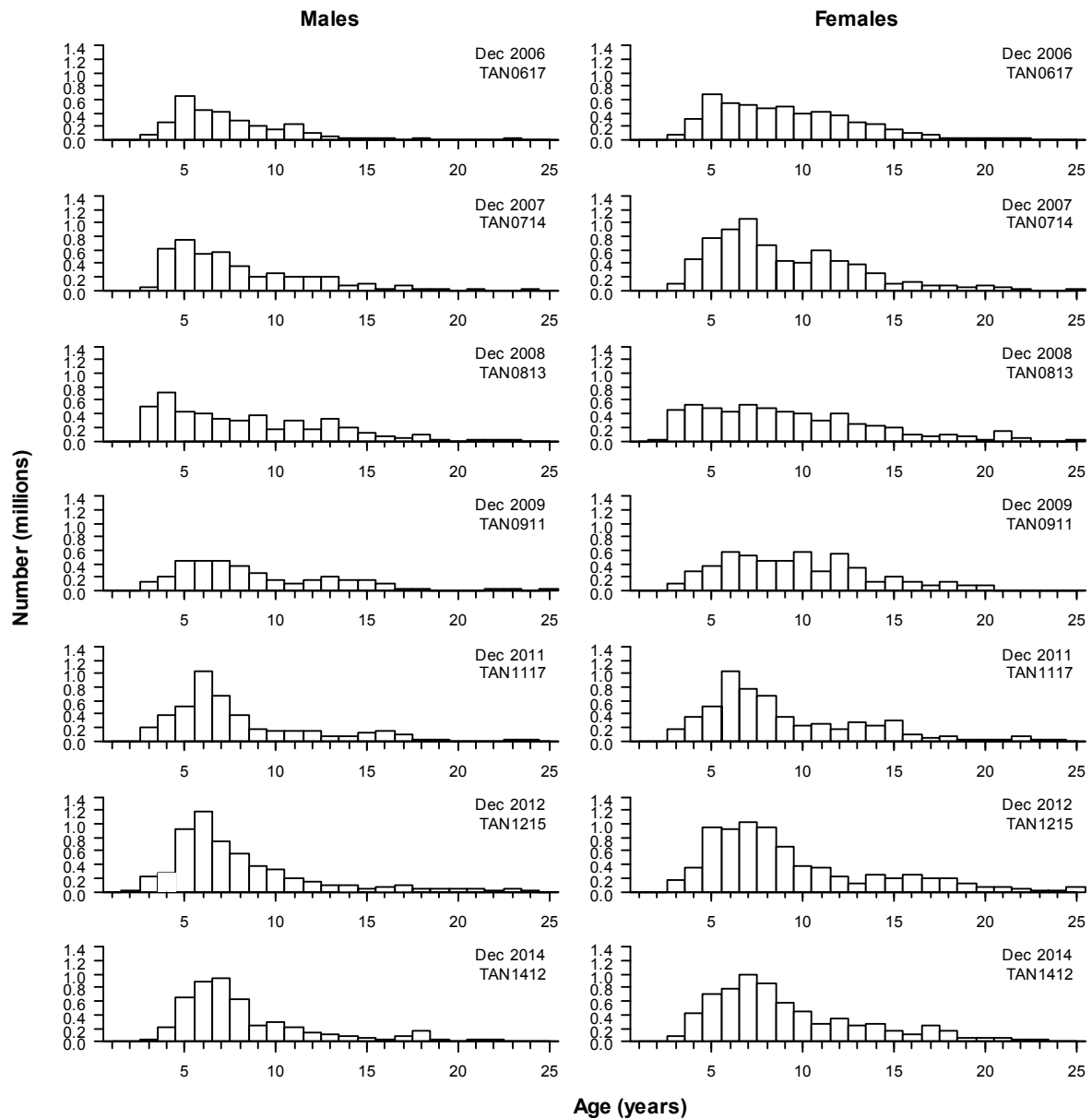


Figure B12 ctd.

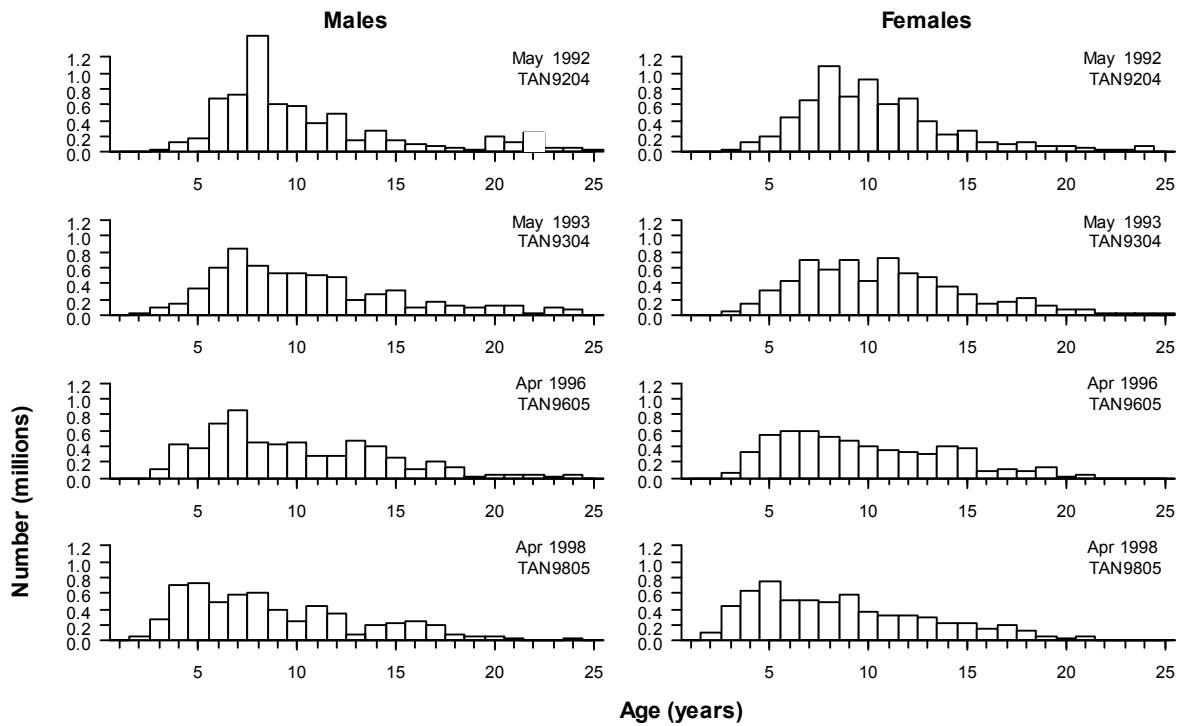


Figure B13: Age frequency distributions of ling (ages 1 to 25) from autumn resource surveys in the Sub-Antarctic, 1992 to 1998.

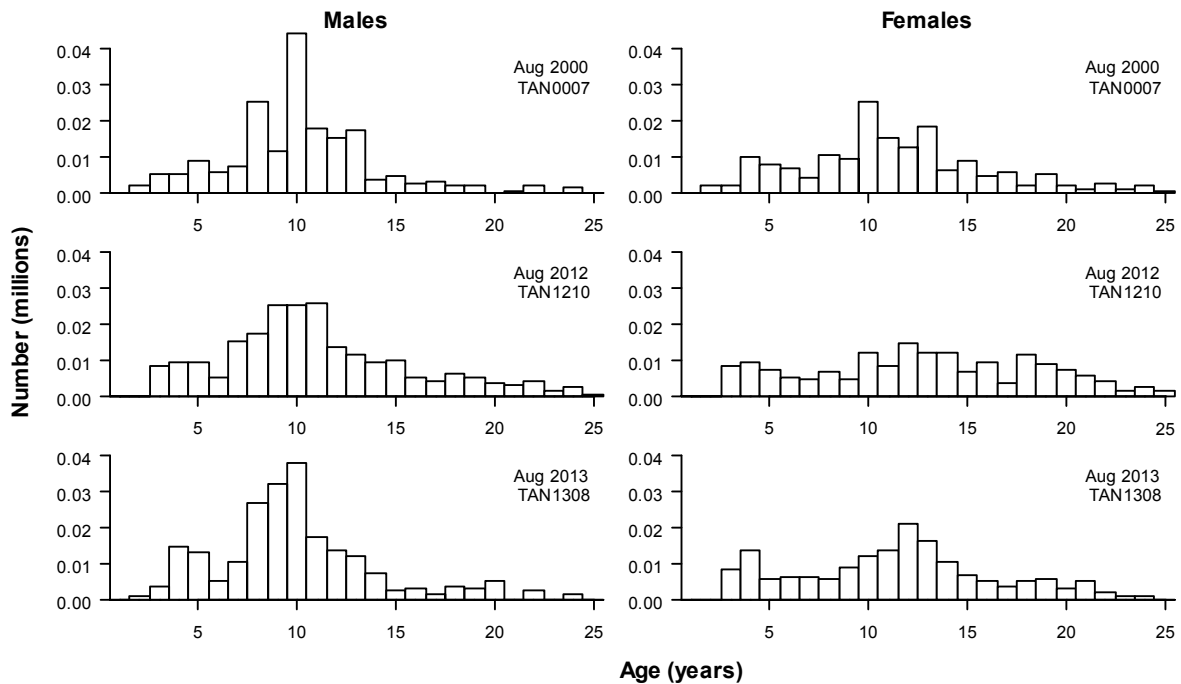


Figure B14: Age frequency distributions of ling (ages 1 to 25) from winter resource surveys off WCSI, 2000 to 2013.