



Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2012–13 fishing year and from trawl surveys in 2013–14, 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. (2014). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2012–13 fishing year and from trawl surveys in 2013–14, 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 2012–13 fishing year (using data and otoliths collected at sea by observers), and from trawl surveys of hoki and middle depth species off the west coast South Island in August 2013 (TAN1308) and on the Chatham Rise in January 2014 (TAN1401). The target coefficient of variation (CV) for each estimated catch-at-age distribution from the observer samples and the two trawl surveys was 30% (mean weighted CV across all age classes).

For hake, the target CV was met for the two commercial fishery samples (west coast South Island, and Sub-Antarctic), but was not met for the two trawl surveys. There were insufficient data to estimate catch-at-age for the Chatham Rise commercial trawl fishery. Age distribution results suggest that strong year classes were spawned on the Chatham Rise in 1990–91 and 2001–02.

For ling, the target CV was met for the commercial trawl samples from Chatham Rise, west coast South Island, and the Sub-Antarctic, and the two trawl surveys. There were insufficient data collected to estimate catch-at-age for the 2013 Cook Strait commercial trawl fishery. Catch-at-age was also produced for the Chatham Rise ling longline fishery in 2012–13 (and the target CV was met). No samples from other longline fisheries were available.

It was not possible to improve the age distribution precision for both species by increasing the sample size, where the target CV was not met, because all available data and otoliths were used in the analyses. If observer coverage of the deepwater fleet increases, catch-at-age should be available from all the New Zealand fisheries each year. It would also 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. The areas and months for each fishery are listed in this document and summaries of all previous catch-at-age distributions made for hake and ling from trawl surveys and commercial fisheries are also provided.

1. INTRODUCTION

The work presented here aimed to determine catch-at-age from the main fisheries for hake and ling in the 2012–13 fishing year, and for hake and ling from trawl surveys conducted during 2013–14. 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 Objectives 3, 4, and 7 (part) of Project MID201001D “Routine age determination of hoki and middle depth species from commercial fisheries and trawl surveys”, funded by the Ministry for Primary Industries. Those objectives are:

3. To determine the catch-at-age from hake fisheries in HAK 1, 4 and 7 from samples collected at sea by the Observer Programme.
4. To determine the catch-at-age from ling fisheries in LIN 3 & 4, 5 & 6 and 7 from samples collected at sea by the Observer Programme, and from other sources.
7. To determine the age and size structure of hoki, hake, ling and jack mackerel from the trawl surveys.

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 number of aged otoliths in square brackets):

HAK 1 — commercial trawl fishery, Sep 2012–May 2013 [600].

HAK 4 — trawl survey, Jan 2014 (project HOK2010-02) [600].

HAK 4 — commercial trawl fishery, Oct 2012–April 2013 [600].

HAK 7 — trawl survey, Aug 2013 (project HOK2010-04) [600].

Only 325 hake were sampled by observers on the Chatham Rise (HAK 4), so a catch-at-age distribution was not able to be produced for that trawl fishery.

An additional commercial fishery catch-at-age distribution for HAK 7 was estimated using the age-length key derived previously from the August 2013 west coast South Island trawl survey plus age data from 138 observer-collected otoliths to better represent hake sizes that were under-sampled by the survey.

HAK 7 — commercial trawl fishery, Jun–Sep 2013.

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

LIN 3&4 — trawl survey, Jan 2014 (project HOK2010-02) [640].

LIN 3&4 — commercial longline fishery, Jun–Oct 2013 [580].

LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2012 [500].

LIN 5&6 — commercial longline fishery, non-spawning, Campbell, Feb–Jul 2013 [500].

LIN 6B — commercial longline fishery, Nov 2012–March 2013 [500].

LIN 7 — trawl survey, Aug 2013 (project HOK2010-04) [600].

LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2013 [500].

No observer otoliths were available from the ling longline fisheries in the Sub-Antarctic (LIN 5&6) or Bounty Plateau (LIN 6B). Also, only 3 ling were sampled by observers from the winter 2013 Cook Strait trawl fishery (LIN 7&2), so a catch-at-age distribution was not able to be produced for those fisheries.

The following additional commercial fishery catch-at-age distributions for ling were estimated using age-length keys derived previously from the January 2013 Chatham Rise trawl survey (LIN 3&4) and the August 2013 WCSI trawl survey (LIN 7). The LIN 7 age-length key included 146 additional age data from observer-collected otoliths to better represent ling sizes that were under-sampled by the survey.

LIN 3&4 — commercial trawl fishery, Oct 2012–May 2013.

LIN 7 — commercial trawl fishery, Jun–Sep 2013.

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 total length frequency was applied to the age-length key. 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 have 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 ≤ 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° W \leq longitude $\leq 179.5^\circ$ W, 42° 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° 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.

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.

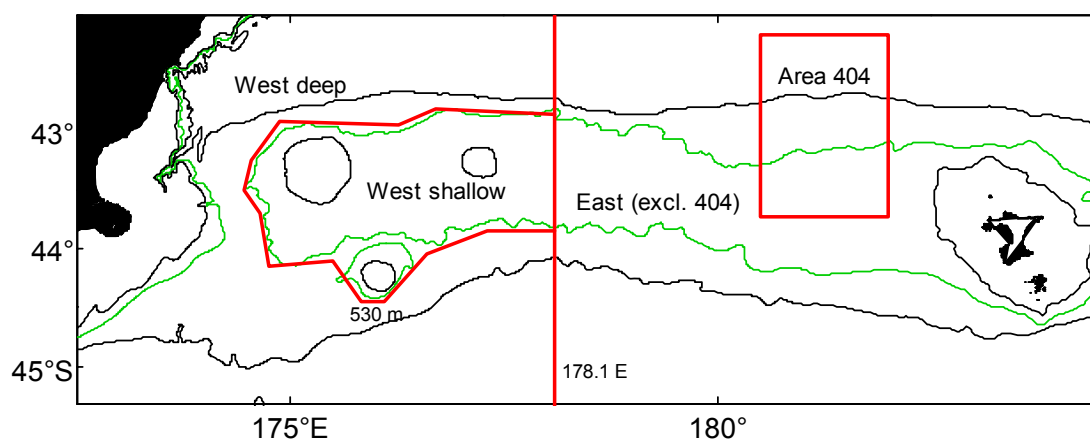


Figure 1: Strata defined for the Chatham Rise hake fishery. The stratum boundary defined by depth (530 m) is shown only approximately. Isobaths at 1000, 500, and 250 m are also shown.

Observer data from each fishery were converted into catch-at-age distributions if there were at least 400 length measurements (west fishery) or 300 length measurements (east fishery). Table 1 summarises the quantities of useful data. In the 2012–13 fishing year, insufficient length data ($n = 148$ from west and 177 from east) and otoliths were available to calculate a catch-at-age distribution for either of the fisheries.

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 (Mal) and female (Fem) hake contributing to samples of proportion-at-age from the two commercial trawl fisheries on the Chatham Rise. The number of tows sampled by observers and the estimated mean weighted CV (%) by age are also listed.

| Fishing year | Measured | | | | | | | | Aged | |
|--------------|----------|-------|------|------|-------|-----|------|------|------|-----|
| | West | | | | East | | | | Mal | Fem |
| | Mal | Fem | Tows | CV | Mal | Fem | Tows | CV | | |
| 1991–92 | 2 112 | 2 636 | 163 | 21.9 | 170 | 247 | 25 | 43.2 | 233 | 230 |
| 1992–93 | | | | | | | | | 0 | 0 |
| 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 |

3.1.2 Sub-Antarctic

There is 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, 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° S and east of 171.6°).
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 2 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 2012–13 fishing year are in Table 3. The mean weighted CV of 20% 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).

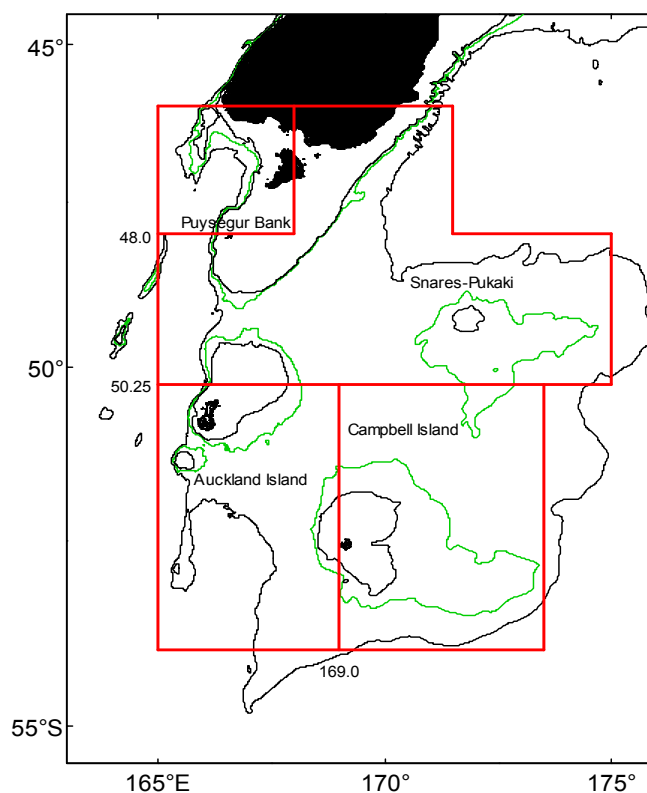


Figure 2: Fishery strata defined for the Sub-Antarctic hake fishery. Numbers show latitudes and longitudes of fishery boundaries. Isobaths at 1000, 500, and 250 m are also shown.

Table 2: 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 |

Table 3: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations in the Sub-Antarctic during September 2012–May 2013. Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|--------|-------|--------|-------|
| 3 | 8 | 1.200 | 17 | 0.936 |
| 4 | 317 | 0.687 | 455 | 0.395 |
| 5 | 2 568 | 0.314 | 574 | 0.377 |
| 6 | 13 564 | 0.196 | 923 | 0.391 |
| 7 | 25 280 | 0.169 | 2 852 | 0.272 |
| 8 | 26 869 | 0.156 | 11 020 | 0.176 |
| 9 | 27 586 | 0.156 | 16 507 | 0.157 |
| 10 | 11 901 | 0.232 | 15 002 | 0.153 |
| 11 | 7 661 | 0.287 | 8 500 | 0.225 |
| 12 | 4 808 | 0.350 | 6 238 | 0.279 |
| 13 | 3 578 | 0.407 | 6 076 | 0.268 |
| 14 | 4 977 | 0.375 | 4 638 | 0.295 |
| 15 | 9 924 | 0.270 | 4 110 | 0.300 |
| 16 | 6 592 | 0.354 | 2 272 | 0.428 |
| 17 | 2 119 | 0.575 | 2 337 | 0.510 |
| 18 | 5 326 | 0.374 | 2 154 | 0.469 |
| 19 | 3 926 | 0.392 | 1 896 | 0.570 |
| 20 | 2 448 | 0.557 | 2 139 | 0.478 |
| 21 | 1 382 | 0.604 | 916 | 0.767 |
| 22 | 491 | 0.977 | 0 | – |
| 23 | 491 | 1.128 | 197 | 1.841 |
| 24 | 801 | 1.091 | 382 | 1.077 |
| 25 | 0 | – | 548 | 0.974 |
| 26 | 0 | – | 0 | – |
| 27 | 564 | 1.077 | 0 | – |
| 28 | 0 | – | 0 | – |
| 29 | 0 | – | 0 | – |
| 30 | 0 | – | 0 | – |
| 31 | 564 | 1.122 | 0 | – |
| Measured males | | | 2 555 | |
| Measured females | | | 1 306 | |
| Aged males | | | 412 | |
| Aged females | | | 666 | |
| No. of tows sampled | | | 100 | |
| Mean weighted CV (sexes pooled) | | | 19.5 | |

3.1.3 West coast South Island (WCSI)

The fishery off WCSI was stratified as follows:

1. Deep (bottom depth ≥ 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 4 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 2012–13 fishing year are in Table 5. The measured sample size was much larger than in all previous years, and the mean weighted CV of 14% was well within the target of 30%. The age-length key used to derive the 2012–13 fishery age distribution included all the age data obtained from the

research survey in July–August 2013, plus 138 additional otoliths, mostly from large fish taken by the commercial fishery. The additional otoliths were chosen to provide age data for hake length classes that did not occur in the survey samples, or were under-represented relative to their abundance in the trawl fishery sample.

All estimated proportion-at-age-distributions from the WCSI trawl fishery are presented in Appendix A (Figure A4). The three year classes that showed up relatively strongly as 2-year-olds in catches from 2005, 2006, and 2007 appear to comprise a high proportion of the catch from 2010 to 2012, particularly for females.

Table 4: 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 |

Table 5: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations off the WCSI during June–September 2013. Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|---------|-------|---------|-------|
| 1 | 13 840 | 0.243 | 9 193 | 0.231 |
| 2 | 2 564 | 0.410 | 4 142 | 0.342 |
| 3 | 3 003 | 0.413 | 1 355 | 0.568 |
| 4 | 26 823 | 0.266 | 1 036 | 0.553 |
| 5 | 169 399 | 0.124 | 26 380 | 0.212 |
| 6 | 220 542 | 0.111 | 79 976 | 0.124 |
| 7 | 136 030 | 0.139 | 108 209 | 0.115 |
| 8 | 89 577 | 0.171 | 96 696 | 0.115 |
| 9 | 35 111 | 0.357 | 41 117 | 0.177 |
| 10 | 12 451 | 0.501 | 27 491 | 0.194 |
| 11 | 6 163 | 0.649 | 10 928 | 0.332 |
| 12 | 8 765 | 0.716 | 3 171 | 0.394 |
| 13 | 3 151 | 0.899 | 4 624 | 0.534 |
| 14 | 17 444 | 0.477 | 8 441 | 0.389 |
| 15 | 14 513 | 0.658 | 2 983 | 0.535 |
| 16 | 4 023 | 0.765 | 6 770 | 0.531 |
| 17 | 373 | 1.049 | 1 225 | 0.883 |
| 18 | 5 454 | 0.710 | 548 | 0.978 |
| 19 | 0 | – | 354 | 0.875 |
| 20 | 0 | – | 0 | – |
| 21 | 0 | – | 335 | 1.075 |
| Measured males | | | 12 352 | |
| Measured females | | | 8 417 | |
| Aged males | | | 325 | |
| Aged females | | | 443 | |
| No. of tows sampled | | | 493 | |
| Mean weighted CV (sexes pooled) | | | 14.3 | |

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 6 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 hake caught in the January 2014 trawl survey are given in Table 7. The mean weighted CV of 55% did not meet the target of 30%. This value cannot be improved as all available length data and otoliths were used in the analysis. The 30% target was met in only one of the 20 surveys (TAN9106, see Table 6).

All estimated proportion-at-age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A5). It 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 6: 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 |

Table 7: 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 2014 (TAN1401). Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|--------|-------|--------|-------|
| 2 | 2 196 | 3.272 | 6 744 | 1.618 |
| 3 | 11 941 | 0.902 | 9 965 | 0.835 |
| 4 | 15 471 | 0.484 | 13 876 | 0.615 |
| 5 | 1 646 | 1.796 | 23 180 | 0.502 |
| 6 | 3 554 | 1.068 | 5 636 | 0.828 |
| 7 | 11 504 | 0.637 | 16 891 | 0.529 |
| 8 | 11 226 | 0.517 | 22 087 | 0.443 |
| 9 | 6 787 | 0.793 | 23 247 | 0.546 |
| 10 | 11 375 | 0.633 | 38 300 | 0.387 |
| 11 | 595 | 1.799 | 12 379 | 0.778 |
| 12 | 8 289 | 0.816 | 5 474 | 1.103 |
| 13 | 0 | – | 11 172 | 0.851 |
| 14 | 4 010 | 1.725 | 0 | – |
| 15 | 0 | – | 14 242 | 0.775 |
| 16 | 0 | – | 0 | – |
| 17 | 2 915 | 1.516 | 0 | – |
| 18 | 9 052 | 0.749 | 12 211 | 0.945 |
| 19 | 0 | – | 4 972 | 0.956 |
| Measured males | | | 38 | |
| Measured females | | | 65 | |
| Aged males | | | 88 | |
| Aged females | | | 91 | |
| No. of tows sampled | | | 46 | |
| Mean weighted CV (sexes pooled) | | | 55.4 | |

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 8 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. No survey of this area was conducted in November–December 2012.

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 8: 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 |
| 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. in prep.), 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 9 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. The estimated catch-at-age distribution for hake caught in the 2013 trawl survey is in Table 10. The mean weighted CV of 34% was slightly higher than the target of 30%.

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

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 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 |

Table 10: Calculated numbers at age in the survey area, separately by sex, with CVs, for hake caught during a trawl survey of the west coast South Island in August 2013 (TAN1308). Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|-------|-------|--------|-------|
| 1 | 6 610 | 0.514 | 3 943 | 0.502 |
| 2 | 285 | 1.364 | 799 | 1.478 |
| 3 | 0 | – | 1 491 | 0.702 |
| 4 | 1 127 | 0.697 | 678 | 1.029 |
| 5 | 4 793 | 0.353 | 3 032 | 0.408 |
| 6 | 6 004 | 0.321 | 8 693 | 0.294 |
| 7 | 4 092 | 0.371 | 12 671 | 0.272 |
| 8 | 2 634 | 0.457 | 10 216 | 0.252 |
| 9 | 677 | 0.758 | 4 790 | 0.265 |
| 10 | 306 | 0.814 | 4 293 | 0.323 |
| 11 | 112 | 0.952 | 1 109 | 0.495 |
| 12 | 217 | 1.172 | 633 | 0.675 |
| 13 | 95 | 2.192 | 395 | 0.766 |
| 14 | 351 | 1.186 | 725 | 0.605 |
| 15 | 297 | 1.264 | 513 | 0.678 |
| 16 | 18 | 2.217 | 823 | 0.659 |
| 17 | 0 | – | 438 | 1.195 |
| 18 | 18 | 2.121 | 164 | 1.318 |
| 19 | 0 | – | 0 | – |
| 20 | 0 | – | 0 | – |
| 21 | 0 | – | 173 | 1.438 |
| Measured males | | | 94 | |
| Measured females | | | 213 | |
| Aged males | | | 255 | |
| Aged females | | | 371 | |
| No. of tows sampled | | | 34 | |
| Mean weighted CV (sexes pooled) | | | 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 data collected from the Chatham Rise ling longline fishery in 2010–2012. The estimated catch-at-age distribution for line-caught ling in the 2012–13 fishing year are in Table 12. The mean weighted CV of 26% was within the target value of 30%.

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

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

Table 12: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial longline operations on the Chatham Rise (LIN 3&4) in June–October 2013. Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|-------|-------|--------|-------|
| 6 | 170 | 1.325 | 0 | – |
| 7 | 526 | 0.772 | 59 | 1.790 |
| 8 | 2 898 | 0.356 | 911 | 0.613 |
| 9 | 3 039 | 0.365 | 2 118 | 0.426 |
| 10 | 2 101 | 0.394 | 3 088 | 0.342 |
| 11 | 2 608 | 0.353 | 4 688 | 0.247 |
| 12 | 2 097 | 0.360 | 3 739 | 0.291 |
| 13 | 1 536 | 0.431 | 6 966 | 0.201 |
| 14 | 1 318 | 0.465 | 7 829 | 0.175 |
| 15 | 1 555 | 0.508 | 6 905 | 0.219 |
| 16 | 1 604 | 0.446 | 4 825 | 0.219 |
| 17 | 1 851 | 0.443 | 2 954 | 0.311 |
| 18 | 1 811 | 0.375 | 3 916 | 0.259 |
| 19 | 1 870 | 0.500 | 1 771 | 0.435 |
| 20 | 227 | 1.245 | 1 431 | 0.460 |
| 21 | 255 | 0.880 | 888 | 0.526 |
| 22 | 0 | – | 907 | 0.574 |
| 23 | 341 | 0.815 | 0 | – |
| 24 | 410 | 0.947 | 961 | 0.576 |
| Measured males | | | | 314 |
| Measured females | | | | 655 |
| Aged males | | | | 112 |
| Aged females | | | | 252 |
| No. of sets sampled | | | | 50 |
| Mean weighted CV (sexes pooled) | | | | 25.9 |

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 are analysed separately from Sub-Antarctic ling because they are believed to comprise a distinct biological stock (Horn 2005).

Table 13 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. There was no observer sampling of either spawning or non-spawning Sub-Antarctic longline-caught ling in the 2012–13 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 13: Numbers of measured male and female ling, age data used in the age-length key, 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 | | Sets | Mean CV |
|---------------------------|----------|------|----------|------|------|---------|
| | Measured | Aged | Measured | Aged | | |
| Spawning line fishery | | | | | | |
| 2000 | 4 044 | 242 | 4 231 | 278 | 83 | 20.6 |
| 2001 | 2 084 | 131 | 1 962 | 143 | 55 | 28.7 |
| 2002 | 670 | 197 | 898 | 284 | 157 | 22.6 |
| 2003 | 1 250 | 211 | 1 687 | 307 | 214 | 20.0 |
| 2004 | 887 | 208 | 1 129 | 289 | 168 | 22.5 |
| 2005 | 193 | 88 | 362 | 179 | 54 | 28.6 |
| 2006 | 233 | 108 | 707 | 345 | 94 | 23.3 |
| 2007 | 412 | 191 | 418 | 217 | 82 | 25.1 |
| 2008 | 227 | 68 | 198 | 62 | 24 | 44.3 |
| 2010 | 89 | 51 | 361 | 177 | 45 | 34.0 |
| Non-spawning line fishery | | | | | | |
| 1998 | 608 | 73 | 2 763 | 395 | 34 | 23.1 |
| 1999 | 3 316 | 214 | 7 535 | 428 | 136 | 18.3 |
| 2001 | 674 | 103 | 2 040 | 235 | 58 | 25.3 |
| 2003 | 304 | 128 | 611 | 273 | 43 | 29.3 |
| 2005 | 413 | 114 | 716 | 307 | 113 | 25.9 |
| 2009 | 165 | 61 | 454 | 196 | 49 | 28.0 |
| 2010 | 151 | 78 | 424 | 214 | 49 | 29.0 |
| 2011 | 180 | 60 | 823 | 267 | 64 | 27.3 |
| 2012 | 316 | 109 | 979 | 320 | 91 | 23.7 |

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 14 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 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. There was no sampling of WCSI longline-caught ling in the 2012–13 fishing year. All estimated proportion-at-age distributions from the WCSI longline fishery are presented in Appendix B (Figure B4).

Table 14: Numbers of measured male and female ling, age data used in the age-length key, sets sampled, and estimated mean weighted CV (%) by age, for the west coast South Island longline fishery.

| Year | Males | | Females | | Sets | Mean CV |
|------|----------|------|----------|------|------|---------|
| | Measured | Aged | Measured | Aged | | |
| 2003 | 123 | 215 | 148 | 246 | 24 | 37.9 |
| 2006 | 104 | 191 | 301 | 329 | 24 | 35.0 |
| 2007 | 109 | 119 | 192 | 169 | 28 | 42.2 |
| 2012 | 190 | 246 | 379 | 311 | 31 | 29.3 |

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 2012–13 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, and sets sampled, and estimated mean weighted CV (%) by age, for the Cook Strait longline fishery.

| Year | Males | | Females | | Sets | Mean CV |
|------|----------|------|----------|------|------|---------|
| | Measured | Aged | Measured | Aged | | |
| 2001 | 315 | 179 | 356 | 194 | 17 | 29.8 |
| 2003 | 165 | 164 | 145 | 142 | 31 | 33.1 |
| 2006 | 607 | 319 | 538 | 275 | 116 | 19.3 |
| 2007 | 238 | 125 | 180 | 92 | 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 2012–13 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, sets sampled, and estimated mean weighted CV (%) by age, for the Bounty Plateau longline fishery.

| Year | Males | | Females | | Sets | Mean CV |
|-----------|----------|------|----------|------|------|---------|
| | Measured | Aged | Measured | Aged | | |
| 1992–93 | 201 | 52 | 237 | 69 | 24 | 50.4 |
| 1999–2000 | 1 102 | 106 | 2 184 | 185 | 41 | 26.9 |
| 2000–01 | 405 | 50 | 713 | 66 | 20 | 43.6 |
| 2003–04 | 1 155 | 200 | 1 628 | 300 | 272 | 20.0 |
| 2007–08 | 308 | 156 | 562 | 271 | 86 | 25.3 |
| 2008–09 | 262 | 116 | 213 | 88 | 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 2012–13 fishing year are given in Table 18. The mean weighted CV of 24% was within 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 |

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 2012–May 2013. Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|--------|-------|--------|-------|
| 2 | 285 | 1.851 | 0 | – |
| 3 | 1 496 | 0.572 | 2 847 | 0.775 |
| 4 | 9 183 | 0.355 | 9 394 | 0.537 |
| 5 | 23 419 | 0.224 | 18 019 | 0.213 |
| 6 | 18 225 | 0.256 | 10 121 | 0.295 |
| 7 | 15 773 | 0.242 | 11 440 | 0.279 |
| 8 | 20 977 | 0.282 | 16 262 | 0.209 |
| 9 | 9 698 | 0.322 | 17 154 | 0.197 |
| 10 | 11 077 | 0.299 | 6 732 | 0.368 |
| 11 | 8 423 | 0.301 | 12 500 | 0.235 |
| 12 | 4 990 | 0.377 | 4 286 | 0.386 |
| 13 | 5 132 | 0.375 | 4 117 | 0.421 |
| 14 | 5 729 | 0.353 | 4 151 | 0.356 |
| 15 | 2 203 | 0.474 | 3 667 | 0.417 |
| 16 | 741 | 0.716 | 3 014 | 0.458 |
| 17 | 2 115 | 0.497 | 4 002 | 0.410 |
| 18 | 1 567 | 0.629 | 1 918 | 0.389 |
| 19 | 1 693 | 0.495 | 3 104 | 0.368 |
| 20 | 668 | 0.803 | 177 | 0.956 |
| 21 | 1 011 | 0.600 | 554 | 0.816 |
| 22 | 1 507 | 0.590 | 450 | 0.674 |
| 23 | 252 | 1.236 | 437 | 0.876 |
| 24 | 956 | 0.982 | 233 | 1.069 |
| 25 | 972 | 0.999 | 164 | 0.925 |
| 26 | 484 | 1.157 | 155 | 1.184 |
| 27 | 0 | – | 222 | 1.579 |
| 28 | 305 | 1.166 | 0 | – |
| 29 | 0 | 7.827 | 49 | 1.882 |
| 30 | 0 | – | 0 | 2.700 |
| 31 | 0 | – | 0 | – |
| 32 | 0 | 7.934 | 0 | – |
| 38 | 0 | 5.721 | 0 | – |
| Measured males | | | | 981 |
| Measured females | | | | 1 083 |
| Aged males | | | | 278 |
| Aged females | | | | 315 |
| No. of tows sampled | | | | 130 |
| Mean weighted CV (sexes pooled) | | | | 24.1 |

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 2012–13 fishing year are given in Table 20. The mean weighted CV of 22% was within 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, and 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 |

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 2012–April 2013. Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|---------|-------|---------|-------|
| 2 | 0 | – | 440 | 1.418 |
| 3 | 707 | 0.742 | 779 | 0.586 |
| 4 | 4 246 | 0.527 | 3 708 | 0.487 |
| 5 | 23 849 | 0.240 | 28 548 | 0.311 |
| 6 | 93 032 | 0.167 | 100 102 | 0.215 |
| 7 | 89 087 | 0.203 | 151 892 | 0.203 |
| 8 | 120 993 | 0.190 | 167 540 | 0.192 |
| 9 | 113 556 | 0.222 | 139 275 | 0.191 |
| 10 | 91 393 | 0.272 | 91 531 | 0.290 |
| 11 | 66 513 | 0.334 | 103 028 | 0.256 |
| 12 | 42 795 | 0.383 | 59 181 | 0.372 |
| 13 | 39 607 | 0.418 | 33 424 | 0.503 |
| 14 | 44 289 | 0.399 | 59 219 | 0.327 |
| 15 | 13 246 | 0.568 | 48 649 | 0.332 |
| 16 | 30 537 | 0.556 | 65 096 | 0.306 |
| 17 | 29 069 | 0.413 | 47 907 | 0.348 |
| 18 | 20 982 | 0.498 | 56 298 | 0.321 |
| 19 | 24 120 | 0.589 | 26 822 | 0.344 |
| 20 | 19 051 | 0.502 | 20 790 | 0.585 |
| 21 | 15 224 | 0.464 | 8 438 | 0.540 |
| 22 | 5 560 | 0.608 | 7 073 | 0.713 |
| 23 | 13 781 | 0.635 | 7 210 | 0.804 |
| 24 | 8 080 | 0.633 | 833 | 1.459 |
| 25 | 0 | – | 15 185 | 0.542 |
| 26 | 0 | – | 2 430 | 1.044 |
| 27 | 3 901 | 1.103 | 684 | 1.026 |
| 28 | 0 | – | 358 | 1.284 |
| 29 | 0 | – | 1 443 | 1.213 |
| 30 | 0 | – | 3 862 | 1.016 |
| 31 | 0 | – | 0 | – |
| 32 | 0 | – | 147 | 2.137 |
| Measured males | | | | 4 565 |
| Measured females | | | | 5 542 |
| Aged males | | | | 286 |
| Aged females | | | | 317 |
| No. of tows sampled | | | | 275 |
| Mean weighted CV (sexes pooled) | | | | 21.6 |

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 ≥ 498 m).
2. North shallow (bottom depth < 498 m, latitude $< 42.42^\circ$ S).
3. South shallow (bottom depth < 498 m, latitude $\geq 42.42^\circ$ 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. In the 2012–13 fishing year, the trawl fishery age-length key was derived using all the age data from the winter 2013 research trawl survey, plus 146 additional age data points derived from otoliths sampled from the commercial trawl fishery. The additional otoliths were chosen to provide age data for ling length classes that did not occur in the survey samples, or were under-represented relative to their abundance in the trawl fishery sample. The details of the estimated catch-at-age distribution for trawl-caught ling in the 2012–13 fishing year are given in Table 22. The mean weighted CV of 24% was within 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 |

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 2013. Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|--------|-------|--------|-------|
| 2 | 159 | 1.801 | 107 | 1.848 |
| 3 | 516 | 0.980 | 1 267 | 0.721 |
| 4 | 11 950 | 0.374 | 9 554 | 0.372 |
| 5 | 9 020 | 0.354 | 6 770 | 0.340 |
| 6 | 4 211 | 0.388 | 5 194 | 0.373 |
| 7 | 5 595 | 0.375 | 6 446 | 0.386 |
| 8 | 17 956 | 0.275 | 10 942 | 0.333 |
| 9 | 18 828 | 0.280 | 18 904 | 0.247 |
| 10 | 22 674 | 0.252 | 14 446 | 0.288 |
| 11 | 11 495 | 0.325 | 15 376 | 0.258 |
| 12 | 10 414 | 0.292 | 16 120 | 0.213 |
| 13 | 7 068 | 0.363 | 12 692 | 0.264 |
| 14 | 4 767 | 0.428 | 6 544 | 0.316 |
| 15 | 1 593 | 0.580 | 4 743 | 0.326 |
| 16 | 1 373 | 0.876 | 2 749 | 0.448 |
| 17 | 1 076 | 0.850 | 1 500 | 0.469 |
| 18 | 939 | 0.637 | 2 108 | 0.455 |
| 19 | 527 | 0.840 | 1 993 | 0.429 |
| 20 | 1 660 | 0.590 | 1 027 | 0.489 |
| 21 | 481 | 0.902 | 2 219 | 0.524 |
| 22 | 1 026 | 0.842 | 891 | 0.531 |
| 23 | 269 | 1.356 | 897 | 0.746 |
| 24 | 522 | 0.762 | 581 | 0.627 |
| 25 | 0 | – | 59 | 1.456 |
| 26 | 102 | 1.380 | 38 | 1.754 |
| 27 | 106 | 1.464 | 275 | 1.109 |
| 28 | 0 | – | 118 | 1.474 |
| Measured males | | | | 1 270 |
| Measured females | | | | 1 302 |
| Aged males | | | | 283 |
| Aged females | | | | 376 |
| No. of tows sampled | | | | 153 |
| Mean weighted CV (sexes pooled) | | | | 23.9 |

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 2013 (i.e., only 3 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: 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 |

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 2014 trawl survey are given in Table 25. The mean weighted CV of 26% was within the target of 30%.

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

Table 25: Calculated numbers at age in the survey area, separately by sex, with CVs, for ling caught during trawl surveys of the Chatham Rise in January 2014 (survey TAN1401). Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|---------|-------|---------|-------|
| 2 | 0 | – | 3 685 | 2.188 |
| 3 | 116 321 | 0.438 | 118 310 | 0.429 |
| 4 | 147 442 | 0.244 | 125 177 | 0.252 |
| 5 | 112 596 | 0.264 | 98 391 | 0.270 |
| 6 | 194 775 | 0.206 | 113 677 | 0.260 |
| 7 | 99 269 | 0.254 | 89 518 | 0.277 |
| 8 | 97 938 | 0.252 | 119 734 | 0.240 |
| 9 | 77 632 | 0.268 | 58 252 | 0.324 |
| 10 | 64 800 | 0.322 | 101 404 | 0.266 |
| 11 | 65 266 | 0.295 | 44 557 | 0.381 |
| 12 | 58 712 | 0.300 | 39 493 | 0.393 |
| 13 | 54 319 | 0.334 | 39 010 | 0.428 |
| 14 | 49 582 | 0.333 | 32 728 | 0.405 |
| 15 | 13 690 | 0.621 | 34 326 | 0.399 |
| 16 | 40 413 | 0.380 | 17 691 | 0.571 |
| 17 | 35 222 | 0.391 | 32 174 | 0.400 |
| 18 | 36 477 | 0.414 | 25 404 | 0.486 |
| 19 | 6 750 | 0.884 | 1 841 | 1.221 |
| 20 | 6 438 | 1.057 | 9 550 | 0.666 |
| 21 | 12 669 | 0.634 | 7 082 | 0.870 |
| 22 | 7 392 | 1.061 | 6 492 | 1.152 |
| 23 | 14 325 | 0.719 | 4 512 | 0.937 |
| 24 | 10 693 | 0.844 | 3 151 | 1.312 |
| 25 | 4 850 | 1.042 | 0 | – |
| 26 | 2 893 | 1.362 | 4 662 | 1.025 |
| 27 | 11 943 | 0.785 | 2 217 | 1.505 |
| 28 | 4 409 | 1.369 | 0 | – |
| 29 | 0 | – | 2 041 | 1.398 |
| 30 | 0 | – | 0 | – |
| 31 | 2 908 | 1.499 | 4 596 | 1.142 |
| 32 | 3 468 | 1.429 | 0 | – |
| 33 | 0 | – | 0 | – |
| 34 | 0 | – | 0 | – |
| 35 | 0 | – | 3 155 | 1.408 |
| 36 | 3 219 | 1.652 | 0 | – |
| 37 | 4 122 | 1.139 | 0 | – |
| Measured males | | | | 515 |
| Measured females | | | | 482 |
| Aged males | | | | 322 |
| Aged females | | | | 275 |
| No. of tows sampled | | | | 82 |
| Mean weighted CV (sexes pooled) | | | | 26.4 |

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 of this area conducted in November–December 2013.

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 | 25.9 |
| 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. in prep.), 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. The details of the estimated catch-at-age distribution for ling caught in the 2013 survey are given in Table 28. The mean weighted CV of 30% met the target of 30%.

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 |

Table 28: Calculated numbers at age in the survey area, separately by sex, with CVs, for ling caught during a trawl survey of the west coast South Island in August 2013 (survey TAN1308). Summary statistics for the samples are also presented.

| Age | Male | CV | Female | CV |
|---------------------------------|--------|-------|--------|-------|
| 2 | 1 144 | 1.110 | 0 | – |
| 3 | 3 818 | 0.479 | 8 234 | 0.490 |
| 4 | 14 684 | 0.271 | 13 637 | 0.282 |
| 5 | 12 970 | 0.268 | 5 839 | 0.373 |
| 6 | 5 446 | 0.442 | 6 430 | 0.339 |
| 7 | 10 744 | 0.312 | 6 200 | 0.391 |
| 8 | 27 119 | 0.250 | 5 471 | 0.353 |
| 9 | 32 219 | 0.298 | 8 846 | 0.293 |
| 10 | 38 120 | 0.289 | 12 244 | 0.334 |
| 11 | 17 254 | 0.394 | 13 530 | 0.323 |
| 12 | 13 556 | 0.374 | 21 290 | 0.282 |
| 13 | 11 853 | 0.437 | 16 191 | 0.343 |
| 14 | 7 496 | 0.480 | 10 247 | 0.351 |
| 15 | 2 427 | 0.723 | 6 951 | 0.436 |
| 16 | 3 314 | 0.814 | 5 410 | 0.439 |
| 17 | 1 636 | 1.051 | 3 843 | 0.461 |
| 18 | 3 572 | 0.574 | 5 283 | 0.507 |
| 19 | 2 809 | 0.682 | 5 961 | 0.393 |
| 20 | 4 928 | 0.537 | 2 991 | 0.518 |
| 21 | 0 | – | 4 946 | 0.530 |
| 22 | 2 409 | 0.745 | 1 766 | 0.502 |
| 23 | 0 | – | 904 | 0.885 |
| 24 | 1 723 | 0.731 | 1 122 | 0.827 |
| 25 | 0 | – | 0 | – |
| 26 | 662 | 1.144 | 311 | 1.335 |
| 27 | 249 | 1.436 | 1 273 | 0.974 |
| Measured males | | | 1 026 | |
| Measured females | | | 768 | |
| Aged males | | | 224 | |
| Aged females | | | 298 | |
| No. of tows sampled | | | 53 | |
| Mean weighted CV (sexes pooled) | | | 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, and the HAK 1 fishery in the Sub-Antarctic. The target has almost always been met for samples in the WCSI fishery (see Table 4). The sampling intensity in the HAK 7 (WCSI) commercial trawl fishery was much higher in 2012–13 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 2) and the sampling intensity of this fishery in 2012–13 was relatively high. Hake on Chatham Rise were analysed as two separate fisheries (see Table 1), but sampling intensity in 2012–13 was too low to enable estimation of catch-at-age distribution for either fishery.

The Chatham Rise survey in January 2014 produced low numbers of hake (103 measured fish in the core strata), and consequently the catch-at-age distribution for the trawl survey had a mean weighted CV much higher than the target of 30% (55%). No improvements in the precision can be achieved, however, as all available data were included in the analysis. The target of 30% was met in only one of the surveys in this series. There was no survey of the Sub-Antarctic trawl in December 2013.

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 appear to be about evenly abundant in all areas except Statistical Area 404, where males dominate the catch (Horn & Sutton 2009). Some year class progressions are apparent. The year class 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 is a clear year class progression apparent in the Chatham Rise survey distributions from 2004 to 2011 (Figure A5). The year class spawned in late 2001 (aged 2+ years in January 2004) clearly progresses 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) are moderately strong.

In the Sub-Antarctic, there are some clear year class progressions, particularly in the male distributions. Figure A3 shows the progressions of hake aged 10 in 1990 through to age 16 in 1996, and aged 6 in 1998 through to age 12 years in 2004.

The WCSI trawl catch is 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 are taken by the fishery, but these do not always manifest as strong cohorts in later years. However, it does appear that the relatively abundant 2-year-old fish in catches from 2005, 2006, and 2007 have progressed to comprise a high proportion of the catch from 2010 to 2012. A characteristic of most of the WCSI distributions is that numbers of fish aged 3 and 4 years are generally very low. It seems likely that fish of this age are much less vulnerable or available to the trawl during the winter months of the fishery than younger or older hake.

4.2 Ling

Catch-at-age distributions were produced for one commercial longline fishery in 2012–13 (Chatham Rise), and the target CV was met. Catch-at-age distributions were scheduled to be produced for the Sub-Antarctic and Bounty Plateau fisheries, but they were not sampled by observers in 2012–13. 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 Chatham Rise distribution used observer length data applied to age-length keys obtained from a trawl survey, i.e., Chatham Rise length data collected from October 2012 to May 2013 were applied to the age-length key from the January 2013 (TAN1301) trawl survey of the Chatham Rise. 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 2012 to April 2013 were applied to the age-length key from the December 2012 (TAN1215) trawl survey of the Sub-Antarctic. The estimated catch-at-age distributions had mean weighted CVs well within the target of 30%. Most distributions calculated for both these fisheries in previous years were within the target. The level of observer sampling of ling from the WCSI commercial fishery was good in 2012–13, in contrast to recent previous years when sampling was inadequate to estimate fishery age structure (see Table 21). The estimated catch-at-age distribution had a mean weighted CV well within the target of 30%. An estimate of catch-at-age for the ling bycatch from the Cook Strait hoki spawning fisheries was not able to be produced for 2013 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 trawl surveys of WCSI (August 2013) and Chatham Rise (January 2014) to meet the mean weighted CV target. The target was met in all previous surveys of these areas, except for Chatham Rise in 2011 (see Tables 24 and 27).

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

Recruitment to the trawl fisheries is generally about two years earlier than to the longline fisheries (i.e., at about 5 years), and most of the catch is 13 years or younger. No clear year class progressions are apparent in any of the trawl series. The ling trawl catch-at-age distributions from the WCSI fishery often exhibit a trough at about age 6 or 7. This is consistent with an inflexion point in the length-frequency distributions at lengths of about 72 cm for males and 77 cm for females (see figure 3 of Horn 2008). It seems likely that fish of this size are less vulnerable or available to the trawl during the winter months of the fishery.

5. ACKNOWLEDGMENTS

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

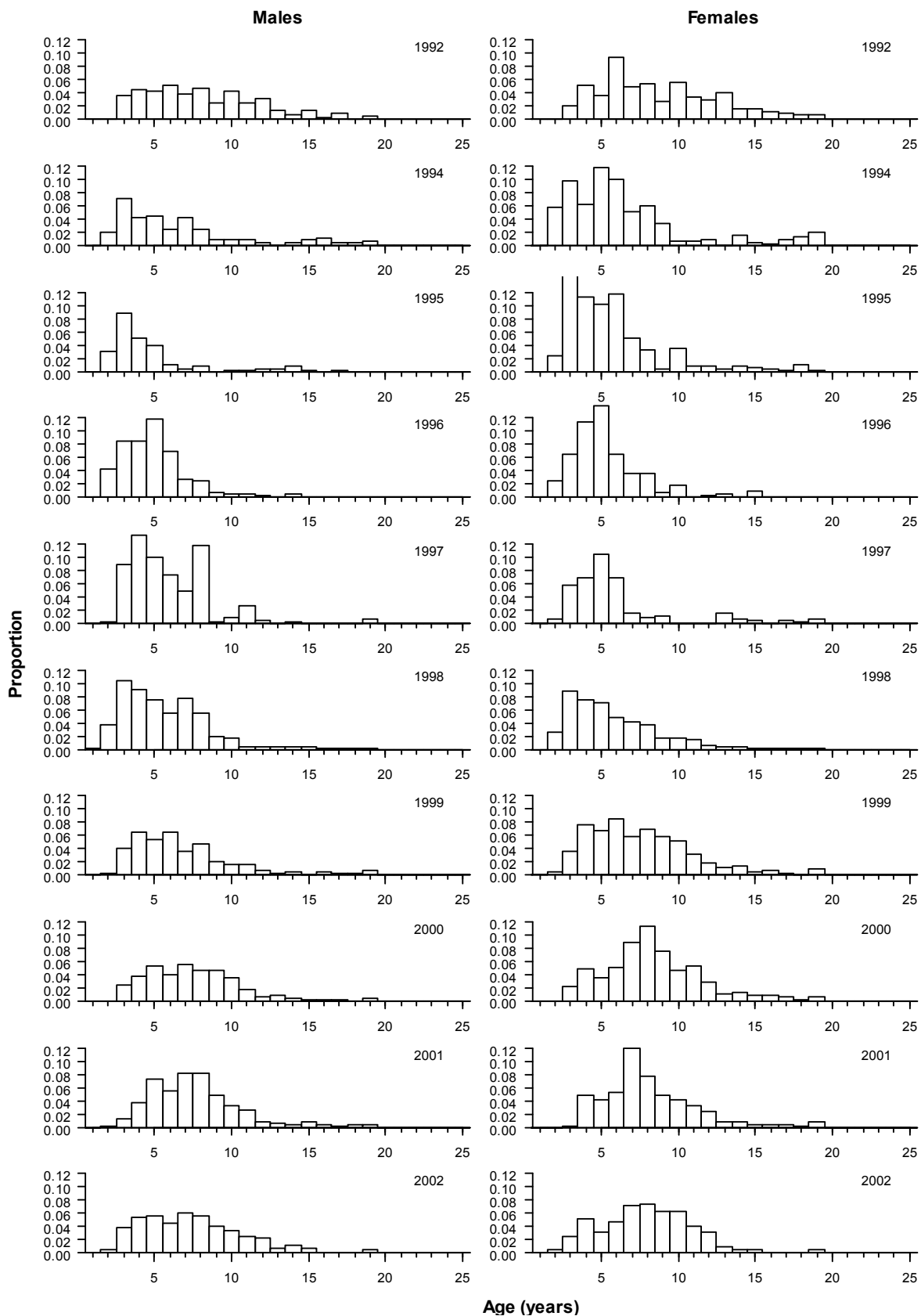


Figure A1: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2013. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–April 2002 sample.

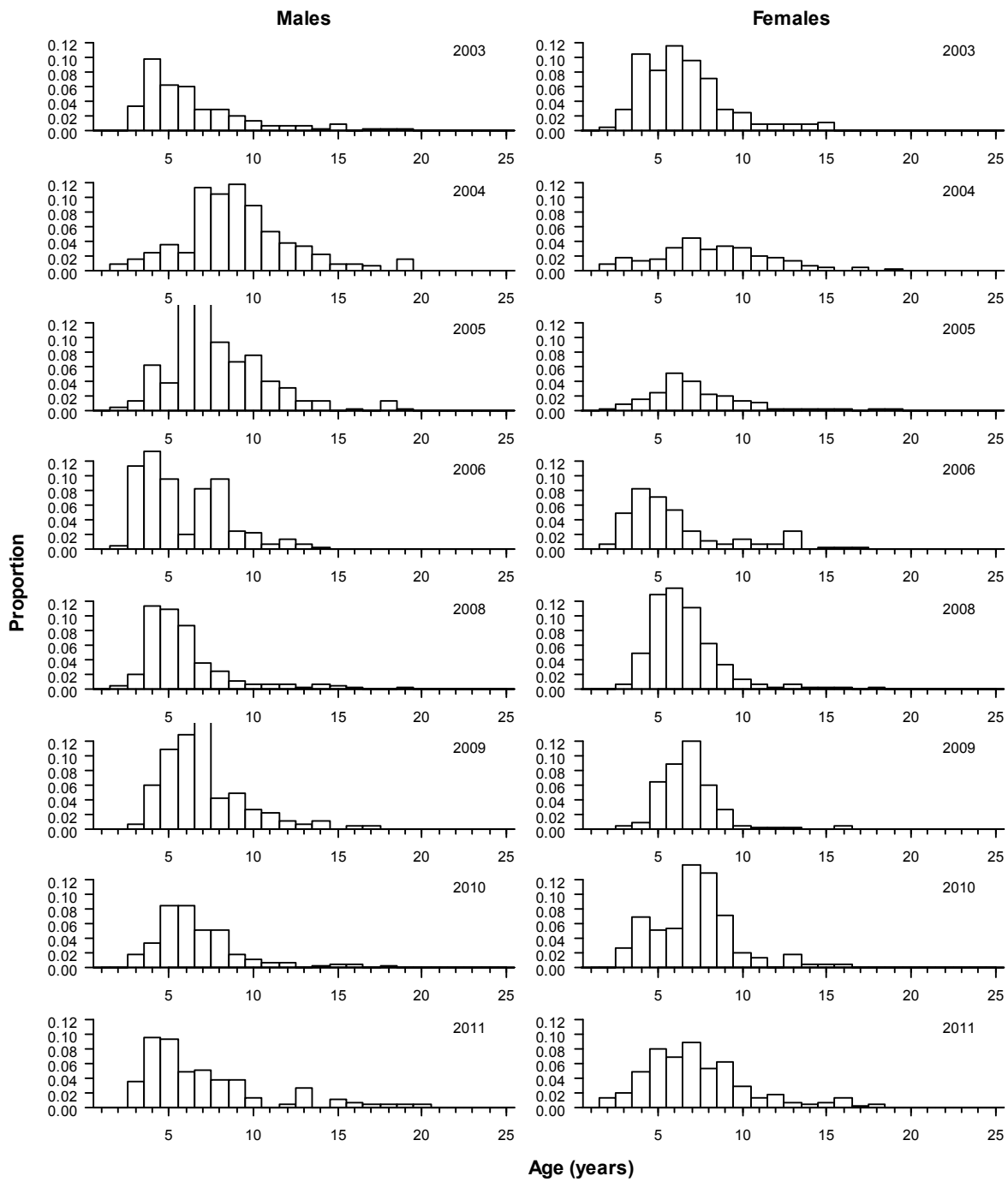


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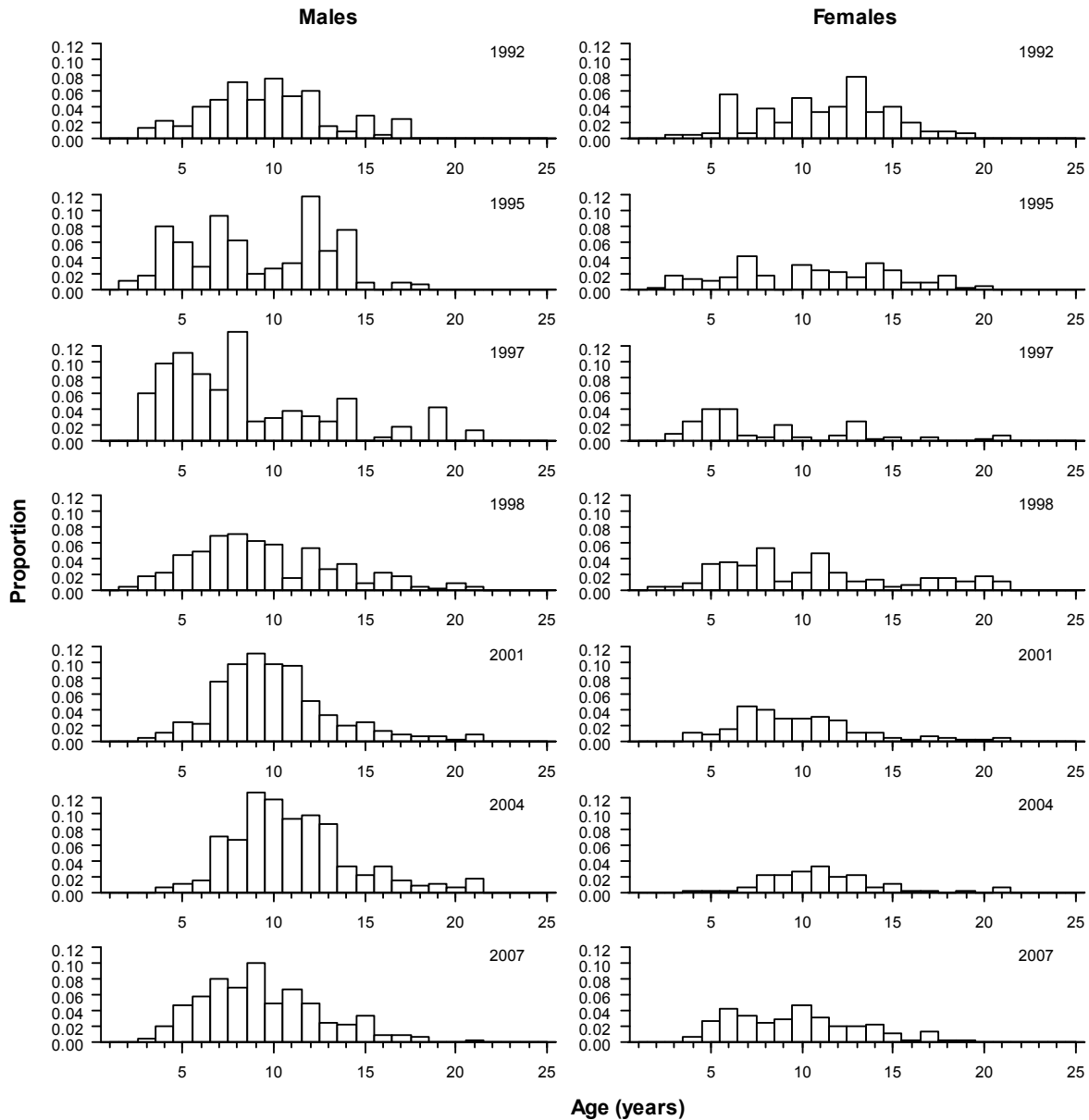


Figure A2: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2013. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “1992” denotes the October 1991–April 1992 sample.

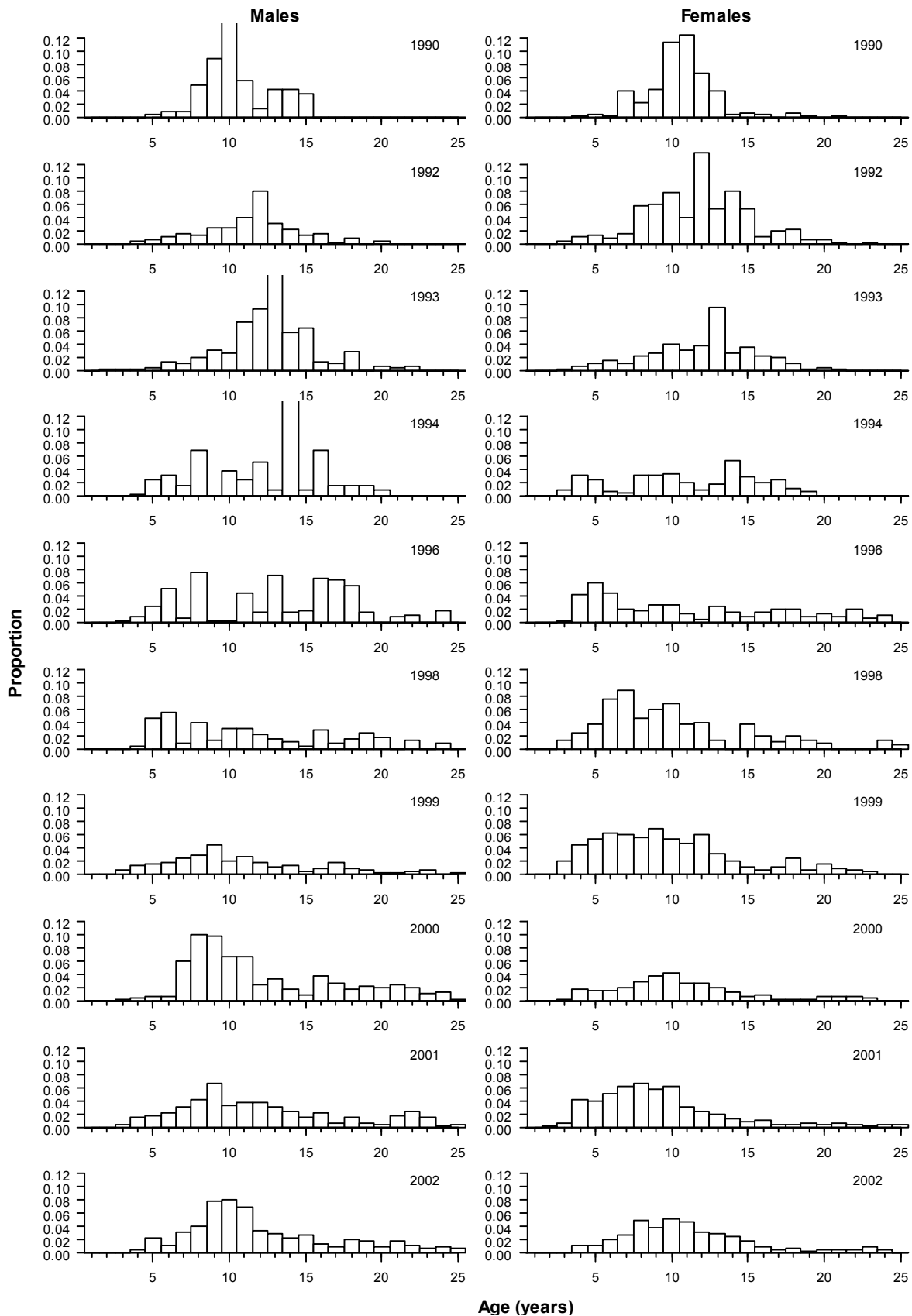


Figure A3: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2013. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the September 2001–May 2002 sample.

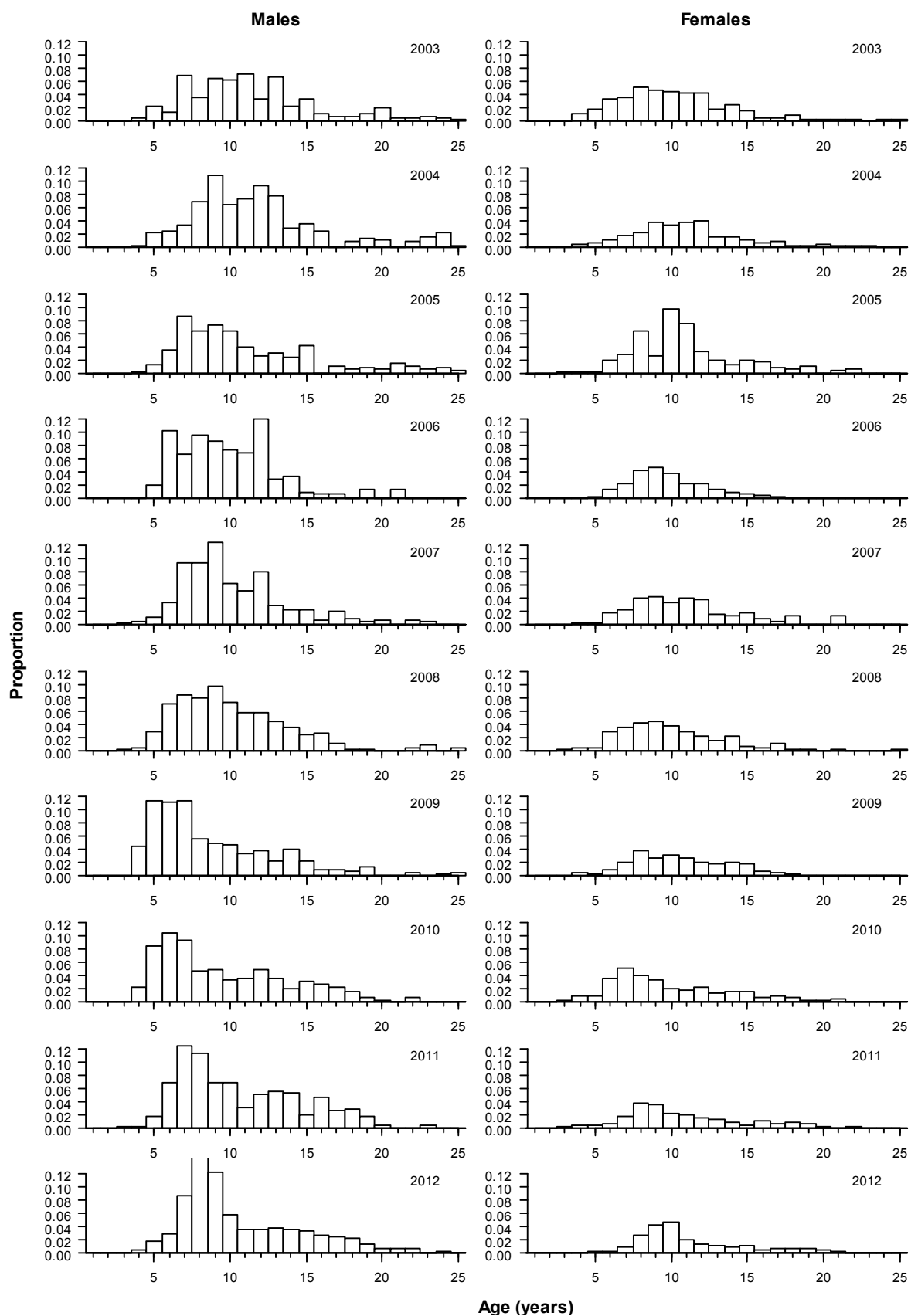


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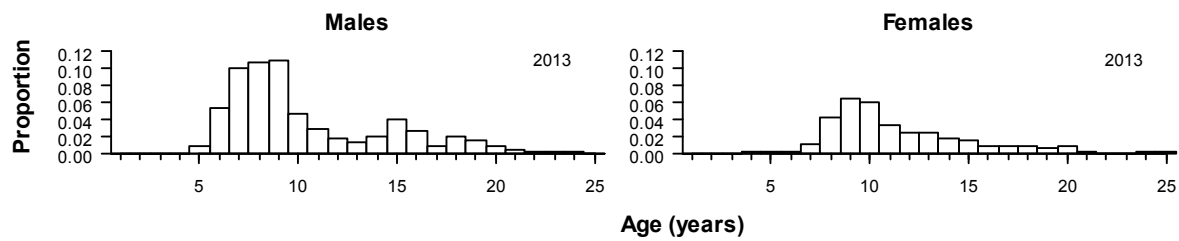


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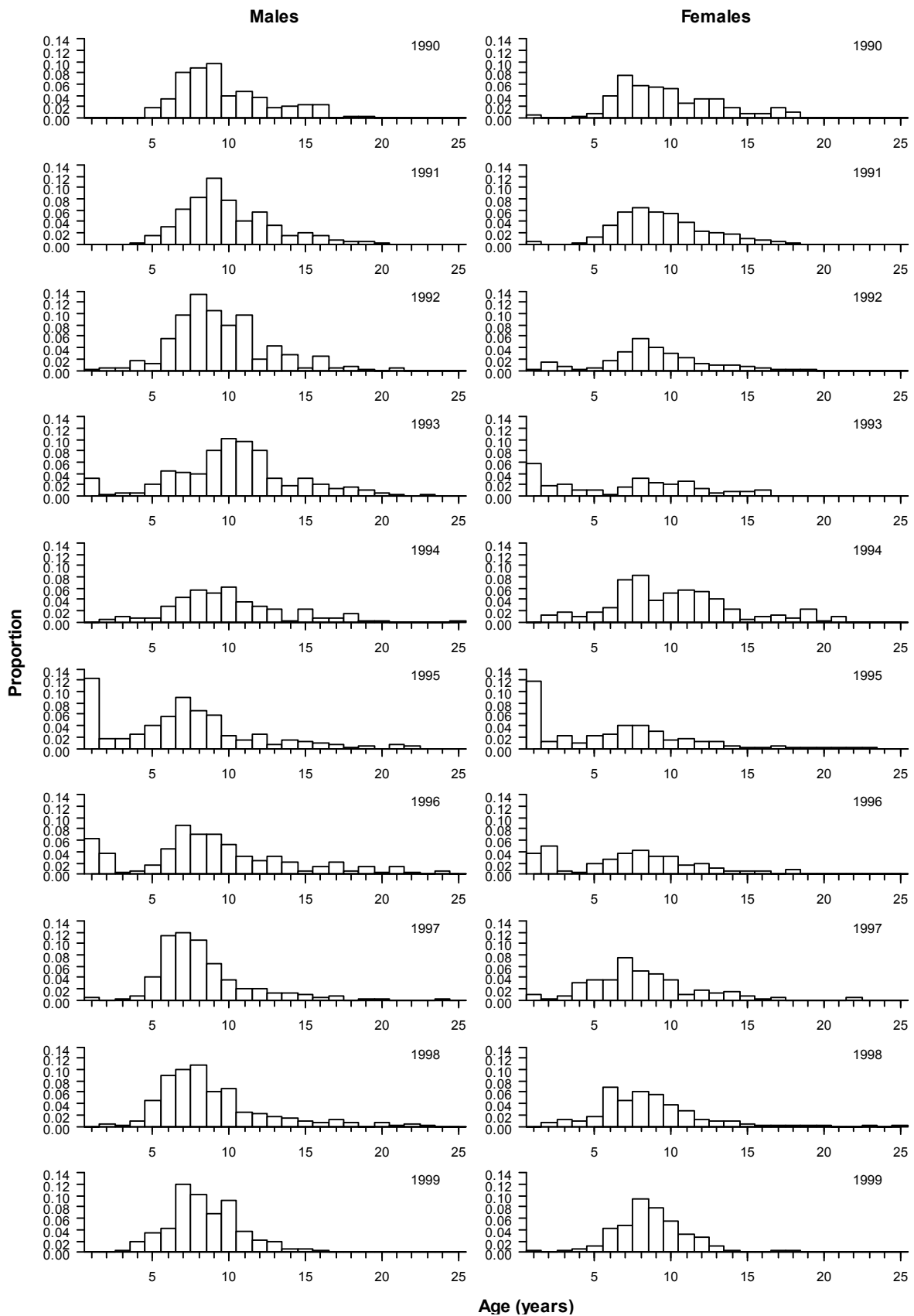


Figure A4: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2013.

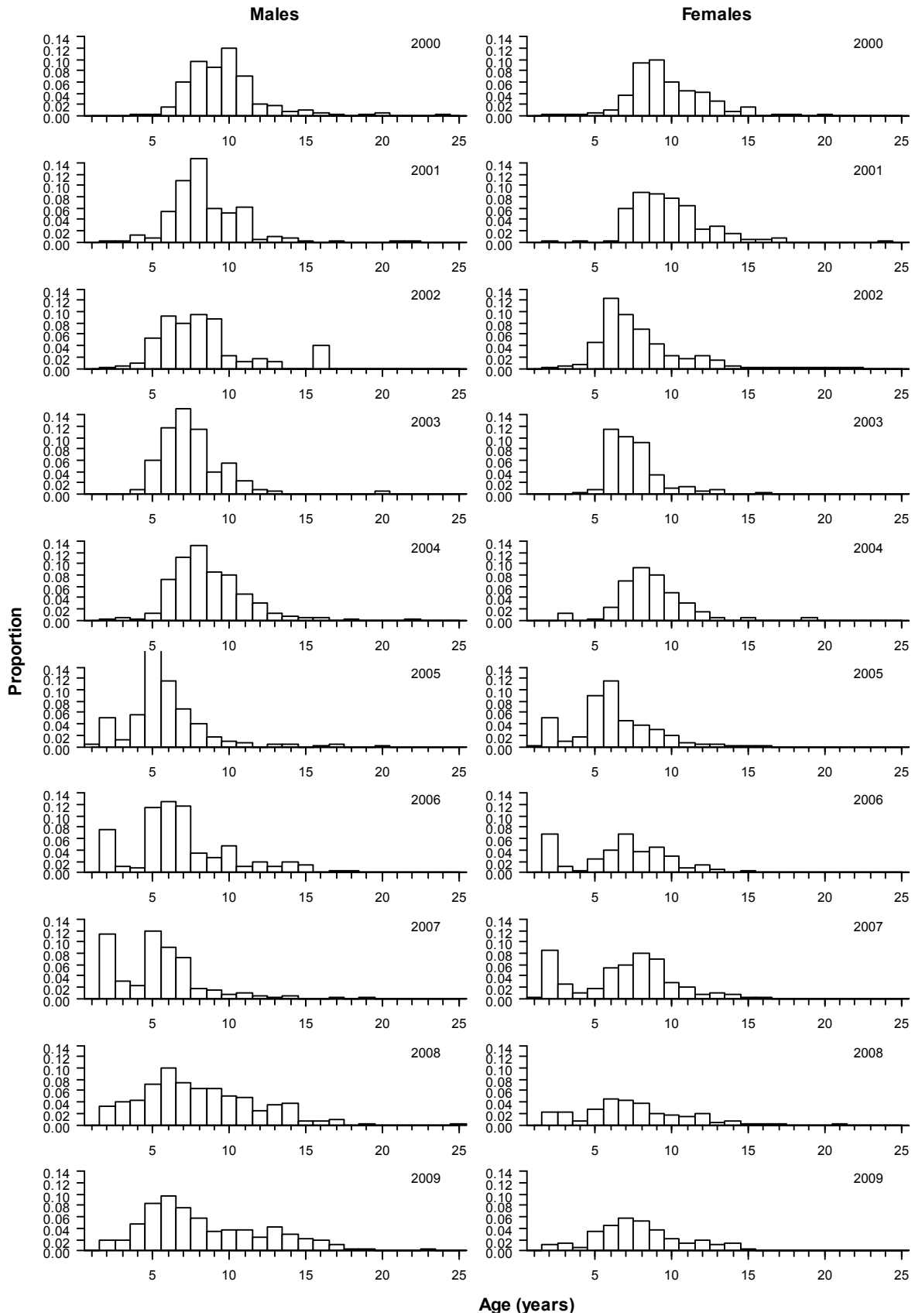


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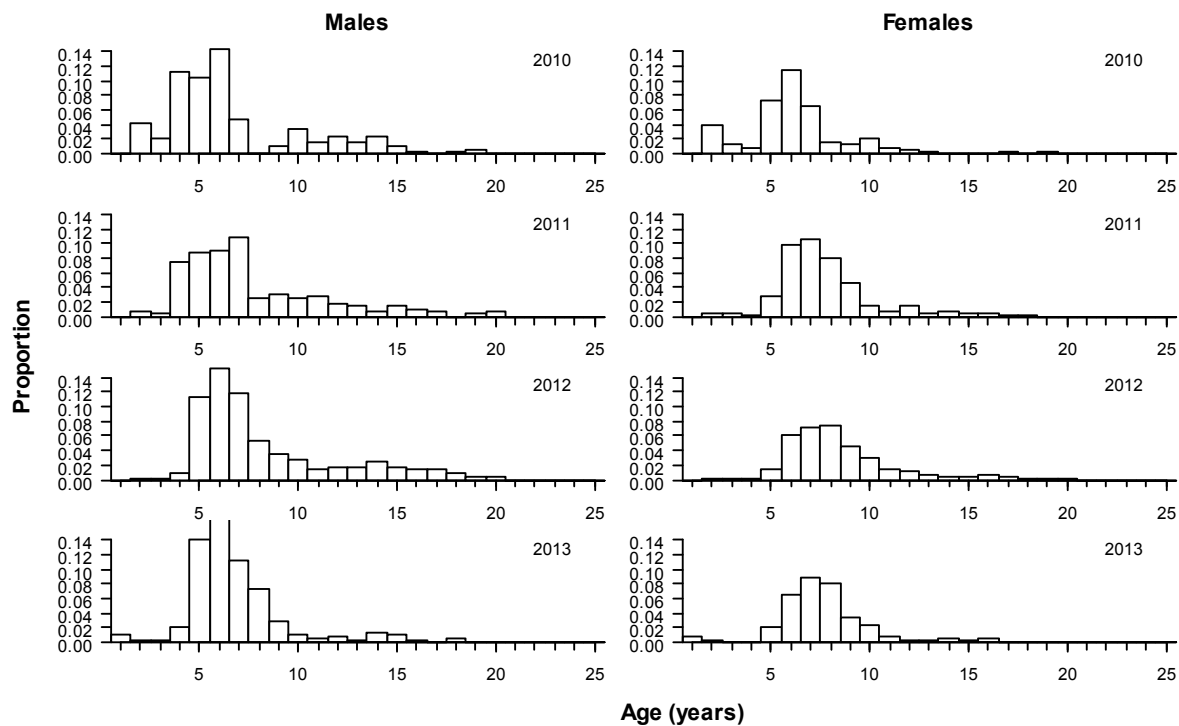


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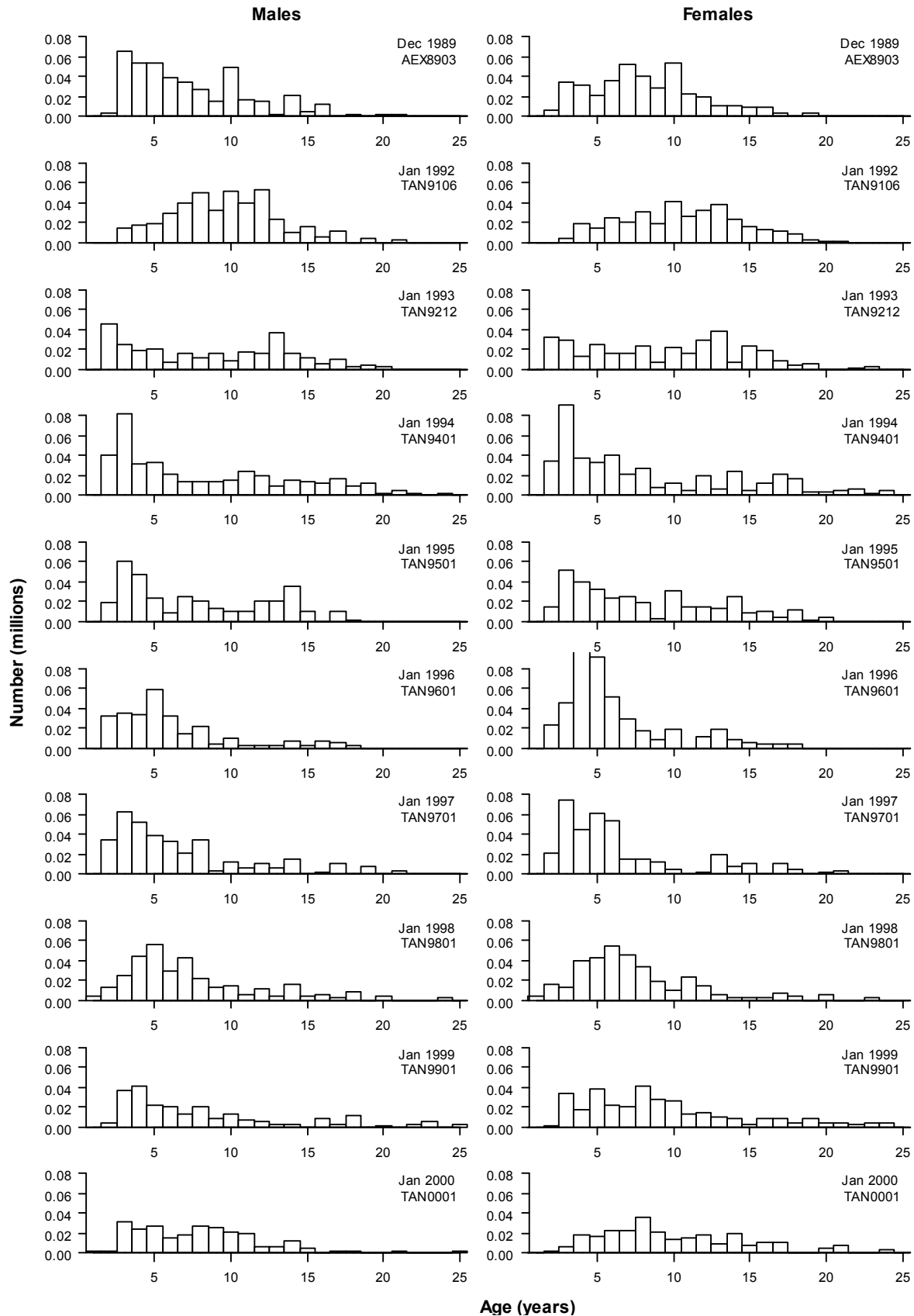


Figure A5: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2013–14.

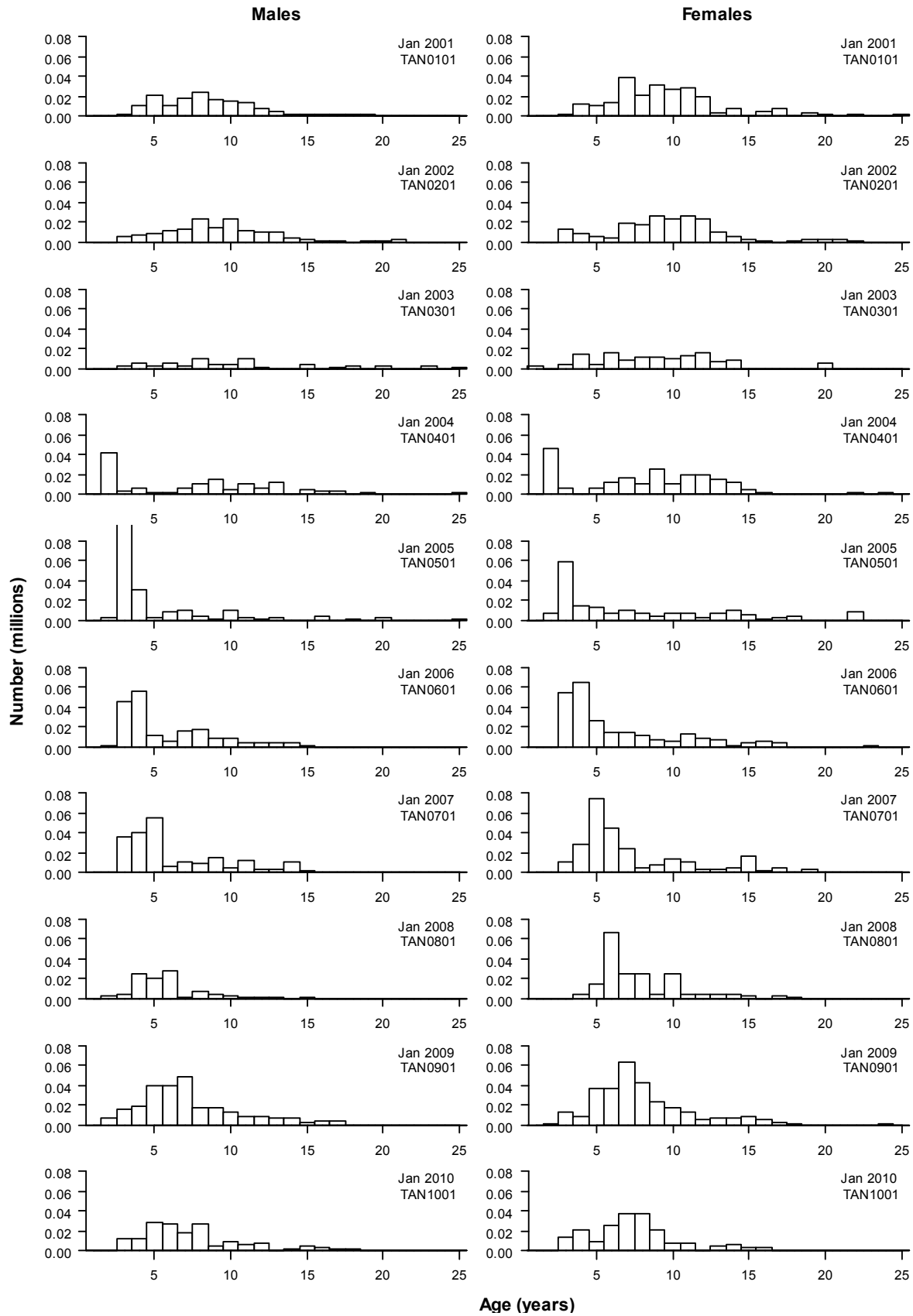


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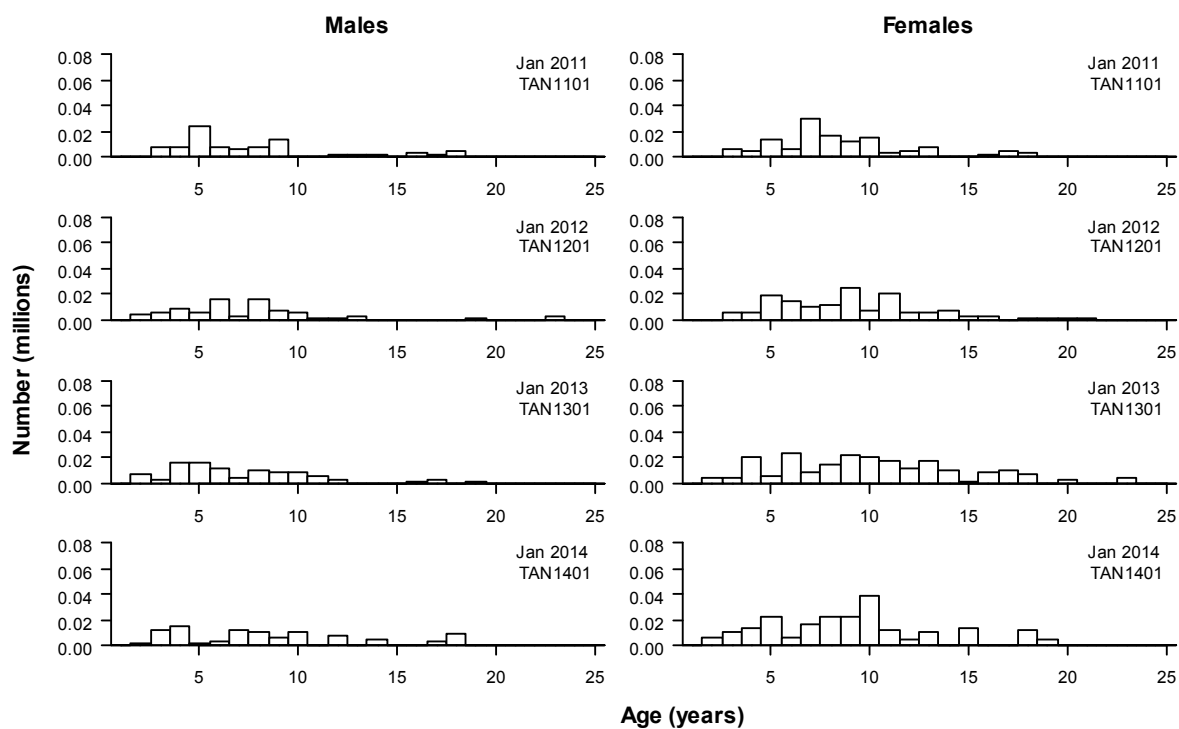


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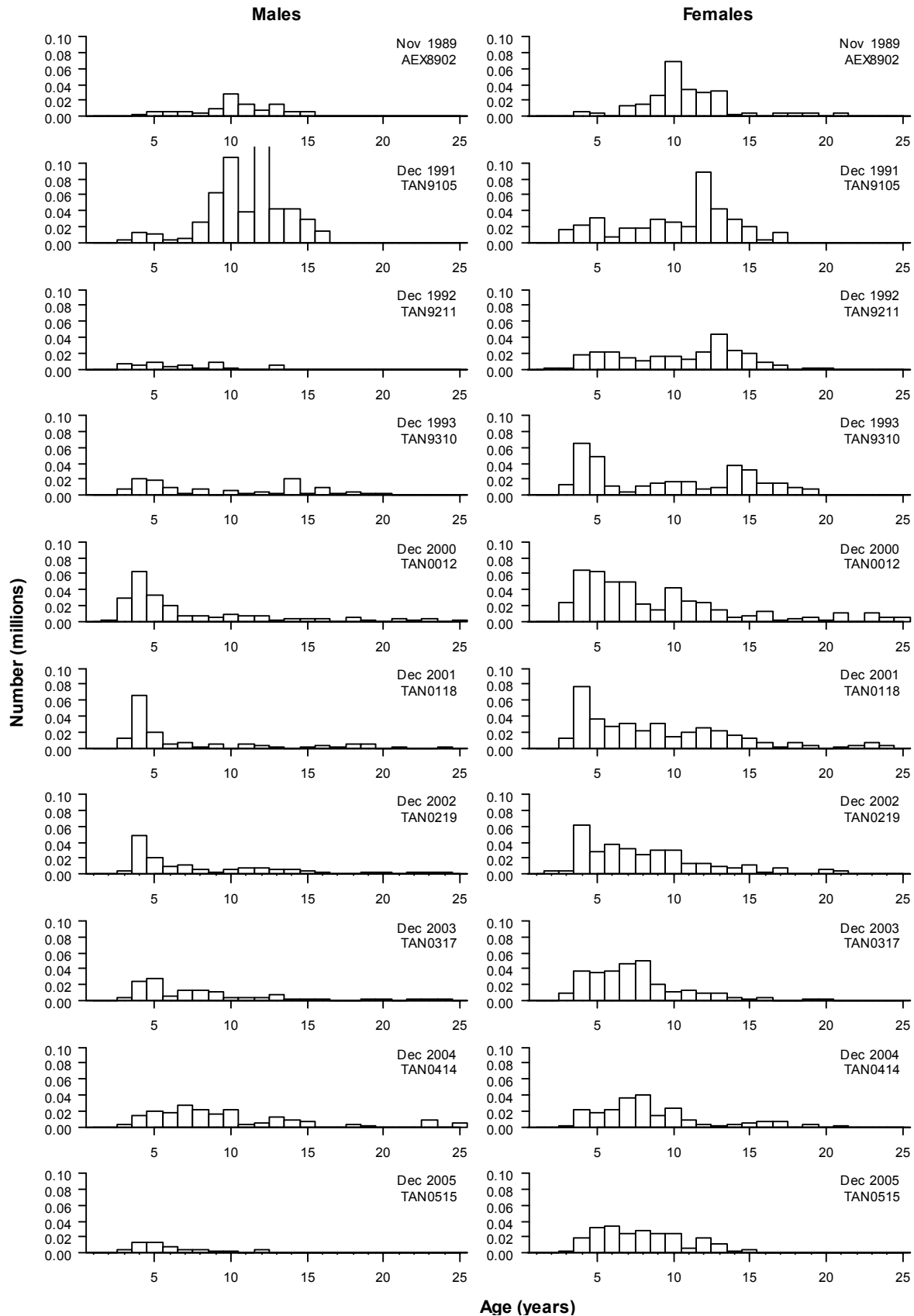


Figure A6: Available age frequencies of hake (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2013.

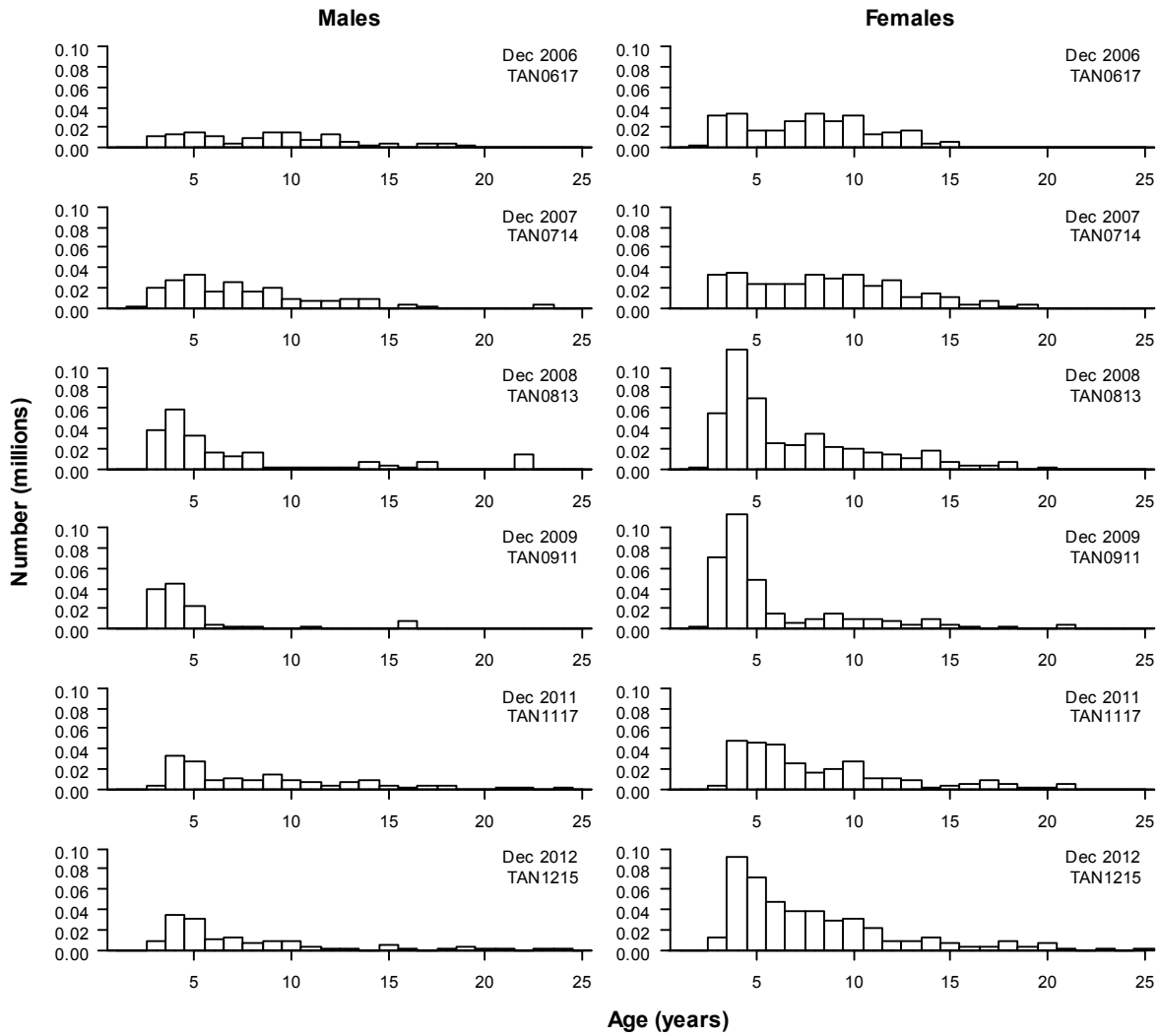


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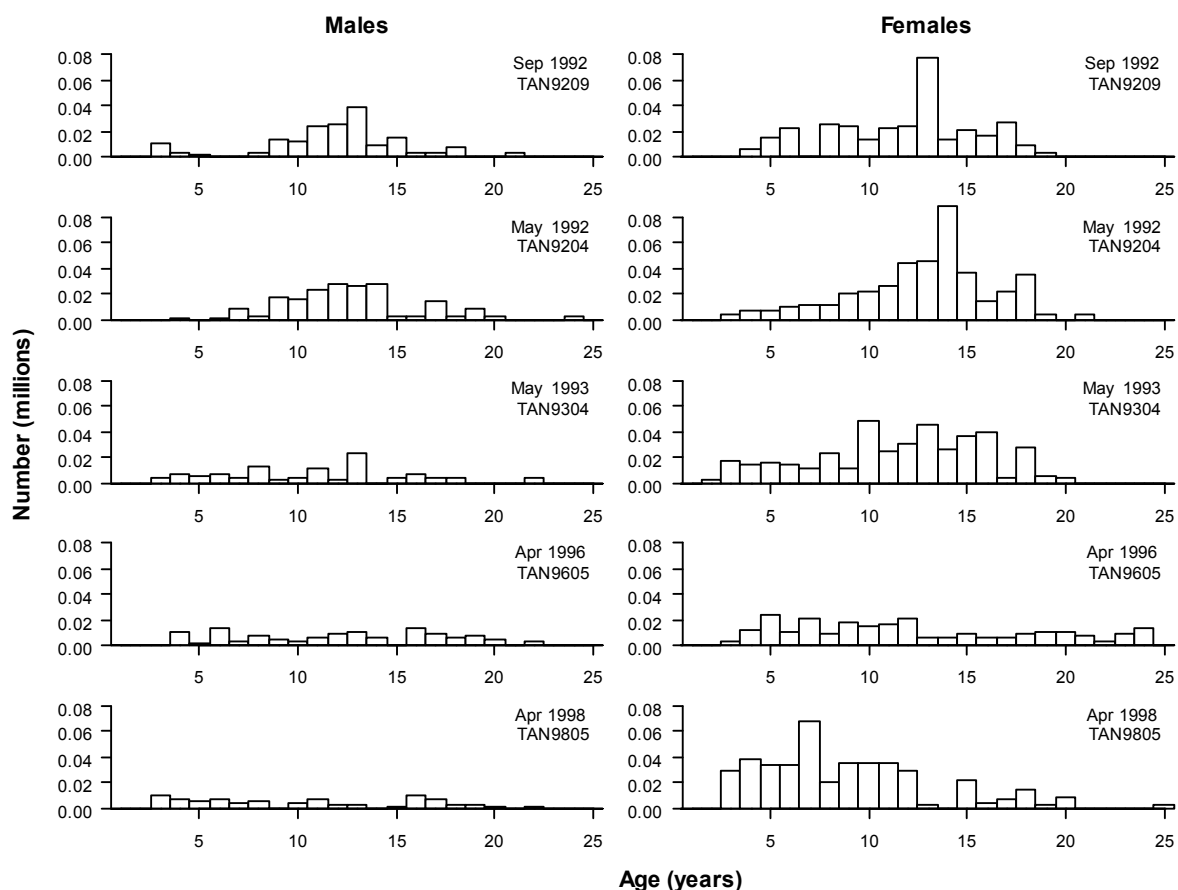


Figure A7: Available age frequencies of hake (ages 1 to 25) from spring and autumn resource surveys in the Sub-Antarctic, 1992 to 1998.

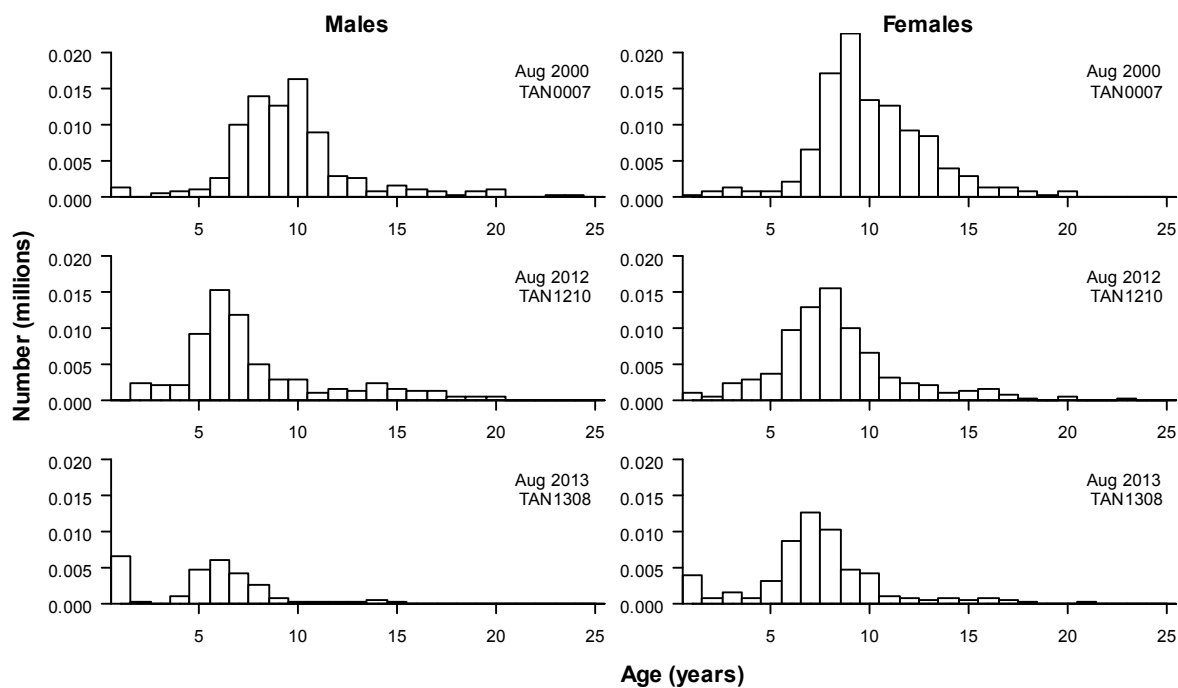


Figure A8: Available age frequencies of hake (ages 1 to 25) from resource surveys off WCSI, from 2000 to 2013.

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

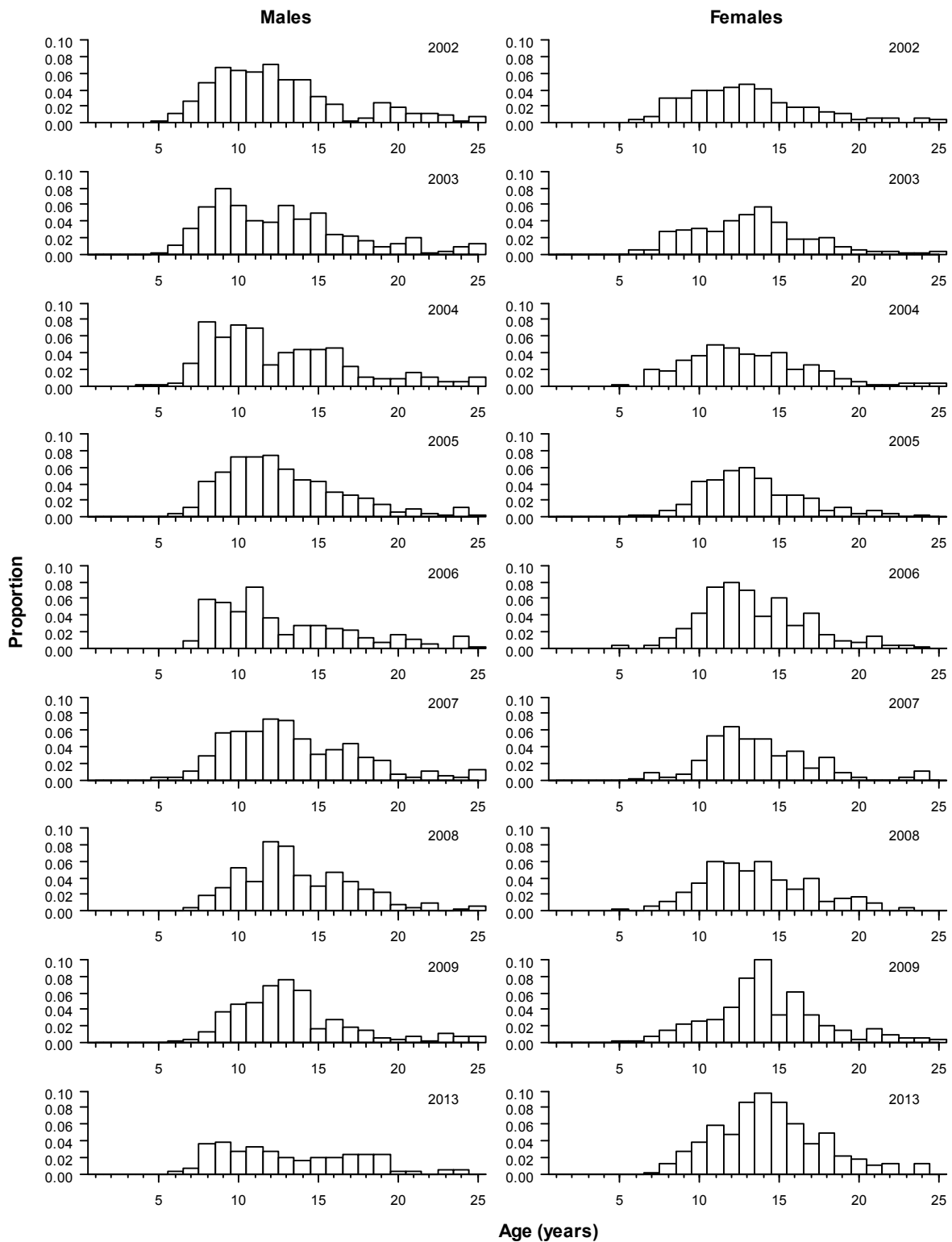


Figure B1: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2013.

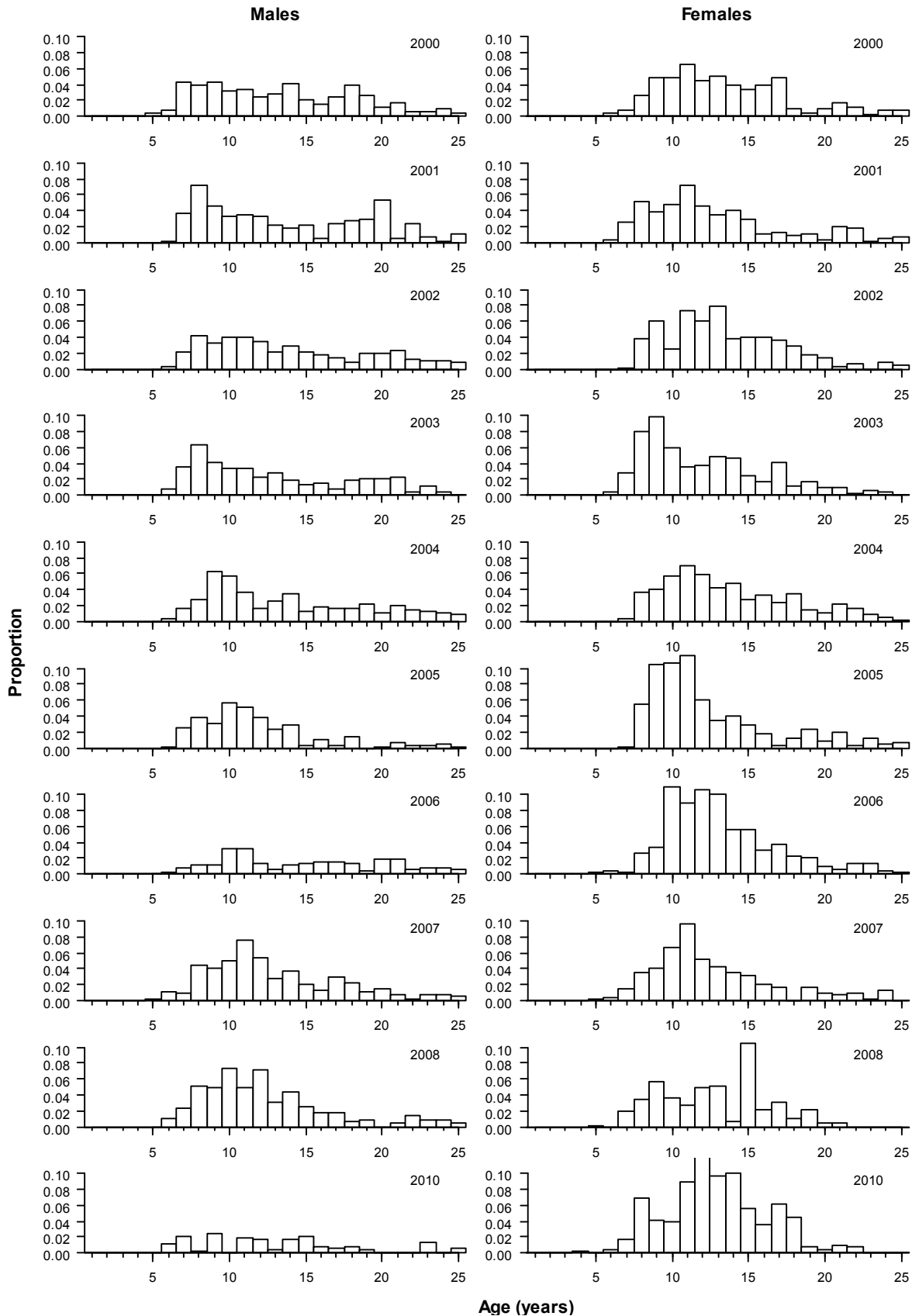


Figure B2: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2013.

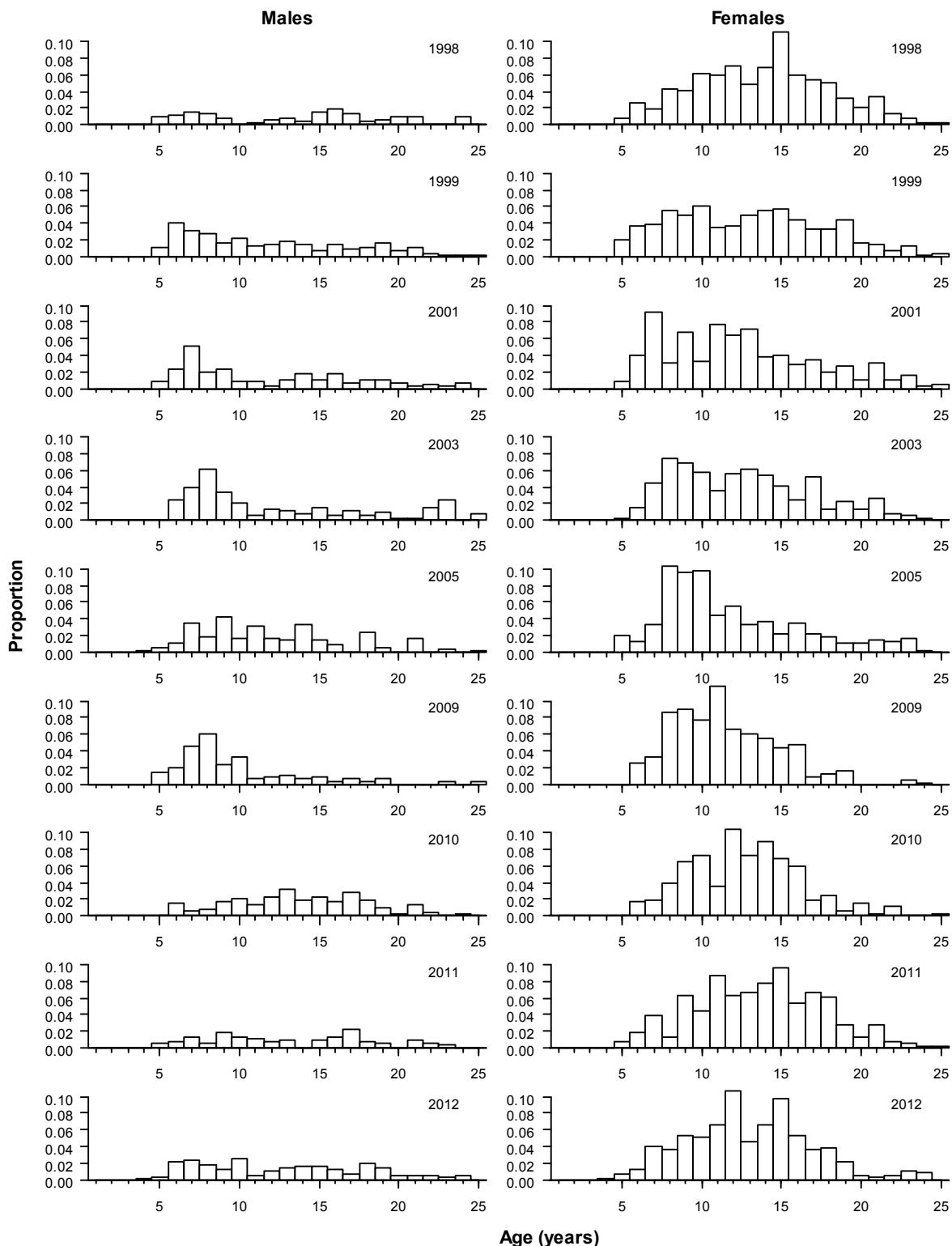


Figure B3: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2013.

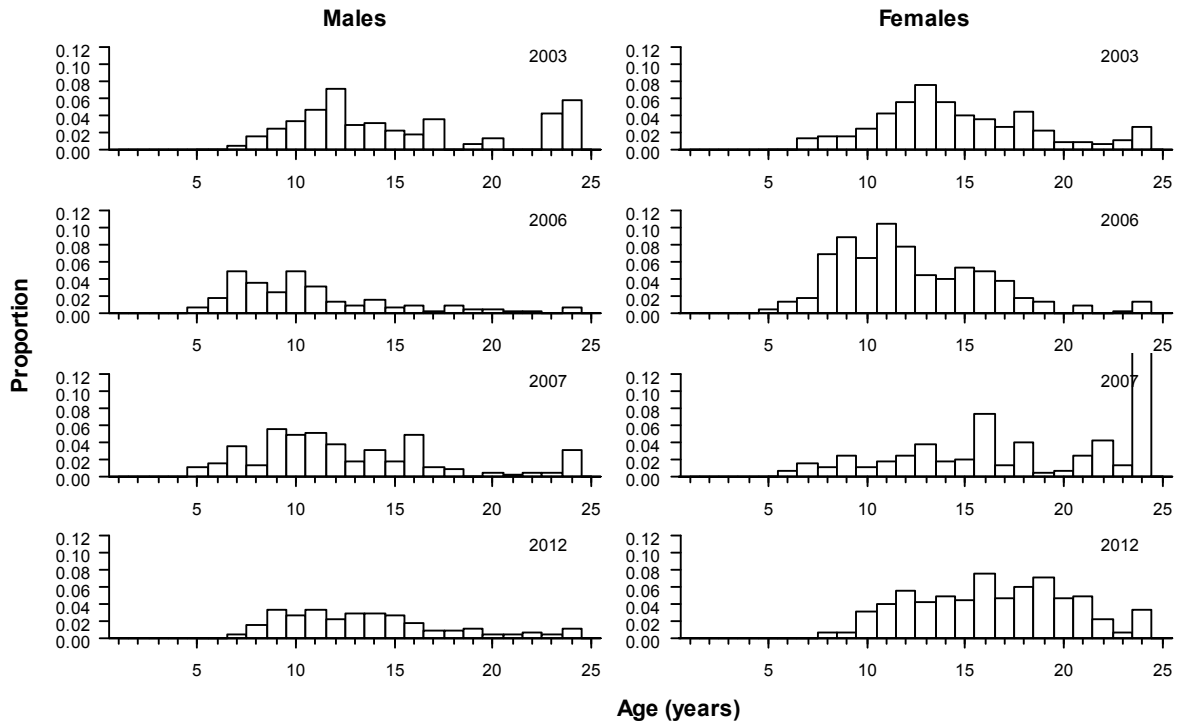


Figure B4: Available age frequencies of ling from commercial catch-at-age data in the west coast South Island line fishery, 2003 to 2013.

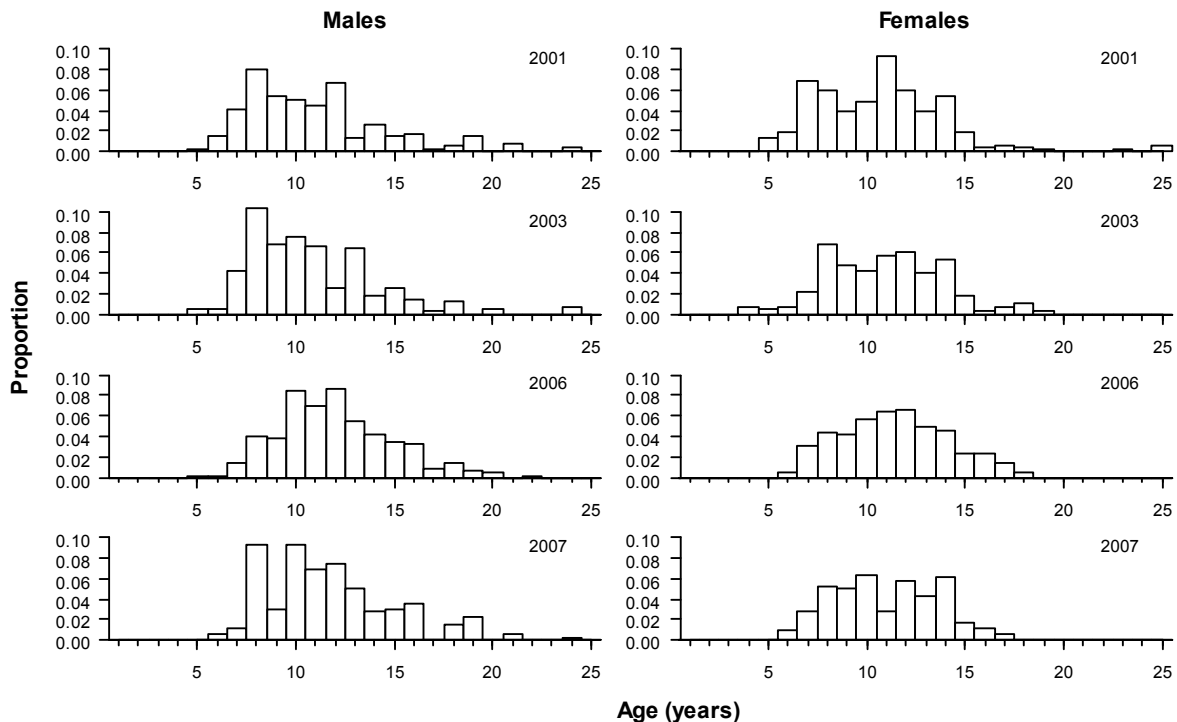


Figure B5: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2001 to 2013.

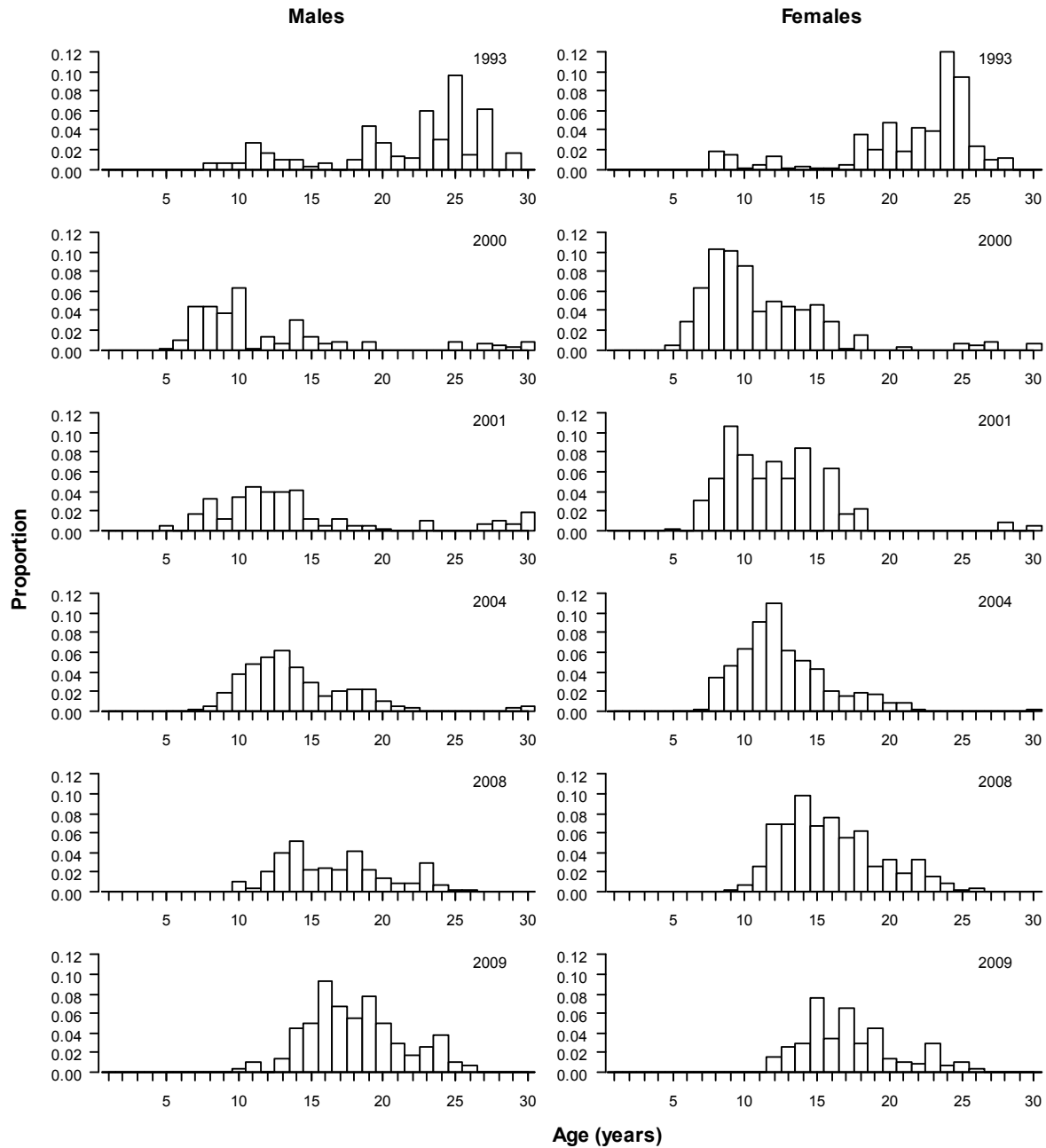


Figure B6: Available age frequencies of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2013.

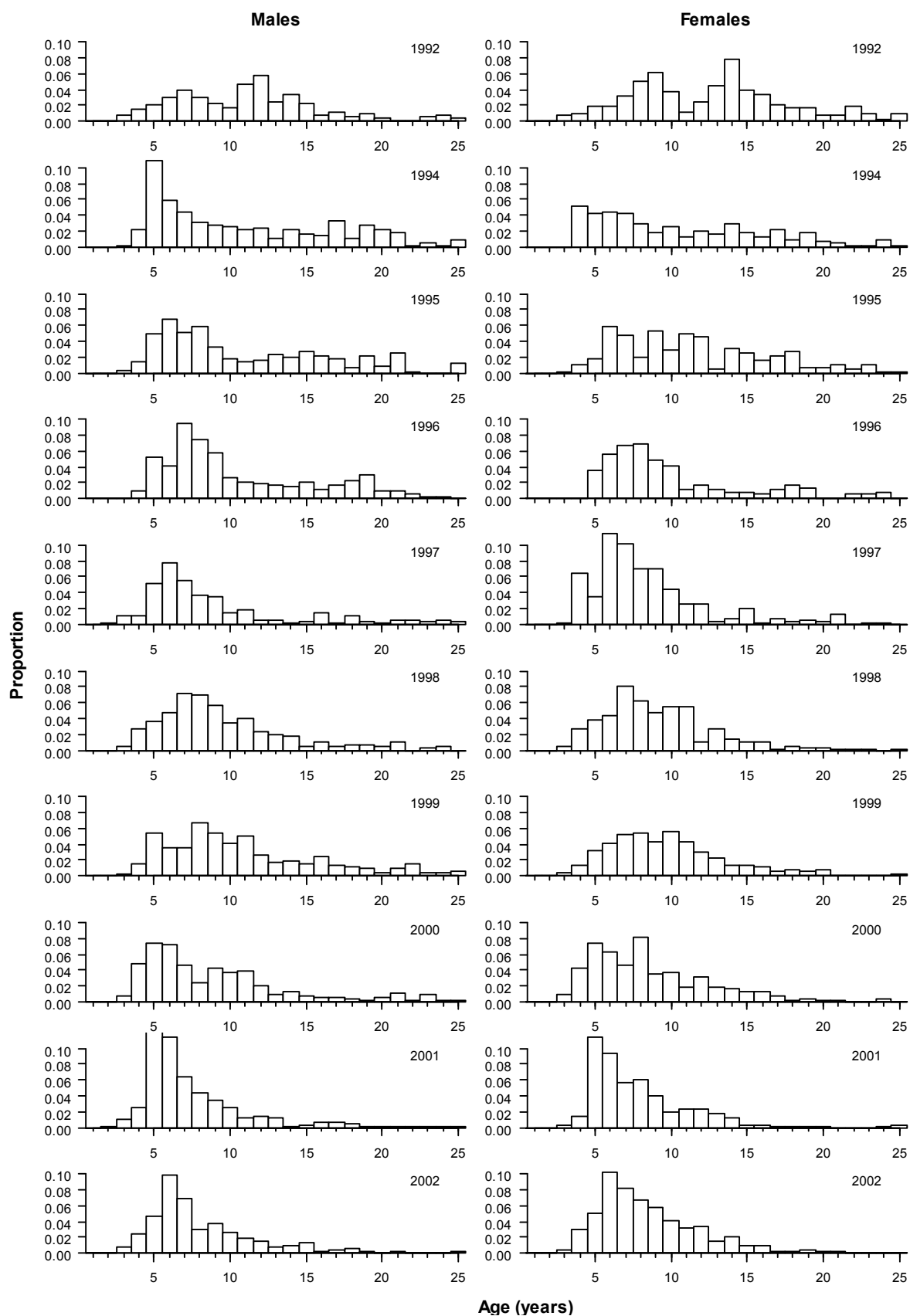


Figure B7: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2013. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–May 2002 sample.

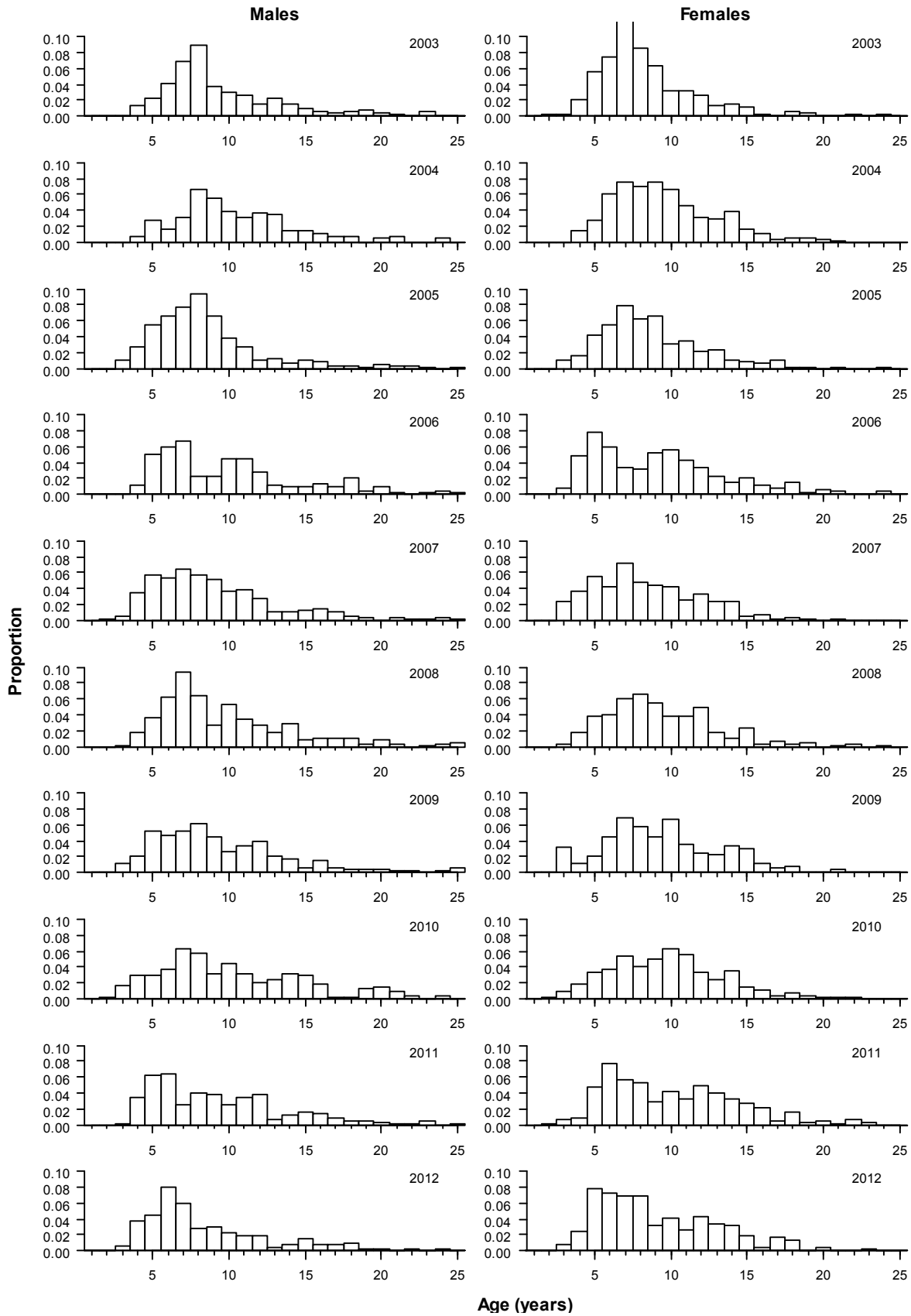


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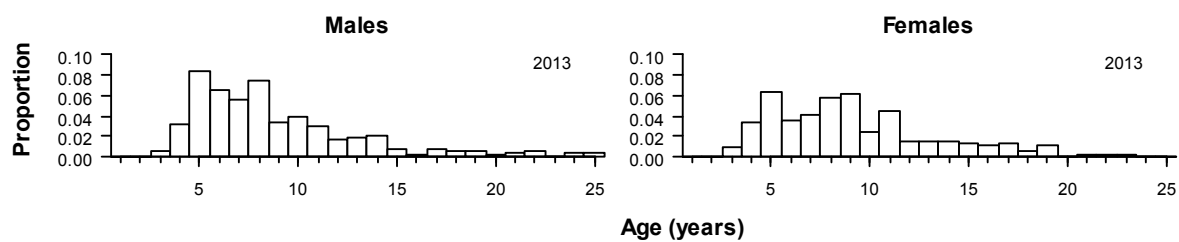


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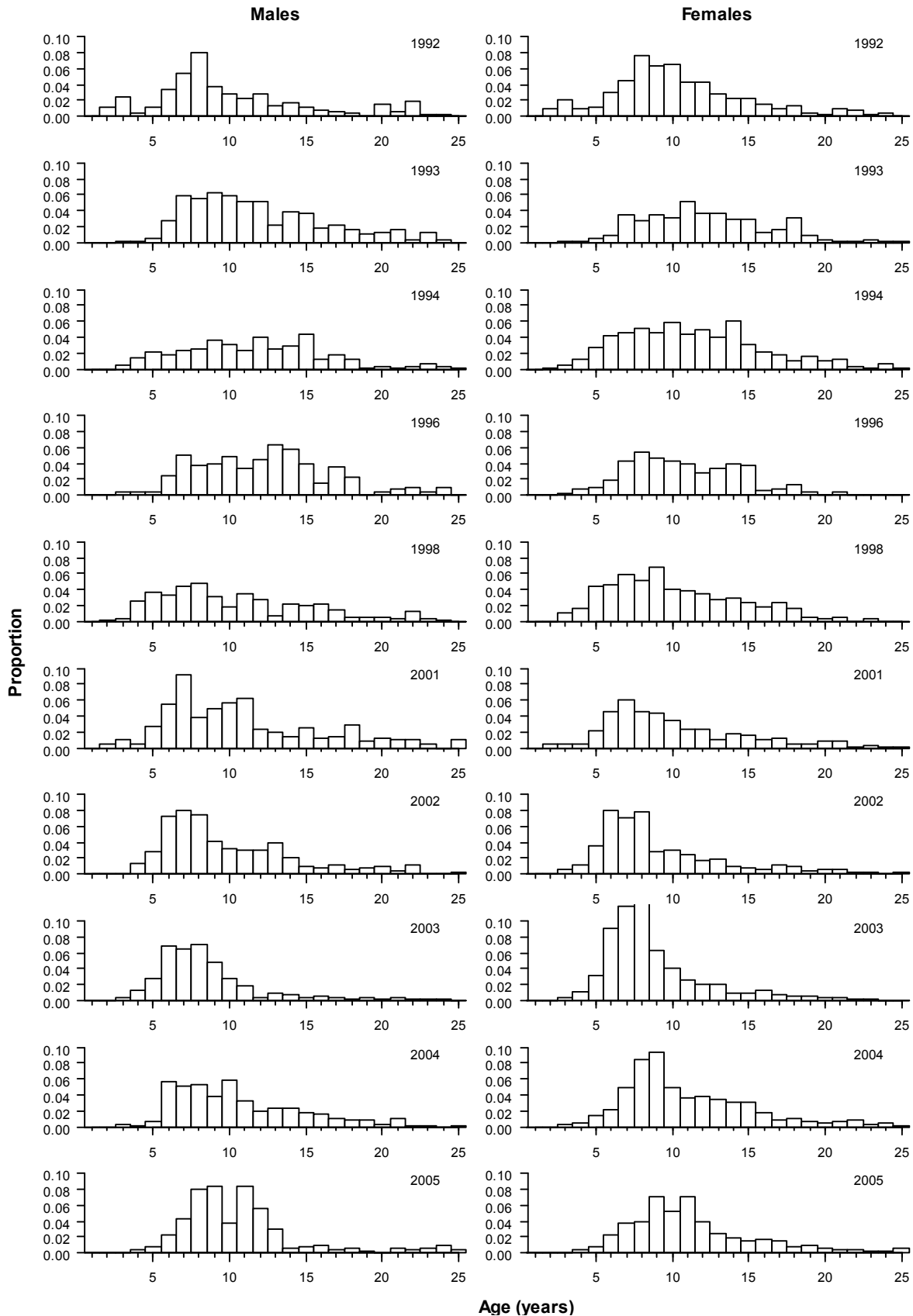


Figure B8: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2013. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2005” denotes the September 2004–April 2005 sample.

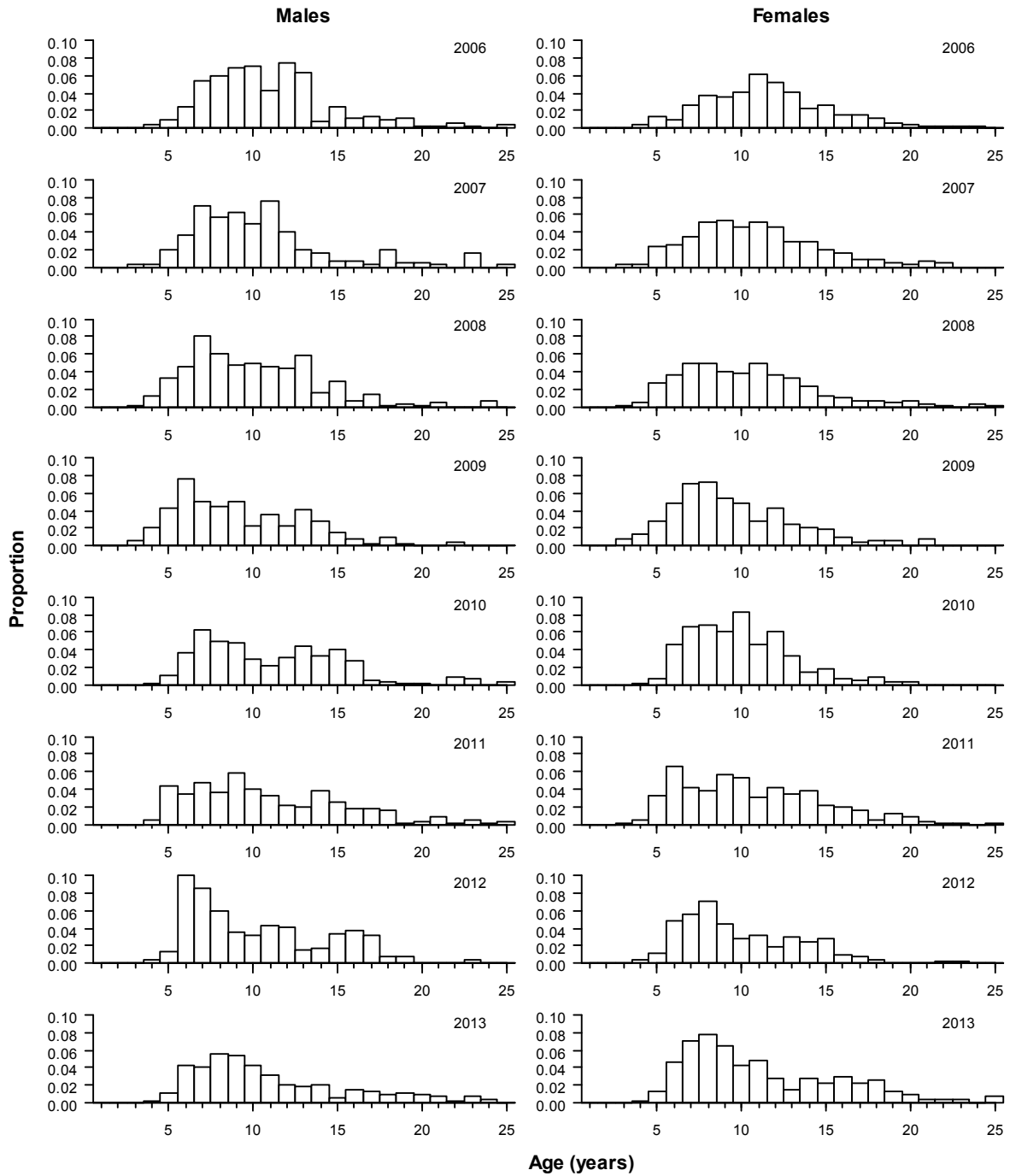


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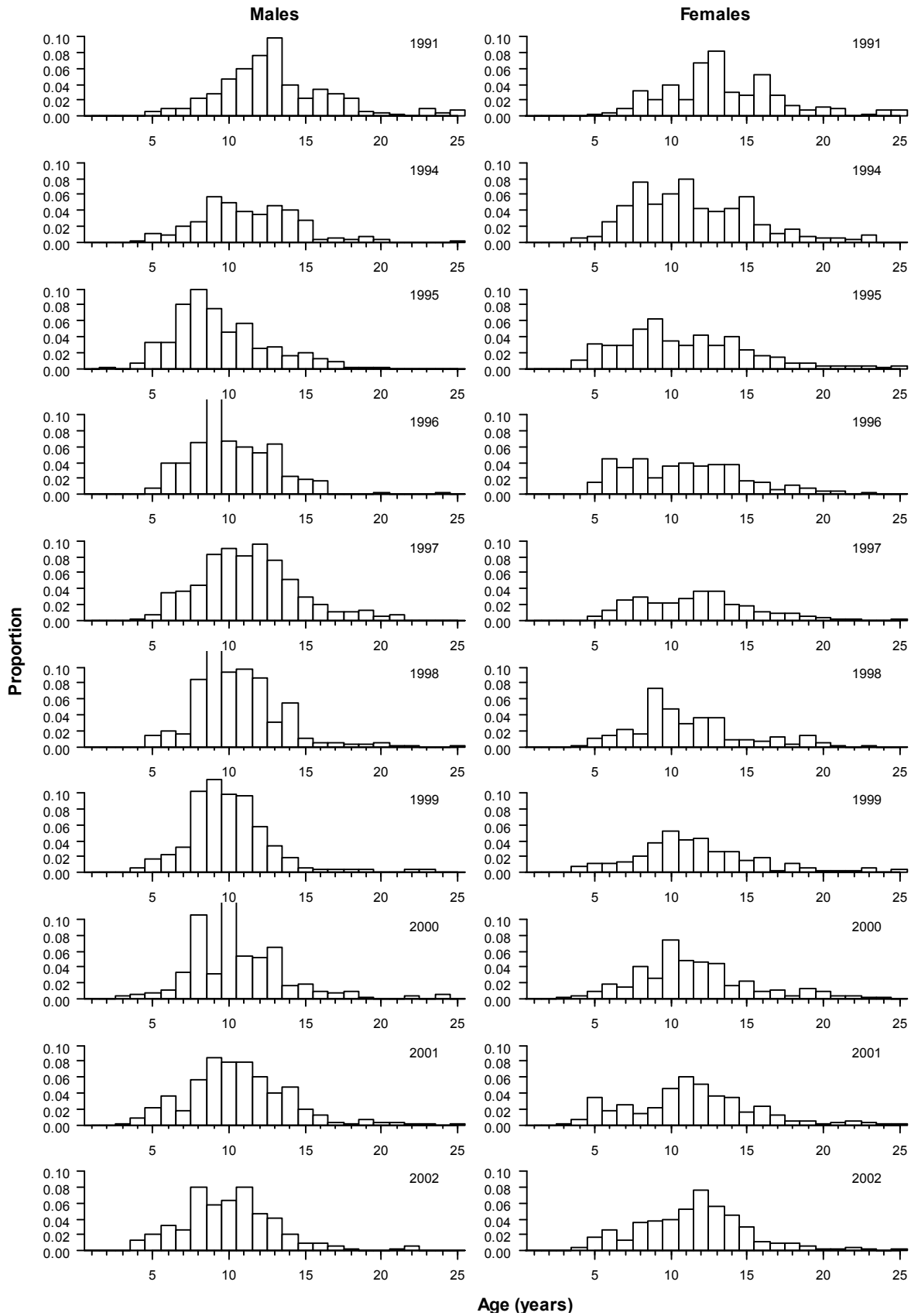


Figure B9: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2013.

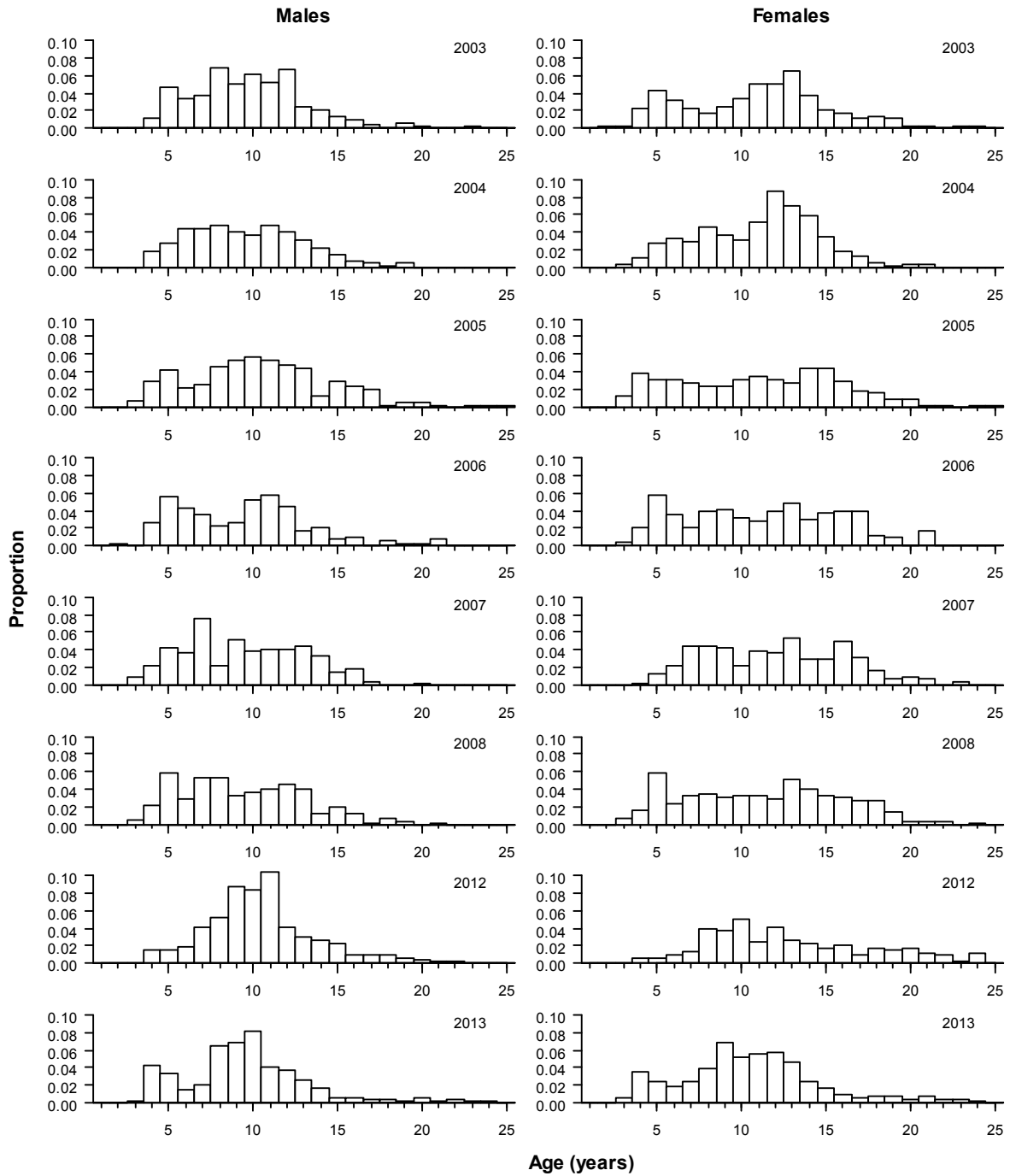


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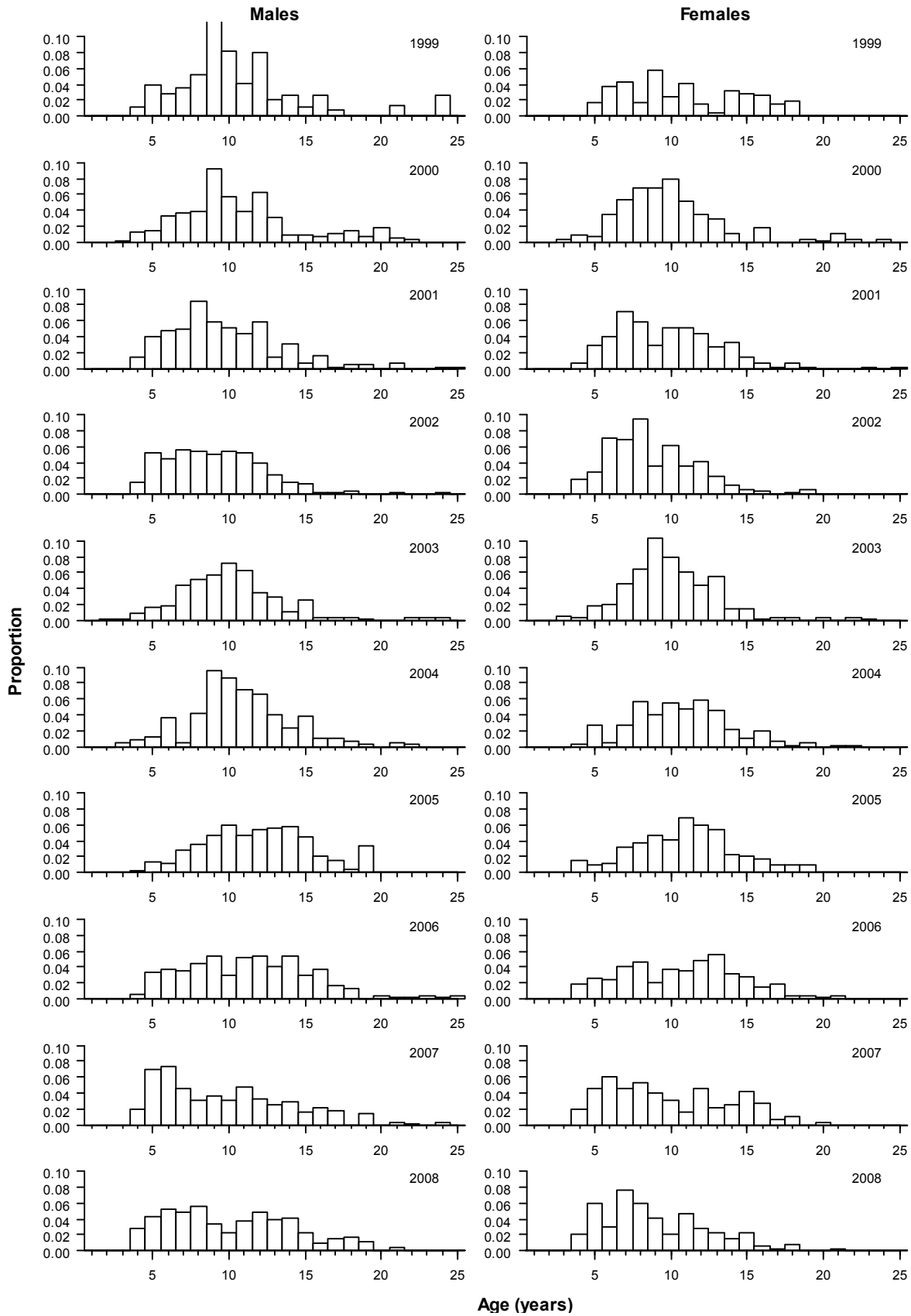


Figure B10: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2013.

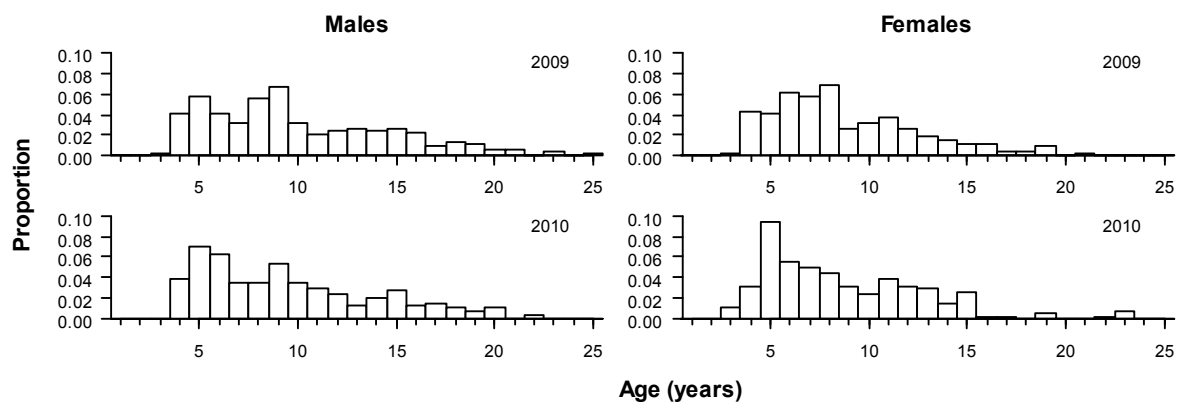


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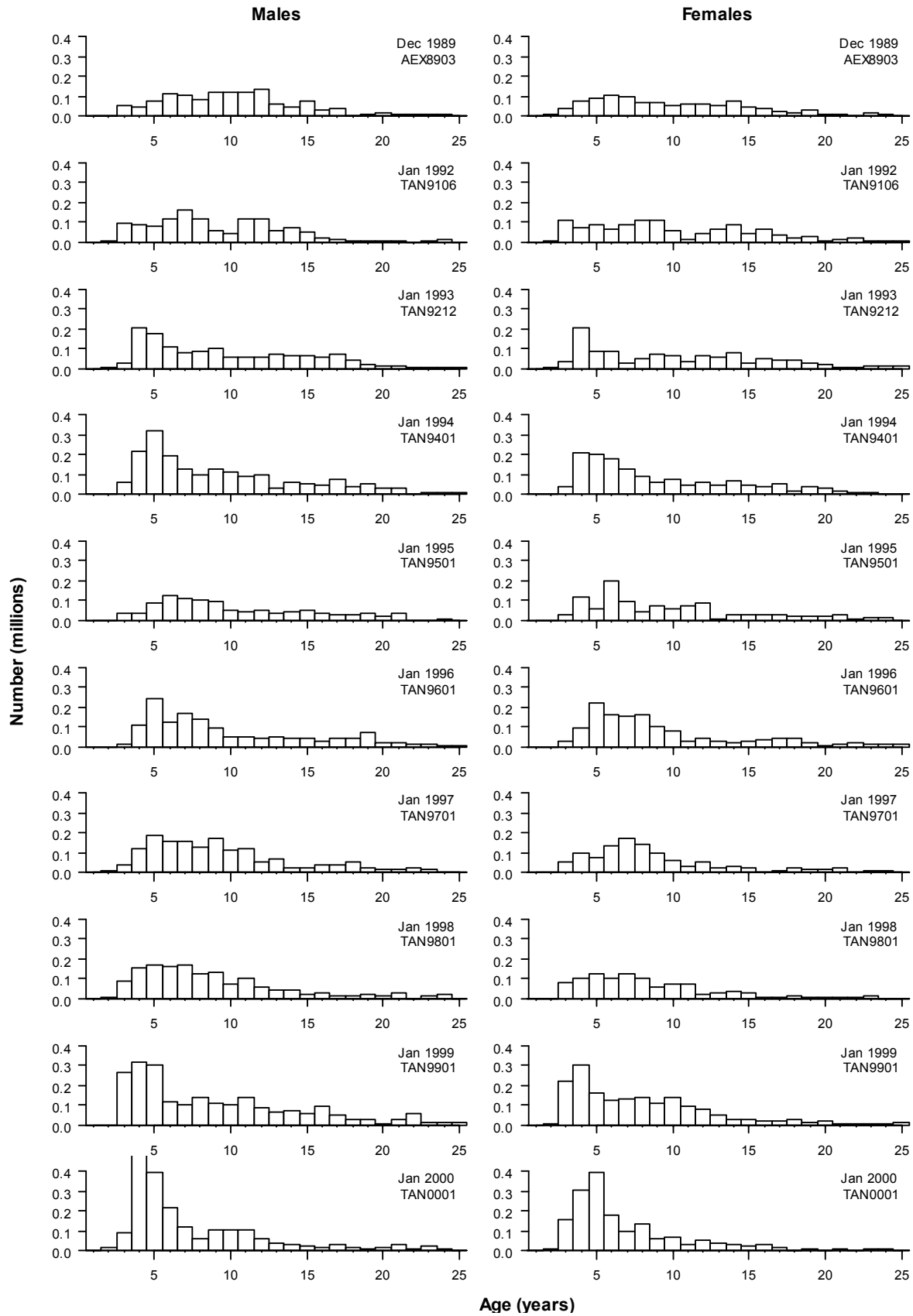


Figure B11: Available age frequencies of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2013–14.

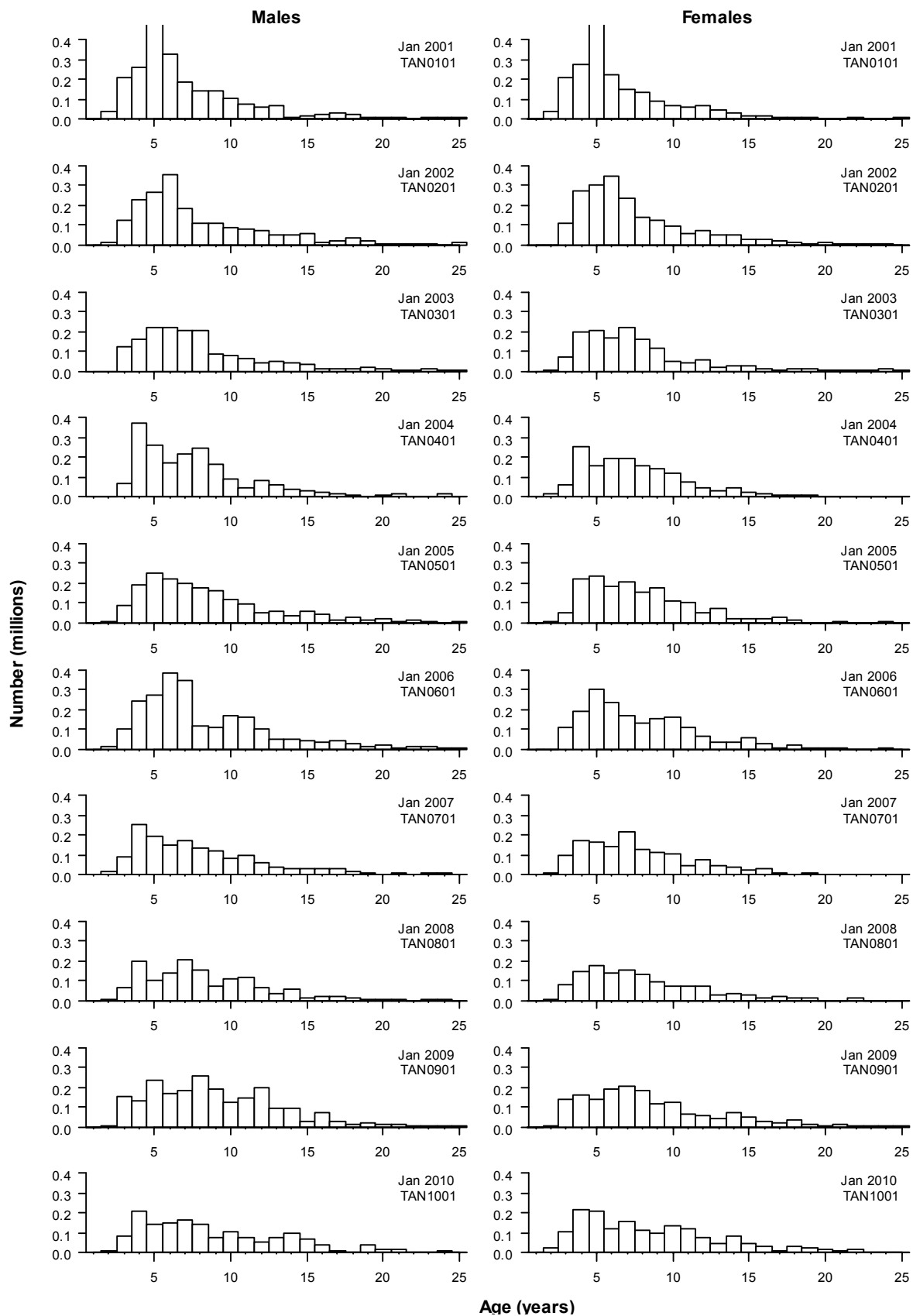


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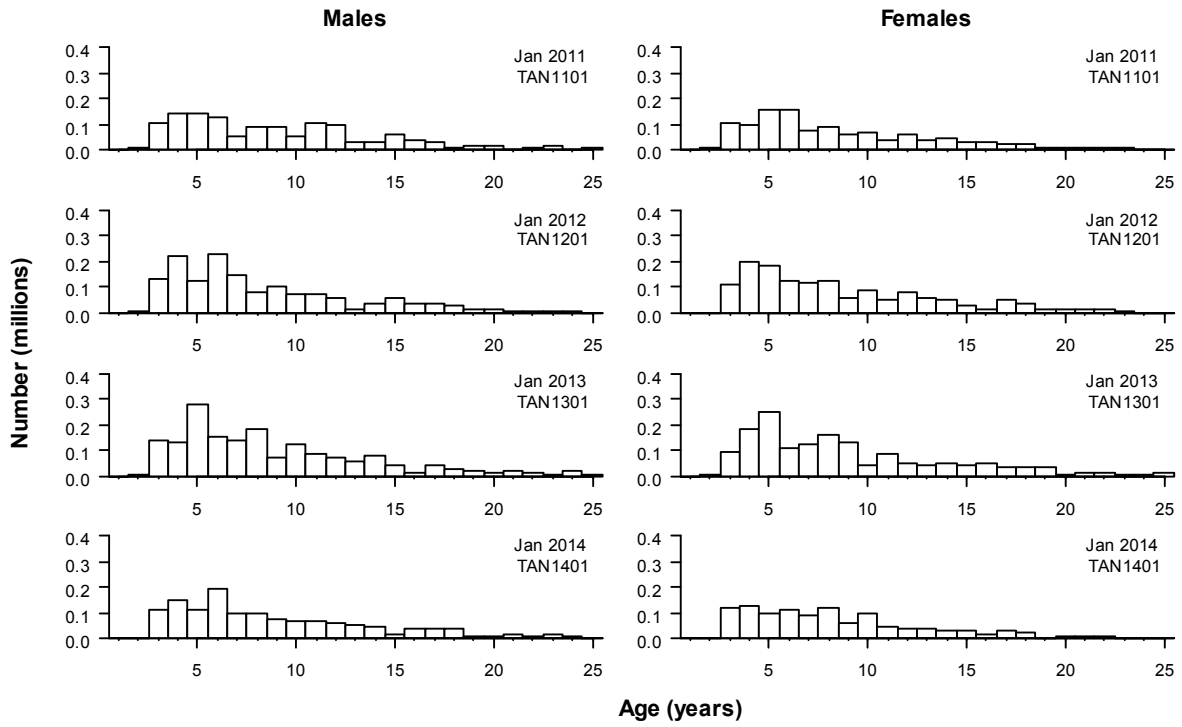


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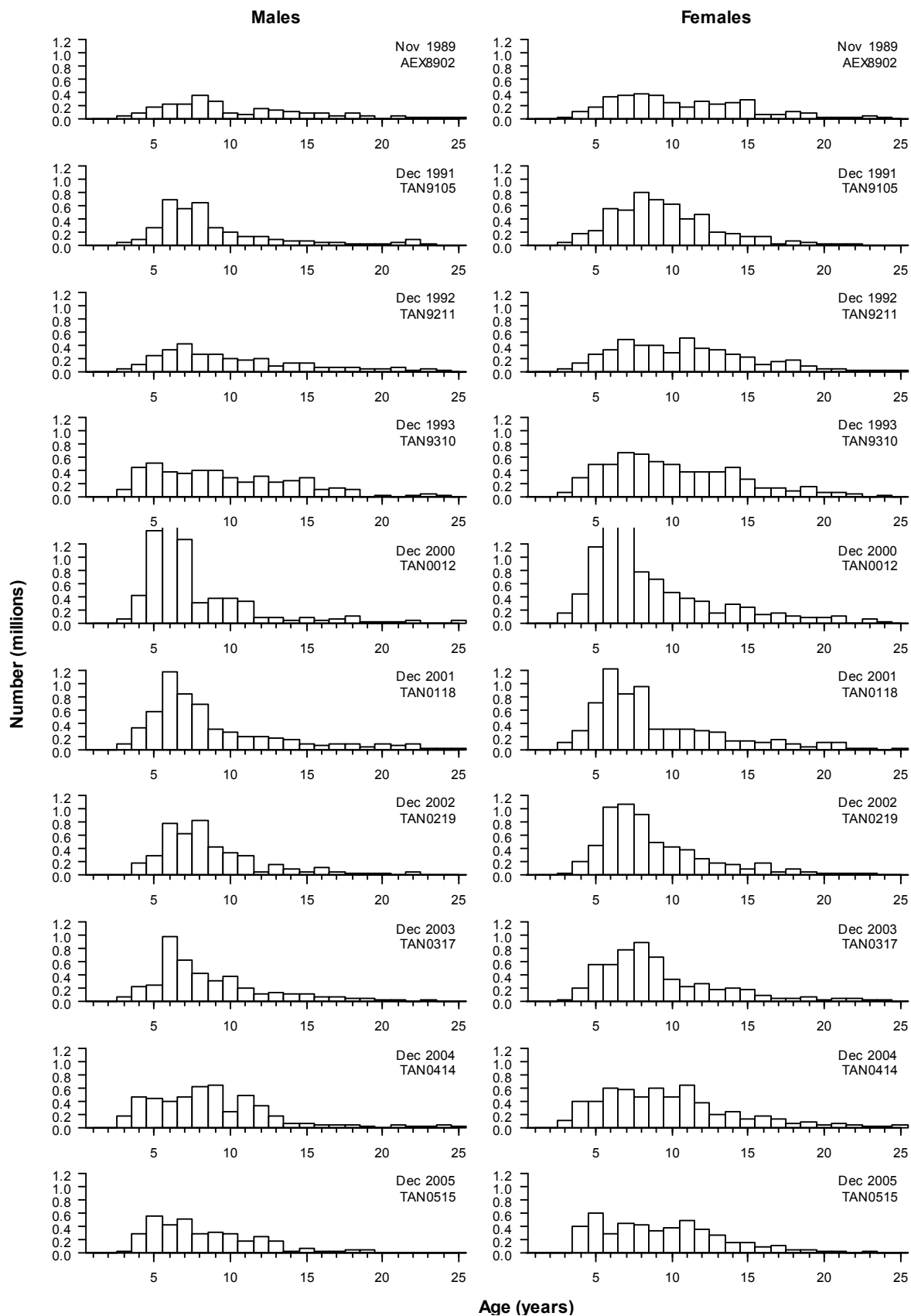


Figure B12: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2013.

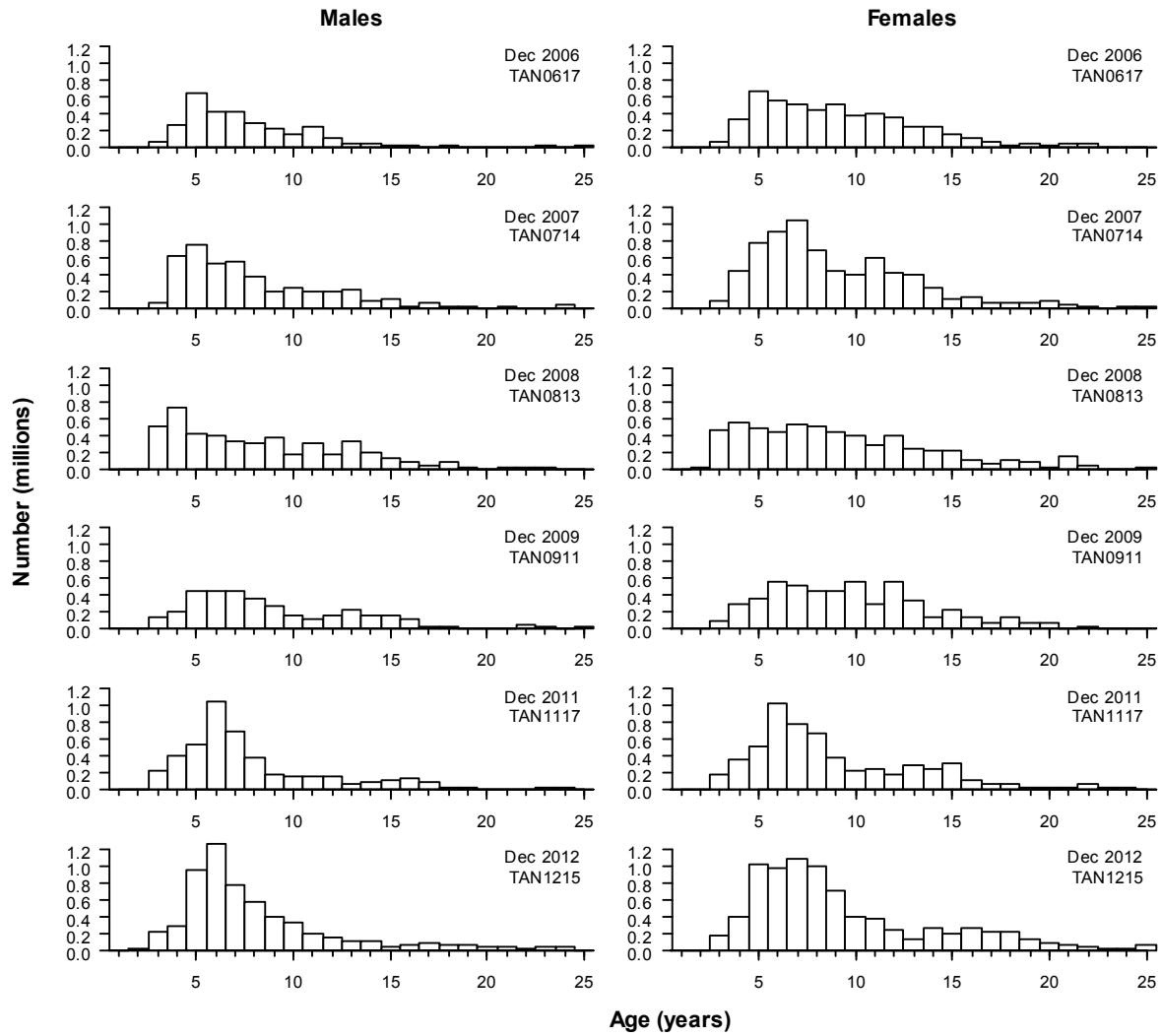


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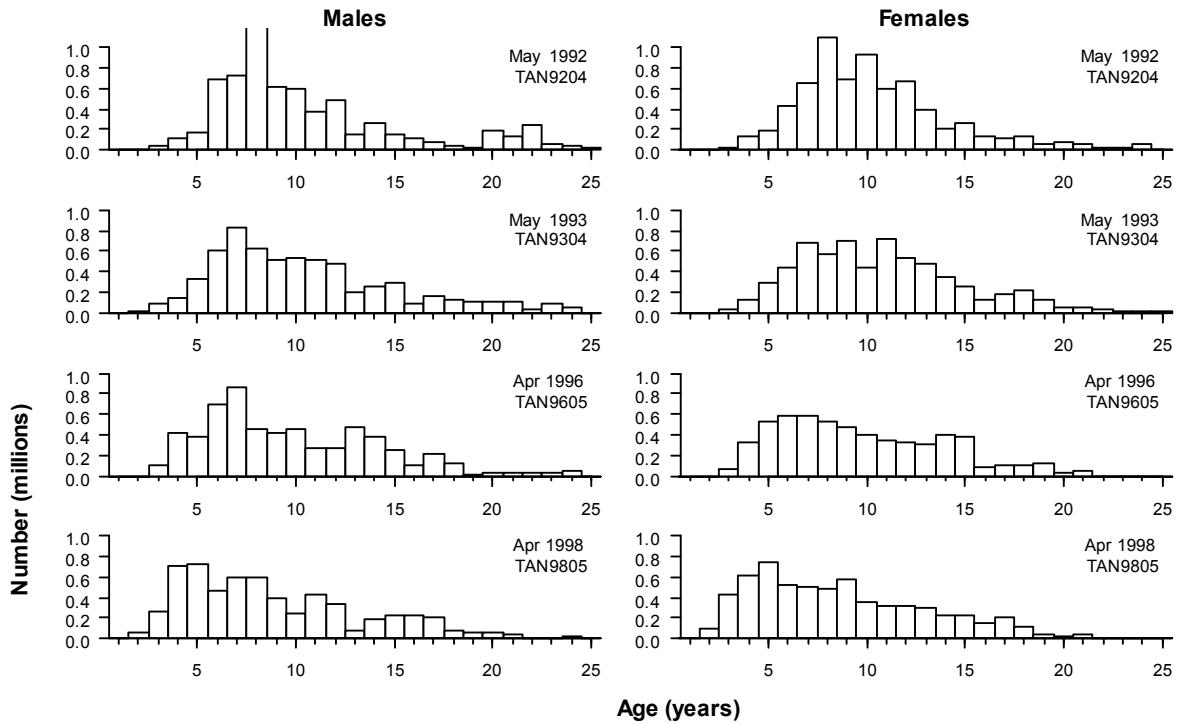


Figure B13: Available age frequencies of ling (ages 1 to 25) from autumn resource surveys in the Sub-Antarctic, 1992 to 1998.

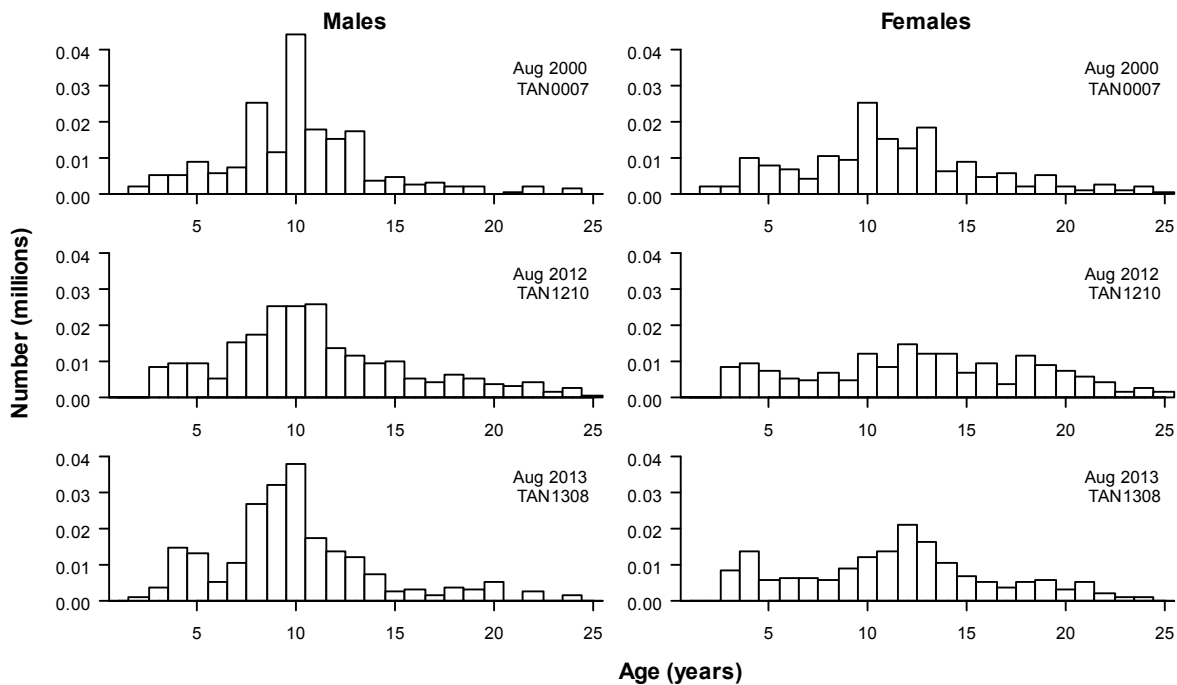


Figure B14: Available age frequencies of ling (ages 1 to 25) from winter resource surveys off WCSI, 2000 to 2013.