



# Fisheries New Zealand

Tini a Tangaroa

Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2016–17 fishing year and from a research trawl survey in 2018, with a summary of all available data sets from the New Zealand EEZ

New Zealand Fisheries Assessment Report 2019/12

P.L. Horn  
C.P. Sutton

ISSN 1179-5352 (online)  
ISBN 978-1-98-859446-0 (online)

April 2019



Requests for further copies should be directed to:

Publications Logistics Officer  
Ministry for Primary Industries  
PO Box 2526  
WELLINGTON 6140

Email: [brand@mpi.govt.nz](mailto:brand@mpi.govt.nz)  
Telephone: 0800 00 83 33  
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:  
<http://www.mpi.govt.nz/news-and-resources/publications>  
<http://fs.fish.govt.nz> go to Document library/Research reports

**© Crown Copyright – Fisheries New Zealand**

## Table of Contents

EXECUTIVE SUMMARY	1
1. INTRODUCTION	2
2. METHODS	2
3. RESULTS	4
3.1 Observer catch-at-age data from hake trawl fisheries	4
3.1.1 Chatham Rise	4
3.1.2 Sub-Antarctic	5
3.1.3 West coast South Island (WCSI)	8
3.2 Trawl survey catch-at-age data for hake	10
3.2.1 Chatham Rise	10
3.2.2 Sub-Antarctic	12
3.2.3 West coast South Island	13
3.3 Observer catch-at-age data from ling longline fisheries	14
3.3.1 Chatham Rise	14
3.3.2 Sub-Antarctic	16
3.3.3 West coast South Island	18
3.3.4 Cook Strait	19
3.3.5 Bounty Plateau	19
3.4 Observer catch-at-age data from ling trawl fisheries	20
3.4.1 Chatham Rise	20
3.4.2 Sub-Antarctic	22
3.4.3 West coast South Island	24
3.4.4 Cook Strait	26
3.5 Trawl survey catch-at-age data for ling	28
3.5.1 Chatham Rise	28
3.5.2 Sub-Antarctic	29
3.5.3 West coast South Island	30
4. DISCUSSION	31
4.1 Hake	31
4.2 Ling	32
4.3 Observer sampling	33
5. ACKNOWLEDGMENTS	33
6. REFERENCES	33
Appendix A: Summaries of the proportions-at-age data for hake	35
Appendix B: Summaries of the proportions-at-age data for ling	51
Appendix C: Observer sampling of hake from the Sub-Antarctic in 2016–17	75



## EXECUTIVE SUMMARY

**Horn, P.L.; Sutton, C.P. (2019). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2016–17 fishing year and from a research trawl survey in 2018, with a summary of all available data sets from the New Zealand EEZ.**

*New Zealand Fisheries Assessment Report 2019/12. 76 p.*

This report describes catch-at-age distributions for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) estimated from commercial fisheries for these species in the 2016–17 fishing year (using data and otoliths collected at sea by observers), and from a research trawl survey of middle depth species on the Chatham Rise in January 2018 (TAN1801). 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 two commercial fisheries (west coast South Island, and Sub-Antarctic), but there were insufficient data to estimate catch-at-age for either the eastern or western Chatham Rise commercial trawl fishery. Catch-at-age for the January 2018 trawl survey of Chatham Rise was also estimated, but the estimated CV (49%) exceeded the target CV.

For ling, the target CV was met for the commercial trawl fisheries from west coast South Island, Chatham Rise, and the Sub-Antarctic, and for the Chatham Rise trawl survey, but there were insufficient data collected to estimate catch-at-age for the 2016 Cook Strait commercial trawl fishery. Catch-at-age was also estimated and the target CV was met for the ling longline fishery on Chatham Rise in 2015–16 and 2016–17. A catch-at-age distribution for the Sub-Antarctic spawning longline fishery was also produced, and the target CV was almost met.

Where target CVs were not met, it was not possible to improve the precision by reading more otoliths (i.e., increasing the sample size), because all available data and otoliths were used in the analyses. We recommend that observer sampling for ling and hake is focused on areas and months needed for existing catch-at-age time-series. 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 2016–17 fishing year, and for hake and ling from a research trawl survey conducted in January 2018. Catch-at-age data are a vital input for 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 extended existing series of catch-at-age data in all cases. It fulfils the reporting requirements for hake and ling in Objective 1 of Project MID201701 “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 2016–May 2017 [650].
- HAK 4 — commercial trawl fishery, Oct 2016–Apr 2017 [650].
- HAK 4 — trawl survey, Jan 2018 (project MID2017-02) [650].
- HAK 7 — commercial trawl fishery, Jun–Sep 2017 [650].

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 2016 [550].
- LIN 3&4 — commercial trawl fishery, Chatham Rise, Oct 2016–May 2017 [600].
- LIN 3&4 — trawl survey, Chatham Rise, Jan 2018 (project MID2017-02) [600].
- LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2016, and non-spawning, Campbell, Feb–Jul 2017 [500 per fishery].
- LIN 7 — commercial trawl fishery, Jun–Sep 2017 [700].
- LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2017 [500].

Insufficient or no observer otoliths were available from the ling longline non-spawning fishery on Sub-Antarctic (LIN 5&6), and also from the winter 2017 Cook Strait trawl fishery (LIN 7&2), so catch-at-age distributions were not able to be produced for those fisheries. There was also insufficient data available from the Chatham Rise (HAK 4) trawl fishery.

The following additional commercial fishery catch-at-age distribution for ling was estimated using an age-length key derived previously from the December 2016 Sub-Antarctic trawl survey (LIN 5&6).

- LIN 5&6 — commercial trawl fishery, Sub-Antarctic, Sep 2016–Apr 2017.

A catch-at-age model describing the age structure of each of the commercial fisheries and surveyed areas was developed as in previous years (most recently by Horn & Sutton 2017) 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 distribution (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. 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 relative biomass available to the trawl in the survey area.

In some instances, trawl surveys occurred around the middle of the periods sampled for commercial fishery catch-at-age (e.g., the January Chatham Rise trawl survey occurred in the middle of the October–April hake trawl fishery and the October–May ling trawl fishery). Consequently, where a survey occurred during a fishery, catch-at-age distributions for the fisheries were estimated using age-length keys developed for the relevant survey. It is sometimes necessary, however, to age some additional fish from the trawl fisheries to cover length-sex combinations that were inadequately sampled by the survey. Such additional samples seldom comprise more than 120 otoliths.

The target mean weighted CV for hake from trawl surveys was often not met. To maximise the chances of meeting the target, all hake from the trawl shots used for 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

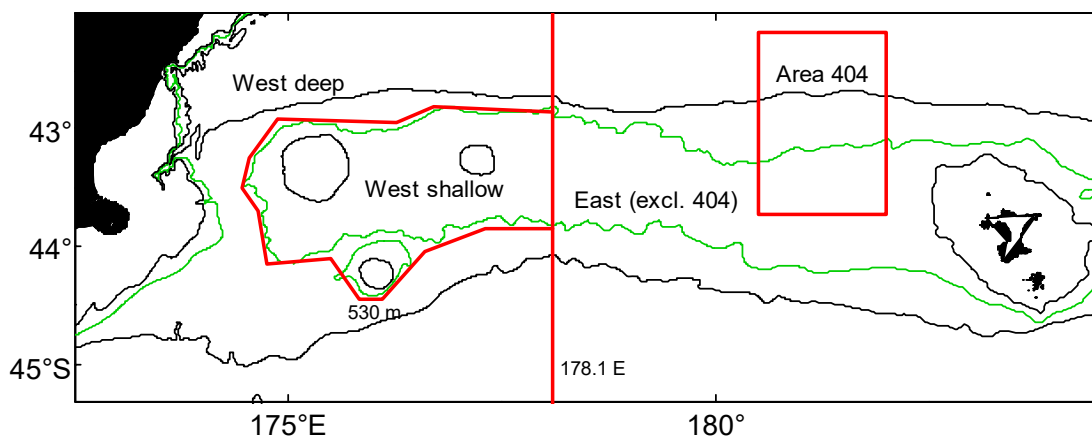
##### 3.1.1 Chatham Rise

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, 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, each with two strata), rather than four fisheries was statistically satisfactory. Consequently, two commercial age frequencies were developed for each year since the start of this series (whenever sufficient data were available) using a single age-length key and two areas 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 (black), 500 (green), and 250 m (black) 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 2016–17 fishing year, insufficient length data were available from both the western ( $n = 70$ ) and eastern ( $n = 90$ ) strata to calculate catch-at-age distributions.

Estimated proportion-at-age distributions for all years 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 from 1991–92 to 2016–17. The number of tows sampled by observers and the estimated mean weighted CV (%) by age are also listed. Values in italics (and where Tows and CV columns are blank) indicate that insufficient length-frequency 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	<i>142</i>	<i>199</i>			181	217
1994–95	318	603	69	32.8	234	88	14	43.1	170	191
1995–96	802	917	103	28.2	250	<i>120</i>			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	78	<i>148</i>			290	440
1999–2000	807	901	168	19.0	<i>101</i>	<i>67</i>			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	<i>175</i>	78			455	419
2002–03	176	272	61	25.4	<i>34</i>	<i>24</i>			256	345
2003–04	597	438	101	26.8	378	92	38	26.6	364	304
2004–05	896	437	82	24.2	59	66			391	343
2005–06	234	330	69	39.1	24	20			189	255
2006–07	66	82			409	278	47	27.6	368	388
2007–08	286	270	53	20.6	71	69			350	335
2008–09	257	162	43	24.3	39	25			237	185
2009–10	147	259	38	25.6	23	14			228	244
2010–11	202	249	46	34.3	50	83			199	251
2011–12	6	8			3	3			0	0
2012–13	<i>84</i>	<i>64</i>			99	78			0	0
2013–14	213	221	37	29.5	49	59			150	145
2014–15	<i>106</i>	<i>142</i>			249	273	33	28.6	91	132
2015–16	307	303	36	28.7	41	42			250	209
2016–17	17	53			35	55			0	0

### 3.1.2 Sub-Antarctic

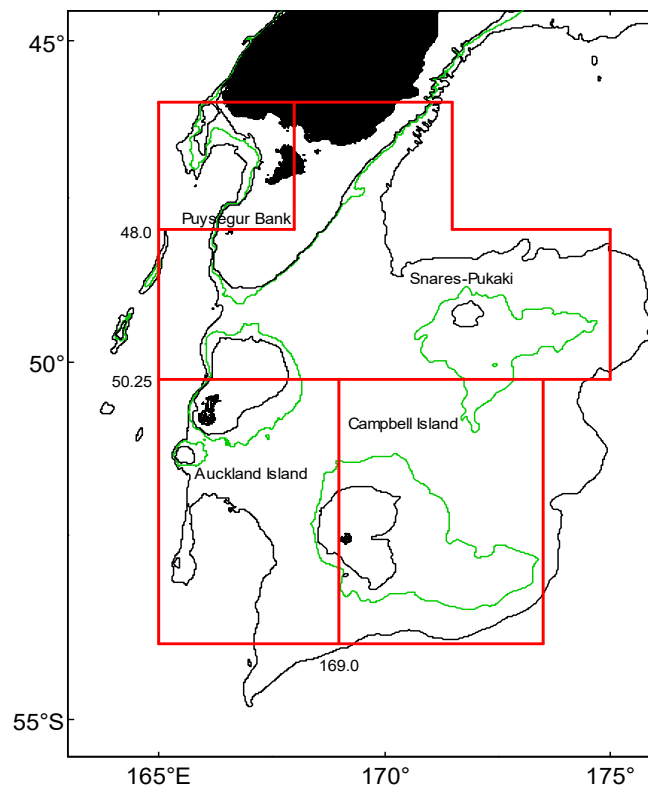
There was one major and three very minor hake fisheries in the Sub-Antarctic area, so a single fishery ogive was used in assessments of this stock. A commercial age frequency was developed using a single age-length key and the four fishery strata shown in Figure 2 (determined by Horn (2008b)), and defined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

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

A tow was included in the catch-at-age analysis if it occurred between 1 September and 31 March, 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 there were sufficient otoliths (n about 400) 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.

Ballara & O’Driscoll (2018) showed that the observer sampling of the Sub-Antarctic hoki fishery in 2016–17 was poorly representative of the fishery, and consequently the hoki catch-at-age data were not used in the hoki stock assessment. Because hake is a major bycatch of the hoki fishery, an analysis was conducted here to establish whether the sampling of hake from the same area and fishing year was adequate (Appendix C). Reported landings of hake from the Sub-Antarctic stock area were compared with landings sampled for hake by observers and concluded that observer sampling of the hake fishery in 2016–17 was adequate. Details of the estimated catch-at-age distribution for trawl-caught hake in the 2016–17 fishing year are in Table 3. The mean weighted CV of 23% was lower than 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 (red lines). Numbers show latitudes and longitudes of fishery boundaries. Isobaths at 1000 (black), 500 (green), and 250 (black) m are also shown.**

**Table 2: Numbers of measured male and female hake, numbers of fish aged and used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic trawl fishery. –, no data.**

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
2015–16	2 125	217	931	166	64	26.4
2016–17	2 409	203	777	143	67	23.2

**Table 3: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations in the Sub-Antarctic, September 2016 – May 2017. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
4	116	0.788	5	1.818
5	7 405	0.212	103	0.724
6	10 373	0.241	2 077	0.403
7	21 295	0.171	2 783	0.270
8	17 492	0.199	4 548	0.237
9	18 788	0.185	5 465	0.293
10	7 980	0.322	2 268	0.339
11	8 199	0.300	2 134	0.366
12	7 095	0.309	2 265	0.477
13	4 854	0.364	805	0.571
14	2 691	0.579	431	0.715
15	0	–	536	0.763
16	1 269	0.743	987	0.512
17	0	–	0	–
18	535	1.070	0	–
19	463	0.928	0	–
20	559	1.110	0	–
21	981	0.756	616	1.486
22	0	–	0	–
23	874	1.147	0	–
24	0	–	0	–
25	0	–	210	1.397
Measured males			2 409	
Measured females			777	
Aged males			203	
Aged females			143	
No. of tows sampled			67	
Mean weighted CV (% , sexes pooled)			23.2	

### 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° S).
3. South shallow (bottom depth  $<$  629 m, latitude  $\geq$  42.55° S).

A tow was included in the catch-at-age analysis if it occurred between 1 June and 30 September, and if at least five hake 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 2016–17 fishing year are in Table 5. The mean weighted CV of 13% was much lower than the target of 30%.

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

**Table 4: Numbers of measured 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
2015–16	5 304	461	4 589	449	240	13.2
2016–17	9 019	363	6 572	382	362	13.3

**Table 5: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations off the WCSI, June–September 2017. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
1	2 579	1.636	1 332	1.603
2	15 517	0.348	17 469	0.212
3	2 587	0.307	1 573	0.432
4	9 278	0.393	1 080	0.588
5	118 171	0.107	22 281	0.245
6	199 510	0.094	88 736	0.110
7	148 349	0.106	99 658	0.108
8	56 420	0.189	63 423	0.132
9	32 714	0.247	39 961	0.172
10	17 063	0.370	13 961	0.278
11	27 323	0.236	9 850	0.322
12	7 981	0.457	12 099	0.290
13	7 890	0.491	9 039	0.313
14	6 619	0.453	3 112	0.592
15	3 035	0.651	755	0.657
16	3 999	0.743	901	1.244
17	6 557	0.580	2 901	0.690
18	7 511	0.568	0	–
19	1 535	0.858	1 220	1.034
20	489	1.086	1 170	1.099
21	4 111	0.592	0	–
Measured males			9 019	
Measured females			6 572	
Aged males			363	
Aged females			4382	
No. of tows sampled			362	
Mean weighted CV (% , sexes pooled)			13.3	

## 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 additional deeper strata (800–1300 m) were 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. The 30% target was met in only one of the 20 surveys (TAN9106, see Table 6). The details of the estimated catch-at-age distribution for hake caught in the January 2018 trawl survey are given in Table 7. The mean weighted CV of 49% did not meet the target of 30%.

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

**Table 6: Numbers of measured male and female hake (used to calculate the catch-at-length and catch-at-age), age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age, for the Chatham Rise trawl surveys. Number of aged fish exceeds the number measured in some years, because hake caught outside the core trawl survey area were also aged.**

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
TAN1801	111	143	107	115	34	49.4

**Table 7: Calculated numbers-at-age in the survey area, separately by sex, with CVs, for hake caught during a trawl survey of Chatham Rise in January 2018 (survey TAN1801). Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
3	5 053	0.851	13 315	0.718
4	14 274	0.597	16 569	0.529
5	18 269	0.580	9 221	0.732
6	17 187	0.532	8 152	0.585
7	8 465	0.609	12 353	0.585
8	13 083	0.507	27 079	0.370
9	14 218	0.516	1 910	1.022
10	4 426	0.686	424	1.995
11	3 001	0.949	5 824	0.663
12	6 138	0.671	11 939	0.539
13	5 941	0.697	9 618	0.549
14	5 929	0.997	8 780	0.632
15	2 376	0.815	10 639	0.576
16	661	1.289	3 949	0.873
17	1 220	1.111	4 729	0.763
18	0	–	2 825	0.921
19	1 602	1.605	4 034	0.971
20	1 602	1.562	432	1.604
21	0	–	3 084	1.165
22	1 385	1.253	0	–
23	0	–	0	–
24	0	–	0	–
25	0	–	0	–
26	0	–	518	1.541
Measured males				111
Measured females				107
Aged males				143
Aged females				115
No. of tows sampled				34
Mean weighted CV (% , sexes pooled)				49.4

### 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 area. 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 were 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. A catch-at-age distribution was not produced for the survey conducted in December 2016 (TAN1614) as only 33 hake were caught and it was not believed that they adequately represented the population. There was no survey of this area conducted in December 2017.

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 (used to calculate the catch-at-length and catch-at-age), numbers of fish aged and used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age for the Sub-Antarctic trawl surveys. —, no data.**

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
TAN1614	1	0	32	0	15	—
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 area. A combined trawl and acoustic survey by *Tangaroa* in winter 2000 (O’Driscoll et al. 2004) was replicated (with some modifications) in 2012 (O’Driscoll et al. 2014), 2013 (O’Driscoll et al. 2015), and 2016 (O’Driscoll & Ballara 2018), so a comparable time series of four surveys is available. The relative biomass estimates from the four 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 & Ballara 2018).

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 to estimate a catch-at-age distribution. The age-length keys for the subsequent surveys were derived using otoliths collected during those surveys. No survey of this area was conducted in winter 2017.

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 (used to calculate the catch-at-length and catch-at-age), 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
TAN1609	43	168	71	210	17	59.3

### 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 10 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 2010–2012. Three trips were observed in 2017, and the details of the estimated catch-at-age distribution are given in Table 11. The mean weighted CV of 28% met the target of 30%.

A revised catch-at-age distribution is also presented for the fishery in 2016 (Table 12). This was necessary because additional length data and otoliths from two short trips were discovered after the publication of last year's report. The revised mean weighted CV improved to 22%, and was lower than the target of 30%.

**Table 10: 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
2015	598	179	778	256	3	116	25.1
2016	799	396	722	368	3	152	21.5
2017	855	229	443	248	3	92	28.0

**Table 11: Calculated numbers-at-age, separately by sex, with CVs, for ling sampled by observers during commercial longline operations on Chatham Rise (LIN3&4) in June–October 2017. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
3	166	1.624	0	–
4	0	–	0	–
5	288	1.212	21	2.616
6	445	0.838	619	0.737
7	2 584	0.371	1 483	0.555
8	2 364	0.423	1 628	0.487
9	8 364	0.245	2 900	0.469
10	4 137	0.365	4 938	0.321
11	4 403	0.323	5 314	0.271
12	5 510	0.278	3 934	0.284
13	3 968	0.376	4 822	0.285
14	3 462	0.341	6 340	0.230
15	2 195	0.369	4 042	0.292
16	5 172	0.342	3 489	0.302
17	3 885	0.326	3 714	0.358
18	2 766	0.368	3 367	0.323
19	2 808	0.417	1 431	0.738
20	1 372	0.466	1 550	0.484
21	2 756	0.367	2 101	0.448
22	2 815	0.374	1 430	0.557
23	1 517	0.501	674	0.937
24	1 067	0.563	713	0.716
25	1 192	0.754	4	2.432
26	896	0.760	0	–
27	134	1.255	0	–
28	0	–	0	–
29	445	1.250	200	1.347
30	134	1.351	0	–
31	98	1.575	0	–
32	0	–	0	–
33	0	–	0	–
34	0	–	0	–
35	0	–	0	–
36	382	1.356	0	–
37	0	–	0	–
38	429	1.276	0	–
Measured males				855
Measured females				443
Aged males				229
Aged females				248
No. of sets sampled				92
Mean weighted CV (% , sexes pooled)				28.0

**Table 12: Calculated numbers-at-age, separately by sex, with CVs, for ling sampled by observers during commercial longline operations on Chatham Rise (LIN3&4) in June–October 2016. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
3	0	–	61	1.752
4	45	1.548	0	–
5	298	0.952	97	1.050
6	2 037	0.540	322	0.740
7	3 581	0.339	1 871	0.556
8	5 094	0.276	3 318	0.334
9	5 015	0.237	2 897	0.375
10	4 833	0.238	3 944	0.233
11	6 184	0.230	5 662	0.194
12	7 030	0.217	5 422	0.207
13	5 892	0.233	3 743	0.210
14	6 469	0.213	4 276	0.229
15	4 613	0.260	4 186	0.232
16	5 276	0.224	2 779	0.288
17	4 049	0.266	3 785	0.267
18	2 948	0.315	3 011	0.283
19	2 925	0.311	1 874	0.376
20	3 538	0.246	908	0.559
21	2 405	0.319	839	0.485
22	2 120	0.365	692	0.614
23	1 330	0.426	114	1.366
24	392	0.696	263	1.041
25	707	0.559	384	0.967
26	0	–	0	–
27	372	1.115	0	–
28	156	1.347	0	–
29	191	1.654	106	1.724
30	0	–	0	–
31	257	1.257	0	–
32	108	1.544	0	–
33	122	1.521	0	–
34	0	–	0	–
35	0	–	0	–
36	0	–	0	–
37	0	–	0	–
38	156	1.411	0	–
Measured males				799
Measured females				722
Aged males				396
Aged females				368
No. of sets sampled				152
Mean weighted CV (% , sexes pooled)				21.5

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 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. Sufficient observer samples were available from the spawning fishery in the 2016–17 fishing year to produce a catch-at-age distribution (Table 14). The mean weighted CV of 32% almost met the target of 30%.

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, 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			
<b>Spawning</b>							
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
2017	305	144	365	160	2	42	32.1
<b>Non-spawning</b>							
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

**Table 14: Calculated numbers-at-age, by sex, with CVs, for ling sampled by observers during commercial longline operations on spawning Sub-Antarctic (LIN 5&6) ling in October–December 2016, i.e., 2016–17 fishing year. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
7	516	1.059	1 232	0.650
8	713	0.849	1 023	0.590
9	1 446	0.488	2 269	0.526
10	2 499	0.407	2 381	0.374
11	3 677	0.336	4 136	0.280
12	2 068	0.455	3 257	0.293
13	2 322	0.338	1 652	0.412
14	2 022	0.356	4 081	0.319
15	2 495	0.361	3 520	0.295
16	2 497	0.356	2 727	0.336
17	1 315	0.470	1 419	0.483
18	2 466	0.427	1 198	0.484
19	867	0.591	843	0.548
20	956	0.582	857	0.563
21	420	0.837	820	0.581
22	1 407	0.463	589	0.591
23	1 474	0.541	258	1.309
24	286	0.851	342	0.893
25	373	1.281	179	1.057
26	342	1.025	140	1.587
27	0	–	179	1.250
28	183	1.174	22	2.028
Measured males				305
Measured females				365
Aged males				144
Aged females				160
No. of sets sampled				142
Mean weighted CV (% , sexes pooled)				32.1

### 3.3.3 West coast South Island

Longline 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 15 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. No longline trips targeting ling off WCSI were sampled in the 2016–17 fishing year. All estimated proportion-at-age distributions from the WCSI longline fishery are presented in Appendix B (Figure B4).

**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 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

### 3.3.4 Cook Strait

The longline 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 16 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 2016–17 fishing year. All estimated proportion-at-age distributions from the Cook Strait longline fishery are presented in Appendix B (Figure B5).

**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 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 17 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 2016–17 fishing year. All estimated proportion-at-age distributions from the Bounty Plateau longline fishery are presented in Appendix B (Figure B6).

**Table 17: 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 were analysed as 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 18 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 2016–17 fishing year is given in Table 19. The observer sampling in 2016–17 was at a relatively low level, but better than in the previous two years. The mean weighted CV of 29% just 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 18: 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
2015–16	371	287	423	292	47	32.8
2016–17	853	220	719	171	76	28.9

**Table 19: Calculated numbers-at-age, separately by sex, with CVs, for ling sampled by observers during commercial trawl operations on the Chatham Rise during October 2016–May 2017. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
3	1 162	0.957	4 453	0.557
4	6 789	0.465	10 030	0.435
5	15 713	0.314	19 182	0.305
6	22 931	0.228	8 656	0.356
7	17 216	0.283	21 043	0.275
8	18 157	0.245	16 500	0.320
9	11 505	0.276	17 028	0.302
10	8 427	0.316	11 329	0.316
11	5 495	0.476	10 761	0.318
12	10 046	0.344	4 651	0.600
13	6 215	0.371	7 373	0.431
14	3 822	0.508	6 835	0.441
15	3 088	0.527	3 711	0.499
16	2 876	0.514	3 501	0.603
17	4 579	0.518	2 361	0.667
18	0	–	964	0.858
19	2 057	0.636	0	–
20	1 618	0.777	520	1.296
21	2 289	0.567	742	1.184
22	2 214	0.522	213	1.583
23	1 231	0.923	0	–
24	366	1.405	0	–
25	773	0.954	0	–
26	2 799	0.690	0	–
27	819	1.176	0	–
28	0	–	0	–
29	274	1.277	0	–
39	1 287	1.320	0	–
Measured males				853
Measured females				719
Aged males				220
Aged females				171
No. of tows sampled				76
Mean weighted CV (% , sexes pooled)				28.9

### 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 20 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 2016–17 fishing year is given in Table 21. The mean weighted CV of 17% was lower 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 20: 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
2015–16	5 419	307	3 637	306	198	18.0
2016–17	4 207	344	3 190	404	218	16.7

**Table 21: Calculated numbers-at-age, separately by sex, with CVs, for ling sampled by observers during commercial trawl operations in the Sub-Antarctic during September 2016–April 2017. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
2	266	2.020	289	1.685
3	1 084	0.654	1 340	0.745
4	10 917	0.392	8 448	0.311
5	31 207	0.311	37 124	0.211
6	141 910	0.149	61 140	0.180
7	148 317	0.161	105 972	0.145
8	144 383	0.164	97 154	0.153
9	100 282	0.200	67 893	0.184
10	106 438	0.175	70 101	0.179
11	63 278	0.237	48 360	0.207
12	57 406	0.223	34 105	0.252
13	32 840	0.302	19 131	0.264
14	23 250	0.352	20 586	0.294
15	26 802	0.339	14 052	0.385
16	13 759	0.404	16 628	0.344
17	31 775	0.298	7 767	0.550
18	19 176	0.437	12 389	0.412
19	13 738	0.432	12 036	0.389
20	11 182	0.443	3 836	0.635
21	13 243	0.402	8 266	0.471
22	26 534	0.325	3 712	0.600
23	5 305	0.783	1 955	0.799
24	3 775	0.793	2 083	1.136
25	4 983	0.687	1 156	1.155
26	1 608	1.137	0	–
27	0	–	1 484	1.337
28	0	–	0	–
29	0	–	0	–
30	0	–	1 168	1.244
Measured males			4 207	
Measured females			3 190	
Aged males			344	
Aged females			404	
No. of tows sampled			218	
Mean weighted CV (% , sexes pooled)			16.7	

### 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 22 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 2009 to 2011. The details of the estimated catch-at-age distribution for trawl-caught ling in 2017 are given in Table 23. The amount of length data and otoliths available from that year was maintained at a relatively high level, as it has been since 2015. The mean weighted CV of 24% was lower 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 22: 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
2016	2 220	336	2 374	367	267	20.1
2017	1 722	296	1 862	319	195	23.6

**Table 23: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial trawl operations off WCSI during June–September 2017. Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
2	380	0.964	1 729	0.960
3	3 288	0.898	5 462	0.887
4	12 931	0.278	8 886	0.318
5	13 434	0.290	10 349	0.341
6	6 064	0.393	4 840	0.496
7	2 610	0.511	5 167	0.436
8	11 503	0.339	11 590	0.281
9	7 861	0.306	7 434	0.335
10	20 163	0.186	9 778	0.279
11	13 999	0.248	11 716	0.243
12	14 633	0.214	9 516	0.274
13	15 062	0.213	11 354	0.262
14	9 539	0.281	21 158	0.188
15	10 324	0.240	15 268	0.206
16	4 609	0.336	8 737	0.248
17	3 341	0.492	5 678	0.319
18	3 903	0.392	5 928	0.391
19	1 215	0.742	1 445	0.518
20	0	–	2 380	0.574
21	767	0.804	711	0.829
22	447	0.905	1 688	0.505
23	472	1.146	1 125	0.627
24	223	0.911	346	0.755
25	577	0.999	669	0.719
26	378	0.944	158	1.250
27	86	1.411	0	–
28	0	–	0	–
29	198	1.247	0	–
30	0	–	255	1.077
31	371	1.245	297	1.142
32	0	–	0	–
33	305	1.433	0	–
Measured males			1 722	
Measured females			1 862	
Aged males			296	
Aged females			319	
No. of tows sampled			195	
Mean weighted CV (% , sexes pooled)			23.6	

### 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 24 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 2017 (145 length measurements).

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

**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 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 additional deeper strata (800–1300 m) were surveyed. However, to ensure comparability, the distributions presented here are for the core strata only, i.e., 200–800 m.

Table 25 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 2018 trawl survey are given in Table 26. The mean weighted CV of 26% was lower 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 25: 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
TAN1801	568	296	576	291	73	26.3



**Table 26: Calculated numbers at age in the survey area, separately by sex, with CVs, for ling caught during a trawl survey of Chatham Rise in January 2018 (survey TAN1801). Summary statistics for the samples are also presented. Age in years.**

Age	Male	CV	Female	CV
2	0	–	6 266	1.285
3	115 662	0.278	56 271	0.384
4	135 361	0.244	159 391	0.236
5	127 057	0.312	138 434	0.239
6	153 562	0.239	157 654	0.229
7	153 551	0.241	120 707	0.276
8	101 196	0.335	98 573	0.282
9	111 812	0.312	98 513	0.280
10	148 734	0.327	76 094	0.303
11	118 450	0.340	51 820	0.343
12	49 639	0.411	46 773	0.378
13	38 231	0.446	52 784	0.345
14	46 957	0.404	45 527	0.400
15	53 004	0.445	31 647	0.492
16	38 624	0.441	50 037	0.375
17	22 098	0.523	23 590	0.480
18	32 966	0.535	23 544	0.515
19	23 064	0.602	30 128	0.493
20	4 036	1.355	5 512	1.070
21	17 990	0.568	13 540	0.702
22	11 519	0.749	10 421	0.787
23	15 145	0.569	5 124	0.994
24	18 896	0.644	6 509	0.876
25	11 041	1.160	5 809	1.002
26	4 488	1.041	4 671	0.945
27	3 107	1.549	5 844	1.421
28	0	–	0	–
29	5 034	1.146	0	–
30	0	–	0	–
31	0	–	526	1.890
Measured males				568
Measured females				576
Aged males				296
Aged females				291
No. of tows sampled				73
Mean weighted CV (% , sexes pooled)				26.3

### 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 area. 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 27 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There was no trawl survey of the Sub-Antarctic in December 2017.

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 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 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
TAN1614	767	225	829	367	55	22.7
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 area. A combined trawl and acoustic survey by *Tangaroa* in winter 2000 (O’Driscoll et al. 2004) was replicated (with some modifications) in 2012 (O’Driscoll et al. 2014), 2013 (O’Driscoll et al 2015), and 2016 (O’Driscoll & Ballara 2018), so a four year comparable time series is available. The biomass estimates from the four 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 & Ballara 2018).

Table 28 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 to estimate a survey catch-at-age distribution. The age-length keys for the subsequent surveys were derived using otoliths collected during each survey. There was no west coast South Island trawl survey conducted in winter 2017.

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

**Table 28: 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 trawl 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
TAN1609	694	267	429	200	32	30.8

## 4. DISCUSSION

### 4.1 Hake

In 2016–17 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 (WCSI, 13%) and the HAK 1 (Sub-Antarctic, 23%) fisheries. The target CV was met in most previous years for samples from the WCSI fishery (see Table 5). The sampling intensity in the WCSI commercial trawl fishery was relatively high in 2016–17, as it was in the previous four years (see Table 4). Sampling intensity in the Sub-Antarctic varied considerably between years, with consequent wide variation in the mean weighted CVs (see Table 2) but it was moderate to high in all years since 2008–09. Hake on Chatham Rise were analysed as two separate fisheries (see Table 1), but sampling intensity in both fisheries was low in 2016–17 and there were insufficient data to produce catch-at-age distributions. 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 two distributions were produced. Sampling of the east Chatham Rise fishery was sporadic since 1991–92, and only one distribution was produced since 2006–07.

The Chatham Rise survey in January 2018 produced more measured hake than in most surveys since the early 2000s (see Table 6), although about half of these were from one station just east of the Mernoo Bank. The target of 30% was met only once in this survey series (TAN9106), although about two-thirds of the values were between 30 and 40%, mainly in the earlier part of the time series (see Table 6).

On the Chatham Rise, younger hake tended 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) tended 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) appeared relatively strong, and was 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.

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. There was no research survey of the Sub-Antarctic in December 2017.

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 appeared to be less abundant in the catch than in most previous years. The catch in most years since 2011 was dominated by males aged 5–7 years and

females aged 6–8 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 the commercial longline fishery on the Chatham Rise in 2015–16 and 2016–17, and the CVs for both (22 and 28% respectively) were below the 30% target. A distribution produced for the Sub-Antarctic longline spawning fishery in 2016–17 almost met the CV target (32%).

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 2016 to April 2017 were applied to an age-length key comprised primarily of data from the December 2016 (TAN1614) trawl survey of the Sub-Antarctic, but augmented with some observer-collected otoliths to cover lengths in the fishery data that were not sufficiently represented in the trawl survey samples. The estimated CV (17%) was much lower than the target value. Most samples in this series had CVs around 20%, and the level of observer sampling was good in most years (see Table 20). The 2016–17 Chatham Rise and WCSI distributions used only observer length data and otoliths. The Chatham Rise catch-at-age distribution had a mean weighted CV (29%) just below the target of 30%, although CVs for this series in the last decade were 24–33%. The WCSI commercial fishery was comprehensively sampled in 2016–17, and only the previous two years had larger sample sizes (see Table 22). Consequently, the 2016–17 estimated catch-at-age distribution had a relatively low mean weighted CV (24%). An estimate of catch-at-age for the ling bycatch from the Cook Strait hoki spawning fisheries was not able to be produced for 2016 as insufficient fish were sampled. No age structure for the Cook Strait fishery was produced since 2010.

Sufficient ling otoliths and length-frequency data were available from a trawl survey of the Chatham Rise (January 2018) to meet the mean weighted CV target (26%). The target was met in all of the previous surveys of this area (see Table 25).

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 were 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 were 12 years old. Ling in the Sub-Antarctic aged 6 and 8 in 2002 were 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 exhibited 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 2017). 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. 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 was rectified since 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, and are summarised below (Table 29).

**Table 29: List of hake and ling fisheries, showing the annual data sampling time periods that were used to produce the catch-at-age series presented above.**

Fishstock(s)	Area	Fishing method	Time period
HAK 1	Sub-Antarctic	Trawl	September–May
HAK 4 & HAK 1	Chatham Rise	Trawl	October–April
HAK 7	WCSI	Trawl	June–September
LIN 3 & LIN 4	Chatham Rise	Longline	June–October
LIN 5 & LIN 6	Sub-Antarctic	Longline spawning	October–December
LIN 5 & LIN 6	Sub-Antarctic	Longline non-spawning	February–July
LIN 6	Bounty Plateau	Longline	November–March
LIN 7	WCSI	Longline	May–August
LIN 2 & LIN 7	Cook Strait	Longline	June–September
LIN 3 & LIN 4	Chatham Rise	Trawl	October–May
LIN 5 & LIN 6	Sub-Antarctic	Trawl	September–April
LIN 7	WCSI	Trawl	June–September
LIN 2 & LIN 7	Cook Strait	Trawl	June–September

## 5. ACKNOWLEDGMENTS

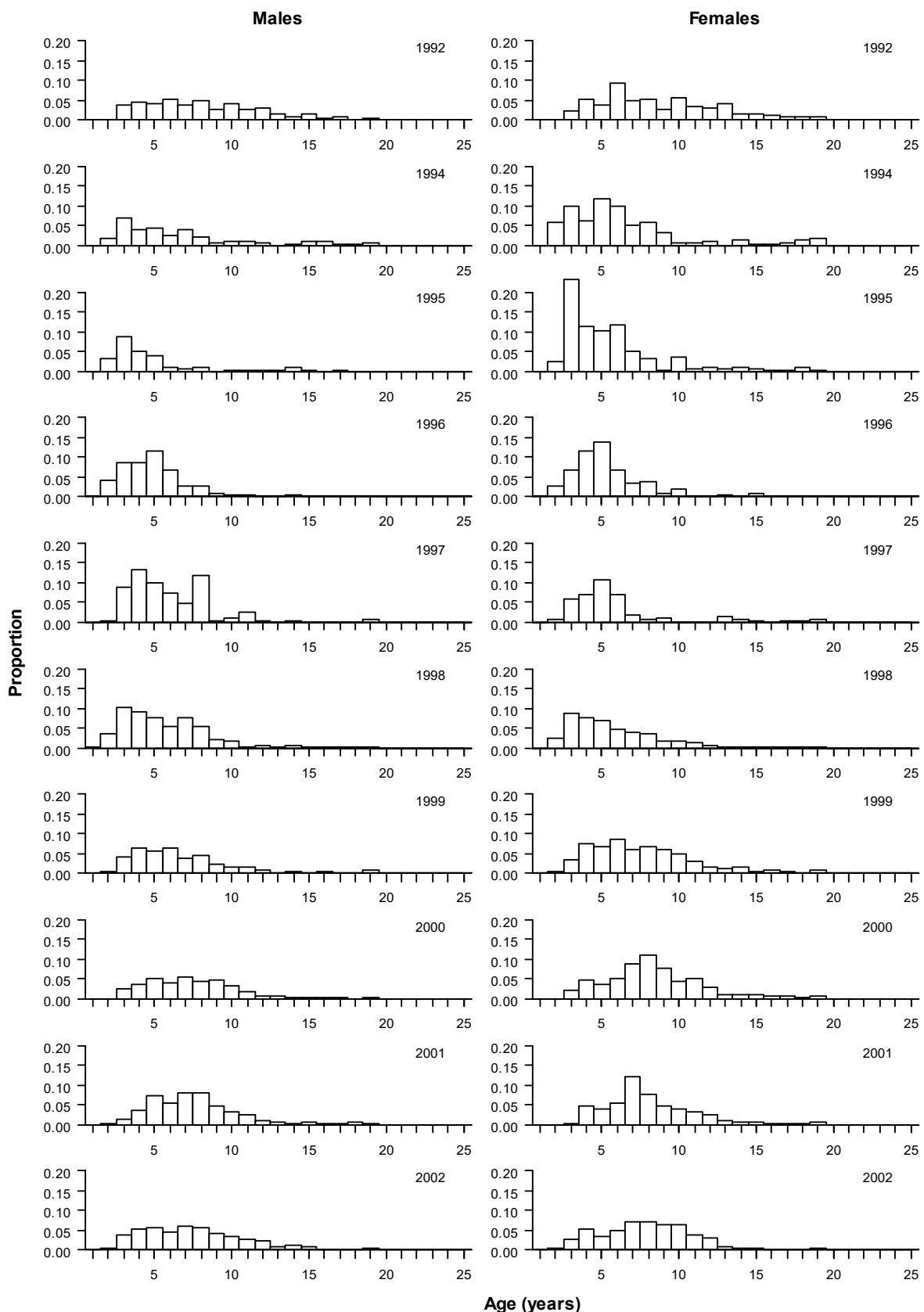
This work was funded by the Ministry for Primary Industries under Project MID201701. We thank Peter McMillan for reviewing the manuscript.

## 6. REFERENCES

- Ballara, S.L.; O’Driscoll, R.L. (2018). Catches, size, and age structure of the 2016–17 hoki fishery, and a summary of input data used for the 2018 stock assessment. *New Zealand Fisheries Assessment Report 2018/38*. 125 p.
- Bull, B.; Dunn, A. (2002). Catch-at-age: User Manual v1.06.2002/09/12. NIWA Internal Report 114. 23 p. (Unpublished report held in NIWA Library, Wellington.)
- Devine, J. (2008). Descriptive analysis of the commercial catch and effort data for New Zealand hake (*Merluccius australis*) for the 1989–90 to 2004–05 fishing years. *New Zealand Fisheries Assessment Report 2008/60*. 73 p.
- Horn, P.L. (1993). Growth, age structure, and productivity of ling, *Genypterus blacodes* (Ophidiidae), in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research* 27: 385–397.

- Horn, P.L. (1997). An ageing methodology, growth parameters, and estimates of mortality for hake (*Merluccius australis*) from around the South Island, New Zealand. *Marine and Freshwater Research* 48: 201–209.
- Horn, P.L. (2005). A review of the stock structure of ling (*Genypterus blacodes*) in New Zealand waters. *New Zealand Fisheries Assessment Report 2005/59*. 41 p.
- Horn, P.L. (2008a). Stock assessment of ling (*Genypterus blacodes*) on the Chatham Rise, Campbell Plateau, and in Cook Strait for the 2007–08 fishing year. *New Zealand Fisheries Assessment Report 2008/24*. 76 p.
- Horn, P.L. (2008b). Stock assessment of hake (*Merluccius australis*) in the Sub-Antarctic for the 2007–08 fishing year. *New Zealand Fisheries Assessment Report 2008/49*. 66 p.
- Horn, P.L. (2017). Stock assessment of hake (*Merluccius australis*) on the Chatham Rise (HAK 4) and off the west coast of South Island (HAK 7) for the 2016–17 fishing year. *New Zealand Fisheries Assessment Report 2017/47*. 70 p.
- Horn, P.L.; Dunn, A. (2007). Stock assessment of hake (*Merluccius australis*) on the Chatham Rise for the 2006–07 fishing year. *New Zealand Fisheries Assessment Report 2007/44*. 62 p.
- Horn, P.L.; Francis, R.I.C.C. (2010). Stock assessment of hake (*Merluccius australis*) on the Chatham Rise for the 2009–10 fishing year. *New Zealand Fisheries Assessment Report 2010/14*. 66 p.
- Horn, P.L.; Sutton, C.P. (2008). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2006–07 fishing year and from trawl surveys in summer 2007–08, with a summary of all available data sets. *New Zealand Fisheries Assessment Report 2008/60*. 54 p.
- Horn, P.L.; Sutton, C.P. (2009). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2007–08 fishing year and from trawl surveys in summer 2008–09, with a summary of all available data sets. *New Zealand Fisheries Assessment Report 2009/41*. 53 p.
- Horn, P.L.; Sutton, C.P. (2017). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2015–16 fishing year and from two research trawl surveys in 2016, with a summary of all available data sets from the New Zealand EEZ. *New Zealand Fisheries Assessment Report 2017/41*. 70 p.
- Langley, A.D. (2001). Summary of biological data collected by the ling longline logbook programme, 1994–95 to 1999–2000. *New Zealand Fisheries Assessment Report 2001/71*. 37 p.
- O’Driscoll, R.L.; Bagley, N.W.; Ballara, S.L.; Ladroit, Y. (2015). Trawl and acoustic survey of hoki and middle depth fish abundance on the west coast South Island, July–August 2013 (TAN1308). *New Zealand Fisheries Assessment Report 2015/20*. 104 p.
- O’Driscoll, R.L.; Bagley, N.W.; Ballara, S.L.; Oeffner, J. (2014). Trawl and acoustic survey of hoki and middle depth fish abundance on the west coast South Island, July–August 2012 (TAN1210). *New Zealand Fisheries Assessment Report 2014/09*. 102 p.
- O’Driscoll, R.L.; Bagley, N.W.; Dunn, A. (2004). Further analysis of an acoustic survey of spawning hoki off west coast South Island in winter 2000. *New Zealand Fisheries Assessment Report 2004/2*. 53 p.
- O’Driscoll, R.L.; Ballara, S.L. (2018). Trawl survey of middle depth fish abundance on the west coast South Island, August 2016 (TAN1609). *New Zealand Fisheries Assessment Report 2018/47*. 76 p.

## 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 2017. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–April 2002 sample.**

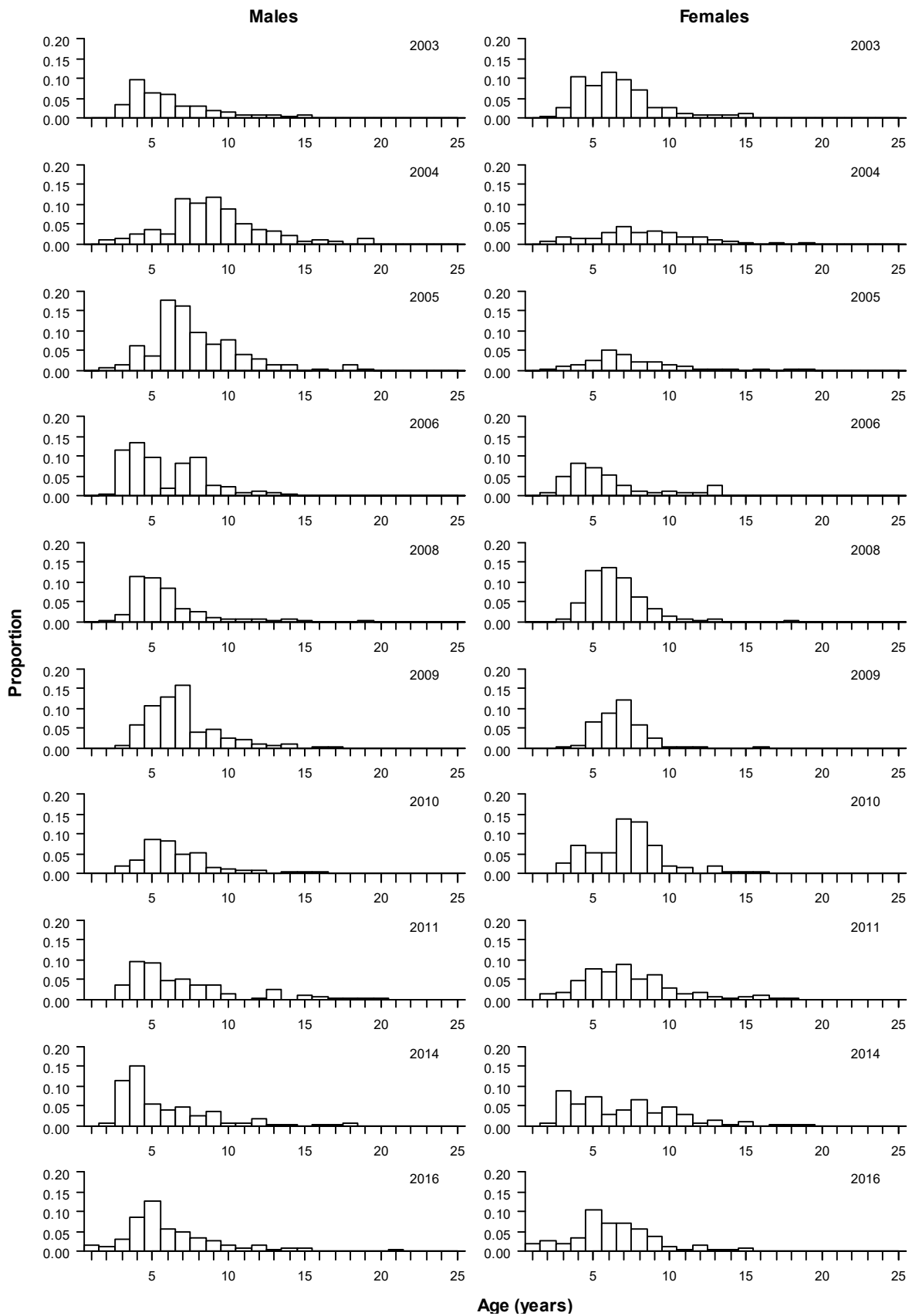
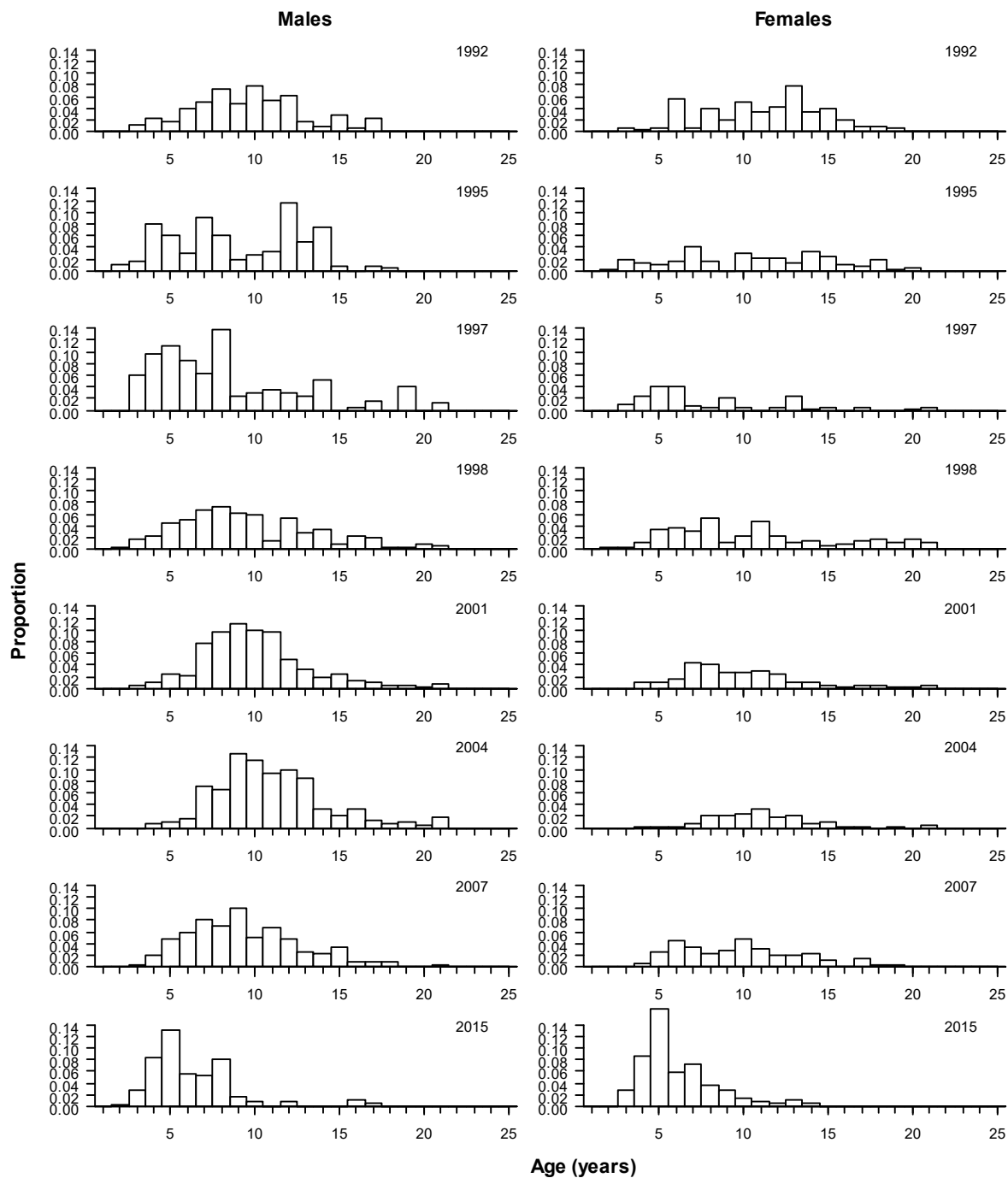
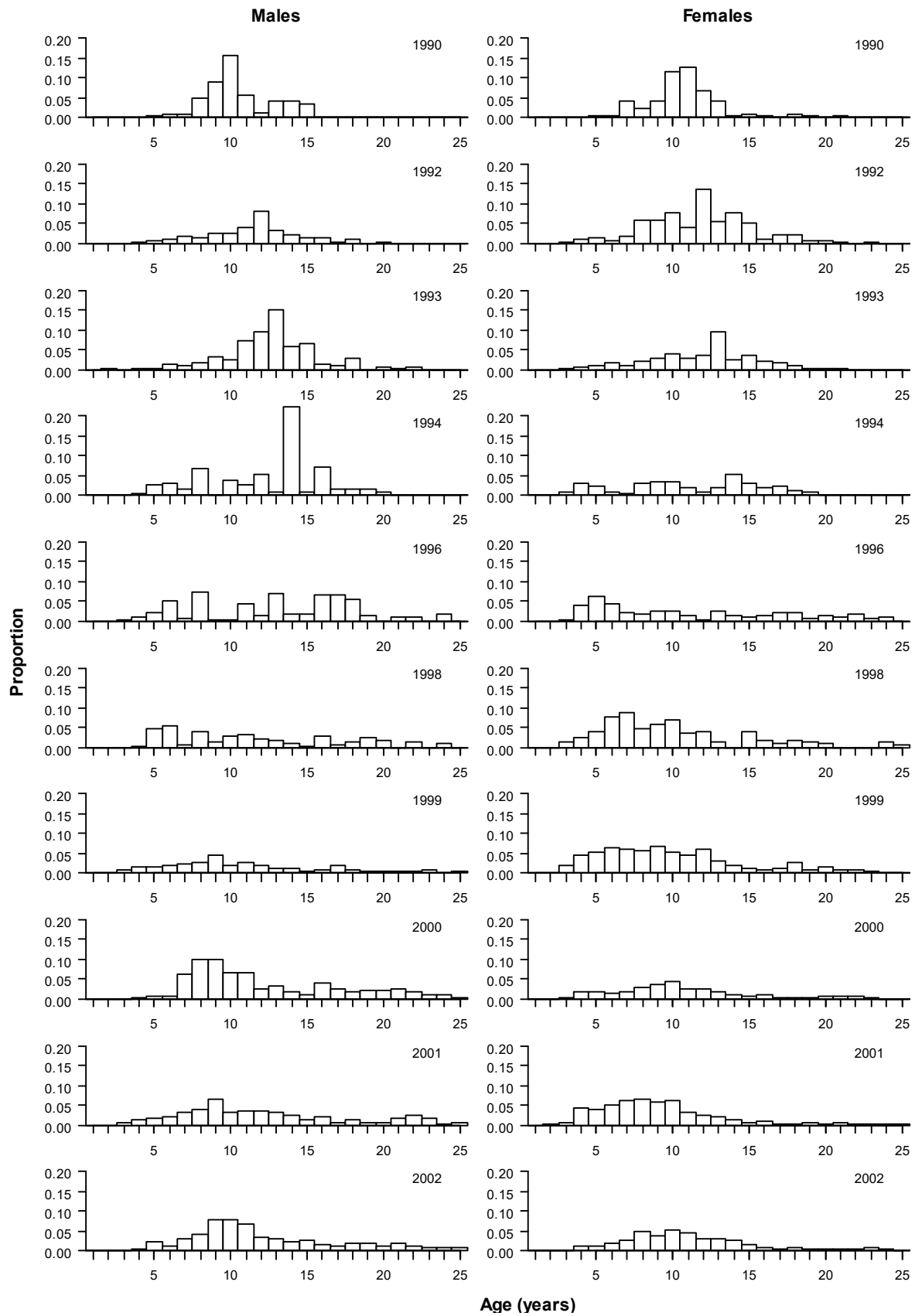


Figure A1 ctd.





**Figure A2: Age frequency distributions of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2017. 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 2017. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the September 2001–May 2002 sample.**

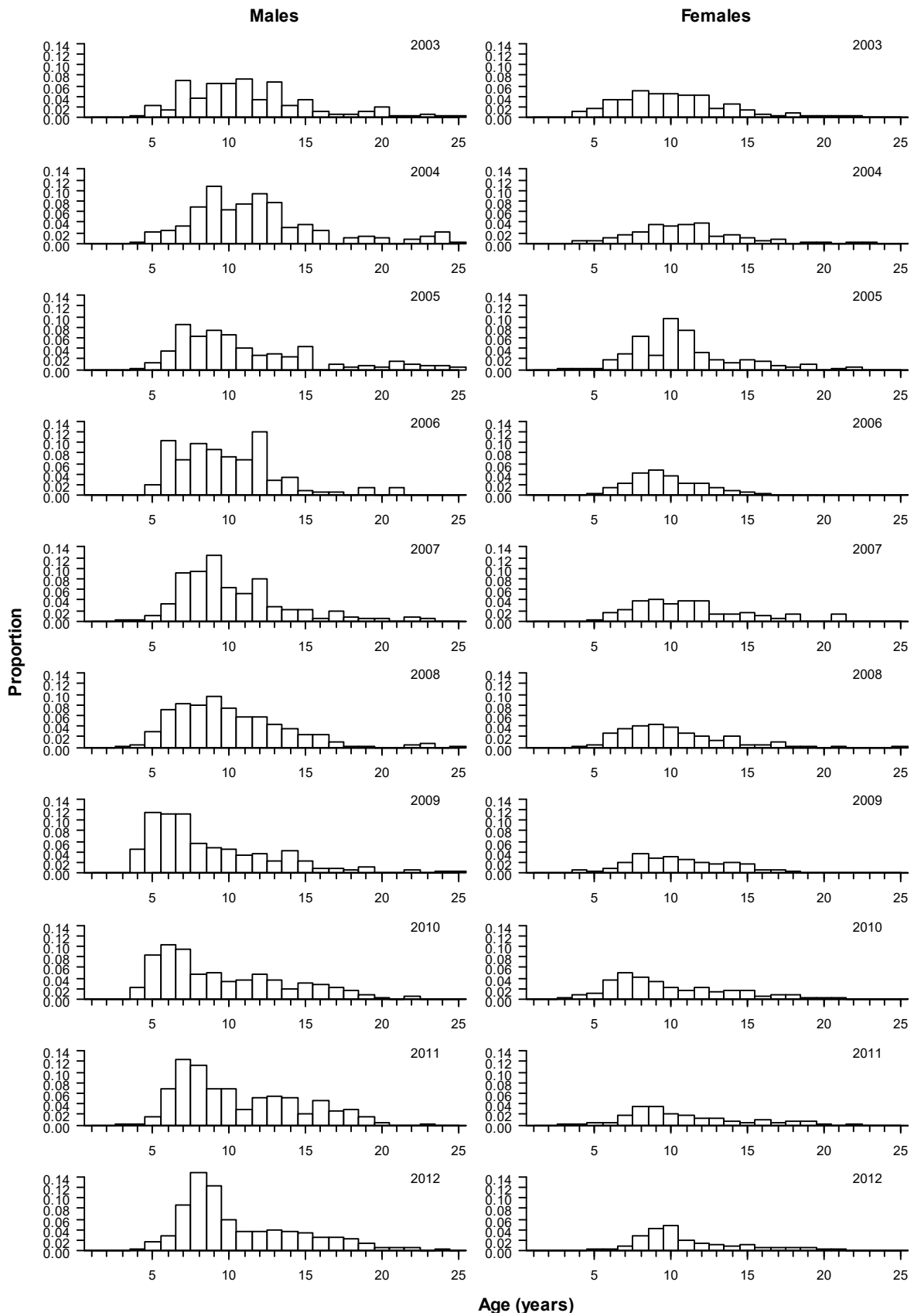


Figure A3 ctd.

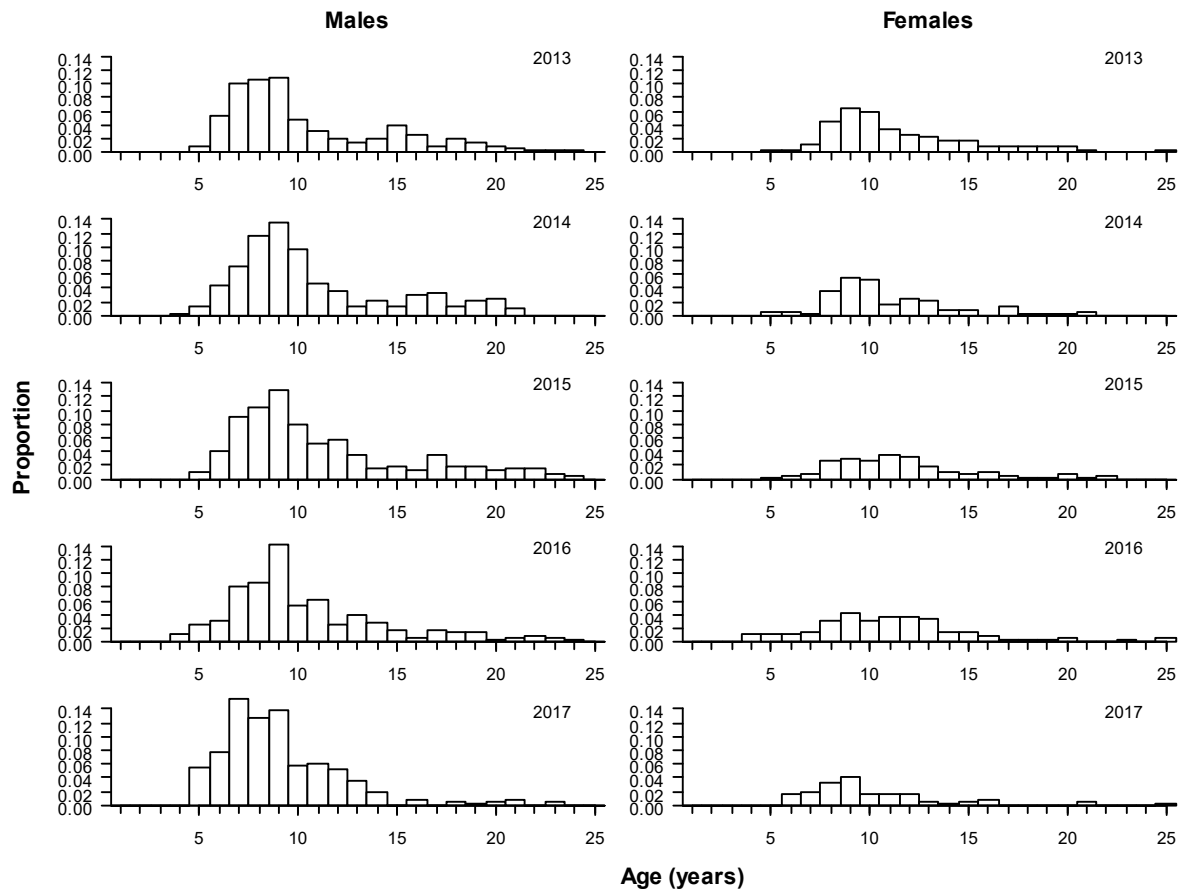
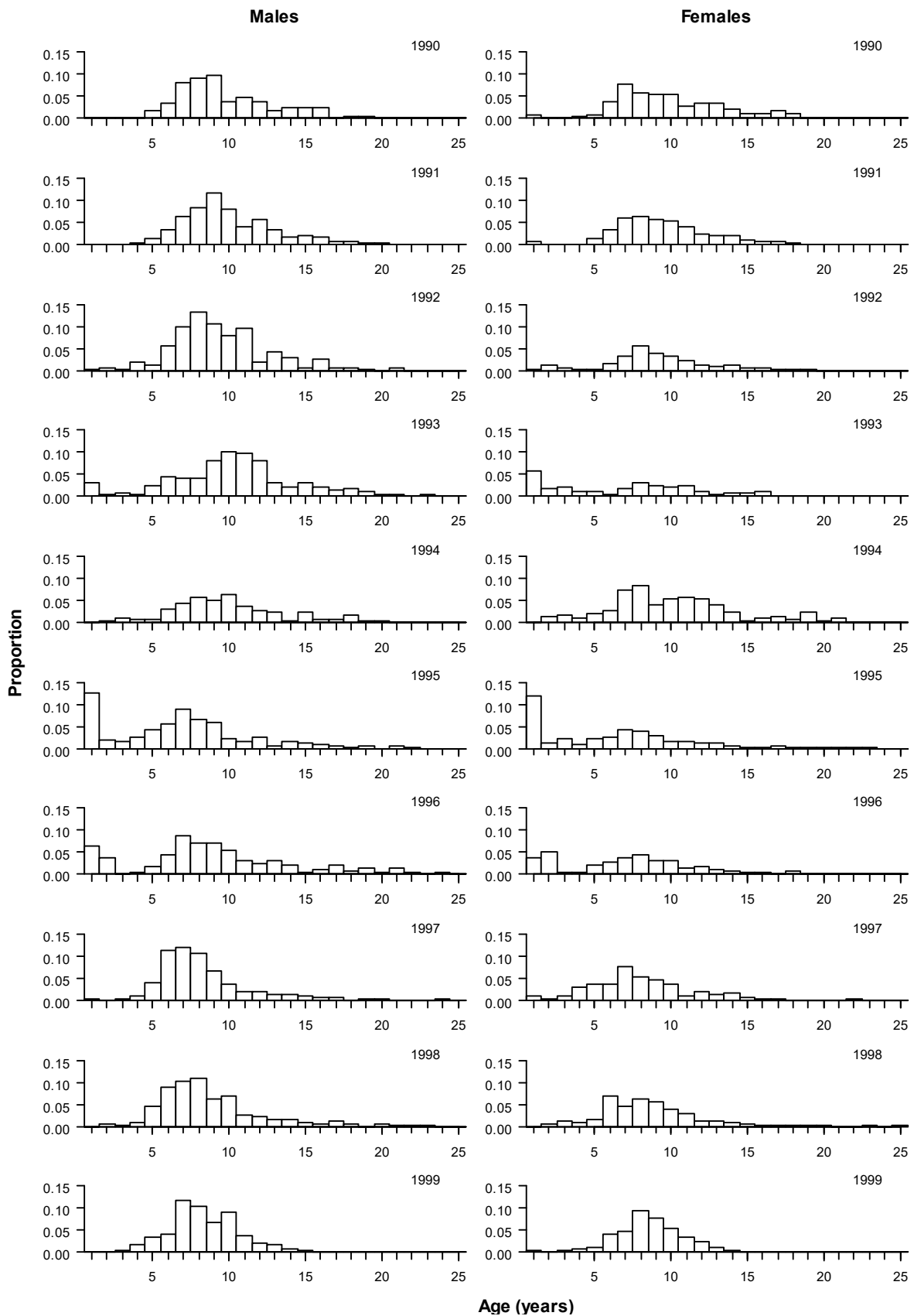


Figure A3 ctd.



**Figure A4: Age frequency distributions of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2017.**

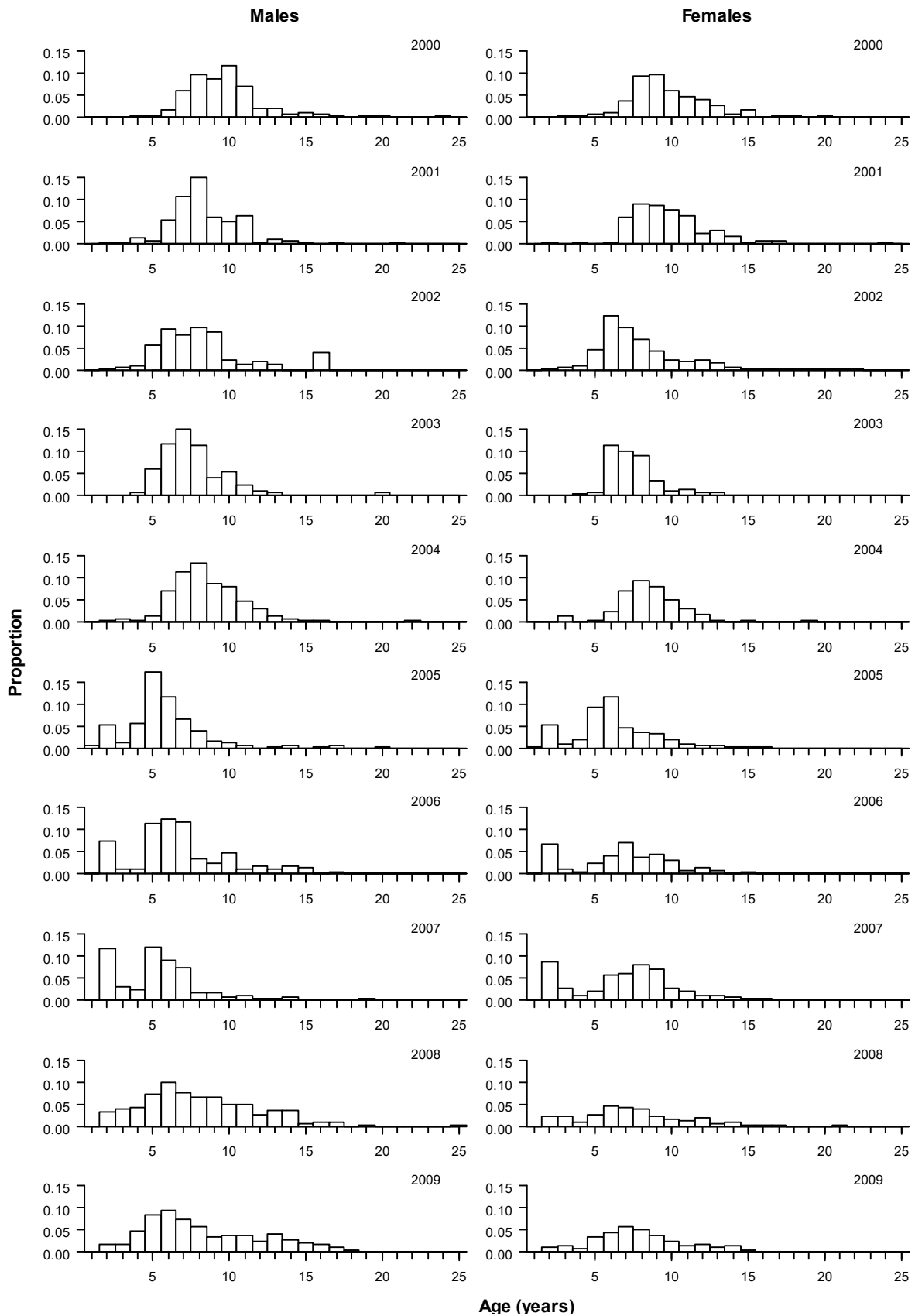


Figure A4 ctd.

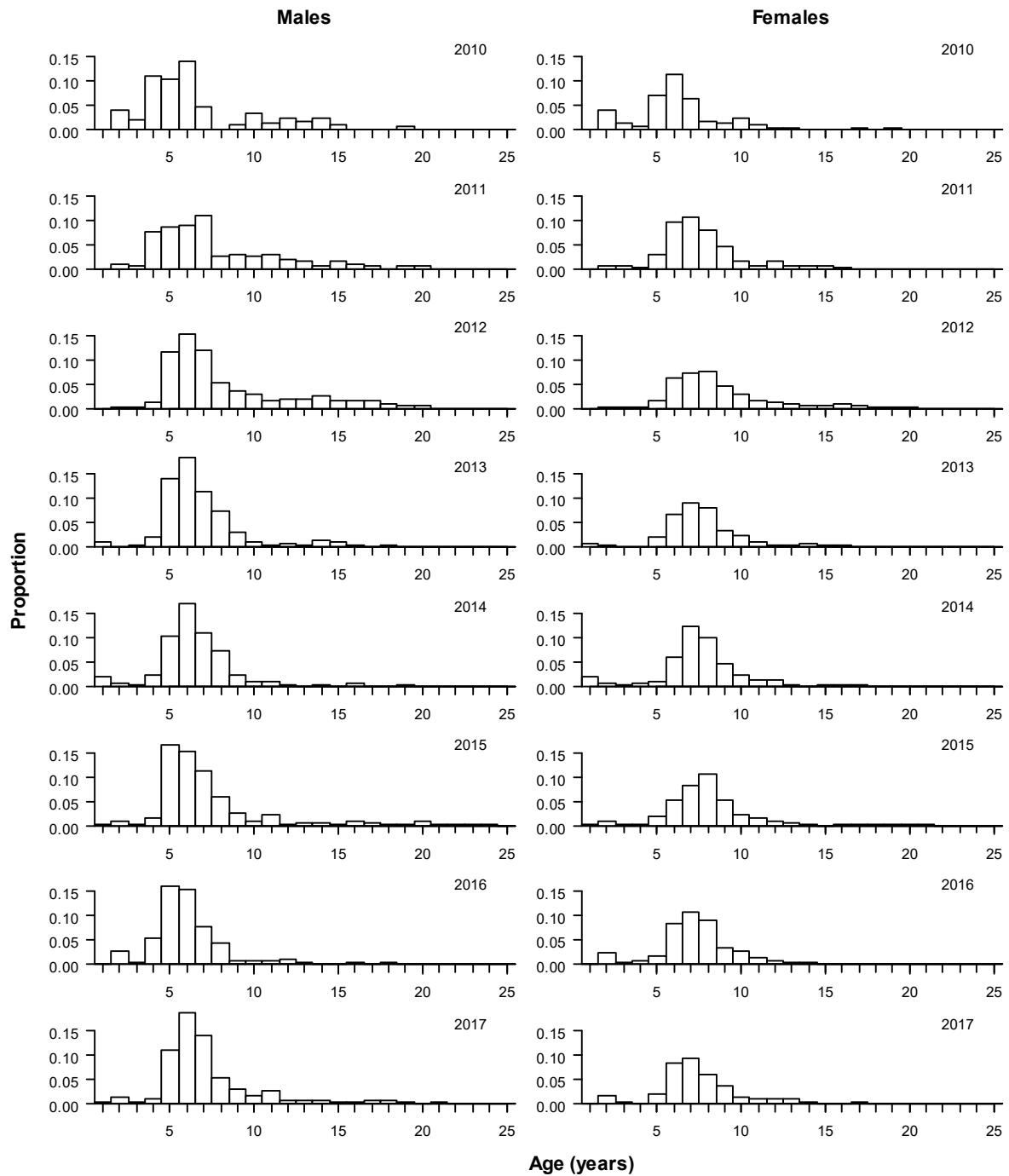
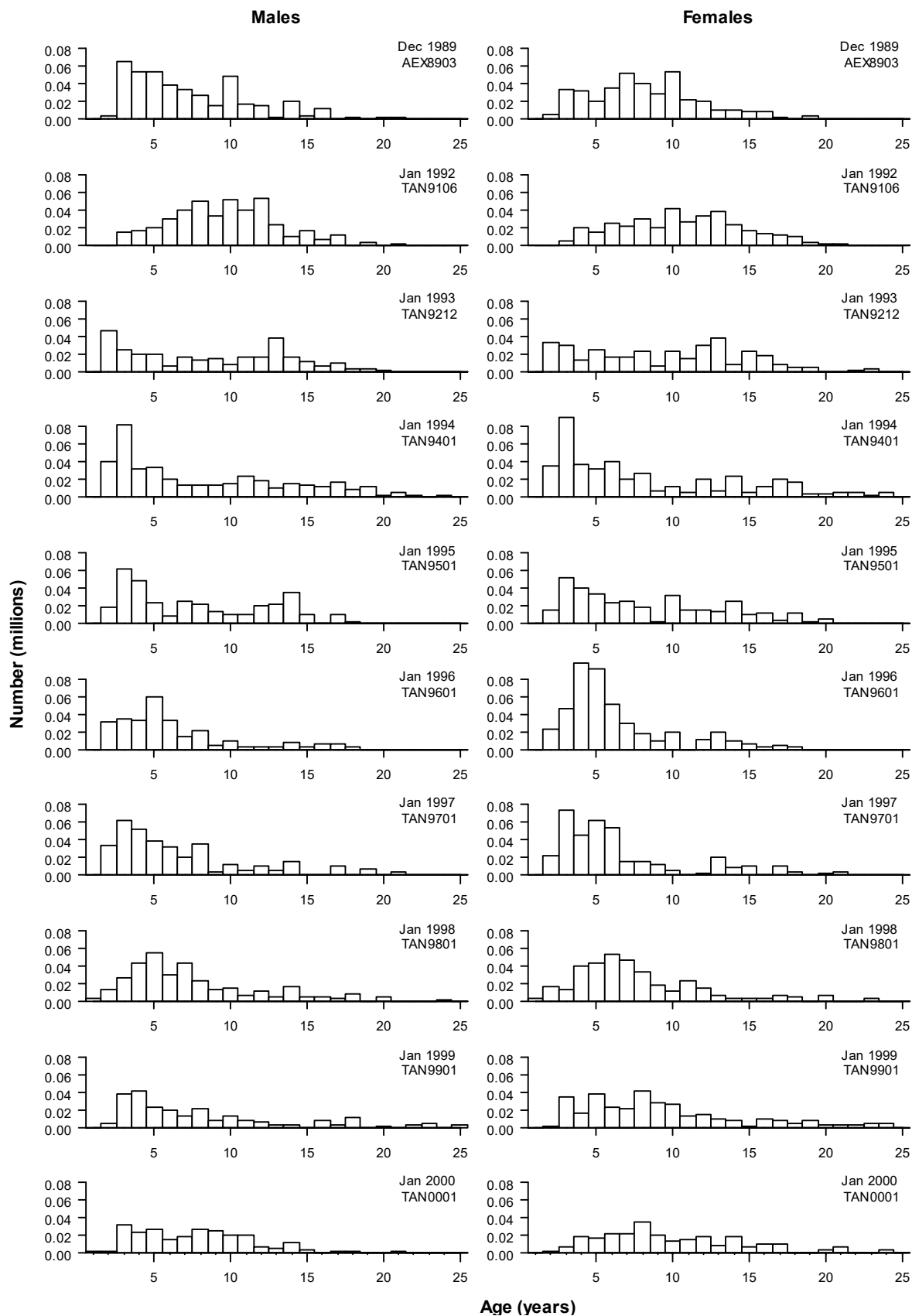


Figure A4 ctd.



**Figure A5: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from trawl surveys of the Chatham Rise, 1989–90 to 2017–18.**



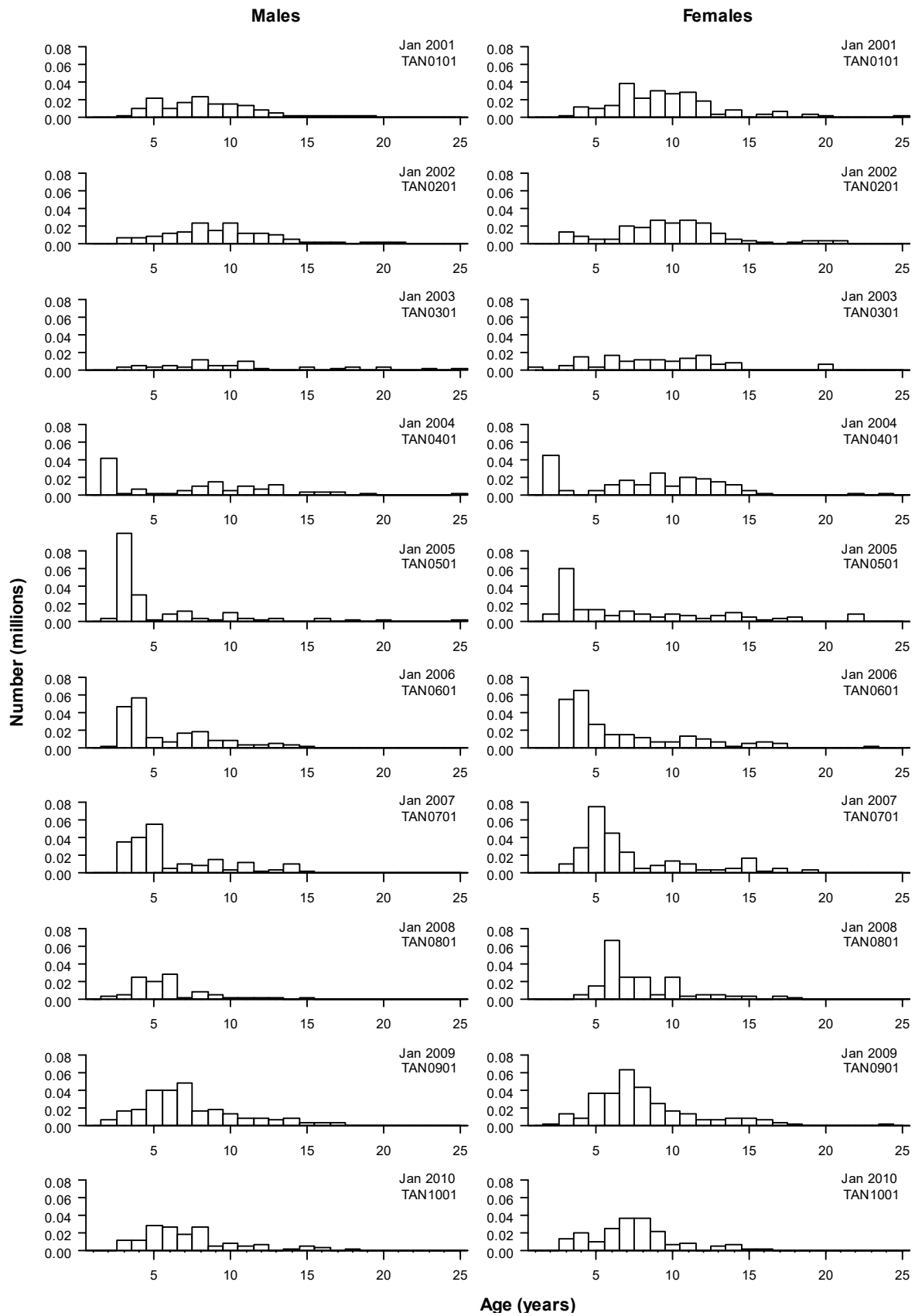


Figure A5 ctd.

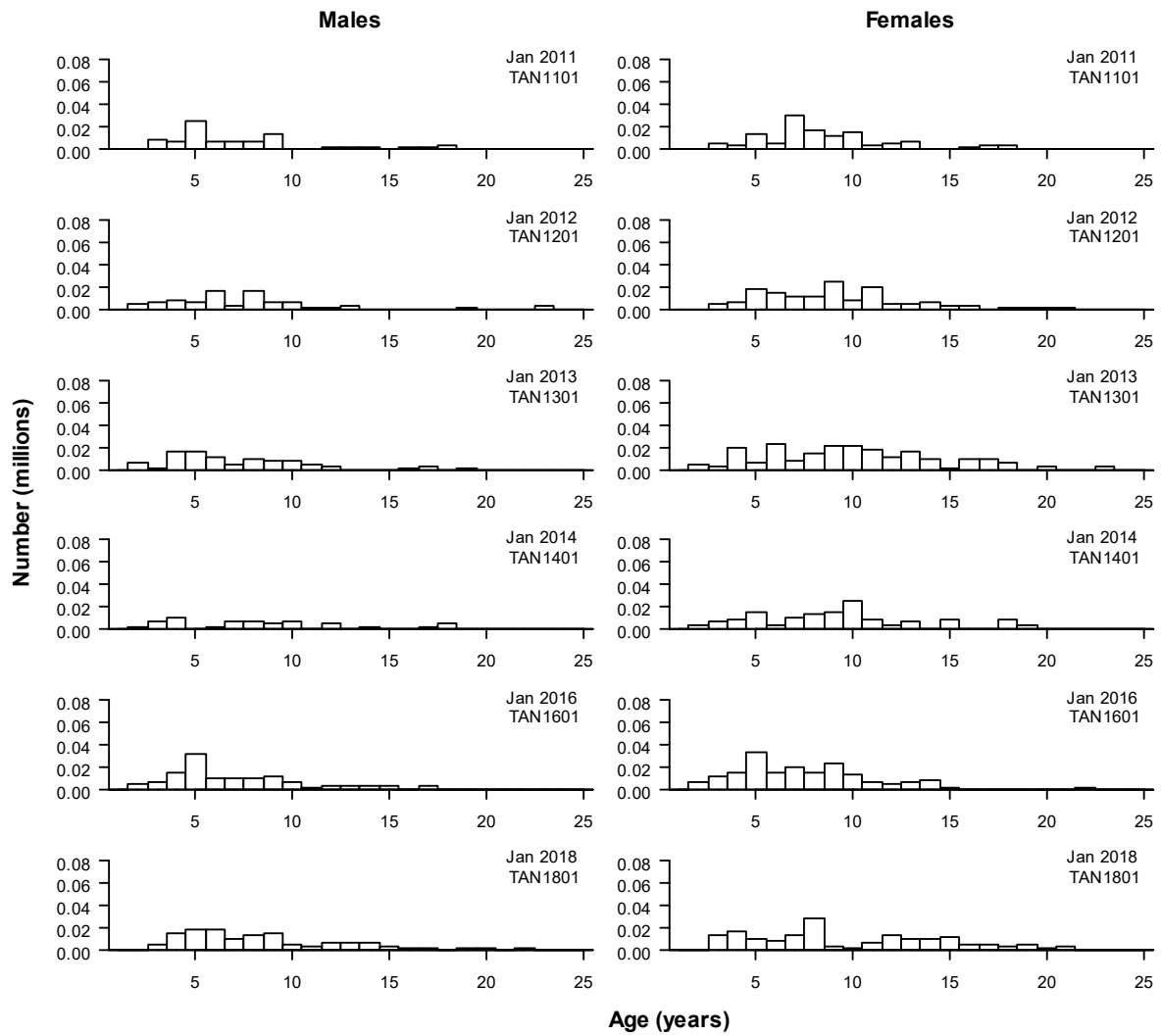
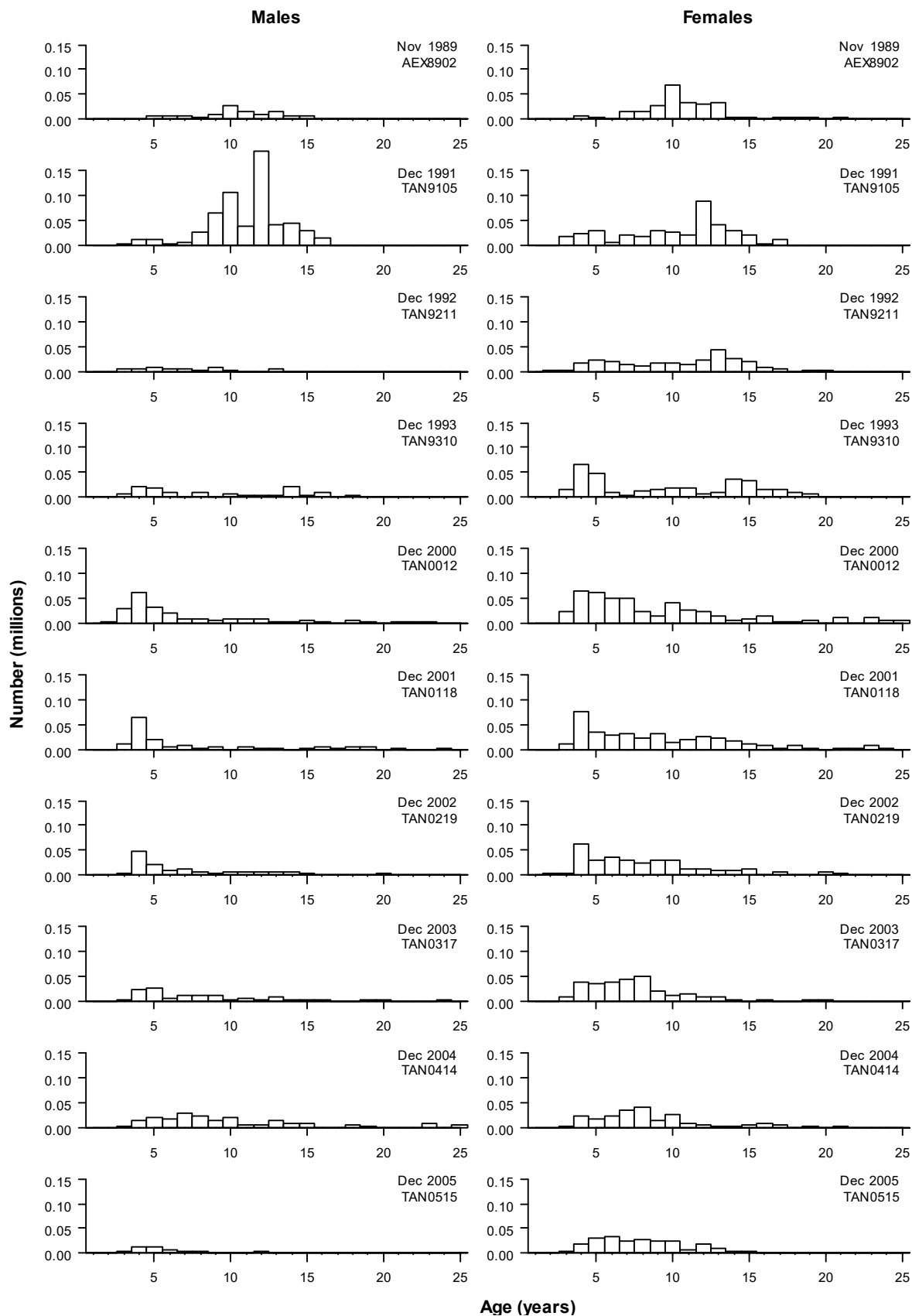


Figure A5 ctd.



**Figure A6: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from summer trawl surveys of the Sub-Antarctic, 1989 to 2016 (small sample, not aged).**

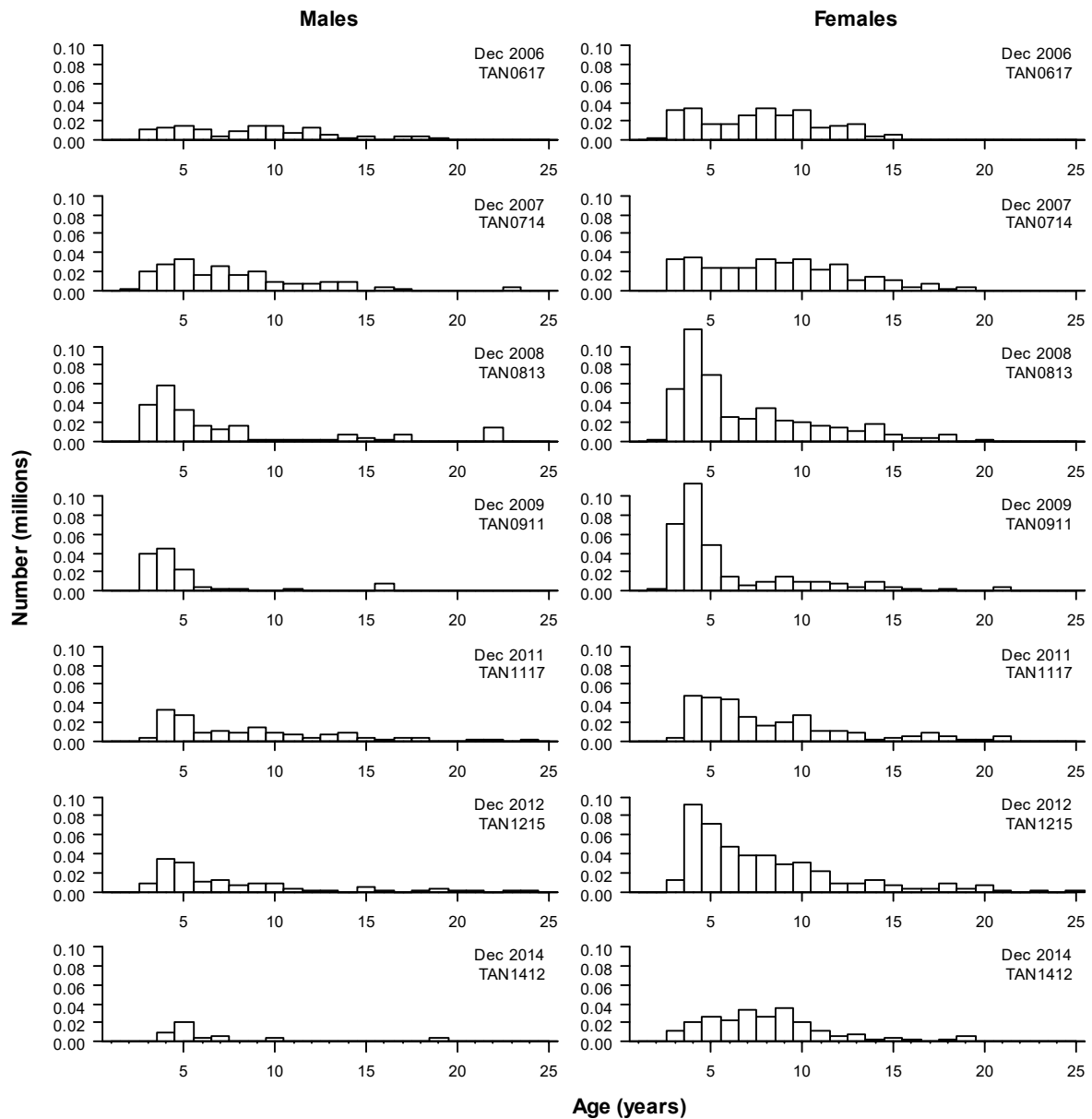
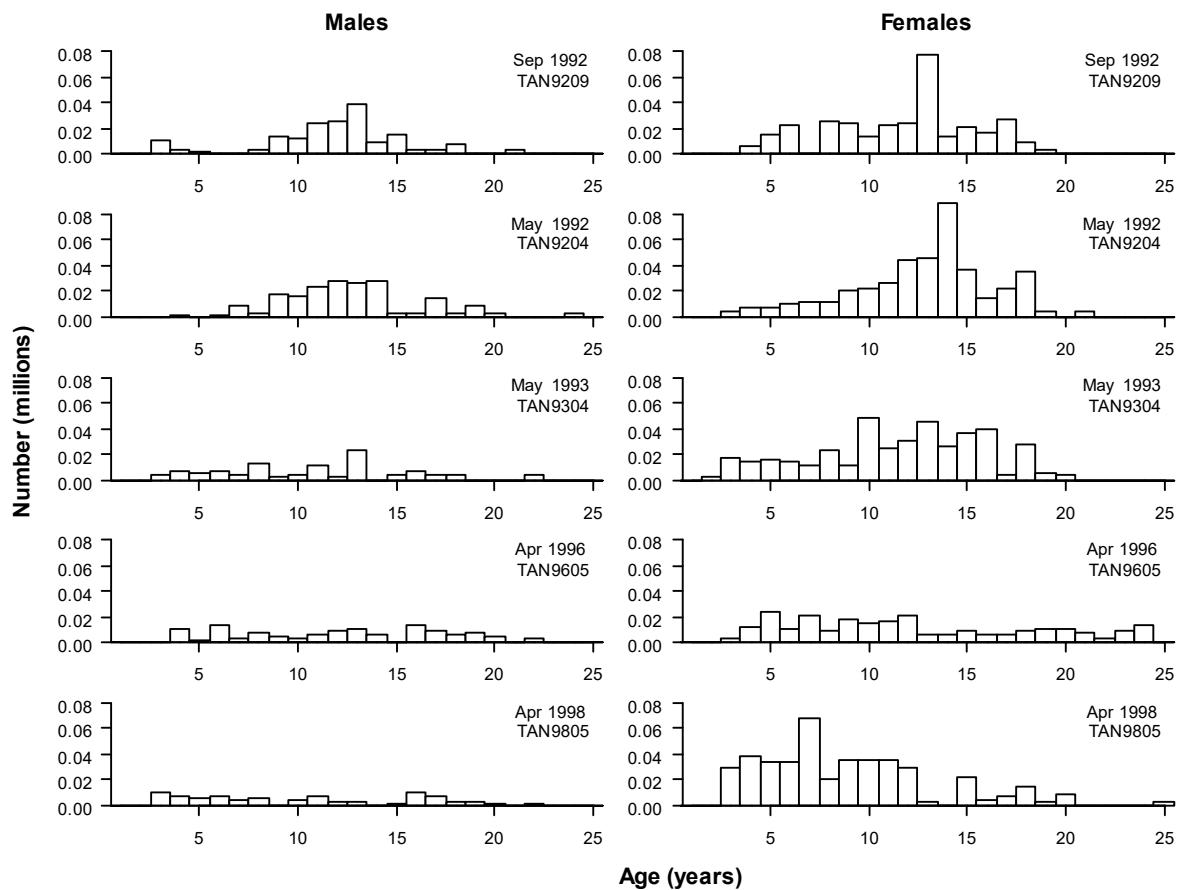
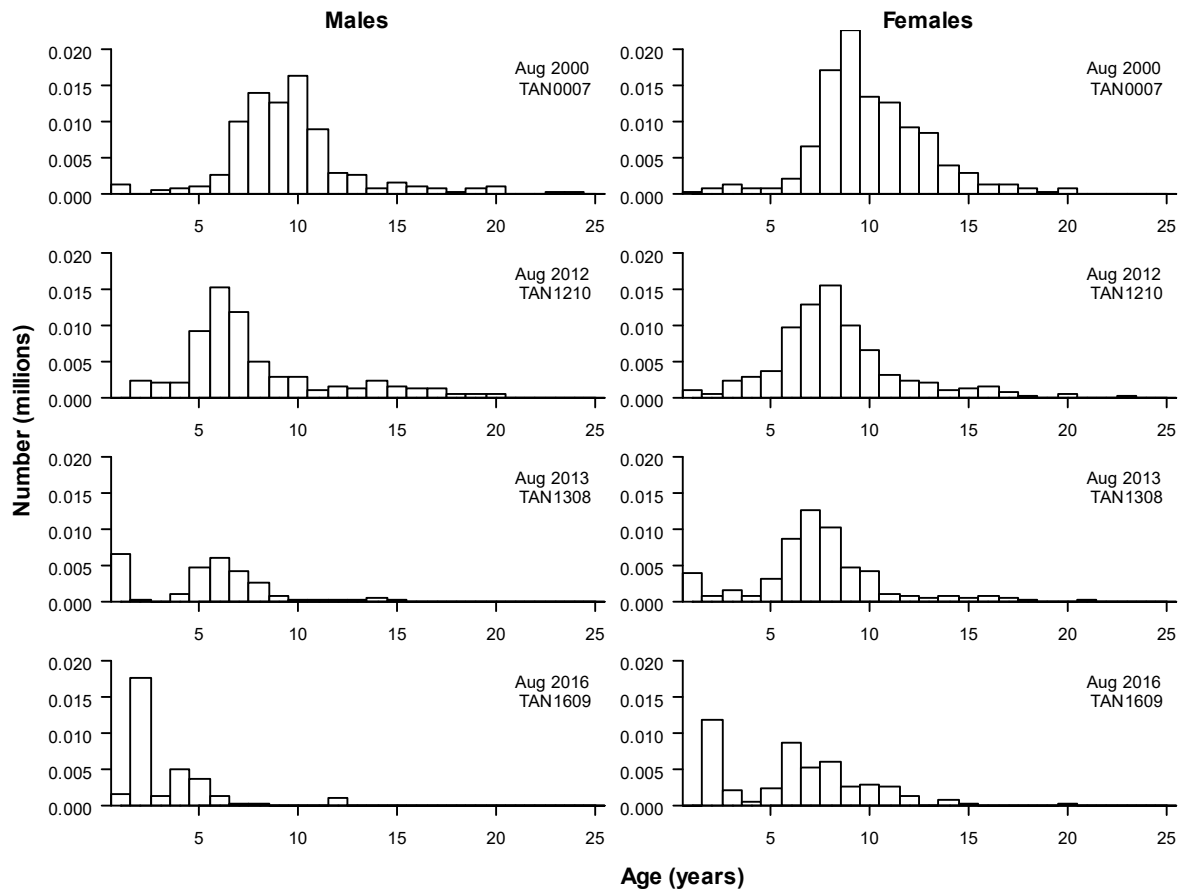


Figure A6 ctd.

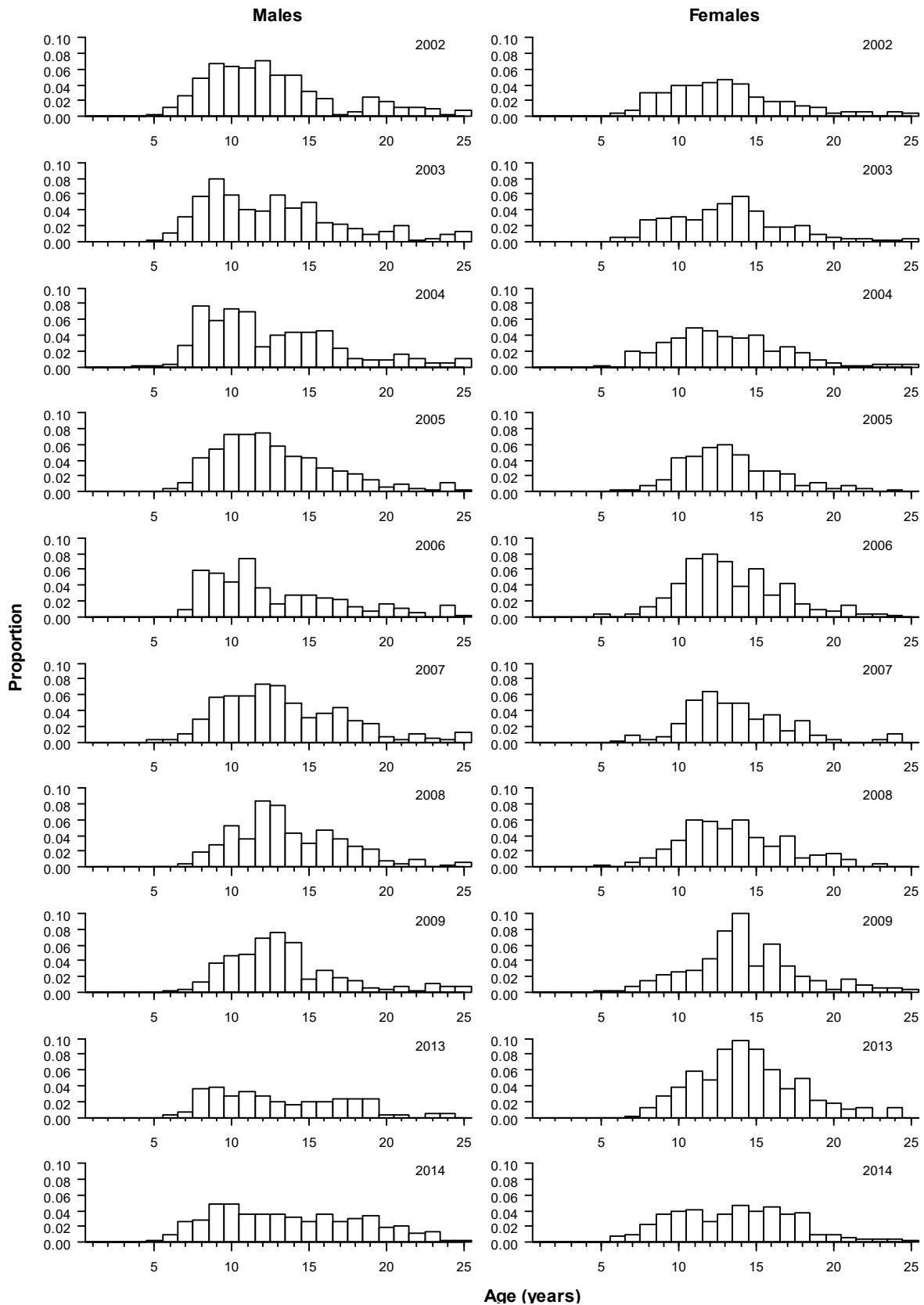


**Figure A7: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from spring and autumn trawl surveys of the Sub-Antarctic, 1992 to 1998.**



**Figure A8: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from trawl surveys of the WCSI, from 2000 to 2016.**

## 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 2017.**

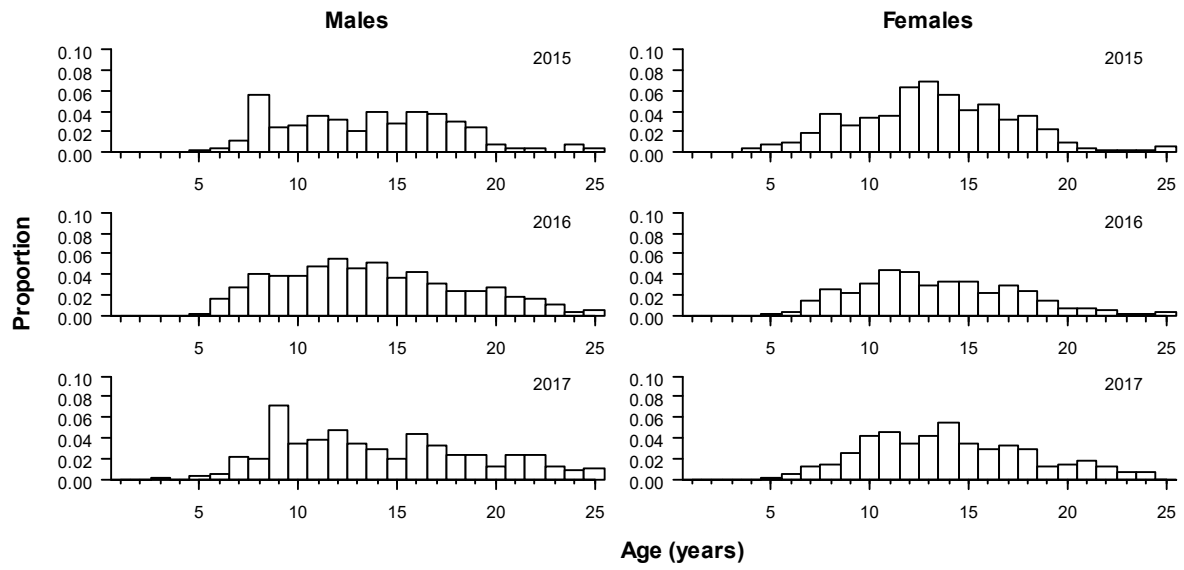
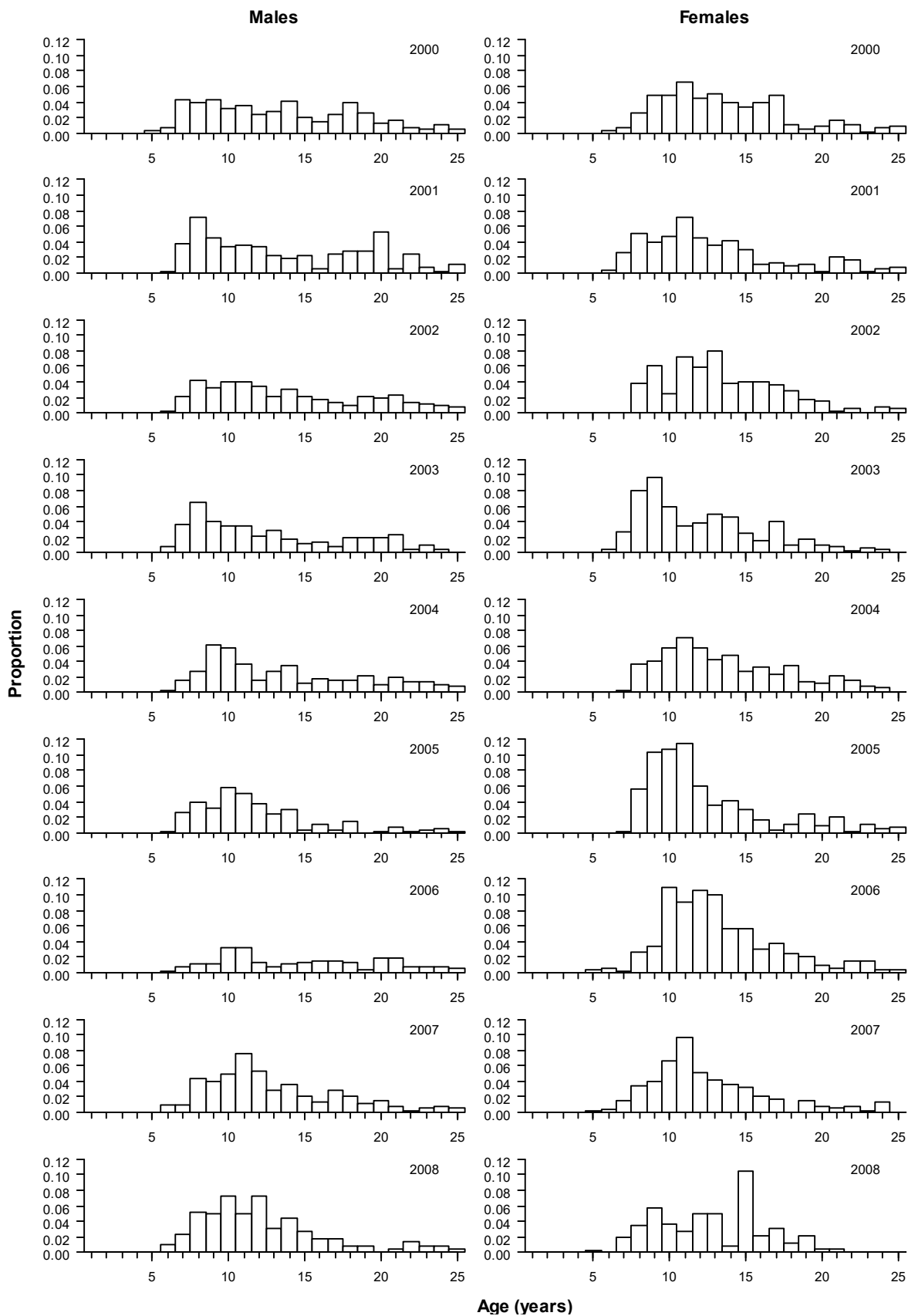


Figure B1 ctd.





**Figure B2: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2017.**

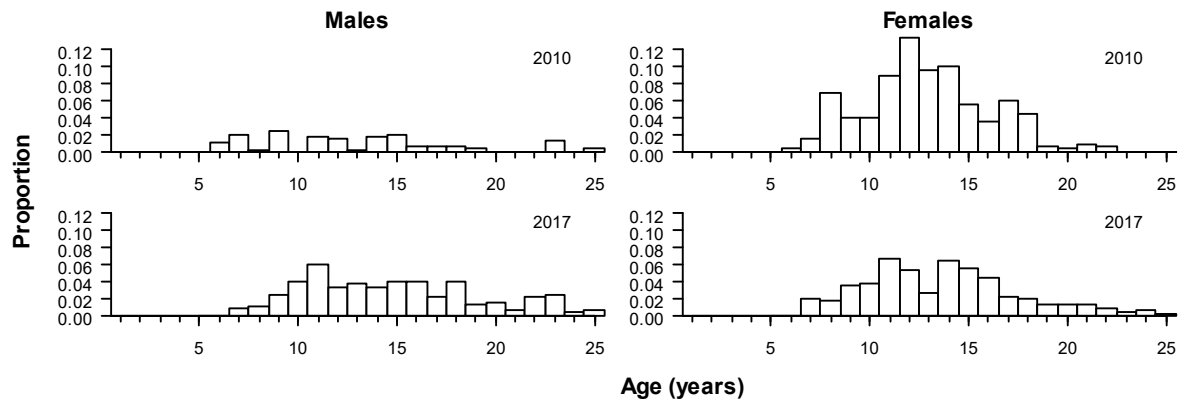
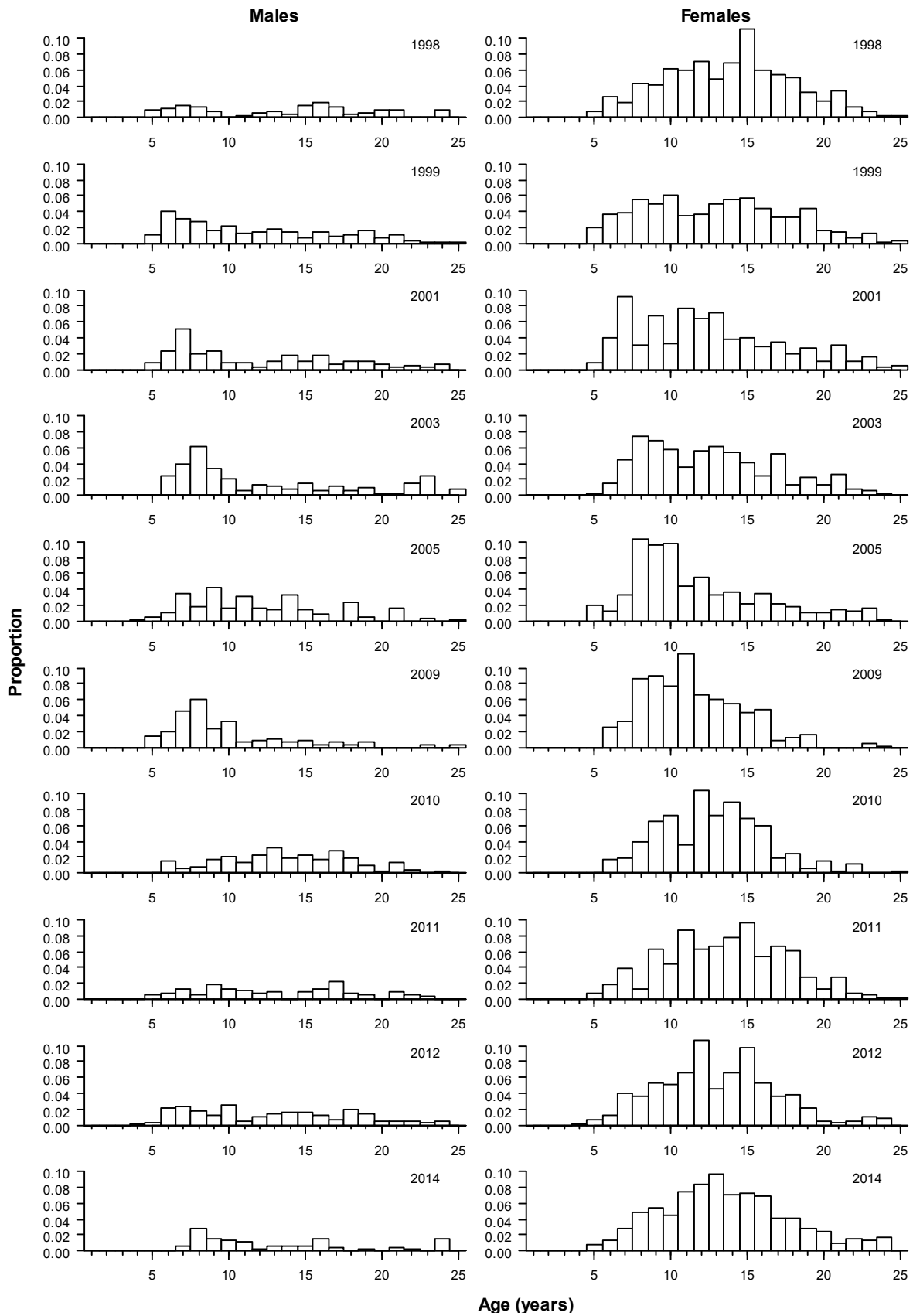
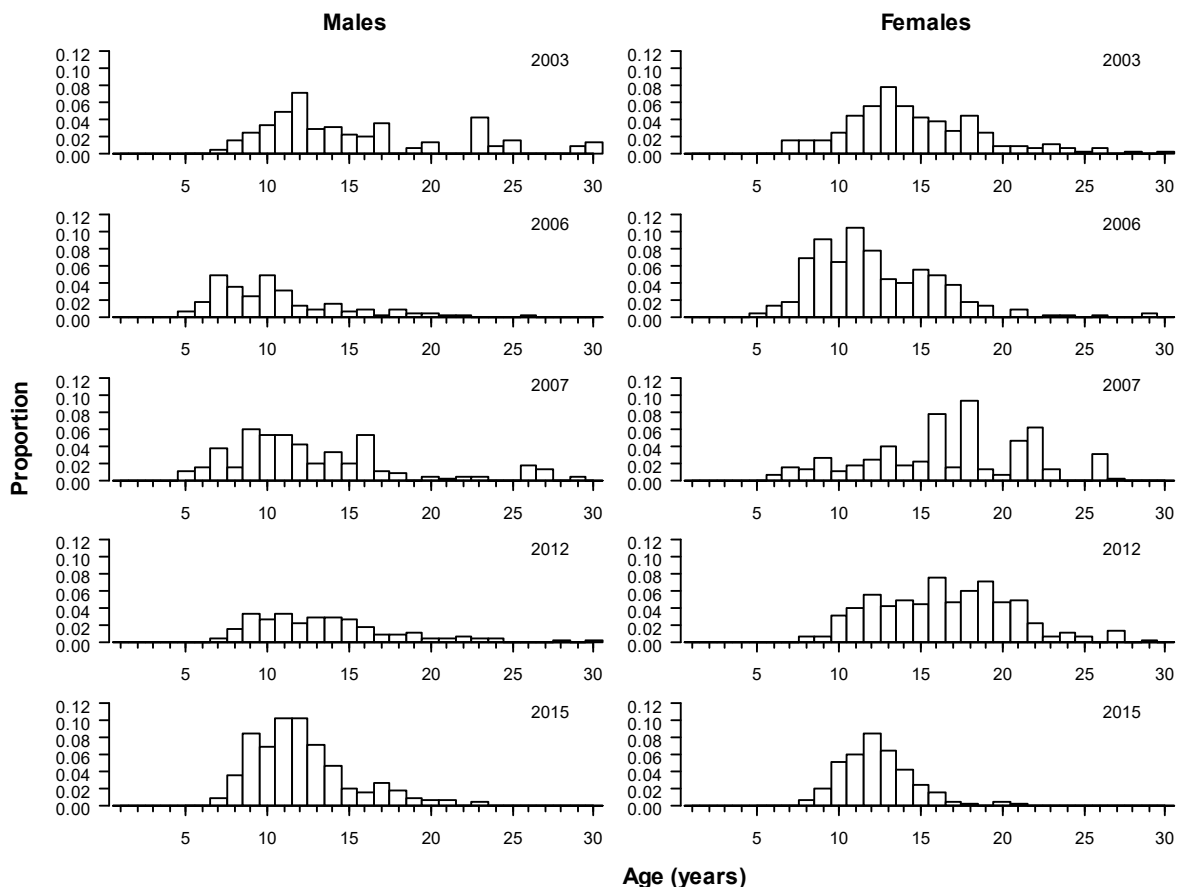


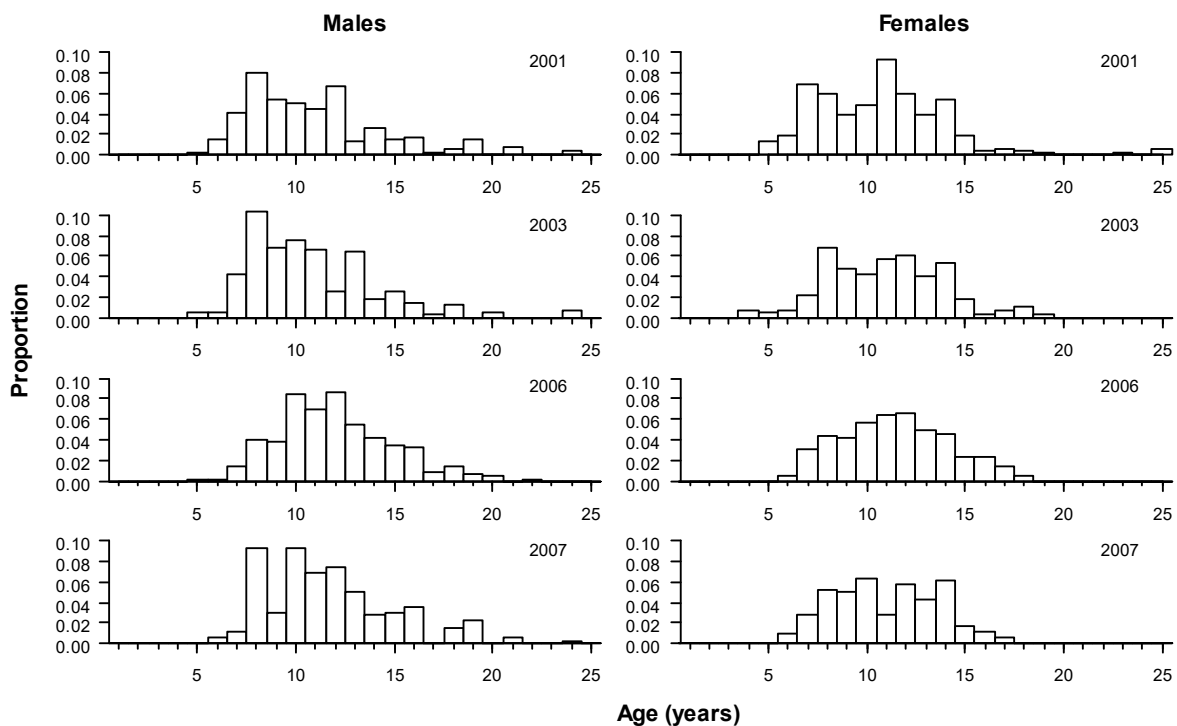
Figure B2 ctd.



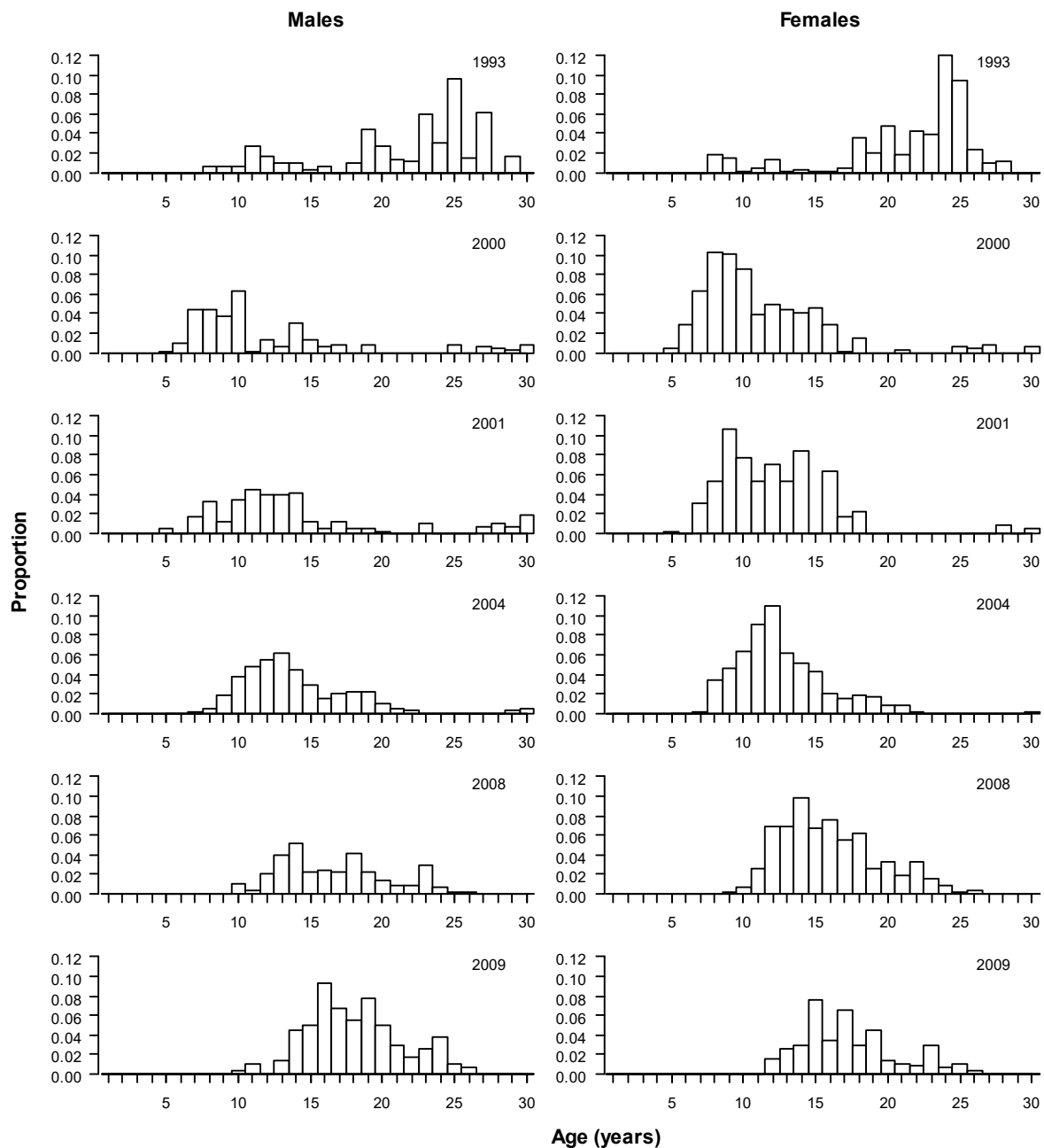
**Figure B3: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2017.**



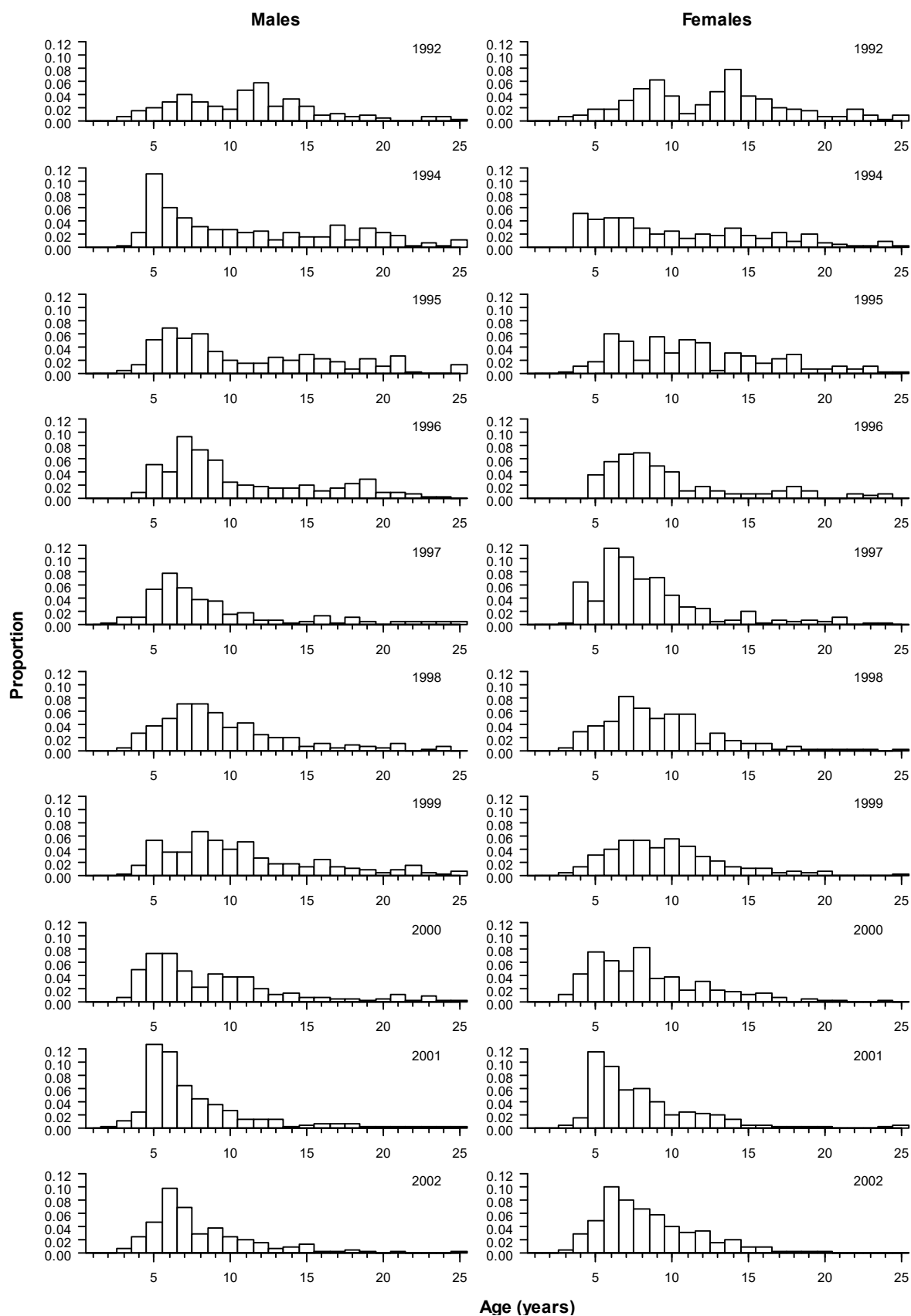
**Figure B4: Age frequency distributions of ling from commercial catch-at-age data in the west coast South Island longline fishery, 2003 to 2017.**



**Figure B5: Age frequency distributions of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2001 to 2017.**



**Figure B6: Age frequency distributions of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2017.**



**Figure B7: Age frequency distributions of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2017. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–May 2002 sample.**

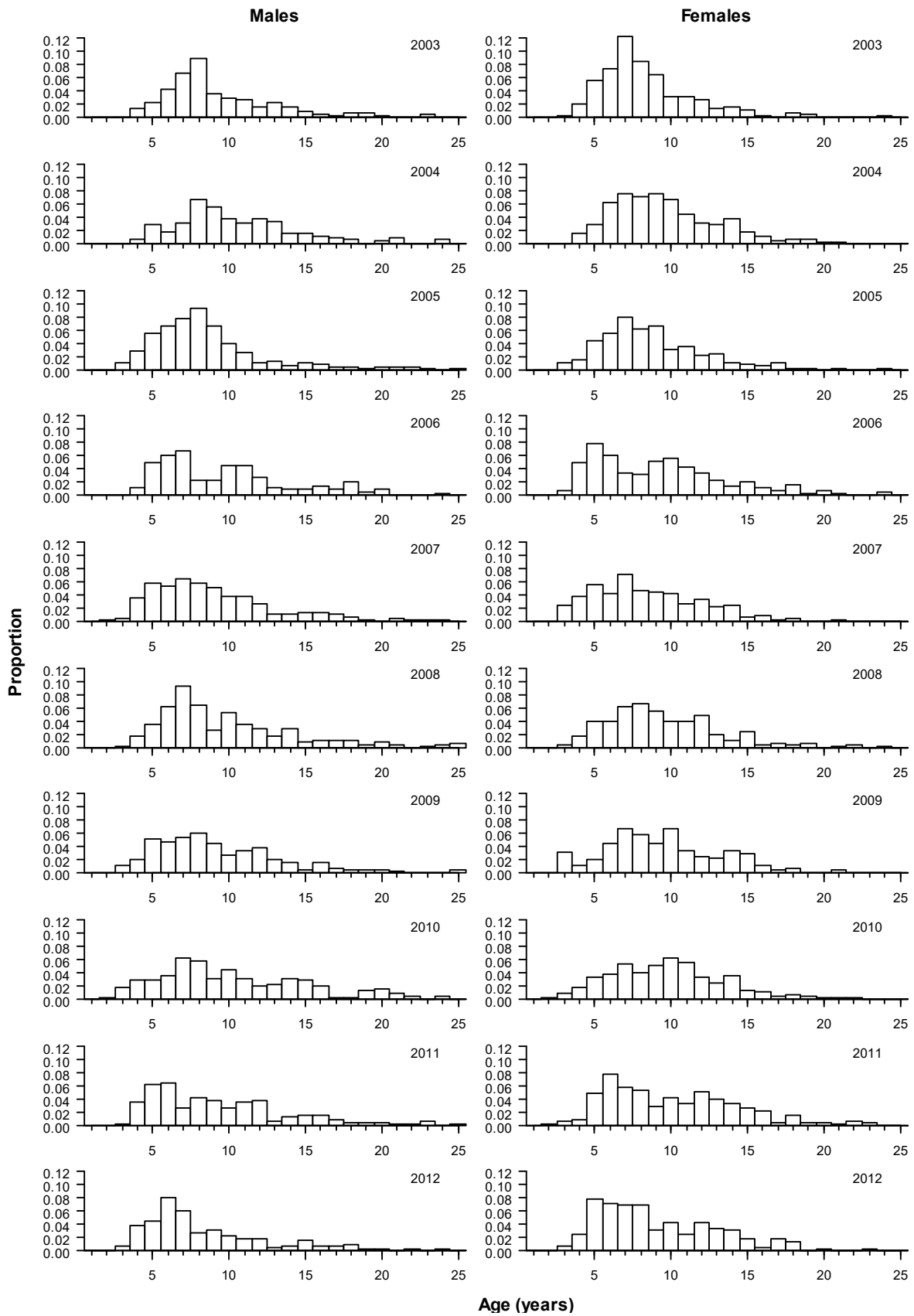


Figure B7 ctd.

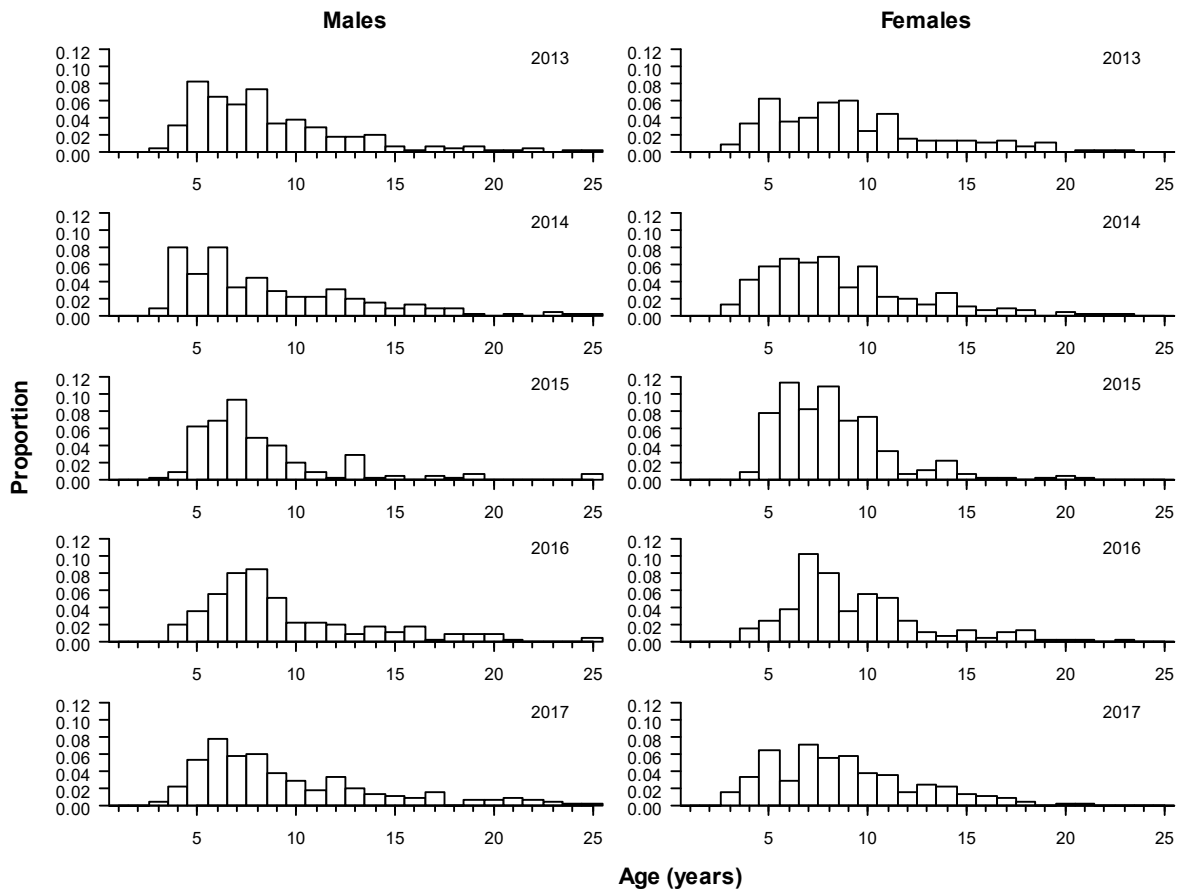
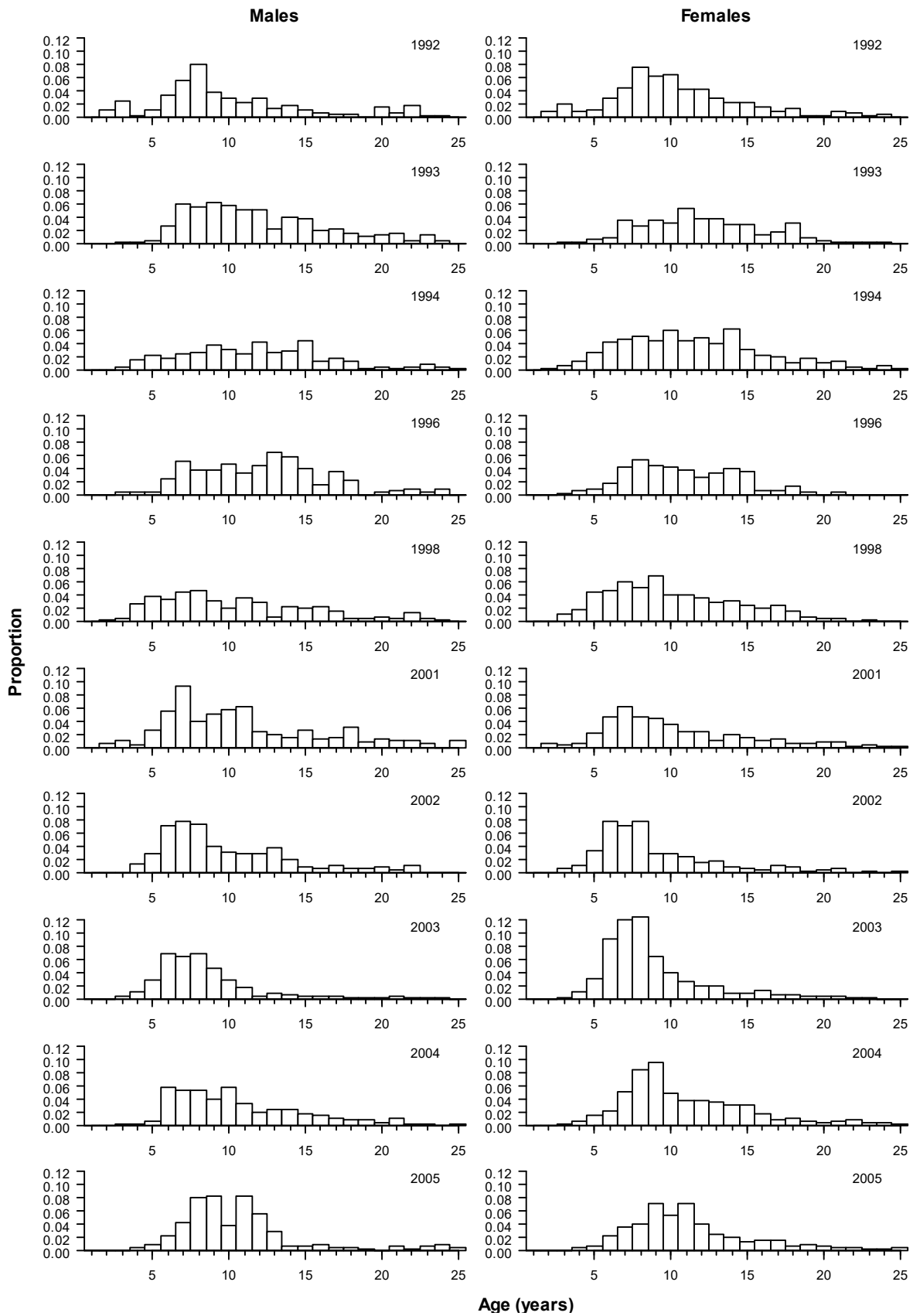


Figure B7 ctd.





**Figure B8: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2017. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2005” denotes the September 2004–April 2005 sample.**

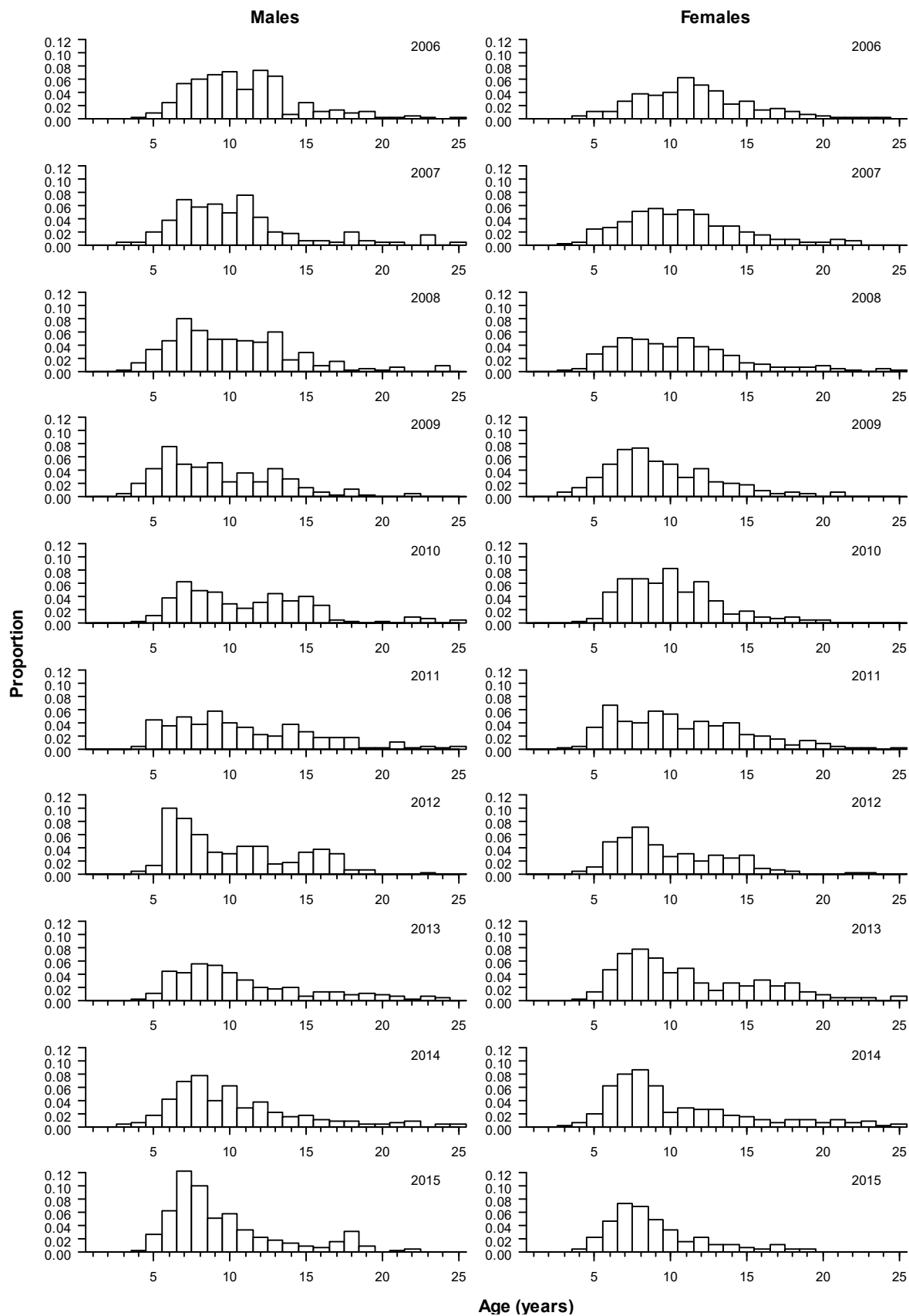


Figure B8 ctd.

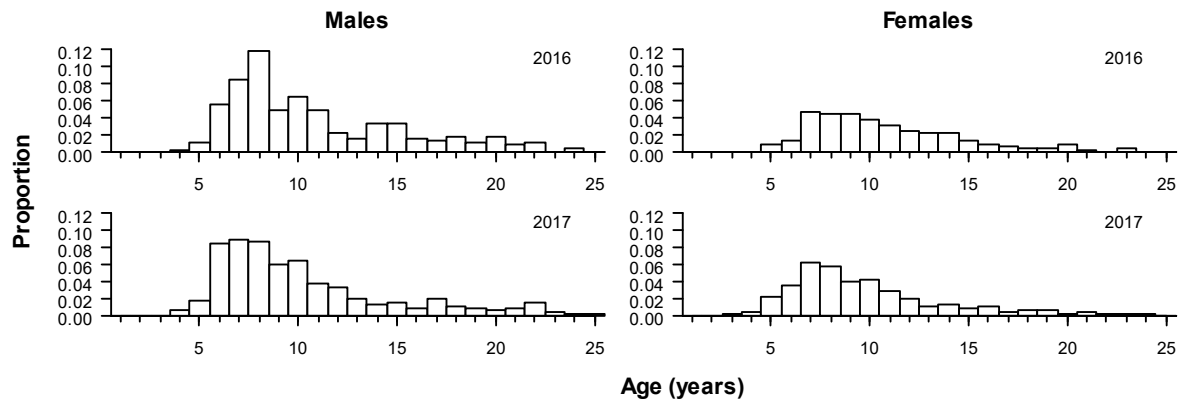
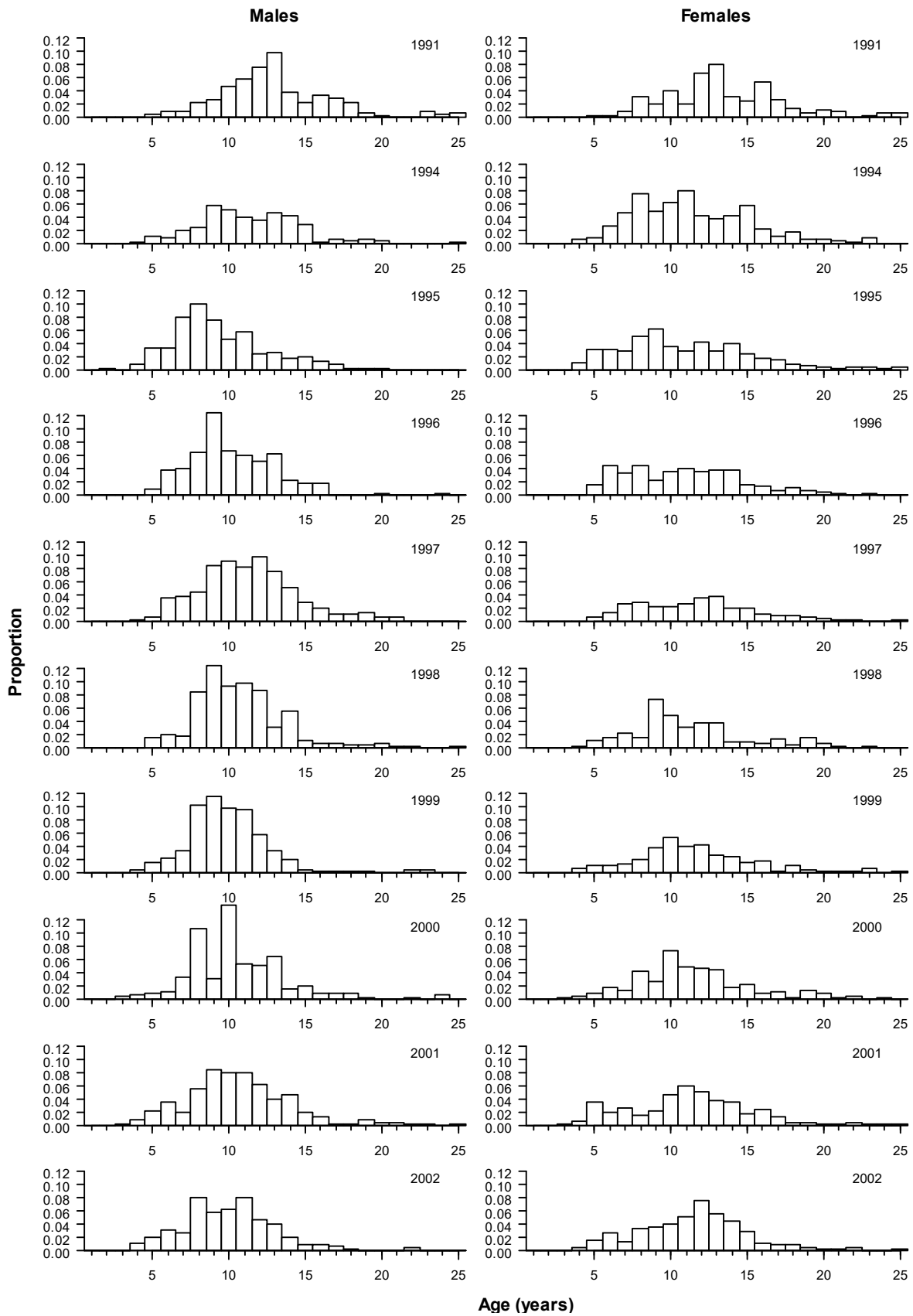


Figure B8 ctd.



**Figure B9: Age frequency distributions of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2017.**

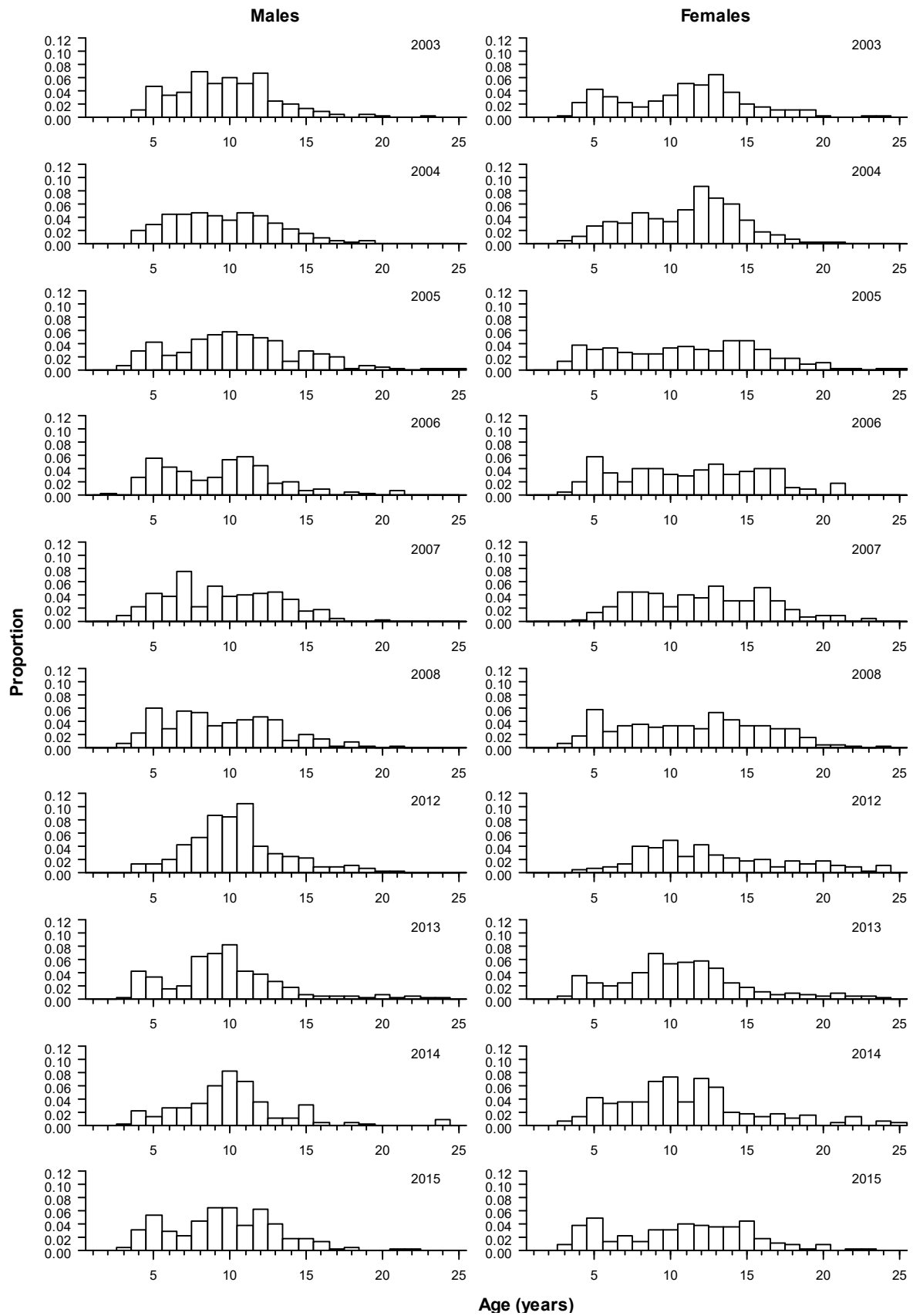


Figure B9 ctd.

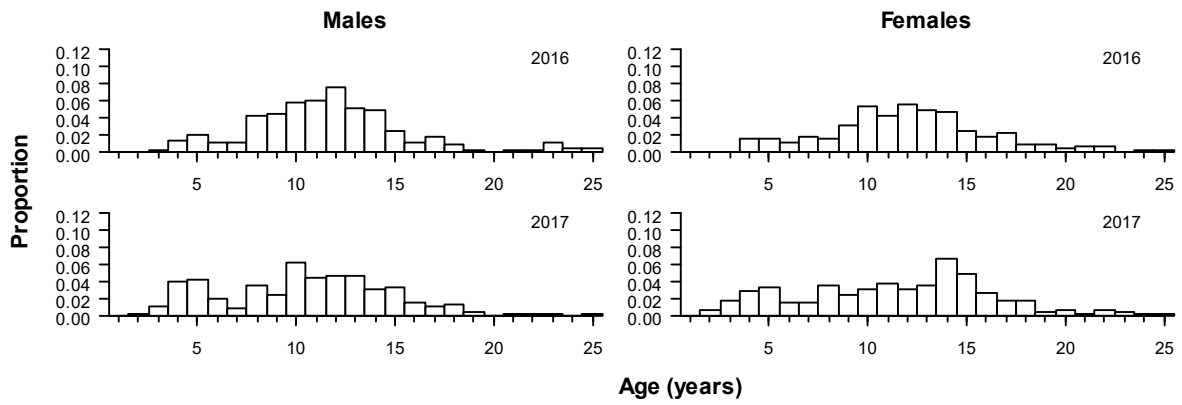
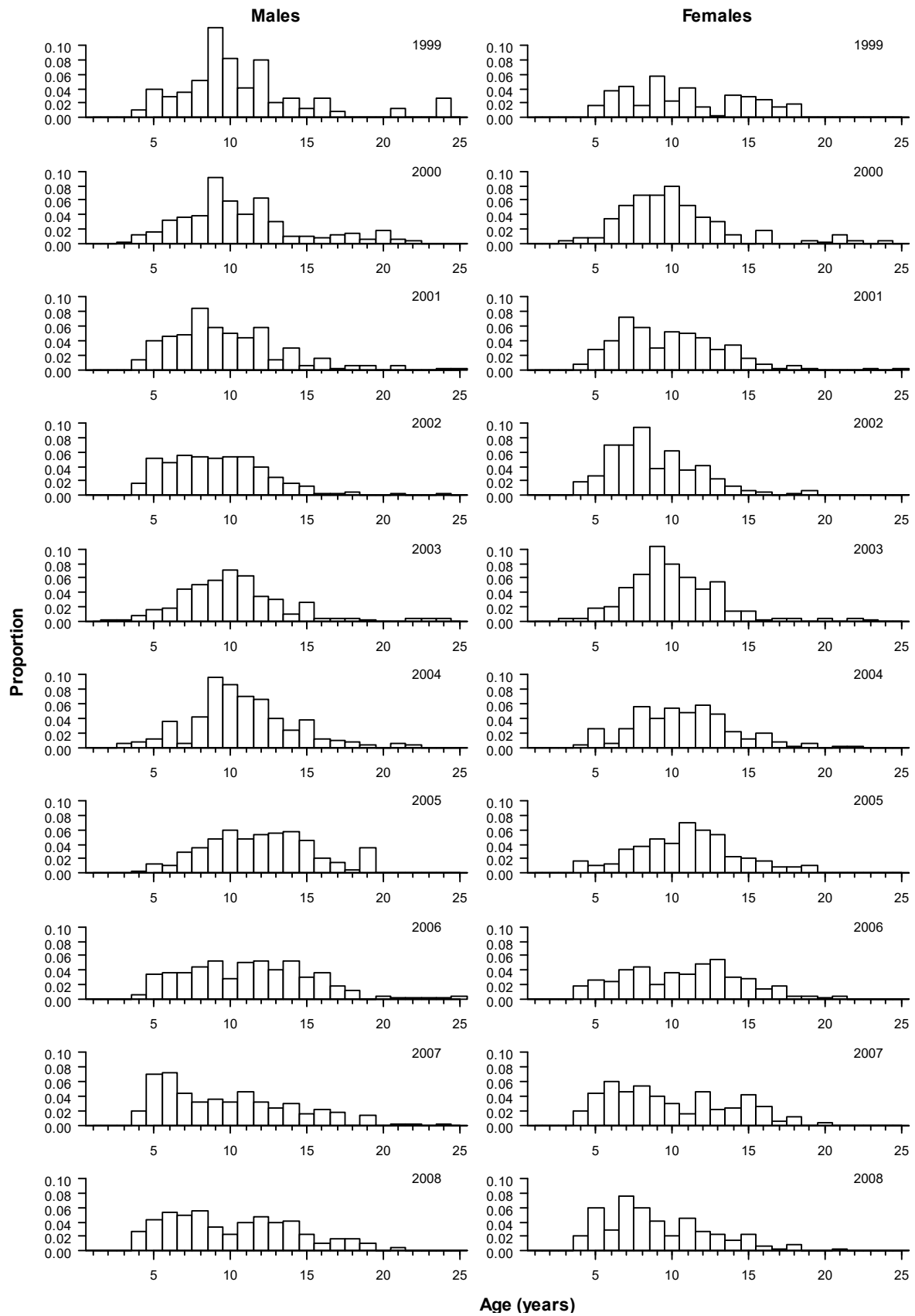


Figure B9 ctd.



**Figure B10: Age frequency distributions of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2017.**

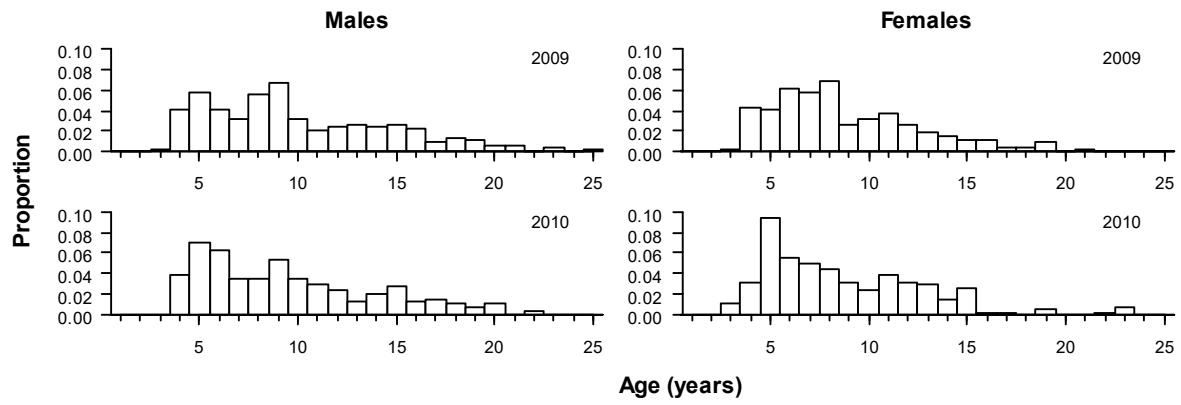
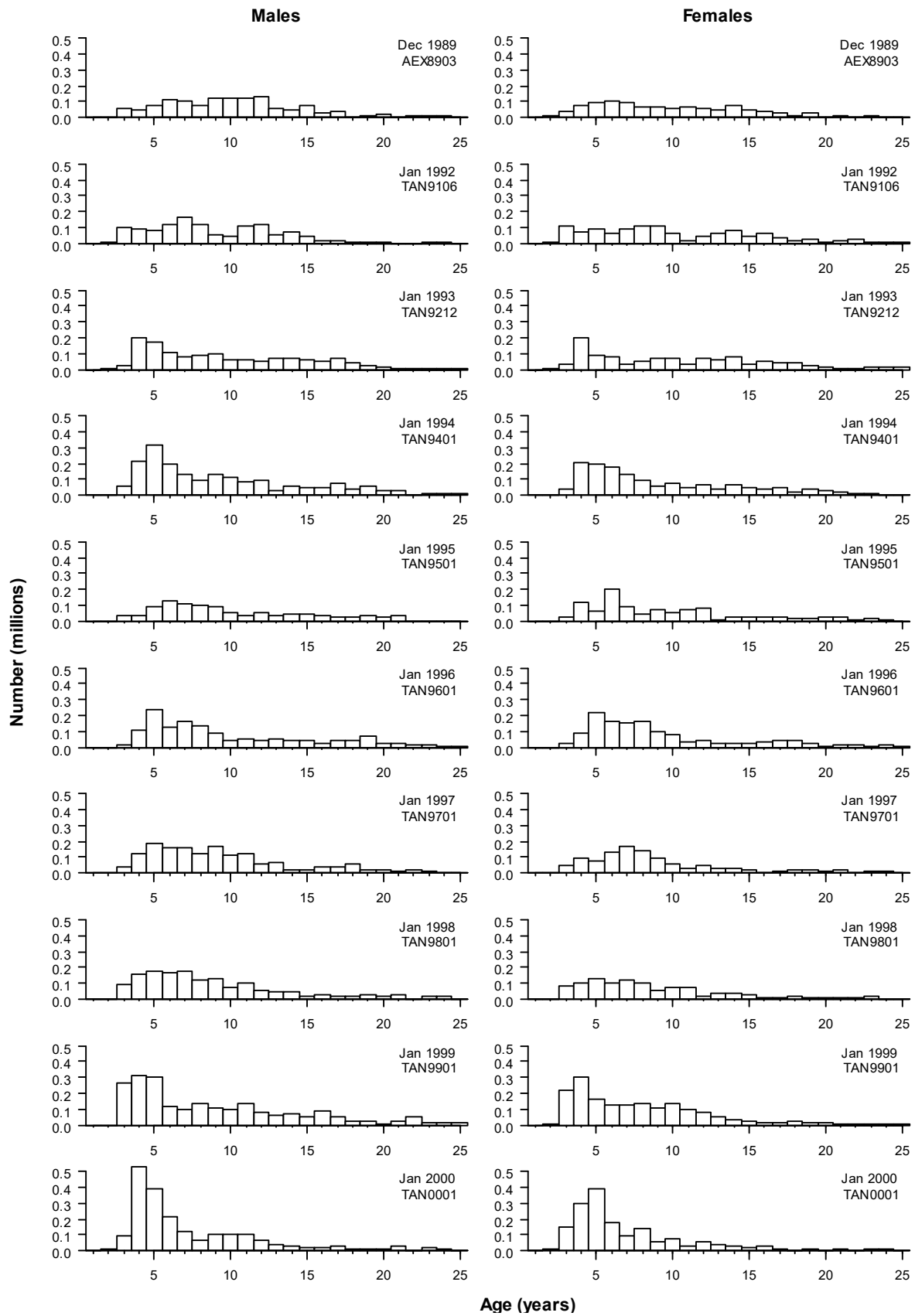


Figure B10 ctd.





**Figure B11: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from trawl surveys of the Chatham Rise, 1989–90 to 2017–18.**

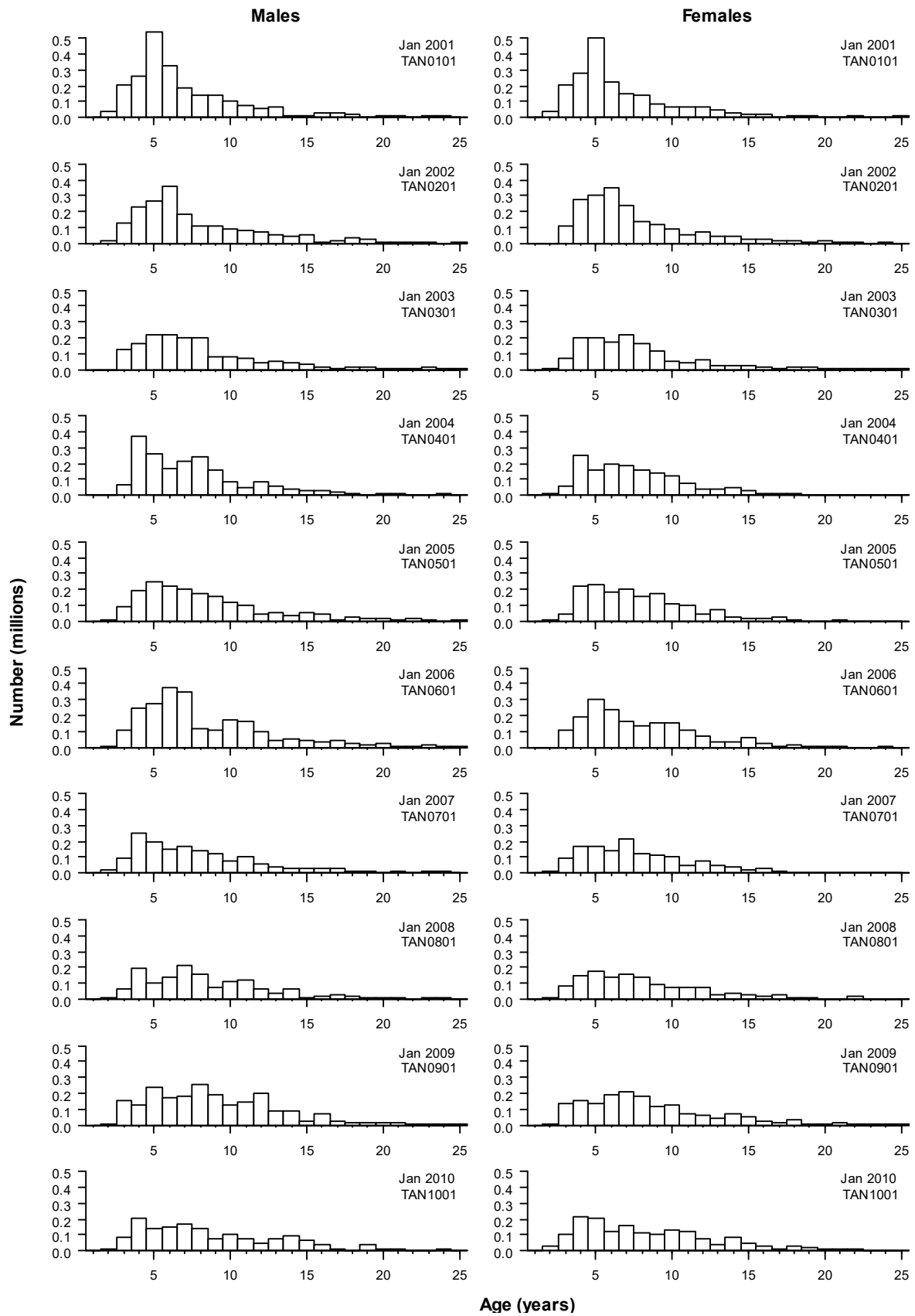


Figure B11 ctd.

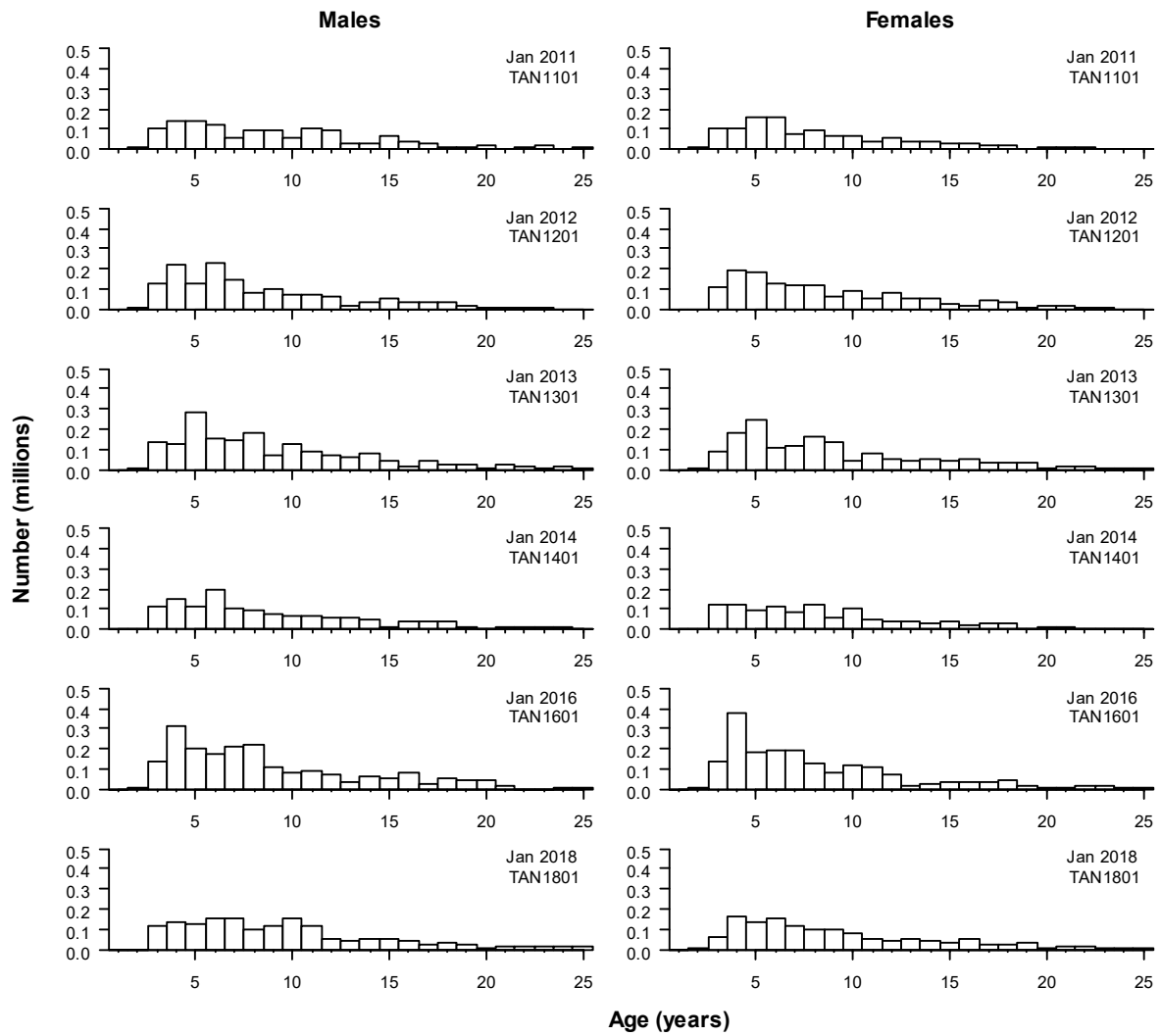
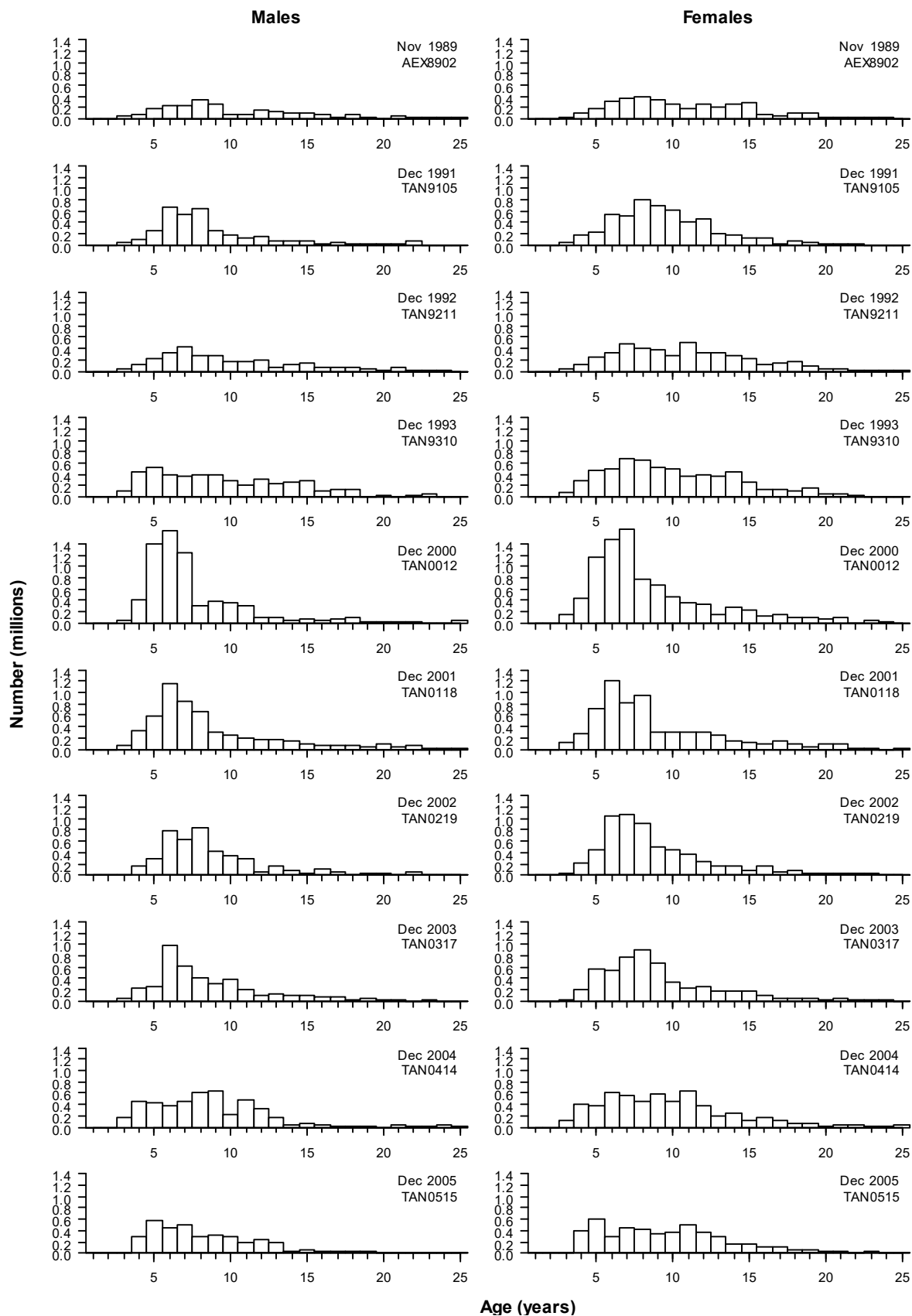


Figure B11 ctd.



**Figure B12: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from summer trawl surveys of the Sub-Antarctic, 1989 to 2017.**

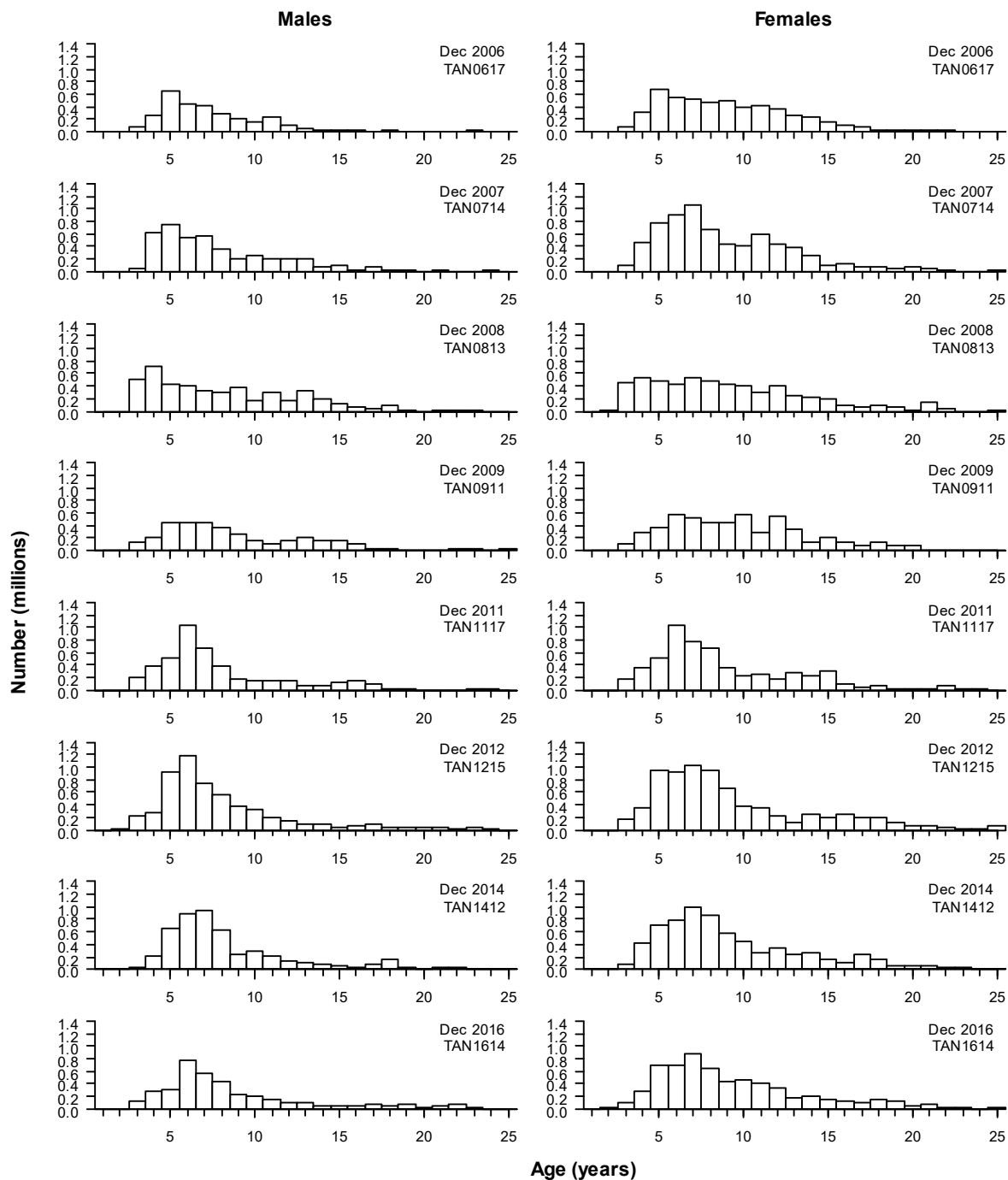
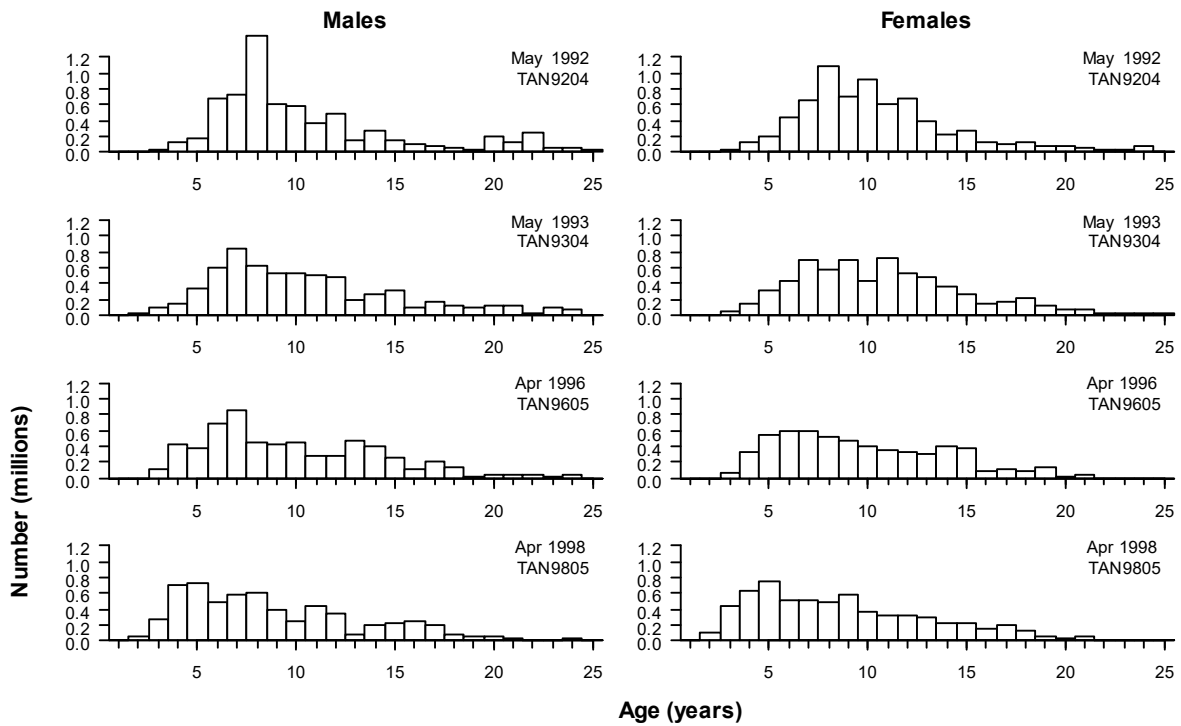
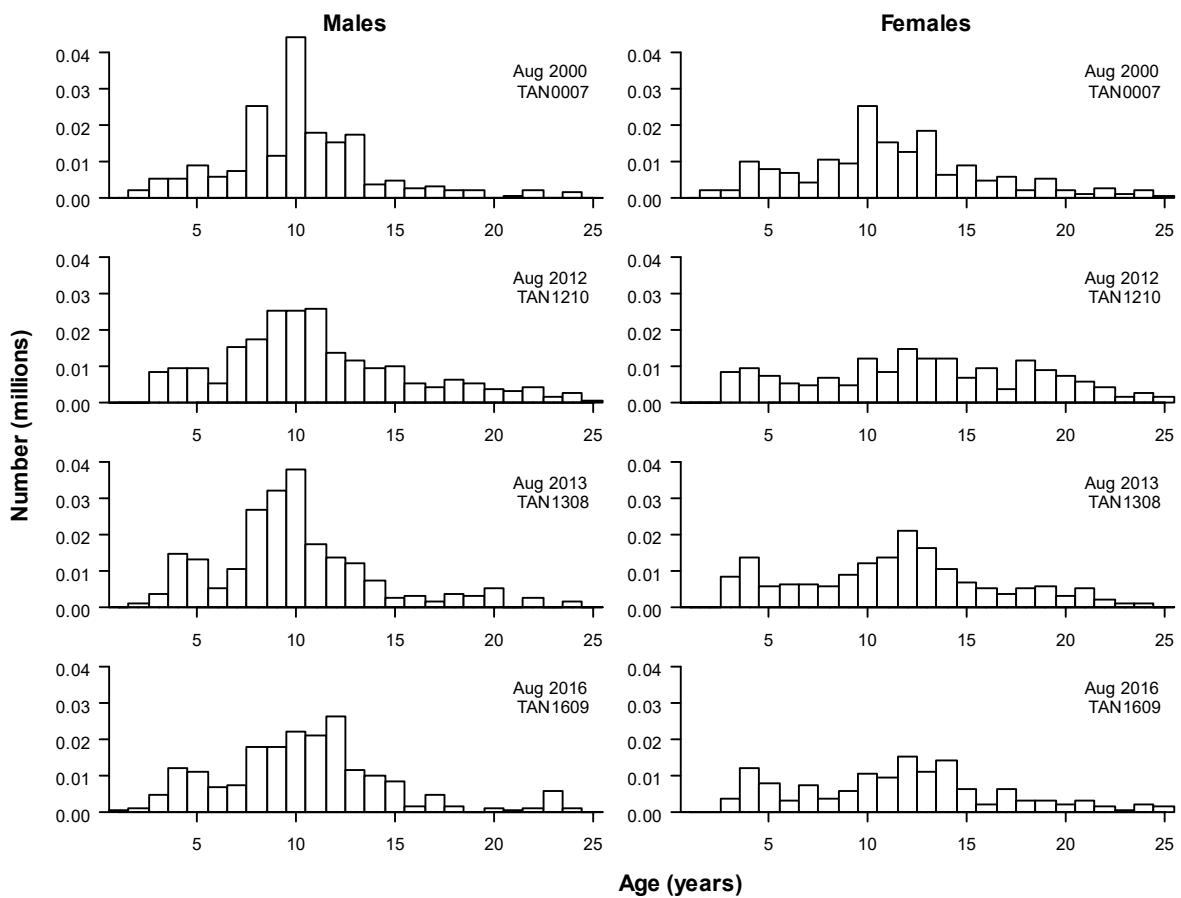


Figure B12 ctd.



**Figure B13: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from autumn trawl surveys of the Sub-Antarctic, 1992 to 1998.**



**Figure B14: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from winter trawl surveys of the WCSI, 2000 to 2017.**

## Appendix C: Observer sampling of hake from the Sub-Antarctic in 2016–17

Ballara & O’Driscoll (2018) showed that the observer sampling of the Sub-Antarctic hoki fishery in 2016–17 was poorly representative of the fishery, and consequently the hoki catch-at-age data from that fishery were not used in the 2017 hoki stock assessment. Because hake is a major bycatch of the hoki fishery, the Deepwater Fisheries Assessment Working Group wished to establish whether the sampling of hake from the same area and fishing year was adequate. Reported landings of hake from the Sub-Antarctic stock area (see Figure 2) were compared to landings that were sampled for hake by observers. The analysis compared landings by target species, month, stratum, and depth bin (Figure C1). All months and strata with substantial hake landings were well sampled. Tows targeting ling (which produced about 10% of the hake landings) were not sampled. The depth range of hake was also reasonably well sampled, although depths greater than 600 m were slightly under-sampled. It was concluded that observer sampling satisfactorily represented the hake fishery.

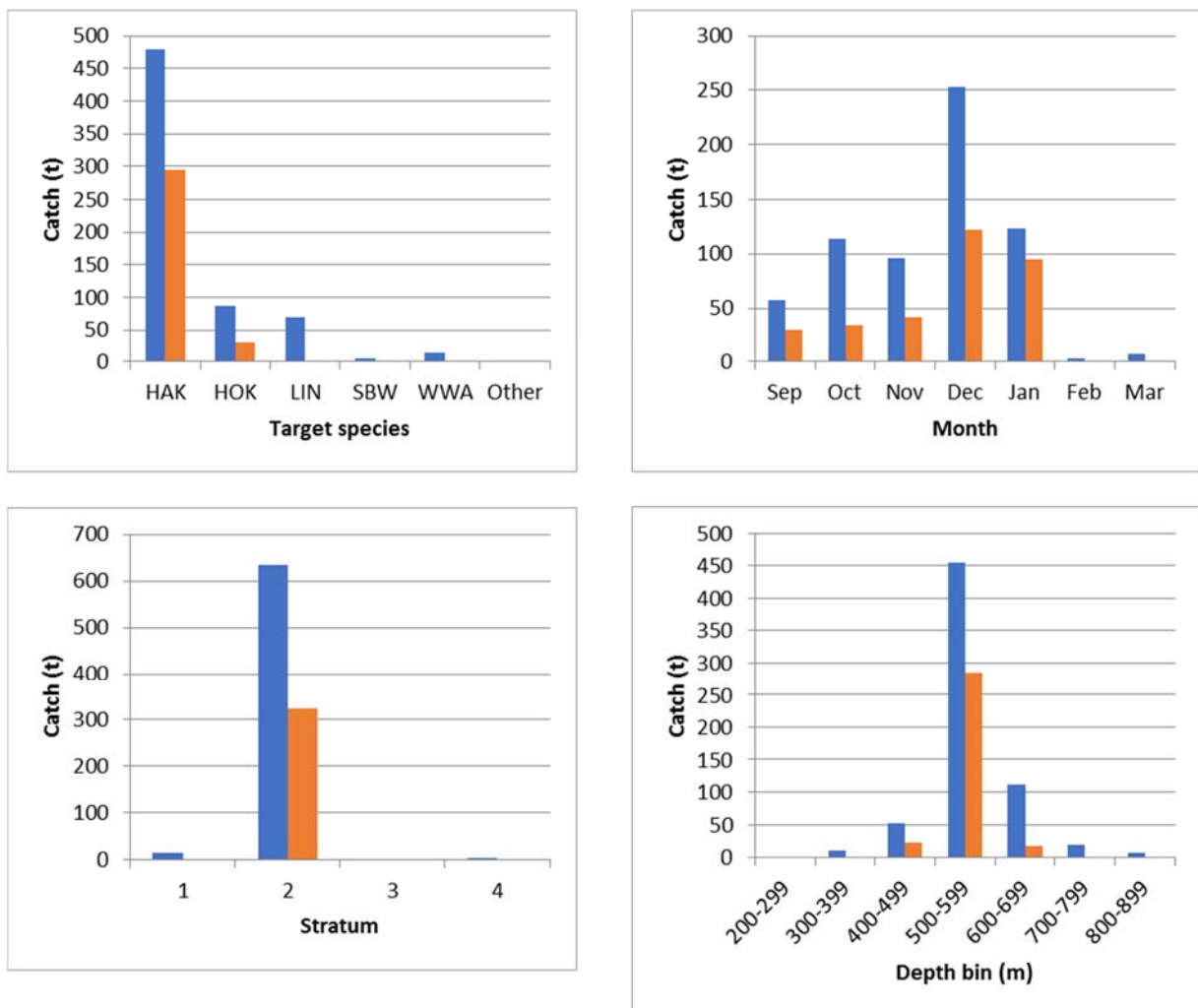
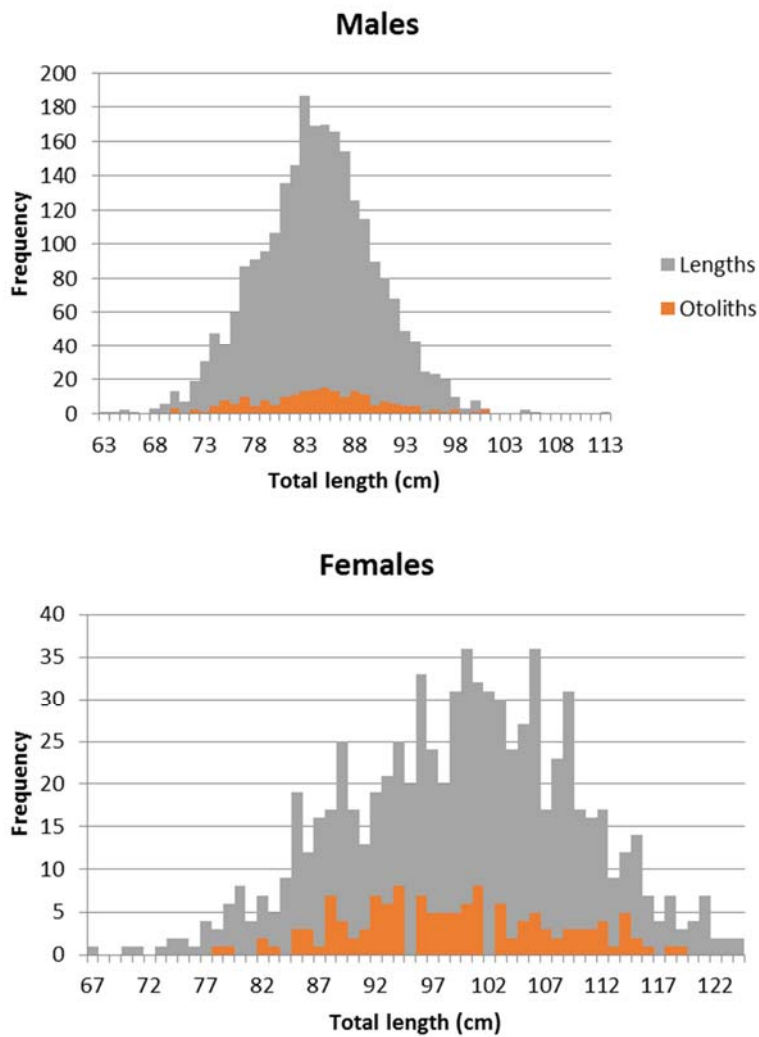


Figure C1: Comparisons of total reported hake landings (blue bars) and observed hake landings (brown bars) in the Sub-Antarctic from September 2016 to March 2017, by target species, month, stratum, and bottom depth.

A comparison of the raw hake length-frequency data collected by observers with the length frequency distribution of fish from which otoliths were available showed that the distributions had similar shapes (Figure C2). Consequently, it was concluded that the estimated catch-at-age

distributions for the 2016–17 hake trawl fishery in the Sub-Antarctic were suitable for use in assessments of this stock.



**Figure C2: Comparisons, by sex, of raw hake length-frequency data (grey bars) and lengths of hake sampled for otoliths (brown bars) in the Sub-Antarctic from September 2016 to March 2017.**