



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

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EXECUTIVE SUMMARY

Horn, P.L.; Sutton, C.P. (2017). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 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.

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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 2015–16 fishing year (using data and otoliths collected at sea by observers), and from research trawl surveys of middle depth species off the west coast South Island in August 2016 (TAN1609) and hoki and middle depth species in the Sub-Antarctic in December 2016 (TAN1614). The target coefficient of variation (CV) for each estimated catch-at-age distribution from the observer samples and the trawl survey was 30% (mean weighted CV across all age classes).

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

For ling, the target CV was met for the commercial trawl fisheries from west coast South Island and the Sub-Antarctic, and both the Sub-Antarctic and west coast South Island trawl surveys. It was nearly met for the Chatham Rise trawl fishery. 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 nearly met for the ling longline fishery on Chatham Rise in 2015–16. No samples from other longline fisheries were available.

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 (and summarised in Table 29). 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 2015–16 fishing year, and for hake and ling from research trawl surveys conducted in August and December 2016. Catch-at-age data are a vital input into the stock assessment process as they provide important information on the year class strength of recruited cohorts, and enable calculation of selectivity ogives for the trawl surveys and commercial fisheries for these species. This report describes the resulting catch-at-age distributions for hake and ling; the new data 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 DEE201620 “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 2015–May 2016 [600].
- HAK 1 — trawl survey, Dec 2016 (project DEE2016-01) [600].
- HAK 4 — commercial trawl fishery, Oct 2015–Apr 2016 [600].
- HAK 7 — trawl survey, Aug 2016 (project DEE2016-03), plus some additional otoliths to enable the survey age-length key to be applied to the commercial trawl fishery, Jun–Sep 2016 [600].

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

- LIN 3&4 — commercial longline fishery, Chatham Rise, Jun–Oct 2016 [550].
- LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2015, or non-spawning, Campbell, Feb–Jul 2016 [500].
- LIN 5&6 — commercial trawl fishery, Sub-Antarctic, Sep 2015–Apr 2016 [600].
- LIN 5&6 — trawl survey, Dec 2016 (project DEE2016-01) [600].
- LIN 7 — trawl survey, Aug 2016 (project DEE2016-03), plus some additional otoliths to enable the survey age-length key to be applied to the commercial trawl fishery, Jun–Sep 2016 [700].
- LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2016 [500].

Insufficient or no observer otoliths were available from either of the ling longline fisheries on Sub-Antarctic (LIN 5&6), and also from the winter 2016 Cook Strait trawl fishery (LIN 7&2). Consequently, catch-at-age distributions were not able to be produced for those fisheries.

The following additional commercial fishery catch-at-age distribution for ling was estimated using an age-length key derived previously from the January 2016 Chatham Rise trawl survey (LIN 3&4).

- LIN 3&4 — commercial trawl fishery, Chatham Rise, Oct 2015–May 2016.

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 (constituting about 2% of that length frequency) were fully sampled. This provided a sample with a mean weighted CV similar to that from proportional sampling, but smaller than from uniform sampling for the older age classes (A. Dunn, NIWA, pers. comm.). Otoliths were prepared and read using the validated ageing technique for hake (Horn 1997) or ling (Horn 1993). Catch-at-age was calculated by constructing age-length keys separately for each sex and applying them to the scaled length frequency data derived from each fishery or survey separately using software developed specifically for this task by NIWA (Bull & Dunn 2002).

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

Observer sampling of the HAK 1 and HAK 4 commercial trawl fisheries 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 2014–15 HAK 1 fishery included otoliths from observer sampling from September 2014 to May 2015 plus age data from the TAN1412 trawl survey in December 2014.

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 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, 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 (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.

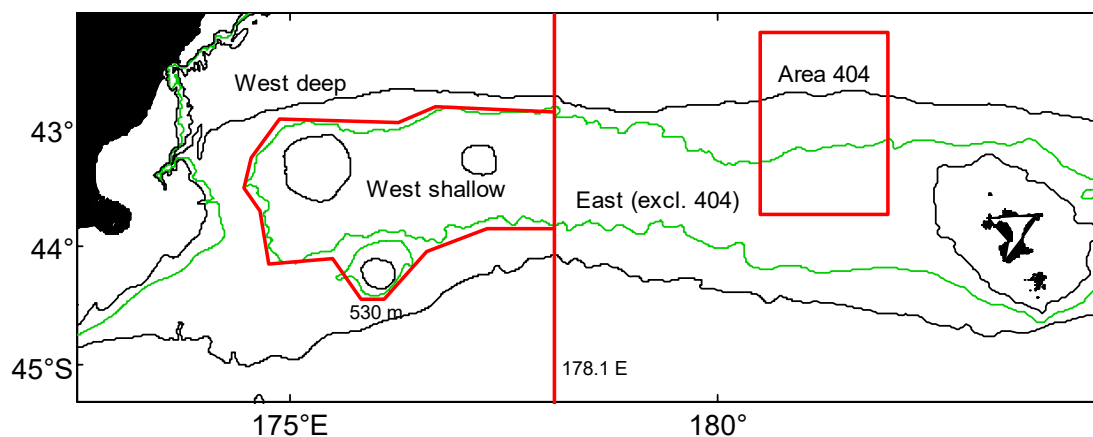


Figure 1: Strata defined for the Chatham Rise hake fishery. The west stratum boundary defined by depth (530 m) is shown only approximately (red). Isobaths at 1000 (black), 500 (green), and 250 m (black) are also shown.

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 2015–16 fishing year, sufficient length data ($n = 610$) were available from the west strata to calculate a catch-at-age distribution, but not for the east strata ($n = 42$). Details of the estimated catch-at-age distribution for west trawl-caught hake in the 2015–16 fishing year are in Table 2. The mean weighted CV of 29% just met the target of 30%.

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

Table 1: Numbers of measured (by fishery) and aged (fisheries combined) male (M) and female (F) hake contributing to samples of proportion-at-age from the two commercial trawl fisheries on the Chatham Rise. The number of tows sampled by observers and the estimated mean weighted CV (%) by age are also listed. Blank cells in the table indicate that insufficient data were available to allow estimation of catch-at-age.

Fishing year	Measured								Aged	
	West				East				M	F
	M	F	Tows	CV	M	F	Tows	CV		
1991-92	2 112	2 636	163	21.9	170	247	25	43.2	233	230
1993-94	355	452	90	36.7					181	217
1994-95	318	603	69	32.8	234	88	14	43.1	170	191
1995-96	802	917	103	28.2					113	165
1996-97	354	233	28	39.6	335	75	28	48.6	145	149
1997-98	3 161	3 046	390	14.9	224	140	44	41.0	393	393
1998-99	712	1 279	171	19.4					290	440
1999-2000	807	901	168	19.0					442	499
2000-01	830	1 135	185	17.6	1 017	283	47	24.7	317	426
2001-02	386	492	89	20.6					455	419
2002-03	176	272	61	25.4					256	345
2003-04	597	438	101	26.8	378	92	38	26.6	364	304
2004-05	896	437	82	24.2					391	343
2005-06	234	330	69	39.1					189	255
2006-07					409	278	47	27.6	368	388
2007-08	286	270	53	20.6					350	335
2008-09	257	162	43	24.3					237	185
2009-10	147	259	38	25.6					228	244
2010-11	202	249	46	34.3					199	251
2011-12									0	0
2012-13									0	0
2013-14	213	221	37	29.5					150	145
2014-15					249	273	33	28.6	91	132
2015-16	307	303	36	28.7					250	209

Table 2: Calculated numbers-at-age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations in the west Chatham Rise during October 2015–April 2016. Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
1	571	1.373	592	1.280
2	339	0.902	844	0.828
3	1 049	0.416	689	0.702
4	2 823	0.259	1 163	0.335
5	4 123	0.175	3 427	0.213
6	1 797	0.298	2 297	0.279
7	1 608	0.258	2 383	0.258
8	1 181	0.277	1 831	0.250
9	926	0.343	1 205	0.321
10	539	0.404	389	0.478
11	244	0.708	203	0.728
12	508	0.482	526	0.479
13	109	0.840	189	0.793
14	256	0.661	148	0.753
15	274	0.677	262	0.758
16	0	–	40	1.252
17	27	1.415	22	2.054
18	0	–	19	1.513
19	5	2.155	0	–
20	41	1.651	0	–
21	103	0.851	0	–
22	0	–	32	1.313
23	0	–	22	1.973
24	32	1.547	4	2.132
Measured males				307
Measured females				303
Aged males				250
Aged females				209
No. of tows sampled				36
Mean weighted CV (% , sexes pooled)				28.7

3.1.2 Sub-Antarctic

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

1. Puysegur Bank ($165^{\circ} \text{ E} \leq \text{longitude} \leq 168^{\circ} \text{ E}$, $46^{\circ} \text{ S} \leq \text{latitude} \leq 48^{\circ} \text{ S}$).
2. Snares-Pukaki ($165^{\circ} \text{ E} \leq \text{longitude} \leq 175^{\circ} \text{ E}$, $46^{\circ} \text{ S} \leq \text{latitude} \leq 50.25^{\circ} \text{ S}$, but excluding the Puysegur Bank stratum and the area north of 48° 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 3 summarises the data used each year to produce the catch-at-age distributions, and the resulting mean weighted CVs. Details of the estimated catch-at-age distribution for trawl-caught hake in the 2015–16 fishing year are in Table 4. The mean weighted CV of 26% was within the target of 30%.

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

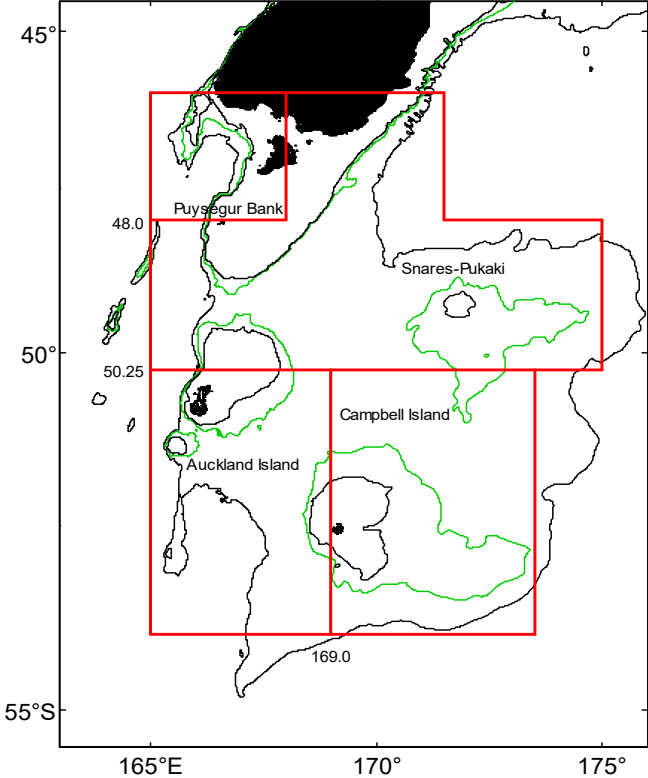


Figure 2: Fishery strata defined for the Sub-Antarctic hake fishery. Numbers show latitudes and longitudes of fishery boundaries. Isobaths at 1000, 500, and 250 m are also shown.

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

Year	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
1989–90	269	47	548	71	74	42.0
1990–91	175	0	588	0	64	–
1991–92	557	215	1 363	409	151	24.9
1992–93	833	183	1 218	518	171	27.6
1993–94	512	87	609	173	119	47.8
1994–95	167	0	597	0	92	–
1995–96	289	65	435	110	75	50.0
1996–97	84	0	219	0	54	–
1997–98	390	82	1 018	193	154	37.7
1998–99	463	174	1 077	322	199	27.4
1999–2000	3 007	259	2 526	421	307	22.5
2000–01	527	388	1 648	698	216	29.6
2001–02	921	333	2 026	874	320	23.4
2002–03	271	258	908	739	197	40.4
2003–04	1 309	350	969	518	165	24.7
2004–05	179	185	424	305	82	40.1
2005–06	1 906	218	1 094	506	153	23.2
2006–07	547	224	666	351	73	38.5
2007–08	891	325	592	682	89	23.2
2008–09	1 221	311	893	498	109	23.9
2009–10	1 879	418	1 029	611	91	18.2
2010–11	3 738	296	1 212	282	117	20.2
2011–12	4 098	581	1 597	605	109	15.0
2012–13	2 555	412	1 306	666	100	19.5
2013–14	4 027	316	1 443	146	90	19.4
2014–15	2 907	256	800	210	94	22.9
2015–16	2 125	217	931	166	64	26.4

Table 4: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations in the Sub-Antarctic during September 2015–May 2016. Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
4	2 161	1.262	2 148	0.965
5	4 828	0.283	2 212	1.040
6	5 883	0.289	2 435	0.705
7	16 246	0.230	3 049	0.642
8	17 250	0.212	6 223	0.276
9	28 011	0.188	8 313	0.256
10	10 422	0.281	6 219	0.287
11	11 967	0.264	7 457	0.273
12	4 795	0.415	7 290	0.247
13	7 723	0.333	6 787	0.312
14	5 527	0.371	2 868	0.445
15	3 279	0.531	2 669	0.451
16	978	1.008	1 646	0.550
17	3 610	0.512	900	0.819
18	2 983	0.563	605	1.172
19	2 731	0.488	802	0.869
20	565	1.045	1 394	0.655
21	1 106	0.663	299	1.181
22	1 543	0.801	0	–
23	980	1.087	404	1.228
24	418	1.047	0	–
25	0	–	979	0.740
Measured males			2 125	
Measured females			931	
Aged males			217	
Aged females			166	
No. of tows sampled			64	
Mean weighted CV (% , sexes pooled)			26.4	

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 5 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. Details of the estimated catch-at-age distribution for trawl-caught hake in the 2015–16 fishing year are in Table 6. The mean weighted CV of 13% was much better than the target of 30%.

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

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

Year	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
1989–90	578	210	567	261	57	23.1
1990–91	2 288	286	1 653	358	146	18.4
1991–92	2 592	196	1 193	261	121	22.5
1992–93	2 129	188	979	163	93	29.1
1993–94	1 598	151	1 643	272	174	32.5
1994–95	2 528	271	2 769	342	152	29.2
1995–96	2 862	287	1 753	326	193	28.9
1996–97	3 286	262	1 720	198	234	21.3
1997–98	2 339	257	1 497	253	237	21.4
1998–99	4 186	270	3 744	240	307	18.3
1999–2000	2 705	258	2 330	269	285	18.9
2000–01	1 529	176	1 723	280	192	23.9
2001–02	2 281	93	2 434	385	380	33.8
2002–03	1 917	227	2 063	234	296	20.0
2003–04	2 702	303	2 181	193	353	16.5
2004–05	2 305	238	2 324	280	217	23.8
2005–06	5 502	276	4 231	298	395	16.3
2006–07	3 385	248	3 258	257	132	16.7
2007–08	4 682	321	2 416	266	147	17.7
2008–09	5 773	301	3 610	301	178	18.8
2009–10	2 454	130	1 877	134	76	25.4
2010–11	2 489	260	2 489	353	104	16.8
2011–12	2 535	357	2 061	381	140	14.4
2012–13	12 352	325	8 417	443	493	14.3
2013–14	8 128	320	7 242	384	360	13.1
2014–15	12 334	329	10 173	363	498	13.6
2015–16	5 304	461	4 589	449	240	13.2

Table 6: Calculated numbers at age, separately by sex, with CVs, for hake sampled by observers during commercial trawl operations off the WCSI during June–September 2016. Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
1	475	0.706	0	–
2	18 200	0.230	15 482	0.184
3	2 062	0.325	2 656	0.268
4	35 860	0.171	4 271	0.421
5	104 456	0.102	11 549	0.298
6	99 252	0.102	53 255	0.132
7	48 886	0.142	68 746	0.117
8	28 383	0.219	57 701	0.121
9	3 884	0.548	21 873	0.206
10	5 772	0.480	18 277	0.218
11	4 704	0.503	8 806	0.323
12	6 228	0.485	4 541	0.442
13	2 293	0.771	3 129	0.634
14	0	–	3 380	0.674
15	437	1.231	213	1.486
16	3 071	0.589	217	1.640
17	0	–	0	–
18	2 537	0.776	0	–
19	0	–	1 251	0.698
20	0	–	737	1.019
21	0	–	0	–
22	0	–	0	–
23	437	1.196	0	–
Measured males				5 304
Measured females				4 589
Aged males				461
Aged females				449
No. of tows sampled				240
Mean weighted CV (% , sexes pooled)				13.2

3.2 Trawl survey catch-at-age data for hake

3.2.1 Chatham Rise

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

Table 7 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The 30% target was met in only one of the 20 surveys (TAN9106, see Table 7). No survey in this series was conducted in January 2017.

All estimated proportion-at-age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A5). 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 its progression is apparent in the survey size distributions at least to TAN1101. A relatively strong year class spawned at the start of the 1990–91 fishing year (age 3 in January 1994) is also apparent.

Table 7: Numbers of measured male and female hake (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.

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

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 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. Although a survey of this area was conducted in December 2016, only 33 hake were caught, and not all core strata were completed. This sample size was insufficient to estimate a useful proportion-at-age distribution, so no fish were aged.

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), age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age for the Sub-Antarctic resource surveys.

Survey	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
Summer surveys						
AEX8902	45	43	76	66	34	52.7
TAN9105	337	117	332	217	61	65.1
TAN9211	14	46	133	168	48	48.6
TAN9310	57	93	181	182	59	47.2
TAN0012	348	239	392	352	56	37.3
TAN0118	219	212	351	349	44	35.6
TAN0219	331	191	490	377	38	36.1
TAN0317	126	186	175	220	30	41.0
TAN0414	178	245	225	283	39	42.8
TAN0515	88	146	265	274	39	39.9
TAN0617	188	190	487	460	39	33.6
TAN0714	166	217	352	423	47	35.4
TAN0813	289	188	808	412	39	30.9
TAN0911	152	164	382	436	37	36.3
TAN1117	405	238	423	357	37	37.3
TAN1215	155	222	359	537	36	39.1
TAN1412	41	41	169	176	29	47.7
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 2017), so a four survey comparable time series is available. The 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 2017).

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 subsequent surveys were derived using otoliths collected during those surveys. The details of the estimated catch-at-age distribution for hake caught in the August 2016 trawl survey are given in Table 10. The mean weighted CV of 59% did not meet 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 (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

Table 10: Calculated numbers-at-age in the survey area, separately by sex, with CVs, for hake caught during a trawl survey off west coast South Island in August 2016 (survey TAN1609). Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
1	1 531	1.170	0	–
2	17 699	0.651	12 027	0.708
3	1 304	1.170	2 096	0.770
4	5 048	0.645	570	1.596
5	3 623	0.721	2 434	0.685
6	1 219	0.780	8 692	0.467
7	151	2.107	5 358	0.336
8	151	1.976	5 943	0.363
9	0	–	2 678	0.467
10	0	–	2 762	0.636
11	0	–	2 704	0.595
12	960	1.828	1 341	0.984
13	0	–	0	–
14	0	–	766	1.078
15	0	–	280	1.496
16	0	–	0	–
17	0	–	0	–
18	0	–	0	–
19	0	–	0	–
20	0	–	177	1.637
Measured males			43	
Measured females			71	
Aged males			168	
Aged females			210	
No. of tows sampled			17	
Mean weighted CV (% , sexes pooled)			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 11 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were no or insufficient data collected from the Chatham Rise ling longline fishery in 2010–2012. One trip was observed in 2016, and the details of the estimated catch-at-age distribution are given in Table 12. The mean weighted CV of 32% almost met the target of 30%.

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

Year	Males		Females		Trips	Sets	Mean CV
	Measured	Aged	Measured	Aged			
2002	4 966	284	2 998	309	5	538	20.4
2003	3 038	337	2 071	289	5	429	19.1
2004	1 066	302	747	293	2	139	21.8
2005	889	356	479	234	1	137	21.6
2006	266	95	294	141	1	48	36.6
2007	351	174	268	139	4	62	31.1
2008	574	216	570	262	4	84	25.9
2009	619	283	798	413	3	147	21.5
2013	314	112	655	252	1	50	25.9
2014	789	288	801	284	3	156	21.9
2015	434	177	615	255	1	84	25.8
2016	231	118	384	199	1	43	31.7

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
5	810	0.863	207	1.457
6	2 015	0.555	709	1.057
7	816	1.000	3 064	0.576
8	3 041	0.613	5 613	0.352
9	3 019	0.478	4 157	0.358
10	4 289	0.404	7 277	0.295
11	4 021	0.432	9 703	0.256
12	2 340	0.541	8 554	0.252
13	3 294	0.578	6 220	0.288
14	4 695	0.435	7 221	0.283
15	2 150	0.609	5 402	0.317
16	3 969	0.387	3 992	0.391
17	1 267	0.768	4 059	0.437
18	1 315	0.727	2 940	0.399
19	642	0.955	2 001	0.523
20	2 672	0.469	708	0.837
21	1 139	0.614	1 577	0.748
22	1 290	0.629	0	–
23	1 379	0.669	0	–
24	0	–	0	–
25	358	1.367	344	1.102
26	0	–	0	–
27	162	1.490	0	–
28	0	–	0	–
29	0	–	213	1.601
Measured males				231
Measured females				384
Aged males				118
Aged females				199
No. of sets sampled				43
Mean weighted CV (% , sexes pooled)				31.7

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. No observer sampling of either the spawning or non-spawning fisheries occurred in the 2015–16 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, trips and sets sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic spawning and non-spawning longline fisheries.

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

3.3.3 West coast South Island

The 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 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 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 2015–16 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, 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 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 2015–16 fishing year. All estimated proportion-at-age distributions from the Cook Strait longline fishery are presented in Appendix B (Figure B5).

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

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

3.3.5 Bounty Plateau

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

Table 16 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were no data collected from the Bounty Plateau ling longline fishery in the 2015–16 fishing year. All estimated proportion-at-age distributions from the Bounty Plateau longline fishery are presented in Appendix B (Figure B6).

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

Year	Males		Females		Trips	Sets	Mean CV
	Measured	Aged	Measured	Aged			
1992–93	201	52	237	69	1	24	50.4
1999–2000	1 102	106	2 184	185	1	41	26.9
2000–01	405	50	713	66	1	20	43.6
2003–04	1 155	200	1 628	300	3	272	20.0
2007–08	308	156	562	271	1	86	25.3
2008–09	262	116	213	88	1	42	37.3

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

3.4.1 Chatham Rise

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

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

Scampi target tows 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 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 2015–16 fishing year is given in Table 18. The observer sampling in 2015–16 was at a relatively low level, but similar to the previous year. The mean weighted CV of 33% almost met the target value of 30%.

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

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

Source	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
1991–92	2 151	252	2 653	281	143	27.0
1993–94	1 127	302	768	302	126	32.9
1994–95	359	236	302	201	59	45.1
1995–96	453	306	399	284	87	30.0
1996–97	162	317	240	242	31	41.1
1997–98	3 463	348	3 117	280	497	18.7
1998–99	3 306	336	2 469	318	312	20.0
1999–2000	887	322	1 013	326	161	24.8
2000–01	1 000	312	988	341	188	21.0
2001–02	642	294	708	334	129	23.8
2002–03	694	317	764	347	114	24.3
2003–04	356	303	600	302	99	30.1
2004–05	869	310	666	326	194	27.9
2005–06	251	328	291	330	54	34.5
2006–07	699	310	687	330	135	22.9
2007–08	2 755	317	2 070	325	276	20.9
2008–09	1 034	323	1 120	298	141	32.4
2009–10	526	318	571	309	87	28.9
2010–11	492	308	521	293	74	27.3
2011–12	739	257	767	297	82	26.4
2012–13	981	278	1 083	315	130	24.1
2013–14	1 385	314	1 674	258	164	29.7
2014–15	330	102	499	176	47	33.4
2015–16	371	287	423	292	47	32.8

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 2015–May 2016. Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
3	0	–	342	2.139
4	7 010	0.674	5 524	0.676
5	12 183	0.456	8 076	0.549
6	18 959	0.347	12 744	0.449
7	26 817	0.286	34 047	0.304
8	28 284	0.272	26 704	0.338
9	16 814	0.391	12 216	0.401
10	7 433	0.454	18 924	0.332
11	7 584	0.430	17 003	0.373
12	6 453	0.507	8 452	0.478
13	3 010	0.850	3 525	0.693
14	6 391	0.512	2 662	0.916
15	4 043	0.548	4 406	0.685
16	5 789	0.504	1 470	0.545
17	1 250	0.813	4 143	0.618
18	3 440	0.559	4 682	0.649
19	3 474	0.616	681	0.828
20	2 837	0.631	1 149	0.963
21	790	0.837	659	0.891
22	170	1.842	322	1.053
23	44	1.741	527	1.411
24	225	1.632	215	1.336
25	1 345	1.338	147	1.566
26	0	–	76	1.836
27	0	–	1 521	1.182
28	88	1.617	0	–
Measured males				371
Measured females				423
Aged males				287
Aged females				292
No. of tows sampled				47
Mean weighted CV (% , sexes pooled)				32.8

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 2015–16 fishing year is given in Table 20. The mean weighted CV of 18% was better than the target value of 30%.

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

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

Source	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
1991–92	1 466	437	1 652	667	141	22.0
1992–93	1 337	235	1 615	363	164	28.3
1993–94	686	256	1 059	357	129	29.2
1995–96	881	366	779	297	83	24.5
1997–98	1 408	274	1 717	302	218	29.0
2000–01	2 192	247	1 947	351	267	28.1
2001–02	1 887	264	2 579	327	424	24.8
2002–03	1 164	434	1 828	625	263	20.9
2003–04	853	246	1 397	337	202	22.9
2004–05	2 324	254	2 415	339	218	21.5
2005–06	2 739	288	2 618	305	252	20.4
2006–07	1 644	225	1 446	382	191	24.3
2007–08	4 104	229	3 258	353	183	23.3
2008–09	2 877	245	3 803	324	184	19.4
2009–10	2 899	226	3 266	336	121	21.7
2010–11	2 212	236	2 630	279	215	21.4
2011–12	2 826	260	2 398	316	131	21.9
2012–13	4 565	286	5 542	317	275	21.6
2013–14	2 236	232	2 716	311	147	20.3
2014–15	3 920	264	3 274	363	229	19.2
2015–16	5 419	307	3 637	306	198	18.0

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 2015–April 2016. Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
3	337	1.202	11	2.172
4	3 076	0.474	498	0.992
5	23 183	0.358	15 382	0.390
6	104 748	0.198	25 257	0.364
7	158 568	0.169	89 623	0.181
8	218 767	0.129	83 586	0.187
9	90 919	0.236	83 484	0.188
10	119 563	0.199	70 830	0.207
11	92 306	0.224	57 477	0.244
12	41 668	0.326	46 262	0.246
13	31 165	0.352	40 818	0.260
14	62 623	0.252	43 719	0.253
15	63 438	0.262	26 042	0.285
16	28 322	0.388	17 642	0.314
17	23 788	0.405	14 578	0.374
18	34 818	0.338	7 760	0.444
19	19 746	0.444	8 734	0.464
20	33 902	0.331	15 560	0.429
21	18 303	0.373	3 205	0.598
22	23 217	0.373	2 670	0.790
23	0	–	8 654	0.557
24	6 952	0.585	409	1.190
25	0	–	0	–
26	0	–	0	–
27	3 484	1.062	0	–
28	0	–	438	1.318
Measured males			5 419	
Measured females			3 637	
Aged males			307	
Aged females			306	
No. of tows sampled			198	
Mean weighted CV (% , sexes pooled)			18.0	

3.4.3 West coast South Island

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

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

Table 21 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were insufficient data (particularly otoliths) collected to estimate the catch-at-age distribution for trawl-caught ling from 2009 to 2011. The details of the estimated catch-at-age distribution for trawl-caught ling in 2016 are given in Table 22. The amount of length data and otoliths from that year was higher than in all other sampled years, except for 2015. The mean weighted CV of 20% was better than the target value of 30%.

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

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

Year	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
1991	563	176	440	220	65	34.8
1994	873	172	1 096	221	141	27.9
1995	1 051	238	794	268	111	24.3
1996	485	247	448	201	83	28.0
1997	1 532	442	901	399	173	19.5
1998	1 063	349	700	279	155	23.6
1999	1 862	285	1 126	263	221	23.7
2000	829	269	783	264	168	26.8
2001	1 106	256	924	307	178	29.6
2002	1 401	283	1 405	321	332	21.4
2003	1 157	293	1 290	302	286	23.3
2004	1 003	243	1 540	352	334	21.4
2005	908	282	899	355	184	24.9
2006	763	276	844	361	154	29.0
2007	228	148	258	158	65	38.7
2008	805	209	824	251	98	24.1
2012	686	321	576	345	83	31.8
2013	1 270	283	1 302	376	153	23.9
2014	619	183	692	202	95	31.6
2015	3 684	292	3 822	363	417	21.2
2016	2 220	336	2 374	367	267	20.1

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 2016. Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
2	162	0.781	373	0.875
3	434	0.521	230	0.553
4	3 909	0.327	4 207	0.300
5	5 406	0.330	4 204	0.325
6	3 291	0.375	2 946	0.380
7	3 363	0.447	4 790	0.304
8	12 032	0.227	4 470	0.360
9	12 676	0.223	8 873	0.255
10	16 320	0.194	14 795	0.188
11	17 034	0.202	11 590	0.221
12	21 052	0.171	15 471	0.167
13	14 079	0.220	13 578	0.202
14	13 744	0.231	13 034	0.209
15	6 932	0.324	7 201	0.279
16	3 286	0.465	4 766	0.354
17	5 091	0.361	6 409	0.289
18	2 592	0.558	2 676	0.431
19	648	0.826	2 656	0.416
20	231	1.246	1 150	0.635
21	837	0.780	1 705	0.596
22	981	1.026	1 872	0.560
23	3 164	0.503	282	0.845
24	1 595	0.609	714	0.736
25	1 332	0.819	774	0.822
26	0	–	1 052	0.903
27	213	1.357	961	0.719
28	173	1.429	0	–
Measured males				2 220
Measured females				2 374
Aged males				336
Aged females				367
No. of tows sampled				267
Mean weighted CV (% , sexes pooled)				20.1

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 2016 (82 length measurements).

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

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

Year	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
1999	226	75	189	54	59	47.9
2000	197	95	191	93	62	40.9
2001	610	205	550	208	72	24.5
2002	583	219	644	241	58	27.9
2003	430	282	437	308	56	24.2
2004	609	269	645	241	48	27.2
2005	617	272	561	264	75	26.4
2006	729	248	539	226	26	26.4
2007	327	143	300	137	19	42.0
2008	569	280	470	226	44	27.0
2009	241	180	219	164	62	33.4
2010	274	195	250	196	41	36.2

3.5 Trawl survey catch-at-age data for ling

3.5.1 Chatham Rise

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

Table 24 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There was no survey in this series conducted in January 2017.

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

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

Survey	Males		Females		Tows	Mean CV
	Measured	Aged	Measured	Aged		
AEX8903	743	303	613	296	130	26.0
TAN9106	1 208	252	1 189	281	174	22.4
TAN9212	1 229	286	1 108	313	177	21.7
TAN9401	1 541	302	1 349	302	157	21.5
TAN9501	583	236	578	201	114	28.1
TAN9601	556	306	509	284	79	27.7
TAN9701	837	317	601	242	98	24.3
TAN9801	665	348	492	280	88	24.5
TAN9901	1 071	336	848	318	111	23.8
TAN0001	1 080	322	969	326	113	22.0
TAN0101	1 145	312	1 084	341	108	20.5
TAN0201	1 053	294	1 170	334	102	19.7
TAN0301	813	317	808	347	98	20.6
TAN0401	865	303	752	302	101	20.2
TAN0501	845	310	801	326	98	22.5
TAN0601	1 007	328	880	330	90	21.0
TAN0701	733	310	732	330	94	21.0
TAN0801	610	317	623	325	92	22.3
TAN0901	946	338	880	312	103	24.3
TAN1001	608	322	882	339	70	25.0
TAN1101	523	334	508	313	80	30.6
TAN1201	656	273	697	313	93	23.0
TAN1301	646	287	652	324	83	24.9
TAN1401	515	322	482	275	82	26.4
TAN1601	860	317	863	325	86	21.8

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 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 December 2016 trawl survey are given in Table 26. The mean weighted CV of 23% was better than the target of 30%. Because of bad weather during the December 2016 survey, five strata had fewer than two completed tows. Biomass estimates and CVs for core strata with more than two stations surveyed were scaled up using a factor based on proportion of the species biomass in the ‘missing’ strata in the 13 previous surveys from 2000–14. Proportions at length and age in missing strata were estimated from the available length frequency data. The one tow from stratum 3A was used to estimate the length frequency in stratum 3A (with biomass estimated from mean annual scaling factor for stratum 3A in 2000–14). The single tow from stratum 1 was used to estimate the length frequency in both strata 1 and 2 (with biomass estimated from mean scaling factors for strata 1 and 2 combined in 2000–14) (R. O’Driscoll, NIWA, pers. comm.).

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 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 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

Table 26: Calculated numbers at age in the survey area, separately by sex, with CVs, for ling caught during a trawl survey of the Sub-Antarctic in December 2016 (survey TAN1614). Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
2	0	–	11 598	1.675
3	134 944	0.520	98 296	0.593
4	281 165	0.310	293 579	0.289
5	301 070	0.329	705 671	0.212
6	766 073	0.186	701 160	0.210
7	575 238	0.207	881 696	0.190
8	442 297	0.241	644 081	0.196
9	231 379	0.308	440 483	0.257
10	210 488	0.341	476 634	0.226
11	164 837	0.323	413 440	0.262
12	114 256	0.406	338 828	0.284
13	96 451	0.425	184 371	0.360
14	44 218	0.631	203 409	0.355
15	60 607	0.488	152 347	0.413
16	48 648	0.577	133 624	0.398
17	85 976	0.485	93 439	0.526
18	50 134	0.630	151 181	0.403
19	72 833	0.625	130 806	0.469
20	33 396	0.665	48 477	0.809
21	41 433	0.688	62 932	0.587
22	66 177	0.533	14 716	1.159
23	12 459	1.107	10 853	1.455
24	5 919	1.362	0	–
25	0	–	14 716	1.211
26	13 389	1.189	0	–
27	0	–	15 336	1.182
28	0	–	0	–
29	0	–	0	–
30	0	–	15 345	1.312
Measured males				767
Measured females				829
Aged males				225
Aged females				367
No. of tows sampled				55
Mean weighted CV (% , sexes pooled)				22.7

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 2017), 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 2017).

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 subsequent surveys were derived using otoliths collected during those surveys. The details of the estimated catch-at-age distribution for ling caught in the August 2016 trawl survey are given in Table 28. The mean weighted CV of 31% almost 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
TAN1609	694	267	429	200	32	30.8

Table 28: Calculated numbers at age in the survey area, separately by sex, with CVs, for ling caught during a trawl survey off west coast South Island in August 2016 (survey TAN1609). Summary statistics for the samples are also presented. Age in years.

Age	Male	CV	Female	CV
1	288	1.659	0	–
2	934	1.563	0	–
3	4 891	0.808	3 579	1.068
4	12 273	0.441	12 120	0.451
5	11 282	0.417	7 902	0.462
6	6 734	0.538	3 200	0.614
7	7 286	0.390	7 364	0.449
8	17 919	0.286	3 888	0.546
9	18 036	0.252	5 755	0.590
10	22 301	0.221	10 318	0.418
11	21 111	0.246	9 481	0.349
12	26 445	0.217	15 409	0.265
13	11 541	0.313	10 811	0.344
14	9 905	0.312	14 318	0.295
15	8 577	0.350	6 192	0.367
16	1 556	0.712	2 322	0.570
17	4 819	0.489	6 510	0.466
18	1 421	0.949	2 896	0.583
19	0	–	2 878	0.566
20	1 031	1.050	2 212	0.735
21	598	1.061	3 331	0.679
22	1 031	1.185	1 372	0.766
23	5 695	0.555	266	1.653
24	1 198	0.985	1 912	0.710
25	0	–	1 298	1.171
26	0	–	1 255	1.060
Measured males			694	
Measured females			429	
Aged males			267	
Aged females			200	
No. of tows sampled			32	
Mean weighted CV (% , sexes pooled)			30.8	

4. DISCUSSION

4.1 Hake

Sufficient otoliths and length-frequency data to produce catch-at-age distributions that met the target mean weighted CV were available from the HAK 7 fishery off WCSI, the HAK 1 fishery in the Sub-Antarctic, and the HAK 4 fishery on the west Chatham Rise. The target CV was almost always met for samples from the WCSI fishery (see Table 5). The sampling intensity in the HAK 7 (WCSI) commercial trawl fishery was relatively high in 2015–16, as it was in the previous three years. Sampling intensity in the Sub-Antarctic varied considerably between years, with consequent wide variation in the mean weighted CVs (see Table 3) 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), and although sampling intensity was low in 2015–16 there were sufficient data to produce a reasonable catch-at-age distribution for the west fishery. 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.

The Sub-Antarctic survey in December 2016 produced very low numbers of hake (33 measured fish in the analysed strata), so no catch-at-age distribution was estimated for the trawl survey. The target of 30% has never been met in this survey series, although the values were often between 30 and 40% (see Table 8). There was no survey of the Chatham Rise in January 2017.

On the Chatham Rise, younger hake tend to be concentrated in the west, with the population dominated by fish aged 2–10 years (see Appendix A, Figure A1). Middle-aged and older hake (i.e., 5–15 years old) tend to dominate catches in the east (see Figure A2). Previous analyses showed that males and females appeared to be about evenly abundant in all areas except Statistical Area 404, where males dominated the catch (Horn & Sutton 2009). Some year class progressions were apparent. The year class that spawned at the start of the 1990–91 fishing year (age 3 years in January 1994) appears relatively strong, and can be tracked in some subsequent distributions through to about 2003. There was a clear year class progression apparent in the Chatham Rise survey distributions from 2004 to 2011 (Figure A5). The year class that spawned in late 2001 (aged 2+ years in January 2004) clearly progressed through to age 9+ years in 2011, for both males and females.

In the Sub-Antarctic, there were some clear year class progressions, particularly in the male distributions. Figure A3 shows the progressions of hake aged 10 in 1990 through to age 16 in 1996, aged 6 in 1998 through to age 12 years in 2004, and age 5 in 2009 through to age 11 years in 2015.

The WCSI trawl catch was dominated by hake aged 5–12 years, with no clearly apparent year class progressions (see Figure A4). In some years, large numbers of 1- or 2-year-old fish were taken by the fishery, but these did not always manifest as strong cohorts in later years. The relatively abundant 2-year-old fish in catches from 2005, 2006, and 2007 progressed to comprise a high proportion of the catch from 2010 to 2012. Since 2011, fish older than 10 years appear to have been less abundant in the catch than in most previous years. A characteristic of most of the WCSI distributions was that numbers of fish aged 3 and 4 years were generally very low. Fish of this age may be much less vulnerable or available to the trawl during the winter months of the fishery than younger or older hake.

4.2 Ling

Catch-at-age distributions were produced for one commercial longline fishery in 2015–16 (Chatham Rise), and the target CV was nearly met. Catch-at-age distributions were scheduled to be produced for the Sub-Antarctic fishery, but this area was not sampled by observers in 2015–16. 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 2015 to May 2016 were applied to the age-length key from the January 2016 (TAN1601) trawl survey of Chatham Rise. The estimated CV was just higher than the target value; for most of the distributions in this series it is close to or just better than the target. The Sub-Antarctic and WCSI distributions used only observer length data and otoliths. The Sub-Antarctic catch-at-age distribution had a mean weighted CV much better than the target of 30%. Most samples in this series had CVs around 20%, and the level of observer sampling was good in most years (see Table 19). The WCSI commercial fishery was comprehensively sampled in 2015–16; only the previous year had a larger sample size (see Table 21). Consequently, the estimated catch-at-age distribution had one of the lowest mean weighted CVs of the series. An estimate of catch-at-age for the ling bycatch from the Cook Strait hoki spawning fisheries was not able to be produced for 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 Sub-Antarctic (December 2016) to meet the mean weighted CV target. 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 can be observed progressing to age 18 in 2007.

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

The ling trawl catch-at-age distributions from the WCSI fishery often exhibited a trough at about age 6 or 7. This is consistent with an inflexion point in the length-frequency distributions at lengths of about 72 cm for males and 77 cm for females (see figure 3 of Horn 2008a). Fish of this size may be less vulnerable or available to the trawl during the winter months of the fishery.

4.3 Observer sampling

All the commercial fishery catch-at-age distributions reported here were reliant on the collection by observers of length data and otoliths. It was noted above that some planned catch-at-age distributions could not be estimated owing to insufficient data being collected. In some situations this has resulted from a marked reduction in effort in a fishery, e.g., the hake trawl fishery on the eastern Chatham Rise has produced relatively small catches since 2009–10 (Horn 2013). But for some fisheries, there was either insufficient or no observer sampling, or the observed trips occurred at times outside the ‘main’ fishery period used to estimate commercial catch-at-age. 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 have been used to produce the catch-at-age series presented above.

Fishstock(s)	Area	Fishing method	Time period
HAK1	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

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

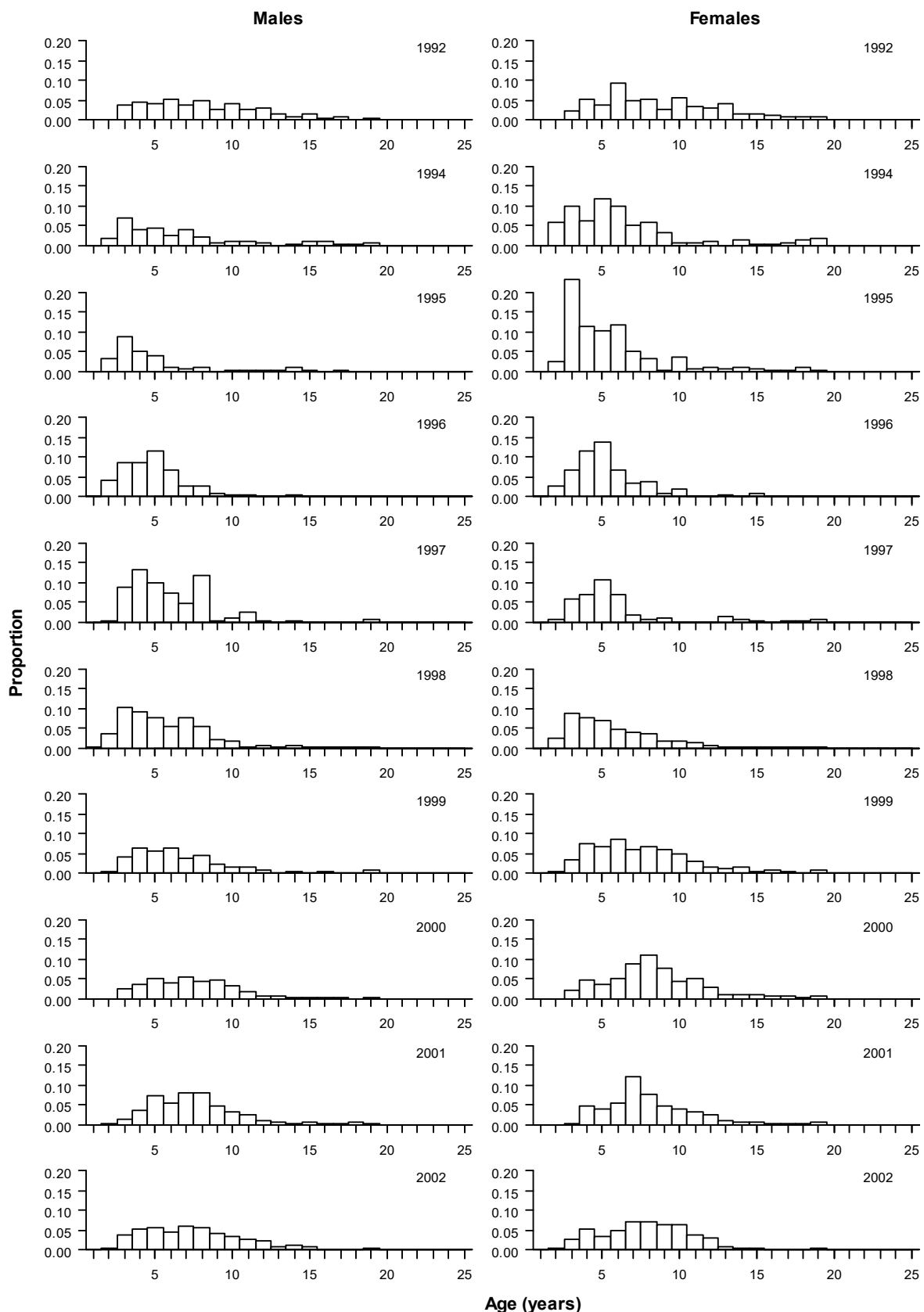


Figure A1: Age frequency distributions of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2016. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–April 2002 sample.

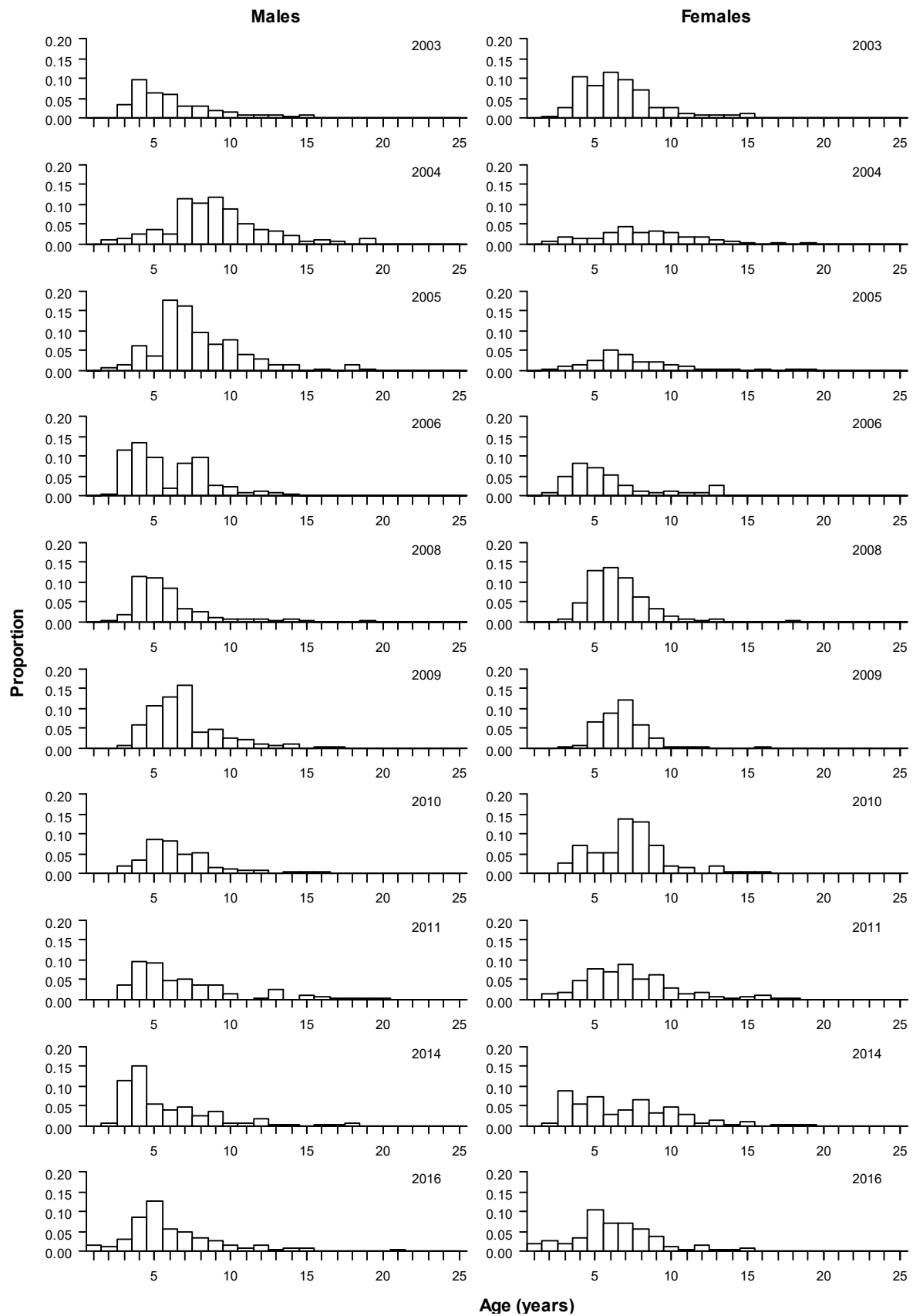


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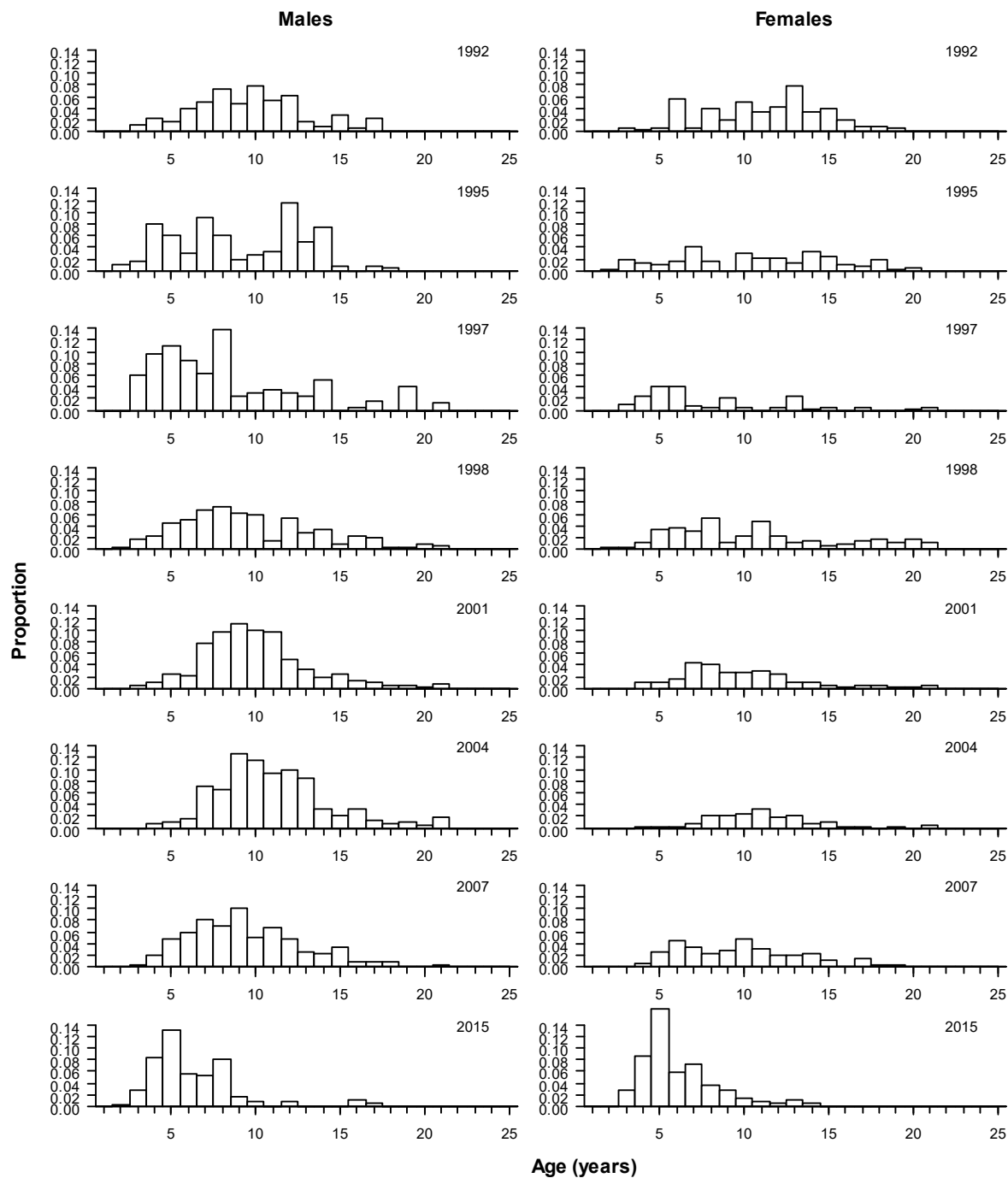


Figure A2: Age frequency distributions of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2016. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “1992” denotes the October 1991–April 1992 sample.

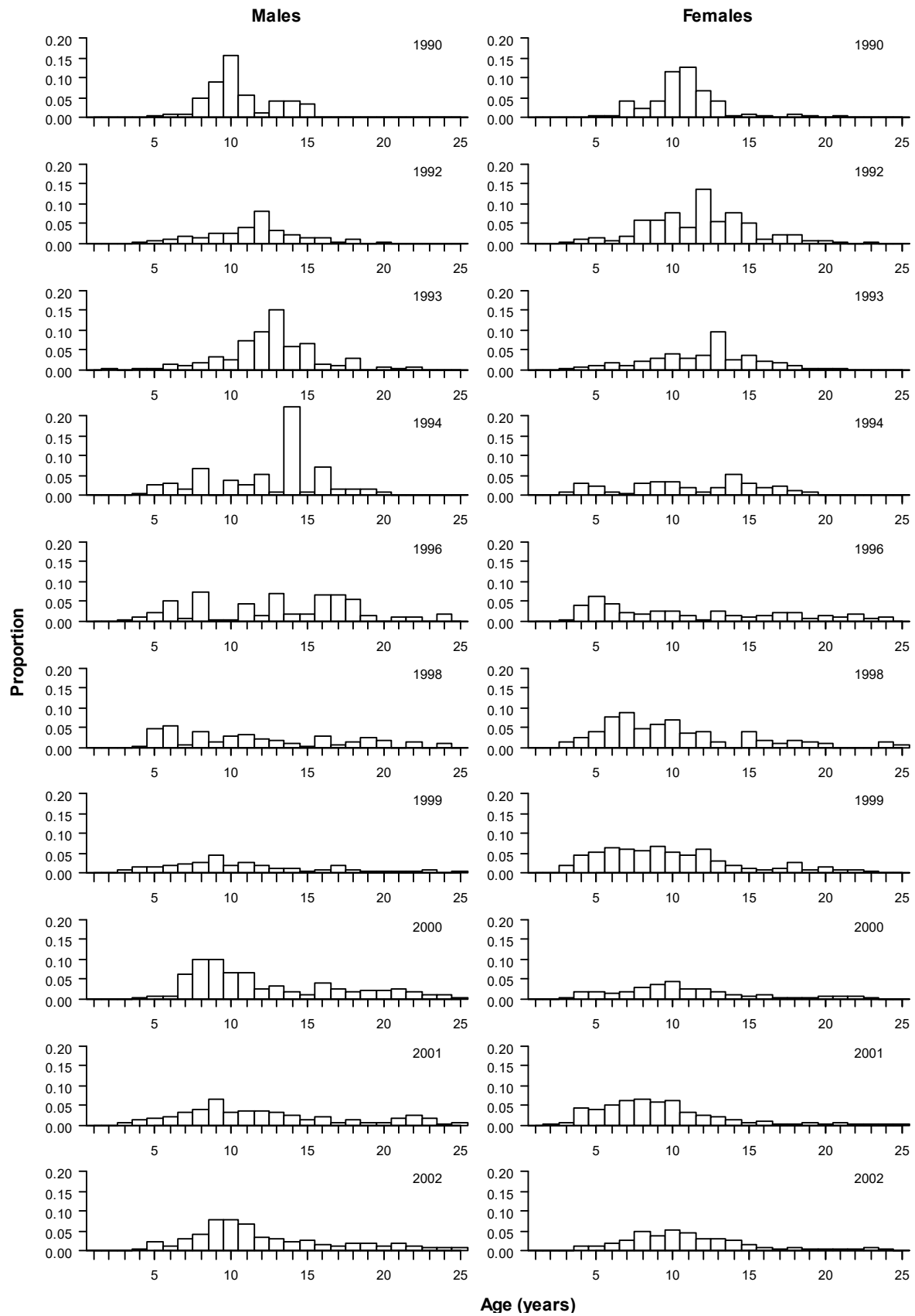


Figure A3: Age frequency distributions of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2016. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the September 2001–May 2002 sample.

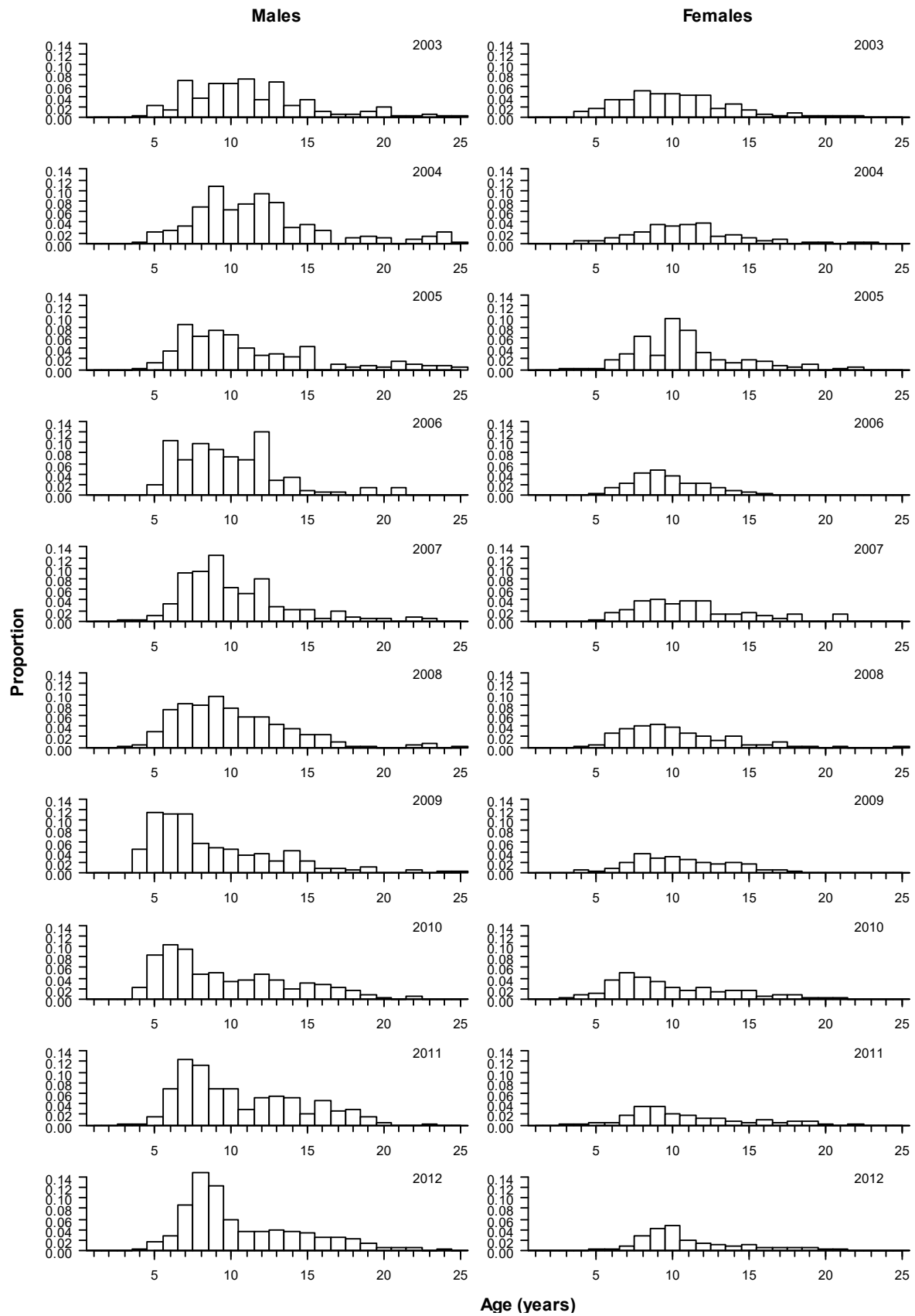


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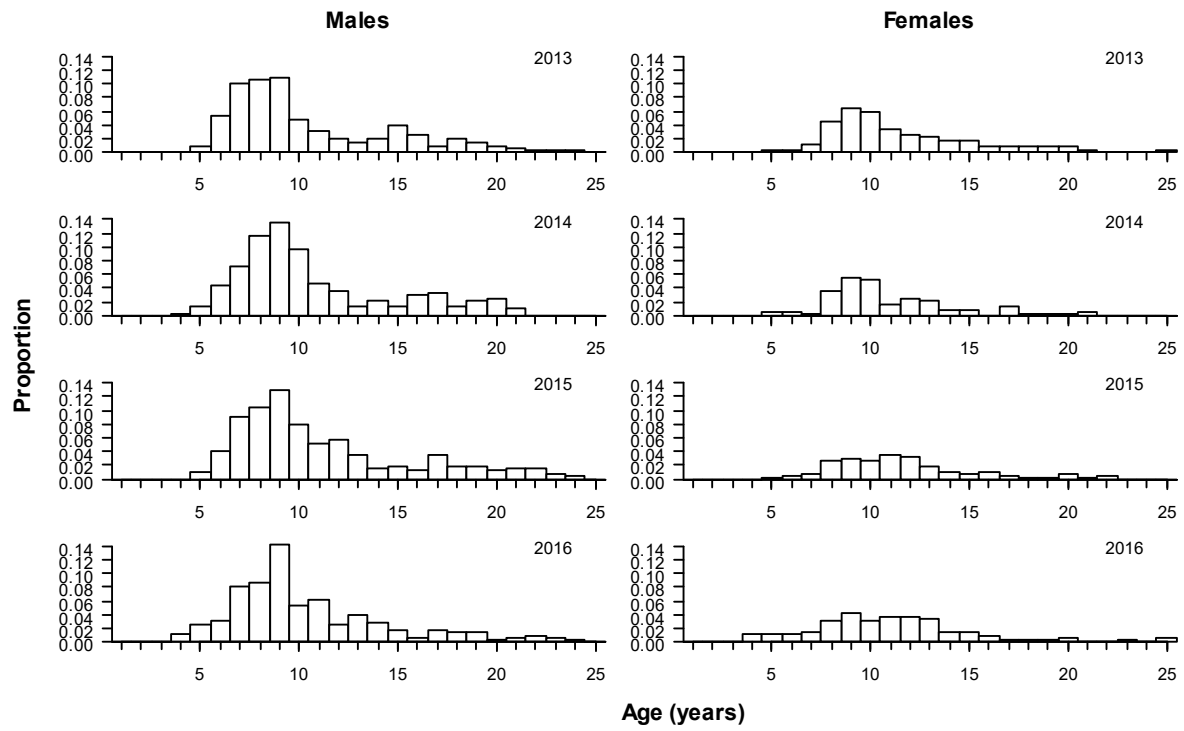


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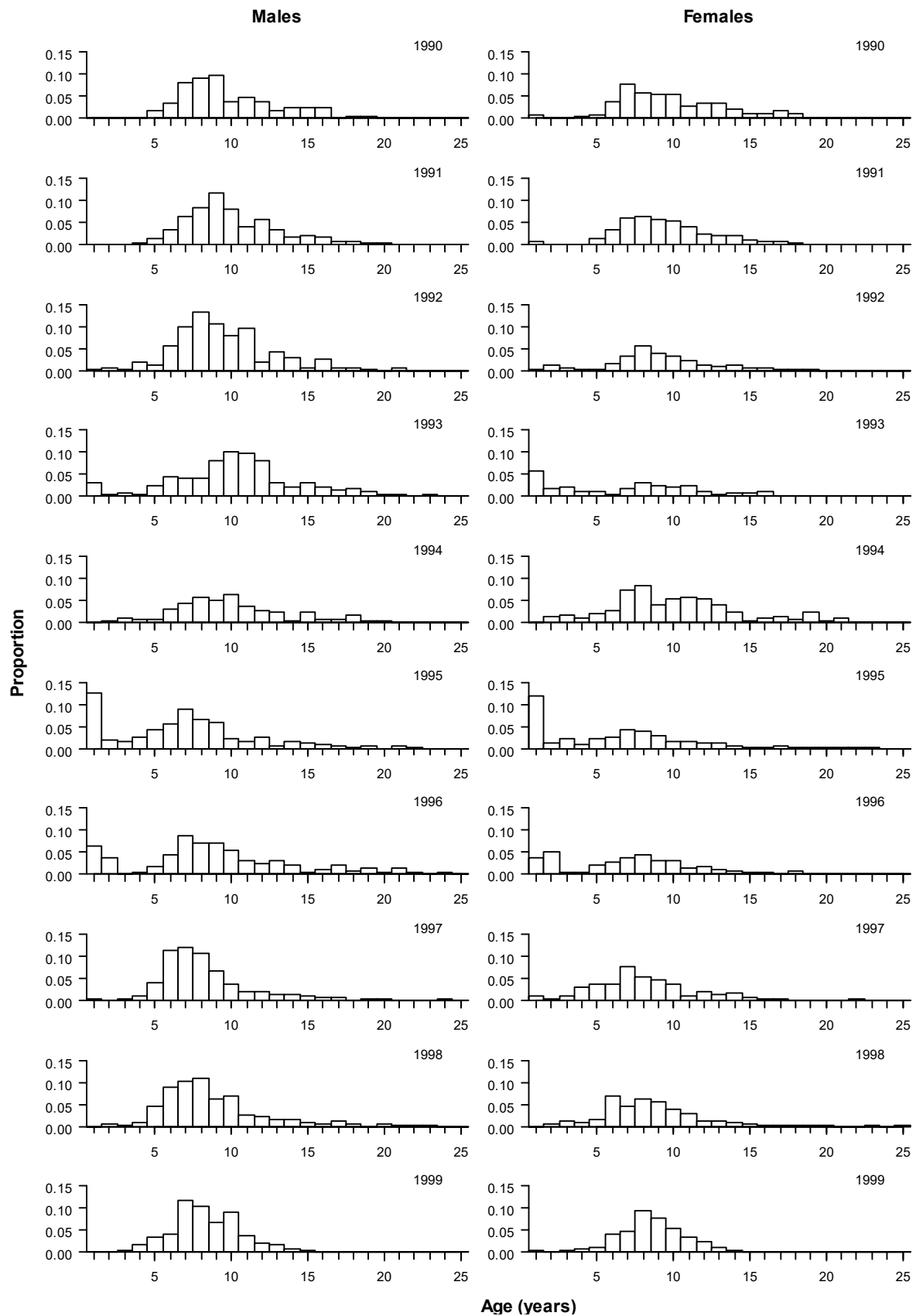


Figure A4: Age frequency distributions of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2016.

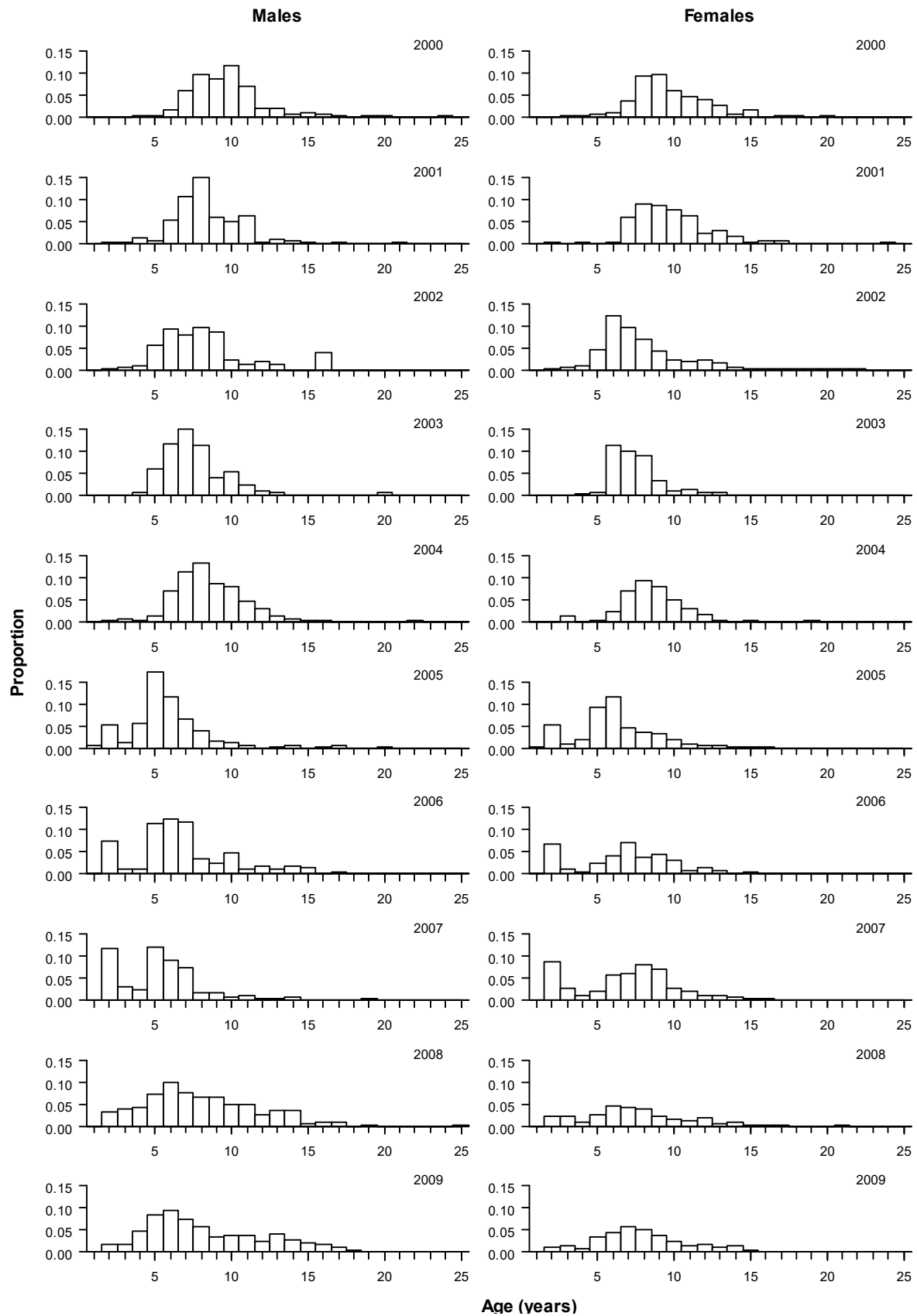


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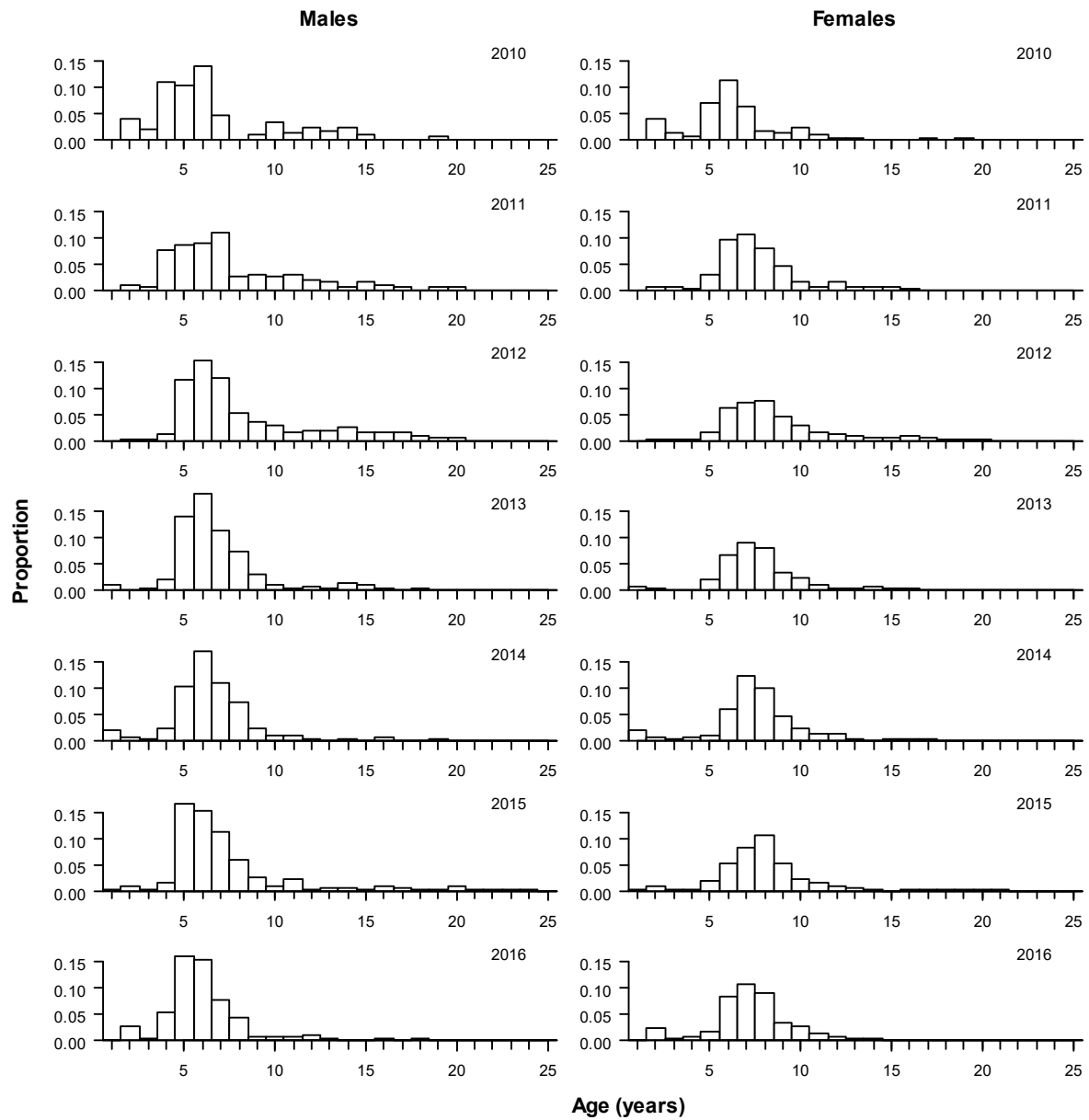


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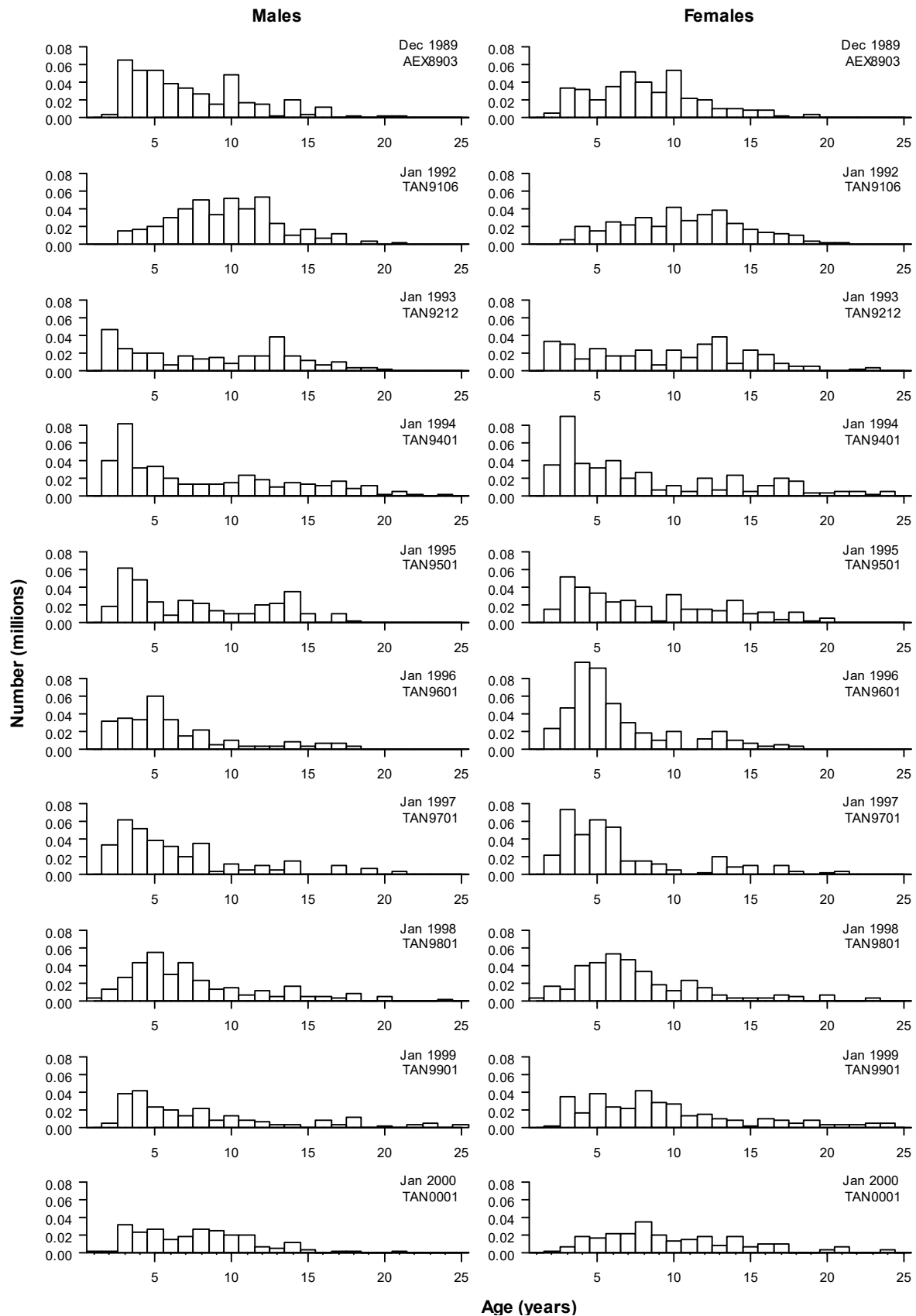


Figure A5: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from resource surveys of the Chatham Rise, 1989–90 to 2016–17.

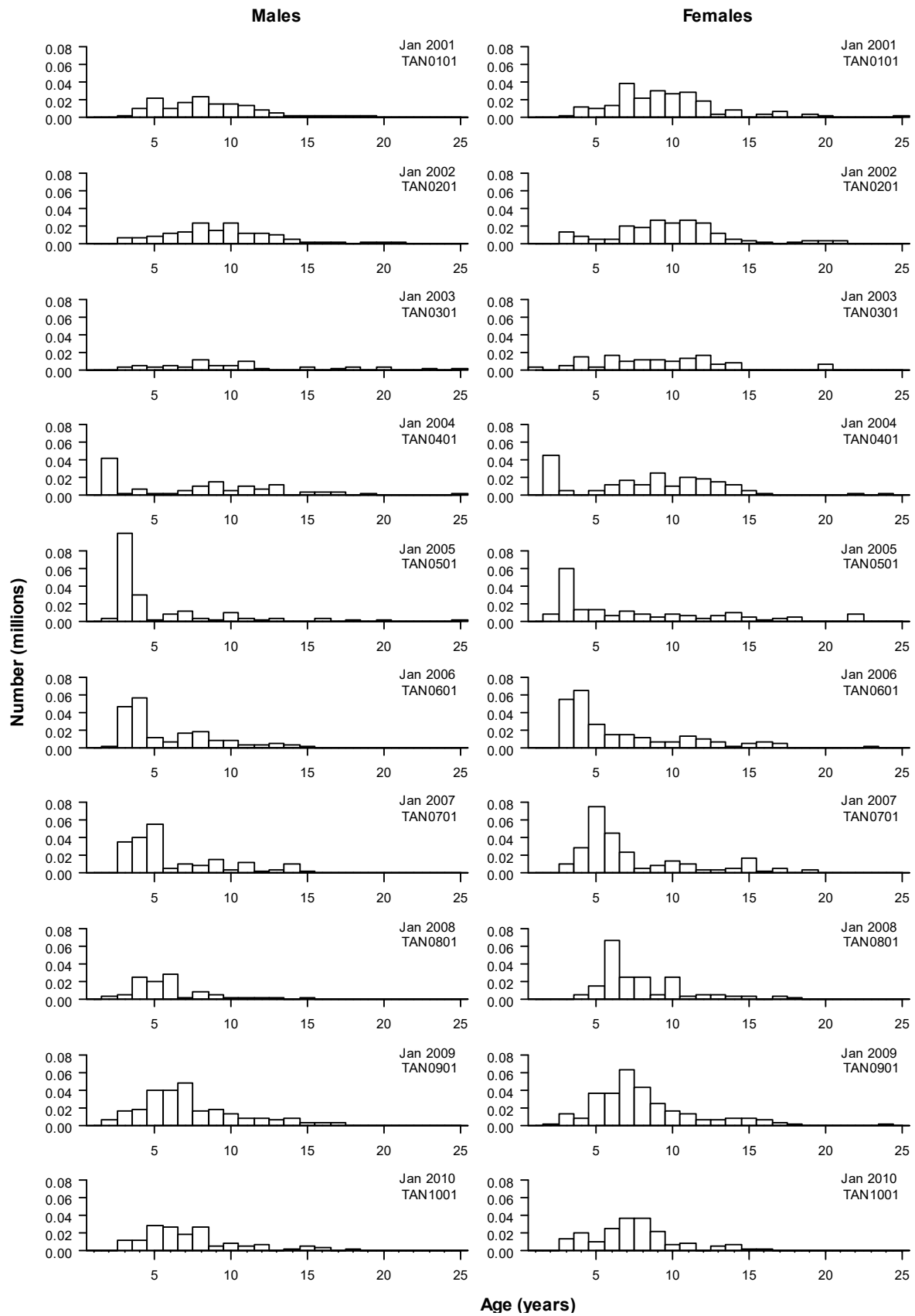


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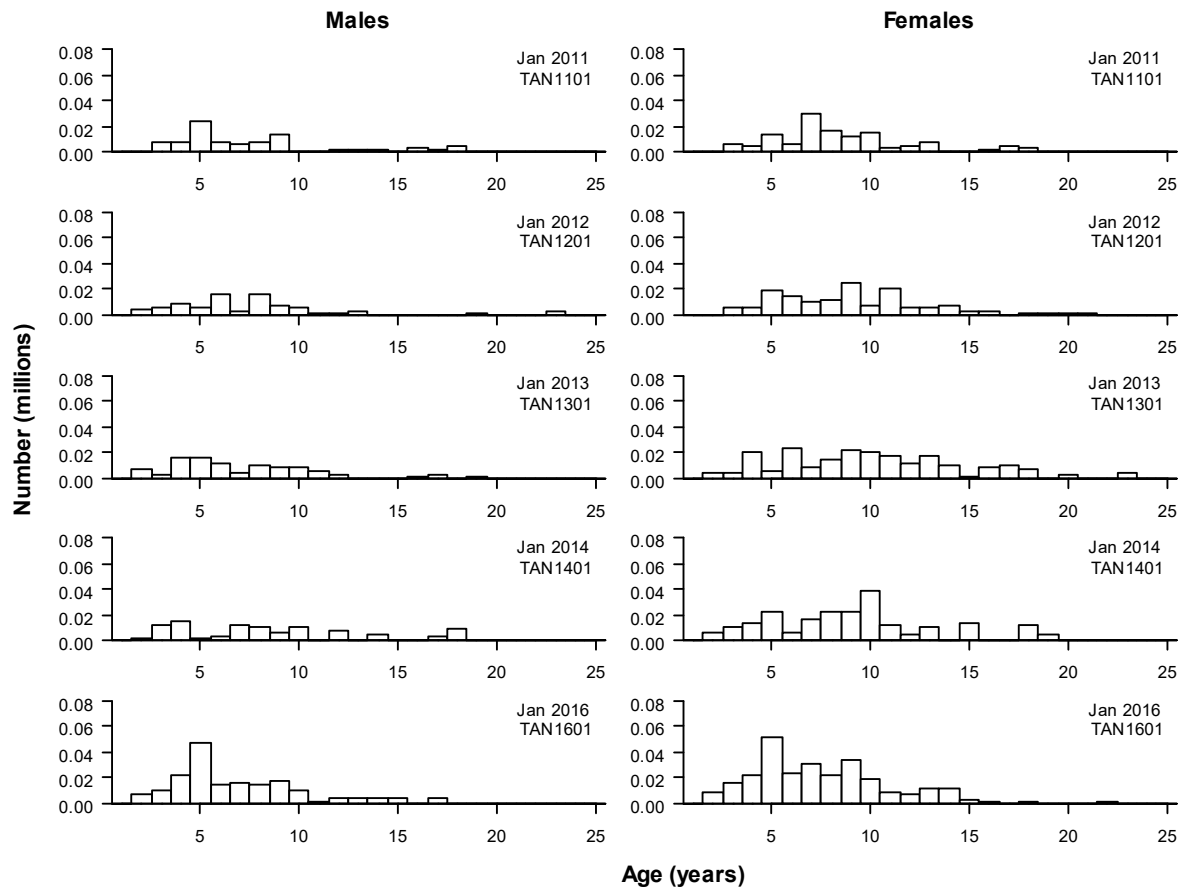


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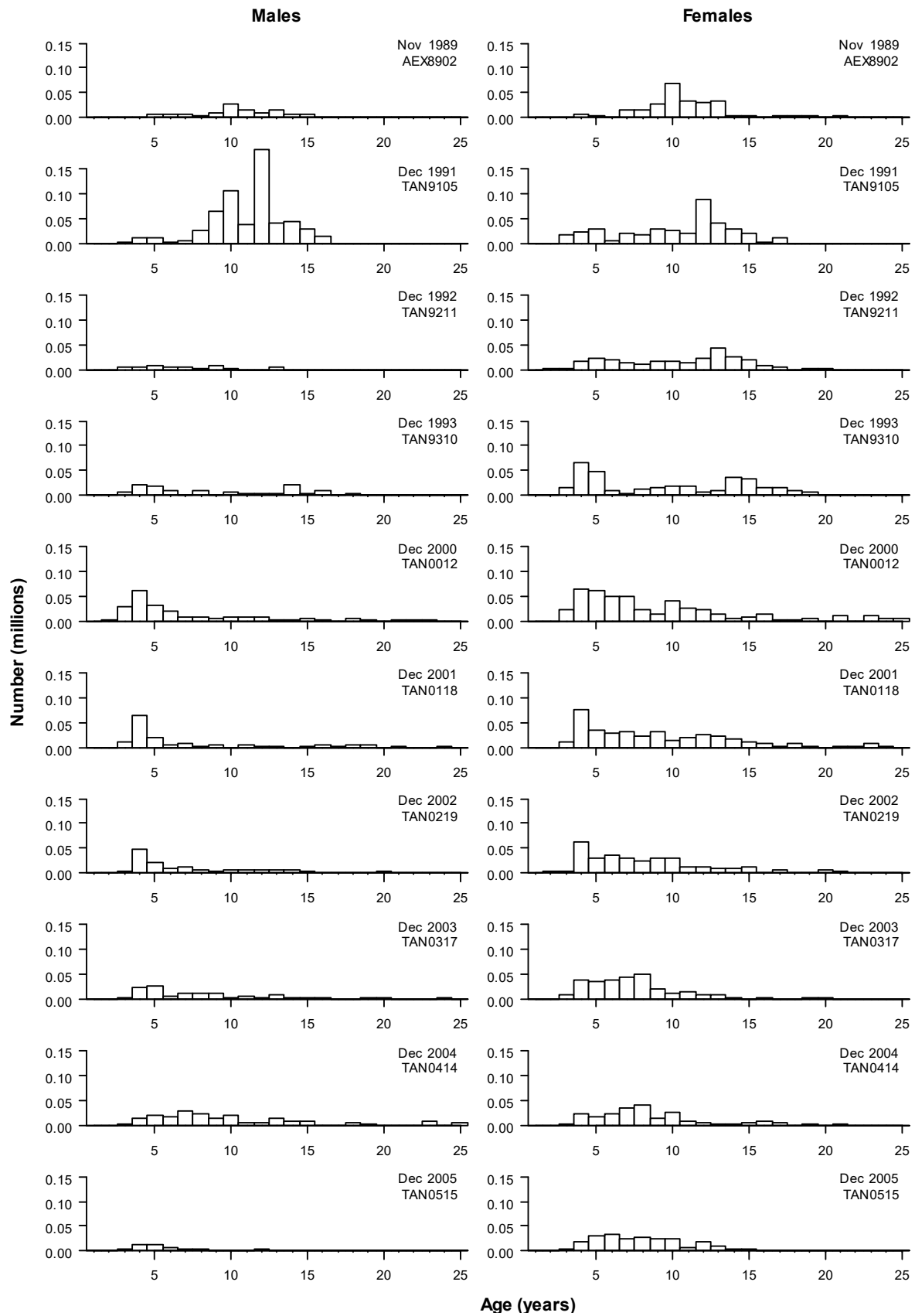


Figure A6: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from summer resource surveys of the Sub-Antarctic, 1989 to 2016 (small sample, not aged).

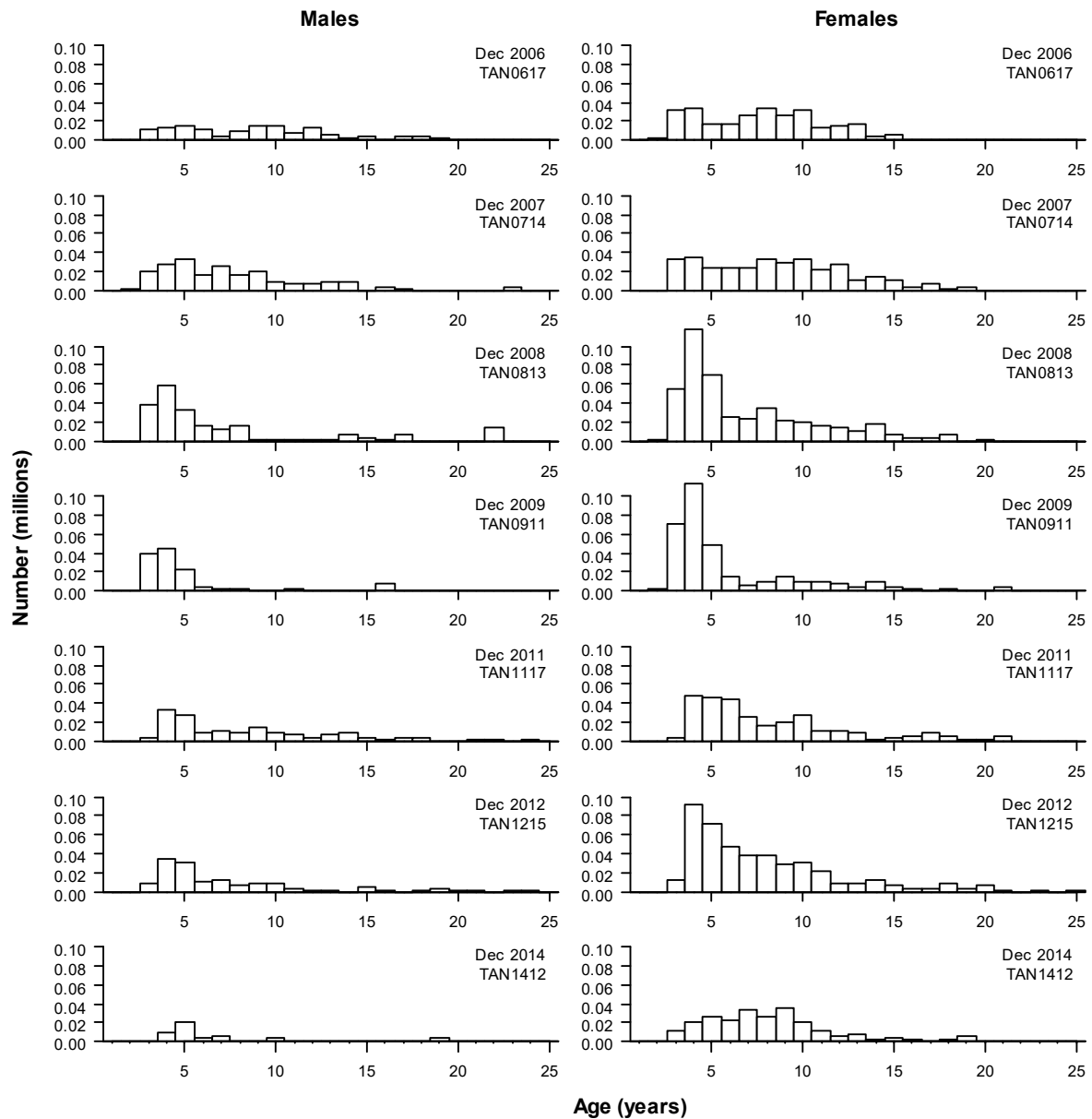


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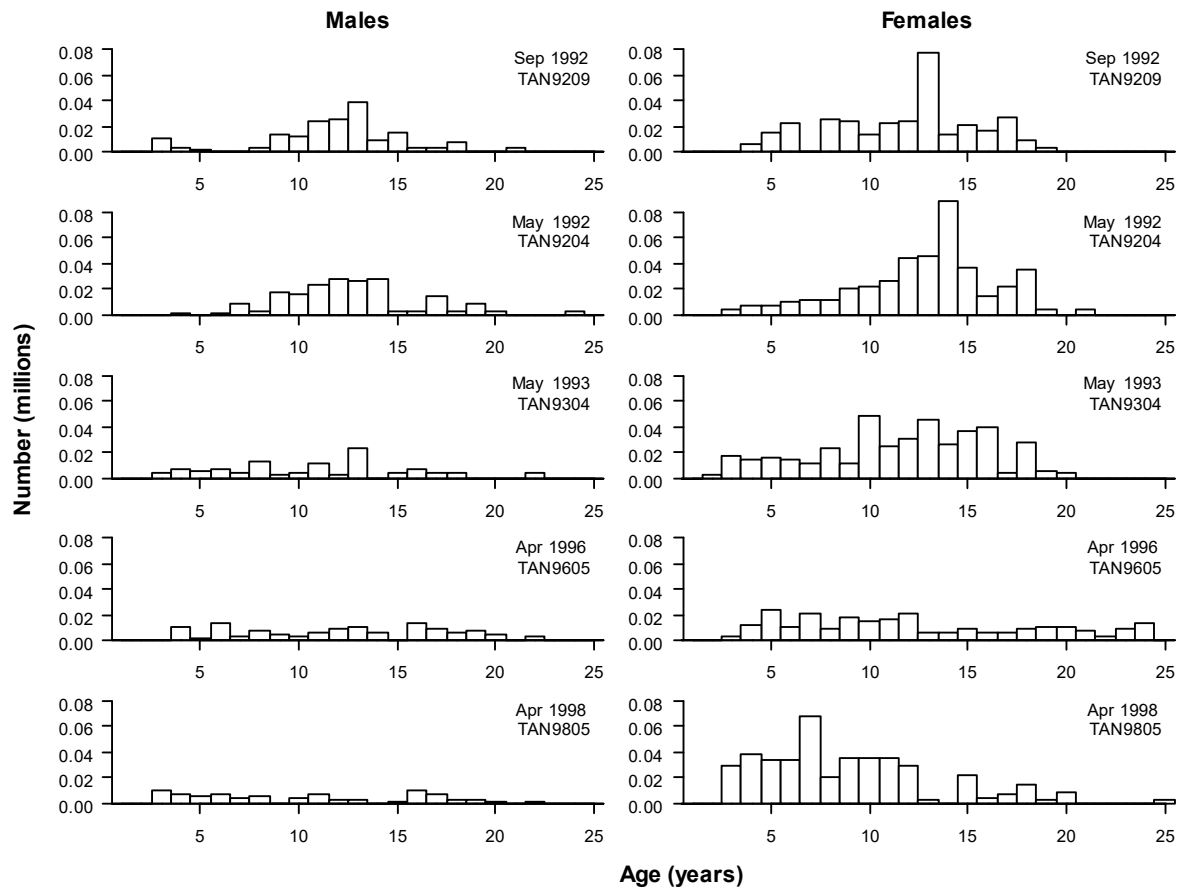


Figure A7: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from spring and autumn resource surveys of the Sub-Antarctic, 1992 to 1998.

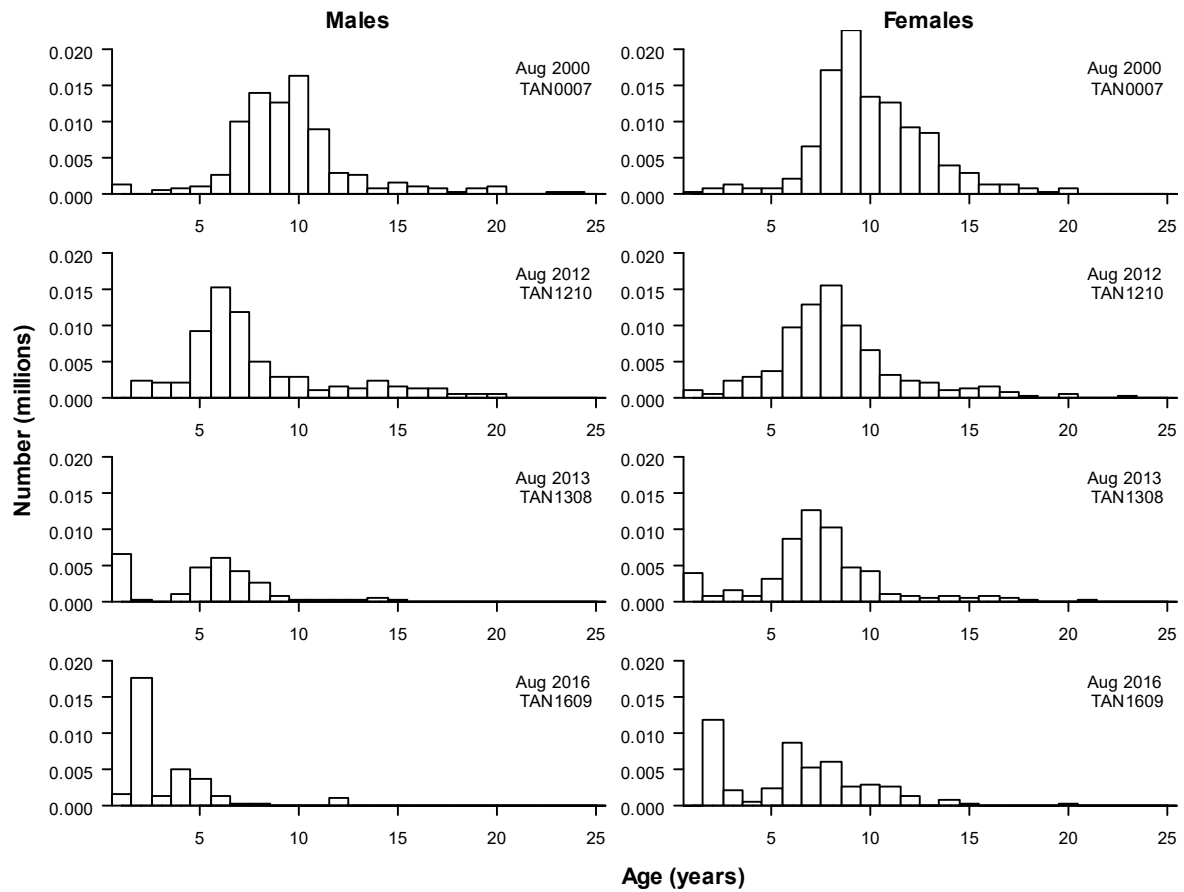


Figure A8: Age frequency distributions of hake (scaled numbers-at-age, ages 1 to 25) from resource surveys of the WCSI, from 2000 to 2016.

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

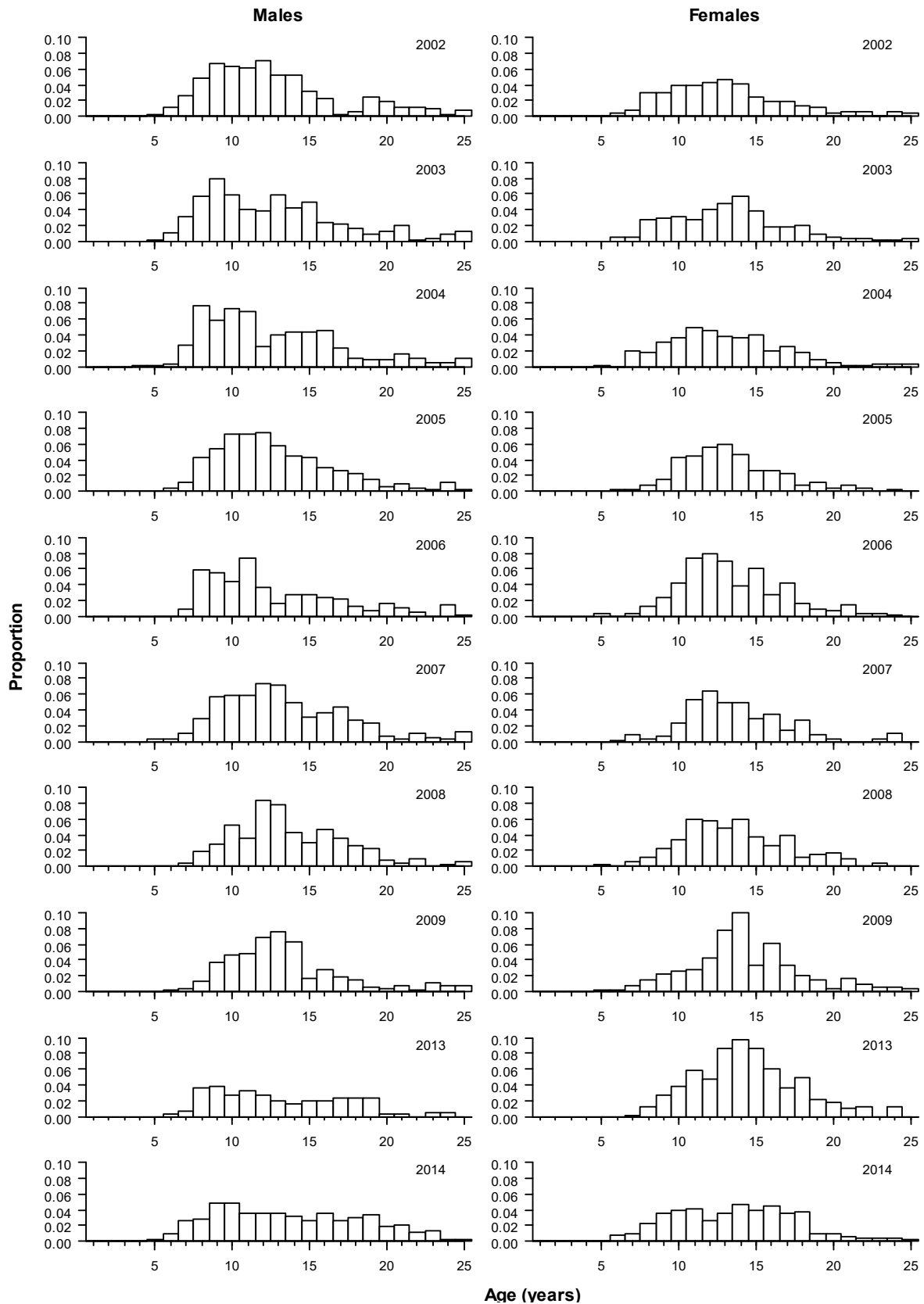


Figure B1: Age frequency distributions of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2016.

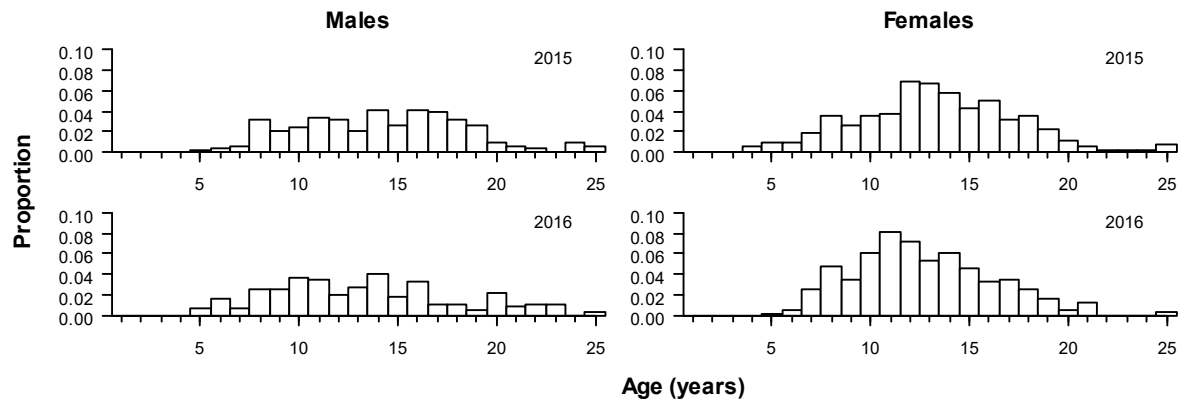


Figure B1 ctd.

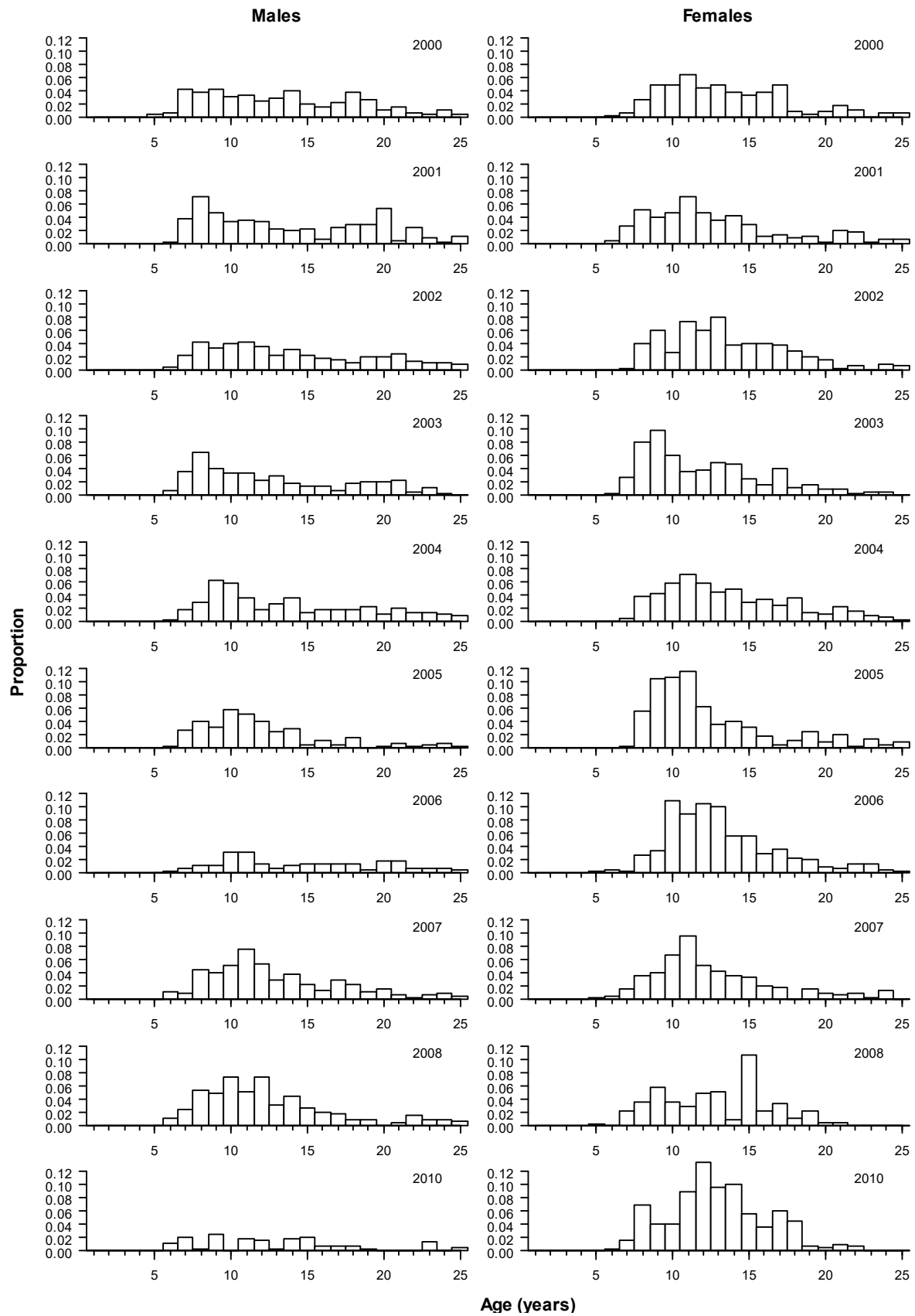


Figure B2: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2016.

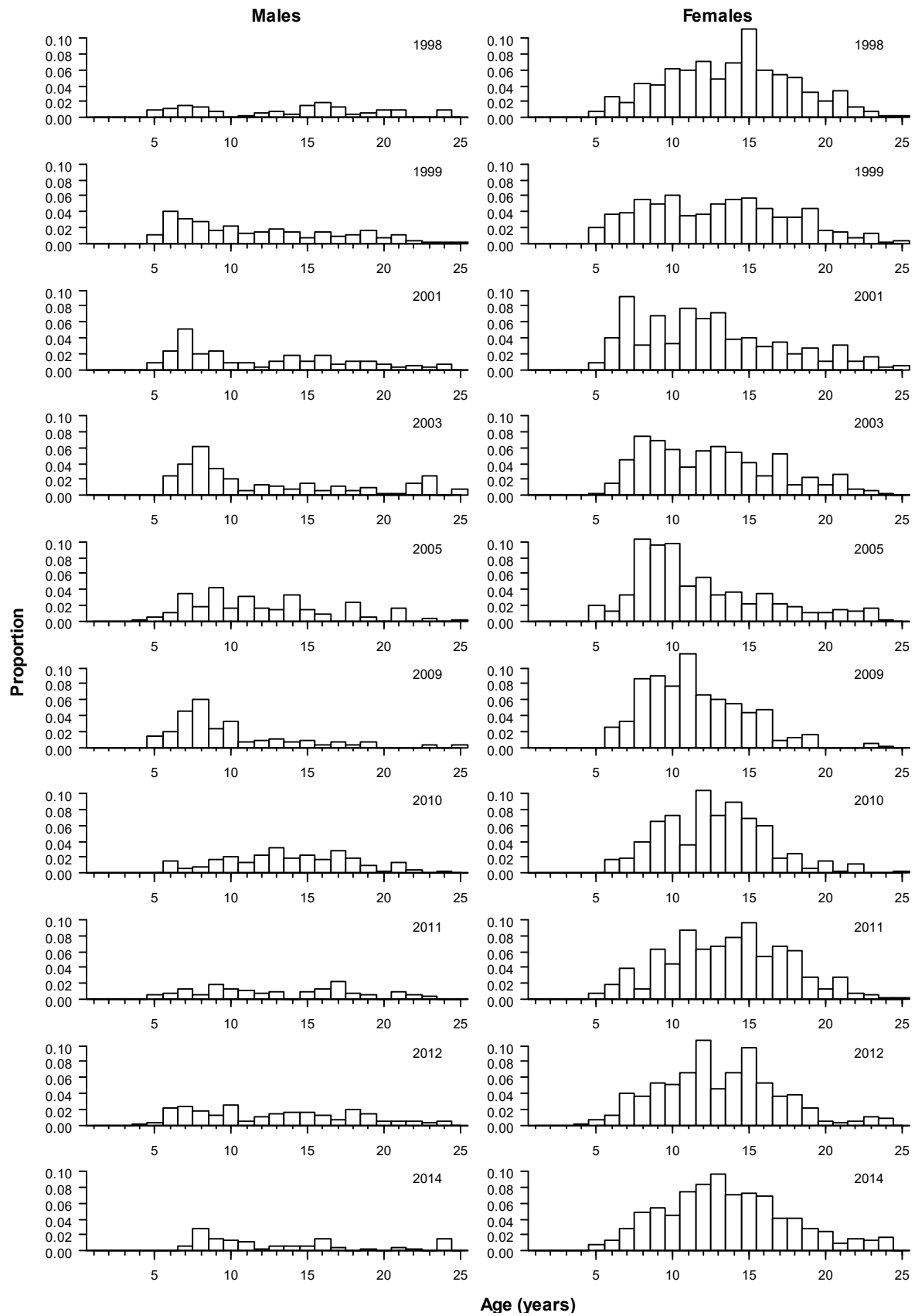


Figure B3: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2016.

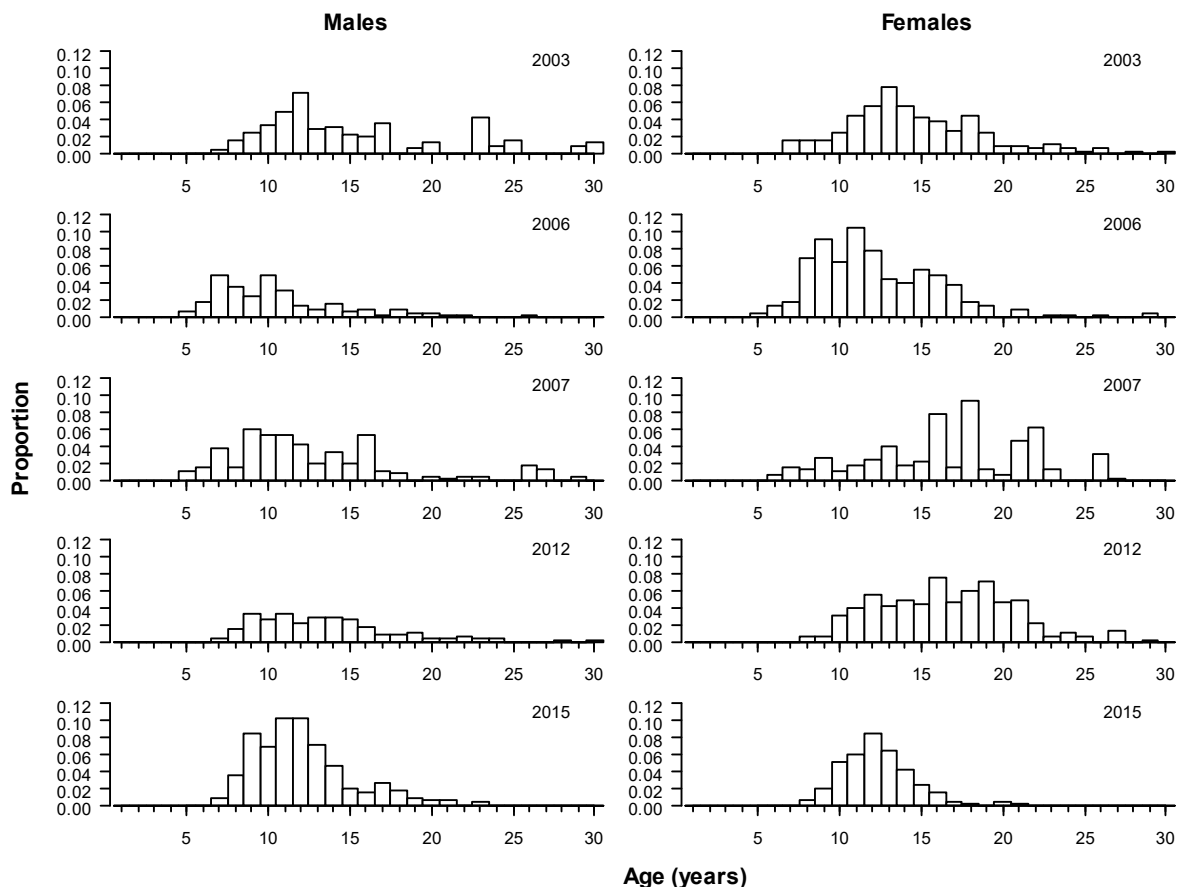


Figure B4: Age frequency distributions of ling from commercial catch-at-age data in the west coast South Island longline fishery, 2003 to 2016.

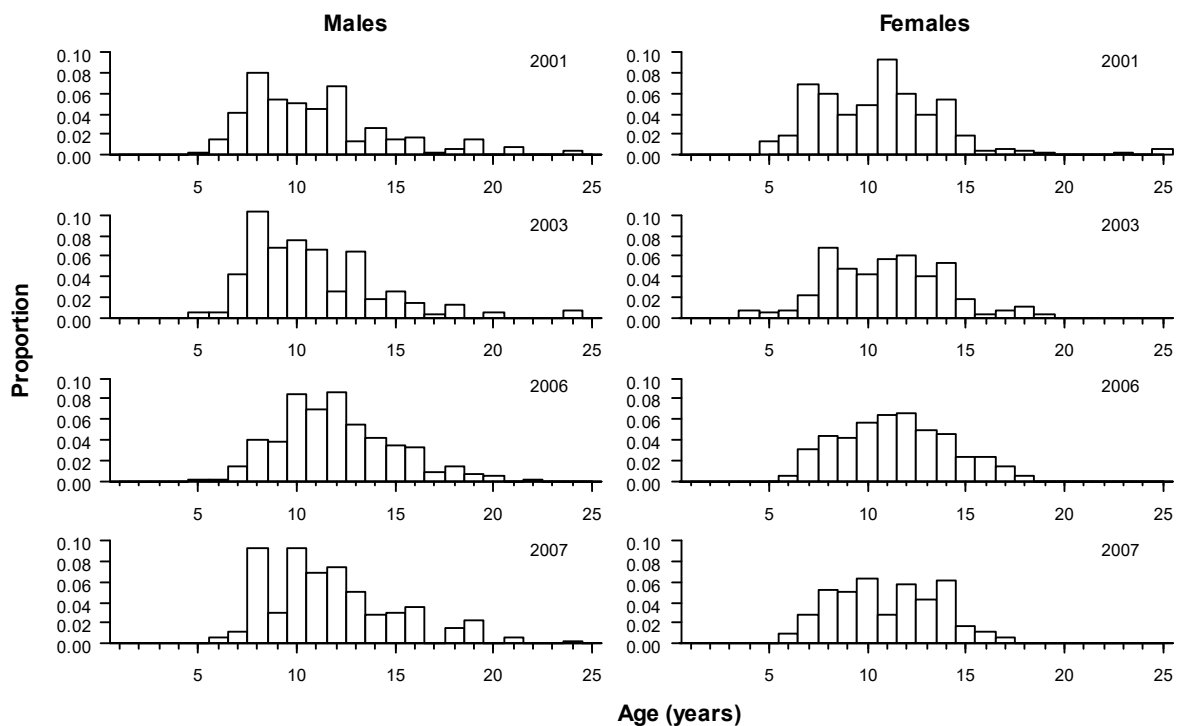


Figure B5: Age frequency distributions of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2001 to 2016.

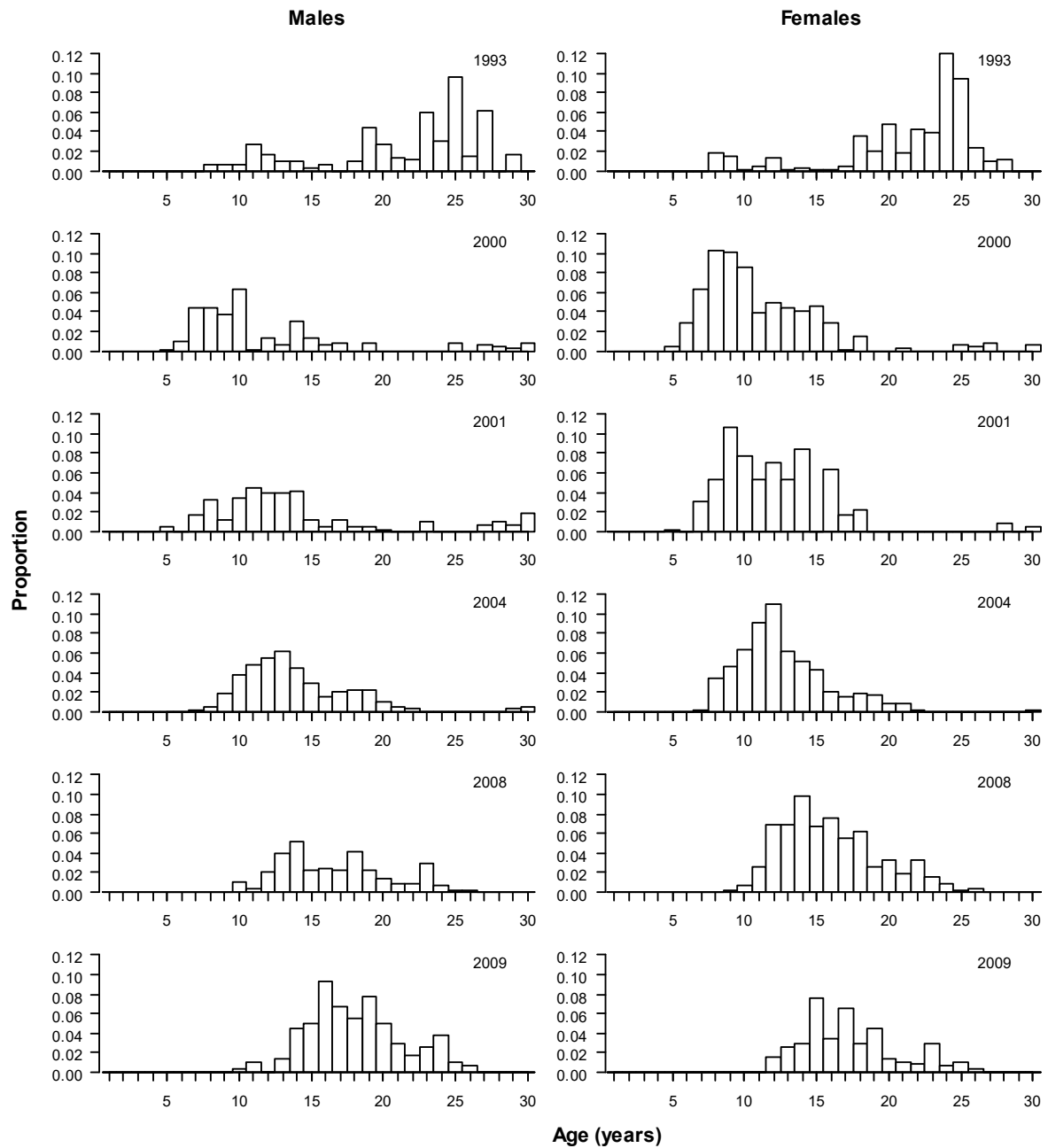


Figure B6: Age frequency distributions of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2016.

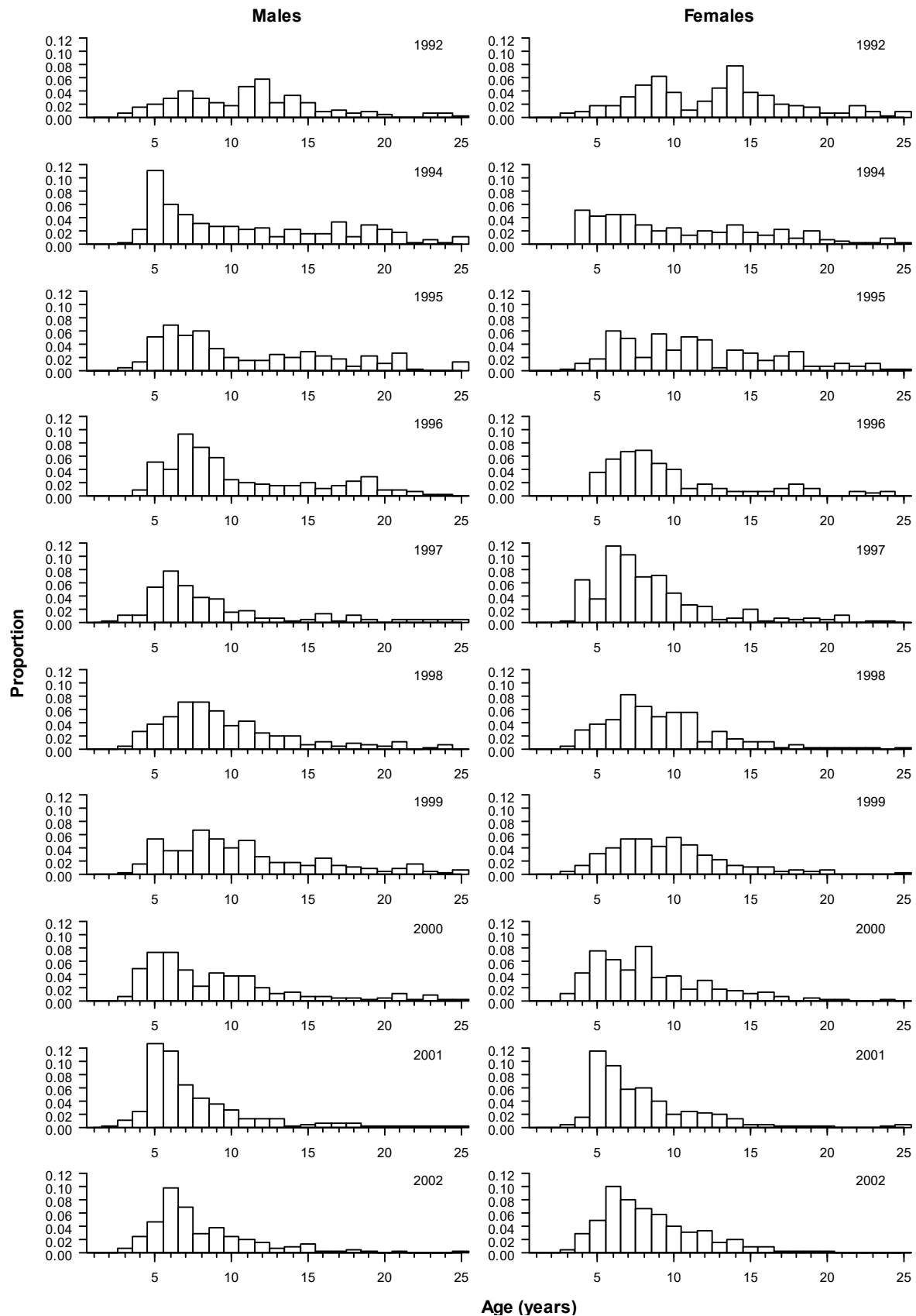


Figure B7: Age frequency distributions of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2016. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–May 2002 sample.

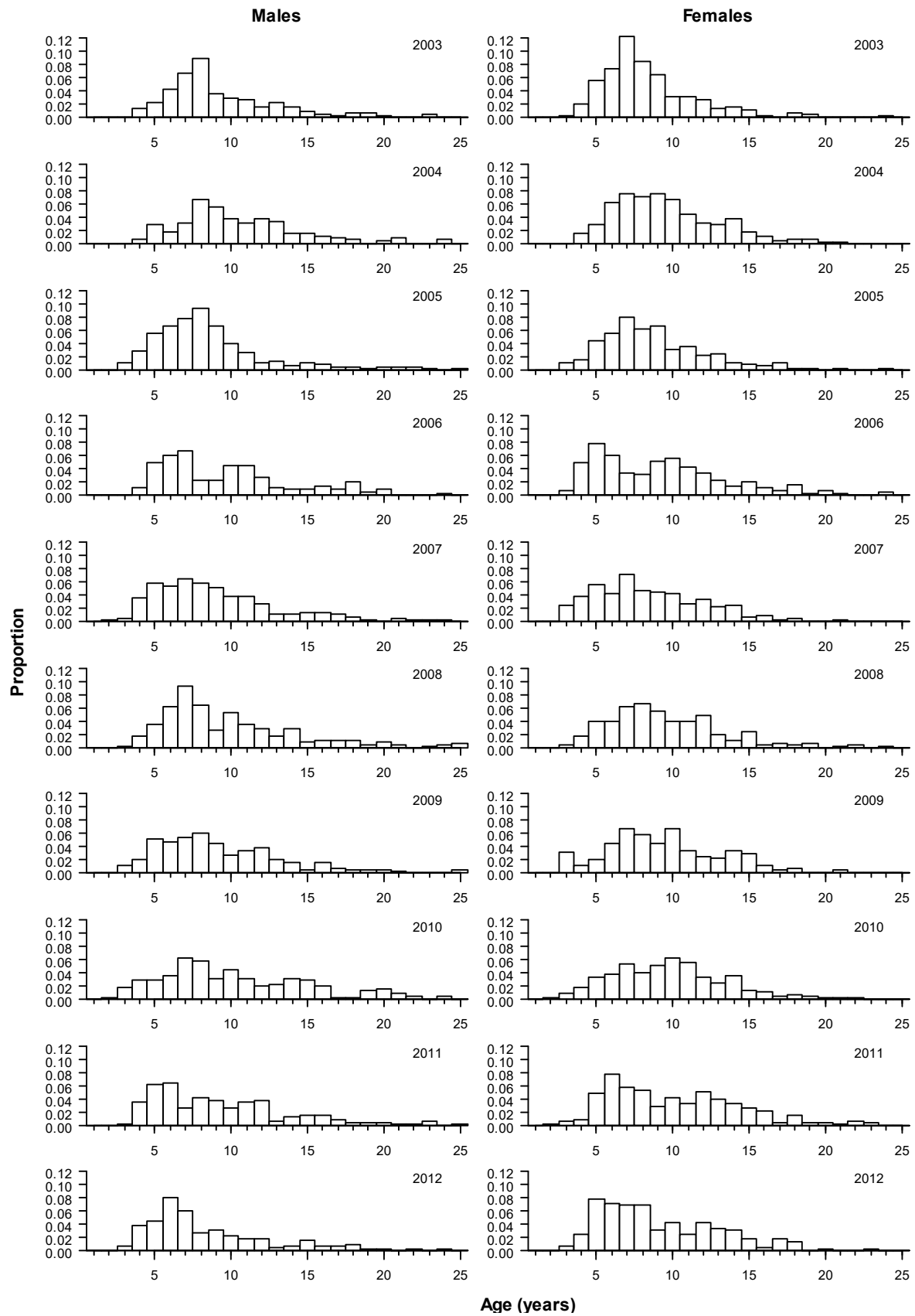


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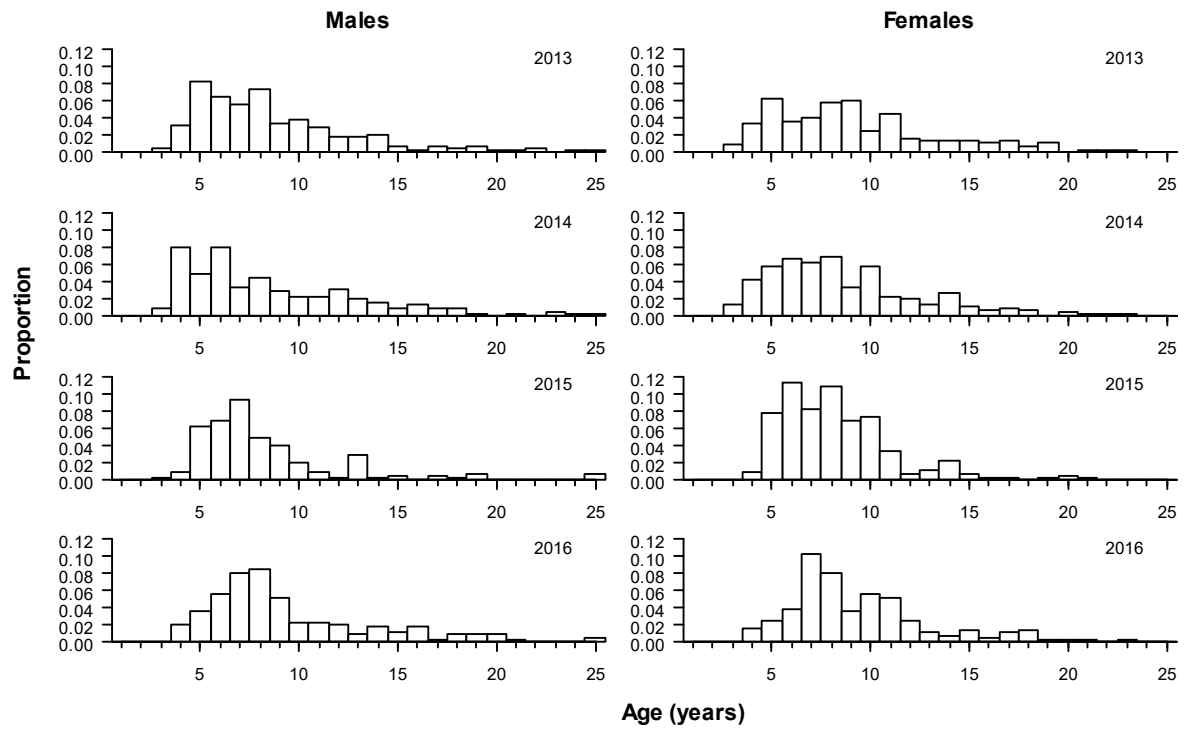


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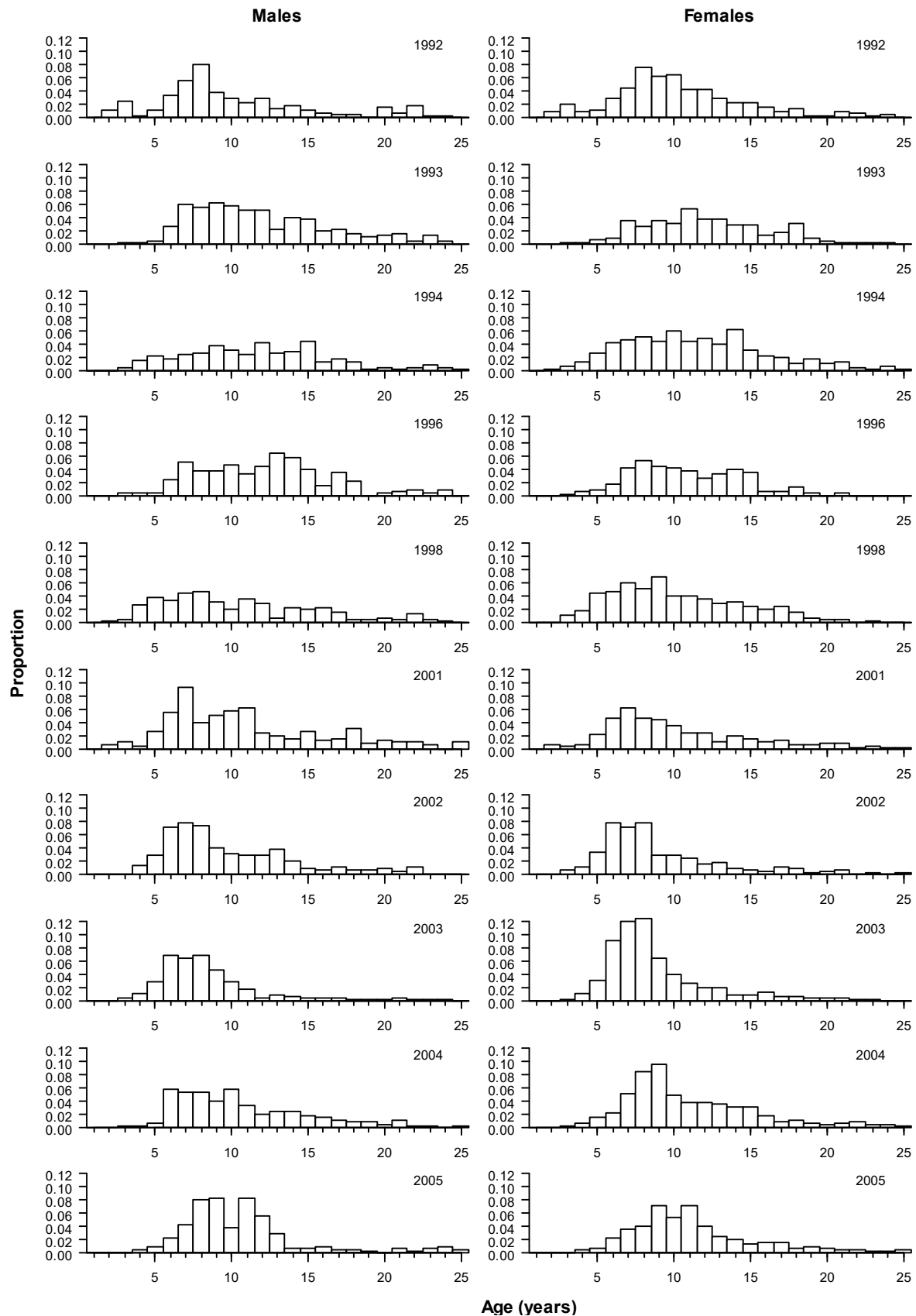


Figure B8: Age frequency distributions of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2016. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2005” denotes the September 2004–April 2005 sample.

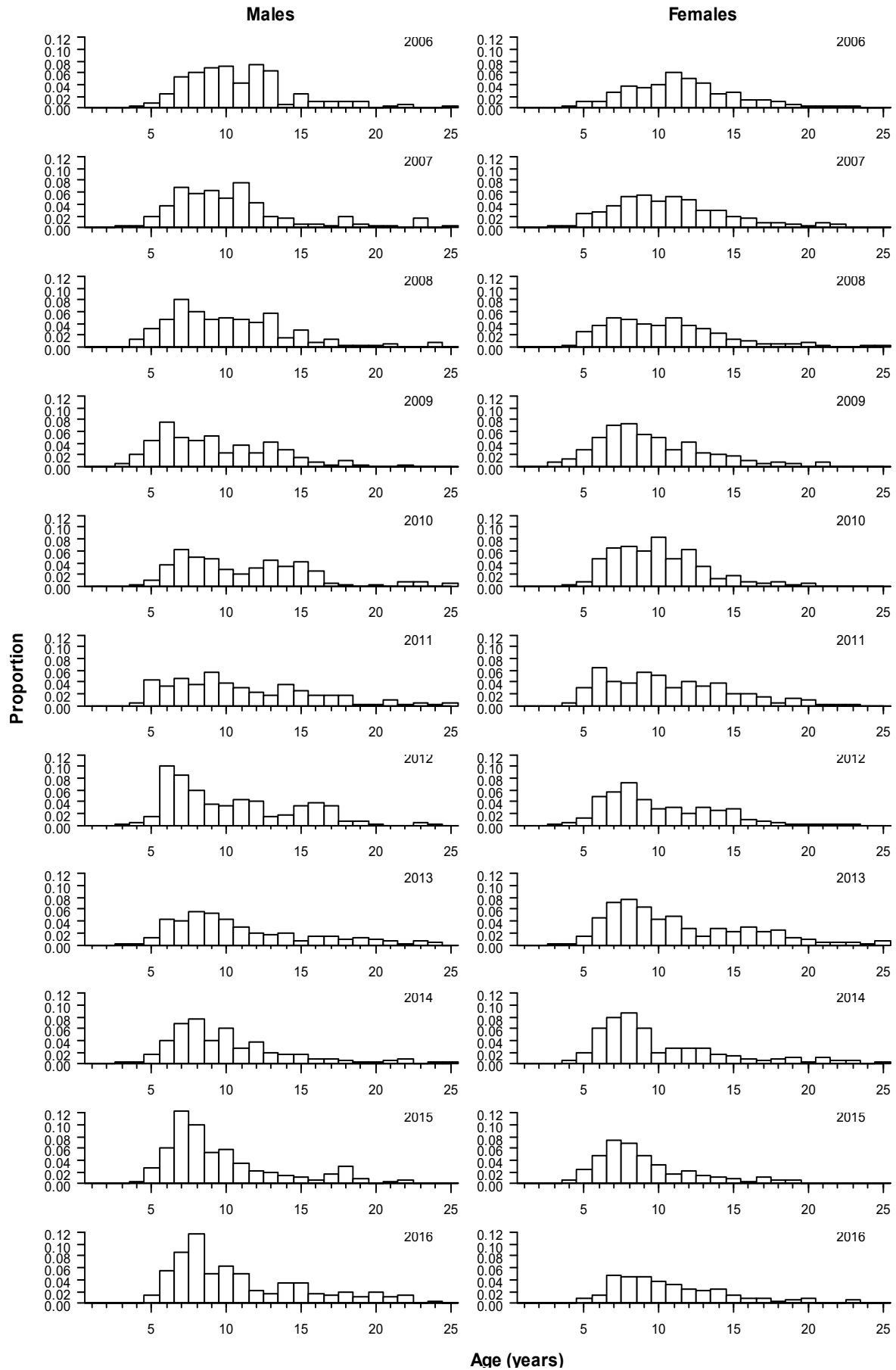


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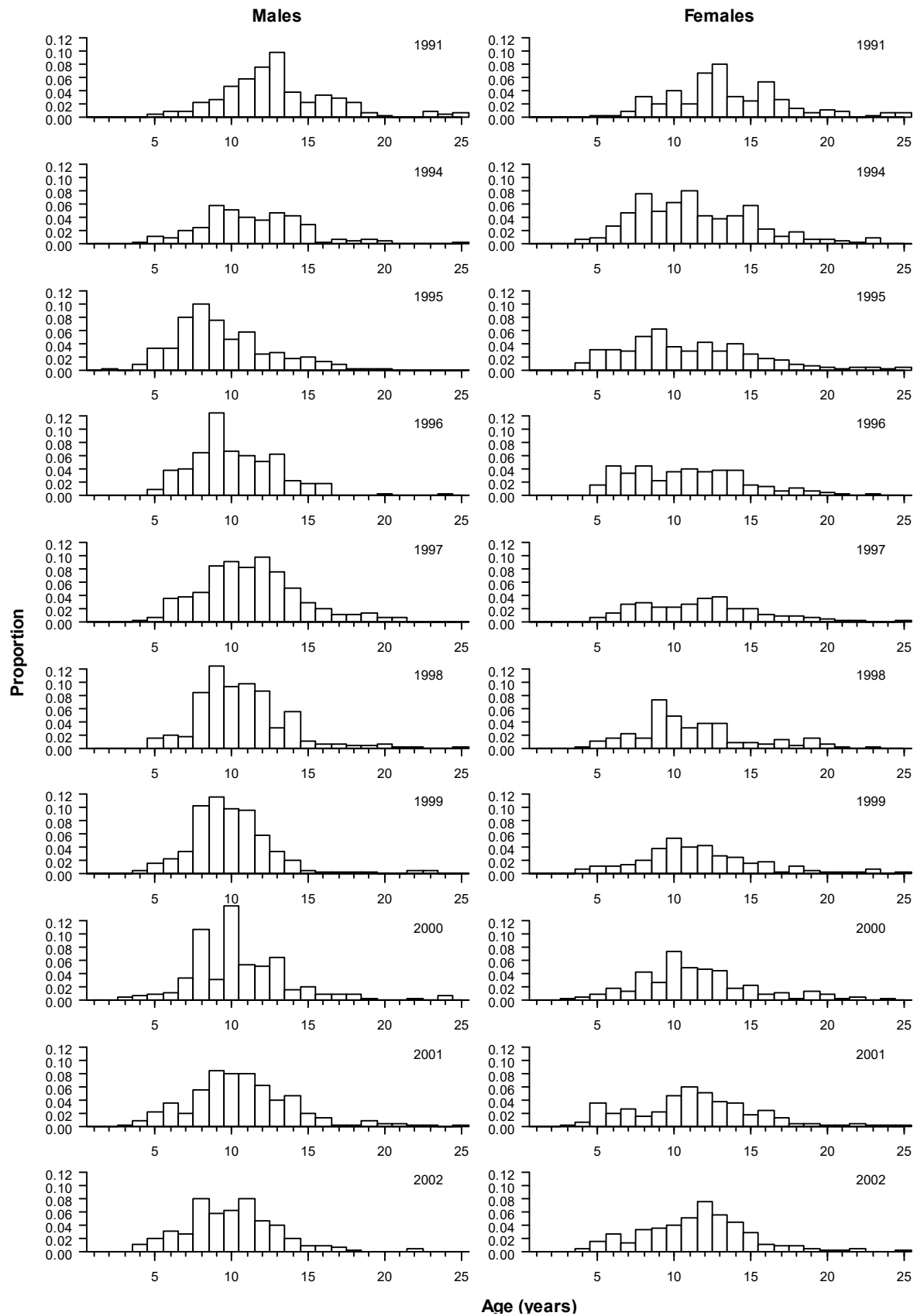


Figure B9: Age frequency distributions of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2016.

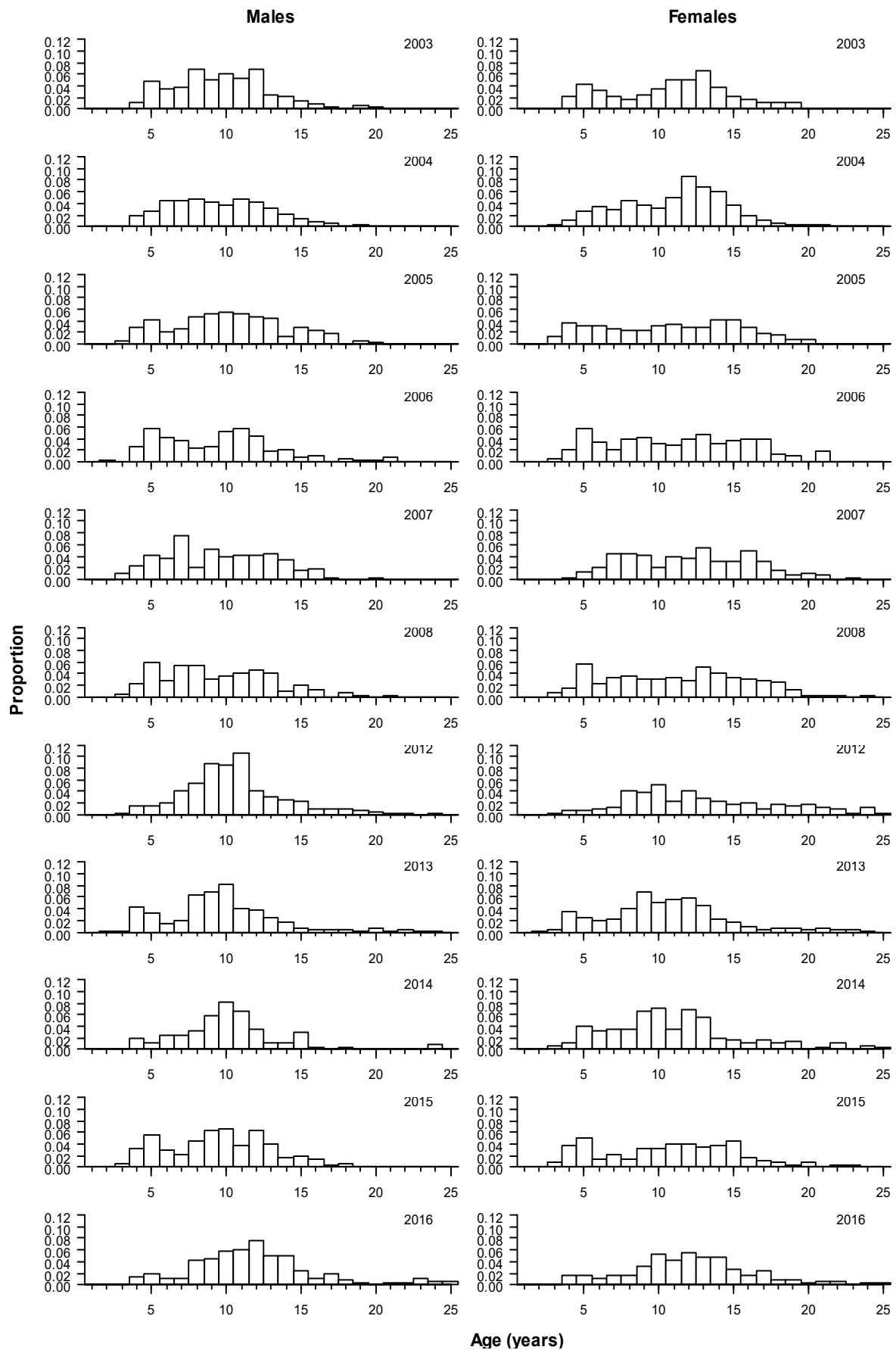


Figure B9 ctd.

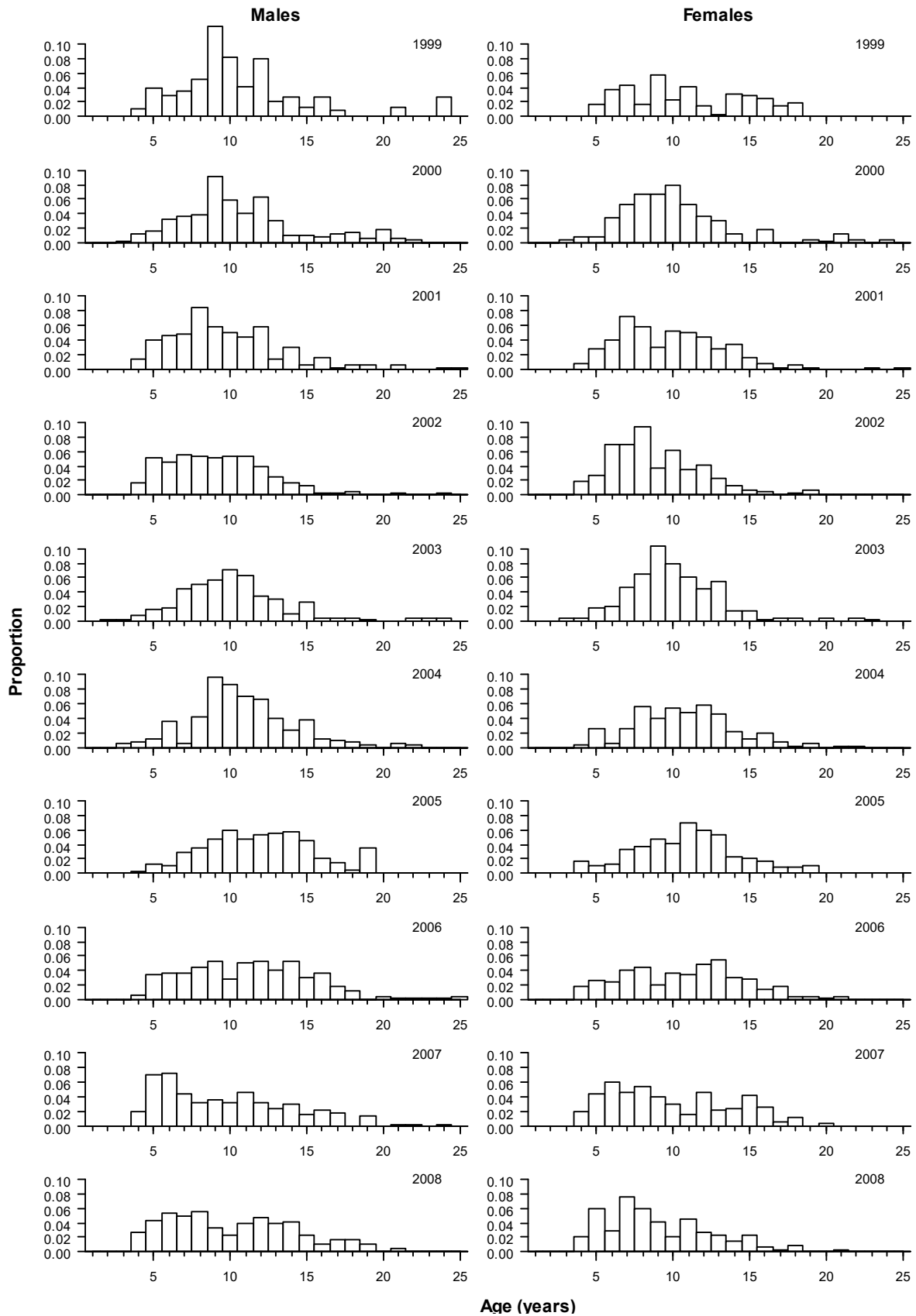


Figure B10: Age frequency distributions of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2016.

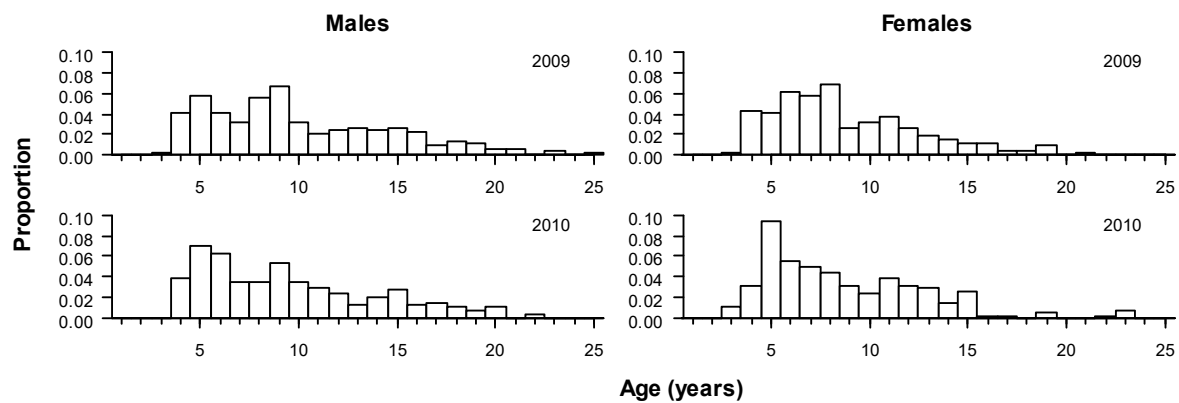


Figure B10 ctd.

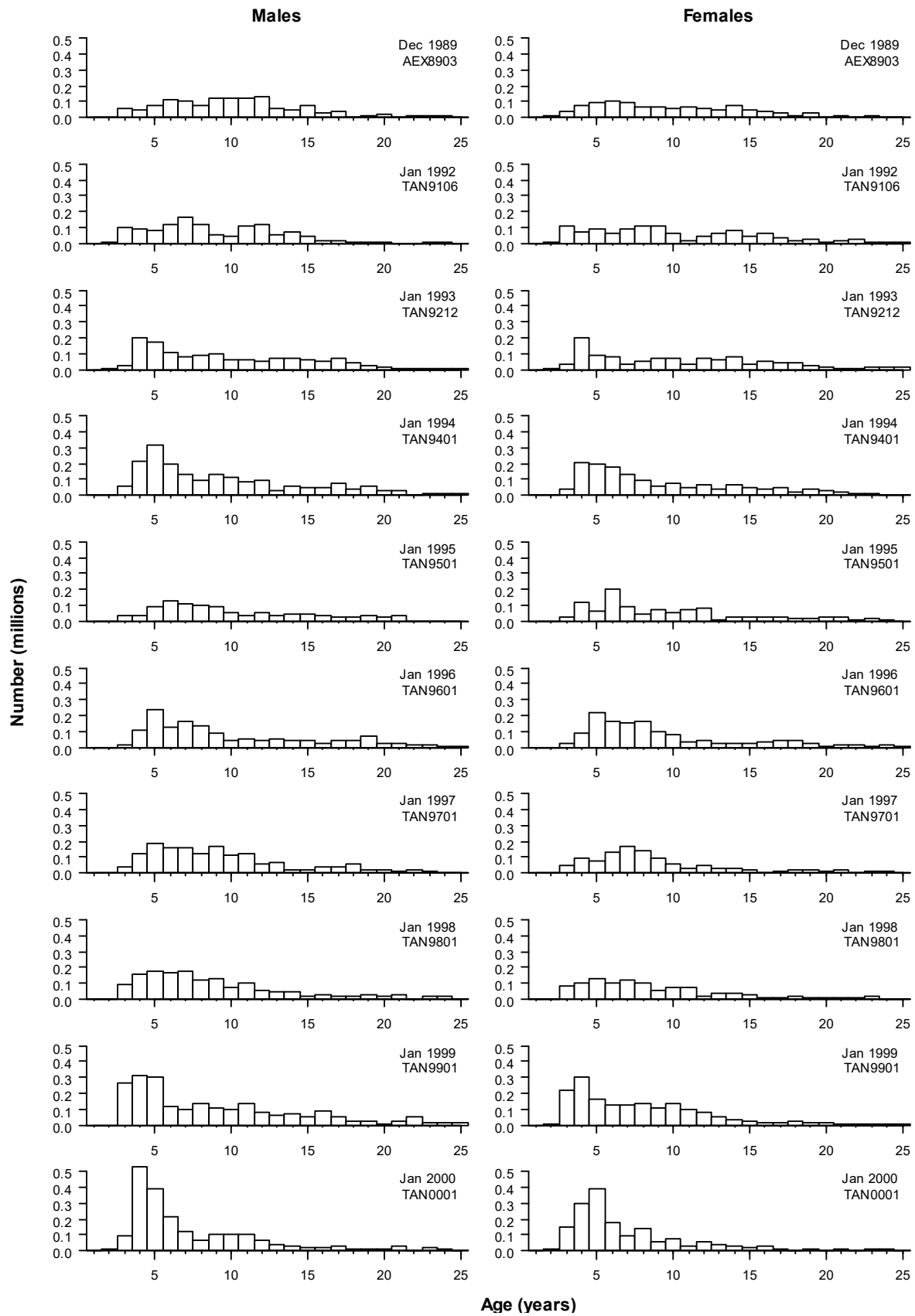


Figure B11: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from resource surveys of the Chatham Rise, 1989–90 to 2016–17.

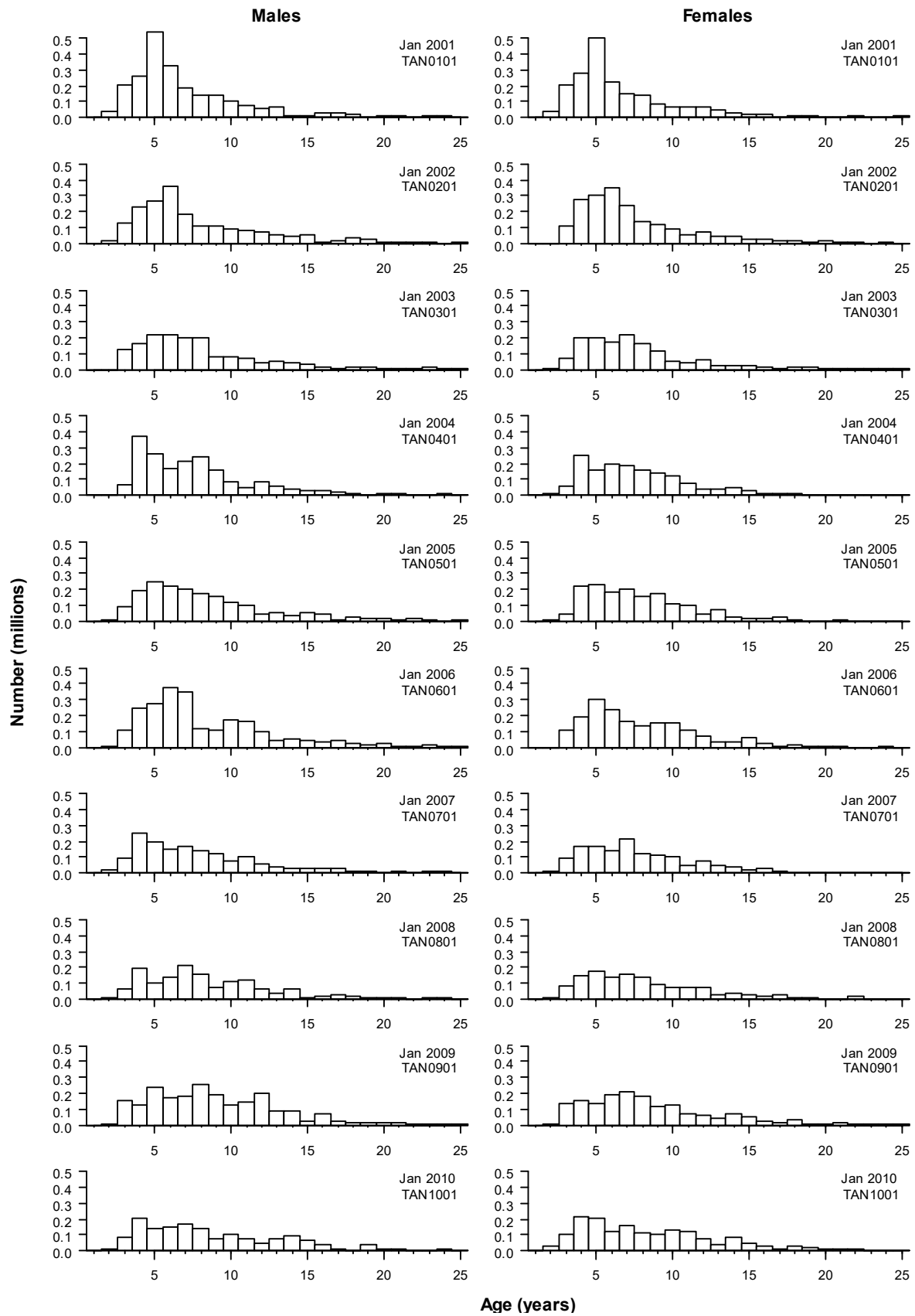


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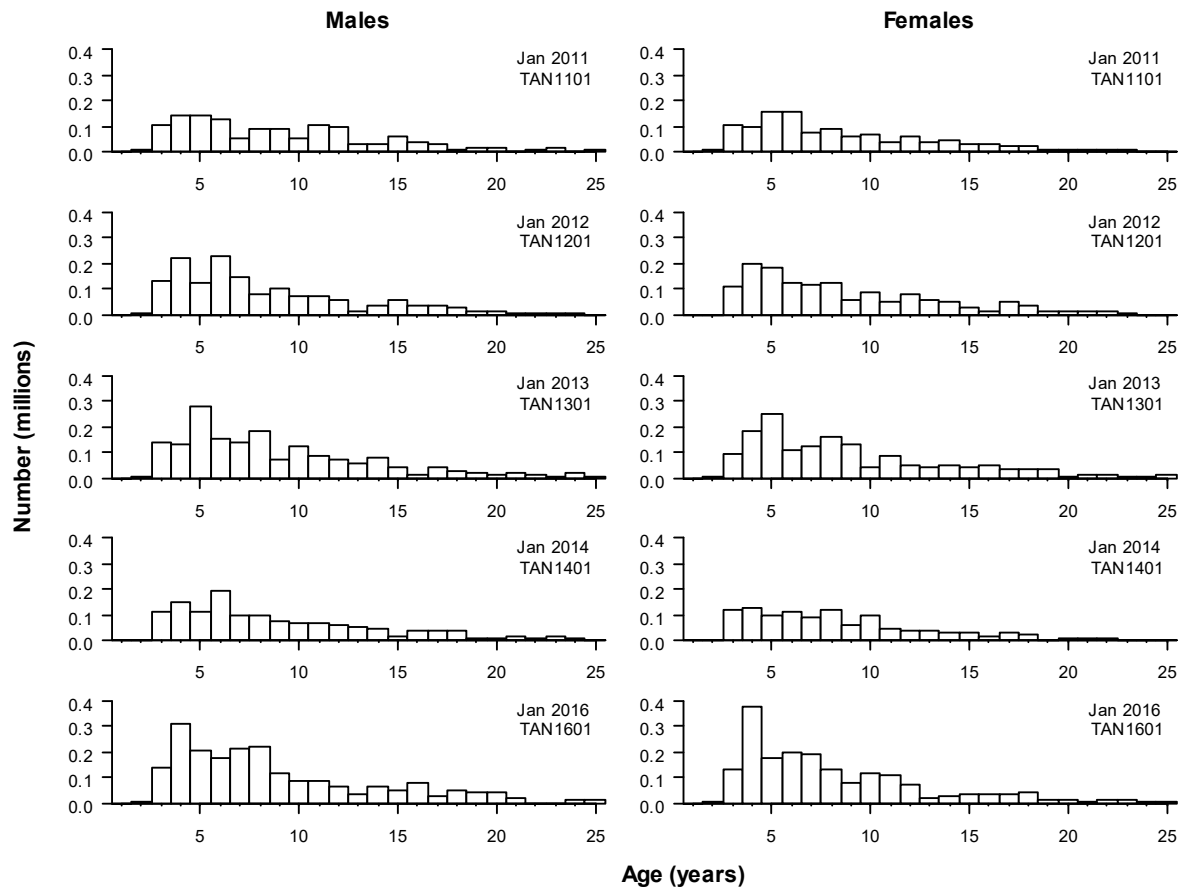


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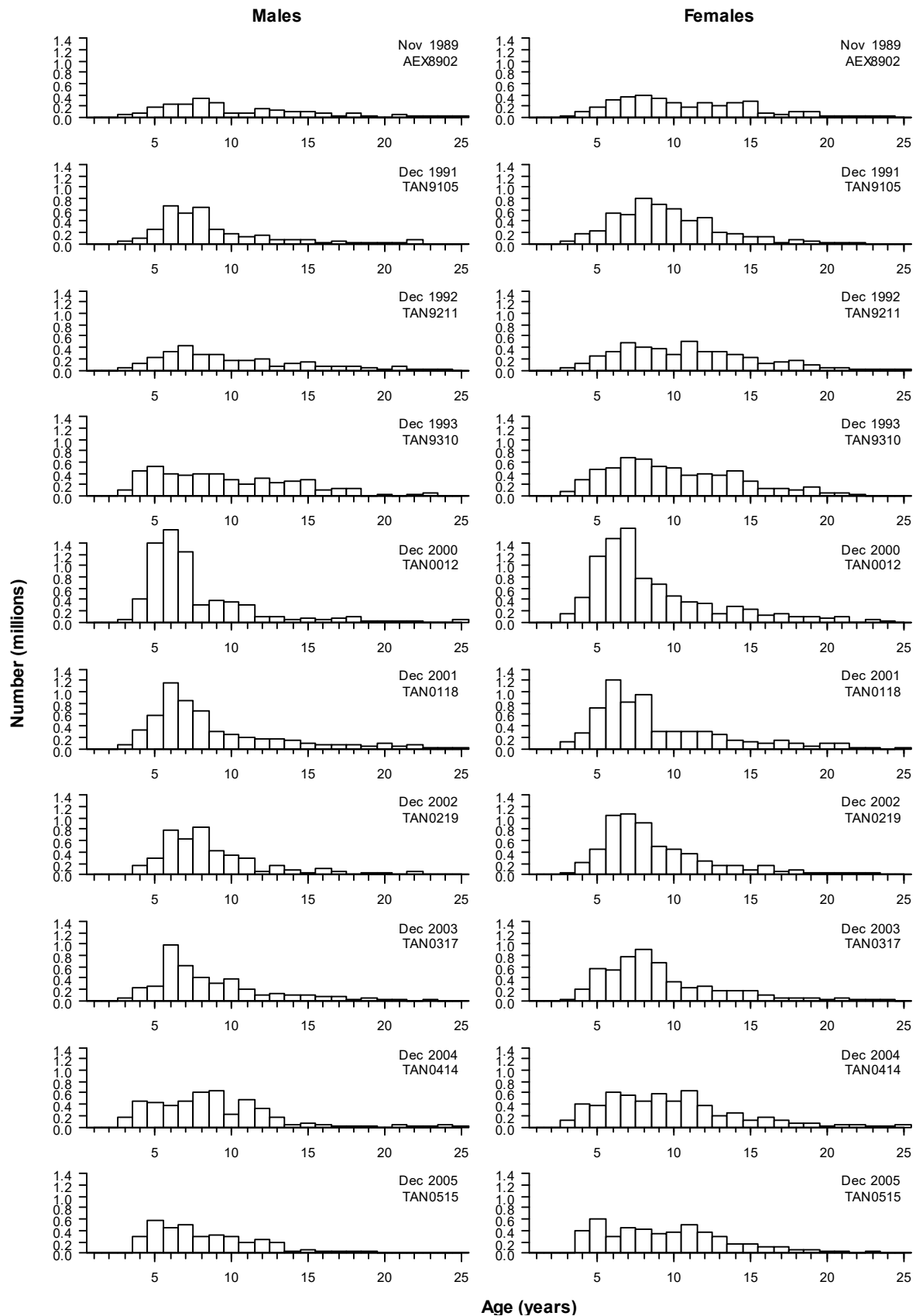


Figure B12: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from summer resource surveys of the Sub-Antarctic, 1989 to 2016.

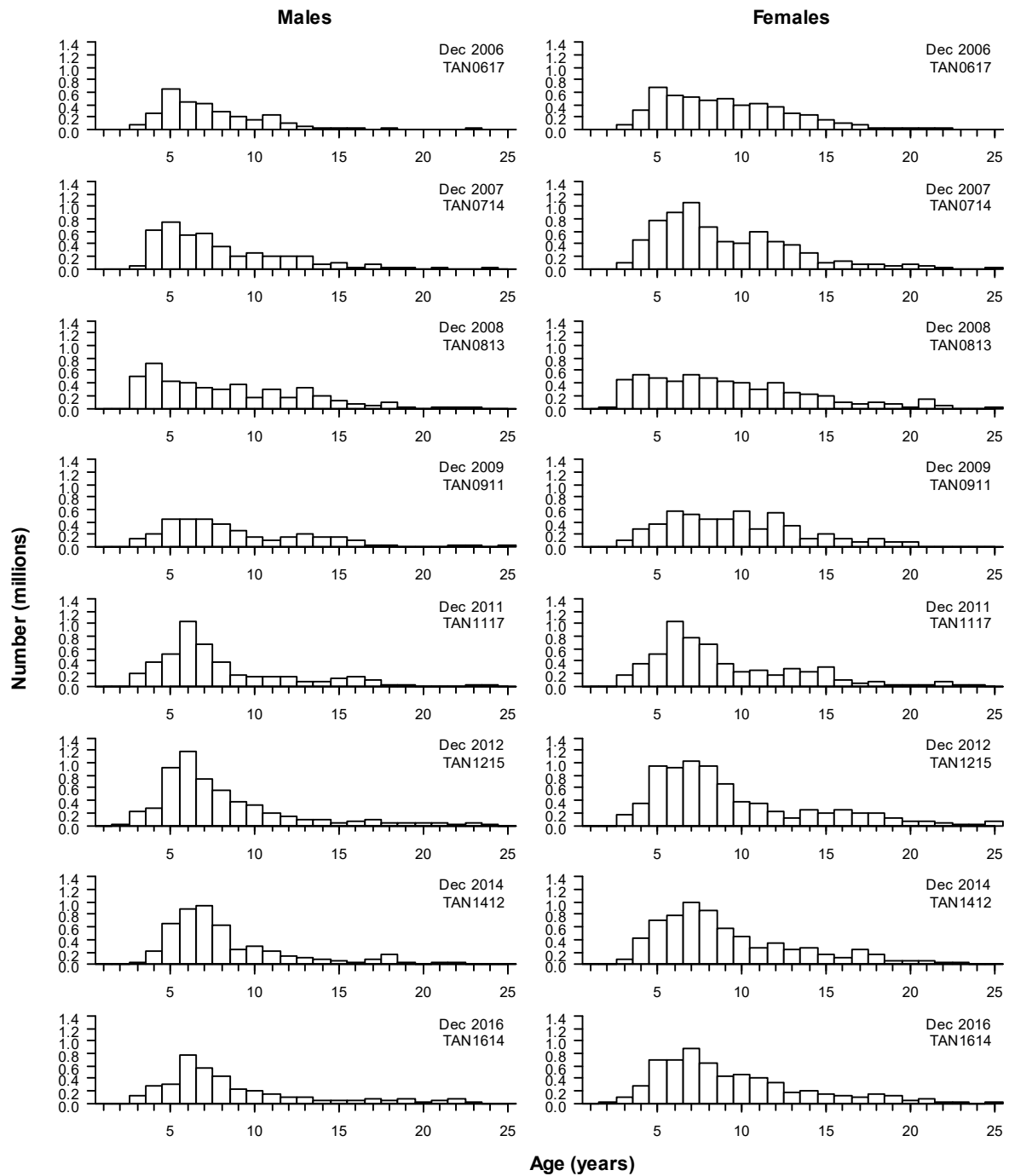


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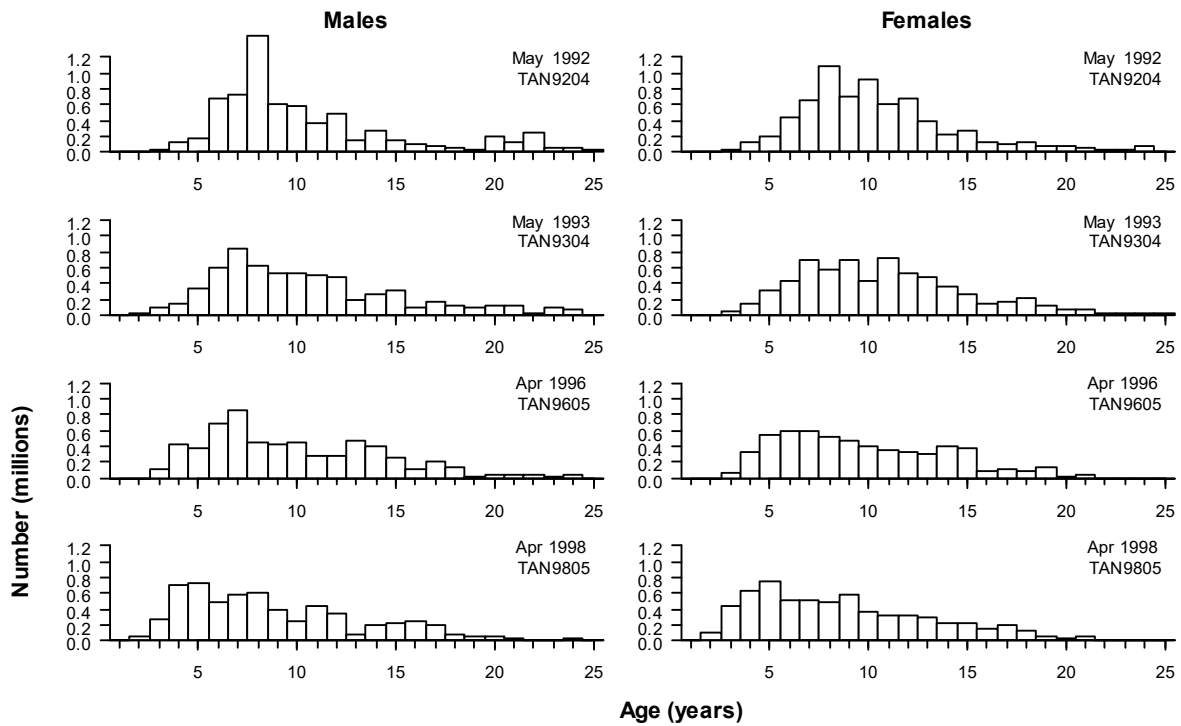


Figure B13: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from autumn resource surveys of the Sub-Antarctic, 1992 to 1998.

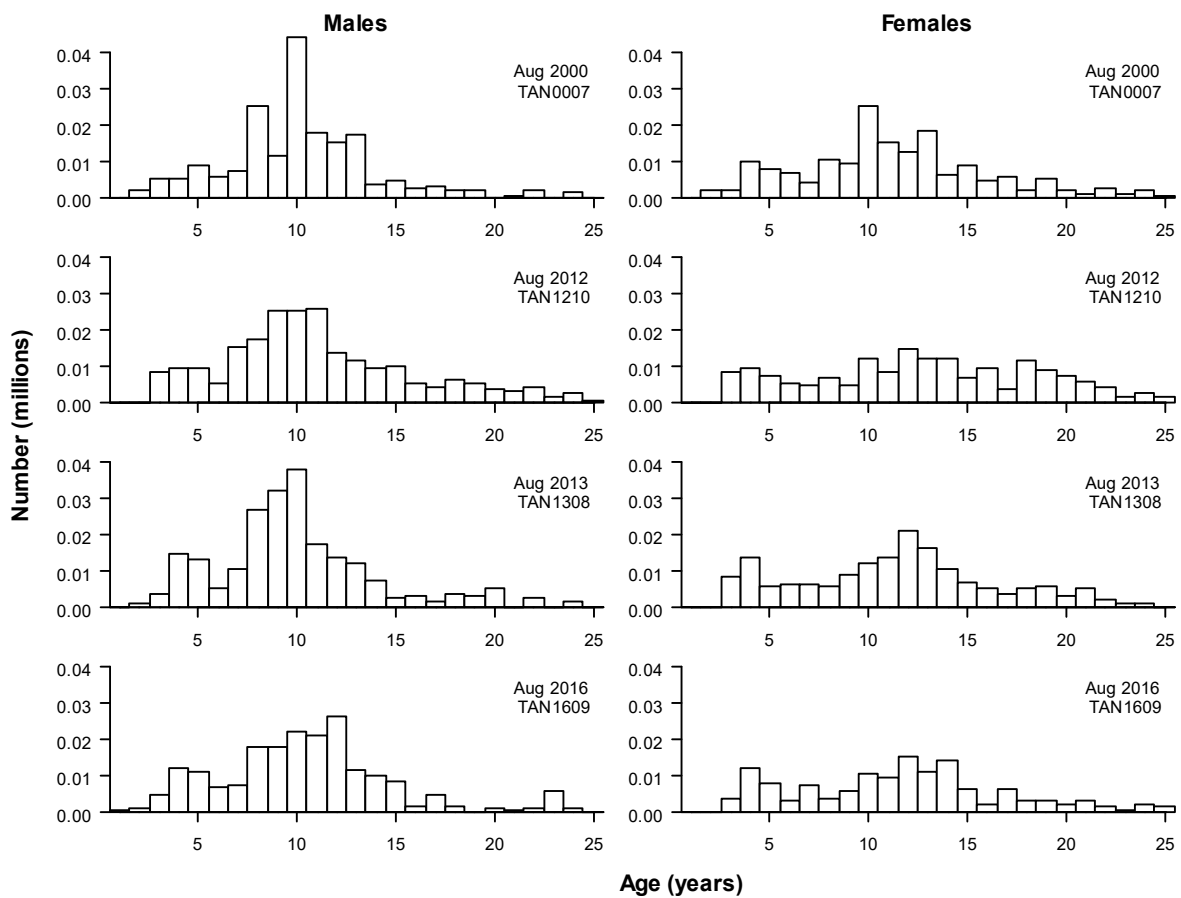


Figure B14: Age frequency distributions of ling (scaled numbers-at-age, ages 1 to 25) from winter resource surveys of the WCSI, 2000 to 2016.