Ministry for Primary Industries
Manatū Ahu Matua

Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2013–14 fishing year and from a trawl survey in 2014, with a summary of all available data sets from the New Zealand EEZ

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Table of Contents

EXECUTIVE SUMMARY

This report describes catch-at-age distributions for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) estimated from commercial fisheries for these species in the 2013–14 fishing year (using data and otoliths collected at sea by observers), and from a trawl survey of hoki and middle depth species in the Sub-Antarctic in December 2014 (TAN1412). The target coefficient of variation (CV) for each estimated catch-at-age distribution from the observer samples and the trawl survey was 30% (mean weighted CV across all age classes).

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

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

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

1. INTRODUCTION

The work presented here aimed to determine catch-at-age from the main fisheries for hake and ling in the 2013–14 fishing year, and for hake and ling from a trawl survey conducted in December 2014. Catch-at-age data are a vital input into the stock assessment process as they provide important information on the year class strength of recruited cohorts, and enable calculation of selectivity ogives for the trawl surveys and commercial fisheries for these species. This report describes the resulting catch-at-age distributions for hake and ling; the new data extend existing series of catch-at-age data in all cases. It fulfils the reporting requirements for Objectives 3, 4, and 7 (part) of Project MID201001E "Routine age determination of hoki and middle depth species from commercial fisheries and trawl surveys", funded by the Ministry for Primary Industries. Those objectives are:

3. To determine the catch-at-age from hake fisheries in HAK 1, 4 and 7 from samples collected at sea by the Observer Programme.

4. To determine the catch-at-age from ling fisheries in LIN 3 & 4, 5 & 6 and 7 from samples collected at sea by the Observer Programme, and from other sources.

7. To determine the age and size structure of hoki, hake, ling and jack mackerel from the trawl surveys.

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

2. METHODS

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

HAK 1 — commercial trawl fishery, Sep 2013–May 2014 [600].
HAK 1 — trawl survey, Dec 2014 (project MDT2010-02B) [600].
HAK 4 — commercial trawl fishery, Oct 2013–Apr 2014 [600].
HAK 7 — commercial trawl fishery, Jun–Sep 2014 [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, Jun–Oct 2014 [580].
LIN 5&6 — commercial trawl fishery, Sep 2013–Apr 2014 [640].
LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2013 [500].
LIN 5&6 — commercial longline fishery, non-spawning, Campbell, Feb–Jul 2014 [500].
LIN 6B — commercial longline fishery, Nov 2013–Mar 2014 [500].
LIN 7 — commercial trawl fishery, Jun–Sep 2014 [600].
LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2014 [500].

No observer otoliths were available from the ling longline fisheries on Chatham Rise (LIN 3&4) and Bounty Plateau (LIN 6B), or from the Sub-Antarctic (LIN 5&6) spawning fishery, and also from the winter 2014 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 2014 Chatham Rise trawl survey (LIN 3&4).

LIN 3&4 — commercial trawl fishery, Oct 2013–May 2014.

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

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

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

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

3. RESULTS

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

3.1.1 Chatham Rise

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

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

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

A tow was included in the catch-at-age analysis if it occurred between 1 October and 30 April, and if at least five hake were measured from it.
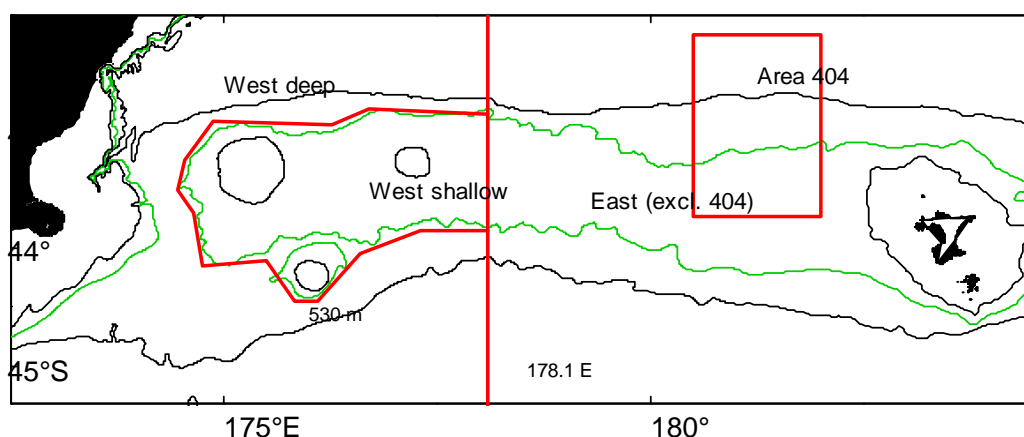
Figure 1: Strata defined for the Chatham Rise hake fishery. The west stratum boundary defined by depth (530 m) is shown only approximately (red). Isobaths at 1000, 500 (green), and 250 m are also shown.

Observer data from each fishery were converted into catch-at-age distributions if there were at least 400 length measurements (west fishery) or 300 length measurements (east fishery). Table 1 summarises the quantities of useful data. In the 2013–14 fishing year, sufficient length data ($n = 434$) were available from the west strata to calculate a catch-at-age distribution, but not for the east strata ($n = 28$). Details of the estimated catch-at-age distribution for west trawl-caught hake in the 2013–14 fishing year are in Table 2. The mean weighted CV of 30% 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.

Fishing year	West				East				Aged	
	M	F	Tows	CV	M	F	Tows	CV	M	F
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

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 2013–April 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
2	85	1.088	103	1.040
3	1 975	0.293	1 528	0.266
4	2 564	0.257	915	0.348
5	914	0.372	1 244	0.312
6	653	0.436	498	0.488
7	782	0.346	656	0.400
8	402	0.427	1 121	0.316
9	630	0.535	530	0.408
10	108	0.767	812	0.360
11	104	0.908	502	0.548
12	274	0.536	96	0.917
13	43	1.369	208	0.634
14	32	2.054	7	1.881
15	0	–	192	0.819
16	6	1.752	0	–
17	58	0.904	11	2.024
18	101	0.765	53	0.862
19	0	–	15	1.735

Measured males	213
Measured females	221
Aged males	150
Aged females	145
No. of tows sampled	37
Mean weighted CV (sexes pooled)	29.5

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° E ≤ longitude ≤ 168° E, 46° S ≤ latitude ≤ 48° S).
2. Snares-Pukaki (165° E ≤ longitude ≤ 175° E, 46° S ≤ latitude ≤ 50.25° S, but excluding the Puysegur Bank stratum and the area north of 48° S and east of 171.6°).
3. Auckland Island (165° E ≤ longitude ≤ 169° E, 50.25° S < latitude ≤ 54° S).
4. Campbell Island (169° E < longitude ≤ 174° E, 50.25° S < latitude ≤ 54° S).

A tow was included in the catch-at-age analysis if it occurred between 1 September and 31 May, and if at least five hake 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 2013–14 fishing year are in Table 4. The mean weighted CV of 19% 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).
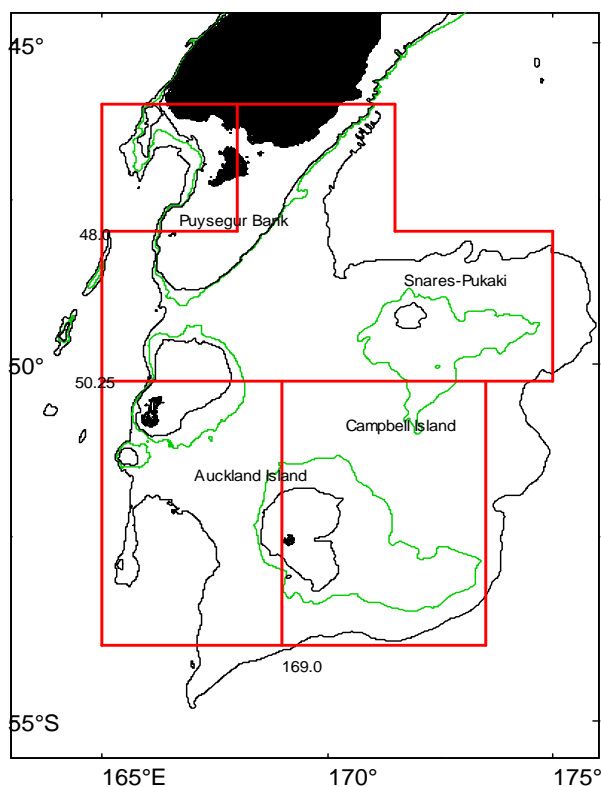

Figure 2: Fishery strata defined for the Sub-Antarctic hake fishery. Numbers show latitudes and longitudes of fishery boundaries. Isobaths at 1000, 500, and 250 m are also shown.

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

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 2013–May 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
4	571	0.690	253	0.602
5	3 743	0.414	1 183	0.364
6	12 386	0.232	1 487	0.578
7	20 300	0.191	959	0.749
8	32 343	0.140	10 030	0.300
9	38 295	0.136	15 610	0.189
10	26 903	0.167	14 591	0.222
11	13 048	0.220	4 467	0.357
12	9 839	0.295	6 573	0.308
13	4 144	0.437	6 027	0.408
14	6 423	0.383	2 013	0.760
15	3 601	0.442	1 876	0.600
16	8 056	0.299	0	–
17	9 234	0.282	3 397	0.553
18	3 859	0.405	346	1.102
19	5 925	0.315	354	1.090
20	7 248	0.310	715	1.101
21	2 621	0.606	1 379	0.841
22	124	1.173	176	1.373

Measured males	4 027
Measured females	1 443
Aged males	316
Aged females	146
No. of tows sampled	90
Mean weighted CV (sexes pooled)	19.4

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 2013–14 fishing year are in Table 6. The measured sample size was much larger than in all previous years except 2012–13, and the mean weighted CV of 13% was much less than the target of 30%.

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

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

	Males		Females		Tows	Mean CV
Year	Measured	Aged	Measured	Aged		
1989–90	578	210	567	261	57	23.1
1990–91	2 288	286	1 653	358	146	18.4
1991–92	2 592	196	1 193	261	121	22.5
1992–93	2 129	188	979	163	93	29.1
1993–94	1 598	151	1 643	272	174	32.5
1994–95	2 528	271	2 769	342	152	29.2
1995–96	2 862	287	1 753	326	193	28.9
1996–97	3 286	262	1 720	198	234	21.3
1997–98	2 339	257	1 497	253	237	21.4
1998–99	4 186	270	3 744	240	307	18.3
1999–2000	2 705	258	2 330	269	285	18.9
2000–01	1 529	176	1 723	280	192	23.9
2001–02	2 281	93	2 434	385	380	33.8
2002–03	1 917	227	2 063	234	296	20.0
2003–04	2 702	303	2 181	193	353	16.5
2004–05	2 305	238	2 324	280	217	23.8
2005–06	5 502	276	4 231	298	395	16.3
2006–07	3 385	248	3 258	257	132	16.7
2007–08	4 682	321	2 416	266	147	17.7
2008–09	5 773	301	3 610	301	178	18.8
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

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 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
0	614	0.590	612	0.574
1	14 686	0.185	15 343	0.368
2	4 244	0.737	5 115	0.452
3	2 592	0.288	1 543	0.297
4	19 834	0.140	4 081	0.289
5	83 049	0.113	8 124	0.318
6	136 508	0.103	49 636	0.154
7	88 671	0.133	99 991	0.110
8	58 454	0.170	80 093	0.112
9	17 536	0.332	38 246	0.143
10	9 128	0.404	17 358	0.245
11	7 775	0.465	9 524	0.338
12	3 568	0.643	9 304	0.344
13	950	1.063	2 395	0.665
14	3 686	0.615	887	0.930
15	935	1.208	3 423	0.520
16	5 302	0.560	2 268	0.725
17	0	0.000	1 397	0.838
18	935	1.020	0	0.000
19	3 040	0.656	533	1.088
20	0	–	0	–
21	0	–	0	–
22	305	1.213	0	–

Measured males	8 128
Measured females	7 242
Aged males	320
Aged females	384
No. of tows sampled	360
Mean weighted CV (sexes pooled)	13.1

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 2015.

All estimated proportion-at-age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A5). It is likely that a strong year class was produced in 2002 (i.e., spawned at the start of the 2001–02 fishing year, and aged 2 years in January 2004), and that it was followed by two further relatively strong year classes in 2003 and 2004. The progression of these year classes, but particularly that from 2002, is apparent in the survey size distributions since TAN0401. A relatively strong year class spawned at the start of the 1990–91 fishing year (age 3 in January 1994) is also apparent.

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

Source	Males Measured	Males Aged	Females Measured	Females Aged	Tows	Mean CV
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

3.2.2 Sub-Antarctic

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

Table 8 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The details of the estimated catch-at-age distribution for hake caught in the November–December 2014 trawl survey are given in Table 9. The mean weighted CV of 48% was greater than the target of 30%.

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

Table 8: Numbers of measured male and female hake, age data used in the age-length key, and tows sampled, and estimated mean weighted CV (%) by age for the Sub-Antarctic resource surveys.

Survey	Males Measured	Aged	Females Measured	Aged	Tows	Mean CV
Summer surveys						
AEX8902	45	43	76	66	34	52.7
TAN9105	337	117	332	217	61	65.1
TAN9211	14	46	133	168	48	48.6
TAN9310	57	93	181	182	59	47.2
TAN0012	348	239	392	352	56	37.3
TAN0118	219	212	351	349	44	35.6
TAN0219	331	191	490	377	38	36.1
TAN0317	126	186	175	220	30	41.0
TAN0414	178	245	225	283	39	42.8
TAN0515	88	146	265	274	39	39.9
TAN0617	188	190	487	460	39	33.6
TAN0714	166	217	352	423	47	35.4
TAN0813	289	188	808	412	39	30.9
TAN0911	152	164	382	436	37	36.3
TAN1117	405	238	423	357	37	37.3
TAN1215	155	222	359	537	36	39.1
TAN1412	41	41	169	176	29	47.7
Autumn surveys						
TAN9204	60	58	113	107	48	46.8
TAN9304	36	36	124	122	54	49.5
TAN9605	32	86	93	137	45	61.9
TAN9805	49	94	146	189	31	52.0
Spring surveys						
TAN9209	76	68	141	113	44	43.8

Table 9: Calculated numbers at age in the survey area, separately by sex, with CVs, for hake caught during a trawl survey of the Sub-Antarctic in November–December 2014 (survey TAN1412). Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
3	0	–	11 158	1.020
4	8 841	0.633	20 144	0.377
5	20 145	0.550	25 628	0.263
6	3 291	0.835	21 884	0.388
7	6 533	0.995	33 976	0.403
8	0	–	25 877	0.342
9	1 184	1.746	35 930	0.404
10	4 345	1.081	21 511	0.607
11	0	–	11 690	0.729
12	1 113	1.872	5 167	0.754
13	0	–	8 041	1.331
14	0	–	2 465	1.104
15	930	1.790	4 441	0.878
16	0	–	1 414	1.041
17	0	–	0	–
18	0	–	1 532	0.978
19	4 345	1.019	6 838	0.964

Measured males	41
Measured females	169
Aged males	41
Aged females	176
No. of tows sampled	29
Mean weighted CV (sexes pooled)	47.7

3.2.3 West coast South Island

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

Table 10 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. Because no otoliths from the 2000 survey were aged, the scaled length-frequency distribution from that survey was applied to the WCSI commercial fishery age-length key for 2000. The age-length keys for the 2012 and 2013 surveys were derived using otoliths collected during the surveys. There was no survey in this series conducted in winter 2014.

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

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

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

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

3.3.1 Chatham Rise

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

Table 11 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were no data collected from the Chatham Rise ling longline fishery in 2010–2012 and 2014.

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

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

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

3.3.2 Sub-Antarctic

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

Table 12 summarises the data used each year to produce the catch-at-age distributions for the two Sub-Antarctic longline fisheries, and also lists the resulting mean weighted CVs. Observer sampling of two trips in the non-spawning fishery occurred in the 2013–14 fishing year; the resulting estimated catch-at-age distribution is given in Table 13. The mean weighted CV of 30% just met the target value 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 12: Numbers of measured male and female ling, age data used in the age-length key, and sets sampled, and estimated mean weighted CV (%) by age, for the Sub-Antarctic spawning and non-spawning longline fisheries.

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

Table 13: Calculated numbers at age, separately by sex, with CVs, for ling sampled by observers during commercial longline operations in the Sub-Antarctic non-spawning fishery (LIN 5&6) in February–July 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
4	0	–	48	1.765
5	84	1.772	642	0.692
6	26	1.779	952	0.554
7	423	0.643	2 073	0.424
8	2 041	0.436	3 584	0.330
9	1 185	0.489	4 036	0.312
10	1 056	0.650	3 263	0.317
11	891	0.667	5 463	0.235
12	216	1.315	6 180	0.223
13	496	0.745	7 085	0.205
14	489	0.687	5 149	0.248
15	462	0.817	5 297	0.245
16	1 125	0.607	5 099	0.228
17	356	1.240	3 047	0.309
18	0	–	3 046	0.298
19	117	1.208	2 148	0.397
20	0	–	1 742	0.481
21	268	0.876	784	0.661
22	119	1.427	1 190	0.479
23	0	–	993	0.657
24	1 101	0.527	1 330	0.583

Measured males	156
Measured females	782
Aged males	57
Aged females	258
No. of sets sampled	59
Mean weighted CV (sexes pooled)	29.8

3.3.3 West coast South Island

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

Table 14 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The 2003, 2006 and 2007 age-length keys were developed using age data from the trawl fisheries in the same years, as no otoliths were sampled from longline trips. The 2012 age-length key was developed using 129 otoliths sampled from a longline trip, plus additional age data from the July 2012 research trawl survey off WCSI. There was no sampling of WCSI longline-caught ling in the 2013–14 fishing year. All estimated proportion-at-age distributions from the WCSI longline fishery are presented in Appendix B (Figure B4).

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

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

3.3.4 Cook Strait

The line fishery data from Cook Strait were analysed using a single area stratum (i.e., those parts of FMAs 2, 7, and 8 between 41° and 42° S and 174° and 175.4° E, equating approximately to Statistical Areas 016 and 017), and a time stratum of 1 June to 30 September.

Table 15 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The 2001 age-length key used 57 otoliths collected from the longline fishery (i.e., all that were collected), plus 316 otoliths collected from the trawl fishery in the same area and year. There was no observer sampling of Cook Strait longline-caught ling in the 2013–14 fishing year. All estimated proportion-at-age distributions from the Cook Strait longline fishery are presented in Appendix B (Figure B5).

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

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

3.3.5 Bounty Plateau

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

Table 16 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were no data collected from the Bounty Plateau ling longline fishery in the 2013–14 fishing year. All estimated proportion-at-age distributions from the Bounty Plateau longline fishery are presented in Appendix B (Figure B6).

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

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

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

3.4.1 Chatham Rise

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

1. Coast (longitude ≤ 174° E, target not scampi).
2. Scampi (all tows targeting scampi).

3. North Rise (latitude < 43.55° S, longitude > 174° E, target not scampi).
4. South Rise (latitude ≥ 43.55° S, longitude > 174° E, target not scampi).

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

Table 17 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. The estimated catch-at-age distribution for trawl-caught ling in the 2013–14 fishing year are given in Table 18. The mean weighted CV of 30% 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 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.

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

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 2013–May 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
3	2 195	1.122	3 515	1.054
4	21 894	0.701	11 180	0.599
5	13 155	0.341	15 779	0.328
6	21 794	0.215	18 346	0.252
7	9 285	0.228	16 741	0.292
8	12 283	0.254	18 713	0.255
9	7 786	0.248	9 312	0.303
10	6 271	0.267	15 427	0.275
11	5 895	0.297	6 191	0.362
12	8 203	0.268	5 353	0.345
13	5 160	0.309	3 857	0.410
14	4 032	0.349	6 930	0.300
15	2 110	0.689	2 667	0.392
16	3 664	0.387	1 564	0.541
17	2 580	0.440	2 204	0.436
18	2 181	0.536	1 699	0.393
19	730	1.037	144	1.234
20	159	1.025	1 354	0.579
21	693	0.677	592	0.847
22	121	1.217	267	1.079
23	895	0.770	294	0.763
24	216	1.103	0	–
25	276	1.005	0	–
26	14	1.684	80	1.833
27	606	0.783	0	–
28	10	2.311	0	–
29	0	–	361	1.278
30	0	–	0	–
31	3	2.290	64	1.629
32	40	1.759	0	–
33	0	–	0	–
34	0	–	0	–
35	0	–	145	1.219
36	75	1.771	0	–
37	218	1.050	0	–

Measured males	1 385
Measured females	1 674
Aged males	314
Aged females	258
No. of tows sampled	164
Mean weighted CV (sexes pooled)	29.7

3.4.2   Sub-Antarctic

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

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

Table 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 2013–14 fishing year are given in Table 20. The mean weighted CV of 20% was less than the target value of 30%.

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

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

	Males		Females			Mean CV
Source	Measured	Aged	Measured	Aged	Tows	
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

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 2013–April 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
2	180	2.655	0	–
3	5 915	0.819	2 479	0.813
4	10 197	0.428	14 097	0.655
5	34 585	0.322	43 311	0.318
6	86 519	0.250	131 030	0.176
7	147 283	0.188	169 120	0.172
8	166 164	0.161	185 178	0.148
9	86 432	0.256	132 492	0.172
10	133 493	0.206	44 354	0.319
11	59 591	0.306	59 247	0.268
12	79 929	0.279	55 817	0.263
13	44 341	0.364	57 024	0.303
14	33 860	0.412	34 451	0.345
15	38 197	0.361	32 070	0.341
16	20 245	0.580	21 918	0.452
17	18 595	0.501	11 779	0.521
18	16 117	0.506	21 506	0.440
19	7 169	0.787	24 034	0.466
20	9 769	0.638	10 168	0.654
21	11 724	0.676	22 594	0.421
22	16 881	0.647	12 979	0.762
23	0	–	14 927	0.628
24	6 049	1.043	3 294	1.078
25	8 440	0.934	5 595	0.747
26	0	–	768	1.596
27	3 539	1.142	0	–
28	0	–	0	–
29	4 936	1.167	0	–
30	796	1.444	0	–

Measured males	2 236
Measured females	2 716
Aged males	232
Aged females	311
No. of tows sampled	147
Mean weighted CV (sexes pooled)	20.3

3.4.3 West coast South Island

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

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

Table 21 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. There were insufficient data (particularly otoliths) collected to estimate the catch-at-age distribution for trawl-caught ling from 2008–09 to 2010–11. The details of the estimated catch-at-age distribution for trawl-caught ling in the 2013–14 fishing year are given in Table 22. The available amount of length data and otoliths was low relative to other years; all available otoliths were aged. Consequently, the mean weighted CV of 32% was just greater 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			Mean CV
	Measured	Aged	Measured	Aged	Tows	
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

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 2014. Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
3	264	1.289	1 443	0.772
4	5 511	0.530	3 458	0.633
5	3 402	0.628	10 872	0.388
6	6 678	0.449	8 733	0.536
7	6 886	0.594	9 558	0.497
8	8 480	0.355	9 196	0.382
9	15 559	0.283	17 437	0.288
10	21 955	0.241	19 187	0.252
11	17 880	0.283	9 434	0.339
12	9 531	0.336	18 772	0.277
13	3 011	0.638	15 259	0.328
14	2 828	0.614	5 350	0.540
15	7 896	0.393	4 654	0.520
16	693	0.982	3 042	0.739
17	0	0.000	4 711	0.699
18	766	1.303	2 782	1.172
19	287	1.150	3 802	0.856
20	0	–	0	–
21	0	–	692	1.377
22	0	–	3 321	0.643
23	0	–	0	–
24	2 371	0.921	1 685	0.852
25	0	–	917	1.218
26	0	–	82	1.680

Measured males	619
Measured females	692
Aged males	183
Aged females	202
No. of tows sampled	95
Mean weighted CV (sexes pooled)	31.6

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 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 2014.

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			Mean CV
	Measured	Aged	Measured	Aged	Tows	
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 2015.

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 Measured	Males Aged	Females Measured	Females Aged	Tows	Mean CV
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

3.5.2 Sub-Antarctic

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

Table 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 November–December 2014 trawl survey are given in Table 26. The mean weighted CV of 21% was less than the target of 30%.

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 Measured	Aged	Females Measured	Aged	Tows	Mean CV
Summer surveys						
AEX8902	760	160	1 067	234	133	28.8
TAN9105	1 563	213	2 079	348	151	19.8
TAN9211	1 249	227	1 668	354	146	20.7
TAN9310	1 520	254	1 894	351	127	22.2
TAN0012	1 761	244	1 696	351	85	19.2
TAN0118	1 316	268	1 290	326	95	19.8
TAN0219	1 661	224	1 606	350	88	20.8
TAN0317	1 270	243	1 156	333	70	22.1
TAN0414	1 433	256	1 146	339	79	26.7
TAN0515	1 095	279	988	300	82	22.4
TAN0617	969	250	1 011	355	80	22.6
TAN0714	1 014	229	1 288	353	79	21.4
TAN0813	1 162	250	994	327	80	26.6
TAN0911	830	232	882	339	70	22.8
TAN1117	1 264	266	1 321	322	80	23.6
TAN1215	1 391	289	1 555	316	80	25.5
TAN1412	1 175	262	1 261	365	76	21.1
Autumn surveys						
TAN9204	1 570	221	1 498	310	90	21.5
TAN9304	1 353	261	1 344	373	97	21.1
TAN9605	1 129	325	902	303	88	21.9
TAN9805	809	271	765	296	64	22.9

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 November–December 2014 (survey TAN1412). Summary statistics for the samples are also presented.

Age	Male	CV	Female	CV
3	39 245	0.749	86 740	0.513
4	212 087	0.314	427 504	0.266
5	666 279	0.226	695 575	0.196
6	880 372	0.211	780 966	0.213
7	936 996	0.202	985 860	0.202
8	641 138	0.234	861 061	0.204
9	251 740	0.320	581 224	0.217
10	285 641	0.284	451 596	0.223
11	205 397	0.330	271 548	0.305
12	135 914	0.407	351 001	0.236
13	107 935	0.410	226 808	0.325
14	80 307	0.482	256 876	0.304
15	58 337	0.545	151 852	0.411
16	33 595	0.744	115 600	0.422
17	82 338	0.484	251 316	0.306
18	152 830	0.343	157 951	0.347
19	37 580	0.645	65 336	0.596
20	13 065	1.033	65 944	0.601
21	33 869	0.590	47 089	0.656
22	32 833	0.725	35 613	0.798
23	3 469	1.626	40 397	0.750
24	5 049	1.701	0	–
25	5 268	1.285	0	–
26	0	–	9 233	2.008
27	0	–	0	–
28	0	–	0	–
29	9 147	1.317	0	–
30	8 292	1.274	0	–

Measured males	1 175
Measured females	1 261
Aged males	262
Aged females	365
No. of tows sampled	76
Mean weighted CV (sexes pooled)	21.1

3.5.3 West coast South Island

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

Table 27 summarises the data used each year to produce the catch-at-age distributions, and also lists the resulting mean weighted CVs. Because no otoliths from the 2000 survey were aged, the scaled length-frequency distribution from that survey was applied to the WCSI commercial fishery age-length key for 2000. The age-length keys for the 2012 and 2013 surveys were derived using otoliths collected during the surveys. No survey in this series was conducted in 2014.

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

4.   DISCUSSION

4.1   Hake

For hake, sufficient otoliths and length-frequency data to produce catch-at-age distributions that met the target mean weighted CV were available from the HAK 7 fishery off WCSI, the HAK 1 fishery in the Sub-Antarctic, and the HAK 4 fishery on the west Chatham Rise. The target was almost always met for samples from the WCSI fishery (see Table 5). The sampling intensity in the HAK 7 (WCSI) commercial trawl fishery was high in 2013–14; the only higher level of sampling was in the previous year. Sampling intensity in the Sub-Antarctic varied considerably between years, with consequent wide variation in the mean weighted CVs (see Table 3) and the sampling intensity of this fishery in 2013–14 was relatively high. Hake on Chatham Rise were analysed as two separate fisheries (see Table 1), and although sampling intensity was low in 2013–14 there were sufficient data to produce a reasonable catch-at-age distribution for the west fishery. Landings (and sampling) levels in the east fishery were low in most years, and particularly since 2002.

The Sub-Antarctic survey in December 2014 produced low numbers of hake (210 measured fish in the analysed strata), and consequently the catch-at-age distribution for the trawl survey had a mean weighted CV much higher than the target of 30% (48%). No improvements in the precision can be achieved, however, as all available data were included in the analysis. 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 2015.

On the Chatham Rise, younger hake tend to be concentrated in the west, with the population dominated by fish aged 2–10 years (see Appendix A, Figure A1). Middle-aged and older hake (i.e., 5–15 years old) tend to dominate catches in the east (see Figure A2). Previous analyses showed that males and females appeared to be about evenly abundant in all areas except Statistical Area 404, where males dominated the catch (Horn & Sutton 2009). Some year class progressions were apparent. The year class spawned at the start of the 1990–91 fishing year (age 3 years in January 1994) appeared 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 spawned in late 2001 (aged 2+ years in January 2004) clearly progressed through to age 9+ years in 2011, for both males and females. It also appeared likely that the two following year classes (2002 and 2003) were moderately strong.

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

The WCSI trawl catch 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. 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 2013–14 (Sub-Antarctic non-spawning), and the target CV was met. Catch-at-age distributions were scheduled to be produced for the Chatham Rise and Bounty Plateau fisheries, but they were not sampled by observers in 2013–14. 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 2013 to May 2014 were applied to the age-length key from the January 2014 (TAN1401) trawl survey of the Chatham Rise. The estimated CV was below the target value, as have most distributions in this series. The Sub-Antarctic and WCSI distributions relied entirely on observer length data and otoliths. The Sub-Antarctic catch-at-age distribution had a mean weighted CV well below the target of 30%; all samples in this series were below the target. The level of observer sampling of ling from the WCSI commercial fishery was relatively low in 2013–14, in contrast to some recent previous years when sampling was inadequate to estimate fishery age structure (see Table 21). The estimated catch-at-age distribution had a mean weighted CV just outside the target of 30%. An estimate of catch-at-age for the ling bycatch from the Cook Strait hoki spawning fisheries was not able to be produced for 2014 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 2014) to meet the mean weighted CV target. The target was met in all 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). No clear year class progressions were apparent in any of the longline series.

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. No clear year class progressions were apparent in any of the trawl series. 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 has either been no observer sampling, or the observed trips have occurred at times outside the 'main' fishery period used to estimate commercial catch-at-age, e.g., the Chatham Rise longline fishery. 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 that have been used to produce the time series reported here. The areas and months for each fishery are listed in this document in the sections above, e.g., for the Chatham Rise ling longline fishery the chosen season is from June to October.

5.   ACKNOWLEDGMENTS

6.   REFERENCES

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Appendix A: Summaries of the proportions-at-age data for hake
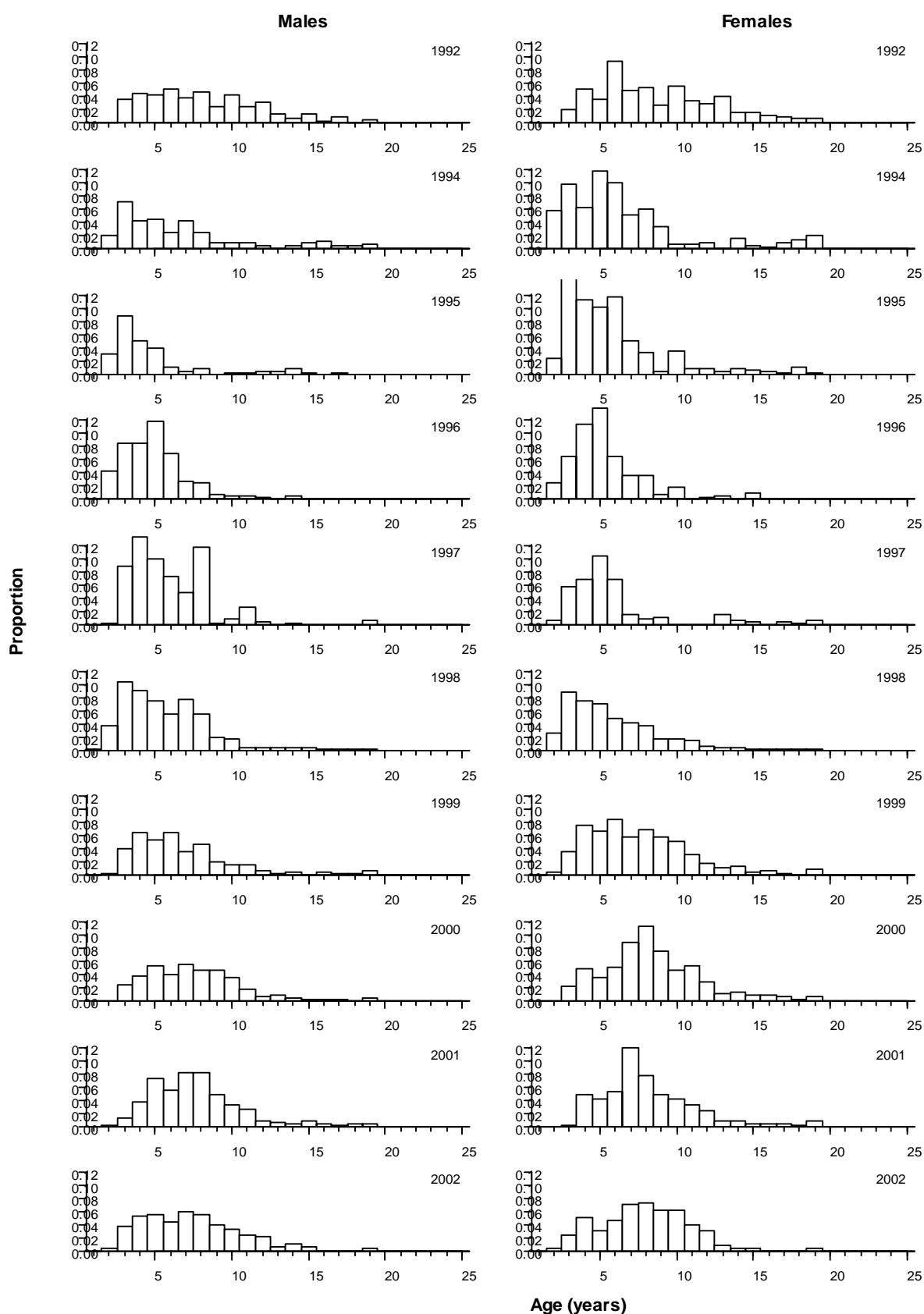
Figure A1: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2014. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., "2002" denotes the October 2001–April 2002 sample.

Males   **Females**

Age (years)

Proportion

Figure A1 ctd.

Males   **Females**
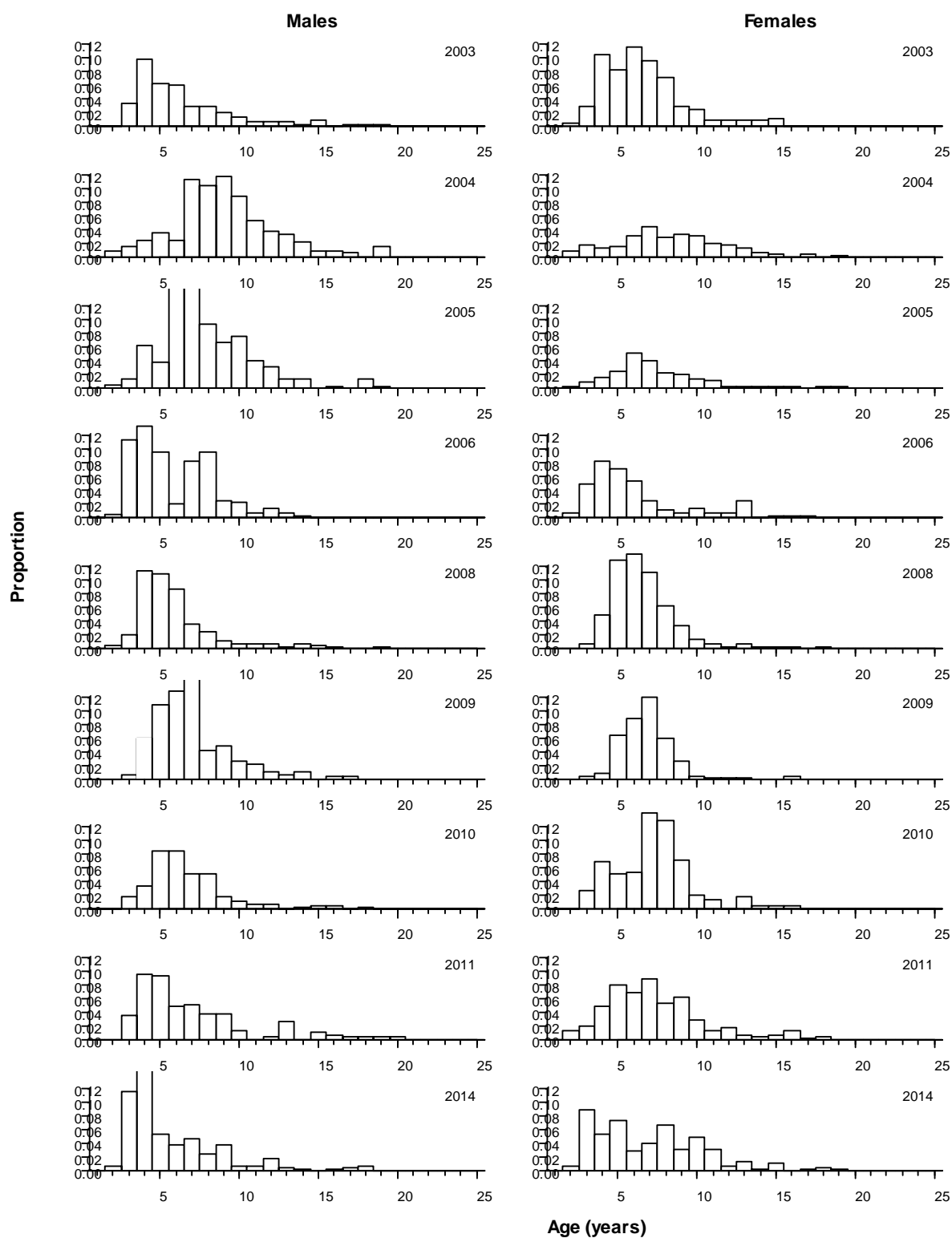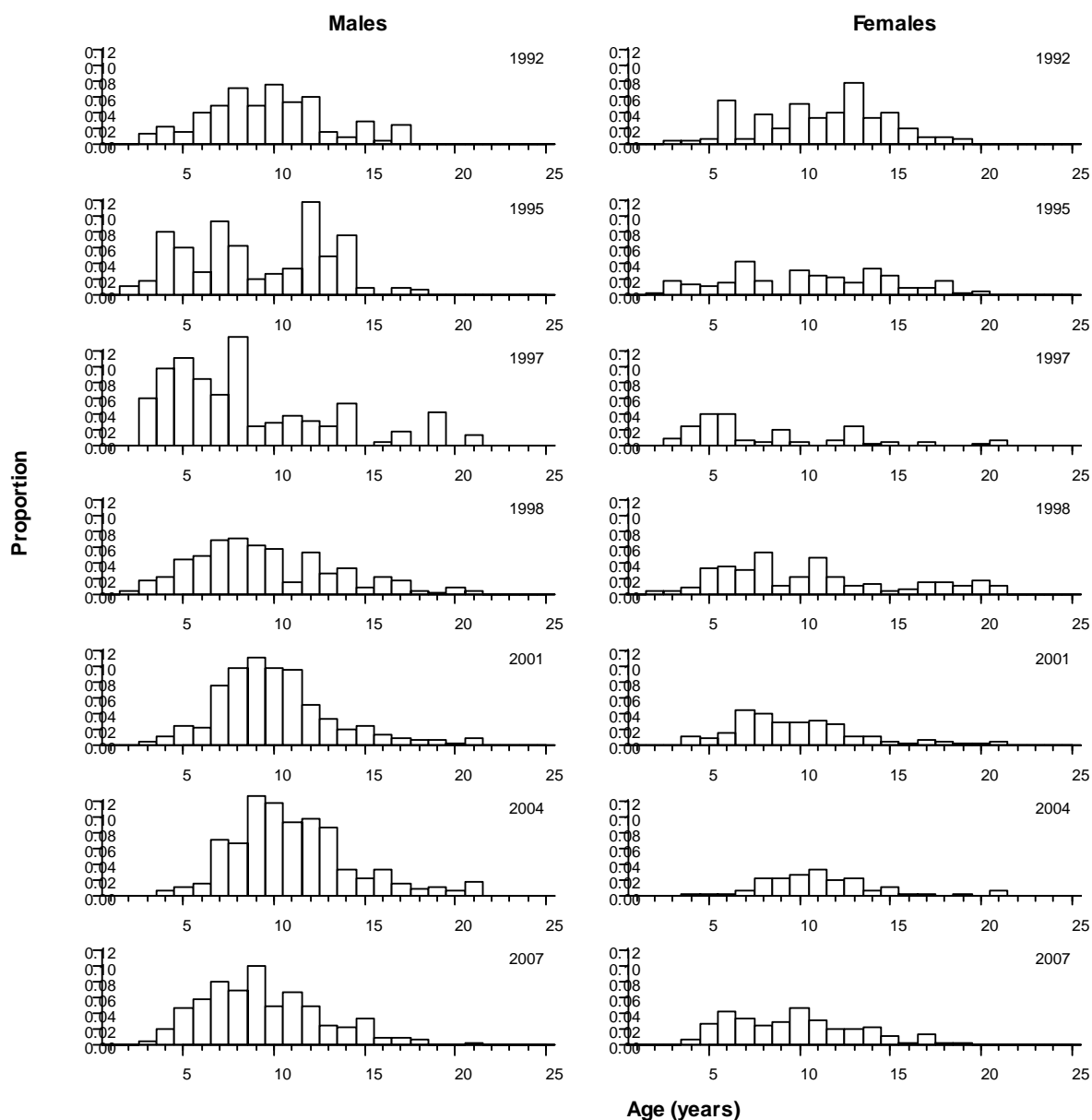
Figure A2: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2014. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., "1992" denotes the October 1991–April 1992 sample.
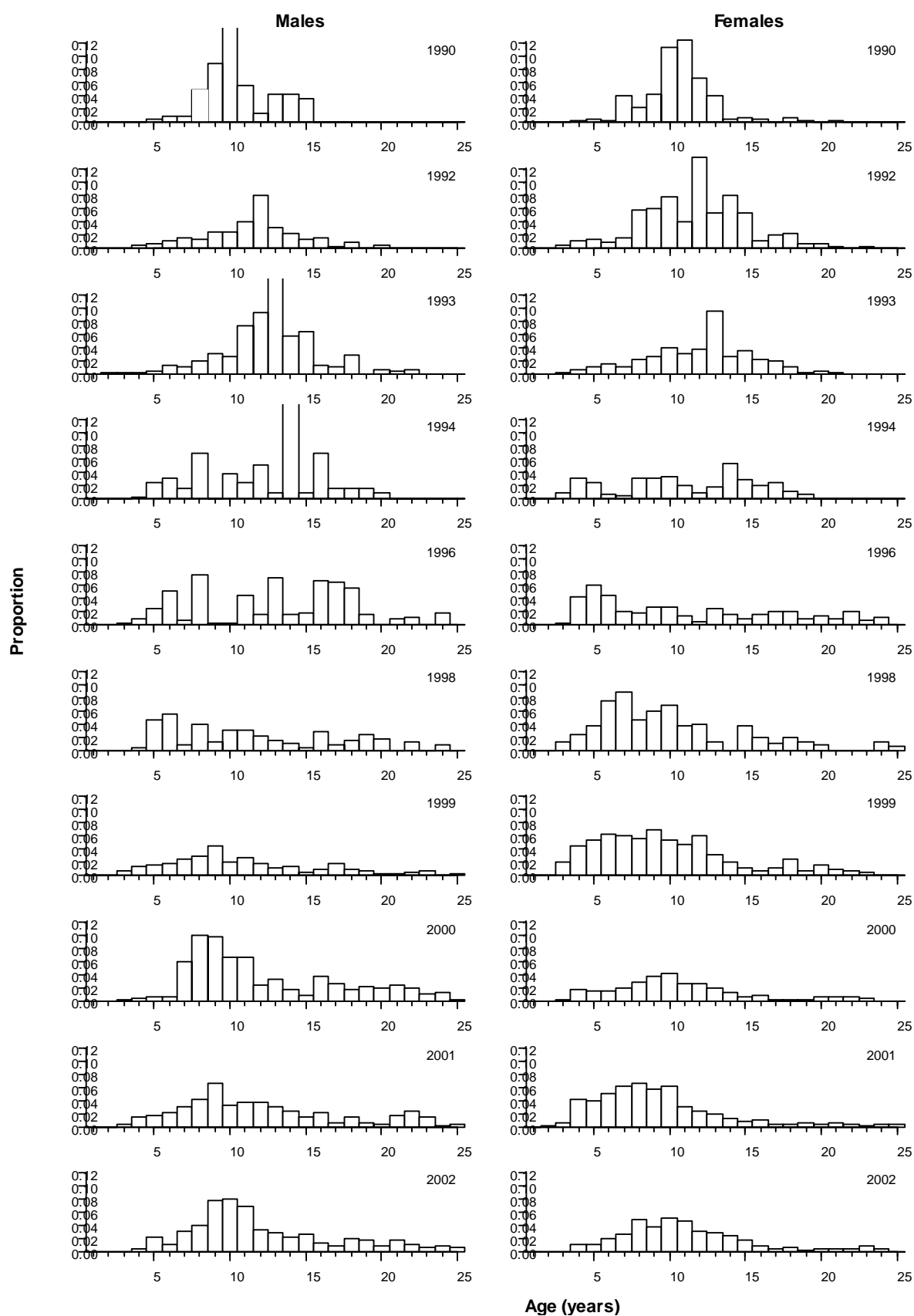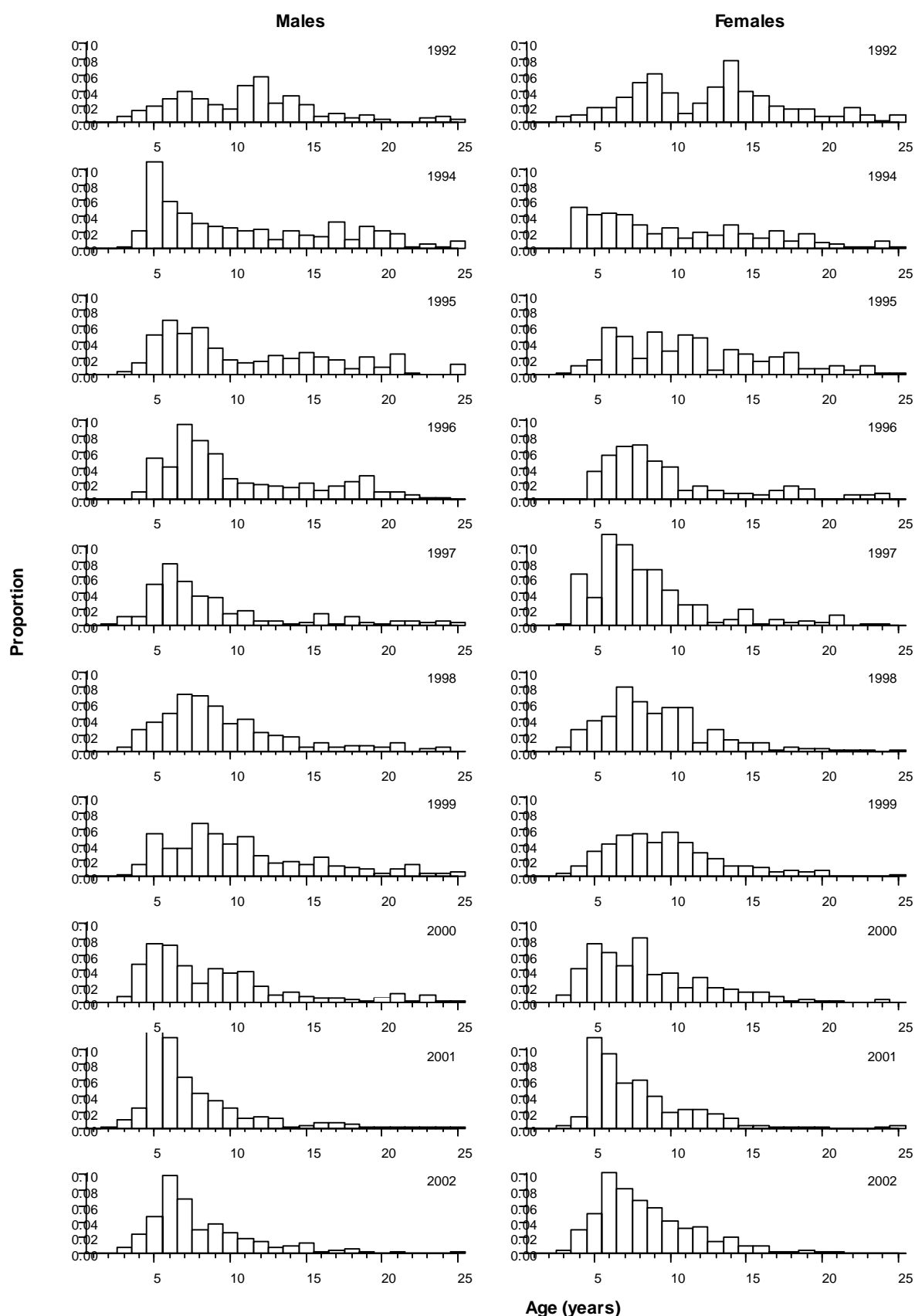
Figure A3: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2014. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., "2002" denotes the September 2001–May 2002 sample.

Figure A3 ctd.

Males 2013 2014 / **Females** 2013 2014

Proportion

Age (years)
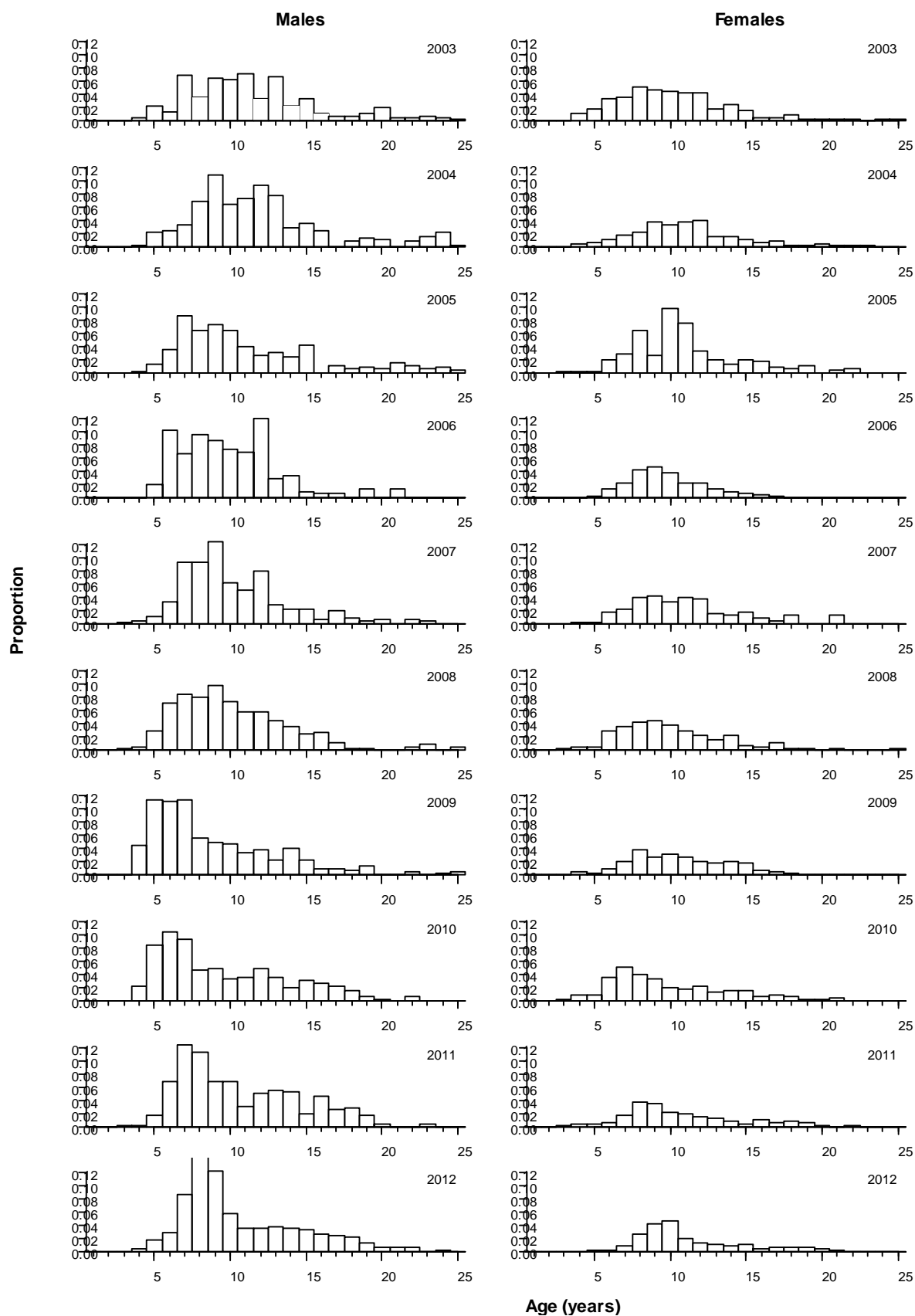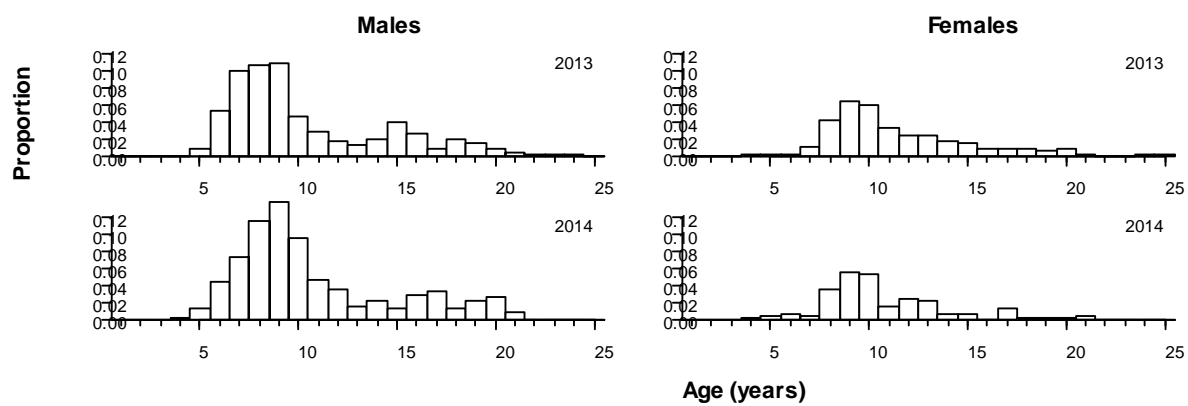
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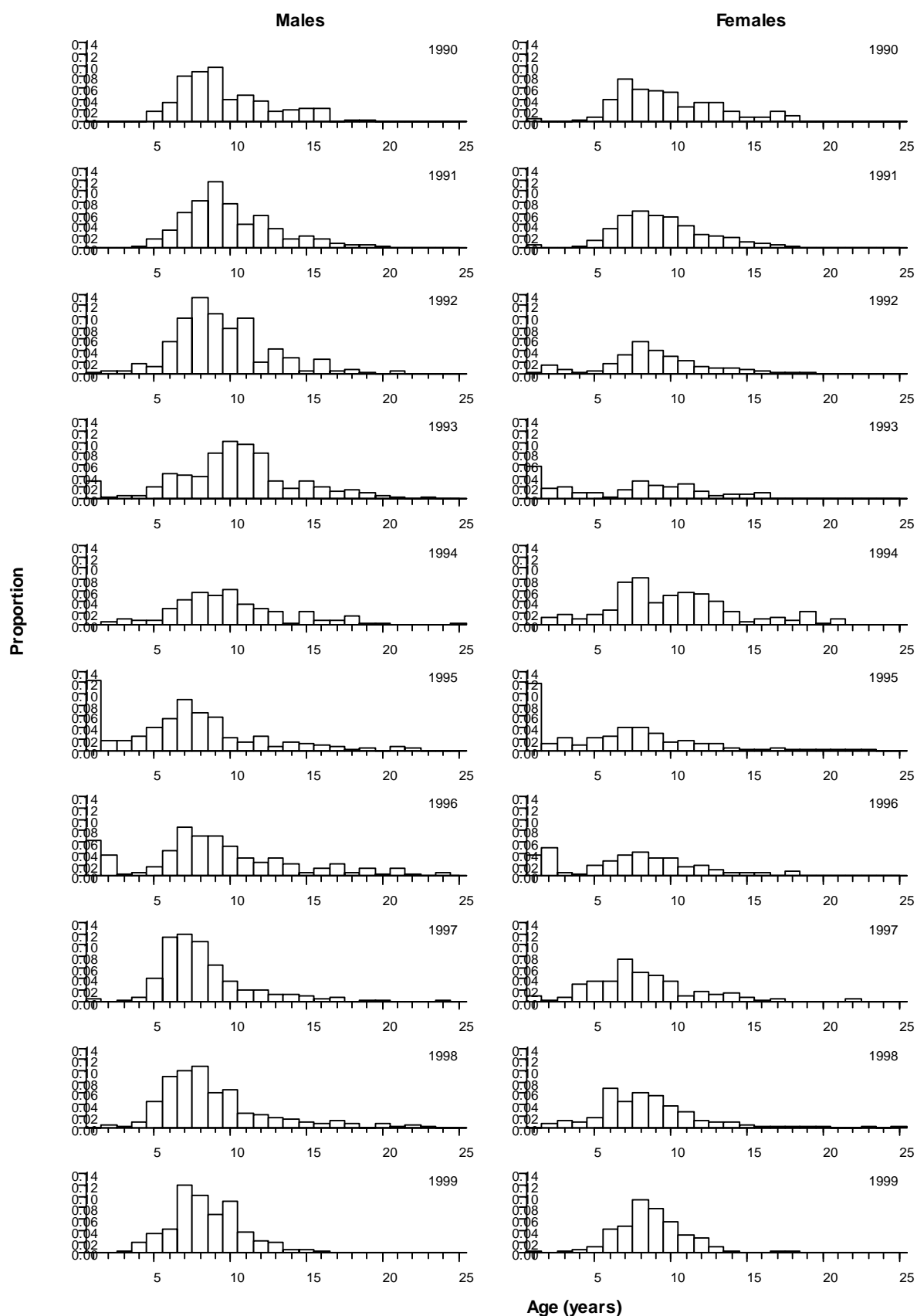
Figure A4: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2014.
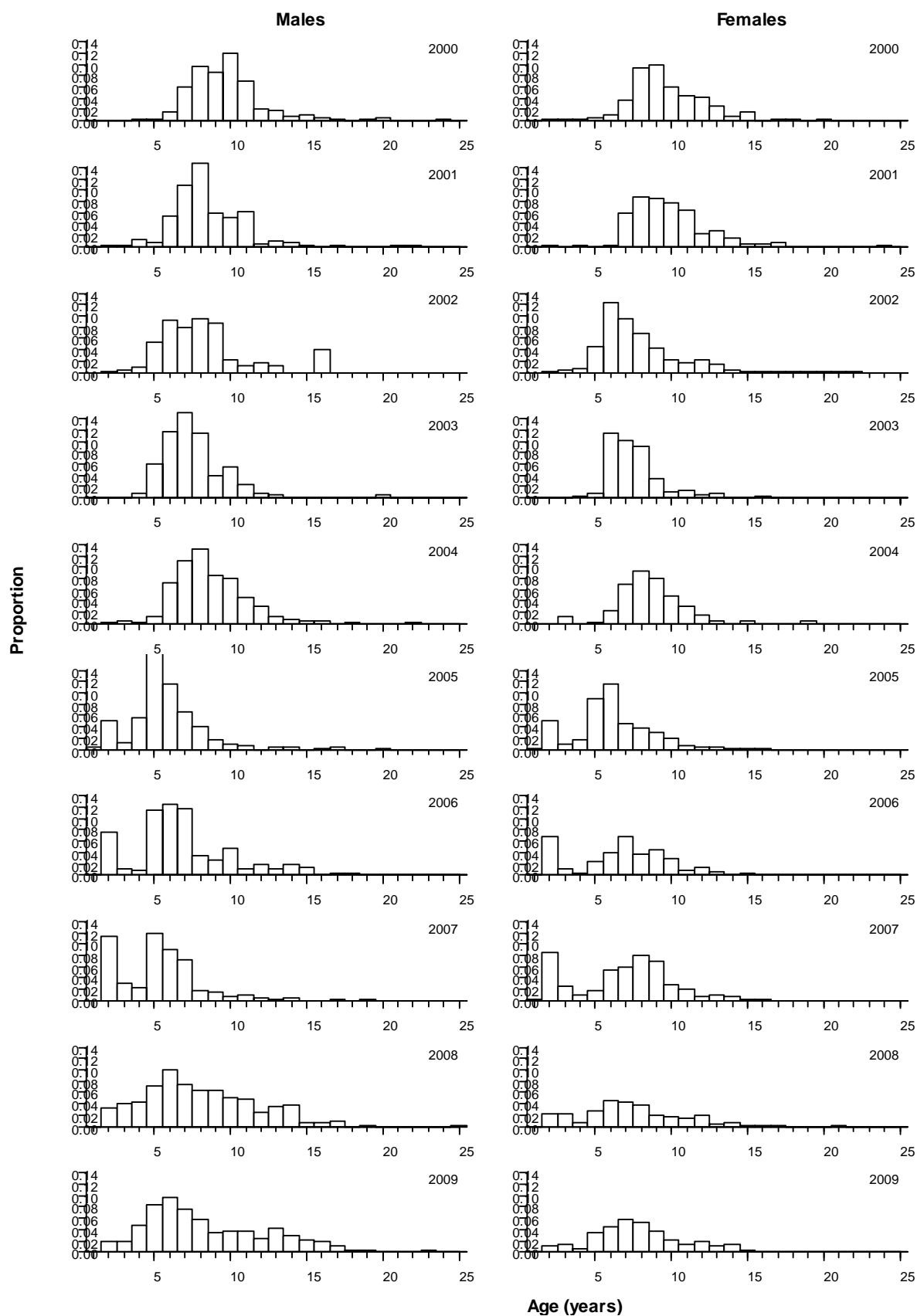
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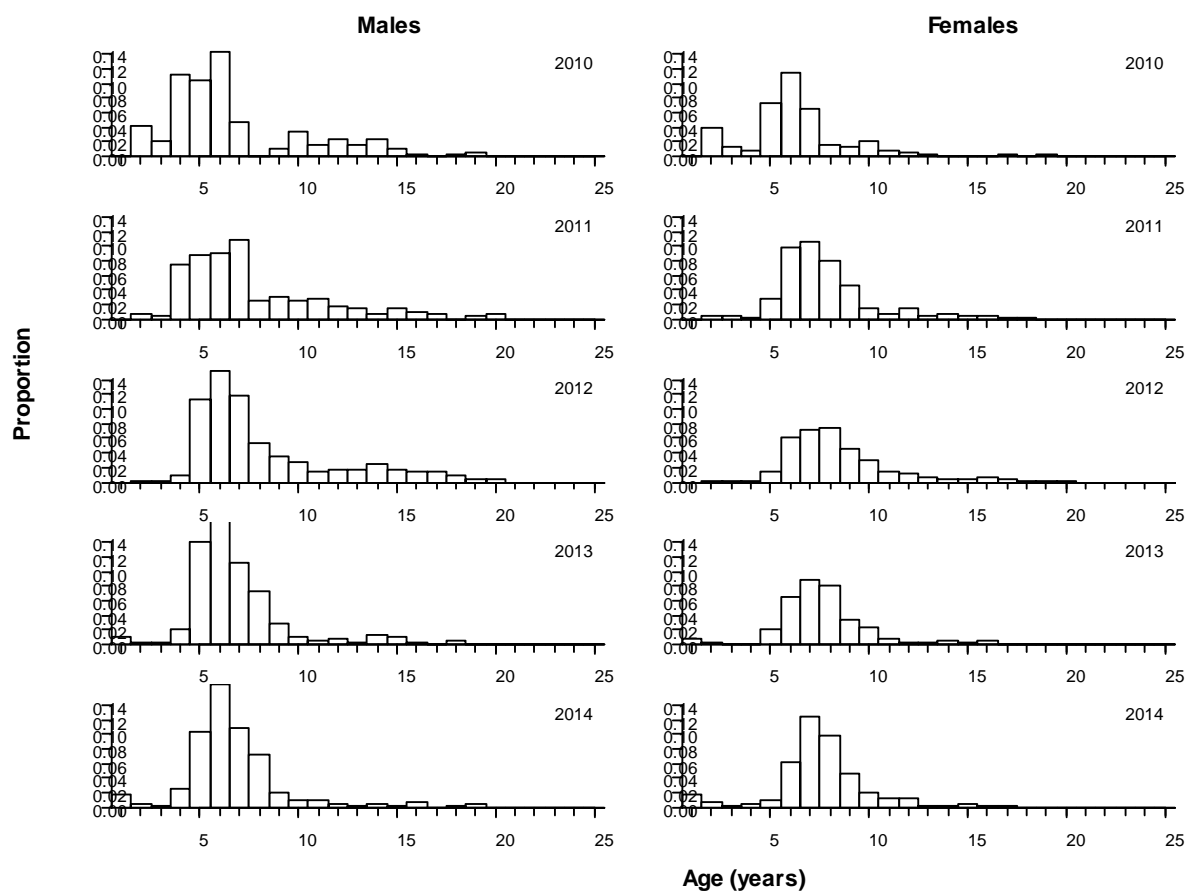
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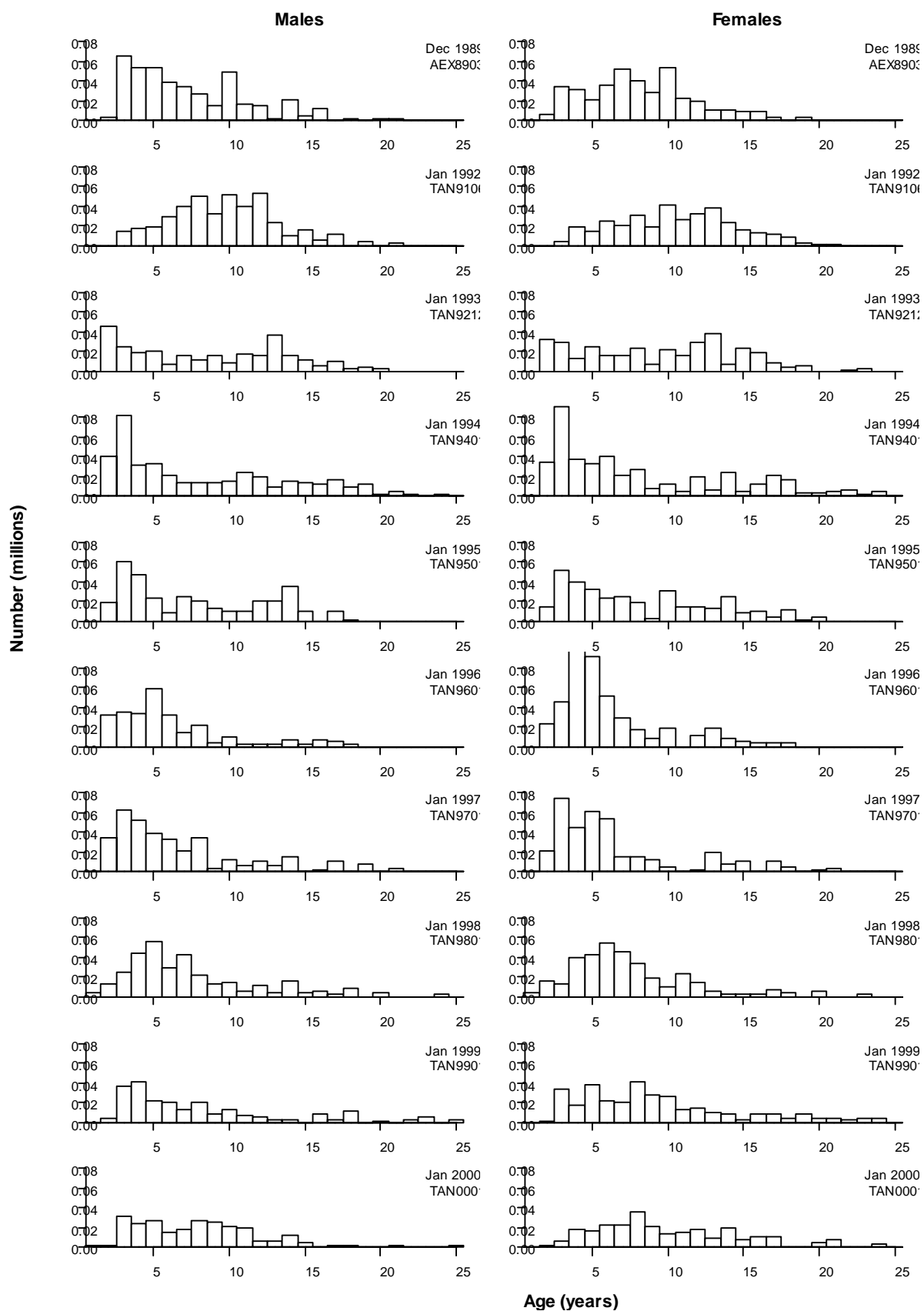
Figure A5: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2014–15.
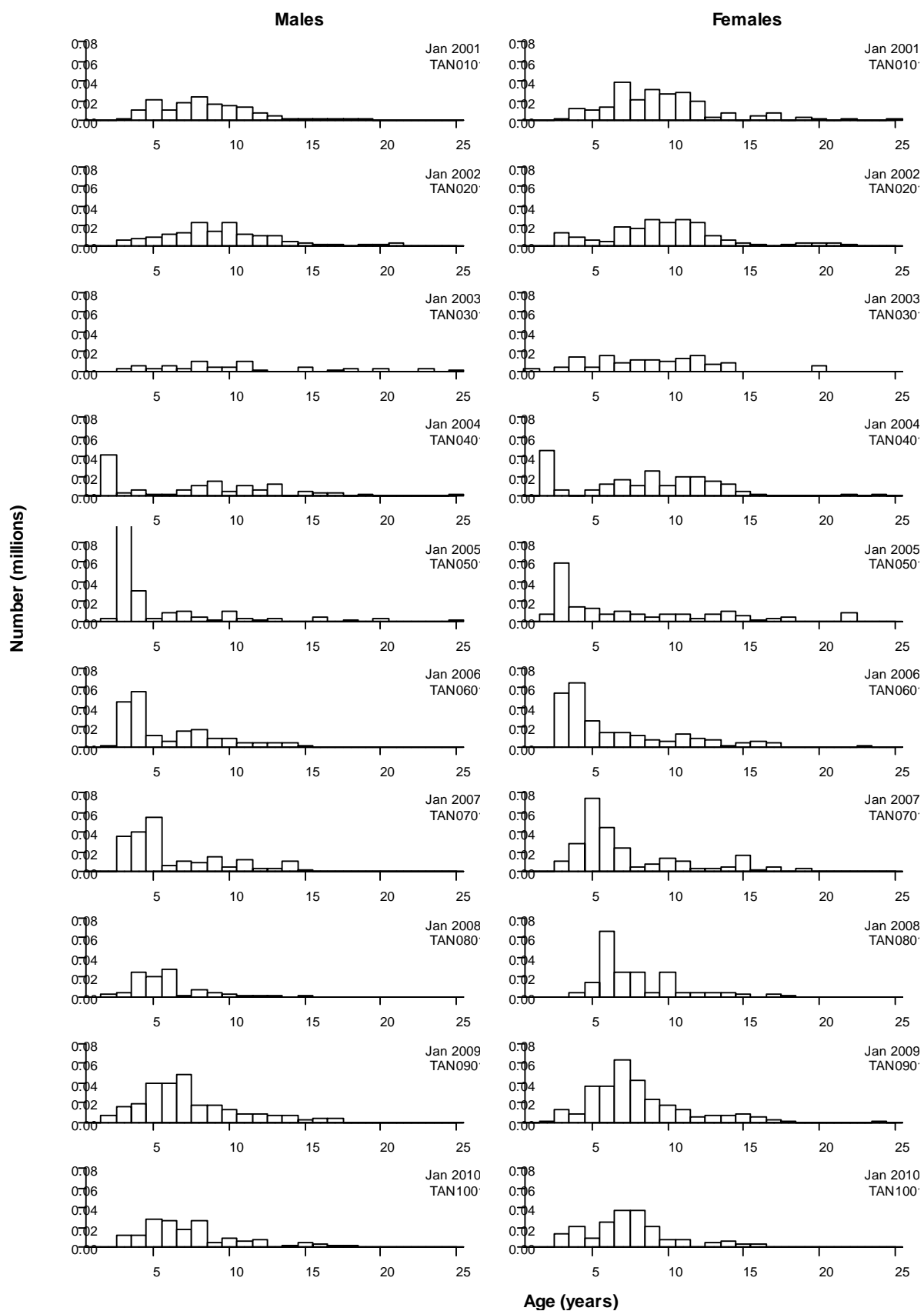
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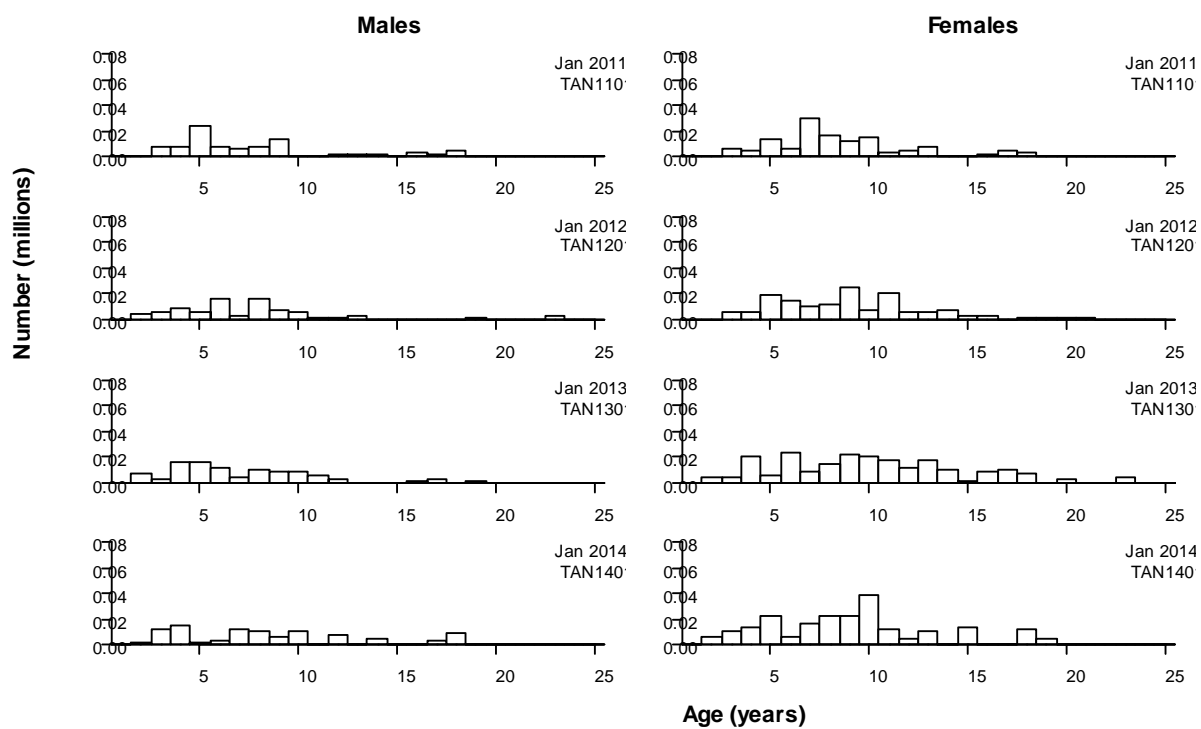
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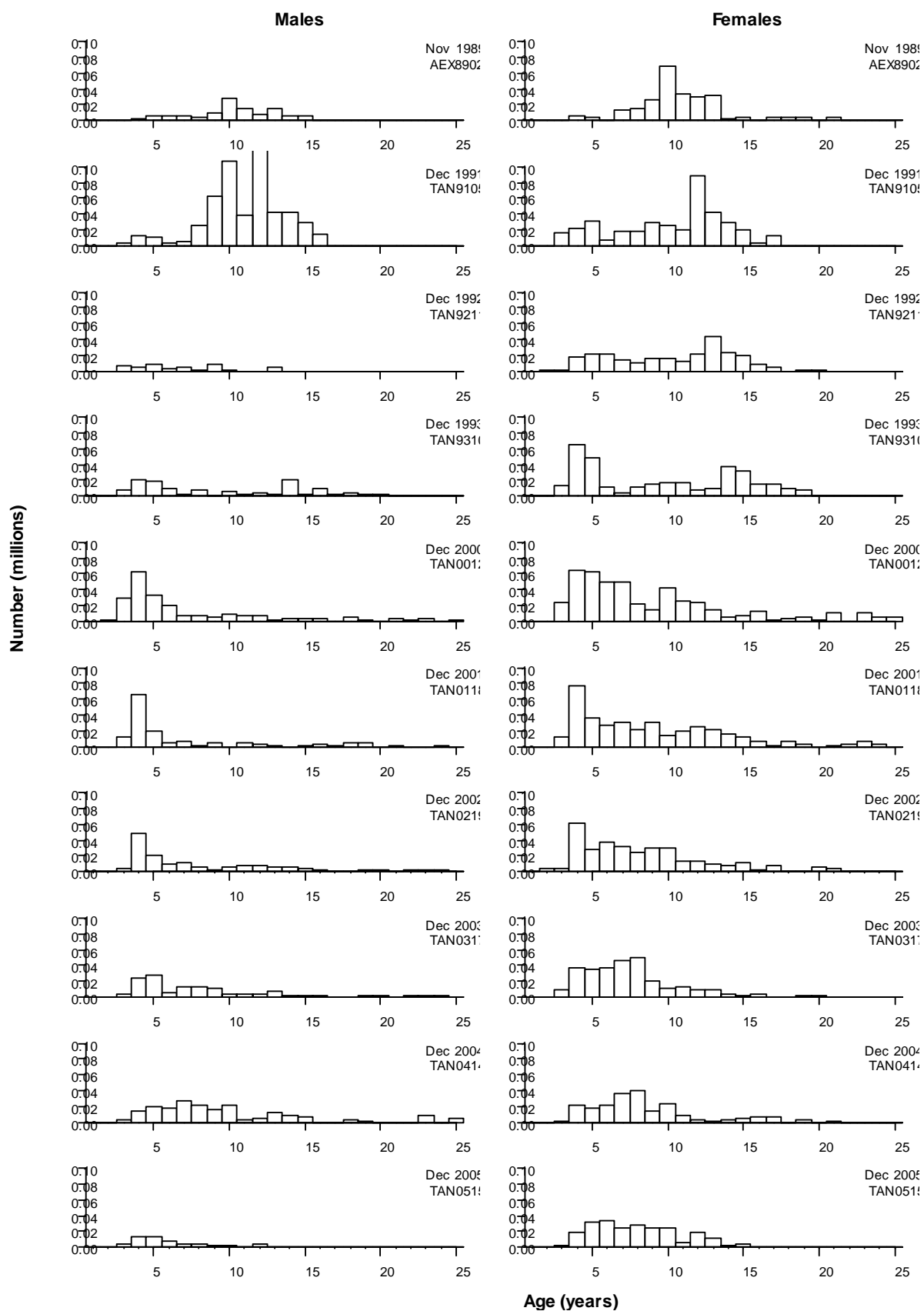
Figure A6: Available age frequencies of hake (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2014.

Males   **Females**

Number (millions)

Age (years)
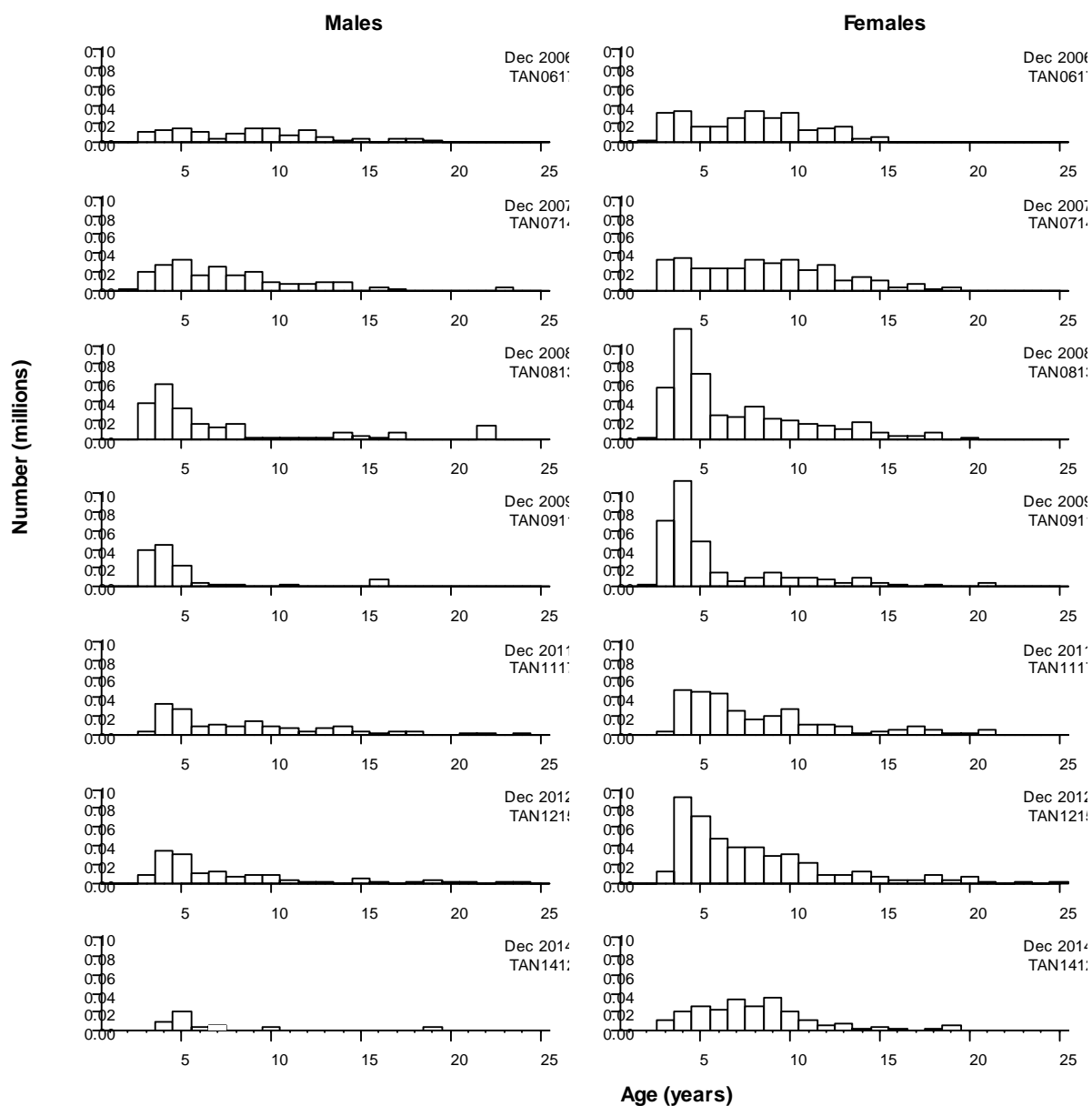
Figure A6 ctd.
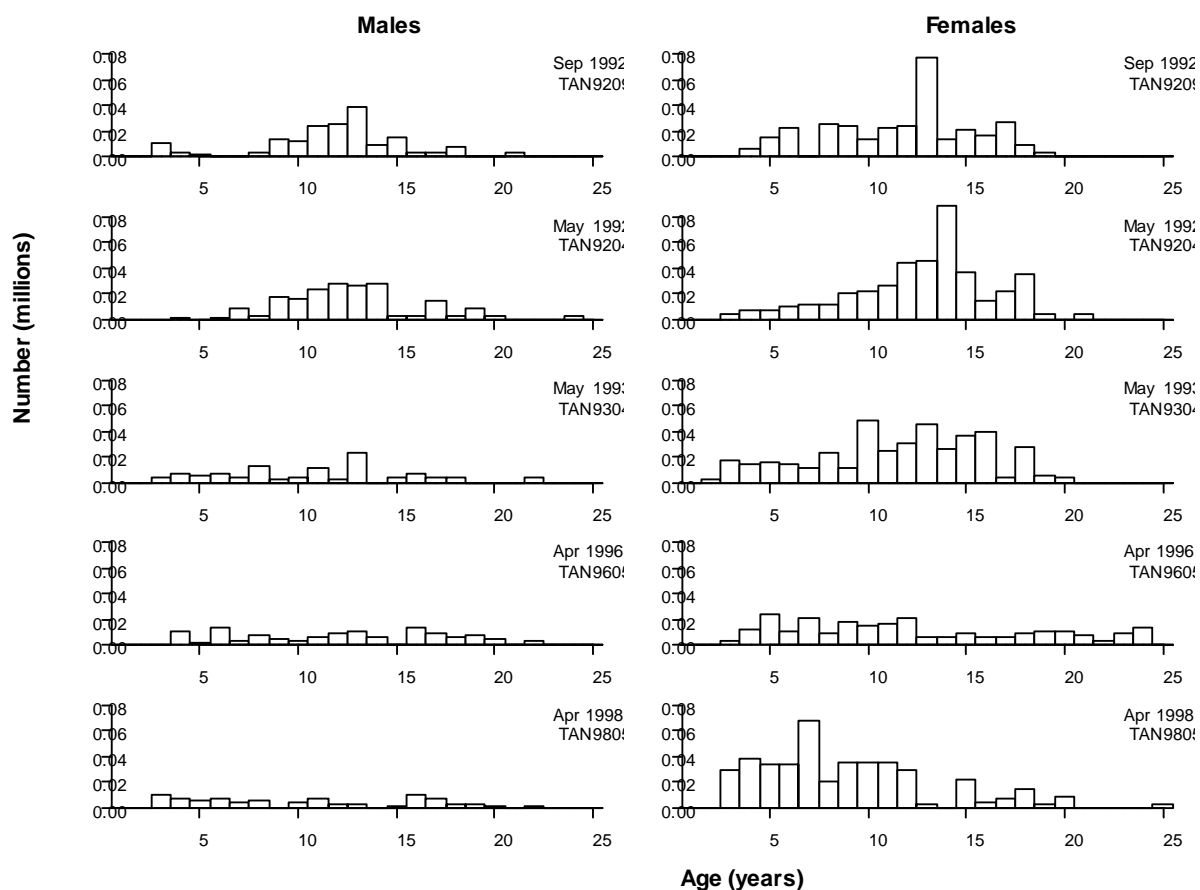
Figure A7: Available age frequencies of hake (ages 1 to 25) from spring and autumn resource surveys in the Sub-Antarctic, 1992 to 1998.
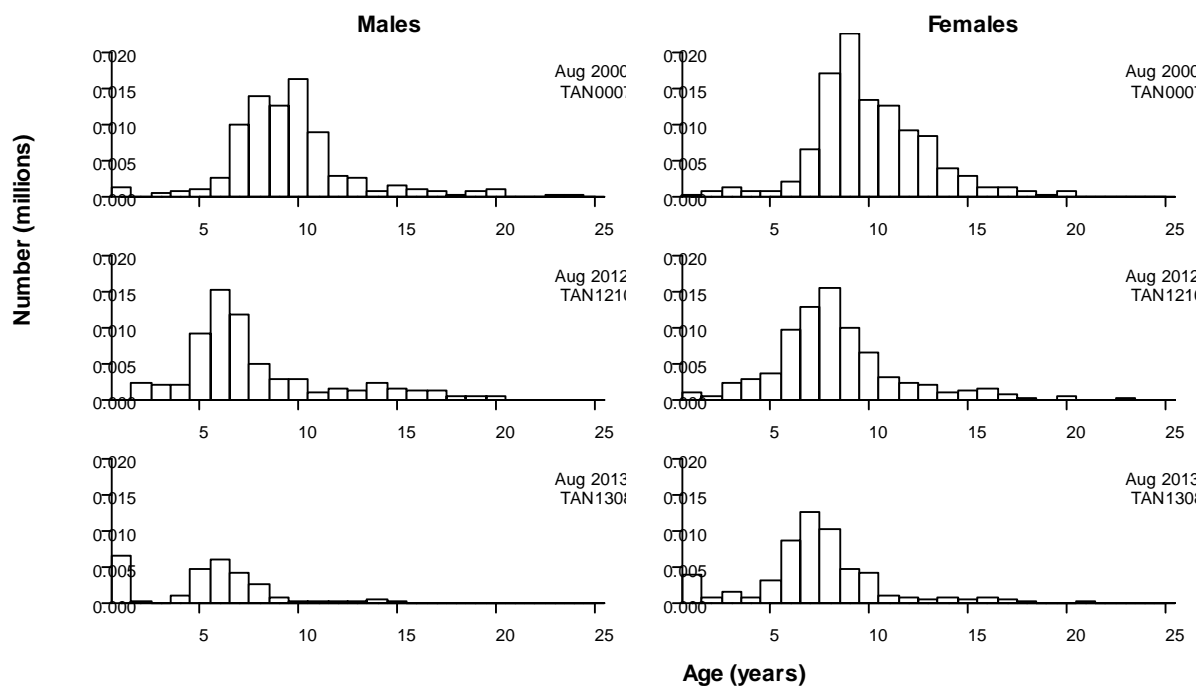
Figure A8: Available age frequencies of hake (ages 1 to 25) from resource surveys off WCSI, from 2000 to 2014.

Appendix B: Summaries of the proportions-at-age data for ling
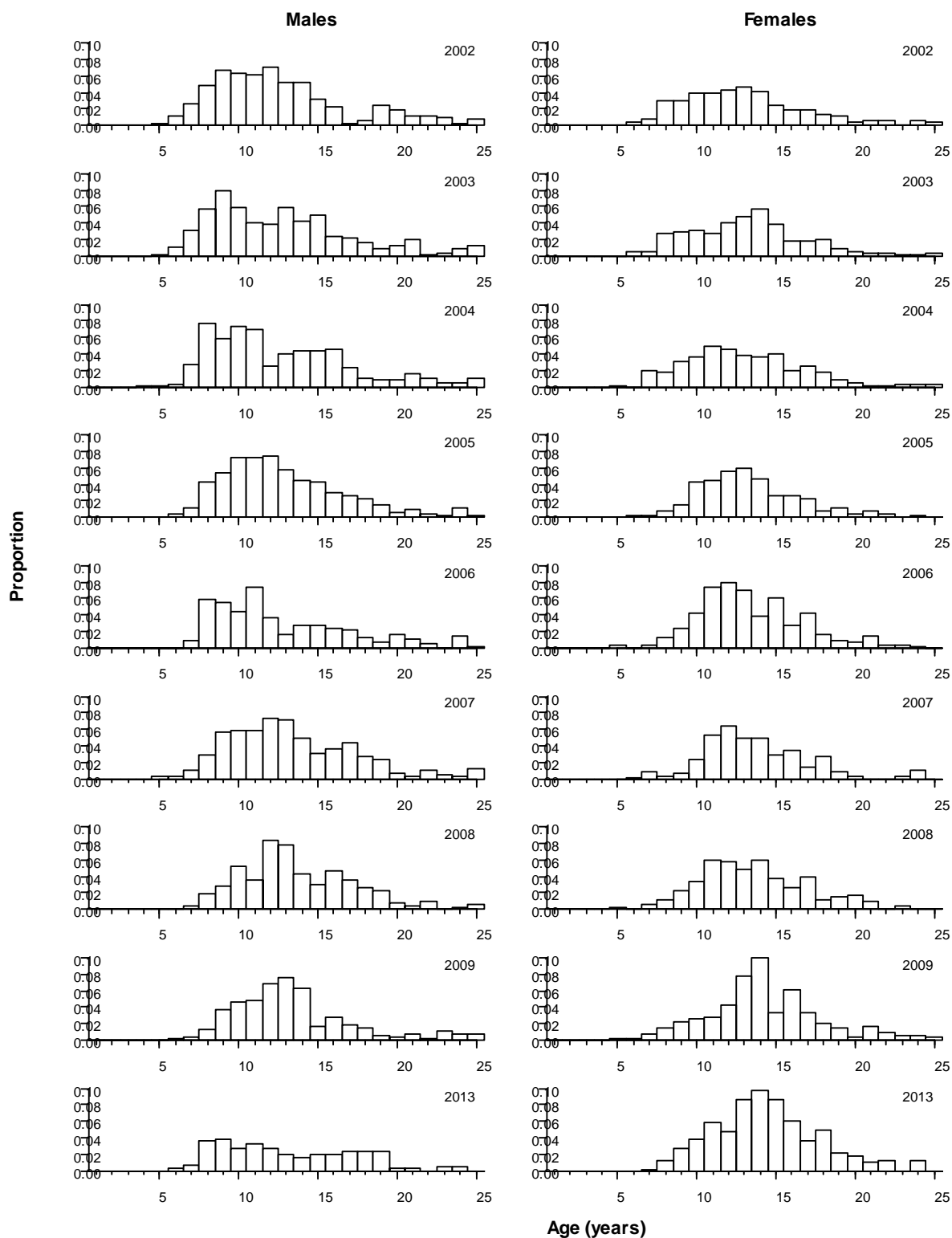
Figure B1: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2014.
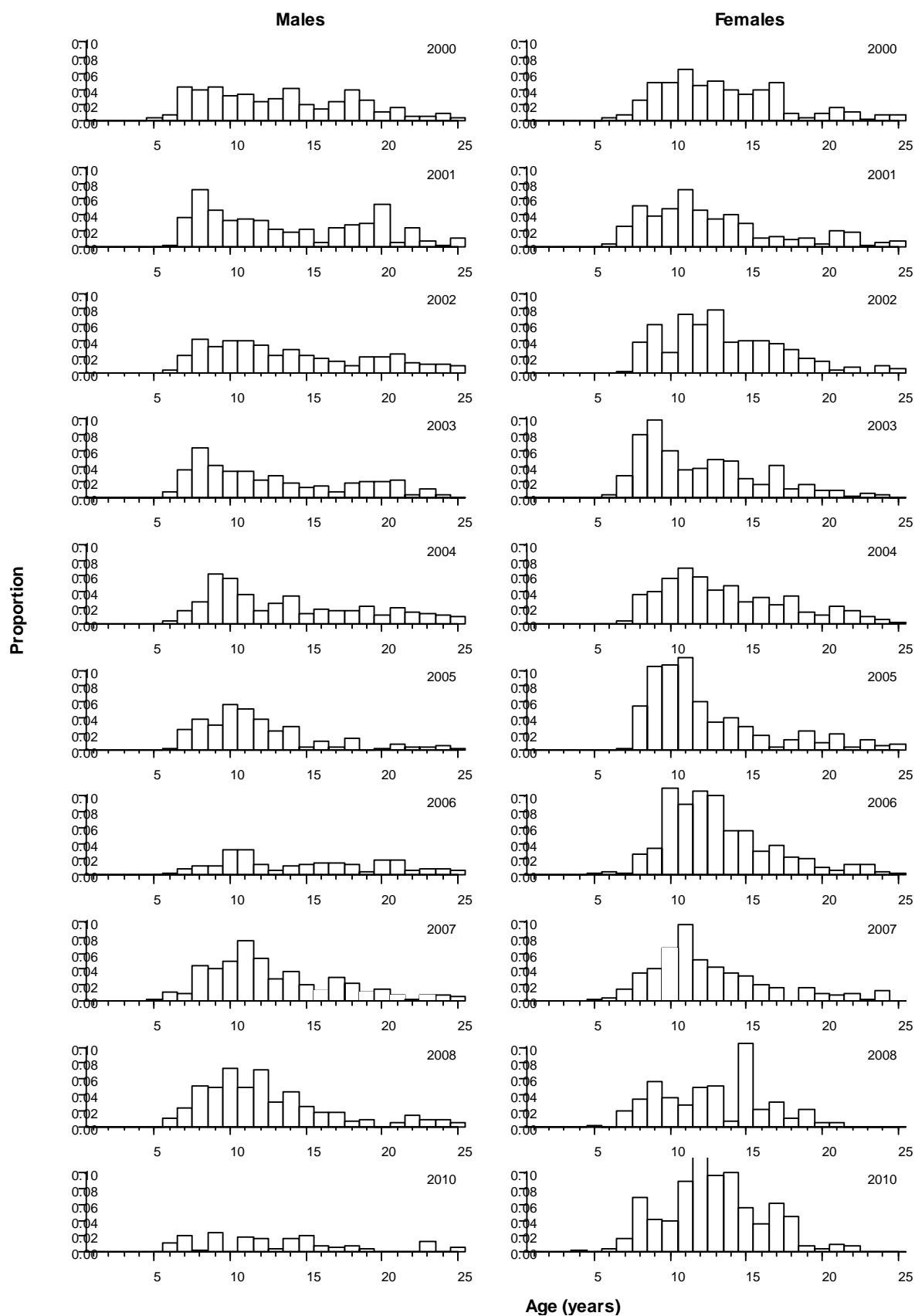
Figure B2: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2014.
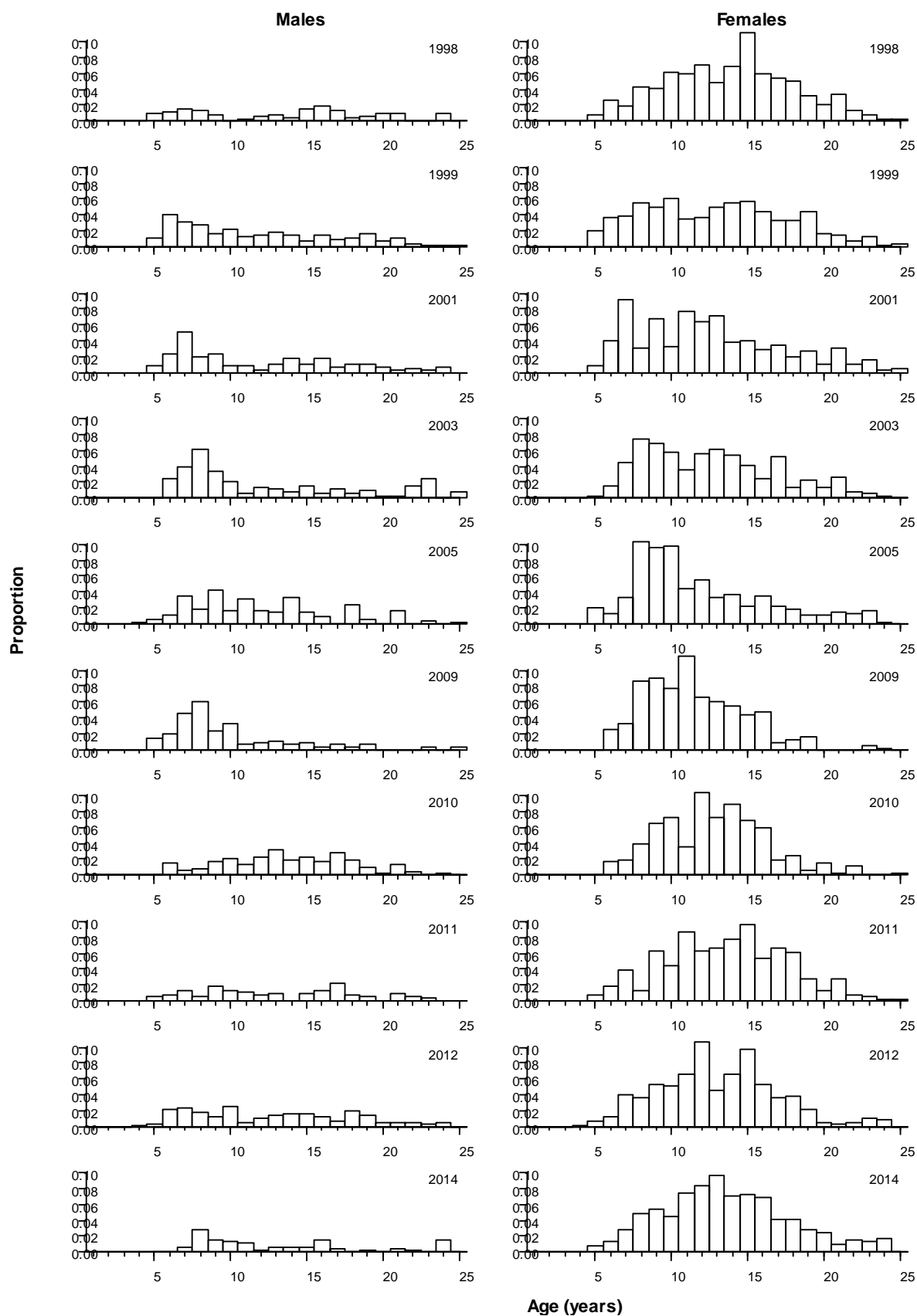
Figure B3: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2014.
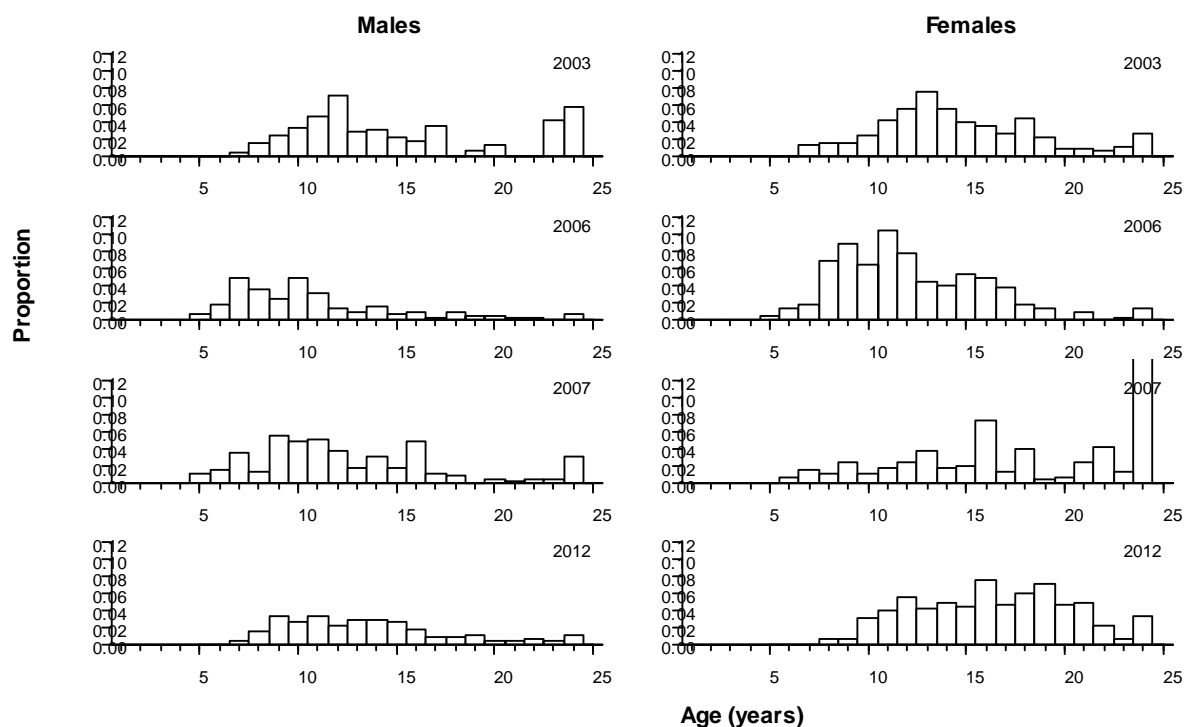
Figure B4: Available age frequencies of ling from commercial catch-at-age data in the west coast South Island line fishery, 2003 to 2014.
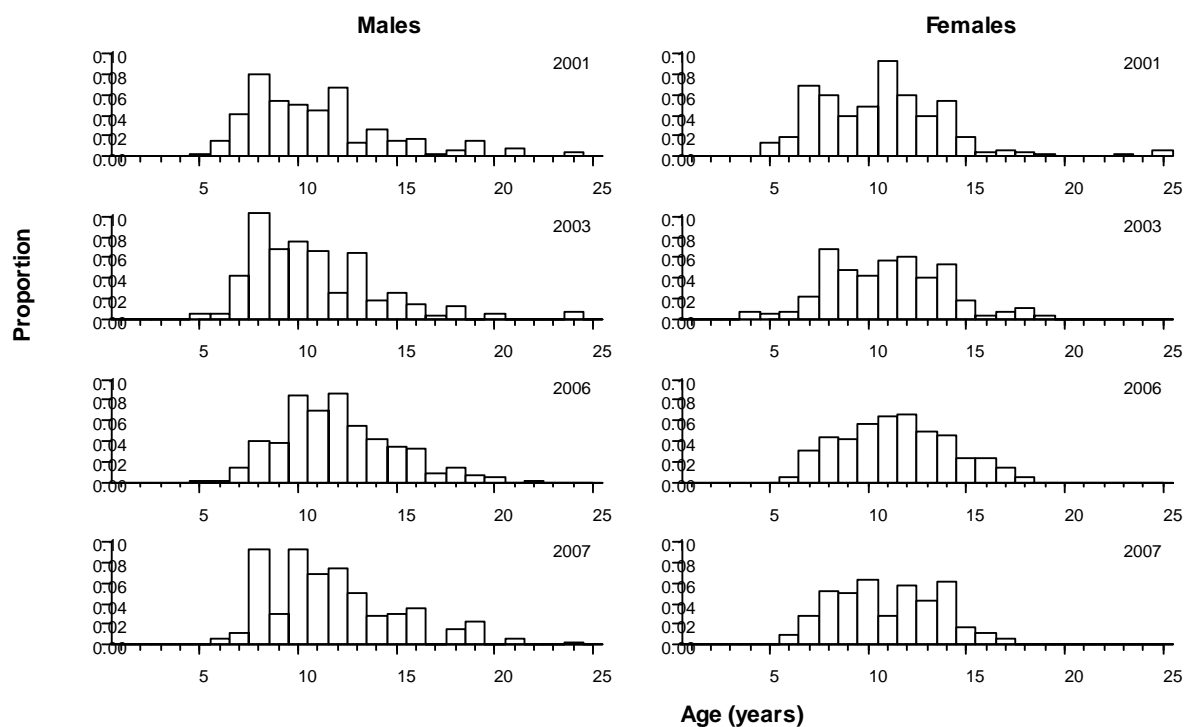
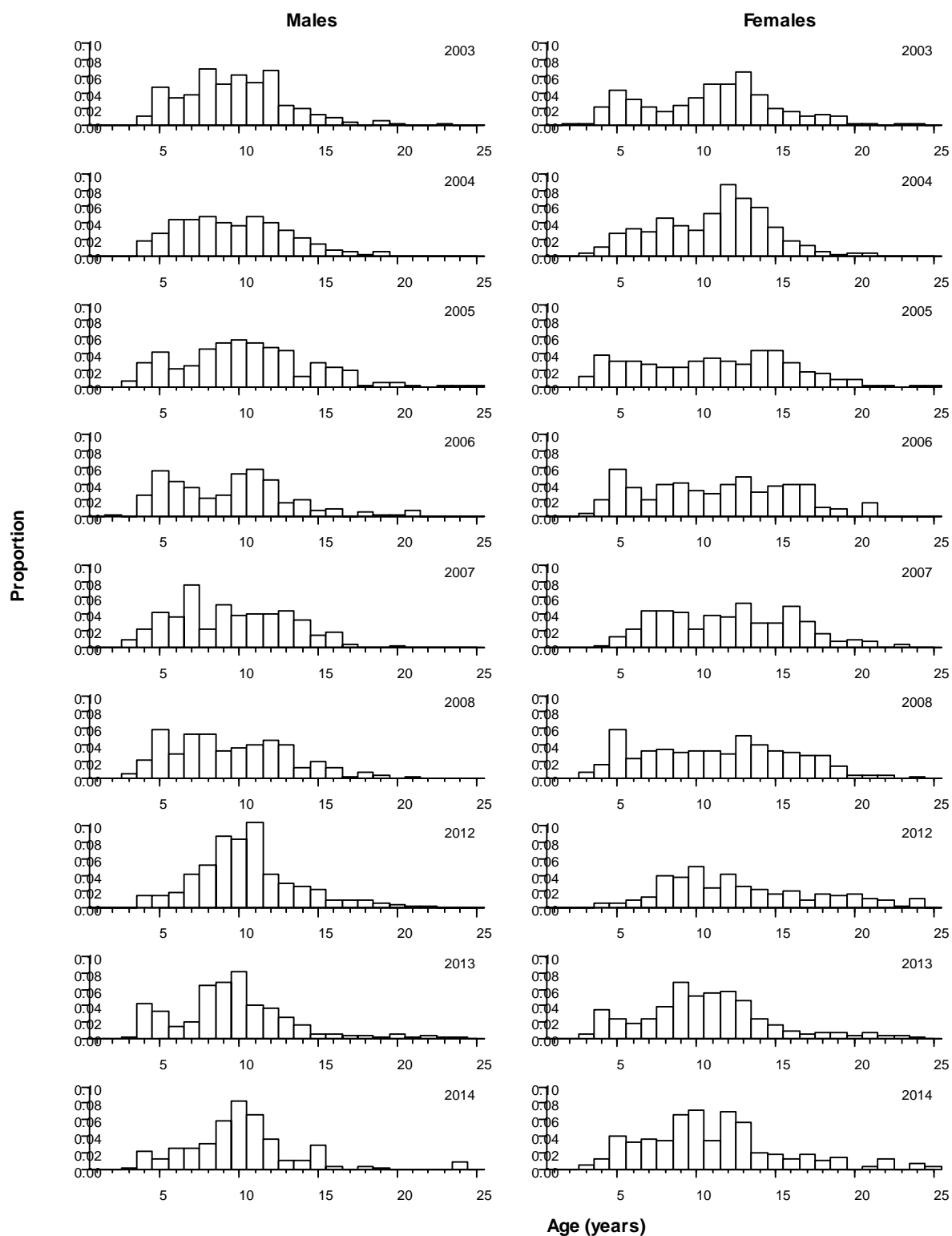**Figure B5: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2001 to 2014.**
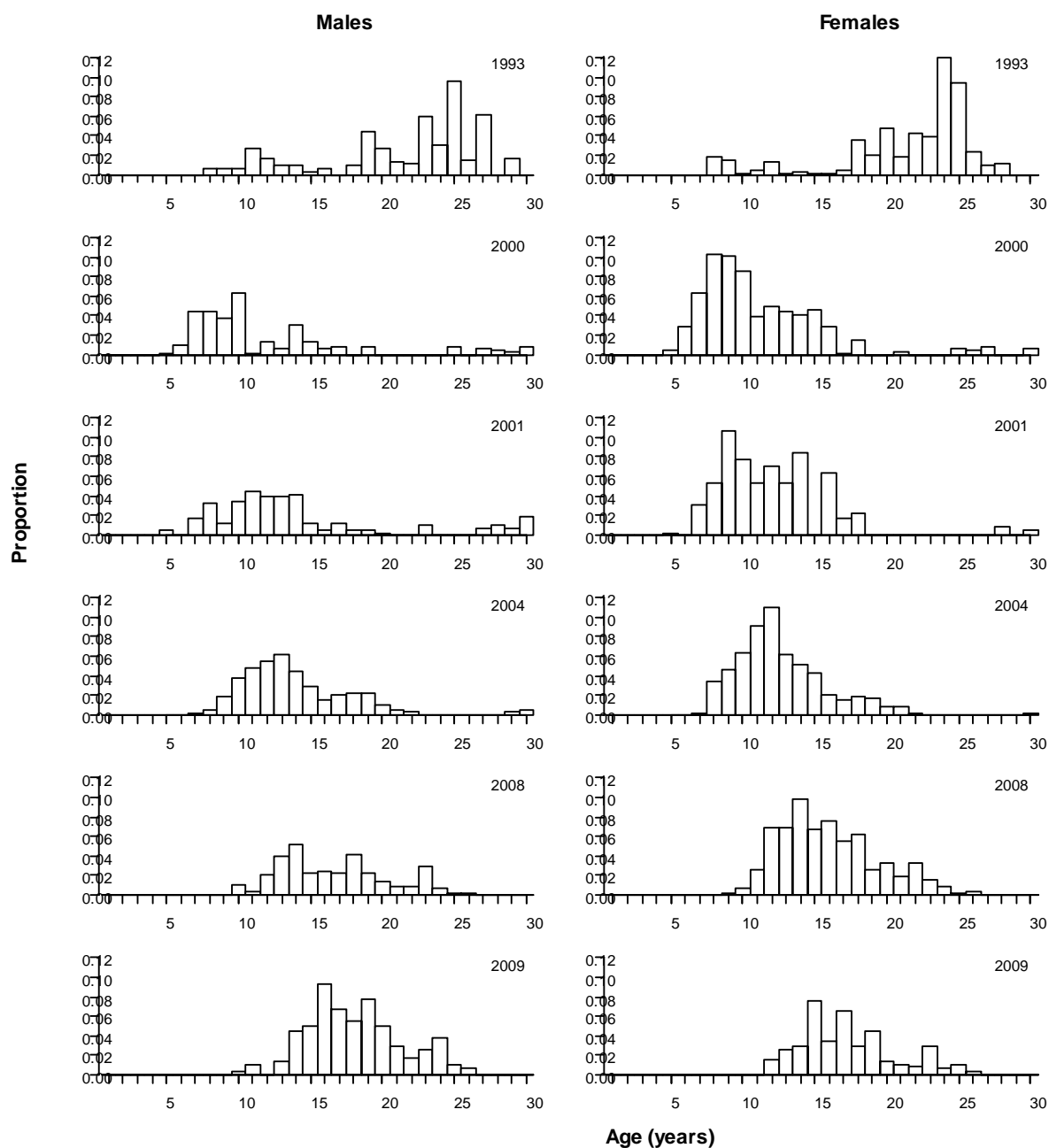
Figure B6: Available age frequencies of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2014.

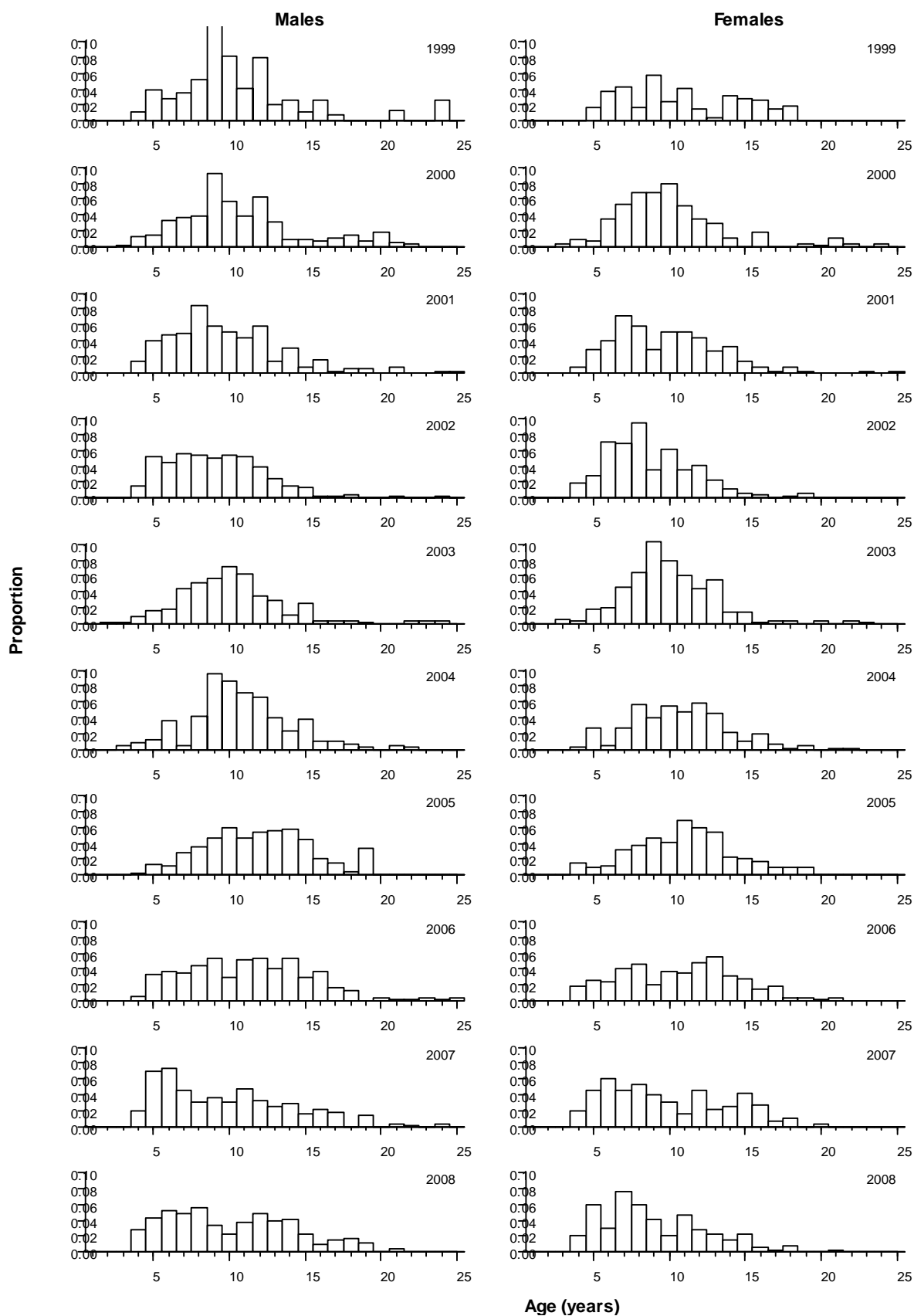**Figure B7: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2014. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., "2002" denotes the October 2001–May 2002 sample.**

Males   **Females**

Figure B7 ctd.

Age (years)
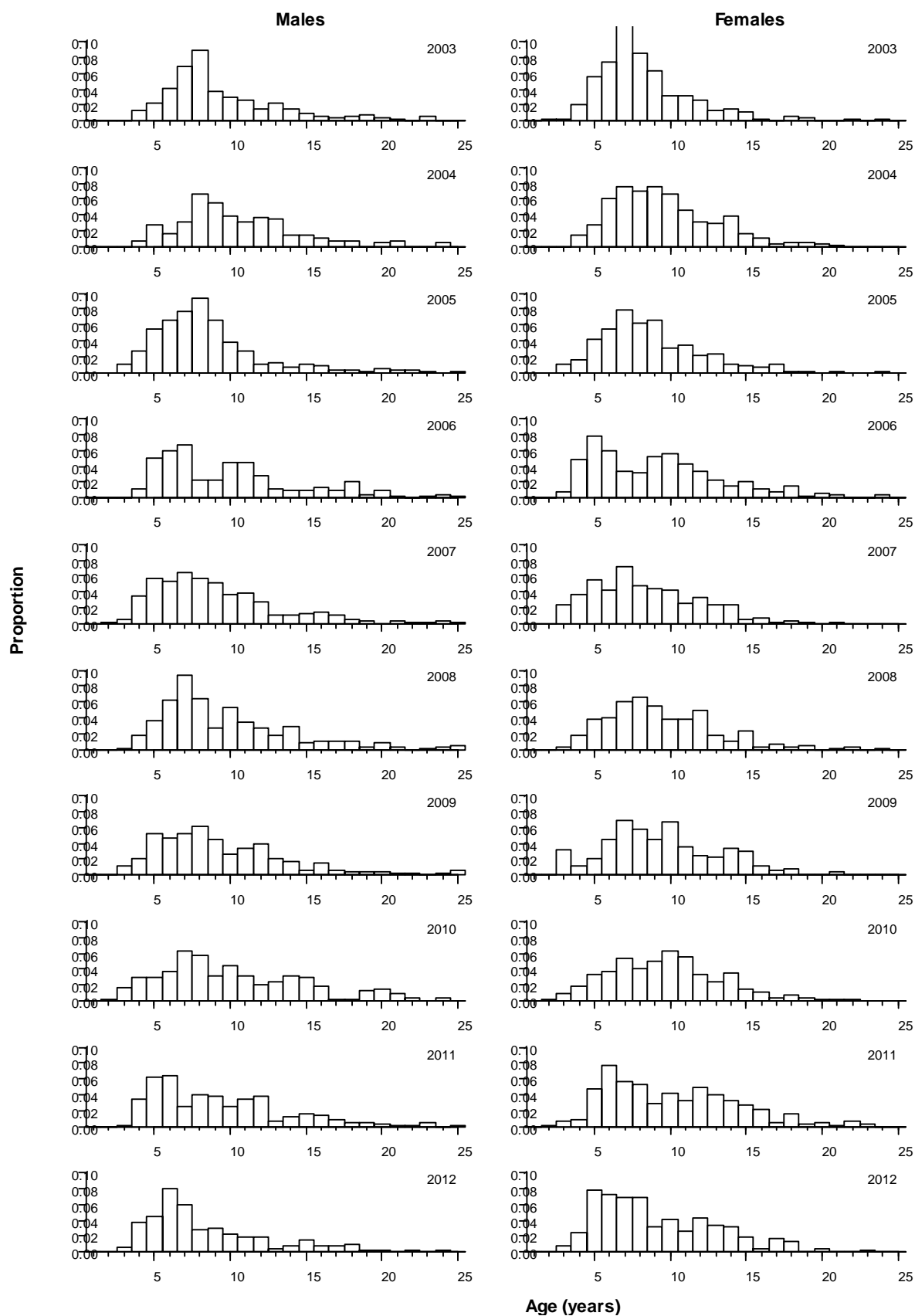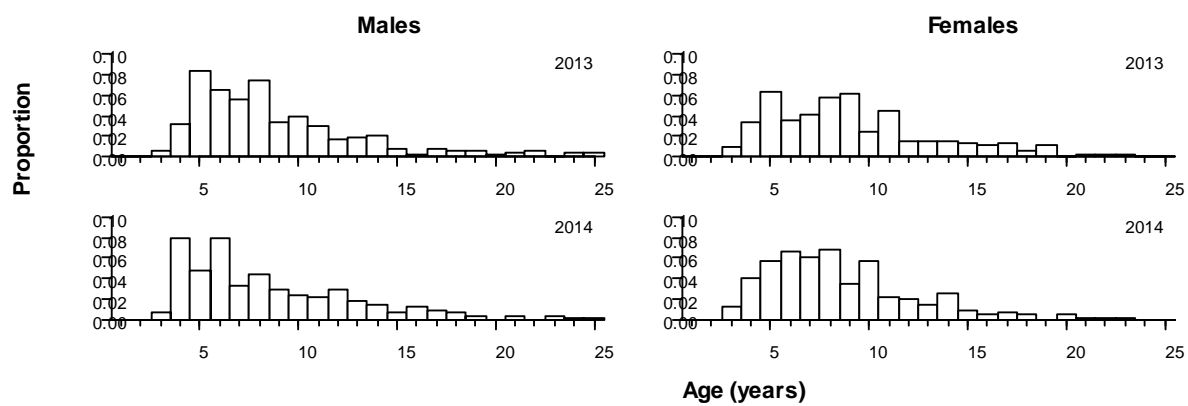
Figure B7 ctd.
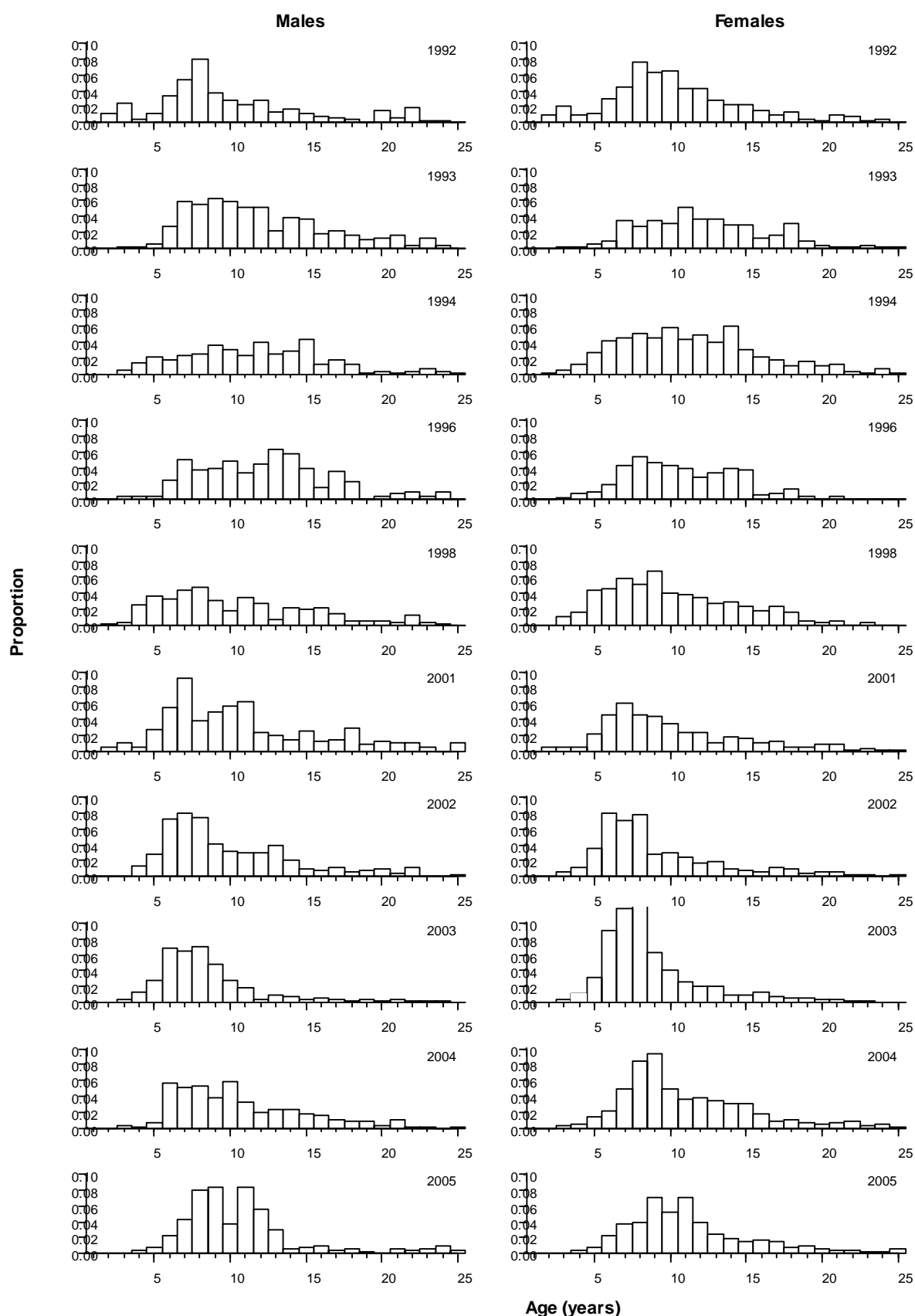
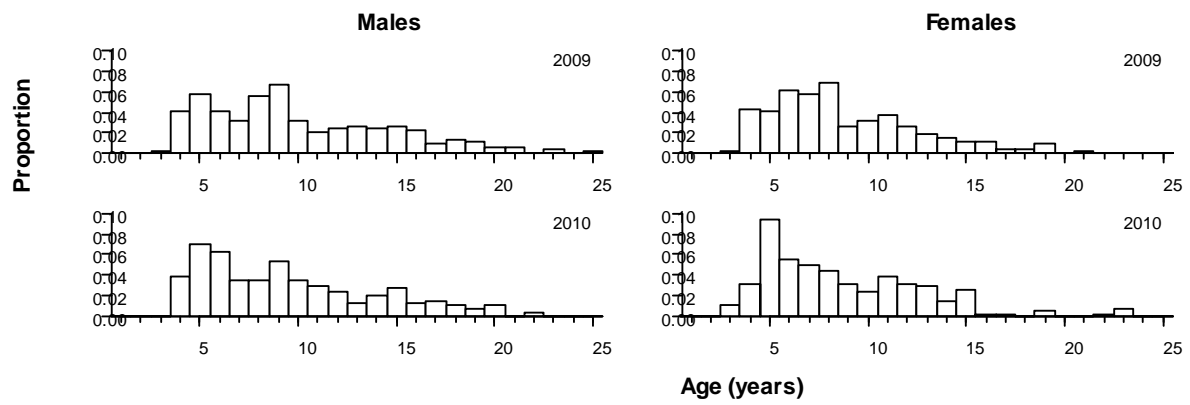**Figure B8: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2014. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., "2005" denotes the September 2004–April 2005 sample.**
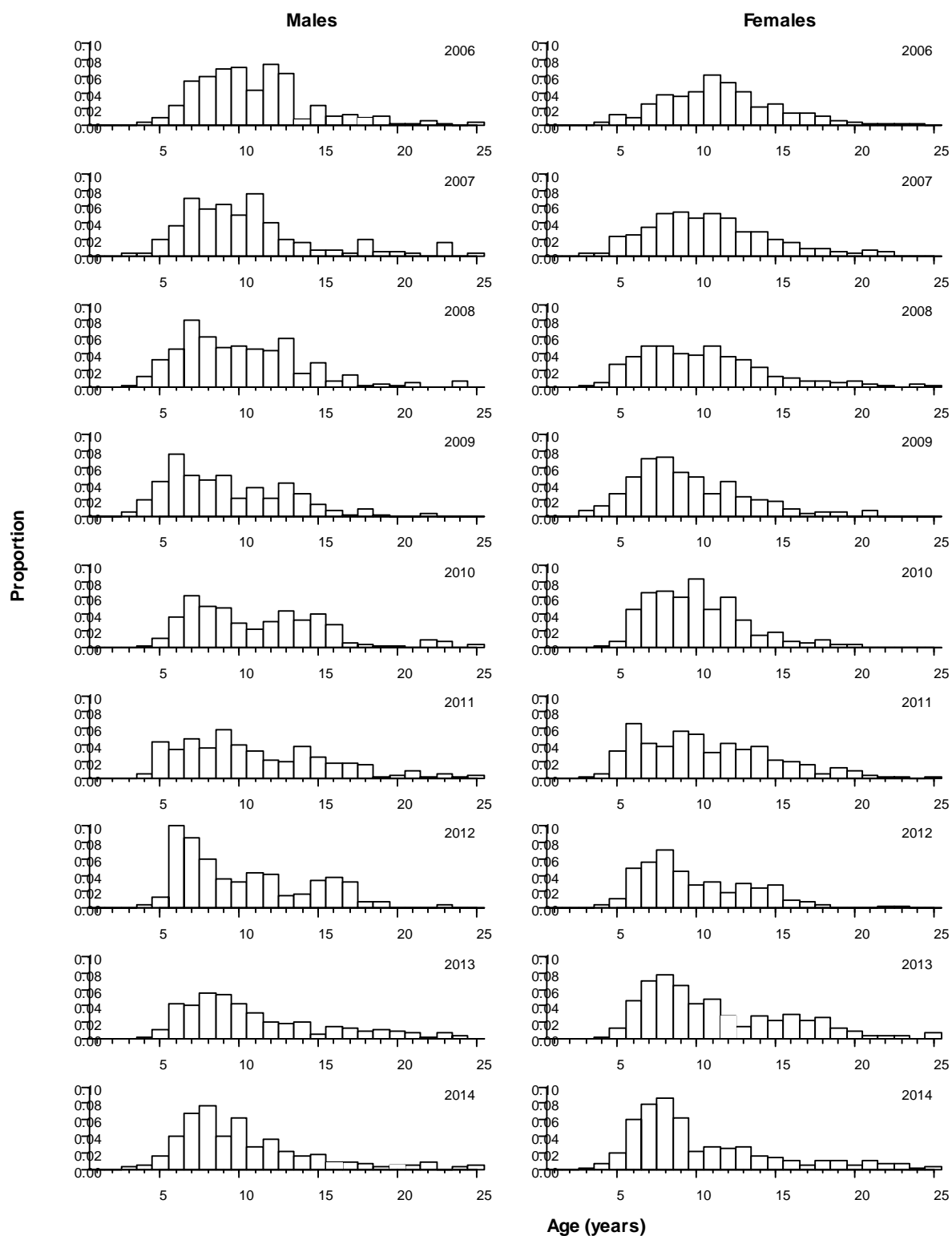
Figure B8 ctd.
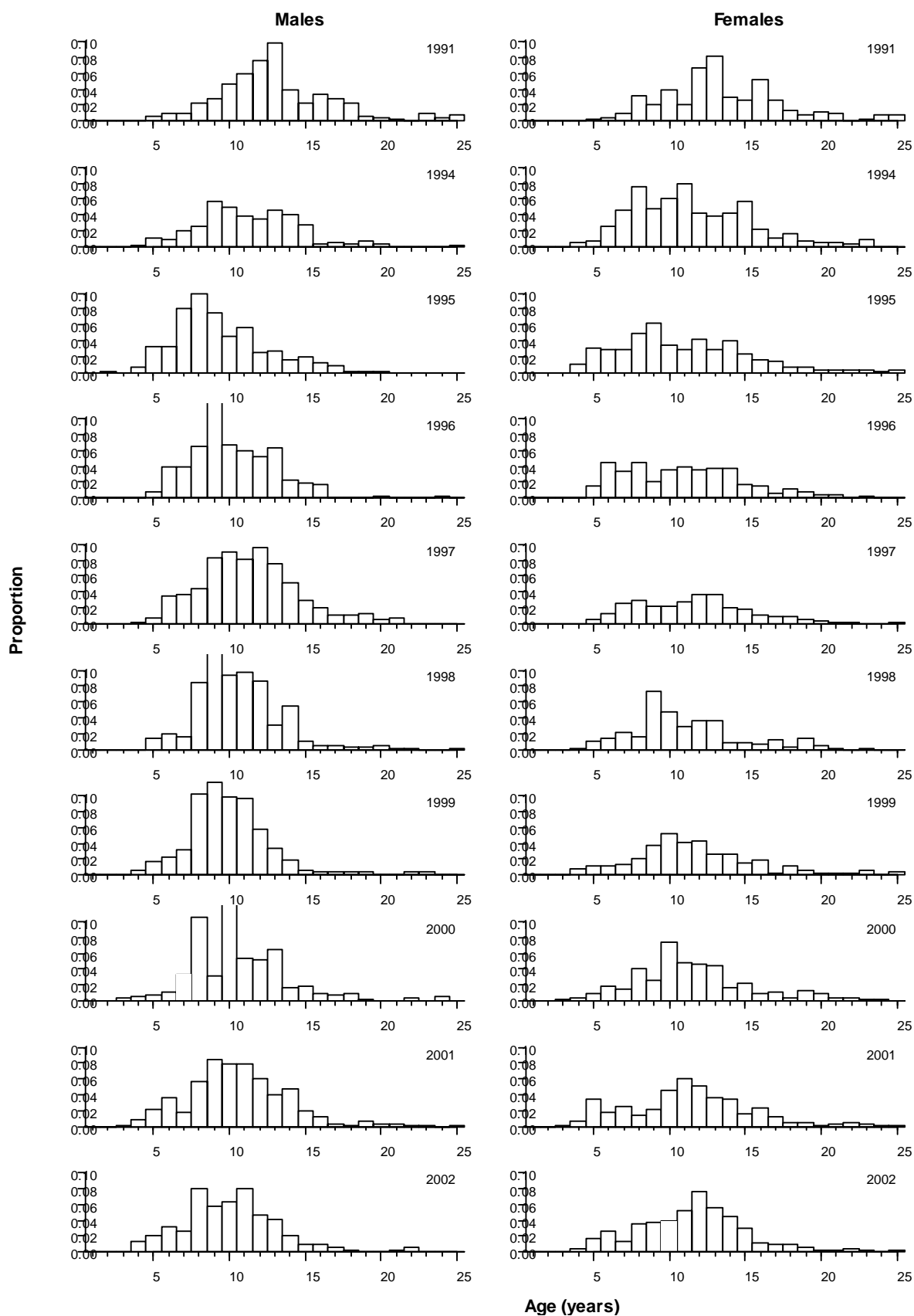
Figure B9: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2014.
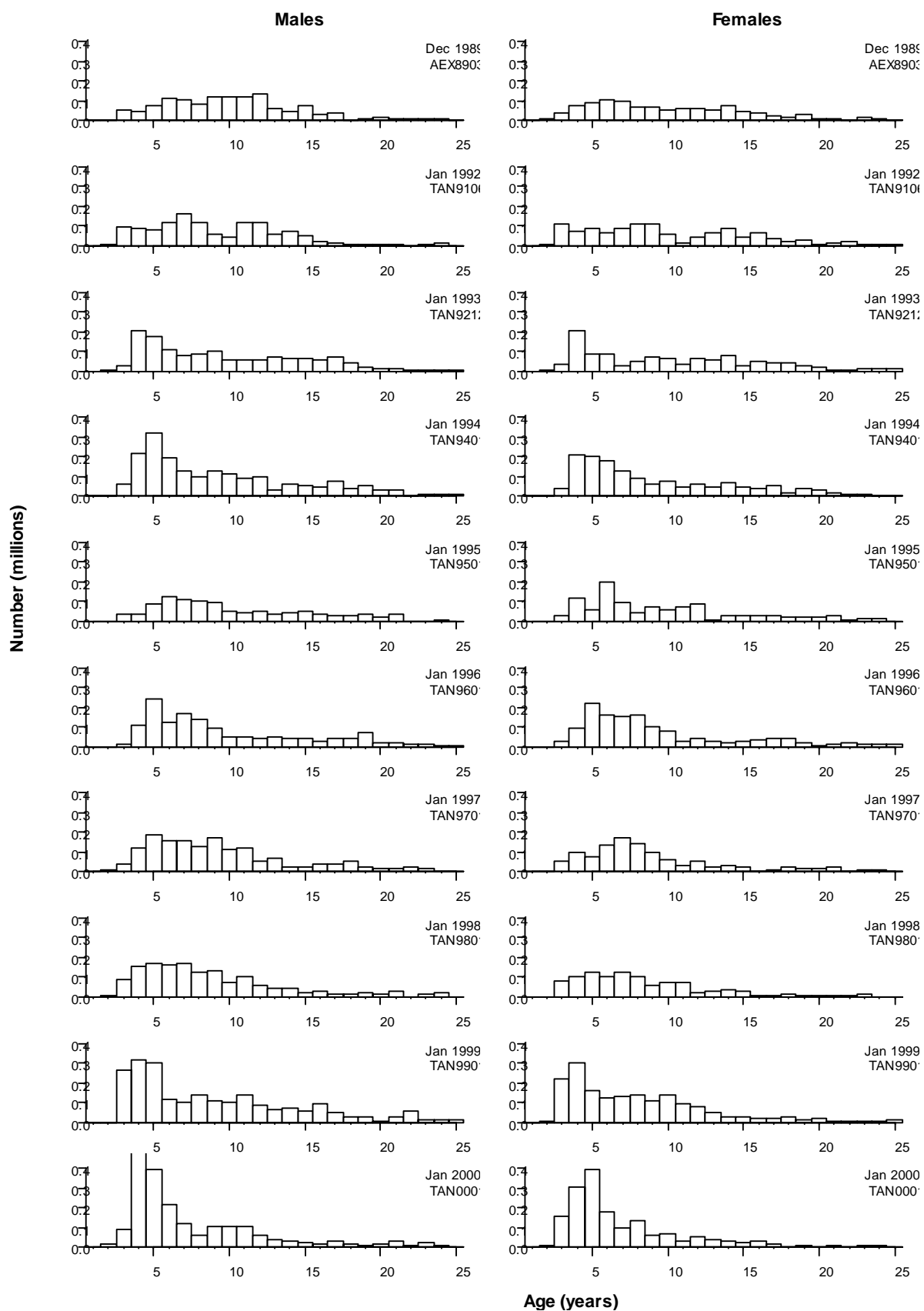
Figure B9 ctd.

Figure B10: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2014.

Males | **Females**

2009

2010

Proportion

Age (years)

Figure B10 ctd.

Figure B11: Available age frequencies of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2014–15.

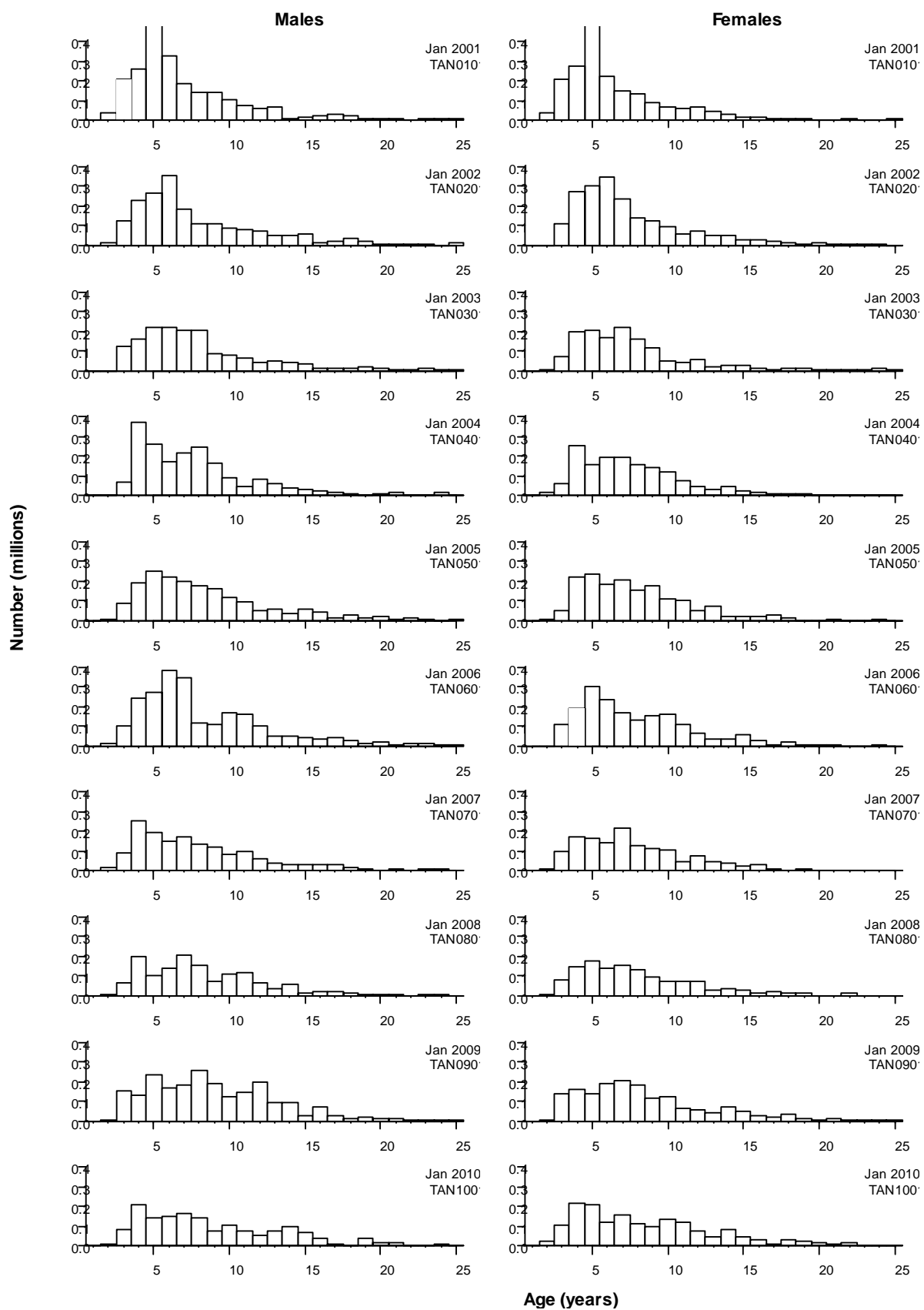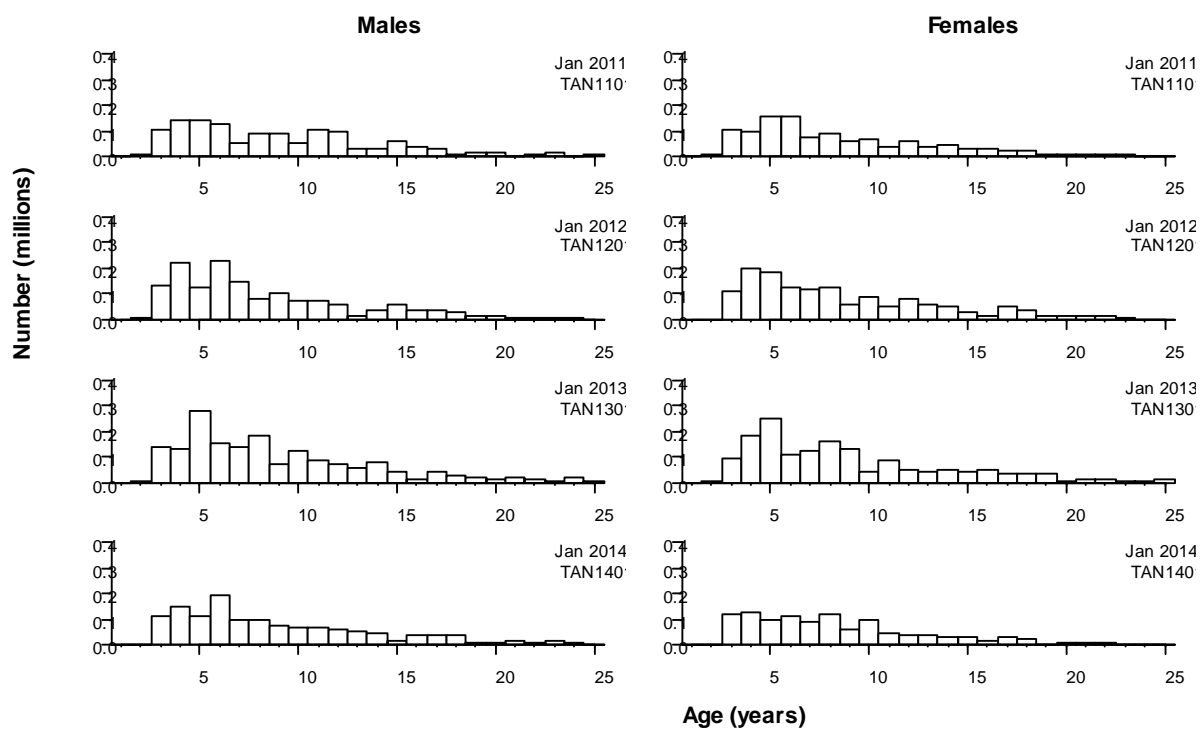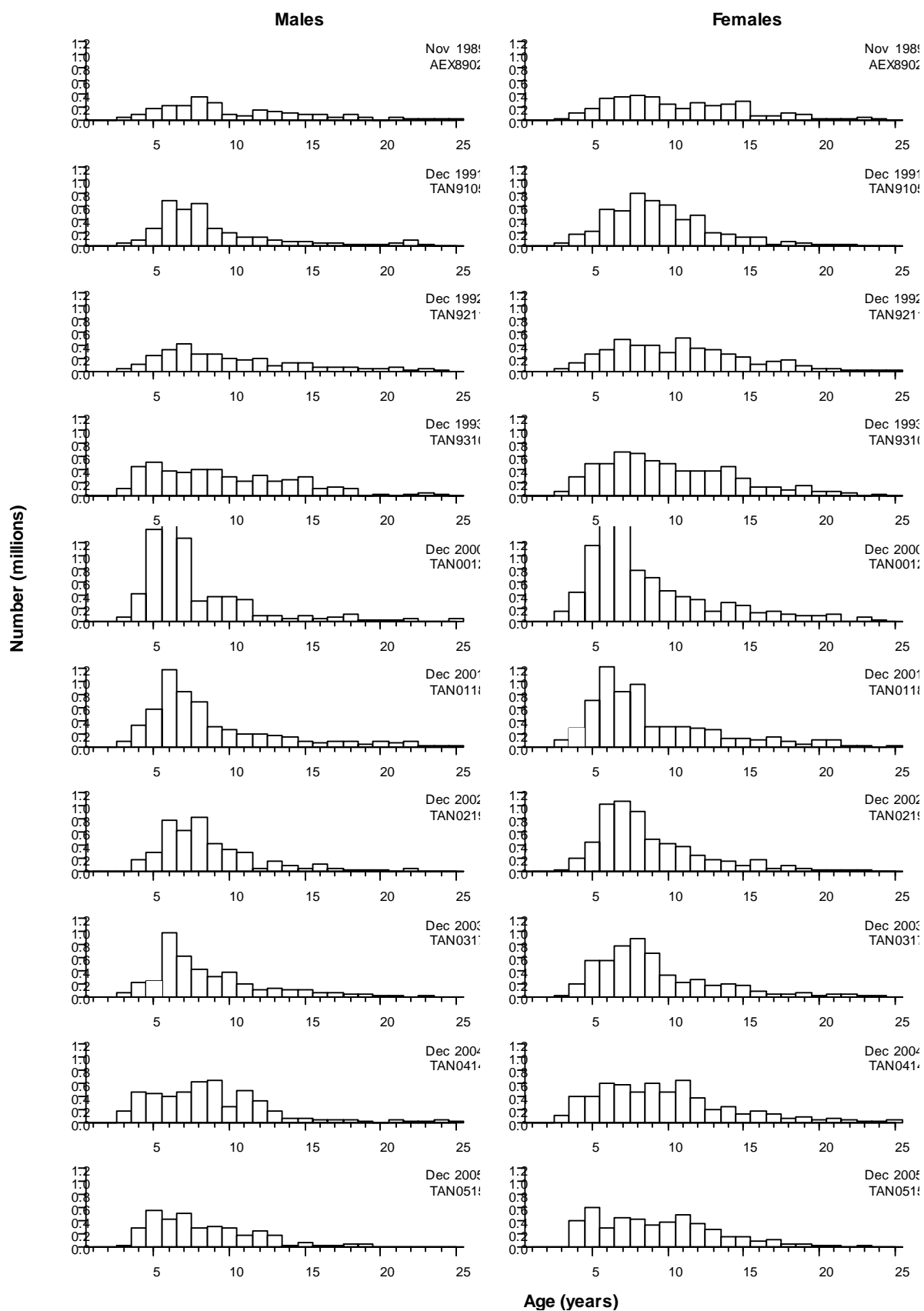**Males**

Females

Jan 2001
TAN010

Jan 2001
TAN010

Jan 2002
TAN020

Jan 2002
TAN020

Jan 2003
TAN030

Jan 2003
TAN030

Jan 2004
TAN040

Jan 2004
TAN040

Jan 2005
TAN050

Jan 2005
TAN050

Jan 2006
TAN060

Jan 2006
TAN060

Jan 2007
TAN070

Jan 2007
TAN070

Jan 2008
TAN080

Jan 2008
TAN080

Jan 2009
TAN090

Jan 2009
TAN090

Jan 2010
TAN100

Jan 2010
TAN100

Number (millions)

Age (years)

Figure B11 ctd.

Figure B11 ctd.

Males   **Females**

Number (millions)

Age (years)

Figure B12: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2014.

Males   **Females**
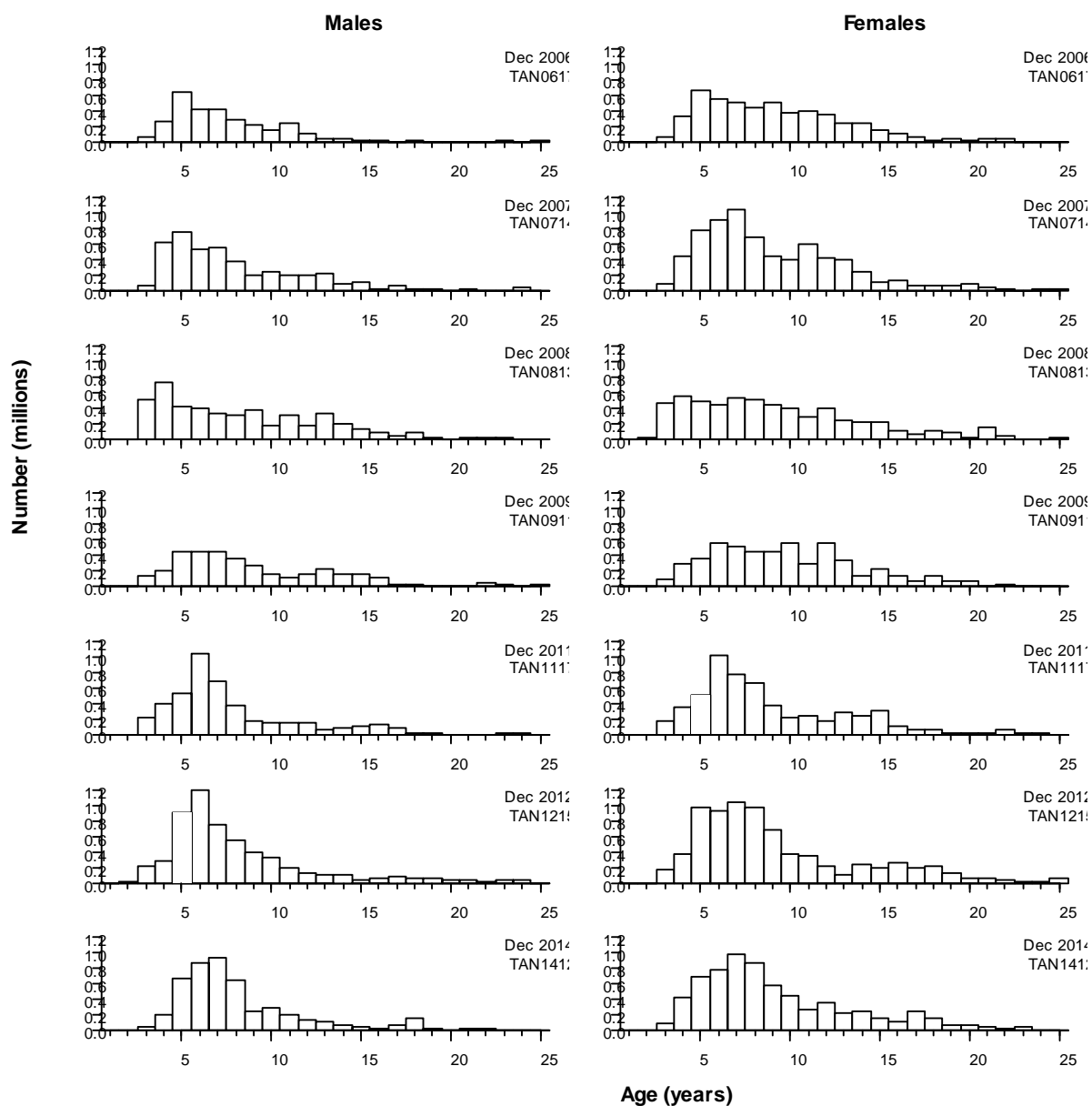
Number (millions)
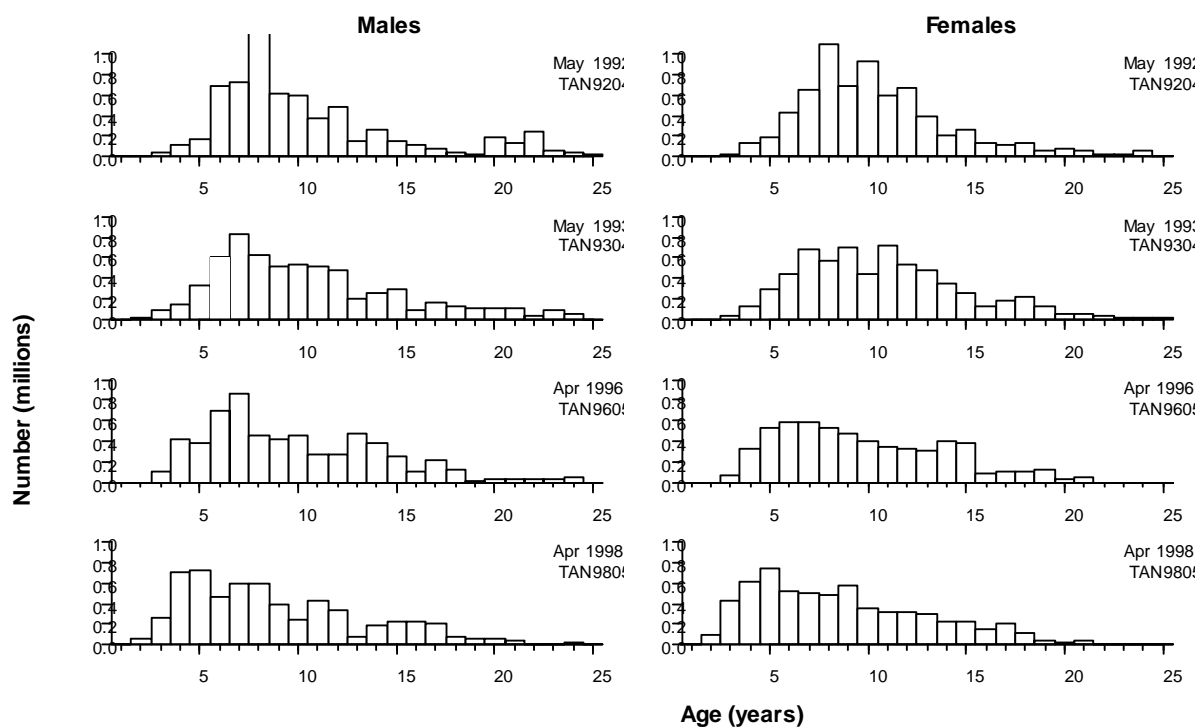
Age (years)

Figure B12 ctd.

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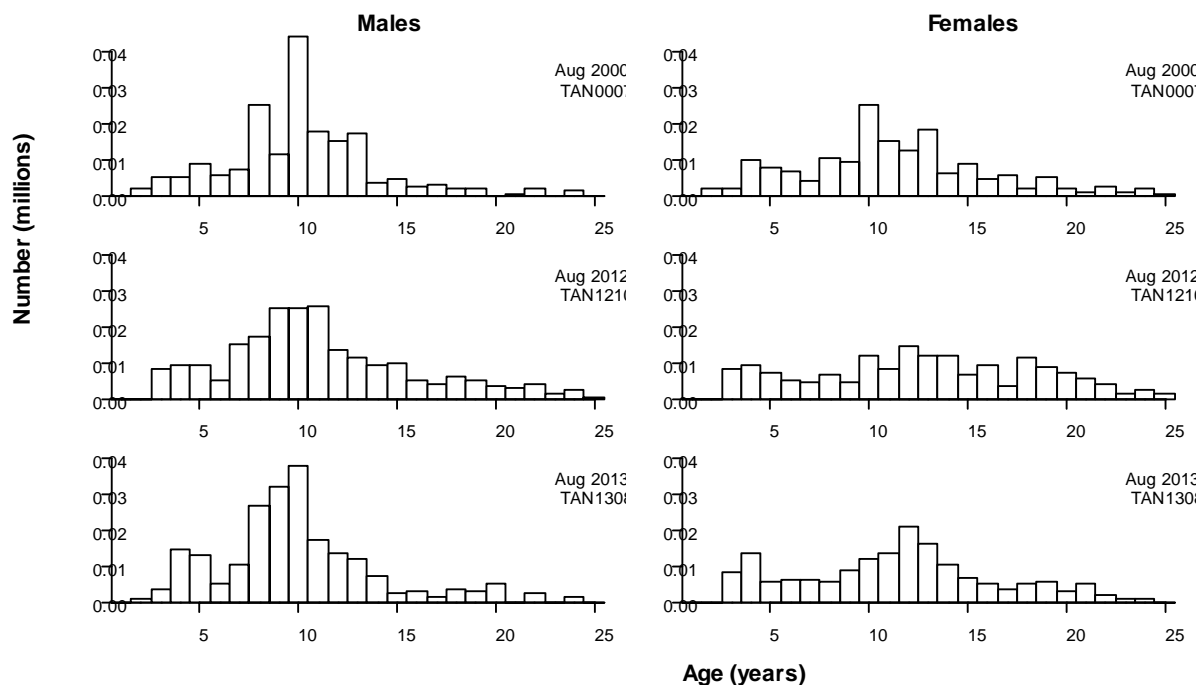

Figure B14: Available age frequencies of ling (ages 1 to 25) from winter resource surveys off WCSI, 2000 to 2014.