



Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2010–11 fishing year and from trawl surveys in summer 2011–12, with a summary of all available data sets.

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EXECUTIVE SUMMARY

Horn, P.L.; Sutton, C.P. (2013). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2010–11 fishing year and from trawl surveys in summer 2011–12, with a summary of all available data sets.

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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 2010–11 fishing year (using data and otoliths collected at sea by observers), and from trawl surveys of hoki and middle depth species in the Sub-Antarctic in December 2011 (TAN1117) and on the Chatham Rise in January 2012 (TAN1201). For each estimated catch at age distribution there was a target coefficient of variation (c.v.) of 30% (mean weighted c.v. across all age classes).

For hake, the mean weighted c.v. targets were met for two of the three commercial fishery samples (WCSI, and Sub-Antarctic), but not met for the Chatham Rise trawl fishery or either of the trawl surveys. It appears likely that three relatively strong years classes were produced on the Chatham Rise in 2001, 2002, and 2003.

For ling, the mean weighted c.v. targets were met for the commercial trawl survey samples from Chatham Rise and the Sub-Antarctic. Targets were almost met for the Sub-Antarctic and Chatham Rise trawl surveys. There were insufficient data collected to estimate catch-at-age for the 2011 WCSI or Cook Strait trawl fisheries. Catch-at-age was also produced for one of the two Sub-Antarctic ling longline fisheries in 2010–11 (the non-spawning fishery), and the target c.v. was met for this sample.

In all age distributions for both species where the target c.v. was not met it was not possible to improve the precision by increasing the sample size as all available data and otoliths had been used in the analyses. It is anticipated that as observer coverage of the deepwater fleet increases, catch-at-age will be available from all fisheries each year. In addition, it would be desirable to ensure that, for all fisheries where catch-at-age is produced, 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.

This report also provides summaries of all catch-at-age distributions available for hake and ling from the various trawl survey and fisheries series.

1. INTRODUCTION

The work presented here aimed to determine catch-at-age from the main fisheries for hake and ling in the 2010–11 fishing year, and for hake and ling from trawl surveys conducted during the summer of 2011–12. 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 MID201001B “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 have been recently modified (Horn & Francis 2010).

2. METHODS

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

HAK 1 — commercial trawl fishery, Sep 2010–May 2011 [600]
HAK 1 — trawl survey, Dec 2011 (project MDT2010–01) [750]
HAK 4 — trawl survey, Jan 2012 (project HOK2010–02) [all available]
HAK 4 — commercial trawl fishery, Oct 2010–April 2011 [500]
HAK 7 — commercial trawl fishery, Jun–Sep 2011 [500]

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

LIN 3&4 — trawl survey, Jan 2012 (project HOK2010-02) [640]
LIN 3&4 — commercial longline fishery, Jun–Oct 2011 [580]
LIN 5&6 — trawl survey, Dec 2011 (project MDT2010-01) [640]
LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2010 [500]
LIN 5&6 — commercial longline fishery, non-spawning, Campbell, Feb–Jul 2011 [500]
LIN 5&6 — commercial trawl fishery, Sep 2010–Apr 2011 [500]
LIN 6B — commercial longline fishery, Nov 2010–March 2011 [500]
LIN 7 — commercial trawl fishery, west coast South Island, Jun–Sep 2011 [600]
LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2011 [500]

No observer otoliths were available from the ling longline fisheries on Chatham Rise (LIN 3&4), Puysegur spawning (LIN 5&6), or Bounty Plateau (LIN 6B). Also, only 195 ling otoliths were collected by observers from the winter 2011 west coast South Island trawl fishery (LIN 7), and only 41 from the

Cook Strait winter trawl fishery (LIN 7&2). These sample sizes were considered to be insufficient to define the age distribution of the catch, so none were read.

The following additional commercial fishery catch-at-age distribution for ling was estimated using age-length keys derived previously from the January 2011 Chatham Rise trawl survey (LIN 3&4).

LIN 3&4 — commercial trawl fishery, Oct 2010–May 2011

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 provides a sample with a mean weighted c.v. 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).

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 have been 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 includes otoliths from observer sampling from September 2008 to May 2009 plus age data from the TAN0813 trawl survey in December 2008.

The mean weighted c.v. targets for hake from trawl surveys have often not been met. To maximise the chances of meeting the target, all hake from the trawl shots used in the survey biomass and scaled length-frequency calculations were measured and had their otoliths collected. Also, any additional hake caught in survey tows not used for biomass calculations (i.e., foul shots, midwater tows, or night tows) were measured, sexed, and had their otoliths removed. 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 has previously been analysed as four separate fisheries (e.g., Horn & Sutton 2009) as shown in Figure 1, and defined as follows:

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

However, following the recent assessment of the Chatham Rise hake stock (Horn & Francis 2010) it was concluded that splitting the data into two fisheries (i.e., west and east) was satisfactory. Consequently, two commercial age frequencies are developed for each year (whenever sufficient data are available) using a single age-length key and two strata separated at longitude 178.1° E. The raw

data are still stratified as shown in Figure 1, so each fishery comprises two strata. A single age-length key for each year is considered to be acceptable 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 had been measured from it.

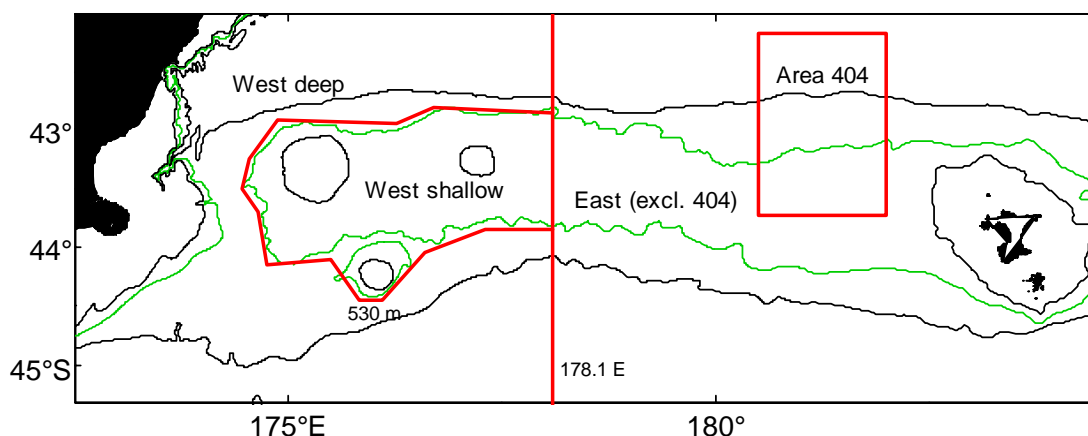


Figure 1: Fishery strata defined for the Chatham Rise hake fishery. The stratum boundary defined by depth (530 m) is shown only approximately. Isobaths at 1000, 500, and 250 m are also shown.

Observer data from each fishery were converted into catch-at-age distributions if there were at least 400 length measurements (west fishery) or 300 length measurements (east fishery). Table 1 summarises the quantities of useful data.

Table 1: Numbers of measured (by fishery) and aged (fisheries combined) male (Mal) and female (Fem) hake contributing to samples of proportion at age from the two commercial trawl fisheries on the Chatham Rise. The number of tows sampled by observers and the estimated mean weighted c.v. (%) by age are also listed.

Fishing year	West				East				Aged	
	Mal	Fem	Tows	c.v.	Mal	Fem	Tows	c.v.	Mal	Fem
1991–92	2 112	2 636	163	21.9	170	247	25	43.2	233	230
1992–93										
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

In the 2010–11 fishing year, sufficient length data and otoliths were available to calculate a catch-at-age distribution for the west fishery only (see Table 1). Details of that estimated distribution are given in Table 2. The sample size of measured fish was just above the threshold of 400, and the mean weighted c.v. of 34% did not meet the 30% target.

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

Table 2: Calculated numbers at age, separately by sex, with c.v.s, for hake sampled by observers during commercial trawl operations on the Chatham Rise (west) during October 2010–April 2011, and in the Sub-Antarctic during September 2010–May 2011. Summary statistics for the samples are also presented.

Age	Chatham Rise (west)				Age	Sub-Antarctic			
	Male	c.v.	Female	c.v.		Male	c.v.	Female	c.v.
2	39	2.281	2 114	1.830	2	0	–	0	–
3	5 528	0.536	3 023	0.748	3	95	1.748	190	1.304
4	14 653	0.338	7 579	0.397	4	263	0.803	582	0.612
5	14 580	0.335	12 210	0.383	5	3 653	0.369	693	0.505
6	7 424	0.360	10 753	0.405	6	15 376	0.200	1 277	0.444
7	8 010	0.376	13 643	0.284	7	27 776	0.144	3 969	0.295
8	5 868	0.384	8 153	0.276	8	25 566	0.151	8 092	0.187
9	5 840	0.412	9 579	0.273	9	15 228	0.204	7 706	0.185
10	2 131	0.597	4 367	0.451	10	15 463	0.214	4 819	0.224
11	16	1.658	2 115	0.502	11	6 685	0.323	4 288	0.273
12	502	1.438	2 556	0.557	12	11 414	0.282	3 112	0.292
13	4 094	0.631	1 029	0.772	13	12 242	0.228	2 828	0.304
14	16	1.651	490	1.425	14	11 888	0.237	1 662	0.399
15	1 754	0.885	946	1.083	15	4 480	0.384	763	0.539
16	1 021	0.887	1 876	1.102	16	10 105	0.315	2 234	0.332
17	535	1.292	411	1.091	17	5 903	0.330	1 281	0.495
18	535	1.208	510	1.088	18	6 371	0.460	1 869	0.496
19	629	1.717	0	–	19	3 632	0.483	1 465	0.413
20	563	1.232	0	–	20	912	0.679	501	0.750
21	0	–	0	–	21	0	–	0	–
22	0	–	0	–	22	0	–	398	0.848
23	0	–	0	–	23	650	1.131	0	–
Measured males				202					3 738
Measured females				249					1 212
Aged males				199					296
Aged females				251					282
No. of tows sampled				46					117
Mean weighted c.v. (sexes pooled)				34.3					20.2

3.1.2 Sub-Antarctic

There are one major and three very minor hake fisheries in the Sub-Antarctic area, so a single fishery ogive is considered suitable for this stock. Consequently, a commercial age frequency is developed using a single age-length key and the four fishery strata shown in Figure 2, and defined as follows:

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

A tow was included in the catch at age analysis if it occurred between 1 September and 31 May, and if at least five hake had been measured from it. The start of the fishing year was not used as the start of the time stratum because a descriptive analysis of this fishery indicated a landings peak from September to February (Devine 2008), so it is logical to include the September catch with landings from the five months immediately following it, rather than with catches taken about seven months previously.

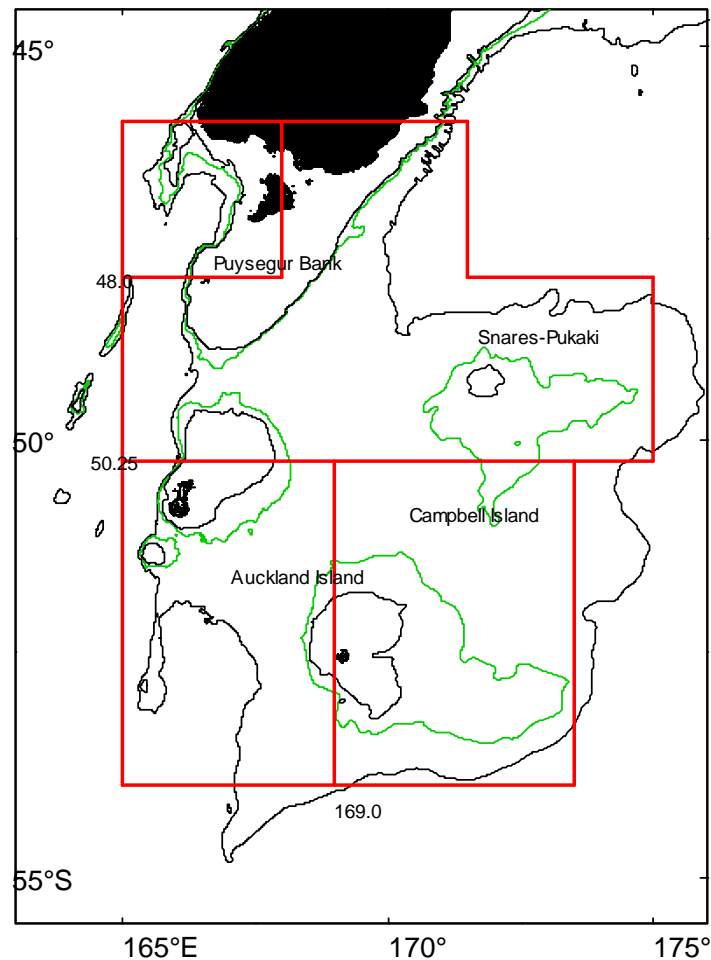


Figure 2: Fishery strata defined for the Sub-Antarctic hake fishery. Numbers show latitudes/longitudes of fishery boundaries. Isobaths at 1000, 500, and 250 m are also shown.

Table 3 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for trawl-caught hake in the 2010–11 fishing year are given in Table 2. The mean weighted c.v. of 20% was well within the target of 30%.

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

Table 3: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic trawl fishery.

Year	Males		Females		Tows	Mean c.v.
	Measured	Aged	Measured	Aged		
1989–90	269	47	548	71	74	42.0
1990–91	175	–	588	–	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	–	597	–	92	–
1995–96	289	65	435	110	75	50.0
1996–97	84	–	219	–	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

3.1.3 West coast South Island

The fishery off WCSI was stratified 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 had been measured from it.

Table 4 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for trawl-caught hake in the 2010–11 fishing year are given in Table 5. The measured sample size was large, and the mean weighted c.v. of 16.8% was well within the target of 30%.

All estimated proportion at age distributions from the WCSI trawl fishery are presented in Appendix A (Figure A4). The three year classes that showed up relatively strongly as 2-year-olds in catches from 2005, 2006, and 2007 now appear to comprise a high proportion of the 2011 catch.

Table 4: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the WCSI trawl fishery.

Year	Males		Females		Tows	Mean c.v.
	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

Table 5: Calculated numbers at age, separately by sex, with c.v.s, for hake sampled by observers during commercial trawl operations off the west coast of South Island (WCSI) during June–September 2011. Summary statistics for the samples are also presented.

Age	Male	c.v.	Female	c.v.
2	6 332	0.335	3 978	0.366
3	4 029	0.375	4 477	0.265
4	56 599	0.172	2 078	0.458
5	65 827	0.159	21 057	0.263
6	67 872	0.158	73 287	0.133
7	82 532	0.157	79 487	0.126
8	19 124	0.338	59 591	0.146
9	22 638	0.278	34 470	0.176
10	18 900	0.320	11 734	0.310
11	22 087	0.315	5 339	0.370
12	13 521	0.383	11 092	0.319
13	11 147	0.426	3 620	0.527
14	5 638	0.581	4 648	0.478
15	11 653	0.449	3 650	0.434
16	7 328	0.571	3 089	0.540
17	5 337	0.669	857	0.866
18	0	–	824	1.099
19	4 124	0.778	0	–
20	5 031	0.620	0	–
21	0	–	495	1.122
Measured males			2 489	
Measured females			2 489	
Aged males			260	
Aged females			353	
No. of tows sampled			104	
Mean weighted c.v. (sexes pooled)			16.8	

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 Rise is surveyed. However, to ensure comparability, the distributions presented here are for the ‘core’ strata only, i.e., 200–800 m.

Table 6 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for hake caught in the January 2012 trawl survey are given in Table 7. The mean weighted c.v. of 49.5% did not meet the target of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis. The 30% target has been met in only one of the 20 surveys (TAN9106, see Table 6).

All estimated proportion at age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A5). It appears 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 in January 2004), and that it was followed by two further relatively strong year classes in 2003 and 2004. The 2006 year class (aged 5 in 2011) may also be stronger than the year classes around it. The progression of these year classes is apparent in the survey size distributions since TAN0401.

Table 6: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Chatham Rise resource surveys.

Source	Males		Females		Tows	Mean c.v.
	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

Table 7: Calculated numbers at age in the survey area, separately by sex, with c.v.s, for hake caught during trawl surveys of the Chatham Rise in January 2012 (survey TAN1201) and the Sub-Antarctic in November-December 2011 (survey TAN1117). Summary statistics for the samples are also presented.

TAN1201					TAN1117				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
2	4 143	1.233	0	–	2	0	–	0	–
3	6 019	0.692	5 197	0.897	3	2 932	0.580	3 378	0.654
4	8 153	0.549	5 997	0.594	4	32 297	0.201	47 075	0.354
5	5 625	0.741	18 572	0.400	5	27 974	0.279	45 376	0.322
6	16 340	0.423	14 075	0.523	6	9 343	0.491	43 801	0.329
7	3 440	0.986	10 828	0.552	7	11 573	0.663	25 905	0.320
8	16 805	0.440	11 816	0.520	8	9 946	0.652	16 002	0.365
9	6 871	0.725	24 898	0.478	9	13 893	0.631	19 424	0.394
10	6 070	0.645	7 424	0.588	10	8 722	0.662	28 417	0.414
11	1 571	1.322	20 056	0.467	11	6 990	0.655	10 554	0.459
12	1 588	1.376	5 567	0.859	12	3 460	0.788	11 160	0.480
13	3 234	0.908	5 499	0.863	13	6 801	0.709	9 083	0.496
14	0	–	7 176	0.701	14	8 715	0.767	1 612	0.837
15	0	–	2 541	0.892	15	4 343	0.807	3 656	0.770
16	0	–	2 349	1.053	16	1 548	1.157	4 842	0.991
17	0	–	0	–	17	2 653	0.982	9 279	1.057
18	0	–	1 688	1.256	18	3 536	0.809	5 002	0.777
19	1 647	1.056	1 414	1.306	19	296	1.595	1 762	0.861
20	0	–	1 527	1.115	20	592	1.149	1 613	0.959
21	0	–	1 430	1.684	21	1 823	1.012	5 266	0.995
22	0	–	0	–	22	1 366	1.081	0	–
23	2 993	1.415	0	–	23	0	–	0	–
24	0	–	0	–	24	989	1.165	0	–
Measured males				48					405
Measured females				83					423
Aged males				78					238
Aged females				98					357
No. of tows sampled				54					37
Mean weighted c.v. (sexes pooled)				49.5					37.3

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 has been conducted in summer. Those surveys have 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. However, 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 spring and autumn surveys are derived from the core 300–800 m strata only.

Table 8 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for hake caught in the November–December 2011 trawl survey are given in Table 7. The mean weighted c.v. of 37% did not meet the target of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis. The 30% target has never been met in any of the Sub-Antarctic surveys (see Table 8).

All estimated proportion at age distributions from the Sub-Antarctic trawl surveys are presented in Appendix A (Figure A6).

Table 8: Numbers of measured and aged male and female hake, and the number of sampled tows and estimated mean weighted c.v. (%) by age for the Sub-Antarctic resource surveys.

Survey	Males		Females		Tows	Mean c.v.
	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
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

3.3 Observer catch at age data from ling longline fisheries

3.3.1 Chatham Rise

The line fishery data from the Chatham Rise are 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 9 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. There were no data collected from the Chatham Rise ling longline fishery in the 2010–11 fishing year or in the previous year.

Table 9: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Chatham Rise longline fishery.

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

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 line fishery data from the Sub-Antarctic stock are 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 30), 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 30 and the Bounty Plateau, with a time stratum of 1 February to 31 July. Ling on the Bounty Plateau are analysed separately for Sub-Antarctic ling because they are believed to comprise a distinct biological stock (Horn 2005).

Table 10 summarises the quantities of 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 c.v.s. The details of the estimated catch at age distribution for non-spawning Sub-Antarctic line-caught ling in the 2010–11 fishing year are given in Table 11. The sample size was relatively small, but the mean weighted c.v. of 27% was below the target value of 30%. There was no observer sampling of spawning Sub-Antarctic line-caught ling in the 2010–11 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 10: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic spawning and non-spawning longline fisheries.

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

Table 11: Calculated numbers at age, separately by sex, with c.v.s, for ling sampled by observers during commercial longline operations in the Sub-Antarctic non-spawning fishery (LIN 5&6) in February–July 2011. Summary statistics for the samples are also presented.

Age	Sub-Antarctic non-spawning			
	Male	c.v.	Female	c.v.
5	423	0.804	603	0.600
6	512	0.700	1 511	0.435
7	1 047	0.547	3 097	0.343
8	375	0.761	982	0.604
9	1 429	0.601	5 099	0.261
10	1 004	0.575	3 532	0.306
11	940	0.539	6 915	0.212
12	647	0.683	5 032	0.259
13	780	0.578	5 356	0.261
14	0	–	6 211	0.233
15	703	0.648	7 671	0.198
16	1 017	0.557	4 242	0.263
17	1 714	0.463	5 385	0.261
18	653	0.656	4 886	0.240
19	464	0.696	2 219	0.353
20	0	–	963	0.488
21	804	0.866	2 201	0.437
22	447	0.934	648	0.671
23	283	1.113	370	0.902
24	0	–	95	1.359
25	0	–	95	1.259
26	0	–	46	1.667
27	287	1.196	221	1.273
28	0	–	0	–
29	0	–	0	–
30	0	–	93	1.336
Measured males				180
Measured females				823
Aged males				60
Aged females				267
No. of sets sampled				64
Mean weighted c.v. (sexes pooled)				27.3

3.3.3 Cook Strait

The line fishery data from Cook Strait are 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 16 and 17), and a time stratum of 1 June to 30 September.

Table 12 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. Note that the 2001 age-length key used 57 otoliths collected from the line fishery (i.e., all that had been collected), plus 316 otoliths collected from the trawl fishery in the same area and year. There was no observer sampling of Cook Strait line-caught ling in the 2010–11 fishing year. All estimated proportion at age distributions from the Cook Strait longline fishery are presented in Appendix B (Figure B4).

Table 12: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Cook Strait longline fishery.

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

3.3.4 Bounty Plateau

The line fishery data from the Bounty Plateau are 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 13 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. There were no data collected from the Bounty Plateau ling longline fishery in the 2010–11 fishing year. All estimated proportion at age distributions from the Bounty Plateau longline fishery are presented in Appendix B (Figure B5).

Table 13: Numbers of measured and aged male and female ling, and the number of sampled sets and estimated mean weighted c.v. (%) by age, for the Bounty Plateau longline fishery.

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

3.4 Observer catch at age data from ling trawl fisheries

3.4.1 Chatham Rise

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

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

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

Table 14 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for trawl-caught ling in the 2010–11 fishing year are given in Table 15. The mean weighted c.v. of 27% was within the target value of 30%.

All estimated proportion at age distributions from the Chatham Rise trawl fishery are presented in Appendix B (Figure B6).

Table 14: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Chatham Rise trawl fishery.

Source	Males		Females		Tows	Mean c.v.
	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

Table 15: Calculated numbers at age, separately by sex, with c.v.s, for ling sampled by observers during commercial trawl operations on the Chatham Rise during October 2010–May 2011, and in the Sub-Antarctic during September 2010–April 2011. Summary statistics for the samples are also presented.

Age	Chatham Rise				Age	Sub-Antarctic			
	Male	c.v.	Female	c.v.		Male	c.v.	Female	c.v.
2	0	–	248	1.967	2	0	–	0	–
3	97	1.640	1 490	0.770	3	126	2.176	1 133	1.346
4	7 643	0.657	1 804	0.631	4	6 096	0.739	5 958	0.822
5	13 536	0.317	10 665	0.285	5	61 133	0.299	44 249	0.414
6	14 245	0.292	16 965	0.242	6	47 544	0.279	90 092	0.254
7	5 531	0.392	12 495	0.293	7	65 354	0.242	57 956	0.271
8	8 895	0.316	11 759	0.342	8	50 540	0.265	53 319	0.247
9	8 233	0.298	6 202	0.373	9	79 732	0.203	78 764	0.180
10	5 611	0.380	9 100	0.367	10	54 885	0.247	72 521	0.193
11	7 786	0.282	7 321	0.390	11	44 263	0.263	41 739	0.271
12	8 269	0.282	10 869	0.287	12	30 402	0.322	57 607	0.225
13	1 503	0.533	8 760	0.314	13	25 823	0.319	47 546	0.250
14	2 647	0.467	7 060	0.323	14	51 436	0.222	53 325	0.239
15	3 445	0.345	5 910	0.379	15	35 367	0.316	29 379	0.300
16	3 239	0.462	4 897	0.435	16	23 707	0.349	26 818	0.302
17	1 998	0.479	895	0.790	17	24 653	0.358	21 239	0.351
18	922	0.677	3 397	0.620	18	23 110	0.369	7 331	0.624
19	948	0.685	668	0.848	19	2 472	1.018	17 231	0.378
20	770	0.677	1 004	0.960	20	3 034	1.037	12 056	0.439
21	171	1.211	380	0.872	21	12 861	0.515	3 313	0.755
22	235	1.078	1 352	0.947	22	1 870	1.166	2 554	1.175
23	1 040	0.692	548	1.048	23	5 324	0.706	1 500	1.149
24	0	–	0	–	24	2 173	1.237	0	–
25	308	1.070	0	–	25	5 198	0.785	641	1.154
26	0	–	0	2.688	26	1 003	1.287	710	1.319
27	388	1.037	0	–					
28	0	–	0	–					
29	0	–	0	–					
30	217	1.237	0	–					
Measured males				492					2 212
Measured females				521					2 630
Aged males				308					236
Aged females				293					279
No. of tows sampled				74					215
Mean weighted c.v. (sexes pooled)				27.3					21.4

3.4.2 Sub-Antarctic

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

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

Table 16 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for trawl-caught ling in the 2010–11 fishing year are given in Table 15. The mean weighted c.v. of 21% was better than the target value of 30%. Age data to produce the age-length key for this fishery are usually derived from the summer trawl survey in the Sub-Antarctic. However, because there was

no survey in December 2010, a sample of otoliths collected by observers in 2010–11 was aged for this purpose.

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

Table 16: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic trawl fishery.

Source	Males		Females		Tows	Mean c.v.
	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

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:

- Deep (bottom depth ≥ 498 m)
- North shallow (bottom depth < 498 m, latitude $< 42.42^\circ$ S)
- South shallow (bottom depth < 498 m, latitude $\geq 42.42^\circ$ S)

Table 17 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. There were insufficient data (particularly otoliths) collected to estimate the catch at age distribution for trawl-caught ling in the 2010–11 fishing year (i.e., 751 length measurements and 198 otoliths).

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

Table 17: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the WCSI trawl fishery.

Year	Males		Females		Tows	Mean c.v.
	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

3.4.4 Cook Strait

The trawl fishery in Cook Strait is 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 16 and 17), and a time stratum of 1 June to 30 September.

Table 18 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. There were insufficient data collected to estimate the catch at age distribution for trawl-caught ling in the 2010–11 fishing year (i.e., 70 length measurements and 41 otoliths).

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

Table 18: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Cook Strait trawl fishery.

Year	Males		Females		Tows	Mean c.v.
	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 is surveyed. However, to ensure comparability, the distributions presented here are for the core strata only, i.e., 200–800 m.

Table 19 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution for ling caught in the January 2012 trawl survey are given in Table 20. The mean weighted c.v. of 23% was well below the target of 30%.

All estimated proportion at age distributions from the Chatham Rise trawl surveys are presented in Appendix B (Figure B10).

Table 19: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Chatham Rise trawl surveys.

Survey	Males		Females		Tows	Mean c.v.
	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	315	93	23.0

Table 20: Calculated numbers at age in the survey area, separately by sex, with c.v.s, for ling caught during trawl surveys of the Chatham Rise in January 2012 (survey TAN1201) and the Sub-Antarctic in November-December 2011 (survey TAN1117). Summary statistics for the samples are also presented.

Age	TAN1201				Age	TAN1117			
	Male	c.v.	Female	c.v.		Male	c.v.	Female	c.v.
2	8 787	1.327	0	–	2	0	–	0	–
3	129 125	0.338	108 308	0.309	3	216 357	0.480	175 255	0.405
4	224 094	0.213	197 275	0.192	4	395 540	0.326	354 577	0.280
5	123 905	0.285	184 191	0.208	5	525 042	0.255	511 871	0.269
6	227 688	0.222	125 356	0.250	6	1 031 077	0.185	1 026 835	0.234
7	144 014	0.242	116 418	0.267	7	681 832	0.227	768 503	0.241
8	80 929	0.352	122 945	0.236	8	375 549	0.295	663 771	0.212
9	103 468	0.276	60 799	0.312	9	177 016	0.415	371 785	0.270
10	76 425	0.308	87 782	0.248	10	144 080	0.389	218 503	0.331
11	71 595	0.318	53 438	0.326	11	155 845	0.363	247 362	0.276
12	61 475	0.325	77 576	0.270	12	148 360	0.345	183 373	0.334
13	15 086	0.685	54 766	0.315	13	66 311	0.503	285 659	0.293
14	36 768	0.404	52 423	0.323	14	76 520	0.501	237 367	0.297
15	55 024	0.365	30 957	0.424	15	117 635	0.427	308 853	0.247
16	33 531	0.435	14 058	0.635	16	139 602	0.333	111 460	0.421
17	38 234	0.403	49 391	0.346	17	91 273	0.387	60 243	0.536
18	31 836	0.421	35 808	0.481	18	29 929	0.626	67 531	0.509
19	12 794	0.653	11 005	0.818	19	26 057	0.654	18 603	0.913
20	10 817	0.810	12 925	0.835	20	4 189	1.356	24 542	0.996
21	8 047	0.847	13 315	0.660	21	0	–	15 085	1.038
22	7 675	0.767	11 829	0.680	22	0	–	63 065	0.561
23	7 198	1.038	6 095	0.962	23	14 405	1.219	23 823	0.877
24	3 017	1.612	0	–	24	10 438	1.080	15 009	1.581
25	0	–	946	1.655	25	0	–	0	–
26	0	–	0	–	26	6 150	1.298	0	–
27	0	–	2 184	1.606	27	1 699	0.966	0	–
28	2 079	1.503	0	–	28	2 557	1.685	9 781	1.366
29	0	–	0	–	29	0	–	0	–
30	0	–	0	–	30	0	–	12 190	1.274
31	3 032	1.332	0	–	31	0	–	0	–
32	2 365	1.199	0	–	32	5 733	1.359	0	–
33	5 364	1.541	0	–					
38	2 278	1.336	0	–					
Measured males				656					1 264
Measured females				697					1 321
Aged males				273					266
Aged females				315					322
No. of tows sampled				93					80
Mean weighted c.v. (sexes pooled)				23.0					23.6

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 has been conducted in summer. Those surveys have 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. However, 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 21 summarises the quantities of data used each year to produce the catch at age distributions, and also lists the resulting mean weighted c.v.s. The details of the estimated catch at age distribution

for ling caught in the November–December 2011 trawl survey are given in Table 20. The mean weighted c.v. of 23.6% was well within the target of 30%, as it has been in all surveys in this series.

All estimated proportion at age distributions from the Sub-Antarctic trawl surveys are presented in Appendix B; Figure B11 shows the summer survey distributions and Figure B12 shows the autumn survey distributions.

Table 21: Numbers of measured and aged male and female ling, and the number of sampled tows and estimated mean weighted c.v. (%) by age, for the Sub-Antarctic trawl surveys.

Survey	Males		Females		Tows	Mean c.v.
	Measured	Aged	Measured	Aged		
Summer surveys						
AEX8902	760	160	1 067	234	133	29.0
TAN9105	1 563	213	2 079	348	151	19.6
TAN9211	1 249	227	1 668	354	146	21.1
TAN9310	1 520	254	1 894	351	127	22.3
TAN0012	1 761	244	1 696	351	85	18.8
TAN0118	1 316	268	1 290	326	95	19.6
TAN0219	1 661	224	1 606	350	88	20.6
TAN0317	1 270	243	1 156	333	70	22.1
TAN0414	1 433	256	1 146	339	79	27.0
TAN0515	1 095	279	988	300	82	22.0
TAN0617	969	250	1 011	355	80	23.1
TAN0714	1 014	229	1 288	353	79	21.7
TAN0813	1 162	250	994	327	80	26.8
TAN0911	830	232	882	339	70	22.8
TAN1117	1 264	266	1 321	322	80	23.6
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

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 c.v.s. were available from the HAK 7 fishery off WCSI, and the HAK 1 fishery in the Sub-Antarctic. Catch-at-age was also produced for the western section of the HAK 1 and 4 fishery on the Chatham Rise. The target has almost always been met for samples in the WCSI fishery (see Table 4). The sampling intensity in the HAK 1 (Sub-Antarctic) commercial trawl fishery was high in 2010–11. Sampling intensity in the Sub-Antarctic has varied considerably between years, with consequent wide variation in the mean weighted c.v.s (see Table 3). Data from the Chatham Rise are analysed as two separate fisheries (see Table 1). Sampling intensity in 2010–11 was relatively low and a catch at age distribution was able to be derived only for the western fishery. It is anticipated that as observer coverage of the deepwater fleet increases, catch-at-age will be available from all fisheries each year.

The Sub-Antarctic trawl survey in December 2011 caught more hake than all but one of the previous surveys in the summer series. Although all available length and otolith data were included in the estimation of catch-at-age, the c.v. target was not met. However, the target of 30% has never been met in any of the Sub-Antarctic surveys. The Chatham Rise survey in January 2012 produced very low numbers of hake (131 measured fish); only two other surveys in the series (TAN0301, TAN1101) have caught fewer fish. The catch-at-age distribution for the trawl survey had a mean weighted c.v. much higher than

the target of 30% (49.5%), but no improvements in the precision can be achieved, as all available data were included in the analysis. The target of 30% has been met in only one of the surveys in this series.

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 eastern Rise (see Figure A2). It has been shown previously that males and females appear to be about evenly abundant in all areas except Statistical Area 404, where males clearly dominate the catch (Horn & Sutton 2009). There is a clear year class progression apparent in the Chatham Rise survey distributions from 2004 to 2011 (Figure A5). The 2001 year class (aged 2+ in January 2004) clearly progresses through to age 9+ in 2011, for both males and females. It also appears likely that the two following year classes (2002 and 2003) are moderately strong.

In the Sub-Antarctic, there are some clear year class progressions, particularly in the male distributions. Figure A3 shows the progressions of hake aged 10 in 1990 through to age 16 in 1996, and aged 6 in 1998 through to age 12 in 2004. The three most recent trawl surveys indicate the possibility of some recent moderately strong recruitment (Figure A6).

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

4.2 Ling

Catch at age distributions were produced for only one commercial longline fishery in 2010–11 (Sub-Antarctic non-spawning), and the target c.v. was met. Catch at age distributions were scheduled to be produced for the Chatham Rise and Bounty Plateau fisheries, but they were either not sampled by observers in 2010–11 (Bounty Plateau) or were sampled but no otoliths were collected (Chatham Rise). It is expected that observer coverage of the ling longline fleet will increase in the near future. 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 two 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 2010 to May 2011 were applied to the age-length key from the January 2011 (TAN1101) trawl survey of the Chatham Rise. The Sub-Antarctic distribution used observer length and otolith data. The estimated catch-at-age distributions had mean weighted c.v.s well within the target of 30%. Most distributions calculated for both these fisheries in previous years had been within the target. Estimates of catch-at-age for the ling bycatch from the WCSI and Cook Strait hoki spawning fisheries were not able to be produced for 2011 as insufficient fish were measured (Cook Strait), or insufficient otoliths were collected (WCSI). This is the first year that sampling of the Cook Strait fishery has been inadequate; in previous years data from this fishery was augmented by market sampling. However, this is the third consecutive year that the volume of ling data from the WCSI fishery has been inadequate to produce a useful catch-at-age distribution. It is hoped that as observer coverage of the deepwater trawl fleet increases, catch-at-age will be available from all fisheries each year.

Sufficient ling otoliths and length-frequency data were available from trawl surveys of the Sub-Antarctic (December 2011) and Chatham Rise (January 2012) to easily meet the mean weighted c.v. target. The target had been met in all previous surveys of these areas, except for Chatham Rise in 2011 (see Tables 19 and 21).

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

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

5. ACKNOWLEDGMENTS

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Appendix A: Summaries of the proportions-at-age data for hake from resource surveys and trawl fishery observer sampling

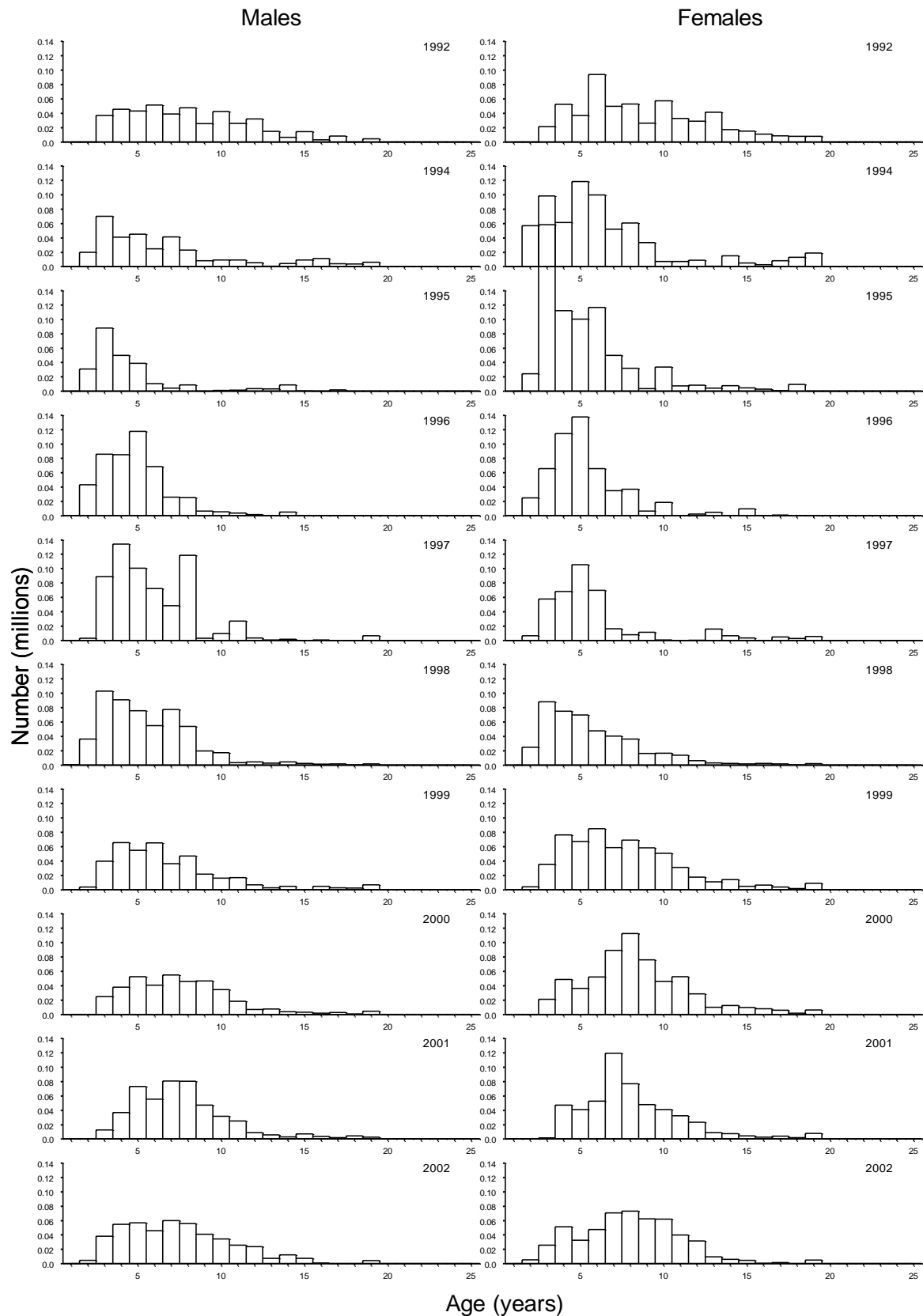


Figure A1: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–April 2002 sample.

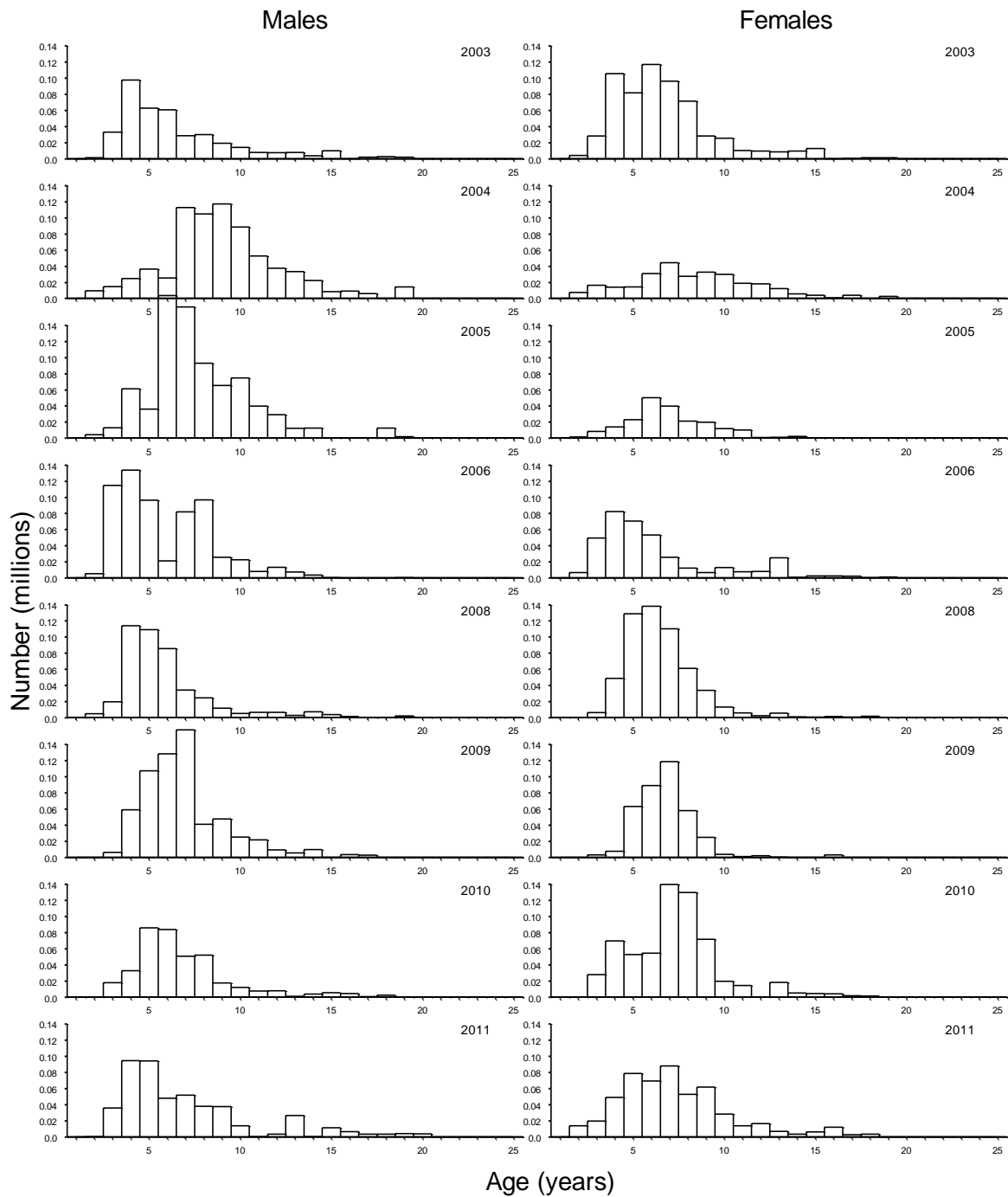


Figure A1 ctd.: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west) trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2003” denotes the October 2002–April 2003 sample.

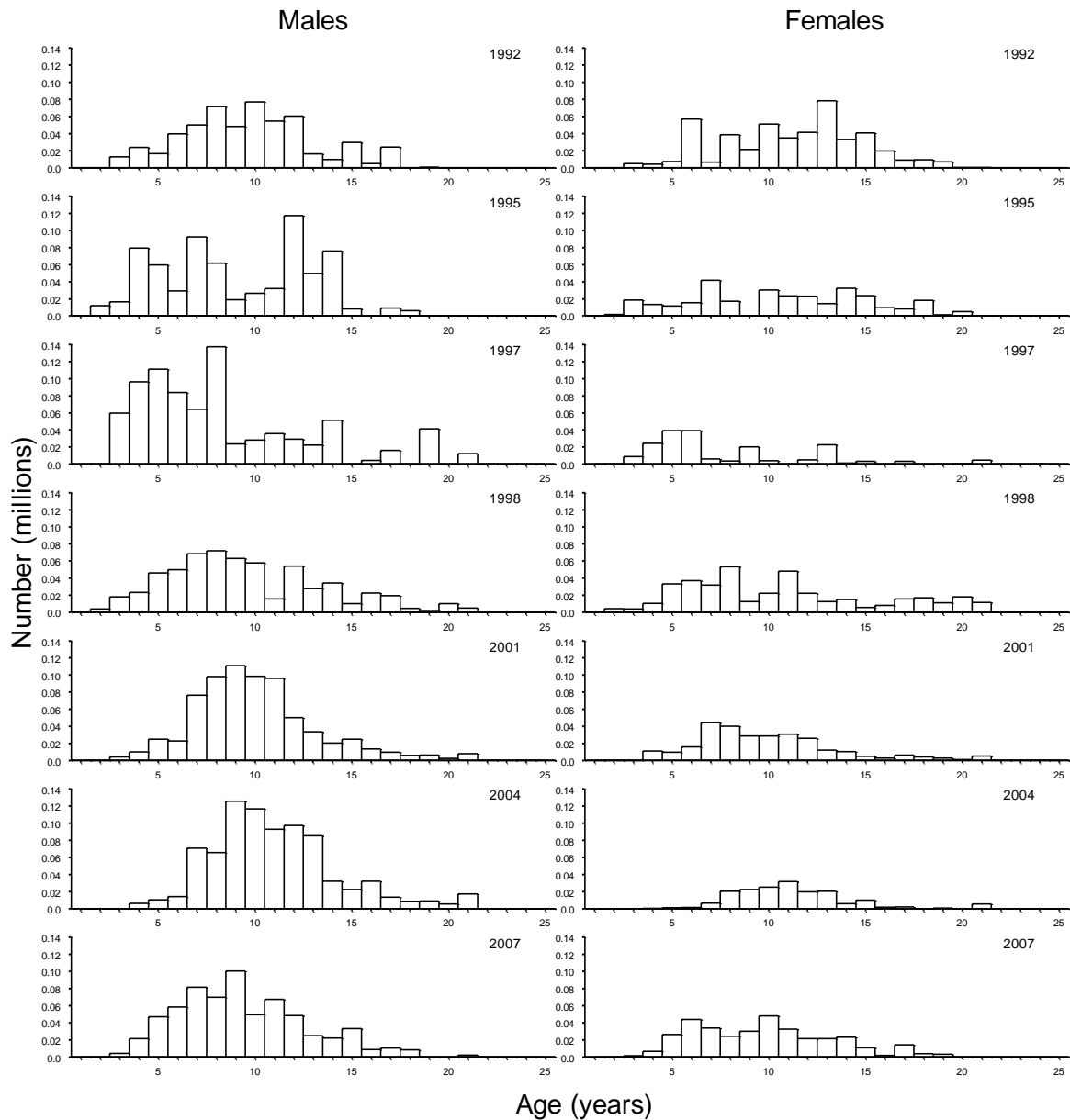


Figure A2: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (east) trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “1992” denotes the October 1991–April 1992 sample.

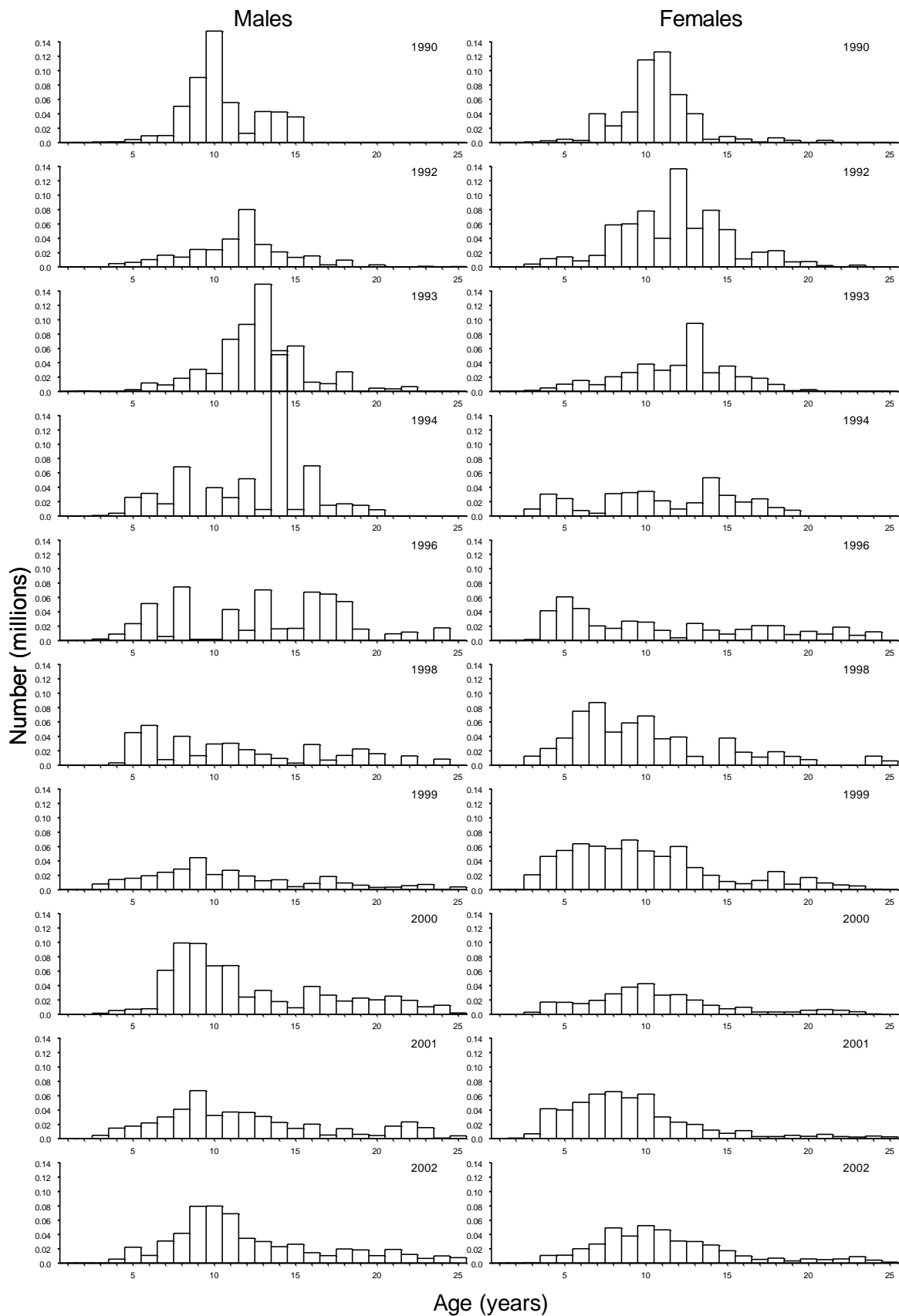


Figure A3: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the September 2001–May 2002 sample.

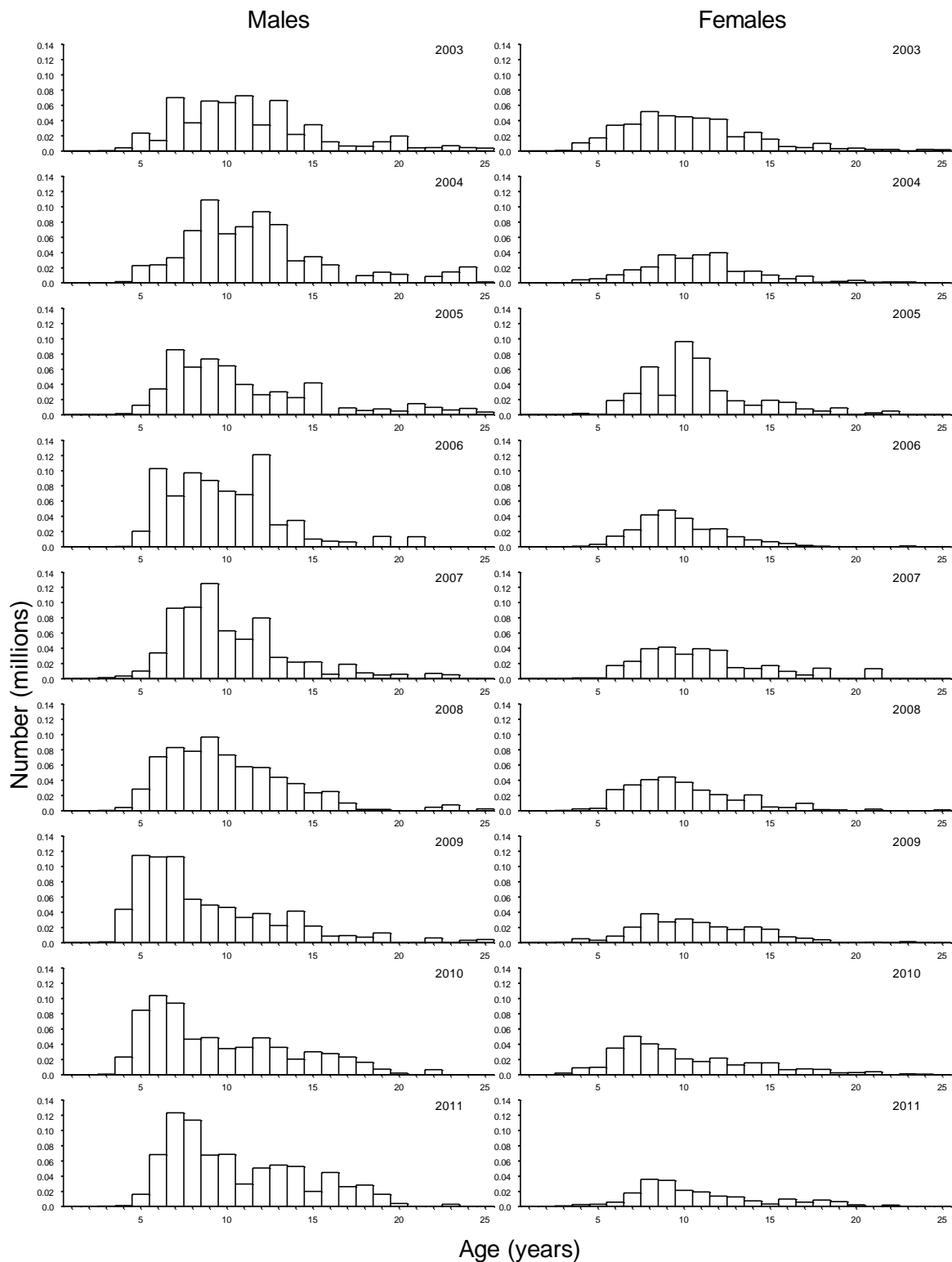


Figure A3 ctd.: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2003” denotes the September 2001–May 2002 sample.

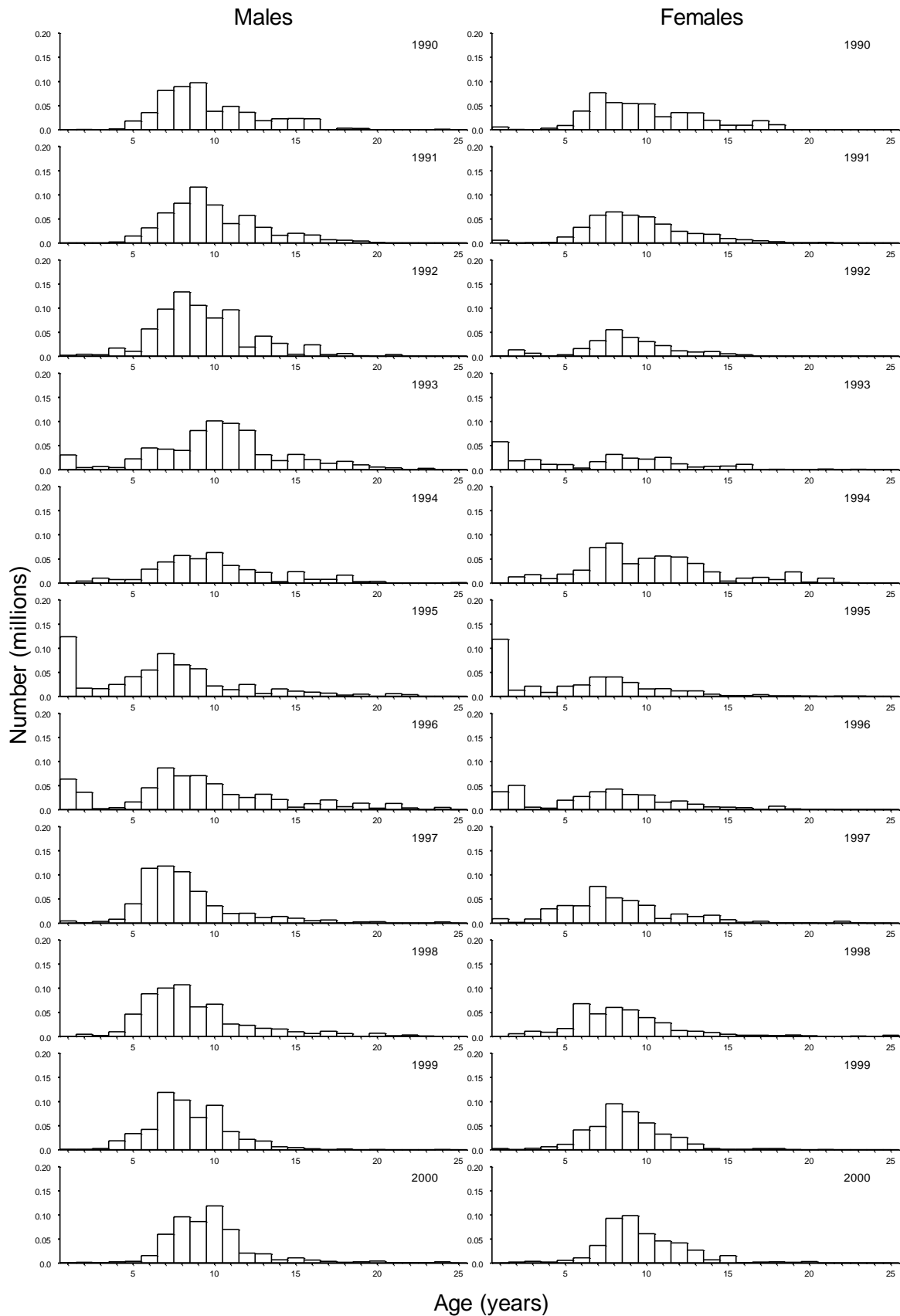


Figure A4: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2011.

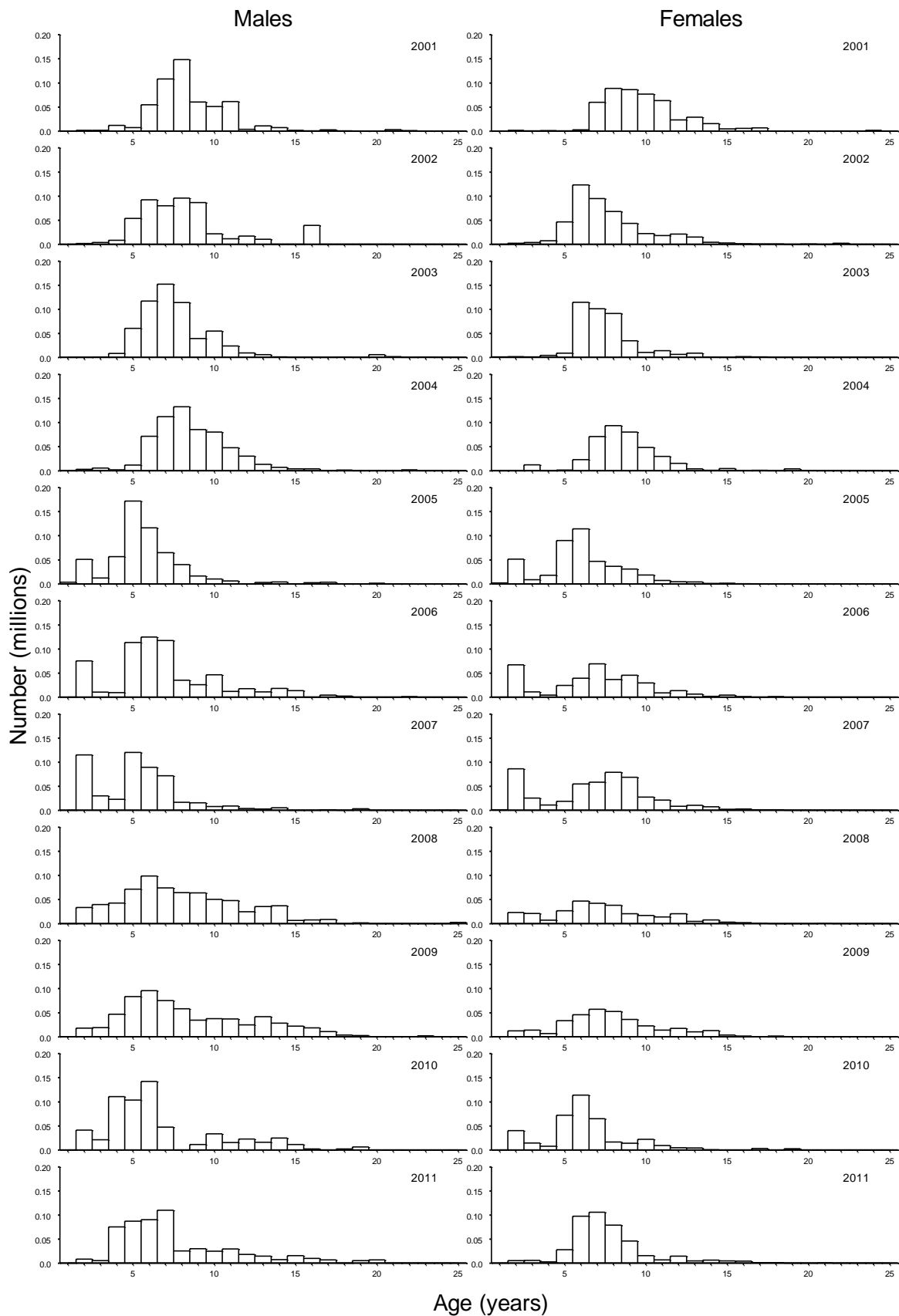


Figure A4 ctd.: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2011.

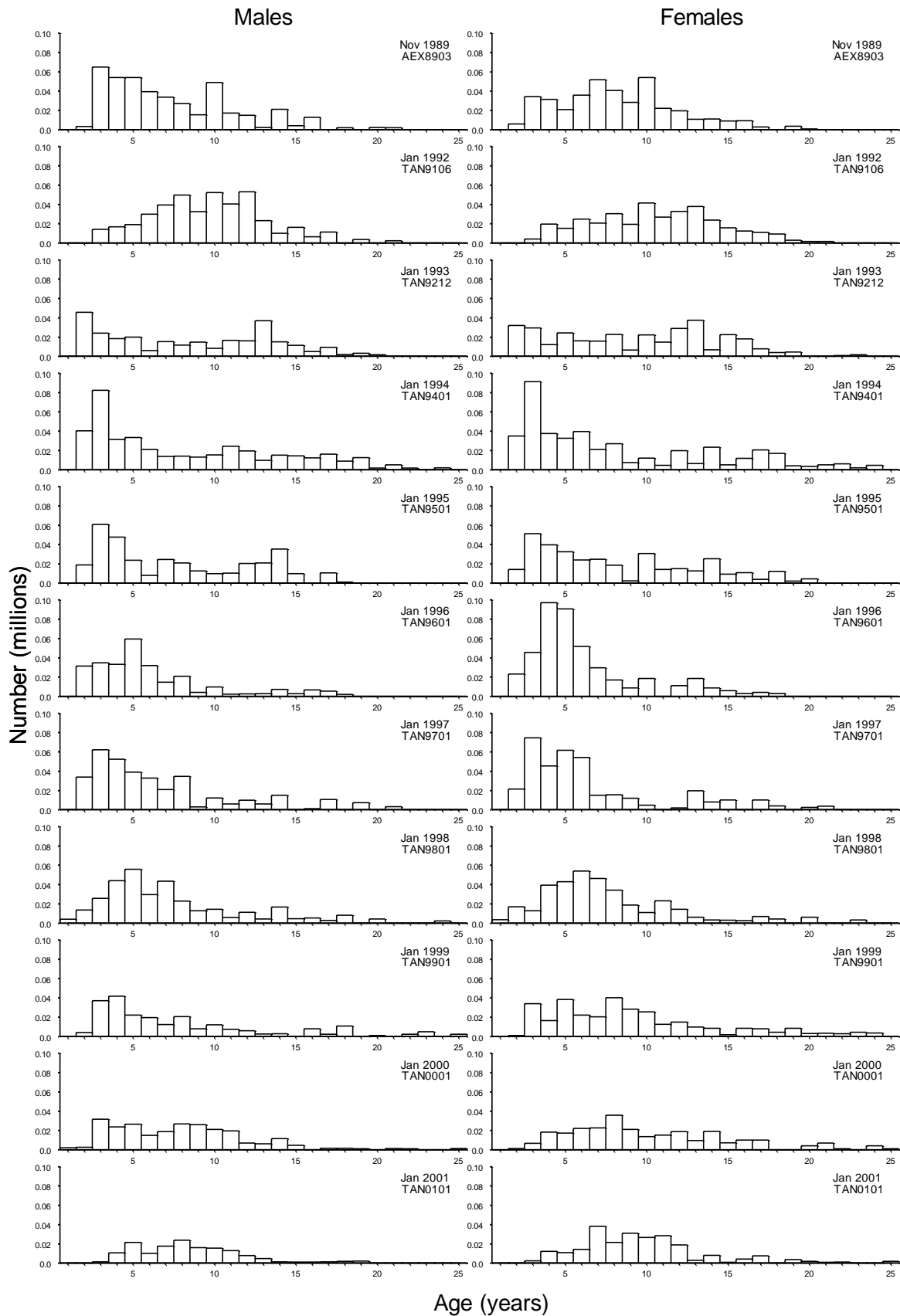


Figure A5: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2011–12.

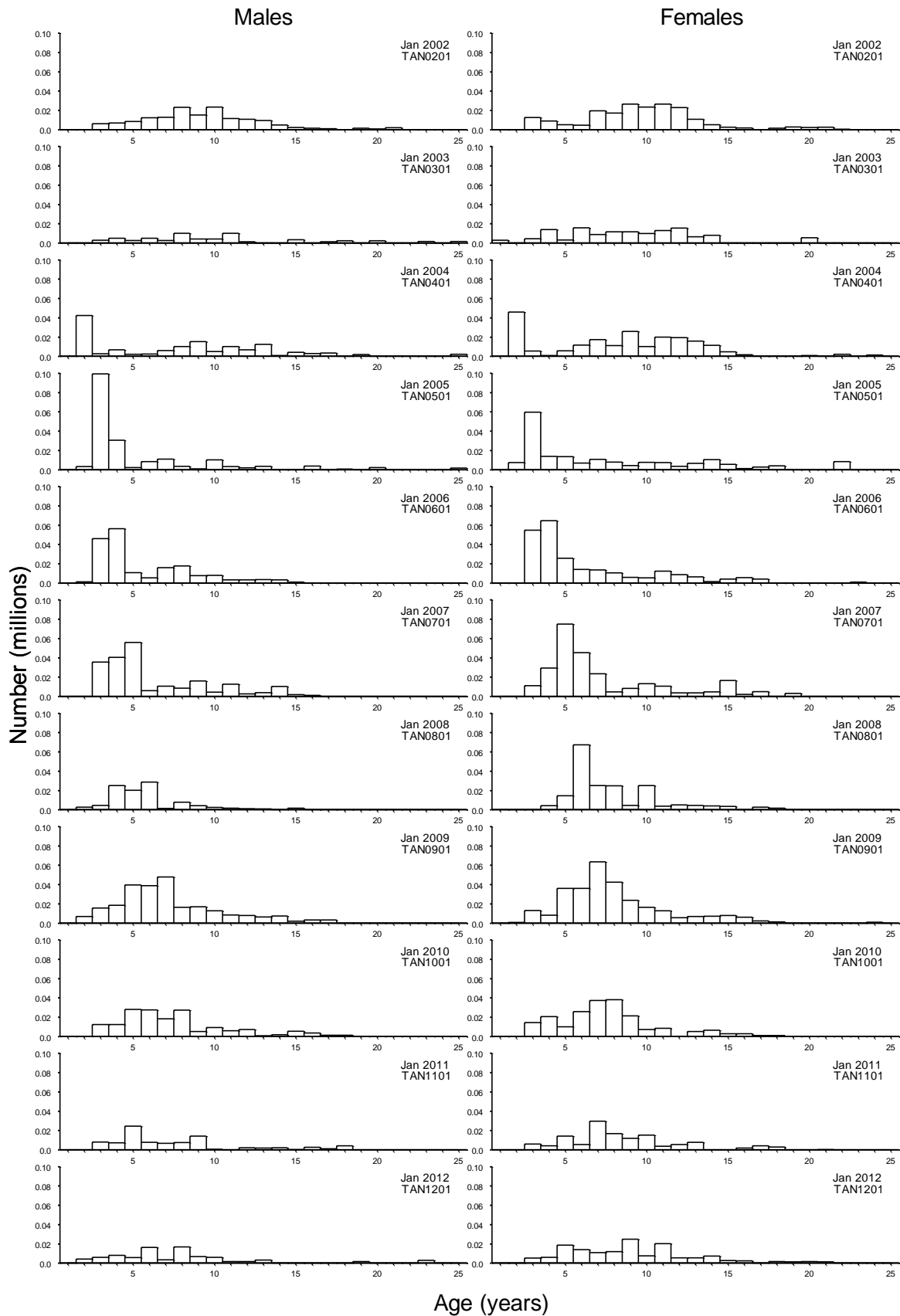


Figure A5 ctd.: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2011–12.

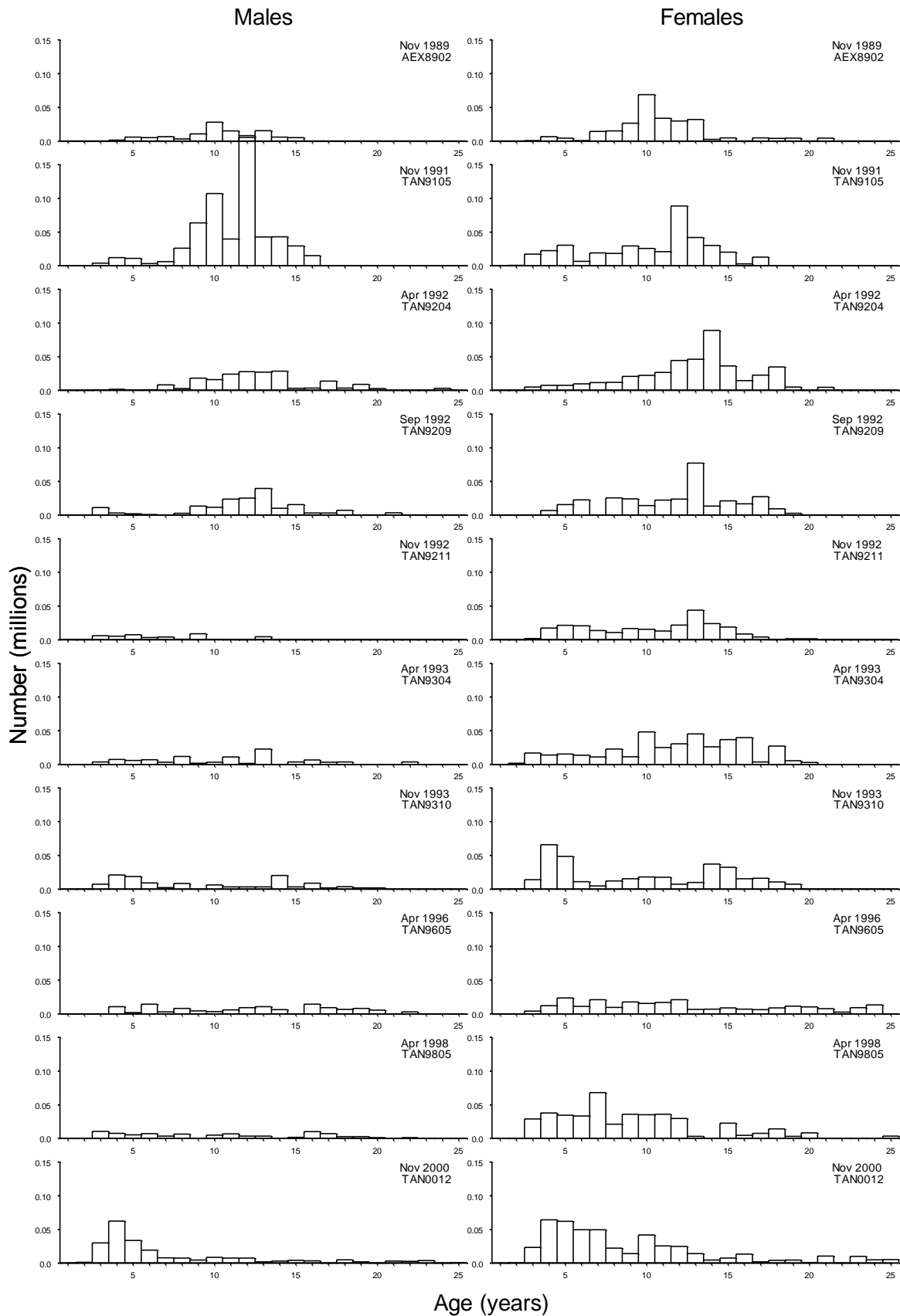


Figure A6: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Sub-Antarctic, 1989 to 2011.

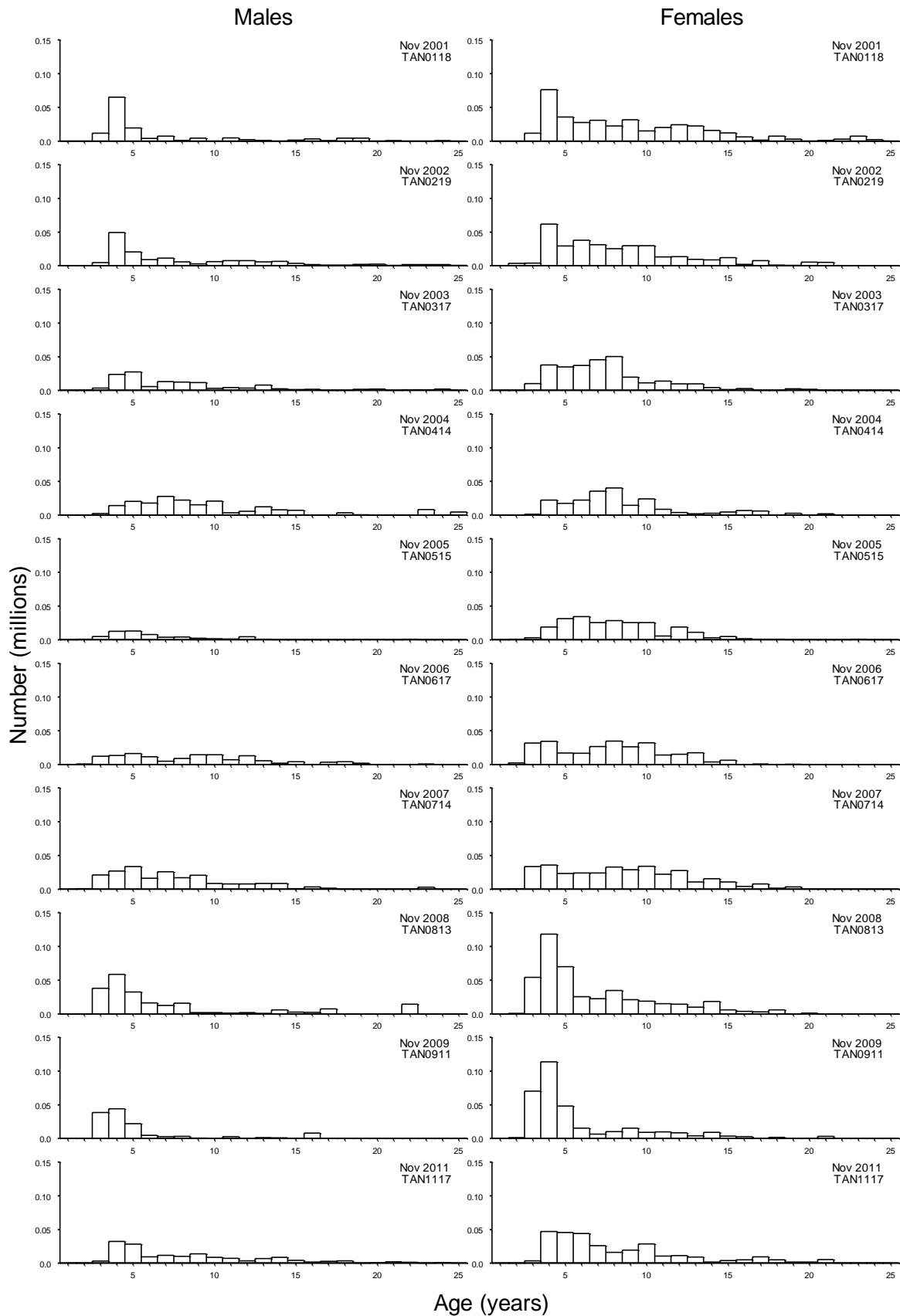


Figure A6 ctd.: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Sub-Antarctic, 1989 to 2011.

Appendix B: Summaries of the proportions-at-age data for ling from resource surveys and observer sampling of line and trawl fisheries

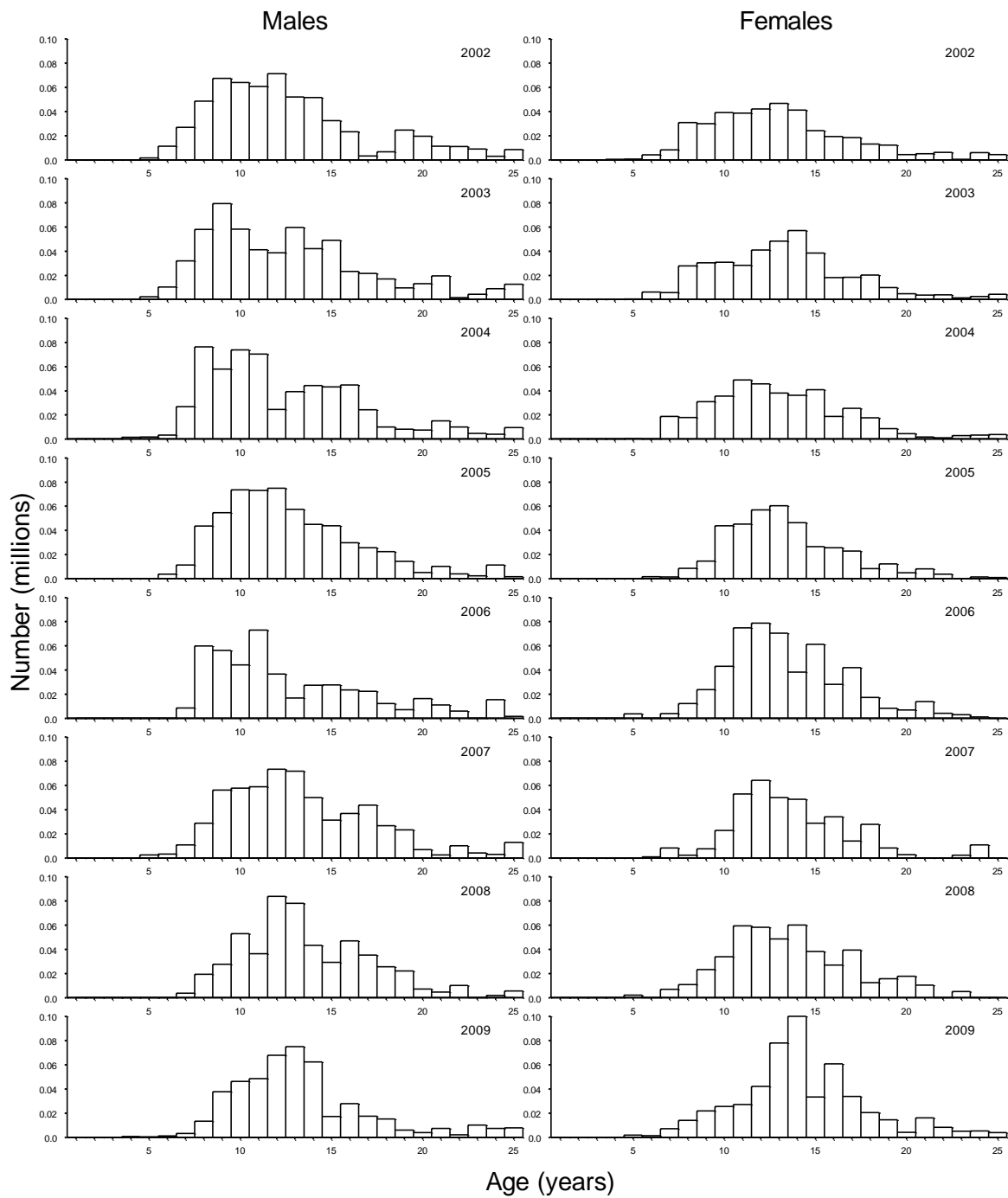


Figure B1: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2011.

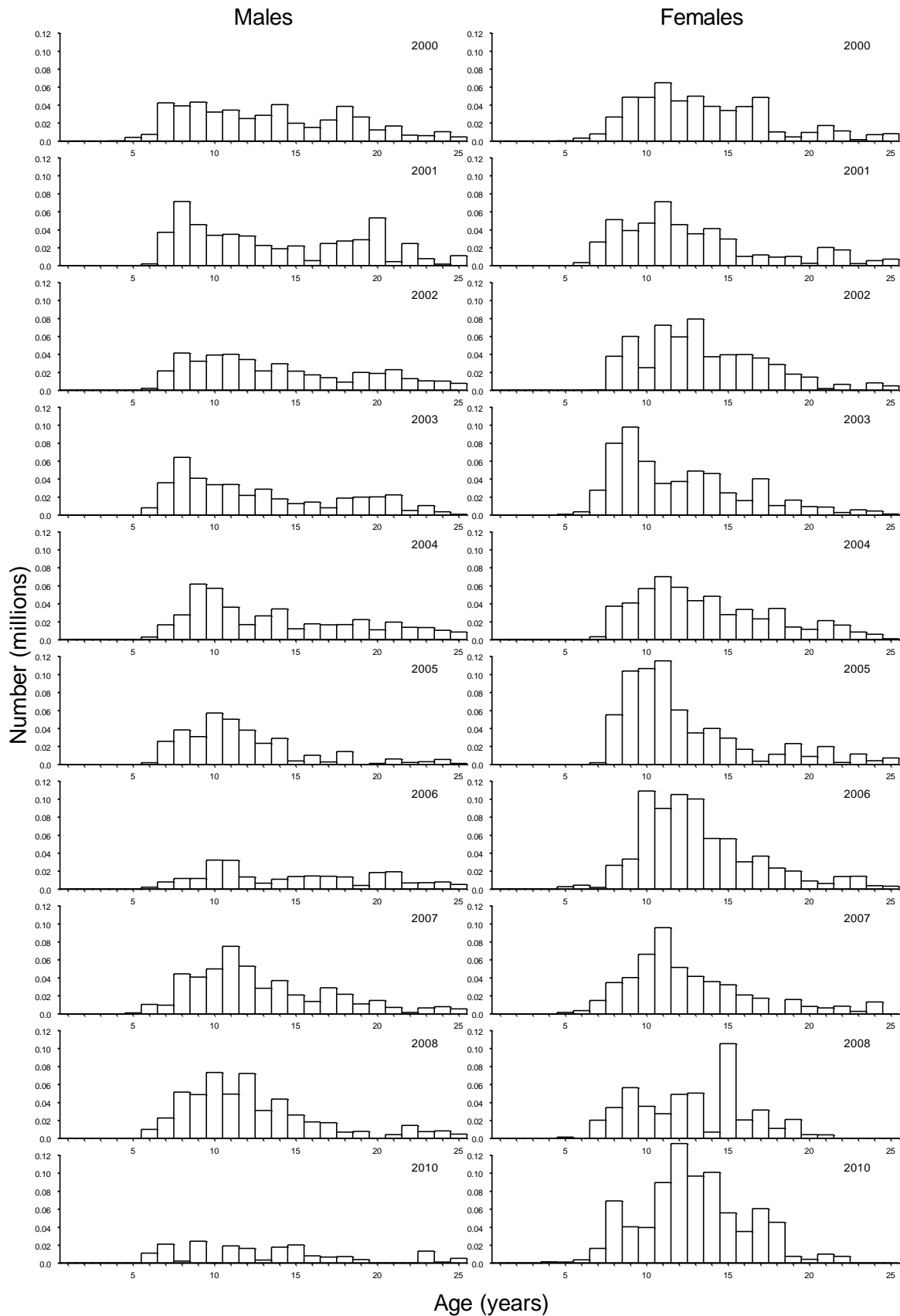


Figure B2: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2011.

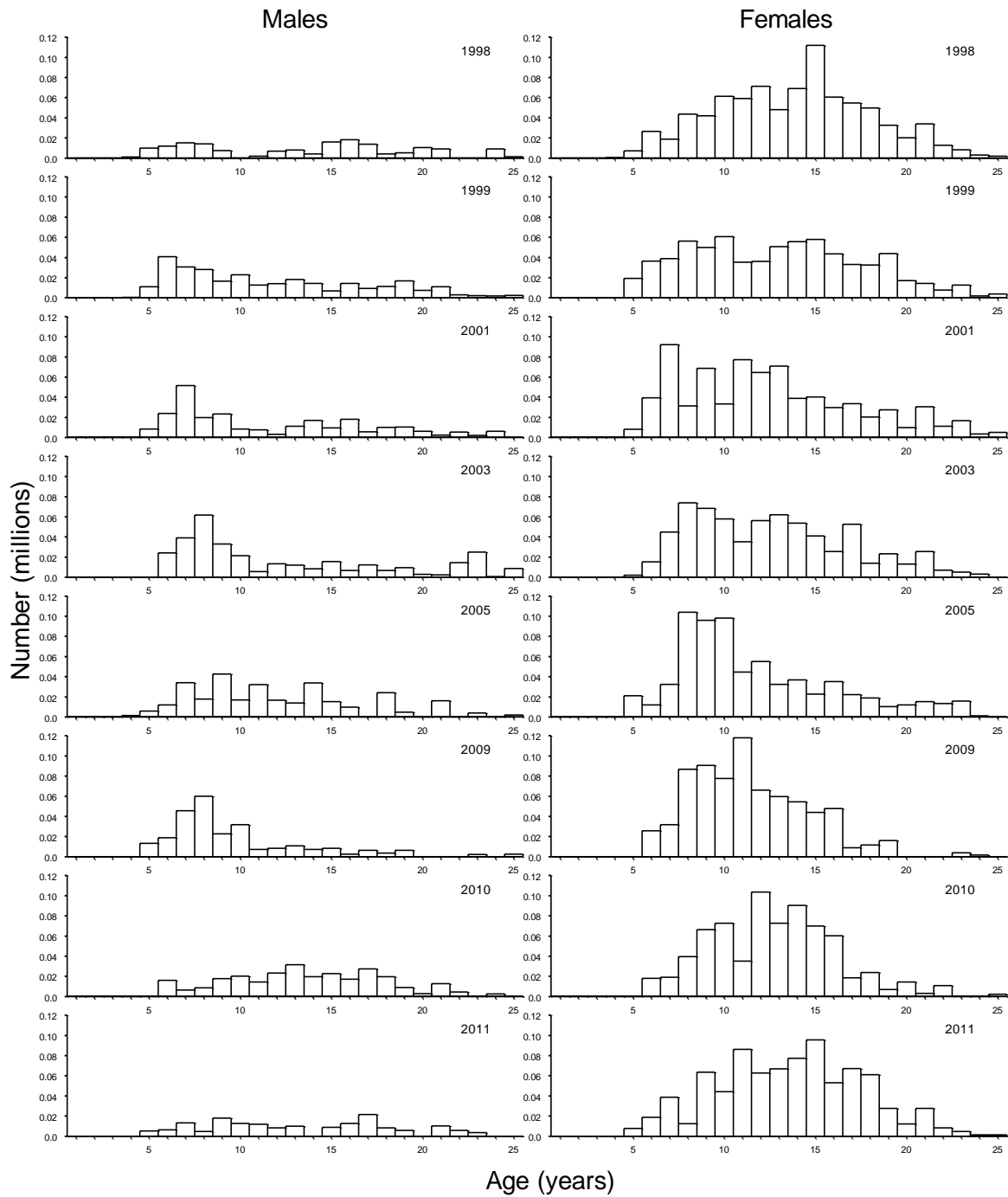


Figure B3: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2011.

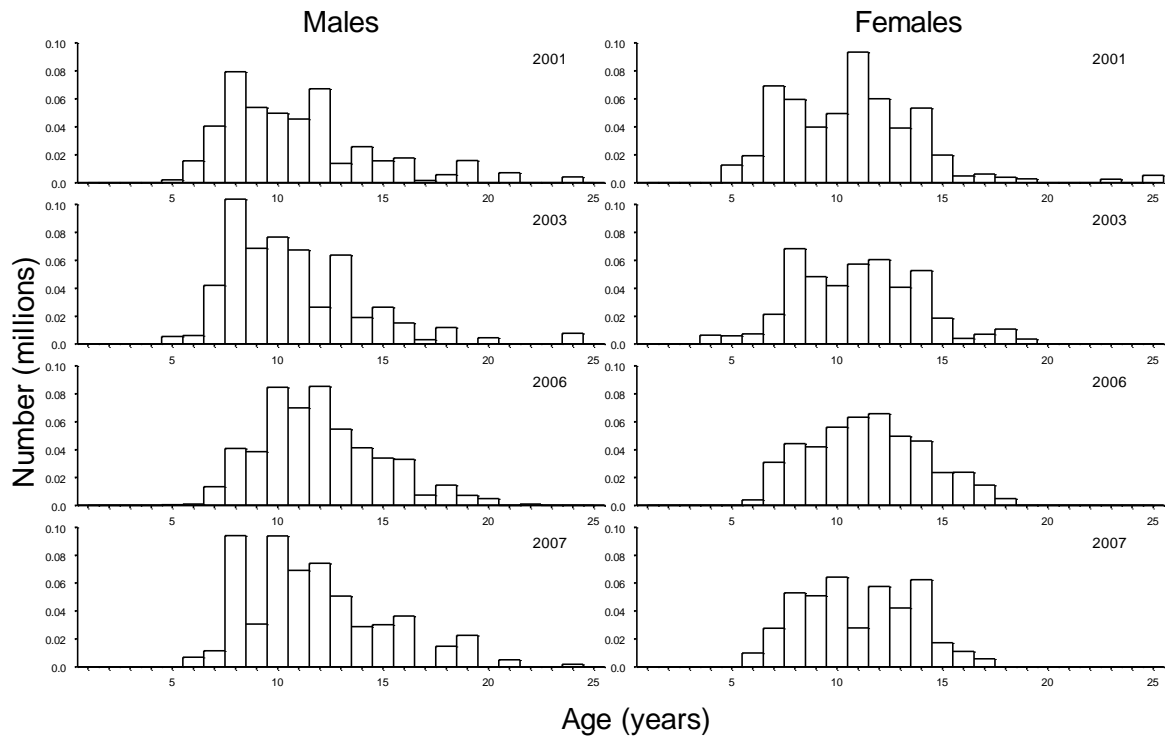


Figure B4: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2001 to 2011.

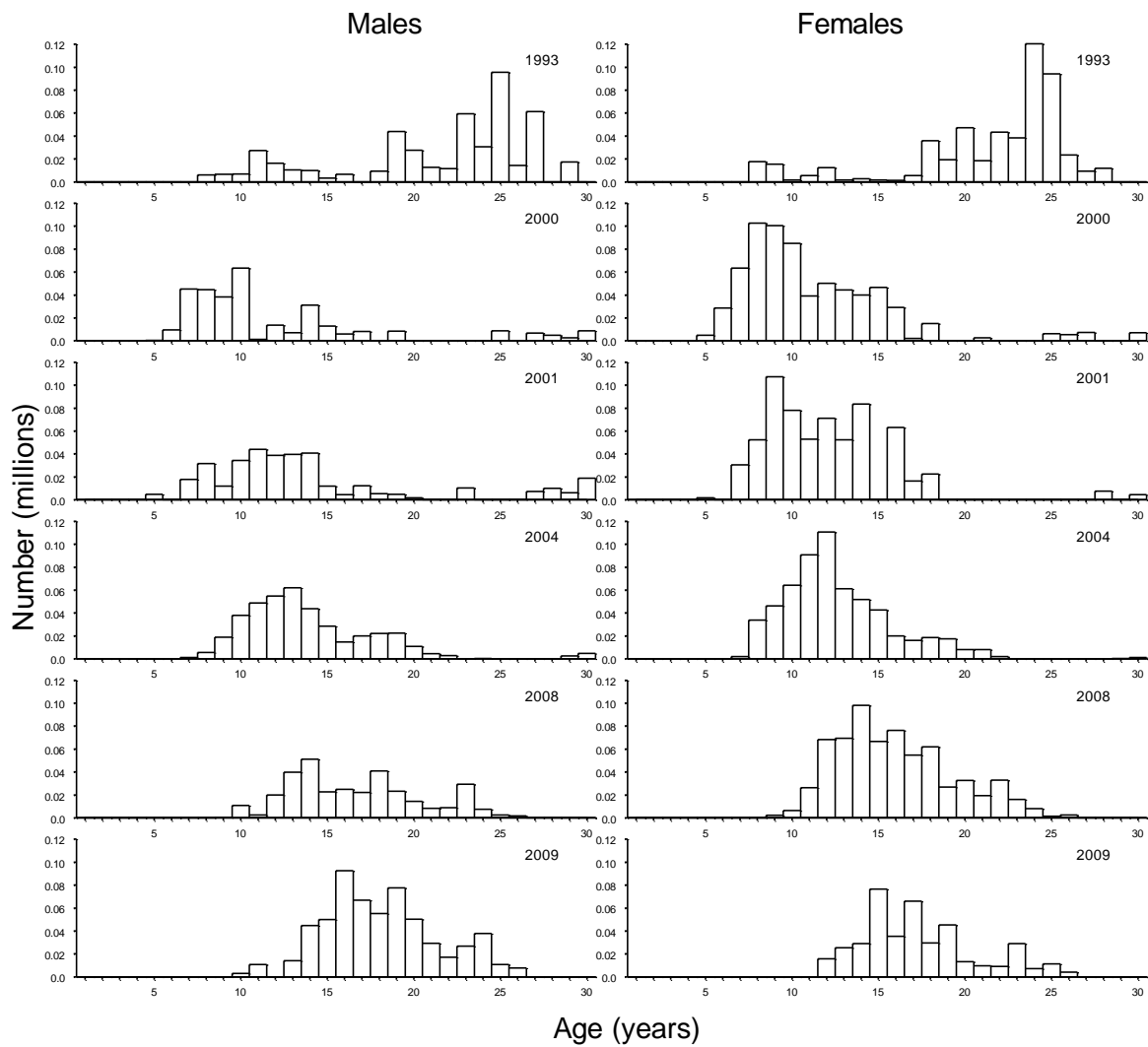


Figure B5: Available age frequencies of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2011.

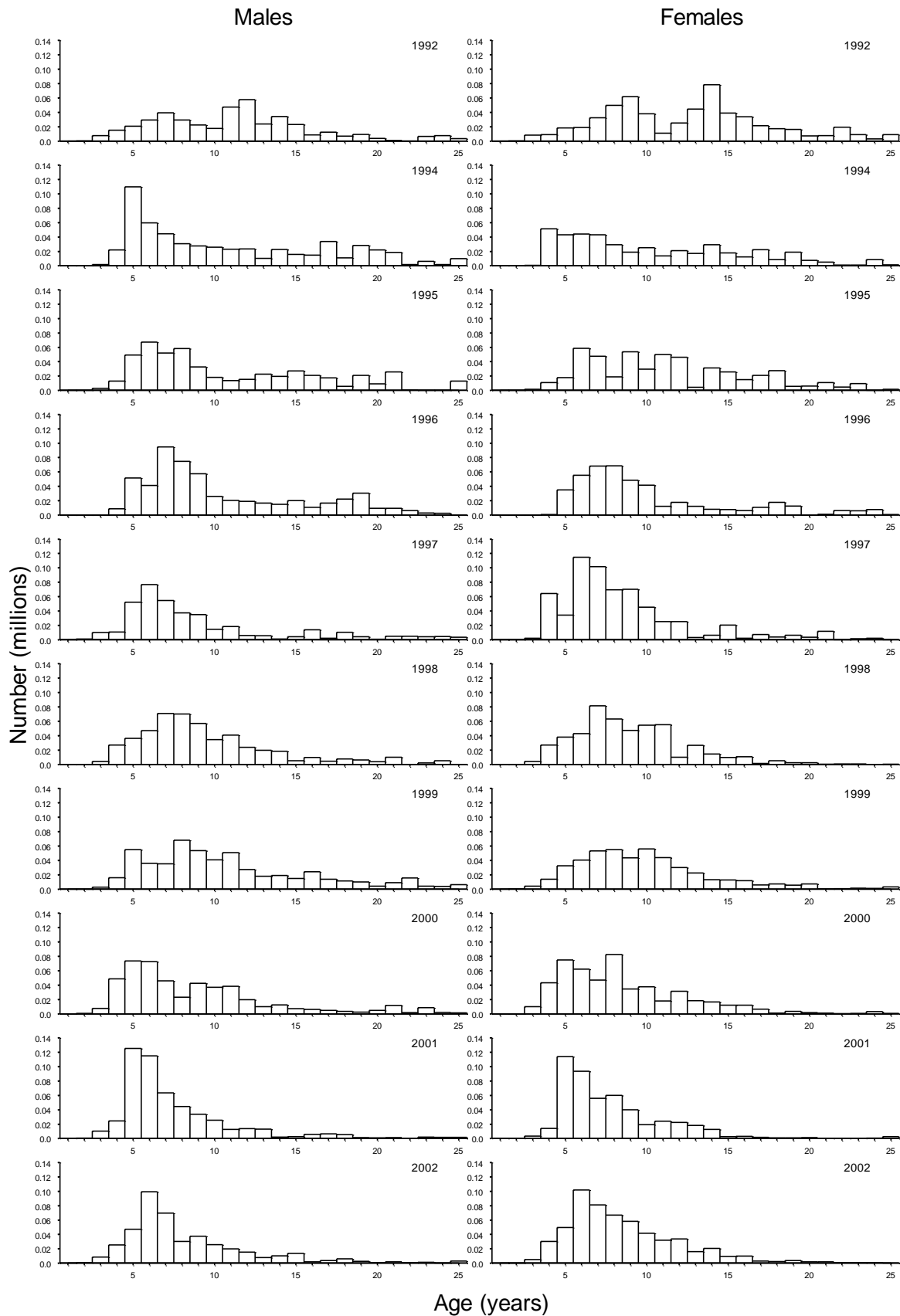


Figure B6: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2002” denotes the October 2001–May 2002 sample.

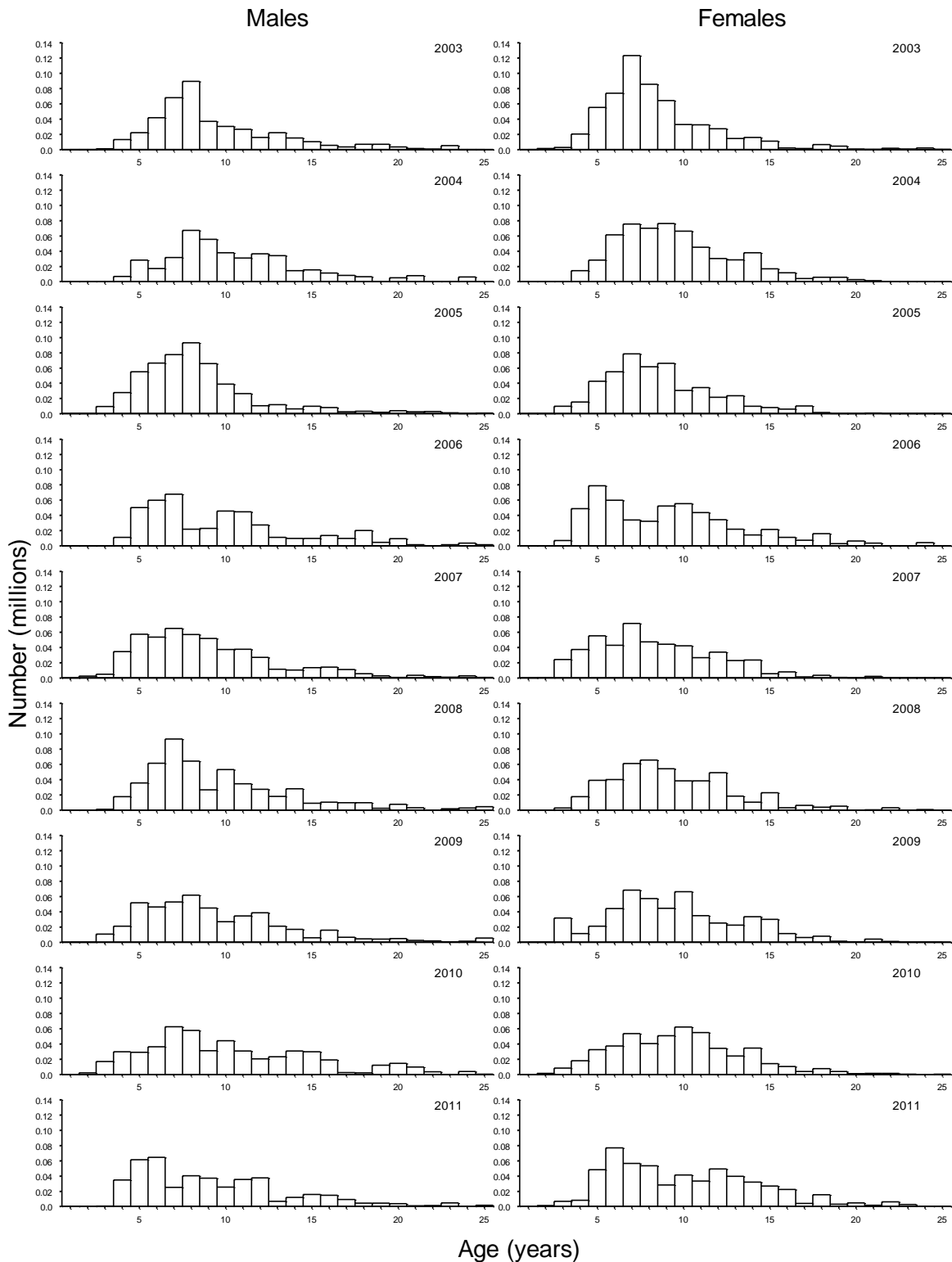


Figure B6 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2003” denotes the October 2002–May 2003 sample.

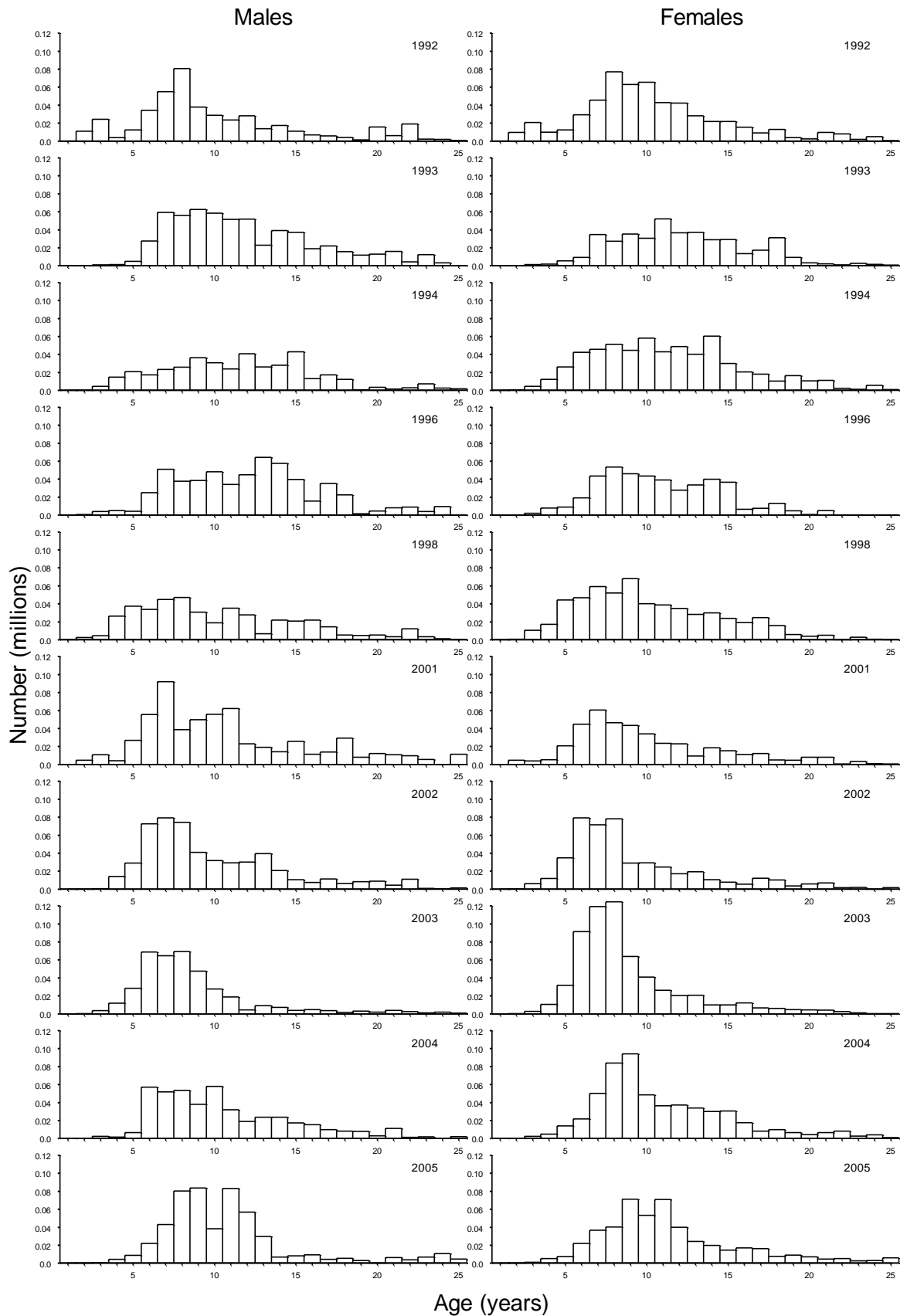


Figure B7: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2005” denotes the September 2004–April 2005 sample.

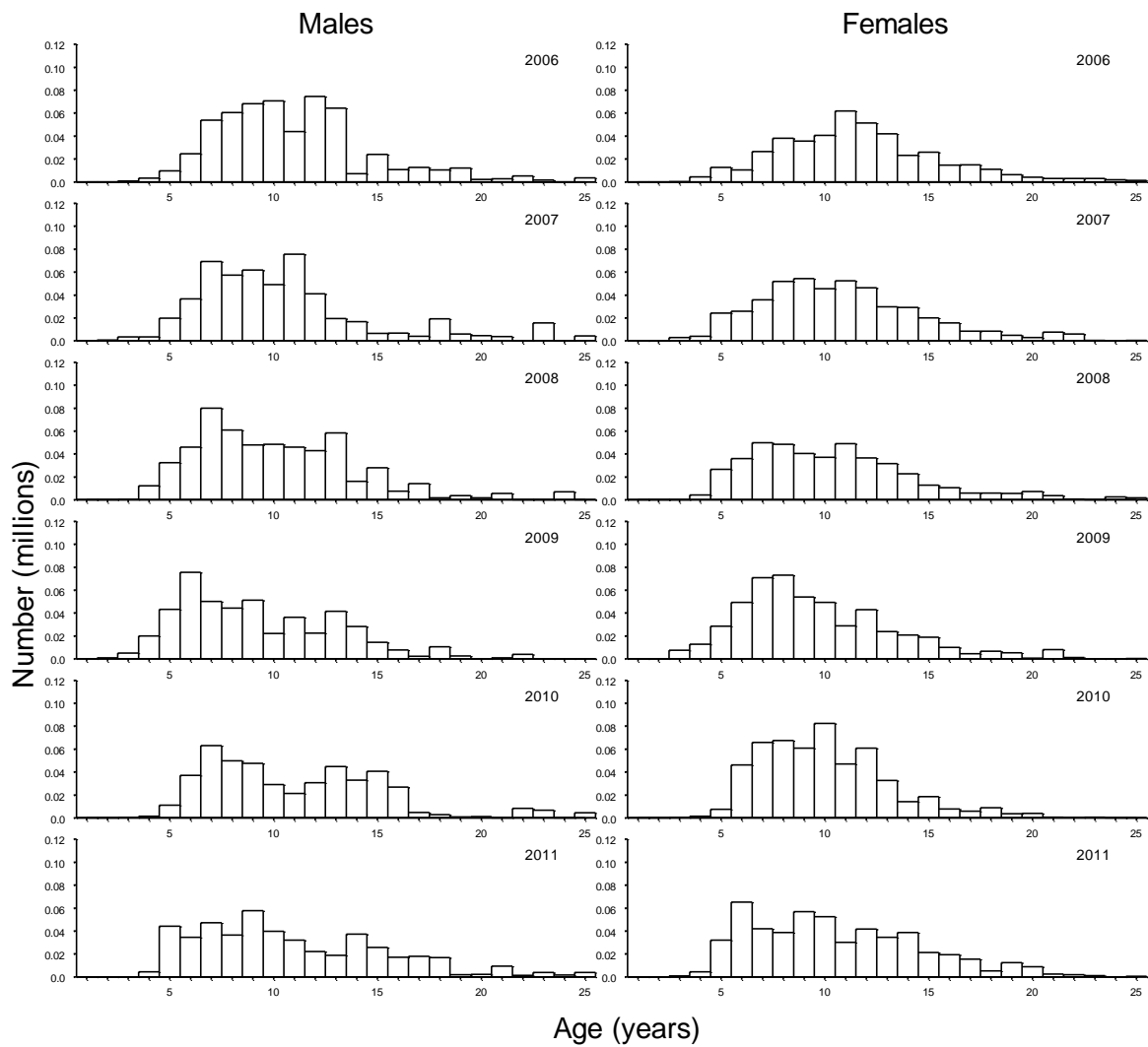


Figure B7 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2011. Year labels relate to the latter year when sampling occurs over two calendar years, e.g., “2006” denotes the September 2005–April 2006 sample.

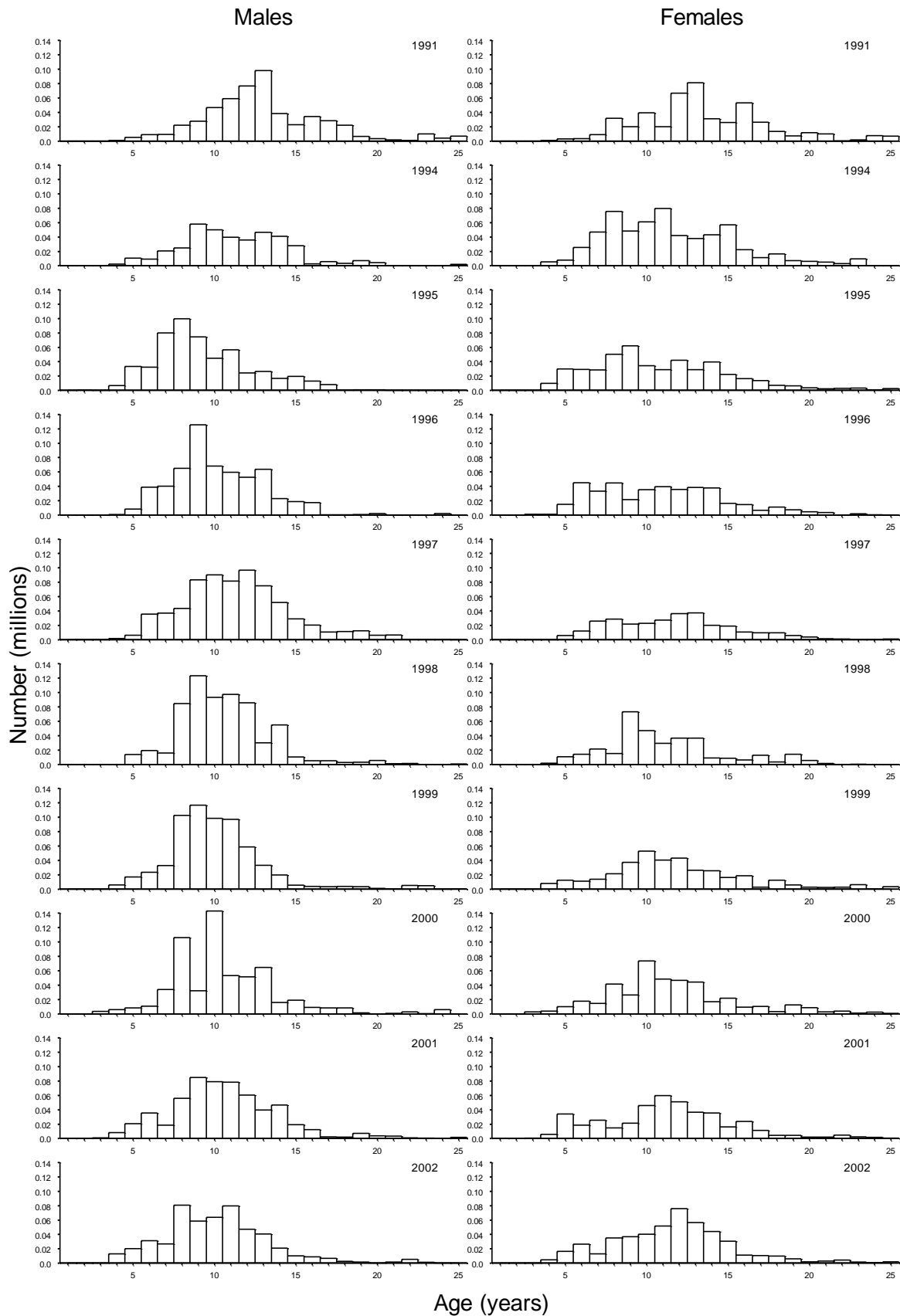


Figure B8: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2011.

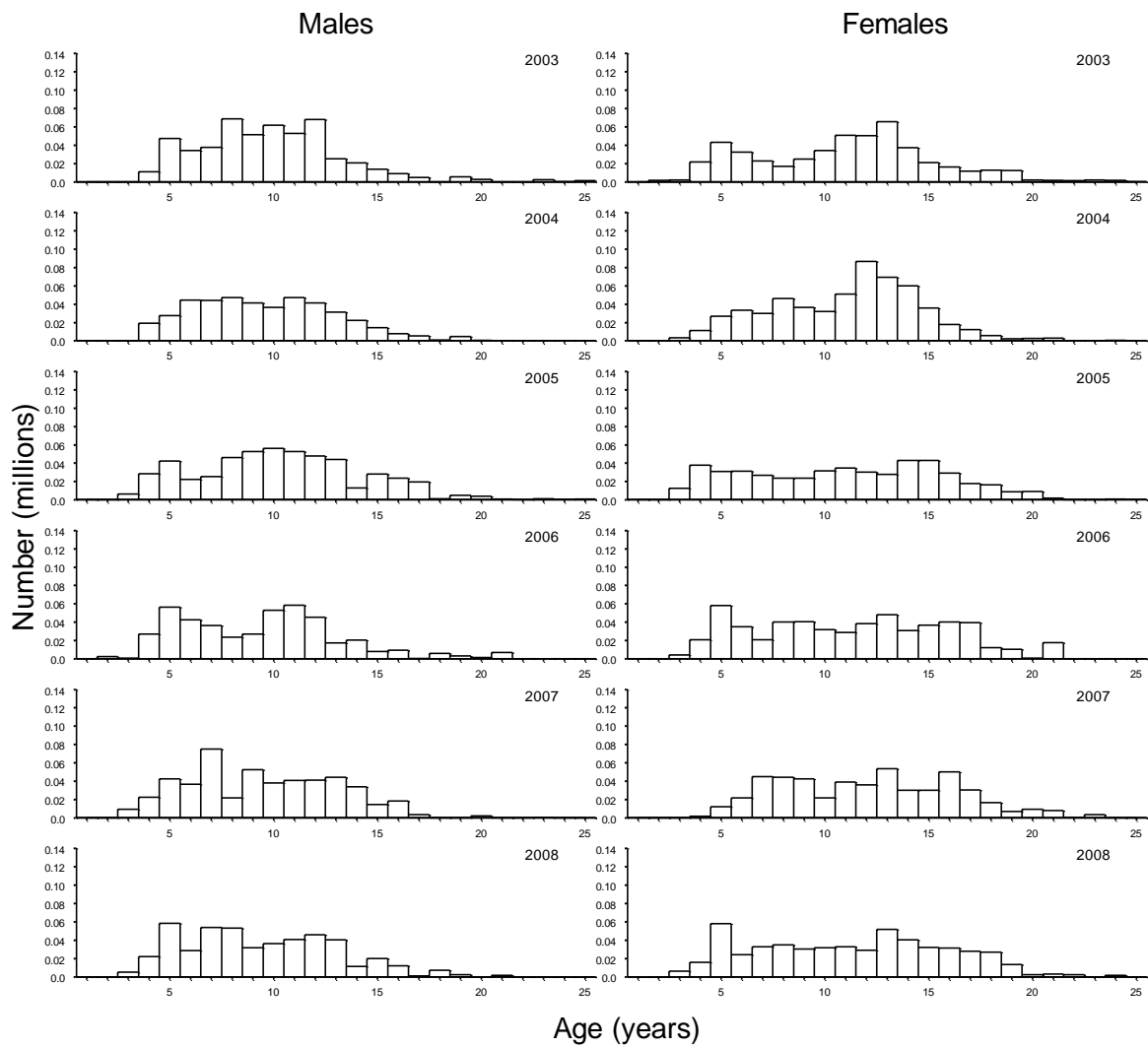


Figure B8 ctd.: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2011.

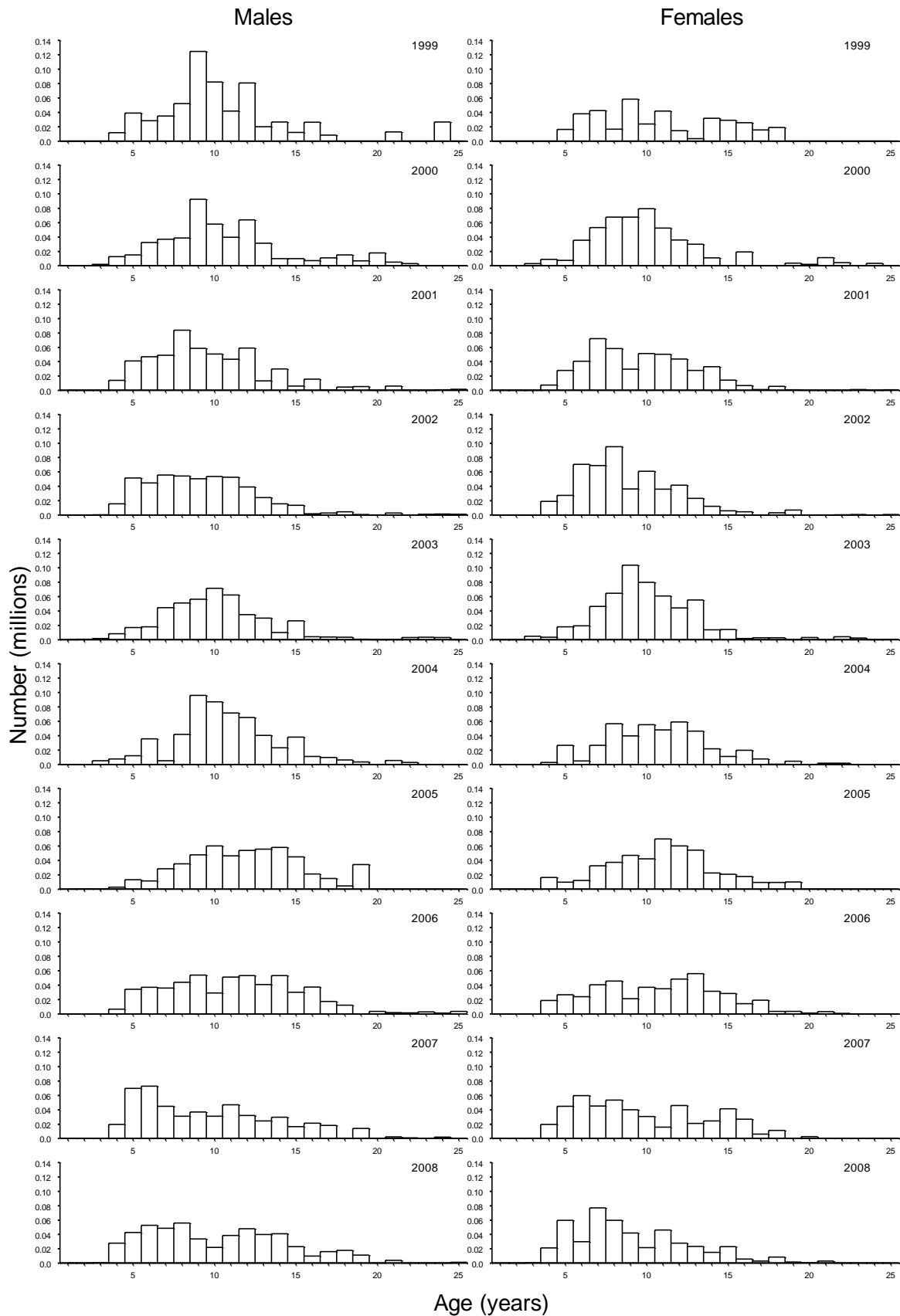


Figure B9: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2011.

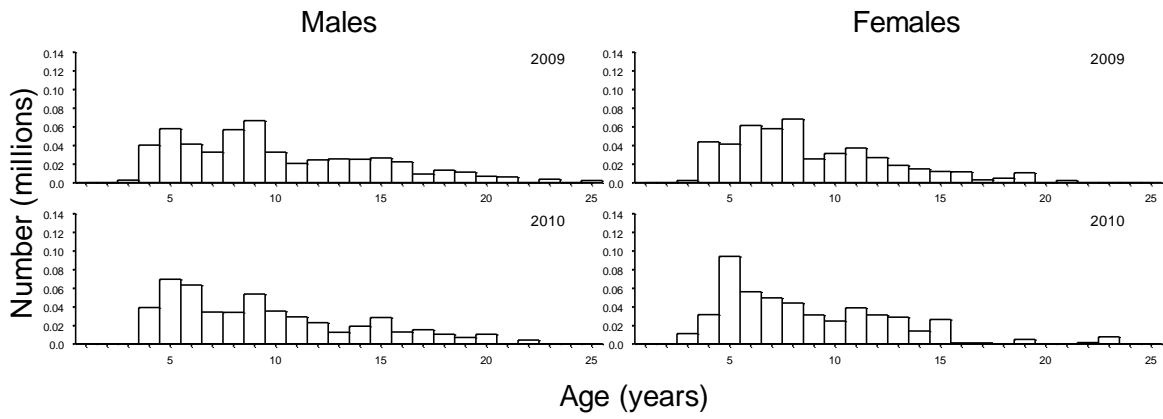


Figure B9 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2011.

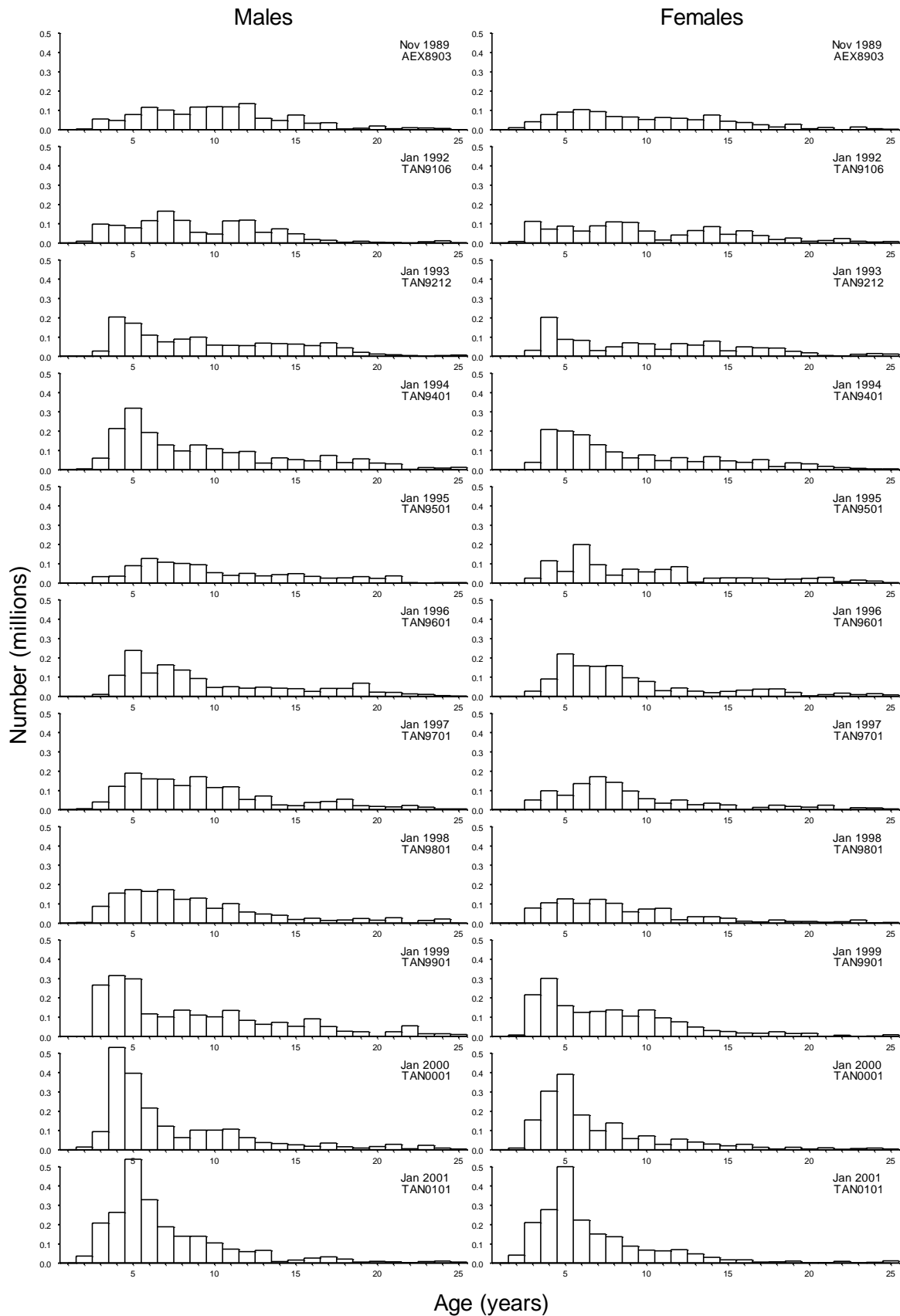


Figure B10: Available age frequencies of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2011–12.

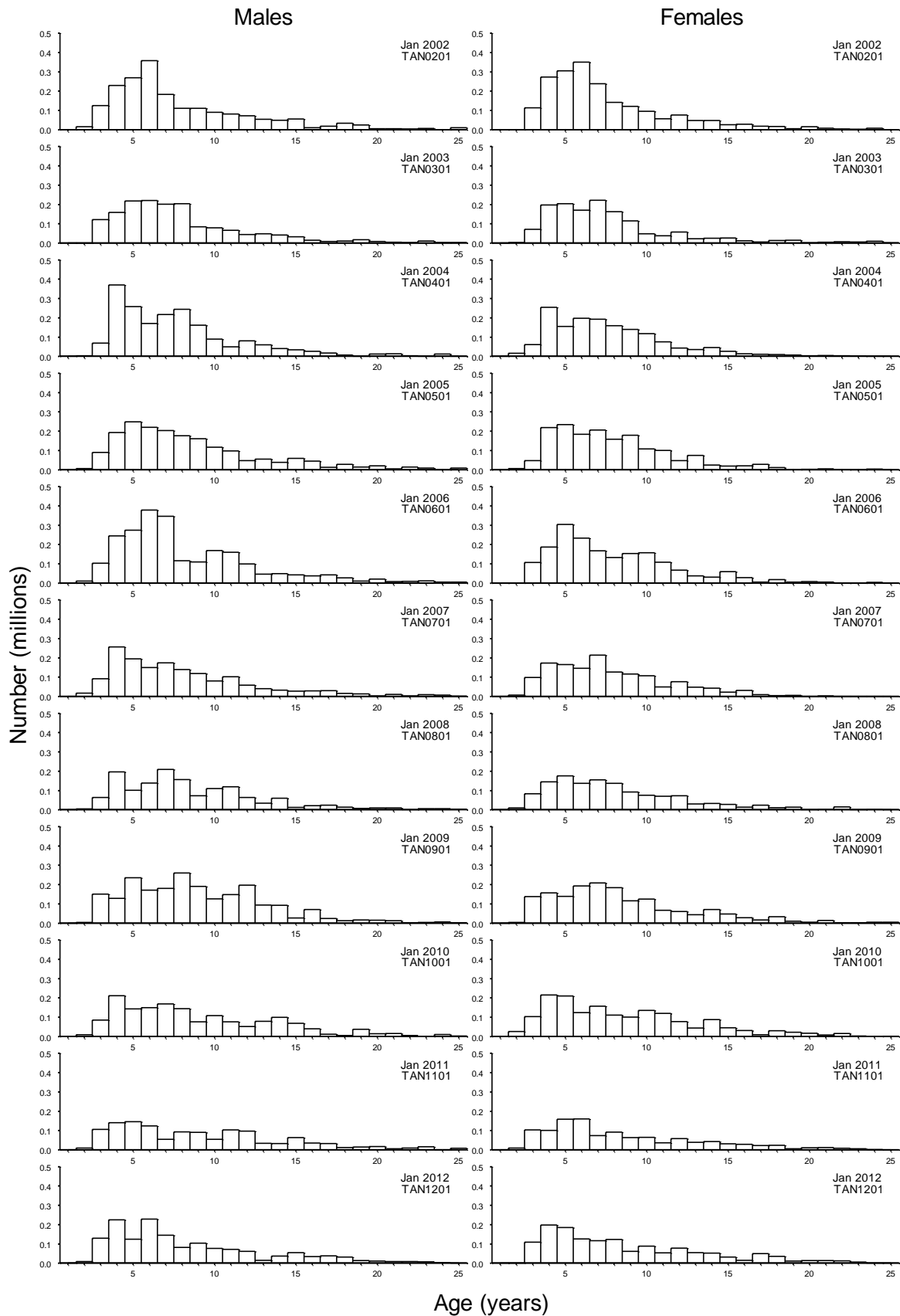


Figure B10 ctd.: Available age frequencies of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2011–12.

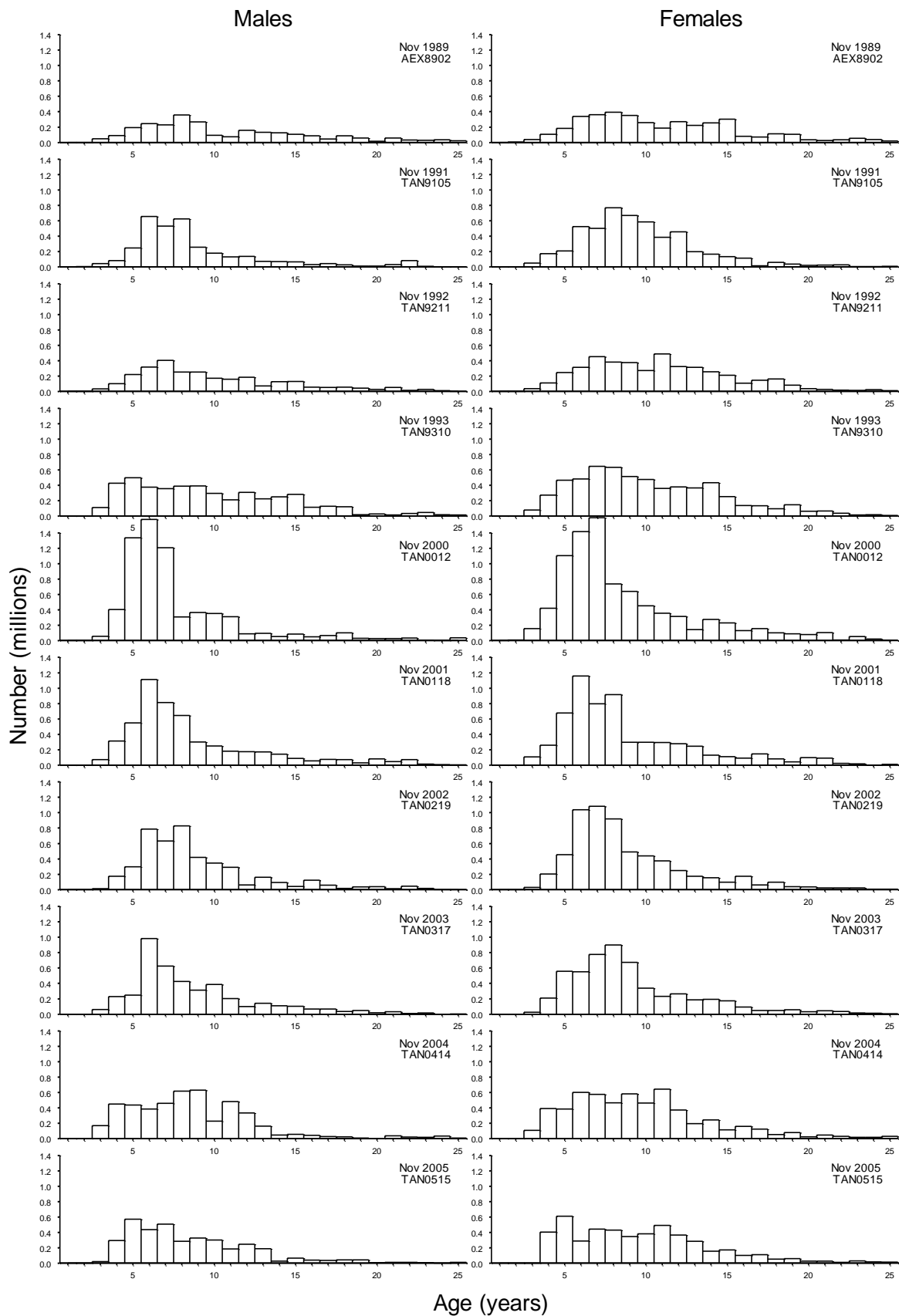


Figure B11: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2011.

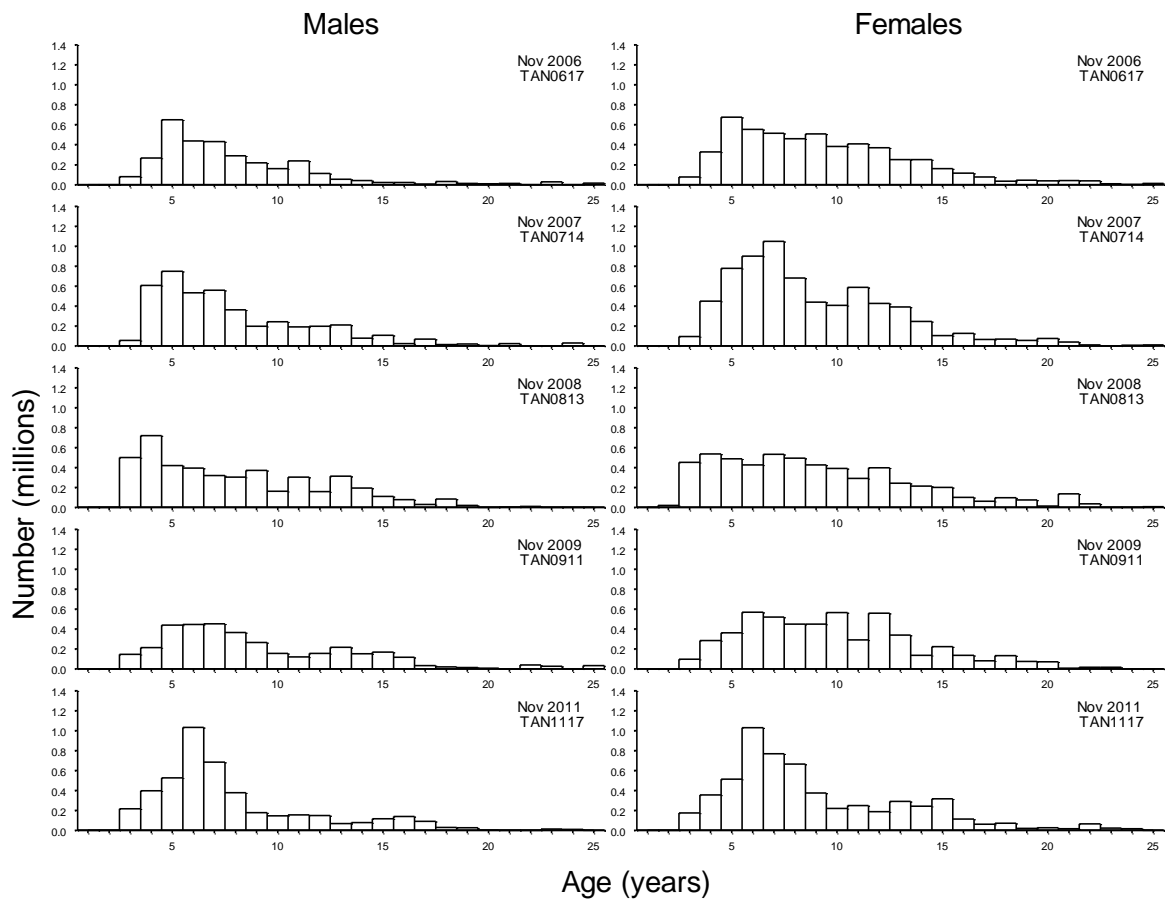


Figure B11 ctd.: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2011.

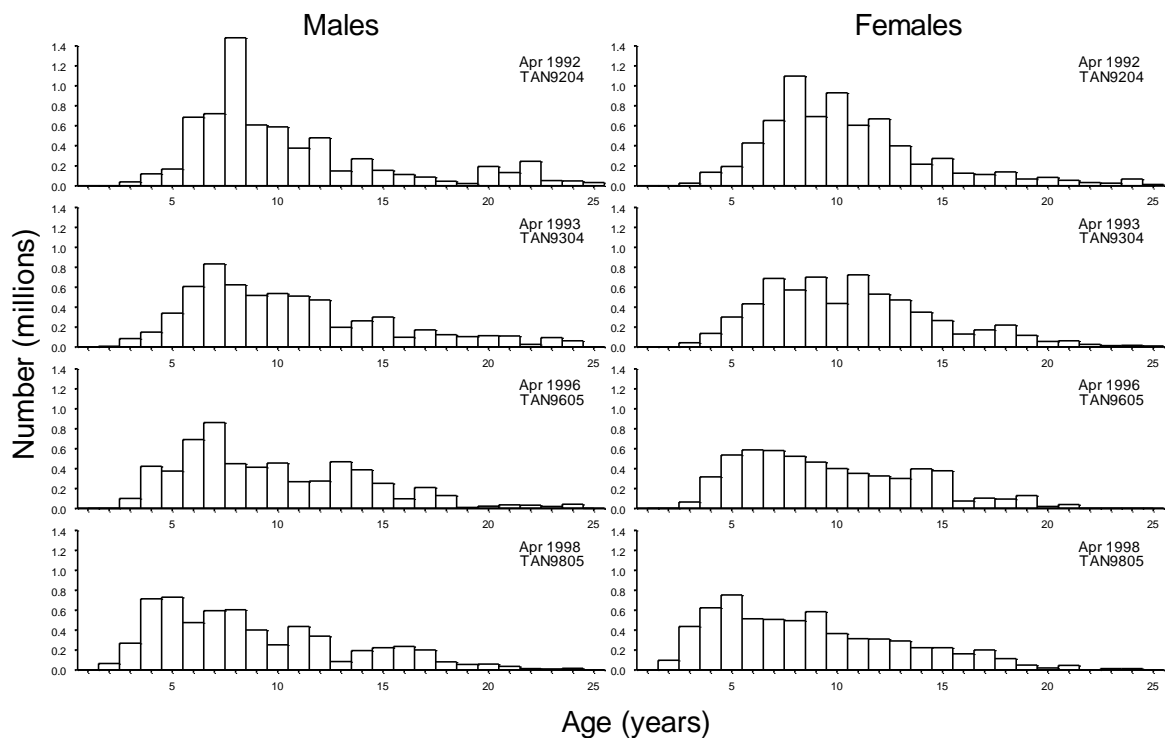


Figure B12: Available age frequencies of ling (ages 1 to 25) from autumn resource surveys in the Sub-Antarctic, 1992 to 1998.