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and from trawl surveys in summer 2008–09,
with a summary of all available data sets

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EXECUTIVE SUMMARY

Horn, P.L.; Sutton, C.P. (2009). Catch-at-age for hake (*Merluccius australis*) and ling (*Genypterus blacodes*) in the 2007–08 fishing year and from trawl surveys in summer 2008–09, with a summary of all available data sets.

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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 2007–08 fishing year (using data and otoliths collected at sea by observers), and from trawl surveys of hoki and middle depth species on the Campbell Plateau in December 2008 (TAN0813) and the Chatham Rise in January 2009 (TAN0901). For each estimated catch at age distribution there is 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 the three commercial fishery samples (WCSI, Sub-Antarctic, and Chatham west deep), and nearly met for the two 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 both trawl survey samples and for the commercial trawl fisheries in the Chatham Rise, Sub-Antarctic, WCSI, and Cook Strait areas. Of the three ling longline fisheries for which catch at age distributions were produced for 2007–08, the c.v. targets were met for the Chatham Rise and Bounty Plateau fisheries, but not for the Sub-Antarctic spawning (Puysegur) fishery.

In all distributions for both species where the target c.v. was not met it was not possible to improve the precision as all available data and otoliths had been used in the analyses.

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 2007–08 fishing year, and for hake and ling from trawl surveys conducted during the summer of 2008–09. 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 second year's reporting requirements for Objectives 4 and 5 and the first year's reporting requirements for Objective 6 of Project MID2007-01 "Determination of catch at age in hoki, hake and ling fisheries", funded by the Ministry of Fisheries. Those objectives are:

4. To determine the catch at age from hake fisheries in HAK 1, 4 and 7 from samples collected at sea by the Observer Programme, by trawl surveys and from other sources in 2007/08, with a target coefficient of variation (c.v.) of 30% for each fishstock (mean weighted c.v. across all age classes).
5. To determine the catch at age from ling fisheries in LIN 3 & 4, 5 & 6 and 7 in 2007/08 from samples collected at sea by the Observer Programme, by trawl surveys and from other sources, with a target coefficient of variation (c.v.) of 30% for each fishstock (mean weighted c.v. across all age classes).
6. To collect the otoliths required for determining the catch at age from the Cook Strait ling fishery in winter 2008 and determine the length frequency distribution of this catch (LIN 2 & 7).

The report also summarises all the available 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).

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 — trawl survey, Dec 2008 (project MDT2007-01B) [600]
HAK 1 — commercial trawl fishery, Sep 2007–May 2008 [600]
HAK 4 — trawl survey, Jan 2009 (project HOK2007-02B) [all available]
HAK 4 — commercial trawl fishery, Oct 2007–April 2008 [500]
HAK 7 — commercial trawl fishery, Jun–Sep 2008 [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 2009 (project HOK2007-02B) [640]
LIN 3&4 — commercial longline fishery, Jun–Oct 2008 [580]
LIN 5&6 — trawl survey, Dec 2008 (project MDT2007-01B) [570]
LIN 5&6 — commercial longline fishery, spawning, Puysegur, Oct–Dec 2007 [500]
LIN 5&6 — commercial longline fishery, non-spawning, Campbell, Feb–Jul 2008 [500]
LIN 7 — commercial trawl fishery, west coast South Island, Jun–Sep 2008 [600]
LIN 7&2 — commercial trawl fishery, Cook Strait, Jun–Sep 2008 [500]

As no observer otoliths were available from the non-spawning Campbell ling line fishery, resources were transferred to processing and reading a sample from the Bounty Plateau line fishery. Samples from this fishery had previously been analysed. Also, the following additional commercial fishery catch-at-age distributions for ling were estimated using age-length keys derived previously from the January 2008 Chatham Rise trawl survey (LIN 3&4) and the December 2007 Sub-Antarctic trawl survey (LIN 5&6).

LIN 3&4 — commercial trawl fishery, Oct 2007–May 2008

LIN 5&6 — commercial trawl fishery, Sep 2007–Apr 2008

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 does better than 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 sometimes provides only small numbers of otoliths. Consequently, catch-at-age distributions for these fisheries are estimated using age-length keys combining commercial fishery and trawl survey age data. For example, the age-length key for the 2007–08 HAK 4 fishery includes otoliths from observer sampling from October 2007 to May 2008 plus age data from the TAN0801 trawl survey in January 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 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

The fishery on the Chatham Rise is stratified 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)

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.

Mean fish length tends to increase from west to east, and with increasing depth. Area 404 is a known spawning ground. Because landings and intensity of observer effort varied markedly over the four strata between years it is necessary to model the Chatham Rise stock with four separate fisheries, each with its own selectivity ogives. Consequently, catch-at-length and catch-at-age series are developed separately for each fishery. Although the observer length data from each year were partitioned into fisheries, the age data from each year were not (i.e., a single age-length key was constructed for each year as Horn & Dunn (2007) showed that mean age at length did not differ between fisheries).

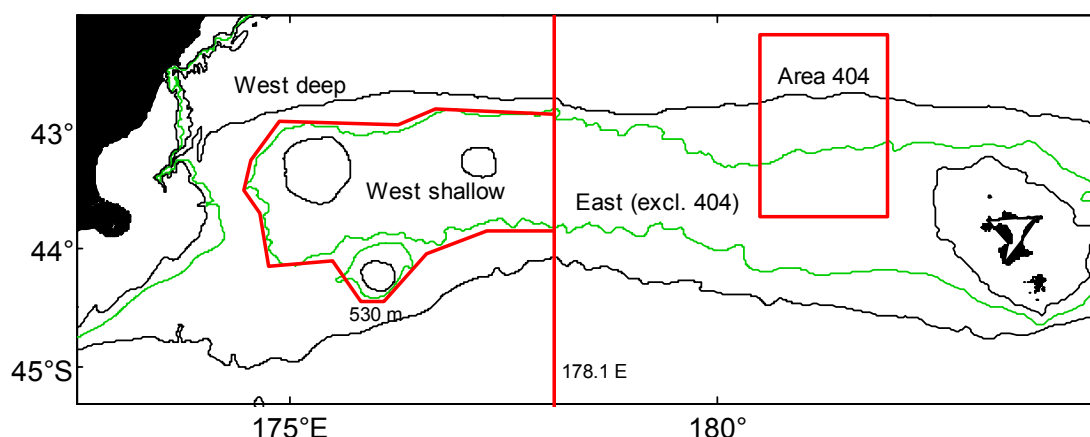


Figure 1: Fishery strata defined for the Chatham Rise hake fishery. The stratum boundary defined by depth (530 m) is shown only approximately. Isobaths at 1000, 500, and 250 m are also shown.

Observer data from each fishery stratum were converted into catch-at-age distributions if there were at least 400 length measurements and the mean weighted c.v. over all age classes was less than 30%. Any data sets not meeting these criteria were accepted as catch-at-length distributions if they contained at least 278 length measurements. Table 1 summarises the quantities of useful data, and the outcome for each data set (i.e., whether it was converted to catch-at-age or catch-at-length).

In the 2007–08 fishing year, sufficient length data and otoliths were available to calculate a catch-at-age distribution for the west deep fishery only (see Table 1). Details of that estimated distribution are given in Table 2. Although the sample sizes of measured fish just met the threshold of 400, the mean weighted c.v. of 23% was within the 30% target.

All estimated proportion at age distributions from the four Chatham Rise trawl fisheries are presented in Appendix A (Figures A1, A2, A3, and A4).

Table 1: Numbers of measured and aged male (Mal) and female (Fem) hake contributing to samples of proportion at age or proportion at length from the four commercial trawl fisheries on the Chatham Rise. The number of tows sampled by observers and the estimated mean weighted c.v. (%) by age when a proportion at age distribution was produced are also listed. A dash in the c.v. column indicates that only a proportion at length distribution was produced.

Fishing year	West shallow						West deep						East excl. 404						Measured Area 404						Aged					
	Fem			Tows			c.v.	Fem			Tows			c.v.	Mal			Fem			c.v.	Mal			c.v.	Tows	Fem	Tows	Mal	Fem
	Mal			Mal				Mal			Mal				Mal			Mal				Mal								
1990-91																														
1991-92	696	1 221	79	26.6		642	471	58	—		747	818	94	—		902	156	23	—											
1992-93																														
1993-94	226	310	55	—																										
1994-95	257	495	54	34.4																										
1995-96	468	569	67	33.0		334	348	36	27.7																					
1996-97	304	174	23	—																										
1997-98	2 081	1 835	209	15.3		1 080	1 211	181	17.1																					
1998-99	460	902	119	22.7		252	377	52	26.9		205	274	45	27.9																
1999-2000	173	362	61	24.1		634	539	103	18.3																					
2000-01	396	633	90	21.7		434	502	95	21.0																					
2001-02	216	326	53	23.1		170	166	36	—		239	219	53	23.9																
2002-03	122	184	33	—																										
2003-04	271	133	39	—		326	305	62	29.1		269	53	23	—																
2004-05	232	187	35	—		664	250	47	24.7																					
2005-06	144	248	37	—																										
2006-07											161	202	48	—		318	173	25	28.0											
2007-08						218	183	42	23.4																					

Table 2: Calculated numbers at age, separately by sex, with c.v.s, for hake caught during commercial trawl operations on the Chatham Rise (west deep fishery) during October 2007–April 2008, and in the Sub-Antarctic during September 2007–May 2008. Summary statistics for the samples are also presented.

Chatham Rise					Sub-Antarctic				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
2	123	1.131	10	3.134	2	0	–	0	–
3	716	0.592	215	1.814	3	178	1.153	65	0.948
4	3 098	0.231	694	0.528	4	1 763	0.573	1 046	0.892
5	3 011	0.191	2 263	0.293	5	12 182	0.354	1 363	0.581
6	2 020	0.203	2 303	0.197	6	30 564	0.268	11 975	0.449
7	762	0.251	1 746	0.184	7	35 900	0.223	14 554	0.245
8	355	0.358	1 031	0.278	8	33 811	0.229	17 619	0.206
9	173	0.516	468	0.424	9	41 870	0.214	19 106	0.182
10	108	0.541	260	0.489	10	31 603	0.230	16 162	0.216
11	86	0.613	114	0.936	11	24 927	0.272	11 639	0.407
12	105	0.504	45	0.909	12	24 485	0.272	9 054	0.301
13	70	0.639	161	1.049	13	19 023	0.324	6 034	0.336
14	165	0.670	48	1.088	14	15 371	0.284	8 888	0.961
15	55	0.893	17	1.380	15	10 172	0.397	2 037	0.549
16	35	1.098	9	1.548	16	10 843	0.380	1 778	0.692
17	0	–	5	1.879	17	4 346	0.595	4 181	0.918
18	0	–	44	1.382	18	760	1.279	534	0.900
19	50	1.256	0	–	19	760	1.172	499	1.606
					20	0	–	0	–
					21	0	–	872	1.743
					22	1 929	1.325	0	–
					23	3 308	0.824	0	–
					24	0	–	0	–
					25	1 022	1.078	436	1.601
Measured males									891
Measured females									592
Aged males									325
Aged females									682
No. of tows sampled									89
Mean weighted c.v. (sexes pooled)									23.2

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)
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.

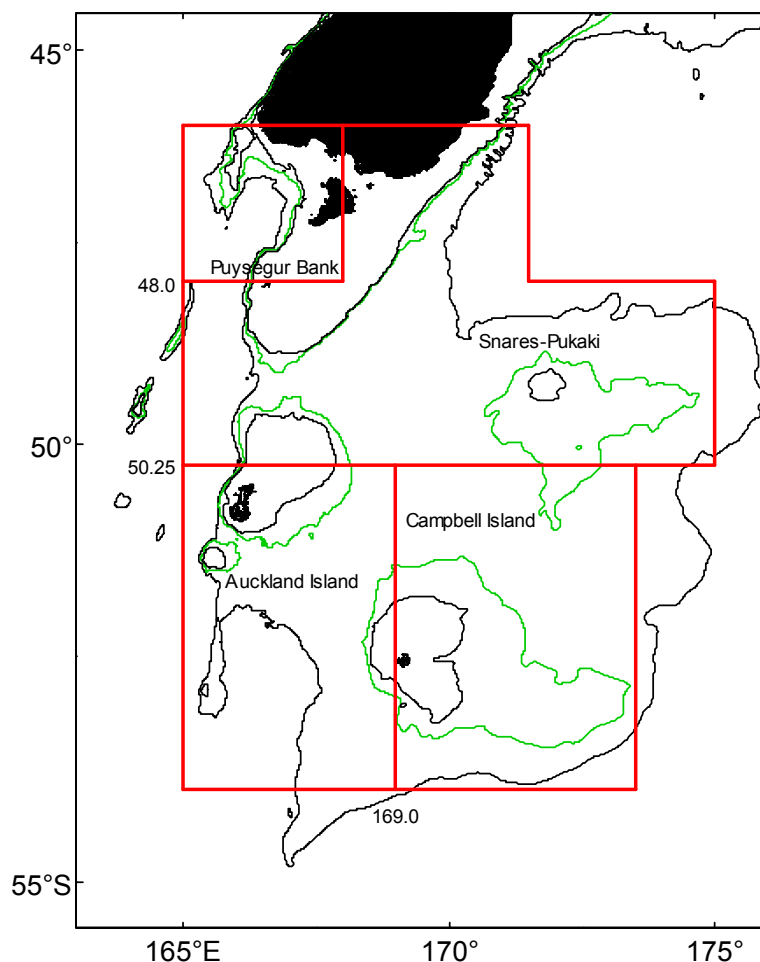


Figure 2: Fishery strata defined for the Sub-Antarctic hake fishery. Numbers show latitudes/longitudes of fishery boundaries. Isobaths at 1000, 500, and 250 m are also shown.

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 2007–08 fishing year are given in Table 2. The mean weighted c.v. of 23.2% 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 A5).

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

3.1.3 West coast South Island

The fishery off WCSI was stratified as follows:

1. Deep (bottom depth ≥ 629 m)
2. North shallow (latitude $< 42.55^\circ$ S)
3. South shallow (latitude $\geq 42.55^\circ$ S)

A tow was included in the catch at age analysis if it occurred between 1 June and 30 September, and if at least five hake 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 2007–08 fishing year are given in Table 5. The measured sample size was large, and the mean weighted c.v. of 18% was well within the target of 30%.

All estimated proportion at age distributions from the WCSI trawl fishery are presented in Appendix A (Figure A6).

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

Table 5: Calculated numbers at age, separately by sex, with c.v.s, for hake caught during commercial trawl operations off the west coast of the South Island (WCSI) during June–September 2008. Summary statistics for the samples are also presented.

Age	WCSI			
	Male	c.v.	Female	c.v.
2	23 395	0.376	15 970	0.318
3	27 650	0.148	14 803	0.182
4	29 827	0.225	5 056	0.273
5	49 981	0.192	18 507	0.227
6	69 313	0.136	32 858	0.171
7	51 749	0.170	29 368	0.168
8	45 008	0.190	26 728	0.191
9	44 719	0.204	14 300	0.242
10	35 205	0.224	11 634	0.283
11	33 571	0.215	9 521	0.298
12	17 060	0.302	14 124	0.228
13	24 692	0.244	3 040	0.509
14	25 887	0.262	5 273	0.436
15	4 587	0.535	1 934	0.614
16	5 242	0.492	1 383	0.708
17	5 864	0.489	680	1.190
18	0	–	0	–
19	890	1.116	0	–
20	0	–	0	–
21	0	–	228	1.285
25	1 597	1.029	0	–
Measured males				4 682
Measured females				2 416
Aged males				321
Aged females				266
No. of tows sampled				147
Mean weighted c.v. (sexes pooled)				17.7

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 2009 trawl survey are given in Table 7. The mean weighted c.v. of 32.5% 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 18 surveys (TAN9106, see Table 6).

All estimated proportion at age distributions from the Chatham Rise trawl surveys are presented in Appendix A (Figure A7). It appears likely that a very strong year class was produced in 2001 (i.e., aged 2 in January 2004), and that it was followed by two further relatively strong year classes in 2002 and 2003. The progression of these year classes is apparent in the survey 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

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 2009 (survey TAN0901) and the Sub-Antarctic in November-December 2008 (survey TAN0813). Summary statistics for the samples are also presented.

TAN0901					TAN0813				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
2	6 792	0.815	562	2.205	2	0	—	433	1.797
3	15 585	0.588	13 138	0.498	3	37 612	0.334	54 016	0.283
4	18 325	0.413	8 225	0.691	4	58 339	0.218	118 118	0.218
5	39 487	0.328	35 891	0.265	5	32 425	0.377	69 852	0.158
6	38 688	0.336	35 851	0.284	6	16 048	0.407	25 356	0.332
7	47 764	0.441	63 300	0.244	7	12 475	0.453	22 493	0.360
8	16 425	0.466	42 372	0.295	8	15 552	0.538	34 375	0.374
9	16 834	0.475	23 632	0.412	9	1 619	0.820	21 015	0.454
10	12 880	0.470	16 479	0.445	10	1 714	1.422	18 590	0.390
11	8 381	0.610	12 641	0.522	11	893	1.337	14 898	0.488
12	7 753	0.562	5 535	0.773	12	1 550	0.893	14 278	0.480
13	6 390	0.732	6 791	0.652	13	764	1.255	9 762	0.551
14	7 313	0.625	7 089	0.617	14	5 611	1.031	18 251	0.578
15	1 944	1.397	7 862	0.645	15	2 499	1.046	5 755	0.568
16	3 210	0.858	5 990	0.645	16	1 899	1.458	3 607	0.943
17	3 200	1.027	2 222	0.927	17	7 317	1.536	2 897	0.732
18	0	—	1 275	1.499	18	0	—	5 856	0.852
19	0	—	0	—	19	0	—	0	—
20	0	—	0	—	20	0	—	785	1.287
21	0	—	0	—	21	0	—	0	—
22	0	—	0	—	22	14 226	1.009	0	—
23	0	—	0	—					
24	0	—	817	1.922					
Measured males								289	
Measured females								808	
Aged males								188	
Aged females								412	
No. of tows sampled								39	
Mean weighted c.v. (sexes pooled)								30.9	

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 2008 trawl survey are given in Table 7. The estimated high abundance of 22-year-old males is a consequence of two relatively large strata, both producing few hake, but each having one male fish of this age. The mean weighted c.v. of 31% nearly met the target of 30%. 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 A8).

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
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. The details of the estimated catch at age distribution for Chatham Rise line-caught ling in the 2007–08 fishing year are given in Table 10. The mean weighted c.v. of 25.9% was well within the target value of 30%.

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

Table 10: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial longline operations on the Chatham Rise (LIN 3&4) in June–October 2008, and in the Sub-Antarctic spawning fishery (LIN 5&6) in October–December 2007. Summary statistics for the samples are also presented.

Chatham Rise					Sub-Antarctic spawning				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
5	0	–	135	1.311	5	0	–	116	1.857
6	0	–	0	–	6	757	0.908	0	–
7	227	0.887	432	0.530	7	1 710	0.573	1 518	0.618
8	1 227	0.454	692	0.494	8	3 872	0.531	2 575	0.516
9	1 757	0.307	1 479	0.373	9	3 669	0.542	4 256	0.409
10	3 381	0.274	2 153	0.326	10	5 505	0.403	2 686	0.637
11	2 322	0.345	3 789	0.230	11	3 707	0.484	2 064	0.593
12	5 339	0.250	3 709	0.240	12	5 439	0.379	3 679	0.475
13	4 975	0.249	3 093	0.263	13	2 330	0.538	3 787	0.653
14	2 764	0.294	3 835	0.254	14	3 285	0.512	537	1.055
15	1 867	0.332	2 431	0.279	15	1 957	0.844	7 918	0.402
16	2 995	0.370	1 714	0.357	16	1 378	0.611	1 551	0.848
17	2 240	0.392	2 515	0.338	17	1 317	0.744	2 376	0.568
18	1 628	0.360	783	0.568	18	538	1.205	840	1.236
19	1 404	0.441	990	0.493	19	586	1.165	1 593	0.695
20	454	0.603	1 124	0.460	20	0	–	325	1.276
21	288	0.816	657	0.569	21	320	1.400	310	1.375
22	646	0.647	0	–	22	1 097	1.186	0	–
23	0	–	322	0.879	23	581	1.237	0	–
24	117	1.155	2	3.674	24	639	1.040	0	–
25	342	0.917	0	–	25	360	1.423	0	–
26	134	1.211	0	–	26	0	–	0	–
27	117	1.173	0	–	27	0	–	0	–
28	110	1.308	1	2.918	28	0	–	0	–
29	278	1.053	128	1.607	29	0	–	0	–
30	220	1.155	0	0	30	0	–	0	–
34	0	–	180	1.6274	34	219	1.524	0	–
45	75	1.372	0	–					
Measured males				574					227
Measured females				570					198
Aged males				216					68
Aged females				262					62
No. of sets sampled				84					24
Meanweighted c.v. (sexes pooled)				25.9					44.3

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 October to 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.

Table 11 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 spawning Sub-Antarctic line-caught ling in the 2007–08 fishing year are given in Table 10. Owing to the relatively small sample size available, the mean weighted c.v. of 44% did not meet the target value of 30%. However, this value cannot be improved as all available length data and otoliths were used in the analysis. There was no observer sampling of non-spawning Sub-Antarctic line-caught ling in the 2007–08 fishing year.

Table 11: 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 & 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
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

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).

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. There was no observer sampling of Cook Strait line-caught ling in the 2007–08 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		
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 28 February.

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. The details of the estimated catch at age distribution for Bounty Plateau line-caught ling in the 2007–08 fishing year are given in Table 14. The mean weighted c.v. of 25.3% was well within the target value of 30%. 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		
1993	201	52	237	69	24	50.4
2000	1 102	106	2 184	185	41	26.9
2001	405	50	713	66	20	43.6
2004	1 155	200	1 628	300	272	20.0
2008	308	156	562	271	86	25.3

Table 14: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial longline operations on the Bounty Plateau during November 2007–February 2008. Summary statistics for the sample are also presented.

Age	Bounty Plateau			
	Male	c.v.	Female	c.v.
9	6	2.037	54	1.100
10	249	0.621	146	0.701
11	60	1.116	603	0.401
12	460	0.491	1 567	0.238
13	917	0.315	1 594	0.200
14	1 176	0.250	2 252	0.180
15	520	0.396	1 531	0.243
16	570	0.354	1 752	0.230
17	506	0.349	1 255	0.265
18	940	0.316	1 419	0.242
19	533	0.359	613	0.380
20	332	0.544	748	0.404
21	189	0.624	446	0.471
22	205	0.643	755	0.365
23	672	0.448	370	0.464
24	173	0.682	187	0.638
25	57	1.306	29	1.402
26	36	1.800	59	1.323
31	30	1.245	31	1.416
32	0	–	67	1.220
33	0	–	0	–
34	57	1.320	83	0.988
35	0	–	0	–
36	56	1.133	46	1.523
37	0	–	89	1.225
38	44	1.261	0	–
41	89	1.211	0	–
Measured males			308	
Measured females			562	
Aged males			156	
Aged females			271	
No. of sets sampled			86	
Mean weighted c.v. (sexes pooled)			25.3	

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)

Table 15 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 2007–08 fishing year are given in Table 16. The mean weighted c.v. of 21% was better than the value of 30% that is usually used as a target for ling catch at age distributions.

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

Table 15: 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

Table 16: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial trawl operations on the Chatham Rise during October 2007–May 2008, and in the Sub-Antarctic during September 2007–April 2008. Summary statistics for the samples are also presented.

Chatham Rise					Sub-Antarctic				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
2	0	–	59	1.414	2	0	–	0	–
3	659	0.694	1 719	0.643	3	1 095	1.892	235	2.384
4	11 219	0.487	11 279	0.454	4	30 779	0.504	10 473	0.748
5	22 742	0.306	24 796	0.250	5	81 712	0.337	67 089	0.361
6	39 136	0.235	25 531	0.240	6	115 878	0.272	90 289	0.262
7	59 326	0.176	38 995	0.206	7	201 186	0.189	125 300	0.181
8	40 979	0.188	41 811	0.195	8	153 202	0.249	121 667	0.196
9	16 822	0.256	34 535	0.229	9	120 582	0.293	101 618	0.236
10	33 859	0.268	24 353	0.260	10	121 960	0.300	93 544	0.231
11	21 918	0.203	24 439	0.249	11	115 560	0.328	123 232	0.195
12	17 347	0.292	31 235	0.241	12	108 155	0.311	91 629	0.214
13	11 362	0.356	11 561	0.346	13	146 454	0.281	79 591	0.227
14	17 910	0.287	6 496	0.342	14	40 852	0.531	57 036	0.297
15	5 609	0.531	14 464	0.382	15	70 319	0.407	32 130	0.442
16	6 631	0.492	1 999	0.634	16	18 711	0.782	26 417	0.409
17	6 096	0.456	3 990	0.443	17	35 573	0.599	14 910	0.665
18	6 129	0.456	2 414	0.572	18	4 348	1.101	14 875	0.625
19	1 543	0.908	3 319	0.474	19	9 140	1.028	13 780	0.434
20	4 842	0.406	0	–	20	4 414	1.242	18 017	0.546
21	1 870	0.600	98	1.828	21	13 821	0.709	9 242	0.806
22	0	–	2 058	0.842	22	0	–	1 586	1.205
23	1 090	0.874	0	–	23	0	–	0	–
24	1 818	0.800	348	1.316	24	17 832	0.794	6 338	0.666
25	2 938	0.668	0	–	25	0	–	4 464	0.883
26	0	–	276	1.275	26	4 414	1.124	0	–
27	0	–	0	–	27	11 255	1.069	0	–
28	2 013	0.628	348	1.302	28	2 803	1.453	27	2.541
29	367	1.223	348	1.167	29	0	–	0	–
30	0	–	202	1.205	30	0	–	0	–
43	433	1.598	0	–	33	63	2.347	0	–
Measured males				2 755					4 104
Measured females				2 070					3 258
Aged males				317					229
Aged females				325					353
No. of tows sampled				276					183
Mean weighted c.v. (sexes pooled)				20.9					23.3

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 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. The details of the estimated catch at age distribution for trawl-caught ling in the 2007–08 fishing year are given in Table 16. The mean weighted c.v. of 23% was better than the value of 30% that is usually used as a target for ling catch at age distributions.

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

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 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

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 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. The details of the estimated catch at age distribution for trawl-caught ling in the 2007–08 fishing year are given in Table 19. The mean weighted c.v. of 24% was better than the value of 30% that is usually used as a target for ling catch at age distributions.

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

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 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

Table 19: Calculated numbers at age, separately by sex, with c.v.s, for ling caught during commercial trawl operations off WCSI during June–September 2008, and in Cook Strait during June–September 2008. Summary statistics for the samples are also presented.

WCSI					Cook Strait				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
3	843	0.691	1 020	0.779	3	20	1.813	19	2.229
4	3 533	0.408	2 575	0.451	4	897	0.496	683	0.480
5	9 419	0.247	9 320	0.266	5	1 367	0.346	1 918	0.414
6	4 626	0.318	3 874	0.447	6	1 690	0.298	960	0.367
7	8 675	0.252	5 256	0.312	7	1 558	0.268	2 466	0.220
8	8 554	0.268	5 599	0.365	8	1 792	0.240	1 914	0.284
9	5 108	0.330	4 914	0.384	9	1 078	0.282	1 349	0.307
10	5 866	0.278	5 123	0.364	10	707	0.357	689	0.414
11	6 571	0.284	5 311	0.327	11	1 236	0.328	1 477	0.304
12	7 413	0.265	4 673	0.309	12	1 542	0.266	891	0.356
13	6 506	0.258	8 340	0.240	13	1 281	0.287	753	0.391
14	1 810	0.474	6 501	0.251	14	1 310	0.345	484	0.436
15	3 215	0.361	5 178	0.267	15	738	0.419	738	0.384
16	1 934	0.482	5 054	0.285	16	312	0.564	184	0.803
17	134	1.396	4 493	0.316	17	515	0.411	95	1.008
18	1 188	0.721	4 322	0.302	18	565	0.476	267	0.805
19	358	1.401	2 175	0.468	19	355	0.616	43	1.457
20	0	—	389	0.849	20	0	—	18	1.687
21	250	1.238	476	0.881	21	127	0.838	95	1.254
22	0	—	369	1.156	22	0	—	0	—
23	0	—	0	—	23	0	—	0	—
24	0	—	282	1.314	24	0	—	0	—
25	0	—	0	—	25	41	1.265	0	—
					28	39	1.237	0	—
					32	21	1.470	0	—
Measured males				805					
Measured females				824					
Aged males				209					
Aged females				251					
No. of tows sampled				98					
Mean weighted c.v. (sexes pooled)				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 20 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 Cook Strait trawl-caught ling in the 2007–08 fishing year are given in Table 19. The mean weighted c.v. of 27% was within the target value of 30%.

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

Table 20: 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

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 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 January 2009 trawl survey are given in Table 22. The mean weighted c.v. of 24.3% 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 Chatham Rise trawl surveys are presented in Appendix B (Figure B10).

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 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

Table 22: 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 2009 (survey TAN0901) and the Sub-Antarctic in November-December 2008 (survey TAN0813). Summary statistics for the samples are also presented.

TAN0901					TAN0813				
Age	Male	c.v.	Female	c.v.	Age	Male	c.v.	Female	c.v.
2	3 674	1.279	3 186	1.233	2	0	—	21 315	1.564
3	149 461	0.263	136 833	0.293	3	500 935	0.495	450 735	0.385
4	127 982	0.325	156 364	0.237	4	719 105	0.393	535 643	0.413
5	234 749	0.233	138 133	0.245	5	418 877	0.272	488 448	0.260
6	170 826	0.272	191 854	0.261	6	394 383	0.247	426 691	0.249
7	179 992	0.288	207 567	0.287	7	320 020	0.277	531 972	0.216
8	259 094	0.278	183 059	0.258	8	305 379	0.280	492 492	0.217
9	189 642	0.282	115 707	0.278	9	372 114	0.269	426 115	0.267
10	126 083	0.298	123 859	0.237	10	162 545	0.345	390 018	0.267
11	147 995	0.270	66 269	0.328	11	303 942	0.301	289 468	0.288
12	196 257	0.238	59 650	0.360	12	160 475	0.385	398 461	0.263
13	93 273	0.304	43 323	0.434	13	312 325	0.315	241 534	0.314
14	92 594	0.303	70 432	0.313	14	193 292	0.332	214 419	0.316
15	26 765	0.533	47 670	0.362	15	111 885	0.440	201 636	0.319
16	70 464	0.323	27 694	0.483	16	78 443	0.546	99 350	0.443
17	23 925	0.609	15 791	0.606	17	28 873	0.942	63 182	0.537
18	12 699	0.869	32 461	0.426	18	85 186	0.500	97 095	0.436
19	16 656	0.704	9 383	0.746	19	19 892	0.877	73 907	0.573
20	14 660	0.712	5 134	1.217	20	0	—	13 109	1.293
21	11 747	0.740	13 431	0.679	21	3 608	1.423	136 831	0.400
22	1 595	1.480	1 508	1.332	22	10 868	0.932	35 292	0.829
23	2 793	1.367	1 684	1.404	23	1 179	2.092	0	—
24	5 836	1.196	4 827	1.126	24	0	—	0	—
25	2 463	1.573	4 827	1.225	25	0	—	8 629	1.591
26	6 679	0.953	0	—	26	0	—	23 044	1.096
27	0	—	0	—	27	0	—	6 224	1.557
28	0	—	0	—					
29	0	—	7 389	0.798					
30	0	—	0	—					
31	2 646	1.026	4 481	1.224					
Measured males								1 162	
Measured females								994	
Aged males								250	
Aged females								327	
No. of tows sampled								80	
Mean weighted c.v. (sexes pooled)								26.8	

3.5.2 Sub-Antarctic

Trawl survey catch at age distributions are estimates of the numbers of ling, by sex and age, available to the trawl in the survey. 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 23 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 2008 trawl survey are given in Table 22. The mean weighted c.v. of 26.8% was 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 B12).

Table 23: 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
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, the HAK 1 fishery in the Sub-Antarctic, and the ‘west deep’ 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). For the HAK 1 (Sub-Antarctic) commercial trawl fishery, sample sizes of lengths (1483) and aged fish (1007) were larger than last year when the c.v. target was not met. 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 four separate fisheries (see Table 1), but a catch at age distribution was able to be derived only for the ‘western deep’ fishery in 2007–08. Available data from the other four fisheries were sparse (numbers of length measurements ranged from 24 to 155 per fishery), so it was not even possible to construct useful length-frequency distributions for any of them.

The Sub-Antarctic trawl survey produced a good sample of aged fish (600), but the Chatham Rise survey was less productive (429 age estimates). Catch-at-age distributions were produced for both the trawl surveys, and both of the estimated mean weighted c.v.s almost met the target of 30% (30.9% for Sub-Antarctic, 32.5% for Chatham Rise). However, no improvements in the precision can be achieved, as all available data were included in the analyses.

On the Chatham Rise, catches of younger hake tend to be concentrated in the west, particularly in the late 1990s (see Appendix A, Figures A1–A2). Throughout the 2000s there was an apparent increase in the mean age of hake caught in that area. However, the most recent catch at age distribution (Figure A2) shows the western population to again be dominated by relatively young fish. The age distribution of male fish in 2008 in the ‘western deep’ section of the Chatham Rise is very similar to the overall male

distribution from the 2008 trawl survey (see Figure A7). Middle-aged and older hake tend to dominate catches in the eastern Rise (see Figures A3–A4). Males and females appear to be about evenly abundant in all areas except Statistical Area 404, where males clearly dominate the catch. There is a clear year class progression apparent in the six most recent Chatham Rise survey distributions (Figure A7). The 2001 year class (aged 2+ in January 2004) clearly progresses through to age 7+ in 2009, 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 A5 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 most recent trawl survey in 2008 indicates the possibility of some recent moderately strong recruitment (Figure A8).

The WCSI trawl catch is dominated by hake aged 6–12 years, with no clearly apparent year class progressions (see Figure A6). In some years, large numbers of 1- or 2-year-old fish are taken by the fishery, but these do not manifest as strong cohorts in later years. 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 three commercial longline fisheries in 2007–08, and the target c.v.s were met for two of these (Chatham Rise and Bounty Plateau). The target was not met for the Sub-Antarctic spawning fishery owing to relatively light sampling of this fishery; only part of one trip was observed in this fishery. A catch at age distribution was scheduled to be produced for the Sub-Antarctic non-spawning fishery, but it was not sampled by observers in 2007–08. Total longline landings from this fishery have been very low since 2006. The resources intended to be used to analyse the non-spawning Sub-Antarctic fishery were transferred to the Bounty Plateau fishery. Only two years of comprehensive sampling for catch at age were previously available for that fishery (see Table 13), so it was considered desirable to add to that series.

Catch at age distributions were produced for trawl fisheries catching ling in four areas. The Chatham Rise and Sub-Antarctic distributions used observer length data applied to age-length keys obtained from trawl surveys, e.g., Chatham Rise length data collected from October 2007 to May 2008 were applied to the age-length key from the January 2008 (TAN0801) trawl survey of the Chatham Rise. The estimated catch at age distributions from both these areas had mean weighted c.v.s well within the usual target of 30%. Most distributions calculated for these fisheries in previous years had also been within the target. Estimates of catch at age were also produced for the ling taken as bycatch in the WCSI and Cook Strait hoki spawning fisheries, and both these estimated distributions also met the target c.v. of 30%. Sampling of both these fisheries was markedly more comprehensive than in 2007, when neither distribution met the c.v. target. However, the level of sampling in 2008 was still low relative to the earlier parts of both series (see Tables 18 and 20).

Sufficient ling otoliths and length-frequency data were available from the Sub-Antarctic and Chatham Rise trawl surveys to easily meet the mean weighted c.v. target. The target has been met in all surveys from these two areas.

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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6. REFERENCES

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

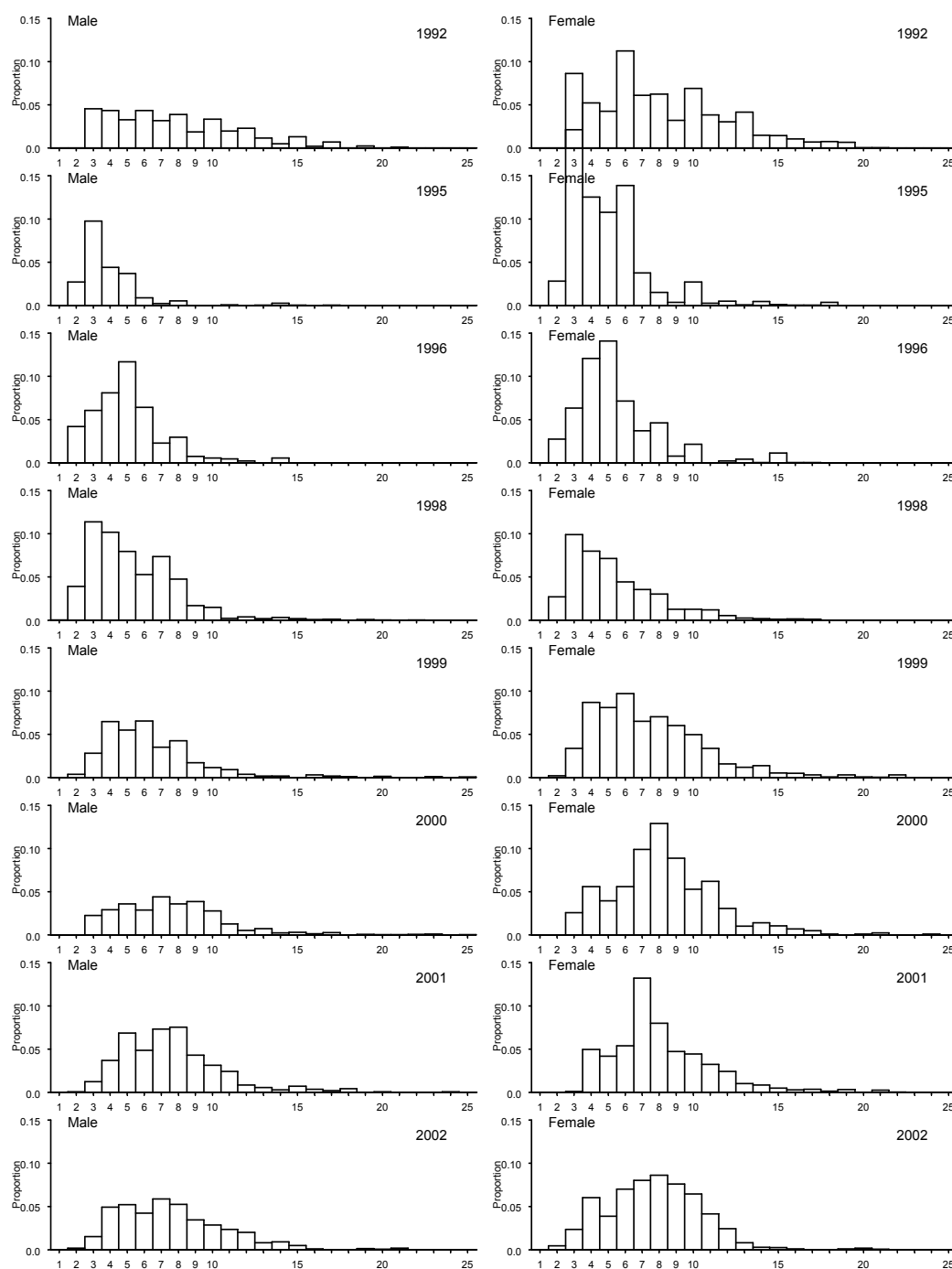


Figure A1: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west shallow) trawl fishery, 1992 to 2008.

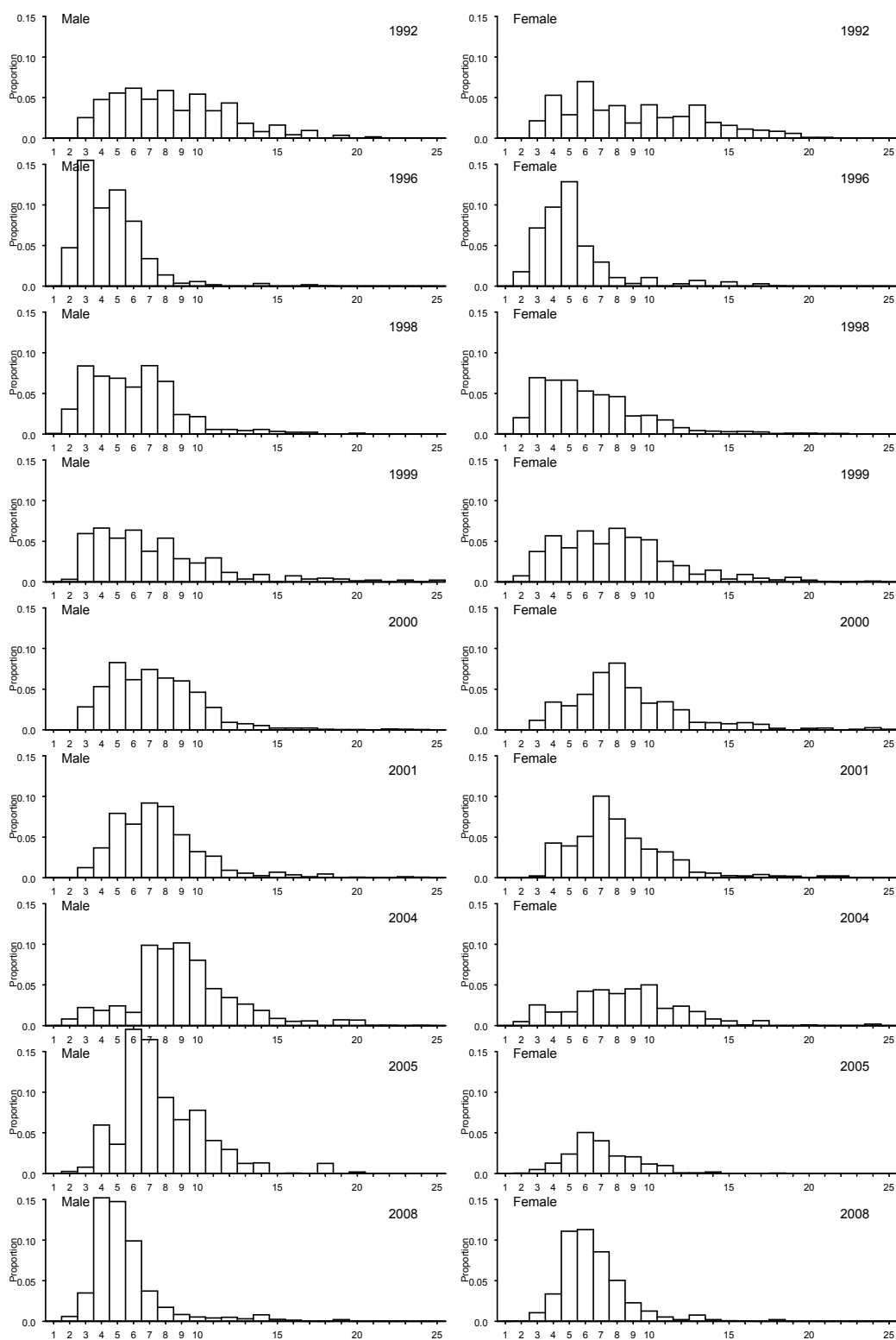


Figure A2: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (west deep) trawl fishery, 1992 to 2008.

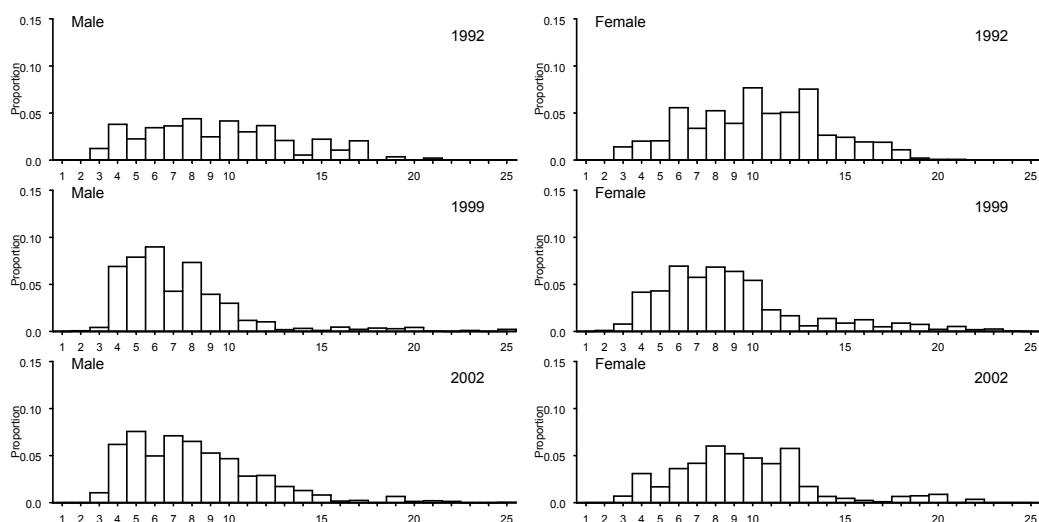


Figure A3: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (east excl. area 404) trawl fishery, 1992 to 2008.

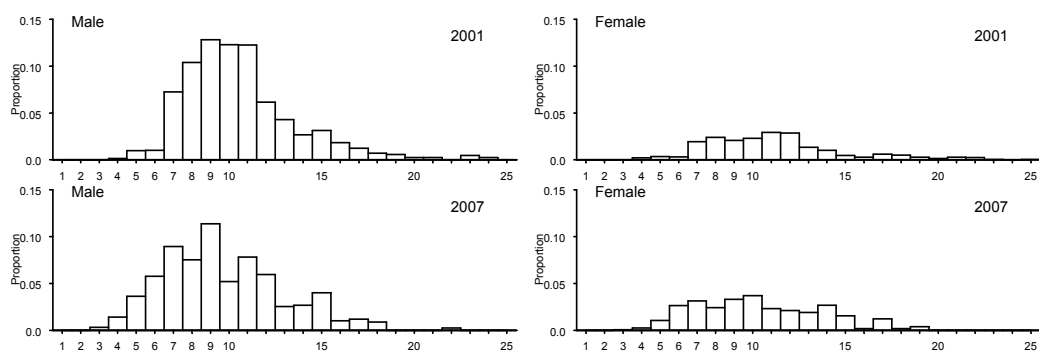


Figure A4: Available age frequencies of hake from commercial catch-at-age data in the Chatham Rise (Statistical Area 404) trawl fishery, 1992 to 2008.

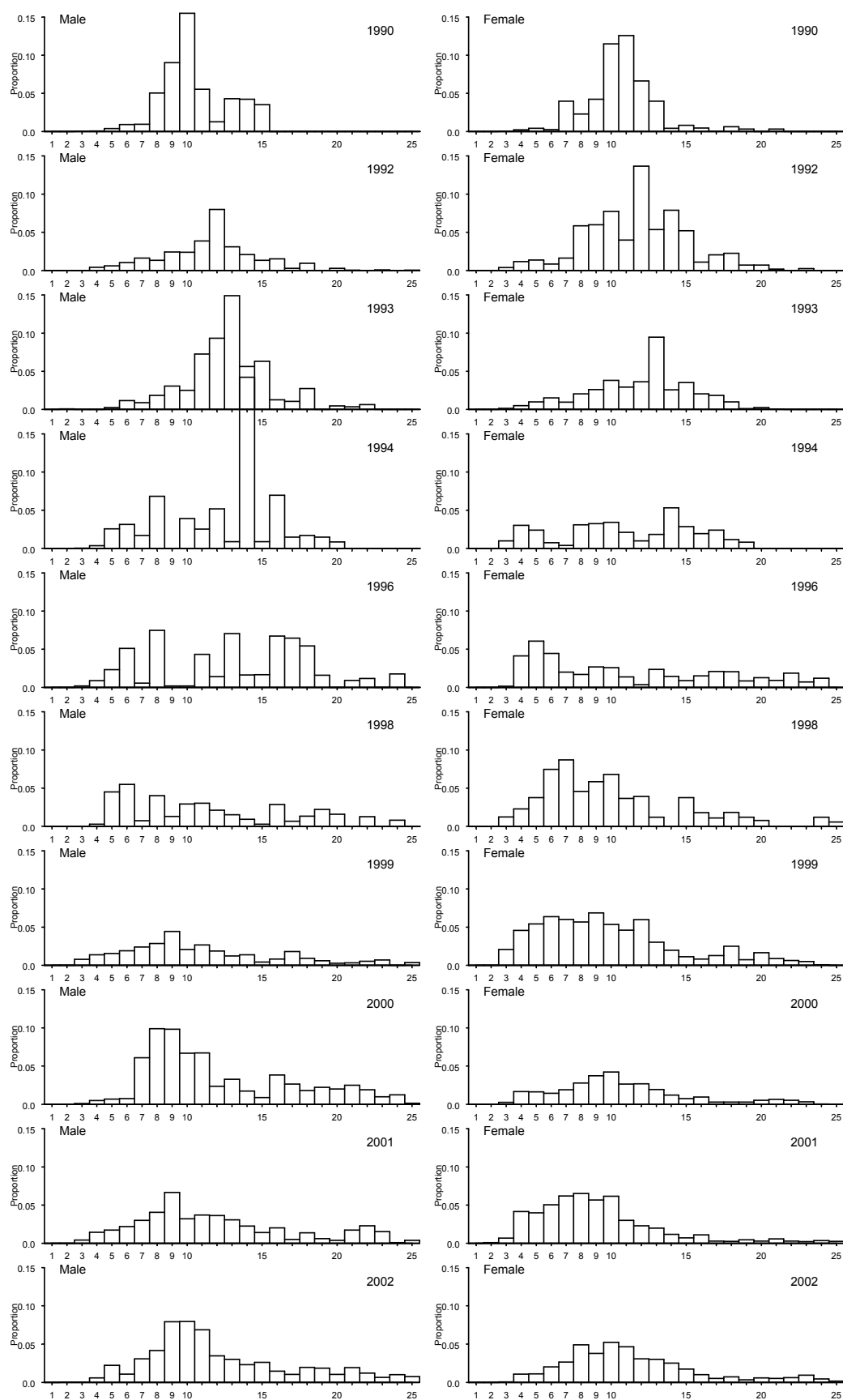


Figure A5: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2008.

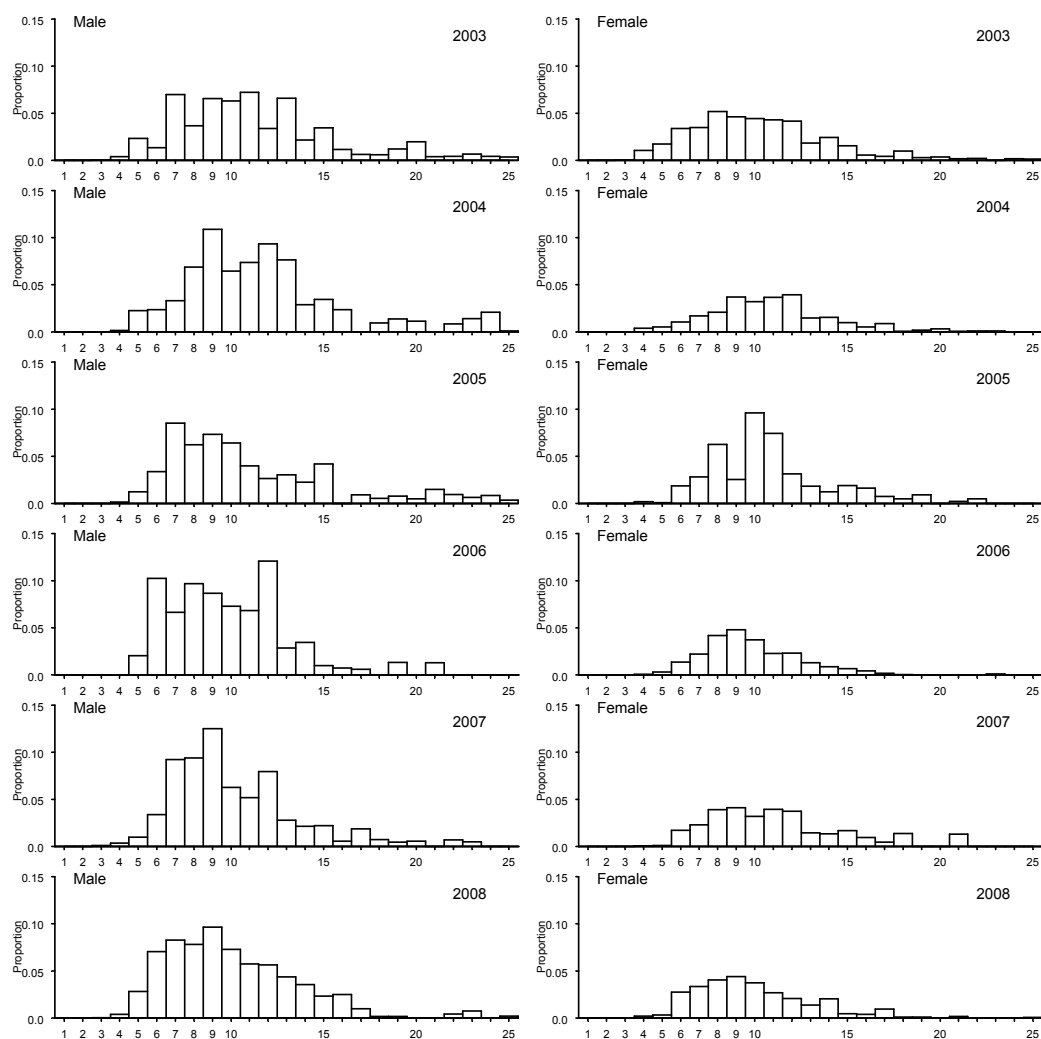


Figure A5 ctd.: Available age frequencies of hake from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1990 to 2008.

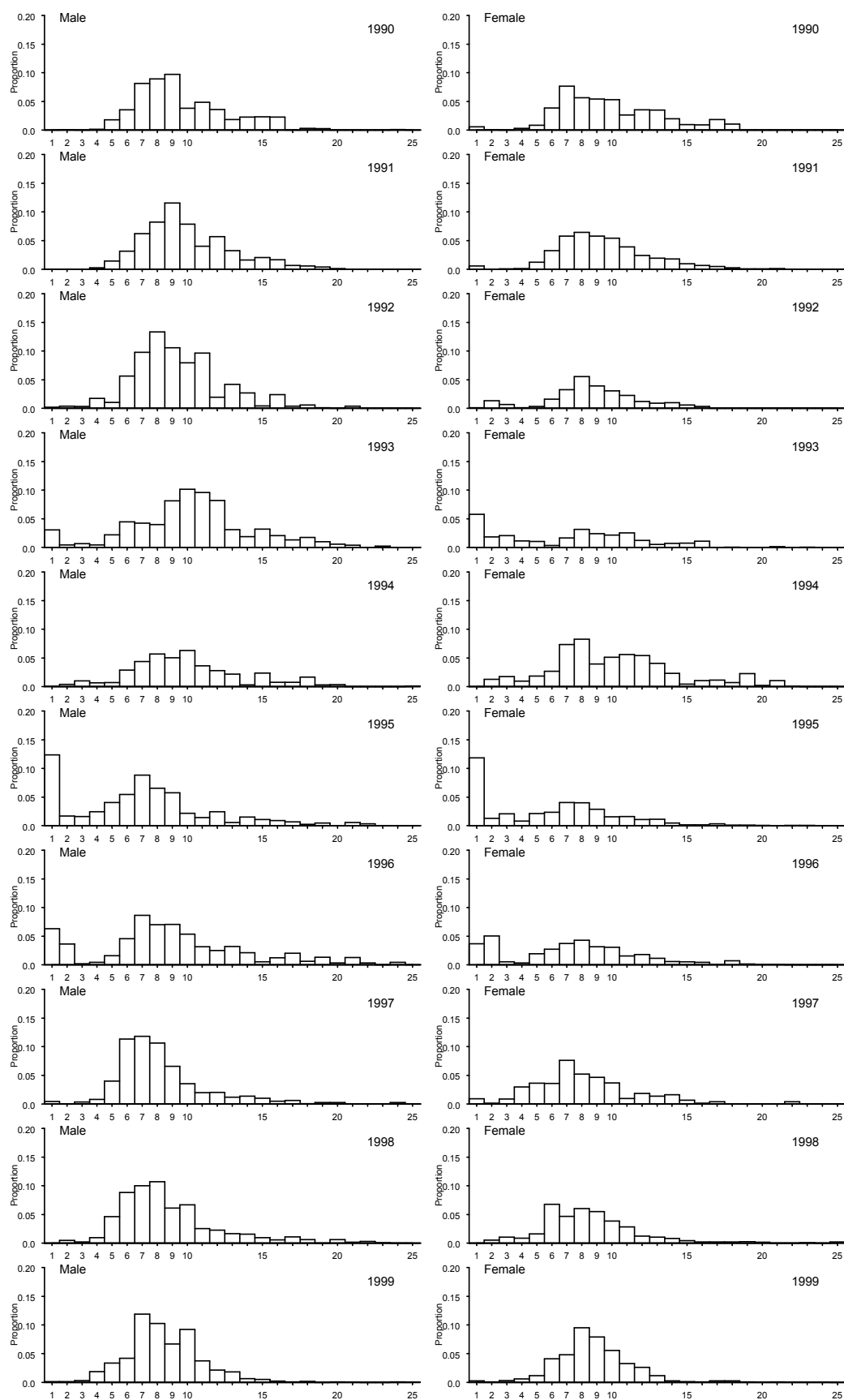


Figure A6: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2008.

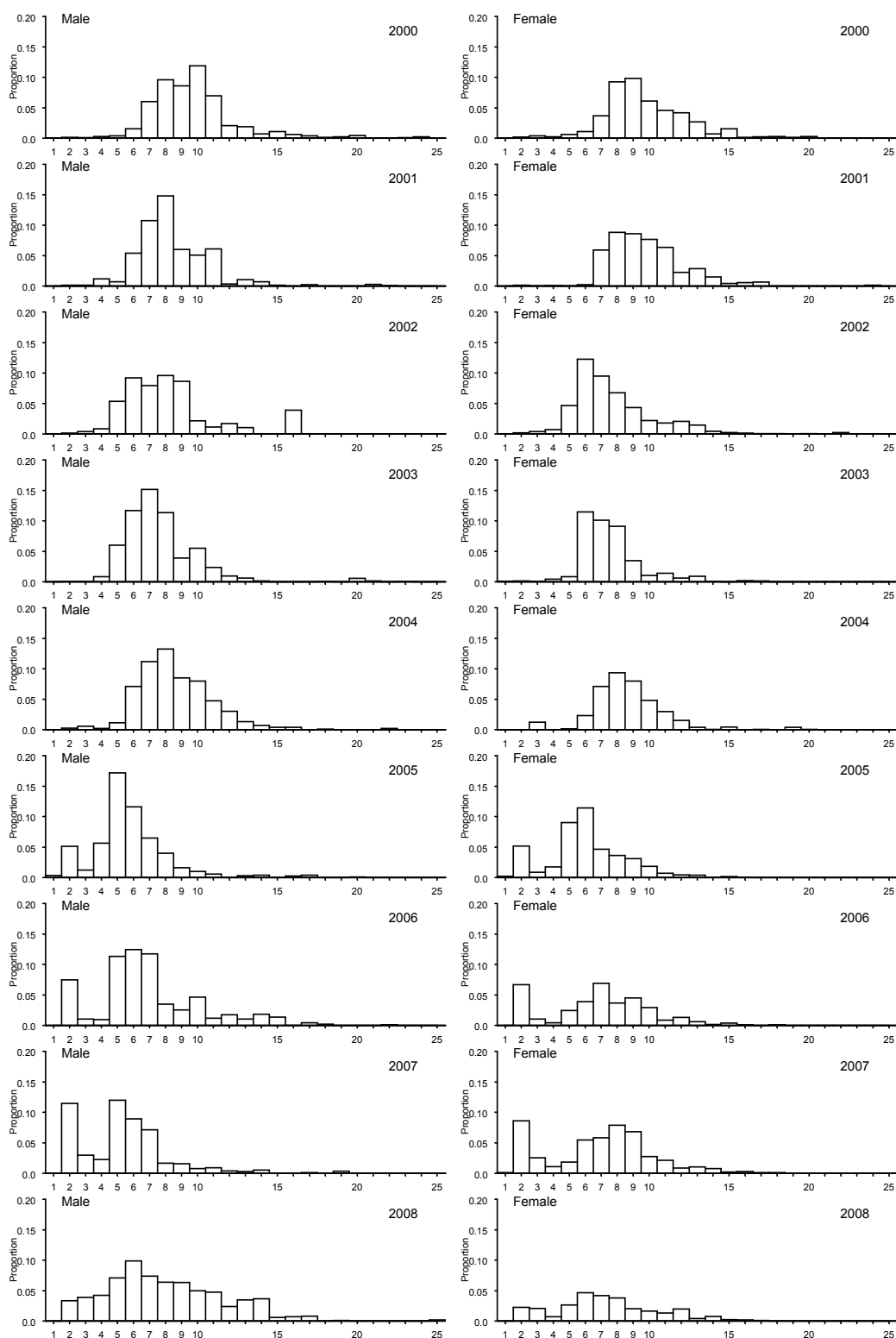


Figure A6 ctd.: Available age frequencies of hake from commercial catch-at-age data in the WCSI trawl fishery, 1990 to 2008.

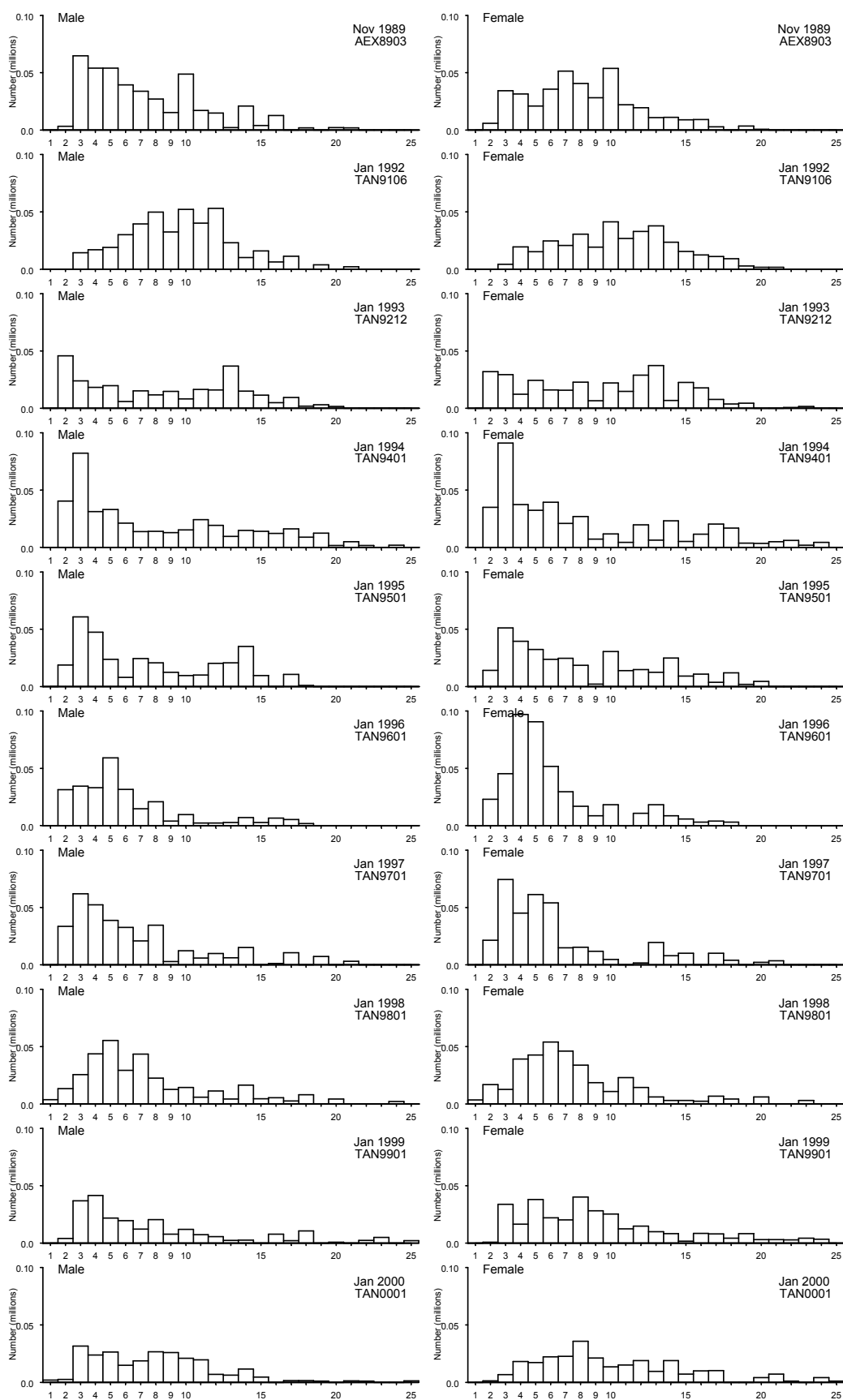


Figure A7: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2008–09.

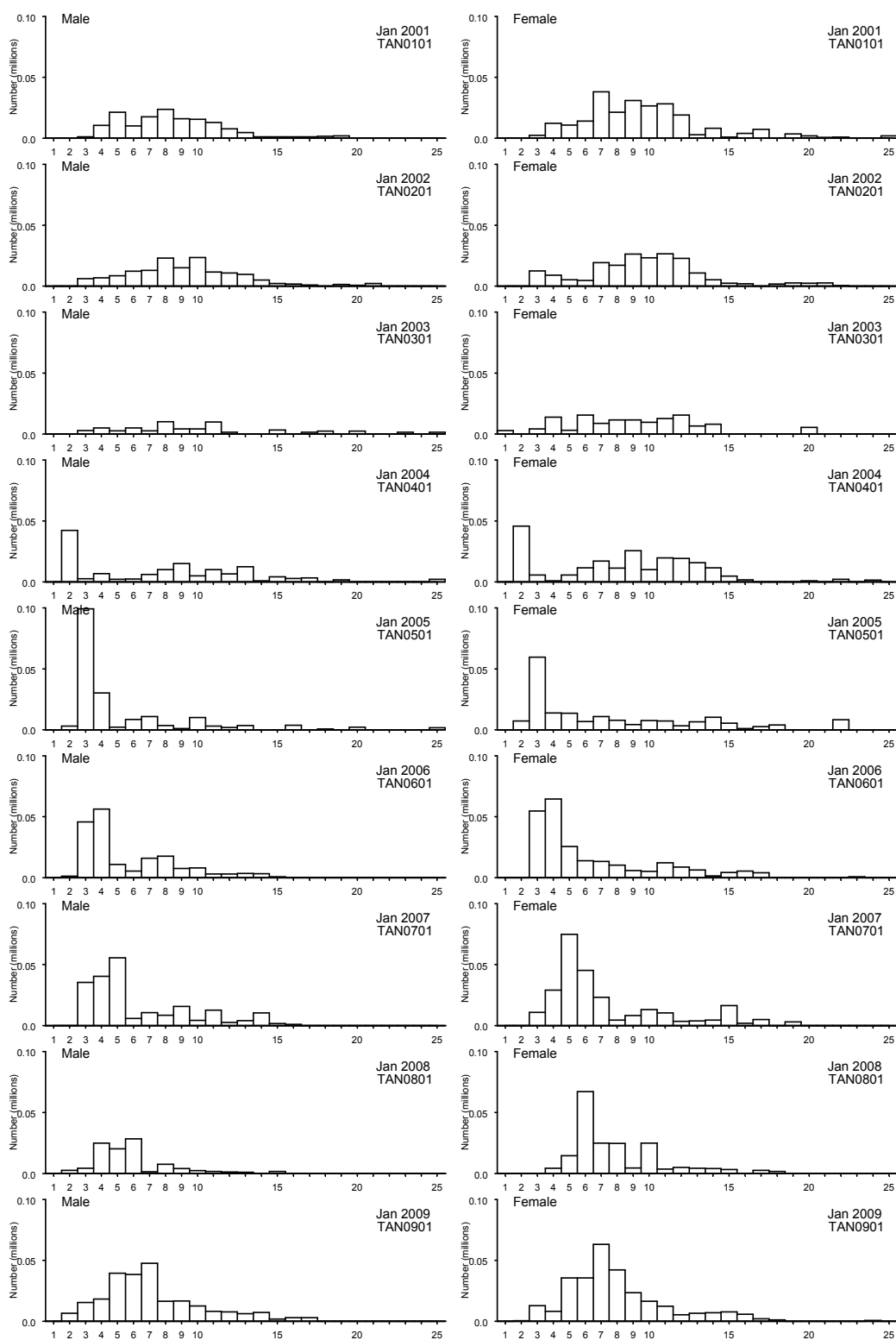


Figure A7 ctd.: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2008–09.

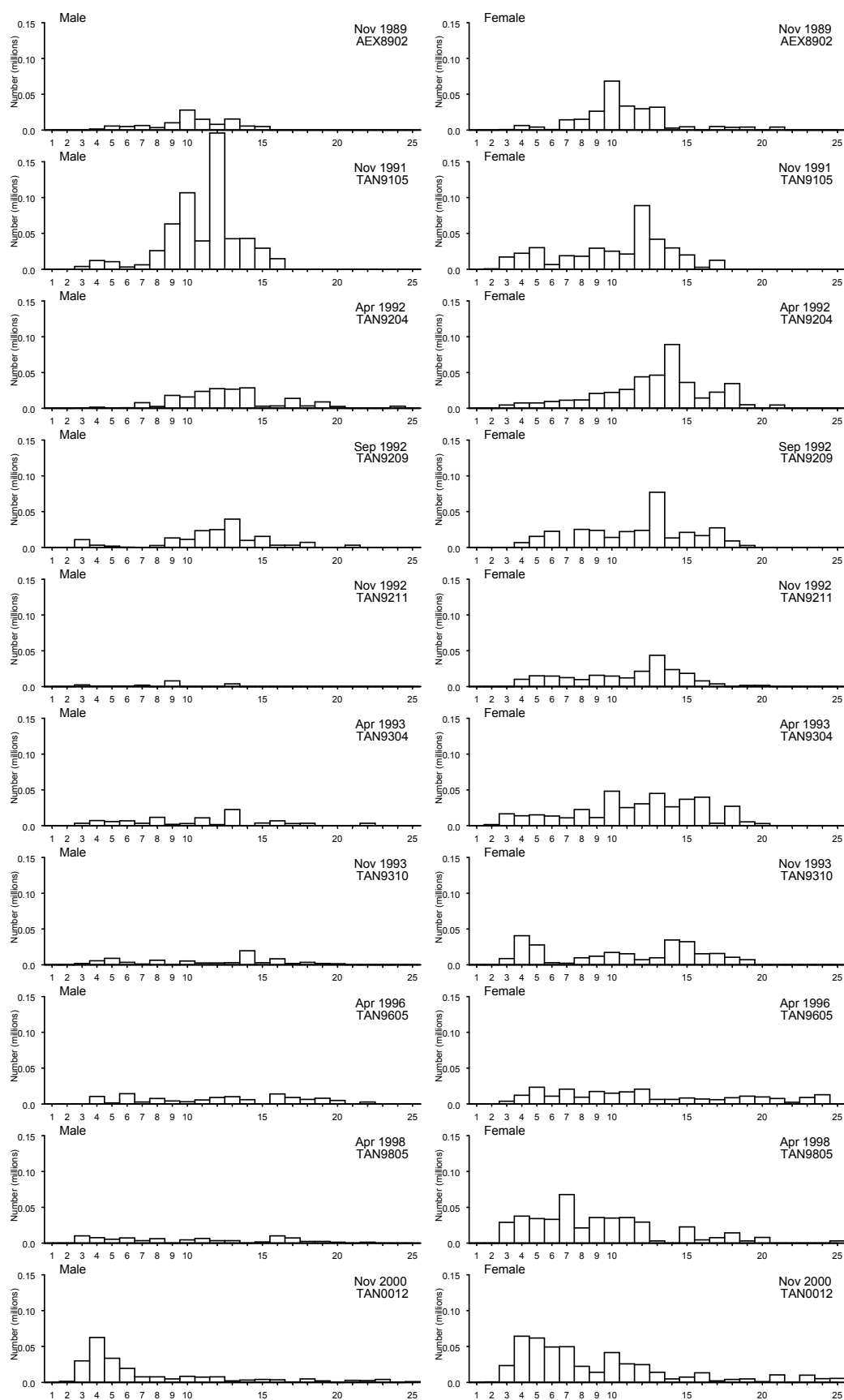


Figure A8: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Sub-Antarctic, 1989 to 2008.

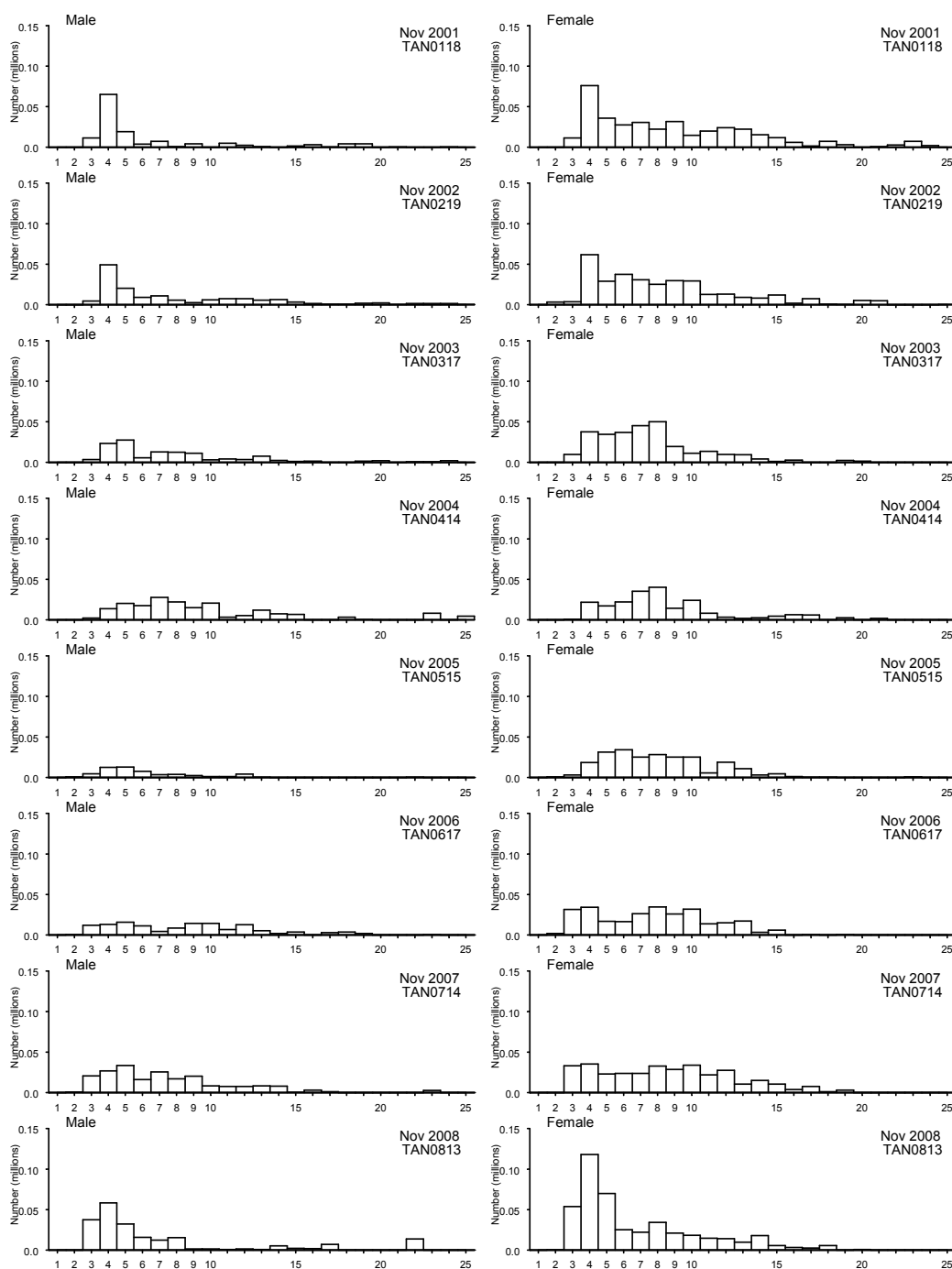


Figure A8 ctd.: Available age frequencies of hake (ages 1 to 25) from resource surveys in the Sub-Antarctic, 1989 to 2008.

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

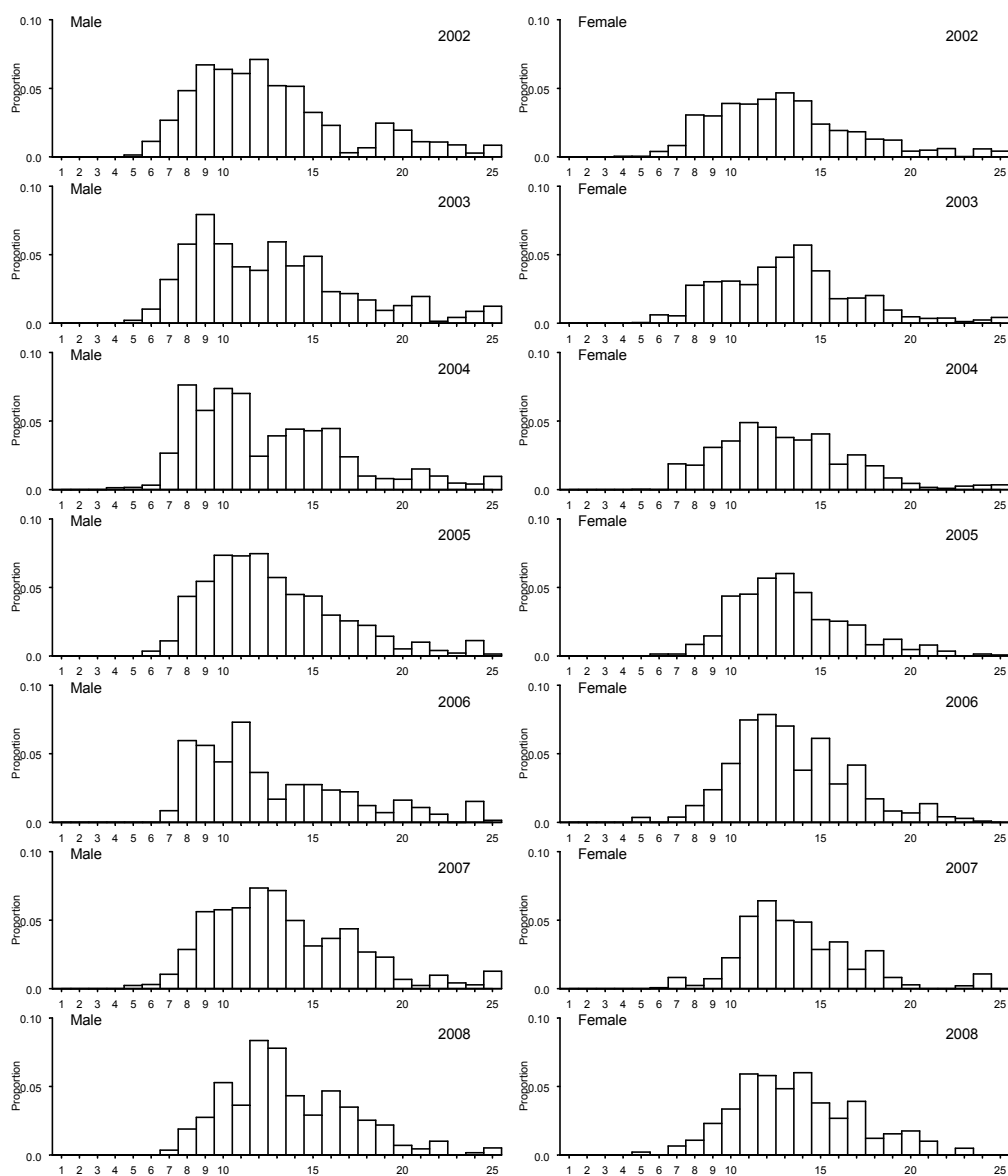


Figure B1: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise longline fishery, 2002 to 2008.

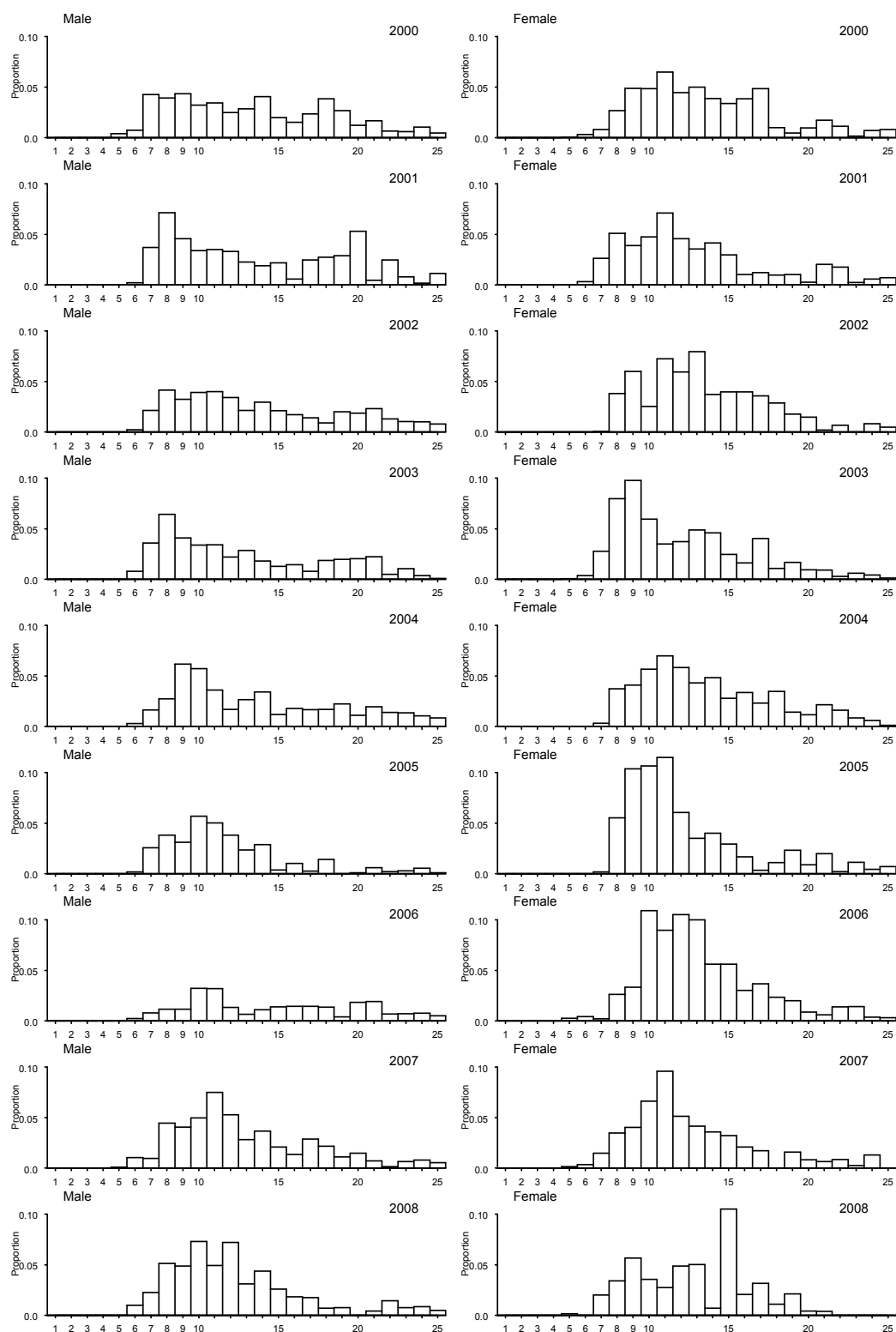


Figure B2: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (spawning season) longline fishery, 2000 to 2008.

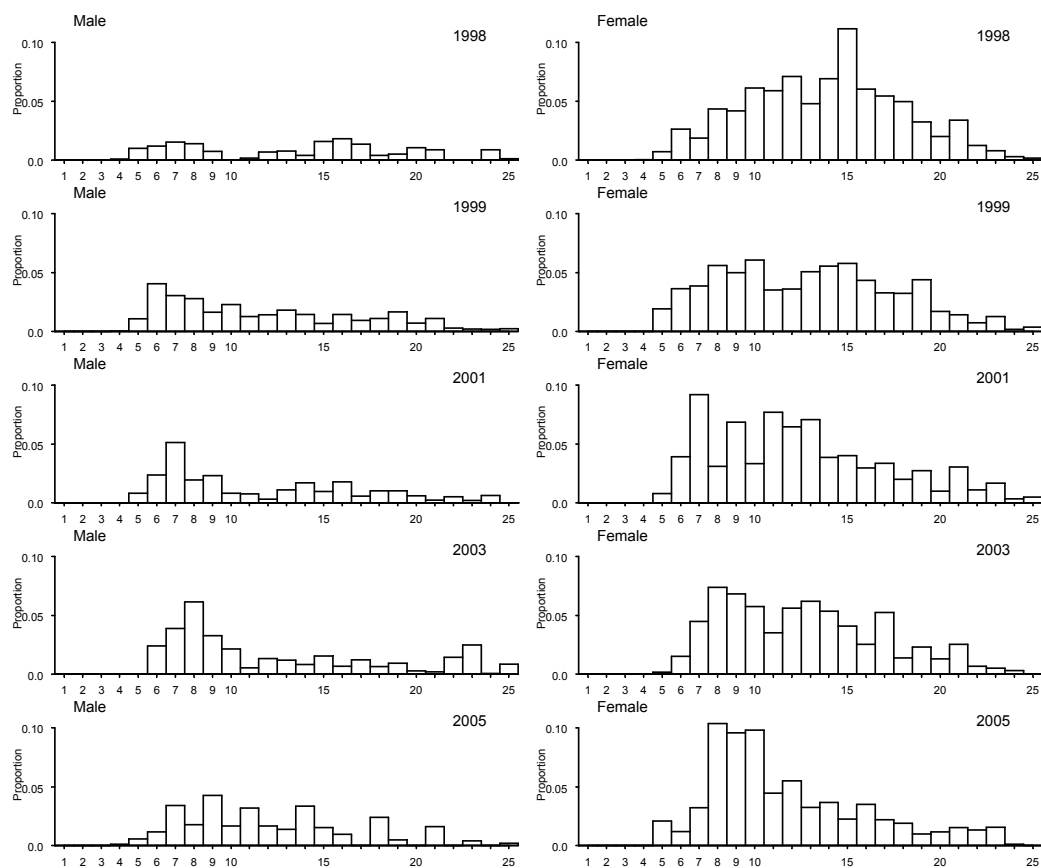


Figure B3: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic (non-spawning season) longline fishery, 1998 to 2008.

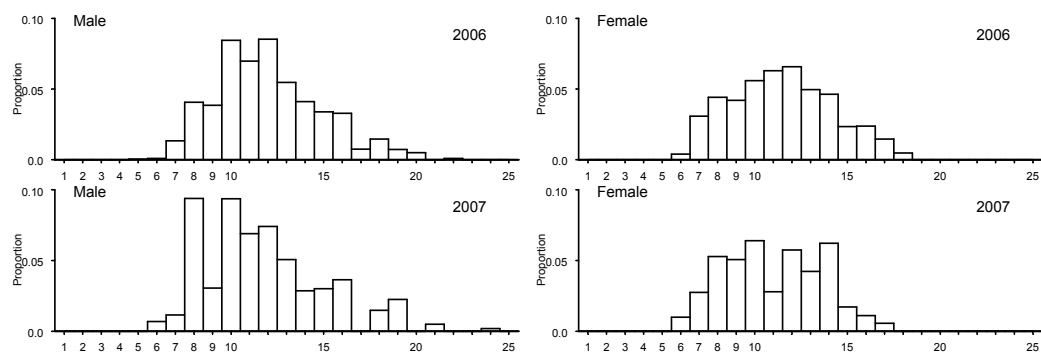


Figure B4: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait longline fishery, 2006 to 2008.

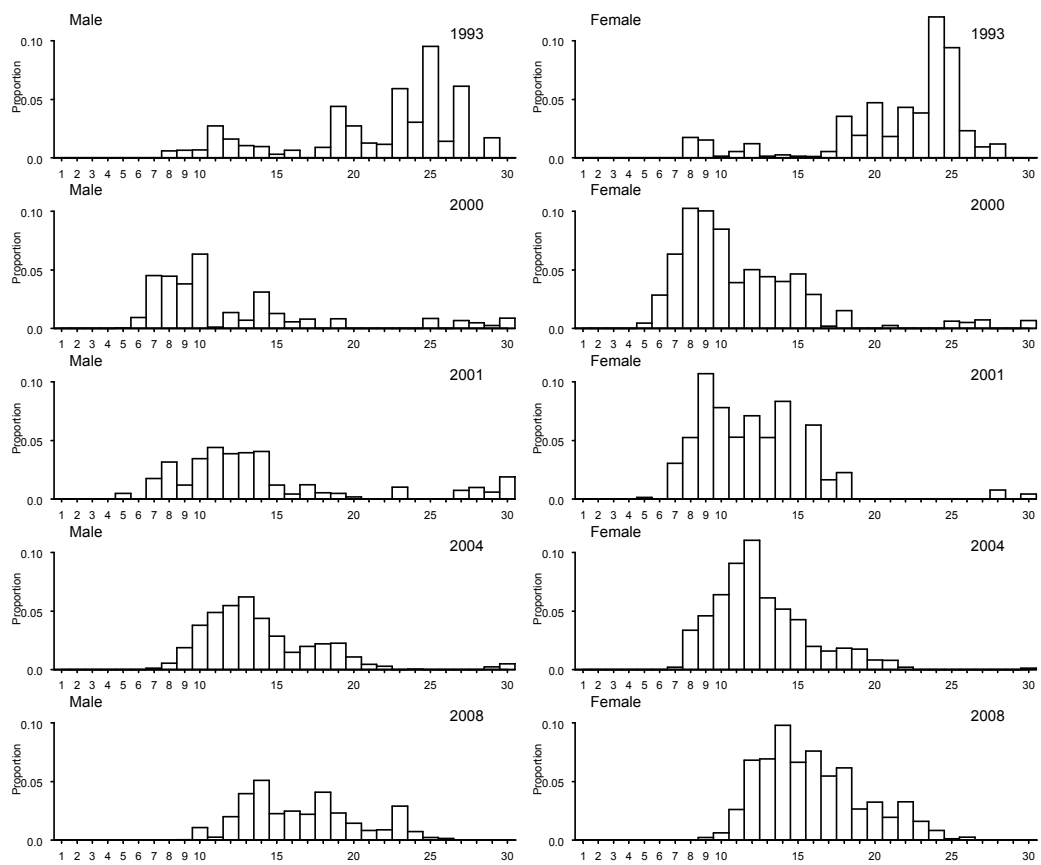


Figure B5: Available age frequencies of ling from commercial catch-at-age data in the Bounty Plateau longline fishery, 1993 to 2008.

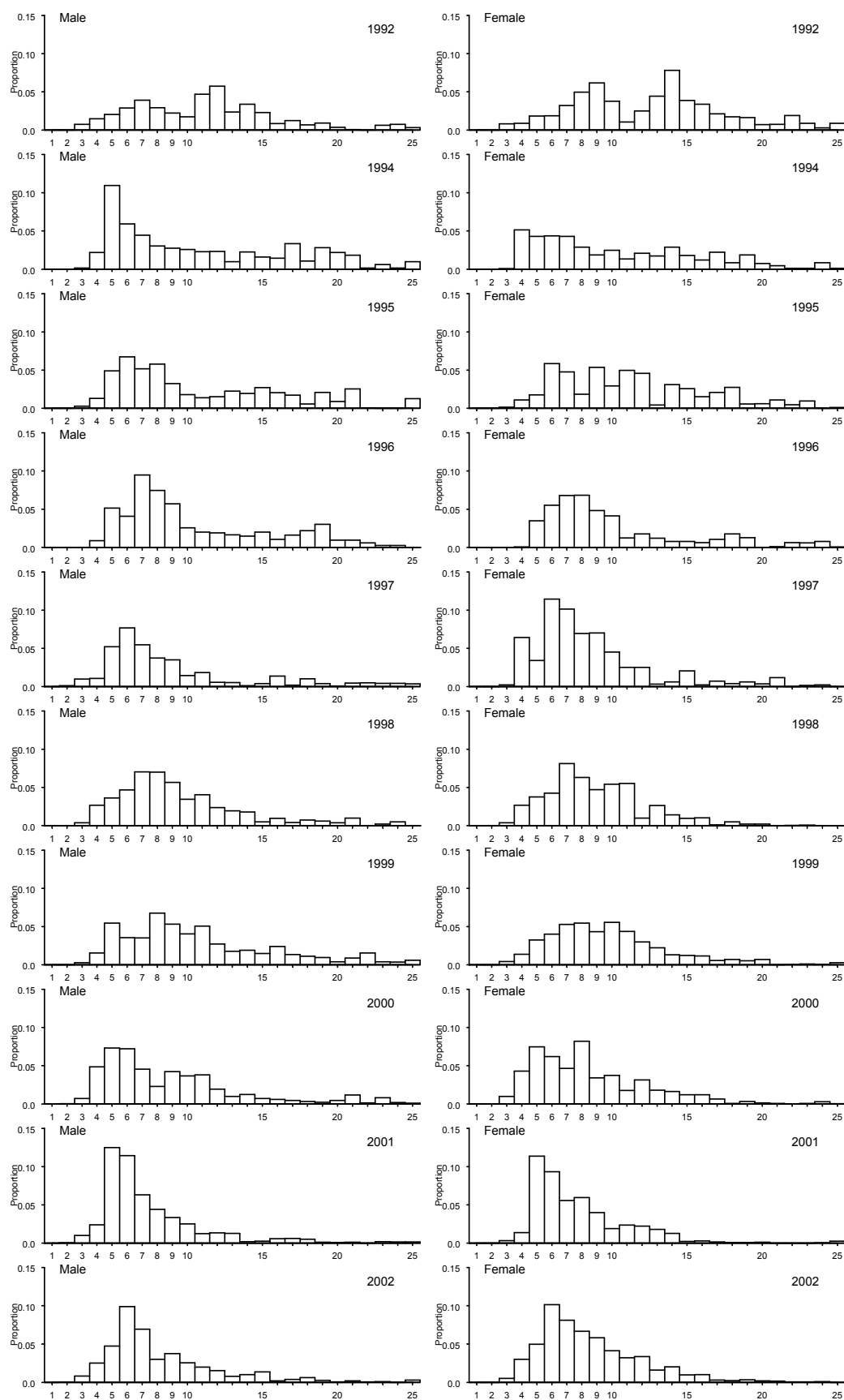


Figure B6: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2008.

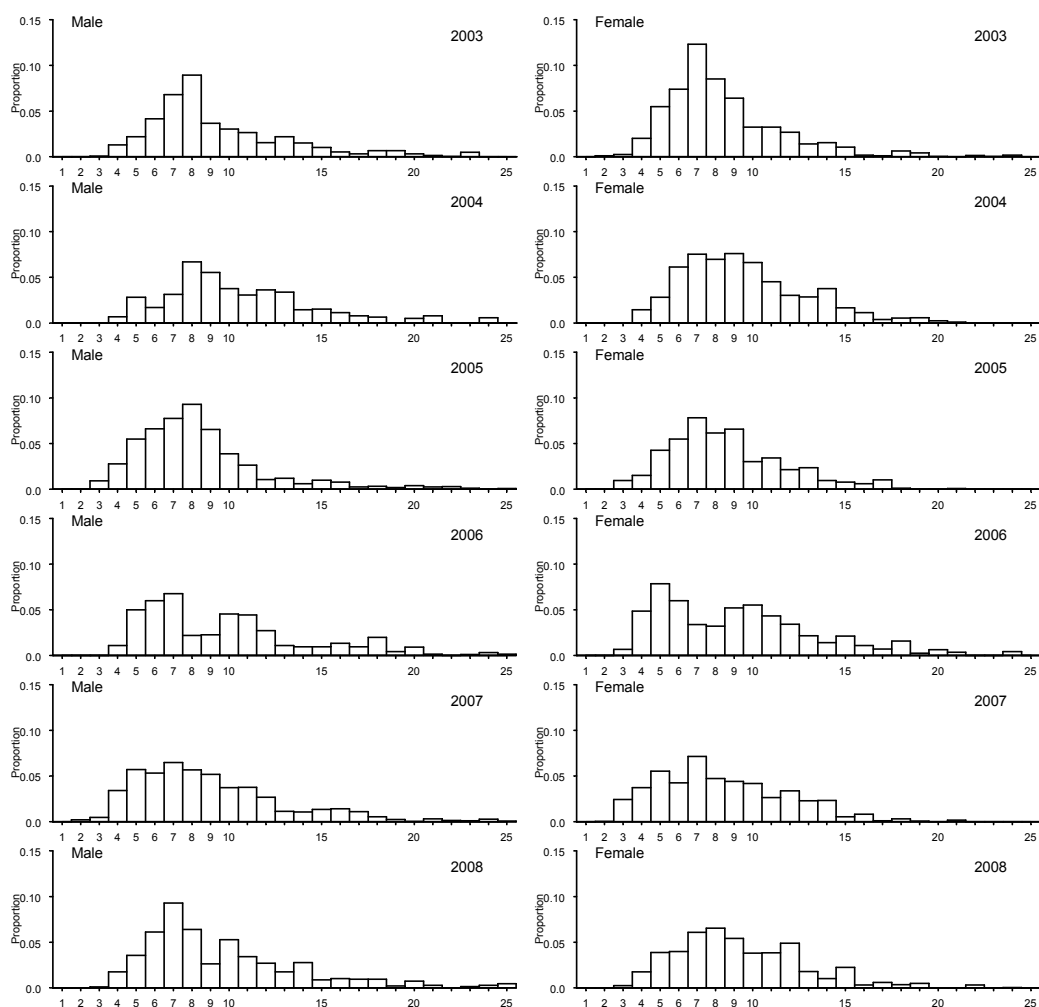


Figure B6 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Chatham Rise trawl fishery, 1992 to 2008.

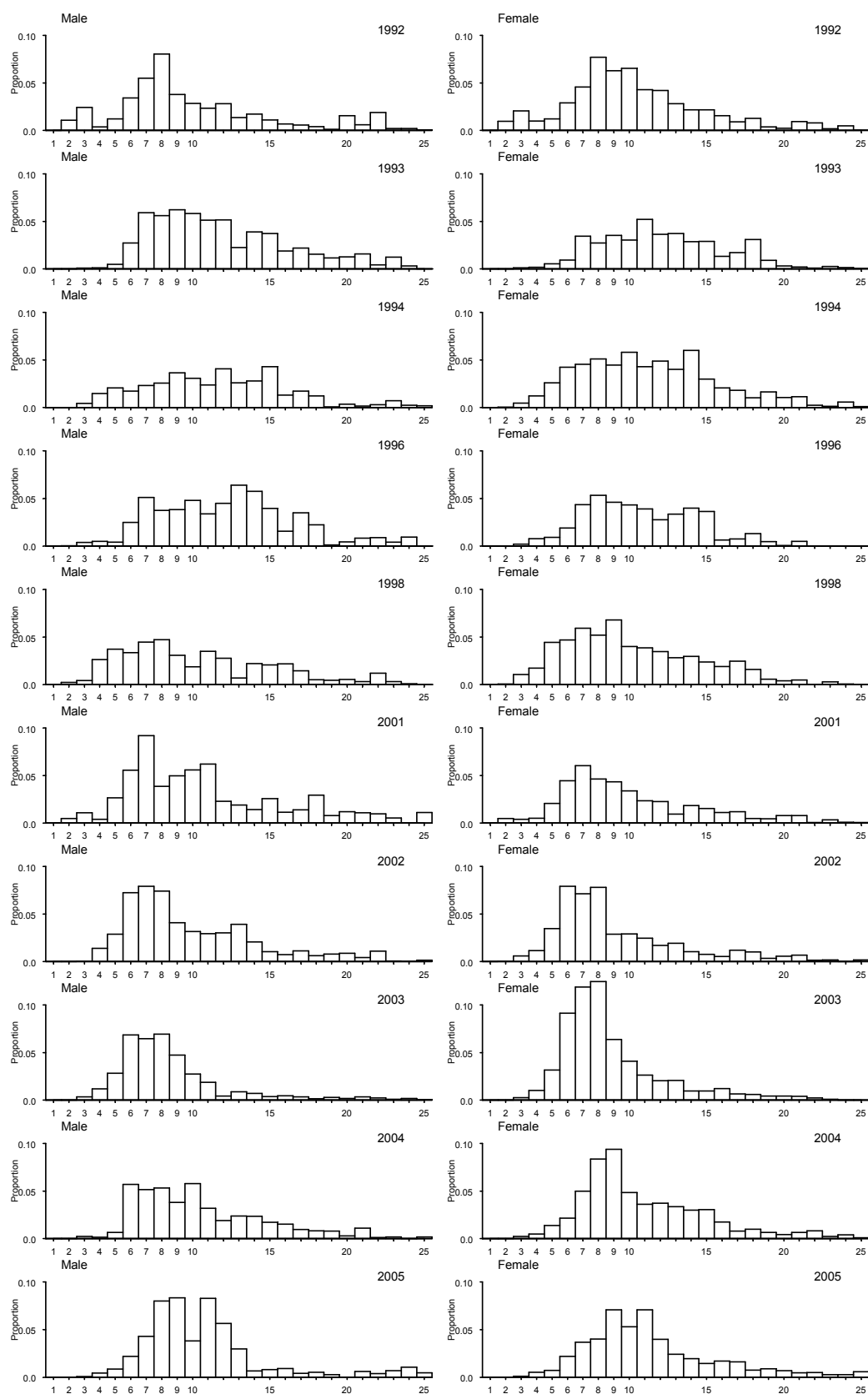


Figure B7: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2008.

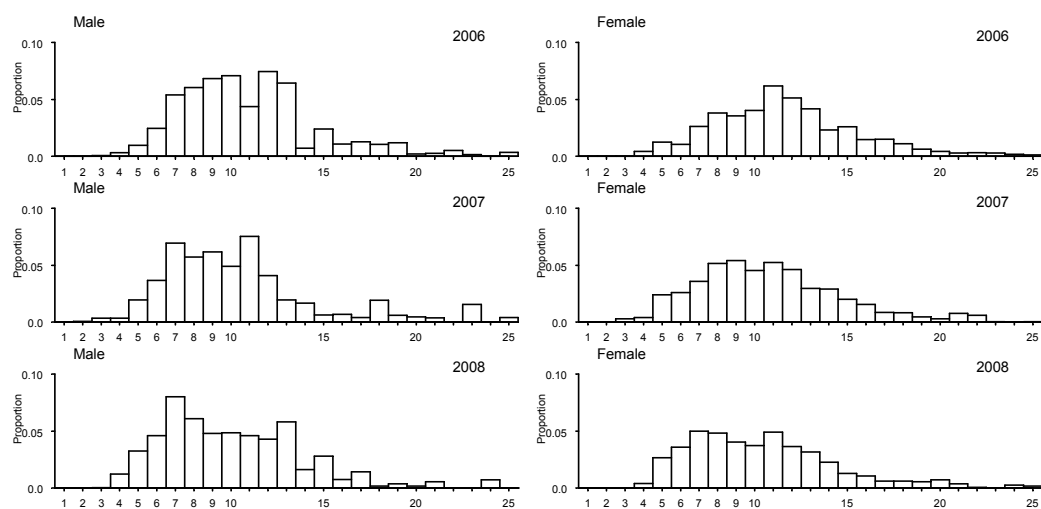


Figure B7 ctd.: Available age frequencies of ling from commercial catch-at-age data in the Sub-Antarctic trawl fishery, 1992 to 2008.

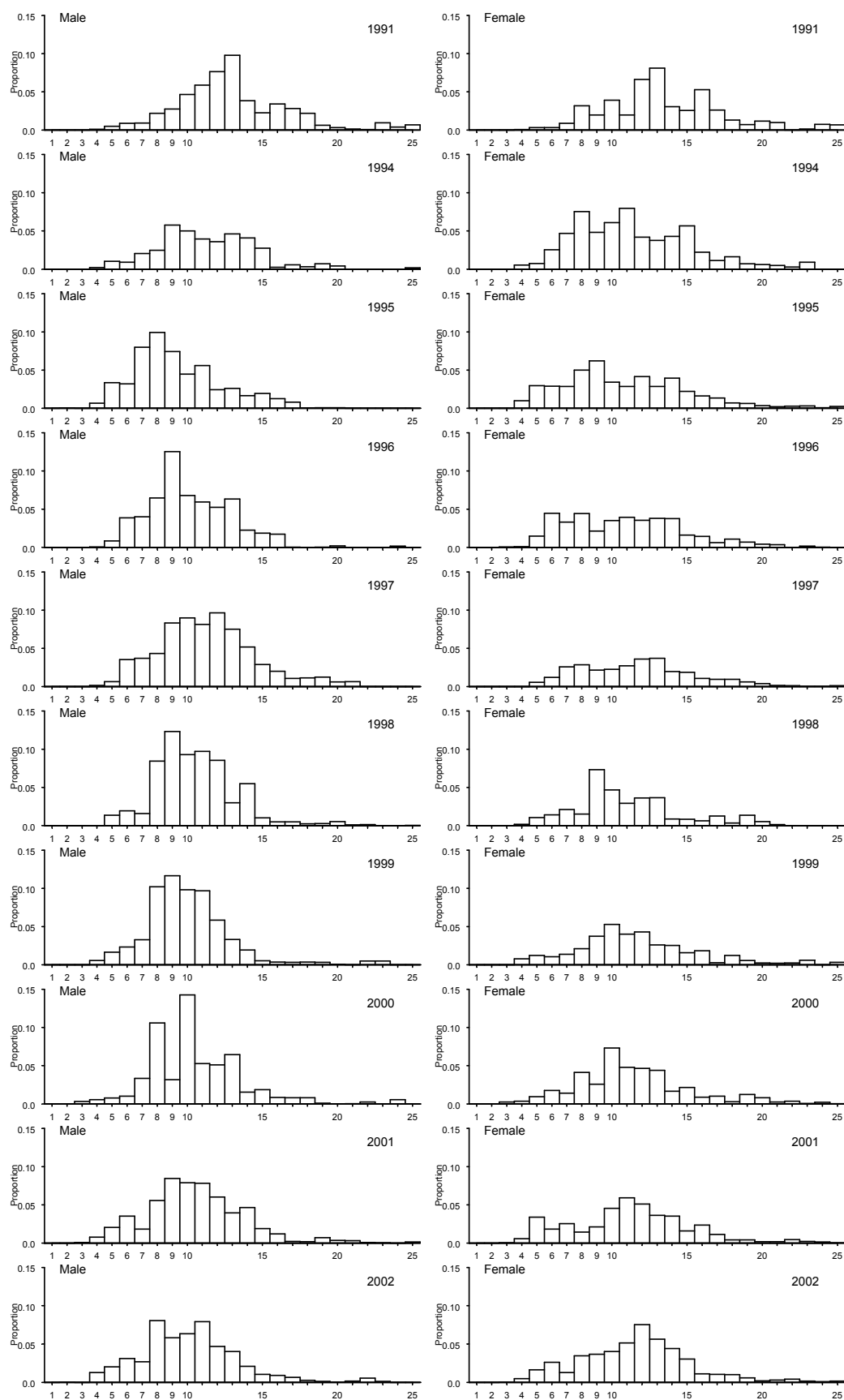


Figure B8: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2008.

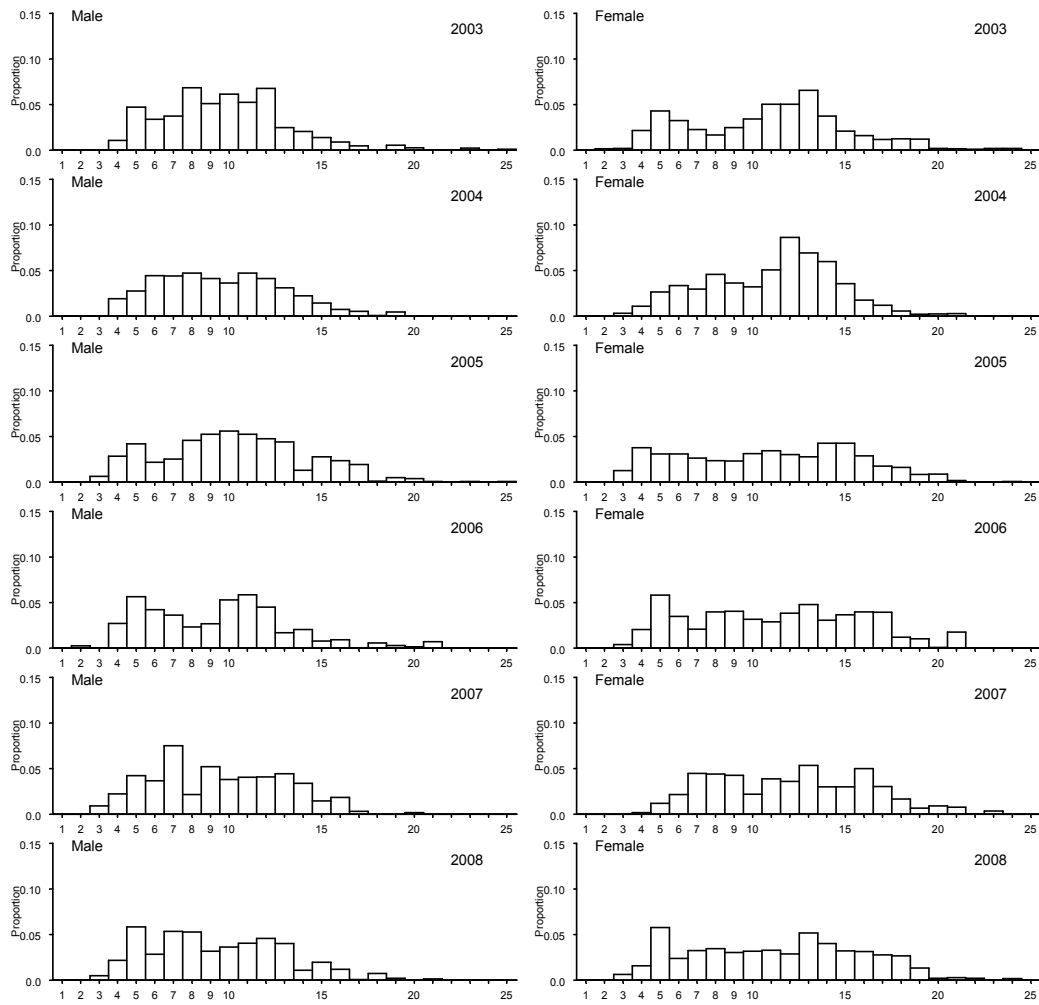


Figure B8 ctd.: Available age frequencies of ling from commercial catch-at-age data in the WCSI trawl fishery, 1991 to 2008.

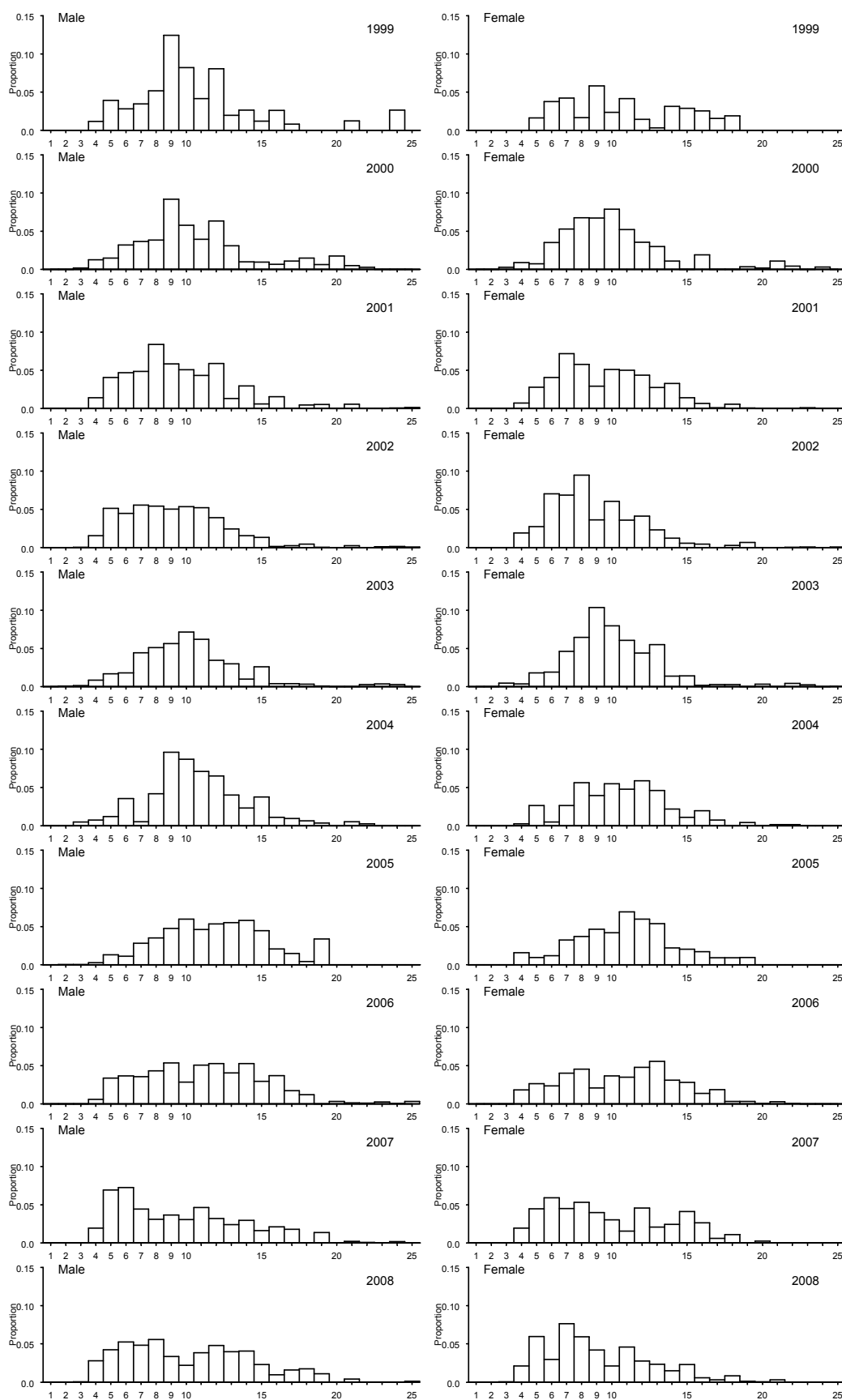


Figure B9: Available age frequencies of ling from commercial catch-at-age data in the Cook Strait trawl fishery, 1999 to 2008.

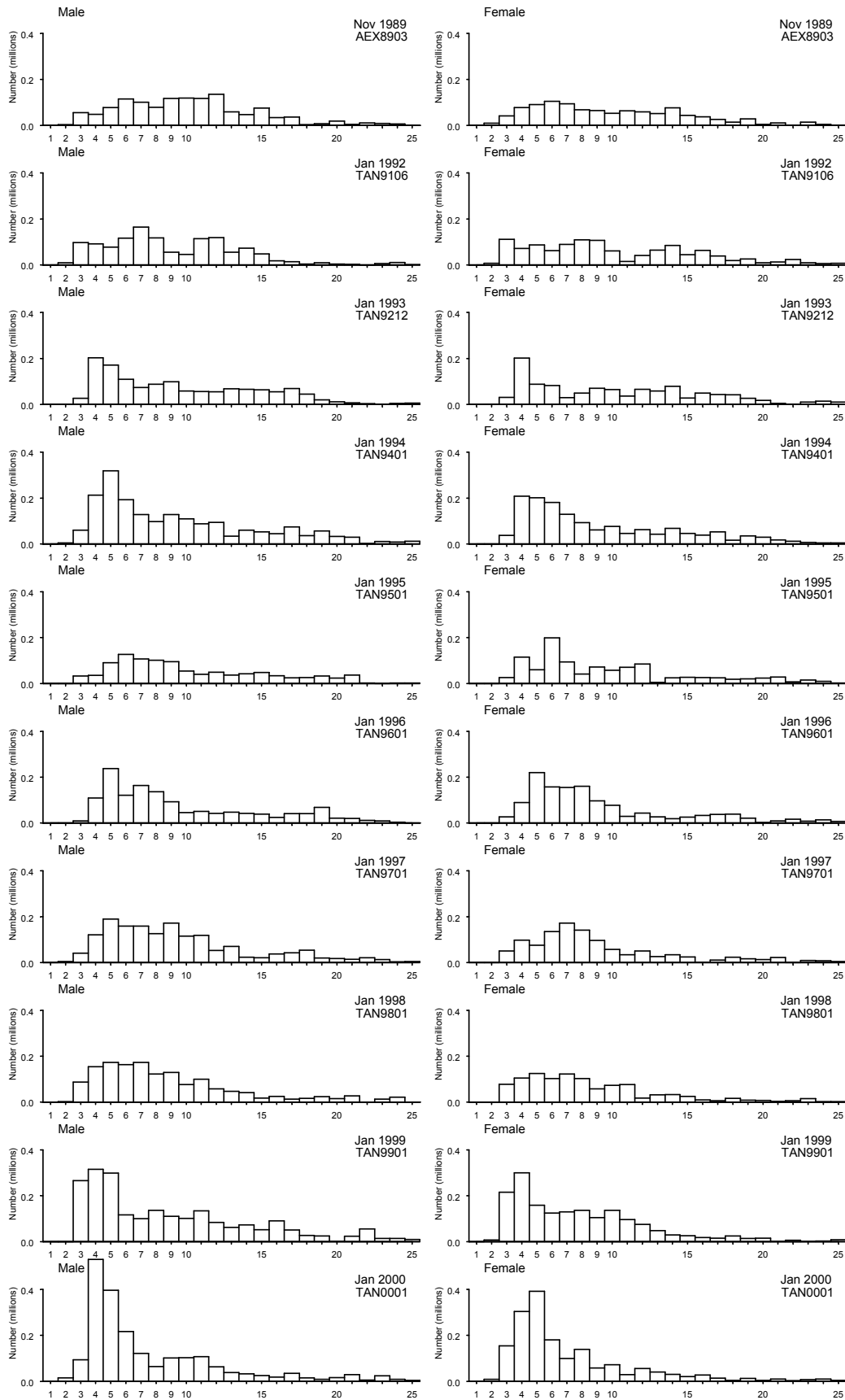


Figure B10: Available age frequencies of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2008–09.

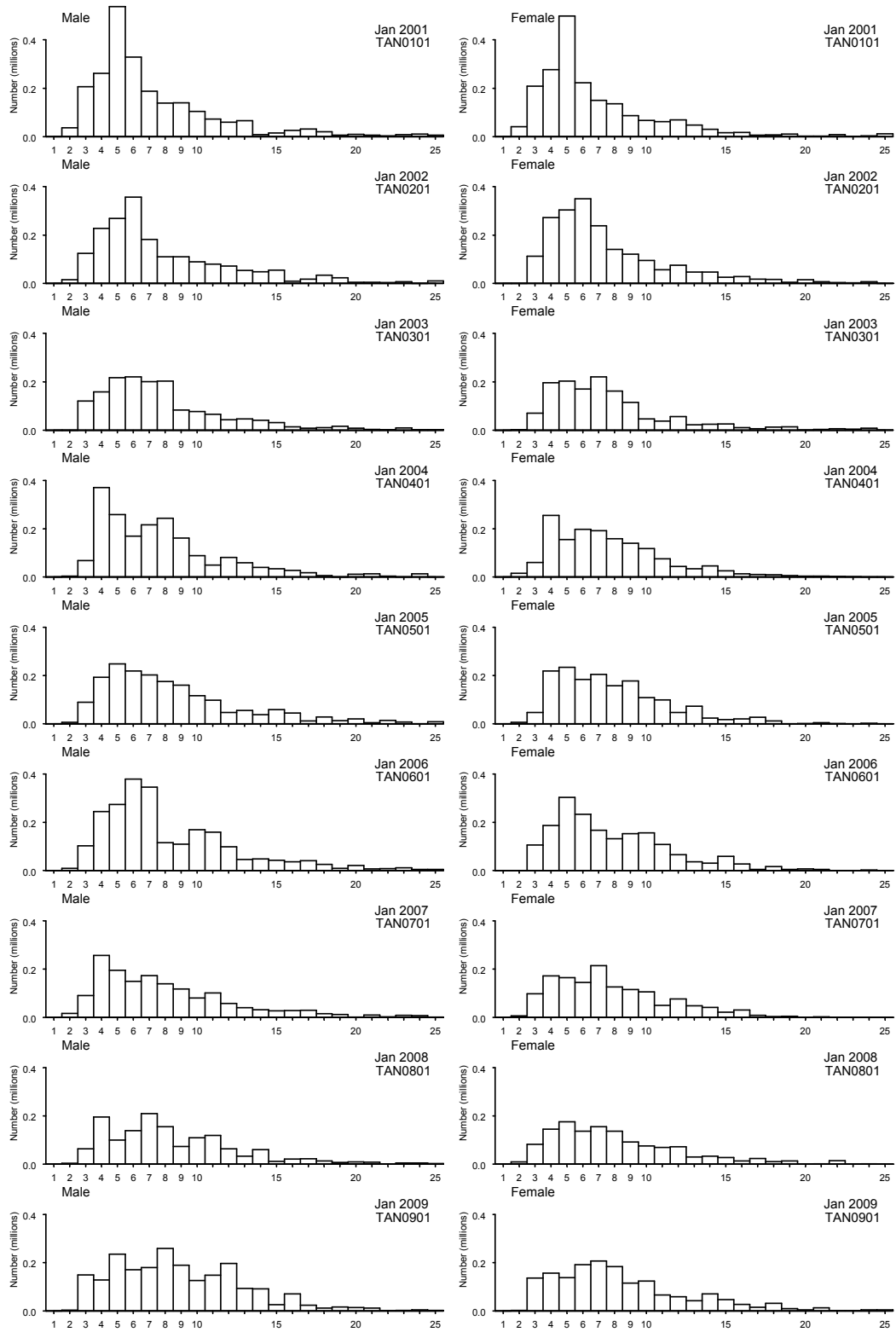


Figure B10 ctd.: Available age frequencies of ling (ages 1 to 25) from resource surveys in the Chatham Rise, 1989–90 to 2008–09.

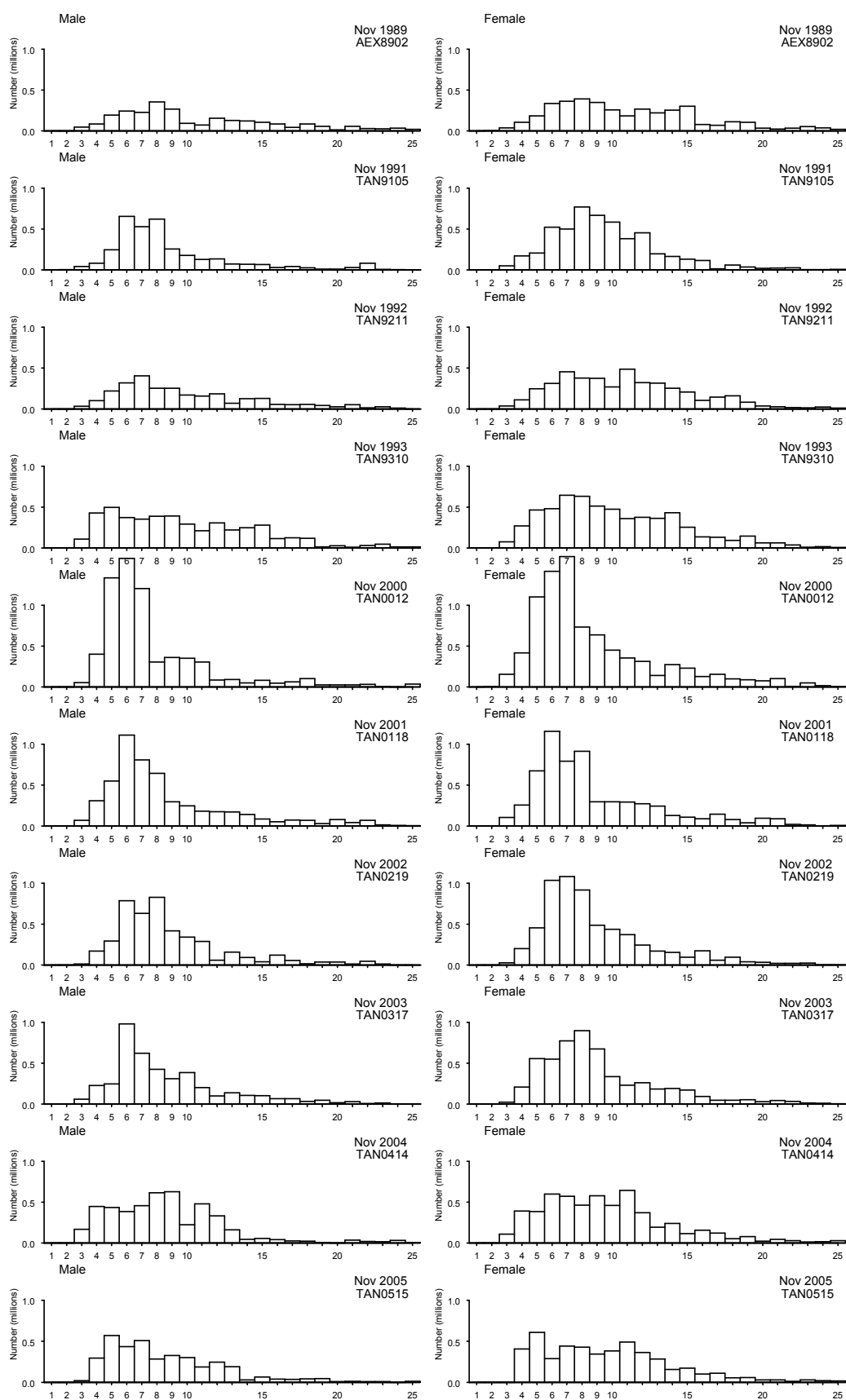


Figure B11: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2008.

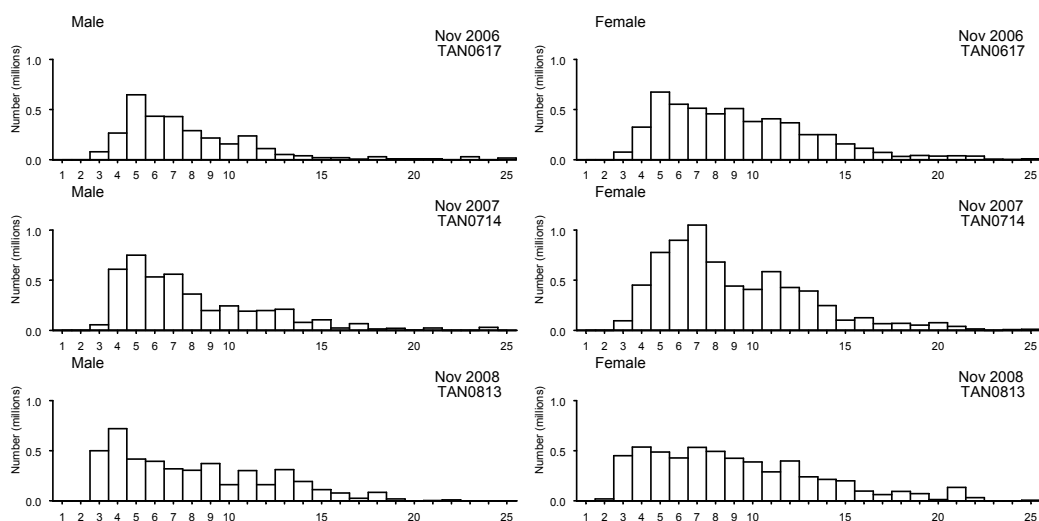


Figure B11 ctd.: Available age frequencies of ling (ages 1 to 25) from summer resource surveys in the Sub-Antarctic, 1989 to 2008.

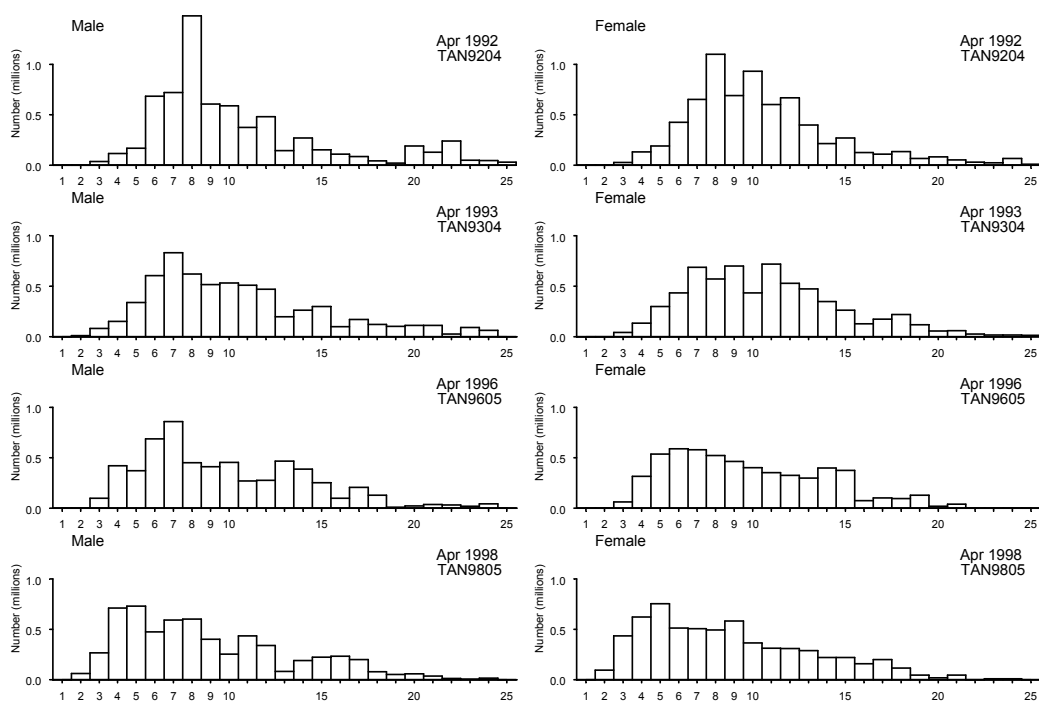


Figure B12: Available age frequencies of ling (ages 1 to 25) from autumn resource surveys in the Sub-Antarctic, 1992 to 1998.