Length and age composition of northern gemfish (SKI 1) in the 2010 target trawl fishery

A.D. Langley[1]
P. Horn[2]
C. Walsh[3]
D.A.J. Middleton[4]

[1]7 Van Diemen Street
Nelson 7010

[2]NIWA
Private Bag 14901
Wellington 6241

[3]Stock Monitoring Services Ltd
16C Gatman St
Birkdale
Auckland 0626

[4]NZ Seafood Industry Council
Private Bag 24901
Wellington 6011

New Zealand Fisheries Assessment Report 2012/14
April 2012

Published by Ministry of Agriculture and Forestry
Wellington
2012

ISSN 1175-1584 (print)
ISSN 1179-5352 (online)
ISBN 978-0-478-38832-9 (online)

Langley, A.D.; Horn, P.; Walsh, C.; Middleton, D.A.J. (2012).
Length and age composition of northern gemfish (SKI 1) in the 2010 target trawl fishery.
New Zealand Fisheries Assessment Report 2012/14. 32 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry of Agriculture and Forestry
P O Box 2526
WELLINGTON

Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry of Fisheries website at
http://fs.fish.govt.nz go to Document library/Research reports
or the MAF website at:
http://www.maf.govt.nz/news-resources/publications.aspx

EXECUTIVE SUMMARY

Langley, A.D.; Horn, P.; Walsh, C.; Middleton, D.A.J. (2012). Length and age composition of northern gemfish (SKI 1) in the 2010 target trawl fishery.

***New Zealand Fisheries Assessment Report 2012/14.* 32 p.**

The 2010 target SKI 1 gemfish trawl fishery operated from mid May to mid June and yielded a catch of approximately 170 t. Sampling of the landed gemfish catch from 13 fishing trips was conducted to determine the length and age composition of the catch. The sampled landings represented a high (61.5%) proportion of the total catch from the fishery and were representative of the spatial and temporal distribution of the total catch. The high level of sampling coverage was facilitated by the concentrated nature of the fishery (in both time and space) and receipt of a high proportion of the catch by the two participating quota owners/processors. An audit of the sampling procedures and the resulting sampling data indicated that the data were collected to a high standard.

The sampling programme achieved relatively precise estimates of the age (and length) composition of the catch, with mean weighted c.v.s for male (14.9%) and female (20.1%) fish, exceeding the specified target level of precision (mean weighted c.v.s of 30%). The age composition of the catch of male fish was dominated by 5–10 year old fish, in particular the 5, 7, and 9 age classes (representing the 2004, 2002 and 2000 year classes, respectively). The female age composition was dominated by 7–12 year old fish and also included a relatively high proportion of fish in the 7 and 9 year age classes.

The male and female age compositions were similar to the time-series of age frequency data previously collected from the fishery. The most recent sampling occurred in 2006 and, consequently, there is limited overlap in the year classes between the previous and current samples. However, the 2000 year class appears to be relatively strong in the two samples (aged 5 yr in 2006 and 9 yr in 2010).

The proportion of male fish (69%) in the 2010 gemfish catch is considerably higher than from previous samples (58% in 2002 and 56% in 2006). This is largely due to the high proportion of 5 year and 7 year fish in the male age composition. In general, male fish recruit to the fishery at an earlier age than female fish and the high proportion of younger male fish in the catch is likely to be indicative of the recruitment of a number of stronger year classes into the fishery.

1. INTRODUCTION

The SKI 1 trawl fishery targets pre-spawning gemfish during a short fishing season that occurs between mid May and mid June. During 2006–2009, the target fishery caught 100–150 t representing 60–80% of the total annual catch from the SKI 1 fishstock. These recent catches are considerably lower than those taken during the late 1980s–mid 1990s when annual catches were about 1000–1300 t. The decline in annual catch followed successive reductions in the SKI 1 TACC to the current level of 210 t established in 2001–02 (Fu et al. 2008).

Sampling of the SKI 1 landed catch was conducted annually during 1989–99, with the exception of 1995, and then intermittently over the last decade (in 2002 and 2006). The time-series of catch-at-age data from the fishery are presented in Fu et al. (2008). These data represent an important input to the stock assessment of the northern gemfish fishstock (SKI 1 and SKI 2 combined) (Fu et al. 2008).

Sampling of the fishery in the 2010 season (2009–2010 fishing year) was initiated as part of an industry pilot sampling programme, and under MFish research project SKI2009/01. The specific objective of the latter project was to determine the length and age composition of the commercial catch of gemfish in SKI 1 during the 2010 fishing season with a target coefficient of variation (c.v.) for the catch at age of 30 % (mean weighted c.v. across all age classes).

The project was conducted as a collaboration between the fishing industry, specifically the main quota owners and processors and the NZ Seafood Industry Council (SeaFIC), and NIWA. SeaFIC was responsible for the design of the sampling programme and the two main quota owners/processors conducted the catch sampling. NIWA staff were responsible for the age determination of the otolith samples and were involved in the analysis of the sampling data in collaboration with SeaFIC. This report documents the final results of the sampling from the 2010 fishery.

2. METHODS

2.1 Sampling design and data collection

The sampling strategy was developed based on an analysis of the operation of the target trawl fishery during May–June 2006–2009. In recent years, most of the target trawl catch was taken during 10–15 fishing trips with some individual trips accounting for a large proportion of the total catch (25–30 t per trip). The catch from these trips was landed at Auckland or Tauranga with most of the catch received by either Sanford Limited or Aotearoa Fisheries Limited (AFL).

The sampling programme was directed towards the larger landings of gemfish to achieve a high level of coverage of the entire target trawl catch. The design specified the sampling of a minimum of 10 landings, each with a total SKI 1 catch exceeding 1 t. It was envisaged that most of the large (exceeding 10 t) landings would be available for sampling. Only landings processed by AFL (Pukekohe) and the Sanford Limited plants in Auckland and Tauranga were available for sampling.

The first phase of the sampling procedure was the random selection of a subsample of the catch from the individual landing. This involved the random selection of 40–50 bins containing a total of approximately 300 fish. All fish in the selected bins were sexed and measured to the nearest centimetre below the fork length (F.L.). The sequential bin number of the sampled fish was also recorded.

Otoliths were collected from the sample following two separate sampling protocols. To obtain a random age sample, otoliths were collected from every third fish measured from the first half of the sample (approximately 150 fish). This sample would subsequently be used to determine a Random Age Frequency (RAF) distribution for the catch. For the second half of the sample, otoliths were

collected in a non random manner from fish belonging to the less common length intervals for each sex. These additional otoliths were used to augment the RAF sample with the intention of deriving an age-length key (ALK) for both sexes. A target of a minimum of five otoliths was set for each 1cm length interval, and for each sex, over all landings sampled.

All sampling was conducted at the AFL and Sanford Auckland processing facilities. For catches landed at Sanford Tauranga, the initial selection of the sampled component of the catch (40–50 bins) was conducted in Tauranga. These bins were then transported to Sanford Auckland for completion of the sampling.

Sampling was undertaken by personnel employed by Sanford Limited and AFL. Staff training and auditing of the sampling procedure and data quality was conducted by Cameron Walsh, Stock Monitoring Services Ltd.

Ageing of the otolith collections was conducted by following established procedures and protocols (Horn & Hurst 1999). Fish are assumed to spawn in July immediately following the main fishery in May-June. The protocol assigns the true integer age, i.e. the age before their theoretical birthday in July. Thus, a fish that was spawned in 2004 (the 2004 year class) was assigned an age of 5 years in the sample collected in May-June 2010.

2.2 Data analysis

The total weight of gemfish in each landing was determined from Catch Landing Returns (CLR) submitted to the Ministry of Fisheries. The CLR data were linked to sampling data based on the name of the fishing vessel and the landing and/or sampling date. This procedure identified two sampled landings that included catches of gemfish from SKI 2. These landings were excluded from the subsequent analysis.

The sampling coverage was determined by comparing the weekly and spatial distribution of the sampled component of the catch with the total fishery. The latter was determined from an extract of catch and effort data provided by the Ministry of Fisheries (Report No. 7986). Catch and effort data from the fishery were summarised to determine the total number of landings and cumulative weight of landings in the sampled population by week and statistical area.

Length compositions were determined for each sex by scaling the individual samples by the weight of the landing. The c.v. of the estimate of the proportion at length for each length interval was determined using a bootstrapping approach based on the methodology used by Blackwell et al. (1999) to compute the c.v. for age frequency distributions.

Unfortunately, the original length frequency data forms from the five AFL samples were lost and no copies of these data exist. The RAF otolith collections from these samples enabled some of the length frequency data to be retrieved, although the sample size is relatively small (approximately 50 fish per landing). The limited length data precluded the reliable estimation of the age frequency distribution from the length frequencies of these landings (via an age-length key). Nonetheless, the otolith samples enable these landings to be incorporated in the determination of the age frequency distributions using the RAF approach.

The otoliths collected under the RAF sampling protocol were applied to determine the combined estimate of the proportions at age for each sex. The estimates of the proportion at age and the associated c.v. were computed using the bootstrapping approach (Blackwell et al. 1999). The overall precision of the age composition was calculated as the average coefficient of variation for each age class, weighted by the proportion of the fish in the interval (MWCV).

For comparative purposes, composite age compositions were determined from the eight samples collected by Sanford Limited using the two approaches; i.e. 1) based on the RAF sampling protocol and 2) by applying the age-length key to the combined length frequency distribution (following Bull & Gilbert 2001).

3. RESULTS

3.1 Sampling protocol

The established sampling protocol assumes that each fish in a sampled landing has an equivalent probability of being sampled for either length and/or RAF otolith. Under the sampling protocol (and with a single catch stratum) this assumption would be violated if systematic sorting of the catch by fish size occurred prior to sampling.

Each sampled fish bin contained 5–8 fish (median 7 fish) with a net weight of 25–40 kg (estimated from the length-weight relationship). The distribution of the number and mean length of fish from individual bins was examined to ensure that no sorting of the catch had occurred prior to sampling. The practicalities of binning fish means that bins with larger fish will contain fewer fish. However, a simple simulation study using the sampling data indicated that the observed distribution of fish (in terms of number of fish per bin, median fish length per bin, and deviance in length within a bin) amongst bins was consistent with a random handling process (see Appendix 9). It was concluded that there was no indication that any systematic sorting of the catch had occurred prior to sampling.

The sampling protocol was designed to ensure that the otoliths for the RAF were collected in an approximately random manner. For each landing, otoliths were collected from every third fish sampled for length from the first half of the sample, resulting in the collection of approximately 50 pairs of otoliths per landing. The length composition of the RAF otolith collection was compared to the total length sample from the landing for those samples for those landings with a complete set of data (i.e. the landings sampled by Sanford Ltd). In general, the length compositions of both male and female fish were comparable in the otolith and length frequency data sets, although the small sample size of the female otolith collections (14–22 otoliths per sample) meant that the corresponding length compositions were poorly determined (Appendix 10).

A statistical comparison of the individual sample/sex data sets was conducted using the test described by Francis (2002). For most of the samples, there was no significant difference between the length composition of the length and otolith samples (Table 1). The exception was for the male fish from two landings (samples 6 and 7); however, these results were not considered to be indicative of a sampling bias in the collection of the otolith set due to the likelihood of type 1 error given the relatively small sample size (50 otoliths for both sexes) and the number of treatments (16).

3.2 Sampling coverage

The SKI 1 trawl fishery operates during May–August. During May–August 2010, most (83%) of the gemfish catch was taken by target trawls. The remainder of the catch was taken as a bycatch of hoki, ling and tarakihi trawls with a smaller bycatch from the scampi trawl fishery.

Gemfish fishing trips were defined as trips that either targeted and caught gemfish in SKI 1 or caught at least 100 kg of gemfish from a single trawl when targeting either hoki, ling or tarakihi. A total of 39 gemfish fishing trips were conducted during May–August 2010 yielding a total SKI 1 target trawl catch of 172 t and representing 70% of the total annual SKI 1 catch (247 t). Twenty-five of these trips landed at least 1 t of gemfish, thereby meeting the criteria for sampling.

Thirteen landings were sampled from the SKI 1 target trawl fishery during the study period. Most of the sampled landings exceeded 5 t of gemfish and three of the landings exceeded 15 t (Appendix 1).

The total sampled catch of 105.7 t represented 61.5% of the total landed catch from the target trawl fishery.

Most (69%) of the total SKI 1 target trawl catch was taken during a two week period in late May-early June and the sampling was concentrated in that period (Table 2, Figure 1). Smaller catches were taken in mid May prior to the commencement of sampling.

Most (90%) of the total gemfish catch was taken within statistical area 008 and only minor catches were taken beyond this area. The spatial distribution of the sampled catch was comparable to the total catch from the fishery (Table 3).

All the sampled landings were dominated by male fish, and males represented 69% of all fish measured. The total RAF sample of otoliths was collected from 658 fish (Appendix 2). An additional 225 pairs of otoliths were collected to augment the RAF otolith sample.

3.3 Length and age composition

The catch was dominated by male fish comprising a single mode occupying the 70–85 cm F.L. length range (Appendix 3, Figure 2). The length composition was determined with high precision, with a c.v. of 9–23% for the main length classes (70–85 cm) and a MWCV of 17.8%. The high level of precision reflects the similarity of the length compositions among the individual landings (Appendix 5).

Female fish represented 31% of the total sampled catch (in numbers). The female length composition was dominated by fish in the 80–95 cm F.L. length range (Appendix 3, Figure 3). The length composition was comparable among the sampled landings (Appendix 6). However, the level of precision of the estimated proportions at length is lower than for male fish with a c.v. of 16–34% for the main length classes (80–95 cm) and a MWCV of 25.8%. The lower precision is likely to be due to the smaller number of female fish measured per sample.

The estimated RAF age composition of the catch of male fish was dominated by 5–10 year old fish, in particular the 5, 7, and 9 age classes (representing the 2004, 2002 and 2000 year classes, respectively) (Appendix 4, Figure 4). The 6 and 8 year age classes are under-represented in the age composition, suggesting weaker 2003 and 2001 year classes. The c.v. associated with the estimate of proportion at age is 8–15% for the dominant 5–10 year age classes and the overall age composition has a MWCV of 14.9%. The age compositions of the RAF samples from the individual landings are presented in Appendix 7. There is considerable variability in the age composition among landings, although the strong 5, 7 and 9 year age classes are represented in most landings albeit in varying proportions.

The female RAF age composition is dominated by 7–12 year old fish (Appendix 4, Figure 5) and hence comprised of older fish than the male component of the catch. The 7 and 9 year age classes are also well represented in the female age composition, while the 8 year age class is under represented. The c.v. associated with the estimate of proportion at age is 11–26% for the dominant age classes and the overall age composition has a MWCV of 20.1%. The age compositions of the individual RAF samples are broadly comparable (Appendix 8) although the sample sizes are small (typically 15–20 otoliths per sample).

For the subset of the landings with a complete set of length data, the male and female age compositions were comparable for the two analytical approaches (RAF and ALK) (Figure 6). The main differences are the higher proportion of male fish in the dominant age classes (7 and 9 year old) of the ALK age composition and the higher proportion of 11 and 12 year old female fish in the RAF age composition. There is also a higher proportion of age 5 year male fish in the RAF age composition (Figure 6). These differences are evident when comparing the scaled length compositions of the individual age classes derived from the two approaches (Figure 7).

4. DISCUSSION

A high proportion of the catch from the 2009–10 SKI 1 target trawl fishery was sampled, resulting in good spatial and temporal coverage of the fishery by the sampling programme. This was facilitated by the concentrated nature of the fishery (in both time and space) and the receipt of a high proportion of the catch by the two participating quota owners/processors. An audit of the sampling procedure and the resulting sampling data indicated that the data were collected to a high standard.

The sampling programme achieved relatively precise estimates of the age (and length) composition of the catch, with mean weighted c.v.s for male (14.9%) and female (20.1%), exceeding the target level of precision specified for the Ministry's SKI2009/01 project (mean weighted c.v.s of 30%).

The age compositions were similar to the time-series of age frequency data previously collected from the fishery. The most recent sampling occurred in 2006 and, consequently, there is limited overlap in the year classes between the previous and current samples. However, the 2000 year class appears to be relatively strong in the two samples (aged 5 yr in 2006 and 9 yr in 2010) (Figure 8 and Figure 9).

The RAF and ALK approaches to the calculation of the age composition yielded comparable results. This is due, at least in part, to the comparable length distribution of individual age classes among landings and the collection of the ALK otolith set across all of the landings sampled.

The proportion of male fish (69%) in the 2010 gemfish catch is considerably higher than from recent samples (58% in 2002 and 56% in 2006) (Fu et al. 2008). This is largely due to the high proportion of age 5 and 7 year fish in the male age composition. In general, male fish recruit to the fishery at an earlier age than female fish and the high proportion of younger male fish in the catch is indicative of the recruitment of a number of stronger year classes into the fishery.

5. ACKNOWLEDGMENTS

The gemfish catches were sampled by Pouha Lotoahea and Elham Tuerxun (Sanford Ltd, Auckland) and Aroha Belcher (AFL). Cameron Walsh (Stock Monitoring Services Ltd) trained the sampling staff and auditing the sampling procedures. The sampling component of the project was managed by David Middleton (SeaFIC), Mark Soboil (AFL) and Andrew Bond (Sanford Ltd) and data were processed by Greg Lydon (SeaFIC) and the staff of Dragonfly Ltd. Ageing of the otolith collections was undertaken by Peter Horn, NIWA. Catch and effort data were provided by the Ministry of Fisheries. Funding for the project was provided by Aotearoa Fisheries Ltd., Sanford Ltd., and the Ministry of Fisheries under project SKI2009/01.

6. REFERENCES

Blackwell, R.G.; Gilbert, D.J.; Davies, N.M. (1999). Age composition of commercial snapper landings in SNA2 and Tasman Bay/Golden Bay (SNA7), 1997–98. New Zealand Fisheries Assessment Research Document 99/17. 23 p. (Unpublished report held in NIWA library, Wellington).

Bull, B.; Gilbert, D.J. (2001). Catch-at-age sampling. *New Zealand Fisheries Assessment Report* 2001/53. 19 p.

Francis, R.I.C.C. (2002). Estimating catch at age in the Chatham Rise hoki fishery. *New Zealand Fisheries Assessment Report* 2002/09. 22 p.

Fu, D.; Dunn, A.; Hurst, R.J. (2008). Standardised CPUE analysis and stock assessment of northern gemfish (*Rexea solandri*) in SKI 1 and 2 for the 2005–06 fishing year. *New Zealand Fisheries Assessment Report* 2008/01. 68 p.

Horn, P.L.; Hurst, R.J. (1999). Age and stock structure of gemfish (*Rexea solandri*) in New Zealand waters. *Marine and Freshwater Research 50*: 103–115.

Table 1. Chi squared ($\chi 2$) and associated p-values for the comparison of the length composition of the RAF otolith collections and the total length samples for male and female fish using the rank test of Francis (2002). The analysis was undertaken for the eight samples with a complete set of length frequency data.

Sample	Male		Female	
	$\chi 2$	p-value	$\chi 2$	p-value
1	7.77	0.558	6.50	0.689
2	6.43	0.696	4.33	0.888
3	13.00	0.163	6.00	0.740
4	7.21	0.616	11.64	0.235
5	8.03	0.531	4.00	0.911
6	17.71	0.039	6.18	0.722
7	27.33	0.001	11.00	0.276
8	8.00	0.534	7.84	0.550

Table 2: Proportion of the total and sampled gemfish catch from the target trawl fishery by week of the year from May to August. Week 22 encompasses 28 May to 3 June.

	Week					
	18	**19**	**20**	**21**	**22**	**23**
Sample	0.000	0.000	0.000	0.033	0.528	0.354
Total	0.004	0.001	0.112	0.109	0.429	0.257
	24	**25**	**26**	**27**	**28**	**29**
Sample	0.085	0.000	0.000	0.000	0.000	0.000
Total	0.053	0.008	0.001	0.001	0.000	0.000
	30	**31**	**32**	**33**	**34**	**35**
Sample	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.000	0.001	0.002	0.002	0.000	0.020

Table 3: Proportion of the total and sampled gemfish catch from the target trawl fishery by statistical area.

	Statistical area							
	002	003	004	008	009	010	046	047
Sample	0.00	0.00	0.06	0.92	0.02	0.00	0.00	0.00
Total	0.00	0.01	0.04	0.90	0.03	0.00	0.02	0.00

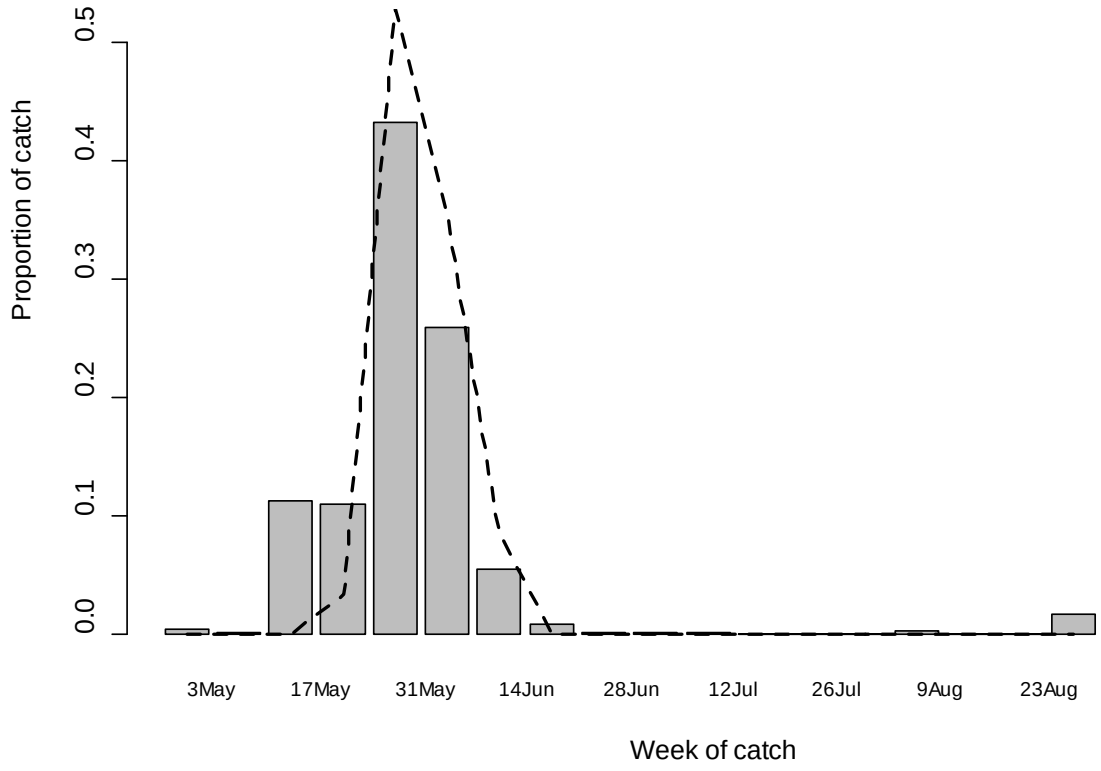


Figure 1: A comparison of the proportional distribution of the weekly total catch from the fishery (bars) and the sampled component of the catch (dashed line).

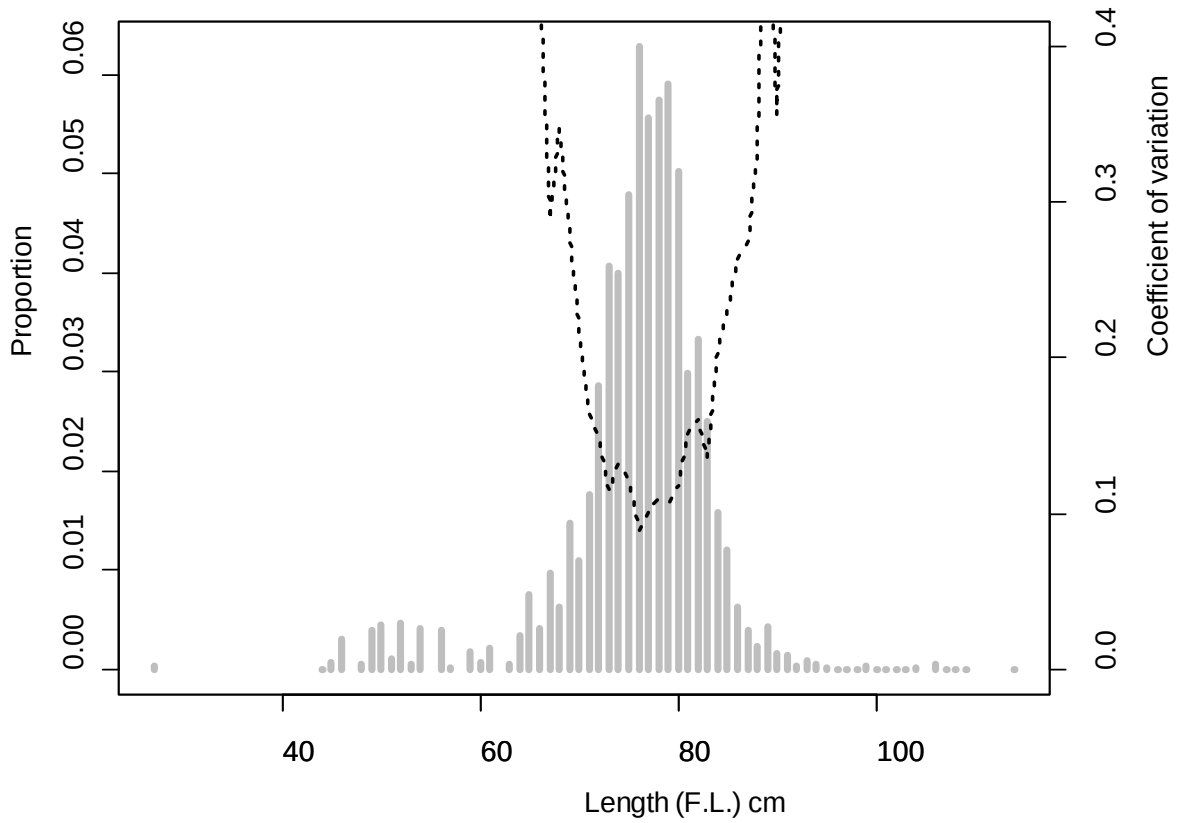


Figure 2: Length composition of male gemfish from the 2009–10 SKI 1 target trawl fishery. The dashed line represents the coefficient of variation associated with the estimates of proportion at length. Number of samples, 13; number of fish measured, 1837; MWCV, 17.8%.

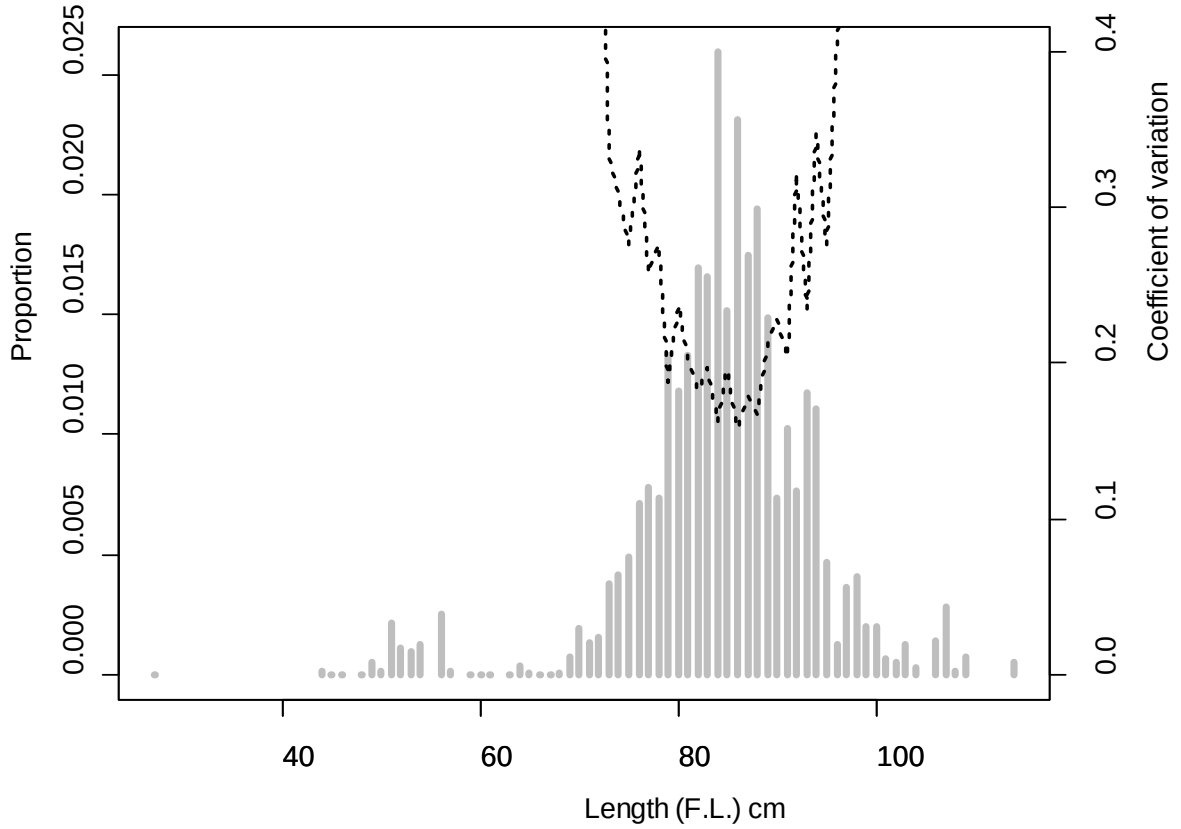


Figure 3: Length composition of female gemfish from the 2009–10 SKI 1 target trawl fishery. The dashed line represents the coefficient of variation associated with the estimates of proportion at length. Number of samples, 13; number of fish measured, 842; MWCV, 25.8%.

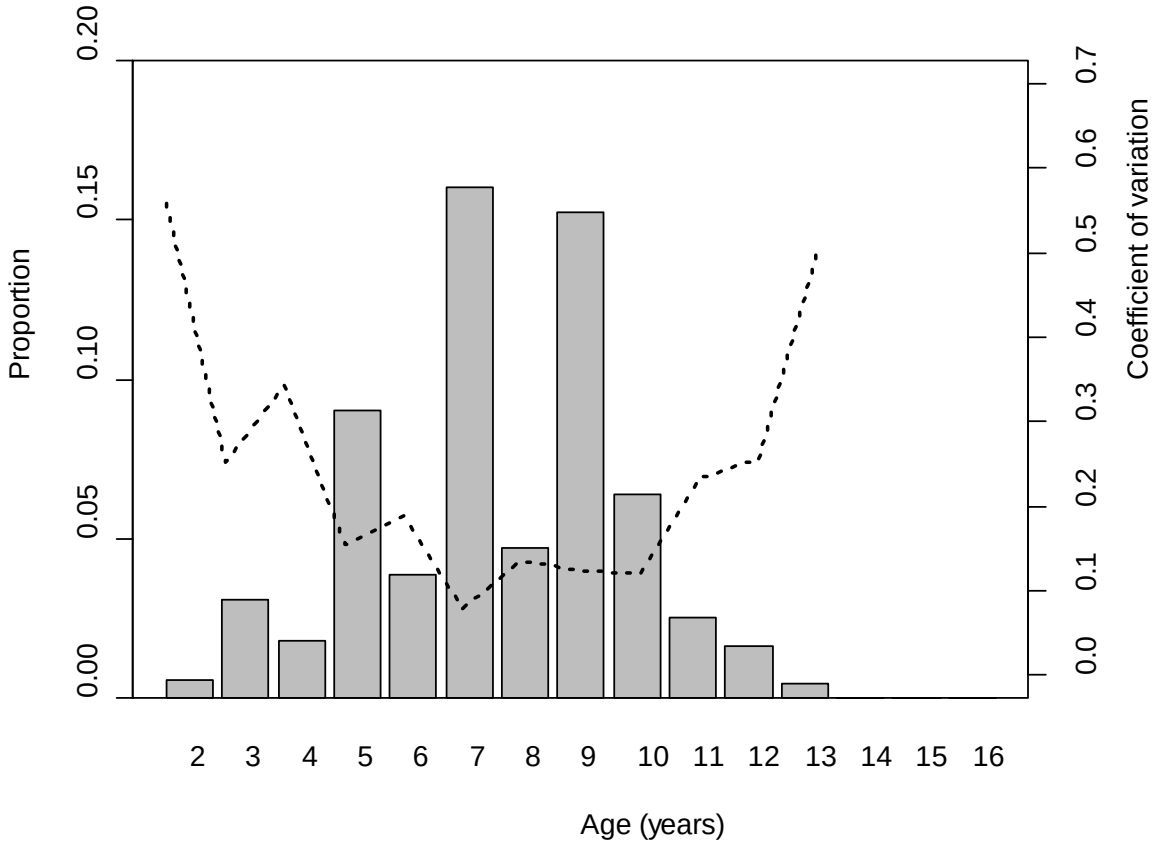


Figure 4: Age composition of the male SKI 1 catch for 2009–10. The dashed line represents the coefficient of variation associated with the estimates of proportion at age. Number of otoliths in the sample, 441; MWCV, 14.9%.

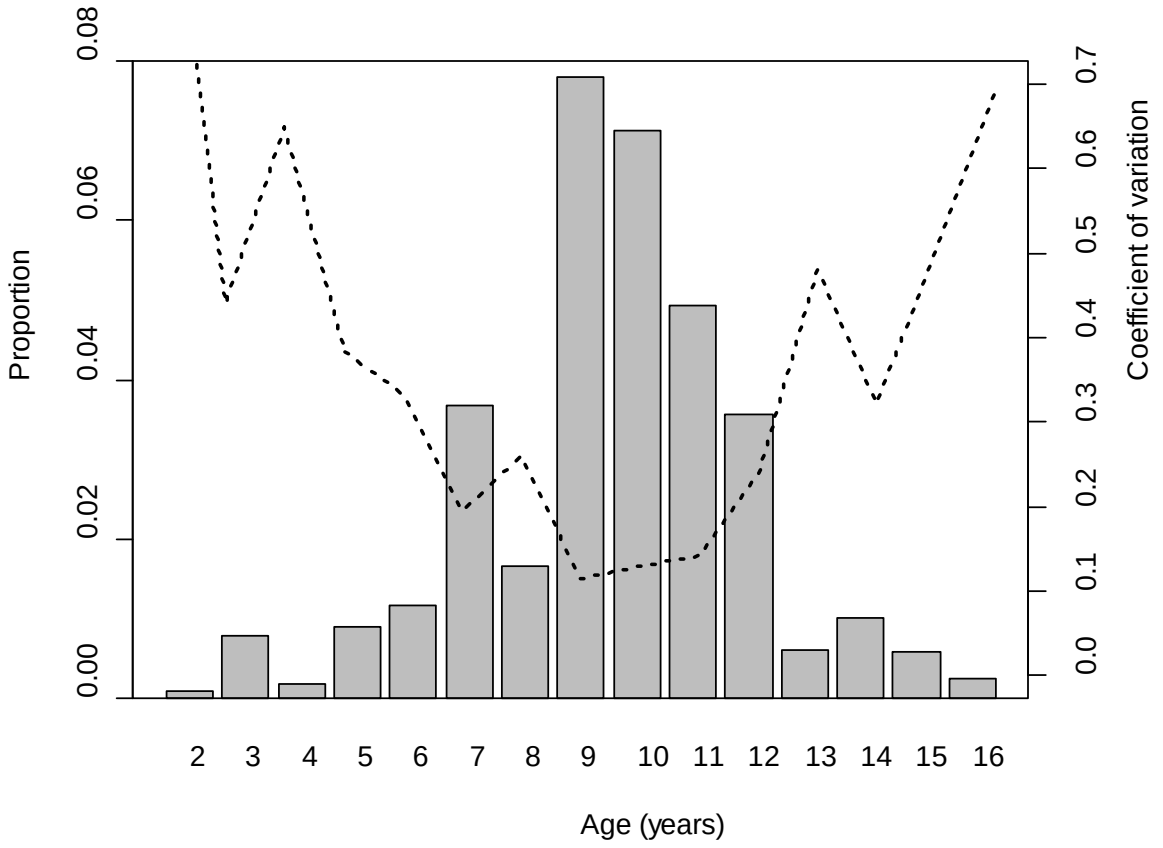


Figure 5: Age composition of the female SKI 1 catch for 2009–10. The dashed line represents the coefficient of variation associated with the estimates of proportion at age. Number of otoliths in the sample, 217; MWCV, 20.1%.

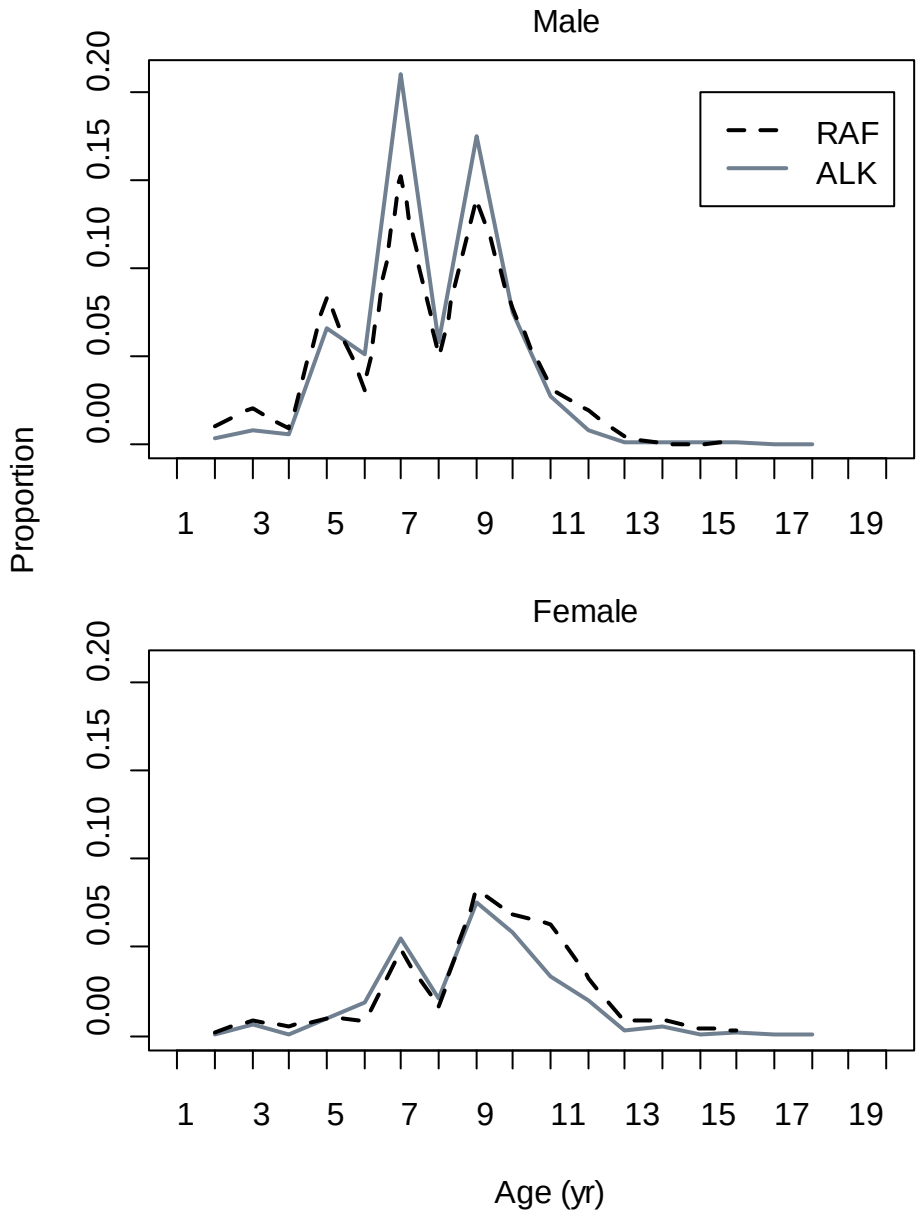


Figure 6: Male and female age compositions derived using RAF and ALK approaches. The comparative age compositions were derived from the subset of landings with a complete set of length frequency sampling data (8 landings).

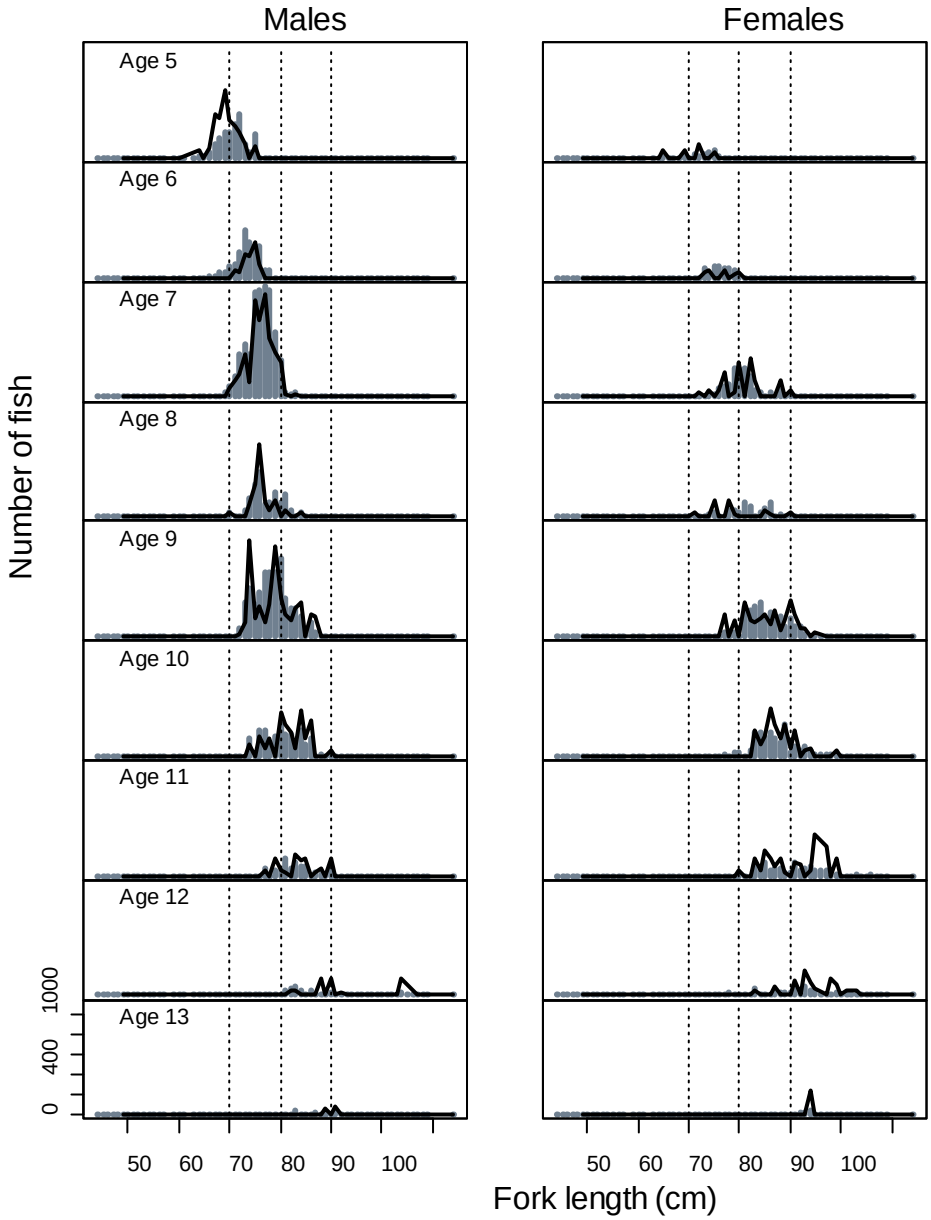


Figure 7. Scaled numbers of male and female fish at length for the main age classes derived from the RAF (black line) and ALK (grey bars) approaches based on the subset of landings with a complete set of length frequency data (eight landings).

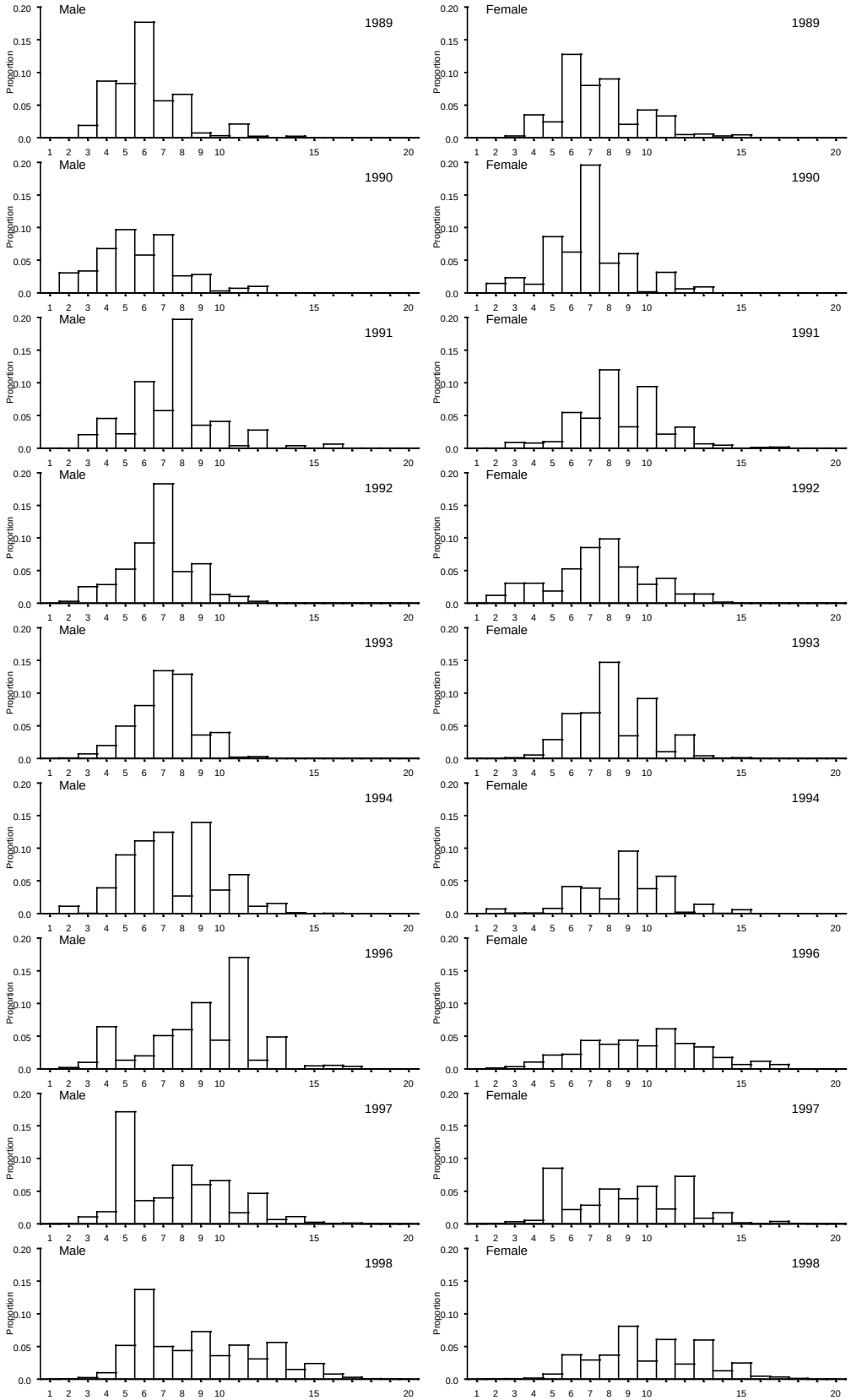


Figure 8. The time-series of estimates of the age composition of male and female gemfish from the SKI 1 target trawl fishery. For comparability, all age compositions were determined using the ALK approach.

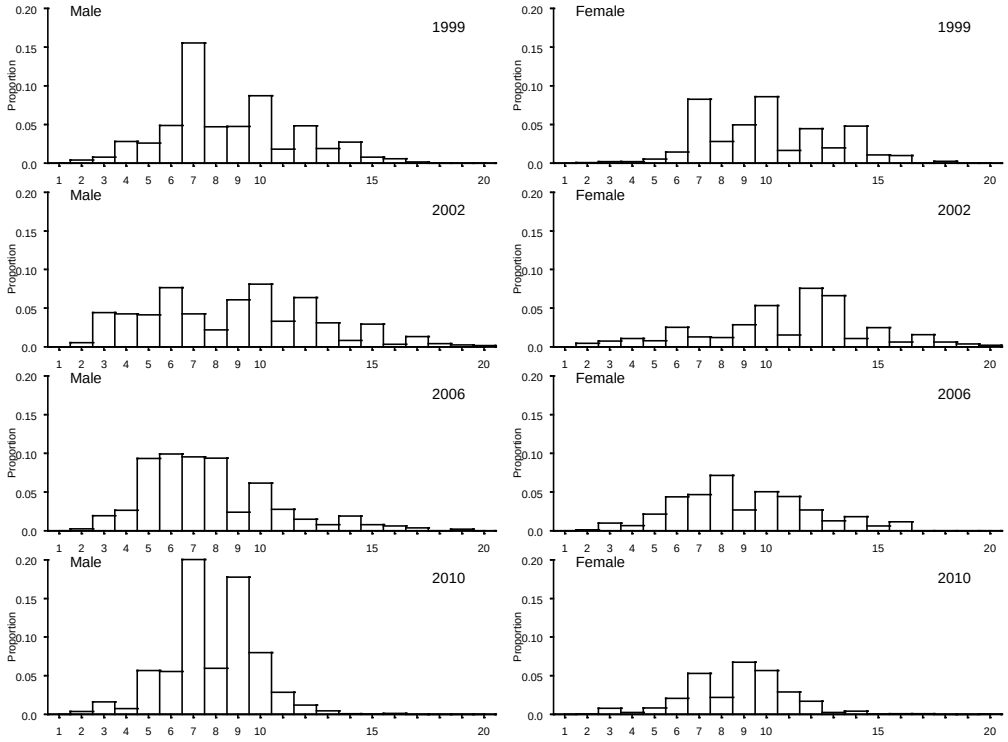


Figure 8 continued.

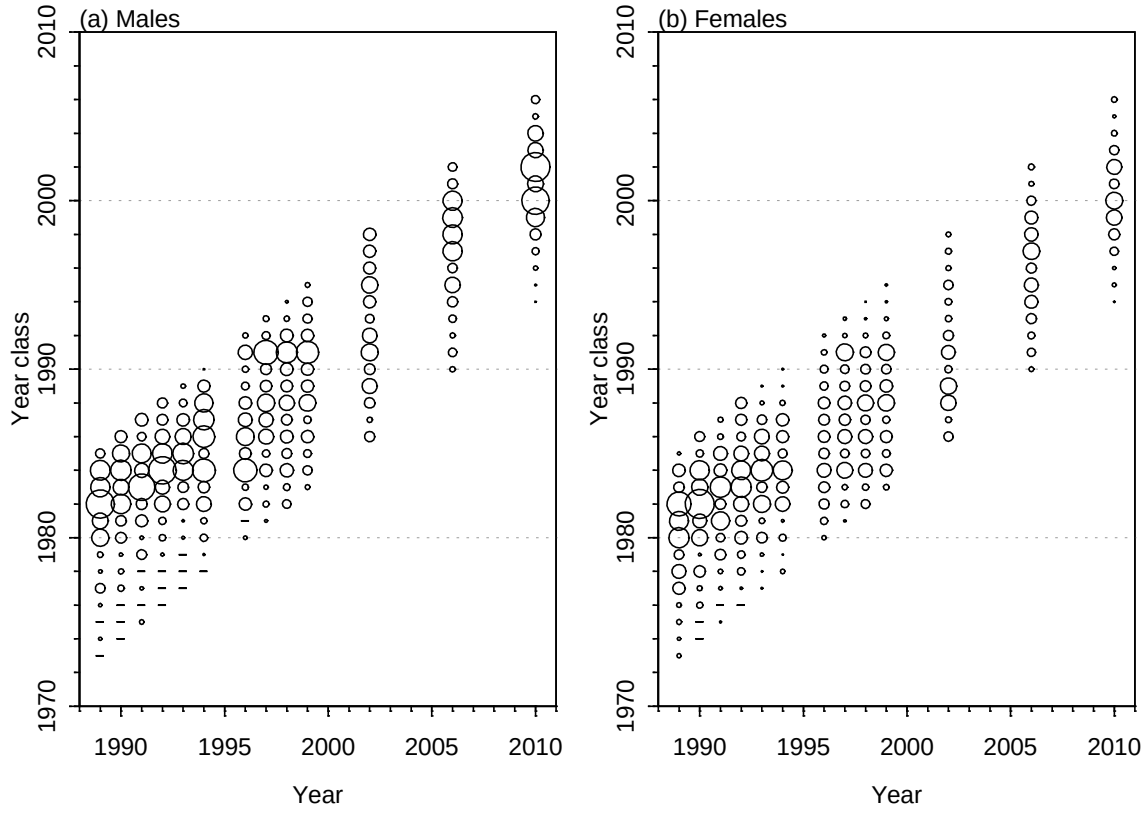


Figure 9: Male and female age frequencies (ages 3-14 years) by year class and year. The symbol area is proportional to the proportion at age for the year.

Appendix 1. Summary of individual landings sampled from the SKI 1 target trawl fishery during the 2009–10 fishing year.

Landing	Vessel name	Port	Landing date	Landed weight
1	Vessel A	Auckland	26/05/2010	2 936
2	Vessel B	Tauranga	2/06/2010	7 004
3	Vessel A	Tauranga	3/06/2010	15 972
4	Vessel C	Auckland	8/06/2010	8 252
5	Vessel A	Tauranga	8/06/2010	5 151
6	Vessel B	Tauranga	11/06/2010	16 393
7	Vessel A	Tauranga	11/06/2010	4 581
8	Vessel A	Auckland	17/06/2010	5 290
9	Vessel D	Auckland	2/06/2010	9 803
10	Vessel E	Tauranga	3/06/2010	8 556
11	Vessel E	Tauranga	8/06/2010	4 058
12	Vessel D	Auckland	10/06/2010	14 876
13	Vessel D	Auckland	17/06/2010	2 854
				105 726

Appendix 2. Summary of the number of fish measured and the number of otoliths collected by sex from each sampled landing.

Landing	Number measured		No. RAF otoliths		No. additional otoliths	
	Male	Female	Male	Female	Male	Female
1	205	95	34	16	4	6
2	219	85	35	15	3	9
3	227	78	37	14	9	13
4	201	103	29	22	9	12
5	208	93	31	20	3	20
6	204	100	28	22	5	10
7	182	118	30	20	12	17
8	204	102	30	20	10	17
9	36	16	36	16	9	12
10	45	6	45	6	7	13
11	37	13	37	13	2	6
12	35	17	35	17	5	2
13	34	16	34	16	7	3
Total	1 837	842	441	217	85	140

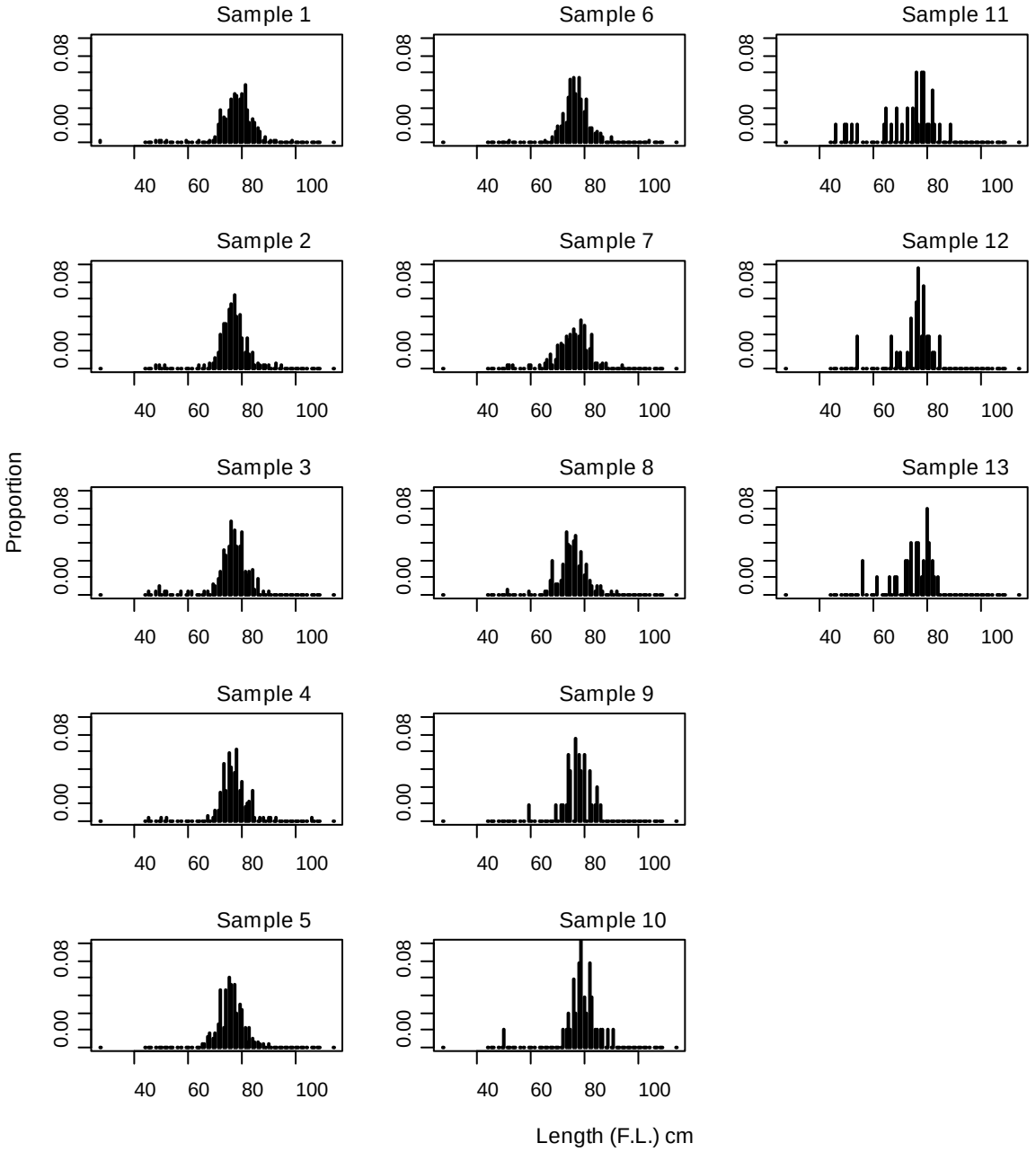
Appendix 3. Estimates of the proportion at length of male and female gemfish from the SKI 1 target trawl fishery in 2009–10.

Length	Male		Female		Length	Male		Female	
(cm)	Prop.	c.v.(%)	Prop.	c.v.(%)	(cm)	Prop.	c.v.(%)	Prop.	c.v.(%)
25	0.0000	0.00	0.0000	0.00	70	0.0109	22.06	0.0019	91.85
26	0.0000	0.00	0.0000	0.00	71	0.0176	16.34	0.0013	43.72
27	0.0002	88.87	0.0000	0.00	72	0.0285	15.02	0.0015	60.82
28	0.0000	0.00	0.0000	0.00	73	0.0407	11.46	0.0038	33.11
29	0.0000	0.00	0.0000	0.00	74	0.0400	13.20	0.0042	30.87
30	0.0000	0.00	0.0000	0.00	75	0.0479	12.20	0.0049	27.57
31	0.0000	0.00	0.0000	0.00	76	0.0629	8.95	0.0071	33.79
32	0.0000	0.00	0.0000	0.00	77	0.0557	10.22	0.0078	25.76
33	0.0000	0.00	0.0000	0.00	78	0.0574	11.03	0.0074	27.62
34	0.0000	0.00	0.0000	0.00	79	0.0592	10.60	0.0133	18.75
35	0.0000	0.00	0.0000	0.00	80	0.0502	11.80	0.0118	23.71
36	0.0000	0.00	0.0000	0.00	81	0.0299	15.15	0.0133	20.22
37	0.0000	0.00	0.0000	0.00	82	0.0333	16.04	0.0170	18.21
38	0.0000	0.00	0.0000	0.00	83	0.0250	13.59	0.0166	19.67
39	0.0000	0.00	0.0000	0.00	84	0.0158	20.78	0.0260	16.26
40	0.0000	0.00	0.0000	0.00	85	0.0120	22.75	0.0152	19.52
41	0.0000	0.00	0.0000	0.00	86	0.0063	26.32	0.0232	15.81
42	0.0000	0.00	0.0000	0.00	87	0.0040	27.50	0.0175	17.84
43	0.0000	0.00	0.0000	0.00	88	0.0023	33.11	0.0194	16.69
44	0.0000	0.00	0.0002	92.94	89	0.0043	56.58	0.0149	21.31
45	0.0007	58.77	0.0000	0.00	90	0.0015	35.66	0.0073	22.83
46	0.0030	80.41	0.0000	0.00	91	0.0014	53.11	0.0103	20.33
47	0.0000	0.00	0.0000	0.00	92	0.0004	68.72	0.0076	32.20
48	0.0006	55.46	0.0000	0.00	93	0.0009	52.23	0.0118	23.47
49	0.0040	61.83	0.0005	80.05	94	0.0005	80.59	0.0111	34.70
50	0.0044	58.51	0.0001	99.97	95	0.0001	93.93	0.0047	27.63
51	0.0011	45.89	0.0022	78.99	96	0.0000	0.00	0.0012	41.24
52	0.0046	51.33	0.0011	84.47	97	0.0000	0.00	0.0036	43.14
53	0.0005	84.12	0.0009	51.71	98	0.0000	0.00	0.0041	45.71
54	0.0041	62.81	0.0013	49.74	99	0.0002	89.79	0.0020	45.90
55	0.0000	0.00	0.0000	0.00	100	0.0000	0.00	0.0020	50.36
56	0.0039	78.79	0.0025	70.48	101	0.0000	0.00	0.0006	64.83
57	0.0002	88.90	0.0001	99.19	102	0.0000	0.00	0.0005	81.35
58	0.0000	0.00	0.0000	0.00	103	0.0000	0.00	0.0012	44.88
59	0.0018	49.78	0.0000	0.00	104	0.0002	93.89	0.0002	87.36
60	0.0007	61.49	0.0000	0.00	105	0.0000	0.00	0.0000	0.00
61	0.0022	82.54	0.0000	0.00	106	0.0005	77.12	0.0014	63.07
62	0.0000	0.00	0.0000	0.00	107	0.0000	0.00	0.0028	59.65
63	0.0005	84.95	0.0000	0.00	108	0.0000	0.00	0.0001	92.33
64	0.0033	77.40	0.0004	64.25	109	0.0000	0.00	0.0008	57.59
65	0.0076	52.88	0.0001	100.82	110	0.0000	0.00	0.0000	0.00
66	0.0042	44.54	0.0000	0.00	111	0.0000	0.00	0.0000	0.00
67	0.0096	28.85	0.0000	0.00	112	0.0000	0.00	0.0000	0.00
68	0.0063	34.70	0.0001	102.30	113	0.0000	0.00	0.0000	0.00
69	0.0148	27.94	0.0008	62.26	114	0.0000	0.00	0.0005	76.67

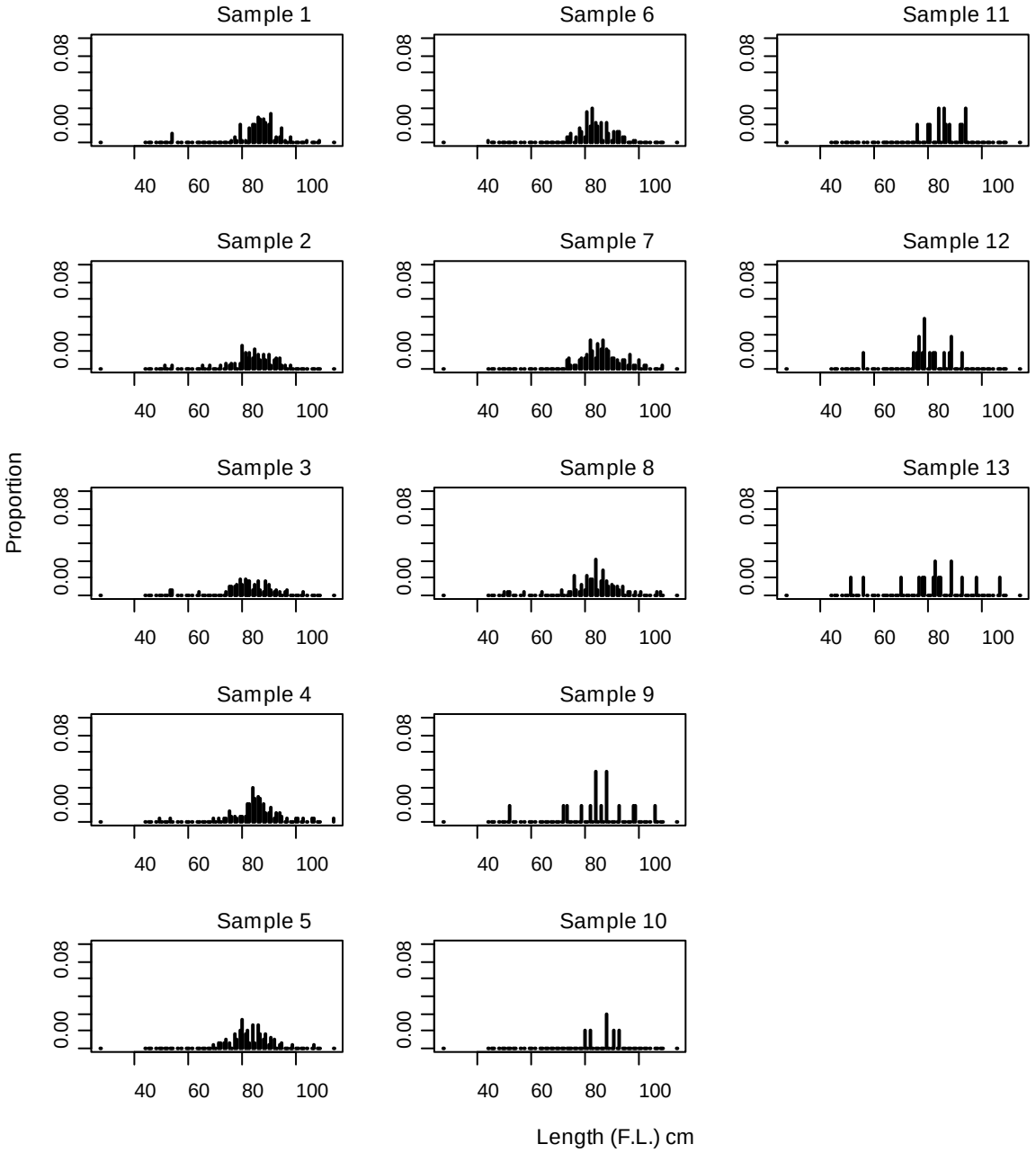
Appendix 4. RAF estimates of proportion at age of male and female gemfish from the SKI 1 target trawl fishery in 2009–10 and the associated coefficient of variations.

Age	Male		Female	
(years)	Prop.	c.v	Prop.	c.v
1	0.0000	0.00	0.0000	0.00
2	0.0056	55.84	0.0009	101.80
3	0.0308	25.16	0.0079	43.92
4	0.0180	34.27	0.0019	64.98
5	0.0903	15.59	0.0091	38.36
6	0.0389	18.78	0.0118	33.19
7	0.1601	7.91	0.0368	19.55
8	0.0471	13.53	0.0167	26.08
9	0.1525	12.38	0.0779	11.47
10	0.0642	12.19	0.0712	12.94
11	0.0254	23.35	0.0494	14.22
12	0.0167	25.63	0.0356	23.91
13	0.0048	50.14	0.0061	48.13
14	0.0000	0.00	0.0101	32.25
15	0.0000	0.00	0.0059	50.66
16	0.0006	88.31	0.0025	69.58
17	0.0000	0.00	0.0000	0.00
18	0.0000	0.00	0.0000	0.00
19	0.0000	0.00	0.0000	0.00
20	0.0000	0.00	0.0000	0.00

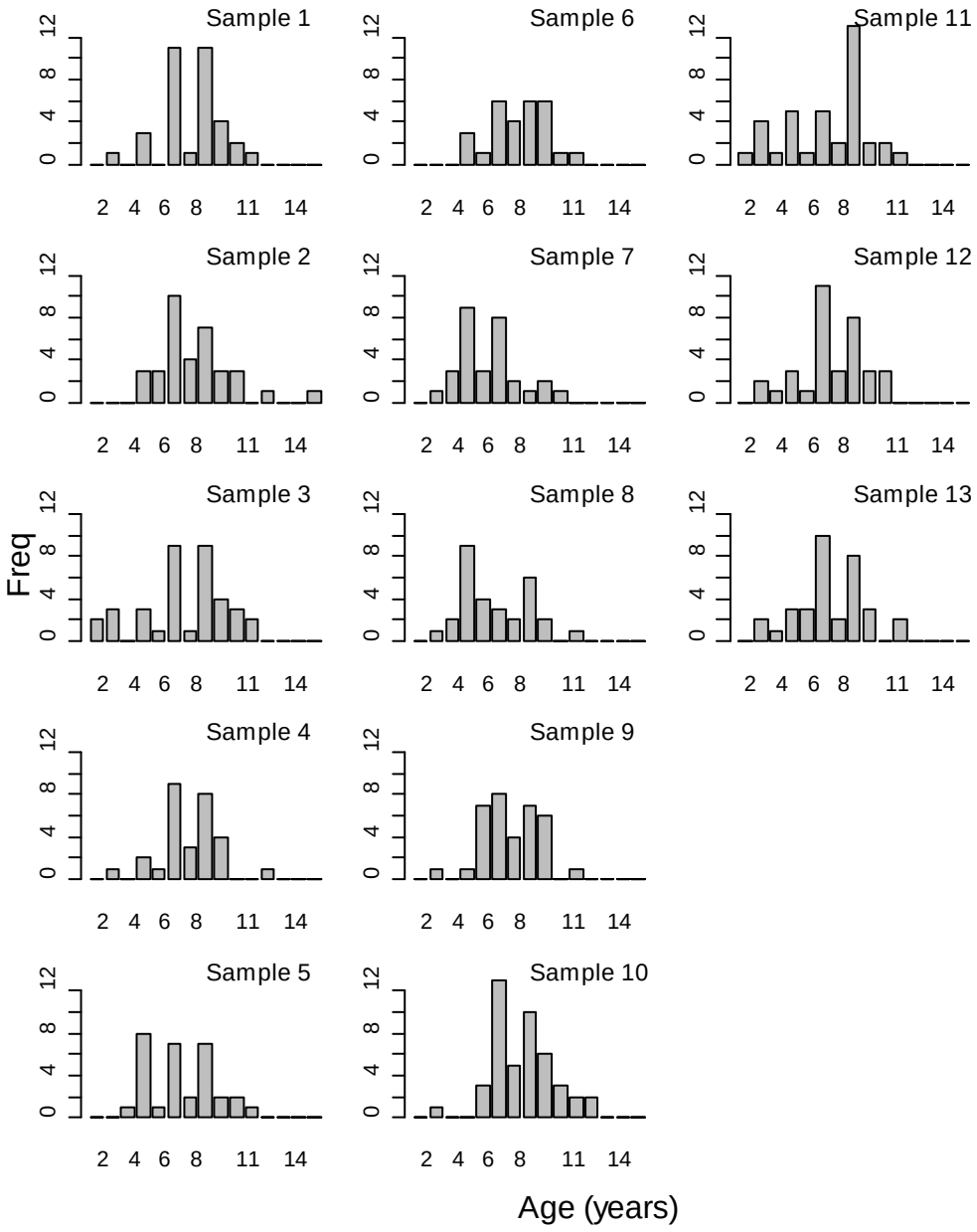
Appendix 5. Proportional length composition of male fish from each landing sampled.



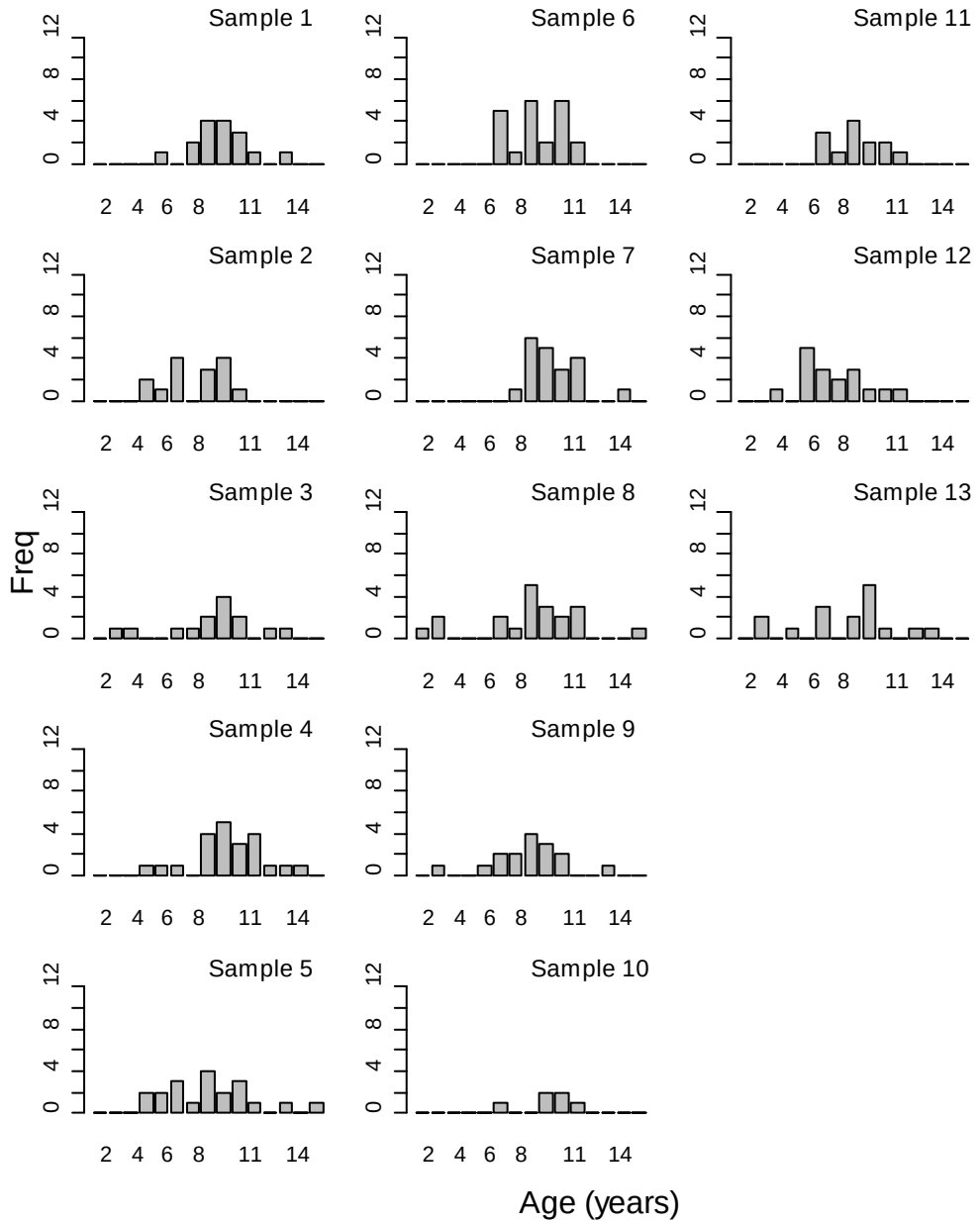
Appendix 6. Proportional length composition of female fish from each landing sampled.



Appendix 7. Random age frequency samples of male fish from each landing.



Appendix 8. Random age frequency samples of female fish from each landing.



Appendix 9. Results of a simulation study to investigate sorting of catch.

The simulation study replicated a random process for the binning of fish in each landing. The results of the simulation were then compared with the observed distribution of fish amongst individual sampled bins.

The analysis was based on the eight SKI 1 landings sampled at Sanford Ltd. These were the only landings for which a complete set of length data were available. The simulation procedure involved the following steps.

1. Select a landing at random.
2. For each bin, randomly select four fish from the entire sample (with replacement).
3. Determine the threshold (net) weight for the bin. This is the net weight above which no additional fish are added to the bin. The threshold weight was determined for each bin assuming a normal distribution (mean = 30, sd = 5).
4. If cumulative fish weight is below the threshold weight then randomly select another fish.
5. Repeat step 4 until cumulative fish weight exceeds threshold weight.
6. Record the number of fish, median fish length and weight, mean fish length and the sum of the deviance in fish length within a bin.
7. Repeat steps 2–6 until at least 300 fish have been selected (approximately 40–50 bins per simulation).

The simulation was repeated 100 times. The results of the analysis are somewhat sensitive to the assumed distribution of the threshold weight. This variable was intended to represent the process whereby a vessel unloader glances at a fish bin and ascertains whether or not to add another fish to the bin. This will depend largely on the bulk of the fish already in the bin and to an extent the size of the average size of fish in the catch (or the fish that he has recently handled).

The distributions of the metrics for the individual fish bins in the observed data set and the simulated data set were compared. The distributions of the number of fish in each bin were comparable between the simulated (pred) and observed data sets (Fig A9-1). Similarly, the distributions of the median fishing length (Fig A9-2), total fish weight per bin (Fig A9-3) and the deviation in fish length per bin (Fig A9-4) were comparable between the simulated (pred) and observed data sets.

Based on these observations there was no evidence that the catch had been systematically sorted prior to sampling.

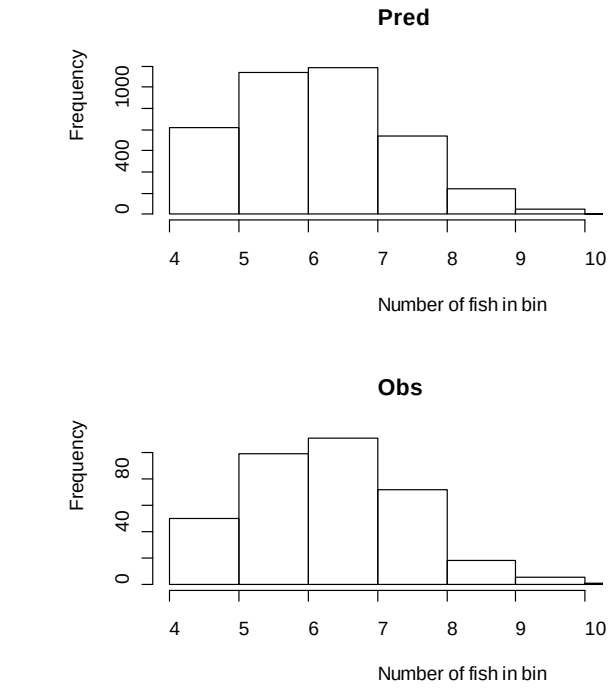


Figure A9-1: A comparison of the simulated (pred) and observed number of fish in each bin.

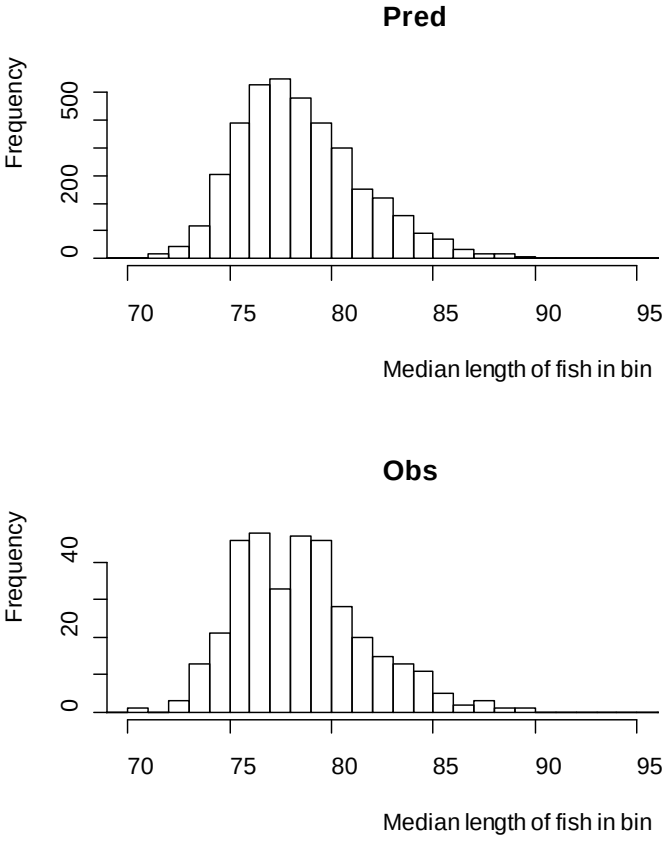


Figure A9-2: A comparison of the simulated (pred) and observed median fish length in each bin.

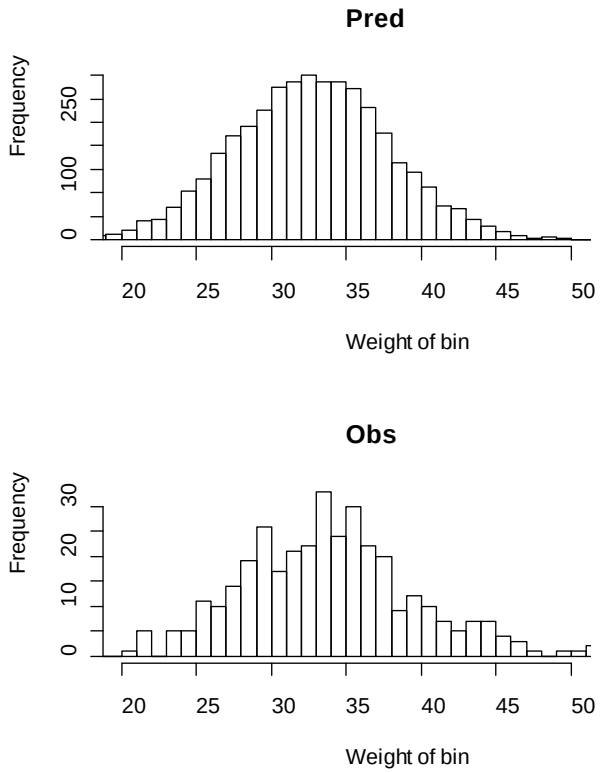


Figure A9-3. A comparison of the simulated (pred) and observed net weight of fish in each bin.

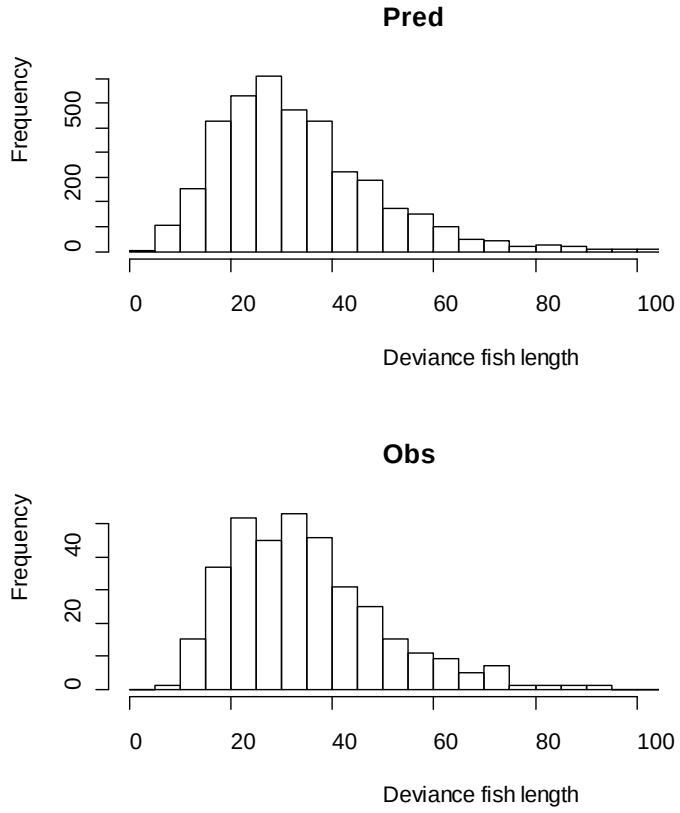


Figure A9-4: A comparison of the simulated (pred) and observed sum of the absolute deviations of the length of fish in each bin.

Appendix 10. A comparison of the length composition of male (left) and female (right) fish sampled for otoliths (RAF only; grey dashed line) and for length (entire sample; black line) from the 8 individual landings (rows) sampled by Sanford Ltd.