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Taihoro Nukurangi

Commercial catch-sampling of red gurnard (*Chelidonichthys kumu*) in GUR 1 during the 2002–03 fishing year

Michael J. Manning and Colin P. Sutton

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Authors:	M. J. Manning and C. P. Sutton
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7. Executive Summary:

A three year commercial catch sampling programme for red gurnard (*Chelidonichthys kumu*) in GUR 1 commenced during the 2002-03 fishing year. The target Mean Weighted Coefficient of Variation (MWCV) for the catch-at-age for the first year of the sampling programme was set at 30%.

Sampling was stratified by area along the line dividing Fisheries Management Areas AKE and AKW in GUR 1 and by method (bottom trawl and Danish seine). No landings of Danish seine catches were received by fishing companies participating in the sampling programme during the 2002-03 fishing year, therefore stratification based solely on area was used.

A total of 10 landings of bottom trawl catches in AKE and 13 landings of bottom trawl catches in AKW were sampled. A total of 2459 fish from AKE and 3475 fish from AKW were measured. A total of 493 sagittal otolith pairs were collected from the catch in AKE and 653 sagittal otolith pairs from the catch in AKW. Relatively few

male fish were collected, suggesting a highly-skewed sex ratio in the catch favouring female fish.

Otoliths from 479 fish from AKE and 632 fish from AKW were prepared and read once each by two readers. Translucent zone counts were converted to estimated ages and the two sets of results compared. The between-reader Index of Average Percentage Error and mean Coefficient of Variation were 8.25% and 11.67% respectively for AKE fish and 8.48% and 11.99% respectively for AKW fish. Age-bias plots suggest no between-reader bias.

Estimated numbers-at-length were calculated and scaled to the estimated total catch in AKE and AKW. The length-at-age data were converted to stratum-specific age-length-sex keys which were then used to convert the estimated numbers-at-length to numbers-at-age. The MWCVs for the catches-at-length were 19.9% for AKE, 18.2% for AKW, and 14.6% overall. The MWCVs for the catches-at-age were 15.3% for AKE, 17.1% for AKW, and 11.8% overall. The MWCVs for male fish were much higher than for female fish. The MWCVs for the male catches-at-age were 31.8% for AKE, 45.2% for AKW, and 27.5% overall reflecting the relatively few male fish sampled. Despite this, the target MWCV for the catch-at-age overall was achieved.

The catches-at-age for each area appear quite different. The AKE catch-at-age includes fewer age-classes overall and with proportionally fewer fish in the remaining older age-classes than the AKW catch-at-age. The oldest fish in the AKE catch-at-age was a 12 year-old male; the oldest fish in the GUR (AKW) catch-at-age was an 18 year-old female. Sex ratios derived from the catches-at-age are 1:2.73 males to females for AKE and 1:5.39 males to females for AKW, corroborating the trend apparent in the raw data. The apparent truncation of the AKE catch-at-age is thought to be due to sustained heavy fishing pressure in the Hauraki Gulf. The reason for the skewed sex-ratios in the catch-at-age in both areas is unclear, although these results are consistent with results from recent trawl surveys of the Hauraki Gulf and west coast of the North Island.

8. Objectives:

Main objective: To determine the length and age structure of the commercial catch of selected species in QMA 1, QMA 2, and QMA 3.

Specific objective: To conduct sampling in fish processing sheds and determine the length and age composition of the commercial catch of red gurnard in GUR 1 during the 2002-03 fishing year. The target coefficient of variation (CV) for the catch-at-age is 30% (mean-weighted CV across all age classes).

9. Introduction:

This report describes the results of the first year of a three year commercial catch sampling programme for red gurnard (*Chelidonichthys kumu*) in GUR 1. The catch sampling programme is scheduled to run from the start of the 2002-03 fishing year to the end of the 2004-05 fishing year. The length and age data collected from the commercial fishery during the 2002-03 fishing year are presented and discussed. This report fulfils the reporting requirements of Ministry of Fisheries research project INS2002-01 Objective 1.

10. Methods:

10.1. Sampling design:

Quota Management Area (QMA) GUR 1 includes Fisheries Management Areas (FMAs) 1 (AKE) and 9 (AKW), encompassing much of the east and west coasts of the northern half of the North Island. Initially, sampling was stratified by coast along the line dividing FMAs 1 and 9 in GUR 1, GUR 1 (AKE) and GUR 1 (AKW) (Figure 1), and by fishing method. samples were allocated to bottom trawl landings in AKE 10 samples to Danish seine landings in GUR 1 (AKE), and 12 samples to bottom trawl landings in (AKW). We refer to the areas GUR 1 (AKE) and GUR 1 (AKW) as "AKE" and "AKW" elsewhere in this report.

Although landings data for GUR 1 for the 2002-03 fishing year were available at the time of writing (FishServe 2003), separate landings data for AKE and AKW were not. Following Hanchet et al. (2000), total landings for each area were estimated by multiplying the total reported landings for GUR 1 for 2002-03 by constants 0.6 and 0.4 respectively. GUR 1 total reported annual landings and the estimated total annual landings for AKE and AKW for the fishing years 1983-84 to 2002-03 are given in Table 1.

10.2. Sampling procedure

A length-frequency sample of 200 fish or more was randomly sampled from each sampled landing. The length of each fish in the sample was recorded to the nearest centimetre below actual fork length. Sagittal otolith pairs were to be collected from every fourth fish in the length-frequency sample and the sex recorded. The sexes of the remaining fish in the samples were not recorded as participating fishing companies would not allow the remaining fish to be cut to allow the sex to be determined. Sampling was carried out by personnel from NIWA and participating fishing companies. All catch-sampling and otolith inventory data have been loaded onto Ministry of Fisheries research databases *market* (Fisher & Mackay 2000) and *age* (Mackay & George 2000) respectively.

10.3. Otolith preparation and reading.

All otoliths collected were selected for preparation and reading using the methods of Sutton (1997). Sutton's (1997) interpretation of red gurnard otoliths follows Elder (1976), who validated the annual formation of translucent zones in red gurnard otoliths. Otolith terminology in this report follows the glossary for otolith studies produced by Kalish et al. (1995).

The right otolith from each pair of sagittal otoliths collected was baked at 285°C for approximately four minutes until amber-coloured. Where the right otolith was not collected or was damaged, the left otolith was used. After baking, the otoliths were embedded in blocks in clear epoxy resin (Araldite K142). After the resin blocks had cured, the otoliths were sectioned transversely through the nucleus using a Struers Accutom-2 diamond-edged saw. After sectioning, the cut surface of each block was polished with P1200 grade carborundum paper.

The prepared otoliths were read under reflected light using a Wild M400 binocular microscope at 30 x magnification. The total number of completed translucent zones in each otolith, a five-point "readability" score, and a three-point "margin state" score were recorded for each otolith (see Table 3 and Table 4, respectively).

All prepared otoliths were read once by both authors. The two sets of readings were compared graphically for between-reader bias using the methods of Campana et al. (1995). Between-reader precision was measured using the Index of Average Percentage Error (IAPE, Beamish & Fournier 1981) and mean Coefficient of Variation (CV, Chang 1982). To preserve homogeneity of method, only one set of readings was used in all following analyses. No attempt was made to resolve disagreements between readers for particular otoliths.

Translucent zone counts were converted to estimated ages using the method of Manning & Sutton (2004), except that landing date was used as the capture date for each fish. A standardised "birth-date" of 1 January and a standardised translucent zone completion date of 1 December were used for all fish. Thus, a fish with nine completed translucent zones, a "narrow" otolith margin, and landed on 27 February 2003, was estimated to be 9.15 years of age (see Figure 3).

10.4. Estimating scaled length and age-frequency distributions using "Catch-at-age" (Bull & Dunn 2002).

"Catch-at-age" (Bull & Dunn 2002) is a library of "R" functions (Ihaka & Gentleman 1996) developed by NIWA that computes scaled length frequency distributions by sex and stratum from commercial catch and length frequency data using the calculations in Bull and Gilbert (2001). If passed a set of age-length data, "Catch-at-age" constructs an age-length key, which is then applied to the estimated scaled length frequency distributions to compute estimated scaled age-frequency distributions (Bull & Gilbert 2001).

"Catch-at-age" computes the CV for each length and age class and the overall MWCV for each length and age distribution produced using a bootstrapping routine. Fish length records are resampled within each landing, landings are resampled within each stratum, and the age-length data are resampled, all with replacement. The bootstrap length and age-frequency distributions are computed for each resample and the CVs for each length and age class computed from the bootstrap distributions.

"Catch-at-age" was used to calculate estimated scaled length-frequency distributions for each sampling stratum separately and for the sampling strata pooled. As the length-frequency samples collected consisted of large numbers of unsexed fish, the catches-at-length were calculated for the sexes combined. The age-length-sex data derived from the prepared otoliths were used to form stratum-specific age-length-sex keys, which were passed to "Catch-at-age" and used to convert the estimated scaled numbers-at-length to numbers-at-age by stratum and sex. Bootstrapped CVs and MWCVs were produced from 300 resamples of the data.

11. Results:

11.1. Landings sampled:

Twenty-three landings were sampled, 5934 fish were measured, and 1146 sagittal otolith pairs were collected from the catch during the 2002-03 fishing year (Table 4). All sampled landings were from bottom trawl catches, with 10 landings of catches from AKE sampled, and 13 landings of catches from AKW sampled (Table 4). All sampled landings were sampled between October 2002 and February 2003. No landings of red gurnard catches from Danish seine vessels were received by participating fishing companies during the 2002-03 fishing year. Therefore stratification based on area only was used in all following analyses. The target and actual numbers of landings sampled, numbers of fish measured and otoliths collected and read by sampling stratum are given in Table 4.

11.2. Otolith readings:

Many of the 1146 otolith pairs collected were chipped, damaged, or smashed with only fragments retained although only less than 4% were completely unsuitable for preparation; a total of 1111 otoliths were prepared. All prepared otoliths exhibited alternating light (opaque) and dark (translucent) zones under reflected light. Both readers noted that the contrast between opaque and translucent zones was generally poorer for fish from AKE than for fish from AKW. Both readers also noted that the damaged otoliths prepared were generally more difficult to read than the undamaged otoliths. All otoliths read are tabulated by reader, stratum, and readability score in Table 5 and by reader, stratum, and margin state in Table 6. Although otolith pairs were to be collected from every fourth-fish in the length-frequency samples, the total number of otolith pairs collected is less than 20% or one-fifth of the total number of fish measured, suggesting that some under-sampling of otoliths relative to the target of one pair from every fourth measured fish had occurred.

The between reader IAPE and mean CV were 8.25% and 11.67% for otoliths collected from fish from AKE and 8.48% and 11.99% for otoliths from fish from AKW (Table 7). Diagnostic bias plots following (Campana et al. 1995) are given in Figure 2. The symmetry of the histograms in Figure 2(A), the relatively even distribution of plotted points about the zero-line in Figure 2(B), and the position of the error bars about the 1:1 line in Figure 2(C) all suggest that no systematic bias exists between readers. The results produced by reader 1 were used in all following analyses. No attempt was made to resolve disagreements between-readers for particular otoliths prior to the following analyses.

11.3. The relationship between length and age and formation of age-length keys:

Lengths-at-age by stratum and sex are plotted in Figure 4. The lengths-at-age appear reasonably flat, with considerable apparent overlap in lengths-at-age for nearly all age classes. Female fish from each stratum appear larger than male fish, suggesting sexual dimorphism, however this cannot be tested without fitting growth models to the data and comparing the model fits quantitatively. These results are generally consistent with results from previous red gurnard age and growth studies (e.g. Elder 1976, Sutton 1997) The oldest fish from AKE was a 12.91 year old male, 40 cm in fork length. The oldest fish from AKW was an 18.03 year old female, 36 cm in fork length.

Relatively few fish in the otolith collections from either stratum were male (23.3% from AKE, 11.7% from AKW, and 16.7% pooled across the strata). As relatively few lengths-at-age from males from either stratum were available, all available length-at-age data in each stratum for both sexes where the corresponding readability score was "4" or better (i.e. less) were used to form the age-length-sex keys used in the following analyses.

11.4. Length and age frequency distributions:

Estimated scaled proportions-at-length for both sexes combined by stratum and for both strata pooled are plotted in Figure 5. Estimated scaled-proportions-at-age by sex and by stratum and for both strata pooled are plotted in Figure 6. The estimated scaled-numbers-at-length are given in Appendix A, the estimated scaled-numbers at length are given in Appendix B, and the stratum-specific age-length-sex keys used to convert the estimated scaled-numbers-at-length to estimated scaled-numbers-at-age are given in Appendix C. The MWCVs for the estimated scaled-numbers-at-length are given in Table 8 and for the estimated-scaled-numbers-at-age in Table 9. Cumulative proportions-at-length for the two sampling strata are compared in Figure 7; cumulative proportions-at-age are compared in Figure 8.

The MWCVs for the catch-at-length were 19.9% for AKE, 18.2% for AKW, and 14.6% overall. The MWCVs for the catch-at-age for all fish were 15.3% for AKE, 17.1% for AKW, and 11.8% overall. The MWCVs for the catch-at-age of male fish specifically were higher than for females. The MWCVs for male catch-at-age were 31.8% for AKE, 45.2% for AKW, and 27.5% overall.

The estimated scaled-proportions-at-length are unimodal with no easily identifiable length modes in the catch for either stratum (Figure 5). The estimated scaled-proportions-at-age are also unimodal, however there is some evidence of differential year-class success, with 3 year-old fish the most common year-class in both strata (Figure 6). The catches-at-age in both strata appear to be dominated by female fish, 2 to 7 years-old, spawned between 1995 and 2000.

The AKE catch-at-age appears truncated relative to the AKW catch-at-age (Figure 6 and Figure 8). Very few fish of either sex older than 10 years are present in the AKE catch, whereas proportionally more fish in the older age classes, especially older and larger females, are present in the AKW catch. The oldest fish in the AKE catch was a 12 year-old male. The oldest fish in the AKW catch was an 18 year-old female. Furthermore, sex ratios derived from the catches-at-age are 1:2.73 (males:females) for AKE, and 1:5.39 (males:females) for AKW, corroborating the trends apparent in the raw data. This is especially apparent when the cumulative proportions-at-age by sex and stratum are compared (Figure 8)

12. Discussion:

12.1. The performance of the sampling design and recommendations for commercial catch sampling for red gurnard in GUR 1 during subsequent fishing years:

Despite not sampling the target number of bottom trawl or Danish Seine catches in AKE, and the large MWCVs for the male catch-at-age in each stratum, the target MWCV for the overall catch-at-age in GUR 1 was achieved. Prior to this study, no commercial catch sampling of red gurnard had been carried out and no data on the number of year-classes in the commercial catch or on between-landing variability in the catch-at-length or at-age were available with which to tune the sampling design.

Following on from the results of the 2002-03 fishing year presented above, we suggest that commercial catch sampling for red gurnard in GUR 1 in subsequent fishing years follow the same sampling design, and that the same target MWCV for the overall catch-at-age be used. Every effort should be made to ensure that the sampling protocol is followed exactly. Every effort should also be made to negotiate the collection of sexed length-frequency samples from the catch. The direct-purchase of sampled fish should be investigated, however this will lead to increased costs. If the collection of sexed length-frequency samples directly from the catch cannot be negotiated, then age-length-sex keys will have to be used to infer proportions at age and sex as was done in this analysis. The optimum number of otoliths to be collected, prepared, and read to meet the target MWCVs should be investigated using simulation methods.

As the Danish seine catches have accounted for up to 25% of the reported total annual catch in AKE (Hanchet et al. 2000), we suggest that every effort be made to sample the Danish seine catch. This will enable any differences in the catches-at-age between the methods to be assessed. We also suggest that every effort be made to work with staff from participating fishing companies to ensure that all data, especially otolith pairs, are collected to the highest possible standards. We suggest that the large number of broken or damaged otoliths that were prepared and read may partly account for the relatively low between-reader precision with otoliths that are regarded as fairly easy to read (e.g. Elder 1976, Sutton 1997).

12.2. Apparent trends in the catches-at-length and at-age in AKE and AKW:

The catches-at-length in each stratum do not show any distinct modes of younger and smaller fish entering the catch. This is probably due to the selectivity effect of the commercial gear, with younger and smaller fish less vulnerable to the commercial codend mesh although they may be present in both areas. Trawl surveys of the west coast of the North Island (Morrison & Parkinson 2001), Hauraki Gulf (Morrison et al. 2002), and Bay of Plenty (Morrison et al. 2001) by RV *Kaharoa* towing trawl gear with a small-mesh codend (40 mm inside-mesh), all show the presence in the survey catch of 10 to 20 cm fork length pre-recruit and recruiting red gurnard that appear to be absent from the commercial catch..

The apparent truncation of the AKE catch-at-age relative to the AKW catch may be due to sustained fishing pressure in the Hauraki Gulf, removing older and larger fish of both sexes from the catch over time. A stock assessment of red gurnard by Hanchet et al. (2000) found that the AKE stock was probably capable of supporting current catch levels, at least in the short term.

The sex ratios calculated from the numbers-at-age presented in this report corroborate the trends apparent in the raw data. The reason for the apparently skewed sex ratios found is unclear. These results are consistent with skewed sex ratios of red gurnard found in recent trawl surveys of the Hauraki Gulf (Morrison et al. 2002) and west coast of the North Island (Morrison & Parkinson 2001)

12. Conclusions:

- Trends in the length-at-age for red gurnard in GUR 1 are generally consistent with trends in the length-at-age for red gurnard from other areas.

- There is no evidence of between-reader bias. Despite this, between-reader precision was relatively low. This is thought to be partly due to the large number of broken otoliths that were prepared and read.

- The target MWCV for the catch-at-age of 30% was met. The current sampling design is recommended for commercial catch sampling in subsequent years. Every effort should be made to ensure that red gurnard catches by Danish Seine catches in AKE are sampled. Every effort should be made to work with personnel from participating fishing companies to ensure that the highest-quality data are collected.

- Pre-recruit and recruit red gurnard less than 20 cm in fork length appear to be missing from the commercial catch-at-length. Research trawl survey catches from the same areas contain red gurnard 10 to 20 cm in fork length. The difference between the commercial and survey catches is presumed to be due to the selectivity effect of the commercial gear rather than poor recruitment in the last two years.

- The catches-at-age in both areas appear to be composed of a number of successful year classes. The AKE catch-at-age appears truncated relative to the AKW catch. This is thought to be due to historical sustained fishing pressure in the Hauraki Gulf.

- Apparently skewed sex ratios found in the raw data were corroborated by sex ratios calculated from the estimated scaled-numbers-at-age for both areas. The reason for this is unclear, although these results are consistent with results from recent trawl surveys of the Hauraki Gulf and west coast of the North Island.

13. Publications:

Nil.

14. Data Storage:

All data are stored on Ministry of Fisheries databases administered by NIWA (*market* and *age*).

15. Acknowledgements:

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Table 1: Reported landings (t) of red gurnard in GUR 1 by fishing year from 1983–84 to 2002–03. Total Allowable Commercial Catches (TACCs) and estimated annual landings (t) for AKE and AKW are provided. Data from 1983-84 to 2001-02 are from Annala et al. (2003); data from 2002-03 are from FishServe (2003).

Fishing year	GUR 1 reported landings (t)			TACC
	AKE	AKW	Total	
1983–84	1259	840	2099	–
1984–85	919	612	1531	–
1985–86	1056	704	1760	–
1986–87	613	408	1021	2010
1987–88	683	456	1139	2081
1988–89	623	416	1039	2198
1989–90	550	366	916	2283
1990–91	674	449	1123	2284
1991–92	776	518	1294	2284
1992–93	977	652	1629	2284
1993–94	692	461	1153	2284
1994–95	632	422	1054	2287
1995–96	698	465	1163	2287
1996–97	633	422	1055	2287
1997–98	609	406	1015	2287
1998–99	556	371	927	2287
1999-00	566	378	944	2287
2000-01	776	518	1294	2287
2001-02	664	443	1107	2287
2002-03	751	500	1251	2287

Table 2: Five-point "readability" score used in otolith readings.

Readability score	Description
1	Otolith very easy to read; excellent contrast between opaque and translucent zones; ± 0 between subsequent counts of this otolith
2	Otolith easy to read; good contrast between opaque and translucent zones, but not as marked as in 1; ± 1 between subsequent counts of this otolith
3	Otolith readable; less contrast between opaque and translucent zones than in 2, but alternating zones still apparent; ± 2 between subsequent counts of this otolith
4	Otolith readable with difficulty; poor contrast between opaque and translucent zones; ± 3 or more between subsequent counts of this otolith
5	Otolith unreadable

Table 3: Three-point marginal state score used in otolith readings.

Readability score	Description
Narrow	Last translucent zone present deemed to be fully formed; a very thin, hairline layer of opaque material is present outside the last translucent zone
Medium	Last translucent zone present deemed to be fully formed; a thicker layer of opaque material, not very thin or hairline in width, is present outside the last translucent zone; some new translucent material may be present outside the thicker layer of opaque material, but generally does not span the entire margin of the otolith
Wide	Last translucent zone present deemed not to be fully formed; a thick layer of opaque material is laid down on top of the last fully formed translucent zone, with new translucent material present outside the opaque layer, spanning the entire margin of the otolith

Table 4: Target and actual number of landings sampled, total landed and sampled catch weights, total number of fish measured, and total number of otoliths collected and prepared by sampling stratum.

(A) Target number of landings to be sampled by method:

	Sampling stratum		
	AKE	AKW	Total
Single trawl	12	12	24
Danish seine	10	0	10

(B) Actual number of landings to be sampled by method:

	Sampling stratum		
	AKE	AKW	Total
Single trawl	10	13	23
Danish seine	0	0	0

(C) Total numbers of fish measured and otoliths collected and read:

	Sampling stratum		
	AKE	AKW	Total
Fish measured	2459	3475	5934
Otoliths collected	493	653	1146
Otoliths read	479	632	1111

(D) Total landed and sampled catch weights (t):

	Sampling stratum		
	AKE	AKW	Total
All landings	750.6	500.4	1251.1
All sampled landings	9.7	44.2	53.9
Total sample weight	1.3	1.5	2.8

Table 5: All otoliths read by reader, stratum, and readability score.

Reader	Stratum	Readability score				
		1	2	3	4	5
Reader 1	AKE	9	110	321	24	15
	AKW	8	100	484	31	9
Reader 2	AKE	3	104	293	70	9
	AKW	10	330	231	53	8

Table 6: All otoliths read by reader, stratum, and margin state.

Reader	Stratum	Margin state		
		Narrow	Medium	Wide
Reader 1	AKE	65	261	134
	AKW	125	270	213
Reader 2	AKE	20	435	17
	AKW	24	420	180

Table 7: Results of between-reader comparison tests by dataset (stratum).

Dataset	Statistic	Precision (%)
AKE	IAPE	8.25
	CV	11.67
AKW	IAPE	8.48
	CV	11.99

Table 8: Mean-weighted-coefficients-of-variation (%) for estimated scaled-numbers-at-length by stratum and sex.

Sex	Stratum		
	AKE	AKW	Pooled
Male	-	-	-
Female	-	-	-
Unsexed	19.9	18.2	14.6
All fish	19.9	18.2	14.6

Table 9: Mean-weighted-coefficients-of-variation (%) for estimated scaled-numbers-at-age by stratum and sex.

Sex	Stratum		
	AKE	AKW	Pooled
Male	31.8	45.2	27.5
Female	16.6	17.1	12.4
Unsexed	-	-	-
All fish	15.3	17.1	11.8

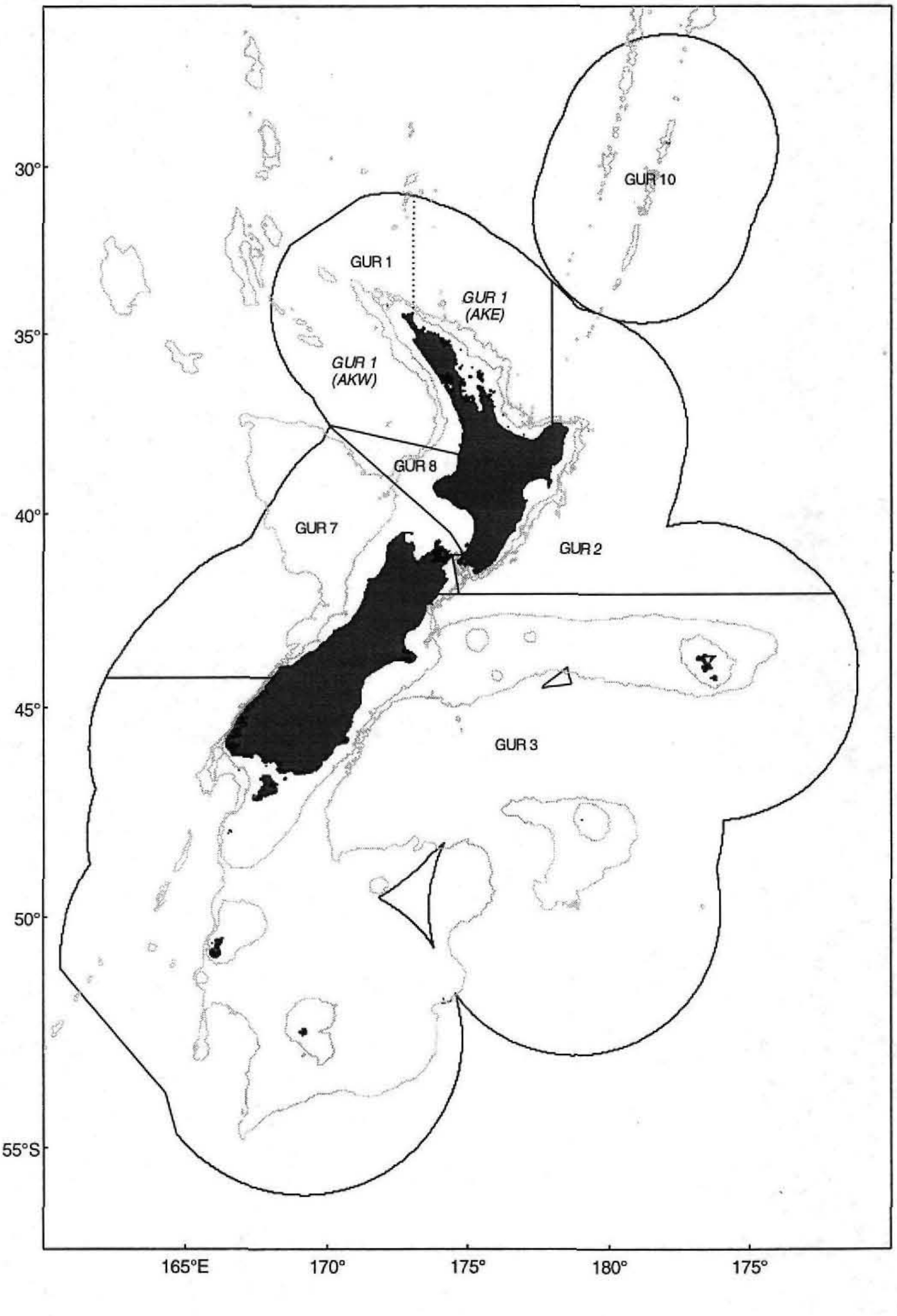

Figure 1: Map of the New Zealand EEZ showing the boundaries of red gurnard fishstocks (solid black lines). The 250 and 1000 m depth contours are overlaid (solid grey lines). GUR 1 is divided into AKE and AKW along the line separating fisheries management areas 1 (AKE) and 9 (AKW) (dashed black line).

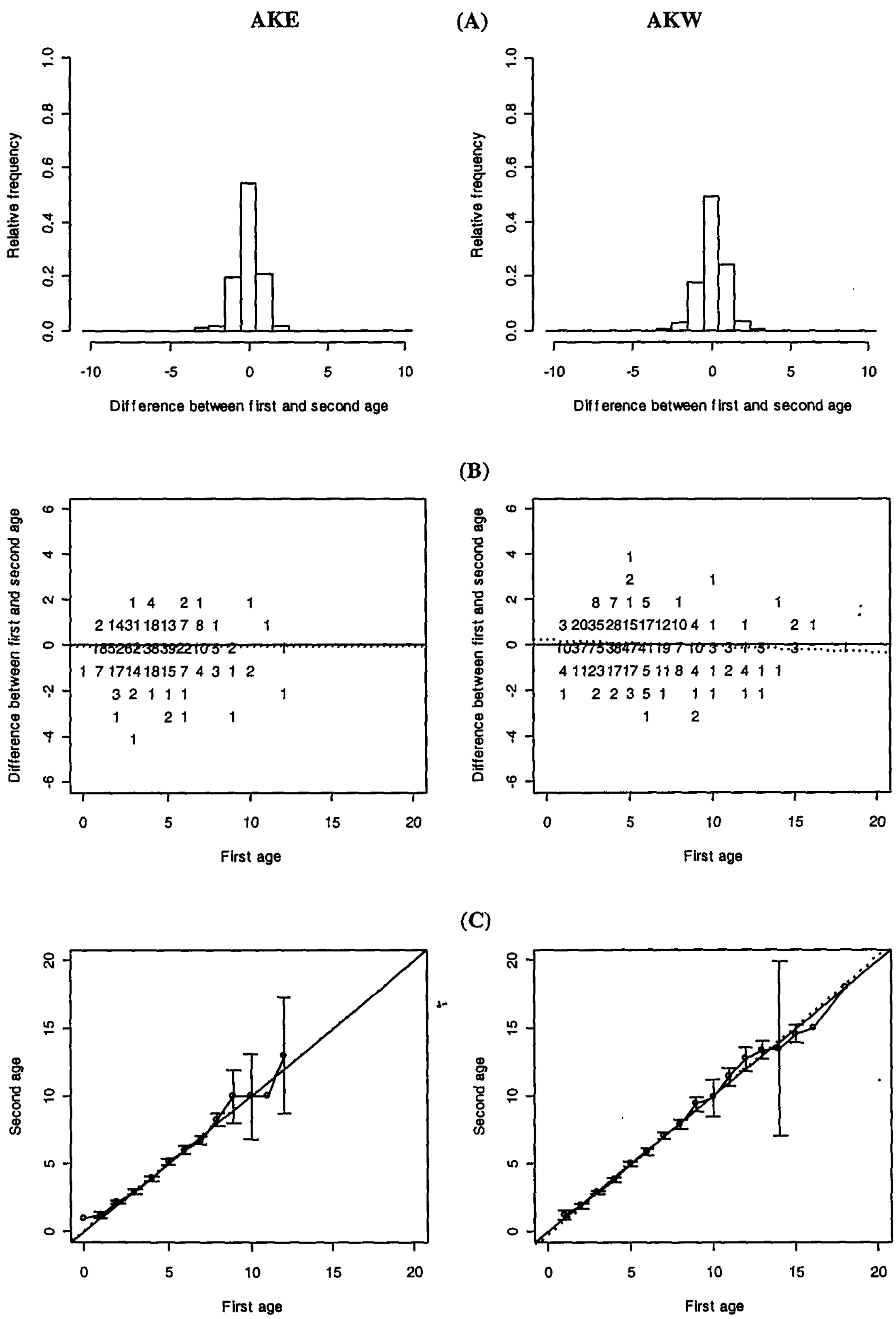

Figure 2: Results of between-reader comparison tests for AKE and AKW datasets: (A) histograms of differences between ages; (B) differences between first and second ages relative to the first age; and (C) bias plots. The expected 1:1 (solid line) and actual relationship (dashed line) between the first and second ages are overlaid on (B) and (C). The numbers on (B) are the numbers of readings at each point. The error bars on (C) are 95% confidence intervals about the mean age produced during the second set of readings for a given age produced during the first set of readings.

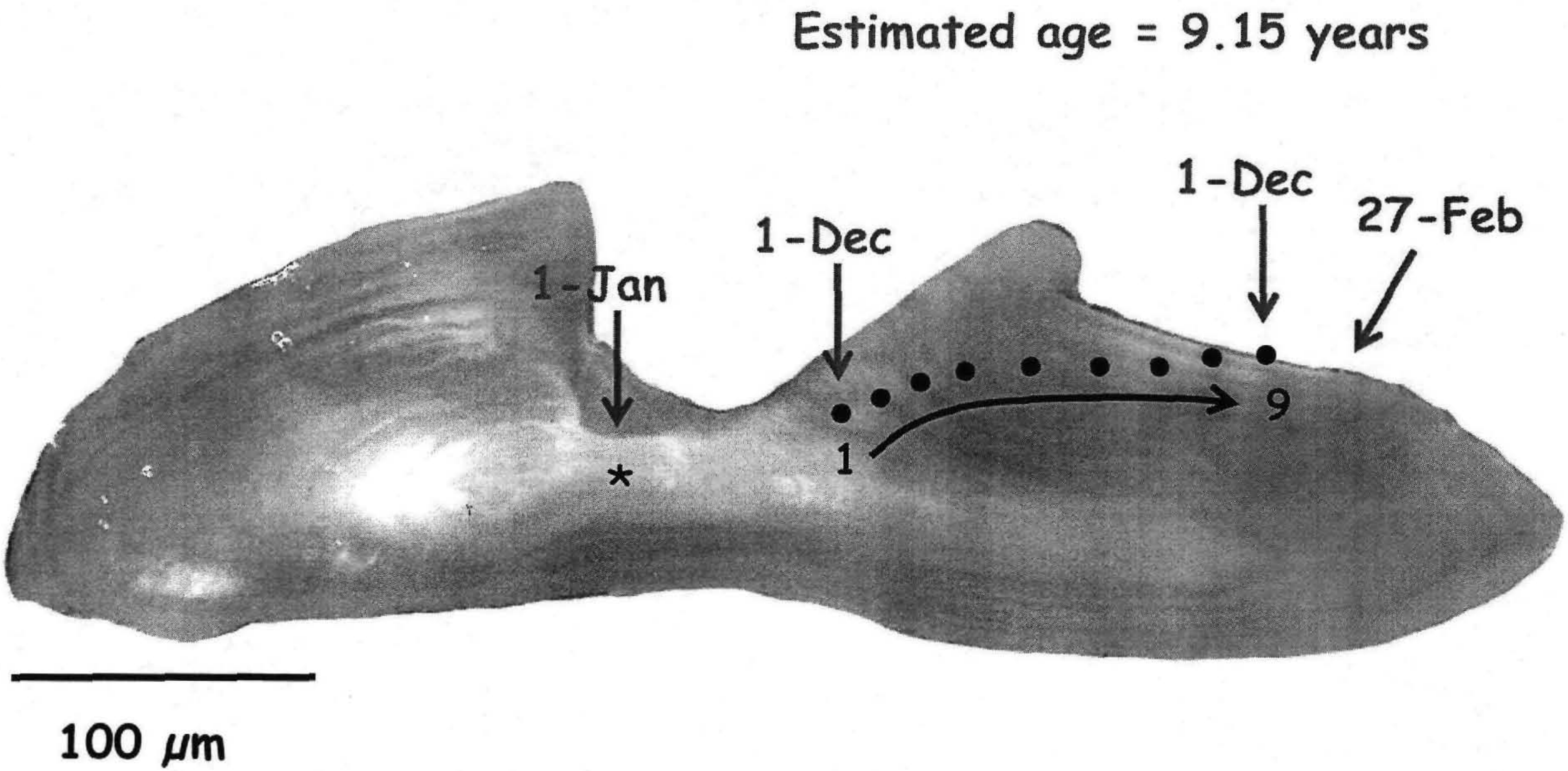

Figure 3: Typical prepared red gurnard otolith from a male fish 36 cm in fork length, landed on 27 February 2003 from a catch made in AKE, illustrating how translucent zone counts were converted to estimated ages. Nine fully-formed translucent zones were counted and a narrow margin recorded, yielding an estimated age of 0.92 + 8 + 0.23 = 9.15 years.

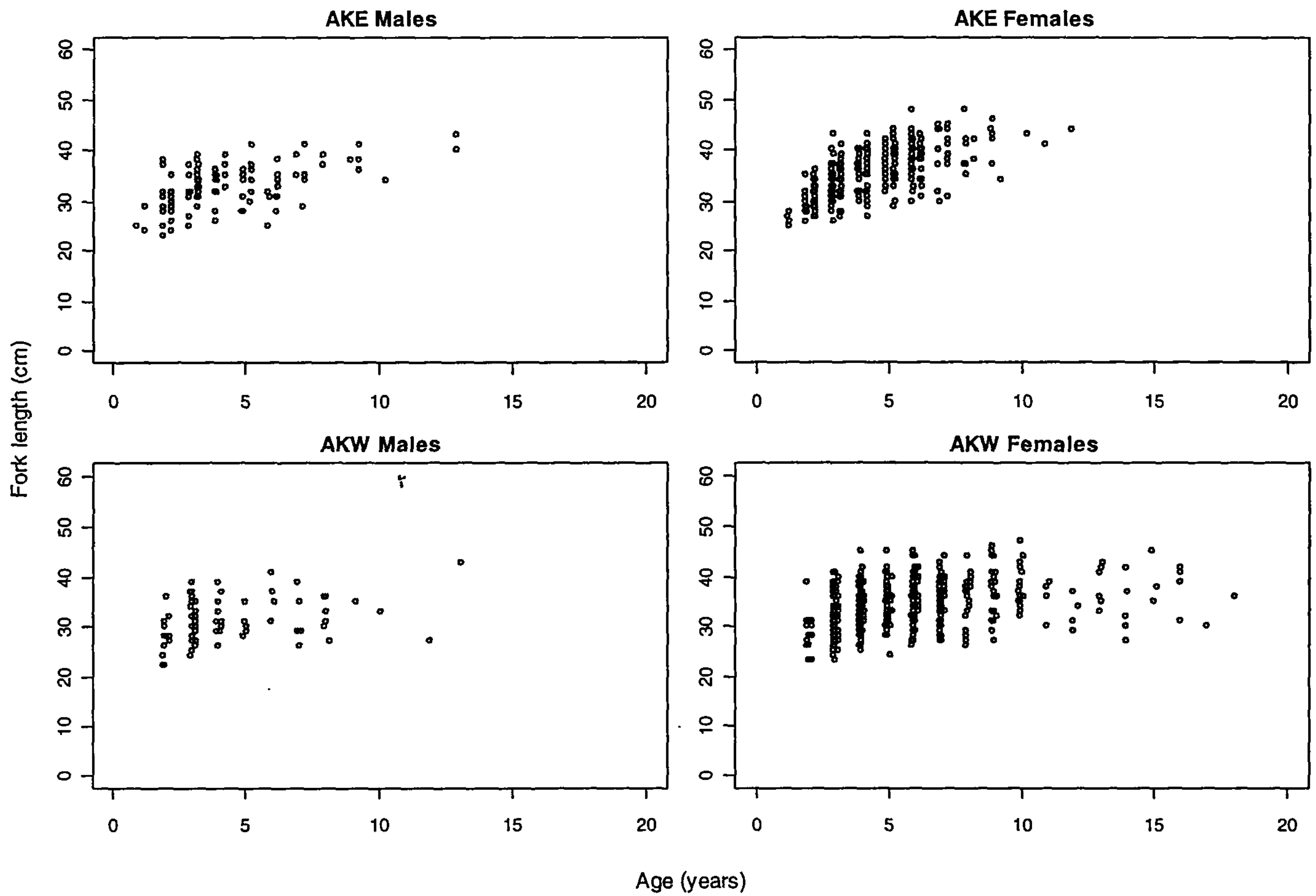

Figure 4: All groomed red gurnard lengths-at-age by stratum and sex derived from those otoliths collected from the commercial catch during the 2002–03 fishing year. All otoliths with high (poor) readability scores (> 4) have been dropped out.

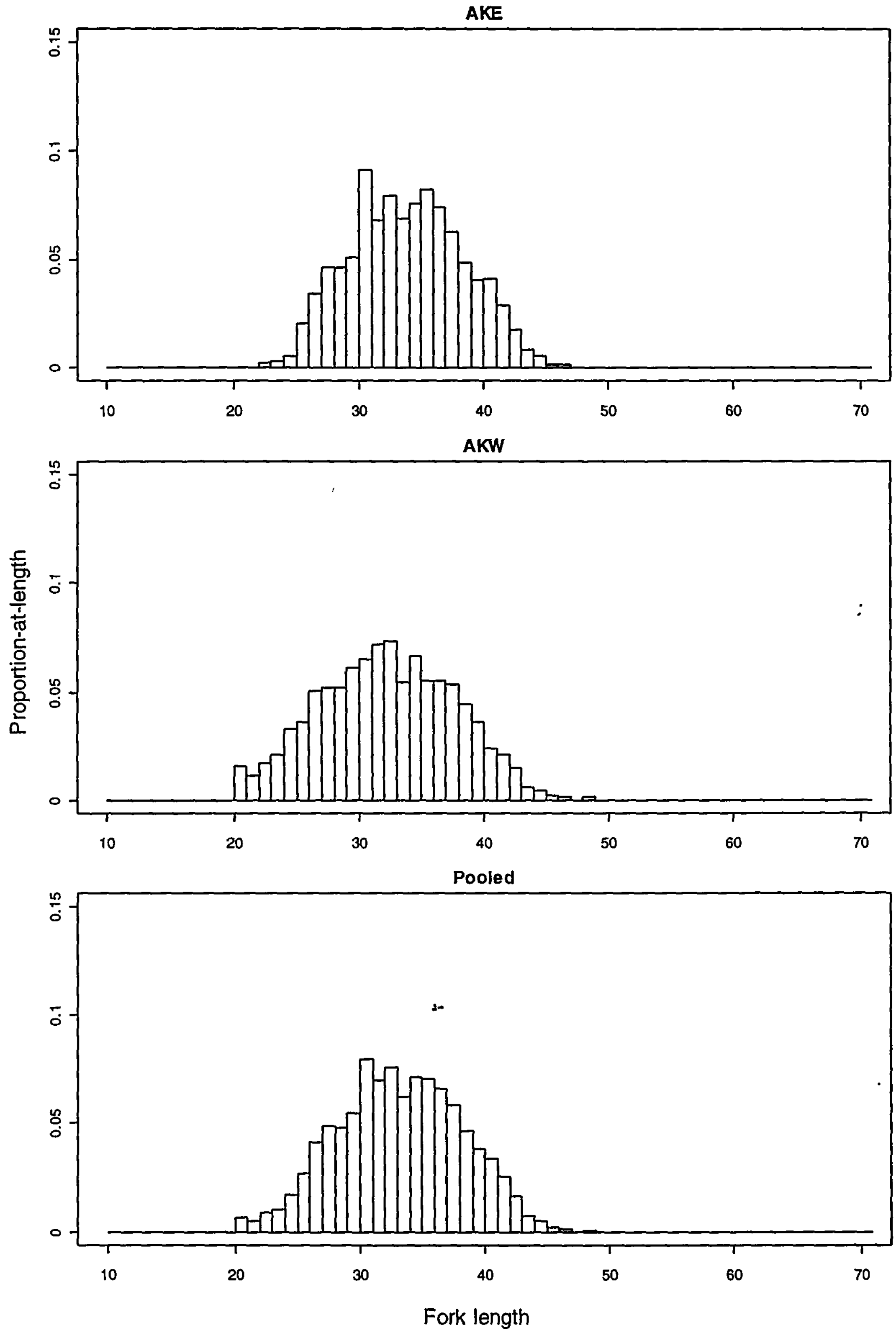

Figure 5: Estimated scaled proportions-at-length for both sexes combined by sampling stratum in the 2002–03 fishing year catch. Fish sexes were not recorded for those fish measured in the length-frequency samples collected from the catch.

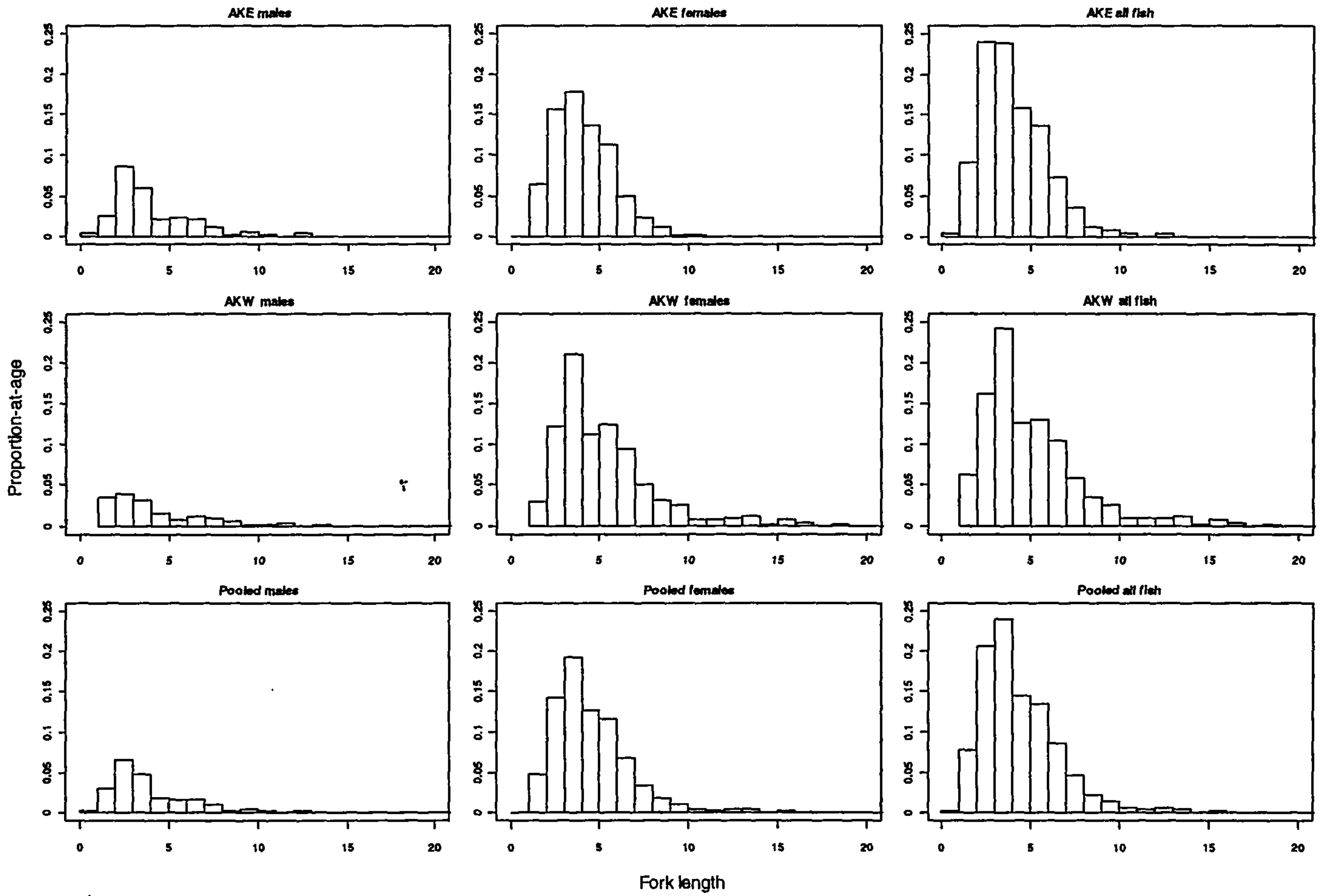

Figure 6: Estimated scaled proportions-at-age by sampling stratum and sex in the 2002–03 fishing year catch. The length-at-age data plotted in Figure 4 were converted to age-length-sex keys which were then applied to the scaled proportions-at-length plotted in Figure 5 to yield the scaled proportions-at-age and sex presented here.

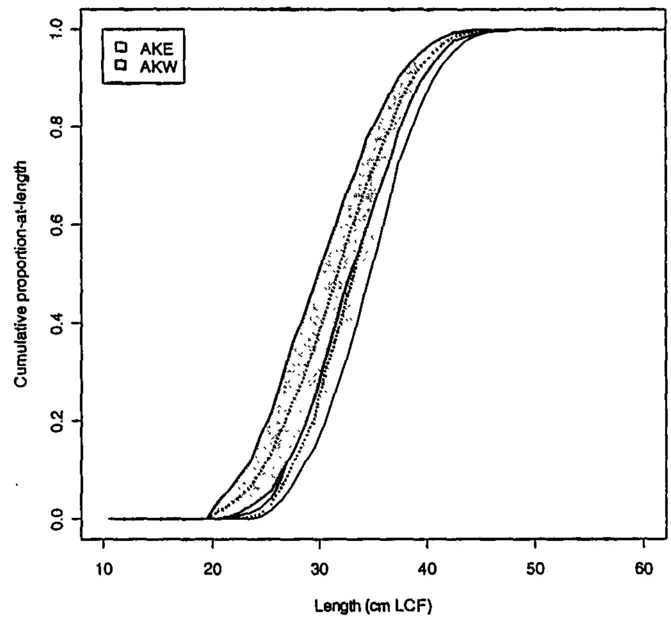

Figure 7: Cumulative proportions-at-length by sampling stratum (AKE and AKW; overlaid) in the 2002–03 fishing year catch (dotted lines). The shaded regions are bootstrapped 95% confidence regions about the cumulative proportions-at-length.

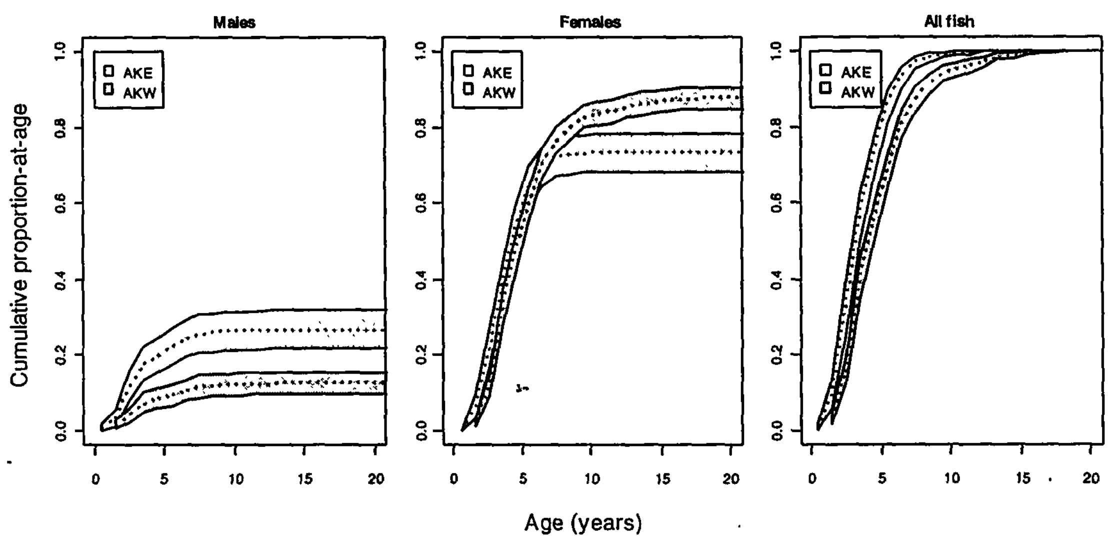

Figure 8: Cumulative proportions-at-age by sex and sampling stratum (AKE and AKW; overlaid) in the 2002–03 fishing year catch (dotted lines). The shaded regions are bootstrapped 95% confidence regions about the cumulative proportions-at-length.

Appendix A: Estimated scaled numbers-at-length.

Table 10: Estimated scaled-numbers-at-length (NAL) and coefficients of variation (CV) from commercial catches of GUR 1 for the 2002-03 fishing year by stratum.

Length	Stratum					
	AKE		AKW		All	
	NAL	CV (%)	NAL	CV (%)	NAL	CV (%)
≤ 10	0	-	0	-	0	-
11	0	-	0	-	0	-
12	0	-	0	-	0	-
13	0	-	0	-	0	-
14	0	-	0	-	0	-
15	0	-	0	-	0	-
16	0	-	0	-	0	-
17	0	-	0	-	0	-
18	0	-	0	-	0	-
19	0	-	0	-	0	-
20	0	-	22429	74.3	22429	74.3
21	326	159.5	16625	57.1	16951	55.4
22	4750	104.7	25321	42.8	30071	40.4
23	5302	88.2	30095	30.1	35397	29.4
24	10518	62.7	47961	43.3	58479	36.4
25	38981	27.6	52218	32.1	91198	22.8
26	65522	34.9	73322	22.2	138844	20.8
27	88170	22.2	75612	31.9	163781	19.2
28	88194	19.1	75382	15.5	163576	12.7
29	96828	20.6	88712	15.0	185540	13.2
30	175196	26.8	94176	16.2	269373	17.9
31	130681	19.2	104151	11.9	234832	11.9
32	151786	18.5	105624	10.5	257410	11.3
33	132620	16.7	78156	13.8	210775	11.6
34	145325	15.2	96144	14.1	241468	10.4
35	158026	12.1	79861	13.3	237886	9.2
36	142588	12.8	79596	12.3	222184	9.3
37	120238	14.8	77609	12.6	197847	10.3
38	92165	17.1	64033	15.1	156198	12.4
39	77373	17.2	52076	17.2	129450	13.2
40	78541	17.3	34912	20.9	113453	13.9
41	55525	29.9	30301	22.4	85825	21.0
42	33386	30.1	22059	29.3	55446	21.0
43	16498	43.7	8355	33.2	24853	32.0
44	9976	52.2	6764	36.4	16740	35.3
45	3617	75.3	3601	48.5	7218	46.9
46	2494	85.9	2348	61.1	4843	57.5
47	380	142.4	505	118.2	885	93.4
48	523	117.4	1805	86.6	2328	69.1
49	100	152.2	0	-	100	152.2
50	0	-	0	-	0	-
51	0	-	428	133.1	428	133.1
52	0	-	0	-	0	-
53	0	-	0	-	0	-
54	0	-	0	-	0	-
55	0	-	0	-	0	-
56	0	-	0	-	0	-
57	0	-	0	-	0	-
58	0	-	0	-	0	-
59	0	-	0	-	0	-
≥ 60	0	-	0	-	0	-

Appendix B: Estimated scaled numbers-at-age.

Table 11: Estimated scaled-numbers-at-age (NAA) and coefficients of variation (CV) from commercial catches of GUR 1 for the 2002-03 fishing year by stratum and sex.

AKE

Age (years)	Males		Females		Unsexed		All fish	
	NAA	CV (%)	NAA	CV (%)	NAA	CV (%)	NAA	CV (%)
0	7796	97.9	0	-	0	-	7796	97.9
1	50675	35.5	122269	29.9	0	-	172945	24.4
2	163273	26.9	297288	16.5	0	-	460562	14.9
3	115574	20.5	341652	11.1	0	-	457226	9.7
4	43536	32.2	259728	12.3	0	-	303264	11.2
5	46444	34.9	214217	13.0	0	-	260661	11.6
6	41440	31.7	94638	20.6	0	-	136078	17.0
7	23254	42.1	46513	29.9	0	-	69767	24.3
8	3072	110.2	20609	40.2	0	-	23681	38.7
9	10192	61.0	3545	109.0	0	-	13737	53.5
10	3545	94.3	4766	83.1	0	-	8310	63.4
11	0	-	998	117.3	0	-	998	117.3
12	5427	79.7	0	-	0	-	5427	79.7
13	0	-	0	-	0	-	0	-
14	0	-	0	-	0	-	0	-
15	0	-	0	-	0	-	0	-
16	0	-	0	-	0	-	0	-
17	0	-	0	-	0	-	0	-
18	0	-	0	-	0	-	0	-
19	0	-	0	-	0	-	0	-
20	0	-	0	-	0	-	0	-

AKW

Age (years)	Males		Females		Unsexed		All fish	
	NAA	CV (%)	NAA	CV (%)	NAA	CV (%)	NAA	CV (%)
0	0	-	0	-	0	-	0	-
1	49139	47.0	40028	38.4	0	-	89167	32.9
2	54441	45.7	174081	21.1	0	-	228521	21.0
3	44363	29.0	297008	11.4	0	-	341371	10.9
4	20169	36.0	157973	11.1	0	-	178142	10.6
5	10039	51.5	175634	12.2	0	-	185673	11.7
6	15626	43.5	133529	12.8	0	-	149155	12.5
7	12286	44.4	71166	18.3	0	-	83452	16.7
8	5817	81.1	43536	21.4	0	-	49352	20.9
9	1566	110.9	34201	23.9	0	-	35767	23.5
10	2004	108.6	9811	46.1	0	-	11815	43.3
11	3601	107.6	8677	52.9	0	-	12277	51.6
12	0	-	12605	42.0	0	-	12605	42.0
13	1393	113.7	14523	45.8	0	-	15916	42.0
14	0	-	2166	77.8	0	-	2166	77.8
15	0	-	9328	46.0	0	-	9328	46.0
16	0	-	2943	103.9	0	-	2943	103.9
17	0	-	0	-	0	-	0	-
18	0	-	1244	102.7	0	-	1244	102.7
19	0	-	0	-	0	-	0	-
20	0	-	0	-	0	-	0	-

Table 11: (continued).

Age (years)	Pooled							
	Males		Females		Unsexed		All fish	
	NAA	CV (%)	NAA	CV (%)	NAA	CV (%)	NAA	CV (%)
0	7796	97.9	0	-	0	-	7796	97.9
1	99815	30.2	162297	24.4	0	-	262112	20.1
2	217714	24.0	471369	13.0	0	-	689083	12.5
3	159937	16.8	638661	7.9	0	-	798598	7.2
4	63705	24.6	417701	8.9	0	-	481406	8.1
5	56483	30.4	389851	8.9	0	-	446334	8.4
6	57066	26.3	228167	11.3	0	-	285233	10.2
7	35540	31.0	117679	15.2	0	-	153219	13.6
8	8889	64.3	64145	18.9	0	-	73033	18.5
9	11758	56.2	37746	23.8	0	-	49504	23.1
10	5548	71.6	14577	40.5	0	-	20126	35.2
11	3601	107.6	9675	49.2	0	-	13275	48.6
12	5427	79.7	12605	42.0	0	-	18032	37.8
13	1393	113.7	14523	45.8	0	-	15916	42.0
14	0	-	2166	77.8	0	-	2166	77.8
15	0	-	9328	46.0	0	-	9328	46.0
16	0	-	2943	103.9	0	-	2943	103.9
17	0	-	0	-	0	-	0	-
18	0	-	1244	102.7	0	-	1244	102.7
19	0	-	0	-	0	-	0	-
20	0	-	0	-	0	-	0	-

Appendix C: Age-length-sex keys

Table 12: Age-length-sex key for AKE

Males

Length (cm)	Age (years) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	0.50	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	0.20	0.20	0.20	-	-	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	0.20	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	0.06	0.11	0.06	0.11	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-
29	-	0.13	0.20	0.07	-	-	-	0.07	-	-	-	-	-	-	-	-	-	-	-
30	-	-	0.29	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-
31	-	0.03	0.09	0.12	0.06	0.03	0.06	-	-	-	-	-	-	-	-	-	-	-	-
32	-	0.03	0.11	0.08	-	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	0.07	0.03	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-
34	-	-	-	0.12	0.02	0.02	0.02	0.02	-	-	0.02	-	-	-	-	-	-	-	-
35	-	-	0.07	0.10	0.05	-	0.07	0.02	-	-	-	-	-	-	-	-	-	-	-
36	-	-	-	0.08	0.03	0.03	-	-	-	0.03	-	-	-	-	-	-	-	-	-
37	-	0.03	0.03	0.03	0.03	0.03	-	0.03	-	-	-	-	-	-	-	-	-	-	-
38	-	0.03	-	0.03	-	-	0.07	-	0.03	0.03	-	-	-	-	-	-	-	-	-
39	-	-	-	0.04	0.04	-	0.04	0.04	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-
41	-	-	-	-	-	0.06	-	0.06	-	0.06	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	0.09	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Females

Length (cm)	Age (years) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	0.40	0.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27	-	0.17	0.33	0.17	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	0.22	0.22	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	0.13	0.27	-	0.07	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-
30	-	0.14	0.19	0.10	0.05	0.14	0.05	-	-	-	-	-	-	-	-	-	-	-	-
31	-	0.06	0.22	0.16	0.09	-	0.03	0.03	-	-	-	-	-	-	-	-	-	-	-
32	-	0.03	0.16	0.27	0.19	0.03	0.03	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	0.27	0.30	0.20	0.07	0.03	-	-	-	-	-	-	-	-	-	-	-	-
34	-	-	0.22	0.20	0.07	0.15	0.10	-	-	0.02	-	-	-	-	-	-	-	-	-
35	-	0.02	0.14	0.19	0.17	0.14	-	0.02	-	-	-	-	-	-	-	-	-	-	-
36	-	-	0.08	0.43	0.14	0.14	0.05	-	-	-	-	-	-	-	-	-	-	-	-
37	-	-	0.11	0.30	0.22	0.08	0.03	0.08	0.03	-	-	-	-	-	-	-	-	-	-
38	-	-	-	0.10	0.27	0.20	0.13	0.07	0.03	-	-	-	-	-	-	-	-	-	-
39	-	-	0.04	0.19	0.23	0.27	0.08	0.04	-	-	-	-	-	-	-	-	-	-	-
40	-	-	0.05	0.10	0.20	0.40	0.20	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	0.12	0.29	0.18	0.06	0.12	-	-	0.06	-	-	-	-	-	-	-	-
42	-	-	-	-	0.09	0.27	0.09	0.27	0.27	-	-	-	-	-	-	-	-	-	-
43	-	-	0.09	-	0.18	0.18	0.27	-	0.09	-	0.09	-	-	-	-	-	-	-	-
44	-	-	-	-	-	0.40	0.20	0.20	0.10	-	-	0.10	-	-	-	-	-	-	-
45	-	-	-	-	-	-	0.50	0.50	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	0.50	-	0.50	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 13: Age-length-sex key for AKW

Males

Length (cm)	Age (years) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	0.25	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	0.06	-	0.12	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	0.10	0.05	-	-	-	-	0.05	-	-	0.05	-	-	-	-	-	-	-
28	-	0.03	0.09	0.03	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	0.07	0.04	0.04	0.07	0.04	-	-	-	-	-	-	-	-	-	-	-
30	-	0.03	-	0.06	0.03	0.03	-	0.03	-	-	-	-	-	-	-	-	-	-	-
31	-	0.02	-	0.04	0.06	0.02	-	-	0.02	-	-	-	-	-	-	-	-	-	-
32	-	-	0.05	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
33	-	-	-	0.05	-	-	-	0.03	-	-	0.03	-	-	-	-	-	-	-	-
34	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	-	-	0.02	0.04	0.04	-	0.02	0.02	-	0.02	-	-	-	-	-	-	-	-	-
36	-	-	0.03	-	-	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-
37	-	-	0.02	0.02	0.02	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-
38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	0.03	0.03	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Females

Length (cm)	Age (years) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	0.33	0.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	0.25	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	0.25	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	-	0.18	0.29	0.18	-	0.06	-	0.06	-	-	-	-	-	-	-	-	-	-	-
27	-	0.05	0.14	0.24	-	0.10	0.10	0.05	0.05	-	-	-	-	0.05	-	-	-	-	-
28	-	0.06	0.22	0.19	0.06	0.09	0.06	0.12	-	-	-	-	-	-	-	-	-	-	-
29	-	-	0.15	0.19	0.07	0.15	0.04	0.07	0.04	-	-	0.04	-	-	-	-	-	-	-
30	-	0.03	0.16	0.25	0.09	0.09	0.09	-	-	-	0.03	-	-	0.03	-	-	0.03	-	-
31	-	0.04	0.09	0.28	0.15	0.06	0.13	-	0.04	-	-	0.02	-	-	-	0.02	-	-	-
32	-	-	0.10	0.29	0.20	0.17	0.05	0.05	-	0.05	-	-	-	0.02	-	-	-	-	-
33	-	-	0.05	0.36	0.13	0.08	0.13	0.05	0.05	0.03	-	-	0.03	-	-	-	-	-	-
34	-	-	0.14	0.26	0.11	0.20	0.17	-	0.03	0.03	-	-	0.03	-	-	-	-	-	-
35	-	-	-	0.18	0.24	0.16	0.18	-	0.02	0.04	-	-	0.02	-	0.02	-	-	-	-
36	-	-	0.05	0.23	0.14	0.12	0.12	0.08	0.03	0.08	0.03	-	0.03	-	-	-	-	-	0.02
37	-	-	0.02	0.09	0.19	0.26	0.12	0.14	0.02	0.02	-	0.02	-	0.02	-	-	-	-	-
38	-	-	0.06	0.24	0.15	0.09	0.09	0.21	0.06	0.03	0.03	-	-	-	-	0.03	-	-	-
39	-	0.03	0.05	0.18	0.24	0.08	0.11	0.05	0.05	0.08	-	0.03	-	-	-	0.03	-	-	-
40	-	-	-	0.17	0.17	0.22	0.22	0.09	0.13	-	-	-	-	-	-	-	-	-	-
41	-	-	0.11	0.05	0.11	0.26	0.11	-	0.11	0.05	0.05	-	0.05	-	-	0.05	-	-	-
42	-	-	-	-	0.20	0.10	0.30	-	-	0.10	-	-	0.10	0.10	-	0.10	-	-	-
43	-	-	-	-	-	-	0.33	-	-	0.33	-	-	-	0.17	-	-	-	-	-
44	-	-	-	-	-	0.38	-	0.25	0.25	-	0.12	-	-	-	-	-	-	-	-
45	-	-	-	0.17	0.17	0.17	-	-	0.33	-	-	-	-	-	0.17	-	-	-	-
46	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
47	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-