REPORT OF WORKING GROUP ON AGE DETERMINATION OF DALL'S PORPOISE, HELD 15-18 JULY 1985

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by

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Age Determination Workshop

In 1984, Japanese and U.S. scientists began comparisons of methods of age determination for Dall's porpoise (Phocoenoides dalli). In a preliminary study, specimens prepared by each researcher from his own samples were exchanged by mail. Growth layers were counted and results compared. Analyses indicated differences between the researchers in counts of growth layers, and possible differences between methods of preparation. One major problem identified was interpretation of growth layers in animals 160 cm or less in body length. It was determined that the scientists should meet to discuss methods to improve agreement between readers and increase the reliability of age determination. The Scientific Subcommittee of the Ad Hoc Committee on Marine Mammals of the International North Pacific Fisheries Commission recommended that a one-week workshop be convened in 1985 to accomplish this work.

A working group was convened at the National Marine Mammal Laboratory, Seattle, Washington, 15-18 July 1985 to compare methods of preparing tooth specimens and counting growth layers in the teeth, and to try to resolve differences in age determination. The participants were T. Kasuya (Far Seas Fisheries Research Laboratory) and N. Miyazaki (National Science Museum) from Japan, and M. Gosho, L. Jones, D. Rice and A. Wolman (National Marine Mammal Laboratory) from the United States.

METHODS

A sample of teeth from 30 Dall's porpoise taken incidentally in the western North Pacific by the Japanese salmon gillnet fishery in 1981 were distributed to each researcher (T. Kasuya, N. Miyazaki and M. Gosho) who prepared them using his own standard methods. To examine the effect of method of preparation on age determination, teeth from animals collected in the same area by salmon gillnets were used. This eliminated effects of difference in age structure in different geographical areas.

Methods of preparation varied. Working separately, Kasuya and Miyazaki used the method described by Kasuya (1978). Both sides of the teeth were hand-ground resulting in a thin longitudinal section of the central portion. This thin section was then decalcified in formic acid and stained with hematoxylin. One section was produced from each tooth.

Gosho decalcified the whole tooth in RDO (manufactured by Dupage Kinetic Laboratories, Inc., Plainfield, Illinois, U.S.A.). Teeth were then sectioned using a freezing microtome and stained with hematoxylin. Ten to twelve sections were produced from each tooth and mounted on a slide.

Each of the four readers estimated the age of the animals from the 30 teeth which they had prepared prior to arrival at the workshop.[1] At the NMML, the prepared teeth were exchanged among four readers and counts made.

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[1] Wolman aged the teeth prepared by Gosho.

No biological information on individual porpoise such as body length, number of ovarian corpora or testis weight were provided to the readers before the slides were read. The prepared slides were numbered so that readers did not know from which porpoise the slides came. Therefore the counts could not be biased by previous readings of other preparations from that animal.

When all the slides had been viewed by four readers, the results were examined. Slides were selected for discussion and comparison of structures counted by each reader. Microscopes with double oculars which permitted two people to view a slide at the same time were used to compare structures.

A video camera mounted on a compound microscope projected an image on a video screen which could be viewed by all participants. However, the equipment used did not produce an image of suitable clarity for counting layers.

In this report, the index of Average Percent Error (APE) (Beamish and Fournier, 1981) was used for making comparisons between methods and readers. Lower APE values are indicative of greater precision.

$$APE\ (\%) = 100 \quad 1/N \sum_{j=1}^{N} \frac{1}{R} \left[\sum_{i=1}^{R} \frac{|Xij - Xj|}{Xj} \right]$$

where N = no. of teeth aged

R = no. of times each tooth was aged

Xij = the ith reading of the jth tooth

X_j = average age of the jth tooth

The sample was not randomly selected. Approximately equal numbers of immature and mature animals of each sex were selected for the comparisons (Figure 1).

RESULTS

The ages assigned to each of the thirty animals by the four readers for the three processing techiques are listed in Table 1. Variability in age determinations between preparation methods and readers is shown in the age-frequency histograms for each reader (Figure 2). Although the tooth slides are all from the same thirty animals, the peak age varies from 1 year to 4 years. The mean age of the sample varied from 3.3 years to 4.6 years (Figure 2).

Effect of Processing Technique

Jones et al. (1985) suggested that the multiple-section slides prepared by Gosho might cause a greater variation in layer counts than the single-section slides prepared by Kasuya and Miyazaki because different readers may examine different sections. The index of APE for slides prepared by each method which were aged by the four readers was calculated to compare the variation in readings between the three methods of preparation. The results were 18.5% for the slides prepared by Kasuya's method, 20.8% for Miyazaki's method, and 19.8% for Gosho's method (Table 2). The pooled APE index for the 90 slide sample aged by the four readers was 19.7% (Table 2), indicating that there is very little difference in variation in readings between the three processing

techniques. The APE values for all three methods are high and indicate the variability between readers may be so high as to mask any effect due to the different preparation methods.

The index of APE was calculated for each reader ageing the slides from the three preparation methods to compare the effect of preparation method on each reader. The APE values were Kasuya, 14.4%; Miyazaki, 18.2%; Gosho, 15.7%; and Wolman, 10.5%. Thus, the method of preparing teeth for ageing has a different effect on each reader. Wolman's readings varied the least with preparation method.

The use of multiple-section slides does not increase variation in age determination. Workshop participants felt that the method using multiple sections from each tooth increased the chance of finding a suitable portion of the cementum for reading.

Comparison between Readers

To test whether the variability between readers increased directly with the number of readers, indices of APE were calculated for combinations involving three readers (i.e., the readings of one of the four readers were omitted). The APE values indicate there would be little difference in the variation of the readings if either Gosho's or Wolman's readings were omitted from the comparison (Table 2). The best agreement occurs between Kasuya, Gosho, and Wolman (omitting Miyazaki's readings); however, the APE value was still somewhat high (13.7%).

Scatter plots of growth layer counts by two readers were used to examine agreement between readers (Figure 3). In general, Kasuya's counts were lower than other readers', especially for animals 3 years of age or less. Miyazaki's counts were higher than other readers' for animals less than 5 years and lower for animals above 5 years of age. Wolman's counts were usually higher on animals 5 years or older. Gosho's counts were more variable without a trend in young or old animals.

The range of the index of APE for the three sets of slides was 8% to 21%, while the range of the number of slides in each set that were read the same by two readers was 9 to 18 (Table 3).

The indices of APE for pairs of readers on all 90 slides (Table 3) ranged from 10.9% (Gosho vs. Wolman) to 17.5% (Kasuya vs. Miyazaki). The second best agreement was Kasuya vs. Gosho (11.7%).

Variation in Readings with Body Length

The frequency of age estimates for each specimen was arranged in ascending order for body length in Table 4. In both males and females, there is less variation in the assigned ages for animals less than 163 cm in body length. These animals were also sexually immature.

Ageing of Immature Animals

Six of the twelve males were immature with testis weights less than 14 gm and body lengths less than 163 cm. These animals were aged

as 1 and 2-year-olds by three readers, with the majority of readings being 1-year (Table 5). One reader aged these as 1 to 3-year-olds, with half being 2-year-olds.

In the sample of females, 8 were immature (no ovarian corpus present) and less than 160 cm in body length. Two readers read all slides for these 8 animals (24 slides) as 1 and 2-year-olds (Table 5). One reader aged the majority as 1 and 2-year-olds but aged 4 slides as 3-year-olds. The final reader's ages were from 1 to 5 years.

In both male and females, Kasuya tended to have the lowest readings and Miyazaki the highest.

Differences in Age Estimates

Following an examination of the age determinations for each slide, individual slides were selected for group review and discussion. Differences in age determinations were in two categories:

1. counts made at different locations along the cementum
2. different interpretations of accessory layers.

All readers agreed that the ideal location to count cemental layers was where the neonatal line intersected the cementum. However, cemental layers were not always most distinct at this location. At other locations along the cementum, problems arose regarding whether or not the first or last layer should be included in the count.

All readers agreed that the initial cementum layers in Dall's porpoise tooth sections are wider than those deposited later, and that the decrease in layer width with age is more or less uniform. However, interpretation of the first or last layer often differed between readers and the resulting counts differed by one or two layers.

Different interpretations of assumed accessory layers resulted in the widest range of counts. Although readers acknowledged the existence of accessory layers formed between assumed annual layers, distinguishing between the two kinds of layers was difficult. To assist in making this distinction, most readers examined the degree of "openness" of the pulp cavity to determine whether the animal was young or old. Pulp cavities of newborn animals are wide but are soon filled with postnatal dentine, leaving a narrow canal (Kasuya 1978). For example tooth sections from specimen number WTE 26, an immature female (body length: 148 cm) had up to five countable layers in the cementum. The ages assigned to this animal ranged from 1 to 5 years. The pulp cavity was still wide open, indicating it was a young animal and therefore some layers were probably accessory rather than annual layers.

Readers agreed that the specimens with multiple sections were more useful for examining the "openness" of the pulp cavity, especially in strongly curved teeth, than the single section preparations.

In addition to the condition of the pulp cavity, some readers examined dentine layers to aid in age determination. Kasuya (1978)

found the number of layers in the cementum and dentine were the same in animals having less than four cemental layers. Some participants felt that after depositon of three dentinal layers, the relationship between cemental and dentinal layers was unreliable. Furthermore, accessory layers can be present in the dentine as well as the cementum and can be difficult to distinguish from annual layers. Therefore, it was felt that dentinal layer counts were less reliable than cemental layer counts.

During the discussion regarding variation in age determinations, individual age estimates were compared with the animal's length and either testis weight or number of ovarian corpora. In some cases, participants thought their age determinations were incorrect when these data were considered. However, it was agreed that biological data should only be consulted after the age was determined, otherwise results would be biased. Therefore, biological data should only be used to check the accuracy of the age determination and to identify unreliable estimates.

In cases where there was a range of likely estimates that were compatible with the biological data, the participants were unable to agree on a best age. Lack of known age Dall's porpoise prevents resolving such differences.

Readings of Previously Exchanged Specimens

Participants re-read a set of 31 slides that had been exchanged previously (Jones et al. 1985). Results of both readings are listed in Table 6.

Consistency of the readers was analyzed by comparing their readings at the workshop with those of 1984. The indices of APE indicate that Wolman was most consistent (Table 6).

The index of APE for the four readers aging 27 of the 31 slides was 18.97%. Comparing this value to that for the 90 slides prepared for the workshop (19.69%), there does not appear to be significant improvement in consistency between readers as a result of the comparisons and discussions at the workshop.

DISCUSSION

The index of average percent error describes the precision, reproducibility, or consistency of a set of age readings (Beamish and Fournier, 1981). In this report, the APE was used to measure how close one reading was to another, or the variability between a set of readings. The accuracy of the readings (amount of deviation from the "true" age of the animal) could not be measured because, at present, there are no known age Dall's porpoise specimens available. For example, the twelve age estimates of specimen WTE 015 were as follows:

AGE:	1 yr.	2 yr.	3 yr.	4 yr.	7 yr.
No.:	1	4	5	1	1

Fairly good precision in the age estimates is seen with the majority of the readings being 2 or 3 years of age. However, this specimen had a body length of 190 cm and 5 ovarian corpora. Thus, 2 or 3 years probably does not reflect the "true" age of the animal.

The previous sections have shown that there is considerable variation in age estimates between readers as well as between repeated readings by the same reader. The variability in the age estimates will also affect the age-related life history parameters such as age at sexual maturity, ovulation rate, growth rate, survival rate, age structure of the population, and the age-length relationship.

For example, if we assume that the 30 workshop specimens represent an imaginary population of Dall's porpoise and let each researcher prepare and age the teeth independently, we can use the data in Table 1 taking Kasuya's ages for Kasuya's slides, Miyazaki's ages for Miyazaki's slides, and Gosho and Wolman's ages for Gosho's slides. The resulting age structure of the sample (Table 7) varies with the reader.

The number of 1-year-olds in this "population" ranged from 10% (Miyazaki) to 43 % (Kasuya). Gosho and Wolman's estimate would be 33 and 30%, respectively.

A further examination of the different age compositions (Table 7) would show that Miyazaki's sample had the highest number of 2-year-olds, while Kasuya's had the lowest. Gosho and Wolman's sample had a higher number of animals greater than 7 years of age.

Similarly, the effect of two independent readings by the same reader can be examined using the data in Table 6, taking the ages of 21 specimens which have been aged twice by all four readers.

The age compositions of each reader differed from one reading to the next (Table 8). In Kasuya's second reading, the number of 2-year-olds increased, while the number of 4-year-olds decreased. In Miyazaki's second reading, the number of 2- and 3-year-olds increased, while the number of 5- and 6-year-olds decreased. In Gosho's second reading, the number of 1- and 2-year-olds increased, while the number of 3- and 5-year-olds decreased. In Wolman's second reading, the number of 3-year-olds increased slightly.

The greatest change in the average age of the sample occurred in Miyazaki's readings; the average age of the sample from the second reading was 1-1/2 years less than that from the previous reading.

The age composition of a sample appears to change significantly each time it is read by the same reader.

In the 1984 study (Jones et al. 1985), the age at which the proportion of sexually mature females exceeded 50% was 5 years for Gosho, 3 for Kasuya, and 5 for Miyazaki. More than 50% of the males were sexually mature at 5 years of age by Gosho's reading, 4 years by Kasuya's, and 5 years by Miyazaki's. Since the same slides were aged by the three readers, the differences in age at sexual maturity resulted solely from variation in age determination between readers.

Thus, an apparent change in the age at sexual maturity, growth rate, or survival rate could be the result of variability in age determination rather than from actual changes in population parameters.

Kasuya (1978) reported that the accuracy of age determination of Dall's porpoise using cemental layers is so bad that two independent counts on a tooth section often give a discrepancy of 20 percent. Although the number of layers in the cementum appears to be the most reliable indicator of age at present, further research is necessary to find other structures or aging techniques which can be more consistently read by different readers to reduce the variability in age determination of Dall's porpoise.

The best agreement in layer counts occurred between Gosho and Wolman (APE = 8.2%) reading Gosho's slides. Gosho and Wolman have consulted frequently on age determination of Dall's porpoise over the past two years and are most familiar with their own preparation technique. In contrast, the workshop participants spent only 3 days reviewing slides on which the age estimates differed. It is possible that more frequent slide exchanges over a longer period of time and comparison of the different age estimates will eventually decrease the variability between readers.

Multiple readings of the same slide set and the elimination of those slides which give variable readings may increase the consistency of a reader and decrease the variability between readings. If the initial sample size is suitably large, the unrealiable specimens could be eliminated and an adequate number would still remain. It is hoped that reliable estimates regarding the mean values could then be obtained.

CONCLUSIONS

1. Age determination of Dall's porpoise is very subjective. Variability between readers is high regardless of the method of preparation. Variability between two readings of the same slides by the same reader can also be high.
2. There was less variation in the age determination of immature animals than in that of mature animals.
3. There was little difference in variability of the readings between the three preparation methods. Each reader was affected differently by the preparation method.
4. The two main causes for discrepancies in age reading were:
   a) readings made at different locations in the cementum and subsequent inclusion or exclusion of the first or last layer (resulting in a one- or two-year difference)

b) interpretation of accessory layers (resulting in a several year or multiple-year difference, such as 3 or 6 years, 4 or 8 years).

5. Indicators supporting age estimate were:
   a) degree of "openness" of pulp cavity; multiple-section slides were especially useful for examining the pulp cavity
   b) number of dentinal layers; these were only reliable for the first two or three years of life
   c) biological data (length, testis weight, ovarian corpora count); these can only be used after the age has been determined to exclude gross inconsistencies.
6. The three-day group discussion on age differences did not significantly decrease the variability in age readings among the four readers.
7. Differences in age-related life history parameters must be carefully examined to determine if they are the result of variability in age determination or from actual changes in population parameters.

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TABLE 1.--Age readings and biological data on 30 workshop specimens read in 1985.

Slide Number	Specimen Number	Kasuya Slides				Miyazaki Slides				Gosho Slides				Length (cm)	Testis Weight	No. of Corpora
		K	M	G	W	K	M	G	W	K	M	G	W			
1	WTE3	5	4	7	5	7	6	7	7	6	4	7	4	196	220g	
2	PJG3	1	1	1	2	2	2	2	2	2	3	1	2	141	7g	
3	DRB6	4	4	4	4	5	5	4	4	5	4	4	4	184		4c
4	ALH9	5	8	4	10	6	7	9	8	8	8	8	8	193	95g	
5	WTE11	8	5	7	11	7	7	6	9	12	11	8	9	185		3c
6	DRB11	4	3	3	3	2	5	3	3	3	4	4	4	176		1c
7	DRB12	1	2	2	2	2	4	1	2	1	3	2	2	155		0c
8	LMT14	1	1	1	1	1	3	1	2	1	1	1	2	161	7g	
9	WTE15	4	3	3	7	1	3	2	3	2	2	3	2	190		5c
10	DRB15	5	5	5	9	5	5	9	5	4	4	4	3	182		4c
11	DRB16	6	5	5	8	6	7	8	7	3	3	5	6	178		5c
12	WTE17	7	6	6	7	5	5	5	6	6	5	5	4	198	125g	
13	DRB18	1	1	2	2	1	3	2	1	1	2	1	1	159		0c
14	RGI58	3	6	6	10	5	5	6	9	3	7	8	12	197		5c
15	ALH25	1	2	2	1	1	2	1	1	1	2	1	1	139	6g	
16	WTE18	7	6	5	8	8	7	7	7	7	6	8	6	198	105g	
17	LMT30	1	2	1	1	1	1	1	1	1	1	2	1	162	13g	
18	DRB26	1	1	1	1	1	2	1	1	1	2	1	1	140	12g	
19	WTE45	7	4	5	5	2	4	3	5	4	6	5	5	185		0c
20	WTE21	4	4	5	6	2	4	4	6	5	5	6	6	190	176g	
21	DRB19	1	2	1	1	1	1	1	1	1	1	1	1	157		0c
22	RGI47	13	11	9	10	12	11	12	12	10	10	12	12	195		6c
23	WTE24	1	2	2	2	1	4	1	3	1	4	2	3	152		0c
24	DRB21	5	5	9	8	6	6	6	6	2	4	9	10	190	150g	
25	LMT27	1	2	2	1	1	2	1	1	1	2	1	1	149		0c
26	ALH40	6	5	4	6	4	6	6	6	7	6	7	7	195		5c
27	WTE26	2	5	2	3	1	4	1	3	2	5	2	2	148		0c
28	LMT21	1	1	1	1	1	2	1	1	1	2	1	1	161	6g	
29	LMT23	1	1	1	1	1	2	1	1	1	1	1	1	147		0c
30	WTE27	1	1	1	1	1	1	1	1	1	1	1	1	156		0c

TABLE 2.--Average Percent Error values for four readers and three readers, omitting one reader in each case. (Calculated from Table 1).

Reader omitted	Method of Preparation			Total (90 slides)
	Kasuya	Miyazaki	Gosho	
None	18.5%	20.8%	19.8%	19.7%
Kasuya	16.4%	18.4%	18.5%	17.8%
Miyazaki	16.6%	11.1%	13.4%	13.7%
Gosho	19.0%	20.4%	19.8%	19.7%
Wolman	15.9%	22.0%	20.0%	19.3%

TABLE 3.--Comparisons of age determinations by method of preparation using Average Percent Error. Number of cases in which both readers counted the same number of layers is given in parentheses. (Calculated from Table 1).

Readers	Method of Preparation			Total (90 slides)
	Kasuya	Miyazaki	Gosho	
K - M	14.4(11)	21.1(10)	16.9(11)	17.5(32)
K - W	14.0(13)	13.5(15)	13.6(14)	13.7(42)
K - G	12.7(11)	9.7(16)	12.9(13)	11.7(40)
M - W	16.4(9)	14.5(10)	15.7(10)	15.6(29)
M - G	9.7(18)	18.8(9)	17.6(9)	15.4(36)
W - G	12.6(13)	11.8(16)	8.2(17)	10.9(46)

TABLE 4.--Frequency of age estimates by body length (from Table 1).

Slide No.	Number of Growth Layers													Length (cm)	Testis weight	No. of Corpora
	1	2	3	4	5	6	7	8	9	10	11	12	13			
Males																
15	8	4												139	6 g.	
18	10	2												140	12 g.	
2	4	7	1											141	7 g.	
28	10	2												161	6 g.	
8	9	2	1											161	7 g.	
17	10	2												162	13 g.	
24		1	-	1	2	4	-	1	2	1				190	150 g.	
20		1	-	4	3	4								190	176 g.	
4				1	1	1	1	6	1	1				193	95 g.	
1				3	2	2	5							196	220 g.	
16					1	3	5	3						198	105 g.	
12				1	5	4	2							198	125 g.	
Females																
29	11	1												147		0c
27	2	5	2	1	2									148		0c
25	8	4												149		0c
23	4	4	2	2										152		0c
7	3	7	1	1										155		0c
30	12													156		0c
21	11	1												157		0c
13	7	4	1											159		0c
6		1	6	4	1									176		1c
11			2	-	3	3	2	2						178		5c
10			1	3	6	-	-	-	2					182		4c
3				9	3									184		4c
19		1	1	3	5	1	1							185		0c
5					1	1	3	2	2	-	2	1		185		3c
9	1	4	5	1	-	-	1							190		5c
26				1	2	6	3							195		5c
22									1	3	2	5	1	195		6c
14			2	-	2	3	1	1	1	1		1		197		5c

TABLE 5.--Age determinations for immature Dall's porpoise by reader. Males: 6 animals, total of 18 slides. Females: 8 animals, total of 24 slides examined (from Table 1).

A. Immature Males (<163 cm)

Reader	Growth Layers		
	1	2	3
K	16(89%)	2(11%)	
M	7(39%)	9(50%)	2(11%)
G	15(83%)	3(17%)	
W	13(72%)	5(28%)	

B. Immature Females (<160 cm)

Reader	Growth Layers				
	1	2	3	4	5
K	21(88%)	3(13%)			
M	8(33%)	8(33%)	2(8%)	4(17%)	2(8%)
G	15(63%)	9(38%)			
W	14(58%)	6(25%)	4(17%)		

TABLE 6.--Repeat readings of Dall's porpoise tooth sections.
APE = Average Percent Error (Beamish and Fournier 1981).

Specimen	Kasuya		Miyazaki		Gosho		Wolman	
	1985	1984	1985	1984	1985	1984	1985	1984
TK-6	3	4	3	4	2	3	3	3
TK-7	2	3	3	4	3	3	2	2
TK-16	1	2	1	2	1	2	1	1
TK-42	5	5	5	6	5	5	6	6
TK-56	9	9	8	9	?	9	8	9
TK-90	2	3	3	5	4	4	5	8
TK-98	3	5	4	5	5	5	5	5
TK-106	1	3	2	5	2	3	3	4
TK-114	2	2	1	5	?	3	5	7
TK-64	5	4	4	5	5	5	5	7
810 715-1	1	1	3	4	3	4	3	3
820 528-1	2	2	2	3	?	2	1	?
820 719-1	7	4	5	9	4	6	7	6
820 505-1	3	3	3	6	4	4	5	5
21399	2	1	2	3	2	3	2	2
SDT 025	1	2	4	5	1	4	4	5
SDT 126	2	2	2	2	2	3	3	2
LMT 036	4	4	4	5	3	3	4	3
LMT 054	5	4	4	6	4	5	5	5
LMT 056	5	4	4	6	5	5	6	6
LMT 057	2	1	2	3	2	3	3	3
LMT 061	4	-	1	-	4	4	5	-
SM 030	1	1	2	4	1	4	3	4
YA 006	3	1	2	4	3	3	4	5
GJC 039	6	5	5	5	4	5	6	6
FVS 039	8	-	6	-	8	10	11	9
FVS 040	1	-	1	-	1	1	1	1
JL 011	1	-	1	-	2	3	1	?
JL 062	3	-	8	-	8	9	11	10
CEB 516	3	-	3	-	?	4	4	5
CEB 543	3	-	4	-	4	5	4	5
APE	15.9% n=24		20.8% n=24		13.3% n=27		6.9% n=28	

TABLE 7.--Age composition of 30 specimen samples prepared and aged independently by each researcher. ( ) = number in age group [from Table 1].

Age group	Kasuya	Miyazaki	Gosho	Wolman
1 year	43.3%(13)	10.0%(3)	33.3%(10)	30.0%(9)
2 year	3.3%(1)	20.0%(6)	13.3%(4)	16.7%(5)
3 year	3.3%(1)	10.0%(3)	3.3%(1)	6.7%(2)
4 year	13.3%(4)	16.7%(5)	10.0%(3)	13.3%(4)
5 year	13.3%(4)	16.7%(5)	10.0%(3)	3.3%(1)
6 year	6.7%(2)	10.0%(3)	3.3%(1)	10.0%(3)
7 year	10.0%(3)	13.3%(4)	6.7%(2)	3.3%(1)
>7 year	6.7%(2)	3.3%(1)	20.0%(6)	16.7%(5)

TABLE 8.--Comparisons of age frequencies of 21 specimens aged twice by each reader. ( ) = number in age group [from Table 6].

Age group	Kasuya		Miyazaki		Gosho		Wolman	
	1985	1984	1985	1984	1985	1984	1985	1984
1 year	23.8% (5)	23.8% (5)	4.8% (1)	-	14.3% (3)	-	4.8% (1)	4.8% (1)
2 year	23.8% (5)	14.3% (3)	28.6% (6)	9.5% (2)	23.8% (5)	4.8% (1)	9.5% (2)	14.3% (3)
3 year	19.0% (4)	19.0% (4)	23.8% (5)	9.5% (2)	19.0% (4)	38.1% (8)	28.6% (6)	19.0% (4)
4 year	4.8% (1)	28.6% (6)	28.6% (6)	23.8% (5)	23.8% (5)	23.8% (5)	14.3% (3)	9.5% (2)
5 year	19.0% (4)	14.3% (3)	14.3% (3)	33.3% (7)	19.0% (4)	28.6% (6)	23.8% (5)	23.8% (5)
6 year	4.8% (1)	-	-	19.0% (4)	-	4.8% (1)	14.3% (3)	19.0% (4)
7 year	4.8% (1)	-	-	-	-	-	4.8% (1)	4.8% (1)
8 year	-	-	-	-	-	-	-	4.8% (1)
9 year	-	-	-	4.8% (1)	-	-	-	-
Average Age:	3.05	2.95	3.19	4.67	3.10	3.91	4.05	4.33
Difference:	+0.10 year		-1.48 year		-0.81 year		-0.28 year	

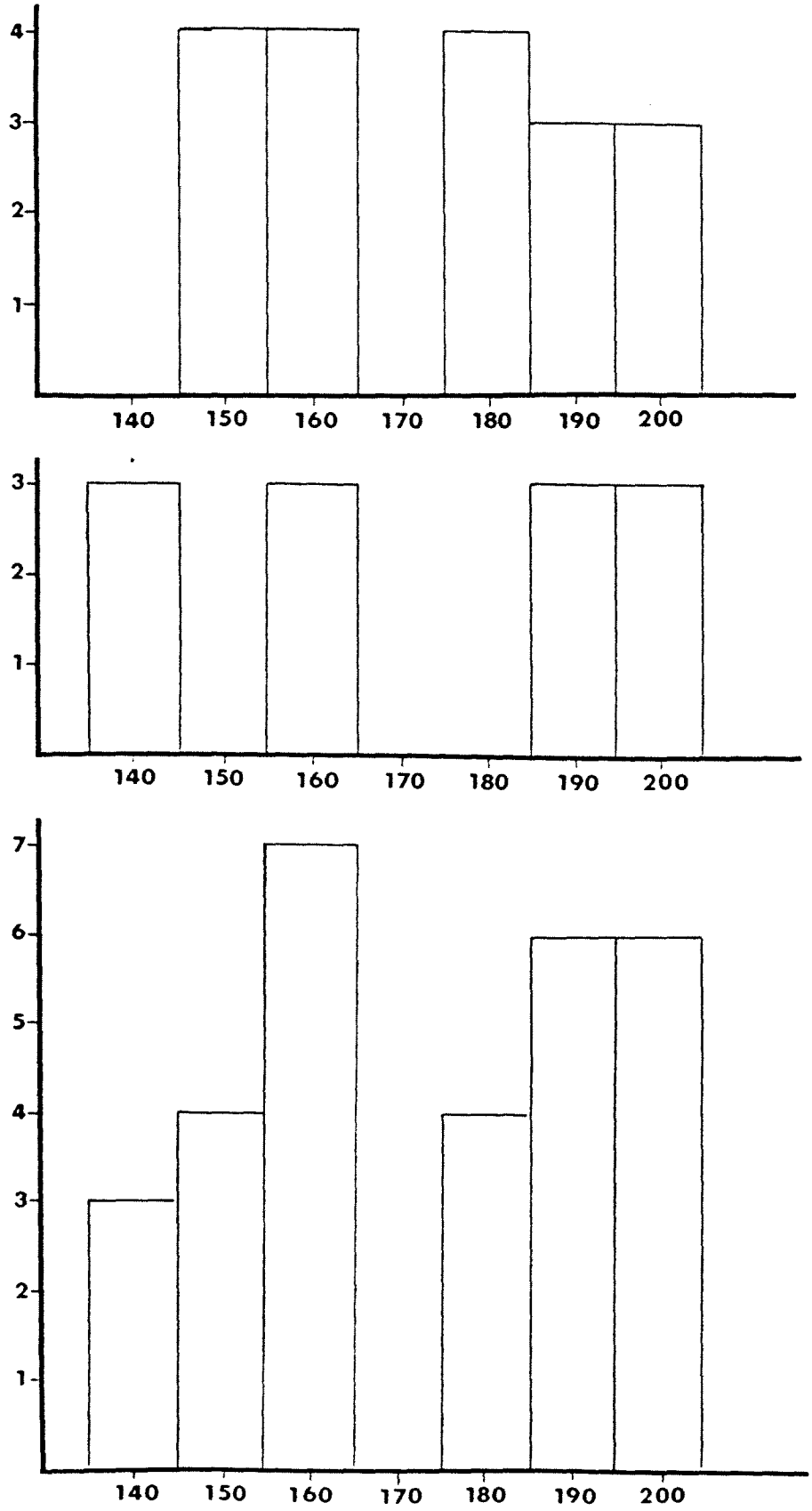

FIGURE 1: Length Frequency Histograms for Specimens Examined at the Workshop. Upper figure: Females (n=18); center: males (n=12); lower: all animals (n=30).

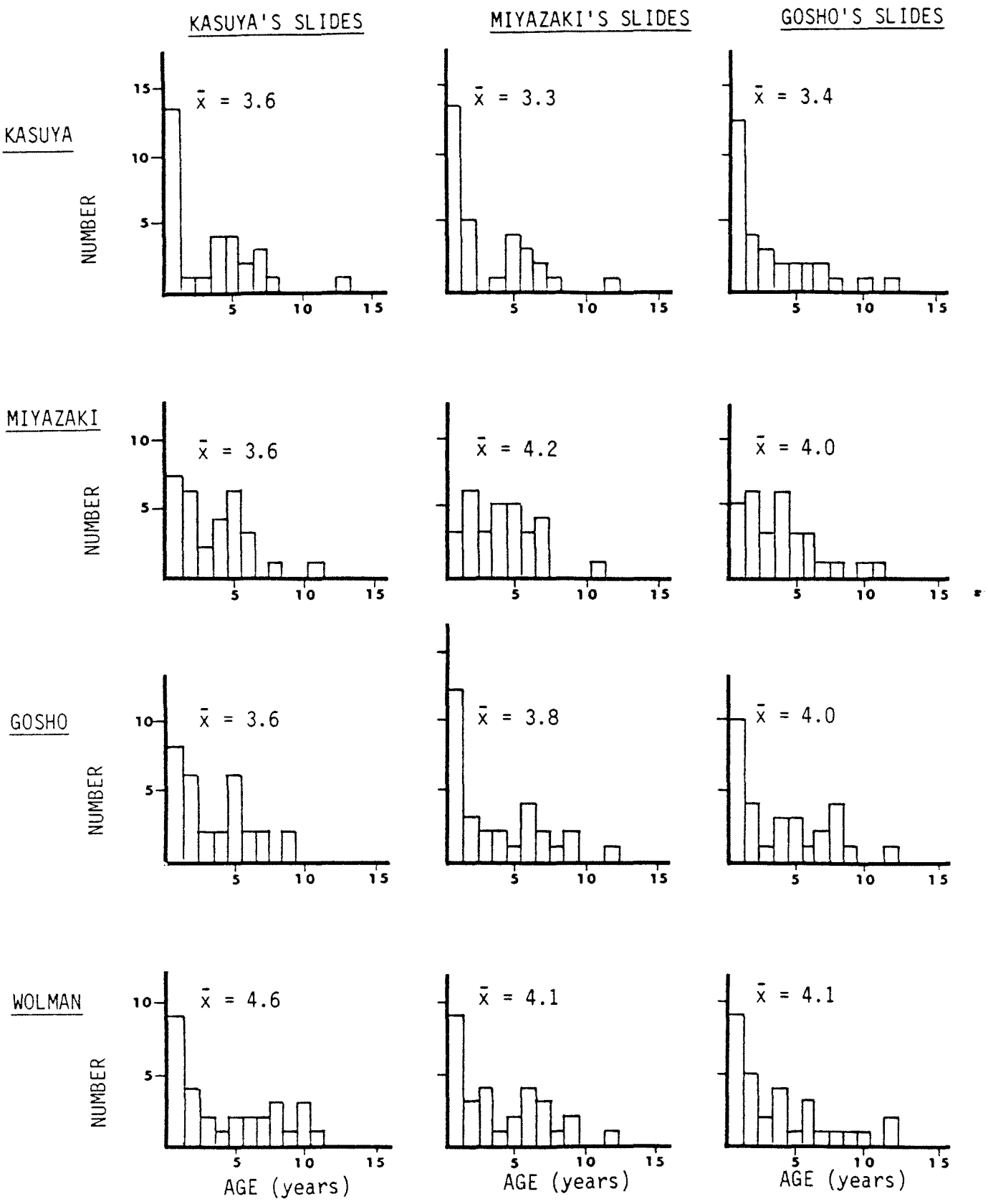

FIGURE 2. Comparison of age composition by reader by slide set (30 slides per set).

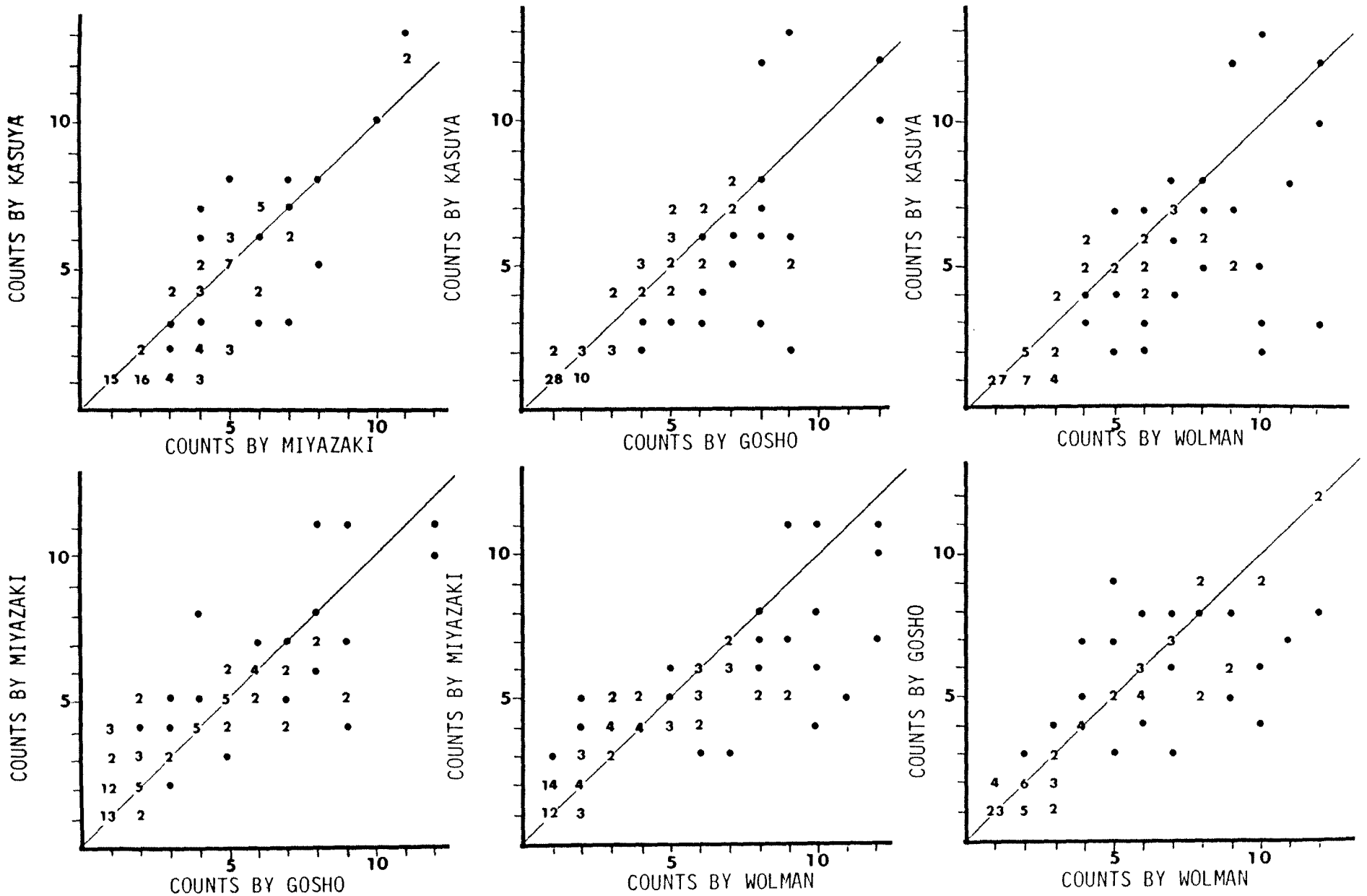

FIGURE 3. Scatter Plots of Age Determinations by Two Readers for All Methods of Preparation (n = 90).