REPORT OF 3rd WORKSHOP ON EUROPEAN HAKE AGE READING

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Abstract

A series of workshops and exchanges have been conducted in the last years in order to increase the precision of age estimation of European hake (1997, 1999, 2001, 2003). The last exchange in 2003 was undertaken mainly due to uncertainty in age estimation of older fish. In 2002 the ICES Working Group on Hake, Monk and Megrim (WGHMM) had shown difficulties in the assessment of hake stocks because of older ages primarily. This has led the WGHMM to continue to use a 8+ group. To address these problems a hake otolith exchange programme focused mainly on older fish was recommended between readers and subsequently an international workshop to discuss the results. Ages were estimated using internationally agreed ageing criteria, which have not been validated. The results of the 2003 otolith exchange programme indicate that the precision of age readings has decreased compared with the precision of the 2001 exchange and a strong bias has been found in estimates of older fish. The overall Average Percent of Error (APE) and coefficient of variation (CV) obtained in 2003 were 35 and 48% respectively while those obtained in 2001 were 19 and 25%, respectively. This loss of precision highlights the problems associated with applying ageing criteria, which are not validated. A second reading of a subset of the otolith collection used in the 2003 was done during the 2004 workshop. The results indicate that ageing fish older than 3 years is not possible with an acceptable level of precision. In addition, recent results from mark-recapture experiments have provided evidence that ages estimated using the internationally agreed criteria are overestimated (De Pontual *et al*., 2003). Taking into account the two aspects referred, the used of age readings data in stock assessment can introduce high uncertainty. Therefore, the workshop recommends to interrupt the supply of age reading data to elaborate Age Length Keys (ALK) for the WGHMM until validated ageing criteria become available.

Key words: Ageing, Hake, Otolith exchange, Workshop
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Contents

1. Introduction

A series of workshops and exchanges have been conducted in the last years in order to increase the precision of age estimation of European hake (1997, 1999, 2001, 2003). The ICES Working Group on the Assessment of Southern Stocks of Hake, Monk and Megrim (WGHMM) showed in 2002 the sensitivity of the XSA model to the age span of the Northern stock of hake. Although the WGHMM applies an 8+ age group, an exercise showed that the XSA model worked better with a 10+ age group (Appendix A - ICES, 2003). However the experts in growth of hake warned that the quality of age estimates of older age groups is poor and they considered impossible to provide age estimates of fish older than 5 years with relative confidence (Piñeiro and Saínza, 2002, WD to the WGHMM). The WGHMM recommended to tackle these problems through a hake otolith exchange programme focusing on older fish followed by an international workshop to discuss the results.

In March 2003 the Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) in Rome, agreed to organize this Workshop in 2004 with the following terms of references (TOR's):

- Check the precision and relative bias in age reading, mainly of older fish, of age readers involved in stock assessment
- Try to establish ageing criteria for old fish
- Incorporate new readers in hake age estimation

As it was mentioned above, the last exchange was conducted in 2003 (Annex 1). In the present workshop two main analyses were undertaken:

- Comparison between the results of the 2003 and the 2001 exchange programmes;
- Comparison of the results of the age reading exercises conducted in the 2003 exchange programme and in the workshop.

The Agenda of the workshop is included in Annex 2. The meeting was partially funded by the EC No 1543/2000 within the framework of "National Data Collection and Management Programme".

Validation studies on age estimation for North East Atlantic hake have not been accomplished until very recently. Therefore, until now attention of researchers and otolith readers has been devoted to improving precision and to developing internationally agreed ageing criteria for the species (see description of criteria in Piñeiro and Saínza, 2003). Recent results from tagging experiments have strongly suggested that those criteria may not be accurate and that they may lead to overestimation of ages (De Pontual *et al*., 2003).

1.1. Terms of References

Recent advances in age and growth estimation from tagging experiments, daily growth

studies and subsequent questions regarding the reliability of Age Length Keys (ALK's) made necessary to change the TOR's of the workshop as follows:

- Discuss the results of the 4th otolith exchange programme conducted in 2003;
- Discuss new information regarding:
  - Age and growth estimation (tag-recapture and otolith microstructure)
  - Alternative methods to obtain ALK's for assessment purposes as for example the elaboration of synthetics ALK
- Check the precision and bias of age readers involved in stock assessment
- Discuss age reading criteria and problems found for young and/or old fish
- Incorporate new readers in hake age estimation

1.2. Participants

The workshop met in Vigo from 18-22 October 2004 with the following participants:

Name	Institution	Country	Reader ID	Degree of Experience
M. Saínza	IEO	Spain	R 1	Expert reader – ALK for WGHMM
M. H. Afonso	IPIMAR	Portugal	R 2	Expert reader– ALK for WGHMM
C. Piñeiro	IEO	Spain	R 3	Most expert reader– ALK for WGHMM
J. Labastie	IFREMER	France	R 4	Most expert reader– ALK for WGHMM
S. Warnes	CEFAS	England	R 6	Reader with limited experience
M. Easey	CEFAS	England	R 7	New reader
S. Hoey	MI	Ireland	R 9	New reader
S. Beattie	MI	Ireland	R 10	New reader
C. Morgado	IPIMAR	Portugal	R11	Expert reader – ALK for WGHMM
M. Marín	IEO	Spain	R 12	Expert reader – ALK for WGHMM
S. Dores	IPIMAR	Portugal	R 13	New reader
A. Maceira	AZTI	Spain	R 14	New reader

All of the above otolith readers participated in the 2003 hake otolith exchange except A. Maceira (R14) who also read the otolith collection outside the exchange period and replaced S. Arego (R5 of the 2003 exchange) during the workshop.

Other participants:

Name	**Reader**	**Institution**	**Country**
B. Maertens	R 15	DVZ	Belgium
P. Lucio		AZTI	Spain
F. Hansen		DIFRES	Denmark
J. Rey		IEO	Spain
J.L. Pérez		IEO	Spain
A. Latrouite		IFREMER	France
H. De Pontual		IFREMER	France

2. Material and Methods

2.1. Methodology used

The workshop was carried out following the recommendations of the EFAN (European Fish Ageing Network) Report 3-2000 on Guidelines and Tools for Age Reading Comparisons (Eltink *et al*., 2000).

The criteria adopted for ageing the exchange collection are described in reports of previous exchanges (Piñeiro, 2000 and Piñeiro, *et al.,* 2000; Piñeiro, and Saínza. 2002).

A summary of statistical indexes and tests that are available in the literature for determining the degree of agreement between readings (Campana, 2001; Morales Nin and Panfili, 2002) were used for analysing consistency bias. One of the simplest methods is to compare the results of several readings from one or several readers for the same calcified structure (CS).

The Percentage of readings agreement (PA) is the ratio between the number of coincident readings and the total number of readings (in percentage). However, PA depends on the lifespan of the species. Therefore, Beamish and Fournier (1981) recommended the use of average percent error (APE), which is an index of reading precision useful for comparing series of observations defined as:

$$APE = 100\% \times \frac{1}{R} \sum_{i=1}^{R} \frac{\left| X_{ij} - \overline{X_j} \right|}{\overline{X_j}}$$

Where X_{ij} is the i^{th} reader age estimation of the j^{th} fish, $\overline{X_j}$ is the mean age of the j^{th} fish, and R is the number of times each fish is aged (reader). When averaged across many fish, it becomes an index of mean APE.

Chang (1982) suggested incorporating the standard deviation in the previous equation rather than the absolute deviation from the mean age. The resulting equation produces an estimate of the Coefficient of variation (CV), and does not assume that the standard deviation is proportional to the mean:

$$CV = 100\% \times \frac{\sqrt{\sum_{i=1}^{R} \frac{\left(X_{ij} - \overline{X_j} \right)^2}{R-1}}}{\overline{X_j}}$$

Where CV can be averaged across a number of fish to produce a mean CV that is statistically more robust than APE and more flexible. There is no CV threshold value for accepting or rejecting the readings, because it depends on the species and the range of ages. Laine *et al*. (1991) suggested a maximum CV value of 5% as the limit for acceptable readings. It should be remembered that the CV is very sensitive to low age

values.

The exchange and the workshop analyses of the age reading results were performed using an Excel ad-hoc Workbook "AGE COMPARATIONS. XLS" from A.T.G.W. Eltink from RIVO. This methodology assumed a reference age for comparison. Since there are no validated ages available, the reference age assumed is the modal from readers that provide ALK's for stock assessment (R1, R2, R3, R4, R5, R11 and R12). In case of bi-modality, the modal age was estimated based on the most expert readers (R3 and R4).

Box-whisker plots were used for the graphical representation of the sample by each reader (median and interquartile range by each reader). This kind of representation is useful to summarise the observations and to compare the distribution of the otolith readings by reader [1].

Age bias plots show both types of age reading errors (affecting precision and accuracy) whenever otoliths of a known age are available. In this case the bias in age reading can only assess the precision.

To identify of the first three annual rings and the check, each reader measured the radius of each ring. These data also allow verifying if readers count the same rings as in the exchange. The ring measurements were analysed using box-whisker plots by age and reader (median and interquartile range).

2.2. Analysis of age readings

In order to make comparisons between readers, readers were split into three groups according to their level of experience: Most expert readers (R3 and R4), readers who provided ALK for WGHMM called as "ALK's readers" (R1, R2, R3, R4, R5, R11, and R12) and all readers (See Annex 3).

2.2.1. Comparison between 2001 and 2003 exchanges

In order to see problems arisen and evaluate tendencies of individual readers, the last two exchanges (2001 and 2003) were compared. However, as they could not be compared directly because they used different samples[2] and the 2003 exchange had focused on old fish, the comparative analysis was done excluding individuals greater than 60 cm total length (TL).

2.2.2. Comparison between 2003 exchange and workshop readings (first and second reading)

To analyse the main problems found in the exchange, an age reading exercise was

[1] *The center line within the box gives the median of the distribution of averaged data. The upper and lower sides of the box give the 25 and 75 percentiles, respectively. The ends of the whisker give the 5 and 95 percentiles, respectively. There are data that fall well outside to the range which are called outliers*

[2] *The loss of the otoliths exchange collection of 2001 at the end of this exchange programme made impossible to use these otoliths for any comparison purposes.*

undertaken during the workshop. Since ageing is time consuming, a subset of 70 otoliths was selected according to their high/low agreement (corresponding to young/old fish) from the 2003 exchange collection (Figure 1). This collection, called "second reading" was read by all participants that read the 2003 exchange collection. Some of the new participant readers also performed this age reading exercise. However, they used microscopes and/or the otolith images, due to time constraints and microscopes available.

A summary of standard ageing criteria with images of the interpreted otoliths was provided to all participants in the exchange protocol in order to facilitate the standardisation of the ageing method (Annex 4). Reader R6 used the standard criteria in the exchange, described in the exchange protocol, whereas he used CEFAS method for the second reading. Reader R7 used the CEFAS method for both readings. According to CEFAS method otoliths are examined using approximately 6-15X magnifications, and transmitted light is the preferred light source, although sections are viewed using both lighting methods. No pre-set interpretation of check rings in the first two years is taken into account.

All workshop collection

The two reading exercises (2003 exchange and workshop) were compared based on the same 70 otoliths. The age reading from the exchange of these 70 otoliths is known as "first reading". Reader R5 who participated in the 2003 exchange but not in the workshop was removed from this comparison.

Individuals smaller than 60 cm from workshop collection

Due to the difficulties associated with age interpretation of older fish, another analysis was performed on individuals under 60 cm of length belonged to the subset sample, (n=44).

2.3. Other discussions undertaken at the workshop

The results of the analysis of the exchange conducted in 2003 were presented by the coordinator (Annex 5) and were discussed by all participants that read the exchange collection. Other contributions were also presented in light of new advances, such as recent results of tagging experiments (Annex 6), daily growth studies (Annex 7) and elaboration synthetic ALK's (Annex 8). A discussion of the problems found followed the presentation of the exchange and the major concern was ageing older fish

Also, a group discussion with images of the otoliths collection and the individual interpretation of every reader was conducted among readers using a projection screen connected to an Image Analysis System (TNPC), whilst the analysis of the second reading results was performed. The classification of the otolith edge type (opaque or translucent) was also undertaken during the discussion.

3. Results and Discussion:

3.1. Comparison between the two last exchanges (2001 and 2003)

The comparison between readings from 2003 (n=127) and 2001 (n=187) exchanges for individual under 60 cm of length shows that the agreement dropped from 72 to 60 % while the APE increased from 19 to 35 % and the CV nearly doubled from 25% to 48% (Table 1). These results are for experienced readers that provide ages for stock assessment (ALK's readers).

The increase of APE and CV from 2001 to 2003 exchanges indicates that precision of age estimation has significantly decreased between both exchanges. This could be explained by reader-drifts from the standard ageing protocol over time. Most expert readers (R3 and R4) were probably confused by recent results on hake age estimation problems highlighted from results of the tagging-recapture experiments. They were involved in the interpretation of marked otolith from recoveries.

3.2. Comparison between 2003 exchange and workshop readings (first and second reading)

All workshop collection

The results of the first and second reading (70 otoliths) by reader, modal age and percentage of agreement are shown in the Table 2. The box-whisker plots for all readers are presented in Figure 2. The results for the first and second readings show that the mean age was similar being 4.4 and 4.0 years old, respectively. However the majority of readers tend slightly to give lower ages in second reading with exception of readers R2, R4 and R11 who tend to give higher ages. It should be noted that R6 did not use the standard criteria for his second reading.

The box whisker plots for the first three rings and check distances measurement indicated that all readers that performed ring measurements (IFREMER, IEO, AZTI and IPIMAR) can clearly distinguish these rings and similar median distances for these rings are obtained (Figure 3). This pointed out that the ageing criteria for these first three rings are adopted by these readers. However it is important to note that the precision of R2 on ring measurements does not reflect the individual growth variability, due to the extended spawning season characteristic of this species.

The age bias plots by each reader, and all readers combined for the first reading show that a higher agreement is reached up to and including age 3, for the majority of readers. Fish older than 3 years showed a higher level of variability in the ages assigned by readers. This is evident in the age bias plot of all readers combined (Figure 4a). Readers R2, R4, and R7 tend to underestimate all ages above age 2 and R9, R11 and R13 tend to underestimate ages above 5. However, Reader R1, R3 and R12 tend to overestimate ages older than 4. Reader R6 tends to overestimate ages 5 and 6 and underestimates above 7.

In the second reading the amplitude of confidence intervals decreased in general for all readers and the ages assigned were lower. Readers R4, R9 and R10 tend again to underestimate ages above 3. Readers R6 and R7 tend to underestimate all ages. It was noted that Reader R6 showed inconsistency in the ageing criteria employed. All readers combined tend to underestimates the ages above 3 (Figure 4 b).

The classification of the otolith edge type (opaque or translucent) was also discussed and main confusion was caused by the frequent occurrence of a translucent edge through the whole year in young fish. In terms of ageing, the major consensus was reached in those individuals captured in first quarter.

Considering the incorporation of new readers at the workshop, Reader R14 tends to over estimate ages up to 8 and underestimated older ages. Reader R15 shows a high variability in ages younger than 5 years and tends to underestimate older fish (Figure 5). These bias plots by reader and all readers combined show the difficulty to recognise the ageing criteria established and reflect the importance of training in otolith age reading.

When the results of the second reading were compared with the first age readings using both, the APE and the mean CV (Table 3) for the same subset of otoliths, it can be seen that both indexes have improved in all the groupings, except for all readers, due to the presence of new readers having none or very little experience.

Figure 6, shows the CV, and percent agreement plotted against the modal age for the subset of 70 otolith in both readings. The average CV was higher for age 1 due to the age value effect of age magnitudes in the calculation of CV already mentioned in the previous section. The average of CV obtained was 32% in the first reading. The agreement is highest up to and including age 3 and afterwards decreased as the age increased up to age 8, being the mean value 42%. In the second reading the value of agreement increased slightly but the CV maintained the same value up to age 8.

The inter-reader bias test (Wilcoxson's test) results for the second reading are given in Table 4. In general, the comparison indicates that there is a significant bias among all readers, except for IPIMAR and IEO readers, who have shown 'no' or 'a possibility' sign of bias between them.

As the second reading was based on otoliths selected according to their high/low agreement (young/old fishes) of the exchange, the number of otoliths from age range 4-6 is not well represented and the precision of these ages cannot be assessed.

Individuals smaller than 60 cm from workshop collection

Considering the analysis of the individuals under 60 cm of length, from the subset sample (n=44) (Table 5), the APE and mean CV values hardly showed any improvement for the three groups of readers.

In summary the increase of CV observed from 2001 to 2003 exchanges shows the actual low of precision for ageing fish older than three years old (model age, not true age). Furthermore, recent advances in age validation indicate the ageing criteria are also inaccurate.

4. Conclusions:

1. The precision of age estimation has decreased from 25 to 48% between the last two exchanges for the same length range.

2. No agreed criteria was establish for older fish, taking into account the low precision obtained for those lengths.

3. The results indicated that it is difficult to maintain precision for fish older than 3 years (model age, not true age). Therefore, using age reading data in stock assessment may introduce high uncertainty.

4. The confident age range dropped from 5 to 3 years old, from 2001 to 2003, as a consequence of hake ageing difficulty with a non validated ageing criteria.

5. At the moment there is a need for research to provide a new interpretation scheme of the otolith structures based on reliable quantities of data. Such needs will be achieved through an appropriate set of reference material provided by tagging material.

6. The studies on hake growth presented at the workshop indicate that the actual ageing criteria are not accurate.

5. Recommendations:

1. Plan an "ad hoc" meeting with the ICES WGHMM chairman, the coordinators of WG Northern and Southern stocks, the National coordinators of Hake fishery monitoring, the chairperson of the present Hake Age Reading Workshop and the people responsible for the tagging experiments surveys. The main objective of the meeting will be to present the results and conclusions of this Workshop and to decide what to do in relation to the ALKs to be provided to ICES WGHMM in the forthcoming years (2005 onwards).

2. Validation studies should be carried out. It is not possible to go further in hake ageing studies without progress in validation. Tagging is a very promising method for validating hake ageing, taking into account the recapture rate obtained in recent studies (De Pontual *et al*., 2003).

3. Interrupt the supply of age reading data to elaborate ALK for the WGHMM until new validated/accurate criteria is available.

4. In the meantime, allocate the effort (time and people) employed until now in the reading of otoliths to other tasks, such as:

    - Tagging surveys, financed by the National Data Collection and Management Programs, to provide reference material which is essential to build accurate age criteria used to provide reliable ALK:

- Create Data base: otoliths images, weight and other complementary biological information
- Otolith microstructure studies (daily growth, etc.)
- Length distribution analysis on surveys and commercial catches available
- Research studies to understand the macrostructure pattern to establish the typology of the rings (annual rings and checks)

5. Proceed with the data and otolith collection for future work.

Finally, the WS notes that these recommendations represent a turning point in the stock assessment of this species. Considering the age reading results obtained in this workshop and the recent advances on hake age validation (tagging and recapture experiments, daily growth) it is necessary to avoid consuming time when obtaining age data without assurance. The scientists involved in stock assessment should be aware of the quality of the age data because managers often use their biological advice to set Total Allowable Catches.

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Table 1.- Agreement (%), CV and APE values of otoliths reading from individuals under 60 cm in the 2001 and 2003 Exchanges.

	otoliths < 60 cm	
	EXCHANGE 2001	EXCHANGE 2003
n	187	127
% Agreement	72	60
CV	25	48
APE	19	35
Readers	R1, R2, R3, R4, R5, R6, R11, R12	

Table 2.- Results of the age readings of First (FR) and Second readings (SR) (Subset of 70 otoliths)

Fish n°	R1 (IEO)		R2 (IPIMAR)		R3 (IEO)		R4 (IFREMER)		R6 (CEFAS)		R7 (CEFAS)		R9 (MI)		R10 (MI)		R11 (IPIMAR)		R12 (IEO)		R13 (IPIMAR)		Modal age		% Agreement	
	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR	FR	SR
395	3	3	2	2	4	3	2	3	4	3	2	2	3	2	3	2	3	3	4	3	5	3	3	3	33%	54%
513	6	4	3	5	6	7	4	5	9	2	3	3	4	3	4	3	3	4	6	6	4	4	4	4	33%	15%
794	4	3	4	4	4	3	3	3	3	4	3	3	4	3	5	3	4	5	4	4	4	4	3	3	25%	46%
816	5	3	3	4	5	4	3	5	9	2	2	2	4	3	4	3	3	3	5	4	4	3	3	3	25%	23%
973	4	4	2	3	4	4	3	4	4	2	3	3	4	2	4	4	2	3	4	4	3	4	4	4	50%	46%
545	6	5	3	4	6	4	4	5	6	3	3	3	4	3	4	4	3	3	7	5	3	3	3	3	33%	23%
257	6	6	4	5	5	6	4	4	8	2	3	3	5	4	5	-	5	5	7	6	4	5	6	6	8%	25%
618	6	5	4	4	6	5	3	4	8	3	1	1	4	4	5	4	3	4	6	6	4	4	4	4	25%	15%
265	6	6	4	5	7	5	4	5	9	3	2	2	5	5	5	5	4	5	8	7	4	5	5	5	17%	62%
117	7	7	5	6	7	7	4	6	10	2	3	3	6	5	6	5	5	7	9	9	5	5	7	7	17%	31%
10401	6	6	5	6	8	5	5	4	8	3	2	2	5	4	6	5	5	7	7	7	5	5	5	5	42%	15%
629	7	5	4	5	5	5	3	5	8	1	2	2	6	5	6	6	5	6	7	5	6	5	5	5	17%	54%
662	7	5	5	6	7	7	4	4	6	2	2	2	6	5	5	6	5	6	7	-	5	6	6	6	17%	17%
29	7	6	5	7	11	8	4	5	7	4	3	3	6	7	7	6	5	7	7	7	4	6	7	7	42%	38%
33	9	5	4	6	9	7	4	4	7	3	3	3	6	5	5	4	5	6	9	7	4	5	5	5	17%	23%
1108	9	6	6	8	13	7	4	5	9	2	2	2	6	5	8	-	5	8	8	7	7	7	7	7	17%	33%
634	9	7	5	7	9	7	3	6	6	3	2	2	6	6	7	7	5	-	9	8	6	6	7	7	17%	42%
373	7	7	3	5	8	7	4	6	5	2	2	2	5	4	6	5	4	-	8	8	7	5	7	7	25%	25%
1117	9	6	5	6	10	7	3	5	6	2	2	2	6	4	6	7	6	6	10	8	4	6	6	6	33%	33%
30400	7	5	4	5	8	8	4	5	6	4	2	2	5	4	7	6	5	5	8	8	5	6	5	5	25%	31%
322	7	7	6	7	9	9	5	5	6	3	2	2	6	6	7	6	6	7	9	8	6	7	7	7	17%	31%
27-01	9	6	5	7	9	7	5	6	5	3	2	2	6	5	7	6	7	6	8	8	6	5	6	6	17%	31%
30153	6	6	4	5	9	9	4	4	6	2	3	3	5	3	7	5	4	6	7	7	5	5	6	6	17%	23%
1200	9	7	7	8	8	7	5	6	5	2	2	2	6	4	8	5	7	7	7	7	7	7	7	7	42%	46%
1197	6	6	6	6	7	7	4	5	6	3	3	3	6	5	7	4	6	6	8	6	8	7	6	6	42%	31%
1078	8	6	6	6	7	7	5	5	5	3	3	3	6	5	7	5	6	7	12	8	5	6	6	6	25%	23%
459	9	8	6	7	11	10	6	5	7	3	2	2	5	6	8	7	6	7	12	7	7	7	7	7	25%	46%
1127	7	6	4	6	9	8	6	5	6	3	2	2	4	4	7	6	5	7	8	8	5	7	6	6	17%	23%
852	7	7	7	8	9	8	5	6	6	4	2	2	7	7	7	7	7	7	7	7	7	7	7	7	58%	23%
782	10	7	7	8	10	9	5	5	6	4	3	3	6	6	8	6	8	8	11	10	7	8	8	8	25%	31%
845	9	8	9	9	9	8	6	7	6	3	3	3	6	7	9	6	10	10	9	8	9	8	8	8	0%	31%
1544	9	7	7	8	7	8	6	8	7	3	4	4	7	5	8	6	8	7	8	7	7	9	8	8	33%	31%
1165	10	8	9	10	12	10	7	8	7	4	5	5	7	7	10	7	9	9	10	10	8	9	8	8	17%	23%
493	10	7	7	8	11	13	7	8	7	5	6	6	7	5	10	6	7	8	13	11	6	8	8	8	8%	38%
1550	8	8	7	9	10	11	7	6	6	5	8	8	7	6	9	-	7	7	11	9	7	8	8	8	25%	25%
10066	11	10	9	10	12	14	7	8	7	5	6	6	6	8	9	7	9	11	15	10	8	10	10	10	0%	31%
1533	9	9	7	8	8	8	7	9	7	3	7	7	6	5	9	6	7	8	10	7	6	8	8	8	8%	15%
45	14	12	11	12	15	15	8	11	8	6	-	-	8	9	9	8	11	10	14	12	9	9	12	12	0%	23%
156	-	-	7	-	10	12	8	8	-	-	-	-	-	5	7	7	8	-	12	12	7	-	12	12	13%	29%
3158	1	1	1	1	1	1	1	1	2	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	75%	85%
52	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	83%	85%
138	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	83%	85%
132	1	1	1	1	1	1	1	1	2	0	1	1	1	1	1	1	1	2	1	1	1	1	1	1	83%	69%
11	1	1	0	0	0	0	1	0	2	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	50%	46%
287	1	1	1	1	1	1	1	0	3	0	1	1	1	1	1	1	2	2	1	1	1	1	1	1	75%	62%
191	2	2	2	2	2	1	2	2	3	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	75%	62%
1765	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	83%	77%
253	2	2	1	2	2	2	1	2	5	1	1	1	1	2	2	2	2	2	3	2	1	1	2	2	33%	69%
64	2	2	2	2	2	2	2	2	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	83%	69%
10208	2	2	2	2	2	1	2	1	2	1	1	1	2	1	2	2	2	2	2	2	2	2	2	2	83%	54%
88-01	2	2	2	2	2	2	2	2	3	1	2	2	2	2	2	2	2	3	3	3	2	2	2	2	75%	62%
798	2	2	2	2	2	2	2	1	3	1	2	2	2	2	2	2	2	2	3	-	2	2	2	2	75%	58%
523	2	2	1	2	2	1	1	1	3	1	1	1	1	2	1	2	2	2	2	2	1	2	2	2	33%	54%
734	3	2	2	2	3	2	2	2	4	0	2	2	2	2	2	3	2	3	3	3	2	2	2	2	58%	62%
93	3	3	2	2	3	2	2	2	4	1	2	2	2	3	2	3	2	3	3	3	2	3	3	3	25%	31%
68	3	3	2	2	3	2	2	3	3	1	2	2	2	2	2	3	2	3	3	3	2	2	3	3	33%	54%
87	3	3	2	2	3	2	3	2	2	1	2	2	2	2	2	2	3	3	3	3	2	2	2	2	50%	54%
48	3	2	2	2	3	2	2	2	2	1	2	2	2	2	2	2	2	2	3	2	3	2	2	2	58%	85%
801	3	3	2	2	3	2	2	2	3	1	2	2	2	2	2	2	2	2	3	3	2	3	2	2	58%	54%
104	3	3	2	2	3	2	2	2	3	1	2	2	2	2	3	2	2	3	3	3	2	2	2	2	50%	62%
1647	3	2	2	3	3	2	3	1	3	1	2	2	2	2	2	2	2	3	2	2	3	3	2	2	50%	46%
732	3	3	2	3	3	3	2	2	4	0	2	2	3	3	2	3	3	3	4	3	3	3	3	3	42%	67%
20	3	3	3	3	4	2	2	3	4	1	2	2	5	3	2	3	3	3	3	3	4	3	3	3	33%	62%
10956	3	3	3	4	4	3	3	2	3	1	2	2	5	3	2	4	4	4	4	3	4	4	3	3	33%	38%
242	3	3	3	3	3	3	2	2	2	1	2	2	4	4	2	3	3	5	3	3	4	3	3	3	42%	46%
1658	3	3	3	3	5	2	2	2	3	1	3	2	5	3	2	3	3	4	5	3	4	3	3	3	42%	46%
88-00	4	4	4	3	4	2	3	3	3	2	3	3	3	4	2	3	3	4	4	4	3	4	4	4	33%	31%
245	2	3	2	4	3	3	2	2	3	2	3	3	3	3	2	4	2	5	3	4	3	4	3	3	50%	23%
1521	4	2	3	3	3	2	2	1	3	1	2	3	5	2	1	2	3	3	4	2	3	3	2	2	17%	38%
474	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	4	4	3	3	3	3	2	2	42%	38%

Table 3.- APE and CV values for first and second readings of the subset sample (70 otoliths): All readers, ALK_readers and most expert readers (R3 and R4).

	R3&R4		ALK_READERS		All READERS	
	FR	SR	FR	SR	FR	SR
APE	22	15	20	15	24	24
CV	31	20	25	20	32	31
n	70	70	70	70	70	70

Table 4.- Inter-reader bias test by reader against modal age for the first (1) and second readings (2).

1) First Reading:

	IEO	IPIMAR	IEO	IFREMER	AZTI	CEFAS	CEFAS	MI	MI	IPIMAR	IEO	IPIMAR
	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13
Reader 1		**	**	**	*	-	**	**	**	**	**	**
Reader 2	**		**	**	**	**	**	-	**	**	**	*
Reader 3	**	**		**	-	*	**	**	**	**	-	**
Reader 4	**	**	**		**	**	**	**	**	**	**	**
Reader 5	*	**	-	**		**	**	**	**	**	-	**
Reader 6	-	**	*	**	**		**	**	-	**	**	**
Reader 7	**	**	**	**	**	**		**	**	**	**	**
Reader 9	**	-	**	**	**	**	**		*	-	**	-
Reader 10	**	**	**	**	**	-	**	*		*	**	-
Reader 11	**	**	**	**	**	**	**	-	*		**	-
Reader 12	**	**	-	**	-	**	**	**	**	**		**
Reader 13	**	*	**	**	**	**	**	-	-	-	**	
MODAL age	**	**	**	**	**	*	**	**	-	*	**	*

2) Second Reading:

	IEO	IPIMAR	IEO	IFREMER	CEFAS	CEFAS	MI	MI	IPIMAR	IEO	IPIMAR	AZTI	BART
	Reader 1	Reader 2	Reader 3	Reader 4	Reader 6	Reader 7	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	Reader 15
Reader 1		-	*	**	**	**	**	**	*	**	-	**	**
Reader 2	-		*	**	**	**	**	**	-	**	-	**	**
Reader 3	*	*		**	**	**	**	**	-	-	**	**	**
Reader 4	**	**	**		**	**	-	-	**	**	**	**	-
Reader 6	**	**	**	**		*	**	**	**	**	**	**	**
Reader 7	**	**	**	**	*		**	**	**	**	**	**	**
Reader 9	**	**	**	-	**	**		**	**	**	**	**	-
Reader 10	**	**	**	-	**	**	**		**	**	**	**	-
Reader 11	*	-	-	**	**	**	**	**		*	**	**	**
Reader 12	**	**	-	**	**	**	**	**	*		**	**	**
Reader 13	-	-	**	**	**	**	**	**	**	**		**	*
Reader 14	**	**	**	**	**	**	**	**	**	**	**		**
Reader 15	**	**	**	-	**	**	-	-	**	**	*	**	
MODAL age	-	-	**	**	**	**	**	**	**	**	-	**	*

no sign of bias ($p>0.05$) = -
possibility of bias ($0.01<p<0.05$) = *
certainty of bias ($p<0.01$) = **

Table 5.- APE and CV values of readings from individuals under 60 cm of the subset sample (70 otoliths) : All readers, ALK_readers and most expert readers (R3 and R4).

SECOND READING < 60 cm	APE	CV	n
R3&R4	11	16	44
ALK_READERS	17	22	44
All READERS	24	32	44

Figure 1- Length frequency distribution (cm) of 2003 exchange collection (blue) and the subset selected (70 otoliths) for the second reading (red).

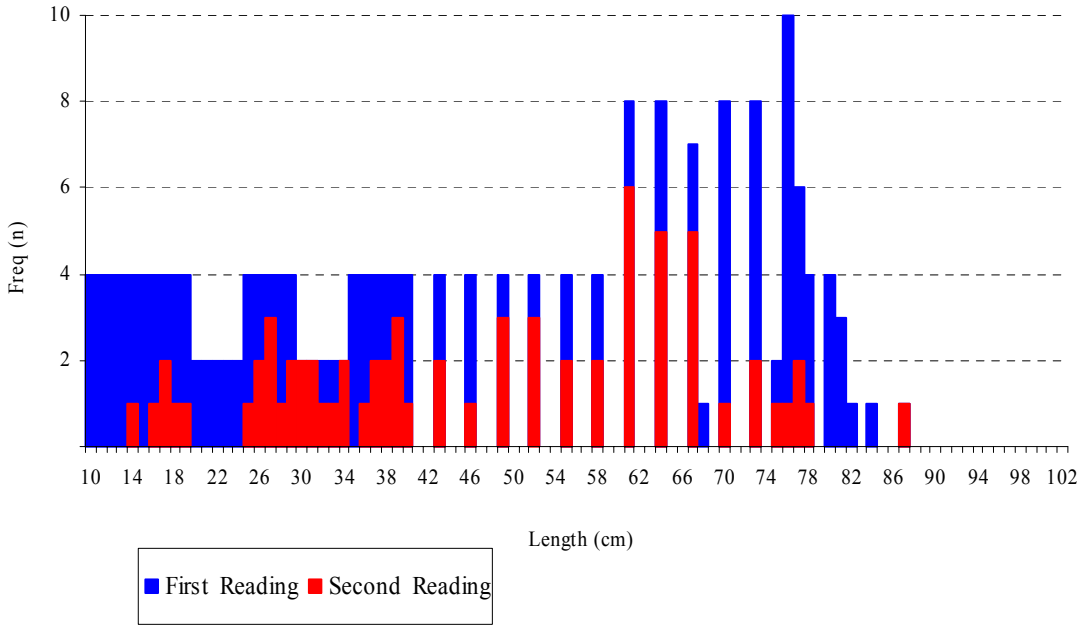


Figure 2- Box whisker plot from First and Second reading carried out by reader.

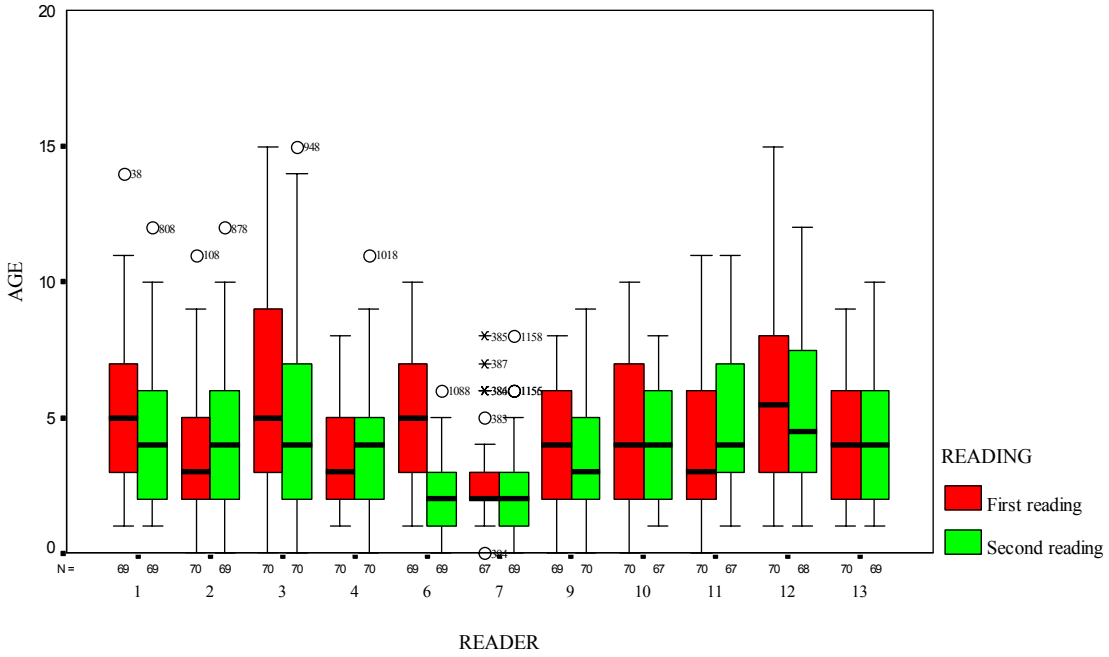
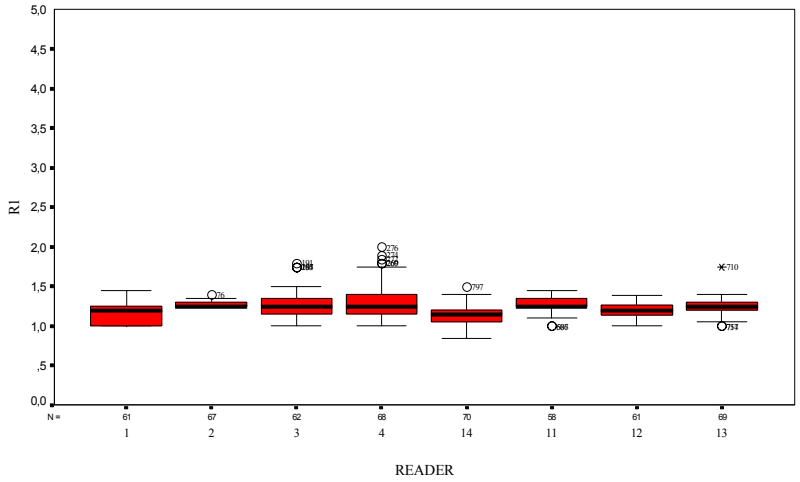
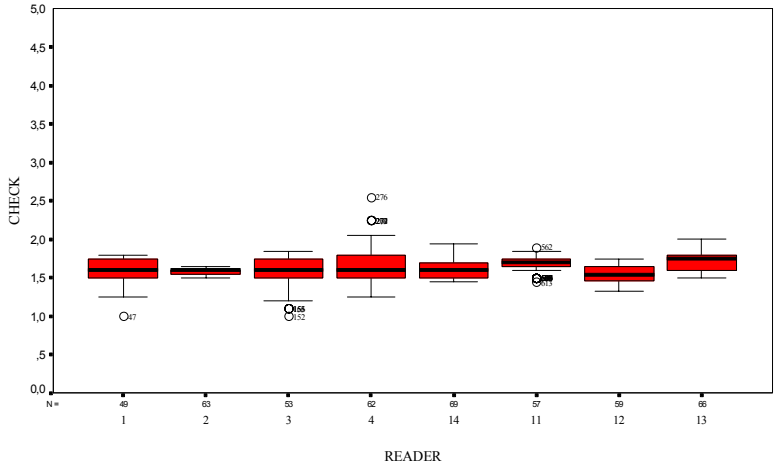
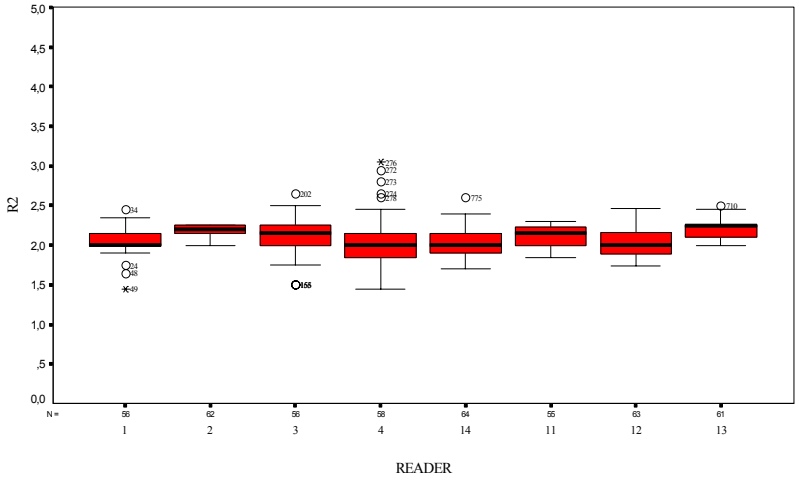


Figure 3.- Box-whisker plots of the distances measured (mm) by reader in the second reading for the following rings : R1, Check, R2 and R3.







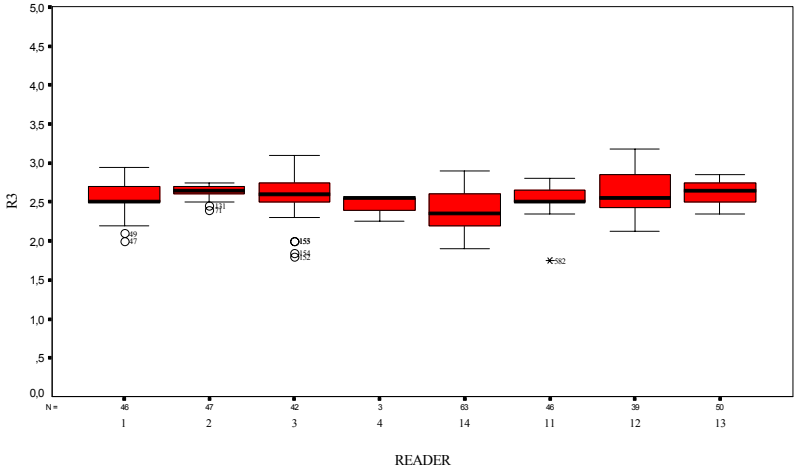
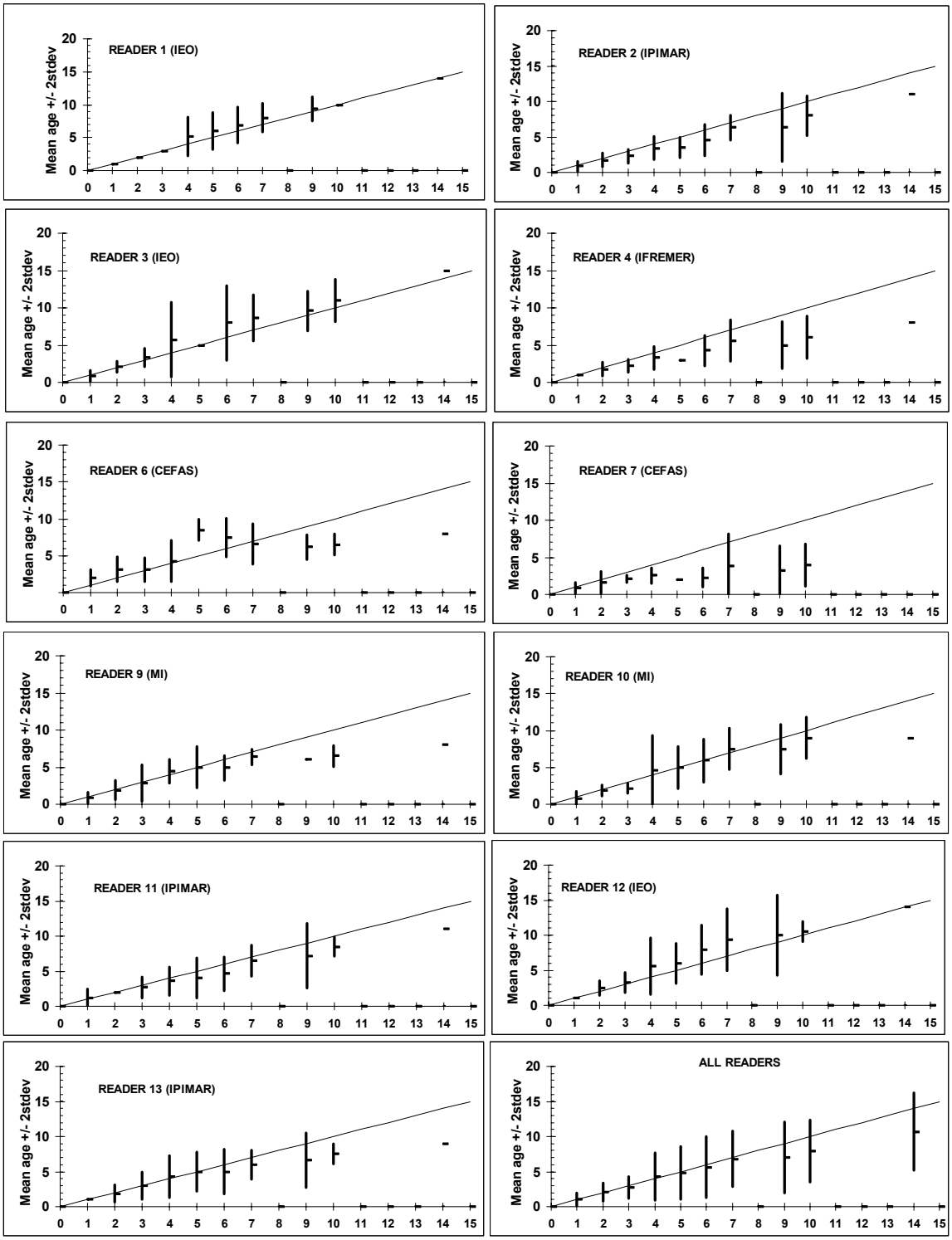


Figure 4.- Ages bias plots: Mean age recorded +/- 2stdev of each age reader in the first (a) and second reading (b) for the same readers involved in 2003 exchange and 2004 workshop. The estimated mean age corresponds to modal age.

a) First reading



b) Second reading

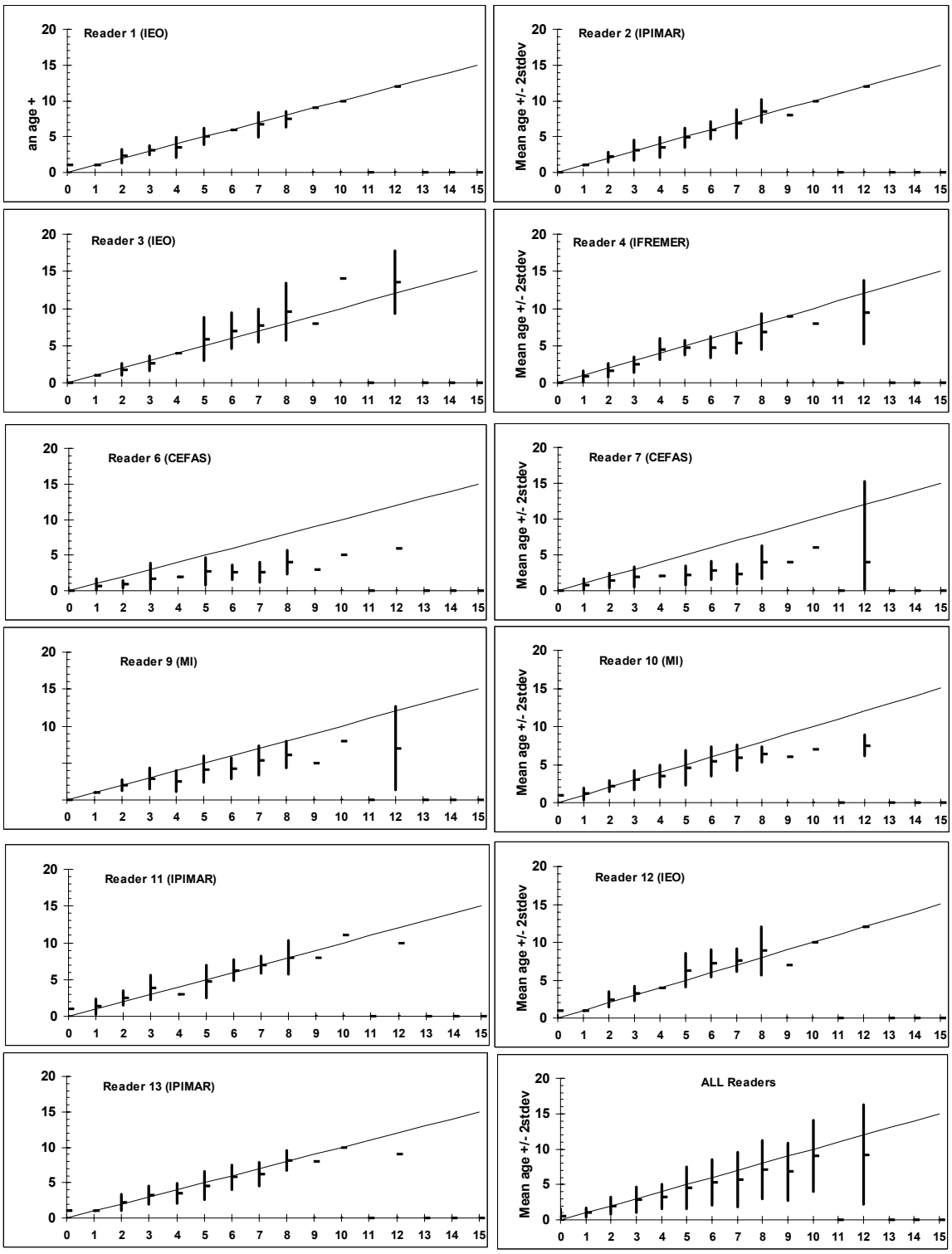


Figure 5.- Ages bias plots by reader and all readers .

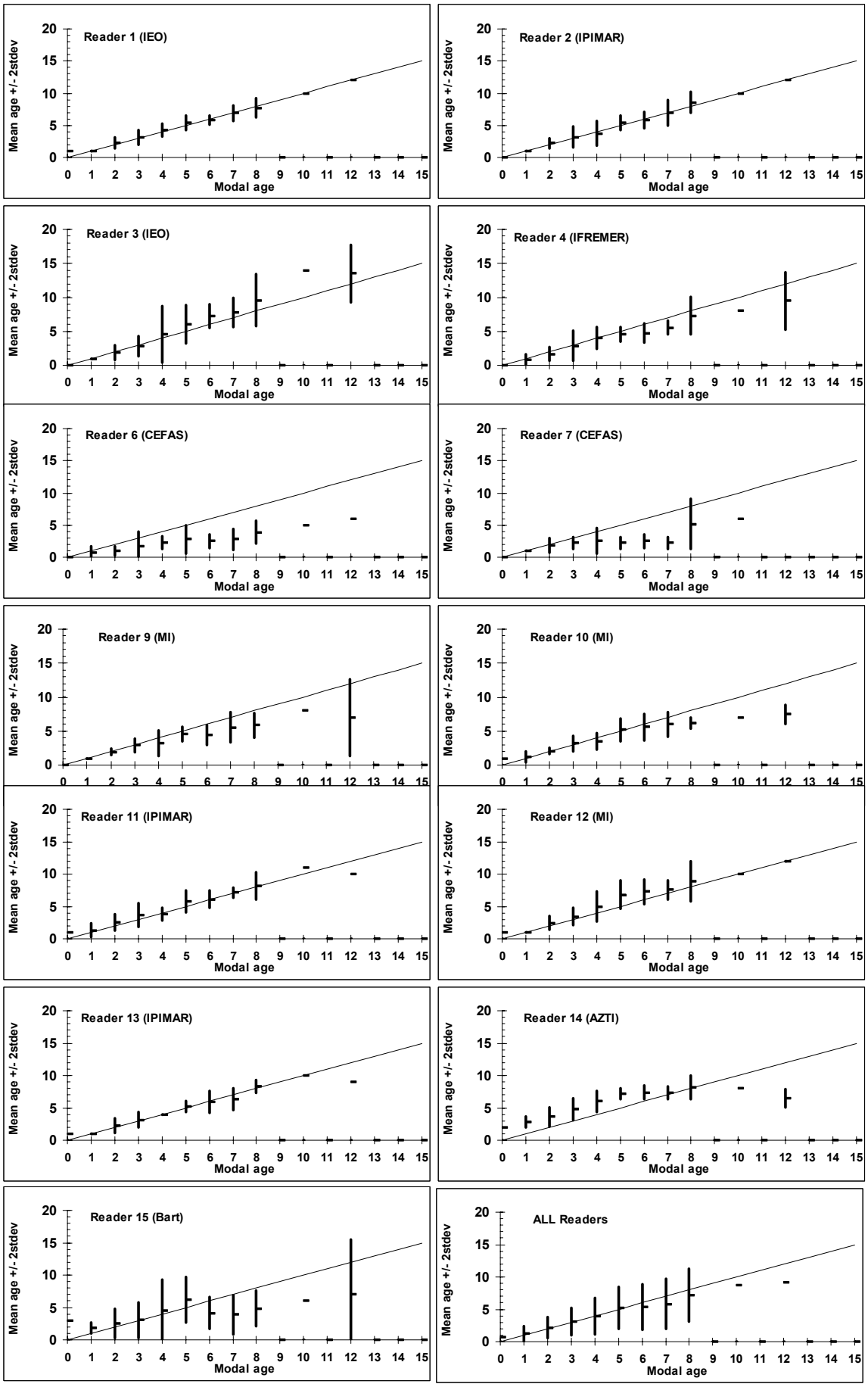
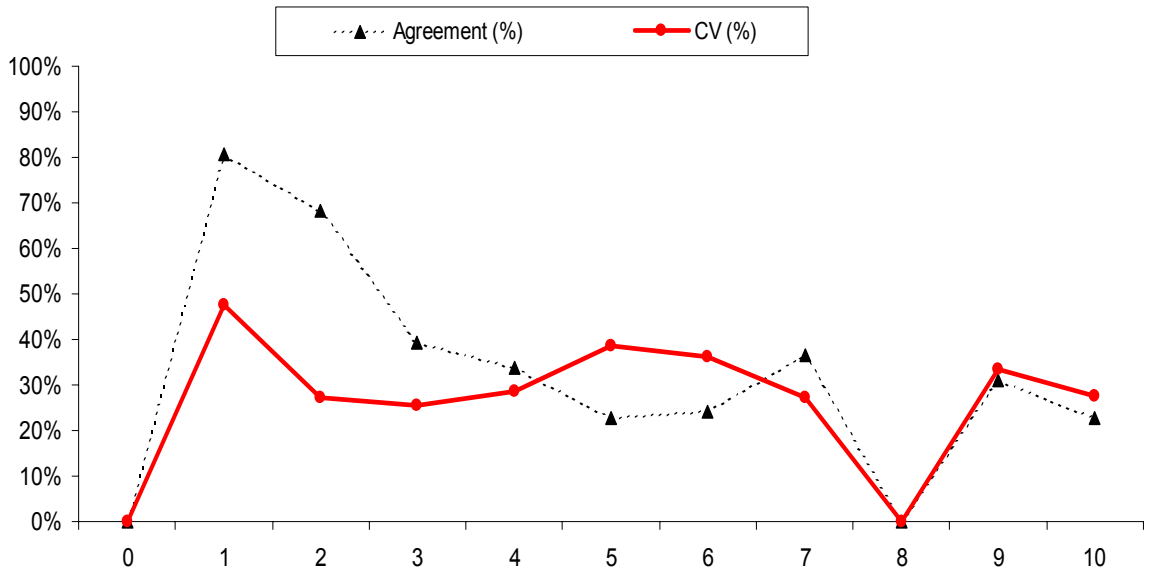


Figure 6.- The coefficient of variation (CV%) and percentage of agreement (%) are plotted against modal age for the subset sample in the first and second reading

a) First reading



b) Second reading