REPORT OF 4th EXCHANGE on EUROPEAN HAKE AGE READINGS

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1. Abstract

In 2002 the ICES WGSSDS showed the difficulties in the assessment of hake due to uncertainty on age estimation of older fish which has led the WG to use a plus group at age 8. To solve these problems an otolith exchange was recommended between readers involved in the assessment and focused mainly on older fishes. Preliminary results of the fourth hake otoliths exchange, conducted in 2003, indicate that the age estimation criteria used up to age 3 was the one adopted previously, however, for older fishes, otolith interpretation presents a higher complexity. The results indicate that the precision of age readings has decreased and a strong bias has been found in age readings of older fishes. Thus, the values of APE and CV in (%) for all readers are 41, and 45 respectively, while the values for assessment readers are 24 and 32. The comparison of these results with those from the previous exchange in 2001 shows the difficulty of this task, and to solve these problems a specific international workshop will be carried out.

2. Introduction

The complexity of Hake age estimation has been widely reported in the literature (Piñeiro and Sainza, 2003) and several international exchanges and workshops (Piñeiro 2000; Piñeiro et al., 2000) have been devoted to the development of a standard ageing method for reading hake otoliths up to age 5. However, ageing hake still presents problems, mainly at older ages and this is a limiting factor for ICES WG that use a plus group at age 8 which is a source of bias for stock assessment (ICES 2003).

Taking this into consideration, the WGSSDS in 2002, recommended to solve these problems through a hake otolith exchange focused on older fishes and a subsequent specific international workshop. This workshop will be celebrated in October 2004 (18-22), within the framework of the National Plan, 2004.

In order to check the precision in age reading and bias of the age readers of this species, the background for ageing hake was based on the reports of Hake Otolith Age Reading Workshops conducted previously (1997 and 1999). They are available on the EFAN home page (http://www.efan.no; Report 6-2000 and Report 7-2000).

The objectives of this exchange were:

- Checking the precision and relative bias in age reading mainly in older ages from age readers involved in stock assessment
- Try to establish an ageing criteria for old fishes
- To incorporate new readers in hake age estimation.

This document presents the preliminary results obtained so far in this otolith exchange and the results are compared to previous one conducted in 2001 (Anon.,2002). Likewise it was sent as a *Working Document to the ICES Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim, WGHMM* celebrated at Gijon, Spain (12-21 May 2004)

3. Material and Methods

The exchange was carried out following the recommendations of the EFAN Report 3-2000 on Guidelines and Tools for Age Reading Comparations, which is available on the EFAN home page.

All readers participating in this exchange, except four (*) were also involved in the last exchange (2001) and the majority of the readers belonging to this group provide age readings to *ICES WGHMM:*

Reader	Name	Institution	Degree of Exp	Country
Reader 1	M. Saínza	IEO	Expert	Spain
Reader 2	M. H. Afonso	IPIMAR	Expert	Portugal
Reader 3	C. Piñeiro	IEO	Most exp.	Spain
Reader 4	J. Labastie	IFREMER	Most exp.	France
Reader 5	S. Arego	AZTI	Expert	Spain
Reader 6	S. Warnes	CEFAS	Little experience	England
Reader 7	M. Easy*	CEFAS	New	England
Reader 9	S. Hoey*	MI	New	Ireland
Reader 10	S. Beattie *	MI	New	Ireland
Reader 11	C. Morgado	IPIMAR	Expert	Portugal
Reader 12	M. Marín	IEO	Expert	Spain
Reader 13	S. Dores *	IPIMAR	New	Portugal

A collection of 200 Hake otolith sections from two ICES areas (100 from Sub-area VII and 100 from Divisions VIIIc + IXa) circulated among interested Institutes during 2003. The exchange scheme started in May and finished in February 2004. Digitalised images from otoliths sections were stored in a CD Rom, which accompanied the exchange collection.

The length range of the fish sampled was between 11cm and 84 cm, collected during all seasons (Figure 1). The age range estimated was between 0 and 15 and only information on catch date and sex were available to the readers. The otolith sections were prepared in Vigo (IEO) using the same technique of previous exchanges. Before circulating the otolith collection, an ageing protocol was provided to all readers. In order to know

whether the readers would count the same rings, the first five rings and the check ring considered by reader for age estimation, were measured.

The level of experience of the readers was split into three levels in order to make comparisons with previous exchanges:
A: all participating readers (including the 4 new readers: R7,R9,R10 and R13)
B: readers involved in hake stock assessment (R1-R5),
C: the most expert readers (R3-R4)

The general criteria adopted for ageing is described in the report of the previous exchange (Hake Otolith Age Reading Workshop, 1999; EFAN 7-2000, Report of 3rd exchange on European hake age readings, 2001 (SAMFISH)).

The analysis of the age reading results was an Excel ad-hoc Workbook "AGE COMPARATIONS. XLS" from A.T.G.W. Eltink from RIVO.

The basic requirement for age reading consistency is the absence of bias among readers over time. To study the variability in the precision of age determinations among readers, an extensive analysis was conducted to provide more details concerning individual performances:

1. Exploratory data analysis (EDA)

Determination of the modal age and the difference between each reader's age and modal age. The modal age was calculated based on the results of the readers involved in the stock assessment: R1, R2, R3, R4 and R5. In the case of bi-modality, the modal age was estimated by the most experienced 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). They were also used to summarise the observations and are useful in observing and comparing the distribution of the otolith readings by reader.

Age bias plots are a perfect way of showing the age readers 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 be shown as a relative bias.

2. In terms of reproducibility measures:

2.1) Average percent age error (APE), Beamish and Fournier (1981) is an index of reading precision to compare a series of observations. The formula is as follows:

$$APE = \frac{100}{n}\sum_{i=1}^{n}\left(\frac{1}{r}\sum_{j=1}^{r}\frac{\left|x_{ij}-\bar{x}_i\right|}{\bar{x}_i}\right) \quad (1)$$

n = number of otoliths

r = number of readings for each otolith

xij = the j value of age estimation for the i otolith

$\bar{x}_i$ = average age calculated for the i otolith

2.2) The Mean Coefficient of Variation (CV). The precision errors in age reading are best described by this coefficient by age group.

$$CV = \frac{100}{n}\left[\sum_{i=1}^{n}\left(\frac{sd}{\bar{x}_i}\right)\right] \qquad (2)$$

sd = the standard deviation for the i otolith

This measurement is more appropriate than the conventional percent of agreement when comparing ages, since it take into account the average year class of fish.

5. Results

The results of the age estimations by reader and the basic information about otolith collection are summarised in Table 1.

In general, the box-whisker plot for all readers shows that the range of ages attributed was very wide with a mean value of 4 years (Figure 2).

The box-whisker plot of Figure 3, illustrates that almost all readers distinguished both the first and the check rings with the exception of R7 and similar median distances for both rings were obtained. Their average distance to the nucleus seems to be around 1.3 and 1.5 mm respectively. This check ring, situated between the first and the second is very useful, since it is often very clear and provides a good reference point to start the counting.

The figures showing the distances measured between the second and third ring indicate that the majority of readers presented similar values; however readers R6, and R7 showed differences. The graphics indicate a high agreement between readers in the location of the first three rings that means that ageing criteria up to age three has been used by practically all the readers. This becomes more evident in the case of assessment readers. The location of the following rings is more inconsistent due to the difficulty of ring pattern interpretation. By contrast, it should be noted the high consistence of readers R2, R11 and R13 to identify all rings. The lack of experience in hake ageing and the misinterpretation of the ageing criteria are the likely causes for the discrepancies observed.

Considering the bias plots for all the readers combined it could be observed that the mean age recorded is very close to the modal age and that the deviations increase relatively from age 7 and over (Figure 4). The main bias is from age 3 onwards and the readers R1, R3 and R12 overestimated the ages meanwhile, R2, R4, R7, R9, R11 and R13 underestimated the ages regarding the modal age. In view of the experience of the majority of the readers, a higher bias than expected is observed. An important factor that could be behind this is that for the first time in the exchanges series there was a blind reading of the otoliths collection.

The precision errors by age reader are best described by the coefficient of variation (CV%) by age group because the CV might often differ by age group. The coefficient of variation (CV%) and percent agreement are plotted against modal age for the last two exchanges in Figure 5. This figures shows the results for the three groups of readers based on the experience (A,B,C) and indicate how the CV and Agreement change accordingly with experience.

Firstly, from all readers (A) the average of CV was 45 %. This value is so high mainly due to an important effect of age magnitudes in the calculation of CV's. In fact, the CV's are much higher for age 0 and afterwards the CV's decreased very much, keeping around 30 % for ages older than three. Percent agreement decreased as the age increased and the mean value obtained was 47%.

Secondly, from readers involved in assessment (B), the average of CV was 32% and this value was much higher for age 0, mainly due to the important effect of age magnitudes in the calculation of CV's, already mentioned. For older ages, the CV's decreased to values around 20 %. The average percent agreement was 57%.

Finally, for the most expert readers (C), the average of CV was 29 % and the average percent agreement was 57% which indicates a lower precision and a higher bias in comparison with the previous exchange.

The results of APE and CV in (%)are presented together with the same results of the previous exchange in order to know the differences (Figure 6). The values of APE and CV obtained for all readers were 41 and 45 respectively, for assessment readers were 24 and 32 and for most expert readers were 21 and 29. These low levels of precision and the high APE should be improved in the workshop.

6. Discussion

In summary, the exploratory and statistical analysis showed that the age precision has decreased considerably while the bias has increased, achieving similar values to 1999 (Figure 6). This might be due to the lack of information on the fish length in this exchange and/or to different ageing methods for older fishes, that have not been established yet.

In particular, the ageing method up to age 3 seems to be the same for almost all the readers since every reader recognised the same rings (Figure 3). However, from the third ring onwards the results show an overlapping of the distribution in the rings measures considered for ageing. This indicates the difficulty for the majority of the readers to interpret the ring pattern of older otoliths. Thus, it was found a strong bias in age readings of larger fishes.

Considering the bias plots the results for all readers' present a higher bias than the previous exchange in 2001 and a lower percent agreement which, on account of the experience of the readers involved, may represent a step backwards. This indicates that the annual increment formation in otoliths is not well understood, although it is commonly assumed that they are related to seasonality in growth.

We think the big quantity of large fishes included in the sample studied and the blind read, could not be the only explanation for these results. Together with the complexity of the interpretation of growth pattern there is a factor (psychological) that could affect and this is the knowledge of the results of the tagging experiment conducted in 2002 (H. Puntual et al 2003) which seems to indicate higher growth rates for hake than was considered previously.

Because of this, despite being different samples in the last two exchanges, a plot of mean length at age by reader (involved in assessment) can be used to diagnose individual reader tendencies (Figure 7). The figures show that, for the same age, some readers obtained larger range of length in 2003 than in 2001. Thus, readers R2, R4, R11, have changed since 3 onwards. Kruskal-wallis test intra reader for ageing samples of the last two exchanges showed no significant bias for all readings obtained by only two readers R1, R3 (Table 2).

The results highlight the difficulties in ageing hake otoliths, mainly in older fishes. A workshop is necessary to minimise the relative bias and CV in order to provide a quality control of age estimations of hake for stock assessment purposes. In our opinion this is the way to work until such time as there is new ageing criteria that is scientifically validated. In the mean time there is no justification for changing current age reading criteria.

7. Conclusions:

a. The level of agreement in the location of the first three annual rings was high for the majority of readers. This is the result of the adoption of the ageing criteria established. Furthermore, new readers showed an adequate interpretation of the ageing criteria.

b. Readers involved in stock assessment had a lower level of agreement and precision reaching the mean values of 57 % and 32% respectively.

c. A consensus ageing method for the ages 5 onwards has to be established in the next workshop in order to provide a quality control for the age estimations used in assessment.

8. Recommendations

Taking into account the results obtained, future efforts must be carried out along two lines:

a. International intercalibration exercises and workshops to ensure consistency and precision between readers. Until such time as a validated knowledge of ageing criteria is available no change is justified.

b. Is strongly necessary to undertake alternative methods (tagging, microchemistry, etc.) to provide information on age validation and the growth of otolith in relation to the increments periodicity at all stages of the life cycle of this species

All these facts together call for new projects in order to obtain information related to stock structure, migrations, growth and mortality which are important to understand the population dynamic of this species.

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Table 1.- Results of age estimation by reader

Stratum	Sample year	Sample no	Fish no	Fish length	Fish Sex	Landing month	IEO Reader 1	IPIMAR Reader 2	IEO Reader 3	IFREMER Reader 4	AZTI Reader 5	CEFAS Reader 6	CEFAS Reader 7	MI Reader 9	MI Reader 10	IPIMAR Reader 11	IEO Reader 12	IPIMAR Reader 13
N	2000	1	49	11	3	1	1	1	1	1	0	2	1	0	0	1	1	1
S	2001	2	3371	10	3	3	1	1	1	2	0	1	1	0	0	1	1	0
S	2000	3	10029	10	3	10	0	0	0	0	0	1	0	0	0	0	0	0
N	2001	4	30105	10	3	9	0	0	0	0	0	0	0	0	0	0	0	0
N	2001	5	30104	10	3	9	0	0	0	0	0	0	0	0	0	0	0	0
S	2001	6	30540	12	3	9	0	0	0	0	0	0	0	0	0	0	0	0
N	2000	7	55-00	12	3	1	1	1	1	0	0	1	1	0	0	1	1	1
S	2002	8	20278	11	3	4	1	1	1	1	0	1	1	0	0	1	1	0
S	2000	9	10044	11	3	10	0	0	0	0	0	0	0	0	0	0	0	0
N	2001	10	30103	11	3	9	0	0	0	1	0	0	0	0	0	0	0	0
S	2002	11	161	13	3	4	1	1	1	0	0	1	1	0	0	1	1	0
S	2001	12	30101	13	3	9	0	0	0	0	0	1	0	0	0	0	0	0
S	2000	13	11332	13	3	10	0	0	0	0	0	1	0	0	0	0	0	1
N	2002	14	155	12	3	4	1	1	1	0	0	1	1	0	0	1	1	0
S	2000	15	11185	12	3	10	0	0	0	0	0	0	0	0	0	0	0	0
N	2001	16	30541	14	3	9	0	0	0	0	0	1	0	0	0	1	0	1
S	2001	17	3158	14	3	2	1	1	1	1	1	2	1	1	0	1	1	1
S	2000	18	11455	14	3	10	0	0	0	0	0	1	0	0	0	0	0	0
N	2000	19	54	14	3	1	1	1	1	1	1	2	1	1	0	1	1	1
N	1994	20	1780	13	3	2	1	1	1	0	1	2	1	0	0	1	1	1
N	2000	21	788	16	3	3	1	1	1	0	1	2	1	1	0	1	1	1
N	2002	22	6	15	3	9	0	0	0	1	1	2	0	0	0	0	0	1
S	2001	23	59-01	15	3	10	0	0	0	0	0	0	0	1	0	0	0	1
N	2000	24	53	15	3	1	1	1	1	1	0	1	1	0	0	1	1	1
S	2002	25	94	15	3	3	1	1	1	0	1	1	1	1	0	1	1	1
S	2000	26	524	17	3	3	1	1	1	1	1	2	1	1	0	1	1	1
N	2000	27	52	17	3	1	1	1	1	1	1	1	1	1	1	2	1	1
S	2000	28	10456	16	3	10	1	1	0	0	1	2	0	1	0	1	0	1
S	2000	29	138	16	3	2	1	1	1	1	1	2	1	1	1	1	1	1
N	2000	30	1720	16	3	10	0	0	0	0	1	1	0	1	0	0	0	1
S	2002	31	132	18	3	4	1	1	1	1	1	2	1	1	1	1	1	1
N	2000	32	1754	18	2	10	1	1	0	0	1	1	0	0	1	0	1	1
N	2000	33	776	18	3	3	1	1	1	1	1	2	1	1	1	1	1	1
N	2002	34	11	17	3	9	1	0	0	1	1	2	0	0	0	0	1	1
S	2001	35	149	17	3	10	0	1	0	0	1	2	0	0	0	0	0	1
S	2001	36	287	19	3	3	1	1	1	1	1	3	1	1	1	2	1	1
S	2002	37	10514	19	2	10	1	1	0	1	1	3	0	1	0	1	1	1
N	2002	38	8	19	1	9	1	1	1	1	1	1	0	1	0	0	1	1
N	2000	39	50	19	3	1	1	1	1	1	1	2	1	1	1	2	2	1
S	2000	40	10547	18	3	10	1	1	0	0	1	2	0	0	0	1	1	1
S	2001	41	200	22	3	3	2	1	1	1	3	3	1	1	1	2	2	1
N	2001	42	311	21	3	4	1	1	1	1	2	2	1	1	1	1	2	1
S	2001	43	222	21	3	3	1	1	1	1	2	2	1	1	1	2	2	1
N	2000	44	795	20	3	3	1	1	1	1	2	2	1	1	1	1	2	1
S	2002	45	10409	20	1	10	1	1	1	0	1	2	0	1	1	1	1	1
N	2000	46	58	24	3	1	1	1	1	1	2	4	1	1	1	2	2	1
N	2001	47	10259	24	2	10	1	1	1	0	2	2	0	1	1	1	1	1
S	2001	48	189	23	1	3	1	1	1	1	2	2	1	1	1	2	2	1
S	2000	49	783	23	3	3	2	1	1	1	3	3	1	1	2	2	2	1
N	2000	50	790	22	3	3	1	1	2	1	2	3	1	1	1	2	2	1
N	2000	51	59-00	25	3	1	2	2	2	1	4	3	1	2	2	2	3	2
N	2000	52	1761	25	1	10	1	1	1	1	3	2	0	1	2	1	2	2
N	2001	53	10424	25	1	10	2	1	1	1	3	2	1	1	1	1	1	1
S	2001	54	191	25	2	3	2	2	2	2	3	3	1	2	2	2	2	2
N	2000	55	62	26	3	1	2	1	2	2	3	3	1	2	2	2	2	2
N	2000	56	1765	26	1	10	1	1	1	1	3	2	1	1	1	1	1	1
N	2000	57	10189	26	1	9	1	1	1	1	3	2	0	1	1	1	2	2
S	2001	58	253	26	2	3	2	1	2	1	4	5	1	1	2	2	3	1
N	2000	59	64	27	3	1	2	2	2	2	4	3	2	2	2	2	2	2
N	2000	60	1726	27	1	10	1	1	2	0	3	2	1	1	1	1	2	1
S	2000	61	10208	27	2	10	2	2	2	2	4	2	1	2	2	2	2	2
S	2001	62	88-01	27	3	1	2	2	2	2	4	3	2	2	2	2	3	2
N	2002	63	1565	28	1	11	2	2	1	1	4	3	1	2	1	2	2	2
S	2001	64	240	28	2	3	2	2	2	2	4	4	1	2	2	2	3	2
N	2002	65	10626	28	1	11	2	1	1	1	3	4	1	1	2	1	2	1
N	2000	66	798	28	3	3	2	2	2	2	4	3	2	2	2	2	3	2
N	2002	67	1543-02	29	2	11	2	1	1	1	3	2	1	1	1	1	2	2
N	2001	68	1138	29	3	10	3	2	2	2	3	3	1	1	2	2	2	2
N	2002	69	523	29	3	5	2	1	2	1	3	3	1	1	1	2	2	1
S	2000	70	734	29	2	3	3	2	3	2	4	4	2	2	2	2	3	2
S	2002	71	93	31	3	2	3	2	3	2	4	4	2	2	2	2	3	2
N	2000	72	68	31	3	1	3	2	3	2	4	3	2	2	2	2	3	2
N	1999	73	87	30	3	2	3	2	3	3	4	2	2	2	2	3	3	2
S	2001	74	48	30	3	1	3	2	3	2	4	2	2	2	2	2	3	3
S	2001	75	55-01	33	3	1	3	3	3	2	4	2	2	2	3	3	3	3
N	2002	76	801	33	1	6	3	2	3	2	4	3	2	2	2	2	3	2
S	2001	77	104	32	3	1	3	2	3	2	4	3	2	2	3	2	3	2
N	2000	78	69	32	3	1	2	3	2	2	4	3	2	2	2	3	3	3
N	2002	79	1498	35	3	11	2	2	2	2	4	2	1	3	2	2	3	3
S	2002	80	10277	35	1	10	2	2	2	2	4	4	2	2	2	2	3	3
N	2000	81	1647	34	1	11	3	2	3	3	4	3	2	2	2	2	2	3
S	2000	82	732	34	2	3	3	3	3	2	4	4	2	3	3	3	3	3
N	2000	83	1649	36	1	11	2	2	2	2	4	3	1	2	2	2	3	3
N	2000	84	1648	36	3	11	2	2	2	2	4	3	1	2	2	2	3	2
N	2000	85	713	35	2	3	3	3	3	2	4	3	2	2	2	3	3	2
S	2001	86	86	35	3	1	3	3	3	2	4	3	3	3	2	3	4	3
S	2000	87	27	37	2	1	3	3	3	3	5	4	2	3	2	3	4	3
S	2002	88	10558	37	2	10	3	3	3	2	4	2	1	2	2	3	3	3
S	2000	89	20	36	2	1	3	2	3	2	5	4	2	3	2	3	4	3
S	2000	90	10291	36	1	10	3	3	3	3	4	3	1	2	2	2	3	3
S	2000	91	10956	38	1	10	3	3	4	2	4	4	2	5	2	3	3	4
N	2002	92	1546	38	1	11	3	3	3	3	4	3	2	5	2	3	4	3
N	2002	93	242	37	2	2	3	3	4	3	4	3	2	5	2	4	4	4
N	2000	94	1658	37	3	11	3	3	3	2	4	2	2	4	2	3	3	4
S	2000	95	88-00	39	1	2	3	3	5	2	4	3	3	5	2	3	5	4
N	2002	96	245	38	2	2	4	4	4	3	4	3	3	3	2	3	4	3
S	2001	97	47	38	3	1	4	3	4	3	4	3	2	4	2	4	4	4
S	2002	98	10551	39	2	10	3	2	3	2	3	3	3	3	2	2	3	3
N	2002	99	1521	39	2	11	2	2	3	2	3	3	3	3	2	2	3	3
N	2000	100	474	39	3	3	4	3	3	2	4	3	2	5	1	3	4	3
S	2001	101	922	40	3	9	3	3	4	3	5	6	2	3	4	3	4	3
S	2001	102	395	40	3	6	3	2	4	2	4	4	2	3	3	3	4	5
S	2001	103	453	40	1	1	5	3	5	3	5	7	2	4	5	4	5	5
S	2001	104	513	43	1	4	6	3	6	4	5	9	3	4	4	3	6	4
S	2001	105	128	43	1	2	4	3	4	3	5	5	3	4	4	3	4	3

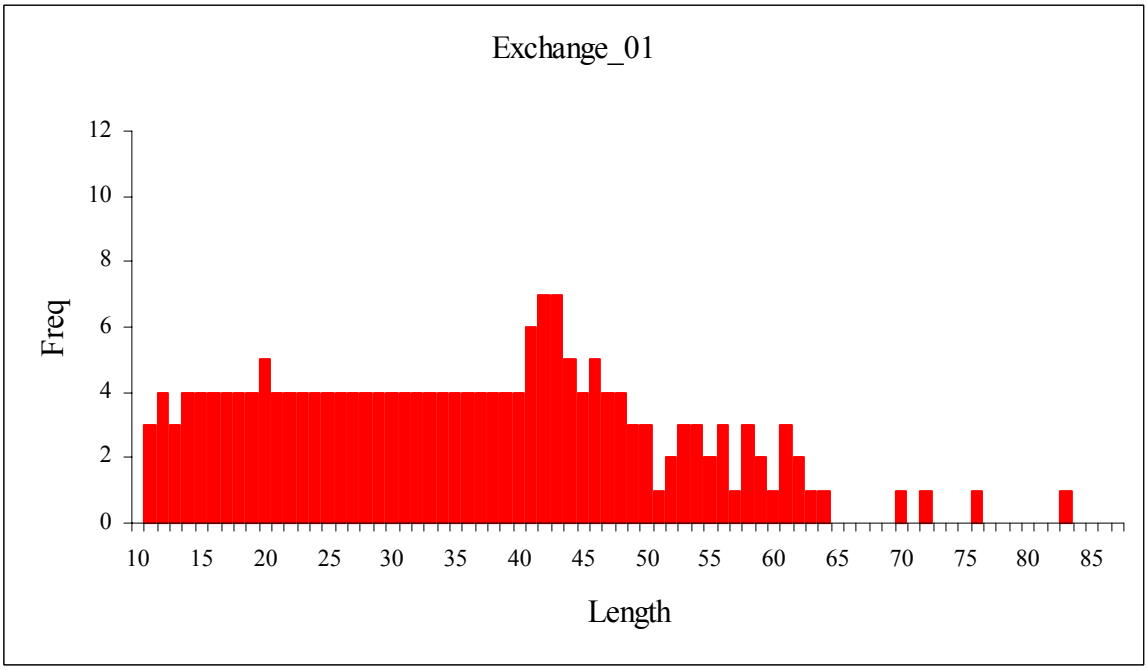
Table 1.- Results of age estimation by reader

Stratum	Sample year	Sample no	Fish no	Fish length	Fish Sex	Landing month	IEO Reader 1	IPIMAR Reader 2	IEO Reader 3	IFREMER Reader 4	AZTI Reader 5	CEFAS Reader 6	CEFAS Reader 7	MI Reader 9	MI Reader 10	IPIMAR Reader 11	IEO Reader 12	IPIMAR Reader 13
S	2001	106	2412	40	1	11	3	3	4	2	4	3	2	3	5	3	4	5
S	2001	107	148	46	3	2	5	4	5	5	6	6	2	6	6	5	6	5
N	2001	108	1082	43	1	10	5	4	5	4	6	8	2	6	5	4	5	4
N	2001	109	794	43	2	7	4	4	4	3	6	3	3	4	5	4	4	4
N	2001	110	1089	46	3	10	4	3	4	3	5	6	2	4	4	3	5	5
N	2001	111	816	46	3	7	5	3	5	3	4	9	2	4	4	3	5	4
N	2001	112	362	46	3	5	5	3	4	3	5	7	2	5	5	3	5	3
S	2001	113	973	49	3	9	4	2	4	3	4	4	3	4	4	2	4	3
N	2001	114	545	49	3	6	6	3	6	4	5	6	3	4	4	3	7	3
S	2001	115	257	49	3	3	6	4	5	4	6	8	3	5	5	5	7	4
N	2001	116	618	52	3	6	6	4	6	3	5	8	1	4	5	3	6	4
S	2001	117	265	52	3	3	6	4	7	4	6	9	2	5	5	4	8	4
S	2001	118	2393	49	2	11	6	3	5	4	4	8	2	4	5	3	6	4
S	2001	119	117	55	1	1	7	5	7	4	7	10	3	6	6	5	9	5
S	2001	120	10401	52	1	10	6	5	8	5	6	8	2	5	6	5	7	5
N	2001	121	30115	52	2	9	6	4	6	3	6	8	2	5	6	4	6	5
S	2001	122	2311	55	2	11	8	5	6	4	6	7	2	5	6	5	8	6
S	2001	123	970	55	3	9	6	5	6	4	5	7	3	6	6	4	6	5
N	2001	124	629	55	3	6	7	4	5	3	6	8	2	6	6	5	7	6
N	2001	125	837	58	3	7	6	4	6	4	5	6	2	5	6	5	5	6
N	2001	126	662	58	3	6	7	5	7	4	6	6	2	6	5	5	7	5
S	2001	127	129	58	2	6	7	4	8	4	5	8	2	4	6	4	6	4
S	2001	128	29	61	3	1	7	5	11	4	6	7	3	6	7	5	7	4
S	2001	129	33	61	3	1	9	4	9	4	6	7	3	6	5	5	9	4
N	2001	130	1108	58	3	10	9	6	13	4	6	9	2	6	8	5	8	7
N	2001	131	843	61	3	7	9	6	9	4	7	6	2	8	9	7	9	6
N	2001	132	634	61	3	6	9	5	9	3	7	6	2	6	7	5	9	6
N	2001	133	373	61	3	5	7	3	8	4	6	5	2	5	6	4	8	7
N	2001	134	1213	61	2	11	7	4	6	4	6	6	2	5	6	5	7	5
N	2001	135	1117	61	3	10	9	5	10	3	6	6	2	6	6	6	10	4
N	2001	136	30400	61	3	9	7	4	8	4	6	6	2	5	7	5	8	5
S	2001	137	322	64	2	5	7	6	9	5	7	6	2	6	7	6	9	6
S	2001	138	27	64	2	1	9	5	9	5	7	5	2	6	7	7	8	6
S	2001	139	16	64	3	1	7	7	9	5	7	6	2	7	8	7	8	6
N	2001	140	30153	64	1	9	6	4	9	4	5	6	3	5	7	4	7	5
N	2001	141	844	64	3	7	8	5	9	5	6	4	4	5	7	5	8	5
N	2001	142	374	64	2	5	7	5	8	5	7	6	2	5	7	5	7	5
S	2001	143	24	67	3	1	7	7	7	6	5	5	3	5	8	7	8	5
N	2001	144	1200	64	3	11	9	7	8	5	6	5	2	6	8	7	7	7
N	2001	145	1197	64	3	11	6	6	7	4	6	6	3	6	7	6	8	8
N	2000	146	1071	68	3	6	10	7	8	6	8	6	2	6	8	8	13	7
N	2000	147	1078	67	3	6	8	6	7	5	7	5	3	6	7	6	12	5
S	2001	148	459	67	3	6	9	6	11	6	7	7	2	5	8	6	12	7
N	2001	149	1127	67	3	10	7	4	9	6	6	6	2	4	7	5	8	5
N	2001	150	852	67	3	7	7	7	9	5	7	6	2	7	7	7	7	7
S	2001	151	782	67	3	9	10	7	10	5	8	6	3	6	8	8	11	7
S	1999	152	260	70	3	3	12	8	10	6	9	9	3	6	10	9	12	7
N	2000	153	508	70	3	1	8	6	9	7	8	8	3	7	8	7	12	5
N	2001	154	1218	67	3	11	10	7	9	5	7	6	2	6	8	7	11	7
N	2001	155	845	70	3	7	9	9	9	6	8	6	3	6	9	10	9	9
N	2000	156	1068	70	3	6	10	6	10	6	7	6	2	6	8	6	12	6
N	2000	157	1067	70	3	6	8	7	8	6	8	7	4	7	8	7	11	6
N	2001	158	1167	70	3	11	9	6	8	6	7	7	4	6	8	7	9	6
N	2001	159	1139	70	3	10	11	10	11	6	8	6	4	6	10	9	11	8
N	2001	160	30399	70	2	9	7	6	8	6	7	7	4	7	8	6	10	5
N	2000	161	1544	73	3	11	9	7	7	6	7	7	4	7	8	8	8	7
N	1998	162	154	73	3	3	8	6	9	6	7	7	4	6	7	7	9	5
N	1998	163	118	73	3	3	8	7	11	5	8	8	4	7	8	7	11	6
N	2001	164	30596	73	2	9	11	9	10	8	8	8	7	8	9	8	11	9
N	2001	165	30324	73	2	9	9	6	11	6	7	7	5	6	9	6	10	6
N	2000	166	1520	73	3	11	10	8	10	6	7	6	4	7	7	8	10	8
S	1998	167	42	76	3	3	9	6	11	6	7	7	5	7	8	7	11	6
N	2001	168	1206	73	3	11	10	6	11	6	7	8	3	6	8	8	10	6
N	2001	169	1165	73	3	11	10	9	12	7	8	7	5	7	10	9	10	8
N	1998	170	491	76	3	8	9	8	9	7	8	6	5	8	8	8	11	7
N	1998	171	145	76	3	3	8	7	9	6	7	7	5	8	9	8	12	6
N	1998	172	151	76	3	3	11	8	12	6	7	7	4	6	9	8	12	6
N	2000	173	1549	76	2	9	9	8	8	7	7	5	4	7	7	8	10	7
N	1999	174	494	76	3	7	11	7	11	7	7	6	6	6	9	7	12	6
N	2001	175	30590	76	2	9	8	9	8	6	6	6	6	6	8	7	10	7
S	1997	176	10336	77	2	9	9	9	8	7	8	6	5	9	9	8	9	8
S	1998	177	44	77	3	3	14	9	13	8	9	8	6	8	10	8	14	6
N	1998	178	605	76	3	12	10	9	9	6	7	6	4	7	8	8	10	9
N	1998	179	493	77	3	8	10	7	11	7	7	7	6	7	10	7	13	6
S	1994	180	1174-94	78	2	10	8	7	8	7	6	8	5	6	10	8	12	7
N	2000	181	1552	77	3	11	10	8	9	6	6	7	5	7	8	9	11	6
N	2000	182	1550	77	3	11	8	7	10	7	7	6	8	7	9	7	11	7
N	2000	183	1518	77	3	11	8	7	8	6	7	7	7	6	9	8	11	6
N	2000	184	1543-00	75	3	11	8	9	7	6	7	9	8	8	9	9	10	8
N	2001	185	1174-01	80	3	11	8	7	9	6	6	8	5	6	8	7	9	7
S	1997	186	4011	78	2	1	7	6	11	7	6	7	6	6	7	6	11	6
S	1998	187	41	78	3	3	7	8	15	8	8	9	7	8	9	9	14	7
N	1999	188	495	82	3	7	14	8	7	8	7	7	6	7	10	8	10	7
N	1998	189	598	80	3	12	11	10	11	8	7	7	7	6	9	9	13	9
S	1993	190	10066	78	2	3	11	9	12	7	8	7	6	6	9	9	15	8
N	2000	191	1558	80	3	11	10	9	11	7	7	6	7	8	9	8	13	7
N	2000	192	1533	75	3	11	9	7	8	7	7	7	7	6	9	7	10	6
S	2001	193	17	81	3	1	10	8	11	7	8	7	7	7	8	9	15	7
S	1985	194	45	87	2	2	14	11	15	8	9	8	-	8	9	11	14	9
N	2001	195	1173	81	3	11	10	10	10	8	7	6	7	8	11	9	14	10
N	2001	196	30386	80	2	9	9	8	11	8	7	8	7	8	9	8	12	7
N	1997	197	4012	76	2	1	10	11	12	9	10	8	8	8	12	11	12	9
N	1998	198	156	76	3	3	-	7	10	8	-	-	-	-	7	8	12	7
N	1998	199	490	81	3	8	8	7	9	8	8	9	7	7	10	7	12	7
N	2001	200	1172	84	3	8	8	6	12	8	7	8	8	6	10	7	13	6
						Total read	199	200	200	200	199	199	198	199	200	200	200	200
						Total NOT read	1	0	0	0	1	1	2	1	0	0	0	0

Table 2.- Results from Kruskal-wallis test intra reader for ageing samples of exchanges 01 and 03 for ages 0-8.

	Age 0	Age 1	Age 2	Age 3	Age4	Age 5	Age 6	Age 7	Age 8
R1	ns	ns	ns	ns	ns	ns	ns	ns	ns
R2	ns	ns	ns	ns	**	**	**	**	**
R3	ns	ns	ns	ns	ns	ns	ns	ns	ns
R4	ns	ns	**	**	**	**	**	**	ns
R5	ns	ns	*	**	**	ns	ns	ns	ns
R6	**	**	**	**	**	**	**	ns	ns
R11	ns	ns	ns	ns	ns	ns	**	**	**
R12	ns	ns	*	**	**	*	**	*	ns

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



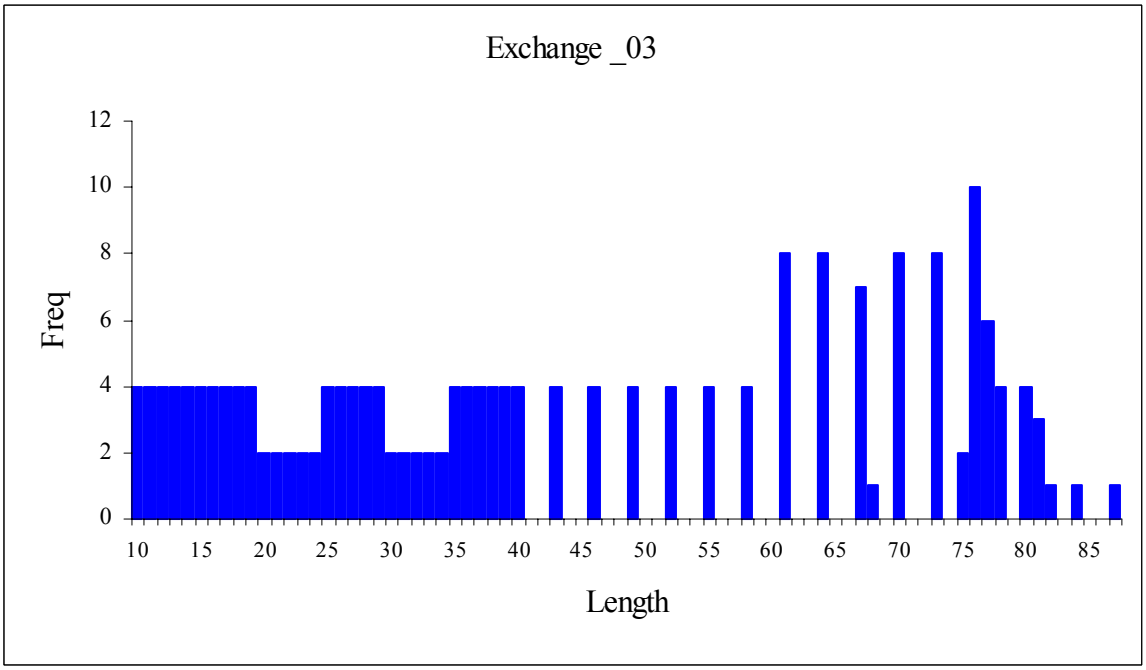


Figure 1.- Length frequency distribution of samples from hake otolith exchanges of 2001 and 2003.

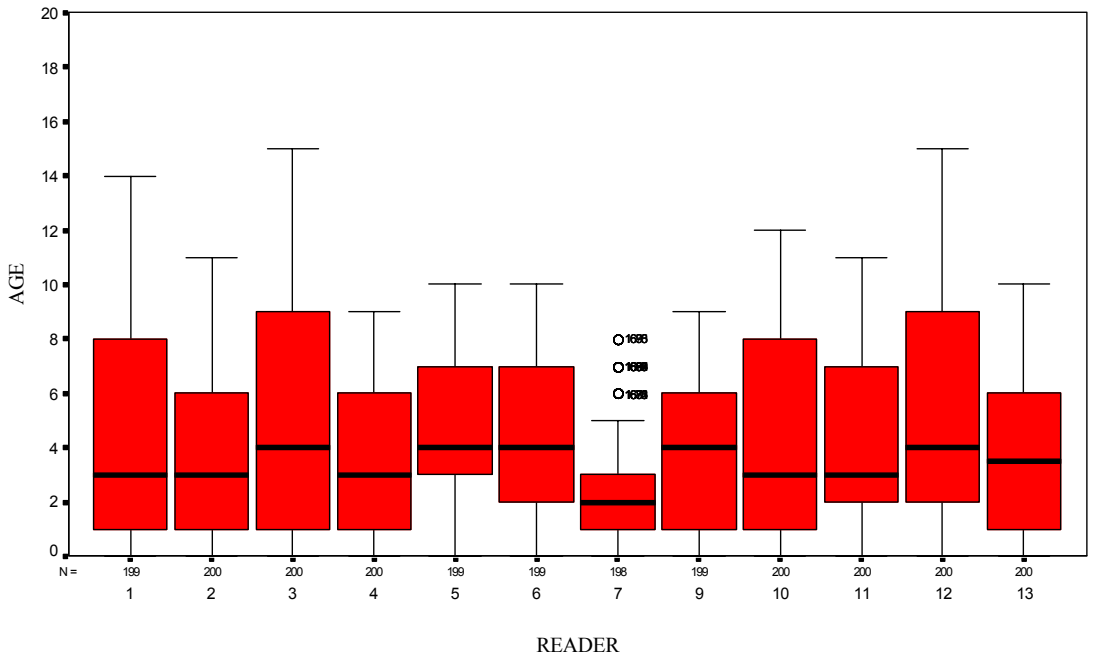


Figure 2.- Box-whisker plot of all readings

.

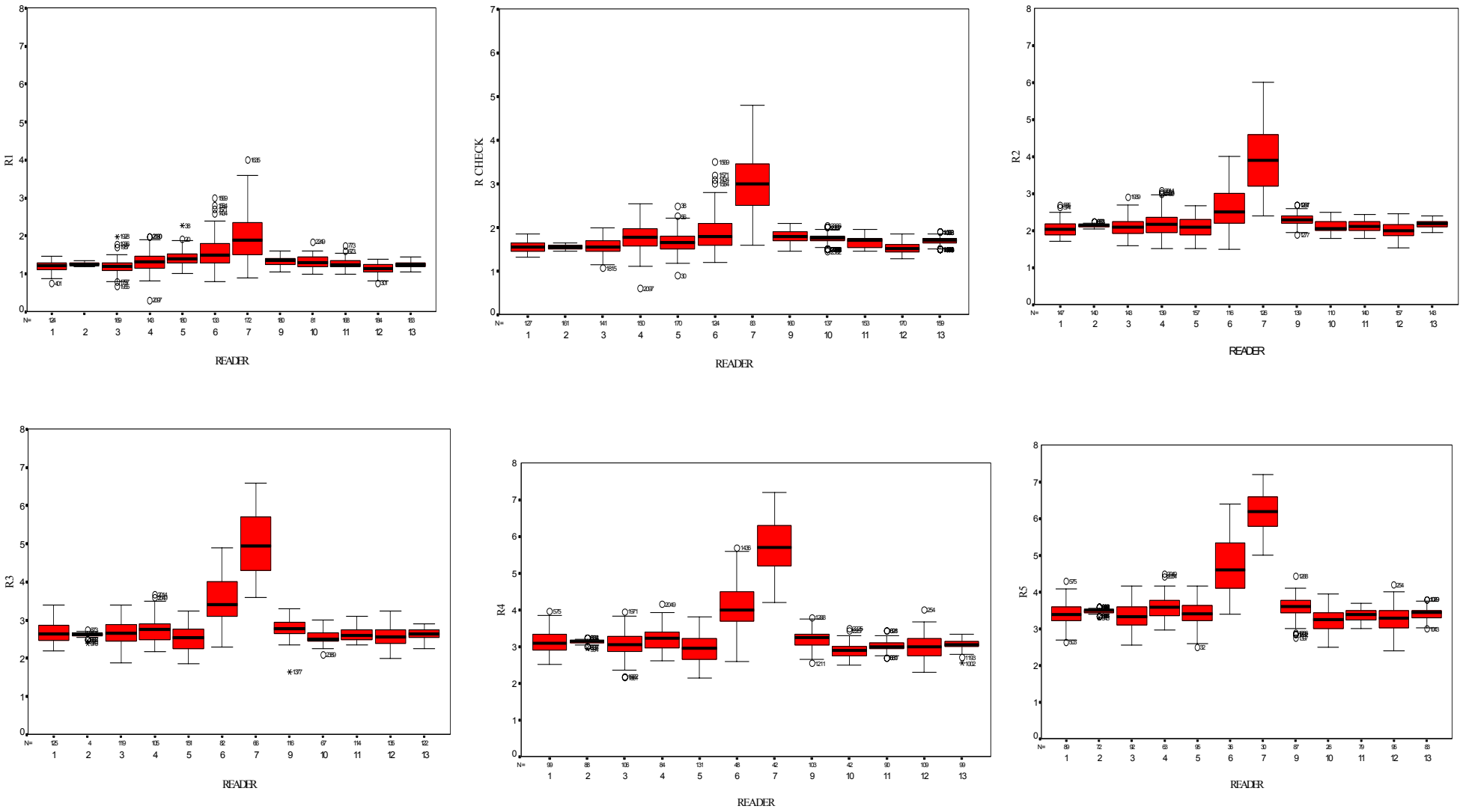


Figure 3 .- Box-whisker plot of the distances measured (mm) from all participant's readers for the following rings : R1-R5 from the first to the fifth ring and CHECK: check ring.

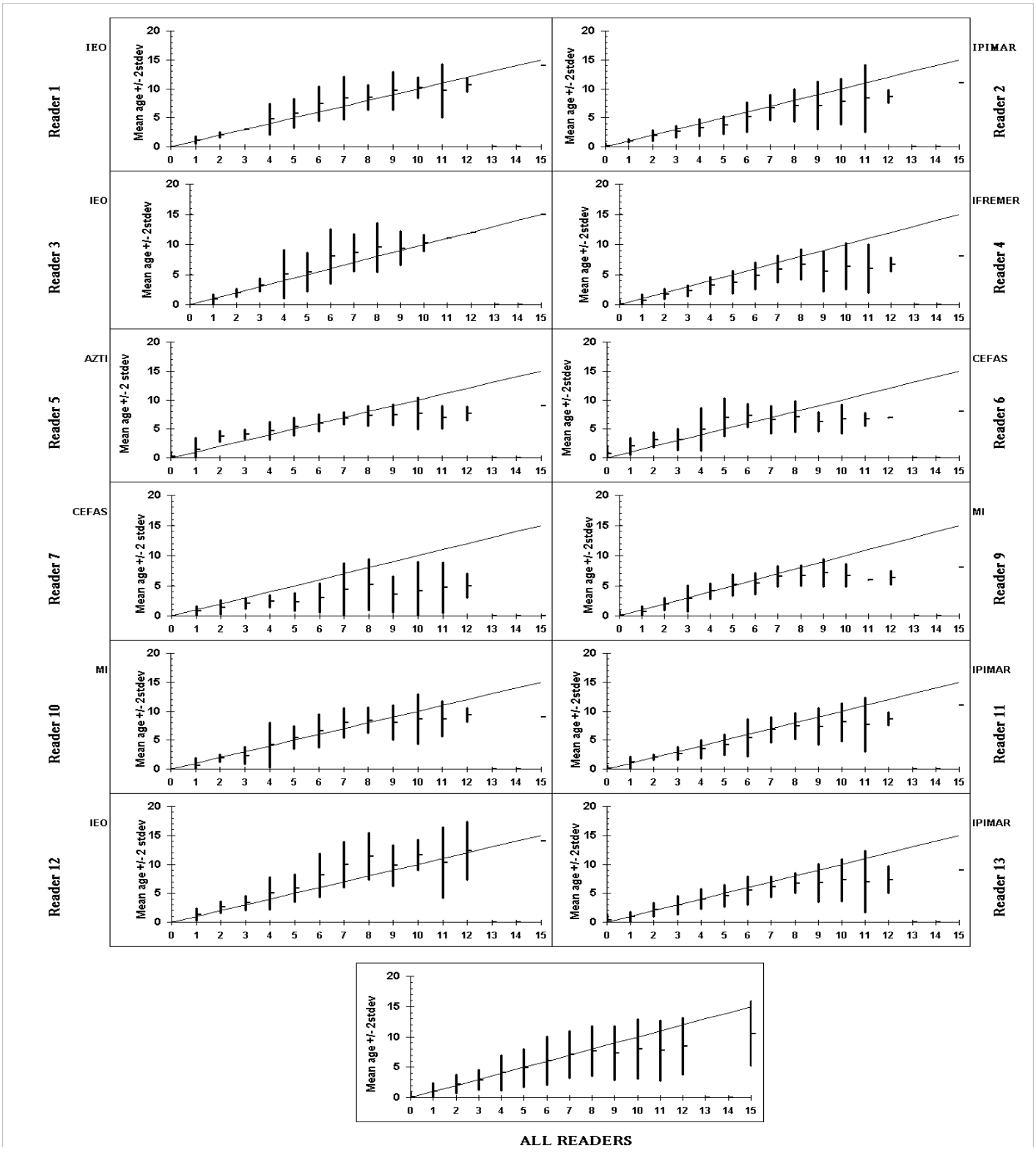


Figure 4 .-Mean age recorded +/- 2stdev of each age reader and all readers combined against the modal age (solid line). Relative bias is the age difference between estimated mean age and modal age.

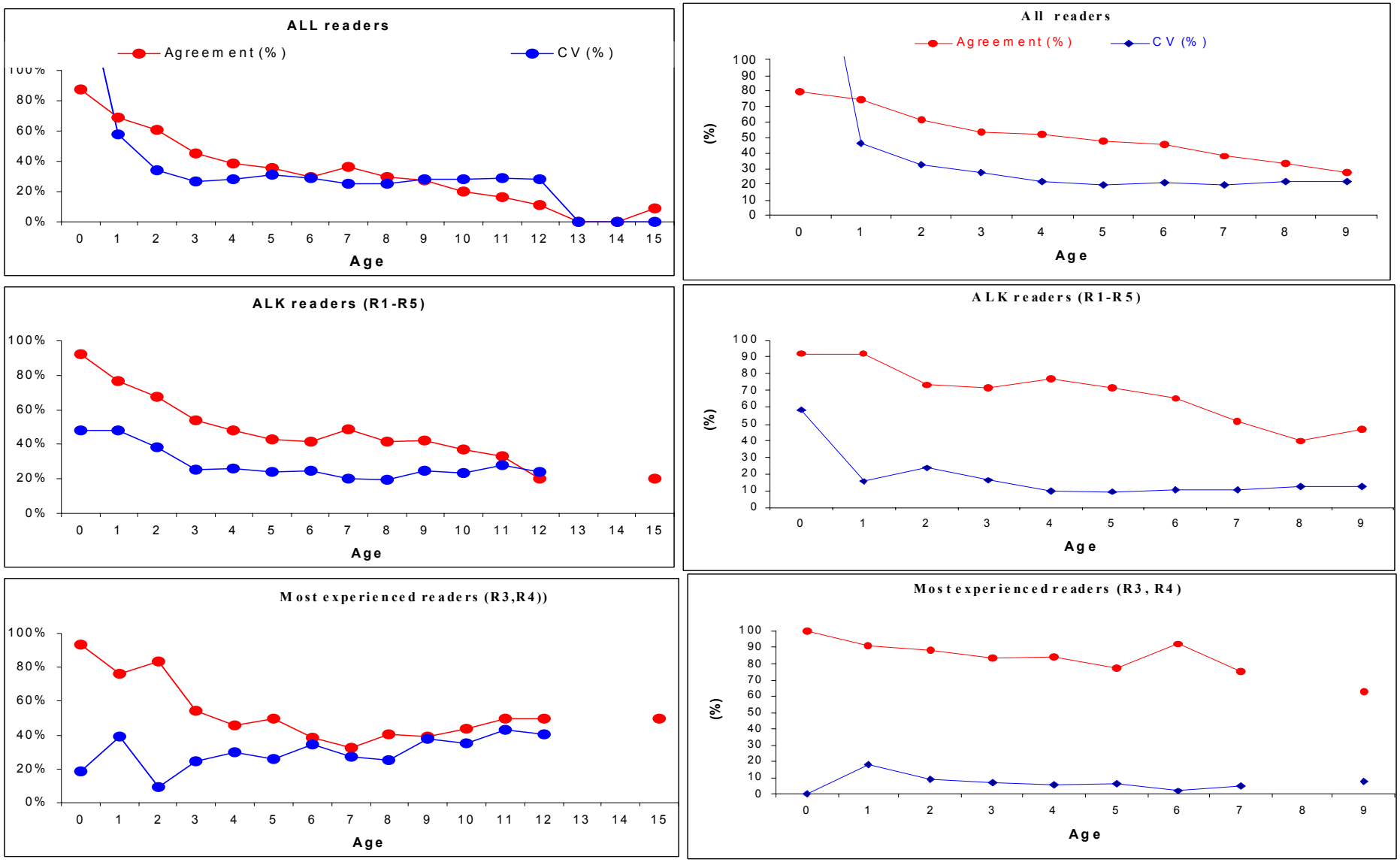


Figure 5.- The Coefficient of variation (CV %) and Percent of Agreement (%) from all participant's readers; readers involved in ALK's and the most expert readers (R3, R4) are plotted against modal age: Exchange 2003 and Exchange 2001

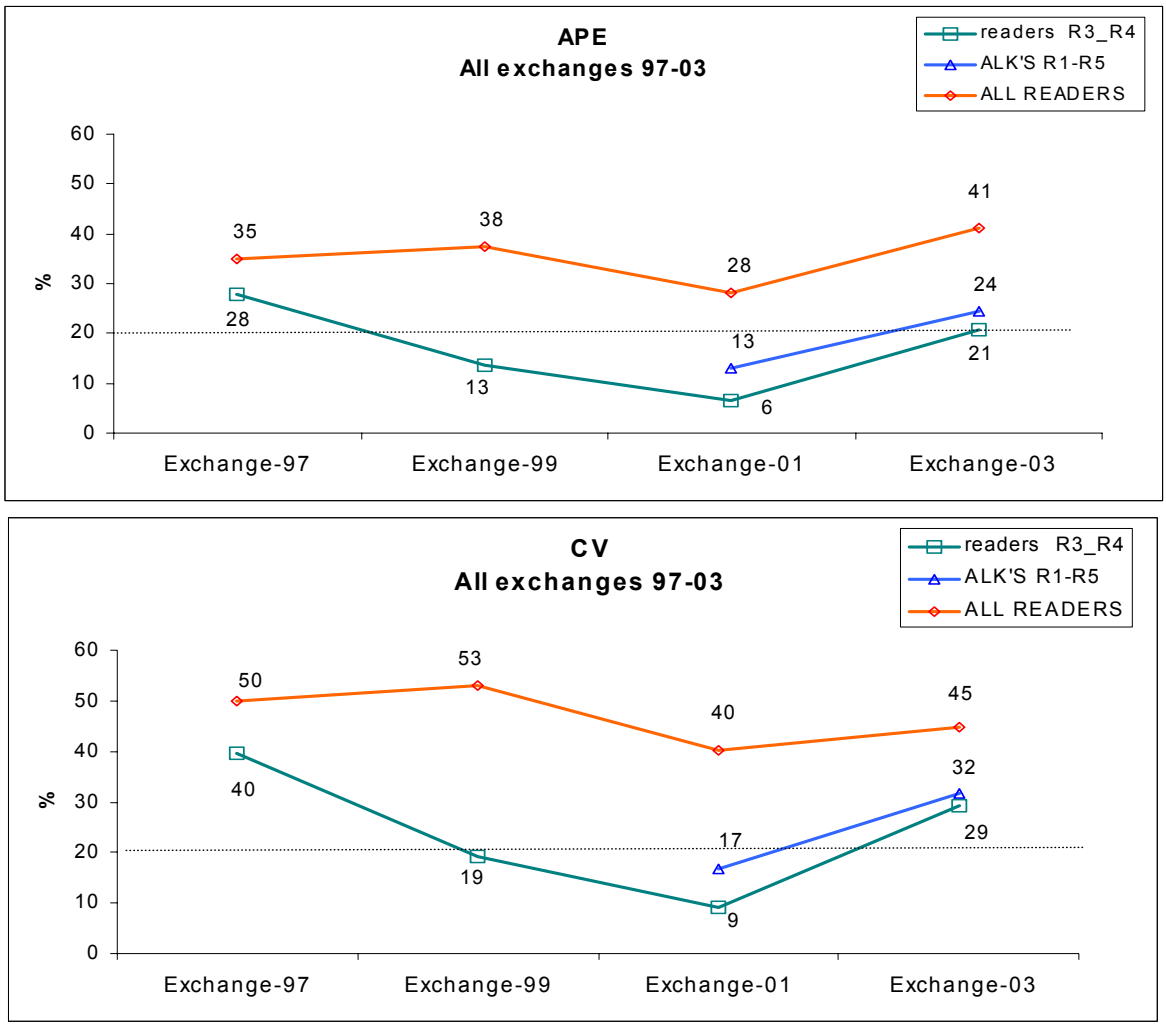


Figure 6.- Indices of Beamish and Fournier (APE) and Coeficient of Variation observed for all participant's readers, experienced readers (Involved in stock assessment: R1-R5) and most experienced readers (R3 and R4) through all series of exchanges (97-03)

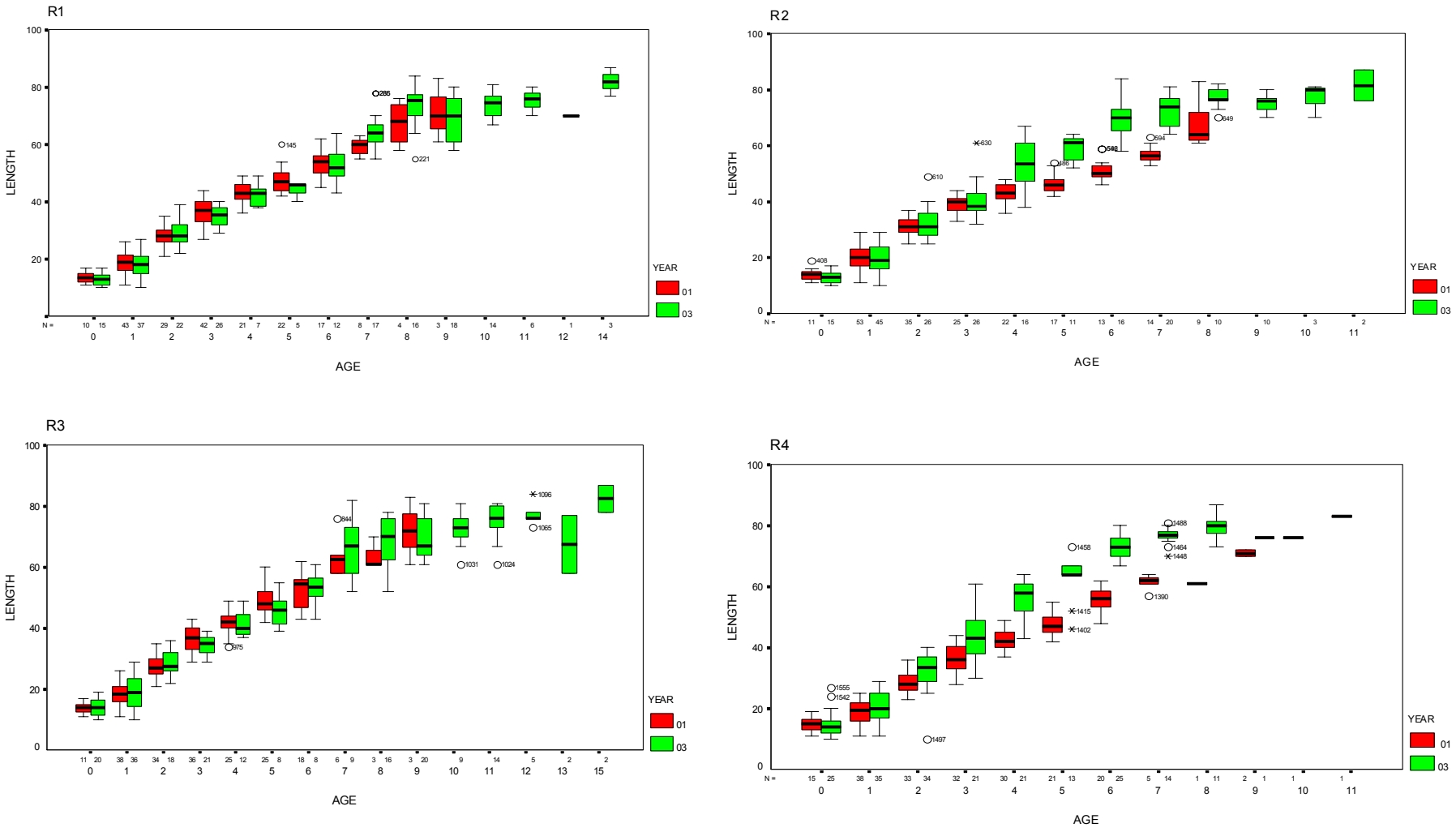


Figure 7.- Box-whisker plot of the length distribution (cm) by age obtained for ALK's readers in the last exchanges 01-03

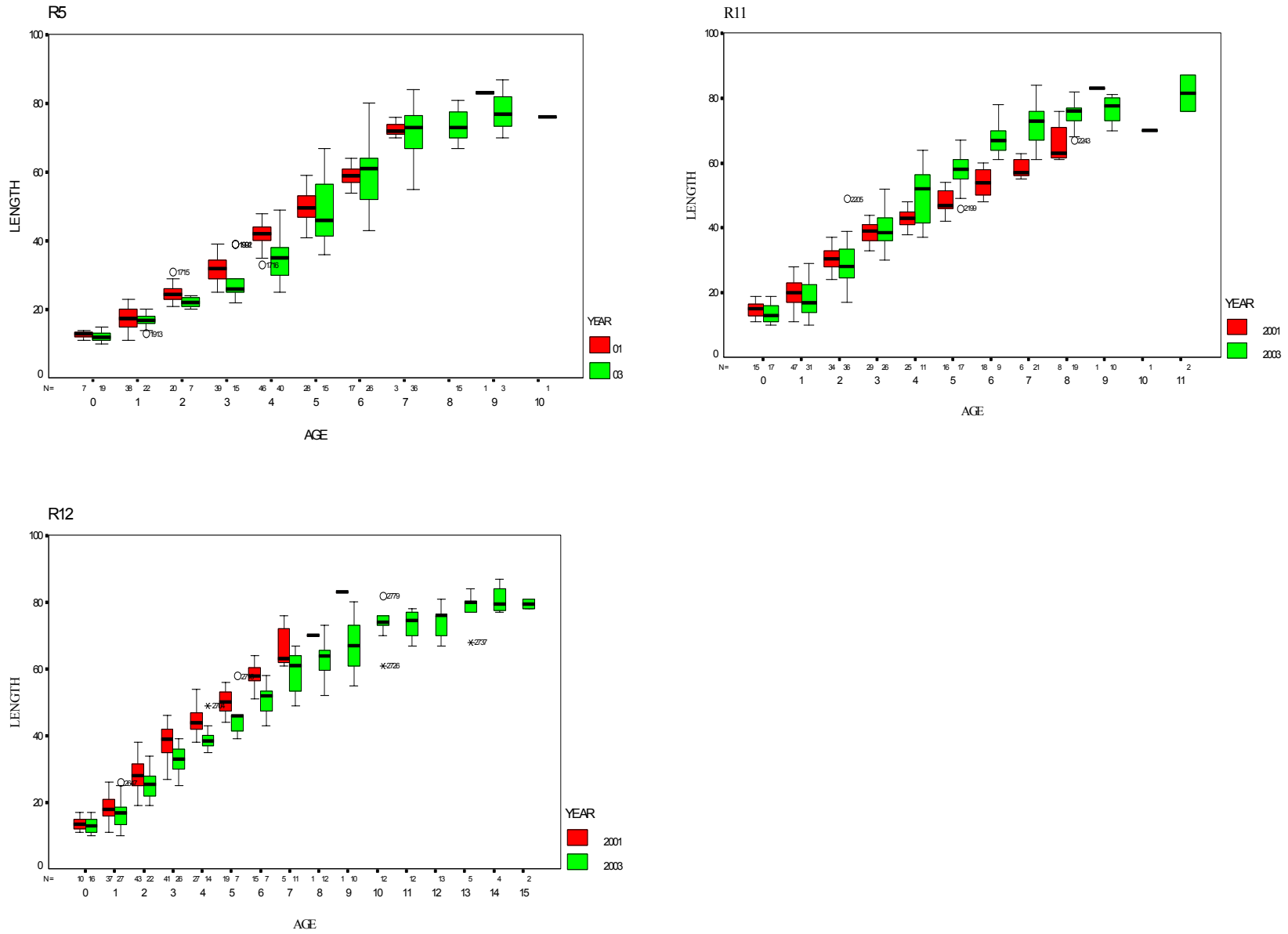


Figure 7.- Box-whisker plot of the length distribution (cm) by age obtained for ALK's readers in the last exchanges 01-03