# ***ANNEX 1***

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# 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

| | Sample | | Fish | Fish | Fish | Landing | IEO | IPIMAR | IEO | IFREMER | AZTI | CEFAS | CEFAS | MI | MI | IPIMAR | IEO | IPIMAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stratum | year | no | no | length | Sex | month | Reader 1 | Reader 2 | Reader 3 | Reader 4 | Reader 5 | Reader 6 | Reader 7 | Reader 9 | Reader 10 | Reader 11 | Reader 12 | 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 |

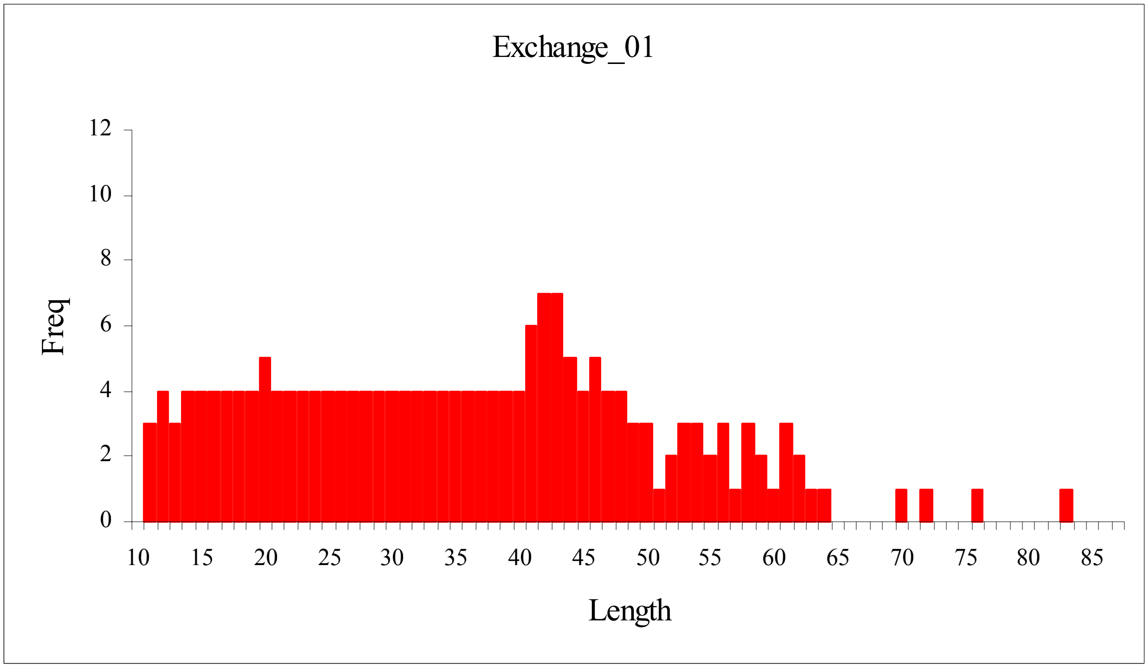
Table 1.- Results of age estimation by reader

| 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 ($p<0.01$)



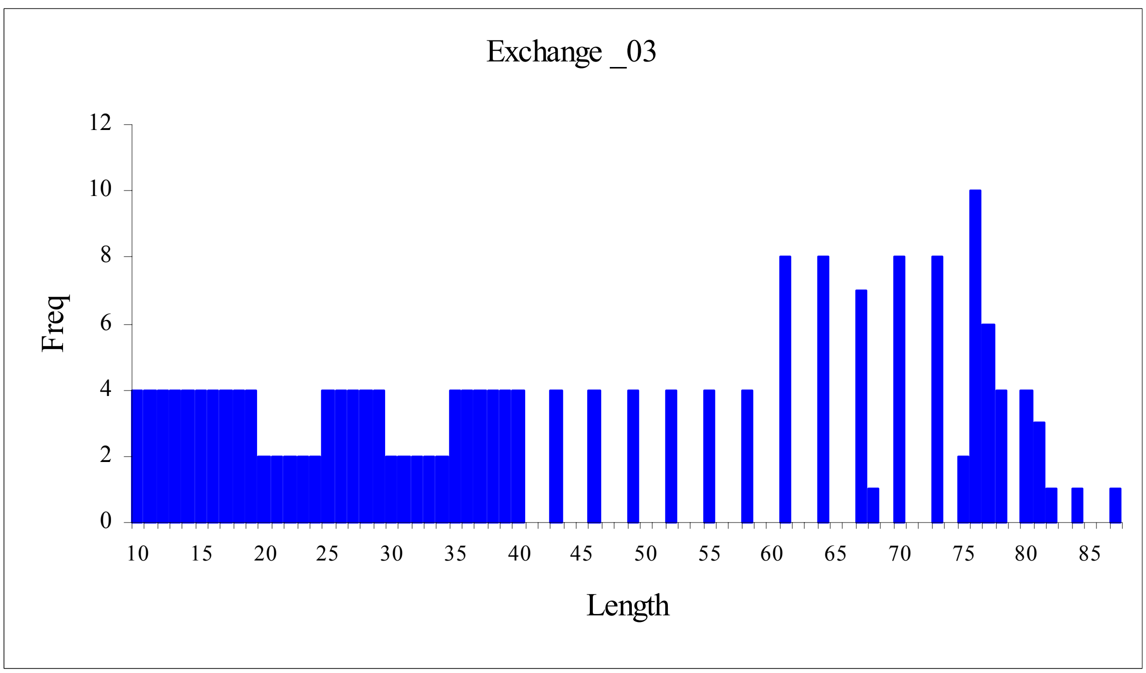




Figure 1.- Length frequency distribution of samples from hake otolith exchanges of 2001 and 2003.

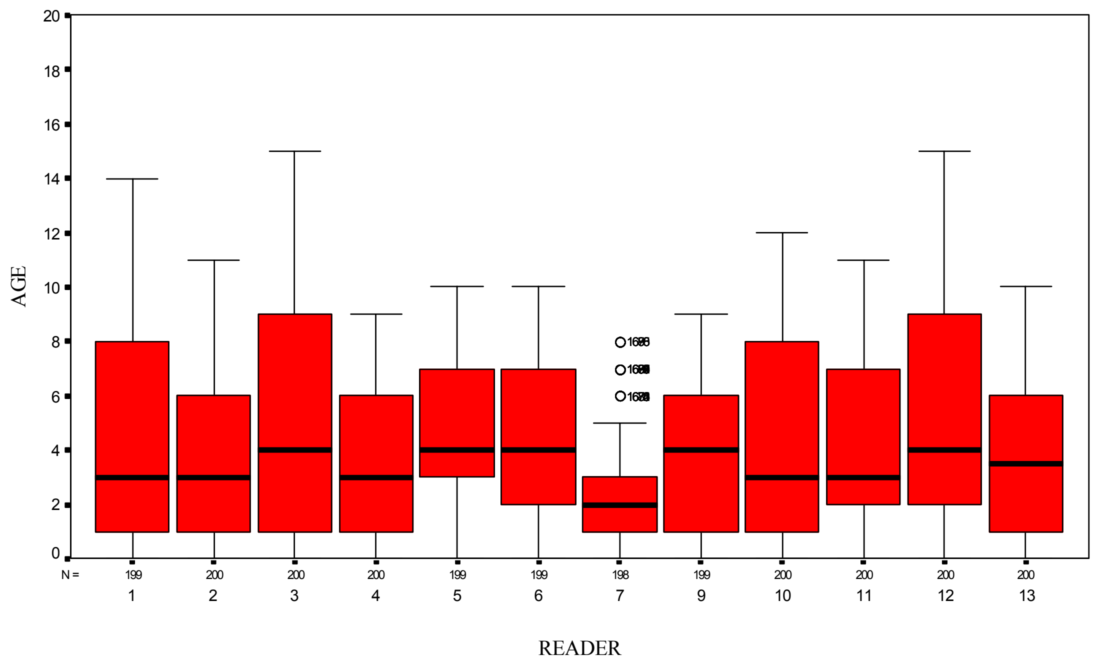



Figure 2.- Box-whisker plot of all readings

.

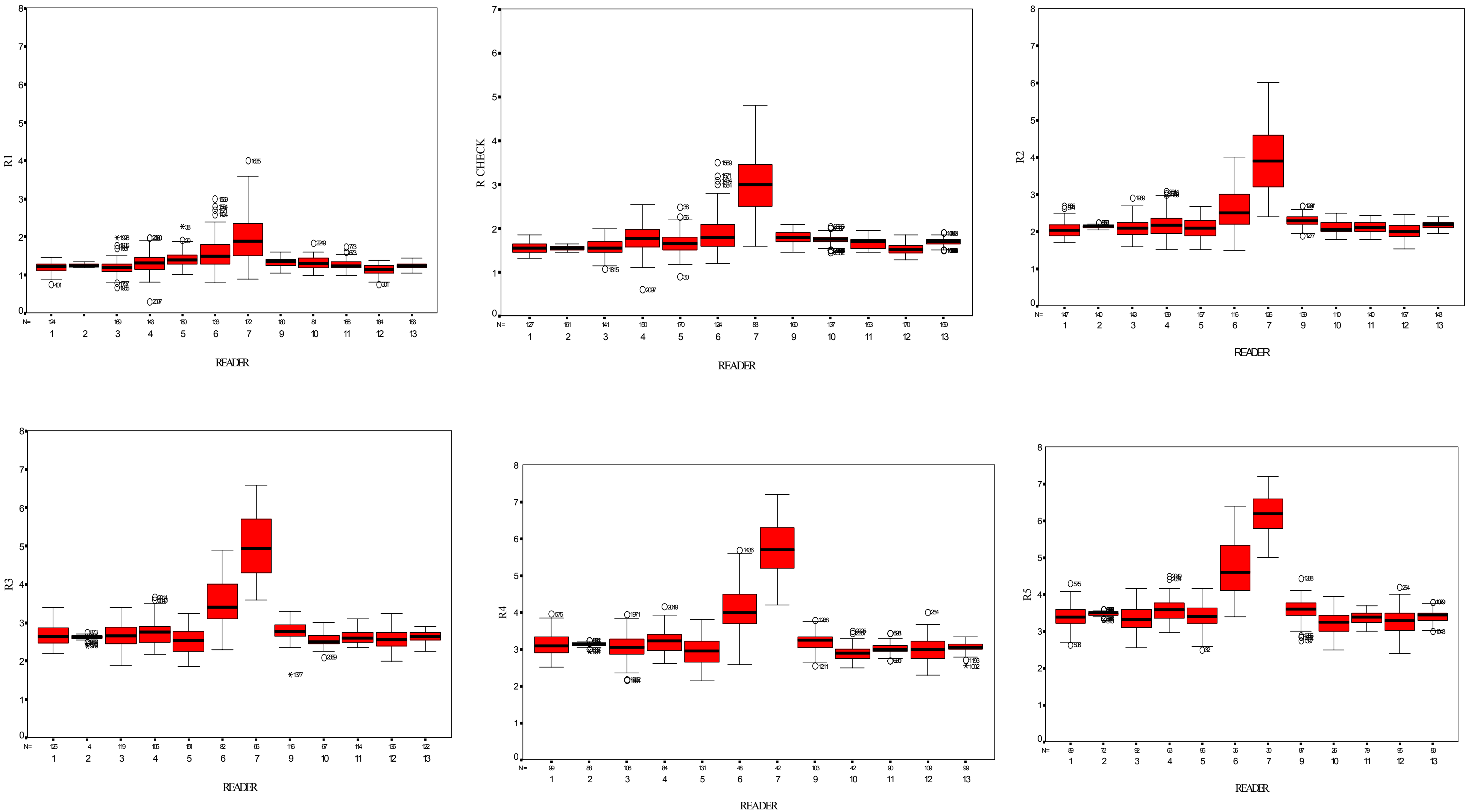



Figure 3 .- Box-whisker plot of the distances measured (mm) from all participant's readers for the following rings : R1-R5 from the first to the fifth ring and CHECK: check ring.

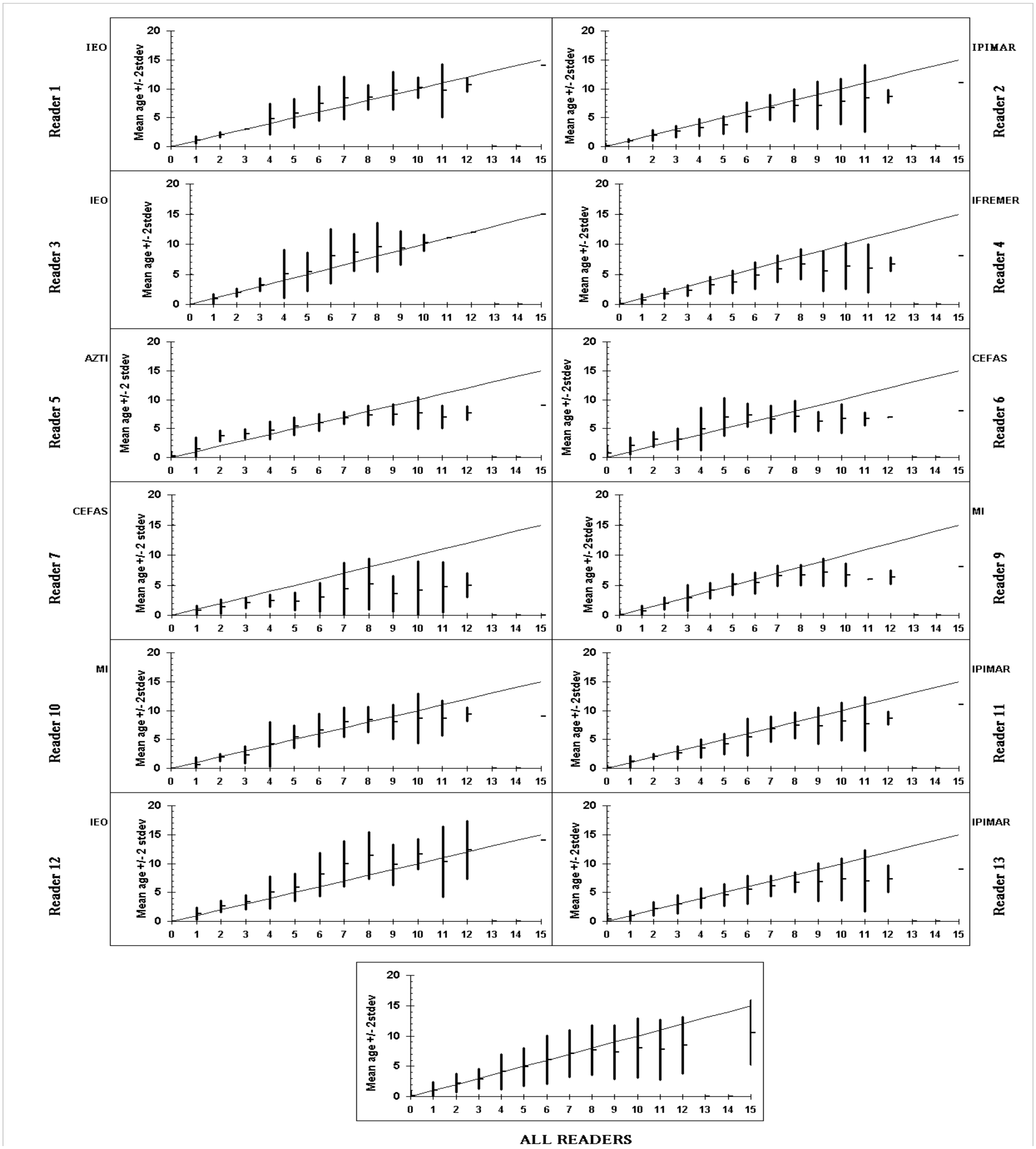



Figure 4 .-Mean age recorded +/- 2stdev of each age reader and all readers combined against the modal age (solid line). Relative bias is the age difference between estimated mean age and modal age.

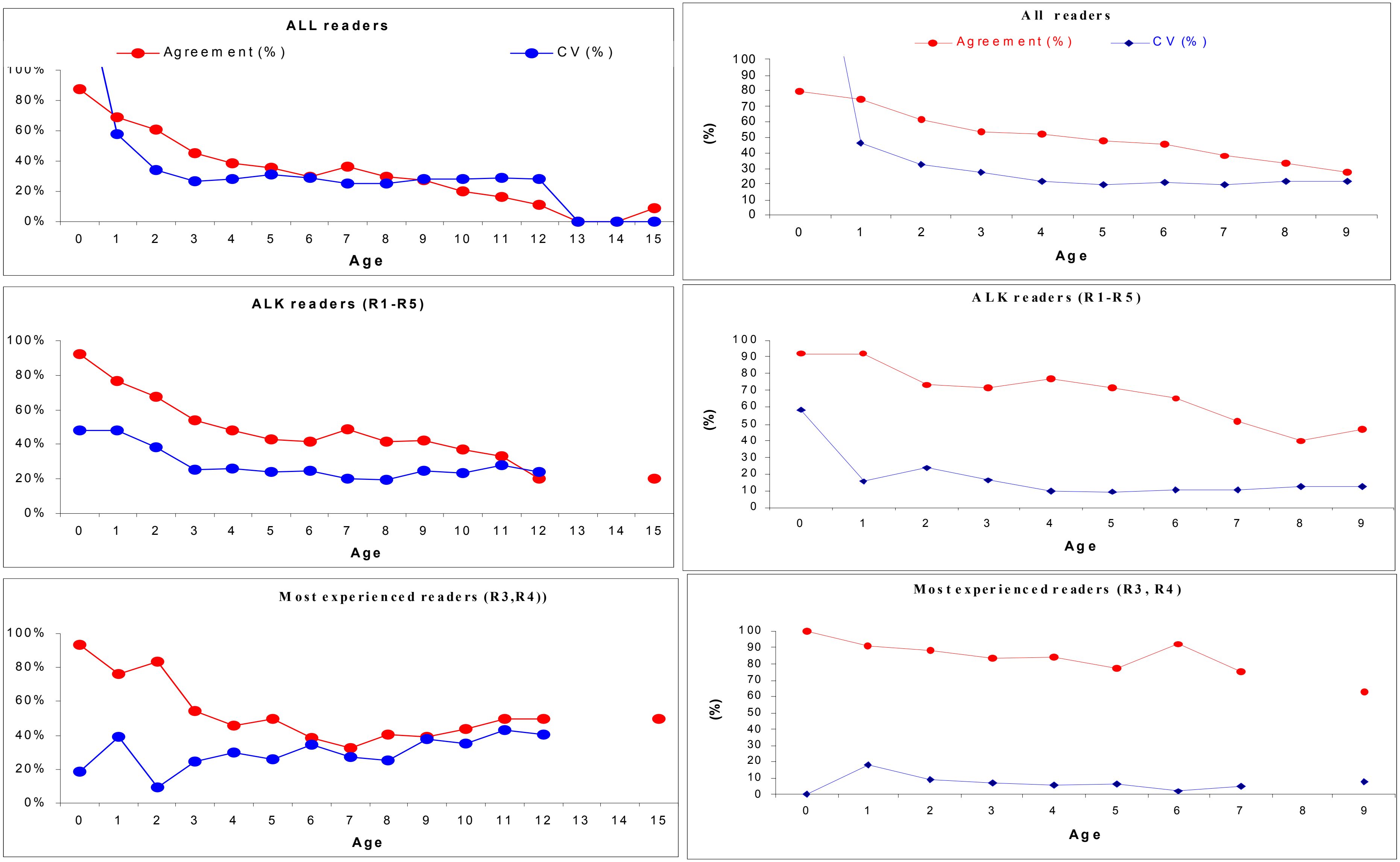



Figure 5.- The Coefficient of variation (CV %) and Percent of Agreement (%) from all participant's readers; readers involved in ALK's and the most expert readers (R3, R4) are plotted against modal age: Exchange 2003 and Exchange 2001

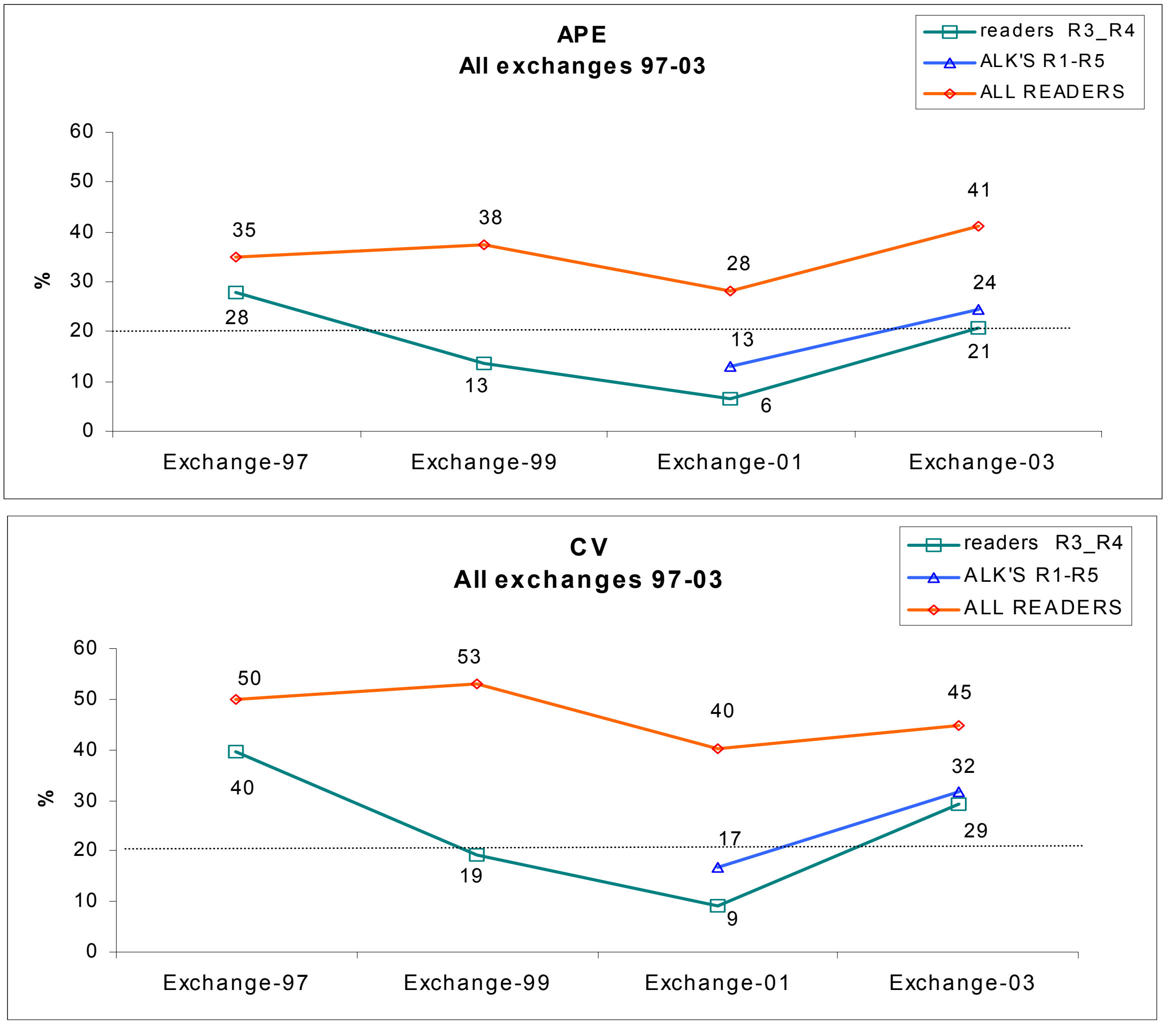



Figure 6.- Indices of Beamish and Fournier (APE) and Coeficient of Variation observed for all participant's readers, experienced readers (Involved in stock assessment: R1-R5) and most experienced readers (R3 and R4) through all series of exchanges (97-03)

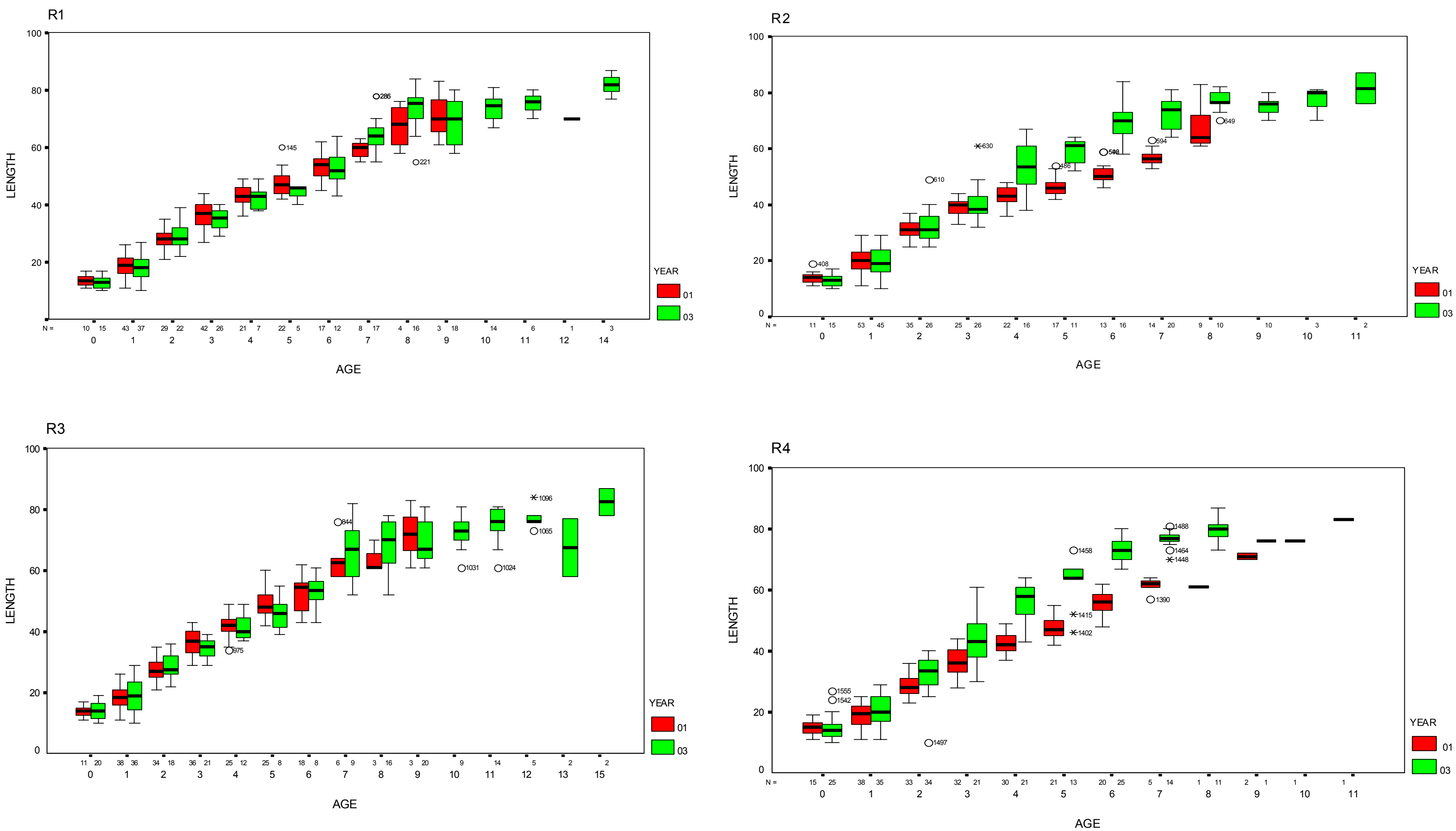



Figure 7.- Box-whisker plot of the length distribution (cm) by age obtained for ALK's readers in the last exchanges 01-03

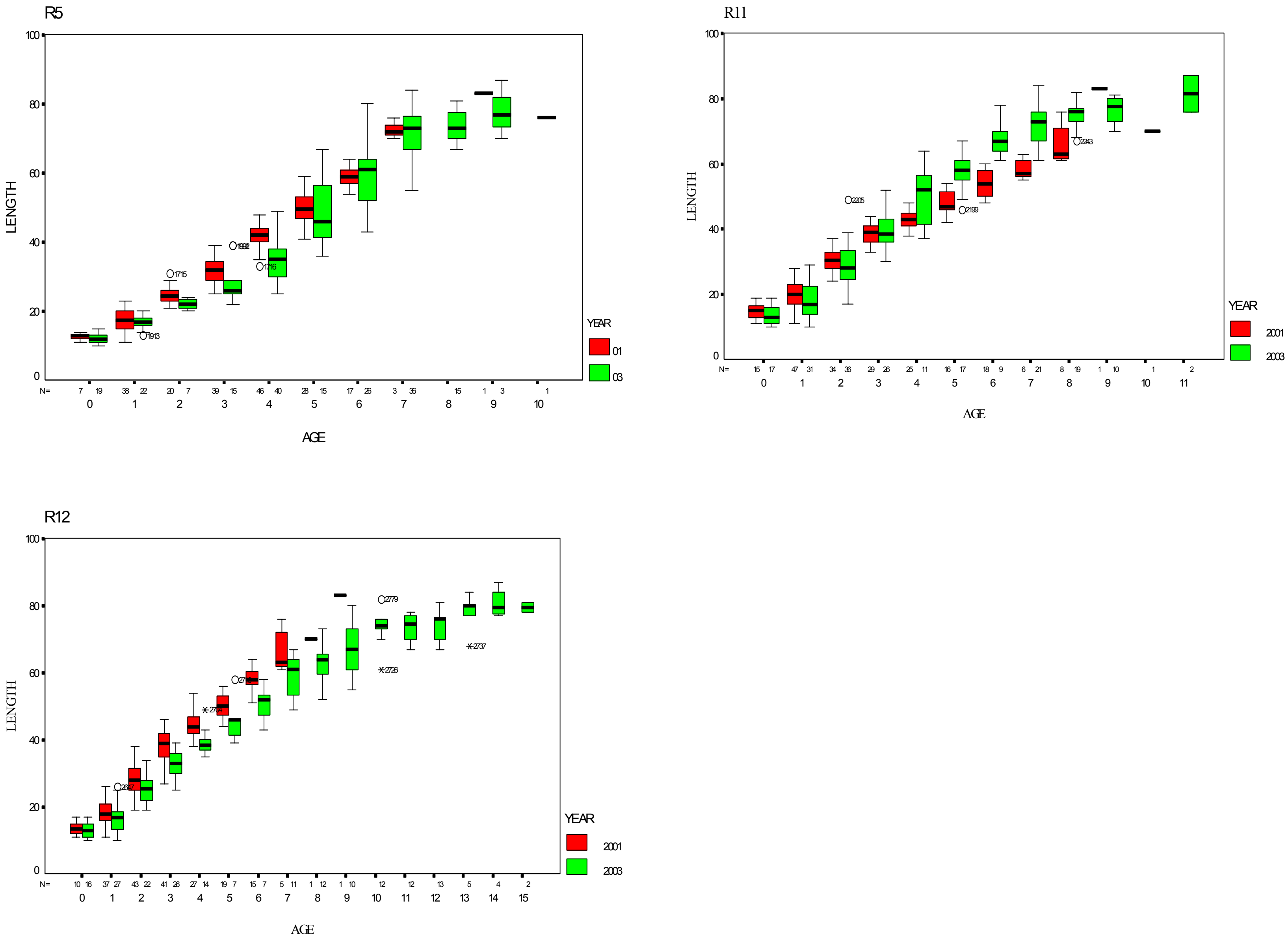



Figure 7.- Box-whisker plot of the length distribution (cm) by age obtained for ALK's readers in the last exchanges 01-03

# ***ANNEX 2***

# AGENDA: " WORKSHOP ON HAKE OTOLITH AGE READING" VIGO , 18-22 October 2004

*18.10.04: Monday      schedule:  10:00-13:30/15:00-17.30*

10:00   - Welcome. Short presentation of the participants
10:30   - Revision of Agenda: Timetable.
11:00   - *Coffee  break*
11:30   - 2003 Hake otolith exchange: Presentation of the results by Carmen Piñeiro
12:30 -  Discussion on otolith reading problems found
13:30 -  *Lunch*
15:00 -  Recent advances in the hake age validation: Results from tagging experiments conducted by IFREMER show that we may be largely underestimating growth rates by Hélène de Pontual
16:00 - Implications of new growth scenario for fisheries and for our work: Brainstorming session.

*19.10.04: Tuesday      schedule:  9:00-13:30/15:00-17.30*

9:00 -  Preliminary results of daily growth study: Does otolith microstructure of juveniles corroborate the fast growth model of European hake ? by Carmen Piñeiro
10:00 - Explanation of the Standard ageing criteria  by Carmen Piñeiro
10:30 - Calibration exercise - precision and consistency of otolith interpretation using current ageing criteria as reference:  Reading of a selected set of otoliths.
11:00 - *Coffee break*
11:30 - Calibration exercise:  Reading of a selected set of otoliths.
13:30- *Lunch.*
15:00- Discussion: Is it possible presently to establish ageing criteria for old fish? – Trials (?) and suggestions for the next future. Discussion with images of otoliths collection : growth interpretation and classification of the otolith edge type (opaque or translucent).
16:30 - Calibration exercise:  Reading of a selected set of otoliths

*20.10.04: Wednesday    schedule:  9:00-:12:00/14:30-17.30*

9.00 - Calibration exercise: Reading of a selected set of otoliths.
10:30-  Input of readings (cont.) and data analysis
12:00- *Lunch.*
14:30- Alternative method: Elaboration of synthetics ALK  (presentation by Paulino Lucio). Discussion: Given the current uncertainty about  the growth pattern of hake, explore interim alternative methods for obtaining ALKs that do not rely on empirical ALKs based on current otolith age reading criteria.

*21.10.04: Thursday schedule: 10:30-13:30/15:00-17.30*

9:00 - Preliminary results of first reading: analysis and discussion
Otolith Reading
11:30 - Preparation of the workshop report: Input draft of report
12:00 - *Lunch.*
14:30 - Discussion on problems found in the second reading
16:00 - Preparation of the workshop report: Input draft of report
21: 00 - Workshop dinner: A restaurant located in Vigo (6-7 Km).

*22.10.04: Friday schedule: 10:00-13:30*

9:00 - Preparation of the workshop report: Input draft of report
Summing up and main conclusions of the workshops
10:00- Elaboration of ALKs to be provided to the WGHMM Methodology for combining the ALKs from 3 institutes (AZTI, IEO, IPIMAR) in the Southern Hake stock.
11.00 - *Coffee break*
11.30 – Review of the draft of the workshop report
13:30 - *Lunch.*

# *ANNEX 3*

**BACKGROUND IN AGEING HAKE OTOLITHS OF THE PARTICIPANTS READER**

| Reader | Name | Institution | Country | ICES Areas | Reading period | N. of otoliths read per year | Participating in workshops: | Participating in exchanges: | ALK's for WG (no/yes - since when?) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | M. Saínza | IEO | Spain | VIIIc+IXa+VII | 1994/2004 | 3000 | 97/99/04 | 97/99/01/03 | 1994 |
| 2 | M. H. Afonso | IPIMAR | Portugal | IX a | 1996/2004 | 1800 | 97/99/04 | 97/99/01/03 | 1998 |
| 3 | C. Piñeiro | IEO | Spain | VIIIc+IXa+VII | 1984/2004 | 2500 | 97/99/04 | 97/99/01/03 | 1993 |
| 4 | J. Labastie | IFREMER | France | IV+V+VI+VII+VIII | 1977/2004 | 2000 | 99/04 | 97/99/01/03 | 1994 |
| 5 | | | | | | | | | |
| 6 | S. Warnes | CEFAS | England | VII+VIIIa | 1986/2004 | 600-2000 | 86/04 | 2003 | no |
| 7 | M. Easy | CEFAS | England | VII+VIIIa | 2002/2004 | 800-1000 | 2004 | 2003 | no |
| 9 | S. Hoey | MI | Ireland | VII | 2002/2004 | 3000 | 2004 | 2003 | 2003 |
| 10 | S. Beattie | MI | Ireland | VII | 2002/2004 | 3000 | 2004 | 2003 | 2003 |
| 11 | C. Morgado | IPIMAR | Portugal | IXa | 1998/2004 | 1800 | 2004 | 2001/2003 | 1999 |
| 12 | M. Marín | IEO | Spain | VIIIc+IXa+VII | 2000/2004 | 3000 | 2004 | 2001/2003 | no |
| 13 | S. Dores | IPIMAR | Portugal | IXa | 2003/2004 | - | 2004 | 2003 | no |
| 14 | A. Maceira | AZTI | Spain | VIIIabd+VII+VIIIc | 2003/2004 | 2000 | 2004 | 2003 | 2003 |
| 15 | B. Maertens | DVZ | Belgium | VIIIab | 2004 | 650 | 2004 | - | no |
| 16 | J. Perez Gil | IEO | Spain | CGPM-I+V+VI | 2003/2004 | 2500 | 2004 | - | no |
| 17 | F. Hansen | DIFRES | Denmark | IV+IIIAN | 2004 | 700 | 2004 | - | no |

# *ANNEX 4*

## Age interpretation criteria for (*Merluccius merluccius*) in Spanish Atlantic water

by

**Carmen Piñeiro y, M. Sainza**
**Instituto Español de Ocenografía**
**Workshop on ageing hake,**
**18-22 of October 2004**
**C.O. de Vigo**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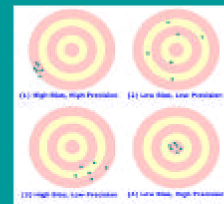
On principle, the age reading errors that affect precision and accuracy have to be estimated.

- Accuracy : closeness of the age estimate to the true value and is difficult because absence of known age structures
- Precisión : Reproducibility of repeated meaurements on a given struture and can be estimated



Ageing error can be of two forms, error that affect

- Recruitment estimation
- Mortality estimation
- Spawning Stock Biomass

However when there is a lack of known age material or any validation method of ages, an interim alternative is to ensure the quality of the age estimations in terms of precision

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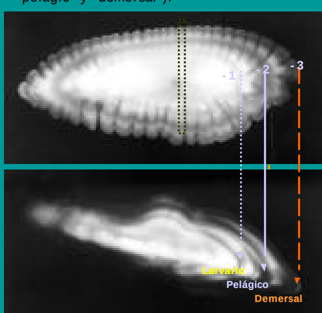
Standard ageing criteria stablished:

During the first year of life, the growth of the otoliths is characterised by the presence of three false rings around the nucleus (“larval”, “pelagic” y “demersal”).




whole

(otolith from an individual of 16 cm, captured in sep-97)

section

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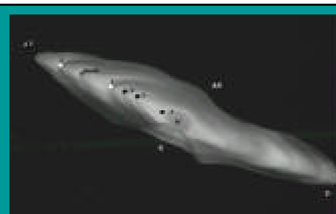
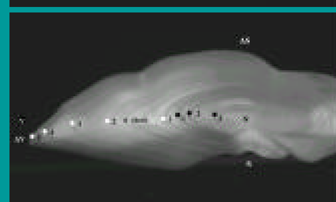


Transversal section of *sagitta* otolith from a Male captured in October 1997
age : 2 + years



Transversal section of *sagitta* otolith from a female captured in April 1997.
Age: 5 years

---

In Older Fish the Increments Are Narrower and More Visible on the Ventral Apex With a Progressive Shift in Growth Towards the Internal Face. The Area Beyond the Sixth Annual Ring Is Complex, the Frequent Appearance of Faint Lines Between Annual Rings Combined With the Gradual Reduction in the Spacing Between Them Made Difficult to Define a Consistent Reading Method.

---

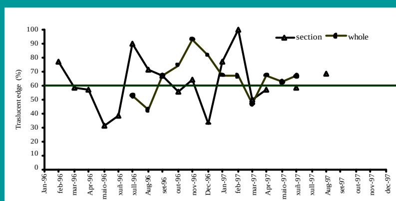
Average Measurements from the Nucleus to First rings in the Hake otolith of Southern Stock

| (mm) | DMedia | Std | Min | Max | N |
|---|---|---|---|---|---|
| R1 | 1.22 | 0.19 | 0.52 | 1.85 | 895 |
| Check | 1.57 | 0.13 | 0.99 | 2.13 | 608 |
| R2 | 1.98 | 0.17 | 1.56 | 2.46 | 656 |
| R3 | 2.49 | 0.2 | 1.73 | 3.09 | 459 |

1.- On average, 60% of the whole otoliths present translucent edge, indicating a high incidence of checks particularly in summer samples.

2.- Overall, two peaks of translucent edges per year are observed in the otoliths. The most important occur in winter (November) and the secondary one in summer (June). These two peaks appear also in otolith sections but they are visible later, the first in February and the second in July.

3.-Nevertheless the optical characteristics of the thin sections under variable light could have affect these results.



# *ANNEX 5*

2003 Hake otolith exchange
(*Merluccius merluccius*) in Atlantic Waters: results

**by**
Carmen Piñeiro and Maria Sainza,
C. O. de Vigo (IEO)

## Introduction:

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. There was a recommendation to present ALKs with the 10+ age group

The experts in growth called the attention of being aware of the quality of basic age data (WD to the WG 2002 in Lisbon) and they considered impossible to provide oldest ages estimates with relative confidence.

This WGHMM recommended to undertake these problems through an exchange focused on older fishes and a subsequent specific international workshop.

In march 2003 the Planning Group in Rome(PGCCDBS), assumed to celebrate this Workshop within the framework of the National Data Collection and Management Programme.

## Objectives :

- 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 fish
- To incorporate new readers in hake age estimation.

The report of this exchange: *WD to the ICES WGHMM* celebrated at Gijon, Spain (12-21 May 2004)

## Participants:

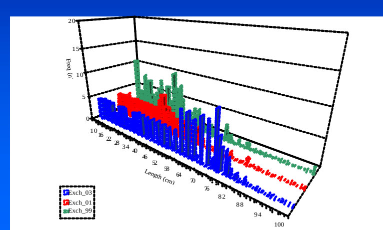
| Reader | Name | Institution | Degree of Exp | Country |
|---|---|---|---|---|
| Reader 1 | M. Saínza | IEO | Expert | Spain |
| Reader 2 | M. H. Afonso | IPIMAR | Expert | Portugal |
| Reader 3 | C. Piñeiro | IEO | Most exp. | Spain |
| Reader 4 | J. Labastie | IFREMER | Most exp. | France |
| Reader 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 |

## The background for ageing hake was based:

- Reports of Hake Otolith Age Reading Workshops (1997 and 1999); EFAN Report 6-2000 and EFAN 7-2000,
- Report of 3rd exchange on European hake age readings, 2001 (SAMFISH).

## Material and methods:

- 200 Hake otolith sections from both, Northern and Southern stocks
- Period: May 2003 - February 2004.
-A protocol and Digitalised images from otoliths sections were available in a CD
- Rings r1-r5 and the check ring considered by reader, were measured.
- Bind read




Exchange collections: 1999-2003

## Material and methods:

- Guidelines and Tools for Age Reading Comparisons, EFAN Report 3-2000.

- The analysis was done: Excel ad-hoc Workbook "AGE COMPARATIONS. XLS" from A.T.G.W. Eltink from RIVO.

- The level of experience of the readers was split into three levels in order to make comparisons with previous exchanges:

A: all participating readers
B: readers involved in hake stock assessment (R1-R5),
C: the most expert readers (R3-R4)

## Material and methods:

Exploratory data analysis (EDA):

- The modal age was calculated based on the results of readers involved in stock assessment: R1-R5.

- Graphical representation: The box-whisker plots and Bias plot were used to summarise the observations

In terms of reproducibility measures:

1.- APE. Beamish and Fournier (1981) is an index of reading precision to compare a series of observations.

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

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

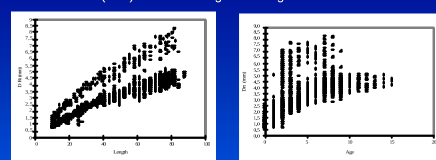
2.- **CV** .The precision errors in age reading are best described by this coefficient by age group, the CV might often differ by age group.

$$CV = \frac{100}{n}\left[\sum_{i=1}^{n}\left(\frac{sd}{x_i}\right)\right]$$

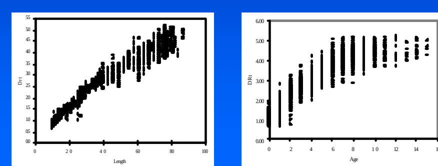
sd= the standard deviation forthe i otolith

## Results:

Otolith radiusRT ( mm) vs fish length and age of fish for all readers

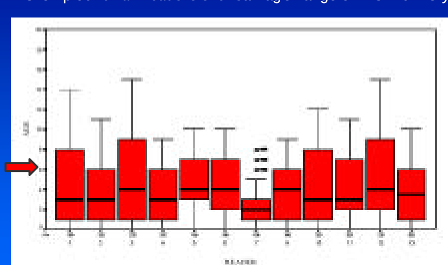


all readers except Reader6 and Reader 7.

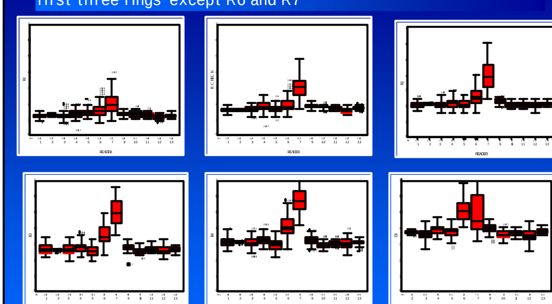


## Results:

Box-wisker plot for all readers showsan age range of fish: 0-15 years

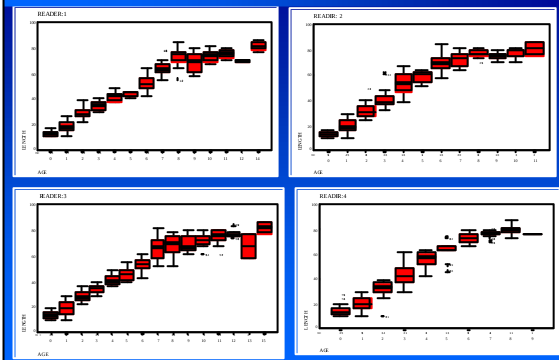


## Results: High agreement between readers in the location of the first three rings except R6 and R7

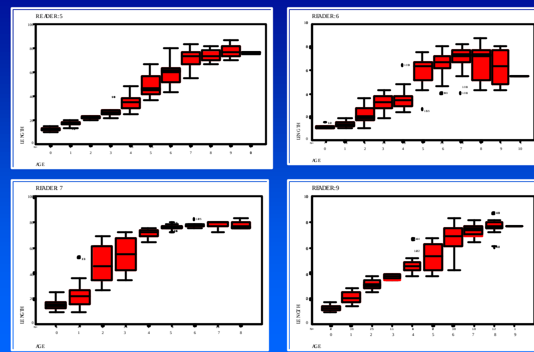


Box-whisker plot of the distances measured (mm) for rings : r1-r5 and check ring.

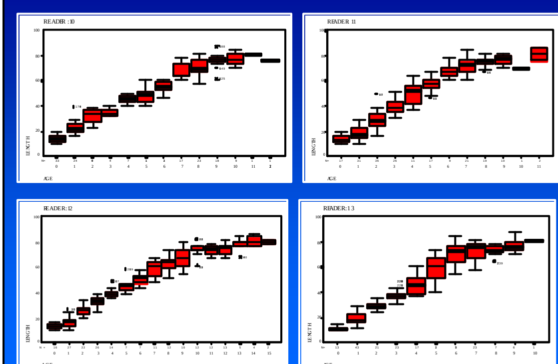
## Results: Box-wisker plot of the ring distances measured by reader (R1-R4)



## Results: Box-wisker plot of the ring distances measured by reader (R5-R9)

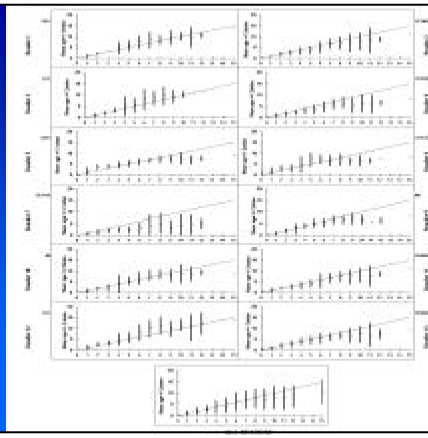


## Results: Box-wisker plot of the ring distances measured by reader (R10-R1



Mean age recorded +/ - 2std 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.



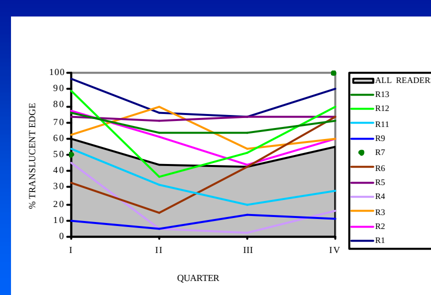
## Wilcoxon signed rank test for the readings of otolith collection

**Inter-reader bias test and reader against MODAL age bias test**

| | IEO Reader 1 | IPIMAR Reader 2 | IEO Reader 3 | IFREMER Reader 4 | AZTI Reader 5 | CEFAS Reader6 | CEFAS Reader 7 | M Reader 9 | MI Reader 10 | IPIMAR Reader11 | IEO Reader 12 | IPIMAR Reader 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reader1 | | ** | * | ** | ** | - | ** | ** | ** | ** | ** | ** |
| Reader2 | ** | | ** | ** | ** | ** | ** | - | ** | ** | ** | - |
| Reader3 | * | ** | | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| Reader4 | ** | ** | ** | | ** | ** | ** | ** | ** | ** | ** | ** |
| Reader5 | ** | ** | ** | ** | | - | ** | ** | - | ** | ** | ** |
| Reader6 | - | ** | ** | ** | - | | ** | ** | - | ** | ** | ** |
| Reader7 | ** | ** | ** | ** | ** | ** | | ** | ** | ** | ** | ** |
| Reader9 | ** | - | ** | ** | ** | ** | ** | | ** | - | ** | - |
| Reader10 | ** | ** | ** | ** | - | - | ** | ** | | ** | ** | ** |
| Reader11 | ** | ** | ** | ** | ** | ** | ** | - | ** | | ** | ** |
| Reader12 | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | | ** |
| Reader13 | ** | - | ** | ** | ** | ** | ** | - | ** | ** | ** | |
| MODAL age | ** | ** | ** | ** | - | - | ** | ** | - | ** | ** | ** |

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

## Classification of the otolith edge throughout the annual period



CV: 45%- 30%

% Agrem:47%

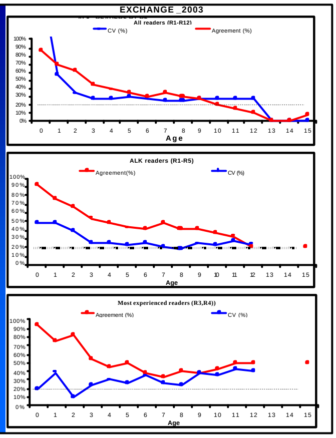
The coefficient of variation (CV%) and percentage of agreement are plotted against MODAL age.

CV: 32% - 20%

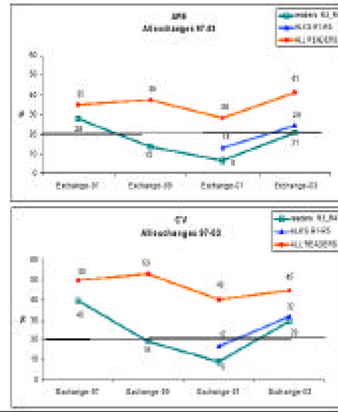
% Agrem:57%

CV: 29%

% Agrem:57%

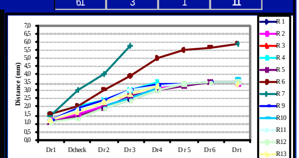



APE, CV, observed for three group of readers (R1- R5), (R3 and R4) through all series of exchanges.

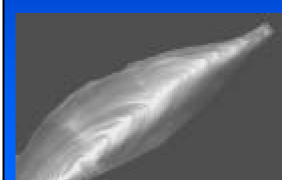


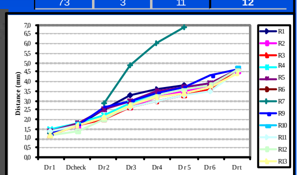

## Otoliths <15 % agreement

| COD: 29 | | | |
|---|---|---|---|
| length | Sex | month | modal age |
| 61 | 3 | 1 | 11 |



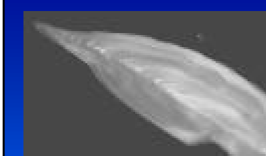

| COD: 1165 | | | |
|---|---|---|---|
| length | Sex | month | modal age |
| 73 | 3 | 11 | 12 |

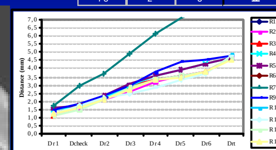




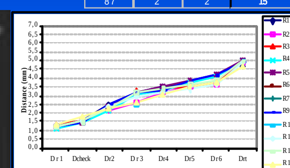

## Otoliths <15 % agreement

| COD: 10066 | | | |
|---|---|---|---|
| length | Sex | month | modal age |
| 78 | 2 | 3 | 12 |



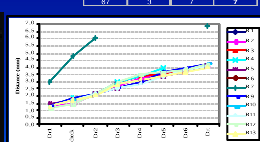



| COD: 45 | | | |
|---|---|---|---|
| length | Sex | month | modal age |
| 87 | 2 | 2 | 15 |

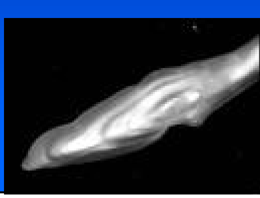


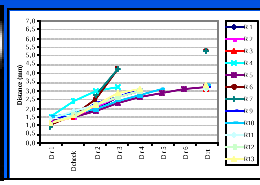

## Otoliths > 50 % agreement

| COD: 852 | | | |
|---|---|---|---|
| length | Sex | month | modal age |
| 67 | 3 | 7 | 7 |



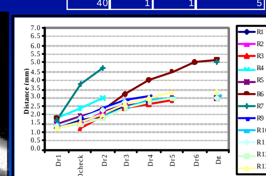

| COD: 794 | | | |
|---|---|---|---|
| length | Sex | month | modal age |
| 43 | 2 | 7 | 4 |



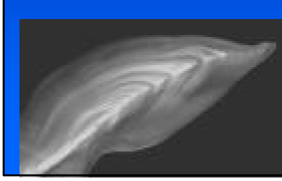


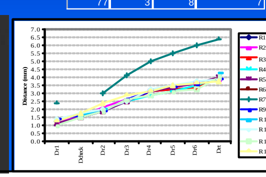

## Otoliths > 50 % agreement

| COD: 453 | | | |
|---|---|---|---|
| length | sex | month | modal age |
| 40 | 1 | 1 | 5 |

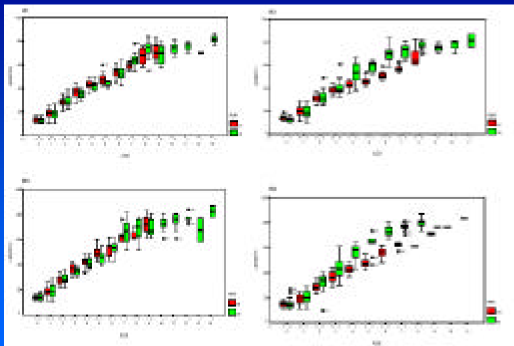



| COD: 493 | | | |
|---|---|---|---|
| length | sex | month | modal age |
| 77 | 3 | 8 | 7 |

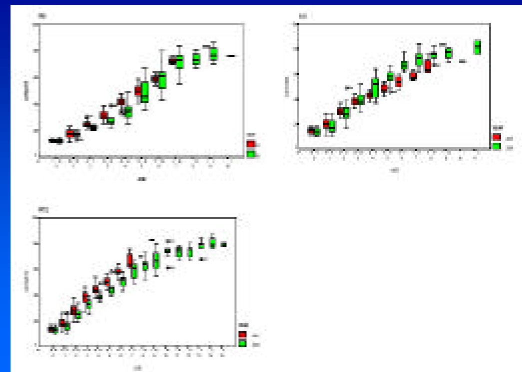




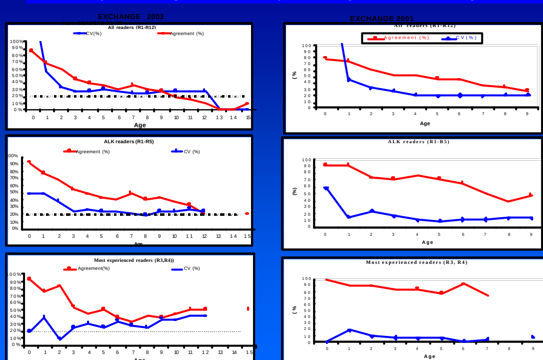
## Box-wisker plot of the readings from otoliths exchanges 2001 and 2003



## Box-wisker plot of the readings from otoliths exchanges 2001 and 2003



## CV % and percent agreement are plotted against MODAL age.




**EXCHANGE 2003** **EXCHANGE 2001**

## Conclusions:

- Age estimation criteria up to age 3 is the same for the readers involved in ALK.
- The precision of age readings has decreased and a strong bias has been found in age readings of older fish.
- The average percentage of agreement was 47% for all readers and 57 % for readers involved in stock assessment
- The values of APE and CV in % for :
  - all readers: 41 and 45 respectively
  - assessment reader 24 and 32

The comparison of these results with those from the previous exchange (2001), shows a higher bias and lower percentage of agreement which represents a backwards step

- A possible account of why this bias happened: the underestimation of growth of hake obtained in the tagging experience of hake conducted in June 2002 by IFREMER. ( Hélene de Pontual, et al ;2003).
- Taking into account these results at the moment is difficult to provide age estimations for fish older than 3 for stock assessment of this species with an acceptable level of assurance
- Ageing criteria for older fishes can not be established, considering the difficulties found with old fish and the low precision obtained for these fish.

## Conclusions:

- These bias plots by reader and all readers combined show the difficulty to recognise the ageing criteria established for new readers and reflect the importance of training in otoliths age reading.
- The complexity of age estimation of European hake remains and the knowledge of ages validated are essential to provide a new interpretation scheme of otolith based on reliable data.

Recommendations:

Future efforts should be carried out along two lines until no more information validated is available on growth rates of hake.

1. To find out other methods to obtain synthetic Alk´s for stocks assessment or methods of assessment without ages, as a interim solution for the present situation.

2. 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 and the recent data obtained by tagging and recapture 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.

Another workshop for scientists working on Hake biology is recommended in order to review and discuss the biological parameters (growth and maturity) in relationship with the recent developments on age validation and their impact on stock assessments and predictions.

# *ANNEX 6*

# Do we need to revise growth estimation of European hake (*Merluccius merluccius*)?

Hélène de Pontual[1], Anne-Laure Groison[1], Carmen Piñeiro Alvarez[2]
1. IFREMER, Laboratoire de Sclérochronologie des Animaux Aquatiques, BP 70, 29280 Plouzané, France.
2. Instituto Español de Oceanografía, IEO, Apdo. 1552, 36200 Vigo, Spain. email : Helene.De.Pontual@ifremer.fr



## Background and hake management issues

European hake are distributed widely over the NE Atlantic shelf from Norway to Mauritania. Total landings have declined from 120.000 tons in 1960' to the current level of 50.000 t. In recent years, assessments have raised concern about the state of the stocks : spawning stock biomass is low and declining and recruitment is poor, both phenomena being linked to overfishing of the population (ICES 2003).

Scientific advice for assessment faces a number of specific problems. Despite a long exploitation, little is known about the basic biology of hake. Uncertainties about growth, natural mortality, spatial structure and dynamics strongly limit the efficiency of stock assessment and prediction of both northern and southern stocks. Mark-recapture experiments can provide invaluable information regarding these aspects.

## The first recorded mass tagging experiment

In 2002 Ifremer carried out a pilot experiment in the northern Bay of Biscay on board the 25m trawler RV "Gwen Drez". We used a 21 m bottom trawl equipped with rockhopper gear and a codend specially designed to avoid crushing fish and to retain water during hauling (fig.1).
Fish were measured to the centimetre below, tagged with a Floy tag® T-bar tag and injected with oxytetracycline (OTC) at a dose of 60 mg per kg.
The methodology is fully described in De Pontual *et al.* (2003).
At the end of the cruise, a total of 1307 fish had been tagged and released.

Fig.1 : codend designed for hake capture

The size range was 13-58 cm with a mode at 28 cm. To date, 35 tagged fished and 5 additional tags have been returned (recapture rate : 3.1%). Time at liberty varies from 1 to 440 days (fig .2). Fish movement vary in distance and direction (fig.2).

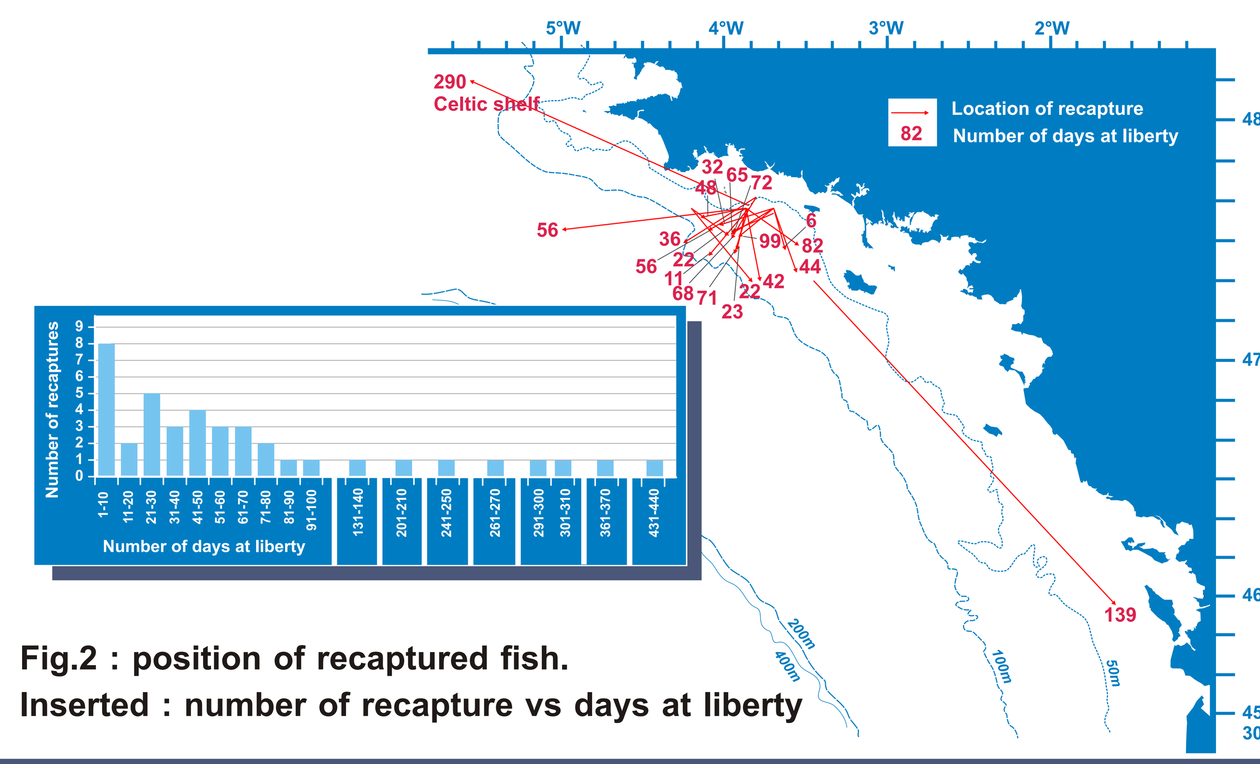



Fig.2 : position of recaptured fish.
Inserted : number of recapture vs days at liberty

## Do we underestimate somatic growth ?

The growth rate of recoveries was estimated at 0.038 0.020 cm. day$^{-1}$ (mean 1 s.d.). There was no significant difference between males and females. Fish which spent at least 1 summer and 1 winter at liberty showed an average growth rate of 21,10 0.91 cm.year$^{-1}$ .
The observed growth was compared to the growth expected from current models (ICES 1993) and Lucio *et al.* (2000)) using the following equation : $L_2 - L_1 = (L \;\; - L_1)(1 - e^{-K(t2-t1)})$.
Observed growth was twice larger than expected (fig.3a).
Available data were used to adjust a new Von Bertallanfy growth curve setting L at 120 cm. Figure 3b presents the comparison between current growth models and what could be the actual growth model for European hake.

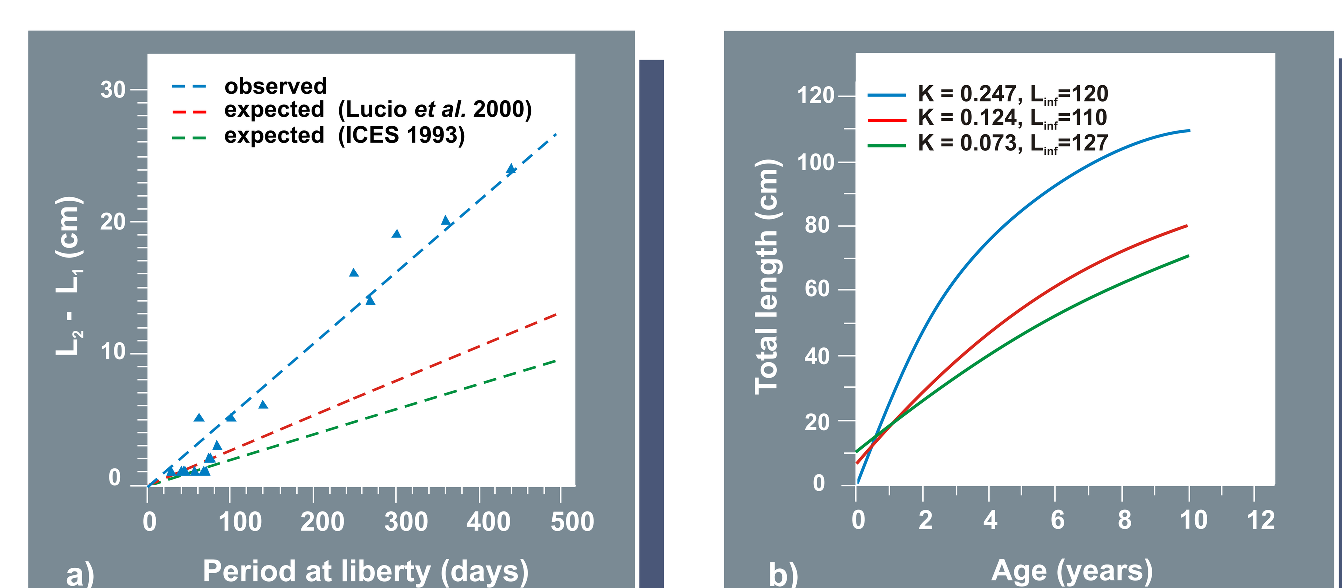



Fig.3 : a) comparision of observed and expected growth, b) corresponding growth models

## Do we overage hake ?

Otolith transverse sections (TS) through the core were prepared for analysing macrostructure (fig.4) & confronting age estimation using internationally agreed criteria with ground truth provided by the OTC mark. TS were red by 2 european experts. Only recapture date was provided. Experts recorded winter rings and false rings on images. Blind interpretation was then compared to interpretation based on the OTC mark position.
New interpretations systematically resulted in younger ages, often by a factor 2 as shown in figure 5.
We adjusted an otolith growth model (Von Bertallanfy) using data obtained during the international exchange on European hake age reading carriedout in 2002 (*Anon.* 2002).
Expected otolith growth was compared to observed growth as previously done regarding somatic growth.
Marked otoliths showed a much faster growth pattern than what was predicted by the model based on conventional ageing criteria (fig.6).
This result confirms the lack of accuracy in hake age estimation using current interpretation criteria.

Beside these aspects the deposition rythm of microincrement was studied on saggital sections. This allowed to validate daily increment deposition (de Pontual & Groison, unpublished) as shown for instance on figure 7. This result is of key interest for studying the growth rate of 0-group juveniles.

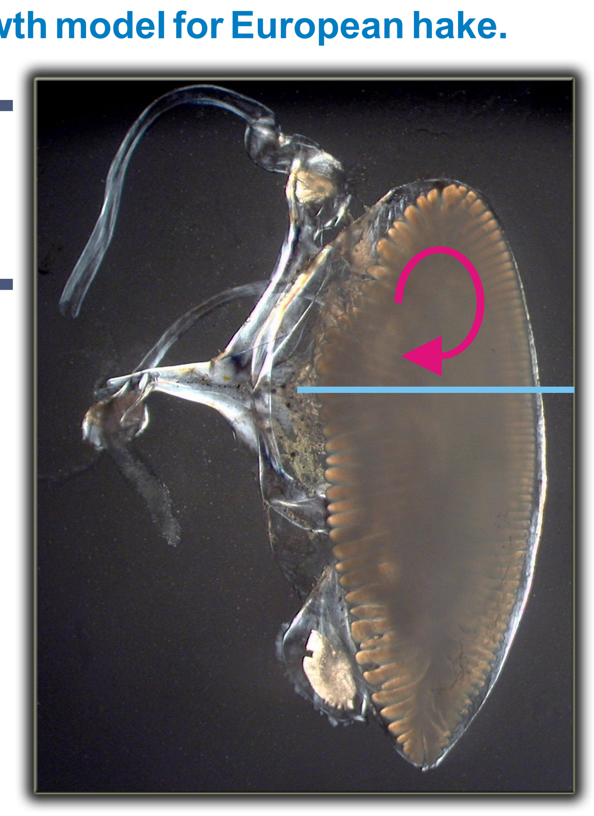


Fig.4 : preparation of hake otoliths: sectionning planes ( : sagittal; — transverse) shown on a sagitta observed within the labyrinth system

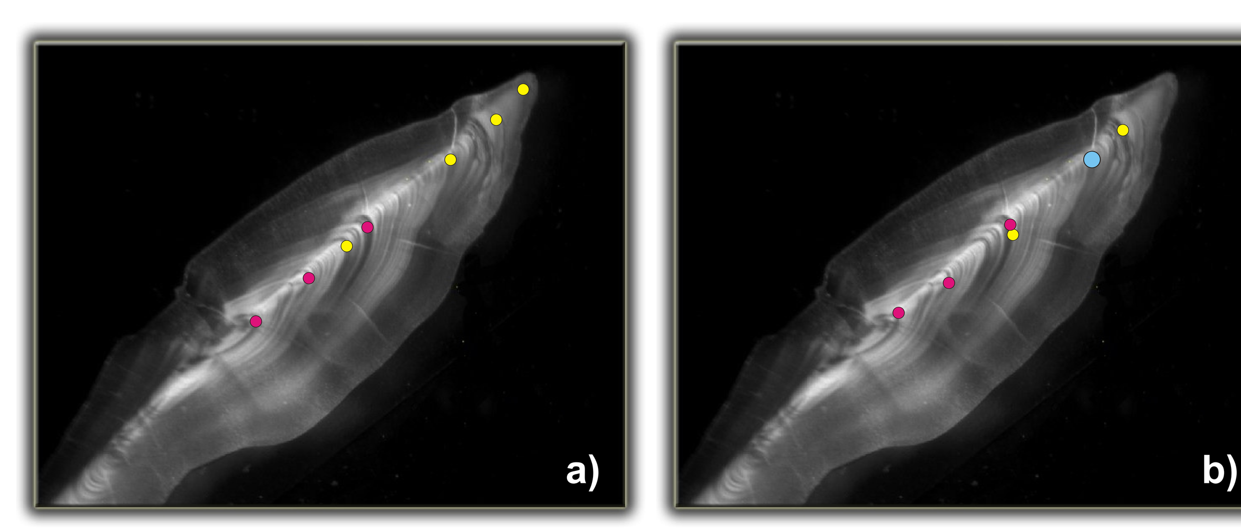



Fig.5 : otolith interpretation of a fish recaptured 301 days after tagging. a) blind interpretation from usual interpretation criteria. b) interpretation based on OTC mark position. Winter rings ( ● ) ; checks ( ● ) ; OTC mark ( ● )

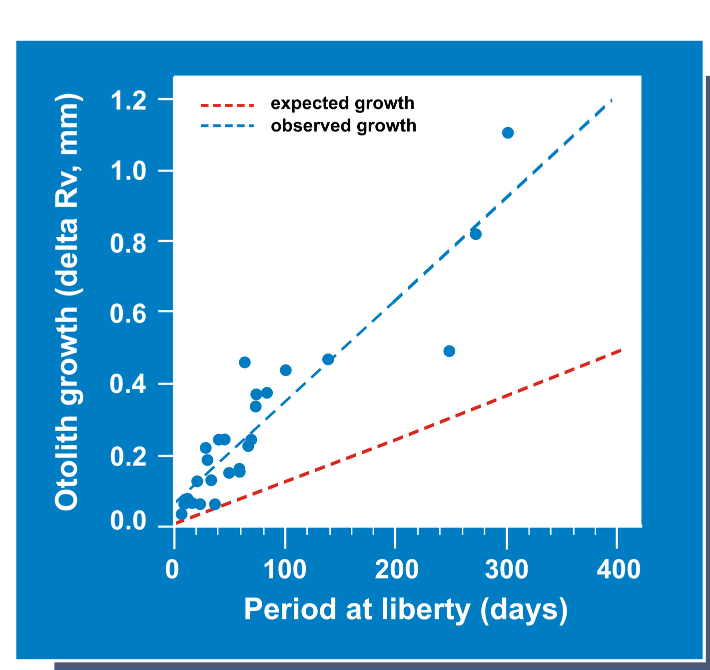



Fig.6 : comparision of observed & expected otolith growth

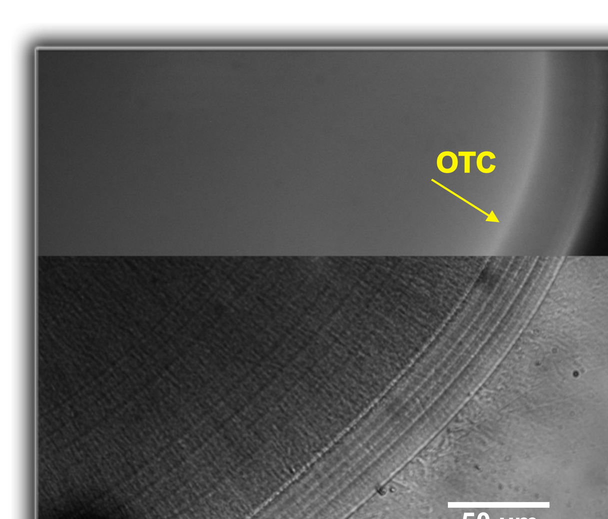
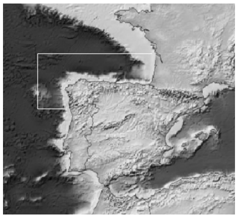



Fig.7 : Sagittal section of a marked otolith observed under UV light (top) & transmitted light (bottom). Six micro increments are clearly visible on this otolith which strictly corresponds to the number of days at liberty the fish had

## Conclusion & prospects

This pilot study demonstrated that hake tagging experiments are feasible at large scale using ad hoc catching device. The few recaptures provided invaluable information and evidence that the current knowledge on growth of European hake may be inacurrate, due to overestimation of ages using internationally agreed ageing criteria. The impact of these results on stock assessment has been analysed through simulation. SSB and F would be strongly modified (see poster CM 2004/K:51). Nevertheless data remains scarce and results need to be confirmed at the population level for both northern and southern stocks. Information on mortality, stock structure & migrations are also required.

# *ANNEX 7*



# Does otolith microstructure corroborate the fast growth model of European hake juveniles?

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Third International Symposium on Fish Otolith Research and Application
Poster nº 112

## Introduction

European hake (*Merluccius merluccius* L.,1758) is a widespread species of commercial importance in the NE Atlantic. European stocks of hake are considered to be outside safe biological limits. The growth of this species, was never validated and estimated ages are controversial. One problem is the location of the first annual ring (Piñeiro and Sainza, 2003).

A recent mark-recapture experiment in the Bay of Biscay showed that somatic and otolith growth were higher than expected (De Pontual et al., 2003 & poster n° 94). Otolith microstructures from recaptured fish were shown to be daily deposited (De Pontual et al. 2003 & poster n° 94). The only daily growth studies on juvenile hake have been carried out in the Mediterranean sea (Morales Nin and Aldebert, 1997) and in the Bay of Biscay and Celtic Sea (Kacher & Amara, Unpublished).

## Material and Methods

The sample includes 100 pairs of otoliths (sagitta) from individuals between 5 and 25 cm collected during a spring survey in the Spanish Atlantic waters in 2002. For each individual, a thin sagittal section (SS) was obtained from the left otolith and a transversal section (TS) from the right one. Two independent age estimates were obtained by counting the number of micro-increments from each section. Counts were made along the longest clear axis between the periphery and a well-defined edge of the primordium in the TS (Fig. 1). To ensure that the same axis was used in both sections, the sagittal section counting was done into the primordium region, throughout the transversal axis from the center to the boundary with the accessory primordium in the ventral face. A linear regression of increment number on otolith radius was performed using SS data (figure 2). This relationship was used to estimate the number of increments into the primordium of TS for individuals where CS was unreadable. To assess age determination errors the APE (Beamish and Fournier, 1981) and CV were calculated. The growth rate was estimated by linear regression TL on age estimated by daily increments analysis.

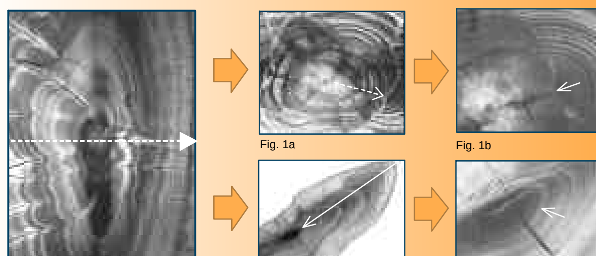



Figure 1. Whole polished otolith showing the microstructures and the axis chosen to obtain the transversal section and the counting axis.

## Objectives

To estimate, for the first time, the growth rate of juvenile hake ( 0-group) based on the assumption that microstructures are daily deposited.

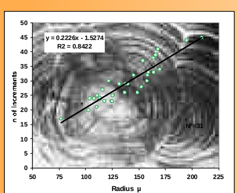


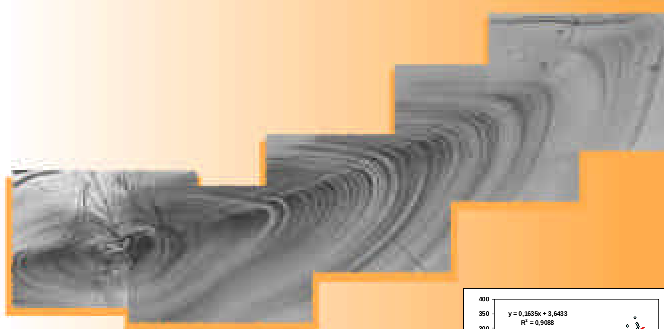

Fig. 2.- Relationship between number of increments and primordiun radius on SS.

| Transversal section | Fish TL mm | N. increments out of primordium | Width of increments (µm) | Total N increments | Radius (µm) |
|---|---|---|---|---|---|
| Mean | 169 | 162 | 6.24 | 193 | 1157.54 |
| Sdv | 36.69 | 59.92 | 1.74 | 58.6 | 341.71 |
| Cv | 21.64 | 36.82 | 27.89 | 30.38 | 29.52 |
| Range | 93-247 | 46-309 | 2-17.3 | 82-336 | 401-1824 |

Table 1

| Primordium of Sagittal section | Fish TL mm | N. increments | Width of increments (µm) | Radius (µm) |
|---|---|---|---|---|
| Mean | 173 | 30 | 3.92 | 136.9 |
| Sdv | 26.5 | 6.94 | 1.03 | 28.79 |
| Cv | 15.28 | 24.02 | 26.36 | 21.03 |
| Range | 76-229 | 17-45 | 1.7-10.4 | 77-209 |

Table 2



## Results

Only 70 transversal and 31 sagittal sections otoliths could be read due to the problems of broken, anatomical plane and over-grinding or unclear microstructure. The APE and mean CV obtained were 3.28 and 4.53, respectively (n:30). The fish and otolith size, number of increments, widths and the total radius obtained are summarized in table 1 and 2.

The central region of SS is characterized by a polygonal primordium with accessory nuclei around, followed by increments with different widths (Fig. 1 a,b). On TS, the central area tends to be opaque with increments poorly defined and difficult to interpret (Fig. 1 c,d) into the primordium. Increments are quite clear and regular on the ventral axis up to the edge which was chosen as reading axis. Data from SS analysis (Fig. 2) and TS analysis (Fig. 3) allowed us to establish an age length relationship (Fig. 4). The average growth rate was estimated at 0.91±0.1157 mm. day$^{-1}$ (mean ± sd, n=70). Fig. 5 compares the present results with the current growth model (Piñeiro and Sainza, 2003) and the growth model obtained from scarce data provided by a recent mark-recapture experiment (De Pontual et al., poster n°94).

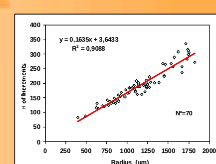



Fig. 3.- Relationship between number of increments and primordium radius on TS.

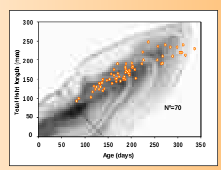



Fig 4.- Relationship between Fish Length (TL) and estimated age using daily increments analysis on TS.

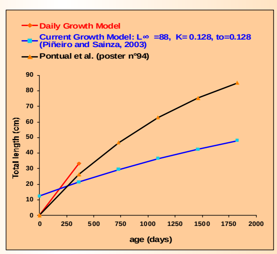



Fig 5.- Comparison of daily growth model estimated to the current growth model (Piñeiro and Sainza, 2003) and that one estimated from recaptured data (De Pontual et al., poster n°94).

## Conclusions

1. Our results are preliminary and need to be refined. However, they support the hypothesis of a faster growth of hake juveniles from Spanish Atlantic waters than previously thought. This is consistent with recent results obtained from a mark-recapture experiment (De Pontual et al., 2003) and recent work carried out on 0-group juvenile from the Bay of Biscay and Celtic Sea (Kacher & Amara, Unpublished).
2. Transverse sections showed a microstructure pattern easier to interpret than sagittal ones and this method can be recommended to study the daily growth of hake juveniles. However, further work is required to ensure that the interpretation method provides reliable data.

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Hélene De Pontual, Michael Bertignac, André Battaglia, Gérard Bavouxet, Phillipe Moguedet, and Anne-Laure Groison, 2003. A Pilot Tagging experiment on European Hake (*Merluccius merluccius*): methodology and preliminary results. ICES Journal of Marine Science, 60:1318-1327.

ICES, 2004. Report of the Working Group on the Assessment of Southern Shelf Demersal Stocks of Hake, Monk and Megrim. ICES CM 2004/ACFM: 02, 447pp.

Morales-Nin, B., and Aldebert, Y., 1997. Growth of juvenile *Merluccius merluccius* in the Gulf of Lions (NW Mediterranean) based on otolith microstructure and length frequency analysis. Fisheries Research, 30: 77-85.

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# *ANNEX 8*

*Working Document for the*
***HAKE AGE READING WORKSHOP***
***Vigo (Spain). 18-22 October. 2004***

# SYNTHETIC ALKS ELABORATION AND USE

## An alternative and interim solution for the present situation
## Basic principles and Application to a practical case: Hake stocks

by

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## INTRODUCTION

At present an increasing incertitude is taking shape on the validity/usefulness of the hake age determination criteria used until now -mainly after considering the preliminary results of the last hake tagging experiments (Pontual & al. 2004). And thus, it is wondered whether it is worth continuing the reading of Hake otoliths when so many doubts in their validity are emerging and the hake age reading results so expensive. No waste more time and money in that task for the moment, it is the conclusion that some responsible people draw from the present situation.

But, by the other hand, there is an unavoidable need to provide to the ICES WGHMM yearly, and too in the next years, elements to calculate the age composition of the Hake catches in order to carry out the annual assessment on the state of the stocks –taking in account moreover that both Northern and Southern Hake stocks are currently under recovery plans. Also, although the emerging doubts on the present hake age ageing criteria seem to be very reasonable, it does not seem prudent to cut drastically with the before way to estimate the age composition of the catches without proposing an acceptable alternative.

Mathematical methods for estimating the hake catches age composition were used by the ICES Hake WG in the past, until 1992. But, with the present knowledge on the hake age determination problems, probably they do not seem to be more advantageous and more accurate to estimate the real age composition of the catches than the otolith reading. They worked based on the length compositions and these ones do not present clear modes. Additionally, some assumptions on $L_\infty$, k and $t_o$ values used, at present are also questioned.

For example, in the 1990 Hake WG (ICES CM 1990/Assess: 22), the methods investigated to the length to age conversion of Northern Hake “were those implemented in the French program VERDHYB (Slicing, Deconvolution, Clark (1981), Hoening and Heisy (1987), and Kimura and Chikuni (1987)”. Age conversions were based on mean lengths at age estimated from growth parameters as previously determined by the Hake WG:

$$L_\infty = 114 \text{ cm}, \qquad k = 0.09, \qquad t_o = -1.16$$

Standard deviations were set at 10% of the mean length excepting for the older age-groups (because of memory overflow problem). The following values were therefore used and the range was set to 2 standard deviations about the mean:

| Age group | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| M. length (cm) | (15) | (24) | 31 | 39 | 45 | 51 | 56 | 61 | 66 | 70 | 74 |
| S.D. (cm) | 1.5 | 2.4 | 3.1 | 3.9 | 4.5 | 5 | 5 | 5 | 5 | 5 | 5 |

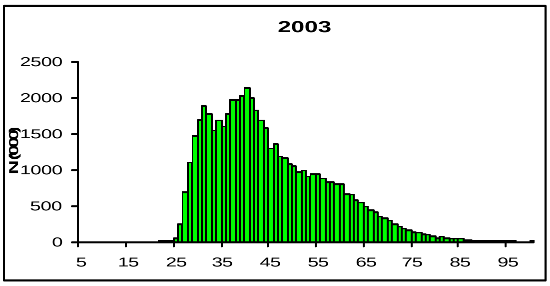
In the 1991 Hake WG (ICES CM 1991/Assess: 20), the Northern Hake length compositions were also converted to age using the Kimura and Chikuni method (1987) employing the same growth parameters as before. The values used for the standard deviation of mean length of each group were as below and the range was set at 2 standard deviations about the mean:

| Age group | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| M. length (cm) | 11 | 20 | 28 | 35 | 42 | 48 | 54 | 59 | 64 |
| S.D. (cm) | 1.5 | 2.5 | 3.0 | 3.5 | 4 | 4 | 4 | 4 | 4 |

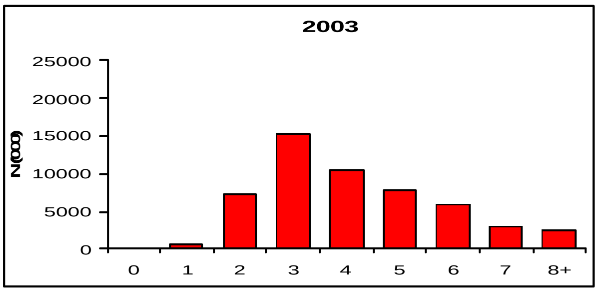
The values used for the Southern Hake age compositions employing similar procedures can be consulted in the same 1990 and 1991 Hake WG reports.

To keep in mind the recent estimated structure in size and age (using Age Length Keys -ALKs- obtained by otolith reading) of the Northern and Southern Hake catches (landings), as an example, the figures for both, length and age composition in 2003, are below presented (ICES CM 2005/ACFM: 02).

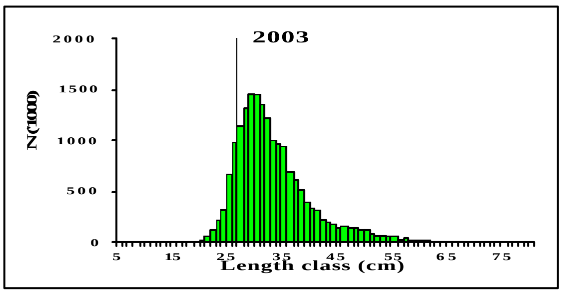
**Northern Hake :** Length composition



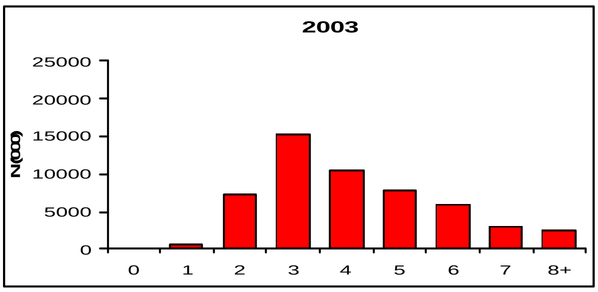

Age composition




**Southern Hake;** Length composition




Age composition




## OUR PROPOSAL

1. In the present circumstances, we propose:

- to continue to collect the Hake otoliths (maintaining the present biological sampling level),
- but to do not process neither read the otoliths until the age reading criteria to be used have been confirmed by validation,
- to carry out tagging surveys or to employ other methods to validate the age determination criteria and the growth pattern,
- and, in the meantime, to use the national/international collection of otolith read (i.e. the ALKs available until now) and apply them in the way more convenient to the catches/ladings/discards length compositions that are to be obtained in the next years, *i.e.* since 2005.
- A practical and available procedure of using these collections in a random, synthetic and robust way is presented below as an example.

## 2. AZTI procedure for obtaining random, synthetic and robust ALKs for hake (or other species)

### 2.1. Basic data used

In our case, the AZTI Collection of Hake otoliths (1987-2003) has been used. Hake otoliths for age determination were collected according to the AZTI's Otoliths Sampling Plan. This sampling program takes in account separately the Northern and Southern stocks, the size categories defined according to the likely higher growth rate of small fish and the eventual different recruitments strength more detectable in the small fish, the economical constrictions (it is necessary to buy the fish to be sampled and this implies a very high cost), the relative importance of the Basque catches in relation to the international catches, and finally the usual proportions of each size category in the landings.

The AZTI collection of Hake otoliths (1987-2003) is integrated by more than 33,000 otoliths. All of them have been read (re-read) according to the criteria adopted by the Hake Age Reading International Workshops (1997, 1999, and 2001).

Collections of other institutes or other countries, separately or together considered, could be also used for the same purpose in the future.

### 2.1. AZTI's Computer Application

*Objective* of the AZTI's Computer Application: It aims the elaboration of robust and random ALKs obtained easy and quickly, friendly and within reach of every institute's present possibilities (i.e. without very complicated or expensive computer program), from the available collections of otoliths read according to the criteria adopted until now. The use of this application, until new and more accurate ageing criteria are implemented, it might avoid at present superfluous expenses in time and money and uncontrolled manipulation of the available data (the subjective handling or "cooking").

*Definition* of the Application: It is developed for Microsoft ® Excel. The processes and functions are written in Visual Basic language designed (oriented) towards Excel. It is performed by means a macro. It needs only that the basic data are presented in a determinate form (Excel files (*.xls) in a defined structure) easily adaptable to future needs.

*Structure* of the data to be used by the Application:

* One file (with similar name) for each year (Examples: ALK1988.xls, ALK1997.xls, ALK2003.xls, …),
* Each file may have several sheets: one for each sea area (stock), named in a similar way (Example: VIIIabd+VII(Q)_1997, or VIIIc(Q)_1997),
* Each sheet must contain 4 tables: one by quarter, although no data are available for one or more quarters,
* Each table (quarter) must have the same structure (the same number of columns and files).
* In the present Application the ranges established for the length and age classes are:

  Length classes: 5-90+ cm

  Age classes: 0-9+ years

  (These settings can be easily modified, but the modifications must be introduced also in the program).
* Running time: It will depend on the amount of the basic available data and the number of years selected. (Examples: For Northern Hake, for a window of 16 years (1987-2003, but no 1994), with >27,700 otoliths and with a rather good coverage by quarter, the process takes about 10 min. For Southern Hake, for the same years, with <6,000 otoliths and a worse coverage by quarter and length class, the process takes more than 15 min. But these times may change quite due to that it is a random process).

*Description* of the Application:

Basically the "re-sampling" plan used by the present application involves choosing randomly a fix, determinate number (10) of fish aged by length class (1 cm), by a defined time period (quarter) from the quarterly pool of the historic series available (in a country or institute or in a combination of several countries or institutes) and defined by the user (selected years).

The user ought to follow only this simple process:

Excel ® Microsoft
- Aleatorio.xls
  - Menu
    - Tools
      - Macro
        - Macros
          - Name of the Macro ("Begin")
            - "Run"
              - Screen:


*Select area (stock)*
*Years to use: From […] To […]*
*Accept (or Cancel)*

The process starts … and when it ends,
The results appears in the sheet "Results"

*Results* of the Application:

The Application permits us to obtain new, virtual and synthetic ALK, based on real readings of otoliths, for each of the periods looked for: $1^{st}$, $2^{nd}$, $3^{rd}$, and $4^{th}$ quarter, and for other additional periods ($1^{st}$ and $2^{nd}$ semester -i.e., $1^{st}$ and $2^{nd}$ part of the year-, and year), with the same number of values for all and each length classes in each time period. These virtual but robust and complete ALKs make possible to eradicate ulterior "handlings" of the usually insufficient basic values that the current ALKs very often present.

*Availability* of the Application:

This AZTI´s Application is (will be) free.
At present some of the sentences are written in Spanish, but very soon a new Application will be available also only in English.
The present settings are for two sea areas -Sub-area VII + Divisions VIIIa,b,d, together considered (*i.e.* Northern Hake), and Division VIIIc (*i.e.* Southern Hake)-, for the length range [5-90+ cm , with 1 cm length classes], and the age range [0-9+ years). But these boundaries can be easily changed in the application.

The application might be used also for other species.

## APPLICATION TO A PRACTICAL CASE

The AZTI´s Application has been employed, as a practical example, to "re-obtain" the age compositions of the landings in 2003 of four Spanish Basque fleets candidates as tuning fleets by the ICES WGHMM. The results have been compared with the results presented to the ICES WGHMM in May 2004 (ICES CM, 2005) for the same fleets.

1. Basic data used:

- Quarterly length compositions of the catches (landings) in 2003 of the following fleets:

- o SP-PAIRT_ON8: Spanish Pair Trawlers of Ondarroa working in Div. VIIIa,b,d
- o SP-PAIRT_PA8: Spanish Pair Trawlers of Pasajes working in Div. VIIIa,b,d
- o SP-BAKON7: Spanish "Baka" Trawlers of Ondarroa working in Sub-area VII
- o SP-BAKON8: Spanish "Baka" Trawlers of Ondarroa working in Div. VIIIa,b,d

The two first fleets were finally used for tuning purposes by the 2004 WGHMM. The other two fleets were presented but not used.

- Quarterly ALKs:
  - o Synthetic ALKs by quarter from the period 1987-2003, 1st run (Synth_ALK-1)
  - o Synthetic ALKs by quarter from the period 1987-2003, 2nd run (Synth_ALK-2)
  - o Synthetic ALKs by quarter from the period 1987-2003, 3rd run (Synth_ALK-3)
  - o Quarterly ALKs of 2003 (*sic?*) used for 2004 WGHMM

The synthetic and random quarterly ALKs obtained were produced in three successive runs (1, 2, 3) maintaining the same settings: for only Northern Hake (VII-VIIIa,b,d) stock, and for the [1987-2003] years window of the AZTI otolith collection. In Table 0, as an example, the synthetic annual ALK obtained by application of the AZTI´s procedure (Synth_ALK_2) is presented. This annual ALK is just the addition of the 1st+2nd+3rd+4th Quarter ALKs).

Only to indicate briefly a part of the variability observed in relation to each age and quarter, the Table below presents the differences between runs in the virtual aged fish number between runs in the new quarterly and annual ALKs obtained. In general, no systematic neither clear trends were observed between the results of the three runs.

| | | AGE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9+** | **Total** |
| **1. Quarter** | **Diff. 1-2** | 0 | -1 | 5 | -10 | 2 | -6 | 2 | 5 | 3 | 0 | 0 |
| | **Diff. 1-3** | 0 | 3 | -4 | 3 | -15 | 16 | -8 | 1 | 3 | 1 | 0 |
| | **Diff. 2-3** | 0 | 4 | -9 | 13 | -17 | 22 | -10 | -4 | 0 | 1 | 0 |
| **2. Quarter** | **Diff. 1-2** | 2 | -3 | 5 | -9 | -5 | 13 | -5 | 4 | -2 | 0 | 0 |
| | **Diff. 1-3** | 1 | -5 | 4 | 0 | -5 | 6 | 5 | -5 | -1 | 0 | 0 |
| | **Diff. 2-3** | -1 | -2 | -1 | 9 | 0 | -7 | 10 | -9 | 1 | 0 | 0 |
| **3. Quarter** | **Diff. 1-2** | 4 | -4 | -4 | 13 | -12 | -5 | 4 | 0 | 5 | -1 | 0 |
| | **Diff. 1-3** | 2 | 3 | -10 | 8 | -7 | -3 | 5 | -4 | 6 | 0 | 0 |
| | **Diff. 2-3** | -2 | 7 | -6 | -5 | 5 | 2 | 1 | -4 | 1 | 1 | 0 |
| **4. Quarter** | **Diff. 1-2** | 0 | -3 | -2 | 7 | -2 | -9 | -1 | 11 | -1 | 0 | 0 |
| | **Diff. 1-3** | 1 | 0 | -2 | 7 | -8 | -9 | 5 | 9 | -4 | 1 | 0 |
| | **Diff. 2-3** | 1 | 3 | 0 | 0 | -6 | 0 | 6 | -2 | -3 | 1 | 0 |
| **Annual** | **Diff. 1-2** | 6 | -11 | 4 | 1 | -17 | -7 | 0 | 20 | 5 | -1 | 0 |
| | **Diff. 1-3** | 4 | 1 | -12 | 18 | -35 | 10 | 7 | 1 | 4 | 2 | 0 |
| | **Diff. 2-3** | -2 | 12 | -16 | 17 | -18 | 17 | 7 | -19 | -1 | 3 | 0 |

In relation to the Quarterly ALKs of 2003 (*sic?*) -used to obtain the abundance indices presented to the May 2004 WGHMM and now for comparison with the synthetic ALKs results-, it is necessary to point out that, in fact, they needed some kind of interpolations and complements –i.e. some kind of "handling".

For some length classes of the range [<45 cm length], due to the lack of real otoliths, it was necessary to use the pull of otoliths from the quarterly collections of 2001-2003 years. For the range [45-59 cm], a half year ALK (for 1st and 2nd Semesters) was used; and for the range [≥60 cm] an annual ALK was employed with some interpolations mainly for the higher lengths, because big fish more than a determinate length it was not possible to sample in 2003.

Thus, they were not "strict" or "pure" 2003 quarterly ALKs. (But it is known that it happens in the practice, to many fishery institutes in relation to some species…).

2. Results and comparisons:

In Figures 1,2,3,4, the estimated quarterly age compositions of the landings in 2003 of the Pair Trawlers of Ondarroa (SP-PAIRT_PA8) working in Div. VIIIa,b,d, using quarterly synthetic ALKs from three different runs (Synth_ALK-1,2,3) or applying the "2003" quarterly ALKs (WG04) are shown. In Tables 1, 2, 3, 4, the annual age compositions of the landings in 2003, in percentages, and the annual mean lengths and ages for the same fleets and ALKs are presented.

In Figures 5, 6, 7, 8, the estimated annual age compositions of the landings in 2003 of four Basque fleets are shown. These fleets are: Pair Trawlers of Ondarroa (SP-PAIRT_PA8), Pasajes (SP-PAIRT_PA8) working in Div. VIIIa,b,d, and "Baka" Trawlers of Ondarroa working in Div. VIIIa,b,d (SP-BAKON8) and Sub-area VII (SPBAKON7). The estimated annual age compositions were obtained by simple addition of the quarterly age compositions above explained. In Tables 5, 6, 7, 8, the annual age compositions of the landings in 2003, in percentages, and the annual mean lengths and ages for the same fleets and ALKs are presented.

Results obtained for each of the fleet selected, indicate, according our opinion, that:

- The age compositions obtained using the synthetic ALKs or the "2003" ALK appear to differ rather slightly between them.
- The "2003" quarterly ALKs used cannot be considered as more representative than the other three synthetic ALKs, because the "2003" ALKs ones needed too to be completed in all the quarters with values from other years due to the lacks in the 2003 sampling.
- A certain degree of variability in the results is observed but without marked trends.
- As it was expected, the resultant age compositions appear to be more dependent on the length distributions than on the kind of synthetic ALK used.
- With this synthetic ALKs approach, the use of quarterly ALKs is possible - although no sufficient number of otoliths are available in a determinate year, and desirable, to take in account the usual very different quarterly length compositions of the catches in many fleets and sea areas.
- Any of the four age compositions obtained using the synthetic ALKs or the "2003" ALK are reasonable and could be accepted for assessment purposes.

**CONCLUSIONS**

1. It is possible and desirable to obtain reasonable synthetic ALKs to be used in the next years until new criteria on hake age determination have been established and validate.
2. Use of quarterly ALKs, although synthetic ones, ought to be attempted in the next future.
3. AZTI's Application to obtain synthetic and random ALKs appears to be a feasible, robust and amicable method to be used, between others possible, to combine all the set of hake otoliths aged until now.

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**HAKE (Merluccius merluccius) :: 1987-2003 YEARS :: VIIIabd+VII (ANNUAL: 1Q+2Q+3Q+4Q**

| Length (cm) | AGE (years) 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | TOTAL | Length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | | | | | | | | | | | | 5 |
| 6 | | | | | | | | | | | | 6 |
| 7 | 10 | | | | | | | | | | 10 | 7 |
| 8 | 20 | | | | | | | | | | 20 | 8 |
| 9 | 30 | 10 | | | | | | | | | 40 | 9 |
| 10 | 27 | 13 | | | | | | | | | 40 | 10 |
| 11 | 27 | 13 | | | | | | | | | 40 | 11 |
| 12 | 25 | 15 | | | | | | | | | 40 | 12 |
| 13 | 20 | 20 | | | | | | | | | 40 | 13 |
| 14 | 20 | 20 | | | | | | | | | 40 | 14 |
| 15 | 19 | 21 | | | | | | | | | 40 | 15 |
| 16 | 11 | 29 | | | | | | | | | 40 | 16 |
| 17 | 5 | 35 | | | | | | | | | 40 | 17 |
| 18 | 3 | 37 | | | | | | | | | 40 | 18 |
| 19 | | 34 | 6 | | | | | | | | 40 | 19 |
| 20 | | 28 | 12 | | | | | | | | 40 | 20 |
| 21 | | 24 | 16 | | | | | | | | 40 | 21 |
| 22 | | 17 | 23 | | | | | | | | 40 | 22 |
| 23 | | 17 | 23 | | | | | | | | 40 | 23 |
| 24 | | 7 | 33 | | | | | | | | 40 | 24 |
| 25 | | 1 | 38 | 1 | | | | | | | 40 | 25 |
| 26 | | | 37 | 3 | | | | | | | 40 | 26 |
| 27 | | | 35 | 5 | | | | | | | 40 | 27 |
| 28 | | | 27 | 13 | | | | | | | 40 | 28 |
| 29 | | | 22 | 18 | | | | | | | 40 | 29 |
| 30 | | | 17 | 23 | | | | | | | 40 | 30 |
| 31 | | | 14 | 26 | | | | | | | 40 | 31 |
| 32 | | | 13 | 27 | | | | | | | 40 | 32 |
| 33 | | | 8 | 32 | | | | | | | 40 | 33 |
| 34 | | | 9 | 31 | | | | | | | 40 | 34 |
| 35 | | | 2 | 33 | 5 | | | | | | 40 | 35 |
| 36 | | | 1 | 35 | 4 | | | | | | 40 | 36 |
| 37 | | | 1 | 31 | 8 | | | | | | 40 | 37 |
| 38 | | | | 28 | 12 | | | | | | 40 | 38 |
| 39 | | | | 20 | 20 | | | | | | 40 | 39 |
| 40 | | | | 12 | 28 | | | | | | 40 | 40 |
| 41 | | | | 11 | 28 | 1 | | | | | 40 | 41 |
| 42 | | | | 12 | 28 | | | | | | 40 | 42 |
| 43 | | | | 6 | 34 | | | | | | 40 | 43 |
| 44 | | | | 5 | 34 | 1 | | | | | 40 | 44 |
| 45 | | | | | 36 | 4 | | | | | 40 | 45 |
| 46 | | | | 1 | 32 | 7 | | | | | 40 | 46 |
| 47 | | | | | 33 | 7 | | | | | 40 | 47 |
| 48 | | | | | 29 | 11 | | | | | 40 | 48 |
| 49 | | | | | 27 | 13 | | | | | 40 | 49 |
| 50 | | | | | 16 | 24 | | | | | 40 | 50 |
| 51 | | | | | 13 | 26 | 1 | | | | 40 | 51 |
| 52 | | | | | 16 | 23 | 1 | | | | 40 | 52 |
| 53 | | | | | 14 | 26 | | | | | 40 | 53 |
| 54 | | | | | 6 | 32 | 2 | | | | 40 | 54 |
| 55 | | | | | 2 | 35 | 3 | | | | 40 | 55 |
| 56 | | | | | 2 | 35 | 3 | | | | 40 | 56 |
| 57 | | | | | | 37 | 3 | | | | 40 | 57 |
| 58 | | | | | | 26 | 14 | | | | 40 | 58 |
| 59 | | | | | | 27 | 12 | 1 | | | 40 | 59 |
| 60 | | | | | | 17 | 23 | | | | 40 | 60 |
| 61 | | | | | | 17 | 23 | | | | 40 | 61 |
| 62 | | | | | | 13 | 26 | 1 | | | 40 | 62 |
| 63 | | | | | | 10 | 30 | | | | 40 | 63 |
| 64 | | | | | | 7 | 30 | 3 | | | 40 | 64 |
| 65 | | | | | | | 37 | 2 | 1 | | 40 | 65 |
| 66 | | | | | | | 35 | 5 | | | 40 | 66 |
| 67 | | | | | | | 34 | 6 | | | 40 | 67 |
| 68 | | | | | | | 31 | 9 | | | 40 | 68 |
| 69 | | | | | | | 28 | 12 | | | 40 | 69 |
| 70 | | | | | | | 16 | 24 | | | 40 | 70 |
| 71 | | | | | | | 7 | 30 | 3 | | 40 | 71 |
| 72 | | | | | | | 9 | 27 | 4 | | 40 | 72 |
| 73 | | | | | | | 8 | 29 | 3 | | 40 | 73 |
| 74 | | | | | | | 4 | 34 | 2 | | 40 | 74 |
| 75 | | | | | | | | 29 | 8 | 3 | 40 | 75 |
| 76 | | | | | | | | 27 | 13 | | 40 | 76 |
| 77 | | | | | | | | 36 | 4 | | 40 | 77 |
| 78 | | | | | | | | 19 | 21 | | 40 | 78 |
| 79 | | | | | | | | 23 | 12 | 5 | 40 | 79 |
| 80 | | | | | | | | 8 | 24 | 8 | 40 | 80 |
| 81 | | | | | | | | 11 | 29 | | 40 | 81 |
| 82 | | | | | | | | 8 | 24 | 8 | 40 | 82 |
| 83 | | | | | | | | | 40 | | 40 | 83 |
| 84 | | | | | | | | | 40 | | 40 | 84 |
| 85 | | | | | | | | | 20 | 20 | 40 | 85 |
| 86 | | | | | | | | | 40 | | 40 | 86 |
| 87 | | | | | | | | | 20 | 20 | 40 | 87 |
| 88 | | | | | | | | | | | | 88 |
| 89 | | | | | | | | | 40 | | 40 | 89 |
| 90 | | | | | | | | | | 40 | 40 | 90+ |
| **TOTAL** | **217** | **341** | **337** | **373** | **427** | **399** | **380** | **344** | **348** | **104** | **3270** | TOTAL |
| Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | | Age |
| Mean length | 12,1 | 17,5 | 26,7 | 35,2 | 45,5 | 55,5 | 65,3 | 74,6 | 83,2 | 86,6 | | Mean length |
| ***S.D. L.*** | 2,7 | 3,8 | 3,7 | 4,1 | 4,5 | 4,4 | 4,2 | 4,0 | 4,2 | 4,0 | | ***S.D. L.*** |
| ***C.V.% L.*** | 22,6 | 21,9 | 13,9 | 11,6 | 9,8 | 8,0 | 6,4 | 5,4 | 5,1 | 4,7 | | ***C.V.% L.*** |

**Table 0.** Synthetic annual (1+2+3+4 Quarters) Age Length Key obtained by application of the AZTI´s procedure (Synth_ALK_2).

Figure 1

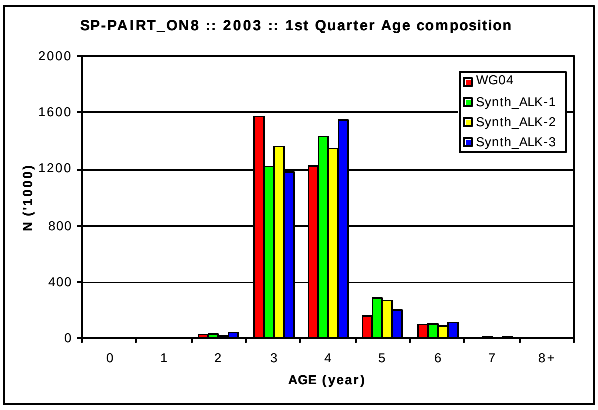


Table 1

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 1 | 1 | 1 | 1 |
| 3 | 51 | 39 | 44 | 38 |
| 4 | 40 | 46 | 43 | 50 |
| 5 | 5 | 9 | 9 | 7 |
| 6 | 3 | 3 | 3 | 4 |
| 7 | 0 | 0 | 0 | 0 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 38,6 | 38,6 | 38,6 | 38,6 |
| Mean Age | 3,4 | 3,4 | 3,4 | 3,4 |

Figure 2

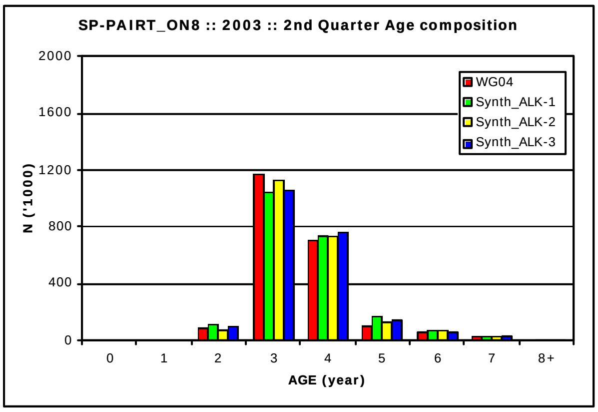


Table 2

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 4 | 5 | 3 | 4 |
| 3 | 54 | 48 | 53 | 49 |
| 4 | 33 | 34 | 34 | 35 |
| 5 | 5 | 8 | 6 | 7 |
| 6 | 3 | 3 | 3 | 3 |
| 7 | 1 | 1 | 1 | 1 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 39,8 | 39,8 | 39,8 | 39,8 |
| Mean Age | 3,6 | 3,6 | 3,5 | 3,5 |

Figure 3

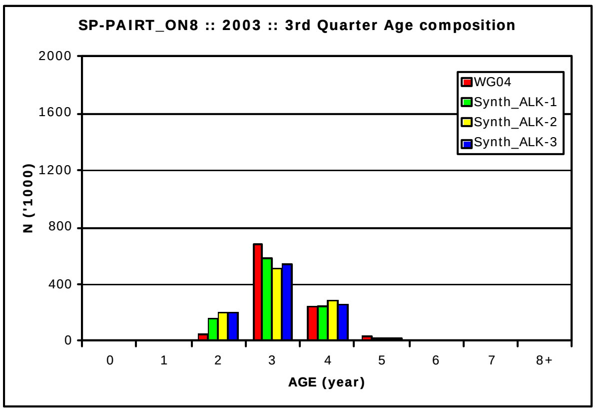


Table 3

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 5 | 16 | 20 | 19 |
| 3 | 67 | 57 | 50 | 53 |
| 4 | 24 | 24 | 28 | 25 |
| 5 | 4 | 2 | 2 | 2 |
| 6 | 1 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 35,1 | 35,1 | 35,1 | 35,1 |
| Mean Age | 3,1 | 3,2 | 3,1 | 3,1 |

Figure 4

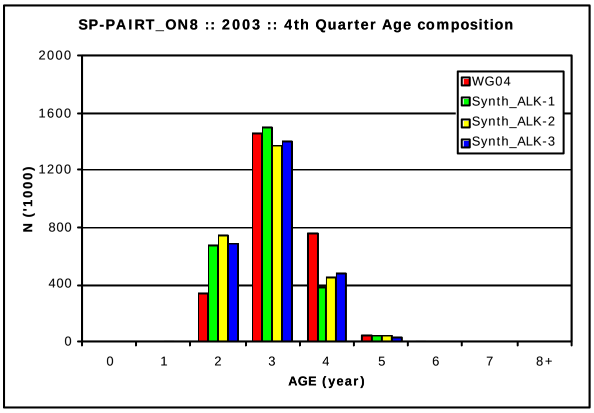


Table 4

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 13 | 26 | 29 | 26 |
| 3 | 56 | 58 | 53 | 54 |
| 4 | 29 | 15 | 17 | 18 |
| 5 | 2 | 1 | 2 | 1 |
| 6 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 40,0 | 40,0 | 40,0 | 40,0 |
| Mean Age | 3,6 | 3,4 | 3,4 | 3,4 |

**Figures 1, 2, 3, 4**. Quarterly age compositions of the landings of Pair Trawlers of Ondarroa working in Div. VIIIa,b,d (SP-PAIRT_ON8), using quarterly synthetic ALKs from three different runs (Synth_ALK-1,2,3) or applying the “2003” quarterly ALKs (WG04).

**Tables 1, 2, 3, 4.** Quarterly age compositions of the landings in percentages, and quarterly mean lengths and ages for the same fleet and ALKs.

Figure 5

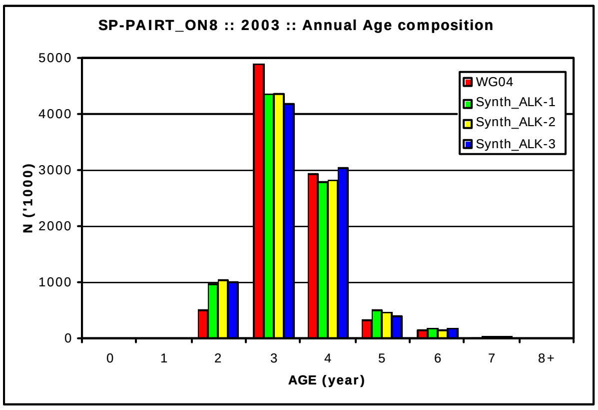


Table 5

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 6 | 11 | 12 | 12 |
| 3 | 55 | 49 | 49 | 47 |
| 4 | 33 | 32 | 32 | 34 |
| 5 | 4 | 6 | 5 | 5 |
| 6 | 2 | 2 | 2 | 2 |
| 7 | 0 | 0 | 0 | 0 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 38,6 | 38,6 | 38,6 | 38,6 |
| Mean Age | 3,4 | 3,4 | 3,4 | 3,4 |

Figure 6

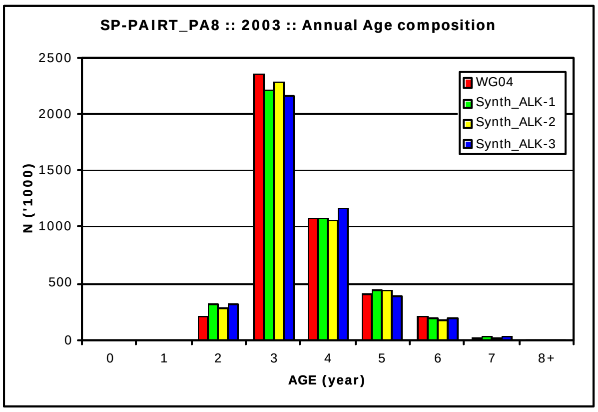


Table 6

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 5 | 8 | 7 | 8 |
| 3 | 55 | 52 | 53 | 51 |
| 4 | 25 | 25 | 25 | 27 |
| 5 | 10 | 10 | 10 | 9 |
| 6 | 5 | 5 | 4 | 5 |
| 7 | 0 | 1 | 1 | 1 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 39,8 | 39,8 | 39,8 | 39,8 |
| Mean Age | 3,6 | 3,6 | 3,5 | 3,5 |

Figure 7

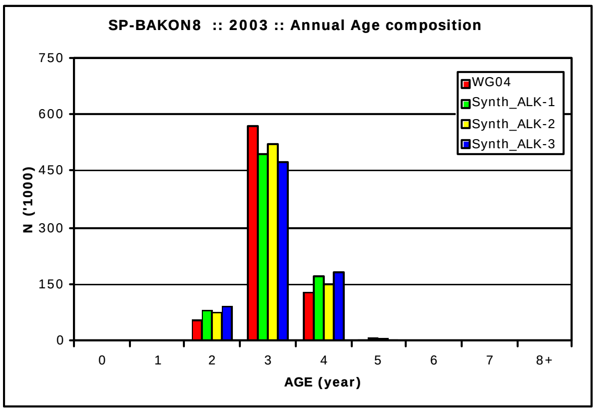


Table 7

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 8 | 11 | 10 | 12 |
| 3 | 75 | 65 | 69 | 63 |
| 4 | 17 | 23 | 20 | 24 |
| 5 | 0 | 1 | 1 | 1 |
| 6 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 35,1 | 35,1 | 35,1 | 35,1 |
| Mean Age | 3,1 | 3,2 | 3,1 | 3,1 |

Figure 8

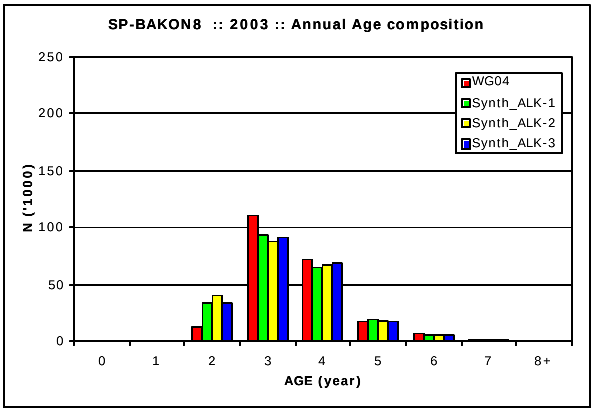


Table 8

| AGE | WG04 | Synth_ALK-1 | Synth_ALK-2 | Synth_ALK-3 |
|---|---|---|---|---|
| | Age composition in % | | | |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 6 | 16 | 18 | 16 |
| 3 | 50 | 42 | 40 | 41 |
| 4 | 33 | 29 | 31 | 31 |
| 5 | 8 | 9 | 8 | 8 |
| 6 | 3 | 3 | 3 | 3 |
| 7 | 1 | 1 | 1 | 1 |
| 8+ | 0 | 0 | 0 | 0 |
| Total | 100 | 100 | 100 | 100 |
| Mean Length | 40,0 | 40,0 | 40,0 | 40,0 |
| Mean Age | 3,6 | 3,4 | 3,4 | 3,4 |

**Figures 5, 6, 7, 8**. Annual age compositions of the landings of Pair Trawlers of Ondarroa (SP-PAIRT_PA8) and Pasajes (SP-PAIRT_PA8) working in Div. VIIIa,b,d, and "Baka" Trawlers of Ondarroa working in Div. VIIIa,b,d (SP-BAKON8) and Sub-area VII (SPBAKON7), using quarterly synthetic ALKs from three different runs (Synth_ALK-1,2,3) or applying the "2003" quarterly ALKs (WG04).

**Tables 5, 6, 7, 8.** Annual age compositions of the landings in percentages, and annual mean lengths and ages for the same fleets and ALKs.