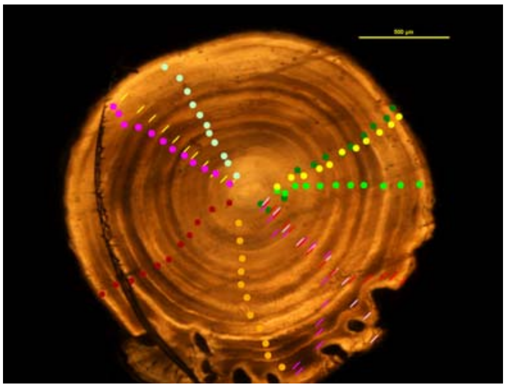
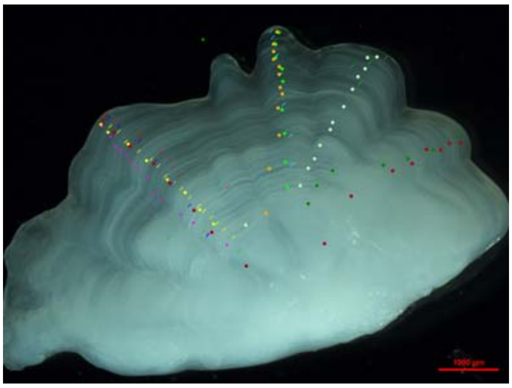
Report of the

Anglerfish (*Lophius piscatorius*) *illicia* and otoliths exchange 2011





coordinated by

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Abstract

The age estimation for stock assessment of white anglerfish (*Lophius piscatorius*) in the ICES area has been traditionally based on two different calcified structures, the *illicium* (used in most of the European countries) and the *sagitta* otolith (used in only two countries). The otoliths from *Lophius* have confusing secondary structures (Woodroffe *et al*., 2003), and an increase in the opacity of the otoliths with age, makes them more difficult for age estimating. The growth pattern is easier to distinguish in the *illicia*, which exhibit fewer secondary structures (Dupouy *et al.*, 1986).

Growth studies alternative to the age estimates on calcified structures (CS) of white anglerfish, such as tagging-recapture (Laurenson *et al*., 2005; Landa *et al.,* 2008a), daily growth (Wright *et al*., 2002) and length frequency distributions of catches (Dupouy *et al*., 1986; Thangstad *et al*., 2002; Landa, 2004; Jónsson, 2007), showed that the growth pattern estimated using the traditional standardized age estimation criterion based on *illicia* (Duarte *et al*., 2002) was underestimated and that criterion was not accurate, although it was standardized and used in several age estimation anglerfish workshops. The last anglerfish *illicia* exchange and workshop using that criterion took place in 2004 (Duarte *et al*., 2005). The ICES Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) (ICES, 2011) recommended an exchange of *illicia* and otoliths for 2011, when a new age estimation criterion on *illicia* was expected. Modifications in the methodology of *illicia* preparation and in the traditional standardized age estimation criterion have allowed a new age estimation criterion on *illicia* to be obtained. Using this new criterion, the catches-at-age have been tracked more successfully (Landa *et al*., pers. com.). Therefore this criterion seems to be more accurate and it was presented in the protocol of the present exchange.

A white anglerfish exchange of 200 images (100 *illicia* and 100 otoliths) from the same specimen took place during the third quarter of 2011. Each reader was asked to mark the annual rings on the images, using an image analysis software program (GIMP). The exchange was carried out through the European Age Readers Forum (EARF). Fourteen readers (including two Mediterranean readers) from ten institutes from eight European countries participated.

Three **age estimation analyses** were performed within each CS: (i) *illicia* age readings, (ii) otoliths age readings, and (iii) a comparison between *illicia* and otoliths age readings. The analyses within each CS (i and ii) were performed for all readers and also for the readers contributing to the stock assessment. For both analyses, the between reader agreement was higher in *illicia* compared to otoliths. The *illicia* readings were less relatively biased than otolith readings, although had slightly lower precision. However the overall values of the mean CV were strongly influenced by the high CV values at first ages, especially at age 0. More specimens were aged 0 years using *illicia* than otoliths, and therefore the slightly lower precision in *illicia* was influenced by that.

i) ***Illicia.*** Analysing <u>all *illicia* readers</u>, the overall percentage **agreement** was **45.0%**, the CV was 26.7%, and the relative bias was 0.39. The first annulus was located by most of readers between 300 and 350 μm. When analysing the <u>*illicia* readers that contribute to the stock assessment</u>, the agreement, precision and especially the relative accuracy increased: the overall percentage **agreement** was **49.3%**, the CV was 22.4%, and the relative bias was 0.11.

ii) **Otoliths.** Similar to the last anglerfish *illicia*/otoliths ageing workshop in 2004, two different analyses had to be performed when the readings were analysed, using R8 and R9 as reference readers, due to the low agreement between both experienced otolith readers. Analysing <u>all otoliths readers</u>, the overall percentage **agreements** were **19.5%** and **19.5%** when R8 and R9 were, respectively, the reference readers; the CV were 23.7% and 24.0%; and the relative biases were -0.96 and 0.47, respectively. There were discrepancies among the readers in the location of the first annulus. Analysing only the <u>otolith readers contributing to the stock assessment</u>, the overall percentage **agreements** were **18.3%** and **25.4%** when R8 and R9 were, respectively, the reference readers; the CV were 13.3% and 16.6%; and the relative biases were -1.23 and 0.52, respectively.

iii) ***Illicia* and otoliths age readings comparison.** Results indicate strong discrepancies between *illicia* and otoliths readings, there are similar to the conclusions in the last anglerfish exchange and workshop in 2004 (Duarte *et al*., 2005). Comparing the <u>expert otoliths readers vs. the expert *illicia* readers</u>, the overall percentage **agreement** were **4.7%** and **16.5%,** when R8 and R9 were compared, respectively, to the modal *illicia* readings; and the relative bias were 2.67 and 0.92, respectively. The 86% and 71% specimens were aged older using otoliths than using *illicia* when the readings of the experienced *illicia* readers and experienced otoliths readers R8 and R9 were compared;

Considering the above there are **implications** regarding the stock assessment of this species, given that the stock is undergoing a benchmark assessment at ICES WKFLAT in 2012, the following should be considered:

i) *Illicia* vs. otoliths. Considering the low levels of agreement between both CS (5-16%) it is not possible to use the age estimations of both *illicia* and otoliths together for stock assessment purposes.

ii) *Illicia.* Although the relative bias values (0.11) among the assessment readers can be considered good, the agreement values (49%) and precision (CV: 22%, APE: 16) suggest that they are not still sufficiently acceptable for building since now a valid ALK for stock assessment, using the readings of several readers. If the new age estimation criterion is validated in other geographical areas by cohorts tracking, and the agreement among readers is increased, then the age estimation using *illicia* could be used for stock assessment in the future.

iii) Otoliths. The age estimation of white anglerfish, based on otoliths, is difficult, mainly due to the occurrence of confusing false annuli and to the increasing of opacity with age. The location of the first annulus is also a problem, even among expert readers, both in the last and present exchanges. There have been advances in daily growth studies that can help locate the first annulus more precisely. It is not possible to use otoliths of white anglerfish for stock assessment without a validated growth pattern and further research in that issue is needed.

Contents

1. INTRODUCTION

White anglerfish (*Lophius piscatorius*) is an important groundfish species of North East Atlantic fisheries.

The age estimation for the stock assessment of white anglerfish in the ICES area has been traditionally based on two different calcified structures, the *illicium* (used in most of the European countries) and the *sagitta* otolith (used in only two countries). The otoliths from *Lophius* have confusing secondary structures or multichecks (Woodroffe *et al*., 2003), and an increase in their opacity with age, which makes them more difficult for age estimating than *illicia*, where the growth pattern is easier to distinguish as they exhibit fewer secondary structures (Dupouy *et al*., 1986; Crozier, 1989; Woodroffe *et al*., 2003). Several European age estimation workshops and calcified structures (CS) exchanges took place for standardizing an age estimation criterion and for comparing the age estimates from both CS of white anglerfish (Anon, 1991; Anon, 1997; Anon, 1999; Landa *et al*., 2002; Duarte *et al*, 2005).

The age estimation from *illicia* of a decadal time-series was performed for the Iberian Atlantic stock of white anglerfish using the standardized age estimation criterion of Duarte *et al.* (2002), but inconsistencies in cohort tracking were found (Azevedo *et al*., 2008). An age-structured model has not been used since then for the assessment of both northern and southern stocks of the European Atlantic southern shelf of white anglerfish (ICES, 2010a). Age estimations are not being used either in the assessment of the European Atlantic northern shelf stock (ICES, 2010b).

Growth studies alternative to the age estimates on CS of white anglerfish, such as tagging-recapture (Laurenson *et al*., 2005; Landa *et al.,* 2008a), daily growth (Wright *et al*., 2002) and length frequency distributions of catches (Dupouy *et al*., 1986; Thangstad *et al*., 2002; Landa, 2004; Jónsson, 2007), showed that the growth pattern estimated using the traditional standardized age estimation criterion based on *illicia* (Duarte *et al*., 2002) was underestimated and that criterion was not accurate, although it was standardized and had been used in several age estimation anglerfish workshops. The last anglerfish *illicia* exchange and workshop using that criterion took place in 2004 (Duarte *et al*., 2005).

A new faster overall growth rate and growth parameters, based on the results obtained in aforementioned growth studies alternative to the age estimates, was then estimated for white anglerfish in European Atlantic waters (Landa *et al*., 2008a).

Modifications in the methodology of *illicia* preparation and in the traditional standardized age estimation criterion have allowed a new age estimation criterion to be obtained for *illicia,* showing a faster growth pattern than the traditional one. This is in more accordance with the faster growth shown by the results of the aforementioned validated growth studies. When this new criterion was applied to an *illicia* time series from Porcupine bank, the cohorts were more successfully tracked in the new performed catches-at-age matrix (Landa *et al.*, pers. com.) Therefore this new criterion seems to be more accurate and it was presented in a working document to be used in the present exchange (Annex 2).

The ICES Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS) (ICES, 2011) recommended an exchange take place using *illicia* and otoliths in 2011, once a new age estimation criterion on *illicia* was ready.

An ICES Benchmark workshop for anglerfish stock assessment will be held in 2012 (WKFLAT), and the results from this exchange will be of interest to it.

2. OBJECTIVES

The objectives of the exchange are to:

- To evaluate the levels of agreement, precision and relative accuracy
  - between both CS (*illicia* and otoliths);
  - among readers (all and those that provide age estimates for the assessment) within each CS;
- To identify the interpretation differences in the positions of the annuli (annual increments).
- To subsequently evaluate the application of the results on the stock assessment.

3. PARTICIPANTS

The age readers from the institutes of the European countries with anglerfish fisheries in Atlantic waters that might be interested in this exchange were contacted by the coordinator. All the participants sent their readings with the exception of AZTI (Spain). Once the exchange began, an institute in the Mediterranean (COISPA, Italy) was also interested in participating and his reader was included. Therefore, almost all European readers involved in the stock assessment of white anglerfish in Atlantic waters have participated in the exchange. In total 14 readers (including two Mediterranean readers) from 10 institutes from 8 European countries participated (Table 1, Annex 1).

The anglerfish ageing experience level was based on the number of historical CS aged by each r reader described by the following levels: "-" (0), "low" (<1000), "med" (1000-5000), "high" (>5000). The more experienced readers were selected as the reference readers in each CS: *illicia* (R3, R4, R7 and R13) and otoliths (R8, R9) (Table 1). The information on the CS read and whether the age estimates have been used for stock assessment by stock, ICES area and assessment WG is also showed in Table 1.

Table 1. Participants in the exchange and their experience in age estimation on white anglerfish. Information on the CS read and age estimates that have been used for assessment by stock, ICES area and assessment WG.

Participants				Age estimation experience		Age estimation for stock assessment purposes					
Name	**Institute**	**Country**	**ID**	**Illicia**	**Otoliths**	**Illicia**	**Otoliths**	**Assessment**	**ICES WG**	**Stocks (1)**	**ICES Subarea or Division**
Pierluigi Carbonara	COISPA	Italy	R1	LOW	-	X	-	-	-	1: O	Mediterranean
Eduardo Santos	IPIMAR	Portugal	R2	-	-	X	-	X	WGHMM	1: S(S)	IXa
Jorge Landa	IEO	Spain	R3	HIGH	LOW	X	-	X	WGHMM	2: S(S), S(N)	VIIIc, IXa, VII
Joaquín Barrado	IEO	Spain	R4	HIGH	LOW	X	-	X	WGHMM	2: S(S), S(N)	VIIIc, IXa, VII
Elena Barcala	IEO	Spain	R5	MED	-	X	-	-	-	1: O	Mediterranean
Karine Sévin	IFREMER	France	R6	LOW	-	X	-	X	WGHMM	1: S(N)	VII, VIIIabd
Helen McCormick	Mar. Inst.	Ireland	R7	HIGH	-	X	-	X	WGHMM, WGCSE	2: S(N), N	VII, VI
Sally Songer	CEFAS	UK (England)	R8	-	MED	-	X	X	WGHMM, WGCSE	2: S(N), N	VIIe-k, IV
Gordon Henderson	MARLAB	UK (Scotland)	R9	-	HIGH	-	X	X	WGCSE	1: N	IVa, VIab
Helle Rasmussen	DIFRES	Denmark	R10	-	LOW	-	X	X	WGCSE	1: N	IVbc
Aage Thaarup	DIFRES	Denmark	R11	-	LOW	-	X	X	WGCSE	1: N	IVbc
Lise Helen Ofstad	FAMRI	Denmark	R12	MED	LOW	X	-	-	-	1: O	Vb
Hanna Elina Djurhuus	FAMRI	Denmark	R13	HIGH	LOW	X	-	-	-	1: O	Vb
Sarah Nebel	BIOPOL	Iceland	R14	LOW	-	-	-	-	-	1: O	Va

(1) Stocks: S(S) = Southern Shelf, Southern stock (VIIIc,IXa); S(N) = Southern Shelf, Northern stock (VIIb-k, VIIIabd); N = Northern Shelf (IIa, IIIa, IV, VI); O = Other (V).

4. MATERIAL AND METHODS

The recommendations from ICES PGCCDBS "Guidelines for Otolith Exchanges" (ICES, 2011), especially those on preparation of collections, analysing results, etc, were used for this exchange. The exchange was run through the European Age Readers Forum (EARF).

4.1. Samples

A sample of 200 CS (100 *illicia* and 100 otoliths) of the same specimen was prepared in order to compare the age estimations between both structures. The exchange was based on digitised images of each CS.

Due to the wide distribution of this species, the growth pattern could show some geographical difference among areas. Therefore, two sub-collections with CS of two European areas were prepared and it may allow the comparison of the results between areas:

- Sub-collection A: ICES Div.VIIbck, provided by IEO, 50 *illicia* and 50 otoliths.
- Sub-collection B: ICES Div.Vb, provided by FMRI, 50 *illicia* and 50 otoliths.

The length frequency distribution of specimens chosen in both sub-collections was similar, covering the most of the length range landed by commercial catches (21-132 cm), with higher sample size (around 3 specimens) in the main length range landed (35-110 cm) (Fig. 1).

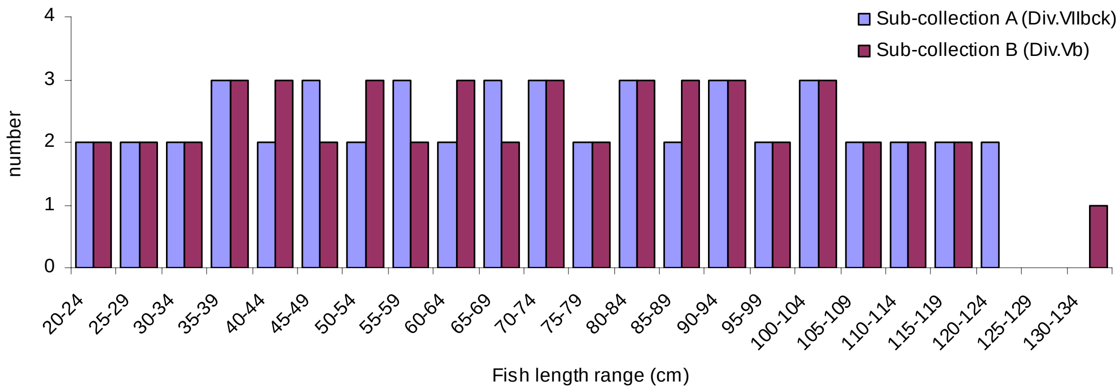


Fig. 1. Length frequency distribution of specimens studied from each ICES Division and Sub-collection.

The exchange was carried out through the EARF (http://groupnet.ices.dk/AgeForum/default.aspx), the ICES PGCCDBS forum for allowing the age readers to have access to the information necessary for the exchanges. The following information was available in a folder called 'Anglerfish *illicia*/otoliths exchange 2011':

- Protocol.
- Digitised images.
- Information provided of each specimen for the age estimation:
  - Code (different code between *illicia* and otoliths in spite of both belonging to the same specimen).
  - Length range (10 cm intervals).

  Both set of data are presented in such a way in order to avoid the identification of the otolith and *illicium* from the same specimen, so that a more independent age estimation between structures will be obtained.
  - Date (quarter).
- Images analysed: for uploading the completed files of images when each reader finish the readings.
- Data completed: for uploading the completed files of data each reader finish the readings.
- Other useful documents for the exchange.

4.2. Age estimation procedure

4.2.1 Age estimation criteria

Dupouy *et al.* (1986) and Woodroffe *et al.* (2003) verified as annual the annuli formation in *illicia*, and Crozier (1989) and Woodroffe *et al.* (2003) did it in sectioned otoliths. In both CS, an annual cycle of growth consists of one wide opaque zone (WOZ) and one wide translucent zone (WTZ), the latter formed in winter. The pattern of laying down of these zones throughout the year also seems to be similar in both structures (Woodroffe *et al.*, 2003).

Illicia. The traditional standardized age estimation criterion based on *illicia* was described in the Anglerfish Ageing Guide (Duarte *et al.*, 2002). Although most of the methodology of *illicia* preparation is similar, modifications in the age estimation criterion are presented in the new age estimation criterion (Annex 2).

Otoliths. The readers of the present exchange that use otoliths for their routine age estimations, read whole otoliths under reflected light. Therefore in the present exchange the images were taken using reflected light, instead of the transmitted light used in the previous anglerfish *illicia*/otolith exchange (Duarte *et al*., 2005). During that last exchange Gordon Henderson showed the methodology for age estimation for whole otoliths under reflected light that is used in FRS (UK) and it was presented in the report (Duarte *et al*., 2005). Pictures illustrating the age estimation criterion were presented. This methodology was the used in the present exchange (Annex 2).

4.2.2. Annotating of annuli on the images

Each reader annotated the supposed annuli on the digitised images using the image manipulation program "GIMP 2.6.11.", downloaded free at *http://www.gimp.org/downloads/*. This program has advantages for a CS exchange, as is its free, easy to use and its ability to select a variety of symbols for indicating the annuli. This is necessary for this exchange which has many participants.

The age estimation on the images was based on the aforementioned growth age estimation criteria. The procedure was to create a new layer by reader in each image, and to annotate the supposed annuli in that layer using the colour and type of brush assigned by reader (Table 2).

Table 2. CS read by reader and information on the images analysing procedure with the GIMP program.

Participants		Hard part read		Program GIMP 2.6. (images)								
					Pencil tool							
					Colour							
Name	ID	illicia	otoliths	Layer name	H	S	V	R	G	B	Type of brushes
Pierluigi Carbonara	R1	X	X	pc	0	97	65	165	5	5	Circle (17) (19 x 19)
Eduardo Santos	R2	X	X	es	40	100	100	255	170	0	Circle (17) (19 x 19)
Jorge Landa (coordinator)	R3	X	X	jl	120	100	50	0	128	0	Circle (17) (19 x 19)
Joaquín Barrado	R4	X	X	jb	120	100	100	0	255	0	Circle (17) (19 x 19)
Elena Barcala	R5	X	X	eb	120	25	100	192	255	192	Circle (17) (19 x 19)
Karine Sévin	R6	X	X	ks	300	100	100	255	0	255	Circle (17) (19 x 19)
Helen McCormick	R7	X	X	hm	60	100	100	255	255	0	Circle (17) (19 x 19)
Sally Songer	R8	X	X	ss	0	100	100	255	0	0	Calligraphic brush (23 x 23)
Gordon Henderson	R9	-	X	gh	120	100	50	0	128	0	Calligraphic brush (23 x 23)
Helle Rasmussen	R10	-	X	hr	240	100	100	0	0	255	Calligraphic brush (23 x 23)
Aage Thaarup	R11	-	X	at	180	100	100	0	255	255	Calligraphic brush (23 x 23)
Lise Helen Ofstad	R12	X	-	lo	300	100	100	255	0	255	Calligraphic brush (23 x 23)
Hanna Elina Djurhuus	R13	X	-	hd	300	25	100	255	192	255	Calligraphic brush (23 x 23)
Sarah Nebel	R14	X	X	sn	60	100	100	255	255	0	Calligraphic brush (23 x 23)

4.2.3. Age readings

Each reader counted the number of supposed annuli (annual increments) and attributed an age to each *illicia* and otolith. Those with doubtful age estimations (i.e. those annotated as 7?) were also included in the analysis (i.e. 7? was considered as 7). When the reader had doubts between two possible age estimations (i.e. 4 and 3) and therefore it was annotated as 4/3, the first annotated age was considered to be the more reliable (i.e. 4/3 = 4) and it was the age subsequently analysed.

The credibility of each age estimate was attributed using the following levels: unreadable (u); low credibility (b); medium credibility (m); high credibility (h).

The type of edge (if was possible) was also described using the codes: hyaline (h); opaque (o); doubtful (?)

Most of the readers also measured the assumed first annulus diameter in the direction of the longest axis.

4.3. Data analysis

4.3.1. Age readings

As in the previous anglerfish *illicia*/otolith exchange (Duarte *et al*., 2005), where *illicia* and otoliths from the same fish were also studied, two types of analysis of the age readings were performed.

<u>4.3.1.1. Within each CS</u>

Firstly the age reading consistency between readers within each CS was analysed. It was performed using an Excel ad-hoc Workbook "AGE COMPARATIONS. XLS" from A.T.G.W. Eltink following the recommendations of EFAN (Eltink *et al*., 2000). This workbook was developed for an easy and fast analysis of age reading results and it ensures that age reading comparisons are carried out in a more standardised way. Eltink's workbook mainly estimates the age reading errors that affect precision and accuracy:

- Precision is estimated by the coefficient of variation (CV) (= SD / mean age, indicates the variability in age reading by modal age; it is independent of the closeness to the true age).
- Accuracy (closeness of a measured value to its true value). In the absence of CS of known age, the accuracy is estimated by the relative bias (the systematically over- or underestimation of age compared to the modal age).
- Agreement with respect to the modal age.
- Mean length at age.

The Average Percent of Error (APE) (Beamish and Fournier, 1981) was also calculated by CS for assessing the precision and for comparing its values with those from the first anglerfish age estimation exchanges and workshops, where this indicator was the only one estimated there.

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

n = number of *illicia*/otoliths
r = number of readings for each *illicia*/otoliths (readers)
xij = the *j* value of age estimation for the *i illicia*/otoliths
xi = average age calculated for the *i illicia*/otoliths

Other additional analyses, not offered by Eltink's workbook, were performed using SPSS software and Microsoft Excel:

- First annulus diameter by reader (box-whisker plot) and by specimen.
- Ageing credibility percentages by reader

The age comparisons are based on a reference age when there are not validated ages available, which is the case for this species. Two independent analyses were performed adopting the following ages as reference in each CS.

Illicia. The modal age from readers with high experience (R3, R4, R7 and R13) (Table 1) was used as the reference age. An additional analysis was carried out using *illicia* ages from the readers which provide or will provide ALKs to the ICES anglerfish stock assessment WG (R2, R3, R4, R6, R7, R12, R13 and R14).

Otoliths. Two different reference ages were used due to the low agreement between the most experienced otoliths readers (R8 and R9) (Table 1). Therefore two otolith analyses are presented using R8 and R9 as reference readers. Similar disagreement between experienced otoliths readers occurred in the previous anglerfish *illicia*/otolith exchange where double analysis was also performed (Duarte *et al*., 2005). An additional analysis was carried out using otolith ages from the readers which provide or will provide ALKs to the ICES anglerfish stock assessment WG (R8, R9, R10 and R11).

4.3.1.2. Between CS

In this second analysis the age reading discrepancies between CS were studied. The difference between otolith reference age (R8 and R9) and the *illicia* modal age was calculated for each fish. The differences were quantified and percentages were calculated.

5. RESULTS AND DISCUSSION

5.1. Age readings

5.1.1. *Illicia* (all readers)

The age readings by each reader and basic information about the *illicia* collection are shown in Annex 3. Following the methodology described by Eltink (2000), the modal age was determined by a selected group of experienced *illicia* readers (R3, R4, R7 and R13) (Table 1). In some *illicia* all age readings were different and the modal age was not possible to be estimated, so the rounded mean age of the experienced readers was used, as recommended by Eltink (2000).

5.1.1.1. Number of age readings
All the readers practically aged the whole sample (between 93 and 100 *illicia*), only a mean of 2 *illicia* were rejected by each reader (Table 3).

5.1.1.2. Coefficient of variation (CV)
The mean CV for all readers was 26.7%. The experienced readers R3, R4 and R13 showed a high precision (Table 3).

The standard deviation (SD) increases with age, while CV remains far more stable since it is much less age dependent. Thus, CV is considered a better index for the precision by age (Figure 3). The overall values of the mean CV seem to be very influenced by low precision in the first ages (Table 3). The highest values of CV were estimated for ages 0 and 1 (115% and 48%, respectively) (Figure 3). Although it could seem to indicate specific problems in the readings of these ages, however SD is the lowest for these ages. Therefore, the high values of CV for ages 0 and 1 are more related to the very low value of the mean ages (0 and 1) because it is necessary to divide the very low value of the SD by 0 or by 1 for calculating those CV values. For ages older than 5 years, CV decreases to lower values than 20%. So, no specific problems in age precision are indicated (Figure 3).

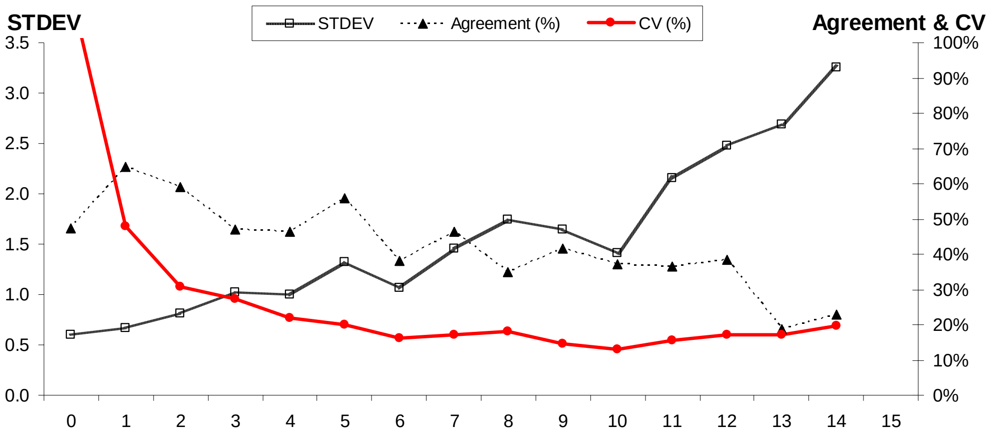


Figure 3. ***Illicia***. CV, percent agreement and standard deviation (STDEV) plotted against modal age of experienced *illicia* readers (R3, R4, R7 and R13).

Table 3. ***Illicia***. Number of age readings, CV, percentage of agreement, relative bias by reference age (mode of experienced *illicia* readers R3, R4, R7 and R13) and overall readers ranking.

NUMBER OF AGE READINGS

	Modal age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	TOTAL
	0	5	5	5	5	5	5	5	5	-	-	-	5	5	3	**53**
	1	8	8	8	8	7	8	8	8	-	-	-	8	8	6	**85**
	2	9	9	8	8	7	9	9	9	-	-	-	9	9	9	**95**
	3	9	9	8	9	9	9	9	9	-	-	-	9	9	9	**98**
	4	8	9	9	9	8	8	9	9	-	-	-	8	8	8	**93**
	5	7	7	7	7	7	7	7	7	-	-	-	7	7	7	**77**
	6	8	8	7	7	7	8	8	7	-	-	-	8	8	8	**84**
	7	9	9	9	9	9	9	9	9	-	-	-	9	9	9	**99**
	8	6	6	6	6	6	6	6	6	-	-	-	6	6	6	**66**
	9	7	7	7	7	7	7	7	7	-	-	-	7	7	7	**77**
	10	5	5	5	5	5	5	5	4	-	-	-	5	5	5	**54**
	11	7	7	7	7	7	7	7	7	-	-	-	7	7	7	**77**
	12	6	6	6	6	6	6	6	6	-	-	-	6	6	5	**65**
	13	3	3	3	3	3	3	3	3	-	-	-	3	3	2	**32**
	14	2	2	2	2	2	2	2	2	-	-	-	2	2	2	**22**
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Total	**0-15**	**99**	**100**	**97**	**98**	**95**	**99**	**100**	**98**	**0**	**0**	**0**	**99**	**99**	**93**	**1077**

COEFFICIENT OF VARIATION (CV)

	Modal age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL Readers
	0	137%	0%	0%	0%	0%	56%	224%	71%	-	-	-	56%	39%	0%	**114.6%**
	1	40%	26%	31%	0%	79%	38%	62%	57%	-	-	-	0%	30%	41%	**47.9%**
	2	25%	30%	17%	0%	33%	22%	34%	60%	-	-	-	32%	24%	41%	**30.8%**
	3	24%	21%	11%	17%	31%	15%	21%	35%	-	-	-	21%	18%	32%	**27.2%**
	4	15%	19%	13%	13%	21%	21%	24%	23%	-	-	-	22%	15%	38%	**21.9%**
	5	14%	9%	7%	0%	20%	9%	17%	36%	-	-	-	14%	12%	26%	**19.9%**
	6	14%	16%	8%	9%	6%	22%	19%	12%	-	-	-	14%	12%	9%	**16.2%**
	7	8%	19%	0%	12%	10%	13%	12%	24%	-	-	-	10%	7%	23%	**17.0%**
	8	10%	10%	0%	5%	16%	8%	16%	17%	-	-	-	11%	16%	12%	**18.1%**
	9	10%	19%	4%	10%	17%	12%	10%	19%	-	-	-	12%	11%	13%	**14.7%**
	10	9%	14%	0%	10%	8%	5%	6%	13%	-	-	-	9%	10%	10%	**12.9%**
	11	28%	16%	5%	7%	21%	12%	12%	16%	-	-	-	9%	11%	18%	**15.4%**
	12	10%	9%	3%	6%	19%	7%	14%	20%	-	-	-	9%	7%	12%	**17.0%**
	13	5%	22%	9%	7%	32%	10%	12%	43%	-	-	-	8%	10%	6%	**17.1%**
	14	32%	34%	5%	0%	16%	6%	0%	42%	-	-	-	11%	31%	22%	**19.8%**
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean	**0-15**	**23.9%**	**17.8%**	**8.4%**	**7.1%**	**22.6%**	**17.8%**	**30.9%**	**32.2%**				**16.0%**	**16.2%**	**22.9%**	**26.7%**
	RANKING	**9**	**5**	**2**	**1**	**7**	**6**	**10**	**11**				**3**	**4**	**8**	

PERCENTAGE AGREEMENT

	Modal age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL
	0	60%	0%	100%	100%	100%	20%	80%	20%	-	-	-	20%	0%	0%	**47%**
	1	88%	25%	88%	100%	57%	63%	75%	63%	-	-	-	100%	13%	33%	**65%**
	2	78%	56%	88%	100%	29%	56%	56%	44%	-	-	-	67%	22%	56%	**59%**
	3	56%	67%	88%	78%	11%	44%	56%	22%	-	-	-	67%	22%	11%	**47%**
	4	38%	33%	78%	78%	38%	63%	22%	44%	-	-	-	50%	38%	25%	**46%**
	5	86%	71%	86%	100%	29%	29%	71%	29%	-	-	-	57%	29%	29%	**56%**
	6	25%	50%	71%	71%	0%	13%	38%	29%	-	-	-	38%	63%	25%	**38%**
	7	67%	33%	100%	56%	33%	11%	33%	11%	-	-	-	56%	78%	33%	**46%**
	8	17%	50%	100%	83%	33%	0%	17%	0%	-	-	-	33%	17%	33%	**35%**
	9	43%	29%	86%	57%	0%	43%	57%	14%	-	-	-	43%	43%	43%	**42%**
	10	40%	20%	100%	60%	20%	40%	40%	0%	-	-	-	40%	20%	20%	**37%**
	11	29%	29%	71%	71%	14%	29%	43%	0%	-	-	-	29%	57%	29%	**36%**
	12	33%	50%	83%	50%	50%	33%	17%	0%	-	-	-	50%	50%	0%	**38%**
	13	0%	0%	67%	33%	0%	33%	0%	0%	-	-	-	33%	0%	50%	**19%**
	14	0%	0%	50%	100%	0%	0%	0%	0%	-	-	-	50%	50%	0%	**23%**
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean	**0-15**	**49.5%**	**39.0%**	**85.6%**	**76.5%**	**28.4%**	**34.3%**	**44.0%**	**22.4%**				**51.5%**	**35.4%**	**28.0%**	**45.0%**
	RANKING	**4**	**6**	**1**	**2**	**9**	**8**	**5**	**11**				**3**	**7**	**10**	

RELATIVE BIAS

	Modal age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL
	0	0.40	1.00	0.00	0.00	0.00	0.80	0.20	1.00	-	-	-	0.80	1.40	1.00	**0.58**
	1	-0.13	0.75	0.13	0.00	0.43	0.38	-0.25	0.13	-	-	-	0.00	1.13	0.83	**0.29**
	2	0.00	0.22	0.13	0.00	1.00	0.44	-0.44	0.11	-	-	-	-0.11	1.00	0.44	**0.24**
	3	-0.22	0.44	0.13	0.00	1.11	0.56	-0.44	1.56	-	-	-	-0.11	1.00	0.78	**0.44**
	4	-0.63	0.56	0.00	0.00	1.00	0.25	-1.00	0.22	-	-	-	-0.63	0.75	0.13	**0.05**
	5	0.29	0.29	0.14	0.00	1.29	0.71	-0.43	2.57	-	-	-	-0.14	0.86	0.71	**0.57**
	6	-0.50	-0.38	0.29	-0.29	1.71	0.13	-1.00	1.00	-	-	-	-0.13	0.50	0.88	**0.18**
	7	0.11	-0.78	0.00	0.33	0.89	0.56	0.00	2.89	-	-	-	0.00	0.00	1.33	**0.48**
	8	0.50	-0.17	0.00	0.17	1.33	1.67	1.00	4.83	-	-	-	-0.33	0.50	1.00	**0.95**
	9	0.43	0.14	0.14	0.29	0.57	0.14	0.29	3.86	-	-	-	0.14	-0.43	0.57	**0.56**
	10	-0.20	-0.80	0.00	0.80	1.40	0.60	-0.60	3.25	-	-	-	-0.20	-1.20	0.00	**0.22**
	11	1.29	0.14	0.00	-0.43	1.71	-0.14	0.00	4.00	-	-	-	-0.57	0.14	0.29	**0.58**
	12	0.17	-0.33	0.17	-0.17	1.33	-0.33	0.50	6.50	-	-	-	0.00	-0.67	0.00	**0.66**
	13	-1.67	-1.00	-0.67	1.00	2.67	-1.33	-0.67	1.67	-	-	-	-1.00	-1.67	-0.50	**-0.28**
	14	1.50	-3.50	-0.50	0.00	-0.50	-2.50	-2.00	4.50	-	-	-	-1.00	-2.50	-1.00	**-0.68**
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean	**0-15**	**0.06**	**-0.01**	**0.05**	**0.07**	**1.08**	**0.31**	**-0.27**	**2.29**				**-0.16**	**0.31**	**0.57**	**0.39**
	RANKING	**3**	**1**	**2**	**4**	**10**	**7**	**6**	**11**				**5**	**7**	**9**	

Overall ranking

	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14
Ranking Coefficient of Variation	9	5	2	1	7	6	10	11				3	4	8
Ranking Percentage Agreement	4	6	1	2	9	8	5	11				3	7	10
Ranking Relative bias	3	1	2	4	10	7	6	11				5	7	9
OVERALL RANKING	**5**	**4**	**1**	**2**	**9**	**7**	**7**	**11**				**3**	**6**	**10**

Table 4. ***Illicia.*** Age composition, mean length at age and inter-reader test (reference *illicia* readers are shadowed).

AGE COMPOSITION

	pc_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL	
Age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	**TOTAL**
0	4	-	5	5	6	1	6	2	-	-	-	1	-	-	**30**
1	10	8	7	8	4	9	11	11	-	-	-	14	4	6	**92**
2	10	11	8	9	3	8	11	8	-	-	-	9	9	10	**96**
3	11	10	9	8	7	9	11	5	-	-	-	10	9	8	**97**
4	4	7	8	8	8	10	6	5	-	-	-	7	10	7	**80**
5	11	13	7	10	6	7	7	6	-	-	-	7	8	6	**88**
6	3	10	6	6	6	9	6	8	-	-	-	6	12	4	**76**
7	9	7	11	5	7	2	4	4	-	-	-	10	11	12	**82**
8	4	9	6	8	14	9	5	6	-	-	-	6	7	5	**79**
9	9	5	6	7	4	9	10	5	-	-	-	7	10	10	**82**
10	6	5	7	5	8	5	6	1	-	-	-	6	5	6	**60**
11	8	6	6	8	4	13	7	6	-	-	-	7	6	10	**81**
12	6	4	6	5	10	6	5	2	-	-	-	6	6	3	**59**
13	1	3	4	2	-	2	1	9	-	-	-	1	1	3	**27**
14	1	1	1	3	1	-	4	5	-	-	-	2	1	2	**21**
15	-	1	-	1	2	-	-	4	-	-	-	-	-	1	**9**
16	-	-	-	-	3	-	-	3	-	-	-	-	-	-	**6**
17	-	-	-	-	1	-	-	2	-	-	-	-	-	-	**3**
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
19	1	-	-	-	-	-	-	1	-	-	-	-	-	-	**2**
20	1	-	-	-	-	-	-	1	-	-	-	-	-	-	**2**
Total 0-15	**97**	**100**	**97**	**98**	**94**	**99**	**100**	**92**	**0**	**0**	**0**	**99**	**99**	**93**	**1072**

MEAN LENGTH AT AGE

	pc_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL	
Age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	**ALL**
0	24.3		24.2	24.2	25.0	21.0	25.5	30.0				21.0			**24.8**
1	31.2	28.5	31.0	32.0	29.8	28.4	33.5	31.3				30.4	25.8	29.5	**30.5**
2	40.4	34.5	38.1	38.6	42.3	36.3	43.1	36.6				41.0	30.7	38.5	**38.0**
3	50.0	46.3	47.4	51.8	38.7	42.8	55.3	49.2				49.1	39.1	49.0	**47.4**
4	58.8	56.3	55.6	53.0	48.9	52.5	65.2	54.2				60.1	47.0	48.6	**53.8**
5	68.0	65.9	65.9	67.3	56.0	66.9	70.0	56.8				67.0	57.9	60.2	**64.4**
6	74.7	71.9	70.7	73.3	60.0	69.2	75.7	54.5				75.2	71.3	62.8	**68.9**
7	80.1	81.7	78.8	77.4	75.3	79.0	83.5	74.0				80.8	78.8	71.8	**78.0**
8	82.5	93.9	88.0	87.0	76.9	81.1	82.6	70.3				86.5	91.0	89.2	**84.1**
9	92.8	95.2	95.8	94.1	84.3	90.0	94.7	82.4				98.7	96.5	90.7	**92.9**
10	98.7	106.0	99.6	101.0	95.1	95.2	101.5	80.0				99.3	105.8	93.3	**98.9**
11	110.0	110.7	108.0	102.1	107.8	107.5	105.6	99.8				107.3	105.8	103.4	**106.1**
12	108.2	102.3	110.5	109.2	104.9	111.0	109.2	94.5				111.5	112.2	109.3	**108.3**
13	117.0	110.0	115.8	119.5	-	118.5	107.0	94.1				132.0	102.0	113.0	**107.9**
14	113.0	120.0	110.0	113.3	102.0	-	118.3	104.0				114.0	115.0	110.0	**111.5**
15	-	120.0	-	132.0	123.5	-	-	96.0				-	-	115.0	**110.9**
16	-	-	-	-	112.7	-	-	97.7				-	-	-	**105.2**
17	-	-	-	-	117.0	-	-	107.5				-	-	-	**110.7**
18	-	-	-	-	-	-	-	-				-	-	-	**-**
19	115.0	-	-	-	-	-	-	107.0				-	-	-	**111.0**
20	120.0	-	-	-	-	-	-	111.0				-	-	-	**115.5**
Weighted mean 0-15	**72.6**	**71.1**	**71.7**	**71.4**	**71.7**	**71.1**	**71.1**	**70.3**				**71.1**	**71.1**	**72.2**	**71.1**

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

	pc_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL
	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14
Reader 1		–	–	–	**	**	*	**				–	*	**
Reader 2	–		–	–	**	*	–	**				–	**	**
Reader 3	–	–		–	**	*	**	**				*	*	**
Reader 4	–	–	–		**	–	*	**				**	*	**
Reader 5	**	**	**	**		**	**	**				**	**	*
Reader 6	**	*	*	–	**		**	**				**	–	–
Reader 7	*	–	**	*	**	**		**				–	**	**
Reader 8	**	**	**	**	**	**	**					**	**	**
Reader 9														
Reader 10														
Reader 11														
Reader 12	–	–	*	**	**	**	–	**					**	**
Reader 13	*	**	*	*	**	–	**	**				**		–
Reader 14	**	**	**	**	*	–	**	**				**	–	
Modal age	–	–	–	–	**	**	*	**				–	**	**

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

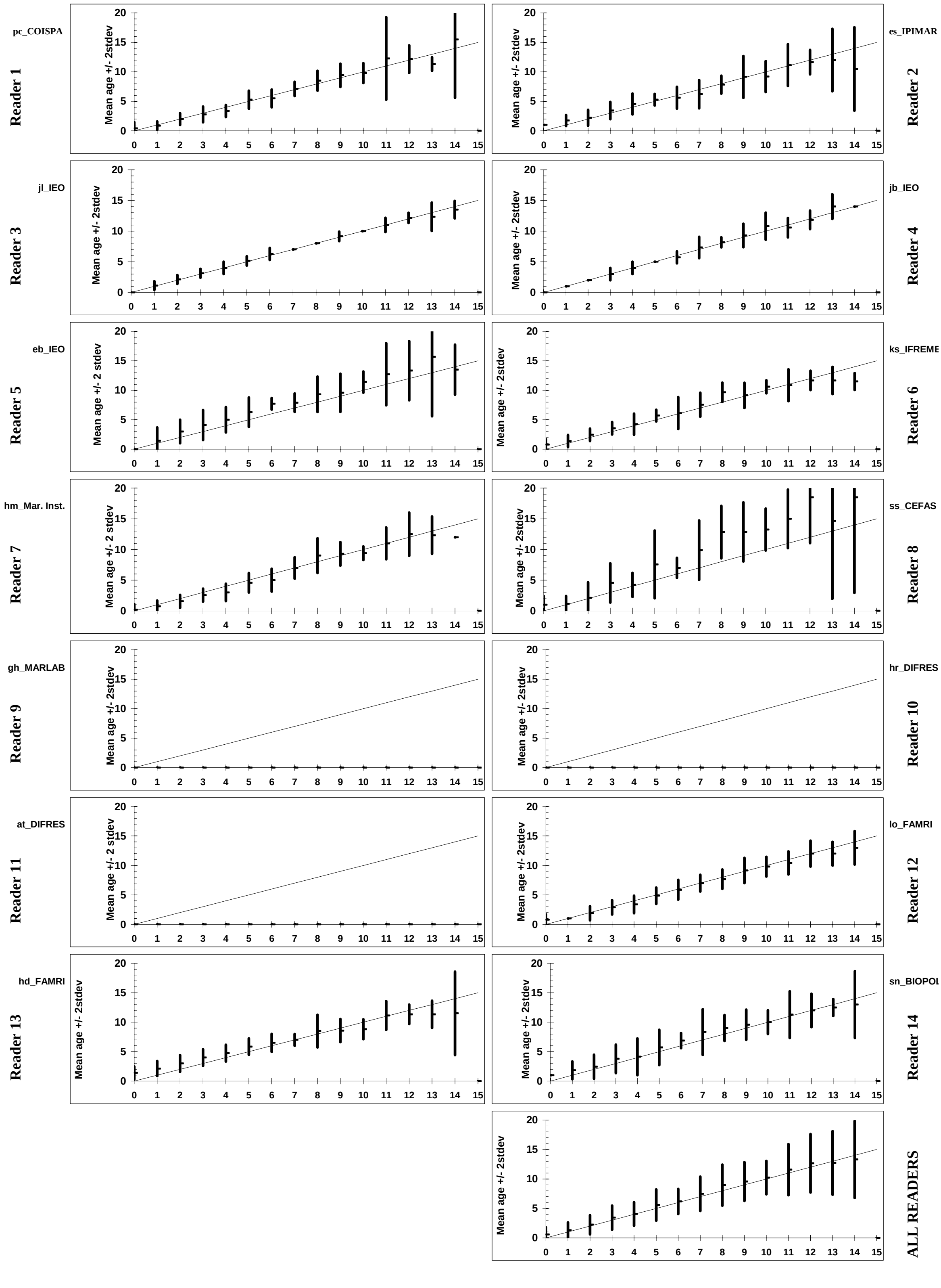


Figure 2. ***Illicia***. Mean age (-) +/- 2stdev versus modal age of experienced *illicia* readers (R3, R4, R7 and R13) (solid line).

5.1.1.3. Agreement

The mean percent agreement with respect to the modal age for all readers was 45.0 % (Table 3). Most readers showed an agreement between 25% and 50%, highlighting the high agreement of two expert readers (higher than 75%) (Table 3).

The agreement is dependent on the age, decreasing as the age increases (Figure 3). An agreement of around 50% is observed up to age 5, decreasing to values lower than 30% in the older ages (Table 3).

5.1.1.4. Relative bias

The relative bias for all readers was 0.4 (Table 3). Low relative biases were estimated for some expert readers and for the inexperienced readers R1 and R2. The higher overestimations were those showed by readers R8 (around 2 age classes of overestimation) and R5 (around 1 age class) (Table 3).

A mean relative bias of between 0.2 and 0.6 was estimated for most ages. The distribution of the age reading errors in percentage by modal age as observed for the whole group of readers is shown in Figure 4. There appears to be no relative bias in most of the ages due to the age reading errors were normally distributed, except for ages 13 and 14, with fewer samples (2-3), that showed an underestimation of the age (Figure 4).

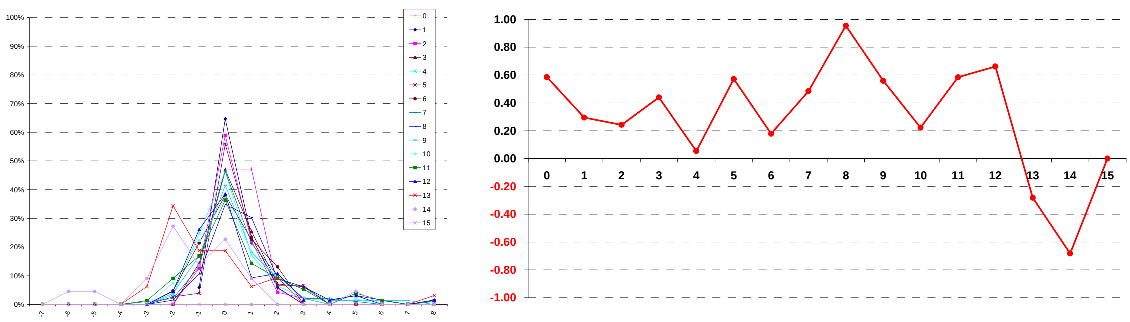


Figure 4. ***Illicia***. Left: Distribution of the age reading errors (%) by modal age for the whole group of readers. Right: Relative bias by modal age as estimated by all age readers combined.

5.1.1.5. Ranking of readers

An overall ranking, based on the results from the CVs, percentages of agreement and relative bias for each reader, was obtained (Table 3). Two expert and three inexperienced readers (R1, R2, R3, R4 and R12) obtained the best results.

5.1.1.6. Age bias plots and mean age

The age bias plots, the mean age recorded (+/- 2stdv.) by each age reader and all readers combined were plotted against the modal age (Figure 2).

Regarding to the precision, the inexperienced readers R8 and R13 showed the higher SD values along most of the age range. The pattern of the SD for all readers was observed to increase with age (Figure 2).

In relation to the accuracy, the mean ages of most of the readers were close to the modal age, except those of the inexperienced readers R8 and R5. Also, the mean ages of the expert readers R7 and R13 showed smaller and higher mean ages respectively in the younger ages compared to the modal ages (Figure 2).

5.1.1.7. Age composition

Ages from 0 to 15 years were estimated by the expert readers (Table 4).

5.1.1.8. Mean length at age

The values of the mean length at age for each reader are shown in Table 4 and Figure 5. Some clear differences between readers were observed in the mean lengths at some ages, as the lower mean lengths at age 3 and age 5 of the inexperienced readers R5 and R8, or the lower and higher mean lengths at first ages of the experienced readers R13 and R7 respectively.

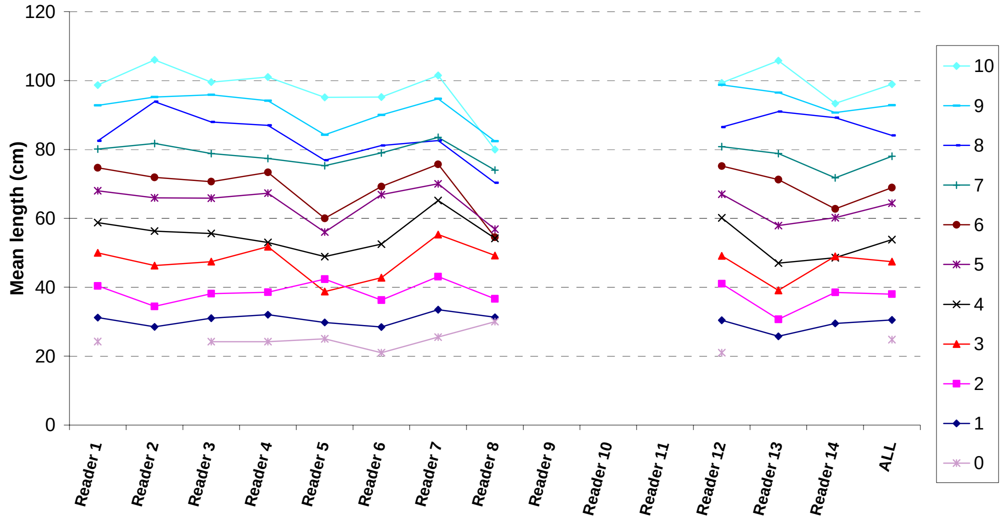


Figure 5. ***Illicia***. Mean length at age of *illicia* as estimated by each age reader.

5.1.1.9. Inter-reader bias test

Ten of the participant readers have used or will use *illicia* to estimate ages for assessment purposes (R1, R2, R3, R4, R6, R7, R12, R13 and R14) (Table 1). The inter-reader bias test showed that 5 of the *illicia* readers (R1, R2, R3, R4 and R12) showed no sign of bias when compared with the modal age, and one (R7) showed possibility of bias (Table 4).

5.1.1.10. First annulus

The 11 readers who read the *illicia* also measured their first annulus, except R2. The box-whisker plots of the first annulus diameter showed that most of readers located it between 300 and 350 µm (median values) (Figure 6). The mean values of the readers R8, R13 and R1 located it below 300 µm. It is also highlighted the higher variability of the measurements of the inexperienced readers R6, R8 and R14.

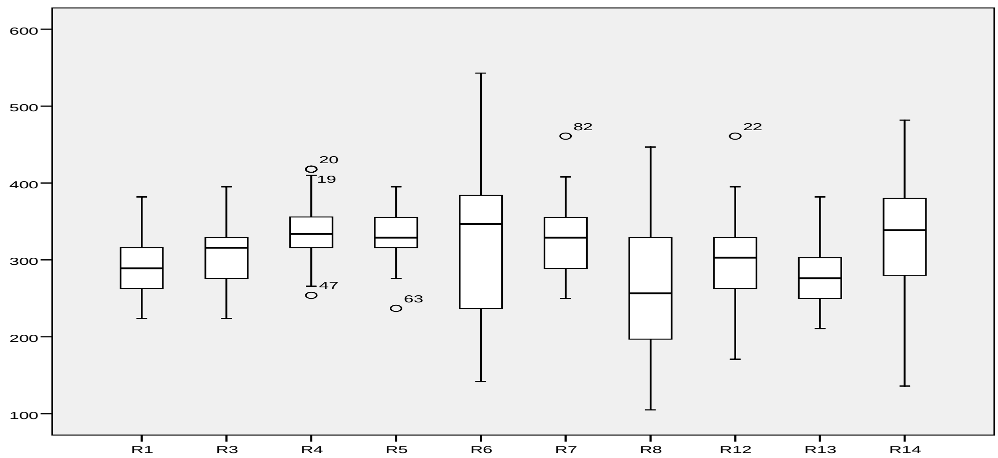
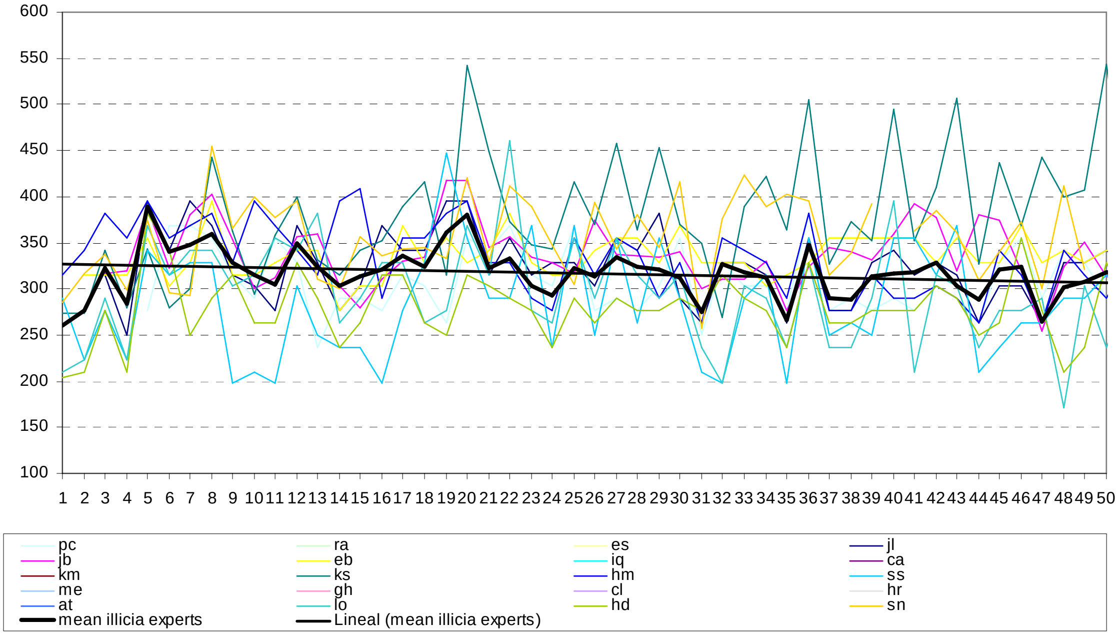


Figure 6. ***Illicia***. Box-whisker plots of the *illicia* first annulus diameter by reader.



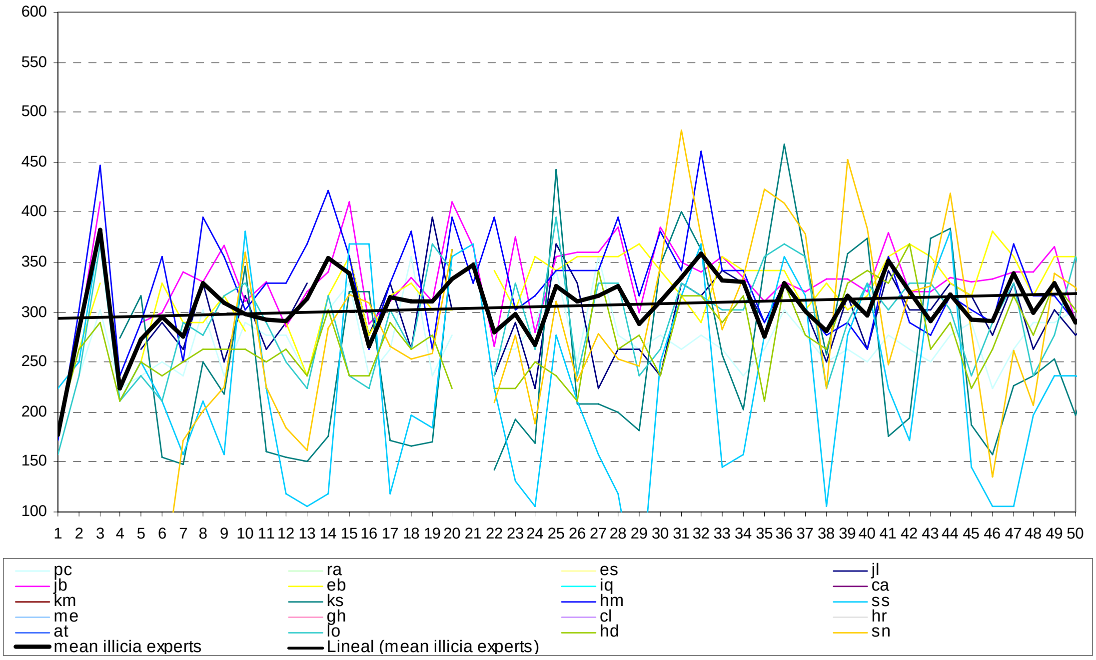


Figure 7. ***Illicia***. Fist annulus diameter by *illicium* for each reader. Above: Sub-collection A. Below: Sub-collection B.

The graphical representation of the fist annulus diameter by *illicium* for each reader is shown in Figure 7. As each *illicia* sub-collection (A and B) was prepared in a different institute, the measurements of the first annulus diameter of each collection were analyzed separately. The overall mean value from all readers was very close to those of the experts, in both collections. The lower values of reader R8 in both sub-collections, and the higher values of the reader R6 in the collection A is highlighted (Figure 7).

Although both sub-collections showed that the average fist annulus diameter was mainly located between 250 and 400 µm, the sub-collection A and B showed similar overall mean values for the experts (317 and 306 µm respectively) (Figure 7). This small difference between collections (3%) is probably due to the different cutting height made on the *illicia* during its preparation in each laboratory, and it demonstrates the accuracy and standardization of cutting height.

The overall average first annulus diameter was 312 µm, when the data of both sub-collections was considered. The recommendation in the protocol of this exchange (Annex 1) was that the first supposed annual increment would tend to be between 300 and 380 µm, following the conclusions of Wright *et al.* (2002) that the first supposed annual increment that was counted in previous age estimation studies on *illicia* did not correspond to an annual period, and that increment should be not counted as an annulus. The present results show that the most of the values obtained by the readers are within the range of aforementioned values recommended. Therefore, it is possible to identify that first annulus quite accurately by most readers.

Also a slight continuous increase with age of the diameter is observed in collection B (from around 290 to 320 µm) (Figure 7). This increasing measure of the diameter with age is probably due to the increase with age of the distance from the base of the *illicia* to which the cut of the section was made.

<u>5.1.1.11. Age reading credibility</u>

The "medium" credibility level was the most frequent for most readers (50%). The "high" and "low" credibility levels were estimated in a similar proportion (around 21-25%) (Figure 8)

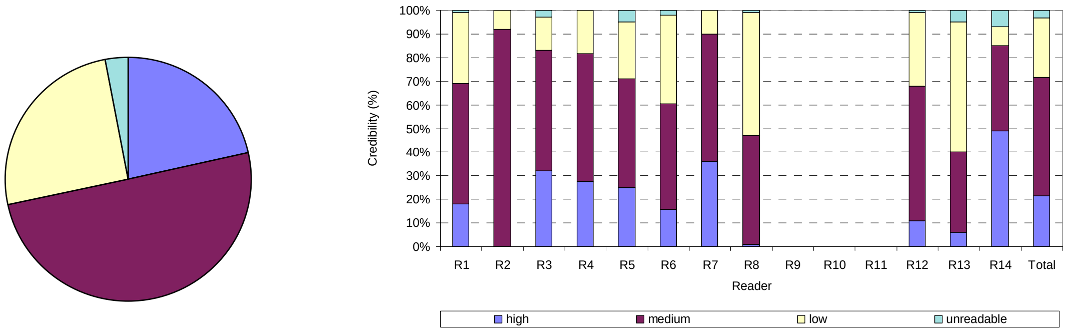


Figure 8. ***Illicia***. Left: overall *illicia* age reading credibility level for the whole group of readers. Right: age reading credibility level by reader.

5.1.2. *Illicia* (stock assessment readers)

An additional analysis was carried out using *illicia* ages from the readers which provide or will provide ALKs to the ICES anglerfish stock assessment WG (R2, R3, R4, R6, R7, R12, R13 and R14). Similar results to those obtained when the age readings from all readers were analysed, were obtained. The summary of these results are showed in Table 8.

5.1.3. Otoliths (all readers)

The age readings by each reader and basic information about the otolith collection are showed in Annex 3. As in the *illicia* analysis, the experienced readers on otoliths were selected as reference readers, based on the reported information on their experience in age estimation of anglerfish and other species (Table 1). They were R8 and R9. Due to the low agreement between both experienced otolith readers, two different otolith analyses had to be performed, using R8 and R9 respectively as reference readers. For the same reason, this approach had been also performed in the last Anglerfish *illicia*/otoliths ageing workshop (Duarte *et al*., 2005).

The percentage agreement between all readers and the precision (obtained by the coefficient of variation) are also presented.

<u>5.1.3.1. Number of age readings</u>

The readers aged most of the sample (between 85 and 100 otoliths), a mean of 6 otoliths were rejected by each reader (Table 5 and 6).

<u>5.1.3.2. Coefficient of variation (CV)</u>

The mean CV for all readers was 23.7% when R8 was the reference reader, and 24.0% when R9 was used (Table 5 and 6).

The overall values of the mean CV seem to be very influenced by low precision in the first ages (Table 5 and 6). The highest values of CV were estimated for ages 1 and 2 (56-74% and 47-56%, respectively) (Figure 9). As in the *illicia* analysis, the high values of CV for ages 1 and 2 are more related to the very low value of the mean ages (1 and 2) because it is necessary to divide the very low value of the SD by 1 or by 2 for calculating those CV values. For ages older than 7 years, CV decreases to lower values than 20%. So, no specific problems in age precision are indicated.

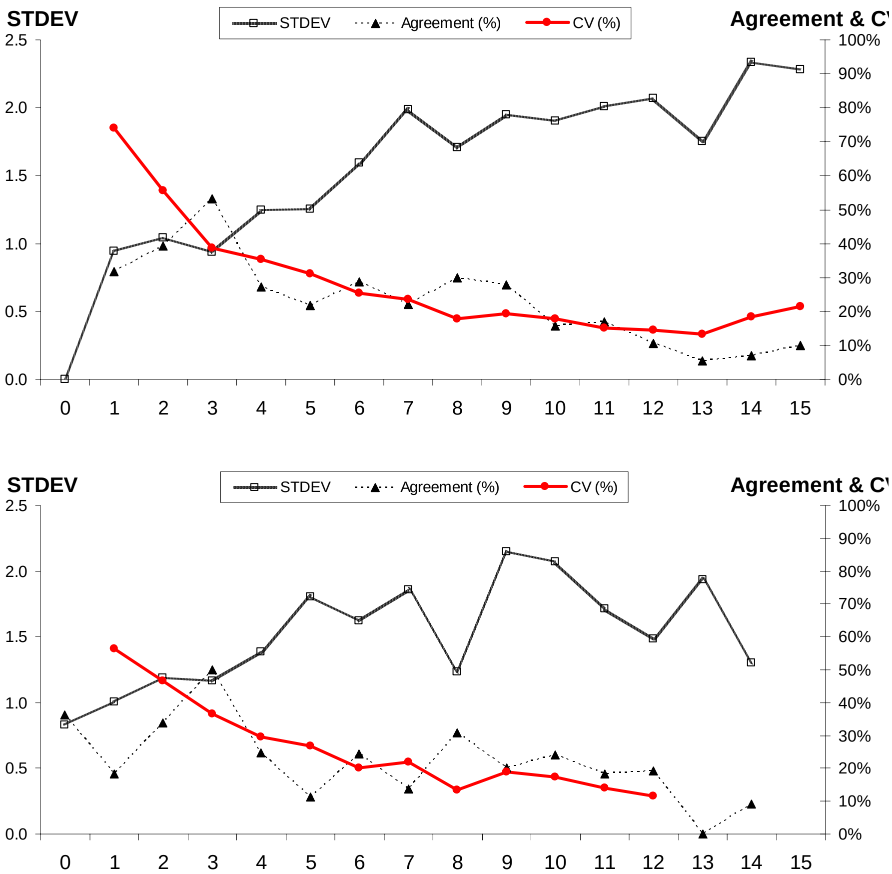


Figure 9. **Otoliths**. CV, percent agreement and standard deviation (STDEV) plotted: (above) against age of reference otolith reader R8; (below) against age of reference otolith reader R9.

Table 5. **Otoliths**. Number of age readings, CV, percentage of agreement, relative bias for each reader compared to the reference ages of reader R8.

NUMBER OF AGE READINGS

	ss_CEFA age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLA Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	TOTAL
	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
	1	2	2	2	2	2	2	2	-	2	2	2	-	-	2	**22**
	2	5	5	4	5	5	4	5	-	4	5	4	-	-	5	**51**
	3	3	3	2	3	3	3	3	-	3	3	3	-	-	3	**32**
	4	5	5	5	5	5	5	5	-	5	5	5	-	-	5	**55**
	5	5	5	5	5	5	5	5	-	5	5	5	-	-	5	**55**
	6	8	8	8	8	8	7	8	-	8	8	8	-	-	8	**87**
	7	10	10	10	9	10	10	10	-	10	10	10	-	-	10	**109**
	8	9	9	9	8	9	9	9	-	8	9	9	-	-	9	**97**
	9	6	6	6	6	6	6	6	-	5	6	6	-	-	6	**65**
	10	5	6	6	5	6	6	6	-	6	6	6	-	-	6	**64**
	11	5	5	4	4	5	5	5	-	5	5	5	-	-	5	**53**
	12	8	8	8	7	8	8	8	-	7	8	8	-	-	8	**86**
	13	5	5	5	5	5	5	5	-	5	5	5	-	-	5	**55**
	14	3	4	4	4	4	4	4	-	4	4	4	-	-	4	**43**
	15	2	2	1	1	2	2	2	-	2	2	2	-	-	2	**20**
Total	**0-15**	**94**	**100**	**94**	**90**	**97**	**92**	**97**	**0**	**85**	**98**	**96**	**0**	**0**	**97**	**1040**

COEFFICIENT OF VARIATION (CV)

	ss_CEFA age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLA Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL Readers
	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1	0%	71%	141%	141%	28%	0%	141%	-	141%	0%	47%	-	-	141%	**74.0%**
	2	20%	25%	115%	137%	30%	23%	56%	-	41%	21%	23%	-	-	30%	**55.6%**
	3	0%	25%	0%	0%	33%	0%	92%	-	50%	22%	22%	-	-	0%	**38.5%**
	4	26%	26%	46%	34%	17%	25%	26%	-	15%	25%	25%	-	-	14%	**35.3%**
	5	20%	34%	21%	0%	25%	21%	41%	-	32%	18%	25%	-	-	26%	**31.1%**
	6	22%	31%	29%	36%	24%	22%	35%	-	15%	22%	16%	-	-	17%	**25.3%**
	7	27%	29%	30%	27%	24%	15%	26%	-	20%	27%	17%	-	-	27%	**23.5%**
	8	23%	18%	27%	26%	22%	14%	21%	-	20%	15%	14%	-	-	19%	**18.0%**
	9	0%	21%	31%	33%	21%	11%	10%	-	29%	20%	16%	-	-	27%	**19.4%**
	10	10%	19%	34%	36%	20%	20%	20%	-	17%	10%	26%	-	-	12%	**17.7%**
	11	12%	17%	11%	19%	24%	15%	23%	-	28%	11%	31%	-	-	12%	**15.0%**
	12	13%	21%	21%	28%	24%	17%	17%	-	17%	16%	23%	-	-	22%	**14.4%**
	13	13%	17%	12%	20%	16%	13%	14%	-	8%	14%	11%	-	-	25%	**13.4%**
	14	22%	15%	29%	24%	9%	22%	23%	-	18%	22%	24%	-	-	18%	**18.3%**
	15	13%	18%	-	-	14%	5%	16%	-	7%	16%	9%	-	-	7%	**21.5%**
Weighted mean	**0-15**	**14.3%**	**20.2%**	**28.0%**	**30.3%**	**19.1%**	**14.2%**	**26.0%**		**22.9%**	**15.4%**	**17.5%**			**19.4%**	**23.7%**
	RANKING	**2**	**7**	**10**	**11**	**5**	**1**	**9**		**8**	**3**	**4**			**6**	

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	ss_CEFA age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLA Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL
	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1	100%	50%	50%	50%	0%	0%	50%	-	0%	0%	50%	-	-	0%	**32%**
	2	80%	80%	0%	0%	40%	50%	0%	-	50%	40%	50%	-	-	40%	**39%**
	3	100%	33%	0%	0%	33%	100%	33%	-	33%	67%	67%	-	-	100%	**53%**
	4	40%	40%	0%	0%	40%	20%	40%	-	60%	20%	20%	-	-	20%	**27%**
	5	40%	0%	0%	0%	40%	40%	20%	-	20%	20%	40%	-	-	20%	**22%**
	6	63%	25%	13%	0%	38%	14%	13%	-	25%	50%	38%	-	-	38%	**29%**
	7	50%	30%	10%	11%	30%	10%	30%	-	20%	40%	10%	-	-	0%	**22%**
	8	22%	33%	22%	63%	33%	22%	22%	-	50%	11%	44%	-	-	11%	**30%**
	9	100%	17%	0%	0%	0%	67%	67%	-	0%	17%	17%	-	-	17%	**28%**
	10	20%	17%	0%	20%	33%	17%	50%	-	17%	0%	0%	-	-	0%	**16%**
	11	40%	20%	0%	50%	20%	20%	0%	-	0%	0%	20%	-	-	20%	**17%**
	12	25%	0%	0%	0%	13%	63%	0%	-	14%	0%	0%	-	-	0%	**10%**
	13	0%	20%	0%	0%	0%	20%	20%	-	0%	0%	0%	-	-	0%	**5%**
	14	33%	0%	0%	0%	0%	50%	0%	-	0%	0%	0%	-	-	0%	**7%**
	15	0%	0%	0%	0%	0%	50%	50%	-	0%	0%	0%	-	-	0%	**10%**
Weighted mean	**0-15**	**39.4%**	**20.0%**	**5.3%**	**11.1%**	**20.6%**	**29.3%**	**20.6%**		**20.0%**	**16.3%**	**18.8%**			**13.4%**	**19.5%**
	RANKING	**1**	**5**	**11**	**10**	**3**	**2**	**3**		**5**	**8**	**7**			**9**	

ABSOLUTE BIAS

	ss_CEFA age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLA Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL
	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1	0.00	1.00	-0.50	-0.50	1.50	1.00	-0.50	-	0.00	1.00	0.50	-	-	0.00	**0.32**
	2	0.20	-0.20	-1.50	-1.60	0.80	0.50	-1.20	-	0.00	0.60	0.50	-	-	0.80	**-0.10**
	3	0.00	-0.67	-2.00	-2.00	0.00	0.00	-1.33	-	-1.00	-0.33	-0.33	-	-	0.00	**-0.66**
	4	-0.80	-0.80	-2.20	-2.40	0.80	0.00	-0.80	-	-0.40	-0.40	-0.40	-	-	1.00	**-0.58**
	5	-0.80	-1.20	-2.40	-3.00	-1.00	0.40	-1.80	-	-1.40	-1.00	-1.00	-	-	-0.60	**-1.25**
	6	-0.25	-1.25	-2.13	-2.88	-0.25	1.29	-0.88	-	-1.00	-0.63	-0.88	-	-	0.25	**-0.80**
	7	0.30	-0.90	-1.90	-2.22	0.10	1.60	0.40	-	-1.20	0.10	-1.10	-	-	1.40	**-0.29**
	8	-0.33	-0.56	-1.56	-1.13	0.00	1.44	0.44	-	-0.50	-0.67	-0.56	-	-	1.22	**-0.19**
	9	0.00	-0.83	-2.17	-2.50	-1.00	0.17	-0.50	-	-2.00	-0.83	-2.00	-	-	1.50	**-0.91**
	10	-1.20	-2.17	-3.17	-2.40	-1.83	0.50	-0.17	-	-2.17	-1.50	-2.33	-	-	-1.00	**-1.58**
	11	0.60	-1.20	-1.50	-1.25	-1.40	1.40	-0.40	-	-0.80	-0.80	-1.60	-	-	-1.40	**-0.74**
	12	-1.50	-1.13	-3.25	-3.29	-1.75	-0.38	-1.75	-	-1.57	-2.00	-2.63	-	-	-1.63	**-1.88**
	13	-2.80	-2.60	-3.80	-3.00	-1.60	-0.60	-2.40	-	-2.80	-3.40	-2.80	-	-	-1.40	**-2.47**
	14	-2.33	-3.75	-5.75	-6.25	-5.00	-2.25	-1.50	-	-4.75	-4.00	-5.25	-	-	-4.25	**-4.14**
	15	-4.00	-3.50	-4.00	-6.00	-5.00	-0.50	-1.50	-	-5.50	-6.00	-7.50	-	-	-5.50	**-4.40**
Weighted mean	**0-15**	**-0.56**	**-1.03**	**-2.06**	**-2.17**	**-0.73**	**0.42**	**-0.66**		**-1.39**	**-0.94**	**-1.39**			**-0.20**	**-0.96**
	RANKING	**3**	**7**	**10**	**11**	**5**	**2**	**4**		**9**	**6**	**8**			**1**	

Overall ranking

	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	jh_MARLA Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14
Ranking Coefficient of Variation	2	7	10	11	5	1	9		8	3	4			6
Ranking Percentage Agreement	1	5	11	10	3	2	3		5	8	7			9
Ranking Absolute bias	3	7	10	11	5	2	4		9	6	8			1
OVERALL RANKING	**2**	**7**	**10**	**11**	**3**	**1**	**4**		**9**	**6**	**7**			**4**

Table 6. **Otoliths**. Number of age readings, CV, percentage of agreement, relative bias for each reader compared to the reference ages of reader R9.

NUMBER OF AGE READINGS

	gh_MARLA	c_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL	
	age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	TOTAL
	0	1	1	1	1	1	1	1	1	-	1	1	-	-	1	11
	1	2	2	2	2	2	2	2	2	-	2	2	-	-	2	22
	2	5	5	4	5	5	5	5	5	-	5	4	-	-	5	53
	3	5	5	4	5	5	5	5	5	-	5	5	-	-	5	54
	4	7	7	7	7	7	7	7	7	-	7	7	-	-	7	77
	5	13	13	13	12	13	12	13	13	-	13	13	-	-	13	141
	6	6	6	6	6	6	6	6	6	-	6	6	-	-	6	66
	7	8	9	8	6	9	9	9	9	-	9	9	-	-	9	94
	8	8	8	8	8	8	8	8	8	-	8	8	-	-	8	88
	9	8	8	7	6	8	8	8	7	-	8	8	-	-	8	84
	10	7	8	8	8	8	8	8	8	-	8	8	-	-	8	87
	11	5	5	5	5	5	5	5	5	-	5	5	-	-	5	55
	12	5	5	5	5	5	5	5	2	-	5	5	-	-	5	52
	13	1	2	2	1	2	2	2	1	-	2	2	-	-	2	19
	14	1	1	1	1	1	1	1	1	-	1	1	-	-	1	11
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0-15	94	100	94	90	97	92	97	85	0	98	96	0	0	97	1040

COEFFICIENT OF VARIATION (CV)

	gh_MARLA	c_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL	ALL
	age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	Readers
	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1	28%	47%	141%	141%	0%	0%	141%	28%	-	28%	0%	-	-	28%	56.4%
	2	58%	21%	82%	105%	14%	47%	39%	58%	-	30%	23%	-	-	26%	46.5%
	3	14%	23%	38%	39%	22%	43%	37%	32%	-	14%	0%	-	-	25%	36.7%
	4	32%	26%	31%	29%	13%	26%	26%	19%	-	24%	17%	-	-	14%	29.5%
	5	31%	31%	23%	32%	24%	21%	32%	15%	-	29%	16%	-	-	26%	26.7%
	6	15%	15%	14%	25%	25%	16%	16%	18%	-	16%	7%	-	-	22%	20.1%
	7	10%	13%	18%	14%	17%	7%	16%	23%	-	12%	15%	-	-	16%	21.9%
	8	9%	13%	10%	10%	9%	11%	6%	19%	-	13%	10%	-	-	10%	13.5%
	9	18%	14%	10%	14%	16%	10%	16%	17%	-	20%	9%	-	-	17%	18.9%
	10	19%	19%	17%	15%	8%	19%	22%	22%	-	15%	16%	-	-	28%	17.2%
	11	12%	9%	11%	13%	13%	11%	23%	7%	-	14%	10%	-	-	16%	14.1%
	12	11%	12%	5%	11%	7%	23%	10%	6%	-	9%	15%	-	-	13%	11.7%
	13	-	17%	6%	-	28%	20%	14%	-	-	0%	0%	-	-	28%	
	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean	0-15	17.8%	16.1%	20.1%	24.8%	13.5%	17.2%	21.2%	19.3%		15.6%	10.5%			17.2%	24.0%
	RANKING	7	4	9	11	2	6	10	8		3	1			5	

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	gh_MARLA	c_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL	
	age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	ALL
	0	0%	0%	100%	100%	0%	0%	100%	0%	-	0%	0%	-	-	100%	36%
	1	0%	50%	50%	50%	0%	0%	50%	0%	-	0%	0%	-	-	0%	18%
	2	40%	40%	25%	20%	0%	60%	40%	40%	-	40%	50%	-	-	20%	34%
	3	80%	40%	0%	0%	40%	60%	60%	20%	-	80%	100%	-	-	60%	50%
	4	43%	57%	0%	0%	14%	14%	43%	43%	-	29%	14%	-	-	14%	25%
	5	8%	8%	15%	17%	15%	8%	0%	8%	-	8%	31%	-	-	8%	11%
	6	17%	17%	33%	17%	17%	0%	17%	33%	-	33%	83%	-	-	0%	24%
	7	0%	22%	25%	17%	11%	0%	11%	22%	-	22%	22%	-	-	0%	14%
	8	13%	25%	38%	63%	25%	0%	38%	50%	-	38%	38%	-	-	13%	31%
	9	25%	0%	29%	17%	25%	0%	25%	0%	-	25%	38%	-	-	38%	20%
	10	29%	38%	25%	25%	38%	0%	13%	13%	-	38%	25%	-	-	25%	24%
	11	20%	40%	20%	20%	20%	0%	0%	0%	-	20%	40%	-	-	20%	18%
	12	20%	0%	0%	20%	40%	0%	40%	50%	-	40%	20%	-	-	0%	19%
	13	0%	0%	0%	0%	0%	0%	0%	0%	-	0%	0%	-	-	0%	0%
	14	0%	0%	0%	0%	0%	100%	0%	0%	-	0%	0%	-	-	0%	9%
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean	0-15	19.1%	20.0%	18.1%	18.9%	17.5%	9.8%	20.6%	20.0%		24.5%	31.3%			14.4%	19.5%
	RANKING	6	4	8	7	9	11	3	4		2	1			10	

ABSOLUTE BIAS

	gh_MARLA	c_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	h_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL	
	age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14	ALL
	0	1.00	1.00	0.00	0.00	2.00	2.00	0.00	1.00	-	2.00	1.00	-	-	0.00	0.91
	1	1.50	0.50	-0.50	-0.50	1.00	2.00	-0.50	1.50	-	1.50	1.00	-	-	1.50	0.82
	2	0.60	0.60	-1.00	-1.20	1.20	0.80	-0.60	0.60	-	0.80	0.50	-	-	1.20	0.34
	3	0.20	-0.60	-1.50	-1.60	0.80	1.20	-0.60	0.60	-	0.20	0.00	-	-	0.60	-0.04
	4	0.43	0.43	-1.43	-2.00	1.14	1.14	0.14	0.86	-	0.71	0.57	-	-	1.43	0.31
	5	0.62	-0.23	-1.00	-1.58	0.85	2.58	0.46	1.77	-	0.54	0.23	-	-	1.92	0.56
	6	1.83	0.67	-0.33	-0.50	0.83	2.50	2.33	1.50	-	1.00	0.17	-	-	2.83	1.17
	7	2.25	0.89	-0.88	-1.33	0.78	2.67	3.00	2.67	-	1.78	-0.44	-	-	2.11	1.32
	8	1.13	0.38	-0.75	-0.50	0.50	1.88	0.63	0.88	-	0.00	-0.38	-	-	1.63	0.49
	9	2.25	1.00	-0.14	-0.83	0.38	3.88	2.25	4.29	-	1.00	-0.13	-	-	1.38	1.43
	10	-0.14	0.00	-0.50	-0.63	0.13	2.13	1.25	1.63	-	-0.50	-1.00	-	-	0.13	0.23
	11	0.20	1.20	-1.20	0.40	0.80	2.60	1.40	1.80	-	0.00	0.40	-	-	0.60	0.75
	12	0.20	0.00	-1.60	-1.60	-0.20	0.40	0.00	-0.50	-	-1.00	-1.20	-	-	-0.60	-0.56
	13	-1.00	-0.50	-1.50	-2.00	-0.50	1.00	-3.00	-1.00	-	-3.00	-2.00	-	-	-0.50	-1.26
	14	-3.00	-5.00	-4.00	-3.00	-2.00	0.00	-4.00	-3.00	-	-4.00	-3.00	-	-	-3.00	-3.09
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean	0-15	0.77	0.25	-0.80	-0.93	0.55	1.89	0.73	1.48		0.34	-0.15			1.07	0.47
	RANKING	6	2	7	8	4	11	5	10		3	1			9	

Overall ranking

	pc_COISPA	es_IPIMAR	jl_IEO	jb_IEO	eb_IEO	s_IFREME	m_Mar. Ins	ss_CEFAS	jh_MARLAI	hr_DIFRES	at_DIFRES	lo_FAMRI	hd_FAMRI	sn_BIOPOL
	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 7	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 13	Reader 14
Ranking Coefficient of Variation	7	4	9	11	2	6	10	8		3	1			5
Ranking Percentage Agreement	6	4	8	7	9	11	3	4		2	1			10
Ranking Absolute bias	6	2	7	8	4	11	5	10		3	1			9
OVERALL RANKING	6	3	8	10	4	11	5	7		2	1			8

Table 7. **Otoliths.** Age composition, mean length at age and inter-reader test (reference *otoliths* readers are shadowed).

AGE COMPOSITION

	Age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	h_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	TOTAL
	0	-	-	3	4	-	-	3	-	1	-	-	-	-	1	**12**
	1	2	2	7	10	-	-	5	2	2	-	1	-	-	-	**29**
	2	6	10	6	12	4	4	5	5	5	6	4	-	-	4	**66**
	3	8	9	10	4	7	7	6	3	5	11	10	-	-	6	**83**
	4	8	9	6	6	8	2	6	5	7	8	5	-	-	7	**72**
	5	3	4	9	8	8	5	4	5	13	3	10	-	-	4	**71**
	6	6	7	8	5	9	2	3	8	6	7	15	-	-	6	**74**
	7	6	10	8	7	7	4	7	10	9	15	12	-	-	9	**94**
	8	7	8	11	9	14	11	7	9	8	9	8	-	-	9	**101**
	9	17	12	3	6	11	14	16	6	8	11	10	-	-	14	**122**
	10	9	8	12	6	8	9	11	6	8	15	8	-	-	13	**107**
	11	8	10	10	8	7	6	7	5	5	6	7	-	-	11	**85**
	12	8	4	1	4	10	9	4	8	5	5	4	-	-	7	**61**
	13	3	5	-	1	2	3	5	5	2	1	2	-	-	-	**24**
	14	3	2	-	-	1	10	5	4	1	1	-	-	-	3	**26**
	15	-	-	-	-	1	3	1	2	-	-	-	-	-	1	**6**
	16	-	-	-	-	-	3	1	-	-	-	-	-	-	2	**6**
	17	-	-	-	-	-	-	1	1	-	-	-	-	-	-	**1**
	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
Total	**0-15**	**94**	**100**	**94**	**90**	**97**	**92**	**97**	**84**	**85**	**98**	**96**	**0**	**0**	**97**	**1040**

MEAN LENGTH AT AGE

	Age	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	h_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ALL
	0			22.7	24.3			27.3		21.0					21.0	**24.1**
	1	24.0	22.5	29.6	31.4			25.4	24.0	26.5		21.0				**28.1**
	2	29.2	32.0	37.0	40.8	26.5	25.0	33.6	26.4	29.2	29.5	25.8			29.8	**32.2**
	3	33.5	35.3	45.0	53.5	30.1	29.1	37.8	30.0	32.2	33.5	33.1			29.5	**35.3**
	4	46.0	50.3	55.2	55.2	41.8	40.5	46.3	37.4	42.1	43.0	39.6			39.7	**45.7**
	5	46.0	58.3	63.0	64.0	45.0	41.2	46.5	40.2	50.8	41.3	51.1			39.3	**51.5**
	6	50.2	54.6	68.4	71.4	53.7	44.0	58.7	50.3	67.8	56.1	62.5			44.2	**58.6**
	7	61.8	68.8	81.9	82.4	62.0	47.3	54.7	62.2	69.8	71.3	76.7			69.8	**69.6**
	8	78.7	78.9	88.0	86.2	74.3	57.3	80.4	75.8	82.3	83.6	83.5			65.9	**77.5**
	9	81.1	85.9	92.0	97.8	83.1	78.0	86.6	76.7	92.8	80.4	96.8			76.1	**84.6**
	10	85.1	93.6	105.1	104.2	94.3	77.1	83.5	75.2	96.0	100.3	104.0			90.2	**93.9**
	11	100.0	107.4	111.6	106.3	101.9	82.7	101.0	93.6	102.4	100.7	107.1			99.2	**102.5**
	12	106.4	102.5	111.0	109.8	111.2	97.7	99.3	95.5	110.0	107.6	111.5			99.3	**105.4**
	13	109.0	104.0		113.0	115.5	109.7	94.6	100.0	121.5	113.0	110.0				**107.0**
	14	105.3	126.0			110.0	101.4	110.2	85.0	115.0	101.0				107.0	**106.9**
	15					132.0	109.3	105.0	97.5						132.0	**116.2**
	16						116.0	91.0							110.0	**109.8**
	17							117.0	98.0							**117.0**
	18															
	19															
	20															
Weighted mean	**0-15**	**70.8**	**71.1**	**72.1**	**69.8**	**71.5**	**72.6**	**71.5**	**67.1**	**70.1**	**71.2**	**71.9**	**-**	**-**	**71.5**	**71.3**

Inter-reader bias test and reader against ACTUAL age bias test

	pc_COISPA Reader 1	es_IPIMAR Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	s_IFREME Reader 6	m_Mar. Ins Reader 7	ss_CEFAS Reader 8	h_MARLAI Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14
Reader 1		**	**	**	–	**	–	**	**	**	**			–
Reader 2	**		**	**	*	**	**	**	*	–	*			**
Reader 3	**	**		–	**	**	**	**	**	**	**			**
Reader 4	**	**	–		**	**	**	**	**	**	–			**
Reader 5	–	*	**	**		**	–	**	**	*	**			**
Reader 6	**	**	**	**	**		**	*	**	**	**			**
Reader 7	–	**	**	**	–	**		**	**	*	**			–
Reader 8	**	**	**	**	**	*	**		**	**	**			–
Reader 9	**	*	**	**	**	**	**	**		*	–			**
Reader 10	**	–	**	**	*	**	*	**	*		*			**
Reader 11	**	*	**	–	**	**	**	**	–	*				**
Reader 12														
Reader 13														
Reader 14	–	**	**	**	**	**	–	–	**	**	**			

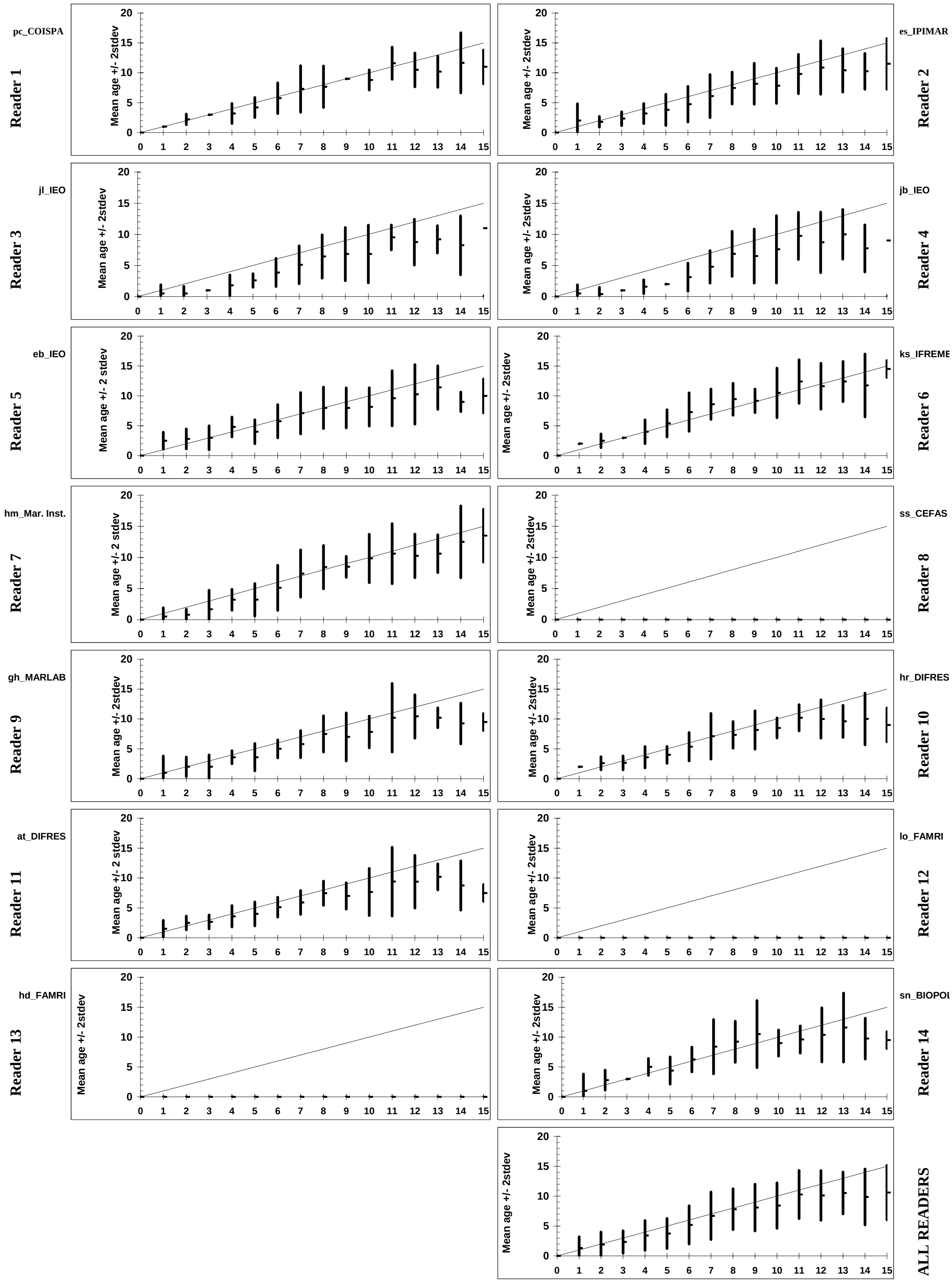


Figure 10. **Otoliths**. Mean age (-) +/- 2stdev versus modal age of experienced otoliths reader R8 (solid line).

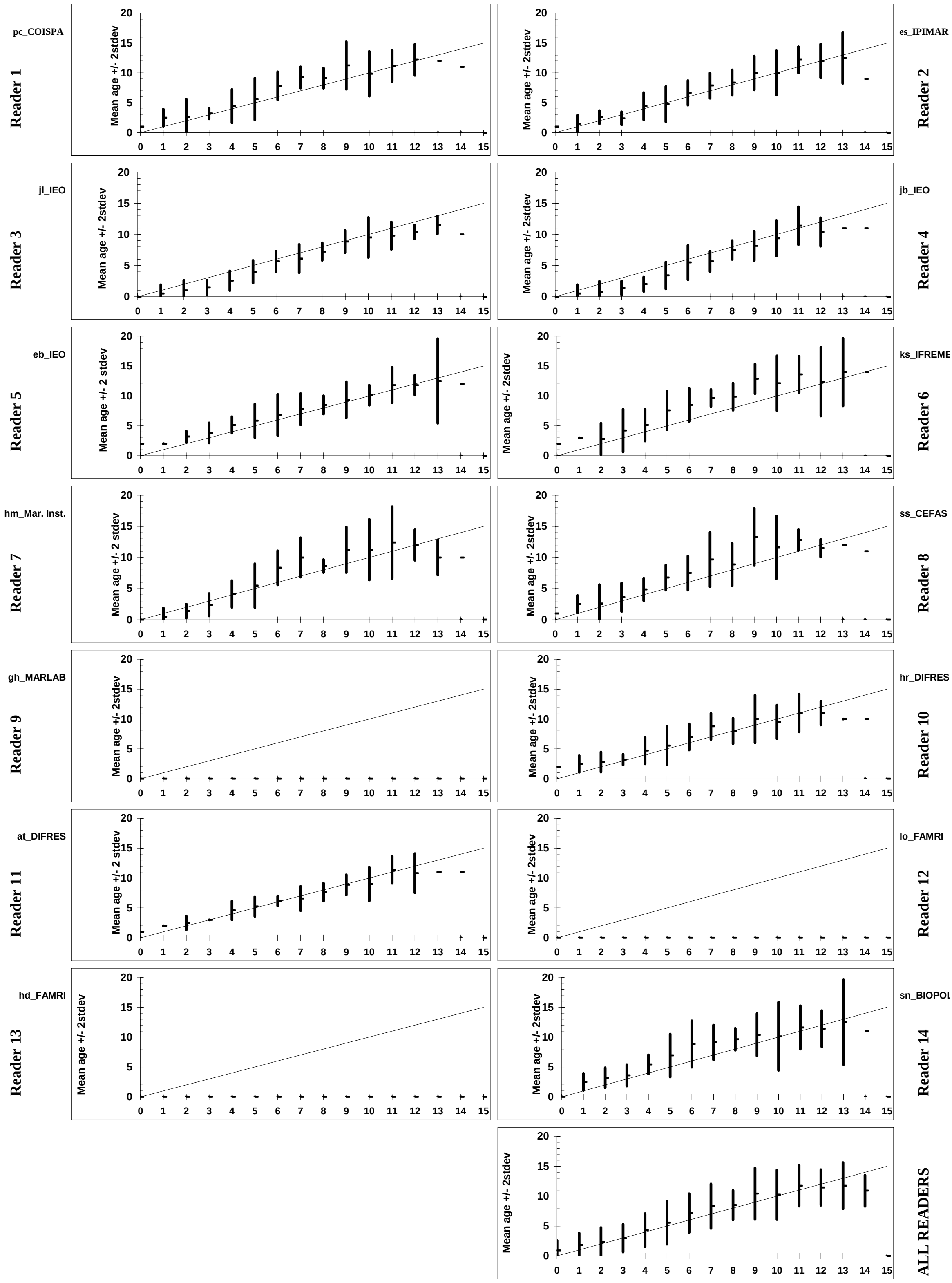


Figure 11. **Otoliths**. Mean age (-) +/- 2stdev versus modal age of experienced otoliths reader R9 (solid line).

5.1.3.3. Agreement

The mean percent agreement for all readers was 19.5 % when R8 or R9 was the reference reader (Table 5 and 6). Most readers showed a low agreement (10-20%). When R8 was the reference reader, it was highlighted the higher agreement among some inexpert readers on otoliths (R1, R5, R6 and R7) than that among the expert ones (Table 5). When R9 was the reference reader, the readers experienced in otoliths (R9 and R10) obtained the highest agreement (Table 6).

The agreement is dependent of the age, decreasing as the age increases (Figure 9). An agreement around 20-30% is observed up to age 9, decreasing to values lower than 10% in the older ages (Table 5).

5.1.3.4. Relative bias

The relative bias for all readers was -0.96 and 0.47 when R8 or R9 were used as reference readers respectively (Table 5 and 6). When R8 was the reference reader, the other expert reader (R9) showed a high relative bias (-1.4), and most of the readers showed a relative bias around -0.5 and -1.5, highlighting the values of around -2 of the inexperienced readers R3 and R4 (Table 5). When the reference reader was R9, the other expert reader (R8) showed a high relative bias (1.5), and most of the readers showed a relative bias around 0 and 1.5, highlighting the negative values of around -0.9 of the inexperienced readers R3 and R4 (Table 6).

The distribution of the age reading errors in percentage by modal age as observed for the whole group of readers is shown in Figure 12. When R8 was the reference reader, a mean relative bias of between 0 and -1.5 was estimated for the most ages up to age 11. From age 12, the values were around -2 to -4 (Table 5, Figure 13). When R9 was the reference reader, a mean relative bias of between 0 and 1.5 was estimated for the most ages, up to age 11. From age 12, the values were around -0.5 to -3 (Table 6, Figure 13).

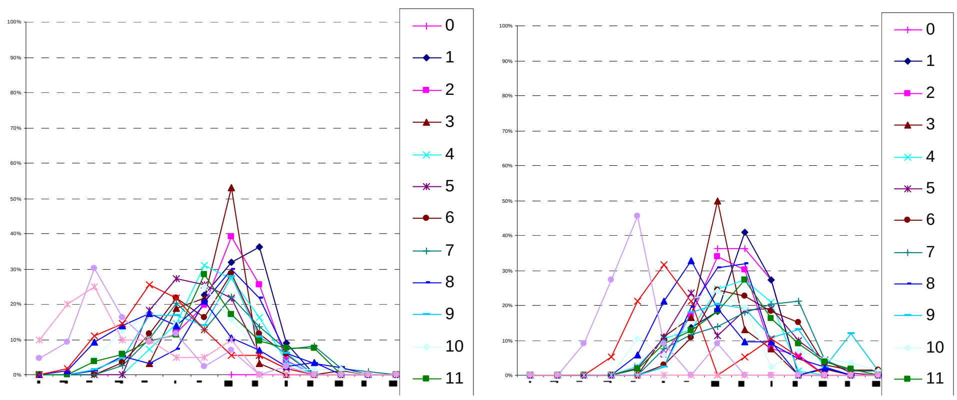


Figure 12. **Otoliths**. Distribution of the age reading errors (%) by modal age for the whole group of readers: (left) taking R8 as the reference reader; (right) taking R9 as the reference reader.

5.1.3.5. Ranking of readers

The overall ranking, based on the results from the CVs, percentages of agreement and relative bias for each reader showed that inexperienced readers for otoliths (R1, R5, R6, R7 and R14) obtained the best results when R8 was the reference reader (Table 5). However, when the reference reader was R9, the other otolith readers (R10, R11) showed the best results (Table 6).

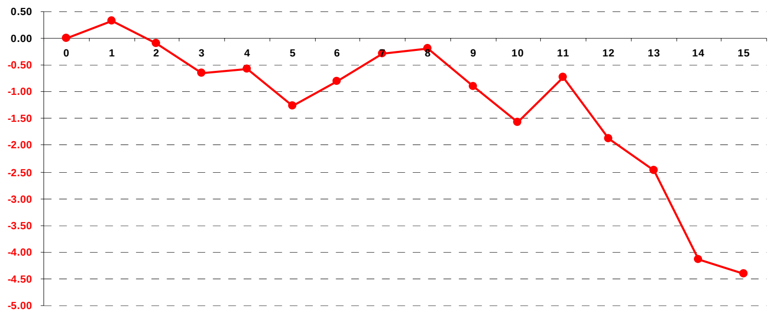
5.1.3.6. Age bias plots and mean age

The age bias plots, the mean age recorded (+/- 2stdv.) by each age reader and all readers combined were plotted against the modal age (Figure 10 and 11).

The two low experienced otolith readers R10 and R11 seem to read more similar to the expert reader R9 than to the expert reader R8 (Figure 10 and 11).

5.1.3.7. Age composition

Ages ranging from 1 to 17 years were estimated by the expert reader R8, and ages ranging from 0 to 14 by the expert reader R9 (Table 7).



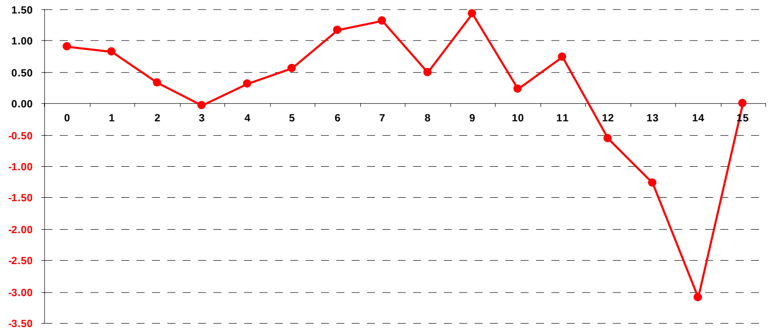


Figure 13. **Otoliths**. Relative bias by modal age as estimated by all age readers combined: (above) taking R8 as the reference reader; (below) taking R9 as the reference reader.

5.1.3.8. Mean length at age

The values of the mean length at age for each reader are shown in Table 7 and Figure 14. Some clear differences between readers were observed in the mean lengths at some ages, such as the higher mean length at age of the inexperienced otolith readers R3 and R4.

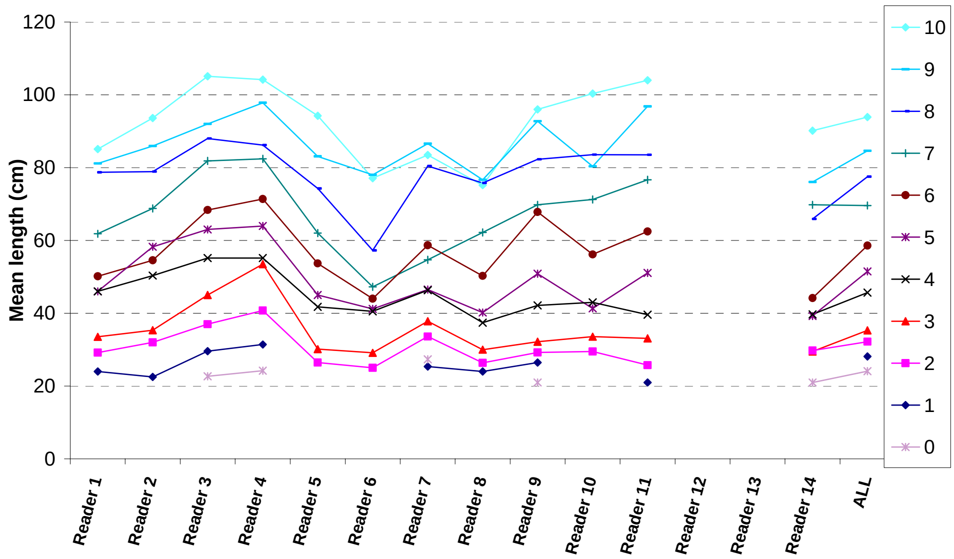


Figure 14. **Otoliths**. Mean length at age of otoliths as estimated by each age reader.

5.1.3.9. Inter-reader bias test

Four of the participant readers have used or will use otoliths to estimate ages for assessment purposes (R8, R9, R10 and R11) (Table 1). The inter-reader bias test showed that the otolith readers obtained possibility or certainty of bias when they were compared amongst themselves; this included the two otolith reference readers (R8 and R9). Only one of the otolith readers (R11) showed no sign of bias when compared with the reference reader R9 (Table 7).

5.1.3.10. First annulus

The information obtained on the first annulus measurements in the otolith is partial because not all readers measured it. Only 7 of the 12 readers who aged the otoliths completed the measurements. The box-whisker plots of the first annulus diameter showed several groups of readers depending on where the first annulus was located by each one (Figure 15). On one hand the expert reader R8 placed it about 2000 µm, while the other expert reader R9 located it about 3000 µm. The rest of readers who measured it are inexperienced. Thus R7 located it to a similar distance as the expert R9, and R5 located the first annulus at a distance similar to that taken by each expert reader (median values of around 2500 µm). The readers R3 and R4 located the first annulus at a higher distance, around 4500 µm. The values of the reader R14 do not seem to be made in the same units (Figure 15). These discrepancies among most of the readers in the location of the first annulus indicate that the identification of it is not easy.

The graphical representation of the average first annulus diameter by age for each reader is shown in Figure 16. An analysis of these measures of the first annulus depending on the fish size shows that most readers located it at a similar distance, independent of fish size. This makes sense, since the measurement of an annulus does not vary when the fish grows. However, the expert reader R8 and the inexperienced reader R5 showed an increase in the measurement of the first annulus as the fish grew.

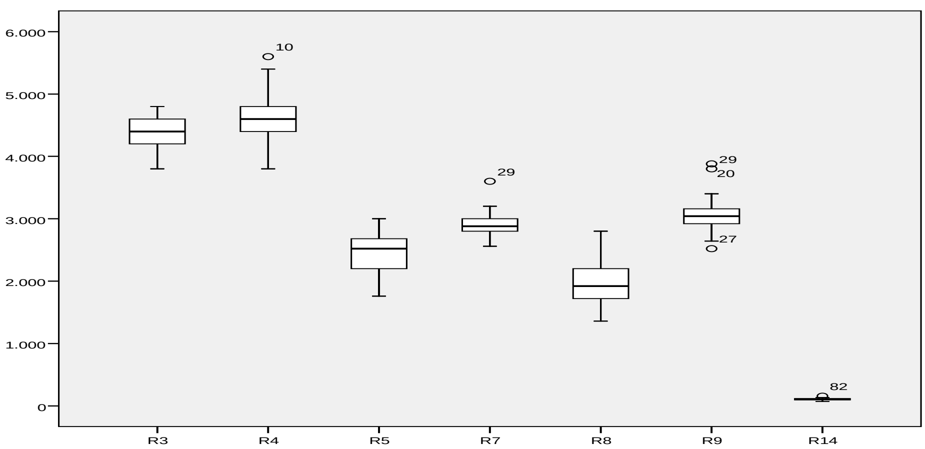


Figure 15. **Otoliths**. Box-whisker plots of the otolith first annulus diameter by reader.

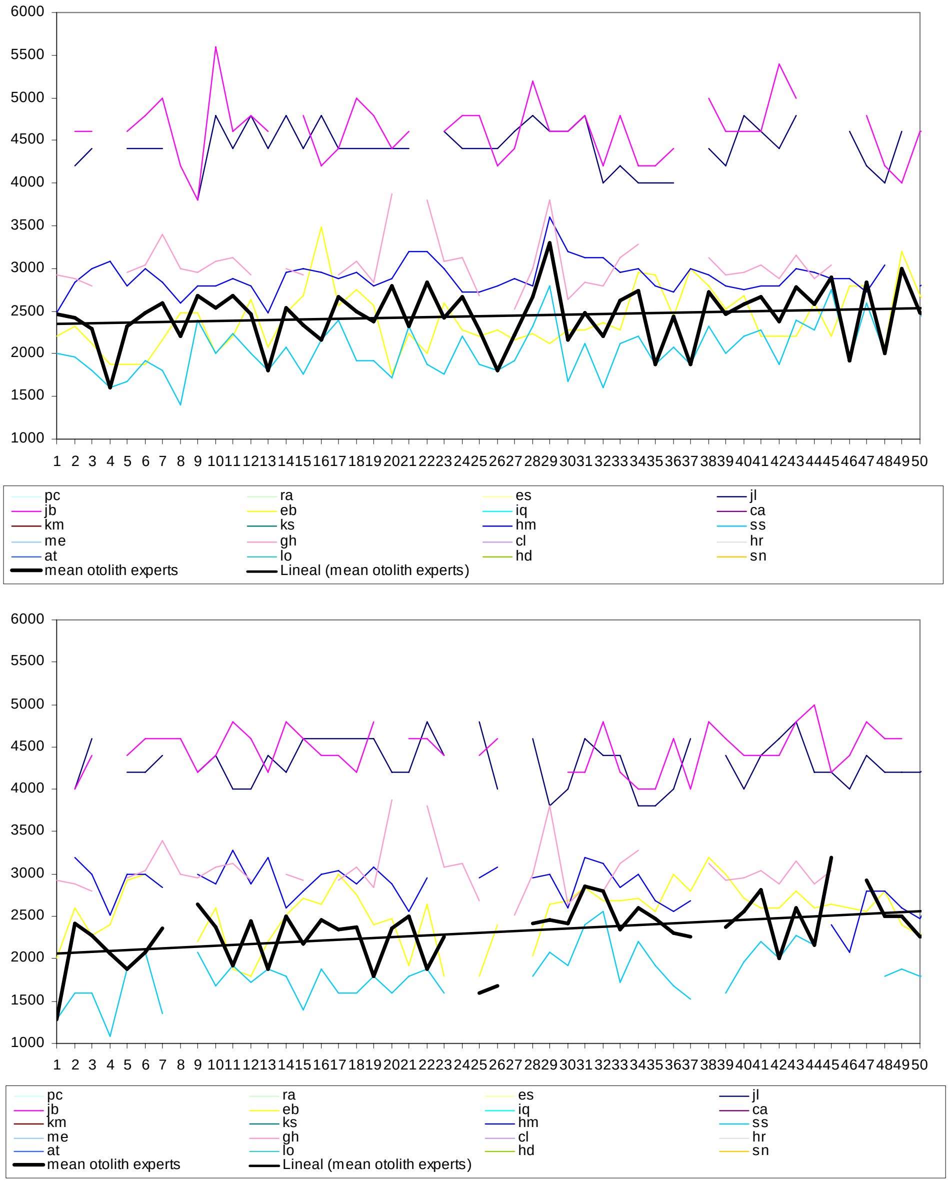


Figure 16. **Otoliths**. First annulus diameter by otolith for each reader. Above: Sub-collection A. Below: Sub-collection B.

5.1.3.11. Age reading credibility

The “medium” and “low” credibility levels were the most frequent for the readers (47% and 37%, respectively). (Figure 17)

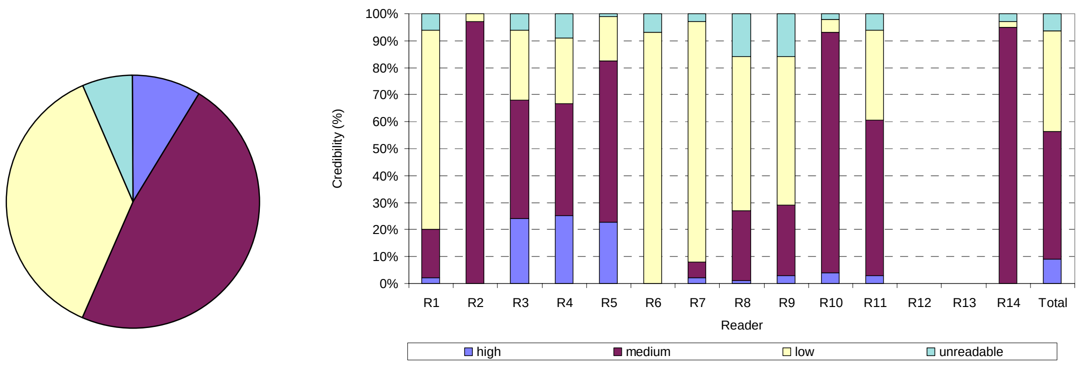


Figure 17. **Otoliths**. Left: overall otolith age reading credibility level for the whole group of readers. Right: age reading credibility level by reader.

5.1.4. Otoliths (stock assessment readers)

An additional analysis was carried out using otolith ages from the readers which provide or will provide ALKs to the ICES anglerfish stock assessment WG (R8, R9, R10 and R11). Similar results to those obtained when the age readings from all readers were analysed, were obtained. The summary of these results are showed in Table 8.

5.1.5. Summary of the results of *Illicia* and otoliths age readings and comparison with previous studies

The comparison between the results of *illicia* and otoliths from the present exchange shows a higher agreement in *illicia* (45% and 49%, respectively for all readers and for the readers contributing to the stock assessment) than in otoliths (20% and 18-25%) (Table 8). The relative accuracy also was better in *illicia* (0.4 and 0.1, that means a difference lower than half age class respect to the reference age) than in otoliths (-1.0, 0.5 and -1.2, 0.5, that means between half and 1 age class of difference) (Table 8). The precision was similar in both structures but slightly better in otoliths, with lower values of CV (24% and 13-17%, respectively for all readers and for the readers contributing to the stock assessment) and APE: 22% and 17%) than in *illicia*, with values of CV (27% and 22%) and APE (18% and 16%) (Table 8). But it must be remembered that the overall values of the mean CV seem to be very influenced by low precision in the first ages, and the number of age 0 and 1 estimated in *illicia* is much higher than in otoliths.

The comparison among the results of *illicia* age readings of the present and previous exchanges and workshops shows similar values of agreement (between 40-49%), relative bias (-0.1- 0.4), and precision: CV (21%-27%), APE (16%-20%) (Table 8). In otoliths, the values of agreement, relative bias and precision are better than in the last workshop in 2004 (Table 8).

Table 8. Summary of the results of the overall reader performance for *illicia* and otoliths of white anglerfish exchanges and workshops. Precision, agreement and accuracy for all readers and for the assessment readers compared to the reference ages of highly experience *illicia* and otolith readers are presented for the present exchange.

Number				illicia						otoliths					
WK or EX	year	readers	hard parts	number of readers	reference readers	precision APE	precision CV	agreement	accuracy relative bias	number of readers	reference readers	precision APE	precision CV	agreement	accuracy relative bias
1º	1991	5	53	5		20	-	-	-	5		29	-	-	-
2º	1997	8	45	8		17	-	-	-	-	-	-	-	-	-
3º	1999	8	147	6-8	modal of expert	16-19	21-25	-	-	-	-	-	-	-	-
4º	2001-2002	8	86	8	modal of expert	-	25	47	-0.1	-	-	-	-	-	-
5º	2004	16	50	15	modal of expert	16	21	40	0.1	11	R_sw R_gh	33	41 46	12 15	1.7 0.2
				11	**modal of expert**	**18**	**27**	**45**	**0.4**	**12**	**R_ss** **R_gh**	**22**	**24** **24**	**20** **20**	**-1.0** **0.5**
6º	**2011**	**14**	**100**	**8 (only assessment readers)**	**modal of expert**	**16**	**22**	**49**	**0.1**	**4 (only assessment readers)**	**R_ss** **R_gh**	**17**	**13** **17**	**18** **25**	**-1.2** **0.5**

5.1.6. *Illicia* and otoliths age readings comparison

Since both CS analyzed belong to the same specimen, the age estimates obtained from *illicia* and otoliths should be similar. The frequency of the age differences between the *illicia* and the otoliths readings for the same fish are shown in Table 9, Table 10 and Figure 18. The *illicia* reference ages used are the modal age from the most experienced readers (R3, R4, R7 and R13) and the otoliths reference ages used are the readings from R8 and R9.

When comparing the results between the *illicia* modal age and otolith readings from R8, only 5% of the ages were in agreement and 68% of the age differences were between -1 and -4, mainly -2 and -3 (40%) (Table 9,

Figure 18). By analysing the age differences by length interval it is seen that higher differences were obtained in the medium size fish (60-99 cm) and not in the smallest and biggest ones (Table 9).

When comparing the results between the *illicia* modal age and otolith readings from R9, 16% of the ages were in agreement and 71% of the age differences were between -1 and -3, mainly -1 (36%) (Table 10, Figure 18). By analysing the age differences by length interval it is seen that R9 counts more annulus in smaller and medium specimens, but in higher specimens R9 counts up to +3 and -3 annulus (Table 10).

Therefore, the results indicated strong discrepancies between *illicia* and otoliths readings, as it was concluded in the last anglerfish exchange and workshop in 2004 (Duarte *et al*., 2005), where also CS belonging to the same individual were analyzed.

Table 9. Frequency (%) of the age differences between the modal *illicia* ages and the otolith readings of R8 by length range for white anglerfish.

Length range (cm)	Age difference between illicia (modal experts) and otoliths (expert R8)														
	-9	-8	-7	-6	-5	-4	-3	-2	-1	**0**	1	2	3	4	Total
20-29							1	4	2	**1**					8
30-39						1	3	2	2						8
40-49						4	1	3		**1**					9
50-59					2	3	5								10
60-69				2	1	3		2		**1**					9
70-79		1	1				2	1	4						9
80-89			1	1	2	1	1	1	2		2				11
90-99			1	1	1	1	1	2	1				1		9
100-109							2	3		**1**	1				7
110-119	1										1	2			4
120-129															0
130-139											1				1
Total	1	1	3	4	6	13	16	18	11	**4**	5	2	1	0	85
Total (%)	1	1	4	5	7	15	19	21	13	**5**	6	2	1	0	100

Table 10. Frequency (%) of the age differences between the modal *illicia* ages and the otolith readings of R9 by length range for white anglerfish.

Length range (cm)	Age difference between illicia (modal experts) and otoliths (expert R9)														
	-9	-8	-7	-6	-5	-4	-3	-2	-1	**0**	1	2	3	4	Total
20-29							1	1	5	**1**					8
30-39								5	1	**1**					7
40-49							3	2	2	**2**					9
50-59								4	5						9
60-69							1	3	4	**1**					9
70-79								1	4	**1**	1				7
80-89							2	2	3	**2**	2				11
90-99								1	2	**4**	1	1			9
100-109							1	2	2		1	3			9
110-119									2	**1**			2		5
120-129									1						1
130-139										**1**					1
Total						0	8	21	31	**14**	5	4	2	0	85
Total (%)						0	9	25	36	**16**	6	5	2	0	100

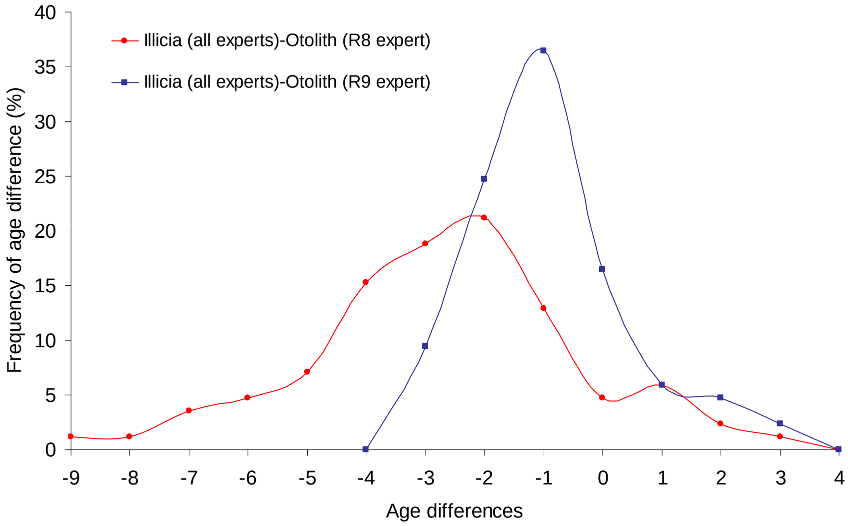


Figure 18. Frequency (%) of the age differences between the modal *illicia* ages and the otolith readings of readers R8 and R9 for white anglerfish.

6. CONCLUSIONS

• The results indicated strong discrepancies **between *illicia* and otoliths readings** from the same fish. This was the same conclusion in the last anglerfish exchange and workshop in 2004 (Duarte *et al*., 2005).

- There was only 4.7% agreement between experienced *illicia* readers and experienced otoliths reader R8. For otolith reader R9 this value was only 16.5%; the relative biases were 2.67 and 0.92, respectively.

- The overall results suggested that the ages from otolith readings were older than those from *illicia* readings from the same fish: 86% and 71% specimens were aged older using otoliths than using *illicia* when the readings of the experienced *illicia* readers and experienced otoliths readers R8 and R9 respectively were compared;

• The analyses **within each CS** showed that the between reader agreement was higher in *illicia* compared to otoliths. The *illicia* readings were less relatively biased than otolith readings, although had slightly lower precision. However the overall values of the mean CV are strongly influenced by the high CV values at first ages, especially at age 0. More specimens were aged 0 using *illicia* than otoliths, and therefore the slightly lower precision in *illicia* was influenced by that.

i) ***Illicia*.** Analysing all *illicia* readers, the **overall percentage agreement** was **45.0%** (22.4-85.6%), the CV was 26.7% (7.1-32.2%), and the relative bias was 0.39 (-0.27-2.29). The first annulus was well located by most of readers between 300 and 350 μm. Analysing only the *illicia* readers contributing to the stock assessment, the agreement, precision and specially the relative accuracy increase: the overall **percentage agreement** was **49.3%** (28.0-85.6%), the CV was 22.4% (7.1-30.9%), and the relative bias was 0.11 (-0.27-0.57).

ii) **Otoliths.** As in the last anglerfish *illicia* and otoliths ageing workshop in 2004, two different otolith analyses had to be performed when the otoliths readings were analysed, using R8 and R9 as reference readers, due to the low agreement between both experienced otolith readers. Analysing all otoliths readers, the **overall percentage agreement** were **19.5%** (5.3-39.4%) and **19.5%** (9.8-31.3%) when R8 and R9 were the reference readers respectively; the CV were 23.7% (14.2-30.3%) and 24.0% (10.5-24.8%); and the relative bias were -0.96 (-2.17-0.42) and 0.47 (-0.93-1.89), respectively. There were discrepancies among the readers in the location of the first annulus. Analysing only the otoliths readers contributing to the stock assessment, the **overall percentage agreement** were **18.3%** (16.3-20.0%) **and 25.4%** (20.0-31.3%) when R8 and R9 were the reference readers respectively; the CV were 13.3% (15.4-22.9%) and 16.6% (10.5-19.3%); and the relative bias were -1.23 (-1.39-(-0.94)) and 0.52 (-0.15-1.48), respectively.

• Regarding the possible **implications of the results** here obtained in the stock assessment of this species in 2012 (stocks are scheduled to be benchmarked in WKFLAT 2012), we can consider the following:

i) *Illicia* vs. otoliths. Considering these low levels of agreement between both CS (5-16%) it is not possible to use the age estimates of both *illicia* and otoliths together for stock assessment purposes.

ii) *Illicia*. Although the relative bias values (0.11) among the assessment readers can be considered good, the agreement values (49%) and precision (CV: 22%, APE: 16) suggest that they are not still sufficiently acceptable for building since now a valid ALK for stock assessment, using the readings of several readers.

The research in a reliable criterion for age estimation of white anglerfish based on CS is more advanced in *illicia* than in otoliths. There is an *illicia* age estimation criterion that allows the cohort tracking (indirect age validation) but it has been only corroborated in an Atlantic area, Porcupine Bank. Further research may be using this *illicia* age estimation criterion and applying it to other areas, to confirm the cohorts tracking. If the new age estimation criterion is validated in other geographical areas by allowing cohorts tracking, and the agreement among readers is increased, then the age estimation using the *illicia* could be used for stock assessment in the future.

Length-structured assessment models, that also enable using growth parameters as an additional input, will be used for white anglerfish in the next 2012 benchmark and assessment. The use of the overall growth parameters based on validated growth evidences (Landa *et al.*, 2008a) seems most appropriate at the current state of the art.

iii) Otoliths. The age estimation of white anglerfish, based on otoliths, is difficult, mainly due to the occurrence of confusing false annuli and to the increasing of opacity with age. The location of the first annulus is also a problem, even among expert readers, both in the last and present exchanges. There have been advances in daily growth studies that can help locate the first annulus more precisely.

The age estimation using otoliths has not been validated. It is not possible to use otoliths of white anglerfish for stock assessment without a validated growth pattern and further research in that issue is needed.

7. RECOMMENDATIONS

Further research should enhance our knowledge of the true growth of white anglerfish by developing and using methodologies that allow validation, before the attempt to standardize reading criteria. It is unproductive to go further in estimating white anglerfish growth patterns and age without progress being made in age validation (Duarte *et al*., 2005). Improving the precision in the absence of accuracy cannot, under any account, guarantee data quality (de Pontual *et al*., 2006).

A collaborative study among several European countries could be based on the following issues:

i) **Indirect growth validation** using the new *illicia* ageing criterion (Annex 2) for testing if cohort tracking is possible in other areas (after the age estimation a time series of *illicia*, similar to what has been done in the Porcupine Bank).

ii) **Direct growth validation** studies. The tagging-recapture of specimens of white anglerfish could be very useful to a further advance on growth validation, especially on that of the large specimens, were validated information is very scarce. Tagging is a direct method of validating the growth of a fish during its time at liberty. Two tagging programs have been undertaken for white anglerfish, one on the Atlantic northern shelf stock (Laurenson *et al*., 2005) and another on the two stocks of the Atlantic southern shelf (Landa *et al*., 2008b). Acceptable recovery rates were obtained in both studies (3.8-4.5%). Given the difficulty of tagging a large number of specimens of this species, it was not possible to obtain information from specimens which had spent much time at liberty. Most of the available information from those tagging-recapture programs corresponded to information from small and medium specimens, but not from large specimens. Despite this, invaluable information was obtained to advance on the validation of the growth pattern of white anglerfish, and to obtain more information on the movements and interaction between stocks (Laurenson *et al*., 2005; Landa *et al*., 2008b).

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Annex 2. Exchange protocol

Protocol for the anglerfish (*Lophius piscatorius*) *illicia* and otoliths exchange 2011

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1. INTRODUCTION

The Planning Group on Commercial Catch, Discards and Biological Sampling (PGCCDBS), identified white anglerfish (*Lophius piscatorius*) as one of the species requiring an international illicium/otolith exchange (ICES, 2011).

1.1. BACKGROUND

The following brief historical overview outlines the sequence of events leading to this exchange.

Two studies were carried out in the 80's on the age estimation of white anglerfish on hard parts in Atlantic waters, one based on *illicia* (Dupouy *et al*., 1986) and another on otoliths (Crozier, 1989). Both structures showed a similar growth pattern, with only one age class in the difference. Both hard parts show opaque and translucent growth zones, however the growth pattern seem to be easier to distinguish in the *illicia*, due to the otoliths showing a more confusing pattern of secondary structures. In addition their opacity increases with age therefore only allowing consistent estimates up to 6-7 years (Crozier, 1989; Woodroffe *et al*., 2003). Several European age estimation workshops and hard parts exchanges took place for standardizing an age estimation criterion and for comparing the age estimation from both hard parts (Anon 1997, 1999; Landa *et al*., 2002; Duarte *et al*, 2005).

The age estimation from *illicia* of a decadal time-series was performed for the Iberian Atlantic stock (southern stock) of white anglerfish using the standardized age estimation criterion of Duarte *et al.,* (2002). A catch-at-age by year matrix was built, but inconsistencies in cohort tracking were found (Azevedo *et al*., 2008a). An age-structured model has not been used since then for the assessment of both northern and southern stocks of the European Atlantic southern shelf of white anglerfish (ICES, 2010a). Age estimations are not either being used in the assessment of the European Atlantic northern shelf stock (ICES, 2010b).

Therefore it was unproductive to continue estimating the age of the white anglerfish without progress being made in age validation (Duarte *et al*., 2005). So, holding a new hard parts exchange and workshop to standardize a biased criterion was not so important as to advance in the knowledge of the real growth pattern of this species.

Studies in the growth of white anglerfish in Atlantic waters had also started recently using micro-increments in hard parts (Wright *et al*., 2002) and other alternative techniques to the common age estimates from hard parts, such as tagging-recapture experiments (Laurenson *et al*., 2005; Landa *et al.,* 2008a) or the analysis of length frequency distributions of catches (Dupouy *et al*., 1986; Thangstad *et al*., 2002; Landa, 2004; Jónsson, 2007). Wright *et al*. (2002) concluded that the first supposed annual increment did not correspond to an annual period, and this increment should not counted be as an annulus.

Landa *et al.* (2008a) estimated a new faster growth rate and growth parameters based on the results obtained in aforementioned growth studies alternative to the age estimates. Their results concluded that the growth pattern estimated using the traditional standardized age estimation criterion based on *illicia* was underestimated. The growth pattern estimated by Landa *et al.* (2008a) was general for the European Atlantic white anglerfish, since the information used in that review came from several studies on Atlantic waters.

Therefore, it could be interesting to test the compliance of that new general faster growth rate to some specific Atlantic area.

Velasco *et al.* (2008) applied the new faster growth model of Landa *et al.* (2008a) on the 6 years time-series of catches of white anglerfish from the annual bottom trawl surveys of Porcupine Bank, showing also, for the first time, results on its abundance and distribution in that area. The results of Velasco *et al.* (2008) showed that applying the traditional standardized age estimation criterion on *illicia* to the survey catches, a mismatch in cohort tracking over time was produced, but when the new faster growth model was applied a successfully tracking of some cohorts was obtained. The mismatch obtained in the cohort analysis suggested that the traditional age estimation criterion underestimated up to three of the younger age classes. When an ALK was estimated numerically from the new faster growth model, this mismatch disappeared; this seemed to confirm faster growth.

Although those overall growth parameters estimated by Landa *et al.* (2008a) are suitable for age-structured stock assessment models, it would be desirable to have the growth pattern that accurately describes growth based on the age estimation of hard parts, as an alternative to the current approach of using those growth parameters. The annual age estimation of hard parts allows having annual catches-at-age that include the annual growth variability and that of the different strength of each cohort. The overall growth parameters from several years and areas of Landa *et al.* (2008a) do not represent this variability.

1.2. ANGLERFISH *ILLICIA* / OTOLITHS EXCHANGE 2011

There is ongoing research (Landa et al., in prep.) that will present a new growth pattern based on *illicia* age estimation of white anglerfish in Porcupine Bank, fitted to the new faster growth model of Landa *et al.* (2008a). Also, modifications in the methodology of *illicia* preparation and in the traditional standardized age estimation criterion that allows obtaining this new growth pattern will be presented. This new growth pattern successfully tracks the cohorts in Porcupine bottom trawl surveys.

It is necessary to test the application of this new *illicia* age criterion among the readers of white anglerfish. A full exchange of *illicia* and otoliths was recommended by PGCCDBS for 2011, when a new age estimation criterion in *illicia* was expected.

A Benchmark workshop for anglerfish will be held in 2012. The preliminary results from this exchange will be of high importance and, if possible, should be reported before that workshop.

The Instituto Español de Oceanografía (IEO) agreed to organize the *illicia*/otoliths exchange and evaluate the results.

The objectives of the exchange are to:

- To evaluate the levels of agreement, precision and relative accuracy
  - among the readers;
  - between *illicia* and otoliths.
- To identify the interpretation differences in the positions of the annuli (annual increments).
- To subsequently evaluate the application of the new *illicia* age estimation criterion and that of the otoliths.

2. EXCHANGE PARTICIPANTS

The participants involved, the calcified structure used by each one for the anglerfish assessment, the assessment ICES WG where the age estimations are used, and the sampling areas are shown in Table 1.

3. EXCHANGE SAMPLE COLLECTION

A sample of 200 hard parts (100 *illicia* and 100 otoliths of the same specimen) was prepared in order to compare the age estimations between both structures.

The recommendations of the PGCCDBS Guidelines for Otolith Exchanges (ICES, 2011) were taken into account for preparing the collections.

Due to the wide distribution of this species, the growth pattern could show some geographical difference among areas. Therefore, two sub-collections with hard parts of two European areas were prepared and it may allow the comparison of the results between areas. It was not easy to find institutes with samples of *illicia* and otoliths from the same specimens and from different areas. IEO and Faroe Marine Research Institute (FMRI) supplied the samples for the preparation of the collection:

- Sub-collection A: ICES Div.VIIbck (around latitude 52-54ºN), provided by IEO, 50 *illicia* and 50 otoliths.

- Sub-collection B: ICES Div.Vb (around latitude 60-63ºN), provided by FMRI, 50 *illicia* and 50 otoliths.

The length frequency distribution of specimens chosen in both sub-collections was similar, covering the most of the length range landed by the commercial catches (Fig. 1).

The information provided of each specimen for the age estimation was:

- Code (different code between *illicia* and otoliths in spite of both belonging to the same specimen).

- Length range (of 10 cm).

Both data are presented in such a way in order to avoid the identification of the otolith and illicium from the same specimen, so that more independent age estimation between structures will be obtained.

- Date (quarter).

A digital image was obtained from each illicium and otolith.

4. Obtaining the information

The exchange will be carried out through the **European Age Readers Forum** (EARF) (http://groupnet.ices.dk/AgeForum/default.aspx). EARF is a ICES PGCCDBS forum that is trying to support as a way of allowing the wider age reading community to have access to age reading information, know the locations of sets of agreed age otoliths/*illicia* or images for training purposes and support an exchange of knowledge on a wide range of topics including age prep methods and age reading criteria, etc.

Your login is the one you use in ICES. If you do not remember your password, you can get a new password on our website: http://www.ices.dk/groupnetpass/.

A folder has been created in the EARF called '**Anglerfish *illicia*/otoliths exchange 2011**'. It can be found on the left hand side of the site under 'documents'. The files (this protocol, images, data files, etc) that are need for the exchange are uploaded in several folders:

1) Protocol, with 2 annexes.

2) Images. There are several folders with the 200 images (.jpg) of hard parts (100 *illicia* and 100 otoliths) organized in two sub-collections (A and B).

3) Data. There is a book named "Collection data.xls" with 4 sheets, one by each sub-collection of *illicia* and otoliths.

4) Images analysed. Here you have to upload your completed files of images (.xcf) when you finish the readings.

5) Data completed. Here you have to upload your completed file of data (Collection data.xls) when you finish the readings.

6) Other documents. Here you can find other useful documents for the exchange, as the *Illicia* anglerfish ageing guide (Duarte *et al*., 2002).

When you click on the folder it opens. You can just **open a file from EARF and save it on your PC**. There is another way to **upload and download the files all together** in sharepoint, that isn't one by one: once you have opened the folder in **EARF** and you see the list of files, there is a button on the top right called 'All documents' if you click on the down arrow on the side you can choose the option 'explorer view'. Once you click on that you will be able to copy all pictures at once and paste them wherever you want. If you want to go back on the 'normal' **EARF** view you need to click again on the down arrow and choose 'all documents'.

5. AGE ESTIMATION PROCEDURE

5.1. AGE ESTIMATION CRITERION

Dupouy *et al*. (1986) and Woodroffe *et al.* (2003) verified as annual the annuli formation in *illicia*, and Crozier (1989) and Woodroffe *et al.* (2003) did it in sectioned otoliths. In both hard parts, an annual cycle of growth consists of one wide opaque zone (WOZ) and one wide translucent zone (WTZ), the latter formed in winter. The pattern of laying down of these zones throughout the year also seems to be similar in both structures (Woodroffe *et al.*, 2003).

5.1.1. Illicia

The age estimation criterion on *illicia* was described in the Anglerfish Ageing Guide (Duarte *et al*., 2002). Although most of the methodology of *illicia* preparation is the same, some modifications in the age estimation criterion with respect to those previously used by Duarte *et al*., 2002) are provided in Annex 1.

5.1.2. Otolith

The readers of the present exchange, that use otoliths for their routine age estimations, read whole otoliths under reflected light. In the present exchange the images were taken using reflected light, instead the transmitted light used in the previous anglerfish *illicia*/otolith exchange (Duarte *et al*., 2005).

Henderson showed the methodology for age estimation for whole otoliths under reflected light that used in FRS (UK) and it was presented in the Report of the last anglerfish age estimation workshop (Duarte *et al*., 2005). He showed some pictures illustrating the age estimation criterion that can be useful in the present exchange (Annex 2).

Other papers on age estimation on otoliths also can be useful for this exchange (Tsimenidis and Ondrias, 1980; Crozier, 1989; Wright *et al*., 2002)

5.2. Annotating of annuli on the images using GIMP 2.6

The readers are asked to annotate the supposed annual rings on the digitised images using the program GIMP 2.6.11. This program permits creating layers and the software is downloaded free at *http://www.gimp.org/downloads/.* Additionally there are tutorials available in several languages at http://www.gimp.org /(Fig. 2).

GIMP is an image manipulation program, for such tasks as photo retouching, image composition etc. It works on many operating systems and in many languages. The official GIMP web site contains information about downloading, installing, and usage.

The age estimation of the *illicia* and otoliths images should be based on the aforementioned growth age estimation criterion (section 4.1).

To annotate your supposed annuli on a layer, please follow the steps below:

1) **Open** the file (eg. Rb_08_107_1b_1.jpg) you want to work using GIMP. It should to be viewed at zoom 25%.

2) You will find one layer: "Background" layer. Please **block** this background **layer** (Fig. 3). This layer contains an image with a scale (of 0.5 mm in the illicium images and 1 mm in otolith images). Please, do not move the background image.

3) **Create** a new **layer**. It has to be a transparent layer (it is the default option). Type your initials as layer name as it is showed in Table 1 (eg. layer name for Jorge Landa will be "jl") (Fig. 4).

4) **Annotate** your **age** estimation in this new layer as follows:
a. Select the <u>pencil</u> tool from the toolbox (Fig. 5a).
b. Select the <u>colour</u> assigned for you (Table 1): left click on and put the numbers assigned in each cell (eg. Jorge Landa has to put the number 120 in cell H; number 100 in cell S; number 50 in cell V; etc) (Fig. 5b).
c. Select the type of <u>brush</u> assigned for you (Table 1), left click on (Fig. 5c) (eg. Some readers as Jorge Landa have assigned: "*Circle (17)(19 x 19)*". Other readers have "*Calligraphic Brush#1 (23 x 23)*").
d. Annotate on your layer the positions of the <u>dark zones</u> (at the outer part of them) considered to be annuli (a growth zone that forms once a year) (Fig. 5d, 5e).

5) **Save** this file with the initials of your name in the GIMP format (button save as .xcf) (eg. for Jorge Landa it will be Rb_08_107_1b_1**_jl.xcf**"). This file should have:
a. A background layer
b. Your layer named with your initials and the positions of the annuli.

6) Proceed with the **next** illicium or otolith image.

5.3. Annotating of the result of the age estimations

The results of your age estimation of the hard parts have to be entered in the respective sheets of the Excel book named "**Collection data.xls**". This book is in the folder "Data". Please follow the steps below:

1) Fill the name of **reader** and **Institute**.

2) Count the number of supposed **annuli** (annual increments) and to attribute an **age** to each section.
If you are certain of the age, please annotate a single number (e.g. "2"). If you have doubts between two possible ages (e.g. 3 or 4), please annotate "3/4". When two possible ages are indicated (e.g. 4/3), the first one is considered to be the more reliable (i.e. the age 4 in the 4/3 case).
The value of the number of annuli and the age class will be the same in most of the specimens (N). However in some of them the value of the age will be, lower than the number of annuli (N-1) when the edge of an otolith is hyaline and it has been captured in the fourth quarter (see section "Ageing criteria" in Duarte *et al.*, 2002).

3) Attribute the respective **credibility** of the age estimation using the following codes:
- u = unreadable
- b = low credibility
- m = medium credibility
- h = high credibility

4) Assign a type of **edge** (if possible) using the following codes:
- h = hyaline

o = opaque
? = doubtful

5) Measure the **horizontal diameter** of the supposed first annuli. The values should be expressed in micrometers units, and the scale on the image will help you to estimate the value. The measurements will be done using the more outer part of the dark zone of the first annuli estimated by the reader (Fig. 5d, 5e). You can easily measure the horizontal diameter of your supposed first annuli with a rule on the screen of your PC, at zoom 25% (Fig. 6). Insert this value in the column J (named "*1st annuli diameter horizontal (mm in screen) zoom 25%*") and its value in micrometers will appear in the column H.

6) Fill the "**comment"** column if you have some remarkable comment in your age estimation for that hard part.

7) **Save** that excel file with the initials of your name (eg. for Jorge Landa it will be "Collection data**_jl.xls**").

5.4. Sending the information

When all the images are analysed and the age estimation information completed in the excel book (sections 4.2 and 4.3), please **upload your completed files** (images (=.xcf) and data (=.xls)) to the respective folders named **"images analysed"** and **"data completed"** in "**Anglerfish *illicia*/otoliths exchange 2011"**, **European Age Readers Forum (EARF)** (http://groupnet.ices.dk/AgeForum/default.aspx) (see section 4).

6. SUPPORT

If you have any questions or need any help please contact Jorge Landa (jorge.landa@st.ieo.es).

7. ACKNOWLEDGEMENTS

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TABLES

Tab. 1. Participants in the Anglerfish *illicia*/otoliths exchange 2011, hard part used in age estimation, stock and species read, ICES WG where the ages have been used for stock assessment and information to use the program GIMP.

							Stocks													
							S(S) = Southern Shelf, Southern stock (VIIIc,IXa)			N = Northern Shelf (IIa, IIIa, IV, VI)			Program GIMP 2.6. (images)							
							S(N) = Southern Shelf, Northern stock (VIIb-k, VIIIabd)			O = Other (V)				Pencil tool						
													Layer name	Colour						Type of brushes
Name	**Institute**	**Country**	**Exchange**	**Illicia**	**Otoliths**	**Assessment**	**ICES WG**	***L.piscatorius***	***L.budegassa***	**Stocks**	**ICES Subarea or Division**	**e-mail**		**H**	**S**	**V**	**R**	**G**	**B**	
Ricardo Alpoim	IPIMAR	Portugal	X	X	-	X	WGHMM	-	X	1: S(S)	IXa	ralpoim@ipimar.pt	ra	0	100	100	255	0	0	Circle (17) (19 x 19)
Eduardo Santos	IPIMAR	Portugal	X	X	-	X	WGHMM	-	X	1: S(S)	IXa	-	es	40	100	100	255	170	0	Circle (17) (19 x 19)
Jorge Landa (coordinator)	IEO	Spain	X	X	-	X	WGHMM	X	X	2: S(S), S(N)	VIIIc, IXa, VII	jorge.landa@st.ieo.es	jl	120	100	50	0	128	0	Circle (17) (19 x 19)
Joaquín Barrado	IEO	Spain	X	X	-	X	WGHMM	X	X	2: S(S), S(N)	VIIIc, IXa, VII	joaquin.barrado@st.ieo.es	jb	120	100	100	0	255	0	Circle (17) (19 x 19)
Elena Barcala	IEO	Spain	X	X	-	-	-		X	1: Mediterranean	Mediterranean	elena.barcala@mu.ieo.es	eb	120	25	100	192	255	192	Circle (17) (19 x 19)
Iñaki Quincoces	AZTI	Spain	X	X	-	X	WGHMM	X	X	1: S(N)	VII, VIIIabd	iquincoces@suk.azti.es	iq	240	100	100	0	0	255	Circle (17) (19 x 19)
Carmen Abaroa	AZTI	Spain	X	X	-	X	WGHMM	X	X	1: S(N)	VII, VIIIabd	cabaroa@azti.es	ca	180	100	100	0	255	255	Circle (17) (19 x 19)
Kélig Mahe	IFREMER	France	X	X	-	X	WGHMM	X	X	1: S(N)	VII, VIIIabd	Kelig.Mahe@ifremer.fr	km	300	100	100	255	0	255	Circle (17) (19 x 19)
Elise Bellamy	IFREMER	France	X	X	-	X	WGHMM	X	X	1: S(N)	VII, VIIIabd	Elise.Bellamy@ifremer.fr	el	300	25	100	255	192	255	Circle (17) (19 x 19)
Helen McCormick	Mar. Inst.	Ireland	X	X	-	X	WGHMM, WGCSE	X	X	2: S(N), N	VII, VI	helen.mccormick@marine.ie	hm	60	100	100	255	255	0	Circle (17) (19 x 19)
Sally Songer	CEFAS	UK	X	-	X	X	WGHMM, WGCSE	X	X	2: S(N), N	VIIe-k, IV	Sally.Songer@cefas.co.uk	ss	0	100	100	255	0	0	Calligraphic brush (23 x 23)
Mark Etherton	CEFAS	UK	?	-	-	-	-	-	-	-	-	mark.etherton@cefas.co.uk	me	40	100	100	255	170	0	Calligraphic brush (23 x 23)
Gordon Henderson	MARLAB	UK	X	-	X	X	WGCSE	X	-	1: N	IVa, VIab	G.I.Henderson@marlab.ac.uk	gh	120	100	50	0	128	0	Calligraphic brush (23 x 23)
Chevonne Angus	NAFC	UK	?	-	X	-	-	X	-	1: N	IV	Chevonne.Angus@nafc.uhi.ac.uk	cl	120	100	100	0	255	0	Calligraphic brush (23 x 23)
Helle Rasmussen	DIFRES	Denmark	X	-	X	X	WGCSE	X	X	1: N	IVbc	hr@dfu.min.dk	hr	240	100	100	0	0	255	Calligraphic brush (23 x 23)
Aage Thaarup	DIFRES	Denmark	X	-	X	X	WGCSE	X	X	1: N	IVbc	att@dfu.min.dk	at	180	100	100	0	255	255	Calligraphic brush (23 x 23)
Lise Helen Ofstad	FMRI	Denmark	X	X	-	-	-	X	-	1: O	Vb	liseo@frs.fo	lo	300	100	100	255	0	255	Calligraphic brush (23 x 23)
Hanna Elina Djurhuus	FMRI	Denmark	X	X	-	-	-	X	-	1: O	Vb	hannadj@frs.fo	hd	300	25	100	255	192	255	Calligraphic brush (23 x 23)
Sarah Nebel	BIOPOL	Iceland	X	-	-	-	-	X	-	1: O	Va	sarah@biopol.is	sn	60	100	100	255	255	0	Calligraphic brush (23 x 23)

FIGURES

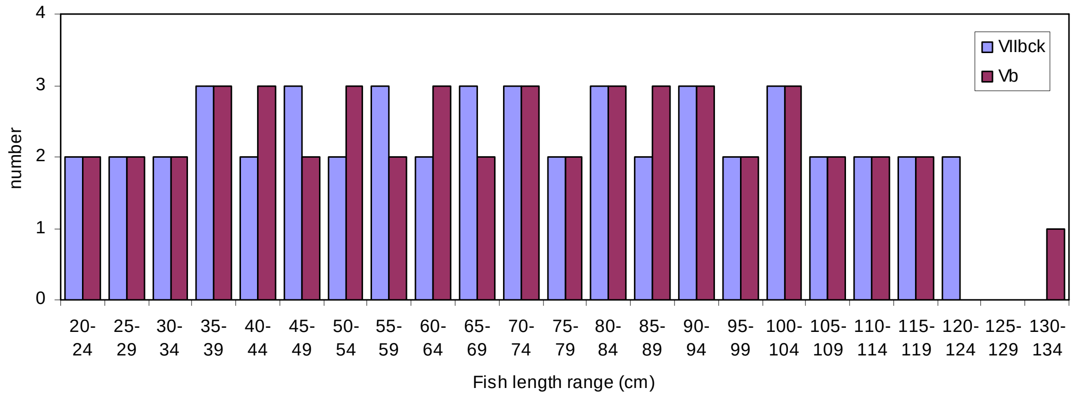

Fig. 1. Length frequency distribution of specimens studied from each ICES Division.

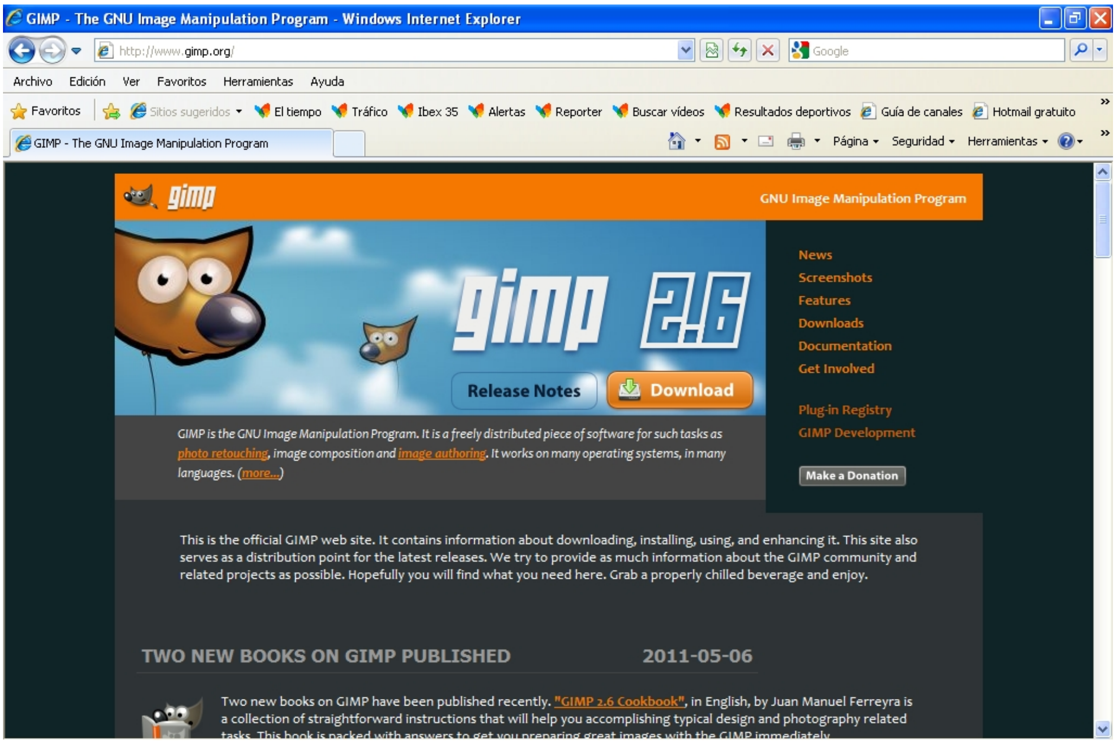

Fig. 2. Program GIMP 2.6.

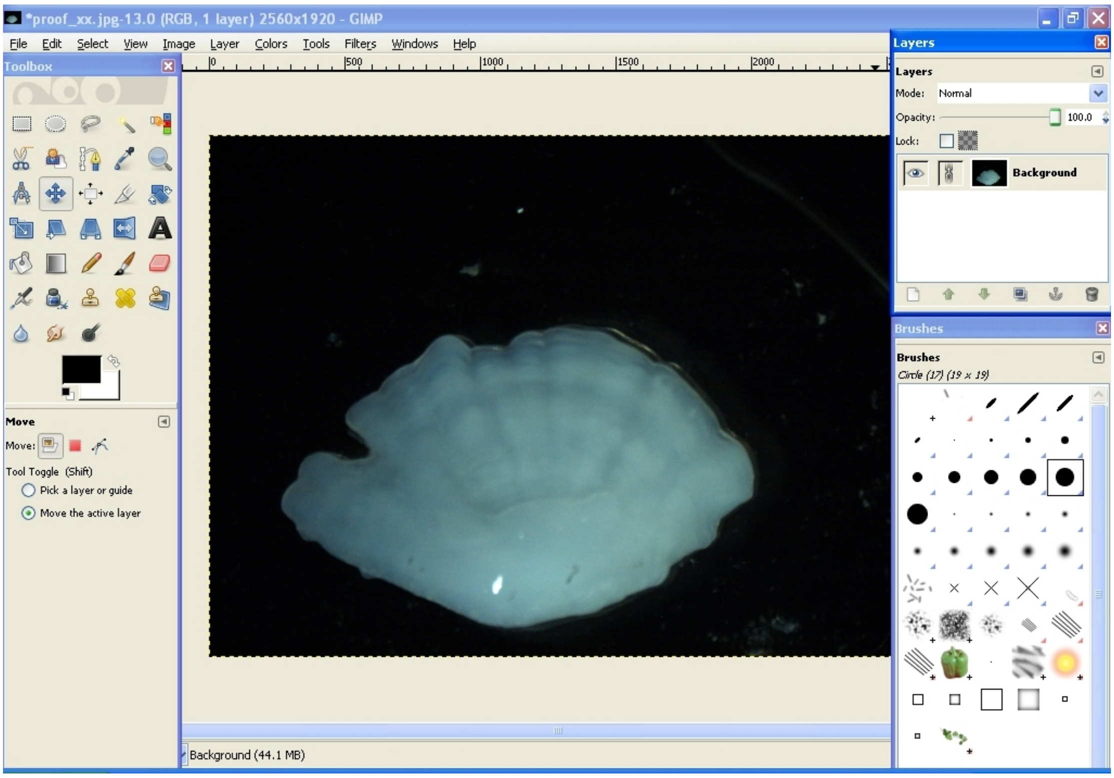

Fig. 3. Blocking the background layer.

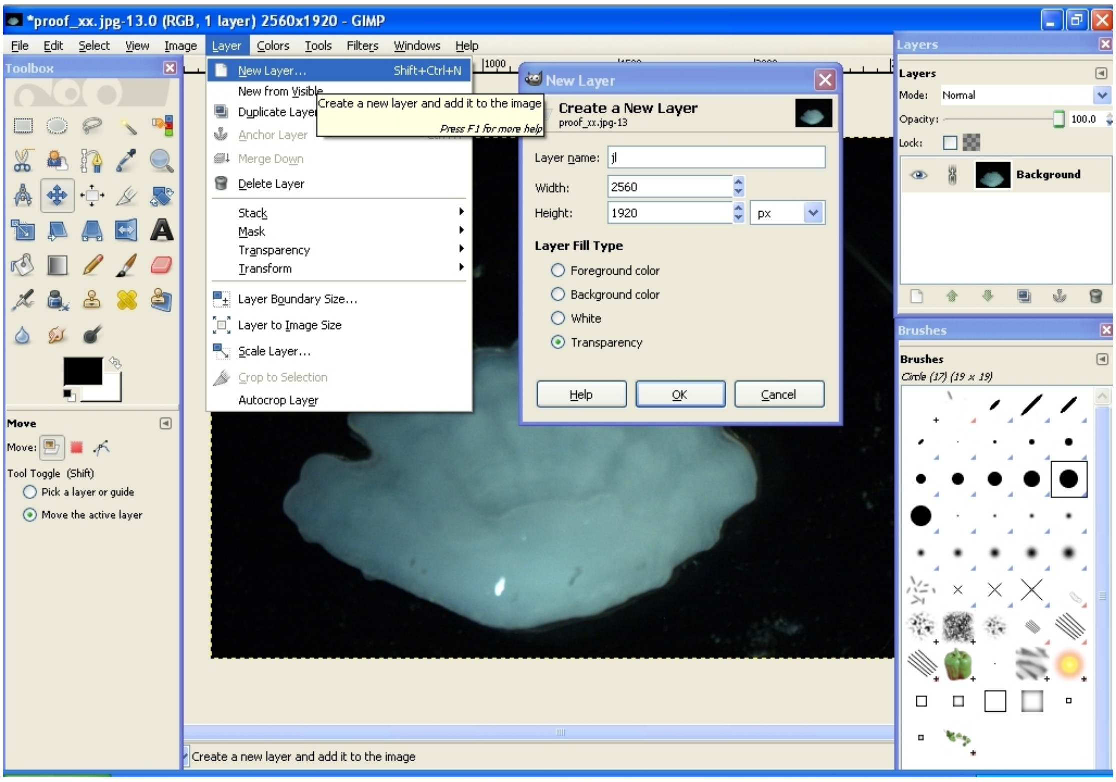

Fig. 4. Creating a new layer.

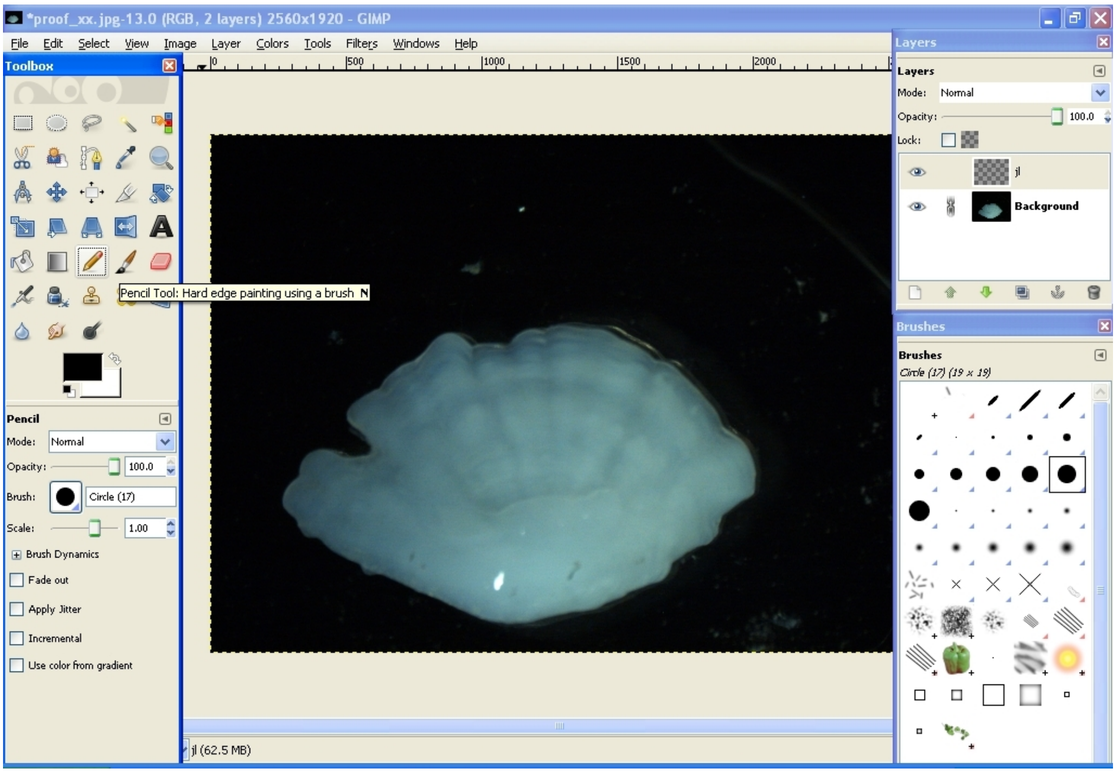

Fig. 5a. Selecting the pencil tool from the toolbox.

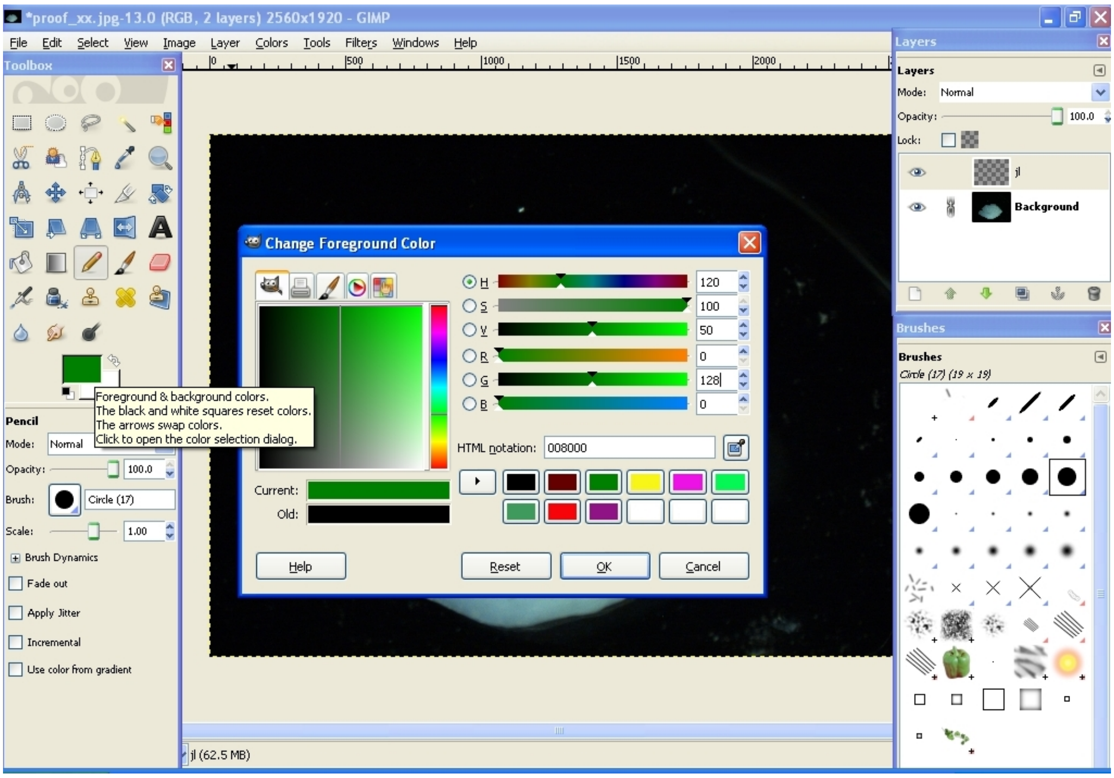

Fig. 5b. Selecting a colour assigned.

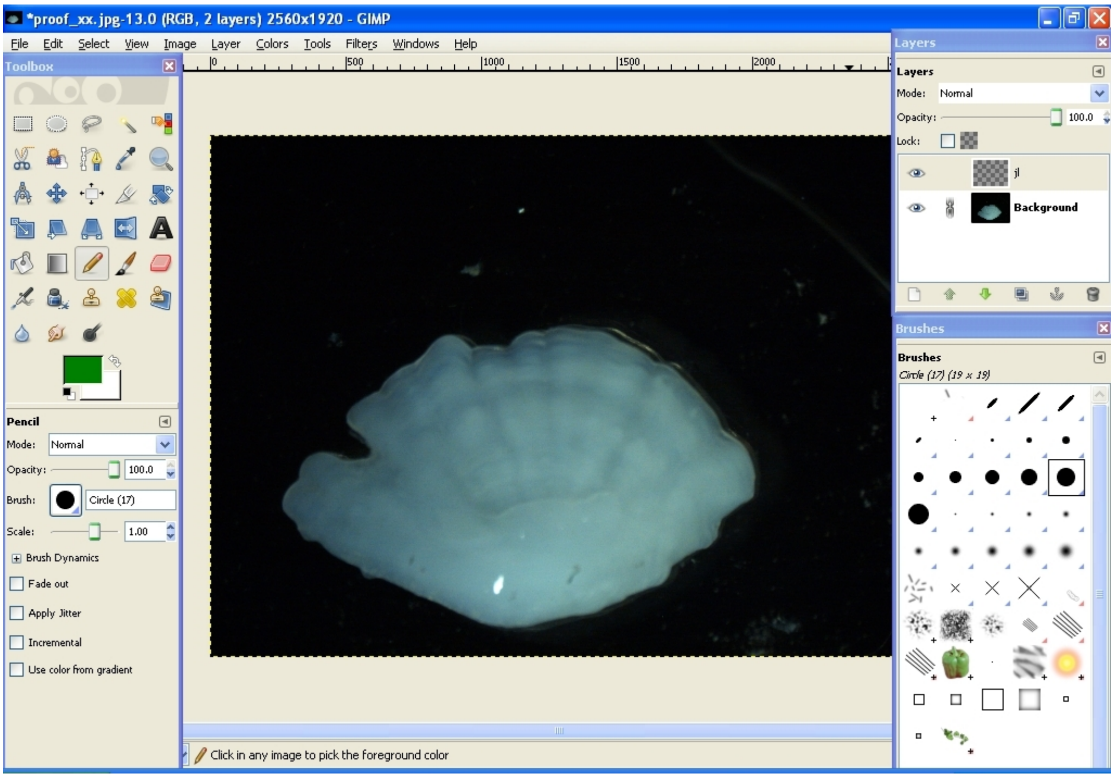

Fig. 5c. Selecting a type of brush assigned.

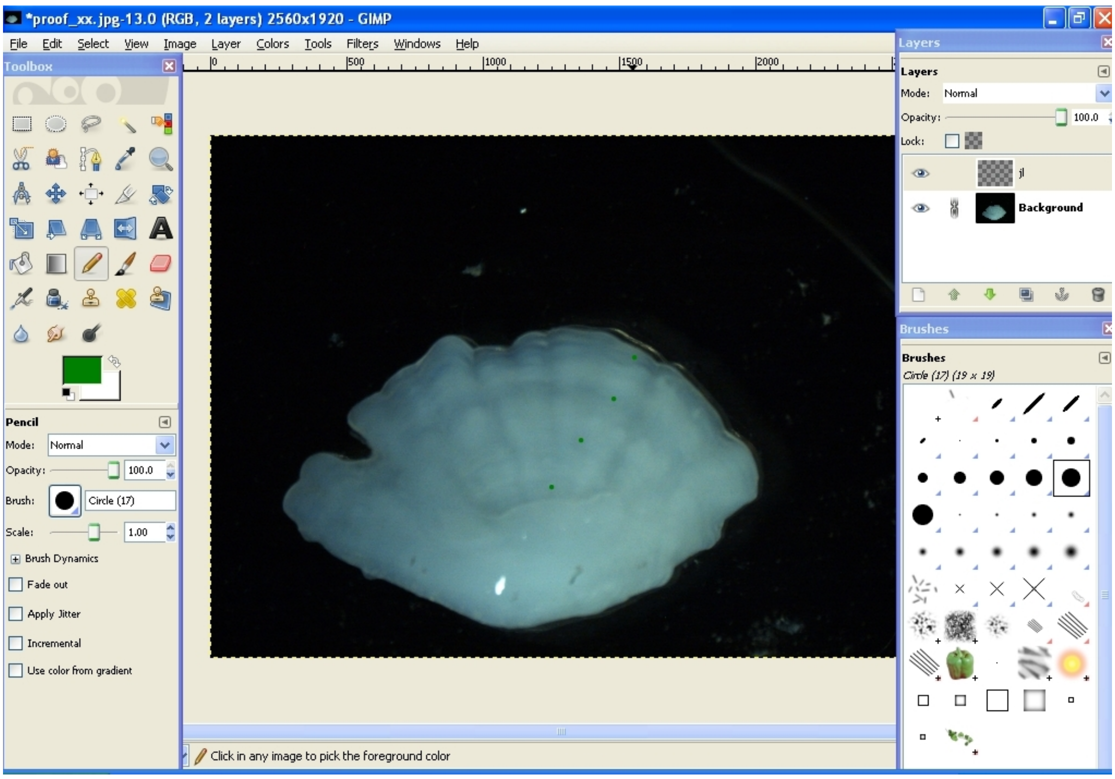

Fig. 5d. Annotating on a personal layer the positions of the dark zones considered to be annuli in an otolith.

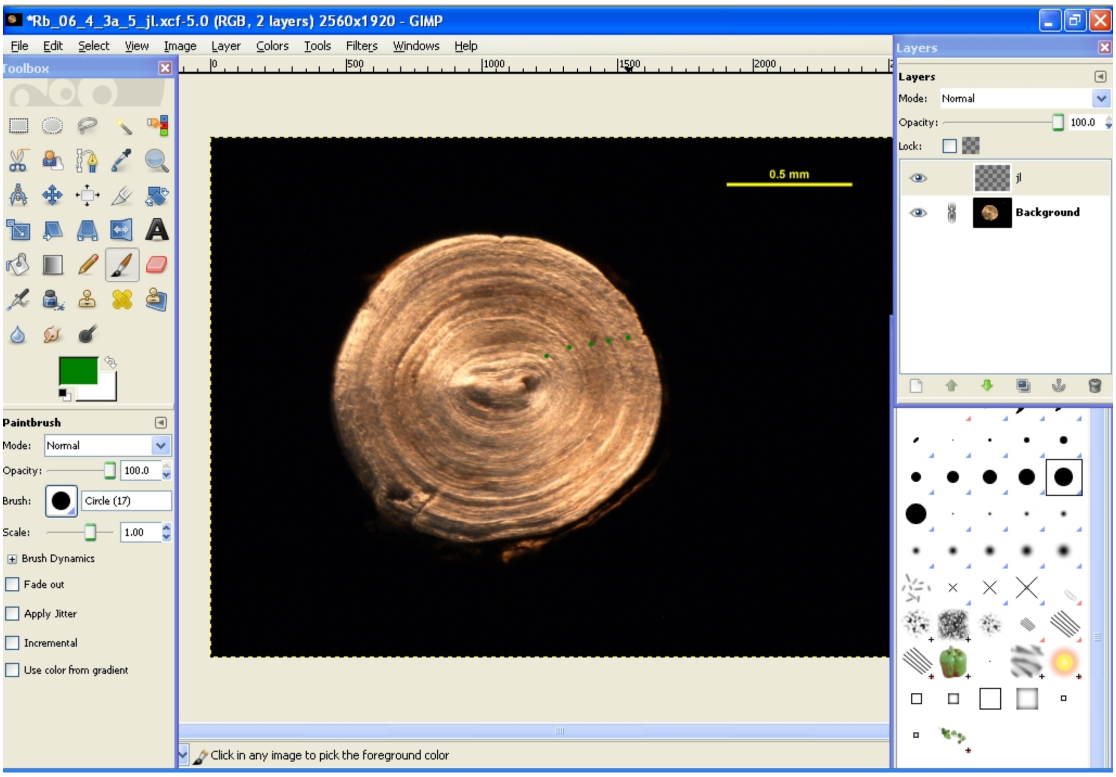

Fig. 5e. Annotating on a personal layer the positions of the dark zones considered to be annuli in an illicium.

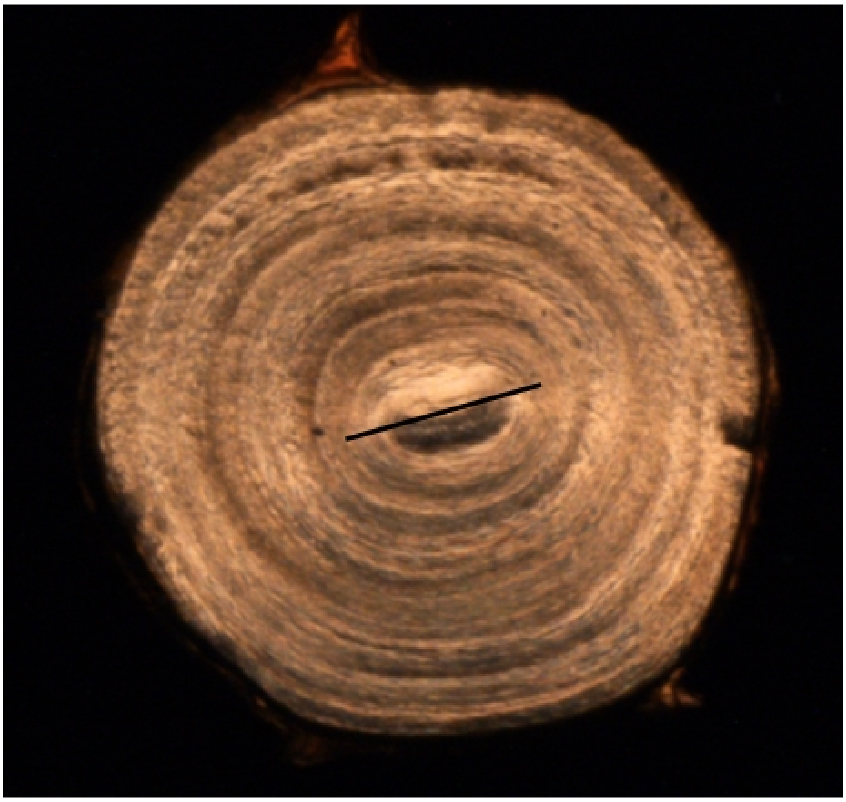

Fig. 6. Black line showing the horizontal diameter of the supposed first annuli that has to be measured.

Methodology for age estimation on *illicia* of anglerfish (*Lophius piscatorius*) in IEO, Spain.

Jorge Landa

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The age of anglerfish (*Lophius piscatorius*) has been routinely estimated since 1996 in our laboratory (Centro Oceanográfico de Santander) belonging to the IEO (Instituto Español de Oceanografía), for stock assessment purposes using the *illicia* and similar methodologies to those used in other European institutes where the *illicia* has been traditionally aged with the same aim (IFREMER, IPIMAR, AZTI).

The traditional standardized age estimation criterion on *illicia* had been based on the observation and counting of growth marks (Duarte *et al.,* 2002). The application of that criterion produced biased ages, as some early growth marks which were considered as annuli did not seem to be annual (Landa *et al*, 2008). Those authors also concluded that more research on optimal sectioning methods and magnifications could help to improve age estimation criteria and the identification of true annuli.

In the present paper, several **modifications** to the traditional standardized methodology of preparation, observation and age estimation on *illicia* are presented, following a revision of the methodologies currently used. It was investigated whether those methodologies had shifted from the first study on *illicia* age estimation (Dupouy *et al*., 1986) and during the several age estimation workshops (Anon 1997, 1999; Landa *et al.*, 2002), that concluded in a standardized *illicia* age estimation guide (Duarte *et al.* (2002). The standardized age estimation criterion from the workshops was the used in most of the growth studies using *illicia* (Duarte *et al*., 1997; Quincoces *et al*., 1998; Landa *et al*., 2001; Ofstad and Laurenson, 2007). However, in most of those studies, the criterion produced biased ages.

Therefore, the following modifications were made to the methodology to allow a clearer observation of the growth pattern, to improve the identification of the supposed real annual increments:

1. Sectioning

After the *illicia* were embedded in resin, several cut thicknesses of the transverse section were tested. The thinner sections led to the observation of more supposed annual increments, and vice-versa using thicker sections, as has been observed in other species (Kopf *et al.*, 2010). The use of transverse sections of around 0.50-0.55 mm thick allowed observation of the clearest marked increments, probably those that are assumed to be annual. However, the using of sections thinner than 0.5 mm (around 0.4 mm) had allowed observation and counting as annuli some false annual increments, as indicated by Landa *et al*, (2008). Therefore, transverse sections of around 0.50-0.55 mm thick were used, and this thickness is recommended for sectioning of *illicia*.

2. Observation

The sections were observed using a profile projector at 50x under transmitted light, as per Dupouy *et al*. (1986). The sections were also examined using a microscope at 100x as per the standard methodology used by Duarte *et al.* (2002) and later age estimation studies. The use of a microscope at 40x also was also tested as an alternative to the profile projector, because the microscope is a more widely available in most of the laboratories. Similar observations were obtained using both types of equipments. The use of higher magnifications (100x) allowed observing and counting as annuli some false annual increments compared to the using of 40-50x, therefore 40-50x magnification is recommended.

3. Age interpretation

The recommendations of Wright *et al*. (2002) were followed, who concluded that the first supposed annual increment did not correspond to an annual period, and this increment should be not counted as an annulus. That supposed first annual increment had been counted when using the traditional age estimation criterion and its horizontal diameter (HD) had between 200 and 300 μm (Duarte *et al.,* 2002). However, the HD of the first annulus measured in the present study, taking into account the recommendations of Wright *et al*. (2002), tends to be between 300 and 380 μm. The HD of other inner, prominent and designated "benthic increment" (false annual increment) by Duarte *et al.* (2002) tends to be between 160 and 220 μm. These new measurements are recommended to be taken into account as reference for identifying the first annulus. Figure 1a shows an image of an illicium of white anglerfish observed under transmitted and reflected light identifying several increments (annuli and false annual increments).

Different optical zones based on their relative translucency appear in calcified structures depending of the type of light. In general, opaque zones are dark in transmitted light and bright in reflected light and inverse for translucent zones.

3.1. Using reflected light

Woodroffe *et al*. (2003) analysed the marginal and edge state on sagitta otoliths and *illicia* of white anglerfish under reflected light and demonstrated that an annulus comprised a multi-ring opaque zone and a wide translucent zone. Narrow translucent zones (NTZ) within the wide opaque zones (WOZ) were found to be significantly narrower than the translucent zones separating them, suggesting that these were false rings. Opaque material was predominantly deposited in both hard parts during the summer months (July–September) and translucent material during the winter (December–February).

Using *illicia* under reflected light, the NTZ can be observed dark and the WOZ are in light/bright grey (Figure 1b). Those NTZ were those formed in *illicia* mainly between January-March (Woodroffe *et al*., 2003). The light grey WOZ usually include a brighter narrow OZ (NOZ), placed much closer to the dark NTZ.

3.2. Using transmitted light

The bright NOZ observed using reflected light are seen as dark (NOZ) when transmitted light is used (Figure 1a), and they could be formed during the spring, when more *illicia* with opaque edge were found by Woodroffe *et al.* (2003). When the horizontal diameters of these dark NOZ under transmitted light were measured (Figure 1a), they showed values usually a little higher than those of the dark narrow zones (NTZ) under reflected light (Figure 1b). It means that the dark NOZ under transmitted light are located a little outer in the *illicia* than those dark NTZ under reflected light.

In relation to the contrast of the increments, the well marked dark annuli in some *illicia* sections under transmitted light are only visible in some areas of the illicium. On the other hand, some dark annuli in some areas of the section are however bright in other areas (Duarte *et al.,* 2002).

Summarizing, the age estimation criterion used in relation to counting the annuli was basically the same as that of Duarte *et al.* (2002), except for the aforementioned issues. It consists of identifying dark and light annuli. For age determination only the dark zones (annuli) under transmitted light are counted (Duarte *et al.,* 2002).

These aforementioned modifications in the methodology of *illicia* preparation and in the age estimation criterion were recently used to estimate the catch-at-age of white anglerfish on the Porcupine Bank, based on the age estimation of *illicia* obtained from a series of annual groundfish surveys. The growth pattern estimated was able to be indirectly validated by cohorts tracking, using the abundance indices from surveys (Landa *et al*., in prep.). Although the age estimation using these methodological modifications can be considered valid in that study of the white anglerfish on the Porcupine Bank, it could be interesting to corroborate if similar results are obtained in other areas when this modified methodology is applied.

Acknowledgements

Thanks are extended to Enrique Rodriguez-Marín and Gordon Henderson for their useful suggestions.

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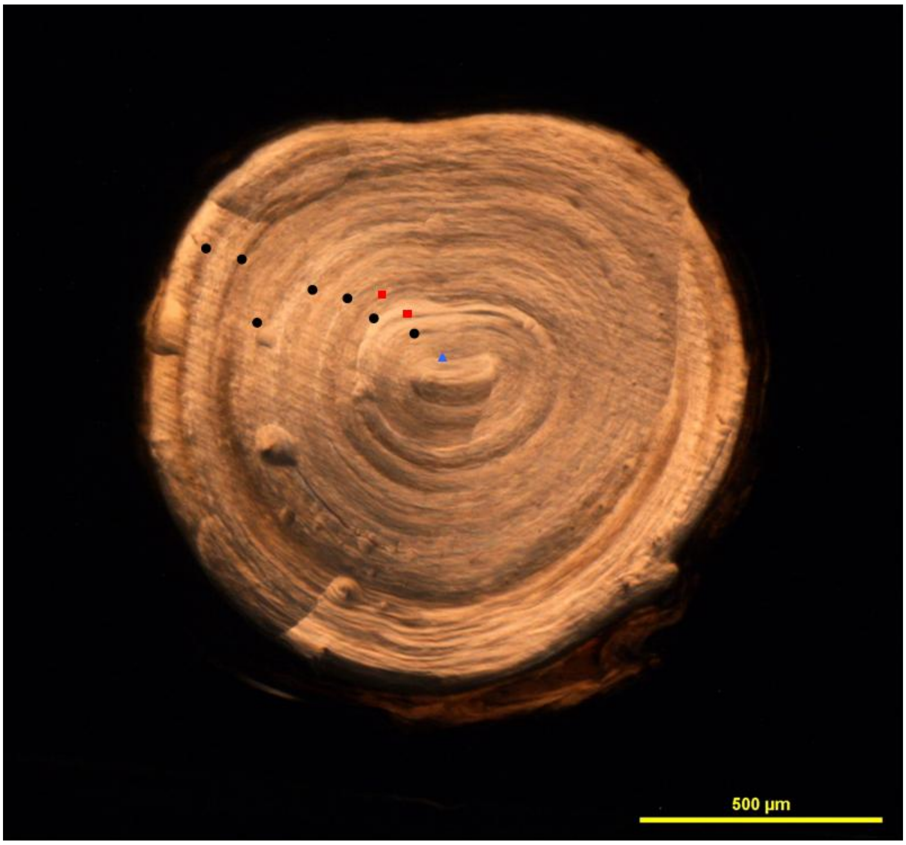
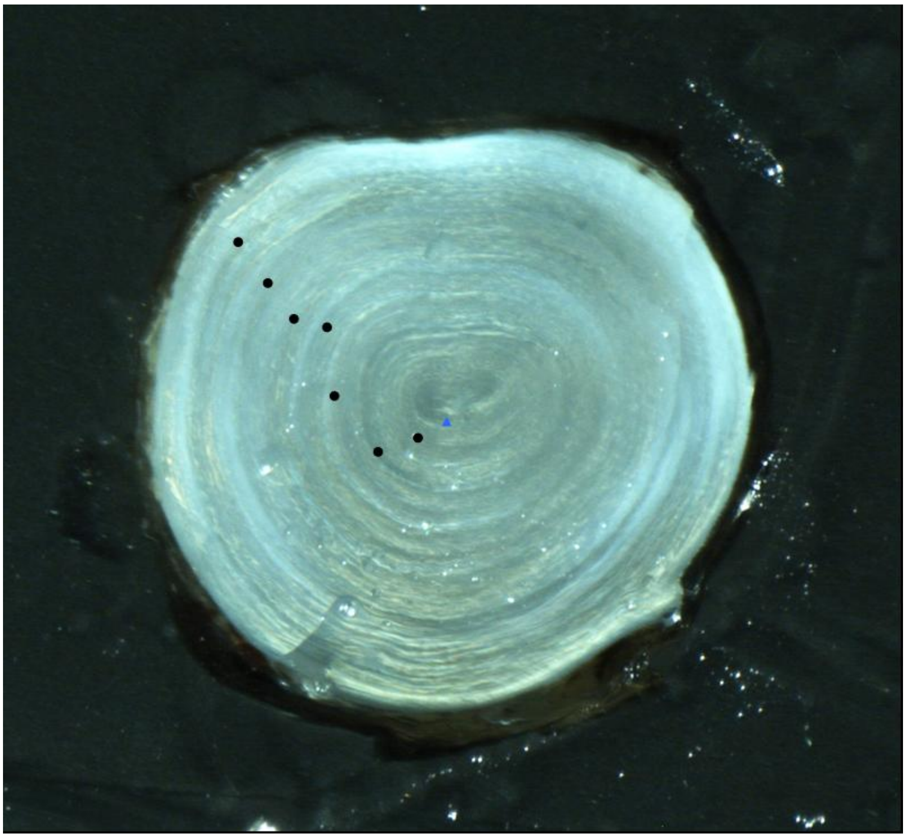
Figure 1 Illicium of *L.piscatorius* with 81 cm in length caught in September, observed at 40x under a) transmitted light and b) reflected light, identifying several increments: ● annual increment (annulus); ▲ "benthic increment" (no annual increment); ■ false annual increment.





Methodology for routine age estimation of *Lophius piscatorius* as used in FRS Marine Laboratory, Aberdeen, Scotland.

Gordon Henderson

FRS Marine Laboratory - Aberdeen, Scotland

The method I currently use was chosen after experimenting with various ways of looking at otoliths including, burning, grinding and illuminating from below, and staining and illuminating from both above and below. In addition, otoliths were sectioned and then read, or sectioned, stained and then read. The methods used by Tsimenidis and Ondrias also influenced the development of current practices, and I will provide references for these further on in this document.

Otoliths are collected from commercial samples in two ICES divisions, IVa and VIa. Collection is done at a level of one otolith per centimetre length, per area, per month. They may be collected from one vessel, or from several vessels fishing in differing locations in the same area.

After collection, the otoliths are stored in individual "Treff" microtubes containing plain tap water, with the fish length marked on the tube. The otoliths are read as soon as possible after collection, as they deteriorate under long storage conditions and become "chalky" and very difficult to age. A small reference collection stored in absolute alcohol for some considerable time shows no such deterioration.

Otoliths are transferred into a black plastic tray containing tap water and read with a stereo zoom microscope at a magnification of 10X. A free standing, 6 volt, 48 watt, bench lamp fitted with a polarising filter to remove the yellow cast from the bulb, provides illumination. The lamp is placed to the right hand side of the microscope stage, and the beam of light is angled down on to the surface of the otolith. Considerable manipulation of each otolith using forceps may be necessary before the annuli become visible. The fish length is known when reading the otoliths.

Using this method, ages up to 8 or 9 are apparent although beyond this, it becomes much more difficult because of the thickening of the otolith centre. Originally, I read the otoliths in conjunction with a mentor but he retired in 1995 and I have been going it alone since then. As far as I am aware, this method has not been verified.

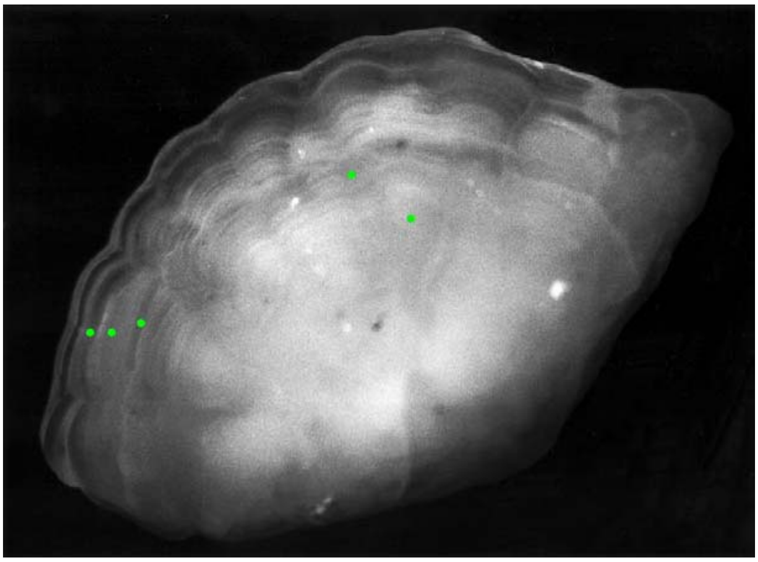
In order to illustrate some of the points above, the following papers may be useful.

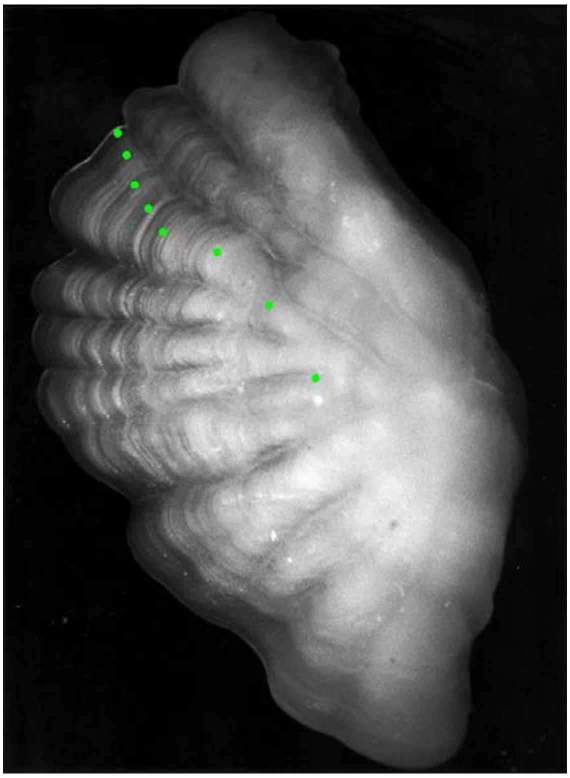
Crozier, W.W., 1989. Age and growth of Angler-fish in the North Irish Sea. Fish.Res., 7: 276 – 278.

Tsimenidis, N. and Ondrias, J. 1980. – Growth studies on the angler-fishes *Lophius piscatorius* L., 1758 and *Lophius spinola* Spinola, 1807 in Greek waters. *Thalassographica* 3 (2) : 63 – 93.

Tsimenidis, N., 1984. The growth pattern of otoliths of *Lophius piscatorius* L., 1758 and *Lophius budegassa* Spinola, 1807 in the Aegean sea. Cybium, 8(3): 35-42.

The following pictures illustrate this methodology:





Annex 3. Age readings

Table 1. ***Illicia***. Age readings by each reader and basic information about the *illicia* collection.

Stratum	Sample year	Sample no	Fish no	Fish length	Sex	Landing quarter	pc_COISP Reader 1	es_IPIMAF Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	ks_IFREM Reader 6	hm_Mar. Ir Reader 7	ss_CEFAS Reader 8	gh_MARL/ Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	expert readers Modal age	Percent agreement	Precision CV
A	-	20-29	_106	23.0	-	3	0	1	0	0	0	1	0	1	-	-	-	1	2	1	0	45%	106%
A	-	20-29	_109	24.0	-	4	0	1	0	0	0	1	0	2	-	-	-	1	2	1	0	45%	108%
A	-	20-29	_109	27.0	-	4	1	1	1	1	1	1	0	1	-	-	-	1	2	2	1	73%	49%
A	-	20-29	_110	29.0	-	4	0	2	1	1	0	1	0	2	-	-	-	1	1	1	1	55%	77%
A	-	30-39	6_2_	38.0	-	3	2	3	2	2	3	3	1	1	-	-	-	1	2	4	2	36%	45%
A	-	30-39	_106	31.0	-	3	1	2	1	1	1	2	1	1	-	-	-	1	2	2	1	64%	37%
A	-	30-39	_106	35.0	-	3	1	2	1	1	3	2	1	2	-	-	-	1	3	3	1	45%	48%
A	-	30-39	_110	32.0	-	4	1	2	2	2	2	2	1	2	-	-	-	1	3	2	2	64%	33%
A	-	30-39	_110	36.0	-	4	2	3	2	2	3	3	2	5	-	-	-	2	4	3	2	45%	35%
A	-	40-49	6_6_	48.0	-	4	3	5	4	4	5	4	2	4	-	-	-	2	4	3	4	45%	28%
A	-	40-49	_106	46.0	-	3	2	4	3	3	4	3	2	6	-	-	-	2	4	4	3	27%	36%
A	-	40-49	_110	40.0	-	4	2	2	2	2	3	3	2	2	-	-	-	2	3	4	2	64%	28%
A	-	40-49	_110	41.0	-	4	2	4	3	2	4	3	2	6	-	-	-	2	3	4	3	27%	39%
A	-	40-49	_110	47.0	-	4	3	3	3	3	4	4	2	6	-	-	-	3	4	5	3	45%	31%
A	-	50-59	5_3_	56.0	-	3	3	5	4	4	4	4	3	6	-	-	-	4	5	4	4	55%	21%
A	-	50-59	_110	51.0	-	4	3	3	3	3	4	4	3	6	-	-	-	3	4	5	3	55%	27%
A	-	50-59	_110	52.0	-	4	3	3	3	3	4	4	3	5	-	-	-	3	4	5	3	55%	22%
A	-	50-59	_111	57.0	-	4	4	4	4	4	5	4	3	5	-	-	-	4	5	6	4	55%	19%
A	-	50-59	_111	59.0	-	4	4	5	4	4	5	5	4	3	-	-	-	4	5	7	4	45%	23%
A	-	60-69	6_4_	68.0	-	3	5	6	5	5	5	6	5	8	-	-	-	5	6	5	5	64%	17%
A	-	60-69	_107	64.0	-	3	5	5	5	5	5	6	5	8	-	-	-	4	6	7	5	55%	20%
A	-	60-69	_107	66.0	-	3	5	5	5	5	6	6	5	5	-	-	-	4	5	6	5	64%	12%
A	-	60-69	_111	62.0	-	4	4	6	4	5	7	6	4	5	-	-	-	4	6	4	4	45%	22%
A	-	60-69	_112	69.0	-	4	5	5	5	5	6	6	5	8	-	-	-	5	6	7	5	55%	18%
A	-	70-79	_108	71.0	-	3	6	6	6	6	8	6	6	6	-	-	-	6	7	7	6	73%	11%
A	-	70-79	_108	74.0	-	3	7	5	6	5	8	6	5	13	-	-	-	6	7	7	5	27%	33%
A	-	70-79	_108	78.0	-	3	8	6	7	7	8	6	7	9	-	-	-	7	7	9	7	45%	14%
A	-	70-79	_112	72.0	-	4	7	7	7	6	8	8	6	8	-	-	-	7	8	7	6	18%	10%
A	-	70-79	_112	75.0	-	4	8	8	7	7	8	8	8	8	-	-	-	8	7	11	7	27%	14%
A	-	80-89	6_5_	81.0	-	3	7	7	7	8	8	8	8	9	-	-	-	7	7	5	7	45%	14%
A	-	80-89	_108	80.0	-	3	7	6	7	7	9	8	8	12	-	-	-	7	7	10	7	45%	22%
A	-	80-89	_109	88.0	-	3	9	7	8	8	9	9	9	13	-	-	-	7	9	11	8	18%	19%
A	-	80-89	_113	83.0	-	4	7	7	7	7	9	8	7	9	-	-	-	7	8	10	7	55%	14%
A	-	80-89	_113	86.0	-	4	9	8	8	8	9	9	9	13	-	-	-	7	10	9	8	27%	17%
A	-	90-99	6_5_	91.0	-	3	10	9	10	11	10	9	9	13	-	-	-	10	11	8	11	18%	13%
A	-	90-99	6_7_	93.0	-	4	10	12	9	9	10	9	10	16	-	-	-	10	9	12	9	36%	20%
A	-	90-99	_113	90.0	-	4	9	8	8	8	10	10	11	14	-	-	-	9	9	8	8	36%	19%
A	-	90-99	_113	96.0	-	4	12	11	11	10	12	12	12	17	-	-	-	10	11	13	11	27%	16%
A	-	90-99	_113	98.0	-	4	9	8	8	8	12	11	10	16	-	-	-	8	9	9	8	36%	25%
A	-	.00-10	5_5_	100.0	-	3	11	12	12	11	11	11	11	15	-	-	-	11	12	-	12	30%	11%
A	-	.00-10	5_5_	105.0	-	3	12	12	12	11	12	11	12	14	-	-	-	12	12	11	12	64%	7%
A	-	.00-10	_109	107.0	-	3	12	10	11	9	16	11	13	19	-	-	-	10	11	14	11	27%	24%
A	-	.00-10	_113	101.0	-	4	11	11	10	9	12	11	11	14	-	-	-	11	9	9	9	27%	14%
A	-	.00-10	_113	102.0	-	4	11	13	11	11	14	11	11	16	-	-	-	9	13	11	11	55%	16%
A	-	.10-11	4_10_	115.0	-	4	19	13	13	14	15	12	12	24	-	-	-	14	14	15	14	27%	24%
A	-	.10-11	5_5_	113.0	-	3	14	13	13	12	12	12	14	23	-	-	-	14	12	14	12	36%	23%
A	-	.10-11	5_5_	117.0	-	3	13	10	12	12	17	13	14	22	-	-	-	12	10	11	12	27%	26%
A	-	.10-11	_113	111.0	-	4	12	12	12	12	16	12	14	20	-	-	-	12	11	13	12	55%	20%
A	-	.20-12	4_8_	120.0	-	3	20	14	11	11	16	12	11	14	-	-	-	11	12	12	11	36%	21%
A	-	.20-12	5_5_	120.0	-	3	12	15	13	13	21	13	12	22	-	-	-	11	12	-	13	30%	27%
B	-	20-29	88: 1	21.0	-	4	0	1	0	0	0	0	0	0	-	-	-	0	1	-	0	80%	211%
B	-	20-29	0048	29.0	-	3	1	1	0	0	0	1	0	1	-	-	-	1	1	1	0	36%	79%
B	-	20-29	klar:	29.0	-	1	1	2	1	1	1	1	1	1	-	-	-	1	2	-	1	80%	35%
B	-	20-29	2 41-	24.0	-	1	1	1	0	0	0	1	1	1	-	-	-	1	1	-	0	30%	69%
B	-	30-39	52: 2-	32.0	-	3	1	2	1	1	1	1	1	1	-	-	-	1	2	-	1	80%	35%
B	-	30-39	0009	36.0	-	1	2	2	2	2	-	2	1	1	-	-	-	2	3	2	2	70%	30%
B	-	30-39	0014	34.0	-	2	1	2	1	1	-	2	1	1	-	-	-	1	2	1	1	70%	37%
B	-	30-39	1101:	39.0	-	4	1	1	2	1	3	1	1	0	-	-	-	1	3	2	1	55%	64%
B	-	30-39	02 1-	38.0	-	1	2	2	-	-	3	2	1	2	-	-	-	2	2	1	2	67%	32%
B	-	40-49	52:2-	43.0	-	3	2	2	2	2	2	2	2	2	-	-	-	2	3	2	2	91%	14%
B	-	40-49	0009	41.0	-	1	2	1	2	2	-	2	2	1	-	-	-	2	3	2	2	70%	30%
B	-	40-49	0014	47.0	-	2	3	4	3	4	4	3	2	4	-	-	-	3	4	3	4	45%	20%
B	-	40-49	0014	40.0	-	2	3	3	3	2	5	3	2	3	-	-	-	3	4	2	2	27%	30%
B	-	40-49	1101:	45.0	-	4	2	3	-	3	3	3	2	3	-	-	-	3	3	2	3	70%	18%
B	-	50-59	52: 1-	57.0	-	3	4	5	4	3	6	4	3	4	-	-	-	4	5	4	3	18%	21%
B	-	50-59	52: 1	52.0	-	3	3	3	3	3	2	3	3	2	-	-	-	3	4	3	3	73%	19%
B	-	50-59	0009	51.0	-	1	3	3	4	4	4	4	3	3	-	-	-	3	4	3	4	45%	15%
B	-	50-59	0014	55.0	-	2	3	4	4	4	6	4	3	4	-	-	-	3	5	3	4	45%	24%
B	-	50-59	1101:	51.0	-	4	3	3	3	4	6	4	3	3	-	-	-	3	5	2	3	55%	32%
B	-	60-69	52: 1-	66.0	-	3	5	6	6	5	7	5	4	7	-	-	-	5	7	6	6	27%	18%
B	-	60-69	52: 3-	64.0	-	3	-	5	5	3	-	-	3	4	-	-	-	-	-	-	4	20%	25%
B	-	60-69	0009	62.0	-	1	5	6	6	6	8	5	4	6	-	-	-	5	6	6	6	55%	18%
B	-	60-69	0014	68.0	-	2	5	6	5	5	8	5	4	5	-	-	-	5	6	3	5	55%	24%
B	-	60-69	1101:	62.0	-	4	5	5	5	5	6	5	3	6	-	-	-	5	5	5	5	73%	15%
B	-	70-79	52: 1	74.0	-	3	5	5	6	5	7	5	4	8	-	-	-	5	6	7	6	18%	21%
B	-	70-79	0009	77.0	-	1	5	5	6	6	8	5	5	7	-	-	-	6	6	7	6	36%	17%
B	-	70-79	1101:	71.0	-	4	6	7	7	7	7	6	6	7	-	-	-	6	6	7	7	55%	8%
B	-	70-79	1101:	76.0	-	4	7	4	7	6	7	7	6	11	-	-	-	6	7	7	7	55%	24%
B	-	70-79	02 1-	72.0	-	1	5	4	-	-	-	8	5	-	-	-	-	7	6	7	6	14%	24%
B	-	80-89	52: 1	86.0	-	3	7	9	8	9	8	9	7	11	-	-	-	7	6	8	8	27%	17%
B	-	80-89	RUN	88.0	-	2	9	8	9	9	8	8	9	9	-	-	-	8	8	9	9	55%	6%
B	-	80-89	RUN	82.0	-	2	6	6	7	6	8	7	6	7	-	-	-	6	6	8	6	55%	12%
B	-	80-89	1101:	82.0	-	4	7	6	7	8	8	8	6	9	-	-	-	7	7	7	7	45%	12%
B	-	80-89	02 1-	87.0	-	1	7	5	7	9	7	9	7	15	-	-	-	8	7	9	7	45%	31%
B	-	80-89	2 41-	80.0	-	1	8	7	8	8	8	10	8	10	-	-	-	8	8	9	8	64%	11%
B	-	90-99	52: 3	91.0	-	3	9	8	9	8	7	9	9	13	-	-	-	8	10	9	9	45%	17%
B	-	90-99	RUN	93.0	-	2	9	9	10	10	10	10	9	11	-	-	-	9	9	9	10	36%	7%
B	-	90-99	1101:	97.0	-	4	8	7	9	9	10	8	8	15	-	-	-	9	9	8	9	36%	23%
B	-	90-99	2 41-	91.0	-	1	10	10	11	11	10	9	10	13	-	-	-	11	9	10	11	27%	11%
B	-	90-99	2 41-	97.0	-	1	9	9	9	11	10	9	9	11	-	-	-	9	7	10	9	55%	12%
B	-	.00-10	52: 3	105.0	-	3	10	11	10	12	11	11	10	13	-	-	-	10	8	9	10	36%	13%
B	-	.00-10	RUN	109.0	-	2	10	9	9	10	10	10	9	12	-	-	-	9	8	10	9	36%	11%
B	-	.00-10	RUN	100.0	-	2	11	10	10	12	12	11	9	15	-	-	-	11	8	10	10	27%	17%
B	-	.00-10	RUN	103.0	-	2	10	8	10	10	12	11	10	-	-	-	-	9	10	11	10	50%	11%
B	-	.00-10	2 41-	104.0	-	1	9	8	10	10	12	10	9	14	-	-	-	10	9	11	10	36%	16%
B	-	.10-11	52: 3	111.0	-	3	11	11	12	11	11	12	11	13	-	-	-	12	11	11	11	64%	6%
B	-	.10-11	RUN	119.0	-	2	11	11	12	13	12	11	10	17	-	-	-	11	11	11	12	18%	16%
B	-	.10-11	RUN	115.0	-	2	11	10	13	14	11	11	11	11	-	-	-	12	12	12	13	9%	10%
B	-	.10-11	02 1-	110.0	-	1	12	8	14	14	12	11	12	13	-	-	-	12	9	11	14	18%	16%
B	-	.30-13	02 1-	132.0	-	1	11	11	11	15	15	11	14	11	-	-	-	13	10	13	13	18%	15%
						Total read	99	100	97	98	95	99	100	98	0	0	0	99	99	93		45.0%	26.7%
						Total NOT read	1	0	3	2	5	1	0	2	100	100	100	1	1	7			

Table 2. **Otoliths**. Age readings by each reader and basic information about the otoliths collection. Referecne reader: R8.

Stratum	Sample year	Sample no	Fish no	Fish length	Sex	Landing area	pc_COISP Reader 1	es_IPIMAF Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	ks_IFREM Reader 6	hm_Mar. Ir Reader 7	ss_CEFAS Reader 8	gh_MARL/ Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	ss_CEFAS age	Percent agreement	Precision CV
A	-	20-29	211	23	-	-	2	2	0	0	3	2	1	-	2	3	2	-	-	4	2	45%	64%
A	-	20-29	214	24	-	-	3	2	1	1	3	3	1	-	3	3	3	-	-	3	2	9%	39%
A	-	20-29	224	27	-	-	1	3	1	1	3	2	1	-	2	2	2	-	-	2	1	36%	41%
A	-	20-29	234	29	-	-	2	2	-	0	4	2	1	-	2	2	-	-	-	3	2	56%	56%
A	-	30-39	222	31	-	-	2	3	1	1	6	3	2	-	4	5	3	-	-	5	4	9%	52%
A	-	30-39	228	35	-	-	3	3	1	1	4	3	3	-	3	3	3	-	-	4	4	18%	35%
A	-	30-39	233	36	-	-	3	2	2	2	5	5	3	-	3	3	3	-	-	5	4	0%	36%
A	-	30-39	235	32	-	-	3	2	-	1	4	3	3	-	3	3	3	-	-	3	3	70%	28%
A	-	30-39	242	38	-	-	4	4	2	2	4	4	4	-	4	4	4	-	-	6	4	73%	28%
A	-	40-49	219	46	-	-	6	4	3	2	5	7	5	-	4	6	5	-	-	6	6	27%	31%
A	-	40-49	225	41	-	-	5	6	3	2	5	6	5	-	4	5	5	-	-	6	5	45%	27%
A	-	40-49	236	47	-	-	6	6	3	3	6	6	5	-	4	6	5	-	-	6	6	55%	24%
A	-	40-49	241	40	-	-	3	2	2	2	5	-	4	-	-	3	3	-	-	4	-	0%	34%
A	-	40-49	248	48	-	-	7	4	3	-	5	8	7	-	5	7	5	-	-	9	7	30%	31%
A	-	50-59	216	56	-	-	4	6	4	4	8	8	7	-	5	7	6	-	-	9	8	18%	29%
A	-	50-59	238	52	-	-	6	5	3	4	7	8	5	-	-	6	7	-	-	7	8	10%	27%
A	-	50-59	239	51	-	-	6	7	4	4	8	10	7	-	5	6	6	-	-	7	6	27%	27%
A	-	50-59	240	59	-	-	5	7	4	3	7	8	7	-	5	6	6	-	-	8	7	27%	27%
A	-	50-59	244	57	-	-	7	6	4	3	7	8	6	-	5	8	5	-	-	8	7	18%	28%
A	-	60-69	201	68	-	-	7	7	5	5	9	7	8	-	6	7	6	-	-	9	7	36%	20%
A	-	60-69	208	69	-	-	9	7	5	6	8	9	9	-	6	9	6	-	-	10	9	36%	22%
A	-	60-69	209	66	-	-	10	9	-	-	6	10	9	-	7	9	6	-	-	8	11	0%	19%
A	-	60-69	220	62	-	-	9	7	5	6	7	9	10	-	7	9	6	-	-	9	10	9%	21%
A	-	60-69	223	64	-	-	10	7	5	5	8	9	10	-	7	9	7	-	-	8	10	18%	22%
A	-	70-79	202	71	-	-	-	9	5	5	8	10	13	-	7	7	6	-	-	8	14	0%	31%
A	-	70-79	203	74	-	-	8	9	6	7	8	9	9	-	-	8	7	-	-	7	12	0%	13%
A	-	70-79	212	75	-	-	8	8	6	6	8	9	10	-	7	9	6	-	-	8	10	9%	17%
A	-	70-79	221	72	-	-	10	8	7	5	9	10	10	-	7	10	5	-	-	9	7	18%	24%
A	-	70-79	232	78	-	-	9	8	8	8	8	9	8	-	8	9	9	-	-	8	8	64%	6%
A	-	80-89	206	86	-	-	10	10	8	8	9	11	10	-	10	8	9	-	-	7	13	0%	13%
A	-	80-89	226	83	-	-	9	9	7	7	9	12	9	-	8	8	7	-	-	10	12	9%	17%
A	-	80-89	227	80	-	-	11	8	8	7	9	11	8	-	8	10	7	-	-	9	11	18%	16%
A	-	80-89	229	88	-	-	11	10	8	7	8	12	11	-	9	11	8	-	-	10	12	9%	17%
A	-	80-89	231	81	-	-	10	8	9	7	8	12	10	-	9	10	8	-	-	10	12	9%	15%
A	-	90-99	204	98	-	-	11	11	9	9	8	14	14	-	9	9	9	-	-	9	17	0%	21%
A	-	90-99	205	96	-	-	14	12	10	8	9	14	12	-	9	11	9	-	-	10	14	18%	19%
A	-	90-99	210	90	-	-	12	10	-	-	9	14	12	-	9	8	8	-	-	9	15	0%	21%
A	-	90-99	245	91	-	-	12	11	10	9	10	14	16	-	11	12	11	-	-	12	14	9%	17%
A	-	90-99	249	93	-	-	-	9	11	11	10	14	13	-	10	9	11	-	-	11	10	20%	15%
A	-	100-10	207	105	-	-	10	13	11	9	11	15	15	-	10	10	7	-	-	10	15	18%	22%
A	-	100-10	215	100	-	-	13	12	10	11	10	14	14	-	10	10	10	-	-	10	11	9%	15%
A	-	100-10	217	102	-	-	11	10	10	10	11	13	11	-	10	11	10	-	-	11	13	9%	8%
A	-	100-10	230	107	-	-	13	11	10	10	11	13	12	-	12	12	13	-	-	10	11	18%	11%
A	-	100-10	237	101	-	-	14	11	10	-	12	14	13	-	9	14	10	-	-	12	-	0%	16%
A	-	110-11	218	113	-	-	11	13	11	13	12	15	14	-	11	13	13	-	-	9	12	9%	14%
A	-	110-11	246	117	-	-	12	11	11	-	12	16	17	-	-	12	12	-	-	12	21	0%	17%
A	-	110-11	247	111	-	-	-	11	12	11	10	16	11	-	13	10	11	-	-	10	-	0%	16%
A	-	110-11	250	115	-	-	10	9	10	11	12	12	11	-	-	10	11	-	-	11	-	0%	9%
A	-	120-12	213	120	-	-	12	14	11	11	13	16	14	-	12	12	9	-	-	11	-	0%	15%
A	-	120-12	243	120	-	-	13	11	11	12	12	13	14	-	-	10	12	-	-	12	-	0%	10%
B	-	20-29	329	21	-	-	1	1	0	0	2	2	0	-	0	2	1	-	-	0	1	27%	107%
B	-	20-29	347	29	-	-	3	2	1	1	2	3	0	-	1	2	2	-	-	3	3	27%	54%
B	-	20-29	316	29	-	-	3	3	1	1	3	3	2	-	2	3	3	-	-	3	3	64%	33%
B	-	20-29	328	24	-	-	2	1	0	0	2	3	1	-	1	3	2	-	-	2	2	36%	67%
B	-	30-39	309	32	-	-	2	2	1	1	2	-	0	-	-	2	3	-	-	2	2	56%	52%
B	-	30-39	303	36	-	-	2	2	2	1	3	-	2	-	-	3	4	-	-	2	-	0%	37%
B	-	30-39	327	34	-	-	4	3	2	2	3	7	2	-	3	4	3	-	-	3	5	0%	43%
B	-	30-39	304	39	-	-	-	2	-	1	-	-	-	-	-	2	-	-	-	-	-	0%	35%
B	-	30-39	342	38	-	-	5	3	2	2	3	5	2	-	2	4	3	-	-	4	5	18%	37%
B	-	40-49	305	43	-	-	3	3	3	2	4	4	3	-	5	3	4	-	-	5	5	18%	26%
B	-	40-49	331	41	-	-	6	3	3	2	4	7	3	-	5	4	4	-	-	6	6	18%	36%
B	-	40-49	306	47	-	-	4	4	3	2	5	5	4	-	4	3	5	-	-	5	4	36%	25%
B	-	40-49	317	40	-	-	4	3	3	2	4	5	3	-	5	4	4	-	-	4	6	0%	24%
B	-	40-49	307	45	-	-	4	4	3	2	5	5	4	-	4	4	5	-	-	4	5	27%	22%
B	-	50-59	340	57	-	-	4	5	4	4	5	8	4	-	5	4	5	-	-	4	7	0%	25%
B	-	50-59	332	52	-	-	7	4	5	5	6	8	7	-	5	5	6	-	-	6	7	18%	20%
B	-	50-59	341	51	-	-	9	6	6	4	6	9	7	-	5	7	6	-	-	9	9	27%	25%
B	-	50-59	318	55	-	-	7	4	5	5	6	8	6	-	5	7	6	-	-	8	7	18%	21%
B	-	50-59	319	51	-	-	4	4	4	3	6	-	4	-	5	4	5	-	-	7	6	10%	26%
B	-	60-69	302	66	-	-	8	6	6	-	6	10	7	-	7	7	7	-	-	9	10	10%	18%
B	-	60-69	313	64	-	-	6	6	5	4	6	8	6	-	6	7	6	-	-	7	6	55%	17%
B	-	60-69	301	62	-	-	8	5	6	5	7	8	8	-	6	6	6	-	-	7	6	36%	17%
B	-	60-69	339	68	-	-	9	7	6	5	7	8	9	-	6	7	7	-	-	8	9	18%	17%
B	-	60-69	346	62	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	0%	0%
B	-	70-79	320	74	-	-	9	7	6	6	7	10	9	-	8	7	7	-	-	11	7	36%	21%
B	-	70-79	338	77	-	-	9	9	6	6	8	11	8	-	-	7	7	-	-	10	9	20%	21%
B	-	70-79	326	71	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-		
B	-	70-79	333	76	-	-	8	8	7	8	4	11	10	-	6	6	6	-	-	12	8	27%	31%
B	-	70-79	350	72	-	-	9	8	7	-	8	9	11	-	7	9	8	-	-	11	8	30%	16%
B	-	80-89	325	86	-	-	9	10	7	8	8	9	9	-	8	8	7	-	-	10	9	27%	12%
B	-	80-89	330	88	-	-	9	9	7	8	9	9	9	-	8	8	8	-	-	9	8	36%	8%
B	-	80-89	308	82	-	-	9	7	8	8	9	9	9	-	8	7	8	-	-	10	8	36%	11%
B	-	80-89	312	82	-	-	9	9	8	9	9	9	9	-	10	10	9	-	-	9	14	0%	6%
B	-	80-89	344	87	-	-	8	9	7	8	9	10	8	-	8	7	8	-	-	10	8	45%	12%
B	-	80-89	334	80	-	-	10	9	8	7	10	11	10	-	7	10	8	-	-	12	7	18%	17%
B	-	90-99	349	91	-	-	9	10	8	10	10	12	9	-	9	8	9	-	-	9	10	27%	12%
B	-	90-99	343	93	-	-	12	13	8	11	11	12	9	-	11	10	11	-	-	11	12	18%	13%
B	-	90-99	324	97	-	-	10	10	9	10	10	-	10	-	-	8	9	-	-	7	-	0%	12%
B	-	90-99	311	91	-	-	7	7	7	7	10	12	9	-	10	7	7	-	-	7	8	0%	22%
B	-	90-99	321	97	-	-	9	8	8	8	11	11	9	-	9	9	10	-	-	14	13	0%	19%
B	-	100-10	335	105	-	-	12	13	10	12	12	12	13	-	11	11	12	-	-	14	13	18%	9%
B	-	100-10	322	109	-	-	9	10	11	10	11	9	9	-	10	11	9	-	-	16	9	36%	19%
B	-	100-10	337	100	-	-	11	11	10	9	11	9	11	-	12	10	10	-	-	11	12	9%	9%
B	-	100-10	315	103	-	-	12	12	11	11	12	10	13	-	-	12	10	-	-	11	-	0%	8%
B	-	100-10	314	104	-	-	11	13	11	12	12	10	12	-	12	11	12	-	-	11	-	0%	7%
B	-	110-11	348	111	-	-	8	12	8	9	13	14	8	-	-	7	9	-	-	16	-	0%	30%
B	-	110-11	336	119	-	-	14	11	10	10	12	14	11	-	12	10	10	-	-	14	-	0%	15%
B	-	110-11	310	115	-	-	11	9	10	11	12	14	10	-	14	10	11	-	-	11	11	36%	14%
B	-	110-11	345	110	-	-	9	11	10	12	14	15	10	-	11	9	10	-	-	12	13	0%	17%
B	-	130-13	323	132	-	-	12	14	11	-	15	12	9	-	13	10	11	-	-	15	12	20%	17%
						Total read	94	100	94	90	97	92	97	0	85	98	96	0	0	97		19.0%	23.7%
						Total NOT read	6	0	6	10	3	8	3	100	15	2	4	100	100	3			

Table 3. **Otoliths**. Age readings by each reader and basic information about the otoliths collection. Referecne reader: R9.

Stratum	Sample year	Sample no	Fish no	Fish length	Sex	Landing area	pc_COISP Reader 1	es_IPIMAF Reader 2	jl_IEO Reader 3	jb_IEO Reader 4	eb_IEO Reader 5	ks_IFREM Reader 6	hm_Mar. Ir Reader 7	ss_CEFAS Reader 8	gh_MARL/ Reader 9	hr_DIFRES Reader 10	at_DIFRES Reader 11	lo_FAMRI Reader 12	hd_FAMRI Reader 13	sn_BIOPOL Reader 14	gh_MARLAB age	Percent agreement	Precision CV
A	-	20-29	211	23	-	-	2	2	0	0	3	2	1	2	-	3	2	-	-	4	2	45%	64%
A	-	20-29	214	24	-	-	3	2	1	1	3	3	1	2	-	3	3	-	-	3	3	55%	40%
A	-	20-29	224	27	-	-	1	3	1	1	3	2	1	1	-	2	2	-	-	2	2	36%	46%
A	-	20-29	234	29	-	-	2	2	-	0	4	2	1	2	-	2	-	-	-	3	2	56%	56%
A	-	30-39	222	31	-	-	2	3	1	1	6	3	2	4	-	5	3	-	-	5	4	9%	52%
A	-	30-39	228	35	-	-	3	3	1	1	4	3	3	4	-	3	3	-	-	4	3	55%	36%
A	-	30-39	233	36	-	-	3	2	2	2	5	5	3	4	-	3	3	-	-	5	3	36%	36%
A	-	30-39	235	32	-	-	3	2	-	1	4	3	3	3	-	3	3	-	-	3	3	70%	28%
A	-	30-39	242	38	-	-	4	4	2	2	4	4	4	4	-	4	4	-	-	6	4	73%	28%
A	-	40-49	219	46	-	-	6	4	3	2	5	7	5	6	-	6	5	-	-	6	4	9%	30%
A	-	40-49	225	41	-	-	5	6	3	2	5	6	5	5	-	5	5	-	-	6	4	0%	26%
A	-	40-49	236	47	-	-	6	6	3	3	6	6	5	6	-	6	5	-	-	6	4	0%	23%
A	-	40-49	241	40	-	-	3	2	2	2	5	-	4	-	-	3	3	-	-	4	-	0%	34%
A	-	40-49	248	48	-	-	7	4	3	-	5	8	7	7	-	7	5	-	-	9	5	20%	30%
A	-	50-59	216	56	-	-	4	6	4	4	8	8	7	8	-	7	6	-	-	9	5	0%	28%
A	-	50-59	238	52	-	-	6	5	3	4	7	8	5	8	-	6	7	-	-	7	-	0%	27%
A	-	50-59	239	51	-	-	6	7	4	4	8	10	7	6	-	6	6	-	-	7	5	0%	26%
A	-	50-59	240	59	-	-	5	7	4	3	7	8	7	7	-	6	6	-	-	8	5	9%	26%
A	-	50-59	244	57	-	-	7	6	4	3	7	8	6	7	-	8	5	-	-	8	5	9%	27%
A	-	60-69	201	68	-	-	7	7	5	5	9	7	8	7	-	7	6	-	-	9	6	9%	19%
A	-	60-69	208	69	-	-	9	7	5	6	8	9	9	9	-	9	6	-	-	10	6	18%	21%
A	-	60-69	209	66	-	-	10	9	-	-	6	10	9	11	-	9	6	-	-	8	7	0%	20%
A	-	60-69	220	62	-	-	9	7	5	6	7	9	10	10	-	9	6	-	-	9	7	18%	22%
A	-	60-69	223	64	-	-	10	7	5	5	8	9	10	10	-	9	7	-	-	8	7	18%	23%
A	-	70-79	202	71	-	-	-	9	5	5	8	10	13	14	-	7	6	-	-	8	7	10%	36%
A	-	70-79	203	74	-	-	8	9	6	7	8	9	9	12	-	8	7	-	-	7	-	0%	20%
A	-	70-79	212	75	-	-	8	8	6	6	8	9	10	10	-	9	6	-	-	8	7	0%	19%
A	-	70-79	221	72	-	-	10	8	7	5	9	10	10	7	-	10	5	-	-	9	7	18%	24%
A	-	70-79	232	78	-	-	9	8	8	8	8	9	8	8	-	9	9	-	-	8	8	64%	6%
A	-	80-89	206	86	-	-	10	10	8	8	9	11	10	13	-	8	9	-	-	7	10	27%	18%
A	-	80-89	226	83	-	-	9	9	7	7	9	12	9	12	-	8	7	-	-	10	8	9%	20%
A	-	80-89	227	80	-	-	11	8	8	7	9	11	8	11	-	10	7	-	-	9	8	27%	17%
A	-	80-89	229	88	-	-	11	10	8	7	8	12	11	12	-	11	8	-	-	10	9	0%	18%
A	-	80-89	231	81	-	-	10	8	9	7	8	12	10	12	-	10	8	-	-	10	9	9%	17%
A	-	90-99	204	98	-	-	11	11	9	9	8	14	14	17	-	9	9	-	-	9	9	45%	26%
A	-	90-99	205	96	-	-	14	12	10	8	9	14	12	14	-	11	9	-	-	10	9	18%	20%
A	-	90-99	210	90	-	-	12	10	-	-	9	14	12	15	-	8	8	-	-	9	9	22%	24%
A	-	90-99	245	91	-	-	12	11	10	9	10	14	16	14	-	12	11	-	-	12	11	18%	17%
A	-	90-99	249	93	-	-	-	9	11	11	10	14	13	10	-	9	11	-	-	11	10	20%	15%
A	-	100-10!	207	105	-	-	10	13	11	9	11	15	15	15	-	10	7	-	-	10	10	27%	24%
A	-	100-10!	215	100	-	-	13	12	10	11	10	14	14	11	-	10	10	-	-	10	10	45%	14%
A	-	100-10!	217	102	-	-	11	10	10	10	11	13	11	13	-	11	10	-	-	11	10	36%	10%
A	-	100-10!	230	107	-	-	13	11	10	10	11	13	12	11	-	12	13	-	-	10	12	18%	11%
A	-	100-10!	237	101	-	-	14	11	10	-	12	14	13	-	-	14	10	-	-	12	9	0%	13%
A	-	110-11!	218	113	-	-	11	13	11	13	12	15	14	12	-	13	13	-	-	9	11	18%	13%
A	-	110-11!	246	117	-	-	12	11	11	-	12	16	17	21	-	12	12	-	-	12	-	0%	24%
A	-	110-11!	247	111	-	-	-	11	12	11	10	16	11	-	-	10	11	-	-	10	13	0%	17%
A	-	110-11!	250	115	-	-	10	9	10	11	12	12	11	-	-	10	11	-	-	11	-	0%	9%
A	-	120-12!	213	120	-	-	12	14	11	11	13	16	14	-	-	12	9	-	-	11	12	20%	16%
A	-	120-12!	243	120	-	-	13	11	11	12	12	13	14	-	-	10	12	-	-	12	-	0%	10%
B	-	20-29	329	21	-	-	1	1	0	0	2	2	0	1	-	2	1	-	-	0	0	36%	91%
B	-	20-29	347	29	-	-	3	2	1	1	2	3	0	3	-	2	2	-	-	3	1	18%	50%
B	-	20-29	316	29	-	-	3	3	1	1	3	3	2	3	-	3	3	-	-	3	2	9%	32%
B	-	20-29	328	24	-	-	2	1	0	0	2	3	1	2	-	3	2	-	-	2	1	18%	63%
B	-	30-39	309	32	-	-	2	2	1	1	2	-	0	2	-	2	3	-	-	2	-	0%	48%
B	-	30-39	303	36	-	-	2	2	2	1	3	-	2	-	-	3	4	-	-	2	-	0%	37%
B	-	30-39	327	34	-	-	4	3	2	2	3	7	2	5	-	4	3	-	-	3	3	36%	44%
B	-	30-39	304	39	-	-	-	2	-	1	-	-	-	-	-	2	-	-	-	-	-	0%	35%
B	-	30-39	342	38	-	-	5	3	2	2	3	5	2	5	-	4	3	-	-	4	2	27%	35%
B	-	40-49	305	43	-	-	3	3	3	2	4	4	3	5	-	3	4	-	-	5	5	18%	26%
B	-	40-49	331	41	-	-	6	3	3	2	4	7	3	6	-	4	4	-	-	6	5	0%	37%
B	-	40-49	306	47	-	-	4	4	3	2	5	5	4	4	-	3	5	-	-	5	4	36%	25%
B	-	40-49	317	40	-	-	4	3	3	2	4	5	3	6	-	4	4	-	-	4	5	9%	28%
B	-	40-49	307	45	-	-	4	4	3	2	5	5	4	5	-	4	5	-	-	4	4	45%	23%
B	-	50-59	340	57	-	-	4	5	4	4	5	8	4	7	-	4	5	-	-	4	5	27%	28%
B	-	50-59	332	52	-	-	7	4	5	5	6	8	7	7	-	5	6	-	-	6	5	27%	20%
B	-	50-59	341	51	-	-	9	6	6	4	6	9	7	9	-	7	6	-	-	9	5	0%	24%
B	-	50-59	318	55	-	-	7	4	5	5	6	8	6	7	-	7	6	-	-	8	5	18%	20%
B	-	50-59	319	51	-	-	4	4	4	3	6	-	4	6	-	4	5	-	-	7	5	10%	27%
B	-	60-69	302	66	-	-	8	6	6	-	6	10	7	10	-	7	7	-	-	9	7	30%	21%
B	-	60-69	313	64	-	-	6	6	5	4	6	8	6	6	-	7	6	-	-	7	6	55%	17%
B	-	60-69	301	62	-	-	8	5	6	5	7	8	8	6	-	6	6	-	-	7	6	36%	17%
B	-	60-69	339	68	-	-	9	7	6	5	7	8	9	9	-	7	7	-	-	8	6	9%	17%
B	-	60-69	346	62	-	-	-	5	5	-	-	-	-	-	-	-	-	-	-	-	-	0%	0%
B	-	70-79	320	74	-	-	9	7	6	6	7	10	9	7	-	7	7	-	-	11	8	0%	21%
B	-	70-79	338	77	-	-	9	9	6	6	8	11	8	9	-	7	7	-	-	10	-	0%	20%
B	-	70-79	326	71	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-		
B	-	70-79	333	76	-	-	8	8	7	8	4	11	10	8	-	6	6	-	-	12	6	18%	29%
B	-	70-79	350	72	-	-	9	8	7	-	8	9	11	8	-	9	8	-	-	11	7	10%	15%
B	-	80-89	325	86	-	-	9	10	7	8	8	9	9	9	-	8	7	-	-	10	8	27%	12%
B	-	80-89	330	88	-	-	9	9	7	8	9	9	9	8	-	8	8	-	-	9	8	36%	8%
B	-	80-89	308	82	-	-	9	7	8	8	9	9	9	8	-	7	8	-	-	10	8	36%	11%
B	-	80-89	312	82	-	-	9	9	8	9	9	9	9	14	-	10	9	-	-	9	10	9%	17%
B	-	80-89	344	87	-	-	8	9	7	8	9	10	8	8	-	7	8	-	-	10	8	45%	12%
B	-	80-89	334	80	-	-	10	9	8	7	10	11	10	7	-	10	8	-	-	12	7	18%	17%
B	-	90-99	349	91	-	-	9	10	8	10	10	12	9	10	-	8	9	-	-	9	9	36%	12%
B	-	90-99	343	93	-	-	12	13	8	11	11	12	9	12	-	10	11	-	-	11	11	36%	13%
B	-	90-99	324	97	-	-	10	10	9	10	10	-	10	-	-	8	9	-	-	7	-	0%	12%
B	-	90-99	311	91	-	-	7	7	7	7	10	12	9	8	-	7	7	-	-	7	10	9%	21%
B	-	90-99	321	97	-	-	9	8	8	8	11	11	9	13	-	9	10	-	-	14	9	27%	20%
B	-	100-10!	335	105	-	-	12	13	10	12	12	12	13	13	-	11	12	-	-	14	11	9%	9%
B	-	100-10!	322	109	-	-	9	10	11	10	11	9	9	9	-	11	9	-	-	16	10	18%	20%
B	-	100-10!	337	100	-	-	11	11	10	9	11	9	11	12	-	10	10	-	-	11	12	9%	9%
B	-	100-10!	315	103	-	-	12	12	11	11	12	10	13	-	-	12	10	-	-	11	-	0%	8%
B	-	100-10!	314	104	-	-	11	13	11	12	12	10	12	-	-	11	12	-	-	11	12	40%	7%
B	-	110-11!	348	111	-	-	8	12	8	9	13	14	8	-	-	7	9	-	-	16	-	0%	30%
B	-	110-11!	336	119	-	-	14	11	10	10	12	14	11	-	-	10	10	-	-	14	12	10%	15%
B	-	110-11!	310	115	-	-	11	9	10	11	12	14	10	11	-	10	11	-	-	11	14	9%	12%
B	-	110-11!	345	110	-	-	9	11	10	12	14	15	10	13	-	9	10	-	-	12	11	9%	18%
B	-	130-13!	323	132	-	-	12	14	11	-	15	12	9	12	-	10	11	-	-	15	13	0%	17%
						Total read	94	100	94	90	97	92	97	85	0	98	96	0	0	97		19.0%	24.0%
						Total NOT read	6	0	6	10	3	8	3	15	100	2	4	100	100	3			