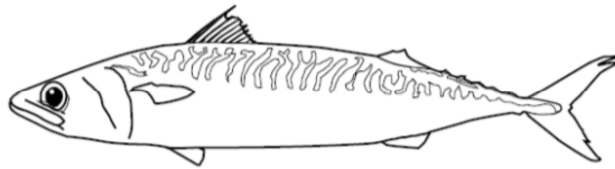


**Small Scale Otolith Exchange
for North East Atlantic Mackerel
(*Scomber scombrus*)
2014**

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Introduction

Atlantic mackerel (*Scomber scombrus*) is a pelagic species of high commercial importance in European waters. Living on both sides of the North Atlantic ICES currently uses the term “Northeast Atlantic (NEA) mackerel” to define the mackerel present in the North East Atlantic with a distribution range from the Iberian Peninsula in the South to the Nordic Sea including Icelandic and Greenland waters and the Western Baltic. Recent ICES stock advice based on an age-based analytical assessment model shows that the stock of NEA mackerel is on a very high level.

Age readings on mackerel are important input data for the assessment and carried out by a number of laboratories using international agreed ageing criteria. However, the report on the latest workshop on age reading of mackerel (WKARMAC, ICES 2010) stated that the frequency of workshops and exchanges on age reading of mackerel in the past was far from impressive. The first reported workshop on mackerel ageing was held in Lowestoft in 1987 and following that only one workshop has been held (in 1995 in Spain) and one additional exchange in 2002. All previous workshops and exchanges have had an outcome stating the overall agreement to be low but fair, but skewed towards having a higher agreement on the younger ages. All workshops discussed and made an effort to standardize age reading methods by preparing a manual and a reference collection of agreed age otoliths.

The overall result of the last exchange and workshop exercise in 2010 was that there were significant variations in mackerel age estimates between readers. Low precision, and large relative biases between readers were found, and the older ages (from age 6) were particularly difficult to reach agreement upon. Following these findings all participants in the workshop agreed to follow the guidelines of the WKARMAC report for the decided upcoming exchange of images to facilitate an evaluation of the guidelines. This short report represents the results of this exchange summarizing the readings of 19 readers of 10 European laboratories in nine countries. The exchange was carried out from December 2013 to April 2014.

Material and Methods

A questionnaire was distributed among mackerel aging institutes before the exchange to get an overview of potential participants and methods used. Table 1 shows the participating countries, institutes, participant names, table 2 the methods used in the different institutes. From all participants seven readers have a long time experience to read mackerel otoliths (experts), seven were intermediate and five trainees.

A set of altogether 164 images of mackerel otoliths were selected and uploaded for analyzing using the WebGR application (Web services for support of Growth and Reproduction Studies <http://webgr.azti.es>). The set consisted of images of otoliths which were embedded in transparent resin between two glass plates laid on a black background.

The otoliths were sampled during observer trips and surveys carried out in 2012 in the 1st and 3rd quarter. It was attempted to cover a wide range of fish sizes from different ICES areas.

The following table shows the number of mackerel otoliths used in this exchange including the sampling specifications:

Source	Gear	Quarter	ICES Area				
			II	IVa,b	VIa	VIIb	all
Observer	Midwater Trawl	Q1 2012			36	30	66
Observer	Midwater Trawl	Q3 2012	23				23
Survey	Bottom Trawl	Q1 2012		38			38
Survey	Bottom Trawl	Q3 2012		37			37
all	all	all	23	75	36	30	164

As guideline the report of the 2010 workshop on age reading of mackerel was provided to all participants by uploading to WebGR.

Age reading results were analyzed using the excel workbook “Age Reading Comparisons” (Eltink 2000) following the guidelines of the *Planning Group for Commercial Catches, Discards and Biological Sampling* for otolith exchanges (ICES 2011).

Results

Overall age reading results are shown in table 3. From the total of 164 pictures of mackerel otoliths seven readers analyzed all images; nine readers analyzed between 161 to 163 images and two readers 156 images (Tab.4).

Overall agreement is 68.2% (Tab.6a). Good agreements are reached for age 1 and 2 (93 and 92%, resp.), for age 3 and 4 agreements are between 74 and 76%, agreement for age 5 is 61% and for age 6 and 7 57%. Only very low agreement is found for the older ages 8 to 14 (between 47% for age 8 and 31% for age 13).

Two additional analyses were performed: Analysis only done with the expert group shows a higher overall agreement of 75.5% (Tab. 6b), analysis referring to experts and intermediate (14 readers) shows an overall agreement of 70.4% (Tab. 6c), still slightly higher than the agreement between all readers.

The analysis including all age readers revealed an overall coefficient of variation (CV) of 15.4% (Tab.5). CV peaked at 24.7% for modal age 1 which was due mostly to two readers who interpreted a number of otoliths as age 0 in opposite to the other readers. Lowest CVs were revealed for modal age groups 2 and 4, highest CVs for 9, 10 and 12. Overall CV for only the expert group is 9.3%, for the group of experts and intermediate reader 13.9%.

Fig.1a and 1b shows age bias plots with the mean age recorded and the standard deviation of each age reader and all readers combined plotted against the modal age. Greatest

deviations from the modal age (solid line) can be seen for the older ages. Like the overall agreement between reader is less with older ages, the standard deviations are also mostly higher for the older ages for all readers combined (Fig.2) but also looking at the individual readers (Fig.1a,b).

Figures 3-6 show images of four different otoliths with the age annotations of all readers. Figure 3 is an example for a 100% agreement for a 29cm/202g mackerel (3 years), figure 4 is an example for a medium high agreement of a 36cm/345g mackerel (74%, annotation of 5-8 years). Figures 5 and 6 are examples for low agreements. Figure 5 shows the annotations for the otolith image of the largest mackerel which was used in this exchange (50cm/1207g with an agreement of 35%, 9 to 15 years old). Figure 6 shows the annotations with the lowest agreement in this exchange (21% for a 40cm/506g fish, 6 to 12 years old).

Discussion

Within the participating institutes the methods of treatment of the otoliths before reading are relatively good standardized. Most institutes are reading whole otoliths embedded in raisin. In this exchange images of otoliths were used which were treated with the same method. Exclusively using images has of course the disadvantage that the readers are not able to re-adjust the sharpness on different levels of the otoliths which can make the interpretation more difficult.

The exchange was carried out by using the WebGR application. Although the crash of the WebGR server delayed the start of this exchange, WebGR made the whole exchange process quite easy. All readers seemed to be familiar with the use of the tool and it proved to be very useful.

According to WKARMAC 2010 the overall agreement of the last exchange (2009) was 68%, but the agreement on an image reading exercise during the last workshop in 2010 was only 25%. WebGR was not used in 2010.

Only 8 readers of the participants of the 2009/2010 exchange and workshop were also participating in the actual exchange with 19 participants. However, the results of the recent exchange show no decline of agreement but a slight improvement with 68.2%. Taking only into account the group of experts, resp. expert and intermediate readers, agreement is better.

Looking at the age compositions estimated by each age reader for the whole group (Tab.7) it can be clearly seen that some single readers are interpreting the age structure of mackerel distinctly different from the majority of readers. Furthermore, especially for the age groups >7 the exchange reveals again higher differences with agreements lower than 50% (Fig.2).

Overall, there is certainly room for improvement both in terms of consistency and agreement between readers. More effort needs to put into the age determination for older mackerel.

Mackerel is not an easy species for age determination. As widely distributed fish species it lives in different areas with very different feeding conditions. As already stated in the WKARMAC report (2010), especially the recent changes in growth patterns, timing of spawning, and the extensive migration of mackerel, all these factors might be the reason for both seasonal and spatial differences/changes in the otolith morphology. This does give differences in the edge appearance within season between areas and might lead to the more frequent occurrence of false or split rings which also leads to disagreements in interpretation.

Age determination is an essential feature in fish stock assessment to estimate the rates of mortalities and growth. Following the results of the benchmark workshop on mackerel in the beginning of 2014 the assessment now uses an analytical age-based assessment model including different tuning series of which some are also relying on age disaggregated data.

Taking the results of the exchange in account the carrying out of a workshop in 2015/2016 is recommended dealing with the generic terms of references (ICES 2011) for workshops on age calibration in order to increase the agreement between the laboratories involved in stock assessment especially for the older fish. Furthermore, growth and validations studies need to be integrated. Following a WKARMAC recommendation WGWIDE is again encouraged to look further into a possibility of incorporating the increased variance around the problematic age groups in assessment, e.g. by suggesting studies dealing with this issue.

References

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ICES, 2010: Report of the Workshop on Age Reading of Mackerel (WKARMAC). ICES CM 2010/ACOM: 46.

ICES, 2011: PGCCDBS Guidelines for Otolith Exchanges (update). ICES online <http://ices.dk/community/Documents/PGCCDBS/PGCCDBS%20Guidelines%20for%20otolith%20exchanges.pdf> .

Tab. 1: List of Participants

Country	Institute	Adress	Name	Email	Expertise
Denmark	DTU Aqua	P.O box 101 9850 Hirtshals	Maria Jarnum	mja@aqua.dtu.dk	intermediate
Faroe Islands	Faroe Marine Research Institute	Nóatún 1, Tórshavn Faroe Islands	Jens Arni Thomassen	jensarni@hav.fo	intermediate
Faroe Islands	Faroe Marine Research Institute	Nóatún 1, Tórshavn Faroe Islands	Poul Vestergaard	poulv@hav.fo	intermediate
France	IFREMER	150 quai Gambetta, BP 699, 62321 Boulogne sur mer	Elise Bellamy	elise.bellamy@ifremer.fr	trainee
Germany	Thünen Institute of Sea Fisheries	Palmaille 9 22767 Hamburg	Gertrud Delfs	Gertrud.delfs@ti.bund.de	intermediate
Iceland	Marine Reserach Institute	Skulagata 4, 121 Reykjavik	Guðrún Finnbogadóttir	gunna@hafro.is	intermediate
Ireland	Marine Institute	Killybegs Harbour Centre, Killybegs, Co. Donegal	Eugene Mullins	eugene.mullins@marine.ie	intermediate
Netherlands	IMARES	PO Box 68, 1970AB IJmuiden	Jan Beintema	jan.beintema@wur.nl	expert
Netherlands	IMARES	PO Box 68, 1970AB IJmuiden	André Dijkman	andre.dijkman@wur.nl	intermediate
Norway	Institute of Marine Research	P.O.Box 1870 Nordnes, 5817 Bergen	Eilert Hermansen	eilert@imr.no	expert
Norway	Institute of Marine Research	P.O.Box 1870 Nordnes, 5817 Bergen	Anne-Liv Johnsen	anne.liv.johnsen@imr.no	expert
Norway	Institute of Marine Research	P.O.Box 1870 Nordnes, 5817 Bergen	Jan de Lange	jan.de.lange@imr.no	expert
Norway	Institute of Marine Research	P.O.Box 1870 Nordnes, 5817 Bergen	Stine Karlson	stine.karlson@imr.no	trainee
Norway	Institute of Marine Research	P.O.Box 1870 Nordnes, 5817 Bergen	Merete Kvalsund	merete.kvalsund@imr.no	trainee
Norway	Institute of Marine Research	P.O.Box 1870 Nordnes, 5817 Bergen	Ørjan Sørensen	orjan.sorensen@imr.no	trainee
Spain	Instituto Español de Oceanografía	Promontorio de San Martín s/n 39004 Santander	Charo Navarro	charo.navarro@st.ieo	expert
Spain	Instituto Español de Oceanografía	Promontorio de San Martín s/n 39004 Santander	Clara Dueñas	clara.duenas@st.ieo.es	expert
Spain	Instituto Español de Oceanografía	Promontorio de San Martín s/n 39004 Santander	Ana Antolinez	ana.antolinez@st.ieo.es	trainee
Spain	AZTI - Tecnalia	Herrera Kaia, Portualdea z/g E-20110, Gipuzkoa	Iñaki Rico	irico@azti.es	expert

Tab. 2: List of otolith preparation methods and other specifications for the participating institutes

Country	Institute	Source of otolith sampling	ICES areas	Time period	Age reading method	Light used
Denmark	DTU Aqua	market sampling and surveys	mainly IV	Q1, Q3, Q4	whole otoliths	transmitted
Faroe Islands	FMRI	market sampling and surveys	II, Vb1	Q2, Q3, Q4	whole otoliths are embedded in resin on a black mold with wells	reflected
France	IFREMER	No sampling	-	-	-	-
Germany	TI-SF	observer trips and surveys	VI, VII, IV	Q1, Q3, Q4	whole otoliths are embedded in resin between glass slides with black background	reflected
Iceland	MRI	observer trips and surveys	mainly Va	Q2, Q3, Q4	whole otoliths are embedded in alcohol, embedded in resin after age reading	reflected
Ireland	MI	market sampling and surveys	VI, VII, IV	Q1,Q4	whole otoliths are embedded in resin	reflected
Netherlands	IMARES	market sampling and surveys	IV, VI, VII	Q1-Q4	whole otoliths embedded in resin	reflected
Norway	IMR	market sampling and surveys	II, IV, VI, VII	Q1-Q4	Whole otoliths embedded in resin on an otolith tray with black background	reflected
Spain	IEO	market sampling and surveys	VIIIc, VIIIb, IXa North	Q1-Q4	Mainly whole otoliths in black moulds and covered with polyester resin (Eukit). Some of them are stored dry and then read with a drop of water	reflected
Spain	AZTI	observer trips and market sampling	VIIIb, VIIIc	Q1, Q2	whole otoliths are embedded in resin between glass slides with black background	reflected

Tab. 3: All age reading results

Stratum	Sample year	no	Fish no	Fish length	Sex	GD DE	J8 NL	AD NL	GF IS	Jd LN	IRE S	AA ES	CD ES	CN ES	JAT FA	PV FA	EM IR	MK N	ALJ N	OS N	SK N	EB F	EH N	MJ DK	MODAL age	Percent agreement	Precision CV	
Via	2012	1	1	200	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0,89	0,35	
Via	2012	2	2	210	U	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0,89	0,35	
Via	2012	3	3	230	F	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	0,89	0,17	
Via	2012	4	4	230	F	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1,00	0,00	
Via	2012	5	5	250	F	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	0,95	0,12	
Via	2012	6	6	250	F	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	0,95	0,12	
Via	2012	7	7	270	M	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	1	2	2	2	0,84	0,20
Via	2012	8	8	270	F	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	0,95	0,12	
Via	2012	9	9	300	F	5	4	5	5	5	5	5	5	5	5	5	5	4	5	5	5	3	4	4	5	0,74	0,12	
Via	2012	10	10	300	M	3	3	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	0,89	0,10	
Via	2012	11	11	320	M	4	4	5	4	5	5	5	5	5	5	4	5	4	4	5	5	3	4	4	5	0,53	0,14	
Via	2012	12	12	320	F	3	3	4	4	5	5	5	4	4	5	4	5	3	4	5	4	3	4	3	4	0,42	0,19	
Via	2012	13	13	330	M	5	-	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	4	5	0,83	0,08	
Via	2012	14	14	330	F	4	4	5	3	5	5	5	4	4	4	4	5	5	4	4	5	5	3	5	3	5	0,47	0,17
Via	2012	15	15	330	F	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	0,95	0,06	
Via	2012	16	16	340	M	6	4	6	6	6	6	6	6	5	6	6	6	5	5	6	6	4	6	4	6	0,68	0,14	
Via	2012	17	17	340	F	4	4	4	4	6	4	6	6	4	4	4	5	6	5	4	5	6	3	6	3	4	0,42	0,23
Via	2012	18	18	350	M	5	5	6	10	7	10	10	9	7	9	10	10	8	7	10	10	4	9	4	10	0,37	0,28	
Via	2012	19	19	350	M	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	6	7	0,89	0,05
Via	2012	20	20	350	M	6	7	6	7	7	7	7	7	7	8	7	8	7	7	8	7	4	7	5	7	0,63	0,14	
Via	2012	21	21	370	M	9	5	7	10	6	10	11	7	8	10	11	9	9	7	7	9	-	9	4	9	0,28	0,24	
Via	2012	22	22	370	M	7	5	6	6	7	7	7	7	7	7	7	9	7	7	9	9	5	9	5	7	0,53	0,18	
Via	2012	23	23	370	F	-	6	5	5	6	6	7	6	6	7	8	8	8	7	9	9	4	7	4	6	0,28	0,23	
Via	2012	24	24	380	F	6	6	6	8	10	9	9	9	10	7	9	10	9	9	10	9	5	10	5	9	0,37	0,22	
Via	2012	25	25	380	F	6	8	8	7	8	8	8	8	7	8	7	9	8	8	8	8	5	8	5	8	0,63	0,14	
Via	2012	26	26	390	F	9	12	10	12	10	14	13	13	14	13	13	13	12	12	13	13	5	13	7	13	0,42	0,21	
Via	2012	27	27	390	F	7	7	7	7	7	7	7	6	7	7	7	10	7	7	7	7	6	7	7	7	0,84	0,11	
Via	2012	28	28	390	F	12	11	10	10	9	11	11	11	12	9	11	12	9	11	11	10	8	10	11	11	0,42	0,11	
Via	2012	29	29	400	F	6	7	7	11	10	10	12	12	8	12	11	11	9	10	12	8	6	9	6	12	0,21	0,23	
Via	2012	30	30	400	M	7	9	7	8	11	9	8	8	9	10	9	12	8	11	8	8	6	9	4	8	0,32	0,22	
Via	2012	31	31	400	F	7	7	8	7	8	8	8	7	7	7	11	7	10	8	7	8	7	7	4	7	0,53	0,18	
Via	2012	32	32	410	F	10	9	7	7	10	10	9	7	10	9	11	11	9	10	8	8	6	10	8	10	0,32	0,16	
Via	2012	33	33	410	F	6	8	6	7	8	8	8	8	8	7	8	8	8	8	8	8	6	8	7	8	0,68	0,10	
Via	2012	34	34	410	F	-	9	9	8	10	10	10	11	9	9	9	11	-	9	11	12	7	10	6	9	0,35	0,16	
Via	2012	35	35	420	F	12	8	5	-	14	12	12	10	12	10	13	12	11	12	12	11	8	12	6	12	0,44	0,23	
Via	2012	36	36	420	M	8	7	7	9	10	9	10	9	10	9	10	12	10	10	10	11	8	10	6	10	0,42	0,16	
VIIb	2012	37	37	250	F	2	2	3	2	2	2	3	3	2	2	2	2	2	2	2	2	1	2	2	2	0,79	0,22	
VIIb	2012	38	38	260	M	2	2	3	2	4	2	4	4	2	2	2	3	2	2	2	2	1	2	2	2	0,68	0,35	
VIIb	2012	39	39	260	M	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0,95	0,11	
VIIb	2012	40	40	330	M	5	4	5	4	5	5	5	5	5	5	5	5	5	4	4	5	4	5	4	5	0,68	0,10	
VIIb	2012	41	41	330	M	5	5	6	5	6	6	6	6	6	5	6	6	6	5	6	6	5	6	4	6	0,63	0,11	
VIIb	2012	42	42	310	F	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	0,89	0,11	
VIIb	2012	43	43	310	M	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	0,89	0,11	
VIIb	2012	44	44	310	M	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	3	4	0,89	0,08	
VIIb	2012	45	45	340	M	7	5	7	6	7	7	6	6	7	6	6	7	6	6	7	7	5	6	5	7	0,42	0,12	
VIIb	2012	46	46	340	M	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	0,95	0,04	
VIIb	2012	47	47	340	F	6	5	5	6	7	6	5	5	6	6	6	6	6	5	6	5	-	5	5	6	0,50	0,11	
VIIb	2012	48	48	350	M	4	5	5	5	7	6	6	5	6	6	7	6	6	5	6	7	4	5	5	5	0,37	0,16	
VIIb	2012	49	49	350	M	7	5	4	7	7	7	7	7	7	6	7	7	6	7	7	7	6	6	4	7	0,63	0,16	
VIIb	2012	50	50	350	M	6	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	0,89	0,05	
VIIb	2012	51	51	360	F	6	5	6	6	7	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	0,74	0,11	
VIIb	2012	52	52	360	F	7	7	7	6	8	8	7	6	8	8	8	8	8	7	7	8	7	6	8	6	8	0,42	0,11
VIIb	2012	53	53	360	F	6	6	6	6	7	7	6	6	7	6	7	6	7	7	7	7	6	6	6	6	0,58	0,08	
VIIb	2012	54	54	370	F	7	7	7	7	8	7	7	7	7	7	7	7	8	7	7	8	-	6	6	6	7	0,67	0,08
VIIb	2012	55	55	370	F	7	7	5	8	7	7	7	7	7	7	10	8	8	7	7	8	6	7	6	7	0,58	0,14	
VIIb	2012	56	56	370	M	7	8	8	8	8	8	8	8	7	7	8	8	8	8	8	7	6	7	6	8	0,63	0,09	
VIIb	2012	57	57	380	F	7	6	7	6	8	8	7	6	10	8	10	7	9	7	8	9	6	7	7	7	0,37	0,17	
VIIb	2012	58	58	380	F	-	7	7	7	8	9	8	8	9	9	9	9	8	7	8	9	9	6	8	5	8	0,33	0,15
VIIb	2012	59	59	390	F	6	5	5	5	6	6	6	6	-	6	8	6	6	6	7	7	5	7	5	6	0,50	0,14	
VIIb	2012	60	60	390	F	6	6	6	6	7	7	7	6	7	7	7	7	7	7	7	7	6	6	5	7	0,63	0,09	
VIIb	2012	61	61	400	F	10	10	9	9	10	10	10	10	10	10	10	11	10	10	10	10	6	10	7	10	0,74	0,12	
VIIb	2012	62	62	400	F	6	6	7	6	6	6	6	6	6	7	9	7	7	6	9	7	5	7	5	6	0,47	0,16	
VIIb	2012	63	63	400	F	6	10	7	9	9	10	9	9	9	9	12	9	11	9	11	10	7	11	9	9	0,47	0,16	
VIIb	2012	64	64	410	F	6	7	6	9	11	7	8	7	7	8	9	8	9	8	8	11	6	9	5	8	0,26	0,21	
VIIb	2012	65	65	410	F	7	7	7	6	8	8	8																

Stratum	Sample year	no	Fish no	Fish length	Sex	GDDE 1	JB NL 2	AD NL 3	GF IS 4	JdL N 5	IR ES 6	AA ES 7	CD ES 8	CN ES 9	JAT FA 10	PV FA 11	EM IR 12	MK N 13	ALJ N 14	OS N 15	SK N 16	EB F 17	EH N 18	MJ DK 19	MODAL age	Percent agreement	Precision CV	
II	2012	81	81	380	F	9	10	8	8	9	8	8	7	8	8	8	9	7	8	9	9	7	9	4	8	0,42	0,16	
II	2012	82	82	390	F	7	7	6	11	11	9	10	10	12	11	9	10	11	9	11	11	6	11	6	11	0,37	0,21	
II	2012	83	83	390	F	8	11	7	9	9	8	10	10	11	10	9	10	11	10	13	9	7	11	9	9	0,26	0,16	
II	2012	84	84	390	F	7	6	5	6	7	7	7	6	7	7	7	6	7	6	9	8	6	7	4	7	0,47	0,16	
II	2012	85	85	400	M	-	7	4	5	10	9	9	8	8	8	8	9	9	7	8	7	6	9	4	9	0,28	0,23	
II	2012	86	86	400	F	9	7	4	7	8	7	6	6	8	7	7	8	7	7	8	8	-	8	6	7	0,39	0,16	
II	2012	87	87	400	F	-	10	4	10	11	10	11	11	11	11	10	11	9	11	12	11	8	12	7	11	0,44	0,20	
II	2012	88	88	410	F	9	10	8	7	9	9	9	7	11	9	9	9	9	10	9	9	8	10	7	9	0,53	0,12	
II	2012	89	89	410	F	5	6	5	5	9	6	6	6	9	9	8	9	8	7	9	9	4	9	5	9	0,37	0,26	
IVa,b	2012	90	90	170	M	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	91	91	170	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	92	92	180	M	1	1	1	1	1	1	1	1	1	1	2	0	1	1	1	1	1	0	1	1	1	0,84	0,43
IVa,b	2012	93	93	180	F	1	1	1	1	1	1	1	2	1	1	1	0	1	1	1	1	1	0	1	1	1	0,84	0,43
IVa,b	2012	94	94	190	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	95	95	190	M	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	96	96	200	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	97	97	200	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	98	98	210	M	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	99	99	210	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	100	100	220	F	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	1	0,89	0,35
IVa,b	2012	101	101																									

Tab. 4: Number of age readings by modal age for each reader

NUMBER OF AGE READINGS																				
MODAL	GD DE	JB NL	AD NL	GF IS	JdL N	IR ES	AA ES	CD ES	CN ES	JAT FA	PV FA	EM IR	MK N	ALJ N	OS N	SK N	EB F	EH N	MJ DK	
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	Reader 15	Reader 16	Reader 17	Reader 18	Reader 19	TOTAL
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	22	22	22	22	22	22	22	22	22	22	21	22	22	22	22	22	22	22	22	417
2	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	626
3	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	266
4	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	114
5	12	11	12	12	12	12	12	12	11	12	12	12	12	11	12	12	11	12	12	224
6	18	19	19	19	19	19	19	19	18	19	19	19	19	19	19	19	18	19	19	358
7	22	22	22	22	22	22	22	22	22	22	21	22	22	22	22	21	19	22	22	413
8	10	12	12	11	12	12	12	12	12	12	12	12	12	12	12	12	11	12	12	224
9	7	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	8	9	9	167
10	5	5	5	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	93
11	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	75
12	3	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	54
13	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	36
14	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0-15	156	162	163	161	164	164	163	162	163	162	164	163	163	164	163	156	164	164	3085

Tab. 5: Coefficient of variation for each reader and for all readers combined

COEFFICIENT OF VARIATION (CV)																				
MODAL	GD DE	JB NL	AD NL	GF IS	JdL N	IR ES	AA ES	CD ES	CN ES	JAT FA	PV FA	EM IR	MK N	ALJ N	OS N	SK N	EB F	EHN	MJ DK	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	Reader 15	Reader 16	Reader 17	Reader 18	Reader 19	Readers
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	0%	0%	0%	0%	39%	0%	0%	27%	0%	0%	21%	131%	0%	0%	0%	0%	123%	0%	0%	24,7%
2	0%	9%	22%	9%	17%	0%	26%	27%	9%	0%	0%	12%	0%	18%	0%	0%	36%	0%	15%	11,8%
3	25%	17%	25%	0%	25%	9%	38%	32%	25%	18%	20%	9%	17%	0%	9%	17%	19%	17%	21%	14,3%
4	11%	11%	0%	0%	19%	10%	24%	24%	0%	10%	10%	19%	16%	0%	12%	19%	0%	19%	15%	12,1%
5	27%	11%	15%	15%	31%	18%	31%	34%	13%	28%	28%	21%	32%	29%	29%	22%	20%	24%	22%	15,3%
6	8%	11%	13%	10%	12%	8%	10%	9%	11%	9%	16%	11%	14%	10%	16%	13%	11%	11%	22%	13,2%
7	9%	11%	18%	10%	7%	7%	9%	10%	11%	10%	18%	11%	12%	9%	11%	11%	12%	12%	24%	13,4%
8	13%	12%	12%	14%	15%	8%	5%	10%	9%	13%	6%	14%	9%	12%	10%	13%	11%	12%	21%	14,4%
9	23%	27%	25%	23%	14%	15%	15%	19%	13%	11%	14%	8%	11%	15%	20%	14%	20%	8%	33%	18,1%
10	25%	36%	18%	14%	14%	6%	5%	14%	14%	5%	11%	11%	11%	19%	9%	12%	26%	5%	26%	19,4%
11	27%	18%	37%	5%	10%	8%	5%	5%	4%	10%	9%	7%	10%	9%	4%	5%	13%	7%	28%	15,5%
12	33%	9%	29%	6%	20%	9%	0%	10%	20%	20%	13%	9%	12%	11%	5%	17%	20%	16%	43%	19,5%
13	-	6%	-	13%	18%	0%	0%	0%	5%	5%	6%	10%	11%	6%	5%	0%	40%	0%	31%	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weighted mean	0-15	10,8%	11,4%	15,7%	8,5%	19,2%	6,2%	15,3%	20,0%	9,9%	8,7%	13,3%	27,8%	9,8%	10,8%	9,0%	9,2%	34,4%	8,6%	18,8%
	RANKING	9	11	14	2	16	1	13	17	8	4	12	18	7	10	5	6	19	3	15
																				15,4%

Tab. 6a: Percentage of agreement for each reader and for all readers combined

		PERCENTAGE AGREEMENT																				
MODAL	age	GD DE	JB NL	AD NL	GF IS	JdL N	IR ES	AA ES	CD ES	CN ES	JAT FA	PV FA	EM IR	MK N	ALJ N	OS N	SK N	EB F	EH N	MJ DK	ALL	
		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 15	Reader 16	Reader 17	Reader 18	Reader 19		
	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	1	100%	100%	100%	100%	95%	100%	100%	91%	100%	100%	95%	36%	100%	100%	100%	100%	41%	100%	100%	93%	
	2	100%	97%	82%	97%	97%	100%	79%	75%	97%	100%	100%	94%	100%	97%	100%	100%	39%	100%	91%	92%	
	3	93%	71%	43%	100%	93%	93%	50%	43%	71%	71%	86%	93%	93%	100%	93%	93%	21%	93%	50%	76%	
	4	83%	83%	100%	100%	67%	83%	50%	67%	100%	83%	83%	67%	67%	100%	67%	83%	0%	83%	33%	74%	
	5	58%	64%	67%	58%	83%	75%	83%	67%	64%	75%	58%	83%	42%	45%	58%	67%	18%	58%	33%	61%	
	6	78%	63%	47%	63%	58%	79%	68%	68%	61%	63%	53%	58%	58%	63%	58%	58%	6%	47%	26%	57%	
	7	77%	64%	36%	59%	68%	77%	59%	41%	77%	68%	57%	68%	73%	64%	55%	52%	11%	59%	14%	57%	
	8	10%	42%	33%	36%	67%	67%	83%	50%	50%	33%	58%	75%	42%	75%	58%	50%	0%	42%	8%	47%	
	9	43%	11%	22%	33%	56%	33%	56%	33%	33%	44%	56%	67%	63%	33%	22%	67%	0%	33%	33%	39%	
	10	60%	20%	0%	25%	80%	60%	80%	40%	60%	25%	60%	20%	40%	60%	80%	40%	0%	80%	0%	44%	
	11	0%	25%	0%	50%	75%	25%	75%	50%	25%	75%	50%	50%	25%	50%	75%	50%	0%	50%	25%	41%	
	12	33%	0%	0%	50%	0%	33%	100%	67%	33%	33%	0%	33%	0%	33%	67%	0%	0%	67%	33%	31%	
	13	0%	0%	0%	0%	50%	0%	100%	100%	50%	50%	50%	50%	0%	0%	50%	100%	0%	100%	0%	39%	
	14	-	0%	0%	0%	100%	100%	0%	0%	0%	100%	100%	0%	100%	100%	100%	0%	0%	0%	0%	-	
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Weighted mean		0-15	76,3%	67,9%	56,4%	72,7%	78,0%	79,9%	73,8%	62,0%	74,1%	74,2%	72,8%	68,3%	72,4%	76,1%	74,4%	74,2%	19,2%	73,2%	48,2%	68,2%
	RANKING		3	15	17	12	2	1	9	16	8	6	11	14	13	4	5	6	19	10	18	

Tab. 6b: Percentage of agreement for each reader and for all readers combined (Experts only)

PERCENTAGE AGREEMENT							
MODAL age	JB NL Reader 2	JdL N Reader 5	IR ES Reader 6	CD ES Reader 8	CN ES Reader 9	ALJ N Reader 14	EH N Reader 18
0	-	-	-	-	-	-	-
1	100%	95%	100%	91%	100%	100%	100%
2	97%	97%	100%	75%	97%	97%	100%
3	69%	100%	100%	46%	77%	100%	100%
4	86%	57%	71%	71%	100%	100%	71%
5	67%	77%	69%	77%	69%	58%	62%
6	74%	58%	79%	68%	61%	68%	42%
7	64%	64%	72%	44%	80%	68%	44%
8	55%	73%	82%	45%	64%	82%	45%
9	67%	33%	33%	33%	100%	67%	33%
10	38%	78%	44%	33%	44%	78%	67%
11	40%	60%	20%	60%	50%	40%	40%
12	50%	0%	50%	0%	50%	100%	50%
13	0%	100%	0%	100%	100%	0%	100%
14	0%	100%	100%	0%	0%	100%	0%
15	-	-	-	-	-	-	-
Weighted mean	0-15	74,7%	78,0%	80,5%	62,6%	82,2%	70,7%
RANKING		5	4	2	7	3	6

Tab. 6c: Percentage of agreement for each reader and for all readers combined (Experts and intermediate readers only)

PERCENTAGE AGREEMENT															
MODAL	GD DE	JB NL	AD NL	GF IS	JdL N	IR ES	CD ES	CN ES	JAT FA	PV FA	EM IR	ALJ N	EH N	MJ DK	
age	Reader 1	Reader 2	Reader 3	Reader 4	Reader 5	Reader 6	Reader 8	Reader 9	Reader 10	Reader 11	Reader 12	Reader 14	Reader 18	Reader 19	ALL
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	100%	100%	100%	100%	95%	100%	91%	100%	100%	95%	36%	100%	100%	100%	94%
2	100%	97%	82%	97%	97%	100%	75%	97%	100%	100%	94%	97%	100%	91%	95%
3	93%	71%	43%	100%	93%	93%	43%	71%	71%	86%	93%	100%	93%	50%	79%
4	88%	88%	75%	88%	50%	63%	63%	88%	75%	75%	50%	100%	75%	38%	72%
5	64%	80%	55%	73%	82%	73%	64%	70%	73%	55%	73%	60%	55%	36%	65%
6	82%	67%	44%	67%	61%	83%	67%	65%	61%	50%	61%	67%	50%	28%	61%
7	78%	65%	35%	57%	65%	74%	39%	78%	70%	55%	65%	61%	57%	9%	58%
8	13%	45%	36%	40%	73%	64%	45%	64%	45%	73%	82%	73%	55%	9%	52%
9	43%	25%	25%	38%	63%	25%	25%	50%	50%	63%	63%	25%	38%	38%	41%
10	50%	17%	0%	20%	83%	50%	33%	67%	20%	50%	33%	50%	83%	0%	40%
11	0%	20%	0%	60%	60%	20%	40%	20%	60%	60%	60%	40%	40%	20%	36%
12	50%	0%	0%	100%	0%	50%	50%	50%	0%	0%	50%	50%	100%	50%	38%
13	0%	0%	0%	0%	50%	0%	100%	50%	50%	50%	50%	0%	100%	0%	35%
14	-	0%	0%	0%	100%	100%	0%	0%	100%	100%	0%	100%	0%	0%	-
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Weighted mean	0-15	78,2%	71,0%	54,6%	74,5%	78,0%	59,5%	77,2%	74,2%	73,5%	67,7%	76,7%	74,4%	48,2%	70,4%
	RANKING	1	10	13	6	2	2	12	4	8	9	11	5	7	14

Tab. 7: The age compositions estimated by each age reader and all age readers combined

AGE COMPOSITION																					
Age	GD DE Reader 1	JB NL Reader 2	AD NL Reader 3	GF IS Reader 4	JdL N Reader 5	IR ES Reader 6	AA ES Reader 7	CD ES Reader 8	CN ES Reader 9	JAT FA Reader 10	PV FA Reader 11	EM IR Reader 12	MK N Reader 13	ALJ N Reader 14	OS N Reader 15	SK N Reader 16	EB F Reader 17	EH N Reader 18	MJ DK Reader 19	TOTAL	
0	-	-	-	-	-	-	-	-	-	-	-	13	-	1	-	-	13	-	-	27	
1	22	23	25	23	21	22	24	22	23	22	20	8	22	22	22	22	29	22	25	419	
2	33	36	34	32	32	33	32	33	35	35	35	32	33	32	33	33	24	33	38	628	
3	14	11	10	15	14	13	12	12	10	10	12	15	14	14	13	13	13	13	16	244	
4	9	11	15	10	5	7	4	7	9	8	6	5	8	11	7	5	12	7	27	173	
5	12	18	23	16	14	12	15	15	12	11	9	11	9	10	10	10	24	9	22	262	
6	24	19	22	20	15	20	24	28	15	16	13	14	16	18	14	16	25	16	18	353	
7	24	23	19	19	22	21	16	17	25	27	18	21	25	23	17	21	8	22	8	376	
8	4	7	7	8	15	13	12	8	11	10	15	16	12	12	17	14	6	9	2	198	
9	9	3	5	7	7	8	7	6	6	11	15	10	12	5	11	13	1	13	3	152	
10	3	7	2	5	10	9	7	6	5	6	8	6	5	8	6	5	-	9	1	108	
11	-	3	1	4	6	2	5	4	5	3	6	6	4	4	7	7	-	5	3	75	
12	2	1	-	2	-	1	3	2	4	1	2	4	1	2	3	1	1	3	1	34	
13	-	-	-	-	-	-	-	3	1	1	2	1	-	-	2	2	-	2	-	18	
14	-	-	-	-	2	3	3	-	1	2	1	-	2	1	2	-	-	-	-	14	
15	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-	1	-	4	
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Total	0-15	156	162	162	161	164	164	162	162	162	162	164	162	162	164	162	156	164	164	2085	

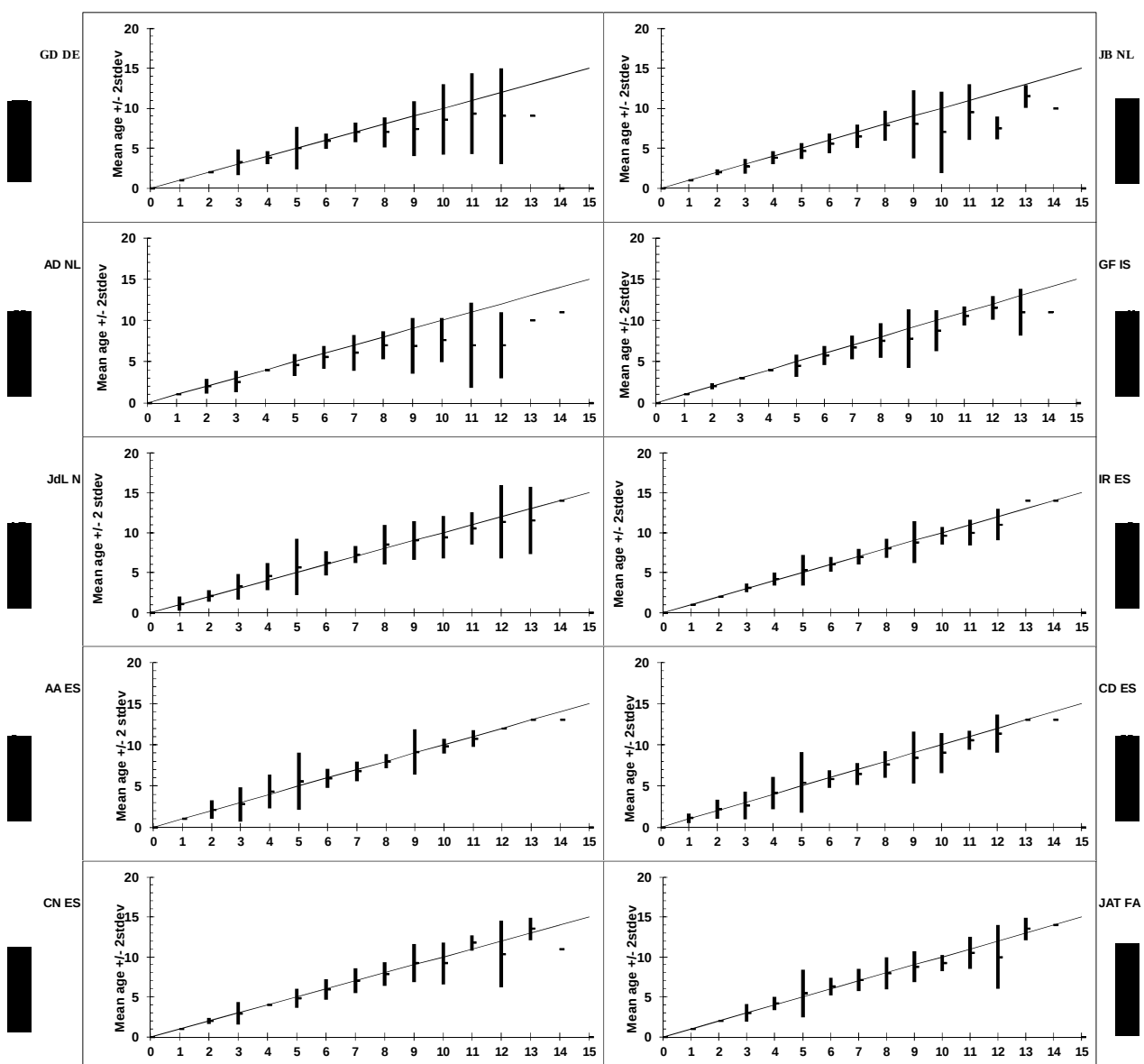


Fig.1a: Age bias plots with the mean age recorded ± 2 stdev of age readers 1 to 10 plotted against the modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

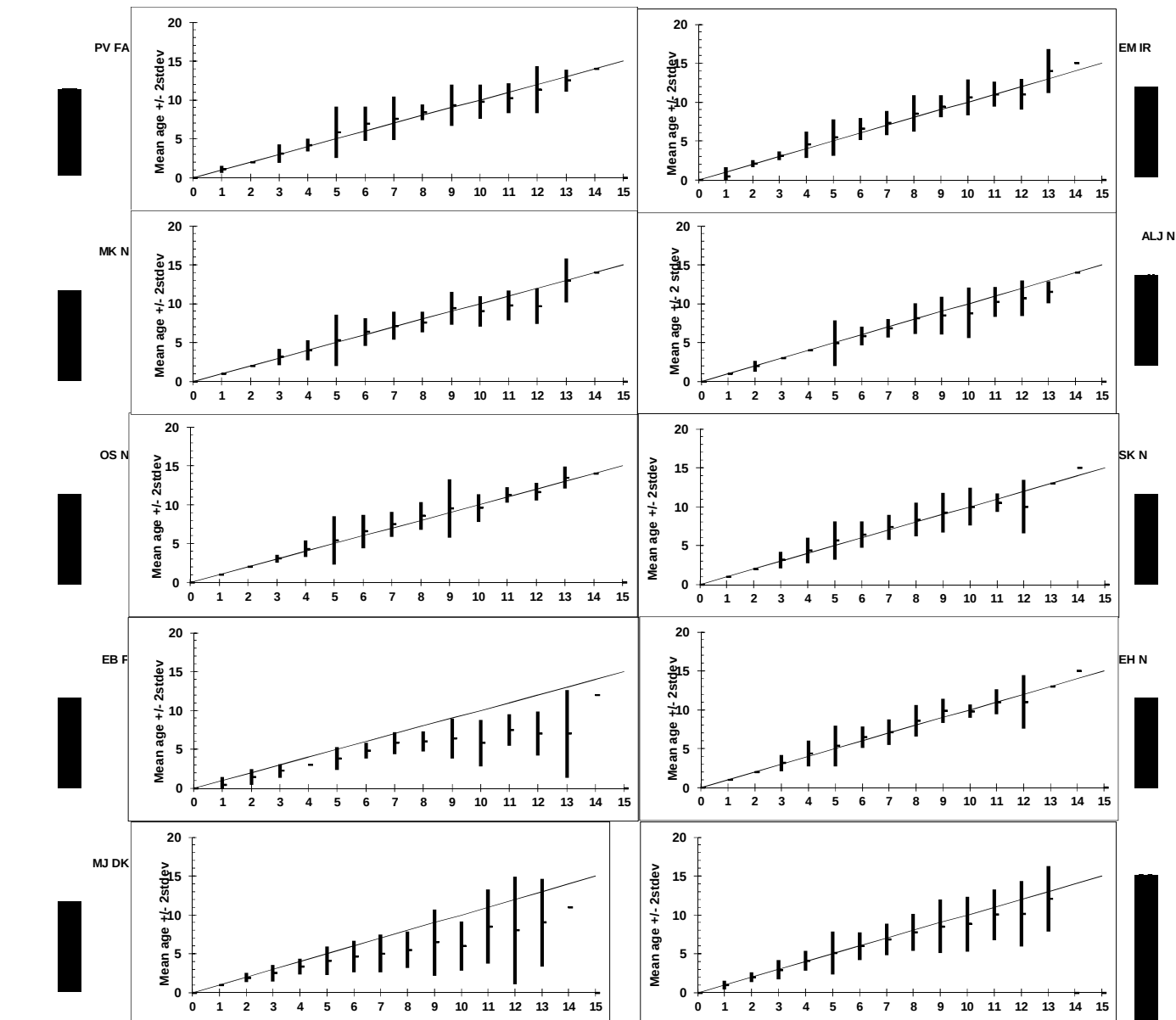


Fig.1b: Age bias plots with the mean age recorded $\pm$ 2stdev of age readers 11 to 19 and all readers (1 to 19) combined plotted against the modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

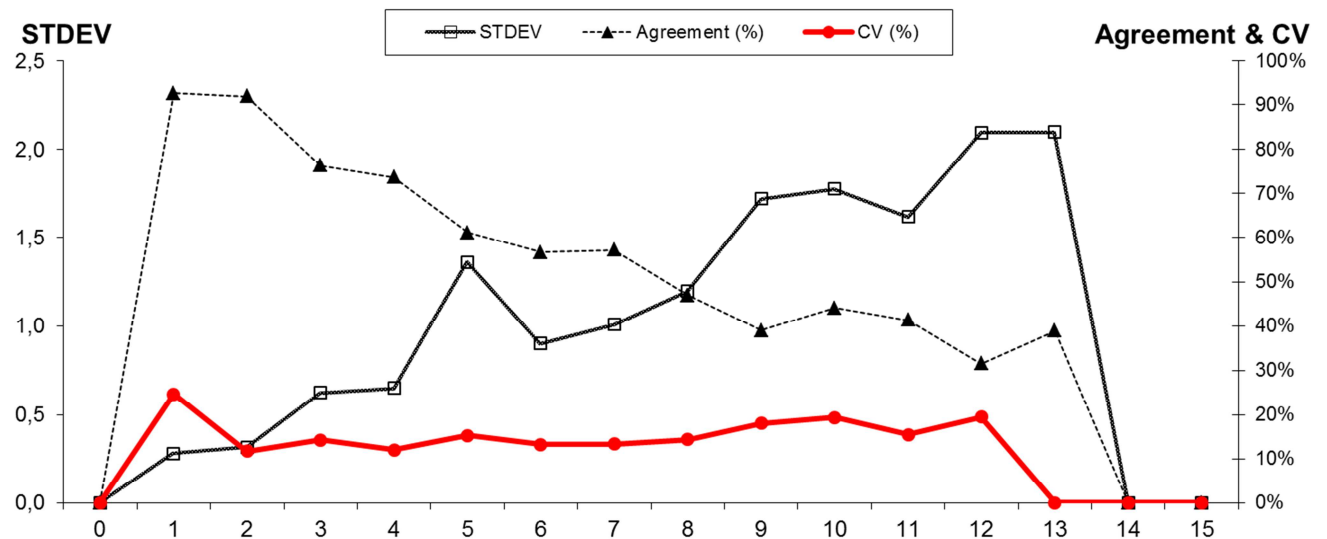
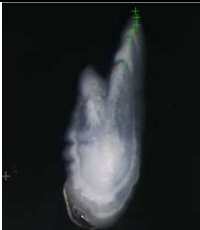
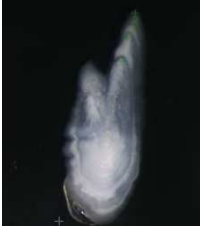
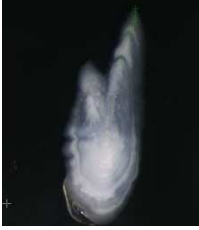
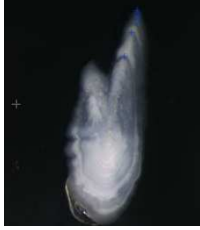
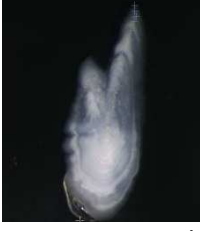
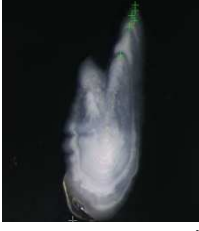
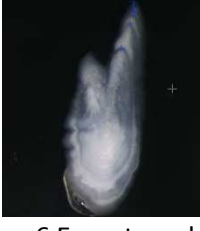
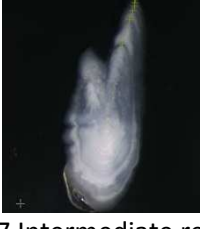
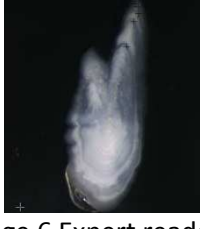
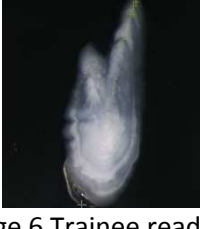
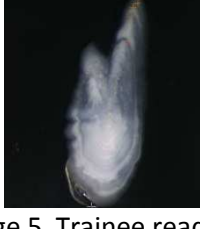
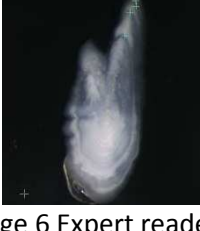


Fig.2: The coefficient of variation (CV%), percent agreement and the standard deviation (STDEV) plotted against modal age.

CV is much less age dependent than the standard deviation (STDEV) and the percent agreement. CV is therefore a better index for the precision in age reading. Problems in age reading are indicated by relatively high CV's at age.

		
Age 3 Intermediate reader	Age 3 Intermediate reader	Age 3 Expert reader
		
Age 3 Intermediate reader	Age 3 Intermediate reader	Age 3 Expert reader
		
Age 3 Expert reader	Age 3 Trainee reader	Age 3 Expert reader
		
Age 3 Expert reader	Age 3 Intermediate reader	Age 3 Intermediate reader
		
Age 3 Intermediate reader	Age 3 Trainee reader	Age 3 Expert reader
		
Age 3 Trainee reader	Age 3 Trainee reader	Age 3 Trainee reader
		Fig.3: Age reading for mackerel 114 29cm, 202g, female, caught in quarter 1 2012 in IVa 100% agreement
Age 3 Expert reader		

		
Age 6 Intermediate reader	Age 6 Intermediate reader	Age 5 Expert reader
		
Age 6 Intermediate reader	Age 6 Intermediate reader	Age 6 Expert reader
		
Age 6 Expert reader	Age 6 Trainee reader	Age 6 Expert reader
		
Age 6 Expert reader	Age 6 Intermediate reader	Age 8 Intermediate reader
		
Age 7 Intermediate reader	Age 6 Trainee reader	Age 6 Expert reader
		
Age 6 Trainee reader	Age 6 Trainee reader	Age 5 Trainee reader
		Fig.4: Age reading for mackerel 51 36cm, 345g, female, caught in quarter 1 2012 in VIIb readings: 5 – 8 years 74% agreement
Age 6 Expert reader		

No reading Intermediate reader	 Age 11 Intermediate reader	 Age 11 Expert reader
No reading Intermediate reader	 Age 10 Intermediate reader	 Age 13 Expert reader
 Age 14 Expert reader	 Age 13 Trainee reader	 Age 13 Expert reader
 Age 13 Expert reader	 Age 14 Intermediate reader	 Age 12 Intermediate reader
 Age 15 Intermediate reader	 Age 14 Trainee reader	 Age 11 Expert reader
 Age 14 Trainee reader	 Age 13 Trainee reader	 Age 9 Trainee reader
 Age 13 Expert reader		Fig.5: Age reading for mackerel 66 50cm, 1207g, male, caught in quarter 1 2012 in VIIb readings: 9 – 15 years 35% agreement

		
Age 6 Intermediate reader	Age 6 Intermediate reader	Age 7 Expert reader
		
Age 7 Intermediate reader	Age 11 Intermediate reader	Age 10 Expert reader
		
Age 10 Expert reader	Age 12 Trainee reader	Age 12 Expert reader
		
Age 8 Expert reader	Age 12 Intermediate reader	Age 11 Intermediate reader
		
Age 11 Intermediate reader	Age 8 Trainee reader	Age 10 Expert reader
		
Age 12 Trainee reader	Age 8 Trainee reader	Age 6 Trainee reader
		Fig.6: Age reading for mackerel 29 40cm, 506g, female, caught in quarter 1 2012 in Vla readings: 6 – 12 years 21% agreement
Age 9 Expert reader		

