SmartDots Report for the 2022 exchange for the central Baltic herring stock *her.27.25-2932* (event ID 449)

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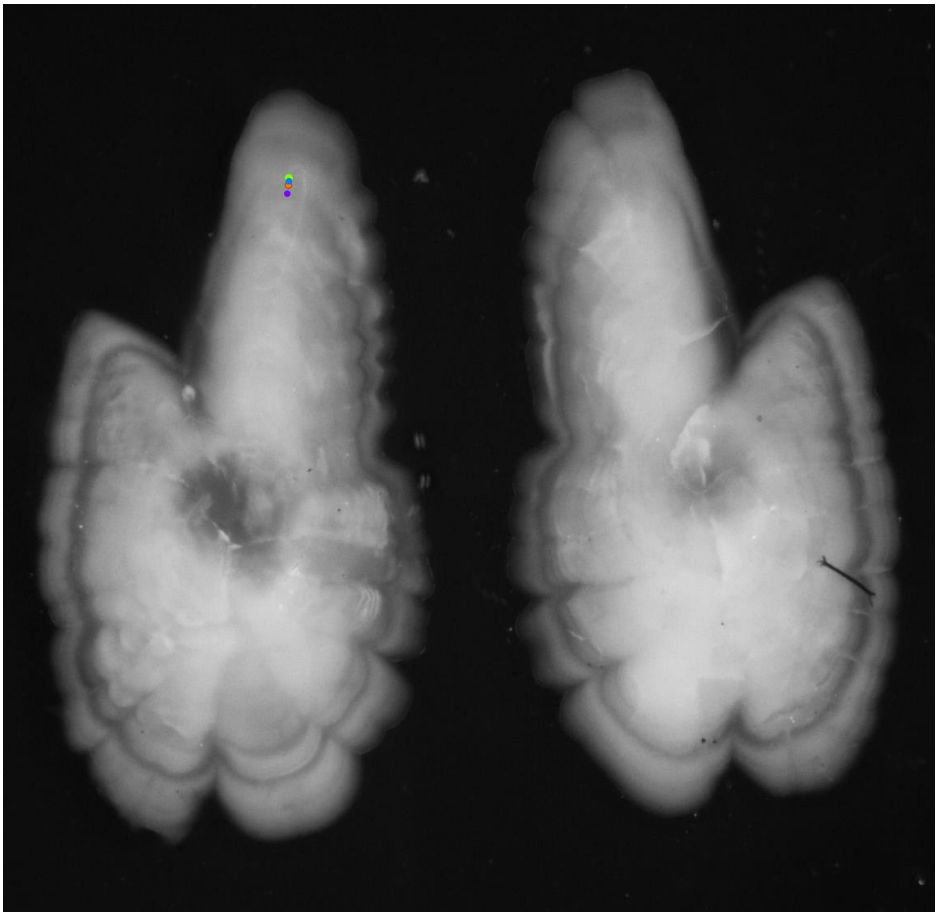

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1 Summary

The 2022 exchange for the central Baltic herring stock *her.27.25-2932* took place via the SmartDots platform between May and October 2022. The exchange was organised following a request from WGBFAS and in preparation for the 2023 benchmark of the stock. Fifteen readers from nine countries took part (Denmark, Poland, Sweden, Germany, Latvia, Lithuania, Estonia and Finland); twelve ”advanced” readers (providing age data for assessment) and 3 ”basic” readers (do not provide age data for assessment). 163 otoliths images, covering ICES SD25, 26, 29 and 32 were provided by Poland and Finland and uploaded to the SmartDots platform. The aim was to include samples from all SD’s included in the stock assessment but the otoliths from SD27 were not included due to lack of resources within the lab photographing the otoliths. Images of whole otoliths from SD’s 25 (n=27) and 26 (n=30) were provided by Poland. For SD 29, images of sectioned and stained and whole otoliths from the same fish (n = 24) plus additional images (n=18) of sectioned and stained otoliths were provided by Finland. For SD32, images of sectioned and stained otoliths (n=40) were provided by Finland. The aim was to cover all areas, quarters and age groups for each ICES SD’s used in the stock assessment but this aim was not reached.

The analysis was carried out by ICES SD as not all readers are experienced in reading otoliths from all areas and the growth patterns observed in the otoliths vary greatly from north to south, meaning a correct interpretation by readers not experienced with samples from another SD would introduce bias in the results. For SD 25, based on advanced readers only, overall PA was 93%, CV was 8% and relative bias -0.04. When all readers were included, overall PA was 79%, CV was 17% and relative bias 0.00. For SD 26, based on only advanced readers only, overall PA was 85%, CV was 9% and relative bias -0.01. When all readers were included, overall PA was 80%, CV was 12% and relative bias -0.03. For ICES SD 29 (only 24 samples where whole and sectioned and stained otoliths from the same fish were included in the analysis), overall PA was 89%, CV was 12% and relative bias 0.06, based on only advanced readers only. When all readers of SD 29 were included, overall PA was 86%, CV was 17% and relative bias 0.06.For ICES SD 32, (based on the ATAQCS analysis) with only 2 advanced readers, overall PA was 70%, CV was 7% and relative bias 0.38. When all readers of SD 32 were included (based on the SmartDots analysis), overall PA was 83%, CV was 18% and relative bias 0.20.

The results were presented at the BWKBALTPEL (ICES benchmark workshop on Baltic Pelagic stocks) 2023 data compilation meeting in November 2022. Following a request from the group age error matrices (AEM’s) were provided. A single matrix per ICES SubDivision (SD) was provided as well as a combined AEM for all SD’s.

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3 Methods

Results presented here are based on output from SmartDots and a standardised r-script. The analysis follows traditional methods where the level of accuracy compared to modal age is indicated by percentage agreement (PA), bias tests and plots, and the level of precision, i.e. the reproducibility of age estimates is indicated by the coefficient of variation (CV). The tables and plots presented are from the Guus Eltink Excel sheet 'Age Reading Comparisons' (Eltink, A.T.G.W. 2000). Additional analyses of age data were included in the form of age error matrices (AEM's).

Where there were age reading from just two age readers to compare the CEFAS ATAQCS (Age Training And Quality Control System) workbook was used

Percentage Agreement

The table presents the percentage agreement (PA) per modal age and reader. The PA's are calculated as the ratio between the total number of age readings in agreement with modal age and the total number of age readings for that sample per reader and modal age:

$$PA = \frac{nmodalage}{ntotal} * 100$$

The PA of all readers combined per modal age and a weighted mean of the PA per reader is added to the table.

Co-efficient of Variation (CV)

The table presents the cv per modal age and reader. The cv's are calculated as the ratio between the standard deviation (σ) and mean value (μ) per reader and modal age:

$$CV = \frac{\sigma}{\mu} \cdot 100\%$$

To the table is also added the CV of all readers combined per modal age and a weighted mean of the CV per reader.

Average Percentage Error (APE)

APE was calculated based on the method outlined by Beamish & Fournier (1981). This method is not independent of fish age and thus provides a better estimate of precision. As the calculations of both CV and APE pose problems if the mean age is close to 0, all observations for which modal age was 0 were omitted from the CV and APE calculations.

The average percentage error is calculated per image as:

$$APE = \frac{100\%}{n}\sum_{i=1}^{n}\left|\frac{a_i - \overline{a}}{\overline{a}}\right|$$

where a_i is the age reading of reader i and $\overline{a}$ is the mean of all readings from 1 to n.

Age error matrix (AEM)

Age error matrices (AEM) were produced following procedures outlined by WKSABCAL (2014) where the matrix shows the proportion of each modal age mis-aged as other ages. The sum of each row is 1, which equals 100%. If a reader is “advanced” then they are considered well trained and they provide ages for stock assessment or similar purposes. When the AEM is compiled for assessment purposes it uses only those “advanced” readers who provide age data for the stock assessment for that specific stock. In this case the analysis was carried out by ICES SD’s and only the “advanced” readers per SD used in the calculation of the AEM.

Otolith Growth Analysis

SmartDots provides a measure of distance between the annotations made by the readers and thus provides a measure of growth increment width. This data is used to establish growth curves for each fish and for each reader.

4 Analysis of age calibration exercise

4.1 ICES SD25

4.1.1 Overview of samples and readers SD25

Table 4.1.1: Overview of samples from SD25 used for the 2022 exchange for the central Baltic herring stock.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2021	27.3.d.25	25	3	8	1-7	10-20 mm
2021	27.3.d.25	25	4	5	1-10	15-20 mm
2022	27.3.d.25	25	1	6	1-7	15-20 mm
2022	27.3.d.25	25	2	8	1-8	10-20 mm

Table 4.1.2: Reader overview SD25

Reader code	Expertise
R01 DK	Advanced
R02 SE	Advanced
R07 PL	Advanced
R08 PL	Basic
R11 DE	Basic
R12 DE	Basic
R13 SE	Basic
R14 SE	Basic
R15 SE	Basic

4.1.2 All readers – SD25

The weighted average percentage agreement based on modal ages for all readers is 79 % (Table 4.1.4) , with the weighted average CV of 17 % (Table 4.1.3) and APE of 12 %. At modal age 1 CV is 50% and PV 71% indicating that there is disagreement on the first winter ring. Figure 4.1 shows an otolith with modal age 1, PA=44% and CV = 49% where readers estimate ages 1, 2 and 3. All readers who are estimating age 1 are counting the outermost winter ring. Those estimating age 2 and 3 are counting additional rings within the otolith. Figure 4.2 shows an otolith with modal age 1, PA=100% and CV=0%. All readers are counting the outermost winter ring. These two images illustrate why there is disagreement at modal age 1. Readers R08 and R13 SE have a weighted mean percentage agreement of 46% and 58% respectively (Table 4.1.4). R08 PL has an overall negative bias indicating underestimation in comparison to modal age and will often omit the first winter ring. R13 SE is overestimating in comparison to modal age 1 and 2 with a tendency to count additional rings towards the otolith edge. Individual reader bias plots can be found in Annex 6.1.1. Figure 4.3 show the age bias plot for all readers and reflects the results in Table 4.1.5.

Table 4.1.3: Coefficient of Variation (CV) table presents the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 DK	R02 SE	R07 PL	R08 PL	R11 DE	R12 DE	R13 SE	R14 SE	R15 SE	all
1	40 %	38 %	0 %	0 %	55 %	67 %	22 %	40 %	0 %	**50 %**
2	0 %	0 %	0 %	29 %	22 %	0 %	18 %	0 %	35 %	**20 %**
3	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	**11 %**
4	0 %	0 %	0 %	33 %	13 %	13 %	13 %	13 %	0 %	**15 %**
5	0 %	0 %	12 %	0 %	0 %	12 %	0 %	0 %	0 %	**8 %**
6	9 %	0 %	0 %	28 %	9 %	0 %	9 %	0 %	11 %	**9 %**
7	6 %	6 %	0 %	14 %	8 %	0 %	12 %	0 %	0 %	**8 %**
8	-	-	-	-	-	-	-	-	-	**6 %**
9	-	-	-	-	-	-	-	-	-	**-**
10	-	-	-	-	-	-	-	-	-	**11 %**
Weighted Mean	**9 %**	**7 %**	**1 %**	**14 %**	**17 %**	**14 %**	**11 %**	**8 %**	**7 %**	**17 %**

Table 4.1.4: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R02 SE	R07 PL	R08 PL	R11 DE	R12 DE	R13 SE	R14 SE	R15 SE	all
1	75 %	50 %	100 %	100 %	50 %	75 %	0 %	75 %	100 %	**71 %**
2	100 %	100 %	100 %	75 %	75 %	100 %	25 %	100 %	67 %	**83 %**
3	100 %	100 %	100 %	0 %	100 %	100 %	100 %	100 %	100 %	**88 %**
4	100 %	100 %	100 %	33 %	67 %	67 %	67 %	67 %	100 %	**77 %**
5	100 %	100 %	67 %	0 %	100 %	67 %	100 %	100 %	100 %	**81 %**
6	67 %	100 %	100 %	50 %	67 %	100 %	67 %	100 %	50 %	**80 %**
7	80 %	80 %	100 %	60 %	60 %	100 %	40 %	100 %	100 %	**79 %**
8	100 %	100 %	100 %	0 %	0 %	100 %	100 %	100 %	100 %	**78 %**
9	-	-	-	-	-	-	-	-	-	**-**
10	100 %	100 %	0 %	0 %	0 %	100 %	100 %	100 %	100 %	**67 %**
Weighted Mean	**89 %**	**89 %**	**93 %**	**46 %**	**67 %**	**89 %**	**58 %**	**93 %**	**89 %**	**79 %**

Table 4.1.5: Relative bias table represents the relative bias per modal age per reader, the relative bias of all readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R01 DK	R02 SE	R07 PL	R08 PL	R11 DE	R12 DE	R13 SE	R14 SE	R15 SE	all
1	0.25	0.50	0.00	0.00	0.75	0.50	1.67	0.25	0.00	**0.44**
2	0.00	0.00	0.00	-0.25	0.25	0.00	0.75	0.00	-0.33	**0.05**
3	0.00	0.00	0.00	-1.00	0.00	0.00	0.00	0.00	0.00	**-0.11**
4	0.00	0.00	0.00	-1.00	0.33	0.33	0.33	0.33	0.00	**0.04**
5	0.00	0.00	-0.33	-1.00	0.00	-0.33	0.00	0.00	0.00	**-0.19**
6	0.33	0.00	0.00	-1.00	0.33	0.00	0.33	0.00	0.50	**0.06**
7	0.20	0.20	0.00	-0.60	-0.40	0.00	0.20	0.00	0.00	**-0.04**
8	0.00	0.00	0.00	-1.00	-1.00	0.00	0.00	0.00	0.00	**-0.22**
9	-	-	-	-	-	-	-	-	-	**-**
10	0.00	0.00	-2.00	-2.00	-2.00	0.00	0.00	0.00	0.00	**-0.67**
Weighted Mean	**0.11**	**0.11**	**-0.11**	**-0.69**	**0.04**	**0.07**	**0.42**	**0.07**	**0.00**	**0.00**

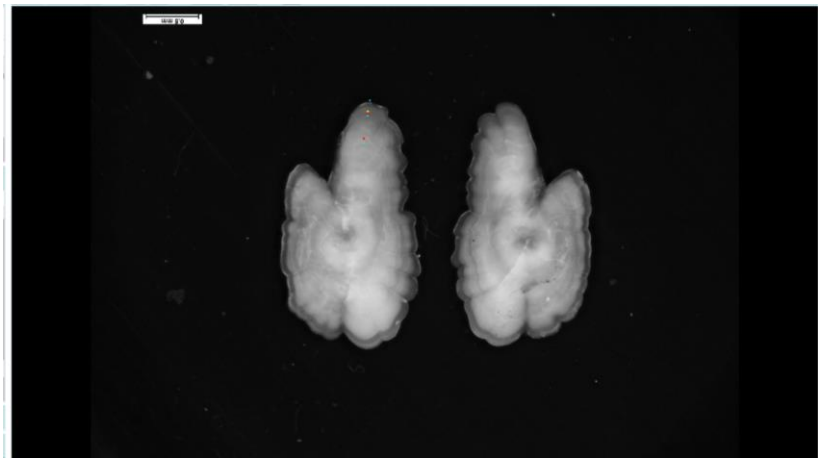


Figure **4.1**: ID 2022_05_09_001-HER-SD25-PL, TL=12cm, catch date=2022_05_09. modal age 1, PA=44%, CV = 49%. Yellow dot=1 year, red dots=2 years and blue dots=3 years.

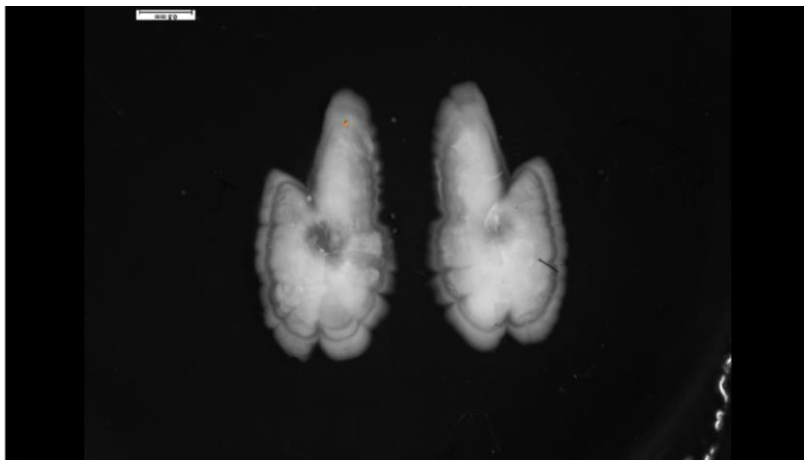


Figure **4.2**: ID 2021_09_21_001-HER-SD25-PL, TL=12cm, catch date=2021_09_21. modal age 1, PA=100%, CV = 0%. All dots are placed on the outermost winter ring.

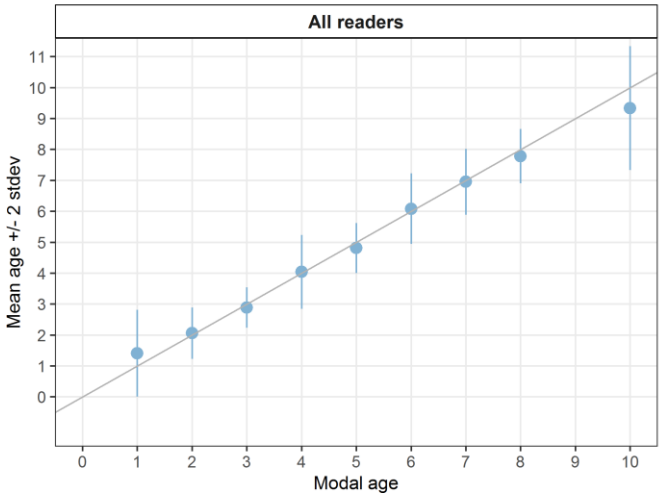


Figure 4.3: Age bias plot for all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

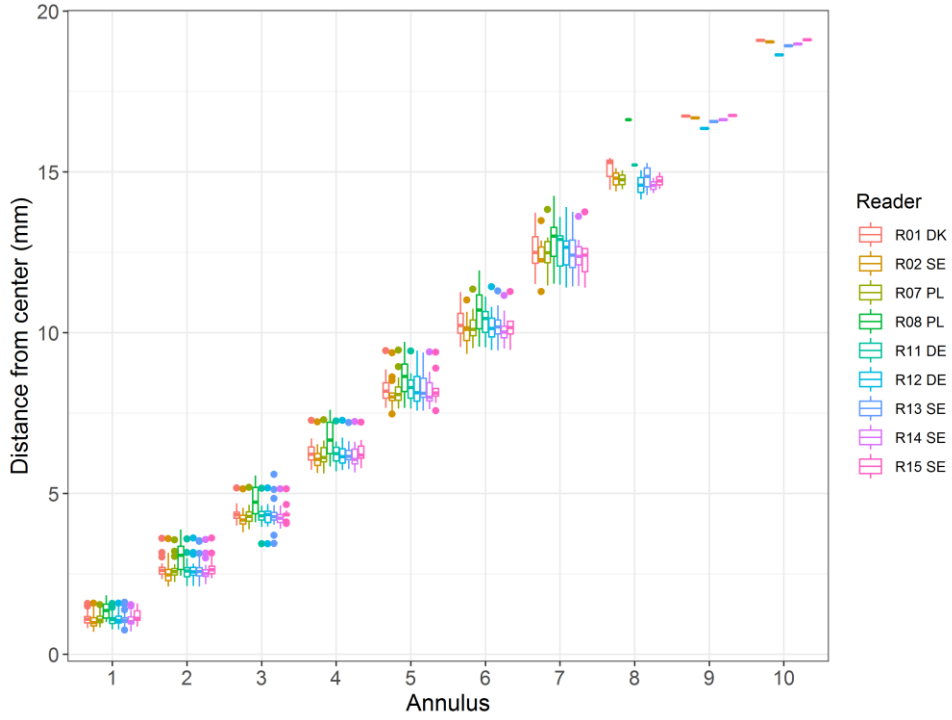


Figure 4.4: Plot of average distance from the centre to the winter rings for advanced readers by strata. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

4.1.3 Advanced readers – SD25

Based on only those three readers who provide age data for stock assessment purposes for SD 25 the weighted average percentage agreement based on modal ages is 93% (Table 4.1.7) with the weighted average CV of 8 % (Table 4.1.6). Overall CV at modal age 1 is high at 30% (PA=89%). This is based on the results of just 3 fish, one of which R02 SE estimates the fish to be 2 years of age based on the comment that the innermost ring is weak but should be counted, see Figure 4.5. At modal age 2 CV is 13% (PA=93%) based on 5 fish. R07 PL underestimates one of the fish to be age 1 by excluding the innermost winter ring. The age error matrix (AEM) (Table 4.1.9) shows the proportional distribution of age readings for each modal age. Only advanced readers are used for calculating the AEM. Figure 4.6 show the age bias plot for all readers and reflects the results in Table 4.1.8. Individual age reader bias plots can be found in Annex 6.1.2.

Table 4.1.6: Coefficient of Variation (CV) table presents the CV per modal age and advanced reader, the CV of all advanced readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 DK	R02 SE	R07 PL	all
1	0 %	43 %	0 %	**30 %**
2	0 %	0 %	25 %	**13 %**
3	0 %	0 %	0 %	**0 %**
4	0 %	0 %	0 %	**0 %**
5	0 %	0 %	12 %	**7 %**
6	9 %	0 %	0 %	**5 %**
7	0 %	0 %	0 %	**0 %**
8	0 %	0 %	9 %	**5 %**
9	-	-	-	**-**
10	-	-	-	**12 %**
Weighted Mean	**1 %**	**5 %**	**7 %**	**8 %**

Table 4.1.7: Percentage agreement (PA) table represents the PA per modal age and reader, advanced the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R02 SE	R07 PL	all
1	100 %	67 %	100 %	**89 %**
2	100 %	100 %	80 %	**93 %**
3	100 %	100 %	100 %	**100 %**
4	100 %	100 %	100 %	**100 %**
5	100 %	100 %	67 %	**89 %**
6	67 %	100 %	100 %	**89 %**
7	100 %	100 %	100 %	**100 %**
8	100 %	100 %	50 %	**83 %**
9	-	-	-	**-**
10	100 %	100 %	0 %	**67 %**
Weighted Mean	**96 %**	**96 %**	**85 %**	**93 %**

Table 4.1.8: Relative bias table represents the relative bias per modal age and advanced reader, the relative bias of all advanced readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R01 DK	R02 SE	R07 PL	all
1	0.00	0.33	0.00	**0.11**
2	0.00	0.00	-0.20	**-0.07**
3	0.00	0.00	0.00	**0.00**
4	0.00	0.00	0.00	**0.00**
5	0.00	0.00	-0.33	**-0.11**
6	0.33	0.00	0.00	**0.11**
7	0.00	0.00	0.00	**0.00**
8	0.00	0.00	-0.50	**-0.17**
9	-	-	-	**-**
10	0.00	0.00	-2.00	**-0.67**
Weighted Mean	**0.04**	**0.04**	**-0.19**	**-0.04**

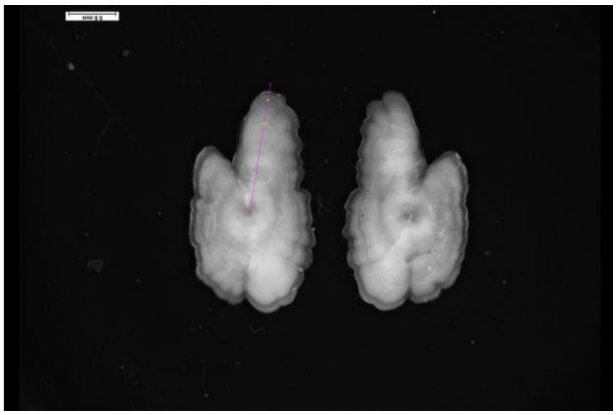


Figure 4.5: ID 2022_05_09_001-HER-SD25-PL, TL=12cm, catch date=2022_05_09. modal age 1, PA=67%, CV = 43%. Dots show the reading from R02 SE

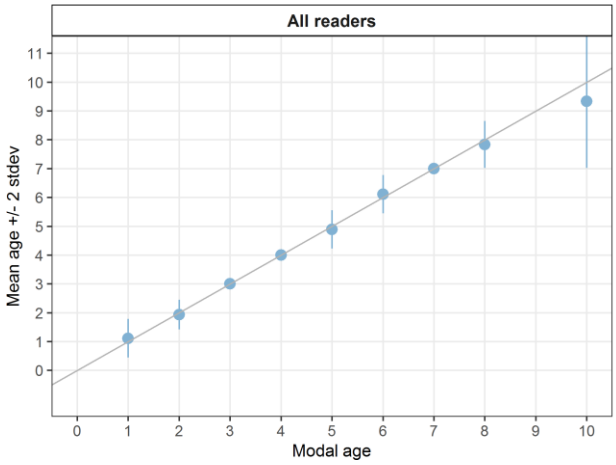


Figure 4.6: Age bias plot for advanced readers.

Table 4.1.9: Age error matrix (AEM) for 25. The AEM shows the proportional distribution of age readings for each modal age. Only advanced readers are used for calculating the AEM.

Read age	1	2	3	4	5	6	7	8	10	Total
Modal age										
Age 1	**0,89**	0,11	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 2	0,07	**0,93**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 3	0,00	0,00	**1,00**	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 4	0,00	0,00	0,00	**1,00**	0,00	0,00	0,00	0,00	0,00	1,00
Age 5	0,00	0,00	0,00	0,11	**0,89**	0,00	0,00	0,00	0,00	1,00
Age 6	0,00	0,00	0,00	0,00	0,00	**0,89**	0,11	0,00	0,00	1,00
Age 7	0,00	0,00	0,00	0,00	0,00	0,00	**1,00**	0,00	0,00	1,00
Age 8	0,00	0,00	0,00	0,00	0,00	0,00	0,17	**0,83**	0,00	1,00
Age 10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,33	**0,67**	1,00
Total	0,96	1,04	1,00	1,11	0,89	0,89	1,28	1,17	0,67	

4.2 ICES SD26

4.2.1 Overview of samples and readers SD26

Table 4.2.1: Overview of samples from SD26 used for the 2022 exchange for the central Baltic herring stock.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2021	27.3.d.26	26	3	6	1-8	15-20 mm
2021	27.3.d.26	26	4	8	1-8	15-20 mm
2022	27.3.d.26	26	1	8	1-8	10-25 mm
2022	27.3.d.26	26	2	8	1-8	10-20 mm

Table 4.2.2: Reader overview SD26

Reader code	Expertise
R01 DK	Advanced
R02 SE	Advanced
R04 LT	Advanced
R07 PL	Advanced
R08 PL	Basic
R09 LV	Advanced
R11 DE	Basic
R12 DE	Basic
R13 SE	Basic
R14 SE	Basic
R15 SE	Basic

4.2.2 All readers – SD26

The weighted average percentage agreement based on modal ages for all readers is 80 % (Table 4.2.4), with the weighted average CV of 12 % (Table 4.2.3) and APE of 6 %. At modal age 1 PA is high at 93% but CV is also high, there are no consistent issues apparent related to age interpretation with the small number of examples where there is not 100% agreement. As age increases the PA decreases which is to be expected as the outermost rings become more difficult to interpret as the otoliths increase in size and the distance between the rings become narrower. Overall bias is negative at -0.03 (Table 4.2.5) and bias per modal age is plotted in Figure 4.7. Individual reader bias (Table 4.2.5) varies greatly from -0.63 (R08 PL) to 0.20 (R13 SE and R14 SE) and readers should examine and compare annotations of otoliths where they are in disagreement with modal age. Individual reader bias plot can be found in Annex 6.2.1.

Table 4.2.3: Coefficient of Variation (CV) table presents the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 DK	R02 SE	R04 LT	R07 PL	R08 PL	R09 LV	R11 DE	R12 DE	R13 SE	R14 SE	R15 SE	all
1	0 %	0 %	0 %	0 %	67 %	40 %	0 %	0 %	40 %	0 %	0 %	**26 %**
2	0 %	0 %	28 %	0 %	0 %	0 %	0 %	0 %	28 %	0 %	0 %	**14 %**
3	0 %	0 %	0 %	16 %	21 %	0 %	14 %	0 %	14 %	0 %	18 %	**11 %**
4	0 %	0 %	0 %	0 %	17 %	0 %	0 %	0 %	13 %	0 %	0 %	**8 %**
5	11 %	0 %	0 %	0 %	20 %	0 %	0 %	0 %	0 %	11 %	0 %	**7 %**
6	8 %	0 %	10 %	0 %	10 %	8 %	8 %	9 %	0 %	8 %	11 %	**9 %**
7	7 %	6 %	12 %	8 %	22 %	7 %	10 %	12 %	10 %	7 %	8 %	**12 %**
8	6 %	0 %	13 %	0 %	14 %	0 %	13 %	6 %	12 %	7 %	7 %	**10 %**
Weighted Mean	**4 %**	**1 %**	**7 %**	**4 %**	**23 %**	**8 %**	**7 %**	**4 %**	**14 %**	**4 %**	**6 %**	**12 %**

Table 4.2.4: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R02 SE	R04 LT	R07 PL	R08 PL	R09 LV	R11 DE	R12 DE	R13 SE	R14 SE	R15 SE	all
1	100 %	100 %	100 %	100 %	75 %	75 %	100 %	100 %	75 %	100 %	100 %	**93 %**
2	100 %	100 %	50 %	100 %	100 %	100 %	100 %	100 %	50 %	100 %	100 %	**91 %**
3	100 %	100 %	100 %	80 %	60 %	100 %	80 %	100 %	80 %	100 %	75 %	**89 %**
4	100 %	100 %	100 %	100 %	33 %	100 %	100 %	100 %	67 %	100 %	100 %	**91 %**
5	67 %	100 %	100 %	100 %	33 %	100 %	100 %	100 %	100 %	67 %	100 %	**88 %**
6	75 %	100 %	25 %	100 %	25 %	75 %	75 %	75 %	100 %	75 %	50 %	**71 %**
7	80 %	80 %	20 %	60 %	40 %	60 %	60 %	40 %	60 %	60 %	50 %	**56 %**
8	75 %	100 %	50 %	100 %	25 %	100 %	75 %	75 %	75 %	50 %	67 %	**72 %**
Weighted Mean	**87 %**	**97 %**	**67 %**	**90 %**	**47 %**	**87 %**	**83 %**	**83 %**	**77 %**	**80 %**	**80 %**	**80 %**

Table 4.2.5: Relative bias table represents the relative bias per modal age per reader, the relative bias of all readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R01 DK	R02 SE	R04 LT	R07 PL	R08 PL	R09 LV	R11 DE	R12 DE	R13 SE	R14 SE	R15 SE	all
1	0.00	0.00	0.00	0.0	-0.25	0.25	0.00	0.00	0.25	0.00	0.00	**0.02**
2	0.00	0.00	0.50	0.0	0.00	0.00	0.00	0.00	0.50	0.00	0.00	**0.09**
3	0.00	0.00	0.00	-0.2	-0.40	0.00	0.20	0.00	0.20	0.00	-0.25	**-0.04**
4	0.00	0.00	0.00	0.0	-0.67	0.00	0.00	0.00	0.33	0.00	0.00	**-0.03**
5	0.33	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.33	0.00	**0.06**
6	0.25	0.00	-0.75	0.0	-0.75	0.25	0.25	-0.25	0.00	0.25	0.50	**-0.02**
7	-0.20	0.20	-1.00	-0.4	-1.20	0.40	0.00	-0.20	0.00	0.40	0.50	**-0.14**
8	0.25	0.00	-0.75	0.0	-1.25	0.00	-0.50	-0.25	0.50	0.50	0.33	**-0.11**
Weighted Mean	**0.07**	**0.03**	**-0.33**	**-0.1**	**-0.63**	**0.13**	**0.00**	**-0.10**	**0.20**	**0.20**	**0.12**	**-0.03**

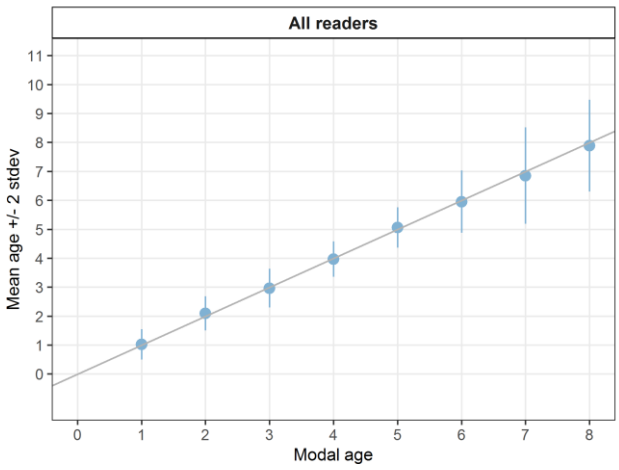


Figure 4.7: Age bias plot for all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

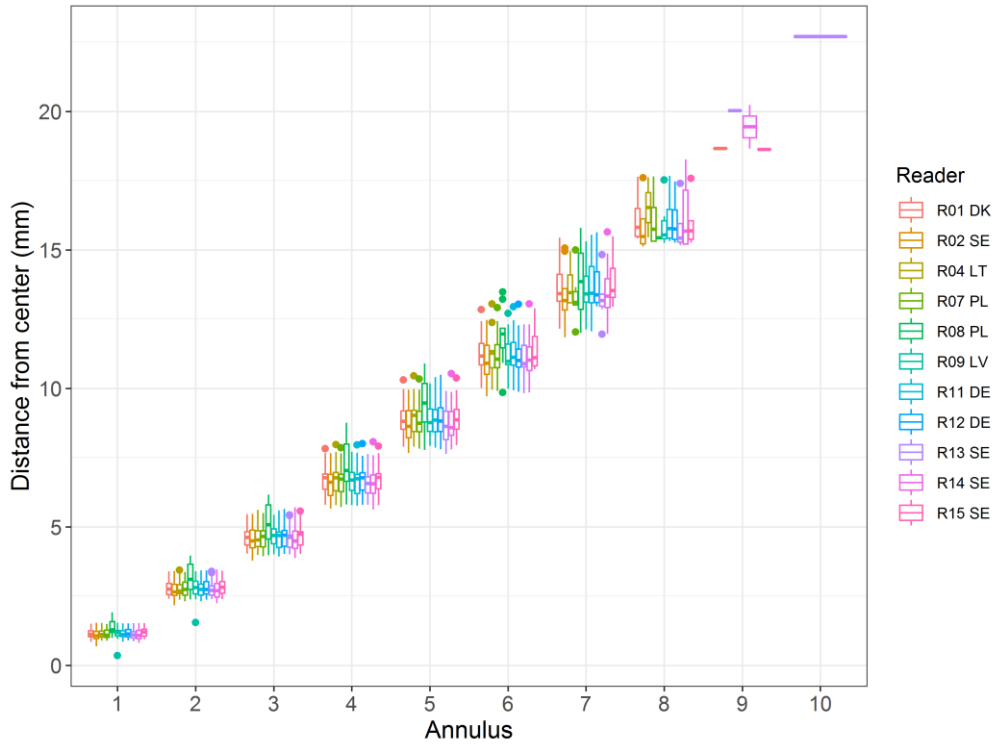


Figure 4.8: Plot of average distance from the centre to the winter rings for advanced readers by strata. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

4.2.3 Advanced readers – SD26

Based on only those three readers who provide age data for stock assessment purposes for SD 25 the weighted average percentage agreement based on modal ages is 85 % (Table 4.2.7), with the weighted average CV of 9 % (Table 4.2.6). When only including expert readers who read for stock assessment one would expect an improvement in the results but this is not the case. At modal age 1 CV is high but this is due to a single fish where R09 LV estimated age 2 but made a comment that this is likely to be an autumn spawner. R04 LT has the lowest average PA at 67% and an average relative bias of -0.30 indicating underestimation of age in comparison to modal age, which is most problematic at the older ages. Overall relative bias is negative at -0.01 (Table 4.2.8) and individual relative bias per reader varies from -0.30 to 0.17. The age error matrix (AEM) (Table 4.2.9) shows the proportional distribution of age readings for each modal age. Only advanced readers are used for calculating the AEM. Individual age reader bias plots can be found in Annex 6.2.2.

Table 4.2.6: Coefficient of Variation (CV) table presents the CV per modal age and advanced reader, the CV of all advanced readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 DK	R02 SE	R04 LT	R07 PL	R09 LV	All
1	0 %	0 %	0 %	0 %	40 %	**21 %**
2	0 %	0 %	28 %	0 %	0 %	**15 %**
3	0 %	0 %	0 %	16 %	0 %	**7 %**
4	0 %	0 %	0 %	0 %	0 %	**0 %**
5	11 %	0 %	0 %	0 %	0 %	**5 %**
6	7 %	7 %	9 %	0 %	9 %	**10 %**
7	0 %	7 %	8 %	7 %	8 %	**9 %**
8	6 %	0 %	13 %	0 %	0 %	**7 %**
Weighted Mean	**3 %**	**2 %**	**6 %**	**4 %**	**8 %**	**9 %**

Table 4.2.7: Percentage agreement (PA) table represents the PA per modal age and reader, advanced the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R02 SE	R04 LT	R07 PL	R09 LV	All
1	100 %	100 %	100 %	100 %	75 %	**95 %**
2	100 %	100 %	50 %	100 %	100 %	**90 %**
3	100 %	100 %	100 %	80 %	100 %	**96 %**
4	100 %	100 %	100 %	100 %	100 %	**100 %**
5	67 %	100 %	100 %	100 %	100 %	**93 %**
6	80 %	80 %	20 %	100 %	60 %	**68 %**
7	100 %	75 %	25 %	75 %	50 %	**65 %**
8	75 %	100 %	50 %	100 %	100 %	**85 %**
Weighted Mean	**90 %**	**93 %**	**67 %**	**93 %**	**83 %**	**85 %**

Table 4.2.8: Relative bias table represents the relative bias per modal age and advanced reader, the relative bias of all advanced readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R01 DK	R02 SE	R04 LT	R07 PL	R09 LV	all
1	0.00	0.00	0.00	0.00	0.25	**0.05**
2	0.00	0.00	0.50	0.00	0.00	**0.10**
3	0.00	0.00	0.00	-0.20	0.00	**-0.04**

4	0.00	0.00	0.00	0.00	0.00	**0.00**
5	0.33	0.00	0.00	0.00	0.00	**0.07**
6	0.20	0.20	-0.80	0.00	0.40	**0.00**
7	0.00	0.25	-0.75	-0.25	0.50	**-0.05**
8	0.25	0.00	-0.75	0.00	0.00	**-0.10**
Weighted Mean	**0.10**	**0.07**	**-0.30**	**-0.07**	**0.17**	**-0.01**

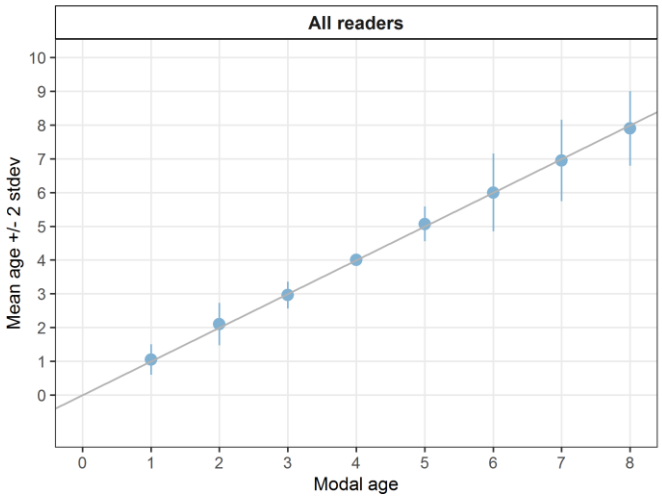


Figure 4.8: Age bias plot for advanced readers.

Table 4.2.9: Age error matrix (AEM) for 26. The AEM shows the proportional distribution of age readings for each modal age. Only advanced readers are used for calculating the AEM.

Read age	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Modal age										
Age 1	**0,95**	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 2	0,00	**0,90**	0,10	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 3	0,00	0,04	**0,96**	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 4	0,00	0,00	0,00	**1,00**	0,00	0,00	0,00	0,00	0,00	1,00
Age 5	0,00	0,00	0,00	0,00	**0,93**	0,07	0,00	0,00	0,00	1,00
Age 6	0,00	0,00	0,00	0,00	0,16	**0,68**	0,16	0,00	0,00	1,00
Age 7	0,00	0,00	0,00	0,00	0,00	0,20	**0,65**	0,15	0,00	1,00
Age 8	0,00	0,00	0,00	0,00	0,00	0,05	0,05	**0,85**	0,05	1,00
Age 9	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00
Total	0,95	0,99	1,06	1,00	1,09	1,00	0,86	1,00	0,05	

4.3 ICES SD29

4.3.1 Overview of samples and readers SD29

From the samples provided from SD29 only 24 are included in the analysis as these were the only samples where images of both whole (WH) and sectioned and stained (SS) otoliths were provided from the same fish. This analysis should not be seen as a comparison of methods as none of the readers are experienced in reading both methods. Readers were asked to annotate only images of the method that they routinely read in their lab.

Table 4.3.1: Overview of samples from SD29 used for the 2022 exchange for the central Baltic herring stock.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2022	27.3.d.29	29	1	24	0-6	95-180 mm

Table 4.3.2: Reader overview SD29

Reader code	Expertise
R01 DK	Basic
R02 SE	Basic
R03 EE	Advanced
R04 LT	Basic
R05 FI	Advanced
R06 FI	Advanced
R10 EE	Advanced
R11 DE	Basic
R12 DE	Basic
R13 SE	Basic
R14 SE	Basic

4.3.2 All readers – SD29

The results here are based on 24 samples from SD29 where images of both whole (WH) and sectioned and stained (SS) otoliths were provided from the same fish and results are based on readings of both methods combined. Readers were asked to annotate only images of the method that they routinely read in their lab. R04 LT, R05 FI, R11 DE and R12 DE read both whole (WH) and sectioned and stained (SS), their inexperience in these methods may lead to biased results. The weighted average percentage agreement based on modal ages for all readers is 86 % (Table 4.3.4), with the weighted average CV of 17 % (Table 4.3.3), and APE of 8 %. CV's are high at modal age 1 and 2, some readers are overestimating and others underestimating the age in comparison to modal age. It should also be noted that growth patterns in the otoliths from fish from the northern parts of the Baltic differ greatly between slow and fast growing fish and readers who are not familiar with these patterns can have difficultly interpreting the age. Overall relative bias is positive at 0.06 (Table 4.3.5), but the weighted means for individual readers varies from 0.26 (R11 DE) to -0.12 (R06 FI), these values are reflected in Figure 4.9. Individual reader bias plots can be found in Annex 6.3.1. Figure 4.11 shows two

images from fish ID 2022-2002-1-HER-2, total length=157mm, catch date=2022_02_01. Figure 4.11.A shows the sectioned and stained (SS) otolith and Figure 4.11.B. shows the whole otolith (WH). For both methods modal age is 5. PA=83% and CV = 8% for SS and PA=70%, CV=10% for WH. Those readers not in agreement with modal age are reading age 6 on the SS otolith and age 4 on the whole otolith.

Table 4.3.3: Coefficient of Variation (CV) table presents the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 DK	R02 SE	R03 EE	R04 LT	R05 FI	R06 FI	R10 EE	R11 DE	R12 DE	R13 SE	R14 SE	all
0	-	-	-	-	-	-	-	-	-	-	-	**-**
1	56 %	0 %	39 %	0 %	33 %	0 %	0 %	0 %	0 %	0 %	0 %	**23 %**
2	0 %	40 %	0 %	0 %	0 %	0 %	0 %	44 %	0 %	0 %	0 %	**24 %**
3	0 %	14 %	14 %	20 %	14 %	0 %	14 %	13 %	0 %	14 %	0 %	**12 %**
4	0 %	13 %	12 %	10 %	24 %	0 %	12 %	11 %	10 %	16 %	15 %	**14 %**
5	0 %	10 %	11 %	7 %	7 %	12 %	9 %	10 %	7 %	10 %	10 %	**10 %**
6	-	-	-	0 %	11 %	0 %	-	11 %	0 %	-	-	**7 %**
Weighted Mean	**13 %**	**14 %**	**17 %**	**7 %**	**16 %**	**2 %**	**7 %**	**15 %**	**2 %**	**9 %**	**4 %**	**17 %**

Table 4.3.4: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R02 SE	R03 EE	R04 LT	R05 FI	R06 FI	R10 EE	R11 DE	R12 DE	R13 SE	R14 SE	all
0	-	-	100 %	100 %	-	-	100 %	-	-	-	-	**100 %**
1	80 %	100 %	67 %	100 %	83 %	100 %	100 %	100 %	100 %	100 %	100 %	**94 %**
2	100 %	75 %	100 %	100 %	100 %	100 %	100 %	78 %	100 %	100 %	100 %	**95 %**
3	100 %	80 %	80 %	90 %	78 %	100 %	80 %	80 %	100 %	80 %	100 %	**88 %**
4	100 %	75 %	75 %	83 %	67 %	100 %	75 %	80 %	83 %	50 %	25 %	**73 %**
5	100 %	50 %	75 %	88 %	88 %	25 %	80 %	62 %	88 %	50 %	75 %	**74 %**
6	-	-	-	100 %	50 %	100 %	-	50 %	100 %	-	-	**80 %**
Weighted Mean	**95 %**	**78 %**	**79 %**	**94 %**	**83 %**	**88 %**	**88 %**	**80 %**	**96 %**	**75 %**	**83 %**	**86 %**

Table 4.3.5: Relative bias table represents the relative bias per modal age per reader, the relative bias of all readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R01 DK	R02 SE	R03 EE	R04 LT	R05 FI	R06 FI	R10 EE	R11 DE	R12 DE	R13 SE	R14 SE	all
0	-	-	0.00	0.00	-	-	0.00	-	-	-	-	**-**
1	-0.20	0.00	0.33	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	**0.03**
2	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	**0.10**
3	0.00	0.20	0.20	0.20	0.22	0.00	0.20	0.20	0.00	0.20	0.00	**0.13**
4	0.00	-0.25	0.25	0.17	0.17	0.00	0.25	0.20	0.17	-0.50	-0.75	**-0.03**
5	0.00	0.50	-0.25	-0.12	0.12	-0.75	-0.20	0.38	-0.12	0.50	0.25	**0.03**
6	-	-	-	0.00	0.50	0.00	-	0.50	0.00	-	-	**-**
Weighted Mean	**-0.05**	**0.17**	**0.12**	**0.04**	**0.15**	**-0.12**	**0.04**	**0.26**	**0.00**	**0.05**	**-0.09**	**0.06**

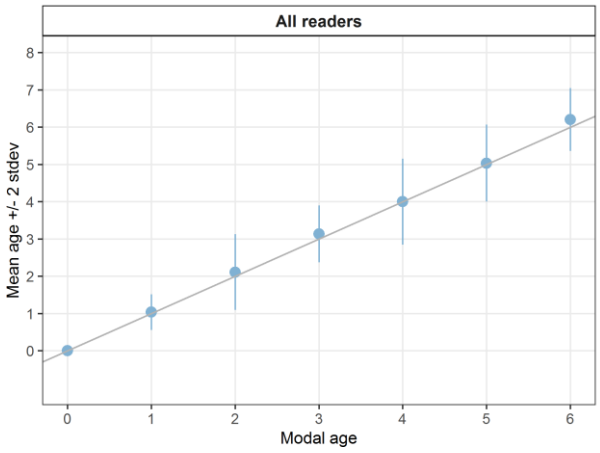


Figure 4.9: Age bias plot for all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

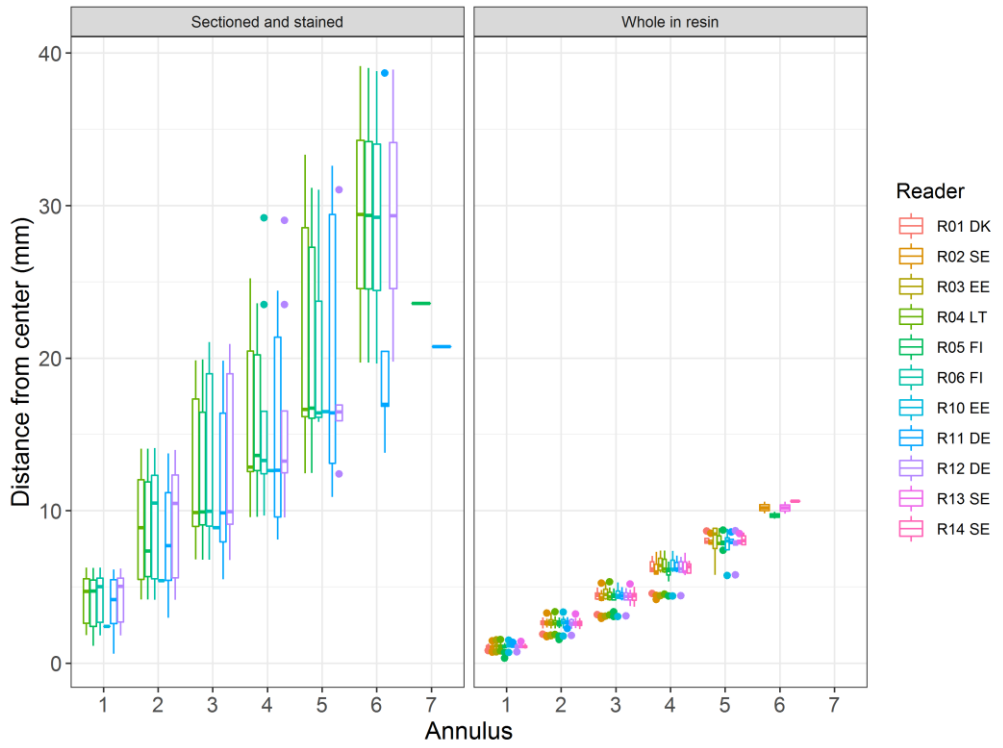
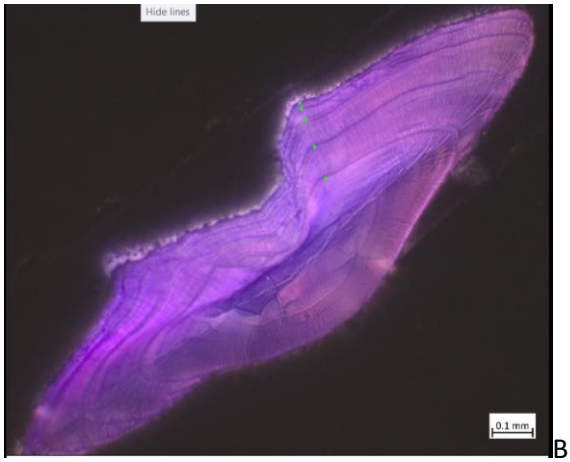


Figure 4.10: Plot of average distance from the centre to the winter rings for all readers by preparation method. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

A. 

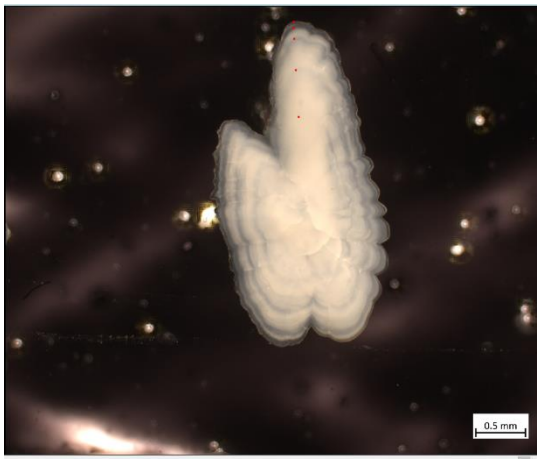
B. 

Figure 4.11: ID 2022-2002-1-HER-2, TL=157mm, catch date=2022_02_01. A. Sectioned and Stained (SS) otolith and B. Whole otolith (WH). For both methods modal age is 5. SS; PA=83%, CV = 8%. WH; PA=70%, CV=10%

4.3.3 Advanced readers – SD29

The weighted average percentage agreement based on modal ages for all readers is 89 % (Table 4.3.7), with the weighted average CV of 12 % (Table 4.3.6) when only including the ages of advanced readers who provide ages for stock assessment purposes for SD29. Readers from Estonia routinely read whole otoliths (WH) while readers from Finland routinely read sectioned and stained (SS) otoliths. All readings were included in the analysis (this is because SmartDots does not allow stratification of results based on area and method simultaneously). Overall relative bias is positive at 0.06 (Table 4.3.8) with R05 FI have a weighted mean value of 0.20. The relative bias values per modal age are reflected in Figure 4.12. R05 FI read both methods but is routinely reading SS and has a tendency to overestimate the ages on the whole otoliths, this is likely to have contributed to the high CV, low PA and high positive bias for this reader which has had a negative effect on the overall results. Moreover, she was on maternity leave when reading the otoliths. Figure 4.13 shows that R05 FI read both methods and R10 EE read one of the SS otoliths. In this figure it is important to note that there is little overlap between the annuli as shown by the boxes, most apparent for WH otoliths. There is overlap for the SS otoliths and the broader interquartile ranges show that there is variability around which structures are identified as the winter rings. A method comparison was not an aim of this exchange but it is worth noting that in Figure 4.11 the SS otolith was read to be age 5 by the readers from Finland and the WH otolith was read to be age 4 by the readers from Estonia. The outer most ring is clearly visible on the SS otolith but not the WH otolith. The age error matrix (AEM) (Table 4.3.9) shows the proportional distribution of age readings for each modal age. Only advanced readers are used for calculating the AEM. Individual age reader bias plots can be found in Annex 6.3.2.

Table 4.3.6: Coefficient of Variation (CV) table presents the CV per modal age and advanced reader, the CV of all advanced readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R03 EE	R05 FI	R06 FI	R10 EE	All
0	-	-	-	-	**-**
1	37 %	28 %	0 %	0 %	**25 %**
2	0 %	0 %	0 %	0 %	**0 %**
3	0 %	14 %	0 %	0 %	**10 %**
4	0 %	19 %	0 %	0 %	**14 %**
5	0 %	14 %	-	0 %	**8 %**
6	-	11 %	0 %	-	**8 %**
Weighted Mean	**8 %**	**15 %**	**0 %**	**0 %**	**12 %**

Table 4.3.7: Percentage agreement (PA) table represents the PA per modal age and reader, advanced the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R03 EE	R05 FI	R06 FI	R10 EE	all
0	100 %	-	-	100 %	**100 %**
1	80 %	91 %	100 %	100 %	**93 %**
2	100 %	100 %	100 %	100 %	**100 %**
3	100 %	78 %	100 %	100 %	**91 %**
4	100 %	33 %	100 %	100 %	**75 %**
5	100 %	60 %	100 %	100 %	**87 %**
6	-	50 %	100 %	-	**75 %**
Weighted Mean	**96 %**	**74 %**	**100 %**	**100 %**	**89 %**

Table 4.3.8: Relative bias table represents the relative bias per modal age and advanced reader, the relative bias of all advanced readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R03 EE	R05 FI	R06 FI	R10 EE	all
0	0.00	-	-	0.00	**-**
1	0.20	0.09	0.00	0.00	**0.07**
2	0.00	0.00	0.00	0.00	**0.00**
3	0.00	0.22	0.00	0.00	**0.06**
4	0.00	0.56	0.00	0.00	**0.14**
5	0.00	0.00	0.00	0.00	**0.00**
6	-	0.50	0.00	-	**-**
Weighted Mean	**0.04**	**0.20**	**0.00**	**0.00**	**0.06**

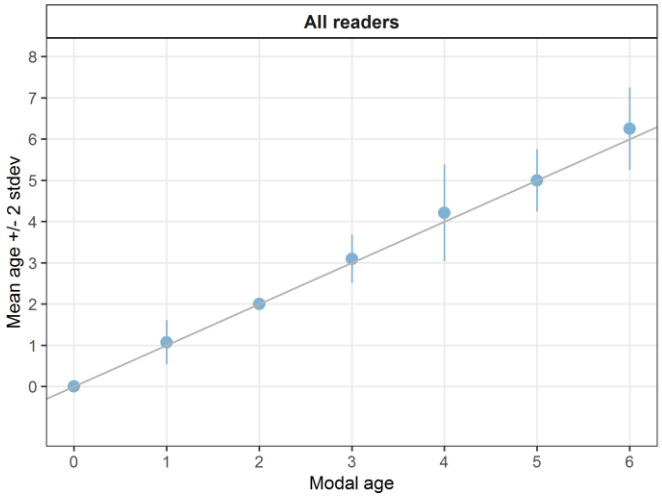


Figure 4.12: Age bias plot for advanced readers.

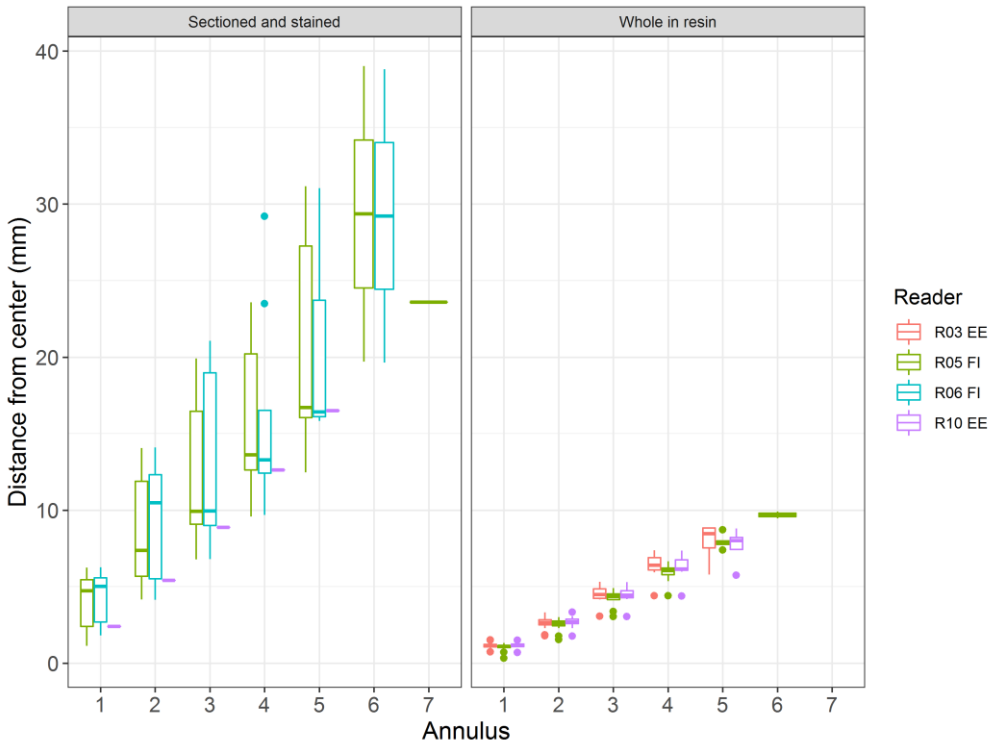


Figure 4.13: Plot of average distance from the centre to the winter rings for all readers by preparation method. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

Table 4.3.9: Age error matrix (AEM) for 29. The AEM shows the proportional distribution of age readings for each modal age. Only advanced readers are used for calculating the AEM.

Read age	0	1	2	3	4	5	6	No age	Total
Modal age									
Age 0	**0,95**	0,05	0,00	0,00	0,00	0,00	0,00	0,00	1,00
Age 1	0,05	**0,90**	0,00	0,00	0,00	0,00	0,00	0,05	1,00
Age 2	0,00	0,00	**0,85**	0,15	0,00	0,00	0,00	0,00	1,00
Age 3	0,00	0,00	0,00	**0,81**	0,19	0,00	0,00	0,00	1,00
Age 4	0,00	0,00	0,00	0,13	**0,63**	0,19	0,06	0,00	1,00
Age 5	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00	0,00
Age 6	0,00	0,00	0,00	0,00	0,00	0,00	**0,00**	0,00	0,00
Age 7	0,95	0,05	0,00	0,00	0,00	0,00	0,00	**0,00**	1,00
Total	1,00	0,95	0,85	1,09	0,81	0,19	0,06	0,05	

4.4 ICES SD32

4.4.1 Overview of samples and readers SD32

Table 4.4.1: Overview of samples from SD32 used for the 2022 exchange for the central Baltic herring stock.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2021	27.3.d.32	32	1	20	1-8	90-175 mm
2021	27.3.d.32	32	2	20	1-8	95-175 mm

Table 4.4.2: Reader overview ICES SD32

Reader code	Expertise
R04 LT	Basic
R05 FI	Advanced
R06 FI	Advanced
R11 DE	Basic
R12 DE	Basic

4.4.2 All readers – SD32

The weighted average percentage agreement based on modal ages for all readers is 83 % (Table 4.4.4), with the weighted average CV of 18 % (Table 4.4.3) and APE of 11 %. The results here are based on 40 otolith images of sectioned stained otoliths provided by LUKE, Finland. Only readers from Finland provide age data for stock assessment purposes from SD32 and only Finland read stained and sectioned herring otoliths from this stock. When the ages from German and Lithuanian readers were included, the agreement was high at 83% but with a strong positive bias (Table 4.4.5), indicating that ages are overestimated in comparison to modal age. Relative bias values per modal age are reflected in Figure 4.14. This is often a result of readers not familiar with this preparation techniques counting too many rings. R05 FI shows a strong positive bias indicating over estimation in comparison to modal age, comments on this can be found in section 4.3.3.

Table 4.4.3: Coefficient of Variation (CV) table presents the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R04 LT	R05 FI	R06 FI	R11 DE	R12 DE	all
1	0 %	0 %	0 %	0 %	0 %	**0 %**
2	0 %	19 %	0 %	34 %	0 %	**21 %**
3	0 %	12 %	18 %	48 %	38 %	**34 %**
4	0 %	17 %	0 %	36 %	9 %	**22 %**
5	0 %	16 %	14 %	10 %	0 %	**11 %**
6	0 %	21 %	9 %	9 %	9 %	**13 %**
7	-	-	-	-	-	**12 %**
8	0 %	0 %	0 %	9 %	0 %	**6 %**
Weighted Mean	**0 %**	**14 %**	**6 %**	**26 %**	**9 %**	**18 %**

Table 4.4.4: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R04 LT	R05 FI	R06 FI	R11 DE	R12 DE	all
1	100 %	100 %	100 %	100 %	100 %	**100 %**
2	100 %	80 %	100 %	70 %	100 %	**90 %**
3	100 %	86 %	71 %	71 %	71 %	**80 %**
4	100 %	57 %	100 %	57 %	86 %	**80 %**
5	100 %	60 %	60 %	60 %	100 %	**76 %**
6	100 %	33 %	67 %	67 %	67 %	**67 %**
7	100 %	100 %	100 %	0 %	100 %	**80 %**
8	0 %	100 %	100 %	50 %	100 %	**70 %**
Weighted Mean	**95 %**	**75 %**	**88 %**	**68 %**	**90 %**	**83 %**

Table 4.4.5: Relative bias table represents the relative bias per modal age per reader, the relative bias of all readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R04 LT	R05 FI	R06 FI	R11 DE	R12 DE	all
1	0.00	0.00	0.00	0.00	0.00	**0.00**
2	0.00	0.20	0.00	0.50	0.00	**0.14**
3	0.00	0.14	-0.29	1.00	0.29	**0.23**
4	0.00	0.57	0.00	1.14	0.14	**0.37**
5	0.00	0.60	0.00	0.40	0.00	**0.20**
6	0.00	1.33	0.33	0.33	0.33	**0.47**
7	0.00	0.00	0.00	2.00	0.00	**0.40**
8	-1.00	0.00	0.00	-0.50	0.00	**-0.30**
Weighted Mean	**-0.05**	**0.35**	**-0.02**	**0.60**	**0.10**	**0.20**

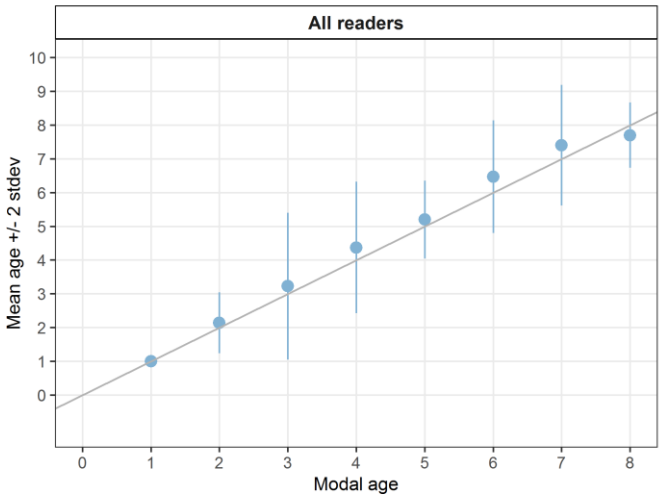


Figure 4.14: Age bias plot for all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

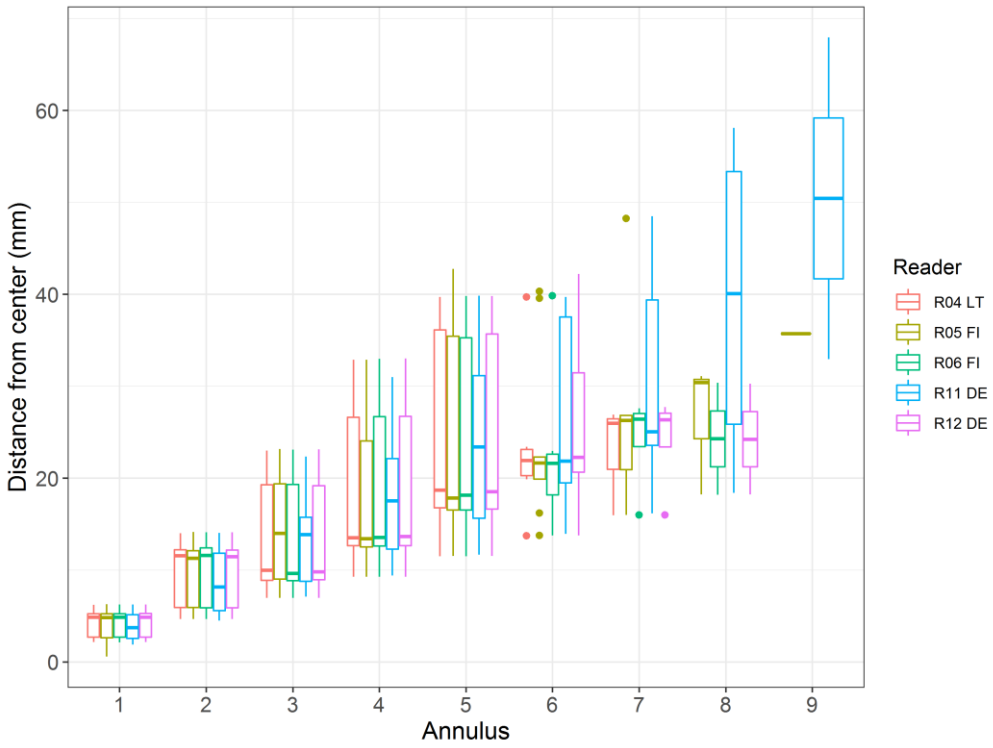


Figure X: Plot of average distance from the centre to the winter rings for advanced readers by preparation method. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

4.4.3 Advanced readers – SD32

When only the two readers from Finland are included in the analysis the CEFAS ATAQCS workbook was used to compare readers as modal age (calculated in the SmartDots report) requires more than two age readings per fish. Percentage agreed was 70%, with a CV 0f 6.7% and an overall positive bias of 0.38. It should be noted that R05 FI was on maternity leave when taking part in the event. When there is disagreement between the readers R05 FI will overestimate the age in comparison to R06 FI, usually by counting an additional ring at the edge. The reader comparison matrix (Table 4.4.7) shows the number of ages read by R05 FI to be in agreement with R06 FI (green) and the number read to be older (red) for each age. No ages were read to be younger (blue).

Table 4.4.6: Overview of results from the CEFAS ATAQCS workbook showing per modal age; number of age readings per age reader, number of agreed ages, % agreement, CV and bias.

Age	R06	R05	No. Agreed	% agreed	CV	Bias
0						
1	5	5	5	100,0	0,000	0,00
2	12	8	8	66,7	0,106	0,33
3	5	8	4	80,0	0,070	0,20
4	8	5	4	50,0	0,093	0,75
5	3	5	3	100,0	0,000	0,00
6	3	3	1	33,3	0,043	0,67
7	2	3	1	50,0	0,088	1,00
8	2	2	2	100,0	0,000	0,00
9	0	1	0			
Totals	**0**	**40**	**40**	**70,00**	**0.067**	**0.38**

Table 4.4.7: Reader comparison matrix. Green area is agreement, red area is overestimation by R05 FI.

R06 FI Age	R05 FI Age									
	0	1	2	3	4	5	6	7	8	9
0										
1		5								
2			8	4						
3				4	1					
4					4	2	2			
5						3				
6							1	2		
7								1		1
8									2	
9										

5 References

Beamish R. J. and Fournier D. A. (1981) A method for comparing the precision of a set of age determination. Canadian Journal of Fisheries and Aquatic Sciences, 38, 982–983

CEFAS ATAQCS (Age Training And Quality Control System). Developed by Mark Etherton. email: Mark.Etherton@cefas.co.uk

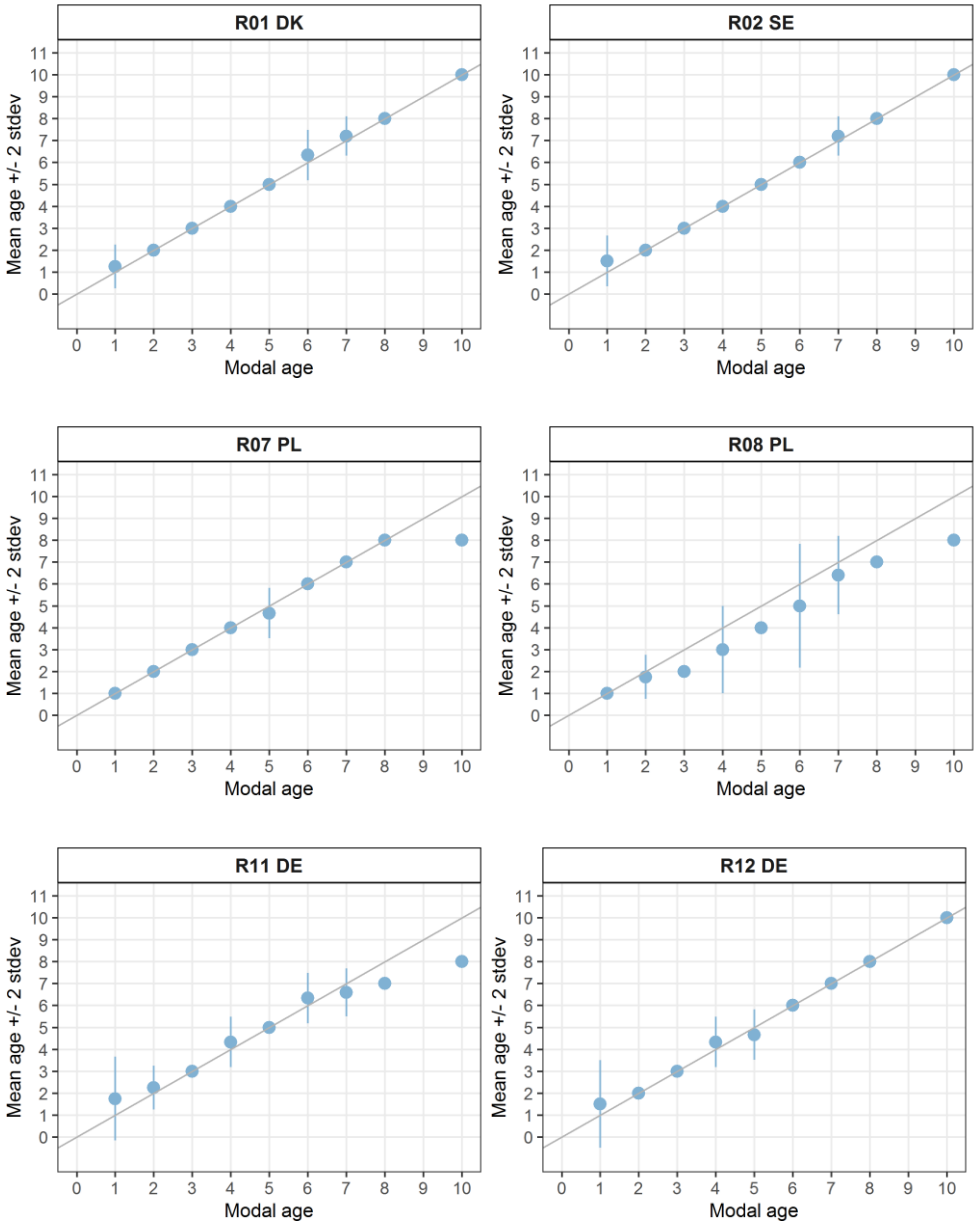
Eltink G. W. (2000) Age reading comparisons. (MS Excel workbook version 1.0 October 2000)

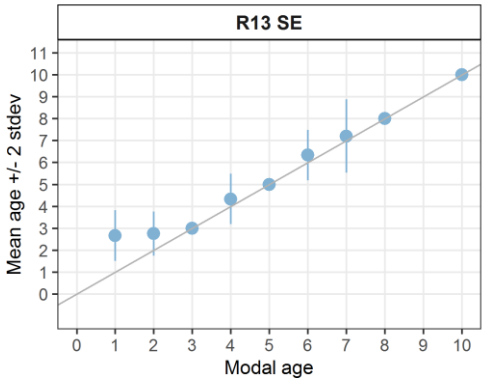
ICES (2014) Report of the Workshop on Statistical Analysis of Biological Calibration Studies (WKSABCAL). ICES CM 2014/ACOM:35

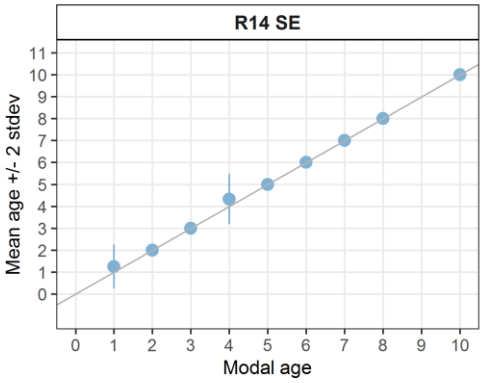
6 Annex 3. Additional results

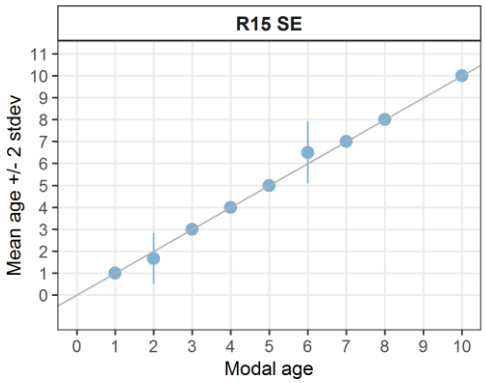
6.1 Results SD25

6.1.1 All readers - SD25

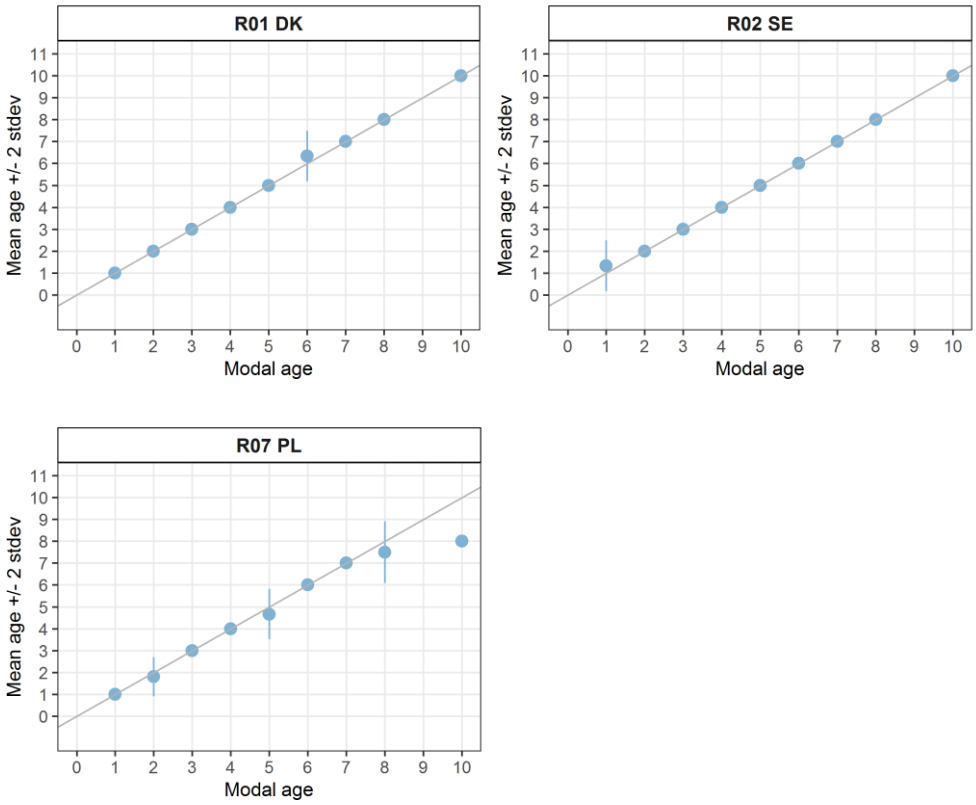



R13 SE
Mean age +/- 2 stdev
Modal age


R14 SE
Mean age +/- 2 stdev
Modal age

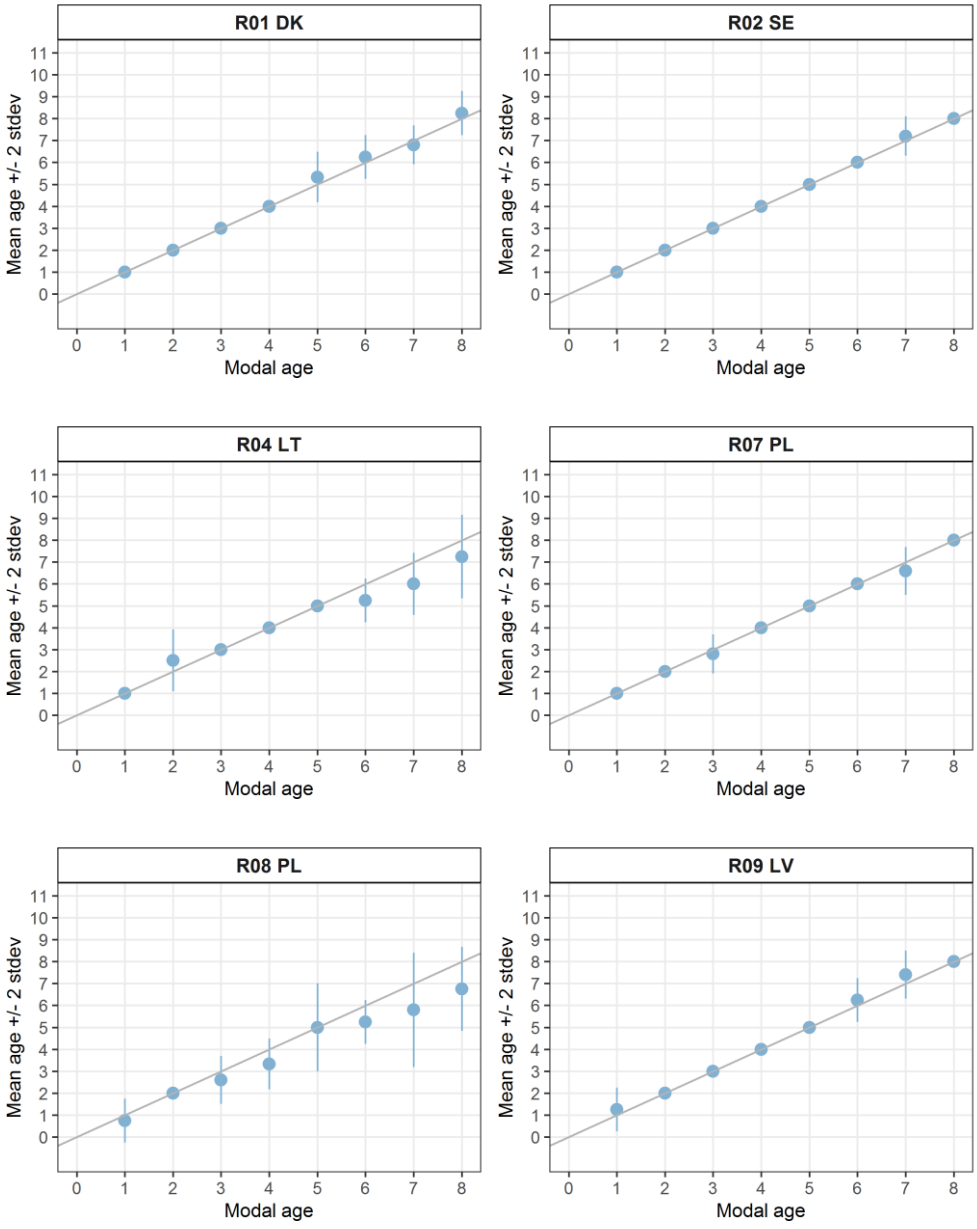

R15 SE
Mean age +/- 2 stdev
Modal age

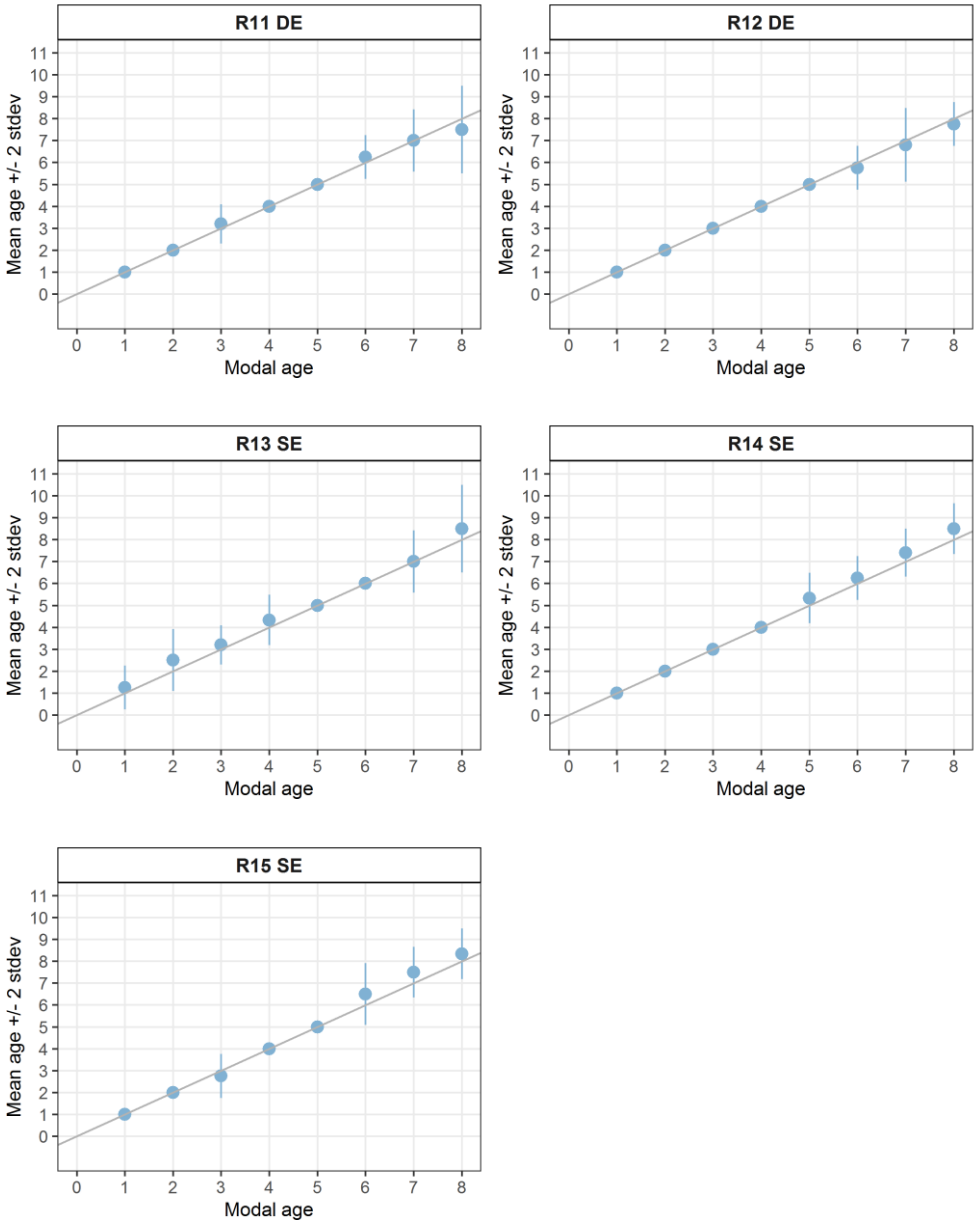
6.1.2 Advanced readers - SD25



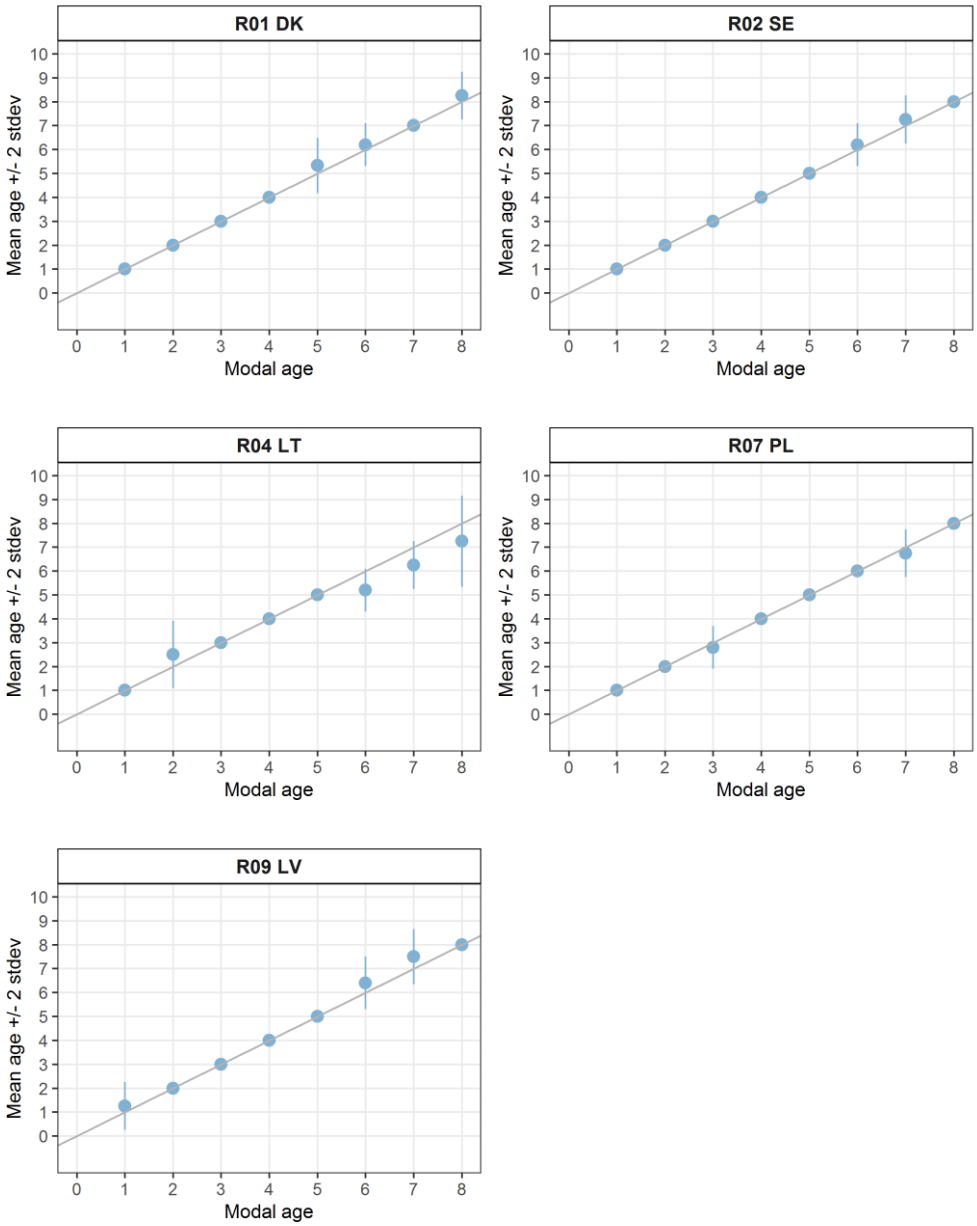
6.2 Results SD26

6.2.1 All readers – SD26



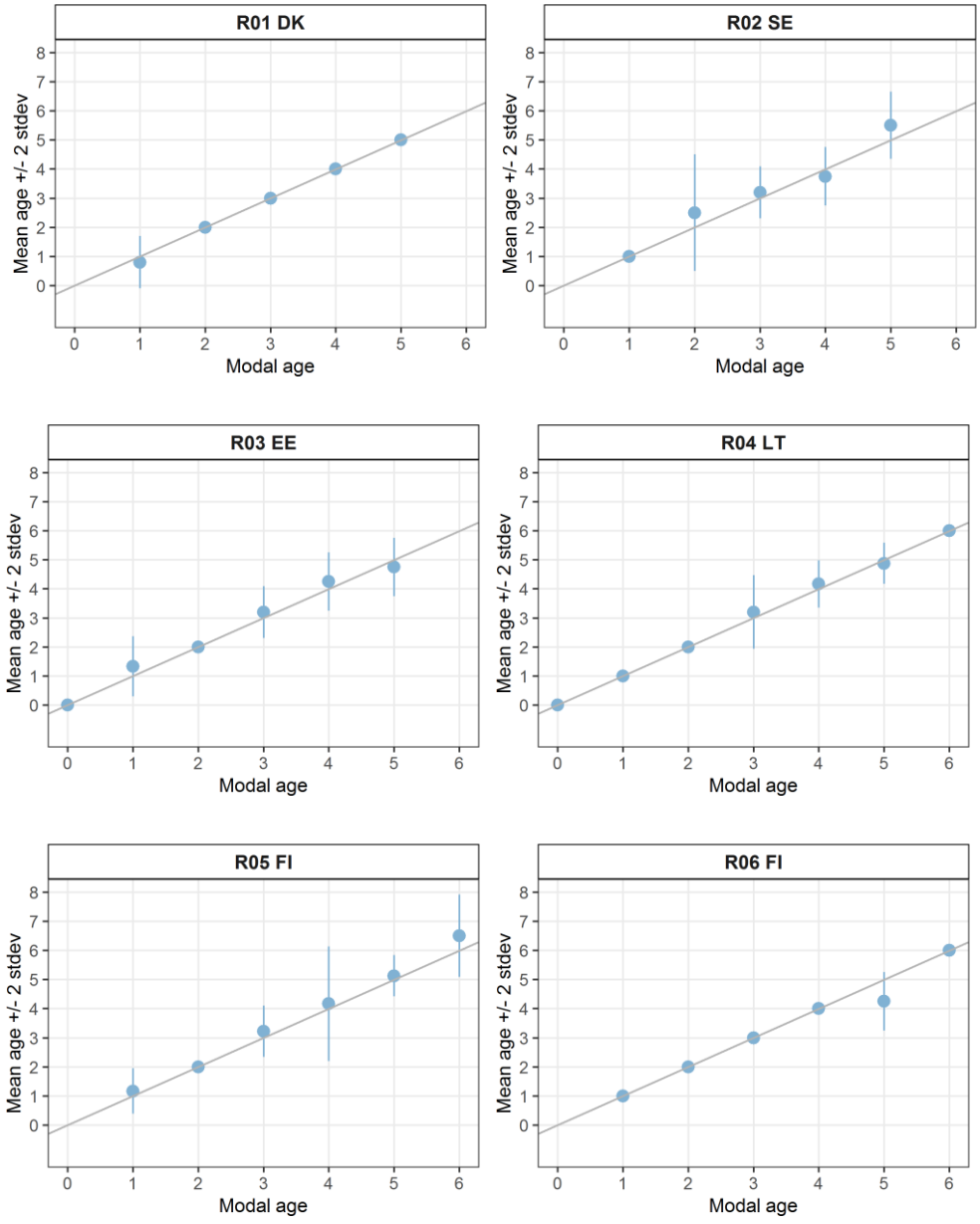

R11 DE
R12 DE
R13 SE
R14 SE
R15 SE
Mean age +/- 2 stdev
Modal age
0 1 2 3 4 5 6 7 8
0 1 2 3 4 5 6 7 8 9 10 11

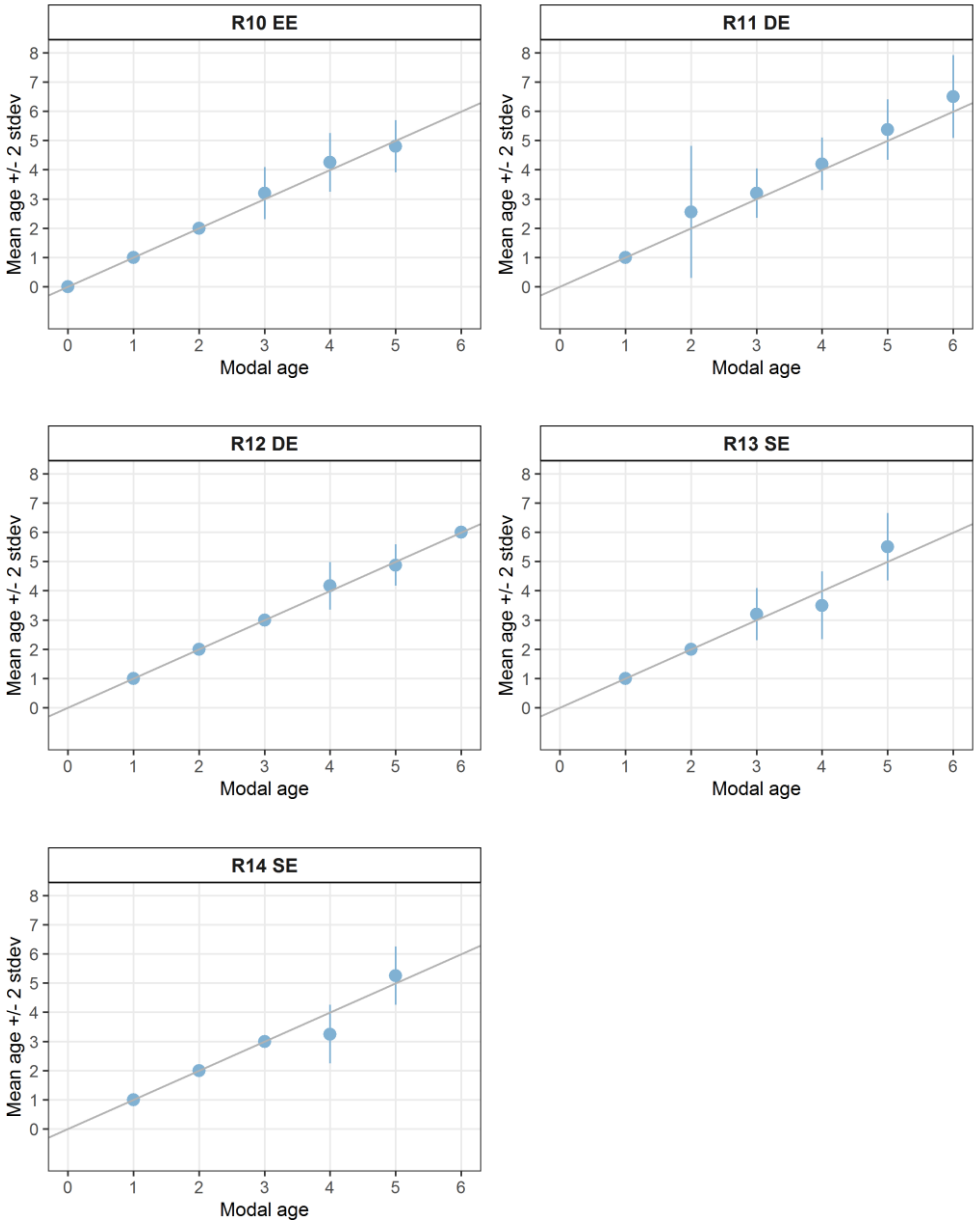
6.2.2 Advanced readers – SD26



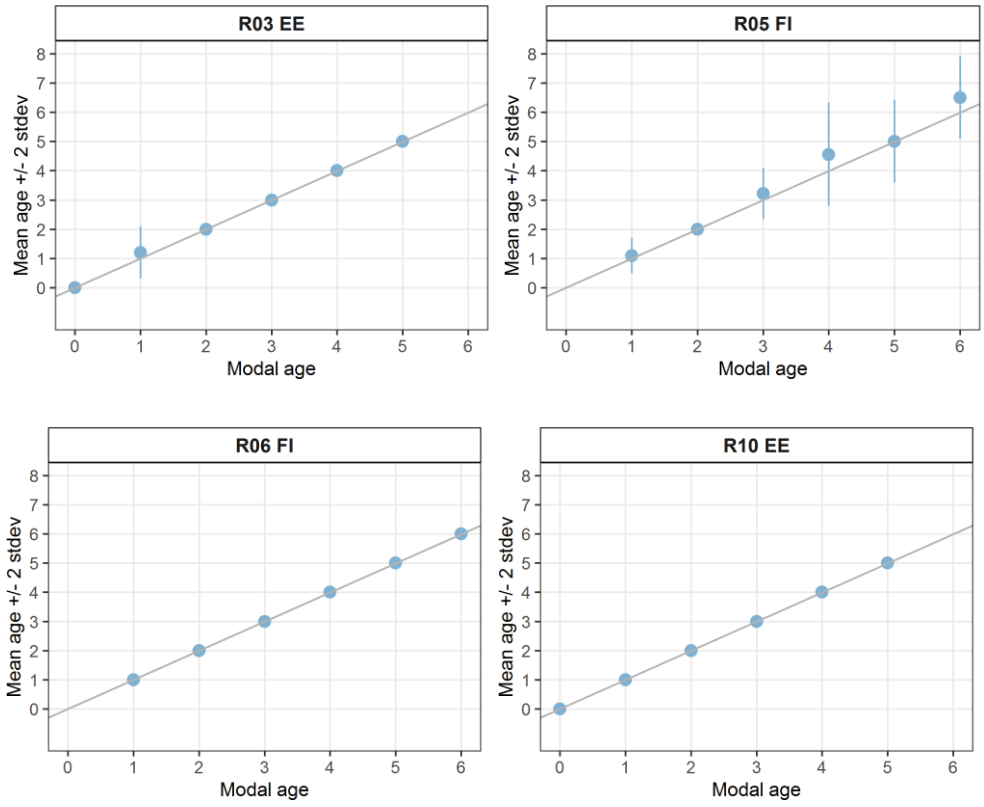
6.3 Results SD29

6.3.1 All readers – SD29




R10 EE
R11 DE
R12 DE
R13 SE
R14 SE
Mean age +/- 2 stdev
Modal age
0
1
2
3
4
5
6
7
8

6.3.2 Advanced readers – SD29



6.4 Results SD32

6.4.1 All readers – SD32