

# SmartDots Report for the 2023 scale exchange for Norwegian spring-spawning herring stock *her.27.1-24a514a* (event 448)

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# 1 Executive summary

The 2023 scales exchange for the Norwegian spring-spawning herring (*Clupea harengus*) stock *her.27.1-24a514a* took place via the SmartDots platform between August 2022 and March 2023. The exchange was organised following a recommendation from WGWIDE to calibrate age reading especially during May where a potential issue with the interpretation of the new growth zone might exist. Nine readers from three countries (Faroese Islands, Iceland, Norway) took part; six “advanced” readers (providing age data for the assessment) and three “basic” readers (do not provide age data for the assessment). For this exchange, advanced readers had access to the physical material, while basic readers only had access to the digital images via SmartDots. A total of 255 scales, covering commercial samples from 1<sup>st</sup> and 4<sup>th</sup> quarter of the year and the two international surveys (IESNS in May and IESSNS in July) providing biomass estimates, were age determined using SmartDots and physical material provided. Norway and Iceland are the two institutes who mainly use scales for age estimation.

The overall agreement (PA) among all readers was 80%, with a weighted average CV of 9% and APE of 4%. The agreement among advanced readers was 88%. Agreement with the modal age was highest from age five to seven years and decreased in older individuals. However, high quality scales in several cases of older individuals had a high PA among readers. The results of this exchange demonstrated that there is no issue with new growth occurring in May. All readers interpreted the new growth similarly resulting in high PA among samples from May.

The results of this exchange were presented and discussed at the WKARNSSH (Workshop on age reading of Norwegian spring-spawning herring) in April 2023.

# 2 Introduction

Ageing of calcified structures in fish, such as otoliths or scales, is the backbone of most stock assessment models. Age-based information are used to infer stock dynamics and status. One of the main objectives for the age reader community is to achieve consistency between age readers estimating the age of a certain species or stock and to minimize the amount of bias in the age data which is used in stock assessment. Such bias can have serious consequences for the scientific advice which is used for the management of fish stocks. The aim of this age reading exchange was to address potential age reading issues apparent with the Norwegian spring-spawning (NSS) herring stock and thus minimize the bias associated with the age data provided to WGWIDE for the assessment of the stock. Especially for NSS herring potential issues exist that can bias the age reading, e.g., different calcified structures are used (otoliths and scales), stock mixing occurs during specific time periods and areas, different interpretations of the first winter ring, are different interpretations of the new annual growth occurring during the international survey IESNS in May. Particularly, the stock mixing issue and how these data are passed on to the stock coordinators needs to be explored further given the serious implications for the quality of the assessment both in terms of age and stock structure. In addition to this scale exchange, an exchange with NSS herring otoliths (event 447) was conducted at the same time and their results were compared and discussed at the WKARNSSH (Workshop on age reading of Norwegian spring-spawning herring) in April 2023.

# 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).

## Percentage Agreement (PA)

The percentage agreement per reader per modal age tells how large is the part of readings that are equal to the modal age. The percentage agreement is estimated by modal age and reader as the proportion (as percentage) of times that the lectures of that reader agreed with the resulting modal age. This percentage is estimated as the number of times that a reader agreed with the modal age divided by the total number of otoliths read by a reader for each modal age.

$$PA = \frac{\text{number of readings that agree with modal age}}{\text{total number of readings by modal age}} \cdot 100\%$$

## Coefficient of Variation (CV)

The table presents the Coefficient of Variation (CV) per modal age and reader. The CV's are calculated as the ratio between the standard deviation ( $\sigma$ ) and mean value ( $\mu$ ) 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)

The Average Percentage Error (APE) was calculated based on the method outlined by Beamish & Fournier (1981). This method is dependent of fish age and thus provides a better estimate of precision than percentage agreement. 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:

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

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

## Relative bias

The relative bias is calculated as the difference between the mean and the modal age. This statistic is presented in first place by modal age and reader, but it is also calculated as an average value by modal age for all readers together (or only advanced readers).

### **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%. The age data was analysed only including the “advanced” readers. 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.

# 4 Analysis of age calibration exercise

## 4.1 Overview of samples and readers

**Table 4.1.1:** Overview of samples used for the xxx exchange.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2021	27.2.a	27.2.a	1	60	3-16	280-375 mm
2021	27.2.a	27.2.a	2	60	4-9	245-350 mm
2021	27.2.a	27.2.a	4	60	3-8	260-350 mm
2021	27.5.a	27.5.a	3	48	4-15	310-390 mm
2021	27.5.b	27.5.b	2	27	5-15	285-390 mm

**Table 4.1.2:** Reader overview.

Reader code	Expertise
R02 NO	Advanced
R04 NO	Advanced
R08 IS	Advanced
R14 NO	Advanced
R16 NO	Basic
R18 IS	Advanced
R24 NO	Advanced
R30 FO	Basic
R32 FO	Basic



# 4.2 Results

## 4.2.1 All readers

### All samples included

The weighted average percentage agreement based on modal ages for all readers is 80% (Table 4.2.1), with the weighted average CV of 9% (Table 4.2.2) and APE of 4%. The PA decreased from above 70% to below 60% at age 10 and older which is not reflected in the CV which is relative constant but slightly higher at the weighted mean. Figure 4.2.1 shows the age bias plot for all readers and reflects the results in Table 4.2.3. Individual reader bias plots can be found in 6. Annex 1.

**Table 4.2.1:** 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.

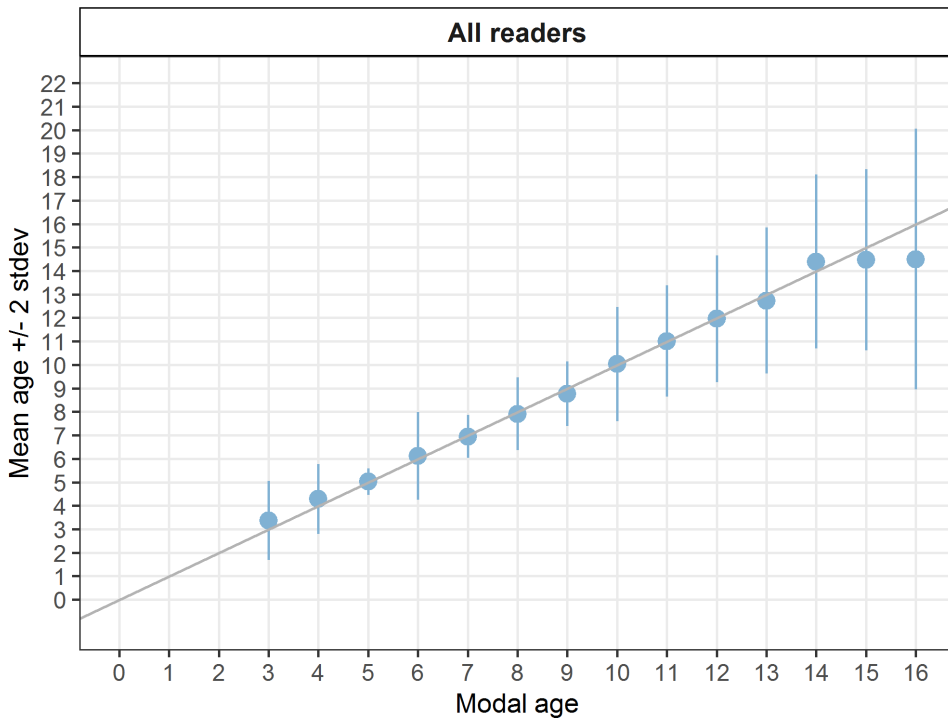
Modal age	R02 NO	R04 NO	R08 IS	R14 NO	R16 NO	R18 IS	R24 NO	R30 FO	R32 FO	all
3	67 %	100 %	100 %	67 %	67 %	100 %	33 %	33 %	67 %	<b>70 %</b>
4	83 %	100 %	83 %	33 %	100 %	83 %	50 %	80 %	33 %	<b>72 %</b>
5	96 %	98 %	98 %	98 %	80 %	96 %	97 %	90 %	88 %	<b>93 %</b>
6	100 %	100 %	86 %	100 %	57 %	100 %	86 %	75 %	88 %	<b>88 %</b>
7	70 %	95 %	85 %	90 %	70 %	85 %	95 %	80 %	70 %	<b>82 %</b>
8	77 %	77 %	92 %	94 %	41 %	93 %	90 %	49 %	51 %	<b>74 %</b>
9	86 %	71 %	86 %	100 %	67 %	86 %	86 %	29 %	43 %	<b>73 %</b>
10	50 %	50 %	88 %	50 %	57 %	100 %	62 %	38 %	38 %	<b>58 %</b>
11	43 %	75 %	89 %	70 %	50 %	50 %	29 %	22 %	40 %	<b>53 %</b>
12	67 %	60 %	33 %	50 %	44 %	64 %	71 %	30 %	36 %	<b>50 %</b>
13	29 %	75 %	86 %	57 %	14 %	80 %	60 %	29 %	29 %	<b>48 %</b>
14	0 %	67 %	67 %	0 %	0 %	0 %	0 %	67 %	67 %	<b>35 %</b>
15	50 %	57 %	25 %	100 %	14 %	62 %	100 %	38 %	25 %	<b>50 %</b>
16	0 %	0 %	100 %	0 %	100 %	-	0 %	0 %	0 %	<b>25 %</b>
<b>Weighted Mean</b>	<b>80 %</b>	<b>87 %</b>	<b>89 %</b>	<b>88 %</b>	<b>63 %</b>	<b>89 %</b>	<b>87 %</b>	<b>68 %</b>	<b>67 %</b>	<b>80 %</b>

**Table 4.2.2:** 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	R02 NO	R04 NO	R08 IS	R14 NO	R16 NO	R18 IS	R24 NO	R30 FO	R32 FO	all
3	31 %	0 %	0 %	17 %	17 %	0 %	25 %	33 %	43 %	<b>25 %</b>
4	10 %	0 %	11 %	11 %	0 %	11 %	12 %	11 %	28 %	<b>17 %</b>
5	5 %	3 %	3 %	3 %	10 %	4 %	3 %	6 %	9 %	<b>6 %</b>
6	0 %	0 %	6 %	0 %	12 %	0 %	6 %	24 %	31 %	<b>15 %</b>
7	10 %	3 %	8 %	5 %	7 %	6 %	3 %	6 %	8 %	<b>7 %</b>
8	9 %	8 %	5 %	8 %	12 %	3 %	5 %	13 %	16 %	<b>10 %</b>
9	4 %	6 %	4 %	0 %	7 %	4 %	4 %	10 %	12 %	<b>8 %</b>
10	18 %	10 %	4 %	9 %	11 %	0 %	9 %	11 %	19 %	<b>12 %</b>
11	17 %	8 %	6 %	4 %	15 %	7 %	6 %	12 %	13 %	<b>11 %</b>
12	7 %	7 %	6 %	14 %	8 %	10 %	9 %	11 %	17 %	<b>11 %</b>
13	18 %	7 %	6 %	10 %	19 %	7 %	8 %	11 %	13 %	<b>12 %</b>
14	10 %	4 %	13 %	-	4 %	0 %	0 %	4 %	18 %	<b>13 %</b>
15	12 %	8 %	11 %	0 %	23 %	6 %	0 %	18 %	13 %	<b>13 %</b>
16	-	-	-	-	-	-	-	-	-	<b>19 %</b>
<b>Weighted Mean</b>	<b>8 %</b>	<b>4 %</b>	<b>5 %</b>	<b>5 %</b>	<b>11 %</b>	<b>4 %</b>	<b>5 %</b>	<b>10 %</b>	<b>13 %</b>	<b>9 %</b>

**Table 4.2.3:** 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	R02 NO	R04 NO	R08 IS	R14 NO	R16 NO	R18 IS	R24 NO	R30 FO	R32 FO	all
3	0.67	0.00	0.00	0.33	0.33	0.00	1.00	0.00	1.00	<b>0.37</b>
4	0.17	0.00	-0.17	0.67	0.00	-0.17	0.50	0.20	1.33	<b>0.28</b>
5	0.02	0.00	0.00	0.00	0.10	0.00	0.03	0.01	0.05	<b>0.02</b>
6	0.00	0.00	-0.14	0.00	-0.14	0.00	0.14	0.38	0.75	<b>0.11</b>
7	-0.15	0.05	0.00	0.00	-0.30	0.05	0.05	-0.10	-0.10	<b>-0.06</b>
8	-0.26	-0.06	-0.06	0.14	-0.45	0.02	0.08	-0.30	0.06	<b>-0.09</b>
9	-0.14	0.00	-0.14	0.00	0.00	0.14	0.14	-1.00	-1.00	<b>-0.22</b>
10	0.50	-0.12	-0.12	0.38	0.43	0.00	0.62	-0.88	-0.50	<b>0.03</b>
11	-0.57	-0.12	0.22	0.30	0.00	0.70	0.86	-0.89	-0.40	<b>0.01</b>
12	-0.22	-0.10	-0.44	0.50	0.56	0.73	0.57	-0.70	-1.00	<b>-0.01</b>
13	-0.57	0.50	-0.29	0.29	-0.29	0.40	0.20	-0.86	-1.14	<b>-0.20</b>
14	3.00	-0.33	-1.00	-1.00	2.50	1.00	1.00	-0.33	-1.33	<b>0.39</b>
15	-0.12	-0.43	-1.00	0.00	1.00	-0.25	0.00	-1.75	-1.75	<b>-0.48</b>
16	-4.00	-2.00	0.00	1.00	0.00	-	1.00	-1.00	-7.00	-
<b>Weighted Mean</b>	<b>-0.05</b>	<b>-0.04</b>	<b>-0.09</b>	<b>0.10</b>	<b>0.00</b>	<b>0.08</b>	<b>0.15</b>	<b>-0.25</b>	<b>-0.14</b>	<b>-0.02</b>



**Figure 4.2.1:** 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 man 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.

## 4.2.2 Advanced readers

### All samples included

For advanced readers only, the weighted average percentage agreement based on modal ages is 88% (Table 4.2.4), with the weighted average CV of 6% (Table 4.2.5) and APE of 3%. Again, the PA decreased from above 75% to below 65% at age 10 and older which is not reflected in the CV which is relative constant but slightly higher at the weighted mean. Figure 4.2.2 shows the age bias plot for all readers and reflects the results in Table 4.2.6.

**Table 4.2.4:** 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. A rank is also assigned to each reader.

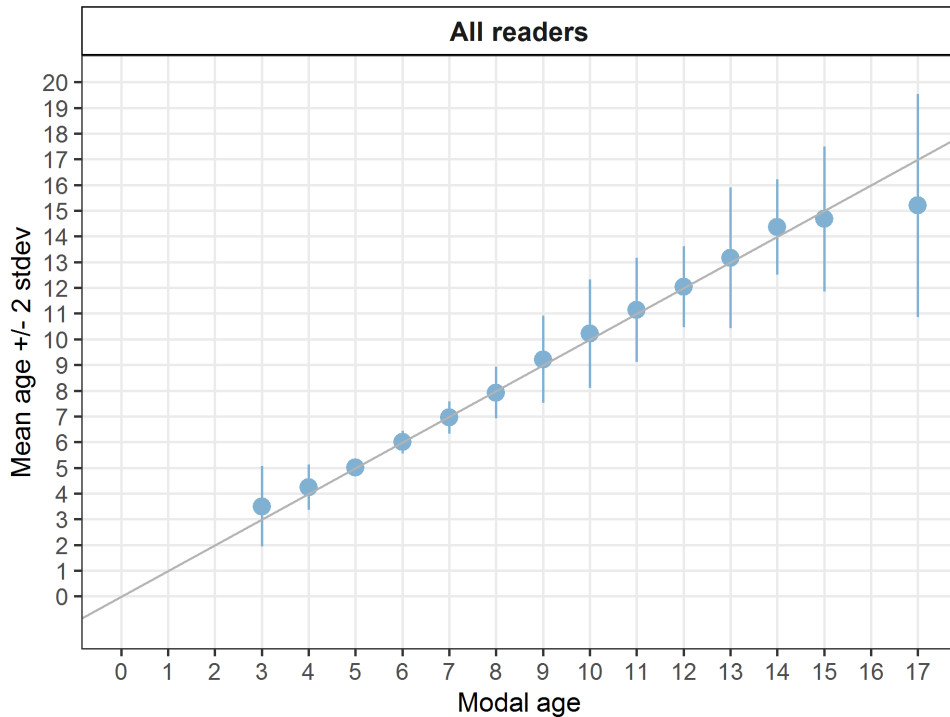
Modal age	R02 NO	R04 NO	R08 IS	R14 NO	R18 IS	R24 NO	all
3	50 %	75 %	100 %	50 %	100 %	25 %	<b>67 %</b>
4	67 %	83 %	100 %	50 %	100 %	50 %	<b>75 %</b>
5	95 %	98 %	99 %	99 %	97 %	97 %	<b>98 %</b>
6	100 %	100 %	86 %	100 %	100 %	86 %	<b>95 %</b>
7	72 %	100 %	94 %	94 %	94 %	100 %	<b>93 %</b>
8	73 %	77 %	94 %	94 %	96 %	90 %	<b>87 %</b>
9	67 %	56 %	88 %	89 %	78 %	75 %	<b>75 %</b>
10	50 %	50 %	88 %	50 %	100 %	62 %	<b>65 %</b>
11	43 %	83 %	88 %	78 %	62 %	40 %	<b>67 %</b>
12	67 %	70 %	27 %	60 %	82 %	75 %	<b>63 %</b>
13	33 %	100 %	67 %	80 %	80 %	60 %	<b>68 %</b>
14	0 %	100 %	100 %	0 %	50 %	0 %	<b>36 %</b>
15	44 %	50 %	22 %	100 %	70 %	100 %	<b>62 %</b>
16	-	-	-	-	-	-	-
17	0 %	0 %	0 %	100 %	-	100 %	<b>40 %</b>
<b>Weighted Mean</b>	<b>78 %</b>	<b>86 %</b>	<b>89 %</b>	<b>90 %</b>	<b>93 %</b>	<b>88 %</b>	<b>88 %</b>

**Table 4.2.5:** 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	R02 NO	R04 NO	R08 IS	R14 NO	R18 IS	R24 NO	all
3	26 %	15 %	0 %	26 %	0 %	23 %	<b>22 %</b>
4	12 %	10 %	0 %	12 %	0 %	12 %	<b>10 %</b>
5	5 %	3 %	2 %	2 %	3 %	3 %	<b>3 %</b>
6	0 %	0 %	6 %	0 %	0 %	6 %	<b>4 %</b>
7	8 %	0 %	7 %	3 %	3 %	0 %	<b>5 %</b>
8	11 %	7 %	4 %	6 %	3 %	4 %	<b>6 %</b>
9	13 %	7 %	4 %	7 %	14 %	5 %	<b>9 %</b>
10	18 %	10 %	4 %	9 %	0 %	9 %	<b>10 %</b>
11	17 %	8 %	6 %	4 %	8 %	5 %	<b>9 %</b>
12	7 %	5 %	7 %	9 %	5 %	4 %	<b>7 %</b>
13	21 %	0 %	8 %	7 %	7 %	8 %	<b>10 %</b>
14	15 %	-	0 %	10 %	5 %	0 %	<b>6 %</b>
15	15 %	7 %	13 %	0 %	5 %	0 %	<b>10 %</b>
16	-	-	-	-	-	-	-
17	-	-	-	-	-	-	<b>14 %</b>
<b>Weighted Mean</b>	<b>9 %</b>	<b>4 %</b>	<b>4 %</b>	<b>4 %</b>	<b>4 %</b>	<b>4 %</b>	<b>6 %</b>

**Table 4.2.6:** 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. A rank is also assigned to each reader.

Modal age	R02 NO	R04 NO	R08 IS	R14 NO	R18 IS	R24 NO	all
3	0.75	0.25	0.00	0.75	0.00	1.25	<b>0.50</b>
4	0.33	0.17	0.00	0.50	0.00	0.50	<b>0.25</b>
5	0.02	0.00	0.01	0.01	0.01	0.03	<b>0.01</b>
6	0.00	0.00	-0.14	0.00	0.00	0.14	<b>0.00</b>
7	-0.06	0.00	-0.11	-0.06	-0.06	0.00	<b>-0.05</b>
8	-0.33	-0.12	-0.08	0.06	0.00	0.02	<b>-0.08</b>
9	0.11	0.22	-0.12	0.22	0.56	0.25	<b>0.21</b>
10	0.50	-0.12	-0.12	0.38	0.00	0.62	<b>0.21</b>
11	-0.57	-0.33	0.25	0.22	0.62	0.60	<b>0.13</b>
12	-0.22	-0.10	-0.36	0.40	0.27	0.25	<b>0.04</b>
13	0.17	0.00	-0.17	0.40	0.40	0.20	<b>0.17</b>
14	0.50	0.00	0.00	0.00	0.50	1.00	<b>0.33</b>
15	0.22	-0.60	-1.44	0.00	0.00	0.00	<b>-0.30</b>
16	-	-	-	-	-	-	-
17	-5.00	-3.00	-1.00	0.00	-	0.00	-
<b>Weighted Mean</b>	<b>-0.05</b>	<b>-0.06</b>	<b>-0.10</b>	<b>0.09</b>	<b>0.07</b>	<b>0.12</b>	<b>0.02</b>



**Figure 4.2.2:** Age bias plot for advanced readers.

**Table 4.2.7:** General Age error matrix (AEM). The modal age is in rows and the age classifications by the advanced readers in columns. Only advanced readers are used for calculating the AEM.

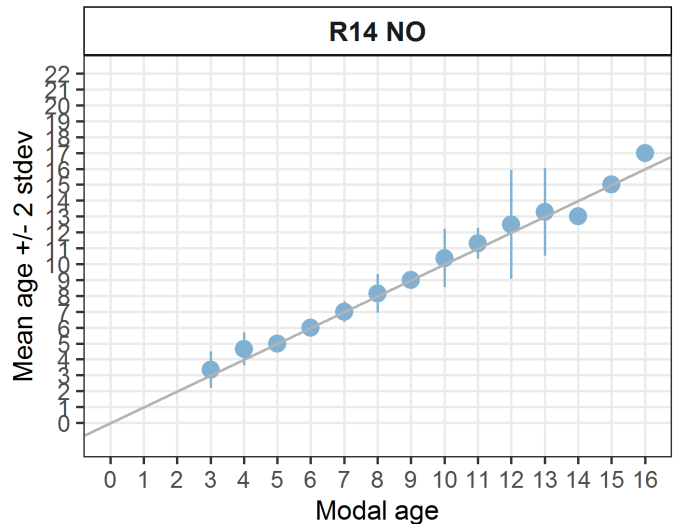
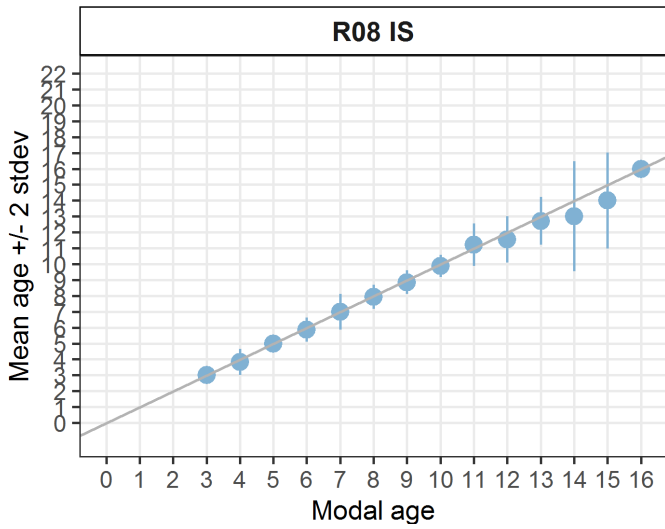
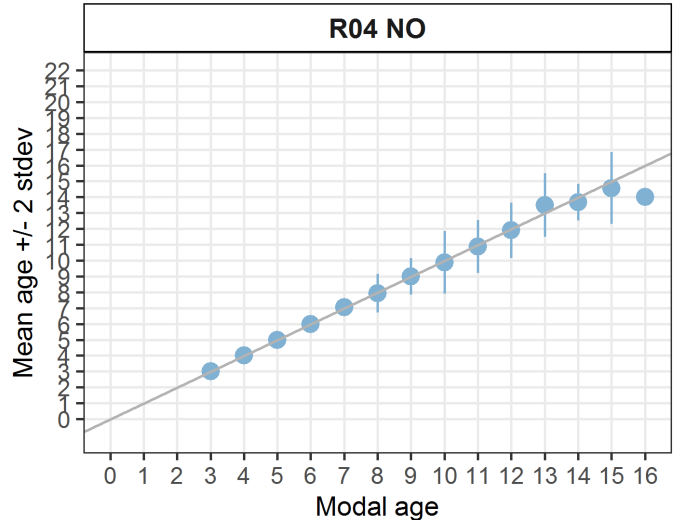
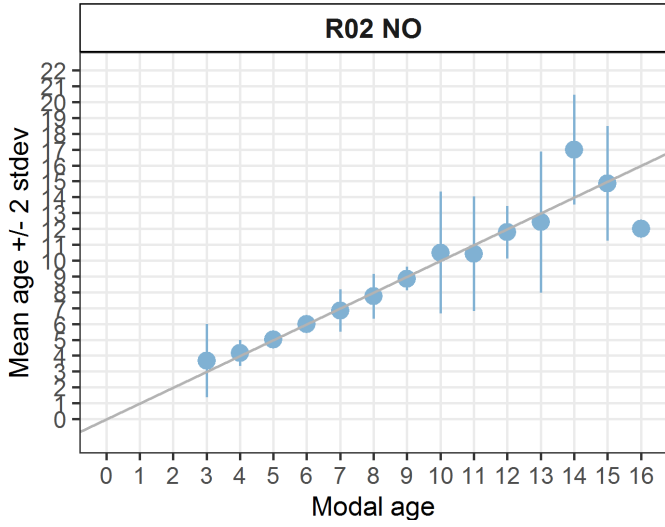
Modal age	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
3	0.7	0.2	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
4	-	0.8	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
5	-	0.0	1.0	0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	1
6	-	-	0.0	0.9	0.0	-	-	-	-	-	-	-	-	-	-	-	-	1
7	-	-	0.0	0.0	0.9	0.0	-	-	-	-	-	-	-	-	-	-	-	1
8	-	-	0.0	0.0	0.1	0.9	0.0	-	0.0	-	-	-	-	-	-	-	-	1
9	-	-	-	-	-	0.1	0.8	0.1	0.0	0.0	0.0	-	-	-	-	-	-	1
10	-	-	-	-	-	0.0	0.1	0.7	0.1	0.1	-	-	0.0	-	-	-	-	1
11	-	-	-	-	0.0	-	0.0	-	0.7	0.2	0.1	-	-	-	-	-	-	1
12	-	-	-	-	-	-	-	0.0	0.2	0.6	0.1	0.0	0.0	-	-	-	-	1
13	-	-	-	-	-	0.0	-	-	0.0	0.0	0.7	0.1	0.1	0.0	-	-	-	1
14	-	-	-	-	-	-	-	-	-	-	0.2	0.4	0.4	0.1	-	-	-	1
15	-	-	-	-	-	-	-	-	0.0	0.0	0.1	0.1	0.6	0.1	-	0	0	1
17	-	-	-	-	-	-	-	-	-	0.2	-	0.2	-	0.2	0.4	-	-	1

# 5 References

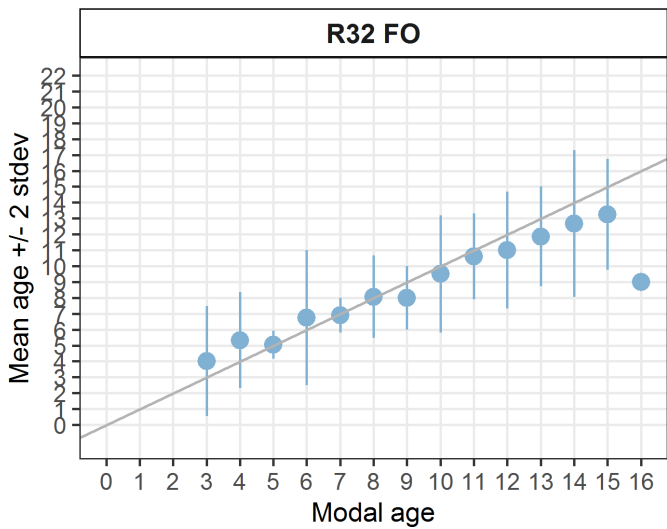
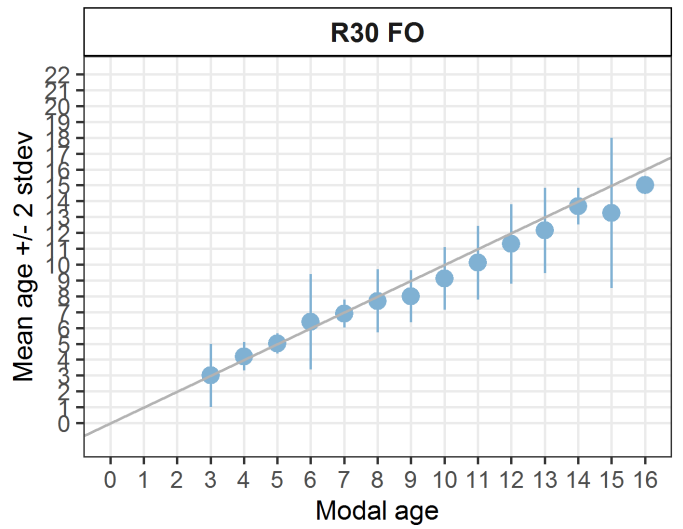
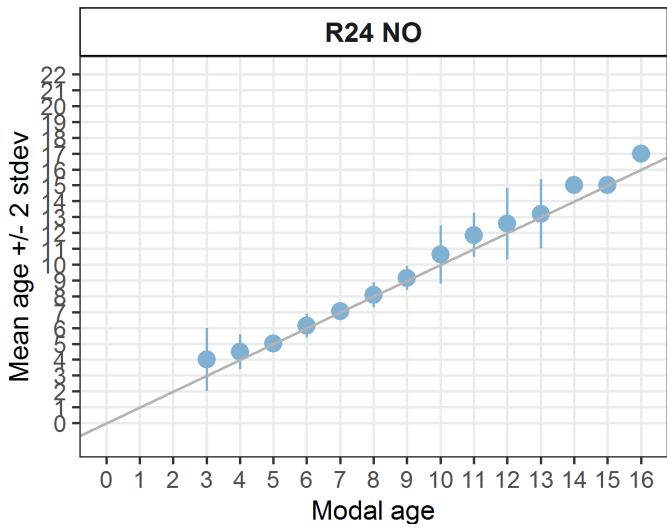
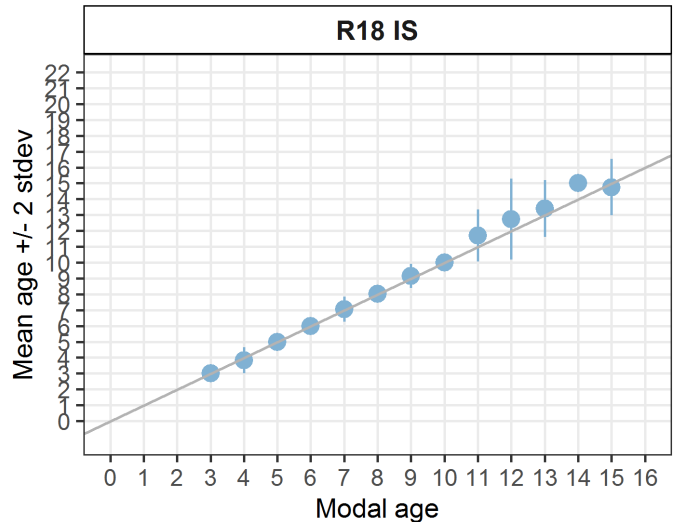
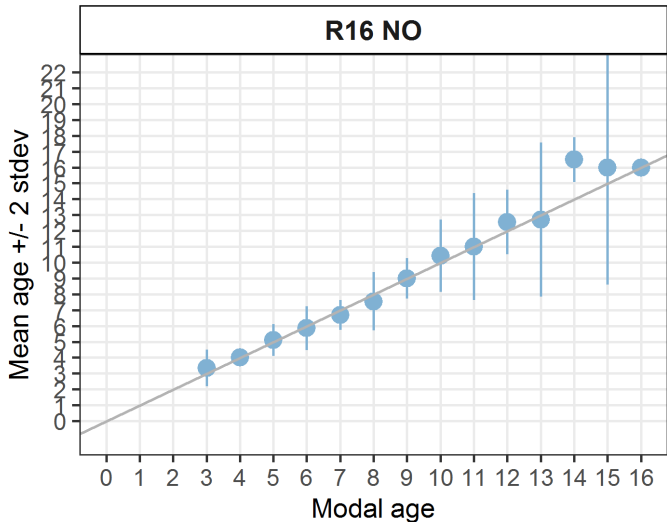
- Beamish R. J. and Fournier D. A. (1981) A method for comparing the precision of a set of age determination. *Canadian Journal of Fisheries and Aquatic Sciences*, 38, 982–983
- Eltink G. W. (2000) Age reading comparisons. (MS Excel workbook version 1.0 October 2000)
- ICES (2014) Report of the Workshop on Statistical Analysis of Biological Calibration Studies (WKSABCAL). ICES CM 2014/ACOM:35

# 6 Annex 1. Additional results

# 6.1 Results all readers







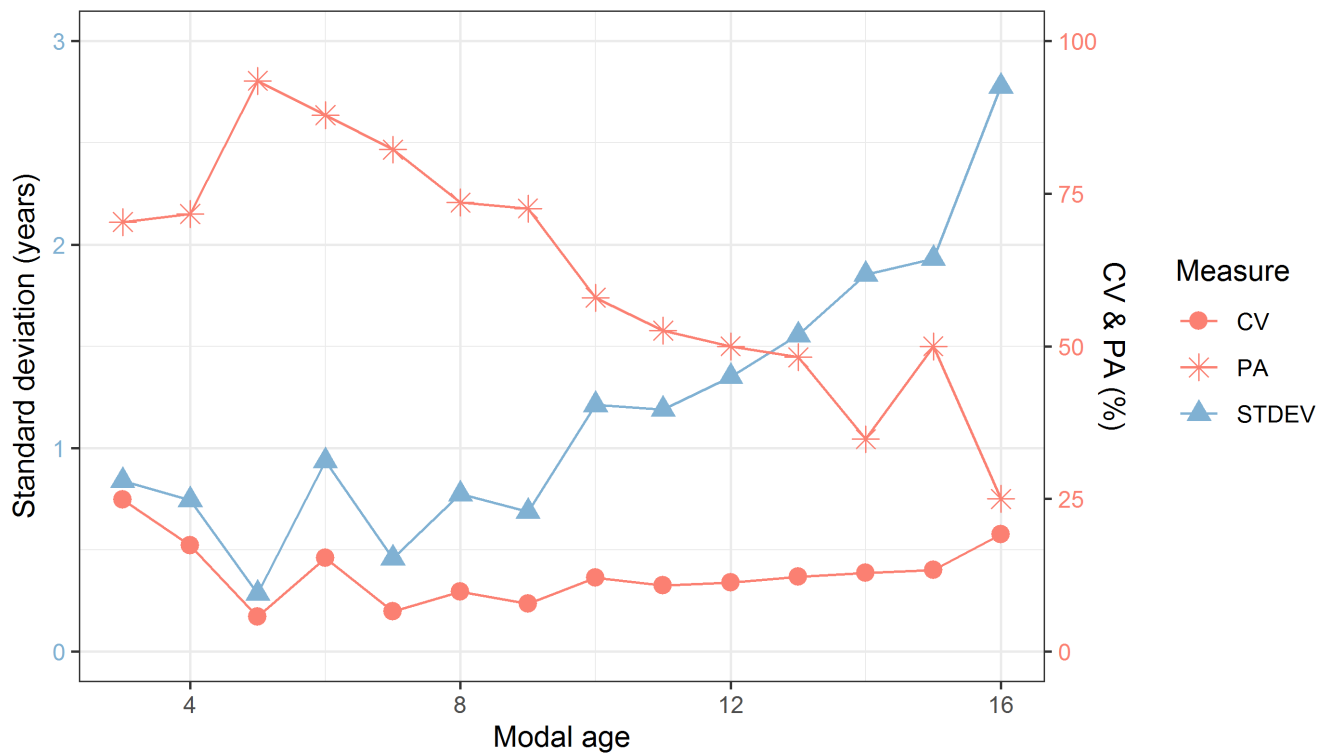


Figure 6.1.1: CV, PA and (STDEV (standard deviation) are plotted against modal age

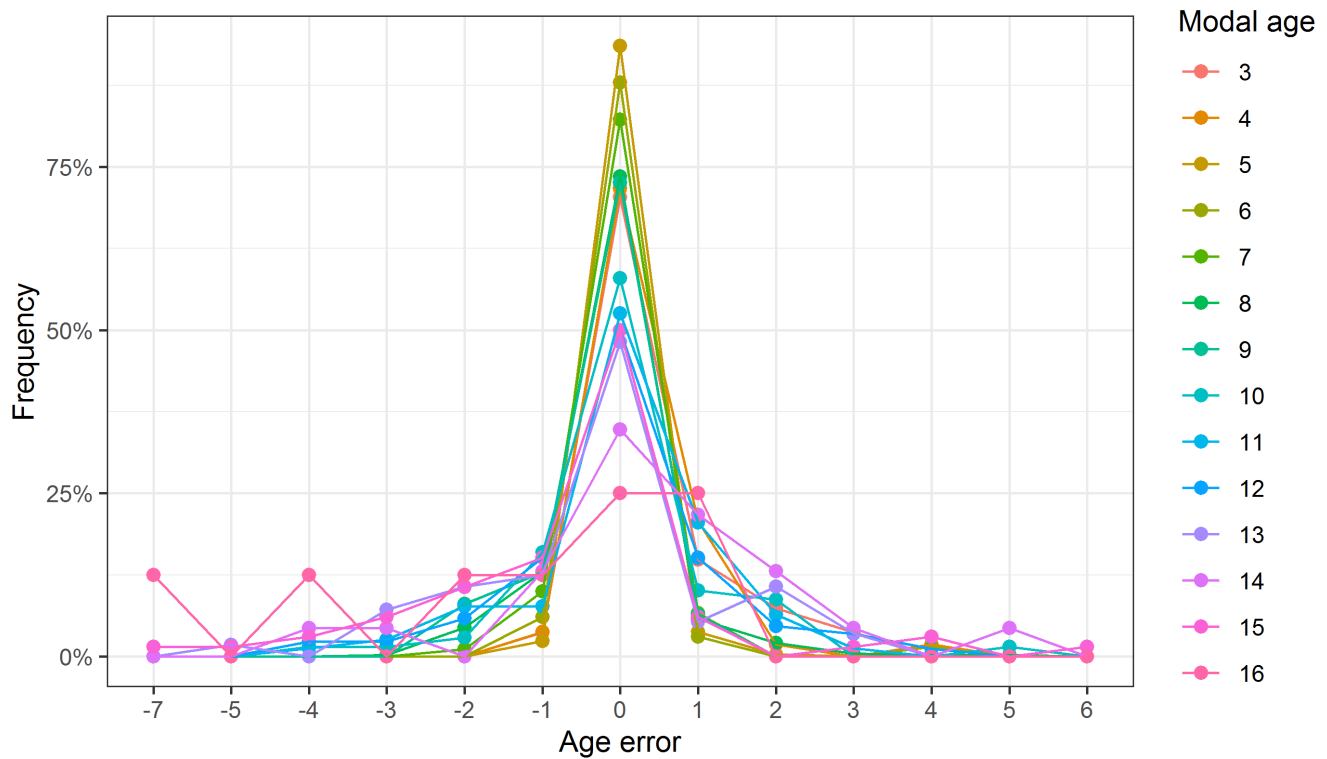


Figure 6.1.2: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age.

## 6.2 Results Advanced readers

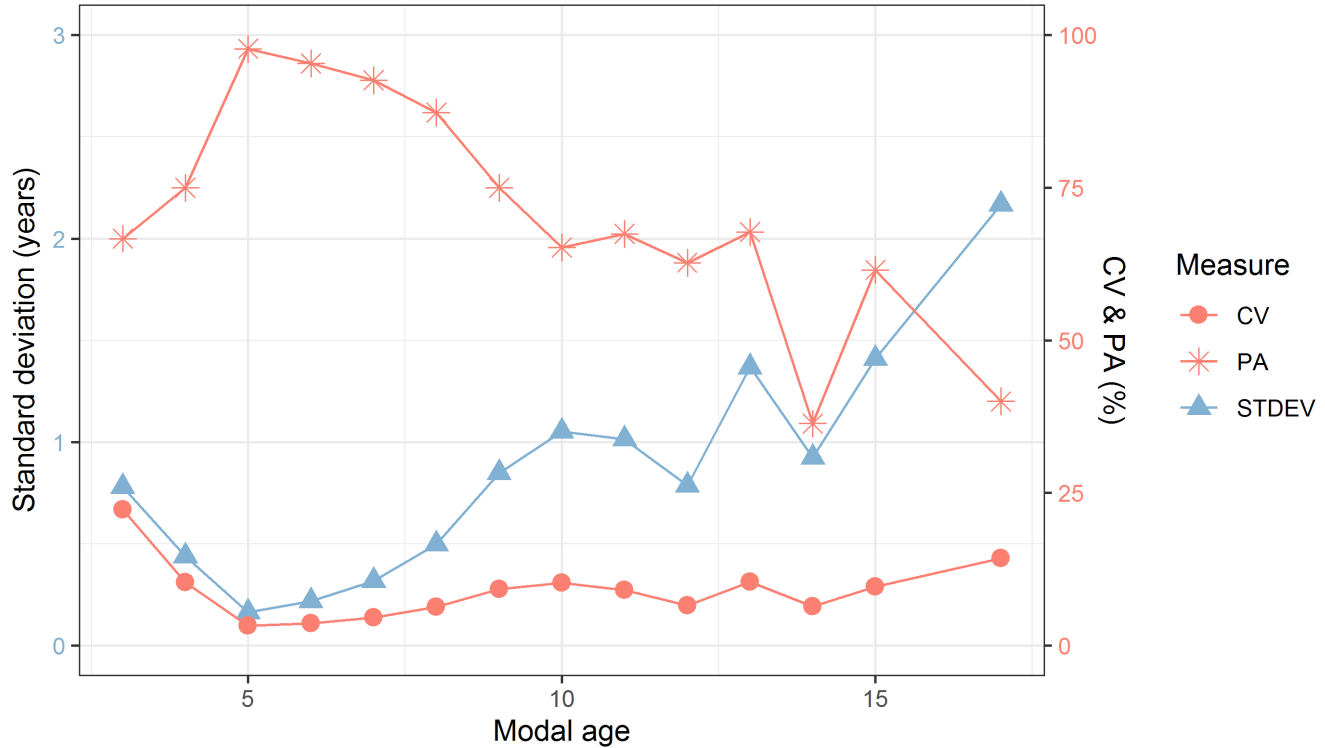


Figure 6.2.1: CV, PA and (STDEV (standard deviation) are plotted against modal age

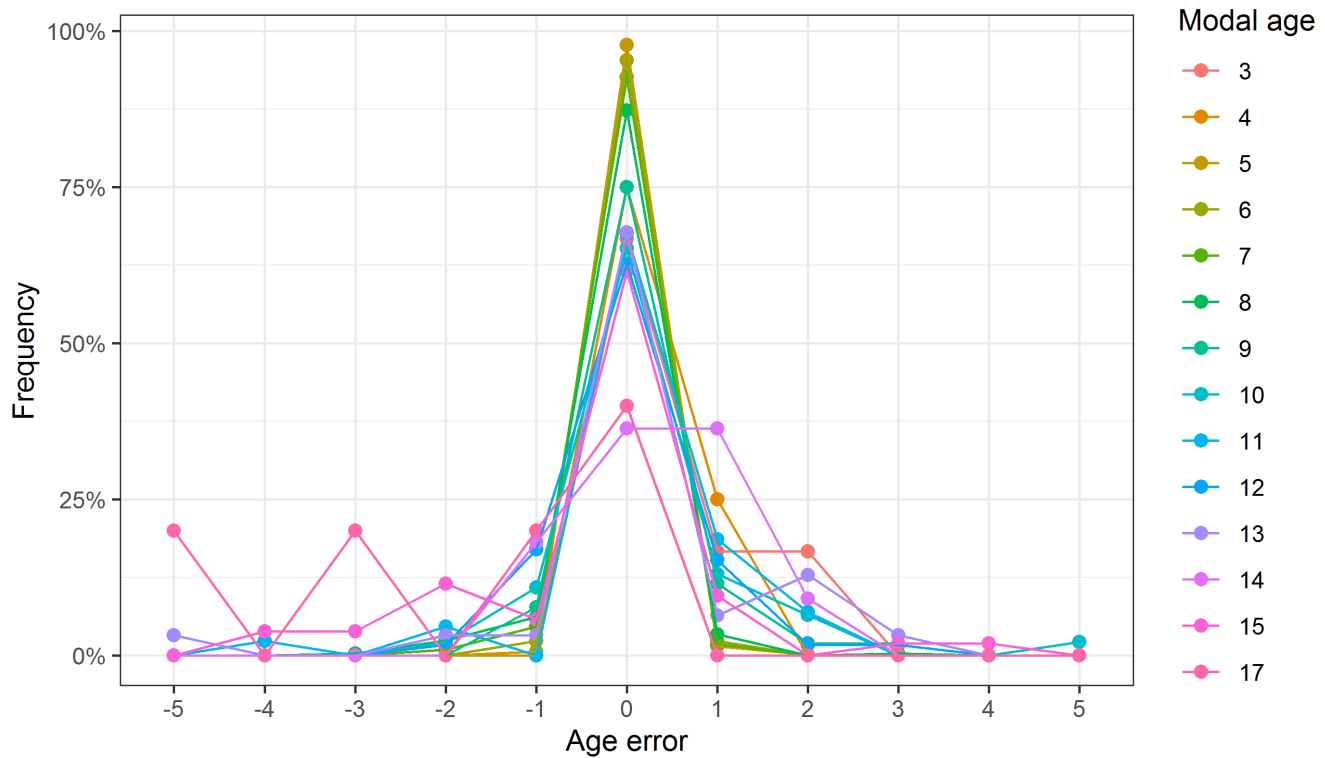


Figure 6.2.2: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age.