Report of the 2022 Greenland halibut (*Reinhardtius hippoglossoides*) age reading exchange (Event 436)

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1 Executive summary

The Greenland halibut stocks are up for benchmark in February 2023 and the assessment of the North-eastern Atlantic stock of Greenland halibut at ICES Arctic Fisheries Working Group (AFWG) is to be updated with age data. To do this, we need to assess the method used to determine ages of Greenland halibut. Age readers from three countries participated in this exchange: Norway, Island, and the Faroe Islands. No physical otoliths were exchanged between readers. Instead, images of otoliths were sent in from Norway, Iceland, Greenland, and Faroe Islands. All images were taken of the whole, right otolith but unfortunately, the procedures of photography varied between the countries. Nonetheless, the results are presented as graphs and tables with percentage agreement (PA), Co-efficient of Variation (CV), and Average Percentage Error (APE). The overall CV of 36 % for all readers and 25 % for advanced readers is too high. There is also a bias, particularly for younger fish. An international workshop should therefore be planned, preferably within two years.

2 Agenda and participant list

The Gadget assessment model for the North-eastern Atlantic stock of Greenland halibut at ICES Arctic Fisheries Working Group (AFWG) needs to be updated to follow the principles of transparency and reproducibility. At the same time, we aim to upgrade the model engine to use gadget3 to include age data. To include age data, we need to assess the method used to determine age.

The PGCCDBS Guidelines for Otolith Exchanges recommends that all the Age Reading Coordinators listed in the contact list updated by PGCCDBS annually are contacted and asked if their readers want to participate in the exchange. Due to the political situation in Ukraine, the age readers from Russia were not invited to the exchange. All the coordinators contacted replied that they wanted to participate in the exchange. We received otolith images from all countries, but unfortunately the readers from Greenland were not able to prioritize the exchange and have not participated beyond sending images. Participants' affiliations and e-mail addresses are given in table 2.1.

Table 2.1: List of participants, institute and Country, email address.

Name	**Institute/Country**	**e-mail**
Auður Bjarnadóttir	HAFRO/Island	audur.bjarnadottir@hafogvatn.is
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Petur Steingrund	Havstovan/Færøyene	peturs@hav.fo
Gunn Hansen	Havstovan/Færøyene	gunnh@hav.fo
Marit Pedersen	Havstovan/Færøyene	maritp@hav.fo
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3 Introduction

During WKARGH in 2011, several age reading methods for Greenland Halibut were described and evaluated. The different methods can be classified into two groups: A) Those that produce age-length relationships that broadly compare with the traditional methods described by the joint NAFO-ICES workshop in 1996 (ICES, 1997), typically indicating age around 10-12 years for 70 cm fish; and B) Several recently developed techniques that provide much higher longevity and approximately half the growth rate from 40-50 cm onwards compared to the traditional method. These typically produce age estimates around 20 years or more for 70 cm fish. All available validation and corroboration results, both several published and a few unpublished, were in favour of group B methods. Norway, Iceland, Greenland, and Faroe Islands now read otoliths using a type B method. In this report we will look at the results of an otolith exchange that aims to determine if the method used gives consistent result between different readers and countries.

In this exchange, all age readings were done using images of the whole, right otolith. No physical otoliths were exchanged between readers. Participating countries were Norway, Iceland, Greenland, and Faroe Islands. All countries were asked to provide two images per 5 cm length group. This resulted in 68 images from Norway (28 to 108 cm), 40 images from Island (10 to 108 cm), 14 images from Faroe Islands (32 to 74 cm) and 32 images from Greenland (13 to 87 cm). To test the readings of individual readers against themselves, 10 of the Norwegian images were added twice. Upon opening the event it was clear that the otoliths were not photographed using the exact same procedure as anticipated. Norway and Iceland use images of otoliths photographed with transmitted light and proximal (concave) side up. Greenland also uses transmitted light, but the otoliths are photographed with the proximal side down. Faroe Island takes pictures with the proximal side up, like Norway and Iceland, but they use reflected light, not transmitted. This should be kept in mind, when interpreting the results. In this report, the results from statistical analysis and comparisons of age readings are presented in tables and graphs produced by SmartDots.

4 Methods

This report contains statistical analyses and comparisons of age readings in the form of tables and graphical plots.

The first part of analysis presents tables and plots from the Guus Eltink Excel sheet 'Age Reading Comparisons' **(Eltink, A.T.G.W. 2000)**.

Percentage Agreement

Percent agreement may be expressed as the percentage of the number of observations showing similar age estimates (as the modal age) to the total number of observations on age estimates.

Co-efficient of Variation (CV)

The table presents the cv per modal age and reader. The CV is 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%. The age data was analysed twice, the first time all readers were included and the second time only the “advanced” readers were included. 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 readers who provide age data for the stock assessment in that specific area.

5 Results

5.1 Overview of samples and readers

An overview of the samples, including sample year, area, strata, quarter, number of samples, modal age, and length range are presented in table 5.1. Participants and their experience level is listed in table 5.2.

Table 5.1: Overview of samples used for the exchange.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2010	21.1.a	21.1.a	3	4	12-27	770-870 mm
2013	21.1.d	21.1.d	3	2	14-15	800-820 mm
2015	27.2.b.2	27.2.b.2	4	2	17	1040 mm
2016	27.5.a	27.5.a	3	2	1-2	170-230 mm
2016	27.5.a	27.5.a	4	1	17	1020 mm
2017	27.2.a.2	27.2.a.2	3	1	25	1080 mm
2017	27.2.b.2	27.2.b.2	3	4	3-17	285-1050 mm
2017	27.5.a	27.5.a	4	1	3	270 mm
2018	27.5.a	27.5.a	4	1	17	1010 mm
2019	27.2.a.2	27.2.a.2	3	34	4-22	340-1030 mm
2019	27.2.b.2	27.2.b.2	3	3	17-22	860-950 mm
2020	21.1.a	21.1.a	2	14	1-13	130-500 mm
2020	21.1.b	21.1.b	2	4	2-9	230-510 mm
2020	27.5.a	27.5.a	1	1	13	530 mm
2020	27.5.a	27.5.a	4	30	1-27	270-1080 mm
2021	21.1.a	21.1.a	2	1	7	700 mm
2021	21.1.a	21.1.a	3	6	7-15	580-700 mm
2021	27.5.a	27.5.a	4	2	3-14	350-1000 mm
2022	27.5.b	27.5.b	2	14	6-16	325-740 mm

Table 5.2: Reader overview.

Reader code	Expertise
R01 NO	Advanced
R02 IS	Advanced
R03 NO	Advanced
R04 NO	Advanced
R05 FO	Basic
R06 FO	Basic
R07 FO	Basic
R08 FO	Basic

5.2 Results

5.2.1 All readers

All samples included

The exchange otoliths were read by 8 readers from 3 different institutes. Of the readers, 4 were set as experienced readers (advanced). The remaining four readers were classed as inexperienced (basic). The result of each reader is compared to the modal age.

The results of the age reading exchange for Greenland halibut showed that the weighted average CV of all readers was 36 % (table 5.3), the weighted average percentage agreement (PA) was 30 % (table 5.4). There was a positive bias for smaller individuals and a negative bias for larger individuals (table 5.5).

Age bias plot for the mean of all readers is presented in figure 5.1. Bias plots for individual readers are given in appendix (figure 9.1). The mean of all readers showed a positive bias (overestimating ages) for the smaller modal age and a negative bias (underestimating ages) for the higher modal ages. The advanced readers have bias of 2.10 or less, while the basic readers have a much higher bias.

Table 5.3: 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 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO	all
1	82 %	54 %	0 %	0 %	40 %	61 %	43 %	45 %	**83 %**
2	0 %	23 %	0 %	20 %	25 %	16 %	16 %	24 %	**65 %**
3	57 %	14 %	25 %	14 %	25 %	25 %	20 %	27 %	**60 %**
4	17 %	0 %	43 %	20 %	20 %	16 %	13 %	15 %	**53 %**
5	21 %	11 %	17 %	20 %	14 %	17 %	9 %	12 %	**46 %**
6	24 %	11 %	13 %	11 %	19 %	18 %	23 %	20 %	**38 %**
7	31 %	23 %	32 %	23 %	22 %	29 %	18 %	31 %	**42 %**
8	20 %	13 %	0 %	14 %	17 %	12 %	31 %	19 %	**30 %**
9	9 %	24 %	8 %	16 %	21 %	12 %	32 %	19 %	**31 %**
10	14 %	15 %	13 %	9 %	16 %	18 %	26 %	12 %	**26 %**
11	13 %	26 %	15 %	12 %	23 %	10 %	15 %	14 %	**28 %**
12	11 %	20 %	27 %	19 %	29 %	14 %	24 %	18 %	**29 %**
13	25 %	41 %	23 %	32 %	21 %	25 %	22 %	7 %	**34 %**
14	10 %	16 %	7 %	11 %	27 %	17 %	18 %	3 %	**26 %**
15	13 %	30 %	20 %	16 %	31 %	21 %	22 %	19 %	**29 %**
16	3 %	26 %	16 %	19 %	14 %	17 %	28 %	8 %	**25 %**
17	9 %	13 %	16 %	17 %	20 %	16 %	12 %	23 %	**23 %**
18	15 %	18 %	4 %	7 %	9 %	-	19 %	8 %	**19 %**
19	12 %	20 %	11 %	16 %	22 %	19 %	14 %	5 %	**24 %**
20	-	-	-	-	-	-	-	-	**26 %**
21	-	-	-	-	-	-	-	-	**11 %**
22	7 %	5 %	19 %	0 %	6 %	8 %	13 %	3 %	**17 %**
23	-	-	-	-	-	-	-	-	**23 %**
24	-	-	-	-	-	-	-	-	**-**
25	-	15 %	4 %	3 %	0 %	-	0 %	22 %	**20 %**
26	-	-	-	-	-	-	-	-	**-**
27	16 %	30 %	4 %	10 %	49 %	0 %	0 %	22 %	**29 %**
Weighted Mean	**20 %**	**23 %**	**16 %**	**16 %**	**22 %**	**20 %**	**21 %**	**18 %**	**36 %**

Table 5.4: 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 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO	all
1	83 %	33 %	100 %	100 %	0 %	0 %	0 %	0 %	**40 %**
2	100 %	60 %	100 %	80 %	0 %	0 %	0 %	0 %	**44 %**
3	0 %	80 %	60 %	80 %	0 %	0 %	0 %	0 %	**28 %**
4	0 %	100 %	67 %	33 %	0 %	0 %	0 %	0 %	**25 %**
5	0 %	67 %	33 %	67 %	0 %	0 %	0 %	0 %	**21 %**
6	50 %	67 %	83 %	67 %	29 %	0 %	0 %	0 %	**37 %**
7	50 %	55 %	50 %	30 %	9 %	0 %	0 %	0 %	**24 %**
8	50 %	50 %	100 %	25 %	0 %	0 %	0 %	0 %	**28 %**
9	67 %	17 %	17 %	67 %	50 %	0 %	17 %	0 %	**30 %**
10	29 %	57 %	71 %	57 %	29 %	0 %	14 %	0 %	**32 %**
11	80 %	20 %	40 %	80 %	40 %	0 %	0 %	40 %	**38 %**
12	33 %	50 %	33 %	50 %	17 %	0 %	17 %	33 %	**29 %**
13	58 %	0 %	58 %	33 %	42 %	0 %	8 %	42 %	**31 %**
14	22 %	44 %	44 %	33 %	33 %	0 %	0 %	78 %	**32 %**
15	62 %	12 %	25 %	50 %	0 %	0 %	0 %	50 %	**25 %**
16	67 %	17 %	33 %	20 %	33 %	0 %	17 %	50 %	**30 %**
17	44 %	50 %	56 %	33 %	33 %	0 %	0 %	44 %	**32 %**
18	0 %	50 %	50 %	50 %	0 %	0 %	0 %	50 %	**27 %**
19	75 %	25 %	50 %	0 %	25 %	0 %	0 %	25 %	**25 %**
20	0 %	0 %	0 %	0 %	0 %	100 %	0 %	100 %	**25 %**
21	0 %	0 %	0 %	100 %	100 %	0 %	100 %	0 %	**38 %**
22	50 %	0 %	0 %	100 %	0 %	0 %	0 %	50 %	**25 %**
23	0 %	0 %	0 %	100 %	0 %	100 %	0 %	0 %	**25 %**
24	-	-	-	-	-	-	-	-	**-**
25	0 %	0 %	0 %	0 %	100 %	0 %	100 %	0 %	**29 %**
26	-	-	-	-	-	-	-	-	**-**
27	0 %	0 %	0 %	0 %	50 %	100 %	100 %	0 %	**31 %**
Weighted Mean	**47 %**	**38 %**	**51 %**	**48 %**	**23 %**	**3 %**	**8 %**	**25 %**	**30 %**

Table 5.5: 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 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO	all
1	0.50	1.17	0.00	0.00	4.67	2.17	5.83	4.83	**2.40**
2	0.00	0.40	0.00	0.20	5.20	3.20	8.00	4.80	**2.72**
3	0.40	0.20	0.60	0.20	5.80	3.60	10.00	6.60	**3.42**
4	2.00	0.00	1.33	1.00	6.67	5.67	12.33	11.33	**5.04**
5	2.33	0.33	1.00	0.67	7.00	5.00	12.67	9.00	**4.75**
6	1.33	0.00	0.33	0.00	1.43	4.83	8.33	5.00	**2.66**
7	0.90	-0.82	1.20	-0.20	4.55	6.60	9.64	6.09	**3.49**
8	1.25	-0.75	0.00	1.25	3.25	5.75	7.00	3.75	**2.69**
9	0.50	-2.33	1.33	-0.33	1.67	6.20	5.00	3.83	**1.98**
10	2.14	-0.57	0.86	0.29	1.86	7.00	5.29	4.86	**2.71**
11	-0.60	-2.00	-0.20	0.60	1.80	7.60	5.00	2.00	**1.78**
12	0.83	-1.67	-1.00	-0.33	2.00	6.17	6.50	1.83	**1.79**
13	-1.25	-4.75	-0.75	-1.83	2.58	3.55	6.67	0.67	**0.61**
14	1.00	-1.33	0.56	-0.44	3.56	8.00	7.44	0.22	**2.38**
15	1.00	-3.25	0.25	-1.00	4.88	7.29	5.50	2.75	**2.18**
16	0.33	-3.50	-0.17	-0.40	3.33	5.80	5.50	0.17	**1.38**
17	1.33	-0.38	1.56	0.78	4.89	9.00	8.56	2.00	**3.47**
18	1.00	-2.00	-0.50	1.00	6.50	8.00	4.00	-1.00	**2.12**
19	1.25	-4.00	0.25	-0.50	4.50	8.75	8.00	1.50	**2.47**
20	-3.00	-9.00	-4.00	-5.00	-6.00	0.00	6.00	0.00	**-2.62**
21	-2.00	-4.00	1.00	0.00	0.00	3.00	0.00	-3.00	**-0.62**
22	-1.00	-7.50	0.00	0.00	0.00	3.50	4.50	-0.50	**-0.12**
23	-3.00	-9.00	-7.00	0.00	-4.00	0.00	6.00	-5.00	**-2.75**
24	-	-	-	-	-	-	-	-	**-**
25	-8.00	-10.50	-7.50	-4.50	0.00	-2.00	0.00	-6.00	**-4.81**
26	-	-	-	-	-	-	-	-	**-**
27	-5.50	-13.00	-9.50	-13.00	-7.00	0.00	0.00	-8.00	**-7.00**
Weighted Mean	**0.44**	**-2.10**	**-0.02**	**-0.47**	**3.26**	**5.67**	**6.97**	**2.82**	**2.07**

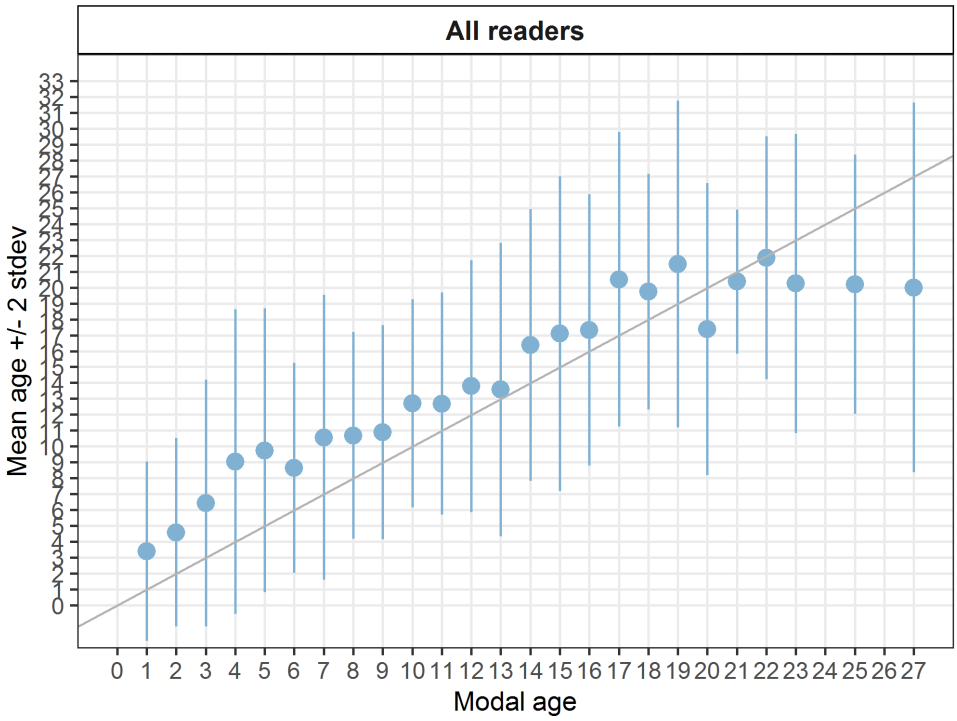

Figure 5.1: Age bias plot for all readers. Mean age recorded +/- 2 st. dev. of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

The bias of each reader against each other is presented in table 5.6. There is certainty of bias between all reader-combination except for reader R01NO-R03NO and R03NO-R04NO. With respect to the modal age, there is no sign of bias for two of the readers. All the other participants have certainty of bias compared to model age.

Table 5.6: Inter reader bias test. The Inter-reader bias test gives probability of bias between readers and with modal age. - = no sign of bias (p>0.05), * = possibility of bias (0.01<p<0.05), * * = certainty of bias (p<0.01)

Comparison	R01 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO
R01 NO	-	**	*	**	**	**	**	**
R02 IS	**	-	**	**	**	**	**	**
R03 NO	*	**	-	*	**	**	**	**
R04 NO	**	**	*	-	**	**	**	**
R05 FO	**	**	**	**	-	**	**	-
R06 FO	**	**	**	**	**	-	**	**
R07 FO	**	**	**	**	**	**	-	**
R08 FO	**	**	**	**	-	**	**	-
Modal age	**	**	-	-	**	**	**	**

Results by strata

The number of samples and distribution of model ages varies significantly between strata (table 5.7). The lowest CV's and bias were from strata 21.1.d and 27.5.b which had samples with intermediate modal ages only (table 5.8-5.10). Strata with a wider range of modal ages had higher CV's and higher bias.

Table 5.7: Number of age readings per strata for all readers. All readers included.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	total
1	32	0	0	0	0	16	0	**48**
2	23	8	0	0	0	8	0	**39**
3	16	0	0	0	8	16	0	**40**
4	0	8	0	16	0	0	0	**24**
5	0	0	0	24	0	0	0	**24**
6	0	8	0	16	0	16	9	**49**
7	20	0	0	24	16	16	8	**84**
8	0	0	0	8	0	8	16	**32**
9	8	8	0	16	0	0	15	**47**
10	8	0	0	8	0	24	16	**56**
11	15	0	0	8	0	8	8	**39**
12	16	0	0	0	0	16	16	**48**
13	24	0	0	48	0	23	0	**95**
14	0	0	8	24	0	40	0	**72**
15	8	0	8	15	0	32	0	**63**
16	8	0	0	16	0	8	14	**46**
17	0	0	0	8	31	32	0	**71**
18	0	0	0	0	0	15	0	**15**
19	0	0	0	24	0	8	0	**32**
20	0	0	0	8	0	0	0	**8**
21	0	0	0	0	8	0	0	**8**
22	0	0	0	8	8	0	0	**16**
23	8	0	0	0	0	0	0	**8**
24	0	0	0	0	0	0	0	**0**
25	0	0	0	8	0	6	0	**14**
26	0	0	0	0	0	0	0	**0**
27	8	0	0	0	0	8	0	**16**
Total	**194**	**32**	**16**	**279**	**71**	**300**	**102**	**994**

Table 5.8: CV per strata. All readers included.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	all
1	67 %	-	-	-	-	85 %	-	**83 %**
2	65 %	70 %	-	-	-	55 %	-	**65 %**
3	53 %	-	-	-	63 %	67 %	-	**60 %**
4	-	46 %	-	58 %	-	-	-	**53 %**
5	-	-	-	46 %	-	-	-	**46 %**
6	-	41 %	-	42 %	-	39 %	25 %	**38 %**
7	44 %	-	-	47 %	36 %	42 %	37 %	**42 %**
8	-	-	-	45 %	-	30 %	22 %	**30 %**
9	39 %	35 %	-	34 %	-	-	21 %	**31 %**
10	35 %	-	-	21 %	-	24 %	21 %	**26 %**
11	29 %	-	-	26 %	-	33 %	21 %	**28 %**
12	28 %	-	-	-	-	33 %	20 %	**29 %**
13	43 %	-	-	31 %	-	26 %	-	**34 %**
14	-	-	9 %	28 %	-	27 %	-	**26 %**
15	25 %	-	21 %	26 %	-	29 %	-	**29 %**
16	16 %	-	-	27 %	-	21 %	24 %	**25 %**
17	-	-	-	26 %	20 %	24 %	-	**23 %**
18	-	-	-	-	-	19 %	-	**19 %**
19	-	-	-	23 %	-	23 %	-	**24 %**
20	-	-	-	26 %	-	-	-	**26 %**
21	-	-	-	-	11 %	-	-	**11 %**
22	-	-	-	16 %	20 %	-	-	**17 %**
23	23 %	-	-	-	-	-	-	**23 %**
24	-	-	-	-	-	-	-	**-**
25	-	-	-	22 %	-	18 %	-	**20 %**
26	-	-	-	-	-	-	-	**-**
27	33 %	-	-	-	-	24 %	-	**29 %**
Weighted Mean	**45 %**	**48 %**	**15 %**	**34 %**	**27 %**	**34 %**	**23 %**	**36 %**

Table 5.9: Percentage Agreement per strata. All readers included.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	all
1	41 %	-	-	-	-	38 %	-	**40 %**
2	43 %	50 %	-	-	-	38 %	-	**44 %**
3	19 %	-	-	-	38 %	31 %	-	**28 %**
4	-	12 %	-	31 %	-	-	-	**25 %**
5	-	-	-	21 %	-	-	-	**21 %**
6	-	25 %	-	38 %	-	31 %	56 %	**37 %**
7	25 %	-	-	21 %	25 %	25 %	25 %	**24 %**
8	-	-	-	25 %	-	38 %	25 %	**28 %**
9	25 %	25 %	-	25 %	-	-	40 %	**30 %**
10	25 %	-	-	50 %	-	25 %	38 %	**32 %**
11	47 %	-	-	25 %	-	38 %	38 %	**38 %**
12	25 %	-	-	-	-	25 %	38 %	**29 %**
13	38 %	-	-	27 %	-	30 %	-	**31 %**
14	-	-	25 %	33 %	-	32 %	-	**32 %**
15	25 %	-	25 %	27 %	-	25 %	-	**25 %**
16	25 %	-	-	31 %	-	25 %	36 %	**30 %**
17	-	-	-	50 %	26 %	34 %	-	**32 %**
18	-	-	-	-	-	27 %	-	**27 %**
19	-	-	-	25 %	-	25 %	-	**25 %**
20	-	-	-	25 %	-	-	-	**25 %**
21	-	-	-	-	38 %	-	-	**38 %**
22	-	-	-	25 %	25 %	-	-	**25 %**
23	25 %	-	-	-	-	-	-	**25 %**
24	-	-	-	-	-	-	-	**-**
25	-	-	-	25 %	-	33 %	-	**29 %**
26	-	-	-	-	-	-	-	**-**
27	25 %	-	-	-	-	38 %	-	**31 %**
Weighted Mean	**32 %**	**28 %**	**25 %**	**28 %**	**28 %**	**30 %**	**36 %**	**30 %**

Table 5.10: Relative bias per strata. All readers included.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	all
1	1.78	-	-	-	-	3.62	-	-
2	2.65	3.25	-	-	-	1.75	-	-
3	4.56	-	-	-	2.50	2.75	-	-
4	-	5.38	-	4.88	-	-	-	-
5	-	-	-	4.75	-	-	-	-
6	-	3.12	-	2.75	-	2.94	1.44	-
7	4.55	-	-	3.75	2.81	3.44	2.25	-
8	-	-	-	3.12	-	2.50	2.56	-
9	1.62	1.88	-	2.31	-	-	1.60	-
10	4.25	-	-	2.00	-	3.38	1.31	-
11	1.67	-	-	3.12	-	0.50	1.50	-
12	2.75	-	-	-	-	2.19	0.44	-
13	-1.75	-	-	0.73	-	2.70	-	-
14	-	-	1.75	1.33	-	3.12	-	-
15	-1.50	-	0.62	1.40	-	3.69	-	-
16	3.00	-	-	2.06	-	2.62	-1.21	-
17	-	-	-	2.38	3.23	4.09	-	-
18	-	-	-	-	-	1.73	-	-
19	-	-	-	1.54	-	5.25	-	-
20	-	-	-	-2.62	-	-	-	-
21	-	-	-	-	-0.62	-	-	-
22	-	-	-	-0.38	0.12	-	-	-
23	-2.75	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-
25	-	-	-	-5.38	-	-4.00	-	-
26	-	-	-	-	-	-	-	-
27	-8.88	-	-	-	-	-5.12	-	-
Weighted Mean	**1.42**	**3.41**	**1.19**	**1.93**	**2.27**	**2.73**	**1.17**	**-**

5.2.2 Advanced readers

The CV for advanced readers were 25 % (table 5.11), much lower than the CV for all readers (36%) but still above the 20 % that is considered acceptable for deep-water species. The PA is 49 % which is much higher than 30 % for all readers (5.12). The relative bias is 0.98 (table 5.13) which is much lower than the 2.07 observed for all readers.

Table 5.11: 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 NO	R02 IS	R03 NO	R04 NO	all
1	82 %	54 %	0 %	0 %	**66 %**
2	0 %	23 %	0 %	20 %	**17 %**
3	57 %	14 %	25 %	14 %	**31 %**
4	17 %	12 %	34 %	17 %	**27 %**
5	21 %	8 %	39 %	42 %	**37 %**
6	31 %	18 %	38 %	30 %	**32 %**
7	31 %	18 %	29 %	23 %	**28 %**
8	31 %	12 %	31 %	17 %	**27 %**
9	22 %	25 %	9 %	10 %	**20 %**
10	17 %	3 %	16 %	13 %	**15 %**
11	23 %	26 %	22 %	17 %	**26 %**
12	29 %	3 %	21 %	25 %	**23 %**
13	29 %	29 %	15 %	27 %	**27 %**
14	15 %	20 %	23 %	24 %	**22 %**
15	13 %	26 %	18 %	3 %	**18 %**
16	9 %	7 %	10 %	12 %	**11 %**
17	10 %	9 %	16 %	15 %	**13 %**
18	-	-	-	-	**11 %**
19	0 %	17 %	10 %	19 %	**12 %**
20	-	-	-	-	**-**
21	-	-	-	-	**-**
22	-	-	-	-	**17 %**
Weighted Mean	**25 %**	**18 %**	**21 %**	**19 %**	**25 %**

Table 5.12: Percentage agreement (PA) table represents the PA per modal age for each advanced reader, the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 NO	R02 IS	R03 NO	R04 NO	all
1	83 %	33 %	100 %	100 %	**79 %**
2	100 %	60 %	100 %	80 %	**85 %**
3	0 %	80 %	60 %	80 %	**55 %**
4	0 %	80 %	60 %	40 %	**45 %**
5	0 %	83 %	17 %	33 %	**33 %**
6	33 %	67 %	67 %	44 %	**53 %**
7	36 %	67 %	45 %	27 %	**44 %**
8	43 %	57 %	71 %	14 %	**46 %**
9	40 %	20 %	40 %	80 %	**45 %**
10	25 %	88 %	50 %	38 %	**50 %**
11	43 %	57 %	43 %	57 %	**50 %**
12	0 %	83 %	33 %	50 %	**42 %**
13	60 %	20 %	60 %	40 %	**45 %**
14	22 %	67 %	33 %	33 %	**39 %**
15	43 %	29 %	29 %	83 %	**44 %**
16	40 %	40 %	33 %	67 %	**45 %**
17	44 %	56 %	44 %	33 %	**44 %**
18	0 %	0 %	100 %	100 %	**50 %**
19	100 %	50 %	50 %	0 %	**50 %**
20	-	-	-	-	**-**
21	-	-	-	-	**-**
22	100 %	0 %	0 %	100 %	**50 %**
Weighted Mean	**38 %**	**57 %**	**51 %**	**49 %**	**49 %**

Table 5.13: Relative bias table represents the relative bias per modal age for advanced readers, the relative bias of all advanced readers combined per modal age and a weighted mean of the relative bias per reader.

Modal age	R01 NO	R02 IS	R03 NO	R04 NO	all
1	0.50	1.17	0.00	0.00	**0.42**
2	0.00	0.40	0.00	0.20	**0.15**
3	0.40	0.20	0.60	0.20	**0.35**
4	2.00	-0.20	1.20	0.80	**0.95**
5	3.67	0.17	3.83	2.17	**2.46**
6	2.78	0.33	1.67	1.22	**1.50**
7	1.45	-0.50	1.82	0.45	**0.81**
8	2.71	-0.29	1.71	2.14	**1.57**
9	2.20	-0.60	0.80	0.40	**0.70**
10	2.25	0.12	1.62	1.38	**1.34**
11	3.43	-1.57	2.57	1.71	**1.54**
12	3.50	0.17	3.00	2.83	**2.38**
13	1.50	-2.10	1.50	0.00	**0.22**
14	2.67	-1.11	2.00	2.00	**1.39**
15	1.43	-2.00	0.86	-0.17	**0.03**
16	0.60	-1.20	0.00	1.33	**0.18**
17	1.67	0.22	2.11	1.89	**1.47**
18	-1.00	-4.00	0.00	0.00	**-1.25**
19	0.00	-2.00	1.50	-0.50	**-0.25**
20	-	-	-	-	**-**
21	-	-	-	-	**-**
22	0.00	-7.00	-3.00	0.00	**-2.50**
Weighted Mean	**1.91**	**-0.57**	**1.52**	**1.07**	**0.98**

Age bias plot for the mean of the advanced readers against modal age are presented in figure 5.2. Bias plots for individual readers are given in appendix (figure 9.7). The age bias plot for the mean of advanced reader is also a lot smoother than the plot for all readers.

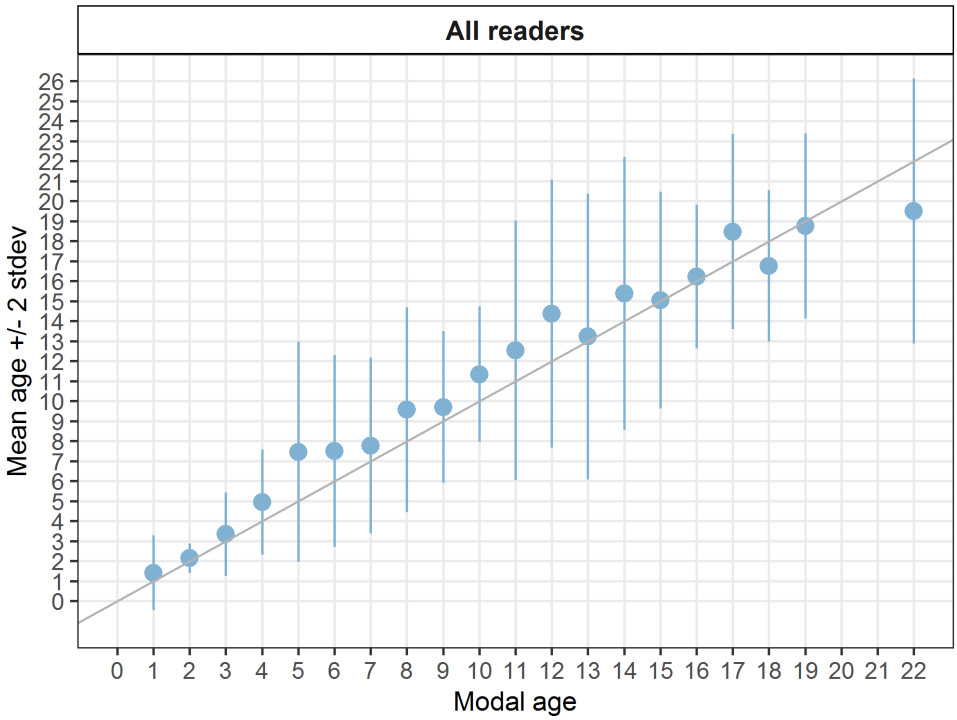

Figure 5.2: Age bias plot for advanced readers.

Results by strata

The number of samples per strata for advanced readers only is shown in table 5.14. The same trend as for all readers is seen. High CV and bias are more prevalent in strata with a wide modal age distribution.

Table 5.14: Number of age readings per strata for advanced readers.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	total
1	16	0	0	0	0	8	0	**24**
2	12	4	0	0	0	4	0	**20**
3	8	0	0	0	4	8	0	**20**
4	4	4	0	12	0	0	0	**20**
5	8	0	0	16	0	0	0	**24**
6	0	4	0	16	0	12	4	**36**
7	9	0	0	12	8	8	8	**45**
8	4	0	0	8	0	8	8	**28**
9	4	4	0	0	0	0	12	**20**
10	0	0	0	16	0	12	4	**32**
11	12	0	0	8	0	0	8	**28**
12	4	0	0	8	0	8	4	**24**
13	4	0	0	20	4	12	0	**40**
14	8	0	4	8	4	12	0	**36**
15	0	0	4	4	0	16	3	**27**
16	4	0	0	0	3	15	0	**22**
17	0	0	0	4	12	20	0	**36**
18	0	0	0	0	0	4	0	**4**
19	0	0	0	4	0	4	0	**8**
20	0	0	0	0	0	0	0	**0**
21	0	0	0	0	0	0	0	**0**
22	0	0	0	4	0	0	0	**4**
Total	**97**	**16**	**8**	**140**	**35**	**151**	**51**	**498**

Table 5.15: CV per strata for advanced readers

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	all
1	46 %	-	-	-	-	79 %	-	**66 %**
2	18 %	0 %	-	-	-	22 %	-	**17 %**
3	27 %	-	-	-	18 %	22 %	-	**31 %**
4	20 %	27 %	-	21 %	-	-	-	**27 %**
5	32 %	-	-	40 %	-	-	-	**37 %**
6	-	27 %	-	34 %	-	29 %	0 %	**32 %**
7	26 %	-	-	33 %	17 %	12 %	29 %	**28 %**
8	24 %	-	-	36 %	-	12 %	19 %	**27 %**
9	23 %	27 %	-	-	-	-	12 %	**20 %**
10	-	-	-	16 %	-	13 %	0 %	**15 %**
11	29 %	-	-	17 %	-	-	22 %	**26 %**
12	11 %	-	-	24 %	-	11 %	4 %	**23 %**
13	17 %	-	-	30 %	14 %	26 %	-	**27 %**
14	32 %	-	8 %	19 %	23 %	6 %	-	**22 %**
15	-	-	22 %	25 %	-	17 %	6 %	**18 %**
16	8 %	-	-	-	9 %	12 %	-	**11 %**
17	-	-	-	12 %	14 %	9 %	-	**13 %**
18	-	-	-	-	-	11 %	-	**11 %**
19	-	-	-	12 %	-	7 %	-	**12 %**
20	-	-	-	-	-	-	-	**-**
21	-	-	-	-	-	-	-	**-**
22	-	-	-	17 %	-	-	-	**17 %**
Weighted Mean	**28 %**	**20 %**	**15 %**	**27 %**	**16 %**	**18 %**	**15 %**	**25 %**

Table 5.16: Percentage Agreement per strata for advanced readers.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	all
1	81 %	-	-	-	-	75 %	-	**79 %**
2	83 %	100 %	-	-	-	75 %	-	**85 %**
3	38 %	-	-	-	75 %	62 %	-	**55 %**
4	50 %	25 %	-	50 %	-	-	-	**45 %**
5	25 %	-	-	38 %	-	-	-	**33 %**
6	-	50 %	-	44 %	-	50 %	100 %	**53 %**
7	56 %	-	-	33 %	50 %	50 %	38 %	**44 %**
8	25 %	-	-	38 %	-	62 %	50 %	**46 %**
9	25 %	50 %	-	-	-	-	50 %	**45 %**
10	-	-	-	38 %	-	50 %	100 %	**50 %**
11	58 %	-	-	25 %	-	-	62 %	**50 %**
12	50 %	-	-	25 %	-	38 %	75 %	**42 %**
13	75 %	-	-	45 %	25 %	42 %	-	**45 %**
14	38 %	-	25 %	38 %	25 %	50 %	-	**39 %**
15	-	-	50 %	50 %	-	44 %	33 %	**44 %**
16	50 %	-	-	-	33 %	47 %	-	**45 %**
17	-	-	-	50 %	33 %	50 %	-	**44 %**
18	-	-	-	-	-	50 %	-	**50 %**
19	-	-	-	50 %	-	50 %	-	**50 %**
20	-	-	-	-	-	-	-	**-**
21	-	-	-	-	-	-	-	**-**
22	-	-	-	50 %	-	-	-	**50 %**
Weighted Mean	**56 %**	**56 %**	**38 %**	**40 %**	**40 %**	**51 %**	**59 %**	**49 %**

Table 5.17: Relative bias per strata for advanced readers.

Modal age	21.1.a	21.1.b	21.1.d	27.2.a.2	27.2.b.2	27.5.a	27.5.b	all
1	0.25	-	-	-	-	0.75	-	**-**
2	0.17	0.00	-	-	-	0.25	-	**-**
3	1.12	-	-	-	-0.25	-0.12	-	**-**
4	0.00	2.25	-	0.83	-	-	-	**-**
5	3.00	-	-	2.19	-	-	-	**-**
6	-	0.50	-	2.25	-	1.33	0.00	**-**
7	0.22	-	-	2.08	-0.25	0.38	0.88	**-**
8	3.25	-	-	2.38	-	0.62	0.88	**-**
9	2.25	-0.75	-	-	-	-	0.67	**-**
10	-	-	-	1.75	-	1.25	0.00	**-**
11	1.08	-	-	3.75	-	-	0.00	**-**
12	1.00	-	-	5.38	-	1.38	-0.25	**-**
13	-1.00	-	-	-0.75	2.75	1.42	-	**-**
14	1.00	-	1.50	0.62	6.25	0.50	-	**-**
15	-	-	-1.75	-0.25	-	0.38	1.00	**-**
16	1.00	-	-	-	1.33	-0.20	-	**-**
17	-	-	-	-0.25	3.25	0.75	-	**-**
18	-	-	-	-	-	-1.25	-	**-**
19	-	-	-	-1.75	-	1.25	-	**-**
20	-	-	-	-	-	-	-	**-**
21	-	-	-	-	-	-	-	**-**
22	-	-	-	-2.50	-	-	-	**-**
Weighted Mean	**0.91**	**0.50**	**-0.12**	**1.41**	**2.17**	**0.64**	**0.47**	**-**

The Age error matrix tables (advanced readers only) shows that there are large differences in the interpretating of ages (table 5.15-5.24). For example, modal age 14 in strata 21.1.a (table 5.18) has age estimates ranging from 7 to 23 years. The worst result is for strata 27.2.a where the linear trend is less clear.

Table 5.18: Age error matrix (AEM) for 21.1.a. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
21.1.a	Age 1	0.8125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 2	0.1250	0.8333	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 3	0.0625	0.1667	0.375	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 4	-	-	0.250	0.50	-	-	0.1111	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 5	-	-	0.250	0.25	0.250	-	-	-	-	-	0.0833	-	-	-	-	-	-	-	-	-
21.1.a	Age 6	-	-	0.125	-	0.125	-	0.1111	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 7	-	-	-	-	0.125	-	0.5556	-	-	-	-	-	-	0.125	-	-	-	-	-	-
21.1.a	Age 8	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 9	-	-	-	-	0.125	-	-	-	0.25	-	-	-	0.25	-	-	-	-	-	-	-
21.1.a	Age 10	-	-	-	-	0.125	-	0.2222	0.25	0.25	-	-	-	-	-	-	-	-	-	-	-
21.1.a	Age 11	-	-	-	-	0.250	-	-	-	0.25	-	0.5833	-	-	-	-	-	-	-	-	-
21.1.a	Age 12	-	-	-	-	-	-	-	-	-	-	0.0833	0.50	-	0.125	-	-	-	-	-	-
21.1.a	Age 13	-	-	-	-	-	-	-	0.25	-	-	-	0.25	0.75	-	-	-	-	-	-	-
21.1.a	Age 14	-	-	-	-	-	-	-	0.25	-	-	-	-	-	0.375	-	-	-	-	-	-
21.1.a	Age 15	-	-	-	-	-	-	-	-	0.25	-	0.0833	0.25	-	-	-	-	-	-	-	-
21.1.a	Age 16	-	-	-	-	-	-	-	-	-	-	-	-	-	0.125	-	0.50	-	-	-	-
21.1.a	Age 17	-	-	-	-	-	-	-	-	-	-	0.0833	-	-	-	-	0.25	-	-	-	-
21.1.a	Age 19	-	-	-	-	-	-	-	-	-	-	0.0833	-	-	-	-	0.25	-	-	-	-
21.1.a	Age 20	-	-	-	-	-	-	-	-	-	-	-	-	-	0.125	-	-	-	-	-	-
21.1.a	Age 23	-	-	-	-	-	-	-	-	-	-	-	-	-	0.125	-	-	-	-	-	-

Table 5.19: Age error matrix (AEM) for 21.1.b. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
21.1.b	Age 2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 4	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 5	-	-	-	-	-	0.25	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 6	-	-	-	0.25	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 7	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 8	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 9	-	-	-	-	-	0.25	-	-	0.50	-	-	-	-	-	-	-	-	-	-	-
21.1.b	Age 10	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-

Table 5.20: Age error matrix (AEM) for 21.1.d. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
21.1.d	Age 9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-
21.1.d	Age 14	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	0.25	-	-	-	-	-
21.1.d	Age 15	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	0.50	-	-	-	-	-
21.1.d	Age 16	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-
21.1.d	Age 17	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-

Table 5.21: Age error matrix (AEM) for 27.2.a.2. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
27.2.a.2	Age 4	-	-	-	0.50000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.a.2	Age 5	-	-	-	0.25000	0.375	-	0.0833	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.a.2	Age 6	-	-	-	0.16667	0.1875	0.4375	-	0.125	-	-	-	-	0.05	-	-	-	-	-	-	-
27.2.a.2	Age 7	-	-	-	0.08333	0.1875	0.1875	0.3333	-	-	-	-	-	0.05	-	-	-	-	-	-	-
27.2.a.2	Age 8	-	-	-	-	-	-	0.08333	0.375	-	-	-	-	0.15	-	-	-	-	-	-	-
27.2.a.2	Age 9	-	-	-	-	0.0625	0.0625	0.16667	0.125	-	-	-	-	-	-	-	-	-	-	-	-
27.2.a.2	Age 10	-	-	-	-	0.0625	0.0625	0.08333	-	-	0.375	-	-	0.05	0.125	0.2	-	-	-	-	-
27.2.a.2	Age 11	-	-	-	-	-	0.0625	0.08333	-	-	0.1875	0.25	-	-	-	-	-	-	-	-	-
27.2.a.2	Age 12	-	-	-	-	-	0.0625	-	-	-	0.125	-	0.25	0.05	-	-	-	-	-	-	-
27.2.a.2	Age 13	-	-	-	-	0.0625	0.0625	-	0.125	-	0.0625	-	-	0.45	0.125	-	-	-	-	-	-

27.2.a.2	Age 14	-	-	-	-	0.0625	0.0625	0.08333	-	-	0.1875	-	-	0.05	0.375	-	-	0.25	-	-	-
27.2.a.2	Age 15	-	-	-	-	-	-	0.08333	0.125	-	-	0.25	-	-	-	0.50	-	-	-	0.25	0.25
27.2.a.2	Age 16	-	-	-	-	-	-	-	0.125	-	0.0625	0.25	0.125	-	0.125	-	-	-	-	0.25	-
27.2.a.2	Age 17	-	-	-	-	-	-	-	-	-	-	0.25	0.125	0.05	0.125	-	-	0.50	-	-	-
27.2.a.2	Age 18	-	-	-	-	-	-	-	-	-	-	-	0.125	0.05	-	-	-	-	-	-	-
27.2.a.2	Age 19	-	-	-	-	-	-	-	-	-	-	-	0.125	-	0.125	0.25	-	0.25	-	0.50	0.25
27.2.a.2	Age 20	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-	-
27.2.a.2	Age 21	-	-	-	-	-	-	-	-	-	-	-	0.125	-	-	-	-	-	-	-	-
27.2.a.2	Age 22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50
27.2.a.2	Age 24	-	-	-	-	-	-	-	-	-	-	-	0.125	-	-	-	-	-	-	-	-

Table 5.22: Age error matrix (AEM) for 27.2.b.2. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
27.2.b.2	Age 2	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.b.2	Age 3	-	-	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.b.2	Age 5	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.b.2	Age 7	-	-	-	-	-	-	0.50	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.b.2	Age 8	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2.b.2	Age 13	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-
27.2.b.2	Age 14	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-
27.2.b.2	Age 15	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-
27.2.b.2	Age 16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3333	-	-	-	-
27.2.b.2	Age 17	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	0.3333	0.33333	-	-	-
27.2.b.2	Age 18	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-	-
27.2.b.2	Age 19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3333	0.08333	-	-	-
27.2.b.2	Age 20	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-	-	-
27.2.b.2	Age 21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25000	-	-	-
27.2.b.2	Age 22	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	0.16667	-	-	-
27.2.b.2	Age 24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08333	-	-	-
27.2.b.2	Age 25	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	0.08333	-	-	-

Table 5.23: Age error matrix (AEM) for 27.5.a. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
27.5.a	Age 1	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 2	-	0.75	0.250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

27.5.a	Age 3	-	0.25	0.625	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 4	0.25	-	0.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 5	-	-	-	-	-	0.08333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 6	-	-	-	-	-	0.50000	0.125	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 7	-	-	-	-	-	-	0.500	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 8	-	-	-	-	-	0.16667	0.250	0.625	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 9	-	-	-	-	-	0.08333	0.125	0.250	-	-	-	-	-	-	-	-	-	-	-	-
27.5.a	Age 10	-	-	-	-	-	0.08333	-	-	-	0.50000	-	-	0.08333	-	0.0625	-	-	-	-	-
27.5.a	Age 11	-	-	-	-	-	-	-	0.125	-	0.08333	-	-	0.08333	-	-	-	-	-	-	-
27.5.a	Age 12	-	-	-	-	-	0.08333	-	-	-	0.16667	-	0.375	-	-	0.0625	-	-	-	-	-
27.5.a	Age 13	-	-	-	-	-	-	-	-	-	0.16667	-	0.250	0.41667	0.08333	-	0.06667	-	-	-	-
27.5.a	Age 14	-	-	-	-	-	-	-	-	-	0.08333	-	0.125	0.16667	0.50000	0.1250	0.20000	-	0.25	-	-
27.5.a	Age 15	-	-	-	-	-	-	-	-	-	-	-	0.125	-	0.25000	0.4375	0.06667	0.05	-	-	-
27.5.a	Age 16	-	-	-	-	-	-	-	-	-	-	-	0.125	-	0.16667	0.1250	0.46667	0.05	-	-	-
27.5.a	Age 17	-	-	-	-	-	-	-	-	-	-	-	-	0.08333	-	-	0.13333	0.50	0.25	-	-
27.5.a	Age 18	-	-	-	-	-	-	-	-	-	-	-	-	0.08333	-	0.0625	-	0.20	0.50	-	-
27.5.a	Age 19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-
27.5.a	Age 20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0625	-	0.10	-	-	-
27.5.a	Age 21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0625	0.06667	0.10	-	0.25	-
27.5.a	Age 22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	-
27.5.a	Age 24	-	-	-	-	-	-	-	-	-	-	-	-	0.08333	-	-	-	-	-	-	-

Table 5.24: Age error matrix (AEM) for 27.5.b. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

strata	Modal age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
27.5.b	Age 5	-	-	-	-	-	-	0.125	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.b	Age 6	-	-	-	-	-	1	0.125	-	-	-	-	-	-	-	-	-	-	-	-	-
27.5.b	Age 7	-	-	-	-	-	-	0.375	0.125	-	-	0.125	-	-	-	-	-	-	-	-	-
27.5.b	Age 8	-	-	-	-	-	-	-	0.500	0.08333	-	-	-	-	-	-	-	-	-	-	-
27.5.b	Age 9	-	-	-	-	-	-	0.125	0.125	0.50000	-	-	-	-	-	-	-	-	-	-	-
27.5.b	Age 10	-	-	-	-	-	-	0.125	-	0.16667	1	0.125	-	-	-	-	-	-	-	-	-
27.5.b	Age 11	-	-	-	-	-	-	-	0.125	0.16667	-	0.625	0.25	-	-	-	-	-	-	-	-
27.5.b	Age 12	-	-	-	-	-	-	0.125	0.125	0.08333	-	-	0.75	-	-	-	-	-	-	-	-
27.5.b	Age 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3333	-	-	-	-	-
27.5.b	Age 16	-	-	-	-	-	-	-	-	-	-	0.125	-	-	-	0.3333	-	-	-	-	-
27.5.b	Age 17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3333	-	-	-	-	-

Within-reader comparison

The results of the within-reader comparison were good. All readers had a CV below 15 % (figure 5.5).

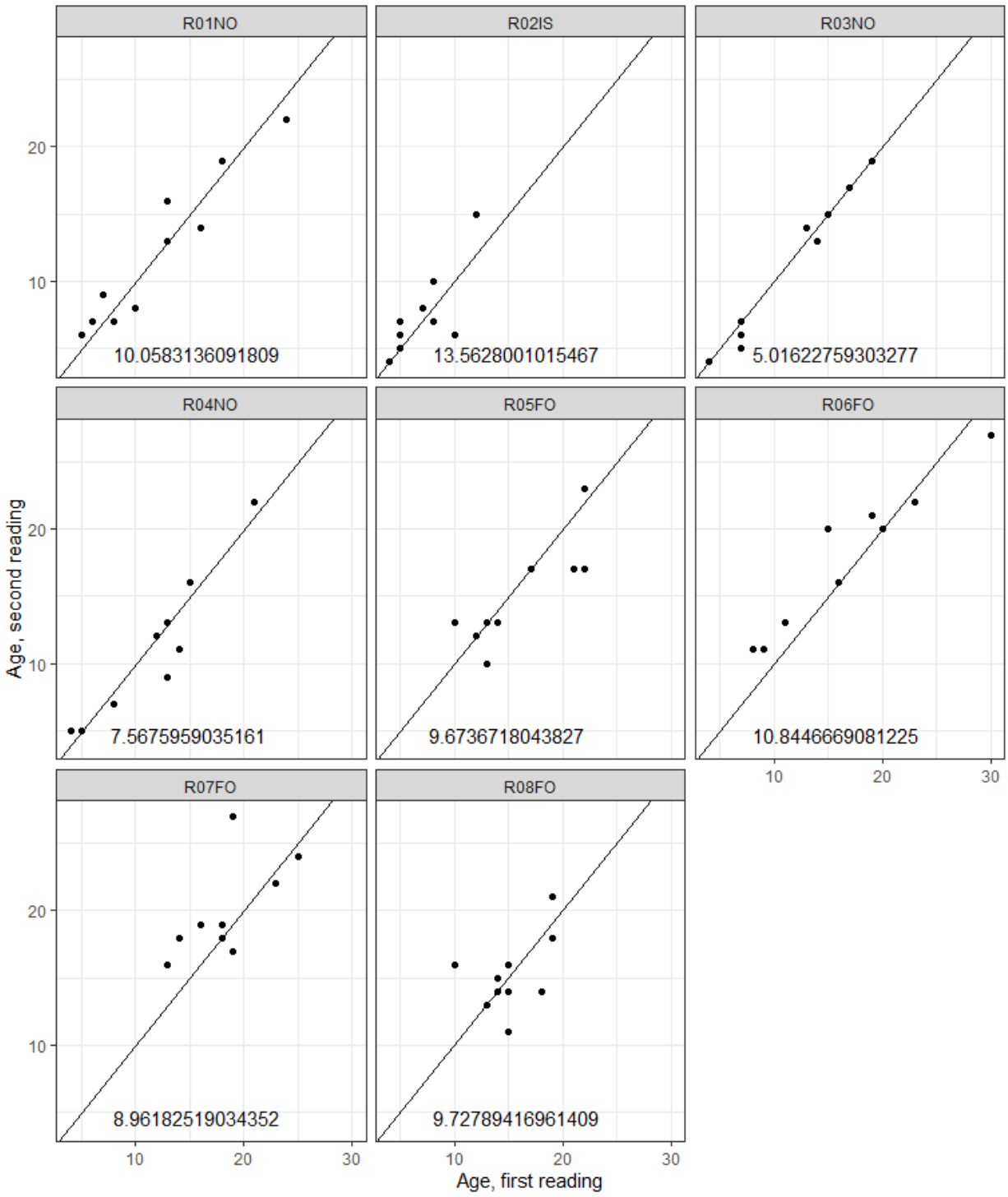

Figure 5.5: Within-reader comparison with ages of both readings per otoliths plotted against each other. The CV for each reader and the 1:1 equivalence line is indicated.

6 Discussion

The overall results could have been better. Deep-water species are notoriously difficult to age, but a CV of less than 15 % should be a requirement (ICES 2013). CV for all readers were 36 %, the PA was only 30 % and there was a lot of bias, particularly for the youngest fish. The results that stood out the most were the readings of the Faroese readers, who consequently read far higher ages than the other readers. The Faroese readers are the only participants with estimated ages of up to 30 years. The highest estimated age for Norwegian and Icelandic readers is 24 and 20, respectively. Furthermore, there were bias between all of them, indicating that they are not in agreement about a common way of estimating age. One reason might be that the Faroese readers have just started reading Greenland halibut otoliths and therefore need more experience. Furthermore, the procedure used in taking the otolith images varied from country to country, making reading the otoliths more challenging because they are different from what the readers are used to reading. The Faroese method of using reflected light, is very different from the other countries that use transmitted light. If this is the method they are used to, they would be at a severe disadvantage since most images were taken using transmitted light. The remaining countries were thus mainly presented with otoliths that looked familiar, even though some of the otoliths were upside down, which is a much smaller problem than the difference in light source direction.

The results for the advanced readers were much better. CV went down from 36 % to 25 %, PA increased from 30 to 49 % and overall bias was reduced from 2.07 to 0.98. The bias for the highest modal ages was particularly reduced. Even so, the results are not good enough. There is still a lot of differences in the way the advanced readers interpret age. This is especially clear in the age error matrices, with a wide distribution of estimated ages per modal age.

Using modal age in calculations of CV for long-lived species is often problematic since a longer life span reduces the probability of reaching the same age. For a short-lived species, you can come to the same age just by chance. For long lived-species, age estimates can be close but not exactly the same. The modal age is set as the age that most readers agree on. In cases where there is a tie, or where nobody has reached the same age, the lowest age will be set as modal age. This will inflate the CV compared to CV for short-lived species. An alternative to CV is the APE (average per cent error). For all readers, APE was 28 %, but for the experienced readers, it was 13 % which is quite good for a long-lived species. Furthermore, the within-reader comparisons were quite good, although the sample size is small. All readers had a CV between 5.0 and 13.5 which is well below the 15 % that is recommended.

7 Conclusion

Considering the result of this otolith exchange, the need for an otolith workshop is pressing. The CV was well above the required level; 36 % for all readers and 25 % for advanced readers. Whether a CV calculated on modal age is the best estimator for a long-lived species is debatable. A better option is the APE, which was 28 % for all readers and only 13 % for the advanced readers. The low APE for advanced readers and the low CV of within-reader comparison proves that reading Greenland halibut otoliths is plausible, but we need to work together to agree on a standard method. An international workshop should therefore be planned, preferably within two years.

8 References

Eltink, A. T. G. W., 2000. Age reading comparison 242. s. (MS Excel workbook version 1 2000) Internet: http://www.efan.no

ICES. 2013. Workshop on Age Estimation Methods on Deep-water Species (WKAMDEEP),21-25 October 2013, Mallorca, Spain. ICES CM 2013/ ACOM: 83. 81 pp.

9 Annex 3. Additional results

9.1 Results all readers

Data Overview

Table 9.1: Summary of statistics; PA (%), CV (%) and APE (%).

CV	PA	APE
36 %	30 %	28 %

Table 9.2: Data overview including modal age and statistics per sample.

Fish ID	Event ID	Image ID	length	sex	Catch date	ICES area	R01 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO	Modal age	PA %	CV %	APE %
2015_73074Okt1_t02	436	-	1040	F	08/10/2015 00:00:00	27.2.b.2	18	13	17	15	17	20	23	19	17	25	17	13
2017_73010aug1_t07	436	-	1080	F	14/08/2017 00:00:00	27.2.a.2	17	13	18	20	25	23	25	16	25	25	22	18
2017_73054aug2_t01	436	-	285	M	22/08/2017 00:00:00	27.2.b.2	8	7	7	5	12	11	13	15	7	25	36	31
2017_73077aug1_t17	436	-	295	F	25/08/2017 00:00:00	27.2.b.2	2	3	3	3	7	5	11	10	3	38	63	52
2017_73079aug1_t12	436	-	1050	F	25/08/2017 00:00:00	27.2.b.2	21	17	22	24	26	31	27	20	17	12	19	15
2019_73002Sep1_t01	436	-	550	F	01/09/2019 00:00:00	27.2.a.2	10	10	10	11	10	15	15	15	10	50	21	19
2019_73002Sep1_t02	436	-	510	F	01/09/2019 00:00:00	27.2.a.2	10	5	14	13	13	15	25	14	13	25	41	25
2019_73002Sep2_t01	436	-	470	M	01/09/2019 00:00:00	27.2.a.2	10	6	11	9	9	14	22	14	9	25	41	30
2019_73002Sep2_t02	436	-	530	M	01/09/2019 00:00:00	27.2.a.2	9	7	11	10	9	14	15	11	9	25	25	19
2019_73002Sep2_t05	436	-	590	M	01/09/2019 00:00:00	27.2.a.2	13	8	13	6	14	14	12	15	13	25	27	21
2019_73002Sep2_t07	436	-	360	M	01/09/2019 00:00:00	27.2.a.2	7	5	7	8	10	9	18	10	7	25	42	28
2019_73002Sep2_t08	436	-	420	M	01/09/2019 00:00:00	27.2.a.2	6	6	6	7	6	11	17	9	6	50	46	34
2019_73004Sep1_t02	436	-	700	F	02/09/2019 00:00:00	27.2.a.2	16	11	17	15	16	19	24	16	16	38	22	15
2019_73004Sep1_t03	436	-	650	F	02/09/2019 00:00:00	27.2.a.2	12	10	14	13	14	20	21	14	14	38	26	19

2019_73004Sep1_t06	436	-	650	F	02/09/2019 00:00:00	27.2.a.2	13	8	13	14	21	23	19	15	13	25	31	25
2019_73004Sep1_t09	436	-	470	F	02/09/2019 00:00:00	27.2.a.2	8	6	8	9	10	13	22	13	8	25	45	33
2019_73004Sep1_t10	436	-	425	F	02/09/2019 00:00:00	27.2.a.2	7	7	6	6	10	8	17	11	6	25	41	31
2019_73004Sep1_t12	436	-	385	F	02/09/2019 00:00:00	27.2.a.2	6	5	7	5	13	8	16	13	5	25	47	40
2019_73004Sep1_t13	436	-	760	F	02/09/2019 00:00:00	27.2.a.2	19	14	17	16	19	29	31	21	19	25	29	23
2019_73004Sep2_t07	436	-	630	M	02/09/2019 00:00:00	27.2.a.2	13	10	13	12	14	16	19	14	13	25	19	14
2019_73005Sep1_t04	436	-	345	F	03/09/2019 00:00:00	27.2.a.2	5	4	4	4	10	8	14	18	4	38	63	50
2019_73005Sep2_t07	436	-	340	M	03/09/2019 00:00:00	27.2.a.2	7	4	6	5	7	8	17	12	7	25	52	38
2019_73008Sep2_t02	436	-	680	M	03/09/2019 00:00:00	27.2.a.2	16	8	15	13	22	19	18	15	15	25	27	19
2019_73012Sep1_t13	436	-	750	F	04/09/2019 00:00:00	27.2.a.2	17	11	16	15	14	20	26	20	20	25	26	20
2019_73022Sep1_t14	436	-	1030	F	05/09/2019 00:00:00	27.2.a.2	15	10	19	15	16	-	22	23	15	29	26	21
2019_73031Sep1_t17	436	-	800	F	06/09/2019 00:00:00	27.2.a.2	14	10	14	13	14	19	20	15	14	38	22	16
2019_73037Sep1_t02	436	-	900	F	07/09/2019 00:00:00	27.2.a.2	24	12	19	21	22	30	25	19	19	25	24	17
2019_73037Sep1_t03	436	-	820	F	07/09/2019 00:00:00	27.2.a.2	16	12	18	17	22	24	30	16	16	25	29	23
2019_73037Sep1_t17	436	-	920	F	07/09/2019 00:00:00	27.2.a.2	19	15	19	16	22	20	23	21	19	25	14	11
2019_73037Sep1_t20	436	-	860	F	07/09/2019 00:00:00	27.2.a.2	17	14	19	17	17	25	29	17	17	50	26	20
2019_73043Sep2_t10	436	-	700	M	07/09/2019 00:00:00	27.2.a.2	11	10	12	14	18	19	18	11	11	25	26	22
2019_73050Sep1_t08	436	-	860	F	08/09/2019 00:00:00	27.2.b.2	19	17	22	21	21	24	21	18	21	38	11	9
2019_73066Sep1_t08	436	-	950	F	10/09/2019 00:00:00	27.2.b.2	20	14	25	22	21	24	29	22	22	25	20	13

2019_73080Sep1_t10	436	-	950	F	11/09/2019 00:00:00	27.2.b.2	17	17	25	21	21	25	25	17	17	38	18	14
2022_73002Sep1_t02	436	-	510	F	01/09/2019 00:00:00	27.2.a.2	8	7	13	13	13	20	24	15	13	38	40	29
2022_73002Sep2_t07	436	-	360	M	01/09/2019 00:00:00	27.2.a.2	9	6	5	7	13	11	18	16	5	12	45	36
2022_73004Sep1_t06	436	-	650	F	02/09/2019 00:00:00	27.2.a.2	16	10	14	11	17	22	27	14	14	25	35	26
2022_73004Sep1_t12	436	-	385	F	02/09/2019 00:00:00	27.2.a.2	7	5	6	5	10	11	19	13	5	25	51	39
2022_73004Sep2_t07	436	-	630	M	02/09/2019 00:00:00	27.2.a.2	13	6	14	12	13	16	17	14	13	25	25	16
2022_73005Sep1_t04	436	-	345	F	03/09/2019 00:00:00	27.2.a.2	6	4	4	5	13	11	18	14	4	25	57	49
2022_73008Sep2_t02	436	-	680	M	03/09/2019 00:00:00	27.2.a.2	14	7	15	9	17	21	19	16	7	12	32	24
2022_73037Sep1_t02	436	-	900	F	07/09/2019 00:00:00	27.2.a.2	22	15	19	22	23	27	24	21	22	25	16	11
2022_73054aug2_t01	436	-	285	M	22/08/2017 00:00:00	27.2.b.2	7	8	7	5	12	13	16	11	7	25	38	32
2022_73074Okt1_t02	436	-	1040	F	08/10/2015 00:00:00	27.2.b.2	19	-	17	16	17	20	22	18	17	29	11	9
22240003_5375	436	-	499	F	12/06/2022 00:00:00	27.5.b	9	8	9	9	13	-	9	10	9	57	17	12
22240003_5379	436	-	518	M	12/06/2022 00:00:00	27.5.b	12	10	9	11	12	15	12	11	12	38	15	11
22240003_5380	436	-	544	F	12/06/2022 00:00:00	27.5.b	12	8	8	11	11	14	13	14	8	25	21	16
22240003_5383	436	-	473	F	12/06/2022 00:00:00	27.5.b	12	7	10	9	11	17	10	13	10	25	27	19
22240003_5391	436	-	741	F	12/06/2022 00:00:00	27.5.b	17	15	16	-	22	-	16	14	16	33	17	11
22240004_5227	436	-	399	F	12/06/2022 00:00:00	27.5.b	6	5	7	7	10	14	13	12	7	25	37	32
22240004_5233	436	-	429	M	12/06/2022 00:00:00	27.5.b	11	9	10	9	14	16	11	12	9	25	21	16
22240004_5239	436	-	592	F	12/06/2022 00:00:00	27.5.b	10	10	10	10	12	13	13	14	10	50	15	13

22240004_5240	436	-	611	M	12/06/2022 00:00:00	27.5.b	16	7	11	11	16	17	13	16	16	38	26	21
22240004_5243	436	-	654	F	12/06/2022 00:00:00	27.5.b	11	12	12	12	10	17	17	16	12	38	21	18
22240004_5245	436	-	327	M	12/06/2022 00:00:00	27.5.b	6	6	6	6	8	9	9	11	6	50	25	21
22240005_5044	436	-	365	M	13/06/2022 00:00:00	27.5.b	-	-	-	-	6	-	-	-	6	100	-	0
22240005_5048	436	-	418	F	13/06/2022 00:00:00	27.5.b	9	7	8	8	10	12	13	11	8	25	22	18
22240006_5023	436	-	569	F	13/06/2022 00:00:00	27.5.b	11	10	11	11	12	18	13	14	11	38	21	15
A11-2016-566-7	436	-	1020	F	16/10/2016 00:00:00	27.5.a	18	20	17	17	29	26	21	16	17	25	23	18
A11-2020-566-1	436	-	870	F	11/10/2020 00:00:00	27.5.a	14	13	16	12	17	19	21	14	14	25	20	16
A11-2020-573-2	436	-	910	M	12/10/2020 00:00:00	27.5.a	16	15	14	15	32	22	22	19	15	25	31	23
A11-2020-574-1	436	-	790	F	12/10/2020 00:00:00	27.5.a	16	14	17	16	20	26	22	18	16	25	21	16
A11-2020-575-8	436	-	840	F	12/10/2020 00:00:00	27.5.a	21	18	17	17	23	31	29	30	17	25	26	22
A11-2020-581-4	436	-	960	F	13/10/2020 00:00:00	27.5.a	21	18	20	15	25	30	29	22	15	12	23	18
A11-2020-581-6	436	-	930	F	13/10/2020 00:00:00	27.5.a	17	14	18	18	23	-	19	16	18	29	16	11
A11-2020-584-1	436	-	880	F	13/10/2020 00:00:00	27.5.a	21	18	17	20	26	26	25	18	18	25	18	15
A11-2020-591-9	436	-	830	F	14/10/2020 00:00:00	27.5.a	17	17	17	15	22	27	26	17	17	50	23	20
A11-2020-601-15	436	-	770	F	16/10/2020 00:00:00	27.5.a	15	14	13	14	14	22	16	14	14	50	19	12
A11-2020-603-2	436	-	960	F	16/10/2020 00:00:00	27.5.a	19	19	22	21	31	32	29	21	19	25	23	20
A11-2020-604-5	436	-	690	F	16/10/2020 00:00:00	27.5.a	24	17	18	13	27	27	27	22	27	38	24	20
A11-2020-609-11	436	-	670	F	17/10/2020 00:00:00	27.5.a	16	14	15	15	17	30	24	14	14	25	32	24

A11-2020-609-9	436	-	270	F	17/10/2020 00:00:00	27.5.a	4	4	1	1	10	7	12	11	1	25	70	60
A11-2020-616-8	436	-	570	F	18/10/2020 00:00:00	27.5.a	14	11	10	10	14	15	12	15	10	25	17	15
A11-2020-632-1	436	-	720	F	20/10/2020 00:00:00	27.5.a	13	14	14	13	16	-	19	13	13	43	15	11
A11-2020-634-4	436	-	810	F	20/10/2020 00:00:00	27.5.a	15	14	16	16	17	28	23	15	15	25	27	21
A11-2020-637-12	436	-	590	F	20/10/2020 00:00:00	27.5.a	15	10	12	15	17	19	16	15	15	38	19	13
A11-2020-641-12	436	-	530	F	21/01/2020 00:00:00	27.5.a	13	10	13	11	20	18	23	12	13	25	31	27
A11-2020-641-2	436	-	480	F	21/10/2020 00:00:00	27.5.a	8	9	8	11	11	19	15	11	11	38	33	24
A11-2020-642-3	436	-	460	F	21/10/2020 00:00:00	27.5.a	7	7	8	9	10	15	17	9	7	25	36	28
A11-2020-643-9	436	-	450	M	21/10/2020 00:00:00	27.5.a	12	9	6	8	15	17	17	12	12	25	35	27
A11-2020-647-9	436	-	340	F	21/10/2020 00:00:00	27.5.a	7	7	8	6	12	15	21	9	7	25	48	38
A11-2020-650-15	436	-	440	F	22/10/2020 00:00:00	27.5.a	8	8	8	9	14	16	12	9	8	38	30	25
A11-2020-654-4	436	-	500	F	22/10/2020 00:00:00	27.5.a	13	10	10	12	11	17	20	13	10	25	27	20
A11-2020-654-7	436	-	380	F	22/10/2020 00:00:00	27.5.a	6	6	6	5	7	12	17	9	6	38	48	37
A11-2020-661-6	436	-	390	F	23/10/2020 00:00:00	27.5.a	10	6	8	6	8	12	14	11	6	25	31	25
A11-2020-667-1	436	-	640	F	25/10/2020 00:00:00	27.5.a	16	14	13	16	21	21	25	13	13	25	26	21
A11-2020-670-1	436	-	740	F	25/10/2020 00:00:00	27.5.a	15	14	14	16	28	24	27	14	14	38	33	29
A11-2020-670-2	436	-	610	M	25/10/2020 00:00:00	27.5.a	12	10	13	10	15	21	17	16	10	25	26	21
A11-2020-674-1	436	-	540	F	26/10/2020 00:00:00	27.5.a	15	12	13	12	17	20	25	17	12	25	27	21
A11-2020-703-1	436	-	1080	F	29/10/2020 00:00:00	27.5.a	-	16	17	21	25	-	25	22	25	33	18	14

A12-2018-528-1	436	-	1010	F	07/10/2018 00:00:00	27.5.a	17	17	16	18	25	29	28	17	17	38	26	23
A13-2017-535-1	436	-	270	F	17/10/2017 00:00:00	27.5.a	2	3	3	3	6	5	10	7	3	38	55	44
AJ-60866	436	-	860	F	23/07/2010 00:00:00	21.1.a	20	14	16	23	19	23	29	18	23	25	23	18
AJ-60867	436	-	870	F	23/07/2010 00:00:00	21.1.a	13	12	12	15	20	22	21	15	12	25	25	22
AJ-60869	436	-	780	F	23/07/2010 00:00:00	21.1.a	19	11	17	15	13	27	27	16	27	25	33	26
AJ-60870	436	-	770	F	23/07/2010 00:00:00	21.1.a	17	16	16	19	20	23	24	17	16	25	16	13
B12-2016-725-1	436	-	170	F	18/07/2016 00:00:00	27.5.a	1	1	1	1	6	2	8	4	1	50	91	75
B12-2016-750-5	436	-	230	F	22/07/2016 00:00:00	27.5.a	2	3	2	2	5	4	8	4	2	38	55	40
HM-141115	436	-	390	M	11/06/2020 00:00:00	21.1.b	7	4	8	6	9	10	17	14	4	12	46	34
HM-141125	436	-	400	M	11/06/2020 00:00:00	21.1.b	9	5	6	6	7	13	12	15	6	25	41	35
HM-141148	436	-	230	M	11/06/2020 00:00:00	21.1.b	2	2	2	2	10	6	10	8	2	50	70	62
HM-141170	436	-	510	M	11/06/2020 00:00:00	21.1.b	9	5	10	9	10	18	13	13	9	25	35	26
HM-141182	436	-	310	F	12/06/2020 00:00:00	21.1.a	5	3	3	4	10	7	13	11	3	25	56	46
HM-141185	436	-	250	M	12/06/2020 00:00:00	21.1.a	2	2	2	3	7	6	-	7	2	43	58	52
HM-141189	436	-	150	F	12/06/2020 00:00:00	21.1.a	1	1	1	1	4	2	5	5	1	50	74	65
HM-141535	436	-	160	U	15/06/2020 00:00:00	21.1.a	1	3	1	1	5	3	4	5	1	38	60	49
HM-142017	436	-	410	M	16/06/2020 00:00:00	21.1.a	6	4	7	7	14	12	17	14	7	25	46	41
HM-142019	436	-	470	M	16/06/2020 00:00:00	21.1.a	9	5	11	6	9	14	14	17	9	25	39	32
HM-142039	436	-	140	F	16/06/2020 00:00:00	21.1.a	1	2	1	1	4	2	5	6	1	38	72	61

HM-142050	436	-	240	F	16/06/2020 00:00:00	21.1.a	2	2	2	2	7	5	12	8	2	50	75	60
HM-142072	436	-	480	M	16/06/2020 00:00:00	21.1.a	11	5	11	11	12	21	18	14	11	38	38	28
HM-142075	436	-	500	F	16/06/2020 00:00:00	21.1.a	14	7	14	12	10	18	19	12	12	25	30	23
HM-142086	436	-	320	F	17/06/2020 00:00:00	21.1.a	6	4	5	3	10	9	15	13	3	12	54	45
HM-142114	436	-	360	M	17/06/2020 00:00:00	21.1.a	5	3	4	4	13	9	13	13	13	38	56	50
HM-142131	436	-	130	U	17/06/2020 00:00:00	21.1.a	1	2	1	1	5	3	7	4	1	38	73	58
HM-142157	436	-	250	F	17/06/2020 00:00:00	21.1.a	2	3	2	2	7	5	10	7	2	38	63	53
PA-96078	436	-	800	F	13/09/2013 00:00:00	21.1.d	15	9	15	14	17	19	18	18	15	25	21	15
PA-96164	436	-	820	F	13/09/2013 00:00:00	21.1.d	17	15	16	14	15	18	17	14	14	25	9	8
SA-149641	436	-	700	M	28/06/2021 00:00:00	21.1.a	-	7	-	-	11	-	12	13	7	25	24	17
SA-149756	436	-	580	F	02/07/2021 00:00:00	21.1.a	11	11	12	11	11	16	-	15	11	57	17	14
SA-150471	436	-	700	F	17/07/2021 00:00:00	21.1.a	15	10	11	9	13	19	16	15	15	25	25	20
SA-151143	436	-	630	M	12/08/2021 00:00:00	21.1.a	11	5	10	7	13	12	18	13	13	25	36	26
SA-151147	436	-	620	M	12/08/2021 00:00:00	21.1.a	13	9	13	13	16	18	22	13	13	50	27	21
SA-151148	436	-	590	M	12/08/2021 00:00:00	21.1.a	10	7	10	7	12	18	20	23	7	25	46	39
SA-151181	436	-	670	M	13/08/2021 00:00:00	21.1.a	14	8	13	10	10	21	20	18	10	25	35	29
TB2-2021-48-15	436	-	350	F	16/10/2021 00:00:00	27.5.a	2	3	4	3	11	7	16	7	3	25	73	55
TB2-2021-9-12	436	-	1000	F	11/10/2021 00:00:00	27.5.a	16	14	15	14	22	24	20	15	14	25	22	19

Table 9.3: Number of age readings table gives an overview of number of readings per reader and modal age. The total numbers of readings per reader and per modal age are summarized at the end of the table.

Modal age	R01 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO	total
1	6	6	6	6	6	6	6	6	**48**
2	5	5	5	5	5	5	4	5	**39**
3	5	5	5	5	5	5	5	5	**40**
4	3	3	3	3	3	3	3	3	**24**
5	3	3	3	3	3	3	3	3	**24**
6	6	6	6	6	7	6	6	6	**49**
7	10	11	10	10	11	10	11	11	**84**
8	4	4	4	4	4	4	4	4	**32**
9	6	6	6	6	6	5	6	6	**47**
10	7	7	7	7	7	7	7	7	**56**
11	5	5	5	5	5	5	4	5	**39**
12	6	6	6	6	6	6	6	6	**48**
13	12	12	12	12	12	11	12	12	**95**
14	9	9	9	9	9	9	9	9	**72**
15	8	8	8	8	8	7	8	8	**63**
16	6	6	6	5	6	5	6	6	**46**
17	9	8	9	9	9	9	9	9	**71**
18	2	2	2	2	2	1	2	2	**15**
19	4	4	4	4	4	4	4	4	**32**
20	1	1	1	1	1	1	1	1	**8**
21	1	1	1	1	1	1	1	1	**8**
22	2	2	2	2	2	2	2	2	**16**
23	1	1	1	1	1	1	1	1	**8**
24	0	0	0	0	0	0	0	0	**0**
25	1	2	2	2	2	1	2	2	**14**
26	0	0	0	0	0	0	0	0	**0**
27	2	2	2	2	2	2	2	2	**16**
Total	**124**	**125**	**125**	**124**	**127**	**119**	**124**	**126**	**994**

Table 9.4: Age composition by reader gives a summary of number of readings per reader.

Modal age	R01 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO
1	5	2	6	6	0	0	0	**0**
2	8	5	5	4	0	3	0	**0**
3	0	8	3	5	0	2	0	**0**
4	1	7	4	3	2	1	1	**3**
5	3	10	2	7	3	4	2	**2**
6	8	8	8	8	4	2	0	**1**
7	8	13	6	6	7	3	1	**4**
8	5	8	9	3	2	4	2	**2**
9	7	5	2	10	4	4	2	**5**
10	6	15	9	5	17	1	4	**3**
11	7	5	7	10	7	5	2	**11**
12	6	5	5	7	8	5	8	**6**
13	9	3	11	8	11	4	10	**13**
14	6	13	9	6	10	6	3	**19**
15	8	5	5	11	3	6	4	**15**
16	10	2	8	7	5	5	7	**11**
17	10	6	11	4	11	5	12	**7**
18	2	3	4	2	1	7	8	**8**
19	6	1	5	1	2	9	7	**3**
20	2	1	1	2	4	7	5	**2**
21	4	0	0	5	5	5	6	**4**
22	1	0	3	2	7	4	7	**4**
23	0	0	0	1	3	4	4	**2**
24	2	0	0	1	0	5	5	**0**
25	0	0	2	0	4	2	8	**0**
26	0	0	0	0	2	3	2	**0**
27	0	0	0	0	1	4	5	**0**
28	0	0	0	0	1	1	1	**0**
29	0	0	0	0	1	2	6	**0**
30	0	0	0	0	0	3	1	**1**
31	0	0	0	0	1	2	1	**0**
32	0	0	0	0	1	1	0	**0**
Total	**124**	**125**	**125**	**124**	**127**	**119**	**124**	**126**

Table 9.5: Mean length at age per reader is calculated per reader and age (not modal age) and for all readers combined per age. A weighted mean is also given.

Age	R01 NO	R02 IS	R03 NO	R04 NO	R05 FO	R06 FO	R07 FO	R08 FO
1	150 mm	160 mm	170 mm	170 mm	-	-	-	-
2	264 mm	198 mm	240 mm	238 mm	-	153 mm	-	-
3	-	278 mm	292 mm	297 mm	-	145 mm	-	-
4	270 mm	346 mm	350 mm	338 mm	145 mm	230 mm	160 mm	**177 mm**
5	338 mm	453 mm	340 mm	344 mm	173 mm	264 mm	145 mm	**155 mm**
6	373 mm	431 mm	391 mm	416 mm	306 mm	240 mm	-	**140 mm**
7	373 mm	502 mm	354 mm	468 mm	308 mm	310 mm	130 mm	**280 mm**
8	437 mm	545 mm	437 mm	409 mm	358 mm	374 mm	200 mm	**235 mm**
9	455 mm	556 mm	508 mm	513 mm	465 mm	342 mm	413 mm	**408 mm**
10	517 mm	641 mm	538 mm	594 mm	428 mm	390 mm	306 mm	**385 mm**
11	577 mm	676 mm	547 mm	551 mm	518 mm	359 mm	362 mm	**423 mm**
12	541 mm	757 mm	679 mm	618 mm	457 mm	446 mm	466 mm	**441 mm**
13	638 mm	997 mm	615 mm	648 mm	519 mm	437 mm	460 mm	**516 mm**
14	682 mm	808 mm	679 mm	790 mm	604 mm	500 mm	402 mm	**604 mm**
15	748 mm	858 mm	766 mm	830 mm	627 mm	491 mm	470 mm	**639 mm**
16	747 mm	925 mm	829 mm	814 mm	736 mm	542 mm	546 mm	**750 mm**
17	874 mm	898 mm	887 mm	885 mm	777 mm	538 mm	499 mm	**776 mm**
18	1030 mm	893 mm	880 mm	970 mm	700 mm	591 mm	544 mm	**781 mm**
19	887 mm	960 mm	922 mm	770 mm	810 mm	702 mm	642 mm	**950 mm**
20	905 mm	1020 mm	960 mm	980 mm	740 mm	779 mm	712 mm	**900 mm**
21	932 mm	-	-	950 mm	810 mm	616 mm	768 mm	**885 mm**
22	900 mm	-	957 mm	925 mm	842 mm	800 mm	761 mm	**920 mm**
23	-	-	-	860 mm	890 mm	840 mm	825 mm	**810 mm**
24	795 mm	-	-	1050 mm	-	874 mm	710 mm	-
25	-	-	950 mm	-	1032 mm	905 mm	822 mm	-
26	-	-	-	-	965 mm	897 mm	790 mm	-
27	-	-	-	-	690 mm	800 mm	782 mm	-
28	-	-	-	-	740 mm	810 mm	1010 mm	-
29	-	-	-	-	1020 mm	885 mm	905 mm	-
30	-	-	-	-	-	843 mm	820 mm	**840 mm**
31	-	-	-	-	960 mm	945 mm	760 mm	-
32	-	-	-	-	910 mm	960 mm	-	-
Weighted Mean	**591 mm**	**592 mm**	**595 mm**	**594 mm**	**594 mm**	**583 mm**	**599 mm**	**596 mm**

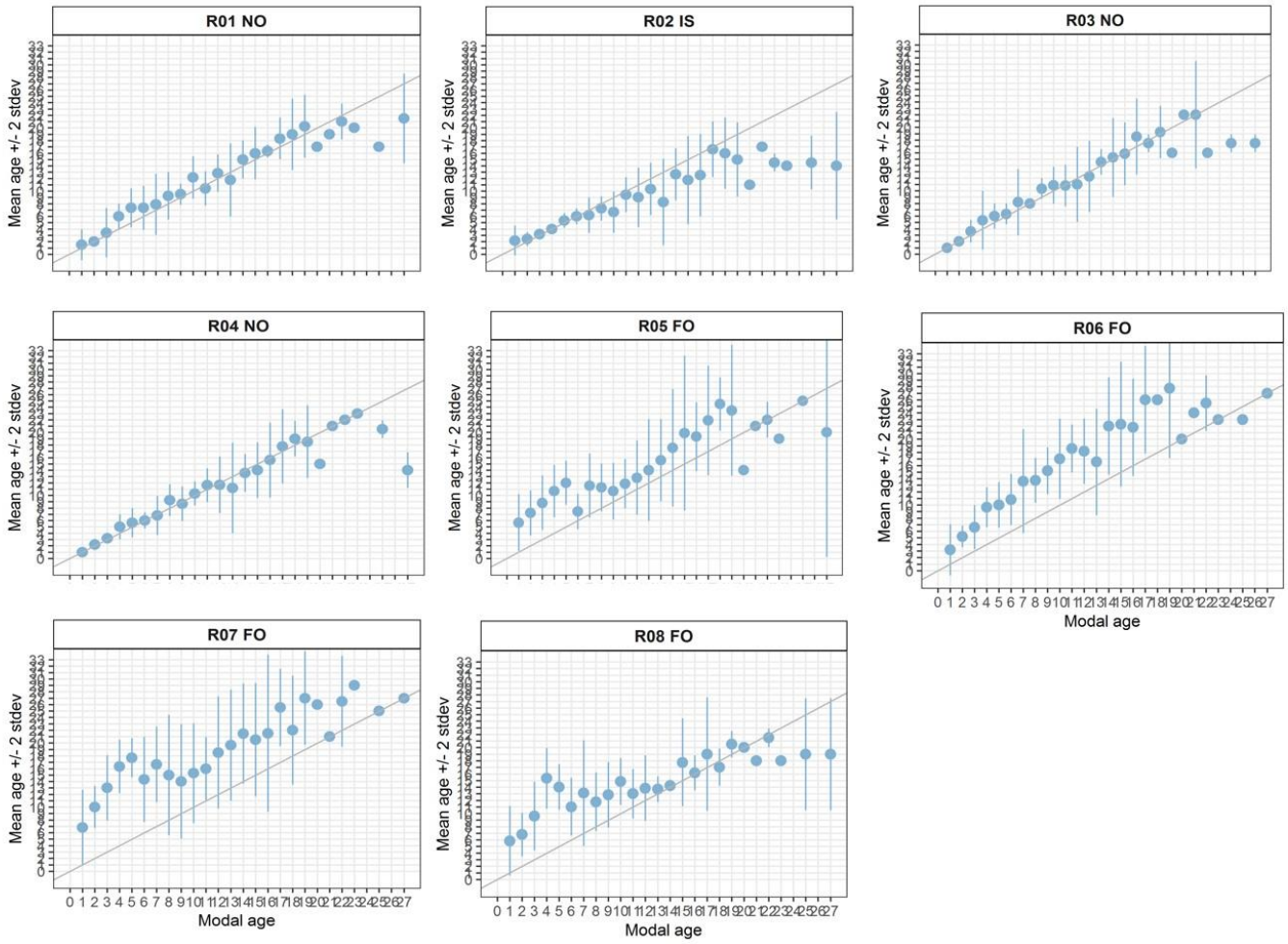

Figure 9.1: Age bias plots of individual readers against modal age. *The 1:1 equivalence line is indicated.*

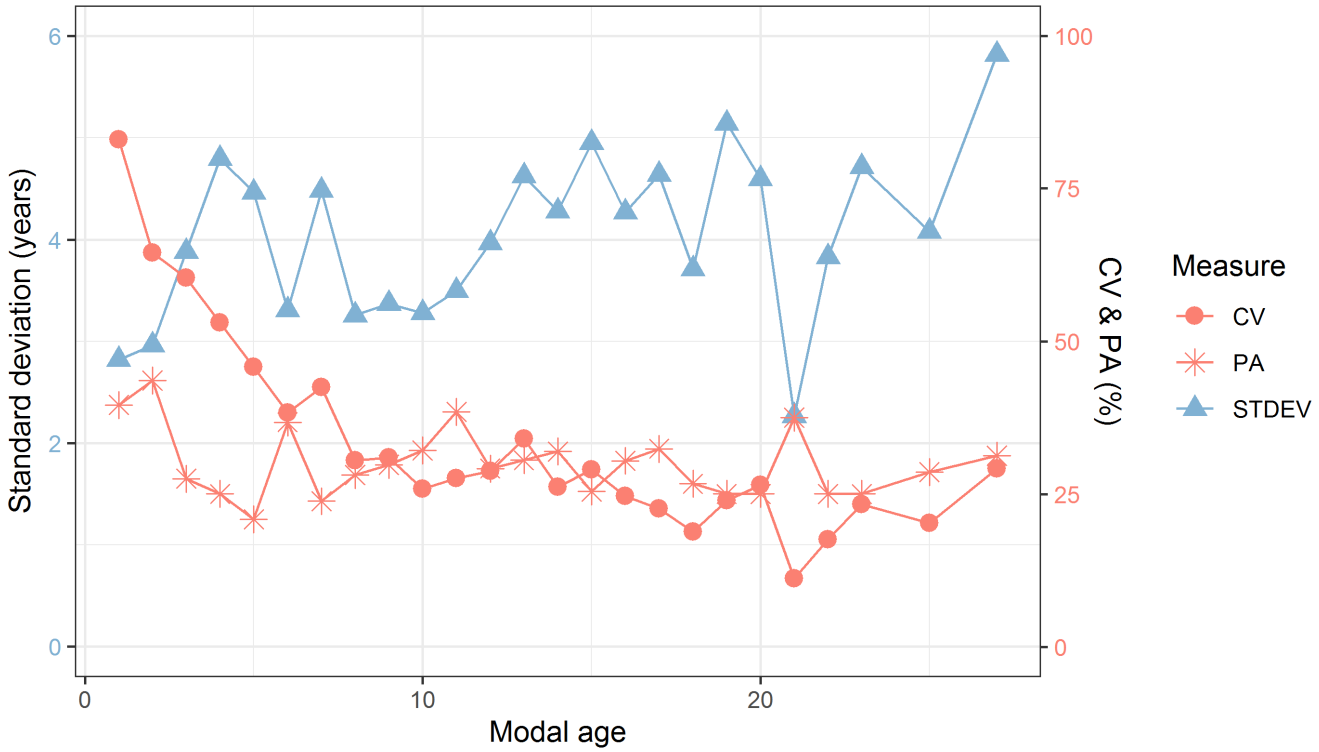

Figure 9.2: CV, PA and STDEV (standard deviation) are plotted against modal age.

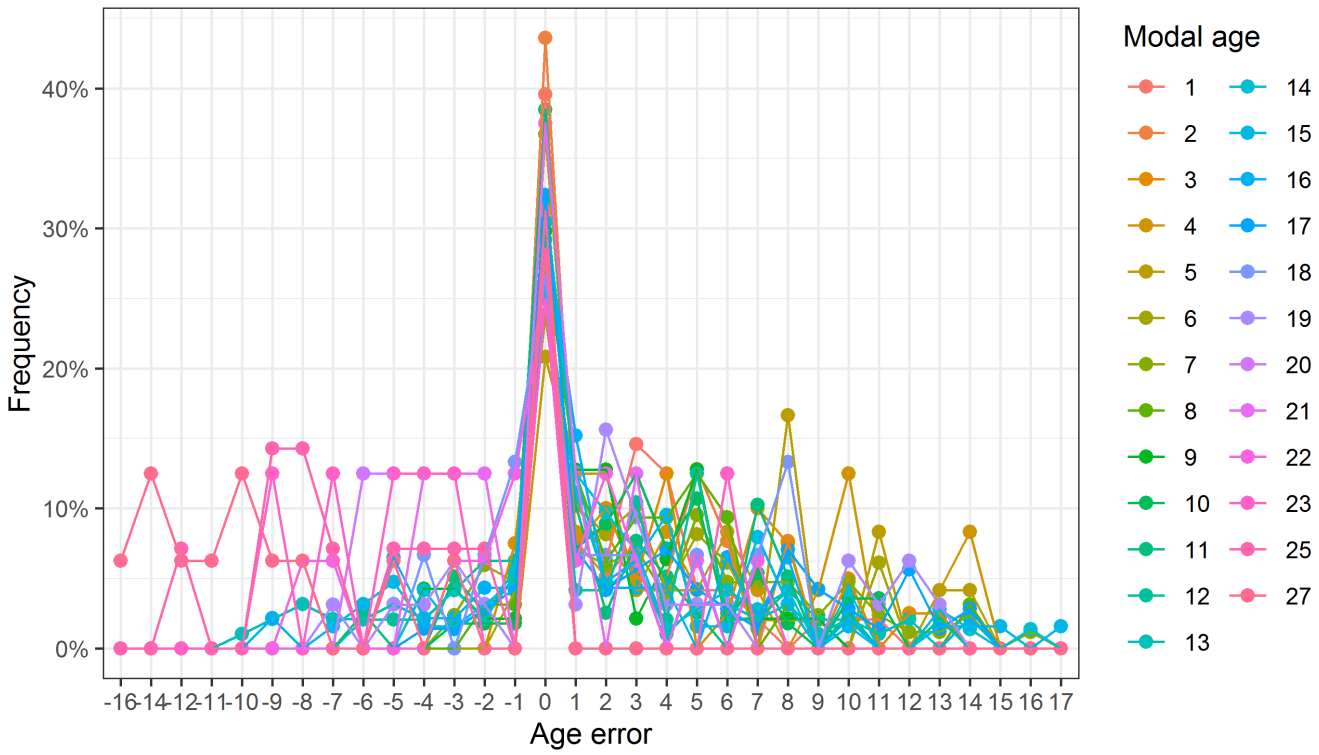

Figure 9.3: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias if the age reading errors are normally distributed. The distributions are skewed if relative bias occurs.

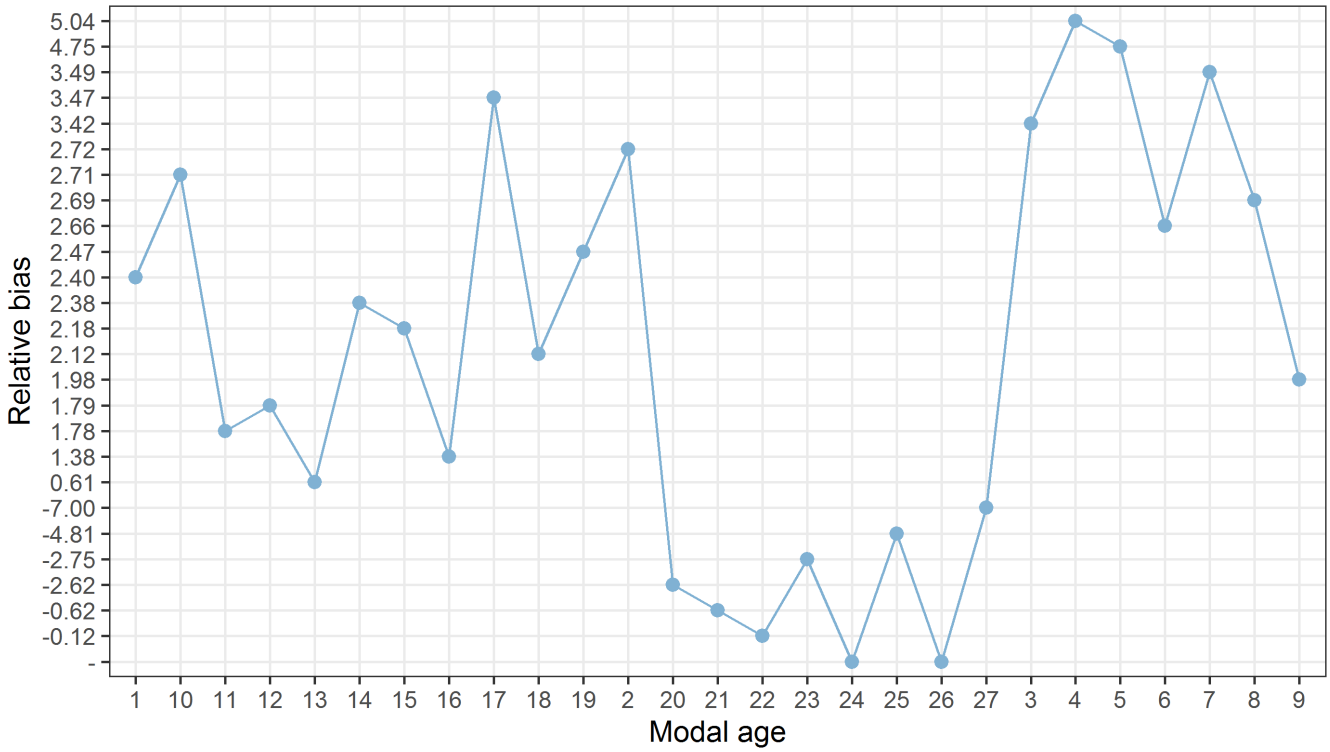

Figure 9.4: The relative bias by modal age as estimated by all age readers combined.

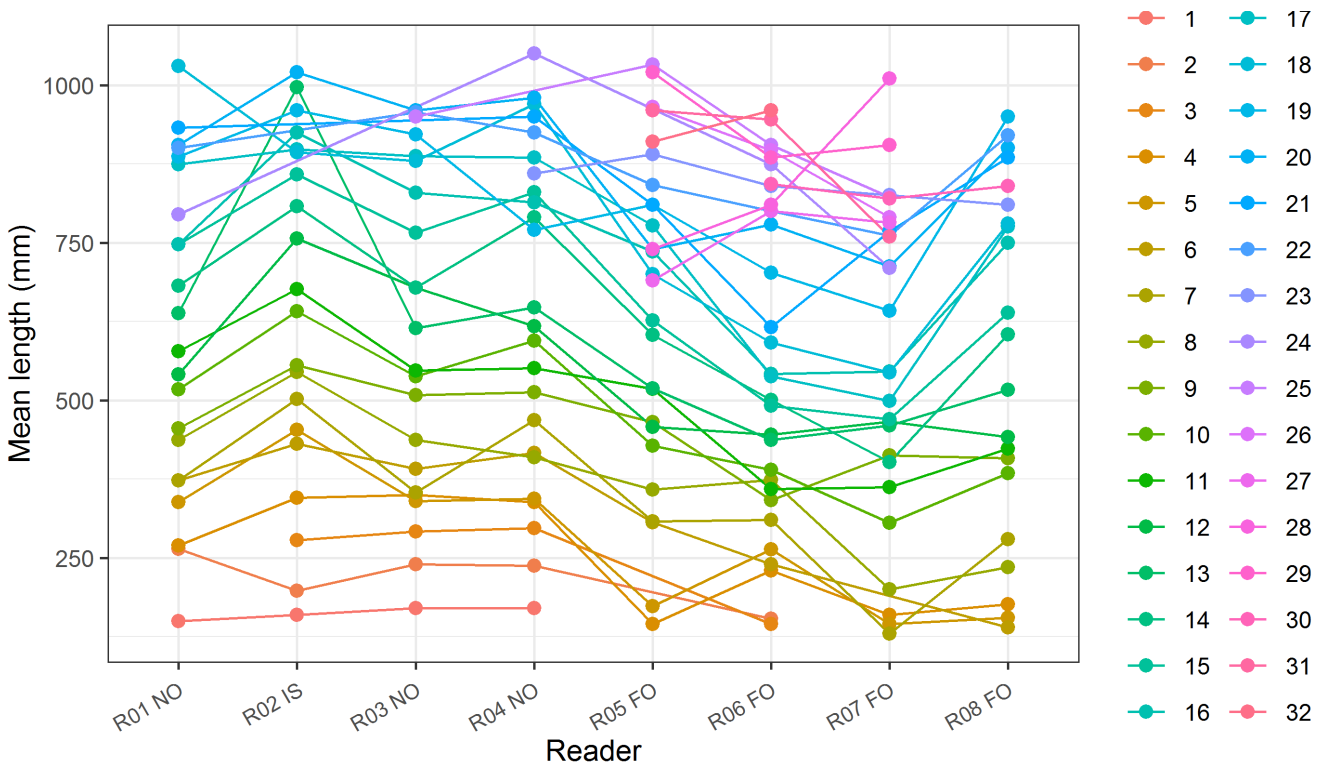

Figure 9.5: The mean length at age as estimated by each age reader.

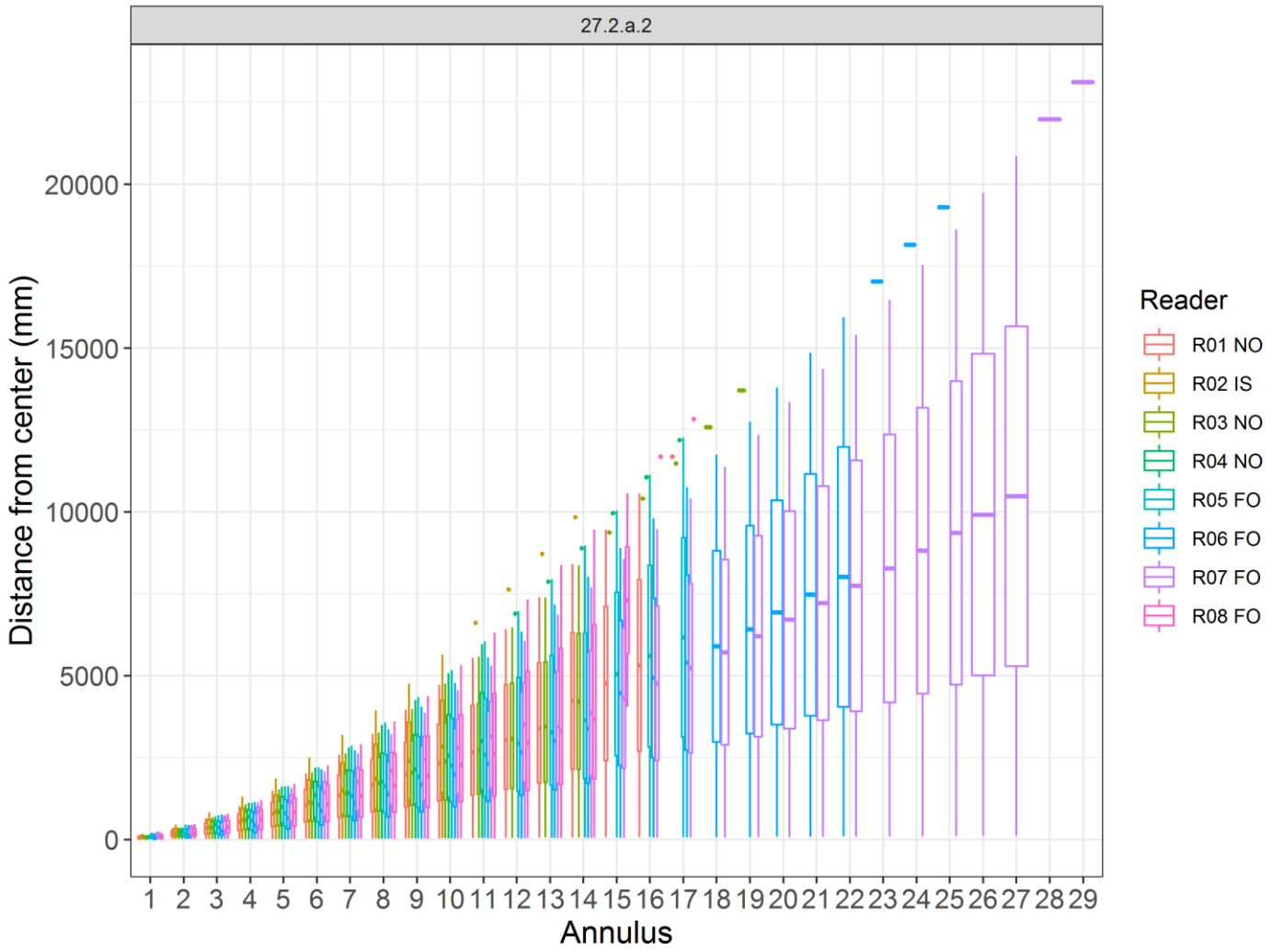

Figure 9.6: Plot of average distance from the centre to the winter rings for advanced readers by strata. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values, and the dots represent the outliers.

9.2 Results Advanced readers

All samples included

Data Overview

Table 9.6: Data overview including modal age and statistics per sample.

Fish ID	Event ID	Image ID	length	sex	Catch date	ICES area	R01 NO	R02 IS	R03 NO	R04 NO	Modal age	PA %	CV %	APE %
2015_73074Okt1_t02	436	-	1040	F	08/10/2015 00:00:00	27.2.b.2	18	13	17	15	13	25	14	11
2017_73010aug1_t07	436	-	1080	F	14/08/2017 00:00:00	27.2.a.2	17	13	18	20	13	25	17	12
2017_73054aug2_t01	436	-	285	M	22/08/2017 00:00:00	27.2.b.2	8	7	7	5	7	50	19	13
2017_73077aug1_t17	436	-	295	F	25/08/2017 00:00:00	27.2.b.2	2	3	3	3	3	75	18	14
2017_73079aug1_t12	436	-	1050	F	25/08/2017 00:00:00	27.2.b.2	21	17	22	24	17	25	14	10
2019_73002Sep1_t01	436	-	550	F	01/09/2019 00:00:00	27.2.a.2	10	10	10	11	10	75	5	4
2019_73002Sep1_t02	436	-	510	F	01/09/2019 00:00:00	27.2.a.2	10	5	14	13	5	25	38	29
2019_73002Sep2_t01	436	-	470	M	01/09/2019 00:00:00	27.2.a.2	10	6	11	9	6	25	24	17
2019_73002Sep2_t02	436	-	530	M	01/09/2019 00:00:00	27.2.a.2	9	7	11	10	7	25	18	14
2019_73002Sep2_t05	436	-	590	M	01/09/2019 00:00:00	27.2.a.2	13	8	13	6	13	50	36	30
2019_73002Sep2_t07	436	-	360	M	01/09/2019 00:00:00	27.2.a.2	7	5	7	8	7	50	19	13
2019_73002Sep2_t08	436	-	420	M	01/09/2019 00:00:00	27.2.a.2	6	6	6	7	6	75	8	6
2019_73004Sep1_t02	436	-	700	F	02/09/2019 00:00:00	27.2.a.2	16	11	17	15	11	25	18	13
2019_73004Sep1_t03	436	-	650	F	02/09/2019 00:00:00	27.2.a.2	12	10	14	13	10	25	14	10
2019_73004Sep1_t06	436	-	650	F	02/09/2019 00:00:00	27.2.a.2	13	8	13	14	13	50	23	17
2019_73004Sep1_t09	436	-	470	F	02/09/2019 00:00:00	27.2.a.2	8	6	8	9	8	50	16	11
2019_73004Sep1_t10	436	-	425	F	02/09/2019 00:00:00	27.2.a.2	7	7	6	6	6	50	9	8
2019_73004Sep1_t12	436	-	385	F	02/09/2019 00:00:00	27.2.a.2	6	5	7	5	5	50	17	13
2019_73004Sep1_t13	436	-	760	F	02/09/2019 00:00:00	27.2.a.2	19	14	17	16	14	25	13	9
2019_73004Sep2_t07	436	-	630	M	02/09/2019 00:00:00	27.2.a.2	13	10	13	12	13	50	12	8
2019_73005Sep1_t04	436	-	345	F	03/09/2019 00:00:00	27.2.a.2	5	4	4	4	4	75	12	9
2019_73005Sep2_t07	436	-	340	M	03/09/2019 00:00:00	27.2.a.2	7	4	6	5	4	25	23	18
2019_73008Sep2_t02	436	-	680	M	03/09/2019 00:00:00	27.2.a.2	16	8	15	13	8	25	27	19

2019_73012Sep1_t13	436	-	750	F	04/09/2019 00:00:00	27.2.a.2	17	11	16	15	11	25	18	13
2019_73022Sep1_t14	436	-	1030	F	05/09/2019 00:00:00	27.2.a.2	15	10	19	15	15	50	25	16
2019_73031Sep1_t17	436	-	800	F	06/09/2019 00:00:00	27.2.a.2	14	10	14	13	14	50	15	11
2019_73037Sep1_t02	436	-	900	F	07/09/2019 00:00:00	27.2.a.2	24	12	19	21	12	25	27	18
2019_73037Sep1_t03	436	-	820	F	07/09/2019 00:00:00	27.2.a.2	16	12	18	17	12	25	17	12
2019_73037Sep1_t17	436	-	920	F	07/09/2019 00:00:00	27.2.a.2	19	15	19	16	19	50	12	10
2019_73037Sep1_t20	436	-	860	F	07/09/2019 00:00:00	27.2.a.2	17	14	19	17	17	50	12	8
2019_73043Sep2_t10	436	-	700	M	07/09/2019 00:00:00	27.2.a.2	11	10	12	14	10	25	15	11
2019_73050Sep1_t08	436	-	860	F	08/09/2019 00:00:00	27.2.b.2	19	17	22	21	17	25	11	9
2019_73066Sep1_t08	436	-	950	F	10/09/2019 00:00:00	27.2.b.2	20	14	25	22	14	25	23	16
2019_73080Sep1_t10	436	-	950	F	11/09/2019 00:00:00	27.2.b.2	17	17	25	21	17	50	19	15
2022_73002Sep1_t02	436	-	510	F	01/09/2019 00:00:00	27.2.a.2	8	7	13	13	13	50	31	27
2022_73002Sep2_t07	436	-	360	M	01/09/2019 00:00:00	27.2.a.2	9	6	5	7	5	25	25	19
2022_73004Sep1_t06	436	-	650	F	02/09/2019 00:00:00	27.2.a.2	16	10	14	11	10	25	22	18
2022_73004Sep1_t12	436	-	385	F	02/09/2019 00:00:00	27.2.a.2	7	5	6	5	5	50	17	13
2022_73004Sep2_t07	436	-	630	M	02/09/2019 00:00:00	27.2.a.2	13	6	14	12	6	25	32	23
2022_73005Sep1_t04	436	-	345	F	03/09/2019 00:00:00	27.2.a.2	6	4	4	5	4	50	20	16
2022_73008Sep2_t02	436	-	680	M	03/09/2019 00:00:00	27.2.a.2	14	7	15	9	7	25	34	29
2022_73037Sep1_t02	436	-	900	F	07/09/2019 00:00:00	27.2.a.2	22	15	19	22	22	50	17	13
2022_73054aug2_t01	436	-	285	M	22/08/2017 00:00:00	27.2.b.2	7	8	7	5	7	50	19	13
2022_73074Okt1_t02	436	-	1040	F	08/10/2015 00:00:00	27.2.b.2	19	-	17	16	16	33	9	6
22240003_5375	436	-	499	F	12/06/2022 00:00:00	27.5.b	9	8	9	9	9	75	6	4
22240003_5379	436	-	518	M	12/06/2022 00:00:00	27.5.b	12	10	9	11	9	25	12	10
22240003_5380	436	-	544	F	12/06/2022 00:00:00	27.5.b	12	8	8	11	8	50	21	18
22240003_5383	436	-	473	F	12/06/2022 00:00:00	27.5.b	12	7	10	9	7	25	22	16
22240003_5391	436	-	741	F	12/06/2022 00:00:00	27.5.b	17	15	16	-	15	33	6	4
22240004_5227	436	-	399	F	12/06/2022 00:00:00	27.5.b	6	5	7	7	7	50	15	12
22240004_5233	436	-	429	M	12/06/2022 00:00:00	27.5.b	11	9	10	9	9	50	10	8
22240004_5239	436	-	592	F	12/06/2022 00:00:00	27.5.b	10	10	10	10	10	100	0	0

22240004_5240	436	-	611	M	12/06/2022 00:00:00	27.5.b	16	7	11	11	11	50	33	21
22240004_5243	436	-	654	F	12/06/2022 00:00:00	27.5.b	11	12	12	12	12	75	4	3
22240004_5245	436	-	327	M	12/06/2022 00:00:00	27.5.b	6	6	6	6	6	100	0	0
22240005_5048	436	-	418	F	13/06/2022 00:00:00	27.5.b	9	7	8	8	8	50	10	6
22240006_5023	436	-	569	F	13/06/2022 00:00:00	27.5.b	11	10	11	11	11	75	5	3
A11-2016-566-7	436	-	1020	F	16/10/2016 00:00:00	27.5.a	18	20	17	17	17	50	8	6
A11-2020-566-1	436	-	870	F	11/10/2020 00:00:00	27.5.a	14	13	16	12	12	25	12	9
A11-2020-573-2	436	-	910	M	12/10/2020 00:00:00	27.5.a	16	15	14	15	15	50	5	3
A11-2020-574-1	436	-	790	F	12/10/2020 00:00:00	27.5.a	16	14	17	16	16	50	8	6
A11-2020-575-8	436	-	840	F	12/10/2020 00:00:00	27.5.a	21	18	17	17	17	50	10	8
A11-2020-581-4	436	-	960	F	13/10/2020 00:00:00	27.5.a	21	18	20	15	15	25	14	11
A11-2020-581-6	436	-	930	F	13/10/2020 00:00:00	27.5.a	17	14	18	18	18	50	11	8
A11-2020-584-1	436	-	880	F	13/10/2020 00:00:00	27.5.a	21	18	17	20	17	25	10	8
A11-2020-591-9	436	-	830	F	14/10/2020 00:00:00	27.5.a	17	17	17	15	17	75	6	5
A11-2020-601-15	436	-	770	F	16/10/2020 00:00:00	27.5.a	15	14	13	14	14	50	6	4
A11-2020-603-2	436	-	960	F	16/10/2020 00:00:00	27.5.a	19	19	22	21	19	50	7	6
A11-2020-604-5	436	-	690	F	16/10/2020 00:00:00	27.5.a	24	17	18	13	13	25	25	17
A11-2020-609-11	436	-	670	F	17/10/2020 00:00:00	27.5.a	16	14	15	15	15	50	5	3
A11-2020-609-9	436	-	270	F	17/10/2020 00:00:00	27.5.a	4	4	1	1	1	50	69	60
A11-2020-616-8	436	-	570	F	18/10/2020 00:00:00	27.5.a	14	11	10	10	10	50	17	12
A11-2020-632-1	436	-	720	F	20/10/2020 00:00:00	27.5.a	13	14	14	13	13	50	4	4
A11-2020-634-4	436	-	810	F	20/10/2020 00:00:00	27.5.a	15	14	16	16	16	50	6	5
A11-2020-637-12	436	-	590	F	20/10/2020 00:00:00	27.5.a	15	10	12	15	15	50	19	15
A11-2020-641-12	436	-	530	F	21/01/2020 00:00:00	27.5.a	13	10	13	11	13	50	13	11
A11-2020-641-2	436	-	480	F	21/10/2020 00:00:00	27.5.a	8	9	8	11	8	50	16	11
A11-2020-642-3	436	-	460	F	21/10/2020 00:00:00	27.5.a	7	7	8	9	7	50	12	10
A11-2020-643-9	436	-	450	M	21/10/2020 00:00:00	27.5.a	12	9	6	8	6	25	29	20
A11-2020-647-9	436	-	340	F	21/10/2020 00:00:00	27.5.a	7	7	8	6	7	50	12	7
A11-2020-650-15	436	-	440	F	22/10/2020 00:00:00	27.5.a	8	8	8	9	8	75	6	5

A11-2020-654-4	436	-	500	F	22/10/2020 00:00:00	27.5.a	13	10	10	12	10	50	13	11
A11-2020-654-7	436	-	380	F	22/10/2020 00:00:00	27.5.a	6	6	6	5	6	75	9	7
A11-2020-661-6	436	-	390	F	23/10/2020 00:00:00	27.5.a	10	6	8	6	6	50	26	20
A11-2020-667-1	436	-	640	F	25/10/2020 00:00:00	27.5.a	16	14	13	16	16	50	10	8
A11-2020-670-1	436	-	740	F	25/10/2020 00:00:00	27.5.a	15	14	14	16	14	50	6	5
A11-2020-670-2	436	-	610	M	25/10/2020 00:00:00	27.5.a	12	10	13	10	10	50	13	11
A11-2020-674-1	436	-	540	F	26/10/2020 00:00:00	27.5.a	15	12	13	12	12	50	11	8
A11-2020-703-1	436	-	1080	F	29/10/2020 00:00:00	27.5.a	-	16	17	21	16	33	15	11
A12-2018-528-1	436	-	1010	F	07/10/2018 00:00:00	27.5.a	17	17	16	18	17	50	5	3
A13-2017-535-1	436	-	270	F	17/10/2017 00:00:00	27.5.a	2	3	3	3	3	75	18	14
AJ-60866	436	-	860	F	23/07/2010 00:00:00	21.1.a	20	14	16	23	14	25	22	18
AJ-60867	436	-	870	F	23/07/2010 00:00:00	21.1.a	13	12	12	15	12	50	11	8
AJ-60869	436	-	780	F	23/07/2010 00:00:00	21.1.a	19	11	17	15	11	25	22	16
AJ-60870	436	-	770	F	23/07/2010 00:00:00	21.1.a	17	16	16	19	16	50	8	6
B12-2016-725-1	436	-	170	F	18/07/2016 00:00:00	27.5.a	1	1	1	1	1	100	0	0
B12-2016-750-5	436	-	230	F	22/07/2016 00:00:00	27.5.a	2	3	2	2	2	75	22	17
HM-141115	436	-	390	M	11/06/2020 00:00:00	21.1.b	7	4	8	6	4	25	27	20
HM-141125	436	-	400	M	11/06/2020 00:00:00	21.1.b	9	5	6	6	6	50	27	19
HM-141148	436	-	230	M	11/06/2020 00:00:00	21.1.b	2	2	2	2	2	100	0	0
HM-141170	436	-	510	M	11/06/2020 00:00:00	21.1.b	9	5	10	9	9	50	27	20
HM-141182	436	-	310	F	12/06/2020 00:00:00	21.1.a	5	3	3	4	3	50	26	20
HM-141185	436	-	250	M	12/06/2020 00:00:00	21.1.a	2	2	2	3	2	75	22	17
HM-141189	436	-	150	F	12/06/2020 00:00:00	21.1.a	1	1	1	1	1	100	0	0
HM-141535	436	-	160	U	15/06/2020 00:00:00	21.1.a	1	3	1	1	1	75	67	50
HM-142017	436	-	410	M	16/06/2020 00:00:00	21.1.a	6	4	7	7	7	50	24	17
HM-142019	436	-	470	M	16/06/2020 00:00:00	21.1.a	9	5	11	6	5	25	36	29
HM-142039	436	-	140	F	16/06/2020 00:00:00	21.1.a	1	2	1	1	1	75	40	30
HM-142050	436	-	240	F	16/06/2020 00:00:00	21.1.a	2	2	2	2	2	100	0	0
HM-142072	436	-	480	M	16/06/2020 00:00:00	21.1.a	11	5	11	11	11	75	32	24

HM-142075	436	-	500	F	16/06/2020 00:00:00	21.1.a	14	7	14	12	14	50	28	20
HM-142086	436	-	320	F	17/06/2020 00:00:00	21.1.a	6	4	5	3	3	25	29	22
HM-142114	436	-	360	M	17/06/2020 00:00:00	21.1.a	5	3	4	4	4	50	20	12
HM-142131	436	-	130	U	17/06/2020 00:00:00	21.1.a	1	2	1	1	1	75	40	30
HM-142157	436	-	250	F	17/06/2020 00:00:00	21.1.a	2	3	2	2	2	75	22	17
PA-96078	436	-	800	F	13/09/2013 00:00:00	21.1.d	15	9	15	14	15	50	22	16
PA-96164	436	-	820	F	13/09/2013 00:00:00	21.1.d	17	15	16	14	14	25	8	6
SA-149641	436	-	700	M	28/06/2021 00:00:00	21.1.a	-	7	-	-	7	100	-	0
SA-149756	436	-	580	F	02/07/2021 00:00:00	21.1.a	11	11	12	11	11	75	4	3
SA-150471	436	-	700	F	17/07/2021 00:00:00	21.1.a	15	10	11	9	9	25	23	17
SA-151143	436	-	630	M	12/08/2021 00:00:00	21.1.a	11	5	10	7	5	25	33	27
SA-151147	436	-	620	M	12/08/2021 00:00:00	21.1.a	13	9	13	13	13	75	17	12
SA-151148	436	-	590	M	12/08/2021 00:00:00	21.1.a	10	7	10	7	7	50	20	18
SA-151181	436	-	670	M	13/08/2021 00:00:00	21.1.a	14	8	13	10	8	25	24	20
TB2-2021-48-15	436	-	350	F	16/10/2021 00:00:00	27.5.a	2	3	4	3	3	50	27	17
TB2-2021-9-12	436	-	1000	F	11/10/2021 00:00:00	27.5.a	16	14	15	14	14	50	6	5

Table 9.7: Number of age readings table gives an overview of number of readings per reader and modal age. The total numbers of readings per reader and per modal age are summarized at the end of the table.

Modal age	R01 NO	R02 IS	R03 NO	R04 NO	total
1	6	6	6	6	**24**
2	5	5	5	5	**20**
3	5	5	5	5	**20**
4	5	5	5	5	**20**
5	6	6	6	6	**24**
6	9	9	9	9	**36**
7	11	12	11	11	**45**
8	7	7	7	7	**28**
9	5	5	5	5	**20**
10	8	8	8	8	**32**
11	7	7	7	7	**28**
12	6	6	6	6	**24**
13	10	10	10	10	**40**
14	9	9	9	9	**36**
15	7	7	7	6	**27**
16	5	5	6	6	**22**
17	9	9	9	9	**36**
18	1	1	1	1	**4**
19	2	2	2	2	**8**
20	0	0	0	0	**0**
21	0	0	0	0	**0**
22	1	1	1	1	**4**
Total	**124**	**125**	**125**	**124**	**498**

Table 9.8: Age composition by reader gives a summary of number of readings per reader.

Modal age	R01 NO	R02 IS	R03 NO	R04 NO
1	5	2	6	**6**
2	8	5	5	**4**
3	0	8	3	**5**
4	1	7	4	**3**
5	3	10	2	**7**
6	8	8	8	**8**
7	8	13	6	**6**
8	5	8	9	**3**
9	7	5	2	**10**
10	6	15	9	**5**
11	7	5	7	**10**
12	6	5	5	**7**
13	9	3	11	**8**
14	6	13	9	**6**
15	8	5	5	**11**
16	10	2	8	**7**
17	10	6	11	**4**
18	2	3	4	**2**
19	6	1	5	**1**
20	2	1	1	**2**
21	4	0	0	**5**
22	1	0	3	**2**
23	0	0	0	**1**
24	2	0	0	**1**
25	0	0	2	**0**
Total	**124**	**125**	**125**	**124**

Table 9.9: Mean length at age per reader is calculated per reader and age (not modal age) and for all readers combined per age. A weighted mean is also given.

Age	R01 NO	R02 IS	R03 NO	R04 NO
1	150 mm	160 mm	170 mm	**170 mm**
2	264 mm	198 mm	240 mm	**238 mm**
3	-	278 mm	292 mm	**297 mm**
4	270 mm	346 mm	350 mm	**338 mm**
5	338 mm	453 mm	340 mm	**344 mm**
6	373 mm	431 mm	391 mm	**416 mm**
7	373 mm	502 mm	354 mm	**468 mm**
8	437 mm	545 mm	437 mm	**409 mm**
9	455 mm	556 mm	508 mm	**513 mm**
10	517 mm	641 mm	538 mm	**594 mm**
11	577 mm	676 mm	547 mm	**551 mm**
12	541 mm	757 mm	679 mm	**618 mm**
13	638 mm	997 mm	615 mm	**648 mm**
14	682 mm	808 mm	679 mm	**790 mm**
15	748 mm	858 mm	766 mm	**830 mm**
16	747 mm	925 mm	829 mm	**814 mm**
17	874 mm	898 mm	887 mm	**885 mm**
18	1030 mm	893 mm	880 mm	**970 mm**
19	887 mm	960 mm	922 mm	**770 mm**
20	905 mm	1020 mm	960 mm	**980 mm**
21	932 mm	-	-	**950 mm**
22	900 mm	-	957 mm	**925 mm**
23	-	-	-	**860 mm**
24	795 mm	-	-	**1050 mm**
25	-	-	950 mm	**-**
Weighted Mean	**591 mm**	**592 mm**	**595 mm**	**594 mm**

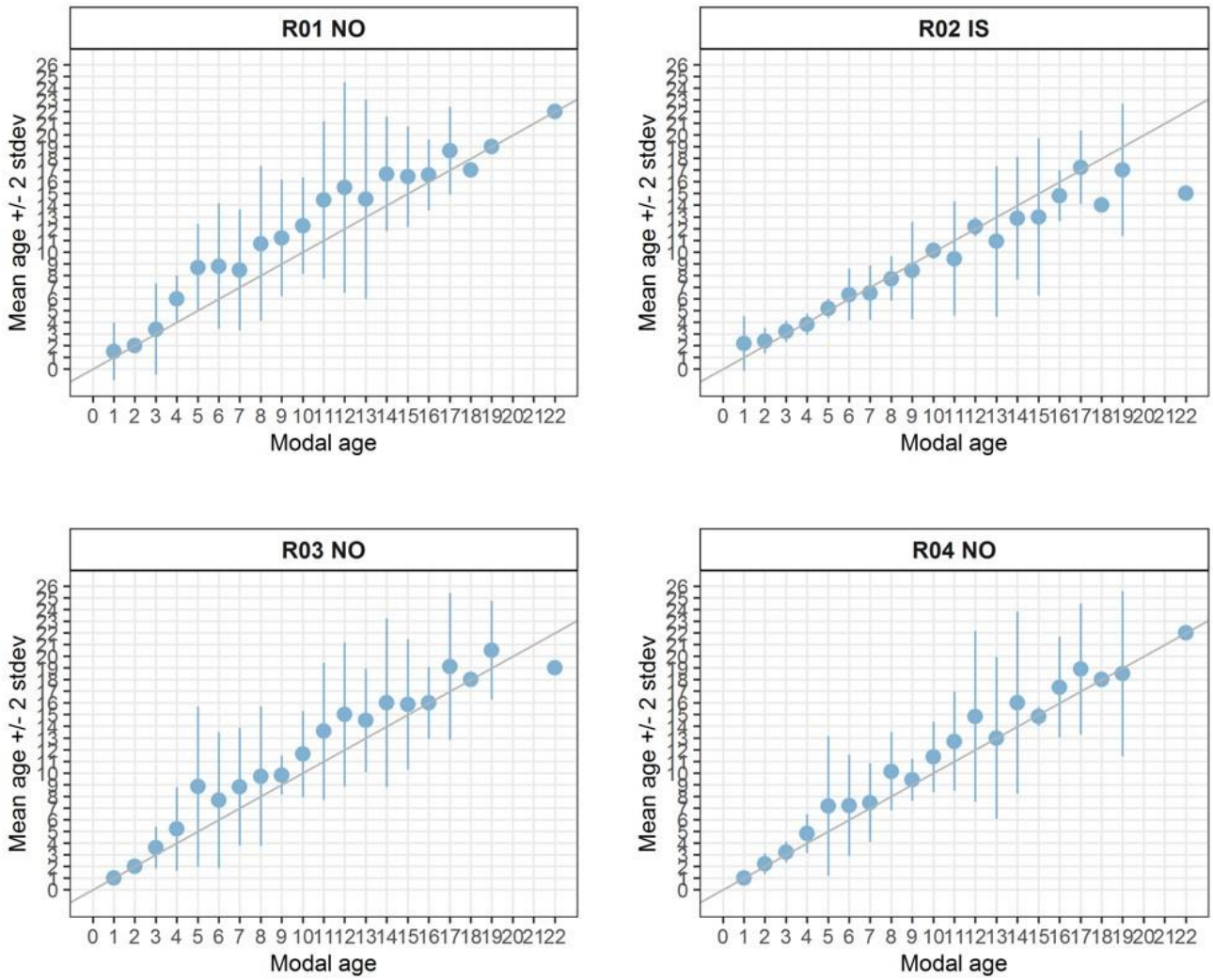

Figure 9.7: Age bias plots of individual advanced readers against modal age. *The 1:1 equivalence line is indicated.*

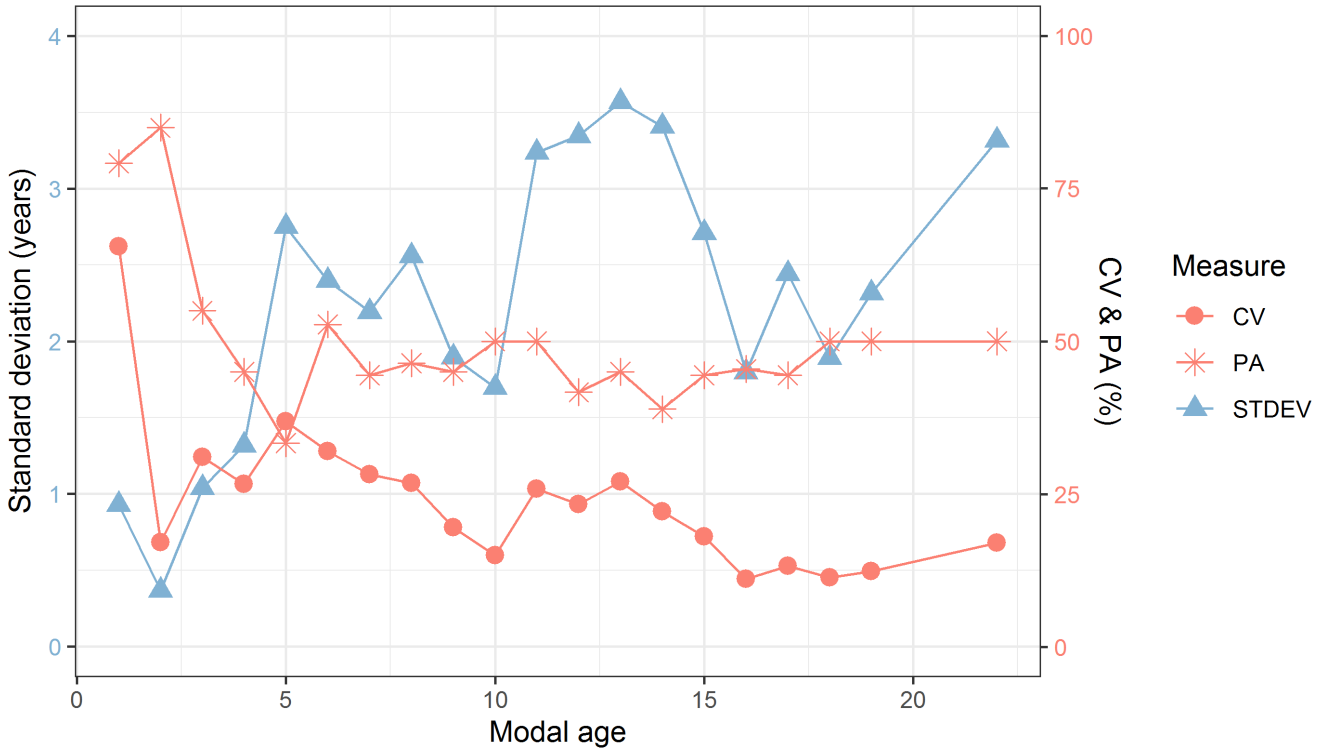

Figure 9.8: CV, PA and STDEV (standard deviation) are plotted against modal age.

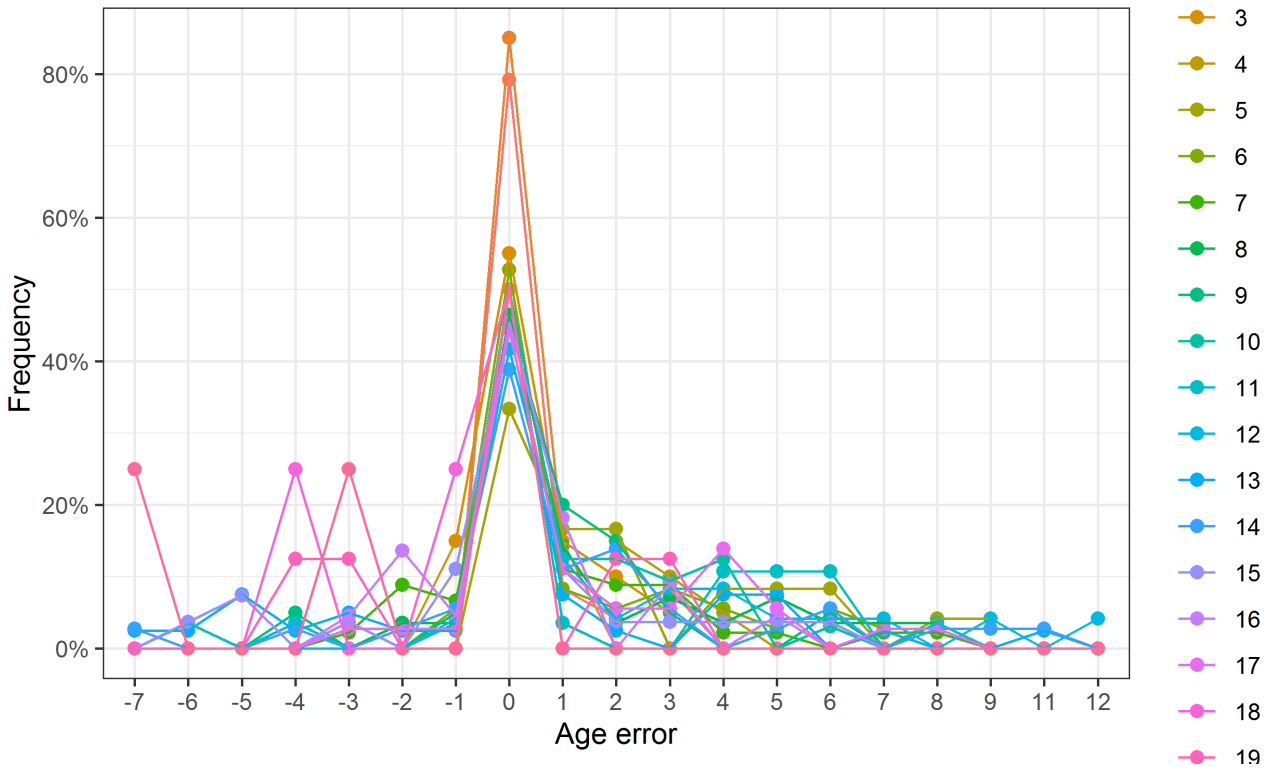

Figure 9.9: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias if the age reading errors are normally distributed. The distributions are skewed if relative bias occurs.

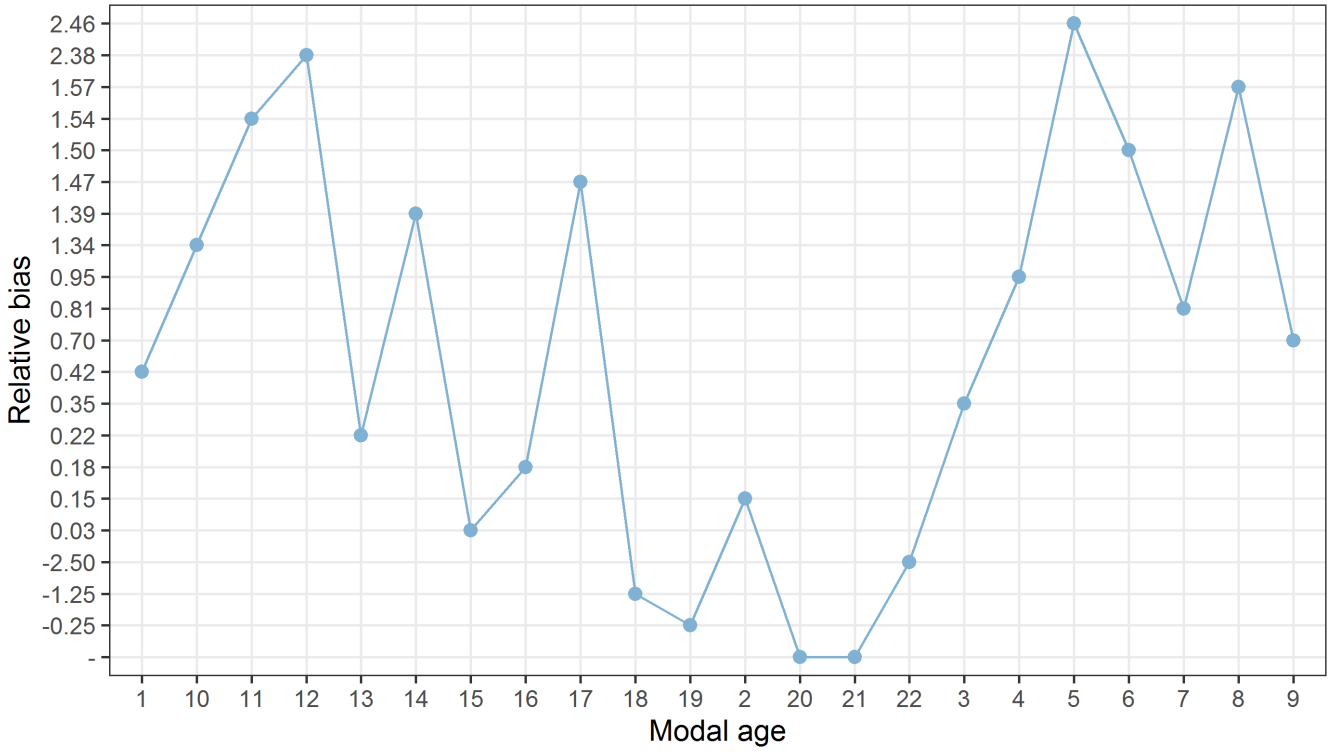

Figure 9.10: The relative bias by modal age as estimated by all age readers combined.

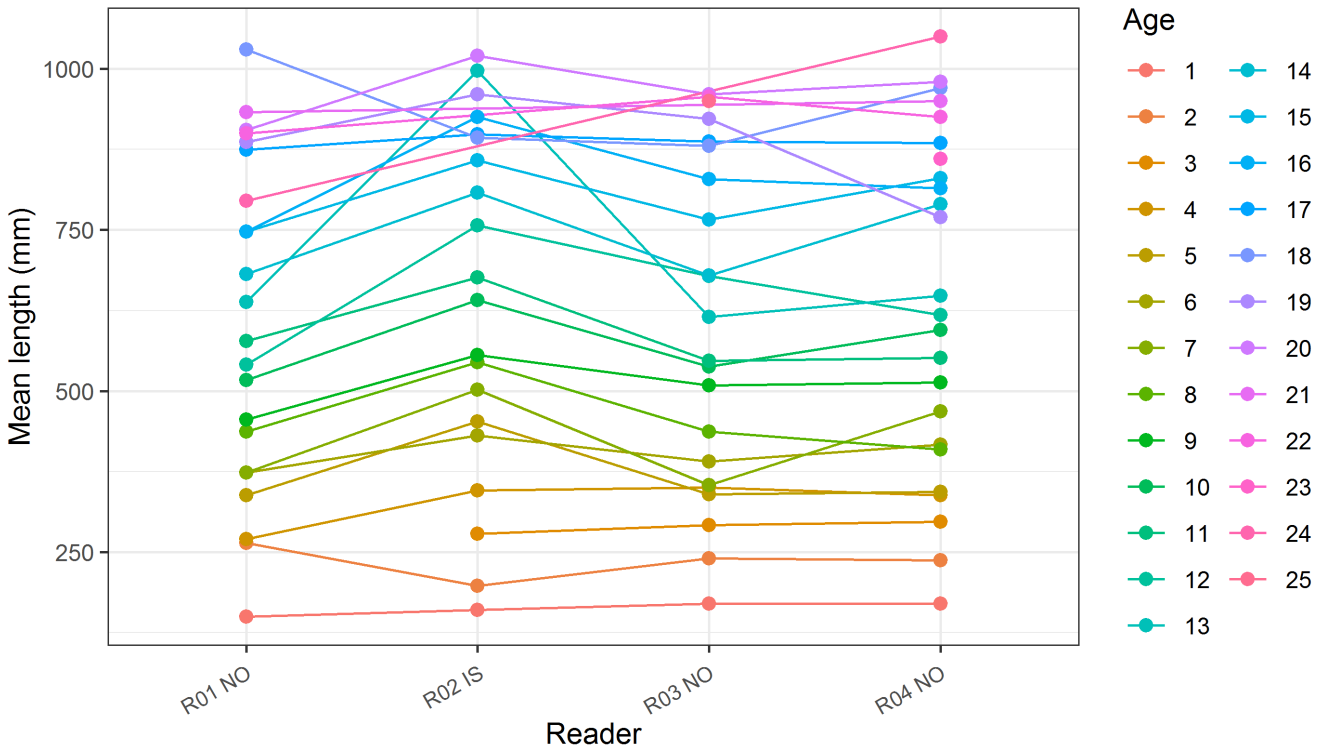

Figure 9.11: The mean length at age as estimated by each age reader.