SmartDots Report for the 2023 Plaice SD 22 exchange (ple.27.21-23 stock) (event ID 698)

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1 Summary

The 2023 exchange for plaice in ICES SD 22 (stock ple.27.21-23) took place via the SmartDots platform between June and September 2023. Twelve readers took part from 4 age reading labs (Denmark, Germany, Poland and Sweden); 9 "advanced" readers , meaning they provide age data for stock assessment purposes and 3 "basic" readers (do not provide age data for stock assessment purposes). Otoliths from 97 fish were included in the exchange (69 were sectioned and sectioned and stained). All otolith processing and imaging was carried out at DTU Aqua, Denmark. As different age reading methods are applied in the age reading labs routinely reading plaice from this area images of the otoliths prepared following the routine age reading methods were made available to the readers. Denmark and Sweden routinely read whole otoliths, soaked in water and viewed under reflected light. Germany routinely read sectioned otoliths viewed under reflected light. Poland read sectioned and stained otoliths but do not routinely read plaice from this area. Images were provided prepared in this way for comparison, to see if this method could improve the reliability of the age estimates.

Separate analysis are possible in the SmartDots reporting environment where specific readers and preparation methods can be analysed separately. This was done for this event and this report constitutes a compilation of results from various report outputs.

The results based on advanced readers of whole otoliths are fair, with overall PA at 71%. The most concerning results are the high CV values at modal age 1 (as high as 65%) and the individual reader relative bias values at modal ages 0 and 1 ranging from -0.07 to 0.27, which indicate large variability in what the readers are estimating in comparison to the modal age. The tendency is for readers to overestimate in comparison to modal age. The results based on advanced readers of sectioned otoliths are not as good, with overall PA at 64%. A similar pattern in seen with the sectioned otoliths where overestimation in comparison to modal age is apparent. The overall relative bias value of 2.67 for advanced readers a modal age 0 is incorrect (due to approval mistakes in SmartDots). When looking at the results based on all readers, the individual reader relative bias values at modal ages 0 and 1 ranges from -0.60 to 1.17.

The results here focus on the youngest ages in this calibration event, the reason being that concerns have been raised on the difficulties in correctly identifying the innermost translucent zones (TZ's) seen in these otoliths. The results show that the age reading of plaice belonging to the ple.27.21-23 stock is highly inconsistent between labs and readers. This has been a concern for plaice in the North Sea and Skagerrak (ple.27.4.20) also and attributed to an extended spawning period of plaice which can lead to huge variability in the distance of the first TZ from the otolith nucleus. Efforts are underway to better understand the patterns seen in the otoliths of the youngest fish from this stock. Samples from a broader area, covering the range of the stock, are required to assess any spatial variation of the growth patterns.

A workshop is recommended to further analyse a larger collection of otoliths, possibly by microchemical and microstructure analysis plus additional length frequency analysis. One of the aims would be to provide updated guidelines for the age readers to correctly estimate the age of these fish.

Age error matrices have not been provided to the stock assessment working group (WGBFAS) given that the resulting data from this exchange does not truly represent the age estimations of the readers who provide age data for the ple.27.21-23 stock. Follow-up work will include communication with the stock assessor on the data needs for assessment.

2 Methods applied

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

Modal age: a multistage approach to define the modal age by sampled fish,

In this event, the multistage approach to calculate the modal age has been used. When summarizing the output and reporting the results of the exchange events developed within the SmartDots framework, the modal age (the most common age decided by the age readers for every fish sample) is the most relevant measurement. It is a key statistic by itself, but it is also fundamental for the estimation of some other relevant statistics to assess the performance of the techniques assessed in the exchange event, like the Percentage Agreement (PA), or input for stock assessments like the Age Error Matrix (AEM) (see below). However, the standard approach of calculating the mode (each reader has the same weight=1) the mode is taken as the lowest age of the multiple modal ages. This way renders multiple cases (fish samples) with multiple modal ages (i.e. different ages got the same highest number of readers). Accordingly, this imply a wrong perception of the age by fish individual and introduction of bias in the calculation of the PA and AEM. As a solution, in this report a multistage approach to select the modal age is used. This multistage approach is based in the different weight given to the age readers according to their experience. Two different weight scores scales were assigned, a weight score decreasing linearly with the experience and another decreasing with a negative exponential shape. The modal age by fish individual is decided following the next approach:

1.-If there is a single mode estimated with the standard approach (equal weight for all readers) this value is used as the modal age, if not

2.-Adding up, for each age category, the score assigned with the linear weighting for all the readers that decided that age for that fish. Next, the modal age is selected as the age category that obtains the highest score sum. If, despite this approach, there were still multiple ages with the same score (and hence multiple modes), the next step is applied:

3.-Adding up, for each age category, the score assigned with the negative exponential weighting for all the readers that decided that age for that fish. Select as the modal age the age with the highest score sum.

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.

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

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 (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.

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).

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:

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

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

Age error matrix (AEM)

Age error matrices (AEM) were produced following procedures outlined by WKSABCAL (2014) where the matrix shows the proportion of each modal age mis-aged as other ages. The sum of each row is 1, which equals 100%. If a reader is "advanced" then they are considered well trained and they provide ages for stock assessment or similar purposes. When the AEM is compiled for assessment purposes it uses only those readers who provide age data for the stock assessment in that specific area.

Otolith Growth Analysis

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

3 Overview of samples and readers

Table 3.1: Overview of samples used for the exchange event number 698. 4 samples from ICES SD24 were include in the analysis. These were captured on the border between ICES SD22 and ICES SD24. For the sake of simplicity these will be included in the analysis of SD22.

Year	ICES area	Quarter	Number of samples	Length range
2019	27.3.d.24	4	1	55 mm
2020	27.3.d.24	1	1	80 mm
2020	27.3.d.24	3	2	70-90 mm
2021	27.3.c.22	1	18	100-380 mm
2021	27.3.c.22	2	15	220-390 mm
2021	27.3.c.22	3	18	130-410 mm
2021	27.3.c.22	4	42	80-390 mm

Table 3.2: Reader overview showing expertise level and routine preparation method applied when age reading, ALA = whole otolith, SEX = Sectioned otolith, SSX = Sectioned and Stained otolith. Expertise rank indicating the readers level of experience from 1-13 (1 being most experienced and 13 the least experience).

Reader code	SmartUser	Expertise	Routine age reading method	Expertise_rank
R01 DK	Hansen	Advanced	ALA	1
R02 DE	Albrecht	Advanced	SEX	2
R03 DK	RasmussenH	Advanced	ALA	3
R04 SE	Bland	Advanced	ALA	4
R05 DE	Dressler	Advanced	SEX	5
R06 SE	Johanssonj	Advanced	ALA	6
R07 PL	Mirny	Advanced	SSS	7
R08 DE	Krumme	Advanced	SEX	8
R09 DK	Levinsky	Basic	ALA	9
R10 SE	WikstromK	Advanced	ALA	10
R11 DE	Hefter-Siebold	Basic	ALA	11
R13 DK	Lundgaard	Basic	ALA	13

4 Results

4.1 Results per age reading method

4.1.1 Advanced readers of whole otoliths

The following section provides the results based on whole otoliths (under reflected light) and only "advanced" age readers (those who provide age data for stock assessment purposes) and routinely reading whole otoliths. The analysis with all age readers who routinely read whole otoliths is included is in section 4.1.2

The multimodal stage approach to reduce the number of samples with multiple modes to 0% was applied. See Annex 7.1 for a more detailed description.

Summary statistics

Table 4.1: Summary of statistics; Total number of samples (NSample), coefficient of variance (CV), percentage of agreement (PA) and average percentage error (APE) for all ages and readers

NSample	CV	PA	APE
97	24 %	71 %	13 %

In this exchange event, 97 otolith fish individuals were aged. Of those, 16 % when the traditional approach (all readers equally weighted) is used to define the mode. The percentage of multiple mode cases is reduced to 0 %. When all the *whole* otolith samples are considered (both single and multimodal cases) the weighted average percentage agreement based on modal ages for all readers is 71 %, with the weighted average CV of 24 % and APE of 13 %. Overall CV is highest at modal age 1 at 42%, indicating wide variability in the estimation of ages and uncertainty as to where the first winter ring is. From age 2-6 the CV ranges from 17%-30% which is also considered high. Agreement between advanced readers is above 80% at modal ages 0-3, after which it decreases to 40-62%. Individual reader PA ranges from 54 – 80%. Overall relative bias is 0.08, ranging from -1.80 to 0.87 with readers from DK generally underestimating in comparison to modal age while readers from SWE generally overestimating in comparison to modal age. For 4 of the 5 readers relative bias is positive at modal age 0. The growth plot in Figure 4.2 shows much overlap between the average distance to the centre of each annulus. Individual reader bias plots can be found in Annex 7.1. The data overview table in Annex 7.2 can be used to find the image names where individual readers are in disagreement with modal age. The search function in the SmartDots software can be used to find the relevant images and annotations for comparison.

Coefficient of Variation (CV)

Table 4.2: Coefficient of Variation (CV) table presents, for whole otoliths, the CV per modal age and advanced reader, the CV of all advanced readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R10 SE	All
0	-	-	-	-	-	-
1	0 %	28 %	65 %	49 %	36 %	**42 %**
2	14 %	14 %	0 %	20 %	20 %	**17 %**
3	15 %	0 %	37 %	22 %	24 %	**22 %**
4	16 %	0 %	12 %	11 %	10 %	**17 %**
5	6 %	34 %	13 %	19 %	21 %	**23 %**
6	22 %	43 %	21 %	25 %	23 %	**30 %**

7	18 %	15 %	6 %	5 %	7 %	**13 %**
8	7 %	12 %	6 %	8 %	12 %	**14 %**
9	0 %	7 %	6 %	5 %	10 %	**12 %**
10	0 %	-	7 %	0 %	7 %	**39 %**
11	16 %	0 %	0 %	18 %	0 %	**14 %**
12	0 %	0 %	6 %	0 %	0 %	**12 %**
Weighted Mean	**10 %**	**19 %**	**22 %**	**22 %**	**20 %**	**24 %**

Percentage of Agreement (PA)

Table 4.3: Percentage agreement (PA) table represents, for whole otoliths, the PA per modal age and reader, advanced the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R10 SE	All
0	86 %	100 %	73 %	87 %	87 %	**86 %**
1	100 %	93 %	80 %	80 %	73 %	**85 %**
2	92 %	92 %	100 %	85 %	77 %	**89 %**
3	80 %	100 %	80 %	60 %	80 %	**80 %**
4	50 %	100 %	75 %	25 %	0 %	**50 %**
5	91 %	82 %	64 %	64 %	9 %	**62 %**
6	75 %	75 %	62 %	25 %	25 %	**52 %**
7	57 %	14 %	86 %	86 %	43 %	**57 %**
8	60 %	60 %	80 %	20 %	20 %	**48 %**
9	100 %	67 %	33 %	0 %	0 %	**40 %**
10	0 %	0 %	50 %	100 %	50 %	**40 %**
11	0 %	100 %	100 %	0 %	0 %	**40 %**
12	0 %	0 %	50 %	100 %	100 %	**50 %**
Weighted Mean	**78 %**	**80 %**	**76 %**	**65 %**	**54 %**	**71 %**

Average Percentage Error (APE)

Table 4.4: Average Percentage Error (APE) table represents, for whole otoliths, the APE per modal age and reader, the APE of all advanced readers combined per modal age and a weighted mean of the APE per reader.

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R10 SE	All
0	-	-	-	-	-	**-**
1	0 %	13 %	27 %	27 %	31 %	**18 %**
2	7 %	7 %	0 %	14 %	16 %	**6 %**
3	11 %	0 %	20 %	13 %	12 %	**10 %**
4	14 %	0 %	9 %	8 %	7 %	**14 %**
5	3 %	20 %	11 %	16 %	15 %	**15 %**
6	17 %	30 %	16 %	20 %	17 %	**19 %**
7	13 %	11 %	4 %	3 %	6 %	**9 %**
8	6 %	10 %	4 %	4 %	9 %	**10 %**
9	0 %	5 %	5 %	4 %	8 %	**10 %**
10	0 %	-	5 %	0 %	5 %	**26 %**
11	11 %	0 %	0 %	13 %	0 %	**10 %**
12	0 %	0 %	4 %	0 %	0 %	**10 %**
Weighted Mean	**7 %**	**11 %**	**12 %**	**14 %**	**15 %**	**13 %**

Relative Bias

Table 4.5: The relative bias (as the difference between the mean and modal age), for whole otoliths, per modal age and advanced reader is presented, as well as the weighted mean relative bias per reader and the relative bias per modal age for all advanced readers combined.

| Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R10 SE	All
0	0.14	0.00	0.27	0.13	0.13	**0.14**
1	0.00	-0.07	0.00	-0.07	0.27	**0.03**
2	-0.08	-0.08	0.00	-0.15	0.23	**-0.02**
3	-0.20	0.00	-0.20	0.00	0.10	**-0.06**
4	-0.50	0.00	0.25	0.75	1.25	**0.35**
5	-0.09	-0.55	0.45	0.73	1.27	**0.36**
6	-0.62	-1.00	0.88	1.38	1.50	**0.42**
7	-0.71	-0.71	-0.14	0.14	0.57	**-0.17**
8	-0.40	-0.60	-0.20	1.00	1.60	**0.28**
/9	0.00	-0.33	0.67	1.67	2.33	**0.87**
10	-2.00	-7.00	-0.50	0.00	0.50	**-1.80**
11	-2.00	0.00	0.00	0.50	2.00	**0.10**
12	-3.00	-2.00	-0.50	0.00	0.00	**-1.10**
Weighted Mean	**-0.31**	**-0.44**	**0.13**	**0.34**	**0.67**	**0.08**
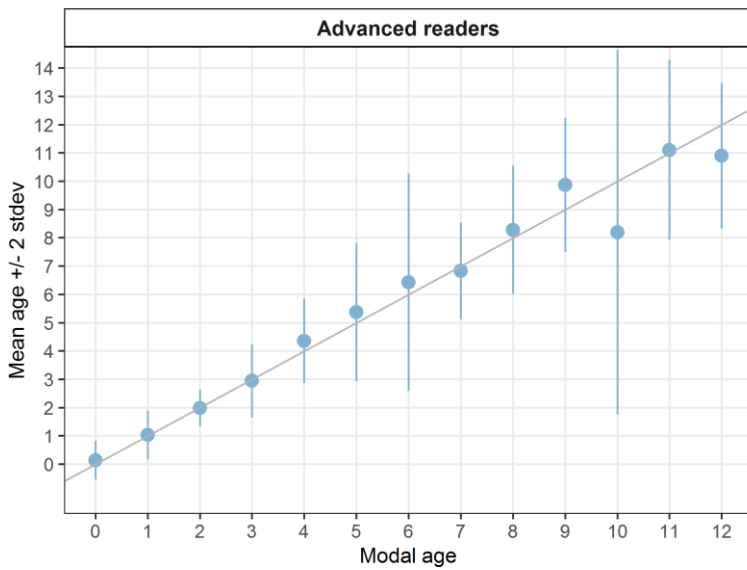
Figure 4.1: Age bias plot for advanced readers of whole otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).
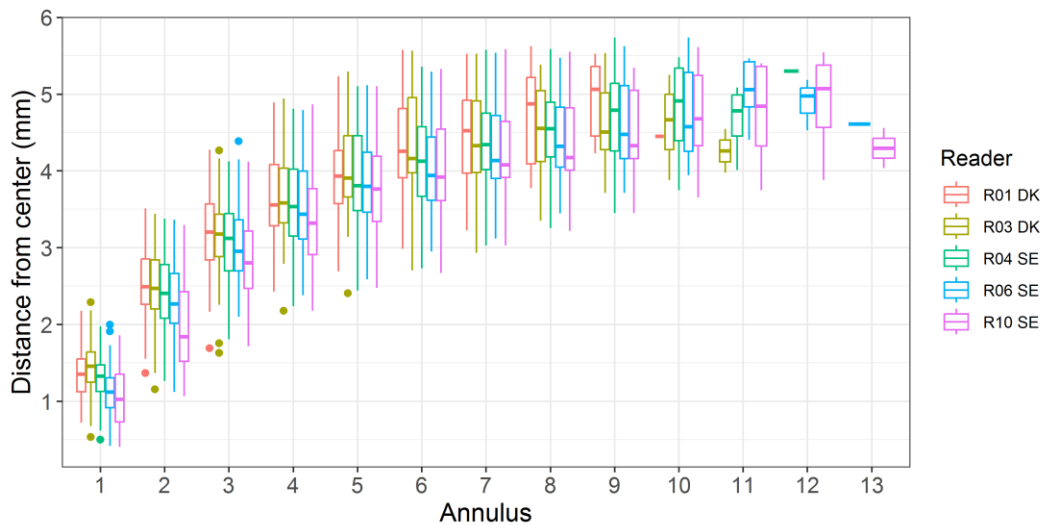
Growth analysis

Figure 4.2: Plot of average distance from the centre to the winter rings for advanced readers of whole otoliths. The boxes represent the mean, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

Of the 15 otoliths at modal age 0, 100% agreement was only reached on 9. The timing of the deposition of the first translucent (TZ) and opaque zones (OZ) are causing uncertainty as to which structures should be included in the count of age. Figure 4.3a and 4.3b show examples of the issues leading to poor agreement at modal age 0 where the deposition of TZ and OZ zones are very different even though the fish are the same sex and length, caught in the same ICES SD (adjacent ICES rectangles) and at the same time of year. Additionally, Figure 4.4 shows a sample with poor agreement on modal age 1 where one of the expert readers commented on the strange growth pattern where a clear opaque zone is identified at the otolith edge, which you would not expect to see when such a fish is caught in December.

At modal age 1, CV is high at 42%, due mostly to age estimations of advanced readers on image 8392351_ALA_RLX_XX which range from age 0 to age 3. Figure 4.5 shows the annotation of the reader estimating age 3, based on a very banded pattern of OZ and TZ in the otolith of this female fish. For modal ages 4 and older the overall PA is below 62%. Readers disagree on the growth structures both in the centre of the otoliths and at the otolith edge as seen in Figure 4.5.

Despite the disagreements at the lower ages the overall PA is above 80% at modal ages 0-3. Relative bias is positive for modal ages 4 and up at all ages except 7, 10 and 12 indicating overestimation of ages in comparison to modal age.
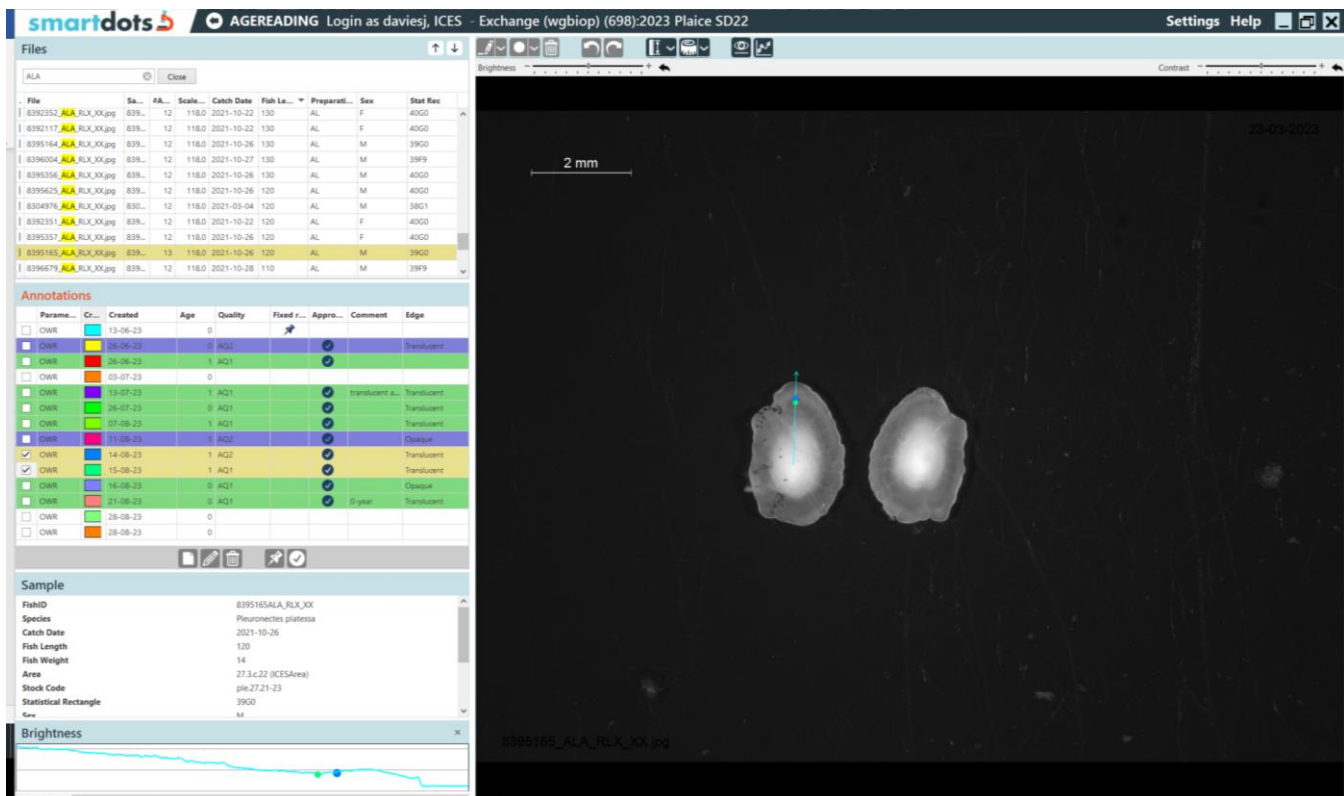
Figure 4.3a: Image 8395165_ALA_RLX_XX; modal age 0, 60% PA, Capture date 26_10_2021, TL 120mm. Blue and Green dots indicating the readings of two individual age readers each estimating the age to be 1.
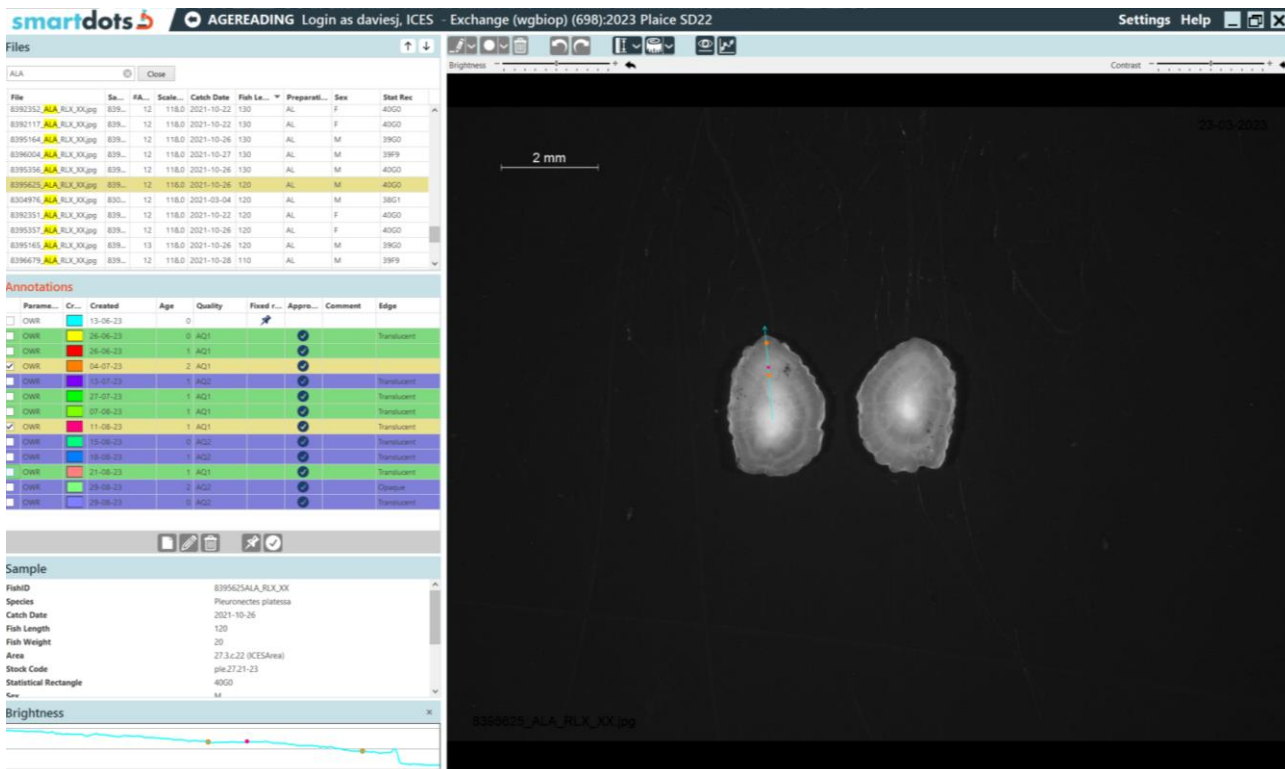

Figure 4.3b: Image 8395625_ALA_RLX_XX; modal age 0, 60% PA, Capture date 26_10_2021, TL 120mm. Red dot indicating the age to be 1 year and Orange dots indicating the age to be 2 years.
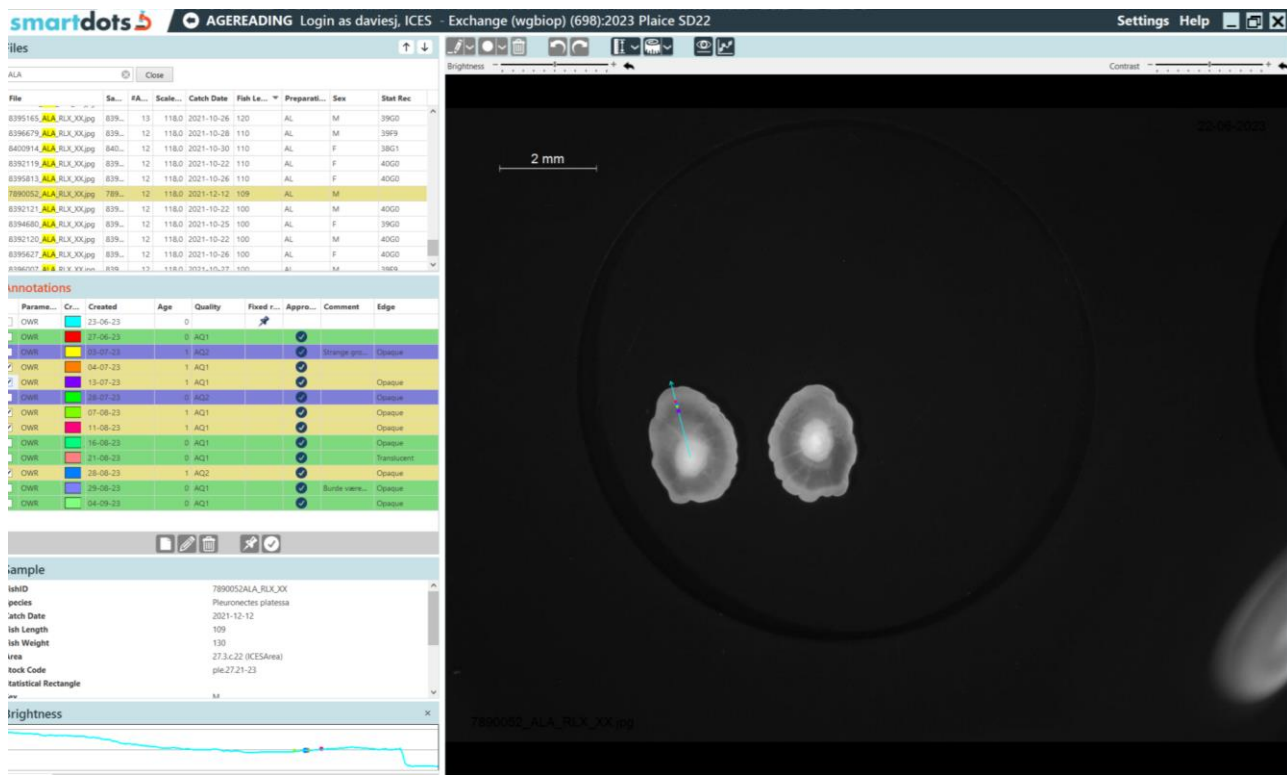
Figure 4.4: Image 7890052_ALA_RLX_XX; modal age 0, 60% PA, Capture date 12_12_2021, TL 109mm. Dots indicating the age to be 1 year by 2 advanced readers and 3 basic readers.
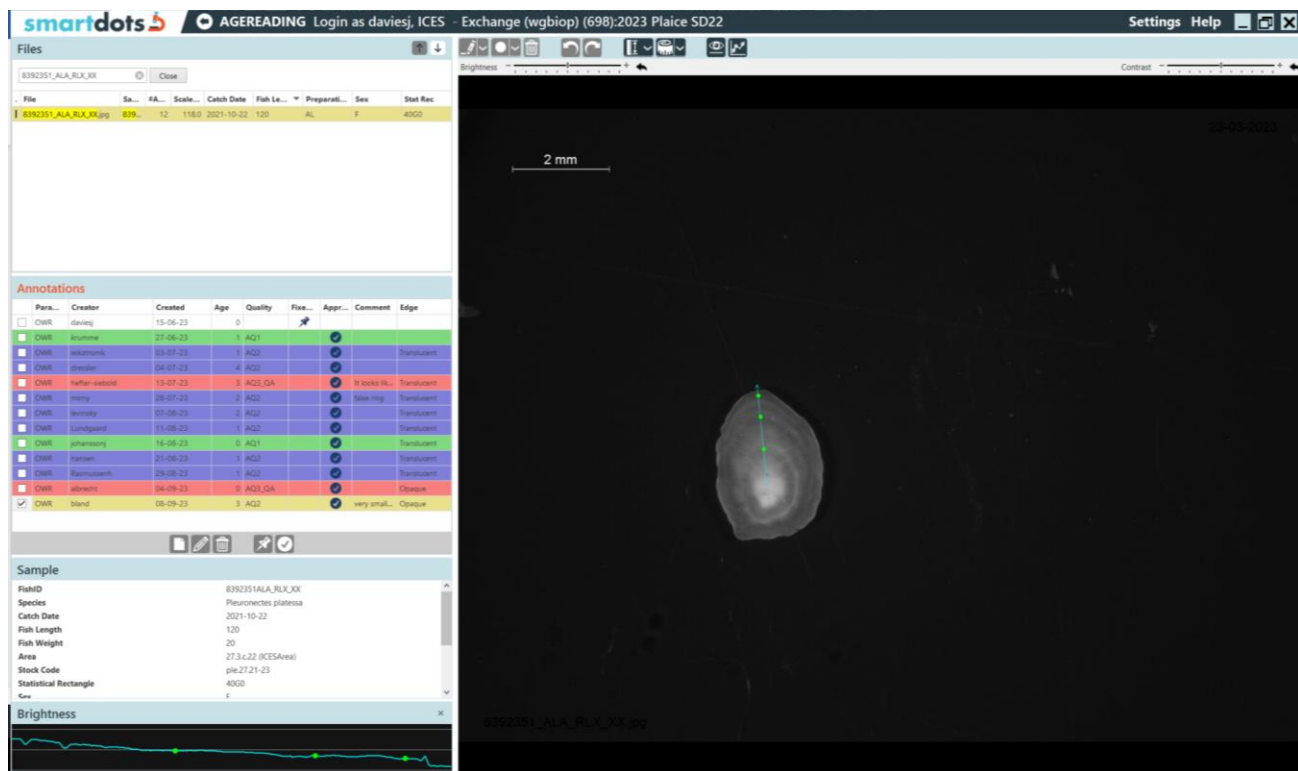

Figure 4.5: Image 8392351_ALA_RLX_XX; modal age 1, 60% PA, Capture date 22_10_2021, TL 120mm. Dots indicating the age to be 3 years by an advanced reader.
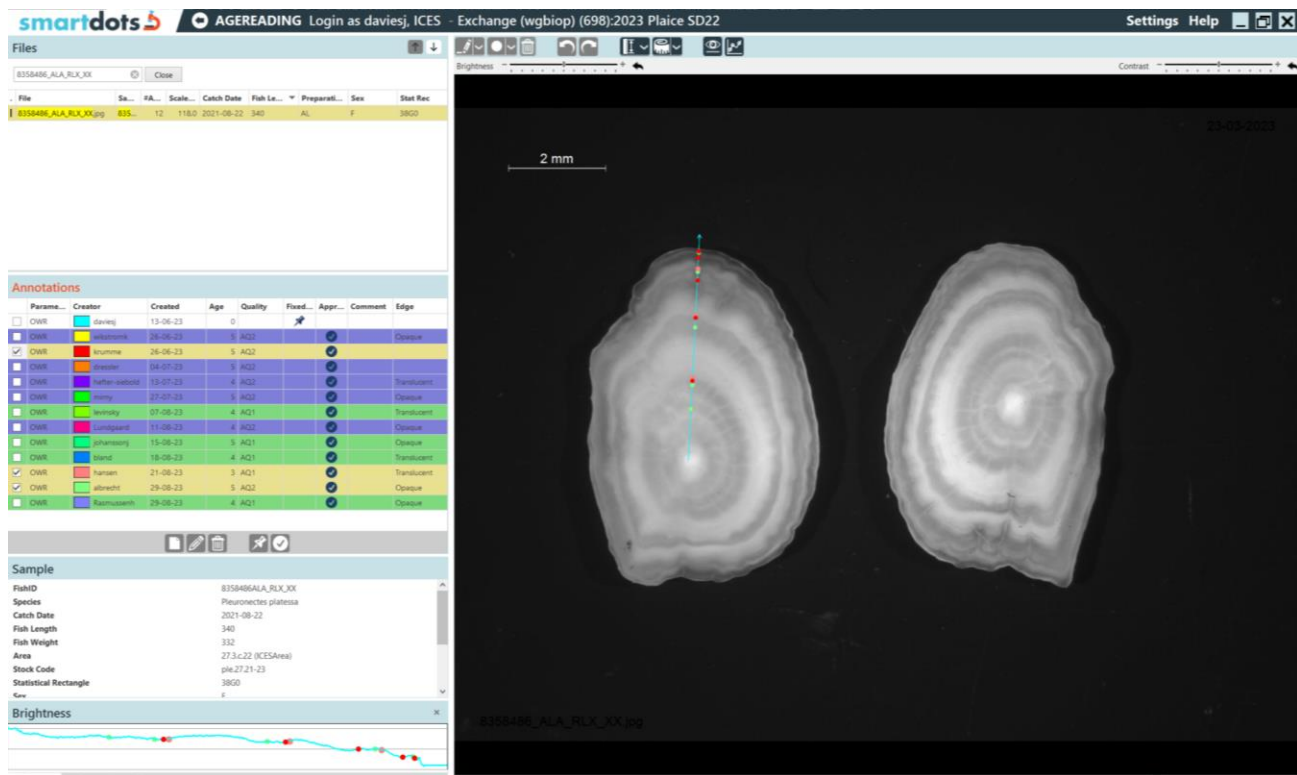
Figure 4.5: Image 8358486_ALA_RLX_XX; modal age 4, 40% PA, Capture date 22_08_2021, TL 340mm. Red and green dots indicating age 5 years and orange dots indicating age 3.

General Age Error Matrix (AEM)

Table 4.6: General Age error matrix (AEM) for whole otoliths. The modal age is in rows and the age classifications by the advanced readers in columns.

modal_age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
0	**0.86**	0.14	-	-	-	-	-	-	-	-	-	-	-	-	1.00
1	0.07	**0.85**	0.07	0.01	-	-	-	-	-	-	-	-	-	-	1.00
2	-	0.06	**0.89**	0.05	-	-	-	-	-	-	-	-	-	-	1.00
3	0.02	-	0.10	**0.80**	0.06	0.02	-	-	-	-	-	-	-	-	1.00
4	-	-	-	0.10	**0.50**	0.35	0.05	-	-	-	-	-	-	-	1.00
5	0.02	-	-	-	0.05	**0.62**	0.18	0.07	0.04	0.02	-	-	-	-	1.00
6	0.03	-	-	0.03	0.05	0.03	**0.52**	0.17	0.05	0.03	0.07	0.03	-	-	1.01
7	-	-	-	-	0.03	0.03	0.20	**0.57**	0.17	-	-	-	-	-	1.00
8	-	-	-	-	-	-	0.04	0.16	**0.48**	0.16	0.12	0.04	-	-	1.00
9	-	-	-	-	-	-	-	-	0.07	**0.40**	0.27	0.13	0.13	-	1.00
10	0.10	-	-	-	-	-	0.10	-	0.20	0.10	**0.40**	0.10	-	-	1.00
11	-	-	-	-	-	-	-	-	0.10	-	0.20	**0.40**	-	0.3	1.00
12	-	-	-	-	-	-	-	-	-	0.20	0.20	0.10	**0.50**	-	1.00

4.1.2 All readers of whole otoliths

The following section provides the results based on whole otoliths (under reflected light) and all age readers who read the whole otoliths in the exchange. Only DK and SE and R11 and R12 from DE routinely read whole otoliths.

The weighted average percentage agreement based on modal ages is 64 %, with the weighted average CV of 26 % and APE of 16 %. These results include the age readings of two basic readers of whole otoliths from DK (R09, R013) and one from DE (R011). Similar patterns showing high variability at modal ages 1 (overall CV of 51%) and 2 (overall CV of 26%) are apparent. Overall relative bias at modal ages 0 and 1 is 0.23 and 0.14 respectively indicating overestimation in comparison to modal age. The overall weighted mean relative bias is 0.05 but this does not truly reflect the individual readers weighted means which vary from -0.62 to 0.53. Individual reader bias plots can be found in Annex 7.2. When all readers are included then the overall PA% is low at 64%. 5 out of the 12 readers have a weighted mean PA of below 60%. R02 and R05 from DE have a low level of agreement with modal ages 0 and 1 and a high positive bias indicating overestimation in comparison to modal age. Figure 4.8 shows an example where these two readers identify a TZ which none of the other readers include in the count of age. Following the regular age reading procedures, when a fish caught in October has a translucent ring at the otolith edge then this ring would not be included in the count of age. This is referred to later in the conclusion.

The data overview table in Annex 7.2 can be used to find the image names where individual readers are in disagreement with modal age. The search function in the SmartDots software can be used to find the relevant images and annotations for comparison.

Table 4.7: Summary of statistics; Total number of samples (NSample), coefficient of variance (CV), percentage of agreement (PA) and average percentage error (APE) for all ages and readers

NSample	CV	PA	APE
97	26 %	64 %	16 %

Coefficient of Variation (CV)

Table 4.8: Coefficient of Variation (CV) table presents, for whole otoliths, the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R09 DK	R10 SE	R02 DE	R05 DE
0	-	-	-	-	-	-	-	-
1	26 %	57 %	70 %	57 %	33 %	52 %	36 %	43 %
2	20 %	20 %	14 %	20 %	23 %	19 %	35 %	14 %
3	16 %	0 %	38 %	21 %	16 %	12 %	14 %	22 %
4	17 %	16 %	0 %	13 %	0 %	0 %	0 %	0 %
5	16 %	9 %	15 %	12 %	9 %	14 %	10 %	54 %
6	21 %	16 %	14 %	13 %	12 %	16 %	8 %	6 %
7	15 %	70 %	8 %	14 %	7 %	15 %	19 %	0 %
8	7 %	12 %	7 %	11 %	15 %	15 %	5 %	7 %
9	7 %	-	6 %	6 %	0 %	11 %	11 %	13 %
10	16 %	20 %	11 %	5 %	16 %	12 %	15 %	12 %
11	11 %	5 %	0 %	13 %	5 %	5 %	7 %	12 %
12	-	-	-	-	-	-	-	-
Weighted Mean	**18 %**	**27 %**	**26 %**	**23 %**	**17 %**	**22 %**	**28 %**	**27 %**

Modal age	R07 PL	R08 DE	R11 DE	R13 DK	all
0	-	-	-	-	-
1	45 %	33 %	54 %	23 %	**51 %**
2	14 %	39 %	20 %	24 %	**26 %**
3	14 %	26 %	21 %	14 %	**21 %**
4	13 %	29 %	20 %	16 %	**19 %**
5	6 %	14 %	16 %	13 %	**19 %**
6	15 %	14 %	15 %	13 %	**16 %**
7	5 %	29 %	9 %	20 %	**23 %**
8	10 %	9 %	10 %	7 %	**11 %**
9	15 %	15 %	5 %	0 %	**21 %**
10	5 %	5 %	13 %	18 %	**17 %**
11	17 %	5 %	5 %	5 %	**13 %**
12	-	-	-	-	**13 %**
Weighted Mean	**18 %**	**24 %**	**23 %**	**17 %**	**26 %**

Percentage of Agreement (PA)

Table 4.9: Percentage agreement (PA) table represents, for whole otoliths, the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R09 DK	R10 SE	R02 DE	R05 DE
0	100 %	100 %	83 %	92 %	75 %	92 %	33 %	17 %
1	94 %	76 %	76 %	76 %	82 %	71 %	19 %	33 %
2	86 %	86 %	93 %	86 %	79 %	79 %	21 %	92 %
3	78 %	100 %	89 %	67 %	78 %	89 %	33 %	44 %
4	33 %	67 %	100 %	67 %	100 %	0 %	0 %	100 %
5	60 %	80 %	70 %	90 %	80 %	20 %	56 %	50 %
6	56 %	67 %	56 %	33 %	78 %	22 %	44 %	88 %
7	43 %	14 %	57 %	57 %	71 %	14 %	43 %	100 %
8	40 %	80 %	60 %	20 %	40 %	20 %	80 %	60 %
9	67 %	33 %	67 %	0 %	100 %	0 %	33 %	0 %
10	0 %	0 %	75 %	75 %	50 %	0 %	25 %	25 %
11	0 %	67 %	100 %	0 %	67 %	0 %	0 %	33 %
12	0 %	0 %	100 %	100 %	0 %	100 %	0 %	0 %
Weighted Mean	**68 %**	**72 %**	**77 %**	**67 %**	**75 %**	**51 %**	**33 %**	**54 %**

Modal age	R07 PL	R08 DE	R11 DE	R13 DK	all
0	100 %	75 %	83 %	92 %	**78 %**
1	71 %	82 %	82 %	94 %	**72 %**
2	93 %	64 %	86 %	79 %	**78 %**
3	78 %	50 %	56 %	78 %	**70 %**
4	67 %	33 %	33 %	67 %	**56 %**
5	90 %	38 %	60 %	60 %	**63 %**
6	56 %	44 %	33 %	67 %	**53 %**
7	86 %	17 %	29 %	57 %	**49 %**
8	40 %	60 %	20 %	60 %	**48 %**
9	33 %	33 %	0 %	100 %	**39 %**
10	75 %	75 %	50 %	25 %	**40 %**
11	0 %	67 %	0 %	67 %	**34 %**
12	100 %	0 %	0 %	100 %	**42 %**
Weighted Mean	**75 %**	**58 %**	**58 %**	**75 %**	**64 %**

Average Percentage Error (APE)

Table 4.10: Average Percentage Error (APE) table represents, for whole otoliths, the APE per modal age and reader, the APE of all advanced readers combined per modal age and a weighted mean of the APE per reader.

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R09 DK	R10 SE	R02 DE	R05 DE
0	-	-	-	-	-	-	-	-
1	12 %	47 %	35 %	47 %	25 %	31 %	28 %	30 %
2	13 %	13 %	7 %	13 %	13 %	15 %	25 %	7 %
3	12 %	0 %	22 %	14 %	12 %	7 %	12 %	18 %
4	13 %	12 %	0 %	10 %	0 %	0 %	0 %	0 %
5	13 %	7 %	10 %	7 %	4 %	7 %	9 %	40 %
6	17 %	14 %	11 %	11 %	9 %	11 %	8 %	4 %
7	12 %	57 %	7 %	11 %	6 %	11 %	15 %	0 %
8	6 %	8 %	6 %	9 %	12 %	12 %	4 %	6 %
9	5 %	-	5 %	4 %	0 %	8 %	7 %	10 %
10	11 %	14 %	8 %	4 %	11 %	8 %	12 %	9 %
11	7 %	4 %	0 %	10 %	4 %	4 %	5 %	9 %
12	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
Weighted Mean	**12 %**	**21 %**	**14 %**	**17 %**	**12 %**	**14 %**	**22 %**	**18 %**

Modal age	R07 PL	R08 DE	R11 DE	R13 DK	all
0	-	-	-	-	-
1	33 %	25 %	29 %	10 %	**33 %**
2	7 %	21 %	13 %	19 %	**12 %**
3	11 %	20 %	16 %	11 %	**12 %**
4	10 %	21 %	13 %	12 %	**15 %**
5	4 %	12 %	12 %	8 %	**10 %**
6	10 %	11 %	11 %	11 %	**11 %**
7	3 %	22 %	6 %	16 %	**14 %**
8	8 %	5 %	8 %	6 %	**9 %**
9	11 %	11 %	4 %	0 %	**13 %**
10	4 %	4 %	11 %	14 %	**14 %**
11	13 %	4 %	4 %	4 %	**10 %**
12	0 %	0 %	0 %	0 %	**11 %**
Weighted Mean	**12 %**	**17 %**	**15 %**	**11 %**	**16 %**

Relative bias

Table 4.11: The relative bias (as the difference between the mean and modal age), for whole otoliths per modal age and reader is presented, as well as the weighted mean relative bias per reader and the relative bias per modal age for all readers combined.

Modal age	R01 DK	R03 DK	R04 SE	R06 SE	R09 DK	R10 SE	R02 DE	R05 DE
0	0.00	0.00	0.17	0.08	0.25	0.08	0.75	0.92
1	-0.06	-0.24	-0.06	-0.24	0.18	0.06	0.69	0.80
2	-0.14	-0.14	-0.07	-0.14	0.07	0.21	0.64	-0.08
3	-0.22	0.00	-0.33	-0.11	-0.22	-0.11	0.67	0.78
4	-0.67	-0.33	0.00	0.33	0.00	1.00	1.00	0.00
5	-0.50	-0.20	0.20	0.20	0.00	1.00	0.44	-0.90
6	-0.78	-0.56	0.33	0.56	-0.33	0.44	0.56	0.12
7	-0.86	-2.71	-0.43	0.71	-0.29	1.43	-0.29	0.00
8	-0.60	-0.40	-0.40	0.40	-0.40	0.80	0.20	0.40
9	-0.33	-3.33	0.33	1.33	0.00	1.67	0.00	-0.33
10	-2.25	-3.00	-0.50	0.25	-1.00	0.75	-1.50	-1.50

11	-2.00	-0.33	0.00	0.67	0.33	1.67	-1.50	-1.33
12	-3.00	-2.00	0.00	0.00	-3.00	0.00	-3.00	-1.00
Weighted Mean	**-0.49**	**-0.62**	**-0.04**	**0.16**	**-0.08**	**0.49**	**0.36**	**0.12**

Modal age	R07 PL	R08 DE	R11 DE	R13 DK	all
0	0.00	0.25	0.17	0.08	**0.23**
1	0.18	0.18	0.12	0.06	**0.14**
2	-0.07	0.00	-0.14	-0.21	**-0.01**
3	0.22	-0.25	0.22	0.22	**0.07**
4	0.33	1.33	1.00	-0.33	**0.31**
5	-0.10	0.38	0.30	0.00	**0.07**
6	0.11	0.44	1.11	-0.44	**0.13**
7	0.14	-0.33	0.86	-0.86	**-0.22**
8	0.20	0.00	1.40	0.40	**0.17**
9	1.33	1.33	2.33	0.00	**0.36**
10	0.25	-0.25	1.25	-0.75	**-0.69**
11	-1.00	-0.33	1.67	0.33	**-0.15**
12	0.00	-1.00	1.00	0.00	**-1.00**
Weighted Mean	**0.09**	**0.15**	**0.53**	**-0.10**	**0.05**
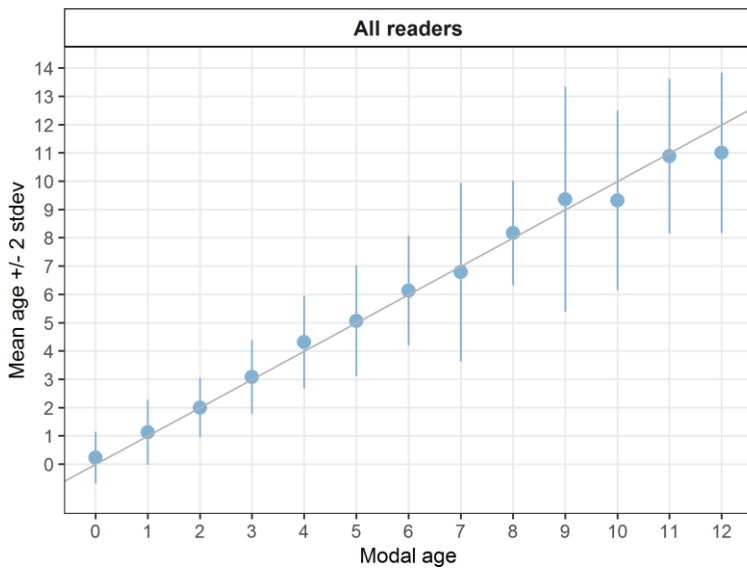
Figure 4.6: Age bias plot for all readers of whole otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.

Inter-reader bias test

Table 4.12: Inter reader bias test for whole otoliths. 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) , / = diagonal of the table (no bias)

Comparison	R01 DK	R03 DK	R04 SE	R06 SE	R09 DK	R10 SE	R02 DE	R05 DE	R07 PL	R08 DE	R11 DE	R13 DK
R01 DK	/	**	*	**	**	**	**	**	**	**	**	*
R03 DK	**	/	*	-	-	**	**	**	**	*	**	*
R04 SE	*	*	/	-	**	*	-	-	**	**	**	**

R06 SE	**	-	-	/	**	-	-	**	**	**	*	**
R09 DK	**	-	**	**	/	-	-	-	**	*	**	**
R10 SE	**	**	*	-	-	/	**	**	-	-	**	*
R02 DE	**	**	-	-	-	**	/	**	-	**	**	-
R05 DE	**	**	-	**	-	**	**	/	**	**	**	-
R07 PL	**	**	**	**	**	-	-	**	/	**	-	*
R08 DE	**	*	**	**	*	-	**	**	**	/	-	-
R11 DE	**	**	**	*	**	**	**	**	-	-	/	**
R13 DK	*	*	**	**	**	*	-	-	*	-	**	/
Modal age	**	**	**	**	**	**	-	-	*	**	**	**

Growth analysis

Figure 4.7: Plot of average distance from the centre to the winter rings for all readers of whole otoliths. 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.
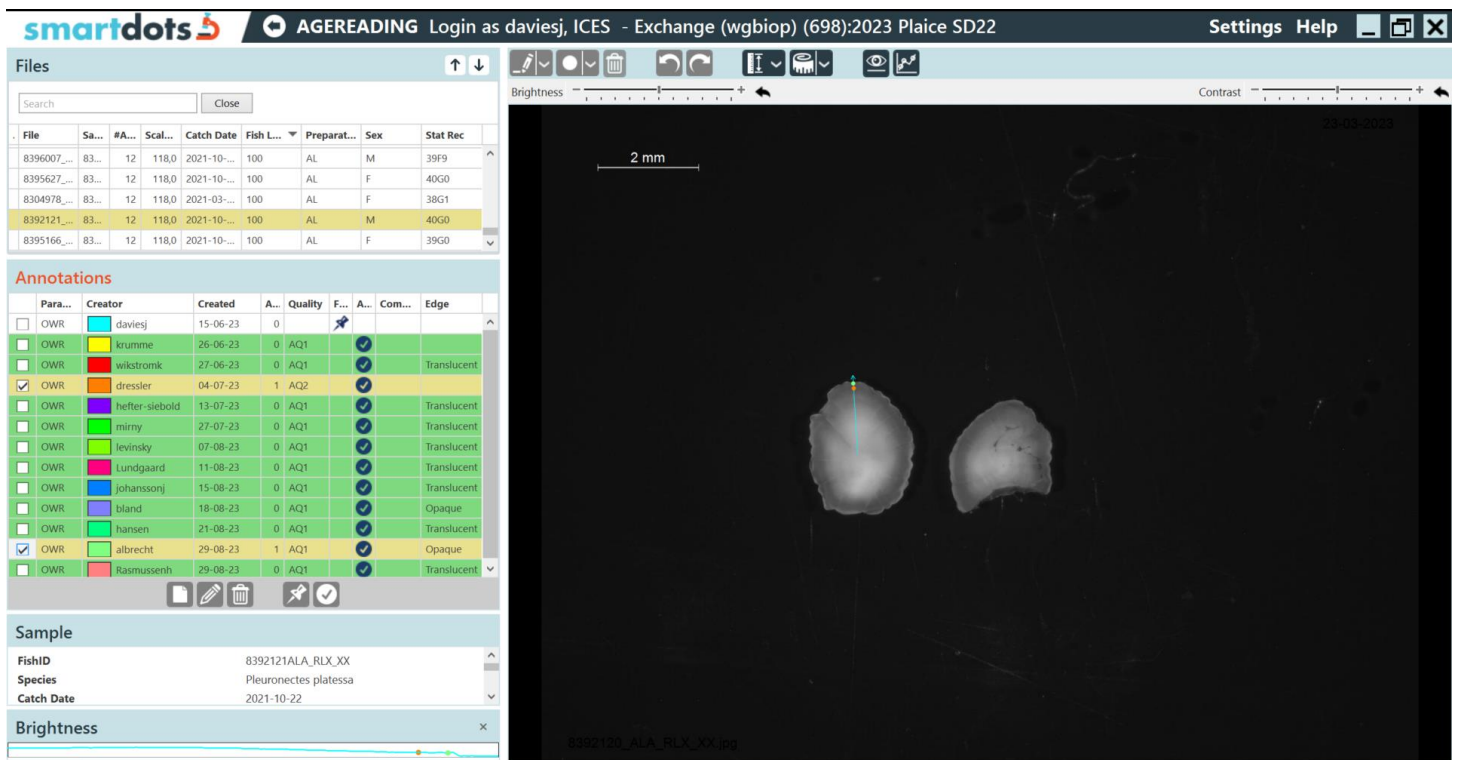
Figure 4.8: Image 8392121_ALA_RLX_XX; modal age 0, 83% PA, Capture date 22_10_2021, TL 100mm. Dots indicating the age to be 1 year by 2 readers.

4.1.3 Advanced readers of sectioned otoliths

The following section provides the results based on sectioned otoliths (under reflected light) and only "advanced" age readers, those who provide age data for stock assessment purposes and routinely reading sectioned otoliths, all three readers are from DE. The analysis with all age readers who routinely read sectioned otoliths is included is in section 4.1.4

The multimodal stage approach to reduce the number of samples with multiple modes to 0% was applied. See Annex 7.3 for a more detailed description.

Summary statistics

Table 4.13: Summary of statistics; Total number of samples (NSample), coefficient of variance (CV), percentage of agreement (PA) and average percentage error (APE) for all ages and readers

NSample	CV	PA	APE
69	19 %	64 %	12 %

In this exchange event, 69 otolith fish individuals were aged. Of those, 26 % when the traditional approach (all readers equally weighted) is used to define the mode. The percentage of multiple mode cases is reduced to 0. When all the *sectioned* otolith samples are considered (both single and multimodal cases) the weighted average percentage agreement based on modal ages for all readers is 64 %, with the weighted average CV of 19 % and APE of 12 %. Modal age ranges from 0 to 16 years. At modal age 0, PA is 67%, this increases to 89% at modal age 1 but ranges from

67% to 33% from modal ages 2 to 12. The relative bias value at modal age 0 of 2.67 is incorrect due to mistakes in how 2 readers were approving annotations. Despite this, the relative bias values, CV and PA at modal ages 1 and 2 indicate that there are issues with the correct identification of the annuli, readers are in disagreement and there is overestimation in comparison to modal age. Figure 4.9 clearly shows this (values at modal age 0 are incorrect). A deeper examination of the data revealed that a mistake had been made when annotation in the SmartDots software. Some readers had approved annotations where no age/dots had been annotated, meaning an age of 0 was used in the reporting module, this has led to a miscalculation at modal age 0 for sectioned otoliths. This is referred to again when comparing age reading methods in Section 4.2.1

Individual reader bias plots can be found in Annex 7.3. The data overview table in Annex 7.3 can be used to find the image names where individual readers are in disagreement with modal age. The search function in the SmartDots software can be used to find the relevant images and annotations for comparison.

These results highlight the issues with the correct identification of the first TZ which is also apparent when looking at the results from the readings of the whole otoliths.

Coefficient of Variation (CV)

Table 4.14: Coefficient of Variation (CV) table presents, for sectioned otoliths, 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 DE	R05 DE	R08 DE	all
0	-	-	-	-
1	43 %	0 %	0 %	**30 %**
2	22 %	29 %	38 %	**31 %**
3	14 %	39 %	10 %	**25 %**
4	0 %	20 %	15 %	**14 %**
5	8 %	16 %	9 %	**12 %**
6	8 %	18 %	17 %	**15 %**
7	-	-	-	**33 %**
8	0 %	17 %	15 %	**14 %**
9	11 %	50 %	15 %	**29 %**
10	4 %	14 %	5 %	**9 %**
11	0 %	15 %	6 %	**12 %**
12	9 %	0 %	5 %	**6 %**
13	0 %	-	10 %	**56 %**
14	-	-	-	-
15	-	-	-	**17 %**
16	-	-	-	**9 %**
Weighted Mean	**9 %**	**23 %**	**12 %**	**19 %**

Percentage of Agreement (PA)

Table 4.15: Percentage agreement (PA) table represents, for sectioned otoliths, the PA per modal age and reader, advanced the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R02 DE	R05 DE	R08 DE	all
0	100 %	100 %	0 %	**67 %**
1	67 %	100 %	100 %	**89 %**
2	75 %	75 %	50 %	**67 %**
3	73 %	55 %	91 %	**73 %**
4	100 %	50 %	60 %	**71 %**

5	80 %	70 %	67 %	**72 %**
6	75 %	75 %	67 %	**73 %**
7	100 %	0 %	0 %	**33 %**
8	100 %	33 %	20 %	**53 %**
9	67 %	50 %	33 %	**50 %**
10	80 %	40 %	75 %	**64 %**
11	100 %	20 %	0 %	**41 %**
12	67 %	100 %	33 %	**67 %**
13	100 %	0 %	50 %	**60 %**
14	-	-	-	-
15	100 %	0 %	0 %	**33 %**
16	100 %	-	0 %	**50 %**
Weighted Mean	**83 %**	**55 %**	**52 %**	**64 %**

Average Percentage Error (APE)

Table 4.16: Average Percentage Error (APE) table represents, for sectioned otoliths, the APE per modal age and reader, the APE of all advanced readers combined per modal age and a weighted mean of the APE per reader.

Modal age	R02 DE	R05 DE	R08 DE	all
0	-	-	-	-
1	33 %	0 %	0 %	**18 %**
2	17 %	21 %	33 %	**23 %**
3	12 %	29 %	5 %	**14 %**
4	0 %	12 %	13 %	**10 %**
5	6 %	8 %	8 %	**8 %**
6	6 %	14 %	13 %	**8 %**
7	0 %	0 %	0 %	**25 %**
8	0 %	13 %	12 %	**11 %**
9	7 %	33 %	12 %	**17 %**
10	3 %	12 %	4 %	**6 %**
11	0 %	10 %	5 %	**9 %**
12	7 %	0 %	4 %	**5 %**
13	0 %	-	7 %	**40 %**
14	-	-	-	-
15	0 %	0 %	0 %	**12 %**
16	0 %	-	0 %	**7 %**
Weighted Mean	**7 %**	**16 %**	**9 %**	**12 %**

Relative Bias

Table 4.17: The relative bias (as the difference between the mean and modal age), for sectioned otoliths, per modal age and advanced reader is presented, as well as the weighted mean relative bias per reader and the relative bias per modal age for all advanced readers combined.

Modal age	R02 DE	R05 DE	R08 DE	all
0	0.00	0.00	8.00	**2.67**
1	0.33	0.00	0.00	**0.11**
2	0.25	-0.20	-0.50	**-0.17**
3	0.27	-0.64	0.09	**-0.09**
4	0.00	0.00	-0.40	**-0.13**
5	0.20	0.00	0.33	**0.18**
6	0.25	-0.50	0.67	**0.14**
7	0.00	-1.00	4.00	**1.00**
8	0.00	-1.17	-0.60	**-0.59**
9	-0.17	-2.00	0.83	**-0.44**
10	0.20	-0.60	0.25	**-0.05**

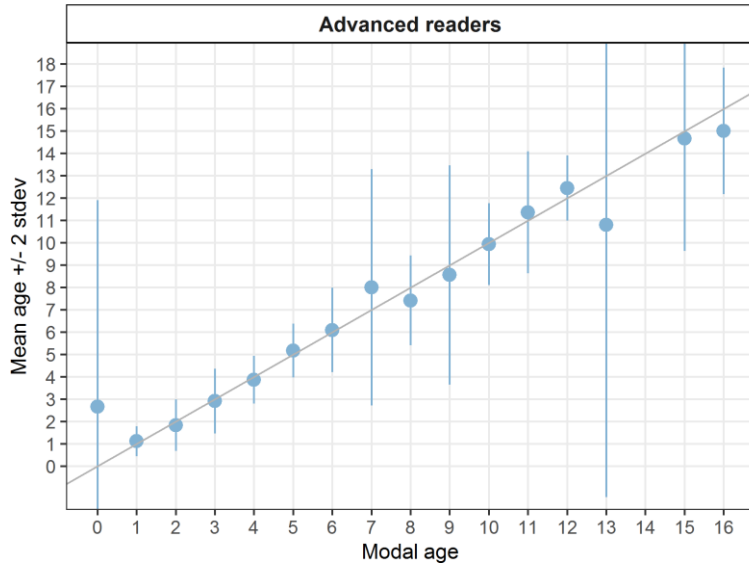|				
11	0.00	-0.80	1.67	**0.29**
12	0.67	0.00	0.67	**0.44**
13	0.00	-13.00	1.00	-4.00
14	-	-	-	-
15	0.00	-3.00	2.00	-0.33
16	0.00	-	-2.00	-
Weighted Mean	**0.14**	**-0.82**	**0.48**	**-0.10**

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

Growth analysis
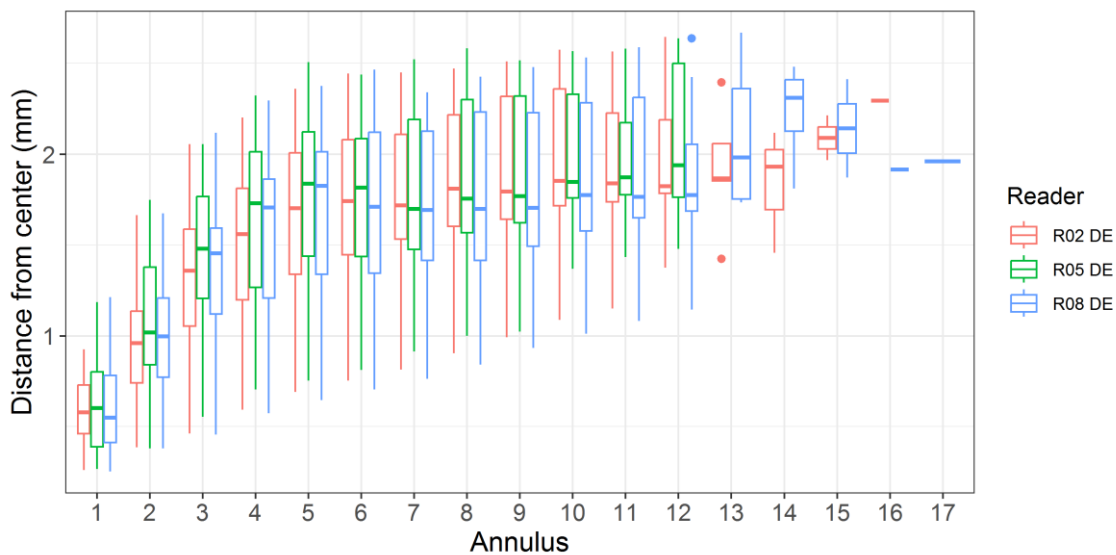
Figure 4.10: Plot of average distance from the centre to the winter rings for advanced readers, of sectioned otoliths. The boxes represent the mean, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

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General Age Error Matrix (AEM)

Table 4.18: General Age error matrix (AEM) for sectioned otoliths. The modal age is in rows and the age classifications by the advanced readers in columns.

modal_age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
0	**0.67**	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-	-	-	-	1.00
1	-	**0.89**	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00
2	-	0.25	**0.67**	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00
3	0.03	-	0.12	**0.73**	0.12	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00
4	-	-	-	0.21	**0.71**	0.07	-	-	-	-	-	-	-	-	-	-	-	-	0.99
5	-	-	-	-	0.07	**0.72**	0.17	0.03	-	-	-	-	-	-	-	-	-	-	0.99
6	-	-	-	-	0.09	-	**0.73**	0.09	0.09	-	-	-	-	-	-	-	-	-	1.00
7	-	-	-	-	-	-	0.33	**0.33**	-	-	-	0.33	-	-	-	-	-	-	0.99
8	-	-	-	-	-	0.06	0.12	0.24	**0.53**	0.06	-	-	-	-	-	-	-	-	1.01
9	0.06	-	-	-	-	-	-	0.11	0.11	**0.50**	0.11	0.06	0.06	-	-	-	-	-	1.01
10	-	-	-	-	-	-	-	-	0.14	-	**0.64**	0.21	-	-	-	-	-	-	0.99
11	-	-	-	-	-	-	-	-	0.06	-	0.12	**0.41**	0.24	0.12	0.06	-	-	-	1.01
12	-	-	-	-	-	-	-	-	-	-	-	-	**0.67**	0.22	0.11	-	-	-	1.00
13	0.20	-	-	-	-	-	-	-	-	-	-	-	-	**0.60**	-	0.20	-	-	1.00
15	-	-	-	-	-	-	-	-	-	-	-	-	0.33	-	-	**0.33**	-	0.33	0.99
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	-	**0.5**	-	1.00

4.1.4 All readers of sectioned otoliths

The following section provides the results based on sectioned otoliths (under reflected light) and all age readers who read the sectioned otoliths in the exchange. R02, R05 and R08 from DE are the only readers who routinely read sectioned otoliths.

Table 4.19: Summary of statistics; Total number of samples (NSample), coefficient of variance (CV), percentage of agreement (PA) and average percentage error (APE) for all ages and readers

NSample	CV	PA	APE
69	24 %	53 %	15 %

Modal age ranges from age 1 to 14. As with the analysis based on only advanced readers the CV is highest at the youngest modal age (65% at modal age 1). Overall PA is just 53%. Individual readers weighted mean PA ranges from 33% to 64%. Overall relative bias is 0.01 but this does not reflect individual reader bias which ranges from 0.78 to -0.76. Individual reader bias plots can be found in Annex 7.4 and clearly show this bias. No modal age 0 is calculated when all readers are included in the analysis.

The data overview table in Annex 7.4 can be used to find the image names where individual readers are in disagreement with modal age. The search function in the SmartDots software can be used to find the relevant images and annotations for comparison.

Coefficient of Variation (CV)

Table 4.20: Coefficient of Variation (CV) table presents, for sectioned otoliths, 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 DE	R05 DE	R08 DE	R01 DK	R04 SE	R06 SE	R07 PL	R09 DK
1	31 %	39 %	35 %	0 %	67 %	-	49 %	62 %
2	13 %	20 %	21 %	0 %	19 %	0 %	22 %	0 %
3	17 %	39 %	20 %	26 %	10 %	37 %	19 %	15 %
4	0 %	16 %	0 %	20 %	20 %	0 %	0 %	0 %
5	21 %	7 %	15 %	8 %	7 %	41 %	21 %	9 %
6	18 %	17 %	14 %	9 %	20 %	26 %	22 %	12 %
7	53 %	49 %	20 %	21 %	19 %	55 %	13 %	12 %
8	11 %	49 %	17 %	8 %	13 %	18 %	18 %	11 %
9	-	-	-	-	-	-	-	-
10	15 %	21 %	5 %	16 %	9 %	51 %	10 %	13 %
11	0 %	6 %	5 %	6 %	17 %	8 %	11 %	9 %
12	10 %	0 %	6 %	16 %	12 %	7 %	8 %	20 %
13	8 %	-	13 %	45 %	22 %	0 %	4 %	18 %
14	-	-	-	-	-	-	-	-
Weighted Mean	**19 %**	**27 %**	**16 %**	**14 %**	**17 %**	**27 %**	**19 %**	**16 %**

Modal age	R10 SE	R11 DE	R13 DK	all
1	90 %	63 %	-	**65 %**
2	22 %	0 %	22 %	**24 %**
3	17 %	37 %	23 %	**26 %**
4	0 %	16 %	0 %	**15 %**
5	15 %	0 %	11 %	**18 %**
6	14 %	10 %	12 %	**18 %**
7	7 %	23 %	18 %	**29 %**
8	21 %	22 %	20 %	**22 %**
9	-	-	-	**13 %**
10	13 %	10 %	16 %	**19 %**
11	7 %	7 %	15 %	**12 %**
12	16 %	8 %	11 %	**12 %**
13	35 %	5 %	8 %	**27 %**
14	-	-	-	**6 %**
Weighted Mean	**22 %**	**19 %**	**16 %**	**24 %**

Percentage of Agreement (PA)

Table 4.21: Percentage agreement (PA) table represents, for sectioned otoliths, 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 DE	R05 DE	R08 DE	R01 DK	R04 SE	R06 SE	R07 PL	R09 DK
1	33 %	67 %	83 %	100 %	75 %	40 %	83 %	67 %
2	0 %	80 %	17 %	100 %	83 %	100 %	83 %	100 %
3	36 %	55 %	73 %	45 %	91 %	73 %	73 %	82 %
4	0 %	50 %	0 %	50 %	50 %	100 %	100 %	100 %
5	38 %	88 %	50 %	86 %	88 %	75 %	38 %	75 %
6	40 %	60 %	50 %	20 %	40 %	80 %	20 %	60 %
7	0 %	67 %	17 %	50 %	50 %	67 %	67 %	83 %
8	17 %	50 %	17 %	67 %	20 %	33 %	50 %	50 %
9	0 %	100 %	100 %	0 %	100 %	100 %	0 %	0 %
10	50 %	33 %	60 %	33 %	40 %	17 %	67 %	17 %
11	100 %	33 %	0 %	0 %	25 %	25 %	25 %	50 %

25

Modal age							
12	50 %	100 %	25 %	25 %	25 %	25 %	25 %	50 %
13	67 %	0 %	33 %	0 %	33 %	100 %	67 %	0 %
14	0 %	-	100 %	100 %	100 %	0 %	0 %	100 %
Weighted Mean	**33 %**	**62 %**	**43 %**	**53 %**	**60 %**	**60 %**	**57 %**	**64 %**

Modal age	R10 SE	R11 DE	R13 DK	all
1	50 %	67 %	50 %	**65 %**
2	67 %	100 %	67 %	**72 %**
3	73 %	64 %	55 %	**65 %**
4	0 %	50 %	100 %	**55 %**
5	50 %	100 %	75 %	**69 %**
6	60 %	40 %	60 %	**48 %**
7	67 %	67 %	33 %	**52 %**
8	50 %	50 %	50 %	**42 %**
9	0 %	0 %	0 %	**36 %**
10	50 %	50 %	0 %	**38 %**
11	50 %	25 %	25 %	**33 %**
12	25 %	50 %	0 %	**36 %**
13	0 %	33 %	33 %	**34 %**
14	0 %	0 %	0 %	**40 %**
Weighted Mean	**51 %**	**60 %**	**45 %**	**53 %**

Average Percentage Error (APE)

Table 4.22: Average Percentage Error (APE) table represents, for sectioned otoliths, the APE per modal age and reader, the APE of all advanced readers combined per modal age and a weighted mean of the APE per reader.

Modal age	R02 DE	R05 DE	R08 DE	R01 DK	R04 SE	R06 SE	R07 PL	R09 DK
1	27 %	33 %	24 %	0 %	50 %	-	33 %	53 %
2	9 %	15 %	11 %	0 %	13 %	0 %	15 %	0 %
3	14 %	24 %	16 %	22 %	6 %	26 %	11 %	6 %
4	0 %	11 %	0 %	14 %	14 %	0 %	0 %	0 %
5	16 %	4 %	11 %	5 %	4 %	26 %	17 %	7 %
6	14 %	13 %	11 %	6 %	16 %	19 %	17 %	7 %
7	40 %	33 %	16 %	17 %	12 %	33 %	12 %	8 %
8	9 %	33 %	15 %	4 %	10 %	15 %	13 %	9 %
9	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
10	11 %	17 %	5 %	13 %	7 %	36 %	6 %	10 %
11	0 %	4 %	4 %	5 %	12 %	6 %	9 %	7 %
12	7 %	0 %	4 %	10 %	8 %	6 %	6 %	14 %
13	7 %	-	9 %	33 %	17 %	0 %	3 %	13 %
14	0 %	-	0 %	0 %	0 %	0 %	0 %	0 %
Weighted Mean	**14 %**	**19 %**	**12 %**	**10 %**	**12 %**	**18 %**	**13 %**	**11 %**

Modal age	R10 SE	R11 DE	R13 DK	all
1	67 %	33 %	-	**39 %**
2	19 %	0 %	19 %	**19 %**
3	11 %	18 %	16 %	**14 %**
4	0 %	11 %	0 %	**12 %**
5	13 %	0 %	5 %	**9 %**
6	11 %	9 %	7 %	**12 %**
7	6 %	16 %	13 %	**16 %**
8	16 %	15 %	14 %	**15 %**
9	0 %	0 %	0 %	**10 %**
10	9 %	8 %	13 %	**13 %**
11	5 %	4 %	11 %	**9 %**

12	12 %	6 %	8 %	**9 %**
13	27 %	4 %	5 %	**18 %**
14	0 %	0 %	0 %	**5 %**
Weighted Mean	**16 %**	**11 %**	**11 %**	**15 %**

Relative bias

The relative bias is the difference between the mean age (per modal age per reader) and modal age. As for the previous tables, a combined bias for all readers and weighted means are calculated.

Table 4.23: The relative bias (as the difference between the mean and modal age), for sectioned otoliths, per modal age and reader is presented, as well as the weighted mean relative bias per reader and the relative bias per modal age for all readers combined.

Modal age	R02 DE	R05 DE	R08 DE	R01 DK	R04 SE	R06 SE	R07 PL	R09 DK
1	0.67	0.33	0.17	0.00	-0.25	-0.60	-0.17	0.67
2	1.17	0.20	1.00	0.00	0.17	0.00	-0.17	0.00
3	0.73	-0.09	0.36	-0.36	-0.09	-0.45	-0.09	0.00
4	1.00	0.50	1.00	-0.50	-0.50	0.00	0.00	0.00
5	0.62	0.12	0.17	-0.14	-0.12	-0.75	-0.50	0.25
6	0.40	-0.60	0.75	-0.80	-0.40	0.80	-0.20	0.00
7	-0.67	-1.00	0.50	-1.00	0.17	-0.50	0.67	-0.33
8	1.50	-1.00	2.17	0.00	0.60	1.83	0.33	-0.67
9	-2.00	0.00	0.00	-2.00	0.00	0.00	1.00	-1.00
10	-0.50	-1.17	0.40	-0.83	-0.80	-1.33	0.17	-0.83
11	0.00	-0.67	1.50	-1.50	-0.75	1.50	0.50	-0.75
12	0.25	0.00	1.00	-2.00	0.00	1.25	-0.25	-0.75
13	0.67	-7.00	2.00	-5.00	-1.00	0.00	0.33	-1.33
14	2.00	-	0.00	0.00	0.00	2.00	1.00	0.00
Weighted Mean	**0.48**	**-0.52**	**0.78**	**-0.76**	**-0.17**	**0.04**	**0.04**	**-0.23**

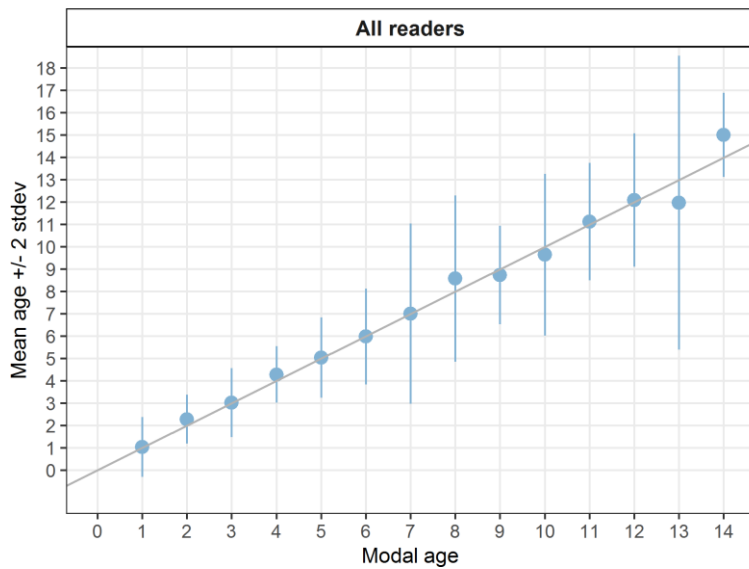| Modal age	R10 SE	R11 DE	R13 DK	all
1	-0.17	0.00	-0.50	**0.01**
2	0.33	0.00	0.33	**0.28**
3	0.09	0.00	0.09	**0.02**
4	1.00	0.50	0.00	**0.27**
5	0.75	0.00	0.00	**0.04**
6	0.60	-0.60	0.00	**-0.00**
7	0.33	0.50	1.33	**0.00**
8	0.50	0.33	0.67	**0.57**
9	-1.00	1.00	1.00	**-0.27**
10	0.17	0.33	0.50	**-0.35**
11	0.00	1.00	0.25	**0.10**
12	-0.25	0.75	1.00	**0.09**
13	-1.33	-0.67	0.00	**-1.21**
14	2.00	1.00	2.00	**-**
Weighted Mean	**0.22**	**0.18**	**0.33**	**0.01**

Figure 4.11: Age bias plot for all readers of sectioned otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line

Inter-reader bias test

Table 4.24: Inter reader bias test for sectioned otoliths. 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) , / = diagonal of the table (no bias)

Comparison	R02 DE	R05 DE	R08 DE	R01 DK	R04 SE	R06 SE	R07 PL	R09 DK	R10 SE	R11 DE	R13 DK
R02 DE	/	**	**	**	*	-	-	-	-	-	*
R05 DE	**	/	-	-	**	-	**	**	-	**	**
R08 DE	**	-	/	**	**	-	-	**	-	-	-
R01 DK	**	-	**	/	-	**	-	-	**	**	**
R04 SE	*	**	**	-	/	-	*	**	-	-	-
R06 SE	-	-	-	**	-	/	-	-	-	**	*
R07 PL	-	**	-	-	*	-	/	-	-	**	-
R09 DK	-	**	**	-	**	-	-	/	-	**	-
R10 SE	-	-	-	**	-	-	-	-	/	-	**
R11 DE	-	**	-	**	-	**	**	**	-	/	-
R13 DK	*	**	-	**	-	*	-	-	**	-	/
Modal age	*	**	**	**	*	-	**	-	-	**	*

Growth analysis

Figure 4.12: Plot of average distance from the centre to the winter rings for all readers of sectioned otoliths. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

4.1.5 All readers of sectioned and stained otoliths

Only 1 age reader, R07 PL, is experienced in the technique of reading plaice otoliths sectioned and stained. The summary statistics from SmartDots are shown here but should be interpreted with caution as the modal age (on which all other statistical analysis are based on) is likely not to be a true representation of the most correct age. Data overview showing all estimated ages by the 11 readers who annotated the images in SmartDots can be found in Annex 7.5.

Summary statistics

Table 4.25: Summary of statistics; Total number of samples (NSample), coefficient of variance (CV), percentage of agreement (PA) and average percentage error (APE) for all ages and readers

NSample	CV	PA	APE
69	27 %	45 %	19 %

Table 4.26 shows the comparison matrix and compares the modal age of all readers against the age of the only expert reader of sectioned and stained otoliths (SSX), R07 PL. This shows that overall the modal age of all readers combined is overestimated in comparison to the expert reader, sometime by 1 year but in some cases by 2 or even 3 years (modal age 5).

Table 4.26: Age comparison matrix show the modal age of all readers in comparison to the estimated age of the only reader (R07 PL) experienced in reading sectioned and stained (SSX) otoliths. Green cells indicating the number of otoliths where the modal age of SSX and the expert reader age are in agreement. Blue cells indicating the number of otoliths where the modal age of SSX is younger than the expert reader. Beige cells indicating the number of otoliths where the modal age of SSX is older than the expert reader.

R07 PL age	Modal age SSX															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	2															
1		4														
2			2	3	2											
3				4	2		1									
4					3											
5						5	2	1	1							
6						1	2	1	1							
7																
8									3	1	1					
9								1	1	2	1					
10											2		4			
11											1	4	1			
12													4			
13														4		
14																
15																2

4.2 Results comparing age reading methods

4.2.1 Comparison of results by age reading method, based only on readers routinely reading each method

When looking at the overall results from the readings of the whole otoliths versus the readings of the sectioned method and based on only the expert readers of each method, the sectioned otoliths revealed a strong bias, 2.67, at modal age 0, compared to a relative bias of just 0.14 for the sectioned otoliths. When investigated further it became apparent that two of the readers of the sectioned otoliths approved their annotations for fish where they had not assigned an age and thus an age of 0 was given for these otoliths. This has resulted in an incorrect calculation of modal age the subsequent calculation of PA, CV, APE and relative bias. The statistics for modal age 0 in Table 4.28 are incorrect and these have a subsequent effect on the weighted mean values. This was only apparent when the event had been completed and the report was being finalised.

Generally speaking, the bias is less variable for the whole otoliths compared to sectioned otoliths for modal ages 0-4. For modal ages 4, 5 and 6 there is high positive bias for whole otoliths, compared to a negative bias at modal age 4 for sectioned otoliths and a small positive bias at modal ages 5 and 6. At modal ages above 6 no consistent pattern is obvious. It is clear that a higher modal age is reached for the sectioned otolith (age 16) compared to the whole otoliths (age 12). Figure 4.13 shows the same otolith and the 3 different preparation methods, the annotation shown on each is that of the most experienced reader for each preparation method, R01 DK for whole, R02 DE for sectioned and R07 PL for sectioned and stained.

All readers of sectioned otoliths are from the same age reading lab (in Germany). The readers of whole otoliths are from two different age reading labs (in Sweden and Denmark). Figure 4.14 aims to show that the age readers estimations of one of the smallest fish in this exchange are more consistent when based on the whole otolith compared to the sectioned otolith. All readers except 1 estimated the age to be 0 based on the whole otolith while on the sectioned otolith the ages estimated were 0, 1 and 2.

Table 4.27: Overview of results (CV, PA, APE and Relative Bias) from readings of whole (ALA) otoliths and based only on those advanced readers who routinely read whole otoliths (R01 DK, R03 DK, R04 SE, R06 SE, R010 SE).

Modal age	No. of age readings ALA		CV ALA	PA ALA	APE ALA	Rel. Bias ALA
0	95		-	86 %	-	0.14
1	144		42 %	85 %	18 %	0.03
2	112		17 %	89 %	6 %	-0.02
3	64		22 %	80 %	10 %	-0.06
4	32		17 %	50 %	14 %	0.35
5	72		23 %	62 %	15 %	0.36
6	80		30 %	52 %	19 %	0.42
7	56		13 %	57 %	9 %	-0.17
8	32		14 %	48 %	10 %	0.28
9	32		12 %	40 %	10 %	0.87
10	24		39 %	40 %	26 %	-1.80
11	16		14 %	40 %	10 %	0.10
12	16		12 %	50 %	10 %	-1.10
Total	**775**	**Weighted Mean**	**24 %**	**71 %**	**13 %**	**0.08**

Table 4.28: Overview of results (CV, PA, APE and Relative Bias) from readings of sectioned (SEX) otoliths and based only on those advanced readers who routinely read sectioned otoliths (R02 DE, R05 DE and R08 DE).

Modal age	No. of age readings SEX		CV SEX	PA SEX	APE SEX	Rel. Bias SEX
0	3		-	67 %	-	2.67
1	9		30 %	89 %	18 %	0.11
2	12		31 %	67 %	23 %	-0.17
3	33		25 %	73 %	14 %	-0.09
4	14		14 %	71 %	10 %	-0.13
5	29		12 %	72 %	8 %	0.18
6	11		15 %	73 %	8 %	0.14
7	3		33 %	33 %	25 %	1.00
8	17		14 %	53 %	11 %	-0.59
9	18		29 %	50 %	17 %	-0.44
10	14		9 %	64 %	6 %	-0.05
11	17		12 %	41 %	9 %	0.29
12	9		6 %	67 %	5 %	0.44
13	5		56 %	60 %	40 %	-4.00
14	0		-	-	-	-
15	3		17 %	33 %	12 %	-0.33
16	2		9 %	50 %	7 %	-
	199	Weighted Mean	19 %	64 %	12 %	-0.10

In the following section all fish which had not been aged but where the annotation had been approved and thus given age 0 were excluded from the analysis. The objective was to give a more realistic comparison of the two methods. This analysis was carried out outside of the SmartDots reporting environment, using both the Guus Eltink workbook and the ATAQCS workbook.

To compare the modal ages from each method, 67 fish with a modal age from both the whole and the sectioned otoliths were compared using the Guus Eltink workbook (Eltink A.T.G.W, 2000). If a modal age was not calculated for a specific fish as no agreement reached between the expert readers, then the age of the most experienced reader was used as the modal age. The modal age for each method was then compared and the results shown in Table 4.26. Of the 67 fish, agreement between modal ages was only reached on 14 otoliths. There are only 2 fish where all 8 expert readers are in 100% agreement on the age, 8335854 and 8326695.
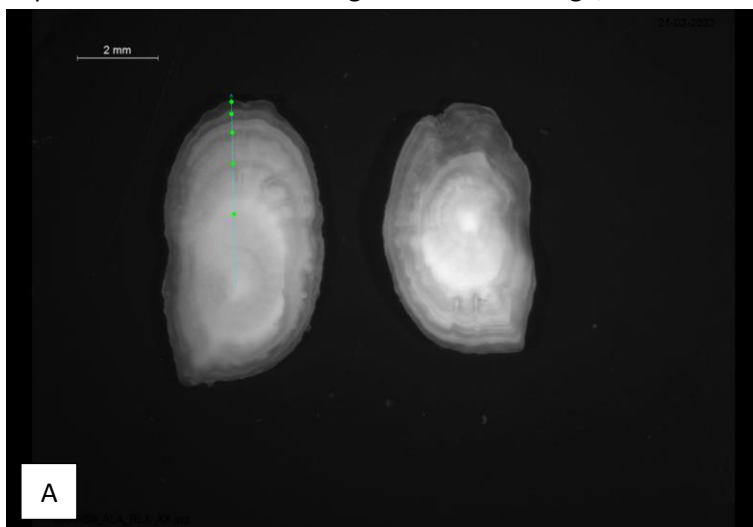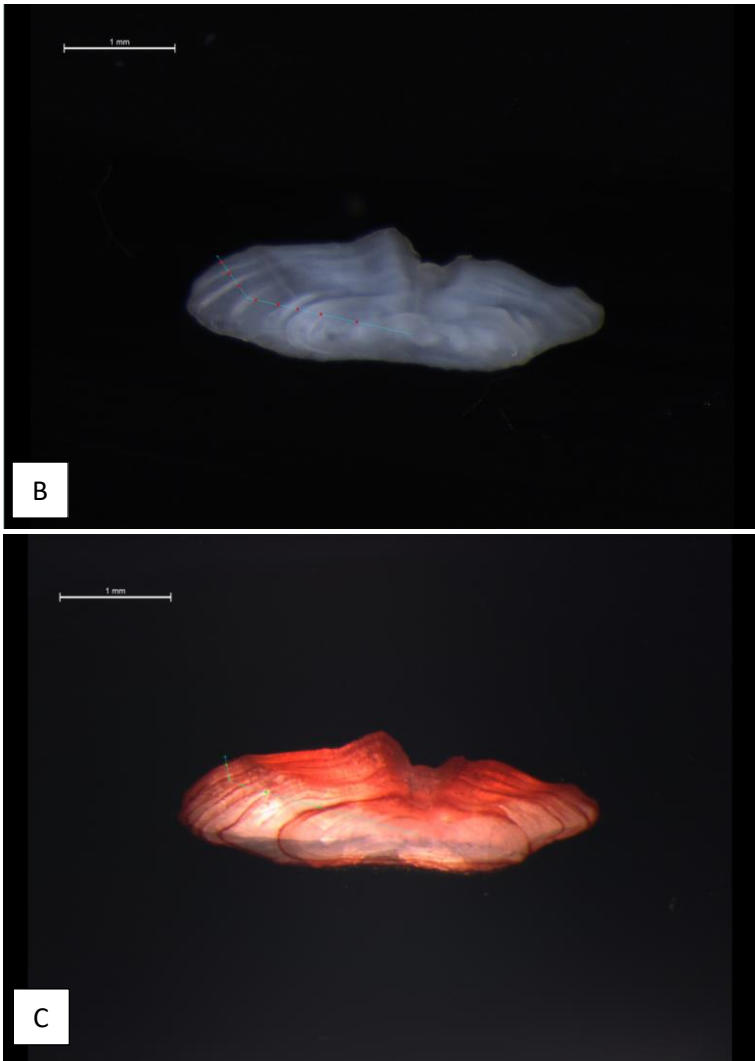
Figure 4.13: 8304959, Capture date: 04/03/2021, TL: 330mm, Sex: F. A; whole (ALA) otolith, age 5. B; sectioned (SEX) otoliths, age 8. C; sectioned and stained (SSX) otolith, age 5

Table 4.26: Age comparison matrix shows the modal age of advanced readers of whole otoliths (ALA modal age) in comparison to the modal age of advanced readers of sectioned otoliths (SEX modal age). Green cells indicating the number of otoliths where the modal age ALA and modal age SEX are in agreement. Blue cells indicating the number of otoliths where the modal age for SEX is younger than the modal age of ALA. Beige cells indicating the number of cells where the modal age of SEX is higher than the modal age of ALA.

ALA modal age	SEX modal age																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0		2															
1			3														
2			1	6	1	1											
3				5	3	2											
4					1	2	1										
5						4	3		2		1						
6						1	2	1	1	1	1	1					
7								3	2	1			1				
8							1		1	2	1						
9										2		1					
10		1									1						
11												1	1				
12												1				1	
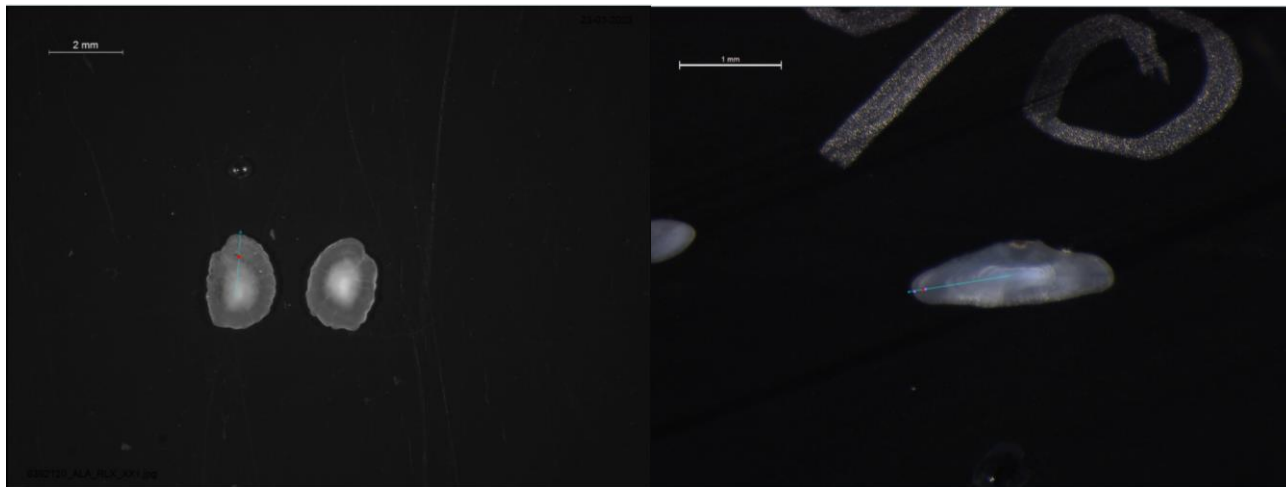
Figure 4.14: 8392120, Capture date: 22/10/2022, TL: 100mm, Sex: M. A; whole (ALA) otolith, age 1 (modal age 0). B; sectioned (SEX) otolith, purple dots showing age 2 and red dot showing age 1 (modal age 1)

5 Conclusion

For this exchange readers were provided with images of otoliths prepared using three different methods; whole in water (soaked for 2 hours) under reflected light, sectioned under reflected light and sectioned and stained under transmitted light. The three countries providing age data for the stock assessment of ple.27.21-23 are Denmark (DK), Sweden (SE) and Germany (DE) with DK and SE routinely reading whole otoliths and DE reading sectioned otoliths. For these reasons otoliths from the same fish were photographed following these two methods. In addition, the otoliths were stained, in order to test to see if this method improved the readability of the otoliths. A comparison of age reading preparation methods should only be carried out using readers who are experienced in reading a particular method. In this exchange readers were asked to annotate all images in SmartDots. Separate analyses are possible in the SmartDots reporting environment where specific readers and preparation methods can be analysed separately. This was done for this event and this report constitutes a compilation of results from various report outputs.

The results based on advanced readers of whole otoliths are fair, with overall PA at 71%. Whan all readers are included it is 64%. The most concerning result is the high CV at the youngest ages. When only advanced readers are included, CV at modal age 1 is 42% (51% for all readers). Based on all readers, the individual reader relative bias values at modal ages 0 and 1 ranges from -0.24 to 0.95 indication large variability in what the readers are estimating in comparison to the modal age. The tendency is for readers to overestimate in comparison to modal age. A similar pattern in seen with the sectioned otoliths where overestimation in comparison to modal age is apparent. Based on advanced readers only the overall PA is 64%, when all readers are included it is 53%. The relative bias value for all advanced readers at modal age 0 of 2.67 is incorrect (due to approval mistakes in SmartDots). When ignoring this and looking at the individual readers relative bias values, based on all readers, at modal ages 0 and 1 it ranges from -0.60 to 1.17. For the sectioned and stained otoliths there is only 1 advanced reader and this reader does not routinely read plaice from ple.27.21-23 but reads plaice from ple.27.24-32. When comparing all readers who read the sectioned and stained otoliths against this reader the tendency was to overestimate the age by 1, 2 and sometimes 3 years.

The results here focus on the youngest ages in this calibration event, the reason being that concerns have been raised on the difficulties in correctly identifying the innermost translucent zones (TZ's) seen in these otoliths. This has been a concern for plaice in the North Sea and Skagerrak (ple.27.4.20) also and attributed to an extended spawning period of plaice which can lead to huge variability in the distance of the first TZ from the otolith nucleus. Studies are underway in Germany with the aim to correctly identify the first TZ in otoliths from plaice from an area of ICES SD 22 using length frequency analysis and mark recapture methods. Based on these studies new age reading practices are being applied in the German age reading lab which could explain some of the disagreements identified between readers at modal ages 0 and 1. The next step is to expand on this study and to analyse otoliths from small fish caught in other areas of this stocks distribution (ICES SD 21 and northern parts of ICES SD 22). Samples have been obtained and these could be analysed in preparation for an age reading workshop for the ple.27.21-23 stock. The low PA, high CV and APE and large variability seen at the younger ages has a knock-on effect on the reliability of the older ages. For this reason it is important to initially solve the age reading issues with the first TZ.

A conclusion on the most reliable age reading method for ple.27.21-23 cannot be concluded from this exercise when there is only one expert age reader for sectioned and stained otoliths. It is clear from the images that no added benefit can be reached from sectioning and staining the otoliths when readers are not trained in this method. In some cases the rings were very visible due to the dye, in other cases not. It is very easy for a reader to overestimate

the age when the dye is picked up by false rings so readers need to be very confident in their interpretation of growth pattern first. When comparing the results from the whole and the sectioned otoliths it is clear that a higher age is reached by the readers of the sectioned otoliths. The workshop for age reading of North Sea plaice (WKARP2, 2022) concluded that sectioning otoliths from fish aged 0-6 does not provide added benefit compared to reading the whole otoliths but could lead to an overestimation of age compared to whole otoliths. The plus group for this stock is 7+ (ICES, 2022a) so further investigations on the added benefit of sectioning fish above age 6 may not necessarily be worthwhile. A more in depth comparison of methods based on the samples in this exchange can be carried out under the proposed age reading workshop.

6 References

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7 Annex 3. Additional results

7.1 Results - Advanced readers based on whole otoliths

Multistage approach

Table 7.1: Summary of statistics; Total number of samples (NSample), a percentage of cases (fish samples) with multiple modes depending on the approach to weight the experience of the reader which will be considered when defining the fish age mode. PercMM_traditional shows the percentage of the total samples for which multiple modes are obtained when all the readers are equally weighted. PercMM_linear_weight shows the percentage of the total samples for which multiple modes are obtained when the weight assigned to the different readers decreases linearly with the experience, while in the PercMM_negexp the weight applied decreases with a negative exponential shape with the experience. The PercMM_multistage shows the percentage of multiple mode cases when a combination of the different methodologies is used, as explained in the material and methods section

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

NSample	CV	PA	APE
97	24 %	71 %	13 %

Table 7.2: List of cases for which multiple modes where obtained when all readers are considered. The column NModes_trad shows the number of multiple modes for each FishID or SampleID when all readers are given the same expertise weight.

NModes_trad	SampleID
2	8304961_ALA_RLX_XX
2	8312102_ALA_RLX_XX
2	8312104_ALA_RLX_XX
2	8326700_ALA_RLX_XX
5	8335700_ALA_RLX_XX
2	8347965_ALA_RLX_BX
2	8347974_ALA_RLX_XX
5	8348004_ALA_RLX_XX
2	8358476_ALA_RLX_XX
2	8358478_ALA_RLX_XX
2	8358483_ALA_RLX_XX
2	8358486_ALA_RLX_XX
2	8358499_ALA_RLX_XX
2	8392101_ALA_RLX_XX
2	8392117_ALA_RLX_XX
5	**8396267_ALA_RLX_XX**

Data overview

Table 7.3: Data overview including modal age and statistics per sample.

Fish ID	length	sex	Catch date	ICES area	R01 DK	R03 DK	R04 SE	R06 SE	R10 SE	Modal age	PA %	CV %	APE %
7890002_ALA_RLX_XX	131	F	24/09/2021 00:00:00	27.3.c.22	1	1	2	2	2	2	60	34	30
7890017_ALA_RLX_XX	79	U	14/02/2020 00:00:00	27.3.d.24	1	1	1	1	1	1	100	0	0
7890026_ALA_RLX_XX	78	U	12/11/2021 00:00:00	27.3.c.22	0	0	0	0	0	0	100	-	-

7890041_ALA_RLX_XX	54	U	01/11/2019 00:00:00	27.3.d.24	0	0	0	0	0	0	100	-	-
7890052_ALA_RLX_XX	109	M	12/12/2021 00:00:00	27.3.c.22	0	0	1	0	1	0	60	-	-
7890053_ALA_RLX_XX	210	F	21/12/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	100	0	0
7890307_ALA_RLX_XX	89	M	04/07/2020 00:00:00	27.3.d.24	0	0	0	1	0	0	80	-	-
7890413_ALA_RLX_XX	69	M	15/09/2020 00:00:00	27.3.d.24	0	0	0	0	0	0	100	-	-
8304959_ALA_RLX_XX	330	F	04/03/2021 06:19:47	27.3.c.22	5	5	5	5	6	5	80	9	6
8304960_ALA_RLX_XB	290	M	04/03/2021 06:19:47	27.3.c.22	4	4	4	4	5	4	80	11	8
8304961_ALA_RLX_XX	280	F	04/03/2021 06:19:47	27.3.c.22	3	4	4	5	5	4	40	20	15
8304966_ALA_RLX_XX	220	F	04/03/2021 06:19:47	27.3.c.22	2	3	3	2	3	3	60	21	18
8304968_ALA_RLX_XX	200	M	04/03/2021 06:19:47	27.3.c.22	3	3	3	3	3	3	100	0	0
8304976_ALA_RLX_XX	120	M	04/03/2021 06:19:47	27.3.c.22	1	1	1	1	1	1	100	0	0
8304978_ALA_RLX_XX	100	F	04/03/2021 06:19:47	27.3.c.22	1	1	1	1	1	1	100	0	0
8305659_ALA_RLX_XX	380	F	05/03/2021 09:17:49	27.3.c.22	6	6	7	7	7	7	60	8	7
8305662_ALA_RLX_XX	300	M	05/03/2021 09:17:49	27.3.c.22	2	3	3	3	3	3	80	16	11
8305667_ALA_RLX_XX	250	F	05/03/2021 09:17:49	27.3.c.22	3	3	3	3	3	3	100	0	0
8305669_ALA_RLX_XB	230	M	05/03/2021 09:17:49	27.3.c.22	2	2	2	2	3	2	80	20	15
8305675_ALA_RLX_BX	170	M	05/03/2021 09:17:49	27.3.c.22	2	2	2	2	2	2	100	0	0
8312102_ALA_RLX_XX	260	M	06/03/2021 12:46:31	27.3.c.22	7	6	6	7	8	7	40	12	9
8312104_ALA_RLX_XX	300	F	06/03/2021 12:46:31	27.3.c.22	7	6	7	8	8	7	40	12	9
8312500_ALA_RLX_XX	280	M	07/03/2021 08:23:06	27.3.c.22	8	8	7	9	8	8	60	9	5
8314059_ALA_RLX_XX	350	F	10/03/2021 06:38:58	27.3.c.22	9	9	9	10	10	9	60	6	5
8315397_ALA_RLX_XX	280	F	12/03/2021 11:43:27	27.3.c.22	7	8	8	9	10	8	40	14	10
8315400_ALA_RLX_XX	310	F	12/03/2021 11:43:27	27.3.c.22	9	10	12	12	12	12	60	13	11
8326654_ALA_RLX_XC	390	F	24/04/2021 00:00:00	27.3.c.22	6	6	6	5	7	6	60	12	7
8326658_ALA_RLX_XX	340	F	24/04/2021 00:00:00	27.3.c.22	4	5	5	5	6	5	60	14	8
8326659_ALA_RLX_XX	390	F	24/04/2021 00:00:00	27.3.c.22	9	9	10	11	12	9	40	13	10
8326663_ALA_RLX_XX	380	F	24/04/2021 00:00:00	27.3.c.22	7	7	7	7	8	7	80	6	4
8326666_ALA_RLX_XX	370	F	24/04/2021 00:00:00	27.3.c.22	4	6	6	6	6	6	80	16	11
8326683_ALA_RLX_XX	380	F	24/04/2021 00:00:00	27.3.c.22	8	8	8	9	10	8	60	10	8

ID													
8326695_ALA_RLX_XX	290	M	24/04/2021 00:00:00	27.3.c.22	5	5	5	5	5	5	100	0	0
8326700_ALA_RLX_XX	290	M	24/04/2021 00:00:00	27.3.c.22	5	5	6	6	7	5	40	14	11
8326705_ALA_RLX_XX	250	F	24/04/2021 00:00:00	27.3.c.22	2	2	2	2	3	2	80	20	15
8335700_ALA_RLX_XX	260	M	11/05/2021 00:00:00	27.3.c.22	5	0	6	8	9	5	20	-	-
8335852_ALA_RLX_XX	250	F	10/05/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	100	0	0
8335854_ALA_RLX_XX	250	M	10/05/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	100	0	0
8335860_ALA_RLX_XX	220	M	10/05/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	100	0	0
8343690_ALA_RLX_XX	390	M	23/06/2021 00:00:00	27.3.c.22	6	6	6	7	7	6	60	9	8
8343692_ALA_RLX_XX	330	M	23/06/2021 00:00:00	27.3.c.22	6	6	7	7	7	7	60	8	7
8347965_ALA_RLX_BX	370	F	05/07/2021 00:00:00	27.3.c.22	5	5	7	7	8	5	40	21	18
8347974_ALA_RLX_XX	390	F	05/07/2021 00:00:00	27.3.c.22	10	11	11	13	13	11	40	12	10
8347975_ALA_RLX_CX	400	F	05/07/2021 00:00:00	27.3.c.22	9	10	11	12	12	12	40	12	10
8347987_ALA_RLX_XX	330	F	05/07/2021 00:00:00	27.3.c.22	5	5	5	5	6	5	80	9	6
8348004_ALA_RLX_XX	410	M	05/07/2021 00:00:00	27.3.c.22	9	8	10	11	12	9	20	16	12
8348005_ALA_RLX_XX	390	F	05/07/2021 00:00:00	27.3.c.22	8	7	8	10	11	8	40	19	15
8348069_ALA_RLX_XX	300	F	06/07/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	100	0	0
8348072_ALA_RLX_XX	250	F	06/07/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	100	0	0
8348073_ALA_RLX_XX	270	M	06/07/2021 00:00:00	27.3.c.22	3	3	3	4	3	3	80	14	10
8348078_ALA_RLX_XX	290	M	06/07/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	100	0	0
8358458_ALA_RLX_XX	410	F	22/08/2021 00:00:00	27.3.c.22	7	8	7	7	7	7	80	6	4
8358476_ALA_RLX_XX	310	F	22/08/2021 00:00:00	27.3.c.22	6	6	10	10	9	6	40	25	21
8358478_ALA_RLX_XX	330	M	22/08/2021 00:00:00	27.3.c.22	6	6	8	8	7	6	40	14	11
8358483_ALA_RLX_XX	290	M	22/08/2021 00:00:00	27.3.c.22	4	4	5	5	6	4	40	17	13
8358485_ALA_RLX_XX	300	F	22/08/2021 00:00:00	27.3.c.22	5	5	6	5	6	5	60	10	9
8358486_ALA_RLX_XX	340	F	22/08/2021 00:00:00	27.3.c.22	3	4	4	5	5	4	40	20	15
8358499_ALA_RLX_XX	310	M	22/08/2021 00:00:00	27.3.c.22	5	4	5	7	4	5	40	24	16
8386600_ALA_RLX_XX	380	M	14/10/2021 00:00:00	27.3.c.22	8	6	10	10	11	10	40	22	18
8392100_ALA_RLX_XX	320	F	22/10/2021 06:10:01	27.3.c.22	5	5	5	5	6	5	80	9	6
8392101_ALA_RLX_XX	300	M	22/10/2021 06:10:01	27.3.c.22	3	3	4	4	5	3	40	22	17

8392104_ALA_RLX_XX	280	F	22/10/2021 06:10:01	27.3.c.22	2	2	2	2	3	2	80	20	15
8392106_ALA_RLX_XX	260	F	22/10/2021 06:10:01	27.3.c.22	2	2	2	2	2	2	100	0	0
8392107_ALA_RLX_XX	240	F	22/10/2021 06:10:01	27.3.c.22	2	2	2	2	2	2	100	0	0
8392115_ALA_RLX_XX	150	M	22/10/2021 06:10:01	27.3.c.22	1	1	1	1	1	1	100	0	0
8392116_ALA_RLX_XX	140	F	22/10/2021 06:10:01	27.3.c.22	-	0	1	0	0	0	75	-	-
8392117_ALA_RLX_XX	130	F	22/10/2021 06:10:01	27.3.c.22	3	3	0	2	2	3	40	61	40
8392119_ALA_RLX_XX	110	F	22/10/2021 06:10:01	27.3.c.22	0	0	0	0	0	0	100	-	-
8392120_ALA_RLX_XX	100	M	22/10/2021 06:10:01	27.3.c.22	0	0	0	0	0	0	100	-	-
8392121_ALA_RLX_XX	100	M	22/10/2021 06:10:01	27.3.c.22	0	0	0	0	0	0	100	-	-
8392351_ALA_RLX_XX	120	F	22/10/2021 08:32:27	27.3.c.22	1	1	3	0	1	1	60	91	60
8392352_ALA_RLX_XX	130	F	22/10/2021 08:32:27	27.3.c.22	1	1	1	1	2	1	80	37	27
8394224_ALA_RLX_XX	350	M	25/10/2021 05:56:14	27.3.c.22	8	0	9	10	10	10	40	57	40
8394225_ALA_RLX_XX	330	F	25/10/2021 05:56:14	27.3.c.22	6	6	6	7	7	6	60	9	8
8394227_ALA_RLX_XX	310	F	25/10/2021 05:56:14	27.3.c.22	8	11	11	10	13	11	40	17	12
8394233_ALA_RLX_XX	250	F	25/10/2021 05:56:14	27.3.c.22	5	5	5	5	6	5	80	9	6
8394421_ALA_RLX_XX	390	F	25/10/2021 08:08:20	27.3.c.22	7	6	8	8	9	8	40	15	12
8394676_ALA_RLX_XX	160	M	25/10/2021 10:11:43	27.3.c.22	2	2	2	1	2	2	80	25	18
8394677_ALA_RLX_XX	150	M	25/10/2021 10:11:43	27.3.c.22	1	1	1	1	1	1	100	0	0
8394680_ALA_RLX_XX	100	F	25/10/2021 10:11:43	27.3.c.22	0	0	0	0	0	0	100	-	-
8395163_ALA_RLX_XX	140	F	26/10/2021 05:59:17	27.3.c.22	2	2	2	1	2	2	80	25	18
8395164_ALA_RLX_XX	130	M	26/10/2021 05:59:17	27.3.c.22	1	1	1	1	1	1	100	0	0
8395165_ALA_RLX_XX	120	M	26/10/2021 05:59:17	27.3.c.22	0	0	1	1	0	0	60	-	-
8395166_ALA_RLX_XX	100	F	26/10/2021 05:59:17	27.3.c.22	1	1	0	0	1	1	60	91	80
8395356_ALA_RLX_XX	130	M	26/10/2021 07:53:23	27.3.c.22	1	1	0	1	1	1	80	56	40
8395357_ALA_RLX_XX	120	F	26/10/2021 07:53:23	27.3.c.22	1	1	1	1	2	1	80	37	27
8395625_ALA_RLX_XX	120	M	26/10/2021 10:17:48	27.3.c.22	1	0	1	0	0	0	60	-	-
8395627_ALA_RLX_XX	100	F	26/10/2021 10:17:48	27.3.c.22	1	0	1	1	1	1	80	56	40
8395810_ALA_RLX_XX	140	F	26/10/2021 14:34:20	27.3.c.22	1	1	1	2	2	1	60	39	34
8395813_ALA_RLX_XX	110	F	26/10/2021 14:34:20	27.3.c.22	1	0	0	0	1	0	60	-	-

SampleID														
8395992_ALA_RLX_XX	260	M	27/10/2021 08:14:48	27.3.c.22	3	4	6	6	6	6	60	28	24
8396004_ALA_RLX_XX	130	M	27/10/2021 08:14:48	27.3.c.22	1	1	1	1	2	1	80	37	27
8396007_ALA_RLX_XX	100	M	27/10/2021 08:14:48	27.3.c.22	0	0	0	0	0	0	100	-	-
8396267_ALA_RLX_XX	280	M	27/10/2021 11:40:40	27.3.c.22	6	0	7	10	11	6	20	-	-
8396668_ALA_RLX_XX	240	M	28/10/2021 08:19:24	27.3.c.22	4	5	7	7	8	7	40	27	22
8396679_ALA_RLX_XX	110	M	28/10/2021 08:19:24	27.3.c.22	1	1	1	1	1	1	100	0	0
8400914_ALA_RLX_XX	110	F	30/10/2021 09:19:48	27.3.c.22	0	0	0	0	0	0	100	-	-

List of multimodal cases

Table 7.4: List of cases for which multiple modes where obtained when all readers are considered. The column NModes_trad shows the number of multiple modes for each FishID or SampleID when all readers are given the same expertise weight.

NModes_trad	SampleID
2	8304961_ALA_RLX_XX
2	8312102_ALA_RLX_XX
2	8312104_ALA_RLX_XX
2	8326700_ALA_RLX_XX
5	8335700_ALA_RLX_XX
2	8347965_ALA_RLX_BX
2	8347974_ALA_RLX_XX
5	8348004_ALA_RLX_XX
2	8358476_ALA_RLX_XX
2	8358478_ALA_RLX_XX
2	8358483_ALA_RLX_XX
2	8358486_ALA_RLX_XX
2	8358499_ALA_RLX_XX
2	8392101_ALA_RLX_XX
2	8392117_ALA_RLX_XX
5	**8396267_ALA_RLX_XX**

Separate age bias plots by reader
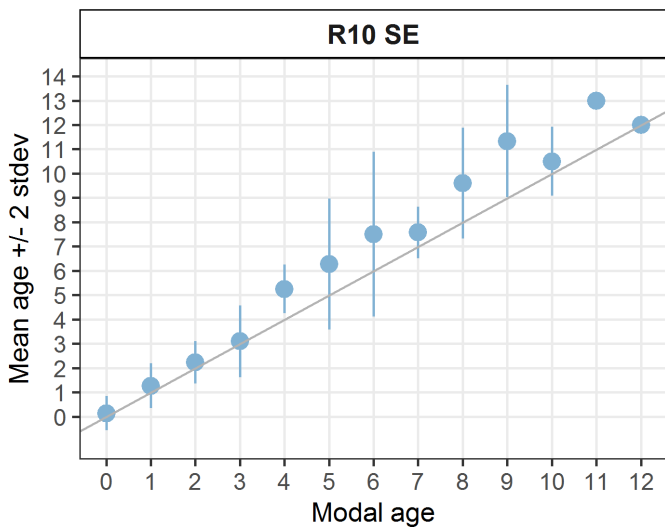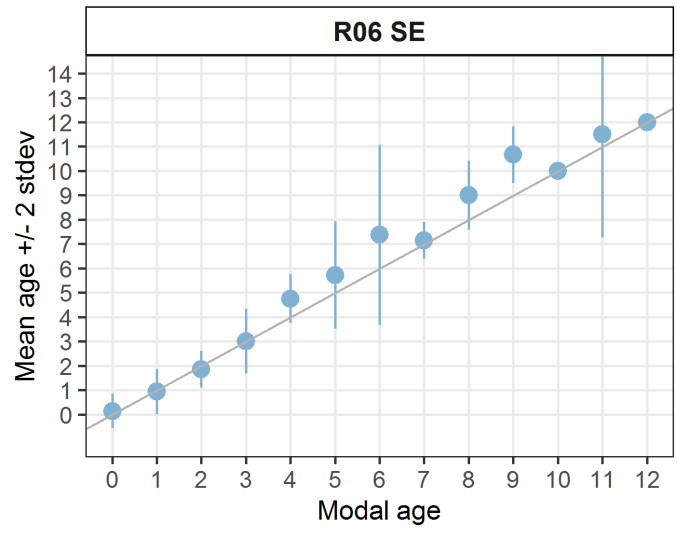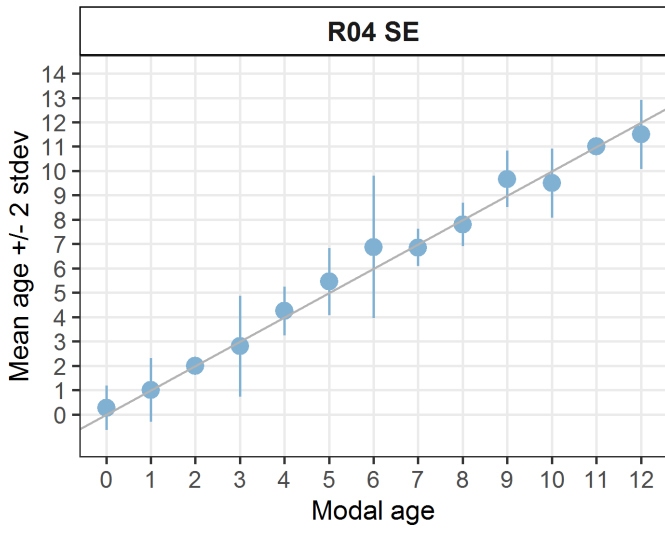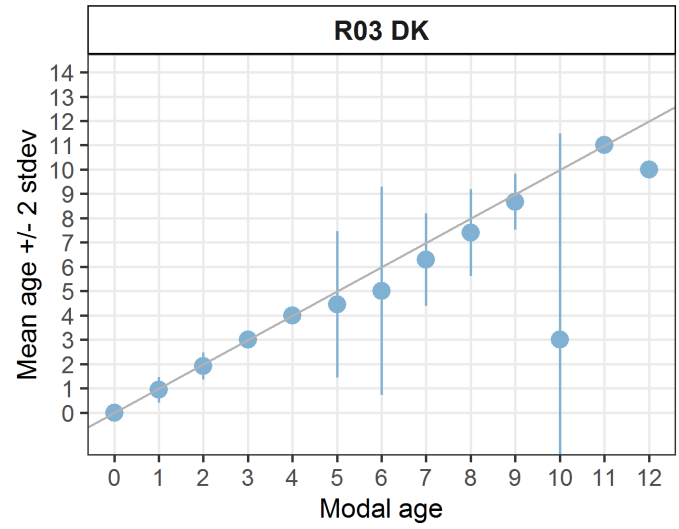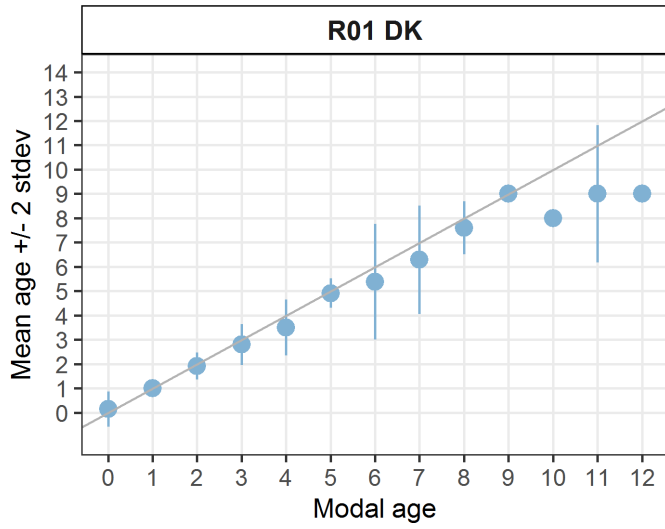
Figure 7.1: Individual reader age bias plot for advanced readers of whole otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).

Statistics by modal age plot (STDEV, CV and PA)
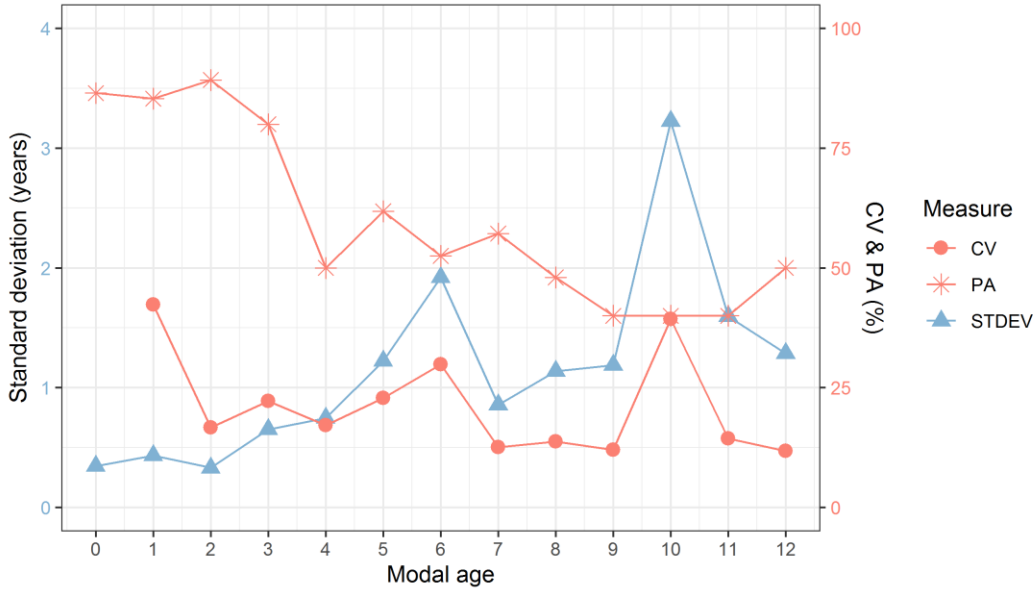
Figure 7.2: CV, PA and (STDEV (standard deviation) are plotted against modal age

Distribution of age reading errors
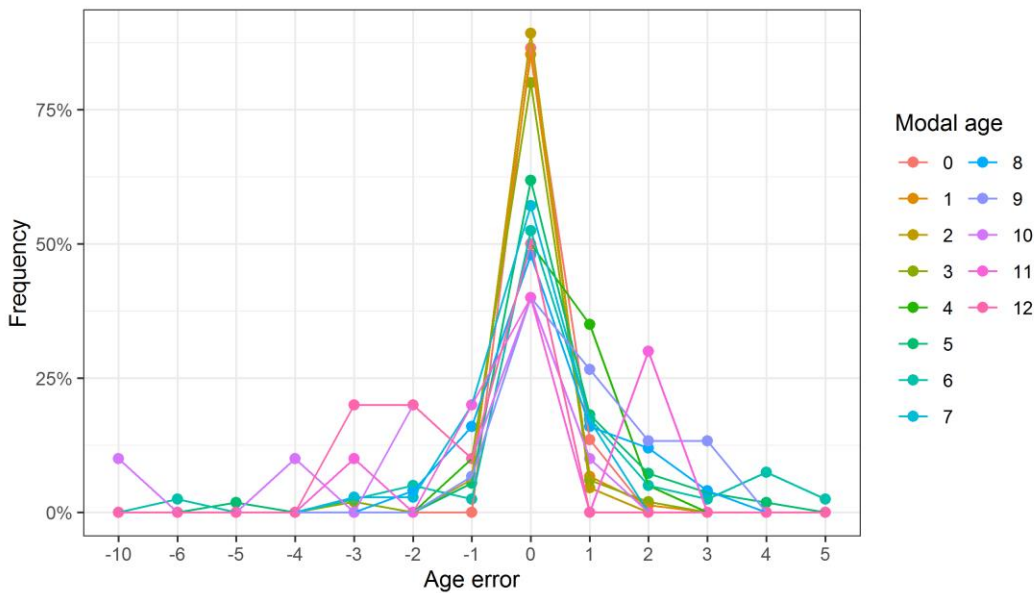
Figure 7.3: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is

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.

Relative bias for all readers
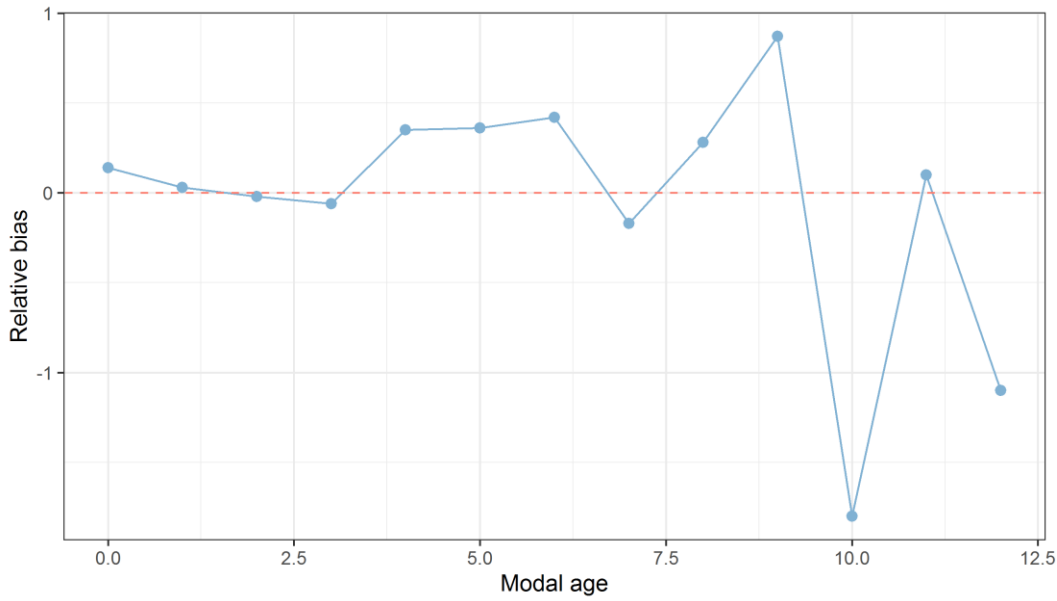
Figure7.4: The relative bias by modal age as estimated by all age readers combined.
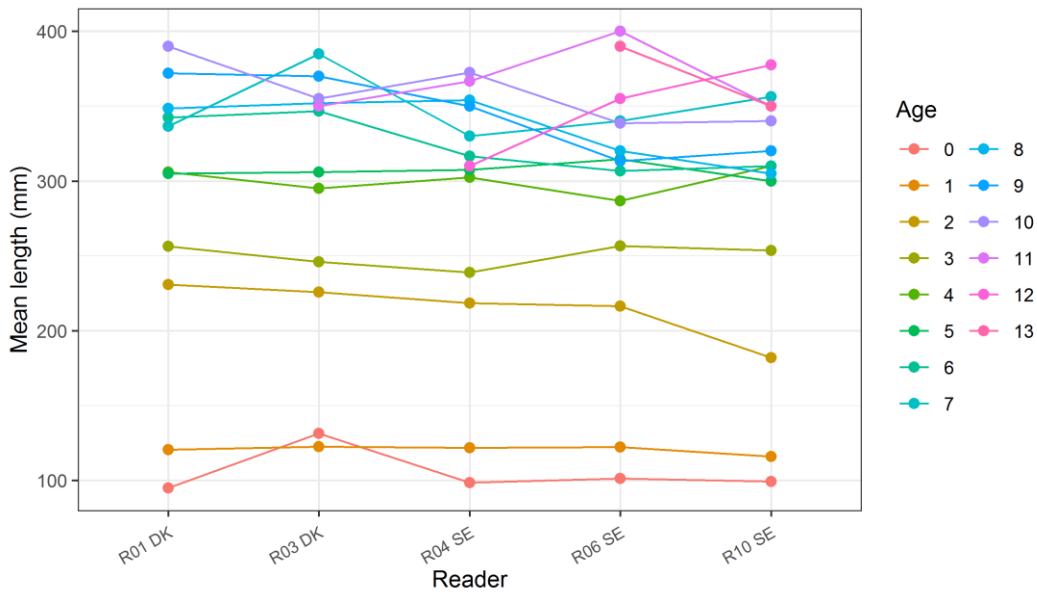
Figure 7.5: The mean fish length at age as estimated by each age reader.

7.2 Results - All readers based on whole otoliths

Summary statistics

Table 7.5: Summary of statistics; PA (%), CV (%) and APE (%).

NSample	CV	PA	APE
97	26 %	64 %	16 %

Data Overview

Table 7.6: Data overview including modal age and statistics per sample.

Fish ID	length	sex	Catch date	ICES area	R01 DK	R03 DK	R04 SE	R06 SE	R09 DK	R10 SE	R02 DE	R05 DE	R07 PL	R08 DE	R11 DE	R13 DK	Modal age	PA %	CV %	APE %
7890002_ALA _RLX_XX	131	F	24/09/2021 00:00:00	27.3.c .22	1	1	2	2	2	2	3	2	1	1	2	1	2	50	39	33
7890017_ALA _RLX_XX	79	U	14/02/2020 00:00:00	27.3. d.24	1	1	1	1	1	1	1	1	1	1	1	1	100	0	0	
7890026_ALA _RLX_XX	78	U	12/11/2021 00:00:00	27.3.c .22	0	0	0	0	0	0	1	0	0	0	0	0	0	92	-	-
7890041_ALA _RLX_XX	54	U	01/11/2019 00:00:00	27.3. d.24	0	0	0	0	0	0	1	0	0	0	0	0	0	92	-	-
7890052_ALA _RLX_XX	109	M	12/12/2021 00:00:00	27.3.c .22	0	0	1	0	1	1	0	1	0	0	1	1	0	50	-	-
7890053_ALA _RLX_XX	210	F	21/12/2021 00:00:00	27.3.c .22	2	2	2	2	2	2	3	2	2	3	2	2	2	83	18	13
7890307_ALA _RLX_XX	89	M	04/07/2020 00:00:00	27.3. d.24	0	0	0	1	1	0	1	1	0	1	1	0	0	50	-	-
7890413_ALA _RLX_XX	69	M	15/09/2020 00:00:00	27.3. d.24	0	0	0	0	0	0	0	1	0	0	0	0	0	92	-	-
8304959_ALA _RLX_XX	330	F	04/03/2021 06:19:47	27.3.c .22	5	5	5	5	5	6	5	0	5	5	5	5	5	83	32	17
8304960_ALA _RLX_XB	290	M	04/03/2021 06:19:47	27.3.c .22	4	4	4	4	4	5	5	4	4	4	4	3	4	75	13	7
8304961_ALA _RLX_XX	280	F	04/03/2021 06:19:47	27.3.c .22	3	4	4	5	4	5	5	4	5	5	6	4	4	42	18	15
8304966_ALA _RLX_XX	220	F	04/03/2021 06:19:47	27.3.c .22	2	3	3	2	2	3	3	4	3	2	2	3	3	50	24	21
8304968_ALA _RLX_XX	200	M	04/03/2021 06:19:47	27.3.c .22	3	3	3	3	3	3	4	4	3	3	3	3	3	83	12	9
8304976_ALA _RLX_XX	120	M	04/03/2021 06:19:47	27.3.c .22	1	1	1	1	1	1	2	2	2	1	1	2	1	67	37	33
8304978_ALA _RLX_XX	100	F	04/03/2021 06:19:47	27.3.c .22	1	1	1	1	1	1	2	2	1	1	1	1	1	83	33	24
8305659_ALA _RLX_XX	380	F	05/03/2021 09:17:49	27.3.c .22	6	6	7	7	6	7	6	7	7	6	7	6	6	50	8	8
8305662_ALA _RLX_XX	300	M	05/03/2021 09:17:49	27.3.c .22	2	3	3	3	2	3	4	3	3	3	4	3	3	67	20	11
8305667_ALA _RLX_XX	250	F	05/03/2021 09:17:49	27.3.c .22	3	3	3	3	3	3	4	3	3	-	3	3	3	91	10	5
8305669_ALA _RLX_XB	230	M	05/03/2021 09:17:49	27.3.c .22	2	2	2	2	2	3	3	2	2	2	2	2	2	83	18	13

ID		Sex	Date	Code																
8305675_ALA_RLX_BX	170	M	05/03/2021 09:17:49	27.3.c.22	2	2	2	2	1	2	0	2	2	1	2	2	2	75	39	30
8312102_ALA_RLX_XX	260	M	06/03/2021 12:46:31	27.3.c.22	7	6	6	7	7	8	8	7	7	6	8	4	7	42	17	12
8312104_ALA_RLX_XX	300	F	06/03/2021 12:46:31	27.3.c.22	7	6	7	8	7	8	7	7	8	-	8	7	7	55	9	7
8312500_ALA_RLX_XX	280	M	07/03/2021 08:23:06	27.3.c.22	8	8	7	9	8	8	8	8	9	8	8	9	8	67	7	5
8314059_ALA_RLX_XX	350	F	10/03/2021 06:38:58	27.3.c.22	9	9	9	10	9	10	10	10	10	9	11	9	9	50	7	6
8315397_ALA_RLX_XX	280	F	12/03/2021 11:43:27	27.3.c.22	7	8	8	9	7	10	8	9	8	7	10	9	8	33	13	11
8315400_ALA_RLX_XX	310	F	12/03/2021 11:43:27	27.3.c.22	9	10	12	12	9	12	9	11	12	11	13	12	12	42	13	11
8326654_ALA_RLX_XC	390	F	24/04/2021 00:00:00	27.3.c.22	6	6	6	5	6	7	7	6	6	7	8	6	6	58	12	10
8326658_ALA_RLX_XX	340	F	24/04/2021 00:00:00	27.3.c.22	4	5	5	5	5	6	-	5	5	6	5	5	5	73	11	6
8326659_ALA_RLX_XX	390	F	24/04/2021 00:00:00	27.3.c.22	9	9	10	11	10	12	9	10	10	10	13	11	10	42	12	9
8326663_ALA_RLX_XX	380	F	24/04/2021 00:00:00	27.3.c.22	7	7	7	7	7	8	8	7	7	8	8	7	7	67	7	6
8326666_ALA_RLX_XX	370	F	24/04/2021 00:00:00	27.3.c.22	4	6	6	6	4	6	7	6	6	6	6	6	6	75	15	10
8326683_ALA_RLX_XX	380	F	24/04/2021 00:00:00	27.3.c.22	8	8	8	9	9	10	8	8	9	9	10	8	8	50	9	8
8326695_ALA_RLX_XX	290	M	24/04/2021 00:00:00	27.3.c.22	5	5	5	5	5	5	6	6	5	-	5	5	5	82	8	6
8326700_ALA_RLX_XX	290	M	24/04/2021 00:00:00	27.3.c.22	5	5	6	6	5	7	7	6	6	6	6	6	6	58	11	8
8326705_ALA_RLX_XX	250	F	24/04/2021 00:00:00	27.3.c.22	2	2	2	2	2	3	3	2	2	2	2	2	2	83	18	13
8335700_ALA_RLX_XX	260	M	11/05/2021 00:00:00	27.3.c.22	5	0	6	8	6	9	5	7	7	3	8	7	7	25	42	30
8335852_ALA_RLX_XX	250	F	10/05/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	4	5	3	3	4	4	3	67	20	16
8335854_ALA_RLX_XX	250	M	10/05/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	4	3	3	2	3	3	3	83	14	6
8335860_ALA_RLX_XX	220	M	10/05/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	2	2	2	2	2	2	2	100	0	0
8343690_ALA_RLX_XX	390	M	23/06/2021 00:00:00	27.3.c.22	6	6	6	7	6	7	7	7	7	8	7	6	7	50	10	8
8343692_ALA_RLX_XX	330	M	23/06/2021 00:00:00	27.3.c.22	6	6	7	7	6	7	7	6	6	7	7	6	6	50	8	8
8347965_ALA_RLX_BX	370	F	05/07/2021 00:00:00	27.3.c.22	5	5	7	7	7	8	5	7	7	7	7	5	7	58	17	15
8347974_ALA_RLX_XX	390	F	05/07/2021 00:00:00	27.3.c.22	10	11	11	13	12	13	-	11	12	11	12	12	11	36	8	7
8347975_ALA_RLX_CX	400	F	05/07/2021 00:00:00	27.3.c.22	9	10	11	12	11	12	10	9	9	11	13	11	11	33	12	10
8347987_ALA_RLX_XX	330	F	05/07/2021 00:00:00	27.3.c.22	5	5	5	5	6	6	6	6	5	6	5	4	5	50	12	10
8348004_ALA_RLX_XX	410	M	05/07/2021 00:00:00	27.3.c.22	9	8	10	11	9	12	9	8	12	10	12	9	9	33	15	13
8348005_ALA_RLX_XX	390	F	05/07/2021 00:00:00	27.3.c.22	8	7	8	10	9	11	8	8	10	10	10	10	10	42	14	12
8348069_ALA_RLX_XX	300	F	06/07/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	3	2	2	2	2	2	2	92	14	7

ID																				
8348072_ALA_RLX_XX	250	F	06/07/2021 00:00:00	27.3.c.22	2	2	2	2	2	2	2	2	2	2	2	2	2	100	0	0
8348073_ALA_RLX_XX	270	M	06/07/2021 00:00:00	27.3.c.22	3	3	3	4	3	3	4	4	4	4	4	3	3	50	15	14
8348078_ALA_RLX_XX	290	M	06/07/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	3	3	3	3	3	3	3	100	0	0
8358458_ALA_RLX_XX	410	F	22/08/2021 00:00:00	27.3.c.22	7	8	7	7	8	7	9	8	8	8	9	8	8	50	9	7
8358476_ALA_RLX_XX	310	F	22/08/2021 00:00:00	27.3.c.22	6	6	10	10	7	9	7	8	10	10	10	7	10	42	20	18
8358478_ALA_RLX_XX	330	M	22/08/2021 00:00:00	27.3.c.22	6	6	8	8	6	7	7	-	8	8	9	6	6	36	15	13
8358483_ALA_RLX_XX	290	M	22/08/2021 00:00:00	27.3.c.22	4	4	5	5	5	6	6	5	5	5	5	5	5	67	12	7
8358485_ALA_RLX_XX	300	F	22/08/2021 00:00:00	27.3.c.22	5	5	6	5	5	6	5	5	5	6	6	6	5	58	10	9
8358486_ALA_RLX_XX	340	F	22/08/2021 00:00:00	27.3.c.22	3	4	4	5	4	5	5	5	5	5	4	4	5	50	15	13
8358499_ALA_RLX_XX	310	M	22/08/2021 00:00:00	27.3.c.22	5	4	5	7	6	4	6	6	6	6	7	5	6	42	18	15
8386600_ALA_RLX_XX	380	M	14/10/2021 00:00:00	27.3.c.22	8	6	10	10	10	11	10	8	11	9	12	9	10	33	17	13
8392100_ALA_RLX_XX	320	F	22/10/2021 06:10:01	27.3.c.22	5	5	5	5	5	6	5	4	5	6	6	5	5	67	11	8
8392101_ALA_RLX_XX	300	M	22/10/2021 06:10:01	27.3.c.22	3	3	4	4	4	5	5	4	4	7	5	4	4	50	25	18
8392104_ALA_RLX_XX	280	F	22/10/2021 06:10:01	27.3.c.22	2	2	2	2	2	3	4	-	2	4	2	2	2	73	33	27
8392106_ALA_RLX_XX	260	F	22/10/2021 06:10:01	27.3.c.22	2	2	2	2	2	2	3	2	2	2	2	2	2	92	14	7
8392107_ALA_RLX_XX	240	F	22/10/2021 06:10:01	27.3.c.22	2	2	2	2	2	2	3	2	2	2	2	2	2	92	14	7
8392115_ALA_RLX_XX	150	M	22/10/2021 06:10:01	27.3.c.22	1	1	1	1	1	1	2	1	1	1	1	1	1	92	27	14
8392116_ALA_RLX_XX	140	F	22/10/2021 06:10:01	27.3.c.22	-	0	1	0	1	0	1	2	0	1	0	0	0	55	-	-
8392117_ALA_RLX_XX	130	F	22/10/2021 06:10:01	27.3.c.22	3	3	0	2	3	2	3	5	4	2	3	4	3	42	45	31
8392119_ALA_RLX_XX	110	F	22/10/2021 06:10:01	27.3.c.22	0	0	0	0	0	0	2	1	0	1	0	0	0	75	-	-
8392120_ALA_RLX_XX	100	M	22/10/2021 06:10:01	27.3.c.22	0	0	0	0	0	0	0	1	0	0	0	0	0	92	-	-
8392121_ALA_RLX_XX	100	M	22/10/2021 06:10:01	27.3.c.22	0	0	0	0	0	0	1	1	0	0	0	0	0	83	-	-
8392351_ALA_RLX_XX	120	F	22/10/2021 08:32:27	27.3.c.22	1	1	3	0	2	1	0	4	2	1	3	1	1	42	78	64
8392352_ALA_RLX_XX	130	F	22/10/2021 08:32:27	27.3.c.22	1	1	1	1	1	2	2	-	1	2	2	1	1	64	37	34
8394224_ALA_RLX_XX	350	M	25/10/2021 05:56:14	27.3.c.22	8	0	9	10	9	10	8	8	9	12	11	9	9	33	35	20
8394225_ALA_RLX_XX	330	F	25/10/2021 05:56:14	27.3.c.22	6	6	6	7	6	7	6	6	5	7	8	5	6	50	14	11
8394227_ALA_RLX_XX	310	F	25/10/2021 05:56:14	27.3.c.22	8	11	11	10	11	13	9	9	9	10	13	11	11	33	15	12
8394233_ALA_RLX_XX	250	F	25/10/2021 05:56:14	27.3.c.22	5	5	5	5	5	6	6	5	5	-	5	6	5	73	9	8
8394421_ALA_RLX_XX	390	F	25/10/2021 08:08:20	27.3.c.22	7	6	8	8	6	9	8	9	7	8	10	8	8	42	15	11

| 8394676_ALA _RLX_XX	160	M	25/10/2021 10:11:43	27.3.c .22	2	2	2	1	3	2	3	1	2	1	1	1	2	42	43	36
8394677_ALA _RLX_XX	150	M	25/10/2021 10:11:43	27.3.c .22	1	1	1	1	1	1	2	1	1	1	1	1	1	92	27	14
8394680_ALA _RLX_XX	100	F	25/10/2021 10:11:43	27.3.c .22	0	0	0	0	0	0	1	1	0	0	0	0	0	83	-	-
8395163_ALA _RLX_XX	140	F	26/10/2021 05:59:17	27.3.c .22	2	2	2	1	2	2	3	2	2	2	1	2	2	75	27	16
8395164_ALA _RLX_XX	130	M	26/10/2021 05:59:17	27.3.c .22	1	1	1	1	1	1	2	1	1	1	1	1	1	92	27	14
8395165_ALA _RLX_XX	120	M	26/10/2021 05:59:17	27.3.c .22	0	0	1	1	1	0	-	-	0	1	1	1	1	60	86	80
8395166_ALA _RLX_XX	100	F	26/10/2021 05:59:17	27.3.c .22	1	1	0	0	1	1	1	1	1	1	1	1	1	83	47	33
8395356_ALA _RLX_XX	130	M	26/10/2021 07:53:23	27.3.c .22	1	1	0	1	1	1	2	2	1	1	1	1	1	75	48	28
8395357_ALA _RLX_XX	120	F	26/10/2021 07:53:23	27.3.c .22	1	1	1	1	2	2	2	2	2	2	1	1	1	50	35	33
8395625_ALA _RLX_XX	120	M	26/10/2021 10:17:48	27.3.c .22	1	0	1	0	1	0	2	2	1	1	1	1	1	58	73	50
8395627_ALA _RLX_XX	100	F	26/10/2021 10:17:48	27.3.c .22	1	0	1	1	1	1	1	2	1	1	1	1	1	83	43	17
8395810_ALA _RLX_XX	140	F	26/10/2021 14:34:20	27.3.c .22	1	1	1	2	3	2	2	2	2	2	2	1	2	58	36	29
8395813_ALA _RLX_XX	110	F	26/10/2021 14:34:20	27.3.c .22	1	0	0	0	1	1	2	2	1	1	0	1	1	50	86	67
8395992_ALA _RLX_XX	260	M	27/10/2021 08:14:48	27.3.c .22	3	4	6	6	6	6	6	6	5	5	6	4	6	58	20	17
8396004_ALA _RLX_XX	130	M	27/10/2021 08:14:48	27.3.c .22	1	1	1	1	2	2	2	2	2	2	1	1	1	50	35	33
8396007_ALA _RLX_XX	100	M	27/10/2021 08:14:48	27.3.c .22	0	0	0	0	0	0	1	1	0	0	0	0	0	83	-	-
8396267_ALA _RLX_XX	280	M	27/10/2021 11:40:40	27.3.c .22	6	0	7	10	7	11	7	7	7	8	9	7	7	50	38	22
8396668_ALA _RLX_XX	240	M	28/10/2021 08:19:24	27.3.c .22	4	5	7	7	5	8	5	0	4	4	7	5	5	33	41	28
8396679_ALA _RLX_XX	110	M	28/10/2021 08:19:24	27.3.c .22	1	1	1	1	1	1	2	2	1	1	1	1	1	83	33	24
8400914_ALA _RLX_XX	110	F	30/10/2021 09:19:48	27.3.c .22	0	0	0	0	0	0	0	1	0	0	0	0	0	92	-	-

Separate age bias plots by reader
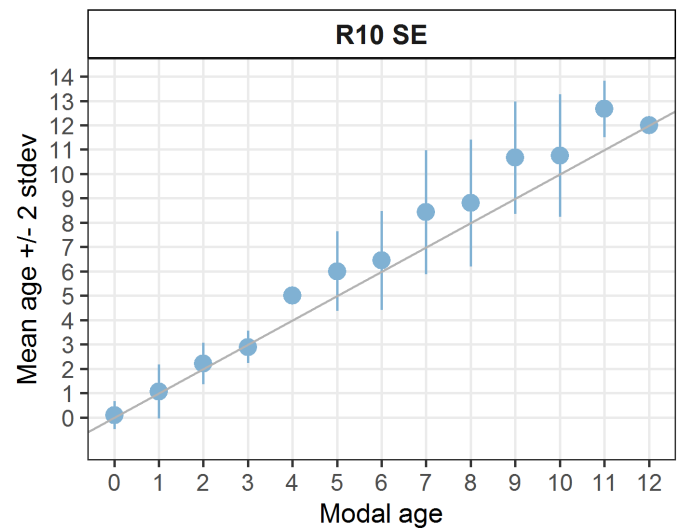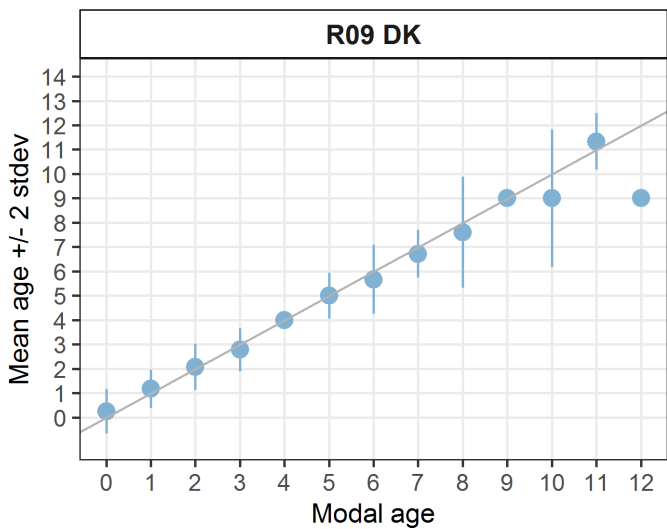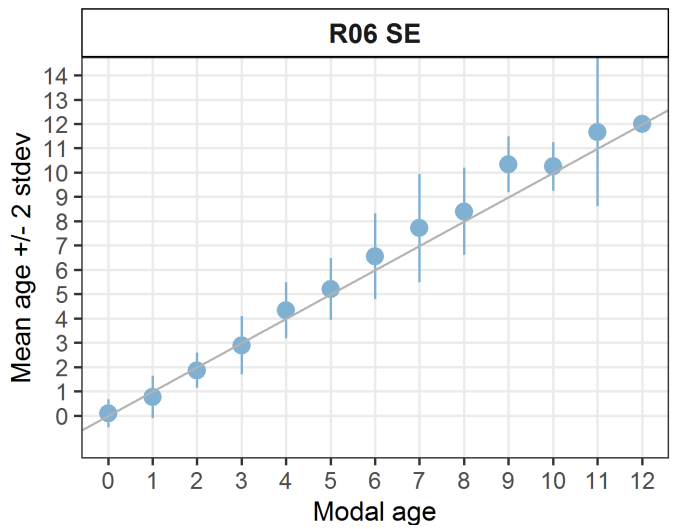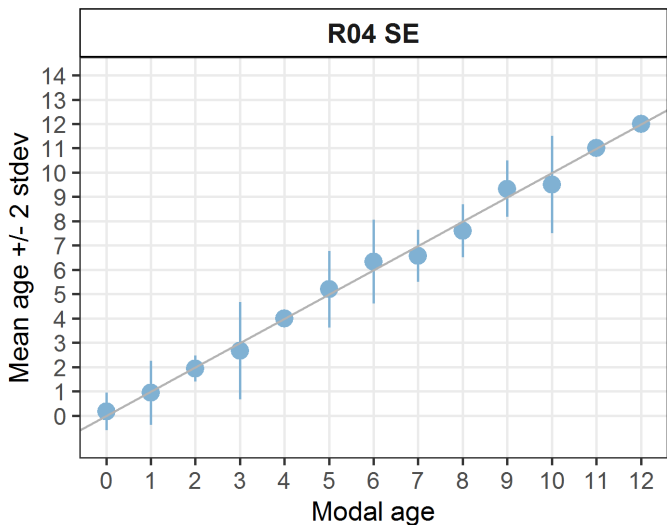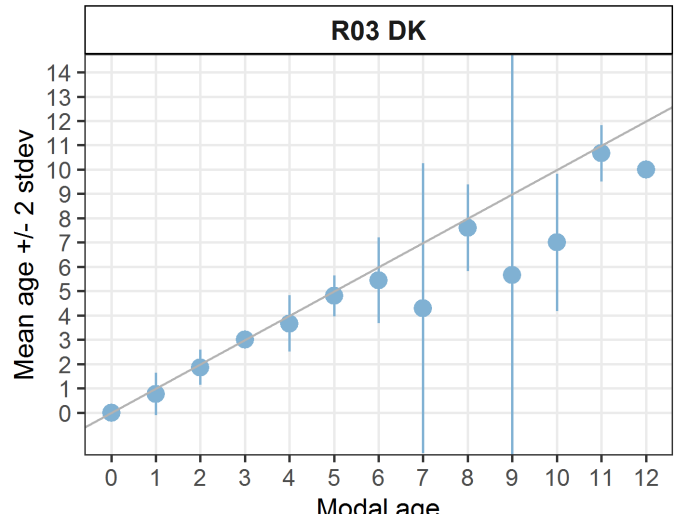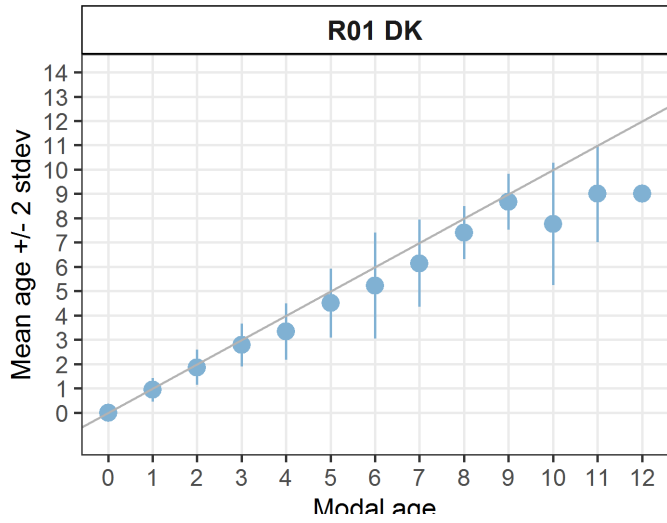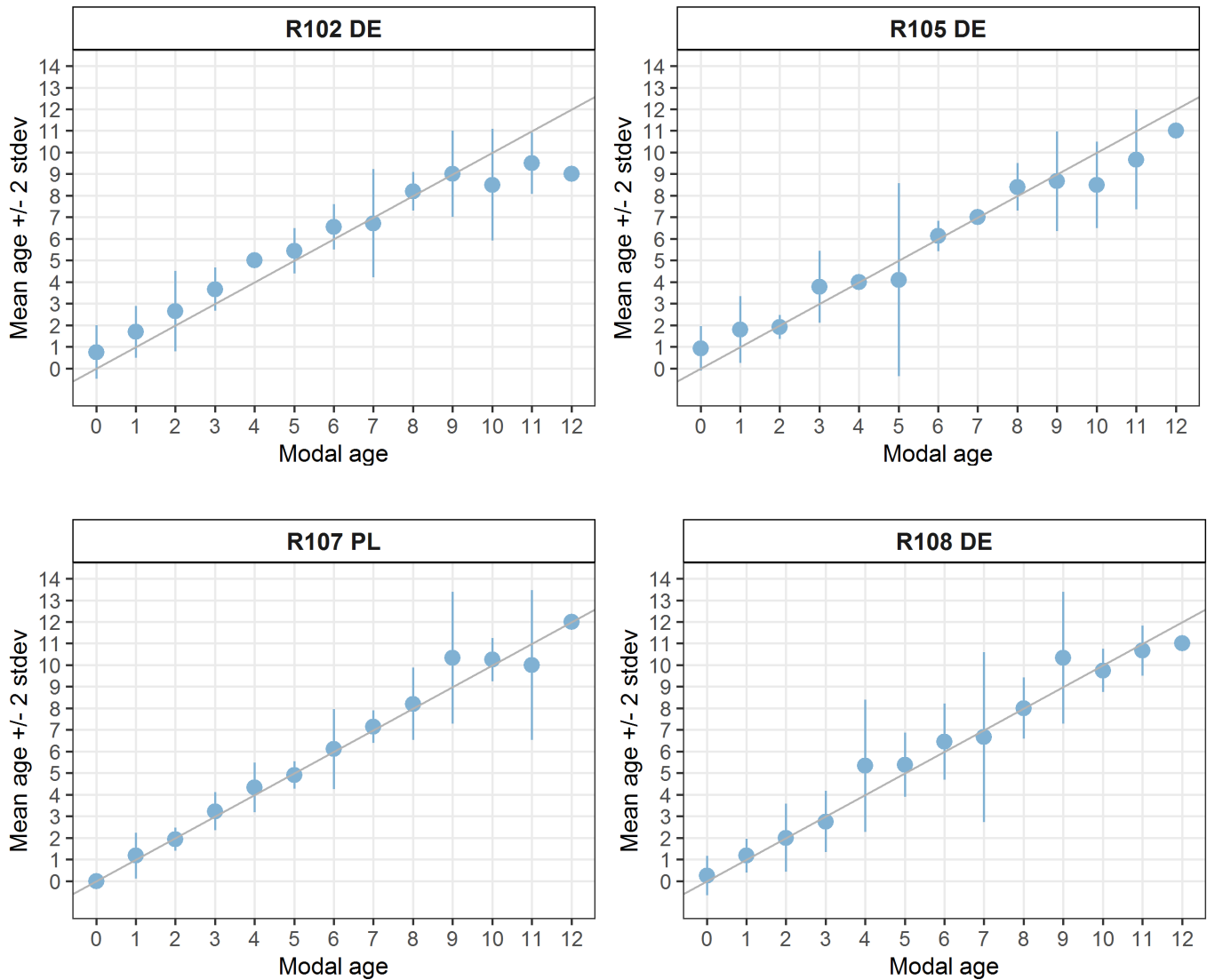
Figure 7.6: Individual reader age bias plot for all readers of whole otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).
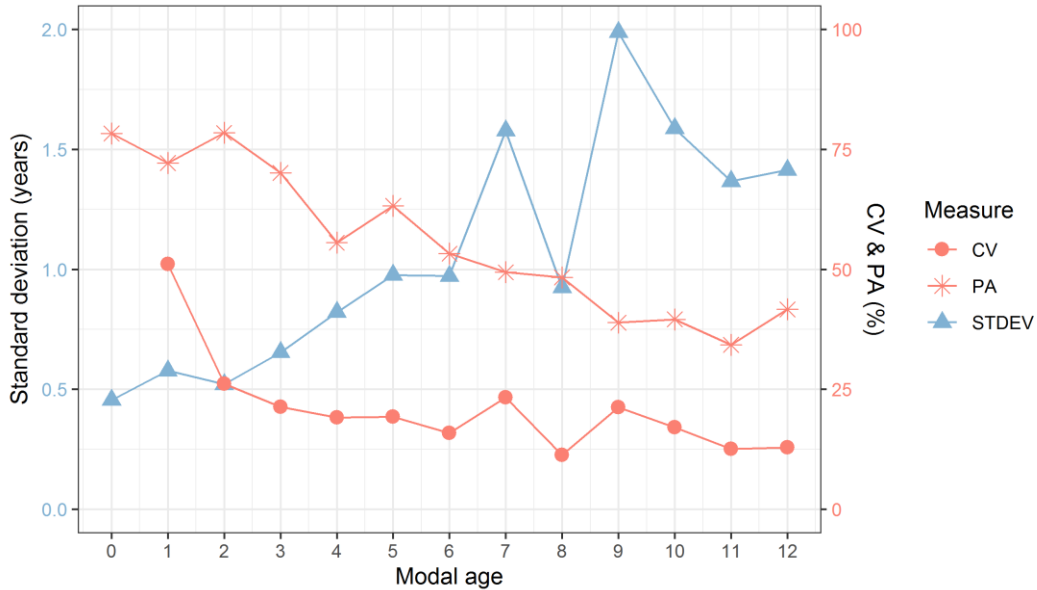
Statistics by modal age plot (STDEV, CV and PA)

Figure 7.7: CV, PA and (STDEV (standard deviation) are plotted against modal age
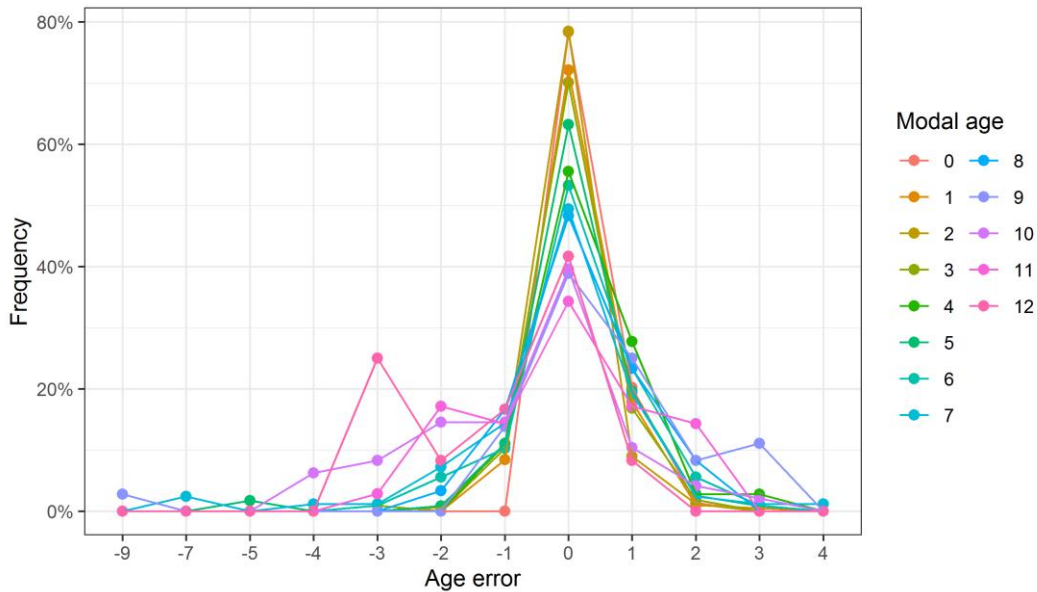
Distribution of age reading errors

Figure 7.8: 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.

Relative bias for all readers
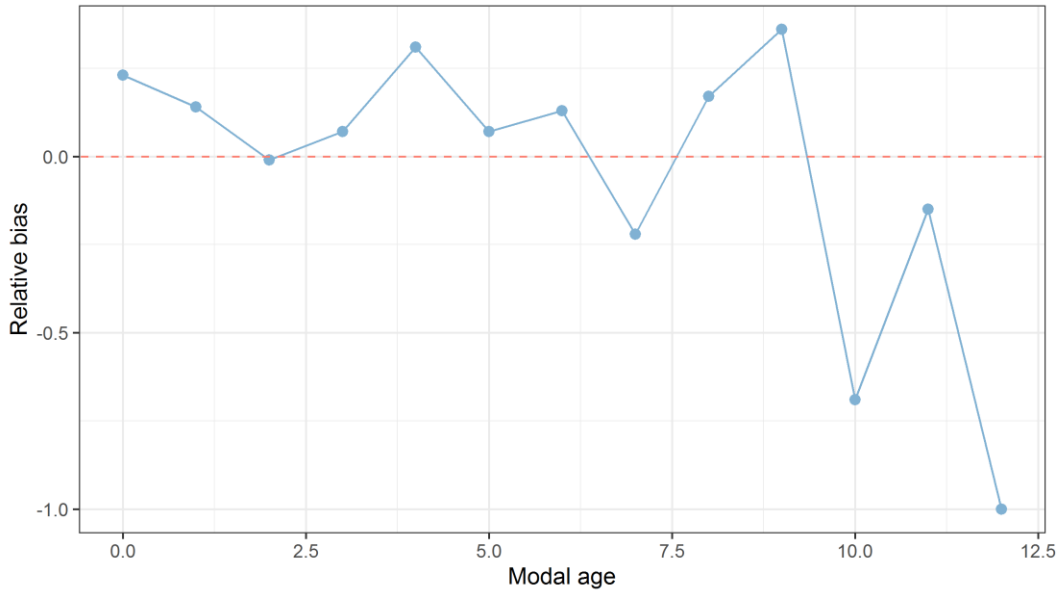
Figure 7.9: The relative bias by modal age as estimated by all age readers combined.

Mean length at age by reader
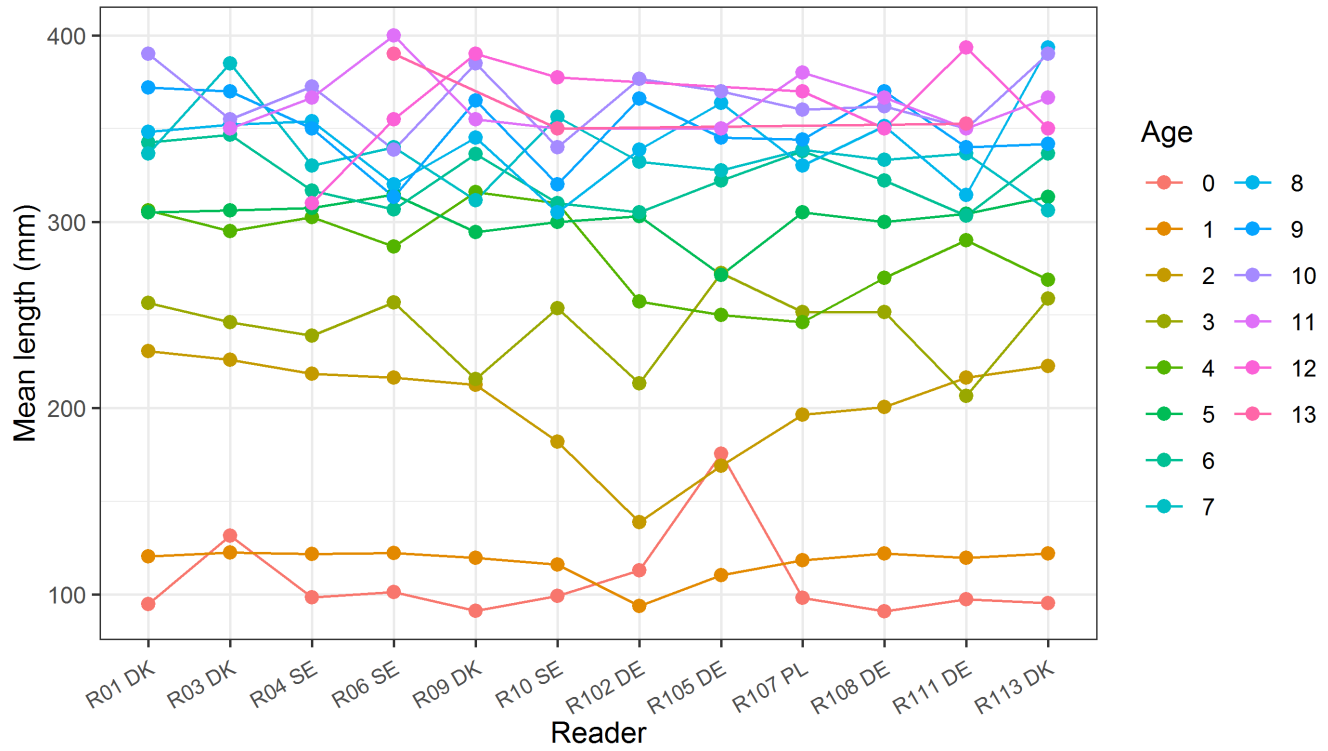
Figure 7.10: The mean fish length at age as estimated by each age reader.

7.3 Results - Advanced readers based on sectioned otoliths

Multistage approach

Table 7.7: Summary of statistics; Total number of samples (NSample), a percentage of cases (fish samples) with multiple modes depending on the approach to weight the experience of the reader which will be considered when defining the fish age mode. PercMM_traditional shows the percentage of the total samples for which multiple modes are obtained when all the readers are equally weighted. PercMM_linear_weight shows the percentage of the total samples for which multiple modes are obtained when the weight assigned to the different readers decreases linearly with the experience, while in the PercMM_negexp the weight applied decreases with a negative exponential shape with the experience. The PercMM_multistage shows the percentage of multiple mode cases when a combination of the different methodologies is used, as explained in the material and methods section

NSample	PercMM_traditional	PercMM_linear_weight	PercMM_negexp_weight	PercMM_multistage
69	26 %	17 %	0 %	0 %

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

NSample	CV	PA	APE
69	19 %	64 %	12 %

Table 7.8: List of cases for which multiple modes where obtained when all readers are considered. The column NModes_trad shows the number of multiple modes for each FishID or SampleID when all readers are given the same expertise weight.

NModes_trad	SampleID
3	8304959_SEX_RLX_UN
3	8305659_SEX_RLX_UN
2	8312500_SEX_RLX_UN
2	8315400_SEX_RLX_UN
3	8326654_SEX_RLX_UN
3	8326663_SEX_RLX_UN
3	8326700_SEX_RLX_UN
2	8343692_SEX_RLX_UN
3	8347974_SEX_RLX_UN
3	8348005_SEX_RLX_UN
3	8358478_SEX_RLX_UN
3	8358486_SEX_RLX_UN
3	8358499_SEX_RLX_UN
2	8394224_SEX_RLX_UN
3	8394227_SEX_RLX_UN
3	8394421_SEX_RLX_UN
3	8395992_SEX_RLX_UN
3	**8396267_SEX_RLX_UN**

Data overview

Table 7.9: Data overview including modal age and statistics per sample.

Fish ID	length	sex	Catch date	ICES area	R02 DE	R05 DE	R08 DE	Modal age	PA %	CV %	APE %
8304959_SEX_RLX_UN	330	F	04/03/2021 06:19:47	27.3.c.22	8	6	7	8	33	14	10
8304960_SEX_RLX_UN	290	M	04/03/2021 06:19:47	27.3.c.22	5	5	5	5	100	0	0
8304961_SEX_RLX_UN	280	F	04/03/2021 06:19:47	27.3.c.22	4	5	4	4	67	13	10
8304966_SEX_RLX_UN	220	F	04/03/2021 06:19:47	27.3.c.22	4	3	3	3	67	17	13
8304968_SEX_RLX_UN	200	M	04/03/2021 06:19:47	27.3.c.22	4	4	3	4	67	16	12
8304976_SEX_RLX_UN	120	M	04/03/2021 06:19:47	27.3.c.22	2	2	1	2	67	35	27
8304978_SEX_RLX_UN	100	F	04/03/2021 06:19:47	27.3.c.22	2	2	1	2	67	35	27
8305659_SEX_RLX_UN	380	F	05/03/2021 09:17:49	27.3.c.22	10	8	11	10	33	16	11
8305662_SEX_RLX_UN	300	M	05/03/2021 09:17:49	27.3.c.22	4	3	3	3	67	17	13
8305667_SEX_RLX_UN	250	F	05/03/2021 09:17:49	27.3.c.22	4	3	4	4	67	16	12
8305669_SEX_RLX_UN	230	M	05/03/2021 09:17:49	27.3.c.22	4	3	3	3	67	17	13
8305675_SEX_RLX_UN	170	M	05/03/2021 09:17:49	27.3.c.22	3	2	2	2	67	25	19
8312102_SEX_RLX_UN	260	M	06/03/2021 12:46:31	27.3.c.22	13	0	13	13	67	87	67
8312104_SEX_RLX_UN	300	F	06/03/2021 12:46:31	27.3.c.22	8	8	7	8	67	8	6
8312500_SEX_RLX_UN	280	M	07/03/2021 08:23:06	27.3.c.22	11	-	12	11	50	6	4
8314059_SEX_RLX_UN	350	F	10/03/2021 06:38:58	27.3.c.22	10	10	-	10	100	0	0
8315397_SEX_RLX_UN	280	F	12/03/2021 11:43:27	27.3.c.22	9	9	12	9	67	17	13
8315400_SEX_RLX_UN	310	F	12/03/2021 11:43:27	27.3.c.22	16	-	14	16	50	9	7
8326654_SEX_RLX_UN	390	F	24/04/2021 00:00:00	27.3.c.22	9	0	8	9	33	-	-
8326658_SEX_RLX_UN	340	F	24/04/2021 00:00:00	27.3.c.22	6	5	5	5	67	11	8
8326659_SEX_RLX_UN	390	F	24/04/2021 00:00:00	27.3.c.22	12	12	13	12	67	5	4
8326663_SEX_RLX_UN	380	F	24/04/2021 00:00:00	27.3.c.22	8	7	6	8	33	14	10
8326666_SEX_RLX_UN	370	F	24/04/2021 00:00:00	27.3.c.22	5	5	6	5	67	11	8
8326683_SEX_RLX_UN	380	F	24/04/2021 00:00:00	27.3.c.22	11	10	10	10	67	6	4
8326695_SEX_RLX_UN	290	M	24/04/2021 00:00:00	27.3.c.22	5	5	-	5	100	0	0
8326700_SEX_RLX_UN	290	M	24/04/2021 00:00:00	27.3.c.22	5	7	6	5	33	17	11

8326705_SEX_RLX_UN	250	F	24/04/2021 00:00:00	27.3.c.22	3	3	3	3	100	0	0
8335700_SEX_RLX_UN	260	M	11/05/2021 00:00:00	27.3.c.22	0	0	8	0	67	-	-
8335852_SEX_RLX_UN	250	F	10/05/2021 00:00:00	27.3.c.22	4	4	3	4	67	16	12
8335854_SEX_RLX_UN	250	M	10/05/2021 00:00:00	27.3.c.22	3	3	3	3	100	0	0
8335860_SEX_RLX_UN	220	M	10/05/2021 00:00:00	27.3.c.22	3	2	3	3	67	22	17
8343690_SEX_RLX_UN	390	M	23/06/2021 00:00:00	27.3.c.22	7	6	6	6	67	9	7
8343692_SEX_RLX_UN	330	M	23/06/2021 00:00:00	27.3.c.22	8	5	-	8	50	33	23
8347965_SEX_RLX_UN	370	F	05/07/2021 00:00:00	27.3.c.22	8	7	8	8	67	8	6
8347974_SEX_RLX_UN	390	F	05/07/2021 00:00:00	27.3.c.22	11	12	14	11	33	12	9
8347975_SEX_RLX_UN	400	F	05/07/2021 00:00:00	27.3.c.22	14	12	12	12	67	9	7
8347987_SEX_RLX_UN	330	F	05/07/2021 00:00:00	27.3.c.22	6	5	5	5	67	11	8
8348004_SEX_RLX_UN	410	M	05/07/2021 00:00:00	27.3.c.22	10	11	10	10	67	6	4
8348005_SEX_RLX_UN	390	F	05/07/2021 00:00:00	27.3.c.22	11	10	13	11	33	13	10
8348069_SEX_RLX_UN	300	F	06/07/2021 00:00:00	27.3.c.22	3	2	3	3	67	22	17
8348072_SEX_RLX_UN	250	F	06/07/2021 00:00:00	27.3.c.22	3	2	3	3	67	22	17
8348073_SEX_RLX_UN	270	M	06/07/2021 00:00:00	27.3.c.22	5	4	5	5	67	12	10
8348078_SEX_RLX_UN	290	M	06/07/2021 00:00:00	27.3.c.22	3	3	4	3	67	17	13
8358458_SEX_RLX_UN	410	F	22/08/2021 00:00:00	27.3.c.22	10	9	9	9	67	6	5
8358476_SEX_RLX_UN	310	F	22/08/2021 00:00:00	27.3.c.22	10	8	10	10	67	12	10
8358478_SEX_RLX_UN	330	M	22/08/2021 00:00:00	27.3.c.22	7	6	11	7	33	33	25
8358483_SEX_RLX_UN	290	M	22/08/2021 00:00:00	27.3.c.22	5	5	6	5	67	11	8
8358485_SEX_RLX_UN	300	F	22/08/2021 00:00:00	27.3.c.22	6	6	6	6	100	0	0
8358486_SEX_RLX_UN	340	F	22/08/2021 00:00:00	27.3.c.22	6	4	8	6	33	33	22
8358499_SEX_RLX_UN	310	M	22/08/2021 00:00:00	27.3.c.22	11	8	12	11	33	20	15
8386600_SEX_RLX_UN	380	M	14/10/2021 00:00:00	27.3.c.22	12	12	13	12	67	5	4
8392100_SEX_RLX_UN	320	F	22/10/2021 06:10:01	27.3.c.22	11	11	12	11	67	5	4
8392101_SEX_RLX_UN	300	M	22/10/2021 06:10:01	27.3.c.22	5	5	5	5	100	0	0
8392104_SEX_RLX_UN	280	F	22/10/2021 06:10:01	27.3.c.22	5	4	5	5	67	12	10
8392106_SEX_RLX_UN	260	F	22/10/2021 06:10:01	27.3.c.22	4	-	4	4	100	0	0

SampleID											
8392107_SEX_RLX_UN	240	F	22/10/2021 06:10:01	27.3.c.22	3	2	3	3	67	22	17
8392115_SEX_RLX_UN	150	M	22/10/2021 06:10:01	27.3.c.22	2	1	2	2	67	35	27
8392116_SEX_RLX_UN	140	F	22/10/2021 06:10:01	27.3.c.22	2	1	1	1	67	43	33
8392117_SEX_RLX_UN	130	F	22/10/2021 06:10:01	27.3.c.22	3	0	3	3	67	87	67
8392120_SEX_RLX_UN	100	M	22/10/2021 06:10:01	27.3.c.22	1	1	1	1	100	0	0
8394224_SEX_RLX_UN	350	M	25/10/2021 05:56:14	27.3.c.22	13	-	15	13	50	10	7
8394225_SEX_RLX_UN	330	F	25/10/2021 05:56:14	27.3.c.22	8	8	9	8	67	7	5
8394227_SEX_RLX_UN	310	F	25/10/2021 05:56:14	27.3.c.22	15	12	17	15	33	17	12
8394233_SEX_RLX_UN	250	F	25/10/2021 05:56:14	27.3.c.22	6	6	-	6	100	0	0
8394421_SEX_RLX_UN	390	F	25/10/2021 08:08:20	27.3.c.22	9	8	11	9	33	16	12
8395627_SEX_RLX_UN	100	F	26/10/2021 10:17:48	27.3.c.22	1	1	1	1	100	0	0
8395992_SEX_RLX_UN	260	M	27/10/2021 08:14:48	27.3.c.22	9	7	10	9	33	18	13
8396267_SEX_RLX_UN	280	M	27/10/2021 11:40:40	27.3.c.22	11	10	13	11	33	13	10
8396668_SEX_RLX_UN	240	M	28/10/2021 08:19:24	27.3.c.22	7	9	9	9	67	14	11

List of multimodal cases

Table 7.10: List of c/ases for which multiple modes where obtained when all readers are considered. The column NModes_trad shows the number of multiple modes for each FishID or SampleID when all readers are given the same expertise weight.

NModes_trad	SampleID
3	8304959_SEX_RLX_UN
3	8305659_SEX_RLX_UN
2	8312500_SEX_RLX_UN
2	8315400_SEX_RLX_UN
3	8326654_SEX_RLX_UN
3	8326663_SEX_RLX_UN
3	8326700_SEX_RLX_UN
2	8343692_SEX_RLX_UN
3	8347974_SEX_RLX_UN
3	8348005_SEX_RLX_UN
3	8358478_SEX_RLX_UN
3	8358486_SEX_RLX_UN
3	8358499_SEX_RLX_UN
2	8394224_SEX_RLX_UN
3	8394227_SEX_RLX_UN
3	8394421_SEX_RLX_UN
3	8395992_SEX_RLX_UN
3	**8396267_SEX_RLX_UN**

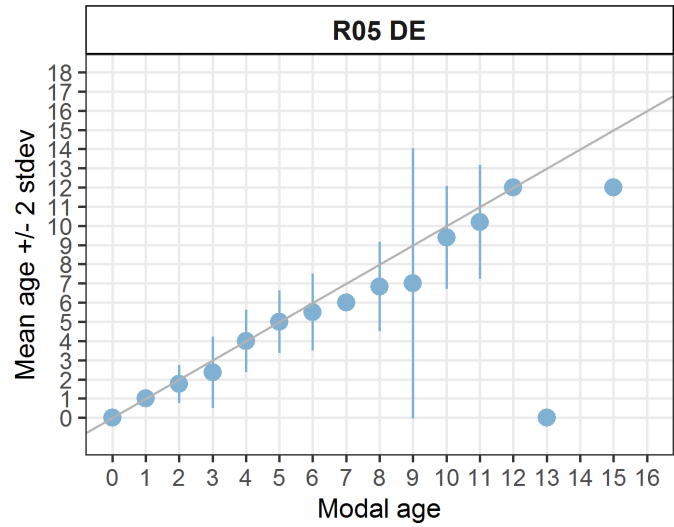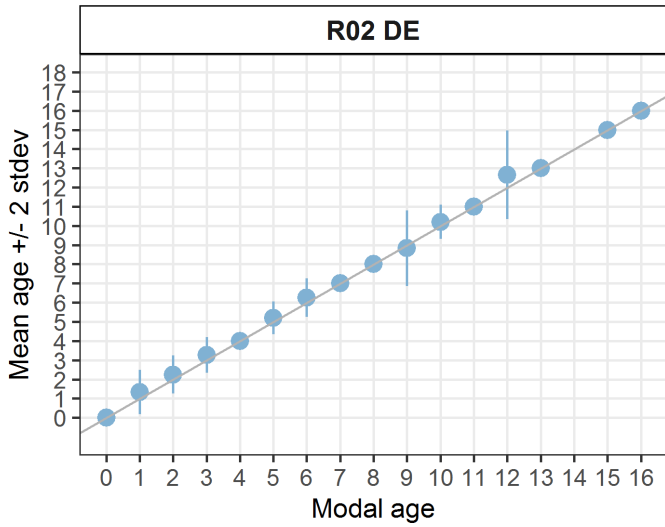*Separate age bias plots by reader*
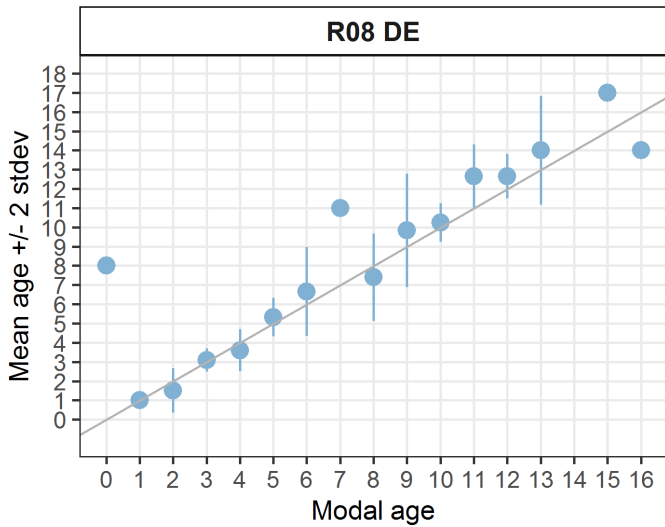
Figure 7.11: Individual reader age bias plot for advanced readers of sectioned otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).

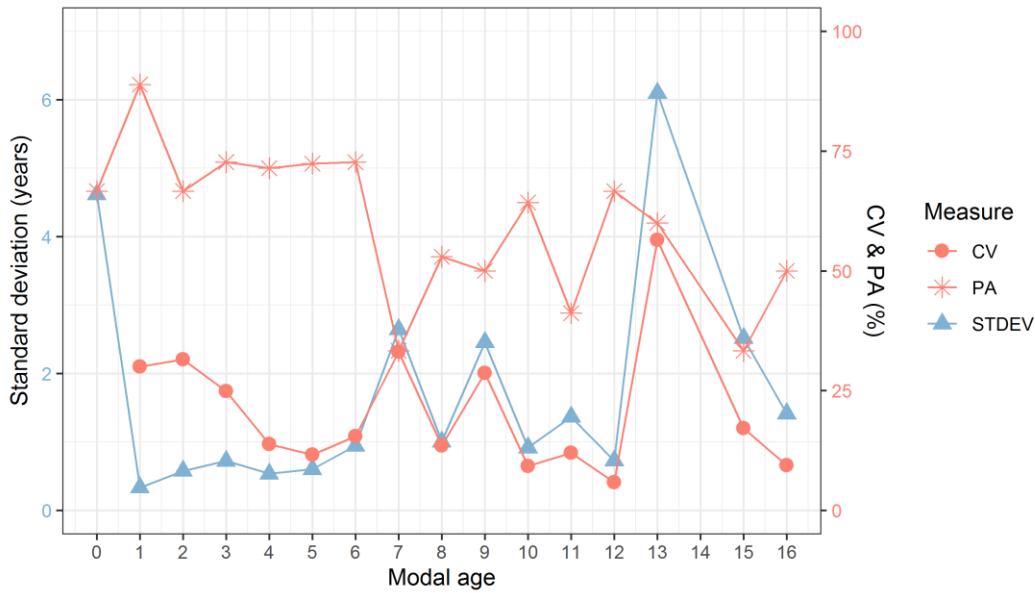*Statistics by modal age plot (STDEV, CV and PA)*

Figure 7.12: CV, PA and (STDEV (standard deviation) are plotted against modal age
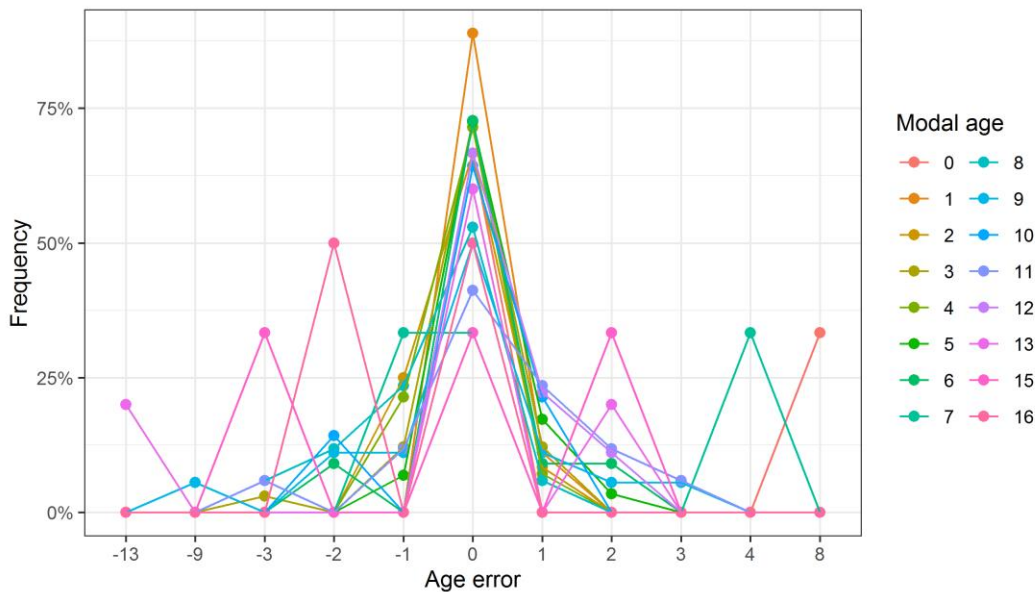
Distribution of age reading errors

Figure 7.13: 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.

Relative bias for all readers
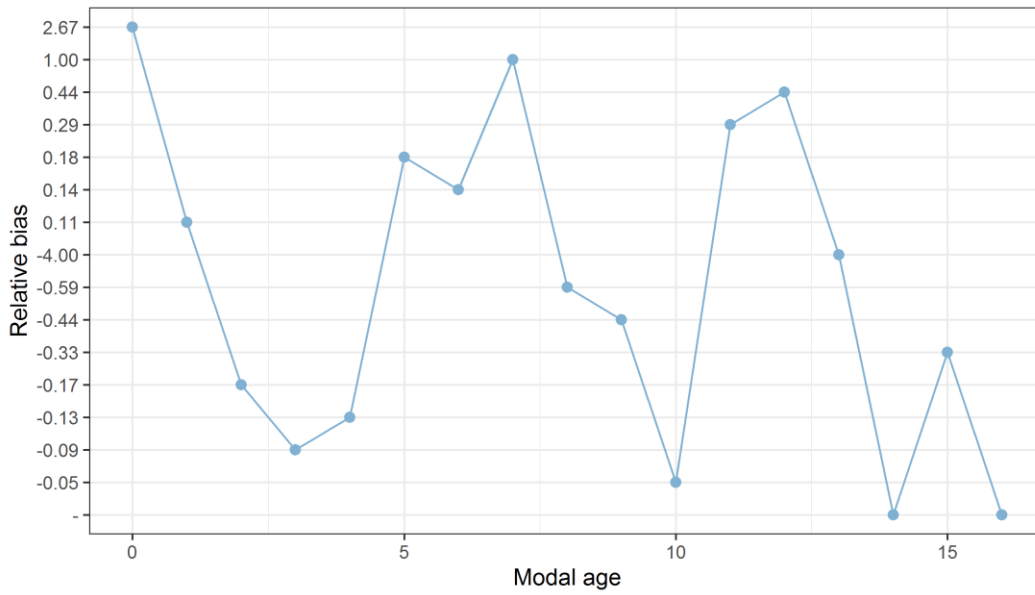
Figure 7.14: The relative bias by modal age as estimated by all age readers combined.
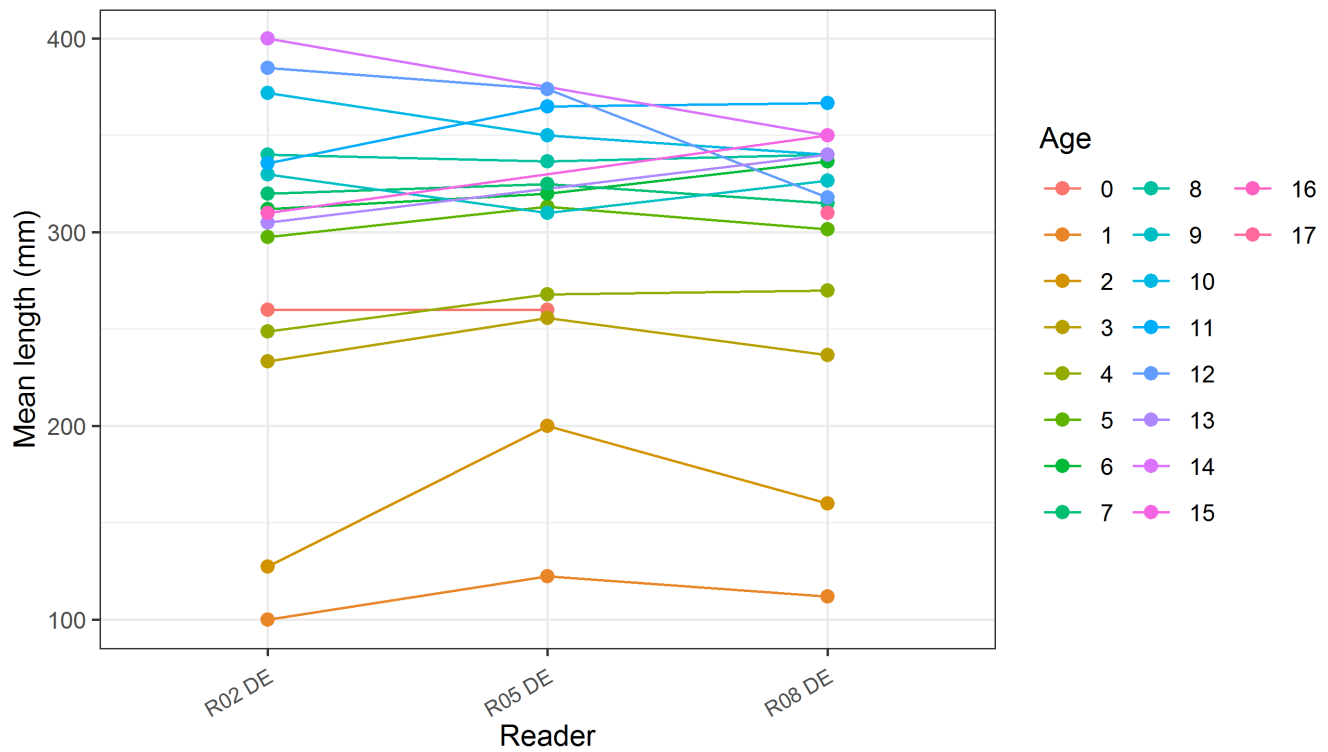
Figure 7.15: The mean fish length at age as estimated by each age reader.

7.4 Results - All readers based on sectioned otoliths

Summary statistics

Table 7.11: Summary of statistics; PA (%), CV (%) and APE (%).

NSample	CV	PA	APE
69	24%	53 %	15 %

Data Overview

Table 7.12: Data overview including modal age and statistics per sample.

Fish ID	length	sex	Catch date	ICES area	R02 DE	R05 DE	R08 DE	R01 DK	R04 SE	R06 SE	R07 PL	R09 DK	R10 SE	R11 DE	R13 DK	Modal age	PA %	CV %	APE %
8304959_SEX _RLX_UN	330	F	04/03/2021 06:19:47	27.3.c. 22	8	6	7	5	7	6	5	6	6	5	7	6	36	16	13
8304960_SEX _RLX_UN	290	M	04/03/2021 06:19:47	27.3.c. 22	5	5	5	4	4	4	4	4	5	5	4	4	55	12	11
8304961_SEX _RLX_UN	280	F	04/03/2021 06:19:47	27.3.c. 22	4	5	4	5	5	5	4	5	5	5	5	5	73	10	8
8304966_SEX _RLX_UN	220	F	04/03/2021 06:19:47	27.3.c. 22	4	3	3	2	3	2	3	2	2	2	3	3	45	26	22
8304968_SEX _RLX_UN	200	M	04/03/2021 06:19:47	27.3.c. 22	4	4	3	3	3	3	3	3	4	3	4	3	64	15	14
8304976_SEX _RLX_UN	120	M	04/03/2021 06:19:47	27.3.c. 22	2	2	1	1	1	0	1	1	1	1	1	1	73	49	30
8304978_SEX _RLX_UN	100	F	04/03/2021 06:19:47	27.3.c. 22	2	2	1	1	0	1	1	1	1	1	0	1	64	63	36
8305659_SEX _RLX_UN	380	F	05/03/2021 09:17:49	27.3.c. 22	10	8	11	9	9	11	8	8	8	7	9	8	36	15	11
8305662_SEX _RLX_UN	300	M	05/03/2021 09:17:49	27.3.c. 22	4	3	3	4	3	3	3	3	3	6	3	3	73	27	19
8305667_SEX _RLX_UN	250	F	05/03/2021 09:17:49	27.3.c. 22	4	3	4	3	3	3	3	3	3	3	3	3	82	13	9
8305669_SEX _RLX_UN	230	M	05/03/2021 09:17:49	27.3.c. 22	4	3	3	2	3	3	2	3	3	2	2	3	55	24	19
8305675_SEX _RLX_UN	170	M	05/03/2021 09:17:49	27.3.c. 22	3	2	2	2	3	2	1	2	2	2	2	2	73	26	16
8312102_SEX _RLX_UN	260	M	06/03/2021 12:46:31	27.3.c. 22	13	0	13	4	9	13	13	10	7	12	14	13	36	46	36
8312104_SEX _RLX_UN	300	F	06/03/2021 12:46:31	27.3.c. 22	8	8	7	5	9	7	7	7	8	7	7	7	55	14	10
8312500_SEX _RLX_UN	280	M	07/03/2021 08:23:06	27.3.c. 22	11	-	12	9	10	13	13	11	11	12	12	11	30	11	9
8314059_SEX _RLX_UN	350	F	10/03/2021 06:38:58	27.3.c. 22	10	10	-	9	9	11	10	11	11	10	11	10	40	8	6
8315397_SEX _RLX_UN	280	F	12/03/2021 11:43:27	27.3.c. 22	9	9	12	8	10	12	10	7	11	8	8	8	27	18	15
8315400_SEX _RLX_UN	310	F	12/03/2021 11:43:27	27.3.c. 22	16	-	14	14	14	16	15	14	16	15	16	14	40	6	5
8326654_SEX _RLX_UN	390	F	24/04/2021 00:00:00	27.3.c. 22	9	0	8	8	-	8	6	6	6	7	8	8	40	39	25

ID		Sex	Date	Code															
8326658_SEX_RLX_UN	340	F	24/04/2021 00:00:00	27.3.c.22	6	5	5	5	5	5	4	6	7	5	5	5	64	15	11
8326659_SEX_RLX_UN	390	F	24/04/2021 00:00:00	27.3.c.22	12	12	13	10	11	13	11	12	13	12	13	12	36	8	6
8326663_SEX_RLX_UN	380	F	24/04/2021 00:00:00	27.3.c.22	8	7	6	7	7	7	7	7	7	6	8	7	64	9	5
8326666_SEX_RLX_UN	370	F	24/04/2021 00:00:00	27.3.c.22	5	5	6	6	6	6	5	6	7	6	6	6	64	10	8
8326683_SEX_RLX_UN	380	F	24/04/2021 00:00:00	27.3.c.22	11	10	10	10	9	8	9	9	10	9	12	10	36	11	9
8326695_SEX_RLX_UN	290	M	24/04/2021 00:00:00	27.3.c.22	5	5	-	5	5	5	6	5	5	5	6	5	80	8	6
8326700_SEX_RLX_UN	290	M	24/04/2021 00:00:00	27.3.c.22	5	7	6	4	5	7	7	5	7	7	8	7	45	20	17
8326705_SEX_RLX_UN	250	F	24/04/2021 00:00:00	27.3.c.22	3	3	3	2	2	2	2	2	2	2	3	2	64	21	20
8335700_SEX_RLX_UN	260	M	11/05/2021 00:00:00	27.3.c.22	0	0	8	7	7	0	9	7	7	7	9	7	45	66	55
8335852_SEX_RLX_UN	250	F	10/05/2021 00:00:00	27.3.c.22	4	4	3	3	3	3	3	3	3	3	4	3	73	14	12
8335854_SEX_RLX_UN	250	M	10/05/2021 00:00:00	27.3.c.22	3	3	3	3	3	3	3	3	3	3	3	3	100	0	0
8335860_SEX_RLX_UN	220	M	10/05/2021 00:00:00	27.3.c.22	3	2	3	2	2	2	2	2	2	2	3	2	73	21	17
8343690_SEX_RLX_UN	390	M	23/06/2021 00:00:00	27.3.c.22	7	6	6	5	6	10	8	5	6	5	5	6	36	25	18
8343692_SEX_RLX_UN	330	M	23/06/2021 00:00:00	27.3.c.22	8	5	-	-	5	0	3	5	7	-	4	5	38	53	37
8347965_SEX_RLX_UN	370	F	05/07/2021 00:00:00	27.3.c.22	8	7	8	7	7	7	7	7	8	7	7	7	73	6	5
8347974_SEX_RLX_UN	390	F	05/07/2021 00:00:00	27.3.c.22	11	12	14	12	14	14	13	12	13	12	14	12	36	8	7
8347975_SEX_RLX_UN	400	F	05/07/2021 00:00:00	27.3.c.22	14	12	12	10	12	14	11	13	12	13	14	12	36	10	8
8347987_SEX_RLX_UN	330	F	05/07/2021 00:00:00	27.3.c.22	6	5	5	5	5	5	5	5	6	5	5	5	82	8	6
8348004_SEX_RLX_UN	410	M	05/07/2021 00:00:00	27.3.c.22	10	11	10	11	10	11	12	10	12	12	12	10	36	8	7
8348005_SEX_RLX_UN	390	F	05/07/2021 00:00:00	27.3.c.22	11	10	13	10	11	13	12	9	12	12	13	11	18	12	10
8348069_SEX_RLX_UN	300	F	06/07/2021 00:00:00	27.3.c.22	3	2	3	2	2	2	2	2	3	2	2	2	73	21	17
8348072_SEX_RLX_UN	250	F	06/07/2021 00:00:00	27.3.c.22	3	2	3	2	2	3	3	3	3	2	2	3	55	21	19
8348073_SEX_RLX_UN	270	M	06/07/2021 00:00:00	27.3.c.22	5	4	5	3	3	4	4	4	5	4	4	4	55	17	12
8348078_SEX_RLX_UN	290	M	06/07/2021 00:00:00	27.3.c.22	3	3	4	3	3	3	3	3	3	3	3	3	91	10	5
8358458_SEX_RLX_UN	410	F	22/08/2021 00:00:00	27.3.c.22	10	9	9	8	8	8	8	8	10	8	8	8	64	10	8
8358476_SEX_RLX_UN	310	F	22/08/2021 00:00:00	27.3.c.22	10	8	10	8	8	10	10	8	10	11	9	10	45	12	11
8358478_SEX_RLX_UN	330	M	22/08/2021 00:00:00	27.3.c.22	7	6	11	7	-	0	10	8	10	10	8	10	30	41	28
8358483_SEX_RLX_UN	290	M	22/08/2021 00:00:00	27.3.c.22	5	5	6	5	5	5	5	5	5	5	5	5	91	6	3
8358485_SEX_RLX_UN	300	F	22/08/2021 00:00:00	27.3.c.22	6	6	6	5	5	5	5	6	6	5	5	5	55	10	9

ID																		
8358486_SEX _RLX_UN	340	F	22/08/2021 00:00:00	27.3.c. 22	6	4	8	5	4	6	5	7	8	6	6	6	36	23	17
8358499_SEX _RLX_UN	310	M	22/08/2021 00:00:00	27.3.c. 22	11	8	12	8	9	11	10	8	8	12	12	8	36	18	16
8386600_SEX _RLX_UN	380	M	14/10/2021 00:00:00	27.3.c. 22	12	12	13	8	11	12	12	8	9	14	11	12	36	18	14
8392100_SEX _RLX_UN	320	F	22/10/2021 06:10:01	27.3.c. 22	11	11	12	10	12	11	10	11	11	11	11	11	64	6	3
8392101_SEX _RLX_UN	300	M	22/10/2021 06:10:01	27.3.c. 22	5	5	5	4	4	4	4	5	5	5	5	5	64	11	10
8392104_SEX _RLX_UN	280	F	22/10/2021 06:10:01	27.3.c. 22	5	4	5	2	3	2	2	3	3	3	3	3	45	34	25
8392106_SEX _RLX_UN	260	F	22/10/2021 06:10:01	27.3.c. 22	4	-	4	2	2	2	2	2	2	2	2	2	80	35	27
8392107_SEX _RLX_UN	240	F	22/10/2021 06:10:01	27.3.c. 22	3	2	3	2	2	2	2	2	3	2	2	2	73	21	17
8392115_SEX _RLX_UN	150	M	22/10/2021 06:10:01	27.3.c. 22	2	1	2	1	-	0	1	3	2	1	1	1	50	60	49
8392116_SEX _RLX_UN	140	F	22/10/2021 06:10:01	27.3.c. 22	2	1	1	1	-	-	1	3	0	2	0	1	44	80	61
8392117_SEX _RLX_UN	130	F	22/10/2021 06:10:01	27.3.c. 22	3	0	3	2	3	0	4	4	4	3	4	3	36	55	41
8392120_SEX _RLX_UN	100	M	22/10/2021 06:10:01	27.3.c. 22	1	1	1	1	1	0	0	1	0	0	0	1	55	96	91
8394224_SEX _RLX_UN	350	M	25/10/2021 05:56:14	27.3.c. 22	13	-	15	11	13	13	14	11	14	12	12	13	30	10	8
8394225_SEX _RLX_UN	330	F	25/10/2021 05:56:14	27.3.c. 22	8	8	9	7	7	9	8	7	8	8	7	8	45	10	8
8394227_SEX _RLX_UN	310	F	25/10/2021 05:56:14	27.3.c. 22	15	12	17	9	14	13	13	14	14	13	13	13	36	15	10
8394233_SEX _RLX_UN	250	F	25/10/2021 05:56:14	27.3.c. 22	6	6	-	5	5	6	6	6	6	5	6	6	70	8	7
8394421_SEX _RLX_UN	390	F	25/10/2021 08:08:20	27.3.c. 22	9	8	11	10	10	12	10	9	8	10	11	10	36	13	10
8395627_SEX _RLX_UN	100	F	26/10/2021 10:17:48	27.3.c. 22	1	1	1	1	1	1	1	1	1	1	1	1	100	0	0
8395992_SEX _RLX_UN	260	M	27/10/2021 08:14:48	27.3.c. 22	9	7	10	6	8	11	9	7	7	11	11	7	27	21	18
8396267_SEX _RLX_UN	280	M	27/10/2021 11:40:40	27.3.c. 22	11	10	13	9	8	13	11	10	10	13	9	11	18	16	13
8396668_SEX _RLX_UN	240	M	28/10/2021 08:19:24	27.3.c. 22	7	9	9	7	9	9	10	8	8	10	10	9	36	13	10

Separate age bias plots by reader
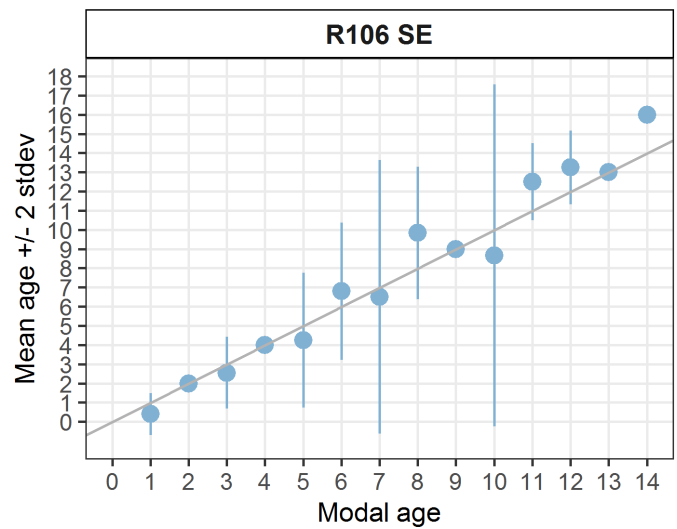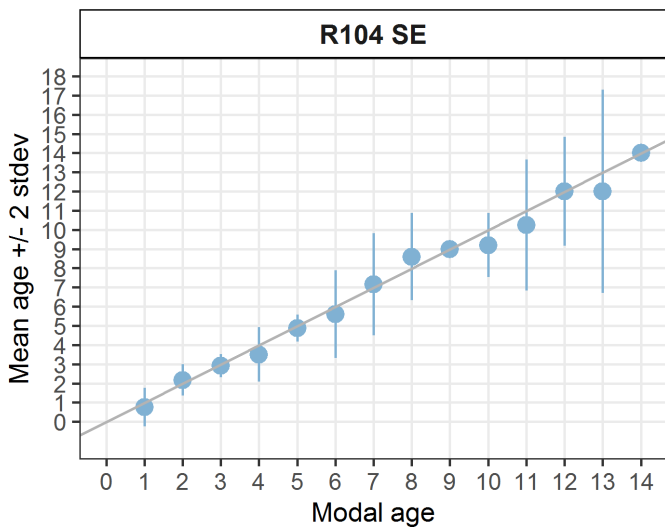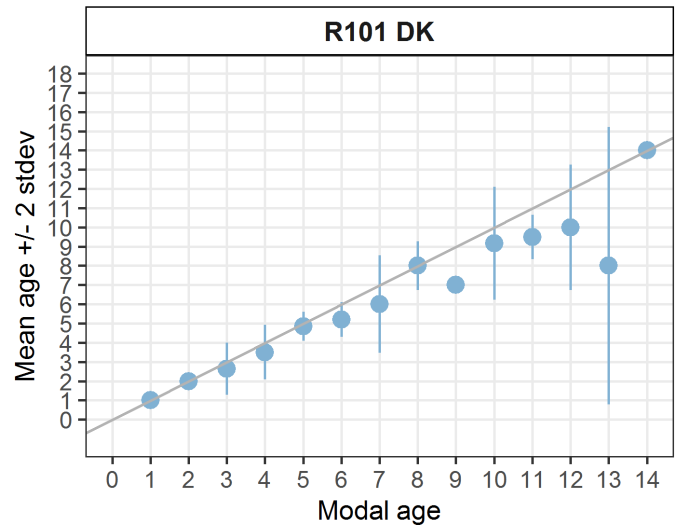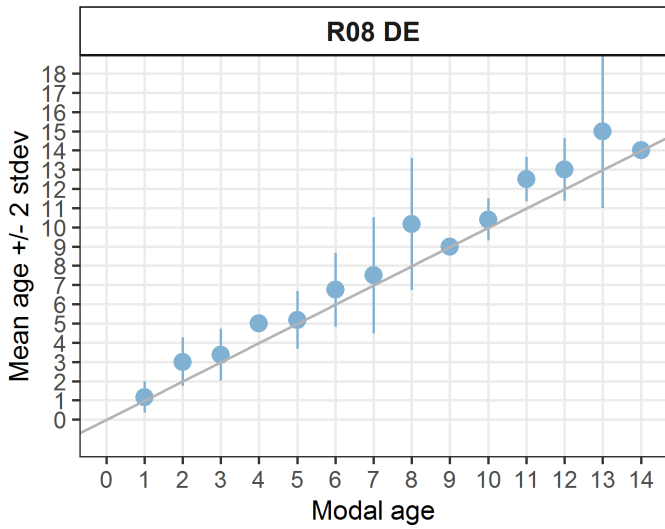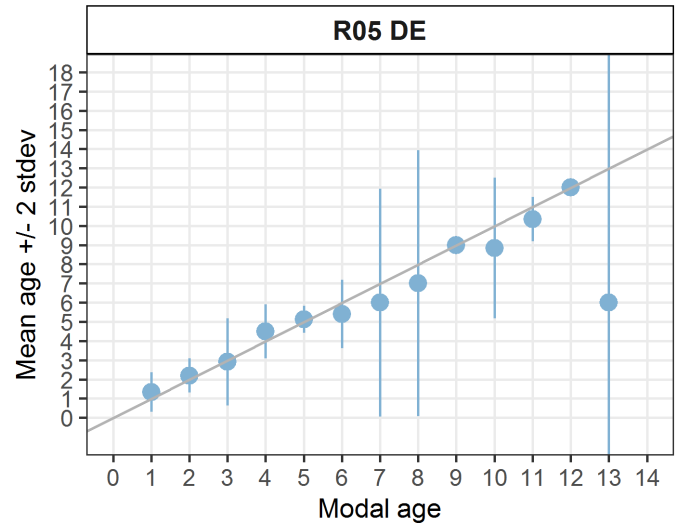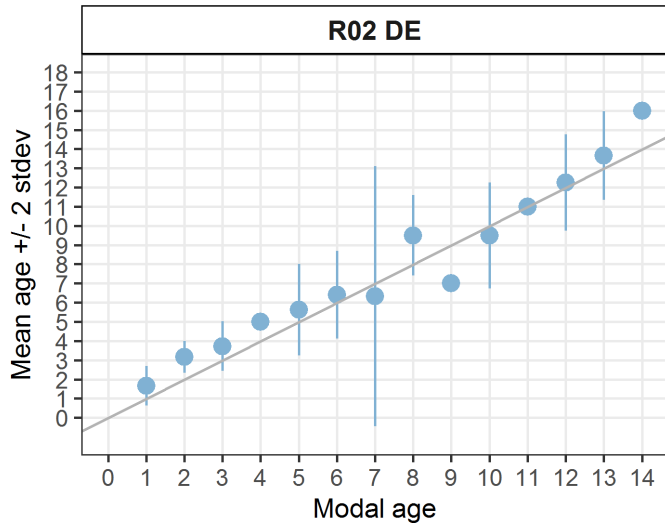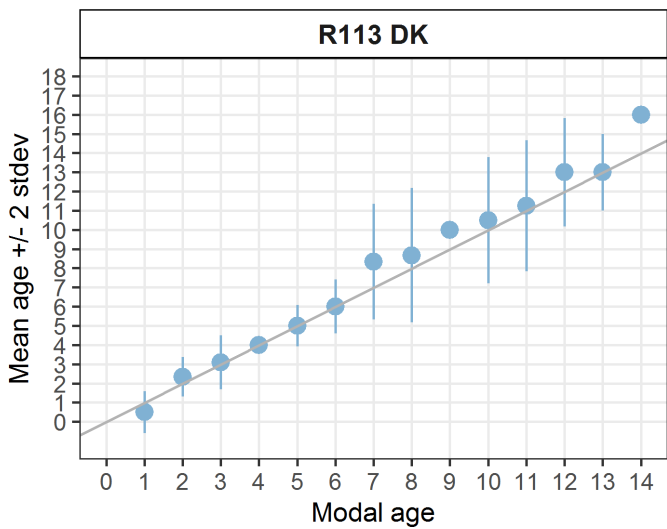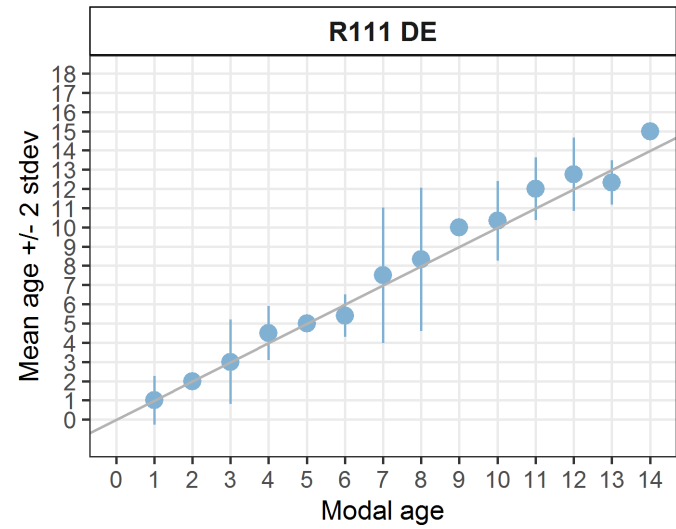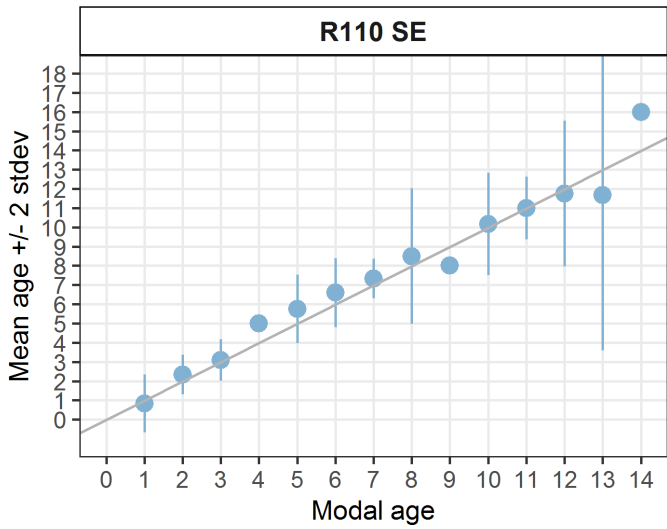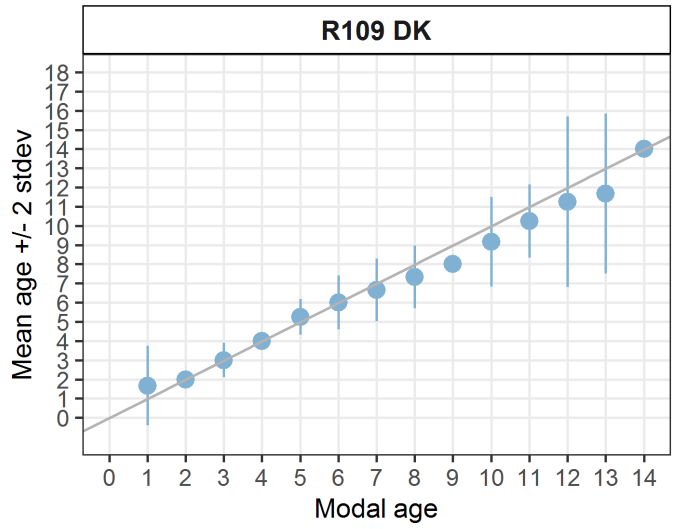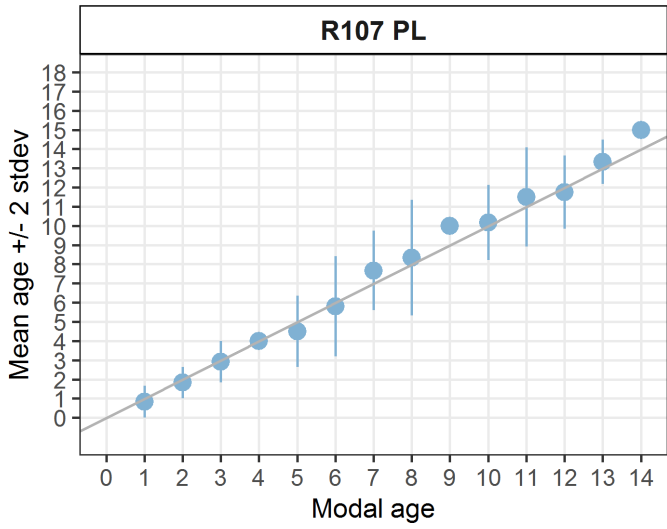
Figure 7.16: Individual reader age bias plot for all readers of sectioned otoliths. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).

Statistics by modal age plot (STDEV, CV and PA)
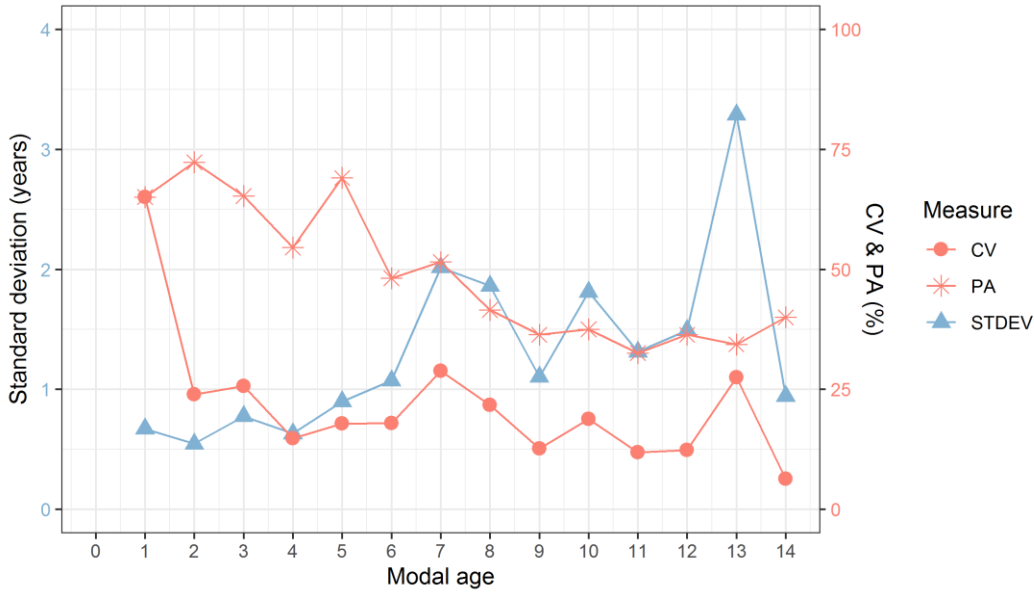
Figure 7.17: CV, PA and (STDEV (standard deviation) are plotted against modal age

Distribution of age reading errors
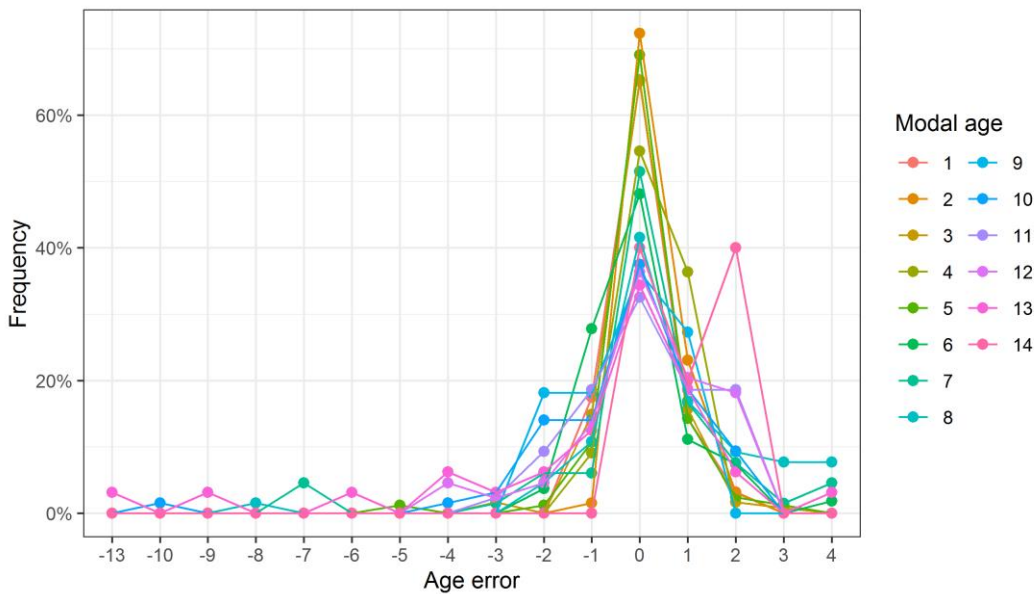
Figure 7.18: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias, if the age reading errors are normally distributed. The distributions are skewed, if relative bias occurs.

Relative bias for all readers
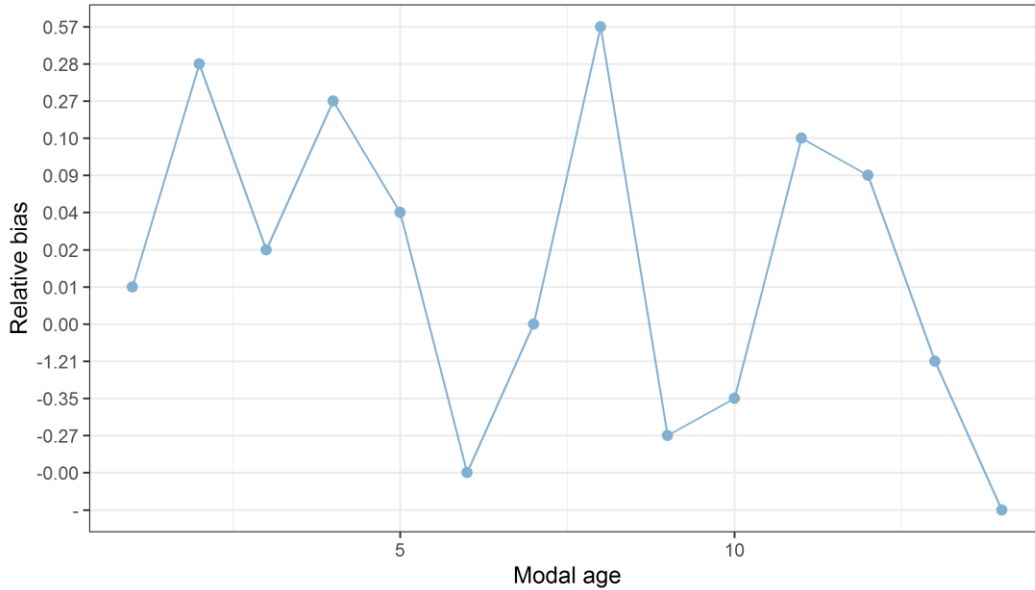
Figure 7.19: The relative bias by modal age as estimated by all age readers combined.

Figure 7.20: The mean fish length at age as estimated by each age reader.

7.5 Results - All readers based on sectioned and stained otoliths

Table 7.13: Data overview for sectioned and stained otoliths, showing ages estimated by the only reader experienced in this age reading method.

Data Overview

Table 7.14: Data overview including modal age and statistics per sample. R07 PL is the only reader experienced in reading sectioned nad stained otoliths from Baltic plaice.

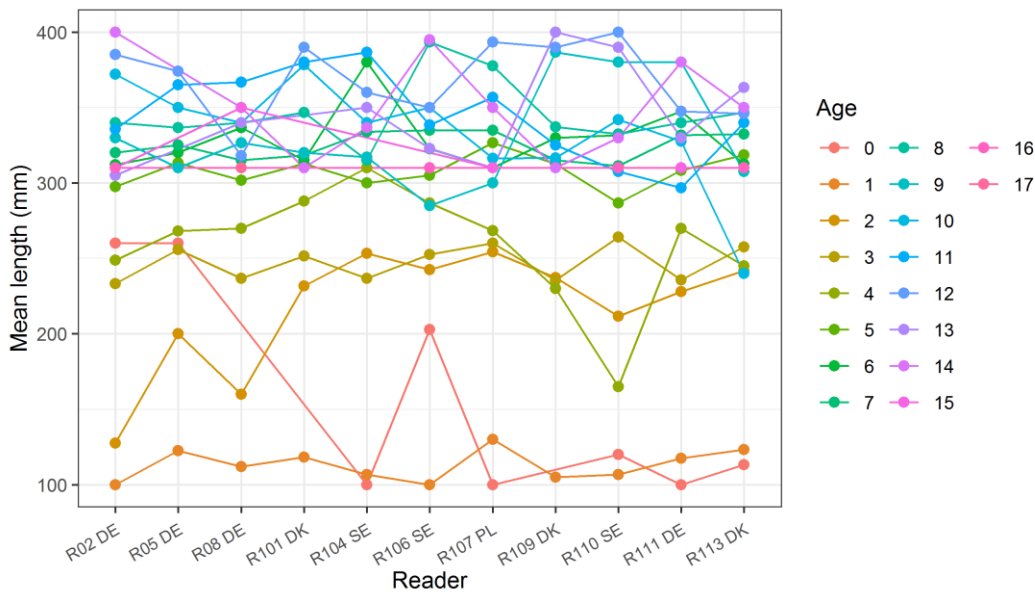| Fish ID	length	sex	Catch date	ICES area	R01 DK	R02 DE	R04 SE	R05 DE	R06 SE	R07 PL	R08 DE	R09 DK	R10 SE	R11 DE	R13 DK	Modal age	PA %	CV %	APE %
8304959_SSX_TLX	330	F	04/03/2021 06:19:47	27.3.c.22	8	-	6	8	8	5	10	8	5	5	8	8	50	24	21
8304960_SSX_TLX	290	M	04/03/2021 06:19:47	27.3.c.22	3	7	3	6	5	3	8	6	4	6	4	3	27	35	29
8304961_SSX_TLX	280	F	04/03/2021 06:19:47	27.3.c.22	4	5	5	5	6	5	6	4	4	5	5	5	55	14	10
8304966_SSX_TLX	220	F	04/03/2021 06:19:47	27.3.c.22	2	4	3	5	3	2	-	5	3	3	4	3	40	32	26
8304968_SSX_TLX	200	M	04/03/2021 06:19:47	27.3.c.22	3	4	-	0	0	4	-	4	2	4	1	4	44	71	62
8304976_SSX_TLX	120	M	04/03/2021 06:19:47	27.3.c.22	1	3	2	4	1	1	2	2	1	2	1	1	45	54	41
8304978_SSX_TLX	100	F	04/03/2021 06:19:47	27.3.c.22	1	3	1	2	1	1	1	2	1	1	0	1	64	62	45
8305659_SSX_TLX	380	F	05/03/2021 09:17:49	27.3.c.22	10	12	9	13	11	9	10	12	9	11	11	9	27	13	11
8305662_SSX_TLX	300	M	05/03/2021 09:17:49	27.3.c.22	-	3	-	5	0	6	-	4	2	-	6	6	29	60	47
8305667_SSX_TLX	250	F	05/03/2021 09:17:49	27.3.c.22	7	4	3	5	3	3	-	4	3	3	3	3	60	35	25
8305669_SSX_TLX	230	M	05/03/2021 09:17:49	27.3.c.22	3	4	3	4	3	3	4	4	3	3	2	3	55	20	16
8305675_SSX_TLX	170	M	05/03/2021 09:17:49	27.3.c.22	-	4	6	4	3	2	3	3	2	2	4	4	30	38	29
8312102_SSX_TLX	260	M	06/03/2021 12:46:31	27.3.c.22	13	12	13	14	13	13	13	15	13	13	14	13	64	6	4
8312104_SSX_TLX	300	F	06/03/2021 12:46:31	27.3.c.22	6	9	8	10	7	8	10	9	6	8	8	8	36	17	13
8312500_SSX_TLX	280	M	07/03/2021 08:23:06	27.3.c.22	9	12	11	12	12	12	12	11	11	13	14	12	45	11	8
8314059_SSX_TLX	350	F	10/03/2021 06:38:58	27.3.c.22	10	12	11	12	11	11	11	11	11	11	11	11	73	5	3
8315397_SSX_TLX	280	F	12/03/2021 11:43:27	27.3.c.22	9	10	8	11	12	10	12	12	8	13	13	12	27	17	15
8315400_SSX_TLX	310	F	12/03/2021 11:43:27	27.3.c.22	12	15	15	16	24	15	-	15	14	16	16	15	40	20	11
8326654_SSX_TLX	390	F	24/04/2021 00:00:00	27.3.c.22	8	8	9	9	11	6	11	10	8	7	13	8	27	22	17
8326658_SSX_TLX	340	F	24/04/2021 00:00:00	27.3.c.22	5	7	5	7	5	5	-	6	5	6	7	5	50	16	14
8326659_SSX_TLX	390	F	24/04/2021 00:00:00	27.3.c.22	11	12	12	14	12	10	12	12	11	13	13	12	45	9	6

ID	W	Sex	Date	Code	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
8326663_SSX_TLX	380	F	24/04/2021 00:00:00	27.3.c.22	7	8	7	11	17	9	-	8	7	7	9	7	40	34	22
8326666_SSX_TLX	370	F	24/04/2021 00:00:00	27.3.c.22	6	8	7	7	7	5	8	7	5	6	7	7	45	15	12
8326683_SSX_TLX	380	F	24/04/2021 00:00:00	27.3.c.22	12	13	12	16	13	12	15	12	13	14	17	12	36	13	10
8326695_SSX_TLX	290	M	24/04/2021 00:00:00	27.3.c.22	4	5	4	6	6	5	6	6	5	7	6	6	45	17	14
8326700_SSX_TLX	290	M	24/04/2021 00:00:00	27.3.c.22	6	7	7	8	8	6	8	7	6	7	7	7	45	11	8
8326705_SSX_TLX	250	F	24/04/2021 00:00:00	27.3.c.22	4	4	7	6	6	2	5	4	4	4	5	4	45	29	23
8335700_SSX_TLX	260	M	11/05/2021 00:00:00	27.3.c.22	-	10	10	10	11	9	7	9	7	-	9	10	33	15	11
8335852_SSX_TLX	250	F	10/05/2021 00:00:00	27.3.c.22	5	5	4	4	6	4	-	6	4	3	7	4	40	26	21
8335854_SSX_TLX	250	M	10/05/2021 00:00:00	27.3.c.22	2	4	2	6	0	2	5	3	2	-	4	2	40	59	47
8335860_SSX_TLX	220	M	10/05/2021 00:00:00	27.3.c.22	2	4	3	2	2	2	-	3	2	-	3	2	56	28	24
8343690_SSX_TLX	390	M	23/06/2021 00:00:00	27.3.c.22	9	9	8	-	10	9	10	12	8	-	12	9	33	16	12
8343692_SSX_TLX	330	M	23/06/2021 00:00:00	27.3.c.22	12	9	8	10	8	9	10	10	7	8	9	8	27	15	11
8347965_SSX_TLX	370	F	05/07/2021 00:00:00	27.3.c.22	9	11	11	10	12	11	11	11	10	12	15	11	45	14	9
8347974_SSX_TLX	390	F	05/07/2021 00:00:00	27.3.c.22	14	13	12	12	13	13	-	13	13	13	13	13	70	4	3
8347975_SSX_TLX	400	F	05/07/2021 00:00:00	27.3.c.22	9	13	13	12	12	13	15	13	13	14	14	13	45	12	8
8347987_SSX_TLX	330	F	05/07/2021 00:00:00	27.3.c.22	7	8	8	9	8	8	13	7	8	9	10	8	45	20	14
8348004_SSX_TLX	410	M	05/07/2021 00:00:00	27.3.c.22	12	12	12	12	12	12	13	12	12	12	12	12	91	2	1
8348005_SSX_TLX	390	F	05/07/2021 00:00:00	27.3.c.22	12	10	12	11	12	10	13	12	11	13	11	12	36	9	7
8348069_SSX_TLX	300	F	06/07/2021 00:00:00	27.3.c.22	-	4	4	3	5	3	-	5	3	4	2	4	33	27	22
8348072_SSX_TLX	250	F	06/07/2021 00:00:00	27.3.c.22	-	4	2	3	0	2	-	3	3	3	1	3	44	52	41
8348073_SSX_TLX	270	M	06/07/2021 00:00:00	27.3.c.22	3	4	5	5	4	3	-	5	4	4	4	4	50	18	13
8348078_SSX_TLX	290	M	06/07/2021 00:00:00	27.3.c.22	4	6	5	6	6	3	-	12	2	-	6	6	44	51	33
8358458_SSX_TLX	410	F	22/08/2021 00:00:00	27.3.c.22	9	9	9	9	9	8	-	11	8	7	8	9	50	12	9
8358476_SSX_TLX	310	F	22/08/2021 00:00:00	27.3.c.22	6	9	9	10	11	8	10	10	9	13	10	10	36	18	13
8358478_SSX_TLX	330	M	22/08/2021 00:00:00	27.3.c.22	-	12	11	11	15	11	16	12	11	13	12	11	40	14	11
8358483_SSX_TLX	290	M	22/08/2021 00:00:00	27.3.c.22	4	7	5	7	5	5	-	7	5	5	5	5	60	20	16
8358485_SSX_TLX	300	F	22/08/2021 00:00:00	27.3.c.22	6	6	5	5	8	5	10	6	6	8	6	6	45	24	19
8358486_SSX_TLX	340	F	22/08/2021 00:00:00	27.3.c.22	5	8	6	7	6	6	-	6	7	6	5	6	50	15	11
8358499_SSX_TLX	310	M	22/08/2021 00:00:00	27.3.c.22	12	13	10	12	12	12	13	11	13	13	9	12	36	11	8

8386600_SSX_TLX	380	M	14/10/2021 00:00:00	27.3.c.22	11	10	10	10	11	11	12	9	11	12	11	11	45	8	7
8392100_SSX_TLX	320	F	22/10/2021 06:10:01	27.3.c.22	9	12	8	12	10	10	13	10	10	10	12	10	45	14	12
8392101_SSX_TLX	300	M	22/10/2021 06:10:01	27.3.c.22	4	5	5	5	5	5	6	6	5	7	5	5	64	15	11
8392104_SSX_TLX	280	F	22/10/2021 06:10:01	27.3.c.22	-	5	6	-	0	4	-	10	3	4	4	4	38	63	42
8392106_SSX_TLX	260	F	22/10/2021 06:10:01	27.3.c.22	4	5	5	-	4	6	-	5	3	4	5	5	44	19	16
8392107_SSX_TLX	240	F	22/10/2021 06:10:01	27.3.c.22	2	5	3	5	3	3	4	4	2	4	3	3	36	30	25
8392115_SSX_TLX	150	M	22/10/2021 06:10:01	27.3.c.22	-	3	3	3	3	2	3	3	1	2	2	3	60	28	24
8392116_SSX_TLX	140	F	22/10/2021 06:10:01	27.3.c.22	1	2	1	0	0	1	2	2	1	1	1	1	55	64	45
8392117_SSX_TLX	130	F	22/10/2021 06:10:01	27.3.c.22	-	3	2	-	0	1	-	5	1	2	1	1	38	83	60
8392120_SSX_TLX	100	M	22/10/2021 06:10:01	27.3.c.22	0	0	0	1	0	0	1	1	0	0	0	0	73	-	-
8394224_SSX_TLX	350	M	25/10/2021 05:56:14	27.3.c.22	13	17	15	16	15	15	16	16	15	16	14	15	36	7	6
8394225_SSX_TLX	330	F	25/10/2021 05:56:14	27.3.c.22	10	10	8	10	9	10	13	11	8	9	11	10	36	15	10
8394227_SSX_TLX	310	F	25/10/2021 05:56:14	27.3.c.22	13	13	12	14	0	13	12	17	10	11	15	13	27	37	22
8394233_SSX_TLX	250	F	25/10/2021 05:56:14	27.3.c.22	5	7	5	7	5	5	7	7	5	5	7	5	55	18	17
8394421_SSX_TLX	390	F	25/10/2021 08:08:20	27.3.c.22	5	-	9	8	0	8	-	6	5	8	7	8	33	44	32
8395627_SSX_TLX	100	F	26/10/2021 10:17:48	27.3.c.22	-	1	1	0	0	0	-	2	0	0	0	0	67	-	-
8395992_SSX_TLX	260	M	27/10/2021 08:14:48	27.3.c.22	10	12	11	12	12	11	13	12	11	12	11	12	45	7	6
8396267_SSX_TLX	280	M	27/10/2021 11:40:40	27.3.c.22	10	10	7	11	10	11	10	10	7	10	11	10	55	15	10
8396668_SSX_TLX	240	M	28/10/2021 08:19:24	27.3.c.22	8	11	12	12	14	10	12	8	8	14	14	12	27	21	18