2019 North Sea Sandeel Age Reading Exchange Report SmartDots ID219

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Table of Contents

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1 Introduction

A summary can be found in the 2019 North Sea Sandeel exchange summery report, available on
http://ices.dk/marine- data/tools/Pages/smartdots.aspx

The last WGBIOP age reading exchange for Sandeel took place in 2016, with seven participants from three institutes taking part. The exercise included 145 otolith images. Denmark and Norway provided the samples collected from Q4 2015 and Q2 2016 SA1 (Sandeel area 1) and Q2 2014 SA3 (Sandeel area 3). The calibration exercise took place on the WebGR platform. The modal age range represented was from 0-5 years. For SA1 the results, based on expert readers alone (only those age readers providing age data for stock assessment purposes) were good, overall percentage agreement was 91.2%, the coefficient of variation was 12.7% and the average percentage error (APE) was 9.4%. For SA3, based on expert readers alone, overall percentage agreement was 66%, the coefficient of variation was 37.3% and the average percentage error (APE) was 28.6%. The SA3 samples (n=25) were included in the exchange for discussion purposes and not considered a true representation of the fish caught in this area. The overall conclusion from that exchange was that for SA1, the level of agreement between readers providing ages for stock assessment was high and the CV low. The age reading issues outlined with image examples to be followed up with the readers were; correct identification of the edge type in Q4, otoliths with a faint translucent zone (false winter ring) visible in the highly opaque centre and finally, otoliths where faint and incomplete opaque zones are considered as true annual growth. As a result of these issues some readers were overestimating in comparison to modal age while others were underestimating, the overall bias was 0.02.

The current exchange, ID219 2019 North Sea Sandeel, was held on the SmartDots platform. Eight readers from three institutes, IMR Norway, DTU Aqua Denmark and IMARES the Netherlands took part. Readers from Norway and Denmark provide age data for stock assessment purposes while readers from The Netherlands took part for training purposes. 120 otolith images were provided by Denmark and Norway, collected from; SA1 Q4 2015, Q2 2016, Q4 2018; SA3 Q2 2016, Q2 2017 and Q4 2018 and SA5 Q2 2011 and represent the Sandeel stocks; san.sa.1r, san.sa.3r and san.sa.5r respectively. The modal age range was from 0-9 years. A subset of 40 otoliths from san.sa.1r with 100% agreement across all readers in the 2016 exchange were included (modal age range 0-4). Those from Norway were pairs of otoliths mounted in eukit and those from Denmark were loose otoliths (some singles and some pairs). Readers were asked to annotate all 120 images of whole otoliths photographed on a black background under reflected light, provide a readability score and to note if any of the samples appeared to be a subspecies of Sandeel and not the lesser Sandeel *Ammodytes marinus.*

2 Methods

The first part of analysis presents the tables and plots from the Guus Eltink Excel sheet 'Age Reading Comparisons' **(Eltink, A.T.G.W. 2000)**. The order and numbering of tables and plots are the same as in the excel sheet. Tables 6.1 - 6.4 from the 'Age Reading Comparisons' sheet are not outputted since these are merely used to do calculations for the other tables.

Percentage Agreement (PA)

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

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

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

Co-efficient of Variation (CV)

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

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

The CV of all readers combined per modal age and a weighted mean of the CV per reader is included in the table.

Average Percentage Error (APE)

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

The average percentage error is calculated per image as:

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

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%. The age data was analysed twice, the first time all readers were included and the second time only the "advanced" readers were included. If a reader is "advanced" then they are considered well trained and they provide ages for

stock assessment or similar purposes. When the AEM is compiled for assessment purposes, it uses only those readers who provide age data for the stock assessment in that specific area.

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 and for each reader.

3 Overview of samples and readers

Samples from SA1 are identified as san.sa.1r, samples from SA3 as san.sa.3r and samples from SA5 as san.sa.5r.

Table 1: Overview of samples used for the 2019 North Sea Sandeel exchange.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2011	27.4.a	san.sa.5r	2	11	2-9	95-215 mm
2015	27.4.b	san.sa.1r	4	20	0-3	100-150 mm
2016	27.4.a	san.sa.3r	2	9	2-7	135-245 mm
2016	27.4.b	san.sa.1r	2	20	1-4	85-185 mm
2016	27.4.b	san.sa.3r	2	4	2	125-160 mm
2017	27.4.a	san.sa.3r	2	7	1-8	100-250 mm
2017	27.4.a	san.sa.5r	2	9	0-5	85-175 mm
2018	27.3.a.20	san.sa.3r	4	2	0	70-80 mm
2018	27.4.b	san.sa.1r	4	20	0-4	70-165 mm
2018	27.4.b	san.sa.3r	4	18	0-4	45-200 mm

Table 2: Reader overview.

Reader code	Expertise	SmartUser
R01 NO	Advanced	Solbakken
R02 DK	Advanced	Hansens
R03 NO	Advanced	Husboe
R04 DK	Advanced	Svolgaard
R05 NO	Advanced	Mjanger
R06 DK	Advanced	Fuglsang
R08 NL	Basic	Huijer
R09 NL	Basic	HoekR

4 Exchange Results

4.1 Results for all readers

In this section, the results are based on all samples and are given for all age readers. The weighted average percentage agreement (PA) based on modal ages for all readers is 77 % and the weighted average coefficient of variation (CV) is 26 %.

At modal age 0, the PA calculated across all readers is 71%, there are 3 readers with PA below 60% (Table 3). At modal ages 1 and 2 the PA increases to 81% and 85% respectively. From modal ages 3 to 8 the PA is between 70 and 50% and at modal age 9 it is 75%. Readers with the lowest PA are R06, R09 and R08 respectively. R06 has poor PA at all ages except 2 and 3, which raises concerns as this reader provides age data for assessment, R09 and R08 are trainees. At modal age 1, the overall CV is high at 40% and no reader is achieving a CV below 20% (Table 4). CV decreases with an increase in age. Readers with the highest weighted mean CV's are R09, R06 and R01.

Positive relative bias indicates an overestimation of age in comparison to the modal age and a negative relative bias indicates an underestimation of age in comparison to modal age. At modal age 0 and 1 the overall bias, calculated across all age readers, is 0.36 and 0.12 respectively, indicating an overestimation in comparison to modal age (as with modal age 6) (Table 5). At modal ages 3-5 and 7-9 the overall negative bias indicates underestimation in comparison to modal age with R06, R08 and R09 contributing most to the bias estimation. The combined age bias plot in Figure 1 clearly depict these results. For each reader it is important to look at the bias at each modal age in Table 5 and the individual reader age bias plots can be found in Annex 3 Figure 8. The inter reader bias test (Table 6) shows that there is a certainty of bias between R02 and R06 and modal age and a possibility of bias between R01 and R08 and modal age. Examination of the images shows that R06 is counting an extra ring at the edge of many otoliths in Q4 (SA1 & SA3), R04 and R09 do this but in a fewer number of samples (Figure 2). Edge interpretation issues are also apparent for readers R08 and R09 in Q2 (SA1 & SA3) where a translucent edge is omitted from the count of age. Even though the overall relative bias is 0.00, the weighted mean bias per reader indicates that for R01, R03, R05, R08 and R09 there is an overall tendency to underestimate the age while for R02, R04 and R06 there is an overall tendency to overestimate the age (in comparison to modal age).

In some examples, there is disagreement between the readers from Norway and Denmark as to whether the first translucent zone should be considered a "false" winter ring or included in the count of age. An example is shown in Figure 3 and Sandeel_SA1_2018_99, Sandeel_SA3_2018_107, Sandeel_SA3_2018_108 and Sandeel_SA3_2018_109. In general, Denmark and the Netherlands will count it but not Norway.

Table 3: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL	all
0	100 %	70 %	100 %	82 %	100 %	18 %	58 %	33 %	**71 %**
1	85 %	91 %	94 %	85 %	88 %	32 %	97 %	74 %	**81 %**
2	91 %	91 %	93 %	95 %	95 %	71 %	81 %	58 %	**85 %**
3	64 %	73 %	45 %	91 %	82 %	73 %	73 %	55 %	**69 %**
4	92 %	73 %	58 %	75 %	100 %	33 %	42 %	50 %	**65 %**
5	67 %	100 %	100 %	100 %	67 %	0 %	33 %	33 %	**62 %**
6	100 %	0 %	100 %	0 %	100 %	0 %	0 %	100 %	**50 %**
7	100 %	100 %	50 %	100 %	100 %	0 %	0 %	0 %	**56 %**
8	100 %	0 %	0 %	0 %	100 %	0 %	100 %	100 %	**50 %**
9	100 %	100 %	100 %	100 %	100 %	0 %	100 %	0 %	**75 %**
Weighted Mean	**88 %**	**84 %**	**85 %**	**87 %**	**92 %**	**47 %**	**76 %**	**58 %**	**77 %**

Table 4: Coefficient of Variation (CV) table presents the CV per modal age and reader, the CV of all readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL	all
0	-	-	-	-	-	-	-	-	-
1	42 %	37 %	25 %	35 %	38 %	31 %	17 %	35 %	**40 %**
2	16 %	14 %	13 %	11 %	11 %	28 %	22 %	34 %	**21 %**
3	27 %	17 %	29 %	10 %	14 %	24 %	17 %	24 %	**22 %**
4	7 %	11 %	24 %	13 %	0 %	21 %	20 %	23 %	**18 %**
5	11 %	0 %	0 %	0 %	20 %	0 %	13 %	13 %	**15 %**
6	-	-	-	-	-	-	-	-	**11 %**
7	0 %	0 %	24 %	0 %	0 %	16 %	0 %	16 %	**20 %**
8	-	-	-	-	-	-	-	-	**12 %**
9	-	-	-	-	-	-	-	-	**5 %**
Weighted Mean	**24 %**	**21 %**	**20 %**	**18 %**	**19 %**	**26 %**	**19 %**	**31 %**	**26 %**

Table 5: Relative bias table represents the relative bias per modal age per reader, the relative bias of all readers combined per modal age and a weighted mean of the relative bias per reader. Numbers in blue indicate a negative bias and numbers in red indicate positive bias.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL	all
0	0.00	0.50	0.00	0.18	0.00	0.91	0.50	0.75	**0.36**
1	-0.15	0.12	0.00	0.09	-0.12	0.71	0.03	0.26	**0.12**
2	-0.05	0.09	-0.02	0.00	0.00	0.24	-0.19	-0.28	**-0.03**
3	-0.45	0.09	-0.64	-0.09	-0.18	0.18	-0.27	-0.27	**-0.20**
4	-0.08	0.27	0.08	0.08	0.00	-0.33	-0.67	-0.67	**-0.16**
5	0.33	0.00	0.00	0.00	0.67	-1.00	-0.67	-0.67	**-0.17**
6	0.00	1.00	0.00	1.00	0.00	-1.00	1.00	0.00	**0.25**
7	0.00	0.00	-1.00	0.00	0.00	-2.50	-2.00	-2.50	**-1.00**
8	0.00	1.00	-1.00	-1.00	0.00	-2.00	0.00	0.00	**-0.38**
9	0.00	0.00	0.00	0.00	0.00	-1.00	0.00	-1.00	**-0.25**
Weighted Mean	**-0.10**	**0.17**	**-0.08**	**0.04**	**-0.03**	**0.25**	**-0.14**	**-0.11**	**0.00**
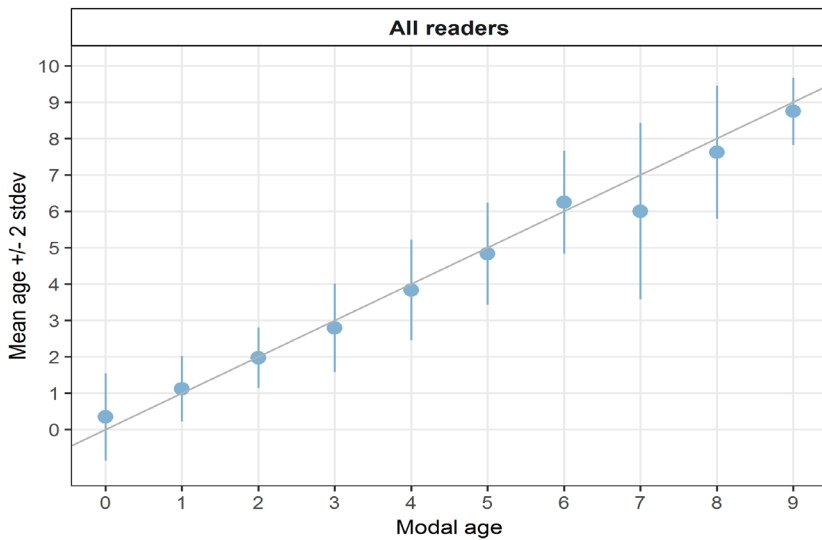
Figure 1: Relative age bias plot for all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).

Table 6: Inter reader bias test. The Inter-reader bias test gives probability of bias between readers and with modal age. - = no sign of bias (p>0.05), * = possibility of bias (0.01<p<0.05), * * = certainty of bias (p<0.01)

Comparison	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL
R01 NO	-	**	-	**	-	**	-	-
R02 DK	**	-	**	*	**	-	**	**
R03 NO	-	**	-	*	-	**	-	-
R04 DK	**	*	*	-	-	*	**	*
R05 NO	-	**	-	-	-	**	-	-
R06 DK	**	-	**	*	**	-	**	**
R08 NL	-	**	-	**	-	**	-	-
R09 NL	-	**	-	*	-	**	-	-
Modal age	*	**	-	-	-	**	*	-

Figure 2. a) Sandeel_SA1_2015_73, catch date 24/11/2015, fish length 100mm. **b)** Sandeel_SA1_2015_72, catch date 24/11/2015, fish length 140m. Red dot at the translucent otoltihs edge should not be counted when the fish is caught in November.
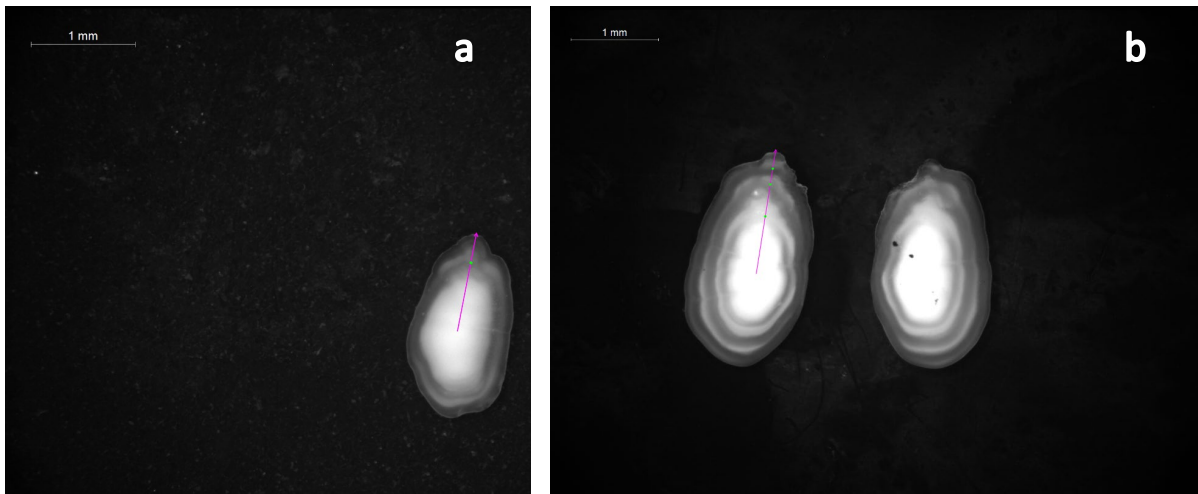
Figure 3. a) Sandeel_SA3_2018_107, catch date 27/11/2018, fish length 100mm. **b)** Sandeel_SA1_2018_82, catch date 21/11/2018, fish length 165mm. Green dot indicting the ring being counted some readers and not others.
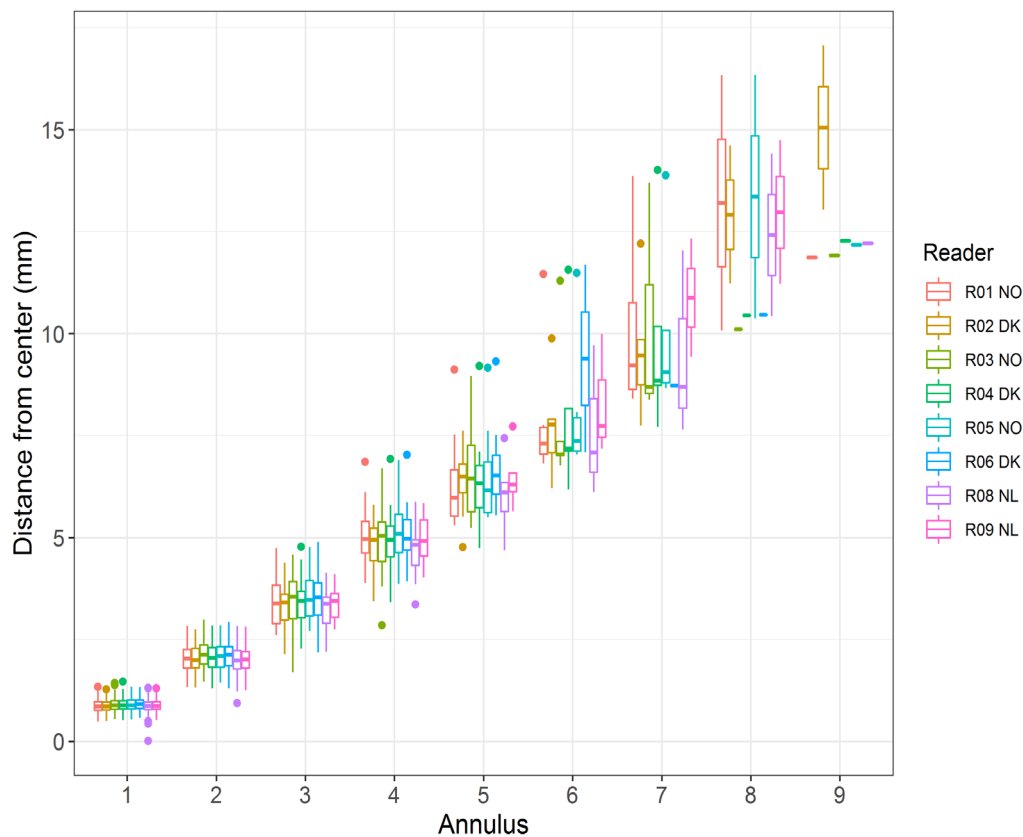
Figure 4: Plot of average distance from the centre to the winter rings for all readers. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

The growth plot in Figure 4 shows almost no overlap between the annotations at annuli 1 and 2 which means that, overall the readers are in agreement as to which structures are used to interpret the age of the fish. From annuli 3, 4 and 5 an overlap is slightly apparent but mostly only seen in the whiskers and outliers. From annuli 6 and upwards the annuli become more difficult to interpret at the edge (due to a narrowing of annulus width with an increase in age) and the overlap more apparent.

4.2 Results for advanced readers

In this section, the results are based on all samples and are given for only the advanced readers (those who provide age data for stock assessment purposes). There follows an analysis where stock code is the defined strata and a separate analysis is done for each stock (san.sa.1r, san.sa.3r and san.sa.5r). The weighted average percentage agreement (PA) based on modal ages for all advanced readers is 81 % (71% based on all readers) and the weighted average coefficient of variation (CV) is 24 % (26% based on all readers).

At modal age 0, the PA calculated across all readers is 78%, R06 has a PA of just 17% and there are just 3 readers with a PA of 100% (Table 7). At modal ages 1 and 2 the PA increases to 80% and 89% respectively. From modal ages 3 to 8 the PA is between 75 and 50%. and at modal age 9 it is 83%. R06 has the lowest weighted mean PA at just 46% whereas all other readers are above 85%. At modal age 1 the overall CV is high at 41% and no reader achieving a CV below 27% (Table 8). CV decreases with an increase in age. Readers with the highest weighted mean CV's are R06 and R01 respectively.

Positive relative bias indicates an overestimation of age in comparison to the modal age and a negative relative bias indicates an underestimation of age in comparison to modal age. The overall relative bias, across all ages, is 0.06, the weighted mean bias per reader indicates that for R01, R03 and R05 there is an overall tendency to underestimate the age while for R02, R04 and R06 there is an overall tendency to overestimate the age in comparison to modal age (Table 9). At modal age 0, 1 and 2 the overall bias, calculated across all age readers, is 0.28, 0.12 and 0.05 respectively, indicating an overestimation in comparison to modal age (as with modal age 6). At modal ages 3-5 and 7-9 the overall negative bias indicates underestimation in comparison to modal age. The combined age bias plot in Figure 6 clearly depict these results. For each reader it is important to look at the bias at each modal age in Table 5 and the individual reader age bias plots can be found in Annex 3 Table 13.

Table 7: Percentage agreement (PA) table represents the PA per modal age and reader, PA of all advanced readers combined per modal age and a weighted mean of the PA per reader.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	all
0	100 %	70 %	100 %	75 %	100 %	17 %	**78 %**
1	88 %	91 %	100 %	84 %	90 %	30 %	**80 %**
2	91 %	89 %	95 %	93 %	95 %	72 %	**89 %**
3	70 %	80 %	50 %	90 %	90 %	70 %	**75 %**
4	91 %	80 %	64 %	82 %	100 %	36 %	**75 %**
5	50 %	100 %	100 %	100 %	50 %	0 %	**67 %**
6	100 %	0 %	100 %	0 %	100 %	0 %	**50 %**
7	67 %	67 %	67 %	100 %	67 %	0 %	**61 %**
8	-	-	-	-	-	-	-
9	100 %	100 %	100 %	100 %	100 %	0 %	**83 %**
Weighted Mean	**88 %**	**85 %**	**90 %**	**87 %**	**92 %**	**46 %**	**81 %**

Table 8: Coefficient of Variation (CV) table presents the CV per modal age and advanced reader, the CV of all advanced readers combined per modal age and a weighted mean of the CV per reader.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	all
0	-	-	-	-	-	-	-
1	38 %	27 %	0 %	36 %	33 %	32 %	**41 %**
2	15 %	15 %	11 %	13 %	11 %	27 %	**17 %**
3	27 %	13 %	29 %	11 %	11 %	25 %	**22 %**

4	8 %	10 %	25 %	11 %	0 %	21 %	**15 %**
5	16 %	0 %	0 %	0 %	24 %	13 %	**16 %**
6	-	-	-	-	-	-	**12 %**
7	8 %	15 %	18 %	0 %	8 %	20 %	**17 %**
8	-	-	-	-	-	-	**-**
9	-	-	-	-	-	-	**5 %**
Weighted Mean	**23 %**	**18 %**	**10 %**	**19 %**	**17 %**	**27 %**	**24 %**

Table 9: Relative bias table represents the relative bias per modal age and advanced reader, the relative bias of all advanced readers combined per modal age and a weighted mean of the relative bias per reader. Numbers in blue indicate a negative bias and numbers in red indicate positive bias.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	all
0	0.00	0.50	0.00	0.25	0.00	0.92	**0.28**
1	-0.12	0.09	0.00	0.09	-0.10	0.76	**0.12**
2	-0.05	0.11	0.00	0.02	0.00	0.23	**0.05**
3	-0.40	0.20	-0.60	-0.10	-0.10	0.20	**-0.13**
4	-0.09	0.20	0.00	0.00	0.00	-0.27	**-0.03**
5	0.00	0.00	0.00	0.00	0.25	-1.25	**-0.17**
6	0.00	1.00	0.00	1.00	0.00	-1.00	**0.17**
7	0.33	0.67	-0.67	0.00	0.33	-2.00	**-0.22**
8	-	-	-	-	-	-	**-**
9	0.00	0.00	0.00	0.00	0.00	-1.00	**-0.17**
Weighted Mean	**-0.08**	**0.17**	**-0.07**	**0.06**	**-0.02**	**0.27**	**0.06**
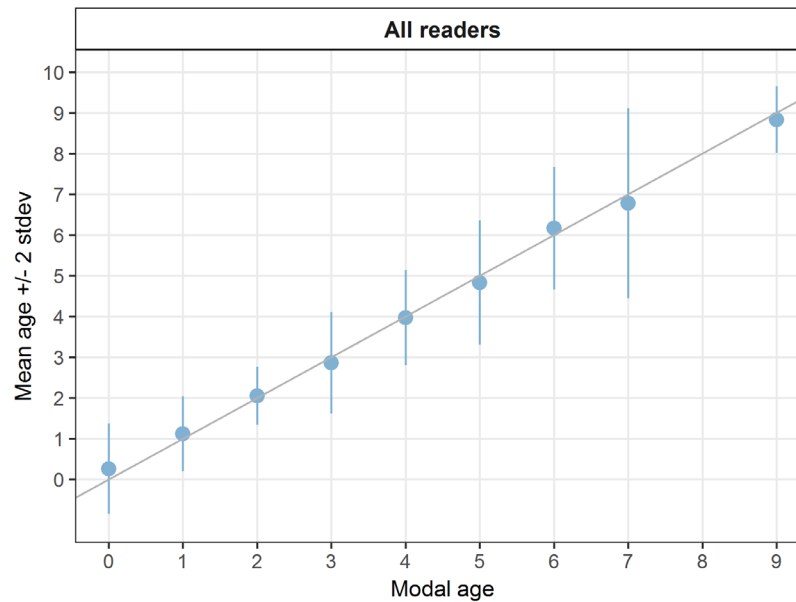
Figure 5: Age bias plot for advanced readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.
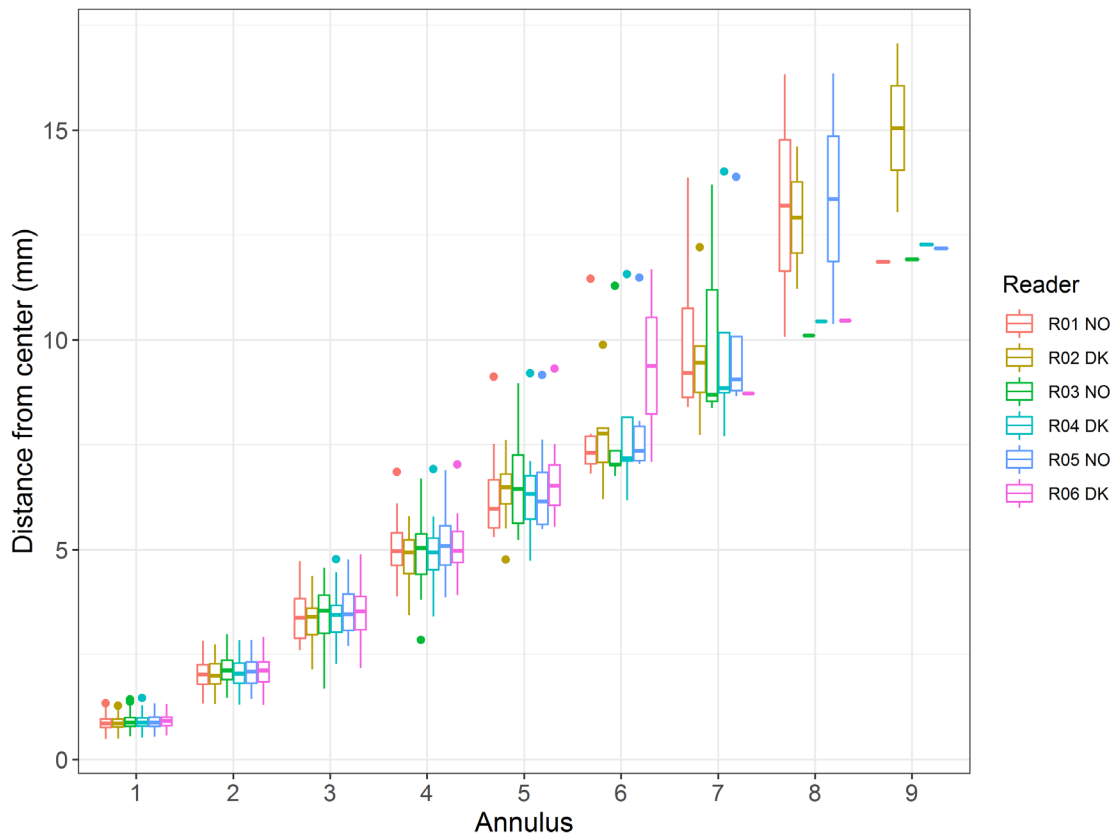
Figure 6: Plot of average distance from the centre to the winter rings for advanced readers. The boxes represent the median, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

The growth plot in Figure 6 shows almost no overlap between the annotations at annuli 1 and 2 which means that readers are in agreement as to which structures are used to interpret the age of the fish. In general there is less variabiltiy seen around the average distances from the centre to each ring when only the advanced readers are include in the analysis. From annuli 3, 4 and 5 an overlap is slightly apparent but mostly only seen in the whiskers and outliers. From annuli 6 and upwards the annuli become more difficult to interpret at the edge (due to a narrowing of annulus width with an increase in age) and the overlap more apparent.

Results by stock

Tables 10, 11 and 12 show the PA, CV and relative bias per stock based on advanced readers only. PA is highest for san.sa.1r (SA1), followed by san.sa.3r (SA3) and san.sa.5r (SA5). The CV is the highest for san.sa.1r followed by san.sa.3r and san.sa.5r. Again, the overall relative bias indicates overestimation at modal ages 0, 1 and 2 and underestimation at modal age 3 and 4. In comparison, the highest bias is seen in san.sa.3r and san.sa.5r respectively.

Age error matrices in Tables 12, 14 and 15 are calculated per stock and based on advanced readers only. They show the proportion of each modal age mis-aged as other ages. The numbers in bold are the proportion of readers estimated ages in agreement with modal age. For san.sa.1r the variability around modal ages 0 to 4 is less and the proportion of ages in agreement with modal ages highest in comparison to the other stocks. For san.sa.3r there is much more variability around the modal age and for san.sa.5r the variability is also higher. Readers assign the most AQ2 (Rings can be counted with difficulty and some doubt) and AQ3_QA (Unreadable or very difficult to age with acceptable precision) otolith readability scores for these stocks. The age range of the samples in san.sa.3r (0-7) and san.sa.5r (0-9) is much wider in comparison to san.sa.1r (0-4). In addition, some of the otoliths from san.sa.3r and san.sa.5r were mounted in eukit before being photographed which can make edge interpretation difficult in otoliths from older fish.

Readers were asked to provide a comment if a sample was likely to be another Sandeel species (as opposed to the lesser Sandeel *Ammodytes marinus)*. 5 samples (4 in san.sa.5r and 1 in san.sa.3r) were identified by two Danish readers. Not all readers are familiar with identifying the otoliths of other Sandeel species and it could be that these numbers are in fact higher.

Table 10: Percentage Agreement per stock based on advanced readers only.

Modal age	san.sa.1r	san.sa.3r	san.sa.5r	all
0	80 %	79 %	67 %	**78 %**
1	82 %	78 %	69 %	**80 %**
2	90 %	90 %	83 %	**89 %**
3	58 %	92 %	75 %	**75 %**
4	89 %	66 %	83 %	**75 %**
5	-	50 %	83 %	**67 %**
6	-	-	50 %	**50 %**
7	-	50 %	83 %	**61 %**
8	-	-	-	-
9	-	-	83 %	**83 %**
Weighted Mean	**84 %**	**79 %**	**77 %**	**81 %**

Table 11: CV per stock based on advanced readers only.

Modal age	san.sa.1r	san.sa.3r	san.sa.5r	all
0	-	-	-	-
1	37 %	48 %	55 %	**41 %**
2	17 %	18 %	18 %	**17 %**
3	31 %	10 %	17 %	**22 %**
4	13 %	16 %	10 %	**15 %**
5	-	21 %	8 %	**16 %**
6	-	-	12 %	**12 %**
7	-	17 %	19 %	**17 %**
8	-	-	-	-
9	-	-	5 %	**5 %**
Weighted Mean	**26 %**	**22 %**	**20 %**	**24 %**

Table 12: Relative bias per stock based on advanced readers only.

Modal age	san.sa.1r	san.sa.3r	san.sa.5r	all
0	0.20	0.29	0.33	**0.28**
1	0.11	0.14	0.25	**0.16**
2	0.03	0.04	0.17	**0.08**
3	-0.38	0.00	0.08	**-0.10**
4	-0.17	0.09	-0.17	**-0.08**
5	-	-0.17	-0.17	-
6	-	-	0.17	-
7	-	-0.08	-0.50	-
8	-	-	-	-
9	-	-	-0.17	-
Weighted Mean	**0.04**	**0.08**	**0.06**	**0.09**

Table 13: Age error matrix (AEM) for san.sa.1r. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases.

strata	Modal age	0	1	2	3	4	5
san.sa.1r	Age 0	**0.80**	0.04	0.01	-	-	-
san.sa.1r	Age 1	0.20	**0.82**	0.02	0.08	-	-
san.sa.1r	Age 2	-	0.14	**0.90**	0.29	0.06	-
san.sa.1r	Age 3	-	-	0.07	**0.58**	0.06	-
san.sa.1r	Age 4	-	-	-	-	**0.89**	-
san.sa.1r	Age 5	-	-	-	0.04	-	-

Table 14: Age error matrix (AEM) for san.sa.3r. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases.

strata	Modal age	0	1	2	3	4	5	6	7	9
san.sa.3r	Age 0	**0.79**	0.06	-	-	-	-	-	-	-
san.sa.3r	Age 1	0.15	**0.78**	0.04	-	-	-	-	-	-
san.sa.3r	Age 2	0.03	0.14	**0.90**	0.04	-	-	-	-	-
san.sa.3r	Age 3	0.03	0.03	0.05	**0.92**	0.14	0.08	-	-	-
san.sa.3r	Age 4	-	-	0.01	0.04	**0.66**	0.25	-	-	-
san.sa.3r	Age 5	-	-	-	-	0.17	**0.50**	-	0.17	-
san.sa.3r	Age 6	-	-	-	-	0.03	0.08	-	0.08	-
san.sa.3r	Age 7	-	-	-	-	-	0.08	-	**0.50**	-
san.sa.3r	Age 8	-	-	-	-	-	-	-	0.17	-
san.sa.3r	Age 9	-	-	-	-	-	-	-	0.08	-

Table 15: Age error matrix (AEM) for san.sa.5r. The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases

strata	Modal age	0	1	2	3	4	5	6	7	9
san.sa.5r	Age 0	**0.67**	0.06	-	-	-	-	-	-	-
san.sa.5r	Age 1	0.33	**0.69**	-	-	-	-	-	-	-
san.sa.5r	Age 2	-	0.19	**0.83**	0.08	-	-	-	-	-
san.sa.5r	Age 3	-	0.06	0.17	**0.75**	0.17	-	-	-	-
san.sa.5r	Age 4	-	-	-	0.17	**0.83**	0.17	-	0.17	-
san.sa.5r	Age 5	-	-	-	-	-	**0.83**	0.17	-	-
san.sa.5r	Age 6	-	-	-	-	-	-	**0.50**	-	-
san.sa.5r	Age 7	-	-	-	-	-	-	0.33	**0.83**	-
san.sa.5r	Age 8	-	-	-	-	-	-	-	-	**0.17**
san.sa.5r	Age 9	-	-	-	-	-	-	-	-	0.83

4.3 Results of the 2016 rereading exercise

Table 16: Overview of samples reread from the 2016 exchange.

Year	ICES area	Strata	Quarter	Number of samples	Modal age range	Length range
2015	27.4.b	san.sa.1r	4	20	0-3	100-150 mm
2016	27.4.b	san.sa.1r	2	20	1-4	85-185 mm

A subset of otoliths which reached 100% agreement across all readers during the Sandeel age reading exchange 2016 were included in this exchange (Table 16). R01 – R05 (inclusive) took part in the 2016 exchange. The weighted average PA based on the 2016 agreed ages for all readers is 78.1 % (Table 17) and the weighted average CV is 27.9% (Table 18). When the results are based on only those readers who took part in the 2016 exchange then the PA increases to 92.5% and the CV decreases to 15%. The readers who did not take part in the 2016 exchange show the same underlying issues; R06 showing a clear positive bias and readers R08 and R09 (both trainees) showing positive bias (Table 19) at age 0 and 1 and negative bias at ages 2, 3 and 4. See section 4.1 for further explanation of age reading issues for these readers. For Sandeel_SA1_2015_42 (modal age 0), R04, R06, R08 and R09 all count an extra winter ring at the edge, where a faint opaque zone between the highly opaque centre and the otolith edge can be seen at the post rostrum only (Figure 7). This issue was noted in the 2016 exchange for clarification with the readers. Table 20 gives the results overview per reader and per sample.

Table 17: Percentage agreement. Percentage agreement (PA) table represents the PA per 2016 age and reader, the PA of all readers combined per 2016 age and a weighted mean of the PA per reader.

Modal age	R01	R02	R03	R04	R05	R06	R08	R09	**ALL**
0	100%	100%	100%	0%	100%	0%	0%	0%	**50%**
1	95%	100%	100%	95%	90%	29%	100%	60%	**84%**
2	92%	92%	85%	92%	100%	92%	31%	23%	**76%**
3	33%	100%	0%	100%	100%	33%	67%	67%	**63%**
4	100%	100%	100%	100%	100%	50%	0%	0%	**69%**
Weighted mean	**90%**	**98%**	**88%**	**93%**	**95%**	**50%**	**68%**	**44%**	**78%**

Table 18: Coefficient of Variation (CV) table presents the CV per 2016 age and reader, the CV of all readers combined per 2016 age and a weighted mean of the CV per reader.

Modal age	R01	R02	R03	R04	R05	R06	R08	R09	**ALL**
0	-	-	-	-	-	-	-	-	**-**
1	23%	0%	0%	21%	33%	27%	0%	36%	**28%**
2	14%	13%	20%	14%	0%	13%	37%	36%	**25%**
3	25%	0%	0%	0%	0%	46%	22%	22%	**23%**
4	0%	0%	0%	0%	0%	20%	0%	0%	**13%**
Weighted mean	**19%**	**4%**	**7%**	**16%**	**17%**	**23%**	**14%**	**32%**	**28%**

Table 19: Relative bias table represents the relative bias per 2016 age per reader, the relative bias of all readers combined per 2016 age and a weighted mean of the relative bias per reader. Numbers in blue indicate a negative bias and numbers in red indicate positive bias.

Modal age	R01	R02	R03	R04	R05	R06	R08	R09	ALL
0	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	0.50
1	-0.05	0.00	0.00	0.05	-0.10	0.71	0.00	0.40	0.13
2	-0.08	0.08	0.00	-0.08	0.00	0.08	-0.69	-0.77	-0.18
3	-0.67	0.00	-1.00	0.00	0.00	0.33	-0.33	-0.33	-0.25
4	0.00	0.00	0.00	0.00	0.00	-0.50	-1.00	-1.00	-0.31
Weighted mean	-0.10	0.03	-0.08	0.03	-0.05	0.43	-0.28	-0.10	-0.02

Table 20: Results overview of the rereading exercise of samples from the 2016 exchange, including modal age and statistics per sample.

Sample ID	Fish length mm	Catch date	R01	R02	R03	R04	R05	Ro6	R08	R09	2016 age	PA	CV
Sandeel_SA1_2016_41	165	16-04-2016	2	2	3	2	2	2	2	2	2	87.5%	16.6%
Sandeel_SA1_2015_42	135	24-11-2015	0	0	0	1	0	1	1	1	0	50.0%	106.9%
Sandeel_SA1_2015_43	140	24-11-2015	1	1	1	1	0	2	1	1	1	75.0%	53.5%
Sandeel_SA1_2015_44	115	28-11-2015	1	1	1	1	1	2	1	1	1	87.5%	31.4%
Sandeel_SA1_2015_45	120	28-11-2015	1	1	1	1	0	2	1	1	1	75.0%	53.5%
Sandeel_SA1_2015_46	130	28-11-2015	1	1	1	2	1	2	1	1	1	75.0%	37.0%
Sandeel_SA1_2015_47	130	28-11-2015	1	1	1	1	1	2	1	1	1	87.5%	31.4%
Sandeel_SA1_2015_48	135	28-11-2015	1	1	1	1	1	2	1	1	1	87.5%	31.4%
Sandeel_SA1_2016_49	110	17-04-2016	1	1	1	1	1	1	1	1	1	100.0%	0.0%
Sandeel_SA1_2016_50	115	17-04-2016	1	1	1	1	1	1	1	-	1	100.0%	0.0%
Sandeel_SA1_2016_51	85	16-04-2016	1	1	1	1	1	1	1	1	1	100.0%	0.0%
Sandeel_SA1_2016_52	90	16-04-2016	1	1	1	1	1	1	1	1	1	100.0%	0.0%
Sandeel_SA1_2016_53	100	16-04-2016	1	1	1	1	1	1	1	1	1	100.0%	0.0%
Sandeel_SA1_2016_54	110	16-04-2016	1	1	1	1	1	1	1	1	1	100.0%	0.0%
Sandeel_SA1_2016_55	120	16-04-2016	1	2	2	2	2	2	1	1	2	62.5%	31.8%
Sandeel_SA1_2016_56	130	17-04-2016	2	2	2	2	2	2	1	1	2	75.0%	26.5%
Sandeel_SA1_2016_57	140	17-04-2016	2	2	2	2	2	2	2	1	2	87.5%	18.9%
Sandeel_SA1_2016_58	150	17-04-2016	2	2	2	1	2	2	1	1	2	62.5%	31.8%
Sandeel_SA1_2016_59	160	17-04-2016	2	2	2	2	2	2	1	1	2	75.0%	26.5%
Sandeel_SA1_2016_60	170	17-04-2016	2	2	2	2	2	2	1	1	2	75.0%	26.5%
Sandeel_SA1_2016_61	135	17-04-2016	2	3	2	2	2	2	1	1	2	62.5%	34.2%
Sandeel_SA1_2016_62	140	17-04-2016	2	2	2	2	2	2	1	1	2	75.0%	26.5%
Sandeel_SA1_2016_63	145	17-04-2016	2	2	2	2	2	2	1	1	2	75.0%	26.5%
Sandeel_SA1_2016_64	150	17-04-2016	2	2	2	2	2	2	1	1	2	75.0%	26.5%
Sandeel_SA1_2016_65	180	17-04-2016	3	3	2	3	3	2	2	2	3	50.0%	21.4%
Sandeel_SA1_2016_66	185	17-04-2016	4	4	4	4	4	4	3	3	4	75.0%	12.3%
Sandeel_SA1_2016_67	160	16-04-2016	4	4	4	4	4	3	3	3	4	62.5%	14.3%
Sandeel_SA1_2015_68	140	24-11-2015	2	3	2	3	3	3	3	3	3	75.0%	16.8%
Sandeel_SA1_2015_69	150	24-11-2015	2	3	2	3	3	5	3	3	3	62.5%	30.9%
Sandeel_SA1_2015_70	145	24-11-2015	2	2	1	2	2	2	2	2	2	87.5%	18.9%
Sandeel_SA1_2015_71	125	26-11-2015	1	1	1	1	1	2	1	1	1	87.5%	31.4%
Sandeel_SA1_2015_72	140	26-11-2015	2	2	2	2	2	3	2	2	2	87.5%	16.6%
Sandeel_SA1_2015_73	100	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2016_74	105	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2015_75	105	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2015_76	105	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2015_77	110	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2015_78	110	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2015_79	115	24-11-2015	1	1	1	1	1	2	1	2	1	75.0%	37.0%
Sandeel_SA1_2015_80	125	24-11-2015	0	1	1	1	1	2	1	2	1	62.5%	57.0%
												78.1%	27.9%

Figure 7: Sandeel_SA1_2015_42, modal age 0), catch date 24/11/2018, fish length 135mm. Red dot is where R04, R06, R08 and R09 have marked a winter ring which should not be inlkcuded in the count of age.

5 Conclusion

Overall, when only the readers providing age data for assessment are included in the analysis the results of this exchange are slightly poorer than the results from the 2016 exchange. Per stock, the PA decreases from 91% to 84% in SA1 (san.sa.1r) and increases from 77% to 79% in SA3 (san.sa.3r). Some reoccurring issues have been addressed in this report and need to be taken up with the readers, the most problematic being the interpretation of the edge in Q4. The disagreement between Denmark and Norway as to whether or not there is a false winter ring laid down before the first true winter ring should be addressed, this may be area specific and otolith microstructure examination of the problematic otoliths which are not mounted in eukit will hopefully clarify this. The rereading of the subset from the 2016 exercise showed a very high level of agreement (PA 92.5%) when only those readers who took part in both exercises were included. This shows how important it is to have all readers participate in the calibration exercises.

Results by stocks showed the highest PA for san.sa.1r and the AEM shows the proportions of age readings in agreement with modal age to also be high. For san.sa.3r there is much more variability around the modal age and for san.sa.5r the variability is also higher. The otolith readability scores show most AQ2's and AQ3_QA's are given for samples belonging to these stocks in comparison to those from san.sa.1r. This may be due to the image quality but it should be taken into consideration that the age range of the samples in san.sa.3r and san.sa.5r is much wider.

Concerns were raised over the image quality of the otoliths mounted in eukit which may have contributed to the lower PA for these areas/stocks. Some of these otoliths were mounted in eukit before being photographed and this makes it very difficult to avoid light reflection when a high light intensity is required to illuminate the otolith edge, especially in the older samples. Readers were instructed to adjust the image brightness and contrast in the SmartDots software accordingly when the instructions were sent out prior to the exchange beginning. Taking images of otoliths in eukit was problematic, however this does not appear to be a problem for Norway and it was agreed that for future exchanges the images of otolith mounted in eukit should be taken in Norway where they are more experienced with this technique.

The presence of otoliths from Sandeel species other than *Ammodytes marinus* was only noted by 2 readers from Denmark. Not all laboratories separate the other species which can be present in the catches and which can be difficult to identify by fish and/or otolith morphology, depending on the species. Investigations are underway at DTU Denmark aiming at developing a quick and cost effective method to separate *Ammodytes marinus* from the coastal species, *Ammodytes tobianus.* The two species are known to co-occur in san.sa.2r.

The exchange is now closed in SmartDots meaning that all readers annotations are visible to all readers for comparison. The overview Tables 22 and 26 give the individual readers ages, modal age, PA, CV and APE per Sample ID.

6 References

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7 Annex 1. Additional results

7.1 Results all readers

Table 21: Summary of statistics; PA (%), CV (%) and APE (%).

CV	PA	APE
26 %	77 %	16 %

Table 22: Data overview including modal age and statistics per sample.

Sample ID	Event ID	length	sex	Catch date	ICES area	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL	Modal age	PA %	CV %	APE %
Sandeel_SA1_2015_42	219	135		24-11-2015	27.4.b	0	0	0	1	0	1	1	1	0	50	-	-
Sandeel_SA1_2015_43	219	140		24-11-2015	27.4.b	1	1	1	1	0	2	1	1	1	75	53	25
Sandeel_SA1_2015_44	219	115		28-11-2015	27.4.b	1	1	1	1	1	2	1	1	1	88	31	19
Sandeel_SA1_2015_45	219	120		28-11-2015	27.4.b	1	1	1	1	0	2	1	1	1	75	53	25
Sandeel_SA1_2015_46	219	130		28-11-2015	27.4.b	1	1	1	2	1	2	1	1	1	75	37	30
Sandeel_SA1_2015_47	219	130		28-11-2015	27.4.b	1	1	1	1	1	2	1	1	1	88	31	19
Sandeel_SA1_2015_48	219	135		28-11-2015	27.4.b	1	1	1	1	1	2	1	1	1	88	31	19
Sandeel_SA1_2015_68	219	140		24-11-2015	27.4.b	2	3	2	3	3	3	3	3	3	75	17	14
Sandeel_SA1_2015_69	219	150		24-11-2015	27.4.b	2	3	2	3	3	5	3	3	3	62	31	17
Sandeel_SA1_2015_70	219	145		24-11-2015	27.4.b	2	2	1	2	2	2	2	2	2	88	19	12
Sandeel_SA1_2015_71	219	125		26-11-2015	27.4.b	1	1	1	1	1	2	1	1	1	88	31	19
Sandeel_SA1_2015_72	219	140		26-11-2015	27.4.b	2	2	2	2	2	3	2	2	2	88	17	10
Sandeel_SA1_2015_73	219	100		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2015_75	219	105		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2015_76	219	105		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2015_77	219	110		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2015_78	219	110		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2015_79	219	115		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2015_80	219	125		24-11-2015	27.4.b	0	1	1	1	1	2	1	2	1	62	57	39
Sandeel_SA1_2016_41	219	165		16-04-2016	27.4.b	2	2	3	2	2	2	2	2	2	88	17	10
Sandeel_SA1_2016_49	219	110		17-04-2016	27.4.b	1	1	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_50	219	115		17-04-2016	27.4.b	1	1	1	-	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_51	219	85		16-04-2016	27.4.b	1	1	1	1	1	1	1	1	1	100	0	0

Sandeel_SA1_2016_52	219	90		16-04-2016	27.4.b	1	1	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_53	219	100		16-04-2016	27.4.b	1	1	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_54	219	110		16-04-2016	27.4.b	1	1	1	1	-	1	1	1	1	100	0	0
Sandeel_SA1_2016_55	219	120		16-04-2016	27.4.b	1	2	2	2	2	2	1	1	2	62	32	29
Sandeel_SA1_2016_56	219	130		17-04-2016	27.4.b	2	2	2	2	2	2	1	1	2	75	26	21
Sandeel_SA1_2016_57	219	140		17-04-2016	27.4.b	2	2	2	2	2	2	2	1	2	88	19	12
Sandeel_SA1_2016_58	219	150		17-04-2016	27.4.b	2	2	2	1	2	2	1	1	2	62	32	29
Sandeel_SA1_2016_59	219	160		17-04-2016	27.4.b	2	2	2	2	2	2	1	1	2	75	26	21
Sandeel_SA1_2016_60	219	170		17-04-2016	27.4.b	2	2	2	2	2	2	1	1	2	75	26	21
Sandeel_SA1_2016_61	219	135		17-04-2016	27.4.b	2	3	2	2	2	2	-	1	2	71	29	14
Sandeel_SA1_2016_62	219	140		17-04-2016	27.4.b	2	2	2	2	2	2	1	1	2	75	26	21
Sandeel_SA1_2016_63	219	145		17-04-2016	27.4.b	2	2	2	2	2	2	1	1	2	75	26	21
Sandeel_SA1_2016_64	219	150		17-04-2016	27.4.b	2	2	2	2	2	2	1	1	2	75	26	21
Sandeel_SA1_2016_65	219	180		17-04-2016	27.4.b	3	3	2	3	3	2	2	2	2	50	21	20
Sandeel_SA1_2016_66	219	185		17-04-2016	27.4.b	4	4	4	4	4	4	3	3	4	75	12	10
Sandeel_SA1_2016_67	219	160		16-04-2016	27.4.b	4	4	4	4	4	3	3	3	4	62	14	13
Sandeel_SA1_2016_74	219	105		24-11-2015	27.4.b	1	1	1	1	1	2	1	2	1	75	37	30
Sandeel_SA1_2018_100	219	165	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_81	219	155	M	21-11-2018	27.4.b	2	2	2	2	2	3	2	2	2	88	17	10
Sandeel_SA1_2018_82	219	165	F	21-11-2018	27.4.b	2	3	2	3	2	3	3	4	3	50	26	20
Sandeel_SA1_2018_83	219	70		21-11-2018	27.4.b	0	0	0	0	0	1	0	0	0	88	-	-
Sandeel_SA1_2018_84	219	80		21-11-2018	27.4.b	0	0	0	0	0	1	0	1	0	75	-	-
Sandeel_SA1_2018_85	219	90		21-11-2018	27.4.b	0	0	0	0	0	1	0	1	0	75	-	-
Sandeel_SA1_2018_86	219	100		21-11-2018	27.4.b	0	0	0	0	0	1	0	1	0	75	-	-
Sandeel_SA1_2018_87	219	100	F	21-11-2018	27.4.b	0	1	1	0	1	2	1	1	1	62	73	50
Sandeel_SA1_2018_88	219	110	M	21-11-2018	27.4.b	1	1	1	1	1	2	1	1	1	88	31	19
Sandeel_SA1_2018_89	219	115	M	21-11-2018	27.4.b	2	2	2	2	2	3	2	2	2	88	17	10
Sandeel_SA1_2018_90	219	125	F	21-11-2018	27.4.b	2	2	2	2	2	0	2	2	2	88	40	25
Sandeel_SA1_2018_91	219	125	M	21-11-2018	27.4.b	1	1	1	2	1	2	1	1	1	75	37	30

Sample				Date	Area												
Sandeel_SA1_2018_92	219	135	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_93	219	140	M	21-11-2018	27.4.b	2	2	2	2	2	3	2	3	2	75	21	17
Sandeel_SA1_2018_94	219	140	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_95	219	145	F	21-11-2018	27.4.b	2	2	2	2	2	3	2	3	2	75	21	17
Sandeel_SA1_2018_96	219	150	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_97	219	155	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_98	219	155	F	21-11-2018	27.4.b	4	4	2	4	4	4	3	2	4	62	27	23
Sandeel_SA1_2018_99	219	160	M	21-11-2018	27.4.b	1	3	1	3	2	3	3	3	3	62	39	33
Sandeel_SA3_2016_21	219	135		13-05-2016	27.4.a	1	2	1	2	1	3	2	2	2	50	40	32
Sandeel_SA3_2016_25	219	125		28-04-2016	27.4.b	2	2	2	2	2	3	2	2	2	88	17	10
Sandeel_SA3_2016_26	219	130		28-04-2016	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2016_27	219	140		28-04-2016	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2016_28	219	160		28-04-2016	27.4.b	2	2	2	2	2	2	2	1	2	88	19	12
Sandeel_SA3_2016_29	219	185		09-05-2016	27.4.a	2	2	2	2	2	2	2	1	2	88	19	12
Sandeel_SA3_2016_33	219	200		09-05-2016	27.4.a	4	4	3	4	4	3	2	2	4	50	27	23
Sandeel_SA3_2016_34	219	180		13-05-2016	27.4.a	4	5	6	3	4	5	4	4	4	50	21	16
Sandeel_SA3_2016_35	219	165		13-05-2016	27.4.a	4	4	4	4	4	4	3	3	4	75	12	10
Sandeel_SA3_2016_36	219	175		13-05-2016	27.4.a	4	-	4	5	4	3	4	4	4	71	14	7
Sandeel_SA3_2016_37	219	175		13-05-2016	27.4.a	4	5	5	5	4	3	4	4	4	50	17	13
Sandeel_SA3_2016_38	219	245		09-05-2016	27.4.a	6	5	5	5	7	4	5	5	5	62	17	12
Sandeel_SA3_2016_39	219	225		09-05-2016	27.4.a	7	7	5	7	7	5	5	4	7	50	21	19
Sandeel_SA3_2017_22	219	100		26-04-2017	27.4.a	1	2	1	1	1	1	1	1	1	88	31	19
Sandeel_SA3_2017_23	219	150		26-04-2017	27.4.a	1	3	2	2	1	2	1	1	1	50	46	38
Sandeel_SA3_2017_24	219	120		26-04-2017	27.4.a	1	1	1	1	1	1	1	1	1	100	0	0
Sandeel_SA3_2017_30	219	210		26-04-2017	27.4.a	3	3	3	3	3	3	2	2	3	75	17	14
Sandeel_SA3_2017_31	219	195		26-04-2017	27.4.a	3	3	3	2	3	3	2	2	3	62	20	18
Sandeel_SA3_2017_32	219	200		26-04-2017	27.4.a	3	3	3	3	3	3	2	2	3	75	17	14
Sandeel_SA3_2017_40	219	250		26-04-2017	27.4.a	8	9	7	7	8	6	8	8	8	50	12	9
Sandeel_SA3_2018_101	219	45		05-12-2018	27.4.b	0	-	0	0	0	0	0	0	0	100	-	-

Sample				Date	Area												
Sandeel_SA3_2018_102	219	70		03-12-2018	27.3.a.20	0	0	0	0	0	0	0	0	0	100	-	-
Sandeel_SA3_2018_103	219	80		03-12-2018	27.3.a.20	0	0	0	0	0	1	0	0	0	88	-	-
Sandeel_SA3_2018_104	219	95	F	05-12-2018	27.4.b	0	3	0	0	0	2	1	1	0	50	-	-
Sandeel_SA3_2018_105	219	125	F	25-11-2018	27.4.b	1	1	1	1	1	2	1	1	1	88	31	19
Sandeel_SA3_2018_106	219	135	F	25-11-2018	27.4.b	1	1	1	1	1	1	1	1	1	100	0	0
Sandeel_SA3_2018_107	219	100		27-11-2018	27.4.b	0	1	1	1	0	2	1	1	1	62	73	50
Sandeel_SA3_2018_108	219	105		27-11-2018	27.4.b	0	1	0	0	0	1	1	1	0	50	-	-
Sandeel_SA3_2018_109	219	115		27-11-2018	27.4.b	0	1	0	-	0	1	1	2	0	43	-	-
Sandeel_SA3_2018_110	219	140	F	25-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_111	219	140	M	25-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_112	219	150	F	25-11-2018	27.4.b	2	2	2	2	2	3	2	1	2	75	27	12
Sandeel_SA3_2018_113	219	155	F	25-11-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_114	219	160	F	05-12-2018	27.4.b	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_115	219	165	M	05-12-2018	27.4.b	1	2	2	2	2	2	2	1	2	75	26	21
Sandeel_SA3_2018_116	219	170	F	05-12-2018	27.4.b	2	2	2	2	2	4	2	2	2	88	31	19
Sandeel_SA3_2018_117	219	175	F	05-12-2018	27.4.b	2	2	2	2	2	3	2	3	2	75	21	17
Sandeel_SA3_2018_118	219	185	M	25-11-2018	27.4.b	3	3	3	3	3	4	3	3	3	88	11	7
Sandeel_SA3_2018_119	219	190	M	25-11-2018	27.4.b	3	4	4	4	4	4	4	4	4	88	9	6
Sandeel_SA3_2018_120	219	200	F	25-11-2018	27.4.b	4	5	5	4	4	5	4	4	4	62	12	11
Sandeel_SA5_2011_08	219	145		08-05-2011	27.4.a	2	2	2	2	2	2	2	1	2	88	19	12
Sandeel_SA5_2011_09	219	95		08-05-2011	27.4.a	2	3	2	2	2	2	2	2	2	88	17	10
Sandeel_SA5_2011_10	219	135		08-05-2011	27.4.a	2	2	2	2	2	-	2	2	2	100	0	0
Sandeel_SA5_2011_12	219	160		08-05-2011	27.4.a	3	2	2	3	3	2	3	3	3	62	20	18
Sandeel_SA5_2011_13	219	170		08-05-2011	27.4.a	3	4	2	3	3	3	3	2	3	62	22	15
Sandeel_SA5_2011_14	219	215		08-05-2011	27.4.a	4	4	4	4	4	3	3	3	4	62	14	13
Sandeel_SA5_2011_15	219	195		08-05-2011	27.4.a	4	4	4	4	4	3	3	4	4	75	12	10
Sandeel_SA5_2011_17	219	185		08-05-2011	27.4.a	5	5	5	5	5	4	4	4	5	62	11	10
Sandeel_SA5_2011_18	219	200		08-05-2011	27.4.a	6	7	6	7	6	5	7	6	6	50	11	9
Sandeel_SA5_2011_19	219	205		08-05-2011	27.4.a	7	7	7	7	7	4	5	5	7	62	20	18

Sandeel_SA5_2011_20	219	215	08-05-2011	27.4.a	9	9	9	9	9	8	9	8	9	75	5	4
Sandeel_SA5_2017_01	219	85	14-05-2017	27.4.a	0	-	1	1	-	1	1	1	1	83	49	33
Sandeel_SA5_2017_02	219	110	14-05-2017	27.4.a	0	-	0	1	0	1	1	1	1	57	94	86
Sandeel_SA5_2017_03	219	140	14-05-2017	27.4.a	0	-	0	1	0	-	2	1	0	50	-	-
Sandeel_SA5_2017_04	219	95	14-05-2017	27.4.a	1	1	1	1	1	3	2	2	1	62	50	42
Sandeel_SA5_2017_05	219	135	14-05-2017	27.4.a	2	2	2	2	2	2	2	2	2	100	0	0
Sandeel_SA5_2017_06	219	105	14-05-2017	27.4.a	1	2	1	2	1	2	1	1	1	62	38	34
Sandeel_SA5_2017_07	219	120	14-05-2017	27.4.a	2	3	2	2	2	3	2	2	2	75	21	17
Sandeel_SA5_2017_11	219	150	14-05-2017	27.4.a	3	4	3	3	3	3	3	3	3	88	11	7
Sandeel_SA5_2017_16	219	175	14-05-2017	27.4.a	5	5	5	5	5	4	4	4	5	62	11	10

Table 23: Number of age readings table gives an overview of number of readings per reader and modal age. The total numbers of readings per reader and per modal age are summarized at the end of the table.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL	total
0	12	10	12	11	12	11	12	12	**92**
1	34	32	34	33	32	34	34	34	**267**
2	43	43	43	43	43	42	42	43	**342**
3	11	11	11	11	11	11	11	11	**88**
4	12	11	12	12	12	12	12	12	**95**
5	3	3	3	3	3	3	3	3	**24**
6	1	1	1	1	1	1	1	1	**8**
7	2	2	2	2	2	2	2	2	**16**
8	1	1	1	1	1	1	1	1	**8**
9	1	1	1	1	1	1	1	1	**8**
Total	**120**	**115**	**120**	**118**	**118**	**118**	**119**	**120**	**948**

Table 24: Age composition by reader gives a summary of number of readings per reader.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL
0	17	7	13	10	16	3	7	**4**
1	33	31	35	31	29	19	45	**47**
2	42	42	47	46	43	54	40	**41**
3	9	14	7	12	10	25	14	**13**
4	11	10	7	9	12	10	7	**10**
5	2	6	6	5	2	5	3	**2**
6	2	0	2	0	1	1	0	**1**
7	2	3	2	4	3	0	1	**0**
8	1	0	0	0	1	1	1	**2**
9	1	2	1	1	1	0	1	**0**
Total	**120**	**115**	**120**	**118**	**118**	**118**	**119**	**120**

Table 25: Mean length at age per reader is calculated per reader and age (not modal age) and for all readers combined per age. A weighted mean is also given.

Age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	R08 NL	R09 NL
0	97 mm	89 mm	95 mm	84 mm	100 mm	80 mm	76 mm	**66 mm**
1	118 mm	113 mm	115 mm	114 mm	114 mm	102 mm	119 mm	**125 mm**
2	145 mm	145 mm	147 mm	144 mm	146 mm	135 mm	150 mm	**141 mm**
3	182 mm	156 mm	186 mm	171 mm	174 mm	160 mm	168 mm	**164 mm**

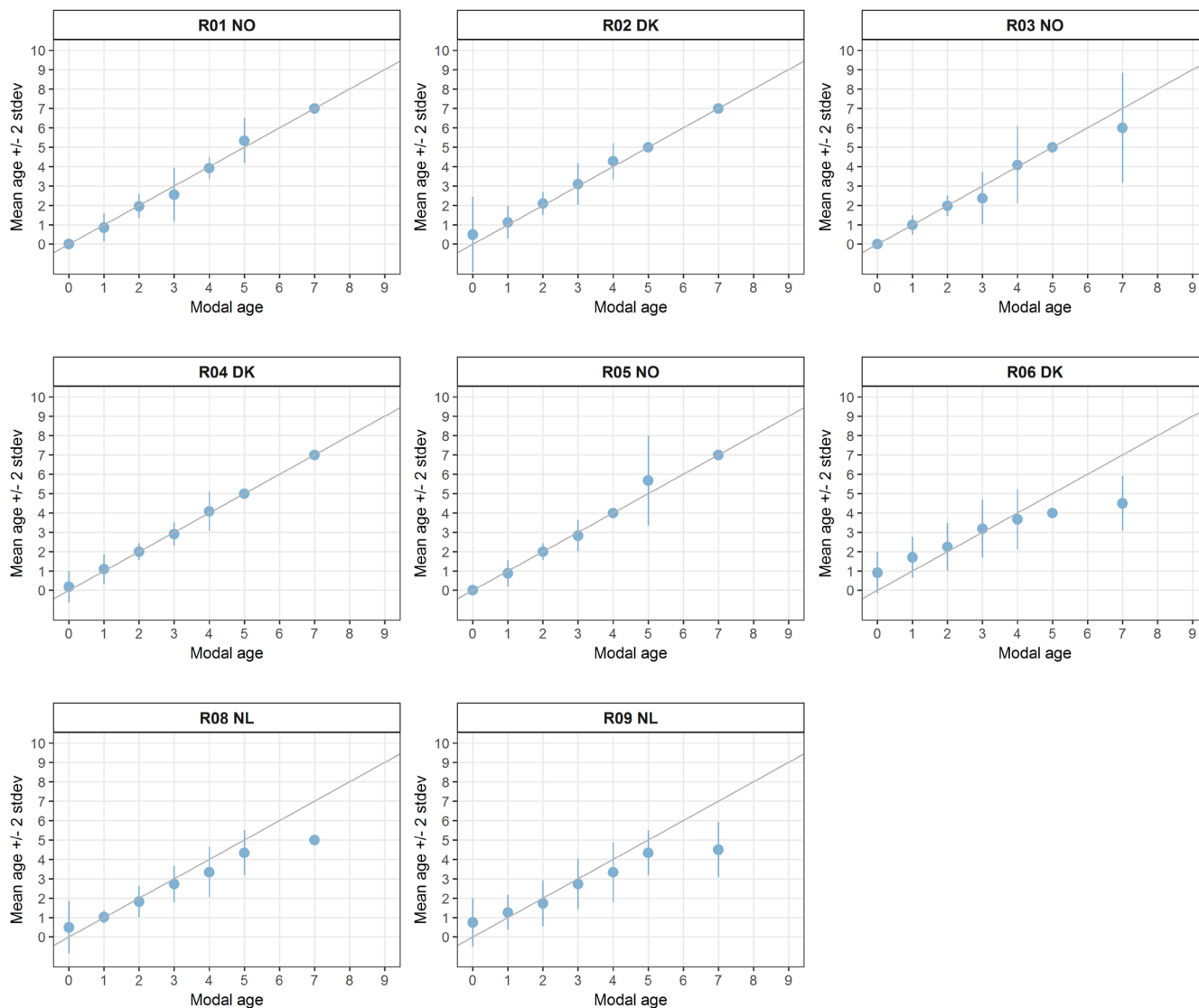|								
4	182 mm	178 mm	184 mm	185 mm	183 mm	186 mm	183 mm	**186 mm**
5	180 mm	193 mm	201 mm	191 mm	180 mm	191 mm	225 mm	**225 mm**
6	222 mm	-	190 mm	-	200 mm	250 mm	-	**200 mm**
7	215 mm	210 mm	228 mm	220 mm	225 mm	-	200 mm	-
8	250 mm	-	-	-	250 mm	215 mm	250 mm	**232 mm**
9	215 mm	232 mm	215 mm	215 mm	215 mm	-	215 mm	-
Weighted Mean	**142 mm**	**143 mm**	**142 mm**	**142 mm**	**142 mm**	**142 mm**	**142 mm**	**142 mm**

Figure 8: Age bias plot for each individual reader. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated man age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.
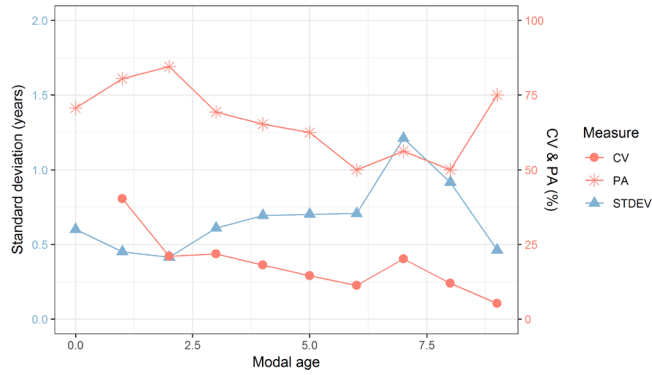
Figure 9: CV, PA and (STDEV (standard deviation) are plotted against modal age
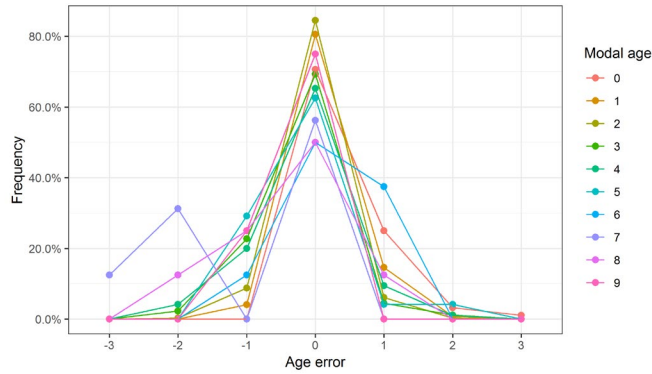
Figure 10: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias, if the age reading errors are normally distributed. The distributions are skewed, if relative bias occurs.

Figure 11: The relative bias by modal age as estimated by all age readers combined.

Figure 12: The mean length at age as estimated by each age reader.

7.2 Results advanced readers

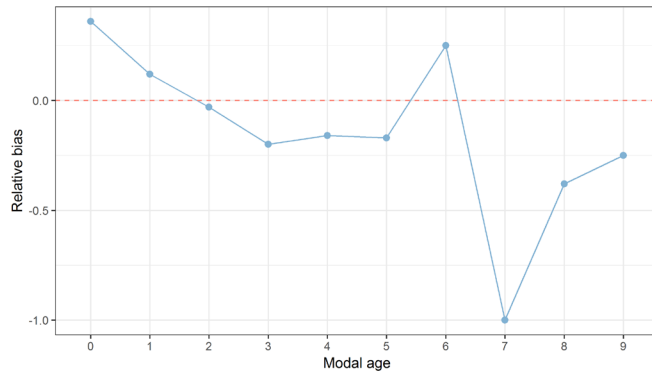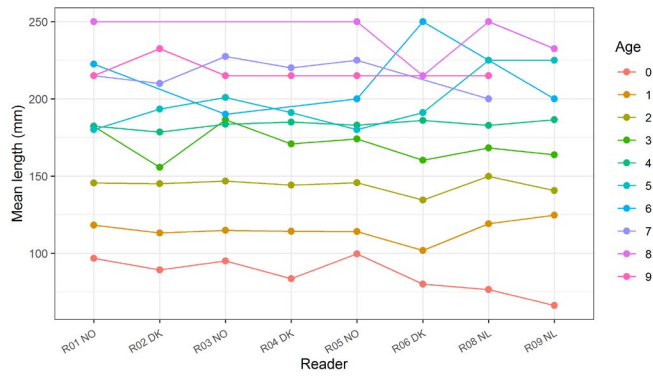**Table 26:** Data overview including modal age and statistics per sample.

Sample ID	Event ID	length	sex	Catch date	ICES area	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	Modal age	PA %	CV %	APE %
Sandeel_SA1_2015_42	219	135		24-11-2015	27.4.b	0	0	0	1	0	1	0	67	-	-
Sandeel_SA1_2015_43	219	140		24-11-2015	27.4.b	1	1	1	1	0	2	1	67	63	33
Sandeel_SA1_2015_44	219	115		28-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_45	219	120		28-11-2015	27.4.b	1	1	1	1	0	2	1	67	63	33
Sandeel_SA1_2015_46	219	130		28-11-2015	27.4.b	1	1	1	2	1	2	1	67	39	33
Sandeel_SA1_2015_47	219	130		28-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_48	219	135		28-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_68	219	140		24-11-2015	27.4.b	2	3	2	3	3	3	3	67	19	17
Sandeel_SA1_2015_69	219	150		24-11-2015	27.4.b	2	3	2	3	3	5	3	50	37	22
Sandeel_SA1_2015_70	219	145		24-11-2015	27.4.b	2	2	1	2	2	2	2	83	22	15
Sandeel_SA1_2015_71	219	125		26-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_72	219	140		26-11-2015	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA1_2015_73	219	100		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_75	219	105		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_76	219	105		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_77	219	110		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_78	219	110		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_79	219	115		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2015_80	219	125		24-11-2015	27.4.b	0	1	1	1	1	2	1	67	63	33
Sandeel_SA1_2016_41	219	165		16-04-2016	27.4.b	2	2	3	2	2	2	2	83	19	13
Sandeel_SA1_2016_49	219	110		17-04-2016	27.4.b	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_50	219	115		17-04-2016	27.4.b	1	1	1	-	1	1	1	100	0	0
Sandeel_SA1_2016_51	219	85		16-04-2016	27.4.b	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_52	219	90		16-04-2016	27.4.b	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_53	219	100		16-04-2016	27.4.b	1	1	1	1	1	1	1	100	0	0
Sandeel_SA1_2016_54	219	110		16-04-2016	27.4.b	1	1	1	1	-	1	1	100	0	0
Sandeel_SA1_2016_55	219	120		16-04-2016	27.4.b	1	2	2	2	2	2	2	83	22	15

Sandeel_SA1_2016_56	219	130		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_57	219	140		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_58	219	150		17-04-2016	27.4.b	2	2	2	1	2	2	2	83	22	15
Sandeel_SA1_2016_59	219	160		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_60	219	170		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_61	219	135		17-04-2016	27.4.b	2	3	2	2	2	2	2	83	19	13
Sandeel_SA1_2016_62	219	140		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_63	219	145		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_64	219	150		17-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2016_65	219	180		17-04-2016	27.4.b	3	3	2	3	3	2	3	67	19	17
Sandeel_SA1_2016_66	219	185		17-04-2016	27.4.b	4	4	4	4	4	4	4	100	0	0
Sandeel_SA1_2016_67	219	160		16-04-2016	27.4.b	4	4	4	4	4	3	4	83	11	7
Sandeel_SA1_2016_74	219	105		24-11-2015	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2018_100	219	165	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_81	219	155	M	21-11-2018	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA1_2018_82	219	165	F	21-11-2018	27.4.b	2	3	2	3	2	3	2	50	22	20
Sandeel_SA1_2018_83	219	70		21-11-2018	27.4.b	0	0	0	0	0	1	0	83	-	-
Sandeel_SA1_2018_84	219	80		21-11-2018	27.4.b	0	0	0	0	0	1	0	83	-	-
Sandeel_SA1_2018_85	219	90		21-11-2018	27.4.b	0	0	0	0	0	1	0	83	-	-
Sandeel_SA1_2018_86	219	100		21-11-2018	27.4.b	0	0	0	0	0	1	0	83	-	-
Sandeel_SA1_2018_87	219	100	F	21-11-2018	27.4.b	0	1	1	0	1	2	1	50	90	67
Sandeel_SA1_2018_88	219	110	M	21-11-2018	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA1_2018_89	219	115	M	21-11-2018	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA1_2018_90	219	125	F	21-11-2018	27.4.b	2	2	2	2	2	0	2	83	49	33
Sandeel_SA1_2018_91	219	125	M	21-11-2018	27.4.b	1	1	1	2	1	2	1	67	39	33
Sandeel_SA1_2018_92	219	135	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_93	219	140	M	21-11-2018	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA1_2018_94	219	140	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_95	219	145	F	21-11-2018	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA1_2018_96	219	150	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA1_2018_97	219	155	M	21-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0

Sandeel_SA1_2018_98	219	155	F	21-11-2018	27.4.b	4	4	2	4	4	4	4	83	22	15
Sandeel_SA1_2018_99	219	160	M	21-11-2018	27.4.b	1	3	1	3	2	3	3	50	45	38
Sandeel_SA3_2016_21	219	135		13-05-2016	27.4.a	1	2	1	2	1	3	1	50	49	40
Sandeel_SA3_2016_25	219	125		28-04-2016	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA3_2016_26	219	130		28-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2016_27	219	140		28-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2016_28	219	160		28-04-2016	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2016_29	219	185		09-05-2016	27.4.a	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2016_33	219	200		09-05-2016	27.4.a	4	4	3	4	4	3	4	67	14	12
Sandeel_SA3_2016_34	219	180		13-05-2016	27.4.a	4	5	6	3	4	5	4	33	23	19
Sandeel_SA3_2016_35	219	165		13-05-2016	27.4.a	4	4	4	4	4	4	4	100	0	0
Sandeel_SA3_2016_36	219	175		13-05-2016	27.4.a	4	-	4	5	4	3	4	60	18	10
Sandeel_SA3_2016_37	219	175		13-05-2016	27.4.a	4	5	5	5	4	3	5	50	19	15
Sandeel_SA3_2016_38	219	245		09-05-2016	27.4.a	6	5	5	5	7	4	5	50	19	15
Sandeel_SA3_2016_39	219	225		09-05-2016	27.4.a	7	7	5	7	7	5	7	67	16	14
Sandeel_SA3_2017_22	219	100		26-04-2017	27.4.a	1	2	1	1	1	1	1	83	35	24
Sandeel_SA3_2017_23	219	150		26-04-2017	27.4.a	1	3	2	2	1	2	2	50	41	30
Sandeel_SA3_2017_24	219	120		26-04-2017	27.4.a	1	1	1	1	1	1	1	100	0	0
Sandeel_SA3_2017_30	219	210		26-04-2017	27.4.a	3	3	3	3	3	3	3	100	0	0
Sandeel_SA3_2017_31	219	195		26-04-2017	27.4.a	3	3	3	2	3	3	3	83	14	10
Sandeel_SA3_2017_32	219	200		26-04-2017	27.4.a	3	3	3	3	3	3	3	100	0	0
Sandeel_SA3_2017_40	219	250		26-04-2017	27.4.a	8	9	7	7	8	6	7	33	14	11
Sandeel_SA3_2018_101	219	45		05-12-2018	27.4.b	0	-	0	0	0	0	0	100	-	-
Sandeel_SA3_2018_102	219	70		03-12-2018	27.3.a.20	0	0	0	0	0	0	0	100	-	-
Sandeel_SA3_2018_103	219	80		03-12-2018	27.3.a.20	0	0	0	0	0	1	0	83	-	-
Sandeel_SA3_2018_104	219	95	F	05-12-2018	27.4.b	0	3	0	0	0	2	0	67	-	-
Sandeel_SA3_2018_105	219	125	F	25-11-2018	27.4.b	1	1	1	1	1	2	1	83	35	24
Sandeel_SA3_2018_106	219	135	F	25-11-2018	27.4.b	1	1	1	1	1	1	1	100	0	0
Sandeel_SA3_2018_107	219	100		27-11-2018	27.4.b	0	1	1	1	0	2	1	50	90	67
Sandeel_SA3_2018_108	219	105		27-11-2018	27.4.b	0	1	0	0	0	1	0	67	-	-
Sandeel_SA3_2018_109	219	115		27-11-2018	27.4.b	0	1	0	-	0	1	0	60	-	-

Sandeel_SA3_2018_110	219	140	F	25-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_111	219	140	M	25-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_112	219	150	F	25-11-2018	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA3_2018_113	219	155	F	25-11-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_114	219	160	F	05-12-2018	27.4.b	2	2	2	2	2	2	2	100	0	0
Sandeel_SA3_2018_115	219	165	M	05-12-2018	27.4.b	1	2	2	2	2	2	2	83	22	15
Sandeel_SA3_2018_116	219	170	F	05-12-2018	27.4.b	2	2	2	2	2	4	2	83	35	24
Sandeel_SA3_2018_117	219	175	F	05-12-2018	27.4.b	2	2	2	2	2	3	2	83	19	13
Sandeel_SA3_2018_118	219	185	M	25-11-2018	27.4.b	3	3	3	3	3	4	3	83	13	9
Sandeel_SA3_2018_119	219	190	M	25-11-2018	27.4.b	3	4	4	4	4	4	4	83	11	7
Sandeel_SA3_2018_120	219	200	F	25-11-2018	27.4.b	4	5	5	4	4	5	4	50	12	11
Sandeel_SA5_2011_08	219	145		08-05-2011	27.4.a	2	2	2	2	2	2	2	100	0	0
Sandeel_SA5_2011_09	219	95		08-05-2011	27.4.a	2	3	2	2	2	2	2	83	19	13
Sandeel_SA5_2011_10	219	135		08-05-2011	27.4.a	2	2	2	2	2	-	2	100	0	0
Sandeel_SA5_2011_12	219	160		08-05-2011	27.4.a	3	2	2	3	3	2	2	50	22	20
Sandeel_SA5_2011_13	219	170		08-05-2011	27.4.a	3	4	2	3	3	3	3	67	21	11
Sandeel_SA5_2011_14	219	215		08-05-2011	27.4.a	4	4	4	4	4	3	4	83	11	7
Sandeel_SA5_2011_15	219	195		08-05-2011	27.4.a	4	4	4	4	4	3	4	83	11	7
Sandeel_SA5_2011_17	219	185		08-05-2011	27.4.a	5	5	5	5	5	4	5	83	8	6
Sandeel_SA5_2011_18	219	200		08-05-2011	27.4.a	6	7	6	7	6	5	6	50	12	9
Sandeel_SA5_2011_19	219	205		08-05-2011	27.4.a	7	7	7	7	7	4	7	83	19	13
Sandeel_SA5_2011_20	219	215		08-05-2011	27.4.a	9	9	9	9	9	8	9	83	5	3
Sandeel_SA5_2017_01	219	85		14-05-2017	27.4.a	0	-	1	1	-	1	1	75	67	50
Sandeel_SA5_2017_02	219	110		14-05-2017	27.4.a	0	-	0	1	0	1	0	60	-	-
Sandeel_SA5_2017_03	219	140		14-05-2017	27.4.a	0	-	0	1	0	-	0	75	-	-
Sandeel_SA5_2017_04	219	95		14-05-2017	27.4.a	1	1	1	1	1	3	1	83	61	42
Sandeel_SA5_2017_05	219	135		14-05-2017	27.4.a	2	2	2	2	2	2	2	100	0	0
Sandeel_SA5_2017_06	219	105		14-05-2017	27.4.a	1	2	1	2	1	2	1	50	37	33
Sandeel_SA5_2017_07	219	120		14-05-2017	27.4.a	2	3	2	2	2	3	2	67	22	19
Sandeel_SA5_2017_11	219	150		14-05-2017	27.4.a	3	4	3	3	3	3	3	83	13	9
Sandeel_SA5_2017_16	219	175		14-05-2017	27.4.a	5	5	5	5	5	4	5	83	8	6

Table 27: Number of age readings table gives an overview of number of readings per reader and modal age. The total numbers of readings per reader and per modal age are summarized at the end of the table.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK	total
0	13	10	13	12	13	12	**73**
1	33	32	33	32	31	33	**194**
2	44	44	44	44	44	43	**263**
3	10	10	10	10	10	10	**60**
4	11	10	11	11	11	11	**65**
5	4	4	4	4	4	4	**24**
6	1	1	1	1	1	1	**6**
7	3	3	3	3	3	3	**18**
8	0	0	0	0	0	0	**0**
9	1	1	1	1	1	1	**6**
Total	**120**	**115**	**120**	**118**	**118**	**118**	**709**

Table 28: Age composition by reader gives a summary of number of readings per reader.

Modal age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK
0	17	7	13	10	16	**3**
1	33	31	35	31	29	**19**
2	42	42	47	46	43	**54**
3	9	14	7	12	10	**25**
4	11	10	7	9	12	**10**
5	2	6	6	5	2	**5**
6	2	0	2	0	1	**1**
7	2	3	2	4	3	**0**
8	1	0	0	0	1	**1**
9	1	2	1	1	1	**0**
Total	**120**	**115**	**120**	**118**	**118**	**118**

Table 29: Mean length at age per reader is calculated per reader and age (not modal age) and for all readers combined per age. A weighted mean is also given.

| Age	R01 NO	R02 DK	R03 NO	R04 DK	R05 NO	R06 DK
0	97 mm	89 mm	95 mm	84 mm	100 mm	**80 mm**
1	118 mm	113 mm	115 mm	114 mm	114 mm	**102 mm**
2	145 mm	145 mm	147 mm	144 mm	146 mm	**135 mm**
3	182 mm	156 mm	186 mm	171 mm	174 mm	**160 mm**
4	182 mm	178 mm	184 mm	185 mm	183 mm	**186 mm**
5	180 mm	193 mm	201 mm	191 mm	180 mm	**191 mm**
6	222 mm	-	190 mm	-	200 mm	**250 mm**
7	215 mm	210 mm	228 mm	220 mm	225 mm	**-**
8	250 mm	-	-	-	250 mm	**215 mm**
9	215 mm	232 mm	215 mm	215 mm	215 mm	**-**
Weighted Mean	**142 mm**	**143 mm**	**142 mm**	**142 mm**	**142 mm**	**142 mm**
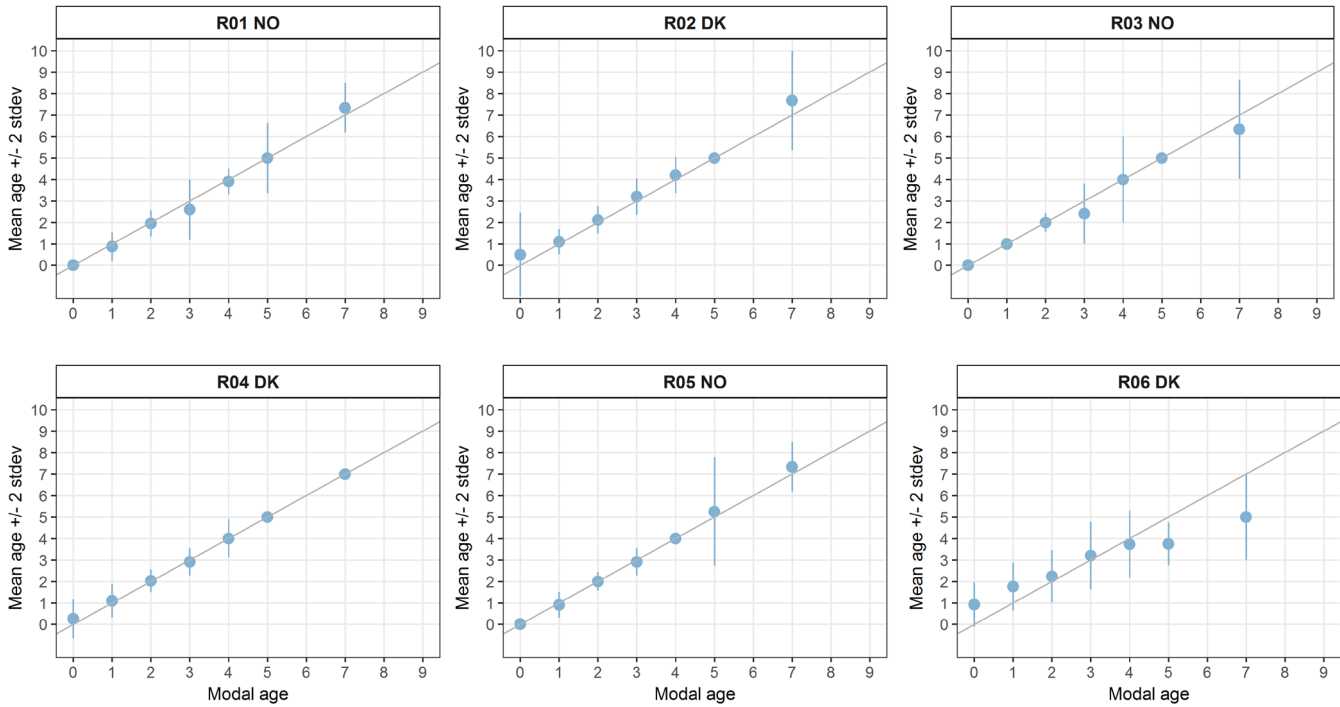
Figure 13: Age bias plot for each individual reader. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between estimated mean age and modal age.
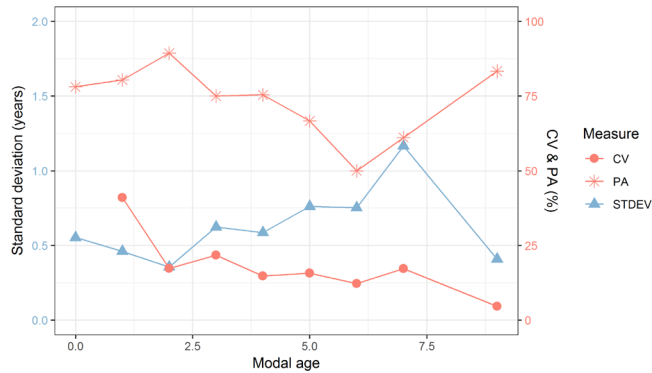

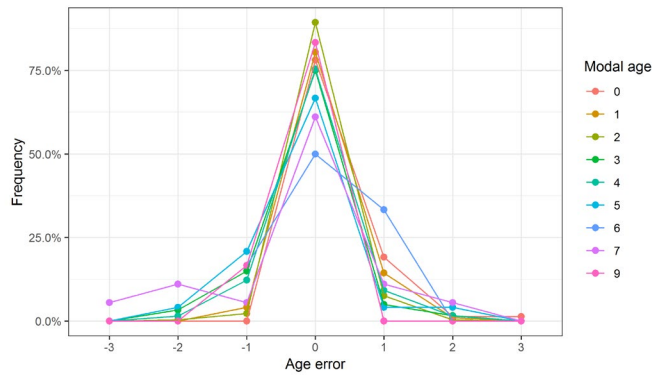**Figure 14:** CV, PA and (STDEV (standard deviation) are plotted against modal age

Figure 15: The distribution of the age reading errors in percentage by modal age as observed from the whole group of age readers in an age reading comparison to modal age. The achieved precision in age reading by MODAL age group is shown by the spread of the age readings errors. There appears to be no relative bias, if the age reading errors are normally distributed. The distributions are skewed, if relative bias occurs.
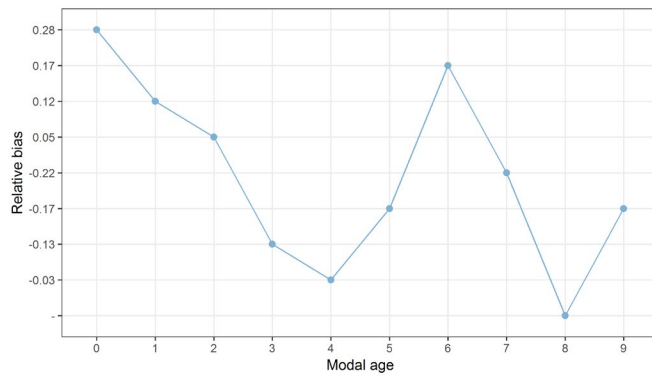

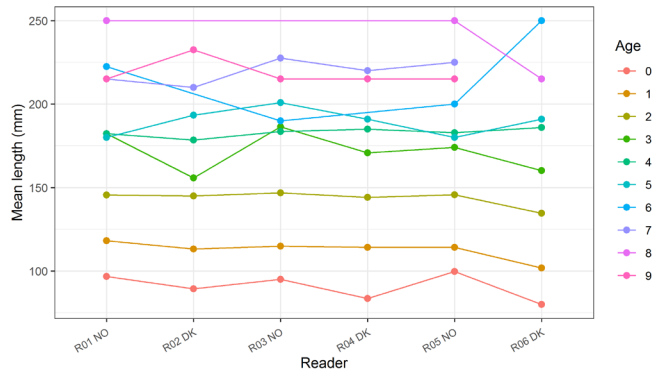**Figure 16:** The relative bias by modal age as estimated by all age readers combined.

Figure 17: The mean length at age as estimated by each age reader.