

Results from the Sandeel age reading exchange 2016

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Readers

Table 1. Participants

Reader Code	First name	Last name	Institute	Expertise level
1_NOR1	Lisbet	Solbakken	IMR Norway	Expert
2_NOR2	Hildegunn	Mjanger	IMR Norway	Expert
3_NOR3	Åse	Husebø	IMR Norway	Trainee
4_NOR4	Inger	Henriksen	IMR Norway	Expert
5_DNK1	Tom	Svoldgaard	DTU Aqua Denmark	Expert
7_DNK2	Susanne	Hansen	DTU Aqua Denmark	Expert
10_GBR1	John	Clarke	Marine Lab Scotland	Expert

Samples

A1_Q4 captured in Sandeel Area 1 in November 2015 and A1_Q2 captured in Sandeel Area 1 in April 2016; both samples provided by DTU Aqua Denmark.

A3_Q2 captured in Sandeel Area 3 in May 2014 and provided by IMR Norway.

Table 2. Sample overview showing number of samples per length group per area. Length is given in mm.

	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	Total	
A1_Q4				2	4	4	6	7	13	8	6	6	2	2									60
A1_Q2	1	1	1	3	3	4	4	1		3	2	3	2	3	6	3	5	5	6	3	1		60
A3_Q2									2	4	4	3	7	4		1							25
Total	1	1	1	5	7	8	10	8	15	15	12	12	11	9	6	4	5	5	6	3	1	145	

Methods

Images of single otoliths (A1_Q4 and A1_Q2) and otolith pairs (A3_Q2) immersed in alcohol were taken on a black background under reflected light using a standard setup at DTU Aqua. The image set was made available for annotation on WebGR. Readers were asked to place their annotations along a defined line in order to standardise the axis where growth increment widths could be measured and give a final estimation of age. Readers were provided with information on the capture date, area and fish TL.

Analysis

Only expert readers who provide age data to be included in stock assessment were included in the final analysis. The estimated age data was used to analyse the agreement between readers by means of the traditional procedures:

- Average percentage agreement ($n_{\text{modal age}}/n_{\text{total}}*100$)
- Coefficient of variation (CV) ($\text{Standard deviation}/\text{average}*100$)
- Bias plots and tests

As the calculations of both CV and APE poses 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. An index of average percentage error (APE) was also calculated as this method is not independent of fish age and thus provides a better estimate of precision.

An age error matrix was produced where the matrix shows the proportion of each modal age mis-aged as other ages. The sum of each row is 1, equal to 100%.

The growth increment width data from WebGR was used to establish growth curves for each fish and for each reader. These growth curves were analysed using Linear Mixed Effects Models (LMEM). The model that best fit the data was a model with winter ring (the log of) and reader as fixed effects and individual images as random effects.

Samples from Sandeel Areas 1 and 3 were firstly analysed together followed by a separate analysis of Sandeel Area 1.

Results for Sandeel Areas 1 and 3 combined

Based on expert readers alone the overall percentage agreement is 86.9% (Table 3) and coefficient of variation is 17% (Table 4). The average percentage error (APE) is 12.8%.

At modal age 0, four of the readers are in 100% agreement with modal age (Table 3) but it is the low level of agreement by one of the Danish readers and to a lesser extent one of the Norwegian readers which brings the overall level of agreement at age 0 down to 83%. In some otoliths there appears to be a faint opaque zone between the highly opaque centre and the otolith edge (Annex Figure 3) which these 2 readers interpret to be a growth zone and thus an extra year is added to the age of these fish.

At modal age 1, the CV is high (Table 4) and this is mostly due to the readings of the otoliths from A3_Q2 which were included in the exchange as “discussion” otoliths, where there is often a faint translucent zone visible in the highly opaque centre (Annex Figure 4). This is sometimes counted as a winter ring by the readers who assign an age of 2 to these fish.

These same otoliths contribute to the high CV at modal age 2.

Table 3. Percentage Agreement based on expert readers

Modal Age	1_NOR1	2_NOR2	4_NOR4	5_DNK1	7_DNK2	10_GBR1	ALL
0	80	100	100	20	100	100	83
1	99	96	95	65	85	94	89
2	69	69	92	92	83	83	81
3	90	90	100	75	90	86	89
4	100	67	100	100	100	100	94
5	100	100	100	0	100	100	83
Weighted Mean	89.6	88	95.3	71.9	86.2	90.5	86.9 %

Table 4. Coefficient of Variation based on expert readers

Modal Age	1_NOR1	2_NOR2	4_NOR4	5_DNK1	7_DNK2	10_GBR1	ALL
0	-	-	-	-	-	-	-
1	11	20	21	36	47	26	20.7
2	28	28	14	13	21	21	15.9
3	10	10	0	17	10	13	7.5
4	0	16	0	0	0	0	3.5
5	0	0	0	0	0	0	8.4
Weighted Mean	22.1	19.6	14.9	27.3	32.3	21.3	17 %

The age bias plots for each expert reader are shown in Figure 1 which illustrates that some readers have a slight tendency to overestimate the ages in comparison to modal age while other have a slight tendency to underestimate the age in comparison to modal age. The overall bias value is just positive (0.02). Most noticeable are the positive bias values for the above mentioned readers (1_NOR1 and 5_DNK1) at age 0. The age error matrix (Table 5) also shows this, where 17% of modal age 0 fish are estimated to be 1 year old.

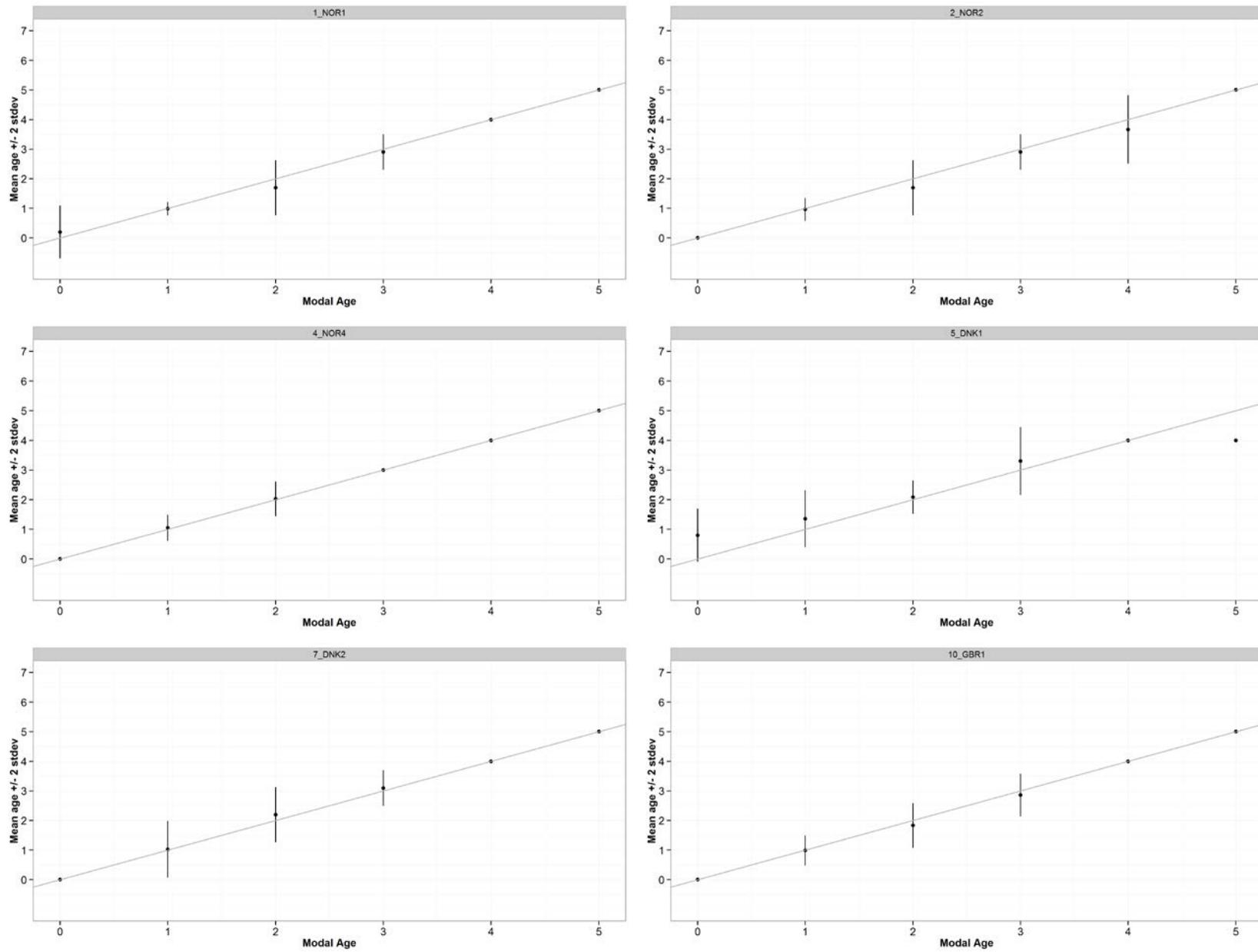


Figure 1. Age bias plots for each reader as mean age \pm 2 SD on modal age

Table 5. Age error matrix based on expert readers. Values in bold indicate the proportion of estimated ages in agreement with modal age, those in red are the proportion estimated to be ages greater than modal age and those in blue are the proportion estimated to be ages less than modal age.

Age Modal Age	0	1	2	3	4	5
0	0.83	0.03	0	0	0	0
1	0.17	0.89	0.13	0	0	0
2	0	0.08	0.81	0.06	0	0
3	0	0	0.05	0.89	0.06	0
4	0	0	0	0.05	0.94	0.17
5	0	0	0	0.01	0	0.83

The Linear Mixed Effect Model used to analyse the growth increment width data showed significant differences ($p < 0.05$) in the intercept and the slope of the LMEM indicating there are differences in the interpretation of the first and subsequent winter rings. A post-hoc Tukey Contrasts test for multiple pairwise comparisons followed to identify inter reader differences and results showed that the Danish reader (5_DNK1) differs from the rest of the group. This is most apparent at ages 1 and 2 (Figure 2).

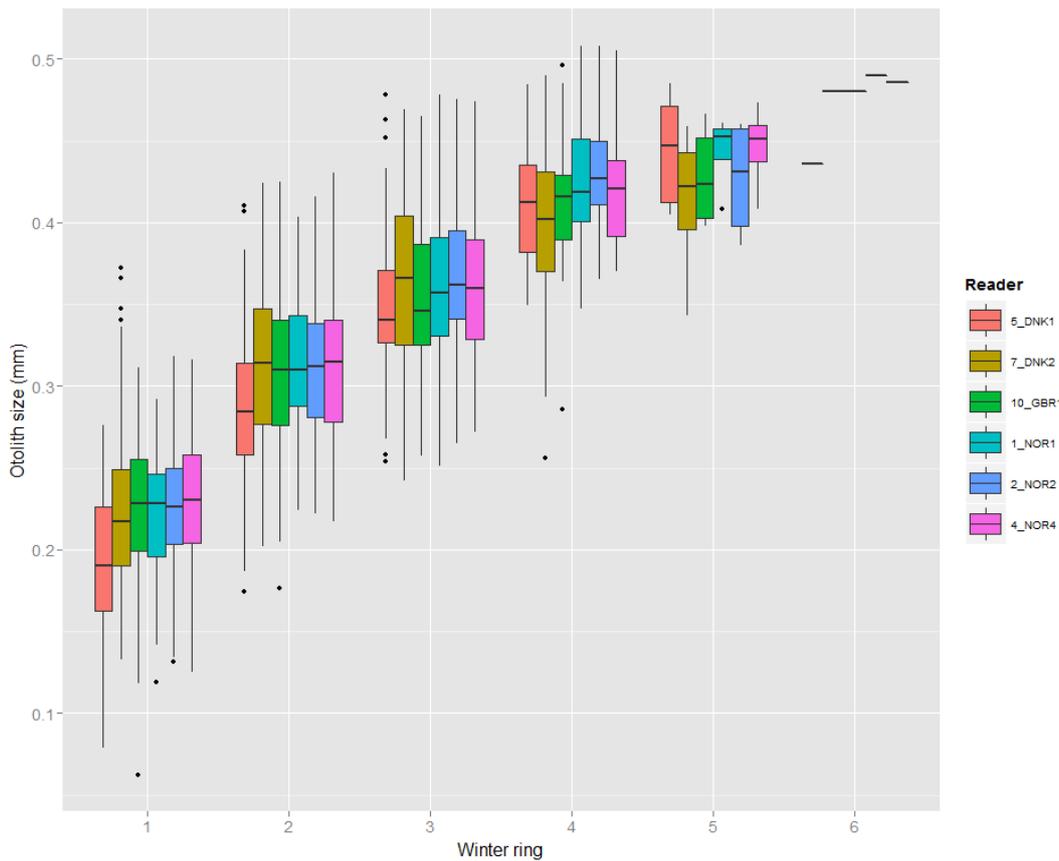


Figure 2. Plot of average distance to the centre for winter rings 1-6 for all expert readers. The boxes represent the mean, upper and lower box boundaries of the interquartile range, whiskers represent the minimum and maximum values and the dots represent the outliers.

Given that the samples from A3_Q2 were included in the exchange set for discussion and were considered problematic a second analysis was carried out by area (based on expert readers only).

Results for Sandeel Area 1

Based on expert readers alone the overall percentage agreement is 91.2% (Table 6) and coefficient of variation is 12.7% (Table 7). The average percentage error (APE) is 9.4%. The relatively high CV at age 1 is mostly attributable to some otoliths where the growth zones are not easily distinguishable from each other and thus a range of estimated ages provided by the readers and a few examples of mis-identification of the edge type by reader 5_DNK1 (Annex Figure 5). The age error matrix (Table 8) shows a decrease in the error at ages 1 and 2.

Table 6. Percentage Agreement for A1_Q4 and A1_Q2 combined

Modal Age	1_NOR1	2_NOR2	4_NOR4	5_DNK1	7_DNK2	10_GBR1	All
0	75	100	100	25	100	100	83
1	98	95	94	77	91	94	91
2	100	96	88	88	100	92	94
3	90	90	100	75	90	86	89
4	100	67	100	100	100	100	94
5	100	100	100	0	100	100	83
Weighted Mean	96.3	93.8	94.2	77.2	93.3	92.6	91.2 %

Table 7. Coefficient of Variation for A1_Q4 and A1_Q2 combined

Modal Age	1_NOR1	2_NOR2	4_NOR4	5_DNK1	7_DNK2	10_GBR1	CV_ALL
0	-	-	-	-	-	-	-
1	13	22	23	35	32	26	17.6
2	0	10	17	16	0	14	5.8
3	10	10	0	17	10	13	7.5
4	0	16	0	0	0	0	3.5
5	0	0	0	0	0	0	8.4
Weighted Mean	15.6	16.2	16	27.8	19.1	19.4	12.7 %

Table 8. Age error matrix for A1_Q4 and A1_Q2 combined. Values in bold indicate the proportion of estimated ages in agreement with modal age, those in red are the proportion estimated to be ages greater than modal age and those in blue are the proportion estimated to be ages less than modal age.

Age Modal Age	0	1	2	3	4	5
0	0.83	0.03	0	0	0	0
1	0.17	0.91	0.03	0	0	0
2	0	0.05	0.94	0.06	0	0
3	0	0	0.03	0.89	0.06	0
4	0	0	0	0.05	0.94	0.17
5	0	0	0	0.01	0	0.83

Results for Sandeel Area 3

Only 25 pairs of otoliths were included in the exchange from this area. As the sample set is very small and was included more for discussion purposes the full set of results are not included here (but will be used for discussion with the readers). Based on expert readers only the overall percentage agreement is 66% and CV is 37.3%. The average percentage error (APE) is 28.6%.

Conclusions

Overall the level of agreement between the readers who are providing ages for stock assessment is high and the CV is low. When only the samples from Sandeel Area 1 are analysed the percentage agreement is 91.2%, CV is 12.7% and the APE is 9.4%.

Some issues need to be clarified and taken up with the readers, namely;

- Otoliths where there appears to be a faint opaque zone between the highly opaque centre and the otolith edge
- Otoliths where there is often a faint translucent zone visible in the highly opaque centre
- Correct identification of the edge type

Image examples of the above mentioned problems can be found in the Annex.

Annex

Image examples of issues that need to be clarified with the readers

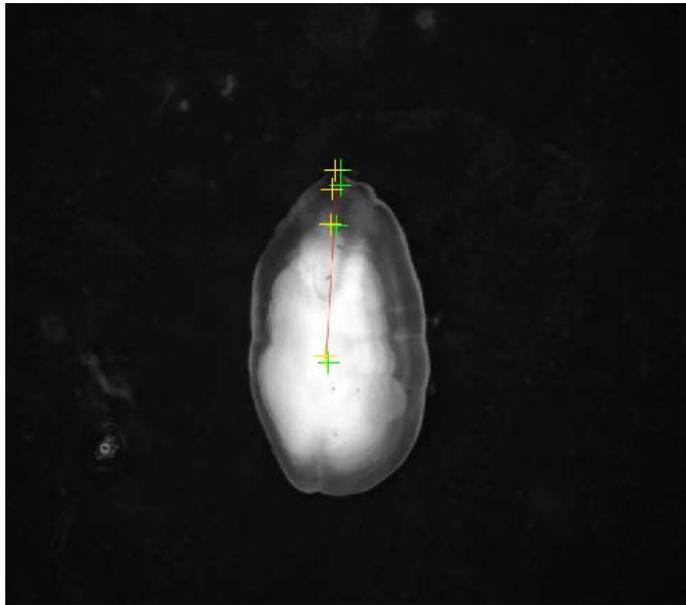


Figure 3. TBM 113; 125mm; capture date 28/11/2015; modal age 0 (tom and lisbet age 1, see annotations on image); 125mm; capture date 28/11/15. See WebGR for otoliths with similar problems: TBM 117, TBM 119 and TBM 95

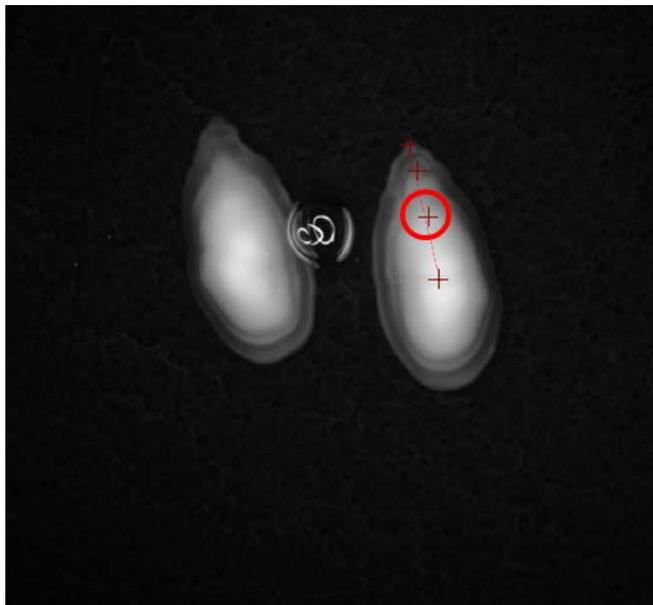


Figure 4. TBM 121; 135mm; capture date 03/05/2015; modal age 1. The false winter ring circled is sometime counted by the readers. See WebGR for similar problems: TBM 124, TBM 126, TBM 128 and TBM 130 and many samples from SA3_Q2.

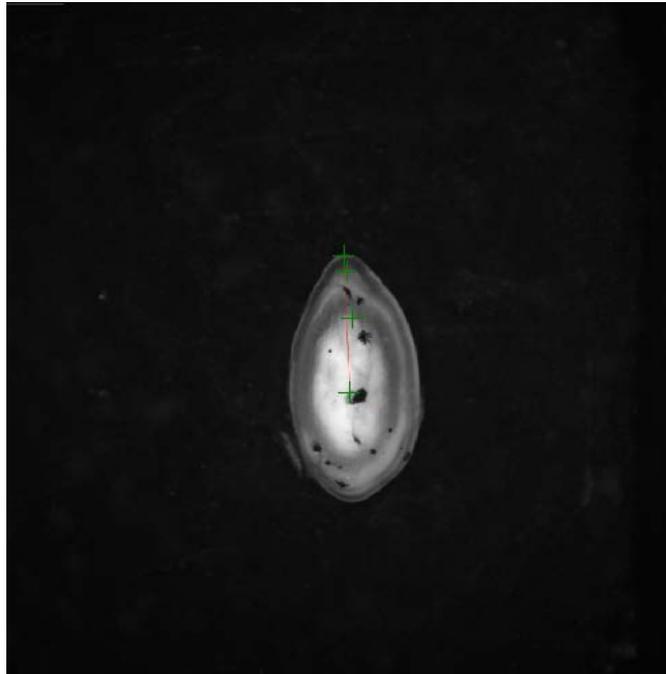


Figure 5. TBM 84; 110mm; capture date 24/11/2015; modal age 1. The annotations here show the outermost translucent zone to be counted as a second winter ring but with capture date in November this translucent ring should not be included in the count of age. See WebGR for similar problems: TBM 89, TBM 92, TBM 97 and TBM 98, TBM 99.

Readers should follow the guidelines for when to count the translucent zones at the edge

- From January 1st – May 31st : include the translucent band on the edge, even if it is not fully developed.
- From June 1st – December 31st : a translucent band on the edge should not be counted