2020 Western Baltic Cod age reading exchange summary report (SmartDots ID 292 & 294)

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1 Executive summary

The 2020 exchange for Western Baltic cod (cod.27.22-24) took place from September to December 2020 via the ICES SmartDots platform https://www.ices.dk/data/tools/Pages/smartdots.aspx . Nine readers with varying levels of experience from Denmark, Germany and Sweden took part. Otoliths from 186 fish, age range 1 – 6 years from ICES SD's 22 and 23 were selected from the 2017, 2018 and 2019 Danish BITS (KASU) Q1 and Q4 surveys after a detailed analyses of the BITS age data during WGBFAS 2020 revealed inconsistencies. For each fish, a photograph of a broken and sectioned otolith was provided for reader annotation. Prior to 2020, Sweden and Denmark routinely read broken cod otoliths but from 2020 onwards, Denmark will read Western Baltic cod otoliths using the sectioned method.

Five participants are considered advanced readers (they provide age data for stock assessment purposes) for this specific stock. Readers level of experience based on number of years reading, number of otoliths read and method have been used to rank the readers level of experience and subsequently applied in the statistical analysis. A summary of the results based only on the advanced readers is given in this report.

Prior to this exchange, two exchanges for cod.27.22-24 took place in 2019. The first, in preparation for the Baltic cod benchmark in Spring 2019 (https://smartdots.ices.dk/ViewEvent?key=201) which included Q3 and Q4 sectioned otoliths (n=49) with an overall weighted average percentage agreement of 85% and an weighted average CV of 15%, based on advanced readers. The second, in Autumn 2019 (https://smartdots.ices.dk/ViewEvent?key=251) which included Q4 and Q1 sectioned otoliths (n=355) with an overall weighted average percentage agreement of 81% and a weighted average CV of 17%, based on advanced readers. Following the Autumn exchange an age reading guide for Western Baltic cod (cod2224) was compiled and circulated to all readers.

This current exchange provides results based on sectioned (SmartDots ID 292) and broken (SmartDots ID 294) otoliths separately. For the sectioned otoliths, the overall weighted average percentage agreement of 91% was reached, with a weighted average CV of 17% based on four advanced readers. For broken otoliths, an overall weighted average percentage agreement of 88% was reached with a weighted average CV of 18% based on three advanced readers. The overall relative bias is positive and in comparison to the 2019 exchanges, the same trends are apparent with the Swedish and Danish readers showing positive relative bias and the German reader negative relative bias.

In addition, a comparison of the modal ages for each fish and each method (broken vs. sectioned) was included and this resulted in agreement on 87% of the samples with a CV of 8.5%. The otolith growth plots show that for broken otoliths there is a greater number of outliers in comparison to the sectioned otoliths, showing readers find it more difficult to identify the transition from translucent to opaque zones on the broken otoliths. Identification of the first TZ and edge characteristics are leading to reader error and most apparent on the broken otoliths.

The weighed modal age from the sectioned otoliths was used to update the age estimations in DATRAS, meaning the results from this exchange directly improve the quality of the data used in the stock assessment of Western Baltic cod. The series of exchanges and close cooperation between age reading labs, stock assessor and stock coordinator in recent years have focussed on solving the age reading issues while also realising the need to standardise the age reading methods so that reliable age data can be used in the stock assessment and advice processes.

2 Overview of samples and advanced readers

Table 2.1: Overview of samples (n=186) used for the 2020 Western Baltic cod exchange. The modal age range for all samples is 1-6.

Year	ICES area	Quarter	Number of samples	Modal age range	Length range
2017	27.3.b.23	1	17	1-2	210-300 mm
2017	27.3.c.22	1	14	1-2	220-290 mm
2018	27.3.b.23	1	42	2-4	360-530 mm
2018	27.3.b.23	4	17	2-5	470-670 mm
2018	27.3.c.22	1	10	2-3	310-440 mm
2019	27.3.b.23	1	33	2-4	260-660 mm
2019	27.3.b.23	4	38	1-6	250-820 mm
2019	27.3.c.22	1	6	1-4	210-700 mm
2019	27.3.c.22	4	9	1-2	260-350 mm

Table 2.2: Overview of advanced age readers participating in 2020 Western Baltic Cod exchange.

Reader code	Expertise	Expertise_rank
R02 DE	Advanced	1
R03 DE	Advanced	2
R04 DK	Advanced	3
R05 DK	Advanced	4

3 Results overview

3.1 PA table

Table 3.1: Percentage agreement (PA) table represents the PA per modal age and reader, the PA of all advanced readers combined per modal age and a weighted mean of the PA per reader. Results are shown for sectioned otoliths (ID 292) and broken otoliths (ID 294) separately.

Modal age	R02 DE	R03 DE	R04 DK	R05 DK	All Sectioned	R01 SE	R04 DK	R05 DK	All Broken
1	98 %	100 %	81 %	78 %	**89 %**	98 %	74 %	98 %	**90 %**
2	95 %	98 %	92 %	84 %	**92 %**	93 %	77 %	98 %	**89 %**
3	93 %	98 %	96 %	80 %	**92 %**	67 %	86 %	95 %	**83 %**
4	100 %	100 %	96 %	91 %	**97 %**	88 %	92 %	96 %	**92 %**
5	83 %	92 %	75 %	100 %	**88 %**	64 %	100 %	100 %	**88 %**
6	-	100 %	100 %	100 %	**100 %**	50 %	50 %	100 %	**67 %**
Weighted Mean	**95 %**	**98 %**	**89 %**	**83 %**	**91 %**	**85 %**	**81 %**	**97 %**	**88 %**

3.2 CV table

Table 3.2: 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. Results are shown for sectioned otoliths (ID 292) and broken otoliths (ID 294) separately.

Modal age	R02 DE	R03 DE	R04 DK	R05 DK	All Sectioned	R01 SE	R04 DK	R05 DK	All Broken
1	15 %	0 %	33 %	34 %	**29 %**	14 %	39 %	14 %	**31 %**
2	10 %	7 %	19 %	21 %	**16 %**	13 %	21 %	7 %	**17 %**
3	8 %	5 %	7 %	22 %	**12 %**	19 %	14 %	7 %	**15 %**
4	0 %	0 %	5 %	8 %	**5 %**	9 %	7 %	5 %	**7 %**
5	13 %	6 %	9 %	0 %	**9 %**	11 %	0 %	0 %	**7 %**
6	-	-	-	-	**0 %**	13 %	13 %	0 %	**9 %**
Weighted Mean	10 %	3 %	18 %	22 %	**17 %**	14 %	21 %	8 %	**18 %**

3.3 Relative bias table

Table 3.3: 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. Results are shown for sectioned otoliths (ID 292) and broken otoliths (ID 294) separately.

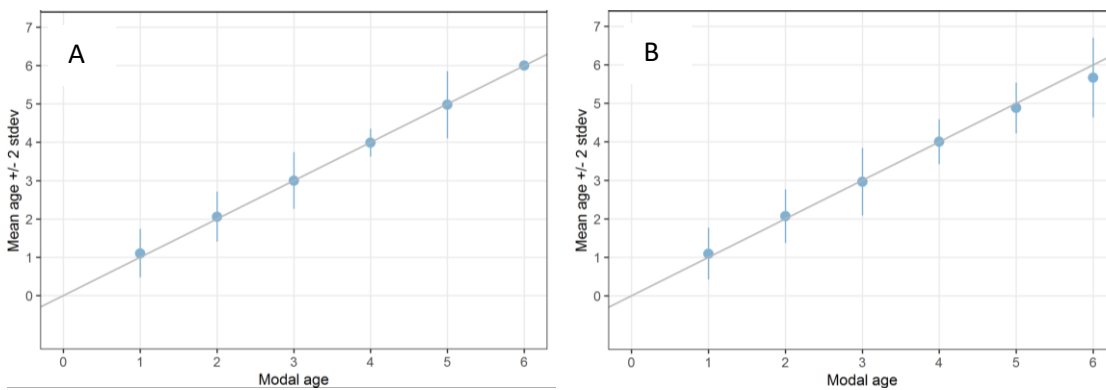| Modal age	R02 DE	R03 DE	R04 DK	R05 DK	All Sectioned	R01 SE	R04 DK	R05 DK	All Broken
1	-0.02	0.00	0.19	0.22	**0.10**	0.02	0.28	-0.02	**0.09**
2	0.05	0.02	0.02	0.14	**0.06**	-0.07	0.25	0.02	**0.07**
3	0.07	0.02	0.00	-0.09	**0.00**	-0.28	0.16	0.00	**-0.04**
4	0.00	0.00	-0.04	0.00	**-0.01**	-0.12	0.08	0.04	**0.00**
5	-0.25	-0.08	0.25	0.00	**-0.02**	-0.36	0.00	0.00	**-0.12**
6	-	0.00	0.00	0.00	**-**	-0.50	-0.50	0.00	**-0.33**
Weighted Mean	**0.01**	**0.01**	**0.07**	**0.08**	**0.04**	**-0.12**	**0.19**	**0.01**	**0.03**

3.4 Bias plot

Figure 1: Age bias plot for advanced readers on A. sectioned otoliths (ID 292) and B. broken otoliths (ID 294).
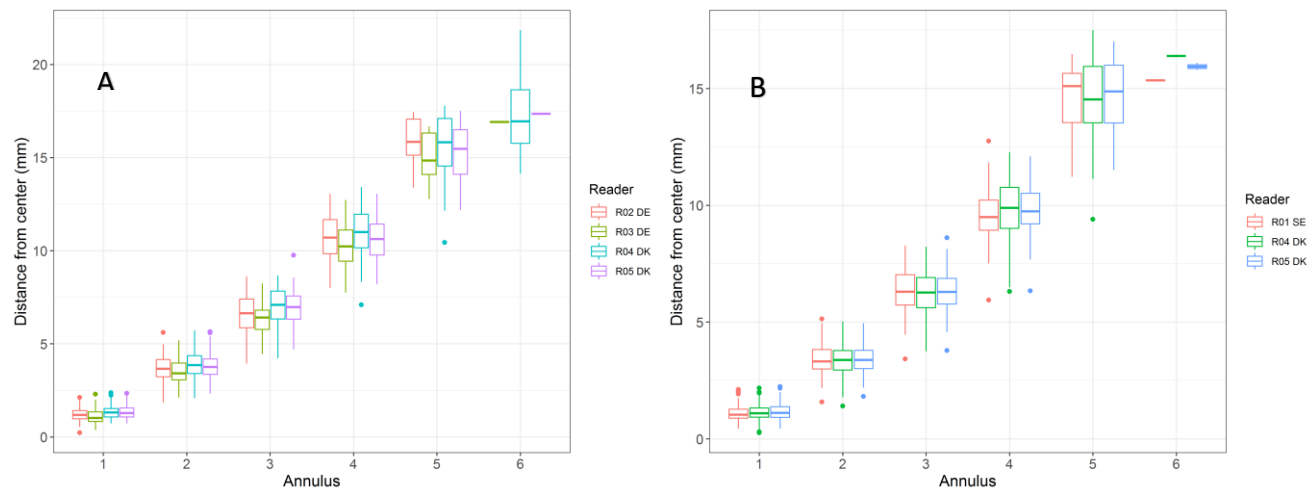
3.5 Otolith growth

Figure 2: Plot of average distance from the centre to the translucent zones for advanced readers on A. sectioned otoliths and on B. broken 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.

3.6 Age error matrices

Table 3.6.1: Age error matrix (AEM) for 27.3.b.23 based on sectioned otoliths (ID 292). The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

Modal age	1	2	3	4	5	6
Age 1	**0.8712**	0.006494	0.012658	-	-	-
Age 2	0.1288	**0.909091**	0.031646	-	-	-
Age 3	-	0.077922	**0.911392**	0.02299	0.02083	-
Age 4	-	0.006494	0.037975	**0.96552**	0.04167	-
Age 5	-	-	0.006329	0.01149	**0.87500**	-
Age 6	-	-	-	-	0.06250	**1**

Table 3.6.2: Age error matrix (AEM) for 27.3.c.22 based on sectioned otoliths (ID 292). The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

Modal age	1	2	3	4
Age 0	0.01282	0.02564	-	-
Age 1	**0.92308**	-	-	-
Age 2	0.06410	**0.97436**	-	-
Age 3	-	-	**0.94737**	-
Age 4	-	-	0.05263	**1**

Table 3.6.3: Age error matrix (AEM) for 27.3.b.23 based on broken otoliths (ID 294). The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

Modal age	1	2	3	4	5	6
Age 0	0.01042	-	-	-	-	-
Age 1	**0.89583**	0.00813	-	-	-	-
Age 2	0.08333	**0.88618**	0.114035	-	-	-
Age 3	0.01042	0.09756	**0.815789**	0.04348	-	-
Age 4	-	0.00813	0.061404	**0.91304**	0.1212	-
Age 5	-	-	0.008772	0.04348	**0.8788**	0.3333
Age 6	-	-	-	-	-	**0.6667**

Table 3.6.4: Age error matrix (AEM) for 27.3.c.22 based on broken otoliths (ID 294). The AEM shows the proportional distribution of age readings for each modal age. Age column should sum to one but due to rounding there might be small deviations in some cases. Only advanced readers are used for calculating the AEM.

Modal age	1	2	3	4
Age 1	**0.90566**	0.06667	-	-
Age 2	0.09434	**0.91111**	0.06667	-
Age 3	-	0.02222	**0.93333**	-
Age 4	-	-	-	1

4   Conclusion

For sectioned otoliths (ID 292), the overall PA was 91%, with individual reader PA ranging from 83% to 98% (Table 3.1). The overall CV was 17% (Table 3.2). The overall relative bias is positive (Table 3.3 and Figure 1) and in comparison to the 2019 exchanges, the same trends are apparent with the Swedish and Danish readers showing positive relative bias and the German reader negative relative bias.

For broken otoliths (ID 294), the overall PA was 88%, with individual reader PA ranging from 81% to 97% (Table 3.1). The overall CV was 18% (Table 3.2). The overall relative bias is positive (Table 3.3 and Figure 1), the Swedish reader underestimating at all ages except modal age 1 and Danish readers showing an overall positive bias.

A modal age comparison, based on only the expert readers for each method was carried out. Modal ages were compared by a two-way comparison. In general, there was a high level of agreement between methods (PA 87%) with a higher number of otoliths being over-aged (n= 14) compared to under-aged (n=9) when broken modal age was compared to sectioned modal age. At modal age 1, this is most noticeable with 5 fish being estimated to be 2 years old by the broken method. Individual reader results (see full report Annex) for each method clearly show that for some expert readers (and even more so for the inexperienced readers), the broken otoliths cause confusion and incorrect age estimates which is in part due to the poor quality of the preparations but also reader errors. The otolith growth plots (Figure 2) show that for the broken otoliths there is a wider range of maximum and minimum values and a greater number of outliers in comparison to that for the sectioned otoliths. This shows that the readers find it more difficult to clearly identify the transition from translucent to opaque zones on the broken otoliths.

This summary report shows only the results of the exchange based on advanced readers (those who provide age data for stock assessment purposes). The results based on all readers can be found in the full report.

The age reading issues apparent from an examination of the otoliths are consistent with previous exchanges for this stock, namely the inclusion of a translucent zone at the edge in the later part of the year, leading to overestimation of age. For Western Baltic cod (age 0 to 3), recent age validation studies using tetracycline marked recaptures showed that the translucent zones (TZ's) are formed during the summer, contrary to the assumption that TZ's are formed during winter (McQueen et al., 2019, Krumme et al., 2020, Plonus et al. 2021). This means that readers need to adjust their interpretations of the TZ's for this stock. No age 0 fish were included in this exchange but the problem is apparent with age 1 fish (see Figure 5.3 in full report). An age reader guide for Western Baltic cod (age 0 to 3) with image examples was compiled after the 2019 exchanges and readers are strongly advised to follow this when reading Western Baltic cod otoliths, especially for training purposes.

The weighed modal age from the sectioned otoliths (determined by the advanced readers, full report Annex 2 Table 6.2) has been used to update the age estimations in DATRAS, meaning the results from this exchange directly improve the quality of the data used in the stock assessment of Western Baltic cod. There has been close cooperation between Danish, German and Swedish age reading labs, Western Baltic cod stock assessor and stock coordinator in recent years. The series of exchanges have focussed on solving the age reading errors that have become apparent during the process, while also realising the need to standardise the age reading methods so that reliable age data can be used in the stock assessment and advice processes.