Workshop 2 on Age Reading of North Sea plaice (*Pleuronectes platessa*) WKARP2 (SmartDots ID 402)

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1 Summary

Workshop 2 on age reading of North Sea plaice (*Pleuronectes platessa*), (WKARP2) (ICES, 2022a; full report https://ices-library.figshare.com/articles/report/Workshop_2_on_Age_Reading_of_North_Sea_plaice_Pleuronectes_platessa_WKARP2_outputs_from_2021_meeting_/20473083) was the first age reading workshop focusing specifically on age reading of the North Sea plaice stock (ple.27.420) in the North Sea and Skagerrak. The objectives of the workshop were: to evaluate the level of agreement between age readers for the stock by reviewing results of the 2020 North Sea Skagerrak plaice exchange in consideration of previous calibration and validation work; to standardize laboratory procedures and age reading methods applied; to provide guidelines for reliable age interpretation; to provide age error data to the stock assessment working group; to create an agreed age reference collection of otoliths.

This summary report outlines the results from Workshop 2 on Age Reading of North Sea plaice (Pleuronectes platessa) WKARP2 (SmartDots ID 402) that took place in December 2021. Results are based only on the advanced age readers who provide age data for stock assessment purposes.

Two age reading exercises, one exchange before the workshop (SmartDots ID 281), and one workshop exercise (ID 402) were completed using SmartDots. Age readers' annotations of growth structures and ageing results from both exercises were examined using standardized quality analyses based on an R script, presented in this report. Age reading error data has been provided to the ICES WGNSSK (Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak) which can be tested in the ple.27.420 stock assessment model. Disagreement between readers is mostly attributable to differences in the identification of the first winter ring as this can vary in width across samples collected from different areas. Results showed that estimated ages in older fish can be unreliable due to a narrowing of the annuli close to the otolith edge. Further work is required to provide guidelines for age readers about which structures should be identified as annuli. Different preparation methods are applied in national laboratories. The group concluded that reading whole and sectioned otoliths viewed under reflected light is optimal; no obvious benefit was identified from sectioning plaice otoliths from fish under the age of 6. Using images of otoliths, the reliability of the age reading results is depending on image quality. To help standardize image format, lighting and calibration a workshop is recommended to establish a set of guidelines for image quality used in age determination.

2 Overview of samples and readers

During the WKARP2 an exercise was made available for readers on SmartDots (ID 402 – 2021 North Sea and Skagerrak Plaice). The total image set comprised 250 images (Table 2.1): 50 samples (fish individuals) from the Skagerrak (27.3.a.20) with three preparation methods for each sample using the same otolith, and 50 samples (fish individuals) from the North Sea (27.4.b and c) with two preparation methods for each sample, not using the same otolith in all cases. The WKARP2 group concluded that plaice otoliths, both whole and sectioned, should be photographed with reflected light as most readers are familiar with this method, and this will bring consistency in the appearance of the growth zones. Sectioned stained otoliths from Skagerrak were found more difficult to read in comparison to the unstained sectioned otoliths, and it was concluded that staining sectioned otoliths did not improve the interpretation of the age. The sectioned otoliths as well as the sectioned and stained otoliths from Skagerrak, photographed with transmitted light, were not used in the comparisons.

Table 2.1. Overview of samples read by advanced readers for the 2021 North Sea and Skagerrak plaice workshop exercise (SmartDots ID 402).

Strata	N samples	N adv. readers	Modal age range	Comments
Skagerrak, 27.3.a.20, whole otoliths/reflected light	50	9	1-13 (0-15 all readers)	Evaluated on stock level together with North Sea
Skagerrak, 27.3.a.20, sectioned otoliths/transmitted light	50	-	-	Not used for comparisons
Skagerrak, 27.3.a.20, sectioned and stained otoliths/transmitted light	50	-	-	Not used for comparisons
North Sea, 27.4.b and c, whole otoliths/reflected light	50*	9	0-11	Evaluated on stock level together with Skagerrak
North Sea, 27.4.b and c, sectioned otoliths/reflected light	50*	7	0-12	

* 25 samples from each of 27.4.b and c, using otoliths from the same fish for both preparation methods.

Table 2.2. Advanced age readers for the 2021 North Sea and Skagerrak plaice workshop exercise (SmartDots ID 402).

Reader code
R02 SE
R04 NL
R06 DK*
R08 SE
R10 NL
R12 BE
R14 BE
R18 DK
R28 GB-SCT*

* Not included in analyses of North Sea, 27.4.b and c, sectioned otoliths.

3 Results

Table 3.1 Overview of results including method comparisons within WKARP2 2021 (SmartDots ID 402).

Subchapter in summary report	Strata	N samples	N advanced readers	Modal age range	PA (%)	CV (%)
3.1	Stock level (ple.27.420), whole	100	9	0-15	74	20
3.2	Skagerrak 27.3.a.20, whole	50	9	0–15	74	18
3.3	North Sea 27.4.b and c, whole	50	9	0–11	74	20
3.4	North Sea 27.4.b and c, sectioned	50	7	0–12	76	14

3.1 Advanced readers: Stock level (ple.27.420)

A stock-level (ple.27.420) analysis of age-reading agreements was carried out using whole otoliths (Table 2.1). Only age readings of those readers who provide age data for stock assessment purposes (advanced readers) were used in this analysis. The SmartDots platform report tool was used. Stock-level results for ple.27.420 show an overall PA of 74% (Table 3.1.2) and CV of 20% (Table 3.1.3). Reader bias is positive overall at 0.06, ranging from 0.08 to 0.28 at modal ages 0 to 7 (except for modal age 4 which is negative) indicating an overestimation of age compared with modal ages. Individual reader bias ranges from −0.32 to 0.53 with the highest bias values being positive and again indicating an overestimation compared with modal age.

Table 3.1.1 Coefficient of Variation (CV) per modal age and reader, the CV of all (advanced) readers combined per modal age, and a weighted mean of the CV per reader (except age 0). Reader number and country is given for each advanced reader for ple.27.420 (whole otoliths).

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	All
0	-	-	-	-	-	-	-	-	-	-
1	28%	33%	68%	34%	0%	0%	28%	0%	33%	**37%**
2	28%	47%	17%	15%	17%	36%	29%	17%	0%	**28%**
3	18%	47%	33%	50%	11%	10%	41%	20%	0%	**36%**
4	10%	10%	10%	9%	18%	9%	17%	17%	13%	**14%**
5	10%	31%	14%	8%	22%	0%	8%	5%	7%	**15%**
6	10%	12%	6%	16%	11%	12%	12%	12%	10%	**12%**
7	0%	12%	7%	13%	5%	10%	10%	5%	5%	**9%**
8	14%	13%	17%	15%	8%	8%	11%	42%	16%	**19%**
9	9%	10%	8%	12%	16%	7%	27%	17%	18%	**17%**
10	5%	5%	8%	5%	5%	0%	9%	5%	5%	**6%**
11	7%	0%	53%	6%	0%	6%	12%	22%	-	**18%**
12	-	-	-	-	-	-	-	-	-	**29%**
13	-	-	-	-	-	-	-	-	-	**5%**
14	-	-	-	-	-	-	-	-	-	**-**
15	-	-	-	-	-	-	-	-	-	**16%**
Weighted mean	**14%**	**24%**	**22%**	**18%**	**12%**	**9%**	**20%**	**14%**	**12%**	**20%**

Table 3.1.2 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. Reader number and country is given for each advanced reader for ple.27.420 (whole otoliths).

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	All
0	75%	100%	100%	100%	100%	100%	100%	100%	0%	**94%**
1	91%	91%	82%	82%	100%	100%	91%	100%	86%	**92%**
2	67%	80%	90%	90%	90%	70%	70%	90%	100%	**81%**
3	70%	70%	50%	60%	90%	90%	60%	90%	100%	**74%**
4	86%	86%	86%	86%	86%	86%	57%	57%	75%	**78%**
5	71%	73%	73%	87%	80%	100%	80%	93%	89%	**83%**
6	71%	86%	86%	50%	57%	57%	71%	57%	57%	**66%**
7	100%	67%	78%	44%	89%	56%	56%	89%	86%	**73%**
8	67%	78%	50%	56%	78%	44%	75%	22%	62%	**59%**
9	75%	56%	44%	67%	56%	67%	44%	67%	62%	**59%**
10	75%	75%	50%	75%	75%	100%	50%	75%	75%	**72%**
11	0%	100%	50%	50%	0%	50%	50%	50%	0%	**41%**
12	0%	100%	0%	100%	0%	0%	100%	0%	0%	**33%**
13	100%	0%	100%	0%	0%	100%	0%	100%	100%	**56%**
14	-	-	-	-	-	-	-	-	-	**-**
15	0%	100%	0%	0%	100%	100%	0%	0%	100%	**44%**
Weighted mean	**74%**	**77%**	**70%**	**71%**	**79%**	**78%**	**68%**	**76%**	**74%**	**74%**

Table 3.1.3 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. Reader number and country is given for each advanced reader for ple.27.420 (whole otoliths). Red or black values (column "all") indicate negative or positive overall bias, respectively. Relative bias is the age difference between the estimated mean age and modal age.

| Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	all
0	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	**0.25**
1	0.09	-0.09	0.36	0.18	0.00	0.00	0.09	0.00	0.14	**0.09**
2	0.11	0.00	-0.10	0.10	-0.10	0.20	0.40	-0.10	0.00	**0.06**
3	0.10	0.50	-0.20	1.20	-0.10	0.10	0.80	0.20	0.00	**0.29**
4	-0.14	-0.14	-0.14	0.14	0.29	0.14	0.57	0.14	-0.25	**0.07**
5	-0.29	-0.20	-0.07	0.00	-0.47	0.00	0.20	-0.07	-0.11	**-0.11**
6	0.00	0.29	-0.14	0.33	0.14	0.57	0.43	-0.14	-0.43	**0.12**
7	0.00	-0.22	-0.22	0.22	0.11	0.00	0.56	-0.11	0.14	**0.05**
8	-0.56	0.56	-1.00	0.22	0.33	0.33	0.50	-1.00	-0.75	**-0.15**
9	-0.38	-0.11	-0.67	0.33	0.67	0.11	1.67	0.33	-0.88	**0.12**
10	-0.25	0.25	0.00	0.25	0.25	0.00	0.75	0.25	-0.25	**0.14**
11	-1.50	0.00	-3.00	0.50	-1.00	0.50	1.00	-1.50	-3.00	**-0.89**
12	-3.00	0.00	-3.00	0.00	-7.00	-4.00	0.00	-4.00	-6.00	**-3.00**
13	0.00	1.00	0.00	2.00	1.00	0.00	1.00	0.00	0.00	**0.56**
14	-	-	-	-	-	-	-	-	-	**-**
15	-4.00	0.00	-5.00	-1.00	0.00	0.00	2.00	-1.00	0.00	**-1.00**
Weighted Mean	**-0.21**	**0.06**	**-0.32**	**0.28**	**-0.03**	**0.09**	**0.56**	**-0.14**	**-0.36**	**0.00**
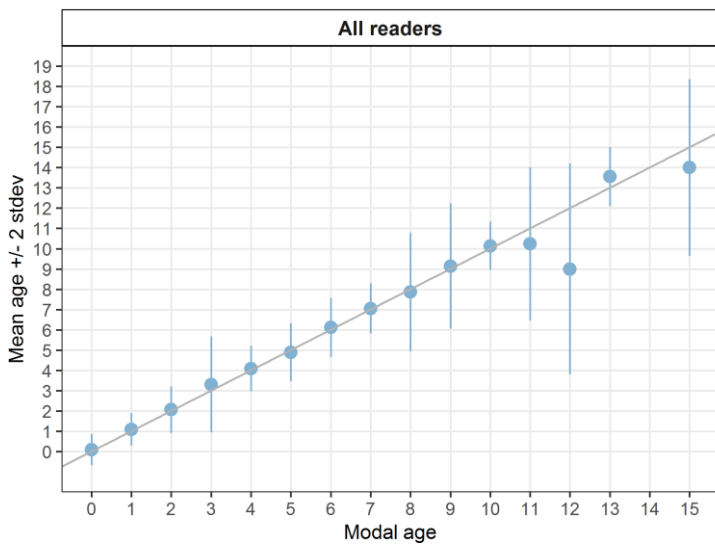
Figure 3.1.1 Age bias plot for all advanced readers for ple.27.420 (whole otoliths). Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line).

3.2 Advanced readers: Skagerrak (27.3.a.20) whole otoliths

Table 3.2.1 Coefficient of Variation (CV) per modal age and reader, the CV of all (advanced) readers combined per modal age, and a weighted mean of the CV per reader (except age 0). Reader number and country is given for each advanced reader for plaice (whole otoliths) in Skagerrak (27.3.a.20).

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	All
0	-	-	-	-	-	-	-	-	-	**-**
1	28%	33%	68%	34%	0%	0%	28%	0%	33%	**37%**
2	28%	47%	17%	15%	17%	36%	29%	17%	0%	**28%**
3	18%	47%	33%	50%	11%	10%	41%	20%	0%	**36%**
4	10%	10%	10%	9%	18%	9%	17%	17%	13%	**14%**
5	10%	31%	14%	8%	22%	0%	8%	5%	7%	**15%**
6	10%	12%	6%	16%	11%	12%	12%	12%	10%	**12%**
7	0%	12%	7%	13%	5%	10%	10%	5%	5%	**9%**
8	14%	13%	17%	15%	8%	8%	11%	42%	16%	**19%**
9	9%	10%	8%	12%	16%	7%	27%	17%	18%	**17%**
10	5%	5%	8%	5%	5%	0%	9%	5%	5%	**6%**
11	7%	0%	53%	6%	0%	6%	12%	22%	-	**18%**
12	-	-	-	-	-	-	-	-	-	**29%**
13	-	-	-	-	-	-	-	-	-	**5%**
14	-	-	-	-	-	-	-	-	-	**-**
15	-	-	-	-	-	-	-	-	-	**16%**
Weighted mean	**14%**	**24%**	**22%**	**18%**	**12%**	**9%**	**20%**	**14%**	**12%**	**20%**

Table 3.2.2 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. Reader number and country is given for each advanced reader for plaice (whole otoliths) in Skagerrak (27.3.a.20).

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	All
0	-	-	-	-	-	-	-	-	-	**-**
1	75%	100%	100%	100%	100%	100%	100%	100%	100%	**97%**
2	67%	86%	86%	86%	86%	71%	57%	86%	-	**78%**
3	71%	71%	57%	57%	100%	86%	57%	86%	100%	**74%**
4	100%	100%	100%	80%	100%	100%	60%	80%	50%	**88%**
5	70%	73%	73%	82%	73%	100%	73%	100%	86%	**81%**
6	100%	100%	100%	100%	100%	100%	50%	50%	50%	**83%**
7	100%	33%	67%	33%	100%	67%	67%	67%	100%	**68%**
8	0%	100%	0%	100%	100%	0%	100%	0%	-	**50%**
9	75%	75%	50%	75%	75%	50%	25%	50%	67%	**60%**
10	50%	50%	50%	50%	50%	100%	0%	50%	50%	**50%**
11	0%	100%	100%	0%	0%	0%	100%	100%	-	**50%**
12	0%	100%	0%	100%	0%	0%	100%	0%	0%	**33%**
13	100%	0%	100%	0%	0%	100%	0%	100%	100%	**56%**
14	-	-	-	-	-	-	-	-	-	**-**
15	0%	100%	0%	0%	100%	100%	0%	0%	100%	**44%**
Weighted mean	**71%**	**78%**	**72%**	**72%**	**82%**	**82%**	**60%**	**78%**	**74%**	**74%**

Table 3.2.3 Relative bias table represents the relative bias (age difference between the estimated mean age and modal age) 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. Reader number and country is given for each advanced reader for plaice (whole otoliths) in Skagerrak (27.3.a.20). Red or black values (column "all") indicate negative or positive overall bias, respectively.

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	all
1	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.03**
2	0.33	0.29	-0.14	0.14	-0.14	0.43	0.57	-0.14	-	**-**
3	0.29	0.86	0.00	1.57	0.00	0.14	1.00	0.29	0.00	**0.46**
4	0.00	0.00	0.00	0.20	0.00	0.00	0.40	0.20	-0.50	**0.03**
5	-0.30	0.18	0.00	0.00	-0.64	0.00	0.27	0.00	-0.14	**-0.07**
6	0.00	0.00	0.00	0.00	0.00	0.00	0.50	-0.50	-0.50	**-0.06**
7	0.00	-1.00	-0.33	-0.67	0.00	-0.33	0.33	-0.33	0.00	**-0.26**
8	-1.00	0.00	-2.00	0.00	0.00	-1.00	0.00	2.00	-	**-**
9	-0.25	-0.25	-0.50	0.75	0.50	0.00	3.00	-0.25	-0.33	**0.30**
10	-0.50	0.50	0.50	0.50	0.50	0.00	1.50	0.50	-0.50	**0.33**
11	-1.00	0.00	0.00	1.00	-1.00	1.00	0.00	0.00	-	**-**
12	-3.00	0.00	-3.00	0.00	-7.00	-4.00	0.00	-4.00	-6.00	**-3.00**
13	0.00	1.00	0.00	2.00	1.00	0.00	1.00	0.00	0.00	**0.56**
14	-	-	-	-	-	-	-	-	-	**-**
15	-4.00	0.00	-5.00	-1.00	0.00	0.00	2.00	-1.00	0.00	**-1.00**
Weighted Mean	**-0.19**	**0.16**	**-0.26**	**0.34**	**-0.24**	**-0.02**	**0.72**	**-0.06**	**-0.48**	**0.00**

Figure 3.2.1 Age bias plot for all advanced readers for plaice (whole otoliths) in Skagerrak (27.3.a.20). 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).
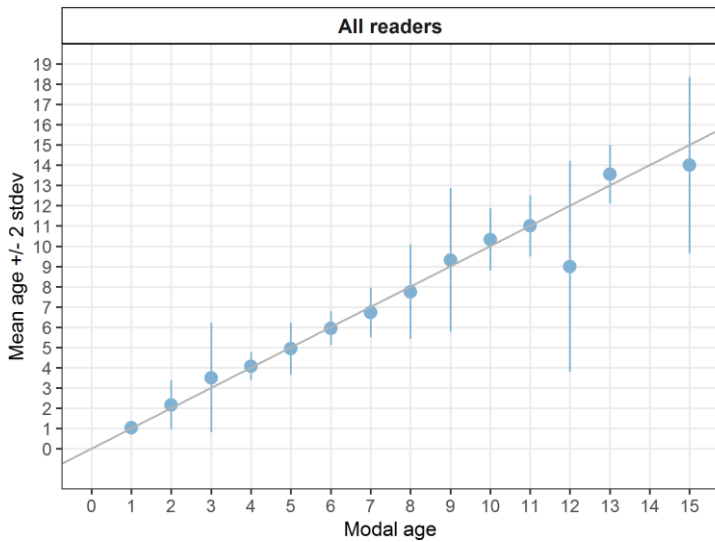
3.3 Advanced readers: North Sea (27.4.b and c) whole otoliths

Table 3.3.1 Coefficient of Variation (CV) per modal age and reader, the CV of all (advanced) readers combined per modal age, and a weighted mean of the CV per reader (except age 0). Reader number and country is given for each advanced reader for plaice (whole otoliths) in North Sea (27.4.b and c).

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	All
0	-	-	-	-	-	-	-	-	-	-
1	0%	44%	72%	38%	0%	0%	33%	0%	35%	**43%**
2	35%	87%	0%	0%	0%	35%	0%	0%	0%	**25%**
3	22%	22%	25%	17%	22%	0%	17%	0%	0%	**18%**
4	20%	20%	20%	0%	28%	16%	28%	35%	0%	**22%**
5	11%	67%	11%	0%	0%	0%	0%	11%	0%	**19%**
6	12%	14%	8%	20%	13%	12%	14%	12%	10%	**13%**
7	0%	6%	6%	11%	6%	11%	11%	0%	6%	**8%**
8	14%	14%	17%	16%	9%	6%	11%	44%	16%	**19%**
9	12%	14%	10%	8%	20%	5%	9%	18%	23%	**15%**
10	0%	0%	7%	0%	0%	0%	0%	0%	0%	**2%**
11	-	-	-	-	-	-	-	-	-	**25%**
Weighted mean	**11%**	**27%**	**21%**	**14%**	**9%**	**7%**	**14%**	**14%**	**13%**	**20%**

Table 3.3.2 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. Reader number and country is given for each advanced reader for plaice (whole otoliths) in North Sea (27.4.b and c).

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	All
0	75%	100%	100%	100%	100%	100%	100%	100%	0%	**94%**
1	100%	86%	71%	71%	100%	100%	86%	100%	83%	**89%**
2	67%	67%	100%	100%	100%	67%	100%	100%	100%	**88%**
3	67%	67%	33%	67%	67%	100%	67%	100%	100%	**74%**
4	50%	50%	50%	100%	50%	50%	50%	0%	100%	**56%**
5	75%	75%	75%	100%	100%	100%	100%	75%	100%	**88%**
6	60%	80%	80%	25%	40%	40%	80%	60%	60%	**59%**
7	100%	83%	83%	50%	83%	50%	50%	100%	83%	**76%**
8	75%	75%	57%	50%	75%	50%	71%	25%	62%	**60%**
9	75%	40%	40%	60%	40%	80%	60%	80%	60%	**59%**
10	100%	100%	50%	100%	100%	100%	100%	100%	100%	**94%**
11	0%	100%	0%	100%	0%	100%	0%	0%	0%	**33%**
Weighted mean	**78%**	**76%**	**67%**	**69%**	**76%**	**74%**	**76%**	**74%**	**74%**	**74%**

Table 3.3.3 Relative bias table represents the relative bias (age difference between the estimated mean age and modal age) 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. Reader number and country is given for each advanced reader for plaice (whole otoliths) in North Sea (27.4.b and c). Red or black values (column "all") indicate negative or positive overall bias, respectively.

Modal age	R02 SE	R04 NL	R06 DK	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	R28 GB-SCT	all
0	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	**0.25**
1	0.00	-0.14	0.57	0.29	0.00	0.00	0.14	0.00	0.17	**0.11**
2	-0.33	-0.67	0.00	0.00	0.00	-0.33	0.00	0.00	0.00	**-0.15**
3	-0.33	-0.33	-0.67	0.33	-0.33	0.00	0.33	0.00	0.00	**-0.11**
4	-0.50	-0.50	-0.50	0.00	1.00	0.50	1.00	0.00	0.00	**0.11**
5	-0.25	-1.25	-0.25	0.00	0.00	0.00	0.00	-0.25	0.00	**-0.22**
6	0.00	0.40	-0.20	0.50	0.20	0.80	0.40	0.00	-0.40	**0.19**
7	0.00	0.17	-0.17	0.67	0.17	0.17	0.67	0.00	0.17	**0.20**
8	-0.50	0.62	-0.86	0.25	0.38	0.50	0.57	-1.38	-0.75	**-0.13**
9	-0.50	0.00	-0.80	0.00	0.80	0.20	0.60	0.80	-1.20	**-0.01**
10	0.00	0.00	-0.50	0.00	0.00	0.00	0.00	0.00	0.00	**-0.06**
11	-2.00	0.00	-6.00	0.00	-1.00	0.00	2.00	-3.00	-3.00	**-1.44**
Weighted Mean	**-0.22**	**-0.04**	**-0.39**	**0.22**	**0.18**	**0.20**	**0.39**	**-0.22**	**-0.30**	**0.00**

Figure 3.3.1 Age bias plot for all advanced readers for plaice (whole otoliths) in North Sea (27.4.b and c). 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).
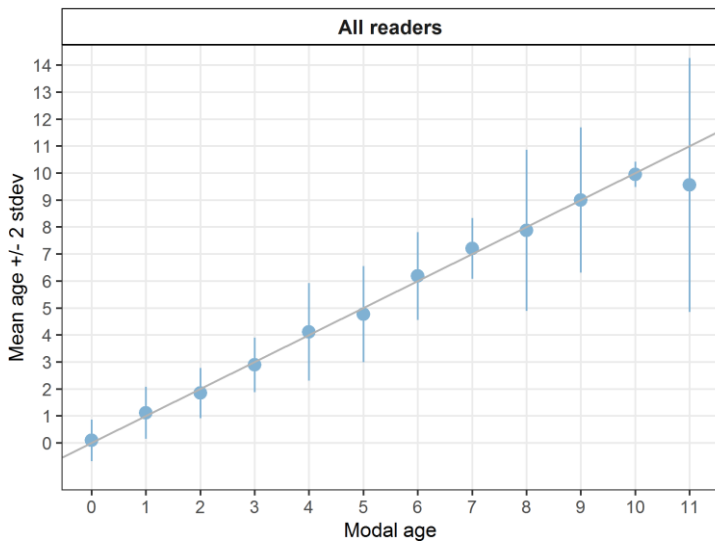
3.4 Advanced readers: North Sea (27.4.b and c) sectioned otoliths

Table 3.4.1 Coefficient of Variation (CV) per modal age and reader, the CV of all (advanced) readers combined per modal age, and a weighted mean of the CV per reader (except age 0). Reader number and country is given for each advanced reader for plaice (sectioned otoliths) in North Sea (27.4.b and c).

Modal age	R02 SE	R04 NL	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	All
0	-	-	-	-	-	-	-	**-**
1	58%	44%	0%	33%	0%	33%	60%	**39%**
2	0%	29%	22%	29%	29%	40%	22%	**28%**
3	0%	0%	0%	0%	20%	0%	20%	**12%**
4	-	-	-	-	-	-	-	**13%**
5	0%	0%	18%	0%	0%	0%	10%	**9%**
6	18%	0%	0%	0%	0%	0%	9%	**7%**
7	10%	5%	5%	14%	0%	12%	0%	**8%**
8	5%	10%	14%	5%	5%	8%	5%	**8%**
9	10%	4%	4%	11%	4%	7%	7%	**8%**
10	6%	0%	5%	5%	6%	5%	5%	**5%**
11	-	-	-	-	-	-	-	**12%**
12	-	-	-	-	-	-	-	**5%**
Weighted mean	**15%**	**13%**	**8%**	**13%**	**5%**	**14%**	**17%**	**14%**

Table 3.4.2 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. Reader number and country is given for each advanced reader for plaice (sectioned otoliths) in North Sea (27.4.b and c).

Modal age	R02 SE	R04 NL	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	All
0	75%	100%	25%	100%	100%	100%	25%	**75%**
1	71%	86%	100%	86%	100%	86%	57%	**84%**
2	100%	75%	75%	75%	75%	75%	75%	**79%**
3	100%	100%	100%	100%	50%	100%	50%	**86%**
4	100%	0%	0%	100%	100%	100%	100%	**71%**
5	100%	100%	75%	100%	100%	100%	50%	**89%**
6	0%	100%	100%	100%	100%	100%	67%	**81%**
7	57%	86%	86%	57%	100%	43%	100%	**76%**
8	83%	83%	33%	83%	83%	67%	83%	**72%**
9	40%	83%	83%	50%	83%	67%	67%	**68%**
10	50%	100%	75%	75%	50%	75%	75%	**71%**
11	0%	0%	100%	0%	100%	100%	0%	**43%**
12	0%	100%	100%	100%	100%	0%	100%	**71%**
Weighted mean	**65%**	**86%**	**74%**	**78%**	**88%**	**76%**	**68%**	**76%**

Table 3.4.3 Relative bias table represents the relative bias (age difference between the estimated mean age and modal age) 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. Reader number and country is given for each advanced reader for plaice (sectioned otoliths) in North Sea (27.4.b and c). Red or black values (column "all") indicate negative or positive overall bias, respectively. (Very few samples were read by reader R06 DK, and to be able to calculate mean bias per modal age these readings were omitted.)

Modal age	R02 SE	R04 NL	R08 SE	R10 NL	R12 BE	R14 BE	R18 DK	all
0	0.25	0	0.75	0	0	0	1	**0.29**
1	0	-0.14	0	0.14	0	0.14	0.14	**0.04**
2	0	-0.25	0.25	-0.25	-0.25	0.5	0.25	**0.04**
3	0	0	0	0	0.5	0	0.5	**0.14**
4	0	-1	-1	0	0	0	0	**-0.29**
5	0	0	0.5	0	0	0	0.5	**0.14**
6	0.33	0	0	0	0	0	0.33	**0.09**
7	0.14	0.14	0.14	0	0	0	0	**0.06**
8	-0.17	0.33	0.17	-0.17	0.17	0	0.17	**0.07**
9	-0.8	0.17	0.17	0.33	0.17	0	0	**0.01**
10	-0.5	0	0.25	0.25	-0.5	-0.25	-0.25	**-0.14**
11	1	-1	0	2	0	0	3	**0.71**
12	-1	0	0	0	0	1	0	**0.00**
Weighted Mean	**-0.08**	**0**	**0.18**	**0.08**	**0**	**0.06**	**0.26**	**0.07**

Figure 3.4.1 Age bias plot for all advanced readers for plaice (sectioned otoliths) in North Sea (27.4.b and c). 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).
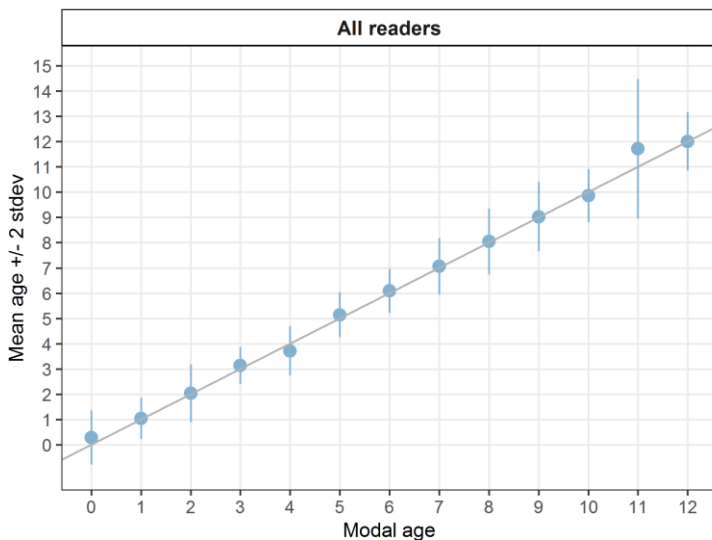
3.5 WKARP2 age error matrices

AEM's (age reading error matrices) have become an output from SmartDots events and can be integrated into the stock assessment models. Following recommendations of The ICES Workshop on the use of Ageing and Maturity Staging Error Matrices in Stock Assessment (WKAMEMSA; ICES, 2022b), the plaice stock (ple.27.420) could be used as a case study for integration of ageing errors in the stock assessment. For the plaice benchmark in 2022, the stock assessor was provided with both the empirical AEM's and the raw data output from both the 2020 exchange and the WKARP2 2021 workshop exercise to use as input in the SAM model. The incorporation of these data into the model runs will allow for an evaluation of the effect of age reading performance on the stock assessment. For clarity, AEM's for Skagerrak (27.3.a.20) whole otoliths, North Sea (27.4.b and c) whole otoliths, and North Sea (27.4.b and c) sectioned otoliths were calculated separately (Tables 3.5.1-3). (A table with combined AEM for Skagerrak and Kattegat was considered to be less transparent and not included.)

Table 3.5.1. Age error matrix (AEM) for Skagerrak (27.3.a.20) – whole otoliths, with proportional distribution of age readings (9 advanced readers) for each modal age. Column values should sum to one but due to rounding there might be small deviations.

Modal age (horizontal) / Age readings (vertical)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	**0.970**	0.055	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	0.030	**0.782**	0.034	-	0.011	-	-	-	-	-	-	-	-	-	-
3	-	-	0.109	**0.741**	0.024	0.032	-	-	-	-	-	-	-	-	-	-
4	-	-	0.055	0.121	**0.881**	0.064	-	-	-	-	-	-	-	-	-	-
5	-	-	-	0.034	0.095	**0.809**	0.111	0.040	-	-	-	-	0.111	-	-	-
6	-	-	-	-	-	0.074	**0.833**	0.240	0.125	-	-	-	0.111	-	-	-
7	-	-	-	0.017	-	0.011	0.056	**0.680**	0.250	0.029	-	-	0.222	-	-	-
8	-	-	-	0.034	-	-	-	0.040	**0.500**	0.171	-	-	0.222	-	-	-
9	-	-	-	0.017	-	-	-	-	-	**0.600**	0.111	-	0.222	-	-	-
10	-	-	-	-	-	-	-	-	0.125	0.086	**0.500**	0.250	-	-	-	0.111
11	-	-	-	-	-	-	-	-	-	0.057	0.333	**0.500**	-	-	-	0.111
12	-	-	-	-	-	-	-	-	-	0.029	0.056	0.250	**0.333**	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	**0.556**	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-	0.333	-	0.222
15	-	-	-	-	-	-	-	-	-	-	-	-	-	0.111	-	**0.444**
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.111
18	-	-	-	-	-	-	-	-	-	0.029	-	-	-	-	-	-

Table 3.5.2. Age error matrix (AEM) for North Sea (27.4.b and c) – whole otoliths, with proportional distribution of age readings (9 advanced readers) for each modal age. Column values should sum to one but due to rounding there might be small deviations.

Modal age (horizontal) / Age readings (vertical)	0	1	2	3	4	5	6	7	8	9	10	11	12
0	**0.939**	0.016	0.038	-	-	0.029	-	-	0.014	-	-	-	-
1	0.030	**0.887**	0.077	-	-	-	-	-	-	-	-	-	-
2	0.030	0.081	**0.885**	0.185	-	-	-	-	-	-	-	-	-
3	-	-	-	**0.741**	0.222	-	-	-	-	-	-	-	-
4	-	0.016	-	0.074	**0.556**	0.088	-	-	-	-	-	-	-
5	-	-	-	-	0.111	**0.882**	0.159	-	0.043	0.023	-	0.111	-
6	-	-	-	-	0.111	-	**0.591**	0.037	0.057	-	-	-	-
7	-	-	-	-	-	-	0.159	**0.759**	0.086	0.068	-	-	-
8	-	-	-	-	-	-	0.091	0.167	**0.600**	0.136	-	0.222	-
9	-	-	-	-	-	-	-	0.037	0.114	**0.591**	0.056	0.111	-
10	-	-	-	-	-	-	-	-	0.057	0.091	**0.944**	0.111	-
11	-	-	-	-	-	-	-	-	0.029	0.045	-	**0.333**	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	0.045	-	0.111	-
14	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.5.3. Age error matrix (AEM) for North Sea (27.4.b and c) – sectioned otoliths, with proportional distribution of age readings (7 advanced readers) for each modal age. Column values should sum to one but due to rounding there might be small deviations.

Modal age (horizontal) / Age readings (vertical)	0	1	2	3	4	5	6	7	8	9	10	11	12
0	**0.750**	0.061	-	-	-	-	-	-	-	-	-	-	-
1	0.214	**0.837**	0.107	-	-	-	-	-	-	-	-	-	-
2	0.036	0.102	**0.786**	-	-	-	-	-	-	-	-	-	-
3	-	-	0.071	**0.857**	0.286	-	-	-	-	-	-	-	-
4	-	-	0.036	0.143	**0.714**	-	-	-	-	-	-	-	-
5	-	-	-	-	-	**0.893**	0.048	0.020	-	-	-	-	-
6	-	-	-	-	-	0.071	**0.810**	0.061	-	-	-	-	-
7	-	-	-	-	-	0.036	0.143	**0.755**	0.140	0.024	-	-	-
8	-	-	-	-	-	-	-	0.163	**0.721**	0.122	-	-	-
9	-	-	-	-	-	-	-	-	0.093	**0.683**	0.214	-	-
10	-	-	-	-	-	-	-	-	0.047	0.146	**0.714**	0.143	-
11	-	-	-	-	-	-	-	-	-	0.024	0.071	**0.429**	0.143
12	-	-	-	-	-	-	-	-	-	-	-	0.143	**0.714**
13	-	-	-	-	-	-	-	-	-	-	-	0.143	0.143
14	-	-	-	-	-	-	-	-	-	-	-	0.143	-

Conclusions

Following the 2020 North Sea and Skagerrak plaice exchange (ICES, 2022a), a smaller age reading exercise was carried out on SmartDots during WKARP2 (2021 North Sea and Skagerrak Plaice, SmartDots ID 402). The traditional approach was applied when calculating modal age. On stock level (ple.27.420) the PA for advanced readers reading whole otoliths is 74% and CV 20%. Comparing areas Skagerrak (27.3.a.20) and North Sea (27.4.b and c), whole otoliths, PA is 74% for both and CV 18% and 20%, respectively. For North Sea (27.4.b and c) sectioned otoliths PA is 76% and CV 14%, i.e., had a slightly higher agreement compared to whole otoliths. However, sectioned otoliths were read by seven advanced readers instead of nine as in the other comparisons, which might influence results.

Information on respective laboratory procedures for age reading of plaice belonging to the stock ple.27.420 were collected. Methods applied are either whole otoliths read with reflected light or sectioned otoliths with reflected light. Sectioned otoliths and sectioned stained otoliths photographed with transmitted light were also provided, but as these were difficult to read they were omitted from further analyses. The group concluded that sectioning otoliths from fish age 0–6 does not provide added benefit compared to whole otoliths, but could lead to an overestimation of age compared to whole otoliths. As in the workshop of 2010, it was concluded that sectioning of otoliths from fish above age of 6 could be beneficial, as it is then easier to avoid an underestimation of age by more easily identifying the growth structures closer to the otolith edge. In terms of guidelines, whole otoliths would probably be easier to work with as many laboratories are not sectioning otoliths routinely. However, for institutes who are sectioning otoliths, it is relevant to include also sectioned samples in future exchanges. Further work is required to find the optimal soaking time in water which is likely to be dependent on otolith size. A manual with set of age reading guidelines was agreed upon and this should be followed by all laboratories age reading plaice from the ple.27.420 stock.

A review of validation studies on first winter ring formation was carried out. It has been identified that the size of the first winter ring can fall within a wide range and is attributable to variations in fish growth, habitat, temperature and spawning behaviour. No definitive conclusions for measurement guidelines can yet be drawn and further work is needed.

A WKARP2 subgroup has been formed to establish a reference collection of plaice otoliths with agreed age. The aim is to establish a reference set module in SmartDots plus a set of criteria which should be met when creating reference sets for future training and calibration purposes, in cooperation with ICES WGSMART (Working Group on SmartDots Governance) and ICES WGBIOP (Working Group on Biological Parameters).

References

ICES (2022a) Workshop 2 on Age Reading of North Sea plaice (*Pleuronectes platessa*) (WKARP2; outputs from 2021 meeting). ICES Scientific Reports. 4:64. 189 pp. http://doi.org/10.17895/ices.pub.20473083.

ICES (2022b) Workshop on use of Ageing and Maturity Staging Error Matrices in Stock Assessment (WKAMEMSA; outputs from 2021 meeting). ICES Scientific Reports. 4:13. 54 pp. https://doi.org/10.17895/ices.pub.10052.