

# Report of Otolith Exchange Analysis for Lemon sole (*Microstomus kitt*) in ICES Divisions 27.4c & 27.7d (SmartDots event 115)

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# 1 Executive summary

This lemon sole age reading exchange took place between July to September 2019 using SmartDots software. No previous age validation has been done on lemon sole from ICES Divisions 27.4 and 27.7d and they can be a difficult species to age. Therefore, it was advised by readers and Working Group on Biological Parameters (WGBIOP 2018) to have a full-scale otolith exchange in order to identify and resolve age interpretation differences between readers, laboratories and methods.

A total of nine participants, from six countries were involved in the exchange. A decision was made to use 27.4 and 27.7d as this is an age assessed stock and including additional areas with so many methods would result in a large number of sets. Following WGBIOP Guideline for Otolith Exchanges (2018) a set of 108 whole, 64 sectioned and 64 broken and burnt otoliths were selected and uploaded on to the SmartDots application. The samples were provided from UK (Cefas) and Belgium (ILVO).

The objectives of the exchange were:

- Evaluate the accuracy and precision in age reading of lemon sole 4 and 7d.
- Identify any issue in reading lemon sole 4 and 7d.
- Identify the accuracy of reading lemon sole IV & VIIId using different preparation techniques.

The statistics representing on age results were calculated using all readers and experienced readers only and by each preparation method. Age readers were asked to read all reading methods, this was due to low numbers of readers per method and to allow us to compare preparation techniques. The results did not show bias towards readers accuracy using preparation techniques they were not familiar with, so I was confident to use these in the final outputs.

Agreement was higher and variance (APE & CV) was lower, but only slightly for those advanced readers compared to all readers for all methods. In all cases, agreement was highest in sectioned, than in whole and broken/burnt. The average percentage agreement of 62% and variance 17%, were reached by all readers annotating sectioned otoliths. There was an improvement when only advanced readers were used: PA=90%; CV=3%, however there were only two readers who were both from the same institute. The percentage agreement for whole and broken and burnt were 49% and 25% respectively. This was improved when only advanced readers were included (51% whole), no advanced broken and burnt readers participated in the exchange. It should be noted that images for broken and burnt otoliths were poor and difficult to capture due to reflection on the surface, this may have had an impact on the low percentage agreement for this preparation method.

Difference in age determination mainly related to readers interpretation of first true ring. It is recommended that following this exchange, a lemon sole workshop should be carried out to learn and improve agreement between readers and institutes.

# 2 Introduction

Once known as *Pleuronectes microcephalus*, but later reclassified *Microstomus kitt* (Rae 1965), lemon sole is an important commercially, valuable species. The species is common in the North Sea and widely distributed in the Celtic Sea, the western English Channel, the Western Approaches and the Irish Sea. They are found on stony seabeds from 20 to 200 m and can be up to 60 cm long, with some individuals living to 17 years (Wheeler 1969). Spawning of lemon sole is poorly understood and they are believed to spawn throughout their range. Spawning takes place from April to September. Sexual maturity in males is 3–4 years, and in females 4–6 years (King *et al*, 2006, Rae, 1965; Knijn *et al* 1993). Eggs and larvae are planktonic, with planktonic post-larvae found in midwater before settlement on the seabed between April and August, at a length of approximately 3 cm (Wheeler, 1978).

This was the first full scale otolith exchange, recommended by Working Group on Biological Parameters (WGBIOP). Lemon sole can be a difficult species to age accurately, so this was also a request from readers of all participating institutes.

The objectives of this new exchange were:

- Estimate the accuracy and precision of the age reading for the whole, sectioned and burnt otoliths.
- Detect any age reading problems.
- Compare the results between different preparation methods.

# 3 Methods

## 3.1 Overview of samples and readers

**Table 1. Overview of samples used for the lemon sole exchange – whole otoliths.**

Year	Quarter	Number of samples	Modal age range	Length range
2007	3	8	1-5	130-320 mm
2014	3	6	2-7	120-320 mm
2015	1	5	3-4	150-235 mm
2015	3	5	5-7	335-415 mm
2015	4	3	4-6	260-305 mm
2016	1	4	4-6	260-280 mm
2016	2	22	2-8	160-360 mm
2016	3	21	0-6	60-400 mm
2017	1	25	4-7	270-390 mm
2017	2	9	4-5	250-310 mm

**Table 2. Overview of samples used for the lemon sole exchange – burnt otoliths.**

Year	Quarter	Number of samples	Modal age range	Length range
2007	3	8	1-5	130-320 mm
2014	3	5	0-5	130-320 mm
2016	1	4	5-6	260-280 mm
2016	2	21	2-8	160-360 mm
2016	3	19	0-9	70-400 mm
2017	2	7	4-6	260-310 mm

**Table 3. Overview of samples used for the lemon sole exchange – sectioned otoliths.**

Year	Quarter	Number of samples	Modal age range	Length range
2014	1	50	3-6	155-305 mm
2015	1	5	3-5	150-235 mm
2015	3	5	5-7	335-415 mm
2015	4	4	5-7	260-305 mm

A total of nine participants from six different countries were involved in the lemon sole otolith exchange. A list of the participants with a summary of their experience in age estimation of lemon sole is shown in Table 4.

**Table 4. Reader overview.**

<b>Reader code</b>	<b>Expertise</b>	<b>Method</b>
R02 IS	Advanced	Whole
R010 IS	Advanced	Whole
R08 DK	Advanced	Whole
R16 DK	Advanced	Whole
R12 BE	Advanced	S&S and whole
R14 BE	Advanced	S&S and whole
R22 DE	Basic	S&S and whole
R26 NL	Basic	Section
R28 GB	Basic	Whole & Broken & burnt

## 3.2 Reading procedure

Date of birth is conventionally attributed to the 1 January. One annulus consists of one opaque and one translucent zone. For age estimation, translucent zones are counted. Each reader was asked to annotate all samples in SmartDots, assign an age quality to his/her reading (from AQ1 to AQ3) and to approve his/her readings.

## 3.3 Statistical Analysis

The analysis follows traditional methods where the level of accuracy compared to modal age is indicated by percentage agreement (PA), bias tests and plots, and the level of precision i.e. the reproducibility of age estimates is indicated by the coefficient of variation (CV). The tables and plots presented are from the Guus Eltink Excel sheet 'Age Reading Comparisons' (Eltink, A.T.G.W. 2000). Additional analyses of age data were included; average percentage error (APE) and age error matrices (AEM's). Age estimates were made on both broken and whole and section and whole otoliths from the same fish and a comparison of calculated modal age from each method is also included.

### Percentage Agreement

The percentage agreement per reader per modal age tells how large is the part of readings that are equal to the modal age. The weighted mean included at the bottom of the table is weighted according to number of age readings.

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

### 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 ( $\sigma$ ) and mean value ( $\mu$ ) per reader and modal age:

Added the CV of all readers combined per modal age and a weighted mean of the CV per reader.

### 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:

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



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

### **Preparation method comparison analysis**

The method comparison analysis is based on the ATAQCS (Age Training and Quality Control System) developed at Cefas for internal quality control. This has been adapted for this exchange providing an interpretation of all the readers readings (whole, broken & sectioned).

# 4 Analysis of age calibration exercise

## 4.1 Results – Sectioned, Whole and Broken/Burnt Otoliths

### All readers

The average percentage agreement of 62% and CV of 17% was reached by all readers annotating sectioned otoliths. There was a large improvement when only advanced readers were combined: PA=90%; CV=3%, however there were only two readers, who were from the same institute.

The average percentage agreement of 49% and CV of 25% was reached by all readers annotating whole otoliths. There was a slight improvement when only advanced readers were combined: PA=51%; CV=25%,

The average percentage agreement of 25% and CV of 29% was reached by all readers annotating burnt otoliths. It should be noted that none of the readers were expert in this method and poor images made annotation of ages more difficult. The Uk is the only institute that reads lemon sole using this method and future exchanges should use otoliths rather than images, until photography of burnt structures can be improved.

Table 5. Coefficient of Variation (CV) tables presents the CV per modal age and reader for all readers, the CV of all readers combined per modal age and a weighted mean of the CV per reader. A rank is also assigned to each reader.

<b>SECTION ALL READERS</b>									
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	NETHERLANDS	UNITED KINGDOM	ALL
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R26 NL	R28 GB	Readers
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	7%	21%	9%	14%	12%	22%	20%	12%	18.6%
4	8%	14%	5%	13%	9%	8%	11%	9%	14.8%
5	7%	10%	9%	0%	7%	23%	17%	11%	14.6%
6	0%	0%	11%	0%	0%	-	0%	28%	13.4%
7	14%	15%	14%	11%	21%	35%	24%	16%	19.0%
8	-	-	-	-	-	-	-	-	-
0-15	7.5%	15.3%	8.0%	10.6%	10.6%	16.7%	15.6%	11.6%	16.6%
RANKING	1	6	2	3	4	8	7	5	

<b>WHOLE ALL READERS</b>										
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	NETHERLANDS	UNITED KINGDOM	ALL
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R26 NL	R28 GB	Readers
0	-	-	-	-	-	-	-	-	-	-
1	52%	91%	49%	34%	0%	0%	38%	0%	0%	72.9%
2	0%	53%	22%	39%	0%	29%	32%	18%	36%	40.5%
3	14%	62%	21%	18%	22%	28%	28%	27%	41%	31.6%
4	13%	27%	14%	29%	19%	12%	25%	18%	17%	22.6%
5	12%	11%	8%	20%	14%	15%	11%	22%	16%	19.3%
6	11%	9%	12%	19%	15%	11%	14%	12%	17%	16.3%
7	12%	19%	7%	10%	6%	24%	13%	58%	14%	23.9%
8	-	-	-	-	-	-	-	-	-	-
0-15	12.5%	27.6%	14.0%	23.9%	13.9%	15.2%	20.3%	19.5%	19.4%	25.3%
RANKING	1	9	3	8	2	4	7	6	5	

<b>BURNT ALL READERS</b>										
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	UNITED KINGDOM	NETHERLANDS	ALL
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R28 GB	R26 NL	Readers
0	-	-	-	-	-	-	-	-	-	-
1	0%	87%	47%	29%	0%	-	0%	29%	40%	78.7%
2	0%	0%	0%	33%	0%	-	100%	35%	43%	50.0%
3	15%	0%	23%	15%	15%	0%	23%	0%	0%	23.8%
4	24%	59%	26%	36%	22%	25%	56%	30%	33%	29.9%
5	0%	16%	0%	13%	24%	16%	0%	0%	16%	14.6%
6	5%	13%	8%	16%	7%	10%	12%	33%	18%	17.0%
7	0%	0%	8%	33%	12%	13%	14%	8%	8%	16.9%
8	-	-	-	-	-	-	-	-	-	-
0-15	4.4%	14.1%	8.2%	13.2%	5.9%	6.5%	15.2%	12.1%	11.9%	28.6%
RANKING	1	8	4	7	2	3	9	6	5	

<b>SECTION EXPERTS</b>			
MODAL	BELGIUM	BELGIUM	ALL
age	R12 BE	R14 BE	Readers
0	-	-	-
1	-	-	-
2	-	-	-
3	10%	0%	2.0%
4	12%	7%	2.5%
5	6%	6%	2.9%
6	0%	0%	0.0%
7	0%	0%	0.0%
8	7%	19%	10.0%
0-15	9.1%	4.6%	2.7%
RANKING	2	1	

<b>WHOLE EXPERTS</b>							
<b>MODAL</b>	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	<b>ALL</b>
<b>age</b>	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	<b>Readers</b>
<b>0</b>	-	-	-	-	-	-	-
<b>1</b>	-	0%	-	20%	0%	-	-
<b>2</b>	0%	56%	0%	58%	0%	25%	<b>49.1%</b>
<b>3</b>	18%	73%	20%	30%	22%	30%	<b>36.7%</b>
<b>4</b>	10%	35%	14%	31%	21%	23%	<b>24.6%</b>
<b>5</b>	5%	14%	9%	22%	17%	14%	<b>19.2%</b>
<b>6</b>	11%	13%	10%	21%	18%	11%	<b>17.0%</b>
<b>7</b>	13%	13%	6%	13%	11%	14%	<b>14.8%</b>
<b>8</b>	47%	24%	-	0%	0%	-	<b>24.7%</b>
<b>9</b>	-	-	-	-	-	-	-
<b>0-15</b>	<b>10.2%</b>	<b>27.5%</b>	<b>11.0%</b>	<b>25.5%</b>	<b>16.8%</b>	<b>17.1%</b>	<b>24.7%</b>
<b>RANKING</b>	<b>1</b>	<b>6</b>	<b>2</b>	<b>5</b>	<b>3</b>	<b>4</b>	

The number of readings that match the modal age is shown by the percentage agreement per reader per modal age. The weighted average at the end of the chart is calculated based on the quantity of age measurements taken. Each reader is also given a rank.

**Table 6. 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. A rank is also assigned to each reader.**

<b>SECTION ALL READERS</b>									
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	NETHERLANDS	UNITED KINGDOM	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R26 NL	R28 GB	ALL
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	95%	42%	91%	75%	83%	19%	25%	88%	100%
4	91%	30%	95%	82%	82%	6%	14%	86%	100%
5	88%	0%	75%	100%	88%	50%	13%	63%	100%
6	100%	0%	50%	100%	100%	0%	0%	50%	100%
7	80%	67%	80%	40%	40%	0%	40%	0%	100%
8	100%	0%	100%	0%	100%	-	0%	0%	100%
9	-	-	-	-	-	-	-	-	-
0-15	91.7%	30.8%	88.5%	77.4%	80.6%	15.2%	19.4%	74.2%	
RANKING	1	6	2	4	3	8	7	5	61.7%

<b>WHOLE ALL READERS</b>										
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	NETHERLANDS	UNITED KINGDOM	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R26 NL	R28 GB	ALL
0	-	-	-	-	-	-	-	-	-	-
1	25%	60%	33%	0%	0%	100%	50%	100%	100%	100%
2	100%	13%	63%	0%	0%	71%	63%	89%	50%	100%
3	73%	64%	40%	27%	36%	75%	60%	64%	60%	100%
4	59%	63%	57%	7%	7%	88%	43%	70%	79%	100%
5	71%	67%	78%	8%	17%	38%	83%	38%	38%	100%
6	74%	70%	64%	32%	14%	35%	55%	41%	38%	100%
7	40%	50%	80%	0%	0%	50%	25%	60%	25%	100%
8	100%	0%	100%	100%	100%	0%	0%	0%	0%	100%
9	-	-	-	-	-	-	-	-	-	-
0-15	67.6%	60.2%	63.0%	14.2%	13.1%	58.4%	57.0%	57.9%	54.9%	
RANKING	1	3	2	8	9	4	6	5	7	49.2%

<b>BURNT ALL READERS</b>										
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	UNITED KINGDOM	NETHERLANDS	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R28 GB	R26 NL	ALL
0	-	-	-	-	-	-	-	-	-	-
1	67%	67%	50%	20%	0%	50%	20%	40%	60%	100%
2	86%	14%	83%	14%	14%	100%	29%	86%	43%	100%
3	75%	0%	50%	75%	75%	0%	50%	100%	0%	100%
4	38%	50%	25%	25%	25%	33%	63%	38%	38%	100%
5	78%	33%	56%	56%	78%	29%	44%	44%	33%	100%
6	80%	27%	63%	40%	55%	42%	68%	35%	30%	100%
7	100%	25%	75%	40%	40%	0%	40%	20%	20%	100%
8	50%	0%	100%	100%	50%	0%	100%	0%	0%	100%
0-15	38.6%	17.7%	30.0%	21.7%	22.6%	19.3%	28.2%	25.4%	16.8%	
RANKING	1	8	2	6	5	7	3	4	9	24.9%

<b>SECTION EXPERTS</b>			
MODAL	BELGIUM	BELGIUM	
age	R12 BE	R14 BE	ALL
0	-	-	-
1	-	-	-
2	-	-	-
3	90%	100%	95%
4	88%	92%	90%
5	90%	90%	90%
6	100%	100%	100%
7	100%	100%	100%
8	67%	67%	67%
9	-	-	-
10	0%	100%	50%
0-15	87.1%	93.5%	
RANKING	2	1	90.3%

<b>WHOLE EXPERTS</b>							
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	ALL
0	-	-	-	-	-	-	-
1	100%	0%	100%	0%	0%	100%	100%
2	100%	0%	100%	0%	0%	80%	100%
3	69%	31%	67%	50%	71%	63%	100%
4	83%	48%	78%	20%	12%	71%	100%
5	93%	48%	89%	19%	26%	22%	100%
6	84%	50%	75%	46%	38%	24%	100%
7	71%	17%	86%	29%	43%	20%	100%
8	50%	0%	100%	100%	100%	0%	100%
9	0%	0%	0%	100%	100%	-	100%
0-15	<b>82.9%</b>	<b>39.8%</b>	<b>80.0%</b>	<b>31.1%</b>	<b>32.7%</b>	<b>41.6%</b>	<b>51.3%</b>
RANKING	1	4	2	6	5	3	

The relative bias is the difference between the mean age (per modal age per reader) and modal age.

Table 7. 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. A rank is also assigned to each reader.

<b>SECTION ALL READERS</b>									
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	NETHERLANDS	UNITED KINGDOM	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R26 NL	R28 GB	ALL
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	0.05	-0.58	0.09	0.25	0.17	-0.86	-0.75	0.04	-0.18
4	0.00	-0.70	0.05	0.23	0.18	-0.94	-0.86	-0.05	-0.24
5	-0.13	-1.14	0.25	0.00	0.13	-0.75	-1.13	-0.38	-0.36
6	0.00	-1.00	0.50	0.00	0.00	-1.00	-1.00	-1.00	-0.40
7	-0.40	0.67	-0.40	0.80	1.60	1.00	-1.40	-1.40	-0.06
8	0.00	-1.00	0.00	1.00	0.00	-	-2.00	-3.00	-0.71
0-15	<b>-0.03</b>	<b>-0.65</b>	<b>0.07</b>	<b>0.26</b>	<b>0.27</b>	<b>-0.80</b>	<b>-0.92</b>	<b>-0.24</b>	<b>-0.23</b>
RANKING	1	6	2	4	5	7	8	3	

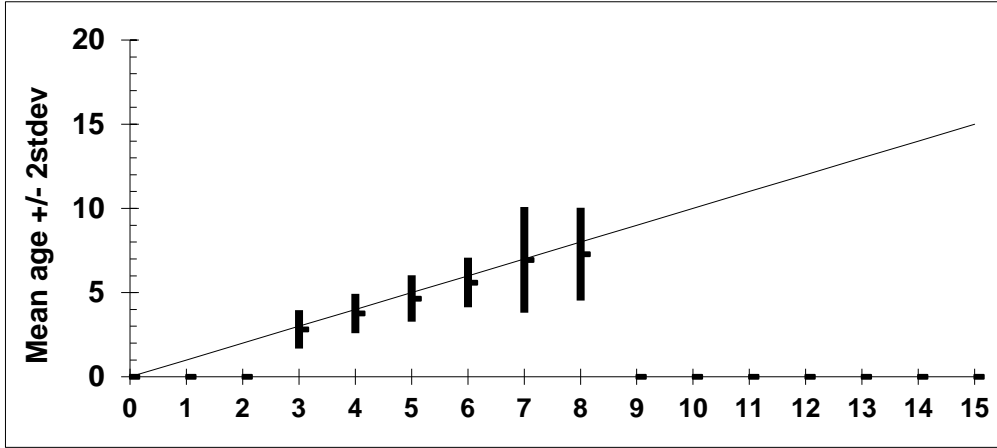
<b>WHOLE ALL READERS</b>										
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	NETHERLANDS	UNITED KINGDOM	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R26 NL	R28 GB	ALL
0	-	-	-	-	-	-	-	-	-	-
1	1.50	-0.40	1.33	3.40	2.00	0.00	0.50	0.00	0.00	0.97
2	0.00	-1.00	0.38	0.78	1.00	0.00	-0.38	-0.11	-0.50	0.04
3	0.27	-0.91	0.40	0.91	1.00	-0.38	-0.50	-0.45	-0.70	-0.02
4	0.34	-0.04	0.50	2.23	1.77	-0.16	0.46	-0.10	-0.07	0.57
5	0.25	-0.25	0.22	1.88	1.08	-0.58	-0.13	-0.54	-0.63	0.14
6	-0.04	-0.13	0.14	1.50	1.64	-0.70	0.09	-0.68	-0.62	0.14
7	0.20	-1.00	-0.20	1.80	1.60	-1.00	0.25	-1.80	-0.25	0.05
8	0.00	-1.00	0.00	0.00	0.00	-3.00	-1.00	-2.00	-2.00	-1.00
9	-	-	-	-	-	-	-	-	-	-
0-15	<b>0.24</b>	<b>-0.34</b>	<b>0.32</b>	<b>1.77</b>	<b>1.43</b>	<b>-0.45</b>	<b>0.06</b>	<b>-0.45</b>	<b>-0.43</b>	<b>0.26</b>
RANKING	2	4	3	9	8	7	1	6	5	

<b>BURNT ALL READERS</b>										
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	UNITED KINGDOM	NETHERLANDS	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R28 GB	R26 NL	ALL
0	-	-	-	-	-	-	-	-	-	-
1	0.00	-0.33	0.50	0.75	2.00	-1.00	-1.00	0.75	0.25	0.36
2	0.00	-1.00	0.00	1.00	1.00	0.00	-1.00	-0.33	-0.67	-0.13
3	0.25	-1.00	-0.50	0.25	0.25	-1.00	-0.50	0.00	-1.00	-0.30
4	0.83	-0.50	0.67	1.17	1.00	0.00	-1.00	-0.17	-0.33	0.22
5	0.00	-0.50	0.00	0.50	1.00	-0.50	0.00	-1.00	-0.50	-0.11
6	0.11	-1.13	0.00	1.00	0.22	-0.57	-0.25	-0.78	-0.89	-0.23
7	0.00	-1.00	0.33	1.75	0.75	-1.50	-0.25	-0.75	-0.75	-0.06
8	0.00	-1.00	0.00	0.00	0.00	-1.00	0.00	-2.00	-1.00	-0.56
9	-	-	-	-	-	-	-	-	-	-
0-15	0.12	-0.49	0.07	0.52	0.42	-0.42	-0.31	-0.22	-0.33	-0.04
RANKING	2	8	1	9	6	7	4	3	5	

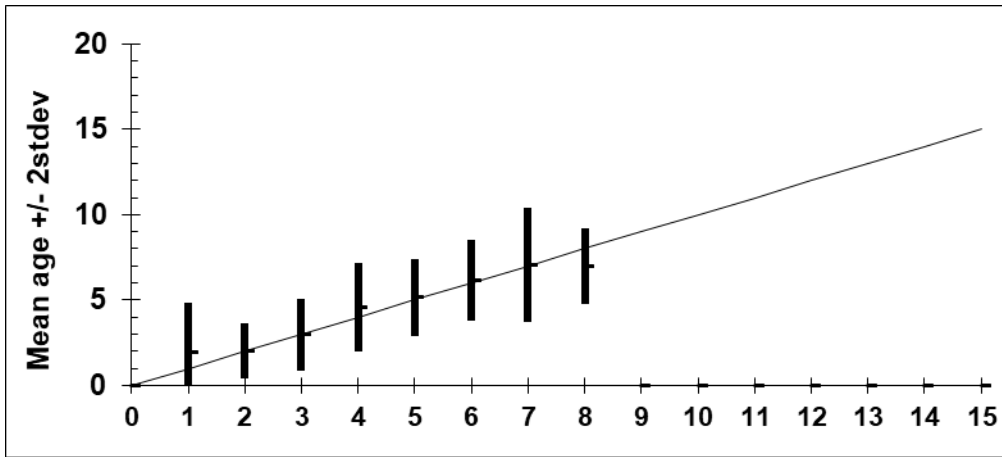
<b>SECTION EXPERT</b>			
MODAL	BELGIUM	BELGIUM	
age	R12 BE	R14 BE	ALL
0	-	-	-
1	-	-	-
2	-	-	-
3	0.10	0.00	0.05
4	0.17	0.08	0.13
5	-0.10	0.10	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.33	1.00	0.67
9	-	-	-
10	-1.00	0.00	-0.50
11	-	-	-
0-15	0.08	0.10	0.09
RANKING	1	2	

<b>WHOLE EXPERT</b>							
MODAL	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	
age	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	ALL
0	-	-	-	-	-	-	-
1	0.00	-1.00	0.00	2.50	2.00	0.00	0.78
2	0.00	-1.20	0.00	0.60	1.00	-0.20	0.03
3	-0.31	-1.46	0.00	0.79	0.43	-0.50	-0.14
4	0.08	-0.39	0.17	1.76	1.40	-0.43	0.48
5	0.07	-0.37	0.07	1.74	1.15	-0.74	0.32
6	-0.16	-0.38	-0.04	1.42	1.25	-0.86	0.23
7	-0.14	-1.17	-0.14	1.14	0.86	-1.20	-0.03
8	-2.00	-2.00	0.00	0.00	0.00	-3.00	-1.10
9	-1.00	-2.00	-3.00	0.00	0.00	-	-1.20
10	-	-	-	-	-	-	-
0-15	-0.10	-0.66	0.01	1.43	1.09	-0.69	0.21
RANKING	2	3	1	6	5	4	

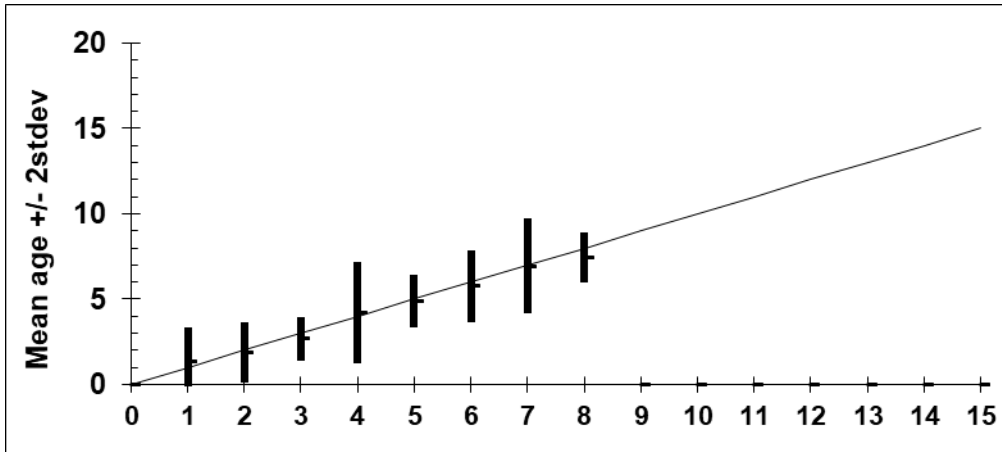
**SECTION ALL READERS**



**WHOLE ALL READERS**

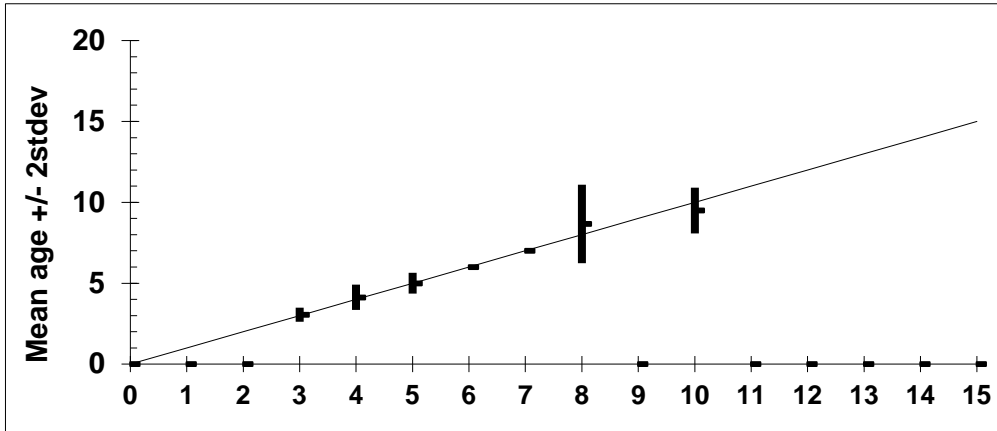


**BURNT ALL READERS**





## SECTION EXPERTS



## WHOLE EXPERTS

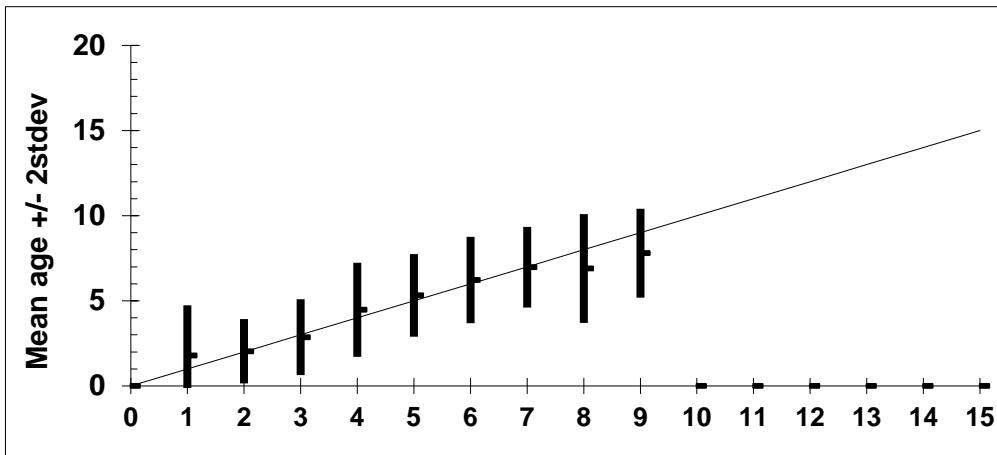


Figure 1. Age bias plot for all readers. Mean age recorded +/- 2 stdev of each reader and all readers combined are plotted against modal age. The estimated mean age corresponds to modal age, if the estimated mean age is on the 1:1 equilibrium line (solid line). Relative bias is the age difference between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

For each pair that is being compared, the differences between the readings per image are found and the frequency of each occurring difference is obtained. A rank value is calculated for the positive and the negative differences (R+ and R- in the Guus Eltink sheet). The value with the smallest rank is then used to calculate a z-value that determines the level of bias.

Table 8. 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 ( $p<0.01$ ).

<b>SECTION ALL READERS</b>									
	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	NETHERLANDS	UNITED KINGDOM
	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R26 NL	R28 GB
R02 IS		**	**	**	**	-	**	**	**
R08 DK	**		**	**	**	**	**	**	**
R10 IS	**	**		**	**	*	**	-	-
R12 BE	**	**	**		**	**	**	**	**
R14 BE	**	**	**	**		**	**	**	**
R16 DK	-	**	*	**	**		**	**	**
R22 DE	**	**	**	**	**	**		**	**
R26 NL	**	**	-	**	**	**	*		**
R28 GB	**	**	-	**	**	**	**	**	

MODAL age	**	**	**	**	**	-	**	-	**
-----------	----	----	----	----	----	---	----	---	----

<b>WHOLE ALL READERS</b>									
	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	GERMANY	NETHERLANDS	UNITED KINGDOM
	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R22 DE	R26 NL	R28 GB
R02 IS		**	**	**	**	-	**	**	**
R08 DK	**		**	**	**	**	**	**	**
R10 IS	**	**		**	**	*	**	-	-
R12 BE	**	**	**		**	**	**	**	**
R14 BE	**	**	**	**		**	**	**	**
R16 DK	-	**	*	**	**		**	**	**
R22 DE	**	**	**	**	**	**		**	**
R26 NL	**	**	-	**	**	**	*		**
R28 GB	**	**	-	**	**	**	**	**	

MODAL age	**	**	**	**	**	-	**	-	**
-----------	----	----	----	----	----	---	----	---	----

## 4.2 Modal age comparison of whole and sectioned otoliths and whole and broken

When comparing the modal age of the whole versus the sectioned otoliths the percentage agreement is 31%. It must be noted that the sample set was very limited (13 pairs of otoliths). This means that of the 13 samples included in the exercise there are four otoliths where the modal age from the sectioned otoliths is the same as the modal age from the whole otoliths. There are nine otoliths where the modal ages are not the same. All bias indicated an underestimation in the whole otoliths, with none more than two years difference. Comparing the modal age of the whole versus the broken/burnt otoliths the percentage agreement is 39%. This means that of the 57 samples included in the exercise there are 22 otoliths where the modal age from the broken/burnt otoliths is the same as the modal age from the whole otoliths. There are 35 otoliths where the modal ages are not the same. An overestimation (no greater than two years) was seen in 18% of the samples and an underestimation overestimation (no greater than two years) was seen in 44% of the samples.

### Section Vs Whole

The modal age comparison matrix (Table 9) is based on the 13 samples where a modal age was calculated for each method. The numbers shown are the actual number (not proportions) of otoliths where the modal age calculated was the same for the two methods (green), the modal age calculated based on the whole otoliths was higher compared to the sectioned otoliths (red) and the modal age calculated based on the whole otoliths was lower compared to the sectioned otoliths (blue). The numbers in blue total to nine, meaning that of the 13 samples where the modal age is not the same for the two methods the nine show a lower modal age is reached from the whole method. The main reasons for this are that the readers are unclear on the first true ring with some including and some excluding from age estimates.

**Table 9. Modal age comparison matrix of section vs whole. Green shaded area is agreement between the two methods, blue represents a lower age from the whole method (underestimation) and red represents a higher age from the whole method (overestimation).**

Section Modal Age	Whole Modal Age								
	0	1	2	3	4	5	6	7	8
0									
1									
2									
3				1					
4				1	1				
5				2	1				
6						1			
7						1	3	1	
8									1
Total	0	0	0	4	2	2	3	1	1

## Broken/burnt vs Whole

The modal age comparison matrix (Table 8) is based on the 57 samples where a modal age was calculated for each method. The numbers shown are the actual number (not proportions) of otoliths where the modal age calculated was the same for the two methods (green), the modal age calculated based on the whole otoliths was higher compared to the broken/burnt otoliths (red) and the modal age calculated based on the broken/burnt otoliths was lower compared to the whole otoliths (blue). The numbers in blue total to 25, meaning that of the 57 samples where the modal age is not the same for the two methods the 25 show a lower modal age is reached from the whole method. The number in red total is 10, meaning of 57 samples where the modal age is not the same for the two methods the 10 show a higher modal age from the whole method. This comparison indicated a higher level of underestimation compared to over estimation when comparing broken/burnt vs whole.

The main reasons for this are:

1. Readers are unclear on the first true ring with some including and some excluding from age estimates.

**Table 10. Modal age comparison matrix of broken/burnt vs Whole. Green shaded area is agreement between the two methods, blue represents a lower age from the whole method (underestimation) and red represents a higher age from the whole method (overestimation).**

Broken Modal Age	Whole Modal Age								
	0	1	2	3	4	5	6	7	8
0	0								
1		1		2					
2		2	3	2					
3			2	2	1				
4					2	2	1		
5				1	5	5	1		
6					2	6	7	1	
7						1	4	2	
8						1		1	
Total	0	3	5	7	10	15	13	4	0

Some readers underestimate ages on the whole otoliths compared to the sectioned and burnt otolith

In Figure 1 and 2 some of the readers include the first ring in their age readings but some chose not to count this as a true first ring. However, the agreement with the first ring between all readers is much higher when the same otolith is sectioned or broken/burnt. This first ring is much less visible on the whole otoliths, which leads to confusion if it should be counted or not.

Fish ID	R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	Modal age	PA %	CV %	APE %
UK_025	5	5	5	5	5	5	5	100	0	0

Fish ID	R02 IS	R04 NL	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	Modal age	PA %	CV %	APE %
UK_025	5	-	4	4	5	5	4	4	50	12	11

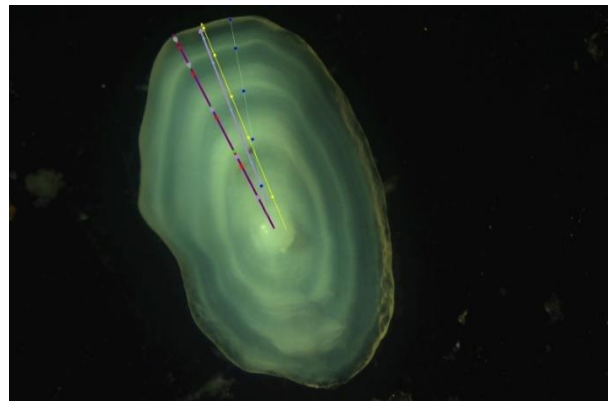
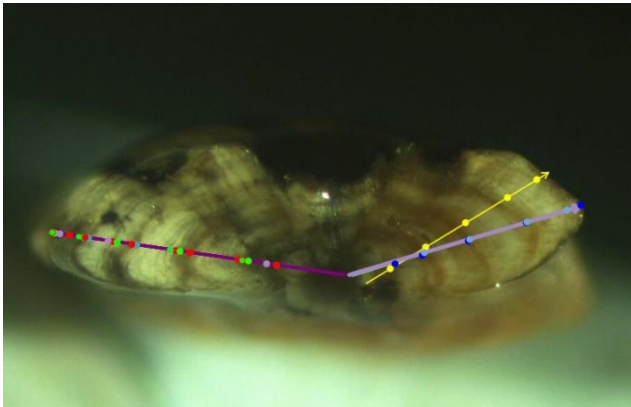


Figure 2. Lemon sole, date 21/04/2016, 28 cm: discrepancy between burnt and whole otolith. In the whole otolith, some readers count the first ring as in the burnt otolith, and some don't.

Fish ID	R02 IS	R04 NL	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	Modal age	PA %	CV %	APE %
BE_004	7	6	7	7	7	7	6	7	71	7	6

Fish ID	R02 IS	R04 NL	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	Modal age	PA %	CV %	APE %
BE_004	7	5	5	6	8	7	5	5	43	20	17

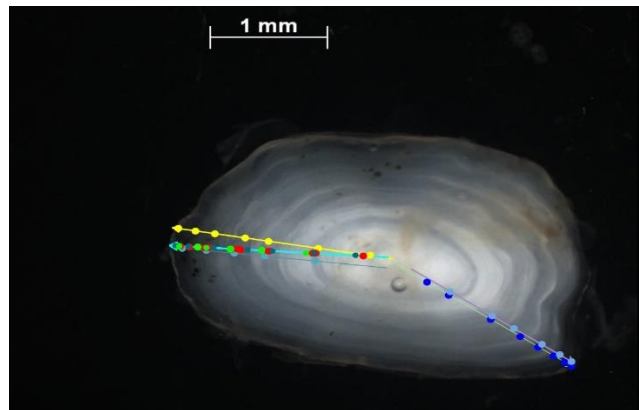
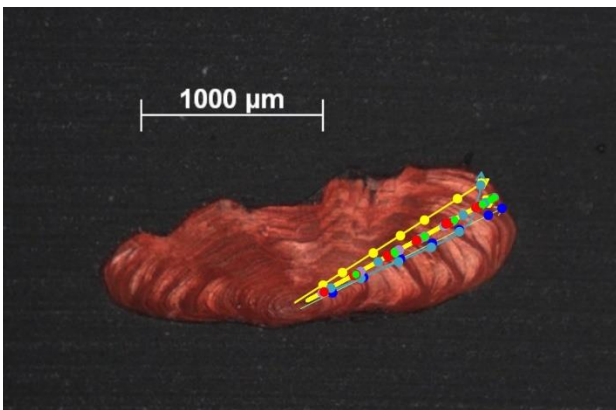


Figure 3. Lemon sole, date 20/07/2015, 41.5 cm: discrepancy between sectioned and whole otolith where the modal age of the whole otolith is lower than the modal age in the sectioned otolith.

# 5 Discussion

The statistics representing age reading performance were calculated for all readers combined and for experienced readers only. As expected, agreement was higher, and variance (APE & CV) was lower for advanced readers compared to all readers regardless of preparation method. All areas were included, and calculations were carried separately for each preparation methods – section, whole and broken/burnt. Due to a low number of readers per preparation method and to allow us to compare accuracy of each preparation method, readers were asked to read all three methods – but it should be noted (Table 2) that not all readers use all three methods to age this species.

In all cases the statistics were significantly better for sectioned otoliths than for whole or broken/burnt.

The average percentage agreement of 62% and CV of 17% was reached by all readers annotating sectioned otoliths. There was a large improvement when only advanced readers were combined: PA=90%; CV=3%, however there were only two readers who were from the same institute.

The average percentage agreement of 49% and CV of 25% was reached by all readers annotating whole otoliths. There was a slight improvement when only advanced readers were combined: PA=51%; CV=25%,

The average percentage agreement of 25% and CV of 29% was reached by all readers annotating burnt otoliths. It should be noted that none of the readers were expert in this method and poor images made annotation of ages more difficult. The UK is the only institute that reads lemon sole using this method and future exchanges should use otoliths rather than images, until photography of burnt structures can be improved.

Institutes tend to use different methods of reading, Denmark and Iceland read whole, Belgium reads whole/sectioned Netherlands reads sectioned and UK reads whole/broken/burnt. Most readers read all three methods to help us get and understanding of accuracy between methods. Due to the number of different of methods used it was decided to include all readers in the results, this could have introduced bias to the results but with the limited number of readers per method it was decided this was the best approach. Trainee readers were also left in as removing them did not seem to have a positive effect on the outcome. All readers method and experience can be seen in Table 2.

WGBIOP (WGBIOP 2018 Guidelines for Workshops on Age Reading Calibration) recommends that target and threshold statistics are formulated for each species and stock. The statistics refer to the percentage agreement, the CV and the bias. The target value is the value you would like to achieve and is possible based on exchange and workshop results. The threshold value is the minimum value required before a reader is qualified to supply data to Working Groups and can if necessary be derived by discussion between expert readers. Usually, a CV of 5% is set as a threshold for sufficient data quality (Campana 2001).

The results of present exchange indicate the proposed threshold statistics are not achieved by all experienced readers. This is related to the interpretation differences and the main discrepancies were caused by uncertainties in the first ring, particularly in whole otoliths (Figure 2). However, it was pleasing to see that readers seemed confident in distinguishing between true and shadow rings.

# 6 Conclusion

Institutes tend to use different methods of reading, Denmark and Iceland read whole, Belgium reads whole/sectioned Netherlands reads sectioned and UK reads broken/burnt.

Percentage agreement between all readers of whole lemons was 49%, sectioned 62% and burnt 25%. Removing readers R08, R16 & R26 (low percentage agreement) from the sectioned results increased percentage agreement to 85%. Removing readers R12 & R14 (lower percentage agreement) from the whole results increased the agreement to 62%, which is still very low. Percentage agreement was very low for burnt otoliths, but this may be due to poor images of the burnt otolith. It is very difficult to take a clear image with water on the surface, but this problem is being looked into to address better ways to photograph such structures. Percentage agreement of expert readers for section was very good at 90%, however this included just two readers who were from the same institute. Percentage agreement for expert readers for whole otoliths was much lower at 51%.

The results from this exercise show sectioned method provides a higher quality preparation for age determination and that results obtained from reading the sectioned otoliths are more reliable than those obtained by the two other methods (whole/ broken & burnt). The results also showed that using the preparation method of whole otoliths, can lead to an underestimation of age readings by some readers, with particular issues in interpreting the first ring.

There cannot be any comparison of results to previous exchanges as this is the first carried out for lemon sole. The low percentage agreement between readers and institute highlights the importance of this exchange.

During this exchange many readers encountered the same issue with some including and some excluding the first ring. Comparisons of the same otolith prepared in different ways showed that the age of whole otoliths was often underestimated as compared to sectioned or broken burnt otoliths. This must be noted however that this was a small sample size and a greater number would be needed to make a true comparison.

Following on from this exchange it would be recommended for a workshop to be carried out to discuss discrepancies in age readings, particularly with the first ring and possibly an otolith chemistry study.

# 7 References

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# 8 Annex 1 Additional results

## Results all readers

## Section

### Data Overview – Section

CV	PA
17 %	62 %

Table A1. Data overview including modal age and statistics per sample.

Sample year	Fish no	Fish length	Sex	Landing month	ICELAND	DENMARK	ICELAND	BELGIUM	BELGIUM	DENMARK	NETHERLANDS	UNITED KINGDOM	MODAL age	Percent agreement	Precision CV
					R02 IS	R08 DK	R10 IS	R12 BE	R14 BE	R16 DK	R26 NL	R28 GB			
17259	BE_062_s.jpg	300			5	4	5	5	5	5	4	4	5	63%	11%
17256	BE_059_s.jpg	295			5	3	6	5	5	-	5	5	5	71%	19%
17255	BE_058_s.jpg	290			5	4	5	5	5	5	4	4	5	63%	11%
17254	BE_057_s.jpg	290			5	4	5	5	5	4	4	5	5	63%	11%
17253	BE_056_s.jpg	280			4	3	4	5	4	3	3	4	4	50%	19%
17260	BE_063_s.jpg	270			6	5	6	6	6	5	5	6	6	63%	9%
17258	BE_061_s.jpg	265			5	4	5	6	5	4	4	4	4	50%	16%
17235	BE_038_s.jpg	240			4	3	4	4	4	3	3	4	4	63%	14%
17237	BE_040_s.jpg	235			4	3	4	4	4	3	3	4	4	63%	14%
17234	BE_037_s.jpg	235			4	4	4	4	4	3	3	4	4	75%	12%
17221	BE_024_s.jpg	235			4	3	4	5	4	3	3	4	4	50%	19%
17218	BE_021_s.jpg	235			4	3	4	4	4	3	3	4	4	63%	14%
17212	BE_015_s.jpg	235			4	3	4	4	4	3	3	4	4	63%	14%
17222	BE_025_s.jpg	230			4	3	4	4	4	3	3	4	4	63%	14%
17219	BE_022_s.jpg	230			4	3	4	4	4	3	3	3	4	50%	15%
17216	BE_019_s.jpg	230			4	3	4	4	4	3	3	3	4	50%	15%
17213	BE_016_s.jpg	225			4	4	4	4	4	3	3	4	4	75%	12%
17225	BE_028_s.jpg	220			3	3	4	4	4	3	3	4	3	50%	15%
17217	BE_020_s.jpg	220			3	3	3	4	4	3	3	4	3	63%	15%
17211	BE_014_s.jpg	220			4	4	4	4	4	3	3	4	4	75%	12%
17215	BE_018_s.jpg	215			4	3	4	4	4	3	3	4	4	63%	14%
17214	BE_017_s.jpg	215			4	4	4	4	4	3	3	4	4	75%	12%
17241	BE_044_s.jpg	210			4	-	4	5	5	3	4	4	4	57%	17%
17238	BE_041_s.jpg	210			4	-	4	4	4	3	3	4	4	71%	13%
17220	BE_023_s.jpg	210			4	3	4	4	4	-	3	4	4	71%	13%
17223	BE_026_s.jpg	205			4	3	4	4	4	-	3	4	4	71%	13%
17242	BE_045_s.jpg	200			3	3	3	3	3	2	3	3	3	88%	12%
17239	BE_042_s.jpg	200			3	2	3	3	3	2	2	3	3	63%	20%
14723	BE_043_s.jpg	195			3	2	3	3	3	2	2	3	3	63%	20%
17243	BE_046_s.jpg	195			3	2	3	3	3	2	2	3	3	63%	20%
17227	BE_030_s.jpg	195			3	2	3	3	3	2	2	2	3	50%	21%
17226	BE_029_s.jpg	195			4	3	4	4	4	3	3	4	4	63%	14%
17224	BE_027_s.jpg	195			4	2	3	4	3	-	3	3	3	57%	22%
17244	BE_047_s.jpg	190			3	2	3	3	3	2	2	3	3	63%	20%
17228	BE_031_s.jpg	180			3	2	3	3	3	2	2	3	3	63%	20%
17249	BE_052_s.jpg	175			-	2	3	3	3	2	2	3	3	57%	21%
17245	BE_048_s.jpg	175			3	3	3	3	3	3	2	3	3	88%	12%
17251	BE_054_s.jpg	165			3	2	3	3	3	2	2	3	3	63%	20%
17248	BE_051_s.jpg	165			3	2	3	3	3	2	2	3	3	63%	20%
17246	BE_049_s.jpg	165			3	3	3	3	3	2	2	3	3	75%	17%
17233	BE_036_s.jpg	160			3	-	3	3	3	2	2	3	3	71%	18%
17252	BE_055_s.jpg	155			3	-	3	3	3	2	2	3	3	71%	18%
17229	BE_032_s.jpg	175			3	-	3	4	3	-	2	3	3	67%	21%
17230	BE_033_s.jpg	180			3	3	3	4	4	-	3	3	3	71%	15%
17232	BE_035_s.jpg	180			3	3	3	3	3	2	2	3	3	75%	17%
17231	BE_034_s.jpg	175			-	-	-	3	3	2	2	3	3	60%	21%
17247	BE_050_s.jpg	155			3	-	3	3	3	2	2	3	3	71%	18%
17250	BE_053_s.jpg	155			3	2	3	3	3	1	2	3	3	63%	30%
17257	BE_060_s.jpg				4	4	5	5	5	-	4	5	5	57%	12%
17200	BE_003_s.jpg	360			7	-	7	9	10	-	7	6	7	50%	20%
17198	BE_001_s.jpg	390			7	7	7	8	8	-	5	6	7	43%	16%
17201	BE_004_s.jpg	415			7	-	7	7	7	-	5	6	7	67%	13%
17203	BE_006_s.jpg	260			7	9	7	8	11	10	7	4	7	38%	28%
17199	BE_002_s.jpg	335			5	7	5	7	7	6	4	6	7	38%	19%
17210	BE_013_s.jpg	150			4	3	4	4	5	-	3	5	4	43%	20%
17209	BE_012_s.jpg	185			5	4	5	5	5	3	3	4	5	50%	21%
17208	BE_011_s.jpg	195			3	3	4	4	4	3	3	3	3	63%	15%
17204	BE_007_s.jpg	280			6	5	7	6	6	-	5	4	6	43%	18%
17206	BE_009_s.jpg	235			3	4	4	-	5	-	4	4	4	67%	16%
17205	BE_008_s.jpg	305			5	-	6	5	6	-	4	5	5	50%	15%
14780	BE_010_s.jpg	220			5	4	5	5	5	-	3	5	5	71%	17%
17202	BE_005_s.jpg	335			8	7	8	9	8	-	6	5	8	43%	19%
Total read					60	52	61	61	62	46	62	62			
Total NOT read					2	10	1	1	0	16	0	0		61.5%	16.6%

**Table A2. 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.**

<b>MODAL age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>NETHERLANDS R26 NL</b>	<b>UNITED KINGDOM R28 GB</b>	<b>TOTAL</b>
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-
3	22	19	23	24	24	21	24	24	181
4	22	20	22	21	22	18	22	22	169
5	8	7	8	8	8	4	8	8	59
6	2	2	2	2	2	1	2	2	15
7	5	3	5	5	5	2	5	5	35
8	1	1	1	1	1	-	1	1	7
<b>Total</b>	<b>60</b>	<b>52</b>	<b>61</b>	<b>61</b>	<b>62</b>	<b>46</b>	<b>62</b>	<b>62</b>	<b>466</b>

**Table A3. Age composition by reader gives a summary of number of readings per reader.**

<b>AGE COMPOSITION</b>									
<b>Age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>NETHERLANDS R26 NL</b>	<b>UNITED KINGDOM R28 GB</b>	<b>TOTAL</b>
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	1	-	-	1
2	-	11	-	-	-	16	18	1	46
3	20	21	21	18	20	20	23	22	165
4	21	9	20	21	21	2	6	22	122
5	5	1	5	8	7	3	2	3	34
6	1	-	2	2	1	-	-	1	7
<b>Total</b>	<b>47</b>	<b>42</b>	<b>48</b>	<b>49</b>	<b>49</b>	<b>42</b>	<b>49</b>	<b>49</b>	<b>375</b>

**Table A4. 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.**

<b>MEAN LENGTH AT AGE</b>									
<b>Age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>NETHERLANDS R26 NL</b>	<b>UNITED KINGDOM R28 GB</b>	<b>ALL</b>
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	155.0	-	-	155.0
2	-	182.7	-	-	-	178.1	175.3	195.0	178.5
3	184.3	215.4	179.8	176.7	177.5	221.4	216.5	182.2	195.6
4	210.7	223.3	221.3	213.0	222.5	277.5	247.8	234.0	223.5
5	276.1	275.0	235.6	237.3	221.8	286.7	330.0	227.9	251.3
6	275.0	-	290.0	271.7	285.0	-	-	354.0	307.2
<b>Total</b>	<b>207.8</b>	<b>210.0</b>	<b>207.5</b>	<b>206.0</b>	<b>205.3</b>	<b>210.6</b>	<b>209.8</b>	<b>212.0</b>	<b>209.6</b>



**Table A6. 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.**

<b>MODAL age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>GERMANY R22 DE</b>	<b>NETHERLANDS R26 NL</b>	<b>UNITED KINGDOM R28 GB</b>	<b>TOTAL</b>
0	-	-	-	-	-	-	-	-	-	-
1	1	1	1	1	1	0	0	1	1	7
2	1	1	1	1	1	1	1	1	1	9
3	2	2	2	2	2	2	2	2	2	18
4	15	14	14	16	16	13	15	16	15	134
5	7	7	7	7	7	7	7	7	7	63
6	7	7	7	7	7	6	7	7	6	61
7	1	0	1	1	1	0	0	1	0	5
8	0	0	0	0	0	0	0	0	0	0
<b>0-15</b>	<b>105</b>	<b>103</b>	<b>100</b>	<b>106</b>	<b>107</b>	<b>89</b>	<b>100</b>	<b>107</b>	<b>102</b>	<b>919</b>

**Table A7. Age composition by reader gives a summary of number of readings per reader.**

<b>Age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>GERMANY R22 DE</b>	<b>NETHERLANDS R26 NL</b>	<b>UNITED KINGDOM R28 GB</b>	<b>TOTAL</b>
0	-	1	-	-	-	-	-	1	-	2
1	1	2	1	-	-	-	1	1	2	8
2	1	-	1	-	-	2	1	2	1	8
3	1	1	1	3	3	3	1	4	3	20
4	12	11	11	1	1	16	5	19	18	94
5	10	12	11	7	8	4	16	6	5	79
6	7	4	5	12	14	4	5	2	2	55
7	2	1	3	4	1	-	2	-	1	14
<b>0-15</b>	<b>34</b>	<b>32</b>	<b>33</b>	<b>35</b>	<b>35</b>	<b>29</b>	<b>32</b>	<b>35</b>	<b>32</b>	<b>297</b>

**Table A8. 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.**

<b>Age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>GERMANY R22 DE</b>	<b>NETHERLANDS R26 NL</b>	<b>UNITED KINGDOM R28 GB</b>	<b>ALL</b>
0	-	60.0	-	-	-	-	-	90.0	-	75.0
1	60.0	140.0	60.0	-	-	-	120.0	60.0	110.0	100.0
2	120.0	-	120.0	-	-	140.0	160.0	140.0	120.0	135.0
3	160.0	250.0	160.0	113.3	113.3	300.0	250.0	308.8	310.0	228.3
4	300.8	318.2	305.0	250.0	250.0	314.1	298.0	321.8	317.5	311.8
5	336.0	327.5	331.4	312.1	319.4	346.3	333.1	338.3	350.0	331.3
6	355.7	368.8	355.0	333.3	322.5	368.8	332.0	370.0	345.0	342.2
7	240.0	325.0	276.7	327.5	365.0	-	345.0	-	350.0	310.7
8	-	-	-	347.0	347.9	-	350.0	-	-	347.7
9	-	-	-	-	90.0	-	-	-	-	90.0
10	-	-	-	220.0	-	-	-	-	-	220.0
11	-	-	-	-	-	-	-	-	-	-
12	-	-	-	290.0	-	-	-	-	-	290.0
<b>0-15</b>	<b>302.4</b>	<b>306.9</b>	<b>301.4</b>	<b>301.4</b>	<b>301.4</b>	<b>312.6</b>	<b>314.1</b>	<b>301.4</b>	<b>305.5</b>	<b>305.0</b>

# Broken/Burnt

## Data Overview – Section

CV	PA
29%	46%

Table A9. Data overview including modal age and statistics per sample.

Fish no	Fish length	Sex	Landing month	ICELAND R02 IS	DENMARK R08 DK	ICELAND R10 IS	BELGIUM R12 BE	BELGIUM R14 BE	DENMARK R16 DK	GERMANY R22 DE	UNITED KINGDOM R28 GB	NETHERLANDS R26 NL	MODAL age	Percent agreement	Precision CV
UK_068_b.jpg	100.0			1	1	2	2	3	-	0	2	1	1	38%	62%
UK_066_b.jpg	100.0			2	1	-	2	3	-	0	2	2	2	57%	55%
UK_067_b.jpg	90.0			1	0	1	2	3	-	0	2	1	1	38%	83%
UK_071_b.jpg	70.0			-	-	-	1	3	0	0	1	2	1	33%	100%
UK_069_b.jpg	160.0			3	2	3	3	3	2	2	3	2	3	56%	21%
UK_065_b.jpg	150.0			2	1	2	3	3	-	1	2	1	2	38%	45%
UK_003_b.jpg	130.0			-	1	-	2	3	-	0	2	1	1	33%	70%
UK_001_b.jpg	170.0			5	-	5	4	4	-	4	3	3	4	43%	20%
UK_004_b.jpg	180.0			3	2	3	4	4	-	2	3	2	3	38%	29%
UK_006_b.jpg	210.0			7	4	6	8	5	-	4	6	3	4	25%	31%
UK_002_b.jpg	320.0			4	3	6	6	7	-	4	4	5	4	29%	28%
UK_013_b.jpg	360.0			8	7	8	8	8	7	8	6	7	8	56%	10%
UK_012_b.jpg	340.0			6	4	6	7	6	5	6	4	4	6	44%	21%
UK_011_b.jpg	320.0			6	4	6	9	6	5	6	6	5	6	56%	23%
UK_062_b.jpg	160.0			4	-	2	3	3	2	3	3	2	3	50%	26%
UK_059_b.jpg	260.0			6	5	6	6	6	6	6	4	5	6	67%	13%
UK_058_b.jpg	270.0			4	-	4	3	5	4	4	3	5	4	43%	46%
UK_057_b.jpg	280.0			5	6	4	6	5	5	4	4	4	4	44%	17%
UK_056_b.jpg	280.0			6	-	5	6	6	6	6	2	5	6	57%	28%
UK_063_b.jpg	140			3	-	2	3	3	2	3	3	2	3	63%	20%
UK_038_b.jpg	130			2	1	2	4	3	2	2	1	1	2	44%	50%
UK_040_b.jpg	360			7	-	-	13	8	-	8	7	6	7	33%	30%
UK_037_b.jpg	150			4	1	3	4	4	3	2	3	2	4	33%	36%
UK_024_b.jpg	280			6	5	6	6	6	5	6	6	5	6	67%	9%
UK_015_b.jpg	290			6	5	6	7	7	5	4	6	5	6	33%	18%
UK_025_b.jpg	280			5	5	5	5	5	5	5	4	4	5	78%	9%
UK_022_b.jpg	260			6	5	6	6	6	-	6	5	4	6	63%	14%
UK_019_b.jpg	270			7	6	8	7	7	6	6	6	7	7	44%	11%
UK_016_b.jpg	310			7	6	7	8	7	6	6	6	6	6	56%	11%
UK_028_b.jpg	240			5	4	5	6	7	4	5	4	5	5	44%	20%
UK_020_b.jpg	270			6	5	6	8	6	6	-	8	7	6	50%	16%
UK_014_b.jpg	290			7	6	7	8	9	-	7	6	6	7	38%	15%
UK_018_b.jpg	300			7	6	7	7	7	5	6	6	6	7	44%	11%
UK_017_b.jpg	310			7	7	7	9	9	-	7	6	6	7	50%	16%
UK_044_b.jpg	250			5	-	7	11	8	-	4	6	6	6	29%	34%
UK_023_b.jpg	260			5	4	5	5	5	4	5	4	4	5	56%	12%
UK_026_b.jpg	240			6	4	6	6	6	4	5	5	5	6	44%	16%
UK_042_b.jpg	350			7	6	7	8	9	6	6	7	6	6	44%	15%
UK_043_b.jpg	210			6	-	-	8	10	-	5	7	4	6	17%	32%
UK_030_b.jpg	220			6	4	5	6	5	5	5	5	4	5	56%	14%
UK_029_b.jpg	230			6	4	5	5	5	4	3	5	5	5	56%	19%
UK_027_b.jpg	250			8	5	6	9	9	4	6	4	6	6	33%	31%
UK_047_b.jpg	280			6	6	7	7	7	6	6	6	6	6	67%	8%
UK_031_b.jpg	220			6	4	5	7	5	-	5	4	4	4	38%	21%
UK_052_b.jpg	310			6	-	8	6	7	-	7	5	6	6	43%	15%
UK_048_b.jpg	270			6	6	6	6	6	5	6	6	5	6	78%	8%
UK_049_b.jpg	260			5	5	6	5	5	4	4	5	2	5	56%	25%
UK_036_b.jpg	180			5	-	3	6	5	-	4	6	3	5	29%	28%
UK_032_b.jpg	130			2	1	2	3	3	-	1	2	2	2	50%	38%
UK_033_b.jpg	140			2	-	-	4	3	1	1	1	2	1	43%	58%
UK_035_b.jpg	150			2	1	2	3	3	-	1	2	1	2	38%	45%
UK_034_b.jpg	160			2	1	2	4	3	-	1	2	1	2	38%	53%
UK_007_b.jpg	130			6	-	6	6	6	-	1	5	3	6	57%	42%
UK_009_b.jpg	160			5	4	5	7	7	-	4	6	4	4	38%	24%
UK_008_b.jpg	170			5	-	4	5	6	-	3	3	4	5	29%	26%
UK_010_b.jpg	320			6	5	7	7	7	-	6	5	4	6	38%	18%
UK_050_b.jpg	260			6	5	6	7	7	-	6	3	2	6	38%	35%
UK_053_b.jpg	300			6	5	8	8	6	-	8	5	4	8	38%	25%
UK_073_b.jpg	380			5	-	8	11	5	10	10	5	5	5	50%	36%
UK_064_b.jpg	140			3	2	3	3	2	-	2	2	2	2	63%	22%
			Total read	58	45	54	60	60	31	59	60	60			
			Total NOT read	2	15	6	0	0	29	1	0	0		45.7%	28.6%

**Table A10. 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.**

<b>MODAL age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>GERMANY R22 DE</b>	<b>UNITED KINGDOM R28 GB</b>	<b>NETHERLANDS R26 NL</b>	<b>TOTAL</b>
0	-	-	-	-	-	-	-	-	-	-
1	2	3	2	4	4	1	4	4	4	28
2	3	3	2	3	3	1	3	3	3	24
3	4	2	4	4	4	3	4	4	4	33
4	6	4	6	6	6	3	6	6	6	49
5	2	2	2	2	2	2	2	2	2	18
6	9	8	9	9	9	7	8	9	9	77
7	4	3	3	4	4	2	4	4	4	32
8	1	1	1	1	1	1	1	1	1	9
<b>0-15</b>	<b>58</b>	<b>45</b>	<b>54</b>	<b>60</b>	<b>60</b>	<b>31</b>	<b>58</b>	<b>60</b>	<b>60</b>	<b>486</b>

**Table A11. Age composition by reader gives a summary of number of readings per reader.**

<b>Age</b>	<b>R02 IS</b>	<b>R08 DK</b>	<b>R10 IS</b>	<b>R12 BE</b>	<b>R14 BE</b>	<b>R16 DK</b>	<b>R22 DE</b>	<b>R28 GB</b>	<b>R26 NL</b>	<b>TOTAL</b>
0	-	1	-	-	-	1	6	-	-	8
1	2	6	1	1	-	-	1	2	5	18
2	3	2	5	4	-	4	4	6	7	35
3	3	1	3	5	10	1	2	7	2	34
4	4	4	2	4	3	2	5	6	4	34
5	4	6	4	1	4	7	2	1	8	37
6	8	5	9	7	7	4	9	9	4	62
7	6	1	3	4	6	1	1	1	3	26
8	1	-	2	5	2	-	2	1	-	13
9	-	-	-	1	1	-	-	-	-	2
10	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-
13	-	-	-	1	-	-	-	-	-	1
<b>0-15</b>	<b>31</b>	<b>26</b>	<b>29</b>	<b>33</b>	<b>33</b>	<b>20</b>	<b>32</b>	<b>33</b>	<b>33</b>	<b>270</b>

**Table A12. 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.**

<b>Age</b>	<b>ICELAND R02 IS</b>	<b>DENMARK R08 DK</b>	<b>ICELAND R10 IS</b>	<b>BELGIUM R12 BE</b>	<b>BELGIUM R14 BE</b>	<b>DENMARK R16 DK</b>	<b>GERMANY R22 DE</b>	<b>UNITED KINGDOM R28 GB</b>	<b>NETHERLANDS R26 NL</b>	<b>ALL</b>
0	-	90.0	-	-	-	70.0	126.7	-	-	115.0
1	95.0	126.7	90.0	70.0	-	-	150.0	100.0	120.0	114.4
2	126.7	170.0	136.0	105.0	-	147.5	155.0	141.7	137.1	138.3
3	160.0	320.0	163.3	176.0	123.0	150.0	150.0	175.7	190.0	160.6
4	225.0	277.5	275.0	157.5	166.7	255.0	254.0	286.7	290.0	245.6
5	242.5	273.3	242.5	280.0	260.0	298.6	260.0	260.0	282.5	271.1
6	287.5	290.0	283.3	274.3	287.1	277.5	291.1	292.2	315.0	287.9
7	290.0	360.0	300.0	300.0	288.3	360.0	290.0	360.0	300.0	301.5
8	360.0	-	315.0	288.0	360.0	-	360.0	270.0	-	318.5
9	-	-	-	320.0	290.0	-	-	-	-	305.0
10	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-
13	-	-	-	360.0	-	-	-	-	-	360.0
<b>0-15</b>	<b>236.1</b>	<b>233.5</b>	<b>236.6</b>	<b>227.9</b>	<b>227.9</b>	<b>244.0</b>	<b>226.6</b>	<b>227.9</b>	<b>227.9</b>	<b>231.3</b>