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International Council for the
Exploration of the sea

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REPORT OF THE BLUE WHITING OTOLITH READING WORKSHOP

Tórshavn, Faroe Islands, 2 - 6 November 1992

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1 INTRODUCTION

1.1 Terms of reference

At the ICES Statutory meeting in 1991 it was agreed to hold a workshop on blue whiting otolith reading in Tórshavn, Faroe Islands (Chairman Mr. Jan Arge Jacobsen) in November 1992, ICES C.Res. 1991/2:22 with the following terms of reference:

a) evaluate the results of the otolith exchange programme carried out during 1988-1990 and the one presently taking place (to be terminated in mid 1992);

b) validate the different methods of reading, i.e. the whole, broken, and sliced otolith;

c) discuss and make recommendations relating to the identification of the first annual ring and the interpretation of the edge and false rings.

In accordance with the terms it was agreed to held the Workshop at the Fisheries Laboratory in Tórshavn.

1.2 Participation

The participants representing four countries (Faroes, Norway, Russia and Spain) were:

Sergey Belikov	Russia
Arnold Hendriksen	Faroe Islands
Jan Arge Jacobsen (Chairman)	Faroe Islands
Manuel Meixide	Spain
Terje Monstad	Norway
Unnur Paturson	Faroe Islands
Marit Pedersen	Faroe Islands
Øyvind Tangen	Norway

2 BACKGROUND AND AIMS

2.1 Background

The differences in ageing blue whiting otoliths among different otolith readers might sometimes create large discrepancies in the catch at age data provided by different countries fishing for blue whiting. The catch at age data is the basic input to the Virtual Population Analysis technique (VPA) used to assess the blue whiting stocks. The results of the acoustic surveys regularly undertaken by Norway and Russia in the spawning area to the west of the British Isles are used to tune the VPA, and inconsistency in this material also generates errors in the VPA. Generally all figures concerning the population biology of blue whiting depends on a consistent and unbiased interpretation of the age of the fish from the otoliths.

Since 1977 when the first otolith exchange programme was initiated (Anon. 1978), several attempts have been made to solve the ageing problems in blue whiting, including otolith exchange programmes as well as otolith reading Workshops (see next section). Otoliths and pictures of otoliths have also been brought to working group meetings, but the time has been limited to discuss these problems properly during the meetings.

2.2 Definition of the problem

The basic problems in age readings from blue whiting otoliths can be divided into following parts:

i) the identification of the first annual ring,
ii) the interpretation of the edge and
iii) the interpretation of false rings.

In addition to the problems defined above there seem to be systematic differences in the population structure between the so-called "southern stock of blue whiting" and the "northern stock of blue whiting". At present it is not clear whether these differences are real or due to different interpretation of the blue whiting otoliths. Generally the agreement is low when a sample of otoliths from the southern stock is read by countries usually reading otoliths from the northern stock (Meixide 1990).

The measurements of the width of each of the growth zones (largest inner diameter ∅) as proposed in Anon. (1979) were done for one of the sample used in this report (see section 4.1). This should make the interpretation of the otoliths easier according to the definitions above.

2.3 Preparation of blue whiting otoliths and age reading techniques

Two different methods are presently used for ageing blue whiting otoliths; analysing them as whole, and while sectioned. By the first method the otoliths are kept in fresh water and analysed when soaked. They are stored dry in envelopes and for later analysing they are again soaked in fresh water for at least 24 hours. The other method include mounting the otoliths in a black polyester resin. thin slices are then cut precisely along the centre of the otoliths. The slices (transverse section of the otoliths) are then mounted and fixed on standard glass microscope slides (Bedford 1983). This method is used by Faroe Islands. The Spanish method is practically the same as used in Faroes, and the only difference is that the otoliths are kept in sea water until slicing, to make the rings more visible.

Russia and Norway, which together count for more than 80 % of the blue whiting landings, use the first method reading whole otoliths. Spain and Faroe Islands use the sectioned otoliths for ageing the blue whiting, although Spain occasionally use the whole otoliths.

3. EVALUATION OF PREVIOUS OTOLITH EXCHANGE PROGRAMMES

3.1 Identification of the exchange programmes

Since 1977 when the first blue whiting otolith exchange programme was initiated, altogether 7 otolith exchanges and Workshops have been completed (Table 3.1.1).

Table 3.1.1. Previous blue whiting otolith exchange programmes and otolith workshops.

No.	Year started	Recommendation in:	Year finished	Reported in:	Chairman
1	1977	Anon. 1978	1978	Jákupsstovu 1978, WG Doc to Anon. 1978	J. Jakobsson
2	1979	Anon. 1979	1981	Anon. 1981	J. Jakobsson
3	1981	Anon. 1981	1983	Anon. 1983	H. í Jákupsstovu
4	1984	Anon. 1984	1986	Seliverstova *et al.* 1986, WG Doc. to Anon. 1987	H. í Jákupsstovu
5	1986	Anon. 1987	1988	Monstad & Linkowski 1988, WG Doc. to Anon. 1989	T. Monstad
6	1988	Anon. 1989	1990	Meixide 1990, ICES paper to Anon. 1991	T. Monstad
7	1990	Anon. 1991	1992	Anon. 1993 (present report)	J.A. Jacobsen

3.2 Results

The results of the different otolith exchanges are reported in various working group reports (see the references in Table 3.1.1). Over the years a general improvement can be noticed, especially in the beginning of the period. However, the results have been variable from one exchange to the next. Generally the agreement has been higher during and after an otolith Workshop, than before the meeting (see e.g. Anon. 1983).

3.3 Discussion

The use of statistical methods as an aid to solve the different problems in reading blue whiting otoliths, has so far not been of very great predictive value. Most tests have only elucidated the problems rather than solved them. This is mainly due to the few parameters available that can be used in statistical tests, and the great variances associated with them. The diameter of the annual rings might be used in such tests together with other measures as fish length and weight. A multiple regression test was done in Anon. (1990), with age as the dependent variable and fish length, fish weight, otolith length, otolith height, and otolith weight as independent variables. The resulting correlation coefficients (r) for males ranged from 0.82 (all age groups) to 0.93 (age groups 0-7), but the standard error of the estimated age was 1.8 and 0.6 years, respectively. More recently Meixide and Piñeiro (1992) in a working document to the present Workshop tested the otolith diameter of each annual ring for different areas, and no significant difference was found among areas (Spanish readings of sample 1a-d in Table 4.1.1 below).

Most work has so far been focused on the precision of the age readings, i.e. minimising the differences among readers, but this does not necessarily imply an unbiased results. In this context the only possibility to estimate the accuracy of the method is by using some validation technique. If a strong year class can be followed through a number of years, it can become a very valuable validation technique.

To conclude this section we can state that even after several otolith exchanges and a few otolith Workshops there are still unsatisfactory discrepancies between countries when ageing blue whiting otoliths.

4 ANALYSIS OF THE 1992 OTOLITH EXCHANGE

4.1 Description of the samples

During the Workshop meeting four samples were used, and these are presented in Table 4.1.1. A detailed list of the age readings fro each sample is given in Appendix A, Tables A1.1-A4.

Table 4.1.1. Otolith samples analysed at the 1992 Otolith Workshop. Sample 1a-d was circulated before the meeting, while sample 2-4 were brought to the meeting.

Sample no.	ICES area	date	Nos. of otoliths whole	sectioned
1a	VIIb,c,g-k	Apr. 1989	25	25
1b	VIa	Apr. 1989	25	25
1c	IVa	Apr.-Jul. 1989	25	25
1d	IIa	Apr. 1990	25	25
2	Vb	Jul. 1992	99	99
3	VIIb,c	Apr. 1992	100	-
4	VIIIc-IXa	Feb. 1992	-	105

Sample no. 1a-d was used for the Otolith Exchange Programme recommended by the Working Group in 1990 (Anon., 1991). Unfortunately the otoliths were broken during the exchange, and hence some of them could not be analysed. The inner diameter of the annual zones (∅) in the sectioned otoliths of this sample were also measured (see Figure 4.1.1). In the same manner the largest inner diameter of the annual zones in the whole otolith was measured by some of the countries reading whole otoliths.

The three additional samples (2-4) were brought to the Workshop and all of the samples were completed by all the readers at the meeting. Some of the otoliths from these samples, as well as from other samples available, were studied using a "Discussion Binocular" allowing two person to look at the same otolith at the same time. This equipment greatly facilitate the possibility to train new readers and allow experienced readers to discuss specific features of the otoliths.

After the Workshop a sample from Spain (Manuel and Piñeiro 1993) was included in the discussion of the present report (see Table A5 in Appendix A). The sample included the measurements of the inner diameter of the annual zones.

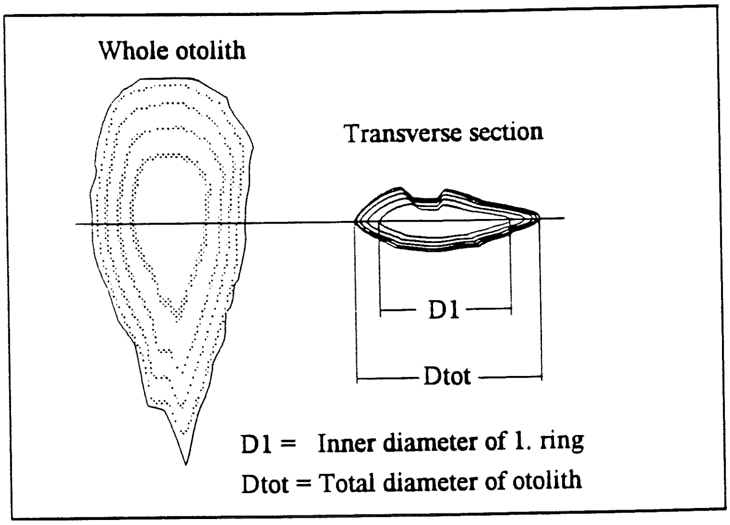

Figure 4.1.1. The lateral view of the whole otolith and the corresponding transverse section showing the measurements of the growth zones, D1, D2, etc. corresponds to the first annual ring, the second annual ring, etc. respectively. Dtot is the total diameter of the transverse section.

4.2 Results

4.2.1 Comparison of agreement between countries

Sample 1:
The results of the age readings (sample 1a-d) in the otoliths exchange programme initiated in 1990 is shown in Table 4.2.1.1. The left part of the table shows the agreement of the sectioned otolith readings, while the right part shows the agreement for the whole otolith readings. The agreement in the sectioned otoliths is rather low and especially for Spain and the other three countries. For the whole otoliths the agreement is on average higher, although the agreement is rather low for Faroes as compared to the other countries. If a comparison is made between countries for the presently used age reading technique, the resulting agreement percentages will be as in Table 4.2.1.2. Again the agreement is low, and especially for Spain as compared to the other countries.

Table 4.2.1.1. Agreement (%) in ageing of sample 1a-d (Divisions VIIb-k,IVa,VIa,IIa) between countries of the sectioned and the whole otoliths.

	Sectioned			**Whole**		
Country	Faroe	Spain	Norway	Faroe	Spain	Norway
Russia	64	32	65	53	77	76
Norway	69	33		53	71	
Spain	39			51		

Table 4.2.1.2. Agreement in ageing of sample 1a-d between countries for presently used methods (%).

Country	Faroe sectioned	Spain sectioned	Norway whole
Russia - whole	67	35	76
Norway - whole	62	33	
Spain - sectioned	39		

The mean age by country from sample 1a-d is given in Table 4.2.1.3, and as can be seen the mean age is not statistically different among countries. However, the slight tendency of Spain reading the fish older can be noticed in Figure 4.2.1.1, mean length at age, and in the mean age at length Figure 4.2.1.2.

Table 4.2.1.3. Observed mean age for sample 1a-d by country, standard deviation and coefficient of variation is also indicated. The probability of the means to come from the same population is 0.028.

Country	Mean age	SD	C.V.
Faroes	3.98	2.48	0.62
Norway	3.62	2.01	0.56
Russia	3.83	2.26	0.59
Spain	4.56	2.41	0.53

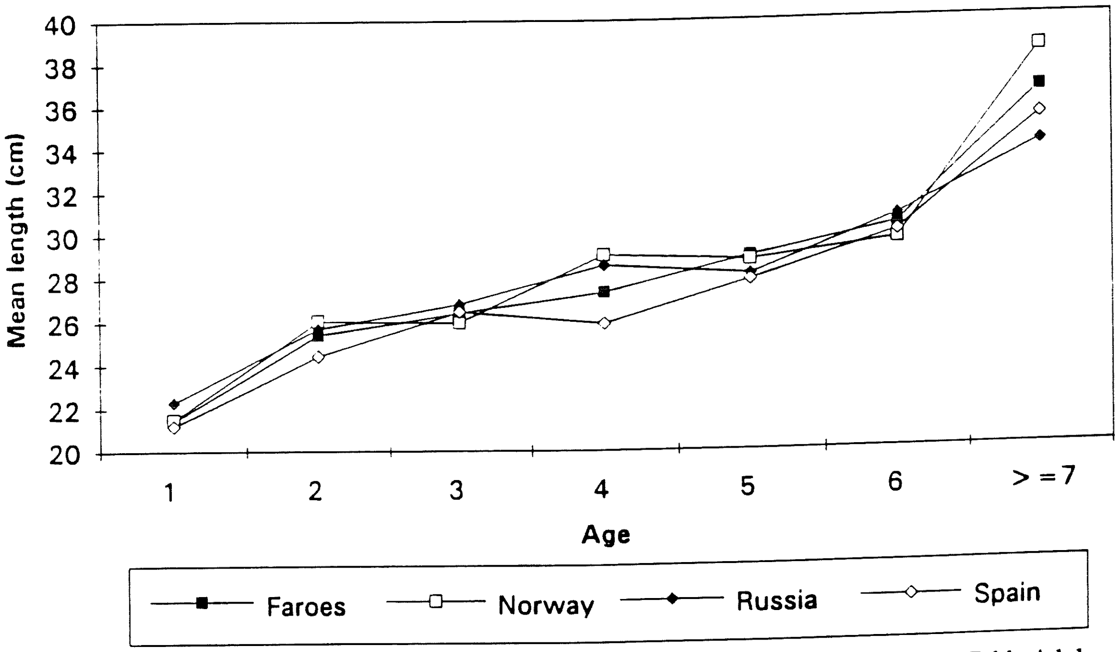

Figure 4.2.1.1. Mean length at age by country. Sectioned otoliths, data from sample 1a-d in Table 4.1.1.

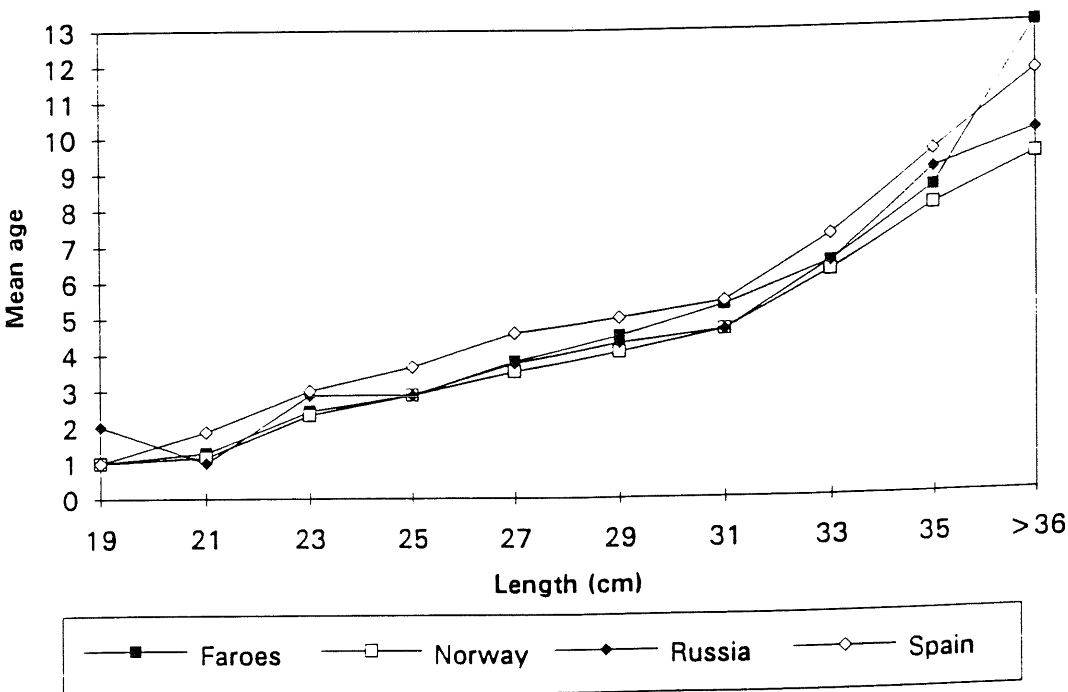

Figure 4.2.1.2. Mean age at length by country. Sectioned otoliths, data from sample 1a-d in Table 4.1.1.

Sample 2:
The results from sample 2 (brought by Faroes) are shown in Tables 4.2.1.4-6. The agreement between countries for this sample is high, both for sectioned and whole otoliths (Table 4.2.1.4). The main reason seems to be the young age of the fish in this sample (see Table A2, Appendix A), indicating that the determination of the first few rings in the otoliths might not be the biggest problem in ageing blue whiting otoliths between countries. There is a tendency of lower agreement between Russia and the other three countries in the whole otoliths (right part of Table 4.2.1.4).

Table 4.2.1.4. Agreement of ageing sample 2 (Division Vb) between countries (%).

	Sectioned			Whole		
Country	Faroe	Spain	Norway	Faroe	Spain	Norway
Russia	74	71	76	63	69	66
Norway	89	94		94	93	
Spain	90			88		

Sample 3:
This sample was brought to the Workshop by Russia (Table A3, Appendix A). The otoliths were sampled in Division VIIb,c in April 1992. The agreement is fairly high for this sample (Table 4.2.1.5). It should be noted that the otoliths were read whole.

Table 4.2.1.5. Agreement of ageing sample 3 (Division VIIb,c) between countries (%).

	Whole		
Country	Faroe	Spain	Norway
Russia	65	59	70
Norway	81	70	
Spain	65		

Sample 4:
This sample was from the southern area (Division VIIIc-IXa) and was brought to the Workshop by Spain (Table A4, Appendix A). The otoliths were sectioned and mounted on glass plates. Generally the agreement is low as can be seen from Table 4.2.1.6, and this is especially true for the Russian readings when compared to the other countries. It should be noted, however, that the otoliths were kept in sea water until they were sectioned and mounted on glass plates. This method (Spanish method) makes the rings more visible in the otolith and might have led to some countries reading false zones.

Table 4.2.1.6. Agreement of ageing sample 4 (Division VIIIc-IXa) between countries (%).

	Sectioned		
Country	Faroe	Spain	Norway
Russia	15	22	17
Norway	61	74	
Spain	65		

4.2.2 Comparison of different age reading techniques

In Table 4.2.2.1 is a comparison of the agreement between age reading techniques for each country for sample 1a-d. As can be seen the agreement is generally lower for countries routinely ageing sectioned otoliths as compared to countries ageing whole otoliths.

Table 4.2.2.1. Agreements of sample 1a-d between methods (%), i.e. sectioned - whole.

Country	% agreement	Mean difference: sectioned-whole (yr)	SD	Presently used method
Faroe	48	0.24	1.0	sectioned otoliths
Norway	73	0.67	0.9	whole otoliths
Russia	69	- 0.21	0.7	whole otoliths
Spain *	36	- 0.10	0.9	sectioned otoliths

* Most otoliths were broken and were not readable, therefore the Spanish results should be treated with precaution

4.2.3 Analysis of otolith diameter measurements in sectioned otoliths

All four countries measured inner diameter of each observed ring in the sectioned otoliths (refer to Figure 4.1.1). The individual measurements by country are given in Table A1.1 (Appendix A). For the whole otoliths only two countries measured these parameters (Norway and Spain, see next section). The resulting mean ring diameter for each annual growth zone in the sectioned otoliths from age 1 to 16 (D1-D16) is shown in Table 4.2.3.1 by country.

Table 4.2.3.1. Mean annuli diameter (mm) in sectioned otoliths by country.

	Annual rings															
Country	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
Faroes	2.6	3.1	3.5	3.7	3.9	4.0	4.1	4.2	4.4	4.5	4.6	4.7	4.8	4.7	4.8	4.9
Norway	2.6	3.2	3.5	3.8	3.9	4.1	4.2	4.4	4.2	4.4	4.6	4.7				
Russia	3.0	3.4	3.8	4.0	4.2	4.3	4.3	4.4	4.7	4.7	4.8	5.0	5.1	5.1		
Spain	2.7	3.2	3.5	3.7	3.9	4.1	4.1	4.2	4.4	4.7	4.8	4.8	4.8	4.9	5.0	
Average	2.7	3.2	3.6	3.8	4.0	4.1	4.2	4.3	4.4	4.6	4.7	4.8	4.9	4.9		
SD	.013	.013	.014	.017	.021	.032	.043	.059	.070	.064	.078	.087	125	.119		

A statistical comparison of the inner diameter of each annual ring in sample 1a-d, lead to a rejection of the hypothesis of equal diameter among countries for the first five annual rings (p=0.000). The rings above D5 were not significantly different among countries (p>0.01).

To examine whether any particular country caused the observed difference, a closer examination was initiated. By testing each pair of countries for difference between mean annual diameter, it is possible to reveal such differences (Table 4.2.3.2). The results demonstrated that Russian measurements of the annual rings were different from the rest (p=0.000, Table 4.2.3.2). This is also clearly seen in Figure 4.2.3.1, showing the measurements of the first four rings for each country, where the Russian measurements are systematically higher for each ring as compared to the other three countries.

In Table 4.2.3.2 it is also seen that the mean diameter of the first annual ring (D1) is different between Faroes and Spain (p=0.002).

Table 4.2.3.2. Statistical test (ANOVA, p values) for differences in the mean ring diameter between countries for the first four rings, sample 1a-d.

	D1 - first ring			**D2 - second ring**		
Country	Faroe	Spain	Norway	Faroe	Spain	Norway
Russia	0.000	0.000	0.000	0.000	0.000	0.000
Norway	0.156	0.088		0.161	0.461	
Spain	0.002			0.018		
	D3 - third ring			**D4 - fourth ring**		
Country	Faroe	Spain	Norway	Faroe	Spain	Norway
Russia	0.000	0.000	0.000	0.000	0.000	0.000
Norway	0.891	0.656		0.173	0.338	
Spain	0.538			0.653		

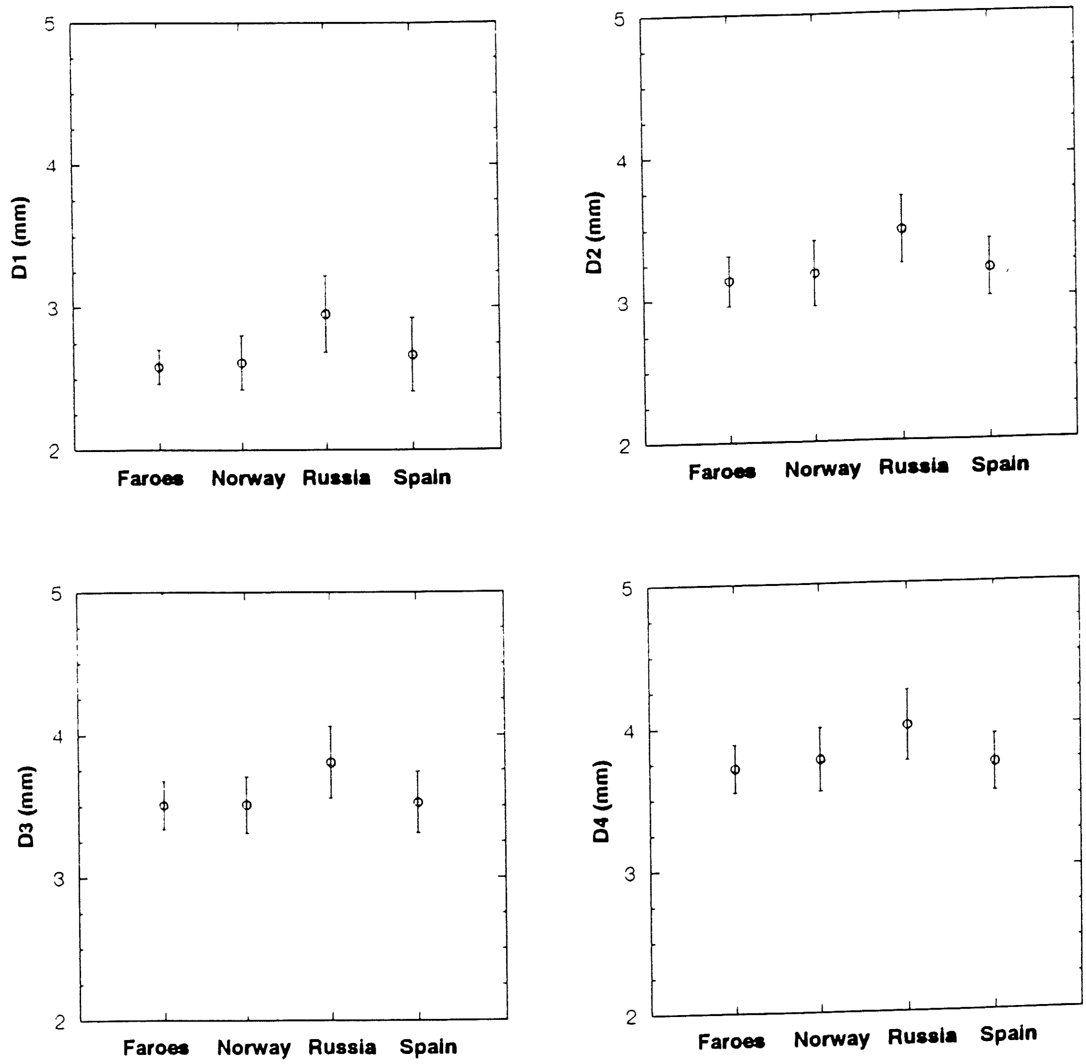

Figure 4.2.3.1. Mean diameter of the first four annual rings (D1-D4) by country, standard deviation is also indicated. Sectioned otoliths, data from sample 1a-d in Table 4.1.1.

The individual measurements (100 otoliths) of the first three rings in the sectioned otoliths by country are shown in Figure 4.2.3.2-4. The systematic higher otolith diameter of the rings in the Russian measurements is clearly seen from the figures. The amount of variation can also be seen as the degree of noise in the line for each country. The four areas: VIIb-k, VIa, IVa and IIa are indicated along the bottom line for each country (25 otoliths in each area, see sample 1a-d in Table 4.1.1, and details in Table A1.1, Appendix A).

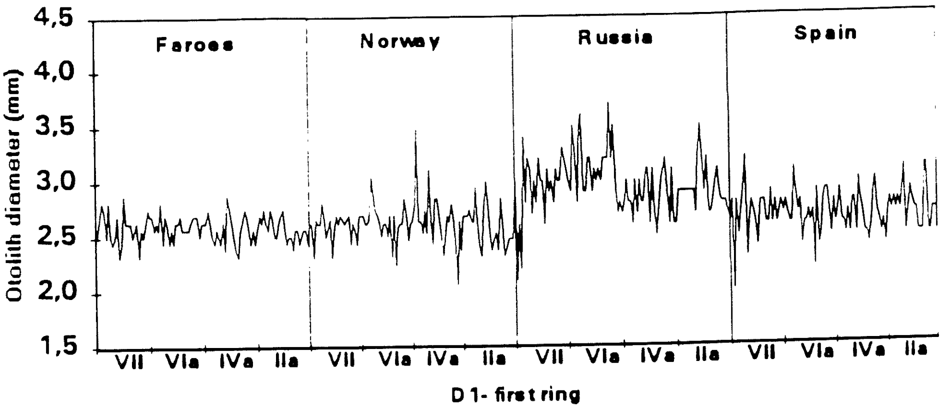

Figure 4.2.3.2. Otolith diameter for the first annual ring (D1) by country. Sectioned otoliths, data from sample 1a-d in Table 4.1.1.

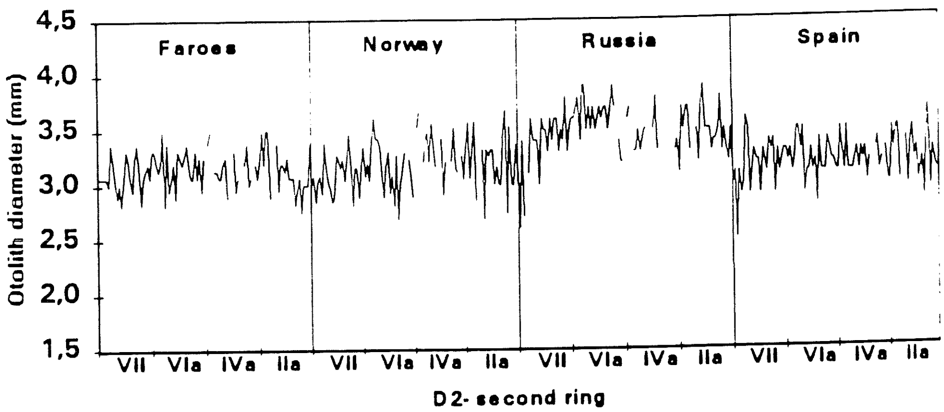

Figure 4.2.3.3. Otolith diameter for the second annual ring (D2) by country. Sectioned otoliths, data from sample 1a-d in Table 4.1.1.

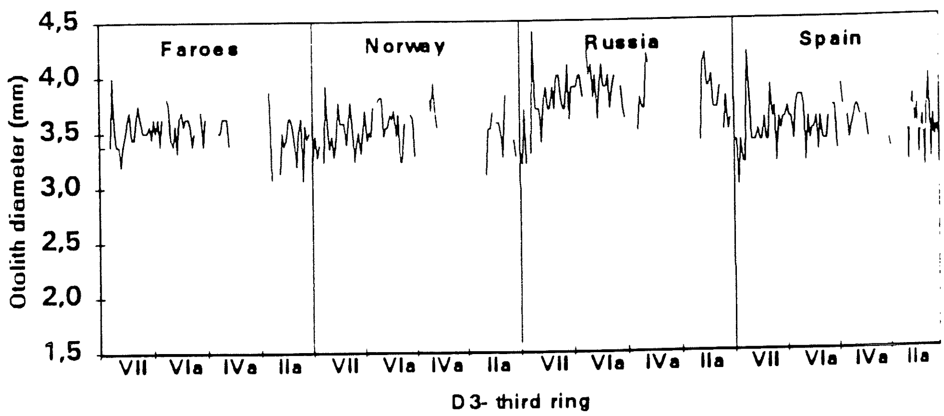

Figure 4.2.3.4. Otolith diameter for the third annual ring (D3) by country. Sectioned otoliths, data from sample 1a-d in Table 4.1.1.

As the Russian measurements were systematically higher than the corresponding measures for the other three countries, they were excluded in the test of possible difference in mean annual ring diameter among the four areas VIIb-k, VIa, IVa and IIa, in sample 1a-d. The mean annual ring diameter for the first three rings were not significantly different among the three countries: Faroes, Norway and Spain (p>0.01).

4.2.4 Analysis of otolith diameter measurements in whole otoliths

Only Norway and Spain measured the ring diameters in the whole otoliths of sample 1a-d (Table 4.1.1). The results of the readings are shown in Table 4.2.4.1 below and individual measurements in Table A1.2 (Appendix A).

Table 4.2.4.1. Mean annuli diameter (D1-D13, mm) by country for the whole otoliths.

Country	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
Norway	8.6	10.4	11.6	12.5	13.1	13.5	13.7	14.4	15.8	15.7	16.1	16.6	16.9
Spain	8.2	10.0	11.0	11.8	12.5	13.1	13.8	14.2					
Average	8.4	10.2	11.3	12.2	12.8	13.3	13.8	14.3					

The individual measurements of the first three rings in the whole otoliths for both countries are shown in Figure 4.2.4.1. Norway measured all rings in the 100 otoliths from sample 1a-d, while the measurements by Spain are not complete, 73 otoliths, due to the large number of broken and unreadable otoliths when the sample arrived Spain (see also Table A1.2, Appendix A).

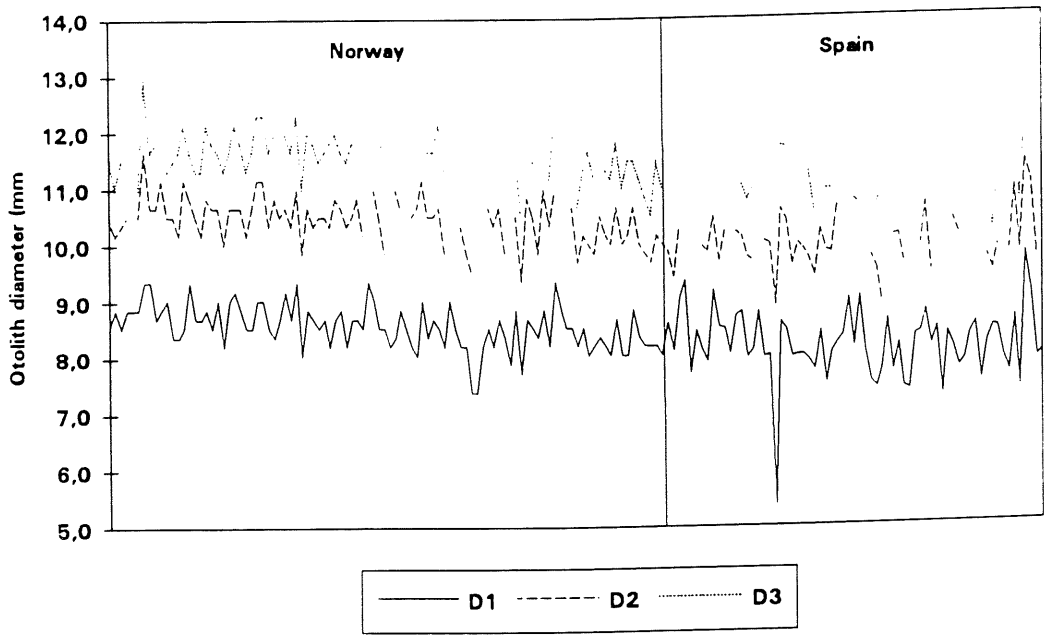

Figure 4.2.4.1. Otolith diameter (D1, D2 and D3) for the first three annual rings by country. Whole otoliths, data from 1a-d (Table 4.1.1).

It is not considered appropriate to make any sophisticate statistics on this data, the reason is that two countries are missing in the analysis and the incomplete measurements by Spain as explained above. However, it is possible to calculate a conversion factor between the sectioned otolith diameter and the whole otolith diameter for the first annual ring from the Norwegian data (Figure 4.2.4.2).

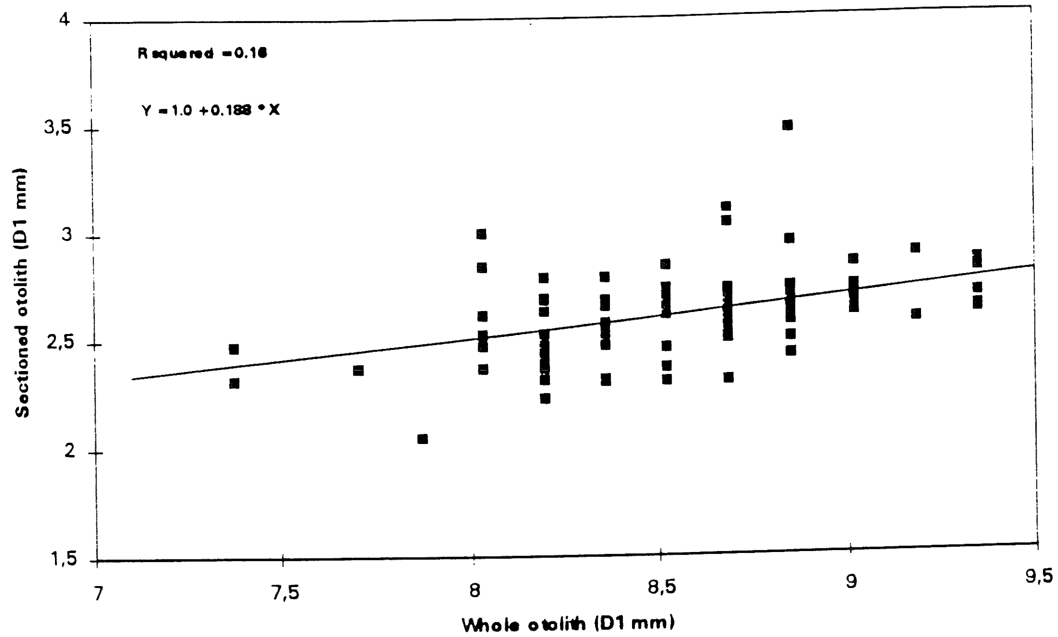

Figure 4.2.4.2. Regression of the first ring diameter of the sectioned otolith vs. the first ring diameter of the whole otolith. The regression line indicate the relationship.

5 DISCUSSION

5.1 Otolith reading techniques

In Anon. (1979) it was stated that: "The accuracy of age determinations did not appear to be primarily a function of the otolith reading technique since the variation was as wide in the sectioned otoliths as it was in the broken ones.". The Working Group in 1979 was unable to demonstrate that the sectioning results in the most reliable otolith reading technique, and a comparison of 25 otoliths preserved in sea water and read both as whole and sectioned otoliths showed no bias due to technique (Anon. 1979). For other species, Eltink (1985) reported a lower standard deviation per age for sectioned otoliths of horse mackerel (*Trachurus trachurus* L.) than for those examined whole or by breaking and burning.

In the results from the otolith exchange programme no. 6 in Table 3.1.1, exchanging otoliths from the southern stock of blue whiting (Division IXa), there was a general tendency to lose one or two early annual rings in the otoliths, while the reverse tendency was observed in the sectioned otoliths, causing misreading due to the presence of false rings (Meixide 1990). In both cases the resulting percentage of agreement was correspondingly low. However, certain precautions should be taken when drawing conclusions from this otolith exchange, as some of the countries were not familiar with the Spanish method of preparing the otoliths from the southern area, as described in section 1.2.

Based on the results from the present otolith reading Workshop (Table 4.2.2.1), it is seen that there is rather low agreement between age readings from sectioned and whole otoliths for Faroes and especially Spain, 48% and 36% respectively, both these countries routinely apply the sectioned technique. A partial reason to the low agreement for Spain is that most of the otoliths were broken when they reached Spain and were not readable. The agreement was higher between methods for Norway and Russia, 73% and 64% respectively. Both countries use whole otoliths when ageing blue whiting. The reason to the relatively good agreement between methods for Norway can partially be explained due to the inclusion of the first annual ring in the age reading, even if it was not clearly seen in the whole otolith.

At present the Workshop could not advise any particular otolith reading technique be used for ageing blue whiting. Instead it is strongly suggested that the different otolith readers be aware of the problems inherent in the different otolith reading techniques as mentioned above.

5.2 First annual ring

The measurements of the inner diameter show that there is no significant overlap between at least the first three annual rings within countries. This may be an important validation technique to decide were the first true annual ring must be, and might be used in each country without involving other institutes or nations.

The analysis of the inner diameter of the first four annual rings of sample 1a-d between countries revealed a difference of the mean diameter of the first growth zone among countries and a closer examination demonstrated that Russian measurements were systematically higher compared to the other three countries (see section 4.2.3). The reason to the difference observed between Russia and the other three countries is not considered due to misinterpretation of the first annual ring by Russia. The systematic difference in all the rings indicate that other factors than misreading are responsible for the difference. If only the first ring was significantly larger in the Russian sample while the outer rings were not different, it would imply that they were missing the first ring, however, this is not the case as the mean age for Russia is not significantly different from the other countries (Table 4.2.1.3). Rather it is suggested that a small difference in the conversion factor in the Russian data when calculating from Ocular Measurement Units (OMU) in the binocular to mm units be responsible for the difference. Alternatively they may have measured the outer ring diameter instead of the inner ring diameter in the otoliths.

The average diameter of the first annual ring from the present Workshop (D1= 2.57 mm, excluding Russia and only averaging over fish aged as one year old in the sample, n= 24) might be compared to measurements reported in literature. It is, however, not possible to read the average D1 directly from the two sources found (Baily 1970 and Jákupsstovu 1979). An indirect method can be applied as the two sources give a relationship of fish length *versus* total otolith diameter (Dtot) for one year old fish. If Dtot for one year old fish can be read from the regressions reported, it might then be multiplied with the relationship between D1 and Dtot in the present Workshop (= 0.831 from text table below). The results are given in the text table. The average length of 21.4 cm is assumed for one year old fish as input to the regressions in both cases. The Dtot is extrapolated from figure 2 in Baily (1970), containing data from June-August samples. In Jákupsstovu (1979), Dtot was read directly from figure 4d for two periods (March and May 1993).

Average (1 year old)	Present Workshop	Baily (1970)	Jákupsstovu (1979)
fish length:	21.4	21.4	21.4
Dtot (mm):	3.16	2.99	3.04-3,65
D1 (mm):	2.57	2.43	2.47-2.97

The Dtot values for one year old fish might change due to different time of year or in a year with "good" or "poor" growth conditions, therefore the results should be treated with care, as the method is rather crude.

5.3 Interpretation of the edge

Generally it is worrying if the largest ring is a long distance from the edge in old fish, and especially during autumn. In summer one should expect a opaque zone and not a year ring. No conclusion concerning the interpretation of the edge was reached upon during the Workshop.

5.4 False rings

A special sub-sample of 4 otoliths (no 29, 40, 50, and 65 from sample 1a-d, Table A1.1, Appendix A) was chosen for further analysis. The sample was not chosen randomly, rather it was looked at old fish and intermediate aged fish. This was done in order to give an idea of the "worst case" in interpretation of growth structures in blue whiting otoliths.

The results are shown in the text table below. The ages as read originally by country for the sectioned and the whole otoliths are indicated in the table, also the **agreed age**, i.e. the age that the Workshop participants could agree upon after closer examination of each otolith.

No.	Sectioned Faroes	Norway	Spain	Russia	Agreed age at meeting	Whole Faroes	Norway	Spain	Russia
29	6	5	7	6	7	5	6	6	6
40	5	4	6	5	6	4	5	5	5
50	11	10	12	11	12	8	9	8	8
51	1	1	2	1	1	1	1	-	1

As can be seen great variances are associated with the age readings of this "worst case" sample. A closer examination of the individual measurements of the annual ring diameters for each country were then undertaken. Three countries, Faroes, Norway and Spain, compared the ring diameters for each otolith in the sample. The results are given in the text table below, showing the details for each country of the four otoliths from the sub-sample, the annual ring diameter and the total otolith diameter is given, and the age reading from the sectioned sample (as read originally) is also given.

No.	Country	Age read	Agreed age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
	Faroes	6		4.3	2.6	3.1	3.4	3.7	3.9	4.0	*					
29	Norway	5	7	4.1	2.6	3.0	3.5	3.7	3.9	*	*					
	Spain	7		4.2	2.6	3.1	3.4	3.7	3.9	4.0	4.2					
	Faroes	5		4.4	2.7	3.2	3.6	3.9	*	4.3						
40	Norway	4	6	4.4	2.7	3.1	*	3.7	4.2	*						
	Spain	6		4.5	2.9	3.5	3.8	4.0	4.2	4.5						
	Faroes	11		4.6	2.6	*	3.3	3.6	3.8	4.0	4.1	4.2	4.3	4.3	4.5	4.5
50	Norway	10	12	4.4	2.6	2.9	3.3	3.7	3.8	4.0	4.1	4.2	4.3	4.4	*	*
	Spain	12		4.7	2.8	3.1	3.3	3.6	3.8	3.9	4.1	4.2	4.3	4.5	4.6	4.7
	Faroes	1		3.2	2.6											
51	Norway	1	1	3.2	2.6											
	Spain	2		3.2	2.6	(3.1)										

* missing ring, value in brackets is ring classified as false.

The examination and comparison of the observed ring diameters measured revealed the possible technique to determine the age of the otolith, by looking at the increments from one ring to the next for the various countries. It seemed possible to determine the presence of false rings and to indicate missing rings if the distance between two consecutive rings was too large. This is indicated in the text table above as an * in the place where a ring measurement is expected to be.

The following discussion on the difference between the age readings read originally and the revised and agreed age of the otoliths, reflected the uncertainties on the interpretation of false rings and on the rings close to the edge. The lower age for many of the Norwegian readings was mainly due to missing rings, especially towards the edge. The same was true for the Faroese readings. The Spanish readings were closest to the agreed age of the otoliths from this sub-sample, and in one case Spain read one additional (false) ring.

The conclusions from this exercise were that:

- no clear pattern of the presence of false rings could be seen, and that
- no simple rule exist to decide where a false ring appears, and
- a possible technique might be to look at the increments from one ring to the next to determine the presence of false rings and to indicate missing rings if the distance between two consecutive rings is too large.

Verification of the age reading technique: The Workshop made no attempt to analyse the catch-at-age matrix as an aid to verify the age reading technique on blue whiting. The main reason was time limitations due to the time required to read and discuss the samples brought to the meeting. Also the presence of two strong year classes of blue whiting in two successive years, 1982 and 1983, made it difficult to analyse the age distributions in the catch matrix. However, the presence of the strong 1989 year class is believed to give the opportunity to validate the age readings, as the surrounding year classes seems to be rather weak. The analysis of length distributions from samples since 1989 should give the possibility to verify age readings of blue whiting. However, analytical methods using length composition data were not used at the Workshop.

6 CONCLUSIONS

It seems that it is necessary to use the same binocular when measuring ring diameter in otoliths. This emerges from the observed systematic difference in mean ring diameter between countries although no difference in mean age could be observed between countries.

No differences in mean annual ring diameter in the otoliths between the so-called "northern blue whiting" and the "southern blue whiting" could be observed. This was clear after a sample provided by Meixide and Piñeiro (1993) from area VIIIc and IXa (see Table A5, Appendix A) was analysed and compared to the measurements from the northern areas (sample 1a-d). This finding is important in the future discussion on the question of stock structure and possible existence of several populations of blue whiting in the north-east Atlantic.

7 RECOMMENDATIONS

1. Inter calibration and co-ordination should be undertaken on a regular basis, e.g. every 5'th year, to maintain the existing quality of age reading and to prevent countries from 'drifting' away from the agreed interpretation of otolith structures.

2. It is of particular importance in the case of blue whiting that the two countries, Norway and Russia, which together stands for the majority of the catch, to continue to meet on a regular basis, and to compare their methods and results. This is believed to be the only safe method to improve and maintain the quality of age reading and hence to improve the biological input to assessment methods.

3. The measurements of the inner diameter show that there is no overlap between at least the first three annual rings. This may be an important validation technique to decide were the first true annual ring must be. This can be used in each country on a regular basis without the arrangement of otolith exchanges and workshops including several nations.

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Table A1.1 **Sample 1a-d. SECTIONED otoliths. Inner diameter (D1-D16, Dtot) measured by country: Faroes, Norway, Russia and Spain (100 otoliths in sample 1a-d).**

Length	Area	Sex	Country	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
27,5	VII	2	Faroes	7	4,0	2,6	3,1	3,4	3,6	3,7	3,8	3,9									
24,5	VII	2	Faroes	4	3,8	2,5	3,1	3,4	3,6												
23,0	VII	2	Faroes	3	3,6	2,7	3,1	3,4													
23,5	VII	2	Faroes	3	3,7	2,8	3,1	3,4													
21,5	VII	1	Faroes	2	3,4	2,8	3,1														
28,5	VII	2	Faroes	6	3,9	2,5	3,0	3,4	3,5	3,6	3,8										
29,0	VII	1	Faroes	3	4,4	2,8	3,4	4,0													
25,5	VII	2	Faroes	4	4,2	2,5	3,3	3,6	3,8												
24,0	VII	1	Faroes	3	3,7	2,4	3,1	3,4													
22,5	VII	2	Faroes	4	3,6	2,5	2,9	3,4	3,5												
22,5	VII	2	Faroes	3	3,5	2,7	3,0	3,2													
26,5	VII	2	Faroes	5	4,1	2,3	2,8	3,4	3,7	3,9											
25,5	VII	1	Faroes	3	3,9	2,4	3,1	3,5													
27,0	VII	2	Faroes	4	4,1	2,9	3,3	3,6	3,8												
26,0	VII	1	Faroes	4	4,1	2,6	3,3	3,7	3,8												
25,0	VII	2	Faroes	4	3,9	2,6	3,1	3,4	3,6												
25,5	VII	2	Faroes	5	4,0	2,6	2,9	3,4	3,6	3,8											
24,5	VII	1	Faroes	3	3,9	2,5	3,3	3,6													
25,5	VII	2	Faroes	3	3,9	2,6	3,4	3,8													
25,0	VII	2	Faroes	4	4,0	2,6	3,2	3,6	3,8												
27,5	VII	2	Faroes	6	4,2	2,3	2,8	3,5	3,6	3,8	4,0										
25,5	VII	2	Faroes	5	4,1	2,6	3,1	3,5	3,7	3,9											
28,0	VII	1	Faroes	4	4,1	2,5	3,1	3,5	3,8												
27,0	VII	1	Faroes	6	4,1	2,6	3,2	3,6	3,8	3,9	4,1										
28,5	VII	2	Faroes	6	4,4	2,8	3,1	3,4	3,9	4,1	4,3										
25,5	VIa	1	Faroes	3	3,9	2,7	3,3	3,6													
28,5	VIa	2	Faroes	4	4,1	2,7	3,3	3,5	3,8												
30,0	VIa	1	Faroes	4	4,1	2,6	3,2	3,6	3,9												
29,0	VIa	2	Faroes	6	4,3	2,6	3,1	3,4	3,7	3,9	4,0										
28,5	VIa	1	Faroes	3	3,8	2,6	3,2	3,6													
26,0	VIa	1	Faroes	2	3,8	2,8	3,5														
32,0	VIa	1	Faroes	6	4,5	2,4	2,8	3,8	4,0	4,2	4,4										
28,0	VIa	2	Faroes	3	3,9	2,7	3,4	3,8													
33,0	VIa	1	Faroes	5	4,5	2,6	2,9	3,4	3,8	4,2											
28,0	VIa	2	Faroes	5	4,1	2,4	3,1	3,4	3,6	3,8											
30,5	VIa	1	Faroes	4	4,1	2,6	3,2	3,6	3,9												
31,0	VIa	2	Faroes	6	4,1	2,4	2,9	3,3	3,7	3,8	4,0										
23,0	VIa	2	Faroes	3	3,8	2,6	3,3	3,6													
26,0	VIa	1	Faroes	3	4,0	2,6	3,3	3,7													
32,0	VIa	1	Faroes	5	4,4	2,7	3,2	3,6	3,9	4,3											
26,5	VIa	1	Faroes	3	3,9	2,6	3,3	3,6													
27,5	VIa	2	Faroes	3	3,9	2,6	3,4	3,6													
27,0	VIa	2	Faroes	5	4,1	2,6	3,2	3,6	3,8	3,9											
29,0	VIa	2	Faroes	6	4,1	2,6	3,1	3,4	3,6	3,8	4,0										
29,0	VIa	2	Faroes	4	4,1	2,6	3,1	3,5	3,8												
24,5	VIa	1	Faroes	2	3,6	2,7	3,3														
22,0	VIa	1	Faroes	2	3,2	2,7	3,1														
30,0	VIa	1	Faroes	4	4,1	2,7	3,3	3,7	3,9												

Table A1.1 cont.

35,0	VIa	1	Faroes	6	4,6	2,5	2,9	3,4	3,7	4,1	4,4										
35,0	VIa	2	Faroes	11	4,6	2,6	3,3	3,6	3,8	4,0	4,1	4,2	4,3	4,3	4,5	4,5					
21,5	IVa	1	Faroes	1	3,2	2,6															
25,5	IVa	1	Faroes	2	3,9	2,6	3,4														
28,0	IVa	1	Faroes	2	4,0	2,8	3,5														
21,5	IVa	1	Faroes	1	3,3	2,6															
25,5	IVa	1	Faroes	2	3,6	2,5	3,1														
27,0	IVa	1	Faroes	3	3,8	2,4	3,1	3,5													
31,5	IVa	2	Faroes	5	4,3	2,6	3,1	3,5	3,9	4,1											
29,5	IVa	1	Faroes	3	3,8	2,5	3,1	3,6													
28,5	IVa	2	Faroes	5	4,3	2,4	3,2	3,6	3,8	4,0											
31,5	IVa	1	Faroes	6	4,6	2,6	3,3	3,6	3,9	4,2	4,4										
32,0	IVa	1	Faroes	6	4,5	2,4	2,9	3,4	3,7	4,0	4,3										
22,5	IVa	0	Faroes	1	3,3	2,9															
21,5	IVa	0	Faroes	1	3,2	2,8															
25,0	IVa	0	Faroes	2	3,6	2,6	3,3														
44,5	IVa	1	Faroes	13	5,2	2,5	2,9	3,4	3,8	4,0	4,2	4,4	4,6	4,7	4,8	4,9	5,0	5,1			
27,0	IVa	2	Faroes	2	3,6	2,4	3,1														
22,5	IVa	2	Faroes	1	3,0	2,3															
22,5	IVa	2	Faroes	1	3,2	2,6															
29,5	IVa	2	Faroes	4	4,1	2,6	3,2	3,5	3,8												
25,5	IVa	0	Faroes	2	3,8	2,8	3,4														
25,0	IVa	0	Faroes	2	3,4	2,7	3,0														
25,0	IVa	0	Faroes	2	3,4	2,6	3,1														
19,5	IVa	0	Faroes	1	3,1	2,4															
26,5	IVa	0	Faroes	2	3,5	2,6	3,2														
25,0	IVa	0	Faroes	2	3,6	2,4	3,1														
26,0	IIa	2	Faroes	2	3,7	2,6	3,2														
26,0	IIa	2	Faroes	2	3,9	2,7	3,5														
28,0	IIa	2	Faroes	3	3,9	2,6	3,2	3,7													
25,5	IIa	2	Faroes	2	3,9	2,8	3,5														
28,0	IIa	1	Faroes	3	4,1	2,6	3,5	3,9													
40,0	IIa	2	Faroes	16	5,0	2,6	2,9	3,1	3,4	3,6	3,8	3,9	4,1	4,2	4,3	4,3	4,4	4,6	4,7	4,8	4,
21,0	IIa	2	Faroes	1	3,1	2,8															
20,5	IIa	2	Faroes	1	3,0	2,7															
26,5	IIa	1	Faroes	2	3,8	2,5	3,4														
27,0	IIa	2	Faroes	8	3,9	2,5	2,9	3,1	3,3	3,5	3,6	3,7	3,8								
28,0	IIa	2	Faroes	4	4,0	2,6	3,2	3,5	3,8												
40,5	IIa	1	Faroes	10	4,8	2,7	3,2	3,4	3,6	3,7	3,9	4,1	4,3	4,4	4,6						
33,5	IIa	1	Faroes	7	4,5	2,8	3,1	3,4	3,8	4,0	4,2	4,3									
27,0	IIa	2	Faroes	3	3,8	2,6	3,3	3,6													
28,0	IIa	2	Faroes	3	4,0	2,4	3,1	3,6													
30,0	IIa	1	Faroes	3	3,8	2,5	3,1	3,6													
31,0	IIa	1	Faroes	5	4,2	2,5	3,1	3,4	3,8	4,0											
29,5	IIa	2	Faroes	7	4,3	2,4	2,8	3,2	3,4	3,7	3,9	4,1									
33,5	IIa	2	Faroes	6	4,4	2,6	2,9	3,5	3,8	4,0	4,2										
29,0	IIa	2	Faroes	4	4,1	2,6	3,1	3,6	3,9												
32,5	IIa	1	Faroes	8	4,3	2,4	2,8	3,1	3,3	3,5	3,8	4,1	4,2								
27,5	IIa	2	Faroes	3	3,8	2,5	3,0	3,6													
27,0	IIa	2	Faroes	4	3,8	2,6	3,0	3,4	3,6												
30,5	IIa	1	Faroes	5	4,1	2,6	3,0	3,5	3,8	3,9											
26,5	IIa	2	Faroes	2	3,7	2,4	3,4														

Table A1.1 cont.: Norway.

Length	Area	Sex	Country	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
27,5	VII	2	Norway	6	3,9	2,6	3,0	3,3	3,5	3,7	3,8										
24,5	VII	2	Norway	3	3,7	2,6	3,1	3,5													
23,0	VII	2	Norway	3	3,6	2,3	2,8	3,3													
23,5	VII	2	Norway	3	3,6	2,7	3,0	3,4													
21,5	VII	1	Norway	2	3,2	2,6	3,1														
28,5	VII	2	Norway	6	3,8	2,6	2,9	3,2	3,3	3,5	3,7										
29,0	VII	1	Norway	3	4,3	2,8	3,4	3,9													
25,5	VII	2	Norway	5	4,0	2,7	3,2	3,6	3,7	3,9											
24,0	VII	1	Norway	3	3,6	2,5	3,0	3,3													
22,5	VII	2	Norway	3	3,7	2,6	3,0	3,5													
22,5	VII	2	Norway	3	3,4	2,7	2,8	3,3													
26,5	VII	2	Norway	5	4,0	2,3	2,9	3,4	3,7	3,8											
25,5	VII	1	Norway	3	3,8	2,6	3,3	3,8													
27,0	VII	2	Norway	4	3,9	2,7	3,2	3,6	3,8												
26,0	VII	1	Norway	4	4,1	2,6	3,2	3,6	3,8												
25,0	VII	2	Norway	3	3,8	2,7	3,2	3,6													
25,5	VII	2	Norway	5	3,9	2,7	3,0	3,4	3,6	3,8											
24,5	VII	1	Norway	3	3,8	2,6	3,2	3,6													
25,5	VII	2	Norway	3	3,9	2,7	3,5	3,8													
25,0	VII	2	Norway	4	3,9	2,7	3,2	3,5	3,7												
27,5	VII	2	Norway	6	4,1	2,4	2,8	3,2	3,6	3,8	4,0										
25,5	VII	2	Norway	5	3,9	2,6	3,2	3,4	3,6	3,7											
28,0	VII	1	Norway	4	3,9	2,6	3,2	3,5	3,7												
27,0	VII	1	Norway	5	4,0	2,4	2,9	3,3	3,7	3,8											
28,5	VII	2	Norway	6	4,3	2,7	3,2	3,5	3,8	4,0	4,2										
25,5	VIa	1	Norway	3	3,8	2,7	3,3	3,7													
28,5	VIa	2	Norway	4	4,0	2,7	3,1	3,4	3,8												
30,0	VIa	1	Norway	4	4,0	2,6	3,2	3,5	3,8												
29,0	VIa	2	Norway	5	4,1	2,6	3,0	3,5	3,7	3,9											
28,5	VIa	1	Norway	3	3,8	2,7	3,3	3,7													
26,0	VIa	1	Norway	2	3,8	3,0	3,6														
32,0	VIa	1	Norway	5	4,4	2,9	3,4	3,8	4,0	4,3											
28,0	VIa	2	Norway	3	4,0	2,7	3,4	3,8													
33,0	VIa	1	Norway	5	4,4	2,7	3,3	3,8	4,1	4,2											
28,0	VIa	2	Norway	5	4,0	2,6	3,1	3,5	3,7	3,8											
30,5	VIa	1	Norway	4	4,1	2,5	2,9	3,5	4,0												
31,0	VIa	2	Norway	4	4,0	2,6	3,2	3,5	3,8												
23,0	VIa	2	Norway	3	3,8	2,6	3,3	3,7													
26,0	VIa	1	Norway	3	4,1	2,5	2,9	3,6													
32,0	VIa	1	Norway	4	4,4	2,7	3,1	3,7	4,2												
26,5	VIa	1	Norway	3	4,0	2,3	2,8	3,5													
27,5	VIa	2	Norway	3	4,0	2,7	3,3	3,7													
27,0	VIa	2	Norway	6	4,2	2,2	2,7	3,2	3,7	3,8	3,9										
29,0	VIa	2	Norway	5	4,2	2,6	3,0	3,2	3,7	3,8											
29,0	VIa	2	Norway	4	4,0	2,6	3,2	3,6	3,8												
24,5	VIa	1	Norway	2	3,6	2,6	3,3														
22,0	VIa	1	Norway	1	3,3	2,8															
30,0	VIa	1	Norway	4	4,0	2,7	3,2	3,7	3,9												
35,0	VIa	1	Norway	6	4,6	2,5	3,1	3,6	3,8	4,0	4,3										

Table A1,1 cont

35,0	VIa	2	Norway	10	4,4	2,6	2,9	3,3	3,7	3,8	4,0	4,1	4,2	4,3	4,4		
21,5	IVa	1	Norway	1	3,2	2,6											
25,5	IVa	1	Norway	2	4,0	2,8	3,5										
28,0	IVa	1	Norway	2	4,1	3,5	3,7										
21,5	IVa	1	Norway	1	3,3	2,6											
25,5	IVa	1	Norway	2	3,6	2,6	3,2										
27,0	IVa	1	Norway	2	3,7	2,5	3,4										
31,5	IVa	2	Norway	4	4,3	2,7	3,5	3,8	4,2								
29,5	IVa	1	Norway	3	3,8	2,5	3,2	3,7									
28,5	IVa	2	Norway	4	4,3	3,1	3,6	3,9	4,2								
31,5	IVa	1	Norway	6	4,6	2,6	3,4	3,7	4,1	4,3	4,5						
32,0	IVa	1	Norway	6	4,5	2,4	3,2	3,5	3,9	4,1	4,4						
22,5	IVa	0	Norway	1	3,4	2,8											
21,5	IVa	0	Norway	1	3,2	2,8											
25,0	IVa	0	Norway	2	3,6	2,7	3,4										
44,5	IVa	1	Norway	8	5,3	2,5	2,9	3,3	3,5	4,1	4,4	4,7	5,0				
27,0	IVa	2	Norway	2	3,6	2,3	3,2										
22,5	IVa	2	Norway	1	3,1	2,5											
22,5	IVa	2	Norway	1	3,3	2,7											
29,5	IVa	2	Norway	4	4,1	2,6	3,2	3,5	3,8								
25,5	IVa	0	Norway	2	3,8	2,8	3,5										
25,0	IVa	0	Norway	2	3,5	2,7	3,2										
25,0	IVa	0	Norway	2	3,5	2,5	3,1										
19,5	IVa	0	Norway	1	3,1	2,1											
26,5	IVa	0	Norway	2	3,5	2,6	3,3										
25,0	IVa	0	Norway	2	3,6	2,4	3,1										
26,0	IIa	2	Norway	2	3,6	2,7	3,3										
26,0	IIa	2	Norway	2	4,0	2,7	3,6										
28,0	IIa	2	Norway	3	4,0	2,7	3,1	3,5									
25,5	IIa	2	Norway	2	4,1	2,7	3,3										
28,0	IIa	1	Norway	2	4,1	2,6	3,6										
40,0	IIa	2	Norway	12	5,1	2,6	2,8	3,2	3,3	3,5	3,6	3,8	3,9	4,1	4,4	4,6	4,7
21,0	IIa	2	Norway	1	3,2	2,9											
20,5	IIa	2	Norway	1	2,9	2,6											
26,5	IIa	1	Norway	2	3,8	2,4	3,3										
27,0	IIa	2	Norway	7	3,8	2,3	2,7	3,1	3,3	3,5	3,6	3,7					
28,0	IIa	2	Norway	4	4,1	2,7	3,3	3,5	3,9								
40,5	IIa	1	Norway	8	4,8	3,0	3,3	3,5	3,9	4,2	4,3	4,4	4,5				
33,5	IIa	1	Norway	7	4,6	2,8	3,3	3,7	3,9	4,2	4,4	4,5					
27,0	IIa	2	Norway	2	3,8	2,5	3,3										
28,0	IIa	2	Norway	3	4,0	2,4	3,0	3,6									
30,0	IIa	1	Norway	3	3,8	2,5	3,2	3,6									
31,0	IIa	1	Norway	4	4,1	2,5	3,0	3,5	3,9								
29,5	IIa	2	Norway	5	4,2	2,4	3,0	3,3	3,5	3,9							
33,5	IIa	2	Norway	5	4,3	2,8	3,5	3,8	4,1	4,2							
29,0	IIa	2	Norway	2	4,1	2,6	3,7										
32,5	IIa	1	Norway	8	4,3	2,3	2,7	3,2	3,5	3,8	3,9	4,1	4,2				
27,5	IIa	2	Norway	2	3,7	2,4	3,5										
27,0	IIa	2	Norway	3	3,9	2,5	3,0	3,4									
30,5	IIa	1	Norway	5	4,1	2,5	3,0	3,3	3,7	4,0							
26,5	IIa	2	Norway	2	3,7	2,5	3,4										

Table A1.1 cont.: Russia.

Length	Area	Sex	Country	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
27,5	VII	2	Russia	6		3,0	3,1	3,3	3,7	3,9	4,1										
24,5	VII	2	Russia	5		2,1	2,6	3,2	3,5	3,8											
23,0	VII	2	Russia	5		2,6	3,4	3,7	4,0	4,1											
23,5	VII	2	Russia	5		2,2	2,7	3,2	3,5	3,7											
21,5	VII	1	Russia	1		3,4															
28,5	VII	2	Russia	7		2,8	3,1	3,3	3,5	3,7	3,8	3,9									
29,0	VII	1	Russia	3		3,2	3,6	4,4													
25,5	VII	2	Russia	5		3,1	3,4	3,7	4,0	4,1											
24,0	VII	1	Russia	3		2,7	3,4	3,7													
22,5	VII	2	Russia	3		3,0	3,4	3,7													
22,5	VII	2	Russia	4		2,8	3,0	3,4	3,6												
26,5	VII	2	Russia	5		3,2	3,6	3,8	4,0	4,1											
25,5	VII	1	Russia	3		3,0	3,5	3,9													
27,0	VII	2	Russia	4		3,0	3,5	3,7	4,1												
26,0	VII	1	Russia	5		2,6	3,3	3,7	3,9	4,1											
25,0	VII	2	Russia	3		3,1	3,6	3,9													
25,5	VII	2	Russia	5		2,9	3,4	3,7	3,9	4,1											
24,5	VII	1	Russia	3		3,0	3,6	4,0													
25,5	VII	2	Russia	3		2,8	3,6	4,0													
25,0	VII	2	Russia	4		3,1	3,3	3,8	4,0												
27,5	VII	2	Russia	6		3,0	3,5	3,7	3,9	4,1	4,2										
25,5	VII	2	Russia	5		3,0	3,4	3,7	3,9	4,1											
28,0	VII	1	Russia	3		3,3	3,8	4,1													
27,0	VII	1	Russia	6		3,2	3,3	3,6	3,9	4,0	4,1										
28,5	VII	2	Russia	6		3,1	3,5	3,9	4,2	4,3	4,4										
25,5	VIa	1	Russia	3		3,0	3,6	3,9													
28,5	VIa	2	Russia	4		2,9	3,6	3,9	4,1												
30,0	VIa	1	Russia	4		3,5	3,7	4,0	4,1												
29,0	VIa	2	Russia	5		3,3	3,8	4,0	4,2	4,3											
28,5	VIa	1	Russia	3		2,8	3,4	3,8													
26,0	VIa	1	Russia	2		3,5	3,9														
32,0	VIa	1	Russia	4		3,6	3,9	4,3	4,5												
28,0	VIa	2	Russia	3		2,9	3,5	4,0													
33,0	VIa	1	Russia	5		2,9	3,7	4,1	4,3	4,5											
28,0	VIa	2	Russia	5		3,2	3,5	3,8	4,0	4,1											
30,5	VIa	1	Russia	4		3,2	3,7	4,0	4,2												
31,0	VIa	2	Russia	5		2,9	3,5	3,6	4,1	4,2											
23,0	VIa	2	Russia	3		3,1	3,6	3,9													
26,0	VIa	1	Russia	3		3,0	3,7	4,1													
32,0	VIa	1	Russia	5		3,1	3,6	3,9	4,2	4,5											
26,5	VIa	1	Russia	3		3,0	3,7	3,9													
27,5	VIa	2	Russia	3		3,2	3,7	4,0													
27,0	VIa	2	Russia	6		3,2	3,5	3,7	3,9	4,0	4,1										
29,0	VIa	2	Russia	5		3,2	3,7	3,9	4,0	4,2											
29,0	VIa	2	Russia	3		3,7	3,9	4,0													
24,5	VIa	1	Russia	2		3,2	3,7														
22,0	VIa	1	Russia	1		3,5															
30,0	VIa	1	Russia	4		2,9	3,4	3,9	4,2												
35,0	VIa	1	Russia	7		2,7	3,2	3,7	4,2	4,4	4,5	4,7									

Table A1.1 cont.

35,0	VIa	2	Russia	11		2,8	3,2	3,6	3,8	4,0	4,1	4,2	4,4	4,5	4,6	4,7			
21,5	IVa	1	Russia	1	3,2	2,7													
25,5	IVa	1	Russia	2	4,0	2,8	3,6												
28,0	IVa	1	Russia	3	4,0	3,0	3,7	4,0											
21,5	IVa	1	Russia	1	3,2	2,8													
25,5	IVa	1	Russia	2	3,6	2,8	3,3												
27,0	IVa	1	Russia	3	3,7	2,6	3,3	3,5											
31,5	IVa	2	Russia	5	4,3	3,0	3,5	3,8	4,0	4,2									
29,5	IVa	1	Russia	3	3,9	2,7	3,3	3,7											
28,5	IVa	2	Russia	5	4,3	3,0	3,4	3,7	4,0	4,2									
31,5	IVa	1	Russia	5	4,6	2,8	3,5	4,2	4,4	4,6									
32,0	IVa	1	Russia	5	4,6	2,8	3,5	4,1	4,4	4,6									
22,5	IVa	0	Russia	1	3,4	3,1													
21,5	IVa	0	Russia	1	3,2	3,1													
25,0	IVa	0	Russia	2	3,7	2,6	3,5												
44,5	IVa	1	Russia	6	5,3	3,1	3,8	4,4	4,5	4,9	5,2								
27,0	IVa	2	Russia	2	3,6	2,7	3,3												
22,5	IVa	2	Russia	1	3,1	2,5													
22,5	IVa	2	Russia	1	3,3	2,7													
29,5	IVa	2	Russia	4	4,1	3,0	3,4	3,7	3,9										
25,5	IVa	0	Russia	1	3,8	3,1													
25,0	IVa	0	Russia	1	3,5	3,2													
25,0	IVa	0	Russia	2	3,5	2,8	3,3												
19,5	IVa	0	Russia	2	3,1	2,6													
26,5	IVa	0	Russia	2	3,6	3,1	3,3												
25,0	IVa	0	Russia	2	3,6	2,6	3,4												
26,0	IIa	2	Russia	2	3,6	2,6	3,1												
26,0	IIa	2	Russia	2	4,0	2,9	3,7												
28,0	IIa	2	Russia	3	4,0	2,9	3,5	3,6											
25,5	IIa	2	Russia	2	3,9	2,9	3,7												
28,0	IIa	1	Russia	2	4,1	2,9	3,7												
40,0	IIa	2	Russia	14		2,9	3,3	3,7	3,9	4,2	4,4	4,6	4,7	4,8	4,8	4,9	5,0	5,1	5,1
21,0	IIa	2	Russia	1	3,2	2,9													
20,5	IIa	2	Russia	1		2,9													
26,5	IIa	1	Russia	2	3,8	2,9	3,5												
27,0	IIa	2	Russia	8		2,7	3,2	3,4	3,6	3,7	3,8	3,9	4,0						
28,0	IIa	2	Russia	3		3,2	3,7	4,1											
40,5	IIa	1	Russia	10		3,5	3,9	4,2	4,3	4,4	4,5	4,6	4,6	4,7	4,8				
33,5	IIa	1	Russia	6		3,2	3,5	3,9	4,2	4,5	4,6								
27,0	IIa	2	Russia	3		2,9	3,5	3,9											
28,0	IIa	2	Russia	3	4,0	3,2	3,5	4,0											
30,0	IIa	1	Russia	3	3,8	2,7	3,3	3,7											
31,0	IIa	1	Russia	4	4,2	2,7	3,4	3,7	4,0										
29,5	IIa	2	Russia	8		2,8	3,4	3,7	3,9	4,1	4,2	4,2	4,3						
33,5	IIa	2	Russia	7		3,0	3,5	3,9	4,1	4,2	4,3	4,4							
29,0	IIa	2	Russia	2	4,2	3,1	3,8												
32,5	IIa	1	Russia	8		2,9	3,3	3,5	3,9	4,1	4,2	4,3	4,4						
27,5	IIa	2	Russia	3		2,8	3,5	3,8											
27,0	IIa	2	Russia	5		2,8	3,3	3,5	3,7	3,9									
30,5	IIa	1	Russia	5		2,8	3,2	3,6	3,8	4,1									
26,5	IIa	2	Russia	2	3,7	2,7	3,5												

Table A1.1 cont.: **Spain.**

Length	Area	Sex	Country	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
27,5	VII	2	Spain	6	4,0	2,6	3,0	3,4	3,6	3,8	3,9										
24,5	VII	2	Spain	4	3,7	2,8	3,1	3,4	3,7												
23,0	VII	2	Spain	4	3,6	2,0	2,5	3,0	3,3												
23,5	VII	2	Spain	4	3,6	2,8	3,1	3,4	3,6												
21,5	VII	1	Spain	3	3,3	2,5	2,9	3,2													
28,5	VII	2	Spain	6	3,9	2,7	3,0	3,2	3,4	3,6	3,8										
29,0	VII	1	Spain	3	4,3	2,9	3,6	4,2													
25,5	VII	2	Spain	5	4,2	3,2	3,5	3,8	4,0	4,1											
24,0	VII	1	Spain	4	3,6	2,3	2,9	3,4	3,6												
22,5	VII	2	Spain	4	3,6	2,6	3,1	3,4	3,5												
22,5	VII	2	Spain	3	3,5	2,8	3,3	3,4													
26,5	VII	2	Spain	6	4,1	2,7	3,2	3,5	3,7	3,8	4,0										
25,5	VII	1	Spain	4	3,8	2,6	3,2	3,4	3,6												
27,0	VII	2	Spain	5	4,1	2,4	2,9	3,4	3,7	3,9											
26,0	VII	1	Spain	5	4,1	2,8	3,3	3,6	3,8	4,0											
25,0	VII	2	Spain	5	3,9	2,8	3,2	3,4	3,6	3,8											
25,5	VII	2	Spain	7	4,1	2,8	3,1	3,4	3,6	3,8	3,9	4,0									
24,5	VII	1	Spain	3	4,0	2,6	3,4	3,9													
25,5	VII	2	Spain	4	3,9	2,6	3,3	3,6	3,9												
25,0	VII	2	Spain	5	4,0	2,9	3,4	3,7	3,8	3,9											
27,5	VII	2	Spain	7	4,2	2,6	2,9	3,2	3,6	3,8	4,0	4,1									
25,5	VII	2	Spain	6	4,0	2,8	3,3	3,6	3,7	3,9	4,0										
28,0	VII	1	Spain	5	4,1	2,6	3,1	3,5	3,7	3,9											
27,0	VII	1	Spain	5	4,2	2,7	3,2	3,6	3,9	4,1											
28,5	VII	2	Spain	6	4,4	2,8	3,3	3,6	3,9	4,1	4,3										
25,5	VIa	1	Spain	4	3,9	2,7	3,3	3,7	3,8												
28,5	VIa	2	Spain	5	4,1	2,8	3,2	3,6	3,8	4,0											
30,0	VIa	1	Spain	4	4,1	2,7	3,3	3,6	3,9												
29,0	VIa	2	Spain	7	4,2	2,6	3,1	3,4	3,7	3,9	4,0	4,2									
28,5	VIa	1	Spain	3	3,8	2,6	3,2	3,7													
26,0	VIa	1	Spain	3	3,8	3,1	3,5	3,8													
32,0	VIa	1	Spain	6	4,5	2,9	3,5	3,8	4,0	4,2	4,5										
28,0	VIa	2	Spain	3	3,9	2,7	3,3	3,8													
33,0	VIa	1	Spain	6	4,6	2,8	3,5	3,7	4,0	4,2	4,4										
28,0	VIa	2	Spain	7	4,1	2,4	2,9	3,2	3,5	3,7	3,9	4,0									
30,5	VIa	1	Spain	4	4,2	2,6	3,1	3,6	4,0												
31,0	VIa	2	Spain	6	4,2	2,6	3,1	3,4	3,7	3,9	4,1										
23,0	VIa	2	Spain	4	3,8	2,7	3,3	3,5	3,7												
26,0	VIa	1	Spain	4	4,0	2,6	3,1	3,5	3,9												
32,0	VIa	1	Spain	6	4,4	2,7	3,2	3,6	3,9	4,1	4,3										
26,5	VIa	1	Spain	5	3,9	2,2	2,8	3,3	3,6	3,8											
27,5	VIa	2	Spain	4	3,9	2,9	3,4	3,6	3,9												
27,0	VIa	2	Spain	7	4,1	2,4	3,1	3,4	3,6	3,8	3,9	4,0									
29,0	VIa	2	Spain	7	4,2	2,5	3,1	3,4	3,6	3,8	4,0	4,1									
29,0	VIa	2	Spain	6	4,1	2,8	3,1	3,4	3,6	3,8	4,0										
24,5	VIa	1	Spain	3	3,7	2,9	3,4	3,6													
22,0	VIa	1	Spain	2	3,4	2,9	3,3														
30,0	VIa	1	Spain	5	4,2	2,7	3,2	3,7	3,9	4,1											
35,0	VIa	1	Spain	7	4,7	2,5	3,2	3,7	4,1	4,3	4,5	4,6									

Table A1.1 cont.

35,0	VIa	2 Spain	12	4,7	2,8	3,1	3,3	3,6	3,8	3,9	4,1	4,2	4,3	4,5	4,6	4,7				
21,5	IVa	1 Spain	2	3,2	2,6	3,1														
25,5	IVa	1 Spain	3	4,0	2,7	3,5	3,9													
28,0	IVa	1 Spain	4	4,1	2,9	3,3	3,7	4,0												
21,5	IVa	1 Spain	2	3,3	2,6	3,1														
25,5	IVa	1 Spain	3	3,7	2,6	3,5	3,6													
27,0	IVa	1 Spain	4	3,7	2,5	3,1	3,4	3,6												
31,5	IVa	2 Spain	5	4,3	2,7	3,1	3,5	4,0	4,1											
29,5	IVa	1 Spain	3	3,9	2,5	3,1	3,6													
28,5	IVa	2 Spain	5	4,3	2,8	3,2	3,7	3,9	4,1											
31,5	IVa	1 Spain	6	4,6	2,8	3,3	3,7	4,0	4,2	4,4										
32,0	IVa	1 Spain	6	4,6	2,5	3,1	3,6	4,0	4,2	4,4										
22,5	IVa	0 Spain	2	3,3	3,0	3,3														
21,5	IVa	0 Spain	2	3,4	2,8	3,2														
25,0	IVa	0 Spain	3	3,7	2,7	3,3	3,6													
44,5	IVa	1 Spain	11	5,3	2,5	3,0	3,4	3,8	4,1	4,2	4,4	4,6	4,8	5,0	5,1					
27,0	IVa	2 Spain	2	3,6	2,5	3,2														
22,5	IVa	2 Spain	1	3,0	2,4															
22,5	IVa	2 Spain	1	3,2	2,6															
29,5	IVa	2 Spain	5	4,1	2,9	3,3	3,5	3,8	4,0											
25,5	IVa	0 Spain	2	3,8	3,0	3,4														
25,0	IVa	0 Spain	2	3,5	2,7	3,1														
25,0	IVa	0 Spain	2	3,5	2,6	3,2														
19,5	IVa	0 Spain	1	3,1	2,5															
26,5	IVa	0 Spain	2	3,5	2,6	3,3														
25,0	IVa	0 Spain	3	3,6	2,4	3,0	3,4													
26,0	IIa	2 Spain	4	3,6	2,7	3,0	3,3	3,4												
26,0	IIa	2 Spain	2	3,9	2,8	3,5														
28,0	IIa	2 Spain	3	4,0	2,7	3,3	3,6													
25,5	IIa	2 Spain	2	3,8	2,8	3,5														
28,0	IIa	1 Spain	2	4,0	2,7	3,5														
40,0	IIa	2 Spain	15	5,0	2,8	3,0	3,2	3,4	3,6	3,8	4,0	4,2	4,4	4,5	4,6	4,8	4,8	4,9	5,0	
21,0	IIa	2 Spain	1	3,3	2,7															
20,5	IIa	2 Spain	1	3,0	2,9															
26,5	IIa	1 Spain	3	3,8	3,1	3,4	3,8													
27,0	IIa	2 Spain	9	3,9	2,5	2,9	3,1	3,3	3,4	3,5	3,6	3,7	3,8							
28,0	IIa	2 Spain	4	4,0	2,7	3,4	3,7	3,9												
40,5	IIa	1 Spain	9	4,8	2,9	3,5	3,8	3,9	4,1	4,2	4,4	4,6	4,7							
33,5	IIa	1 Spain	9	4,5	2,8	3,2	3,5	3,7	3,9	4,1	4,3	4,4	4,5							
27,0	IIa	2 Spain	3	3,8	2,7	3,3	3,7													
28,0	IIa	2 Spain	7	4,0	2,7	3,0	3,2	3,5	3,7	3,8	3,9									
30,0	IIa	1 Spain	3	4,3	2,5	3,1	3,5													
31,0	IIa	1 Spain	5	4,1	2,5	3,2	3,6	3,9	4,0											
29,5	IIa	2 Spain	9	4,2	2,5	2,8	3,1	3,4	3,6	3,7	3,9	4,0	4,2							
33,5	IIa	2 Spain	6	4,4	3,1	3,6	3,8	4,0	4,1	4,3										
29,0	IIa	2 Spain	3	4,1	3,1	3,7	4,0													
32,5	IIa	1 Spain	8	4,2	2,5	2,9	3,2	3,5	3,7	3,9	4,0	4,2								
27,5	IIa	2 Spain	3	3,7	2,5	3,3	3,6													
27,0	IIa	2 Spain	5	3,8	2,7	3,2	3,4	3,6	3,8											
30,5	IIa	1 Spain	5	4,1	2,7	3,1	3,5	3,8	4,0											
26,5	IIa	2 Spain	4	3,6	2,7	3,1	3,4	3,6												

Table A1.2 **Sample 1a-d. WHOLE otoliths. Inner diameter (D1-D13, Dtot) measured by country: Norway and Spain (100 otoliths in sample 1a-d).**

Length	Area	Sex	Country	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
27,5	VII	2	Norway	6	13,4	8,5	10,5	11,6	12,3	12,8	13,3							
24,5	VII	2	Norway	3	11,3	8,9	10,2	11,0										
23,0	VII	2	Norway	3	11,8	8,5	10,3	11,5										
23,5	VII	2	Norway	3	12,1	8,9	10,5	11,6										
21,5	VII	1	Norway	1	10,0	8,9												
28,5	VII	2	Norway	6	13,1	8,9	10,5	11,0	12,0	12,6	13,0							
29,0	VII	1	Norway	3	13,3	9,3	11,6	13,0										
25,5	VII	2	Norway	5	13,0	9,3	10,7	11,6	12,1	12,6								
24,0	VII	1	Norway	3	12,1	8,7	10,7	11,8										
22,5	VII	2	Norway	2	12,0	8,9	11,1											
22,5	VII	2	Norway	3	11,6	9,0	10,5	11,3										
26,5	VII	2	Norway	5	12,8	8,4	10,5	11,5	12,1	12,6								
25,5	VII	1	Norway	3	12,0	8,4	10,2	11,6										
27,0	VII	2	Norway	4	13,0	8,5	11,1	12,1	12,8									
26,0	VII	1	Norway	4	12,5	9,3	10,8	11,6	12,3									
25,0	VII	2	Norway	3	11,6	8,7	10,5	11,3										
25,5	VII	2	Norway	4	12,6	8,7	10,2	11,3	12,1									
24,5	VII	1	Norway	3	12,6	8,9	10,8	12,1										
25,5	VII	2	Norway	3	12,1	8,5	10,7	11,8										
25,0	VII	2	Norway	4	12,5	9,0	10,7	11,6	12,3									
27,5	VII	2	Norway	5	13,0	8,2	10,0	11,3	12,0	12,6								
25,5	VII	2	Norway	5	12,6	9,0	10,7	11,6	12,1	12,5								
28,0	VII	1	Norway	4	13,4	9,2	10,7	12,1	13,1									
27,0	VII	1	Norway	5	13,6	8,9	10,7	11,8	12,8	13,3								
28,5	VII	2	Norway	6	13,4	8,5	10,2	11,3	12,3	12,8	13,1							
25,5	VIa	1	Norway	3	12,0	8,5	10,7	11,6										
28,5	VIa	2	Norway	4	13,3	9,0	11,1	12,3	13,1									
30,0	VIa	1	Norway	4	13,4	9,0	11,1	12,3	13,1									
29,0	VIa	2	Norway	6	13,6	8,5	10,3	11,6	12,5	13,1	13,4							
28,5	VIa	1	Norway	3	12,5	8,4	10,8	12,0										
26,0	VIa	1	Norway	2	11,0	8,7	10,5											
32,0	VIa	1	Norway	5	14,1	9,2	10,7	12,0	13,1	13,8								
28,0	VIa	2	Norway	3	12,0	8,7	10,3	11,6										
33,0	VIa	1	Norway	5	15,1	9,3	11,0	12,3	13,6	14,9								
28,0	VIa	2	Norway	6	13,3	8,0	9,8	11,0	11,8	12,5	13,1							
30,5	VIa	1	Norway	4	13,1	8,9	10,7	12,0	12,6									
31,0	VIa	2	Norway	5	14,1	8,7	10,3	11,8	13,0	13,9								
23,0	VIa	2	Norway	3	11,8	8,5	10,5	11,5										
26,0	VIa	1	Norway	3	12,1	8,7	10,5	11,6										
32,0	VIa	1	Norway	5	14,1	8,2	10,3	11,8	12,6	13,8								
26,5	VIa	1	Norway	3	12,5	8,7	10,8	12,0										
27,5	VIa	2	Norway	3	12,0	8,9	10,7	11,6										
27,0	VIa	2	Norway	6	13,4	8,2	10,3	11,5	12,3	13,0	13,3							
29,0	VIa	2	Norway	5	13,8	8,7	10,5	11,8	12,8	13,6								
29,0	VIa	2	Norway	4	12,8	8,7	10,8	11,8	12,5									
24,5	VIa	1	Norway	2	10,5	8,5	10,2											
22,0	VIa	1	Norway	1	10,3	9,3												
30,0	VIa	1	Norway	4	13,3	9,0	11,0	12,3	13,1									

Table A1.2 cont.

35,0	VIa	1	Norway	6	15,1	8,5	10,5	12,1	13,9	14,3	14,8							
35,0	VIa	2	Norway	9	15,6	8,5	9,8	11,5	12,5	13,3	13,9							
21,5	IVa	1	Norway	1	10,0	8,2												
25,5	IVa	1	Norway	2	11,6	8,4	11,0											
28,0	IVa	1	Norway	3	12,1	8,9	10,7	11,6										
21,5	IVa	1	Norway	1	10,2	8,5												
25,5	IVa	1	Norway	2	11,3	8,2	10,5											
27,0	IVa	1	Norway	2	11,6	8,0	10,7											
31,5	IVa	2	Norway	4	13,8	9,0	11,1	12,5	13,3									
29,5	IVa	1	Norway	3	12,3	8,4	10,5	11,6										
28,5	IVa	2	Norway	6	13,4	8,7	10,5	11,6	12,3	12,6	13,1							
31,5	IVa	1	Norway	6	14,8	8,5	10,7	12,1	13,1	13,8	14,4							
32,0	IVa	1	Norway	6	14,1	8,2	9,8	11,3	12,3	13,3	13,9							
22,5	IVa	0	Norway	1	9,7	9,0												
21,5	IVa	0	Norway	1	9,5	8,5												
25,0	IVa	0	Norway	2	11,0	8,2	10,3											
44,5	IVa	1	Norway	11	15,1	8,2	9,8	10,7	11,8	12,5	13,1							
27,0	IVa	2	Norway	2	10,2	7,4	9,5											
22,5	IVa	2	Norway	1	9,2	7,4												
22,5	IVa	2	Norway	1	10,0	8,2												
29,5	IVa	2	Norway	4	12,6	8,5	10,7	11,8	12,3									
25,5	IVa	0	Norway	2	10,8	8,2	10,3											
25,0	IVa	0	Norway	2	11,3	8,7	10,7											
25,0	IVa	0	Norway	3	11,0	8,4	9,8	10,8										
19,5	IVa	0	Norway	1	9,0	7,9												
26,5	IVa	0	Norway	3	12,0	8,9	10,5	11,6										
25,0	IVa	0	Norway	3	11,0	7,7	9,3	10,5										
26,0	IIa	2	Norway	2	11,1	8,7	10,8											
26,0	IIa	2	Norway	3	11,8	8,5	10,5	11,5										
28,0	IIa	2	Norway	4	12,1	8,4	9,8	11,1	11,8									
25,5	IIa	2	Norway	2	11,5	8,9	11,0											
28,0	IIa	1	Norway	3	11,6	8,2	10,3	11,1										
40,0	IIa	2	Norway	13	17,2	9,3	11,0	12,3	13,3	13,9	14,4	14,8	15,1	15,4	15,7	16,1	16,6	16,9
21,0	IIa	2	Norway	1	9,3	8,9												
20,5	IIa	2	Norway	1	9,2	8,5												
26,5	IIa	1	Norway	2	11,3	8,5	10,7											
27,0	IIa	2	Norway	7	12,6	8,2	9,7	10,7	11,3	11,8	12,1	12,5						
28,0	IIa	2	Norway	4	12,1	8,5	10,2	11,3	12,0									
40,5	IIa	1	Norway	9	16,6	8,0	10,0	11,6	12,8	13,4	14,1	14,8	15,6	16,2				
33,5	IIa	1	Norway	6	13,9	8,2	9,8	11,1	12,1	12,8	13,4							
27,0	IIa	2	Norway	2	11,3	8,4	10,5											
28,0	IIa	2	Norway	3	11,6	8,2	10,2	11,3										
30,0	IIa	1	Norway	3	11,5	8,0	10,0	11,1										
31,0	IIa	1	Norway	4	13,0	8,7	10,7	11,8	12,6									
29,5	IIa	2	Norway	8	13,4	8,0	10,0	11,0	11,8	12,5	12,8	13,1	13,3					
33,5	IIa	2	Norway	7	13,9	8,0	10,2	11,5	12,3	12,8	13,3	13,8						
29,0	IIa	2	Norway	3	12,0	8,9	10,7	11,5										
32,5	IIa	1	Norway	8	14,1	8,4	10,0	11,1	12,0	12,5	13,0	13,3	13,8					
27,5	IIa	2	Norway	3	11,1	8,2	9,8	10,8										
27,0	IIa	2	Norway	4	12,0	8,2	9,7	10,5	11,5									
30,5	IIa	1	Norway	5	13,0	8,2	10,2	11,5	12,3	12,8								
26,5	IIa	2	Norway	3	11,6	8,0	10,0	11,0										

Table A1.2 cont.: **Spain. As many of the otoliths were broken, only 73 were aged, and only a few otoliths could be completly measured.**

Length	Area	Sex	Country	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
24,5	VII	2	Spain	5		8,6	9,9											
23,5	VII	2	Spain	3		8,1	9,4											
28,5	VII	2	Spain	6		9,0	10,3											
25,5	VII	2	Spain	4		9,4												
24,0	VII	1	Spain	3		7,7												
22,5	VII	2	Spain	3		8,5												
26,5	VII	2	Spain	5		8,1	10,0	11,0										
25,5	VII	1	Spain	3		7,9	9,9											
26,0	VII	1	Spain	4		9,2	10,5											
25,5	VII	2	Spain	5	12,0	8,5	9,7	10,5	11,2	11,8								
24,5	VII	1	Spain	3		8,5	10,2											
25,5	VII	2	Spain	3		8,1												
25,0	VII	2	Spain	4		8,7	10,2											
25,5	VII	2	Spain	5		8,8	10,1	11,0										
27,0	VII	1	Spain	5		8,0	9,8	10,8										
28,5	VII	2	Spain	6		8,1	9,7	11,0	11,8									
28,5	VIa	2	Spain	4		8,8												
29,0	VIa	2	Spain	6	13,3	8,0	10,0	11,0	11,9	12,6	13,2							
28,5	VIa	1	Spain	3		8,0	10,0											
26,0	VIa	1	Spain	2		5,4	8,9											
33,0	VIa	1	Spain	4		8,6	10,6	11,7	13,0									
30,5	VIa	1	Spain	4		8,5	10,4	11,7										
31,0	VIa	2	Spain	5		8,0	9,6											
23,0	VIa	2	Spain	3		8,0	10,0											
26,0	VIa	1	Spain	3		8,0	9,9											
23,0	VIa	1	Spain	5		7,9	9,7	11,3	12,2									
26,5	VIa	1	Spain	4		7,8	9,4	10,5										
27,5	VIa	2	Spain	3		8,4	10,2											
27,0	VIa	2	Spain	6		7,5	9,9	10,9	11,8	12,4								
29,0	VIa	2	Spain	5		8,1	9,8	10,9	11,7									
29,0	VIa	1	Spain	4		8,2	10,6											
24,5	VIa	1	Spain	2		8,4												
22,0	VIa	1	Spain	1		9,0												
25,5	IVa	1	Spain	2		8,2	10,7											
28,0	IVa	1	Spain	3		9,0	10,7											
21,5	IVa	1	Spain	1		8,1												
25,5	IVa	1	Spain	2		7,5	9,8											
27,0	IVa	1	Spain	3		7,4	9,5	10,7										
32,0	IVa	1	Spain	5		7,8	8,9	10,8	12,0	13,0								
21,5	IVa	0	Spain	1	9,8	8,6												
25,0	IVa	0	Spain	2		7,7	10,1											
44,5	IVa	1	Spain	10		8,2	10,1	11,5	12,7	13,6	14,5	15,3	15,7					
27,0	IVa	2	Spain	2		7,4	9,6											
22,5	IVa	2	Spain	1	9,6	7,4												
22,5	IVa	2	Spain	1		8,3												
25,5	IVa	0	Spain	2		8,4	9,9											
25,0	IVa	0	Spain	2		8,8	10,7											
25,0	IVa	0	Spain	3	11,1	8,2	9,5	10,5										

Table A1.2 cont.

26,5	IVa	0	Spain	3		8,5							
25,0	IVa	0	Spain	3		7,3	9,3						
26,0	IIa	2	Spain	2		8,4							
26,0	IIa	2	Spain	3		8,1	10,4						
28,0	IIa	2	Spain	3		7,8	10,1						
28,0	IIa	1	Spain	2		7,9							
21,0	IIa	2	Spain	1		8,3							
20,5	IIa	2	Spain	1		8,5							
26,5	IIa	1	Spain	3		7,5							
27,0	IIa	2	Spain	8	12,8	8,2	9,7	10,6	11,1	11,7	12,0	12,3	12,6
28,0	IIa	2	Spain	5		8,5	9,5	10,2	11,0				
33,5	IIa	1	Spain	7		8,4	9,9	11,1	12,1				
27,0	IIa	2	Spain	3		7,9							
28,0	IIa	2	Spain	4		7,7	9,8						
31,0	IIa	1	Spain	5		8,6	10,9	11,8					
29,5	IIa	2	Spain	8		7,4	9,8	10,7	11,4	12,1	12,7		
33,5	IIa	2	Spain	6		9,8	11,4	12,2					
29,0	IIa	2	Spain	3		9,0	11,0						
27,0	IIa	2	Spain	5		7,9	9,6	10,5					
26,5	IIa	2	Spain	3		8,0							

Table A2. Sample 2. Faroese sample 1992, WHOLE and SECTIONED otoliths.

R= Russia, N= Norway, F= Faroe Isl, S= Spain

			Whole				Sectioned			
No.	Lentgh	Sex	R	N	F	S	R	N	F	S
1	19	2	1	1	1	1	1	1	1	1
2	21	2	1	1	1	1	1	1	1	1
3	21	2	1	1	1	1	1	1	1	1
4	22	2	1	1	1	1	2	1	1	1
5	22	2	1	1	1	1	1	1	1	
6	22	2	1	1	1	1	2	1	1	1
7	22	2	2	1	1	1	2	1	1	1
8	22	2	1	1	1	1	1	1	1	1
9	22	2	1	1	1	1	1	1	1	1
10	22	2	1	1	1		1	1	1	1
11	22	2	1	1	1	1	2	1	1	1
12	22	2	1	1	1	1	1	1	1	1
13	23	2	2	1	1	1	1	1	1	1
14	22	2	1	1	1	1	1	1	1	1
15	22	2	2	1	1	1	2	1	1	1
16	22	2	1	1	1	1	1	1	1	1
17	22	2	1	1	1	1	1	1	1	1
18	23	2	1	1	1	1	1	1	1	1
19	23	2	1	1	1	1	1	1	1	1
20	23	2	1	1	1	1	1	1	1	1
21	23	2	2	1	1	1	1	1	1	1
22	23	2	2	3	3	3	2	1	3	3
23	23	2	2	1	1	1	1	2	1	1
24	23	2	1	1	1	1	1	1	1	1
25	23	2	1	1	1	1	1	1	1	1
26	23	2	1	1	1	1	1	1	1	1
27	23	2	1	1	1	1	1	1	1	1
28	23	2	2	1	1	1	1	1	1	
29	23	2	1	1	1	1	1	1	1	
30	23	2	2	1	1	1	1	1	1	1
31	23	2					1	1	1	1
32	24	2	3	3	3	3	3	3	3	3
33	24	2	1	1	1	1	2	1	1	1
34	24	2	2	3	3	3	2	3	3	3
35	24	2	3	3	2	3	3	3	3	3
36	24	2	1	1	1	1	2	1	1	1
37	24	2	2	1	1	1	2	1	2	1
38	25	2	2	1	1	1	2	1	1	1
39	25	2	3	3	2	3	2	3	3	3
40	25	2	2	1	1		2	1	1	1
41	25	2	3	3	3	3	3	3	3	3
42	25	2	3	3	2	3	2	2	2	2
43	25	2	2	2	3	2	3	3	3	3
44	25	2	3	3	3	3	2	3	3	3
45	26	2	3	3	3	3	3	3	3	3
46	26	2	3	3	3	3	3	3	3	3
47	26	2	3	3	3	3	3	3	3	3

Table A2. cont.

48	26	2	3	3	3	3	3	3	3	3
49	26	2	3	3	3	3	3	3	3	3
50	26	2	3	3	3	3	3	3	3	3
51	26	2	3	3	3	3	3	3	3	
52	26	2	2	3	3	3	3	3	3	3
53	27	2	3	3	3	3	3	3	3	3
54	27	2	3	3	3	3	3	3	3	4
55	27	2	3	3	3	3	3	3	3	3
56	28	2	3	4	4	3	3	4	4	4
57	28	2	4	3	3	3	4	4	3	5
58	28	2	3	3	3	2	4	4	3	4
59	28	2	3	3	3	3	4	4	3	4
60	30	2	4	5	4	5	4	4	4	4
61	32	2	5	1	4	5	5	6	6	6
62	21	1	1	1	1		1	1	1	1
63	22	1	1	1	1	1	1	1	1	1
64	22	1	2	1	1	1	1	1	1	1
65	22	1	1	1	1		1	1	1	1
66	22	1	1	1	1	1	2	1	1	1
67	22	1	1	1	1	1	1	1	1	1
68	22	1	1	1	1	1	1	1	1	1
69	22	1	2	1	1	1	1	1	1	1
70	22	1	1	1	1	1	1	1	1	1
71	23	1	1	1	1		2	1	2	1
72	23	1	1	1	1	1	1	1	1	1
73	23	1	2	1	1	1	1	1	1	1
74	23	1	2	1	1	1	1	1	1	1
75	23	1	1	1	1	1	1	1	1	1
76	23	1	1	1	1	1	1	1	1	1
77	23	1	1	1	1	1	1	1	1	1
78	23	1	1	1	1	1	1	1	1	1
79	23	1	2	1	1	1	1	1	1	1
80	23	1	2	1	1	1	1	1	1	1
81	23	1	1	1	1	1	1	1	1	1
82	23	1	1	1	1	1	1	1	1	1
83	23	1	1	1	1	1	1	1	1	1
84	23	1	2	1	1	1	1	1	1	1
85	23	1	2	1	1	2	1	1	1	1
86	23	1	1	1	1	1	2	1	2	1
87	23	1	1	1	1	1	1	1	1	1
88	24	1	2	1	1	1	1	1	1	1
89	24	1	1	1	1	1	2	1	2	2
90	24	1	2	1	1	1	1	1	1	1
91	24	1	1	1	1		1	1	2	1
92	25	1	2	1	1	1	2	1	3	1
93	25	1	2	1	1	1	2	2	2	1
94	27	1	4	2	2	4	3	3	3	3
95	29	1	3	3	3	3	3	3	3	3
96	30	1	4	3	3	3	4	3	3	3
97	30	1	4	3	3	3	4	3	3	3
98	31	1	3	3	3	3	4	3	3	3
99	33	1	4	5	5	4	4	5	5	5
100	36	1	5			4	5	6	6	6

Table A3. Sample 3. Russian sample 1992, WHOLE otoliths.

R = Russia, N = Norway, F = Faroe Isl, S = Spain

			Whole			
No.	Length	Sex	R	N	F	S
1	37,1	1	10	8	10	9
2	39,1	1	11	10	12	8
3	36,2	1	7		7	
4	33,5	2	9		6	
5	39,8	1	7		8	
6	37,2	1	7	7	7	5
7	37,3	1	8	7	7	6
8	29,2	1	4	4	3	2
9	26,9	2	3	3	3	3
10	27,0	1	3	3	3	3
11	24,2	2	3	3	3	3
12	23,7	2	3	3	3	3
13	26,0	2	3	3	3	3
14	22,7	2	3	3	3	3
15	22,1	2	3	3	3	
16	19,6	1	1	1	1	1
17	24,6	2	3	3	3	3
18	34,2	1	9	7	7	6
19	35,4	1	9	9	9	8
20	34,5	1	7	6	6	5
21	35,0	1	5	4	4	4
22	31,2	2	6	5	6	5
23	32,5	1	4	4	4	4
24	28,3	2	4	3	3	4
25	32,2	2	7	6	6	6
26	23,0	2	3	3	3	3
27	21,7	1	1	1	1	1
28	34,1	1	5		4	
29	29,5	1	3	3	3	3
30	36,8	1	8	6	6	6
31	32,1	2	6	7	6	6
32	32,5	1	8	6	7	7
33	31,2	1	4	4	4	5
34	26,5	1	3	3	3	3
35	28,8	1	4	3	3	2
36	28,2	1	4	3	3	3
37	27,7	1	3	3	3	
38	26,5	2	3	3	3	
39	27,6	1	3	3	3	3
40	19,2	2	1	1	1	1
41	24,5	2	3	3	3	3
42	35,7	1	7	6	6	6
43	36,1	1	7	6	6	5
44	38,5	1	12	10	12	
45	20,6	1	1	1	1	1
46	35,6	1	8	7	7	7
47	35,5	1	7	7	7	7

Table A3. cont.

48	35,6	1	8	8	7	7
49	36,6	1	8	8	8	8
50	36,8	1	6	6	6	5
51	36,5	1	7	7	7	7
52	33,2	1	5	5	5	
53	28,5	2	4	4	4	4
54	32,5	1	7	7	7	7
55	27,6	1	3	3	3	3
56	32,8	1	4	4	4	5
57	27,6	1	3	3	3	3
58	26,0	2	4	3	3	5
59	30,7	1	5		4	
60	27,6	1	4	3	3	
61	33,3	1	5	4	5	4
62	27,5	2	3	3	3	3
63	33,7	1	6	6	5	7
64	34,8	1	7	6	5	6
65	35,2	1	5	5	5	6
66	30,9	2	4	4	4	5
67	27,6	2	3	3	3	3
68	28,2	2	3	3	3	3
69	27,2	1	3	3	3	3
70	27,6	1	3	3	3	4
71	27,0	2	3	3	3	3
72	30,5	2	4	4	4	4
73	19,8	2	1	1	1	1
74	24,5	2	3	3	3	3
75	27,6	1	3	3	3	
76	27,0	2	4	4	4	5
77	27,1	1	2	3	3	3
78	27,5	1	3	3	3	3
79	29,0	1	3	3	3	
80	28,1	1	3	3	3	3
81	27,3	1	3	3	3	3
82	31,5	2	5	6	6	6
83	27,1	2	3	3	3	3
84	26,5	2	4	4	3	
85	30,0	2	5		5	
86	27,5	2	3	3	3	3
87	26,2	2	3	3	3	
88	28,0	1	3	3	3	3
89	36,0	1	7	6	8	
90	30,8	1	5	5	4	5
91	33,0	1	8	6	6	
92	34,5	1	7	7	8	7
93	34,2	1	8	8	7	
94	35,0	1	6	6	7	6
95	27,1	1	3	3	3	3
96	30,0	2	9	7	6	7
97	32,0	2	8	7	7	8
98	26,5	2	3	3	3	3
99	29,0	1	3	3	3	3
100	28,0	1	3	3	3	3

Table A4. Sample 4. Spanish sample 1992, SECTIONED otoliths.

R = Russia, N = Norway, F = Faroe Isl, S = Spain

			Sectioned			
No.	Length	Sex	R	N	F	S
1	15	2	1	1	1	1
2	15	2	2	1	1	1
3	16	2	2	1	1	1
4	17	2	2	1	1	1
5	17	2	3	1	1	1
6	17	2	3	1	1	1
7	17	2	3	1	1	1
8	17	2	2	1	1	1
9	18	2	3	1	1	1
10	18	2	2	1	1	1
11	18	2	2	1	1	1
12	18	2	2	1	1	1
13	18	2	2	1	1	1
14	18	2	2	1	1	1
15	18	2	2	1	1	1
16	18	2	3	1	1	1
17	19	2	4	2	2	2
18	19	2	4	2	2	2
19	19	2	3	2	2	2
20	19	2	3	2	2	2
21	19	2	5	2	2	2
22	19	2	4	2	2	2
23	19	2	4	2	2	2
24	19	2	4	2	3	2
25	20	2	3	2	2	2
26	20	2	4	2	3	2
27	20	2	4	2	2	2
28	20	2	4	2	3	
29	20	2	5	2	2	2
30	20	1	2	1	2	1
31	21	2	3	2	3	2
32	21	2	3	2	2	2
90	28	2	7	9	8	8
91	28	2	7	7	7	7
92	28	2	6	8	7	7
93	28	2	10	9	8	8
94	28	2	9	9	9	9
95	28	2	9	10	9	9
96	28	2	7	8	6	7
97	28	2	7	10	9	9
98	28	2	6	8	8	10
99	28	2	7	9	8	9
100	29	2	6	6	5	6
101	29	2	6	7	5	6
102		2	8	8	10	
103		2	10	10	9	10
104		2	9	9	9	8

Table A4. cont.

105	32	2	11	11	10	10
106	16	1	3	1	1	1
107	16	1	1	1	1	1
108	17	1	2	1	1	1
109	17	1	2	1	1	1
110	19	1	3	1	2	1
111	19	1	5	2	4	2
112	20	1	4	2	4	2
113	20	1	4	2	3	2
114	20	1	4	2	3	3
115	20	1	3	2	2	2
166	27	1	6	5	5	6
167	27	1	7	5	5	5
168	27	1	5	5	4	5
169	28	1	8	6	7	7
170	28	1	5	4	5	5
171	28	1	6	5	5	5
172	28	1	6	4	4	4
173	28	1	8	4	4	5
174	29	1	7	5	4	5
175	29	1	9	7	7	7
176	29	1	5	5	4	5
177	29	1	6	5	4	5
178	29	1	10	6	6	7
179	30	1	5	5	5	5
180	30	1	7	5	5	5
181	30	1	6	4	4	5
182	31	1	10	6	6	7
183	31	1	6	5	6	6
184	31	1	7	6	6	7
185	32	1	8	6	7	6
186	32	1	9	9	8	9

Table A5. Blue whiting, southern area VIIIc and IXa 1993. Otolith diameter (mm).

Length	Age	Dtot	D1	D2	D3	D4	D5	D6	D7	D8
27	8	4,06	0,17	2,79	3,08	3,33	3,53	3,68	3,81	3,95
27	5	4,06	2,90	3,29	3,59	3,79	4,00			
27	4	4,25	3,04	3,59	3,95	4,17				
28	5	4,05	2,72	3,14	3,51	3,77	4,00			
28	7	4,19	2,72	3,18	3,51	3,70	3,87	4,00	4,13	
28	5	4,23	3,02	3,49	3,71	4,01	4,16			
28	5	4,24	3,02	3,39	3,81	4,06	4,22			
29	5	4,61	3,13	3,68	4,05	4,33	4,49			
26	5	4,03	2,88	3,42	3,66	3,85	3,98			
26	5	4,35	3,07	3,57	3,96	4,17	4,33			
27	6	4,38	2,58	3,20	3,61	3,87	4,13	4,34		
27	6	4,46	2,61	3,15	3,58	3,96	4,18	4,38		
27	6	4,36	2,77	3,20	3,62	3,88	4,06	4,31		
27	6	4,63	2,99	3,59	3,87	4,12	4,29	4,52		
27	5	4,23	2,96	3,48	3,90	4,08	4,18			
27	5	4,12	2,78	3,25	3,63	3,87	4,08			
27	5	4,12	2,87	3,48	3,63	3,87	4,06			
27	6	4,17	2,61	3,08	3,64	3,81	3,97	4,10		
23	7	4,35	2,66	3,20	3,55	3,83	4,01	4,18	4,32	
23	5	4,13	2,76	3,29	3,67	3,89	4,09			
24	6	4,05	2,48	2,97	3,45	3,66	3,83	3,99		
24	7	4,19	2,61	3,08	3,46	3,69	3,84	4,03	4,16	
24	4	4,99	2,96	3,41	3,77	3,97				
24	7	4,16	2,74	3,12	3,50	3,72	3,87	4,03	4,14	
22	6	4,09	2,98	3,34	3,58	3,75	3,91	4,04		
22	4	3,73	2,72	3,09	3,49	3,70				
22	6	4,13	2,66	3,12	3,51	3,71	3,87	4,07		
23	5	3,67	2,66	3,06	3,27	3,45	3,62			
23	6	4,17	2,75	3,35	3,61	3,82	4,00	4,13		
23	6	3,95	2,51	2,93	3,33	3,59	3,81	3,91		
23	4	3,89	2,80	3,31	3,69	3,83				
23	5	3,99	2,80	3,22	3,48	3,72	3,90			
Average:		4,19	2,72	3,26	3,61	3,84	4,01	4,11	4,11	3,95