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REPORT OF THE WORKSHOP ON OTOLITH READING OF BLUE

WHITING

Tórshavn 14-17 June 1983

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REPORT OF THE WORKSHOP ON OTOLITH READING OF BLUE WHITING

1. INTRODUCTION

1.1 Terms of Reference

The Workshop on Otolith Reading of Blue Whiting met in Tórshavn 14-17 June 1983. The terms of reference were set by the Council's resolution, passed at its 70th Statutory Meeting (C.Res.1982/2:29).

"It was decided, that a Workshop on Otolith Reading of Blue Whiting, convened by Mr H í Jákupsstovu, should be held in Tórshavn, Faroe Islands, for 4 days in June 1983. It is of special importance that readers from countries fishing large quantities of Blue Whiting attend the Workshop".

1.2 Participants

J Dufor	France
H í Jákupsstovu (Chairman)	Faroe Islands
T Monstad	Norway
R Mouritsen	Faroe Islands
R Robles	Spain
N Schultz	German Democratic Republic
S Sveinbjörnsson	Iceland
U Vang	Faroe Islands
Maria Elisa Vasconcelos	Portugal

The absence of representatives from countries taking the major part of the annual blue whiting landings was felt by the Workshop as a great limitation to the work done.

1.3 Previous Experience

A blue whiting otolith program completed in 1978 demonstrated quite unacceptable variability in age determination made by otolith readers from different countries. As a result of this, an Otolith Reading Workshop was incorporated in the terms of reference of the 1979 Blue Whiting Planning Group. The result of this exercise (Anon.,1979) was that a number of problems in reading blue whiting otoliths were identified. During the Workshop, by discussing a number of otoliths shown on a video-monitoring equipment, the 1979 Workshop felt that a higher agreement on the interpretation of the growth zones in the otoliths was reached. In order to standardise the age-reading and reporting, a number of recommendations were made by the Workshop. Further a new otolith exchange programme was initiated to demonstrate any improvements achieved by the Workshop. This programme, which was completed and reported to the 1981 Blue Whiting Assessment Working Group (Anon.,1981), did not, however, in any way support the feeling of the 1979 Workshop. Of the 100 otoliths read by 11 different readers there was no agreement on any of the otoliths. And the difference in age determination of the same otoliths was up to 11 years, and generally

from 3-8 years. Based on marks made by each reader on photographs of 30 otoliths in the sample on the zones counted, a systematic difference of the readers most accustomed to read blue whiting otoliths resulted, however, in a fairly good agreement.

The assessment of the northern blue whiting stock has so far, mainly due to the short history of the fishery, been based on acoustic assessment surveys. The last three years, however, the Blue Whiting Assessment Working Group has made some trial VPA runs of the northern stock based on the age-reading provided at the meeting. The 1980 and 1981 Working Group did not use the VPA in their report, while the 1982 Working Group calibrated the VPA against the acoustic assessment survey and then used the VPA for the predictions. The Working Group, however, recognised that any VPA based on the age-readings provided to the Working Group meeting without any standardisation was of limited value only and consequently recommended that a new workshop was held in 1983.

For the southern blue whiting the Blue Whiting Working Group made a tentative assessment based on a VPA by length in 1981.

2. IDENTIFICATION OF PROBLEMS

The Workshop identified the following items which could lead to differences in age reading:

a) Treatment of the otolith before ageing

Presently 3 different methods are in use. At some laboratories the otoliths are read whole soaked in fresh or sea water, at some the otolith is broken and age determined on the broken surface using incident or translucent light, and finally some laboratories use sections through the nucleus either embedded in eucit or moistened with alcohol.

b) Variation in growth rate by area and season could result in a variation of annual and intraseasonal check rings by area.

c) Differences in interpretation by readers

The most important areas where differences in interpretation might arise are: Identification of the first wintering from checkrings inside it (equal to the Bowers zone in whiting otoliths), (Gambell and Messtorff, 1964), different interpretation of multiple rings and of the edge.

3. MATERIAL

The material used when discussing interpretational differences was provided by Faroese and consisted of 4 samples of blue whiting otoliths each consisting of 25 pairs of otoliths. Of each pair one otolith was sectioned using the Lowestoft method (Bedford, Ref.), the other was kept whole and soaked in water. The samples were from Faroese waters fished in August, December, March and May, respectively.

In order to discuss the information of the first winter zone the Workshop was provided with samples from Iceland and Norway consisting of otoliths from the juvenile blue whiting year class, which recruited to the industrial fishery in Norway in August 1982 and to the south of Iceland at the same time. Three samples were provided by each country

from autumn 1982, winter and spring 1983, respectively. Due to the limited time available to the Workshop only the Norwegian samples were analysed.

The discussion on differences by area in growth pattern and consequent zone formation was based on material of blue whiting otoliths from the southern area brought to the Workshop by Spain. Altogether 8 samples of otoliths from juvenile and adult blue whiting from 4 different seasons were provided in the form of sections through the nucleus. Material brought to the meeting by Portugal was not discussed due to time limitation.

4. HANDLING OF MATERIAL

The Faroese material enabled the Workshop to discuss differences in ageing resulting from two different ways of handling the otoliths before age determination: reading whole and sectioned otoliths respectively. This material was also used when discussing interpretational differences. In order to achieve this the participants were divided into 4 sub-groups. Within each, every reader separately read the sectioned and whole otoliths from one sample. In addition to ageing the otoliths the readers were asked to grade the difficulty in interpreting the age using a scale from 1 to 3 (1 = easy, 2 = fairly easy, 3 = difficult), to note down the edge character (H = dominantly hyaline edge, O = dominantly opaque edge) and any rings found inside the first winter zone counted (Bowers zone). After completing the ageing, each sub-group discussed all the sectioned otoliths when displayed on a video monitor, trying to identify the interpretational differences between readers and to describe them.

Finally, selected sectioned otoliths from each sample were discussed in front of the video equipment by the whole Workshop.

From the Norwegian samples one otolith of each pair was sectioned. The samples were aged by one sub-group only, noting down the age, edge character and any check rings seen. The samples were then finally discussed in front of the video equipment.

The Spanish samples were read separately by 3 readers accustomed to ageing northern blue whiting and 1 reader accustomed to southern blue whiting. Finally, the samples were discussed in front of the video monitor.

5. RESULTS

5.1 Faroese Material

5.1.1 Initial age determination

In Tables 1 to 4 details of the Faroese samples and the age determination by each sub-group is given for whole and sectioned otoliths, respectively. The agreement between readers varied markedly from one sub-group to another and also within each sub-group when reading whole and sectioned otoliths. Group No.1 arrived at the same age in 12 otoliths when reading them whole, but on only 5 when reading them sectioned. In Group No.2 the figures are 13 and 3, respectively. Group No.3 reached a higher agreement on the sectioned otoliths than on the whole otoliths, 15 and 9 respectively, whereas Group No.4 reached almost the same agreement using both methods.

All the readers found the blue whiting otoliths in general difficult to read (Table 5).

The interpretation of the edge character (Table 6) varied markedly between readers and also by the same reader when reading sectioned and whole otoliths. Although the samples are from 4 different seasons, seasonal regularity of the edge character was not demonstrated in this material.

5.1.2 Age determination in front of the video equipment (Only sections)

During the discussion in front of the video equipment, each sub-group separately could attribute the discrepancies found between readers to the same main items as listed in Section 2. Of these, interpretation of the intermediate zones was the most frequent reason for the discrepancies in age-reading followed by difficulties in determining the first winter-zone and the edge character (Tables 1 to 4). From this discussion some alternations in the initial age-readings were achieved between the readers within a sub-group resulting in a higher agreement. An example of this is given in Table 1.

5.2 Norwegian Samples

All the Norwegian otoliths belonged to fish of the same year class (1982), which were sampled in August 1982 and February and April 1983.

From Table 7 it can be seen that there was a fairly good agreement between the two readers on the character of the edge. Of a special interest is the August sample, where 7 otoliths were considered to have a hyaline edge which may be a precursor of a Bower zone (see also Table 8). The samples from February and April had the expected edge characteristics.

Also with regard to the Bower zone there was a good agreement (Table 7). The readers agreed completely on the presence and absence of a Bower zone in the August and April samples, but the presence of a series of weak and narrow hyaline rings inside the 1st winter zone in the February sample made it difficult to decide whether these should be interpreted as Bowers zones or not. Those rings were also present in many otoliths of the August and April samples, but there the Bowers zone was usually also present.

5.3 Spanish Samples

The age determination of the Spanish samples by the various readers is presented in Tables 9 and 10, the edge characteristics in Table 11, the existence of Bower zone and other checks inside the first winter zone in Table 12, and the grading of the difficulty in ageing the otoliths in Table 13.

There was in general a good agreement between the readers in the age determination of the various otoliths. In otoliths from fish <20 cm the disagreement between the readers was mainly created by different interpretation of the Bowers zone, and in a few cases also by the edge character. In otoliths from fish >25 cm the disagreement was mostly caused by the presence of multiple rings, only one case was referred to a different interpretation of the Bowers zone and none to the edge.

Of the 20 otoliths from fish > 25 cm only in one case was the difference between readers more than two years.

Although the "southern expert" found a higher seasonality in the edge characteristics there was a good agreement between the readers in interpreting the edge. Some differences existed between readers in their description of the Bower zone and checks inside the first winter zone.

6. DISCUSSION

The main aim of the discussion in front of the video monitor was to arrive at some criteria which could be used in the future to advise readers in their interpretation when ageing blue whiting otoliths. The Workshop was fully aware of how difficult a task this is and also of the danger for a bias which might arise from such an approach. The variance between readers experienced at present, however, is too great for assessment purposes, and the Workshop, therefore, felt that more consistency in age determination was urgently needed.

The age determination of the same fish differed by most readers with the treatment of the otolith. This is illustrated in Figure 1 where the age arrived at on the sectioned otolith is plotted against the age arrived at by the same reader when reading the whole otolith. Six of the readers generally arrived at higher ages when reading the sections compared to the whole otoliths, whereas two which had experience in both methods, got the same general trend. Thus the differences may be attributable to inexperience in using one or both methods.

Comparing the analysis of the otoliths from the southern and northern areas the impression given is that the growth rate of blue whiting in the southern area is less than in the northern (for example, it is hard to find in the northern area fish up to 20 cm which are more than 1 year), while in the southern area the readings in some cases goes up to 3 years (see Table 9).

As stated earlier the edge character of the otoliths was found to be more clearly related to the various seasons in the southern area than in the northern.

In fish > 25 cm from the southern area, the annual zones in the otoliths seem to be easier to interpret than corresponding otoliths from the north.

However, the possible differences mentioned should preferably be confirmed further by analysing a larger material than was possible during the Workshop.

In almost all of the otoliths discussed, the Group had no problems in distinguishing the first winter zone from the inner rings. The following conclusions were drawn:

Juvenile fish. The first winter zone is almost always complete and more defined (sharper) compared to the Bowers zone which is more diffuse generally and often not complete.

Adult fish. The first winter zone is likewise almost always complete and more defined than the inner rings. The Bowers zone can in adult fish be distinct near the sulcus but is rarely complete.

The majority of the discrepancies in age determination could be attributed to different interpretations of multiple zones. Although it is hard to see any systematic approach which could resolve this problem, the good agreement found by the Group composed of the most experienced otolith readers indicate that this problem could, to some extent, be resolved with better training of the readers.

The analysis of the otolith edge character showed a remarkably high disagreement between the different readers in interpreting it to be either hyaline or opaque. In many cases it seems to be rather difficult to decide whether the hyaline or the opaque are dominating along the edge.

The samples were collected from various seasons of the year, and hence were expected to show differences in the edge character. The result of the analysis, however, did not demonstrate such a seasonal regularity.

In the material from the southern area, this phenomenon was, however, demonstrated fairly clearly, the edge character of the otolith showing an obvious seasonal relation.

In order to check whether a higher degree of agreement was reached as a result of the Workshop, 4 new samples of sectioned otoliths were read by the same sub-groups. Although it is hard to quantify, the general impression is that some improvement was reached. The differences encountered, again mainly due to different interpretation of the multiple zones, might have been caused by the different appearance of the rings in sections compared to how they appear for instance on the broken surface of an otolith or when reading a whole otolith.

7.

ADVICE TO OTOLITH READERS

- 1) The Workshop advises that readers distinguish between zones and rings. A zone is generally a broader area of either hyaline or opaque material which could be composed of one or more rings, especially in the pointed area of the sections.

Apart from this it is hard to give any distinct rules on how to interpret the zones. The width of the rings and zones and the distance between them has to be taken into account while ageing.

- 2) In otoliths from young fish (<2 years) it can be difficult to distinguish the first winter zone from Bowers zone and checks, especially in the first quarter of the 1 group fish. This problem can in most cases be overcome by experience, but systematic measurements of the rings and the first winter zone are badly needed.

In older fish the first ring to be counted should be fairly clear and usually complete. The "Bowers" zone and other checks found inside it are distinguished from the first winter zone by being thinner and more often incomplete.

- 3) Both hyaline and opaque material can be found throughout the year at the edge, and it is often difficult to decide which is dominant. As a rule the Workshop recommends that for otoliths sampled in the first quarter of the year, where no distinct winter zone can be found at the edge, an additional year should be counted.

8. FUTURE RESEARCH RECOMMENDATIONS

The following recommendations for future research are made:

- a) that the seasonal formation of the zones is investigated,
- b) that comparisons be made of the reliability of different otolith reading techniques,
- c) that regular exchange of otoliths on a bilateral basis is established,
- d) that otoliths from fish <10 cm should be collected whenever possible.

REFERENCES

- Anon., 1979. Report of the Blue Whiting Planning Group. ICES, C.M. 1979/H:2.
- Bedford, B.C. 1977. Further development of the technique of preparing thin sections of otoliths sets in black polyester resin. ICES, C.M.1977/F:24, 11 pp.
- Gambell, R. and Messtorff, J. 1964. Age determination in the whiting (Merlangius merlangus L.) by means of the otoliths. J.Cons.Int.Explor.Mer, 28:393-404.

Table 1. Result of ageing the Faroese samples from December (readers No.1 and 2).

No.	Whole otoliths		Sectioned otoliths		Final reading on sectioned	Remarks about the differences on the sectioned otoliths after the final reading
	1	2	1	2		
1	6	6	9	6	7	(3)
2	4	4	9	5	5	(3)
3	6	6	6	7	difficult	(1)
4	7	7	6	8	7	(2)
5	4	4	5	5	5	
6	6	6	9	9	difficult	(1) (2)
7	5	5	7	6	7	(3)
8	4	4	5	4	4	(2)
9	5	6	8	9	7	(1) (2)
10	-	-	4	4	4	
11	6	8	13	10	difficult	(2)
12	7	7	7	10	difficult	(1)
13	6	7	10	10	10	
14	7	7	8	9	difficult	(2)
15	6	6	5	9	7	(1) (2)
16	4	8	11	10	difficult	(3)
17	7	8	7	10	9	(1) (2)
18	8	8	11	9	9	(3)
19	4	6	5	6	6	(1)
20	5	7	6	6	6	
21	5	6	6	7	difficult	(3)
22	-	-	4	5	6	(1) (2)
23	5	7	8	9	9	(3)
24	-	-	7	8	8	(3)
25	8	7	7	9	9	(3)

1 = Split rings, 2 = Bailey rings, 3 = Edge thickness

Table 2. Result of ageing the Faroese samples from August (readers No.3 and 4)

No.	Sectioned otoliths		Whole otoliths		Remarks about the differences on the sectioned otoliths.
	3	4	3	4	
1	6	4	4	3	1
2	4	4	4	3	
3	6	3	4	3	1 and 2
4	5	2	3	3	1
5	5	5	4	4	
6	7	4	3	6	1 and 2
7	8	4	4	4	1
8	5	3	3	3	1
9	6	4	4	4	1
10	7	3	4	4	1 and 2
11	6	4	4	4	1
12	6	4	4	4	1
13	7	4	6	4	1
14	6	4	3	4	1
15	6	4	3	5	1
16	6	3	3	4	1
17	7	4	4	4	1
18	9	7	6	6	2
19	10	7	5	5	1
20	10	8	5	6	1 and 2
21	6	4	4	4	2 and 3
22	9	4	4	4	1 and 2
23	7	6	3	5	2
24	10	5	4	4	1
25	9	5	4	5	1 and 2

1 = Split rings, 2 = Bailey rings, 3 = Edge

Table 3. Result of ageing the Faroese samples from May (readers No.5 and 6)

No.	Whole otoliths		Sectioned otoliths		Remarks about the difference
	5	6	5	6	
1	8	5	8	5	(1)
2	5	4	4	3	(1)
3	6	4	5	5	(1)
4	7	7	7	7	
5	8	7	8	8	
6	8	5	6	5	(1)
7	7	7	8	7	(3)
8	9-8	6	8	8	(1)
9	6	4	4	4	
10	2	2	3	3	(3)
11	7	5	7	7	(3)
12	X	X	3	4	
13	9	9	9	9	
14	4	4	4	4	
15	8	9	10	11	(3)
16	4	4	4	4	
17	3	3	3	3	
18	6	6	6	6	
19	2	X	3	X	
20	7	6	5	6	(1)
21	8	6	7	6	
22	5	6	6	6	(1)
23	6	6	7	7	
24	5-6	X	10	14	(1)
25	X	X	4	4	

1 = Split rings, 2 = Bailey rings, 3 = Edge

Table 4. Result of ageing the Faroese samples from March (readers No.7 and 8)

No.	Whole otoliths		Sectioned otoliths		Remarks about the difference on the sectioned otoliths.
	7	8	7	8	
1	6	7	9	9	
2	-	6	9	9	
3	7	5	7	8	(3)
4	2	1	2	1	(2)
5	9	9	11	13	(1)
6	5	4	7	6	(3)
7	9	4	10	8	(2)
8	8	8	10	10	(2-difference between the first and final
9	4	4	5	5	
10	8	6	6	9	(1)
11	8	7	7	9	(1)
12	7	7	10	9	(2)
13	6	6	11	9	(1) (2)
14	7	6	8	7	(1)
15	5	4	6	6	
16	8	5	11	8	(1)
17	4	3	5	4	(3)
18	-	4	8	6	(1)
19	6	4	7	4	(1) (3)
20	5	3	5	4	(3)
21	9	6	9	8	(3)
22	-	4	9	9	
23	11	7	11	10	(1)
24	7	4	9	7	(1) (2)
25	-	6	-	-	

1 = Split rings, 2 = Bailey rings, 3 = Edge

Table 5. Distribution of remarks about the differences in reading the otoliths by sub-groups.

Sub-group	Reader no.	Sectioned			Whole		
		1	2	3	1	2	3
no. 1	1	0	6	19	4	11	7
	2	7	7	11	4	6	12
no. 2	1	0	16	9	0	16	9
	2	0	24	1	3	15	7
no. 3	1	17	2	6	19	0	6
	2	6	13	6	18	3	4
no. 4	1	3	12	9	4	9	9
	2	2	9	13	6	9	10

Table 6. Distribution of edge character by reader and sub-group

Sub-group no.	Reader no.	Sectioned		Whole	
		opaque	hyaline	opaque	hyaline
1	1	24	1	15	7
	2	7	18	10	12
2	1	22	3	25	0
	2	25	0	25	0
3	1				
	2	18	7	14	11
4	1	24	0	25	0
	2	17	8	2	21

Table 7. Distribution of the edge character in the Norwegian samples.

Month	Reader no. 1		Reader no. 2	
	Hyaline	Opaque	Hyaline	Opaque
August	7	3	7	3
February	15	0	11	4
April	1	14	1	14

Table 8. The interpretation of the Norwegian samples in relation to absence/presence of a Bowers zone.

Month	Reader no. 1			Reader no. 2		
	Distinct	Indistinct	Absent	Distinct	Indistinct	Absent
August	8	0	2	3	5	2
February	1	2	12	1	10	-
April	10	4	1	10	4	-

Table 9. Result of ageing the Spanish samples of blue Whiting < 20 cm

<u>1. Quarter.</u>			Source of disagreement	<u>2. Quarter.</u>			Source of disagreement
Length	Reader no.			Length	Reader no.		
	5	2		4	6	2	
16	1	1		17	1	1	1
16	1-2	1	3	17	1	1	3
17	2	1	2	18	1	1	1
17	1	1		18	1	1	2
18	1	1		19	1	1	2
18	1	1		19	1	1	2
19	2	2		19	1-2	0	2
19	3	3		19	1	1	2
19	2	2		19	1	1	1
19	1	2	3	19	1	1	2

<u>3. Quarter.</u>			Source of disagreement	<u>4. Quarter.</u>			
Length	Reader no.			Length	Reader no.		
	4	6	2		5	2	
13	1	1	0	2	17	1	1
13	2	0	1-0	2	17	1-2	1
15	1	1	0	3	18	1	1
15	1	1	0	2	18	1	1
16	1	-	0	2	19	0	1
16	1-2	1	1-0	-	19	1	1
16	1	1	1	2-3			
17	1	1	1				
18	-	0	1				
19	1	0	0	2-3			

1 = Split rings, 2 = Bowers zone, 3 = Edge

Table 10. Result of ageing the Spanish samples of blue whiting > 25 cm.

Fish no.	Reader no.			Source of difference in interpretation
	4	6	2	
1	5 (?)	5	4	(2)
2	4 (?)	5-6	5	(1)
3	3	3	4	(1)
4	5 (?)	6	7	(1)
5	4	5	5	(1)
6	5	4	5	(1)
7	9	8	8	(3)
8	7	6	7	(1)
9	10	6	9	(1)
10	7	6	8	(1)
11	6	7	5	(3)
12	5	4	3	(1)
13	4-5	4-6	4	(1)
14	5	5	6	(1)
15	2	2	2	-
16	4	4-5	5	(1)
17	6	5	5	(1)
18	5	6	5	(1)
19	6	7	7	(1)
20	4	4-5	4	(1)

1 = Split rings, 2 = Bowers zone, 3 = Edge.

Table 11. Distribution of edge character in the Spanish samples.

Reader no.	1. quart			2. quart			3. quart			4. quart		
	0	H	OH	0	H	OH	0	H	OH	0	H	OH
2	-	20	-	13	7	-	11	4	5	3	5	1
5	8	10	(2)							2	6	(1)
4				10	4	6	17	1	(2)			
6				10	9	1	17	1	2			

Table 12. Presence/absence of Bowers zones in the Spanish samples.

Reader no.	1. quart			2. quart			3. quart			4. quart		
	+	+	?	+	+	?	+	+	?	+	+	?
2	16	-	4	14	6	-	15	1	4	7	-	2
5	20	-	-							8	-	-
4				20	-	-	18	1	1			
6				20	-	-	19	1	-			

Table 13. Distribution of difficulties in reading the Spanish samples.

Reader no.	1. quart			2. quart			3. quart			4. quart		
	1	2	3	1	2	3	1	2	3	1	2	3
2	7	11	2	4	11	5	6	6	8	3	3	3
5	3	6	11							2	3	4
4				12	7	1	10	9	(1)			
6				8	6	6	5	11	4			

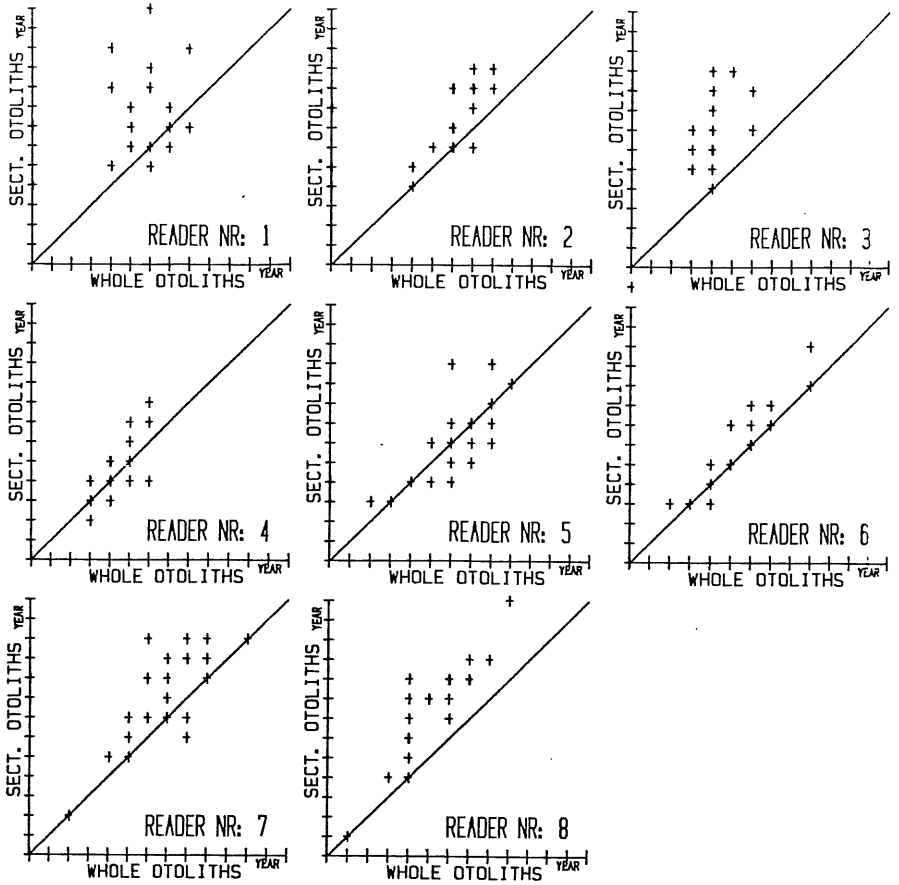


Fig. 1. Age determination of sectioned otoliths plotted against age determination on whole otolith from the same fish by reader.

