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Report on the cod otolith photograph exchange scheme 1963/67

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Introduction

Following the report of the 1962 Ageing workshop, and the development of a simple apparatus for photographing gadoid otoliths (Blacker, 1964), the Working Group on Ageing Techniques at the 1963 ICNAF Annual Meeting recommended "that future co-ordination of age-reading techniques take the form of exchange of sets of photographs marked by each country in the way that they would read them. The photos should be accompanied by the corresponding otoliths". (ICNAF, 1963a). Dr. Messtorff and Dr. Kohler were asked to supply a sample of cod otoliths from Subarea 4 and the Lowestoft Laboratory was asked to undertake the photography and distribution.

As a result the cod otolith photograph exchange was started late in 1963. Since then twelve sets of otoliths and photographs, totalling 233 otoliths, have been circulated. Samples from Subareas 1D, 1E, 1F, 2H, 2J, 3K, 3L, 3O, 3P, 4T and 4V have been used. Five of the samples were specially selected for this exchange and the remainder were chosen from those used in the 1962 exchange (DeBaie, 1964). At the start of the scheme fourteen countries were on the circulation list and for the first two series, photographs only were sent out in the first instance as it was felt that circulation of the otoliths would take too long. A detailed report on the first two series was sent to all readers and the otoliths themselves were circulated after all the results had been received. However, at the 1964 ICNAF Annual Meeting the Subcommittee on Ageing Techniques asked for otoliths to be circulated with the photographs, and the number of countries taking part in the scheme was reduced. (ICNAF, 1964). The procedure for the remaining samples was then changed so that two sets of photographs for annotating were sent to each participant. The interpretations of the otoliths themselves were to be marked on the photographs, one set of which was returned to Lowestoft, and the other kept for future reference. When all the results for each series were returned a detailed report was prepared and sent to all participants. (Reports on Series 10, 11 and 12 are in preparation and will be sent out as soon as possible). Even with the reduced numbers of readers for each series, few of them have completed their circulation in less than six months.

The samples from the 1962 exchange were sent to the countries on the normal circulation list for each subarea (ICNAF, 1964) and to any others of the five countries who took part in the 1962 exchange scheme. This allows a comparison of the 1963/67 exchange results with those of the 1962 exchange and gives a measure of the consistency of the age-readings of those five countries.

Results

The full results are given in Appendix 1.* In some countries several readers took part and the figures given in the tables are the majority readings wherever there was a clear majority age. Where more than one age was given without any indication of preference, the age taken for the subsequent analyses is underlined in the tables.

For purposes of analysis each otolith has been given a "best age" which has been decided after consideration of the otolith itself and all the interpretations given by other readers. The best age is not necessarily the majority reading nor is it the mean of the exchange readings as these ages may definitely be wrong for various reasons given below. Table 1 summarizes for all samples the comparison of all readings with the best age and this is shown graphically in Figure 1. Full details are given in Appendix 2. In Table 1 the differences from the best age are given as percentages in two ways: firstly for all fish of all ages (233 fish) and secondly for those fish younger than 10 years (best age) (187 fish). For the first group the percentage of readings agreeing with the best age varies from 35.2% in Series 7 to 91.3% in Series 2, while for fish younger than 10 years the variation is from 50.4 to 90.9%. However for most samples the numbers of fish of 10 years and older is small and the difference in the percentage agreement may not be significant. The one sample (Series 7) which showed the greatest difference consisted of only 12 fish of which 7 were older than 9 years. 75% to 99% of the readings for all ages agree with, or differ by only one year from the best age.

A comparison of the readings obtained from the nine countries who read most samples is given in Table 2 and illustrated by Figure 2. The results from the five other countries who read only one, two or three of the earlier series are too few for inclusion. The percentage of readings agreeing with the best age

*The appendices to this document are on file in the Secretariat varies from 54.1 to 82.8 but the latter figure for the English readings is obviously biassed towards the writer's 'best' age. Excluding the English readings, the percentage agreement with the best age varies from 54.1% (USSR) to 73.3% (Iceland), and from 80.3% (USSR) to 93.4% (Canada, St. John's) of the readings agree with or are within one year of the best age. Apart from Norway (86.1%) and USSR (80.3%) about 90% or more of the readings are within one year of the best age. According to Gulland (1955) readings within one year of the correct age are reasonably acceptable for statistical calculations for stock assessments, and so are these results assuming that these exchange samples are representative of the otoliths of cod populations in the ICNAF area.

Comparison of the 1962 and 1963/67 exchange results

Canada (St. Andrews and St. John's), Germany, Norway and Spain took part in the 1962 exchange scheme and seven samples from the same otoliths have been used in the present exchange. The results of the 1962 exchange given by DeBaie (1964) and those for the same otoliths in the 1963/67 exchange are given in Appendix 3, and both have been compared with the best age. The comparison is shown in Table 3 as the percentage of readings from 0 to > 3 years different from the best age and is also shown in Figure 2 for the appropriate countries. Spain shows a striking improvement from 45.8% of readings within one year of the best age in 1962 to 90.0% in 1963/67. The two Canadian laboratories and Germany show nearly 5% improvement, but Norway's readings have deteriorated by 8.5%, for these seven samples.

Discussion

The use of photographs for recording the interpretations of a large number of otoliths, for the first time allows a detailed comparison of readings, and it is possible to find the actual causes of some of the differences between readers. The average number of different interpretations of the otoliths in each series is shown in Table 1. The figures for individual otoliths are given in the tables in Appendix 2. For one otolith there were twelve different interpretations giving five different ages, and in only 24 out of the 233 otoliths did all readers agree on both the age and the intepretation (Table 1). On eleven occasions nobody gave the best interpretation. The tables in Appendix 2 also show that the best age was sometimes arrived at by two, three or even four different interpretations some of which indicate that the arrival at the best age was a chance occurrence, not a logical deduction from the otolith zones.

Judging from these exchange results there are several important causes of error or of disagreements amongst otolith readers. These are:-

1. Incorrect cutting of the otoliths. This is one reason why the best age often differs from all readings in these samples. The report of the 1962 Workshop (ICNAF,1963b) stressed the importance of breaking or cutting cod otoliths in the correct place (through the centre of the interruption in the *sulcus accusticus*). Several of the otoliths of the 1962 samples had to be reground to the correct plane, while others had already been ground too much. Few readers commented on these mistakes, although an error in ageing of one year may easily be caused by them.

2. The interpretation of the central zones. This has been one of the main causes of age differences in the exchange results and the situation has been aggravated by (1) above. There are obviously widely differing opinions on which is the first annual hyaline zone. Series 6 (K16-25) illustrates the problem: nine out of the ten otoliths have a single well-marked hyaline zone in the centre as in K17 (Fig. 3) which all readers except Norway counted as the first annual zone. Yet in Series 9 (K26-40) from the same sub-area the identical zone was counted by Norway as the first annual zone in all cases except one. Such lack of consistency is not entirely confined to Norway and it is one of the main causes of discrepancy between the readings from the USSR and those from other countries.

This zone may be the so-called larval check ring laid down when the young cod change from being pelagic to demersal, but there is little published evidence to support this theory. Until evidence supporting or disproving this theory is obtained, greatest consistency will be obtained if all readers count such structures as annual zones.

The interpretation of the second winter zone has also caused difficulties. In some otoliths there is a complete broad hyaline zone which most readers have taken as the second winter zone as in O8 (Fig. 4) but others, Canada, St. Andrew's in particular, have sometimes taken such zones as checks. There may be unpublished evidence for discounting such zones but if there is, they should consistently be discounted. At present it seems to be better to count them always as annual zones.

In many of the otoliths the first well-defined hyaline zone is followed by a succession of narrow opaque and hyaline rings which may be interpreted in many ways, then outside these the zones from a distinct pattern which cannot be missed. The only valid method of interpreting these is to examine the zones for repetition of a pattern. For example in H8 (Fig. 5) the innermost hyaline (zone 1) is split to form a definite double structure, which is followed by three more hyaline zones each containing a marked check. All readers counted zones 1 and 4 and some counted both zones 2 and 3 while others discounted one or both of them. These four zones are very similar in structure and the fact that zones 2 and 3 are close together does not seem to be a valid reason for discounting either or both of them.

3. Interpretation of the otolith edge. Counting the current year's growth as an annual zone is a common cause of an error of one year in age reading. In Appendix 1 (Table 2) the readings which contain this error are marked with an asterisk. However it is often very difficult to decide whether a hyaline edge is the current or previous year's in mature fish when the hyaline zone may be a single narrow ring laid down very late in the year and not completed until the following spawning season. As a general rule the opaque zone is laid down earlier in the year in young fish than in the older ones.

Related to this error is the failure to count spawning zones in otoliths where these hyaline zones are not laid down all around the otolith (Figure 6). This is the main source of the high proportion of Russian readings which differ by more than three years from the best age. The probable cause of this error is always reading the age along the same line towards the wide end of the otolith.

4. Unreadable otoliths. In most otoliths in the exchange samples the hyaline and opaque zones form a pattern which can reasonably be interpreted, but others like H7 (Fig. 7) show what can only be described as a conglomeration of rings which do not fall into any recognizable pattern at all. The best interpretation of these is probably "?" or "unreadable" and it is surprising that in all the exchange series few readers described any otoliths as unreadable. In Jensen's notation (1963) these are defined as "poor" and the definition includes the phrase "... or where the age is merely estimated". Often these 'estimations' must have no basis other than the length of the fish, but length is not a valid criterion of age and the inclusion of such 'ages' in data for age/length keys may cause considerable errors.

Conclusions and Recommendations

The 1963/67 exchange results show that there is a considerable measure of agreement amongst the otolith readers from the participating countries, but there are also some disagreements which might be lessened by a meeting of practising otolith readers. If such a meeting is practicable, it should perhaps be held before any further otolith exchanges are started.

The recommendations of the 1962 Workshop are still important, although some of the required material and data may have been collected by other laboratories since the recommendations were published (ICNAF, 1963b).

The problem of interpreting the central zones can only be solved by large collections of otoliths from small fish - presumed to be O-, I- and II-group - taken at all seasons of the year. Studies on the feeding habits and seasons of these fish are also required. The otolith zones are presumed to be closely correlated with growth and feeding so the data should be collected to prove or disprove this. Laboratory experiments may also help in studies of otolith structure. The writer recommends that the collection of these data should be continued.

Other recommendations are that:-

1. Otolith readers should be reminded that the length of a fish is very rarely a valid criterion in determining its age.
2. Otolith readers should be encouraged to use a category "unreadable" instead of guessing the age of some poor otoliths.
3. Unless evidence to the contrary is, or becomes available, the type of first hyaline zone illustrated in Figure 3 should be counted as the first annual zone whenever it occurs.
4. Likewise the type of zone counted as the second annual zone in Figure 4 should be counted until proved otherwise.
5. All published validation studies should include annotated photographs of the otoliths or whatever other structures are used for age determination.

Acknowledgements. The writer wishes to thank all those who have taken part in this otolith photograph exchange scheme for their cooperation.

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Table 1. Comparison of the 1963/67 exchange results with best age, for each Subarea

	Subarea											
	1 D,E,F				2H		2 J		3K			
Series Number	2		3		8		5		4		6 & 9	
Number of readers	15		8		8		7		6		9	
	All ages	< 10	All ages	< 10	All ages	< 10	All ages	< 10	All ages	< 10	All ages	< 10
Number of otoliths	29	25	20	18	26	18	23	17	15	10	25	22
% readings (0 yrs	91.3	90.9	73.1	74.2	58.5	66.2	67.7	67.3	70.0	71.7	68.2	72.2
differing (1 yr	7.6	8.0	20.4	22.1	30.5	27.9	24.8	23.5	26.7	26.6	28.5	25.0
from best (2 yrs	1.1	1.1	4.6	3.7	9.0	5.9	7.5	9.2	2.2	-	1.9	2.2
age by (3 yrs	-	-	2.0	-	1.0	-	-	-	1.1	1.7	0.5	-
(>3 yrs	-	-	-	-	1.0	-	-	-	-	-	0.5	-
Age range (yrs)	3-10	3-9	4-10	4-9	3-16	3-9	2-16	2-9	1-20	1-9	2-13	2-9
Average number of interpretations per otolith	2.0		3.0		3.6		2.6		2.0		3.4	
No. of otos. with complete agreement on age and interpn.	4		1		1		1		4		1	
Number with no best interpretation given	0		1		1		0		1		2	

Table 1 (continued)

	3L		30		3P		4 T,V		
Series Number	10		11		12		1	7	
Number of readers	9		8		7		18	9	
	All ages	< 10	All ages	< 10	All ages	< 10	All ages 10	All ages	< 10
Number of otoliths	28	22	25	22	15	13	15	12	5
% readings differing from best age by (0 yrs	57.1	64.4	70.5	72.7	51.5	53.9	50.4	35.2	63.0
(1 yr	29.9	31.4	24.5	23.9	41.9	39.5	34.4	39.8	32.6
(2 yrs	6.7	4.3	5.0	3.4	6.7	6.6	11.5	13.9	4.4
(3 yrs	4.8	-	-	-	-	-	3.7	11.1	-
(> 3 yrs	4.0	-	-	-	-	-	-	-	-
Age range (yrs)	1-21	1-9	2-16	2-9	4-11	4-9	4-9	6-15	6-9
Average number of interpretations per otolith	3.8		2.9		3.8		5.5	5.5	
No. of otos. with complete agreement on age and interpn.	5		5		1		0	1	
Number with no best interpretation given	1		1		1		1	2	

Table 2. Comparison of all readings with best age for the main participants

Percentage of total readings

No. of years difference from best age	Canada St. Andrew's	Canada St. John's	Germany	Iceland	Norway	Portugal	Spain	USSR	England
0	61.7	67.1	67.0	73.3	57.8	59.2	65.7	54.1	82.8
1	27.4	26.3	24.5	18.6	28.3	33.5	26.3	26.2	12.2
2	6.3	3.8	5.1	5.0	7.8	4.7	2.9	13.3	2.2
3	2.9	0.9	0.9	0.9	2.2	0.9	2.9	2.1	0.7
>3	-	0.5	0.9	0.5	1.1	-	0.6	2.1	-
(No decision)	(1.7)	(1.4)	(1.7)	(1.8)	(2.8)	(1.7)	(1.7)	(2.1)	(2.2)
No. of otoliths read	175	213	233	221	180	233	175	233	139

Table 3. Comparison of 1962 and 1963/67 exchange results for the 5 participants in both exchanges

Percentage of total readings

No. of years difference from best age	Canada	St. Andrew's	Canada	St. John's	Germany		Norway		Spain	
	1962	1963/67	1962	1963/67	1962	1963/67	1962	1963/67*	1962	1963/67
0	49.6	57.3	56.5	61.1	57.3	63.4	54.2	45.0	8.4	61.8
1	35.1	31.3	32.0	32.0	26.7	25.2	34.4	33.6	37.4	28.2
2	8.4	6.1	7.6	3.8	9.2	6.9	9.2	3.8	25.2	3.1
3	3.1	3.1	1.5	-	3.1	0.8	-	1.5	14.5	3.8
> 3	1.5	-	-	0.8	1.5	1.5	-	1.5	8.4	0.8
(No decision)	(2.3)	(2.3)	(2.3)	(2.3)	(2.3)	(2.3)	(2.3)	(3.1)	(6.1)	(2.3)

* only 6 series returned

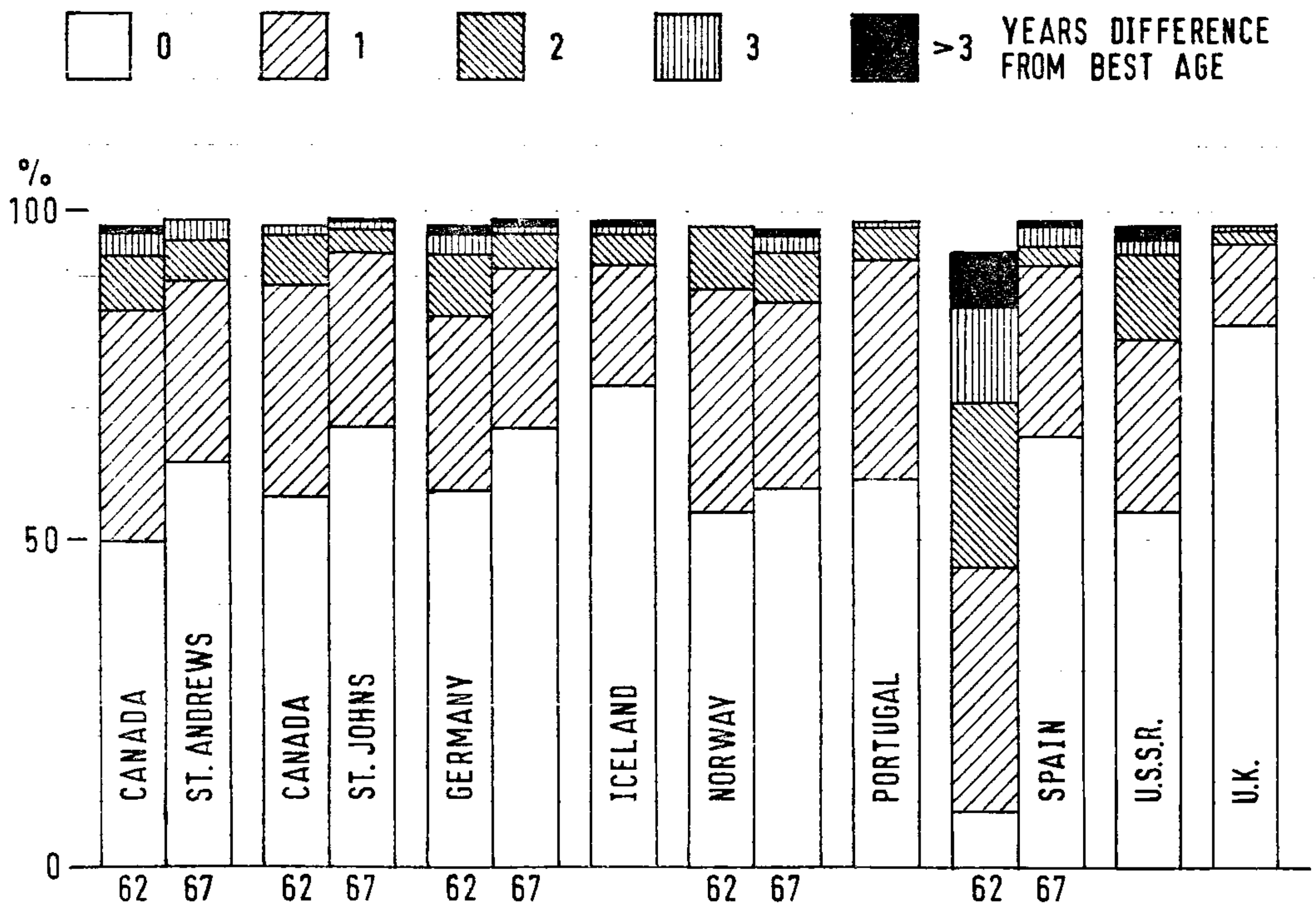

Figure 1. Percentage agreement of 1963/67 exchange results with best ages plotted for each Subarea represented in the samples. The values for fish of all ages and those for fish nine years old or less are given.

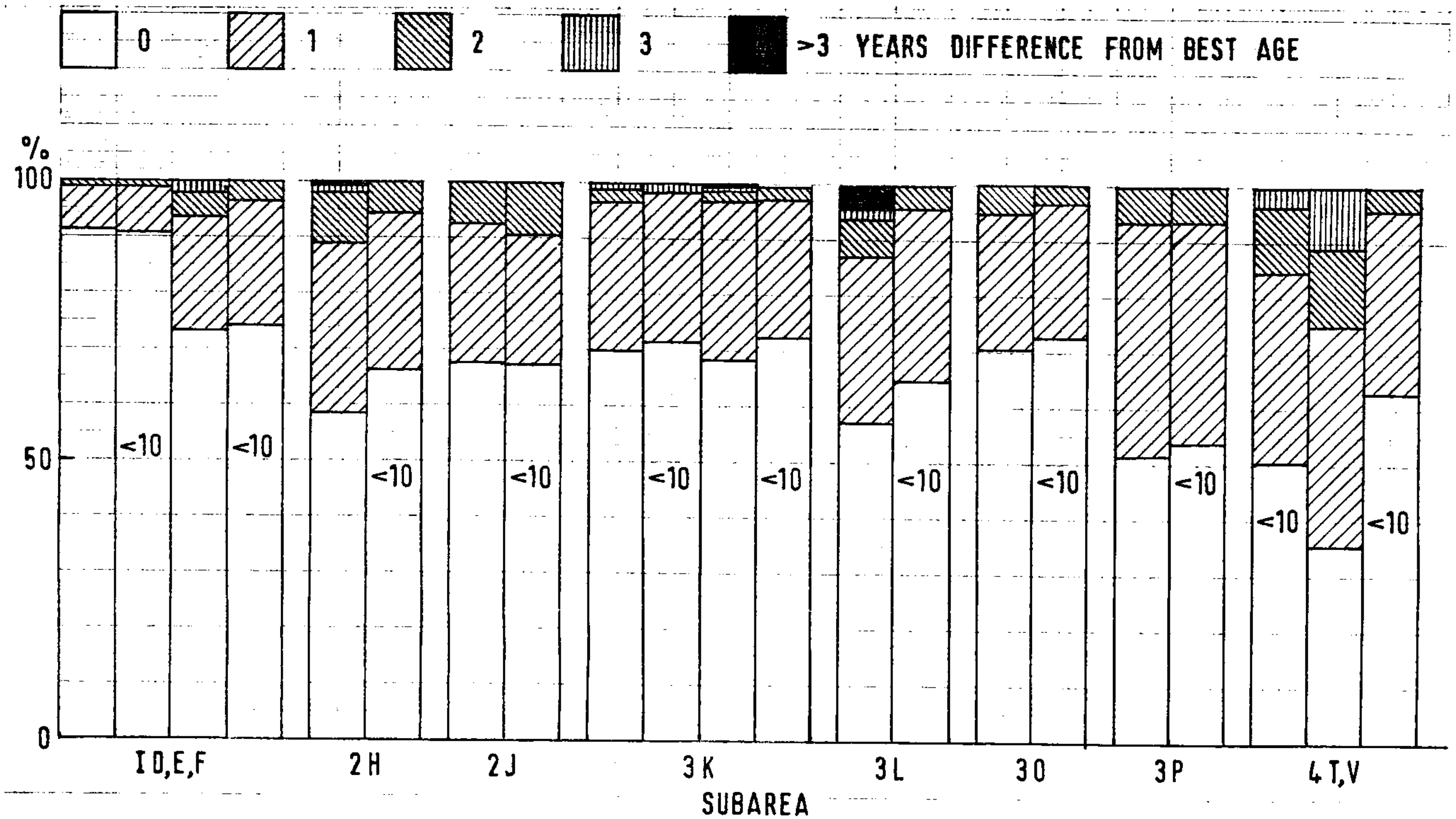

Figure 2. Percentage agreement of 1963/67 exchange results with best age for the nine main participants. The comparison with the 1962 exchange results is given where appropriate.

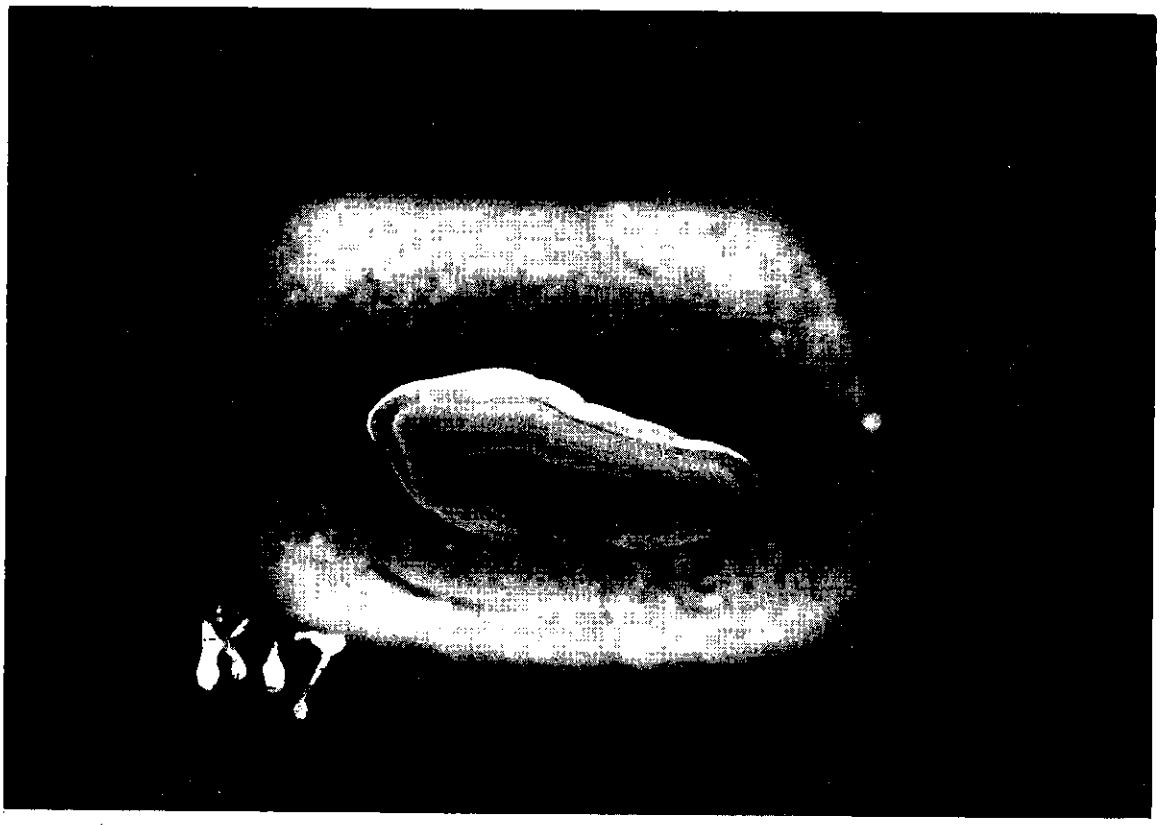

Figure 3. Cod otolith K17, (17 cm, caught July 1961) showing a characteristic narrow but complete innermost hyaline zone, which all readers except Norway counted as the first annual zone.

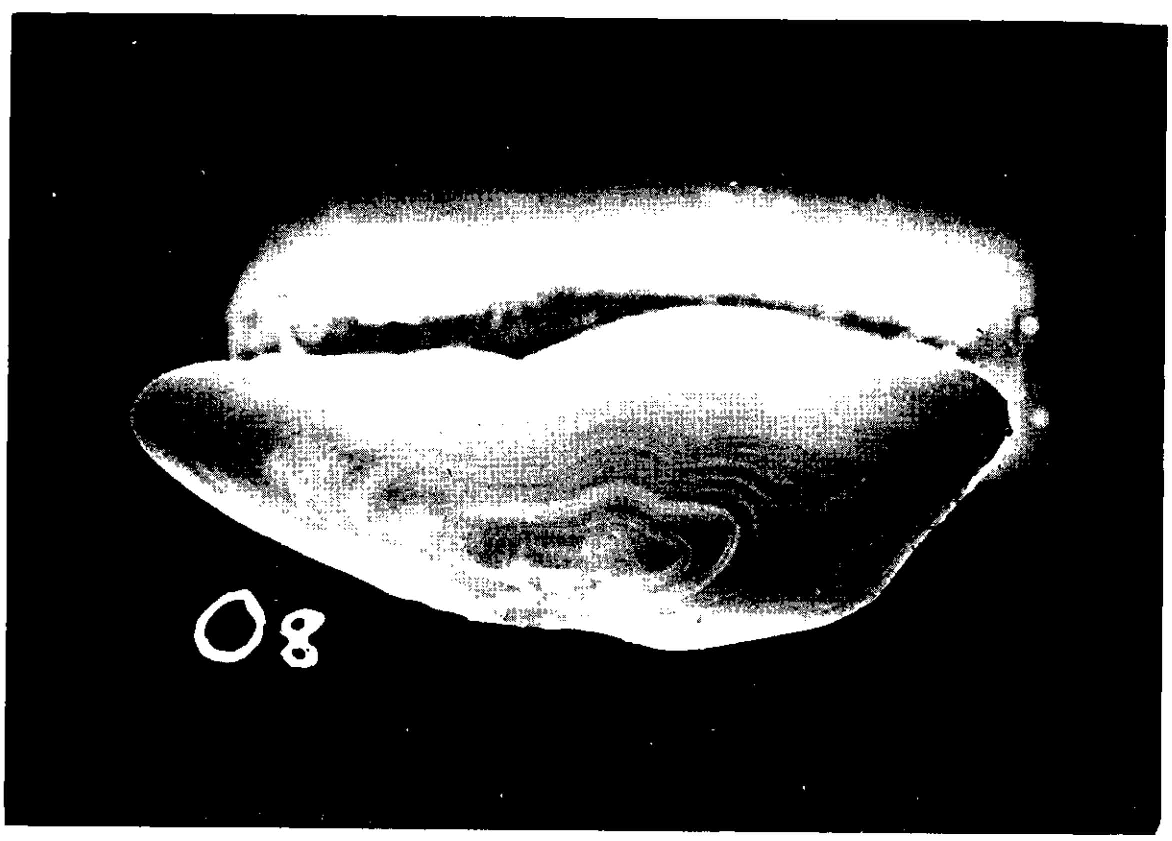

Figure 4. Cod otolith 08 (59 cm, caught June 1961) showing the type of broad second hyaline zone which should always be counted as an annual zone

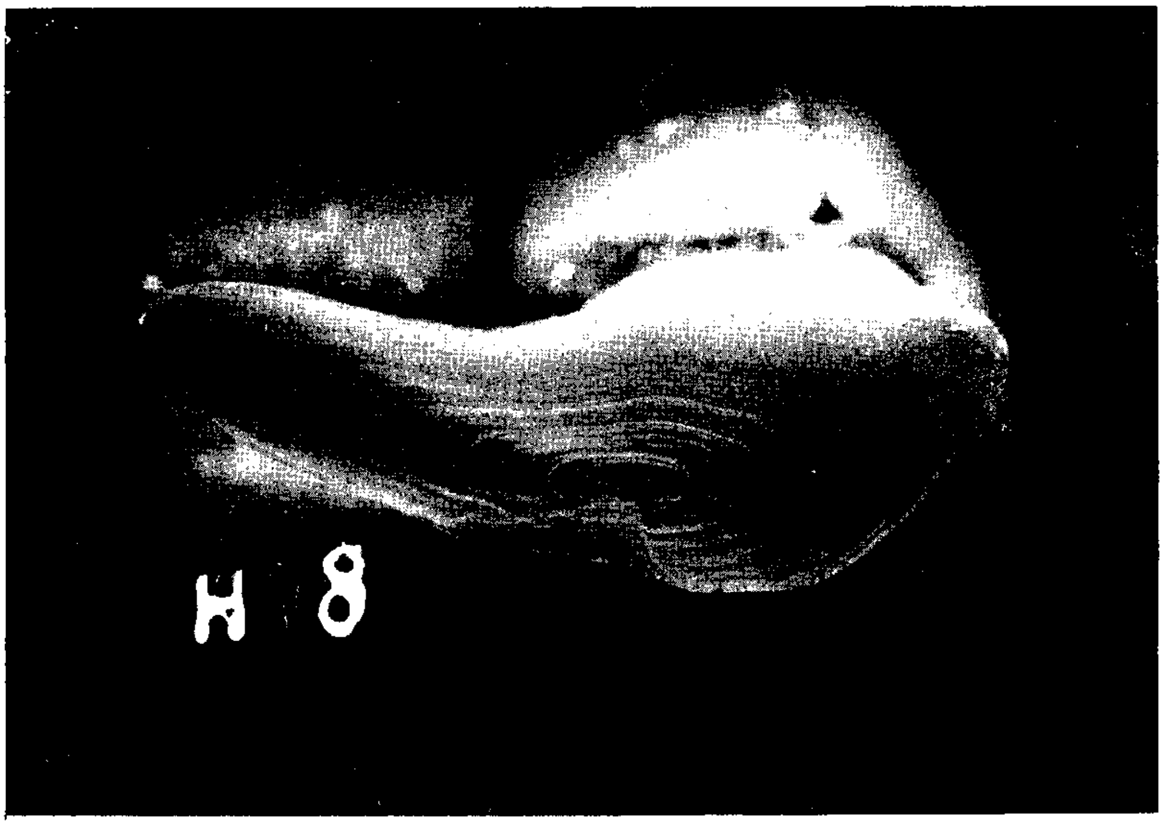

Figure 5. Cod otolith H8 (60 cm, caught August 1960) showing four inner hyaline zones with the same structure, all of which should probably be counted as annual zones.

Figure 6. Cod otolith K10 (60 cm, caught August 1962) illustrates the discontinuity in the outermost zones towards the blunt tip.

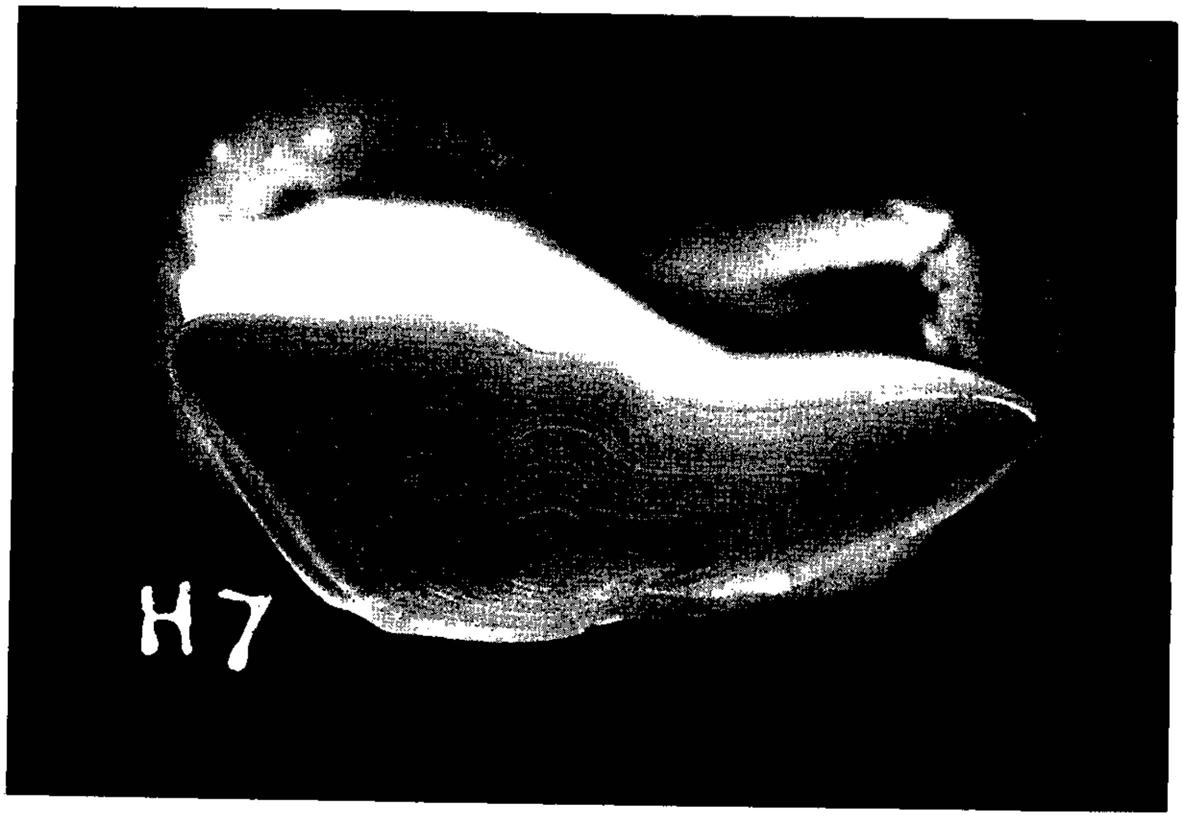

Figure 7. Cod otolith H7 (60 cm, caught August 1960). Ages from 6 to 11 years were given. Any age is a guess and the best interpretation is "unreadable".