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A NOTE ON THE INTERPRETATION OF HAKE OTOLITHS

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INTRODUCTION

At the December 1983 meeting of the ad hoc working group on age and growth of the International Commission for the Southeast Atlantic Fisheries (ICSEAF), it was discovered "... that, because of substantial variation in the data..." on hake "..., a detailed analysis was not possible" (ICSEAF 1984). Discrepancies between the age length keys of several countries were evident, and it was decided that specific steps be taken to remedy this deficiency.

Differences were particularly noticeable between the data of countries having submitted a broad age length key, i.e., one in which readings of otoliths from a wide length range of fish were presented. Spain and South Africa were two such countries and, when the opportunity to read similar age material together arose, the authors took advantage of it. The comparative readings form the basis of this paper.

MATERIAL AND METHODS

During July 1984, both authors counted the age rings on approximately 2 500 hake otoliths collected by South Africa in ICSEAF Divisions 1.5, 1.6, and 2.1 although the majority of otoliths were from Division 1.6. The otoliths were derived from both hake species, **Merluccius capensis** and **M. paradoxus**.

A third South African scientist (reader 3) read many of the otoliths either as first reader or as final reader. All otoliths were read at least twice, the third reading only being necessitated if the first two readings were in disagreement (Botha 1971).

Otoliths were fresh and had been initially immersed, as is standard South African practice, in a very weak solution of KOH. This solution aided their subsequent cleaning. They were then stored until reading in fresh water to preserve their clarity and transparency. Both South Africans (readers 1 and 3) read the

otoliths with a naked eye and reflected light against a dark background (Botha 1971). The Spanish reader (reader 2) used a microscope with a magnification of 4-6x also under reflected light and against a dark background.

A first analysis was made on the degree of agreement between all three readers on the age of 100 otoliths. Subsequent analyses were on the readings made for Division 1.6 otoliths by only two readers, usually reader 2 and either reader 1 or 3. The final analysis was on the interpretation of all otoliths by readers 1 and 2 only.

Readings were compared in a tabulated form. Age keys were constructed and the von Bertalanffy parameters were calculated by the Allen method and using a program developed at the Instituto de Investigaciones Pesqueras de Barcelona. These parameters were compared directly.

RESULTS

Readings of 100 otoliths made by all three scientists are given in Tables 1, 2, and 3.

Agreement between readers 1 (South African) and 2 (Spanish) was good (62,3 %), though reader 2 had a tendency to count 1 ring less (29,6 %). There was also good agreement (59,8 %) between the Sough African readers (1 and 3), but reader 3 tended to count 1 ring less in otoliths of young fish (30,9 %). Readers 2 and 3 agreed less frequently (39,4 %) and variation was wide, though the counts of reader 3 tended to be higher.

The mean and ranges of length at age derived from the readings of these 100 otoliths are given in Figure 1.

The interpretation of two of the three readers of the same otolith is compared further in tabular form. All otoliths were derived from Division 1.6. For **Merluccius capensis** (Tables 4-6), agreement averaged 72 %, but reader 2 (Spain) tended to count one ring less than reader 1 (15 %) and reader 3 read 20 % as one ring fewer than reader 1. The interpretations of reader 3 were variable when compared to those of reader 2, 11 % being 1 year less and 14 % 1 year more.

Growth parameters were calculated from each set of age readings of **M. capensis**. The data from reader 3 did not permit such calculation.

The parameters calculated from the interpretation of age by reader 1 (Table 7) fell, with a level of significance of 0,05, within the range of variation of those of reader 2 (Table 8). The data from readers 1 and 2 were therefore combined (Table 9), agreement being good (72 %) with no clear trend of disagreement. The growth parameters were, however, unrealistic if all data were used, but if data from fish up to 8 years of age only were employed they were more acceptable (Tables 10 and 11). Since only 0,001 % of the total otoliths successfully aged were taken from fish over 8 years of age, omission of these few is probably justified.

For **M. paradoxus** otoliths (Tables 12-14), agreement between reader 1 and each of readers 2 and 3 was high (72 % on the average), but slightly lower between readers 2 and 3 (69 %). Again, as for **M. capensis**, reader 2 tended to count one ring less than reader 1 (17 %), but variation was great. Again, there was no clear trend in the comparisons of counts between reader 3 and the others.

Paucity and limitation in spread of data precluded calculation of growth parameters for this species.

DISCUSSION

The results presented in this paper demonstrate the sensitivity of the methods of calculation of growth parameters to the age key used. Even with an actual accord of 72 % between readers, the trends were sufficiently high to cause growth parameters to differ significantly.

The methodology employed is not considered to have adversely affected the age determination to any significant degree.

It is recommended that such comparative studies be continued with a view to calculating more realistic growth parameters for use in the stock assessments of ICSEAF.

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TABLE 1. Interpretation of the age of 100 hake otoliths by readers 1 and 2

	Reader 1							
Reader 2	Age							
Age	1	2	3	4	5	6	7	Frequency
1	8	12	1					21
2	1	39	9					49
3			13	2				15
4			1		2			3
5					3	4	1	8
6						2		2
Frequency	9	51	24	2	5	6	1	98

Degree of variation (%):
One year more: 2
Coincidence: 0
One year less: 29,6
Two years less: 2

TABLE 2. Interpretation of the age of 100 hake otoliths by readers 1 and 3

	Reader 1							
Reader 3	Age							
Age	1	2	3	4	5	6	7	Frequency
1	9	27						36
2		22	2					29
3		2	17					19
4			4	1				5
5				1	5			6
6						3	1	7
7						2	1	3
Frequency	9	51	23	2	5	5	2	97

Degree of variation (%):
One year more: 30,9
Coincidence: 59,8
One year less: 9,27

TABLE 3. Interpretation of the age of 100 hake otoliths by readers 2 and 3

	Reader 3							
Reader 2	Age							
Age	1	2	3	4	5	6	7	Frequency
1	11	9	2					22
2	26	13	8	2				49
3		1	11	2	1			15
4			1		2		1	4
5					3	3	2	8
6						1		1
Frequency	37	23	22	4	6	4	3	99

Degree of variation (%):
Three years more: 1,01
Two years more: 7,1
One year more: 24,3
Coincidence: 39,4
One year less: 28,3

TABLE 4. Interpretation of the age of **M. capensis** in Division 1.6 by readers 1 and 2

	Reader 1												
Reader 2	Age												
Age	0	1	2	3	4	5	6	7	8	9	10	11	Frequency
0	11												11
1		58	1										59
2		15	80	6									101
3			4	55	5								64
4				15	26	7							48
5					2	13	8						23
6						4	27	7					38
7							10	23	2				35
8								8	9	1			18
9									2	3			5
10										1	1		2
Frequency	11	73	85	76	33	24	45	38	13	5	1		405

Degree of variation (%):
One year more: 9,38
Coincidence: 75,5
One year less: 5,6

TABLE 5. Interpretation of the age of **M. capensis** in Division 1.6 by readers 1 and 3

	Reader 1											
Reader 3	Age											
Age	1	2	3	4	5	6	7	8	9	10	11	Frequency
1	29	1										30
2	1	17	2									20
3		5	20	1								26
4			16	27	1							44
5			3	17	26	2						48
6					9	29	4					42
7						8	22	6				36
8								8	1			9
9												
10										1	1	2
Frequency	30	23	41	45	36	39	26	14	1	1	1	257

Degree of variation (%):
One year more: 6,8
Coincidence: 71,8
One year less: 20,2
Two years less: 0,9

TABLE 6. Interpretation of the age of **M. capensis** in Division 1.6 by readers 2 and 3

	Reader 3							
Reader 2	Age							
Age	1	2	3	4	5	6	7	Frequency
1	4							4
2	1	10						11
3		2	11	4				17
4			3	24	8			35
5				4	31	7		42
6					3	12		15
7								
8							1	1
Frequency	4	12	14	32	42	19	1	125

Degree of variation (%):
One year more: 14,5
Coincidence: 74,9
One year less: 11,3

TABLE 7. Growth parameters of **M. capensis** in Division 1.6 as determined from the results of reader 1

Age	Length	Calculated length	Frequency
1	19,8	18,7	67
2	25,9	27,8	80
3	37,2	36,6	105
4	44,8	44,8	37
5	54,0	52,8	42
6	60,1	60,3	66
7	66,9	67,5	53
8	74,2	74,3	20
9	85,0	80,7	4
10	81,0	86,9	1
11	91,0	92,8	1

L_∞ = 210,46 k = 0,0489 t_0 = -0,9069

Confidence intervals at a significance level of 0,05:
L_∞: 144,52 to 276,41 cm
k: 0,0291 to 0,0686
t_0: -1,1271 to -0,6867

TABLE 8. Growth parameters for **M. capensis** in Division 1.6 as determined from the results of reader 2

Age	Length	Calculated length	Frequency
1	20,1	19,3	67
2	26,3	28,1	84
3	37,8	36,5	78
4	43,9	44,4	77
5	52,4	51,9	60
6	59,7	59,1	52
7	65,3	65,8	53
8	70,1	72,4	18
9	83,0	78,5	7
10	86,0	84,4	2

L_∞ = 196,69 cm k = 0,0508 t_0 = -1,0325

Confidence intervals at a significance level of 0,05:
L_∞: 123,89 to 269,49 cm
k: 0,0262 to 0,0753
t_0: -1,3223 to -0,7427

TABLE 9. Interpretation of the age of **M. capensis** in the total ICSEAF area by readers 1 and 2

	Reader 1												
Reader 2	Age												
Age	0	1	2	3	4	5	6	7	8	9	10	11	Frequency
0	11												11
1		71	13	1									85
2		18	132	16									166
3			8	81	9								98
4				18	42	18							78
5					5	25	17	3					50
6						4	46	12					62
7						1	13	28	6				48
8								8	11	1	1		21
9										4			4
10										1		1	2
Frequency	11	89	153	116	56	48	76	51	17	6	1	1	625

Degree of variation (%):
Two years more: 0,008
One year more: 14,9
Coincidence: 72,2
One year less: 12
Two years less: 0,001

TABLE 10. Growth parameters for **M. capensis** in the whole area based on the results of reader 1

Age	Length	Calculated length	Frequency
1	20,1	19,1	73
2	26,1	27,9	96
3	37,1	36,3	121
4	44,3	44,5	57
5	53,2	52,3	60
6	59,3	59,8	86
7	66,9	66,9	67
8	73,8	73,8	24

L_∞ = 239,29 cm k = 0,0409 t_0 = -1,0278

Confidence intervals at a significance level of 0,05:
L_∞: 135,99 to 342,58 cm
k: 0,0190 to 0,0627
t_0: -1,2783 to -0,7772

TABLE 11. Growth parameters for **M. capensis** in the whole area based on the results of reader 2

Age	Length	Calculated length	Frequency
1	20,4	19,2	72
2	26,4	20,1	94
3	37,2	36,4	96
4	43,9	44,4	105
5	52,5	51,8	75
6	59,4	58,9	75
7	65,6	65,5	59
8	70,1	71,8	21

L_∞ = 173,40 cm k = 0,0595 t_0 = -0,9690

Confidence intervals at a significance level of 0,05:
L_∞: 114,21 to 232,58 cm
k: 0,0321 to 0,0869
t_0: -1,2585 to -0,6795

TABLE 12. Interpretation of the age of **M. paradoxus** in Division 1.6 by readers 1 and 2

	Reader 1												
Reader 2	Age												
Age	0	1	2	3	4	5	6	7	8	9	10	11	Frequency
0	8												8
1		70	5	1									76
2		5	104	13									122
3		1	22	86	5								114
4				9	51	11							71
5				1	13	47	8	1					70
6						23	62	6	2				93
7							20	41	9				70
8							1	15	28	4			48
9									10	10	2		22
10										1	1	1	3
11											1		1
Frequency	8	76	131	110	69	81	91	63	49	15	4	1	698

Degree of variation (%):
Two years more: 0,005
One year more: 9,2
Coincidence: 72,8
One year less: 17,1
Two years less: 0,004

TABLE 13. Interpretation of the age of **M. paradoxus** in Division 1.6 by readers 1 and 3

	Reader 1							
Reader 3	Age							
Age	1	2	3	4	5	6	7	Frequency
1	14	2						16
2	2	17	1					20
3			10	10				20
4				6	4			10
5					2			2
6						1	1	2
Frequency	16	19	11	16	6	1	1	70

Degree of variation (%):
One year more: 25
Coincidence: 71
One year less: 0,02

TABLE 14. Interpretation of the age of **M. paradoxus** in Division 1.6 by readers 2 and 3

	Reader 3							
Reader 2	Age							
Age	1	2	3	4	5	6	7	Frequency
1	5							5
2	8	18						26
3		3	10					13
4								10
5						2		2
6					3	2		5
7								
8							1	1
Frequency	13	21	10		3	4	1	52

Degree of variation (%):
One year more: 3,8
Coincidence: 67
One year less: 29,9

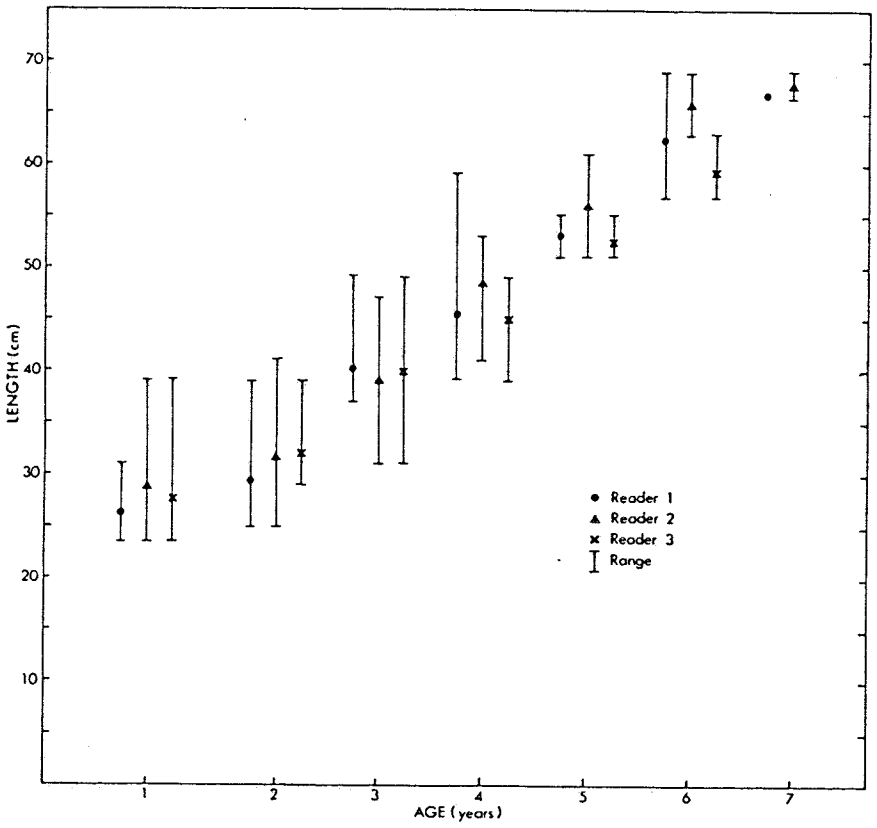

FIG. 1 Mean and range of length at age for 100 **M. capensis** otoliths read by all three readers