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On methods for the determination of age and growth rate in redfish

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Introduction

The determination of age in redfish is a rather laborious and complicated process. Additional zones seen on the scales and otoliths make the counting of annual rings difficult. The majority of foreign investigators have concluded that otoliths were most suitable for determining age in redfish (Kelly and Wolf, 1959; Kelly and Barker, 1961; Kotthaus, 1961; Sandeman, 1961, 1969). At present only the scientists of the USSR determine the age in redfish from the scales.

Having compared the ages of redfish from both scales and otoliths, Bratberg (1955, 1956) concluded that annual rings on scales and otoliths are formed simultaneously.

Results of studies using scales and otoliths are given in papers by Sandeman (1961), Perlmutter and Clarke (1949).

Investigations on age determination of redfish were carried out in the USSR for the first time by Veschezerov (1944). He examined different structures: scales, otoliths, operculum, cleithrum and vertebrae. The instrument used by Veschezerov (Reichert binocular with objective x 50 and eye-piece x 9) made it possible to determine that the more suitable structure for the determination of age in redfish is the scale.

Based on the analysis of voluminous material, Surkova (1957, 1962) investigated the structural features of scales in redfish and suggested a method of ageing from the scale. Data on the age composition of redfish obtained using this method were presented by the Polar Institute to ICES and ICNAF. To establish the amount of disagreement in results of ageing from otoliths and scales, a comparative analysis of these methods was made. This paper deals with results of the determination of age and growth rate in Sebastes mentella Travin by scales and otoliths.

Material and Methods

A sample of 300 redfish was analysed. Each fish was weighed and measured. The mucous and scales adhering from other fish were removed. About 10-20 scales were taken from the middle of the body of each fish (below the anterior part of the dorsal fin and above the lateral line). The scales were then washed with a weak solution of alkali, dried and placed between two subject-glasses and examined under a microprojector x 35 magnification. Scales from 284 of the 300 fish were suitable for the determination of age.

Otoliths as well as scales were taken from each fish in the sample. On board the vessel they were placed in an alcohol-glycerine solution (50% alcohol and 50% glycerine) and were brought to the shore laboratory. Before examination, the otoliths were broken into two equal portions. Their edges were then polished, burnt, moistened with glycerine and examined under the microscope with eye-piece x 8 and objective x 4 by falling light. Otoliths of 274 redfish were suitable for the determination of age. Annual rings were counted along the longitudinal short half-axis of an otolith. Along the long half-axis there are, as a rule, many extra rings.

Growth rates were determined from both scales and otoliths. Scales with more distinct annual rings were selected for examination. Annual rings were traced under the microprojector on paper tapes. Distances between the rings were recorded in mm. Back calculations were made using the Einar Lea formula (Chugunova 1959).

$$L' = \frac{S'}{S} L,$$

where L is the total length of fish (in cm)

L' is the length of fish during the first year of life (in cm)

S is the total length of scale (in mm)

S' is the length of scale at the end of the first winter (in mm),

and by the Roza Lee formula (Chugunova, 1959).

$$L' = 4 + \frac{S'}{S} (L - 4),$$

where L, L', S, S' have the same definitions as in the Lea formula above. The free term, 4, is the length of the fish in cm when scales are first visible.

On the otolith distances between annual rings were measured using an ocularmicrometer. Back calculations were also made using the Einar Lea formula but in this cade:

L is the total length of fish

S is the length of a short half-axis of the otolith

S' is the distance from the centre to the first annual ring.

The Structure of Redfish Otoliths and Scales

A band between a dark hyaline layer and the following light opaque zone was considered to be an annual ring of the otolith.

The complicated structure of the otolith as well as fractures made during the polishing and burning process make age determination difficult. A mistake in determining the first annual ring is also possible. Trout (1961) points out that the otolith core is separated from the next zone by a narrow hyaline ring which is easily mistaken for an annual ring.

The alternate dark and light zones are seen distinctly on scales examined under the microprojector. The space between a narrow winter ring and a broad zone of summer increment was considered to be an annual ring. Between the first winter ring and the centre there are 6-9 widely separated concentric series of sclerites.

Two to three series of sclerites that come closer together are often observed in younger redfish. They can be considered as annual rings on a relatively thin scale. But more careful examination shows that these rings are false because their line is discontinuous. According to our observations, such false rings are more often formed between the 3rd and 8th annual rings.

Redfish scales with broken centres are often found. Such scales are not suitable for the determination of age. Nevertheless, among 10-20 scales obtained from each specimen one can always find 1-2 scales with their structure well preserved.

Well-marked annual rings are found in redfish 10-15 years of age. It is difficult to distinguish the first 3-5 rings in the central part of the otolith in redfish older than 15 years.

In Sandeman's opinion (1969), only during the first 10 years is one hyaline ring formed each year on the otolith. It is difficult to read age from both otoliths and scales in fish older than 10 years. Thus, accuracy in age determination, which is the basis of a fishing stock of redfish, does not depend on the method used.

Results from the Determination of Age and Growth Rate

Tables 1 and 2 compare results obtained while determination of the age of redfish by scales and otoliths. These tables show that there is no significant difference between the results using the two methods; in fact the results are almost the same. The average age in both cases is the same and the difference in the average length is only 0.01 cm.

Both the Lea and Lee formulae used for the calculation of the length from the scales give similar results. The greatest difference is 0.2 cm (Table 3).

The fish length determined from otoliths is somewhat smaller than that calculated from scales; however, the difference in the length of fish of 11 to 21 years of age in any year-class does not exceed 0.8 cm.

Consequently, the length of fish obtained using the back calculation method from scales and otoliths are very similar and there is no doubt that one method can be substituted for another.

An attempt was made to establish the quantitative dependence between the age of redfish and its length using the method of least squares. The length of the fish during each year of life was obtained by the method of back calculation of scales and otoliths using the Einar Lea formula.

The following equations were drawn up:

$$Y_x = 0.83x - 15.71$$
$$X_y = 1.06+ \quad 21.08 \quad \text{(by scales)}$$
$$Y_x = 0.79- \quad 14.32$$
$$X_y = 1.06+ \quad 21.20 \quad \text{(by otoliths)},$$

where x is the length of redfish

y is the age of redfish

X_y is the length of redfish at an age of y years

Y_x is the age of redfish of x cm in length.

Direct regressions are drawn that correspond to these equations (Fig.1). In both cases almost all the empirical points are located on straight lines. The correlation coefficient (r) between length and age when calculated from scales is 0.94 and from otoliths is 0.91. The most probable error of the correlation coefficient (E) is $\pm$ 0.021 in the first case and $\pm$ 0.032 in the second. The degree of stability of relation $\left(\frac{r}{E}\right)$ amounts to 44 and 28.3 respectively.

Thus, since we have not found any disagreement in principle in the determination of the age in redfish by scales and otoliths, we consider it reasonable to continue determining ages from scales.

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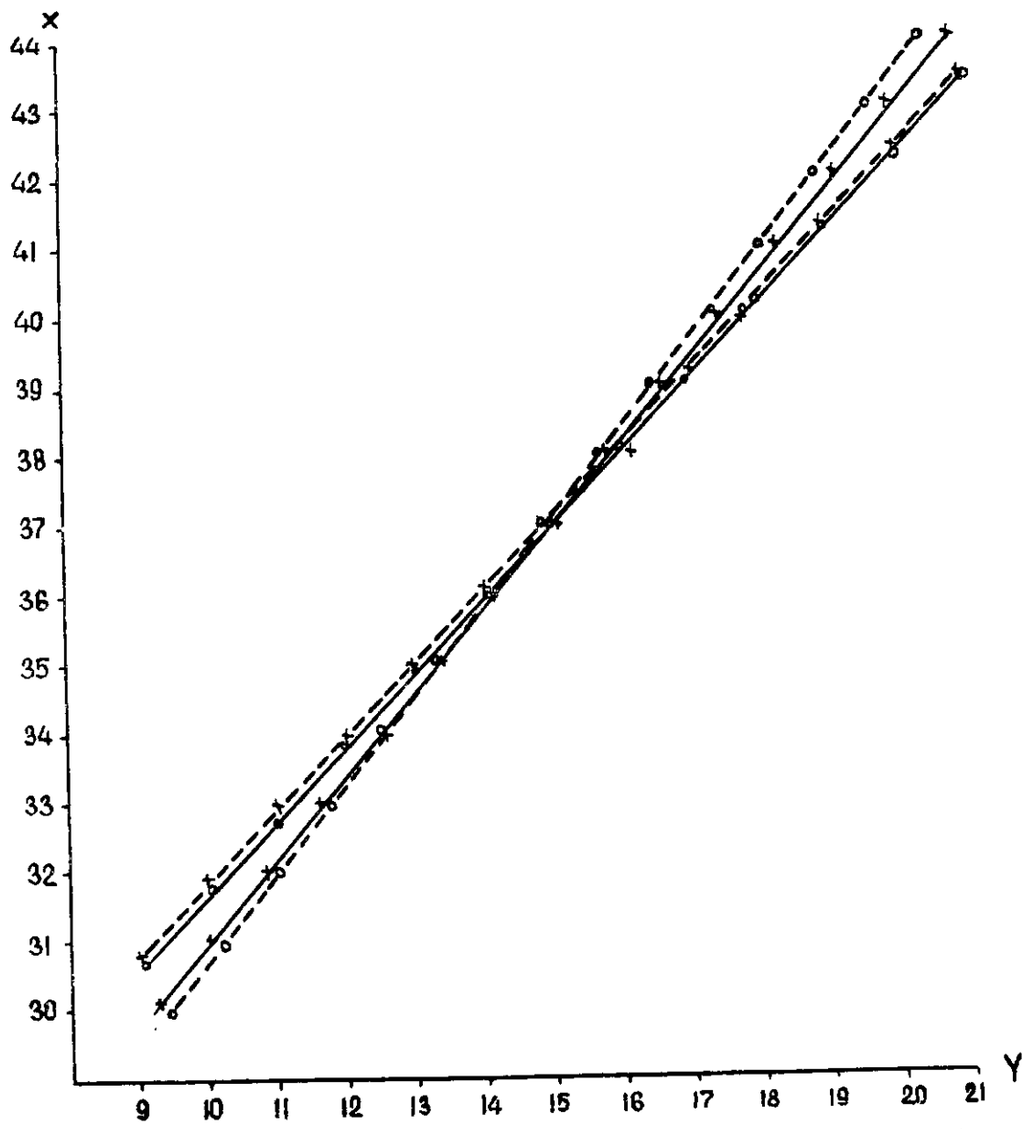

Fig. 1. The ratio of the length and age of redfish determined by otoliths (broken line) and scales (solid line).

Table 1

The length of redfish at a different age determined by scales

Age	Length in cm																							n	M
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49		
6	I																									I	25,00
7																										-	-
8		I	I																							2	26,50
9			I		I	2																				4	29,00
10						4		3	I	I																9	31,44
11						2		I	4	3																10	31,80
12								I		4	10	6														21	33,95
13										I	4	12	4	3	I											25	35,28
14												7	5	2	3											17	36,06
15												3	5	21	10											39	36,97
16														8	16	5	3	2	I							35	38,37
17															11	6	3	I								21	38,71
18															2	8	5	I		2						18	39,72
19																2	6	4	4		I	I				18	41,06
20																I	6	8	7	10	I					33	41,67
21																	2	2	2	5	4					15	42,47
22																		2		3	3	4	I			13	43,77
23																										-	
24																							I			I	47,00
25																							I		I	2	48,00
n	I	I	2	-	I	8	2	7	9	15	28	14	34	43	22	25	20	14	20	9	5	I	2	-	I	284	37,95