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An Examination of Scales from some adult Salmon tagged as Smolts

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Scale-reading is based on a distinctive seasonal pattern in the scales of the fish examined, and the ability of the reader to interpret it. Whilst it is certain that a sequence of bands of widely-and closely-spaced ridges on the scale may correspond to a sequence of periods of fast and slow growth, and by inference to an annual succession, the pattern found in salmon is frequently neither simple nor immediately obvious. Variations in the rate of growth of the scales may be due to physiological factors either originating in the fish or impressed on it by the environment; we are not at present concerned with their causes, and it is sufficient to recognise that they may either produce a check - that is, a band of close ridges - which is not due to winter conditions, or alternatively may counteract the factors normally causing a winter check, so that this is not registered.

It is the task of the scale-reader to discriminate between such casual features and those which are significant, and this involves him in a personal selection of the scale features which he accepts, basing his choice on what he considers to be reasonable in the light of his experience. This leads him to interpret the scale pattern in any given case so that it conforms to a familiar type, though as his experience accumulates, the bounds of what must be considered possible steadily widen. In the end, the scale-reader becomes unwilling to interpret single specimens at all, and possibly over-confident with homogeneous collections.

Although this personal system is logically indefensible, it conforms to the normal scientific principles; the study of individual specimens as a group pre-supposes the existence of common characteristics, and specimens are expected to conform to a general pattern unless proved to be exceptional.

The system remains, however, inherently irrational, and attempts have been made to remove the subjective element from it. In certain establishments it is the practice to submit scales for reading not as homogeneous collections, but as mixtures of specimens of different origin, in order to ensure that they are read entirely by their visible pattern without any modification to suit the views of the reader. This has the effect of depriving him of almost all his past experience; it may be successful in cases where the pattern is clear and regular, but where difficult scales are involved, the expert reader is in a worse position than an utter beginner, as he is aware of possible exceptions to the general rules without knowing when he is probably encountering one. Whilst it is not subjective, this system has the grave defect of producing utter nonsense at times.

It was hoped that the Koo system of ridge-frequency analysis might eliminate the subjective approach and provide a rational basis for scale-reading, but as far as it has been applied to salmon frequenting the English rivers, it has shown that they are not sufficiently regular in their growth to respond to the technique as originally proposed. The essential difficulty arises from the disordered and fragmentary nature of the individual scale ridges, which present, in bulk, the appearance of obvious zones, but if counted exactly as they exist produce a chaotic frequency pattern. It is necessary to revert to a subjective interpretation of each individual ridge to produce a plot representing the general appearance of the scale, and comparable with neighbouring scales.

Discussion of this topic has emphasized the need to discover how reliable the ordinary subjective method of scale-reading may be. Clearly the reliability of the deductions depends to a great extent on the amount of information available with the scales for checking the inferences drawn from them.

The most significant item of information is the date of capture, which enables summer and winter checks to be distinguished even in the presence of scale erosion. Whilst the scale shown in Figure 1 presents no difficulty, those shown in Figures 2, 3, and 4 would be difficult to read without a capture date.

If the length of the fish is available also, it is possible to decide between some alternatives which would both be possible on the basis of the pattern alone. Figure 3 shows a .2+ winters scale in which the first sea winter is very poorly developed; this type can in some cases be taken for a .1+ winters specimen if it is not known to have come from a large fish.

Unfortunately fish older than .2 winters at sea cannot be distinguished by size alone, so that the length by itself is not conclusive in distinguishing the subsequent year classes, but it does allow the scales to be measured instead of simply read.

This is not the place to discuss the validity of back-calculated lengths, because their strict comparability is irrelevant for the purpose in hand; it does not matter whether an indicated first winter length of 45 cms ought to be 47.5 cms or not. The important point is that among normal fish a winter will occur in the general position of 45-50 cms, and that a second is unlikely to be found before a length of 70 cms is reached. Thus, a scale reading which suggests that a fish had three winter bands at 45, 51 and 69 cms is immediately suspect; the data can probably be explained in some way more consistent with normal experience.

It is possible with the measuring projector described earlier (Hartley 1958) to measure the scales as easily as to read them, and if a specimen of about six scales is examined, the better ones can be measured and the results compared. With a well marked specimen, the agreement between different scales is very close; a typical example is shown in Figure 1.

Salmon 5926/E2 Tagged 24/4/57, 15.5 cm.
Recaptured 21/7/59, 80 cm.
Apparent winter length in centimetres

Scale	I	II	1	2
A	6	14.5	49	77
B	6.5	14.5	49	76.5
C	6.5	14.5	48	76
D	6	14.5	47.5	76

In such a case the reading can be accepted as valid; there has been no doubt about the identity of the checks, or of their exact positions in the scale, so that the differing lengths for the various winters can be averaged.

In contrast is the specimen shown in Figure 2. This is characterized by the duplication of the checks marking the first and second years at sea, and by a powerful check near the margin. It could very easily be mistaken for a .3+ winters fish, particularly as fish with very little new marginal growth are caught quite late in each year. The scales were originally measured as follows:-

Salmon 4192/E2

Tagged 19/4/57, 13 cms.
Recaptured 21/7/59, 83 cms.
Apparent winter lengths in centimetres

Scale	I	II	1	2
A	6	13.5	45	72.5
B	6	13	53	83
C	6	13	49	83

It is at once evident that the features being considered in the different scales are themselves different; the discrepancies in the measurements cannot be eliminated by taking an average. The prominent marginal check has been taken as the second sea winter in two cases, and there is similar confusion about the first one.

The specimen was re-examined, and measurements taken for all the prominent checks, They were as follows:-

Salmon 4192/E2

Apparent winter lengths in centimetres

Scale	I	II	ch.	ch.	ch.	ch.
D	6.5	13	45	51	69	80
E	6	12	45	51	70	79.5
F	5.5	11	44.5	52	70	78.5
G	6	12	43.5	52.5	70	79
H	6.5	13.5	46	53	71	80

These indicate that a consistent pattern can be identified, so that this is not a case in which a mixture of scales from different fish is being examined. The third check in the marine phase, at 70 cms, is continuous down the sides of the scale, and may be taken as the second sea winter band, in preference to the 80 cm. check which is apical, and consistent with a summer check. The proper position of the first sea winter remains doubtful; the check at 52 cms is the better defined, but hardly consistent with a second winter at 70 cms. The 45 cm. check is in a more usual position, and would agree with the suggested position for the second sea winter in what appears to have been a slow-growing fish. In any event, there are two sea winters, not three; it is thus possible to obtain an age determination for this scale, but it would be inadvisable to regard the calculated lengths as valid for comparison with other fish.

The scale shown in Figure 3 is even more intractable. It comes from an 80 cm. fish caught on 28th July after two winters at sea. The only really obvious check is at the scale margin, though a faint indication can be seen about midway between the parr area and the margin. Measurements give the following results:-

Salmon 4273/E2

Tagged 19/4/57, 14.5 cm.
Recaptured 28/7/59, 80 cm.
Apparent winter lengths in centimetres

Scale	I	II	1	2
A	6.5	16	50	77
B	6.5	15	50	80
C	7	15.5	47	75
D	6.5	15.5	45	75
E	7	15.5	45/53	75

It will be seen that considerable doubt exists over the position of the first winter band, whilst reference to Figure 3, which represents one of the most boldly-marked scales, shows that the feature located at approximately 75 cms. can hardly be considered as the resumption of open growth.

This scale is in fact unreadable. The known dates of tagging and recapture allow it to be interpreted, but without them nothing could be said with certainty, if only this one specimen were concerned. In a homogeneous collection, however, the situation is somewhat different. A collection will contain individuals in every state between those shown in Figures 2 and 3, and within this frame of reference it becomes possible to recognise patterns which in isolation cannot be distinguished. For this reason it is best when dealing with a collection to pass by ambiguous scales, and to return to them when the collection has been read; they very seldom remain ambiguous.

The specimen shown in Figure 4 is included for its interest. It comes from a .1+ salmon 75 cms long, caught on 19th October 1961 off Kangamiut, on the west coast of Greenland. This fish was tagged as a smolt on 27th April 1960 when it was rescued from the cooling water system of a power station at the mouth of the River Usk, which enters the Bristol Channel. The scales show very uniform growth, though it is possible to locate the first sea winter band approximately at 54 cms, which is to be expected with a west coast fish, and the apparent smolt length is 16 cms.

The accuracy of back-calculated lengths has been questioned for about half a century, and it is therefore of interest to consider a case in which comparison can be made in individual salmon. In 1957, the individual lengths of 4529 salmon smolts were recorded when they were tagged as they entered the tidal part of the River Coquet, Northumberland. Scales and data are available for 64 recaptures from these, and the apparent length at the start of sea growth has been measured. The calculated and measured lengths compare as follows :-

	Centimetres error in smolt length derived from scale measurement									
	-1.5	-1.0	-0.5	0	+0.5	+1.0	+1.5	+2.0	+2.5	+3.0
Number	1	1	7	24	14	5	7	3	1	1
Per cent	1.6	1.6	10.9	37.5	21.9	7.8	10.9	4.7	1.6	1.6

These figures are put forward purely as experimental results, and are not intended to support any theory.

Summary Scale-reading is essentially a subjective art, and cannot be regarded as unquestionably correct in every individual case. The accuracy increases considerably as more data are available about the specimens, and particularly when a homogeneous collection is treated as a whole.

Reference

Hartley W. G. 1958 A projector for the measurement of fish-scales

J. Roy. Micr. Soc 76 (4) 162-167

Figures

Figure 1 Salmon 5926/E2 Tagged 24/4/57, R. Coquet 15.5 cms
Recaptured 21/7/59 in coastal nets; 80 cms.

Figure 2. Salmon 4192/E2 Tagged 19/4/57, R. Coquet 13 cms.
Recaptured 21/7/59 in coastal nets; 83 cms.

Figure 3. Salmon 4273/E2 Tagged 19/4/57, R. Coquet 14.5 cms.
Recaptured 28/7/59 in coastal nets: 80 cms.

Figure 4 Salmon 7462/E1 Tagged 27/4/60, R. Usk (length unknown)
Recaptured 19/10/61 off Kangamiut, West Greenland
($65^{\circ}50'N$, $53^{\circ}21'W$)

Fig. 1

Fig. 2

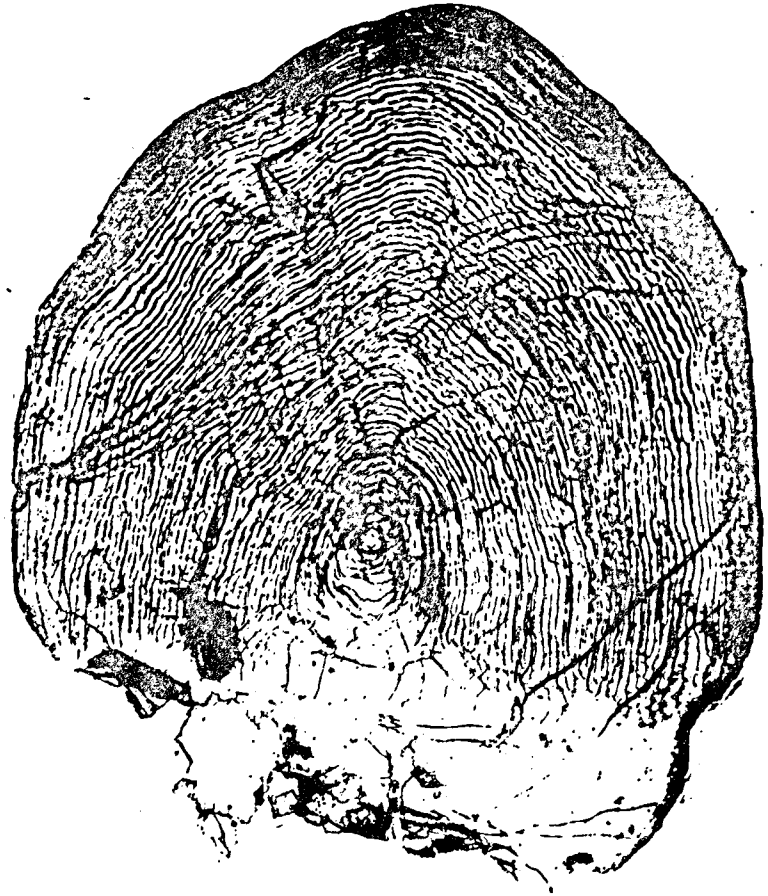

Fig. 3

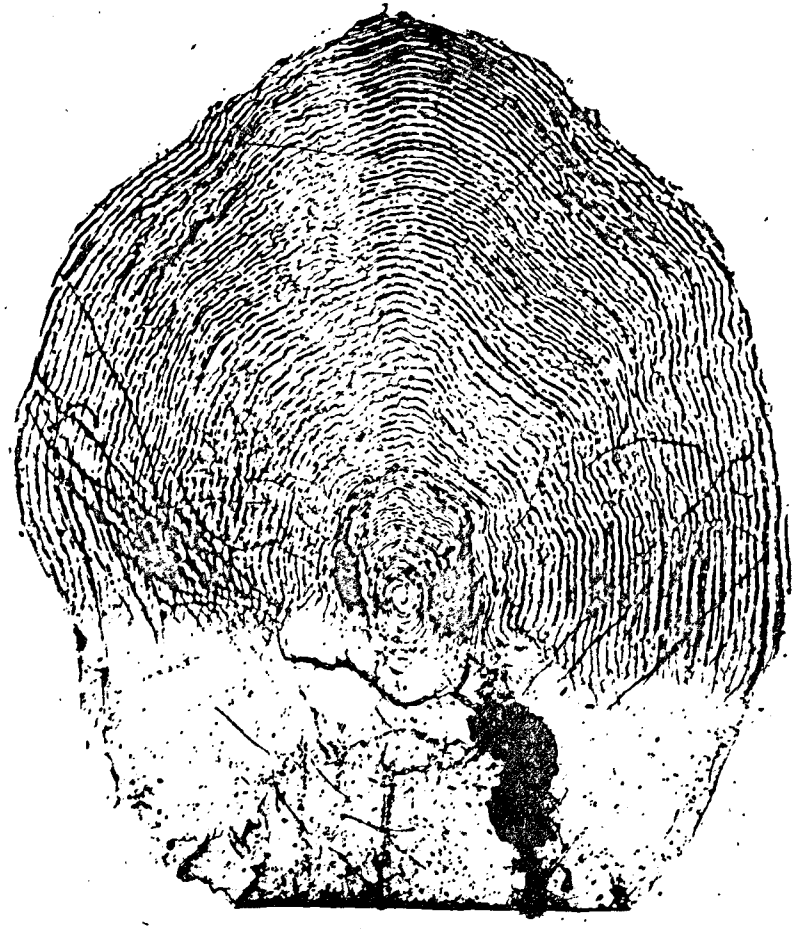

Fig. 4