The Incidence of Regenerated Scales among Fraser River and Skeena River Sockeye Salmon *(Oncorhynchus nerka)*

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THE INCIDENCE OF REGENERATED SCALES AMONG FRASER RIVER AND SKEENA RIVER SOCKEYE SALMON (*Oncorhynchus nerka*)

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ABSTRACT

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Scales of 4- and 5-year-old Skeena River and 4 year old Fraser River sockeye of the 1963 brood year were examined for the incidence of regenerated scales. For the Skeena and Fraser 4-year-old sockeye the incidence of regenerated scales was 11.1 and 8.2%, respectively. For Skeena sockeye, the incidence of regenerated scales was 8.2 and 24.0%, respectively between 4's and 5's. Detailed examination of the regenerated scales indicated that most scales were lost early in the first ocean year, after the fish had left freshwater.

Key words: sockeye salmon, regenerated scales, Fraser and Skeena rivers

RESUME

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On a examiné des écailles de saumons rouges nés en 1963 afin de déterminer la fréquence d'écailles régénérées. Ceux de la rivière Skeena étaient âgés de 4 et 5 ans et ceux du fleuve Fraser, de 4 ans. La fréquence d'écailles régénérées s'élevait à 11,1 et à 8,2%, respectivement, chez les poissons de 4 ans capturés dans les deux cours d'eau. Pour ce qui est du saumon de la Skeena, elle se chiffrait respectivement à 8,2 et 24,0% chez les poissons de 4 ans et de 5 ans. Un examen détaillé des écailles régérées a révélé que la plupart étaient perdues au début de la première année de vie marine, une fois le poisson parti des eaux douces.

Mots-clés: saumon rouge, écailles régénérées, fleuve Fraser, rivière Skeena

INTRODUCTION

Scales of teleost fishes develop as bony plates embedded in pockets of fibrous connective tissue in the skin (Neave 1936, 1940; Yamada 1936). As the scales grow they form on their outward surface circular ridges known as circuli or sclerites. Growth of the scale roughly parallels linear growth of the fish. In Pacific salmon, scale formation begins soon after the young become free swimming. Foerster (1929), studying the scales of sockeye salmon fry from Cultus Lake, B.C., reported that scale rudiments appear when the fish reached 38 m.m. in length. From that time onward, growth of the fish is accompanied by a continuous increase in scale diameter and in the number of circuli. It is generally accepted that the number of circuli formed, and the width of the intervening spaces, reflect the seasonal changes in growth rates of the fish. During the relatively good spring and summer growing conditions, the circuli formed are more numerous and widely spaced ("summer" bands) than those formed during the poorer growing conditions of fall and winter when the circuli are bunched together to form so-called "annuli" or "winter" bands. By counting the annuli on the scales the age of the fish can be determined. Frequently, however, atypical scales are observed that are formed to replace scales that have been lost through mechanical abrasion. These are called regenerated scales. In these, the focus is replaced by an expanded central area, of varying size, that is devoid of circuli and is rough or granular in appearance. As a result, because these scales do not contain a complete record of the life history of the fish, they cannot be used to determine the age of the fish.

This report the incidence of regenerated scales in sockeye salmon of the Fraser and Skeena rivers.

MATERIALS AND METHODS

Scales from 1,104 four- and 350 five-year-old Skeena river sockeye of the 1963 brood year were examined. The fish were obtained from test fishing catches in 1967 and 1968. Scales from 3,054 four year old Fraser river sockeye of the 1963 brood year were also examined for regenerated scales. The fish were obtained from commercial fishery catches in 1967. Because, typically, over 90% of Fraser sockeye mature in their fourth year of life, scales of 5-year-olds from this run were not included in the analysis.

All scales in the samples were either the "preferred scale" or had been taken from the "preferred area" (see INPFC Annual Report for 1955). Total ages of the regenerated scales were estimated from the length of the fish, the scale size, and the number of ocean annuli still present on the scale. In most cases the number of years the fish had spent in freshwater prior to emigration to the sea could not be determined. However, as 95% of the Skeena test fishing samples in 1967 and 1968, and 99% of the Fraser catch samples contained "1 year freshwater" type, it was assumed that virtually all

of the regenerated scales were of the 1-year-freshwater type. All scales were examined in detail under a Leitz Prado 500 microprojector at 100X magnifications. Circulus number, year-band widths, and measurements of total scale radius were made from the center of the regenerated area along the longest anterior axis of the scale to its edge. The diameter of the regenerated area was also measured along the same axis.

RESULTS

The percent incidence of regenerated scales was statistically different for the Fraser and Skeena river 4-year-old sockeye (11.1 and 8.2%, respectively, Yates chi-squared = 7.15, $P<.01$, Table 1).

For the Skeena sockeye, the percentage of regenerated scales between 4- and 5-year-old fish was statistically different (8.2 and 24.0%, respectively, Yates chi-squared = 61.87, $P<.002$, Table 1).

The extent of regeneration on scales of sockeye from the two runs was measured and classified according to Fig. 1 and the results are given in Table 1. Among the Fraser and Skeena sockeye, regardless of age, loss of scales, as evidenced by the regeneration, occurred for the most part in the second year of growth. This indicates that for most fish, scale loss occurred early in their first year in the ocean after they had left freshwater. The results also suggest that only a small number of fish had lost their scales while they were still in freshwater, and this appeared to have occurred mainly during the early to midpoint of their freshwater residence. The second greatest period when fish suffered scale loss appeared to be mostly at the beginning of their third year of life, early in their second year in the ocean. A few lost their scales early in their fourth year of life, early in their third year in the ocean.

DISCUSSION

The results indicate that for both Fraser and Skeena river 4-year-old sockeye, the incidence of regenerated scales differed, a higher proportion of regenerated scales was observed among those from the Fraser.

For Skeena sockeye, the incidence of regenerated scales was higher among 5- than among 4-year-olds. Why this difference occurred is not understood. Perhaps the observed difference was due to sampling error. However there may have been biological factors which might have accounted for the difference. Perhaps smolts that subsequently returned as 5's, migrated to

sea at a time when water levels in the Skeena were high and more turbulent, resulting in a greater loss of scales through mechanical contact with objects.

The most interesting aspect of scale regeneration to come out of this study was that most fish which lost their scales appeared to lose them early in their first year in the ocean after they had left freshwater. It might be expected that most scale loss would occur during the fish's migration down the river to the sea, where they would be more likely to be subjected to turbulence, and abrasion. Why did most of it apparently occur after entering the ocean where the opportunity for mechanical loss of scales would appear not to be as high? This is an area of research that requires more attention.

In general, the objective of most aging laboratories is to estimate both the age and growth of the fish under study. As a result, regenerated scales are not used, and are usually discarded. This study, however, suggests that regenerated scales may be of scientific value. Detailed examination of them could provide estimates both of the incidence of scale loss and when occurred in the fish's life history. These estimates might eventually show some relationship with the strength of the returns. If this could be demonstrated, then monitoring of the juveniles at the time when scale loss is commonest might lead to better predictions of returning adults.

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Table 1. Incidence, measurement and classification of the extent of regeneration on scales of sockeye from the Fraser and Skeena river runs.

Run	Age	Area regenerated on scale		Extent of regeneration within each year-band: Beginning	Middle	End	Total
Fraser	4	1st year - freshwater	No.	10	30	11	51
			%	19.6	58.8	21.6	100.0
		2nd year - first ocean	No.	159[a]	59	15	23
			%	68.2	25.3	6.5	100.0
		3rd year - second ocean	No.	31	15	3	49
			%	63.3	30.6	6.1	100.0
		4th year - third ocean	No.	5	-	-	5
			%	100.0	-	-	100.0
		Total	No.	205	104	29	338
			%				11.1[b]
Skeena	4	1st year - freshwater	No.	5	6	1	12
			%	41.7	50.0	8.3	100.0
		2nd year - first ocean	No.	42	10	3	55
			%	76.4	18.2	5.4	100.0
		3rd year - second ocean	No.	15	4	-	19
			%	78.9	21.1	-	100.0
		4th year - third ocean	No.	4	-	-	4
			%	100.0	-	-	100.0
		Total	No.	66	20	4	90
			%				8.2
	5	1st year - freshwater	No.	5	1	2	8
			%	62.5	12.5	25.0	100.0
		2nd year - first ocean	No.	40	8	6	54
			%	74.1	14.8	11.1	100.0
		3rd year - second ocean	No.	17	3	-	20
			%	85.0	15.0	-	100.0
		4th year - third ocean	No.	1	1	-	2
			%	50.0	50.0	-	100.0
		Total	No.	63	13	8	84
			%				24.0[d]

[a]This indicates 159 scales were regenerated on which the freshwater growth was missing as well as the early part of growth in the first ocean years. However, most of the first ocean growth was present as well as all subsequent years' growth.

[b]Of the 3054 scales examined 338 or 11.1% were regenerated.

[c]Of the 1104 " " 90 or 8.2% " "

[d]Of the 350 " " 84 or 24.0% " "

FIGURE CAPTIONS

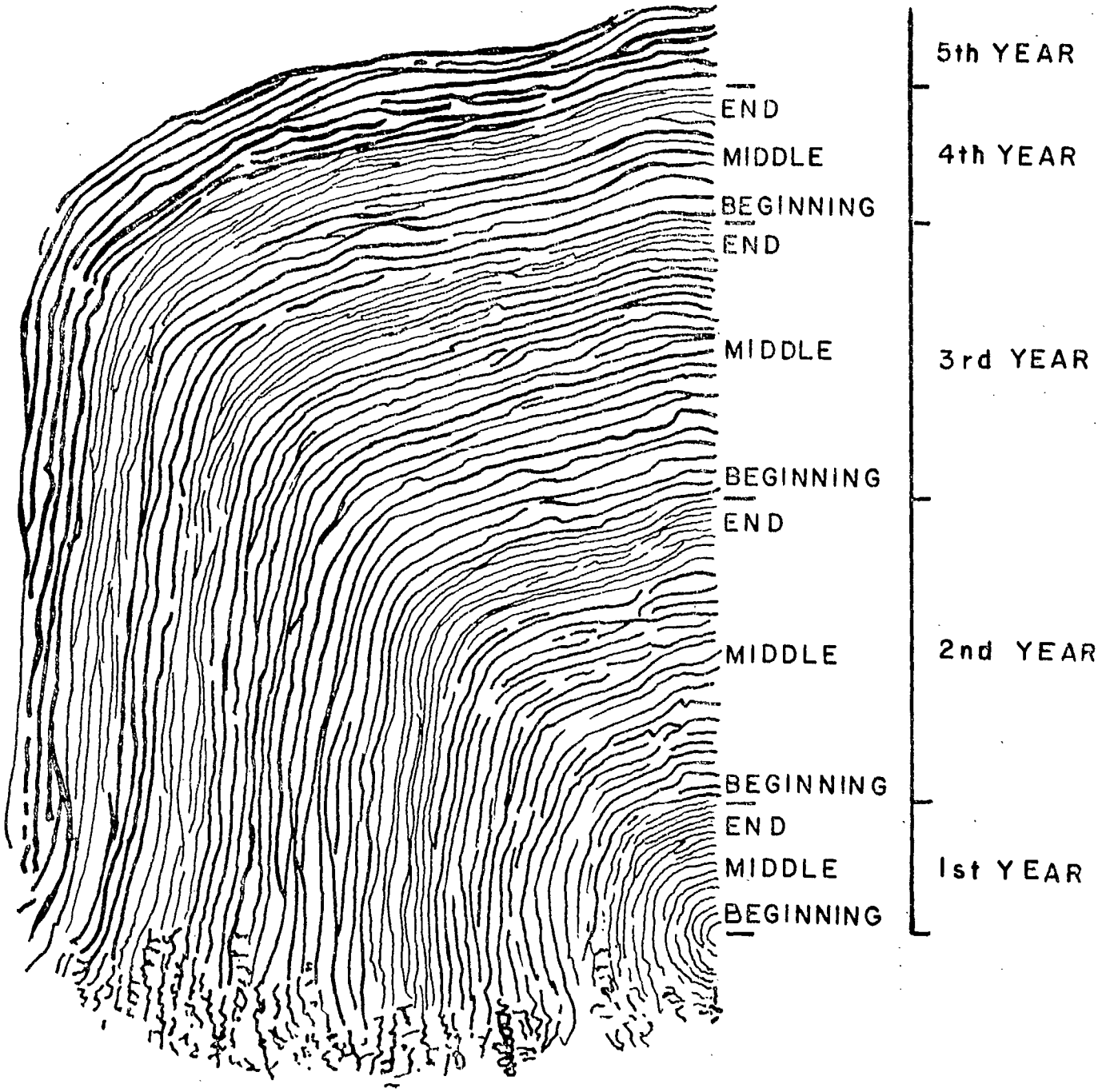

Fig. 1. Diagram of sockeye salmon scale, illustrating the classification of extent of regeneration within each-band.