577

Relation of Scale Characteristics to River of Origin in Four Stocks of Chinook Salmon (*Oncorhynchus tshawytscha*) in Alaska

SPECIAL SCIENTIFIC REPORT—FISHERIES No. 577

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Special Scientific Report--Fisheries are preliminary or progress reports and reports on scientific investigations of restricted scope. Established as Special Scientific Reports in 1940, nos. 1 to 67 were issued from that date to 1949, when the new series, Special Scientific Report--Fisheries, with new serial numbering, was started.

Special Scientific Report--Fisheries are distributed free to libraries, research institutions, State agencies, and scientists.

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Relation of Scale Characteristics to River of Origin in Four Stocks of Chinook Salmon (*Oncorhynchus tshawytscha*) in Alaska

By

RICHARD G. ROWLAND

United States Fish and Wildlife Service
Special Scientific Report--Fisheries No. 577

Washington, D.C.
January 1969

CONTENTS

Relation of Scale Characteristics to River of Origin in Four Stocks of Chinook Salmon (*Oncorhynchus tshawytscha*) in Alaska

By

RICHARD G. ROWLAND,[1] Fishery Biologist

Bureau of Commercial Fisheries Biological Laboratory
Auke Bay, Alaska 99821

ABSTRACT

Differences in numbers of circuli and lengths of radii through the first fresh-water annulus were used to test the hypothesis that the river of origin could be determined from these characteristics. Analyses indicated that males and females and different age groups of a brood year could be combined for each river, but that comparisons between rivers should be restricted to common brood years. Although average counts of circuli and average lengths of radii were different in samples from each river, the variability in these characteristics is great, and neither characteristic is clearly diagnostic for the stock in any of the rivers.

INTRODUCTION

Historically, the chinook salmon (*Oncorhynchus tshawytscha*) taken in the troll fishery in southeastern Alaska originated mainly in rivers of British Columbia, Washington, and Oregon (Rich and Ball, 1935; Parker and Kirkness, 1956). Catches of chinook salmon in Alaska's troll fishery have declined drastically from a high of about 17 million pounds in 1937 to about 4.5 million pounds in recent years.

Before fishery workers can effectively manage the stocks to counter this decline, they must be able to determine the river or area of origin of individual fish. The pattern of fresh-water growth on the scales is used to determine the major stocks or rivers of origin for individual sockeye salmon (*O. nerka*) of the Fraser River system (Henry, 1961). I hypothesized that the same method could be used to identify the river of origin of chinook salmon. As the first step in testing this hypothesis I compared the growth pattern of the fresh-water area of scales taken from adult salmon returning to four widely separated streams in Alaska.

The scale samples came from chinook salmon from the Taku, Alsek, Copper, and Anchor Rivers (fig. 1). In the first three rivers, which are large, the fish were taken in commercial gill nets set in the mouths of the rivers. In the Anchor River, which is a much smaller stream, the fish were captured on sport fishing gear.

Although several characteristics of a scale reflect differences in the pattern of fresh-water growth of a fish, I chose to count the number of circuli and measure the lengths of radii. Each of these characters was compared to determine differences (1) between sexes, (2) between age groups of a brood year,[2] (3) between brood years in each river, and (4) among brood years in the four rivers.

SELECTION AND PREPARATION OF SCALES

The first scales formed during the fresh-water growth of a salmon are preferred for a study of river of origin because they provide the best record of the fresh-water period of a salmon's life. Brown and Bailey (1952) and Clutter and Whitesel (1956) showed that scales of salmonids form first along the posterior half of the lateral line. I have observed this type of scale development on juvenile chinook salmon in Alaska.

I used the scale at the intersection of the second row of scales above the lateral line

[1] The author was drowned in a boating accident at Traitors Cove, Alaska, in April 1964 in pursuit of his research. This manuscript was completed by his colleagues.

[2] The term "brood year" describes the year of spawning of the fish's parents. Salmon that spawn in 1967 produce the 1967 brood year.

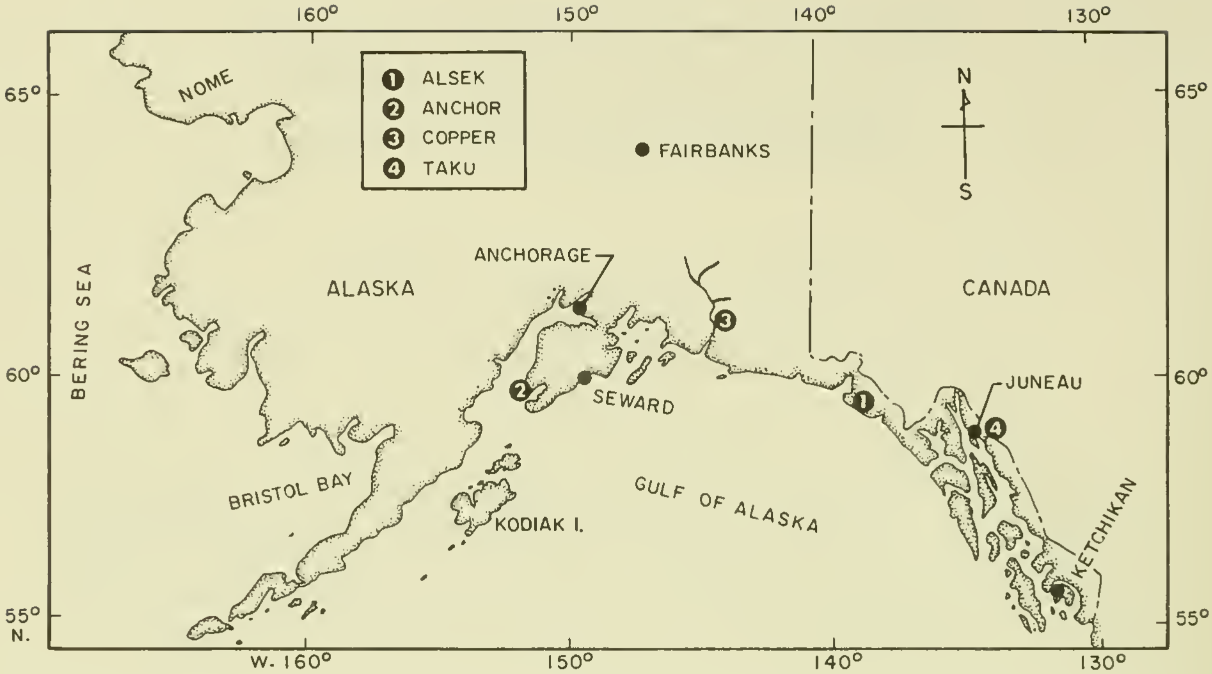

Figure 1.--Four rivers in Alaska where scale characteristics of chinook salmon were studied to distinguish river of origin.

and the diagonal row of scales that originates at the insertion of the dorsal fin. This location on the body of the salmon was selected by the International Pacific Salmon Fisheries Commission for collecting scales to be analyzed (Clutter and Whitesel, 1956) and has proved to be satisfactory (Henry, 1961). If the selected scale was regenerated, it was replaced from a group of additional scales taken from above the lateral line in the immediate area. The substitution of these scales seems justified by similarity of counts of circuli of scales from this area (Clutter and Whitesel, 1956).

The selected scale was attached to a gummed card, and 6 to 12 adjacent scales were placed in an envelope for use if the first scale subsequently proved to be regenerated. Later the scale was cleaned, examined under a microscope, and transferred to a new gummed card--or replaced, if it was regenerated. Plastic impressions of the scales were made by the technique developed by Koo (1955) and Clutter and Whitesel (1956).

EXAMINATION OF SCALE CHARACTERISTICS

I determined the scale characteristics--numbers of circuli and lengths of radii--only for scales with one fresh-water annulus and included only the first year's growth (platelet through first annulus). Scales with no fresh-water annulus or those with two were relatively few and were not used because of the possibility that the fresh-water growth of the scale during the first year might be affected by the length of time the fish was in fresh water. Age determinations, counts, and measurements were made on an image of the scale impression projected at a magnification of 80X.

I determined the age of the fish sampled by counting annuli on the scales. A 2-digit symbol was used to express age by the method of Gilbert and Rich (1927). A superscript denotes the age at which the fish was captured and a subscript the year of life in which the fish migrated to sea. For example, a 5_2 fish is in its fifth year of life (has four annuli on its scales) and migrated to sea in its second year (had one annulus when it entered the ocean).

I used the methods of Clutter and Whitesel (1956) for counting the circuli and measuring the radii. Starting from but not including the innermost circulus, all circuli to the outer edge of the first fresh-water annulus were counted. The outer edge of the first annulus was considered to be at the point where the space between circuli began to increase. The length of the radius is the distance from the innermost circulus (the margin of the focus) to the outer edge of the first fresh-water annulus and is measured along a line extending ventroanteriorly from the focus at an angle 20 degrees from the horizontal axis of the scale. All measurements were of the projected image to the nearest millimeter.

DIFFERENCES IN SCALE CHARACTERISTICS BETWEEN SEXES

To determine if the sexes could be combined in later analyses, I compared the scale characteristics of scales from salmon in the 5_2 age group from the 1961 Alsek River sample (1956 brood year), which included more readable scales than the other samples. Differences in mean numbers of circuli and lengths of radii for 108 males and 177 females were not significant ($t = 0.9225$ for numbers of circuli and 0.4017 for lengths of radii). I therefore combined males and females in the analyses. Clutter and Whitesel (1956) also found no significant difference between sexes of sockeye salmon for these scale characteristics.

DIFFERENCES IN SCALE CHARACTERISTICS BETWEEN AGE GROUPS OF A BROOD YEAR

To determine if fish of different ages could be combined for later analyses, I compared the scale characteristics of samples taken from the Alsek and Anchor Rivers in 1960 and 1961. The sample represented two age groups of the 1955 and 1956 brood years (fig. 2). Comparisons could not be made with data from the Copper and Taku Rivers because I had samples from these streams for only 1 year. A modification of the graphic method for comparing samples described by Dice and Leraas (1936) is used in figure 2 (and later figures). The horizontal line defines the range of sample observations; the vertical line intersecting the range denotes the sample mean; and the shaded rectangle represents ± 1 times the standard error of the mean. Where shaded rectangles overlap, differences between sample means are not likely to be significant.

In both the Alsek and Anchor River samples the shaded rectangles representing age groups of the same brood year overlap broadly. Differences between sample means are not significant at the 95-percent level for any of the eight comparisons shown in figure 2. I therefore conclude that the numbers of circuli and lengths of radii through the first annulus are not correlated with total age of the adult, and that for each stream the different age groups of a brood year can be combined to compare fresh-water growth of the scales.

DIFFERENCES IN SCALE CHARACTERISTICS BETWEEN BROOD YEARS

The next step was to determine if scale characters of two or more brood years could be combined for comparisons among populations from different rivers. Differences in numbers of circuli and lengths of radii between years for each system were usually not significant (the 95-percent confidence limits usually overlapped--table 1), but the general similarity among the four rivers in the year-to-year changes (fig. 3) indicates that these changes are real and not due to sampling error. Therefore, since the observed range of average numbers of circuli and lengths of radii for the four rivers overlap, I have restricted comparisons between rivers to common brood years.

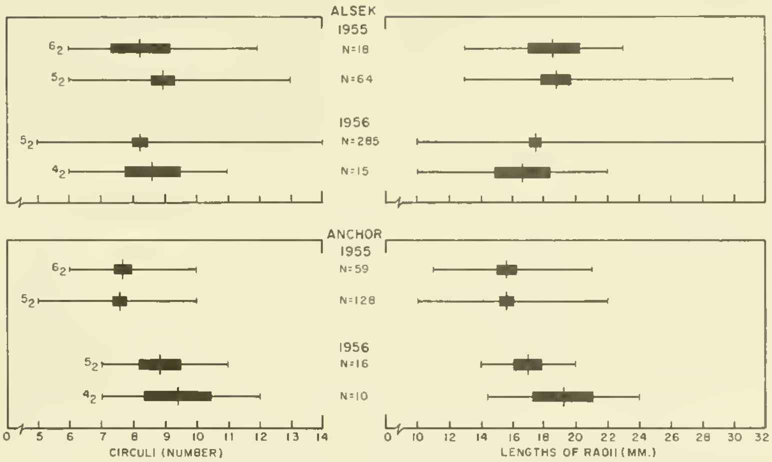

Figure 2.--Numbers of circuli and lengths of radii from the innermost circulus to the end of the first fresh-water annulus for scales of chinook salmon of 1955 and 1956 brood years, by age class, from the Alsek and Anchor Rivers. The horizontal line defines the range of sample observations; the vertical line intersecting the range denotes the sample mean; and the shaded rectangle represents ± 1 times the standard error of the mean.

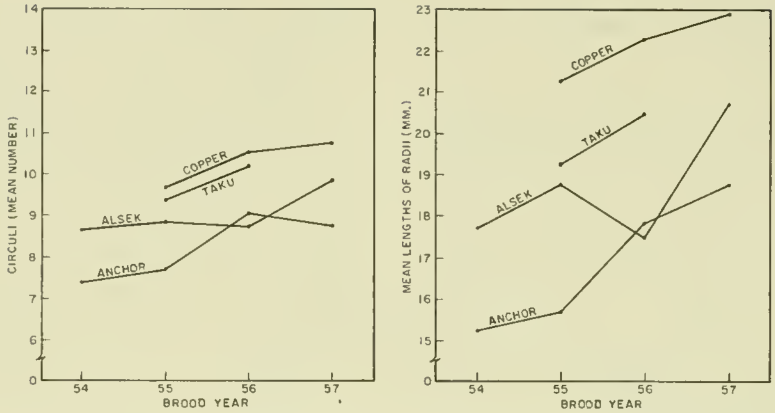

Figure 3.--Mean numbers of circuli and lengths of radii from the innermost circulus to the outer edge of the first fresh-water annulus in chinook salmon scales from the Alsek, Anchor, Copper, and Taku Rivers, 1954-57.

Table 1.--Mean numbers of fresh-water circuli and mean lengths of radii through the first fresh-water annulus of scales of chinook salmon from four Alaska rivers for 4 brood years

River and brood year	Fresh-water circuli		Length of radii	
	Mean	95-percent confidence limits of the mean	Mean	95-percent confidence limits of the mean
	Number	Number	Mm.	Mm.
Alsek:				
1954.....	8.64	±1.03	17.71	±2.18
1955.....	8.84	±0.72	18.81	±1.60
1956.....	8.28	±0.31	17.49	±0.76
1957.....	9.89	±1.00	20.74	±2.15
Anchor:				
1954.....	7.42	±0.80	15.21	±1.97
1955.....	7.63	±0.29	15.67	±0.65
1956.....	9.04	±1.10	17.85	±1.69
1957.....	8.78	±1.52	18.78	±3.78
Copper:				
1955.....	9.68	±0.76	21.30	±1.75
1956.....	10.57	±0.43	22.33	±0.90
1957.....	10.75	±0.80	22.99	±1.63
Taku:				
1955.....	9.40	±0.64	19.31	±1.39
1956.....	10.26	±0.44	20.48	±0.90

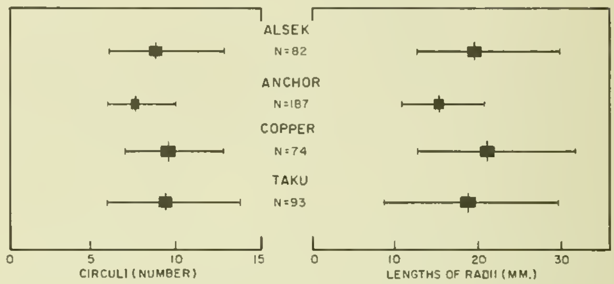

Figure 4.--Numbers of circuli and lengths of radii from the innermost circulus to the end of the first fresh-water annulus of scales of chinook salmon from the Alsek, Anchor, Copper, and Taku Rivers in the 1955 brood year. The horizontal line defines the range of sample observations; the vertical line intersecting the range denotes the sample mean; and the shaded rectangle represents ± 1 times the standard error of the mean.

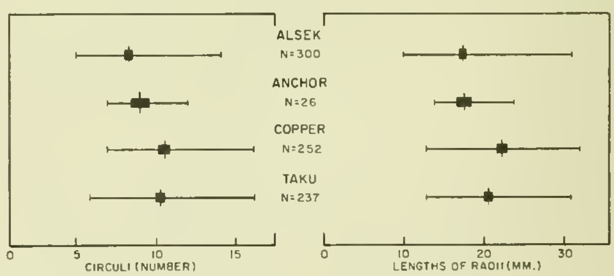

Figure 5.--Numbers of circuli and lengths of radii from the innermost circulus to the end of the first fresh-water annulus of scales of chinook salmon from the Alsek, Anchor, Copper, and Taku Rivers in the 1956 brood year. The horizontal line defines the range of sample observations; the vertical line intersecting the range denotes the sample mean; and the shaded rectangle represents ± 1 times the standard error of the mean.

DIFFERENCES IN SCALE CHARACTERISTICS AMONG FOUR RIVERS

Chinook salmon of both the 1955 and 1956 brood years were represented in samples from the four rivers. The numbers of fresh-water circuli and lengths of radii for the four rivers are shown in figure 4 for the 1955 brood year and in figure 5 for the 1956 brood year. Although counts and measurements of these characteristics tend to be somewhat lower in the Alsek and Anchor Rivers than in the Copper and Taku Rivers, the overlap is considerable, and neither characteristic is clearly diagnostic of fish from any of the rivers.

CONCLUSIONS

Yearly variations in fresh-water growth of the scales of chinook salmon make it necessary to limit comparisons of first-year scale growth to fish of the same brood year. But even when fish of the same brood year were compared, differences in numbers of circuli and lengths of radii were not sufficient for reliable classification of fish according to river of origin in the four stocks studied.

LITERATURE CITED

BROWN, C. J. D., and JACK E. BAILEY.
1952. Time and pattern of scale formation in Yellowstone cutthroat trout *Salmo clarkii lewisii*. Trans. Amer. Microscop. Soc. 71: 120-124.

CLUTTER, R. I., and L. E. WHITESEL.
1956. Collection and interpretation of sockeye salmon scales. Int. Pac. Salmon Fish. Comm., Bull. 9, 159 pp.

DICE, LEE R., and HAROLD J. LERAAS.
1936. A graphic method for comparing several sets of measurements. Contrib. Univ. Mich. Lab. Vertebrate Genet., 3, 3 pp.

GILBERT, CHARLES H., and WILLIS H. RICH.
1927. Investigations concerning the red-salmon runs to the Karluk River, Alaska. U.S. Bur. Fish., Bull. 43 (pt. 2): 1-69.

HENRY, KENNETH A.
1961. Racial identification of Fraser River sockeye salmon by means of scales and its applications to salmon management. Int. Pac. Salmon Fish. Comm., Bull. 12, 97 pp.

KOO, TED SWEI-YEN.
1955. Biology of the red salmon *Oncorhynchus nerka* (Walbaum) of Bristol Bay, Alaska, as revealed by a study of their scales. Ph. D. Thesis, Univ. Wash., Seattle, 164 pp.

PARKER, ROBERT R., and WALTER KIRKNESS.
1956. King salmon and the ocean troll fishery of southeastern Alaska. Alaska Dep. Fish., Res. Rep. 1, 64 pp.

RICH, WILLIS H., and EDWARD M. BALL.
1933. Statistical review of the Alaska salmon fisheries. Part IV: Southeastern Alaska. Bull. [U.S.] Bur. Fish. 47: 437-673.

MS. #1802

GPO 863-110

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources."

The Department works to assure the wisest choice in managing all our resources so each will make its full contribution to a better United States -- now and in the future.

U.S. DEPARTMENT OF THE INTERIOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES
WASHINGTON, D.C. 20240

OFFICIAL BUSINESS

Return this sheet to above address, if you do NOT wish to receive this material [ ], or if change of address is needed [ ] (indicate change including ZIP Code).

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF THE INTERIOR
THIRD CLASS