



A study of scales from known-age trout
by William Alvord

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:

A total of 1055 scale samples from tagged, recaptured brown trout, rainbow trout, and eastern brook trout; and 129 scale samples from planted, marked rainbow trout were taken from Prickley Pear Creek, Montana, between June, 1949, and October, 1951. In addition, 69 scale samples were obtained from rainbow trout planted as fry in Savage Lake, Montana, and 42 scale samples were secured from known-age rainbow trout brood stock at the U.S. Fish and Wildlife Service Fish Hatchery, Ennis, Montana. Studies of these scales substantiated the scale method of aging wild trout and trout planted as fry or young-of-the-year fingerlings.

Marks which may have been caused by shocking, handling, and tagging were present on some scales from Prickley Pear Creek, but they did not occur with any uniformity or regularity.

Scales from the known-age rainbow trout brood stock had "annuli" in varying numbers and positions on fish of the same age. These "annuli" did not conform to the known age of the trout and were probably caused by the hatchery feeding practices and handling during spawning operations.

Annuli beyond the third were, in general, in closer proximity to one another and were more difficult to interpret. In many instances, erosion or absorption obliterated scale characters on the scales of older fish.

Annulus formation had been completed in 74.8 percent of the brown trout and 89.3 percent of the rainbow trout by the latter part of June in 1950. In 1951, 72.3 percent of the brown trout and 78.6 percent of the rainbow trout had formed new annuli by the second week in July. The failure of some trout to form new annuli during the period of annulus formation was almost always associated with little or no gain in total length.

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WILLIAM ALVORD

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Submitted to the Graduate Faculty

in

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Introduction

While there have been numerous investigations made on the age and growth of fishes in both Europe and America, few critical studies of the scale method have appeared, particularly in America. Van Oosten (1941) recognized the lack of such studies and stated that in over 150 papers, only some half dozen gave a critical evaluation of the scale method.

Studies made on age and growth of trout in this country include those of Applegate (1947) who secured scales from known age lake trout, Cristivomer n. namaycush, and Cooper (1951) who used tagged wild brook trout, Salvelinus fontinalis, to substantiate the scale method for fish more than three years old. Van Oosten (1923) studied the scales from known-age whitefishes, Coregonus clupeaformis, and Brown (1943) made a study of known-age grayling, Thymallus signifer.

This study concerns the characters on the scales taken from known-age trout. The objectives were: to provide a check on the scale method of aging wild trout; to determine what effect shocking, handling, and tagging of trout might have on scale characters; to determine whether hatchery-raised trout, planted at different seasons, showed peculiar or variable scale characters; and to study the scale characters of hatchery brood stock held at more or less constant temperatures.

Known-age fish, in this report, includes both wild and hatchery trout. Since the actual hatching dates of the wild trout were not known, the term, "known-age", is applied to that portion of their lives between the first capture and subsequent recaptures. The intervals between

captures ranged from approximately one to 26 months, and some fish were recaptured as many as five times.

The species studied were: brown trout, Salmo trutta; rainbow trout, Salmo gairdnerii; and eastern brook trout, Salvelinus fontinalis.

Sources of scale samples

All scale samples from known-age wild trout were obtained from fish captured in conjunction with a fish population and movement study carried out by the Montana Fish and Game Department on Prickley Pear Creek, Lewis and Clark County, Montana, (Stefanich 1952). A rather complete description of the study area is given in the population and movement report and will not be repeated here. Scale samples totaling 1055 were taken from recaptured wild trout during the period from June, 1949, to October, 1951, (Table 1).

Table 1

Number of times trout were recaptured after the first tagging.

Species	Number of	1949	1950			1951					Total ¹
		No. times recaptured	No. times recaptured			No. times recaptured					
		1	1	2	3	1	2	3	4	5	
Brown	Trout		106	43	16	29	13	19	15	3	244
	Samples		212	129	64	58	39	76	75	18	671
Rainbow	Trout	2	84	23	3	26	10	4	2	1	153
	Samples	4	168	69	12	52	30	16	10	6	363
Brook	Trout		6	1		3					10
	Samples		12	3		6					21
Totals	Trout	2	196	67	19	58	23	23	17	4	407
	Samples	4	392	201	76	116	69	92	85	24	1055

¹First capture is added to recapture for totals of scale samples.

Records of plants made previous to the study show 23,800 brown trout (1.5 inches) on June 3, 1948; 3,150 eastern brook trout (3 inches) on June 19, 1947; 28,000 brown trout (1.5 inches) on June 4, 1947; and 34,320 brown trout (advanced fry) on June 11, 1946. Although some of these planted fish may be included in the wild trout numbers, all would have been in the stream at least one year before first capture in 1949. The four plants of hatchery-raised rainbow trout made in Frickley Pear Creek during the period of study were as follows: 2955 fingerlings (2-5 inches) on September 8, 1949; 811 yearlings (average 6 inches) on May 13, 1950; 3000 fingerlings (average 3 inches) on September 17, 1950; and 997 yearlings (average 6 inches) on May 17, 1951. A total of 129 scale samples were taken from recaptured hatchery fish in 1950 and 1951.

Savage Lake (Lincoln County, Montana) received a plant of 50,000 rainbow trout fry on March 18, 1949. The lake had been previously poisoned on August 23, 1948, and practically all of the fish removed. Scale samples were obtained from three of the planted fish in 1949, 52 in 1950, and 14 in 1951.

Scale samples were secured from 63 known-age rainbow trout at the U. S. Fish and Wildlife Service Fish Hatchery, Ennis, Montana. These trout were brood stock from five different year classes, each of which could be identified by a combination of clipped fins. Water temperature of the ponds in which the brood stock was held did not vary more than plus or minus five degrees from 50 degrees Fahrenheit throughout the year.

Methods

In Prickley Pear Creek, most of the scale samples came from trout captured with an A. C. electric shocker, (collection periods, Table 2). Only 51 samples were secured from trout caught by fishermen. "shocked" fish were anesthetized in a solution of urethane, and when sufficiently calmed, were weighed, total length measured, and scale samples taken. After recovery in holding cages, fish were released in the areas from which they were captured. Wild trout, on first capture, were marked with numbered, metal jaw tags. Scale samples were taken on all wild trout at the time of first capture, and on all recaptured fish from November, 1949, to October, 1951.

Table 2

Collection periods and areas of scale removal

Year	Number	Inclusive dates	Section of dorsal fin below which scale sample was removed
1949	1	June 22 - July 13	
1949	2	August 11 - 17	
1949	3	September 16 - 23	
1949	4	November 24 - 27	Anterior - left
1950	5	June 22 - 30	Anterior - right
1950	6	August 7 - 15	Middle - left
1950	7	September 18 - 25	Middle - right
1951	8	July 7 - 18	Posterior- left
1951	9	September 6 - 14	Posterior- right

Scales were removed from the fish in the area between the dorsal fin and the lateral line. To minimize the number of regenerated scales taken, this area was divided into three sections on each side as follows: below the anterior one-third, below the mid one-third, and below the posterior one-third of the dorsal fin. On first capture, all scale

samples were taken on the left side of the fish below the anterior one-third of the dorsal fin, and on recaptured fish, a different section was used for each collection period, (Table 2).

Hatchery trout planted in Prickley Pear Creek were identified by clipping the adipose and either the right or left pelvic fin. These fish were collected at the same time and in the same manner as wild trout.

In Savage Lake, all scale samples were obtained from fish caught by angling.

The brood trout from the Ennis Hatchery were secured with a dip net. All scales taken from 21 of 63 hatchery fish were regenerate. This large proportion of regenerated scales in hatchery brood stock may be the result of handling at previous spawning operations.

Scales used in this study were mounted in a gum arabic medium on glass slides. Six good scales were mounted, if available, for each sample. Scales were projected on a conventional type scale machine for interpretation, at which time, the annuli positions and the circuli counts along the anterior radius of the scale were marked on heavy paper tabs. Any obvious irregularities in scale characters were also noted on the tabs.

Some of the scales were photographed in order to facilitate more minute comparisons of scale characters. Photographs permitted simultaneous viewing of scales taken at different times from the same fish. Scales were used as negatives in the photographing process and projected onto F-4 Kodak Velox single weight paper. Recommended developing procedure was used. A stage micrometer was used to determine magnifications.

Scale characters on "known-age" wild trout

Annuli were determined by the usual characters of "cutting over", packing of circuli, and irregularities associated with a change in growth of the scale. Some scales lacked a band of closely spaced circuli (Fig. 1), in others the peripheral area was so jumbled that interpretation was impossible (Fig. 2). In general, annuli on the scales of older trout were less definite beyond the third; their close proximity to one another in the outer region of the scale made interpretation difficult. Erosion or absorption obliterated scale characters in many instances (Fig. 3).

Annuli on scales taken in 1949 and 1950 were first determined without referring to the history of the tagged fish. These determinations were later compared to the "known-age" portion of growth and were found to generally agree.

Annuli were usually complete and surrounded by from one to four circuli by late June for fish from Prickley Pear Creek. Between the last 1949 collection period (November 24-27) and the first 1950 (June 22-30), 74.8 percent of 107 brown trout, 89.3 percent of 28 rainbow trout, and all (2) eastern brook trout had formed new annuli.

Between the last 1950 collection period (September 18-25) and the first 1951 (July 7-18), 72.3 percent of 47 brown trout and 78.6 percent of 14 rainbow trout had formed new annuli.

Some trout failed to form annuli during the period of annulus formation between capture in one growing season and recapture in the next.

This failure was almost always associated with little or no increase in body length and occurred, for the most part, in older fish (3 years or over). Total length gains of less than 0.8 of an inch between growing seasons were found in 69 instances for brown trout, 15 for rainbow trout, and two for eastern brook trout. In these slow-growing fish, the expected new annuli were lacking in 59.4 percent of the brown trout, 33.3 percent of the rainbow trout, and 50.0 percent of the eastern brook trout (Table 3). Seven of the brown trout and three of the rainbow trout in this slow-growing group had either sore mouths due to jaw tag irritation, or deformed backs, probably resulting from the effect of electric shocking. Eight of these 10 fish failed to form annuli during the expected annulus formation periods. In all trout combined there were 219 gains in total length of more than 0.8 of an inch between growing seasons. Only 3.7 percent of these failed to form new annuli as expected.

A comparison was made between the gain in the number of scale circuli and the increase in total body length for the intervals between collection periods for each age class of the "known-age" wild trout. There was considerable variation in these measurements between individual fish. Averages for the brown trout and the rainbow trout, however, were somewhat similar (Table 4), with too few eastern brook trout to justify comparison. In 58 instances, the circuli and body length gains for brown trout (473) and rainbow trout (249) covered identical periods. Gains in both body length and number of circuli decreased in fish past their second year - the sharpest decrease occurring after the third year. Combined averages

of gains showed that one circulus was formed for approximately each 0.2 of an inch gain in total body length. Over-all brown trout gains were slightly better than those of the rainbow trout.

The percent of increase in body length was plotted against the percent of increase in length of the anterior scale radius for 196 trout (120 comparisons). A total of 26 scale radius comparisons were either zero or minus values, while only in four cases did fish showing such values fail to increase in body length. To test whether or not these minus values resulted from scale sampling methods, anterior radius measurements of 20 scales from each of the six sampling areas were made on six rainbow trout and five brown trout (9-16 inches total length). These fish were collected from the West Gallatin River on November 11, 1952. Differences between the largest and smallest measurement within any one area ranged from 27.0 to 112.6 millimeters (X 147). Means of the 20 anterior radius measurements, however, showed that scales increased in size from anterior to posterior, and that scales from comparable areas on right and left sides were of similar size. It was not possible, with the scale sampling technique used, to determine the exact relationship between body length and anterior scale radius. Such information could only be obtained from scales taken with great care from very limited, or "key" areas.

Table 3

Annulus formation and total length gains

Age Class	From Nov. 1949 Collection to June 1950 collection		From Nov. 1949 Collection to last 1950 collection		From Sept. 1950 Collection to July 1951 collection		From Sept. 1950 Collection to last 1951 collection	
	Annulus With	Annulus With-out	Annulus With	Annulus With-out	Annulus With	Annulus With-out	Annulus With	Annulus With-out
BROWN TROUT								
0	4	1	12	0	2	0	4	0
I	40	0	61	0	4	0	7	0
II	17	1	26	0	21	0	28	0
III	16	10	28	15	4	5	6	5
IV	6	9	8	13	3	8	6	9
V	1	2	1	3	0	0	0	1
Totals	84	23	136	31	34	13	51	15
Total length gains less than 0.8 inch	7	21	24	29	4	10	4	12
Total length gains more than 0.8 inch	77	2	112	2	30	3	47	3
RAINBOW TROUT								
0	1	0	1	0	0	0	1	0
I	12	1	21	1	8	0	16	0
II	11	1	17	1	2	2	3	2
III	1	0	2	0	1	1	1	1
IV	0	1	0	2	0	0	0	0
Totals	25	3	41	4	11	3	21	3
Total length gains less than 0.8 inch	9	3	9	4	1	1	1	1
Total length gains more than 0.8 inch	16	0	32	1	10	2	20	2
EASTERN BROOK TROUT								
I	1	0	1	0	0	0	0	0
II	1	0	1	1	0	0	0	0
Totals	2	0	2	1	0	0	0	0
Total length gains less than 0.8 inch	1		1	1				
Total length gains more than 0.8 inch	1		1	0				

Table 4

Total length gains and circuli gains between collection periods

Collection period ¹	Av. No. Days	O					
		Brown Trout			Rainbow Trout		
		No. Fish	Circuli Gain	Length Gain	No. Fish	Circuli Gain	Length Gain
1 - 5	358						
1 - 6	406						
1 - 7	447						
2 - 5	315	2	2 (2-2)	0.4" (0.0-0.8)			
2 - 6	363	2	10 (6-14)	1.6" (0.7-2.5)			
2 - 7	404	1	6	1.1"			
3 - 5	278	1	3	0.5"	1	3	0.6"
3 - 6	326	2	10 (8-11)	1.8" (1.5-2.0)	1	8	1.6"
3 - 7	367	1	10	2.2"			
4 - 5	212	2	2 (1-2)	0.6" (0.5-0.7)			
4 - 6	260	2	10 (9-11)	2.1" (2.0-2.2)	1	12	2.6"
4 - 7	301	3	12 (10-14)	2.5" (2.0-3.0)			
5 - 6	48						
5 - 7	89						
5 - 8	384						
5 - 9	444						
6 - 7	41				1	0	0.4"
6 - 8	331						
6 - 9	396				1	9	2.4"
7 - 8	305	1	11	2.9"			
7 - 9	364	2	15 (13-17)	2.6" (2.6-2.6)	1	9	2.0"
8 - 9	59						

¹Table 2

Table 4 (continued)

Collection period	Av. No. Days	I					
		Brown Trout			Rainbow Trout		
		No. Fish	Circuli Gain	Length Gain	No. Fish	Circuli Gain	Length Gain
1 - 5	358	13	10 (6-12)	2.0" (1.4-3.0)	2	8 (6-10)	2.0" (1.8-2.2)
1 - 6	406	8	13 (6-17)	2.4" (1.9-3.0)	3	10 (8-11)	2.8" (2.4-3.4)
1 - 7	447	9	15 (11-20)	3.1" (2.3-3.8)	2	13 (13-13)	3.3" (3.0-3.5)
2 - 5	315	21	4 (2-9)	1.4" (0.6-2.5)	3	2 (0-3)	0.9" (0.7-1.2)
2 - 6	363	20	8 (4-16)	2.1" (1.2-2.7)	3	8 (7-9)	2.0" (1.5-2.3)
2 - 7	404	12	10 (5-19)	2.4" (1.3-3.2)	4	10 (6-15)	2.2" (1.3-3.0)
3 - 5	278	3	3 (1-6)	0.7" (0.4-0.8)	3	1 (1-2)	1.1" (0.4-1.0)
3 - 6	326	3	6 (5-7)	1.5" (1.0-2.1)	3	9 (4-16)	2.5" (1.5-3.0)
3 - 7	367	2	10 (6-13)	3.0 (2.7-3.3)	3	8 (5-11)	2.2" (1.6-2.9)
4 - 5	212	3	4 (2-5)	0.8" (0.7-0.9)	5	3 (1-5)	0.7" (0.3-1.0)
4 - 6	260	2	7 (3-10)	1.2" (0.9-1.5)	3	9 (5-15)	1.5" (1.3-1.8)
4 - 7	301	1	5 (1-10)	1.1" (0.8-1.4)	3	5 (0-14)	1.6" (1.0-2.3)
5 - 6	48	6	6 (4-8)	1.1" (1.0-1.2)	9	6 (4-9)	1.1" (0.4-1.7)
5 - 7	89	8	9 (4-15)	1.6" (1.1-2.0)	7	8 (3-12)	1.7" (0.4-2.3)
5 - 8	384	1	15 (11-19)	2.8" (2.3-3.3)	2	13 (12-14)	2.7" (2.4-2.9)
5 - 9	444	1	21 (16-26)	3.6" (3.1-4.1)	1	16 (11-21)	3.4" (2.9-3.9)
6 - 7	41	30	2 (0-8)	0.4" (0.1-1.1)	46	2 (0-6)	0.6" (0.0-1.2)
6 - 8	331	2	11 (11-11)	1.9" (1.8-1.9)	6	9 (5-11)	2.0" (1.7-2.3)
6 - 9	396	4	14 (8-20)	3.1" (2.6-4.0)	8	14 (5-25)	2.8" (1.4-4.4)
7 - 8	305	4	9 (6-15)	1.5" (1.1-2.0)	4	7 (2-10)	1.2" (1.0-1.3)
7 - 9	364	4	10 (4-13)	2.2" (1.8-2.7)	5	13 (9-22)	1.9" (1.0-2.4)
8 - 9	59	8	1 (1-9)	1.1" (0.4-1.8)	12	6 (3-9)	1.2" (0.6-1.8)

Table 4 (continued)

Collection period	Av. No. Days	II					
		Brown Trout			Rainbow Trout		
		No. Fish	Circuli Gain	Length Gain	No. Fish	Circuli Gain	Length Gain
1 - 5	358	14	7 (1-12)	1.7" (0.7-2.5)	4	3 (4-11)	1.7" (0.9-2.4)
1 - 6	406	8	8 (5-12)	1.3" (0.6-2.2)	5	14 (8-18)	2.5" (1.8-3.3)
1 - 7	447	8	6 (0-11)	1.7" (0.1-2.7)	3	15 (12-18)	2.3" (2.0-3.6)
2 - 5	315	2	6 (2-9)	1.2" (1.0-1.3)	5	2 (0-5)	0.6" (0.0-1.8)
2 - 6	363	1	9	1.9"	1	6	2.3"
2 - 7	404	2	8 (4-11)	2.9" (2.1-3.6)	1	3	1.7"
3 - 5	278	2	4 (3-4)	1.0" (0.7-1.2)	2	2 (1-3)	0.0" (0.0-0.0)
3 - 6	326	2	8 (7-9)	1.6" (1.4-1.7)			
3 - 7	367	2	8 (2-13)	2.3" (1.9-2.7)			
4 - 5	212				2	4 (2-5)	0.7" (0.5-0.9)
4 - 6	260						
4 - 7	301						
5 - 6	48	26	4 (1-9)	0.5" (0.1-1.1)	11	4 (0-8)	1.1" (0.5-1.2)
5 - 7	89	19	5 (1-8)	0.9" (0.4-1.3)	8	6 (2-9)	1.0" (0.1-1.6)
5 - 8	384	8	14 (10-21)	2.3" (1.1-3.4)	4	9 (5-15)	1.9" (1.6-2.4)
5 - 9	444	5	7 (10-13)	2.4" (1.2-3.3)	2	12 (11-12)	2.6" (2.5-2.7)
6 - 7	41	31	2 (0-6)	0.4" (0.1-0.8)	16	1 (0-4)	0.2" (0.1-0.5)
6 - 8	331	13	8 (3-14)	1.9" (1.5-2.4)	3	4 (1-9)	0.5" (0.2-0.8)
6 - 9	396	9	7 (1-16)	1.9" (0.6-3.0)	1	5	0.5"
7 - 8	305	11	7 (3-13)	1.4" (1.0-1.8)	3	1 (0-2)	0.3" (0.3-0.4)
7 - 9	364	11	6 (0-9)	1.6" (0.5-2.3)	2	7 (5-9)	1.1" (0.9-1.2)
8 - 9	59	5	3 (1-6)	0.5" (0.3-0.8)	10	4 (0-7)	0.9" (0.2-1.6)

Table 4 (continued)

Collection period	Av. No. Days	III					
		Brown Trout			Rainbow Trout		
		No. Fish	Circuli Gain	Length Gain	No. Fish	Circuli Gain	Length Gain
1 - 5	358	22	3 (0-7)	0.8" (0.1-1.5)	1	3	0.0"
1 - 6	406	12	2 (0-5)	0.8" (0.0-1.9)	1	6	1.4"
1 - 7	447	11	4 (1-9)	1.1" (0.1-1.7)			
2 - 5	315	2	3 (1-5)	0.8" (0.5-1.0)			
2 - 6	363	1	6	1.2"			
2 - 7	404	2	3 (1-5)	0.9" (0.5-1.2)			
3 - 5	278	1	4	0.5"			
3 - 6	326	1	5	0.9"			
3 - 7	367	2	2 (2-2)	0.3" (0.1-0.4)			
4 - 5	212						
4 - 6	260						
4 - 7	301						
5 - 6	48	8	2 (0-3)	0.2" (0.0-0.5)	2	4 (2-6)	0.1" (0.0-0.3)
5 - 7	89	10	2 (0-5)	0.6" (0.1-2.0)	3	4 (4-5)	0.4" (0.0-0.8)
5 - 8	384	6	4 (0-9)	0.9" (0.4-2.1)	1	1	0.4"
5 - 9	444	4	6 (3-11)	1.5" (0.8-2.8)	1	-2	0.0"
6 - 7	41	12	2 (0-3)	0.2" (0.0-0.5)	6	2 (-2-5)	0.3" (0.1-0.6)
6 - 8	331	6	4 (0-6)	0.6" (0.2-1.6)	2	1 (-2-3)	0.6" (0.6-0.6)
6 - 9	396	6	5 (1-9)	1.6" (0.7-2.9)	1	-4	0.6"
7 - 8	305	3	3 (2-4)	0.6" (0.4-1.1)	1	-2	0.4"
7 - 9	364	4	4 (0-7)	1.5" (0.6-2.7)	1	-4	0.4"
8 - 9	59	7	2 (0-9)	0.5" (0.1-1.3)	3	1 (-2-5)	0.4" (0.0-0.9)

