



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

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Table of Contents

Abstract 3

Introduction 4

 Sources of scale samples 5

 Methods 7

Scale characters on "known-age" wild trout. 9

Effects of shocking, handling, and tagging of trout on their
scale characters 18

Scale characters of hatchery raised trout planted in
Prickley Pear Creek 18

Scale characters of rainbow trout planted in Savage Lake . . . 20

Scale characters of the Ennis Hatchery rainbow trout 21

Acknowledgements 21

Summary 22

Literature Cited 25

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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 (11-21)	3.6" (3.1-4.1)	1	16 (16-16)	3.4" (3.1-3.7)
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)

Table 4 (continued)

Collection period	Av. No. Days	IV						V		
		Brown Trout			Rainbow Trout			Brown Trout		
		No. Fish	Circuli Gain	Length Gain	No. Fish	Circuli Gain	Length Gain	No. Fish	Circuli Gain	Length Gain
1 - 5	358	11	1 (0-2)	0.3" (0.0-0.9)	1	1	0.0"	3	1 (0-3)	0.2" (0.1-0.3)
1 - 6	406	8	2 (0-6)	0.5" (0.0-1.1)	1	2	0.2"			
1 - 7	447	8	2 (0-7)	0.5" (0.0-1.2)	2	1 (1-1)	0.2" (0.0-0.3)	1	0	1.0"
2 - 5	315	2	3 (1-5)	0.5" (0.4-0.6)						
2 - 6	363	1	1	0.2"						
5 - 6	48	8	0 (0-1)	0.2" (0.0-0.6)				1	0	-0.2"
5 - 7	89	10	1 (0-5)	0.1" (0.1-2.0)						
5 - 8	384	6	2 (0-4)	0.4" (0.0-1.0)						
5 - 9	444	4	2 (0-6)	0.8" (0.1-1.6)				1	2	0.1"
6 - 7	41	7	0 (0-2)	0.04" (0.1-0.3)				1	3	0.1"
6 - 8	331	5	1 (0-5)	0.2" (0.2-0.8)						
6 - 9	396	3	4 (0-6)	0.9" (0.1-1.7)						
7 - 8	305	5	1 (0-6)	0.5" (0.1-0.9)						
7 - 9	364	2	3 (0-6)	0.9" (0.3-1.4)						
8 - 9	59	8	1 (0-4)	0.3" (0.1-0.7)						

Effects of shocking, handling, and tagging of trout
on their scale characters

A comparison between average total lengths at the time of collection was made between tagged wild trout which had been recaptured from one to five times and wild trout from the same area captured only once (Table 5). Tagged brown trout in their third year of life averaged 5.6 percent smaller than brown trout of the same age class captured only once. In their fourth year, the tagged brown trout were 9.0 percent smaller, and in their fifth year, 7.0 percent smaller. The slower growth rate of the older tagged brown trout was characterized by the close proximity of annuli on the outer edges of the scales, and the failure, in some instances, to form new annuli. Rainbow trout were apparently less affected by the shocking, handling, and tagging. Total lengths within year classes for the tagged rainbow trout were very similar to those of the rainbow trout captured only once.

"check-marks" which may have been caused by shocking, handling, and tagging were present on some scales (Fig. 4, 5, 6, 7), however, most of the scale marks did not occur with any regularity and were peculiar to the individual fish rather than to groups.

Scale characters of hatchery-raised rainbow trout
planted in Prickley Pear Creek

One group of rainbow trout fingerlings were fin clipped September 8, 1949. Of this group, 2955 were planted in Prickley Pear Creek and 100 were retained at the hatchery to determine the extent of fin regeneration as part of another study. Scales taken from hatchery-held fish May 3, 1950,

exhibited a "check-mark" (Fig. 8) very similar in position to the annulus (Fig. 9) on scales taken from the planted fish on August 10, 1950. Scales taken from the planted trout on July 9, 1951, had two annuli with growth beyond (Fig. 10). Scales from trout of this group which had been planted in Prickley Pear Creek had no discernible differences from scales of wild trout of comparable age and size.

Table 5

Average lengths of Prickley Pear trout at time of capture

BROWN TROUT										
Collection period ¹	0		I		II		III		IV	
	Recap tured	Wild ²	Recap tured	Wild						
1		2.9	5.5	5.6	8.3	8.3	11.0	11.4	13.8	14.0
2	3.6	3.3	6.4	6.2	8.8	8.0	11.9	12.3	13.9	15.8
3	3.9	4.0	6.8	6.6	9.3	10.1	12.2	13.5		13.2
4	4.2	4.2	6.3	7.1		10.4	10.9	12.3		15.2
5	3.8		4.9	4.9	7.8	7.7	10.8	12.2	13.0	13.8
6		2.1	5.8	5.7	8.3	9.7	10.9	12.3	12.9	16.1
7	3.9	3.7	6.3	6.4	8.8	11.1	11.0	11.8	12.8	13.8
8			5.0	5.0	7.8	8.0	10.5	11.7	13.5	13.3
9		3.5	6.0	6.2	8.5	9.2	10.5	12.3	13.2	13.6
RAINBOW TROUT										
1			5.2	5.4	8.4	8.1	10.0	10.9	12.3	12.5
2		2.7	6.3	6.1	9.6	9.2		11.0		10.4
3		3.5	6.7	6.3	9.5	8.6		11.9		
4	4.1	3.8	6.6	6.9	9.3	9.8		12.8		
5			4.7	4.6	7.5	7.1	10.1	8.5	11.2	
6	4.5		5.8	5.8	8.1	8.9	10.9	10.4	11.9	
7	4.9	3.6	6.4	6.2	8.4	9.0	11.1	11.0	11.8	
8	4.0		5.2	4.8	7.6	7.7	10.1	9.7	9.8	15.4
9		2.9	6.3	6.6	8.3	9.6	10.0	9.0	12.8	

¹Table 2²Bishop (1953)

Yearling rainbow trout which averaged 6 inches in total length were planted on May 13, 1950. Scales taken from these fish on June 17, 1950, had closely packed circuli near the outer edge and exhibited two to four "check-marks" (Fig. 11, 12). Scales from most wild trout collected at this time had new annuli and several widely spaced circuli beyond. Miller (1952) found that planted trout did not begin eating for about 40 days, and Bhatia (1932) produced so-called "annual zones" on the scales of trout by altering the food supplies of the fish. These findings may explain the slow growth indicated on the scales of planted yearling fish.

Young-of-the-year rainbow trout which averaged 3 inches in total length were planted in Prickley Pear Creek on September 17, 1950. On November 24, 1950, scales from these fish had closely spaced circuli near the edges (Fig. 13), but did not differ greatly from scales of wild trout of approximately the same size collected at the same time (Fig. 14). Scales taken September 11, 1951, from trout of this plant had one annulus with average growth beyond.

Scales from yearling rainbow trout planted May 17, 1951, had one to four "check-marks" (Fig. 15, 16) when collected on July 17, 1951. These marks lacked most characteristics of annuli. As with yearling trout planted in 1950, circuli were more closely packed on the outer edges of their scales.

Scale characters of rainbow trout planted in Savage Lake

Rainbow trout fry were planted in Savage Lake on March 18, 1949. These fish were over 8 inches in total length by August 26, 1949, when

scales were taken. This rather exceptional increase in body length was reflected in the scales which had widely spaced circuli with almost no irregularities (Fig. 17). By June 25, 1950, these trout ranged from 9.3 to 11.0 inches in total length. Scales taken at this time exhibited one annulus and new growth beyond (Fig. 18). Scales were taken again on August 1, 1950, and the only change noted was additional growth beyond the annulus. The last scale samples studied from the Savage Lake rainbow trout were taken May 7, 1951. The second annulus had not formed at this time (Fig. 19).

Scale characters of the Ennis Hatchery rainbow trout

"Annuli" on the scales of Ennis Hatchery rainbow trout brood stock did not conform to the known age of the fish, nor did they always appear in similar positions on the scales of trout of the same age. Scales from trout hatched in 1948 had from two to five "annuli" (Fig. 20, 21, 22, 23). Scales from trout hatched in 1947 were equally as varied in "annuli" numbers (Fig. 24, 25, 26, 27), and could only be differentiated from the other trout by the fin-clip. Since temperatures of the ponds in which the brood stock were held remained fairly constant throughout the year, the "annuli" probably resulted from feeding practices and handling of the fish during spawning operations.

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Summary

1. Scale samples taken and studied during the period from June, 1949 to October, 1951, included 1055 from tagged wild trout and 129 from planted trout in Prickley Pear Creek, Montana; 52 from trout planted in Savage Lake, Montana; and 42 from rainbow trout brood stock at the U. S. Fish and Wildlife Service Fish Hatchery, Ennis, Montana.
2. Scales from "known-age" brown trout, rainbow trout, and eastern brook trout were studied.
3. Scales from trout over three years old were more difficult to interpret than those from younger fish. Annuli were in closer proximity on the scales of the older fish and, in many instances, erosion or absorption obliterated scale characters.
4. By the latter part of June, 1950, 74.8 percent of the brown trout, 89.3 percent of the rainbow trout, and all (2) eastern brook trout had formed new annuli. 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.

5. The failure of trout, in some instances, to form new annuli during the period of annulus formation was almost always associated with little or no increase in body length.

6. Tagged brown trout in their third, fourth, and fifth years were 5.6, 9.0, and 7.0 percent smaller respectively, than brown trout of the same age classes captured only once. Within year classes, total lengths of tagged rainbow trout were very similar to those of rainbow trout captured only once.

7. Scale marks which may have been caused by shocking, handling, and tagging were present on some scales, but did not occur with any uniformity or regularity.

8. In individual fish, there was considerable variation between the gain in number of scale circuli and the increase in total body length for the intervals between collection periods. Averages of gains for the brown trout and rainbow trout were similar. Combined averages showed one circulus formed for approximately each 0.2 of an inch gain in total body length.

9. Scale sizes (anterior radius) within the six sampling areas used showed differences of 27.0 to 112.6 millimeters ($\times 147$) within an area. Averages of radius measurements within all areas showed an increase in scale size from anterior to posterior. Scales from comparable areas on right and left sides were of similar size.

10. Scales from marked rainbow trout fingerlings planted in Frickley Pear Creek in 1949 and 1950 were little different from scales of wild fish

of comparable age and size. Scales from hatchery-raised yearling rainbow trout planted in Prickley Pear Creek in 1950 and 1951 had from two to four "check-marks", and closely spaced circuli on the outer edges of the scales indicated slower growth following planting.

11. Scale characters on rainbow trout planted as fry in Savage Lake, Montana, conformed to the known age of the fish.

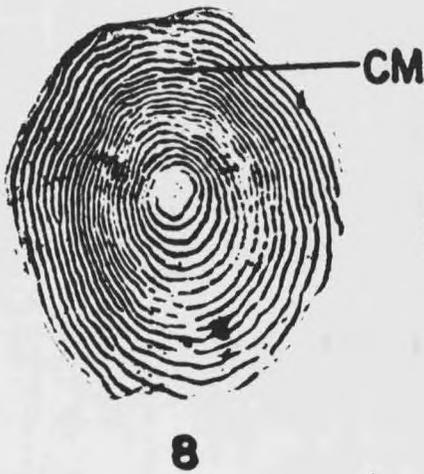
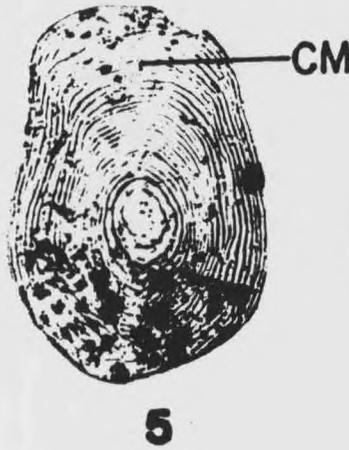
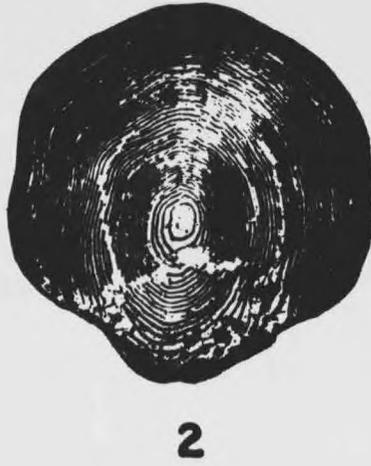
12. "Annuli" varied considerably in both number and position on scales of rainbow trout brood stock from the Ennis Hatchery. Ages of the trout, known from the fin clips, did not conform to the "annuli" on the scales.

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Explanation of Figures

- Fig. 1 - Brown trout scale lacking a band of closely spaced circuli.
- Fig. 2 - Brown trout scale with a jumbled peripheral area.
- Fig. 3 - Brown trout scale showing obliteration of scale characters by erosion or absorption.
- Fig. 4, 5, 6, 7 - A series of scales from a brown trout showing a "check-mark" (CM) which may have been caused by shocking, handling, and tagging.
- Fig. 8 - Scale from a hatchery-held rainbow trout showing a "check-mark" (CM).
- Fig. 9 - Annulus (A) on the scale of a rainbow trout planted in Prickley Pear Creek as a fingerling.



Explanation of Figures

- Fig. 10 - Scale from rainbow trout planted as a fingerling in 1949 showing two annuli in 1951.
- Fig. 11, 12 - Scales from planted yearling rainbow trout showing two to four "check-marks".
- Fig. 13 - Scale from planted rainbow trout fingerling showing more closely spaced circuli on the outer edge of the scale.
- Fig. 14 - Scale from a wild rainbow trout fingerling of approximately the same size as the planted trout in Fig. 13.
- Fig. 15, 16 - "Check-marks" on the scales of rainbow trout planted as yearlings in May, 1951.
- Fig. 17 - Scale from fast growing rainbow trout planted as fry in Savage Lake. Approximately six months growth is shown on the scale.
- Fig. 18 - Scale showing one annulus on rainbow trout planted as fry in Savage Lake.

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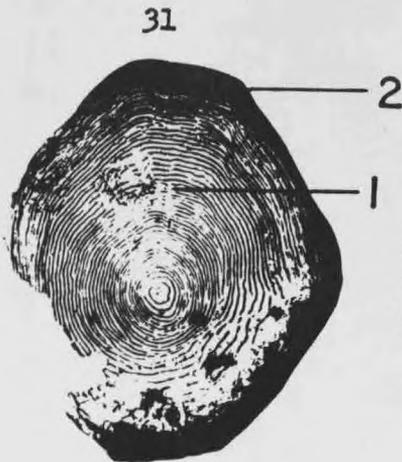
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Explanation of Figures

- Fig. 19 - Scale from rainbow trout planted as fry in Savage Lake in 1949-
second annulus has not yet formed in May of 1951.
- Fig. 20, 21, 22, 23 - Scales from Ennis Hatchery rainbow trout brood stock
(1948 hatch) showing varying numbers of "annuli".
- Fig. 24, 25, 26, 27 - Scales from Ennis Hatchery rainbow trout brood stock
(1947 hatch) with varying "annuli" numbers.



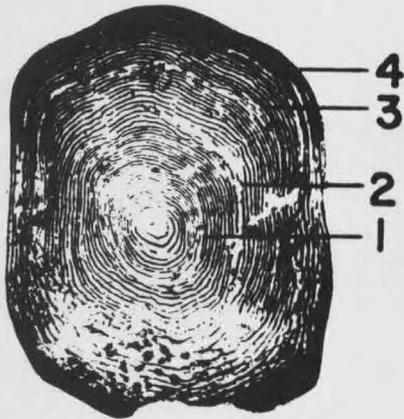
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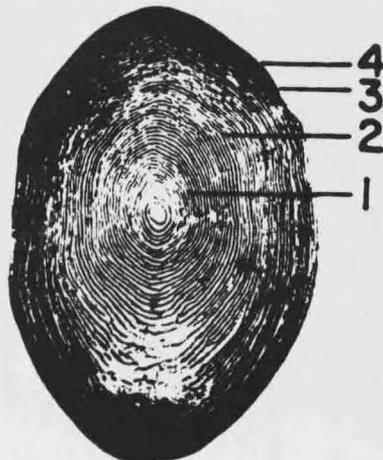
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A study of scales from known-age trout

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