Age, growth and condition of trout in Prickley Pear Creek, Montana
by Clinton G Bishop

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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Montana State College

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Abstract

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Introduction

An intensive trout population study made on Prickley Pear Creek, Montana during the summers of 1949, 1950 (Stefanich, 1952), and continued in 1951, provided an unusual opportunity to collect trout for age, growth, and condition studies as they were related to population changes during the three years. The samples collected represent near total populations for the sections covered. Alvord (1953) studied the scale characters of known age trout in Prickley Pear Creek. Age and growth of rainbow and brown trout from a section of the Missouri River adjacent to the mouth of Prickley Pear Creek were presented by Kathrein (1951). Purkett (1951) reported on the growth rate of trout in relation to elevation and temperature on three Montana streams. Two of the most important trout age and growth studies involving whole populations are those of Shetter and Leonard (1943) in Hunt Creek, Michigan and Schuck (1945) in Crystal Creek, New York. Shetter and Hazzard (1939) investigaged age but not growth of trout populations in three Michigan trout streams.

Description of Stream

Prickley Pear Creek is 23 miles long, flowing in a northeasterly direction and entering the Missouri River 6 miles upstream from Craig, Montana. According to Stefanich (1952) the lower 13 miles, from which samples were taken, varied in width from 15 to 60 feet, with a maximum depth of 8 feet, and a fall of approximately 41 feet per mile. The distance between pools of 3 feet or greater in depth averaged approximately

260 feet. The stream bottom in riffle areas was gravel and rubble. The average water temperature during study periods for the three years was 54.6 degrees F., with a maximum of 67 degrees F. Water levels were high in late spring and early summer with a sudden decrease in late summer followed by a small somewhat steady decrease through fall and winter.

Fish Present

Brown trout (Salmo trutta) was the most numerous salmonid followed by rainbow trout (Salmo gairdnerii). Small numbers of eastern brook trout (Salvelinus fontinalis) and only one cutthroat trout (Salmo clarkii) were found. Mountain whitefish (Prosopium williamsoni) though never abundant were most numerous in the spring. The longnose sucker (Catostomus catostomus) was abundant especially in spring and early summer. A few western white suckers (Catostomus commersoni sucklii), carp (Cyprinus carpio) and burbot (Lota lota maculosa) were present. Fresh water sculpins (Cottus bairdii punctulatis) were abundant at all times.

Methods and Equipment

Fish were taken by the electric shock method from six 600 foot sections established for the population study (Stefanich, 1952). Nine collections were made as follows: four in 1949, three in 1950 (part of one section was shocked a fourth time), and two in 1951.

Captured fish were anesthetized in urethane. Total lengths were taken to the nearest 0.1 inch and weights to the nearest 0.02 pound. All fish were marked and released. No scale samples from recaptured or

hatchery fish were used in this study since growth may have been affected by handling and tagging.

Scales were taken from either the right or left side between the dorsal fin and lateral line. These were cleaned and mounted in a glycerine-gum arabic medium and examined and measured on a conventional scale projection machine. Scale measurements were made from the center of the focus along the median anterior radius. The calculated growth at the end of each year of life was determined by use of a nomograph.

Scales from 1,284 brown trout, 866 rainbow trout, and 127 eastern brook trout were studied (Table 1).

Table 1. The numbers of each species of trout in the sample for each collection in Prickley Pear Creek.

Species	First collection	Second collection	Third collection	Fourth collection	Totals
		1949			
Brown	304	226	169	91	790
Rainbow	140	91	67	70	368
Eastern brook	7	16	13	7	43
				Total	1201
		1950			
Brown	58	75	93	12*	237
Rainbow	47	105	117	6*	275
Eastern brook	13	15	11	1*	40
				Total	552
		1951			
Brown	66	191			257
Rainbow	57	166			223
Eastern brook	13	31			44
				Total	524
				Grand total	2277
Brown trout grand total		1284			
Rainbow trout grand total		866			
Eastern brook trout grand total		127			

*Partial collections.

The relationship between anterior scale radius and total length for each species was examined by plotting total length against anterior scale radius and fitting a regression line to the data, using the method of least squares. The estimating equation used follows:

$$\hat{Y} = a+bX$$

where X = scale radius

Y = total length

$\hat{Y}$ = estimated value of Y for a given X

$$b = \frac{\Sigma XY - (\Sigma X)(\Sigma Y)/n}{X^2 - (\Sigma X)^2/n} = \frac{\Sigma xy}{\Sigma x^2}$$

$$a = \bar{Y} - b\bar{X}$$

$$\bar{X} = \frac{\Sigma X}{n}$$

$$\bar{Y} = \frac{\Sigma Y}{n}$$

Significance of regression was tested by the equation

$$F = \frac{b(\Sigma xy)}{s_e^2}$$

$$\text{where } s_e^2 = \frac{(Y - \hat{Y})^2}{n - 2}$$

In all three species the slope of the regression line was found to differ significantly from zero.

The fit of the data to a straight line was tested by the formula:

$$F = \frac{\sum_{i=1}^{k} Ni(\bar{Y} - z - bX_i)^2/(k - 2)}{\sum_{i=1}^{k}\left\{\sum_{j=1}^{ni} (Y_{ij} - \bar{Y}_i)^2\right\}/(n - k)}$$

The data on rainbow trout and eastern brook trout were such that a straight line could be considered a good fit. For brown trout, the fit was not as good as for the other species. However, a straight line seemed best from a practical standpoint. This was verified by test of fit of data to a second degree polynomial and by examination of the location of the actual values with reference to the straight line.

Calculated lengths for each year of life were adjusted according to the intercepts of the regression lines for each species by using the intercepts as the zero point on the nomograph. These intercept values are 1.1 for rainbow trout, 1.0 for brown trout, and 0.9 for eastern brook trout.

Coefficients of condition (C) were calculated for each fish from the formula:

$$C = \frac{W \times 10^5}{L^3}$$

where W = weight in pounds

L = total length in inches

Age and Growth

Length Frequency

The average length at capture for each age group was compared with the length frequency modes determined for these trout by Stefanich (Unpublished data). These agree well with the outstanding peaks in the length frequencies (Table 2). Too few eastern brook trout were captured in any one collection to show definite modes in a length frequency.

Table 2. Comparison of average length at capture for each age class with length frequency modes of brown trout and rainbow trout collected in 1949 and 1950 (length in inches).

Collection		Age class	Length frequency modes	Average length at capture
			Brown trout	
1949	1	I	5.1-6.0	5.6
	2	0	3.1-4.0	3.3
	2	I	6.1-7.0	6.2
	3	0	3.1-4.0	4.0
	3	I	6.1-7.0	6.6
	4	0	3.1-4.0	4.2
	4	I	7.1-8.0	7.1
1950	1	I	4.1-5.0	4.1
	1	II	7.1-8.0	7.7
	2	0	2.1-3.0	2.1
	2	I	5.1-6.0	5.7
	3	0	3.1-4.0	3.7
	3	I	6.1-7.0	6.4
			Rainbow trout	
1949	3	0	2.1-4.0	3.5
	4	0	3.1-4.0	3.8
	4	I	6.1-7.0	6.9
1950	2	I	5.1-6.0	5.8
	3	0	3.1-4.0	3.6
	3	I	6.1-7.0	6.2

Calculated Length

Brown trout. The grand average calculated lengths for brown trout at annulus formation for years 1-5 were: 3.8, 7.7, 11.1, 13.7, and 16.5 (Table 3). The legal length of 7 inches was reached in the second year. Greatest growth occurred in the second year with a marked drop in the fourth year. The population for the sections covered was made up principally of younger age classes. Eighty-six percent of the fish were in age groups I-III, with age group I being the largest.

Brown trout growth rate in Prickley Pear Creek was better than that of brown trout taken in Crystal Creek, New York, by Schuck (1945). The

Table 3. Average calculated total length and increment at each annulus of brown trout from Prickley Pear Creek (length in inches).

Age group	Number fish	Average length at capture	Annulus 1	2	3	4	5	6	7
	First collection, June 22 to July 13, 1949								
I	131	5.6	4.0						
II	50	8.3	3.7	7.0					
III	79	11.4	3.9	7.8	10.6				
IV	32	14.0	4.1	8.3	11.5	13.3			
V	6	16.1	4.8	7.5	11.2	13.8	15.4		
VI	3	20.9	4.6	8.3	13.2	16.9	19.2	20.5	
VII	1	22.6	4.8	8.7	12.7	17.5	19.4	20.8	22.2
	Second collection, August 11-17, 1949								
0	95	3.3							
I	90	6.2	3.9						
II	17	8.0	3.3	6.1					
III	19	12.3	4.1	8.0	11.2				
IV	2	15.8	4.1	8.7	12.4	15.0			
V	3	17.6	4.8	9.8	12.9	15.2	16.8		
	Third collection, September 16-23, 1949								
0	1188	4.0							
I	44	6.6	3.8						
II	9	10.1	3.7	7.5					
III	6	13.5	4.5	9.6	12.5				
IV	1	13.2	4.2	7.8	11.7	12.5			
V	1	15.8	5.2	9.9	11.7	13.7	14.9		
	Fourth collection, November 24-27, 1949								
0	35	4.2							
I	24	7.1	3.9						
II	6	10.4	3.8	7.7					
III	18	12.3	4.1	8.4	10.8				
IV	6	15.2	4.7	8.4	12.5	14.4			
V	2	16.2	4.0	8.6	11.8	14.3	15.2		
Average calculated length			3.9	7.7	11.2	13.9	16.5	20.5	22.2
Increment			3.9	3.8	3.5	2.7	2.6	4.0	1.7
Number of fish	788		550	261	179	57	16	4	1
	First collection, June 22-30, 1950								
I	33	4.9	4.1						
II	11	7.7	3.5	6.8					
III	7	12.2	4.7	8.7	11.6				
IV	6	13.8	4.9	9.2	11.8	13.4			
VI	1	19.7	5.1	8.2	11.6	14.5	17.3	19.1	

Age group	Number fish	Average length at capture	Annulus 1	2	3	4	5	6	7
		Second collection, August 7-15, 1950							
0	3	2.1							
I	49	5.7	3.6						
II	15	9.7	4.3	7.9					
III	4	12.3	4.2	8.2	10.8				
IV	3	16.1	3.2	7.9	11.0	13.9			
V	1	16.5	4.7	8.3	11.6	13.4	15.8		
		Third collection, September 18-25, 1950							
0	62	3.7							
I	24	6.4	3.6						
II	5	11.1	4.2	8.2					
III	1	11.8	4.2	7.4	9.9				
IV	1	13.8	3.9	6.5	10.3	12.8			
Average calculated length			3.9	8.0	11.3	13.6	16.6	19.1	
Increment			3.9	4.1	3.3	2.3	3.0	2.5	
Number of fish	226		161	55	24	12	2	1	
		First collection, July 7-18, 1951							
I	41	5.0	3.5						
II	16	8.0	3.5	6.6					
III	6	11.7	3.5	7.6	10.5				
IV	3	13.3	3.5	6.7	9.9	12.4			
		Second collection, September 6-14, 1951							
0	60	3.5							
I	97	6.2	3.4						
II	17	9.2	3.3	6.8					
III	9	12.3	3.7	8.0	10.9				
IV	7	13.6	3.5	7.3	10.8	12.7			
V	1	16.4	4.0	9.3	12.1	14.0	15.7		
Average calculated length			3.4	7.1	10.7	12.7	15.7		
Increment			3.4	3.7	3.6	2.0	3.0		
Number of fish	257		197	59	26	11	1		
Grand average calculated length			3.8	7.7	11.1	13.7	16.5	20.2	22.2
Increment			3.8	3.9	3.4	2.6	2.8	3.7	2.0
Number of fish	1271		908	375	229	80	19	5	1

average total lengths are not as great as those reported by Purkett (1951) for the West Gallatin River, Montana or by Kathrein (1951) for the Missouri River, Montana.

Rainbow trout. The grand average calculated lengths for rainbow trout at annulus formation for years 1-4 were: 3.5, 6.6, 9.4, and 11.8 (Table 4). Legal length was not reached until the third year. This was substantially less than for brown trout. Growth rate was greatest in the first year with a gradual decline through the third year. Ninety-eight percent of the rainbow trout population was made up of fish in age groups I-III. Age class I was the largest, closely followed by age class II.

Rainbow trout in Prickley Pear Creek grew at a more rapid rate than those collected by Shetter and Hazzard (1939) in three Michigan trout streams, with the exception of yearling fish. In these latter, growth was slightly better in Michigan fish. The average total lengths at each annulus were about the same as those reported by Purkett (1951) for the West Gallatin River and by Holton (1953) for Trout Creek, Montana. Rainbow trout taken from the Missouri River by Kathrein (1951) showed a greater rate of growth.

Eastern brook trout. The grand average calculated lengths for eastern brook trout at annulus formation for years 1-3 were: 4.1, 7.0, and 9.6 (Table 5). Legal length was reached in the second year as in the brown trout. Growth was slightly better than for rainbow trout but less than for brown trout. First year eastern brook trout were larger than either rainbow trout or brown trout probably due to earlier hatching.

Table 4. Average calculated total length and increment at each annulus of rainbow trout from Prickley Pear Creek (length in inches).

Age group	Number fish	Average length at capture	Annulus 1	2	3	4	5
	First collection, June 22 to July 13, 1949						
I	45	5.6	3.7				
II	68	8.1	3.4	6.6			
III	21	10.9	3.4	7.1	10.1		
IV	6	12.5	3.6	7.4	10.0	11.9	
	Second collection, August 11-17, 1949						
0	3	2.7					
I	61	6.1	3.5				
II	22	9.2	3.6	6.8			
III	3	11.0	3.4	6.1	9.1		
IV	2	10.4	3.3	4.8	6.9	8.6	
	Third collection, September 16-23, 1949						
0	24	3.5					
I	22	6.3	3.2				
II	16	8.6	3.4	6.0			
III	5	11.9	4.0	8.0	10.4		
	Fourth collection, November 24-30, 1949						
0	16	3.8					
I	34	6.9	3.5				
II	17	9.8	3.6	6.7			
III	2	12.8	3.5	9.1	11.4		
V	1	17.3	4.4	8.1	11.6	15.1	16.7
Average calculated length			3.5	6.8	10.0	11.5	16.7
Increment			3.5	3.3	3.2	1.5	5.2
Number of fish	368		325	163	40	9	1
	First collection, June 22-30, 1950						
I	22	4.6	3.6				
II	15	7.1	3.5	6.4			
III	10	8.5	3.4	5.5	7.7		
	Second collection, August 7-15, 1950						
0	1	2.0					
I	84	5.8	3.4				
II	13	8.9	3.5	6.7			
III	7	10.4	3.1	5.8	8.6		
	Third collection, September 18-25, 1950						
0	45	3.6					
I	63	6.2	3.4				
II	7	9.0	3.8	6.9			
III	2	11.0	3.9	6.5	9.3		

Tabe 4 (continued)

Age group	Number fish	Average length at capture	Annulus 1	2	3	4	5
Average calculated length			3.4	6.3	8.2		
Increment			3.4	2.9	1.9		
Number of fish	269		223	54	19		
	First collection, July 7-18, 1951						
I	25	4.8	3.5	[illegible]			
II	30	7.7	3.5	6.2			
III	1	9.7	3.3	6.1	9.1		
IV	1	15.4	3.7	7.8	12.1	14.5	
	Second collection, September 6-14, 1951						
0	24	2.9					
I	121	6.6	3.5				
II	19	9.6	3.6	7.0			
III	2	9.0	3.3	6.0	8.1		
Average calculated length			3.5	6.5	9.4	14.5	
Increment			3.5	3.0	2.9	5.1	
Number of fish	269		199	53	4	1	
Grand average calculated length			3.5	6.6	9.4	11.8	16.7
Increment			3.5	3.1	2.8	2.4	4.9
Number of fish	860		747	270	63	10	1

Table 5. Average calculated total length and increment at each annulus of eastern brook trout from Prickley Pear Creek (length in inches).

Age group	number fish	Average length at Capture	Annulus 1	2	3
	First collection, June 22 to July 13, 1949				
I	5	5.9	4.4		
II	1	9.2	3.7	6.0	
III	1	12.1	5.1	8.4	10.6
	Second collection, August 11-17, 1949				
0	4	3.3			
I	10	6.0	4.2		
II	2	8.8	3.8	7.4	
	Third collection, September 16-23, 1949				
0	5	3.7			
I	6	6.3	4.1		
II	2	9.4	5.2	8.4	
	Fourth collection, November 24-27, 1949				
I	4	6.8	4.1		
II	3	9.9	4.8	8.1	
Average calculated length			4.3	7.8	10.6
Increment			4.3	3.5	2.8
Number of fish	43		34	9	1
	First collection, June 22-30, 1950				
I	2	6.0	4.2		
II	9	7.9	4.2	6.7	
III	2	10.8	4.3	7.0	9.8
	Second collection, August 7-15, 1950				
0	2	3.6			
I	12	5.8	4.0		
II	1	9.5	4.0	6.8	
	Third collection, September 18-25, 1950				
0	4	4.0			
I	7	6.7	4.3		
Average calculated length			4.1	6.7	9.8
Increment			4.1	2.6	3.1
Number of fish	39		33	12	2
	First collection, July 7-18, 1951				
I	8	5.0	3.9		
II	5	8.0	3.7	5.8	

Table 5 (continued)

Age group	Number fish	Average length at capture	Annulus 1	2	3
	Second collection, September 6-14, 1951				
0	3	3.6			
I	20	6.4	4.0		
II	6	9.2	4.2	7.3	
III	2	10.5	4.0	6.4	8.8
Average calculated length			3.9	6.6	8.8
Increment			3.9	2.7	2.2
Number of fish	44		41	13	2
Grand average calculated length			4.1	7.0	9.6
Increment			4.1	2.9	2.6
Number of fish	126		108	34	5

The population of these trout was composed only of fish up to three years old, with one year old fish being the largest age class.

The growth rate for these trout was better than that reported by Shetter and Hazzard (1939) for three Michigan trout streams and by Shetter and Leonard (1943) for a limited area in Hunt Creek, Michigan. The average total lengths are not as great as those reported for Bridger-Spring Creek, Montana (Purkett, 1951). Growth of eastern brook trout in Prickley Pear Creek was approximately the same as that reported for Trout Creek (Holton, 1952).

Condition Factor

Condition factors (C) remained approximately the same for each species of trout throughout years 1-4 (Table 6). Rainbow trout ranged from 35.6 to 41.4 with an average of 39.5 and had a higher condition factor than either brown trout or eastern brook trout. The lowest coefficient of condition was for eastern brook trout, with a range of 33.9 to 40.1 and an average of 37.5. Brown trout ranged from 35.3 to 39.6 with an average of 37.7.

Comparison of Summer Growth and Condition

The average total weight of all fish in the June-July and September collections for 1949 was 398.34 pounds. This decreased to 245.67 in 1950 and to 221.11 in 1951 for comparable periods (Table 7). This amounted to a 44.5 percent loss for the two year period. The loss in weight of all brown trout was proportional to the total for all fish. The weight of

Table 6. Average coefficients of condition (C) for trout from Prickley Pear Creek for each year.

Species		Age Group I		II		III		IV	
		C	No.	C.	No.	C	No.	C	No.
Brown									
	1949	37.8	175	37.9	59	37.7	85	35.6	33
	1950	39.0	57	37.0	16	39.6	8	35.3	7
	1951	38.4	138	37.6	33	37.2	15	37.8	10
Rainbow									
	1949	40.1	67	39.6	84	38.3	26	41.4	6
	1950	39.1	85	35.6	22	38.2	12	....	....
	1951	40.4	146	39.1	49	40.5	3	39.4	1
Eastern brook									
	1949	37.2	11	40.1	3	33.9	1		
	1950	35.7	9	35.7	9	37.8	2		
	1951	38.4	28	37.6	11	38.8	2		

Table 7. Average growth per day from collection 1-3 each year for brown and rainbow trout with average total weight of all fish for these two collections (growth in inches and weight in pounds).

Year	Species	Average growth per day from collection 1 to collection 3				Interval between collections in days	Average total weight of all fish
		I		II			
		Growth	Number	Growth	Number		
1949	Brown	0.013	175	0.010	73	78	398.34
	Rainbow	0.012	67	0.010	117		
1950	Brown	0.018	57	0.015	95	86	245.67
	Rainbow	0.019	85	0.016	32		
1951	Brown	0.020	138	0.019	44	59	221.11
	Rainbow	0.030	146	0.023	95		

rainbow trout remained relatively high with a loss of only 13.6 percent. Length frequency modes remained relatively the same throughout the three years with a gradual reduction in the numbers in each mode. Condition factors remained about the same during the study period.

There was no marked difference between the growth of non-tagged and the tagged fish from the same collections studied by Alvord (1953). Average lengths for I and II year classes were computed for each of the first and third collections of each year.

Due to variation in the length of the interval between the first and third collections for each of the three years (59-86 days), it was not feasible to use the difference in growth between these collections for comparison, so the average growth per day for these periods was used (Table 7). The growth per day increased for both brown trout and rainbow trout for each succeeding year. In yearling brown trout the length per day increased from 0.013 inch in 1949 to 0.020 inch in 1951. In two year old fish the increase was from 0.010 to 0.019 for the same period. Rainbow trout grew more rapidly with yearling fish increasing from 0.012 inch in 1949 to 0.030 inch in 1951 and the two year olds from 0.010 to 0.023. The growth rate in terms of length increased as the total weight of fish decreased for the study area.

Summary

1. A study was made of age, growth and condition of the trout in Prickley Pear Creek, Montana. Samples from six study sections were collected

for the summers of 1949, 1950 and 1951.

2. The scales from 1,284 brown trout, 866 rainbow trout and 127 eastern brook trout were examined.
3. All three species of trout were found to have a reasonably good fit to a straight line for the length-scale radius relationship.
4. Brown trout growth was the most rapid. Eighty-six percent were in age groups I-III. Calculated lengths at annulus formation for years 1-5 were: 3.8, 7.7, 11.1, 13.7 and 16.5.
5. Rainbow trout growth was the lowest. Ninety-eight percent were in age groups I-III. Calculated lengths at annulus formation for years 1-4 were: 3.5, 6.6, 9.4 and 11.8.
6. Eastern brook trout growth rate was slightly higher than for rainbow trout. No fish over three years old was found. Calculated lengths at annulus formation for years 1-3 were: 4.1, 7.0 and 9.6.
7. Condition factors remained relatively the same for each species with averages of 37.7 for brown trout, 39.5 for rainbow trout and 37.5 for eastern brook trout.
8. Average growth per day from first to third collection of each year increased for each succeeding year for both brown trout and rainbow trout for age classes I and II.
9. Growth in length increased for both brown trout and rainbow trout as the total weight of all fish decreased during the three year period. The total weight of all fish decreased 44.5 percent over this period.

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