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Life History of the Cutthroat Trout Salmo Clarkii Richardson in the Logan River, Utah

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GEORGE GORDON FLEENER

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LIFE HISTORY OF THE CUTTHROAT TROUT *SALMO CLARKII* Richardson IN THE LOGAN RIVER, UTAH

by

George Gordon Fleener

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of

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To my Mother and Father

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INTRODUCTION

The study of the cutthrout trout in the Logan River drainage was initiated in cooperation with the Utah Cooperative Wildlife Research Unit and the Utah Fish and Game Department during May of 1948. The first field work began that month. The taking of fish was terminated in November, 1949, although several trips were made into the study area as late as January, 1950.

Comparative inquiries elsewhere included the study by Robertson (1947) of the Yellowstone cutthroat trout (Salmo clarkii lewisi) in two high mountain lakes, and the study of the black-spotted trout (Salmo clarkii henshawi) in Blue Lake, California by Calhoun (1944).

Species other than the cutthroat have been studied and the material made available by numerous other workers. Schuck (1945) studied age and growth, movement, and population density in the brown trout (Salmo trutta fario). Snyder (1938) studied the rainbow trout (Salmo irideus) from Waddell Creek, California, and stated in regard to the aging of trout that "as in the case with many other fish, the anatomical structure of the scales of trout furnishes the best means of determining the age of the individuals, and, at the same time, it offers clues to the solution of questions relating to other factors in their life-history". Summer (1948) determined the age and growth rate of the steelhead trout (Salmo gairdnerii) from Oregon. A series of rainbow trout from some Michigan waters were studied for essentially the same information by Greeley (1933).

Studies have been made of the golden trout (Salmo agua-bonita) by Curtis (1934), and of a series of known-aged lake trout (Cristivomer

n. namaycush)[1] by Applegate (1947). Ricker (1932), Shetter (1937), and Baldwin (1948) determined growth rate of the eastern brook trout (Salvelinus f. fontinalis) in three different areas.

Food habits studies of cutthroat trout have been published by Muttkowski (1925) and Calhoun (1944). Hazzard and Madsen (1933) presented the food habits of cutthroat trout from a series of streams throughout the intermountain region. Hildebrand and Towers (1927) analyzed a small number of cutthroat trout stomachs in connection with a study of the food of several species of trout from Fish Lake, Utah.

Spawning habits of the cutthroat have been studied by Schultz (1938), Cramer (1940), and Smith (1941 and 1945). Speciation and distribution problems have been dealt with by Snyder (1917) and Jordan (1928) as well as by several present day taxonomists who are trying to determine the status of the several more or less well defined subspecies of Salmo clarkii.

The following fish are found in the Logan River: cutthroat trout, brown trout, rainbow trout, eastern brook trout, mountain whitefish (Prosopium williamsoni), Belding's muddler or sculpin (Cottus beldingii), and smallfin redside shiner (Richardsonius balteatus hydrophlox).

The Utah cutthroat trout (Salmo clarkii utah), the mountain whitefish, and Belding's muddler were presumably native to this drainage. The cutthroat under consideration will be designated as Salmo clarkii since the subspecific identification was impossible.

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1. Listed as Salvelinus n. namaycush in a letter from Dr. Robert R. Miller, Associate Curator of Fishes, Univ. of Mich., Ann Arbor, to Dr. William F. Sigler, Assistant Professor of Wildlife Management, Utah State Agric. College., Logan, December 22, 1949.

DESCRIPTION OF THE AREA

Location

The study area embraced the Logan River watershed from the Idaho state line to a point one half mile below the first dam located just east of Logan City, a total highway distance of 32.6 miles. In addition, a cooperative agreement with the Idaho Fish and Game Commission resulted in the collection of useful data in the headwaters of Beaver Creek and the Logan River proper. Nearly the entire length of the stream is located on the Cache National Forest and is readily accessible by highway, with resultant high recreational use of the entire area.

The cutthroat trout is present in the greatest numbers in the Logan River drainage above the point where Temple Fork Stream enters the main river (Figure 1). Only a few cutthroat trout have been encountered at any point below the mouth of Right Hand Fork Stream. Due to distribution, limited in part by an increased stream gradient such as on Beaver Creek and the other streams in this drainage, the study has of necessity been conducted almost entirely in the head waters previously mentioned.

Climate

The climate of the Logan Canyon bottom differed appreciably from that of Logan City. The 1941 Yearbook of Agriculture entitled 'Climate and Man' gives 157 days as the normal growing season in Logan City. This 40 year average also gives the first and last dates of killing frost as May 7 and Oct. 11, respectively. The climatic conditions in Logan Canyon are actually more severe. An attempt was made

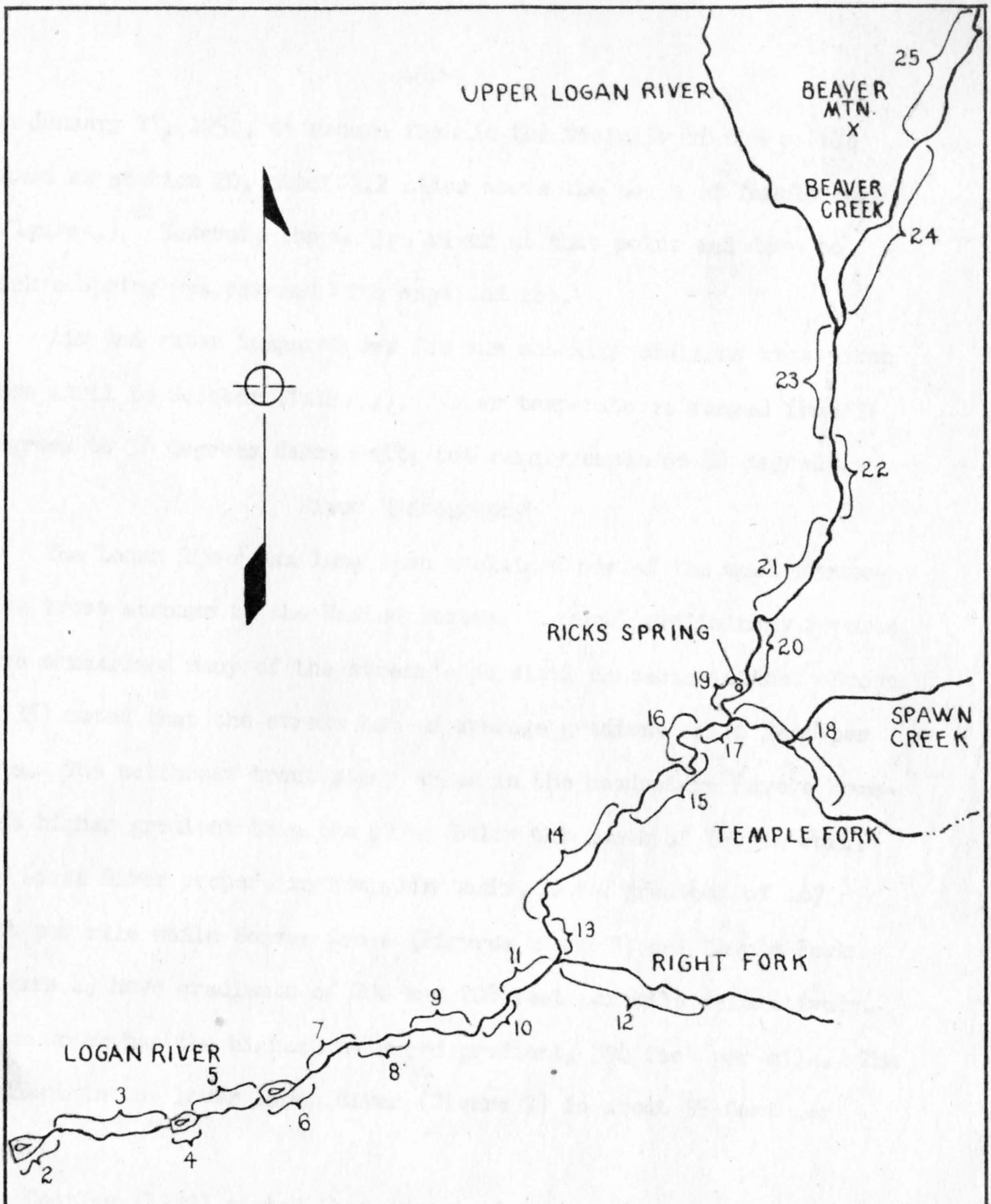

Figure 1.

Sections of the Logan River used in fisheries investigations during 1948 and 1949 on January 17, 1950, to secure fish in the vicinity of the cattle guard at station 20, about 2.2 miles above the mouth of Temple Fork (Figure 1). However, the entire river at that point and down to Rick's Spring was covered with snow and ice.

Air and water temperatures for the shocking stations were taken from April to October (Table 1). Water temperatures ranged from 37 degrees to 56 degrees fahrenheit, but rarely exceeded 48 degrees.

River Hydrography

The Logan River has long been acclaimed one of the most productive trout streams in the United States. Several preliminary reports have summarized many of the stream's physical characteristics. Brown (1935) noted that the stream had an average gradient of 70 feet per mile. The cutthroat trout study areas in the headwaters have a somewhat higher gradient than the river below the mouth of Temple Fork. The Logan River proper, in Franklin basin, has a gradient of 167 feet per mile while Beaver Creek (Figures 2 and 3) and Temple Fork (Figure 4) have gradients of 200 and 208 feet per mile respectively. Spawn Creek has the highest measured gradient, 394 feet per mile. The gradient in the lower Logan River (Figure 7) is about 35 feet per mile.

Costley (1939) stated that by actual measurement the Logan River covered an area of 133.96 surface acres. However, Costley did not state the number of stream miles used in the calculation, nor did he give the time of year that the measurements were made. Brown (1935) found an average depth of 0.74 feet and attributed the low depth figure to an almost total lack of pools. This, in his opinion,

Table 1. Description of shocking stations in the Logan River, Utah.

Sta. No.	Lgth.	Location	Temperature air	Temperature water	Date	Ave. width (feet)	Ave. depth (feet)	Ave. vel. ft./sec.
1	100	Crockett Avenue dam downstream	60	50	7-25-48	25	1	3
3a	176	First bridge above 1st dam		48	3-29-49	16	1	1.8
3b	110	Just below 3a	74	52.5	7-21-49	20	3	1.5
5a	176	First picnic area below 3rd dam. Lower limit at bridge	80	53	7-21-49	30	2	2
5b	100	Upper limit begins at lower limit of Sta. 5a			7-8-49	30	3	2
6		3rd dam of Logan River						
7a		DeWitt's picnic area just above 3rd dam	60	47	4-5-49	30	5	2.5
9a	125	.4 miles below Card Ranger Station	64	47	3-19-49	20	2.5	2.5
12a	176	Below the fork at the Boy Scout Camp	50	49	10-9-48	4	.66	2
12b	176	At the upper limit of the car road	63	54	6-20-49	15	1.5	1.25
13a	120	China row	78	48	8-16-48	30	2	3
14a		Upper end of Wood Camp		47	3-29-49	25	1.3	2.5
18a	176	Below 2nd bridge on Temple Fork Stream	68	52	10-9-48	8	1	2
18b	176	At ford on Temple Fork Stream	76	50	10-9-48	8	1	2

Table 1. Description of shocking stations in the Logan River, Utah (Continued).

Sta. No.	Lgth.	Location	Temperature air	Temperature water	Date	Ave. width (feet)	Ave. depth (feet)	Ave. vel. ft./sec.
18c	176	.5 miles above mouth of Spawn Creek	66	55	6-16-49	6	1.5	1.75
18d	176	3 miles above mouth of Temple Fork Stream	65	48	6-16-49	8	1.5	1.88
18e	176	Mouth of Temple Fork Stream	68	55.	6-16-49	15	3	4.25
22a	176	Summer Camp Bridge	70	48	8-2-48	20	2	2.5
22b	276	Between Tony Grove Nursery and Forestry Summer Camp	63	46	7-8-48	20	1.5	2.5
23a	176	First picnic area above Red Banks. Above mouth of White Pine Creek	66	49	8-23-48	30	1.5	3
23b	176	50 yards below bridge at Franklin Basin road junction to 130 yards above the bridge	53	42	4-12-49	6	3	2.5
24a	176	.5 miles below Beaver Creek road	64	37	4-19-49	8	1.5	2.5
25a	176	First bridge on Beaver Creek	65	56	4-13-49	9	2	2.25
25b	176	2 miles from the main highway on Beaver Creek	78	50	8-30-48	5	.5	2.8
25c	176	3rd bridge from main highway on Beaver Creek. Among beaver dams	58	44	6-18-48	12	2	2.5
25d	176	.5 miles below Saw Mill on Beaver Creek	67	50	6-27-49	12	3	1.5

Table 1. Description of shocking stations in the Logan River, Utah (Continued).

Sta. No.	Lgth.	Location	Temperature air	Temperature water	Date	Ave. width (feet)	Ave. depth (feet)	Ave. vel. ft./sec.
25e	176	.25 miles below Saw Mill on Beaver Creek	65	50	6-27-49	10	3	1.5
A	60	.8 miles over State line on Idaho side in Franklin Basin at ford	78	51.8	6-30-49	5	.75	.55
B	176	.8 miles over State line on Idaho side in Franklin Basin at bridge	78	52	6-30-49	5	1.5	.5
C	90	Franklin Basin. Just above the junction	72	50	4-12-48	20	3	4.2
D	350	Franklin Basin. ½ way between state line and road	70	45	8-2-48	18	6	
E		Franklin Basin 5 miles below Idaho line	74	46	8-2-49	10	1	2.5

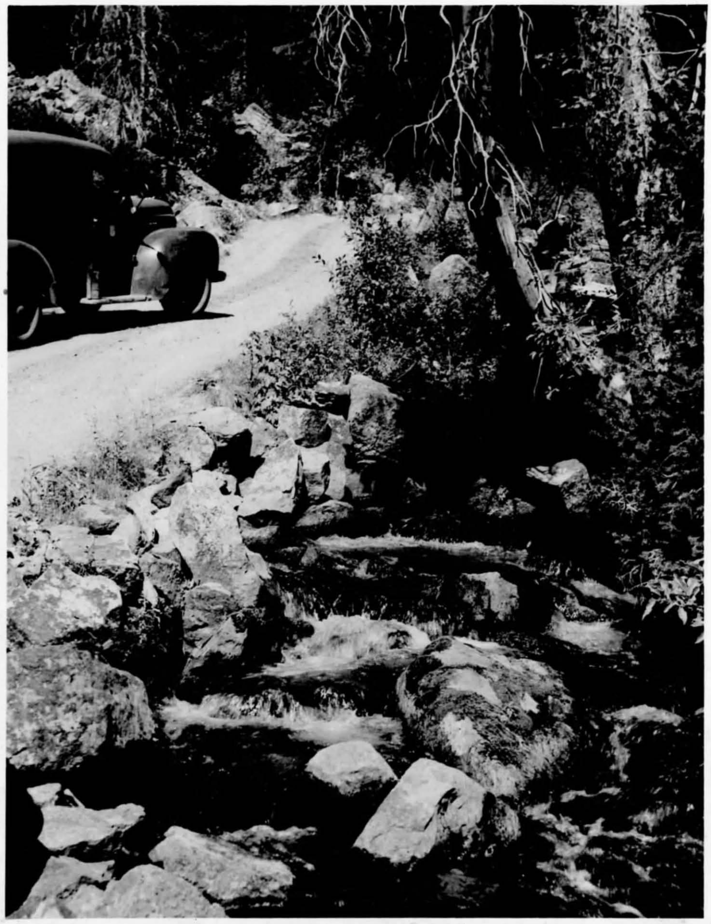

Figure 2. A section of Beaver Creek just below the Utah-Idaho state line. The gradient in this area exceeds 400 feet per mile. Taken September 9, 1949.

Figure 3. A section of Beaver Creek just above the Utah-Idaho state line. Taken September 9, 1949.

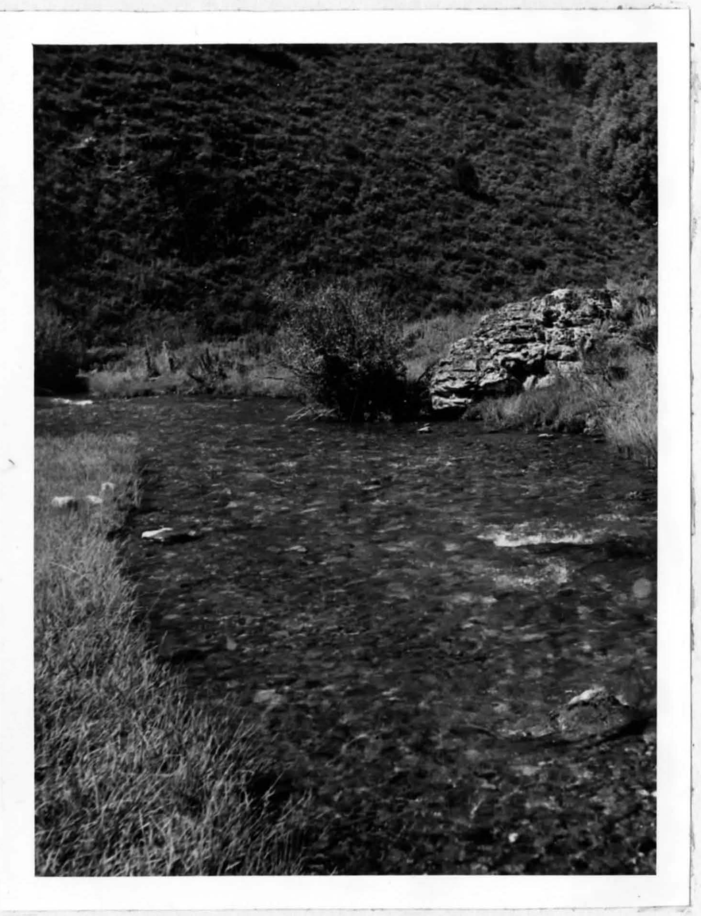

Figure 4. A section of Temple Fork taken September 9, 1949.

was probably the most undesirable situation existing from the standpoint of fish production. He also noted a width of 9.2 feet for Beaver Creek. During the summer of 1949 the average width of the upper Logan River was calculated as 9.8 feet. This was based upon 120 measurements taken within the various shocking stations. The stream's mean depth was 1.8 feet.

The average daily discharge of 247 cubic feet per second for the Logan River is based upon the records of three seasons (Table 2). The spring runoff is especially high during the months of May and June when the average daily discharge is 717 and 612, or approximately 3 times the average daily discharge.

Brown (1935) listed the average volume in cubic feet per second as 3.27 for Beaver Creek, and the average velocity as 1.29 feet per second. He also concluded that 60 per cent of the Logan River flow comes from above Temple Fork.

The stream bottom is composed of coarse rubble and large gravel in most of the study area. Suitable spawning areas are present in Spawn creek. In Beaver Creek, spawning areas are present in the lower ends of small pools, which average 20 to 30 feet apart.

Topography and Geology

The topography of the upper Logan River area is extremely varied. Williams (1948) stated that "the Bear River range, at least in the Logan quadrangle, consists essentially of two tilted blocks bounded by the same kind of faults (Tertiary)." According to Williams the Bear River range consists of two ridges which are separated by a dip. The Upper Logan River occupies the northern end of the dip or depression,

Table 2. The daily discharge in cubic feet per second, of the Logan River, 1946-1949.*

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Mean
1946										170	149	132	
1947	115	115	138	215	692	503	280	203	164	145	128	115	240
1948	106	102	98	226	763	776	342	227	182	161	142	125	248
1949	114	108	124	312	697	557	298	211	182				252
monthly average	112	108	120	251	717	612	307	214	176	159	140	124	247

* Information furnished by Mr. D. R. Woodward, Assistant District Engineer, United States Department of the Interior, Geological Survey; and Mr. W. V. Iorns, Project Engineer, Water Resources Division, Surface Water Branch, Logan, Utah, in letters to Dr. W. F. Sigler, Assistant Professor of Wildlife Management, September 21, 1949 and October 12, 1949.

while the western ridge or front ridge is the elevated western edge of a fault block. Mount Logan is in the western ridge and the eastern ridge is composed of Temple Ridge and Hayes Ridge. With the exception of the Permian which is eroded, Williams (1948) listed the entire geologic sequence from the Cambrian of the Paleozoic up to the Quaternary of the Recent and Pleistocene for the Logan quadrangle. He stated that the high-angled Basin and Range faults are primarily responsible for the present topography of the area. Williams in speaking of glaciation stated that Young[1] found no trace of glaciation around Temple or Hayes ridges. However, Williams concluded that a number of alluvial terraces were present in Logan Canyon between the mouth of Mill Hollow and the forks.

1. Joseph L. Young, Glaciation in Logan Quadrangle, Utah. Thesis submitted to Utah State Agricultural College, Logan. 1939.

MATERIALS AND METHODS

Number of Fish Collected

The study of the Logan River cutthroat trout was based on a total of 306 specimens. The numbers of fish used in the study were as follows; length-scale ratio, 284; age and growth, 234; length-weight relation, 276; food habits, 235; sex ratio, 241; and coefficient of condition, 241. Since the final data available on individual fish often varied, different numbers of fish were present in each category of the study.

Methods of Collection

The need for a ready method of conducting population studies was felt during the spring of 1948. At that time a portable electrical shocking machine was devised. This machine, described in detail by Thoreson (1949), is essentially a 600 watt, 110 volt, alternating current generator driven by a small gasoline engine.

The majority of the fish used in this study were secured by the electric shocking machine and in addition to the obvious value of being able to secure an adequate sample of fish at the proper time and place, this type of gear also gave excellent information on population studies. A series of small sample areas typical of the stream, were chosen for the shocking operations (Table 1). Since the stations were set up primarily to secure population samples, they were usually 176 yards or one tenth of a mile in length.

Throughout 1948 and 1949 a total of 44 shocking operations were conducted in the headwater areas of the Logan River drainage. During 1948 the total number of operations was 16, and during 1949 the number was increased to 28. Shocking for the 1949 season covered the period from March 3 to November 19.

The low mortality in connection with population studies was attributed to handling rather than to electric shock. Thoreson (1949) repeatedly shocked 48 cutthroat trout at the time of capture, then held them for a period of two months without mortality.

During 1949 a similar experiment was conducted with 10 brown trout. On July 14 they were removed by electric shock from an area just above the power installation at the mouth of Logan Canyon and were placed in a holding box in the tail-race of the hydroelectric plant. They were held for 51 days without mortality.

Technique in Taking Records

The scale samples were taken from the left side of the fish above the lateral line and just below the anterior margin of the dorsal fin. After placing the scales on a slip of absorbent paper they were stored in a scale envelope. The following information was recorded on the outside of the envelope: serial number, collection number, species, locality, lengths (total, fork, standard), weight, sex maturity, method of collecting, collector, date, and remarks. The last notation was used for such additional information as condition of the sex organs, parasitism, and whether the stomach was saved for analysis. Under locality, the stream section and shocking station was listed as well as the county, range, township, section, and drainage. No key scales were taken.

The standard length was the measurement from the tip of the snout, with the mouth closed, to the posterior edge of the hyperal plate, the posterior segment being defined by Carlander and Smith (1945) "as the posterior end of the hyperal plate, at or near the median axis of the posterior part of the vertebral column". The total length was obtained in the manner prescribed by Lagler (1949) where the two caudal rays were compressed to give the longest measurement. A measuring board, graduated in millimeters, was used for all fish. Fork length was from the end of the snout to the tail fork. Lengths were determined to the nearest millimeter.

All fish were weighed on a weight balance scale manufactured by the Newark Scale Works, Newark, New Jersey. The scale had a 610 gram capacity and provided accuracy to one tenth of a gram.

It was not possible to sex any fish under 60 millimeters in standard length. Nearly all of the fish above 90 millimeters could be sexed accurately. All of the fish used in determining the sex ratio information were in their second year of life.

The maturity was recorded in the manner presented by Lagler (1949). During the spawning season the organs were classified as immature, ripe, or spent. Throughout the balance of the year those fish which had no visible eggs or sperm were classified as immature.

Preparation and Examination of Scale Samples

The scales were removed from the envelope, placed in a petri dish, and allowed to soak in water for approximately five minutes. After they had been separated and cleaned by gentle agitation, from eight to ten scales were mounted on each microscope slide in a gelatin-glycerin medium prescribed by Van Oosten (1929). The label for each slide had information on the collection number, serial number, and the standard length of each fish.

A table model microprojector with a magnification of 50 was used to examine the scales. A strip of tag board was marked with the projected scale focus, each annulus, and the anterior edge of the scale. In the subsequent method used to determine growth of the Logan River cutthroats it would have been unnecessary to mark the strips. The direct recording of the actual measurement between each of the items enumerated above would have been sufficient. Photographs were taken with a Bausch and Lomb photomicrographic camera and microscope. An apochromatic objective of N.A. 0.30 and 12.5X and 10.0X compensating oculars were used.

Age Determination and Validity of the Annulus as a Year Mark

Many anatomical features have been employed in determining the age of fish. The cutthroat trout in this drainage have been aged by determining the number of annuli on the scales. The annulus, according to Snyder (1938), is a narrow region which is known to mark a period of interrupted or comparatively slow growth.

An examination of the scales, taken throughout 1948 and 1949, revealed that the annuli were usually formed during the first two weeks in October. A fish spawned in 1948 with one annulus laid down that fall would be in its second year of life the following summer. It is customary to record the growth of such a fish as Roman numeral one since it has only one completed annulus. Fish longevity under this system is not calculated in calender years since the cutthroat trout in year class I may have been spawned in April with a consequent growth of about 5 months including hatching time up to the few day period the annulus was laid down. Similarly, a fish without a year mark would be designated as an 0 group fish or as a young fish.

It is essential that the validity of the annulus as a year mark be established in determining age and rate of growth in a species. Hile (1941) has concluded that the interpretation of the annulus as a year mark may be demonstrated by "(1) Correlation between size and age, (2) Agreements among calculated growth histories, and (3) Persistant abundance or scarcity of certain year classes." Although these data have not been presented by year classes to show the conditions indicated by item (3), nevertheless the correlations by size and age mentioned in item (1) are demonstrated in this population. As the length of the fish increase, there is a corresponding increase in the number of annuli. However, individual fish could not be placed in proper age classes on the basis of length alone.

Length conversion factors for a total of 305 fish of both sexes, ranging from 40 to 290 millimeters in total length, were computed as follows:

Standard length (mm.) = .8367 x total length (mm.)
Standard length (mm.) = 21.253 x total length (in.)
Total length (in.) = .04705 x standard length (mm.)
Total length (in.) = 1.1950 x standard length (mm.)

Marked Fish and Creel Census

During 1949 wild fish taken by electric shocking machines were marked with a circular tag in the lower jaw, measured, and released for future recovery. This provided a check on the age and growth study by scale analysis. In the absence of known age fish, known rate of growth is of aid in establishing the validity of the annulus as a year mark.

Fifteen marked cutthroats, or 10.6 percent, were recovered (Table 3).

The marked fish later recaptured also revealed extent of movement. None had moved out of the one tenth mile shocking station where they had been released. The low recovery rate by shocking is in part attributed to extremely heavy fishing pressure.

During 1948 the cutthroat trout composed 24 percent of the total Logan River catch (Thoreson, 1949), and in 1949, 31.5 percent.[1] In the upper Logan River the cutthroat is the principal game fish and for the drainage as a whole it contributes nearly one third of the catch.

Food Analyses

The food habits of the cutthroat trout in the Logan River were studied in essentially the same manner as that employed by Sigler (1949). The stomachs were removed and rolled in strips of cheese cloth together with a label bearing the collection number, serial number, date, and species of fish. Preservation was in a ten percent solution of formalin. The intestines were not saved due to the almost complete digestion of all food items within the stomach.

Analysis was conducted by first deformalizing the cloth rolls in a special solution, then placing each stomach in a petri dish, washing its contents out with water, and identifying each organism to genus and in many instances to species. The number of each organism together with its volume was recorded on a file card. Volume was measured to the nearest one tenth and estimated to the nearest one hundredth of a cubic centimeter by water displacement.

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1. Louis S. Pechacek, in a personal conversation with the writer. Based on Master's thesis to be submitted to Utah State Agricultural College, Logan, 1950.

Table 3. Summary of Logan River cutthroat trout tagged, released, and recovered during 1949. All measurements are presented as total length in millimeters.

Tag #	Release		Recovery		Days in Stream	Growth
	Date	Length	Date	Length		
AC 4515	6-27-49	152	9-7-49	172	71	20
AC 4519	6-27-49	184	9-7-49	192	71	8
AC 4616	7-16-49	224	9-7-49	224	53	0
AC 4621	7-16-49	194	9-7-49	200	53	6
AC 4622	7-16-49	234	9-7-49	250	53	16
AC 4646	7-16-49	175	9-7-49	175	53	0
AC 4647	7-16-49	206	9-7-49	206	53	0
AC 4656	7-16-49	197	9-7-49	204	53	7
AC 4658	7-16-49	175	9-7-49	179	53	4
AC 4891	9-7-49	169	11-19-49	171	73	2

In the final tabular form the food items were presented by percentages of frequency of occurrence of the organism, and by the percentage of the total volume of organisms. Sigler (1947) showed that almost no correlation existed between the percentage of the total number of items in each stomach, in the Spirit Lake, Iowa, white bass. This was demonstrated for the Logan River cutthroat in the May, 1949 summary of food items. Fish occurred once in eight stomachs with a percentage by the total numbers of items in all stomachs of 0.4 percent. Based on a total of eight stomachs the percentage of occurrence was 12.5. The percentage by total volume of all organisms was 48.4 or nearly one half by volume of the whole amount of food consumed by the eight fish. Therefore, the presentation by percentage of numbers is deemed to give a distorted picture as far as the actual dietary habits are concerned.

Van Oosten and Deason (1938) in their study of the lake trout and lawyer (Lota maculosa) of Lake Michigan used a combination of these methods. Leonard and Leonard (1949) concluded that frequency of occurrence is of prime consideration. They felt that many published reports have relied solely on volume as the criteria for relative importance of food organisms so they included volumetric figures, obtained by displacement, in their paper. Ball (1948) believed that the volumetric method was the only suitable one for the field.

In this study of the food habits of 235 cutthroat trout, a combination of percentages of frequency of occurrence together with the percentages of the total volume of the same organisms is believed to give the most representative picture. All data were handled progressively.

That is, each group of headings collectively equals 100 percent. For example, in table 23 insects, arachnids, annelids and fish collectively make up the diet; or the total of the subheadings under these also equals the total diet.

Stream Bottom Sampling

During the 1948 season a small number of bottom samples were taken from the shocking stations. The stream bottom samples from these stations gave an indication of the available food in the stream. A comparison of availability with food taken revealed to some extent the degree the selectivity by the fish.

The stream bottom samples were taken in the manner prescribed by Needham (1940). A field note form was developed during the 1948 study as an aid in taking systematic data. A copy of this field note form as it was actually filled out for a sample is shown in tables 4 and 5.

There is considerable variation in the size of samples analyzed. Twenty samples from pools had a wet weight ranging from 0.02 to 15.2 grams while the range of weights of 16 samples taken from riffle areas was 0.05 to 13.2. The average weight of pool samples was slightly higher than those from ripples (Table 6). Needham (1940) emphasized that fair averages of food conditions at any point in the stream must be based on a comparatively large number of samples, because of the great variability from place to place. Pennak and Van Gerpen (1947) also stated that a stream survey should be based on a sufficient number of samples as well as a calculation of the relative percent of substrate types comprising the stream bed.

The number and volume of all caddis fly cases was recorded.

Table 4. Front view of the bottom sample form used in 1948.

Date 9-28-1948 Station 25

Hour 1515 Area type pool

Distance of collection from shore 10'

Depth at which sample was secured 18"

Bottom type (%) Rubble 70, Gravel 30 Width 30'

Depth of stream 14" Velocity 4.05'/sec

Sq. Ft. Sampler Temp: air, 74; water, 49.2

Table 5. Back view of the bottom sample form used in 1948.

Species	Number	Vol. in Ml.
Ephemeroptera		
Rithrogena mimus	1	0.20
Plecoptera		
Acroneuria pacifica	1	0.22
Trichoptera		
Brachycentrus	20	1.62
Hydropsyche	4	0.14
Unidentified	1	0.01
Total	27	2.19

Wet weight (grams): .99

Table 6. Comparison of available fish foods from pools and riffles in the upper Logan River, Utah, 1948.

	Wet weight* (grams per square foot)	Number of samples
Pools	2.46	21
Riffles	1.97	16

* Blotted dry before recording weight.

Table 7. Numbers and volume of aquatic insects of riffle areas in the Logan River, Utah, 1948*.

Order	Number	Percent of total number	Volume in ml.	Percent of total vol.
Ephemerida	72	16.0	1.21	10.5
Plecoptera	16	3.6	2.10	18.1
Trichoptera	211	46.9	5.50	47.6
Diptera	145	32.2	2.54	22.0
Miscellaneous aquatic insects	6	1.3	.21	1.9
Grand Totals	450	100.0	11.56	99.9

* Based on 17 samples taken from June 20 to September 4, 1948.

Table 8. Numbers and volume of aquatic insects of pool areas in the Logan River, Utah, 1948.*

Order	Total number	Percent	Total volume in ml.	Percent
Ephemerida	75	9.9	1.59	3.3
Plecoptera	37	4.9	5.67	11.9
Trichoptera	573	75.6	35.76	75.1
Diptera	63	8.3	4.46	9.4
Miscellaneous Aquatic insects	10	1.3	.11	.2
Grand Totals	758	99.8	47.59	99.9

* Based on 22 samples taken from June 20 to September 4, 1948.

Table 9. Comparison of available aquatic insects from riffles and pools in the upper Logan River, Utah, 1948.

Order	Riffles		Pools	
	Percent numbers	Percent vol.	Percent number	Percent vol.
Ephemerida	16.0	10.5	9.9	3.3
Plecoptera	3.6	10.1	4.9	11.9
Trichoptera	46.9	47.6	75.6	75.1
Diptera	32.2	22.0	8.3	9.4
Miscellaneous aquatic insects	1.3	1.9	1.3	.2

Examination of fish stomachs revealed that both full and empty cases were ingested. The greater number of Trichoptera were found in the pool areas while the Ephemeroptera were considerably more numerous in the riffles (Tables 7, 8 and 9).

This preliminary work should be followed by other studies of bottom sampling based on pool and riffle areas, on the altitudinal distribution of the stream, and upon the substrates. A measurement of the total food supply provides a ready index to carrying capacity of the stream, assuming of course, that such a project can be carried out on a stream section basis. Needham (1934) showed that the seasonal abundance, rate of increase, and availability of organisms must be stressed.

RELATIVE ABUNDANCE OF FISH

Use of the electric shocking machine provides information on fish populations (Tables 10, 11, 12, and 13). The totals given are obviously the minimum number and must be so considered in drawing conclusions. The estimated recovery ranged from nearly 100 percent to probably not greater than 25 percent. The degree of recovery is due to many variables, such as water velocity and flow, overhanging banks, and extensively brushy stream areas which tend to exclude the desired number of men to recover fish. Small fish are easily overlooked and often escape or may be washed through the mesh of the seines placed at the lower end of the area being shocked.

The cutthroat trout is the most abundant fish in the headwaters of the Logan River drainage, but in the river below Temple Fork the brown trout is the most numerous wild fish.

The cutthroat trout in the Logan River show a considerable tendency

Table 10. Summary of cutthroat trout recovered by electric shock from a series of stations in the Logan River, Utah, 1948.

Sta. No.	Lgth. of station (yards)	Date	Length of fish in inches: 0-2	3-4	5-6	Total sub-legal	7-9	10-12	13-15	16 +	Total legal	Total fish
5a	176	7-26										1
12a	176	9-23	1		2	3						3
12a		10-9	1		5	6	1				1	7
12b	176	7-2		10	4	14	1				1	15
12b		9-23	2	16	2	20						20
12b		10-9	7	23	1	31						31
13a	120	8-16		1		1						1
18a	176	10-9	7	41	39	87	8	1			9	96
18b	176	10-9	1	2	10	13	9				9	22
18c	176	7-2	5	14	13	32	3	1			4	36
18d	176	7-2										5
22a	176	8-2		17	9	26	4	1			5	31
22b	276	8-8	1	1	18	20	11	1			12	32
23a	176	8-23		11	14	25	9	3			12	37
24a	176	6-28		90	48	138	6		1		7	145
24a		8-30		63	89	152	18				18	170
25a	176	6-18										50
25a		7-26		21	23	44	10				10	54
25b	176	8-30	2	10	26	38	6				6	44
25c	176	6-18										34
C	90	7-7									2	2
D	350	8-2										2
E	176	7-19		2	6	8	6				6	14
F	176	7-19	1	24	32	57	7				7	64

Table 11. Summary of cutthroat trout recovered by electric shock from a series of stations in the Logan River, Utah, 1949.

Sta. No.	Lgth. of station (yards)	Date	Length of fish in inches: 0-2	3-4	5-6	Total sub-legal	7-9	10-12	13-15	16 +	Total legal	Total fish
3a	176	3-29					1				1	1
5a	176	3-19					1				1	1
9a	125	3-19			1		1					1
13b	176	3-29	2	3	6	11	2	3			5	16
18b	176	8-12	1	2	3	6						6
18c	176	6-16		10	6	16	2	1			3	13
18c	176	8-12	1	5		6						6
18d	176	6-16			1	1	4	1			6	6
18e	176	6-16		8	1	9	5	1			6	15
23b	176	6-12	6	7	13	26	15	8			23	49
24a	176	6-19	10	20	27	57	10				10	67
24a	176	7-26		34	49	83	43	4			47	130
25a	176	6-13	7	51	19	77	5	2			7	84
25a	176	9-7		15	24	39	4				4	43
25b	176	5-3	10	19	23	52	3	1			4	56
25b	176	6-27	1	14	21	36	8				8	44
25c	176	7-16	4	10	28	51	20	1			21	72
25c	176	9-7		4	18	22	10	2			12	34
25d	180	6-27		5	5	10	8	1			9	19
25e	176	6-27	2	7	2	11	2				2	13
A	60	6-30		2		2						2
B	60	6-30		6	1	7	1				1	8
F	176	6-30		3	6	9	20	4			24	33

Table 12. Summary of German Brown Trout recovered by electric shock from a series of stations in the Logan River, Utah, 1948.

Sta. No.	Lgth. of Station (Yards)	Date	Length of fish in inches 0-2	3-4	5-6	Total sub-legal	7-9	10-12	13-15	16 +	Total legal	Total fish
1	100	8-25	2	3	4	9	8	2	5		15	24
3a	176	9-15			1	1	5	2	1	1	9	10
5a	176	7-26		11	22	33	21	10			31	64
6	*	9-22					1	3			4	4
12a	176	9-23	2	18	47	67	7				7	74
12a	176	10-9	5	19	58	82	17	1	1		19	101
12b	176	7-2	5	14	43	62	15	3			18	80
12b	176	9-23	16	19	55	90	23	1			24	114
12b	176	10-9	3	23	42	68	13	3		1	17	85
13a	120	8-16							1		1	1
18b	176	10-9		1		1		1			1	2
18c	176	7-2	3	4	10	17	5				5	22
23a	176	8-28						1			1	2
24a	176	6-28			1	1						1
24a	176	8-30					2				2	2
25b	176	8-30					2				2	2

* Gill nets (350 feet of experimental mesh for 4 hours).

Table 13. Summary of German Brown Trout recovered by electric shock from a series of stations in the Logan River, Utah, 1949.

Sta. No.	Lgth. of Station (Yards)	Date	Length of fish in inches: 0-2	3-4	5-6	Total sub-legal	7-9	10-12	13-15	16 +	Total legal	Total fish
3a	176	3-29					16	4			20	20
3a		7-14			2	2	4	6	1		11	13
3b	110	7-14			1	1	6	2	1		9	10
5a	176	3-19		7	12	19	58	10	1		69	88
5a	176	8-8		3	8	11	14	7	1		22	38
5b	100	7-8		2	1	3	1				1	4
6	*	6-8					1	3	1	1	6	6
7a		4-5		8	20	28	18	17	7	2	44	72
9a	125	3-19		1		1	8	11	11		30	31
12a	176	7-5		13	42	55	17				17	72
12b	176	7-20	24	7	4	35	20	2			22	57
13b	176	3-29		1		1						1
18c	176	6-16		15	12	27	2				2	29
25c	176	8-15						2			2	2

* Gill nets (400 feet of experimental mesh for 2 hours).

to remain, for the most part, in the smaller streams with steeper gradients. It appears improbable that a correlation exists between the water temperature and distribution of Logan River trout, since the temperatures range between 47 and 53 degrees fahrenheit for the greater portion of the stream's length. Only an occasional cutthroat trout has been recovered in areas below Right Hand Fork. On two different surveys, 15 and 20 fish respectively were removed from one tenth mile sections on Right Hand Fork. Large numbers of cutthroat trout were found in the mouth of Temple Fork, 90 percent of which were sub-legals, or less than seven inches in total length. The areas above the Utah State Agricultural College Forestry Summer Camp is populated predominantly by cutthroats and the number per one tenth mile section often exceeds 150 (Figure 5).

The brown trout is confined for the most part to three definite areas of the Logan River. The largest number, legals and sub-legals, are found in the area from the Crockett avenue dam, in Logan City, to the mouth of Right Hand Fork (Figure 6). The second area, Right Hand Fork, has a large population; often as many as 100 fish in a one tenth mile section, but the number of sub legal fish is disproportionately high. Lower Temple Fork, principally Spawn Creek, is the third area with an abundant population of brown trout. In this area, sub-legal fish ranging up to 29 per one-tenth mile predominate.

The rainbow trout is stocked throughout the length of the Logan River. Eastern brook trout are limited in range to the area above the Forestry Summer Camp. Numbers of this species are minimal and it is probably of little importance as a competitor with the cutthroat

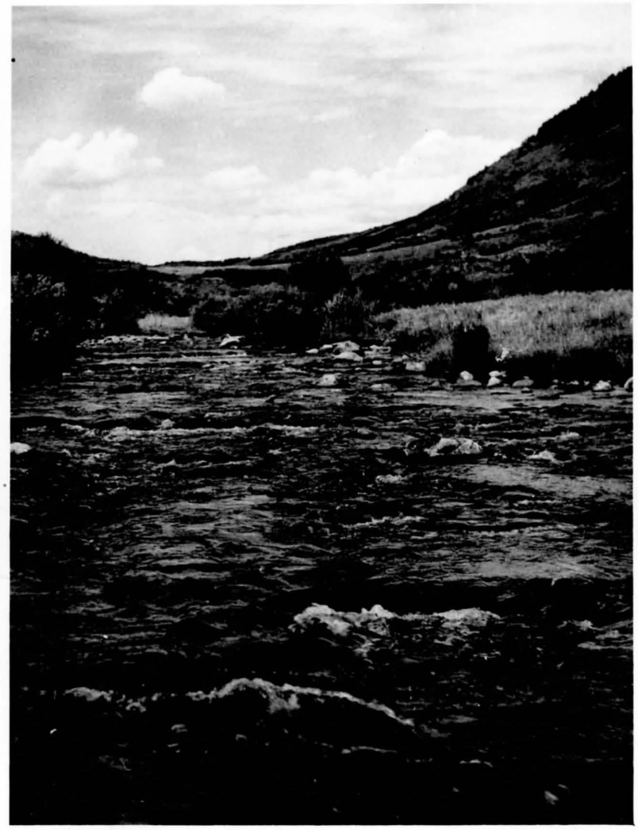

Figure 5. A section of the Logan River at Station 21, taken September 9, 1949.

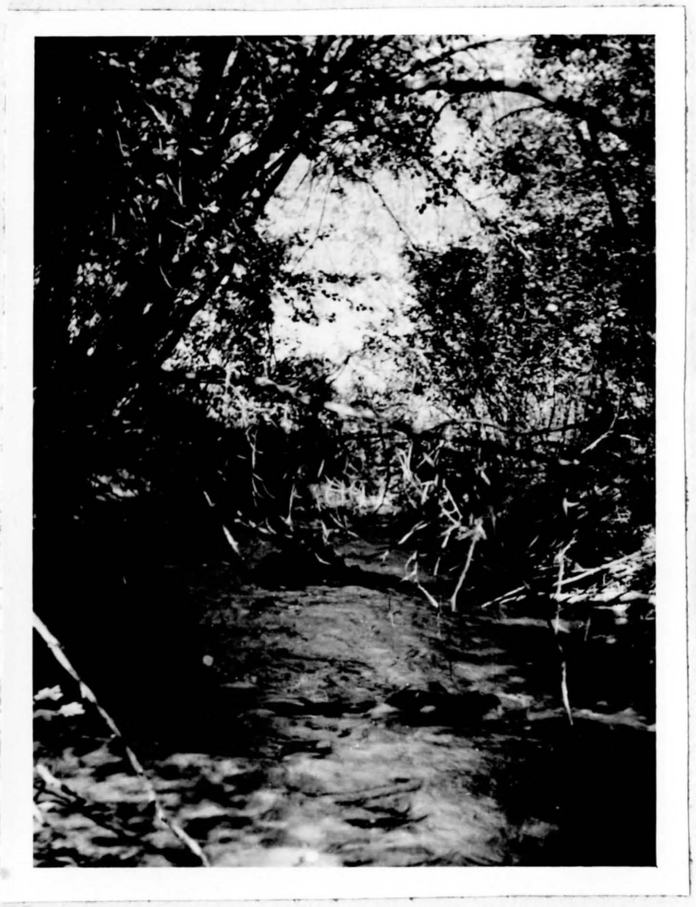

Figure 6. A section of Right Hand Fork taken September 9, 1949.

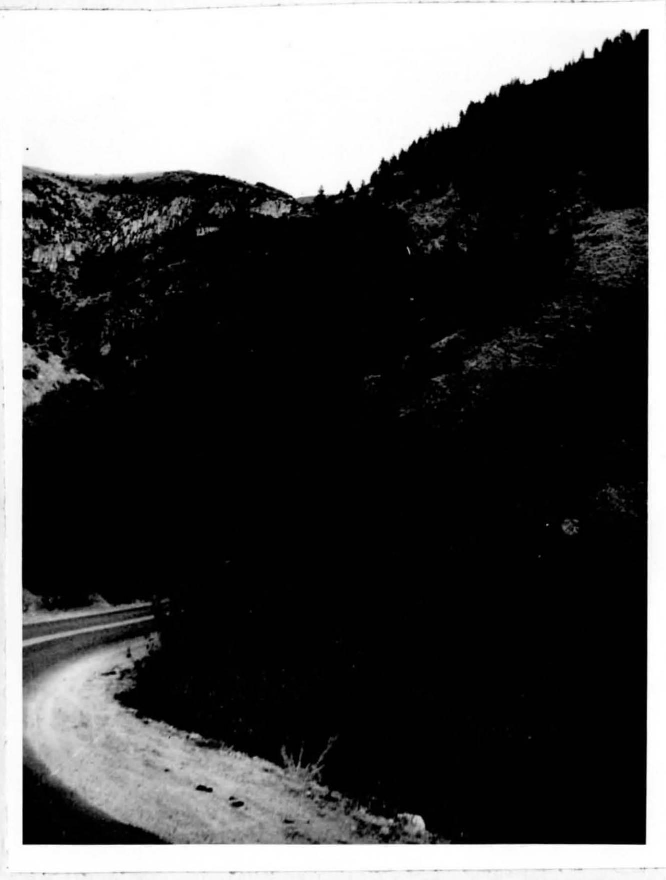

Figure 7. A section of the lower Logan River at Station 9, taken September 9, 1949. The gradient in this locality is about 35 feet per mile.

trout for food or space.

Mountain whitefish are present in the deep areas from about one mile above the Franklin Basin road junction to below the first dam of the Logan River. This species is extremely numerous in the impoundments and is undoubtedly a competitor with the brown trout. No mountain whitefish have been obtained from electric shocking operations in the tributaries of the Logan River, although further studies may reveal inroads into the smaller side streams during the spawning period, with subsequent competition at that time of year.

Belding's muddler is present in large numbers in the lower Logan River, with some areas yielding as many as 150 per one tenth mile section. Preliminary food habits studies of the brown trout have revealed to some extent the importance of the muddler as a food item for that species. In the upper Logan River, the number of sculpins is small and the line of demarcation above which no sculpins have been obtained is the lower end of station 25.

The smallfin redside shiner was recovered only at stream section 6.

In addition to estimating the population of the cutthroat trout the pounds per acre was determined for 476 yards of stream (Table 14). This figure is based on the average recovery from four stations chosen from the total 16.9 miles of stream above the juncture of Temple Fork. The area was determined for each section September 9, 1949.

The total of 55.5 pounds per acre represents the number recovered and must be considered as a minimum population. More fish may have been present. However, in the operations evaluated in table 14, extreme care was taken to insure the greatest possible recovery. Nets were

Table 14. The pounds of fish per acre and the number of fish per mile recovered in the headwaters of the Logan River, Utah, 1949. Based on 4 stations with a total length of 476 yards

Species	Pounds per acre	Number per mile
Cutthroat trout	43.6	565
German Brown trout	9.2	20
Eastern Brook trout	2.7	10
Total	55.5	595

placed at both ends of the section and the entire area was shocked four to six times. When consideration is given as to the relative accessibility of these stations it is concluded that they are representative of the greater part of the stream.

The figure of 43.6 pounds of cutthroat trout per acre represents the standing crop of fish at that time for the drainage. Although it is not a final figure based on all of the shocking operations performed, nevertheless it is useful as an indicator of fish productivity for this drainage.

A total weight of 9.2 pounds per acre for the brown trout is based upon two large fish with a combined weight of 1.75 pounds. Recoveries of brown trout above Temple Fork were meager, although a population ranging from 22 to 29 brown trout per one tenth mile section was found in Spawn Creek. Brown trout were taken only eight times in the 44 operations conducted in waters where cutthroat were the most abundant fish.

A comparison of the Logan River with a number of other trout waters where surveys of standing crops have been made indicated that the cutthroat waters of this drainage had a poundage and makeup similar to a number of streams. Smith, Johnson, and Hinér (1949) listed the pounds per acre of trout on the Minnesota north shore as ranging from 101.2 in French River down to as low as 2.85 in Manitou River. They found about 44 pounds per acre of trout in the Root River, although this represented only 17 percent of the total of 251.1 pounds of fish recovered in that stream. Hoover (1938) described similar conditions among fish populations in brook trout streams in New Hampshire.

Although the Logan River supported a standing crop of fish nearly equal to that of some other good trout streams the number of forage fish here was negligible. No muddlers, the principal forage fish in the lower Logan River, were taken in any of the four stations selected for the study of the standing crop. In no instance were muddlers recovered above station 24, an area representing nearly one fourth of the study site.

TAXONOMIC PROBLEMS

Identification of the cutthroat trout in the Logan River is, for the most part, difficult. Two features make the taxonomic problem in this area exceedingly complex. The original native found in this drainage was the Utah cutthroat trout, believed at the present time to be extinct.[1] In all probability, its eradication was due, in part, to the indiscriminate planting of the Yellowstone cutthroat. This resulted in hybridization of the subspecies of Salmo clarkii. In addition, introduced rainbow trout further complicated identification by hybridizing with the cutthroats.

A number of collections of fish whose identity was uncertain were sent to Dr. Robert R. Miller, Museum of Zoology, University of Michigan, Ann Arbor, Michigan, for identification. A collection was taken on November 18, 1949 at a point approximately 3.5 miles below the Idaho state line on Beaver Creek. Six of the fish were photographed in color after which the fish were labeled, described on the basis of color of the throat patch, before being sent to Miller. A great deal of variation can be seen from the typical cutthroat mark of the upper fish

1. Letter from Dr. Robert R. Miller, Associate Curator of Fishes, Univ. of Mich., Ann Arbor, to Dr. William F. Sigler, Assistant Professor of Wildlife Management, Utah State Agricultural College, Logan, Utah. February 18, 1949.

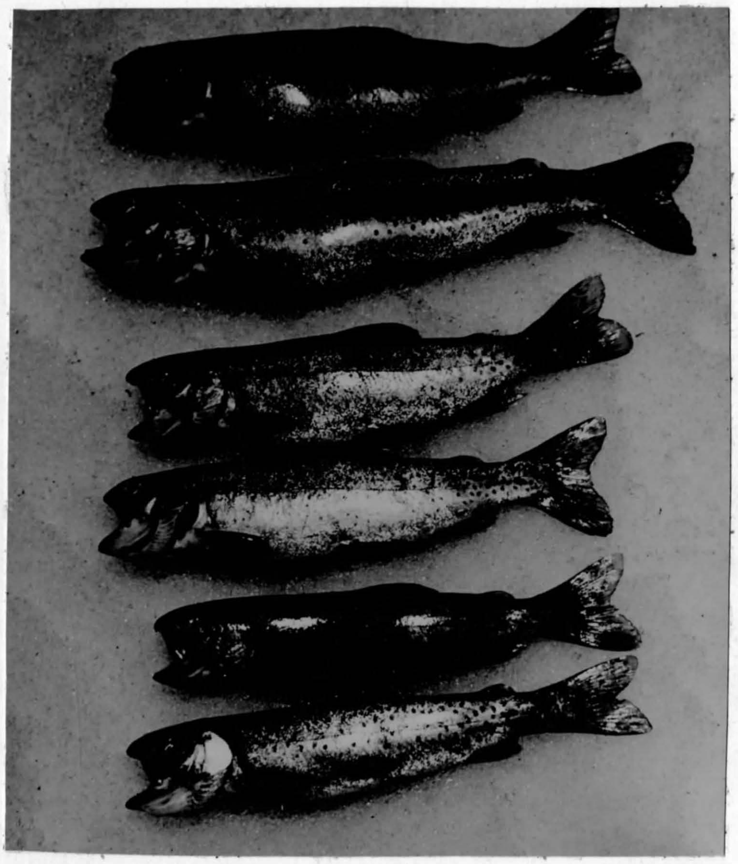

Figure 8. A series of cutthroat trout captured November 19, 1949, showing variation in the coloring of the throat mark. (x.30).

through the hybrid coloration of the lowermost fish (Figure 8). All of the fish in figure eight were cutthroats.[1] One of the principal bases for Miller's interpretation appeared to be the hyoid teeth which are present in this species and absent in the rainbow trout. A group of fish taken one half mile above the former collection station and dated June 19, 1949 contained some hybrids and at least one cutthroat.[2]

Collections sent to Miller have shown for the most part that the stock further up stream is usually less apt to show hybridization. Several small lots taken in the headwaters, above the state line in both Beaver Creek and in the Logan River west of Beaver Mountain, were composed entirely of cutthroats. The line of demarcation for hybrids and cutthroats cannot be defined. Rainbow trout have been planted beneath the first bridge on the Beaver Creek road just north of the main highway. The fish found in the stream above station 24, about one half mile below the bridge just mentioned, are mostly cutthroats. The problem areas are for the most part from station 24 down to the mouth of Temple Fork.

Since the study was not confined to the extremely high areas, a criteria was sought for choosing reliable specimens of cutthroat trout. For field identification, characteristics listed in table 15, prepared by Miller, were used to compare rainbow and cutthroat trout.

In many instances, the cutthroat marks found beneath the lower jaw may be misleading. Identification based on one character appears to

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1. Letter from Dr. Robert R. Miller, Associate Curator of Fishes, Univ. of Mich., Ann Arbor, to Dr. William F. Sigler, Assistant Professor of Wildlife Management, Utah State Agricultural College, Logan, Utah. February 15, 1950.
2. Loc. cit. August 3, 1949.

Table 15. A provisional comparison between cutthroat and rainbow trouts of the Intermountain Region.*

Character	Cutthroat (*Salmo clarkii*)	Rainbow (*Salmo gairdnerii*
Cutthroat mark	Typically a conspicuous blood-red dash, visible externally; varying from yellowish-orange to salmon and strawberry: weaker in young fish	Absent; occasionally with an indistinct, pale yellowish or reddish dash not visible externally.
Hyoid teeth	Present; 3 to 13.	Absent
Border on anal, pelvic and dorsal fins	Typically not light: red, rosy, dusky or plain in life; tips occasionally light.	Conspicuously milky-white, orange or yellowish in life.
Oval or round spot behind eye	Well developed, particularly in adults	Absent
Spotting	Spots usually larger, more regular in size and shape, and typically concentrated posteriorly.	Spots usually smaller, more irregular in size and shape and more diffuse.
Red lateral band	Usually weak or absent; sometimes with a reddish-pink, or salmon-pink "Band", but narrower than the "rainbow band" of <u>gairdnerii</u>.	Usually broad and well developed, with definite margins; red or pink in life.
Length of upper jaw 1/	Conspicuously longer; 1.6 to 2.1, usually 1.7 to 1.9, in head length	Noticeably shorter; 1.9 to 2.2; usually 2.0 to 2.1, in head length.
Shape of head	Longer and more pointed; conical	Shorter and blunter; rounded.
Number of scales	Usually more than 155 scales along side 2 rows above lateral line (150 to 205)	Usually less than 155 scales along side 2 rows above lateral line (116 to 165)
Pyloric caeca 2/	27 to 40	39 to 80

* Compiled by Dr. Robert R. Miller, Associate Curator of Fishes, University of Michigan, Ann Arbor, September, 1949.

1/ There is considerable sexual dimorphism in this character, particularly in breeding fish. The maxillary often becomes attenuate in old rainbows, extending far beyond the eye.

2/ Based only on a few counts of local populations. Hundreds of more counts on widely ranging material are needed to verify this difference.

be better determined by an examination for the presence of hyoid teeth (Table 15). Needham stated that a check of the hyoid teeth (basic branchials) of cutthroats was the best character for differentiating them from rainbows.[1] This character, in combination with the throat mark and the body spotting usually determines the species in hand with reliability.

The problem of fertility of the rainbow-cutthroat cross has arisen as a result of the observed hybridization. Sigler stated in personal conversation with Mr. H. W. Baker of the Fish and Wildlife Service Fish Hatchery at Ennis, Montana, that the latter's experiments over a period of many years with this type of hybrid have shown that they are fertile among themselves and also in backcrosses.[2]

There is a large number of sub legal fish per mile in the area of the Logan River inhabited principally by hybrids. This may indicate that a high number of the hybrid trout are fertile.

REPRODUCTION

Several authors have studied the spawning habits of cutthroat trout. The actual spawning act has been described by Smith (1941) and Cramer (1940). Smith (1945) presented information on mortality and showed it was highest just after the emergence of the fry from the gravel.

In this drainage, some information on the period of spawning has been provided by examination of specimens collected in the course of

1. Dr. P. R. Needham, Department of Zoology, University of California, in a personal conversation with the writer, 15th North American Wildlife Conference, San Francisco, March 6, 1950.
2. Dr. William F. Sigler, Assistant Prof. of Wildlife Management, Utah State Agricultural College, Logan, in a personal conversation with the writer.

shocking operations. During 1948 most of the females were ripe; that is, the eggs could be removed by stripping up to June 18. In 1949 the period was noted more closely and was found to range from April 12 up to August 16 although the principal number of fish taken after July 19 were spawned out. **Smith** (1941) listed the spawning dates as May 4 to May 15 (1940) for the cutthroat trout taken from Heenan lake and transported to Convict Creek for observations. The Lahontan cutthroat (Salmo clarkii henshawi) were reported spawning in Beaver creek, Elko county, Nevada on April 25, (1949), yet the same species from Walker Lake, Nevada, were stripped a number of times during the period May 15 to May 24 (1948).[1] The spawning period of the cutthroat trout in this drainage appears to cover a period of approximately four months.

No measurements of the amount of eggs present in a breeding female have been made available for the Logan River cutthroat. Smith (1945) said that female cutthroats produced an average of 2800 eggs. The Walker lake fish produced eggs which varied in size from 286 to 340 per (fluid) ounce although the numbers taken per fish were unknown.[2]

Most of the gravid females in the Logan River were found in areas where the total flow did not exceed four second feet. The adult females ranged in size from 11 inches total length downward. Walker lake cutthroats spawned in streams in which the depth varied from three to six inches and the total flow fluctuated between 5 and 8 second feet.[3] For the age of the mature females, see the section on age and growth.

1. Letter from Thomas J. Trelease, Fisheries Technician, Nevada Fish and Game Commission, to the author, dated March 27, 1950.
2. op. cit.
3. op. cit.

PARASITISM

Each stomach was examined for parasites. One species of nematode was found in 16 of the fish, an incidence of 6.8 percent. Identification other than to phylum was not accomplished. In eight of the occurrences, only one parasite was present in each stomach, while in the other eight, 2 round worms were discovered in each instance. The average length of the parasite, based on the measurements of 8 specimens, was 45 millimeters.

A tapeworm was observed in the lower intestine of one specimen of cutthroat trout.

No other parasitism, either external or internal, was found.

AGE AND RATE OF GROWTH

Number of Fish Studied

A total of 49 young fish and 234 fish one or more years old were used in the age and growth studies. Although scale measurements were taken of all fish, only those having one or more annuli were used in the summary of the average calculated growth. The 1948 and 1949 fish were placed in 10 millimeter length classes, sexes combined.

The Body-Scale Relationship and Calculation of Growth

An examination of the body-scale relationship in table 16 revealed that a straight line or linear relationship could not be used for the calculation of growth. The ratio was high in the length groups from 40 to 60 millimeters, low from 70 to 130, and again increasingly high in the groups from 140 to 250. Essentially, the scales grew faster in proportion to body length in those fish between 70 and 130 milli-

Table 16. The length-scale ratio of 284 Logan River cutthroat trout. Based on 10 millimeter standard length intervals.

Average standard length	Average scale radius	Length-scale ratio	Number of fish
44.1	6.2	7.11	8
64.4	10.4	6.19	10
74.0	14.1	5.27	12
86.1	16.6	5.19	15
96.6	17.1	5.65	23
105.6	18.6	5.66	20
115.4	19.9	5.80	19
125.7	21.0	5.99	26
135.5	25.7	5.27	28
145.2	23.1	6.29	29
155.8	23.4	6.66	15
165.3	25.8	6.41	20
175.8	28.5	6.17	9
185.5	28.9	6.42	13
195.2	28.7	6.80	14
203.5	29.6	6.88	8
219.6	31.0	7.08	3
224.8	28.6	7.86	6
236.5	34.0	6.96	2
243.0	37.0	6.57	2
255.0	33.0	7.72	2
Weighted Average		6.08	

meters in length than in those individuals above and below these limits.

The general mathematical relationship between the standard length and the scale radius of fish was described by Hile (1941) as:

$$L = cS^n$$

where L = body length
S = anterior scale radius
and c and n = constants

The values of c and n were found by the least squares method with the values of standard lengths and the magnified scale radii of the fish converted to logarithms. The resulting equation was:

$$\text{Log } L = 0.53923 + 1.20061 \text{ Log } S$$

The arithmetic form of the above equation is:

$$L = 3.4111 \, S^{1.20061}$$

The closeness of fit between actual and calculated data is apparent (Figure 9). The 10 millimeter length groups at either end of theoretical curve show the greatest disagreement, but are based on relatively few fish.

All scales used in the study were read three times, and in each instance were aged without regard to previous determinations. Less than two percent of the fish were eliminated from the final calculations because of questionable scale readings.

The computation of growth was determined by the use of a nomograph in which the movable rule was graduated in body length values determined by the logarithmic formula, and the stationary base was graduated into equal parts as scale radius values.

Table 17 is a summary of the average calculated lengths and increments of growth for 234 cutthroat trout. The growth increment for each

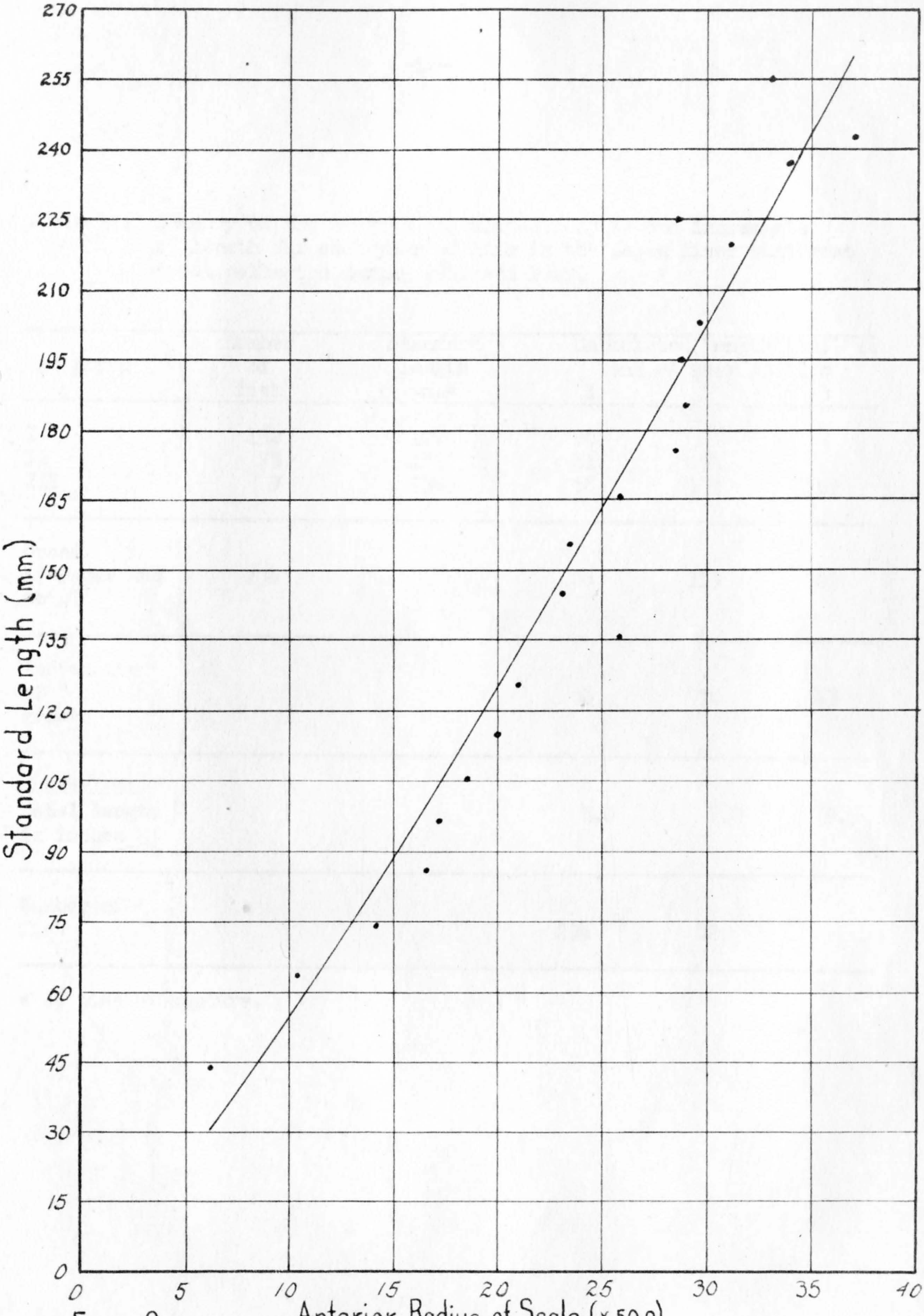

Figure 9.

Body-scale relationship of 284 Logan River cutthroat trout. Dots are based on the averages of table 16.

Table 17. Summary of the average calculated lengths and increments of length for each year of life in the Logan River cutthroat trout collected during 1948 and 1949.

Age group	Number of fish	Standard length mm.*	Calculated length (mm.) at end of year of life 1	2	3
I	152	127	90		
II	73	183	81	151	
III	9	235	68	131	202
Grand averages and total	234		86	149	202
Increments of growth			86	70	53
Equivalent total length in inches			4.0	7.0	9.5
Number of fish			234	82	9

* At time of capture.

year shows a uniform decrease of about 16 millimeters. It is at once evident from the summary of ages that few fish attain the age group III, which is actually the fourth year of life.

The relatively small sample of fish precluded determining whether or not a dominant year class existed.

Although the time of annulus formation was determined, some difficulty was encountered when fish of the same size were found that had either one or no annulus. A nearly parallel situation was encountered by Robertson (1947) who concluded that certain of the young cutthroat trout had failed to reach the length at which scales are formed before the growth check of the first winter. Needham and Vestal (1938), in a study of the Golden trout in two high sierra lakes, pointed out that in one year old trout from one lake, no growth check was present, although the fish were recovered during the second year and after an entire winter in the lake. They believed the actual scales were not formed until the fish reached their second summer. Repeated observation in this area failed to reveal any fish that had passed into the first winter without scales. However, the fish with less than 7 circuli apparently failed to lay down a growth check at the end of the first calender year.

A series of small trout were taken into the laboratory on October 1, 1949 and examined for amount of scalation. Figure 10 shows a highly magnified view of a scale from a trout 39 millimeters long, in which the scales are just beginning to appear in the pockets. In figure 11 the scales are from a fish with a length of 45 millimeters having three circuli visible. In figure 12 the fish which is 63 millimeters in

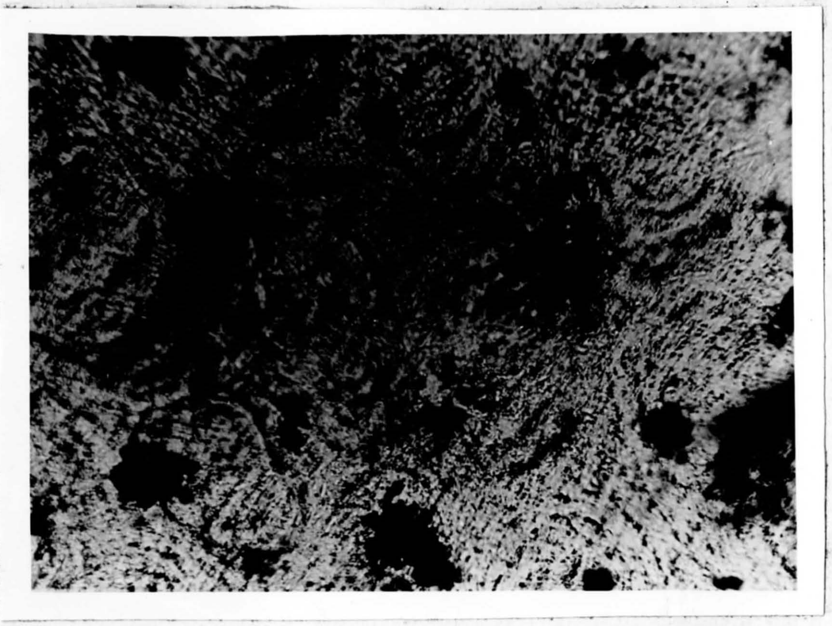

Figure 10. Scale buds of a 39 millimeter cutthroat trout, captured October 1, 1949. (x 400).

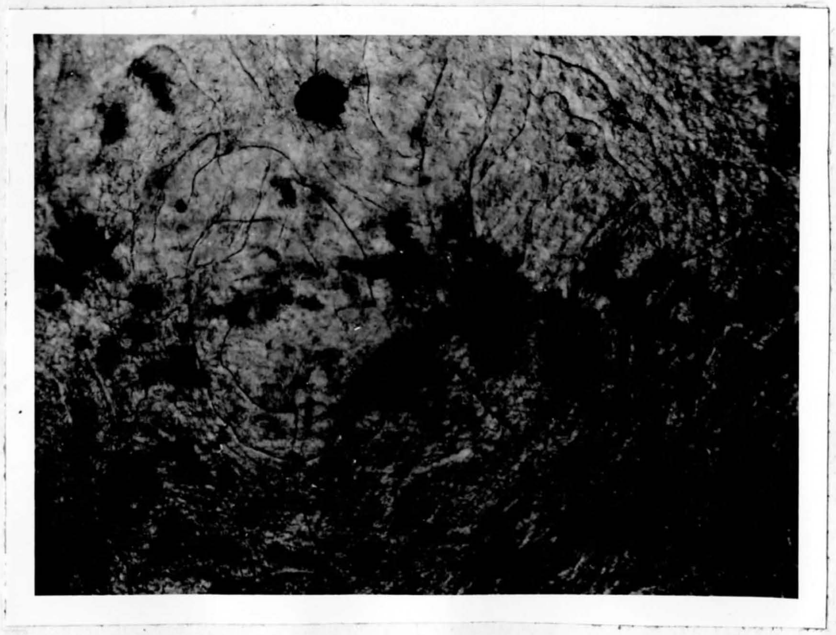

Figure 11. Section of skin with scales from a 45 millimeter cutthroat trout, captured October 1, 1949. Three circuli are visible. (x 400).

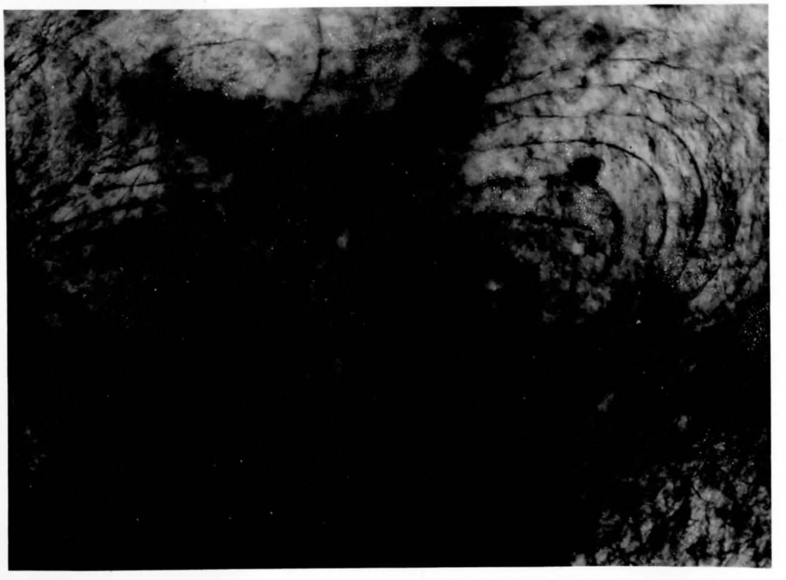

Figure 12. Section of skin with scales from a 63 millimeter cutthroat trout, captured October 1, 1949. Seven to nine circuli are visible. (x 400).

Figure 13. Scale of a 165 millimeter cutthroat trout, captured October 9, 1948. The current annulus is complete. (x 700).

Figure 14. Scale of a 181 millimeter cutthroat trout, captured May 31, 1948. Growth for current season has begun. (x 1300).

Figure 15. Scale of a 229 millimeter cutthroat trout, captured May 31, 1948. Growth for current season has begun. (x 1300).

length has from 6 to 7 circuli. In the Logan River population, no first annulus was found in fish with less than 7 to 9 circuli. Robertson (1947) observed a series of 6 to 11 completed circuli before the first growth check.

It is apparent that a small percent of the fish may not be aged correctly. That is, some of the fish may actually be a year older than is indicated. This produces no great error in representing the age or rate of growth, since the fish which fail to form a growth check are spawned quite late, and thus have a comparatively short first growing season of from one to two months. (See section on reproduction).

Figure 13 shows the scale from a 165 millimeter cutthroat trout, recovered on October 9, 1948. Two annuli are present with the one for the current year being laid down at the time of the fish's capture. Figure 14 is of a scale photo from a 181 millimeter fish taken May 31, 1948. Two annuli are also visible in this scale and a bit of the 1948 growth is present at the extreme edge of the scale. Figure 15 is a scale from a fish with a standard length of 229. It is just one year older than the fish in Figure 14 and also shows the beginning of the current (1948) seasonal growth.

Age and Length at Maturity

During 1949 a total of 109 fish were examined for sexual development. All of the fish examined were two or more years old.

The standard length class 121 to 130 millimeters contained 6 adult males (average total length 5.8 inches). This group, which contained a total of 26 fish, also included 8 sub-adult females.

One adult male of 120 millimeters was noted while the smallest adult female was 134 millimeters in length.

The males matured faster in every instance. Very few mature females were present in the length classes below 180 millimeters. Adult females were usually slightly longer than the seven inch legal length limit, but a number of adult males did not exceed the minimum legal size.

In age group I, 34 percent of the fish were mature. In age group II, 100 and 92 percent respectively of the males and females were adults.

Length-Weight Relationship and Coefficient of Condition

The length weight relationship was determined by the following formula:

$$W = CL^n$$
where C = a constant
and n = a constant

This type of equation has been used by Beckman (1948), Hile (1941), and numerous other workers.

Values for the constants C and n were found by the least squares methods by converting the average lengths and average weights of each length class to logarithms.

The data are presented with sexes and length groups combined in the following logarithmic equation:

$$\text{Log } W = -4.36207 + 2.82534 (\text{Log } L)$$

Or arithmetically as:

$$W = 4.344 \times 10^{-5} L^{2.82534}$$

The length-weight relationship of the Logan River cutthroat is summarized in table 18, whereas in figure 16 the actual weights and

Table 18. The length weight relationship of the cutthroat trout from the Logan River, Utah. Based on the lengths and weights of 276 fish taken during 1948 and 1949. Sexes combined.

Average standard length in mm.	Equivalent fork length in inches	Equivalent total length in inches	Ave. weight in ounces	Ave. weight in grams	Calculated weight in grams[1]	Difference between actual and calculated weight in grams	Number of fish
64.4	2.95	3.16	.24	6.5	5.6	- .9	10
74.0	3.35	3.56	.28	8.0	8.3	+ .3	12
86.1	3.89	4.14	.43	12.3	12.4	+ .1	15
96.6	4.33	4.59	.57	16.1	17.6	+ 1.5	23
105.6	4.73	5.01	.75	21.1	22.7	+ 1.6	20
115.4	5.15	5.48	.98	27.8	29.1	+ 1.3	19
125.7	5.62	5.96	1.30	37.0	37.9	+ .9	26
135.5	6.05	6.40	1.64	46.4*	45.9	- .5	28
145.2	6.48	6.83	2.03	57.4	55.8	- 1.6	29
155.8	6.89	7.26	2.42	68.6	68.0	- .6	15
165.3	7.34	7.76	2.98	84.4	80.4	- 4.0	20
175.8	7.80	8.23	3.52	99.6	95.7	- 3.9	9
185.5	8.19	8.64	4.08	115.6	111.4	- 4.2	13
195.2	8.66	9.10	4.49	127.2	128.6	+ 1.4	14
203.5	9.04**	9.46	5.42	153.3	144.7	- 8.6	8
219.6	9.72	10.16	5.66	160.3	179.4	+ 9.1	3
224.8	9.91	10.41	7.00	198.1	192.6	- 5.5	6
236.5	10.39	10.83	8.36	236.6	221.2	-15.4	2
243.0	10.67	11.18	7.99	226.2	238.8	+12.6	2
255.0	11.18	11.65	9.52	269.5	273.6	+ 4.1	2

1. Computed by the formula: $\log W = 4.36207 + 2.82534 (\log L)$.

* n = 27

**n = 7

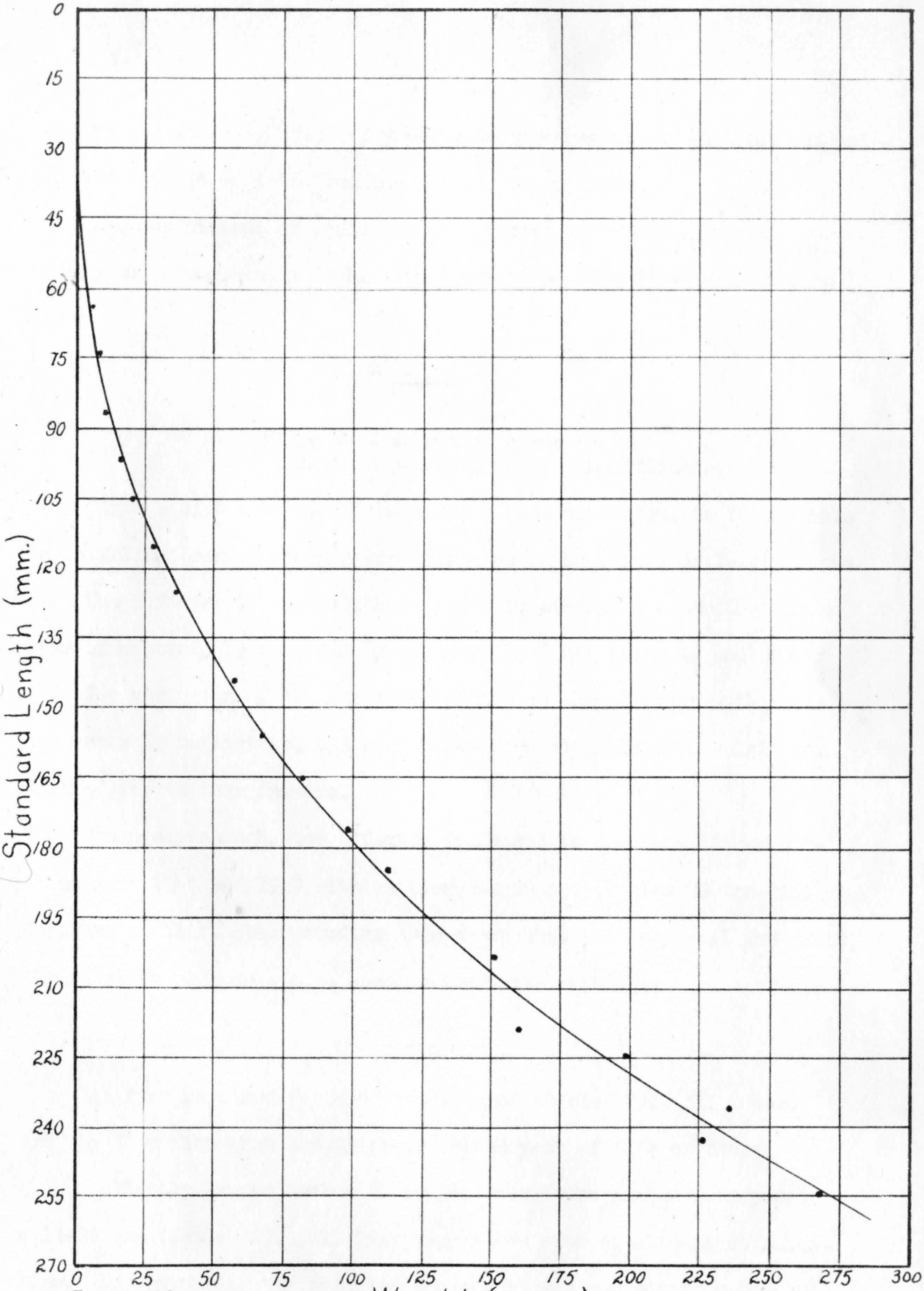

Figure 16.

Length-weight relationship of 276 Logan River cutthroat trout. Dots are based on the average standard lengths and actual weights of table 18.

lengths are shown as dots. The curve is based on actual lengths and calculated weights derived from the formula shown above.

The coefficient of condition or K factor is a commonly used measure of plumpness in fish. The formula by which it was determined is:

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

where W = weight in grams
and L = standard length in millimeters

Since a high value of K indicates a good condition, it is possible to establish trends within a population on an age, sex, or length basis.

The K factor of the cutthroat trout is presented according to the year of capture, by sex, and by standard length (Tables 19 and 20).

The variation of the condition of the cutthroat trout within the two years is negligible, although males have slightly more weight per unit of length than females.

Strangely enough, the K factor decreased in the Logan River cutthroats in 1948 and 1949 with an increase in age (Tables 20 and 21). Contrary to this, other studies have shown that in nearly all instances, the relative plumpness of a species increases with age.

SEX RATIO

All fish retained for study were sexed (Table 22). All records are based on fish that are in their second year of life or older.

A slightly larger number of females was found in the 35 separate collections (Table 22). All fish were taken with no attempt at selection. Except during the spawning season, it was not possible to sex

Table 19. The coefficient of condition of the Logan River cutthroat captured in 1948 and 1949. Sexes presented separately and combined.

Year of collection	Sex	Sexes combined	K factor
1948	Male	47	1.841
	Female	51	1.746
	Total	98	1.791
1949	Male	67	1.876
	Female	76	1.806
	Total	143	1.839
1948 and 1949	Male	114	1.862
	Female	127	1.782
	Total	241	1.819

Table 20. The coefficient of condition in relation to the standard length of 277 cutthroat trout collected from March through November during 1948 and 1949 from the Logan River, Utah. Years of capture and sexes combined.

Average standard length	K factor	Number of fish
64.4	2.373	9
74.0	1.969	12
86.1	1.891	14
96.6	1.811	23
105.6	1.800	20
115.4	1.806	19
125.7	1.863	26
135.5	1.872	27
145.2	1.873	29
155.8	1.804	16
165.3	1.870	20
175.8	1.830	10
185.5	1.810	13
195.2	1.735	15
203.5	1.820	8
219.6	1.532	3
224.8	1.742	6
236.5	1.788	2
243.0	1.626	3
255.0		2

Table 21. The coefficient of condition (K factor) in relation to the standard length and sex of 241 cutthroat trout collected from March through November during 1948 and 1949 from the Logan River, Utah.

Standard length (mm.)	Number of specimens		K factor
50-74	Male	1	2.025
	Female	3	1.742
75-99	Male	10	1.856
	Female	14	1.815
100-124	Male	20	1.892
	Female	25	1.832
125-149	Male	28	1.940
	Female	33	1.798
150-174	Male	20	1.869
	Female	23	1.797
175-199	Male	22	1.823
	Female	14	1.745
200-224	Male	10	1.708
	Female	7	1.751
225-249	Male	3	1.733
	Female	6	1.589
250 and above	Male	-	----
	Female	2	1.621

Table 22. The sex ratio of 241 cutthroat trout *Salmo clarkii* retained during 1948 and 1949 from the Logan River, Utah.

Year of capture	Number of males	Number of Females	Females per 100 males
1948	47	51	108
1949	67	76	113
both years combined	114	127	111

the fish by external characteristics. Therefore, those fish which were released were rarely sexed.

FOOD HABITS

General Feeding Habits and Trends

Very few studies of the food habits of the cutthroat trout have been published. Hazzard and Madsen (1933) concluded that trout from rather similar streams but in different regions showed a high degree of variation in the items consumed. Their findings were in direct contrast with those of Muttkowski (1925), who stated that "the mountain streams of the park (Yellowstone) and their fish are typical of the trout streams throughout the Rockies." Muttkowski indicated that the physical conditions present in streams of several Rocky mountain states did affect, to a certain degree, the native redthroat or cutthroat trout. He found that stoneflies comprised 90 percent of their diet, while mayflies were second in importance. The caddis flies, by nature well protected with their cases, formed the third most important item of diet.

Calhoun (1944) in a study of the black-spotted trout in two Sierra Nevada lakes found that the most important food was an immature chironomoid. He noted an almost complete absence in the trout diet of a small minnow which was abundant in the shallows around the lake.

Hildebrand and Towers (1927) showed that relatively few classes of food organisms were present in Fish Lake, Utah, Daphnia pulex being the principal food item. Immature midges were second only to Daphnia in the quantity taken.

Numerous studies of food habits of trout other than the cutthroat revealed trends similar to those observed in the upper Logan River cutthroat. Needham (1933) found 50 percent of the food of the rainbow trout in the Wasatch mountains of northern Utah to be mayfly nymphs of the genus Ephemerella.

The Logan River cutthroat trout had a diet composed almost entirely of insects. The bulk of the insects were Ephemeroptera and Trichoptera. The only vertebrate taken was fish. The amount of plant material was negligible. Almost no spawn entered the diet.

The absence of a suitable forage fish in the headwaters of the Logan River drainage may in part be responsible for the comparatively small size of the cutthroat trout. Ricker (1930) found that the food of speckled trout in Ontario changed with increase in size of the fish from entomostraca to chironomid larvae, to other aquatic and terrestrial insects, then crayfish, and finally fish.

Over the two year study period, material has been gathered during the seven months of March through October. No data were taken in September. Many of the summer months were repeated the second year so the food habits are presented for eleven months during the two year period.

No stomachs were taken from November through February of either year. However, this absence of stomachs during that period should not decrease the value of this study since the growth period has been covered. (See section on age and growth). Ball (1948) in speaking of warm water lakes says:

> "It is believed that inability to take fish (bass, bluegills) in winter on this lake (Third Sister Lake, Michigan) does not in any way invalidate the conclusions drawn from food studies carried out during the open-water period. Any change in the food supply during the winter would have little or no effect on the growth of game fish since the low temperature reduces their metabolism to a point where food taken during

Table 23. Food of the 1948 cutthroat trout from the Logan River, Utah expressed as percentages of frequencies of occurrence, and percentages of total volume of food items.

Date of collection	May		June		July		August		October	
Number of stomachs taken	14		17		35		16		3	
Number of stomachs containing food	13		17		34		16		2	
Percent of stomachs containing food	93		100		97		100		66.7	
Total volume of food (cc)	13.57		15.54		34.30		10.33		.05	
Total length of fish (mm.) Range	109-266		90-262		110-290		118-249		185-198	
Mean	194.5		188.1		180.7		156.4		190.3	
	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume
Insects	100.0	97.6	100.0	52.6	100.0	100.0	100.0	100.0	100.0	100.0
Undetermined insects	61.5	23.4	58.8	14.5	82.4	30.2	68.8	36.3		
Determined insects	100.0	74.2	100.0	38.1	100.0	69.8	100.0	63.7	100.0	100.0
Orthoptera			5.9	4.5	20.6	6.6	6.2	.2		
Plecoptera			76.5	4.5	14.7	3.1	43.7	7.4		
Odonata					2.9	.1				
Ephemeroptera	92.3	12.2	82.4	7.1	79.4	30.8	100.0	34.8		
Hemiptera	23.1	.9			5.9	.1				
Neuroptera					5.9	.2				
Trichoptera	61.5	27.7	64.7	15.1	52.9	11.0	68.8	15.5		
Diptera	8.5	20.0	58.8	4.5	55.9	8.1	18.7	5.6	100.0	100.0
Coleoptera	38.5	10.6	23.5	1.0	32.3	4.4				
Hymenoptera	53.8	2.8	47.1	1.4	50.0	5.4	6.2	.2		
Arachnoidea	15.4	2.4								
Aranae	15.4	2.4								
Annelida			23.5	14.3						
Fish			5.9	33.1						
Cutthroat trout			5.9	33.1						

Table 24. Food of the 1949 cutthroat trout from the Logan River, Utah, expressed as percentages of frequencies of occurrence, and percentages of total volume of food items.

Date of Collection	March		April		May		June		August		October	
Number of stomachs taken	8		14		9		42		6		71	
Number of stomachs containing food	8		13		8		42		6		69	
Percent of stomachs containing food	100.0		93		89.0		100.0		100.0		97	
Total volume of food (cc)	3.41		3.11		10.53		20.23		3.71		12.72	
Total length of fish (mm.) Range	126-294		83-229		88-208		91-272		125-218		75-257	
Mean	181.		138.6		147.9		177.5		188.2		146.6	
	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume	Occurrence	Volume
Insects	100.0	100.0	100.0	96.1	100.0	50.6	100.0	99.2	100.0	100.0	100.0	92.6
Undetermined insects	75.0	17.0	69.2	35.0	75.0	10.9	83.3	35.0	83.3	24.8	26.1	14.3
Determined Insects	87.5	83.0	100.0	61.1	100.0	39.7	95.2	64.2	100.0	75.2	100.0	78.3
Collembola											1.4	.2
Orthoptera											5.8	2.0
Plecoptera	50.0	12.9	69.2	6.2	25.0	.4	7.1	.7	33.3	2.7	33.3	4.1
Odonata											4.3	2.3
Ephemeroptera	75.0	10.0	38.5	9.7	12.5	1.9	81.0	27.5	100.0	35.3	17.4	4.3
Hemiptera			7.7	.6	62.5	2.1	2.4	.1			11.6	1.7
Neuroptera											1.4	.1
Trichoptera	75.0	50.2	76.9	28.6	100.0	17.7	79.4	13.5	66.7	30.2	50.7	23.7
Lepidoptera							2.4	.4				
Diptera	25.0	7.0	61.5	14.1	87.5	6.2	40.5	3.6	16.7	.8	36.2	6.7
Coleoptera	12.5	2.9	15.4	1.9	12.5	11.4	23.8	3.7			42.0	7.2
Hymenoptera							59.5	14.7	33.3	6.2	45.0	26.0
Crustacea											2.9	.1
Malacostraca											1.4	.1
Cladocera											1.4	tr
Arachnoidea			7.7	3.9			2.4	.8			2.9	.2
Aranae			7.7	3.9			2.4	.8			2.9	.2
Diplopoda											1.4	1.0
Annelida					12.5	1.0					5.8	1.4
Fish					12.5	48.4						
Cutthroat trout					12.5	48.4						
Fish eggs											2.9	.3
Plant material											5.8	4.4

the period of ice cover would produce little or no growth."

Since the Logan River cutthroats fed principally on insects, a study of the orders taken provides information on preference. The other food items will also be treated in detail. The absence of the larger forms of food eliminates the necessity of breaking down the food presentation on an age or length basis (Tables 23 and 24).

Specific Feeding Trends

Insects:

Ephemeroptera. Mayflies, in nearly every instance were in the nymphal stage. They were taken in greater volume and occurred more often throughout the two years than any other food item. The number consumed was also large. During July of 1948, each stomach contained an average number of 20 ephemerids. One fish had taken 130, mostly *Ephemerella coloradensis*. Mayflies were consumed every month that stomachs were taken with no apparent trend by percentages of occurrence over that period.

Trichoptera. Trichoptera is believed to have contributed less to the cutthroat diet than did the mayflies. The percentages, by volume, consumed was nearly the same for both mayflies and caddis flies. However, the number and volume of all caddis fly cases have been included in the tables because the fish take encased caddis flies in such numbers as to not warrant omitting the additional volume from the total. Ball (1947) stated that the case of a prominent species in his study area was broken down by digestion although he was not sure how much food value was present. If the food habits of the cutthroat trout were being studied from the nutritional standpoint, then the exclusion of the volume of the cases would be justified.

Diptera. This order ranked third in importance of items taken. True flies were taken in the greatest amount in May of 1949 when they accounted for 87.5 percent of the diet, by frequency of occurrence. The composition of the May, 1949 sample was nearly all chironomid larva, which accounted for the low value of 6.2 percent by volume. Chironomids were nearly always found in the larval form, with few pupal forms being determined. A number of the Tipulidae were found, often in an advanced stage of digestion. Identifications, when possible, showed a prediliction toward Tipula, while Antocha, Eriocera, and Ptychopera were recovered in some numbers.

Plecoptera. Although stoneflies were taken in 9 of the 11 months, they contributed little to the diet, since they were taken in small numbers (up to 9 individuals by one fish). The volume was inconsequential, ranging up to 12.9 percent of the total food consumed in a one month period. Nearly all of the stoneflies were the western drummer (Acroneuria pacifica). Several members of the Capniidae were found in fish from the relatively still headwaters of Beaver Creek in Idaho.

Odonata. Dragonflies appeared five times during the entire food habits study. They constituted two percent by volume of the food for October, 1949.

Neuroptera. There were two occurrences of the snake fly, Raphidia: one during July of 1948, the other during October of 1949. No other members of the order were found in stomach contents although numerous adult sialids were seen in the vicinity of the Utah-Idaho state line on

Beaver Creek and in the area of Temple Fork.

Lepidoptera. This order appeared once during June, 1949. Numerous butterflies and moths were found throughout the study area and it is likely that these soft bodied insects may be taken more than the study suggests.

Coleoptera. Beetles were of importance as a food source. During May, 1948, they comprised nearly 40 percent, by occurrence, of the food items taken. On the basis of occurrence, it was the most important terrestrial order of insects encountered. Identification of the adult beetles could often be based on the markings of the elytra, and it is believed that a higher percentage of this order may have been identified and summarized than with those insects that have relatively soft body parts. Undue weight may be given to this order as a food producer unless the percentage of volume is used. In May, 1948, this was 10.6. A large number of families was identified, most of them being terrestrial forms which had undoubtedly been taken from the water's surface. One 239 millimeter fish, captured in June of 1949, had a total of six different families represented in its stomach. These included Cerambycidae, Elateridae, Cicindellidae, Hydrophilidae, Buprestidae, and Chrysomelidae.

Hymenoptera. Formicids, while high in individual numbers, were relatively low in total volume consumed. In this order, as with others utilized by the cutthroat trout, the food contribution by months was nearly equal. Ants were taken in about equal numbers during May and June of 1948; and June, August and October of 1949. Ichneumon wasps, bees (Bombus sp.), members of the Vespidae and Sphecidae, and one occurrence of a sawfly (Tenthrenidae), was also noted.

Hemiptera. Members of this order were not fed on heavily. They appeared in the two top months as equalling approximately two percent by total volume. The system of classification employed by Essig (1942) was used to group the suborders heteroptera and homoptera. Members of the f milies Nabidae, Pentatomidae, Cicadellidae and Chermidae were identified from the stomach contents. No water striders were determined although they are seen occasionally in the pool areas of Temple Fork.

Orthoptera. Fragments of the red-legged grasshopper (Melanoplus femur-rubrum) and an unidentified genus were found in several stomach contents. In July, 1948, grasshoppers appeared as an item of some importance, with a percentage of volume of 6.6 although they were not present in the 1949 diet until October.

Collembola. Springtails appeared only once when 7, with a total volume of 0.02 millimeters, were found in a cutthroat 118 millimeters long. This recovery took place in October of 1949.

Crustacea:

Malacostraca. One occurrence of a gammarid was cited for October of 1949.

Cladocera. A small water mite found in one instance during October of 1949. It was recorded by volume as a trace since it displaced less than 0.01 milliliters of water.

Arachnoidea:

Aranae. Spiders occurred in four stomachs. They were inconsequential by total volume, ranging from 0.2 to 3.9 percent.

Diplópoda:

A millipede, probably <u>Spirobolus</u> sp., was taken from a fish collected during October of 1949.

Annelida:

The segmented worms were fed on heavily. All were of the class Oligochaeta. Considerable numbers of annelids were recovered when bottom samples were being taken from the stream during June of 1948. The percentage, by occurrence, of annelids in the cutthroat trout diet during that period was 23.5, although the relatively small size of the items gave a percentage by total volume of only 14.3.

Fish:

The fish found in the stomach contents was identified as cutthroat trout. Only two occurrences were detected in a total of 235 specimens analyzed.

The cutthroat trout is the only abundant fish in the area where most specimens for food analyses were taken. No muddlers, the principal forage fish in the lower Logan River, were found in any of the stomachs. A few muddlers, 30 to 50 to the mile, have been taken by electric shocking from the lower one fourth of the study site. The upper limit of the sculpins in Beaver Creek is about four miles below the state line (See section on relative abundance of fish).

Baldwin (1948) noted the brook trout in Redrock Lake, Ontario, ate a predominance of adult and immature insects during May and June. However, Baldwin further observed a change to yellow perch fry during July and August with a subsequent increase in growth rate. In his conclusions, Baldwin believed that the presence of forage fish caused large sized trout to prevail and in contrast the presence of plankton or immature insects produced a population of small fish.

Fish eggs:

Two occurrences of fish eggs were found in October of 1949, out of a total of sixty nine stomachs analyzed during that period. The number taken by the October sample of fish would indicate that natural spawning would suffer very little. It was impossible to determine whether or not the eggs were fertile. The only fall spawning fish present in the study area were a very few brown trout and a number of eastern brook trout. The latter species was observed spawning in the stream section of Beaver Creek that lies in the meadow area from 0.3 to 0.6 miles above the Utah-Idaho state line. The date of the observation of the spawning was on the first of October, 1949, the same day the fish containing the eggs were collected.

Plant material:

Very little plant material was consumed, four occurrences being recorded for all the stomachs analyzed. One fish had a trace of green algae (Chlorophyceae), in its stomach. Five seeds of Prunus sp. were identified in another stomach. A total of 4.4 percent by total volume for the month of October, 1949, comprised the entire amount of food material over the two year period.

SUMMARY

The study of the cutthroat trout in the Logan River, Utah, was based on 306 specimens collected during 1948 and 1949. Numbers of fish utilized in the study were: age and growth, 234; length-scale ratio, 284; length-weight relationship, 276; and food habits, 235.

The Logan River study area is located in the Cache National Forest. Logan River has an average daily discharge of 247 cubic feet per second. The topography of the area is varied, mountains throughout the drainage being of the block fault type.

An electric shocking machine was used to secure nearly all fish. There was a very low mortality from the total of 44 shocking operations and this was attributed to faulty handling rather than to electric shock.

Subspecific identification of the cutthroat trout Salmo clarkii in the study area was impossible. Identification of the cutthroat was based on a number of characteristics. The presence of hyoid teeth was the best single feature for differentiating them from rainbow trout. The throat mark showed a great deal of variation within series of fish identified as cutthroats.

Cutthroats composed 24 percent of the total Logan River catch during 1948, and 31.5 percent in 1949. The greatest numbers were found in areas with a high stream gradient. A minimum number of 43.6 pounds per acre and 565 fish per mile was obtained from a series of shocking operations during 1949.

Scale analysis was employed in determining the age of the fish. The validity of the annulus as a year mark was established by a correlation

between length and age.

The body scale ($L/Sc.$) relationship of the cutthroat trout was described as a curvilinear regression line, and expressed by the equation:

$$L = 3.4111\ S^{1.20061}$$

In a series of known-growth cutthroats 10.6 percent were recaptured. One fish grew 20 millimeters in 71 days. The smallest average annual growth increment was 53 millimeters. This was based on a growing season of approximately 200 days. Growth began in the latter part of March and extended to early in October, at which time the annulus was laid down.

No recovered, marked fish moved out of the one tenth mile area where they were released.

Males matured earlier than females. Although many mature males did not exceed the seven inch legal limit, very few adult females were present in size classes under this length.

The relationship between standard length and weight was expressed arithmetically as:

$$W = 4.344 \times 10^{-5}\ L^{2.82534}$$

The coefficient of condition decreased as the length of the fish increased. Male cutthroats had slightly more weight per unit of length than females.

The spawning period of the cutthroat trout in this area lasted about four months and ranged from early April to the middle of August. Adult females captured ranged in size from 11 inches downward.

Slightly more females were present in a total of 35 separate collections. It was impossible to sex cutthroats by external characteristics, except during the spawning season.

Insects were the principal item in the diet of the Logan River cutthroats. Ephemeroptera, Trichoptera, and Diptera were the principal aquatic orders taken while the most important terestrial order was Coleoptera. The small numbers of fish eggs taken indicated that natural spawning was not affected. Little plant material was consumed. Only two occurrences of fish were detected in the entire food habits study. The small size of the cutthroats in this area is in part attributable to the almost total absence of forage fish in the upper Logan River.

LITERATURE CITED

Applegate, Vernon C.
1947. Growth of Some Lake Trout, Cristivomer n. namaycush, of Known Age in Inland Michigan Lakes. Copeia., (4):237-241.

Baldwin, N. S.
1948. The Speckled Trout of Redrock Lake. Sylva., 4 (4):25-31.

Ball, Robert C.
1948. Relationship Between Available Fish Food, Feeding Habits of Fish and Total Fish Production in a Michigan Lake. Tech. Bull. 206. Mich. State. Coll. and Agr. Exp. Sta.

Beckman, William C.
1948. The Length-Weight Relationship, Factors for Conversions Between Standard and Total Lengths, and Coefficients of Condition for Seven Michigan Fishes. Trans. Am. Fish. Soc., 75 (1945):237-256.

Brown, C. J. D.
1935. A Survey of the Waters of the Cache National Forest, Utah. Dept. of Comm. Bur. of Fish. mimeo.

Calhoun, A. J.
1944. Black-Spotted Trout in Blue Lake, California. Calif. Fish and Game., 30 (1):22-44.

Calhoun, A. J.
1944. The Food of the Black-Spotted Trout (Salmo clarkii henshawi) in Two Sierra Nevada Lakes. Calif. Fish and Game., 30 (2):80-85.

Carlander, Kenneth D. and Lloyd L. Smith, Jr.
1945. Some Factors to Consider in the Choice Between Standard, Fork, or Total Lengths in Fishery Investigations. Copeia., (1):7-12.

Costley, Richard J.
1941. A Preliminary Study of the Productiveness of the Logan River. Proc. 21st Annual Conf. West. Assoc. State Game and Fish Comm. 68-71.

Gramer, Frederick K.
1940. Notes on the Natural Spawning of Cutthroat Trout (Salmo clarkii clarkii) in Oregon. Proc. Sixth Pacific Sci. Congress, the Pac. Sci. Assoc. 52: 335-339.

Curtis, Bryan
1934. The Golden Trout of Cottonwood Lakes. Trans. Am. Fish. Soc., 64 (1934): 259-265.

Essig, E. O.
1942. College Entomology. Macmillan Co. New York, N. Y. 900 p.

Greeley, John R.
1933. The Growth Rate of Rainbow Trout From Some Michigan Waters. Trans. Am. Fish. Soc., 63 (1933):361-378.

Hazzard, A. S. and M. J. Madsen
1933. Studies of the Food of the Cutthroat Trout. Trans. Am. Fish. Soc., 63 (1933):198-203.

Hildebrand, Samuel F. and Irving L. Towers.
1927. Food of Trout in Fish Lake, Utah. Ecology. 8 (4):389-397.

Hile, Ralph
1941. Age and Growth of the Rock Bass, Amplopites ruprestris (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wisconsin Acad. Sci., Arts, and Letters., 33:189-337.

Hoover, Earl E.
1938. Fish Populations of Primitive Brook Trout Streams of Northern New Hampshire. Trans. Third. N. Am. Wildl. Conf. 486-496.

Jordan, David Starr
1928. The Distribution of Fresh-Water Fishes. Annual Report Smith. Inst., (1927):355-385.

Lagler, Karl F.
1949. Studies in Freshwater Fishery Biology. J. W. Edwards. Ann Arbor, Michigan. 231 p.

Leonard, J. W. and F. A. Leonard.
1949. An Analysis of the Feeding Habits of Rainbow Trout and Lake Trout in Birch Lake, Cass County, Michigan. Trans. Am. Fish. Soc., 76 (1946):301-314.

Muttkowski, Richard A.
1925. The Food of Trout in Yellowstone National Park. Roosevelt Wildl. Bull., 2 (4):470-497.

Needham, James G.
1933. Mayflies- A Staple Food of Fishes in Hill Streams. Trans. Am. Fish. Soc., 63 (1933): 178-181.

Needham, Paul R.
1940. Trout Steams. Comstock Publishing Co. Ithaca, N. Y. 233 p.

Needham, P. R.
1930. Studies on the Seasonal Food of Brook Trout. Trans. Am. Fish. Soc., 70 (1930):73-88.

Needham, P. R.
1934. Quantitative Studies of Stream Bottom Foods. Trans. Am. Fish. Soc., 64 (1934):238-247.

Needham, P. R. and E. H. Vestal
1938. Notes on Growth of Golden Trout (Salmo aqua-bonita) in Two High Sierra Lakes. Calif. Fish and Game., 24 (3): 273-279.

Pennack, Robert W. and Ernest D. Van Gerpen
1947. Bottom Fauna Production and Physical Nature of the Substrate in a Northern Colorado Trout Stream. Ecology., 28 (1):42-48.

Ricker, William E.
1930. Feeding Habits of Speckled Trout in Ontario Waters. Trans. Am. Fish. Soc., 60 (1930):64-72.

Ricker, W. E.
1932. Studies of Speckled Trout (Salvelinus fontinalis) in Ontario. Univ. of Toronto Studies., No. 44.

Robertson, O. H.
1947. An Ecological Study of Two High Mountain Trout Lakes in the Wind River Range, Wyoming. Ecology., 28 (2):87-112.

Schuck, Howard A.
1945. Survival, Population Density, Growth, and Movement of the Wild Brown Trout in Crystal Creek. Trans. Am. Fish. Soc., 73 (1943):209-230.

Schultz, Leonard P.
1938. The Breeding Habits of Salmon and Trout. Annual Report Smith. Inst. (1937):365-376.

Shetter, David S.
1937. Migration, Growth Rate, and Population Density of Brook Trout in the North Branch of the Au Sable River, Michigan. Trans. Am. Fish. Soc., 66 (1936):203-210.

Sigler, William F.
1947. The Life History and Management of the White Bass, Lepibema chrysops (Rafinesque), in Spirit Lake, Iowa. Unpublished Thesis. Iowa State College. Ames. 116 p.

Sigler, William F.
1949. Life History of the White Bass, Lepibema chrysops (Rafinesque), of Spirit Lake, Iowa. Research Bull. 366. Iowa State Coll. Ames.