Original: Fish Division
cc: Education-Game
Institute for Fisheries Research
D. S. Shetter
Rifle River Area
C. T. Yoder
H. Gowing

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

June 2, 1952

Report No. 1335

1950 FALL BIOLOGICAL INVESTIGATION OF THE RIFLE RIVER WATERSHED

By

Howard Gowing

Abstract

This report, representing one phase of the Rifle River Watershed Development Program, is a record of an inventory of the Rifle River drainage north of highway M-55 in Ogemaw County conducted in the fall of 1950.

Employing an A.C. shocker for collecting fish, sampling stations were established on the Rifle River, Houghton Creek, Vaughn Creek, Bixby Creek, Wilkins Creek, Prior Creek, Klacking Creek, and Ammond Creek. Throughout most of the waters of the drainage brown trout were the predominant species of trout, with brook trout confined generally to the headwaters of the streams, and native rainbow (a few young-of-the-year fish) found only in Klacking Creek. Shocking for one hour at each of seven stations on the Rifle River revealed: (1) a relatively rich fauna of fish, (2) no succession of fish species from headwaters downstream, (3) white suckers to be the most prevalent fish, reaching their greatest concentration in numbers and weight in the Rifle River Area, and (4) that the pattern of distribution of brown trout fluctuated widely.

Based on the mark-and-recapture method of Petersen (1896), trout population estimates were made on three areas of Houghton Creek, designated "upper," "middle," and "lower," with respective lengths of 3,325 feet, 2,127 feet and 1,580 feet. From the "upper" area to the "lower" area the total population estimates of brown trout decreased while the average total length and age increased. Based on calculated growth, brown trout from Houghton Creek showed the best average growth, Rifle River brown trout relatively poorer, and Vaughn Creek poorest. Determining the coefficient of Condition C, brown trout from Klacking Creek and Wilkins Creek had the lowest C values, while brown trout from Houghton, Bixby, and Vaughn creeks had the highest C values. Prior Creek, comparatively rich in fish species in its lower reaches, was inhabited by larvae of the sea lamprey throughout its length.

Original: Fish Division
cc: Education-Game
Institute for Fisheries Research
D. S. Shetter
Rifle River Area
C. T. Yoder
H. Gowing

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

June 2, 1952

Report No. 1335

1950 FALL BIOLOGICAL INVESTIGATION OF THE RIFLE RIVER WATERSHED

By

Howard Gowing

Introduction

In the summer of 1950, the Lake and Stream Improvement Section of the Fish Division began work on a long range project for the Rifle River drainage. The primary aim of this project, the Rifle River Watershed Development Program, is the improvement and restoration of the watershed to its maximum land use level. The fisheries resources of the watershed are an integral part of this overall land use picture.

Objectives

The purpose of this report is twofold: (1) to record the findings of a fisheries inventory of the drainage immediately prior to watershed improvement, and (2) to establish a biological yardstick to measure changes that may occur in fish populations of the streams of the watershed after the various improvements are in effect.

The entire drainage of the main stream of the Rifle River north of State Highway M-55 in Ogemaw County falls within the scope of the work program. The area is delimited on the north by the Ogemaw County line, on the west by the Old State Road Truck Trail, and on the east by the drainage of George and Henderson lakes.

Field methods and equipment

Field investigations were conducted on the following streams: (1) Rifle River, (2) Houghton Creek, (3) Vaughn Creek, (4) Bixby Creek, (5) Wilkins Creek, (6) Prior Creek, (7) Ammond Creek, and (8) Klacking Creek. See map, Figure 1, for locations. Because the initial field work was begun September 13, 1950, and had to be completed by early winter, time permitted only a cursory investigation of these principal streams of the upper Rifle River drainage. More time was allotted to Houghton Creek and the Rifle River than to the other streams. Houghton Creek, the principal tributary of the Rifle River north of M-55, was of special interest because it presented serious run-off problems. The Rifle River may prove to be the ultimate barometer of changes brought about by land and water management practices on the tributary streams.

Two men operated as a working team in the field, but a three-man crew would have been much more efficient. An A.C. shocker, powered with a 500 watt, 100 volt alternating current generator, described by Shetter (1947), was employed for capturing fish for weights, lengths, and scale samples. The shocker was towed in a shallow-draft boat. All fish less than 500 grams in weight were weighed directly in grams on a Chatillon spring balance (platform type). Those fish in excess of 500 grams were weighed in pounds and ounces on a Chatillon spring scale with a suspended platform. Fish lengths were measured and recorded as total lengths in inches and tenths of inches.

The dimensions of each sample station (length, width, and depth) were measured by means of a steel tape, yardstick, and a wooden pole six feet long marked off in inches. With the exception of the two lower stations on Houghton Creek, all the tributary streams of the Rifle River are relatively small, varying from nine to twenty-six feet in width. In

the latter cases the linear length of each sample station was measured along the center of the stream. The width of the stream was measured at fifty-foot intervals and here depths were taken at three points. At the two lower stations on Houghton Creek, widths were measured every one hundred feet and four depths were recorded.

Acknowledgments

The writer wishes to thank Robert Ellis, co-worker in the field, who ably assisted in the collection of the data for this report, and who shared the same leaky roof at the "ranch house" during the period of the survey. Drs. Ralph Hile and Edwin L. Cooper were kind enough to clarify a few points in the handling of age and growth data, and Dr. David S. Shetter offered helpful suggestions during the organization of the report. George F. Lunger of the U. S. Fish and Wildlife Service gave assistance in the determination of confidence limits.

Rifle River

Unlike many streams that have their headwaters in springs, the Rifle River begins at the dam on Devoe Lake as lake surface run-off (figure 2). This fact to some degree influences the species composition of the fishes found in the river. There was no marked succession of fish species from headwaters downward. The entire length of the river in the study area exhibited a comparatively rich fauna of fishes, including perch, rock bass, and largemouth bass, which are relatively uncommon in trout streams. Devoe Lake was doubtless responsible for the presence of these species. The species of minnows in the stream are more often found in warm-water non-trout streams or in lower reaches of some trout streams. Houghton Creek, which enters the Rifle River a short distance below Devoe Lake dam, lowers the water temperature of the Rifle River during the greater part of the year.

Figure 1.--Map of the "Upper" portion of the Rifle River Area.

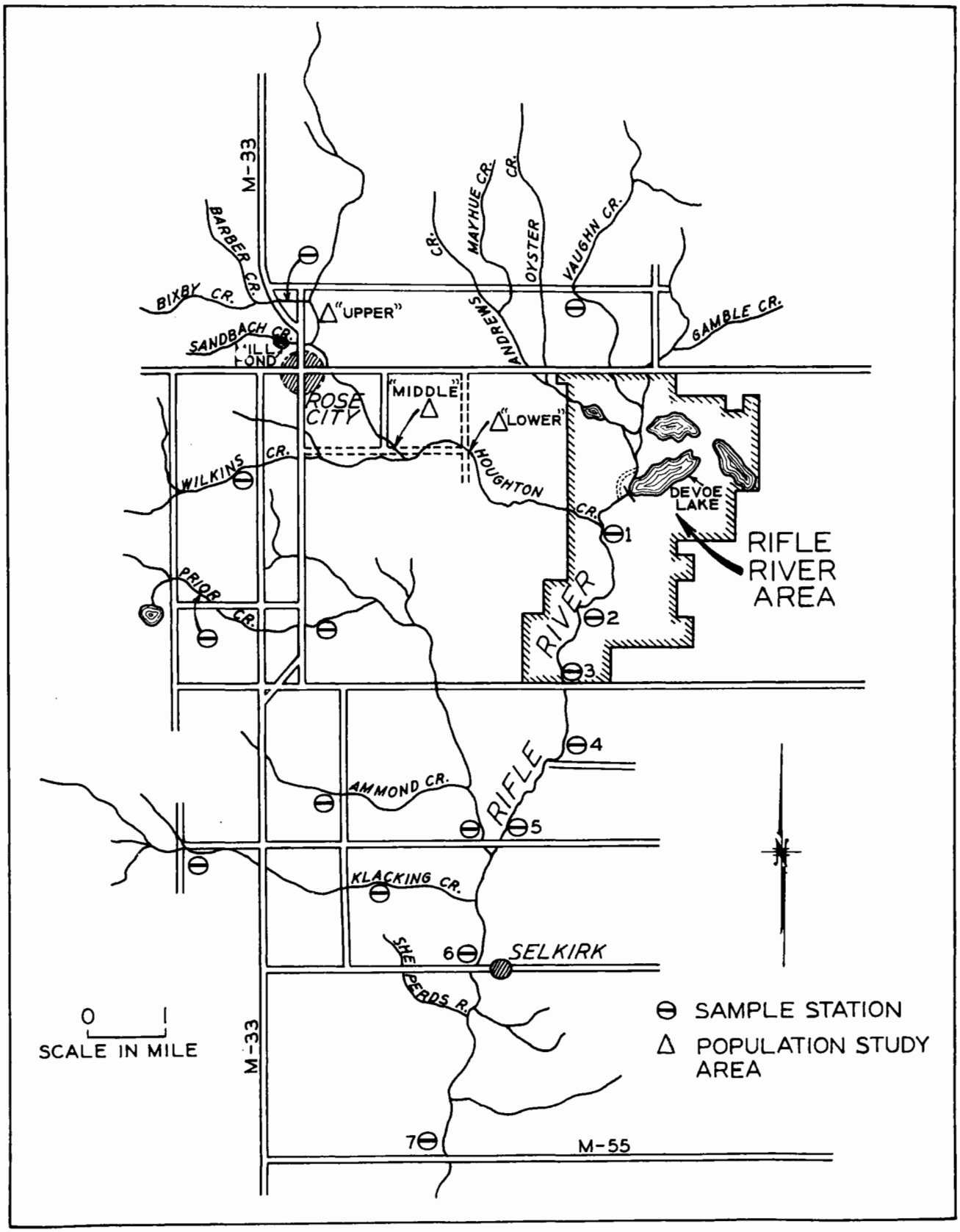

M-33
BARBER CR.
BIXBY CR.
SANDBACH CR.
MILL POND
"UPPER"
ROSE CITY
"MIDDLE"
"LOWER"
WILKINS CR.
HOUGHTON CR.
MAYHUE CR.
OYSTER CR.
VAUGHN CR.
ANDREWS CR.
GAMBLE CR.
DEVOE LAKE
RIFLE RIVER AREA
RIFLE RIVER
PRIOR CR.
AMMOND CR.
KLACKING CR.
SHE PEROS R.
SELKIRK
M-55
1
2
3
4
5
6
7
0 1
SCALE IN MILE
SAMPLE STATION
POPULATION STUDY AREA

Figure 2.--The beginning of the Rifle River at the low head dam on DeVoe Lake (Winter 1950).

As an example of this temperature difference, on October 6, 1950, the following temperatures were recorded:

Stream	Temperature	Time	Location
Rifle River	Air - 60° F. Water - 56° F.	11:25 a.m.	Above mouth of Houghton
Houghton Creek	Air - 62° F. Water - 50° F.	12:10 p.m.	Mouth of Houghton Creek
Rifle River	Air - 62° F. Water - 53° F.	12:20 p.m.	Rifle River-ranch bridge

The cooling effect of Houghton Creek upon the Rifle River was demonstrated by Locke (1951, Institute Report No. 1282)[1] in his survey of the Rifle River drainage during the summer of 1941. On August 6, 1941, hourly air and water temperatures were taken at the mouth of Houghton Creek and on the Rifle River both above and below the mouth of Houghton Creek. During a period of approximately twelve hours on this day when air temperatures varied between 67.5° and 81.0° F., water temperatures of the Rifle River above Houghton Creek ranged from 71.0° to 81.0° F., while the water temperatures of Houghton Creek ranged between 57.5° and 64.0° F. For temperature differences between the Rifle River and Houghton Creek through the months of September, October, and November, 1951, see Figure 3.

Seven sample stations were established on the main stream of the Rifle River. Each station is numbered in consecutive order, with No. 1 being the station farthest upstream (map, Figure 1). Listed below are the station numbers and locations of each sampling site. Henceforth they will be referred to by numbers only.

(1) Station: Upstream from "ranch bridge," T23N, R3E, Sec. 11.

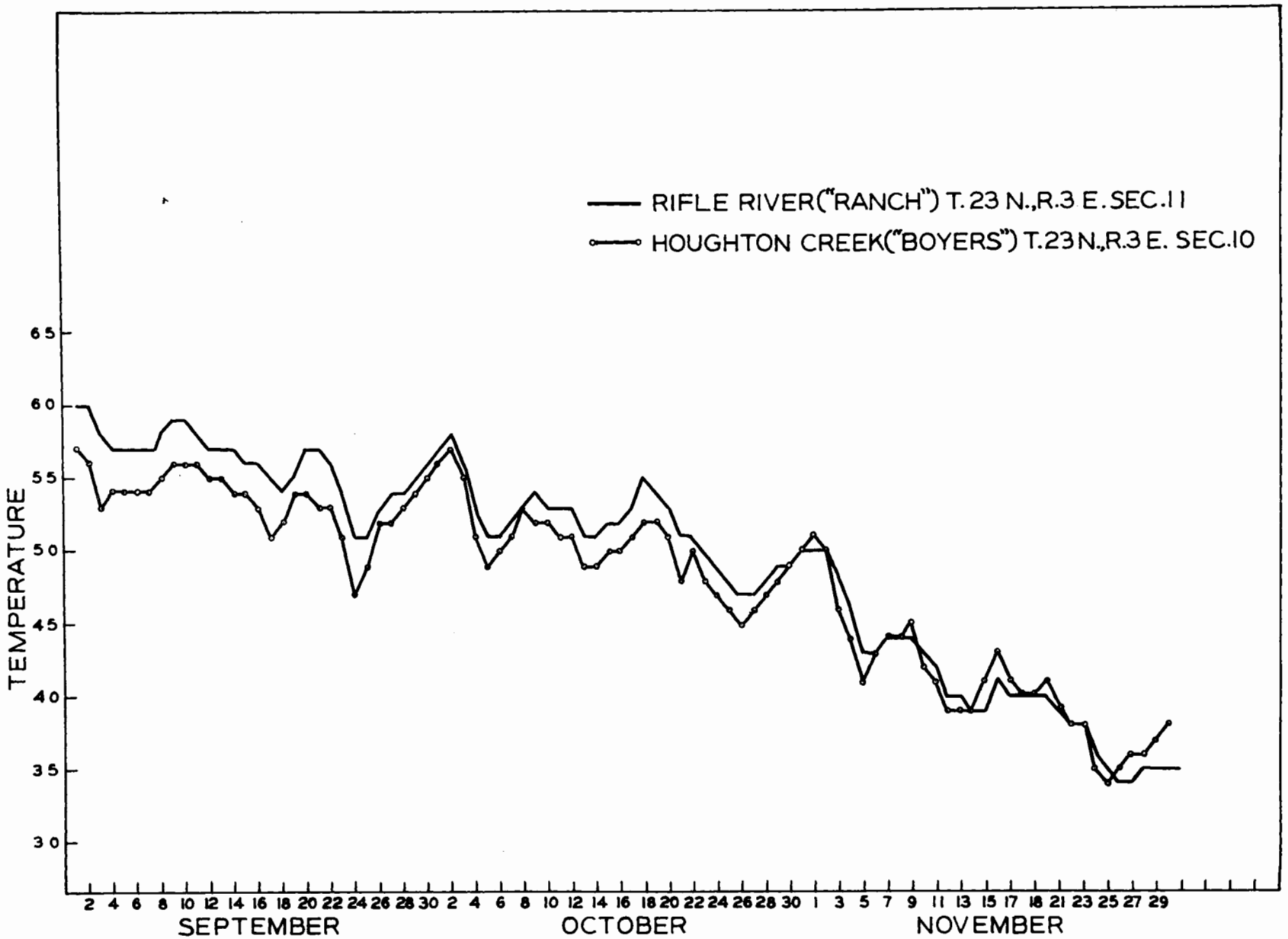
(2) Station: "Birch Run," Rifle River Area, T23N, R3E, Sec. 23.

(3) Station: Upstream from bridge at south end of Rifle River Area, T23N, R3E, Sec. 22.

---

[1] While Locke surveyed the entire Rifle River drainage in 1941, all references and discussions of his findings in this paper are made only as they are applicable to that part of the watershed north of Highway M-55.

Figure 3.--Mean daily water temperatures of the Rifle River and Houghton Creek (1950). These data were kindly furnished through the cooperation of the U. S. Geological Survey.


RIFLE RIVER("RANCH") T. 23 N., R. 3 E. SEC. 11
HOUGHTON CREEK("BOYERS") T. 23 N., R. 3 E. SEC. 10
TEMPERATURE
65
60
55
50
45
40
35
30
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 18 21 23 25 27 29
SEPTEMBER
OCTOBER
NOVEMBER

(4) Station: Upstream from old bridge site, T23N, R3E, Sec. 27.

(5) Station: Upstream from bridge, T23N, R3E, Sec. 34.

(6) Station: Upstream from bridge, T22N, R3E, Sec. 9.

(7) Station: Upstream from bridge, T22N, R3E, Sec. 21.

In order to place sampling on a comparable basis, the factor of time was held constant for each station. One hour of shocking time was apportioned to each sampling site. An attempt was made to collect all fish shocked during this period of time. The length of the stream shocked varied largely with the numbers of fish handled at each station. Certain problems were encountered in shocking the river: (1) Since the river ranged in width from approximately 25 to 60 feet, it was as impractical to shock all the water at each station as it was to collect all the minnows present; (2) White suckers tended to school ahead of the electrodes, then turned en masse and attempted to swim through the electrical field; when this occurred it was infeasible to scap all the stunned fish, some of which soon drifted out of reach; (3) Trout were often able to circumvent the electrical field of the electrodes; (4) Excessive depth of the water at two locations (Station No. 1) prevented adequate shocking. With these inherent difficulties in mind, the numbers of fish collected per unit of shocking time (one hour) yielded a rough measure of the relative abundance of fish species present at each station.

By far the most prevalent species of fish in the Rifle River is the white sucker, Catostomus commersoni (See Table 1). Their largest concentrations were at Stations 1, 2, 3, and 5, with respective total weights at each station of 17.7 pounds, 29.6 pounds, 18.3 pounds and 15.7 pounds (Figure 4). These stations are similar in that they all have quiet, deep pools and runs. Here also were found islands of submerged vegetation that frequently harbored numbers of white suckers. Only at Stations 4, 6, and 7 did the brown trout outnumber the suckers. In the sample at Stations 6 and 7 brown trout

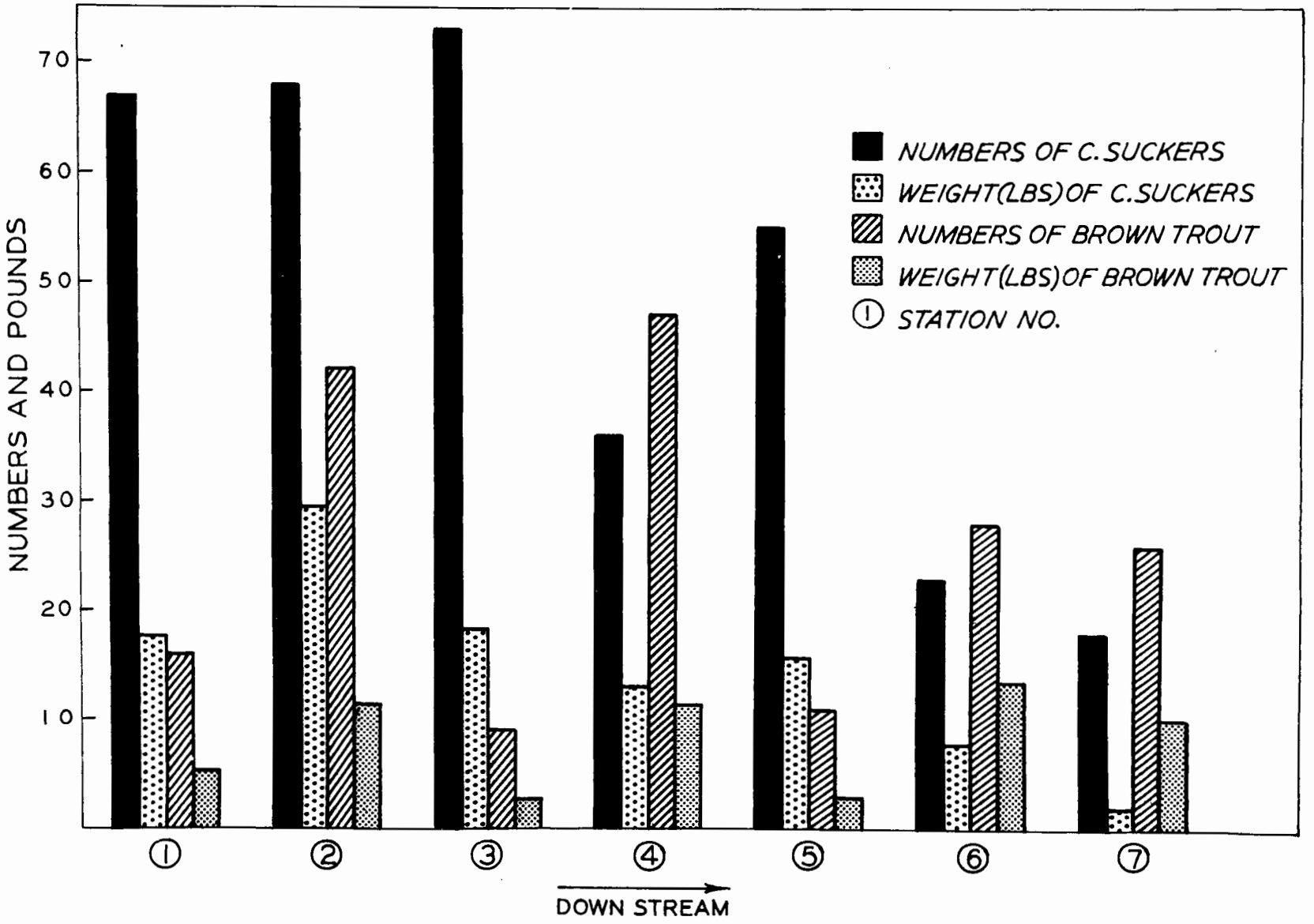
Table 1.--Numbers of fish, and their range in length (in parentheses), from seven stations on the Rifle River[1]

Species	Station No. 1	Station No. 2	Station No. 3	Station No. 4	Station No. 5	Station No. 6	Station No. 7
	Number of fish	Number of fish	Number of fish	Number of fish	Number of fish	Number of fish	Number of fish
Brown trout	16 (5.8-16.1)	42 (5.9-15.5)	9 (8.5-10.9)	47 (4.0-15.1)	11 (6.8-11.0)	28 (4.8-17.8)	26 (6.8-13.6)
White sucker	67 (2.7-16.3)	58 (2.3-15.7)	73 (2.0-13.4)	36 (2.1-14.1)	56 (2.2-16.7)	23 (2.5-12.8)	18 (2.1-12.3)
Creek chub	3 (3.7-4.5)	8 (2.8-7.1)	29 (3.0-8.2)	19 (2.0-5.9)	40 (1.7-7.3)	10 (3.5-5.5)	17 (2.0-7.2)
Hornyhead chub and River chub	17 (3.8-5.8)	11 (2.5-5.1)	11 (2.0-5.0)	9 (3.2-5.7)	21 (2.5-6.6)	3 (4.7-6.3)	4 (3.7-5.0)
Blacknose dace	1 (3.3)	6 (2.4-3.3)	6 (1.0-3.6)	7 (2.2-3.8)	6 (2.7-3.6)	14 (1.7-3.4)	24 (1.2-3.5)
Hog sucker	4 (5.0-9.8)	3 (6.0-7.0)	1 (7.3-)	11 (1.5-6.8)	11 (1.8-7.9)	6 (2.0-8.8)	12 (1.8-7.5)
Freshwater sculpin	2 (2.0)	5 (2.5-3.6)	10 (2.3-4.7)	9 (1.7-4.3)	8 (1.7-4.1)	7 (2.1-3.6)	2 (2.0)
Common shiner	23 (2.4-5.3)	7 (2.5-5.2)	11 (1.3-3.6)	---	7 (2.6-3.9)	1 (3.8)	1 (2.7)
Johnny darter	---	5 (2.5-2.8)	9 (1.5-2.7)	10 (2.3-3.0)	21 (1.5-3.0)	12 (2.1-2.8)	6 (2.3-2.9)
Rainbow trout	12[2] (7.7-8.5)	4[2] (8.0-9.7)	4[2] (7.6-9.0)	1 (9.0-)	---	2 (8.9-9.1)	---
Rock bass	18 (3.0-9.2)	---	8 (3.4-7.6)	1 (8.8)	2 (5.5-6.4)	8 (6.3-9.3)	---
Logperch	---	2 (4.3-4.7)	1 (4.7-)	2 (3.8-4.2)	2 (4.8-5.0)	3 (3.6-4.5)	---
Yellow perch	5 (3.9-6.7)	1 (2.9)	6 (4.5-6.7)	---	3 (4.0-6.0)	---	2 (5.0-6.2)
Rainbow darter	3 (2.0-2.2)	---	1 (2.4-)	---	2 (2.0-2.3)	10 (1.3-2.8)	8 (2.1-2.5)
Longnose dace	---	1 (4.0)	---	---	1 (3.7)	3 (3.0-4.0)	12 (3.6-5.0)
Stonecat	---	1 (3.8)	---	---	3 (3.6-3.7)	4 (5.0-6.3)	1 (7.7)
Brook stickleback	---	---	1 (2.2-)	---	2 (2.0)	---	---
Largemouth black bass	1 (3.3)	---	---	---	---	---	---
Blackside darter	---	---	---	---	1	--- (3.5)	---
Carp	1	---	---	---	---	---	---

[1] One hour of shocking at each station.

[2] Hatchery rainbow trout.

Figure 4.--Brown trout and common suckers captured at seven stations on the Rifle River: one hour shocking time at each station (A.C. shocker).


NUMBERS AND POUNDS
70
60
50
40
30
20
10
NUMBERS OF C. SUCKERS
WEIGHT(LBS) OF C. SUCKERS
NUMBERS OF BROWN TROUT
WEIGHT(LBS) OF BROWN TROUT
① STATION NO.
①
②
③
④
⑤
⑥
⑦
DOWN STREAM

outnumbered as well as outweighed the sucker. There appeared to be a steeper stream gradient between Stations 6 and 7 and the remaining stations, particularly near M-55 (Figures 5 and 6). The greater part of these two stations (6 and 7) are riffles with gravel and rubble bottom. All the brown trout captured at Stations 6 and 7 were found along the banks where low overhanging bushes afforded little cover. Station 4, which has largely sand and gravel bottom, yielded the greatest number of brown trout.

Ten thousand hatchery rainbow trout were planted on May 2 and 3, 1950, in the Rifle River below DeVoe Lake dam and at the "ranch bridge." The trout ranged from 2.6 to 9.3 inches long and were marked by the removal of the left pelvic fin. From October 2 to October 11, 1950, the period in which the Rifle River was sampled, none of these hatchery rainbow trout were recovered below Station 3. Twelve were taken at Station 1 and four each at Stations 2 and 3. In addition to the above planting, 1,500 rainbows of legal or near-legal length were planted in the Rifle River north of M-55 during the spring and summer of 1950. It is noteworthy that only three unmarked rainbows were captured during the entire sampling period on the Rifle River.

Between May 31 and August 22, 1950, plantings totaling 3,175 hatchery brown trout of legal size (7 inches) were made in the Rifle River above M-55. The fall sampling yielded only five hatchery brown trout that were considered recognizable in the field by their pigmentation.

Following the brown trout spawning season, all stations, except 4, were spot-checked for brown trout redds. No brown trout redds were observed at either Stations 1 or 2. It is questionable whether seven freshly scoured gravel areas in 29 to 33 inches of water at Station 3 were brown trout redds. The water was but slightly riffled, more nearly a glide. A stream improvement crew working near this location informed me that earlier five or six large brown trout were seen in this area of the stream. Three brown trout redds

Figure 5.--Sample station No. 6 on the Rifle River. Looking upstream from the bridge at Selkirk (March, 1951).

Figure 6.--Sample station No. 7 on the Rifle River upstream from bridge at M-55 (March, 1951).

were found at Station 5 and four at Sation 6. There were observed what appeared to be four atypically shaped brown trout redds in the coarse gravel and rubble bottom at Station 7. This spot check for brown trout redds covered but a small portion of the Rifle River north of M-55.

Only two young-of-the-year brown trout were shocked in the Rifle River---one at Station 4, the other at Station 6. The main stream of the Rifle River north of M-55 should be cruised to determine the amount of spawning. Observations made during the time of study indicated that spawning here was limited. Jaw-tagging or fin-clipping experiments might reveal the degree to which brown trout in the Rifle River use the tributaries for spawning and the extent of recruitment of brown trout from the tributaries to the main stream.

Houghton Creek

From its spring headwaters, Houghton Creek, the principal tributary of the Rifle River drainage, courses its way approximately 9.7 miles before emptying into the river a short distance below Devoe Lake dam. From headwaters to mouth, Houghton Creek receives additional water mainly from Simons Creek, Bixby Creek, Sandbach Creek, and largest of all, Wilkins Creek.

Located on Sandbach Creek, about one city block west of M-33 and within the limits of Rose City, is a small mill pond and power site operated by the local lumber company (Figure 7). Below the dam to the mouth of Sandbach Creek the bottom is largely clay hardpan overlaid with rubble. Depending upon the operation of the mill, the discharge of water from Sandbach Creek is responsible for almost daily fluctuations of water level in Houghton Creek of approximately three inches. These rather sudden discharges of water from the dam, scour the hardpan bottom of Sandbach Creek, rendering the waters of Houghton Creek a weak milky color.

Figure 7.--Mill dam on Sandbach Creek, west of Highway M-33 in Rose City.

The raw sewage of Rose City enters Houghton Creek a few hundred feet below the bridge east of town.

Three population study areas were established in Houghton Creek. The "upper" population area consists of 3,325 feet of stream below the bridge, in Section 31, T. 24 N., R. 3 E. The "middle" area begins at the mouth of Wilkins Creek and extends 2,127 feet upstream through Section 8 and 5, T. 23 N., R. 3 E. Beginning at a point 500 feet above the bridge in Section 4, T. 23 N., R. 3 E., and extending downstream 1,580 feet is the "lower" study area (maps, Figures 1 and 8).

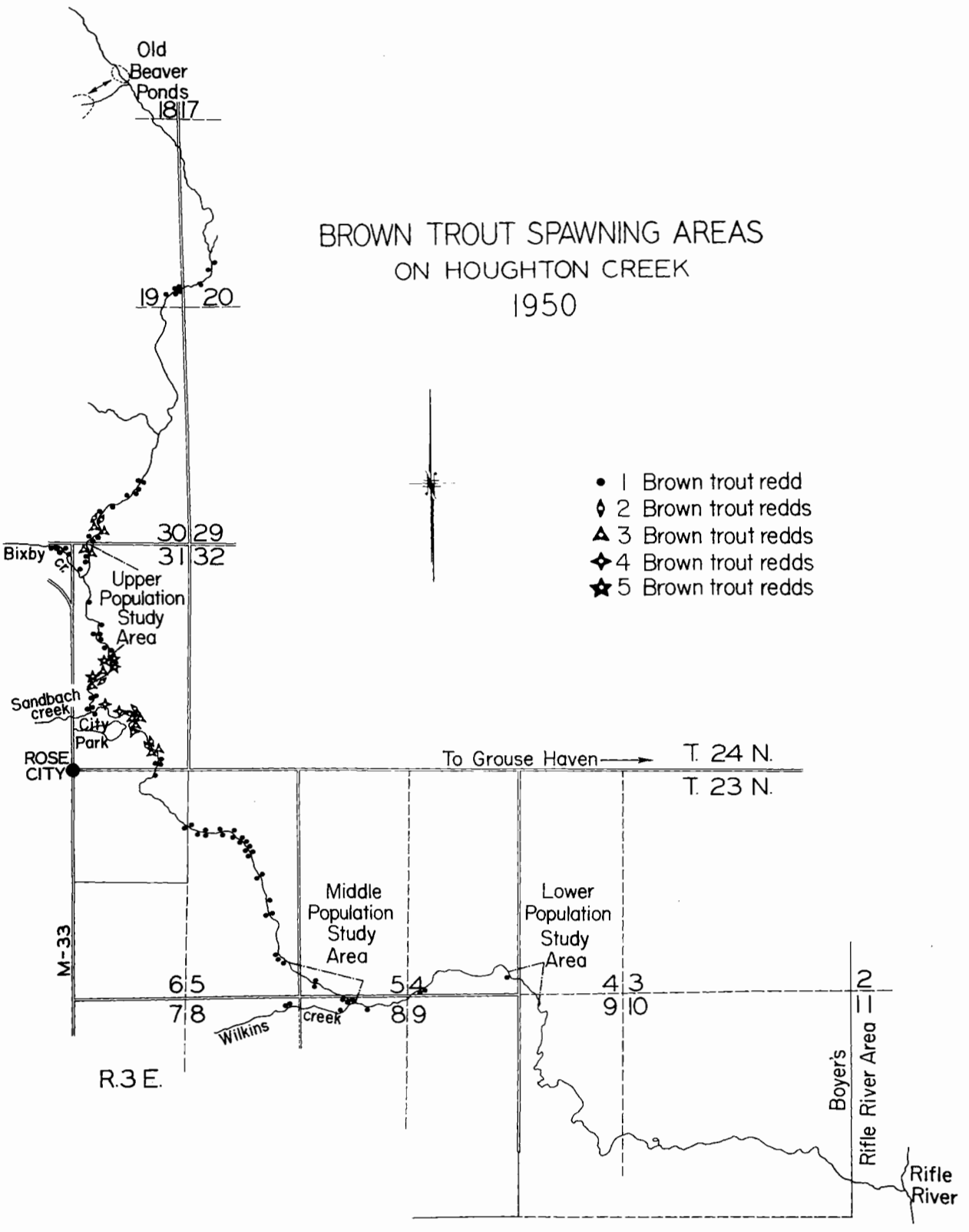
Population methods

Population estimates for three stations on Houghton Creek (Figure 8) were based on the mark-and-recapture method of Petersen (1896). Trout were marked by clipping off a fin or a portion thereof: "lower" station, adipose fin; "middle" station, lower half of caudal fin; "upper" station, upper half of caudal fin.

This method of population estimates in its simplest form involves a finite but unknown population (N) containing a known number of marked fish (T) and unmarked fish (U=N-T); one random sample (n) is drawn without replacement containing marked (t) and unmarked u=n-t fish. Assuming $\frac{N}{T} = \frac{n}{t}$, the estimate of N is $N = \frac{nT}{t}$. For this study, a range of values was then determined within which N was expected to lie at a 95 percent confidence interval. The Petersen method has been used by numerous investigators in the past to estimate populations of various organisms. Chapman (1948) refers to this estimate as the maximum likelihood estimate of N.

For illustrative purposes, two approaches to the determination of population estimates are treated here. If this population is broken down into sub-groups based upon sex, age, race, etc., and the estimate of each sub-group added together to arrive at the total population estimate, according

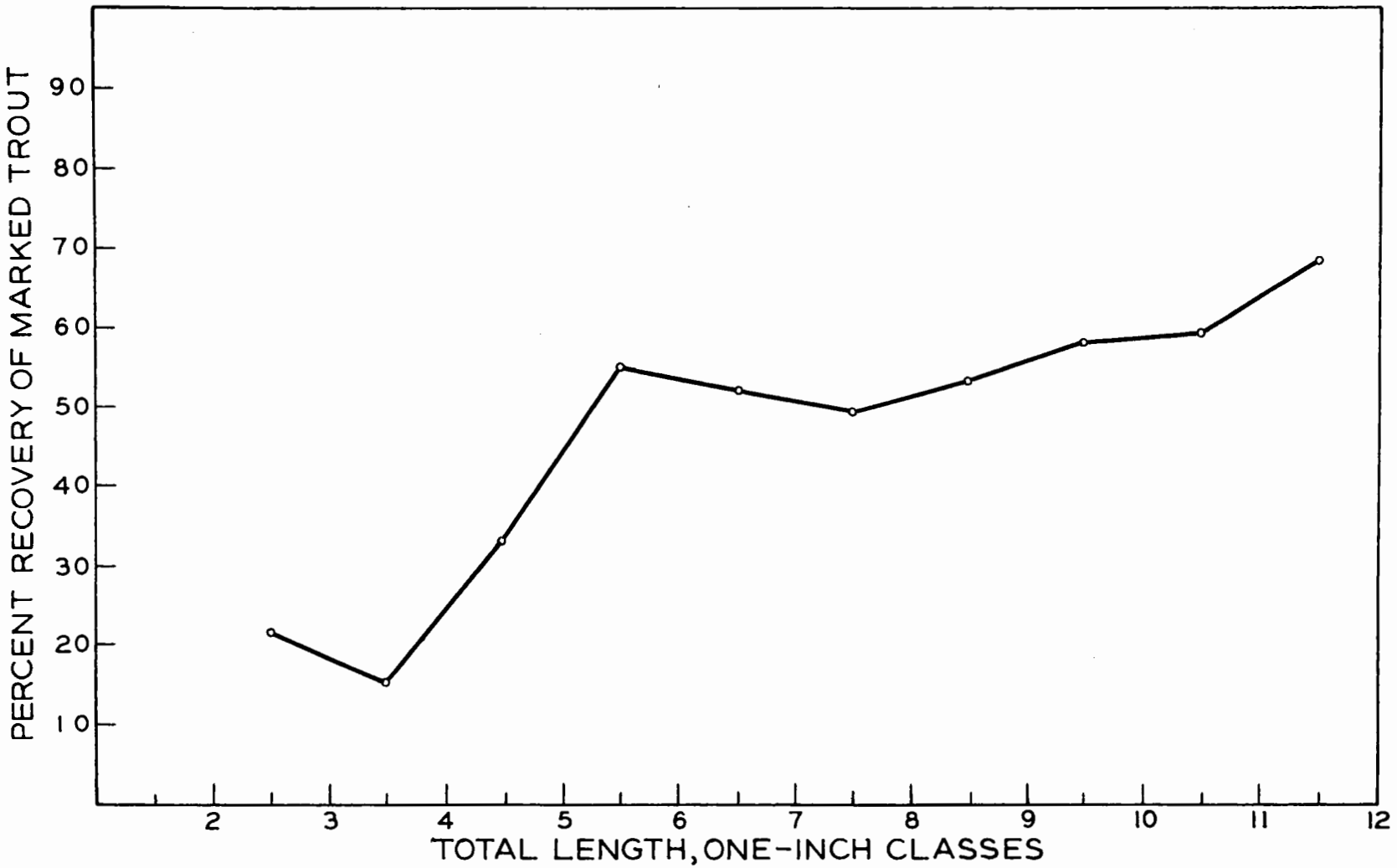
Figure 8.--Brown trout spawning areas on Houghton Creek, 1950.


BROWN TROUT SPAWNING AREAS
ON HOUGHTON CREEK
1950
• 1 Brown trout redd
2 Brown trout redds
3 Brown trout redds
4 Brown trout redds
5 Brown trout redds
Old Beaver Ponds
18 17
19 20
30 29
31 32
Bixby
Upper Population Study Area
Sandbach creek
City Park
ROSE CITY
To Grouse Haven
T. 24 N.
T. 23 N.
Middle Population Study Area
Lower Population Study Area
M-33
6 5
7 8
5 4
8 9
4 3
9 10
2
11
Wilkins creek
R.3 E.
Boyer's
Rifle River Area
Rifle River

to Chapman (1951), the question arises as to the assurance that the condition of randomness is satisfied for each sub-group. He also states that the total population estimate obtained by totaling the estimates of the sub-groups is more variable than if the estimate were arrived at directly from the whole sample. Using the "upper" population study area on Houghton Creek as an example, the total estimated population of brown trout based upon the ratio of total marked to unmarked in the entire sample was $1,308 < 1,443 < 1,635$ at a 95 percent level. Here the actual task of determining confidence limits was provided for in a compilation of curves for a hypergeometric distribution by Chung and DeLury (1950). In their publication are curves for obtaining confidence limits for three population sizes, 500, 2,500, 10,000, at ten sampling rates, 5 percent through 90 percent, each at three confidence levels, 90 percent, 95 percent, and 99 percent. Sampling rates are determined by the equation $s = \frac{n}{N}$, and interpolation with respect to population sizes was calculated by the argument $\frac{1}{N}$.

A second population estimate from the same data was obtained by breaking down the population into length groups and summing the estimates of the groups. Employing the A.C. shocker for capturing trout, it was found that the percentage recovery of larger marked trout was higher than for small trout. In Figure 9 the percentage recovery of marked trout was plotted against length by one-inch groups. The recovery of marked trout from 2 to 4 inches long was 20 percent and for trout 10 inches in length or longer, 59 percent. With these length groups as cleavage points, the population was grouped into three length classes: 2 to 4 inches (young-of-the-year trout), 5 to 9 inches, 10 inches and over. The total population estimate by grouping was 1,699 brown trout, compared to 1,443 brown trout estimated directly from the whole sample. The whole-sample approach does not take into account the relative rates of recovery of marked trout by lengths, and it imparts no information as to the size distribution of the population

Figure 9.--Relationship between percentage recovery of marked trout and total length by one-inch classes on "Upper" Houghton Creek, employing an A.C. shocker.


PERCENT RECOVERY OF MARKED TROUT
90
80
70
60
50
40
30
20
10
2
3
4
5
6
7
8
9
10
11
12
TOTAL LENGTH, ONE-INCH CLASSES

only as sizes can be inferred from either the size distribution of the marked trout or of the sample recovered. When the population estimate is predicated upon sub-groups, the selection of these sub-groups, though they may be indicated in the data, are somewhat arbitrary. However, in this particular population study on "upper" Houghton Creek, changing the sub-groups (from the 3 listed above) into a number of different length categories failed to alter the population estimate significantly.

Confidence limits (95 percent) for the sub-groups in Table 2 were determined from a table of confidence limits for a binomial distribution by Snedecor (1950).

Houghton Creek at the "upper" population study area has an average depth of 10 inches with an average width of 15.2 feet. Much of this stream site is riffles, and the bottom, gravel and sand (Figures 10 and 11). A few areas of clay hardpan are present. Along the edge of the stream is a narrow border of cedar, replaced in a few areas by tag alder.

On September 25 and 26, 1950, a trout population estimate was made at the "upper" station on Houghton Creek. The bulk of the trout in this area of the stream are from 2 to 9 inches long (Table 2). The preponderance of young-of-the-year brown trout in the 2- to 4-inch group is direct evidence of the heavy spawning that occurs in this part of the stream. It required six stopping-off points to measure and mark all the trout shocked. Thus the stream was arbitrarily divided into six unequal sections on the initial population run. On the following day a recovery run was made and the identity of the six sections was retained. From Table 3, there appears to be no discernible pattern of movement of brown trout following their liberation into the stream after shocking. Only two brook trout were captured during the population study.

Through three-quarters of the upper length of the "middle" population study area, Houghton Creek flows through a mixed stand of broad-leafed and

Table 2.--Population estimates of brown trout for three areas on Houghton Creek (Fall, 1950)

Stream	Length group (inches)	Percent recovery (approximate)	Population estimate	
			Number	Confidence interval (95%)
"Upper" Houghton Creek	2-4.9	20	1,213	1,520-1,013
	5-9.9	54	434	485-395
	10-over	59	52	73-40
Total			1,699	
"Middle" Houghton Creek	3-4.9	...	40✓	
	5-9.9#	14	1,103	1,800-788
	10-over	20	40	214-23
Total			1,183	
"Lower" Houghton Creek	3-4.9	...	8✓	
	5-9.9++	18	410	612-297
	10-over+++	35	42	117-29
Total			452	

✓ Since no marked recoveries were taken, this figure represents the minimum known number of trout in this size range.

~~For the same reason as above.~~

+ Six hatchery brown trout were involved in the calculation of this estimate.

++ Five hatchery brown trout were involved in the calculation of this estimate.

+++ One hatchery brown trout was involved in the calculation of this estimate.

Figure 10.--"Upper" Houghton Creek showing the size of the stream with its border of cedar trees.

Figure 11.--Characteristic spawning site of brown trout in shallow gravel riffles at "upper" Houghton Creek.

Table 3.--The location and numbers of brown trout marked and subsequently sampled at "upper" Houghton Creek based on six unequal but arbitrarily selected comprising total study area

Brown trout	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	7-7.9	8-8.9	9-9.9	10-10.9	11-11.9	12-12.9	13-13.9	14-14.9	20-20.9	Total	Percent recovery marked
Initial run																
Lower end	4	25	3	9	4	5	2	2	2	1	0	0	0	0	57	
2nd stop	10	52	4	21	9	8	5	3	1	2	0	1	0	0	116	
3rd stop	4	37	6	10	9	11	8	6	5	0	0	0	1	0	97	
4th stop	33	94	7	15	7	8	6	7	3	2	0	1	0	1	184	
5th stop	5	38	3	19	10	16	22	13	8	2	1	0	0	0	137	
6th stop	8	29	3	18	3	18	3	3	6	0	1	0	0	0	61	
Recovery run																
Lower end																
Marked	3	2	1	7	3	3	1	0	0	1	0	0	0	0	21	
Unmarked	1	13	3	2	2	2	0	2	1	0	0	0	0	0	26	36.8
2nd stop																
Marked	1	9	1	6	2	3	2	1	2	1	0	0	0	0	28	
U Unmarked	8	31	4	11	5	2	1	1	0	0	0	0	1	0	64	24.1
3rd stop																
Marked	3	11	1	13	6	2	3	4	2	1	0	0	0	0	46	
Unmarked	0	21	1	6	2	6	1	2	1	0	0	0	0	0	40	50.5
4th stop																
Marked	6	20	3	6	3	4	6	5	2	1	1	1	0	0	58	
Unmarked	15	43	5	9	3	3	2	5	4	0	0	0	0	0	89	31.5
5th stop																
Marked	0	4	1	4	5	9	12	6	5	1	0	0	0	0	47	
Unmarked	6	19	3	6	8	5	6	1	2	2	0	0	0	0	58	34.3
6th stop																
Marked	1	5	2	12	3	0	2	2	1	0	0	0	0	0	28	
Unmarked	9	17	3	3	1	1	2	0	0	1	0	0	0	0	37	45.9

coniferous trees. The lower portion of the stream in this area is bordered by pasture. The banks of the stream, especially in the wooded area, have been gutted by flood waters, exposing the roots of trees that line the banks (Figure 12). The eroding action of high water has felled the many trees that lace the bottom of the stream. Near the mouth of Wilkins Creek, cattle are largely responsible for a few raw eroded banks. Sand is the prevailing bottom type, with gravel confined to a short stretch of water above the mouth of Wilkins Creek. Flocculent silt was found in the lee of the current along the banks. On the average, the stream is 18 inches deep and 23.3 feet wide. The major portion of the brown trout population at this location is in the 5- to 9-inch group (Table 2). The paucity of young-of-the-year brown trout is attributed to very limited spawning that occurs in this area. Of the three population sites, the "middle" station had the poorest recovery of marked fish, 13.6 percent, as contrasted to 35.4 percent for the "upper" station and 20.3 percent for the "lower" station. This poor recovery was due primarily to (1) untimely rise in water level with accompanying discoloration of water caused by the dam on Sandbach Creek, (2) good cover of log jam, partially exposed tree roots, and numerous logs, (3) difficulty of shocking in strong current with an A.C. shocker.

White suckers were first encountered in Houghton Creek at this site. Thirteen were captured during the population study, ranging in length from 1.5 to 4.2 inches. Also, two minnows were taken for the first time; two longnose dace, Rhinichthys cataractae cataractae, and two creek chubs, Semotilus atromaculatus atromaculatus.

Houghton Creek at the "lower" population study area meanders through pasture land, with the immediate banks of the stream bordered by a narrow row of mature elm trees. The average width of the stream is 24.4 feet and the average depth is 26.4 inches. Here again very few young-of-the-year brown trout were found (Table 2). Following the brown trout spawning season, only one redd was found in this area (Figure 13). Most of the brown trout

Figure 12.--Deeply cut, eroded banks typical of a large portion of "middle" Houghton Creek population study area.

Figure 13.--Quieter running water at the "lower" Houghton Creek station which is generally true of the lower reaches of the river. Little spawning occurs here.

fall in the 5- to 9-inch group, with an increase in the numbers of brown trout exceeding 15 inches.

Accompanying the physical transition of Houghton Creek from the "upper" to the "lower" population study areas, there was a change in the size composition and density of brown trout. While the lengths of the three selected study areas were progressively shorter from "upper" to lower" ("upper" 3,325 feet, "middle" 2,127 feet, "lower" 1,580 feet), inversely, the number of acre-feet increased progressing downstream - 0.99 acre/ft. (43,464.4 cu. ft.), 1.70 acre/ft. (74,338.6 cu.ft.), and 1.94 acre/ft. (84,814.4 cu. ft.). The increase of stream width and depth accounted for this increase in volume.

In the "upper" population study area, young-of-the-year brown trout in the 3- to 4-inch group accounted for approximately 71 percent of the 1,699 total estimated population; about 25 percent were in the 5 to 9-inch group. With a total estimated population of approximately 1,166 brown trout in the "middle" area, about 94 percent fell in the 5- to 9-inch group, with the 3- to 4-inch group poorly represented. On a comparable basis, 89 percent of the estimated population of 458 brown trout in the "lower" area were in the 5- to 9-inch group, and here again the young-of-the-year brown trout represented a very insignificant part of the population. Brown trout in excess of 10 inches at the "lower" station reflect a higher percentage of the total estimate than do the other two stations. Of the total number of brown trout exceeding 15 inches in length captured but once during the population studies at the three stations, only one was taken at the "upper", two at the "middle", and ten at the "lower" area. Based on the initial population run, the average total length by 1-inch groups of all brown trout captured at each site were as follows:

(1) "upper" population study area 5.2 inches

(2) "middle" population study area 7.1 inches

(3) "lower" population study area 7.9 inches

Statistically, these means are significantly different at 95 percent level of probability.

Locke (op. cit.) reports that yearling rainbow trout were quite common in Houghton Creek in the summer of 1941. He also notes having found a few young-of-the-year rainbow trout. Hatchery records show that no rainbow were planted in Houghton Creek or its tributaries during the years 1939 through 1941. However, planting records do show that in 1940, 5-month-old rainbows were planted in the Rifle River in Section 14, T. 23 N., R. 3 E., and in Section 22, T. 23 N., R. 3 E., in 1941. These plantings in the Rifle River might conceivably account for the presence of young-of-the-year and yearling rainbow trout in Houghton Creek, although it is improbably. As Locke states, rainbow trout in Houghton probably were the result of natural reproduction. In the fall survey of 1950, only one rainbow trout was collected at three stations on Houghton Creek, representing 7,031 feet of stream sampled. This unmarked rainbow was probably one of 500 rainbows planted in Houghton Creek in April of 1950.

Since it was impossible to follow through the trout spawning season on all the streams under investigation, Houghton Creek was singled out as a representative stream in the watershed where spawning activities might be more closely observed. As determined by a map measurer from an aerial photograph, Houghton Creek is approximately 9.7 miles long. On November 13 and 14, 1950, by which time spawning had been completed, the entire length of Houghton Creek was traversed on foot. All the brown trout redds were tallied along with their location. This information was incorporated on a map of the stream made from a tracing off an aerial photograph (map, Figure 8). In heavily spawned areas of the stream, the numbers of redds were often difficult to determine. Frequently brown trout redds were found abandoned at different stages of construction.

Krause's bridge, between Sections 30 and 31. T. 24 N., R. 3 E., appears to be the lower limit of brook trout habitation in Houghton Creek. Progressing upstream from Krause's bridge, brown trout redds decreased in number and brook trout redds increased. A total of 146 brown trout redds were counted on Houghton Creek plus an additional 22 doubtful redds. From map, Figure 8, it will be noted that little or no spawning occurs in the lower reaches of the stream but that the area of concentrated spawning activity is located in the middle portion, especially in Section 31, T. 24 N., R. 3 E.

The first sign of the approaching spawning season occurred on October 2, 1950, when a 20.1 inch gravid female and a mature male brown trout, 19.5 inches long, moved up into the "upper" population study area. These fish were not in this area of the stream previous to September 26. The earliest opportunity to observe the construction of a brown trout redd happened on October 12 in Section 30, T. 24 N., R. 3 E. On this day at 8:00 a.m. the water temperature was 46° F. and the air temperature 48° F. The peak period of spawning activity occurred between October 26 and November 6, 1950. During this period the air temperatures ranged between 38° and 75° F. and the water temperatures 44° and 53° F. Spawning took place in typical situations of slight to strong riffle areas over medium to coarse gravel. The depth of the water varied between 6 and 18 inches, with the majority of brown trout redds in water 9 to 12 inches deep.

Wilkins Creek

The site chosen for sampling on Wilkins Creek, the largest tributary of Houghton Creek, was limited to 365 feet of stream above the bridge in Section 12, T. 23 N., R. 2 E. The brown trout is the predominant species of trout present at this station. Ninety-eight trout were sampled, of which

96 were brown trout, ranging from 2.9 to 17.5 inches. Forty-three brown trout were of legal length (7 inches) and 34 were sublegal. Young-of-the-year browns totaled 19. One 7-inch brook trout and one 5.9-inch rainbow trout made up the balance of the sample. The rainbow trout was probably a migrant from the hatchery planting in Houghton Creek, April 25, 1950.

In the central section of Wilkins Creek (Section 12 to M-33), Locke (op. cit.) noted that brown trout were first in abundance and brook trout second, and that both species apparently reproduced in this area.

On May 26 of this year, 600 hatchery brown trout were planted in Wilkins Creek and on August 11, 1950, an additional 800 were planted. Both plantings were of legal-sized fish (7 inches). Fourteen of the 96 brown trout sampled at this station were judged to be hatchery fish.

One hundred feet above the bridge in Section 12 is the site of an old power dam. This stretch of stream is strongly riffled over coarse gravel and rubble. Approximately 50 feet above the dam site the stream bottom is clay hardpan. The remaining stream bottom of the sample station is sand. The stream averages 17.3 feet in width and 1.44 feet in depth.

According to Mr. Church, a local resident on Wilkins Creek, when the power dam was in operation there was excellent brook trout fishing in the impounded water as well as in the stream below the dam. He also states that after the dam went out (about 1937) brown trout were introduced into the watershed and it was not long afterward that brook trout almost disappeared in Wilkins Creek. This year (1950) was the first year since 1933 that brown trout were planted in Wilkins Creek, although brown trout had access to the stream from Houghton Creek at a much earlier date (1936). Between the years 1933 and 1941 a total of 18,530 brook trout from 6 to 8 months old were planted in Wilkins Creek.

Locke (op. cit.) found fingerling, sublegal, and legal rainbow trout in Wilkins Creek. Their presence he attributes to natural reproduction. The

first planting of rainbow trout previous to that year (1941) in Wilkins Creek (or Houghton Creek) was in 1937 when 3-month-old rainbow trout were introduced.

Prior Creek

Three sample stations were set up on Prior Creek. Their locations are as follows:

(1) "upper" Prior -- beginning at a point 125 feet below bridge in Section 13, T. 23 N., R. 3 E., and extending downstream 324 feet.

(2) "middle" Prior-- from the bridge at M-33 beginning at the fence line and extending downstream 555 feet in Section 19, T. 23 N., R. 3 E.

(3) "lower" Prior -- approximately one-half mile above bridge in Section 33, T. 23 N., R. 3 E. (measured from aerial photograph with a map measurer).

At the "upper" Prior station the creek is small, averaging 9.1 feet in width and 9 inches in depth (Figure 14). The bottom is sand. Despite the shallowness of the creek, trout cover is good. This is made possible by the tag alders that hem the banks. Thirty-nine brown trout were captured at this station. Sixteen, or 41 percent of this number, were 7 inches or larger. The brown trout varied in size from 3.0 to 12.1 inches. In the summer of 1941, Locke (op. cit.) found that although brown trout were distributed throughout the course of the stream, brook trout were abundant in the water above M-33. However, in the present 1950 survey, no brook trout were collected at the "upper" Prior Creek station which is located near the headwaters. It is interesting to note that a larva of Petromyzon marinus was taken at this station.

On November 16, 1950, four brown trout redds were observed in Prior Creek at the upper end of Section 13. Also, 3 brown trout redds and 2 probable brook trout redds were found a short distance above the bridge in Section 14, T. 23 N., R. 2 E.

In checking a small tributary of Prior Creek in Section 18, T. 23 N., R. 3 E., on November 16, two brook trout redds were located (Figure 15).

Figure 14.--"Upper" Prior Creek sample station where 16 legal length brown trout were taken in 324 feet of stream.

Figure 15.--A small tributary of Prior Creek where brook trout redds were observed.

At the time, 4:00 p.m., one brook trout was observed over each redd. The air temperature was 39° F. and the water 39° F.

At the "middle" Prior station a 555-foot section of stream was shocked. The creek here averaged 0.72 feet deep and 13.5 feet wide. Altogether, 162 trout were captured. This figure is broken down as follows:

112 brown trout (2.7 to 8.9)	50 brook trout (2.1 to 8.9)
19 brown trout (sublegal)	46 brook trout (sublegal)
11 brown trout (legal)	4 brook trout (legal)

Larvae of Petromyzon marinus were present at this station as well as at "upper" Prior Creek.

On November 16, this site, which is largely gravel bottom and riffles, was examined for trout redds. Five brown trout redds were counted. A small brook trout of approximately 7 inches was observed occupying a redd for short periods of time (2 to 3 minutes). Three brook trout were in the vicinity of this redd. The air temperatureswas 41° and the water 44° F. at 2:30 p.m.

From data collected in 1941, Locke (op. cit.) states that water temperatures above M-33 were suitable for brook trout throughout the summer and that the water below M-33 was subject to sudden rises in temperatures in warm weather which might exceed 75° F. In an open stretch of water approximately one-half mile below M-33, which includes the upper 555 feet of the present sample station, Locke reports a temperature rise of 11° F. During the interim between 1941 and 1950, the upper one-quarter mile of stream below M-33 has changed from one devoid of bank cover to one now bordered by tag alders (see Figure 16). Trout shocked here in the first 555 feet of stream below M-33 represented the largest series of brook trout sampled in the 1950 fall survey (Table 4). The effects of bank cover upon stream temperatures and brook trout distribution are unknown.

Figure 16.--"Middle" Prior Creek sample station looking downstream from the road culvert at M-33 showing tag alders that have taken hold sometime during the past nine years.

Table 4.--Composition and distribution of brook trout and rainbow trout in samples taken from tributary streams of Rifle River✓

Stream	Age group	Number of fish	Average length (Emp.)
Brook trout			
Middle Prior	0	33	3.5
	I	19	5.9
	II	2	8.2
Vaughn Creek	0	6	3.1
	I	6	5.3
	II	1	6.7
Wilkins Creek	I	1	7.0
Bixby Creek	I	2	5.2
Upper Klacking Creek	0	2	3.4
Rainbow trout			
Upper Klacking Creek	I	2	5.5
Lower Klacking Creek	0	10	3.2

✓ Reference here is made to native trouts only. Klacking Creek is planted with hatchery brook trout of legal size yearly. Rifle River and Houghton Creek were planted with legal hatchery rainbow trout in 1949 and 1950.

Tentative plans called for a population study at the "lower" Prior Creek station. However, since only 57 brown trout were shocked in approximately one-half mile of stream on the initial run, these circumstances did not warrant completing a population estimate. As a result, "lower" Prior Creek was treated only as another sampling station. Forty-five of the 57 brown trout were at least 7 inches long. Three were young-of-the-year fish.

"Lower" Prior Creek flows through a forest stand of deciduous trees. A beaver dam was located approximately one-half of the total distance shocked, above the road culvert in Section 33, T. 23 N., R. 3 E. This dam, with a 2- to 4-inch head, was new and not completely constructed. Gravel is the principal bottom type at this station. In the quiet water above the dam, siltation had set in.

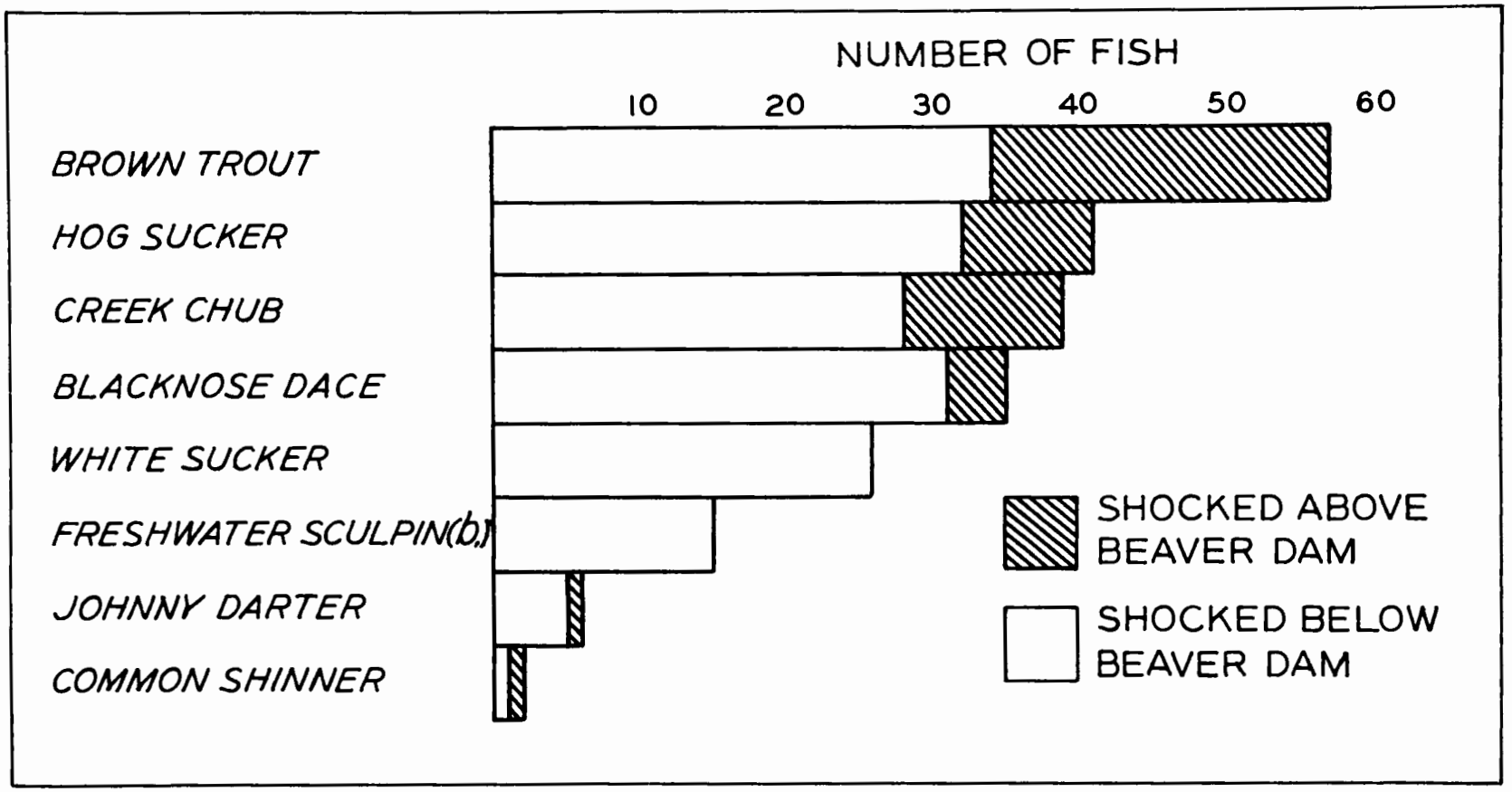
Like the Rifle River, the "lower" Prior Creek station showed a relatively rich fauna of fishes. Thirteen species were recorded. The beaver dam seemed to have had some effect upon the distribution of fish at this location. All the white suckers collected were found in the quiet water above the dam. Hog suckers, blacknose dace, and creek chubs were more prevalent in the shallow gravel riffles, characteristic of the stream below the dam. About 60 percent of the trout were found below the dam (Figure 17).

Following the trout spawning season, on November 27, six brown trout redds were seen between the beaver dam and the road culvert.

Klacking Creek

Klacking Creek was sampled at two locations designated as "upper" Klacking and "lower" Klacking. "Upper" Klacking Creek station extends downstream for 509 feet from a bridge; location of the station is Section 1, T. 22 N., R. 2 E. The stream banks below the station have narrow borders of trees, with the adjoining land on the north bank under cultivation. The stream bottom is of approximately equal proportions of sand and gravel. There are about equal numbers of riffles and glides. The creek averages 19.6 feet in width and 11.6 inches in depth.

Figure 17.--The distribution of fish in a restricted portion of stream following the construction of a new beaver dam at "lower" Prior Creek station.


NUMBER OF FISH
10
20
30
40
50
60
BROWN TROUT
HOG SUCKER
CREEK CHUB
BLACKNOSE DACE
WHITE SUCKER
FRESHWATER SCULPIN(b)
JOHNNY DARTER
COMMON SHINNER
SHOCKED ABOVE BEAVER DAM
SHOCKED BELOW BEAVER DAM

Of the 140 trout shocked, 133 were brown trout ranging in size from 2.4 to 17.8 inches. There were 24 brown trout of at least 7 inches and 67 young-of-the-year brown trout. Two sublegal rainbow trout of age group I were captured. Only 5 brook trout were shocked, one of which was of legal length (7 inches), and two were young-of-the-year fish.

"Lower" Klacking Creek station is delimited as follows: 721 feet below the bridge in Section 5, T. 22 N., R. 3 E., marks the upper end of the station, an island 425 feet downstream from this point marks the lower end of the site. The creek flows through a narrow patch of cedar on one Mr. Parliament's property. Cattle graze the adjoining land but are fenced off from the creek.

By and large, the creek from the bridge to the island is strongly riffled over gravel and rubble. The creek has an average width of 17.4 feet and an average depth of 1.2 feet. The following trout were sampled:

Total trout - 71

(1) brown trout - 61
- legal - 17
- sublegal - 44
- 0 age group - 21

(2) rainbow trout - 10
- 0 age group - 10

All the rainbow trout were obviously the result of natural reproduction for there have been no plantings of rainbow trout in Klacking Creek since 1938.

Despite the fact that 3,500 legal-size brook trout were planted in Klacking Creek during the spring and summer of 1950, only 5 brook trout were shocked in 1,034 feet of stream sampled. These 5 fish, of which 2 were in their first summer of life, were captured at "upper" Klacking Creek station.

Locke (op. cit.) stated that in upper Klacking Creek below the dam (Section 35) brown and brook trout were present in about equal numbers. He also reported that Brook, brown and rainbow trout were collected in good numbers in the central portion of the stream.

Mr. Klacking, whose grandfather was one of the earliest settlers in this area and after whom Klacking Creek is named, remarked that following the decline of lumbering operations, brook trout fishing in this stream was excellent. According to Mr. Klacking, not until about 1943 did brook trout fishing quality decline. Planting records show that brook trout fingerlings have been planted in the stream as far back as 1910. Including 1944 and every succeeding year, legal-size brook trout have been planted in Klacking Creek. At least as far back as 1938 no brown trout had been planted in this creek.

Vaughn Creek

Vaughn Creek is a tributary of Gamble Creek. Gamble Creek in turn empties into Devoe Lake. A sample station was established on this creek beginning at the road culvert and extending 500 feet downstream in Section 34, T. 24 N., R. 3 E. (Figure 18). At the lower end of this site a beaver dam was found in an early stage of construction. The average width of the creek at this station is 13.8 feet with an average depth of 1.27 feet. The bank cover is of tall grasses and sparse tag alders, with a few poplar trees at the downstream end. Approximately half the creek bottom is covered by large beds of Chara, and the remaining half is bare sand and clay hardpan. Very little gravel is present. In the one hour required to shock this 500-foot section, 65 trout were captured for weights and lengths. Of these, 52 were brown trout; 9 legal and 43 sublegal. Eighteen of the 43 sublegal brown trout were young-of-the-year fish, varying in length from 2.1 to 2.6 inches. Thirteen brook trout collected were 2.8 to 6.7 inches long.

On October 24, 1950, Vaughn Creek was examined on foot beginning at the lower end of Section 27, T. 24 N., R. 3 E. The entire length of this

Figure 18.--A view of Vaughn Creek sample station from the road culvert downstream.

portion of the creek is bordered by cedar. The creek bottom through Section 27 is almost entirely sand. Immediately below the road culvert in Section 27, there are 25 feet of exposed gravel bottom. On November 22, 1950, 5 brown trout redds were found in this area. One other brown trout redd was observed in Section 27; here a female brown trout had removed 2 inches of sand before gravel was exposed.

Vaughn Creek through Section 26 received additional water from numerous springs. The creek bed has cut a though, approximately 2 feet deep, through the swamp floor. The substratum of the creek is an impervious layer of clay. The sand bottom is littered with forest detritus, and the banks are cushioned with a mat of organic matter. A beaver dam was located at the upper end of Section 26. One brook trout was seen in the pond. The south boundary of Section 23 and the north boundary of Section 26, T. 24 N., R. 3 E., cuts across a series of beaver dams. It was only above the upper beaver pond that an appreciable amount of gravel bottom was found. Here 6 brook trout redds were counted. Many more springs enter Vaughn Creek in Section 23. From these observations there appear to be limited spawning areas for a large portion of the upper half of Vaughn Creek, particularly for brown trout.

Bixby Creek

Bixby Creek is a small tributary of Houghton Creek, flowing in a easterly direction. Barber Creek and an unnamed creek empty into Bixby Creek from the north. A 425-foot section of stream above the bridge in Section 31, T. 24 N., R. 3 E., was selected as a sampling site. One hundred and fourteen trout, ranging in length from 2.2 to 9.7 inches, were shocked at this station. Nine brown trout exceeded 7 inches in length, and of the remaining 103 sublegal brown trout, 70 percent were

in the 2- to 3-inch group. Only two brook trout were captured, both sublegal.

The creek at this site has an average width of 11.5 feet and an average depth of 9.5 inches. There are two 50-foot sections of fast riffles over gravel. The remaining areas are smooth glides over sand and clay. A perceptible amount of flocculent silt covers the creek bottom in the quieter water. A small cedar swamp marks the upper end of the station.

Brown trout spawning in Bixby Creek is confined to the lower reaches of the creek. On October 5, five brown trout redds were observed between the mouth and the first upstream tributary (unnamed creek). Immediately below the mouth of Barber Creek were two brook trout redds. Bixby Creek was summarized by Locke (op. cit.) as being too small to be considered a fishing or spawning area.

Ammond Creek

The sample station on Ammond Creek begins at the bridge and extends upstream 265 feet in Section 31, T. 23 N., R. 3 E. This portion of the creek is a smooth glide averaging 12.3 feet in width and 19.3 inches deep. The creek bottom of fine gravel and rubble is covered by a layer of silt. In the bend pools and along the banks this flocculent silt is from 1 to 8 inches deep. Tall grasses and low bushes border the creek. Ammond Creek empties into the lower reaches of Prior Creek.

Only one trout was captured at this station and this was a brown trout measuring 16.1 inches. The white sucker was the most prevalent species of fish present, numbering 74 and ranging in size from 1.7 to 12.0 inches. Next in order of abundance were creek chubs which numbered

55 and were from 1.1 to 6.2 inches in length; 22 freshwater sculpins (Cottus bairdi bairdi), 19 Johnny darters, 11 common shiners, and 1 blacknose dace comprised the remainder of the sample.

Creek chubs and common shiners were heavily infested with black spot parasite, Neascus sp. Only a few white suckers were so infested. Locke (op. cit.) lists 8 species of forage fish plus 1 white sucker taken in seining operations on Ammond Creek in 1941: creek chub, freshwater sculpin (bairdi), Johnny darters, brook stickleback, brassy minnow, fathead minnow, redbelly dace, and finescale dace. Locke found no evidence of trout present. In 1940 and 1941, 4,775 brook trout (7 months old) were planted in Ammond Creek.

Shepards Creek

Portions of Shepards Creek in Sections 9 and 16, T. 22 N., R. 3 E., were examined for a possible sampling site. Here the creek flows through a low forested area (flood plain). Much of the immediate bank cover is tag alders. The creek varies from approximately 2 to 8 feet in width and is generally shallow. At intervals along the creek, forest litter has piled up two feet high or more across the stream, forming small dams. Thus much of the water is sluggish. Large quantities of forest detritus and silt blankets the bottom. Apparently the creek carries a large volume of water during its flood stage, conveying with it an abnormal amount of eroded soil and drift material. Because of the difficulty of moving the shocking equipment up through Shepards Creek, the plan for sampling this stream was abandoned.

Age and growth

Body-scale relationship

The validity of the annulus as a true year-mark, as successfully demonstrated for many fishes, is assumed to hold true for brown trout, particularly since Cooper (1949) has shown that for brook trout scales the annulus is a true year-mark.

Key scales were removed from a restricted area in the region of the lateral line between the most posterior edge of the dorsal fin and the most anterior portion of the anal fin. These key scales were removed from the same region of the body as a designated by Cooper (1949) for brook trout. Scales were soaked in water and cleaned with a small brush or wooden probe. One representative scale with a normal focus was selected and a water mount made. Regenerated and asymetrical scales were discarded. All scales were examined under a micro-projection machine at a magnification of x90. The determination of age of brown trout from scales was based on the relative spacing of circuli. Annular marks were penciled off on a tag-board from the center of the focus out to the margin of the scale along the most anterior scale radius. The body-scale correlation was based on the total length of the trout in inches from the tip of the snout to the extended tips of the caudal fin.

The relationship between total body length and the length of the anterior scale radius (magnified x90) is expressed by the equation: $Y = a X^b$

where Y = anterior scale radius (ASR)

X = total body length in inches

a and b are constants to be derived

The equation was fitted to the empirical data on body length and anterior scale radius. Figures 19 and 20 show the curves of the equations plotted

Figure 19.--Relationship between body length and scale length in brown trout, Rifle River.

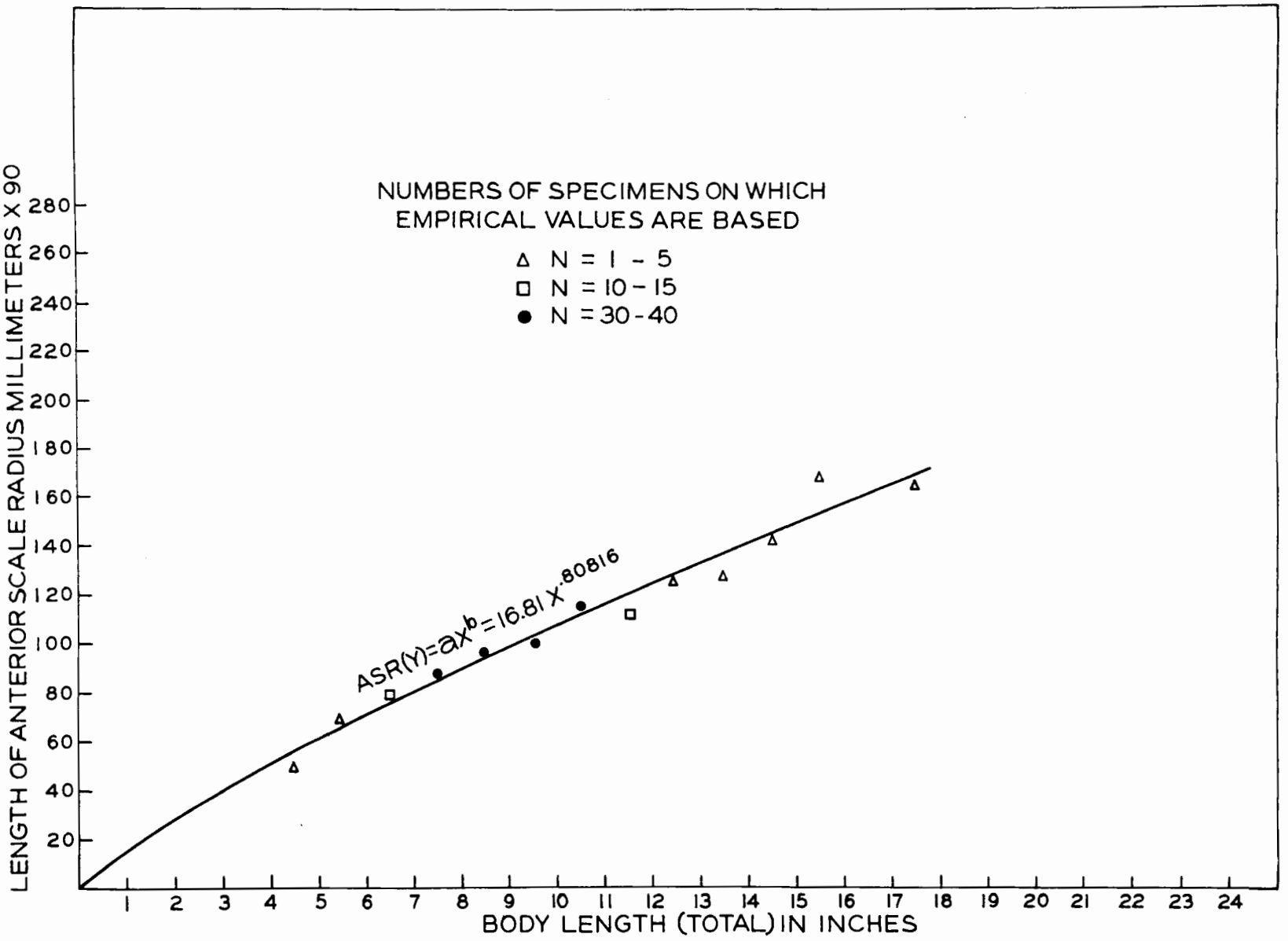
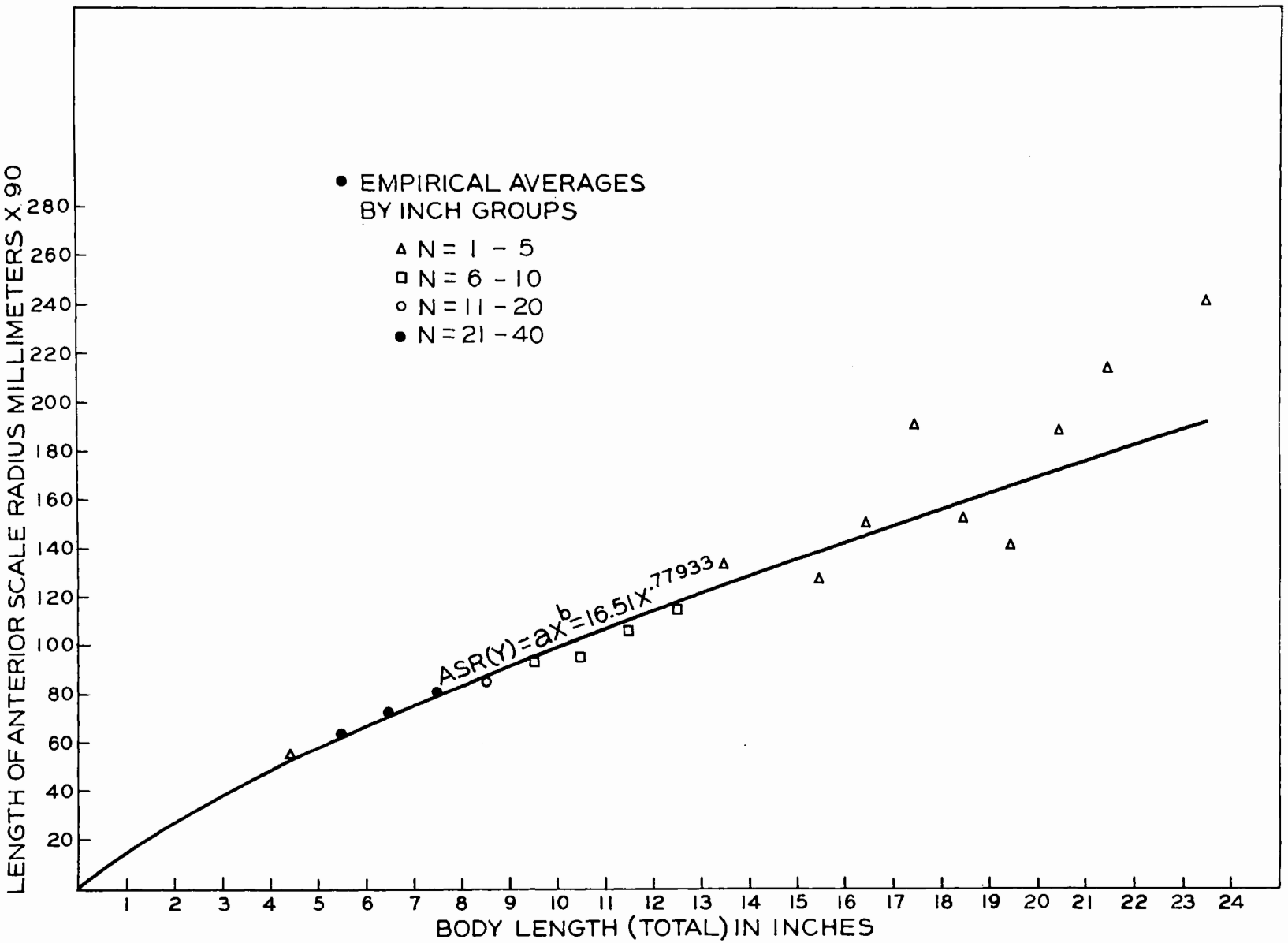

NUMBERS OF SPECIMENS ON WHICH
EMPIRICAL VALUES ARE BASED
△ N = 1 - 5
□ N = 10 - 15
● N = 30 - 40
ASR(Y)=ax^b=16.81 X^.80816
LENGTH OF ANTERIOR SCALE RADIUS MILLIMETERS X 90
20
40
60
80
100
120
140
160
180
200
220
240
260
280
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
BODY LENGTH (TOTAL) IN INCHES

Figure 20.--Relationship between body length and scale length of brown trout in Houghton Creek. Number of specimens on which averages are based are indicated by the legend.


• EMPIRICAL AVERAGES
BY INCH GROUPS
△ N = 1 - 5
□ N = 6 - 10
○ N = 11 - 20
● N = 21 - 40
ASR(Y) = aX^b = 16.51X^.77933
LENGTH OF ANTERIOR SCALE RADIUS MILLIMETERS X 90
20
40
60
80
100
120
140
160
180
200
220
240
260
280
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
BODY LENGTH (TOTAL) IN INCHES

against scale measurements averaged by inch groups. It will be seen that empirical data fall away from the curve at the upper end where the sample is exceedingly small. Variation in the expression of the body-scale relationship of the various streams in the Rifle River watershed are shown in Table 5. Sizes of the samples upon which the body-scale relationships rests are small, especially for Bixby Creek and Vaughn Creek. A larger sample for each stream would have been highly desirable.

To illustrate the differences or similarities in the body-scale relationships of brown trout between streams, a hypothetical fish of 18 inches in total length with an anterior scale radius of 180 millimeters and an assigned age of VI was applied to each body-scale relationship. The results are seen in Table 6. From a practical point of view, Wilkins Creek and Houghton Creek might logically be lumped together. The same is true of the Rifle River and Klacking Creek. However, since the body-scale relationship for each stream rests upon a relatively small sample, all equations except for Bixby Creek and Vaughn Creek were retained until such time when further sampling can be done. For calculated growth histories, Vaughn Creek brown trout were included in with those of Houghton Creek as their body-scale relationships were similar. Similarly, the equation of the body-scale relationship for Klacking Creek brown trout was employed in determining the calculated growth histories of brown trout from Bixby Creek.

Computation of individual growth histories of brown trout

The original scale measurements marked off on a tag-board were normalized by means of a simple nomograph as outlined by Hile (1941). Individual growth histories were then computed from a table of solutions of the equation of the body-scale relationship. In this table are tabulated body lengths corresponding to one millimeter intervals of scale

Table 5.--Variation in body-scale relationships[+] between streams in the Rifle River watershed

Stream	Number of fish	Range total length	a	b
Wilkins Creek	57	4.8-17.5	17.46	.74919
Houghton Creek	155	4.6-23.2	16.51	.77933
Rifle River	176	4.0-17.8	16.81	.80818
Klacking Creek	106	3.9-17.8	15.70	.82882
Prior Creek	143	4.2-17.8	13.98	.88494
Vaughn Creek	33	3.8-11.5	16.20	.78098
Bixby Creek	39	3.7-9.7	15.75	.82765
All stream combined	709	3.7-23.2	15.85	.81151

[+] Body-scale relationship is expressed by the formula:

$Y = aX$

Y = (ASR) = Anterior scale radius

X = Total length of fish in inches

a and b are constants

Table 6.--Calculated total lengths in inches of a brown trout based on various body-scale relationships employing a hypothetical trout of 18 inches total length with an anterior scale radius of 180 millimeters

Stream	Calculated lengths at the end of each year of life						
	1	2	3	4	5	6	Margin of scale
Wilkins Creek	2.4	5.1	7.1	11.7	13.4	15.9	18.0
Houghton Creek	2.6	5.3	7.3	11.8	13.6	16.1	18.0
Rifle River	2.8	5.6	7.6	12.1	13.8	16.1	18.0
Klacking Creek	2.9	5.8	7.8	12.1	13.9	16.2	18.0
Prior Creek	3.3	6.2	8.2	12.4	14.1	16.3	18.0
All streams combined[+]	3.0	5.7	7.8	12.2	13.9	16.2	18.0

[+] A body-scale relationship was determined by combining the data from all the streams sampled. See Table 5.

length up to 90 millimeters. Beyond this length the equation was solved for 5 millimeter intervals of scale length as the curve of the equation tended to flatten out. Points in between were interpolated.

Growth

For a comparison of the growth of brown trout see Table 7. Based on total calculated lengths, brown trout from Houghton Creek and Prior Creek averaged 7 inches in length at the end of the second summer of growth. However, at the end of the third year of life, Houghton Creek trout exceeded in length the brown trout from Prior Creek. In general the brown trout from the Rifle River showed comparatively poorer growth. Brown trout from Vaughn Creek exhibited poor growth, exceedingly so in their first year of life.

Length-weight relationship

For the computation of the length-weight relationship an equation for a parabola (1) $W = eL^n$ was used;

where W = weight in grams
L = total length in inches
and e and n are constants

in logarithmic form

(2) $\text{Log } W = \log e + n \log L$

For further discussion reference is made to Hile (1936) and Beckman (1938).

The length-weight relationships for brown trout in four streams of the Rifle River watershed are:

(1) Rifle River $\text{Log } W = -0.77524 + 2.98707 \log L$
(2) Houghton Creek $\text{Log } W = -0.84941 + 3.09930 \log L$
(3) Klacking Creek $\text{Log } W = -0.78983 + 2.98829 \log L$
(4) Prior Creek $\text{Log } W = -0.83162 + 3.06238 \log L$

Table 7.---Age composition and growth of brown trout for seven streams in the Rifle River watershed. Calculated lengths based on average total lengths at the end of each year of life

Stream	Age years	Calculated lengths		Age group	Empirical averages	
		Calculated total length	Calculated increment		Number of fish	Average total length
Rifle River	1	2.9	2.9	0	2	4.4
	2	6.1	3.2	I	70	7.7
	3	9.6	3.5	II	82	9.5
	4	13.4	3.8	III	20	10.8
				IV	2	17.6
				V	1	15.5
Houghton Creek	1	3.0	3.0	0	72	3.6
	2	7.0	4.0	I	98	6.6
	3	11.1	4.1	II	40	9.0
	4	14.6	3.5	III	7	12.4
	5	16.9	2.3	IV	5	16.8
	6	20.0	3.1	V	2	18.1
				VI	1	21.0
				VII	1	23.2
Prior Creek	1	3.3	3.3	0	59	3.5
	2	7.0	3.7	I	85	6.3
	3	10.0	3.3	II	44	8.9
	4	13.8	3.5	III	10	11.6
				IV	2	16.6
Klacking Creek	1	2.8	2.8	0	88	3.1
	2	6.6	3.8	I	72	5.9
	3	10.8	4.2	II	20	8.1
	4	14.4	3.6	III	10	12.3
				IV	4	16.8
Wilkins Creek	1	2.6	2.6	0	19	3.3
	2	6.1	3.5	I	23	5.8
	3	11.0	4.1	II	34	7.8
	4	13.5	2.5	III	1	12.8
				IV	1	17.5
Vaughn Creek	1	1.9	1.9	0	18	2.4
	2	4.9	3.0	I	19	4.4
	3	8.2	3.3	II	10	7.5
				III	4	10.0
Bixby Creek	1	3.0	3.0	0	73	3.1
	2	5.7	2.7	I	26	5.6
	3	8.0	2.3	II	11	7.7
				III	1	9.7

For the Rifle River, Klacking Creek, and Prior Creek, weights calculated from these equations agree reasonably well with those found empirically (Table 8 and Figures 21, 22 and 23). This held true for Houghton Creek only at the lower length ranges where the sizes of the samples were more adequate. In the small sample of larger fish, empirical averages by inch groups fell consistently below the calculated curve (Figure 24). The trend of the curve appears to be strongly influenced by the larger samples in the smaller inch groups and/or the small sample of large fish is unable to materially alter the direction of the curve. To achieve a better fitting curve for this particular sample of fish, an average length and weight was assigned to each inch group for the calculation of the curve $\log W = \log c + n \log L$. Thus each inch group will bear an equal influence upon the determination of the curve. The results of this weighting is a curve expressed by the equation, $\log W = -0.66564 + 2.91146 \log L$. Referring to Figure 24, the new calculated curve fits the empirical data better than does the first calculated curve (Table 9). It is interesting to note that a plotted curve based on the average condition factor (C) for Houghton Creek in the equation $W = \frac{39.11\ L^3}{100,000}$, results in averaging out, beyond the 13-inch group, the differences of the first and second calculated curves (Figure 24).

Coefficient of condition

To compare the "condition" of brown trout from the various streams in the watershed, the English coefficient of condition (C) was employed. It is expressed by the equation:

$$C = \frac{100,000\ W}{L^3}$$

where C = coefficient of condition

W = weight in pounds

L = total length in inches

Table 8.--Length-weight relationship for brown trout

Range	Klacking Creek				Rifle River				Prier Creek			
	Number fish	Average length	Weight-pounds		Number fish	Average length	Weight-pounds		Number fish	Average length	Weight-pounds	
			Empirical	Calculated			Empirical	Calculated			Empirical	Calculated
2 - 2.9	23	2.7	.01	.01					7	2.8	.01	.01
3 - 3.9	61	3.4	.02	.02					38	3.5	.02	.02
4 - 4.9	13	4.4	.03	.03	2	4.4	.03	.03	20	4.3	.03	.03
5 - 5.9	27	5.5	.06	.06	3	5.8	.07	.06	18	5.7	.07	.07
6 - 6.9	28	6.4	.09	.09	15	6.5	.10	.10	48	6.4	.10	.10
7 - 7.9	16	7.3	.15	.15	34	7.4	.15	.16	22	7.4	.15	.15
8 - 8.9	10	8.4	.25	.21	34	8.5	.22	.22	16	8.4	.22	.21
9 - 9.9	2	9.2	.32	.30	39	9.3	.29	.31	15	9.4	.31	.30
10 - 10.9	3	10.1	.37	.40	22	10.4	.41	.41	5	10.5	.39	.43
11 - 11.9	2	11.2	.46	.52	12	11.2	.52	.48	8	11.4	.56	.57
12 - 12.9					4	12.4	.67	.67	5	12.4	.72	.71
13 - 13.9	1	13.8	.45	.85	3	13.4	.90	.88				
14 - 14.9	2	14.3	.99	1.04	2	14.4	1.04	1.08				
15 - 15.9					2	15.3	1.18	1.32	1	15.5	1.56	1.43
16 - 16.9	3	16.2	1.42	1.48								
17 - 17.9	3	17.6	2.03	1.81	2	17.6	2.00	1.87	1	17.8	1.94	2.18
	Log W = -0.78983 + 2.98829 log L				Log W = -0.77524 + 2.98707 log L				Log W = -0.83162 + 3.06238 log L.			

Figure 21.--Length-weight relationship of brown trout in the Rifle River, Fall, 1950.

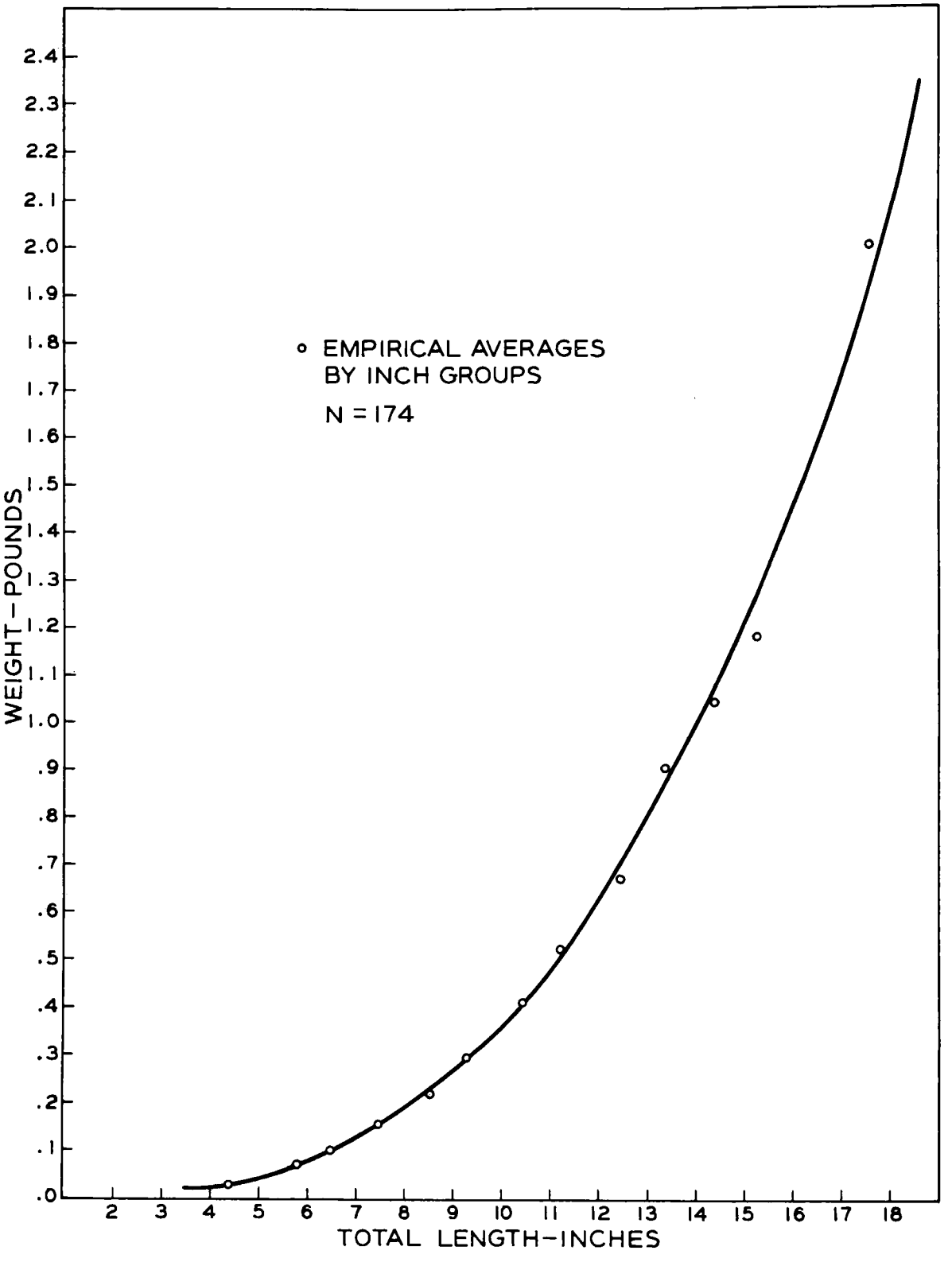

WEIGHT–POUNDS
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
o EMPIRICAL AVERAGES
BY INCH GROUPS
N = 174
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
TOTAL LENGTH–INCHES

Figure 22.--Length-weight relationship of brown trout in Klacking Creek, Fall, 1950.

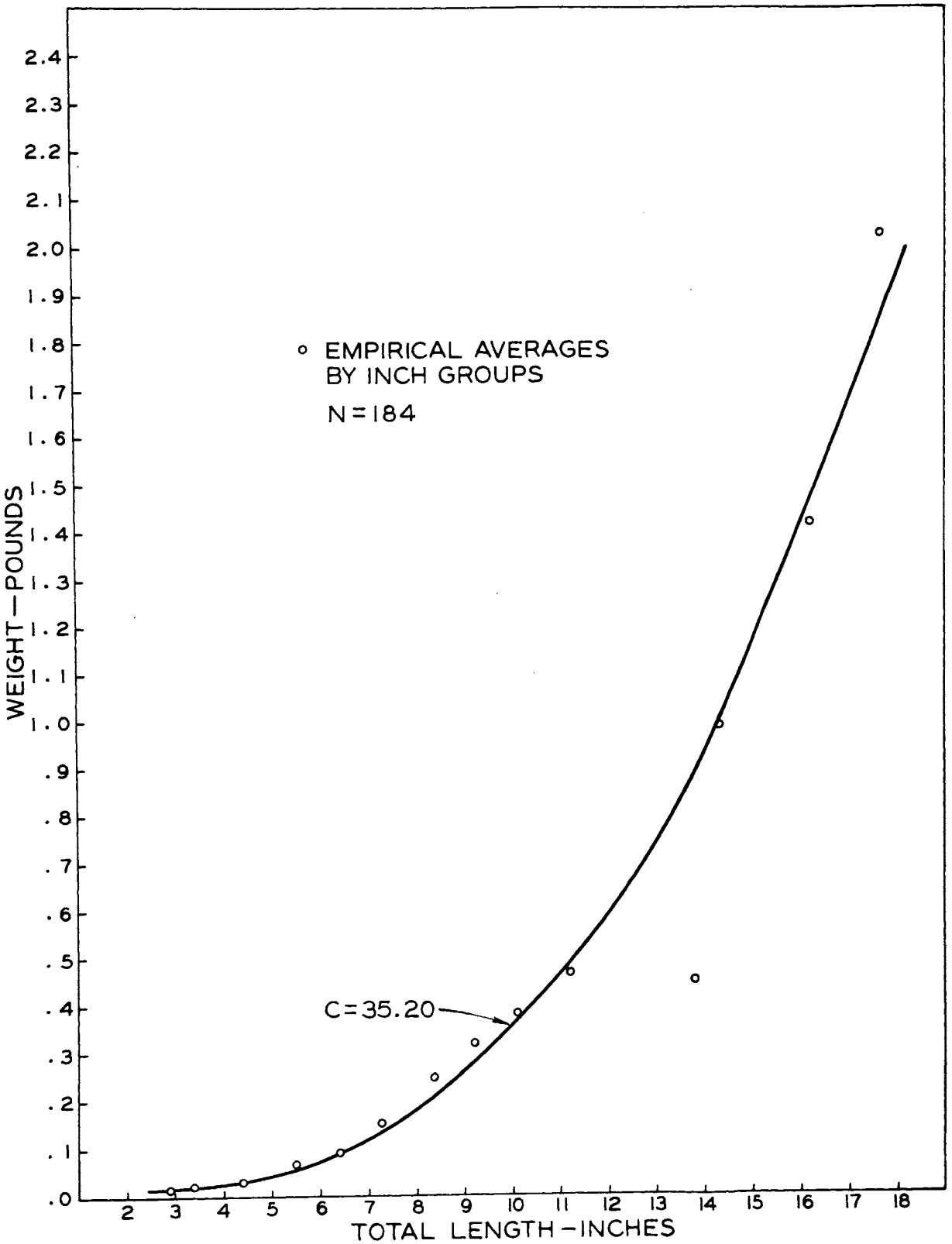

WEIGHT—POUNDS
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
EMPIRICAL AVERAGES
BY INCH GROUPS
N=184
C=35.20
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
TOTAL LENGTH—INCHES

Figure 23.--Length-weight relationship of brown trout in Prior Creek, Fall, 1950.

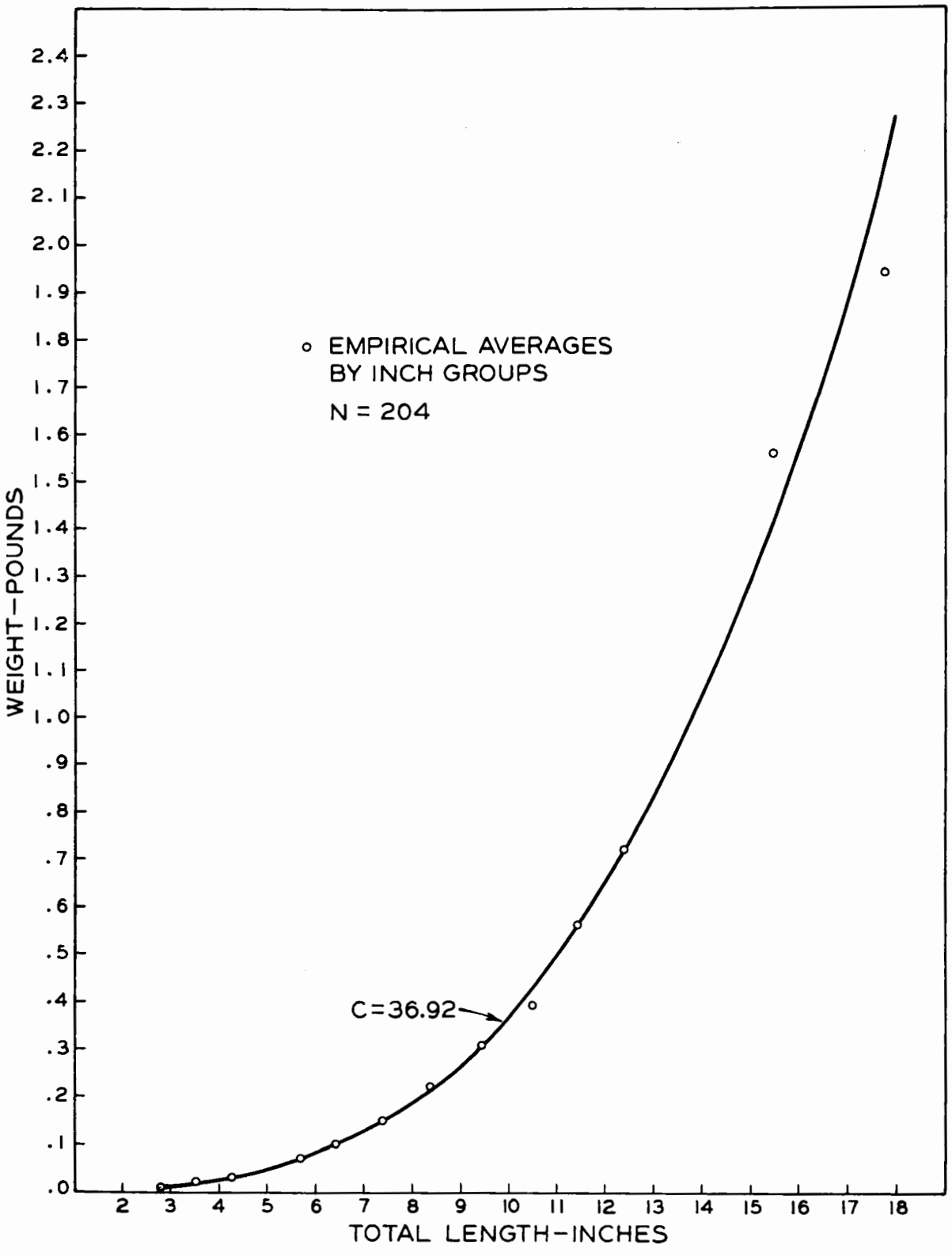

WEIGHT—POUNDS
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
EMPIRICAL AVERAGES
BY INCH GROUPS
N = 204
C=36.92
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
TOTAL LENGTH—INCHES

Figure 24.--Length-weight relationship of the brown trout in Houghton Creek, Fall, 1950.

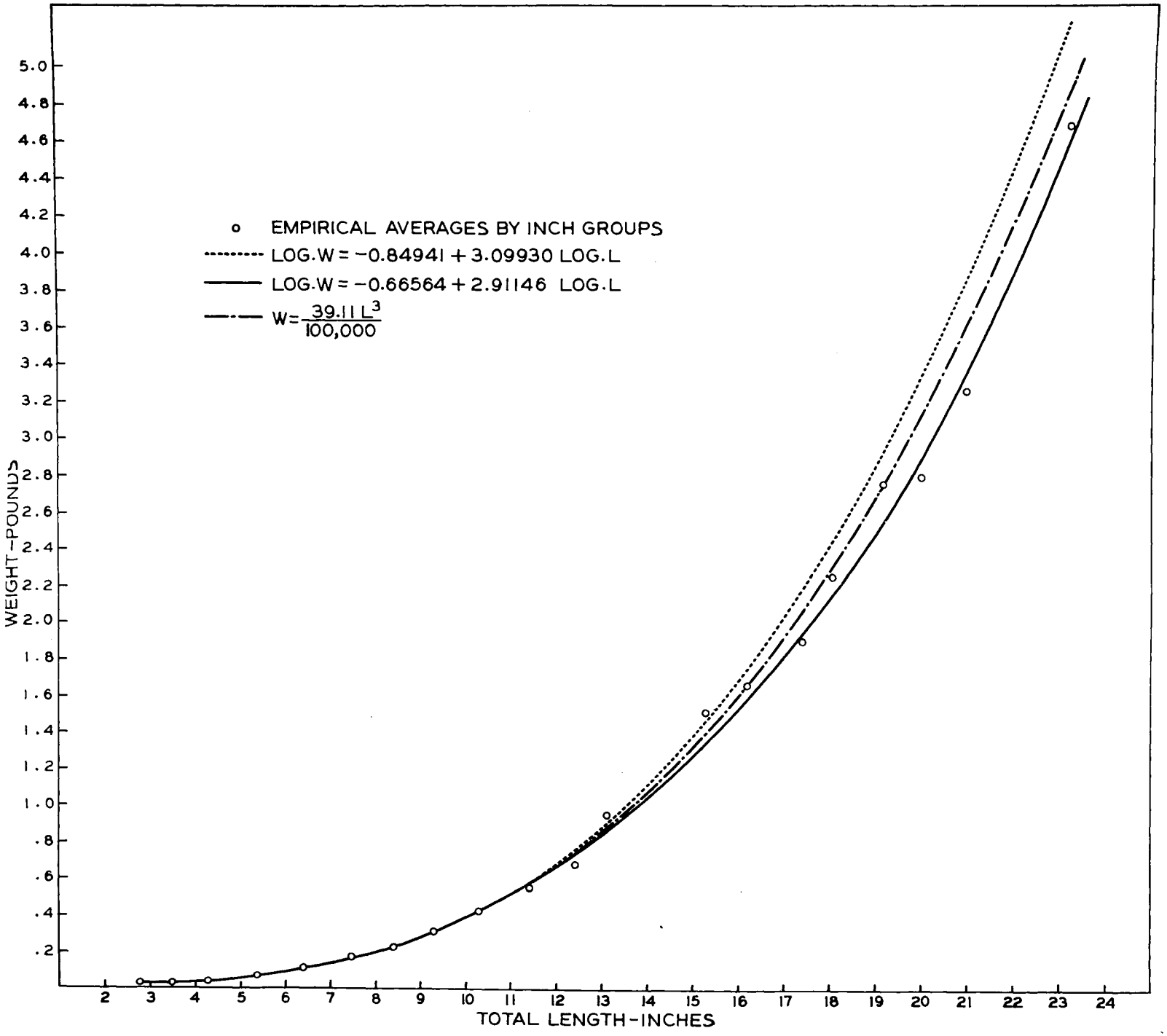

o EMPIRICAL AVERAGES BY INCH GROUPS
LOG.W = −0.84941 + 3.09930 LOG.L
LOG.W = −0.66564 + 2.91146 LOG.L
W = 39.11 L³ / 100,000
WEIGHT-POUNDS
TOTAL LENGTH-INCHES
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Table 9.--Length-weight relationship of brown trout in Houghton Creek

Range	Number fish	Average length	Empirical weight	Calculated weight	Calculated weight	Calculated weight
2 - 2.4	6	2.7	.01	.01	.01	.01
3 - 3.9	48	3.5	.02	.02	.02	.02
4 - 4.9	21	4.3	.03	.03	.03	.03
5 - 5.9	28	5.4	.06	.06	.06	.06
6 - 6.9	28	6.4	.11	.10	.11	.10
7 - 7.9	40	7.5	.17	.17	.17	.16
8 - 8.9	17	8.4	.22	.22	.23	.23
9 - 9.9	8	9.3	.32	.32	.32	.31
10 - 10.9	8	10.3	.42	.42	.41	.43
11 - 11.9	7	11.4	.55	.60	.58	.58
12 - 12.9	2	12.4	.68	.75	.71	.75
13 - 13.9	1	13.1	.95	.92	.87	.88
15 - 15.9	2	15.3	1.50	1.42	1.30	1.40
16 - 16.9	5	16.2	1.65	1.75	1.59	1.66
17 - 17.9	2	17.4	1.90	2.17	1.94	2.06
18 - 18.9	1	18.1	2.25	2.50	2.22	2.32
19 - 19.9	2	19.2	2.75	2.89	2.54	2.77
20 - 20.9	2	20.1	2.78	3.35	2.90	3.17
21 - 21.9	1	21.0	3.25	3.62	3.33	3.62
23 - 23.9	1	23.2	4.68	5.49	4.63	4.88
				$\text{Log } W = -0.84941 + 3.09930 \log L$	$\text{Log } W = -0.66564 + 2.91146 \log L$	$C = \frac{100,000\ W}{L^3}$
						$W = \frac{39.11\ L^3}{100,000}$

Table 10 lists the average "C" values for seven streams in the Rifle River drainage. Statistically, the coefficient of condition (C) of brown trout from Houghton Creek is significantly higher than all streams except Bixby and Vaughn creeks (Table 11 and 12). Brown trout from Wilkins and Klacking creeks have the lowest "C" values. Based on the average condition factor (C) of Houghton Creek and Wilkins Creek, the respective weights of a 10-inch brown trout would be 0.39 and 0.35 pounds (Table 13). This is a difference of 0.04 pounds or approximately 18 grams.

Summary

The composition, density, and distribution of trouts in the Rifle River watershed north of M-55 have undergone some changes between 1941 and 1950. Brown trout have so intrenched themselves that they are now the predominant species of trout throughout most of the waters of the drainage.

The following pertinent information was gleaned from Locke's report (op. cit.): (1) rainbow trout were more abundant in the Rifle River than brown trout, largely the result of natural reproduction; (2) Houghton Creek produced fair numbers of yearling and young-of-the-year rainbow trout, and this was also true of Wilkins Creek; (3) brown and rainbow trout were predominant in the lower reaches of Klacking Creek. However, in the present (1950) survey, rainbow trout were the fewest in numbers and were largely the result of hatchery plantings in the Rifle River. The only positive evidence of native or wild rainbow trout in the drainage were young-of-the year rainbows collected at the "lower" Klacking Creek station. The factors that have led to their decline in the Rifle River system are not known.

Table 10.--Coefficient of condition[+] of brown trout from various streams in the Rifle River watershed, fall, 1950

Stream	Size range in inches				Total number	Average condition
	4.0-6.9	7.0-9.9	10.0-15.9	16-over		
Houghton						
Number of samples	77	65	20	14	176	...
Condition (C)	39.94	38.91	37.84	37.27	...	39.11
Bixby						
Number of samples	30	9	...	...	39	...
Condition (C)	38.12	39.34	...	...	...	38.40
Vaughn						
Number of samples	23	6	3	...	32	...
Condition (C)	38.15	38.07	37.10	...	...	38.04
Upper Klacking						
Number of samples	43	19	5	1	68	...
Condition (C)	34.66	38.13	35.02	33.15	...	35.63
Lower Klacking						
Number of samples	25	9	3	5	42	...
Condition (C)	35.82	36.06	26.65	35.73	...	35.20
U and L Klacking combined						
Condition (C)	...	...	...	...	...	35.47
Upper Prior						
Number of samples	20	15	2	...	37	...
Condition (C)	35.90	35.72	43.12	...	...	36.22
Middle Prior						
Number of samples	54[++]	9[+++]	2	...	65	...
Condition (C)	36.16	37.58	39.85	...	...	36.47
Lower Prior						
Number of samples	12	29	15	1	57	...
Condition (C)	39.20	37.92	37.02	34.39	...	37.89
U, M and L Prior combined						
Condition (C)	...	...	...	...	...	36.92
Rifle River						
Number of samples	20	108	45	2	175	...
Condition (C)	36.95	35.83	36.44	36.71	...	36.13
Wilkins						
Number of samples	31	21	6	1	59	...
Condition (C)	36.36	35.01	34.86	35.74	...	35.74

[+] The coefficient of condition (C) is based on the English system of pounds and inches in the following equation: $C = \frac{100,000\ W}{L^3}$, W = weight in pounds, L = total length in inches.

[++] In the 4.0-6.9 inch group 21 brook trout had an average condition factor (C) of 33.55.

[+++] The average condition factor (C) of 4 brook trout in the 7.0-8.9 inch range was 34.60

Table 11.--Comparison of the coefficient of condition (C) for seven streams in the Rifle River drainage

Stream	Number of fish	Range length	Mean (C)	Standard deviation	Standard error of mean
Houghton Creek	176	4.0-23.2	39.11	4.06	0.305
Rifle River	175	4.0-17.8	36.13	3.30	0.249
Prior Creek	159	4.0-17.8	36.92	3.69	0.291
Klacking Creek	110	4.0-17.8	35.47	5.37	0.511
Wilkins Creek	59	4.8-17.5	35.74	3.54	0.460
Bixby Creek	39	4.0-9.7	38.40	4.30	0.688
Vaughn Creek	32	4.0-11.5	38.04	4.51	0.796

Table 12.--Significant differences[+] in the coefficient of condition of brown trout between streams in the Rifle River drainage

	Vaughn Creek	Bixby Creek	Wilkins Creek	Klacking Creek	Prior Creek	Rifle River	Houghton Creek
Houghton Creek	1.255	0.943	6.105	6.116	5.194	7.569	
Rifle River	2.290	3.102	0.745	1.160	2.062		
Prior Creek	1.321	1.981	2.167	2.465			
Klacking Creek	2.716	3.418	0.392				
Wilkins Creek	2.501	3.214					
Bixby Creek	0.342						
Vaughn Creek							

[+] Underscored figures indicate a statistically significant difference in condition (C) based on a 95 percent level of probability.

Table 13.--Comparative weights of a ten-inch brown trout based on average condition factor (C) of each stream

Stream	Length	Weight Hundredth pounds
Houghton Creek	10.0	0.39
Bixby Creek	10.0	0.38
Vaughn Creek	10.0	0.38
Prior Creek	10.0	0.36
Rifle River	10.0	0.36
Wilkins Creek	10.0	0.35
Klacking Creek	10.0	0.35

The distribution of brook trout in the Rifle River watershed has undergone a modicum of change but within this range there apparently has been an encroachment of brown trout. Brook trout, though confined generally to the upper reaches of the streams, were either collected or observed in all of the streams of the drainage except the Rifle River. Locke (op. cit.) collected a few brook trout in the Rifle River near the mouth of Detrich Creek, one at Selkirk, and four in the upper part of the Rifle River. As Locke infers, these brook trout were probably migrants from colder tributary streams of the Rifle River. Water temperatures of the Rifle River in mid-summer are considered unsuitable for brook trout. Their numbers in the Rifle River are negligible.

Brown trout have borne a progressively increasing portion of the angling pressure in recent years. Many trout fishermen have remarked about the excellent brook trout fishing in the past and many now complain about brown trout "taking over" the streams of the watershed. The "disappearance" of brook trout and the increase in numbers of brown trout reflect in part a difference in the biology of the two species and their relative rates of exploitation. Generally speaking, brook trout are sexually mature at the end of their second or third year of life, at about 7 inches. On the other hand, brown trout are usually sexually mature at the end of the third or fourth year of life, at a greater length. Through inherent wariness and its nocturnal habits, the brown trout has greater survival to spawning age. The brook trout, being more exploitable, almost to its 7-inch legal length, by a growing legion of trout fishermen, has not been able to adequately maintain itself for high angling quality under existing conditions.

In that part of the Rifle River considered in this study there is no succession of fish species from headwaters downstream. The white sucker, which is the most prevalent species of fish in the stream, in 1950 had

its greatest concentration in total numbers and weight in the Rifle River Area at the three upper stations. Brown trout in the Rifle River showed no recognizable pattern of distribution but tended to fluctuate in numbers from one station to the next.

From the "upper" to the "lower" population study areas in Houghton Creek there was evidence of a change in composition and density of brown trout. In the "upper" station brown trout were numerically strong, and averaged smaller in size and younger in age. Progressing downstream through the "middle" to the "lower" population study area, brown trout became fewer in number, averaged larger in length and older in age.

Based on average calculated lengths at the end of each year of life, brown trout from Houghton Creek showed the best growth and the Rifle River brown trout comparatively poor growth. Poorest growth was exhibited by brown trout from Vaughn Creek. Employing the English coefficient of condition (C), brown trout from Houghton Creek had a significantly higher C value than all streams except Bixby and Vaughn creeks. The coefficients of condition of brown trout were lowest in Wilkins Creek and Klacking Creek.

INSTITUTE FOR FISHERIES RESEARCH

Howard Gowing

Report approved by: A. S. Hazzard

Report typed by: M. C. Tait

Literature cited

American Fisheries Society

1948. A list of common and scientific names of the better known fishes of the United States and Canada. Spec. Publ. No. 1, 45 pp.

Beckman, William C.

1945. The length-weight relationship, factors for conversions between standard and total lengths, and coefficients of condition for seven Michigan fishes. Trans. Amer. Fish. Soc., Vol. 75, pp. 237-256.

Chapman, D. G.

1948. A mathematical study of confidence limits of salmon populations calculated from sample tag ratios. Internat. Pac. Sal. Fish. Comm., Bull. II, pp. 69-84. New Westminister, B. C.

1951. Some properties of the hypergeometric distribution with applications to zoological sample censuses. Univ. of Calif. Publs. in statistics. Vol. I, No. 7, pp. 131-160. Univ. of Calif. Press, Berkeley and Los Angeles.

Chung, J. H. and D. B. DeLury

1950. Confidence limits for the hypergeometric distribution. Ontario Research Foundation, Univ. of Toronto Press, Canada.

Cooper, Edwin L.

1949. Age and growth of the brook trout, Salvelinus fontinalus (Mitchill), in Michigan. Unpublished. IFR Report No. 1249, pp. 1-138.

Hile, Ralph

1936. Age and growth of the cisco, Leucichthys artedie (Le Sueur), in the lakes of the northeastern highlands, Wisconsin. Bull. U. S. Bur. of Fish., Vol. 48, pp. 211-317.

1941. Age and growth of the rock bass, Ambloplites rupestris (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wis. Acad. of Sci., Arts, and Lett. Vol. 33, pp. 187-337.

Locke, Fred E.

1951. A survey of the Rifle River system, Arenac and Ogemaw counties, Michigan. Unpublished. IFR Report No. 1282, pp. 1-166.

Petersen, C. G. J.

1896. The yearly immigration of young plaice into the Limfjord from the German Sea, etc. Report Danish Biol. Sta. for 1895. Vol. 6, pp. 1-48.

Shetter, David S.

1947. The electric "shocker" and its use in Michigan streams. Mich. Cons., Vol. XVI, pp. 8-10.

Snedecor, G. W.

1950. Statistical methods. The Iowa State College Press, Ames, Iowa. pp. 1-485.

Appendix I

Physical dimensions of sampling stations and the numbers of trout[+] captured at each site

Stream	Length sample station (feet)	Average depth (feet)	Average width (feet)	Volume (cu. ft.)	Number of acres	Acre feet	Number of sublegal trout	Number of legal trout	Total trout	Trout per 1,000 cu. ft.	Pounds per acre foot
"Upper" Houghton[++]	3325	.86	15.2	43464.4	1.16	.99	493 (2 bk)	163	656	15	...
"Middle" Houghton[++]	2126	1.50	23.3	74338.6	1.13	1.70	143 (1 bow)	152	295	4	...
"Lower" Houghton[++]	1580	2.20	24.4	84814.4	.88	1.94	42	81	123	1	...
Wilkins Creek	365	1.44	17.3	9092.8	.14	.20	55 (1 bow)	43 (1 bk)	98	11	75.10
"Upper" Prior	324	.75	9.1	2211.3	.06	.05	23	16	39	18	116.00
"Middle" Prior	555	.72	13.5	5394.6	.17	.12	147 (46 bk)	15 (4 bk)	162	30	79.25
"Lower" Prior	Approx. 1/2 mile	...	...	...	...	...	12	45	57	...	...
"Upper" Klacking	509	.97	19.6	9677.1	.23	.22	115 (4 bk-2 bows)	25 (1 bk)	140	14	54.68
"Lower" Klacking	425	1.20	17.4	8874.0	.16	.20	54 (10 bows)	17	71	8	74.10
Ammond	265	1.60	12.3	5215.2	.07	.11	0	1	1	.2	6.27
Vaughn	500	1.27	13.8	8763.0	.15	.20	56 (13 bk)	9	65	7	23.03
Bixby	425	.88	11.5	4301.0	.11	.09	105 (2 bk)	9	114	26	59.11

[+] Where brook trout (bk) and rainbow trout (bows) occurred their numbers are indicated by parentheses and are included in the figure immediately above (brown trout).

[++] Physical dimensions taken from three population study areas and the numbers of trout captured on initial run.

Appendix II

Check list of fish taken from the Rifle River*

Brown trout	Salmo trutta Linnaeus
Rainbow trout	Salmo gairdneri irideus Gibbons
White sucker	Catostomus commersoni (Lacepede)
Hog sucker	Hypentelium nigricans (LeSueur)
Creek chub	Semotilus atromaculatus atramaculatus (Mitchill)
Blacknose dace	Rhinichthys atratulus meleagris Agassiz
Johnny darter	Etheostoma nigrum nigrum (Rafinesque)
Rainbow darter	Etheostoma caeruleum (Storer)
Hornyhead chub	Hybopsis biguttata** (Kirtland) (Nacomis biguttatus)
River chub	Hybopsis micropogon** (Cope) (Nocomis micropogon)
Stonecat	Noturus flavus Rafinesque
Common shiner	Notropis cornutus frontalis (Agassiz)
Longnose dace	Rhinichthys cataractae (Valenciennes)
Blackside darter	Hadropterus maculatus (Girard)
Brook stickleback	Eucalia inconstans (Kirtland)
Logperch	Percina caprodes semifasciata (De Kay)
Yellow perch	Perca flavescens (Mitchill)
Rock bass	Ambloplites rupestris rupestris (Rafinesque)
Largemouth black bass	Micropterus salmoides (Lacepede)
Freshwater sculpin	Cottus bairdi bairdi Girard
Carp	Cyprinus carpio Linnaeus
American brook lamprey (larvae)	Lampetra lamottei** (LeSueur) (Entosphenus lamottenii)

* All names are in accordance with the American Fisheries Society's list of common and scientific names of the better known fishes of the United States and Canada (1948).

** Name revised as of February, 1951, by Reeve M. Bailey, Curator of Fishes, University of Michigan Museum. Previous accepted scientific name in parentheses.

Appendix III

Check list of fish taken from Prior Creek*

Brown trout	Salmo trutta Linnaeus
Eastern brook trout	Salvelinus fontinalis (Mitchill)
White sucker	Catostomus commersoni (Lacepede)
Hog sucker	Hypentilium nigricans (LeSueur)
Creek chub	Semotilus atromaculatus atromaculatus (Mitchill)
Blacknose dace	Rhinichthys atratulus meleagris Agassiz
Freshwater sculpin	Cottus bairdi bairdi Girard
Freshwater sculpin	Cottus cognatus gracilis Hackel
Johnny darter	Etheostoma nigrum nigrum (Rafinesque)
Common shiner	Notropis cornutus frontalis (Agassiz)
Central mudminnow	Umbra limi (Kirtland)
American brook lamprey (larvae)	Lampetra lamottei** (LeSueur) (Entosphenus lamotten:
Sea lamprey (larvae)	Petromyzon marinus Linnaeus

* All names are in accordance with the American Fisheries Society's list of common and scientific names of the better known fishes of the United States and Canada (1948).

** Name revised as of February, 1951, by Reeve M. Bailey, Curator of Fishes University of Michigan Museum. Previous accepted scientific name in parentheses.