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Education - Game
Institute for Fisheries Research
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Contribution from the Michigan Institute for Fisheries Research

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Edwin L. Cooper

Michigan Department of Conservation

Vanderbilt, Michigan

Abstract

The Pigeon River Trout Research Area contains 4.8 miles of trout stream averaging about 40 feet wide. In this area a complete census of fishing is accomplished by means of a compulsory permit system. Estimates of the native trout population were made in September of 1949 and 1950 immediately following the close of the trout season. Comparing the total catch with the population remaining at the close of the season, it is indicated that native eastern brook trout are much easier to exploit than native brown trout. Combining data for 1949 and 1950, anglers took 3.0 brook trout for each one remaining at the close of the season. For brown trout, only 0.4 fish was caught for each one remaining.

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RATE OF EXPLOITATION OF NATIVE EASTERN BROOK TROUT AND BROWN TROUT POPULATIONS IN THE PIGEON RIVER, OTSEGO COUNTY, MICHIGAN

By

Edwin L. Cooper

Introduction

At the northern tip of the Lower Peninsula of Michigan is a connected series of three large lakes: Burt, Mullett, and Black, draining into Lake Huron by way of the Cheboygan River. Each of these lakes receives a large tributary stream from the south: the Sturgeon River emptying into Burt Lake, the Pigeon River into Mullett Lake, and the Black River into Black Lake. The three rivers have roughly parallel drainage areas and flow in a northerly direction from their sources a few miles east of the town of Gaylord, covering a straight line distance of approximately 35 miles. The Pigeon River, the middle one of the three, was selected as the site for a trout research area because of the large amount of state-owned stream frontage and also because it was believed to be somewhat representative of many other Michigan trout streams.

The Pigeon River Trout Research Area comprises 4.8 miles of trout stream and a series of seven small lakes suitable for trout. The portion of the stream under study has been arbitrarily divided into four fishing sections of nearly equal length, hereafter referred to as Sections A (furthest downstream), B, C, and D. Preliminary investigations with an electric shocker disclosed that Section A differed markedly from the others as to the numbers of trout present, although the physical features of the sections are similar (Table 1). The upper three sections (B, C, and D) support a fair native population

Table 1.--Morphometry of Pigeon River Trout Research Area, survey of 1949-1950.

Item	Section A	Section B	Section C	Section D	Total
Length - miles	1.31	1.19	1.13	1.18	4.80
Average width - feet	45	41	40	40	41
Area - acres	7.16	5.90	5.39	5.65	24.10
Percent gradient	0.18	0.18	0.23	0.15	0.18

of both eastern brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta). Rainbow trout (Salmo gairdneri) are present in much smaller numbers. Much of the lower section (A) is sluggish with a sandy bottom and contains fewer trout.

A permit-type of creel census was operated on the experimental waters during the seasons of 1949 and 1950. In Michigan, the general trout season opens on the last Saturday in April and ends on the second Sunday in September, resulting in a 135-day season. Each fisherman desiring to fish a particular portion of the stream was required to register at a centrally-located checking station and obtain a permit. At the close of fishing in that particular section of the stream, he was required to return his permit to the checking station and report his fishing success. No charge was made for a permit and a person could fish in as many sections of the stream as he wished. Permits were issued at any time of the day or night. A general willingness on the part of the public to cooperate with this program provided us with a very accurate record of the results of fishing in the area.

The rather extensive data of fishing results in the area permit a wide variety of experiments in trout stream management. Evaluation studies of various angling restrictions are in progress coupled with continuous records of catch statistics, growth rate and seasonal changes in the condition of the trout, and estimates of the native trout populations. Studies involving the release of marked hatchery trout are also included in the program. The present discussion deals with the stream production of native trout to the angler in relation to the total trout population of the stream as measured by population estimates.

Method of Estimating Trout Populations in Pigeon River

The mark-and-recapture method used in estimating the trout population in a portion of the Pigeon River is dependent upon the efficiency of the electric shocker in capturing a sizable portion of the trout present. Although the use of electricity for catching fish is by no means new (Burr, 1932; Haskell, 1940), its application to estimating stream populations of fish has not been fully exploited. The present study represents an advance over attempts at stream population estimates using seines or water diversion (Hoover, 1948; Needham, Moffett and Slater, 1945; Shetter and Hazzard, 1939; Shetter and Leonard, 1943). It is also believed to be somewhat better than attempts at estimating the total populations of larger portions of streams with electric shockers using randomly selected small samples (Smith, Johnson and Hiner, 1949; Schuck, 1945; Mottley, 1942), in that the data obtained are based on a large sample of the population of a continuous 4.8 mile portion of a stream. Unpublished data by D. S. Shetter, as well as our present observations, indicate that the variation in population density may be so great in small adjacent portions of trout streams that the total estimate of a large portion is more efficient and more accurate than the results from an appreciable number of randomly-selected small areas. The method employed in this study is quite similar to that used by Shetter, 1950.

The accuracy of the method depends to a large extent on the adequacy of the sample and upon the validity of several assumptions discussed below. It should be emphasized that the data obtained in this and similar studies are only approximations of the actual populations. The confidence in estimations of this kind will depend on how well this information agrees with data derived from other life history studies of the trout populations in question.

It is necessary to assume that the initial capture of the fish by an A. C. electric shocker, marking by fin clipping a portion of the caudal fin, and immediately returning them to the same portion of the stream, do not measurably affect the recapture of the fish 3 to 4 days later. Any large-scale mortality, movement from the sampling area, or future avoidance of capture would adversely affect the accuracy of the estimate. Exact quantitative data on these three possible sources of error are lacking. However, observations made at the research area during two years of extensive use of the shocker supports the assumption made above. If the shocking method of collecting fish exerts an appreciable extra mortality on the populations present, the amount of shocking done in the past two years should have had a tremendous effect in decreasing the population. Such a decrease was not demonstrated by creel census records or by population estimates.

During the spring of 1951, data on movement of native trout following shocking and fin clipping were obtained. Several hundred native trout were collected with the shocker, fin clipped and returned to the stream. Angler recoveries from these experiments indicate very little movement out of the section in which they were originally captured and marked. Also, this same program of shocking and marking indicated that fish were not avoiding recapture to any great extent. During the later runs with the shocker through the sections sampled, a large proportion of the fish captured were those that had previously been captured and marked. These field observations, while not as valuable as exact data, do lend support to the assumption that errors in the method of estimating populations due to mortality, movement or changes in catchability are minimal.

Another assumption that needs to be examined is that the three species of trout encountered in the Pigeon River (eastern brook, brown, and rainbow) are equally susceptible to capture by this method. If such

an assumption is valid, better estimates of individual species are possible, especially in the case of the rainbow trout where the number of fish sampled is small. In examining the rate of recovery of eastern brook and brown trout of various sizes for the two years, there are no consistent differences in rate of recovery between these two species (Table 2). The small number of rainbow trout encountered does not warrant their inclusion in the table. Differences in the rate of recovery are also haphazard and relatively small when the different sections of the stream are compared (Table 2). However, there is a consistent difference in the recovery rate of trout of different sizes, and these differences must be considered in the method of estimating the total population. The small fish are not only harder to stun with the shocker but are also harder to see by the operator and are thus less easily captured than larger fish.

- An alternating current electric shocker has been used throughout this study. However, any collecting apparatus that enables one to handle more fish and thus have a larger percentage of the population marked from which to draw recoveries, will increase the accuracy of the estimate, assuming no important degree of bias. From limited experience, the D. C. shocker seems to be far superior to the A. C. shocker in catching fish, under the conditions in which we have been operating. The Pigeon River in the research area averages 40 feet wide and about 1 1/2 feet deep, with frequent pools as deep as 5 feet.

The estimates given deal only with the trout populations present although small numbers of other species of fish do occur, such as northern muddler (Cottus b. bairdi), western blacknose dace (Rhinichthys atratulus meleagris), northern creek chub (Semotilus a. atromaculatus) and the common white sucker (Catostomus c. commersonni).

Table 2.--Number of trout marked (M) and percentage of recovery (R) of wild trout in Pigeon River, Otsego County, Michigan, compared as to species, size and stream section.

Item	M	R	M	R	M	R	M	R
Size group in inches	2.0 - 3.9		4.0 - 6.9		7.0 and over			
September, 1949								
Brook trout								
Section A	9	11.1	38	13.2	4	50.0		
Section B	33	0.0	64	14.1	12	41.7		
Section C	114	9.6	212	28.8	26	34.6		
Section D	73	9.6	235	20.4	49	22.4		
All sections	229	8.8	549	22.4	91	29.7		
Brown trout								
Section A	12	8.3	30	23.3	34	29.4		
Section B	38	2.6	35	34.3	62	29.0		
Section C	33	12.1	38	36.8	56	32.1		
Section D	10	30.0	16	31.3	53	30.2		
All sections	93	9.7	119	31.9	205	30.2		
Brook and brown trout combined								
Section A	21	9.5	68	17.6	38	31.6		
Section B	71	1.4	99	21.2	74	31.1		
Section C	147	10.2	290	30.0	82	32.9		
Section D	83	12.0	251	21.1	102	26.5		
All sections	322	8.7	668	24.1	296	30.1		
Size group in inches	2.0 - 4.9		5.0 - 6.9		7.0 - 9.9		10.0 and over	
September, 1950								
Brook trout								
Section A	27	3.7	24	16.7	12	33.3	1	0.0
Section B	60	5.0	43	16.3	20	25.0	0	...
Section C	76	2.6	83	9.6	28	14.3	0	...
Section D	120	10.0	129	14.7	43	32.6	0	...
All sections	283	6.4	279	13.6	103	26.2	1	0.0
Brown trout								
Section A	4	25.0	2	0.0	19	21.1	11	36.4
Section B	38	5.3	25	32.0	49	34.7	22	45.4
Section C	14	0.0	18	5.6	49	24.5	17	23.5
Section D	12	0.0	10	40.0	48	39.6	18	50.0
All sections	68	4.4	55	23.6	165	31.5	68	39.7
Brook and brown trout combined								
Section A	31	6.5	26	15.4	31	25.8	12	33.3
Section B	98	5.1	68	22.1	69	31.9	22	45.4
Section C	90	2.2	101	8.9	77	20.8	17	23.5
Section D	132	9.1	139	16.5	91	36.3	18	50.0
All sections	351	6.0	334	15.3	268	29.5	69	39.1

The general procedure of the study is as follows. The 4.8 miles of experimental stream is traversed by a crew of about five men using an A. C. electric shocker. Each trout captured is measured to the nearest inch, fin clipped, and immediately returned to the stream. At the conclusion of the first run through the stream, we thus have a known number of marked trout present. Theoretically these are distributed throughout the stream in about the same manner as they were prior to the initial sampling. Also, the classification of these fish both as to species and size makes it possible to judge their species and size frequency.

The same section of stream is then shocked the second time. All fish again are measured and additional data as to the number of mrked fish and unmarked fish are recorded. On the assumption that marked and unmarked trout are captured in this second run in direct proportion to their numbers present in the stream, the total number of all species of trout present in the 4.8 miles of stream is estimated. Since large fish are captured more easily than small ones, it is necessary to make separate estimates for different sizes.

The total estimate may be further subdivided into numbers of fish of each of the different species on the assumption that the number of the different species are represented in the total population in direct proportion to their representation in all of the sampling.

A similar breakdown may be made as to the numbers of fish in the different portions of the stream, assuming that the efficiency of capture of the trout does not change markedly from one section of the stream to another. This method of subdividing the total estimate is believed to be more accurate than estimating the numbers of fish of each size, species, and small portion of the stream separately and combining all the individual estimates for the total population. By using smaller individual units in the estimations, the numbers of marked fish recovered, upon which the

estimates are based, become smaller and probable errors increase accordingly. The total number of all fish taken in the two different sampling runs of the entire area and the numbers taken in component portions indicate the constancy of the shocker in catching fish (Table 3). Also, as will be shown later, the population estimates obtained were consistent with the creel census data obtained during the same seasons.

Estimates of populations of eastern brook, brown and rainbow trout in 4.8 miles of Pigeon River, 1949 and 1950.

A population estimate of the trout present in the research area of the Pigeon River was made in September, 1949, immediately after the close of the trout season. This estimate disclosed a residual population of legal-sized wild fish per acre of stream of: 10.9 brook trout, 23.8 brown trout, and 0.6 rainbow trout (Table 4).

In September, 1950, a population estimate was again made for the same portion of the river. At the close of this season there was a residual population of legal-sized fish per acre of: 12.4 brook trout, 27.7 brown trout and 0.5 rainbow trout.

Catch statistics for 1949 and 1950

As noted earlier, a permit system creel census was in operation on the experimental sections of the Pigeon River for the 1949 and 1950 seasons. The creel census data thus represent the complete production of the stream to the anglers. Fishing intensity was high; more than two thousand fishing trips (or 250 to 280 hours per acre) were recorded in each of the two seasons. These fishermen accounted for approximately one thousand wild trout in each of the two years, with brook trout outnumbering brown trout about 3 to 1. Wild rainbow trout were rarely recorded in the catch (Table 5).

Table 3.--A comparison of the number of fish taken in different sections of the stream in the two sampling runs.

Size group in inches	2.0 - 3.9			4.0 - 6.9			7.0 and over		
	Number of trout in first run	Number of trout in second run	Percent deviation	Number of trout in first run	Number of trout in second run	Percent deviation	Number of trout in first run	Number of trout in second run	Percent deviation
1949									
Section A	21	15	-28.6	68	52	-23.5	60	64	+6.7
Section B	71	57	-19.7	99	85	-14.1	175	171	-2.3
Section C	148	183	+23.6	250	252	+00.8	273	235	-13.9
Section D	83	121	+45.8	251	226	-10.4	120	108	-10.0
All Sections	323	376	+16.4	668	614	- 8.1	628	578	-8.0
1950									
Section A	31	38	+22.6	26	22	-15.3	63	56	-11.1
Section B	98	83	-15.3	72	55	-23.6	115	107	-7.0
Section C	91	94	+ 3.3	104	62	-40.4	126	69	-45.2
Section D	137	215	+56.9	140	159	+13.6	112	115	+2.7
All Sections	357	430	+20.4	342	298	-12.9	416	347	-16.6

Table 4.--An estimate of the wild trout population of 4.8 miles of the Pigeon River, Otsego County, Michigan.

Species, year and stream section	2.0 - 4.9 inches Total length		5.0 - 6.9 inches Total length		7.0 inches and larger Total length	
	Number of trout per acre	Pounds per acre	Number of trout per acre	Pounds per acre	Number of trout per acre	Pounds per acre
Brook trout						
September, 1949						
Section A	26.4	0.53	9.1	0.74	3.5	0.58
Section B	92.7	1.85	16.3	1.33	5.3	0.88
Section C	378.7	7.56	67.9	5.56	13.5	2.26
Section D	277.7	5.55	68.0	5.57	23.5	3.94
All Sections	180.3	3.60	37.8	3.10	10.9	1.82
Brook trout						
September, 1950						
Section A	64.9	1.43	19.3	1.58	7.5	1.26
Section B	168.6	3.71	38.5	3.15	10.5	1.75
Section C	255.3	5.62	77.9	6.38	11.1	1.86
Section D	465.8	[illegible]	148.3	12.14	21.8	3.63
All Sections	226.9	5.00	67.3	5.51	12.4	2.07
Brown trout						
September, 1949						
Section A	24.2	0.45	4.8	0.46	12.6	3.79
Section B	76.9	1.42	9.7	0.91	29.8	8.99
Section C	104.8	1.93	11.1	1.04	30.2	9.12
Section D	41.6	0.77	4.1	0.38	25.7	7.74
All Sections	59.2	1.09	7.3	0.68	23.8	7.18
Brown trout						
September, 1950						
Section A	23.3	0.48	1.3	0.12	11.9	3.59
Section B	116.3	2.39	24.9	2.34	33.9	10.25
Section C	58.4	1.20	14.8	1.39	31.0	9.37
Section D	68.8	1.41	13.1	1.23	38.1	11.51
All Sections	64.6	1.33	12.9	1.21	27.7	8.37
Rainbow trout						
September, 1949						
Section A	23 0	0	0	0	1.1	0.18
Section B	1.2	0.02	0	0	0.8	0.14
Section C	3.5	0.05	0	0	0	0
Section D	1.0	0.02	0	0	0.4	0.06
All Sections	1.1	0.02	0	0	0.6	0.10
Rainbow trout						
September, 1950						
Section A	1.3	0.02	0	0	0.4	0.07
Section B	0	0	2.5	0.23	0.3	0.06
Section C	5.2	0.07	1.7	0.15	0.9	0.15
Section D	43.9	0.61	0.5	0.05	0.5	0.09
All Sections	11.8	0.16	1.1	0.10	0.5	0.09

Table 5.--A comparison of the total yield to fishermen with the residual population in September of legal-sized trout in the Pigeon River, Otsego County, Michigan.

Species, year, and stream section.	Yield to Anglers		Residual population	
	Number of trout per acre	Pounds per acre	Number of trout per acre	Pounds per acre
Brook trout				
1949				
Section A	13.1	2.24	3.5	0.58
Section B	25.3	4.30	5.3	0.88
Section C	52.7	8.97	13.5	2.26
Section D	47.1	8.02	23.5	3.94
All Sections	32.9	5.60	10.9	1.82
Brook trout				
1950				
Section A	13.0	2.01	7.5	1.26
Section B	25.8	4.31	10.5	1.75
Section C	57.7	8.61	11.1	1.86
Section D	64.2	9.55	21.8	3.63
All Sections	38.1	5.82	12.4	2.07
Brown trout				
1949				
Section A	3.8	1.00	12.6	3.79
Section B	11.2	2.98	29.8	8.99
Section C	11.7	3.11	30.2	9.12
Section D	7.4	1.98	25.7	7.74
All Sections	8.2	2.19	23.8	7.18
Brown trout				
1950				
Section A	3.8	0.93	11.9	3.59
Section B	15.4	3.66	33.9	10.25
Section C	16.3	3.98	31.0	9.37
Section D	8.7	2.35	38.1	11.51
All Sections	10.6	2.61	27.7	8.37
Rainbow trout				
1949				
Section A	2.1	0.55	1.1	0.18
Section B	2.9	0.75	0.8	0.14
Section C	3.0	0.77	0.0	0.00
Section D	1.6	0.42	0.4	0.06
All Sections	2.4	0.62	0.6	0.10
Rainbow trout				
1950				
Section A	0.4	0.04	0.4	0.07
Section B	1.4	0.21	0.3	0.06
Section C	0.6	0.07	0.9	0.15
Section D	0.4	0.04	0.5	0.09
All Sections	0.7	0.14	0.5	0.09

Comparing the data from the creel census with that of the population estimates, we find that there is considerable agreement as to the distribution of the trout in the different portions of the stream. For example, Sections C and D produced the greatest share of wild brook trout to the anglers. The population estimates of brook trout in these sections also were very high compared with the other sections. Section B and C had a high population density of brown trout, heavy fishing pressure, and also gave the highest return to fishermen for this species (Table 5).

It is important to observe the tremendous differences in population density (as measured both by the catch and by population estimates) between these relatively small adjacent portions of the stream. The physical characteristics of the river differ only slightly from one section to another (Table 1). The difference in maximum water temperatures is also slight. A maximum temperature of 80° F. has been recorded at the upper end of Section B and 75° F. at the upper end of Section D, which is the upstream boundary of the experimental area.

Exploitation of native trout

It is of utmost importance in the management of a sport fishery to know the effect of the fishery on the available stocks. This rate of exploitation may be estimated or at least an index of its rate may be obtained in several ways.

The total catch per acre has been compared with the population remaining at the close of the season (Table 5). For the brook trout, three fish were caught for each one remaining in the stream. This ratio was reversed for brown trout; only one fish was caught for three remaining at the close of the season.

This difference in exploitation by anglers between brook and brown trout is shown also by an analysis of the catch as to size-frequency (Figure 1). The two species are growing at similar rates in this stream, yet very few brook trout live long enough to grow to 10 inches. Brown trout over 10 inches long are caught each year, and many more of this size are left after the season closes. The difference in angling quality furnished by brook versus brown trout was noted by Shetter (1950) and Schuck (1942). However, neither author mentioned what appears to be the most logical explanation of this phenomenon; that there is an inherent wariness on the part of the brown trout in avoiding capture that is not shared in equal measure with the brook trout. It has been "known" to many anglers for some time that brown trout are not so easily fooled as brook trout, but few data have previously been advanced to support this belief.

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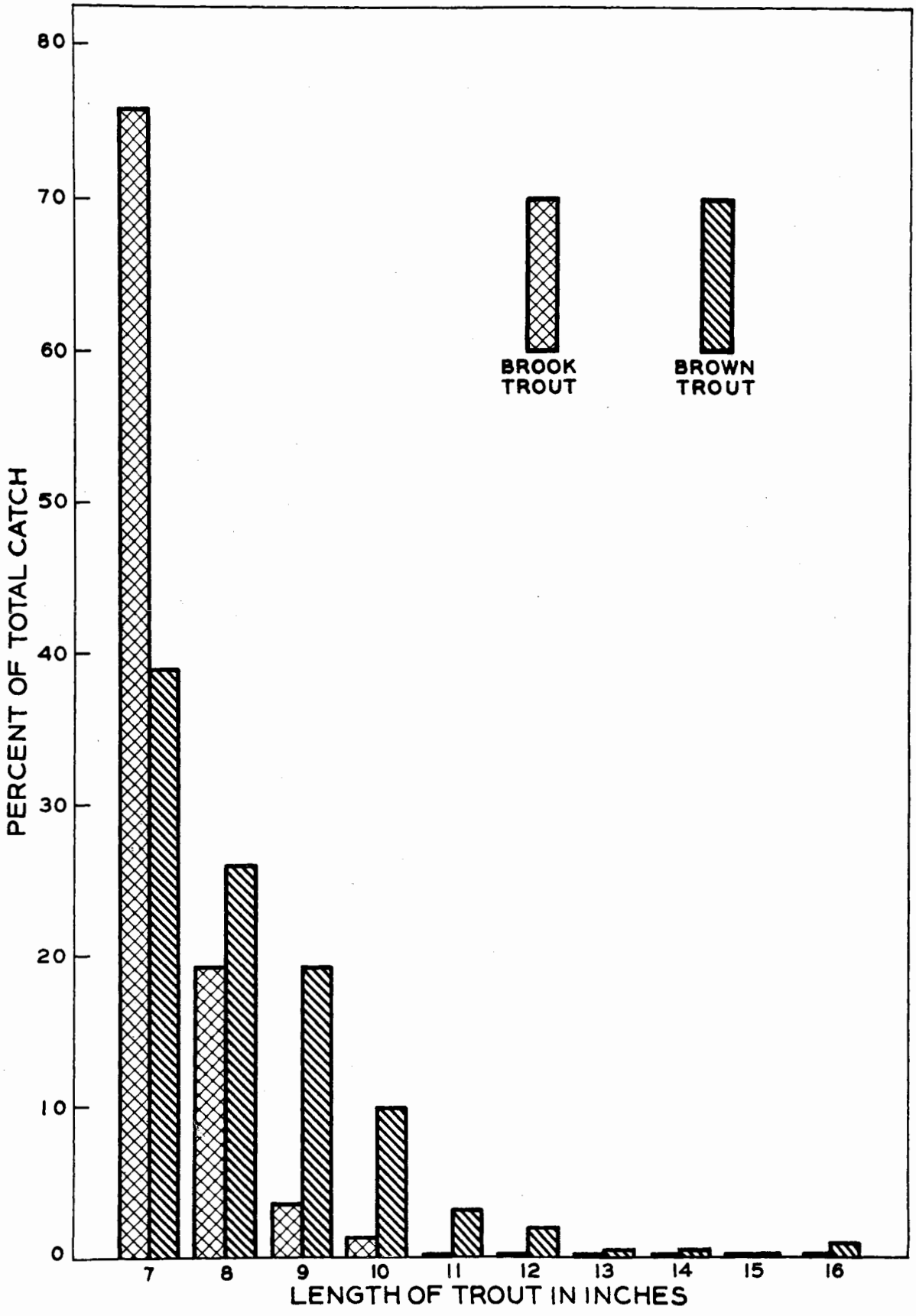

Figure 1.---Size distribution of native brook and brown trout caught by anglers in the Pigeon River during 1949 and 1950.

Literature Cited

Burr, J. G.

1932. Electricity as a means of garfish and carp control. Trans. Amer. Fish. Soc., Vol. 61 (1931), pp. 174-182.

Haskell, David G.

1940. An electrical method of collecting fish. Trans. Amer. Fish. Soc., Vol. 69 (1939), pp. 210-215.

Hoover, Earl E.

1938. Fish populations of primitive brook trout streams of Northern New Hampshire. Trans. 3rd N. Amer. Wildlife Conf., pp. 486-496.

Mottley, C. McC.

1942. Modern methods of studying fish populations. Trans. 7th N. Amer. Wildlife Conf., pp. 356-360.

Needham, Paul R., James W. Moffett, and Daniel W. Slater

1945. Fluctuations in wild brown trout populations in Convict Creek, California. Jour. Wildlife Management, 1945, Vol. 9, No. 1, pp. 9-25.

Schuck, Howard A.

1942. The effect of population density of legal-sized trout upon the yield per standard fishing effort in a controlled section of stream. Trans. Amer. Fish. Soc., Vol. 71 (1941), pp. 236-248.

1945. Survival, population density, growth, and movement of the wild brown trout in Crystal Creek. Trans. Amer. Fish. Soc., Vol. 73 (1943), pp. 209-230.

Shetter, David S.

1950. The relationship between the legal-sized trout population and the catch by anglers in portions of two Michigan trout streams. Pap. Mich. Acad. Sci., Arts and Letters,,Vol. 24, 1948, pp. 97-107.

Shetter, David S. and Albert S. Hazzard

1939. Species composition by age groups and stability of fish populations in sections of three Michigan trout streams during the summer of 1937. Trans. Amer. Fish. Soc., Vol. 68 (1938), pp. 281-302.

Shetter, David S. and Justin W. Leonard

1943. A population study of a limited area in a Michigan trout stream, September 1940. Trans. Amer. Fish. Soc., Vol. 72 (1942), pp. 35-51.

Smith, Lloyd L. Jr., Raymond E. Johnson and Laurence Hiner

1949. Fish populations in some Minnesota trout streams. Trans. Amer. Fish. Soc., Vol. 76 (1946), pp. 204-214.

INSTITUTE FOR FISHERIES RESEARCH

Edwin L. Cooper

Approved by A. S. Hazzard

Typed by B. A. Lowell