Original: Fish Division
cc: Education - Game
Institute for Fisheries Research
D. S. Shetter
J. A. Scully
J. T. Wilkinson
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INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

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ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

April 4, 1950

REPORT NO. 1250

PIGEON RIVER TROUT RESEARCH AREA
INITIAL REPORT OF FISHING
1949

By

Edwin L. Cooper

Pigeon River Trout Research Area

Initial Report of Fishing

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ABSTRACT

The fine spirit of cooperation on the part of the angling public in submitting to a compulsory permit system creel census enabled the department's fish division to obtain valuable catch records of the trout fishing in the Pigeon River for the 1949 season. A total of 2,233 fishing days spent on 4.8 miles of public-owned trout stream indicates an intensive use of this resource.

Fishing success was rather poor. More than half of the fishermen were unable to catch a single legal trout, even though 4,500 legal-sized trout had been planted in little more than two miles of stream.

Persons fishing when the barometer was falling caught just as many fish as those who fished when the barometer was rising. However, those who fished when the barometer was steady were more successful in catching fish than those who fished when the barometer was either rising or falling. Predictions of good or bad fishing days made from fishing calendars based on lunar cycles were not substantiated from the 1949 fishing records obtained on the Pigeon River. High water temperatures during June, July and August caused a marked

decline in fishing success. The type of bait preferred by trout fishermen was nearly equally divided between worms and flies, with the catch per hour being almost identical in the two types of fishing.

Scattering hatchery trout widely over stream sections did not prove to be superior in any respect to planting them in groups of as many as 450 in one spot. Spot-planted fish yielded the largest number of fish returned, more successful fishing trips, and more individual anglers benefitting than did scatter-type plantings. Brook and rainbow trout produced much better returns to the anglers than did equal numbers of planted brown trout.

A reduction in the daily creel limit from fifteen trout to five trout failed to spread the catch over more fishermen. In order to produce any substantial effect in sharing the catch among more fishermen, the creel limit theoretically would have to be reduced to two fish per day. Even in sections that were planted at rates of 381 to 417 legal trout per acre, 92 to 96 per cent of all fishermen took less than five fish in a single fishing trip.

Plantings of rainbow trout and brown trout influenced the catch for longer periods of time than did plantings of brook trout. Of the total number of hatchery fish recovered, rainbows were first with a range in recovery from 20 per cent to 74.3 per cent and a total of 45 per cent, brooks were next with recoveries on individual plantings ranging from 9.7 to 71.0 and a total of 40 per cent, and brown trout recovered from various plantings from 10.7 to 4.5 per cent and totalling 26 per cent. Migration of hatchery fish following planting was slight; 80 to 95 per cent of the fish recaptured had moved less than two miles from the point of release and 65 to 85 per cent had moved less than half a mile from the point of release. More movement was noted for brook trout than either the browns or rainbows.

The 4.8 miles of stream produced 1048 wild trout weighing 202.65 pounds, which was at the rate of 8.41 pounds per acre. Of these, 76 per cent were

brook trout, 19 per cent were brown trout, and 5 per cent were rainbows. Of the legal-sized wild trout remaining in the stream after the trout season closed, 33 per cent were brook trout, 67 per cent were brown trout, and rainbow trout were too rare to give a reliable estimate.

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Introduction

At the northern tip of the lower peninsula of Michigan is a connected series of three large lakes, Burt, Mullett and Black lakes, 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 map distance of approximately 35 miles. The Pigeon River, the middle one of the three, was selected as a site for a trout experiment station because of the large amount of state-owned frontage on this stream, and also because it was believed to be somewhat representative of many other Michigan trout streams.

The portion of the stream selected for use as an experimental area is located in the vicinity of the old site of the Pigeon River State Forest Headquarters, 13 miles east of Vanderbilt. A continuous stretch of 4.8 miles of stream is bordered by state-owned land and public access is made easy by a system of roads and fire lines constructed during the CCC days.

Upstream from the experimental area, the land bordering the stream is entirely in private ownership except for one 40-acre plot owned by Otsego County. Public fishing is permitted at only a few places along this stretch of privately owned frontage. This portion of the stream comprises the upper third of the drainage area and contains the greater part of good trout water in the whole stream system. Below the experimental area, a large part of the stream frontage is state-owned and public access is assured to practically all of the stream. From preliminary survey data acquired this past summer, it is believed that this portion of the stream does not support a very large trout population largely due to temperature conditions which are usually too warm for trout in the summer. The stream is more subject to heavy flooding toward the lower end of the drainage area. However, steep clay banks and a hard bottom of clay, gravel and rocks have kept erosion to a minimum.

There are also seven small trout lakes included in the experimental area. Creel census records were obtained from these lakes, but their analysis will be included in the general report covering the results of experimental fertilization of these lakes. This program is being undertaken by Mr. Howard Tanner working on an Institute fellowship under the direction of Dr. Robert C. Ball of Michigan State College.

The approximately 5 miles of water under experimental management and control have been arbitrarily divided into four convenient fishing sections of approximately equal length. It was hoped that these sections would be similar enough in character so that results might be compared with one another. After one season of work on these four sections, it was immediately apparent that the lower section differed markedly from the others in regard to the size of the trout population, although the physical features of the sections are quite similar (Table 1). The upper three sections (B, C, and D) support a native population of both brook and brown trout. Rainbow trout are present

Table 1. Morphometry of Pigeon River Trout Research Area, Survey of 1949-50.

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
Gradient - feet					
Per section	12.61	11.34	13.72	9.07	46.74
Per mile	9.63	9.53	12.20	7.69	9.74
Per cent	0.18	0.18	0.23	0.15	0.18

in much smaller numbers. Most of the lower section (A) is sluggish with a sandy bottom and contains a relatively small number of trout.

A permit-system-type of creel census was operated on the experimental waters during the past season. Each fisherman desiring to fish a particular portion of the stream was required by Conservation Commission order to register at a centrally-located checking station and obtain a daily 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. A general willingness on the part of the public to submit to this program provided us with a very accurate record of the results of fishing. 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.

The four fishing sections, designated as A, B, C, and D, were established in order to test the effect of changes in fishing regulations and other forms of management. For the first two years it was decided to reduce the daily creel limit on two sections from 15 fish to 5 fish. Also, it was thought desirable to test the effect of a lower creel limit on the recovery of hatchery fish since continued stocking of this portion of the stream at a rate equal to the past three years was planned. Accordingly, the restrictions on the various sections were established as follows: (Refer to Figure 1).

Section A (Furthest downstream). Creel limit 5 fish per day. No hatchery fish to be stocked in this section. This latter provision would also give a partial check on downstream migration of marked hatchery fish.

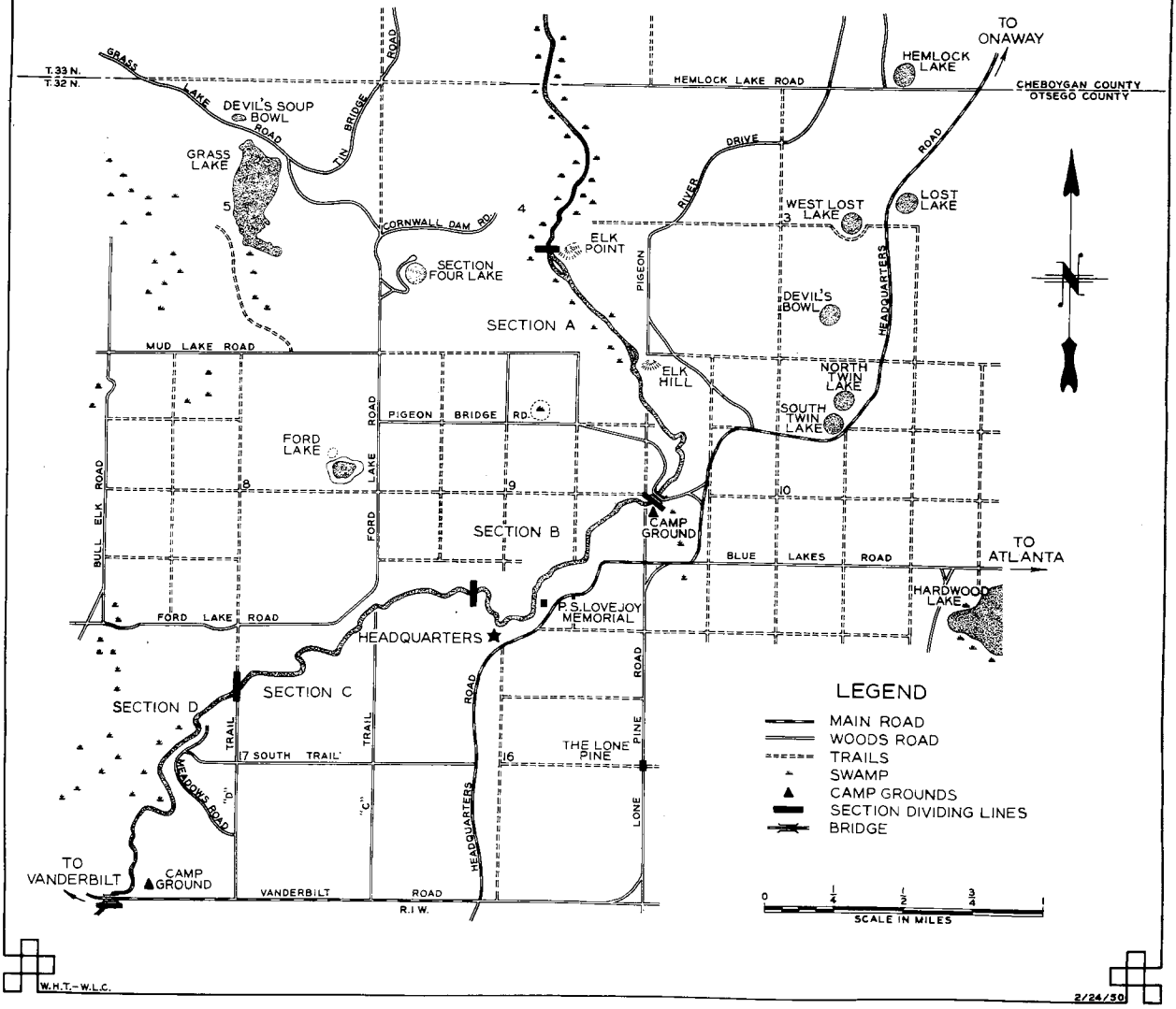
Section B (Next upstream). Creel limit 5 fish per day. Seven hundred fifty each of brook, brown and rainbow trout to be planted in this section in 5 installments of 150 per month per species throughout the fishing season. All hatchery trout were marked individually with a jaw tag.

Figure 1. Map of Pigeon River Trout Research Area, 1949.

MICHIGAN DEPARTMENT OF CONSERVATION
FISH DIVISION

PIGEON RIVER TROUT RESEARCH AREA

OTSEGO AND CHEBOYGAN COUNTIES



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Section C (Next upstream). Creel limit 15 fish per day. Hatchery fish to be planted at the same rate as in Section B.

Section D (Furthest upstream). Creel limit 15 fish per day. No stocking. As in section A, this section would provide a partial check on migration of planted fish.

Fishing Intensity

During the trout season of 1949 (April 30 to September 11, inclusive) 2,233 fishing trips were made in the 4.8 miles of the stream under investigation. These fishing trips amounted to 6,817 hours of fishing, which is equivalent to 1,420 hours per mile of stream or 283 hours per acre (Table 2). This is believed to represent a very high fishing pressure when compared with other bodies of water in Michigan. The intensity of fishing on the two sections planted with hatchery trout was even higher than the average for the entire experimental stream (Section B--2,004 hours per mile, 404 hours per acre; Section C--2,266 hours per mile, 473 hours per acre). It is unknown whether this fishing pressure represents the average condition on Michigan trout streams that are regularly stocked with trout, although it probably was representative of this portion of the Pigeon River. No special effort was made to publicize the hatchery plantings. Many anglers when applying for permits stated that they had been fishing this particular portion of the river for many years and their general acceptance of the permit system indicated that it should have little effect in changing the normal fishing intensity for this portion of the river.

Fishing intensity throughout the season was fairly uniform, although the fishing pressure was higher during May and September than during June, July or August (Table 3). There were 143 fishermen on the opening day of the season. The three major holidays (Memorial Day, Fourth of July, and Labor Day) also

Table 2. General results of fishing, Pigeon River, season of 1949.

	Section A	Section B	Section C	Section D	Total
Number of fishing trips	282	858	763	330	2233
Number of hours fished	861	2385	2550	1021	6817
Per cent of total hours	12.6	35.0	37.4	15.0	...
Number of trout taken					
Wild trout	136	232	363	317	1048
Hatchery trout	108	719	813	30	1670
Number of trout per trip	0.86	1.11	1.54	1.06	1.22
Per cent trips unsuccessful	59.9	52.7	48.8	54.8	52.6
Number of trout per successful fishing trip	2.25	2.34	3.01	2.36	2.58

Table 3. Distribution of angling pressure throughout the season, Pigeon River, 1949.

Week of season	Number of fishing trips	Period	Number of fishing trips	Average fishing trips per day
April 30 - May 6	269*/	April 30	143	...
May 7 - May 13	103	May 1-31	678	22
May 14 - May 20	121	June 1-30	398	13
May 21 - May 27	147	July 1-31	437	14
May 28 - June 3	205*/	August 1-31	369	12
June 4 - June 10	74	Sept. 1-11	208	19
June 11 - June 17	100			
June 18 - June 24	132			
June 25 - July 1	81			
July 2 - July 8	158*/			
July 9 - July 15	119			
July 16 - July 22	40			
July 23 - July 29	82			
July 30 - August 5	71			
August 6 - August 12	54			
August 13 - August 19	93			
August 20 - August 26	110			
August 27 - September 2	102			
September 3 - September 9	141*/			
September 10 - September 11	31			
Total	2233			

*/ Includes opening weekend, Decoration Day, Fourth of July, and Labor Day, respectively.

drew many fishermen, as did Saturdays and Sundays which alone accounted for 48 per cent of the total. These data on the seasonal distribution of fishing intensity may be put to good use in formulating a hatchery stocking program in order to get the most out of the fish planted.

Each fisherman was required to sign the permit allowing him or her to fish in a designated section. The number of persons fishing in the area could therefore be determined. A total of 1,226 different individuals accounted for the 2,233 fishing trips recorded. About two-thirds of the fishermen fished the Pigeon River only once during the season and 90 per cent of the individuals fished fewer than four times. A few fished as many as 20 times, and one of the department employees fished 42 times during the season (Table 4).

Residence of Anglers

The residence of anglers fishing the Pigeon River in 1949 has been tabulated on a basis of the number of fishing trips rather than individuals (Table 5). There is some advantage in tabulating the residence on this basis because it gives a better idea of the per cent of total fishing pressure coming from different geographical areas. However, there would be little change in the general presentation of these data if the number of individuals had been used because most anglers fished only one time.

The distribution of the anglers according to their residence follows quite closely the distribution of the population of the state, i.e., large numbers of fishermen came from areas of high population density. The local county was one of the major exceptions, but this was affected some by the personnel living at the station. Very few fishing trips were made by residents of Michigan's upper peninsula (only 3 of 2233). It was also interesting to note that very few fishermen came from counties adjacent to Otsego to fish in the Pigeon River (Table 6). It appears that trout fishermen prefer to fish in their own back yard when that back yard has something to offer.

Table 4. Distribution of the number of fishing trips per angler, Pigeon River, 1949.

Number of fishing trips	Number of anglers
1	818
2	225
3	84
4	34
5	19
6	13
7	9
8	6
9	2
10	2
11	1
12	2
13	3
...	...
16	1
17	2
...	...
20	1
21	1
...	...
23	1
...	...
25	1
...	...
42	1

Total number of individuals = 1226

Total number of fishing trips = 2233

Table 5. Distribution of fishing trips according to residence of anglers, Pigeon River, 1949.

County	Number of fishing trips	County	Number of fishing trips	State	Number of fishing trips
Wayne	517	Montmorency	10	Michigan	1934
Otsego	279	Gratiot	10	Ohio	243
Genesee	154	Charlevoix	8	Indiana	17
Ingham	113	Sanilac	8	Illinois	11
Oakland	111	Newaygo	8	Kentucky	7
Washtenaw	96	Lapeer	7	Oklahoma	4
Hillsdale	46	Grand Traverse	7	New York	4
Bay	43	Ogemaw	6	Pennsylvania	4
Kent	43	Livingston	6	Maryland	2
Kalamazoo	39	Lenawee	6	Florida	2
Cheboygan	35	Clinton	6	Missouri	1
Midland	34	Tuscola	6	Utah	1
Monroe	30	Antrim	5	Kansas	1
St. Joseph	29	Mason	3	Washington, D.C.	1
Saginaw	29	Gladwin	3	Unknown	1
St. Clair	27	Montcalm	3		
Shiawassee	25	Kalkaska	3		
Jackson	22	Roscommon	3		
Muskegon	20	Isabella	3		
Alpena	20	Crawford	3		
Clare	20	Berrien	2		
Branch	18	Huron	2		
Calhoun	13	Lake	2		
Presque Isle	12	Marquette	2		
Macomb	12	Houghton	1		
Emmet	11	Mecosta	1		
Eaton	11	Allegan	1		

Table 6. Number of anglers fishing Pigeon River from areas adjacent to Otsego County, 1949.

County	Number of fishing trips
Otsego	279
Cheboygan	35
Presque Isle	12
Emmet	11
Montmorency	10
Charlevoix	8
Antrim	5
Crawford	3
Kalkaska	3
Oscoda	0

Indices of Fishing Quality

It has been customary in creel census studies to use the number of fish caught per hour of fishing as the criterion in comparing the quality of fishing success. When this criterion is used to compare samples of the same type of fishing taken under similar conditions, it is probably the best index that we have. However, most investigators have failed to analyze the data in a manner which would enable them to evaluate the significance of differences in fishing quality based on well-known statistical procedures. */ There is, therefore, little common ground on which to compare the results of this study of fishing quality with other creel census reports of trout fishing. The unit of fishing quality used in this report is the catch per hour per fishing trip. The statistical tools employed have been limited to the mean, the standard deviation and the standard error of the mean. Only by the use of criteria such as these is it possible to judge the probable significance of differences in fishing quality between different samples. Also, with some knowledge of the amount of variation in individual fishing quality, it is possible to determine the size of the sample necessary to show significant differences within any prescribed limits of accuracy. On the Pigeon River for example, in order to show differences in the catch per hour of 0.1 fish per hour to be significant at the 99 per cent level of probability, a sample of about 400 fishing trips in each group is necessary. This large sample is necessary because we find that individual fishing success varies tremendously, from zero to as high as ten fish per hour. Weekly values of the catch per hour from our data mean very little because of the relatively small numbers of anglers and therefore have not been used in this report.

---

*/ The methods employed in the statistical analysis of the creel census data have been adopted from the unpublished work of the late Mr. Henry E. Predmore, formerly on the Institute staff.

Factors Influencing Fishing Success

Anglers and fisheries investigators have long sought for the answers to why fishing is better at some times than at others. This report will shed but little light on these matters but a few conclusions are justified from a critical examination of the records of 2,233 fishing trips on the Pigeon River during 1949. (1) It was possible to improve the catch per hour by planting large numbers of hatchery fish, and the return from plantings in heavily-fished waters was considerable. (2) High water temperatures caused a significant decrease in fishing quality. (3) Predictions of fishing based on periods of the moon, changes in barometric pressure, etc., were not generally substantiated. (4) One of the most important factors influencing trout fishing success was the individual angler's ability to creel fish. (5) Differences in the trout catch due to the type of bait used were not significant.

Effect of Barometric Pressure on Fishing Quality

There is a wide-spread theory among anglers that fishing is poorer when the barometer is falling and that the inclination of the fish to feed is dependent upon changes in the atmospheric pressure. We have been fortunate to have a recording barometer in operation at the station since May 12, 1949 and the greater portion of last season's fishing reports have been compared with changes in atmospheric pressure. Individual days of the season were classified as to rising barometer, falling barometer or steady barometer. The amount of change necessary for a rising or falling category was established as 0.1 mm. mercury or more. This classification resulted in 22 days of rising barometer, 34 days of falling barometer, and 67 days of steady barometer. When the mean catch per hour of these categories was computed, it was found that a steady barometer was conducive to better fishing than either a rising or falling

one and that the differences were significant at a 97 to 99.9 per cent level of probability (Table 7). There was no difference between a rising and a falling barometer. The differences noted could not be attributed to known differences due to the hot weather period, since "hot" and "cool" days (the other factor known to affect fishing quality) were represented in about the same proportion in the entire season.

The individual days were then reclassified as to high pressure (29.61 to 30.20 mm. mercury) or low pressure (29.00 to 29.60 mm. mercury). The summary of these days indicated that there was about an 80 per cent probability that fishing was a little better when the barometer was high, not to be considered a significant difference(Table 8). The significance of this difference is further lessened by the fact that more "cool" days than "hot" days coincided with a high barometer, and the catch per hour was decidedly less during the "hot" days as will be shown in a later section.

Effect of the moon--Fishing calendars

It was also possible to compare fishing quality with predictions of "best," "good" or "fair" days for fishing according to Joe Godfrey's fishing calendar. (Apparently there are no "poor" or "bad" days to go fishing.) A summation of the catch per hour on "best" days happened to be almost identical with the catch per hour on "fair" days (Table 9). Further analysis of the "good" days was not made.

Coble's fisherman's guide was similarly tested for accuracy in predicting fishing. The catch per hour on his best days was not significantly greater than the catch per hour on his worst days (Table 9).

Flies vs. Worms in Trout Fishing

There has always been considerable controversy among trout fishermen as to the effectiveness of worms compared with flies in catching fish. Some

Table 7. Relationship between change in atmospheric pressure and fishing quality, Pigeon River, 1949

	Number of days	Number of fishing trips (N)	Mean catch/hour (M)	Standard error of the mean (σ_M)	Per cent fishing trips unsuccessful
Steady barometer (less than 0.1 mm change in 24 hours)	67	976	.454	.024	50.0
Rising barometer	22	303	.363	.034	55.1
Falling barometer	34	605	.345	.021	54.7

Rising vs. Steady

Difference between means = .091
Standard error of difference=.042
t = 2.2 = 97% probability that means are different

Falling vs. Steady

Difference between means = .109
Standard error of difference = .032
t = 3+ = 99.9% probability that means are different

Rising vs. Falling

Difference between means = 0.018
Standard error of difference=0.040
t = 0.45 = 34.7% probability that means are different

Table 8. Relationship between level of atmospheric pressure and fishing quality, Pigeon River, 1949.

	Number of days	Number of fishing trips (N)	Mean catch/hour (M)	Standard error of mean (σ_M)	Percent fishing trips unsuccessful
High Barometer (29.61 - 30.20)	46	811	.428	.026	50.1
Low Barometer (29.00 - 29.60)	77	1073	.387	.018	54.1

Difference between means = .041
Standard error of difference = .032
t = 1.28 = 79.9% probability that means are significant.

Table 9. Relationship between fishing quality and phase of the moon, Pigeon River, 1949.

Item	Number of days	Number of fishing trips (N)	Mean catch/hour (M)	Standard error of the mean (σ_M)	Per cent unsuccessful fishing trips
Joe Godfrey's guide					
New Moon - Fair days (Apr.30, May 1,25-30, June 23-29, July 22-28, Aug.21-27)	30	718	0.394	0.031	57.2
Full Moon-Best days (May 9-15, June 7-13, July 7-13, Aug.5-11, Sept. 4-10)	35	476	0.396	0.026	49.8
Difference between means = .002 Standard error of difference=.040 t = 0.05 = 4% probability that means are different.					
Coble's guide					
Best days	48	962	0.417	0.025	53.8
Worst days	50	757	0.389	0.020	50.9
Difference between means = 0.028 Standard error of difference = 0.032 t = 0.88 = 62% probability that means are different.					

fly fishermen claim that the worm fisherman, or "meat fishermen" as he is sometimes disparagingly called, catches all the fish. And, in the next breath, the fly fisherman is likely to claim that he can catch more with flies than with worms. As is often the case, he is probably wrong both times. The data collected from the 2,233 fishing trips on the Pigeon River show no significant difference in the catch per hour between the three most common types of lure used (Table 10). There was also little difference in the per cent of successful fishing trips between different lures used.

Effect of Water Temperature on Fishing Quality

The Pigeon River is a good example of a stream in which summer water temperatures become too warm for trout. During June, July and August, maximum water temperatures were frequently above 70 degrees F., which is usually considered the limit of toleration for brook trout fishing. The quality of fishing was very poor during these periods of high water temperatures and the catch per hour was significantly less than early or late in the season (Table 11 and Figure 2). Further evidence that the decrease in fishing quality was due to high water temperatures is found in the differences noted between the sections. In Section A (furthest downstream) the decrease in the catch per hour was greatest and in Section D (furthest upstream), fishing was as good or better during the hot period than at other times. The temperatures in Section D averaged several degrees cooler than in Section B or A during the hot part of the summer. The temperatures recorded in Table 12 and Figure 2 were taken at the upper end of Section B and probably were a little cooler than those in Section A.

Some mortality of trout was observed during these hot periods largely among planted fish (Table 13). However, the observed mortality of hatchery trout fell far short of what was inferred from the numbers of fish recovered

Table 10. Relationship between type of lure used and fishing quality, Pigeon River, 1949.

Type of lure	Number of fishing trips (N)	Mean catch/hour (M)	Standard error of mean (σ_M)	Per cent of unsuccessful fishing trips
Worms	719	.398	.026	51
Flies	901	.401	.021	54
Worms and Spinner	271	.437	.051	48
Miscellaneous	342	.358	.032	57

Per cent of probability that catch-per-hour is different when different lures were employed

	Worms	Flies	Worms and spinner
Flies	7.2		
Worms and Spinner	50.3	48.4	
Miscellaneous	67.3	74.2	81.3

Table 11. Relationship between water temperature and catch per hour, Pigeon River, 1949.

Period	Average maximum water temperature in Sec. B	Section A	Section B	Section C	Section D	All sections combined
April 30 - June 20	62.6					
Number of fishing trips (N)		154	420	372	133	1088
Mean catch/hour (M)		.306	.473	.441	.322	.420
Standard error of mean (σ_M)		.036	.038	.034	.044	.020
June 21 - August 15	72.3					
Number of fishing trips(N)		84	263	236	129	712
Mean catch/hour (M)		.191	.282	.341	.420	.316
Standard error of mean (σ_M)		.048	.032	.034	.056	.020
August 16 - September 11	67.3					
Number of fishing trips(N)		44	166	155	68	433
Mean catch/hour (M)		.398	.552	.529	.228	.477
Standard error of mean (σ_M)		.087	.075	.074	.042	.041

Per cent of probability that catches-per-hour for all sections combined are different

	April 30-June 20	June 21-August 15
June 21-August 15	99.9	
August 16-September 11	78.5	99.9

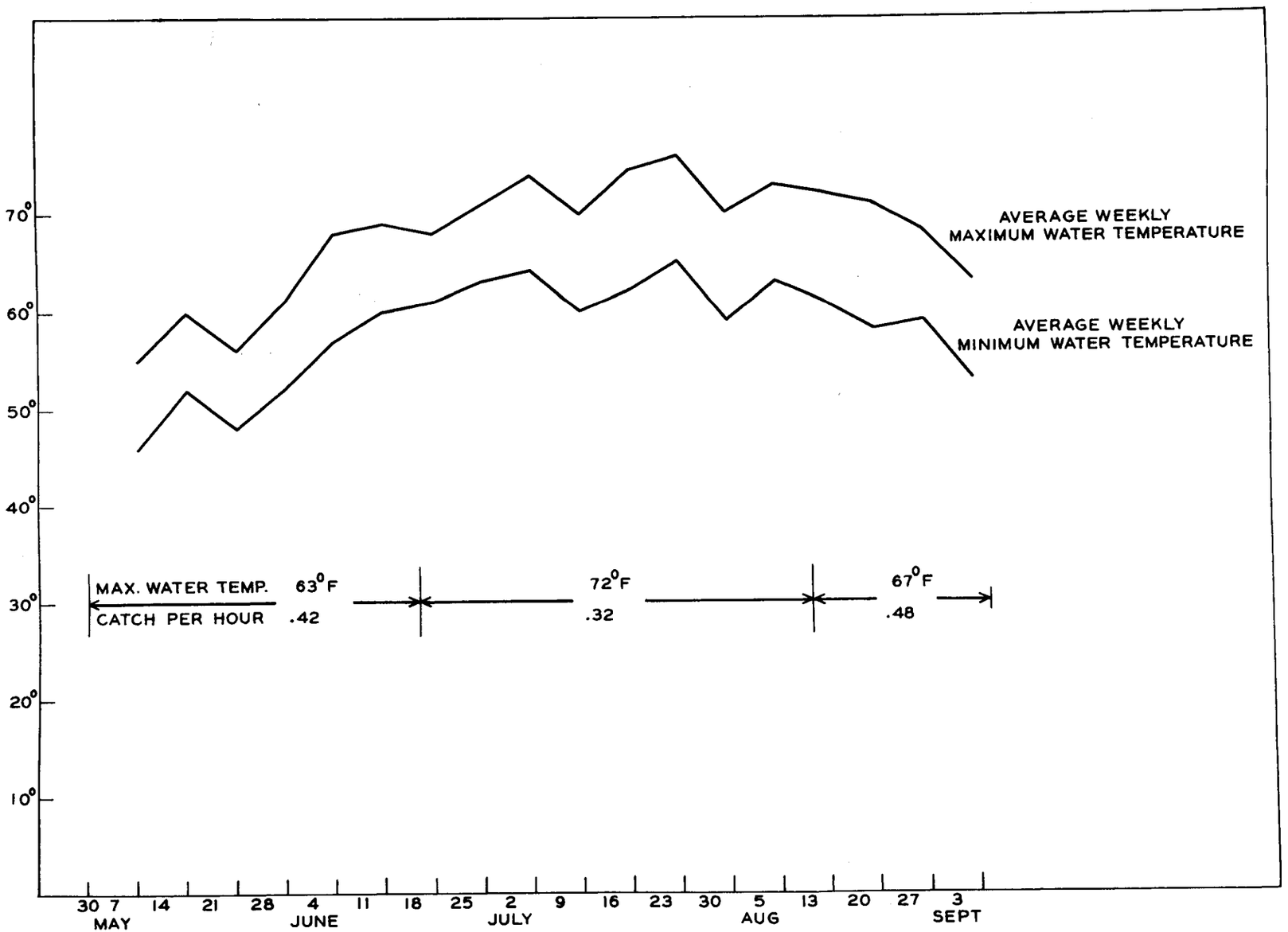
70°
60°
50°
40°
30°
20°
10°
AVERAGE WEEKLY
MAXIMUM WATER TEMPERATURE
AVERAGE WEEKLY
MINIMUM WATER TEMPERATURE
MAX. WATER TEMP.
CATCH PER HOUR
63°F
.42
72°F
.32
67°F
.48
30 7 14 21 28 4 11 18 25 2 9 16 23 30 5 13 20 27 3
MAY
JUNE
JULY
AUG
SEPT

Figure 2. Relationship between water temperature and catch per hour, Pigeon River, 1949.

Table 12. · Daily water temperature record of Pigeon River, May 11-September 11, 1949. Temperatures were recorded near the upper end of Section B.

Date	Minimum water temperature	Maximum water temperature	Date	Minimum water temperature	Maximum water temperature	Date	Minimum water temperature	Maximum water temperature
May 11	47	57	June 30	64	74	Aug. 19	59	72
12	44	53	July 1	66	74	20	56	70
13	48	56	2	65	75	21	54	69
14	50	58	3	66	78	22	55	70
15	50	61	4	67	76	23	58	70
16	50	58	5	65	74	24	60	72
17	52	63	6	62	72	25	60	69
18	55	60	7	62	71	26	61	74
19	56	63	8	61	72	27	64	74
20	48	58	9	61	74	28	64	70
21	48	58	10	60	68	29	61	70
22	48	59	11	60	69	30	58	69
23	49	54	12	60	69	31	58	66
24	51	59	13	60	70	Sept. 1	53	63
25	50	58	14	61	71	2	52	62
26	45	54	15	60	72	3	55	65
27	47	52	16	60	71	4	55	67
28	46	52	17	61	74	5	59	70
29	46	56	18	62	75	6	55	64
30	46	59	19	62	76	7	54	61
31	52	58	20	64	75	8	49	57
June 1	55	64	21	61	74	9	48	57
2	58	69	22	62	72	10	48	60
3	58	70	23	60	74	11	51	62
4	61	72	24	62	74			
5	60	72	25	62	71			
6	60	68	26	64	75			
7	56	68	27	68	79			
8	52	66	28	72	79			
9	54	65	29	69	80			
10	58	66	30	65	79			
11	59	72	31	60	79			
12	61	73	Aug. 1	59	69			
13	64	76	2	56	62			
14	62	72	3	57	66			
15	60	68	4	58	65			
16	58	63	5	59	69			
17	58	60	6	60	70			
18	59	64	7	60	68			
19	62	69	8	62	73			
20	...	...	9	...	...			
21	64	72	10	64	78			
22	59	68	11	68	78			
23	62	70	12	63	71			
24	59	65	13	60	72			
25	60	69	14	61	72			
26	62	69	15	62	74			
27	62	69	16	62	72			
28	64	71	17	63	73			
29	64	73	18	60	70			

Table 13. Individual trout found dead in Pigeon River during the season of 1949.

Date	Species	Where found
	Hatchery trout	
May 18	Brook	B
28	Brown	B
July 2	Brown	B
3	Brown	B
3	Brown	A
4	Brown	B
4	Brown	B
4	Rainbow	B
4	Rainbow	B
6	Brook	Below Red Bridge
9	Brook	B
12	Brook	B
31	Brown	C
Aug. 28	Brown	B
31	Brown	B
31	Brown	C
Sept. 3	Rainbow	B
	Wild Trout	
June 2	Brown	D

from the plantings and other data on migration. This paucity of trout found dead or dying is quite revealing. At the time when extreme water temperatures occurred, a concerted effort was made to observe the effects on the trout present in the stream. In many instances, trout were seen in schools in the vicinity of springs entering the stream. However, dead fish or fish in distress were rarely observed. The majority of the fish reported dead were turned in by fishermen. It seems likely that day to day mortalities of less than catastrophic proportions largely go unnoticed even to the trained observer.

Comparison of Planting Methods

In the past, there has been considerable criticism of the earlier methods of planting hatchery trout. Many claims by fishermen were made against the practice of spot planting, i.e., dumping large numbers of trout in one part of the stream. (1) This type of planting favored "meat fishing," since it was supposedly easy to take your limit of 15 in a short time. (2) Only a few persons benefitted from this type of planting. (3) The fish were soon caught out. To counteract this criticism, valid or otherwise, Michigan has developed methods of scattering the fish as widely as possible over the stream, usually from a boat with live wells or from a portable live crate. A group of preliminary experiments conducted earlier to evaluate returns from the two types of plantings could not demonstrate any advantage of scatter planting over spot planting.

In conjunction with the planting program on the Pigeon River in the 1949 season, it was decided to further test the relative merit of spot and scatter planting. Accordingly, half of the fish were spot planted, the other half scatter planted. The locations of the plantings by different methods were interchanged between the two planted sections to avoid errors due to variation in fishing intensity (Table 14). Considering the total number of fish returned

Table 14. List of hatchery trout planted in experimental sections of Pigeon River, season of 1949. Brook trout were from the Oden Hatchery, brown and rainbow trout were from the Wolverine Rearing Ponds.

Date	Spot planted			Range in size - inches	Scatter planted		
	Number	Species	Section planted		Number	Species	Section planted
April 28, 1949	75	Brook	C	6.8-10.2	75	Brook	C
	75	Brown	C	7.5-12.5	75	Brown	C
	75	Rainbow	C	7.2-14.6	75	Rainbow	C
	75	Brook	B	6.8-10.2	75	Brook	B
	75	Brown	B	7.5-12.5	75	Brown	B
	75	Rainbow	B	7.2-14.6	75	Rainbow	B
May 25, 1949	75	Brook	C	6.9-9.3	75	Brook	C
	75	Brown	C	7.0-10.7	75	Brown	C
	75	Rainbow	C	7.4-12.6	75	Rainbow	C
	75	Brook	B	6.9-9.3	75	Brook	B
	75	Brown	B	7.0-10.7	75	Brown	B
	75	Rainbow	B	7.4-12.6	75	Rainbow	B
June 29, 1949	150	Brook	B	7.2-11.0	150	Brook	C
	150	Brown	B	7.1-13.2	150	Brown	C
	150	Rainbow	B	7.0- 9.9	150	Rainbow	C
July 27, 1949	150	Brook	C	7.0-10.6	150	Brook	B
	150	Brown	C	7.1-11.1	150	Brown	B
	150	Rainbow	C	7.0-10.5	150	Rainbow	B
August 17, 1949	150	Brook	C	7.0-10.8	150	Brook	B
	150	Brown	C	7.5-11.7	150	Brown	B
	150	Rainbow	C	7.0-11.8	150	Rainbow	B
Total	2250				2250		

from each of the two methods, spot plantings were better than boat plantings (Table 15). Of the number of successful fishing trips benefitting from the plantings, there was little difference but this was in favor of the spot planting. Similarly, of the number of different anglers sharing the catch from the two methods of planting there was a slight difference in favor of the spot plantings. There were more fish caught per successful fishing trip and more fish per successful angler from the spot plants than from the scatter plants. However, these differences were slight and neither of the methods were so conducive to easy fishing as to describe it as "meat fishing." If the total numbers of fishing trips were considered instead of the successful trips, the average number of planted fish caught per trip would be approximately one fish. This hardly justifies the contention that it is easy for the average fisherman on the average day to catch his limit of hatchery fish. In Section C, with a 15 fish limit, about one person in a hundred caught his limit; in Section B, with a five fish limit, about one person in 14 caught his limit.

Trout that had been scatter planted did not contribute to the catch for a longer period of time than did spot planted trout. The rate at which plantings are depleted is more dependent on the species of trout used than on the method of planting (Table 23).

The data from these experiments do not support the criticisms against spot planting when the number of fish used in a spot plant does not exceed 500. Under these conditions the scatter type of planting would not seem to be justified if one considers the extra time and cost involved in planting fish by this method.

Table 15. Spot planting vs. scatter planting - returns to anglers.

Month of planting	Total fish recovered		Number of successful fishing trips		Number of different fishermen sharing catch		Number of fish per successful trip		Number of fish per successful angler	
	Spot	Scatter	Spot	Scatter	Spot	Scatter	Spot	Scatter	Spot	Scatter
April	294	264	188	175	135	140	1.6	1.5	2.2	1.9
May	251	196	161	144	114	105	1.6	1.4	2.2	1.9
June	81	60	58	55	47	47	1.4	1.1	1.7	1.3
July	104	58	71	44	60	38	1.5	1.3	1.7	1.5
August	201	128	74	86	58	69	2.7	1.5	3.5	1.9
Total	931	706	552	504	414	399	1.7	1.4	2.2	1.8

Differences in Catch per Hour Between Sections

As one might expect, the catch per hour was better in planted sections than in sections which were not planted (Table 16). However, the catch was not so high as might have been expected from the number of fish stocked in these sections. The planting program was a disturbing influence in determining fishing intensity in the different sections. Most fishermen preferred to fish in sections that had been planted where they thought they would have a better chance to catch something and this increased pressure undoubtedly lowered fishing success in these sections somewhat. It is perhaps unfortunate that the total fishing pressure in the different sections was not controlled. This would have made it possible to compare fishing success in the different sections on a basis of equal fishing intensity.

It is also possible that fishermen of better than average ability chose to fish in sections that had not been planted. This would have had an equalizing effect on the catch per hour considering all sections. It would seem true from the fishing records obtained this past season that fishing success is more dependent on the individual angler's ability to take fish than on any other factor. In spite of the fact that the available stocks of trout in two sections were more than doubled by hatchery plantings, the per cent of successful anglers fishing these planted sections was only slightly greater than in unplanted sections (Table 16). It appears that planting fish merely makes it easier for the person who can catch fish to take more of them rather than enabling more persons to share in the total yield. Fortunately, the expert is a rather rare phenomenon in fishing as in other forms of competetive sports and on the Pigeon River this season limit catches occurred infrequently, even following hatchery plantings.

Table 16. Quality of fishing in different sections of Pigeon River, 1949.

Stream section	Number of fishing trips* (N)	Mean catch/hour (M)	Standard deviation (σ)	Standard error of mean (σ_M)	Per cent fishing trips unsuccessful	Per cent of total fishing trips in which a hatchery fish was caught	Per cent of total fishing trips in which a wild fish was caught
A	282	0.286	0.473	0.028	59.9	22.3	25.2
B	858	0.430	0.762	0.026	52.7	40.0	19.2
C	763	0.428	0.669	0.024	48.8	39.7	27.5
D	330	0.341	0.543	0.030	54.8	7.6	42.4
Total	2233	0.398	0.671	0.014	52.6	32.9	26.2

Probability that mean catches-per-hour between sections are different.

	A	B	C
B	99.98%		
C	99.98%	6.96%	
D	80.64%	97.22%	97.86%

* Size of sample necessary if σ = 0.671, t = 3 and difference between means are the following:

0.05 fish per hour = 1681 fishing trips
0.1 fish per hour = 404 fishing trips
0.2 fish per hour = 101 fishing trips

Frequency Distribution of Trout in Catch

Ever since creel limits for trout were established, the daily number allowed has been reduced from time to time until the present limit of 15 fish per day on streams has been reached. It is interesting to look at fishing success on a basis of the number of trout caught per fishing trip. The one experimental change in fishing regulations that was made at the Pigeon River during 1949 (a reduction in the creel limit from 15 per day to 5 per day) was done in an attempt to find out what effect this change would have in spreading the catch over more fishermen or in allowing a greater escapement of legal trout for spawning. The reduction in the daily limit was made on two sections, one in which hatchery fish were planted (Section B) and the other in which hatchery fish were not planted (Section A). In the other two sections, one with hatchery fish (Section C) and the other without hatchery fish (Section D) the daily limit remained 15 fish.

The fishing records for these sections have been summarized on a basis of the number of fish caught per fishing trip and the percentage of the total catch which it represents (Table 17). Probably the most important conclusion that is readily apparent is that restricting the creel limit to five fish would have affected less than 10 per cent of all the anglers since 92 to 96 per cent of all the fishermen took four fish or less in a single fishing trip. This was true even for the planted sections.

The records have also been tabulated to show the number of hatchery fish, wild fish and total fish taken by individual anglers (Table 18). In this summary, 90 per cent of the fishermen took five fish or less in their total season catch from the Pigeon River and 96 per cent of the anglers took 10 fish or less from this part of the Pigeon River during the season. At the other extreme the 1.3 per cent of the anglers who fished 10 or more times during the

Table 17. Number of trout per fishing trip, Pigeon River, 1949.

	Number of fish caught							
	0	1	2	3	4	5	6 to 10	11 to 15
Section A								
Number and	175	45	21	16	14	11		
per cent of fishing trips	61.7	16.0	7.5	5.7	5.0	3.9		
Per cent of total fish caught	0	18.3	17.1	19.5	22.8	22.4		
Section B								
Number and	451	166	82	69	37	53		
per cent of fishing trips	52.6	19.3	9.6	8.0	4.3	6.2		
Per cent of total fish caught	0	17.5	17.3	21.8	15.6	27.6		
Section C								
Number and	375	136	98	52	38	14	37	13
per cent of fishing trips	49.1	17.9	12.9	6.8	5.0	1.8	4.8	1.7
Per cent of total fish caught	0	11.8	16.2	13.4	13.1	6.0	24.0	15.6
Section D								
Number and	183	54	43	21	14	8	7	
per cent of fishing trips	55.0	16.5	13.1	6.4	4.3	2.4	2.1	0
Per cent of total fish caught	0	15.6	24.8	18.2	16.1	11.5	13.8	0

Table 18. Number of trout in season catch of individual anglers, Pigeon River, 1949.

Number of fish caught	Number of anglers taking hatchery fish	Number of anglers taking wild fish	Number of anglers taking hatchery and wild fish combined	Number of fish caught, range	Per cent of anglers taking hatchery fish	Per cent of total catch	Per cent of anglers taking wild fish	Per cent of total catch	Per cent of anglers taking hatchery and wild fish combined	Per cent of total catch
0	786	854	625	0-5	93.1	42.5	97.5	60.8	89.7	38.4
1	175	175	204							
2	78	86	99							
3	54	46	88							
4	25	23	44							
5	24	11	40							
6	20	7	20	6-10	4.0	21.2	1.4	12.6	6.1	21.4
7	11	3	11							
8	9	5	21							
9	4	2	13							
10	5	1	10							
11	3	2	6	More than 10	2.9	36.3	1.1	26.6	4.2	40.2
12	2	1	2							
13	4	2	4							
14	4	...	2							
15	4	...	4							
16	2	...	2							
17	2	1	3							
18	3	1	4							
19	4	...	6							
20	2	1	2							
21	2	1	1							
...	...	...	...							
23	...	1	4							
24	...	...	2							
...	...	...	...							
26	...	...	2							
27	1	1	...							
28	...	...	1							
...	...	...	...							
30	...	...	1							
...	...	...	...							
33	...	...	1							
...	...	...	...							
37	1	...	...							
...	...	...	...							
40	...	1	...							
41	1	...	...							
...	...	...	...							
46	...	...	1							
...	...	...	...							
50	...	1	...							
...	...	...	...							
55	...	...	1							
...	...	...	...							
58	...	...	1							
...	...	...	...							
91	...	...	1							

season took 14.2 per cent of all the hatchery fish and 23.4 per cent of all the wild fish recorded for the entire season (Table 19). Their average catch per hour was much better than the average for all the anglers. This fact and the predominance of wild fish taken is an indication that the people who fish the most during the season on the Pigeon River are generally better anglers and are less interested in taking hatchery fish. It is known that many hatchery fish were caught and released by some anglers. These have not been tabulated in the records for the simple reason that it is nearly impossible for an otherwise honest person to tell the truth when speaking of his fishing ability.

Another point of considerable interest is that limiting the creel to five fish per day in Sections B and A had little or no effect in spreading the catch over more fishermen (Tables 2 and 17). If the limit in Section C had been five fish per day instead of fifteen per day, theoretically 18 per cent of the catch recorded for that section should have been available for redistribution (Table 20). Presumably, a like number should have been available for redistribution in Section B which had a five fish limit. Nevertheless, the variation in the percentages of anglers taking from 0 to 4 fish per trip in the different sections of the river was too small to be considered significant using the chi-square test (Table 17). The differences in the number of fish per fishing trip between sections with a five fish limit and sections with a 15 fish limit were also small (Table 2). It appears again that, within limits, angling success is more dependent on the individual skill of the angler than on the number of fish in the stream. Limiting the catch to five fish per day therefore will probably be of benefit only psychologically since it will tend to direct the fisherman's thinking toward fishing for sport rather than for something to eat. It will not be very effective in permitting a greater percentage of fishermen to catch fish.

Table 19. Fishing statistics of all anglers fishing Pigeon River 10 or more times during the season of 1949.

Anglers (name withheld)	Bait used	Number of fishing trips	Total hours	Number of hatchery fish	Number of wild fish	Total fish	Mean catch/hour
1 *	Flies	42	99.5	19	27	46	0.57
2	Flies	25	70.0	15	40	55	0.81
3 *	Flies	23	48.0	10	23	33	0.73
4	Flies	21	62.5	13	11	24	0.39
5	Flies	20	69.0	37	21	58	0.85
6	Flies	17	59.0	41	50	91	1.93
7	Both	17	36.5	4	1	5	0.14
8	Both	16	57.5	15	8	23	0.37
9	Flies	13	42.5	5	6	11	0.34
10	Both	13	22.0	4	3	7	0.46
11	Both	13	41.5	20	6	26	0.59
12	Worms	12	33.0	16	5	21	0.65
13 *	Flies	12	24.5	8	20	28	1.07
14	Worms	11	54.0	21	5	26	0.44
15	Both	10	26.0	2	17	19	0.77
16	Flies	10	27.0	7	2	9	0.38

* Pigeon River Research staff members.

Table 20. Theoretical effect of a lower daily creel limit in spreading the catch over more fishermen, Pigeon River, 1949.

If daily creel limit were:	Per cent of catch available for distribution:			
	Section A	Section B	Section C	Section D
10	...	...	0.45	0.0
5	...	...	18.0	3.7
4	4.5	5.6	23.6	8.0
3	14.6	15.1	32.4	16.4
2	31.3	31.8	45.6	30.8

Another item of some importance is the effect of a lower creel limit on the escapement of wild and hatchery fish. Can we increase the native spawning stocks of trout by restrictions of this kind, and also, does this restriction on take affect the total returns from hatchery plantings? Partial answers to these questions were obtained by computing the escapement of various segments of the trout population, from the catch records and population estimate made at the close of the season (Table 21). At first glance it appears that the restricted creel limit had some effect in allowing more native brook trout to escape since there were more of them left in Sections A and B than in Sections C and D. However, lack of corroborative evidence of other species, both wild and hatchery, suggests some other explanation. For wild brown trout and all hatchery trout, evidence was lacking of an increase in escapement in sections where the daily creel limit was reduced from 15 fish to 5 fish per day. This agrees essentially with what was expected in view of the very low percentage of people who take more than five fish in a single fishing trip.

Length of Time Planted Trout Influence the Catch

Equal numbers of brook, brown and rainbow trout were planted in the Pigeon River during the open trout season. Each fish was marked with a serially numbered jaw tag, making it possible to establish the monthly planting from which it originated. Recoveries have been tabulated on a daily basis from the catch records (Table 22).

Except for a very few marked trout captured outside the experimental area (Table 26), the numbers tabulated represent the entire catch by fishermen. Migration from the experimental area was very small as determined from frequent checks with an electric shocker and from the creel census records (see later section on migration).

Table 21. Escapement of trout under different daily creel limits, Pigeon River, 1949.

Section	Daily creel limit	Hatchery fish planted	Per cent escapement					
			Wild Fish			Hatchery Fish		
			Brook	Brown	Rainbow	Brook	Brown	Rainbow
A	5	No	28	74	...	...	...	...
B	5	Yes	37	73	...	10	50	27
C	15	Yes	21	71	...	13	54	41
D	15	No	25	82	...	...	...	...

Table 22. Summary of returns from brook, brown and rainbow trout planted in Pigeon River, 1949.

Date	Number of fisherman days	Total hours	Brook trout					Brown trout					Rainbow trout				
			Month in which planting occurred														
			April	May	June	July	August	April	May	June	July	August	April	May	June	July	August
April 28			300 planted April 28					300 planted April 28					300 planted April 28				
29																	
30	143	395.0	33					7					28				
May 1	72	261.0	31					6					11				
2	21	39.5	7					0					6				
3	5	37.0	8					0					2				
4	12	42.0	25					0					5				
5	6	14.5	1					1					1				
6	10	29.0	5					1					5				
7	36	130.0	13					1					16				
8	11	35.5	10					1					5				
9	7	19.0	2					1					7				
10	16	45.5	4					0					1				
11	10	35.0	4					0					2				
12	12	33.0	3					1					2				
13	11	47.5	1					0					1				
14	29	154.0	17					8					7				
15	30	108.0	6					1					6				
16	2	10.0	1					0					0				
17	11	21.0	1					0					0				
18	10	31.5	1					4					5				
19	12	36.5	0					3					3				
20	27	92.5	1					4					6				
21	35	108.5	6					6					7				
22	27	70.0	1					2					3				
23	14	50.5	1	300 planted				6	300 planted				1	300 planted			
24	13	41.0	1	May 25				1	May 25				1	May 25			
25	16	39.5	2	23				1	4				3	7			
26	21	74.5	1	12				4	10				2	10			
27	21	49.5	3	11				0	2				2	4			
28	54	179.0	3	14				10	8				8	18			
29	71	211.0	4	19				5	6				6	22			
30	48	153.0	8	16				8	5				4	12			
31	8	26.0	0	2				3	0				1	1			
June 1	6	32.0	0	7				0	2				1	5			
2	17	72.0	2	2				2	2				1	3			
3	1	1.0	0	0				0	0				0	0			
4	16	54.5	0	2				3	1				1	3			
5	16	45.5	0	0				0	0				0	2			
6	4	17.0	0	0				1	1				2	2			
7	18	50.0	1	1				5	6				2	7			

2

	4	16	54.5	0	2		3	1		1	3	
	5	16	45.5	0	0		0	0		0	2	
	6	4	17.0	0	0		1	1		2	2	
	7	18	50.0	1	1		5	6		2	7	
	8	7	26.0	0	1		3	0		4	1	
	9	7	24.5	0	0		1	2		0	4	
	10	6	30.0	0	1		1	3		1	3	
	11	26	97.0	0	5		2	1		11	9	
	12	18	57.5	1	0		1	3		2	5	
	13	10	29.5	0	0		1	4		1	6	
	14	0	0	0	0		0	0		0	0	
	15	7	23.0	0	0		1	1		1	1	
	16	19	45.5	1	1		0	1		1	6	
	17	20	68.5	0	1		6	4		6	11	
	18	25	75.0	0	0		0	4		5	8	
	19	25	79.5	0	0		0	1		0	5	
	20	18	45.5	1	2		2	1		2	4	
	21	21	64.0	0	1		1	0		1	4	
	22	10	26.5	0	0		1	0		2	0	
	23	12	34.0	0	0		0	2		0	0	
	24	21	65.5	0	0		0	1		0	2	
	25	9	21.5	0	0		1	1		0	0	
	26	7	10.0	0	0		0	0		1	0	
	27	19	65.0	1	1	300 planted	1	1	300 planted	3	2	300 planted
	28	7	14.0	0	0	June 29	1	0	June 29	1	0	June 29
	29	16	31.0	0	0	0	1	1	3	3	0	3
	30	10	23.5	0	0	3	1	1	3	0	2	2
July	1	13	46.5	0	0	3	0	3	3	0	2	5
	2	38	98.5	0	0	6	3	0	9	1	3	3
	3	38	87.5	0	1	2	0	1	2	2	2	0
	4	26	80.5	0	0	1	0	0	2	1	1	1
	5	21	68.0	0	1	1	1	0	1	0	1	1
	6	13	36.5	0	0	0	1	0	1	0	0	1
	7	11	41.0	1	0	0	1	1	1	1	0	1
	8	11	30.0	1	0	1	1	2	0	0	2	0
	9	18	36.0	0	0	0	0	0	0	0	0	0
	10	14	48.0	0	0	0	0	0	0	0	0	0
	11	11	30.0	0	0	2	1	0	1	0	0	1
	12	27	61.5	0	0	0	1	3	3	0	1	3
	13	14	33.5	0	0	0	0	1	2	0	1	0
	14	18	48.0	0	0	0	0	1	2	0	0	0
	15	17	57.0	0	0	1	0	0	0	0	2	1
	16	5	10.0	0	0	0	0	0	0	0	0	0
	17	12	34.5	0	0	0	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	0	0	0	0
	19	9	32.0	0	0	0	0	0	1	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0
	21	9	25.0	0	0	0	0	0	1	1	1	1
	22	5	14.0	0	0	0	0	0	0	0	1	0
	23	5	11.5	0	0	1	0	0	0	0	0	0

3

	22	5	14.0	0	0	0			0	0	0			0	1	0			
	23	5	11.5	0	0	1			0	0	0			0	0	0			
	24	16	51.5	0	0	0			0	0	0			0	1	0			
	25	14	50.0	0	0	0	300 planted		0	0	0	300 planted		0	0	0	300 planted		
	26	6	11.0	0	0	0	July 27		0	0	0	July 27		0	0	0	July 27		
	27	14	26.5	0	0	0	2		0	0	0	0		0	0	2	7		
	28	9	20.0	0	0	0	3		0	0	0	1		0	0	0	4		
	29	18	45.5	0	0	0	0		0	0	0	1		0	1	1	4		
	30	8	18.5	0	0	0	1		0	0	0	1		0	0	0	1		
	31	17	40.5	0	0	0	1		1	0	0	0		0	0	0	1		
Aug.	1	6	17.5	0	0	1	2		0	0	1	0		0	0	0	4		
	2	14	53.5	0	0	0	2		0	0	1	1		0	1	1	0		
	3	8	42.0	0	0	0	3		0	0	2	2		1	0	1	0		
	4	13	29.0	0	0	0	2		0	1	0	0		0	0	0	1		
	5	5	15.0	0	0	0	0		0	0	0	1		0	0	0	0		
	6	16	51.0	0	0	0	2		1	1	2	4		0	0	0	0		
	7	5	17.5	0	0	0	0		0	0	0	0		0	0	1	0		
	8	7	22.5	0	0	0	1		0	0	0	1		0	1	0	0		
	9	2	9.0	0	0	0	0		0	0	0	0		0	0	0	0		
	10	10	23.5	0	0	0	0		0	1	2	0		0	0	0	1		
	11	5	15.0	0	0	0	0		0	0	0	0		0	0	0	0		
	12	9	22.0	0	0	0	1		0	0	0	0		0	0	0	0		
	13	17	41.0	0	0	1	0		0	0	1	2		0	0	0	2		
	14	17	54.5	0	0	0	0		1	2	1	1		0	0	1	5		
	15	10	19.0	0	0	0	0	300 planted	0	0	0	1	300 planted	0	0	0	1	300 planted	
	16	14	33.0	0	0	0	0	Aug. 17	0	1	1	0	Aug.17	0	0	0	0	Aug.17	
	17	11	40.5	0	0	0	0	7	0	0	0	0	2	1	0	0	0	3	
	18	12	24.0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	1	
	19	12	28.0	0	0	0	0	13	0	0	0	1	5	0	0	2	0	8	
	20	26	90.0	0	0	0	0	26	0	2	0	1	5	0	1	0	4	25	
	21	28	88.0	0	0	0	1	21	0	1	2	1	9	0	1	1	2	13	
	22	6	23.0	0	0	0	1	3	0	0	0	0	1	0	0	0	0	1	
	23	15	89.5	0	0	0	3	23	0	1	3	3	7	0	1	2	4	10	
	24	7	25.5	0	0	0	1	7	0	0	0	2	0	0	0	2	0	1	
	25	15	26.5	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4	
	26	13	41.5	0	0	0	0	2	0	1	0	0	1	0	2	0	1	2	
	27	15	36.5	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	
	28	23	70.5	0	0	1	3	6	0	0	0	1	0	0	1	0	2	3	
	29	19	49.5	0	0	1	0	1	0	0	2	0	4	0	1	0	2	0	
	30	5	10.5	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	
	31	4	5.0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	
Sept.	1	12	38.0	0	0	0	2	7	0	0	0	0	1	0	2	3	4	6	
	2	24	77.0	0	0	1	3	14	0	2	1	0	2	1	0	4	3	5	
	3	45	139.0	0	0	2	13	12	0	1	0	2	0	0	5	1	11	5	
	4	39	117.5	0	0	0	1	5	1	1	1	1	4	3	0	2	4	3	
	5	24	76.0	0	0	0	1	6	0	0	0	0	3	0	1	3	2	2	
	6	15	65.5	0	0	0	1	5	0	0	2	0	1	1	0	2	3	0	
	7	5	16.5	0	0	0	1	1	0	2	0	0	0	0	1	2	1	0	
										0	0	1	0	0	0	2	0	4	

4

5	24	78.0	0	0	0	1	0	0	0	0	0	3	0	1	3	2	2
6	15	65.5	0	0	0	1	5	0	0	2	0	1	1	0	2	3	0
7	5	16.5	0	0	0	1	1	0	2	0	0	0	0	1	2	1	0
8	8	20.0	0	0	0	0	4	0	0	0	1	0	0	0	2	0	4
9	5	13.5	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0
10	17	50.0	0	0	0	2	4	0	0	0	0	2	0	1	2	1	2
11	14	49.5	0	0	1	1	1	0	0	0	1	1	0	2	2	1	1
Total	2233	6817.0	213	124	29	54	180	135	108	58	32	51	223	209	60	77	102
Per cent recovery			71.0	41.3	9.7	18.0	60.0	45.0	36.0	19.3	10.7	17.0	74.3	69.7	20.0	25.7	34.0

Total trout recovered:

	Number	Per cent
Brook	600	40.0
Brown	384	25.6
Rainbow	671	44.7
Total	1655	36.8

Stocked in two plants - 1500 each plant

The number of recoveries from different plantings of the three species of trout varied greatly (Table 22): percentage recovery for brook trout ranged from 9.7 (June) to 71.0 (April 28) with an average of 40.0; for brown trout, 10.7 (July) to 45.0 (April 28), average 25.6 and for rainbow trout from 20.0 (June) to 74.3 (April 28), average 44.7 per cent. Certain conclusions seem to be justified from the experiments carried on this season. Brook trout stimulated angling success immediately after planting but this effect was very short-lived (Tables 22, 23). The per cent of recovery makes this species a preferred one for put-and-take fishing of short duration. However, their intolerance of warm water should be considered in establishing stocking policies. The two plantings made in the Pigeon River during the hot weather of June and July furnished very little fishing. This was also true to a somewhat lesser degree for the rainbows and browns (Table 22).

Rainbow trout furnished the highest per cent of recovery for the season and their effect on the catch was more prolonged than the brook trout (Tables 22 and 23). In order to get the most out of plantings of this species, it would seem to be advantageous to plant rainbows during the early part of the season and discontinue such plantings after the middle of the season. The greatest number of recoveries of this species (as of brooks and browns also) was made from the early-season plantings and a few rainbows from April and May plantings were being caught as late as 70 to 100 days after planting. This species might be considered more extensively for sustained yields throughout the fishing season. They are not caught out so readily as the brook trout under heavy fishing pressure, yet their relative ease of capture as compared with brown trout allows a higher total return.

There is little that can be said in favor of planting brown trout in the Pigeon River, judging from returns to the angler. Their reluctance to take a

Table 23. Length of time plantings of brook, brown and rainbow trout influence the catch.

Planting date	Number of trout planted	Number of trout recovered in different periods following planting						
		1st 20 days	2nd 20 days	3rd 20 days	4th 20 days	5th 20 days	6th 20 days	7th 20 days
		Brook trout - Spot plantings						
April	150	91	17	2	1	0	0	0
May	150	70	4	0	0	0	0	...
June	150	13	1	0	4	...	...	...
July	150	13	17	3	...	...	...	...
August	150	91	5	...	...	...	...	...
		Brook trout - Scatter plantings						
April	150	71	16	2	1	0	0	0
May	150	48	3	1	0	0	0	...
June	150	7	1	1	2	...	...	...
July	150	7	11	3	...	...	...	...
August	150	69	10	...	...	...	...	...
		Brown trout - Spot plantings						
April	150	20	38	7	3	0	2	0
May	150	34	12	7	2	5	6	...
June	150	18	7	4	4	...	...	...
July	150	12	11	2	...	...	...	...
August	150	34	5	...	...	...	...	...
		Brown trout - Scatter plantings						
April	150	16	27	12	8	2	0	1
May	150	24	10	3	1	3	0	...
June	150	12	3	6	3	...	...	...
July	150	4	3	1	...	...	...	...
August	150	11	1	...	...	...	...	...
		Rainbow trout - Spot plantings						
April	150	61	24	21	3	2	1	2
May	150	64	22	7	2	6	6	...
June	150	12	6	3	16	...	...	...
July	150	23	25	1	...	...	...	...
August	150	59	6	...	...	...	...	...
		Rainbow trout - Scatter plantings						
April	150	51	29	16	4	1	0	4
May	150	57	31	3	2	1	6	...
June	150	9	3	5	7	...	...	...
July	150	8	13	7	...	...	...	...
August	150	36	1	...	...	...	...	...

hook makes them a poor investment compared with either the brooks or rainbows. Brown trout do affect the catch over a more prolonged period than the brooks and by limiting plantings to the early part of the season a fair return of this species may be realized.

The plantings of hatchery fish made during the months of June and July failed to stimulate fishing and the returns from these plants were very low. As pointed out in an earlier section, water temperatures at this time were higher than those generally associated with good trout fishing.

Movement of Hatchery Fish

During the 1949 season on the Pigeon River, it was possible to obtain some valuable information on the movement of hatchery fish following planting. Each fish was identified by a serially numbered jaw tag and the permit system of creel census enabled experienced personnel to record accurate information as to species, point of recapture, etc. Plantings of equal numbers of the three species were made at five times during the season. The fish were divided between the middle two sections with an unplanted section on either side. The operation of the permit system was such that a complete record of the fisherman's catch was made at the checking station. Since an accurate record of the fishing intensity for each section is thus available, and the number of recoveries of marked fish for each section, indices of movement between these sections may be accurately estimated.

In order to properly evaluate the degree of movement of fish planted at a particular location, it is necessary to compare the numbers of fish recovered from a given area on a basis of equal amounts of effort expended in obtaining recoveries. For example, the actual numbers of fish recovered in Section A from the April planting in Section B were multiplied by a factor which compensated for the difference in fishing intensity between the two sections.

Thus, if the fishing intensity or effort expended in Section A was half that of Section B for the period during which a planting was exposed to capture, the number of recoveries made in Section A would have to be multiplied by 2 to give an accurate estimate of the dispersion of the fish during that period. Movement indices for the different plantings have been estimated in this manner.

In general, there was little movement from the vicinity in which the fish were planted (Tables 24 and 25). Spot planted trout did not move from the vicinity in which they were planted any more than did trout that were scattered. This was true of all three species of trout, even though the rainbows have often been considered to be too much inclined to wander to use extensively in a planting program. There was a moderate downstream movement in excess of that which moved upstream for the brook and rainbow trout. A few more brown trout moved upstream than down. Voluntary returns of tagged fish recovered outside the experimental area were few in number, and 10 of the 16 fish reported in this manner had moved less than 5 miles from the point of release (Table 26). From plantings made in the two fishing sections during 1949, 90 to 95 per cent of the recaptures were made within two miles of the point of release, and 65 to 85 per cent were made within one-half mile of the point of release. From this, it appears that movement from the area in which hatchery trout were stocked was not an important factor in explaining low recovery rates of these trout.

If dispersion is not an important disturbing factor, we may arrive at some approximate figures on mortality for the planted trout during the period of the fishing season (Table 27). The mortality of brook trout during the trout season was fairly high, judging by the few fish remaining at the time of the population estimate. Mortality of brown and rainbow trout, though noticeably less than brook trout, were still considerable. The causes of

Table 24. Movement of hatchery fish following spot planting, based on recoveries made by anglers. Movement indices have been adjusted to account for differences in fishing intensity between the sections.

Month of planting	Down 2 sections	Down 1 section	No movement	Up 1 section	Up 2 sections	
Brook trout						
April	12	4	52	0	...	
April	...	3	52	3	0	
May	6	3	34	0	...	
May	...	19	26	3	0	
June	...	7	12	5	0	
July	34	12	15	0	...	
August	13	9	83	5	...	Total
	65	57	274	16	0	412
Per cent total	15.8	13.8	66.5	3.9	0.0	
Brown trout						
April	0	0	36	8	...	
April	...	0	29	4	3	
May	0	0	36	5	...	
May	...	0	25	2	2	
June	...	0	32	3	2	
July	0	5	19	5	...	
August	0	0	39	0	...	Total
	0	5	216	27	7	255
Per cent movement	0.0	2.0	84.7	10.6	2.7	
Rainbow trout						
April	6	10	42	0	...	
April	...	0	63	2	5	
May	0	2	54	0	...	
May	...	10	48	0	0	
June	...	0	40	1	0	
July	0	7	43	0	...	
August	0	12	53	3	...	Total
	6	41	343	6	5	401
Per cent movement	1.5	10.2	85.6	1.5	1.2	

Table 25. Movement of hatchery fish following scatter planting, based on recoveries made by anglers. Movement indices have been adjusted to account for differences in fishing intensity between the sections.

Month of planting	Down 2 sections	Down 1 section	No movement	Up 1 section	Up 2 sections	
Brook trout						
April	3	3	45	3	...	
April	...	12	39	0	3	
May	10	8	15	0	...	
May	...	29	15	2	0	
June	4	4	5	2	...	
July	...	25	12	4	3	
August	...	13	66	16	0	Total
	17	94	197	27	6	341
Per cent movement	5.0	27.6	57.7	7.9	1.8	
Brown trout						
April	3	1	29	3	...	
April	...	18	26	4	0	
May	0	0	22	0	...	
May	...	6	13	3	2	
June	7	4	17	2	...	
July	...	0	10	0	0	
August	...	4	11	1	0	Total
	10	33	128	13	2	186
Per cent movement	5.4	17.7	68.8	7.0	1.1	
Rainbow trout						
April	9	20	36	0	...	
April	...	48	34	1	0	
May	6	8	36	0	...	
May	...	26	44	2	0	
June	0	3	21	0	...	
July	...	13	28	2	0	
August	...	30	30	3	0	Total
	15	148	229	8	0	400
Per cent movement	3.8	37.0	57.2	2.0	0	

Table 26. Recovery of tagged trout outside permit area, Pigeon River, 1949.

Moved upstream */			Moved downstream		
Species	Minimum distance-miles	Date of capture	Species	Distance - miles	Date of capture
Brown	1	May 22	Rainbow	2	April 30
Brown	1	June ?	Rainbow	2	June ?
Brook	1	June 16	Rainbow	2	June 16
Brown	1	August 5	Brook	2	July 9
			Brook	2	August 7
			Brook	2	August 7
			Rainbow	8	May 1
			Rainbow	8	May 15
			Brook	8	June ?
			Brook	8	July 30
			Brook	12	June 9
			Brook	25	May 25

*/ The presence of an impassable dam (at the Lansing Club) prevents movement upstream more than about 4 miles from the lowest point of release in the planted section.

Table 27. Approximate mortality of hatchery fish during the season in which planted.

Species	Number planted	Per cent caught by anglers	Per cent remaining at end of season	Approximate per cent mortality through season
Brook	1500	40	5	55
Brown	1500	26	30	44
Rainbow	1500	45	25	30

this rather high mortality during the season are not adequately known nor are they easy to detect. A small daily loss of fish would be missed, even by very intensive observations, due to the many predators, scavengers, etc., that are normally present in the area. Even sudden and extensive losses such as those due to pollution or rises in water temperature, though more apparent, cannot be determined exactly. There is considerable evidence that high water temperatures did result in loss of planted trout in the Pigeon River during 1949. This was both direct (observations of more dead fish immediately following onset of high water temperatures) and indirect (low recovery rates of all three species for the two plantings made during the hot weather and their scarcity in the population estimate at the end of the season). The different mortality values during the season for the three species of trout calculated from creel census records and population estimate (Table 27) agree with the known information on tolerance of these species to high water temperatures. This is further evidence that high temperature was a major factor in the loss of hatchery trout in the stream.

Wild Fish Production

Of the wild trout present in the Pigeon River, the brook trout furnished the most fish to the anglers. Brown trout were next in importance with rainbows being rather infrequently caught. All of the wild trout were measured and weights and scale samples were taken from the majority of the fish. It is thus possible to arrive at some total production figures from the different sections of the Pigeon River and to analyze the catch on a basis of the age groups represented. A population estimate of the trout population, by the mark and recovery method, taken at the close of the fishing season also gives an idea of what was left by the anglers, referred to in this report as the escapement. By this rather simple means of "keeping books" one can get a little

better picture of the exploitation of the trout populations and perhaps devise a better management program to ensure the wise utilization of the existing stocks of wild fish.

Total wild fish production for the 4.8 miles of the Pigeon River during the 1949 season was 1,048 trout which weighed a total of 202.6 pounds. This production is at the average rate of 8.4 pounds per acre. The numbers and total weight of fish caught varied considerably from one section to another, as did the production on a pounds per acre basis (Table 28).

Rate of Exploitation of Wild Fish

One of the important questions in fishery management is the rate of exploitation of the available stocks of wild fish. Until only recently these data have been unavailable due mostly to a lack of technical information concerning the estimation of stream fish populations. The permit system furnished a very accurate count of the total number of fish caught by anglers during the season. The population estimate at the close of the season supplied a fairly accurate account of what was still available. From this information may be deduced what effect the fishing intensity is having on the stocks of fish. It is very important to note the differences in catch and residual population between brook trout and brown trout (Table 29). This difference in exploitation between brook trout and brown trout is not generally recognized, or at least has not been considered in fishing regulations or other management programs. Data on the exploitation of rainbow trout are inadequate due to the small population present in the Pigeon River.

Age-Group Composition of Catch of Wild Fish

Of equal importance to the rate of exploitation of fishery stocks is the age-group composition of the catch. Effective management of a fishery is possible only if it is known what is happening to each year's hatch of fry.

Table 28. Production of wild trout from Pigeon River, season of 1949.

	Section A	Section B	Section C	Section D	Total
Brook trout					
Number	94	149	284	266	793
Total weight: lbs.	16.01	25.37	48.36	45.30	135.04
Pounds/acre	2.24	4.30	8.97	8.02	5.6
Brown trout					
Number	27	66	63	42	198
Total weight: lbs.	7.19	17.58	16.79	11.19	52.75
Pounds/acre	1.00	2.98	3.11	1.98	2.19
Rainbow trout					
Number	15	17	16	9	57
Total weight: lbs.	3.91	4.43	4.17	2.35	14.86
Pounds/acre	0.55	0.75	0.77	0.42	0.62
Total trout					
Number	136	232	363	317	1048
Total weight: lbs.	27.11	47.38	69.32	58.84	202.65
Pounds/acre	3.79	8.03	12.85	10.42	8.41

Table 29. Effect of fishing pressure on available stocks of legal-sized fish in Pigeon River, season of 1949.

	Brook trout		Brown trout		Rainbow trout	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Total anglers' catch	793	600	198	384	57	671
Population estimate September, 1949	290	80	602	452	No data	380
Per cent escapement	27	12	75	54	...	36

Table 30. Age-group composition of the catch of wild trout in the Pigeon River, 1949.

Month of capture	Age-group	Brook trout		Brown trout		Rainbow trout	
		Number	Average length: inches	Number	Average length: inches	Number	Average length: inches
May	I	7	7.2	0	...	1	7.6
June	I	18	7.4	6	7.3	7	7.5
July	I	45	7.3	23	7.5	8	7.4
August-September	I	52	7.3	43	7.5	9	7.4
May	II	116	7.8	24	9.1	11	9.4
June	II	42	8.2	26	9.9	6	9.7
July	II	39	8.1	13	10.1	6	9.7
August-September	II	46	8.1	15	10.9	5	9.5
May	III	5	9.4	1	12.2	0	...
June	III	2	10.3	1	11.7	0	...
July	III	1	10.0	0	...	0	...
August-September	III	0	...	1	16.8	2	16.4

When do they enter the catch? When do they first spawn? How long do they influence the catch? The present information indicates that in the Pigeon River, brook trout are being exploited at a very rapid rate and a three- or four-year-old fish is a rare occurrence (Table 30.) Other information to be obtained on growth rate of the trout populations present in the Pigeon River and the relationship of this information to management practices will be the subject of a future report.

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INSTITUTE FOR FISHERIES RESEARCH

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SOLUNAR
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June 13, 1950

Director of Research
Michigan Conservation Commission
Lansing, Michigan

Dear Sir:

It has been brought to our attention that the Mail Pouch Tobacco Company's Fishing and Hunting Club of the air has seen fit to take the SOLUNAR TABLES to task on a recent program, basing their arguments on a survey made by your unit.

Would it be possible for you to send us a copy of the report on the tests conducted by your department?

Any assistance you can give us on this matter would be appreciated.

Sincerely,

/s/ Richard Alden Knight

Richard Alden Knight

RAK:pw

Original letter to Hazzard. Put this in Hazzard open file. VB

"Institute" 4-4-49 to F. Waterman from Dr. Hazzard