Prepared for presentation at the American Fisheries Society meetings, September 8-10, 1952.

Original: American Fish. Soc.
cc: Fish Division
Education - Game
Institute for Fisheries Research
D. S. Shetter
C. T. Yoder
E. L. Cooper

August 5, 1952

Report No. 1346

Returns from plantings of legal-sized brook, brown and rainbow trout in the Pigeon River, Otsego County, Michigan

[1] Contribution from the Michigan Institute for Fisheries Research

Edwin L. Cooper

Michigan Department of Conservation

Vanderbilt, Michigan

Abstract

A complete census of fishing on 4.8 miles of the Pigeon River, together with population estimates made at the end of the open season, made possible an accurate evaluation of the yield and survival of open-season plantings of hatchery trout. Fishing intensity in this research area for three years averaged 2,414 daily trips per year which was equivalent to 278 hours of fishing effort per acre per year. Sections in which hatchery fish were planted attracted about three times as much fishing as did the unplanted sections.

Fishing quality, measured by the catch per hour per fishing trip, was generally poor for native fish, averaging less than 1 fish for 5 hours of effort. Hatchery fish made up about 70 percent of the total catch for the three years.

Planting trout from a live-crate a few at a time (scatter planting) did not prove to be advantageous over the practice of liberating large numbers of fish in one hole (spot planting). Trout that had been scatter planted did not contribute to the catch for a longer period of time, and resulted in fewer successful fishing trips, fewer total fish returned to anglers, and slightly fewer anglers sharing in the total catch. However, the practice of making several plantings on different dates, a few fish at a time, proved to be successful in permitting more individual anglers to share in the catch.

Although 4,500 legal-sized trout were planted each year, about half of the fishing trips were unsuccessful. Limiting the daily catch to 5 trout, instead of 15, did very little to reduce the percentage of unsuccessful anglers. Further reduction to 2 fish per day lowered the unsuccessful fishing trips to 36 percent.

Plantings of rainbow trout and brook trout gave much higher returns to the fishermen than did equal numbers of brown trout. Rainbow trout also survived over winter to successive seasons as well as did brown trout, although in both species these values were less than 10 percent. Over-winter survival of brook trout was less than 3 percent. Fin-clipped trout were recovered by fishermen more readily than those which were jaw-tagged. This was especially apparent during the first week following planting.

Rainbow trout and brook trout, planted when water temperatures were below 50° F., exhibited an immediate downstream movement, with the majority of the recoveries being taken several miles below the planting site. Plantings made when water temperatures were above 50° F. showed very little movement, with the majority of the fish being recovered within 1 mile of the planting site.

Legal-sized brook, brown and rainbow trout, planted in a stream subjected to heavy fishing pressure, contributed to the catch for a relatively short time. Brook trout were exploited most readily; only 4 percent of the recoveries were taken after 40 days of liberty. For brown trout and rainbow trout these values were 26 percent and 22 percent, respectively. In all of the plantings there was a considerable unexplained loss, and this loss was greatest when poor conditions for exploitation by anglers prevailed over the initial 20 to 40 days following planting.

Planting large numbers of hatchery fish (up to 431 trout per mile) apparently had no effect upon the catch of wild fish in the stream. Although the catch per hour of the planted trout increased greatly at the time of planting, the corresponding weekly catch-per-hour data for the wild trout showed no such correlation.

Spinners plus worms, and worms, generally were more effective in catching trout in the Pigeon River than were flies or miscellaneous baits. However, this was due almost entirely to the predominance of hatchery trout taken by persons using worms, or spinners plus worms, and was in spite of the marked superiority of flies or fly fishermen in catching wild trout.

Prepared for presentation at the American Fisheries Society meetings, September 8-10, 1952.

Original: American Fish. Soc.
cc: Fish Division
Education - Game
Institute for Fisheries Research
D. S. Shetter
C. T. Yoder
E. L. Cooper

August 5, 1952

Report No. 1346

Returns from plantings of legal-sized brook, brown and rainbow trout in the Pigeon River, Otsego County, Michigan

By

Edwin L. Cooper

Introduction

In April, 1949, the Pigeon River Trout Research Area was established on the site of the State Forest Headquarters, 13 miles east of the town of Vanderbilt in Otsego County. Here, a portion of the Pigeon River 4.8 miles in length was set aside for detailed studies of the life history and management of the three species of trout common to Michigan. The present report is a summary of the principal results of investigations on plantings of legal-sized hatchery trout completed during the first three years of operation at the station.

The 4.8 miles of stream under experimental control have been arbitrarily divided into four convenient fishing sections of approximately equal length (Figure 1). Weirs or other barriers to movement are not present within the research area. The lower section (A) supports a poor native population of trout compared to the other sections, although the physical features of the stream sections, except for minor differences in temperatures, are quite similar (Table 1). Native brook trout outnumber brown trout in the stream about 3 to 1, and native rainbow trout are rarely encountered.

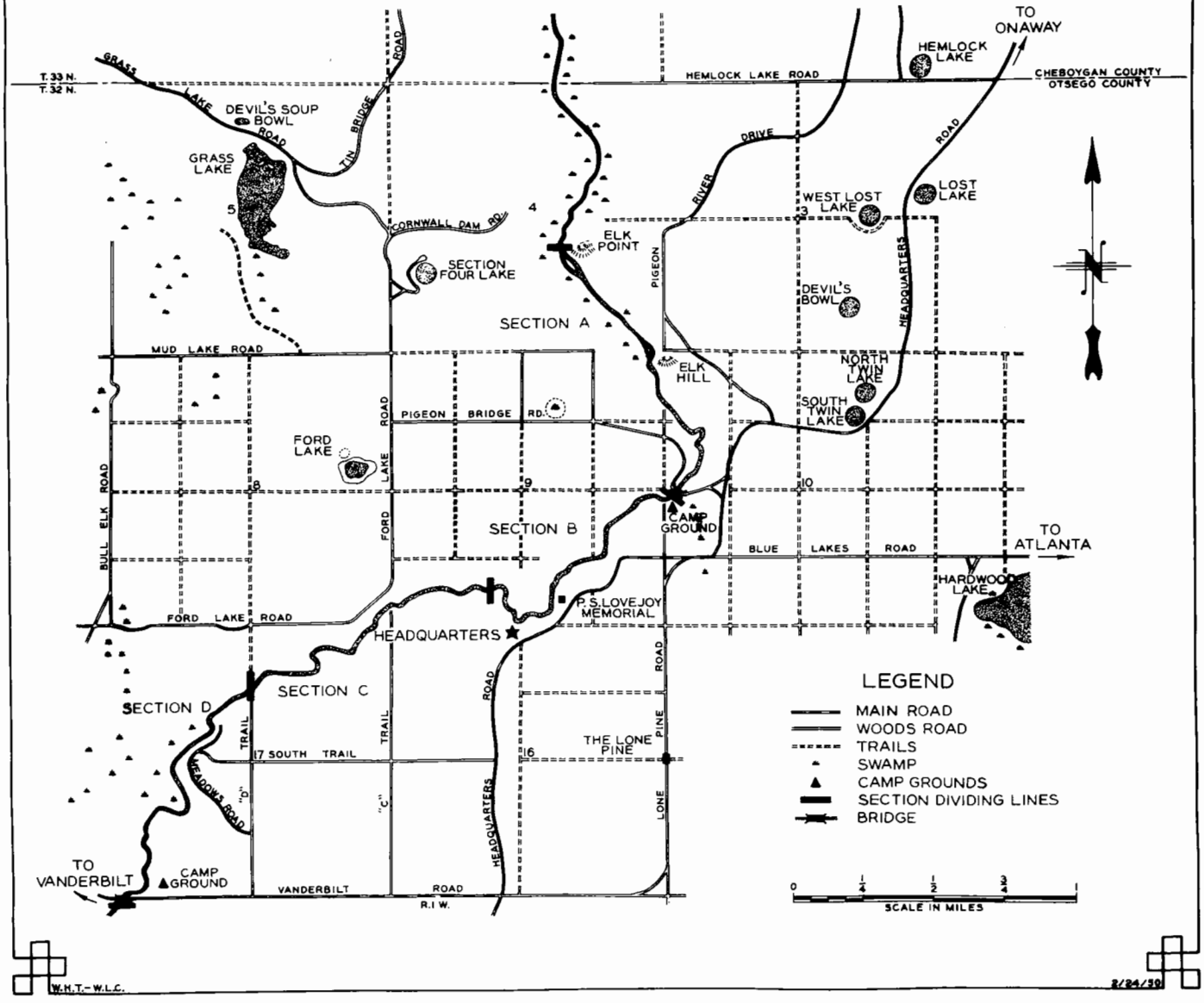
A permit-type of creel census was operated on the experimental waters during the three years. Each fisherman was required by Conservation Commission order to register at a checking station (headquarters) to obtain a daily permit. At the close of fishing in a particular section

Figure 1.--Map of a section of the Pigeon River in Otsego County, Michigan, showing the four experimental sections (A to D) and location of the creel census headquarters.

MICHIGAN DEPARTMENT OF CONSERVATION
FISH DIVISION

PIGEON RIVER TROUT RESEARCH AREA

OTSEGO AND CHEBOYGAN COUNTIES



W.H.T.-W.L.C.

8/24/39

Table 1.--Morphometry of the experimental portion of the Pigeon River

Physical feature	Section A	Section B	Section C	Section D	Total
Length in miles	1.31	1.19	1.13	1.18	4.80
Average width in feet	45	41	40	40	41
Area in acres	7.16	5.90	5.39	5.65	24.10
Gradient in feet per mile	9.63	9.53	12.20	7.69	9.74

of the stream, the angler 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 a very complete and 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 by securing additional permits.

Fishing intensity

Fishing intensity in the experimental waters for the three years averaged 2,414 daily trips per year (Table 2). This was equivalent to 100 fishing trips per acre per year or 278 hours per acre per year. The sections in which hatchery fish were planted (Sections B and C) attracted more fishermen than did the unplanted sections; 155 fishing trips per acre per year to 52 per acre per year, respectively. The majority of the fishing was done on week ends and holidays, with Saturdays and Sundays alone accounting for about half of the fishing. July and August averaged fewer fishermen per day than did May, June and September.

About 1,200 different individuals fished in the area during each of the three seasons. Of these individuals, two-thirds fished only once, about 95 percent fished less than 5 times and only about 2 percent fished 10 or more times during the season.

Residence of anglers

The residence of anglers who fished the Pigeon River was tabulated for the three years. In general, areas of the state with high population density furnished large numbers of fishermen. The local county (Otsego) was well represented, but not counties immediately

Table 2.--Fishing intensity of 4.8 miles of the Pigeon River, seasons of 1949, 1950 and 1951

	Stream sections				
	A	B	C*	D*	All sections
Acreage	7.16	5.65	5.90	5.39	24.10
1949					
Number of fishing trips	282	330	858	763	2,233
Total hours	861	1,021	2,385	2,550	6,817
1950					
Number of fishing trips	333	397	814	616	2,160
Total hours	898	1,276.5	2,130.5	1,890	6,195
1951					
Number of fishing trips	367	277	1,252	954	2,850
Total hours	950.5	818.5	3,148	2,159	7,066
1949 to 1951 inclusive					
Number of fishing trips	982	1,004	2,924	2,333	7,243
Total hours	2,709.5	3,116	7,663.5	6,599	20,098
Average trips per acre per year	51.7		155.2		100.2
Average hours per acre per year	151.6		421.1		278.0

* Sections in which hatchery trout were planted.

adjacent. There was an almost complete lack of fishermen from the Upper Peninsula, but there were anglers from nearly all (58 out of 68 ~~63~~) of the counties from the Lower Peninsula.

Out-of-state anglers comprised about 10 percent of the total. Ohio predominated over all other states followed by Indiana and Illinois. During the three years, fishermen were recorded from 23 different states and the province of Manitoba.

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 index is used to compare samples of the same type of fishing, it is probably the best index that we have. However, most investigators have failed to analyze the data by well-known statistical procedures which would enable them to evaluate the significance of differences in fishing quality.

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 and the standard error of the mean. All fishing trips have been used in the computation of these statistics, even though inclusion of the unsuccessful trips results in highly skewed distribution of catch-per-hour-per-angler values. An additional index of fishing quality used is the percentage of successful fishing trips (i.e., catching at least 1 legal trout). These values are usually given in conjunction with the mean catch per hour per angler.

The fishing quality in different sections of the Pigeon River has been summarized for the three-year period, 1949 to 1951 (Table 3). Fish from hatchery plantings, and naturally spawned fish, have been tabulated separately. The differences in fishing quality of hatchery

Table 3.--Fishing quality in the Pigeon River, 1949 to 1951 inclusive, for brook, brown and rainbow trout combined

Stream section and fishing statistics	Year and source of trout					
	1949		1950		1951	
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
Section A						
Mean catch per hour	0.125	0.161	0.331	0.135	0.144	0.259
Standard error of mean	0.018	0.021	0.032	0.016	0.021	0.029
Percent successful fishing trips	22.3	23.8	36.9	24.6	20.4	31.6
Section B√						
Mean catch per hour	0.334	0.095	0.650	0.124	0.694	0.123
Standard error of mean	0.024	0.009	0.047	0.012	0.042	0.009
Percent successful fishing trips	40.1	19.2	46.9	20.5	45.7	19.9
Section C√						
Mean catch per hour	0.287	0.135	0.488	0.181	0.760	0.024
Standard error of mean	0.020	0.011	0.042	0.014	0.033	0.005
Percent successful fishing trips	39.7	27.5	41.4	30.5	62.4	4.0
Section D						
Mean catch per hour	0.025	0.306	0.030	0.328	0.036	0.062
Standard error of mean	0.006	0.028	0.006	0.030	0.009	0.013
Percent successful fishing trips	6.6	40.9	7.5	38.5	7.2	13.4
All sections						
Mean catch per hour	0.244	0.150	0.441	0.180	0.581	0.101
Standard error of mean	0.012	0.007	0.023	0.008	0.022	0.006
Percent successful fishing trips	32.6	26.1	36.6	27.3	44.3	15.4

√ Planted sections.

fish between sections and between years are discussed below. The data for the wild fish indicated a rather stable fishery during the three years. The catch and rate of exploitation were very similar for the same species from year to year, but brook trout were markedly easier to exploit than brown trout. The drop in fishing quality in 1951 for Sections C and D was due in great part to the change in fish regulations from a 7-inch minimum size limit to a 9-inch minimum size limit. In these sections the daily limit in 1951 was also reduced from 15 per day to 2 per day.

Brook trout outnumbered brown trout in the catch about 3 to 1. The residual fall population of legal-sized fish based on population estimates with electrofishing devices, was composed of about 3 brown trout to 1 brook trout. On the whole, fishing for wild trout was poor, averaging less than 1 fish for 5 hours of effort. It is believed that this was due to the heavy annual fishing pressure and also to the depleted condition of the native trout population.

Open-season plantings of legal-sized trout

For the past several years in Michigan, emphasis has been placed on the supplemental planting of legal-sized trout, just before and during the open season. The results of many experiments in Michigan and elsewhere involving experimental plantings of this kind have already been published. The present discussion is a continuation, in this state, of previous experiments (Hazzard and Shetter, 1939; Shetter and Hazzard, 1941; Shetter, 1947). Its chief value lies in the more accurate creel census data obtained through the compulsory permit system and the possibility of estimating residual populations by electrofishing devices. Some of the conclusions reached in previous studies are untenable in the light of present knowledge, but in general there is good agreement between present

studies and previous data published both from Michigan and from other states. A good review of previous investigations involving legal-sized trout plantings is given by Shetter (1947).

Comparison of planting methods

In the past there has been much public criticism of the methods of "spot planting" legal trout, i.e., liberating large numbers of fish in one part of the stream. The objections have been that this type of planting made fishing too easy and too artificial, and that only a few persons benefitted from the plantings. 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 (Shetter, 1947) conducted to evaluate returns from the two types of plantings could not demonstrate any advantage of scatter planting over spot planting.

During 1949 and 1950, equal numbers of hatchery fish were stocked in the experimental area of the Pigeon River by both methods, and the results from the two types of planting were compared. Combining the returns from all three species of trout, more fish were recovered from the spot-planted fish than the scatter-planted fish; spot plants resulted in a greater number of successful fishing trips than did scatter plants; and the number of different anglers who benefitted from the two planting methods was almost equal (Table 4).

Trout that had been scatter-planted did not contribute to the catch for a longer period of time than did spot-planted trout. As is shown below, the rate at which plantings were depleted was more dependent on the species of trout than on the method of planting.

Table 4.--Relationship between method of planting legal-sized trout and returns to anglers

Item	Year and method of planting			
	1949		1950	
	Spot	Scatter	Spot	Scatter
Total fish recovered	931	706	1,649	933
Number of successful fishing trips	552	504	466	445
Number of different anglers sharing the catch	414	399	273	283

In each of the three seasons, a total of 4,500 trout were planted in approximately 2.3 miles of stream. The number of individual plantings varied from 3 plantings in 1950, to 5 in 1949, and 7 in 1951. The practice of planting smaller numbers of fish at more frequent intervals proved to be more effective in spreading the fish over more fishing trips and individual anglers than the scatter-type planting method. In effect, it is a scatter-planting method in time rather than in space. More fishermen shared in the catch and more fishing trips were successful when many individual plantings were made (Table 5).

Table 5.--Relationship between number of individual plantings and returns to anglers

Year and number of plantings	Total number of fish recovered	Number of successful fishing trips	Number of individual anglers sharing the catch
1950 - 3 plantings	2,313	790	446
1949 - 5 plantings	1,655	916	440
1951 - 7 plantings	2,677	1,247	553

Effect of daily limits on distribution of trout in catch

Daily creel limits for trout are based on the assumption that the fish saved by limiting the catch will be available to, and be used by,

other anglers or to the same anglers on additional days. Actually, it is a penalty imposed on the more skillful or more fortunate anglers and is presumably justified on the basis of a more equal sharing of the total production of the lake or stream. The effect of daily creel limits was investigated somewhat by changing fishing restrictions on different sections of the Pigeon River from year to year (Table 6).

The hatchery plantings in Sections B and C furnished 78 percent of the fishing in these sections or about 3 1/2 times the wild catch. This heavy rate of stocking induced a much higher fishing intensity in these sections than in unplanted ones, yet one would expect that a large proportion of the anglers would catch fish in the planted sections. Actually, about half of the fishing trips were unsuccessful, and limiting the daily catch to 5 trout instead of 15 trout had very little effect on reducing the percentage of unsuccessful anglers. Further reduction of the daily limit to 2 trout with stocking at 400 legal fish per acre per year resulted in 36 percent of the fishing trips still unsuccessful (Table 6).

Table 6.--Frequency of trout in daily catch

Stream section, regulations and year	Number and species planted	Percent of total fishing trips catching the following numbers of trout per fishing trip							
		0	1	2	3	4	5	6-10	11-15
Section B	750 each of								
5 trout per day	brook, brown								
1949	and rainbow	52.6	19.3	9.6	8.0	4.3	6.2	...	...
1950	1,250 brook 1,000 rainbow	47.3	15.2	8.8	5.0	5.5	18.0	0.2	...
1951	2,250 rainbow	47.7	14.7	9.5	7.5	5.0	15.5	0.1	...
Section C	750 each of								
15 trout per day	brook, brown								
1949	and rainbow	49.1	17.9	12.9	6.8	5.0	1.8	4.8	1.7
1950	1,250 brook 1,000 rainbow	47.2	14.8	10.7	6.7	4.5	3.9	8.3	3.9
2 trout per day									
1951	2,250 rainbow	36.3	16.8	16.8	0.1	...	...	...	...

Returns from different species compared

Plantings of rainbow trout and brook trout gave much higher returns to the fishermen than did equal numbers of brown trout (Table 7). Returns from individual plantings varied from 9.7 percent to 74.3 percent. Plantings made in June and July of 1949, when water temperatures were high, resulted in poor returns for all three species. During these hot weather periods mortality or predation must have been high, although it was impossible to find sufficient numbers of dead or dying fish to explain the unaccounted high loss from these particular plantings. Movement out of the planted area was also too slight to be an important factor during hot weather, although movement of the planted fish, because of cold water, was believed to have been the dominant reason for low returns of the plantings made during April of 1950 and 1951.

Returns from plantings made in April of 1950 and 1951 are not considered complete because of the impossibility of contacting many anglers who fished outside the research area and because of the demonstrated movement of these plantings outside the area.

The returns of brook and rainbow trout planted under optimum conditions of water temperature and fishing pressure averaged better than 50 percent, and the average for the 3,856 rainbow trout planted in 1951 (excluding the one planting deliberately made during cold weather) was better than 67 percent (Table 7).

Rainbow trout also survived to successive seasons nearly as well as did brown trout, although in both instances these values were very small (Table 8). The fact that the legal-sized hatchery trout grew less than an inch per year in the stream after planting minimized to a large extent the value of these over-winter recoveries.

Estimates of the number of trout surviving from the open-season plantings were made each September by use of electrofishing methods. This made

Table 7.--Returns from individual plantings of legal-sized trout from the Pigeon River. Recoveries made during same season in which trout were planted.

Planting date	Average maximum water temperature for 7 days following planting date, in degrees F.	Brook trout		Brown trout		Rainbow trout	
		Number planted	Percent recovered	Number planted	Percent recovered	Number planted	Percent recovered
April 28, 1949	55	300	71.0	300	45.0	300	74.3
May 25, 1949	56	300	41.3	300	36.0	300	69.7
June 29, 1949	75	300	9.7	300	19.3	300	20.0
July 27, 1949	75	300	18.0	300	10.7	300	25.7
August 17, 1949	71	300	60.0	300	17.0	300	34.0
April 26, 1950	45	1,000	35.8	...	...	1,000	36.5
June 1, 1950	65	1,000	54.8	...	...	1,000	71.1
August 8, 1950	72	500	66.2	...	...	...	...
April 19, 1951	42	...	...	...	...	644	26.9
May 3, 1951	55	...	...	...	...	644	70.8
May 17, 1951	62	...	...	...	...	636	72.1
May 31, 1951	61	...	...	...	...	642	67.4
June 14, 1951	68	...	...	...	...	644	70.5
July 26, 1951	72	...	...	...	...	644	55.7
August 9, 1951	65	...	...	...	...	636	69.5

Table 8.--Recoveries and survival of legal-sized trout planted in the Pigeon River during open seasons of 1949, 1950 and 1951. Percent of total planted given in parentheses

Item	Year and species of trout planted					
	1949			1950		1951
	Brook	Brown	Rainbow	Brook	Rainbow	Rainbow
Number planted	1,500	1,500	1,500	2,500	2,000	4,500
Number recovered during 1st season	600 (40.0)	384 (25.6)	671 (44.7)	1,237 (49.5)	1,076 (53.8)	2,677 (59.5)
Estimated residual population, 1st fall	80 (5.3)	452 (30.1)	380 (25.3)	75 (3.0)	151 (7.6)	374 (8.3)
Number recovered during 2nd season	0	33 (2.2)	34 (2.3)	2 (0.08)	16 (0.8)	...
Estimated residual population, 2nd fall	0	31 (2.1)	2 (0.13)	0	4 (0.2)	...
Number recovered during 3rd season	0	1 (0.07)	0	...	...	...
Estimated residual population, 3rd fall	0	4 (0.27)	0	...	...	...

possible an evaluation of returns from fall-planted fish (or, more correctly, fish remaining in the fall from spring and summer plantings). Returns from these residual fall populations of brook, brown or rainbow trout varied from 0.0 percent to 10.6 percent, with brook trout never exceeding 2.7 percent. One brown trout from an original planting of 1,500 was recaptured in the second season following planting (Table 8).

Comparison of rate of recovery of tagged and fin-clipped fish

In June, 1950, and August, 1950, due to a shortage of jaw tags, it was necessary to fin clip half of each planting. This afforded a chance to evaluate returns from tagged and fin-clipped fish. Separate plantings were made (brook, spot planted; brook, scatter planted; rainbow, spot; and rainbow, scatter). In each planting half of the fish were tagged, half fin clipped. Recoveries have been tabulated separately.

In all of the plantings, fin-clipped fish were recovered more readily by anglers than were tagged fish. This was especially apparent during the first week (Table 9).

Movement following planting

An important factor that needs to be considered in the choice of the species of trout to be used for supplemental stocking is the direction and degree of movement of these fish following planting. Of the four experimental sections on the area, trout were stocked in the center two sections only, permitting an estimation of movement in either direction. Also, complete records of fishing effort in all four sections made possible the computation of movement indexes based on returns by anglers. When these indexes were compared for individual plantings for all three species, it was readily apparent that there was a decided tendency for the fish to remain in the immediate vicinity of

Table 9.--Comparison of rate of recovery of tagged and fin-clipped trout from the Pigeon River

Species, planting date, and method of planting	Number of recoveries, tagged : fin clipped	Adjusted Chi-square
TOTAL RECOVERIES FROM PLANTINGS		
Rainbow trout		
June 1, 1950		
Spot	164 : 203	3.93
Scatter	137 : 207	13.84
Brook trout		
June 1, 1950		
Spot	127 : 175	7.32
Scatter	101 : 145	7.52
August 8, 1950		
Spot	73 : 101	4.19
Scatter	77 : 80	0.02
RECOVERIES FIRST WEEK AFTER PLANTING		
Rainbow trout		
June 1, 1950		
Spot	34 : 63	8.08
Scatter	36 : 85	19.04
Brook trout		
June 1, 1950		
Spot	104 : 141	5.29
Scatter	49 : 73	4.34
August 8, 1950		
Spot	44 : 73	6.70
Scatter	29 : 45	3.04

planting sites (Tables 10, 11 and 12). Exceptions to this tendency were noted in the plantings made in early April and are believed to have been associated with water temperatures at the time of planting. The pronounced downstream movement of both rainbow trout and brook trout planted in April, 1950, noted from angler recoveries, prompted a repeat experiment in 1951 using rainbow trout only.

The data from angler recoveries were supplemented with electrofishing records obtained immediately following the 1951 plantings by the following procedure. The stream was divided into 200-yard sections starting from the downstream border of the area. Hatchery fish were stocked on different dates at designated spots on the stream and the hatchery trout captured by D.C. electrofishing were recorded in successive 200-yard sections. In this way the distribution of the hatchery plantings was established on several dates following planting. These data indicated an immediate downstream movement of the planted fish when the temperature at time of planting was less than 50° F., but very little movement when temperatures at planting time were above 50° F. Data from the plantings of April 19 and May 3, 1951, only, are presented on this basis (Table 13). Subsequent plantings in 1951 exhibited movement to a degree similar to the May 3 planting.

Length of time plantings influence catch

Legal-sized brook, brown and rainbow trout, planted in a stream subjected to heavy fishing pressure, contributed to the catch for a relatively short time. Recoveries from plantings made in the Pigeon River for the past three years have been tabulated according to the time spent in the stream after planting (Table 14). Brook trout were exploited the most readily; 96 percent of the recoveries were taken during the first 40 days of liberty. For brown trout and rainbow trout

Table 10.--Movement of hatchery rainbow trout following planting in the Pigeon River shown by angling recoveries. Fishing sections are each approximately 1.2 miles in length. Water temperatures given are mean maximum water temperatures for the seven days following each planting

Planting date	Water temperature	Direction and index of movement				
		Down 2 sections	Down 1 section	No movement	Up 1 section	Up 2 sections
April 28, 1949	55	6	10	42	0	...
		...	0	63	2	5
		9	20	36	0	...
		...	48	34	1	0
April 26, 1950	45	26	14	11	0	...
		23	16	19	0	...
		...	40	11	1	0
		...	26	21	1	1
April 19, 1951	42	16	4	2	0	...
		...	30	3	1	0
May 3, 1951	55	17	8	56	6	...
		...	6	52	1	0
May 17, 1951	62	15	8	63	5	0
		...	2	57	0	0
May 25, 1949	56	0	2	54	0	...
		...	10	48	0	0
		6	8	36	0	...
		...	26	44	2	0
May 31, 1951	61	8	5	59	3	...
		...	0	56	1	2
June 1, 1950	65	...	2	50	3	0
		...	3	58	6	2
		0	2	45	2	...
		3	6	65	4	...
June 14, 1951	68	9	4	63	1	...
		...	0	47	1	0
June 29, 1949	75	...	0	40	1	0
		0	3	21	0	...
July 26, 1951	72	2	4	33	2	...
		...	2	35	1	0
July 27, 1949	75	0	7	43	0	...
		...	13	28	2	0
August 9, 1951	65	6	9	33	3	...
		...	1	35	1	0
August 17, 1949	71	0	12	53	3	...
		...	30	30	3	0

Table 11.--Movement of hatchery brown trout following planting in the Pigeon River shown by angling recoveries. Fishing sections are each approximately 1.2 miles in length. Water temperatures given are mean maximum water temperatures for the seven days following each planting

Planting date	Water temperature	Direction and index of movement				
		Down 2 sections	Down 1 section	No movement	Up 1 section	Up 2 sections
April 28, 1949	55	0	0	36	8	...
		...	0	29	4	3
		3	1	29	3	...
		...	18	26	4	0
May 25, 1949	56	0	0	36	5	...
		...	0	25	2	2
		0	0	22	0	...
		...	6	13	3	2
June 29, 1949	75	...	0	32	3	2
		7	4	17	2	...
July 27, 1949	75	0	5	19	5	...
		...	0	10	0	0
August 17, 1949	71	0	0	39	0	...
		...	4	11	1	0

Table 12.--Movement of hatchery brook trout following planting in the Pigeon River shown by angling recoveries. Fishing sections are each approximately 1.2 miles in length. Water temperatures given are mean maximum water temperatures for the seven days following each planting

Planting date	Water temperature	Direction and index of movement				
		Down 2 sections	Down 1 section	No movement	Up 1 section	Up 2 sections
April 28, 1949	55	12	4	52	0	...
		...	3	52	3	0
		3	3	45	3	...
		...	12	39	0	3
April 26, 1950	45	19	17	17	1	...
		16	14	15	2	...
		...	32	11	2	0
		...	32	12	1	0
May 25, 1949	56	6	3	34	0	...
		...	19	26	3	0
		10	8	15	0	...
		...	29	15	2	0
June 1, 1950	65	4	4	39	1	...
		1	4	57	1	...
		...	14	22	4	3
		...	19	36	5	1
June 29, 1949	75	...	7	12	5	0
		4	4	5	2	...
July 27, 1949	75	34	12	15	0	...
		...	25	12	4	3
August 8, 1950	72	6	5	14	1	...
		4	7	23	0	...
		...	10	15	1	1
		...	6	16	2	0
August 17, 1949	71	13	9	83	5	...
		...	13	66	16	0

Table 13.--Movement of hatchery rainbow trout following planting in the Pigeon River, 1951, as evidenced by recoveries[+] with D.C. electrofishing. Water temperature on April 19, 1951 was 43° F.; on May 3, 1951, 54° F.

Planted between Stations 40 and 42 on April 19, 1951				Planted between Stations 50 and 52 on April 19, 1951			
Stream markers in hundreds of yards above lower boundary	Date of recapture			Stream markers in hundreds of yards above lower boundary	Date of recapture		
	April 20	April 24	May 1		April 20	April 24	May 1
64	0	0	0	64	0	0	0
62	0	0	0	62	0	0	0
60	0	0	0	60	0	0	0
58	0	0	0	58	0	1	0
56	0	0	0	56	0	0	0
54	0	0	0	54	0	0	0
52	0	0	0	52[++]	1	0	0
50	0	0	0	50[++]	1	0	0
48	0	0	0	48	0	0	0
46	0	0	0	46	0	0	0
44	0	0	0	44	0	0	0
42[++]	April 19	April 23	April 30	42	April 19	April 23	April 30
40[++]	3	0	0	40	4	0	0
38	4	0	1	38	3	0	0
36	3	0	0	36	9	1	0
34	2	1	0	34	2	0	0
32	3	1	0	32	2	0	0
30	3	0	0	30	0	0	0
28	0	0	0	28	0	0	0
26	3	0	1	26	1	0	0
23	0	0	0	23	0	0	0

Planted between Stations 40 and 42 on May 3, 1951				Planted between Stations 50 and 52 on May 3, 1951			
	May 4	May 8	June 5		May 4	May 8	June 5
64	0	0	0	64	0	0	0
62	0	0	0	62	0	0	1
60	0	0	1	60	0	0	0
58	0	0	0	58	0	0	4
56	0	0	0	56	0	0	0
54	0	0	0	54	0	2	3
52	0	0	0	52[++]	0	8	1
50	0	0	0	50[++]	13	45	11
48	0	0	0	48	2	9	3
46	0	0	0	46	0	1	0
44	May 3	May 7	June 4	44	May 3	May 7	June 4
42[++]	0	0	0	42	0	0	0
40[++]	11	31	6	40	0	0	0
38	0	9	7	38	0	0	0
36	0	1	2	36	0	0	0
34	0	1	1	34	0	0	0
32	0	1	0	32	0	0	0
30	0	1	0	30	0	0	0
28	0	1	0	28	0	0	0
26	0	0	0	26	0	1	0
23	0	1	0	23	0	0	2

[+] Recoveries for a particular section are listed for the lower marker of that section; e.g., recoveries made between markers 40 and 42 are listed for marker 40, etc.

[++] Locations of plantings; two asterisks on 40 and 42 mean that planting was made between stations 40 and 42, etc.

Table 14.--Length of time hatchery trout influence the catch. Only the recoveries from plantings made in April, May, and June are tabulated

Species planted	Year	Number planted	Number of trout caught in 20-day periods following planting date						
			1st	2nd	3rd	4th	5th	6th	7th
Brook	1949	900	300	42	6	8	0	0	0
	1950	2,000	711	157	30	4	3	1	0
Brown	1949	900	124	97	39	21	10	8	1
Rainbow	1949	900	254	115	55	34	10	13	6
	1950	2,000	504	325	101	65	45	22	14
	1951	3,220	1,139	452	220	99	45	23	6

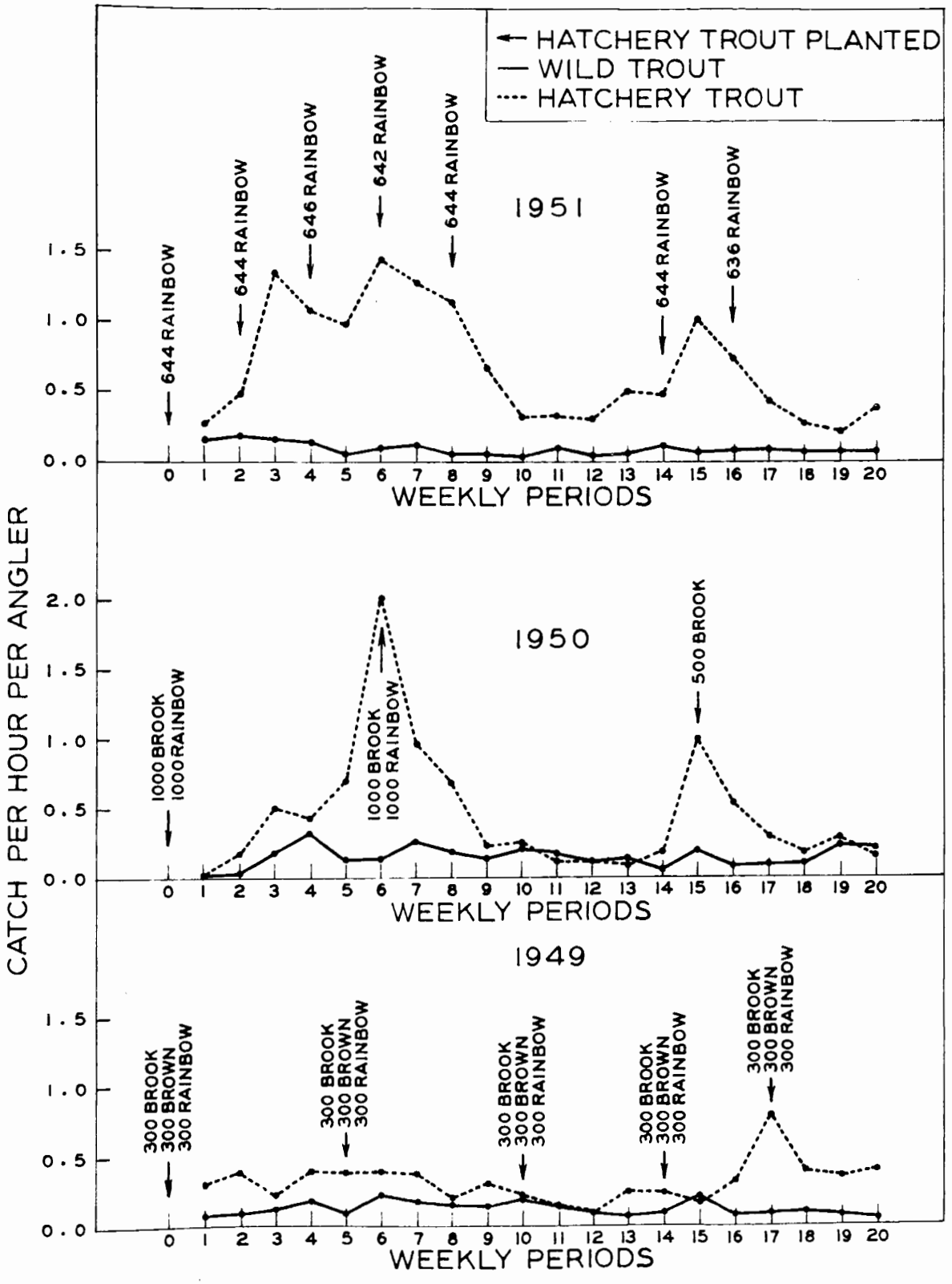
these values were 74 percent and 78 percent, respectively. Recoveries past one winter were minimal for brown and rainbow trout and practically nonexistent for brook trout (Table 8). In all of the plantings there was a considerable unexplained loss and this loss was greatest when poor conditions for exploitation by anglers prevailed over the initial 20 to 40 days following planting.

Effect of planting legal hatchery fish on the catch of wild fish

As a result of previous experiments in Michigan involving plantings of brook and rainbow trout, Hazzard and Shetter (1939) concluded that planting legal-sized hatchery fish markedly increased the catch of wild fish. The cause and effect relationship cited was operative only for individual species, i.e., plantings of brook trout would affect the catch of wild brook trout and not of the other two species, etc. In a later paper (1941) the same authors further limited the cause and effect relationship described above to those instances in which individual plantings were at the rate of more than 160 legal trout per mile of stream, because of the failure to demonstrate this result in plantings in which the stocking rate was from 100 to 160 legal trout per mile.

The stocking program for the Pigeon River for 1949, 1950 and 1951, in conjunction with the permit system of fishing, afforded an opportunity to evaluate the effect of plantings of hatchery trout upon the catch of wild trout. When fluctuations of the catch per hour per angler of hatchery fish were compared to those of wild fish, without regard to species planted or numbers in the individual plantings, no correlation was apparent (Figure 2). Also, when the data from plantings of brook trout at rates varying from 216 trout per mile to 431 trout per mile

Figure 2.--A comparison of the fishing quality of hatchery trout and wild trout in the Pigeon River for 1949, 1950, and 1951.


HATCHERY TROUT PLANTED
WILD TROUT
HATCHERY TROUT
1951
644 RAINBOW
644 RAINBOW
646 RAINBOW
642 RAINBOW
644 RAINBOW
644 RAINBOW
636 RAINBOW
1950
1000 BROOK
1000 RAINBOW
1000 BROOK
1000 RAINBOW
500 BROOK
1949
300 BROOK
300 BROWN
300 RAINBOW
300 BROOK
300 BROWN
300 RAINBOW
300 BROOK
300 BROWN
300 RAINBOW
300 BROOK
300 BROWN
300 RAINBOW
300 BROOK
300 BROWN
300 RAINBOW
CATCH PER HOUR PER ANGLER
WEEKLY PERIODS
WEEKLY PERIODS
WEEKLY PERIODS

were analysed, no effect on the catch of wild brook trout could be noted (Table 15). Nor can the views of Chamberlain (1943) that the planting of hatchery trout protects the wild fish be justified on the basis of our experiments. Planting hatchery trout increased the fishing pressure and this had a tendency to lower the catch per hour for wild fish, but the total exploitation for the season remained quite the same. It appeared, for the brook trout at least, that comparatively few fishing trips materially reduced the numbers of trout of legal size, and that additional fishing trips were consequently less successful.

Fishing quality compared with type of lure used

In the Pigeon River three types of lure were used enough to warrant separate tabulations. These were worms, spinner and worms, and flies. All other baits and lures, or combinations of the three listed above, were grouped into a fourth category. Spinner and worms, and worms, generally were more effective in catching trout in the Pigeon River than were flies or miscellaneous baits (Table 16). However, this was due almost entirely to the hatchery plantings because of the marked superiority of flies in catching wild trout (Table 17). The question has been raised as to whether this difference in catchability of wild trout and hatchery trout due to type of lure used is due to the lure per se or due to a difference in angling ability of the individuals using the different baits. No record is possible of the number of fish caught and released; although it is known that some fly fishermen released sizeable numbers of hatchery trout and these trout were not recorded. A determination of this question is not now possible with the data at hand, but the fact remains that flies or fly fishermen accounted for a larger proportion of the native fish caught from the Pigeon River than did other baits.

Table 15.--Effect of planting hatchery brook trout on the catch of wild brook trout in the Pigeon River, 1950.[+] Plantings made on April 26, 1950, at 431 trout per mile; on June 1, 1950, at 431 trout per mile, and on August 8, 1950, at 216 trout per mile

Weekly period	Total hours fished	Hatchery fish		Wild fish	
		Number caught	Catch per hour	Number caught	Catch per hour
April 29 - May 5	197.5	1	0.01	0	0.00
May 6 - 12	91.5	15	0.16	5	0.05
May 13 - 19	319.5	111	0.35	42	0.13
May 20 - 26	217.5	34	0.16	54	0,25
May 27 - 31	372.5	17	0.05	44	0.12
June 1 - 7	334.0	353	1.06	34	0.10
June 8 - 14	314.0	84	0.27	41	0.13
June 15 - 21	241.0	50	0.21	33	0.14
June 22 - 28	191.0	16	0.08	22	0.12
June 29 - July 5	279.0	11	0.04	35	0.13
July 6 - 12	150.5	2	0.01	28	0.19
July 13 - 19	149.0	3	0.02	10	0.07
July 20 - 26	74.0	1	0.01	9	0.12
July 27 - August 2	92.0	1	0.01	5	0.05
August 3 - 7	67.5	0	0.00	15	0.22
August 8 - 14	231.5	178	0.77	19	0.08
August 15 - 21	145.5	41	0.28	10	0.07
August 22 - 28	234.5	45	0.19	17	0.07
August 29 - September 4	221.5	29	0.13	26	0.12
September 5 - 10	97.0	11	0.11	14	0.14

[+] Coefficient of correlation between catch per hour of hatchery fish and catch per hour of wild fish computed to be---0.12.

Table 16.--A comparison of fishing quality of wild and hatchery trout combined with the type of lure used in the Pigeon River, seasons of 1949, 1950 and 1951

Lure used	Number of fishing trips	Catch per hour		Percent fishing trips successful
		Mean	Standard error	
1949				
Worms	719	0.40	0.026	48.7
Flies	901	0.40	0.021	45.6
Worms and spinner	271	0.44	0.051	52.4
Other	342	0.36	0.032	43.0
1950				
Worms	878	0.64	0.042	48.9
Flies	696	0.58	0.039	52.2
Worms and spinner	276	0.75	0.074	56.5
Other	310	0.53	0.060	40.0
1951				
Worms	1,254	0.79	0.040	53.3
Flies	772	0.57	0.034	48.8
Worms and spinner	327	0.60	0.054	54.4
Other	497	0.64	0.056	47.3

Table 17.--A comparison of the number of hatchery trout and wild trout taken with different lures in the Pigeon River, seasons of 1949, 1950 and 1951

Lure used	Number of fishing trips	Number of trout caught per 100 trips	
		Hatchery	Wild
1949			
Worms	719	91	35
Flies	901	51	60
Spinner and worms	271	108	45
Other	342	78	37
1950			
Worms	878	116	37
Flies	696	68	86
Spinner and worms	276	159	53
Other	310	119	40
1951			
Worms	1,254	112	19
Flies	772	69	38
Spinner and worms	327	96	19
Other	497	92	22

Acknowledgments

The experiments outlined above would not have been possible without the assistance of many individuals associated with the Michigan Department of Conservation. Messrs. Wayne H. Tody, Norman G. Benson, and Gerald F. Myers deserve special mention for their contributions to the detailed analysis of much of the creel census data. Drs. A. S. Hazzard, D. S. Shetter, and G. P. Cooper contributed to the evaluation of results and also to the preparation of the manuscript.

Literature cited

Chamberlain, Thomas K.

1943. Research in stream management in the Pisgah National Forest. Trans. Amer. Fish. Soc. (1942) 72 : 150-176.

Cooper, Edwin L.

1951. Rate of exploitation of wild eastern brook trout and brown trout populations in the Pigeon River, Otsego County, Michigan. Trans. Amer. Fish. Soc. (In Press).

Hazzard, Albert S. and David S. Shetter

1939. Results from experimental plantings of legal-sized brook trout (Salvelinus fontinalis) and rainbow trout (Salmo irideus). Trans. Amer. Fish. Soc. (1938) 68 : 196-210.

Shetter, David S.

1947. Further results from spring and fall plantings of legal-sized, hatchery-reared trout in streams and lakes of Michigan. Trans. Amer. Fish. Soc. (1944) 74 : 35-58.

Shetter, David S. and Albert S. Hazzard

1941. Results from plantings of marked trout of legal size in streams and lakes of Michigan. Trans. Amer. Fish. Soc. (1940) 70 : 446-468.

Snedecor, George W.

1946. Statistical methods. The Collegiate Press, Inc., Ames, Iowa. XVI, 485 pp.

INSTITUTE FOR FISHERIES RESEARCH

Edwin L. Cooper

Report approved by A. S. Hazzard

Report typed by B. A. Lowell