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RESULTS FROM PLANTINGS OF MARKED TROUT OF LEGAL SIZE IN STREAMS AND LAKES OF MICHIGAN[1]

[1] Contribution from the Michigan Institute for Fisheries Research.

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ABSTRACT

Results from plantings at various seasons over a period of from one to three years of marked legal-sized brook, brown or rainbow trout in sections of five public and in two private streams were secured mainly through intensive creel census. Similar data for plantings of rainbow trout in five lakes are presented. Returns from fall planting in streams never exceeded 5.3 per cent; spring and open season releases resulted in from 4.9 to 61.9 per cent recovery by anglers. Fall plantings of rainbow trout in lakes yielded up to 66 per cent. From 100 to 160 trout per mile of stream averaging 50 feet in width yielded higher percentages than did larger plantings, benefited relatively more anglers and did not stimulate the catch of wild fish. Effect upon the catch per hour and percentage of the total catch appeared to be inversely proportional to the size of the native population of the species stocked and directly proportional

to the number of fish planted. The percentage of the total catch contributed by moderate plantings in the spring or during the season varied from 1.8 to 30.4. It is concluded that in northern Michigan streams major dependence for good fishing must be placed on the wild stock. Rainbow and brown trout were caught for at least eight weeks following planting although the majority were removed by the end of four weeks; few if any brook trout were taken after four weeks. Very few planted trout survive one or more winters even in private streams not subject to intense angling. Most of the trout were taken within five miles of the points of release and usually downstream, but of the three species, rainbows migrated most extensively. From 5.7 to 20.6 per cent of the fisherman-day records showed marked trout. Apparently as many anglers benefited by "spot" plantings as by wider distribution by boat. Control experiments proved jaw-tagging and fin-clipping to be effective during the period of investigation and that mortality and effect on growth by either method were negligible.

INTRODUCTION

The results of earlier experiments by the authors (Hazzard and Shetter, 1939) led to the expansion of a research program initiated in 1937 to determine the returns to the angler of plantings of legal-sized trout [2] in Michigan waters. Creel censuses were carried out

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[2] In Michigan, the minimum legal size for brook, brown, and rainbow trout is seven inches (total length).

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on sections of four additional public streams in which plantings of tagged or fin-clipped brook (Salvelinus fontinalis), rainbow

(Salmo irideus) and brown trout (Salmo trutta) were made in fall, early spring and during the fishing season. Similar data from two private streams and from several trout lakes are also included in the present paper.

Our discussion of the results from plantings of marked trout will be confined to the percentage of the plantings taken by anglers, the proportion of hatchery fish in the catch and a comparison of results from two methods of planting. Detailed data on growth and migration of planted trout will be presented in a later publication.

METHODS

Methods employed during 1938 and 1939 were essentially the same as described previously (Hazzard and Shetter, 1939). Briefly they consisted of planting jaw-tagged or fin-clipped trout seven inches or more in length in sections of five trout streams and four small lakes which were covered by intensive creel census. A crew of trained census clerks in charge of a qualified biologist camped at strategic locations on the Pine River and secured records of almost all of the fishing in the sections in which the trout were planted. On all other public streams and on the lakes, CCC enrollees conducted creel census under the supervision of the Institute.

All of the trout used in the experiments during 1938 and 1939 were either fin-clipped or jaw-tagged and were supplied and planted by the most conveniently located hatchery. The senior author did the marking and assisted in distributing almost all of the fish used.

RESULTS OF SIMILAR EXPERIMENTS IN OTHER STATES

Cobb (1934), in a description of experiments conducted in Connecticut in 1933, reported recoveries of 5,403 (33 per cent) of 15,875 tagged legal brown and brook trout. The internal tag was used. The internal or belly tag is a small piece of numbered celluloid which is inserted into the body cavity through a narrow slit in the side of the fish. His results indicated rapid depletion, usually within a week, of the brook trout released during the season, but demonstrated that the brown trout provided fishing over a longer time. Of the fish recovered, 80 per cent of the brook trout were recovered near the point of planting; 7 per cent moved upstream, 9 per cent moved downstream, and 4 per cent moved into the tributaries. About 66 per cent of the brown trout had not moved; 7 per cent had moved upstream and about 27 per cent had moved downstream.

Cobb also stated that fall plantings of legal trout in Connecticut waters had failed to carry over the winter, but offered no evidence on this point.

Nesbit and Kitson (1937), working in Massachusetts, made releases of legal-sized brown and rainbow trout in the fall of 1934 and the spring of 1935. All fish were tagged with the internal tag in October, 1934. Each species of trout was separated into two lots, one planted in November, 1934, the other in March, 1935. The fish planted in the spring were held and observed for mortality and loss of tags. Recovery percentages of the fall-planted fish were based

on the number of fish planted in the fall minus the number of fish dying and losing tags over the winter among the trout held in the hatchery.

Recovery by anglers was as follows:

Rainbow trout	Spring plantings	Fall plantings
Planted in rivers	14.9	1.5
" in ponds	9.2	4.3
Brown trout		
Planted in rivers	9.1, 11.7	3.1, 2.3
" in ponds	2.2	1.1

Nesbit and Kitson concluded that the spring planting was more efficient than fall planting by an average ratio of 5 to 1, and in some instances as high as 10 to 1 for streams. For ponds, they concluded that the spring planting was also more efficient than fall releases, but the advantage appeared to be only slightly more than 2 to 1.

Hoover and Johnson (1938) planted legal brook trout in New Hampshire streams in 1936, using a paper clip on the gill cover and releasing the fish during the open season. A recovery of 76 per cent was made within 3 weeks after planting, another indication of the rapid depletion of planted stock when released during the open season.

RESULTS OF MICHIGAN EXPERIMENTS

In our experiments an attempt was made to answer the following questions:

1) What percentage of plantings of legal-sized trout are caught by anglers?

2) What is the relative value of fall, early spring and open season plantings?

3) What sized planting gives the best returns?

4) Which method of planting--boat or spot--yields the most trout to the most anglers?

5) What is the effect of the plantings of legal-sized trout on the catch per hour and the total yield?

6) What percentage of anglers take legal-sized trout from these plantings and what is the average number taken by such anglers?

7) How long does a planting affect the catch?

8) How much do planted trout migrate?

9) How well do planted legal-sized trout grow in length and weight?

In this paper particular attention will be given to the first seven questions. For the sake of completeness, results from all three years will be summarized and discussed. The majority of the data are from public fishing streams but some corroborative evidence is available from two private streams. Records from experimental plantings in five trout lakes, though not as complete as for streams, are given since the results appear to be reliable and are of considerable interest. The questions listed will be discussed for public streams, private streams and lakes.

Public Streams

Percentage of planted trout caught. The percentage of marked brook trout from various plantings caught during the three years of census (Tables 1-3) varied from 3.3 to 62.0; for rainbow trout from 0.6 to 62.8; brown trout from 2.0 to 19.2. All percentages of plantings recaptured must be considered minimal since a few records were undoubtedly missed and some catches of marked fish outside census areas were probably unreported.

Relatively high recovery percentages were noted in the Pine River from plantings made during June and July of 1938 and 1939. Just why a release of 250 brook trout in July, 1939, should yield better returns than one of 488 planted in June, 1939, cannot be explained (Table 3).

In the Pigeon River, the best returns were from the plantings made in June. The releases of both brown and rainbow trout in July were almost failures. The fact that 12 of the 17 marked brown trout recovered were found dead about 10 days after planting, suggests that the water temperature may have been too high for successful introduction at this time of the year. A similar mortality of the tagged brown trout occurred in late June and early July in the Little Manistee River. However, in the latter stream anglers reported the death of a number of unmarked brown and rainbow trout which were not from these plantings.

The averages by seasons of planting (Table 4) are most significant. Data for brown trout and for fall and spring releases of rainbow trout probably are not adequate for definite conclusions.

TABLE 1. SUMMARY OF RECOVERIES BY ANGLERS OF MARKED HATCHERY TROUT OF LEGAL SIZE AVAILABLE DURING THE 1937 TROUT SEASON

Stream	Date of planting 1937	Species of trout planted	Number planted	[1] Method of marking and proportion marked	Recoveries - 1937 Number	Recoveries - 1937 Percentage	Percentage of marked fish in total catch 1937
Pine River	May 18-19	Brook	3,000	1/3 jaw-tag	[2] 1,207	40.2	38.1
	June 15	Brook	959	All jaw-tag	58	6.0	1.8
		Rainbow	2,007	1/2 jaw-tag	[2] 448	22.3	34.4
	July 13	Brook	2,004	1/4 jaw-tag 1/4 dorsal fin	[2] 98	4.9	3.1
		Rainbow	1,000	1/4 jaw-tag 1/4 dorsal fin	[2] 102	10.2	3.1
	August 10	Brook	1,550	1/3 jaw-tag 1/3 dorsal fin	[2] 125	8.1	3.9
		Rainbow	1,000	1/4 jaw-tag 1/4 dorsal fin	[2] 136	13.6	4.1
Total brook trout	...	...	7,513	...	[2] 1,488	19.8	46.9
Total rainbow trout	...	...	4,007	...	[2] 686	17.1	20.6
Pigeon River							
Total rainbow trout	August 4	Rainbow	985	1/2 jaw-tag 1/2 dorsal fin	148	15.0	25.0

[1] Where fin is named, this fin and the adipose fin were removed for a distinguishing mark.

[2] Numbers of hatchery fish taken were calculated from the percentage marked and actual numbers of marked fish retaken by anglers.

TABLE 2. SUMMARY OF RECOVERIES BY ANGLERS OF MARKED HATCHERY TROUT OF LEGAL SIZE AVAILABLE DURING THE 1938 TROUT SEASON

Stream	Date of planting	Species of trout planted	Number planted	[1] Method of marking	Recoveries - 1938 Number	Recoveries - 1938 Percentage	Recoveries - 1939 Number	Recoveries - 1939 Percentage	Percentage of total catch 1938	Percentage of total catch 1939
Pine River	Oct.,1937	Brook	1,000	Jaw-tag	53	5.3	...	...	2.6	...
		Rainbow	500	Jaw-tag	6	1.2	...	...	0.6	...
	Apr.,1938	Brook	1,000	Jaw-tag	349	34.9	1	0.1	14.9	0.03
		Rainbow	500	Jaw-tag	192	38.4	3	0.6	3.1	0.03
	May, 1938	Brook	500	Jaw-tag	516	51.6	1	0.1	21.9	0.03
		Brook	500	L. pelvic						
		Rainbow	500	Jaw-tag	441	44.1	5	0.5	7.2	0.05
		Rainbow	500	L. pelvic						
	July,1938	Rainbow	500	Jaw-tag	236	[2] 59.0	7	1.4	3.9	0.08
Total brook trout	...	...	3,000	...	918	30.7	2	0.1	39.5	0.10
Total rainbow trout	...	...	2,500	...	875	35.0	15	0.6	14.8	0.10
Canada Creek										
Total brook trout	Mar.,1938	Brook	500	Jaw-tag	180	36.0	...	...	[3] 18.2	...

[1] Where fin is named, that fin and the adipose fin were removed for a distinguishing mark.

[2] The recovery percentage is calculated on the basis of recoveries from 400 fish which were planted within the creel census area.

[3] The percentage of the total catch made up of marked brook trout was calculated on the basis of 140 recoveries made within the creel census area.

TABLE 3. SUMMARY OF RECOVERIES BY ANGLERS OF MARKED HATCHERY TROUT OF LEGAL SIZE AVAILABLE DURING THE 1939 TROUT SEASON

Stream	Date of planting	Species of trout planted	Number planted	Method of marking [1]	Recoveries - 1939 Number	Recoveries - 1939 Percentage	Percentage of total catch, 1939
North Branch Au Sable	Nov.,1938	Brook	500	Jaw-tag	32	6.4	1.7
		Brook	500	R. pelvic	12	2.4	0.6
	Mar.,1939	Brook	500	Jaw-tag	119	23.8	5.8
		Brook	500	L. pelvic	28	5.6	1.5
Total brook trout			2,000	...	[2] 241	12.1	[2] 11.8
Pine River	Nov.,1938	Brook	499	Jaw-tag	5	1.0	0.3
		Brook	299	R.pectoral	11	3.7	0.8
	Apr.,1939	Brook	500	Jaw-tag	207	41.2	14.4
		Brook	300	L.pectoral	73	24.3	5.2
	June,1939	Brook	488	Jaw-tag	114	23.2	7.9
		Rainbow	249	Jaw-tag	154	61.9	2.6
	July,1939	Brook	250	Jaw-tag	146	58.4	10.2
		Rainbow	250	Jaw-tag	150	60.0	2.5
Total brook trout			2,336	...	[3] 571	26.2	[3] 39.8
Total rainbow trout			499	...	307	61.5	5.2
Pigeon River	Nov.,1938	Brown	500	Jaw-tag	16	3.2	7.3
		Rainbow	500	Jaw-tag	3	0.6	0.5
	Apr.,1939	Brown	500	Jaw-tag	34	6.8	15.5
		Rainbow	500	Jaw-tag	50	10.0	8.0
	June,1939	Brown	250	Jaw-tag	39	15.6	20.1
		Rainbow	250	Jaw-tag	61	24.4	9.0
	July,1939	Brown	250	Jaw-tag	5	2.0	2.3
		Rainbow	250	Jaw-tag	20	8.0	3.2
Total brown trout			1,500	...	94	6.3	45.2
Total rainbow trout			1,500	...	134	8.9	20.7
Little Manistee River	June,1939	Brown	250	Jaw-tag	48	19.2	17.2
	July,1939	Brown	250	Jaw-tag	38	15.2	14.2
		Brook	250	Jaw-tag	81	32.4	30.4
Total brown trout			500	...	86	17.2	15.7
Total brook trout			250	...	81	32.4	30.4

[1] Where fin is named, that fin and the adipose fin were removed for a distinguishing mark.

[2] Fifty fish added to obvious total; these fish were fin-clipped but fin not distinguished by creel census clerks.

[3] Fifteen marked brook trout with tag or mark not distinguished added to totals.

TABLE 4. SUMMARY OF RESULTS FROM PLANTINGS OF MARKED LEGAL-SIZED BROOK, BROWN, AND RAINBOW TROUT IN MICHIGAN TROUT STREAMS IN FALL, EARLY SPRING (PRE-SEASON), AND DURING THE OPEN TROUT SEASON, 1937 TO 1939 INCLUSIVE. (THE DATA ARE BASED ON FIGURES OBTAINED BY INTENSIVE CREEL CENSUSES ON THE STREAMS WHERE PLANTINGS OF MARKED TROUT WERE MADE.)

	Fall releases			Spring releases			Open season releases		
Species planted on number of streams	Number of experiments	Number of fish planted	Percentage recovered	Number of experiments	Number of fish planted	Percentage recovered	Number of experiments	Number of fish planted	Percentage recovered
Brook trout Totals, averages 4 streams	3	2,798	4.4	4	3,300	29.8	8	9,501	24.7
Rainbow trout Totals, averages 2 streams	2	1,000	0.9	2	1,000	24.2	10	7,391	25.7
Brown trout Totals, averages 2 streams	1	500	3.2	1	500	6.8	4	1,000	13.0
All trout Totals, averages 5 streams	6	4,298	3.4	7	4,800	26.2	22	17,892	24.5

Experiments are planned this year to supply additional information. However, based on our results and those of the other workers previously mentioned, brook and rainbow trout plantings yield about the same returns to the angler but fewer brown trout are caught. Whether this is due to a heavier mortality of planted brown trout or to their greater ability to escape capture has not been determined.

Time of planting. The season of 1938 yielded the first comparable results of fall, early spring (pre-seasonal) and open season plantings in the Pine River. The percentage of recovery of spring-planted brook trout was over six times greater than for brook trout planted in the fall and 32 times greater in the case of rainbow trout (Table 2). During the fall of 1938 and the spring of 1939, equal numbers of legal-sized marked brook trout were planted in the North Branch of the Au Sable and in the Pine River; and equal numbers of marked rainbow and brown trout were planted in the Pigeon River (Table 3). Again spring planting was found to be much more efficient than fall planting. The averages for brook trout were 4.4 and 29.8 per cent for fall and spring plantings respectively; for rainbow trout 0.9 and 24.2; and for brown trout 3.2 and 6.8 (Table 4). The one experiment with brown trout indicated less difference in results from the two contrasted seasons of planting.

Plantings of brook trout during the open fishing season appear to be slightly less efficient than during early spring. No significant difference is apparent in the rainbow yield. Limited tests with brown trout favor those during the open season.

Size of plantings. The relative percentages of recovery following plantings varying from 3,000 to 500 trout at each campground on the Pine River indicate that, on the average, the smaller the number of trout released the higher the percentage caught (Tables 1-3). From 100 to 160 trout per mile of stream averaging fifty feet in width yielded to fishermen from 23.2 to 62.8 per cent. Furthermore, the lighter stocking in 1938 and 1939 benefited a somewhat larger number of fishermen (Table 7) and contributed to the catch for a longer period. Also, as will be shown later, smaller plantings did not cause depletion of the wild stock.

Method of planting. In 1937 and 1938 two methods of distribution in the Pine River were tested (Table 5). Spot planting, the usual method, consisted of scattering the fish over from one-fourth to one-half mile of stream adjacent to each campground. In boat planting, a specially constructed metal boat with a center well was used to place a few trout in each pool of the section of stream stocked. Results from this phase of the experimental work are not conclusive as both methods were not employed simultaneously over the same water and the marked fish released in the two manners were not subject to the same angling pressure.

More anglers took spot-planted than boat-planted trout (both brook and rainbow) in 1937 and 1938. (No boat plantings were made in 1939.) A higher percentage of spot-planted fish were taken in 1937, but in 1938 a higher percentage of boat-planted trout were captured. The average number of trout caught from spot plantings was higher in 1937, but lower for boat plantings in 1938. Probably

TABLE 5. COMPARISON OF RESULTS FROM "SPOT" AND "BOAT" PLANTINGS OF TROUT IN THE PINE RIVER IN THE SPRING AND DURING THE OPEN SEASON, 1937 TO 1939

Item	1937		1938		1939	
	Brook trout	Rainbow trout	Brook trout	Rainbow trout	Brook trout	Rainbow trout
Number of trout spot-planted	1,000	1,007	1,000	1,000	1,538	499
Number of trout boat-planted	2,963	1,000	1,000	1,000	...	...
Number of anglers taking spot-planted trout	96	75	225	353	330	243
Number of anglers taking boat-planted trout	69	61	187	290	...	...
Number of spot-planted trout caught	402	224	296	422	555	307
Percentage	40.2	22.3	29.6	42.2	36.0	61.5
Number of boat-planted trout caught	161	119	516	441	...	...
Percentage	5.4	11.9	51.6	44.1	...	...
Average number of spot-planted trout caught per angler	4.2	3.0	1.3	1.2	1.6	1.3
Average number of boat-planted trout caught per angler	2.3	2.0	2.8	1.5	...	...

the smaller size of the plantings in 1938 may have been responsible for these changes since the fish were not as concentrated and limit catches of marked trout were not as common.

Effect upon the catch. The influence of the planted fish on the total catch may be seen by comparing the percentage of the catch of the various species that consisted of marked trout (Tables 1-3).

In the Pine River the percentage of "wild" and "planted" trout in the total catch has been as follows:

1937	Wild brook trout	53.1 per cent
	Planted brook trout	46.9 per cent
	Wild rainbow trout	79.4 per cent
	Planted rainbow trout ...	20.6 per cent
1938	Wild brook trout	60.5 per cent
	Planted brook trout	39.5 per cent
	Wild rainbow trout	85.2 per cent
	Planted rainbow trout ...	14.8 per cent
1939	Wild brook trout	60.2 per cent
	Planted brook trout	39.8 per cent
	Wild rainbow trout	94.8 per cent
	Planted rainbow trout ...	5.2 per cent

In the Pigeon River, although marked adult rainbows were not released until August, 1937, with less than a month of the season remaining, the total number of marked fish recovered constituted 25 per cent of the total catch of that species. During 1939 the percentage of wild and hatchery fish in the total catch ran as follows:

Wild rainbow trout	79.3 per cent
Planted rainbow trout ..	20.7 per cent
Wild brown trout	54.8 per cent
Planted brown trout	45.2 per cent

Marking experiments and creel census data from the North Branch of the Au Sable River for the 1939 trout season showed that the total brook trout catch consisted of 11.8 per cent marked (hatchery) brook

trout and 88.2 per cent wild brook trout. It should be pointed out that the planting of 2,000 legal trout for the 1939 season yielded many more fish to the anglers than did the release of 9,778 fingerlings (averaging 3.5 inches long) in the fall of 1936. Of the latter planting, only three fish were recorded in the creel census during the 1937 and 1938 trout seasons (Shetter, 1939). However, the catch per hour fell from 0.48 trout in 1938 to 0.41 in 1939, despite the addition of 2,000 legal brook trout.

The recoveries (140) from the single planting of 500 tagged adult brook trout in Canada Creek in March, 1938, constituted 18.2 per cent of the total catch of brook trout, while the remaining 81.8 per cent originated from wild stock and fingerling plantings.

In the Little Manistee River during the 1939 trout season, plantings of tagged brook and brown trout which were subsequently recovered made up 30.4 per cent of the total catch of brook trout, and 34.4 per cent of the total catch of brown trout.

In no instance where fall planting was employed (Table 2, 3) have the marked fish released at that time contributed more than 7 per cent of the total catch of that species. The marked trout contributing to the total catch of the three species are almost always those that are released in the spring or during the open season.

The differences in the percentages of the total catch consisting of planted adult trout reflect, to a large degree, the relative abundance of the several species of trout in the various streams under consideration. The Pine River, for example, is dominantly rainbow trout water in the 10-mile section where the experiments were conducted. Releases of smaller numbers of marked rainbows in 1939 were literally lost among the numerous native fish. Native brook trout were less

abundant, and the introduction of marked hatchery brook trout contributed noticeably to the total catch of that species in the Pine River.

In the earlier paper by the authors (Hazzard and Shetter, 1939) it was shown that monthly introductions of approximately 2,000 brook trout and 1,000 rainbow trout of legal size during the 1937 trout season increased the catch per hour of wild (unmarked) fish immediately following planting to two or three times over that recorded for weeks just previous to planting. A similar rise in the catch per hour occurred after a release of 985 marked adult rainbow trout in the Pigeon River in August, 1937 (Figures 1, 2).

In the 1938 trout season, the catch per hour during the opening week on the Pine River of wild brook trout was approximately the same as in 1937, despite the introduction of 1,000 tagged brook trout (all of legal size) one month before the opening of the season. Possibly competition was less at that time of year or enough trout had moved out of the area planted by the opening of the season. The planting of 1,000 marked brook trout during the fourth week of the season, as in 1937, stimulated the catch per hour of wild fish for the fourth week from 0.06 to 0.18. Again, as during 1937 and in the case of the spring planting in 1938, the influence of the planting on the catch of wild fish was lost within two weeks.

Plantings of marked adult rainbow trout also were reduced in number during the 1938 investigations on the Pine River. Five hundred fish were released one month before the opening day; 1,000 were introduced during the fourth week of the season, and 500 more were planted in the twelfth week. There were slight increases in the catch per hour of wild fish during the periods when the rainbows were introduced, but they were of such small magnitude as to be of doubtful significance (Figures 1, 2).

(These graphs will be mailed to the editors as soon as the Institute draftsman returns from his vacation)

Figure 1. Catch per hour of wild (unmarked) and marked brook trout in the stream section under creel census on the Pine River, Michigan, for the 1937, 1938, and 1939 trout seasons.

(These graphs will be mailed to the editors as soon as the Institute draftsman returns from his vacation.)

Figure 2. Catch per hour of wild (unmarked) and marked rainbow trout in the stream section under creel census on the Pine River, Michigan, for the 1937, 1938, and 1939 trout seasons.

In the Pine River during 1939 the plantings of marked brook and rainbow trout varied from 250 to 800 fish. These plantings of comparatively small numbers of fish exerted little if any influence on the catch per hour of the wild (unmarked) brook trout or rainbow trout (Figures 1, 2).

The effect of the introductions of hatchery trout on the quality of the fishing (as measured by the catch per hour of trout) is dependent on the relative abundance of the native and introduced species (Table 6). For example, the relatively small number of rainbow trout planted had little effect on the total catch per hour of that species in the Pine River where the native population of rainbow trout is comparatively larger. However, the catch per hour of brook trout, a species that is considerably less abundant naturally than are the rainbow trout, usually was increased by plantings to almost double that obtained for wild fish alone. In general, plantings of marked hatchery fish in the several streams have ranged from 8 to 25 per cent of the total catch per hour.

Percentage of anglers benefited and extent. The percentage of anglers fishing streams covered by creel census who took marked trout was consistently low (Table 7), ranging from a high of 20.6 on the Pine River in 1938 to a low of 5.7 on the North Branch of the Au Sable in 1939. These percentages suggest rather forcefully that only a small fraction of the trout-fishing public benefits from what might be considered as heavy plantings of adult trout and that in such streams, the wild stock furnishes most of the fishing. The local fishermen who find out when plants have been made, and the fortunate tourists who happen to fish newly planted sections, take the bulk of the hatchery fish.

TABLE 6. THE EFFECT OF PLANTINGS OF MARKED TROUT ON THE QUALITY OF THE FISHING AS MEASURED BY THE CATCH PER HOUR

Stream	Year	Total catch per hour	Catch per hour of brook trout		Catch per hour of rainbow trout		Catch per hour of brown trout		Total number of marked trout available		
			Wild	Marked	Wild	Marked	Wild	Marked	Brook	Rainbow	Brown
Pine River	1937	0.77	0.20	0.18	0.31	0.08	...	...	7,513	4,007	...
	1938	0.50	0.08	0.06	0.31	0.05	...	...	3,000	2,500	...
	1939	0.49	0.06	0.04	0.37	0.02	...	...	2,336	499	...
Pigeon River	1937	0.48	0.30	...	0.10	0.04	0.04	...	...	985	...
	1939	0.48	0.35	...	0.07	0.02	0.02	0.02	...	1,500	1,500
North Branch of the Au Sable	1938	0.48	0.39	...	0.02	...	0.07	...	...	...	...
	1939	0.41	0.30	0.04	...	...	0.07	...	2,000	...	...
Little Manistee	1939	0.37	0.07+	0.04+	0.14+	...	0.07+	0.04+	250	...	500
Canada Creek	1938	0.41	0.33	0.07+	...	...	0.00+	...	500	...	...

TABLE 7. DISTRIBUTION OF THE CATCH OF MARKED TROUT AMONG ANGLERS ON THE PINE AND OTHER CREEL-CENSUSED STREAMS IN 1937, 1938 AND 1939

Item	River and year: Pine 1937	Pine 1938	Pine 1939	North Branch 1939	Pigeon 1939	Little Manistee 1939	Canada Creek 1938
Total number of anglers [1]	2,010	4,109	3,933	2,107	2,213	491	494
Number of anglers taking marked fish	229	847	523	118	147	60	64
Percentage of anglers taking marked fish	11.4	20.6	13.3	5.7	6.6	12.3	12.9
Total number of marked trout available	5,970	5,500	2,835	2,000	3,000	750	500
Total number of marked trout recaptured	906	1,825	869	228	228	160	140
Average number of marked trout taken by anglers taking marked trout	4.0	2.2	1.7	1.9	1.6	2.7	4.6
Range in number of marked trout in creels	1 to 16 [2]	1 to 15	1 to 11	1 to 10	1 to 7	1 to 15	1 to 11

[1] Figures are actually for "fisherman-days" and not for individual fishermen. For example, if one man fished two days on any stream he would be recorded as two fishermen.

[2] Although 15 trout is the legal limit, one fisherman was found to have 16 marked trout in his possession.

Duration of effect of planting. The findings of others concerning the rate of removal of legal-sized fish are confirmed by results in Michigan. Essentially the same results were secured on the Pine River during 1938 and 1939 as were reported in an earlier paper (Hazzard and Shetter, 1939). The bulk of the catch of marked brook trout was removed within the first two weeks after stocking, while marked rainbow and brown trout contributed to the catch in fair numbers for at least 8 weeks after release. By the end of the fourth week from 67 to 100 per cent (average 92 per cent) of the marked trout recovered had been taken. Results from releases of marked brook trout in other streams were similar.

Rainbow trout plantings generally contributed to the catch for a much longer period than did brook trout plantings. In the three years of the Pine River census, by the end of the fourth week from 34 to 100 per cent (average 67 per cent) of the season's catch of marked rainbow trout was removed. On the Pigeon River marked rainbow trout were removed at about the same rate in both 1937 and 1939.

If the results on a single stream are indicative, brown trout may be expected to survive longer than either brook or rainbow. At the end of four weeks from 30 to 100 per cent of the catch of marked fish was recorded (average 51 per cent).

Brook and rainbow trout from the smaller plantings of marked fish made during 1938 and 1939 were caught for a longer period than were fish from the larger plantings made in the preceding year.

Migration. The majority of brook trout were caught within 5 miles of the point of release and in contrast to results from the Pine River in 1937, reported by the authors, the dominant movement, if any, was downstream. Brown trout migrated even less. In no case did

the movement of marked brown trout exceed 5 miles in any direction with the exception of brown trout from a planting in Kinne Creek, a few of which descended into the Pere Marquette River. Rainbow trout, however, tend to move considerably farther and in larger numbers. Such movement is generally downstream and was particularly noticeable in Pigeon River plantings, where several tagged fish were taken over 15 miles from the points of release.

Private Streams

Data from two private club streams are presented briefly since on these the fishing pressure is not as heavy as on public waters and records of the catch covered entire streams. The data on recoveries of tagged trout planted in two private streams parallel closely those from public waters except that the percentage of recovery is not as high, probably because of lower angling intensity.

Salmon Trout River. In 1938, Lloyd Smith, a graduate student of the University of Michigan, was engaged to make a general survey of the sport fisheries of the Huron Mountain Club. As a part of his researches, Mr. Smith marked legal-sized hatchery brook trout with jaw-tags before planting in the Salmon Trout River, which flows into Lake Superior. Mr. Smith has kindly allowed us to present certain of his data in this paper.

All trout taken by the club members were examined by Mr. Smith or his assistants, assuring a 100 per cent record of the catch. The data on percentage of recovery from the 1938 and 1939 plantings are as follows: 15.3 per cent of 254 trout released May, 1938; 0.002 per cent of 1,263 trout planted November, 1938; 21.9 per cent of 600 trout stocked May, 1939; 16.6 per cent of 500 trout planted in June, 1939. It will be noted that few fish were recaptured from those released

in November, 1938, whereas plantings during the season returned percentages comparable to those on public streams. The percentages of the total catch made up of tagged trout were 3.7 in 1938 and 15.1 in 1939. No recoveries of marked brook trout planted in May, 1938, were reported in 1939.

Kinne Creek. Since 1938, members of the Institute staff have been furnished experimental facilities by the Wingleton Club, and the club members have cooperated by reporting their catches in considerable detail. A planting of 1,500 brook trout purchased from a private hatchery by the club was jaw-tagged and released by the senior author on April 12-13, 1938. The average size of these trout was 7 1/4 inches (total length), of which 847 were legal (7 inches or larger) while 653 were from 6 to 7 inches.

A total of 343 brook trout was taken in the 1938 season, of which 180 (52.5 per cent) were tagged fish. Although a relatively high percentage of the total brook trout catch, it was a recovery percentage of only 12 per cent. However, in this stream the brook trout population was relatively low. During the 1939 season, not a single tagged trout of the 1938 planting was recovered in a total catch of 92 brook trout. Some of these marked brook trout could have escaped into the Pere Marquette River through the rotary screens, but if any large number had escaped alive, some reports of tagged fish would have been received from the Pere Marquette River anglers. Since this agrees with results from other experiments, the only logical conclusion is that there is an extremely heavy season-to-season mortality. That fall plantings of fingerlings suffer similar losses is indicated by results secured by Shetter (1939) and by Surber (1940). Results from fall

plantings in all streams where experiments have been conducted indicate that winter may be a critical period.

On April 11-12, 1939, legal-sized brown trout (944 in number) were marked with jaw-tags and released in Kinne Creek. A mortality of unknown extent occurred among the fish of this planting in excess of 63 of the marked fish. A large number of the known dead were crushed to death between the rotary screens and the sill boards of the lower dam, and a few were picked up just above the lower dam. Nine recoveries sent in by anglers from the Pere Marquette River proved definitely that an unknown percentage of this planting was able to survive passage through the screens. Apparently a number of the legal-sized brown trout were not strong enough to breast the rather sluggish current of the lower pond, or were intent on moving downstream. The first hypothesis seems more likely, since the fish were thin on delivery, although there was no external evidence of disease, and on release into the stream they swam away in a lively manner. Examination of the dead tagged fish by Leonard Allison, Institute pathologist, disclosed no evidences of internal parasites or diseases.

From this planting, 98 tagged fish (10.2 per cent) were taken by Wingleton Club fishermen in the 1939 trout season. The tagged brown trout comprised 35.1 per cent of the total legal catch of brown trout for the season. To date this year (July, 1940), seven tagged brown trout from the planting in April, 1939 have been reported by the club members.

FAILURE OF MARKED LEGAL TROUT TO SURVIVE FROM ONE SEASON TO ANOTHER WHEN PLANTED IN STREAMS

In Kinne Creek, Canada Creek, and the Salmon Trout River there have been no recoveries reported of marked legal-sized brook trout planted in previous open seasons. In the North Branch of the Au Sable River, one report has been received of a tagged brook trout surviving to the 1940 season from the spring planting of 1939.

In the Pigeon River, no marked rainbow trout were reported in 1938 or in 1939 from the release of August, 1937, nor have any recoveries been reported during the current season (1940) from the 1938 fall or 1939 summer plantings of brown or rainbow trout, or the 1939 spring planting of brown trout. One rainbow trout from the April 1, 1939, release of tagged rainbow trout has been reported, after a migration of 260 miles to a point 17 miles off Sarnia, Ontario.

However, a small percentage of "carry-over" from one season to the next was observed on both brook and rainbow trout from the plantings made in the Pine River. During the 1938 season, a total of four marked brook trout and five marked rainbow trout were recovered which originated from plantings during the summer of 1937.

In 1939, a total of eighteen tagged trout were recovered from releases made in previous years; seventeen (15 rainbow trout, 2 brook trout) were from plantings made during 1938, and one brook trout which came from the July planting of 1937. Recoveries during the 1939 trout season from the 1938 plantings were as follows: 1 brook trout and 3 rainbow trout from the April, 1938 release; 1 brook trout and 5 rainbow trout from the May, 1938 release; and 7 rainbow trout from the July, 1938 release.

Concerning the season-to-season survival of brown trout, there is evidence that a very small percentage of fish may survive from one season to the next. From 500 tagged brown trout released in June and July, 1939, two reports have been mailed in by anglers to date (July, 1940) from 1940 angling in the Little Manistee River. Wingleton Club catch records show a total of seven tagged brown trout recovered during the 1940 season to date from a planting of 994 fish in April, 1939. However, we have received no reports in 1940 from the Pigeon River, where tagged brown trout were released in April, June and July of 1939.

We have obtained no records of any fall-planted marked trout surviving more than one winter, and very few records of spring-planted marked trout surviving to the second season. The greatest numbers of fish recovered in the second season came from plantings made during the summer months of the previous year.

Season-to-season survival, on the basis of the data now at hand, appears to be best in rainbow trout, next best in brown trout, and poorest in brook trout.

LAKES

It has been pointed out in the preceding pages that yearling trout do not "winter over" successfully when planted in streams, and contribute few fish to the catch during the following season. However, when fall plantings of adult rainbows were made in several trout lakes of the Pigeon River Forest, generally good results were obtained (Eschmeyer, 1937). These lakes of the "pot-hole" type vary in size from 5 to 40 acres. They have neither inlets nor outlets, hence spawning facilities are lacking and fishing must be maintained by introduction of hatchery trout. More exact figures from these lakes

show recovery percentages (obtained by creel census) on these waters as high as 66 per cent in the season following planting (Table 8). These results are in direct contrast to those recorded for fall plantings of legal-sized rainbow trout in the streams where 1.2 per cent represented the maximum recovery by anglers in the following year (Tables 2 and 3).

In South Twin Lake no rainbow trout were present before the planting of 100 adults in the fall of 1935. During the 1936 trout season, creel census clerks recorded 62 of these fish, and 2 were later netted by an Institute survey party. No fish were planted in 1936, but in 1937 of the 36 fish theoretically remaining, 9 were recorded in the creel census, or a total known survival to the angler of 73 per cent of the original planting.

Similar results occurred after the introduction of 100 marked adult rainbow trout in North Twin Lake in the fall of 1937. The 1938 creel census for this lake showed 66 of these fish taken by anglers.

Pickerel Lake was planted with 400 fin-clipped adult rainbow trout in the fall of 1939. Creel census records for the period April 27-May 5, 1940, listed 93 marked trout recovered (23 per cent) of a total catch of 112 rainbows. Since May 6 there have been unverified reports that at least 20 other marked rainbows have been captured in Pickerel Lake.

In Hemlock Lake 303 fin-clipped rainbow trout were available for the 1940 season from July and October, 1939 introductions. The creel census clerks recorded 113 marked rainbow trout (the entire catch) during the first nine days of the season, a known return of at least 37 per cent from these plantings.

TABLE 8. RESULTS OF FALL STOCKING OF ADULT RAINBOW TROUT IN CERTAIN MICHIGAN LAKES AS DETERMINED FROM CREEL CENSUSES AND MARKING EXPERIMENTS

Lake	Date stocked	Number stocked	Number retaken	Percentage retaken	Year retaken
1/ South Twin	1935	100	64	64.0	1936
1/ North Twin	1937	100	66	66.0	1938
2/ Pickerel	1939	400	93	23.3	1940
2/ Hemlock	1939	303	113	37.3	1940
3/ Burt	1939	500	76	15.2	1940

1/ Creel census operated entire season.

2/ Creel census only for first nine days of 1940 season.

3/ No creel census; returns on marked fish were voluntarily sent in by anglers, and are still coming in.

Interesting results are appearing from a planting made in September, 1939, of tagged yearling rainbow trout in Burt Lake (area approximately 25 square miles). Of 500 tagged fish, a total of 76 (15 per cent) have been taken to date (August, 1940). They have been recaptured in every stream tributary to or distributary from Burt Lake. The longest migration recorded from this planting was approximately 50 miles to the headwaters of the West Branch of the Sturgeon River, the branch of a tributary to Burt Lake. One fish was recaptured at the paper mill dam at Cheboygan (passing through Indian River, Mullet Lake, and down the Cheboygan River), while another moved up the Crooked River and into Crooked Lake. The majority of recaptures has been made in the Sturgeon River between Burt Lake and the town of Wolverine.

The growth of these fish over the winter and through spring ranged from one-half to five inches.

It should be emphasized that the returns from this planting in Burt Lake were obtained through the cooperation of the anglers, newspaper publicity, and stream-side posters calling attention to the release. ~~Many records were received from the attendant of the rearing station located on the Sturgeon River.~~

The results from experimental releases of marked adult rainbow trout during the open season in the Pigeon River Forest lakes previously mentioned demonstrate that the anglers will remove about the same percentage, or possibly more, than when similar plantings are made during the open season in streams. Two hundred fin-clipped rainbow trout were planted in July, 1939, in Hemlock Lake, and before the season closed, 97 were captured by anglers--a recovery of 48 per cent. A planting of 300 marked rainbow trout in North and South Twin lakes at the same time was a failure by comparison, as only five fish were

retaken during the 1939 season, and only three fish of this same release were recorded in the first nine days of 1940.

Obviously in these small lakes, the entire catch of the angler is of hatchery origin. As on the streams, a very large percentage of the total catch is removed by a small percentage of anglers. Fishing on these lakes is best in May and June (well before many tourists can come to Michigan) and sometimes in late August. The local anglers take more than their share of the trout from these lakes before the surface waters are too warm, and almost never visit the lakes during the months of July and August, while the tourist fishes vainly for his trout.

Because of their small size, these lakes can be planted from the most convenient point on the shoreline with the assurance that the trout will distribute themselves in the lake more or less at random.

POSSIBLE SOURCES OF ERROR IN THE DATA

Loss of tags. At the end of the 1938 season we were not certain that our results concerning the relative merits of spring and fall planting of legal trout were correct, because a control experiment indicated an extreme loss of tags from fish released in the fall of 1937. Another control experiment was re-established at the Grayling Hatchery on October 21, 1938, using monel metal tags from two different companies (Table 9). Brook, brown and rainbow trout, all 7 inches or larger, were used. The experimental fish were examined on July 7, 1939 and on April 18, 1940.

There has been no evidence of losses of tags from either brook or brown trout, but the rainbow trout at the last examination showed losses of tags caused by jaw growth to the extent of eight per cent

TABLE 9. CONTROL EXPERIMENT ON MARKED TROUT OF LEGAL SIZE, INITIATED OCTOBER 21, 1938, AT GRAYLING HATCHERY

(LENGTHS ARE GIVEN IN MILLIMETERS)

Date of examination	Item	Brook trout				Brown trout		Rainbow trout	
		Unmarked fish	Tagged fish (Tag No. 1)	Tagged fish (Tag No. 2)	Fin-clipped fish	Unmarked fish	Tagged fish	Unmarked fish	Tagged fish
Oct. 21, 1938	Number of fish	100	50	50	50	50	50	50	50
	Average total length	187	190	193	186	190	197	201	195
July 7, 1939	Number of fish	99	37	35	28	37	41	45	47
	Average total length	231	244	244	248	248	247	270	256
Apr. 18, 1940	Number of fish	82	35	32	28	36	41	45	49
	Average total length	283	290	292	299	285	281	331	307
	Average increase in length to date	96	100	99	113	95	84	130	112
	Percentage surviving to date	82	70	64	56	72	82	90	98
	Percentage observed to die at hatchery	9	15		0	0	0	0	0
	Percentage of unobserved mortality or escapement	9	18		44	28	18	10	2

of the original number tagged. It may be safely concluded that the tags were of the proper material and construction to stay in place on all species of trout at least over one winter after tagging. Parallel results from spring and fall plantings of fin-clipped trout verify the conclusion.

Mortality due to marking (tagging or fin-clipping). The control experiment referred to above also indicates that there may be a somewhat higher mortality in both tagged and fin-clipped brook trout than in the normal fish. However, mortality among the experimental trout is uncertain, and the figures presented in Table 9 are probably too high, because of the known escapement of marked experimental fish from the holding pond, verified by the recovery of one of the tagged experimental rainbow trout from the East Branch of the Au Sable River above the Grayling hatchery. To date, mortality on the tagged brown and rainbow trout has been less than on the untagged control fish of the same species.

The fins removed on the fin-clipped brook trout have regenerated either very little or not at all; in no instance would a fish so marked be unrecognizable to a trained census clerk inspecting a creel.

Mass migration of the planted fish, or a poor creel census. In the course of the last three years, streams and lakes where tagged fish were released have been well posted with signs requesting reports of recaptures. The digest of the fishing laws distributed to all who purchase licenses calls attention to the presence of marked fish and requests reports of capture. Local and state newspapers have carried accounts of marking experiments and pictures of tagged or fin-clipped fish. If any large proportion of tagged trout moved out of the census area, a number of returns would have been received by mail. Each year

during the census we received fewer returns from the Pine River by mail; only five marked trout were reported in this manner in 1939. This also indicates that the creel census crew was performing its work efficiently in the census area. The crew on the North Branch of the Au Sable River had a similar record.

The road pattern in the vicinity of the Pigeon and Little Manistee rivers interfered with the efficiency of the creel censuses on those waters. Returns by mail were more numerous and of great value, particularly from the Pigeon River, where it was found that there was a fairly large downstream movement of the spring planted rainbow trout.

Scarcity of returns outside of the census areas as contrasted with 76 voluntary reports from the Burt Lake planting (page 31), where no census was conducted and where reports from anglers furnished the only records, further indicate that there was no extensive migration outside the census areas and that the crews on the Pine River and the North Branch of the Au Sable were reasonably efficient.

SUMMARY

1. Comparable plantings (equal numbers of fish released at the same time of year) of legal-sized brook and rainbow trout yield approximately equal returns to the angler's creel. A smaller return to the angler of brown trout is indicated by limited data.

2. Fall planting of all species of trout in streams has been found to be inefficient. For brook trout, returns from early spring introductions were six times greater than from fall plantings; for rainbow trout 32 times greater; and for brown trout twice as great. Low survival over the winter seems definitely established by all experiments which have been conducted in trout streams. Plantings

approximately a month prior to the open season yielded about the same returns as during the fishing season for brook and rainbow trout but were not as efficient for brown trout.

3. Smaller plantings (from 100 to 160 adult trout per mile of stream averaging 50 feet in width) resulted in higher recovery percentages for brook and rainbow trout. A greater percentage of anglers benefited over a longer period of time from smaller releases, migration appeared to be less and depletion of the wild fish was lessened or avoided. Similar comparative data for brown trout are not available.

4. No significant difference in the percentage caught, duration of plantings, or number of fishermen benefited resulted from spot or boat plantings during 1938 when smaller plantings were made.

5. In general, the effect upon the total catch and the quality of the fishing (catch per hour per angler) was inversely proportional to the size of the wild population of the species planted and to some extent directly proportional to the size of the planting.

6. The percentage of anglers benefiting from the stocking of legal-sized trout was extremely low (from 5.7 to 20.6, average 11.8) in spite of plantings which were considered generous. Actually the number of individuals was less than this since records were based upon fisherman-days and not upon individual anglers. In a number of instances the same local fishermen or campers took large numbers of the newly planted fish for several days in succession. In northern Michigan streams it seems evident that chief reliance must be placed upon the wild stock to yield the bulk of the anglers' catch. Doubtless this would not hold on southern streams where the fishing pressure is heavier and ecological conditions are generally less suitable to trout.

7. Marked rainbow and brown trout contributed to the catch for at least eight weeks after release, while brook trout were caught out usually within four weeks. The majority of all planted fish taken were caught by the end of four weeks. The number of marked fish surviving from one season to the next is an insignificant percentage of the total catch.

8. Results from marking experiments on private streams were of a similar nature to those obtained on public trout streams.

9. Adult rainbow trout can be released in the fall in trout lakes at the rate of between 30 to 50 fish per acre of lake surface with the expectation that at least from 50 to 70 per cent will be taken during the following season.

10. A control experiment set up on October 21, 1938 at the Grayling hatchery proved that there has been no loss of tags from brook and brown trout, but that 8 per cent of the rainbow trout had lost their tags during the second winter. Such mortality as has occurred would not affect the validity of the conclusions presented. Publicity through newspapers, fishing law digests, and stream-side posters have aided in obtaining returns outside creel-censused areas, and returns by mail have shown no evidence of mass migration. The relative scarcity of returns by mail also indicates fairly efficient coverage of the fishing by the creel censuses.

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