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Mr. Ruhl

REPORT NO. 480

RESULTS FROM EXPERIMENTAL PLANTINGS OF LEGAL-SIZED TROUT[1]

Albert S. Hazzard and David S. Shetter
Michigan Department of Conservation

Abstract

An intensive creel census in conjunction with monthly releases, during the fishing season, of legal-sized trout, approximately one-half of which were jaw-tagged or fin-clipped, furnished data for the evaluation of such plantings in the Pine River. Nearly 8,500 hours of fishing yielded 3,171 brook trout and 3,333 rainbow trout, an average catch of 0.77 fish per hour. Forty-six per cent of the brook trout reported and twenty-one per cent of the rainbows were from these plantings. Incomplete records of the marked fish showed recovery of 19.8 per cent of 7,513 brook trout planted and 17.5 per cent of 4,007 stocked rainbows. The catch per hour ranging from 0.3 to 1.3, averaged 0.77 for the Pine and was considerably higher than for other streams covered by census which were not planted with large fish. Such plantings influenced the catch for a period of from two to three weeks. Apparently few of these fish survive to the next season. Movement of planted fish was mainly upstream regardless of the method of planting. Within two weeks the fish which remained were

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[1] Contribution from the Institute for Fisheries Research, ~~Michigan Department of Conservation~~ and University ~~of Michigan~~.

uniformly distributed over the stream. "Spot" planting resulted in a larger percentage caught than scattering by boat but increased "meat fishing." Every planting during the open season markedly increased the catch of wild fish of the same species. It is concluded that although planting legal fish during the season temporarily improves fishing it depletes a stream of wild adults. Such depletion will affect natural production and result in poorer fishing in succeeding years. A legal-sized program appears justified only in heavily fished streams incapable of supporting a permanent trout population during the summer or where no results from natural reproduction are possible.

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In recent years a number of states, particularly those with very limited trout water subjected to heavy fishing pressure, have been stocking many adult trout. Fisheries administrators in these states seem to feel that this is the only way to at least partially satisfy the anglers. In a recent address delivered before the New York State Wildlife Conference, Senator Walcott (1938) described the present large fish planting program in Connecticut with the statement that the "program works in a small state where you can keep it under control and face the facts by deliberately treating it as a manufacturing proposition."

Michigan has been planting a small percentage of yearling trout in certain waters but recently there have been increased demands for larger fish in different parts of the state. Before embarking on a program which would entail new pond development and heavy additional expense, our Commission decided that experiments should be performed by its Institute for Fisheries Research to determine the results from such plantings.

A portion of the Pine River, a branch of the Big Manistee, was chosen as the test stream where most of the experiments were to be conducted. In the section under observation the stream has an average width of about fifty feet. The current is rapid to sluggish and the bottom is dominantly of sand and gravle with rather frequent clay outcrops (Figure 2). Two fair-sized tributaries and a number of springs feed this portion of the river. The land along this portion of the river for a distance of about twelve miles below the Walker Bridge is owned or leased by the Department of Conservation. The Department has developed five public campsites in this section as indicated in Figure 1.

In conducting the census, C. C. C. enrollees were stationed at each camp ground (the usual points of access to the river) from 8 a.m. to 8 p.m., Sundays and holidays included, during the entire fishing season. Records were taken on regulation creel census forms as described by Eschmeyer (1935) and were submitted to the Institute for tabulation and analysis.

Beginning May 18, 1937, monthly plantings, each consisting of three thousand trout of legal size (7 inches or over), were made in that part of the stream covered by the census. The usual composition of the releases was 2,000 brook trout and 1,000 rainbow trout. Approximately one-half of each planting was jaw-tagged according to the method described by Shetter (1935) or were marked by removal of dorsal and adipose fins.

Two methods were employed in planting the fish. The first lot of each species was "spot planted," i.e., a thousand or so trout were distributed over not more than one-quarter of a mile of stream from the bank nearest the road. This is the usual method of planting trout in most states at the present time. Later releases were made by the

use of a planting boat (equipped with central well) from which the trout were liberated a few in each pool as the crew moved downstream.

Excellent publicity was accorded the experiment by the newspapers. Illustrated posters (Figure 4) explaining the purpose of the work and requesting cooperation in reporting catches were placed at all camp grounds and at road crossings above and below the section. Many voluntary reports were received from fishermen who had been missed by the census-takers or who had caught tagged trout outside of the patrolled portion.

DISCUSSION OF DATA

Tabulations of the fishing records have been made by weekly periods (Tables 2 and 3) except for the last period of the season (August 28-September 6). Nearly 8,500 hours of fishing were recorded during which 6,504 legal trout were caught, an average of 0.77 fish per hour. The total reported catch was made up of 3,171 brook trout and 3,333 rainbow trout. Ninety-five brown trout were reported but as their identity was questionable they were not included in the calculations.

The record of trout caught in the census area is not complete since a few fishermen left the stream before the arrival of the patrol and others fished too late in the evening to be interviewed. The amount of training and supervision given the enrollees was not sufficient to ensure altogether complete and satisfactory data. However, it is believed that an adequate statistical sample was obtained of the season's fishing on the Pine River.

Percentage of plantings caught, Table 3. The percentage of marked brook trout reported from plantings varied from 4.9 to 40.2 with a weighted average of 19.8; the percentage from rainbow trout

plantings, from 10.2 to 22.3 with a weighted average of 17.5. The percentage of all fish stocked recorded by the census was 18.9. These returns are lower than those reported by Cobb (1933) and Hoover (1937) but are higher on the average than found by Nesbit and Kitson (1937). Since it is known that a number of marked trout were captured outside the census area and were not reported, the numbers given above should be considered as minimum. However, it is also known that there is some mortality following planting of trout of this size. A total of seventeen dead trout were picked up on two occasions following plantings. Of these seven were tagged, three fin-clipped and seven unmarked. Since the unmarked fish were of the same size range as the marked fish and the loss occurred at about the same time and in approximately the proportions existing in the plantings it can be assumed that marking was not responsible for the loss. These fish were examined by Lowell A. Woodbury who reported death as due to disease or probable injuries in planting.

Effect upon the catch. The catch per unit of fishing effort (in this case the average number of legal trout taken per fisherman-hour) is considered by fisheries biologists as the proper index to yield. This is given by weekly periods in Table 2 and also in Figures 5 and 6 for the Pine River. These figures should be compared with Figures 7 and 8 in which are shown the catch per hour for two other Michigan streams covered by similar censuses during 1937. A marked fluctuation in the catch per hour is evident in these graphs, ranging from 0.2 to 0.8 fish per hour in the North Branch of the Au Sable River ~~to~~ from 0.3 to 1.3 for the Pine. It will also be noted that the brook trout catch showed a greater variation than that of

the other species, whereas the brown trout catch showed the least. This observation on one stream is contrary to the accepted notion that brook trout are easiest to catch and bite most consistently.

The effects of planting "keeper" trout are readily observed in the charts for the Pine and the Pigeon rivers. These plantings are responsible for the tremendous peaks in the curves and resulted in higher average catches for the season as a whole. The average catch per hour was as follows: for the North Branch of the Au Sable, 0.47; for the Pigeon River, 0.46; for the Pine River, 0.77. There is no question but that the legal-sized plantings accounted for the higher average catch per hour in the Pine River.

How long do "keeper" plantings influence the catch? Regardless of the method used in planting, the liberation of such large numbers of trout does not markedly affect the fishing for longer than two or three weeks (Figures 5, 6 and 7). By that time the trout have disappeared from the section stocked and few if any appear in the catch thereafter. These results are in general agreement with those of Cobb (1933) except that in the case of two plantings he found that the greatest number of trout were taken twenty-three and thirty-six days respectively after release. However since Cobb did not consider the fishing intensity during the period, it is possible his figures are not significant.

Hoover (1937) reports that in one New Hampshire stream fishing declined rapidly during the first month of the open season (May) and "might be described as poor by the end of May at which time only 15 per cent of the 4,000 previously stocked fish had been removed." On the basis of marking experiments, he estimates that of a planting of 2,000 legal-sized brook trout made in June, 70 per centwere removed

within three weeks after planting.

It therefore seems evident that in order to keep fishing at a high level in this section of the Pine River, it would be necessary to plant 3,000 legal trout each two weeks during the open season assuming that the angling pressure remains constant. The possibility that ~~constant~~ smaller plantings at such intervals would produce as good fishing is being investigated.

To date (June 16, 1938) very few reports of marked trout planted during the 1937 fishing season have been received in the census being conducted this year by trained Department employees. This is in agreement with reports by Cobb (1933), Nesbit and Kitson (1937), Walcott (1938) and Hewitt (1938), all of whom emphasize that legal-sized trout do not winter over successfully.

Migration of plantings. An analysis of the movements of marked fish demonstrates that the large majority of the recoveries of the large-sized fish was made at or relatively near (within one to three miles) the location of planting and usually within two weeks after release. In general, after two weeks, trout planted at any particular point were more or less equally abundant at all points but in considerably diminished numbers. A few individuals were recovered between fifteen and twenty miles from the point of stocking.

"Spot-planted" brook trout moved both up and downstream within the first week's stocking, but even greater movement occurred during the second week. Brook trout planted by boat were caught upstream only. The one spot planting of rainbows showed dominant upstream migration reaching a peak during the third week after release. Rainbows distributed by boat also showed a dominant upstream movement.

Greater movement of trout occurred following spot plantings than when the fish were distributed a few in each pool from the planting boat. Boat planting seems to result mainly in upstream migration. In either method, movement of legal-sized trout appears to be mostly upstream.

Comparison of planting methods. In addition to the effect upon movements after planting, significant differences in the catch resulted from the two methods. As shown by Table 3, spot planting yielded the largest catch from a given number stocked both in brooks and rainbows. In neither case did the more expensive and difficult method of planting by boat result in a longer improvement in the fishing. In fact, the single spot planting of rainbows influenced the catch for several weeks longer than did boat plantings.

The main objection to spot planting of large trout is that, no matter how secretly done, it leads to "meat fishing" and highly undesirable concentrations of fishermen. In either method trout are caught out rapidly and no particular skill or persistence is required to take the limit in a short time.

Percentage of planted and "wild"[1] fish in the catch. The relative

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[1] This term will be used for fish resulting from natural spawning or previous fingerling plantings.

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contribution to the catch by planted "keepers" and by wild fish is of greatest significance in this investigation. Fortunately a complete record of the fish yield is not required for such a calculation. In the Pine River the planted brook trout made up 46.9 per cent of the number of this species taken by anglers; planted keepers constituted 20.6 per cent of the rainbows caught. Considering the entire take,

33.9 per cent of all trout caught in this section of the Pine River came from legal-sized plantings. On this basis Nature and the "fingerling program" seem to be doing a pretty good job in the Pine River and at a fraction of the cost of the "keeper" plantings.

Effect upon the catch of wild trout. The most startling and unexpected result of this investigation has been the establishment of definite proof that planting legal-sized hatchery fish markedly increases the catch of wild fish. Reference to Figures 5 and 6 shows that in every instance plantings caused a significant rise in the wild fish curve. In every case except one these plantings caused the catch per hour of wild fish to exceed even that of the recently stocked fish! This is further confirmed by the results of the single planting of rainbow trout in the Pigeon River (Figure 7), although here the rise in catch of hatchery fish and that of wild rainbows was delayed one and two weeks respectively. It is interesting to note that only the wild trout of the species planted were affected. This suggests that competition may be keener between individuals of the same species than between the different species of trout.

It is entirely possible and it seems reasonable that planting large numbers of big trout in a stream may increase competition for food and shelter to the point that wild fish are forced to forage more extensively and are caught more rapidly than normal. After all, the supporting capacity as well as the productive capacity of any body of water has definite limitations and unless more "homes" and food can be supplied, a stream cannot support more than a given number of fish. Hewitt (1938) stresses this point in his challenging paper "What Happens to Our Trout." Surber (1936) has shown that doubling the usual plant of fingerling rainbow trout (which he found reached legal size next season) did not result in an increase in the catch the following year.

CONCLUSIONS

These findings leave considerable room for speculation but one conclusion appears to be justified, namely, that consistently planting a stream with legal-sized trout during the fishing season will eventually lower the number of adult trout of breeding size to a point where the contribution to the catch from natural spawning is seriously impaired. Furthermore this forced drain on the stock of larger trout in a stream means poorer fishing during the following seasons, especially since legal-sized trout planted during one season do not "winter over" with much success. If carried to excess the result would be a stream practically barren of trout except for those planted just prior to and through the season.

As Senator Walcott (1938) reports, this program may be the only solution for a small state with limited mileage of stream, much of which may become too warm for trout in mid-summer and in which suitable breeding grounds or breeding stock are lacking. Planting legal-sized trout may also be justified in the smaller streams of southern Michigan where the demands of fishermen are heavy and the habitat for trout is extremely limited provided the group benefited is willing to pay what it costs to manufacture this substitute for the kind of fishing still available in our northern streams. It would be a financial impossibility to supply such artificial trout fishing to some 300,000 anglers in the 15,000 miles of trout stream in this state.

Planting keeper trout does "pep up the fishing," but apparently this stimulant works the same as morphine in man--there is a drain on the reserve which demands larger and repeated doses and even then the result cannot compare with normal conditions. If our conclusions are correct (more exact information will be available at the end of this fishing season), the eventual fate of a stream stocked with large trout would be something like this--few or no legal trout left to breed, few fish except those fresh out of the hatcheries and few if any "lunkers" to provide the thrill that all trout fishermen look forward to while catching the eight to ten inch fish for the pan.

ACKNOWLEDGMENTS

The writers wish to express their appreciation to the Michigan Conservation Commission, especially Chairman William H. Loutit, who has personally sponsored this project, for the opportunity to carry on the investigation. We also deeply appreciate the encouragement and help offered by F. A. Westerman and A. E. Cook of the Fish Division. Robert Fortney, District Supervisor of Fisheries Operations, efficiently organized the planting program and assisted in many ways. The state and later the U. S. Forest Service supplied the C.C.C. enrollees for the project. We are also indebted to our colleagues, Dr. Ralph Hile and Dr. R. W. Eschmeyer, for critical reading of the manuscript and for ~~their~~ aid in interpretation of the data.

TABLE 1. DETAILS OF LEGAL-SIZED TROUT PLANTINGS MADE IN THE PINE RIVER DURING THE 1937 TROUT SEASON

Date Planted	Species	Average total length (inches)[1]	How marked (number)	Total planted	How planted	Where planted[2]
May 18, 19	Brook	9.0	Jaw-tagged (1,000)	3,000	Spot	Walker, Canfield
June 15	Brook	8.8	Jaw-tagged (959)	959	Boat	Walker to Lincoln
June 15	Rainbow	10.1	Jaw-tagged (1,007)	2,007	Spot	Canfield, Elm Creek
July 13	Brook	8.8	Jaw-tagged (504) Fin-clipped (500)	2,004	Boat	Walker to Lincoln
July 13	Rainbow	9.8	Jaw-tagged (250) Fin-clipped (250)	1,000	Boat	Lincoln to Elm Creek
August 10	Brook	8.6	Jaw-tagged (500) Fin-clipped (500)	1,550	Boat	Lincoln to Elm Creek
August 10	Rainbow	10.6	Jaw-tagged (250) Fin-clipped (250)	1,000	Boat	Walker to Lincoln
Total	Brook		Jaw-tagged (2,963) Fin-clipped (1,000)	7,513		
Total	Rainbow		Jaw-tagged (1,507) Fin-clipped (500)	4,007		

[1] Based on average length of tagged fish.

[2] See map, Figure 1, for locations.

TABLE 2. COMPOSITION OF CATCH AS RECORDED IN PINE RIVER CENSUS BY WEEKLY PERIODS DURING 1937 FISHING SEASON

Weekly period number	Week	Number of Fishermen	Hours fished	Total marked fish[2] Brook	Total marked fish[2] Rainbow	Calculated total brook Wild	Calculated total brook Hatchery	Calculated total rainbow Wild	Calculated total rainbow Hatchery	Catch per hour of brook Wild	Catch per hour of brook Hatchery	Catch per hour of rainbow Wild	Catch per hour of rainbow Hatchery	Catch per hour. All trout
1	Apr. 24-30	200	864.75	...	...	143	...	137	...	0.16	...	0.16	...	0.32
2	May 1-7	170	688.25	...	...	136	...	236	...	0.20	...	0.34	...	0.54
3	May 8-14	146	758.25	...	...	100	...	250	...	0.13	...	0.33	...	0.46
4	May 15-21[1]	192	758.75	241	...	65	723	212	...	0.09	0.95	0.28	...	1.32
5	May 22-28	200	840.00	154	...	293	462	184	...	0.35	0.55	0.22	...	1.12
6	May 29-June 4	153	613.50	5	...	145	15	136	...	0.24	0.02	0.22	...	0.48
7	June 5-11	141	646.50	1	...	90	3	214	...	0.13	0.01	0.33	...	0.47
8	June 12-18[1]	92	345.25	15	68	102	30	149	136	0.30	0.09	0.43	0.39	1.21
9	June 19-25	70	261.50	11	35	12	22	67	70	0.04	0.08	0.26	0.27	0.65
10	June 26-July 2	57	278.50	...	33	18	...	62	66	0.06	0.00	0.22	0.24	0.52
11	July 3-9	90	344.25	4	26	35	8	115	52	0.10	0.03	0.33	0.15	0.61
12	July 10-16[1]	30	150.75	20 (9)	20 (1)	69	40	54	40	0.45	0.27	0.36	0.27	1.35
13	July 17-23	69	279.50	22 (11)	43 (10)	82	44	138	88	0.29	0.16	0.49	0.31	1.25
14	July 24-30	56	207.25	3 (1)	7	63	6	71	14	0.30	0.03	0.34	0.07	0.74
15	July 31-Aug. 6	53	232.50	1	21	49	2	105	42	0.21	0.01	0.45	0.18	0.85
16	Aug. 7-13[1]	68	222.00	17	43 (15)	20	26	128	86	0.09	0.12	0.57	0.39	1.17
17	Aug. 14-20	89	369.00	55 (26)	40 (4)	133	85	143	80	0.36	0.23	0.39	0.22	1.20
18	Aug. 21-27	54	232.00	14 (1)	4	81	22	107	8	0.35	0.10	0.46	0.03	0.94
19	Aug. 28-Sept. 6	80	367.00	...	3	47	...	139	6	0.13	0.00	0.38	0.01	0.52
	Total numbers, average catch per hour	2,010	8,459.50	563 (48)	343 (30)	1,683	1,488	2,647	686	0.20	0.18	0.31	0.08	0.77

[1] Weeks of planting of hatchery fish (see Table 1)

[2] To the listed total there should be added
8 marked trout, no data
6 fin-clipped rainbow, no data
2 tagged rainbow, no data

( ) - Indicates number of fin-clipped fish included in total number of marked fish recovered.

TABLE 3. CALCULATED NUMBER OF HATCHERY TROUT CAUGHT FROM EACH PLANTING IN SUCCESSIVE WEEKS.

(* DENOTES WEEKS IN WHICH PLANTINGS WERE MADE.)

Weekly period number	Dates, numbers and species planted						
	May 18, 19 3000 brook	June 15 959 brook	June 15 2007 rainbow	July 13 2004 brook	July 13 1000 rainbow	August 10 1550 brook	August 10 1000 rainbow
1*	723	...	...	...	...	...	...
5	462	...	...	...	...	...	...
6	15	...	...	...	...	...	...
7	3	...	...	...	...	...	...
8*	4	26	136	...	...	...	...
9	...	22	70	...	...	...	...
10	...	...	66	...	...	...	...
11	...	8	52	...	...	...	...
12*	...	...	20	40	20	...	...
13	...	2	50	42	36	...	...
14	...	...	8	6	6	...	...
15	...	...	22	2	20	...	...
16*	...	...	8	...	20	26	58
17	...	...	10	4	...	81	70
18	...	...	4	4	...	18	4
19	...	...	2	...	...	...	4
Totals	1,207	58	448	98	102	125	136
Per cent of plant	40.2	6.0	22.3	4.9	10.2	8.1	13.6

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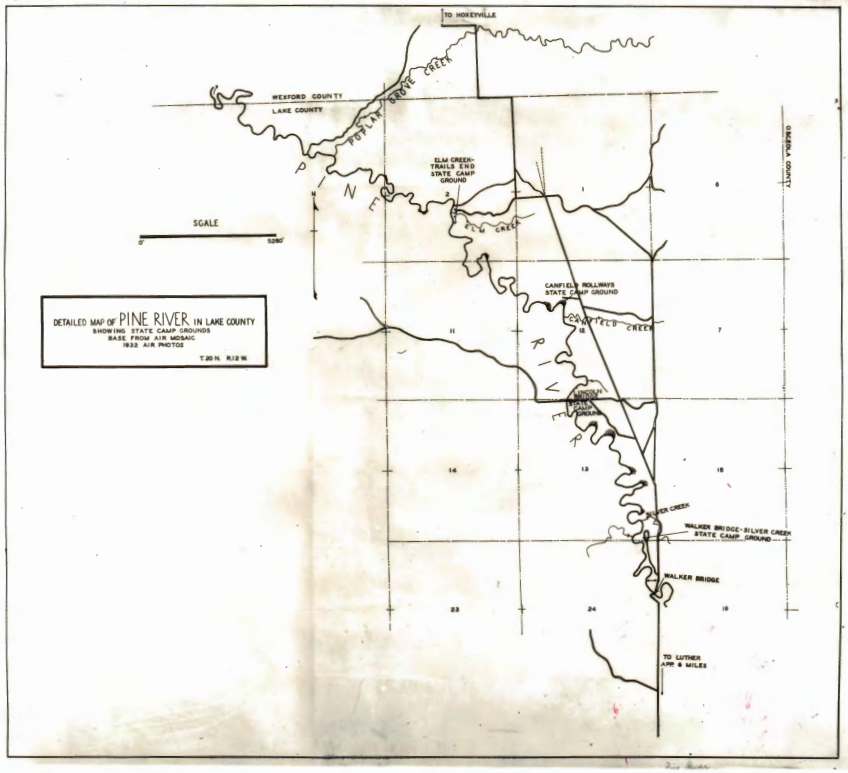
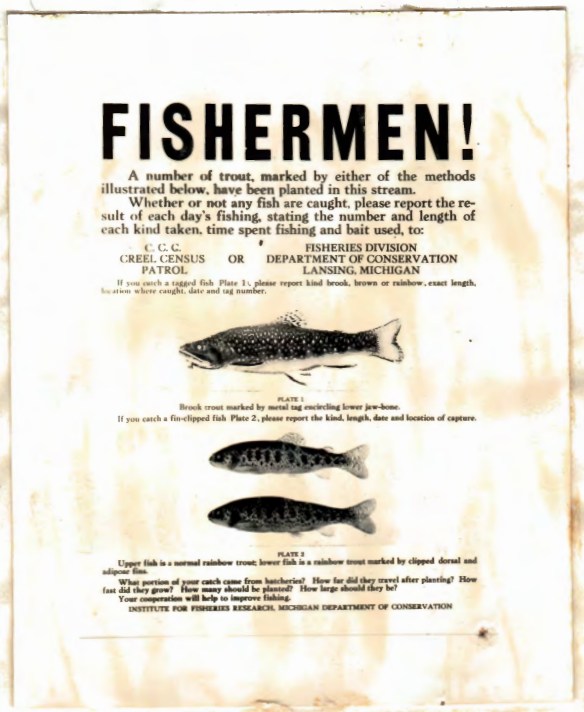


Figure 1. Section of Pine River showing location of state camp grounds.

Figure 2. The Pine River viewed from Canfield Rollways.

Figure 3. Loading trout from the tank truck into the planting boat.



FISHERMEN!

A number of trout, marked by either of the methods illustrated below, have been planted in this stream.

Whether or not any fish are caught, please report the result of each day's fishing, stating the number and length of each kind taken, time spent fishing and bait used, to:

C. C. C.
CREEL CENSUS
PATROL

OR

FISHERIES DIVISION
DEPARTMENT OF CONSERVATION
LANSING, MICHIGAN

If you catch a tagged fish Plate 1, please report kind brook, brown or rainbow, exact length, location where caught, date and tag number.

PLATE 1

Brook trout marked by metal tag encircling lower jaw-bone.

If you catch a fin-clipped fish Plate 2, please report the kind, length, date and location of capture.

PLATE 2

Upper fish is a normal rainbow trout; lower fish is a rainbow trout marked by clipped dorsal and adipose fins.

What portion of your catch came from hatcheries? How far did they travel after planting? How fast did they grow? How many should be planted? How large should they be?
Your cooperation will help to improve fishing.

INSTITUTE FOR FISHERIES RESEARCH, MICHIGAN DEPARTMENT OF CONSERVATION

Figure 4. Poster used to acquaint fishermen with the experimental planting program.

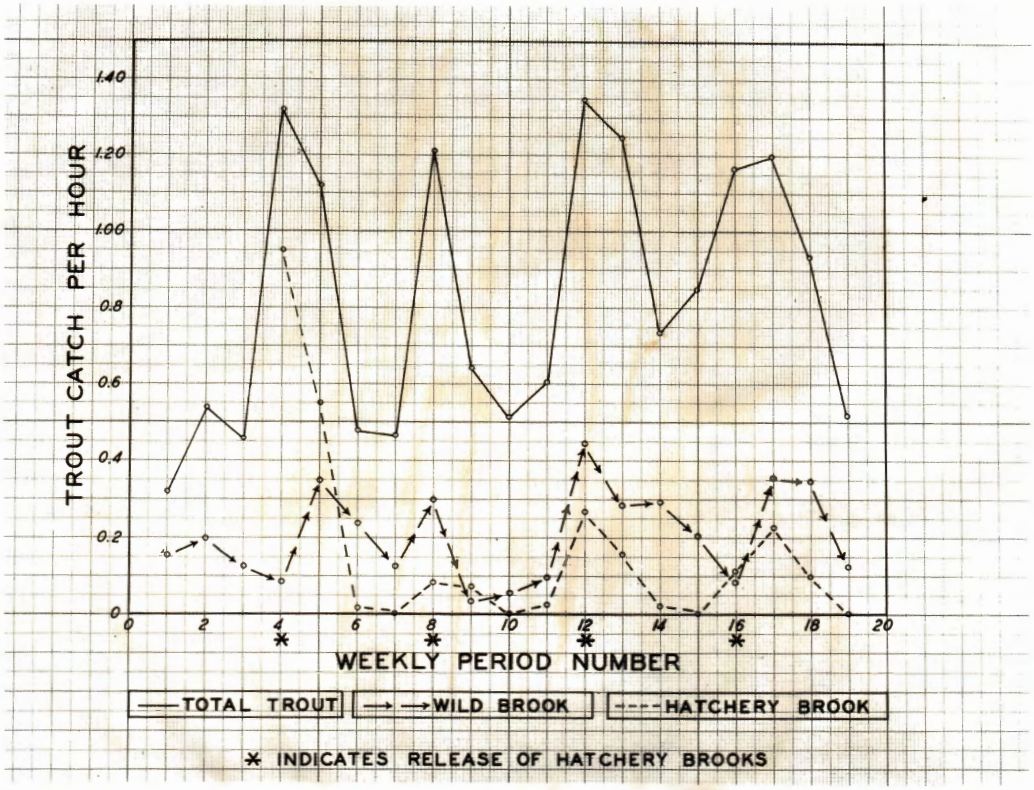


Figure 5. Catch per hour of brook trout on the Pine River during the 1937 fishing season.

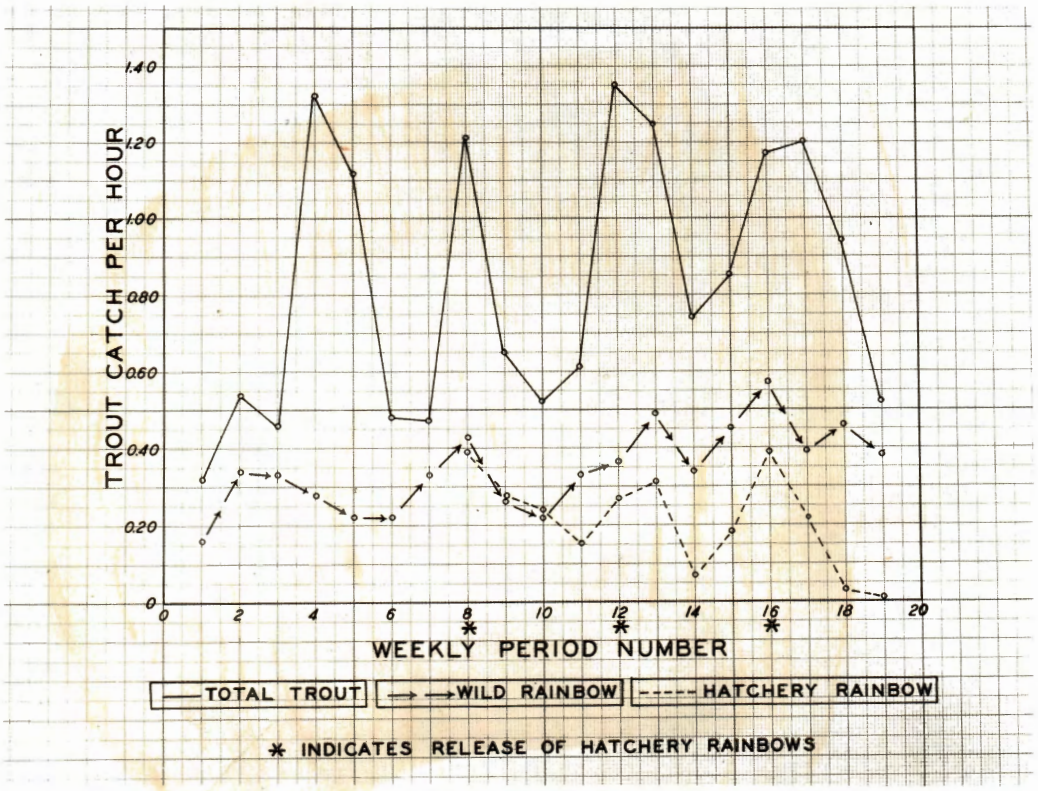


Figure 6. Catch per hour of rainbow trout on the Pine River during the 1937 fishing season.

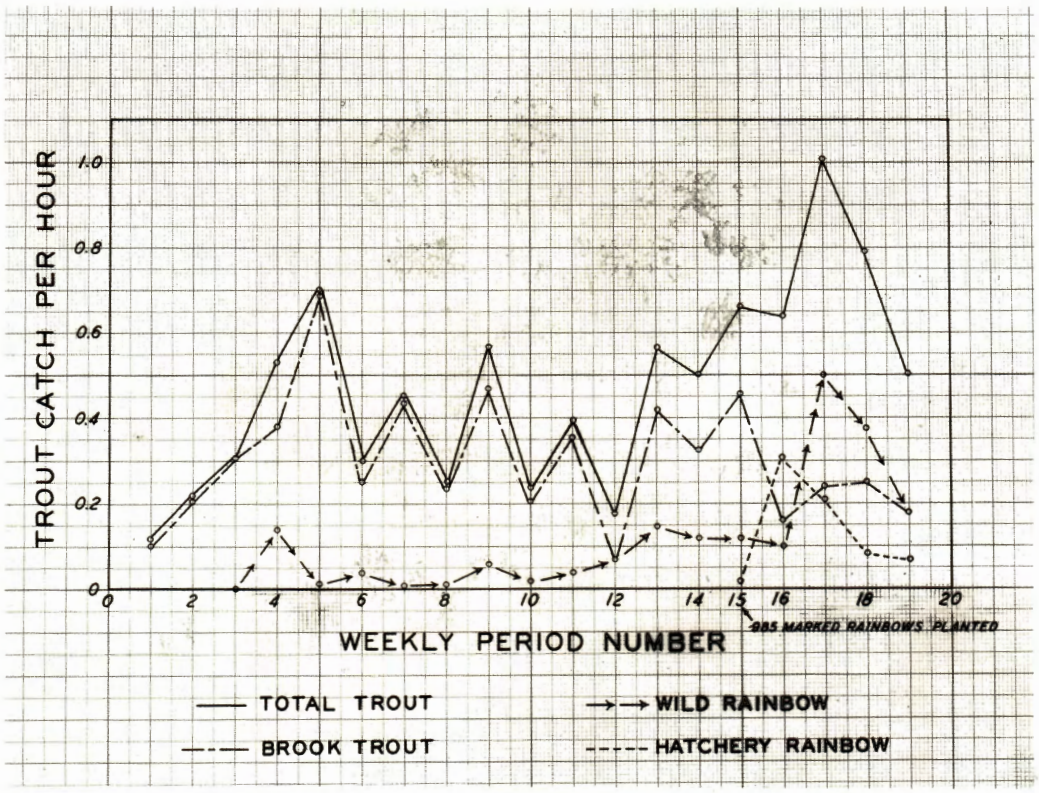


Figure 7. Catch per hour of brook and rainbow trout on the Pigeon River for 1937.

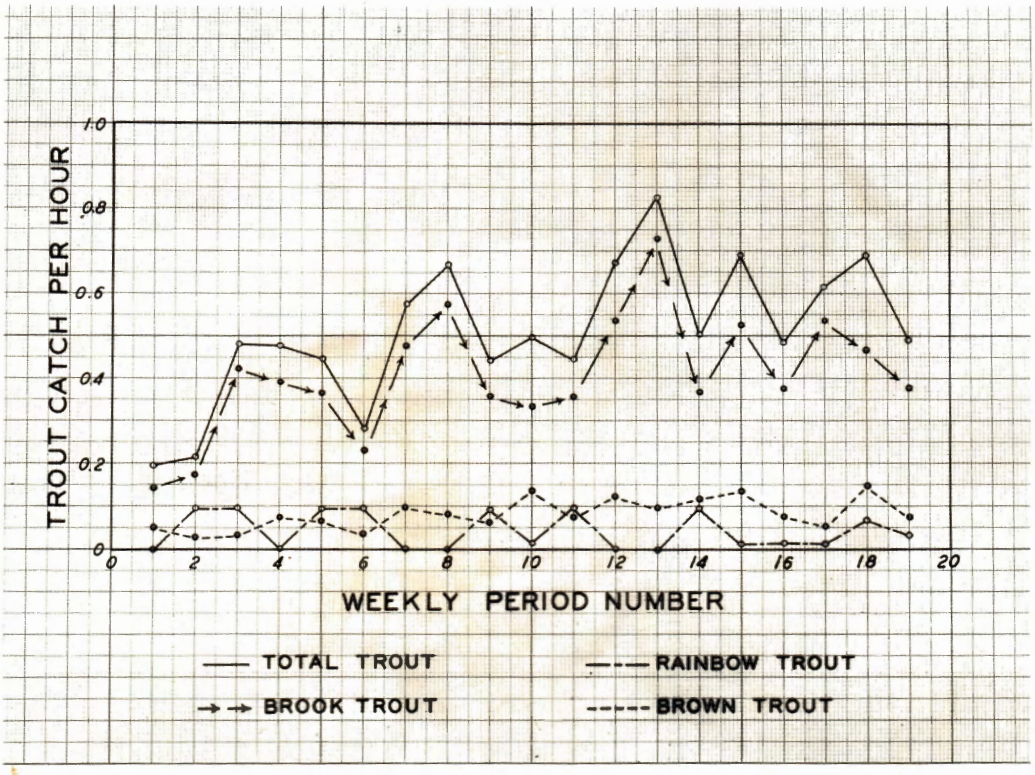


Figure 8. Catch per hour of all trout on the North Branch of the Au Sable River for 1937.

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Introduction

In recent years a number of states, particularly those with very limited trout water subjected to heavy fishing pressure, have been stocking many adult trout. Fisheries administrators in these states seem to feel that this procedure is the only way to satisfy the anglers at least partially. In a recent address delivered before the New York State Wildlife Conference, Senator Walcott (1938) described the present large fish planting program[1] in Connecticut with the statement that the

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[1] Connecticut releases a large number of legal sized trout but also stocks spring-fed tributaries with fry and the less heavily fished larger streams with fingerlings.

"program works in a small state where you can keep it under control and face the facts by deliberately treating it as a manufacturing proposition."

Michigan has been planting a small percentage of yearling trout in certain waters but recently there have been increased demands for larger fish in different parts of the state. Before embarking on a program which would entail new pond development and heavy additional expense, our Commission decided that experiments should be performed by its Institute for Fisheries Research to determine the results from such plantings.

A portion of the Pine River, a branch of the Big Manistee, was chosen as the test stream where most of the experiments were to be conducted. In the section under observation the stream has an average width of about fifty feet. The current is rapid to sluggish and the bottom is dominantly of sand and gravel with rather frequent clay outcrops (Figure 1). Two fair-sized tributaries and a number of springs feed this portion of the river. The land along this portion of the river for a distance of about twelve miles below the Walker Bridge is owned or leased by the Department of Conservation. The Department has developed five public campsites in this section as indicated in Figure 2.

In conducting the census, C.C.C. enrollees were stationed at each camp ground (the usual points of access to the river) from 8 a.m. to 8 p.m., Sundays and holidays included, during the entire fishing season. Records were taken on regulation creel census forms as described by Eschmeyer (1935) and were submitted to the Institute for tabulation and analysis.

Figure 1. The Pine River viewed from Canfield Rollways.

Figure 2. Section of Pine River showing location of state camp grounds.

Beginning May 18, 1937, monthly plantings, each consisting of three thousand trout of legal size (7 inches or over), were made in that part of the stream covered by the census. The usual composition of the releases was 2,000 brook trout and 1,000 rainbow trout (Table 1). Approximately one-half of each planting was jaw-tagged according to the method described by Shetter (1935) or marked by removal of dorsal and adipose fins.

Two methods were employed in planting the fish. The first lot of each species was "spot planted," i.e., a thousand or so trout were distributed over not more than one-quarter of a mile of stream from near the road. This is the usual method of planting trout in most states at the present time. Later releases were made by the use of a planting boat, equipped with a central well, (Figure 3) from which the trout were liberated a few in each pool as the crew moved downstream.

Excellent publicity was given the experiment by the newspapers. Illustrated posters (Figure 4) explaining the purpose of the work and requesting cooperation in reporting catches were placed at all camp grounds and at road crossings above and below the section. Many voluntary reports were received from fishermen who had been missed by the census-takers or who had caught tagged trout outside of the patrolled portion.

Angling Results in Relation to Plantings of Hatchery Fish

Tabulations of the fishing records have been made by weekly periods (Tables 2 and 3) except for the last period of the season (August 28-September 6). Nearly 8,500 hours of fishing were recorded during which 6,504 legal trout were caught, an average of 0.77 fish per hour. The

Figure 3. Loading trout from the tank truck into the planting boat.

Figure 4. Poster used to acquaint fishermen with the experimental planting program.

TABLE 3. CALCULATED NUMBER OF HATCHERY TROUT CAUGHT FROM EACH PLANTING IN SUCCESSIVE WEEKS.

(* DENOTES WEEKS IN WHICH PLANTINGS WERE MADE.)

Weekly period number	Number of fish caught from plantings						
	May 18, 19 3000 brook	June 15 959 brook	June 15 2007 rainbow	July 13 2004 brook	July 13 1000 rainbow	August 10 1550 brook	August 10 1000 rainbow
1*	723	...	...	...	...	...	...
5	462	...	...	...	...	...	...
6	15	...	...	...	...	...	...
7	3	...	...	...	...	...	...
8*	4	26	136	...	...	...	...
9	...	22	70	...	...	...	...
10	...	...	66	...	...	...	...
11	...	8	52	...	...	...	...
12*	...	...	20	40	20	...	...
13	...	2	50	42	36	...	...
14	...	...	8	6	6	...	...
15	...	...	22	2	20	...	...
16*	...	...	8	...	20	26	58
17	...	...	10	4	...	81	70
18	...	...	4	4	...	18	4
19	...	...	2	...	...	...	4
Totals	1,207	58	448	98	102	125	136
Per cent of plant	40.2	6.0	22.3	4.9	10.2	8.1	13.6

total reported catch was made up of 3,171 brook trout and 3,333 rainbow trout. Ninety-five brown trout were reported but as their identity was questionable they were not included in the calculations.

The record of trout caught in the census area is not complete since a few fishermen left the stream before the arrival of the patrol and others fished too late in the evening to be interviewed. The amount of training and supervision given the enrollees was not sufficient to ensure altogether complete and satisfactory data. However, it is believed that an adequate statistical sample was obtained of the season's fishing on the Pine River.

Percentage of plantings caught, Table 3. The percentage of captures of marked brook trout reported from plantings varied from 4.9 to 40.2 with a weighted average of 19.8; the percentage from rainbow trout plantings, from 10.2 to 22.3 with a weighted average of 17.5. The percentage capture of all fish stocked recorded by the census was 18.9. These returns are lower than those reported by Cobb (1933) and Hoover (1937) but are higher on the average than found by Nesbit and Kitson (1937). Since it is known that several marked trout were captured outside the census area and were not reported, the numbers given above should be considered as minimal. However, it is also known that there is some mortality following planting of trout of this size. A total of seventeen dead trout was picked up on two occasions following plantings. Of these seven were tagged, three finclipped and seven unmarked. Since the unmarked fish were of the same size range as the marked fish and the loss occurred at about the same time and in approximately the proportions that existed in the plantings it can be assumed that marking was not responsible for the loss. These fish were examined by Lowell A. Woodbury who reported death as due to disease or injuries probably received in transportation.

Effect upon the catch. The catch per unit of fishing effort (in this paper the average number of legal trout taken per fisherman-hour) is considered by fisheries biologists as the proper index to yield. The catch per hour for the Pine River is given by weekly periods in Table 2 and also in Figures 5 and 6. These figures should be compared with Figures 7 and 8 in which are shown the catch per hour for two other Michigan streams covered by similar censuses during 1937. A marked fluctuation in the catch per hour is evident in Figures 5 to 8, ranging from 0.2 to 0.8 fish per hour in the North Branch of the Au Sable River from 0.3 to 1.3 for the Pine.

The effects of planting "keeper" trout are readily observed in the charts for the Pine and the Pigeon rivers. These plantings are responsible for the tremendous peaks in the curves and increased the average catch per hour for the season as a whole. The average catch per hour was as follows: for the North Branch of the Au Sable, 0.47; for the Pigeon River, 0.46; for the Pine River, 0.77. There is no question but that the legal-sized plantings accounted for larger catches in the Pine River.

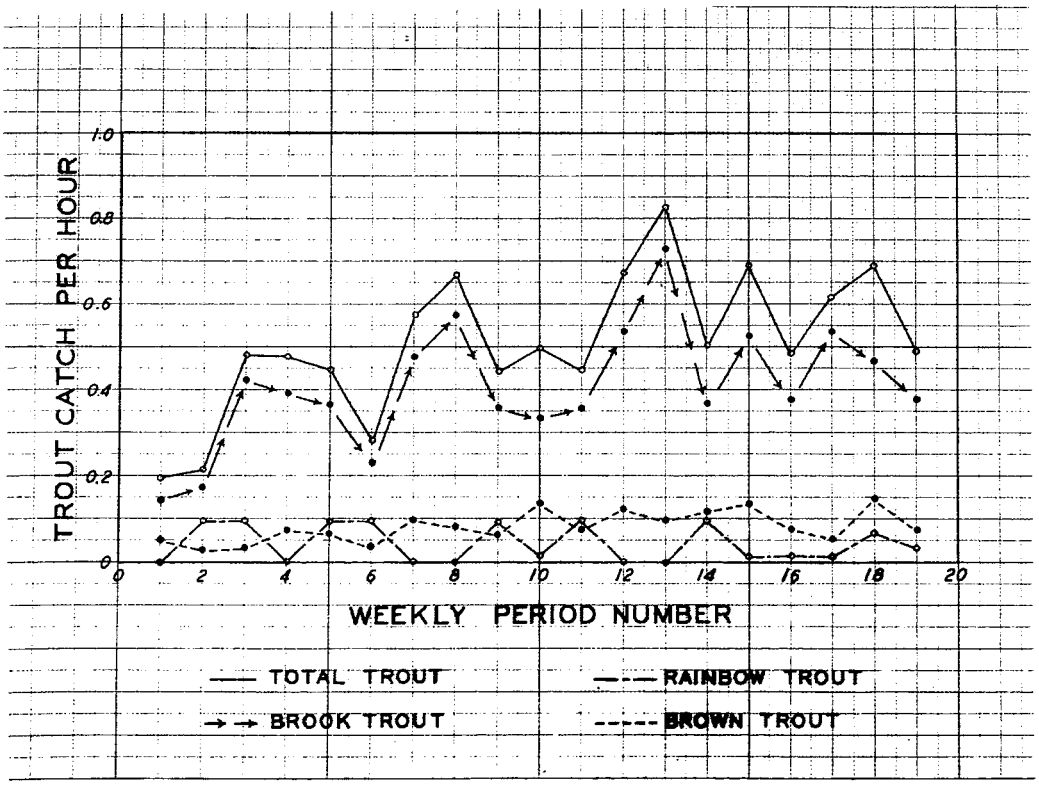
How long do "keeper" plantings influence the fishing? Regardless of the method used in planting, the liberation of such large numbers of trout does not markedly affect the fishing for longer than two or three weeks (Table 3 and Figures 5, 6 and 7). Apparently by that time the trout have disappeared from the section stocked and few if any appear in the catch thereafter. These results are in general agreement with those of Cobb (1933) except that in two plantings he found that the greatest numbers of trout were taken twenty-three and thirty-six days respectively after release. However since Cobb did not consider the fishing intensity during the period, it is possible his figures for different plantings are not comparable.

Figure 5. Catch per hour of brook trout on the Pine River during the 1937 fishing season.

Figure 6. Catch per hour of rainbow trout on the Pine River during the 1937 fishing season.

Figure 7. Catch per hour of brook and rainbow trout on the Pigeon River for 1937.

Figure 8. Catch per hour of all trout on the North Branch of the Au Sable River for 1937.



Hoover (1937) reported that in one New Hampshire stream fishing declined rapidly during the first month of the open season (May) and "might be described as poor by the end of May at which time only 15 per cent of the 4,000 previously stocked fish had been removed." On the basis of marking experiments, he estimated that of a planting of 2,000 legal-sized brook trout made in June, 70 per cent were removed within three weeks after planting.

It therefore seems evident that in order to keep fishing at a high level in this section of the Pine River, it would be necessary to plant 3,000 legal trout each two weeks during the open season assuming that the angling pressure remains constant. The possibility that smaller plantings would produce as good fishing is being investigated.

To date (June 16, 1938) very few reports of marked trout planted during the 1937 fishing season have been received in the census being conducted this year by trained Departmental employees. This result is in agreement with reports by Cobb (1933), Nesbit and Kitson (1937), Walcott (1938) and Hewitt (1938), all of whom emphasized that legal-sized trout do not winter over successfully.

Migration of plantings. An analysis of the movements of marked fish demonstrates that the large majority of the recoveries of the large-sized fish was made at or relatively near (within one to three miles) the location of planting and usually within two weeks after release. In general, after two weeks, trout planted at any particular point appeared to be rather uniformly distributed over the census section but in considerably diminished numbers. A few individuals were recovered between fifteen and twenty miles from the point of stocking.

"Spot-planted" brook trout moved both up and downstream within the first week's stocking, but even greater movement occurred during the second week. Brook trout planted by boat were reported taken in or above the section in which they were distributed. The one spot planting of rainbows showed a dominant upstream migration which reached a peak during the third week after release. Rainbows distributed by boat also showed a dominant upstream movement.

Greater movement of trout occurred following spot plantings than when the fish were distributed a few in each pool from the planting boat. Boat planting seemed to result mainly in upstream migration. In either method, the general movement of legal-sized trout appeared to be mostly upstream.

Comparison of planting methods. In addition to the effect upon movements after planting, significant differences in the catch resulted from the two methods. As shown by Table 3, spot planting yielded the largest catch from a given number of stocked trout both in brooks and rainbows. In neither fish did the more expensive and difficult method of planting by boat result in a longer improvement in the fishing. In fact, the single spot planting of rainbows influenced the catch for several weeks longer than did boat plantings.

The main objection to spot planting of large trout is that, no matter how secretly done, it leads to "meat fishing" and highly undesirable concentrations of fishermen. In either method trout are caught out rapidly and no particular skill or persistence is required to take the limit in a short time.

Percentage of planted and "wild"[1] fish in the catch. The relative

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[1] This term will be used for fish resulting from natural spawning or previous fingerling plantings.

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contribution to the catch by planted "keepers" and by wild fish is of greatest significance in this investigation. Fortunately a complete record of the fish yield is not required for such a calculation. In the Pine River the planted brook trout made up 46.9 per cent of the number of this species taken by anglers; planted keepers constituted 20.6 per cent of the rainbows caught. Considering the entire take, 33.9 per cent of all trout caught in this section of the Pine River came from legal-sized plantings. On this basis Nature and the "fingerling program" seem to be doing very well in the Pine River and at a fraction of the cost of the "keeper" plantings.

Effect upon the catch of wild trout. The most startling and unexpected result of this investigation has been the establishment of definite proof that planting legal-sized hatchery fish markedly increases the catch of wild fish. Reference to Figures 5 and 6 shows that every planting caused a significant rise in the wild fish curve. All but one of these plantings caused the catch per hour of wild fish to exceed even that of the recently stocked fish! The reality of this relationship is further confirmed by the results of the single planting of rainbow trout in the Pigeon River (Figure 7), although here the rises in catch of hatchery fish and of wild rainbows were delayed one and two weeks respectively. It is interesting to note that only the wild trout of the species planted were affected. This fact suggests

that competition may be keener between individuals of the same species than between the different species of trout.

It is entirely possible and it seems reasonable that planting large numbers of big trout in a stream may increase competition for food and shelter to the point that wild fish are forced to forage more extensively and are caught more rapidly than normal. After all, the supporting capacity as well as the productive capacity of any body of water has definite limitations and unless more "homes" and food can be supplied, a stream cannot support more than a given number of fish. Surber (1936) has shown that doubling the usual plant of fingerling rainbow trout (which he found reached legal size next season) did not result in an increase in the catch the following year.

Conclusions

These findings leave considerable room for speculation but one conclusion appears to be justified, namely, that the consistent planting of a stream with legal-sized trout during the fishing season will eventually lower the number of adult trout of breeding size to a point where the contribution to the catch from natural spawning is seriously impaired. Furthermore this forced drain on the stock of larger trout in a stream means poorer fishing during the following seasons, especially since legal-sized trout planted during one season do not "winter over" with much success. If carried to excess the result would be a stream practically barren of trout except for those planted just prior to and through the season.

As Senator Walcott (1938) has said, planting large numbers of legal-sized trout may be the only solution for a small state with limited mileage of stream, much of which may become too warm for trout in mid-summer and in which suitable breeding grounds or breeding stock are lacking. Planting legal-sized trout may also be justified in the smaller streams of southern Michigan where the demands of fishermen are heavy and the habitat for trout is extremely limited provided the group benefited is willing to pay what it costs to manufacture this substitute for the kind of fishing still available in our northern streams. It would be a financila impossibility to supply such artificial trout fishing to some 300,000 anglers in the 15,000 miles of trout stream in Michigan. Fall planting of large trout in pot hole lakes as described by Eschmeyer (1937) may also prove to be good management inasmuch as the fish appear to winter over successfully in such waters and provide better fishing than do fingerling plantings. Planting keeper trout during the fishing season in waters which are overpopulated with stunted trout as a result of too successful natural reproduction may be desirable, as such plantings should reduce the number of wild breeders and thus allow for better growth of the future progeny.

Planting keeper trout does "pep up the fishing," but apparently this stimulant works the same as morphine in man--there is a drain on the reserve which demands larger and repeated doses. If our conclusions are correct (more exact information will be available at the end of this fishing season), the eventual fate of a stream stocked with large trout would be something like this--few or no legal trout left to breed,

few fish in the stream except those fresh out of the hatcheries and very few if any "lunkers" to provide the thrill anticipated by all trout fishermen while catching the eight to ten inch fish for the pan.

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