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INVESTIGATIONS OF BROWN TROUT IN A PART OF BALDWIN RIVER, LAKE COUNTY, FROM 1953 TO 1956[1]

by

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INTRODUCTION

The present study is concerned with survival, and returns to the angler's creel, of sublegal brown trout of wild and hatchery origin. Previous studies in Michigan (Shetter, 1939; Gowing, 1954) had indicated a relatively low return on plantings of fingerling browns, as well as other species of trout, when planted during the fall in streams. The present study was made on Baldwin River because local fishermen believed that planted browns might do better there than elsewhere.

Experimental fall plantings of sublegal brown trout were made during 1953 and 1954; a study of survival and of creel returns was continued through 1956, and then terminated. The results for 1954 and 1955 were summarized in I. F. R. Reports Nos. 1407 and 1469 (Schultz, 1954 and 1956). The present report summarizes the results for the three years of study, 1954-1956.

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[1]Part of the field work, analysis of data, and preparation of the report were undertaken with Federal Aid to Fish Restoration funds under Dingell-Johnson Project Number F-2-R.

[2]The field crews for the four years consisted of Conservation Department employees and the author. Sixteen Department employees worked on this project at various times.

1953 PLANTING

On October 14, 1953, 1,481 hatchery brown trout fingerlings, averaging 4.5 inches in length, were released in Baldwin River at the Chesapeake and Ohio Railroad bridge (T. 17 N., R. 13 W., Section 15) near Baldwin. They were marked by the removal of the right pelvic and adipose fins. A direct-current shocker collection, covering 2,500 feet of Baldwin River at the release point, was made on June 15, 1954. A total of 61 wild brown trout, 6 fin-clipped brown trout and 17 rainbow trout were captured. It was estimated, at that time, that at least 5 trout escaped for each one that was caught because unfavorable stream conditions made collecting difficult. Heavy rains had decreased the water conductivity, raised the stream level and reduced visibility in the water.

The crew returned to Baldwin River on August 28, 1954, when shocking conditions were greatly improved. At that time 245 wild brown trout, 23 fin-clipped brown trout and 163 rainbow trout were captured.

On October 27 and 28, 1954, two shocker runs, for a population estimate, were made through 1,206 feet of Baldwin River at the release point. The total catch consisted of 157 wild brown trout, 5 fin-clipped brown trout and 106 rainbow trout.

In view of these preliminary results it was decided that a study should be made of comparative survival of hatchery and wild brown trout and that the fish should be tagged rather than fin-clipped.

1954 PLANTING

General procedure of study

A new study was begun in October, 1954. Two sections of Baldwin River were mapped and shocked to obtain population estimates. One section, 1,316 feet long and 1.06 acres in surface area, was at the public fishing site

(T. 17 N., R. 13 W., Section 10) one mile south of Baldwin. This section was dropped from the study because adverse shocking conditions did not permit the capture of a sufficient number of fish to calculate a population estimate.

The other section, 1,206 feet long and with a surface area of 0.91 acre, was located at the Chesapeake and Ohio Railroad bridge (T. 17 N., R. 13 W., Section 15) about two miles south of Baldwin. Study continued in this section through 1956 when the project was terminated.

Following the shocking for population estimates in 1954 (mentioned above), a stretch of Baldwin River about 5 miles long was shocked to obtain sublegal wild brown trout for tagging. This 5-mile stretch extended from the mouth of Baldwin River (2.4 miles downstream from the railroad bridge) upstream to the M-37 highway bridge (2.65 miles above the railroad bridge). The catch of 1,073 fish (mostly 4 to 5 inches) were tagged and released in the study area at the Chesapeake and Ohio Railroad bridge. District Fisheries Supervisor Edward H. Andersen had 1,075 hatchery-reared sublegal brown trout (mostly 4 to 5 inches) tagged and released at the same place. Tag numbers were assigned at random to fish in the two lots.

In June, 1955, the same 5-mile section of Baldwin River was shocked. All brown trout between 4 and 10 inches in length were examined for tags. A record was kept of each tagged fish, including the date of capture, tag number, location of capture, and length of the fish. In September, 1955, two runs were made with a shocker for a population estimate in the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge.

Procedures in 1956 were similar to those of 1955. In June, a run with the shocker was repeated in the river from the mouth of the Baldwin upstream to the M-37 highway bridge; in September, a population estimate was made in the 1,206-foot study area.

Methods

All exploratory runs in the 5-mile stretch of stream were made by a 3-man crew. Two men each held a positive electrode and a scap net for collecting fish. The third man pulled the shocker boat containing the 230-volt, 10.9-ampere, direct-current, gasoline-driven generator. The negative electrode was a metal plate on the bottom of the boat. The man pulling the boat recorded the capture of tagged fish.

The population estimates were made by a 5-man crew using the same equipment. Three men operated the boat and electrodes while the fourth man wore a belly net with a measuring board and carried a fin-clipping shears. All captured trout were placed in the belly net, from which they were identified, measured and part of the dorsal lobe of the caudal fin removed. Tag numbers were recorded at first capture only. The fifth man recorded the information. The crew worked through the 1,206-foot study area in one day. The next day the same section of river was again shocked and records were kept of the previously clipped fish and unclipped fish. All trout captured the second day had a small part of the ventral lobe of the caudal fin clipped to prevent duplication in case a fish was recaptured after being recorded and released. This procedure was carried out over the same mapped section of river each of the three years.

The population estimate for a given year, for a size class of one species, was determined by the following method:

m = number of fish marked on the first run;

x = number of marked fish recovered on the second run;

y = number of unmarked fish captured on the second run.

To calculate the population, the formula was:

$$\text{Population estimate} = \frac{m(x + y)}{x}$$

The 95 percent confidence limits on the estimate were calculated from graphs published by Adams (1951). Estimates (Table 5) were calculated for each size class on the basis of all fish captured, then prorated among the tagged categories according to relative numbers caught.

The area of the 1,206-foot study section was 0.91 acre. The figures on trout population estimates converted to fish per acre are given in Table 4.

Assistance of Dr. Don W. Hayne in the quantitative aspects of the study is acknowledged.

Survival results

The total number of surviving tagged trout cannot be surely known at any time, but the minimum figures based on tag returns are shown in Table 1. Anglers reported catches of 32 tagged hatchery brown trout during 1955, or 3 percent of those released in 1954. One more was reported as caught in 1956. The catch by anglers probably was greater because some fishermen may not have reported the tagged fish they caught. As the trout increased in size during 1955, some lost their tags; none of these fish were reported by anglers. Shocker collections in September, 1955, showed that 33 percent of the marked fish captured had lost tags by that time. By June of 1956, 66 percent may be calculated to have lost tags. Assuming that such fish were caught and not reported, the total minimum catch by anglers, for the two years, can be increased to 51 hatchery fish or a return of 4.7 percent. A similar calculation for tagged wild fish suggests a return of 4.6 percent.

Of 63 tagged trout reported by anglers, only 2 fish were caught outside the 5-mile section of Baldwin River that was shocked each year. One trout was of hatchery origin and the other wild. Both were caught in the Pere Marquette River downstream from the study area. The number of recaptures of

Table 1.--Numbers of tagged sublegal brown trout released for present study, numbers recovered by shocker and by anglers, and ratio of wild trout to hatchery trout among the recoveries, Baldwin River, 1954-1956

	Date	Area[1] covered	Tagged trout		Fish[2] that lost tags	Ratio: Hatchery trout per wild trout
			Hatchery	Wild		
Original release	Oct. - Nov. 1954	Study area	1,075	1,073	...	1.00
Shocker recaptures	June, 1955	River	18	39	0	0.46
	Sept., 1955	Study area	12	56	38	0.21
	June, 1956	River	2	9	21	0.22
	Sept., 1956	Study area	0	0	...	....
Angler[3] returns	Summer, 1955	River	32	27	...	1.18
	Summer, 1956	River	1	3	...	0.33

[1] The areas are the study section, 1,206 feet long, at the Chesapeake and Ohio Railroad bridge, and the Baldwin River from its mouth at the Pere Marquette River to the M-37 highway bridge 5 miles upstream.

[2] These fish were examined by the crew while shocking, and each had a broken mandible where the tag had been attached.

[3] Theoretical considerations do not allow direct comparison of the two sets of ratios.

tagged fish was highest near the release point and decreased rapidly both up- and downstream from that area. From this it was concluded that most of the tagged hatchery and wild trout (i.e., the survivors) remained in the 5-mile study section of Baldwin River.

Something about the comparative survival rates of hatchery and wild fish may be inferred from the change in the numerical ratio of hatchery to wild fish among fish taken by shocker and by anglers (see Table 1). A continuous decrease in this ratio during the first year implies better survival for wild fish, and the few returns after the first year suggest an equal rate of survival from that time onward. Both natural mortality and that which resulted from angling were involved. The ratio of hatchery to wild fish at the time of release (October and November, 1954) was 1 to 1. Tag returns from shocking in June, 1955, showed that twice as many wild trout as hatchery trout (assuming equal susceptibility to shocking) survived the previous winter and spring--a single run with the shocker captured 18 hatchery and 39 wild tagged trout. By September this ratio had changed to one hatchery fish to 5 wild trout, calculated from the capture of 12 hatchery and 56 wild tagged trout. Part of the difference in mortality is explained by tag returns from anglers. Those returns show that anglers caught 1.2 hatchery fish for each wild trout while there were between 2 and 5 wild trout for each hatchery trout in the river. That portion of the greater mortality of hatchery fish which ends up in the angler's creel is, of course, not a net loss so far as trout management is concerned. But the greater catchability of hatchery trout would not account for most of the differential mortality, judging from the relatively few recoveries of tagged trout reported by anglers. A shocker collection of 11 tagged fish in June of 1956 showed the same survival ratio as that of the preceding September--0.22 to 1.0. Possibly after one year in the river the few hatchery fish left can survive as well as wild trout.

Population estimates

Population estimates were calculated for each of the three years--1954, 1955 and 1956. The 95 percent confidence limits were calculated for each estimate, as shown in Tables 2, 3 and 4. Shocking conditions affecting the collecting, such as depth, temperature and conductivity of the river water, may have caused variations beyond the confidence limits. The spawning movement of brown trout and low water temperatures during the late shocking date in October, 1954, probably exerted a strong influence on the estimate of that date. The 1955 and 1956 collections were made in early September.

Table 2 gives the calculations and population estimates by size classes for brown trout for each of the three years. Table 3 gives the same information for wild rainbow trout. Rainbow trout were not considered in the survival study, but were included in the estimates because of their possible competition with brown trout for food and space. Table 4 gives the population estimates of both species in terms of trout per surface acre of water in the study area.

The extent to which the hatchery trout added to the population of resident brown trout, during the fall of 1955 (one year after release), is shown in Table 5. The number of hatchery trout in the study area was determined from the population estimates. In this analysis, those tagged wild brown trout which had been imported from outside the 1,206-foot study area are excluded, so that the figures would depict fairly the extent to which hatchery fish supplemented the resident population. The tagged hatchery trout were all within the size range of 5.9 to 9.9 inches. In the fall of 1955, one year after release, these hatchery browns made up 4.3 percent of the population of brown trout of all sizes, 10.4 percent of the population of legal-size

Table 2.--Summary of population estimates[1] of brown trout (wild plus hatchery) in the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge, Baldwin River, 1954, 1955 and 1956

Size class (inches)	m	x	x + y	Population estimate	95 percent confidence limits of estimate	
October, 1954						
2.0 - 6.9	57	14	78	318	238	407
7.0 - 9.9	7	2	11	39	20	70
10.0+	8	1	18	144	73	400
Totals	72	17	107	501	...	...
September, 1955						
2.0 - 6.9	186	75	185	459[2]	388	581
7.0 - 9.9	89	51	113	197[3]	168	262
10.0+	15	7	12	26	18	50
Totals	290	133	310	682[4]	...	...
September, 1956						
2.0 - 6.9	54	17	40	127	104	159
7.0 - 9.9	54	23	53	124	102	154
10.0+	16	10	14	22	18	33
Totals	124	50	107	273	...	...

[1] For explanation of symbols and for method, see text (page 4).

[2] Includes 40 tagged trout.

[3] Includes 105 tagged trout.

[4] Includes 145 tagged trout.

Table 3.--Summary of population estimates[1] of wild rainbow trout in the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge Baldwin River, 1954, 1955 and 1956

Size class (inches)	m	x	x + y	Population estimate	95 percent confidence limits of estimate	
October, 1954						
1.0 - 6.9	53	17	66	206	161	265
7.0 +	2[2]	0	2	4[3]	...	...
Totals	55	17	68	210	...	...
September, 1955						
1.0 - 6.9	344	121	346	984	839	1,147
7.0 - 9.9	8	4	8	16	11	33
Totals	352	125	354	1,000	...	...
September, 1956						
1.0 - 6.9	390	86	444	2,010	1,773	2,167
7.0 - 9.9	10	4	20	50	23	133
Totals	400	90	464	2,060	...	...

[1] For explanation of symbols and for method, see text (page 4).

[2] Includes 1 rainbow trout 23 inches long.

[3] The total number of fish handled is given because lack of recaptures made an estimate impossible.

Table 4.--Estimated number of trout per surface acre of water in the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge, Baldwin River, 1954, 1955 and 1956

Year	2.0" - 6.9"			7.0" - 9.9"			10.0" +			Total fish in estimate
	Estimate	95 percent confidence limits		Estimate	95 percent confidence limits		Estimate	95 percent confidence limits		
Brown trout										
1954	349	262	447	43	22	77	158	80	440	551
1955	504[1]	426	638	216[2]	185	288	29	20	55	749[3]
1956	140	114	175	136	112	169	24	20	36	300
Rainbow trout										
1954	226	177	291	4	...	...	...	...	...	230
1955	1,081	922	1,260	18	12	36	...	...	...	1,099
1956	2,209	1,948	2,381	55	25	146	...	...	...	2,264

[1] Includes 44 tagged trout, 34 of wild origin and 10 from the hatchery.

[2] Includes 116 tagged trout, 98 of wild origin and 18 from the hatchery.

[3] Includes 160 tagged trout, 132 of wild origin and 28 from the hatchery.

Table 5.--Population estimates of resident wild brown trout, imported wild brown trout, and hatchery brown trout in the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge, Baldwin River, September, 1955

Size class (inches)	Origin of trout			Percentage of hatchery fish in trout population[1]
	Resident wild	Imported wild	Tagged hatchery	
2.0 - 6.9	421	29	9	2.1
7.0 - 9.9	112	69	16	12.5
10.0 +	26	0	0	0.0[2]
Total	559	98	25	4.3

[1] Excluding imported wild fish.

[2] The percentage of legal-length hatchery fish in the population of legal-length trout, 7 inches and larger, was 10.4.

fish, and 16.4 percent of the population of brown trout within the size range of 5.9 to 9.9 inches. In terms of contribution made by the hatchery fish, the 16.4 percent figure is probably the most significant.

In the fall of 1956, two years after the release, no tagged trout, either hatchery or wild, were captured in the study area during the two checks made with the shocker for the population estimates. There is a possibility that some surviving fish may have escaped the shocker. An upper reasonable limit to the number of tagged fish present may be set as follows (as suggested by Dr. Hayne). During 1955, of 290 fish marked on the first shocker run, 133 (46%) were recovered on the second run; and during 1956, of 124 marked fish, 50 (40%) were recovered on the second run. It thus appears that about 45 percent of the fish in the stream were taken with one run of the shocker. Therefore, the escape probability for one run would be 0.55. How many could be present so that the probability of all escaping both runs would be 0.05 (accepted as the threshold value for an unlikely event)? The answer, where n is the number of fish, is:

$$(0.55^2)^n = 0.05$$

$$2n \log 0.55 = \log 0.05$$

$$2n(-0.259) = -1.301$$

$$n = 2.5 \text{ fish}$$

Thus, assuming that shocking conditions were similar to those of the previous year, the population of tagged fish present during the fall of 1956 was not likely to have been in excess of 3 fish in the study area. As to the assumption that shocking conditions were similar during 1955 and 1956, conditions appeared to the field party to be similar, and the close agreement of recapture percentages (46% and 40%) for the two years indicates that shocker efficiency was about the same.

The almost complete disappearance of 2,148 fingerling brown trout (half hatchery, half wild) within 2 years time would seem to require some special explanation. The river supports a good population of browns, hence is a good habitat for the species. A high mortality rate of something over 75 percent might be normal for fish during 2 years beyond the fingerling size, but "normal" rate of mortality would not alone account for almost complete disappearance. The handicap of carrying jaw tags may have been a contributing factor.

Growth rate

The use of individually numbered tags enabled comparison of the rate of growth of the two categories of tagged fish and untagged wild trout. The ages of the untagged wild fish were determined from scale samples taken from 89 specimens. A comparison of the averaged lengths by age class showed that the tagged trout had grown less than the untagged trout (Table 6). The averaged lengths of the tagged fish, 6.4 inches for the 17 hatchery trout and 6.8 for the 39 wild trout, captured with the shocker in June, 1955, indicates that most of them were of sublegal size. A total of 45 untagged wild brown trout in the same age group, I, taken at the same time, averaged 7.5 inches in length. Only 8 of the untagged trout were less than 7 inches in length. Table 6 also shows that angling selected the faster growing tagged fish.

Homing tendency and dispersion

The present analysis of migration is based on tagged fish caught and reported by anglers, and on fish taken by shocker in single "runs" through the 5-mile stretch of river. Fish taken by shocker from the 1,206-foot study area, during population estimates, are not included because such records would complicate and bias the analysis.

Table 6.--Numbers and lengths in inches of tagged wild and hatchery trout (age 0) released during 1954 in the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge, Baldwin River, and numbers recovered during 1955-1956 with shocker and by anglers, with data on age and length at time of release and recapture

Origin of trout, and method of recovery	Total number of fish	Length at age 0 when released		Recaptured at age I				Recaptured at age II	
				May and June		July, Aug. and Sept.			
		Average length	Standard error	Average length	Standard error	Average length	Standard error	Average length	Standard error
Wild trout tagged in 1954	1,073	4.78	0.02	...	...	...	...	...	...
Hatchery trout tagged in 1954	1,075	4.51	0.02	...	...	...	...	...	...
Tagged wild trout caught with shocker	39	4.90	0.10	6.80	0.11	...	...	...	...
	56	4.88	0.08	...	...	7.60	0.10	...	...
	8	4.93	0.19	...	...	...	...	9.63	0.18
Tagged wild trout caught by anglers	18	5.17	0.10	7.00	0.23	...	...	...	...
	6	5.30	0.19	...	...	8.20	0.23	...	...
	3	5.23	0.27	...	...	...	...	9.50	0.27
Tagged hatchery trout caught with shocker	17	4.39	0.10	6.42	0.12	...	...	...	...
	12	4.43	0.18	...	...	7.25	0.16	...	...
	2	5.70	0.00	...	...	...	...	9.90	0.25
Tagged hatchery trout caught by anglers	15	5.24	0.15	7.36	0.24	...	...	...	...
	14	4.86	0.18	...	...	7.57	0.14	...	...
	1	5.40	...	...	...	...	...	11.00	...
Untagged wild trout caught with shocker June 1955	45	...	...	7.49	0.10	...	...	...	...
	28	...	...	...	...	...	...	10.93	0.14

The locations of all recaptures of tagged fish made with the shocker were known, and in most cases the place of capture was known for the tagged fish caught by anglers. The place of original capture of each wild fish had been recorded when it was tagged, and that location was designated as the fish's home site. All fish were released in the 1,206-foot study area at the railroad bridge. From these records the direction and distance of travel after release was determined for 76 wild and 51 hatchery trout which were recaptured (Table 7).

Of 26 wild trout originally captured downstream from the study section, 16 were recaptured in the study section where they had been released. Only 1 was recaptured upstream of the release point and only 1 was taken downstream from its home site. The remaining 8 fish were shocked at their home sites.

Of wild trout which were originally caught upstream from the release point, recaptures numbered 38. Downstream recaptures totaled 7, while 11 remained at the release point. Upstream of the release point 10 trout were shocked at their home sites and another 10 were recaptured between their home sites and the point of release.

A group of 12 trout which were recaptured had the study area for a home site; 5 of them remained there, 1 trout went downstream, and 6 went upstream.

In summary, of the 76 tagged wild trout which were recaptured, nearly half of them (32) had remained for 6 to 20 months in the 1,206-foot section at the railroad bridge where they had been released. Among the 44 fish which had migrated beyond this release section, there was a marked tendency for migration (either downstream or upstream) toward the home site from which these fish had been collected originally.

Home site has no meaning for the hatchery fish, so only the direction of travel was noted. Of 51 recaptures, 27 were taken in the study area where they

Table 7.--Movement of tagged brown trout in Baldwin River from the 1,206-foot study area at the Chesapeake and Ohio Railroad bridge (where fish were released), analyzed according to location of original capture. Fish were released during 1954; most recaptures were made in 1955; recaptures made during 1956 are given in parentheses. Recaptures made by shocker in the 1,206-foot study area during population estimates are not included

Location of original capture of fish (i.e., home site)	Point of recapture						
	Movement downstream			R. R. bridge (Point of release)	Movement upstream		
	Below home site	At home site	Above home site		Below home site	At home site	Above home site
Downstream from railroad bridge	1	6 (2)	..	13 (3)	..	..	1
At railroad bridge	.. (1)	..	..	4 (1)	..	..	5 (1)
Upstream from railroad bridge	7	..	..	11	10	6 (4)	..
Hatchery fish[1]	7 (1)	..	..	26 (1)	..	..	15 (1)

[1] Home site has no meaning for the fish of hatchery origin, so only direction of travel from the release point is indicated.

had been released, 8 went downstream, and 16 went upstream. One hatchery trout was recaptured by an angler in the Pere Marquette River 4.7 miles downstream from the study area.

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