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EFFECTS OF MARKS UPON THE GROWTH, SURVIVAL, AND EXPLOITATION OF HATCHERY RAINBOW TROUT FINGERLINGS PLANTED IN HUNT CREEK, MONTMORENCY COUNTY, MICHIGAN [1]

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Abstract

Approximately equal numbers (995 to 1,000) of jaw-tagged, fin-clipped, and unmarked rainbow trout fingerlings were planted in experimental sections of Hunt Creek in October, 1952. Observations on these fish during 1952-1957 provided data on the effects of marking on growth, survival, and angler exploitation.

Jaw-tagged fish grew more slowly than did either the fin-clipped or unmarked fish; differences in growth increments were between 0.15 and 0.45 inch over a 2-year period. There was little difference in growth between fin-clipped and normal fish. Relatively few rainbow trout attempted to migrate, and no difference in extent of attempted migration was detected between marked and unmarked fish.

There was no significant difference in angler exploitation rates among the three groups of fish in any 1 year, but the 5-year totals for the three groups showed highly significant differences. Tagged, fin-clipped, and normal rainbow trout were caught in increasing numbers, in that order.

Calculations of instantaneous mortality percentages indicated that significantly more tagged fish than normal fish were lost to causes other than fishing, and that fin-clipped fish were intermediate in this regard.

The superimposition of 3,000 rainbow trout fingerlings on the Hunt Creek brook trout population in 1.75 miles of stream did not noticeably affect either the brook trout population or the brook trout angling during the 5 years involved.

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Many investigators have used marked fish to obtain information on growth, survival, movements, exploitation rates, and other aspects of fishery biology. Typically, results are based on examination of fish recaptured at various intervals of time after their release. In many studies the possibility of adverse effects from the marking was not determined. In this study I found that the attachment of jaw tags to fingerling rainbow trout retarded their growth and had related effects, but fin-clipping had little effect on the fish.

Methods

Hunt Creek is located in the north-central part of Michigan's lower peninsula. It supports a good population of wild brook trout, Salvelinus fontinalis. The physical characteristics of the stream were reported by Shetter and Leonard (1943). Throughout the present study, blocking weirs at the lower end of Section Z and the upper end of Section C prevented unrecorded emigration of trout from the experimental area during most of the year (Fig. 1). Thus it was possible to keep a continuous, long-time record on the experimental fish.

Rainbow trout (Salmo gairdneri) fingerlings from the state fish hatchery at Oden, Michigan were used as experimental fish. The 3,000 test fish were planted on October 22, 1952. One-third of them were tagged with fingerling-size (#1) Monel metal jaw tags,[2] one-third were fin-clipped by removal of the adipose and right pectoral fins with sharp

[2] The tags, when flattened, measured 20 x 2 mm and weighed 0.16 g. They were manufactured by the National Band and Tag Company, Newport, Kentucky.

manicure scissors, and one-third served as unmarked controls. The fish were hand-counted and 10% of each group were measured to determine the average lengths at time of planting. No rainbow trout were present in Hunt Creek at the time the test fish were introduced. Since the introduced fish did not spawn until the spring of 1955, positive recognition of the experimental rainbow trout of all groups was possible at all times.

The fate of the three groups of rainbow trout was followed by (1) sampling with electrofishing gear in November and December, 1952 and April, 1953; (2) modified Petersen estimates of the population by size groups each fall from 1953 through 1957; (3) a complete creel census on the test stream area; and (4) almost daily weir inspections from October 1952 through October 1956.

Results

Growth

Survivors from each lot of rainbow trout were measured on seven occasions. The numbers measured and the average total lengths, with standard errors for each group, are given in Table 1. At any one examination, average differences between groups ranged from 0.1 inch to as much as 5.5 inches. In the following analysis of differences by the "student" t test, a probability of 0.05 of a difference as large or larger than that observed is regarded as significant.

At planting time in October 1952, the tagged group averaged 3.95 inches in total length, a little longer than those in the other groups (3.75 and 3.74 inches). This difference was statistically significant. In November 1952, 3 weeks after release, almost one-half of the fish planted were measured again after capture during one "run" with electrofishing gear. Tagged fish were still significantly longer (4.16 inches) than either the fin-clipped (4.02 inches) or unmarked rainbow trout (3.66 inches). The average length of the fin-clipped fish also was significantly greater than that of the unmarked group, but no biological importance is attached to what is believed to be chance sampling. The same differences between groups occurred among fish collected in December 1952 and April 1953, but not in September 1953. By then tagged fish were slightly smaller, on the average, than fin-clipped and normal trout, and their growth was slower thereafter. Fin-clipped and normal trout differed little in average total length up to September 1954. Subsequently the observed average differences were not assessable because of small sample size.

Average growth increments for three periods between October 1952 and September 1954 also were compared--periods in which there were more than 10 specimens available for measurement. The average increments, in inches, were as follows (data derived from Table 1, number of fish in parentheses):

Period	Average growth increment		
	Tagged	Fin-clipped	Unmarked
October 1952-April 1953	0.68(267)	0.77(286)	0.70(243)
April 1953-September 1953	1.38(101)	1.81(123)	1.83(149)
September 1953-September 1954	1.91(13)	2.33(13)	2.06(13)

Although it cannot be supported by statistical tests, the evidence still suggests that tagged fish had smaller average growth increments than either unmarked or fin-clipped fish. After the first 6 months in the stream, the average growth increments of tagged fish in any one period was 0.1 to 0.4 inch less than that of fish in the other groups. There was little difference in growth increments between unmarked and fin-clipped fish up to September 1953. After that time, too few specimens were measured to permit meaningful comparison.

Starting with the angling season in late April 1953, anglers began creeling those fish which reached the minimum legal length of 7.0 inches. This removal probably depressed the September average sizes in all years because a noticeable fraction of the larger rainbow trout were creeled. The numbers and lengths of rainbow trout in the

test groups which were removed by angling during 1953, 1954, and 1955 are given in Table 2. Differences in average total lengths between the three groups were subjected to the "student" t test. There were no significant differences between groups caught in 1953, but unmarked fish creeled in 1954 were significantly longer than tagged fish. Among the relatively few recaptures in 1955, the unmarked fish were significantly longer than tagged fish and fin-clipped fish probably were longer than tagged fish ($.05 < P < .10$). Other differences were not significant.

It was concluded that the presence of fingerling-size jaw tags on rainbow trout 2.5-5.0 inches long when released reduced their growth rate during the following 2 years (the time period during which an adequate number of specimens were measured). Based on measurements available from the creel census (the largest samples), captured unmarked rainbow trout grew 0.28 inch more than tagged fish and 0.12 inch more than fin-clipped fish by September 1954. These calculations do not take into account the small but pertinent differences in length at planting time nor the variation in capture dates during the trout seasons. Differences in rate of growth between normal and fin-clipped rainbow trout did not appear to be of significant proportions.

Movement

A small number of rainbow trout attempted to migrate downstream out of the study area, especially between October 1952 and March 1953, but none were permitted to leave until October 1953;

fish taken in the downstream traps were simply released back upstream. Starting in October 1953, test fish attempting to leave the test waters were liberated downstream and their numbers were recorded. This migration consisted of 1 to 6 fish per month from October to March, 28 in April, 37 in May, and a few fish in 1955. Between October 1953 and September 1954, the downstream escapement amounted to 25 tagged fish, 21 fin-clipped fish, and 39 unmarked fish. A Chi-square test indicated that these numbers did not differ significantly from a 1:1:1 ratio.

The small observed mortality among these test fish plus the migration records (Fig. 2) provided some assurance that observed mortality and migration patterns were similar for the three groups of fish.

Records of capture and recapture sites listed during the electrofishing of November and December 1952 and April 1953 indicated that, for the first 6 months in the stream, a high fraction of the tagged fish were sedentary. In November, the capture sites in Sections Z, A, B and C for 196 tagged fish were recorded. In December, 112 of these 196 fish were recaptured and 106 (95%) were in the same 1-mile stream section as in November. The other 6 had moved less than 1,500 feet downstream. In April 1953, 46 of 56 recaptures (82%) were in the same section as in November. Of the rest, 1 had moved upstream about 300 yards, 8 had moved downstream less than 1/4 mile, and 1 was recaptured about 1.5 miles downstream.

Of 287 rainbow trout captured by anglers during 1953, 1954, and 1955, all but 3 were taken in the experimental sections. Two unmarked fish and one fin-clipped specimen were caught a short distance upstream in Fuller Creek, the main tributary on the area.

The attempted emigration by some of the test fish in the months immediately following release is believed to be the result of superimposing a population of fingerling rainbow trout on a fairly dense, native population of brook trout (see Table 6).

Exploitation by angling

Many of the rainbow trout grew to the minimum legal length of 7.0 inches during the 1953 trout season and were captured that year as well as during the following four seasons. The total catches are listed in Table 3. Also shown are the numbers of tagged, fin-clipped, and normal rainbow trout longer than 7.0 inches estimated to be present each year in September 1953, 1954, and 1955.

The estimated numbers of legal rainbow trout available to anglers in 1954 and 1955 included those that were liberated through the weirs during the trout season. The percentage of exploitation was obtained by dividing the anglers' catch by the estimated available population of legal-size trout (Table 3).

Annual exploitation rates for each group from 1953 to 1955 (when adequate numbers of recaptures were observed) were subjected to a 3 x 2 Chi-square test (Snedecor, 1956). No statistically significant differences between experimental groups for any single year can be demonstrated.

However, when the total data for 1953 to 1957 were tested similarly (assuming that by 1957 all experimental fish would have reached the minimum legal size had they survived) highly significant differences in percentages of recapture between experimental groups were found (Chi-square = 40.5, 2 d.f. $P < 0.005$). Over a 5-year period, after release of almost identical numbers of rainbow trout fingerlings, anglers caught 53 (5.3%) tagged rainbow trout, 103 (10.3%) fin-clipped fish, and 131 (13.1%) normal rainbow trout.

A 2 x 2 Chi-square test was used to compare the catch of tagged fish with normal and fin-clipped fish. Anglers recovered significantly fewer tagged than fin-clipped fish (Chi-square 16.42, $P < 0.01$), and the difference between the catch of tagged and normal trout was even greater. Of those fish calculated to be available in 1953, 1954, and 1955 a slightly higher proportion of fin-clipped fish were caught than normal fish.

Survival

A detailed tabulation of known mortality and the numbers of fish in each category surviving to September of each year is given in Table 4. The difference between the sum of the known losses and the population calculated to be present the preceding fall was recorded as unobserved mortality.

Respective losses of tagged, fin-clipped, and normal rainbow trout over the 5 years due to angling and migration amounted to 7.8, 12.6, and 17.2% of the total number originally planted. Mortality of various other kinds removed 92.2, 87.4, and 82.8% respectively.

The mortalities among the three groups listed at the bottom of Table 4 were subjected to Chi-square tests. The 3 x 2 test indicated highly significant differences existed between groups (Chi-square, 39.3, 2 d.f., $P < 0.01$). Further 2 x 2 tests between groups demonstrated the following highly significant differences ($P < 0.01$, 1 d.f.):

(1) more tagged fish died than either fin-clipped fish (Chi-square, 11.75) or normal fish (Chi-square, 38.9);

(2) more fin-clipped fish died than normal fish (Chi-square, 7.98).

Also, similar tests for the mortality fractions noted for the October 1952-September 1953 period yielded the same results.

Utilizing the data of Table 4, annual instantaneous mortality percentages were computed for each group of fish using Ricker's (1958) method. All natural and unobserved mortalities were considered as "natural" mortality (q); angler-caught fish and recorded migrants were grouped under "fishing" mortality (p).

The data in Table 5 show that during the first 2 years after planting, when there were reasonably adequate numbers of all three test groups of fish in the stream, instantaneous natural mortality percentages were greater (and instantaneous fishing mortality percentages were smaller) for tagged fish than for the others. The reverse was true for normal fish, whereas the rates for fin-clipped fish were intermediate.

Rainbow trout-brook trout relationship

Did the presence of stocked rainbow trout affect the size of the population of native brook trout or the brook trout fishing adversely? The data in Table 6 suggest neither were affected. Estimates of the total fall populations of brook trout were lower during 1949-1952 than during 1953-1957 (when rainbow trout were present). Similarly, the average annual catch of wild brook trout was lower during 1949-1952 than during 1953-1957.

Despite wide variations in angling pressure it can be shown that the average catch per hour of 0.415 brook trout during 1949-1952 was not significantly different than during 1953-1957 when the average catch per hour of brook trout was 0.406 ($P > 0.81$).

A correlation test was performed on the number of "available" rainbow trout (annual catch plus estimated fall population) each year and the yearly catch of wild brook trout (Table 6) for the 1953-1957 period. A non-significant correlation was found ($r = -0.543$, 3 d.f., $t = 1.118$, $P > 0.30$). It was concluded that the presence of the planted rainbow trout (of the densities dealt with here) during 1953-1957 did not adversely affect either the angling or the populations of brook trout in Sections Z, A, B, and C of Hunt Creek.

Discussion

The presence of the fingerling jaw tags on rainbow trout of the size dealt with here (which were smaller at tagging than reported elsewhere in the literature) retarded the growth of tagged fish by a small but measurable amount. Conventional statistical comparisons are negated by the fact that the three test groups differed in average total length when planted. The best judgment as to the effect of the tag on growth is based on a comparison of growth increments, even though these cannot be tested statistically. The best evidence (from angler-caught fish in 1954) suggests that the tagged rainbow trout had grown about 0.3 inch less than the normal trout up to September 1954. Fin-clipped fish seemed to grow at about the same rate as unmarked fish.

Because of slower growth, tagged fish were not subjected to angler harvest as soon as unmarked fish and were thus exposed to various other forms of mortality (hooking loss, predation) for a longer time than were unmarked rainbow trout. Also, some tags were undoubtedly lost because of erosion and/or jaw growth after the first year, as pointed out by Stauffer and Hansen (1966, unpublished).[3] Calculations of instantaneous percentages of fishing and natural mortalities tended to confirm these relationships, and it was noted that tagged and fin-clipped fish had higher percentages of instantaneous natural mortality than did normal fish.

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[3] Stauffer, Thomas M., and Martin J. Hansen. 1966. Marks for rainbow trout. Michigan Department of Conservation Research and Development Report No. 78.

The findings suggested by these data are similar to those reported by Schuck (1942) for brown trout, and Cooper (1953) who compared angling returns from tagged and fin-clipped brook and rainbow trout. These results, however, should not deter the investigator from the use of marked fish in his experiments. Rather, he should be aware of possible sources of bias, and either offset them experimentally or interpret his results accordingly.

Acknowledgments

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INSTITUTE FOR FISHERIES RESEARCH

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Table 1.--Average total lengths (in inches) of tagged, fin-clipped and unmarked rainbow trout collected by d-c shocker in Hunt Creek on various dates, 1952-1955

Mark and date	Number of fish	Average total length	Standard error
Tagged			
October 20, 1952	100	3.95	0.054
November 6-10, 1952	552	4.16	0.025
December 2-8, 1952	450	4.15	0.028
April 20-21, 1953	267	4.63	0.042
September, 1953	101	6.01	0.102
September, 1954	13	7.92	0.371
September, 1955	2	8.40	0.200
Fin-clipped			
October 20, 1952	100	3.75	0.048
November 6-10, 1952	481	4.02	0.027
December 2-8, 1952	412	4.05	0.031
April 20, 21, 1953	286	4.52	0.042
September, 1953	123	6.33	0.095
September, 1954	13	8.66	0.266
September, 1955	1	13.90	-
Unmarked			
October 20, 1952	100	3.74	0.053
November 6-10, 1952	480	3.66	0.048
December 2-8, 1952	404	3.90	0.031
April 20, 21, 1953	243	4.44	0.044
September, 1953	149	6.27	0.085
September, 1954	13	8.33	0.419
September, 1955	4	11.62	0.990

Table 2. --Average total length (in inches) of angler-caught rainbow trout taken from Hunt Creek experimental waters during the 1953, 1954, and 1955 trout seasons

Mark and season	Number	Total length		
		Average	Range	Standard error
Tagged fish				
1953	13	7.4	6.7- 8.1	0.167
1954	34	8.0	7.0- 9.4	0.124
1955	6	9.4	8.1-10.2	0.313
Fin-clipped fish				
1953	33	7.4	6.8- 8.9	0.075
1954	66	8.2	7.1-11.5	0.113
1955	4	10.3	9.7-10.9	0.333
Unmarked fish				
1953	41	7.4	7.0- 8.4	0.056
1954	86	8.3	7.0-11.0	0.098
1955	2	10.9	10.5-11.3	0.400

Table 3.--The numbers of legal rainbow trout in each experimental lot that were available and caught in 1953, 1954, and 1955

Season and item	Tagged fish	Fin-clipped fish	Normal fish	Totals, all fish	Chi-square (2 d.f.)
1953					
Available	43	79	109	231	
Creeled	13[a]	33[b]	41	87	
Not creeled	30	46	68	144	1.578
Percentage exploitation	30.2	41.8	37.6	37.7	
1954					
Available	60	93	127	280	
Creeled	34	66	86	186	
Not creeled	26	27	41	94	3.519
Percentage exploitation	56.7	71.0	67.7	66.4	
1955					
Available	9	5	7	21	
Creeled	6	4	2	12	
Not creeled	3	1	5	9	3.730
Percentage exploitation	66.7	80.0	28.6	57.1	
Totals					
Number planted	995	1,000	1,000	2,995	
Creeled	53	103	131[c]	287	
Not creeled	942	897	869	2,708	35.6[d]
Percentage recovery	5.3	10.3	13.1	10.6	

[a] Includes four 6.6-6.9-inch fish creeled.

[b] Includes one 6.9-inch fish creeled.

[c] Includes one fish creeled in both 1956 and 1957.

[d] Significant at the 1% level.

Table 4.--Annual estimates of the number of surviving experimental rainbow trout, and the number of deaths from various causes in Sections Z, A, B and C, Hunt Creek, October, 1952-September, 1957

Item	Tagged		Fin-clipped		Normal	
	Alive	Dead	Alive	Dead	Alive	Dead
Oct. 1952-Sept. 1953						
Planted Oct. 22, 1952	995		1,000		1,000	
Observed deaths [a]		37		26		15
Stomach collections		-		7		5
Escaped downstream		-		2		1
Unobserved deaths		782		753		722
Creeled		13		33		41
Population estimate, September	163		179		216	
Oct. 1953-Sept. 1954						
Observed deaths		4		1		2
Moved downstream		25		21		39
Unobserved deaths		82		75		69
Creeled		34		66		86
Population estimate, September	18		16		20	
Oct. 1954-Sept. 1955						
Observed deaths		-		-		-
Moved downstream		-		-		1
Unobserved deaths		9		11		12
Creeled		6		4		2
Population estimate, September	3		1		5	
Oct. 1955-Sept. 1956						
Observed deaths		-		-		-
Unobserved deaths		1		1		2
Creeled		-		-		1
Population estimate, September	2		0		2	

(continued, next page)

Table 4.--concluded.

Item	Tagged		Fin-clipped		Normal	
	Alive	Dead	Alive	Dead	Alive	Dead
Oct. 1956-Sept. 1957						
Observed deaths		-		-		-
Unobserved deaths		1		-		1
Creeled		-		-		1
Population estimate, September	1				0	
Totals						
Observed deaths		41		34[b]		22[b]
Migrants		25		23		41
Unobserved deaths		875		840		806
Creeled		53		103		131

[a] Dead fish found in weirs, along the stream, and brought in by anglers.

[b] Includes fish killed for stomach samples.

Table 5.--Instantaneous mortality rates and survival percentages for tagged, fin-clipped, and normal hatchery-reared rainbow trout, 1952-1955

Time period, item[a]	Rates			Percentage of instantaneous mortality		
	Tagged	Fin-clipped	Normal	Tagged	Fin-clipped	Normal
Oct. 1952 - Sept. 1953						
i	-1.808	-1.720	-1.532	83.6	82.1	78.4
q	-1.779	-1.646	-1.449	83.1	80.7	76.5
p	-0.029	-0.074	-0.083	2.9	7.1	8.0
Percentage survival	16.4	17.9	21.6			
Oct. 1953 - Sept. 1954						
i	-2.207	-2.419	-2.375	89.0	91.1	90.8
q	-1.309	-1.127	-0.860	73.0	67.6	57.7
p	-0.898	-1.292	-1.515	59.2	72.5	78.0
Percentage survival	11.0	8.9	9.2			
Oct. 1954 - Sept. 1955						
i	-1.790	-2.781	-1.386	83.3	93.8	75.0
q	-1.074	-2.038	-1.109	65.8	87.0	67.0
p	-0.716	-0.743	-0.277	51.1	52.3	24.2
Percentage survival	16.7	6.2	25.0			

[a] i = total mortality; q = natural mortality; p = fishing mortality.

Table 6.--Yearly angling pressure in hours, catch, catch per hour, and estimated fall populations of brook and rainbow trout, Sections Z, A, B, and C of Hunt Creek, 1949-1957 inclusive

Year	Hours of angling	Total legal catch		Catch per hour		Fall population estimate	
		Brook trout	Rainbow trout	Brook trout	Rainbow trout	Brook trout	Rainbow trout
1949	773	361	-	0.47	-	6,216	-
1950	890	326	-	0.36	-	6,405	-
1951	888	349	-	0.39	-	6,392	-
1952	1,163	515	-	0.44	-	7,027	-
1953	1,304	418	87	0.32	0.06	7,172	558
1954	1,848	427	186	0.23	0.10	8,602	54
1955	1,251	556	12	0.44	0.01	6,889	91
1956	1,171	666	1	0.56	0.00+	6,848	136
1957	996	482	1	0.48	0.00+	8,431	40

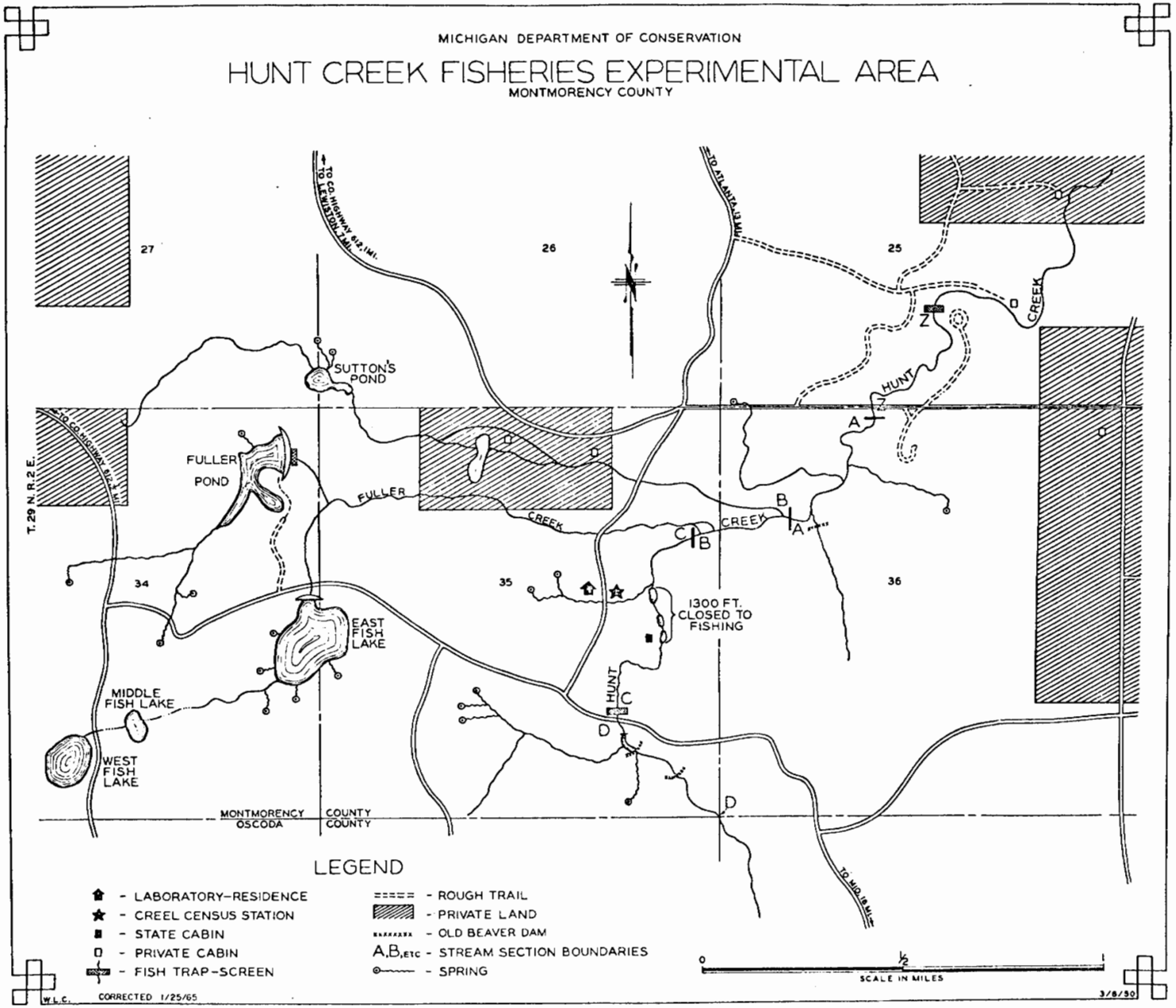

Figure 1. --Map of the Hunt Creek Trout Research Station

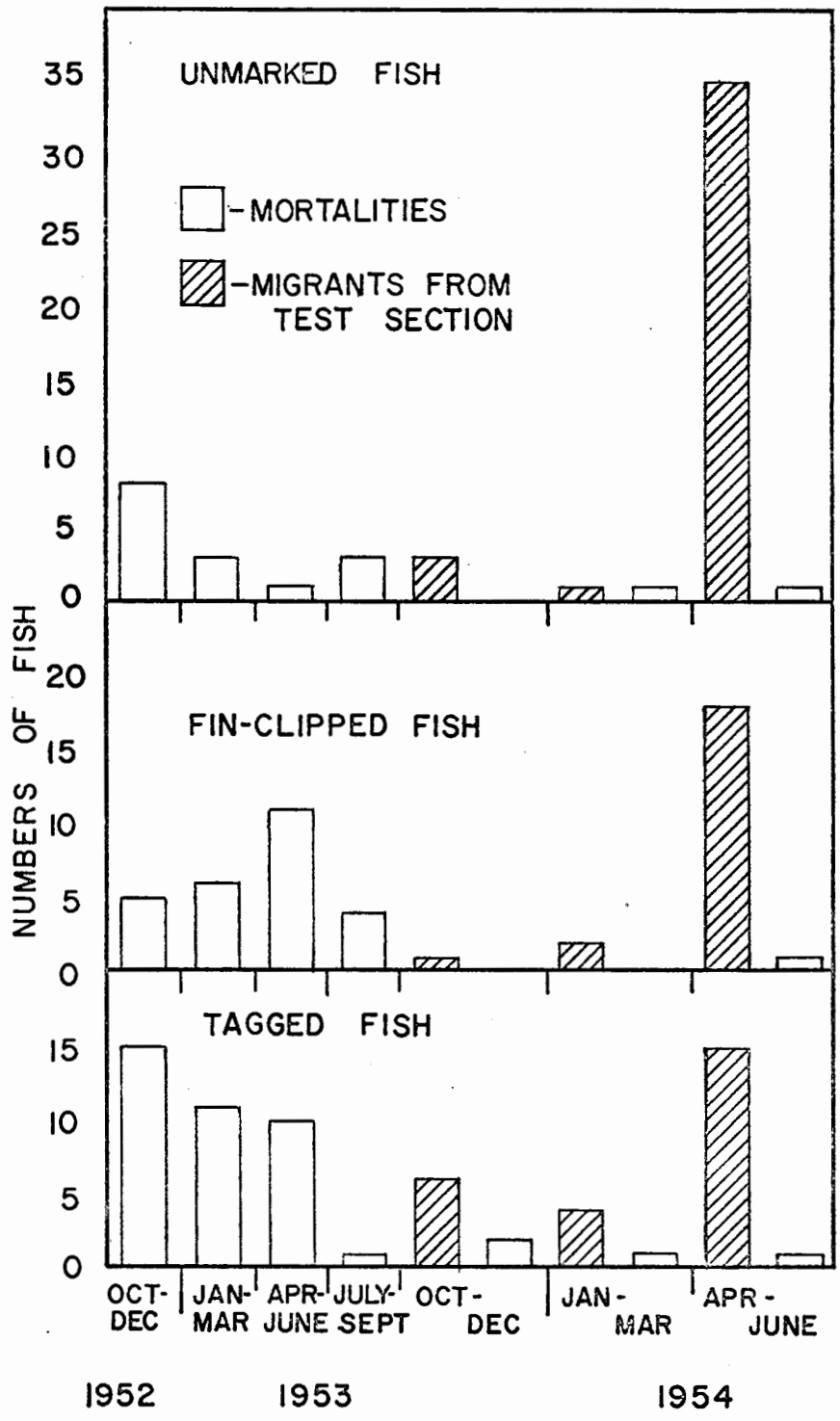

Figure 2.--Observed mortality of rainbow trout in Hunt Creek, October 1952-June 1954, and number of rainbows transferred downstream from the experimental area, October 1953-June 1954.