Original: Fish Division
cc: Education-Game
Institute for Fish. Res.
Hunt Creek Station
Pigeon River Station
D. S. Shetter
G. R. Alexander

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

GERALD P. COOPER PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

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RESULTS OF EXPERIMENTAL ANGLING ON THE NORTH BRANCH OF THE AU SABLE RIVER DURING 1959

By David S. Shetter and Gaylord R. Alexander

Special trout fishing regulations (9-inch minimum size limit, 5-fish daily creel limit, lures restricted to artificial flies only) have been in effect on portions of the North Branch of the Au Sable River--here termed the "special" water. The remaining, "normal" water of the North Branch has been fished under the usual state-wide angling regulations (a 7-inch minimum size limit, a 10-fish daily creel limit, and no restrictions on conventional natural or artificial lures). The effect of the special regulations on trout fishing is being evaluated, in part, by a stratified random sampling (creel census) of fishing effort and catch.

Starting with mid-season of 1958, the creel census of public angling included records on trout smaller than the minimum legal size which anglers had caught and released; there is some inherent error in these records because anglers were asked to recall, or estimate, the number of sublegal trout which they had caught during the fishing trip. Prior to 1958, only legal-size trout were recorded by the census. Even though sublegal trout are released, their capture by anglers is of interest

for two reasons: (1) anglers derive much recreation from catching these fish; and (2) the rate at which these small trout are caught, and killed by hooking mortality, may have some relation to total annual mortality of trout.

The present study by experimental angling was made to obtain data--for comparison with public angling--on the quality of fishing provided by the special water and the normal water for trout of different sizes (legal and sublegal) captured by fly and by worm. The study provides data of special interest, because the same four anglers fished in both types of water under a stratified random sampling procedure, which is not true for public anglers. The present study involved test fishing by four Department employees, using both artificial flies and worms in both special and normal water.

At the time of this study, all of the North Branch in Crawford County was special water, and all of the stream in Otsego County was normal water. The test fishing was done in the upstream half of the special water (that portion of the stream which had been under a flies-only regulation for the longest period of time), and between Dam 2 and the Crawford-Otsego County line of the normal water. For the stratified creel census, the special water had been divided into seven sections and the normal water into four sections. Each section was approximately one and one-half miles long. These same sections were utilized in the experimental design of the present test fishing.

Design of the experiment

A factorial design was used for this experiment involving five factors, all or which were regarded as fixed (Snedecor, 1956). These factors were: quarter of the season, time of day, stream area, lure, and angler. In a design of this type the series of treatments are used in all combinations. The individual fishermen and the two lures were assigned to special water and normal water by use of the scheme presented in Table 1. The test fishing was allocated to three time periods of the day and to the four quarters of the trout season by use of a stratified random design. The results of the experiment were evaluated by an analysis of variance.

The fishing season was divided into five-week quarters: April 25-May 29; May 30-July 3; July 4-August 7; and August 8-September 13. The fishing day was divided into three time periods: 8 A.M.-1 P.M.; 1 P.M.-6 P.M.; 6 P.M.-11 P.M. These divisions of the season and day, as with divisions of the stream (see above), corresponded to the divisions used in the creel census of public angling.

Each of the four anglers fished four hours during each time period of each quarter of the season; and of the four hours, two hours were spent on the special water and two hours on the normal water. Within each two hours on one type of water, one hour was spent fishing with flies and one hour with worms. Fly-fishing was done with either dry or wet flies on hooks of sizes 8 to 14; in worm fishing, one-half of a night crawler was used on a No. 6 long-shank hook. The angling plan shown in Table 1 was followed by both pairs of test fishermen.

Table 1.--Angling pattern for the North Branch Au Sable test fishing, showing the sequence of water type and lure fished by one pair of test anglers, on a given date

Type of water	1st hour	2nd hour	3rd hour	4th hour
Special	A - f[1]	A - w	B - f	B - w
Normal	B - f	B - w	A - f	A - w

[1] A and B designate individual anglers; f = fly fishing, w = worm fishing. The sequence of water fished by an individual, and the sequence of lures fished were determined immediately before angling, on any test date, by coin flipping. The particular sections to be fished in the normal and special waters were determined by random numbers, utilizing the seven sections of the special water and the four sections of the normal water previously established for creel census sampling.

The four anglers were matched as two pairs, and the two anglers of a pair fished at the same time throughout the tests. Generally only one pair of anglers fished on any given date. One member of a pair fished in the special water while his partner fished in the normal water, and both used the same type of lure during the same hour.

With one sampling restriction, one pair of anglers (here designated as A, B) did their fishing on dates within each quarter of the season which were determined by use of a table of random numbers; the second pair (C, D) chose angling dates, within each quarter, that did not conflict with other work assignments. The one sampling restriction was that neither pair fished on weekend days, so as to avoid possible public relations problems connected with using worms in the flies-only water; it is believed that this restriction did not bias the results with respect to most comparisons that are made. One possible source of bias is that the week-end congestion (or greater concentration) of public anglers on the stream might have lowered their catch per hour because of disturbance to the fish, but for most comparisons (see below) the test fishermen did not have a better catch per hour than the public anglers.

For each pair of anglers the selection of the sequence of the three time periods and the selection of the stream sections (among the seven in the fly water and the four in the normal water) were made at random. For each fishing trip, the pair determined by flipping a coin which lure would be fished first, and which member of the pair would begin fishing in special water, which in normal water.

Each angler kept records on his fishing of: date, time, type of water, stream section, lure, and individual lengths of brook and brown trout caught. All fish were released after measurement. No attempt was made to assess mortality among hooked fish after release, but it appeared to be of minor proportions.

Angling results

Collectively the four anglers fished 96 hours on the special water, 96 hours on the normal water (total, 192 hours); 96 hours with flies, and 96 hours with worms. The catch was 555 brook trout and 24 brown trout. The length range of the 579 trout was 3.0-13.0 inches. With flies as lures the catch was 249 trout or 2.59 trout per hour; with worms as lures, 330 trout or 3.44 trout per hour. The catch of brook trout and brown trout (combined) is summarized by quarter of the season, individual angler, type of water, lure, and size of fish, in Table 2.

From daily records of the test fishing (on file at the Hunt Creek Trout Research Station), an analysis of variance was made for each quarter of the season, utilizing a logarithmic transformation,[1] log [(catch per hour x 100) plus 1], of the catch-per-hour data (Snedecor, 1957). The five size categories of fish for which the catch data were

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[1] Because the analysis of variance cannot be performed on data in which there exists a direct relationship between the mean and variance (as is the case with catch-per-hour data), a transformation is necessary. The one used here stabilizes the variance, and also takes care of the numerous instances where the catch per hour was zero.

Table 2.--Trout caught by four experimental anglers in special water and normal water on flies and worms, North Branch Au Sable River, 1959 trout season.
Brook trout and brown trout combined are tabulated by size groups in inches

Quarter of season	Angler	Special water						Normal water						Total
		Fly			Worm			Fly			Worm			
		0-6.9"	7-8.9"	9.0" +	0-6.9"	7-8.9"	9.0" +	0-6.9"	7-8.9"	9.0" +	0-6.9"	7-8.9"	9.0" +	
1	A	3	1	0	0	3	2	5	0	0	0	2	0	16
	B	3	1	3	8	4	1	3	1	0	7	2	0	33
	C	12	1	1	13	5	0	9	0	1	4	1	0	47
	D	6	0	0	3	0	0	9	1	1	6	2	0	28
		24	3	4	24	12	3	26	2	2	17	7	0	124
2	A	22	2	1	4	6	5	7	1	0	2	3	0	53
	B	15	7	1	8	4	6	14	5	0	3	2	0	65
	C	15	4	0	21	12	0	9	2	0	12	0	0	75
	D	7	2	1	3	3	1	9	3	0	7	5	0	41
		59	15	3	36	25	12	39	11	0	24	10	0	234
3	A	5	2	1	0	10	1	1	1	0	2	0	2	25
	B	9	7	0	5	12	1	3	1	0	5	2	1	46
	C	2	1	0	11	9	0	1	0	0	0	1	0	25
	D	0	2	0	0	2	0	1	2	0	0	0	0	7
		16	12	1	16	33	2	6	4	0	7	3	3	103
4	A	0	1	0	1	9	0	0	1	0	0	1	0	13
	B	0	0	0	3	11	4	3	2	0	11	8	0	42
	C	2	5	1	19	12	1	0	0	0	0	0	0	40
	D	3	3	0	7	8	0	0	1	0	0	1	0	23
		5	9	1	30	40	5	3	4	0	11	10	0	118
Totals	A	30	6	2	5	28	8	13	3	0	4	6	2	107
	B	27	15	4	24	31	12	23	9	0	26	14	1	186
	C	31	11	2	64	38	1	19	2	1	16	2	0	187
	D	16	7	1	13	13	1	19	7	1	13	8	0	99
Grand total		104	39	9	106	110	22	74	21	2	59	30	3	579

partitioned for testing are listed below. (The somewhat illogical sequence is established for convenience in analysis and discussion of the results.)

1. Total fish, regardless of size.
2. Number of sublegal trout (smaller than 9 inches in the special water, smaller than 7 inches in the normal water).
3. All trout larger than 7 inches.
4. Number of legal trout (larger than 9 inches in the special water, larger than 7 inches in the normal water).
5. All trout smaller than 7 inches.

For each of the above categories an analysis of variance was made utilizing the entire season's data and treating quarter of the season as a main effect. Summaries of these analyses are given in Tables 3 and 4. In these tables, only the degrees of freedom and mean squares for the various main effects and first-order interactions are given. The second- and higher-order interactions were combined and are listed as "residual mean square." Where statistical significance (determined by reference to appropriate tables in any standard statistical text) was found for the calculated "F" value (F equals effect mean square, or interaction mean square, divided by residual mean square), this is indicated in Tables 3, 4, and 5 by one star (for significance at the 95 percent confidence level) or two stars (significance at the 99 percent confidence level).

In this series of analyses of variance, where no statistically significant interactions were found, "F" values for testing main effects (differences between lures, between areas, etc.) were determined in the manner described

Table 3.--Analysis of variance of the logarithmic transformation of catch-per-hour data for: all trout, sublegal trout and trout larger than 7 inches; N. Br. Au Sable River, experimental angling, 1959 trout season.
See p. 6 for transformation.
[d.f. = degrees of freedom; m.s. = mean square]

Source	d.f.	All trout m.s.	Sublegal trout m.s.	Trout larger than 7 inches m.s.
Total	191			
Lure (flies, worm)	1	0.1813 $\downarrow^{2}$	0.0585 $\downarrow^{1}\downarrow^{2}$	6.8699*
Area (special, normal)	1	11.6230** $\downarrow^{1}$	32.4970** $\downarrow^{1}$	15.0752** $\downarrow^{1}$
Time period (AM, PM, Eve.)	2	10.4697**	10.6491**	4.7560*
Quarters (1, 2, 3, 4)	3	11.2957** $\downarrow^{2}$	11.8296** $\downarrow^{2}$	3.9958*
Anglers (A, B, C, D)	3	2.6619* $\downarrow^{1}$	4.5966** $\downarrow^{1}$	1.4911 $\downarrow^{1}$
Pair (AB, CD)	(1)	(0.9213)	(0.1919)	(2.1000)
Within pair	(2)	(3.5532)*	(6.8034)**	(1.1867)
Lure x Area	1	2.7265	9.6257**	2.2367
Lure x Time period	2	0.2060	0.0298	0.7045
Lure x Quarter	3	3.0506*	3.2724*	1.1881
Area x Time period	2	1.2376	0.9315	2.1402
Area x Quarter	3	1.1099	1.7484	1.1531
Lure x Angler	3	1.5657	0.8280	2.3857
Lure x Pair	(1)	(0.6233)	(0.1339)	(5.2675)*
Lure x Within Pair	(2)	(2.0368)	(1.1750)	(0.9448)
Area x Angler	3	4.4326**	3.7439**	3.8245*
Area x Pair	(1)	(1.8252)	(0.6804)	(0.0646)
Area x Within Pair	(2)	(5.7363)**	(5.2756)*	(5.7045)**
Quarter x Angler	9	1.6150	1.4693	0.9279
Quarter x Pair	(3)	(3.6572)*	(3.4507)*	(1.7191)
Quarter x Within Pair	(6)	(0.5939)	(0.4786)	(0.5323)
Time period x Angler	6	0.7681	0.9622	0.4913
Time period x Pair	(2)	(1.7432)	(1.7238)	(0.2564)
Time period x Within Pair	(4)	(0.2806)	(0.5814)	(0.6088)
Time period x Quarter	6	1.7745	0.5492	1.7998
Residual mean square	143	0.8466	0.9154	1,0661
Pooled error mean squares	146[a]	0.9203 $\downarrow^{1}$	(147)[c] 1.0324 $\downarrow^{1}$	(146)[e] 1.1228 $\downarrow^{1}$
	146[b]	0.8919 $\downarrow^{2}$	(146)[d] 0.9190 $\downarrow^{2}$	...

$\downarrow^{1}\downarrow^{2}$ Main effects tested with the indicated pooled error mean square.

[a] Pooled error mean square resulting from summation of residual sum of squares + sum of squares for Area x Angler and dividing by 146 d.f.

[b] Pooled error mean square resulting from summation of residual sum of squares + sum of squares for Lure x Quarter and dividing by 146 d.f.

[c] Pooled error mean square resulting from summation of residual sum of squares + sum of squares for Area x Angler + sum of squares for Lure x Area and dividing by 147 d.f.

[d] Pooled error mean square resulting from summation of residual sum of squares + sum of squares for Lure x Quarter and dividing by 146 d.f.

[e] Pooled error mean square resulting from summation of residual sum of squares + sum of squares for Angler x Area and dividing by 146 d.f.

Table 4.--Analysis of variance of the logarithmic transformation of catch-per-hour data for: legal trout, and all trout smaller than 7 inches; N. Br. Au Sable River, experimental angling, 1959 trout season. See p. 6 for transformation.

[d.f. = degrees of freedom; m.s. = mean square]

Source	d.f.	Legal trout m.s.	Trout smaller than 7 inches m.s.
Total	63		
Quarter	3	1.1108	6.0507**
Lure	1	0.5311	0.4456
Area	1	6.0454**	1.5688
Angler	3	2.5628**	2.4435**
Pairs	(1)	(5.6465)**	(0.0031)
Within Pairs	(2)	(1.0209)	(3.6636)**
Quarter x Lure	3	0.0823	1.3281
Quarter x Area	3	0.1106	0.8473
Quarter x Angler	9	0.6711	0.8955
Quarter x Pair	(3)	(0.4308)	(1.7929)*
Quarter x Within Pair	(6)	(0.7912)	(0.4468)
Lure x Area	1	0.2614	0.5183
Lure x Angler	3	1.0673	0.8086
Lure x Pair	(1)	(3.1907)*	(0.0297)
Lure x Within Pair	(2)	(0.0057)	(1.1981)
Area x Angler	3	0.9101	1.1537
Area x Pair	(1)	(0.3954)	(1.8700)
Area x Within Pair	(2)	(1.1975)	(0.7956)
Residual mean square	33	0.5496	0.4718

above. If, on the other hand, statistically significant interactions were found, a more conservative test for evaluating the main effects is obtained by calculating a "pooled error mean square." This is done by summing the residual sum of squares with the interaction sum of squares previously determined to be statistically significant, and also summing the respective degrees of freedom involved. The pooled error mean square is found by division of the pooled sum of squares by the pooled degrees of freedom (Steel and Torrie, 1960). Finally the pooled error mean square is divided into the mean square for the particular main effect to obtain the "F" value.

An example of the use of pooled error mean square is seen in the data for trout larger than 7 inches where the simple "F" test showed a statistically significant Area x Angler interaction (see Table 3). A pooled error mean square was obtained by adding the sum of squares for residual error and the sum of squares for Area x Angler, adding the degrees of freedom involved, and dividing the pooled sum of squares by the pooled degrees of freedom. The pooled error mean square of 1.1228 with 146 degrees of freedom replaced the residual mean square of 1.0661 with 143 degrees of freedom. "F" values for the main effects, Area and Angler, were then computed with the pooled error mean square, with the results indicated in the table.

The example cited above illustrates the type of involvement which is commonly encountered in a simultaneous analysis of several main effects. On the one hand the "F" test showed a highly significant difference between

areas, but not between anglers, in the catch of trout over 7 inches. On the other hand the significant interaction between Areas and Anglers means that certain anglers made a much higher proportion of their catch in one type of water (the special water) than did other anglers.

All trout, sublegal trout, and trout larger than 7 inches

The data in Table 3 provide a summary for the entire season for these three categories. For lures, only among trout larger than 7 inches was the catch per hour on worms (1.72) found to be significantly greater than the catch per hour on flies (0.74).[2] Fishing in the morning and afternoon was better, for all size categories of fish, than the evening angling; the second quarter of the season provided the best fishing for all size categories; only in the fishing for trout larger than 7 inches was there no significant difference found between anglers; and in all three size categories there was a statistically significant difference between areas, with the special-regulation water yielding the higher catch per hour.

Legal trout

Since there were numerous hourly trips on which no legal trout were captured, and also because it was quite obvious that the evening angling was the least productive, catches of legal trout by individual anglers were combined by five-week periods and no attempt was made to analyze the effect of time period for the 87 legal trout captured (31 from the special

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[2] Here, and elsewhere in the text, the comparative data given are in terms of simple catch per hour, i.e., number of fish divided by number of hours required to catch them.

water, 56 from the normal water). A summary of the analysis is given in Table 4 (here the log transformation was applied to the catch-per-hour figures for each three hours of fishing with a given lure in each quarter in each type of water).

The catch of legal trout per hour was significantly better in the normal water than in the special water (0.58 as against 0.32); Angler B (0.83 fish per hour) was more efficient than anglers A (0.44) and D (0.37) who, in turn, were more efficient than angler C (0.17). Pair AB (0.63 trout per hour) were more efficient at catching legal trout than pair CD (0.27 trout per hour). The minor interaction Lure x Pair proved to be statistically significant, because pair AB caught about 3 1/2 times as many legal trout on worms as did pair CD. The second five-week period provided the best fishing.

Trout smaller than 7 inches

A total of 343 trout smaller than 7 inches were caught (104 on flies and 106 on worms in the special water; 74 on flies and 59 on worms in the normal water). The main effects tested were lure, area, quarter of season, and angler. Time period during the day was ignored here for reasons previously given.

Only one of the minor interactions (Quarter x Pair) proved to be statistically significant. The "F" test indicated that the catch per hour for flies (1.85) was not significantly different from that for worms (1.72), nor was there a significant difference in catch per hour for special and

normal waters. The latter finding was somewhat unexpected in that the actual catch per hour for the special water was 2.19 (210 fish in 96 hours) as against 1.39 (133 fish in 96 hours) for the normal water. The explanation appears to involve the high variability among the four anglers in their success in catching fish. Anglers B and C were more efficient than A and D, and the catch per hour was best during the second quarter of the season.

Angling quality in relation to stream area

At this point an interested angler might ask: "On the basis of the experimental angling, and under the present regulations in force on the North Branch, which stream area provides the most sport? The most trout in the creel?"

The answers to these two questions can be found if we first exclude the experimental angling data for worms in the special water, and then analyze the data for all trout and for trout of legal size (Table 5).

For all trout, the adjusted analysis (by "F" tests) showed no significant interactions among the primary factors, and no significant difference in catch per hour between anglers. There was a significant difference between quarters of the season. There was a 61 percent higher catch per hour in the special water (3.17 compared with 1.97) than in the normal water. The analysis of variance indicates that this difference between areas is not statistically significant, due to relatively small sample size and high variability among the individual catch-per-hour data. Based on empirical data only, total sport provided, as measured by all trout caught, was approximately 60 percent better in the special water than in the normal water.

Table 5.--Analysis of variance of the logarithmic transformation of catch-per-hour data, based on existing regulations and experimental results, for: all trout, and legal trout; N. Br. Au Sable River, 1959 trout season. See p. 6 for transformation.

[d.f. = degrees of freedom; m.s. = mean square]

Source	All trout[1]		Legal trout[2]	
	d.f.	m.s.	d.f.	m.s.
Total	143		47	
Quarter	3	15.1464**	3	0.7741
Area	1	3.7469	1	6.3191**
Angler	3	1.4039	3	1.2127
Pair	(1)	(1.4042)	(1)	(1.6837)
Within Pair	(2)	(1.4037)	(2)	(0.9772)
Quarter x Area	3	0.0783	3	0.0981
Area x Angler	3	2.0440	3	0.7994
Area x Pair	(1)	(1.3326)	(1)	(0.0931)
Area x Within Pair	(2)	(2.3997)	(2)	(1.1526)
Quarter x Angler	9	1.4611	9	0.6128
Quarter x Pair	(3)	(3.4214)	(3)	(0.5683)
Quarter x Within Pair	(6)	0.4809	(6)	(0.6350)
Experimental error	121	1.0596	25	0.5621

[1] Includes the trout caught only on flies in the special water, but all trout caught on either flies or worms in the normal water.

[2] Includes trout larger than 9 inches caught only on flies in the special water, but all trout larger than 7 inches caught on either flies or worms in the normal water.

For legal fish the adjusted analysis (Table 5) showed no significant effect of quarter of the season, or of angler, and no significant interactions. There was, however, a significant effect of stream area. The catch of 7-inch-plus trout with any lure in the normal water was 5.9 (95 percent confidence limits, 1.2 to 15.6) times better than the catch of 9-inch-plus trout with flies in the special water, as determined from the transformed data. The actual catch was 56 trout in 96 hours or 0.58 trout per hour in the normal water, and 9 trout in 48 hours or 0.19 trout per hour in the special water. This finding was not unexpected in view of the differences in minimum size limits in force on the two areas, and the usual size distribution of trout in populations (more 7- to 9-inch trout than trout larger than 9 inches).

Average size of trout caught

The average total lengths (and standard errors) of brook trout and brown trout caught by experimental angling on flies and worms in special and normal waters are shown in Table 6. Average length of brook trout caught on worms in the special water (7.13 inches) was significantly larger ($P < 0.1$ percent) than that of brook trout caught on worms in the normal water (6.62 inches). Fly-caught brook trout from the special water and the normal water were not significantly different in average length (6.55 and 6.34 inches, respectively; $P < 20$ percent). Too few brown trout were caught in either water for valid comparisons. In both waters, brook trout caught on worms were of significantly greater average total length than those caught on flies ($P < 0.1$ percent in both comparisons).

Table 6.--Average total length (in inches) of trout taken by experimental angling, N. Br. Au Sable River, 1959 trout season

Species	Lure	Special water			Normal water		
		Number	Length	Standard error	Number	Length	Standard error
Brook	Fly	140	6.55	0.085	93	6.34	0.107
	Worm	233	7.13	0.071	89	6.62	0.095
Brown	Fly	12	7.85	0.529	4	6.75	0.441
	Worm	5	9.80	0.913	3	9.20	1.144
All fish		390	6.98	0.060	189	6.53	0.101

The 390 trout (brook and brown combined) from the special water were 6.98 inches in average length; the 189 trout from the normal water had an average length of 6.53 inches; the difference is statistically significant at the 99.9 percent level. The minimum size regulations in force very likely were responsible for this difference in size between special and normal waters. In the special water, trout of 7.0 to 8.9 inches in length were more abundant presumably because anglers had not been able to keep them in the creel, whereas the continual harvesting of trout in the normal water by public angling had left proportionately fewer fish of this size range.

Ratio of brook trout to brown trout in experimental catch

The total catch by the experimental anglers in the special water was 373 brook trout and 17 brown trout (approximately 22:1). Direct-current electrofishing samples taken at two sites in the special water in July, 1959 yielded 75 brook trout and 24 brown trout larger than 3.0 inches, or a 3:1 ratio for the summer population of the stream.

In the normal water, experimental angling caught 182 brook trout and 7 brown trout, a ratio of 26:1; electrofishing samples taken at three sites in July, 1959 yielded 179 brook trout and 53 brown trout larger than 3.0 inches, or a ratio of 3.3:1.

The numbers of brook trout and brown trout of various size groups taken by experimental angling and by electrofishing are given in Table 7. As is generally accepted, brook trout are several times more vulnerable to angling than are brown trout of similar size.

Table 7.--Numbers of trout of various lengths caught by direct-current shocker during July, 1959, and by experimental angling during the trout season of 1959, in special water and normal water, North Branch Au Sable River

Length (inches)	Species	Special water		Normal water	
		Shocker	Angling	Shocker	Angling
3.0-6.9	Brook	56	206	147	131
	Brown	7	4	22	2
7.0-8.9	Brook	15	143	31	47
	Brown	11	6	18	4
9.0+	Brook	4	24	1	4
	Brown	6	7	13	1
Total	Brook	75	373	179	182
	Brown	24	17	53	7

Comparative efficiency of flies and worms in special and normal waters

Table 8 gives the numbers of trout of various size groups that were caught in the two types of water by equal amounts of experimental angling with the two types of lures (96 hours in each type of water--48 hours with fly, 48 hours with worm).

For the special water, a Chi-square test of homogeneity on the catch records showed a highly significant relationship between type of lure and size of trout which were caught (Chi-square equals 20.2, 2 d.f., $P < 0.5$ percent). Worms and flies took about the same number of trout under 7 inches, but worms took many more trout over 7 inches than did flies (see Table 8).

In the normal water, flies and worms were about equally effective in catching trout of different sizes (the test of homogeneity gave a Chi-square of 2.53, 2 d.f., $P < 20$ percent).

Chi-square tests were next applied to the data of Table 8 subdivided into trout smaller and trout larger than 7.0 inches, as caught on flies and worms in the special and normal waters. Each size group was given the 2 x 2 test of homogeneity. For trout less than 7.0 inches long, no significant effect of lure on number of trout in the catch could be discerned (Chi-square equals 0.99, 1 d.f., $P < 50$ percent). The experimental catch of trout larger than 7 inches was treated similarly, and we found that in the special water flies were measurably less efficient than worms (Chi-square equals 3.55, 1 d.f., $P < 6$ percent or approaching statistical significance).

Table 8.--Numbers of trout of various lengths taken by fly and worm in special and normal water during experimental angling, North Branch Au Sable River, 1959 trout season

Lure	Total length of trout (inches)	Special water	Normal water
Fly	0.0-6.9	104	74
	7.0-8.9	39	21
	9.0+	9	2
Worm	0.0-6.9	106	59
	7.0-8.9	110	30
	9.0+	22	3
Totals	...	390	189
Chi-square between lures	...	20.2**	2.53

** The difference in catch between lures on the special water is statistically significant at the 99 percent level.

The first conclusion is supported by the analysis of variance for trout less than 7 inches (Table 4), where the Lure x Area interaction was not statistically significant. On the other hand, for trout larger than 7 inches, the analysis of variance yielded non-significant results for the Lure x Area interaction (Table 3), but the test for homogeneity on the same data yielded nearly significant differences; the disparity is not great, however, because both tests gave "borderline" conclusions.

Why are the larger trout (those over 7.0 inches) apparently more vulnerable to worm angling than to fly angling in the special water, but not in the normal water? The question is perhaps too presumptive, because it is based on a borderline statistical conclusion, but it leads to interesting speculation. One might conclude that trout in the special water were more gullible to worm-hooking because they had not been conditioned to (made wary of) this type of bait. Much of the logic of this explanation is lost, however, because trout under 7 inches in the special water were not caught more readily on worms than on flies.

Experimental angling compared to public angling

A creel census (by stratified random sampling) was conducted during 1959 on public angling on the same areas of the North Branch of the Au Sable where the experimental angling was done. Catch-per-hour data, in logarithmic form, for the two types of angling are given in Table 9. There was not a statistically significant difference in the catch per hour made by

Table 9.--A comparison of catch per hour per trip (transformed data) of experimental and public angling, North Branch Au Sable River, 1959 trout season

Transformation used: log [(catch per hour x 100) + 1]

Size group	Item	Special water		Normal water			
		Fly		Fly		Worm	
		Experimental	Public	Experimental	Public	Experimental	Public
Legal trout	n	48	86	48	34	48	86
	mean	0.302	0.203	0.810	0.604	0.975	0.622
	Std. error	0.107	0.058	0.147	0.154	0.156	0.166
	t	0.811		0.968		1.549	
Sub-legal trout	mean	1.761	1.290	1.341	1.367	0.859	0.583
	Std. error	0.174	0.132	0.169	0.195	0.171	0.187
	t	2.15*		0.101		1.090	

* Denotes statistical significance between means at the 95 percent level of confidence.

experimental and public anglers for either fly or worm fishing in the normal water, or in the catch of legal-size trout in the special water. However, in the special water experimental anglers caught significantly more sublegal trout per hour than did the public anglers ($P < 5$ percent).

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INSTITUTE FOR FISHERIES RESEARCH

David S. Shetter and Gaylord R. Alexander

Report approved by G. P. Cooper

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ABSTRACT NO. 192

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(Institute for Fisheries Research Report No. 1645)

RESULTS OF EXPERIMENTAL ANGLING ON THE NORTH BRANCH OF THE AU SABLE RIVER DURING 1959

By David S. Shetter and Gaylord R. Alexander

June 26, 1962

During the 1959 trout season four Department employees fished equal amounts of time on the special-regulation water (flies-only, 9-inch minimum size, 5-fish creel limit) and the normal-regulation water (any lure, 7-inch minimum size, 10-fish creel limit) of the North Branch of the Au Sable River in Crawford and Otsego counties. In this test fishing, both artificial flies and worm-baited hooks were used on each type of water. The objective of the experiment was to compare angling quality in the two types of water.

The experimental procedure was one of stratified random sampling. Stream sections to be fished, dates of fishing, time of day (A.M., P.M., evening), sequence of lures, and sequence of waters were determined randomly. The catch data were treated by an analysis of variance, regarding the design as a five-factor experiment, with quarter of the season, time of day, stream area, lure, and angler as fixed effects. For statistical treatment, the individual figures on catch per hour per trip were transformed to: log [(catch per hour x 100) plus 1].

The four anglers fished a total of 192 hours (48 hrs. each) and caught 579 trout (555 brook trout and 24 brown trout) ranging in size from 3.0 to 13.0 inches; all trout were returned to the stream. Flies caught 249 trout in 96 hours, worms took 330 trout in 96 hours. The data on catch were summarized for five different size categories of trout: all trout, sublegal trout (as defined by law); trout larger than 7 inches; legal trout (as defined by law); and trout smaller than 7 inches. Legal trout (as defined by law) means trout over 9 inches in the fly water, and trout over 7 inches in the any-lure water.

(over)

The following conclusions are based on differences in catch data which proved to be statistically significant at the 95 percent (or higher) confidence level.

Comparing catch by both flies and worms in the special water with catch by both flies and worms in the normal water:

1. Worms gave a higher catch than flies, of trout over 7 inches.
2. The special water gave a higher catch than the normal water, of "all trout," and of sublegal trout.
3. The normal water gave a higher catch of trout over 7 inches than the special water gave of trout over 9 inches.
4. The special water gave a higher catch than the normal water, of trout over 7 inches.
5. The best fishing was in the second quarter of the season (May 30-July 3).
6. The poorest fishing was during the evening (6 P.M.-11 P.M.).
7. Worms caught brook trout of larger average size in the special water than in the normal water, but flies did not. Brown trout were too few for comparison.

Comparing catch by test fishing with flies (only) in the special water and with flies and worms in the normal water (i.e., fishing comparable to public angling):

1. The normal water gave a higher catch of trout over 7 inches than the special water gave of trout over 9 inches.
2. Empirical data suggest that the catch of all trout was about 60 percent greater in the special water than in the normal water, although the analysis of variance indicated this difference was not statistically significant.
3. Fishing was best in the second quarter of the season.
4. The four test fishermen had a better catch of sublegal trout (on flies) in the special water than that reported by public anglers during the 1959 season (data from a creel census of public fishing on the North Branch); but the test fishermen did not excel public anglers in the catch per hour of (1) legal-size trout (on flies) in the special water or (2) legal-size or sublegal trout on either flies or worms in the normal water.

Collecting by electric shocker during mid-summer of 1959 gave a ratio of about 3 brook trout to 1 brown trout in the special and normal waters of the North Branch. The brook:brown ratio among trout caught by the test fishermen was 22:1 in the special water and 26:1 in the normal water.

Distribution: A and AA