MICHIGAN DEPARTMENT OF CONSERVATION
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COMPARATIVE RECOVERY TO THE CREEL, AND BEHAVIOR OF RAINBOW TROUT STOCKED IN THE GREAT LAKES[1]

By Martin J. Hansen[2] and Thomas M. Stauffer

Abstract

Stocking of hatchery-reared rainbow trout in the Great Lakes may be a valuable management practice because the survivors, when they are caught by anglers, are relatively large fish. In this study, we planted 125,503 tagged legal-sized rainbow trout during 1955-59 at 27 locations along Michigan shores of the Great Lakes. Three strains of trout were used: (1) progeny of Michigan hatchery brood stock, (2) progeny of Great-Lakes-run rainbow trout and (3) progeny of sea-run rainbow (steelhead) trout from the State of Washington. Matched plants were used to study four factors that might have influenced recovery rates, namely: (1) month of planting, (2) strain of trout, (3) size of trout, and (4) location of planting (stream versus lake). These, and other plants, also provided information on behavior of rainbow trout in the Great Lakes.

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* Institute for Fisheries Research Report No. 1739.

1 Investigations conducted, in part, under Dingell-Johnson projects F-18-R-1 to F-18-R-2; F-27-R-1 to F-27-R-4 and F-31-R-1, Michigan.

2 Deceased.

All recoveries of trout were reported voluntarily by anglers. An unknown number of trout were caught and not reported. Publicity on the study was not uniform geographically; thus, relative rates of returns between localities far apart do not provide valid comparisons. Returns on trout caught by anglers within the first week or two after planting could not be used as a valid part of this study since the fish were still small. Rather, we used only records on fish which had grown 3 inches or more and presumably had been in the Great Lakes for one or more growing season(s). These fish added up to 1.2% of the total planted; the rates ranged from 0.0 to 9.3% among the many localities and plantings.

For the factors studied, we found: (1) May plantings produced the highest returns, (2) there was not a consistent difference in returns among the three strains, (3) larger fish gave better returns than smaller fish, and (4) lake stocking of the Michigan hatchery strain produced better returns than did stream stocking. For the plants as a group, the fish ranged widely, and only about 50% of the recovered fish "homed" to the planted stream. In the Great Lakes, planted trout grew to an average length of 16.4 inches in one growing season, and to 21.4 inches in two growing seasons. Most trout were recovered in spawning streams during spring and autumn, and within 2 years of the planting date.

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Immature wild rainbow trout (Salmo gairdneri) migrate downstream to the Great Lakes at the age of 1 to 3 years. Because of an excellent growth rate in the Great Lakes, the mature fish are relatively large when they return to the spawning streams. Previous studies of stocking of hatchery-reared rainbow trout in the Great Lakes or ocean have demonstrated that at least some behave as wild trout (Stauffer, 1955a; Larson and Ward, 1955; Hallock, Van Woert, and Shapovalov, 1961). This type of stocking would be a valuable management practice if many survivors were available to anglers as large mature fish. However, the number of planted trout surviving to maturity and large size is influenced by many factors.

We stocked hatchery-reared rainbow trout in the Great Lakes and tributaries to determine the effect of certain of these factors on survival to the creel. Factors considered included:

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2 Deceased.

(1) date of stocking, (2) strain of trout, (3) size of fish planted, (4) planting site, (5) predation, (6) angling pressure and (7) migration among streams. Also, for the stocked fish, we obtained data on: (1) migration in the Great Lakes, (2) time of recovery, (3) growth, (4) sex ratios and (5) maturity.

Methods

A detailed description of the methods in this study was given by Hansen (1960). In brief, 125,503 rainbow trout of three strains were measured, jaw-tagged and released (either in the lakes or streams) mostly within 1 mile of the mouth of 27 Great Lakes tributaries (Fig. 1). Plantings were made also at two sites in Burt Lake, Cheboygan County. The planting sites are described in detail in the Appendix table. The 1955-56 releases were of "domestic" fish (progeny of Michigan hatchery brood stock), but the 1957-59 plantings included two other strains: "Michigan wild" (progeny of Great-Lakes-run rainbow trout) and "West Coast" (progeny of sea-run rainbow or steelhead trout from the State of Washington). The trout were released mostly in May or June; they were 5 to 12 inches long and 1 to 3 years old. Loss of the jaw tags probably was slight and had little effect on recovery rates (Stauffer and Hansen, 1966).

Returns came from voluntary reports by commercial fishermen and anglers; and some tagged trout were caught at sea lamprey weirs. Most returns (86%) came from voluntary

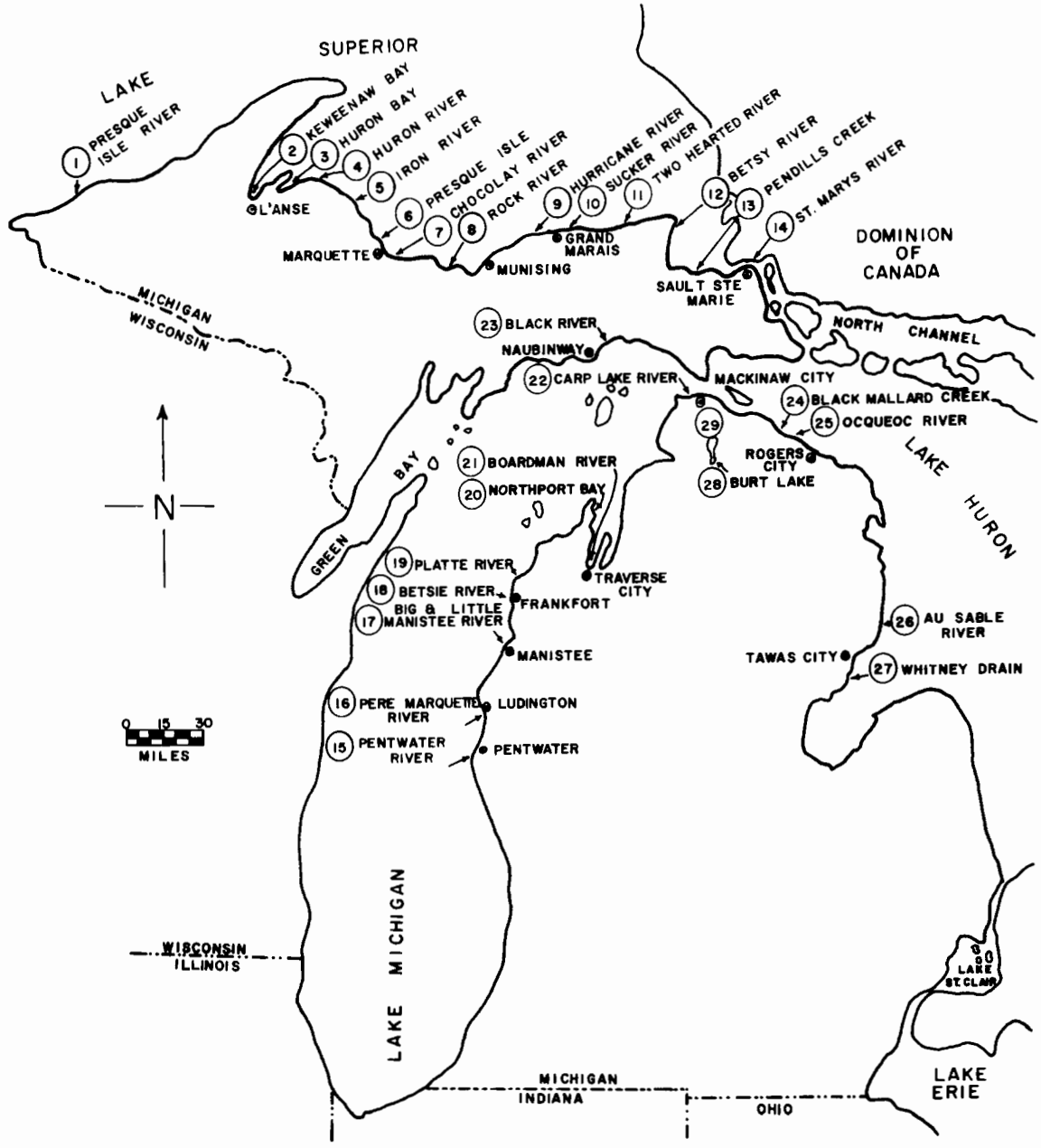

Figure 1.--Rainbow trout planting sites, 1955-59. Site numbers are the same as in Table I (appendix) and the text.

reports by anglers fishing rainbow trout streams during April-June and September-November. Some trout were caught in streams shortly after planting and before adding any growth; others were caught after they had made considerable growth in the Great Lakes. Because the larger fish are much more desirable to anglers, we were concerned principally with recoveries of fish after one or more growing seasons in the lakes. Hence, unless specified otherwise, the term "recovery rate" applies only to angler recoveries of these relatively large lake-run fish. In this report, "lake-run" refers to fish which had grown at least 3.0 inches (presumably in the Great Lakes) during the first season after planting. "Non-lake-run" refers to fish which had grown less than 3.0 inches before recapture and presumably either had not moved out of the stream, or had moved into it after a lake planting.

The voluntary reports of recovery by anglers were used to compare survival to the creel. This method of evaluation necessarily limits the usefulness of the data for comparing rates of return from different plants. The rate of angler response, and hence the rate of return, likely varies among recovery sites and to a lesser degree, among years. Thus, comparison of recovery rates of two groups of fish planted and recovered at different locations (regardless of time) can only be made with extreme caution. Comparisons of recovery rate of trout planted and recovered in different years at the same place must also be made with caution. On the other hand, comparisons of rate of return from plants in or near the same stream in the same year can be made with more confidence since there remains no variable which

would cause a difference in response. These paired plants were used to assess most of the factors affecting survival to the creel. Migration in the Great Lakes, time of recovery, growth and maturity were also assessed, to a large degree, from voluntary reports by anglers or commercial fishermen. These data, with the probable exception of migration, did not appear to be biased by the voluntary returns. Parametric tests (Dixon and Massey, 1951) were used where appropriate. Non-parametric tests (Siegel, 1956) were used when the data did not meet the requirements of parametric statistics.

Release and recovery data for each plant are given in detail in the appendix table; the records are summarized by year in Table 1. For lake-run fish there was a recovery rate of 1.2%. There was extreme variability in recovery rates among plants; they varied from 0.0 to 9.3%. In the literature we find three similar studies on stocking migrant-sized rainbow trout in Pacific Coast streams. Reported recovery rates (adults returned from the ocean) for various plants ranged from 0.2 to 12.7% (Larson and Ward, 1955), 0.3 to 8.0% (Hallock, et al., 1961), and 0.0 to 10.0% (Wagner and Wallace, 1963). Their recoveries were by both fish traps and anglers. Thus, our voluntary but minimal recovery reports (see below) compare favorably with rates obtained on the West Coast.

Table 1. --Total number and percentage recovery each year of rainbow trout stocked near the mouths of Great Lakes tributaries, 1955-59[a]

[Number of recaptured trout in parentheses]

Year stocked	Number stocked	Recoveries by anglers				Miscellaneous recoveries	Grand totals
		Lake-run	Non-lake-run	Growth history unknown	Totals		
1955	21,368	1.5 (317)	1.8 (386)	0.3 (61)	3.6 (764)	0.3 (71)	3.9 (835)
1956	28,505	1.3 (378)	1.6 (445)	0.6 (176)	3.5 (999)	0.5 (146)	4.0 (1,145)
1957	30,833	0.9 (276)	1.4 (443)	0.1 (45)	2.5 (764)	0.3[b] (98)	2.8 (862)
1958	20,850	1.6 (344)	0.7 (153)	0.1 (24)	2.5 (521)	0.5 (101)	3.0 (622)
1959	23,947	0.9 (227)	0.8 (186)	0.1 (18)	1.8 (431)	0.6 (153)	2.4 (584)
Totals	125,503	1.2 (1,542)	1.3 (1,613)	0.2 (324)	2.8 (3,479)	0.4 (569)	3.2 (4,048)

[a] Burt Lake plants not included.

[b] Fin-clipped fish (1957 Black River plant) recovered by miscellaneous methods are not included because duplicate recoveries could not be detected.

Effect of certain factors on survival to the creel

The number of planted, lake-run rainbow trout creeled by anglers may be influenced by a number of factors which include: (1) date of stocking, (2) strain of trout, (3) size of fish planted, (4) planting site, (5) predation, (6) angling pressure and (7) migration among streams. An additional factor which has a pronounced influence on the recovery rate is the percentage of nonresponse by anglers. These items are discussed below.

Date of planting.--West Coast investigators (Larson and Ward, 1955; Hallock, et al., 1961; and Wagner and Wallace, 1963) concluded that releases of hatchery-reared rainbow trout during downstream migration of juvenile wild trout provided the highest returns. Much of the downstream migration of juvenile wild trout in the Great Lakes region occurs in May and June (Stauffer, 1955b). For domestic trout released in the Black River, Mackinac County, a May 1954 release produced a significantly higher recovery (chi-square = 6.77, 1 d.f., $P < .01$) than an October 1953 release (Hansen, 1960). In 1955 and 1956, domestic trout were released in March (1956 only), April, May, and June near the mouth of Black River either in the stream or lake. In both years, there were significantly greater returns ($F = 69.8$, $P < 0.05$, d.f. 2, 2) from the May releases (see Table I of appendix). In 1959, releases of three strains of rainbow trout in the Boardman River, Grand Traverse County, were

spaced at monthly intervals (April, May, June) to test for differences in recovery rates due to date of stocking. An analysis of variance showed no significant difference ($F = 1.68$, $P > 0.25$, d.f. 2, 4) among the recovery rates from the different months; however, the test is based on few returns. For the Black River, at least, it seems fairly certain that May releases (when wild juveniles are migrating) will produce the best survival to the creel.

Strain planted.--The three strains were planted together at four locations in 1957, at nine locations in 1958, and six in 1959 (Table 2). All locations were lake sites, except the St. Marys River. Fish were selected so that the average lengths for the strains in each planting combination were about equal. The average maximum difference in mean length for the three strains within the plants was 1.4 inches (range 0.3-3.6). Domestic trout were 2 years old, West Coast fish were 2 (1957, 1959) and 3 (1958), and Michigan wild trout were 2 (1957) and 3 (1958, 1959) years old. Friedman non-parametric analyses of variance (Siegel, 1956, p. 166) indicated no significant differences in recovery rates among the three strains in any year.

Size planted.--Each trout planted was measured and identified by a numbered tag. Thus, it was possible to use nonparametric sign tests to compare the average length at planting of recovered and non-recovered trout; this was done for 21 plants, each with 15 or more recoveries. If the larger trout gave a higher return, the average length (at planting) of recovered trout should be

Table 2. --Percentage recovery from three strains of rainbow trout released together, 1957-59

Year and stocking location	Strain		
	Domestic	West Coast	Michigan wild
1957			
Two Hearted River	1.2	1.4	0.7
Boardman River	3.9	0.6	3.7
Black River	1.1	0.0	0.7
Ocqueoc River	1.6	1.1	2.0
1958			
Huron Bay	0.4	0.8	2.0
Huron River	0.5	0.8	0.4
Two Hearted River	0.9	0.4	2.0
Pendills Creek	2.6	1.2	2.0
St. Marys River	2.4	0.4	0.8
Boardman River	1.4	0.2	2.3
Black River	4.2	0.4	1.6
Ocqueoc River	0.6	0.8	0.4
Sturgeon River	0.8	3.2	2.4
1959			
Two Hearted River	0.8	0.5	1.1
St. Marys River	0.2	0.0	1.0
Boardman River	1.0	1.5	0.5
Au Sable River	4.5	2.0	2.0
Whitney Drain	3.0	0.5	2.0
Sturgeon River	0.5	0.3	2.0

greater than that of non-recovered trout. In 12 of 13 releases (ties excluded) of domestic trout and in all 6 releases of Michigan wild trout, the average release lengths of recovered trout were longer ($P<0.01$; $P<0.05$) than those of non-recovered trout (Table 3). We conclude that domestic and Michigan wild trout planted at a larger size survive better than smaller trout. Others who found that larger fish provided higher returns include Larson and Ward (1955), Hallock, et al. (1961) and Wagner and Wallace (1963).

Location planted. --A comparison of recoveries from paired lake and stream releases of domestic trout in or near Black River in 1955-57 suggested that lake plantings produced a higher return (Hansen, 1960). In 1959, 26 paired, simultaneous lake and stream plantings were made near the mouths of six rivers. Nonparametric sign tests were used to detect possible differences in rates of return (Table 4) between lake and stream plantings of the three strains. With domestic trout, lake plantings produced significantly higher returns than stream plantings ($P<0.01$). There was no significant difference for West Coast and Michigan wild trout.

Predation. --Although all of the releases were made at streams which either support or formerly supported natural runs of rainbow trout, some of these streams contained populations of warmwater fish near the mouth. Predation on the newly released trout by northern pike (Esox lucius), burbot (Lota lota), gar

Table 3.--The average release lengths (inches) of recovered and non-recovered trout in various plants, 1955-59[a]

Strain and stocking location	Year stocked	Number stocked and site[b]	Age[c]	Length at release	
				Recovered	Non-recovered
Domestic					
Huron River	1956	1,979 S	2	9.3	9.1
Presque Isle	1956	3,000 L	2	9.2	9.1
Pendills Creek	1957	1,000 L	2	9.1	8.8
Manistee River	1956	2,498 S	2	9.7	8.9
Betsie River	1955	3,000 S	2	9.6	9.1
Betsie River	1956	3,000 S	2	9.3	8.8
Northport	1955	1,998 L	2	8.9	9.1
Northport	1956	1,986 L	2	9.2	9.0
Boardman River	1955	2,000 S	2	9.2	9.0
Boardman River	1956	1,992 S	2	9.5	9.0
Boardman River	1957	998 L	2	8.8	8.5
Black River	1958	994 L	2	9.6	9.3
Black Mallard Creek	1955	997 L	2	9.0	9.0
Ocqueoc River	1957	999 L	2	7.8	7.8
Whitney Drain	1958	999 L	2	8.9	8.6
Michigan wild					
Presque Isle River	1959	925 S	3	11.7	11.5
Two Hearted River	1958	996 L	3	8.8	8.6
Boardman River	1957	998 L	2	7.5	7.4
Boardman River	1958	993 L	3	9.7	9.0
Black River	1958	984 L	3	9.7	8.7
Ocqueoc River	1957	996 L	2	7.5	7.4

[a] Only plantings from which 15 or more trout were recovered are listed.

[b] S = stream; L = lake. [c] Age in years.

Table 4.--Returns from paired simultaneous lake and stream plantings of rainbow trout, 1959

Strain and stocking location	Month stocked	Recovery percentages	
		Lake releases	Stream releases
Domestic			
Two Hearted River	May	1.0	0.0
Two Hearted River	May	0.8	0.0
Boardman River	April	1.0	0.0
Boardman River	May	1.0	1.0
Boardman River	June	1.0	0.5
Ocqueoc River	May	1.1	0.0
Au Sable River	May	2.0	0.5
Au Sable River	May	4.5	3.5
Whitney Drain	May	3.5	1.5
Whitney Drain	May	3.0	1.5
West Coast			
Huron River	May	0.8	0.2
Two Hearted River	May	0.5	0.5
Boardman River	April	0.0	0.5
Boardman River	May	1.5	0.0
Boardman River	June	0.0	0.5
Au Sable River	May	0.0	1.0
Au Sable River	May	2.0	0.0
Whitney Drain	May	0.5	0.5
Michigan wild			
Huron River	May	0.6	0.4
Two Hearted River	May	1.1	0.8
Boardman River	April	0.0	0.0
Boardman River	May	0.5	1.5
Boardman River	June	0.0	0.0
Ocqueoc River	May	2.0	1.4
Au Sable River	May	2.0	2.0
Whitney Drain	May	2.0	1.5

(Lepisosteus sp.) or bowfin (Amia calva) may have affected the recovery rates. To examine the possible influence of warmwater fish predation on the recovery rates, simultaneous releases at six streams were made both upstream and downstream from lakes that contained predatory species. Four releases of domestic trout upstream from inland lakes produced fewer returns than downstream releases (Table 5). In single trials of paired plantings of West Coast and Michigan wild trout, upstream releases produced greater returns than did downstream releases. Predation may have affected returns from upstream releases of domestic trout providing other factors such as high angling pressure on newly released trout or pollution were not involved. There was no indication of any predation effect on West Coast steelhead or Michigan wild trout.

Sea gull predation on newly released trout in the Two Hearted River, Pendills Creek, and Black River was reported by Leland R. Anderson, District Fisheries Biologist. Predation was especially severe when onshore winds kept the fish in shoal water or in the stream. Gull predation could be reduced by night stocking or daylight stocking in calm weather.

Angling pressure.--Angling pressure can affect the recovery rate in two ways: (1) heavy angling pressure for newly released trout may decrease the subsequent catch of lake-run trout, and (2) heavy angling pressure for lake-run trout increases recovery rates.

Table 5.--Recovery of lake-run rainbow trout from releases both upstream and downstream from estuarine lakes containing predatory fish

Strain	Year released	River planted	Average length (inches)		Percentage return	
			Down-stream	Up-stream	Down-stream	Up-stream
Domestic	1959	Pentwater	6.1	6.0	0.6	0.0
Domestic	1959	Pere Marquette	8.2	8.2	0.8	0.0
Domestic	1957	Big Manistee	8.5	8.2	1.1	0.1
Domestic	1957	Little Manistee	8.5	8.2	1.1	0.1
West Coast	1959	Pentwater	5.9	5.9	0.0	0.4
Michigan wild	1959	Pere Marquette	8.4	8.4	1.6	2.0

We observed extremely heavy angling pressure on newly released domestic trout in certain plants. As high as 10% of the fish in a plant were reported caught before they could migrate to the Great Lakes. Many others were caught and not reported. To determine the effect of heavy angling pressure over newly released fish on subsequent recoveries of lake-run fish, the Boardman River was closed for 1 month after a stocking of 1,992 domestic trout in 1956. Recoveries of newly released fish and lake-run fish were not different than those from a similar plant in 1955 with no closed season (Hansen, 1960). The closure for 1 month apparently did not protect the newly released fish, assuming that nonresponse was similar for the two plants. Although early exploitation doubtlessly reduces subsequent lake-run recoveries, the magnitude of this reduction remains unknown. Non-lake-run recoveries from locations where two strains were planted together were compared to determine if there were differences in rates of early exploitation among the strains. The plants used for this comparison had been made in all of the upper Great Lakes in 1957-59; the average lengths of the two strains in each plant were greater than 7.0 inches. Domestic trout were much more vulnerable to early angling than West Coast steelhead and Michigan wild fish. They had the higher early exploitation rates in 17 of 19 plants of domestic and West Coast steelhead together and in 19 of 23 plants of domestic and Michigan wild trout together. A nonparametric sign test demonstrated

that these proportions differed significantly from the expected 50:50 ratio ($P = 0.002$ and 0.02). The sign test showed no difference in early vulnerability between West Coast steelhead and Michigan wild trout planted together at 13 locations.

Data on the relative amounts of fishing pressure for lake-run trout at the various stocking sites were scarce. However, the plants that produced the highest recovery rates were made at streams that seemed to have heavy angling pressure (judging from reports of District Fisheries Supervisors).

Migration among streams.--Planted trout caught during the spawning season in streams other than the release stream were considered "strays." Trout recaptured away from the release site during the fall or in the Great Lakes proper were not considered strays as they might have subsequently returned to the "parent" stream to spawn.

Presumably, trout straying from a lightly fished to a heavily fished stream could raise the recovery rates; conversely, trout straying from a heavily fished to a lightly fished stream could depress the recovery rate. Since the apparent movement is influenced by fishing pressure and the proportion of unreported tag recoveries, which vary from one location to another, the computed rates of straying at individual locations are probably not entirely reliable. For example, it is possible that the returns from two adjacent stocking locations may show widely divergent rates of

straying because of differences in fishing pressure and the tendency to report tags, even though the actual rate of straying between the two sites is similar.

Fifty-one per cent of the fish recovered during January 1-July 31 were strays (Table 6). The percentages of straying for lake-planted fish (54%) and stream-planted fish (45%) were different (chi-square = 4.83, 1 d.f., $P<0.01$). For lake-planted trout, there were differences in straying among the three strains (chi-square = 25.74, 2 d.f., $P< 0.001$). These tests suggest, unless they are biased by variable nonresponse, that stream-planted fish stray less than lake-planted fish and that domestic trout stray less than West Coast and Michigan wild fish. To lessen the effect of variable nonresponse, straying from locations where two strains were planted together was compared by nonparametric sign tests. These plants were made in all three Great Lakes during 1957-59; some straying of each pair member occurred in each plant. Domestic trout strayed less than West Coast fish in six of eight plants, and less than Michigan wild in six of eight plants. Michigan wild fish strayed less than West Coast fish in five of nine plants. Although these data are somewhat suggestive of less straying by domestic trout, the differences were not significant statistically.

Nonresponse by anglers.--Some anglers do not report the tagged fish they catch. Stroud and Bitzer (1955), McCammon and LaFaunce (1961), Hallock, et al. (1961), and Butler (1962) reported nonresponse rates of 20 to 91%. The percentage of nonresponse

varies and presumably depends on angler interest. In our study, we did not have measurements of nonresponse; therefore, the recovery rates reported here are minimal.

Migration and distribution in the Great Lakes

The prevailing direction of movement appeared to be down lake (Table 6 and Fig. 2). A noteworthy percentage of recoveries (12%) were reported from waters of other states and Canada. Migration among the upper Great Lakes was negligible but some trout from Lake Huron migrated into lakes Erie and Ontario. Straying from several planting sites appeared to be to specific locations, usually the better and/or more heavily fished rainbow trout streams. Migrations of 100 miles or over were common and 11 trout were recaptured at locations over 500 miles from the release point.

The distribution of rainbow trout recaptured by commercial fishermen in the Great Lakes proper is shown in Figure 2. All recoveries were made within 12 miles of shore, mostly at depths of 6-60 feet. Although this may simply indicate the major fishing locations, it also means that many rainbow trout inhabit shoal water in the Great Lakes. It is significant that no rainbow trout were reported caught far from shore, although some commercial fishing does occur there. Several recovery concentrations are evident, notably near Mackinaw City, Michigan and Toledo, Ohio.

Table 6.--Percentages of recaptured rainbow trout that strayed varying distances from their release sites to other streams, 1955-59 [a]

Release location and strain	Total number of recoveries	Distance traveled from release location				Total percentage straying	Recoveries in other states or Canada	Direction of movement [b]	
		10 miles or less	11-50 miles	51-100 miles	Over 100 miles			Up-lake	Down-lake
Lake									
Domestic	197	4	15	8	14	41	11	29	71
West Coast	75	5	19	17	29	70	24	9	91
Michigan wild	146	5	22	8	29	64	20	44	56
Sub-total or weighted average	418	4	18	10	22	54	16	31	69
Stream									
Domestic	171	1	20	9	9	39	4	37	63
West Coast	4	0	25	0	25	50	0	0	100
Michigan wild	36	3	11	14	50	78	11	21	79
Sub-total or weighted average	211	1	19	9	16	45	5	32	68
Total or weighted average	629	3	18	10	20	51	12	31	69

[a] Includes only stream-caught trout recaptured during January 1-July 31. Trout from releases at Huron and Keweenaw bays, Presque Isle, Black River (1957), and Northport Bay were excluded.

[b] Percentages of direction of movement based on total number of strays.

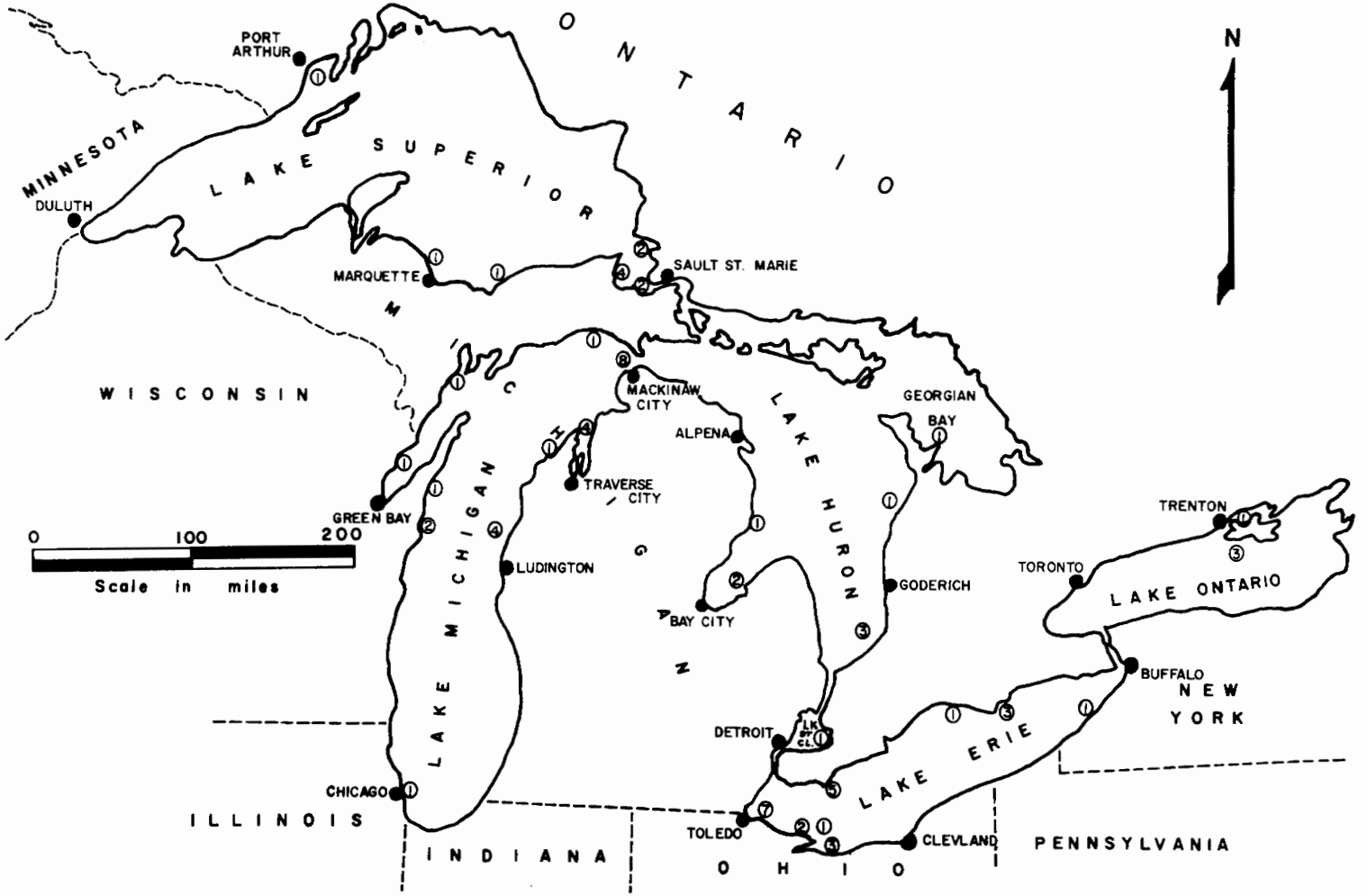

Figure 2. --Number of planted rainbow trout (circled numbers) caught by fishermen at various locations in the Great Lakes.

Time between release and recovery

Fish recovered in the spring and fall of the year planted were considered first-year recoveries; in the year after, second-year recoveries; and those subsequently recovered, third-year or more recoveries. Most fish were recovered either during April-June or September-November. Although fishing pressure is lower in the fall than in the spring, a surprisingly large proportion of trout (40%) were caught during the fall.

For the 1955-56 plantings of domestic trout, 93% of the fish recovered were caught within 2 years of release (Hansen, 1960). For trout planted in 1957-59, only 77% of the recovered fish were caught within 2 years of release because of the presence of West Coast and Michigan wild trout (see below).

The recovery rates from the 1957-59 plants were analyzed to determine the effect of certain factors on time between release and recovery. Recovery rates (percentage of total recaptures) during the first year after planting were subjected to a three-way analysis of variance in which the factors were lake, strains and year planted. Recovery rates in the second and third or later years after planting were analyzed by a four-way analysis of variance where lakes, strains, year and interval of capture were the factors. Since the year planted had no significant effect on time between release and recovery, recovery rates for years were combined in Table 7 to illustrate the effect of lake and strain on time of recovery.

Table 8. --Unweighted mean percentages of lake-run rainbow trout recovered in successive years after release from stockings made in three of the Great Lakes in 1957-59

Item	Year								
	First			Second			Third or more		
	Spring[a]	Fall[b]	Total	Spring	Fall	Total	Spring	Fall	Total
Lake									
Superior	2	10	12	28	12	40	45	3	48
Michigan	1	29	30	47	13	60	8	2	10
Huron	0	42	42	38	10	48	9	1	10
Average	1	26	27	38	12	50	21	2	23
Strain									
Domestic	3	41	44	30	18	48	6	2	8
West Coast	0	19	19	51	6	57	22	2	24
Michigan wild	0	22	22	32	10	42	34	2	36
Average	1	26	27	38	12	50	21	2	23

[a] January 1-July 31.

[b] August 1-December 31.

In the first year, a higher percentage of fish was recovered from lakes Huron and Michigan than from Lake Superior plants ($F = 7.49$, $P<0.05$, d.f. 2, 8). More domestic trout were recovered than West Coast and Michigan wild trout ($F = 6.37$, $P<0.05$, d.f. 2, 8). Recoveries of West Coast and Michigan wild trout were not different. In the second year, there were no differences in percentage of return among the three lakes. Among strains, West Coast trout produced higher returns than domestic ($F = 45.43$, $P<0.05$, d.f. 1, 8) and domestic trout higher than Michigan wild ($F = 6.97$, $P<0.05$, d.f. 1, 8). After 2 years, Lake Superior plants produced more fish than did Michigan and Huron plants ($F = 8.52$, $P<0.05$, d.f. 1, 8). Recoveries from lakes Michigan and Huron plants did not differ. Michigan wild plants produced more recoveries than domestic ($F = 15.52$, $P<0.05$, d.f. 1, 8); there were no other differences.

In summary, fish from Lake Superior plants contributed to the angler catch for a longer time than did fish planted in lakes Michigan and Huron. A comparatively low rate of angler exploitation and relatively light sea lamprey predation in Lake Superior may have been the reason. Practically all domestic trout were caught within 2 years of planting while most West Coast and Michigan wild trout were caught after 1 year at liberty. Earlier maturity and/or greater vulnerability to angling of domestic trout may have caused the difference.

Growth rates

Native rainbow trout grow rapidly after migrating into the Great Lakes. The growth of hatchery-reared rainbow trout in the Great Lakes also was rapid. The lake growth of wild rainbow trout and domestic 2-year-old trout released in the Black River (where all fish recovered were accurately measured) is shown in Table 8. The domestic trout, which were longer when released, maintained their greater length until the third spring after release. By this time the two groups were about the same size.

The average length of three strains of recaptured hatchery-reared rainbow trout at successive intervals after release (as reported by anglers) is given in Table 9. Lengths reported by anglers appeared to be valid since they were similar to those of hatchery fish measured at Black River. All three strains grew rapidly. At successive intervals after stocking, West Coast and Michigan wild trout nearly always attained greater lengths than domestic trout, even though domestic trout were frequently larger when planted. The growth of the jaw-tagged trout in this study may have been below normal because jaw tagging slightly inhibits growth of rainbow trout (Stauffer and Hansen, 1966).

Sex ratios and maturity

Planted fish recaptured by anglers on the Black River were examined for maturity and sex. Of 87 fish examined, only 13 caught in the first fall or second spring were immature. For the mature

Table 8.--Average length (inches) and weight (pounds) of lake-run rainbow trout recovered at successive intervals after release in the Black River, Mackinac County, 1951-59 [a]

[Number of trout examined in parentheses]

Strain and origin	Average length at release[b]	Year of recovery[c]							
		First		Second				Third	
		Fall		Spring		Fall		Spring	
		Length	Weight	Length	Weight	Length	Weight	Length	Weight
Domestic, hatchery	9.2	15.3 (28)	1.5 (20)	16.1 (29)	1.6 (24)	19.9 (11)	3.5 (7)	19.8 (6)	3.2 (6)
Wild rainbow trout Black River	7.3	13.8 (37)	1.1 (34)	14.3 (42)	1.1 (37)	16.2 (7)	2.1 (6)	19.6 (23)	2.7 (20)

[a] Compiled from all sources of recovery (angler and miscellaneous). All fish were 2 years old when released and were examined by trained personnel at release and recapture.

[b] Average lengths at release of trout which were subsequently recovered.

[c] The fall season was August 1-December 31; the spring season included January 1-July 31.

Table 9.--Average length (inches) of three strains of rainbow trout at successive intervals after release, 1955-59 [a]

[Number of recoveries in parentheses]

Stocking location and strain	Release data		Year of recovery [c]				
	Age (years)	Average length (inches)[b]	First Fall	Second Spring	Second Fall	Third Spring	Fourth Spring
Lake Superior							
Domestic	2	9.1	15.3 (44)	16.1 (70)	19.3 (26)	19.8 (30)	21.5 (2)
West Coast	2-3	8.4	15.0 (1)	18.0 (21)	22.1 (4)	23.8 (24)	25.6 (8)
Michigan wild	2-3	9.2	16.8 (2)	19.5 (19)	24.2 (5)	22.6 (37)	24.8 (27)
Lake Michigan							
Domestic	2	9.2	15.6 (188)	16.9 (183)	19.5 (26)	24.1 (8)	-
West Coast	2-3	8.0	15.7 (5)	18.1 (14)	19.8 (3)	25.0 (1)	-
Michigan wild	2-3	8.3	15.4 (25)	17.8 (28)	22.2 (14)	24.4 (13)	24.0 (2)
Lake Huron							
Domestic	2	8.7	15.5 (103)	16.7 (38)	19.3 (29)	22.7 (4)	-
West Coast	2-3	7.9	13.6 (3)	19.4 (21)	19.5 (2)	-	-
Michigan wild	2-3	7.9	15.9 (19)	18.2 (42)	22.7 (8)	22.9 (13)	28.5 (1)

[a] Compiled from all sources of recovery (angler and miscellaneous).

[b] Average length of recovered trout at release.

[c] The fall season includes the period August 1-December 31; the spring season, January 1-July 31.

fish, the ratio of males to females was 3.9:1, even though females are more susceptible to angling than males (Withler, 1966). Furthermore, the ratio of mature males to females taken in an upstream trap was 3.6:1. Earlier return to the parent stream, occasioned by their earlier maturity, doubtlessly accounts for the predominance of males in the angler catch and spawning runs.

Summary

1. Our principal objectives were to determine the influence of certain factors on survival to the creel of rainbow trout planted in the Great Lakes and to get knowledge of their behavior.

2. Hatchery rainbow trout (125, 503) of three strains were measured, tagged and released in or near the Great Lakes at 27 locations in 1955-59.

3. Comparative survival was assessed from voluntary reports by anglers. Recovery rates are minimal because the amount of nonresponse was unknown.

4. The reported recovery rate was 1.2%, ranging from 0.0 to 9.3% for the various plants.

5. Releases in May produced the best return.

6. There was no difference in recovery rates among the three strains (domestic, West Coast and Michigan wild rainbow trout).

7. Larger fish produced higher returns than smaller fish.

8. For domestic trout, lake plantings produced better returns than stream plantings.

9. Predation by other fish and sea gulls reduced the recoveries of domestic trout by an undetermined extent.

10. Domestic trout were more susceptible to angling immediately after planting than were West Coast and Michigan wild rainbow trout.

11. Planted rainbow trout ranged widely in the Great Lakes and only about 50% of those recovered returned to the planted stream to spawn.

12. Most trout were caught within 2 years of release.

13. One growing season after planting (at an average length of 8.8 inches) rainbow trout were 16.4 inches long; after two seasons, 21.4 inches long.

14. The planting locations are described in the appendix.

Recommendations

From present knowledge, the following stocking practices should provide the maximum rate of return to the anglers:

1. Stock in May and June during the normal downstream migration of wild juvenile rainbow trout.

2. Plant the domestic strain of rainbow trout because they grow faster in the hatchery, probably stray less after release than the West Coast and Michigan wild strains, yet provide similar returns.

3. Use fish of the largest feasible size.

4. Plant in the Great Lakes near the mouth of tributary streams.

5. To reduce avian predation, stock in calm weather or at night.

6. Protect plantings from early exploitation by stream closure.

7. Plant heavily at a few high-use rainbow trout streams rather than a few fish at many locations.

Voluntary reporting of recoveries to assess planting methods is inadequate. The return of adult fish to the spawning stream must be evaluated by an upstream trap or by a well planned creel census. The actual recovery rate may have changed now, in view of the much increased alewife population in the Great Lakes and reduced populations of sea lampreys. We suggest replication of some of the 1955-59 plants to measure these effects.

Stocking and hatchery methods not yet investigated, but which may prove useful in increasing recovery rates, are imprinting (Hasler, 1966) and selective breeding. Trout could be held for a period of time in a stream and then released with non-imprinted trout to compare rates of return to the parent stream. For selective breeding experiments, stocked trout that survived to sexual maturity would be bred and presumably the characteristics enhancing survival would be inherited. The resulting young then would be planted with normal hatchery stock and their recovery rates compared.

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Appendix

The stocking sites in 1955-58, virtually complete recoveries from the 1955-56 plantings, and incomplete recoveries from the 1957-58 plantings, have been described (Hansen, 1960). In this Appendix, complete returns from the 1955-59 plantings (a planting was considered to be a single-strain release made at a specific location and date) are summarized and the new stocking locations for 1959 are described (see also Table I of Appendix). Information of interest to fish managers is given for each stocking site. This information includes: (1) number, location, and strain for each planting; (2) rates of recovery; (3) factors which may have affected the recovery rate; (4) time of recovery; and (5) amount of straying.[3] In the discussions on time of recovery (spring or fall), the first refers to the year of release; the second and third to successive years thereafter. For sites first stocked in 1959, the physical nature of the streams, unusual stocking locations, presence and character of natural runs of rainbow trout, weirs, and other factors which conceivably could influence or aid in the interpretation of the recovery rates are noted.

The stocking sites mentioned in the text are numbered as in Figure 1 and Table I. A second number, in parentheses, identifies the number of the planting as given by Hansen (1960). The year(s) of planting is in parentheses after the site name.

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[3] See section on migration (p. 16) for limitations of these data.

1. (-) Presque Isle River (1959). --This large river supports moderate spring and fall runs of rainbow trout. Spawning habitat is confined to the 1/2-mile of stream downstream from a natural barrier, Manido Falls. Stream temperatures may be marginally high at times. Angling pressure was light to moderate. Because of poor road conditions, all trout (domestic and Michigan wild) were stocked 1/2 mile upstream from Manido Falls. The recovery rate may have been reduced by mortality among trout migrating downstream.

A recovery of 2.4% was reported from the release of Michigan wild trout, but only 1 trout was recovered from the release of 982 domestic trout. The reason for the lower recovery rate of domestic trout is unknown. Virtually all recaptured trout were reported from other Lake Superior streams east of the Presque Isle River. Seventy per cent of the recoveries were reported during the second spring after release.

2. (1) Keweenaw Bay (1958). --This lake stocking of domestic and West Coast trout, at the south end of Keweenaw Bay, resulted in an extremely low rate of recovery (domestic, 0.0%; West Coast, 0.6%). Angling pressure was light in the bay but heavy in nearby streams during the spring. However, the few recoveries came from Lake Superior streams 80-100 miles to the east during the second spring and third spring after release.

3. (2) Huron Bay (1958). --This lake stocking of the three strains of trout at the south end of Huron Bay resulted in a recovery rate of 0.4% for domestic trout, 0.8% for West Coast trout, and 2.0%

for Michigan wild trout. Angling pressure was light in the bay but heavy in nearby streams in the spring. Seventy-five per cent of the trout were caught at streams near the release location during the third spring after release.

4. (3) Huron River (1955-59). --Eleven plantings were made in 1955-59. All three strains were used and releases were made in both the lake and stream. Although angling pressure was heavy, the recovery rates were not high, ranging from 0.2 to 2.9%; the highest recovery rate resulted from the release of domestic trout in 1955. Northern pike predation in the lower river may have affected the recovery rates.

Thirty-three per cent of the recoveries were reported from the Huron River, 30% were from streams in the Marquette-Munising area and the rest were from other tributaries of Lake Superior. About one-half of the recovered trout were caught during the second spring after release; the other recoveries were about equally distributed among the first fall, second fall, and third spring.

5. (4) Iron River (1955-56). --Two stream releases of domestic rainbow trout were made in this non-trout stream in 1955-56. An extremely low recovery rate (0.0-0.1%) was reported. Probable limiting factors were northern pike predation, inadequate spawning environment (a dam located about 2 miles upstream from the mouth blocks access to the headwaters), high stream temperatures below the dam during the summer, and light fishing pressure.

6. (5) Presque Isle (1956). --A planting of domestic trout in Lake Superior, 4 miles away from the nearest rainbow trout stream, gave a recovery rate of 1.8%. Angling was light to moderate at the release site. Thirty-one per cent of the recovered trout were taken at Presque Isle; the rest were recovered at widely scattered Lake Superior streams. Most of the recoveries (64%) were made during the first fall and second spring.

7. (6) Chocolay River (1955). --No lake-run recoveries were reported from this stream planting of domestic rainbow trout. Two probable explanations for the poor recovery were (1) heavy angler exploitation of newly planted fish observed by the junior author (5.5% were reported), and (2) a population of northern pike in the release area.

8. (7) Rock River (1957). --Although angling pressure was heavy, a low rate of recovery (0.3%) was reported from this lake stocking of domestic trout. The reason for the low recovery rate is unknown.

9. (8) Hurricane River (1958-59). --Three lake releases of domestic and two of Michigan wild trout were made at this small but excellent rainbow trout stream. Although angling pressure was heavy in the spring, the rate of recovery (0.0-2.8%) was moderate. The highest return came from a Michigan wild trout planting in 1959.

Of the recoveries, 27% were from the Hurricane River, 27% from streams nearby, 17% from the Miners River, Alger County, and the rest from more distant Lake Superior streams. Most domestic trout were caught during the second spring after release, but all

recoveries of Michigan wild trout occurred during the third spring after release or later.

10. (9) Sucker River (1957). --A stream stocking of domestic trout produced no angler recoveries. Northern pike predation in East Bay (at the mouth of the river), light angling pressure, poor angler response, and inadequate spawning grounds may have contributed to the lack of recoveries.

11. (10) Two Hearted River (1955-59). --Sixteen plants were made. Each of the three strains was stocked both in the lake and the stream. The recovery rates ranged between 0.0 and 3.3%; the highest recovery rate of any plant in Lake Superior was reported from the 1955 lake release of domestic trout. Angling pressure was especially heavy in the spring.

Although the recovery rate from the 1955 stocking was the highest for Lake Superior, the recovery rates from all releases at the Two Hearted River might have been higher except for: (1) mortality due to inshore commercial fishing, (2) heavy sea gull predation on newly released trout and (3) poor angler response. In addition, the newly released trout of the 1956 planting were subject to heavy angler exploitation (4.3%) and newly released trout from the 1959 plantings suffered mortality at a sea lamprey weir.

About one-half of the fish were recovered from the Two Hearted River; the rest were caught in numerous other Lake Superior streams. Approximately equal percentages of trout were recaptured during the first fall, second spring, second fall, and third spring.

12. (11) Betsy River (1955-56).--Very few fish from the two stream releases of domestic trout were caught (0.4% each year). Angling pressure was light. Mortality from commercial fishing operations off the mouth of the Betsy River, northern pike predation, and poor angler response also may have contributed to the low rate of recovery.

None of the recoveries were from the Betsy River but one-third were from the St. Marys River and the rest were from various other Lake Superior streams. The highest percentage of recoveries (46%) was from the second spring after release.

13. (12) Pendills Creek (1955-58).--Seven lake releases were made (four domestic, two Michigan wild and one West Coast). The recovery rates were between 0.9 and 2.6% and the highest return came from a domestic release in 1958. A control dam for a trout hatchery near the mouth may limit the available spawning area. Considerable sea gull predation occurred when onshore winds kept newly released fish in shoal water.

Thirty-five per cent of the recoveries came from Pendill's Creek, 37% came from the St. Marys River, and the rest came from other Lake Superior streams. Fifty-nine per cent of the trout were recaptured during the first fall and second spring after release.

14. (13) St. Marys River (1957-59).--Three domestic, two West Coast and two Michigan wild releases were made in this large river. Angling pressure was moderate to heavy and recovery rates ranged from 0.0 to 2.4%. The highest recovery was from the

1958 release of domestic trout. Little straying occurred from this river. Of the recoveries, 70% were obtained during the first fall and second spring after release.

15. (-) Pentwater River (1959). --This large river formerly supported heavy runs of rainbow trout, but in recent years the runs have been very light. The South Branch is a warmwater stream. The North Branch is a fairly good trout stream, with temperatures almost always within tolerable limits for trout. Angling pressure was very light on the North Branch. Pentwater Lake, at the mouth of Pentwater River, is a warmwater lake. There are probably fairly large numbers of burbot in the stream and gar, northern pike, and bowfin are abundant in Pentwater Lake.

Domestic and West Coast trout were released both in upper Pentwater Lake and in the river downstream from Pentwater Lake. There were few returns (0.0-0.6%) from these releases. Warmwater fish predation on these relatively small fish (average length, 6.0 inches) may have reduced the population. One-half of the recoveries were from the Pentwater River, and most of the recovered trout were caught during the second spring after release.

16. (-) Pere Marquette River (1959). --This large river supports substantial runs of upstream-migrating rainbow trout. Water temperatures are cold in the upper river but probably are excessively warm in the vicinity of Pere Marquette Lake, located at the mouth of the river, and in the lake itself. Angling pressure was heavy early in the season but light thereafter. Large brown trout (Salmo trutta) are

numerous in the river and bowfin, gar, northern pike and muskellunge (Esox masquinongy) are present in Pere Marquette Lake.

Two releases (domestic and Michigan wild) were made upstream from Pere Marquette Lake and two (domestic and Michigan wild) were made downstream from the lake. Recovery rates ranged between 0.0 and 2.0%. Twenty-five per cent of the recoveries were from the Pere Marquette River, 38% from the Pentwater River, and the rest from various other Lake Michigan streams. Most of the trout (54%) were recovered during the first fall and second spring after release.

17. (14) Manistee River (1955-57). --Seven stream plantings of domestic trout were made at this site. Five plantings were made in the stream above Manistee Lake and two below the lake.

The highest recovery rates (1.6 and 1.1%) originated from the 1956 and 1957 plantings which were made below Manistee Lake. The recovery rates from locations above Manistee Lake were extremely low; no recoveries of lake-run or newly released trout were reported from the 1955 planting in the Big Manistee River or the 1956 planting in the Little Manistee River. Pollution, warmwater fish predation in Manistee Lake, and the relatively long distance of the planting sites from Lake Michigan may have been responsible for the extremely low rate of recovery from plantings above Manistee Lake. Intensive early exploitation (4.3% in 1955; 8.1% in 1957) of the newly released trout by anglers in the Little Manistee River also may have contributed to the low recovery rates from these plantings.

Of the recoveries, 33% were from the Manistee River, 13% were from the Pentwater River, and 13% were from the Betsie River. The others were from scattered Lake Michigan streams. Most of the recovered trout (90%) were caught during the first fall and second spring after release.

18. (15) Betsie River (1955-56).--Two stream plantings of domestic trout were made in this stream. Returns of 1.0 and 1.5%, respectively, were reported from the 1955 and 1956 releases. Angling pressure is moderate to heavy. Northern pike predation and unreported recaptures of newly released trout may have reduced the recovery rates.

Twenty-eight per cent of the recovered trout were caught in the Betsie River and the rest were from various other Lake Michigan streams. Most of the recovered trout (86%) were caught during the first fall and second spring after release.

19. (16) Platte River (1957).--This stream stocking of domestic trout resulted in an extremely low return (0.1%). Angling pressure was usually light to moderate. However, heavy early exploitation by anglers of newly stocked trout (at least 10.0% were caught) no doubt reduced the subsequent recovery rates.

20. (17) Northport Bay (1955-56).--Returns of 1.8 and 2.0%, respectively, were produced by these two lake releases of domestic trout in 1955 and 1956. Angling pressure was light in the release area.

No fish were recaptured at the release site, but 56% were reported from the Boardman River and the rest came from various other Lake Michigan streams. Most of the recovered trout (84%) were caught during the first fall and second spring after release.

21. (18) Boardman River (1955-59). --Ten domestic, eight West Coast, and eight Michigan wild releases were made either in the lake or stream. Recovery rates ranged between 0.0 and 5.2%. The highest recovery rate was from the 1955 release of domestic trout. The recovery rate in 1956 (4.7%) was also relatively high but there was a progressive decline for subsequent years.

Factors responsible for the relatively high rate of return from the early plantings include heavy angling pressure, proximity of a Conservation Department field station (where anglers can conveniently report their recoveries), excellent cooperation displayed by anglers in reporting recaptures and the blocking (and concentrating) effect of a dam near the mouth of the stream. The gradual decline in annual recovery rates may have resulted from a declining interest in reporting them.

Eighty per cent of the recovered trout were taken either in the Boardman River or the West Arm of Grand Traverse Bay, 7% were recovered at the Elk River (Antrim County) and the rest were from scattered streams in Lake Michigan. Of the recoveries, 86% were taken during the first fall and second spring.

22. (19) Carp Lake River (1955-57). --Four lake releases, including three domestic and one West Coast release, were made off the mouth of this stream. Recovery rates ranged between 0.3 and 1.1%. Light angling pressure was one of the reasons for the low rate of recovery.

One-third of the recoveries were from the Carp Lake River; the rest were from various other Lake Huron streams. Eighty-five per cent of the recaptures were taken during the first fall and second spring after release.

23. (20) Black River (1955-58). --Seventeen domestic, three West Coast, and three Michigan wild releases were made, either in the stream or lake. Recovery rates were variable, ranging from 0.0 to 5.5% for the domestic planting of May, 1956. Non-response of anglers was minimized to an extent by a creel census of about 30% of the angling during 1955-59. Of the 449 lake-run trout checked during the creel census, 121 were planted fish. Although the heavy plantings increased the anglers' catch by 37%, catches of two weirs operated in April-July and September-November, 1955-59 showed that the planted fish increased the runs by only 8.8%. At the weirs, 68 hatchery trout were recaptured out of a total of 772 lake-run trout.

Heavy angling pressure enhanced recovery. Also, heavy exploitation of newly planted trout from the May and June stream plants in 1955-56 plus sea-gull predation on newly planted trout in the lake probably reduced the subsequent recovery of lake-run trout.

Because of the creel census, virtually all of the recovered trout (94%) were reported from the Black River. Of the recoveries, 76% were caught during the first fall and second spring after release.

24. (21) Black Mallard Creek (1955-56). --Two lake stockings of domestic trout were made in this stream. The 1955 and 1956 releases produced recoveries of 2.7 and 1.3%.

No recoveries were reported from Black Mallard Creek, probably because of unfavorably high water temperatures. Almost equal numbers of recoveries were obtained, however, from the Ocqueoc, Au Gres and Au Sable rivers. Virtually all of the recoveries were made during the first fall and second spring after release.

25. (22) Ocqueoc River (1957-59). --Five domestic, two West Coast and five Michigan wild releases were made here. Recovery rates were between 0.0 and 2.0%. Lake stocking of Michigan wild trout in 1957 and 1959 produced the best returns. Angling pressure was relatively light.

Only 8% of the recoveries were from the Ocqueoc River; the remainder were from scattered streams along Lake Huron. Most (83%) were recaptured during the first fall and second spring after release.

26. (-) Au Sable River (1959). --Light to moderate runs of rainbow trout occur in the spring and fall in this large river. Foote Dam, a barrier to upstream-migrating trout, is located approximately 10 miles upstream from the mouth. Much of the stream bed below the dam consists of shifting sand. The water level below the dam is subjected to extreme fluctuations due to operation of the power dam. Angling pressure on rainbow trout was light.

Ten lake or stream releases (four domestic, four West Coast, two Michigan wild) were made in this river. The recovery rates were

between 0.0 and 4.5%, and the greatest return was provided by a lake stocking of domestic trout.

Twenty per cent of the recovered trout were from the Au Sable River, 40% were from the Au Gres River, and the rest were from other Lake Huron streams. Eighty-five per cent of the recoveries were caught during the first fall and second spring after release.

27. (23) Whitney Drain (1958-59).--Five domestic, two West Coast and three Michigan wild releases were made in this stream. Recovery rates were between 0.5 and 9.3%. The highest recovery rate (9.3%) for this plant was from the 1958 planting of domestic trout. The intense fishing pressure and the cooperation of business people (in publicizing the releases) and anglers were partially responsible for the high rate of recovery in 1958. However, in 1959, diminished interest and relatively heavy exploitation of newly released trout could have reduced the recovery rate.

About one-half of the recovered trout were either from Whitney Drain or the Au Gres River; the rest were from several Lake Huron streams. Of the recovered trout, 61% were caught during the first fall after release, 19% the second spring, 13% the second fall, and 7% the third spring.

28. (24) Sturgeon River (1958-59).--Nine releases (two domestic, four West Coast and three Michigan wild) were made in Burt Lake off the mouth of the Sturgeon River. Recovery rates were

between 0.0 and 3.2%. The highest return came from a lake stocking of West Coast trout off the mouth of the river in 1958. Angling pressure was heavy in the lower portion of this stream.

With the exception of several trout caught in Burt Lake, all of the recovered trout were caught in the Sturgeon River. An unusually large number of these recaptures (38%) were taken during the spring of release and 54% were taken the first fall after release.

29. (-) Maple River (1959). --One release of each of the three strains was made in Burt Lake off the mouth of the river. Recovery was nil, probably because of light angling pressure for migratory rainbow trout at this location.

INSTITUTE FOR FISHERIES RESEARCH

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Report approved by G. P. Cooper

Typed by M. S. McClure

Table I. --Summary of recovery data for several strains and sizes of rainbow trout planted at 29 locations in Michigan, 1955-59

Locality	Fish planted: Year	Number and site [a]	Strain[b] and age	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Unknown[c] Number	Unknown[c] Percentage
Lake Superior										
1. Presque Isle River	1959	982-S	D(2)	10.5	1	0.1	15	1.5	0	0.0
Gogebic Co.		925-S	M(3)	11.5	22	2.4	16	1.7	1	0.1
2. Keweenaw Bay	1958	494-L	D(2)	9.3	0	0.0	21	4.2	0	0.0
Baraga Co.		495-L	W(3)	10.5	3	0.6	4	0.8	0	0.0
3. Huron Bay	1958	499-L	D(2)	9.2	2	0.4	11	2.2	0	0.0
Baraga Co.		484-L	W(3)	10.3	4	0.8	3	0.6	0	0.0
		498-L	M(3)	8.8	10	2.0	0	0.0	0	0.0
4. Huron River	1955	1,000-S	D(2)	9.3	29	2.9	0	0.0	1	0.1
Marquette Co.	1956	1,979-S	D(2)	9.1	33	1.7	15	0.8	3	0.2
	1957	1,000-L	D(2)	8.0	5	0.5	5	0.5	0	0.0
		1,000-L	W(2)	7.6	6	0.6	0	0.0	0	0.0
	1958	999-L	D(2)	9.1	5	0.5	6	0.6	1	0.1
		490-L	W(3)	10.5	4	0.8	0	0.0	0	0.0
		994-L	M(3)	9.0	4	0.4	1	0.1	0	0.0
	1959	494-L	W(2)	6.2	4	0.8	1	0.2	0	0.0
		485-L	M(3)	6.0	3	0.6	0	0.0	0	0.0
		490-S	W(2)	6.1	1	0.2	0	0.0	0	0.0
		491-S	M(3)	6.1	2	0.4	0	0.0	0	0.0

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Locality	Year	Fish planted: Number and site [a]	Strain[b] and age	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Unknown[c] Number	Unknown[c] Percentage
5. Iron River	1955	700-S	D(2)	7.3	0	0.0	0	0.0	6	0.8
Marquette Co.	1956	1,999-S	D(2)	8.4	2	0.1	19	1.0	0	0.0
6. Presque Isle Marquette Co.	1956	3,000-L	D(2)	9.1	55	1.8	29	1.0	24	0.8
7. Chocolay River Marquette Co.	1955	1,500-S	D(2)	9.4	0	0.0	83	5.5	10	0.7
8. Rock River Alger Co.	1957	1,500-L	D(2)	7.7	4	0.3	1	0.1	2	0.1
9. Hurricane River Alger Co.	1958	499-L	D(2)	9.1	0	0.0	3	0.6	0	0.0
		493-L	M(3)	8.7	10	2.0	4	0.8	0	0.0
		500-L	D(1)	7.9	5	1.0	0	0.0	0	0.0
	1959	500-L	D(2)	8.7	4	0.8	15	3.0	0	0.0
		498-L	M(3)	8.7	14	2.8	0	0.0	0	0.0
10. Sucker River Alger Co.	1957	1,000-S	D(2)	8.4	0	0.0	1	0.1	0	0.0
11. Two Hearted River Luce Co.	1955	1,500-L	D(2)	9.1	49	3.3	26	1.7	8	0.5
	1956	3,000-S	D(2)	9.0	4	0.1	130	4.3	54	1.8
	1957	1,000-L	D(2)	8.0	12	1.2	21	2.1	0	0.0
		1,000-L	W(2)	7.6	14	1.4	1	0.1	0	0.0
		993-L	M(2)	5.7	7	0.7	3	0.3	2	0.2
	1958	999-L	D(2)	9.2	9	0.9	16	1.6	6	0.6
		498-L	W(3)	10.4	2	0.4	1	0.2	0	0.0
		996-L	M(3)	8.5	20	2.0	4	0.4	0	0.0

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Locality	Fish planted				Recoveries					
					Lake-run		Non-lake-run		Unknown[c]	
	Year	Number and site [a]	Strain[b] and age	Average length (inches)	Number	Percentage	Number	Percentage	Number	Percentage
11. Two Hearted River (cont.)	1959	398-L	D(1)	6.6	4	1.0	1	0.2	0	0.0
		395-L	D(2)	6.7	3	0.8	1	0.2	0	0.0
		393-L	W(2)	6.1	2	0.5	1	0.2	0	0.0
		377-L	M(3)	6.1	4	1.1	0	0.0	0	0.0
		393-S	D(1)	6.6	0	0.0	3	0.8	0	0.0
		394-S	D(2)	6.6	0	0.0	4	1.0	0	0.0
		388-S	W(2)	6.2	2	0.5	0	0.0	0	0.0
		392-S	M(3)	6.0	3	0.8	1	0.2	0	0.0
12. Betsy River Chippewa Co.	1955	1,000-S	D(2)	8.2	4	0.4	2	0.2	0	0.0
	1956	2,000-S	D(2)	9.1	9	0.4	13	0.6	0	0.0
13. Pendills Creek Chippewa Co.	1955	500-L	D(2)	8.2	11	2.2	2	0.4	1	0.2
	1956	1,000-L	D(2)	8.3	9	0.9	7	0.7	4	0.4
	1957	1,000-L	D(2)	8.7	16	1.6	0	0.0	0	0.0
		1,000-L	W(2)	7.6	10	1.0	1	0.1	0	0.0
	1958	500-L	D(2)	9.1	13	2.6	4	0.8	2	0.4
		500-L	W(3)	10.3	6	1.2	0	0.0	0	0.0
		500-L	M(3)	8.7	10	2.0	1	0.2	2	0.4
Totals (Lake Superior)		47,104			455	1.0	496	1.1	127	0.3

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Locality	Fish planted: Year	Number and site [a]	Strain [b] and age	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Unknown [c] Number	Unknown [c] Percentage
St. Marys River										
14. St. Marys River Chippewa Co.	1957	1,000-S	D(2)	8.3	11	1.1	2	0.2	0	0.0
	1958	499-S	D(2)	9.1	12	2.4	8	1.6	0	0.0
		496-S	W(3)	10.6	2	0.4	3	0.6	0	0.0
		498-S	M(3)	8.6	4	0.8	0	0.0	0	0.0
	1959	500-S	D(2)	8.9	1	0.2	2	0.4	0	0.0
		499-S	W(2)	6.1	0	0.0	0	0.0	0	0.0
		500-S	M(3)	8.9	5	1.0	0	0.0	0	0.0
Totals (St. Marys River)		3,992			35	0.9	15	0.4	0	0.0
Lake Michigan										
15. Pentwater River Oceana Co.										
(in upper Pentwater Lake)	1959	500-S	D(1)	6.0	0	0.0	0	0.0	1	0.2
		499-S	W(2)	5.9	2	0.4	0	0.0	0	0.0
(below Pentwater Lake)		499-S	D(1)	6.1	3	0.6	1	0.2	1	0.2
		498-S	W(2)	5.9	0	0.0	0	0.0	0	0.0
16. Pere Marquette River Mason Co.										
(above Pere Marquette Lake)	1959	497-S	D(2)	8.2	0	0.0	4	0.8	0	0.0
		498-S	M(3)	8.4	10	2.0	0	0.0	0	0.0
(below Pere Marquette Lake)		498-S	D(2)	8.2	4	0.8	7	1.4	0	0.0
		494-S	M(3)	8.4	8	1.6	0	0.0	0	0.0

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Locality	Fish Planted				Recoveries					
					Lake-run		Non-lake-run		Unknown[c]	
	Year	Number and site [a]	Strain[b] and age	Average length (inches)	Number	Percentage	Number	Percentage	Number	Percentage
17. Manistee rivers Manistee Co.										
Manistee River (above Manistee Lake)	1955	2,496-S	D(2)	9.1	0	0.0	0	0.0	0	0.0
(below Manistee Lake)	1956	2,498-S	D(2)	8.9	40	1.6	4	0.2	0	0.0
(above Manistee Lake)	1957	1,997-S	D(2)	8.2	1	0.1	0	0.0	1	0.1
(below Manistee Lake)	1957	998-S	D(2)	8.5	11	1.1	17	1.7	2	0.2
Little Manistee River	1955	2,497-S	D(2)	9.2	0	0.0	108	4.3	2	0.1
	1956	2,484-S	D(2)	8.9	0	0.0	0	0.0	0	0.0
	1957	1,997-S	D(2)	8.2	1	0.1	161	8.1	5	0.2
18. Betsie River Benzie Co.	1955	3,000-S	D(2)	9.4	30	1.0	12	0.4	5	0.2
	1956	3,000-S	D(2)	8.8	45	1.5	21	0.7	20	0.7
19. Platte River Benzie Co.	1957	1,500-S	D(2)	8.5	2	0.1	150	10.0	12	0.8
20. Northport Bay Leelanau Co.	1955	1,998-L	D(2)	8.9	35	1.8	2	0.1	4	0.2
	1956	1,986-L	D(2)	8.9	40	2.0	5	0.2	10	0.5
21. Boardman River Grand Traverse Co.	1955	2,000-S	D(2)	8.8	105	5.2	53	2.6	12	0.6
	1956	1,992-S	D(2)	9.0	93	4.7	75	3.8	35	1.8
	1957	998-L	D(2)	8.5	39	3.9	21	2.1	6	0.6
		985-L	W(2)	7.6	6	0.6	0	0.0	1	0.1
		998-L	M(2)	7.3	37	3.7	0	0.0	4	0.4

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Locality	Fish planted				Recoveries					
					Lake-run		Non-lake-run		Unknown[c]	
	Year	Number and site [a]	Strain[b] and age	Average length (inches)	Number	Percentage	Number	Percentage	Number	Percentage
21. Boardman River (cont.)	1958	997-L	D(2)	8.7	14	1.4	18	1.8	8	0.8
		487-L	W(3)	12.3	1	0.2	0	0.0	0	0.0
		993-L	M(3)	9.2	23	2.3	13	1.3	2	0.2
	1959									
	April 16	200-L	D(2)	d	2	1.0	2	1.0	1	0.5
		200-L	W(2)		0	0.0	2	1.0	0	0.0
		200-L	M(3)		0	0.0	0	0.0	0	0.0
		200-S	D(2)		0	0.0	1	0.5	3	1.5
		200-S	W(2)		1	0.5	0	0.0	0	0.0
		200-S	M(3)		0	0.0	0	0.0	0	0.0
	May 16	199-L	D(2)	6.4	2	1.0	0	0.0	2	1.0
		200-L	W(2)	6.1	3	1.5	1	0.5	0	0.0
		200-L	M(3)	6.0	1	0.5	0	0.0	0	0.0
		198-S	D(2)	6.5	2	1.0	6	3.0	2	1.0
		200-S	W(2)	6.1	0	0.0	0	0.0	0	0.0
		199-S	M(3)	6.0	3	1.5	0	0.0	1	0.5
	June 16	200-L	D(2)	6.8	2	1.0	0	0.0	0	0.0
		200-L	W(2)	5.7	0	0.0	0	0.0	0	0.0
		200-L	M(3)	5.0	0	0.0	0	0.0	0	0.0
		200-S	D(2)	6.4	1	0.5	3	1.5	2	1.0
		200-S	W(2)	5.6	1	0.5	1	0.5	0	0.0
		200-S	M(3)	5.3	0	0.0	0	0.0	0	0.0

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Locality	Fish planted				Recoveries					
					Lake-run		Non-lake-run		Unknown[c]	
	Year	Number and site[a]	Strain[b] and age	Average length (inches)	Number	Percentage	Number	Percentage	Number	Percentage
22. Carp Lake River Emmet Co.	1955	980-L	D(2)	8.8	11	1.1	2	0.2	1	0.1
	1956	974-L	D(2)	8.9	7	0.7	28	2.9	1	0.1
	1957	1,000-L	D(2)	7.7	3	0.3	6	0.6	5	0.5
		999-L	W(2)	7.7	5	0.5	1	0.1	0	0.0
23. Black River Mackinac Co.	1955									
	Apr. 18	200-L	D(2)	9.5	1	0.5	5	2.5	2	1.0
	May 17	200-L	D(2)	8.2	7	3.5	3	1.5	1	0.5
	June 20	200-L	D(2)	8.2	4	2.0	7	3.5	0	0.0
	Apr. 18	200-S	D(2)	9.5	0	0.0	17	8.5	0	0.0
	May 17	200-S	D(2)	8.2	3	1.5	34	17.0	4	2.0
	June 20	200-S	D(2)	8.4	1	0.5	30	15.0	3	1.5
	1956									
	Mar. 19	199-L	D(2)	7.8	2	1.0	6	3.0	1	0.5
	Apr. 18	200-L	D(2)	8.0	0	0.0	4	2.0	0	0.0
	May 18	200-L	D(2)	8.4	11	5.5	3	1.5	1	0.5
	June 19	200-L	D(2)	8.7	4	2.0	0	0.0	1	0.5
	Mar. 19	201-S	D(2)	7.7	2	1.0	3	1.5	1	0.5
	Apr. 18	200-S	D(2)	8.2	2	1.0	11	5.5	0	0.0
	May 18	200-S	D(2)	8.5	5	2.5	35	17.5	4	2.0
	June 19	200-S	D(2)	8.7	2	1.0	33	16.5	17	8.5
	1957[e]	1,000-L	D(2)	6.4	11	1.1	3	0.3	0	0.0
		990-L	W(2)	6.2	0	0.0	0	0.0	0	0.0
		982-L	M(2)	7.0	7	0.7	0	0.0	0	0.0
		1,000-S	D(2)	6.4	4	0.4	11	1.1	0	0.0
		951-S	W(2)	6.3	2	0.2	2	0.2	0	0.0
		954-S	M(2)	7.1	15	1.6	8	0.8	0	0.0

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Locality	Fish planted: Year	Number and site [a]	Strain[b] and age	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Unknown[c] Number	Unknown[c] Percentage
23. Black River (cont.)	1958	994-L	D(2)	9.2	42	4.2	13	1.3	3	0.3
		494-L	W(3)	10.3	2	0.4	0	0.0	0	0.0
		984-L	M(3)	8.8	16	1.6	3	0.3	0	0.0
Totals (Lake Michigan)		58,582			737	1.2	956	1.6	187	0.3
Lake Huron										
24. Black Mallard Cr. Presque Isle Co.	1955	997-L	D(2)	8.9	27	2.7	0	0.0	1	0.1
	1956	993-L	D(2)	8.6	13	1.3	4	0.4	0	0.0
25. Ocqueoc River Presque Isle Co.	1957	999-L	D(2)	7.7	16	1.6	19	1.9	1	0.1
		996-L	W(2)	7.7	11	1.1	1	0.1	2	0.2
		996-L	M(2)	7.4	20	2.0	8	0.8	2	0.2
	1958	992-L	D(2)	8.5	6	0.6	5	0.5	0	0.0
		489-L	W(3)	9.1	4	0.8	1	0.2	0	0.0
		990-L	M(3)	7.1	4	0.4	9	0.9	0	0.0
	1959	350-L	D(2)	8.4	4	1.1	3	0.8	0	0.0
		347-L	M(3)	8.3	7	2.0	0	0.0	0	0.0
		350-S	D(2)	8.2	0	0.0	11	3.1	0	0.0
		347-S	M(3)	8.3	5	1.4	0	0.0	0	0.0
		350-S	D(2)	8.3	0	0.0	19	5.4	0	0.0
		349-S	M(3)	8.3	3	0.8	4	1.1	0	0.0
26. Au Sable River Iosco Co.	1959	200-L	D(1)	6.2	4	2.0	0	0.0	0	0.0
		199-L	D(2)	8.4	9	4.5	2	1.0	1	0.5
		100-L	W(2)	5.9	0	0.0	0	0.0	0	0.0
		100-L	W(2)	7.7	2	2.0	0	0.0	0	0.0
		199-L	M(3)	8.4	4	2.0	0	0.0	0	0.0
		200-S	D(1)	6.2	1	0.5	1	0.5	0	0.0
		198-S	D(2)	8.3	7	3.5	0	0.0	0	0.0

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Locality	Fish planted				Recoveries					
					Lake-run		Non-lake-run		Unknown[c]	
	Year	Number and site [a]	Strain[b] and age	Average length (inches)	Number	Percentage	Number	Percentage	Number	Percentage
26. Au Sable River (cont.)	1959	100-S	W(2)	6.1	1	1.0	0	0.0	0	0.0
		100-S	W(2)	7.7	0	0.0	0	0.0	0	0.0
		200-S	M(3)	8.4	4	2.0	0	0.0	0	0.0
27. Whitney Drain Arenac Co.	1958	999-L	D(2)	8.6	93	9.3	1	0.1	0	0.0
		500-L	M(3)	7.1	14	2.8	0	0.0	0	0.0
	1959	395-L	D(1)	7.5	14	3.5	1	0.2	0	0.0
		397-L	D(2)	8.2	12	3.0	2	0.5	0	0.0
		398-L	W(2)	7.7	2	0.5	0	0.0	0	0.0
		397-L	M(3)	8.5	8	2.0	0	0.0	1	0.2
		400-S	D(1)	7.5	6	1.5	4	1.0	0	0.0
		398-S	D(2)	8.2	6	1.5	36	9.0	1	0.2
		400-S	W(2)	7.7	2	0.5	4	1.0	0	0.0
		400-S	M(3)	8.4	6	1.5	11	2.8	1	0.2
Totals (Lake Huron)		15,825			315	2.0	146	0.9	10	0.06
Burt Lake										
28. Sturgeon River Cheboygan Co.	1958	998-L	D(2)	8.4	8	0.8	34	3.4	13	1.3
		1,000-L	W(3)	9.3	32	3.2	11	1.1	18	1.8
		1,000-L	M(3)	8.2	24	2.4	2	0.2	8	0.8
	1959	1,000-L	D(2)	8.3	5	0.5	11	1.1	4	0.4
		648-L	W(2)	7.6	2	0.3	5	0.8	2	0.3
		16-L	W(2)	10.6	0	0.0	1	6.2	0	0.0
		335-L	W(4)	11.8	5	1.5	26	7.8	4	1.2
		150-L	M(3)	8.6	3	2.0	8	5.3	1	0.7
		848-L	M(3)	11.2	23	2.7	30	3.5	10	1.2

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Locality	Fish planted				Recoveries					
					Lake-run		Non-lake-run		Unknown[c]	
	Year	Number and site[a]	Strain[b] and age	Average length (inches)	Number	Percentage	Number	Percentage	Number	Percentage
29. Maple River Cheboygan Co.	1959	498-L	D(1)	6.1	0	0.0	1	0.2	0	0.0
		487-L	W(2)	6.0	1	0.2	0	0.0	0	0.0
		490-L	M(3)	6.1	0	0.0	0	0.0	0	0.0
Totals (Burt Lake)		7,470			103	1.4	129	1.7	60	0.8

[a] L = lake plant; S = stream plant.

[b] D = domestic rainbow trout; W = West Coast rainbow trout; M = Michigan wild rainbow trout. Approximate age in years in parentheses.

[c] Length at time of recapture not known.

[d] Fish in the April 16 releases ranged from 5.0-7.0 inches in length. No length measurements were made.

[e] The fish released in the Black River in 1957 were marked by fin clipping.