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RECOVERIES BY ANGLERS OF HATCHERY-REARED RAINBOW TROUT STOCKED NEAR THE MOUTHS OF GREAT LAKES TRIBUTARIES, 1955-1958

By Martin J. Hansen

Young wild rainbow trout (Salmo gairdneri) migrate downstream to the Great Lakes for the first time at the age of one to three years; in the Great Lakes, the growth rate is greatly accelerated, and when the fish return to the parent stream, they are available to the angler as relatively large fish. Studies by Stauffer (1955) and Larson and Ward (1955) suggested that hatchery-reared trout of migrant age stocked in or near the Great Lakes or ocean would also grow rapidly in these waters and subsequently contribute to the anglers' take of large fish. The present study was undertaken to evaluate more precisely this type of stocking in the Great Lakes.

Methods

In 1955-1958,[1] 99,063 rainbow trout were released at 22 locations which were selected to compare returns from different "strains" of trout planted at different sites in Lakes Superior, Michigan, and Huron. Unless stated otherwise, releases were made within one mile of the mouths of tributary streams, either in the Great Lakes proper or in the streams themselves. In addition, one plant was made in the

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[1] The stocking records and returns for the final series of stockings (1959) are not included in this report because anticipated returns are far from complete.

St. Marys River, Chippewa County, and one in Burt Lake, Cheboygan County. All trout were marked[2] and released in late May or early June. The trout (with few exceptions) were of legal size, and from one to three years old. Individual total length was recorded with the corresponding tag number for most of the released trout. The three strains of rainbow trout which were used included a "domestic" strain (reared from eggs taken from Michigan hatchery brood stock), a "Michigan wild" strain (eggs from Great-Lakes-run rainbow trout taken during their spawning migration), and a "West Coast" strain (eggs from sea-run rainbow trout, originating from and provided by the State of Washington).

Voluntary returns from anglers accounted for 90.4 percent of the total number of trout reported; the remainder were from miscellaneous sources such as weirs (operated by the Michigan Department of Conservation and the U. S. Bureau of Commercial Fisheries), commercial fishermen, and others. Anglers were alerted to the presence of marked fish in the release areas by posters, newspaper notices, television announcements, and contacts with sportsmen's organizations. Reports of the recapture of marked rainbow trout were acknowledged by a form letter which described known aspects of the life history of the recaptured fish.

When legal-size rainbow trout (seven to nine inches long) are planted near stream mouths during May or June, many are caught by anglers within a week or two, and before they have had a chance to make much additional growth. Those which escape this initial angling pressure and which enter or remain in the Great Lakes grow rapidly, and subsequently return (after a period of several months or more) to a stream where they are available to anglers as relatively large fish. In the present analysis, returns are grouped according to growth history: "lake-run" designates fish which had grown three inches or more

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[2] Number 3 strap tags were used in 1955. Except for No. 3 strap tags and fin-clips which were used in the Black River in 1956 and 1957, respectively, No. 8 or 10 monel ring tags (inside diameter, 0.274 and 0.336 inch, respectively) were used in 1956-1958.

(presumably in a lake) after planting, and "non-lake-run" refers to fish which had added less than three inches of growth and presumably had not moved out of the stream after planting. If a fish has added three inches of growth during the first season after planting, it is safe to assume that it is a "lake-run" fish which had spent most of the growing season in one of the Great Lakes or in a large inland lake, where food is more plentiful than in streams. Greeley (1933) noted that fast growth in lakes is recorded on the scales by widely spaced circuli and this pattern was observed in scale samples from 62 out of 64 lake-run fish caught during the first year after release. It is recognized that the three-inch criterion is not as useful for identifying lake-run fish recaptured after more than one summer's growth. Virtually all of the trout reported after longer intervals displayed a very pronounced length increment (averaging between 9.4 and 14.2 inches), however, and it is believed that, with few exceptions, the trout recaptured in these intervals were also assigned to the correct growth category. (Scales from 12 trout out for more than one year also showed the widely spaced circuli of lake-run fish.)

This paper includes reports of recoveries received prior to November 20, 1958. Returns from the 1955 and 1956 plants are considered complete or nearly so, but additional returns are expected from the 1957 and 1958 plants. As only those fish which migrate to or remain in the Great Lakes contribute large fish to the angler, this report is primarily concerned with returns of lake-run rainbow trout. Unless specified otherwise, the term "recovery rate" applies only to the reported angler recoveries of lake-run rainbow trout.

Statistical tests were conducted to detect differences which were significant at the five-percent level.[3] The chi-square test for homogeneity was used where appropriate. In some instances, analysis of variance (Snedecor, 1956; Dixon and

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[3] Statistical tests were not employed unless specifically stated.

Massey, 1951) or the nonparametric Mann-Whitney test (Siegel, 1956) were used. It must be emphasized that voluntary returns, especially in small numbers, are subject to major chance fluctuations. Variation in fishing pressure and the proportion of unreported returns at the various stocking locations influenced the recovery rates to an unknown degree.

Stocking locations

The localities at which marked rainbow trout were planted in 1955-1958 are shown in Figure 1. Release and recovery data are presented in Table 1 and summarized in Table 2.

All stocking sites (numbered as in Figure 1 and Table 1) and unusual recovery rates are discussed in the text. Factors such as physical nature of the streams, angling pressure, unusual stocking locations, presence and character of natural runs of rainbow trout, predation, and others which conceivably could influence or aid in interpreting the recovery rates are noted. These data were obtained from Institute for Fisheries Research stream survey records, district fisheries supervisors, the U. S. Bureau of Commercial Fisheries,[4] and/or from personal observations by the author. The presence of weirs for capturing sea lampreys (Petromyzon marinus) is mentioned as there is evidence that these devices may divert and/or block a portion of the rainbow trout migrating upstream (Eschmeyer, 1959).

The rates of "straying" from individual stocking locations are discussed because of their pronounced effect on recovery at the original release sites. A trout recaptured in a stream system other than where released was considered a "stray." It is recognized that some of the trout designated as strays, especially those recaptured in the fall, might also have returned to the "parent"

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[4] Programs and Progress, 1957 and 1958. Mimeographed reports of the Great Lakes Fisheries Investigations, Bureau of Commercial Fisheries, Fish and Wildlife Service, U. S. Dept. of Interior.

Figure 1.--Localities at which tagged rainbow trout were planted in the Great Lakes and connecting waters, 1955-1958. The different sites are numbered progressively (down-lake), from west to east in Lake Superior, south to north in Lake Michigan, and north to south in Lake Huron. These numbers also identify the streams in Table 1 and in the text.

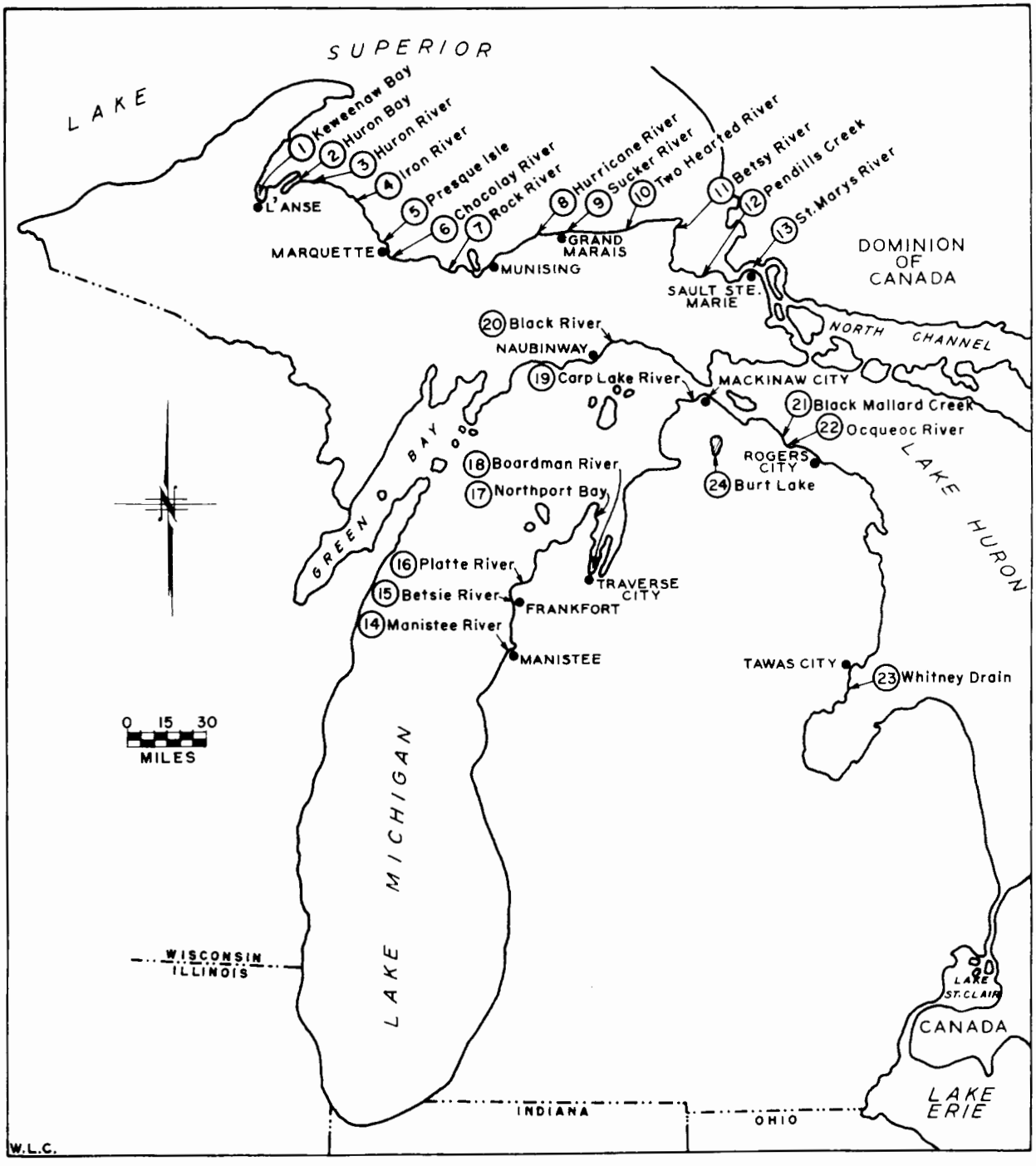
LAKE SUPERIOR
1 Keweenaw Bay
2 Huron Bay
3 Huron River
4 Iron River
5 Presque Isle
6 Chocolay River
7 Rock River
8 Hurricane River
9 Sucker River
10 Two Hearted River
11 Betsy River
12 Pendills Creek
13 St. Marys River
L'ANSE
MARQUETTE
GRAND MARAIS
MUNISING
SAULT STE. MARIE
DOMINION OF CANADA
NORTH CHANNEL
20 Black River
NAUBINWAY
19 Carp Lake River
MACKINAW CITY
21 Black Mallard Creek
22 Ocqueoc River
ROGERS CITY
24 Burt Lake
LAKE HURON
18 Boardman River
17 Northport Bay
GREEN BAY
16 Platte River
15 Betsie River
14 Manistee River
TRAVERSE CITY
FRANKFORT
MANISTEE
TAWAS CITY
23 Whitney Drain
0 15 30
MILES
LAKE MICHIGAN
WISCONSIN
ILLINOIS
LAKE ST. CLAIR
CANADA
LAKE ERIE
INDIANA
OHIO
W.L.C.

Figure 1

Table 1.--Recoveries through November 20, 1958, of marked rainbow trout planted during 1955-1958, by planting site and year of planting

Locality	Fish planted: Year	Fish planted: Number and site[1]	Fish planted: Strain[2]	Fish planted: Average length (inches)	Recoveries: Lake-run: Number	Recoveries: Lake-run: Percentage	Recoveries: Non-lake-run: Number	Recoveries: Non-lake-run: Percentage	Recoveries: Growth history unknown[3]: Number	Recoveries: Growth history unknown[3]: Percentage
Lake Superior										
1. Keweenaw Bay, Baraga County	1958	494-L	D (2)	9.3	0	0.0	21	4.2	0	0.0
		495-L	W (3)	10.5	0	0.0	4	0.8	0	0.0
2. Huron Bay, Baraga County	1958	499-L	D (2)	9.2	1	0.2	9	1.8	0	0.0
		484-L	W (3)	10.3	0	0.0	3	0.6	0	0.0
		498-L	M (3)	8.8	0	0.0	0	0.0	0	0.0
3. Huron River, Marquette County	1955	1,000-S	D (2)	9.3	29	2.9	0	0.0	1	0.1
	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	4	0.4	5	0.5	0	0.0
		1,000-L	W (2)	7.6	1	0.1	0	0.0	0	0.0
	1958	999-L	D (2)	9.1	2	0.2	6	0.6	1	0.1
		490-L	W (3)	10.5	0	0.0	0	0.0	0	0.0
		994-L	M (3)	9.0	0	0.0	1	0.1	0	0.0
4. Iron River, Marquette County	1955	700-S	D (2)	7.3	0	0.0	0	0.0	6	0.8
	1956	1,999-S	D (2)	8.4	2	0.1	19	1.0	0	0.0
5. Presque Isle, Marquette County	1956	3,000-L	D (2)	9.1	53	1.8	29	1.0	23	0.8
6. Chocolay River, Marquette County	1955	1,500-S	D (2)	9.4	0	0.0	83	5.5	10	0.7

Table 1, continued

Locality	Fish planted: Year	Fish planted: Number and site[1]	Fish planted: Strain[2]	Fish planted: Average length (inches)	Recoveries: Lake-run: Number	Recoveries: Lake-run: Percentage	Recoveries: Non-lake-run: Number	Recoveries: Non-lake-run: Percentage	Recoveries: Growth history unknown[3]: Number	Recoveries: Growth history unknown[3]: Percentage
7. Rock River, Alger County	1957	1,500-L	D (2)	7.7	4	0.3	1	0.1	2	0.1
8. Hurricane River, Alger County	1958	499-L	D (2)	9.1	0	0.0	3	0.6	0	0.0
		493-L	M (3)	8.7	0	0.0	4	0.8	0	0.0
		500-L	D (1)	7.9	1	0.2	0	0.0	0	0.0
9. Sucker River, Alger County	1957	1,000-S	D (2)	8.4	0	0.0	1	0.1	0	0.0
10. Two Hearted River, Luce County	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	53	1.8
	1957	1,000-L	D (2)	8.0	11	1.1	21	2.1	0	0.0
		1,000-L	W (2)	7.6	9	0.9	1	0.1	0	0.0
		993-L	M (2)	5.7	2	0.2	3	0.3	2	0.2
	1958	999-L	D (2)	9.2	5	0.5	15	1.5	3	0.3
		498-L	W (3)	10.4	1	0.2	1	0.2	0	0.0
		996-L	M (3)	8.5	1	0.1	4	0.4	0	0.0
11. Betsy River, Chippewa County	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
12. Pendills Creek, Chippewa County	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

Table 1, continued

Locality	Fish planted: Year	Number and site[1]	Strain[2]	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Growth history unknown[3] Number	Growth history unknown[3] Percentage
	1957	1,000-L	D (2)	8.7	16	1.6	0	0.0	0	0.0
		1,000-L	W (2)	7.6	5	0.5	1	0.1	0	0.0
	1958	500-L	D (2)	9.1	6	1.2	4	0.8	0	0.0
		500-L	W (3)	10.3	0	0.0	0	0.0	0	0.0
		500-L	M (3)	8.7	0	0.0	1	0.2	0	0.0
Totals (Lake Superior)		39,109			272	0.7	435	1.1	117	0.3
St. Marys River										
13. St. Marys River, Chippewa County	1957	1,000-S	D (2)	8.3	6	0.6	2	0.2	3	0.3
	1958	499-S	D (2)	9.1	9	1.8	7	1.4	0	0.0
		496-S	W (3)	10.6	1	0.2	3	0.6	0	0.0
		498-S	M (3)	8.6	2	0.4	0	0.0	0	0.0
Lake Michigan										
14. Manistee River, Manistee County	1955	2,496-S	D (2)	9.1	0	0.0	0	0.0	0	0.0
	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
(In Channel)	1957	998-S	D (2)	8.5	6	0.6	17	1.7	6	0.6

Table 1, continued

Locality	Year	Fish planted: Number and site[1]	Strain[2]	Fish planted: Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Growth history unknown[3] Number	Growth history unknown[3] Percentage
Little Manistee River, Manistee County	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	2	0.1	162	8.1	4	0.2
15. Betsie River, Benzie County	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
16. Platte River, Benzie County	1957	1,500-S	D (2)	8.5	1	0.1	150	10.0	13	0.9
17. Northport Bay, Leelanau County	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
18. Boardman River, Grand Traverse County	1955	2,000-S	D (2)	8.8	105	5.2	53	2.6	11	0.6
	1956	1,992-S	D (2)	9.0	89	4.5	75	3.8	34	1.7
	1957	998-L	D (2)	8.5	28	2.8	21	2.1	6	0.6
		985-L	W (2)	7.6	5	0.5	0	0.0	0	0.0
		998-L	M (2)	7.3	28	2.8	0	0.0	4	0.4
	1958	997-L	D (2)	8.7	5	0.5	12	1.2	8	0.8
		487-L	W (3)	12.3	1	0.2	0	0.0	0	0.0
		993-L	M (3)	9.2	6	0.6	12	1.2	1	0.1

Table 1, continued

Locality	Fish planted: Year	Number and site[1]	Strain[2]	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Growth history unknown[3] Number	Growth history unknown[3] Percentage
19. Carp Lake River, Emmet County	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	4	0.4	1	0.1	0	0.0
20. Black River, Mackinac County	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	2	1.0
	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[4]	1,000-L	D (2)	6.4	11	1.1	2	0.2	0	0.0
		990-L	W (2)	6.2	0	0.0	0	0.0	0	0.0
		982-L	M (2)	7.0	6	0.6	0	0.0	0	0.0
		1,000-S	D (2)	6.4	4	0.4	12	1.2	0	0.0
		951-S	W (2)	6.3	1	0.1	2	0.2	0	0.0
		954-S	M (2)	7.1	15	1.6	8	0.8	0	0.0

Table 1, continued

Locality	Fish planted: Year	Number and site[1]	Strain[2]	Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Growth history unknown[3] Number	Growth history unknown[3] Percentage
	1958	994-L	D (2)	9.2	23	2.3	14	1.4	2	0.2
		494-L	W (3)	10.3	0	0.0	0	0.0	0	0.0
		984-L	M (3)	8.8	4	0.4	3	0.3	0	0.0
Totals (Lake Michigan)		51,003			600	1.2	923	1.8	172	0.3
Lake Huron										
21. Black Mallard Creek, Presque Isle County	1955	997-L	D (2)	8.9	28	2.8	0	0.0	1	0.1
	1956	993-L	D (2)	8.6	13	1.3	4	0.4	0	0.0
22. Ocqueoc River, Presque Isle County	1957	999-L	D (2)	7.7	15	1.5	20	2.0	1	0.1
		996-L	W (2)	7.7	10	1.0	1	0.1	0	0.0
		996-L	M (2)	7.4	16	1.6	8	0.8	1	0.1
	1958	992-L	D (2)	8.5	1	0.1	0	0.0	0	0.0
		489-L	W (3)	9.1	1	0.2	1	0.2	0	0.0
		990-L	M (3)	7.1	1	0.1	1	0.1	0	0.0
23. Whitney Drain, Arenac County	1958	999-L	D (2)	8.6	62	6.2	1	0.1	0	0.0
		500-L	M (3)	7.1	2	0.4	0	0.0	0	0.0
Totals (Lake Huron)		8,951			149	1.7	36	0.4	3	0.03

Table 1, continued

Locality	Year	Fish planted: Number and site[1]	Strain[2]	Fish planted: Average length (inches)	Recoveries: Lake-run Number	Lake-run Percentage	Non-lake-run Number	Non-lake-run Percentage	Growth history unknown[3] Number	Growth history unknown[3] Percentage
Burt Lake										
24. Burt Lake, Cheboygan County	1958	998-L	D (2)	8.4	4	0.4	29	2.9	11	1.1
		1,000-L	W (3)	9.3	27	2.7	7	0.7	17	1.7
		1,000-L	M (3)	8.2	17	1.7	1	0.1	6	0.6

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

[2] D = domestic rainbow trout, W = West Coast rainbow trout, M = Michigan wild rainbow trout; approximate age in years in parentheses.

[3] Length at time of recapture not known.

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

Table 2.--Total percentage recovery of hatchery-reared rainbow trout stocked near the mouths of Great Lakes tributaries, 1955-1958[1]

[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 (318)	1.8 (386)	0.3 (59)	3.6 (763)	0.3 (76)	3.9 (839)
1956	28,505	1.3 (372)	1.6 (445)	0.6 (173)	3.5 (990)	0.5 (142)	4.0 (1,132)
1957	29,833	0.7 (208)	1.5 (443)	0.2 (45)	2.3 (696)	0.3[2] (103)	2.6 (799)
1958	19,357	0.6 (123)	0.6 (120)	0.1 (15)	1.3 (258)	0.4 (70)	1.7 (328)
Totals	99,063	1.0 (1,021)	1.4 (1,394)	0.3 (292)	2.7 (2,707)	0.4 (391)	3.1 (3,098)

[1] Excludes St. Marys River, Chippewa County (1957-1958) and Burt Lake, Cheboygan County (1958).

[2] Fin-clipped fish (1957 Black River plant) recovered by miscellaneous methods are not included, since duplication of recoveries could not be detected.

stream if they had not been recaptured at some other location first. Trout which were recovered in the Great Lakes were not treated as strays as they might have returned to the "parent" stream. The proportion of apparent movement is influenced by the fishing pressure and the proportion of unreported tag recoveries, which vary from one location to another. As no quantitative data are available for equating the various stocking locations in respect to these factors, the computed rates of straying are probably not entirely reliable. For example, because the fishing pressure is quite certainly different, and the tendency to report fish probably varies among anglers at different localities, it is possible that the returns from two adjacent stocking locations may show widely divergent rates of straying, even though the actual rate of straying between the two is similar. Because of the limited number of recoveries from Michigan wild and West Coast rainbow trout, rates of straying were computed for domestic rainbow trout only.

In the following sections, the calendar years during which plantings were made are given in parentheses.

1-2. Keweenaw and Huron bays (1958).--These plants were made near the south end of each bay. Four good rainbow trout streams enter the bays near the stocking localities; although angling pressure is light in the bays, the streams are heavily fished during the spring rainbow trout migrations. Only one lake-run fish has been reported from the Huron Bay release and none from the Keweenaw Bay release.

3. Huron River (1955-1958).--This large river supports heavy runs of rainbow trout in the spring and fall and has extensive spawning grounds. Angling pressure is heavy, especially in the spring. A lamprey weir, situated about two miles upstream from the mouth, has been operated since 1954.

The 1955 plant resulted in a relatively high rate of recovery (2.9 percent). Approximately 63 percent of the recoveries from the fish released during the four-year period were from locations other than the Huron River. The strays were reported most commonly from the Two Hearted, Rock, Chocolay, and St. Marys rivers.

Northern pike (Esox lucius) enter the estuarine waters and oxbows in the lower portion of the stream in the spring.

4. Iron River (1955-1956).--This medium-sized stream is classified as nontrout water although a small run of rainbow trout occurs in the spring. A lamprey weir (two miles upstream from the mouth) has been operated since 1954.

An extremely low rate of recovery (0.0 and 0.1 percent) was reported from these plantings. Possible limiting factors are: 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.

5. Presque Isle (1956).--This plant was made a short distance off a rocky peninsula, seven miles from the nearest major rainbow trout stream (Chocolay River). Fishing pressure is light to moderate at the release site. A high proportion of straying occurred from the vicinity of Presque Isle. Percentages (of the total recovered) reported at varying distances from the release site were: 29 percent , 10 miles or less; 20 percent, 11-50 miles; 22 percent, 51-100 miles; and 29 percent, over 100 miles.

6. Chocolay River (1955).--Abundant spawning facilities are present in this large river, and a moderate run of rainbow trout occurs in the spring and fall. Fishing pressure is moderate in the spring and somewhat less in the fall. A lamprey weir, located about six miles upstream from the mouth, has been operated since 1954.

The reasons for the absence of lake-run recoveries are not known, particularly since there are three Conservation Department offices within three miles of the planting site where anglers can conveniently report their recoveries. A large population of northern pike in the release area and the observed heavy angler exploitation of newly-planted fish (5.5 percent were reported) are possible explanations.

7. Rock River (1957).--Rainbow trout enter this relatively small stream in large numbers in the spring, and an abundance of good spawning habitat is present. Angling pressure is heavy during the spring migration of rainbow trout. A lamprey weir has been operated since 1955 near the mouth of the stream. The low rate of recovery (0.3 percent) is unexplained. Approximately 33 percent of the fish reported were recovered at locations other than the release site.

8. Hurricane River (1958).--Large numbers of rainbow trout enter this small stream in the spring. Spawning habitat is abundant. Angling pressure is heavy in the spring and early summer. A lamprey weir, located near the mouth of the stream, has been operated since 1954. Since this stream does not support a fall run of rainbow trout, no recoveries were expected before 1959.

9. Sucker River (1957).--A relatively small number of rainbow trout enter this medium-sized stream in the spring. The amount of good spawning habitat may be limited as a large proportion of the stream bed is apparently composed of shifting sand. Angling pressure is light. A lamprey weir, located two miles upstream from the mouth, has been operated since 1953.

No lake-run recoveries, and only one non-lake-run recovery, were reported from this stocking. The plant was made in East Bay, a lake of about 80 acres in area, at the mouth of the Sucker River. A short channel connects East Bay with West Bay, which opens into Lake Superior.

Northern pike predation in East Bay and poor angler response in reporting recoveries may have contributed to the low rate of recovery. District Fisheries Supervisor Leland Anderson believes that commercial fishing operations in Lake Superior off the Sucker, Two Hearted, and Betsy rivers (see below) may have taken some of the planted fish. If this fishing mortality occurred near these three stocking locations, it was largely unreported.

10. Two Hearted River (1955-1958).--This large river is noted for its heavy spring and fall runs of rainbow trout. An abundance of good spawning habitat is

present. The angling pressure, especially in the spring, is heavy. A lamprey weir has been operated near the mouth of the stream since 1953. The 1955 Two Hearted River plant produced the highest recovery rate (3.3 percent) from Lake Superior. Approximately 30 percent of the trout reported from the 1955-1958 plants were recaptured at locations other than the release site.

Although the recovery rate from the 1955 stocking was the highest for Lake Superior, the following factors may have tended to reduce the recovery rate from this and other stockings: unreported mortality caused by commercial fishing operations in the adjacent lake areas; onshore winds which concentrated newly released trout in shoal water, exposing them to predation by sea gulls; and poor angler response in reporting recoveries because of the remoteness of this location. Because of poor road conditions, the 1956 plant had to be released two miles upstream from the mouth. Heavy early exploitation by anglers (4.3 percent were taken in the river shortly after planting) and the relatively long distance from Lake Superior also may have contributed to the low rate of recovery of lake-run trout (0.1 percent) from the 1956 plant.

11. Betsy River (1955-1956).--This medium-sized stream supports a small run of rainbow trout. Good spawning habitat is limited and the angling pressure is light. A lamprey weir, located about three miles upstream from the mouth, has been operated since 1953.

The recovery rate (0.4 percent in both years) was extremely low. All of the recoveries from these releases were reported from other locations, mainly the St. Marys River. Unreported mortality from commercial fishing operations off the mouth of the Betsy River, a northern pike population in various portions of the stream, and a poor angler response in reporting recoveries may have contributed to the low rate of recovery.

12. Pendills Creek (1955-1958).--This small stream supports a light run of rainbow trout. A trout hatchery control dam near the mouth may limit the available spawning area. A lamprey weir has been operated near the mouth since 1953. The average rate of straying from these plants was 71 percent. Approximately

64 percent of the recaptured trout were reported from the St. Marys River, 20 miles away. Considerable early mortality of trout was noted at release when adverse winds held the fish inshore and thus encouraged sea gull predation.

13. St. Marys River (1957-1958).--This site differed from other stocking sites and is not considered a Great Lakes planting. The Sault Ste. Marie locks may have partially blocked upstream migration into Lake Superior (the releases were made below the locks), while the long distance from the stocking site to Lake Huron (approximately 40 miles) may have discouraged migration in that direction. The St. Marys River apparently supports a medium to large resident population of rainbow trout in addition to a run of spawning migrants. Angling pressure is moderate to heavy, occasioned in part by the proximity of the city of Sault Ste. Marie.

While migration from stocking locations in Lake Superior to this stream was common, no straying was recorded from the St. Marys River releases. Low water levels (due to operation of the Sault Ste. Marie locks), which caused increased sea gull predation on newly-stocked trout, may have reduced the recovery rates.

14. Manistee River (1955-1957).--This large system is divided into two main branches, the Manistee and Little Manistee rivers, which join at Manistee Lake (a generally shallow warm-water lake of 930 acres) before emptying into Lake Michigan at the city of Manistee via a dredged boat channel approximately one mile long. The Manistee River is regarded as one of the better rainbow trout streams in Michigan. Rainbow trout ascend the river in both spring and fall. Tippy Dam, located approximately 25 miles above the mouth, prevents lake-run migrants from reaching the spawning grounds in the headwaters. Sizeable numbers of rainbow trout are trapped and transferred over this dam each spring by personnel of the Fish Division. Although the main stream below Tippy Dam is generally unsuited for rainbow trout reproduction, Bear Creek and the Little Manistee River,

which enter the main stream below the dam, contain spawning areas. Angling pressure is concentrated immediately below Tippy Dam and in the vicinity of Manistee Lake.

Rainbow trout were released at several different locations at this site. Specific stocking locations are shown below:

Date stocked	Location
June 16, 1955	Manistee River, above Manistee Lake (T22N, R16W, S34)
May 29, 1956	Manistee River, in channel (T21N, R17W, S11)
June 11, 1957	Manistee River, above Manistee Lake (T22N, R17W, S36)
June 11, 1957	Manistee River, in channel (T21N, R17W, S11)
June 16, 1955	Little Manistee River, above Manistee Lake (T21N, R16W, S21)
May 29, 1956	Little Manistee River, above Manistee Lake (T21N, R16W, S20)
June 11, 1957	Little Manistee River, above Manistee Lake (T21N, R16W, S20)

The highest recovery rates (1.6 and 0.6 percent) originated from the 1956 and 1957 plantings, which were made in the channel 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 plant in the Big Manistee River or the 1956 plant in the Little Manistee River. The average rate of straying from all plants combined was 30 percent.

Although the reasons for the extremely low rate of recovery from plants above Manistee Lake are unknown, Taube (1958) suggested that pollution and northern pike predation in Manistee Lake, and the relatively long distance of the planting sites from Lake Michigan may have been responsible. Intensive early exploitation (4.3 percent in 1955; 8.1 percent in 1957) of the newly released trout by anglers in the Little Manistee River also may have contributed to the low recovery rates from this planting. A part-time creel census, which was conducted at the Little Manistee River in 1957 for two weeks immediately following the releases, undoubtedly inflated the reported recovery rate for that year. However, observations by the

author and reports from interested persons indicated that the number of tagged fish caught greatly exceeded the number recorded. In contrast, a creel census conducted during the same period at the two stocking sites on the Manistee River indicated little early exploitation by anglers.

15. Betsie River (1955-1956).--This medium sized stream flows through Betsie Lake (a small lake of about 160 acres, located in the city of Frankfort) before entering Lake Michigan via a dredged channel. Rainbow trout enter this stream in the spring and fall. Homestead Dam, located about 10 miles upstream from the mouth, is a barrier to rainbow trout migrating upstream. Angling pressure is most intense downstream from this dam. Summer water temperatures below the dam are generally submarginal for trout. A lamprey weir has been operated in the lower Betsie River since 1957.

Of the recaptured trout from the 1955 and 1956 releases, 85 and 79 percent were reported from streams other than the Betsie River. A large proportion (41 percent) of the recovered fish migrated to the Manistee River. Although these plants were both located in the channel between Betsie Lake and Lake Michigan, they may have been subject to some predation by northern pike from Betsie Lake. District Fisheries Supervisor Stanley Lievense stated that perch fishermen took a considerable number of newly planted rainbow trout at the mouth of the river (apparently very few of the tags were reported).

16. Platte River (1957).--This medium sized river, which originally was famous for its heavy runs of rainbow trout, now supports only a small run of spring migrants from Lake Michigan. Near the mouth, the stream flows through Platte and Round lakes, which raise summer water temperatures considerably. The most favorable rainbow trout habitat is located upstream from Platte Lake.

The recovery rate (0.1 percent) was extremely low. Many of the trout remained at or near the release site, where they were readily visible, for at least several

weeks after stocking. This made them especially vulnerable to anglers and may have reduced the recovery of lake-run trout. Although angling pressure was reportedly light, a part-time creel census, conducted at the release site, demonstrated that at least 10 percent of the fish were caught during the two weeks after stocking. The presence of a small population of northern pike downstream from Platte Lake may also have caused some mortality among the newly released fish.

17. Northport Bay (1955-1956).--This plant, like the Presque Isle stocking, differed from most of the Great Lakes releases in that the trout were liberated in the bay at some distance from a major rainbow trout stream. The nearest rainbow trout stream of any consequence is the Boardman River (25 miles distant), from which 77 and 43 percent of the recoveries from the 1955 and 1956 stockings were reported.

Although it was noted that some of the trout remained in the planting vicinity for some time after release, fishing pressure at the release site was light. Predation by other fish was considered negligible as the only possible predators at this site were large rainbow trout and smallmouth bass (Micropterus dolomieui).

18. Boardman River (1955-1958).--Many rainbow trout enter this large river in the spring and fall. Old Mill Dam (one mile upstream from the mouth, in Traverse City), prevents lake-run rainbow trout from using the spawning grounds in the headwaters. With the exception of a small tributary, no spawning habitat is present in the river downstream from the dam. In this area, water temperatures are cold until July; temperatures over 80° F. are commonly recorded during August. Fish kills have occurred at various times when the local sewage plant was unable to neutralize wastes from manufacturing establishments near the river. Few predatory fish are present below the dam. Angling pressure, which is heavy in the spring, decreases in intensity during the summer and fall.

Recovery rates were among the highest from Great Lakes stockings (5.2 percent from the 1955 plant; 4.5 percent from the 1956 plant). A relatively low average

rate of straying (3 percent) was recorded from the 1955-1958 plants. Migration from other stocking locations to the Boardman River commonly occurred.

The cause of the exceptionally high recovery rates from this location is not known. The available stream environment appears decidedly unsuitable for rainbow trout production. Factors which may be responsible for the high rate of return include heavy angling pressure; proximity of a Conservation Department field station (where anglers can conveniently report their recoveries) to the fishing locations; excellent cooperation displayed by the anglers in reporting recoveries; and the blocking effect of the dam which concentrates migrant trout in a relatively small area of stream, thus facilitating their harvest.

19. Carp Lake River (1955-1957).--Very few rainbow trout enter this small stream. Spawning habitat is adequate. Angling pressure on rainbow trout entering this stream is light. A mechanical lamprey weir, which captures both upstream- and downstream-migrating lampreys and fish, has been operated near the mouth since 1948 (Applegate and Brynildson, 1952).

A high average rate of straying (89 percent) was reported from these plants. The reasons for the low recovery percentages (0.3-1.1) are unknown.

20. Black River (1955-1958).--Large numbers of rainbow trout formerly entered this medium sized stream in the spring and fall, although the size of the run has decreased in the past several years. Reproductive facilities are near optimum. The angling pressure is heavy, especially in the spring. An experimental sea lamprey barrier dam (1950-1957) and an electrical weir (1958) were located one-half mile above the mouth. A part-time creel census during the spring and fall runs (1950-1958) augmented the voluntary reports of recovery.

In general, despite the creel census, the recovery rates from the various Black River plants were not outstandingly high. The average rate of straying (1955-1958) was comparatively low (6 percent).

In 1955 and 1956, the May and June stream plants were heavily exploited by anglers (15.0-17.5 percent), which may have reduced the subsequent recovery of lake-run trout. Sea gull predation may have caused some early mortality among the lake stockings.

Special studies at the Black River are discussed below.

21. Black Mallard Creek (1955-1956).--Apparently this small stream (1.5 miles long) is of negligible importance as a rainbow trout stream. High summer water temperatures may be a limiting factor. In both 1955 and 1956, all of the recoveries of tagged fish planted at this locality were from other streams, mainly the Ocqueoc, Au Gres, and Au Sable (Iosco County) rivers.

22. Ocqueoc River (1957-1958).--This large river supports a small to medium run of rainbow trout in the spring and fall. An adequate amount of spawning habitat is present. The angling pressure is relatively light. A lamprey weir, near the mouth of the river, has been operated intermittently during the past several years.

Of the total recaptures to date (1957 and 1958 plantings combined), 60 percent were from other streams (27 percent from the Au Sable River).

23. Whitney Drain (1958).--The Whitney Drain, a 3 1/2-mile drainage ditch which connects Lake Huron with the East Branch of the Au Gres River, offers a minimum of adequate spawning habitat and cover, as the substrate is composed almost entirely of shifting sand. Flooding is extensive in the spring, and water temperatures may be submarginal during the summer months. The Au Gres River above the junction with the Whitney Drain contains a greater reproductive potential, however. Moderate numbers of rainbow trout ascend this system in the spring and fall. A dam, operated by the Sportsman's Improvement Association of Saginaw on Guiley Creek, a tributary of the East Branch of the Au Gres River, allows upstream migration of rainbow trout in the spring but arrests downstream movement.

This stocking has already resulted in one of the highest recovery rates from domestic rainbow trout (6.2 percent). One angler recaptured about one-third of the total number of trout caught at this site. Approximately 16 percent of the recoveries strayed to other locations (mainly to the Au Sable River, 30 miles away).

The intense fishing pressure on the East Branch of the Au Gres River and the Whitney Drain throughout the fishing season may have been partially responsible for the high rate of recovery. Local business people in this area displayed excellent cooperation in helping to publicize the rainbow trout releases.

24. Burt Lake (1958).--This planting was made off the mouth of the Sturgeon River, which drains into Burt Lake (a large inland lake). Rainbow trout from Burt Lake ascend the Sturgeon River in the spring and fall. Good spawning facilities are present in this river. Angling pressure is heavy in the lower portion of the stream.

Three strains of rainbow trout were released at this location. An unusually high rate of return of West Coast rainbow trout was reported (2.7 percent); the return from the stocking of Michigan wild rainbow trout was 1.7 percent, while the return from domestics was only 0.4 percent. With the exception of several trout caught in Burt Lake, all of the trout were taken in the Sturgeon River.

Evaluation of factors affecting rate of return

The objective of making numerous plants in different streams was to learn something about the conditions contributing to more successful planting. The only information on the success of the planting of these rainbows comes from tags which are returned voluntarily, and this fact severely limits the reliable information which can be derived. We would wish to measure the actual success of a planting in terms of adult rainbows caught by fishermen. The data, however, reflect beyond this the variable fishing pressure, and the presumably variable tendency for fishermen to return tags. Thus, any comparison of different streams on the

basis of tag returns involves also a comparison of fishing pressure along with tendency to return tags, neither of which is measurable here. Although it is easy to demonstrate from the meager returns that more tags are returned from some streams than from others, this is not necessarily the biological information needed to manage the planting program.

On the other hand, certain comparisons furnish much more reliable information. If several different kinds of plantings are made in the same stream, at the same time, then the comparative returns must come much closer to reflecting true differences in success. Such simultaneous plantings in the same stream were made with different sizes and strains of fish at two locations, either in the stream itself or in the lake within a mile of the stream mouth. Nearly simultaneous plants were made at different seasons, but in the same stream, and with recoveries over the next several years provided by fishermen who were fishing over survivors from all plants.

A further and more subtle difficulty is encountered in trying to analyze the matter of straying, that is, the return of a tag from a fish taken at some stream other than that where planted. Here the proportion of returns from strays depends upon a complex ratio involving the relative fishing pressure at the stream as compared to all other streams and the comparative tendency to return tags as well as upon the proportions of the planted fish running up the other streams. It is probably no accident that many strays were taken in heavily fished streams. With this subject, as well as with others, the limitations of the data must be considered in interpreting the results.

Evaluation of different planting dates

In the Black River, the downstream migration of young native rainbow trout to Lake Michigan occurred in May, June, and July, with the peak movement in June (Stauffer, personal communication). This suggested that the most advantageous time to stock hatchery-reared rainbow trout would also be in the spring and/or early summer.

The recovery rates from spring and fall stockings of rainbow trout were compared at the Black River in 1953-1954. A plant of 500 trout in Lake Michigan, near the mouth, on October 26, 1953, resulted in a known recovery of 0.4 percent. A similar plant on May 12, 1954, produced a significantly higher recovery rate of 2.6 percent (chi-square = 6.77) indicating that this spring stocking was more productive of lake-run rainbow trout than the stocking of the previous fall.

To test the effect of month of release, stream and lake plantings near the mouth of the Black River were spaced at monthly intervals in the spring (1955, April-June; 1956, March-June) to examine any possible difference in the recovery rates (Table 3). The observed recovery rates from stockings in May were greater in both years at both stocking locations. An analysis of variance showed the differences among months to be significant ($F = 69.8$, 2 and 2 degrees of freedom). However, the difference between stream and lake location of planting was not significant here.

Time of recovery

It is apparent that a large proportion (93.3 percent) of the recoveries from the 1955-1956 stockings were recaptured within the first two years after release (Table 4). No recoveries were reported in the fourth year (data complete only for 1955) and recovery in the third year was generally light. However, recoveries by anglers in Lake Superior apparently were more evenly distributed throughout the three-year period following release than in Lakes Huron and Michigan. A homogeneity test between Lake Superior and Lake Michigan gave a significant chi-square value of 17.31 for the 1955 plants and a highly significant chi-square value of 75.53 for the 1956 plants, indicating that a larger proportion of trout were harvested during later intervals after release in Lake Superior than in Lake Michigan (because of the small number of returns, Lake Huron was not included in the test).

Table 3.--Percentage recovery of rainbow trout planted in the Black River in 1955 and 1956

Month planted	Year of planting			
	1955		1956	
	Lake	Stream	Lake	Stream
March	(no plantings)		1.0	1.0
April	0.5	0.0	0.0	1.0
May	3.5	1.5	5.5	2.5
June	2.0	0.5	2.0	1.0

Analysis of variance of arc-sine transformed data, omitting March 1956 figures.

Source of variation	Degrees of freedom	Mean square
Location (planting in stream or in lake)	1	14.30 (F = 1.5)
Year	1	5.75
Month	2	59.34 (F = 69.8)[1]
Location x month	2	7.10
Location x year (error for testing location)	1	9.53
Month x year (error for testing month)	2	0.85
Location x month x year	2	7.42

[1] Significant at the 5-percent level.

Table 4.--Number and percentage[1] of lake-run rainbow trout recovered at successive intervals after release

Release area	Year[2]					
	First		Second		Third	
	Number	Percentage	Number	Percentage	Number	Percentage
Lake Superior						
1955	24	25.8	58	62.4	11	11.8
1956	24	21.8	61	55.4	25	22.7
Lake Michigan						
1955	85	43.1	108	54.8	4	2.0
1956	161	64.6	83	33.3	5	2.0
Lake Huron						
1955	14	50.0	13	46.4	1	3.6
1956	8	61.5	5	38.5	0	0.0

[1] Based on total recaptures.

[2] First year refers to interval between date of planting and December 31; subsequent intervals refer to full calendar years.

Recovery rates from three different strains of rainbow trout

Table 5 presents the recovery rates from simultaneous stockings of different strains of rainbow trout at eight locations in 1957. An analysis of variance revealed no significant difference in the recovery rates. Possible differences in the recovery rates from the three strains may become evident upon completion of the returns. Because of the short time since release and the relatively small number of returns, recoveries from the simultaneous releases in 1958 were not analyzed.

Recovery rates from different release sizes

The recovery rates of domestic rainbow trout from different size groups at release in 1955 and 1956 are shown in Tables 6 and 7. An analysis of variance revealed no difference in the rate of recovery from different size groups from the 1955 releases. However, the same test applied to the 1956 releases did show a significant difference ($F = 12.74$, 4 and 20 degrees of freedom). Although the present data are not consistent, the completed returns from the 1957-1959 plants may be helpful in resolving this question.

Comparison of recoveries from lake stockings and stream stockings

Pooled data (1955-1958) from all three Great Lakes did not reveal a significant difference between the recovery rates (all strains) from lake and stream stockings (Table 8). However, since the recovery rates (all strains) from the individual locations are highly variable and the Lake Huron stockings were all made in the lake, an analysis of the pooled data may not be reliable.

In a comparison of the nearly complete returns from the 1955 and 1956 plants alone, the Mann-Whitney U test revealed no significant difference between the recovery rates from stream and lake plants in Lake Michigan. For Lake Superior,

Table 5.--Percentage recovery from three different strains of rainbow trout released in 1957

[Total number of returns in parentheses]

Strain	Stocking site							
	Two strains			Three strains				
	Pendills Creek	Huron River	Carp Lake River	Black River (stream)	Black River (lake)	Two Hearted River	Board-man River	Ocqueoc River
Domestic	1.6 (16)	0.4 (4)	0.3 (3)	0.4 (4)	1.1 (11)	1.1 (11)	2.8 (28)	1.5 (15)
West Coast	0.5 (5)	0.1 (1)	0.4 (4)	0.1 (1)	0.0 (0)	0.9 (9)	0.5 (5)	1.0 (10)
Michigan wild	...	...	...	1.6 (15)	0.6 (6)	0.2 (2)	2.8 (28)	1.6 (16)

Analysis of variance of arc-sine transformed data on comparative plantings of two strains

Source of variation	Degrees of freedom	Mean square
Stocking site	2	4.75
Strain	1	3.45 (F = 1.96)
Site x strain (error)	2	1.76

Analysis of variance of arc-sine transformed data on comparative plantings of three strains

Source of variation	Degrees of freedom	Mean square
Stocking site	4	9.61
Strain	2	14.46 (F = 3.32)
Site x strain (error)	8	4.35

Table 6.--Recovery of domestic rainbow trout from different size groups released in 1955

[For each stocking site the upper figures are the percentage returns, the middle figures are the total number of recoveries, and the lower figures are the total number released.]

Stocking sites[1]	Length (in inches) at release				
	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0 and over
Black Mallard Creek	2.6	3.5	2.1	3.7	1.8
	8	9	4	5	2
	301	256	191	136	113
Northport Bay	2.8	1.8	1.2	1.1	2.7
	10	11	7	4	3
	355	621	559	349	112
Betsie River	0.2	0.9	1.3	1.4	1.7
	1	7	11	7	4
	574	814	871	510	229
Boardman River	4.7	4.8	6.4	4.5	6.7
	27	25	27	13	13
	576	522	419	289	194
Totals	2.5	2.3	2.4	2.2	3.4
	46	52	49	29	22
	1,806	2,213	2,040	1,284	648

Analysis of variance of arc-sine transformed data on comparative returns from different sizes of fish released at four sites in 1955

Source of variation	Degrees of freedom	Mean square
Stocking site	3	53.18
Size of fish	4	1.12 (F = 0.34)
Site x size (error)	12	3.26

[1] Releases which resulted in no recoveries or which lacked significant numbers in any size group were not included.

Table 7.--Recovery of domestic rainbow trout from different size groups released in 1956

[For each stocking site the upper figures are the percentage returns, the middle figures are the total number of recoveries, and the lower figures are the total number released.]

Stocking sites[1]	Length (in inches) at release				
	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0 and over
Presque Isle	1.2	1.6	1.7	2.3	3.4
	3	19	19	9	3
	245	1,156	1,107	393	87
Huron River	1.6	1.8	1.2	1.4	5.2
	2	13	9	4	4
	129	699	760	289	77
Northport Bay	1.5	2.4	1.4	2.5	4.3
	5	15	9	7	4
	341	634	636	283	92
Betsie River	1.1	1.2	1.2	3.4	5.0
	8	12	10	11	4
	761	1,011	827	321	80
Manistee River	0.2	0.9	2.2	4.0	3.3
	1	8	16	12	3
	488	880	739	300	91
Boardman River	2.3	2.3	5.2	8.3	13.2
	8	16	32	24	9
	341	685	610	288	68
Totals	1.2	1.6	2.0	3.6	5.4
	27	83	95	67	27
	2,305	5,065	4,679	1,874	495

Analysis of variance of arc-sine transformed data on comparative returns from different sizes of fish released at six sites in 1956

Source of variation	Degrees of freedom	Mean square
Stocking site	5	25.68
Size of fish	4	48.67 (F = 12.74)[2]
Site x size (error)	20	3.82

[1] Releases which resulted in no recoveries or which lacked significant numbers in any size group were not included.

[2] Significant at the 5-percent level.

Table 8.--Recovery percentages of rainbow trout from lake and stream stockings,[1] 1955-1958

[Number of fish recovered shown in parentheses]

Release area	Year released and location									
	1955		1956		1957[2]		1958[2]		Totals	
	Lake	Stream	Lake	Stream	Lake	Stream	Lake	Stream	Lake	Stream
Lake Superior	3.0 (60)	0.8 (33)	1.6 (62)	0.5 (48)	0.6 (52)	0.0 (0)	0.2 (17)	...	0.8 (191)	0.6 (81)
Lake Michigan[3]	1.5 (46)	1.4 (135)	1.6 (47)	1.7 (174)	1.4 (68)	0.2 (10)	0.5 (12)	...	1.3 (173)	1.2 (319)
Sub-totals	2.1 (106)	1.2 (168)	1.6 (109)	1.2 (222)	0.9 (120)	0.1 (10)	0.2 (29)	...	0.9 (364)	1.0 (400)
Lake Huron	2.8 (28)	...	1.3 (13)	...	1.4 (41)	...	1.7 (67)	...	1.7 (149)	...
Totals	2.2 (134)	1.2 (168)	1.5 (122)	1.2 (222)	1.0 (161)	0.1 (10)	0.6 (96)	...	1.1 (513)	1.0 (400)

[1] Lake releases (26) were in the Great Lakes proper and stream releases (21) within the stream confines.

[2] All strains combined.

[3] Black River (1955-1958) excluded.

on the other hand, recovery rates from lake plants were significantly greater ($p = .048$) than from stream plants.

Further evidence of a higher recovery from lake plants in Lake Superior was found by reversing the stocking sites at two streams during two consecutive years. The lake stocking at the Two Hearted River in 1955 produced a return of 3.3 percent, while the 1956 stream plant (two miles from the mouth) resulted in the significantly lower rate of 0.1 percent (chi-square = 81.65). Similarly, the 1955 stream plant in the Chocolay River resulted in no lake-run recoveries, whereas the 1956 lake plant off Presque Isle (seven miles from the mouth of the Chocolay River) produced a return of 1.8 percent, again a significant difference (chi-square = 25.31). It should be noted that the greater distances of the two 1956 releases from the mouths of the rivers may have resulted in different recovery rates than if the releases had been made within one mile of the mouths (the usual site for stream plantings).

A more precise study was conducted at the Black River where simultaneous stockings were made in the stream and in the lake. In 1955-1956, domestic trout were released at several monthly intervals in the spring, and in 1957 on one date only (Table 1). An analysis of variance showed evidence of consistent superiority, from year to year, of lake over stream stockings ($F = 18.5$, 1 and 2 degrees of freedom) (Table 9). However, when the data were considered month by month, within each year, certain inconsistencies appeared which upset the appearance of a difference in the recovery rates from the two stocking locations (see Table 3 and related text).

To summarize, the bulk of the evidence indicates a higher rate of return from lake than from stream plantings, although the data are conflicting in some respects.

Table 9.--Comparative returns from simultaneous plantings of rainbow trout in the stream and lake, near the mouth of the Black River (from Table 1)

Year	Stream planting	Lake planting
1955	0.7	2.0
1956	1.4	2.1
1957	0.4	1.1

Analysis of variance of arc-sine transformed data on returns from plantings in the Black River and in Lake Michigan near the mouth of the stream

Source of variation	Degrees of freedom	Mean square
Year	2	3.81
Planting site	1	8.77 (F = 18.5)[1]
Year x site (error)	2	0.4

[1] Significant at the 5-percent level.

Sea lamprey predation

It has been well established that rainbow trout, in addition to other fishes in the Great Lakes, are subject to predation by the sea lamprey. A generally downward trend of the rainbow trout run, which coincided with heavy predation by sea lampreys (as shown by scarring records), was observed at the Black River, Mackinac County, 1951-1957.[5] Consequently, it is probable that sea lamprey predation has reduced the recovery rates of planted rainbow trout to some degree. It is evident, however, that sea lamprey predation is less severe on rainbow trout than on lake trout (Salvelinus namaycush) since the rate of decline in the rainbow trout population has not been so sharp.

Sea lamprey predation was assumed to be lighter in Lake Superior (because of the later establishment of the lamprey population) than in Lakes Michigan and Huron. If this assumption is valid, then the proportion of fish recovered at later intervals after release and the percentages of recovery should be discernibly higher in Lake Superior. The proportion of recovery in later intervals after release was significantly higher in Lake Superior than in Lake Michigan (Table 4). However, the total recovery rate from Lake Superior plants (1955-1958) was not greater than those from Lakes Huron and Michigan (Table 1) even though the early season for rainbow trout was open in Upper Peninsula streams in 1957 but not in streams in the Lower Peninsula. The data are thus inconclusive, possibly because other differences between the lakes (fishing pressure, proportion of unreported recoveries, and environment) obscured the effect of sea lamprey predation.

Protective regulations

It was thought that heavy angling pressure immediately after stocking might significantly reduce the subsequent recovery of lake-run rainbow trout. In 1956,

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[5] Minutes of the Annual Meeting of the Upper Great Lakes Fishery Committee, 1957.

angling was prohibited in the stocking vicinity at the Boardman River (from the Old Mill Dam, Traverse City to Lake Michigan) for an interval of one month after the release date. A comparison of the recovery rates from the 1956 plant with the unprotected 1955 plant is shown below:

Stocking date	Number stocked	Average length (inches)	Recoveries			
			Lake-run trout		Newly released trout	
			Number	Percentage	Number	Percentage
June 10, 1955	2,000	8.8	105	5.2	45	2.2
June 1, 1956	1,992	9.0	89	4.5	54	2.7

The slight (and contradictory) difference in the recovery rates of lake-run trout from these two years was not significant. The observed slight difference in percentage recovery of newly released fish (caught during the first two months after release) was also not significant.

Straying of domestic rainbow trout

Although there was extreme variation in rates of straying among the individual plants, there appeared to be little difference in the average rates of straying from stream and lake locations (Table 10). However, the average rates of straying from releases in Lake Superior and Lake Huron appeared higher than from Lake Michigan releases. Greater opportunities for straying may exist in Lakes Huron and Superior because of the relatively large number of rainbow trout streams tributary to each of these lakes. The operation of lamprey weirs in all streams where releases were made may also have contributed to the higher rate of straying in Lake Superior. On the other hand, weirs were lacking in Lake Huron[6] where a high rate of straying also occurred.

[6] An experimental sea lamprey weir was operated intermittently at the Ocqueoc River in 1948-1959.

Table 10.--Rates of straying of domestic rainbow trout, 1955-1958[1]

[Percentages computed using total recoveries as a base;[2] number of recoveries in parentheses]

Release location	Total number recoveries	Distance traveled from release location				Total percentage straying	Recoveries in other states or Canada	Direction of movement	
		10 miles or under	11-50 miles	51-100 miles	Over 100 miles			Up-lake	Down-lake
Lake Superior									
Lake plant	115	0.0 (0)	30.4 (35)	7.0 (8)	10.4 (12)	47.8 (55)	5.2 (6)	27.3 (15)	72.7 (40)
Stream plant	71	1.4 (1)	23.9 (17)	11.3 (8)	26.8 (19)	63.4 (45)	9.8 (7)	15.6 (7)	84.4 (38)
Lake Michigan									
Lake plant	95	1.1 (1)	7.4 (7)	2.1 (2)	12.6 (12)	23.2 (22)	4.2 (4)	9.5 (2)	90.9 (20)
Stream plant	306	1.3 (4)	14.4 (44)	5.9 (18)	1.6 (5)	23.2 (71)	0.0 (0)	61.4 (43)[3]	38.6 (27)
Lake Huron									
Lake plant	107	15.0 (16)	6.5 (7)	15.9 (17)	13.1 (14)	50.5 (54)	10.3 (11)	24.1 (13)	75.9 (41)

[1] Trout recovered in the Great Lakes proper and from releases at Huron and Keweenaw bays, Presque Isle, St. Marys River, Black River (1957 only), and Northport Bay were excluded.

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

[3] No direction could be assigned to one recovery.

A noteworthy percentage of recoveries from stockings in Lakes Superior and Huron were reported from other states or Canada (Table 10). A comparatively low rate of straying to other states was reported from Lake Michigan stocking sites. This may be due, in part, to the scarcity of suitable rainbow trout streams in other states bordering Lake Michigan.

The prevailing direction of movement appeared to be down lake with the exception of the Lake Michigan stream plants. Straying from several planting sites appeared to be to specific locations, usually the better and/or more heavily fished rainbow trout streams. As mentioned previously, however, the apparent rates of straying may be misleading because of variation in fishing pressure and in the tendency of fishermen to report recoveries. Migrations of 100 miles or over were common; the longest journey on record was from the Ocqueoc River to the Bay of Quinte, Lake Ontario, a distance in excess of 600 miles.

Growth of rainbow trout

The reported rate of growth of lake-run rainbow trout after stocking was rapid. As an example, in the Black River (1951-1953) age-group-II immature native rainbow trout (average length, 7.2 inches) were marked during their normal downstream migration (April-July) to Lake Michigan. Upon their recovery at subsequent intervals the average increment (in inches) was as follows (number of fish in parentheses): first fall, 6.1 (15), second spring, 6.6 (21), and third spring, 12.0 (8)--see Stauffer, 1955. Corresponding average increments of hatchery-reared rainbow trout (average length, 9.0 inches) approximated the rapid growth of native rainbow trout (Tables 11 and 12). Because of the few recoveries from individual planting sites where simultaneous stockings were made, statistical testing for possible differences in growth among the three strains and between lake and stream stocking locations was not attempted.

Table 11.--Average length and increment of domestic rainbow trout at successive intervals after release, 1955-1958[1]

[Number of recoveries in parentheses; recovery length and increment[2] in inches]

Stocking location	Average length at release	Season of recovery[3]							
		First fall		Second spring		Second fall		Third spring	
		Average length	Increment	Average length	Increment	Average length	Increment	Average length	Increment
Lake Superior									
Lake	9.1	15.5 (50)	6.0 (34)	16.2 (64)	6.8 (41)	19.5 (26)	9.4 (13)	20.2 (21)	10.9 (14)
Stream[4]	9.2	15.4 (13)	5.5 (9)	16.5 (43)	6.8 (21)	20.5 (11)	11.4 (9)	19.4 (11)	10.4 (10)
Totals	9.1	15.5 (63)	5.9 (43)	16.4 (107)	6.8 (62)	19.8 (37)	10.2 (22)	19.9 (32)	10.7 (24)
Lake Michigan									
Lake	9.0	15.2 (77)	6.0 (67)	16.5 (105)	7.9 (84)	20.2 (15)	11.1 (11)	22.8 (3)	13.9 (2)
Stream	9.3	15.9 (154)	6.2 (146)	17.1 (110)	8.0 (98)	19.4 (19)	10.7 (15)	21.9 (9)	13.8 (5)
Totals	9.2	15.7 (231)	6.1 (213)	16.8 (215)	8.0 (182)	19.8 (34)	10.9 (26)	22.1 (12)	13.8 (7)
Lake Huron									
Lake	8.9	15.7 (69)	6.7 (69)	16.5 (20)	7.6 (20)	19.4 (5)	11.5 (5)	...	...

[1] Compiled from all sources of recovery (angler and miscellaneous). Data for the first spring and third fall are not presented because of the limited number of recoveries.

[2] Includes only trout of known length at release.

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

[4] Excludes St. Marys River, 1957-1958.

Table 12.--Average increment[1] (inches) of three strains of rainbow trout, compiled from all sources of recovery (angler and miscellaneous)

[Number of recoveries in parentheses]

Year stocked and type of combination	Season of recovery[2]								
	First fall			Second spring			Second fall		
	Domestic	Michigan wild	West Coast	Domestic	Michigan wild	West Coast	Domestic	Michigan wild	West Coast
1957									
Two strains (domestic and West Coast)[3]	4.8 (10)	...	...	7.7 (11)	...	9.5 (9)	10.0 (3)	...	14.0 (2)
Three strains[3]	6.2 (17)	8.2 (21)	7.9 (2)	9.1 (21)	10.4 (19)	10.1 (20)	11.9 (8)	11.3 (5)	14.2 (3)
1958									
Two strains (domestic and Michigan wild)[3]	7.1 (38)	8.5 (2)	...	...	...	...	...	...	...
Three strains[4]	5.5 (46)	6.9 (11)	6.3 (3)	...	...	...	...	...	...
Three strains (Burt Lake, Cheboygan County)	5.1 (5)	5.1 (18)	4.9 (35)	...	...	...	...	...	...

[1] Average increment was computed from recoveries of known length at release and recapture.

[2] Fall season, August 1-December 31; spring season, January 1-July 31.

[3] Stockings made at three locations.

[4] Stockings made at eight locations.

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