

Migration, Growth Rate and
Population Density of Brook
Trout in the North Branch of
the Au Sable River, Michigan

DAVID S. SHETTER

*Institute for Fisheries Research, Michigan Conser-
vation Department, Ann Arbor, Michigan*



Reprinted from

VOLUME 66 (1936) TRANSACTIONS OF THE
AMERICAN FISHERIES SOCIETY
INVESTMENT BUILDING, WASHINGTON, D. C.

1937

MIGRATION, GROWTH RATE, AND POPULATION DENSITY OF BROOK TROUT IN THE NORTH BRANCH OF THE AU SABLE RIVER, MICHIGAN*

DAVID S. SHETTER

*Institute for Fisheries Research, Michigan Conservation Department
Ann Arbor, Michigan*

Since the trouts, and particularly the brook trout, are among the important fishes pursued by the sport fishermen in the waters of Michigan, any information concerning their habits in natural waters will be a distinct aid in a management program. This paper discusses briefly the information obtained to date from recoveries of tagged wild brook trout marked and recovered in the North Branch of the Au Sable River. Tagging has been carried on since July 1934, and is being followed through at the present time.

These studies have been conducted on the North Branch in the region of Lovells, Michigan, located in the northeastern corner of Crawford County. This particular stream was chosen for the following reasons:

1. It supports a relatively large brook trout and brown trout population. There were formerly many rainbow present but they have dwindled in recent years.

2. It is, through most of its course, a wide and relatively shallow stream and consequently is more readily seined than most trout streams.

3. It is rather heavily fished by an exceptionally intelligent class of fishermen, and it was felt that they would readily cooperate by reporting any captures of tagged trout.

The so-called "strap" or clip type tag, bearing a serial number, was chosen from the three types † available as the tag most suitable. This tag is applied to the mandible of the trout by a relatively simple operation. A small slit is made with a sharp knife or scalpel under and inside the mandible. The short end of the tag is inserted through this slit and is then clamped through the lock-hole on the opposite (long) end of the tag so that the jawbone is completely and firmly encircled when the projecting lockpiece is pinched down with a jeweler's pliers. To allow for growth of the jawbone, the resulting elongated oval is spread to an approximately circular shape by pressure on the tag applied from both ends by means of the pliers. The feasibility of this method of tagging has been demonstrated by hatchery experiments (Shetter, 1935).

* This study has been conducted through the medium of tagging. It has been in operation since July 1934, and still is being followed through at the present time.

† Cobb (1933) conducted an experiment along similar lines in Connecticut trout waters. However, he worked with hatchery fish using the internal tag, and all recoveries were made by fishermen.

The pools or portions of the stream that were seined were selected by cruising the stream carefully to locate comparatively heavy concentrations of fish in water that could be seined. Seines of different mesh size and lengths were tried out, but the most success was obtained by the use of a 3/8" mesh (bar measurement) fifty feet long and six feet deep.

With the exception of a few quiet-water pools, most of the seining had to be done down stream or across the current. Captured fish were placed immediately in a wash tub half full of water, or were measured and tagged directly from the seine. The fish were measured on a board on which a ruler had been inset. Total lengths only were recorded during the first two summers, but since this spring, standard, total and fork measurements have been taken.

Careful notes, both on tagging and on subsequent recovery are kept as follows: date, location, lengths, species, tag number. During this summer (1936), scale samples have been taken from all fish tagged and all fish recovered.

Each recovery is recorded on a separate card, as this was found to be the most convenient method of filing the recoveries (Figure 1). This filing method facilitates compilation of all data.

193.....	NORTH BRANCH OF THE AU SABLE					
Year						Experiment
(BROOK), (BROWN), (RAINBOW),					(.....)
.....						
Species			Tag No.			
How Recovered (SEINED), (FISHING)			By Whom (I. F. R.)			
Date when Recovered.....			Length when Recovered.....			
Date when Tagged.....			Length when Tagged.....			
Total Days Out.....			Growth in Eighth Inches.....			
Stream or Lake	County	T	R	Sec.	Location	
Where Tagged NORTH BRANCH						
Where Recovered.....						
Distance traveled.....miles			Direction traveled (UP), (DOWN), (NONE)			
INSTITUTE FOR FISHERIES RESEARCH MICHIGAN CONSERVATION DEPARTMENT						
TAGGING EXPERIMENTS			RECOVERY DATA			

Fig. 1—Card used to file information on the recovery of a tagged fish. Size 3 x 5 inches.

Migration—The migration data of this paper are based on recoveries obtained from brook trout tagged between July 25, 1934 and February 15, 1936. Between these dates 3,098 brook trout, 161 brown trout and 6 rainbow trout were tagged. Between the same dates 776 (25%) brook trout, 17 (10.5%) brown trout, and 2 (33%) rainbow trout were re-

covered—a total of 795 trout or 24.3%. A large number of the brook trout have been recovered from one to five times during various seasons; therefore many more records of growth and migration are available than the above figures indicate. These duplicate recoveries should be an added source of detailed information on seasonal growth and movements when the study is completed, since through these recoveries one can trace the life history of individual fish over a period of time.

Recoveries have been assembled into two different groups:—those recovered during the same year that they were tagged, and those that were recovered after they had been free over at least one winter. Tables 1 and 2 give the results of the recoveries within the years 1934 and 1935 respectively. Tables 3 and 4 give the results of over-winter recoveries for the years 1935 and 1936 respectively. The following facts may be determined from the data in these tables:—

1. The brook trout in the region of Lovells do not undertake any extensive movement during the months of June, July, August, and early September. The majority (anywhere from fifty to 100 per cent) show no migration (Tables 1 and 2).

TABLE 1. WILD BROOK TROUT TAGGED AND RECOVERED DURING 1934

Tagged		Recovered					
Month	Month	No.	Down Stream %	No Migration Av. Miles	No Migration %	Up Stream %	Up Stream Av. Miles
July	July	42	23	0.45	67	10	1.10
July	Aug.	135	6	0.35	83	11	0.62
July	Sept.	62	21	0.50	60	19	0.50
July	Nov.	48	31	0.40	11	58	0.59
Aug.	Aug.	57	..	....	100	..	....
Aug.	Sept.	60	10	0.60	75	15	0.26
Aug.	Nov.	18	45	0.40	..	55	0.30
Sept.	Sept.	89	4	0.60	91	5	0.10
Sept.	Nov.	84	15	0.19	33	52	0.65
Nov.	Nov.	6	..	....	67	33	0.24

2. Recaptures of tagged brook trout on the spawning beds during late October and early November indicate that the majority (between fifty and fifty-five per cent) of the breeding fish moved upstream on the average of less than a mile (0.785 mi.) to spawn. Approximately twenty per cent of the fish recovered were found to spawn in the immediate vicinity of the tagging locality. Approximately twenty-five per cent of the fish recovered had moved down stream to spawn, traveling on the average slightly less than one-half mile (Table 1 and 2).

3. The direct evidence on the winter migration habits of the brook trout is scanty. Results of winter and early spring seinings in the same areas that ordinarily contain trout throughout the warmer months of

the year are shown in Table 5. The scarcity of fish in the seine hauls certainly indicates that the trout population has deserted this region during the colder months.

TABLE 2. WILD BROOK TROUT TAGGED IN 1935 AND RECOVERED JUNE 1935 THRU JANUARY 1936

Tagged			Recovered				
Month	Month	No.	Down Stream %	Av. Miles	No Migration %	Up Stream %	Av. Miles
June	June	10	..	....	90	10	0.12
June	July	2	50	0.25	..	50	1.50
June	Aug.	35	36	0.32	48	16	0.16
June	Sept.	8	13	3.00	50	37	0.12
June	Nov.	33	21	0.75	30	49	1.60
Aug.	Aug.	33	13	0.50	69	18	0.10
Aug.	Sept.	100	4	0.10	92	4	0.35
Aug.	Nov.	82	19	0.44	35	46	0.60
Sept.	Nov.	21	9	0.75	29	62	0.30
Nov.	Nov.	28	29	0.70	64	7	0.20
June	Jan.	6	16	0.12	17	67	0.43
Aug.	Jan.	16	37	0.32	13	50	0.40
Sept.	Jan.	2	50	1.12	..	50	0.06
Nov.	Jan.	52	19	0.31	54	27	0.08

However, from Tables 3 and 4 it will be seen that the majority (fifty-three per cent) of the fish recovered in April and May were taken at points down stream from where they were recorded during the summer and autumn of the previous year. This fact, combined with the results of the winter seining of 1936, seems to bear out the conclusion that there is a downstream movement of the bulk of the trout population during the colder, winter months. This movement may possibly carry them as far as the Main Stream of the Au Sable (18 miles down stream). One recovery of a tagged fish from a stream on the southern side of the Au Sable drainage suggests the possibility that some, at least, may perform this relatively lengthy migration.

4. It will be noted that at least one-third of the over-the-winter recoveries taken in mid-summer and early fall were fish that had returned to the place where they were tagged the previous year. The remaining two-thirds of the mid-summer and early fall recoveries were, on the average, less than a mile up stream or down stream from the point of tagging, indicating that the bulk of the population returns each year to the same general areas occupied the preceding year (Tables 3 and 4).

Growth Rate—Since certain European writers (Wunder, Debrosses, 1935) have expressed the opinion that tagging on the gill cover of coarse fishes reduces the rate of growth, the effect of jaw tagging on rate of growth of trout was tested in two hatchery experiments. The results of these experiments are shown in Table 6.

TABLE 3. OVER-THE-WINTER RECOVERIES MADE DURING 1935 ARRANGED TO SHOW MIGRATION TRENDS

Tagged		Recovered								
Month 1935	Month 1936	Total No.	No.	Down Stream		No Migration		Up Stream		
				%	Ave. Miles	No.	%	No.	%	Ave. Miles
Sept.	May	1	..	..	....	..	..	1	100	0.50
Nov.	May	2	1	50	0.75	1	50	..	..	....
July	June	6	4	67	1.30	..	..	2	33	1.50
Aug.	June	2	1	50	0.12	..	..	1	50	1.75
Sept.	June	11	5	45	0.80	4	37	2	18	2.00
Nov.	June	8	3	37.5	0.33	3	37.5	2	25	0.50
July	Aug.	5	2	40	1.75	2	40	1	20	0.06
Sept.	Aug.	5	2	40	0.38	1	20	2	40	0.63
Nov.	Aug.	6	1	13	0.25	..	..	5	87	0.87
July	Sept.	2	..	..	....	1	50	1	50	1.625
Sept.	Sept.	2	1	50	0.12	1	50	..	..	....
July	Nov.	2	1	50	0.12	..	..	1	50	0.12
Sept.	Nov.	4	2	50	0.37	2	50	..	..	....
Nov.	Nov.	5	..	..	....	4	80	1	20	1.25

TABLE 4. OVER-THE-WINTER RECOVERIES MADE DURING 1936 (TO JULY 26) ARRANGED TO SHOW MIGRATION TRENDS

Tagged		Recovered								
Month 1935	Month 1936	Total No.	No.	Down Stream		No Migration		Up Stream		
				%	Ave. Miles	No.	%	No.	%	Ave. Miles
June	April	1	1	100	0.5	..	..	..	..	....
Aug.	April	4	2	50	2.0	2	50	..	..	....
Sept.	April	3	3	100	0.2	..	..	..	..	....
Nov.	April	2	..	..	....	1	50	1	50	11.0
June	May	3	2	67	1.0	1	33	..	..	....
July	May	2	..	..	....	1	50	1	50	4.0
Aug.	May	10	4	40	2.8	1	10	5	50	0.4
Sept.	May	6	2	33	*	1	16	3	50	1.1
Nov.	May	9	8	89	1.0	..	..	1	11	3.25
Aug.	June	6	1	16	0.75	2	33	3	50	1.0
Nov.	June	3	2	67	1.75	..	..	1	33	1.0
Aug.	July	10	3	30	0.75	5	50	2	20	0.06
Sept.	July	1	..	..	....	1	100	..	..	....
Nov.	July	17	5	30	0.75	11	63	1	7	1.75

* Mileage not given as one trout moved out of the North Branch.

TABLE 5. ABUNDANCE OF BROOK TROUT IN SEINE HAULS DURING MID-WINTER AND EARLY SPRING, 1936, IN THE NORTH BRANCH OF THE AU SABLE RIVER, MICHIGAN

Month	Number of Hauls ¹	Total Trout Captured	Ave. Number of Trout Per Haul	Remarks
Jan.	11	800-1000	80-100	Close to normal summer size range.
Feb.	12	43	3.0	About 5% legal trout (7 inches).
March	14	11	0.8	All less than 6 inches.
April	15	55	4.0	About 5% legal fish.
May	21	336	16.0	Less than 10% legal fish.

¹ 30 ft. x 6 ft. seine used, mesh 3/8 inches, bar measurement.

TABLE 6. RESULTS OF HATCHERY EXPERIMENTS TO DETERMINE THE EFFECT OF JAW-TAGGING ON GROWTH RATE

	Tagged		Un-tagged ¹	
	Number	Ave. Total Length (inches)	Number	Ave. Total Length (inches)
Northville Hatchery Brook Trout				
Measured Oct. 7, 1935	100	4.0	100	4.0
Remeasured Apr. 2, 1936	83 ²	6.8	100	6.6
Paris Hatchery Brown Trout				
Measured Jan. 4, 1936	202	8.8	53	8.7
Remeasured Mar. 18, 1936	179 ³	8.9	52 ³	8.7

¹ The un-tagged fish measured as controls were random samples from the same population as the tagged fish.

² 17 tagged fish probably lost through merganser predation.

³ 23 tagged and 1 un-tagged fish died during the sub-zero weather in February. No deaths since then.

TABLE 7 GROWTH OF WILD BROOK TROUT OF VARIOUS SIZE GROUPS AT DIFFERENT "SEASONS"

Size Group (inches) *	2-3 %	4-5 %	6-7 %	8-9 %
Grand Average				
"Summers" 1934, 1935				
Trout Recovered	24	75	243	22
Ave. Days Out	24.2	26.7	34.0	19.8
Ave. Increase Per Day (inches x 10)	0.09	0.09	0.10	0.08
Grand Average				
"Autumn" 1934, 1935				
Trout recovered	2	56	36	11
Ave. Days Out	49.0	50.1	53.8	53.7
Ave. Increase Per Day (inches x 10)	0.05	0.07	0.05	0.06
Grand Average				
"Early Winter" 1935, 1936				
Trout Recovered	1	31	14	6
Ave. Days Out	61.0	60.6	60.3	60.5
Ave. Increase Per Day (inches x 10)	0.02	0.03	0.02	0.03

Although a slightly different type of jaw tag was used in the Paris experiment, and the experimental subject was the brown trout instead of the brook, the results are of a similar nature, and indicate that there is no significant difference in the growth rate between tagged and untagged fish, at least under hatchery conditions. Insofar as has been determined from the literature, this is the first time that a systematic study of the effect of tagging on the growth rate of the fish has been carried out. If tagging does not interfere with the growth of the fish, growth studies made by means of tagging are valid.

In studying the growth rate of the wild fish, individuals were grouped in intervals of two inches and three arbitrary time periods were set

up. The time periods chosen were "Summer" (June 1—early September); "Autumn" (late September—mid-November); "Early Winter" (from the spawning season till mid-January).

Although approximately 776 brook trout were recovered by seining in the one and one-half years of study, only slightly more than half were tagged and recovered within one of the single time periods defined above. Growth on these particular fish has been computed as the average increase per day. The results of the computations will be found in Table 7.

The following conclusions seem to be justified by the data in the foregoing tables:

1. Growth is progressively slower from summer through early winter but there is a measurable increment during this latter period.

2. There was a slight indication that fish of two to eight inches total length grew faster during the summer and autumn periods than did those of the eight to ten inch group. All fish apparently grew at about the same rate during the early winter period.

Recoveries during the months of February, March and April have been too few to attempt an analysis of growth during late winter and early spring.

Population Density—Since the total number of fish, both tagged and untagged, was known for thirteen seine hauls made during the spawning season of 1935, an attempt was made to calculate the population of that portion of the stream in which these seine hauls were made. If it is assumed that there was no loss of tagged fish by death, or loss of tags from fish, and that all tagged fish taken from the stream by fishermen were reported, the number of tagged brook trout in the stream at the time of the 1935 spawning season may be estimated at 2,437.

From carefully counted seine hauls at several different points within one and three-quarters miles, 463 untagged brook trout and 69 tagged brook trout were obtained. The estimate of the population of this stretch of the river is made by means of the following computation:—

$$\text{Number of brook trout in stream (1.75 mi.)} = 2,437 \times \frac{463}{69} = 17,059 \text{ brook trout.}$$

From this result it may be determined that the number of brook trout (size range four to ten inches) per mile of stream in the region of Lovells is approximately 9,700. From the same figure, the number per acre is approximately 700.

The following problems are among those being studied at present by means of tagging experiments conducted by the Institute for Fisheries Research:

1. The applicability of the scale method of growth determination with respect to different species is being tested by scale samplings from trout and other game fish both on tagging and on recovery. The combined data when correlated with length measurements taken at the same times should yield important information on the relationship between scale growth and body growth.

2. The tagging of 500 hatchery fish and 500 wild fish early this spring on the North Branch will, we hope, make possible a comparison of the possible differences in the growth rate, the survival, and the migration habits of the two types of fish.

3. Tagging of several hundred game fish in Fife Lake, Michigan, just before the opening of the season in combination with the intensive creel census there should also give us information on the population density and the growth rate of the species tagged.

LITERATURE CITED

Cobb, Eben W.

1933. Results of Trout Tagging to Determine Migrations and Results from Plants Made. *Trans. Am. Fish. Soc.*, vol. 63, pp. 308-312.

Debrosses, P.

1935. Contribution A La Biologie Du Roget-Barbet en Atlantique Nord. *Revue de Travaux de L'office des Peches Maritimes*. Tome VIII, Fasc. 3, No. 31, pp. 255-258.

Shetter, David S.

1935. The Jaw-Tag Method of Marking Fish. *Papers of the Michigan Academy of Science, Arts and Letters*, Vol. XXI, 1935. Published in 1936. pp. 651-653.

Wunder, W.

1935. The Marking of Carp in Pond Management. *Fischerei-Zeitung, Sonderdruck Aus Nr. 41. Band 38*, 1935.

RECEIVED
AUG 31 1933
FISH DIVISION

see revision attached

c.c. Seth Gordon
Fish Division ✓
Game Division

August 18, 1936

REPORT NO. 578

Prepared for
Am. Fish. Soc.
Grand Rapids, 1936.

MIGRATION, GROWTH RATE, AND POPULATION
DENSITY OF BROOK TROUT IN THE NORTH
BRANCH OF THE AU SABLE RIVER, MICHIGAN.

David S. Shetter

Institute for Fisheries Research
Michigan Conservation Department

Since the trouts, and particularly the brook trout, are among the important fishes pursued by the sport fishermen in the waters of Michigan, any information concerning their habits in natural waters will be a distinct aid in a management program. This paper discusses briefly the information obtained to date from recoveries of tagged brook trout marked and recovered in the North Branch of the Au Sable River. Tagging has been carried on since July 1934, and is being followed through at the present time.

These studies have been conducted on the North Branch in the region of Novells, Michigan, located in the northeastern corner of Crawford County. This particular stream was chosen for the following reasons:-

1. It supports a relatively large brook trout and brown trout population. (There were formerly many rainbow present, but they have dwindled in recent years.)
2. It is, through most of its course, a wide and relatively shallow stream and consequently is more readily seined than most trout streams.
3. It is rather heavily fished by an exceptionally intelligent class of fishermen, and it was felt that they would readily cooperate by reporting any captures of tagged trout.

The so-called "strap" or clip type tag, bearing a serial number, was chosen from the three types available as the tag most suitable. This mark is applied to

the mandible of the trout by a relatively simple operation. A small slit is made with a sharp knife or scalpel under and inside the mandible. The short end of the tag is inserted through this slit and is then clamped through the ~~lock-hole~~ hole on the opposite (long) end of the tag so that the jawbone is complete and firmly encircled when the projecting lockpiece is pinched down with the jeweler's pliers. To allow for growth of the jaw-bone, the resulting elongate oval is spread to an approximately circular shape by pressure on the tag applied from both ends by means of the pliers.

The feasibility of this method of tagging has been demonstrated by hatchery experiments (Shetter, D.S. - 1935).

The pools or portions of the stream that were seined were selected by cruising the stream carefully to locate comparatively heavy concentrations of fish in water that could be seined. Seines of different mesh size and lengths were tried out, but the most success was obtained by the use of a $3/8$ " mesh (bar measurement) fifty feet long and six feet deep.

With the exception of a few quiet-water pools, most of the seining had to be done down stream or across the current. Captured fish were placed immediately in a wash tub half full of water, or were measured and tagged directly from the seine. The fish were measured on a board on which a ruler had been inset. Total lengths only were recorded during the first two summers, but since this spring, standard, total and fork measurements have been taken.

Careful notes, both on tagging and on subsequent recovery are kept as follows: date, location, lengths, species, tag number. During this summer (1936), scale samples have been taken from all fish tagged and all fish recovered.

Each recovery is recorded on a separate card, as this was found to be the most convenient method of filing the recoveries (Figure 1.). This filing method facilitates compilation of all data.

Migration

The migration data of this paper are based on recoveries obtained from brook

trout tagged between July 25, 1934 and November 16, 1936. As shown in Table 1, a total of 3,265 trout were tagged of which 1,111 (34.1%) were recovered, 981 (29.5%) by seining; the balance by returns from fishermen.

Recoveries have been assembled into two different groups; - those recovered during the same year that they were tagged, and those that were recovered after they had been free over at least one winter. Tables 2 and 3 give the results of the recoveries within the years 1934 and 1935 respectively. Tables 4 and 5 give the results of over-winter recoveries for the years 1935 and 1936 respectively. The following facts may be determined from the data in these tables:-

1. The brook trout in the region of Lovells do not undertake any extensive movement during the months of June, July, August, and early September. The majority (anywhere from fifty to 100 percent) show no migration (Tables 2 and 3).

2. Recaptures of tagged brook trout on the spawning beds during late October and early November indicate that the majority (between fifty and fifty-five percent) of the breeding fish moved upstream on the average of less than a mile (0.785 mi.) to spawn. Approximately twenty percent of the fish recovered were found to spawn in the immediate vicinity of the tagging locality. Approximately twenty-five percent of the fish recovered had moved down stream to spawn, travelling on the average slightly less than one-half mile (Tables 2 and 3).

3. The direct evidence on the winter migration habits of the brook trout is scanty. Results of winter and early spring seining in the same areas that ordinarily contain trout throughout the warmer months of the year are shown in Table 6. The scarcity of fish in the seine hauls certainly indicates that the trout population has deserted this region during the colder months.

However, from Tables 4 and 5 it will be seen that the majority (fifty-three percent) of the fish recovered in April and May were taken at points down stream from where they were recorded during the summer and autumn of the previous year. This fact, combined with the results of the winter seining of 1936, seems to bear out the conclusion that there is a downstream movement of the bulk of the trout population during the colder, winter months. This movement may possibly carry

them as far as the Main Stream of the Au Sable (18 miles down stream). One recovery of a tagged fish from a stream on the southern side of the Au Sable drainage suggests the possibility that some, at least, may perform this relatively lengthy migration.

4. It will be noted that at least one-third of the over-the-winter recoveries taken in mid-summer and early fall were fish that had returned to the place where they were tagged the previous year. The remaining two thirds of the mid-summer and early fall recoveries were, on the average, less than a mile up stream or down stream from the point of tagging, indicating that the bulk of the population returns each year to the same general areas occupied the preceding year (Tables 4 and 5).

Growth Rate

Since certain European writers (Wunder, Debrosses, 1935) have expressed the opinion that tagging on the gill cover of coarse fishes reduces the rate of growth, the effect of jaw tagging on rate of growth of trout was tested in two hatchery experiments. The results of these experiments are shown in Table 7.

Although a slightly different type of jaw tag was used in the Paris experiment, and the experimental subject was the brown trout instead of the brook, the results are of a similar nature, and indicate that there is no significant difference in the growth rate between tagged and untagged fish, at least under hatchery conditions. Insofar as has been determined from the literature, this is the first time that a systematic study of the effect of tagging on the growth rate of the fish has been carried out. If tagging does not interfere with the growth of the fish, growth studies made by means of tagging are valid.

In studying the growth rate of the wild fish, individuals were grouped in intervals of two inches and three arbitrary time periods were set up. The time periods chosen were "Summer" (June 1 - early September); "Autumn" (late September - mid-November); "Early Winter" (from the spawning season till mid-January).

Although approximately 950 brook trout were recovered by seining in the one

and one-half years of study, only slightly more than half were tagged and recovered within one of the single time periods defined above. Growth on these particular fish has been computed as the average increase per day. The results of the computations will be found in Table 3.

The following conclusions seem to be justified by the data in the foregoing tables:

1. Growth is progressively slower from summer through early winter but there is a measurable increment during this latter period.

2. There was a slight indication that fish of two to eight inches total length grew faster during the summer and autumn periods than did those of the eight to ten inch group. All fish apparently grew at about the same rate during the early winter period.

Recoveries during the months of February, March and April have been too few to attempt an analysis of growth during late winter and early spring.

Population Density

Since the total number of fish, both tagged and untagged, were known for thirteen seine hauls made during the spawning season of 1935, an attempt was made to calculate the population of that portion of the stream in which these seine hauls were made. If it is assumed that there was no loss of tagged fish by death, or loss of tags from fish, and that all tagged fish taken from the stream by fishermen were reported, the number of tagged brook trout in the stream at the time of the 1935 spawning season may be estimated at 2437.

From carefully counted seine hauls at several different points within one and three-quarters miles 483 untagged brook trout and 89 tagged brook trout were obtained. The estimate of the population of this stretch of the river is made by means of the following computation:-

Number of brook trout in stream (1.75 mi.) = $2437 \times \frac{483}{89} = 17059$ brook trout.

From this result it may be determined that the number of brook trout

(size range four to ten inches) per mile of stream in the region of Lovells is approximately 9700. From the same figure, the number per acre is approximately 700.

The following problems are among those being studied at present by means of tagging experiments conducted by the Institute for Fisheries Research:

1. The applicability of the scale method of growth determination with respect to different species is being tested by scale samplings from trout and other game fish both on tagging and on recovery. The combined data when correlated with length measurements taken at the same times should yield important information on the relationship between scale growth and body growth.

2. The tagging of 500 hatchery fish and 500 wild fish early this spring on the North Branch will, we hope, make possible a comparison of the possible differences in the growth rate, the survival, and the migration habits of the two types of fish.

3. Tagging of several hundred game fish in Pife Lake, Michigan, just before the opening of the season in combination with the intensive creel census there should also give us information on the population density and the growth rate of the species tagged.

Literature Cited

Debrosses, P.

1935. Contribution à l'écologie Du Roguet-Barbet en Atlantique Nord. Revue de Travaux de L'office des Peches Maritimes. Tome VIII, Fasc. 3, No. 31, pp. 255-258.

Shetter, David S.

1935. The Jaw-Tag Method of Marking Fish. Papers of the Michigan Academy of Sciences, Arts, and Letters, Vol. XXI, 1935. Published in 1936. pp 651-653.

Wunder, W.

1935. The Marking of Carp in Pond Management. Fischerei-Zeitung, Sonderdruck Aus Nr. 41. Band 38, 1935.

195

NORTH BRANCH OF THE AU SABLE

Year

Experiment

(BROOK), (BROWN), (RAINBOW), ()

Species

Tag No.

How Recovered (SKINNED), (FISHING) By Whom (I. F. R.)

Date when recovered _____ Length when recovered _____

Date when Tagged _____ Length when Tagged _____

Total Days Out _____ Growth in Eighth Inches _____

Where	Stream or Lake	County	T	R	Sec.	Location
Tagged	NORTH BRANCH					

Where	Stream or Lake	County	T	R	Sec.	Location
Recovered						

Distance traveled _____ miles Direction traveled (UP), (DOWN), (NONE)

INSTITUTE FOR FISHERIES RESEARCH

MICHIGAN CONSERVATION DEPARTMENT

TAGGING EXPERIMENTS

RECOVERY DATA

Fig. 1- Card used to file information on the recovery of a tagged fish, Size 3 x 5 inches.

**Table 1. Number of Trout Tagged, Number Recovered
and Method of Recovery.**

Year	Brook Trout			Brown Trout			Rainbow Trout		
	Tagged	Recovered Seine	Fishing	Tagged	Recovered Seine	Fishing	Tagged	Recovered Seine	Fishing
1934	1,576	491	48	67	7	1	2	--	--
1935	1,612	376	99	104	7	2	4	2	--
1936	10	79	--	--	--	--	--	--	--
Total	3,098	946	147	161	14	3	6	2	--

Table 2. Brook Trout Tagged and Recovered During 1934.

<u>Tagged</u>	<u>Recovered</u>						
	<u>Month</u>	<u>No.</u>	<u>Down Stream</u>		<u>No Migration</u>	<u>Up Stream</u>	
			<u>%</u>	<u>Av. Miles</u>	<u>%</u>	<u>%</u>	<u>Av. Miles</u>
July	July	42	23	0.45	67	10	1.10
July	Aug.	135	6	0.35	83	11	0.62
July	Sept.	62	21	0.50	60	19	0.50
July	Nov.	48	31	0.40	11	58	0.59
Aug.	Aug.	57	--	--	100	--	--
Aug.	Sept.	60	10	0.60	75	15	0.26
Aug.	Nov.	18	45	0.40	--	55	0.30
Sept.	Sept.	89	4	0.60	91	5	0.10
Sept.	Nov.	64	15	0.19	33	52	0.65
Nov.	Nov.	6	--	--	67	33	0.24

Table 3. Brook Trout Tagged in 1935 and Recovered June 1935
thru January 1936.

<u>Tagged</u> Month	<u>Recovered</u>						
	Month	No.	<u>Down Stream</u>		<u>No Migration</u>	<u>Up Stream</u>	
			%	Ave. Miles	%	%	Ave. Miles
June	June	10	--	--	90	10	0.12
June	July	2	50	0.25	--	50	1.50
June	Aug.	36	36	0.32	48	16	0.16
June	Sept.	8	13	3.00	50	37	0.12
June	Nov.	33	21	0.75	30	49	1.60
Aug.	Aug.	33	13	0.50	69	18	0.10
Aug.	Sept.	100	4	0.10	92	4	0.35
Aug.	Nov.	82	19	0.44	35	46	0.60
Sept.	Nov.	21	9	0.75	29	62	0.30
Nov.	Nov.	28	29	0.70	64	7	0.20
June	Jan.	6	16	0.12	17	67	0.43
Aug.	Jan.	16	37	0.32	13	50	0.40
Sept.	Jan.	2	50	1.12	--	50	0.06
Nov.	Jan.	52	19	0.31	54	27	0.08

Table 4. Over-the winter Recoveries Made During 1935
 Arranged to Show Migration Trends (fishermen's returns
 and recoveries from seining by the Institute for Fish-
 eries Research are included).

Tagged Month 1934	Month 1935	Total No.	Recovered							
			Down Stream			No Migration		Up Stream		
			No.	%	Ave. Miles	No.	%	No.	%	Ave. Miles
Sept.	May	1	--	--	--	--	--	1	100	0.50
Nov.	May	2	1	50	0.75	1	50	--	--	--
July	June	6	4	67	1.30	--	--	2	33	1.50
Aug.	June	2	1	50	0.12	--	--	1	50	1.75
Sept.	June	11	5	45	0.80	4	37	2	18	2.00
Nov.	June	8	3	37.5	0.33	3	37.5	2	25	0.60
July	Aug.	5	2	40	1.75	2	40	1	20	0.06
Sept.	Aug.	5	2	40	0.38	1	20	2	40	0.63
Nov.	Aug.	6	1	15	0.25	--	--	5	87	0.87
July	Sept.	2	--	--	--	1	50	1	50	1.625
Sept.	Sept.	2	1	50	0.12	1	50	--	--	--
July	Nov.	2	1	50	0.12	--	--	1	50	0.12
Sept.	Nov.	4	2	50	0.37	2	50	--	--	--
Nov.	Nov.	5	--	--	--	4	80	1	20	1.25

Table 5. Over-the-winter Recoveries Made During 1936

(to July 28) Arranged to Show Migration Trends.

Tagged Month 1935	Month 1936	Total No.	Recovered								
			Down Stream			No Migration		Up Stream			
			No.	%	Ave. Miles	No.	%	No.	%	Ave. Miles	
June	April	1	1	100	0.6	--	--	--	--	--	
Aug.	April	4	2	50	2.0	2	50	--	--	--	
Sept.	April	3	3	100	0.2	--	--	--	--	--	
Nov.	April	2	--	--	--	1	50	1	50	11.0	
June	May	3	2	67	1.0	1	33	--	--	--	
July	May	2	--	--	--	1	50	1	50	4.0	
Aug.	May	10	4	40	2.8	1	10	5	50	0.4	
Sept.	May	6	2	33	*	1	16	3	50	1.1	
Nov.	May	9	8	89	1.0	--	--	1	11	3.25	
Aug.	June	6	1	16	0.75	2	33	3	50	1.0	
Nov.	June	3	2	67	1.75	--	--	1	33	1.0	
Aug.	July	10	3	30	0.75	5	50	2	20	0.08	
Sept.	July	1	--	--	--	1	100	--	--	--	
Nov.	July	17	5	30	0.75	11	65	1	7	1.75	

*Mileage not given as one trout moved out of the North Branch.

Table 6. Abundance of Brook Trout in Seine Hauls
 During Mid-Winter and Early Spring, 1936, in the
 North Branch of the Au Sable River, Michigan.

Month	Number of Hauls ¹	Total Trout Captured	Ave. Number of Trout Per Haul	Remarks
Jan.	11	800-1000	80-100	Close to normal summer size range.
Feb.	12	48	3.0	About 5% legal trout (7 inches).
March	14	11	0.8	All less than 6 inches.
April	15	58	4.0	About 6% legal fish.
May	21	838	16.0	Less than 10% legal fish.

¹30 ft. x 6 ft. seine used, mesh 3/8 inches, lar measurement.

Table 7. Results of Hatchery Experiments to Determine the Effect of Jaw-tagging on Growth Rate.

Northville Hatchery Brook Trout	Tagged		Un-tagged ¹	
	Number	Ave. Total Length (inches)	Number	Ave. Total Length (inches)
Measured Oct. 7, 1935	100	4.0	100	4.0
Remeasured Apr. 2, 1936	83 ²	6.8	100	6.8
.....				
Paris Hatchery Brown Trout				
Measured Jan. 4, 1936	202	8.8	55	8.7
Remeasured Mar. 18, 1936	179 ³	8.9	52 ⁶	8.7

¹The un-tagged fish measured as controls were random samples from the same population as the tagged fish.

²17 tagged fish probably lost through merganser predation.

³25 tagged and 1 un-tagged fish died during the sub-zero weather in February. No deaths since then.

**Table 8. Growth of Brook Trout of Various
Size Groups at Different "Seasons."**

Size Group (inches)	2-3 7/8	4-5 7/8	6-7 7/8	8-9 7/8
Grand Average				
"Summers" 1934, 1935				
Trout Recovered	24	75	243	22
Ave. Days Out	24.2	26.7	34.0	19.8
Ave. Increase Per Day (inches × 10)	0.09	0.09	0.10	0.08
Grand Average				
"Autumn" 1934, 1935				
Trout recovered	2	56	35	11
Ave. Days Out	49.0	50.1	53.8	53.7
Ave. Increase Per Day (inches × 10)	0.05	0.07	0.05	0.06
Grand Average				
"Early Winter" 1935, 1936				
Trout Recovered	1	31	14	6
Ave. Days Out	61.0	60.8	60.3	60.5
Ave. Increase Per Day (inches × 10)	0.02	0.03	0.02	0.03

Table 1 of the original Report No. 378 has
been omitted, the original Table 2 becoming
Table 1 of this paper, Table 3 becoming Table 2,
etc.

Original: Mr. Seth Gordon
cc - Fish Division
Mr. Ruhl
Mr. Shetter

Revision of text
of Report No. 378

Prepared for
Am. Fish. Soc.
Grand Rapids, 1936

MIGRATION, GROWTH RATE, AND POPULATION
DENSITY OF BROOK TROUT IN THE NORTH
BRANCH OF THE AU SABLE RIVER, MICHIGAN

David S. Shetter

Institute for Fisheries Research

Michigan Conservation Department

Since the trouts, and particularly the brook trout, are among the important fishes pursued by the sport fishermen in the waters of Michigan, any information concerning their habits in natural waters will be a distinct aid in a management program. This paper discusses briefly the information obtained to date from recoveries of tagged brook trout marked and recovered in the North Branch of the Au Sable River. Tagging has been carried on since July 1934, and is being followed through at the present time.

These studies have been conducted on the North Branch in the region of Lovells, Michigan, located in the northeastern corner of Crawford County. This particular stream was chosen for the following reasons:-

1. It supports a relatively large brook trout and brown trout population. (There were formerly many rainbow present, but they have dwindled in recent years.)
2. It is, through most of its course, a wide and relatively shallow stream and consequently is more readily seined than most trout streams.
3. It is rather heavily fished by an exceptionally intelligent class of fishermen, and it was felt that they would readily cooperate by reporting any captures of tagged trout.

The so-called "strap" or clip type tag, bearing a serial number, was chosen from the three types available as the tag most suitable. This mark is applied to the mandible of the trout by a relatively simple operation. A small slit is made with a sharp knife or scalpel under and inside the mandible. The short end of the tag is inserted through this slit and is then clamped through the lock-hole on the opposite (long) end of the tag so that the jawbone is complete^{ly} and firmly encircled when the projecting lockpiece is pinched down with ^athe jeweler's pliers. To allow for growth of the jawbone, the resulting elongate^d oval is spread to an approximately circular shape by pressure on the tag applied from both ends by means of the pliers.

The feasibility of this method of tagging has been demonstrated by hatchery experiments (Shetter, D. S. - 1935).

The pools or portions of the stream that were seined were selected by cruising the stream carefully to locate comparatively heavy concentrations of fish in water that could be seined. Seines of different mesh size and lengths were tried out, but the most success was obtained by the use of a 3/8" mesh (bar measurement) fifty feet long and six feet deep.

With the exception of a few quiet-water pools, most of the seining had to be done down stream or across the current. Captured fish were placed immediately in a wash tub half full of water, or were measured and tagged directly from the seine. The fish were measured on a board on which a ruler had been inset. Total lengths only were recorded during the first two summers, but since this spring, standard, total and fork measurements have been taken.

Careful notes, both on tagging and on subsequent recovery are kept as follows: date, location, lengths, species, tag number. During this summer (1936), scale samples have been taken from all fish tagged and all fish recovered.

Each recovery is recorded on a separate card, as this was found to be the most convenient method of filing the recoveries (Figure 1). This filing method facilitates compilation of all data.

Migration

The migration data of this paper are based on recoveries obtained from brook trout tagged between July 25, 1934 and February 15, 1936. Between these dates 3,098 brook trout, 161 brown trout and 6 rainbow trout were tagged. Between the same dates 776 (25%) brook trout, 17 (10.5%) brown trout, and 2 (33%) rainbow trout were recovered--a total of 795 trout or 24.3%. A large number of the brook trout have been recovered from one to five times during various seasons; therefore many more records of growth and migration are available than the above figures indicate. These duplicate recoveries should be an added source of detailed information on seasonal growth and movements when the study is completed, since through these recoveries one can trace the life history of individual fish over a period of time.

Recoveries have been assembled into two different groups: - those recovered during the same year that they were tagged, and those that were recovered after they had been free over at least one winter. Tables 1 and 2 give the results of the recoveries within the years 1934 and 1935 respectively. Tables 3 and 4 give the results of over-winter recoveries for the years 1935 and 1936 respectively. The following facts may be determined from the data in these tables:-

1. The brook trout in the region of Lovells do not undertake any extensive movement during the months of June, July, August, and early September. The majority (anywhere from fifty to 100 per cent) show no migration (Tables 1 and 2).

2. Recaptures of tagged brook trout on the spawning beds during late October and early November indicate that the majority (between fifty and fifty-five per cent) of the breeding fish moved upstream on the average of less than a mile (0.785 mi.) to spawn. Approximately twenty per cent of the fish recovered were found to spawn in the immediate vicinity of the tagging locality. Approximately twenty-five per cent of the fish recovered had moved down stream to spawn, travelling on the average slightly less than one-half mile (Tables 1 and 2).

3. The direct evidence on the winter migration habits of the brook trout is scanty. Results of winter and early spring seining in the same areas that ordinarily contain trout throughout the warmer months of the year are shown in Table 5. The

scarcity of fish in the seine hauls certainly indicates that the trout population has deserted this region during the colder months.

However, from Tables 3 and 4 it will be seen that the majority (fifty-three per cent) of the fish recovered in April and May were taken at points down stream from where they were recorded during the summer and autumn of the previous year. This fact, combined with the results of the winter seining of 1936, seems to bear out the conclusion that there is a downstream movement of the bulk of the trout population during the colder, winter months. This movement may possibly carry them as far as the Main Stream of the Au Sable (18 miles down stream). One recovery of a tagged fish from a stream on the southern side of the Au Sable drainage suggests the possibility that some, at least, may perform this relatively lengthy migration.

4. It will be noted that at least one-third of the over-the-winter recoveries taken in mid-summer and early fall were fish that had returned to the place where they were tagged the previous year. The remaining two-thirds of the mid-summer and early fall recoveries were, on the average, less than a mile up stream or down stream from the point of tagging, indicating that the bulk of the population returns each year to the same general areas occupied the preceding year (Tables 3 and 4).

Growth Rate

Since certain European writers (Wunder, Debrosses, 1935) have expressed the opinion that tagging on the gill cover of coarse fishes reduces the rate of growth, the effect of jaw tagging on rate of growth of trout was tested in two hatchery experiments. The results of these experiments are shown in Table 6.

Although a slightly different type of jaw tag was used in the Paris experiment, and the experimental subject was the brown trout instead of the brook, the results are of a similar nature, and indicate that there is no significant difference in the growth rate between tagged and untagged fish, at least under hatchery conditions. Insofar as has been determined from the literature, this is the first time that a systematic study of the effect of tagging on the growth rate of the fish has been

carried out. If tagging does not interfere with the growth of the fish, growth studies made by means of tagging are valid.

In studying the growth rate of the wild fish, individuals were grouped in intervals of two inches and three arbitrary time periods were set up. The time periods chosen were "Summer" (June 1 - early September); "Autumn" (late September - mid-November); "Early Winter" (from the spawning season till mid-January).

Although approximately 950 brook trout were recovered by seining in the one and one-half years of study, only slightly more than half were tagged and recovered within one of the single time periods defined above. Growth on these particular fish has been computed as the average increase per day. The results of the computations will be found in Table 7.

The following conclusions seem to be justified by the data in the foregoing tables:

1. Growth is progressively slower from summer through early winter but there is a measurable increment during this latter period.
2. There was a slight indication that fish of two to eight inches total length grew faster during the summer and autumn periods than did those of the eight to ten inch group. All fish apparently grew at about the same rate during the early winter period.

Recoveries during the months of February, March and April have been too few to attempt an analysis of growth during late winter and early spring.

Population Density

Since the total number of fish, both tagged and untagged, ^{was} were known for thirteen seine hauls made during the spawning season of 1935, an attempt was made to calculate the population of that portion of the stream in which these seine hauls were made. If it is assumed that there was no loss of tagged fish by death, or loss of tags from fish, and that all tagged fish taken from the stream by fishermen were reported, the number of tagged brook trout in the stream at the time of

the 1935 spawning season may be estimated at 2,437.

From carefully counted seine hauls at several different points within one and three-quarters miles, 463 untagged brook trout and 69 tagged brook trout were obtained. The estimate of the population of this stretch of the river is made by means of the following computation:-

Number of brook trout in stream (1.75 mi.) = $2,437 \times \frac{463}{69} = 17,059$ brook trout.

From this result it may be determined that the number of brook trout (size range four to ten inches) per mile of stream in the region of Lovells is approximately 9,700. From the same figure, the number per acre is approximately 700.

The following problems are among those being studied at present by means of tagging experiments conducted by the Institute for Fisheries Research:

1. The applicability of the scale method of growth determination with respect to different species is being tested by scale samplings from trout and other game fish both on tagging and on recovery. The combined data when correlated with length measurements taken at the same times should yield important information on the relationship between scale growth and body growth.

2. The tagging of 500 hatchery fish and 500 wild fish early this spring on the North Branch will, we hope, make possible a comparison of the possible differences in the growth rate, the survival, and the migration habits of the two types of fish.

3. Tagging of several hundred game fish in Fife Lake, Michigan, just before the opening of the season in combination with the intensive creel census there should also give us information on the population density and the growth rate of the species tagged.

Literature Cited

Debrosses, P.

1935. Contribution A La Biologie Du Roget-Barbet en Atlantique Nord. Revue de Travaux de L'office des Peches Maritimes. Tome VIII, Fasc. 3, No. 31, pp. 255-258.

Shetter, David S.

1936. The Jaw-Tag Method of Marking Fish. Papers of the Michigan Academy of Science, Arts, and Letters, Vol. XXI, 1935. Published in 1936. pp. 651-653.

Wunder, W.

1935. The Marking of Carp in Pond Management. Fischerei-Zeitung, Sonderdruck Aus Nr. 41. Band 38, 1935.

David S. Shetter, Institute for Fisheries Research