

March 12, 1940

REPORT NO. 586

THE MOVEMENTS OF MARKED FISH  
IN DOUGLAS LAKE, MICHIGAN<sup>1</sup>

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This study of the movements of fish in Douglas Lake, Cheboygan County, Michigan is the outgrowth of other investigations carried out in the lake by the writer during two previous summers. During the summer of 1937, ten experimental brush shelters were installed and studied at Grapevine Point in Douglas Lake (see map, Fig. 1), to determine to what extent fish of various species and sizes would use such devices as a warm weather habitat (Rodeheffer, 1939). In July and August of 1938 the same shelters were kept under continued observation to discover if the same species and sizes of fish would again be found using the structures, and to obtain further evidence on the differences in the fish population utilizing the artificial covers by day and by night (Rodeheffer, 1940). To ascertain how rapidly and to what extent shelters would become repopulated if all fish were removed, four more shelters were built and placed in North Fishtail Bay in July, 1938.

These investigations by the writer during the summer seasons of 1937 and 1938, in the eastern end of Douglas Lake showed that:

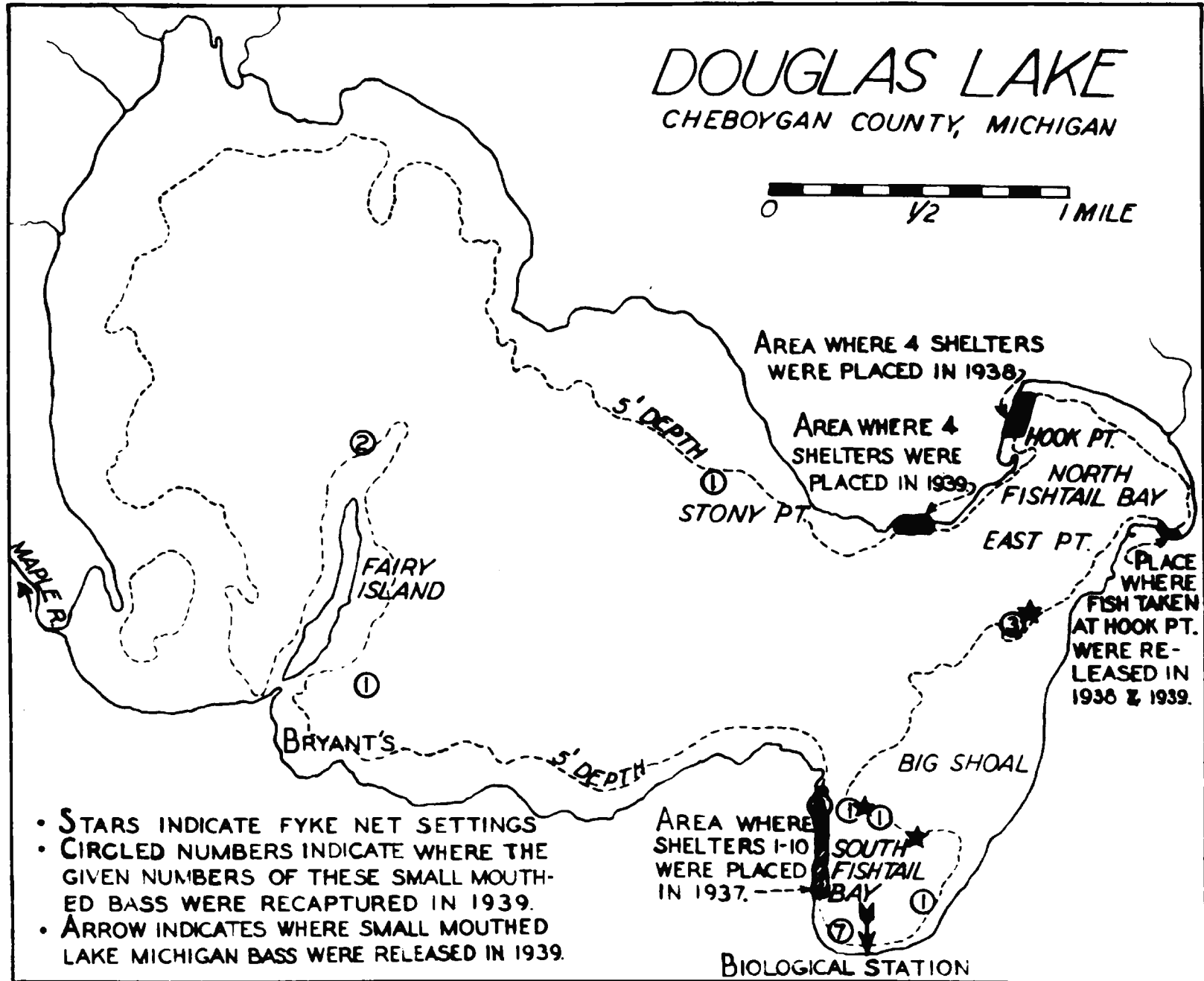
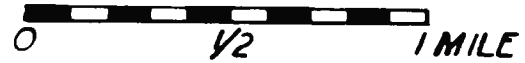
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<sup>1</sup>Contribution from the Institute for Fisheries Research of the Michigan Department of Conservation and the Biological Station of the University of Michigan.

Fig. 1. Douglas Lake, Michigan, showing points where fish were  
marked and released in a study of their movements.

# DOUGLAS LAKE

CHEBOYGAN COUNTY, MICHIGAN



- STARS INDICATE FYKE NET SETTINGS
- CIRCLED NUMBERS INDICATE WHERE THE GIVEN NUMBERS OF THESE SMALL MOUTHED BASS WERE RECAPTURED IN 1939.
- ARROW INDICATES WHERE SMALL MOUTHED LAKE MICHIGAN BASS WERE RELEASED IN 1939.

AREA WHERE 4 SHELTERS WERE PLACED IN 1938

AREA WHERE 4 SHELTERS WERE PLACED IN 1939

AREA WHERE SHELTERS 1-10 WERE PLACED IN 1937

PLACE WHERE FISH TAKEN AT HOOK PT. WERE RE-RELEASED IN 1938 & 1939.

BIOLOGICAL STATION

1. If fish shelters are installed on a practically barren shoal, such devices will attract fish (Rodeheffer, 1939).
2. There is a great diurnal fluctuation of fish populations within a given area (Rodeheffer, 1940).
3. As fish are removed from a part of a lake where protection is offered others will repopulate such regions (Rodeheffer, 1940).

Primarily in connection with the studies of the utilization of the brush shelters by fish, many game fish were marked at Grapevine Point in the summer months of 1937 and 1938 and at Hook Point, North Fishtail Bay in August, 1938. As the main focus of interest shifted to an analysis of fish movements, marking was continued at these locations and at other points in Douglas Lake in 1939. Small-mouthed bass transported from Lake Michigan and planted in Douglas Lake were marked before their release. To add to the little that is known of the wanderings of game fish in a lake, the data on the dispersion of these marked fish as determined by recaptures are presented in this paper.

A better knowledge of the movements of fish is one of the major problems that confronts the fisherman and the scientist. "Where are the fish today?" is a stock phrase of the sportsman and even the most experienced angler will excuse a poor day's fishing by saying that the fish have left his favorite fishing bed.

The practical fisheries manager is especially concerned with the distribution of fish. Should fish be planted at one convenient spot, or would the added expense of stocking fish at several points on a lake be justified? Is it possible that the same condition exists in our lakes that is found in the deer country--starving fish

in one part of a lake and an abundance of food in another? Will some sections be over fished while others are not fished at all? Does the installation of artificial covers make the taking of fish so easy as to deplete the stock? These are only a few of the questions that may be more adequately answered by a knowledge of the actions of fish.

To the fisheries biologist, information on the shifting location of fish is essential in life history and migration studies. What places are sought out for breeding by different species, and do they vie with each other for spawning grounds? Do they seek feeding areas where the young of certain species congregate?

Some insight into the movements of fish may be of value to general biologists and to specialists in fields other than fisheries research. In his study of the ecology of any organism, the biologist will be aided by knowing where all fish are to be found at different times in a body of water. The possibility of racial segregation or even differentiation within a lake is another general problem in which such knowledge is of prime importance. The limnologist, too, may find that this information will throw new light on the various biological aspects of his studies, such as those on productivity.

#### Acknowledgments

The writer again wishes to express appreciation to Dr. A. S. Hazzard, Director of the Institute for Fisheries Research, for assistance in planning this work, and to Dr. George R. La Rue, Director of the Biological Station, for suggestions and equipment. As in former years, I owe a great debt to Dr. Carl L. Hubbs for guidance in this investigation and help in the preparation of the

report. Thanks to the officials of the Michigan State Civilian Conservation Corps, labor was again furnished by selected enrollees.

#### Methods of Marking Fish

1. FIN CLIPPING.— The pelvic fins and pectoral fins were clipped on certain fish. Removing different fins made it possible to distinctively designate the fish of different locations. Regeneration of the clipped fins was prevented by removing them at the base with a pair of curved manicure scissors.

2. JAW TAGGING.— Numbered metal jaw tags (Shetter, 1936) were placed on the mandible maxillary or premaxillary. This method permits the tracing of the movements of individual fish.

3. SILVER WIRE.— Fine silver wire was twisted around the right or left mandible of a limited number of fish. The specimen was grasped in the left hand and held against the body. After a piece of fine silver wire, cut to the proper length, had been inserted around the mandible, the ends were securely held, close to the fish's jaw, by the thumb and forefinger of the left hand, so that a loose loop was formed as the ends were twisted together by tagging pliers in the right hand. The ends were then bent back against the twisted part of the wire to prevent catching on the net or other objects.

Rock bass (Ambloplites rupestris), pumpkinseeds (Lepomis gibbosus) and yellow perch (Perca flavescens) were marked by all three methods. Small-mouthed bass (Micropterus d. dolomieu) and large-mouthed bass (Huro salmoides) were fin-clipped in 1937 and tagged with metal jaw tags in 1938 and 1939. Northern pike (Esox lucius) were tagged with metal jaw tags.

### Methods Used to Recapture Marked Fish

Several different methods were used to get returns on marked fish in Douglas Lake:

1. A 140-foot bag seine, made of  $\frac{1}{4}$ -inch mesh in the bag, of  $\frac{3}{8}$ -inch mesh next to the bag and of  $\frac{7}{8}$ -inch mesh at the ends of the wings, was used for all seining. For deep shelters and weed beds a piece of net 6 x 80 feet was attached to the top of the center section of the seine to permit effective work in deeper water.
2. Posters were placed around the lake at the various resort centers asking fishermen to report any marked fish.
3. Two fyke nets, the property of the Biological Station, were used to catch fish on several drop-offs away from shore.

### Experiments at Grapevine Point

In 1937 ten experimental fish shelters were built and placed on the shoal of Douglas Lake between Grapevine Point and the University of Michigan Biological Station boat house (See Fig. 1). A description of the area and of these constructions are given in a former paper (Rodeheffer, 1939). The first brush pile called shelter 1 was placed just south of the little bay formed by Grapevine Point in about 6 feet of water. All other constructions, located on the six-foot contour were numbered consecutively to the southward. They were set approximately 80 feet apart except where control areas were designated. Here the distance between the installations was about 180 feet. Control areas established between shelters 2 and 3, 4 and 5, 6 and 7, 8 and 9, and south of shelter 10 were sections similar to the locations where fish protections were installed. This arrangement separated shelters 1 and 10 by approximately 1100 feet. The devices were constructed and

placed so they could be removed to determine to what extent they were used by fish and the size and species of game fish found in them. Before the brush piles were removed the 140-foot bag seine was laid around them in the form of a semicircle. When the shelters were pulled shoreward the net was carefully drawn along behind, catching the fish in or near the artificial covers. The captured fish were identified, checked for previous markings, measured and released.

In 1937, to discover if fish used the brush devices as a summer habitat, the pelvic fins were clipped on all game fish before they were freed. On August 2, 4, and 6, the right pelvic fin was removed on all captured game fish. The left pelvic fin was clipped on the fish seined on August 23, 24, and 25. Fish that were recaptured on August 2, 4, and 6 were recorded as marked, then returned to the lake. When any fish with the right pelvic fin missing was retaken on August 23, 24, and 25, the left pelvic was also excised. Fish caught with both pelvic fins clipped were so recorded and set free. Table 1 presents the data of the species and numbers of fish with one or both pelvic fins removed. In 1938 the same shelters were again pulled from the water and the fish counted, identified, checked for markings, and measured. On July 12 and 13 shelters 1, 2, and 10 were taken out and all game fish of sufficient size were tagged with metal jaw tags. Thirty-eight small-mouthed bass taken from all ten shelters and in four control areas between July 12 to August 26 were tagged.

To economize on time and tags in 1938, it was decided to clip the pectoral fins on all game fish except small-mouthed bass, large-mouthed bass, and northern pike, at shelters 1, 4, and 10 at Grapevine Point. Following July 13, all rock bass, yellow perch, and pumpkinseeds taken in the net, had the right pectoral fin removed at shelter 1, the left



pectoral at shelter 10 and both pectorals at shelter 4. All fish tagged or fin-clipped in 1938 were returned to the water at the shelter after it had been replaced. The number and species of fish marked by the different methods in 1938 are given in Table 1.

In 1939 all bass and northern pike were again tagged. On shelter 1 the right mandible of rock bass, yellow perch, and pumpkinseeds of sufficient size was marked with silver wire. Fish from shelter 10 were wired on the left mandible. At shelter 4 all fish were tagged with metal jaw tags. Table 1 also details the number and species of fish marked in 1939.

#### Recaptures of Marked Fish at Grapevine Point

Marking the fish caught at Grapevine Point made it possible to keep a record of the number of fish that were recaptured in 1937, 1938, and 1939. Fish were retaken

1. With pelvic fins missing: fish marked in 1937,
2. With metal jaw tags or pectoral fins clipped: fish marked 1938,
3. With metal jaw tags or wired jaws: fish marked in 1939.

Table 1 gives the percentage of the fish recaptured each year, according to the different marking devices. The percentage of recovery for fin clipped and wired fish has probably been increased by reason of the fact that some fish were netted more than once. For the tagged fish, which were marked so as to be individually identified, it was found that of the fish tagged in 1938 at Grapevine Point, one rock bass was retaken twice, two perch were recaptured twice, the one sunfish and the one northern pike were both taken a second time, and five of the small-mouthed bass were twice recovered, in 1938. Of the rock bass

TABLE I

NUMBER OF FISH BY SPECIES THAT WERE MARKED BY DIFFERENT MARKING METHODS AT GRAPEVINE POINT, DOUGLAS LAKE, MICHIGAN, AND PERCENTAGE RETAKEN (ALL AT GRAPEVINE POINT), IN 1937, 1938, AND 1939

The percentage figures on recoveries are based on all fish recaptured, whether retaken once or more than once, because many of the fish were not marked so as to be individually recognizable, and because the recaptured fish were released alive.

Item	Rock Bass	Yellow Perch	Pumpkin-seeds	Small-mouthed Bass	Large-mouthed Bass	Northern Pike	All Species
Number marked August 2 to 25, 1937 by clipping one or both pelvic fins	1320	663	262	210	22	...	2477
Recoveries in 1937	38.5%	16.9%	21.8%	13.3%	4.5%	...	28.5%
Recoveries in 1938	13.4%	3.3%	1.5%	...	...	...	8.2%
Recoveries in 1939	4.4%	0.3%	...	...	...	...	2.4%
Number marked July 12 to August 26, 1938 by clipping one or both pectoral fins	582	566	95	...	...	...	1243
Recoveries 1938	15.3%	13.3%	6.3%	...	...	...	13.7%
Recoveries 1939	16.2%	2.7%	1.1%	...	...	...	8.9%
Number marked July 12 to August 26, 1938 with numbered jaw tags	185	137	17	38	...	1	378
Recoveries in 1938	13.0%	13.1%	11.8%	47.4%	...	200.0%	16.9%
Recoveries in 1939	3.8%	...	...	...	...	...	1.9%
Number marked July 24 to August 16, 1939 by silver wire	134	76	34	...	...	...	244
Recoveries in 1939	42.5%	5.3%	2.9%	...	...	...	25.4%
Number marked July 11 to August 16, 1939 with numbered jaw tags	71	66	51	20	6	1	215
Recoveries in 1939	50.7%	3.0%	5.9%	30.0%	33.0%	...	22.8%
Total number marked by all methods 1937, 1938, and 1939	2292	1508	459	268	28	2	4557
Recoveries in same year	31.2%	14.0%	15.0%	19.4%	10.7%	100%	23.1%
Recoveries in second year <sup>✓</sup>	13.3%	2.8%	1.3%	...	...	...	7.8%
Recoveries in third year <sup>✓</sup>	4.4%	0.3%	...	...	...	...	2.4%

<sup>✓</sup>In percentage of marked fish then potentially available for recapture.

tagged in 1938, three were again secured in 1939 and one of these was recorded five times. Of the fish individually tagged in 1939, six rock bass were recovered twice and five were caught thrice. None of the fish of the other species tagged were re-seined more than once at Grapevine Point. In 1937 and 1939 a high percentage of retakes is indicated of the fish that were tagged the same year. Table 1 shows a declining number taken in 1938 and 1939 of those marked in 1937. A smaller percentage of the fish tagged in 1938 was retaken in 1938, with an unexplained increase in 1939 in the number of rock bass recaptured. There is also some difference in the percentage of re-netted fish that were tagged and fin-clipped and marked with silver wire. The number of returns by each marking method is, however, probably too small to warrant any conclusions as to which procedure may be the most satisfactory.

#### The Movements of Fish at Grapevine Point

Tagging and fin-clipping in 1938 and 1939 at Grapevine Point made it possible to trace the movements of fish between shelters during the two summers. Table II specifies, for fish which were retaken, how far they had wandered from the point of original capture (or from the point of last capture, for the fish tagged for individual recognition) during the first and second year. It thus includes records for fish which are known to have been netted a number of times. An exaggerated amount of traveling may be indicated since it is possible that some fish not individually marked swam to another shelter, making that cover a permanent habitat at which they may have been taken several times. For each such recapture the motion would be recorded as from the shelter where the fish had first been marked and released.

The maximum number (5) of changes noted for a single fish were made by a rock bass which was tagged at shelter 2 on July 13, 1938 although it was not re-seined in 1938. In 1939 it was caught at shelter 2 on July 19 (and therefore recorded as not having traveled). On July 28 it was taken on shelter 4, an indicated travel of 260 feet. On August 2 the same fish was recovered at shelter 2, so that the same distance was listed. On August 4 it was seined at shelter 4, after another known shift of 260 feet. On August 16 the fish was again caught at shelter 1 (a recorded dispersal of 340 feet). The sum of the known movements of this rock bass was 1120 feet, but all of the back and forth roaming so far as known was within a distance of 340 feet.

Table II indicates that the meanderings of fish are quite limited within a given area. The larger number of fish were found to remain near the place of original capture. Rock bass show the greatest tendency to stay at (or to return to) the same refuge the second year. Yellow perch, usually considered a free swimming fish seem to live near the shelter where first captured, the first year. The few retaken in the area the second summer may merely indicate random swimming. Small-mouthed bass, although marked in small numbers, showed restricted travel in one season with no indications of a return to the same region the second year. Pumpkinseeds, large-mouthed bass, and northern pike were so few in number that conclusions regarding their wanderings are not warranted. It is most striking that not a single fish of the 4557 marked at Grapevine Point from 1937 to 1939 was recovered at any other point in the lake. Returns from sportsmen fishing in other parts of Douglas Lake might not have been expected, as there is little angling here for pan fish, but a large amount of collecting was done around the eastern part

TABLE II

MOVEMENTS OF MARKED GAME FISHES AT GRAPEVINE POINT, DOUGLAS LAKE, MICHIGAN, AS DETERMINED BY THE DISTANCE IN FEET BETWEEN POINTS OF CAPTURE AND OF RECAPTURE

For fish not individually marked it was necessary to assume that the movement was always from the point of original capture and marking. This circumstance may have exaggerated the indicated amount of wandering.

Species, Year of Recaptures (and Number of Records)	Known Distance Traveled in Feet								
	0	80	170	260	340	430 or 520	600 or 690	780 or 860	1040 or 1120
<b>Rock Bass</b>									
First year (206)	105	30	1	10	27	13	7	12	1
Second year (101)	46	14	...	10	10	10	1	3	7
<b>Perch</b>									
First year (98)	39	52	7	3	6	1	4	2	4
Second year (15)	13	2	...	...	...	...	...	...	...
<b>Pumpkinseed</b>									
First year (12)	1	4	1	2	2	2	...	...	...
Second year (1)	...	...	...	1	...	...	...	...	...
<b>Small-mouthed Bass</b>									
First year (24)	4	9	4	2	3	2	...	...	...
Second year (...)	...	...	...	...	...	...	...	...	...
<b>Large-mouthed Bass</b>									
First year (2)	...	2	...	...	...	...	...	...	...
Second year (...)	...	...	...	...	...	...	...	...	...
<b>Northern Pike</b>									
First year (2)	2	...	...	...	...	...	...	...	...
Second year (...)	...	...	...	...	...	...	...	...	...
<b>All Species</b>									
First year (344)	151	77	13	17	38	18	11	14	5
Second year (117)	59	16	0	11	10	10	1	3	7

of the lake not only by the writer but also by other workers at the Biological Station, all of whom were looking for the marked fish. At Grapevine Point 1051 recaptures were recorded during the year of marking, 320 during the following year, and 60 during the third year. It can only be guessed what happened to the marked fish that were never re-netted. The rate of mortality among marked fish is not known but only 7 marked rock bass and 3 marked perch were found dead during the three years despite the fact that the beach around South Fishtail Bay was repeatedly traversed during all three summers. In 1939 a daily check was made of the entire shore from Grapevine Point to Pine Point (Fig. 1).

No doubt many fish including perhaps some which had been marked were eaten by gulls.

#### Experiments at North Fishtail Bay

To gather more information regarding the movements of fish, four additional brush shelters were constructed and placed in Douglas Lake just north of Hook Point in North Fishtail Bay in July of 1938 (Rodeheffer, 1940). These shelters were removed and the fish caught at intervals between August 3 and 22, 1938, and between July 20 and August 9, 1939. To determine how rapidly and to what extent such shelters become repopulated, all fish netted from these structures were carried a straight line distance of about 0.6 mile across North Fishtail Bay, to be released in the small sheltered cove which lies to the east of East Point (Fig. 1). All game fish of sufficient size were tagged with metal jaw tags before being set free to see if any would return to the artificial covers. These operations also provided

a further means of checking on the movements of fish marked at Grapevine Point and of those liberated at East Point. There were few returns from the fish that were tagged at Hook Point and put back into the water at East Point, but the few taken at various locations (as specified in Table III) suggest that these fish reacted similarly to planted fish, in moving around somewhat at random. The fact that most of the recoveries were of rock bass, from the shelters at Hook Point, may be explained by the preference of rock bass for brush shelters (Rodeheffer, 1938, 1939). As indicating the limited natural movements of fish in the lake, it may be again pointed out that nineteen seine hauls in 1938 and ten hauls in 1939 with a 140-foot seine from shelters and control areas at Hook Point failed to capture any of the 4557 marked fish released at Grapevine Point in 1937, 1938, and 1939.

The return of fish from East Point to Hook Point might be regarded as evidence of homing behavior, but no such conclusion is warranted by the facts at hand. Hook Point forms a natural trap and was a favorable and well-populated fish habitat even before the brush shelters were installed.

#### Other Attempted Recoveries

Investigations in 1937 and 1938 showed a limited movement of fish in Douglas Lake. In attempting to determine how restricted the wandering is (and also to discover if fish of different sizes inhabit shelters at different depths), two ladder-shaped shelters (Hubbs and Eschmeyer, 1939: 74-80, figs. 16-19) were made and placed in 5 feet of water, and two at a depth of 10 feet. These were installed in 1939, just east of Sedge Point, at a location distant in a straight line

TABLE III

KNOWN MOVEMENTS OF FISH CAPTURED AND TAGGED AT HOOK POINT, DOUGLAS LAKE, MICHIGAN  
AND RELEASED AT EAST POINT (SEE MAP, FIG. 1)

Recoveries are indicated for the several points in Douglas Lake where collections were made in the given year.

Item	Rock Bass	Yellow Perch	Pumpkin-seeds	Small-mouthed Bass	Large-mouthed Bass	Northern Pike	All Species
Number tagged in 1938	206	160	70	20	6	3	465
Recoveries in 1938							
Hook Point	16	3	0	1	0	0	20
Grapevine Point	0	0	0	0	0	0	0
Pine Point	1	0	0	0	0	0	1
Recoveries in 1939							
Hook Point	10	1	0	0	0	0	11
Sedge Point	0	0	0	0	0	0	0
Pine Point	0	0	0	0	0	0	0
South drop-off, Big Shoal	0	0	0	0	0	0	0
East drop-off, South Fishtail Bay	0	0	0	0	0	0	0
Grapevine Point	1	0	0	0	0	0	1
Number tagged in 1939	115	98	74	9	6	2	303
Recoveries in 1939							
Hook Point	4	1	1	0	0	0	6
Sedge Point	2	0	0	0	0	0	2
Pine Point	0	0	0	1	0	0	1
South drop-off, Big Shoal	0	0	0	0	0	0	0
East drop-off South Fishtail Bay	0	0	0	0	0	0	0
Grapevine Point	0	0	0	0	0	0	0
Total number tagged in 1938 and 1939	320	258	144	29	11	5	768
Total number recaptured in 1938 and 1939	34	5	1	2	0	0	42



approximately 0.6 mile from the shelters at Hook Point and about 1 mile from the Grapevine Point constructions. These new shelters were removed 20 times, control areas were seined 5 times and weed beds west of the shelters were seined 9 times, between July 25 and August 17, 1939. For the shelters at a 10-foot depth and the weed beds, a 6 x 80-foot section of seine was fastened to the top of the middle section of the 140-foot seine used in all seining operations. At Sedge Point 12 large rock bass were tagged, of which 4 were retaken, 15 small-mouthed bass were tagged and 7 of these were re-netted, 7 large-mouthed bass and 6 northern pike were taken from the weed beds along the drop-off just west of the shelter. Four of the large-mouthed bass and 1 pike were recaptured in the same weed beds. None of the fish tagged at Sedge Point were seined again at any other location, nor were any of the fish marked at Grapevine Point caught at Sedge Point. Of the fish set free at East Point only two rock bass were recovered at Sedge Point (one was taken a second time).

The weed beds along the drop-off where the Big Shoal and the deep water of South Fishtail Bay meet (see map, Fig. 1) was chosen as another spot for the attempted recapture of some of the marked fish. This area lies in a straight line distance roughly 0.5 mile from the Grapevine Point shelters, about 1.2 miles from the Sedge Point seining grounds and about 1.5 miles from the Hook Point installations. Four seine hauls with the 140-foot bag seine, to which the 6 x 80-foot section of seine had been fastened, did not take any marked fish, although a total of 549 of the species marked in Douglas Lake were caught.

In a further effort to secure marked fish, fyke nets were set in several places, as specified below, between July 28 and August 17, 1939.

Twelve small-mouthed bass caught in the fyke nets were tagged and let go. One of these bass, tagged and liberated about 200 feet east of the Point of the Big Shoal, was later recaptured in a fyke net about 0.2 mile further east along the south drop-off of the Big Shoal. A small-mouthed bass released at East Point was later found in a fyke net at Pine Point. Eight large rock bass and eleven large pumpkin-seeds were tagged and returned to the lake at the fyke net settings, but none of these were retaken. No other marked fish were taken in the fyke nets.

#### The Movements of Planted Small-Mouthed Bass in Douglas Lake

On June 27, July 13 and 24, 1939, a total of 271 small-mouthed bass of almost the legal size of 10 inches or larger, were received from Lake Michigan and released at the boat dock of the Biological Station, after they had been measured and weighed and scale samples had been taken. The shore from Grapevine Point to Pine Point was checked every morning for dead fish (8.5 per cent of the planted bass were found dead during the first 9 days after planting). Posters were placed at the various resorts on the lake asking fishermen to report any tagged fish caught. Three per cent of the planted fish were recaptured with nets and 6.3 per cent were caught and reported by fishermen between July 16 and September 1, 1939. The 8 fish recovered with nets were all taken around the shelters at Grapevine Point. The 17 small-mouths taken with hook and line were found in different parts of the lake, as indicated by the numbers enclosed in small circles on the map (Fig. 1). Two fish were hooked at the tip of Fairy Island, 1 in the bay near Bryant's, 1 at Stony Point, 3 at Pine Point, 2 along the south side of the Big Shoal, 1 on the drop-off

of the depression in South Fishtail Bay, approximately 0.4 mile east of the Biological Station, and 7 in the weed beds on the drop-off at the Biological Station boathouse. The number of planted small-mouthed bass retaken is too small to justify very definite conclusions, but even this limited information seems to indicate that planted fish do more roaming than the native fish.

#### Discussion and Summary

The results of three summers' work at Douglas Lake quite definitely indicate that there is little movement of the native game fish from one part of the lake to another. Of all the fish marked at several locations in Douglas Lake and loosed at the point of capture none were retaken in distant parts of the lake. Recaptures were made only in the near vicinity of original capture and release.

Many game fish (4557) were marked for three consecutive years at Grapevine Point but none were caught again at any other location. Seining operations were performed at several places, located 0.5 of a mile to 1.5 miles in a straight line from Grapevine Point. A limited number (40) of fish were tagged and freed at Sedge Point in 1939. All recoveries (16) of these marked fish were made in the vicinity of Sedge Point.

Fyke net settings, the nearest of which was only about 800 feet from the Grapevine Point shelters on the south drop-off of the Big Shoal did not take any marked fish from Grapevine Point. Weed bed seining along the southeast shore of South Fishtail bay failed to bring in any marked fish.

In the work at Hook Point in 1938 and 1939 no marked fish were netted from any other place of release, except a few fish which had been caught at Hook Point but liberated near East Point.

In 1938 and 1939 posters were placed around Douglas Lake asking fishermen to report the catching of any marked fish. Only two rock bass were reported, both of which were tagged in 1938 at Hook Point and released at East Point. One was caught at Pine Point in 1938 the other was secured at the shelters at Hook Point in July, 1939. The paucity of these returns may be explained in part by the fact that little fishing is done for rock bass, yellow perch or pumpkinseeds in Douglas Lake.

This evidence brings out rather conclusively the fact that there is little movement of marked native fish in the eastern end of Douglas Lake when such fish are released at the point of first capture. They do not seem to migrate to new locations that offer similar habitats. One factor that may tend to inhibit such dissemination is the fact that the Big Shoal almost separates North Fishtail Bay from South Fishtail Bay. The water over the greater part of the Big Shoal is shallow (5 feet or less in depth) and almost devoid of cover; and the shoal is surrounded on 3 sides by deep water with rather steep drop-offs which may tend to retard fish from swimming across the wide, open shoal. The deep waters of the lake may also act as barriers to the free dispersion of fish.

Recaptures of the marked fish at Grapevine Point indicate a restricted movement even within a short distance along one shore. The evidence that fish wander little in Douglas Lake is in line with the fact that the fishing boats congregate in certain favored spots, which are known to the local guides who make a business of taking sportsmen to good fishing grounds. Some locations are known as bass fishing grounds, others as pike grounds. Indications are that fish

congregate in these particular places year after year since these guides use them every season. They are very particular to get on the exact spot, for they claim that a difference of a few boat lengths will affect the fishing. Of course the abundance of fish on certain fishing grounds may be due more to the attractiveness of the habitat to the fish than to their restricted movements.

That the fish populations are localized in Douglas Lake is supported by observations made in 1921 by Dr. Carl L. Hubbs and Dr. Charles W. Creaser, who found evidence that the perch in the northwestern part of the lake are of the type occurring in Bessy Creek and Lancaster Lake of which it is the outlet, rather than the type occupying other parts of Douglas Lake (personal communication). Investigations by Dr. Frank E. Eggleton present further evidence that there are distinct perch populations in Douglas Lake (personal communication).

There is other evidence that Douglas Lake is not a simple unit. Limnological investigations (Welch, 1927, and Welch and Eggleton, 1932 and 1935) disclose that the six major submerged depressions in the main basin of Douglas Lake act as independent lakes, each with its own physical, chemical and biological characteristics.

The capture at Sedge Point, Grapevine Point and Pine Point of fish that had been seined at Hook Point and returned to the water at East Point suggests the deduction that native fish which are taken from the place of capture and planted in another part of a lake do move from the point of release to other places in the lake.

Recoveries at numerous points in Douglas Lake of planted small-mouthed bass indicate that such fish wander more than native fish. The stocked bass seem to move around in the lake almost at random but apparently seek some shelter, since all recaptures were made either at the brush constructions or in weed beds.

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