

Original: Fish Division
cc: Education - Game
Mr. H. Carlson
Institute for Fisheries
Research
Dr. P. H. Eschmeyer
Mr. J. T. Wilkinson

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

ALBERT S. HAZZARD, PH.D.
DIRECTOR

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ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

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A REVIEW OF PIKEPERCH TAGGING EXPERIMENTS IN MICHIGAN,
WITH PARTICULAR REFERENCE TO STUDIES ON THE MUSKEGON RIVER

By

Paul H. Eschmeyer

Studies involving the marking of yellow pikeperch in Michigan waters are discussed in the following Institute for Fisheries Research reports: No. 195, "Results of tagging experiments on Muskegon River, 1932" by Carl L. Hubbs; No. 439, "Contributions to the natural history of some game fishes of Michigan, particularly the brook trout, Salvelinus f. fontinalis (Mitchill), as determined by tagging experiments" by David S. Shetter; No. 1142, "Observations on certain waters of the Muskegon River drainage with particular reference to the annual transfer of adult yellow pikeperch to these waters from the river below Newaygo Dam" by the writer; and No. 1210, "Reproduction and migration of yellow pikeperch in Michigan" by the writer. In addition, W. F. Carbine and V. C. Applegate published (1946) a report on recaptures of pikeperch tagged in Houghton Lake.

The purpose of the present paper is to summarize briefly the results of these and other studies involving the tagging of pikeperch in Michigan; to present data concerning the contribution of introduced pikeperch to the catch in the Muskegon River impoundments, as determined by tagging studies;

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and to record certain observations concerning the effect of jaw tags on condition and growth rate of pikeperch. This report is in large part a continuation of I.F.R. Report No. 1142 and part 2 of No. 1210, to which the reader is referred for an introduction to the problems here discussed.

Muskegon River Tagging Experiments

Each year for the past 26 years varying numbers (usually thousands) of pikeperch running up the Muskegon River on their spawning migration from Lake Michigan have been captured in dipnets below Newaygo Dam and transferred to upstream impoundments and to certain other waters of the drainage. This annual conveyance of fish around the dam is known as the "Newaygo transfer."

During the 1932 Newaygo transfer, 172 pikeperch were tagged in the gill covers before being released in upstream areas. There were 3 returns (1.7 percent).

In 1947 and 1948 more extensive tagging operations were undertaken. During each of these years 1,375 jaw-tagged pikeperch were distributed among the five major upstream impoundments. (These are, in ascending sequence: Newaygo, Croton, Hardy, Rogers and Big Rapids.) The results have been discussed in detail in I.F.R. Report No. 1210, and are here summarized (to March 15, 1949) in Table 1.

During the first year following tagging, there was a return of 15.7 percent from the fish tagged in 1947 and a return of 17.7 percent (to March 15, 1949) from fish tagged in 1948. The additional return during the second fishing season from the fish tagged in 1947 was only 1.3 percent. This low return may be due to a high rate of mortality of the fish introduced into the impoundments or to an extensive loss of tags from marked fish. The latter

Table 1.--Summary of recoveries of tagged yellow pikeperch, Muskegon River, 1947 and 1948.

Impoundment where released	Number released April, 1947	Percentage recovered (to April 15, 1948)	Percentage recovered (April 16, 1948, to March 15, 1949)	Total recovery (percent)	Number released April, 1948	Percentage recovered (to March 15, 1949)
Newaygo	150	12.0	2.7	14.7	300	10.3
Croton	501	16.0	2.2	18.2	300	22.3
Hardy	200	26.5	1.0	27.5	300	24.7
Rogers	500	12.0	0.2	12.2	275	13.8
Big Rapids	24	20.8	0.0	20.8	200	16.5
Totals	1,375	15.7	1.3	17.0	1,375	17.7

possibility is considered unlikely. It is of interest to note (Table 1) that the percentage of returns from each impoundment during the second year after tagging is inversely proportional to the distance of the reservoir from Lake Michigan (which is clearly the source of most fish ascending the Muskegon River). In view of the proclivity of pikeperch to return downstream through the power dams (see I.F.R. Report No. 1210), one may suspect that the hazards to survival increase with the number of dams which must be passed to reach the original habitat.

During the 23-month study in the Muskegon River, downstream movement through dams was demonstrated by recovery of 61 tagged fish which survived passage through Newaygo Dam and 28 which negotiated Croton Dam. Seventeen passed down through Hardy Dam, 88 through Rogers, and 38 through Big Rapids Dam. Pikeperch which passed through more than one dam between the time of release and re-capture were as follows: Big Rapids and Rogers, 12; Big Rapids, Rogers and Hardy, 1; Rogers and Hardy, 6; Hardy, Croton and Newaygo, 2; and Croton and Newaygo, 21.

Of 100 pikeperch stocked in the small impoundment above Morley Dam in the Little Muskegon River on April 13, 1948, 12 were recovered near the place of release and 1 was recaptured above Croton Dam, after passing through Morley Dam and moving 21 miles downstream.

Of particular interest among the returns from the Muskegon River is a report recently received of the recovery of two tagged pikeperch in early June, 1948, near Porter Beach, Indiana, in Lake Michigan. One of these had been released just below Croton Dam on April 14, 1947, and had passed through Newaygo Dam and traveled a minimum distance of 163 miles to reach

the point of capture. The other was tagged in Muskegon Lake on March 30, 1948. It had moved about 114 miles to reach the point where recaptured.

Of 31 recoveries (10.4 percent) from 292 tagged pikeperch released below Newaygo Dam in 1948, 7 were taken in various portions of the river, 4 were caught in Muskegon Lake, 12 were trapped by commercial fishermen in Lake Michigan within a two-mile radius of Muskegon, and the remainder had moved to other areas in Lake Michigan. These returns, compared with returns from the impoundments, indicate a substantially higher percentage of return to the angler's creel (during the first year after tagging) from fish transferred to upstream impoundments than from fish which are not transferred. Returns during future years from the two groups of fish (transferred and not transferred) will be observed with interest, however. It seems likely that fish not exposed to the hazards of (1) removal from their native habitat, (2) transfer by tank truck to upstream areas, and (3) downstream migration through power dams, would contribute to the angler's catch in larger numbers and over a longer period of time than fish which are exposed to such hazards.

It is of interest to note that over 64 percent of the recoveries from tagged fish released below Newaygo Dam were from Lake Michigan. The number of recoveries from this water is somewhat unusual when viewed in the light of returns from tagged pikeperch released in other Great Lakes waters. Doan (1942) obtained a return of only 1.8 percent from 1,248 pikeperch tagged in Lake Erie, and there was a 2.0 percent return from 198 pikeperch tagged in Saginaw Bay by the Institute for Fisheries Research in 1942.

The effect of the Newaygo transfer on the sport fishery in the Muskegon River impoundments, in the river below Newaygo Dam, and in

Muskegon Lake is a matter of vital concern to many anglers. Certain aspects of the problem, together with a description of the waters concerned, are presented in I.F.R. Report No. 1142. Further observations having a bearing on the problem were made in 1948.

For the period extending from May 1 to September 30, 1948, a creel census was conducted on the Muskegon River and Muskegon Lake. In addition to securing information on species composition of the catch and quality of fishing, an objective of the census was to determine what percentage of the catch of pikeperch in the Muskegon impoundments was contributed by transferred fish. During the census period the creel census clerk¹ spent two days each week at Muskegon Lake, one at Newayge Pond and the sections of stream immediately below it (in Newaygo County), one at Croton Pond, one at Hardy Pond, and one day each week divided between Rogers and Big Rapids ponds. The work schedule was arranged to distribute the census days at each water about equally among the seven days of the week, during the five-month period of the census. For each water (except Muskegon Lake) a work day extending from 7:00 a.m. to 4:00 p.m. was alternated with one extending from 11:00 a.m. until 8:00 p.m., so that both morning and evening fishing might be about equally represented.

The results of the creel census² in the impoundments are brought together in Table 2. The census obtained by the creel census clerk is separated from that compiled from reports turned in by 21 volunteers (boat liverymen, guides and interested anglers) who cooperated in the project.

¹/ Floyd Simonis of the Institute staff.
²/ Compiled by Howard Loeb of the Institute staff.

Table 2.--Summary of an intensive creel census on the impoundments of the Muskegon River, May 1 to September 30, 1948.

Impoundment	Number of anglers	Percentage of anglers unsuccessful	Number of fishing hours	Number of fish caught	Catch per hour	Northern pike	Brook, brown, rainbow trout	Yellow perch	Yellow pikeperch			Small-mouth bass	Large-mouth bass	Pumpkin-seed	Blue-gill	Rock bass	Black crappie	Bull-head	Catfish	Sucker	Carp	
									Native	Transferred	Under-sized ¹											
<u>Census by creel census clerk:</u>																						
Newaygo	89	75.3	273.5	38	0.14	3	...	8	6	1	...	14	4	...	...	4	3	2	...	7	...
Croton	319	58.0	1,128.0	342	0.30	9	2	176	86	7	9	56	10	...	...	1	25	2	...	15	...
Hardy	214	76.2	759.5	106	0.14	3	...	28	51	5	3	47	6	...	...	6	...	...	...	4	...
Rogers	133	84.2	430.5	38	0.09	2	...	3	9	4	3	...	...	...	8	6	3	...	...	...	...
Big Rapids	17	64.7	35.0	19	0.54	3	...	1	...	...	...	...	9	...	...	...	...	...	...	6	...
Total	772	69.7	2,626.5	543	0.21	20	2	216	152	17	15	117	29	...	8	1	41	8	2	...	32	...
<u>Census by boat liverymen and others:</u>																						
Newaygo	231	34.6	1,904.5	331	0.17	2	96 ²	39		Native and transferred 146	1	62	46	1
Croton	749	35.1	4,316.5	2,334	0.54	65	1	1,587	210	28	65	28	3	13	16	366	10	1	5	1	...	
Hardy	655	43.4	3,896.5	1,106	0.28	9	1	415	573	16	119	58	1	...	1	28	3	...	...	...	1
Rogers	120	53.3	544.5	116	0.21	8	9	35	14	10	11	3	...	16	5	1	5	6	1	3	...	
Total	1,755	39.4	10,662.0	3,887	0.36	84	107	2,076	943	55	257	135	5	29	22	395	18	7	6	4	1	
Grand total	2,527	48.6	13,288.5	4,430	0.33	104	109	2,292	1,110	72	374	164	5	37	23	436	26	9	6	36	1	

¹ Not included in calculation of catch per hour.
² Fifty-two rainbow trout, 44 brown trout.

Significant to the pikeperch problem in the impoundments is the fact that 34 percent of the total catch recorded by the creel census clerk (26 percent in the combined census) consisted of yellow pikeperch. This highly important contribution to the catch is exceeded in numbers (but probably not in weight) only by the yellow perch.

It is of further interest to note that 9.2 percent of the fish examined by the creel census clerk were tagged, and an additional 8.2 percent were recognizable as fish which had been transferred (recognition of transferred fish, by observing frayed caudal and dorsal fins, is discussed below). Judging by this sample, 17 percent of the fish caught were introduced during the Newayge transfer, whereas the remainder (83 percent) were native fish.

A total of 55 (5.5 percent) of the 998 pikeperch reported in the volunteer census was tagged. Since untagged transferred fish are not readily recognized by untrained observers, no separation of these was made by the volunteer clerks. In 1948, 3,565 pikeperch were transferred to the impoundments and 1,375 (38.6 percent) of these were tagged. One may thus multiply the number of tagged fish reported in the volunteer census (55) by the factor 2.6 to determine the approximate number of transferred fish which were included among the pikeperch reported in the census. This indicates that about 143 (14.3 percent) of the pikeperch reported in the volunteer census were transferred fish, if it is assumed that tagged and untagged fish are equally vulnerable to a baited hook. (This was not shown in figures based on the census clerk's reports. He found 17 tagged fish among 32 transferred fish encountered. Judging by the factor given, 2.6,

there should have been as many as 27 untagged transferred fish among those examined by him.)

It should be noted that the movement of some tagged fish out of the impoundments during the fishing season does not invalidate the above computation. It may be safely assumed that proportional numbers of untagged transferred fish also moved through the dams, so that the percentage of tagged fish in the catch should continue to be representative of the contribution of transferred fish to the impoundment fisheries.

It is clear, from the above data, that between 80 and 85 percent of the pikeperch caught in the Muskegon River impoundments between May 1 and September 30, 1948, were native fish.

From the reports submitted by the creel census clerk one may estimate roughly the total catch of pikeperch in the Muskegon impoundments during the year. From all sources, 219 tagged fish were reported caught by anglers in the impoundments during the 1948 season. Of these, the creel census clerk found 17 during the course of his regular census, or, in other words, may have censused $\frac{17}{219}$ (7.8 percent) of the year's pikeperch fishing. He reported a total of 184 pikeperch caught; if this constituted 7.6 percent of the total, about 2,350 pikeperch were caught in the impoundments during the summer. The same computation for the volunteer census yields an estimate of about 4,000 pikeperch caught.

The figures shown are based on the assumption that tagged and untagged (transferred and native) fish were caught throughout the year in the same proportion in which they appeared in the summer creel census. It is also based on the assumption that all tagged fish caught were eventually reported by anglers, which is assuredly not true. Unreported tagged fish caught

would reduce the proportion of the fishing covered by the intensive census (as computed above) and thus would increase the estimate of total fish caught. As a result the estimates given are probably strongly conservative.

The summary given in Table 2 reveals that 2,527 anglers were contacted and 13,288 fishing hours were included in the combined census. A total of 4,430 fish was taken at the rate of about one-third fish per hour. The higher catch per hour and the lower percentage of unsuccessful fishermen reported in the volunteer census reveal a commonly observed tendency on the part of anglers to fill out creel census slips only after successful fishing trips.

Yellow perch were taken in the largest numbers, followed by yellow pikeperch. Rock bass and smallmouth bass were commonly taken and northern pike added variety to the catch. Rainbow and brown trout contributed heavily to the catch reported by guides fishing the stretch of stream above Newaygo Reservoir (for convenience creel reports for the unimpounded portions of stream above each reservoir were included with those from the impounded area). Other less important species included pumpkinseeds, black crappies, bluegills and largemouth bass. Some suckers, a few bullheads and catfish, and one carp were reported.

The residence of fishermen using the Muskegon River impoundments during the summer of 1948 is shown in Table 3 (combined census). Seven states and 31 Michigan counties are represented. Besides showing the extensive area from which fishermen are attracted to the Muskegon impoundments, the table indicates the importance of these waters to residents

Table 3.--Residence of fishermen, Muskegon River impoundments,

May 1 to September 30, 1948.

State or county	Number of fishermen
Florida	8
Illinois	66
Indiana	298
Iowa	2
Ohio	265
South Dakota	6
Wisconsin	2
Bay	3
Berrien	45
Branch	6
Calhoun	28
Clinton	3
Eaton	5
Genesee	35
Gratiot	8
Hillsdale	4
Ingham	30
Ionia	45
Iron	6
Isabella	8
Jackson	20
Kalamazoo	38
Kent	827
Lenawee	9
Mecosta	132
Montcalm	10
Muskegon	18
Newaygo	248
Osceola	2
Otsego	3
Ottawa	6
Roscommon	13
Saginaw	20
St. Joseph	16
Washtenaw	6
Wayne	30
Wexford	1
Van Buren	1
Unknown	254
Total	2,527

of Kent County (particularly Grand Rapids). Most outstate residents came from Ohio and Indiana.

Creel census records (combined census) taken in the Muskegon River below Newaygo Dam (in Newaygo County) are summarized in Table 4. Anglers contacted totalled 461. They took 768 legal fish in 3,590 hours of fishing, for an average catch of 0.21 fish per hour. The table reveals the outstanding importance of pikeperch to the fishery here during April and May and the importance of smallmouth bass during July and August. Pikeperch are of relatively little importance in the fishery during other months of the year, although some undersized and small legal-sized fish are taken during the summer months. Perhaps these are fish moving toward Lake Michigan from the upstream impoundments, although this possibility remains as yet unconfirmed.

The residences of outstate fishermen contacted in the Muskegon River below Newaygo Dam were as follows: Indiana, 175; Illinois, 26; Ohio, 14; and Wisconsin, 8. Counties in Michigan which were represented were: Newaygo, 84; Kent, 49; Calhoun, 25; Ottawa, 18; Kalamazoo, 12; Iron, 6; Van Buren, 6; Clinton, Genesee, Muskegon, Jackson and Wayne, 3 each; and Wexford, 1. The residence of 22 anglers was not recorded.

Further study of Table 2 reveals that 39 percent of the pikeperch reported by the creel census clerk were under legal size (14 inches in total length). For the volunteer census (in which sub-legal fish were not always recorded) this percentage was 24. Although these numbers do not appear as excessive as reports of individual anglers might sometimes lead one to believe, the occurrence of unusual numbers of undersized pikeperch in the catch from Muskegon impoundments has been a source of

Table 4.--Summary of intensive creel census, Muskegon River below

Newaygo Dam, Newaygo County, Michigan, 1948.

	April	May	June	July	August	September	Totals
Number of anglers contacted	31	342	6	11	54	17	461
Percentage of fishermen unsuccessful	29.0	23.7	100.0	9.1	38.9	17.6	26.2
Total hours fished	271	2,770	7.5	102	363	76	3,589.5
Total legal fish caught	55	515	...	29	123	46	768
Catch per hour	0.20	0.19	0.0	0.28	0.34	0.61	0.21
Species:							
Brook trout	...	1	...	...	...	...	1
Rainbow trout	2	22	...	3	4	1	32
Brown trout	...	5	...	1	...	...	6
Northern pike	13	1	...	...	1	1	16
Yellow perch	...	2	...	...	10	18	30
Yellow pikeperch	40	459	...	6	13	5	523
(Yellow pikeperch, undersized) ¹ ✓	...	(22)	...	(3)	(17)	(1)	(43)
Sauger	...	11	...	3	18	...	32
Largemouth bass	...	...	...	...	...	2	2
Smallmouth bass	...	2	...	12	72	8	94
Bluegill	...	2	...	...	...	1	3
Rock bass	...	9	...	...	4	7	20
Black crappie	...	...	...	...	...	2	2
Suckers	...	1	...	...	1	1	3

¹✓ Not included in totals.

inquiry and complaint by anglers for at least the past 10 years. This is particularly true of Hardy Reservoir, where 44 percent of the pikeperch reported in the intensive census of 1948 were under 14 inches in length.

In August, 1947, gill nets were set in Hardy Reservoir, in the vicinity of the dam. Forty-four of 58 pikeperch taken (mostly in gill nets with graded mesh) were in the three-year age group and averaged 13.8 inches in length. Only 5 fish from older age groups were taken and the catch showed a striking dominance of undersized fish (Fig. 1). The fish appeared to be in good condition, with moderate amounts of mesenteric fat; the growth rate³ exceeded the tentative state average for the species, indicating that the population is not stunted. Taken together with the persistent reports by fishermen of large numbers of undersized pikeperch being caught, the observed abundance of fish of this size near the dam, and the fact that considerable numbers of large transferred pikeperch pass through the power dams, these data provide grounds for suspicion that native pikeperch may also pass downstream, possibly during about their fourth year of life.

During two periods of the summer of 1948 small trap nets were set in Hardy Pond with a view to capturing a large number of pikeperch for tagging, so that any downstream movement which might occur could be detected. Between May 28 and June 14, 107 native pikeperch were tagged (18 of these were taken with hook and line, but no legal pikeperch were taken during the angling period) and from August 24 to September 6, 186 were taken. Three were taken by fishermen at other times during the summer and tagged by the creel census clerk. In addition 2 were tagged in Croton Pond and 6 in

³ Determined by William C. Beckman of the Institute staff.



Figure 1. Yellow pikeperch and other fish taken in an overnight gill net set in Hardy Pond, August 6 to 7, 1947. Eleven of the pikeperch shown are undersized. Two large fish (upper left) were probably transferred from the river below Newaygo Dam (see text for discussion).

Newaygo Pond. The tagged fish averaged 12.8 inches in length; 76 percent were under legal size.

The rather unusual structure of the pikeperch population in the reservoir, as revealed by the trap netting, is shown in Table 5 and Figure 2, where the size groups and origin of the pikeperch caught are differentiated. Untagged transferred fish were recognized by the marked fraying of the caudal and soft dorsal fins characteristic of fish transferred during the Newaygo transfer. This fraying is illustrated in Figure 3, which shows the fins of a Lake Gogebic fish which had been trap-netted and tagged in May, 1947, and was recaptured in July of that year. It is believed that all fish transferred to the Muskegon impoundments are recognizable to the experienced observer throughout the first fishing season following transfer. The constant opportunity for comparison with tagged fish (caught in the trap nets) which were known to have been transferred, further facilitated recognition of the untagged transferred fish.

The trap net catches show that few native fish exceeded 16 inches in length, and most native fish taken were undersized. All pikeperch of large size (18 inches or more) which were caught had been transferred from the river below Newaygo Dam. Their presence indicates that the nets were taking fish of all sizes (although some fish under 12 inches in length escaped through the mesh of the traps), and that if larger native fish had been present, they should have been taken.

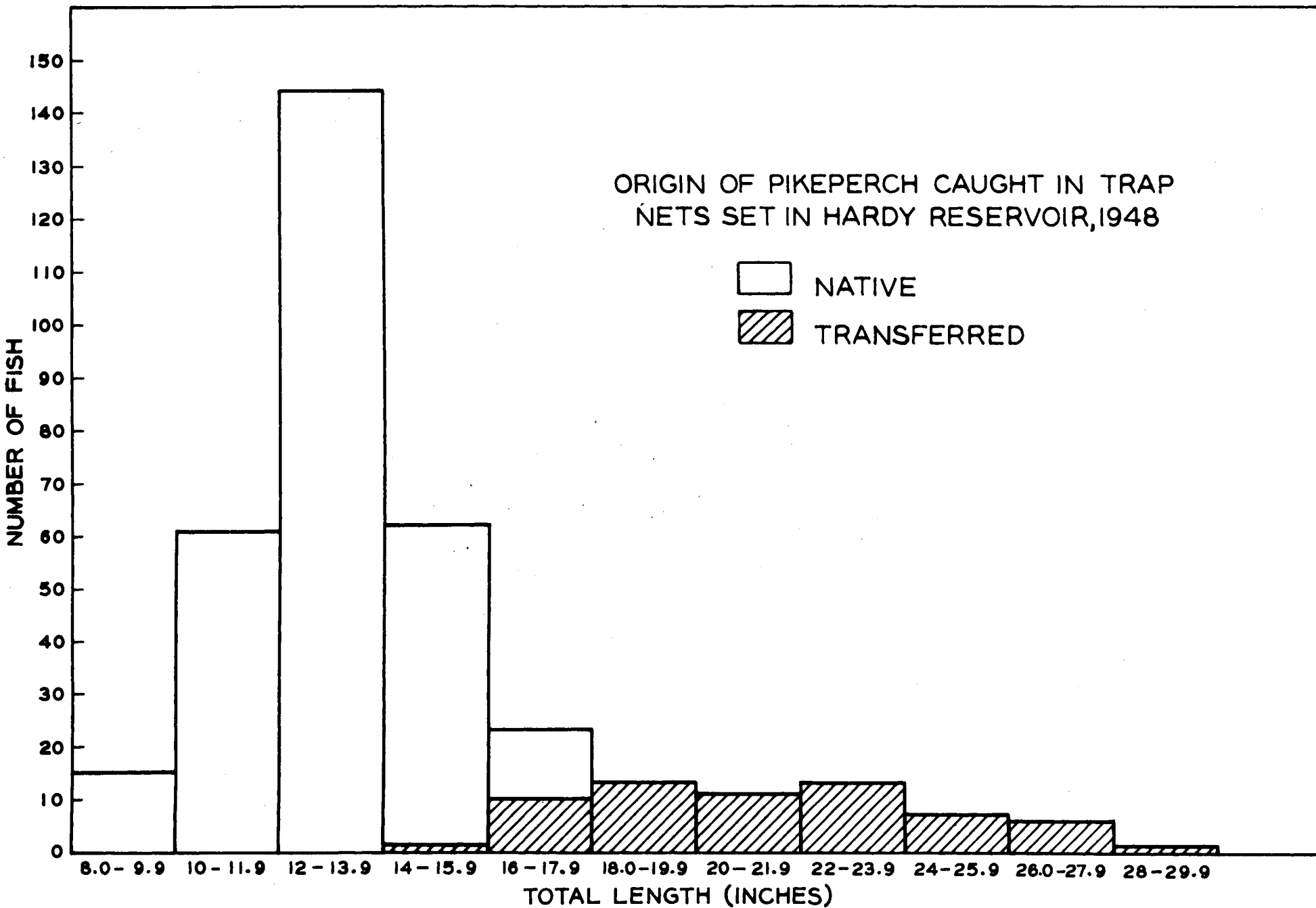
Fifteen two-year-old fish collected during the netting operation averaged 12.6 inches in length; this exceeds by over one inch the tentative state average for pikeperch, thus adding evidence to the information obtained

Table 5.--Size classes and origin of yellow pikeperch caught in trap
nets set in Hardy Pond, 1948.

Size range (total length in inches)	Numbers of pikeperch caught					Total
	Native		Transferred			
	June	August	June	August		
8.0 - 9.9	1	14	...	...	15
10.0 - 11.9	9	52	...	...	61
12.0 - 13.9	19	125	...	...	144
14.0 - 15.9	47	14	...	1	62	
16.0 - 17.9	13	...	1	9	23	
18.0 - 19.9	...	...	3	10	13
20.0 - 21.9	...	...	5	6	11
22.0 - 23.9	...	...	6	7	13
24.0 - 25.9	...	...	5	2	7
26.0 - 27.9	...	...	3	3	6
28.0 - 29.9	...	...	1	...	1
Totals	89	205	24	38	356	

Figure 2. Origin of pikeperch caught in trap nets set in Hardy Pond, 1948.

ORIGIN OF PIKEPERCH CAUGHT IN TRAP
NETS SET IN HARDY RESERVOIR, 1948



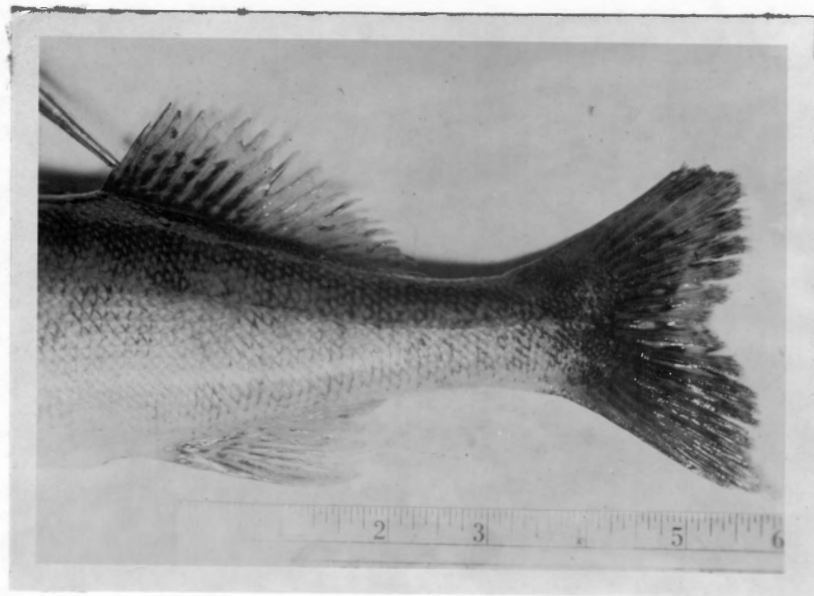


Figure 3. Frayed dorsal and caudal fins of an adult pikeperch caught in Lake Gogebic on July 9, 1947. The fish had been caught in a trap net and tagged on May 11, 1947.

during 1947 that stunting is not involved in the problem here concerned.

To gain further insight into the problem, a river guide at Hardy Pond and another at Newaygo Pond were requested to preserve the viscera of pikeperch caught by their fishing parties. Containers and preservative were provided. The object of the collection was to determine whether mature pikeperch remained in the reservoirs or disappeared before reaching maturity.

The results of the study are shown in Table 6. Ninety-one percent of the fish examined were from Hardy Pond. Of 119 female fish examined, only 10 percent had reached maturity at the time of capture; over 92 percent of the males were mature. (Differentiation of mature and immature males in midsummer is difficult and may be subject to error. However, maturity of females may be determined with facility, using characteristics outlined in I.F.R. Report No. 1210.)

It is noteworthy that 90 percent of the females occurring in this sample were caught by anglers before spawning once. The remaining 10 percent may have been composed entirely or in part of transferred fish (viscera of fish from the two origins were not separated). It seems evident that nearly all native female pikeperch are lost to the population before reaching sexual maturity, as a result of angling, downstream migration, or death from unknown causes. Males, which ordinarily mature at least a year earlier in life than female pikeperch, mature sexually in the impoundments but do not attain the sizes which one might ordinarily expect them to attain under the conditions present there.

During the 1948 fishing season, 3 tagged native fish of legal size were reported by fishermen in Hardy Pond. At least 60 marked legal-sized

Table 6.--The sex and degree of maturity of legal-sized pikeperch taken by anglers in two Muskegon River impoundments, 1948.

Impoundment	Maturity of gonads			
	Females		Males	
	Immature	Mature	Immature	Mature
Hardy Pond	94	10	9	100
Newaygo Pond	13	2	...	6
Totals	107	12	9	106

fish were available to them throughout much of the fishing season, this many having been tagged in early June (see Table 5). This rate of exploitation (5 percent) is not in itself excessive, and on the basis of present information cannot be held responsible for the unusual scarcity of mature females in the population. The 3 marked legal fish, together with 3 marked sub-legal fish reported caught by anglers, were taken in Hardy Reservoir. There is as yet no direct evidence that downstream migration of native pikeperch occurs. It seems clear that further tagging of native fish should be undertaken in the near future, in order to obtain further information concerning the rate of exploitation of native pikeperch by anglers, and the occurrence of downstream migration.

The data obtained to date permit the inference that transferred female pikeperch contribute heavily to the reproduction of the species in the Muskegon impoundments. Only about 5 percent or less of the females transferred in 1947 and in 1948 were fully spent; in 1947 about 30 percent had not yet begun to spawn at the time of transfer; in 1948 this percentage was 51. Only one transferred pikeperch has been reported which was resorbing its eggs; Muskegon River pikeperch transferred to a hatchery pond in April, 1947, spawned successfully during that year even under conditions thought to be unfavorable. It seems probable that at least some of the transferred fish spawn successfully immediately or soon after transfer, and, in view of the scarcity of mature native females, that their progeny contributes materially to the numbers of pikeperch found in the impoundments.

Tagging Experiments in Inland Lakes

For many years pikeperch and other game fish have been transferred each spring from the Cheboygan River below Cheboygan Dam to upstream waters of the Inland Waterway System, Cheboygan and Emmet counties, in an operation known as the "Cheboygan transfer." In 1931, 213 pikeperch were tagged before transfer but only 3 recoveries (1.4 percent) were obtained. In 1932, 2,154 fish were tagged and 29 recoveries (1.3 percent) were reported. Fish of both series were marked by the attachment of tags to the gill cover. The longest time interval between tagging and recapture was 193 days.

During the 1942 Cheboygan transfer, 568 pikeperch were jaw-tagged. Recoveries extended over a seven-year period (1942-1948) and equaled 10.4 percent. In general there was a wide dispersal from all points of release. Results are discussed in detail in I.F.R. Report No. 1210.

On April 28 and 29, 1948, 300 native pikeperch were jaw-tagged in Burt Lake, which is in the Inland Waterway System. By March 15, 1949, 24 (8 percent) of these had been recaptured by anglers. Nineteen were taken in Burt Lake, 1 in Pickerel Lake, 1 in Indian River, and 3 in the Sturgeon River.

A total of 4,400 pikeperch was tagged in Lake Gogebic in May, 1947. During the first year following tagging there was a return of only 66 fish (1.5 percent). This low return occurred in spite of extensive publicity given the project and the presence of a creel census clerk on the lake throughout the summer. From May 15, 1948 to March 15, 1949, there were additional reports of the recapture of 83 fish (1.9 percent).

The low total return (to date) of 3.4 percent during the 22-month period is puzzling, particularly since there was an 11.6 percent return (over a three-year period) from 95 pikeperch tagged at the Lake Gogebic weir in 1940. However, 6 of the 11 fish recovered were caught in the pool below Bergland Dam, where fish passing through the weir apparently tended to concentrate and where fishing pressure is usually heavy during the spring. Lake Gogebic is lightly fished and the returns indicate a low rate of exploitation of the large population of pikeperch present there. In contrast, an early cropping of pikeperch, soon after reaching legal size, was revealed in heavily fished Houghton Lake, where Carbine and Applegate (1946) obtained a 19-percent recovery during a two-year period from 100 pikeperch tagged in 1939 and 1940.

In connection with the Newaygo transfer, 375 tagged pikeperch were released in the Newaygo lakes in April, 1947. The results are summarized in Table 7. One planting of 50 fish in Pickerel Lake yielded a return of 42 percent during the nearly two-year period (to March 15, 1949). In Brooks Lake there was a return of only 5.3 percent from a planting of 75 fish. The return from all four lakes (combined) was nearly 22 percent. The recaptures reveal that introduced pikeperch move about freely among the north Newaygo lakes (Pickerel, Emerald, Sylvan and Kimball) but that little movement occurs between the south Newaygo lakes (Hess and Brooks). No fish is known to have regained the Muskegon River from either group of lakes, although they are connected with the river by small outlet streams.

A total of 103 pikeperch was tagged in East Twin Lake, Montmorency County, by Walter Crowe in connection with a study undertaken there in

Table 7.--Summary of recoveries of marked yellow pikeperch,
Newaygo lakes, April, 1947, to March 15, 1949.

Lake	Number planted	Recoveries (percent) April, 1947 to April 15, 1948	Recoveries (percent) April 15, 1948 to March 15, 1949	Total recoveries (percent)
Pickereel	50	38.0	4.0	42.0
Emerald	150	17.3	2.7	20.0
Hess	100	8.0	...	8.0
Brooks	75	5.3	...	5.3
Totals	375	15.2	6.7	21.9

1939. Although details of the work are not available at present, it is interesting to note that after a lapse of several years during which no tagged pikeperch were caught, 3 were taken by anglers fishing through the ice during the winter of 1949, nearly ten years after tagging. The fish ranged from 21 to 23 inches in length at the time of recapture.

The Effect of Jaw Tags on Pikeperch

The effect of jaw tags on the survival, growth rate, and condition of fish is a matter about which there is considerable controversy. It is generally felt that some effect is exerted by tags, but the extent or exact nature of such effect is not known. A few observations having a bearing on this problem were made in connection with the tagging studies described above.

On April 18, 1947, 48 pikeperch (24 tagged and 24 untagged) were placed in Pond No. 19 of the Lydell Hatchery, Comstock Park. Among the tagged fish were 12 males and 12 females, with an average length of 20.3 inches. Eight were tagged with No. 3 strap tags around the lower jaw, 8 with No. 3 strap tags around the maxillary and premaxillary, and 8 were marked with large-sized "Hasco" sheep ear tags around the lower jaw. The untagged fish were composed of 14 females and 10 males; their average length was 20.2 inches.

Sucker fingerlings and fry were added to the pond for food, as required.

The course of the experiment may be followed by reference to Table 8. On July 22, 3 months after being placed in the pond, 21 tagged and 22 untagged fish remained. It is interesting to note that 18 of the

Table 8.--Summary of results of pikeperch tagging experiment, Lydell Hatchery, 1947-1948,
including condition factor (k).

Tag number	Sex	Large jaw tags	April 18, 1947	July 22, 1947	November 10, 1947	June 3, 1948	September 3, 1948			
			Total length, inches	Total length, inches	Total length, inches	k	Total length, inches	k	Total length, inches	k
576	F	J	22.1	21.8	21.7	0.92	...	...	...	...
577	M	J	21.8	21.7	...	...	...	...	...	...
578	F	J	22.6	22.4	21.9	1.06	...	...	...	...
579	M	J	22.0	21.6	...	...	...	...	...	...
580	F	J	22.4	21.8	...	...	...	...	...	...
581	F	J	22.3	21.9	22.0	1.04	...	...	...	...
582	M	J	21.0	20.7	20.9	1.69	20.6	1.49	20.4	1.34
583	M	J	21.9	21.5	20.6	1.03	...	...	...	...
Number 3 tags, lower jaw										
20	M	j	16.6	16.8	17.7	1.49	17.3	1.36	17.9	1.38
21	M	j	19.7	19.6	19.9	...	19.9	1.28	20.1	1.36
22	M	j	19.9	19.7	20.4	1.38	...	...	...	...
27	M	j	16.1	16.1	17.4	1.44	17.2	1.75	17.5	1.41
28	M	j	19.0	18.7	...	...	...	...	...	...
29	F	j	19.8	19.6	21.0	1.57	20.8	1.39	21.4	1.46
34	M	j	12.7	13.0	14.5	1.71	14.4	1.42	...	...
35	M	j	15.3	...	...	...	...	...	...	...
Number 3 tags, premaxillary										
23	M	m	22.1	22.0	23.0	1.54	22.7	1.35	22.9	1.33
24	F	m	23.8	...	...	...	...	...	...	...
25	F	m	21.0	20.5	...	...	...	...	...	...
26	F	m	21.1	20.7	21.3	1.32	...	...	...	...
30	F	m	21.6	21.2	...	...	...	...	...	...
31	F	m	20.3	20.0	20.9	1.38	20.7	1.40	...	...
32	F	m	22.5	...	...	...	...	...	...	...
33	F	m	19.6	19.2	20.2	1.42	...	...	...	...
Tagged fish alive and average condition factor			24	21	15	1.36	8	1.43	6	1.38
Untagged fish alive and average condition factor			24	22	16	1.42	12	1.22	10	1.34

✓ Standard length omitted by error; k not computed.

tagged fish had become reduced in total length, 2 had gained slightly, and the length of 1 had remained unchanged. The average loss of length as determined from summation of gains and losses of each fish was 0.24 inches; based on the average length of the survivors this loss was 0.28 inches, whereas the average length of the untagged survivors had become reduced by 0.27 inches.

On November 10, 15 tagged and 16 untagged fish remained. Ten of the tagged fish showed a gain in length during the summer. The lengths of 5 (each tagged with a large size jaw tag) continued to be less than in April, when the fish were placed in the pond.

On June 3, 1948, 8 tagged fish and 12 untagged fish remained. All surviving tagged fish had again suffered a loss in total length, as compared to measurements made in late November. Presumably this loss, apparently resulting largely from breakage and fraying of distal elements of the caudal fin, had again occurred due to handling. No portion of the growing season had intervened between November and June to allow for any substantial repair of the damaged area.

On September 3, 16 1/2 months after the beginning of the experiment, 6 (25 percent) of the tagged fish and 10 (41 percent) of the untagged fish remained. With the exception of one fish with a large size tag which never during the course of the experiment regained its original length, all surviving tagged fish had gained slightly in length during the previous growing season.

Weight and standard length of all fish were taken on November 10, 1947, June 3, 1948, and on September 3, 1948, so that conditions⁴ might

$$k \text{ (condition factor)} = \frac{(\text{Weight in grams})^{10^2}}{(\text{Standard length in millimeters})^3}$$

be computed. The results (Table 8) show that tagged fish were in about the same or slightly better condition than the untagged fish during the last 10 months of the experiment. It is observed that on November 10, when 15 tagged survivors remained, the fish tagged with large jaw tags were in almost uniformly poorer condition (one exception) than fish tagged with small tags. The lone survivor to later dates suffered a progressively decreasing condition factor after November 10. The only maxillary-tagged fish surviving the experiment had lost its tag (by a clean break through a point near the center of both the maxillary and premaxillary bones) just previous to the time of the last measurement (September 3, 1948). It should be noted that 4 of the 6 marked fish surviving the experiment were tagged with a small jaw tag around the lower jaw. A conclusion favoring this type and location of tag may not be justified, however, because the fish so marked were smaller in average size than the others, and 7 of the 8 fish concerned were males. Among untagged fish, 6 males (60 percent of the original number) and 4 females (29 percent) survived. Five of the 6 surviving tagged fish were males. Seven of the 8 maxillary-tagged fish, which showed up poorly in the experiment, were females. A better rate of survival of male than female fish in this study is indicated.

An unexpected development in connection with the hatchery experiment was the occurrence of reproduction in the pond in both 1947 and 1948. On November 10, 1947, 14 young pikeperch averaging 9.8 inches in length were removed from the pond and on September 3, 1948, 4 young fish averaging 6 inches in length were found.

In the Muskegon River during 1948, 21 pikeperch which had been transferred to Hardy Pond from the river below Newaygo Dam in April, 1948, were recaptured in trap nets during the spring and summer of that year. Thirteen others taken by anglers were measured by the creel census clerk. The fish were measured on measuring boards of identical design both at the time of tagging and of recapture, by the same persons who measured the fish at the time of tagging. The results are shown in Table 9.

The total length of 21 of the 34 fish measured was less at the time of recapture than when released; one had gained in length; for the remainder the two measurements were identical. It seems clear that most pikeperch suffer a loss in length after tagging and transfer. In the specimens examined this amounted to an average of 0.16 inch. The loss appeared to be accentuated, rather than diminished, by late August, when a good share of the growing season had presumably passed.

Five tagged pikeperch which had been tagged and transferred in 1947 were recaptured in the Newaygo transfer of 1948, presumably after having regained their native habitat (Lake Michigan) sometime during the summer. The fish showed an increase in total length of between 0.6 and 0.8 inch. Four were tagged with maxillary tags and one was marked with a large jaw tag. On the other hand, a 21-inch fish which was transferred to Croton Pond on April 23, 1947, and caught by an angler in Newaygo Pond on July 12, 1948, had the same total length on both dates (both measurements were made by the creel census clerk). Reliable measurements of other fish which had spent over a year in the impoundments were not obtained. Measurements reported by anglers were of doubtful accuracy and were not used in the study.

Table 9.--A comparison of total lengths in inches of pikeperch at the time of tagging and at recapture in Muskegon River impoundments.

Tag number	Total length at time of tagging (April, 1948)	Total length at time of recapture	Increase in length, inches	Date of length measurement	Method of capture
2170	24.5	24.4	-0.1	May 28-June 14	Trap net
2228	21.4	21.3	-0.1	do	do
2273	22.3	22.2	-0.1	do	do
2278	20.5	20.5	0.0	do	do
2822	24.4	24.2	-0.2	do	do
2933	19.4	19.4	0.0	do	do
9048	21.3	21.3	0.0	do	do
8770	18.7	18.6	-0.1	do	do
9119	20.1	20.1	0.0	do	do
2187	24.7	24.3	-0.3	August 24-Sept. 3	Trap net
2199	21.7	21.4	-0.3	do	do
2202	21.3	22.0	0.7	do	do
2212	26.2	25.7	-0.5	do	do
2240	20.2	19.8	-0.4	do	do
2268	21.3	21.1	-0.2	do	do
2270	24.2	23.8	-0.4	do	do
2272	20.4	20.2	-0.2	do	do
2657	19.7	19.6	-0.1	do	do
8773	21.3	21.3	0.0	do	do
8787	22.8	22.6	-0.2	do	do
9056	21.7	21.6	-0.1	do	do
8580	18.7	18.3	-0.4	May 14	Angling
2167	27.0	26.4	-0.6	June 12	do
2492	20.3	20.3	0.0	June 13	do
2571	27.9	27.5	-0.4	June 15	do
2155	26.5	26.4	-0.1	June 19	do
8745	26.4	26.2	-0.2	June 19	do
9065	21.0	21.0	0.0	June 19	do
8575	19.8	19.5	-0.3	June 20	do
2475	19.6	19.3	-0.3	July 1	do
8627	23.4	23.0	-0.4	July 1	do
2846	16.0	16.0	0.0	July 3	do
2970	22.9	22.7	-0.2	July 3	do
2259	20.5	20.5	0.0	August 13	do

Average -0.16

In 1948, for example, 29 of 178 (30 percent) of the measurements reported by anglers showed an increase in length of over 0.5 inch or a loss of over 0.7 inch--both rather unlikely in the light of measurements of tagged fish recaptured in trap nets (Table 9). Fishermen reported losses of as much as 3.6 inches and gains as large as 8.5 inches.

Eschmeyer and Jones (1941) observed a loss in length after tagging among fish of several species in Norris Reservoir. They found that the lengths of tagged fish recaptured by fishermen at the opening of the season tended to be several millimeters shorter than measurements of the same fish at the time of tagging, a few weeks earlier. They attributed the loss to shrinkage during the interval between tagging and recapture, but made no mention of the condition of the caudal fin of the fish concerned.

A total of 37 pikeperch which were tagged in Lake Gogebic in May, 1947, were recaptured in trap nets and remeasured in October. Only 2 of the tagged fish examined showed a loss in length during the period; the measurements of 2 were the same; and the remainder had gained in length (Table 10). For the group, the average increase in length was 0.65 inch. Seventeen females had a greater average increase (0.82 inch) than the 20 males examined (0.51 inch), which conforms with the general growth pattern for the two sexes in Lake Gogebic, although it is a slower rate of growth than occurs in untagged fish of similar age groups.

The average condition factor of the 34 tagged fish from Lake Gogebic (Table 10) was 1.69, or slightly higher than the average condition factor of 40 untagged females (1.65) and 66 untagged males (1.66) which were within the same length range as the tagged fish and which were caught in

Table 10.--Condition (k) and growth in total length (inches) of tagged pikeperch in Lake Gogebic, May to October, 1947.

Tag number	Total length, May, 1947	Total length, October, 1947	Increase in length	k (at time of recapture)
Females				
1765	18.8	19.8	1.0	1.61
1879	21.0	21.2	0.2	1.75
2600	16.3	17.4	1.1	1.82
2614	16.7	17.5	0.8	1.53
2806	20.4	20.5	0.1	1.81
3258	18.2	19.9	1.7	1.83
3268	18.6	19.6	1.0	1.64
3488	16.8	17.5	0.7	1.64
3906	18.2	18.9	0.7	1.80
3918	17.4	19.0	1.6	1.69
6562	17.2	18.8	1.6	1.76
6599	18.5	19.2	0.7	1.91
6659	18.2	19.7	1.5	...
6665	17.8	18.3	0.5	1.50
6690	19.0	19.4	0.4	1.58
6819	18.2	18.6	0.4	1.64
7113	18.2	18.2	0.0	1.60
Average, females			0.82	1.69
Males				
369	18.2	19.2	1.0	1.72
756	14.6	15.9	1.3	1.62
760	16.0	16.7	0.7	1.75
822	15.0	15.6	0.6	1.47
883	15.3	16.0	0.7	1.47
1067	17.6	17.7	0.1	1.72
1069	16.1	16.4	0.3	1.61
1226	18.7	18.8	0.1	1.76
1232	15.7	16.4	0.7	1.61
1963	14.7	16.0	1.3	1.76
2112	18.9	18.8	-0.1	1.76
2532	18.0	18.0	0.0	1.85
2729	15.7	16.8	1.1	2.06
3122	18.0	18.1	0.1	1.67
3684	16.5	16.8	0.3	1.77
3993	15.4	15.8	0.4	1.54
6318	16.2	16.7	0.5	1.71
6606	18.2	18.0	-0.2	1.69
7105	16.0	16.4	0.4	1.75
7172	14.2	15.1	0.9	1.53
Average, males			0.51	1.69
Grand average			0.65	1.69

the trap nets at the same time. Pikeperch, both tagged and untagged, were in excellent condition at the time of the study, as may be judged by Figure 4, which shows the rich supply of mesenteric fat in the body cavity of a pikeperch which had borne a jaw tag for about five months.

Some consideration should be given to a comparison of the effectiveness of the types of tags used in the studies discussed above. In this connection, results of experiments in 1931 and 1932 in the Inland Waterway System and in the Muskegon River serve to condemn the opercle (gill cover) tag for marking pikeperch. In both areas the experiments were followed by studies involving the use of jaw tags, which produced much higher returns extending over much longer periods of time. It is very probable that opercle tags are lost sometime during the first season after tagging, whereas at least some jaw tags appear to remain in place indefinitely (nearly ten years in East Twin Lake, for example).

In the Newaygo transfer of 1948, a total of 1,750 fish was tagged. Of these, 435 were tagged with No. 3 strap tags around the maxillary and premaxillary; 460 were tagged around the lower jaw with this tag; and 855 were tagged with large-sized jaw tags, described above. Considering the first 267 recoveries during the season following tagging, the return from upper jaw tags was 14.9 percent; from small lower jaw tags, 11.7 percent; and from large lower jaw tags, 17.3 percent (Table 11). The percentages are inconclusive evidence of the superiority of large tags, however, since upper jaw tags showed a better percentage of returns in two of the four waters in which both were used. However, the small lower jaw tag produced fewer returns than the other two tags except from the 50 marked fish released in Pickerel Lake. During the second fishing season there



Figure 4. Dissection of 19.8-inch yellow pikeperch from Lake Gogebic, showing mesenteric fat on the visceral organs. This fish had been tagged for a period of five months.

Table 11.--A summary of tag returns from yellow pikeperch, with reference to size and location of tags,
in the Muskegon River drainage, 1947.

Water	Number 3 tags, upper jaw		Number 3 tags, lower jaw		"Hasco" (large size) tags, lower jaw		All tags	
	Number tagged	Percentage of returns	Number tagged	Percentage of returns	Number tagged	Percentage of returns	Number tagged	Percentage of returns
Newaygo Pond	50	12.0	39	7.7	61	14.8	150	12.0
Croton Pond	104	19.2	114	13.2	283	15.9	501	16.0
Hardy Pond	50	18.0	49	16.3	101	30.7	200	24.0
Rogers Pond	163	14.1	140	9.3	197	11.2	500	11.6
Big Rapids Pond	...	...	14	14.3	10	30.0	24	20.8
Pickereel Lake	...	...	12	50.0	38	34.2	50	38.0
Emerald Lake	...	...	29	13.8	121	18.2	150	17.3
Hess Lake	68	10.3	32	3.1	100	8.0
Brooks Lake	31	6.5	44	6.8	75	6.7
Totals	435	14.9	460	11.7	855	17.3	1,750	15.3

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were 9 returns (2.0 percent) from small jaw tags, 11 (1.3 percent) from large jaw tags, and only 3 (0.7 percent) from maxillary tags. The returns are too few in number to permit a conclusion that maxillary tags are less durable than lower jaw tags, although these percentages, together with the observed loss of a maxillary tag in the hatchery pond experiment (see above) and the occasional observation in nature of pikeperch which have lost maxillaries or premaxillaries or both (without apparent harm), might lead one to believe so. The improved showing of small jaw tags during the second year may be related to their use on fish of smaller size than the fish marked with the other tags. Also, a larger percentage of the smaller fish were males, which tended to show a better return than females. A total of 672 males tagged in 1947 yielded a return of 17.6 percent; 1,059 females gave a return of 14.8 percent. During the second year the returns continued to favor males (1.6 percent) over females (1.1 percent). Mortality of females after the transfer may be somewhat greater than males. Of 19 tagged pikeperch found dead after the 1947 Newaygo transfer, 13 were females. Twelve of these had not begun spawning (i.e., were green) at the time of transfer.

INSTITUTE FOR FISHERIES RESEARCH

Paul H. Eschmeyer

Approved by A. S. Hazzard

Typed by M. J. Lambert

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