Original: Fish Division
cc: Institute for Fisheries Research
Education-Game
Mr. Paul 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

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

December 2, 1947

Report No. 1142

OBSERVATIONS ON CERTAIN WATERS OF THE MUSKEGON RIVER DRAINAGE, WITH PARTICULAR REFERENCE TO THE ANNUAL TRANSFER OF ADULT YELLOW PIKE-PERCH TO THESE WATERS FROM THE RIVER BELOW NEWAYGO DAM

by

Paul H. Eschmeyer

RE: Institute Report No. 1142

January 28, 1948

Dr. A. S. Hazzard, Director
Institute for Fisheries Research
University Museums Annex
Ann Arbor, Michigan

Dear Dr. Hazzard:

I wish to acknowledge receipt of Institute Report No. 1142 entitled "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", which Paul H. Eschmeyer of your staff has prepared and a copy of which has been turned over to J. T. Wilkinson, Regional Supervisor at Paris.

COPY

I feel that Mr. Eschmeyer has performed a valuable service in assembling the available information relative to this walleye fishing in the Muskegon River. I know it represents many hours of work, and it will serve as a most useful reference in connection with future studies that we have promised to carry on in order to fill in some of the gaps or questions that still remain unanswered.

I am rather surprised at the low oxygen values found in the deeper waters of several of the impoundments, especially since a relatively good current is maintained at all seasons of the year.

I am also interested in the factor which would seem to indicate that the walleyed pike transferred over the dam do not continue to grow or improve. I suppose we might say that they don't appear content in these waters and apparently would congregate en masse down river perhaps in Lake Michigan if it were not for the dams. To this degree, their behavior seems to be quite different from that of the walleye population in Lake Gogebic or even in Houghton Lake at the source of the Muskegon River.

The results obtained by anglers in Hess and Brooks lakes do not seem to justify continuing transfers to those lakes, and I believe this should be considered in planning the distribution program this coming spring unless Mr. Eschmeyer feels disposed to experiment another year with some tagged fish.

In the section devoted to the Muskegon impoundments I find no reference to the dam near Michaelson built by the Game Division a few years ago in connection with the so-called Muskegon flooding project or to the dam above this which controls the level of Houghton Lake. I mention this simply as it may be an oversight not to have included a reference to them.

I will be glad to discuss the future research program with you as I think this should be actively carried on until we get better answers to some of the questions that have been raised.

Very truly yours,

F. A. Westerman
FISH DIVISION

FAW:vb
cc: J. T. Wilkinson

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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.

ABSTRACT

Five power dams cross the main branch of the Muskegon River between Newaygo, which is 38 miles upstream from the mouth of the river, and Big Rapids, a stream distance of 46 miles above Newaygo. Yellow pikeperch and other game fish congregate below Newaygo Dam each spring during their spawning migration. Starting in 1923, varying numbers of these have been caught in dipnets and moved to upstream impoundments and lakes in an operation known as the "Newaygo transfer." This transfer is opposed by persons and groups in downstream areas, particularly those interested in Muskegon Lake, and favored by those primarily concerned in upstream fisheries, particularly in Newaygo County.

Total catch below Newaygo Dam since 1928 has been 197,551 game fish, of which 96.4 percent were yellow pikeperch. Annual catches have ranged from 469 (1928) to 43,088 (1933). Size of catches at Newaygo and the catch of pikeperch by commercial fishermen in southern Lake Michigan have very similar trends for the period from 1929 to 1943.

In 1947, twelve nets used for capturing fish below the Newaygo Dam covered one-third of one percent of the area of river bottom between the two extremities of the netting area.

Pikeperch transferred during 1947 averaged 21.6 inches in length and their ages ranged from 3 to 10 years. Growth rate of transferred fish far exceeded the state average for inland waters, and females showed a materially faster rate of growth than males.

Seventy-nine percent of the adult pikeperch transferred from the Muskegon River since 1933 have been stocked in six upstream impoundments. The remainder has been distributed among 19 lakes in the drainage; since 1943 to seven lakes more immediately connected with the Muskegon River.

The Department of Conservation and the Consumers Power Company share the cost of the transfer. Average annual cost of the transfer to the Department for the past five years has been $848.63, or about $0.16 per fish transferred. Average cost per fish to Consumers Power Company has been about $0.11.

The five impoundments in the main stream of the Muskegon (Newaygo, Croton, Hardy, Rogers, and Big Rapids) have suitable spawning facilities for pikeperch, and native populations are known to be established in at least the first three named. Game fish in the impoundments are growing at a rate faster than the state average for the species concerned.

Hess and Brooks Lakes are shallow, weedy lakes just south of Newaygo, in which considerable numbers of pikeperch have been stocked in recent years. Bluegills are the dominant species present. All game fish are seriously stunted in growth. This stunting has occurred in the face of almost annual plantings of yellow pikeperch, and native populations of northern pike, largemouth bass, and longnose gars.

Kimball, Pickerel, Emerald and Sylvan lakes are other waters near Newaygo which have frequently been stocked with adult pikeperch. Chemical and thermal stratification occurs in each, and the last three named are suitable for trout. Growth rate of game fish present exceeds the state average for the species concerned.

Returns from 250 gamefish of 3 species tagged before transfer in 1932 amounted to only 2 percent, possibly due to poor tagging methods. In 1947, a total of 1,750 jaw-tagged yellow pikeperch were stocked in five upstream impoundments and four lakes near Newaygo. A total of 221 of these (12-1/2 percent) were reported caught by November 15, 1947. Sixty percent of the fish recaptured in impoundments were caught in the same waters in which they were stocked. Numbers of tagged fish known to have passed through the various power dams are as follows: Newaygo, 12; Croton, 8; Hardy, 11; Rogers, 42; and Big Rapids, 5. All fish passing through Hardy Dam had to pass through power developing units of the dam, since no water was spilled there during 1947. Twelve pikeperch (5.4 percent of the total recoveries) returned to Muskegon Lake (3) or Lake Michigan (9).

Returns from lakes near Newaygo averaged 12.5 percent, but ranged from 32 percent in Pickerel Lake to only 5 and 3 percent in Brooks and Hess Lakes, respectively.

The largest numbers of tag returns were received during July and August. Only six tagged pikeperch caught had moved upstream from the point of release. A large percentage of the tagged fish taken in the impoundments were caught immediately above the power dams.

Twenty-one counties, 6 states and Washington, D. C. were among the residences claimed by persons catching tagged fish.

Twenty-four tagged and 24 untagged pikeperch were held in a hatchery pond. Observation after three months disclosed no significant difference in growth or mortality rate between the two groups.

The facts at hand to date indicate that the transfer has had no harmful effects on the sport fishery either above or below Newaygo Dam, and that it is of some benefit to the upper waters. Further information is required before a definite conclusion can be reached as to the exact effects of the transfer. Unless and until future study reveals facts which void the general conclusions reached in this report, it is recommended that the transfer of pikeperch at Newaygo be continued as a regular annual operation of the Department of Conservation.

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December 2, 1947

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

Paul H. Eschmeyer

I. Introduction

The Muskegon River is located in the west-central portion of the lower peninsula of Michigan. It has its origin in Houghton Lake, Roscommon County, and flows in a southwesterly direction over a winding, nearly 200-mile course* to southern Lake Michigan. It enters

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*Divided among seven counties as follows: Houghton, 14; Missaukee, 15; Clare, 30; Osceola, 30; Mecosta, 36; Newaygo, 46; Muskegon, 26.

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the lake by way of Muskegon Lake, which is located near the city of Muskegon. The drainage basin of 2,663 square miles covers portions of nine counties. There is a drop in elevation of 620 feet between source and mouth.

From the standpoint of both power development and recreational use, the Muskegon is among Michigan's most important waterways. Five power dams have been erected in the 46-mile stretch of stream between Big Rapids and Newaygo, and a sixth is located in its principal tributary, the Little Muskegon River, near the village of Morley. The sport fishery in the Muskegon ranks with the best which Michigan has to offer. Thousands of residents and tourists alike annually fish its waters for the trout, yellow pikeperch, smallmouth bass, and other game fish for which the stream has become so widely known. Hunting, trapping, boating, hiking, picnicking, and camping are among the other recreational pursuits for which the river and its immediate shores offer unusual opportunities. Certain portions of it are famed for their inspiring scenic beauty.

It is obvious that one of these major uses of a waterway, power development, must necessarily exert a wide influence on recreation in its various forms and especially on fishing. Upon the erection of a dam, the change from stream to lake conditions frequently destroys the habitat for some species of fish (and many other animals and plants as well), while it greatly improves conditions for others, which were possibly not even present before impoundment. Modern power dams are nearly always very effective barriers to upstream migration of fish, while downstream movement may be sharply restricted.

All power dams now in the Muskegon have been in place for at least fifteen years. Consequently, few anglers any longer lament the loss to the impoundments of stretches of trout or bass stream which may have at one time been favorite fishing grounds. Fisheries involving predominantly lake species are enjoyed in the backwaters of the dams, while

stream fishermen direct their attention to unflooded areas above and below the ponds. However, the effect of the dams as barriers to fish movement, and the proper management of game fish whose movements are thus restricted, continues to constitute a problem of very considerable magnitude, involving conflicting views of large numbers of fishermen. It is essentially certain aspects of this problem with which this paper deals.

Each spring large numbers of yellow pikeperch and, to a much smaller extent, certain other game fish ascend the Muskegon on their annual spawning migration. Many thousands of fish congregate in the section of stream below the Newaygo Dam, which is the farthest downstream of the several power dams in the river. For a period of over twenty years, varying numbers (generally running into the thousands) of game fish have been transferred by mechanical means from this area of seasonal concentration to various points in the stream above and to certain connecting waters located in its drainage. This annual conveyance of fish around the dam has become generally known as the "Newaygo Transfer."

Almost since the year of its inception, the transfer has been a source of argument and sometimes bitter controversy between interested individuals and organized groups primarily concerned in the river or connecting waters above Newaygo Dam, on the one hand, and those interested in the fishery below this point, particularly in Muskegon Lake, on the other.

Essentially, the downstream interests contend that the numbers involved in the transfer are of sufficient magnitude to deplete the game fish population of the lower river and to have a seriously detrimental effect on the quality of the sport fishery in Muskegon Lake. Fish

moved around the dams are thought to be unable to return to the areas which they would normally frequent, leaving fewer fish available to downstream anglers than would be the case if the transfer did not take place. Halting of the transfer has been repeatedly requested by various individuals and groups. The most recent formal request was directed to the Conservation Commission under date of February 13, 1947. It reports that a motion for the discontinuation of the transfer for a period of five years, beginning in 1947, was passed unanimously by the Muskegon Conservation Club Board of Directors, Muskegon County Boat Livery Association, City Government of Muskegon, Muskegon Heights City Government, North Muskegon City Government, and Muskegon County Board of Supervisors. It further states that this should be considered as a research and experimental measure to determine whether or not the transfer has any direct bearing on the fishing in Muskegon Lake.

Individuals and groups from Newaygo County have always strongly favored the continuation of the transfer and have opposed the placing of limitations on the numbers of fish moved to upstream areas and connecting waters. Their contention is that, since the barrier at Newaygo prevents the migration of fish up the river, upstream areas do not obtain the share of fish to which they are entitled, unless these are mechanically moved to points above the dams. They believe that fishing in the waters above the dam is materially improved by the annual transfer. It is further asserted that the spring netting of game fish below the dam removes only a very small percentage of the migrating fish, with the implication that the number taken is insufficient to significantly affect the fishing in downstream areas. The opinion has been repeatedly voiced that downstream movement through the power dams can and does occur,

thus permitting ultimate completion of the normal migratory movements of the species concerned. Persons holding the views favoring the transfer are fully aware of the opposition of those located downstream. Many letters and petitions have been received during the past fifteen years, expressing anxiety over the possible interruption of the transfer, or urging its continuation.

The problem is at once seen to involve a number of intricate biological and sociological ramifications. To suppose that one might immediately and with ease effect a solution equally agreeable to all individuals on both sides of such a controversial issue is to borrow from the hallucinatory delusions of the demented. To effect a sound solution, based at least in part on scientific fact, the answers to several specific questions would be extremely desirable. The fact that the answers may not now be at hand should not dissuade us from recognizing that the questions exist. Among the more important of these are the following:

1. Do the yellow pikeperch migrating up the Muskegon River originate in Muskegon Lake, thus forming part and parcel of the fishery there, or do they come essentially from Lake Michigan, thus providing (one would judge, in a democratic state) an equal claim to both upstream and downstream residents?

2. What percentage of the migrating fish reaching Newaygo Dam are removed during the average transfer? Is the number sufficient to cause depletion of the pikeperch fishery in downstream areas?

3. Are sufficient numbers of the transferred game fish taken by anglers in upstream waters to justify the transfer economically, and do such fish make a significant contribution to the upstream fishing?

4. Are physical, chemical and biological conditions in the upstream waters such that the transfer is desirable, and required, to provide good fishing?

5. Are game fish capable of returning downstream through the power dams to the points of origin of their upstream migration, or are they permanently lost to these points?

6. If such fish are capable of moving downstream, do native fish, hatched and reared in upstream areas, also move through the dams and thus contribute to the downstream fisheries?

During past years and particularly during the past summer, the Institute has collected information having a bearing on some of the above questions. This is presented in the following pages. Various aspects of the transfer are discussed, observations on conditions in upstream waters are briefly summarized, and the movements of marked fish in these waters during the 1947 fishing season are analyzed in detail.

II. The Newaygo Transfer

A. History -- The transfer of game fish around Newaygo Dam to various upstream waters was first undertaken in 1923*. In that year,

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*From an article in the Grand Rapids Press, April 2, 1932.

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through the efforts of the Fremont, Grant and Newaygo chapters of the Izaak Walton League, permission for the transfer was obtained from the Department of Conservation. The operation was conducted on a very limited scale by two individuals. Others assisted in the work in the several following years until 1928 when the Department began actively supervising the work and transporting the fish caught. The operation has been carried on annually without interruption since that time.

Since its earliest beginning, the netting has been done by private individuals using large dipnets, lifted by hand-operated winches. The netting is done mostly at night.

Various plans for payment of the dipnetters have been followed during the period of the transfer. Prior to 1928, there is no record of such payment having been made, and certain individuals apparently undertook the work purely in the interest of improving fishing. In 1928, the Conservation Department and the Newaygo Chamber of Commerce shared equally the cost of the operation, paying netters 30 cents each for rainbow trout, yellow pikeperch and a few bass. Since 1928, the Consumers Power Company, which operates the Newaygo Dam and others above it, has taken an active interest in the work. During recent years they have provided the funds for payment of the netters, while during the earlier years of the operation they reportedly bore a portion of the transportation cost as well. In 1932, netters were paid 20 cents each for the first 10 fish caught, and 15 cents for the balance of each day's catch. In 1933, a plan for payment was agreed upon which has remained materially unchanged since that time. As it has been practiced, the Consumers Power Company pays 20 cents per fish for all fish netted and transferred, up to a maximum of 3,750 (or $750.00). If over 3,750 fish are caught in a given season, this same amount is divided among the netters in proportion to the number of fish caught by each. For some time a premium was placed on game fish other than yellow pikeperch and they were paid for at a higher rate, but this provision was dropped in 1944.

Suckers which are taken each year during the netting have been disposed of in various ways in past years. Prior to 1933 they were turned over to some person in the Newaygo Area responsible for welfare work, for distribution. From 1934 to 1943, they were bought from the

netters by some local business establishment (Mr. Ed Henning's Sport Shop, during most of those years), and resold to the public. Since 1944 they have been sold directly to the public by Department of Conservation personnel supervising the operation, and the entire proceeds have been distributed among the netters in proportion to the number of suckers taken by each.

In 1934 and from 1936 to 1941, the transfer work was materially aided by labor, and in some cases supervisory personnel, provided by the Civilian Conservation Corps (M.E.C.W.) of the U. S. Forest Service.

Throughout its duration, personnel of the Field Administration Division of the Department has assisted with the supervision of the transfer, in addition to enforcement of the regulations associated with the operation. At the beginning of the netting period each year, a permit is issued to each netter for taking game fish within prescribed regulations governing the species which may be taken, location of the nets, hours of netting, method of handling the fish, and so on. Law enforcement has presented a problem almost since the beginning of the transfer. Pikeperch sales were made by certain dipnetters in 1934 and several arrests resulted. As recently as 1943, a live box containing 296 pikeperch was stolen and towed downstream for two miles by three local business men, who were later apprehended while sacking the fish. Seventeen others were arrested during this same year for complicity in game fish sales.

In 1944 the regulations which are at present in effect were drawn up by fishermen, residents of Newaygo and representatives of the Department of Conservation (State Fish Hatchery, Paris, March 20). The transfer has proceeded without major violations since that time, due

in part perhaps to the provision which strictly limits the distribution of the netters along the river. In most previous years, netters chose their own locations. Nets were in operation over an extended area below the dam, making adequate supervision difficult. Pertinent excerpts from the 1947 regulations are as follows:

REGULATIONS GOVERNING USE OF DIP NETS

UNDER PERMIT IN MUSKEGON RIVER AT NEWAYGO

1. OFFICIALS IN CHARGE

All netting operations shall be by special permit and in accordance with the established rules and regulations and under the instruction and direction of District Conservation Supervisor Karl Kidder of Baldwin. Supervisor Kidder will be represented locally by Conservation Officers, who will issue permits and maintain his office on the state-owned river property during the time netting is in progress.

The determination of the period of netting and the collection, planting and payment for game fish will be under the jurisdiction of Regional Fisheries Supervisor J. T. Wilkinson, State Fish Hatchery, Paris, Michigan.

2. WHO MAY OBTAIN PERMITS

A permit will be issued to not more than two persons of 17 years or more of age, whose name and address will appear in the permit. Permit will allow the use of one dip net for taking game fish and suckers for the Michigan Department of Conservation.

Not more than one permit shall be issued to any one or two persons.

3. LOCATION OF NETS

Nets may be fished only on that portion of the north bank of the Muskegon River at Newaygo downstream from the lower bridge in the area marked by flags or posts set upon the stream bank.

The issue of a permit by the Department of Conservation for use of a net in this area shall not be construed as authority for trespass upon privately-owned property in the area. Persons desiring locations on such privately-owned property shall complete the necessary arrangement with the owners.

Permits for use of a net to be set on state-owned land in the area shall be sufficient authority for use of such land.

Any dispute between net owners as to location and operation of nets shall be amicably settled between them, otherwise the conservation officer in charge of the operations shall determine the right of each and his decision shall be final.

4. REQUIREMENTS FOR PERMIT

(a) Applicant for permit shall be 17 years or more of age.
(b) Applicant will have selected a location and established his net.
(c) Applicant will have provided a live box having a hinged cover with hasp for locking and of a sufficient size and so located that fish can be held and handled in good condition.

These requirements must be approved by the officer in charge before permit will be issued.

5. WHERE PERMITS ARE OBTAINED

Applications for permits will be made to conservation officers in charge of netting operations at Conservation Headquarters on the north bank of the Muskegon River, below the lower bridge in Newaygo, Michigan.

6. OPERATION OF NETS

Netting will be permitted only between the hours of 7:00 p.m. and 8:00 a.m., Eastern Standard Time, from the declared opening date which will be announced by the officer in charge and as determined by the regional fisheries supervisor.

Fishing will be permitted during these hours each night until 10,000 walleyed pike are taken or for a period of 15 nights from the start of the fishing operations, whichever comes first. However, if the number of fish taken during the 15-day period falls short of the desired number because of the low volume of water and restricted fishing, the regional fisheries supervisor may in his discretion authorize a reasonable extension to the fishing period and will so inform the officer in charge.

All game fish and suckers taken under authority of a permit shall be carefully handled and deposited in the owner's live box.

Sturgeon shall be immediately released alive to the river but the length and weight should be estimated and the time of capture should be reported to the officer in charge.

Live boxes shall be locked except when net is in operation and key to box shall be deposited with the officer in charge at the conclusion of each day's fishing for retention by him until fishing is again resumed.

No net shall be operated by any person excepting the person or persons named in the permit or unless such person is present and in attendance when such net is operated by any other person.

7. PAYMENT FOR FISH TAKEN

The Department of Conservation will each day remove all fish from each live box and will issue a receipt to the owner thereof for all fish in good condition. Duplicates of such receipts will be the basis of the record furnished the Consumers Power Company who will pay each fisherman for the number of game fish taken.

Payment for the game fish will be made by the Consumers Power Company upon the conclusion of the operations at the rate of 20 cents for each walleyed pike, rainbow trout and northern pike, or if the total catch of such fish exceeds 3750 then the sum of $750 will be apportioned among all fishermen upon the basis of the number of game fish each will have delivered. Rainbow trout and other game fish will count as one fish in the computation of the payment.

Suckers when removed from the live box will be delivered to the officer in charge of the operations and held for public sale by him at his headquarters from 7:00 p.m. to 8:00 p.m. daily, Eastern Standard Time. Prices charged for suckers shall not be less than 10 cents nor more than 25 cents each, depending upon size. The officer in charge will keep a record of all suckers received each day from each fisherman, number of suckers sold each day and the total value of the daily sales. Upon conclusion of the fishing operations the total receipts, without any deduction for handling charges, shall be apportioned among the fishermen in accordance with the number of suckers received from each and a complete record of the receipts and disbursements shall be submitted to the district fisheries supervisor.

8. RESPONSIBILITY OF MICHIGAN DEPARTMENT OF CONSERVATION

The Department of Conservation assumes responsibility only for the employees and state property engaged in supervising the fishing operations and in the transfer of fish. It does not assume responsibility for the nets, live boxes, or other property of fishermen to whom permits are issued or for personal injuries of persons engaging in fishing under authority of the permits.

By: DEPARTMENT OF CONSERVATION
FISH DIVISION
LANSING, MICHIGAN

April 3, 1947

B. Fishing Gear and Technique.-- Although regulations governing the work have been altered from time to time, and the numbers of fish transferred from year to year has varied greatly, the actual mechanics of the transfer - the procurement of the fish and their transportation to other waters - has remained practically unchanged since the date of its origin

over 20 years ago. The equipment used and the methods employed are illustrated in the photographs below (Figures 1-9). The figures were prepared by Wm. Cristanelli of the Institute Staff, from kodachrome transparencies taken by the writer in April, 1947.

Figure 1 shows a downstream view of the river in the area where netting is done (trees and ground are covered with snow). A dipnet used in the netting is shown at the right in the picture. The entire apparatus is better shown in Figure 2. The net in this photograph is 10-1/2 feet square. It consists of a steel frame which supports a rather deep bag. The bag is made of heavy netting of about 3/4-inch mesh. The net frame is supported at each corner by wires of equal length which extend to a common point above the center of the net. Here they are joined to a cable or heavy rope. This passes through a pulley which is firmly attached to the upper end of a sturdy, angling pole of about 30 feet in length, anchored to the bank and supported near its middle, as shown. The cable or rope suspending the net leads from the pulley to a hand-operated winch, anchored near the center of the supporting pole, by means of which the operator raises or lowers the net. A wire attached to the upstream side of the net frame leads to the outer end of a pole extended horizontally from the shore, near the surface of the water, and 10 to 15 or more feet upstream from the net (foreground, Figure 1). This arrangement prevents the net from being swept downstream when it is lowered into the water. A live box (shown just beneath and beyond the operator's pier in Figure 2), a long-handled scap for removing fish taken in the net, and generally a small shanty for shelter during inclement weather or during slack fishing periods, completes the equipment of the average operator.

Figure 1.--View downstream from public fishing site near Newaygo, Muskegon River, 1947.

Figure 2.--A dipnet used in the capture of game fish below Newaygo Dam in the Muskegon River.

In operation, the net is lowered into the river in such a manner that the net frame and net rest on the bottom. It is left for a period varying from less than a minute to a much longer time, depending on the numbers of fish being taken at the time, and the inclinations of the operator. In lifting the net, the operator turns the winch, lifting the net vertically out of the water at a moderate, steady speed. If fish are taken in the lift, a long-handled net is extended into the net (Figure 3), the fish is secured (Figure 4), and transferred to a livebox (Figure 5).

In the transfer of the fish on the following day, they are counted as they are removed from the livebox (Figure 6) and each fisherman is credited with the number of fish which he has taken during the night. The pikeperch are placed in the aerated tank of a planting unit (Figure 7) and transported to the point where they are to be stocked. Here the vehicle is parked near the shore, the fish are placed in a scap net and carried to the water (Figure 8), where they are released (Figure 9) and the operation is complete.

C. Catch Records.--The numbers of game fish and suckers taken by dip-netters during the period extending from 1928 to 1947 are summarized in Table I. The record is fairly complete for yellow pikeperch and trout during this period, but totals of other game fish and suckers are incomplete for the early years of the transfer. The table shows a total catch of 197,551 game fish, 13,317 suckers and 14 sturgeons during the 20-year period covered. Of the game fish, 190,542 (96.4 percent) were yellow pikeperch and 6,539 were trout (nearly all rainbows). Northern pike, bass, perch and rock bass are represented by much smaller numbers, and only during some years of the transfer. Not shown in the records are "a few" stone rollers and three large smelt reported in 1937. Occasional

Figure 3.--A long-handled net is used to remove fish from dipnet.

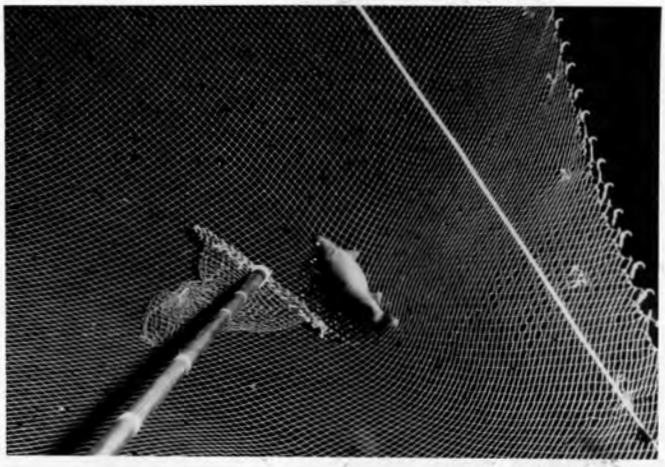


Figure 4.--A large pikeperch being removed from dipnet.

Figure 5.--The pikeperch is transferred to a livebox.

Figure 6.--Pikeperch being removed from livebox for transfer to upstream waters.

Figure 7.--N. Feldpausch, Harrietta, placing pikeperch in aerated tank of planting unit for transfer.

Figure 8.--J. Lamb, Newaygo, about to plant pikeperch in an upstream impoundment.

Figure 9.--Large adult pikeperch just before release in Rogers Pond.

Table I.--A summary of the Newaygo transfer in the Muskegon River, showing species and numbers of fish taken in dipnets from 1928 to 1947.

Year	Yellow pikeperch	Trout[1]	Northern pike	Bass[2]	Perch	Rock bass	Sturgeon	Suckers[3]
1928	469	409	...	...	...	...	...	...
1929	3,680	1,024	...	...	...	...	3	...
1930	8,327	1,712	...	...	...	...	...	...
1931	1,547	291	...	...	...	...	...	...
1932	3,151	791	...	...	...	...	2	2,148
1933	43,088	819	...	...	...	...	3	...
1934	24,284	465	...	...	...	...	1	...
1935	24,241	230	...	...	...	...	...	2,226
1936	6,676	69	...	...	...	...	...	...
1937	6,931	128	13	...	...	...	3	1,100
1938	7,020	193	5	...	...	...	...	2,250
1939	6,345	127	27	?	...	...	...	1,037
1940	2,641	112	94	46	141	...	...	1,044
1941	12,460	43	31	65	30	...	...	864
1942	12,469	57	...	...	...	...	...	419
1943	13,186	32	...	...	...	...	...	487
1944	3,318	9	10	...	...	...	...	202
1945	789	10	...	...	...	...	...	591
1946	4,380	12	1	1	...	...	...	686
1947	5,540	6	3	...	...	1	2	263
1948	4,734							
Total	~~190,542~~	6,539	184	114	171	1	14	13,317

[1] Mostly rainbow trout. Occasional brook and brown trout

[2] Bass were not identified as to species in annual reports

[3] Data for suckers lacking for some years. The 1947 total is approximate.

sea lampreys taken during the netting are also unrecorded. A 21.7-inch specimen taken on April 19, 1947 was the first lamprey reported in the state for the season, which had begun its spawning migration.

Numbers of pikeperch taken per year range from only 469 in 1928 to 43,088 in 1933. Trout range in number from 1,712 in 1930 to only 6 in 1947. A more complete analysis of the catches of yellow pikeperch is shown in Table II. For the years from 1933 to 1940 and from 1942 to 1947, daily catches during the period of the transfer are recorded. The number of individuals participating in the netting are shown for each year, together with the estimated "net days" (one dipnet fished for one night) and the average catch per net day.

The length of the dipnetting periods (further summarized in Table III) has varied from a high of 33 days in 1933 to only 8 days in 1942. It has been started as early as March 26 (1933) and as late as April 14 (1947). The operation was terminated by April 8 in 1942, but held over as long as April 28 during 1934 and 1936.

The number of dipnetters participating in the transfer has ranged from 8 in 1945 to 37 in 1933. (Correspondence for the year reports 48 for 1942, not shown in the table). The average for the period from 1933 to 1947 is between 21 and 22.

The estimate of the number of net days fished each year is based on the assumption that all of the netters began dipping on the first day of the season and continued until the last day. This has not in general been true, since during most years a few netters are late in getting underway, and occasionally some quit before the operation is officially terminated. However, it is a common observation that most netters are interested in the work and are anxious to begin at once, and

Table II.--A daily record of catches of yellow pikeperch by means of dipnets below Newaygo Dam in the Muskegon River, 1928-1947.

Year	March 26	27	28	29	30	31	April 1	2	3	4	5	6	7	8	9
1928[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1929[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1930[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1931[2]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1932[2]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1933	2	6	17	24	75	24	338	345	297	1,333	540	1,928	899	1,926	2,162
1934	...	...	...	...	...	...	...	...	76	196	228	69	559	720	977
1935	...	...	...	...	...	...	85	208	739	1,179	1,298	1,072	1,157	1,202	1,680
1936	...	...	...	...	...	...	...	...	...	...	...	...	...	36	41
1937	...	...	...	...	...	...	...	...	56	175	179	204	123	266	351
1938	...	...	...	...	...	...	...	439	468	365	558	514	475	393	413
1939	...	...	...	...	...	...	...	75	180	242	113	198	272	263	250
1940	...	...	...	...	...	...	...	15	21	41	53	94	110	98	122
1941[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1942	...	...	...	...	...	...	440	1093	1391	1,469	1,646	1,926	2,417	2,087	...
1943	...	...	...	...	...	...	...	...	...	...	111	178	185	392	945
1944	...	...	...	...	...	...	...	...	...	...	...	195	105	138	110
1945	...	...	...	...	...	...	...	...	...	195	128	80	49	45	64
1946	...	...	...	174	201	270	251	390	364	346	337	414	337	317	375
1947	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Year	April 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total number for year	Number of dipnets	Estimated net days	Estimated average catch per net day
1928[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	469	...	...	...
1929[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,680	...	...	...
1930[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8,327	...	...	...
1931[2]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1,547	...	...	...
1932[2]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,151	...	...	...
1933	2,150	1,643	1,561	1,418	3,059	2,618	3,177	3,882	3,235	2,774	2,799	1,481	307	2,113	264	364	84	243	...	43,088	37	1,221	353
1934	1,637	1,033	1,170	1,057	1,150	403	1,018	1,966	1,152	1,811	1,758	1,635	635	666	1,045	1,701	708	569	345	24,284	35[3]	910	267
1935	1,734	2,067	1,744	1,875	1,372	1,211	872	1,040	915	899	581	565	348	204	155	39	...	...	...	24,241	33	858	283
1936	98	...	...	...	484	590	664	664	542	380	444	740	443	414	286	360	187	193	110	6,676	23	414	161
1937	425	423	566	607	835	489	545	405	287	269	272	174	180	100	...	...	...	...	...	6,931	21	441	157
1938	310	503	579	600	455	420	225	116	61	55	29	15	14	8	5	...	...	...	...	7,020	31	713	98
1939	309	370	257	338	177	303	163	269	307	402	300	235	625	420	142	135	...	...	...	6,345	28[3]	672	94
1940	140	150	111	93	123	175	222	220	158	114	142	103	163	173	...	...	...	...	...	2,641	20[3]	572	46
1941[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12,460	27	...	...
1942	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12,469	23	184	678
1943	2,032	2,659	1,715	988	1,566	1,989	426	...	...	...	...	...	...	...	...	...	...	...	...	13,186	23	276	478
1944	222	243	347	324	311	182	190	190	273	196	7	157	128	...	...	...	...	...	...	3,318	10	170	20
1945	79	67	43	39	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	789	8	80	10
1946	255	188	161	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4,380	11	165	27
1947	...	...	...	...	274	527	705	586	593	468	505	448	464	378	227	365	...	...	...	5,540	12	144	38

[1] No daily catch records available

[2] No daily catch records available. About 75 percent of the fish were taken between April 5 and April 20

[3] Number of dipnetters estimated, not included in determination of average number

Table III.--Duration of dipnetting periods at Newaygo Dam in the Muskegon River, 1933 - 1940 and 1942 - 1947.

Year	Beginning of netting	End of netting period	Days of netting	Days of largest catches during netting period
1933	March 26	April 27	33	April 16 - 18
1934	April 3	April 28	26	April 19 - 21
1935	April 1	April 25	25	April 11 - 13
1936	April 14	April 28	15	April 15 - 17
1937	April 3	April 23	21	April 12 - 14
1938	April 2	April 24	23	April 11 - 13
1939	April 2	April 25	24	April 18 - 20
1940	April 2	April 23	22	April 15 - 17
1942	April 1	April 8	8	April 6 - 8
1943	April 5	April 16	12	April 10 - 12
1944	April 6	April 22	17	April 12 - 14
1945	April 4	April 13	10	April 4 - 6
1946	April 29	April 12	15	April 2 - 4
1947	April 14	April 25	12	April 16 - 18

likewise remain on the job until the end of the transfer period. Any variations which may occur probably enter the picture about as much during any one year as another (with some possible exceptions), so that the figures shown are believed to constitute a fair criterion of the comparable amount of effort expended during the various years in taking the number of fish shown in the totals. This effort varied from an estimated 80 net days in 1945 to over 1,200 in 1933. Estimated average catch per net day varied from a low of 10 in the former year to as many as 678 in 1942. Checks made during the 1947 season, on April 15 and 16, showed that nearly all netters began work at 7:00 p.m. (the official starting time) and continued throughout the night (or at least retained the keys to their live boxes) until between 6:40 and 7:00 a.m., about an hour before the official quitting time. General observations on later days seemed to indicate that these hours held pretty well throughout the season. The suggestion is that the average net day, at least during 1947, was between 11 and 12 hours in length. If about the same hours prevailed during 1942 (not unlikely), an average catch of well over 50 fish per hour per net was made during the very heavy "run" of that year.

The date limits and length in days of the dipnetting periods during the years of the transfer are summarized in Table III. Duration of the period and size of the catch were not specifically limited prior to 1936. During that year, in response to complaints of Muskegon County fishermen concerning the poor fishing in Muskegon Lake, a limit of 10,000 pikeperch or a period of operation of not to exceed 15 days was agreed upon for the 1936 season. The 15-day limit was discarded in subsequent years, but the total of 10,000 has been used more or less as a guide

and has been exceeded on only three occasions (1941, 1942, and 1943) since that time, in each case by relatively small margins. The average netting period for the years for which data are available has been about 19 days. The "peak periods" of the run (the three-day period during each season when more fish were taken than during any other period of three contiguous days) are also shown in Table III. The fact that a peak exists in the spawning run, that is, that the number of pikeperch congregated in the area below the dam increases over a period of days until it reaches a maximum, and then subsides, has been noted by local residents for many years. These maxima of abundance are more clearly shown by reference to Table IV, which groups the catches in terms of 3-day periods, dating from the beginning of the netting. Nearly all seasons show such a peak, or the totals for short periods of netting in recent years indicates that a peak has or is about to occur. It has been the aim of field personnel in charge of the dipnetting to "hit the peak of the run," in order to obtain maximum numbers of fish in a minimum amount of time, and at smallest cost per fish. By and large, the peaks appear to have been covered. In 1942, the quota for the year was filled just as the peak was being reached. During several other years peaks of abundance are less clearly shown. The course of four netting seasons (1933, 1935, 1937 and 1943) is illustrated graphically in Figure 10. The short period of operation in 1943 provides a less complete curve than for the other years, but a peak is nevertheless indicated. It should perhaps be repeated that low points in the curve for the first one or two days of the season and possibly for an equal period toward the end of the operation may be somewhat accentuated by the decreased number of netters at these times. However, the principal

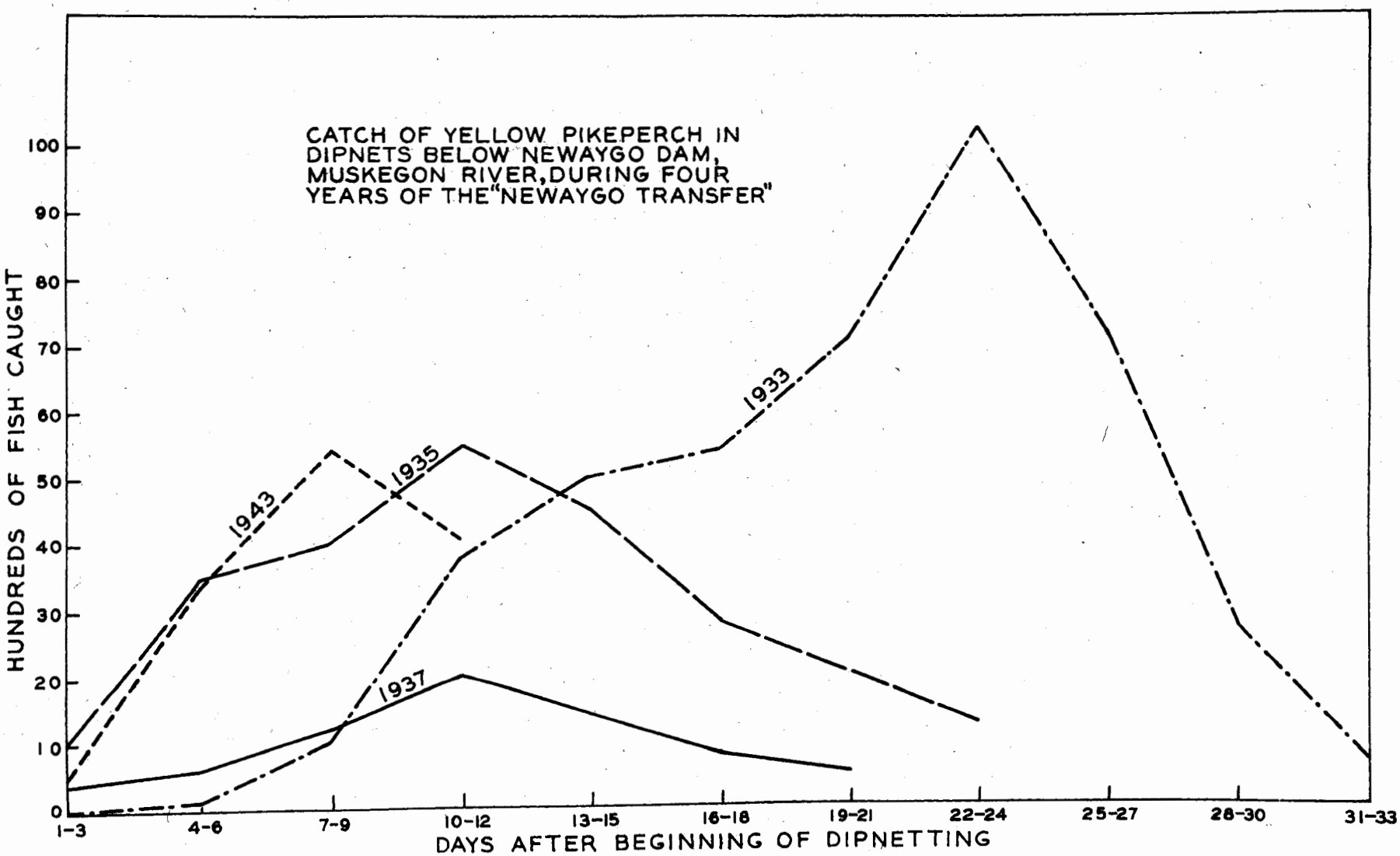
Table IV.--A record of catches of yellow pikeperch by means of dipnets below Newaygo Dam in the Muskegon River, summarized by three-day intervals.

Year	Days after beginning of netting period											Total
	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	
1933	25	123	980	3,801	4,987	5,354	7,095	10,294	7,054	2,684	691	43,088
1934	500	1,348	3,647	3,377	3,387	4,721	2,936	3,454	914[1]	...	...	24,284
1935	1,032	3,549	4,039	5,545	4,458	2,827	2,045	707	39[2]	...	...	24,241
1936	175	...	1,738	1,586	1,627	1,060	490	...	...	...	...	6,676
1937	410	593	1,199	2,008	1,439	828	454	...	...	...	...	6,931
1938	1,272	1,547	1,116	1,682	1,100	232	58	13[1]	...	...	...	7,020
1939	497	583	822	965	643	978	1,160	697	...	...	...	6,345
1940	77	257	360	354	520	492	408	173[2]	...	...	...	2,641
1942	2,924	5,041	4,504[1]	...	...	...	...	...	...	...	...	12,469
1943	474	3,369	5,362	3,981	...	...	...	...	...	...	...	13,186
1944	438	575	982	562	476	285[1]	...	...	...	...	...	3,318
1945	403	158	189	39[2]	...	...	...	...	...	...	...	789
1946	645	1,005	1,097	1,029	604	...	...	...	...	...	...	4,380
1947	1,506	1,647	1,417	970	...	...	...	...	...	...	...	5,540
											Grand total	160,908

[1] Total for 2 days only

[2] Total for 1 day only

Figure 10


CATCH OF YELLOW PIKEPERCH IN DIPNETS BELOW NEWAYGO DAM, MUSKEGON RIVER, DURING FOUR YEARS OF THE "NEWAYGO TRANSFER"
HUNDREDS OF FISH CAUGHT
0
10
20
30
40
50
60
70
80
90
100
1933
1935
1943
1937
1-3
4-6
7-9
10-12
13-15
16-18
19-21
22-24
25-27
28-30
31-33
DAYS AFTER BEGINNING OF DIPNETTING

portions of the curves are not so affected, with a relatively constant number of netters being the rule.

The wide variation in catch during the different years of the Newaygo transfer is very apparent in Tables I, II, and IV (above). Analysis of the tables shows that the variation cannot be attributed entirely to length of the netting season, number of dipnetters, or degree of success in hitting the peak of the run.

The sizes of annual catches have in the past been frequently attributed at least in part to water flow. Thus, for the highly successful year of 1942, we can glean from correspondence[*] that the season was

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[*] Robert J. Fortney to M. J. DeBoer, April 6, 1942

"characterized by high water which is colored, making an ideal situation for catching fish," while in 1944, when fewer fish were taken, there was an appreciable depth or flow of water for only a 3-day period during the transfer. Ice was present on Hardy and Croton Ponds during the latter year almost to the end of the operation, and very little water was allowed to spill.

In an attempt to determine the effect of water flow on catch, Mr. John T. Van Norman, in cooperation with the Consumers Power Company, conducted some tests involving variation in the rate of flow through Newaygo Dam, between April 12 and April 20, 1937[*]. Water was periodically

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[*] John T. Van Norman, "Water Flow Experimentation," 1937 (ms).

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raised and lowered over this period and catches of pikeperch and trout during high- and low-water intervals were compared. Numbers of fish

caught did not fluctuate beyond the numbers which might be expected in the normal course of variations in a spawning run so that the results did not support the theory that heavy runs were caused by high water.

Although various factors may enter into the picture, a clue to a contributing cause of the evident variation in numbers may be obtained from an inspection of Table V, some of the data for which were provided by Dr. Ralph Hile, of the U. S. Fish and Wildlife Service. The table shows the pronounced variation in abundance of yellow pikeperch in the waters of southern Lake Michigan from 1929 to 1946, as judged by catches of commercial fishermen. Numbers of fish (in thousands) taken in the Muskegon River transfer during this period are also shown. The same data are presented graphically in Figure 11. An inspection of the table and graph shows that the basic trends in the abundance of yellow pikeperch in southern Lake Michigan and as indicated by transfer operations in the Muskegon River are very similar for the 15-year period between 1929 and 1943. The figures given are not exactly comparable, since the Lake Michigan data cover the entire season's catch in each case, while the figures for the Muskegon more often than not cover only a part of the period when fish congregate below the dam.

The data from 1929 to 1943 openly suggest that the populations in the stream and in Lake Michigan are either part of the same population or are closely related populations showing characteristically similar trends in their cycle of abundance from year to year.

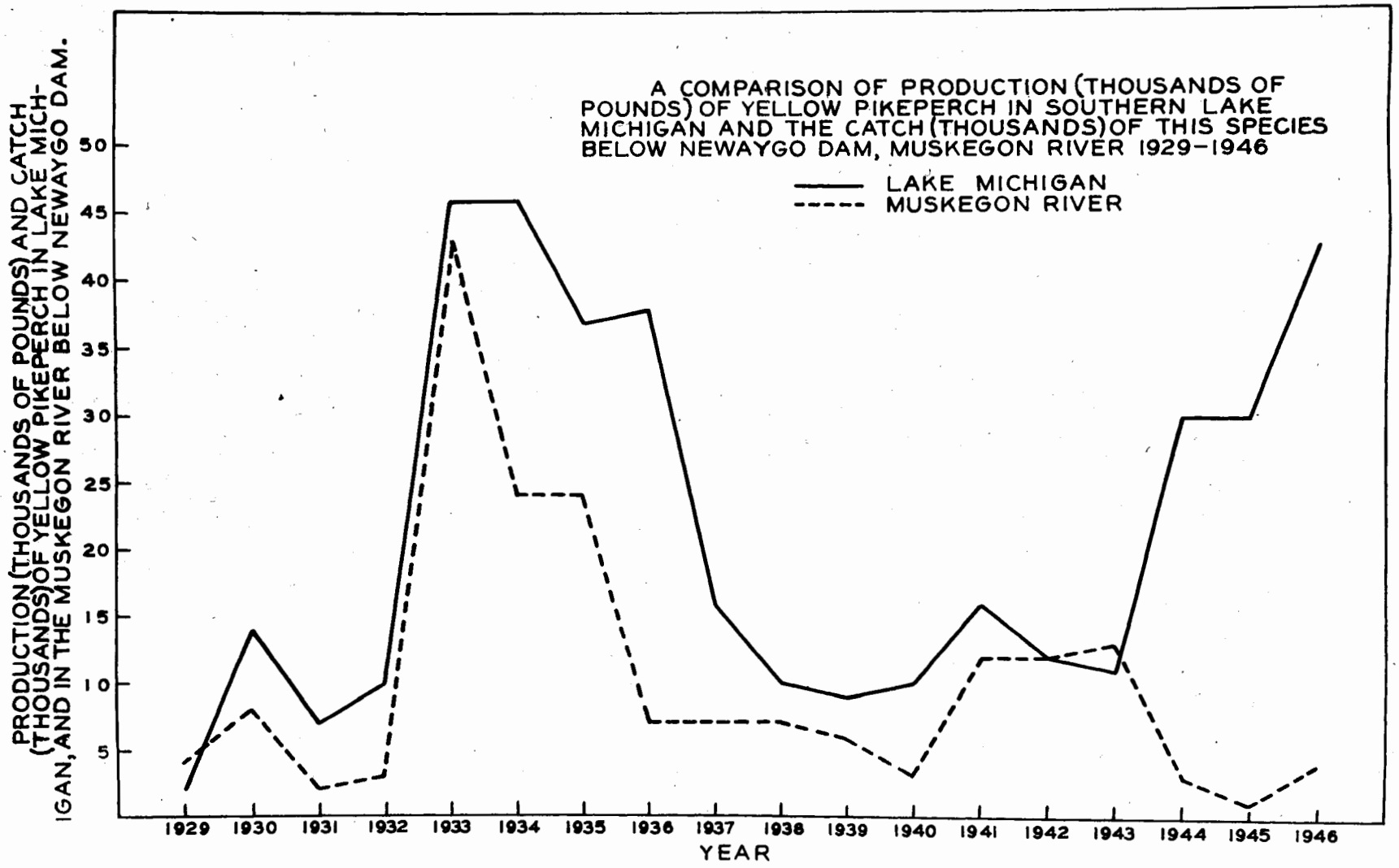
A very marked deviation from the pattern set by earlier data is shown for the period from 1944 to 1946. Earlier trends would have justified the prediction of a substantially larger catch in the Muskegon during the latter period than actually occurred. The fact that the number of nets used during the past several years was about half or less

Table V.--Production (thousands of pounds) and abundance (expressed as percentage of the 1929 - 1943 mean) of yellow pikeperch in the State of Michigan waters of Lake Michigan, from Arcadia south to the Indiana Line, 1929 - 1946,* compared with catch of this species (in thousands) below Newaygo Dam in the Muskegon River.

Year	Lake Michigan		Muskegon River
	Production	Abundance	catch
1929	2	84	4
1930	14	94	8
1931	7	53	2
1932	10	66	3
1933	46	203	43
1934	46	211	24
1935	37	135	24
1936	38	107	7
1937	16	78	7
1938	10	65	7
1939	9	59	6
1940	10	69	3
1941	16	98	12
1942	12	106	12
1943	11	72	13
1944	30	95	3
1945	30	152	1
1946	43	127	4
1947	...	...	6

* Data supplied by Dr. Ralph Hile, U. S. Fish and Wildlife Service

Figure 11


A COMPARISON OF PRODUCTION (THOUSANDS OF POUNDS) OF YELLOW PIKEPERCH IN SOUTHERN LAKE MICHIGAN AND THE CATCH (THOUSANDS) OF THIS SPECIES BELOW NEWAYGO DAM, MUSKEGON RIVER 1929–1946
LAKE MICHIGAN
MUSKEGON RIVER
PRODUCTION (THOUSANDS OF POUNDS) AND CATCH (THOUSANDS) OF YELLOW PIKEPERCH IN LAKE MICHIGAN, AND IN THE MUSKEGON RIVER BELOW NEWAYGO DAM.
50
45
40
35
30
25
20
15
10
5
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
YEAR

than half of the number used in earlier years would without doubt contribute to the catch of smaller numbers of fish. However, even doubling or tripling the 1944 - 1946 figures would not substantially alter the wide discrepancy in the catches in the two waters. There are no data at hand which would indicate the reason for this pronounced change in the trends of the catches. A search for the cause would probably be incomplete, however, if the netting regulations governing the work at Newaygo were not considered. In 1944 the netters were for the first time in the history of the operation confined to about a 1/4-mile length of stream along the north shore of the river. The same was true in subsequent years. It seems quite possible that confinement of the netters to a limited area may have had the effect of making the catch less representative of the numbers of fish in the stream than was the case in earlier years. Observations made by Mr. R. B. Quigg of the U. S. Forest Service from April 9 to April 25, 1936 perhaps lend some support to this possibility. The studies were made at night, and apparently water was sufficiently clear during that year to allow direct observation of the fish in the stream. Quigg reports [1] that a large

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[1] Quigg, R. B., "Notes of Boat Trips Made on Muskegon River during the Pike Run," 1936 (ms).

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percent of the fish seemed to stay toward the center of the stream rather than close to shore. This is a very general observation, but suggests that areas of concentration may occur. Very probably certain areas within reach of shore-based dipnets are more used by the pikeperch than other areas, depending on bottom types, flow of water, depth and other

factors. Inability of netters to net areas of possibly greater fish abundance may have substantially reduced the catch per net.

D. The 1947 Newaygo Transfer.--During the 1947 season, the progress of the dipnetting below Newaygo Dam was followed in somewhat greater detail than in previous years. The handling of considerable numbers of fish in connection with a tagging program undertaken there (discussed below) provided an opportunity to obtain certain information of interest which was not obtained in earlier years.

The dipnetting season of 1947 was much delayed due to the extreme lateness of the season and the failure of pikeperch to appear below the dam in appreciable numbers until mid-April. Netting was begun on the night of April 13, the latest opening date in the history of the transfer. The last night on which nets were used was on April 24th. The 12 days of fishing with 12 nets yielded 5,540 pikeperch, or an average of around 38 per net day. These figures are considerably smaller than the average for the period from 1933 to 1947, which was 21.6 nets and 236 pikeperch per net day. There was a greater fluctuation in daily catch than in most previous seasons, and the peak of the run was not sharply pronounced.

Throughout the 1947 transfer, the river was high and the water roiled. Weather was moderately severe for the season of the year, and a snowfall occurred during the operation. Temperatures of the air and water compared fairly well, however, with those taken in 1936 and 1944, the only other two seasons for which records are quite complete. Temperatures for these three years are shown in Table VI. The readings were made by various Department personnel engaged in the supervision of the transfer.

Table VI.--A record of temperatures in degrees Fahrenheit during netting periods in the Muskegon River below Newaygo Dam, 1936, 1944 and 1947.

	1936		1944		1947					
	(noon)		(10 a.m.)		(3-5 a.m.)		(8-9 a.m.)		(2-5 p.m.)	
April	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
6	...	...	36	36	...	...	...	...	...	...
7	...	...	48	36	...	...	...	...	...	...
8	38	34	45	37	...	...	...	...	...	...
9	40	35	52	39	...	...	...	...	...	...
10	47	38	44	36	...	...	...	...	...	...
11	...	...	42	38	...	...	...	...	...	...
12	...	...	38	38	...	...	...	...	...	...
13	44	39	46	38	42	37	...	...	...	...
14	64	41	40	36	36	38	49	38	56	40
15	50	41	32	36	33	36	39	38	50	40
16	38	41	32	36	32	40	34	38	46	40
17	38	42	54	40	36	38	40	38	50	40
18	44	42	56	40	28	36	34	38	34	40
19	46	42	43	38	36	37	34	38	38	40
20	48	42	53	40	32	38	36	38	48	41
21	36	40	44	40	42	38	38	39	52	42
22	46	41	53	42	52	44	42	40	55	43
23	53	41	...	...	40	42	55	41	60	44
24	55	43	...	...	40	42	48	42	60	46
25	63	43	...	...	...	...	43	42	...	...
26	55	46	...	...	...	...	...	...	...	...
27	62	45	...	...	...	...	...	...	...	...

The water temperature records show a range between 39 and 46 degrees F. during the principal netting season of 1936, 36 to 42 degrees during 1944, and 36 to 46 during 1947. A number of spent female pikeperch were taken on April 14 and 15 during the latter year, together with ripe fish. Spawning was apparently well underway and the peak of the daily catches for the season had already passed, while water temperatures never exceeded 40 degrees Fahrenheit. This also appears to have been true in 1944, although water temperatures may have exceeded 40 degrees during the afternoons of some days during the period from April 6 - 18. In 1936 temperatures ran somewhat higher, and the apparent peak of the migration occurred while water temperatures (taken daily at noon) were 41 to 42 degrees. It is probable that from the standpoint of temperature, spawning of yellow pikeperch, during the three years covered by the table, began when river water reached a maximum daily water temperature of between 37 and 39 degrees (or lower), and reached its height at temperatures ranging from about 38 to 42 degrees.

Certain detailed observations were made of the nets in use on April 15, two days after the beginning of the operation. Twelve nets were set up on that date. The farthest upstream of these was located on the north shore of the river, directly beneath the so-called "lower street bridge" in Newaygo, which crosses the river approximately three-quarters of a mile below Newaygo Dam. The farthest downstream net was located 1,078 feet below this point, a short distance west of the west boundary of the public fishing site located in that area. Nets were spaced at irregular intervals along the stretch of river bank between these extremities. Distances between nets varied from 15 to 525 feet, with an average interval of 90 feet. Outside dimensions of individual nets (all were approximately square) ranged from 7 feet, 8 inches to 10-1/2 feet, covering areas

when set ranging from 59 to 110 square feet (average, 86 square feet). Distance from the inner edge of the net to the shore varied from 9 to 23 feet among the various nets (average, 15 feet), and this same edge of the net was suspended over water varying from 5 to 6 feet in depth and averaging 5.3 feet. Rubble and gravel, insofar as could be determined, constituted the predominant bottom types beneath all nets.

The river at the lower street bridge was 260 feet in width on the date of the above observations. The width of the stream does not appear to change materially in the immediate area downstream. Within the 1,078-foot linear distance of river where nets were in operation, the river thus covers an area of around 280,280 square feet. All 12 nets, when placed in position, covered a total of 1,034 square feet of river bottom, or slightly over 1/3 of one percent (0.37 percent) of the river bottom within the upstream and downstream limits which were being fished. Bottom types are similar throughout the area concerned; current appeared to be about equally swift throughout the period in the area involved; and river depths there do not vary greatly.

The netting during 1947 began when the run was apparently fully underway, and ended while it was still very much in progress. This is rather unfortunate from the standpoint of analysis of certain of the data obtained dealing with the spawning population, as they do not cover the biologically interesting periods of increase and decline at the beginning and end of the run, respectively. However, the material provides some points of interest concerning the mid-portion of the run, and these are included at this point.

In connection with a tagging experiment carried on at Newaygo from April 14 to April 25, 1,750 pikeperch were measured to the nearest 1/10 inch

and the sex of all but 19 (omitted by error) was determined. The results are shown in Table VII, and are further summarized in Table VIII.

Table VII, which shows the lengths, by 2-inch groups of the males and females measured during each day of the work, demonstrates no particularly significant changes in the size of fish composing the spawning population as the season progressed. Among the males, the size group including fish between the lengths of 19 to 21 inches was represented by the largest numbers almost throughout the transfer period. The 17 to 19-inch group was slightly better represented on April 15, 16, 18 and 21, but the margin over numbers of the 19 to 21-inch group was slight on three of these days. The latter group composed 37 percent of the total males for the period of operation. Among the female pikeperch, the group measuring 23 to 25 inches was dominant throughout most of the period and constituted 34.7 percent of the total number of females measured.

The data on sex and size show no significant trends in the representation of any particular size group during the period. In the interest of guarding against too close judgment of slight variations on any given day, it should be noted that some selectivity occurred in the selection of the fish for measurement which tended to slightly favor the representation of larger fish in the total in some instances. In removing fish from crowded live boxes, it was noted that larger fish were generally caught first, while smaller fish frequently escaped capture until most of the larger fish had been removed. On some occasions it happened that tagging was interrupted at the end of a working day while a live box was only partially emptied. This would tend to increase the representation of larger fish in the total. Although operating largely to increase the

Table VII.--Daily record of yellow pikeperch tagged at Newaygo Dam in the Muskegon River, showing size groups and sex*/

Length, inches	April 14		15		16		17		18		19		20		21		22		23		24		25		Totals	Average percent of totals
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent		
Males																										
13.0-14.9	3	3.6	2	3.7	2	4.5	7	5.2	2	4.2	5	10.4	1	2.3	1	2.1	4	8.0	2	6.1	1	2.4	2	4.6	32	4.8
15.0-16.9	21	25.3	7	12.7	3	6.8	28	20.6	6	12.8	2	4.2	6	14.0	7	14.6	8	16.0	2	6.1	3	7.1	2	4.6	95	14.1
17.0-18.9	18	21.7	19	34.5	16	36.4	34	25.0	14	29.8	5	10.4	7	16.3	18	37.5	13	26.0	5	15.1	9	21.4	10	23.3	168	25.0
19.0-20.9	30	36.1	18	32.7	15	34.1	50	36.8	13	27.7	22	45.8	19	44.2	8	16.6	19	38.0	15	45.5	19	45.2	22	51.2	250	37.2
21.0-22.9	11	13.3	7	12.7	8	18.2	15	11.0	12	25.5	10	20.8	9	20.9	13	27.1	4	8.0	8	24.2	7	16.7	5	11.6	109	16.2
23.0-24.9	...	...	2	3.7	...	...	1	0.7	...	...	4	8.4	1	2.3	1	2.1	1	2.0	1	3.0	2	4.8	2	4.7	15	2.2
25.0-26.9	...	...	...	...	...	...	1	0.7	...	...	...	...	...	...	...	...	1	2.0	...	...	1	2.4	...	...	3	0.5
Totals	83	...	55	...	44	...	136	...	47	...	48	...	43	...	48	...	50	...	33	...	42	...	43	...	672	...
Females																										
17.0-18.9	...	...	...	...	3	5.4	1	0.7	2	3.8	1	0.5	2	1.9	1	2.0	1	1.0	1	1.5	1	1.8	1	1.9	14	1.3
19.0-20.9	12	10.34	8	11.8	5	8.9	17	12.2	2	3.9	11	5.4	5	4.9	2	3.9	6	6.1	5	7.6	6	10.7	6	11.6	85	8.0
21.0-22.9	35	30.2	24	35.3	13	23.2	46	33.1	14	26.9	56	27.7	30	29.1	13	25.5	31	31.6	20	30.3	21	37.5	9	17.3	312	29.5
23.0-24.9	33	28.4	23	33.8	19	33.9	46	33.1	13	25.0	77	38.1	38	36.9	18	35.3	38	38.8	22	33.3	22	39.3	19	36.5	368	34.7
25.0-26.9	28	24.1	10	14.7	15	26.8	24	17.3	17	32.7	46	22.8	23	22.3	17	33.3	19	19.4	17	25.8	5	8.9	13	25.0	234	22.1
27.0-28.9	8	6.9	3	4.4	1	1.8	3	2.2	3	5.8	10	5.0	4	3.9	...	...	3	3.1	1	1.5	1	1.8	4	7.7	41	3.9
29.0-30.9	...	...	...	...	...	...	2	1.4	1	1.9	1	0.5	1	1.0	...	...	...	...	...	...	...	...	...	...	5	0.5
Totals	116	...	68	...	56	...	139	...	52	...	202	...	103	...	51	...	98	...	66	...	56	...	52	...	1,059	...

*/ Nineteen unsexed fish are not included in these totals.

Table VIII.--Summary of average lengths and sex of yellow pikeperch tagged at Newaygo Dam in the Muskegon River, 1947.

Date	Males		Females		Both sexes	
April	Number	Average length (Inches)	Number	Average length (Inches)	Number	Average length (Inches)
14	83	18.6	116	21.0	200	20.0
15	55	19.0	68	23.1	124	21.3
16	44	19.0	56	23.5	101	21.5
17	136	18.7	139	23.2	275	21.0
18	47	19.1	52	24.0	100	21.6
19	48	19.7	202	23.8	250	23.0
20	43	19.4	103	23.5	150	22.2
21	48	19.0	51	23.7	100	21.4
22	50	18.7	98	23.5	150	21.9
23	33	19.6	66	23.4	100	22.2
24	42	19.7	56	22.9	100	21.5
25	43	19.5	52	23.7	100	21.9
	672	19.1	1,059	23.2	1,750[1]	21.6

[1] Nineteen fish of unknown sex included in this total

number of females over the (smaller) males in the total (61.2 percent in this sample as compared to 57.7 percent in a random sample--see below), some degree of selectivity favoring larger size groups of a given sex may also have been exerted.

Table VIII shows the average lengths (based on measurements to the nearest 1/10-inch) of the two sexes as the season progressed. Males ranged in average length from 18.6 to 19.7 inches and this figure equaled 19.1 inches for the period. Daily averages of females were between 21 and 24 inches, while the average for the period was 23.2. Both sexes taken together averaged from 20 to 23 inches in length, and the grand average for the whole period was 21.6 inches. Again, no significant changes are shown in average size of either or both sexes with the progress of the season.

The length of yellow pikeperch in relation to age in the spawning population is shown in Table VIII-A. The figures are based on scale samples taken from 125 pikeperch during the course of the transfer. Judging by the sample, age groups III to X were included in the spawning population. Probably several older age groups were present in small numbers. Comparison of Tables VIII and VIII-A suggests that the spawning run was probably dominated in numbers by 5- and 6-year-old males and 6-, 7- and 8-year-old females. Males of these year classes averaged 18.8 and 20.0 inches respectively, while the average length of 672 males handled during the transfer was 19.1 inches. Females of the age of 6 years averaged 22.6 inches, those 7 years old, 23.3 inches, and those 8 years old averaged 25 inches in length. The average length of 1,059 females measured during the transfer was 23.2 inches. The sample of fish from which the data in Table VIII-A are derived were taken at random, and present further evidence that the above-named age groups dominated the

Table VIII-A.--Growth rate of yellow pikeperch taken in the Muskegon River below Newaygo Dam, April 1947.

Sex	III	IV	V	VI	VII	VIII	IX	X
Males	15.7(3)[3]	18.1(7)	18.8(11)	20.0(17)	21.8(4)	24.5(1)	...	...
Females	...	19.5(3)	20.8(9)	22.6(21)	23.3(22)	25.0(19)	26.4(8)	27.5(1)
Combined sexes	15.7(3)	18.5(10)	19.7(20)	21.5(38)	23.1(26)	25.0(19)	26.4(8)	27.5(1)
Tentative state average, inland waters (combined sexes)	13.4	14.6	15.5	16.8	17.6	18.2	19.2	...

spawning run. A comparison of tables VII and VIII-A suggests a fairly strong representation of 3-year-old males among the spawners, but very few, if any, females of that age. Four-year-old and 7-year-old males may have been about equally represented in the total. Females outside of the three dominant age groups mentioned were few in number, with older fish showing up in somewhat larger numbers than those younger than the dominant groups. A considerably faster growth is shown by females than by males in the sample taken. The tentative state average for lengths of yellow pikeperch at various ages (combined sexes) in inland waters is given in Table VIII-A, for comparison with the Muskegon River fish. The latter are seen to grow at a far faster rate than the average for inland waters. Although no figures are available pertaining to growth rate of yellow pikeperch from southern Lake Michigan, rapid growth, as well as a materially faster rate of growth of females than males, has been demonstrated for certain other Great Lakes waters. Eight pikeperch collected by an Institute survey party in August of 1936 ~~(in about 24 gill-net days)~~ were distributed among five age groups and provide insufficient data upon which to base the average growth rate of even any one age group in the population as a whole. Age groups, total length in inches, and numbers of specimens in each group were as follows: II, 13.1 (2); III, 14.3 (2); IV, 16.6 (1); VI, 17.0 (1); VII, 15.7 (1). The few specimens examined showed a growth rate which is for the most part somewhere between the state average and the average for Muskegon River fish. A larger midsummer collection (with the hope of further sampling the resident population), in addition to a collection of scale samples from pikeperch in southern Lake Michigan, might provide worthwhile data upon which to base an inference as to the source of the pikeperch which migrate up the Muskegon River each spring.

The proportional representation of the two sexes during the 1947 season, based on a total of 1,298 pikeperch examined at random, is shown in Table IX. (Sex is readily determined during the spawning season. Slight pressure on the posterior portion of the abdomen of sexually mature males causes milt to be extended from the vent (Figure 12), and they can thus be unmistakably distinguished from females). Included in the totals are only fish taken from live boxes which were completely emptied, and in which all occupants were sexed. The assumption made is that fish taken by dipnetters are taken at random. No check was made to determine whether this occurs, but it does not appear that the gear used would be selective in this regard. Although females taken in the daily samples constituted up to nearly 75 percent of the catch, and down to as low as 39 percent (on successive days!), the average ratio for the period was about four males to six females. Daily totals do not deviate from this general average with sufficient consistency to permit the recognition of significant basic trends or changes in the representation of the sexes as the season progresses. Although the average figure is thought to be near to a true value, the daily totals are probably based on numbers of fish which are insufficiently large to permit serious conclusions. Thus an attempted explanation of the daily variations in ratio does not seem required, and none is offered here.

The condition, with regard to development of the ovaries, of 964 female pikeperch examined between April 16 and April 25 is shown in Table X. About 2/3 (66.5 percent) of the females examined were "ripe" (extruded eggs freely upon the exertion of slight abdominal pressure), making it quite apparent that spawning was actively occurring in the immediate area where netting was done. Thirty percent of the fish were "green" (had not yet begun spawning, as revealed by widely distended

Table IX.--A comparison of numbers of male and female yellow pikeperch occurring below Newaygo Dam in the Muskegon River, April 1947.

Date	Number sexed	Males		Females	
		Number	Percent	Number	Percent
April					
14	153	68	44.4	85	55.6
15	119	51	42.9	68	57.1
16	81	34	42.0	47	58.0
17	252	129	51.2	123	48.8
18	65	32	49.2	33	50.8
19	149	38	25.5	111	74.5
20	46	28	60.9	18	39.1
21	89	45	50.6	44	49.4
22	95	33	34.7	62	65.3
23	84	30	35.7	54	64.3
24	96	41	42.7	55	57.3
25	69	20	29.0	49	71.0
	1,298	549	42.3	749	57.7

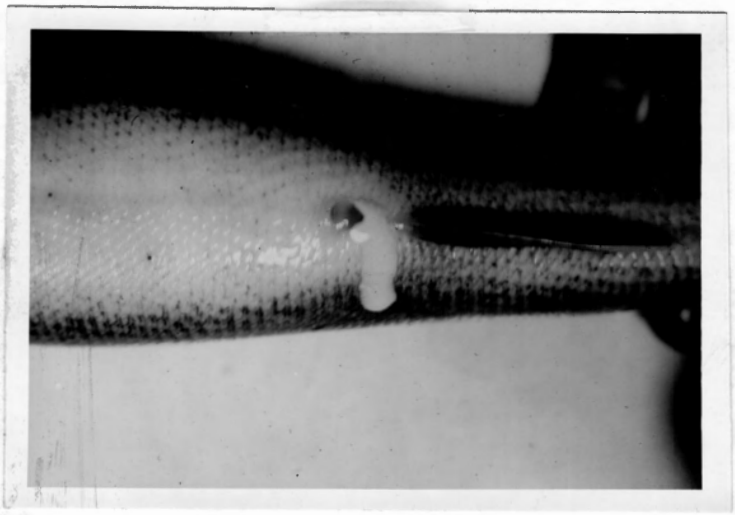

Figure 12.--Milt flowing from the vent of a sexually mature male pike-perch during the spawning season.

Table X.--Condition of ovaries of female yellow pikeperch examined below Newaygo Dam in the Muskegon River, April 1947.

Date	Number of females examined	Ripe		Green		Spent	
		Number	Percent	Number	Percent	Number	Percent
April							
16	94	53	56.4	38	40.4	3	3.2
17	140	88	62.9	40	28.5	12	8.6
18	91	56	61.5	28	30.8	7	7.7
19	202	106	52.5	93	46.0	3	1.5
20	103	74	71.9	26	25.2	3	2.9
21	64	41	64.1	20	31.2	3	4.7
22	98	74	75.5	23	23.5	1	1.0
23	64	47	73.4	15	23.5	2	3.1
24	57	55	96.5	2	3.5	0	0
25	51	47	92.2	4	7.8	0	0
	964	641	66.5	289	30.0	34	3.5

abdomens and failure to release eggs when pressure was applied). The remaining 3.5 percent were "spent" (recognized by lean, flat abdomens and failure to extrude eggs in any quantity upon the application of pressure). Green females constituted 46 percent of the 202 females examined on April 19 (just past the peak of the spawning migration, as judged by daily catch records for the season). In general, they decreased in numbers from this point on, appearing in much reduced numbers in the totals for April 24 and 25, while the number of ripe females increased proportionately. Reduction in numbers of green females would logically indicate the approach of the end of the spawning season. By April 24 and 25, virtually all females remaining in the area were actively engaged in spawning. Spent females were few in number throughout the period, suggesting that female pikeperch leave the area very soon after the discharge of sexual products has been completed; otherwise their numbers should have increased steadily with the progress of the season. The time required for a female to release its eggs is not known, but an extended period is not necessary. Eggs throughout the ovaries appear to ripen suddenly and simultaneously, when a certain stage in development is reached. On the morning of April 21, 13 green females were carefully chosen for egg counts, the selection involving the exertion of severe pressure on the abdomens to make certain that no eggs had been extruded. By mid-afternoon, upon removal from a live box in which they were held, two of these had begun passing eggs very freely. Upon dissection, the contents of both ovaries were found to consist of an entirely unconsolidated, fluid mass of eggs, all of which appeared to be equally ready for discharge. Puncture of an ovary wall resulted in an unrestricted flow of eggs which continued at steady rate (with the ovary

lying on a flat surface) until a large proportion of the contents had poured forth, and pressure within the ovary had become completely dissipated.

E. Stocking Records.--A discussion of the Newaygo transfer would scarcely be complete without some mention of the ultimate disposal of the thousands of game fish which have been caught. Stocking records for adult yellow pikeperch taken during the transfers of the past 20 years are shown in Table XI. Adults of this species have been planted in each of the six Muskegon impoundments and in a total of 19 lakes during the years for which there are records. During the past 10 years, distribution has been restricted to the impoundments and nine lakes of the drainage, in the vicinity of Newaygo. In the 15 years for which records are complete, 137,977 pikeperch (78.8 percent of the total) have been planted in the Muskegon impoundments and 37,018 (21.2 percent) have been stocked in neighboring lakes. Newaygo, Hardy and Croton Ponds, in that order, have received the largest shares of fish among the impoundments, while among the lakes, the high totals are for Hess, Pickerel, Emerald and Fremont Lakes, respectively. During 1947, 75.4 percent of the pikeperch were placed in the impoundments and the remainder in nearby lakes.

There are slight differences in the totals listed in Table XI, as compared to catch records listed in Table II. Some of the older catch records were taken from various sources, and are apparently somewhat incomplete. In certain other years, occasional mortality has occurred. In 1947, 64 fish were used for scientific purposes (experiments to determine the effect on growth and mortality of tagging and for egg counts).

F. Cost Records.--The cost of the Newaygo transfer has varied within rather wide limits during different years, changing with economic

Table XI.--Stocking records for yellow pikeperch taken by means of dipnets below Newaygo Dam in the Muskegon River, 1928-1947.

Year	Newaygo Pond	Croton Pond	Hardy Pond	Rogers Pond	Big Rapids Pond	Little Muskegon or Morley	Hess Lake	Brooks Lake	Kimball Lake	Pickerel Lake	Emerald Lake	Sylvan Lake	Fremont Lake	Robinson Lake	Half Moon Lake	Lake Missaukee	Bill's Lake	Clear Lake	Gull Lake	Long Lake	Crystal Lake	Secord Lake	Chippewa Lake	Emery Lake	Leelanau Lake	Totals
1928	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	469
1929	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,680
1930	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8,327
1931	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1,547
1932	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3,151
1933	11,005	8,400	14,205	771	2,768	...	2,378	...	...	3,545	...	513	...	...	445	101	...	150	...	...	442	404	305	...	...	45,432
1934	4,897	3,981	5,746	2,001	1,588	...	1,332	...	599	875	1,321	...	...	...	395	400	486	...	...	...	...	...	...	...	...	23,621
1935	3,242	5,710	4,819	2,216	1,610	909	1,124	...	412	581	1,109	...	829	401	234	337	...	343	348	...	...	...	...	...	...	24,224
1936	1,012	955	1,095	990	737	540	250	...	...	...	...	...	274	...	...	200	...	...	200	...	...	...	...	223	200	6,676
1937	1,691	1,057	932	788	722	627	322	...	242	70	214	...	251	...	...	...	...	...	...	...	...	...	...	...	...	6,916
1938	1,279	1,202	1,094	569	278	316	240	...	298	278	...	374	480	284	...	...	...	...	...	374	...	...	...	...	...	7,066
1939	1,247	1,267	551	797	279	134	314	177	189	273	221	281	278	199	...	...	...	...	...	135	...	...	...	...	...	6,342
1940	519	490	93	140	114	100	98	222	142	110	110	150	122	158	...	...	...	...	...	73	...	...	...	...	...	2,641
1941	4,427	2,893	1,537	1,274	...	...	654	...	...	574	752	...	349	...	...	...	...	...	...	...	...	...	...	...	...	12,460
1942	3,271	3,029	1,323	1,218	...	316	755	706	135	...	494	...	751	473	...	...	...	...	...	...	...	...	...	...	...	12,471
1943	5,136	2,034	1,992	1,221	317	183	349	307	...	326	670	319	332	...	...	...	...	...	...	...	...	...	...	...	...	13,186
1944	820	698	623	406	222	224	195	...	...	...	...	127	...	...	...	...	...	...	...	...	...	...	...	...	...	3,315
1945	652	...	...	...	...	...	...	49	43	45	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	789
1946	1,125	1,053	930	673	250	...	60	60	82	67	80	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4,380
1947	410	1,854	572	1,116	177	518	250	196	...	176	207	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5,476
Totals	40,733	34,623	35,512	14,180	9,062	3,867	8,321	1,717	2,142	6,920	5,178	1,764	3,666	1,515	1,074	1,038	486	493	548	582	442	404	305	223	200	192,169

conditions, length of the netting season, number of fish transferred, and the amount of assistance rendered by the U. S. Forest Service (C.C.C. labor). By and large, the shorter the season, the less has been the expense, although increases in the numbers of fish handled have tended to decrease the cost per fish. Since 1933, the cost to the Consumers Power Company has been $750 per year, except during the 3 years (1940, 1944 and 1945) when the catch did not attain a total of 3,750 game fish.

An analysis of the costs for the 4-year period from 1943 to 1947 is shown in Table XII. Average costs to the Conservation Department for these years have amounted to $141.69 for supervision, $257.62 for labor, $203.79 for patrolmen, $73.48 for travel expenses, $164.30 for motor vehicle operation, and $9.75 for miscellaneous items. The average annual cost for the period has been $848.63. During this time 27,213 yellow pikeperch have been transferred at an average cost (if the few other game fish are ignored), of about $0.16 per fish. This amount has varied from slightly under $0.06 in 1943 to over ten times this amount in 1945, when less than 800 fish were handled. These figures are tabulated in Table XIII. Cost to the Consumers Power Company has varied from about $0.06 in 1943 to $0.20 during the two years in the period when relatively few fish were taken. Total average cost for each fish transferred has ranged from $0.11 to $0.83 at the 1947 rate of recovery of marked fish (discussed below) at least one out of eight of the transferred fish reached angler's creels during the first season of fishing following the transfer. If it is assumed that this recovery rate has been relatively constant during the period concerned, the returns to anglers from the fish planted have been about as shown in column seven of Table XIII. The resulting cost to the Department per

Table XII.--A summary of the cost to the Conservation Department of the Newaygo transfer, 1943-1947[1]

	1943	1944	1945	1946	1947
Supervision (Fish and Field Administration Divions)	$ 84.31	$ 255.06	$ 77.10	$107.99	$ 184.00
Labor (Clerical, drivers, assistants)	286.74	285.76	176.64	254.42	284.55
Patrolmen	175.00	287.04	109.34	217.06	230.50
Travel expenses (All employees)	53.48	123.82	46.31	75.79	68.00
Motor vehicles	144.00	175.40	85.00	162.70	254.40
Miscellaneous (Maintenance, postage, telephone fees, etc.)	8.00	13.00	6.00	12.00	...
Total	$751.53	$1,140.08	$500.39	$829.96	$1,021.45

[1] Cost analyses by Mr. J. T. Wilkinson, Regional Fisheries Supervisor, Paris, Michigan.

Table XIII.--A summary of costs of the Newaygo transfer, on a unit basis, 1943-1947

Year	Total cost of transfer to Department of Conservation	Number of fish transferred	Cost per fish to Department	Cost per fish to Consumers Power	Total average cost per fish transferred	Probable recoveries during first fishing season (12.5 percent)	Estimated cost to Department per fish creeled during the first fishing season	Total estimated cost per fish caught during the first fishing season	Total estimated cost, assuming eventual 25 percent recovery
1943	$ 751.53	13,186	$0.06	$0.06	$0.11	1,648	$0.46	$0.91	$0.46
1944	1,140.08	3,318	0.34	0.20	0.54	415	2.75	4.35	2.18
1945	500.39	789	0.63	0.20	0.83	99	5.05	8.34	4.17
1946	829.96	4,380	0.19	0.17	0.36	548	1.51	2.88	1.44
1947	1,021.45	5,540	0.18	0.14	0.32	692	1.48	2.56	1.28
Totals	$4,243.41	27,213	0.16	0.11	0.27	3,402	1.25	2.15	1.08

fish caught by anglers during the first season after transfer has ranged from $0.46 in 1943 to $5.05 in 1945, and the total cost (including funds provided by Consumers Power) has been between $0.91 and $8.34. It is not yet known what numbers of fish are caught during the years following a given transfer. It is reasonable, however, to assume that some fish are taken for a period of several years, within the Muskegon drainage or in Lake Michigan. It is very doubtful, however, if the sum of the numbers caught during subsequent years ever equals the number caught during the first season after transfer. Hence halving the cost per creeled fish taken during the first year provides a minimum figure for the cost of each transferred fish eventually taken by anglers. For the Department, these costs would range from $0.23 to $2.53.

Comparable figures for other transfer operations are lacking. However, estimated costs (about 1945) to the Department of each legal-sized trout planted in Michigan streams which is eventually creeled is between $0.80 (brook and rainbow trout) and $1.60 (brown trout).*

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*Westerman, F. A., and Hazzard, A. S., "For Better Fishing," Michigan Conservation, Nos. 7, 8, 9 and 10, 1945.

III. General observations on physical, chemical and biological conditions in the Muskegon River impoundments and in six Newaygo County lakes.

A. The Muskegon impoundments

Newaygo Pond is the farthest downstream of the series of impoundments in the Muskegon River. It is the result of a dam located in Section 19, T12N, R12W, Newaygo County, within the city limits of

Newaygo, and approximately 38 miles above the mouth of the Muskegon River, at Lake Michigan. Highway M-37 crosses the river immediately east of the dam. A portion of the impoundment, as well as the dam and the highway bridge are shown in Figure 13. The dam is 17 feet in height and was erected before 1900. It is reported to have been purchased from a cement company by Consumers Power Company in 1923, and has been used by the latter organization for power development since that time. It was reconstructed soon after purchase. Except for a partial washout in 1943, it has been in operation without interruption since that time. A chute-type fish ladder is present, but it is not known to be functional insofar as game fish migration is concerned.

The impoundment is shallow as compared to several of the others in the series, as might be judged by the height of the dam. It is restricted on each side by steep valley banks, and its width at most points does not greatly exceed the width of the river channel. There is a distance of over 12 miles between Newaygo Dam and the next dam upstream, but only about 1/3 of the distance between the two dams is included in the impounded area.

Croton Dam is located in Section 18, T12N, R11W, near the village of Croton and only a few hundred yards below the confluence of the Muskegon and its principal tributary, the Little Muskegon River. The structure is 42 feet in height and was built in 1907 by Consumers Power. There is a fish ladder present, but its value in facilitating fish migration is very doubtful.

The impoundment resulting from the presence of Croton Dam is considerably larger than that produced by Newaygo Dam. The backwater is divided into two distinct ponds, connected by a steep, narrow channel passing beneath a road bridge. The larger of the ponds extends northward

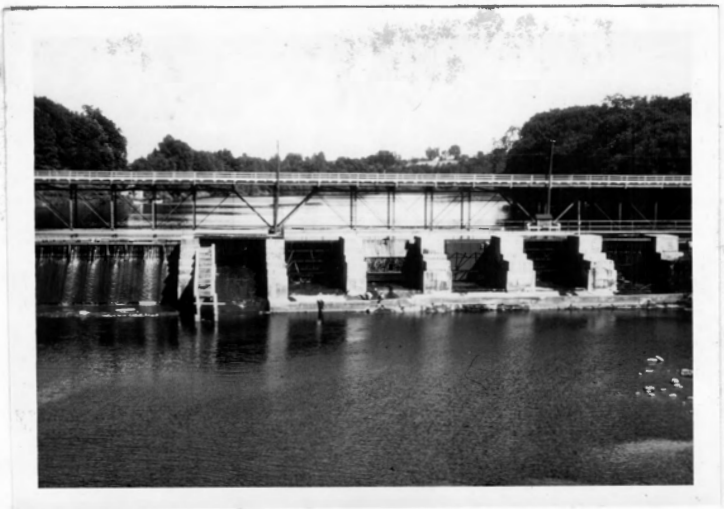

Figure 13.--Newaygo Dam, Muskegon River, showing impoundment and Highway M-37 bridge in background. August, 1947.

up the main stream to Hardy Dam, which is 5 miles upstream. It is up to a half mile in width and reaches a depth of about 40 feet. The smaller pond extends up the Little Muskegon for about 1-1/2 miles.

Hardy Dam, the largest earth-filled dam in the world, is the newest of the Muskegon River dams. It is 100 feet in height and was built in 1931. It is located in Section 28 of T15N, R11W, Newaygo County, about 2 miles south of the village of Big Prairie. It impounds water upstream for a distance of over ten miles, into the southwestern portion of Mecosta County. The pond has a depth considerably greater than 100 feet at some points, and is up to a mile in width.

Rogers Dam is located 19 miles upstream from Hardy Dam. It is in Section 11, T14N, R10W, Mecosta County, six miles south of the city of Big Rapids. Highway U.S-131 passes just west of the dam and parallels the west shore of the impoundment for a short distance. The dam has a height of 40 feet and was built in 1905. Although it impounds water upstream for a distance of several miles, the pond does not much exceed a quarter of a mile in width and 40 feet in depth.

Big Rapids Dam is located within the city limits of Big Rapids. It is the same height as Newaygo Dam (17 feet), and was built in 1911.

These five dams, Newaygo, Croton, Hardy, Rogers and Big Rapids constitute the major dams in the drainage. A sixth, smaller dam is located on the Little Muskegon River. It is in Section 30, T13N, R9W of Mecosta County, near the village of Morley, and impounds an area of water of small size (well under 100 acres). The remains of a dam are located near the village of Leota, for upstream on the Muskegon, at a point about 30 miles below Houghton Lake. It has not been used for many years, and as early as 1932 was not considered an obstacle to fish movement except during periods of low water.

The area surrounding the Muskegon impoundments is for the most part wooded, with rolling topography and essentially sand and clay soils. All ponds bear extensive scars of past erosion. In Rogers and Newaygo Ponds the once eroded areas are largely covered with vegetation. In Croton and Hardy Ponds, however, barren, eroded banks rise almost vertically from the water's edge to heights of 30 feet or more. Some of these (in Croton Pond) are shown in Figure 14. Much of the shoreline of the lower reaches of Hardy Pond is lined with such eroding cliffs, and in Croton Pond, which is almost 25 years older than Hardy, it is only the less precipitous banks which have acquired a cover of vegetation. Severe rains, spring run-off and the wash of waves during storms contribute to the quantities of silt and sand poured into the ponds. Aquatic vegetation has little opportunity to become established in the loose, shifting bottom soils below these precipices, with the result that plants are scarce or absent in most such areas. The barren, eroded banks materially detract from the scenic beauty of the impoundments, and are a source of annoyance to the esthetic sense of all but the insensitive among those who view them.

Resort development along impounded portions of the Muskegon by and large, is not extensive. The number of cottages along the shores of any one pond probably does not exceed a hundred (excluding villages), and is considerably smaller than this in the case of several of the backwaters. Several boat liveries are distributed among the impoundments.

Temperature and chemical conditions in the ponds vary with their respective depths. Although the impoundments have a number of characteristics of lakes, the flow of a considerable volume of water through each causes some differences between the two types of waters. Certain observations made during September, 1947, are summarized in Table XIV.

Figure 14.--View of eroded shoreline at Croton Pond, Muskegon River, 1947.

Table XIV.--Temperatures, dissolved oxygen, and alkalinity of water in four Muskegon River impoundments, September, 1947.

Location of station	Depth of water at station in feet	Date 1947	Water depth, feet	Temperature, degrees Fahrenheit	Oxygen parts per million	Methyl orange alkalinity
Newaygo Pond						
200 feet above dam	12	September 10	Surface	74.1	...	131
			10	73.8	7.3	135
Croton Pond						
800 feet above dam	33	September 9	Surface	75.9	...	128
			7	74.3	...	...
			10	72.1	...	...
			13	70.2	5.6	...
			16	68.7	3.5	...
			20	66.6	0.7	...
			24	64.8	1.7	...
			27	64.0	...	...
			30	61.5	0.0	144
Hardy Pond						
1,000 feet above dam	115	September 11	Surface	75.4	...	133
			20	74.3	5.0	...
			30	72.7	1.7	...
			40	71.2	...	...
			43	69.8	...	...
			50	68.0	0.2	...
			58	67.3	...	...
			66	66.0	0.2	...
			70	65.5	...	...
			79	62.2	...	...
			82	61.9	...	...
			85	61.2	...	...
			90	60.6	...	...
			99	57.6	0.0	133
Rogers Pond						
1,000 feet above dam	35	September 11	Surface	76.3	...	147
			15	72.3	...	...
			18	71.6	...	...
			21	71.2	...	...
			24	69.8	4.0	...
			27	69.1	...	...
			30	67.6	...	...
			33	66.4	0.4	154

As might be expected, Newaygo Dam probably has an ample supply of dissolved oxygen to support fish throughout its shallow depth. Its methyl orange alkalinity (alkalinity resulting from dissolved minerals and certain buffer salts, a criterion of hardness of the water) ranges from 131 to 135 parts per million, indicating that the water is quite hard. Temperatures on September 10 were about the same at the surface as at a depth of 10 feet.

The oxygen distribution in Croton Pond during the summer months is such as to be definitely restricting to fish movements. The amount of oxygen ordinarily considered as being required to sustain fish life (three to four parts per million) is present only in about the upper 16 feet of water, and fades rapidly below this point. This is consistent with the observations of a number of local residents who have noticed that bait minnows lowered into deep water during the summer die very quickly. The thermocline (an area of rapidly decreasing temperature with increase in depth), often present in deep lakes during the summer, is very weakly developed in Croton Pond. On the date of the water analysis, temperatures from surface to bottom approached a rather even temperature gradient, ranging from about 76 degrees F. at the surface to 61.5 degrees near the bottom. It should be noted that if conditions near the spillway are similar to those at the point at which the analyses were made (800 feet above the dam), fish would be unable to move downstream during summer months, even though water is spilled from the bottom of the spillway, because of the low oxygen levels at that depth.

From the standpoint of temperature and dissolved oxygen, conditions at Hardy Pond are somewhat similar to those at Croton. In late summer, oxygen supply diminishes below depths of about 20 feet, and insufficient

oxygen is present at a depth of 30 feet to maintain fish. During the summer there is a fairly uniform temperature gradient from surface to bottom. Temperatures ranged from 75.4 degrees Fahrenheit at the surface to 57.6 degrees at 99 feet, on the day of the examination.

Rogers Pond exhibits conditions not materially different from Hardy and Croton. It has a temperature gradient from surface to bottom, and a deficiency of oxygen in the deeper parts of the pond. A somewhat higher content of dissolved minerals and buffer salts is revealed by the higher methyl orange alkalinity in this pond.

No records are available for Big Rapids Pond. In an impoundment of its size and depth, conditions probably parallel those behind Newaygo Dam, with little variation in temperature or dissolved oxygen at different depths at any given time.

Detailed observations of biological conditions in the impoundments, outside of studies of the fish present in each, were not made during 1947. In general, large numbers of crayfish were observed in portions of each impoundment, and many fish of forage size were collected during the seining of shoreward areas. Vegetation is varied in abundance among the impoundments, with Hardy Pond having somewhat fewer plants than the other waters. This would be expected, since it is the newest of the reservoirs. Although some localized areas already have considerable numbers of aquatic plants, an increase in other areas can probably be expected as the reservoir increases in age. Croton Pond appears to offer an example in this regard. An extensive, shallow shoal in the principal impoundment, along the east shore and just north of the confluence of the two impoundments (main stream and the Little Muskegon), was seined by members of the Institute Staff on July of 1935 and again in 1947. In the former year, vegetation was listed as "scarce," while

in the latter year, the entire shoal was so thickly covered with submerged pondweeds, coontail, stonewort and other plants that seining was very difficult. Unless water fluctuation was considerably more severe in the former year than in the latter, a substantial increase of vegetation during the intervening period seems to be indicated. Croton Pond, in general, has adequate cover in the form of aquatic plants, although areas lying directly beneath actively eroding banks continue to be relatively barren. Vegetation in Newaygo Pond is of moderate abundance. Rogers Pond has dense beds of submerged vegetation on both sides of the main river channel. Some of these are over a hundred feet in width and extend across unbroken areas of a half mile or more in length. Large numbers of young game fish and minnows frequent these heavily vegetated areas.

The species of fish known to be present in the four major impoundments are listed in Table XV. The entries are based on collections made by members of the Institute staff and by other Fish Division personnel in 1926, 1928, 1929, 1934, 1935 and 1947. A very general estimate of the abundance of the various species is given, based (by inspection) on their representation in the various collections and on general creel census reports.

Ten species of game fish have been collected in each of the waters except Hardy Pond. Pumpkinseeds have not been collected by the Institute in the latter water, although they undoubtedly occur in small numbers. Other species common to all ponds are rainbow trout, northern pike, yellow perch, yellow pikeperch, smallmouth bass, largemouth bass, bluegills, rock bass and black crappies. Of the coarse species, only white suckers and various species of redhorse are known to be found in all ponds. Thirteen species of forage fish have been collected in Newaygo

Table XV.--A record of species of fish collected in four Muskegon River impoundments, with estimates of their abundance.[1]

	Newaygo Pond	Croton Pond	Hardy Pond	Rogers Pond
	General abundance			
Game fishes				
Rainbow trout	occasional	occasional	rare	occasional
Northern pike	common	occasional	rare	common
Yellow perch	common	abundant	abundant	common
Yellow pikeperch	common	abundant	abundant	rare
Smallmouth bass	common	common	occasional	common
Largemouth bass	rare	rare	rare	abundant
Bluegill	occasional	common	rare	common
Pumpkinseed	rare	rare	...	common
Rock bass	common	abundant	common	abundant
Black crappie	occasional	common	common	common
Coarse fishes				
White sucker	abundant	common	common	common
Redhorse (various spp.)	abundant	common	common	common
Hog sucker	rare	rare	...	...
Black bullhead	common	...	...	...
Brown bullhead	...	rare	...	...
Obnoxious fishes				
Bowfin	rare	...	...	...
Carp	...	...	rare	...
Forage fishes				
Blacknose shiner	rare	...	...	...
Blackchin shiner	abundant	...	...	...
Mimic shiner	abundant	common	occasional	...
Sand shiner	rare	common	...	occasional
Common shiner	common	common	occasional	...
Rosyface shiner	occasional	rare	...	...
Bluntnose minnow	abundant	common	common	common
Logperch	occasional	common	common	occasional
Johnny darter	occasional	common	occasional	occasional
Blacksided darter	occasional	rare	...	common
Creek chub	common	occasional	rare	...
Hornyhead chub	common	rare	...	...
Brook stickleback	abundant	...	...	...
Stone roller	...	...	...	rare
Brook silversides	...	rare	...	...

[1] Based on occurrence in Institute collections and in general creel census reports.

Pond, while somewhat fewer species have been taken in upstream areas. Doubtless extensive seining would provide further records for the upper impoundments as well. It is of some interest in passing to note the difference in seining results on the area of shoal mentioned above, where vegetation was reported as "scarce" on July 25, 1935, and as "abundant" on July 29, 1947. On the former date, 2-1/2 hours of seining with a 100-foot bag seine produced four species of game fish, three of coarse fishes, and one forage species. Water temperature was 84.2 degrees Fahrenheit. On July 29, 1947, four hours of seining yielded nine species of game fish, four coarse fish, and eight forage species. Water temperature was 74 degrees. On both occasions, seining was done during the afternoon. Although other factors may have been involved, the difference in the amount of vegetation present on the shoal no doubt contributed heavily to the differences in catch on the two dates.

Suitable spawning facilities for all game fish listed are present in some portions of each impoundment. Young-of-the-year of yellow pikeperch were taken in Newaygo, Hardy and Croton Ponds. They were especially common in Newaygo Pond, where up to 25 were taken in a single haul with a 25-foot bag seine. No young pikeperch or perch were collected in Rogers Dam. Possibly these species frequent the upper portions of the impoundment, where seining was much less extensive than in areas nearer the dam.

Gill nets were set in each of the four major impoundments during the summer of 1947, with the aim of obtaining a series of scale samples from yellow pikeperch in each pond. Success was varied. In Newaygo Pond, 13 net days (one gill net, 125 feet long, set for 24 hours) of fishing between July 23 and July 26 yielded only a single game fish (a 5-1/2-inch perch), 6 white suckers and 7 redhorse. Few game fish appear to frequent

the principal portion of the impoundment during mid-summer. Eighteen net days of fishing in Croton Pond between July 28 and August 2 produced 31 pikeperch, 12 perch, 8 rock bass, 2 rainbow trout, 1 smallmouth bass, 1 bluegill, 8 redhorse and 1 white sucker. In 23 net days in Hardy Pond between August 4 and August 7, the catch included 62 pikeperch, 21 perch, 6 rock bass, 1 rainbow trout, and 16 redhorse. A typical day's catch in gill nets in this pond is shown in Figure 15. The fish were taken in overnight gill net sets between August 4 and 5, 1947; included in the picture are 17 pikeperch, 3 yellow perch (middle right), 1 rock bass, 4 redhorse, and 1 white sucker (extending off the picture, in the foreground). Thirty-one net days in Rogers Pond yielded 1 pikeperch, 21 rock bass, 10 perch, 4 smallmouth bass, 5 black crappie, 3 northern pike, 3 bluegills, 1 largemouth bass, 3 yellow bullheads, 8 redhorse and 2 suckers. The efficiency of gill nets varies somewhat with the species of fish concerned, and the catches are not direct criteria of the proportional abundance of the various species. Nets were not set at random with respect to habitat, but with a view toward obtaining as many pikeperch as possible. This would tend to decrease the proportion of certain other species in the catch.

The general creel census in Michigan is based on creel reports collected by conservation officers in the course of their contacts with fishermen in the various waters of the state. A summary of their reports for three Muskegon impoundments and for the Muskegon River in Mecosta County (essentially above Rogers and Big Rapids Dams) is shown in Table XVI. The amount of fishing censused during some years, although making a definite contribution to the state-wide creel census on all waters, is insufficient to provide an accurate estimate of quality of fishing in the specific water concerned. However, the proportions of the

Figure 15.--Fish taken in gill nets set at Hardy Pond through the night of August 4-5, 1947.

Table XVI.--Summary of general creel census records for four Muskegon River impoundments, 1928 - 1947.[1]

Year	Number of anglers	Hours fished	Legal fish caught	Catch per hour	Brown trout	Rainbow trout	Brook trout	Northern pike	Yellow perch	Yellow pikeperch	Smallmouth bass	Large-mouth bass	Pumpkin-seed	Bluegill	Rock bass	Crappie	Suckers and redhorse	Catfish and bullheads	Bowfin
Newaygo Pond																			
1928	4	26.0	46	1.77	...	...	...	2	26	...	...	...	...	9	9	...	...	...	...
1929	1	4.0	14	3.50	...	...	...	3	...	...	...	...	...	4	7	...	...	...	...
1941	4	38.0	20	0.53	...	...	...	2	...	18	...	...	...	...	...	...	...	...	...
Total	9	68.0	80	1.18	...	...	...	7	26	18	...	...	...	13	16	...	...	...	...
Croton Pond																			
1931	10	23.5	21	0.89	...	...	...	6	...	14	1	...	...	...	...	...	...	...	...
1932	9	44.0	29	0.66	...	...	...	1	2	10	8	...	...	8	...	...	...	...	...
1936	52	182.0	27	0.15	...	...	...	...	11	13	...	...	...	...	2	1	...	...	...
1937	25	71.0	39	0.55	...	...	...	2	2	1	10	...	...	...	24	...	...	...	...
1938	5	10.0	5	0.50	...	...	...	...	3	2	...	...	...	...	...	...	...	...	...
1939	21	83.0	41	0.49	...	...	...	...	30	...	2	1	...	...	8	...	...	...	...
1941	39	153.5	71	0.46	...	...	...	...	47	4	4	...	...	...	10	6	...	...	...
1944	21	34.0	19	0.56	...	...	...	...	4	3	3	...	...	...	9	...	...	...	...
1947	370	1,312.5	502	0.38	...	...	...	3	237	49	22	1	4	15	159	5	7	...	...
Total	552	1,943.5	754	0.39	...	...	...	12	336	96	50	2	4	23	212	12	7	...	...
Hardy Pond																			
1932	3	13.5	9	0.67	...	...	...	1	...	8	...	...	...	...	...	...	...	...	...
1936	11	42.0	10	0.24	...	...	...	3	...	6	...	1	...	...	...	...	...	...	...
1937	15	51.0	16	0.31	...	...	...	1	...	12	1	...	...	...	2	...	...	...	...
1938	12	60.5	22	0.36	...	...	...	1	1	11	6	...	...	1	2	...	...	...	...
1942	41	120.0	42	0.35	...	...	...	...	37	3	...	...	...	...	...	2	...	...	...
1943	16	40.8	34	0.83	...	...	...	...	30	3	...	...	...	...	...	1	...	...	...
1944	2	7.0	...	0.00	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1945	12	33.5	14	0.42	...	...	...	...	13	1	...	...	...	...	...	...	...	...	...
1946	35	114.5	48	0.42	...	...	...	...	42	5	...	...	...	...	...	1	...	...	...
1947	52	152.5	61	0.40	...	...	...	...	42	19	...	...	...	...	...	...	...	...	...
Total	199	635.3	256	0.40	...	...	...	6	165	68	7	1	...	1	4	4	...	...	...
Muskegon River, Mecosta County																			
1932	11	24.0	34	1.42	...	1	...	8	...	9	6	...	...	10	...	...	...	...	...
1933	5	13.0	12	0.92	...	...	...	3	...	5	4	...	...	...	...	...	...	...	...
1934	39	139.8	245	1.75	...	...	...	28	3	90	21	...	...	38	63	...	1	1	...
1935	321	866.0	497	0.57	...	...	...	11	6	173	22	4	...	...	46	23	210	2	...
1936	64	168.5	235	1.39	...	...	3	13	38	71	57	1	...	...	18	...	31	1	2
1938	1	1.5	1	0.67	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...
1940	24	67.0	18	0.27	...	...	...	...	9	3	...	...	...	...	...	6	...	...	...
1941	5	35.2	37	1.05	...	...	...	...	28	7	...	...	...	...	...	2	...	...	...
1942	49	173.5	133	0.77	...	...	...	23	3	18	...	...	...	...	2	55	30	2	...
1944	44	206.5	112	0.54	2	...	...	2	51	37	...	...	...	...	...	...	19	1	...
1946	90	380.0	185	0.49	1	...	1	14	4	109	25	2	...	...	...	...	28	1	...
1947	11	39.5	40	1.01	3	5	...	3	...	6	...	...	...	...	...	8	15	...	...
Total	664	2,114.5	1,549	0.73	6	6	4	105	142	529	135	7	...	48	129	94	334	8	2

[1] Summaries prepared by K. G. Fukano of the Institute staff. Records for 1947 are incomplete.

various species in the catch, taken as an average for the period covered, is probably somewhat representative of their actual proportions in fishermen's catches during this time. It is interesting to note that the yellow perch is the outstanding pan fish in each of these waters, followed by rock bass, bluegills, and crappies. Yellow pikeperch have a definite margin in the catch among the larger game fish in each pond during most seasons as well as in the average for the various periods covered. Smallmouth bass are next (except in the few records for Newaygo Pond) while northern pike rank third. Largemouth bass and pumpkinseeds are relatively unimportant in the catch. The records as a whole permit the generalization that fishing during recent years has been about equally good in Croton and Hardy Ponds, ranging between .4 and .5 fish per hour. A better figure is given for Mecosta County waters, but here the total includes a considerable number of suckers, not generally desired by fishermen. The game fish catch for the past four years in this section of the Muskegon, based on 800 hours of fishing census, has been slightly less than one-half fish per hour.

The rate of growth of game fish in the four principal Muskegon reservoirs is shown in Table XVII. Tentative state averages for the various species are included in the table for comparison. The principal disclosure of the table is that, by and large, game fish in the impoundments are growing at a somewhat faster rate than the average for these species in other waters of the state. Growth of yellow pikeperch, judging by the few specimens available for the age groups concerned, is slightly behind the state average for the first two years of life in Newaygo, and for the first year in Croton and Hardy. After this a faster rate is maintained, and legal size (14 inches) is reached during the fourth year. It is of interest to note that in the case of Croton

Table XVII.--Rate of growth of game fish in four Muskegon River impoundments, 1947.[1]

Species and pond	Age group[2] (Roman numerals) and average total length in inches						
	I	II	III	IV	V	VI	VII
Yellow pikeperch							
Newaygo	8.5(4)[3]	9.7(3)	14.0(6)	16.0(2)	...	...	...
Croton	7.7(1)	12.5(3)	13.6(17)	15.1(9)	19.9(5)	20.9(2)	25.2(3)
Hardy	7.9(5)	13.0(4)	13.8(44)	16.9(3)	17.7(2)	...	...
Rogers	...	...	...	14.8(1)	...	...	...
State average	8.4	11.5	13.4	14.6	15.5	16.8	17.6
Yellow perch							
Newaygo	5.5(1)	...	...	...	...	...	...
Croton	5.3(10)	...	9.1(2)	...	...	...	...
Hardy	6.1(1)	5.6(1)	10.0(5)	10.1(7)	...	...	13.4(2)
Rogers	...	...	8.7(7)	9.2(2)	10.1(1)	...	...
State average	4.1	5.8	6.4	7.5	8.5	...	10.4
Rock bass							
Newaygo	...	5.9(1)	6.1(3)	8.1(1)	...	...	...
Croton	...	...	6.1(4)	7.3(3)	...	10.1(1)	...
Hardy	3.5(1)	...	7.2(1)	8.1(3)	9.5(1)	...	...
Rogers	...	4.2(6)	6.0(4)	6.6(6)	7.7(2)	...	...
State average	3.2	4.3	5.2	6.2	7.3	7.9	...
Smallmouth bass							
Newaygo	...	10.7(2)	...	...	...	...	...
Croton	...	...	11.2(1)	...	...	...	...
Rogers	5.4(1)	10.4(1)	11.0(3)	...	...	...	...
State average	5.9	9.0	11.2	...	...	...	...
Bluegill							
Croton	...	...	8.0(1)	...	...	...	...
Rogers	...	6.0(3)	...	...	...	...	...
State average	...	4.3	5.4	...	...	...	...
Black crappie							
Rogers	4.4(5)	...	...	...	...	...	...
Largemouth bass							
Rogers	...	...	12.7(1)	...	...	...	...
Rainbow trout							
	...	15.1(2)	...	...	...	...	...

[1] Age determinations by Dr. Wm. C. Beckman

[2] Roman numerals indicate number of annuli on scales. Mose specimens were collected during August and have added a portion of the following year's growth.

[3] Figures in parentheses show number of specimens on which average length is based.

Pond, in particular, growth of pikeperch is near the state average for the first four years, and far exceeds it in the four older age groups. The obvious inference is that the older fish originated from the Newaygo transfer. The thirty fish in the first four age groups were taken in gill nets, together with one large tagged fish. The other larger fish were taken by fishermen in the immediate vicinity of the powerhouse where these larger transferred fish appear to congregate.

Most of the fish taken in Hardy Reservoir were taken in the general vicinity of the intake structure for the dam. It is interesting to note the outstanding dominance of 3-year old fish in this area. It appears to be somewhat out of proportion to both the younger and older age groups, and may possibly signify a markedly greater survival of this one-year class as compared to the others. However, the taking of large numbers of pikeperch "not quite big enough to keep" has been a source of inquiry and complaint by anglers for at least the past ten years, and the situation does not appear to change materially from year to year. Table XVIII demonstrates that stunted growth is not responsible for this condition. The determination of whether three-year-old fish are dominant in the reservoir each year or during most years and if so, whether these die in large numbers, pass downstream through the dam and proceed toward Lake Michigan, or are lost to the impoundment in some other way is a matter of considerable importance to the pikeperch fishery in this particular impoundment.

Yellow perch grew faster than the state average for the species in all of the impoundments, and the same may be said for rock bass. Both species appear to reach legal size at least a full year before the average for the species in the state. Other species are poorly represented in the catches, and averages are based on only a few individuals. Insofar

Table XVIII.--Temperatures, dissolved oxygen, and alkalinity of water in Hess and Brooks lakes, Newaygo County, Michigan.

Location of station	Depth of water at station in feet	Date	Water depth, feet	Temperature, degrees Fahrenheit	Oxygen, parts per million	Methyl orange alkalinity
Hess Lake						
Major depression, near center of lake	27	August 5, 1940[1]	Surface	78.0	7.0	108
			10	78.0	...	...
			15	78.0	...	...
			20	74.0	4.8	113
			26	68.0	1.3	118
Near major depression at center of lake	20	September 16, 1947	Surface	69.3	...	85
			18	68.7	7.6	86
Brooks Lake						
Near center of lake	12	August 15, 1939[1]	Surface	78.0	8.2	109
			5	78.0	...	...
			10	77.0	7.6	113
Depression near east end of lake	13	September 10, 1947	Surface	78.4	...	94
			3	78.4	...	...
			6	78.4	...	...
			9	78.1	...	...
			12	74.8	7.6	95

[1] Analysis by A. G. Horn, U. S. Forest Service.

as can be determined by the available data, there are no problems of stunted growth associated with the game fish populations in the Muskegon River impoundments.

B. The South Newaygo Lakes.--Hess and Brooks Lakes are located just southeast of the city limits of Newaygo, and are frequently referred to locally as the "south lakes." Both have been liberally stocked with adult pikeperch from below Newaygo Dam during the past 10 to 15 years (See Table XI). They are connected by a small stream and are in many respects similar waters, so they are considered together here. Contour maps of both lakes were made by personnel of the Manistee National Forest, in 1940.

Hess Lake is the larger of the two lakes, with an area of 1,125 acres and a shoreline 7 miles in length. It covers portions of Sections 21, 32 and 33 in T12N, R12W, and of Sections 4 and 5, T11N, R12W, in Newaygo County. The basin of the lake is somewhat elongate and irregular in shape, with a maximum length of about 2-1/4 miles and a width which reaches 1-3/8 miles at the widest point. Although the basin is for the most part shallow, there are three distinct depressions which have water depths of 25 feet or more. Two of these are near the center of the lake, about 1/4 mile apart and separated by a long, narrow bar over which the water is less than 10 feet deep. The third depression is located in the extreme western end of the lake. Four small inlets enter the lake from the south and east. The longest of these is known as Wheeler Drain. It is about 5 miles in length and enters the southeast corner of the lake. The outlet of the lake is about 10 feet across and up to 18 inches deep at the point where it leaves the lake. However, the volume of water flowing through it in September, 1947, was very small. Several past attempts to dam the outlet at the point where

it leaves the lake have been unsuccessful, and the remnants of the makeshift structures exert no effect on water level or fish movement at the present time. Bottom soil in Hess Lake is varied, with sand, muck, pulpy and fibrous peat occurring, together with small amounts of marl.

Brooks Lake is located in Sections 27, 28, 29 and 33, T12N, R12W, Newaygo County, about 1/4 mile northeast of Hess Lake. It is a smaller lake (293 acres) and has a more irregular shoreline (5.4 miles in length). The basin has a maximum dimension of about one mile. The shoreline is flooded as the result of a 3-1/2-foot dam across the outlet, located near the northwest corner of the lake. Its only inlet is the outlet of Hess Lake, which enters from the south. The basin is shallow, with two principal depressions. One of these is located in the northwest end of the lake and is 22 feet deep. A small area of 19 feet in depth is located in the northeast portion of the lake. Bottom soils consist of pulpy and fibrous peat, muck, and sand. The outlet of Brooks Lake is crossed by a dam about 3-1/2 feet high located at the shore of the lake. The stream flows in a westerly direction, entering the Muskegon at a point just above the lower street bridge in Newaygo, a distance of 3-1/2 miles from Brooks Lake. An almost perpendicular falls of over 10 feet in height occurs along its course, effectively preventing upstream migration.

The country surrounding Hess and Brooks Lakes is wooded, with sand and clay soils and a rolling topography. Recreational use of the waters is moderately heavy. Over 150 cottages line the south, west and north shores of Hess Lake, while about 50 are located in the vicinity of Brooks Lake. There are several boat liveries on each, and fishing pressure is moderately heavy. Both lakes have a public fishing site, owned by the state, which insures public access to these waters.

A brief summary of temperatures, dissolved oxygen, and methyl orange alkalinity in the south Newaygo lakes is given in Table XVIII. Water analyses in 1939 and 1940 were made by Mr. A. G. Horn, of the U. S. Forest Service. Hess Lake was found to have a thermocline in 1940, beginning at about the 20-foot level. In 1947, the major depression in the lake was not located, and an analysis was made in water 20 feet in depth. No significant decrease in oxygen or material difference in temperature was found between surface and bottom. The 1940 analysis suggests that chemical and thermal stratification occurs during at least some years in at least one of the three depressions in the lake. However, the deep water portions of the lake are so restricted in area that the significance of such stratification to the lake as a whole is very slight. Brooks Lake showed no meaningful difference in dissolved oxygen between surface and bottom at the time the water analyses were made. A rather unexpected drop in temperature between the 9 and 12 foot levels was observed in 1947. Readings of methyl orange alkalinity varied between 85 and 118 in Hess Lake and 94 and 113 in Brooks Lake. Fairly hard water is indicated, and a good productivity might be predicted on the basis of these observations.

Both Hess and Brooks Lake have an abundance of aquatic vegetation. The dam in the outlet of the latter lake provides sufficient depth to keep a large proportion of the surface open, but submerged plants are present in large numbers and cover large areas. Hess Lake is literally choked with vegetation throughout the summer months, and the main body of the lake is practically inaccessible from some sections of shoreline. A number of inquiries concerning the problems presented by the vegetation have been received during the past several years from persons interested in the lake. The water offers a good site for research

dealing with aquatic plant control. A rich variety of species is present, large numbers of people would benefit from any positive results achieved, and there is present a problem involving a seriously stunted fish population which may be the result, in part, of the overabundance of cover in the lake.

A record of the species of fish present in Hess and Brooks Lakes is shown in Table XIX. Abundance is estimated on the basis of collections made in 1926, 1935 and 1947, and on creel census records. Smallmouth bass were collected in Hess Lake only in 1926 (one small specimen) and yellow pikeperch are known only from creel census and planting records. Bluegills are extremely abundant, and northern pike and yellow perch are common in both lakes. Other species present are largemouth bass, pumpkinseeds, crappies and (in Hess Lake), rock bass. Bullheads are present in both lakes, as are longnose gars. A number of very large carp were reported speared near the Hess Lake outlet early in 1947, during their spawning season. Several forage species are found in each water, among which brook silversides are particularly abundant.

Gill netting in Hess Lake on September 3 and 4, 1947, yielded, in 8 net days (one gill net set for 24 hours), 14 bluegills, 14 black crappies, 11 perch, 6 pumpkinseeds, 1 northern pike, 30 brown bullheads, 3 yellow bullheads, 7 golden shiners and 9 longnose gar. Five net days in Brooks Lake (September 4-5) produced 16 bluegills, 13 yellow perch, 2 black crappies, 1 pumpkinseed, 3 northern pike, 1 yellow bullhead and 1 longnose gar.

General creel census records for the period from 1930 to 1946 are given in Table XX. A high predominance of bluegills among the fish caught is indicated, with perch a very poor second. Pumpkinseeds, black crappies and (in Hess Lake) rock bass and bullheads are also recorded. Northern

Table XIX.--A record of species of fish collected in Hess and Brooks lakes, Newaygo County, with estimates of their abundance.

	Hess Lake	Brooks Lake
Game fishes		
Northern pike	Common	Common
Yellow perch	Common	Common
Yellow pikeperch	Occasional	Occasional
Smallmouth bass	Rare	Rare
Largemouth bass	Common	Occasional
Bluegill	Abundant	Abundant
Pumpkinseed	Common	Occasional
Rock bass	Occasional	...
Black crappie	Common	Occasional
Coarse fishes		
Lake chubsucker	Rare	...
Brown bullhead	Abundant	...
Yellow bullhead	Occasional	Occasional
Obnoxious fishes		
Longnose gar	Common	Occasional
Bowfin	Rare	...
Forage fishes		
Blackchin shiner	Common	Common
Sand shiner	...	Rare
Golden shiner	Common	...
Pugnose shiner	Rare	...
Bluntnose minnow	Occasional	Occasional
Bigmouth shiner	...	Occasional
Creek chub	Rare	...
Banded killifish	Rare	...
Johnny darter	Rare	...
Iowa darter	Occasional	...
Brook silversides	Abundant	Abundant

Table XI.--Summary of general creel census records for Haas and Brooks lake, Kenayge County, 1930-1946.[1]

Year	Number of Anglers	Hours fished	Legal fish caught	Catch per hour	Northern pike	Yellow perch	Yellow pike-perch	Large-mouth bass	Pumpkin-seed	Bluegill	Rock bass	Crappie	Bull-heads
Haas Lake													
1936	16	43.5	57	1.31	8	12	7	7	6	10	...	7	...
1937	89	49.0	197	4.02	3	21	...	2	6	165	...	...	...
1938	9	20.0	10	0.52	...	...	...	...	...	7	...	3	...
1939	11	10.0	18	1.80	1	...	...	1	...	16	...	...	...
1940	26	71.5	80	1.12	1	...	...	3	8	68	...	...	...
1941	32	61.0	87	0.44	4	1	...	2	2	11	...	7	...
1942	89	94.5	95	1.01	2	26	2	4	13	47	...	1	...
1943	2	6.0	3	0.50	3	...	...	...	...	...	...	...	...
1944	11	31.0	33	1.06	4	1	...	...	...	28	...	...	...
1945	9	26.0	11	0.42	4	...	...	...	...	7	...	...	...
1946	14	84.0	34	1.48	1	8	...	...	...	25	...	...	...
Total	188	436.5	565	1.29	31	69	9	19	35	384	...	18	...
Brooks Lake													
1930	4	11.0	40	3.64	1	12	...	...	...	24	...	...	3
1931	20	89.0	25	0.28	19	2	...	4	...	...	...	...	...
1941	8	28.0	22	0.78	6	...	...	...	...	16	...	...	...
1942	21	56.0	76	1.36	...	4	...	...	2	70	...	...	...
1943	6	14.0	12	0.86	8	...	...	...	...	4	...	...	...
1944	5	9.0	30	0.33	...	1	...	...	...	28	1	...	...
1945	5	9.0	20	2.22	...	2	...	...	...	18	...	...	...
1946	19	86.5	34	1.88	...	9	...	3	...	20	...	2	...
Total	88	242.5	259	1.07	34	30	...	7	2	180	1	2	3

[1] Summaries prepared by Mr. K. O. Putnam.

pike lead the larger game fish in numbers, followed by largemouth bass and (in Hess Lake) introduced pikeperch. On the average, the catch of fish has slightly exceeded one per hour, but fish taken have doubtless been of small size, consisting mostly of bluegills just over 6 inches in length. An intensive creel census conducted at Hess Lake during the winter of 1933-1934 showed a predominance of perch in the catch at that time. A census of 4,890 hours of hook and line fishing showed a total catch of 2,111 fish, including 1,402 perch, 58 pikeperch, 398 northern pike, 236 black crappie, 12 bluegills, 1 bullhead, 2 rock bass and 2 bowfin.[*]

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[*] Eschmeyer, R. W., "Analysis of creel census, winter of 1933-34, Conducted on Hess Lake by Camp Newaygo, 107-S, M.E.C.W.," Institute for Fisheries Research Report No. 265, January 4, 1934 (ms).

The rate of growth of game fish in Hess and Brooks Lakes is summarized in Table XXI. State averages for the species concerned are also shown. A comparison of the two permits the clear generalization that all game fish in Hess and Brooks Lakes for which adequate data are available are growing at a rate less than the average for the species in the state, and that growth of species common to the two lakes is somewhat slower in Hess Lake than in Brooks. The only exceptions, judging by Table XXI, are three-year-old perch in Brooks Lake, which appear to slightly exceed the average, and one-year-old perch in Hess Lake. The one pumpkinseed from the former water also exceeds the state average, but examination of a single scale does not provide data applicable to the population as a whole. Bluegills in Hess Lake are seriously stunted in growth. Out of 19 bluegills collected, none was of legal size (6 inches). In the

Table XXI.--Rate of growth of game fish in Hess and Brooks lakes, 1947.[1]

Species and Lake	Age group[2] (Roman numerals) and average total length in inches						
	I	II	III	IV	V	VI	VII
Bluegill							
Hess Lake	...	3.4(2)[3]	4.1(2)	5.0(11)	5.6(2)	5.8(2)	...
Brooks Lake	...	...	5.1(1)	5.6(12)	6.0(1)	...	...
State average	...	4.3	5.4	6.6	7.3	7.7	...
Yellow perch							
Hess Lake	4.8(9)	...	6.1(1)	6.6(8)	7.6(1)	...	...
Brooks Lake	...	...	6.5(12)	7.2(1)	...	...	...
State average	4.1	...	6.4	7.5	8.5	...	...
Black crappie							
Hess Lake	...	4.6(5)	6.3(1)	6.4(1)	7.4(4)	8.1(1)	8.8(1)
Brooks Lake	...	...	7.0(1)	7.1(1)	...	...	...
State average	...	5.9	8.0	9.0	9.9	10.7	11.3
Pumpkinseed							
Hess Lake	...	3.6(4)	4.6(3)	5.4(6)	4.8(1)	...	...
Brooks Lake	...	...	6.1(1)	...	...	...	...
State average	...	4.1	4.9	5.7	6.2	...	...
Rock bass							
Hess Lake	...	4.2(3)	...	...	...	...	...
State average	...	4.3	...	...	...	...	...
Largemouth bass							
Hess Lake	4.5(1)	5.9(1)	...	...	...	...	...
State average	6.1	8.7	...	...	...	...	...

[1] Age determinations by Dr. Wm. C. Beckman

[2] Roman numerals show number of annuli on scales.

[3] Collections were made in early September. Figures in parentheses indicate number of specimens on which average length is based.

average Michigan water, bluegills attain legal size early in the fourth year of life, while in Hess it is probably often not attained until the sixth or seventh year. In Brooks Lake the stunted condition is somewhat less severe, although the growth of the species is at least a year behind the state average in this water as well. Yellow perch, black crappie, pumpkinseeds and largemouth bass are also, on the whole, well behind state averages for the species. It is apparent that Hess Lake, and to a less extent Brooks, are overpopulated with panfish. An over-abundance of fish of small sizes, with insufficient food for the numbers present, an excess of thick cover which provides excellent escapement for small fish, and failure of any disease or predators to effectively reduce the numbers of undersized fish, are inter-related factors contributing to the presence of stunted populations. It is interesting to note that stunting of such large numbers of fish has occurred in the face of an average annual introduction of nearly 300 adult pikeperch per year for the past ten years in Hess Lake, and about 175 in the smaller Brooks Lake. There are already native populations of northern pike, longnose gar, and largemouth bass, all of which are essentially piscivorous.

C. The North Newaygo Lakes.--A chain of four lakes, Kimball, Pickerel, Emerald and Sylvan located about two miles north of Newaygo and just west of Highway M-37 are often referred to locally as the "north lakes." They are connected by short stretches of stream which are passable by row boats, and are in many respects somewhat similar. Detailed surveys of the lakes have not been made, but certain observations made essentially during 1947 are reported here.

Kimball Lake is the westernmost of the chain of four lakes. It is located in Section 2 of T12N, R12W, in Newaygo County. The basin is somewhat irregular in outline. It has an area of around 200 acres and a maximum depth of about 40 feet (both figures are estimates). Bottom types include marl and sand, with muck present in some areas. The single inlet, from Long (Ryerson) Lake enters from the northwest. The lake drains through a short stretch of open stream, about 15 to 20 feet in width, which leaves its southeast corner and enters the southwest end of Pickerel Lake. Vegetation is of moderate abundance. About 20 cottages and 3 boat liveries are located on the lake, and fishing pressure is moderately heavy.

Pickerel Lake is the largest of the north Newaygo lakes, with an area which probably exceeds 400 acres. It is located almost entirely in Section 1 of T12N, R13W. The basin is irregular in shape and has a maximum length of about a mile. There are two principal depressions, separated by shallow water. One of these, with a depth of over 40 feet, is located near the west end and the other, with a depth of over 60 feet, is in the eastern portion of the lake. Bottom typesare principally marl and sand. The drop-off is steep in some areas, but extensive shallows with dense vegetation are present. Stonewort is very abundant, together with submerged pondweeds, coontail, and water milfoil. Around 100 cottages and 4 boat liveries are located at the lake. Fishing pressure is moderately heavy.

Emerald Lake is about one-quarter mile east of Pickerel Lake, and is located in Section 6, T12N, R12W. Sylvan Lake is to the immediate northeast. The two lakes are very close together and are connected by a channel of some depth passing under a road bridge. Both are around a

hundred acres in area or less, and are typical marl lakes, with the very distinct green color of such waters. They were worked by a cement company many years ago, and traces of the excavations still exist. Sylvan Lake is over 60 feet in depth and Emerald exceeds 40 feet at one point. Bottom soils are almost exclusively marl, and objects lying in the water are heavily encrusted with the substance. Drop-offs are for the most part steep. Vegetation is sparse, and where present in submerged forms is likewise heavily encrusted with calcium carbonate.

As has been mentioned above, Kimball Lake drains into Pickerel Lake. The latter has an outlet flowing about due east from its eastern end. At a point about one-quarter mile below the lake, the outlet joins the outlet of Emerald Lake near the latter lake, and the resulting stream flows eastward as a branch of Penoyer Creek. Penoyer Creek empties into the Muskegon just below Newaygo Dam, a stream distance of about 4-1/2 miles from the confluence of the two outlets. Within about one-quarter mile of the junction of the outlets, the common outlet is crossed by a low dam, erected through the efforts of property owners on the lake. It is a well-built structure and serves to maintain constant lake levels in each of the four lakes of the chain. A second small dam crosses Penoyer Creek near its mouth, and water passes through an industrial plant before entering the river, largely through an iron pipe raised well above the usual level of the water in the Muskegon River. Upstream migration of fish from the main stream probably does not take place.

Observations of the temperatures, dissolved oxygen, and methyl orange alkalinity of water in the north Newaygo lakes is shown in Table XXII. All four of the lakes show a typical thermocline, with a decrease in dissolved oxygen at various levels below the top of the thermocline. The water

Table XXII.--Temperatures, dissolved oxygen and alkalinity of water in the north Newaygo lakes, Newaygo County.

Location of station	Depth of water at station in feet	Date	Water depth, feet	Temperature, degrees Fahrenheit	Oxygen, parts per million	Methyl orange alkalinity
Pickerel Lake						
Depression in southwest portion of lake	48	September 12, 1947	Surface	77.7	...	105
			15	76.8	...	...
			18	75.2	...	...
			21	67.1	...	...
			24	60.6	5.0	...
			30	51.8	0.0	...
			33	49.8	...	...
			36	49.1	...	...
			45	47.8	0.0	135
Kimball Lake						
Near center of lake	34.5	September 12, 1947	Surface	78.3	...	115
			12	76.8	...	...
			15	74.7	4.8	...
			16.5	...	4.3	...
			18	66.9	0.2	...
			21	59.0	0.2	...
			24	55.4	...	...
			27	51.6	...	...
			33	49.6	0.0	146
Emerald Lake						
Approximate center of lake	46	August 29, 1941[1]	Surface	72	8.7	121
			5	72	...	...
			10	71	...	...
			15	71	...	...
			20	71	...	...
			25	67	10.5	153
			30	67	...	...
			35	65	2.2	168
			40	64	...	...
			45	64	0.4	187
Approximate center of lake	32	September 15, 1947	Surface	75.2	...	113
			15	75.2	...	...
			18	74.5	...	...
			21	69.1	...	...
			27	56.5	...	...
			30	54.1	7.6	139
Sylvan Lake						
West central portion of lake	61	August 2, 1940[2]	Surface	79	8.9	116
			15	76	...	...
			20	66	...	...
			25	57	6.2	152
			30	51	...	...
			35	49	4.5	155
			40	46	...	...
			50	44	...	...
			55	44	0.1	169
			60	44	...	...
West central portion of lake	61	September 15, 1947	Surface	74.7	...	110
			15	74.5	...	...
			18	74.5	...	...
			21	70.9	...	...
			30	53.1	10.2	...
			33	50.5	...	...
			36	48.4	...	...
			39	47.1	...	...
			40	...	4.6	...
			45	45.3	1.1	...
			60	44.4	0.0	163

[1] Analysis by "Cleveland and Middlebrook," U. S. Forest Service (?).

[2] Analysis by A. G. Horn, U. S. Forest Service.

in three of the lakes, Pickerel, Emerald and Sylvan, is suitable for trout from the standpoint of temperature and dissolved oxygen during the summer. Kimball Lake is not suitable for cold water species, since water of suitable temperature has insufficient oxygen to support fish. Methyl orange alkalinities for all four lakes are high, indicating hard water.

A record of the species of fish in the north lakes is shown in Table XXIII. Estimates of abundance are indicated, based on the frequency of occurrence of the species in Institute collections, and in creel census records. Collections were made in 1926, 1934, 1941 and 1945. In addition to the species shown, yellow pikeperch are known to be present from past planting records, as well as from creel census records, although the species has not been collected by netting. Due to the wide connections between the four lakes, it can probably be assumed that all species occurring in one lake probably occur in the others at least in small numbers or at certain times of the year. Nine species of game fish collected in Pickerel Lake include northern pike, yellow perch, largemouth bass, green sunfish, bluegills, pumpkinseeds, rock bass, crappies and mud pickerel. Of these, mud pickerel and green sunfish have not been collected in Kimball Lake. A few smallmouth bass have occurred in creel census records from the latter water, as well as from Sylvan Lake. By and large, although the species present are about the same in all four lakes, game fish are fewer in number in Emerald and Sylvan Lakes than in the other two lakes of the chain. Forage fish are also fewer in number in the latter water. The generally low population of game fish in these two lakes is probably closely related to the dearth of submerged aquatic vegetation or other suitable cover there,

Table XXIII.--A record of species of fish collected in the north Newaygo lakes, Newaygo County, with estimates of their abundance.

	Pickerel Lake	Kimball Lake	Emerald Lake	Sylvan Lake
		General abundance		
Game fishes				
Mud pickerel	Rare	...	...	...
Northern pike	Common	Occasional	Rare	Rare
Yellow perch	Common	Abundant	Rare	Rare
Smallmouth bass	...	Rare	...	Rare
Largemouth bass	Abundant	Abundant	Common	Occasional
Green sunfish	Common	...	Rare	Common
Bluegill	Abundant	Abundant	Rare	Occasional
Pumpkinseed	Common	Common	...	...
Rock bass	Common	Occasional	Common	Common
Black crappie	Occasional	Occasional	Rare	Occasional
Coarse fishes				
White sucker	...	Rare	...	...
Yellow bullhead	Common	Occasional	Occasional	...
Forage fishes				
Blackchin shiner	Abundant	Abundant	...	...
Blacknose shiner	Occasional	Occasional	...	...
Golden shiner	Common	Occasional	...	...
Bluntnose minnow	Common	Abundant	Occasional	Occasional
Mudminnow	Rare	...	...	...
Banded killifish	Common	Common	...	...
Johnny darter	Common	Rare	Common	Occasional
Iowa darter	Common	Rare	Common	Common

together with probable low productivity of the almost pure marl substratum.

Near mid-September, 1947, five net days (one gill net, 125 feet long, set for 24 hours) in Pickerel Lake yielded 32 bluegills, 20 yellow perch, 6 northern pike, 6 rock bass, 2 black crappies, 1 pumpkinseed, 1 largemouth bass and 7 yellow bullheads. A similar amount of netting in Kimball Lake produced 82 perch, 24 bluegills, 10 rock bass, 5 black crappie, 4 northern pike, 3 largemouth bass, 3 yellow bullheads, 1 sucker and 2 golden shiners. In 1-1/2 net days at Emerald Lake, the catch was 4 rock bass, 1 northern pike and 1 bluegill. In Sylvan Lake the yield for a similar period was 18 rock bass, 3 bluegills, 3 green sunfish, 1 black crappie, 1 northern pike, and 1 yellow perch.

General creel census records for the chain of four lakes, for the period from 1941 to 1947, are tabulated in Table XXIV. Bluegills have dominated the recorded catch in each of these waters during the period, with perch, rock bass, crappies and pumpkinseeds also occurring in some numbers in certain of the lakes. The hours of fishing censused during each season have been rather few. By and large, the reports showed better than average fishing throughout most of the period in each lake, with the exception of Emerald lake, where reports are too few in number to permit any conclusions.

The rate of growth of game fish in the north Newaygo lakes is shown in Table XXV. A very distinct contrast from the situation in the south lakes, discussed above, is indicated. The data presented demonstrate that, by and large, rate of growth of game fish in the north Newaygo lakes is equal to or exceeds the average for these species throughout the state. Perch grow considerably faster than the average,

Table XXIV.--Summary of general creel census records for the north Newaygo Lakes, Newaygo County, 1932-1947.[1]

Year	Number of anglers	Hours fished	Legal fish caught	Catch per hour	Northern pike	Yellow perch	Yellow pikeperch	Small-mouth bass	Large-mouth bass	Pumpkin-seed	Blue-gill	Rock bass	Crappie	Sucker
Pickerel Lake														
1941	5	10.5	44	4.19	...	3	...	...	...	...	41	...	...	...
1942	16	37.2	27	0.73	1	10	...	...	...	7	9	...	...	...
1943	17	42.3	109	2.58	...	7	...	...	...	4	97	...	1	...
1944	27	65.0	71	1.09	...	8	...	...	1	2	50	10	...	...
1945	25	58.5	34	0.58	...	...	1	...	...	...	31	2	...	...
1946	37	69.5	76	1.09	3	8	1	...	...	...	51	...	13	...
1947	5	3.5	12	3.43	...	...	...	...	...	...	12	...	...	...
Total	132	286.5	373	1.30	4	36	2	...	1	13	291	12	14	...
Kimball Lake														
1932	2	8.0	13	1.63	...	3	...	...	...	...	10	...	...	...
1933	1	3.0	15	5.00	...	...	2	...	...	2	8	3	...	...
1934	38	153.0	264	1.73	3	47	56	5	2	12	111	28	...	...
1935	9	33.0	26	0.79	...	2	4	...	...	...	20	...	...	...
1936	39	124.5	439	3.53	1	56	2	5	10	14	261	1	89	...
1937	3	12.0	53	4.42	...	...	...	...	...	...	53	...	...	...
1939	16	39.0	33	0.85	...	...	...	...	...	2	31	...	...	...
1942	2	1.0	...	0.00	...	...	...	...	...	...	...	...	...	...
1943	9	7.5	21	2.80	...	1	...	...	...	...	19	...	1	...
1944	4	9.0	19	2.11	...	3	...	...	...	...	16	...	...	...
1945	15	36.0	7	1.94	...	...	...	...	...	...	7	...	...	...
1946	9	24.0	29	1.21	...	...	...	...	...	...	29	...	...	...
1947	2	1.5	2	1.33	...	...	...	...	...	...	2	...	...	...
Total	149	451.5	921	2.04	4	112	64	10	12	30	567	32	90	...
Emerald Lake														
1932	9	23.0	40	1.74	1	...	...	...	...	2	26	11	...	...
1936	2	6.5	2	0.31	1	...	...	...	1	...	...	...	...	...
1941	3	5.5	2	0.36	...	...	...	...	...	...	2	...	...	...
1942	9	18.2	22	1.21	...	...	...	...	...	...	7	...	15	...
1944	3	9.0	...	0.00	...	...	...	...	...	...	...	...	...	...
1945	1	2.5	...	0.00	...	...	...	...	...	...	...	...	...	...
1946	5	10.0	12	1.20	...	4	...	...	...	...	...	...	1	...
Total	32	74.7	78	1.04	2	4	...	...	1	2	35	18	16	...
Sylvan Lake														
1934	7	29.0	44	1.52	...	2	2	3	...	...	33	4	...	...
1935	3	6.0	...	0.00	...	...	...	...	...	...	...	...	...	...
1936	4	6.0	2	0.33	...	...	...	1	...	...	...	1	...	...
1937	4	24.0	6	0.25	...	...	2	...	...	...	4	...	...	...
1939	11	30.0	68	2.27	...	...	...	...	...	...	28	...	40	...
1940	4	10.0	30	3.00	...	...	...	...	...	...	30	...=	...	...
1941	3	4.0	6	1.50	...	...	...	...	...	...	6	...	...	...
1942	10	16.5	106	6.42	...	...	...	...	...	...	3	...	103	...
1944	6	15.0	12	0.80	1	10	1	...	...	...	...	...	...	...
1946	8	10.0	22	2.20	...	...	...	...	...	...	22	...	...	...
Total	60	150.5	296	1.97	1	12	5	4	...	...	126	5	143	...

[1] Summaries prepared by Mr. K. G. Fukano. Records for 1947 are incomplete.

Table XXV.--Rate of growth of game fish in the north Newaygo lakes, 1947.[1]

Species and lake	Age group[2] (Roman numerals) and average length in inches						
	I	II	III	IV	V	VI	VII
Yellow perch							
Pickerel Lake	...	6.4(9)[3]	8.1(8)	10.4(2)	11.3(1)	...	...
Kimball Lake	...	6.8(2)	8.8(46)	9.7(33)	...	...	...
Sylvan Lake	...	6.7(1)	...	...	...	...	...
State average	...	5.8	6.4	7.5	8.5	...	...
Bluegill							
Pickerel Lake	...	4.2(11)	5.5(4)	6.6(3)	...	...	...
Kimball Lake	...	4.1(3)	6.0(7)	7.4(4)	...	...	...
Sylvan Lake	...	...	...	6.5(1)	...	...	...
Emerald Lake	...	...	...	5.5(1)	...	...	...
State average	...	4.3	5.4	6.6	...	...	...
Black crappie							
Pickerel Lake	...	7.3(2)	...	...	...	...	...
Kimball Lake	...	6.7(2)	8.0(3)	...	...	...	...
Sylvan Lake	4.7(1)	...	...	...	...	...	...
State average	...	5.9	8.0	...	...	...	...
Rock bass							
Pickerel Lake	...	...	5.8(1)	7.0(3)	7.8(2)	...	...
Kimball Lake	3.9(1)	...	...	6.6(4)	7.8(1)	...	...
Sylvan Lake	...	4.1(5)	4.5(5)	6.6(3)	...	...	...
Emerald Lake	...	...	5.3(2)	...	7.3(1)	...	...
State average	3.2	4.3	5.2	6.2	7.3	...	...
Largemouth bass							
Pickerel Lake	...	...	11.4(1)	...	...	...	...
Kimball Lake	7.6(3)	...	...	...	...	...	...
State average	6.1	...	10.0	...	...	...	...

[1] Age determinations by Dr. Wm. C. Beckman

[2] Roman numerals show number of annuli on scales. Collections were made during September.

[3] Figures in parenthesis show number of specimens on which average length is based.

reaching legal size (6 inches) late in their first or early in their second year of life. Bluegills appear to grow at about an average rate (to slightly above average) in age groups where sufficient numbers of specimens are present to provide an average figure which is likely to be representative of the group. The same is true of black crappies and rock bass, although two- and three-year-old rock bass in Sylvan Lake are somewhat behind state averages. Largemouth bass are too few in number to permit conclusions, although the few individuals sampled showed a good rate of growth. Pickerel and Kimball Lakes are, in general, productive, hard water lakes typical of many in southern Michigan. Vegetation covers most of the declivities and shallows but is not present in too great abundance. A good balance at present appears to be maintained between predators and forage species. Sylvan and Emerald lakes are much less productive. For the relatively fewer numbers of game fish present, growth appears to be slower than in Kimball and Pickerel Lakes, although the rate does not fall seriously behind the state average for any of the species concerned. The effect on growth rate of other species of the plantings of adult yellow pikeperch made in the chain during the past 15 years is a subject for interesting conjecture, upon which we have no definite evidence at the present time.

IV. Results of a tagging experiment conducted in certain waters of the Muskegon River Drainage during 1947.

A. Introduction.

Marking of fish by some means or other, as by fin-clipping or by attachment of tags at any one of several parts of the body, is a well-established and much-used method for studying fish movement. The

use of a numbered tag manufactured from a non-rusting metal (usually monel) permits recognition of a fish throughout the period of its life span following tagging. Its movement between the time of release and recapture can thus be ascertained, and information concerning its growth is often obtained as well.

The fate of game fish which are moved to upstream waters during the Newaygo transfer has been a matter of speculation for many years. Many anglers have claimed that fish are never able to return to their original habitat once they are transferred. Others claim with equal vigor that most of the fish return to downstream areas or to Lake Michigan within a short period. It is believed by some that the transfer materially improves pikeperch fishing in the waters which are stocked, while others doubt its value in this respect. Reliable observations concerning these matters have never been reported.

In the interest of obtaining information about the fate of transferred fish, the Institute first conducted a marking experiment in 1932.* Mr. C. J. Hyland, then employed by the Conservation Department,

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*Hubbs, Carl L., "Results of Tagging Experiments on Muskegon River, 1932," Institute for Fisheries Research Report No. 195, March 7, 1933 (ms).

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tagged 250 game fish between April 3 and April 22 of that year, which were distributed among four upstream impoundments. The total included 172 yellow pikeperch ranging from 10 to 36 inches in length and averaging 18.8 inches; 65 rainbow trout, 10-1/4 to 32 inches long (average 24.4 inches); and 13 northern pike with an average length of 22.9 inches.

The tags used were No. 3 strap tags (such as those shown in the top half of Figure 16, below), fastened to the gill covers of the fish. The returns from the tagging experiment were disappointingly small. Nearly a year after tagging (March 7, 1933), only five reports of recaptures had been submitted by anglers. Two of these were trout and three were pikeperch. Of the latter, one had passed through Rogers Dam and the other two remained in the ponds in which they had been released (Croton and Hardy, respectively). The report on the work suggests that poor cooperation in reporting tags, or unsatisfactory attachment of the tags, may have been responsible for the low (2 percent) return. The attachment of tags on gill covers of these species has lost favor in Michigan during recent years, and its reliability has been questioned. Several of these factors and others may have contributed to the small return in the 1932 experiment.

To meet a long-standing need for further evidence on the movements of yellow pikeperch transferred to upstream waters from the river below Newaygo Dam, a more extensive tagging program was undertaken in the spring of 1947. Between April 14 and April 25, a total of 1,750 tags were placed on yellow pikeperch before they were stocked in upstream impoundments and certain lakes in the Newaygo area.[*]

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[*] Mr. Clarence Taube and Mr. Floyd Simonis, of the institute staff, assisted with the tagging. Mr. Leland Anderson, of the staff, and Mr. and Mrs. Fred Stanley, Newaygo, assisted with the work for a portion of the period during which tagging was done.

B. Technique.--Two sizes of tags were used in the marking of transferred pikeperch, a No. 3 strap tag (used in most of Michigan's fish

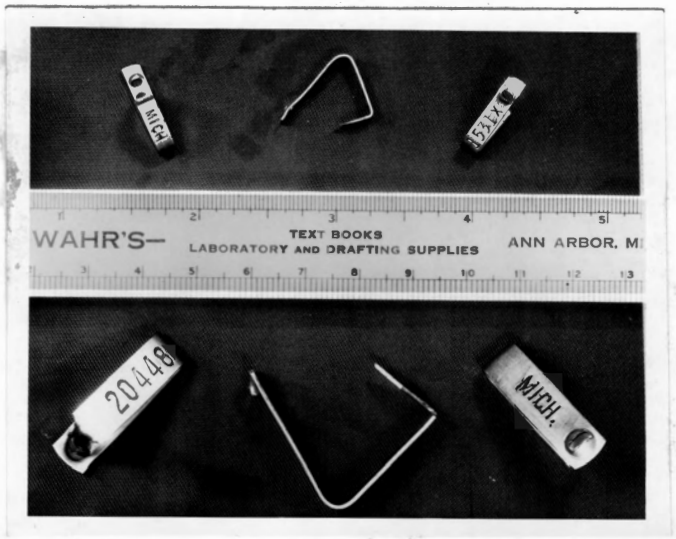


Figure 16.--Two sizes of tags used for marking yellow pikeperch in the Muskegon River, 1947.

marking studies) and a "Hasco" livestock ear tag (manufactured by the National Band and Tag Company). The tags used are shown in Figure 16. The smaller tag, shown in the top half of the photograph, is slightly over one-half inch long when in position on the fish. It is about one-eighth inch in width and has a weight of very slightly over one-half gram. The larger tag, shown in the lower half of the figure is slightly over an inch long, has a width of 5/16 inches and an average weight of 3-1/3 grams. The latter tag was, in general, used on fish of large size (over 20 inches) and was fastened around the lower jaw of the fish, piercing the gular membrane. A tag of this type is shown in place in Figure 17. The smaller size tag was placed on fish under 20 inches in length, in the same position as the larger tag. The width of the dentary bone in pikeperch makes use of the small tag on the lower jaw very difficult in large fish. By way of an experiment, and particularly after the supply of large tags was exhausted, a considerable number of the fish tagged were marked on the upper jaw, with the tag passing around the maxillary and premaxillary bones, as shown in Figure 18. Nearly all fish so marked were over 20 inches in length. In fish of large size, the distal ends of the maxillary bones are sufficiently wide to prevent the tag from being forced off in a backward direction, as might conceivably occur in smaller fish. Several large fish tagged in the upper jaw which were examined after a period of several months, were observed to have the tag pushed snugly up against the widened end of the maxillary, where it was being held firmly in place.

In the tagging operation, pikeperch were removed from the live boxes of the netters and placed in a metal tub, in lots of 10 or 20, depending upon size. Each was then measured to the nearest 1/10 inch

Figure 17.--A large tag in position on the lower jaw of a pikeperch.

Figure 18.--A small tag in position on the upper jaw of a pikeperch.

(Figure 19) and sexed. These data were recorded, together with the condition of the ovaries in the case of females (all males were ripe, shedding quantities of milt upon the slightest touch). One worker then grasped the fish by the head and nape, holding its body snugly up against his side and beneath the arm (Figure 17). The mouth of the fish was held open with the index finger of one hand. (Although the yellow pike-perch has very formidable dentition, it was found that an ordinary cloth work glove, preferably with the index finger reinforced with adhesive tape, offers sufficient protection to avoid injury). With the jaws thus held open, a second worker applied the tag, utilizing two pairs of sharp-nosed pliers in holding and clinching it. (Automobile pliers were found to be somewhat more satisfactory for the large tags). After tagging, the fish were placed in a second tub of water and later removed to a live box to await transfer to an upstream area.

In general, work progressed rather slowly. Fish were removed from live boxes, hauled up the river bank in small lots, tagged and later returned to a live box. Changes in tagging station were required, as the supply of fish in each live box became exhausted. The larger fish struggled formidably, and time was consumed in getting them measured and in position for tagging. Etherization was attempted, but the need for constantly guarding against over-anesthetization while at the same time having a sufficiently strong solution to be effective, together with the reduction in the number of fish which could be handled in a given lot, appeared to void the advantage of easier handling offered by the stunned fish. A tagging rate as high as 50 per hour occurred infrequently and never over a prolonged period. The maximum number tagged per day by the three-man crew was 275.

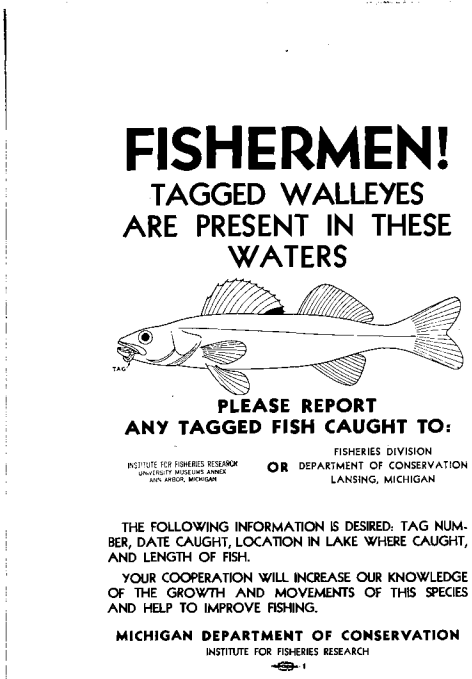
Figure 19.--Clarence Taube measures a large pikeperch as Floyd Simonis records the length, tag number, and sex.

The tagged fish, along with others taken by the netters, were stocked in the five impoundments of the main stream of the river (Newaygo, Croton, Hardy, Rogers, and Big Rapids) and in four lakes near Newaygo (Hess, Brooks, Pickerel and Emerald). Points of access to the various waters were posted with signs (Figure 20), requesting that fishermen send in records of tag numbers, lengths, and dates and locations of capture of any tagged fish caught.

C. Controls.--In order to determine whether there might be a significant mortality of tagged fish over and above untagged fish handled in the transfer, a group of 48 fish, one-half of which was tagged and the other half untagged, was held in a hatchery pond for observation. Detailed data concerning these fish are shown in Table XXVI. Eight of the group of 24 tagged fish were tagged with large jaw tags, eight with small jaw tags, and the remainder with maxillary (upper jaw) tags. The numbered fish averaged 20.3 inches in length and the untagged 20.2 inches. The tagged series was divided into 12 males and 12 females while the unmarked group consisted of 14 females and 10 males. All fish were placed in Pond No. 19 at Lydell Hatchery, Comstock Park, on April 18. This pond has an area of 0.92 acres and is up to 4 or 5 feet in depth when filled.

On April 21, 3,009 10-month-old suckers, averaging 3.9 inches in length, were stocked in the pond for forage. This total was augmented on May 17 by 82,000 advanced sucker fry.

Employees at the Lydell Hatchery observed the pond for mortality at frequent intervals. One untagged dead fish was removed on April 29, and another on May 27. A badly decomposed pikeperch which had probably borne a tag was removed on May 17, and No. 35 was found dead on May 27.



FISHERMEN!

TAGGED WALLEYES ARE PRESENT IN THESE WATERS

PLEASE REPORT ANY TAGGED FISH CAUGHT TO:

INSTITUTE FOR FISHERIES RESEARCH
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

OR

FISHERIES DIVISION
DEPARTMENT OF CONSERVATION
LANSING, MICHIGAN

THE FOLLOWING INFORMATION IS DESIRED: TAG NUMBER, DATE CAUGHT, LOCATION IN LAKE WHERE CAUGHT, AND LENGTH OF FISH.

YOUR COOPERATION WILL INCREASE OUR KNOWLEDGE OF THE GROWTH AND MOVEMENTS OF THIS SPECIES AND HELP TO IMPROVE FISHING.

MICHIGAN DEPARTMENT OF CONSERVATION
INSTITUTE FOR FISHERIES RESEARCH

Figure 20.--Sign used for posting waters in which tagged pikeperch (walleyes) were stocked. Signs were cardboard, 14 inches by 11 inches.

Table XXVI.--Data pertaining to yellow pikeperch controls held at Lydell Hatchery, 1947.

A. Tagged fish

Tag number	April 18				July 22		November 10						
	Total length (inches)	Sex	Condition	Type tag [1]	Total length (inches)	Gain in length (inches)	Standard length (inches)	Total length (inches)	Gain in length (Since April 18)	Weight Pounds	Weight Ounces	Condition of caudel fin	Lympho-cystis
576	22.1	F	G	J	21.8	-0.3	18.6	21.7	-0.4	2	12	frayed	...
577	21.8	M	R	J	21.7	-0.1	...	...	...	...	...	...	...
578	22.6	F	G	J	22.4	-0.2	19.2	21.9	-0.7	2	11	frayed	present
579	22.0	M	R	J	21.6	-0.4	...	...	...	...	...	...	...
580	22.4	F	R	J	21.8	-0.6	...	...	...	...	...	...	...
581	22.3	F	G	J	21.9	-0.4	19.0	22.0	-0.3	2	9	frayed	...
582	21.0	M	R	J	20.7	-0.3	17.7	20.9	-0.1	3	6	frayed	...
583	21.9	M	R	J	21.5	-0.4	18.4	20.6	-1.3	2	5	frayed	...
20	16.6	M	R	j	16.8	0.2	15.0	17.7	1.1	1	13	frayed	...
21	19.7	M	R	j	19.6	-0.1	16.7	19.9	-0.2	...	...	...	...
22	19.9	M	R	j	19.7	-0.2	17.4	20.4	0.5	2	10	normal	...
27	16.1	M	R	j	16.1	0.0	14.8	17.4	1.3	1	11	normal	present
28	19.0	M	R	j	18.7	-0.3	...	...	...	...	...	...	...
29	19.8	F	G	j	19.6	-0.2	17.7	21.0	1.2	3	2	frayed	present
34	12.7	M	R	j	13.0	0.3	12.2	14.5	1.8	1	2	normal	...
35	15.3	M	R	j	...	...	...	...	...	...	...	...	...
23	22.1	M	R	m	22.0	-0.1	19.4	23.0	0.9	4	1	normal	...
24	23.8	F	R	m	...	...	...	...	...	...	...	...	...
25	21.0	F	G	m	20.5	-0.5	...	...	...	...	...	...	...
26	21.1	F	R	m	20.7	-0.4	18.2	21.3	0.2	2	14	normal	...
30	21.6	F	R	m	21.2	-0.4	...	...	...	...	...	...	...
31	20.3	F	G	m	20.0	-0.3	17.7	20.9	0.6	2	12	normal	present
32	22.5	F	G	m	...	...	...	...	...	...	...	...	...
33	19.6	F	G	m	19.2	-0.4	17.5	20.2	0.6	2	12	frayed	...
Average	20.30	...	...	...	20.02	-0.24	17.30	20.23	0.35	2	10	...	...

[1] In this column, "J" indicates a large jaw tag, "j", a small jaw tag, and "m" a tag across the maxillary and premaxillary in the upper jaw.

Table XXVI.--Data pertaining to yellow pikeperch controls held at Lydell Hatchery, 1947.

B. Untagged fish

April 18			July 22	November 10					
Total length (inches)	Sex	Condition	Total length (inches)	Standard length (inches)	Total length (inches)	Weight Pounds	Weight Ounces	Condition of caudal fin	Lympho-cystis
18.3	M	R	14.4	14.0	16.5	1	7.5	normal	present
22.6	M	R	15.3	14.2	16.6	1	7	normal	...
21.7	M	R	15.5	14.4	16.9	1	6	normal	present
20.2	M	R	17.1	14.8	16.9	1	7	frayed	...
21.4	M	R	18.3	16.6	19.4	2	6	normal	...
15.4	M	R	19.1	16.4	19.6	2	3	normal	...
19.2	M	R	19.1	17.6	20.1	2	10	frayed	...
13.7	M	R	19.1	17.6	20.7	3	3	normal	...
14.5	M	R	19.9	18.4	21.1	3	3.5	frayed	present
17.4	M	R	20.0	18.1	21.4	3	1	normal	...
23.4	F	G	20.3	18.5	21.5	4	1	frayed	present
22.3	F	R	20.4	18.8	21.9	3	9	frayed	...
21.3	F	R	20.7	18.7	21.9	...	...	...	...
23.3	F	R	21.2	19.3	22.6	3	13	normal	...
21.5	F	R	21.3	19.2	22.6	3	5	frayed	...
23.5	F	R	21.5	19.9	23.3	3	10	frayed	present
20.5	F	G	21.6	...	...	...	...	...	...
19.1	F	G	22.1	...	...	...	...	...	...
20.1	F	R	22.7	...	...	...	...	...	...
21.1	F	R	22.8	...	...	...	...	...	...
21.4	F	R	22.8	...	...	...	...	...	...
20.2	F	S	23.2	...	...	...	...	...	...
22.9	F	G	...	...	...	...	...	...	...
19.7	F	R	...	...	...	...	...	...	...
20.20	...	...	19.93	17.28	20.19	2	11	...	...

On July 22, the pond was lowered and the pikeperch were removed by seining, for observation. Twenty-two untagged and 21 tagged fish, as indicated in Table XXVI, were removed, measured, and returned to the pond. The table shows that 18 of the tagged fish (individually recognizable) had become reduced in total length, two had gained slightly, and the length of one had remained unchanged. Average length of the tagged survivors was 20.02 inches, while that of the untagged fish was 19.93, indicating an average loss of 0.28 inches in the former and 0.27 inches in the latter. The average loss as determined from summation of specific gains and losses of each tagged fish was 0.24 inches. This figure is more accurate than the other average given, since the size of the fish which died during the experiment would have a considerable bearing on the average size of the survivors, and might easily obscure individual losses or gains in length.

The midsummer inspection, brought on by the curiosity of the writer concerning the fate of the controls and its bearing on each of two sizeable pikeperch tagging experiments then underway, probably caused some mortality. The pond refilled more slowly than was expected, and fish were replaced in the pond while the water was still shallow, very roiled, and warmer by over ten degrees than that to which the fish had been accustomed. By August 6, six untagged pikeperch and three tagged fish (numbers 580, 25, and one other) had been found dead. Two additional tagged fish (numbers 577 and 30) were removed in late August (mortality probably not caused by the July handling). Two fish (Nos. 583 and 578) dropped a distance of two feet during the July handling, and which struggled for several seconds on the dry ground, were later found to have survived.

All fish were removed from the pond and measured again on November 10. The data taken are shown in Table XXVI. Fifteen tagged and 16 untagged fish survived. Except for one tagged fish which was not recovered, all dead fish had been observed by employees at the hatchery. By November 10, average gain in length of tagged fish, based on individual measurements, was 0.35 inches. Nine showed a gain in length during the summer and the lengths of six continued to be less than when the fish were first placed in the pond in April.

Weights of the surviving tagged and untagged fish are given in the table. Although most of the lengths among the marked fish do not have exact opposites among the untagged fish, for comparison there is a general indication that untagged fish are heavier than tagged fish of the same size.

Among the survivors in November, eight tagged fish and seven untagged fish showed severely frayed caudal fins. Lymphocystis, a virus disease characterized by tumorous outgrowths on the fins and body, occurred about equally in both groups. The disease was not observed among fish selected for controls in April although it was very much in evidence among pikeperch in the Muskegon River, and was not noticed in July. One of the untagged control fish observed in November was severely afflicted with the disease.

Loss of condition, gaunt, lean form, was very evident among some fish, both tagged and untagged, in July, but was much less often observed in November among the controls. Such loss was also observed during July among both tagged and large untagged pikeperch (probably also originating from the transfer) in the upstream impoundments, and appears to occur even in the presence of an abundance of food, and the cause is not well understood.

The most important revelation of the control experiment is that there was probably no significant mortality as a result of tagging. Thus returns to anglers of tagged pikeperch should be representative of the returns of all fish moved in the Newaygo transfer during 1947.

An unexpected development in the control experiment was the finding of 14 young pikeperch in the control pond in November. Natural reproduction had evidently occurred, with spawning probably taking place very soon after the introduction of the fish in April. It may have occurred on a small section of the bottom where scattered gravel is exposed, or near the intake pipe where both a sand bottom and a steady flow of water occur. Judging by the usual spawning habitat chosen by pikeperch, reproduction would not have been expected. Its occurrence in the pond possibly lends credence to occasional reports of young pikeperch occurring (always in very small numbers) in waters into which ripe adults have been introduced, but in which reproduction would scarcely be expected to occur. The young pikeperch found in the pond averaged 9.8 inches in length and 4.7 ounces in weight.

D. Notes on the recoveries of tagged pikeperch by anglers and movements of this species in the Muskegon drainage.--The first tag return received after the transfer was for a pikeperch which had been caught on April 26, just 12 days after stocking at a point just below Croton Dam. From that time on, letters reporting tagged fish began reaching the Institute in increasing numbers until the end of July, when the number subsided somewhat. A record of the date of tagging, size of the fish, and distance traveled between the time of release and recapture was sent to the fishermen when addresses were known. Dr. William C. Beckman acknowledged many of the letters during the summer, while the writer was in the field.

A total of 221 tagged pikeperch had been reported by November 15, giving a return of over 12-1/2 percent on the 1,750 fish tagged.

Data regarding the recoveries, both at the time of release and as reported by anglers at the time of recapture, are shown in the various sections of Table XXVII. Each section of the table deals with the tagged fish stocked in the specific water named. The length, sex, condition (if a female) and location of release is shown, together with the date and location of recovery, length of the fish as reported by the angler, and the county (if a resident) or state of residence of the fisherman.

The summary shown in Table XXVIII is derived from an analysis of the data in Table XXVII. A concise picture is given of the more important results of the tagging study during the first fishing season following transfer. A return of 165 pikeperch, or 12 percent of the tagged fish stocked in the impoundments, and a 12.6 percent return (47 fish) of those planted in the Newaygo lakes is indicated. Recovery information on nine other tag returns is incomplete.

Largest returns among fish stocked in the impoundments were from those stocked in Big Rapids and Hardy Ponds, with returns of 20.8 and 18.5 percent respectively. Croton showed a 12.6 percent return and Rogers and Newaygo 9.6 and 8 percent respectively. Sixty percent of the fish recaptured in the impoundments were caught in the same water in which they had been stocked. For the Newaygo lakes this figure was 55 percent. Over 85 percent of the recoveries of tagged fish stocked in Croton and Hardy Ponds were made in these same ponds, although Rogers Pond appears to have retained only 12.5 percent of its fish. All recoveries of tagged fish stocked in Big Rapids Pond were made at points

Table XXVII--Tabulation of returns from tagged yellow pikeperch stocked in certain waters of the Muskegon River drainage, 1947.

A. Tag returns from yellow pikeperch stocked in Newaygo Pond, Newaygo County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date of release	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (State or county)
77	16.8	M		j	April 20	Newaygo	May ?	10+	3	...	...	Newaygo
97	24.3	F	R	m	20	Newaygo	July 13	84	...	...	...	Montcalm
107	18.9	M		j	20	Newaygo	July 10	81	12	...	...	...
138	25.2	F	R	m	20	Muskegon Lake	July 12	83	47	...	...	Muskegon
146	24.9	F	R	m	20	Newaygo	September 22	155	...	22.3	-2.6	Kent
431	21.6	F	...	J	14	Muskegon Lake	July 10	87	44	23.0	1.4	Muskegon
432	19.0	M		J	14	Lake Michigan	June 12	59	50	...	...	Muskegon
434	25.4	F	...	J	14	Kalamazoo River	August 15	123	92	23.5	-1.9	Ottawa
438	26.7	F	...	J	14	Saugatuck	July ?	77+	90	...	...	Allegan
453	24.5	F	...	J	14	Lake Michigan	August 12	120	90	24.0	-0.5	Van Buren
460	22.5	M		J	14	Newaygo	May 6	22	...	...	...	Muskegon
49612	18.6	M		j	14	Newaygo	April 26	12	0	...	...	Kent

B. Tag returns from yellow pikeperch stocked in Croton Pond, Newaygo County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date Released	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county
50	19.3	M		j	April 19	Croton	September 24	158	1	19.5	0.2	Indiana
53	19.5	M		j	19	Croton	July 31	103	1	19.2	-0.3	Kent
327	22.0	F	?	J	14	Lake Michigan	June 12	59	51	...	...	Muskegon
347	21.7	F	?	J	14	Croton	October 7	176	1	20.0	-1.7	Kent
355	22.3	M		J	14	Newaygo	July 12	89	13-1/2	22.0	-0.3	Kent
373	20.0	M		J	14	Croton	August 17	125	3/4	20.0	0.0	Ohio
386	22.7	F	?	J	14	Croton	July 26	105	1/2	23.0	0.3	Kent
391	20.7	M		J	14	Saugatuck	July ?	77+	91	...	...	Allegan
684	23.8	M		J	19	Croton	July 13	85	1	24.1	0.3	Wayne
702	20.9	M		J	19	Croton	September 20	154	1	19.0	-1.9	Florida
704	23.9	F	G	J	19	Muskegon Lake	July 2	74	48-1/2	...	...	Muskegon
705	22.1	F	G	J	19	Croton	August ?	103+	1	...	...	...
712	25.6	F	G	J	19	Croton	July ?	72+	3/4	26.3	0.7	Kent
718	22.7	F	R	J	19	Newaygo	July 27	99	12-1/2	22.5	-0.2	Kent
721	20.8	F	R	J	19	Croton	July 28	100	1/2	20.8	0.0	Kent
722	20.4	F	R	J	19	Croton	May ?	11+	...	21.0	0.6	...
730	24.8	F	R	J	19	Croton	September 10	144	1	24.3	-0.5	Newaygo
733	22.7	F	R	J	19	Croton	July 13	85	3/4	22.8	0.1	Ohio
736	25.2	F	R	J	19	Croton	July 9	81	1	25.3	0.1	Ingham
737	25.3	F	R	J	19	Croton	August 2	105	1	...	...	Muskegon
741	25.7	F	R	J	19	Croton	June 5	47	1	26.0	0.3	Newaygo
742	23.5	F	G	J	19	Lake Michigan	June 18	60	51	...	...	Muskegon
746	21.8	M		J	19	Croton	August 4	107	Up 1	...	...	Indiana
748	23.8	F	R	J	19	Croton	August 16	117	1	24.0	0.2	Berrien
752	25.2	F	R	J	19	Croton	August 9	112	1	25.0	-0.2	Kent

752	25.2	F	R	J	19	Croton	August 9	112	1	25.0	-0.2	Kent
756	26.6	F	R	J	19	Croton	August 9	112	1	26.0	-0.6	Kent
1069	24.2	F	R	J	23	Croton	July 21	89	...	23.8	-0.4	Newaygo
1074	27.0	F	R	J	23	Croton	July 25	93	2-1/2	27.0	0.0	Kent
1079	24.4	F	R	J	23	Croton	July 26	94	2-1/2	24.0	-0.4	Ohio
1082	25.6	F	R	J	23	Croton	July 10	78	2-1/2	25.0	-0.6	Ohio
1084	22.1	F	R	J	23	Croton	July 17	85	2-1/2	...	...	Wayne
1097	22.4	F	R	J	23	Croton	July 27	95	2-1/4	20.0	-2.4	Kent
1099	21.9	F	R	J	23	Croton	July 9	77	2-1/2	21.5	-0.4	Ohio
1100	24.2	F	R	J	23	Croton	September 15	145	2-1/2	24.0	-0.2	Kent
1102	21.0	F	G	J	23	Croton	September 26	156	2-1/2	21.0	0.0	Indiana
1107	22.1	M		J	23	Croton	July 26	94	2-1/2	22.0	-0.1	Kent
1110	20.4	M		J	23	Croton	July 18	86	2-1/2	20.0	-0.4	Kent
1123	23.1	F	G	J	23	Croton	June 23	61	1/2	25.0	1.9	Indiana
1266	24.6	M		m	25	Croton	October 19	177	Up 1-1/4	...	...	Kent
1267	22.8	F	R	m	25	Croton	June ?	36+	2-1/4	22.0	-0.8	Kent
1276	22.6	F	R	m	25	Croton	July 26	92	2-1/2	22.0	-0.6	Kent
1278	26.2	F	R	m	25	Croton	July 29	95	2-1/4	25.6	-0.6	Washtenaw
1290	19.1	M		j	25	Croton	October 18	176	2-1/2	19.0	-0.1	Kent
1295	26.0	F	R	m	25	Croton	July 24	90	2-1/2	27.0	1.0	Ohio
1301	18.7	M		j	25	Croton	July 22	88	2-1/2	23.8	5.1	Newaygo
1304	23.3	?		m	25	Croton	July 12	78	2-1/2	23.0	-0.3	Kent
1307	19.1	M		j	25	Croton	June 23	59	2-1/2	20.0	0.9	Kent
1310	18.1	M		j	25	Croton	June 28	64	2-1/2	17.5	-0.6	Kent
1314	20.6	M		m	25	Croton	August 2	99	2-1/2	20.5	-0.1	Kent
1324	27.2	F	R	m	25	Croton	July 26	92	2-1/2	27.0	-0.2	Kent
1331	18.9	M		j	25	Croton	August 10	107	2-1/4	19.0	0.1	Ohio
1335	19.6	M		j	25	Croton	July 21	87	2-1/2	18.5	-1.1	St. Joseph
		F		m	25	Croton	July 3	69	2-1/2	27.5	0.6	Kent

							Croton	June 25	61	1/2	25.0	1.9	Indiana
1266	24.6	M		m	25	Croton	October 19	177	Up 1-1/4	...	...	Kent
1267	22.8	F	R	m	25	Croton	June ?	36+	2-1/4	22.0	-0.8	Kent
1276	22.6	F	R	m	25	Croton	July 26	92	2-1/2	22.0	-0.6	Kent
1278	26.2	F	R	m	25	Croton	July 29	95	2-1/4	25.6	-0.6	Washtenaw
1290	19.1	M		j	25	Croton	October 18	176	2-1/2	19.0	-0.1	Kent
1295	26.0	F	R	m	25	Croton	July 24	90	2-1/2	27.0	1.0	Ohio
1301	18.7	M		j	25	Croton	July 22	88	2-1/2	23.8	5.1	Newaygo
1304	23.3	?		m	25	Croton	July 12	78	2-1/2	23.0	-0.3	Kent
1307	19.1	M		j	25	Croton	June 23	59	2-1/2	20.0	0.9	Kent
1310	18.1	M		j	25	Croton	June 28	64	2-1/2	17.5	-0.6	Kent
1314	20.6	M		m	25	Croton	August 2	99	2-1/2	20.5	-0.1	Kent
1324	27.2	F	R	m	25	Croton	July 26	92	2-1/2	27.0	-0.2	Kent
1331	18.9	M		j	25	Croton	August 10	107	2-1/4	19.0	0.1	Ohio
1335	19.6	M		j	25	Croton	July 21	87	2-1/2	18.5	-1.1	St. Joseph
1342	26.9	F		m	25	Croton	July 3	69	2-1/2	27.5	0.6	Kent
1347	20.9	M		j	25	Croton	July 28	94	2-1/2	22.0	1.1	Ohio
1349	20.1	M		m	25	Croton	July 4	70	2-1/2	21.0	0.9	Kent
1356	19.9	M		j	25	Croton	July 18	84	2-1/2	19.0	-0.9	Kent
1358	16.5	M		j	25	Croton	June 22	58	2-1/2	16.5	0.0	...
27669	18.4	M		j	14	Croton	June 28	75	1-3/4	18.0	-0.4	Kent
49721	18.7	M		m	16	Croton	May 31	45	1	20.0	1.3	Ionia
49737	18.5	M		j	16	Saugatuck	August 1	106	91	18.5	0.0	Ottawa
49746	22.4	F	R	m	16	Croton	July 25	100	1	22.0	-0.4	Kent
49744	24.6	F	R	m	16	Croton	September 23	160	1	24.0	-0.6	Ohio
49723	19.5	M		m	16	Saugatuck	July ?	75+	91	...	...	Allegan

Table XXVII (Continued)

C. Tag returns from yellow pikeperch stocked in Hardy Pond, Newaygo County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date released	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
3	21.6	F	R	m	April 18	Hardy	June 21	64	1-1/2	...	...	Ionia
7	18.8	M		m	18	Hardy	June 18	61	1-1/2	...	...	Kent
8	21.0	M		m	18	Hardy	August ?	104+	1-1/2	22.0	1.0	Montcalm
272	19.5	M		j	22	Croton	July 17	86	6-1/2	19.5	...	Kent
277	16.6	M		j	22	Hardy	August 9	109	1-1/2	...	...	Allegan
404	20.7	F	...	J	14	Croton	September 26	165	6-3/4	21.0	0.3	Indiana
405	22.6	F	R	J	14	Hardy	June 29	76	1	22.5	-0.1	Kent
407	23.5	F	...	J	14	Hardy	May ?	16+	1-1/2	...	...	Ingham
409	22.4	F	...	J	14	Hardy	October 12	181	...	22.0	-0.4	Ingham
410	23.4	F	...	J	14	Hardy	July 7	84	1-1/2	23.0	-0.4	Illinois
411	25.1	F	...	J	14	Croton	July 3	80	6-3/4	25.0	-0.1	Kent
423	24.0	F	R	J	14	Hardy	July 27	104	Up 9-1/2	23.5	-0.5	Kent
430	19.4	M		J	14	Hardy	October ?	169+	1	...	...	Ottawa
551	23.0	F	R	J	18	Hardy	July 4	77	Up 1/2	22.0	-1.0	Kent
554	23.0	M		J	18	Hardy	June 12	55	Up 2-1/2	23.5	0.5	Kent
555	21.2	M		J	18	Hardy	August 23	127	Up 1/2	21.0	-0.2	Kent
558	25.5	F	G	J	18	Hardy	August 18	122	1-1/2	24.5	-1.0	Indiana
560	24.3	F	R	J	18	Hardy	August ?	104+	1-1/2	26.5	2.2	Kent
562	22.5	F	S	J	18	Hardy	July 24	97	1-1/2	...	...	Kent
564	22.0	F	R	J	18	Hardy	July 28	101	1-1/2	21.0	-1.0	Ohio
568	25.3	F	[illegible]	J	18	Hardy	June 20	63	1/2	26.0	0.7	Kent
569	24.7	F	R	J	18	Hardy	September ?	135+	1-1/2	27.0	2.3	Tuscola
571	25.6	F	R	J	18	Hardy	September 21	156	1-1/2	...	...	Ingham
573	26.5	F	R	J	18	Hardy	August 3	107	1-1/2	26.5	0.0	Kent
966	25.1	F	R	J	22	Hardy	August 30	134	1-1/2	25.0	-0.1	Indiana
975	24.9	F	R	J	22	Hardy	June 13	52	1	...	...	Kent
979	23.6	F	R	J	22	Hardy	September 24	155	1-1/2	23.0	-0.6	Cass
982	23.5	F	G	J	22	Hardy	August 10	110	1-1/2	24.0	0.5	Kent
987	26.1	F	R	J	22	Hardy	June 30	69	1-1/2	...	...	Kent
1000	20.1	M		J	22	Croton	August 1	101	6-3/4	19.8	-0.3	Kent
27684	16.4	M		j	14	Hardy	October 5	174	...	17.0	0.6	Ingham
27687	19.4	M		j	14	Hardy	July 29	106	1-1/2	18.0	-1.4	Newaygo
27698	15.5	M		j	14	Hardy	September 8	147	1-1/2	15.8	0.3	Indiana
49957	19.7	M		j	18	Croton	July 17	90	6	19.5	-0.2	Kent
49968	23.4	F	R	m	18	Hardy	July 29	102	1-1/2	23.0	-0.4	Newaygo
49979	20.2	M		m	18	Hardy	October 12	177	...	25.0	4.8	Ingham
49998	22.5	M		m	18	Hardy	August ?	104+	1-1/2	22.3	-0.2	Kent

D. Tag returns from yellow pikeperch stocked in Rogers Pond, Mecosta County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date released	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
					April							
163	22.6	F	R	m	21	Hardy	June 7	47	20-1/2	...	...	Washtenaw
173	21.3	F	R	m	21	Hardy	July 5	75	22	...	...	Midland
186	22.5	F	R	m	21	Croton	July 25	95	24-1/4	23.0	0.5	Newaygo
206	25.3	F	R	m	21	Hardy	September 20	152	22-1/2	...	...	Kent
218	25.5	F	R	m	21	Hardy	August 2	103	23	...	...	Newaygo
219	23.9	F	G	m	21	Hardy	June ?	40+	22	23.8	-0.1	Kent
227	19.3	M		j	21	Hardy	August 13	114	23	...	...	Indiana
238	18.3	M		j	21	Hardy	July 26	96	23	18.0	-0.3	Kent
295	19.5	?		j	24	Hardy	October ?	159+	16	19.0	-0.5	Ingham
301	17.6	M		j	24	Hardy	August 19	117	21	17.5	-0.1	Iowa
314	22.8	F	R	m	24	Hardy	July 29	96	21	23.0	0.2	Newaygo
315	23.6	F	R	m	24	Hardy	July 30	97	21	24.0	0.4	Washington, D.C.
832	23.5	F	R	J	20	Rogers	July 3	74	4	...	...	Mecosta
833	26.1	F	R	J	20	Hardy	August 30	132	23	26.5	0.4	Indiana
840	24.6	F	R	J	20	Hardy	July 26	97	23	27.0	2.4	Kent
883	21.7	F	R	J	21	Hardy	August 10	111	22	21.3	0.4	Saginaw
901	22.3	F	R	J	20	Rogers	July 3	74	4	...	...	Mecosta
908	24.2	F	G	J	22	Hardy	July 31	100	20-3/4	24.5	0.3	Kent
920	23.8	F	R	J	22	Hardy	October ?	161+	16	23.0	-0.8	Ingham
924	26.1	F	[illegible]	J	22	Hardy	July 26	95	21	[illegible]		
925	23.4	F	R	J	22	Rogers	July 1	70	2	26.0		
937	20.5	M		J	22	Croton	June 14	53	21	...	...	Ingham
943	20.5	M		J	22	Rogers	October ?	161+	7-1/2	21.0	0.5	Indiana
953	20.1	M		J	22	Croton	July 11	80	26	18.0	-2.1	Kent
963	23.5	F	R	J	21	Hardy	July 4	74	22	...	...	Washtenaw
1140	23.4	M		J	24	Hardy	June 6	43	20-1/2	...	...	Kent
1141	22.9	F	R	J	24	Hardy	May 11	17	16	23.2	0.3	Kent
1151	25.6	F	R	J	24	Hardy	June 16	53	18	26.0	0.4	Montcalm
1191	20.9	F	R	J	24	Hardy	August 6	104	19	20.8	-0.1	Kent
8356	24.0	F	S	m	17	Hardy	August 19	124	23	24.0	0.0	Iowa
8371	19.7	M		j	17	Hardy	June ?	44+	4-1/4	...	...	Mecosta
8374	22.0	M		j	17	Hardy	September 20	156	22-1/2	22.0	0.0	Kent
8379	16.6	M		j	17	Hardy	October ?	166+	18	14.0	-2.6	Ingham
8381	23.0	F	G	m	17	Hardy	October 10	176	5+	22.0	-1.0	Montcalm
8386	22.8	F	R	m	17	Hardy	July 30	104	23	23.0	0.2	Washington, D.C.
8389	25.1	F	G	m	17	Hardy	July 29	103	4-1/4	24.5	-0.6	Mecosta
49665	20.1	M		j	16	Hardy	July 28	103	23	21.0	0.9	Ohio
49676	25.7	F	G	m	16	Hardy	August 14	120	23	25.0	-0.7	Kent
49680	18.4	M		j	16	Croton	October 7	176	28-1/4	17.0	-1.4	Kent
49692	25.1	F	R	m	16	Rogers	July 11	86	4	...	...	Kent
49695	20.6	M		m	16	Hardy	August 2	108	23	21.0	0.4	Kent
49700	19.1	M		j	16	Hardy	August 9	115	23	...	...	Allegan
49703	23.0	F	R	m	16	Hardy	June 21	66	23	...	...	Ionia
49704	23.0	F	R	m	16	Croton	October 3	170	28	22.0	-1.0	Newaygo
49710	24.8	F	R	m	16	Hardy	May 30	44	23	...	...	Kent
49880	21.7	M		m	17	Rogers	August 3	108	4	23.5	1.8	Kent
49883	20.7	F	G	m	17	Hardy	July 20	94	22	21.0	0.3	Kent
49905	20.1	M		m	17	Hardy	July 22	96	19	...	...	Ohio

E. Tag returns from yellow pikeperch stocked in Big Rapids Pond, Mecosta County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date of release	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
1241	23.6	F	...	J	April 15	Hardy	October 7	175	29-1/2	23.0	-0.6	Clinton
1249	19.8	F	...	J	15	Croton	July 7	81	34	...	...	Ohio
1250	21.2	F	...	J	15	Hardy	September 23	161	29-1/2	21.0	-0.2	Indiana
49626	18.1	M		j	15	Hardy	July 23	99	29-1/2	...	...	Ohio
49653	19.7	M		j	15	Hardy	July 25	101	29-1/2	...	...	Ohio

Table XXVII(Continued)

F. Tag returns from yellow pikeperch stocked in Pickerel Lake, Newaygo County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date of release	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
472	20.3	M		J	April 15	Pickerel	June 1	47	0	...	...	Ohio
477	24.3	F	...	J	15	Pickerel	August 5	112	0	24.0	-0.3	Manistee
485	23.0	F	...	J	15	Pickerel	August 9	116	0	23.5	0.5	Florida
488	24.8	F	...	J	15	Kimball Lake	September 23	161	1/2	25.0	0.2	Newaygo
489	21.0	F	...	J	15	Penoyer Creek	July 13	89	1	...	...	Newaygo
492	21.2	F	...	J	15	Kimball Lake	July 24	100	1/2	21.0	-0.2	Illinois
495	24.9	F	...	J	15	Pickerel	October 25	193	0	26.0	1.1	Indiana
1201	24.8	F	...	J	15	Kimball	October 6	174	1/2	24.0	-0.8	Indiana
1203	22.6	M		J	15	Pickerel	October ?	168+	0	22.0	-0.6	Ohio
1209	21.7	F	...	J	15	Kimball	July 24	100	1/2	24.0	2.3	Muskegon
49613	19.4	M		j	15	Kimball	June 20	66	1/2	20.3	0.9	Kent
49614	16.7	M		j	15	Pickerel	August 6	144	0	17.0	0.3	Kent
49615	16.5	M		j	15	Kimball	July 15	91	1/2	16.5	0.0	Newaygo
49618	18.4	M		j	15	Emerald	July 24	100	1/2	18.0	-0.4	Kent
49622	20.7	M		j	15	Kimball	September 2	140	1/2	21.0	0.3	Newaygo
49624	16.3	M		j	15	Kimball	July 29	74	1/2	15.5	-0.8	Newaygo

G. Tag returns from yellow pikeperch stocked in Emerald Lake, Newaygo County

Release							Recovery					
Tag number	Length	Sex	Condition, if female	Type tag	Date of release	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
584	20.9	M		J	April 19	Emerald	September ?	134+	0	...	...	Kent
585	26.0	F	R	J	19	Sylvan	June ?	42+	1/2	...	...	Kent
592	27.2	F	G	J	19	Emerald	August 3	106	0	...	...	Kent
595	22.6	F	R	J	19	Emerald	June 30	72	0	...	...	Indiana
605	20.7	F	G	J	19	Emerald	September ?	134+	0	...	...	Kent
615	21.9	F	G	J	19	Emerald	July 14	86	0	22.5	0.6	Kent
628	23.7	F	S	J	19	Emerald	August 9	112	0	24.0	0.3	Kent
632	27.2	F	G	J	19	Emerald	August 3	106	0	...	...	Kent
633	23.4	F	R	J	19	Pickerel	July 7	79	1/2	...	...	Indiana
651	22.0	F	R	J	19	Emerald	September ?	134+	0	...	...	Kent
655	25.6	F	R	J	19	Emerald	June 26	68	0	25.5	-0.1	Saginaw
670	23.6	F	G	J	19	Emerald	July 24	127	0	23.5	-0.1	Kent
672	27.3	F	G	J	19	Emerald	August ?	103+	0	27.3	0.0	Kent
1211	23.8	F	...	J	15	Emerald	June 29	75	0	24.0	0.2	Kent
1212	25.0	F	...	J	15	Sylvan	August 9	116	1/2	25.5	0.5	Kent
1223	25.6	F	...	J	15	Pickerel	August 1	107	1/2	25.4	-0.2	Newaygo
1229	22.6	F	...	J	15	Sylvan	July 13	89	1/2	20.0	-2.6	Kent
1230	20.6	F	...	J	15	Sylvan	July 27	103	1/2	22.5	1.9	Kent
1231	24.3	F	...	J	15	Pickerel	July 23	99	1/2	25.5	1.2	Illinois
1237	21.6	M		J	15	Kimball	October 12	180	1	21.0	-0.6	Kent
1240	25.7	F	...	J	15	Emerald	July 21	97	0	25.0	-0.7	Kent
49631	15.8	M		j	15	Emerald	August 19	126	0	...	...	Missouri
49646	18.4	M		j	15	Kimball	October 9	177	1	18.0	-0.4	Indiana
49647	17.5	M		j	15	Emerald	August 16	123	0	17.5	0.0	Newaygo

Table XXVII(Continued)

H. Tag returns from yellow pikeperch stocked in Hess Lake, Newaygo County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date of release	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
49766	22.8	F	R	m	April 17	Hess	July ?	74+	0	...	...	Newaygo
49800	21.7	M		m	17	Brooks	July 20	94	1/2	20.0	-1.7	Genesee
49845	19.8	M		j	17	Hess	August 30	135	0	22.0	2.2	Cass

Table XXVII(Continued)

I. Tag returns from yellow pikeperch stocked in Brooks Lake, Newaygo County

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date released	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of anglers (state or county)
530	21.6	F	R	J	April 17	Brooks	August 15	120	0	21.0	-0.6	Kent
535	20.5	F	G	J	17	Brooks	July 12	86	0	20.5	0.0	Kent
49933	18.3	M		j	17	Brooks	August 18	123	0	18.0	-0.3	Newaygo
49941	15.3	M		j	17	"S. Br. Muskegon"	July 9	83	...	18.0	2.7	Allegan

Table XXVII (Continued)

J. Incomplete reports of tagged fish taken in the Muskegon River

Release						Recovery						
Tag number	Length	Sex	Condition, if female	Type tag	Date released	Location	Date	Days out	Miles traveled	Reported length	Gain in length	Residence of angler (state or county)
1015	...	...	...	...	April ...	Hardy	June 18	...	...	...	...	Ionia
...	...	...	...	...	...	Croton	August 10	...	...	21.0	...	Kent
...	...	...	...	...	...	Hardy	July ?	...	...	...	...	Kent
...	...	...	...	...	...	Hardy	October ?	...	...	...	...	Ingham
...	...	...	...	...	...	Croton	October 7	...	...	...	...	Kent
251[1]	13.1	M		j	22	Hardy (from Rogers)[2]	October 5	166	...	16.0	2.9	Ingham
917[1]	26.5	F	R	J	22	Hardy (from Rogers)[2]	October 4	165	...	26.6	0.1	Ingham
972[1]	23.2	F	R	J	22	Hardy (from Hardy)[2]	October 4	165	...	24.0	0.8	Ingham
27685[1]	19.0	M		j	14	Hardy(from Hardy)[2]	October 5	174	...	...	...	Ingham

[1] Detailed data received too late for inclusion in tables in this report. Included in other tables as "incomplete."

[2] Indicates place of release of fish

XXVIII
Table .--Summary of recoveries of marked yellow pikeperch, Muskegon River drainage, 1947.

Water	Number tagged	Total number	Total percent	Recoveries: Where stocked: Number	Recoveries: Where stocked: Percent of recoveries	Recoveries: Elsewhere: Number	Recoveries: Elsewhere: Percent of recoveries
Newaygo Pond	150	12	8.0	6	50.0	6	50.0
Croton Pond	501	63	12.6	55	87.3	8	12.7
Hardy Pond	200	37	18.5	32	86.5	5	13.5
Rogers Pond	500	48	9.6	6	12.5	42	87.5
Big Rapids Pond	24	5	20.8	0	0.0	5	100.0
Total for impoundments	1,375	165	12.0	99	60.0	66	40.0
Pickerel Lake	50	16	32.0	6	37.5	10	62.5
Emerald Lake	150	24	16.0	15	62.5	9	37.5
Hess Lake	100	3	3.0	2	66.7	1	33.3
Brooks Lake	75	4	5.3	3	75.0	1	25.0
Total for lakes	375	47	12.5	26	55.0	21	45.0
Incomplete data	...	9	...	...	...	...	...
Grand total	1,750	221	12.6	125	59.0	87	41.0

in the stream below this impoundment, and in the case at Newaygo Pond half the recoveries were from this impoundment and the remainder were from points downstream.

With regard to the important matter of the passage of fish through the various dams, an analysis of Table XXVII shows that the numbers of tagged fish which were recovered after passing through each of the various dams were as follows: Newaygo, 12; Croton, 8; Hardy, 11; Rogers, 42; and Big Rapids, 5. Only 24 tagged fish were stocked above Big Rapids Dam, while numbers whichwere stocked at points above the other dams are much larger. (See Table XXVIII). One fish was recovered after passing through three dams (Big Rapids, Rogers and Hardy). Four passed through Big Rapids and Rogers, and five through Rogers and Hardy. None are known to have gone through both Croton and Hardy, but six went through both Croton and Newaygo; together with six which were stocked just below Croton Dam, these went on to Muskegon Lake (three) and to Lake Michigan (nine).

Movements of tagged pikeperch in the river are graphically shown in figures 21, 22 and 23.* Figure 21 shows the approximate locations

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*Drafted by Wm. Cristanelli

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of stocking and recovery of tagged pikeperch planted in Big Rapids and Rogers Ponds, Figure 22 gives the same information for Hardy Pond, and Figure 23 for those in Croton and Newaygo Ponds.

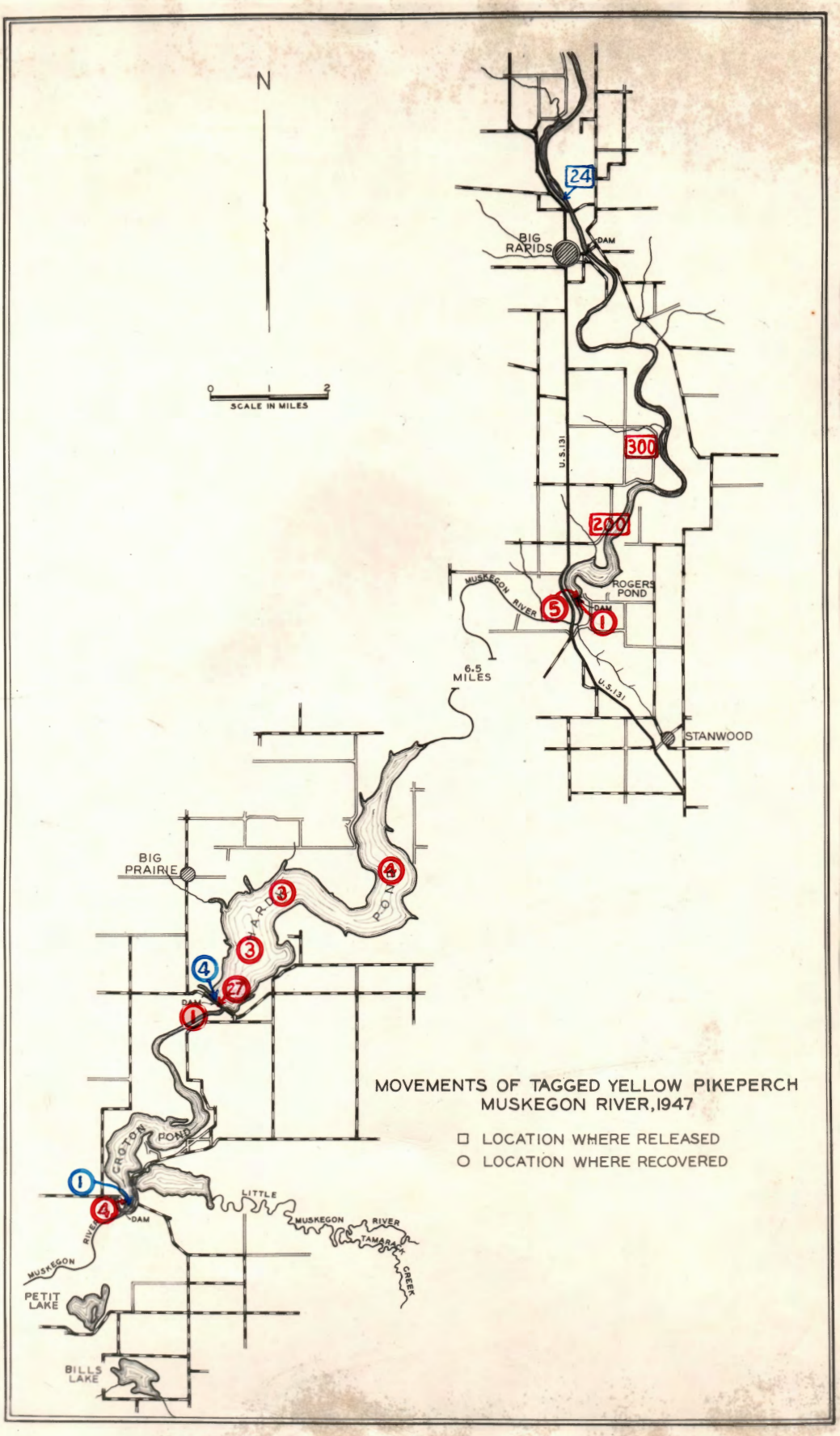

Figure 21

Movements of yellow pikeperch stocked in Big Rapids and Rogers Ponds

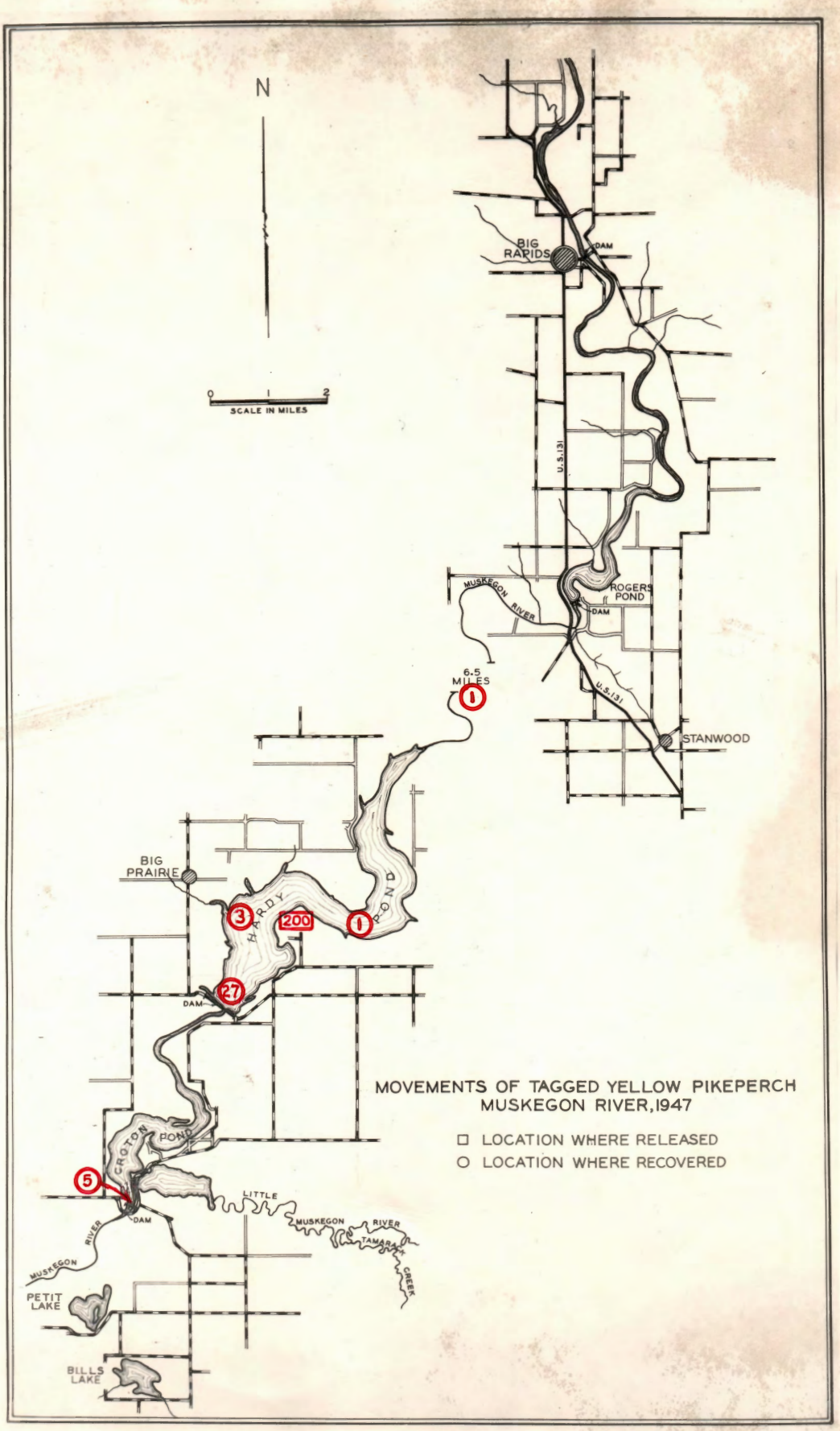

Figure 22

Movements of tagged yellow pikeperch stocked in Hardy Pond

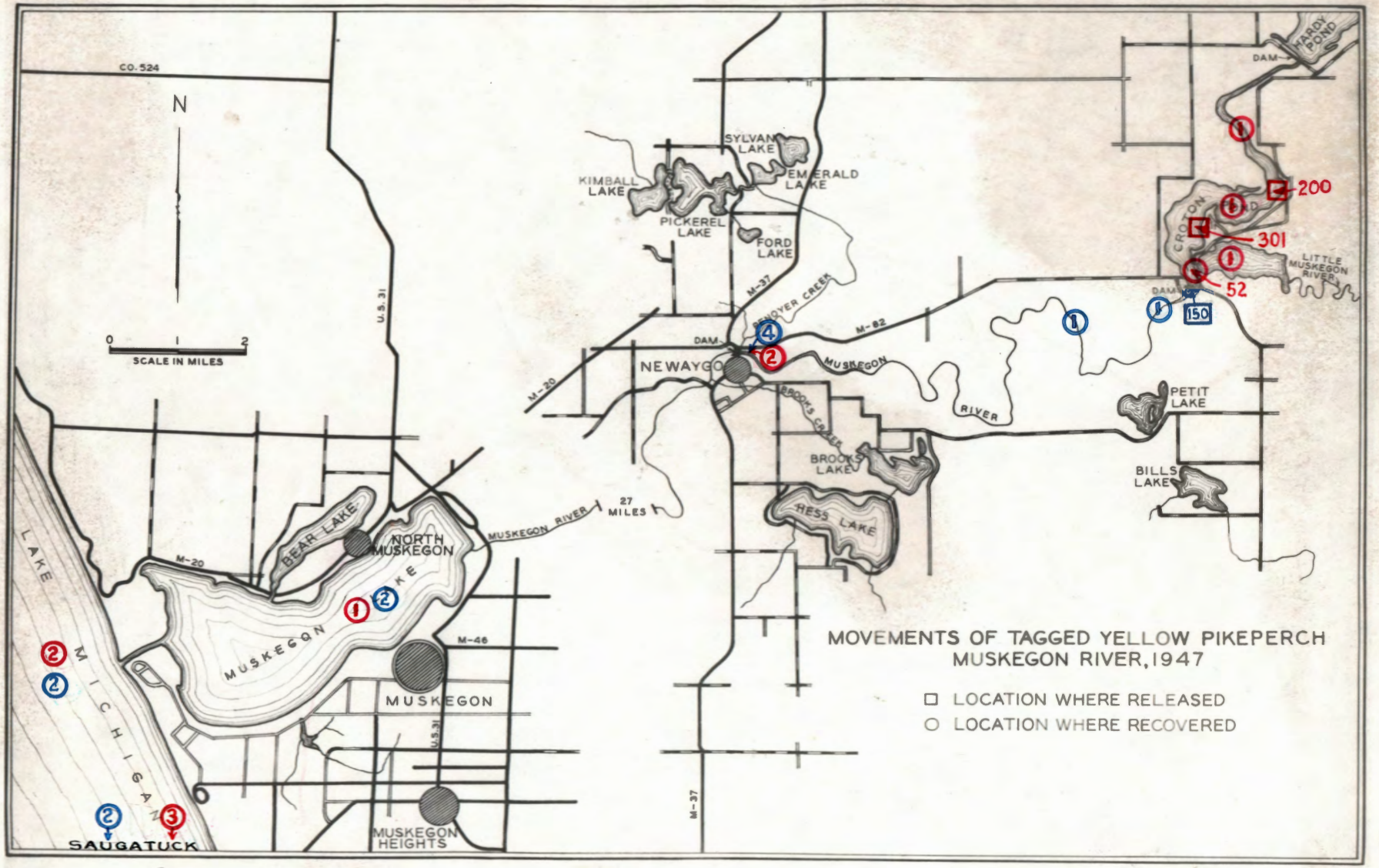

Figure 23

Movements of tagged yellow pikeperch stocked in Croton and Newaygo Ponds

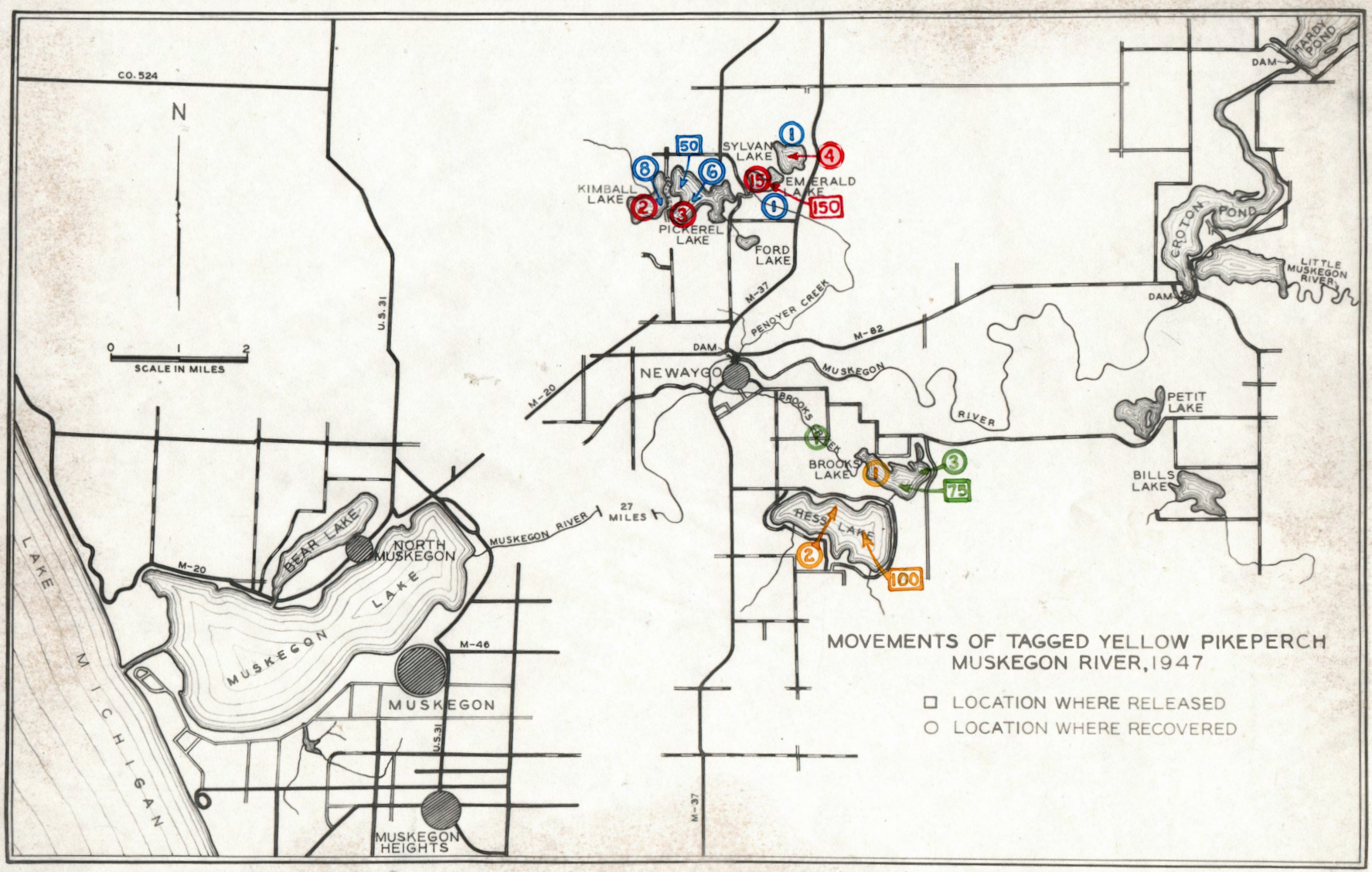

Figure 24

Movements of yellow pikeperch stocked in the Newaygo Lakes

It has been shown[*] that pikeperch move from a point one mile below

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[*] Carbine, W. F., and Applegate, Vernon C., "Recaptures of Tagged Walleyes, Stizostedion v. vitreum (Mitchill) in Houghton Lake and the Muskegon River, Roscommon County, Michigan," Copeia, 1942, No. 2, pp. 97 - 100.

Houghton Lake to Big Rapids Dam. The movements of the species in the lower Muskegon, as described above, complete the proof that it would be possible for a pikeperch to migrate from Houghton Lake to Lake Michigan, although no individual fish has been known to do so.

The observations of movement of transferred fish as described above make it possible and of considerable interest to outline the probable fate of the 4,129 pikeperch which were stocked above the five dams during the 1947 Newaygo transfer. This is attempted in Table XXIX. Figures in the table are based on the assumption that tagged and untagged fish were taken by anglers with equal facility and in numbers exactly proportional to their respective representation among the transferred fish. Whether or not this was true is of course not definitely known, although the assumption is believed to be entirely logical. It is further assumed that opportunity for and inclination toward movement through the dams were equal for marked and unmarked fish. A third assumption is that mortality among tagged and untagged fish is equal, a supposition well borne out by the control experiment at the Lydell Hatchery (discussed above). Mortality figures are not known, and are not considered in the table. All totals shown are reducible by a small percentage, logically equal for all figures, to allow for mortality.

Table XXIX.--Probable (estimated) movements during the first fishing season of 4,129 yellow pikeperch stocked in Muskegon River impoundments in 1947.

Location where stocked	Number stocked	Number remaining in water where stocked		Probable numbers moving to:							
				Newaygo		Croton		Hardy		Lake Michigan	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Newaygo Pond	410	205	50.0	...	...	...	...	...	...	205	50.0
Croton Pond	1,854	1,619	87.3	59	3.2	...	...	...	...	176	9.5
Hardy Pond	572	495	86.5	...	...	77	13.5	...	...	...	...
Rogers Pond	1,116	140	12.5	...	...	116	10.4	860	77.1	...	...
Big Rapids Pond	177	0	0.0	...	...	35	20.0	142	80.0	...	...
Totals	4,129	2,459	59.6	59	1.4	228	5.5	1,002	24.3	381	9.2

A total of 19 tagged fish (1.4 percent of the total planted in the impoundments) were recovered dead, as tabulated in Table XXX. The reports of dead fish by anglers and others are probably not complete, however, and the percentage is thought to be slightly higher than this figure would indicate. On the other hand, it is almost undoubtedly lower than the 10.4 percent mortality figures which the controls would indicate (as of July 22). The controls were probably insufficient in number to give a reliable estimate of mortality to all transferred fish. At the low water temperatures during and after the transfer, fish killed during the transfer would be expected to float for a period of several days. Any mortality of consequence would have undoubtedly been observed and reported by Consumers Power employees who remove debris which collects near intakes to the turbines, at frequent intervals. Although, as mentioned above, the figure is not definitely known, a guess of 4 or 5 percent might be advanced as being fairly well in line with actuality.

The figures in Table XXIX show that of the 4,129 fish stocked, 2,459, or about 60 percent, probably remained in the water in which they were planted, while the remainder migrated through one or more dams. A total of about a thousand reached Hardy Pond from upstream areas and remained there, 228 left upstream areas to reside in Croton Pond, and 59 took up residence in Newaygo Pond. One hundred seventy-six from Croton and 205 from Newaygo Reservoir, went all the way back to Muskegon Lake or to Lake Michigan.

The tagging results show unmistakably that any of the power dams on the Muskegon can be negotiated by large adult fish wishing to move downstream. Although no single fish is known to have passed through all five dams, there is no cause for belief that this could not or does not occur. Big Rapids, Rogers, and Newaygo dams apparently offer little in

Table XXX .--Tagged fish found dead after stocking in the Muskegon River.

Release					Release	
Tag number	Length	Sex	Condition, if female	Type tag	Date released	Location
193	22.9	F	G	m	April 21	Rogers
214	16.7	M		j	21	Rogers
317	22.0	F	G	m	24	Rogers
692	24.8	F	G	J	19	Croton
828	24.8	M		J	20	Rogers
844	25.0	F	G	J	20	Rogers
847	22.2	F	G	J	20	Rogers
871	20.4	?		J	21	Rogers
882	21.2	F	G	J	21	Rogers
898	21.3	F	G	J	22	Rogers
900	22.4	F	G	J	22	Rogers
911	24.0	M		J	22	Hardy
1135	25.3	F	G	J	23	Croton
1152	27.0	F	G	J	24	Rogers
1178	21.5	F	G	J	24	Rogers
1248	20.5	F	...	J	15	Big Rapids
1254	23.2	F	G	m	24	Rogers
8399	21.7	M		m	17	Rogers
...	...	...	...	...	...	Rogers

the way of an obstacle to downstream migration during at least some portion of the year. Croton and Hardy dams appear to be considerably more difficult to negotiate. This is quite understandable in the case of the latter, since water has been spilled through it on only rare occasions since its construction, and none was passed during 1947. All fish passing through this dam had to go through the power developing units of the dam. It is presumed that if this occurs in the case of Hardy Dam, it may also occur among the other dams. Reports of mangled fish being found below the various dams, received from time to time, suggest that not all fish are successful in negotiating the structures unharmed. The most recent report reached the Institute in the form of a letter from Mr. J. T. Wilkinson, Regional Fisheries Supervisor at Paris, to Dr. L. N. Allison, Pathologist of the Fish Division, under date of May 29, 1947. It quotes in part a letter written by Conservation Officer Alger Cline to the Field Administration Division's District Supervisor at Baldwin, Mr. Karl Kidder. A portion of the letter is requoted here in turn:

"I have made an investigation regarding the dead walleyes which have been found below the dam at Hardy Pond.

"I feel sure that these fish were killed in the wheel at the power house. I talked with several people who say that this always happens when there is a period of extreme high water.

"While there is no proof they think that the grates are removed at this time so as to be cleaned and this lets the fish get to the wheels."

Whether transferred and other fish moved through the dam at this or at other times is not known, and the dates when the fish passed through the spillways or turbines of other dams can only be surmised. Table XXXI gives some indication of the periods during which spillways of some of

Table XXXI.--Foot hours[1] of water passing through spillways of certain Muskegon River dams from April 1 to August 31, 1947.

	Newaygo	Croton	Hardy	Rogers	Big Rapids
April	8,761	3,447	...	3,741	8,349
May	7,273	1,632	...	1,867	4,811
June	2,001	...	...	...	747
July	231	...	...	...	...
August	256	...	...	...	14

[1] One gate open a distance of 1 foot for one hour.

the dams may have been negotiated. It shows in foot hours (to the nearest foot hour - one gate open for a distance of 1 foot for 1 hour) the amount of water spilled during and since the 1947 transfer, up to the end of August. The figures were provided by Mr. B. A. Wood, of Consumers Power Company. Spilling took place beneath the spillway gates, except in the case of Croton Dam, where the amounts of water spilled above and below the gates was about equal. These figures suggest that possibly most movement through spillways took place during May, after pikeperch were completely through spawning and while they were attempting their customary downstream migration following the release of sexual products. The dates on which the first tagged fish were caught which had passed through the various dams gives some further information concerning the same point. The first fish known to have passed through Big Rapids Dam was caught on July 5. (This pikeperch had also negotiated Rogers Dam). May 11 was the first record for a fish which had moved through Rogers Dam and July 3 was the first record in the case of Hardy Dam. One fish had run both Croton and Newaygo Dams and reached Lake Michigan by June 12 and another had done the same by June 18.

Among the Newaygo Lakes in which fish were stocked, the best returns were from Pickerel Lake (32 percent) and poorest from Hess (3 percent). Returns were good from Emerald Lake (16 percent) and poor from Brooks (slightly over 5 percent). Over 60 percent of the fish stocked in Pickerel Lake apparently moved to other waters in the chain, while Emerald Lake retained the majority of its fish. It lost 3 tagged fish to Pickerel Lake and received one in return. The general conclusions are that utilization of stocked pikeperch is heavy in the north Newaygo lakes, but that these contribute little to the Hess and Brooks Lake fisheries.

Pikeperch are able to negotiate the stream connecting Brooks and Hess Lakes and apparently move freely about among the north lakes, (Pickerel, Kimball, Emerald and Sylvan). None, or virtually none, appear to get back to the Muskegon River during the first season after transfer.

The figures given in Table XXXII result from summarizing some of the results shown in other form in Table XXVII. They indicate that during the first fishing season, fish were at large for an average of somewhat over three months in both the impoundments and lakes before they were captured by anglers. The periods in days were slightly longer than those shown in the table. Some anglers did not give dates of capture in their reports of tagged fish caught. In these cases the time between release and recapture was computed as of the first day of the month during which the fish was caught.

Stream distances traveled by fish in the river varied from 0 to 92 miles and averaged 17.9 miles. The fish traveling the greatest distance swam from a point just below Croton Dam through Newaygo Dam to the mouth of the Muskegon and southward in Lake Michigan to the Kalamazoo River, where it was captured about 2 miles east of Douglas. The trip required 123 days. The most rapid movement recorded was by a fish which traveled down 50 miles of river to Lake Michigan (and an unknown number of miles in the lake--the location of capture in the lake was not reported) in a period of 59 days. This record may have been bettered by several others, however, which reached Saugatuck (about 90 miles) in a period of somewhere between 77 to 108 days (exact dates of capture were not reported by the fishermen). The fact that five of the nine fish which reached Lake Michigan were taken in the immediate vicinity of Saugatuck suggests that considerable numbers of pikeperch which migrated

XXXII

Table .--Period between time of release and recapture, and distances traveled for yellow pikeperch in the Muskegon River drainage, 1947.

Water	Days between tagging and recapture: Number of records	Days between tagging and recapture: Average	Distance traveled in miles: Number of records	Distance traveled in miles: Average
Newaygo Pond	12	76	9	47.5
Croton Pond	63	95	61	8.9
Hardy Pond	37	107	34	2.4
Rogers Pond	48	101	48	18.5
Big Rapids Pond	5	123	5	30.4
Totals for impoundments	165	99	157	17.9
Pickerel Lake	16	117	16	0.3
Emerald Lake	24	108	24	0.2
Hess Lake	3	101	3	0.2
Brooks Lake	4	103	3	0.0
Totals for lakes	47	110	46	0.25
Totals, all waters	212	101	203	13.9

up the Muskegon in the spring of 1947 apparently frequented the mouth of the Kalamazoo River during the summer.

It is of interest to note that only six pikeperch were caught in the river which had moved upstream from the point at which they were stocked. Distances traveled upstream were small, although one fish in Hardy Pond was recovered 9-1/2 miles above the point of release.

It is a matter of common knowledge that pikeperch in the impoundments tend to congregate just above the grates guarding the intake structures of the dams. This may be more true of transferred than of native fish, although both are caught in some numbers. A substantial percentage of the tagged fish caught in Croton Pond during 1947 were taken by anglers fishing from the boom (or from boats anchored near by) which intercepts debris floating toward the grates. The boom at Croton is shown in Figure 25. Dozens of fishermen were observed fishing from this structure on some days during July, 1947. Rogers Dam has a similar boom (Figure 26), but angling success was much less pronounced there than at Croton (possibly because most transferred fish apparently moved downstream very soon after transfer). Hardy Dam has a different type of intake structure (Figure 27). Anglers are familiar with the rewards derived from fishing in the general vicinity of this structure, and gill nets set near it in August took better catches of pikeperch than those set elsewhere in the pond. Newaygo Dam has a narrow raceway leading from the impoundment to the power house, and fishermen line the shores near the grates when pikeperch are biting. Consumers Power has erected signs warning of the danger of fishing in these areas but the public is not prevented from doing so.

The reason for the concentration of pikeperch near the grates is not known, but it seems to be obviously associated with their inclination

Figure 25.--Boom above power plant at Croton Dam, Muskegon River

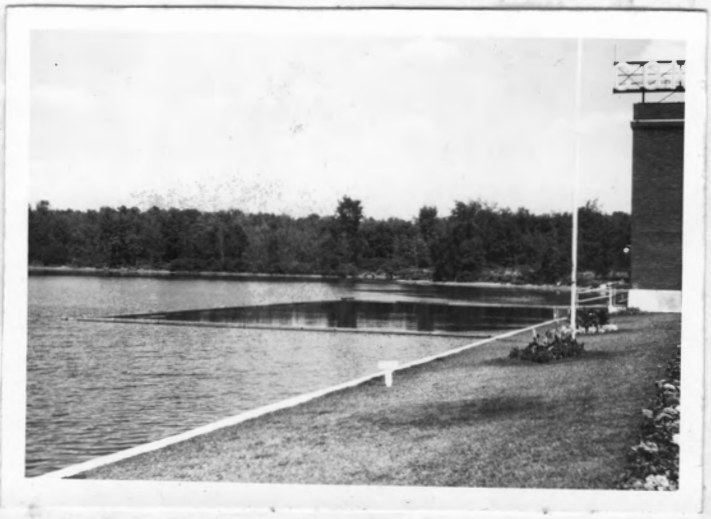

Figure 26.--Boom above power plant at Rogers Pond, Muskegon River

Figure 27.--Intake structure for power plant at Hardy Dam, Muskegon River. The road crossing the dam is shown at the extreme right.

to move downstream. The fact that many native fish of sub-legal size are taken in these areas, coupled with our knowledge of the movements of certain tagged fish through the power turbines, suggests that at least some of the former also migrate downstream.

The month of recovery of the tagged fish which figured in the 1947 Newaygo transfer is summarized in Table XXXIII. It shows that almost 40 percent of the fish recovered were taken during July, nearly 22 percent in August, and 14 percent in June. The fact that pikeperch are seldom taken in any numbers in other waters during the hot summer months lends particular interest to these results.

A further study of Table XXVII reveals that the anglers participating in the harvest of the fish transferred in 1947 came from a wide geographic area. Twenty-one Michigan counties, 6 states and Washington D. C. were represented. Ninety of the reports received were submitted by Kent County fishermen, 20 were from Newaygo, and 15 from Ingham. Other counties represented are Muskegon (8), Allegan (6), Montcalm (4), Ottawa (4), Ionia (4), Mecosta (4), Washtenaw (3), Saginaw (2), Cass (2), Wayne (2) and Van Buren, Clinton, Manistee, Genesee, Berrien, St. Joseph, Tuscola and Midland (1 each). Most outstate anglers came from Ohio (18), and Indiana (17). Others were from Illinois (3), Florida (2), Iowa (2), Washington D. C. (2) and Missouri (1).

Measurements turned in by fishermen were apparently of widely varying accuracy, and are considered insufficiently reliable to warrant statistical treatment. Judged by the measurements reported, 79 fish showed a loss in length and 73 an increase. That some fish did show a loss in length was indicated by the controls (discussed above) as well as by several careful measurements of tagged fish in the impoundments

Table XXXIII.---Summary of reports of tagged yellow pike-perch taken in the Muskegon River in 1947, showing month of recovery.

Month	Number of recoveries	Percent of total
April	1	0.5
May	7	3.2
June	31	14.0
July	88	39.8
August	48	21.7
September	20	9.0
October	26	11.8
Total	221	100.0

made by the writer during July. The loss is believed to be almost entirely due to the fraying and breakage of distal ends of the caudal fins during and immediately following the handling associated with the transfer. The soft dorsal and sometimes the spiny dorsal likewise exhibit this effect to greater or less degree.

E. An analysis of tag returns in relation to size and location of tag, and to size, sex and condition of the pikeperch tagged.--With the hope of comparing the effectiveness of the tagging, with regard to size and location of the tag, Table XXIV was compiled. The size and position of tags used have been discussed above. The table includes the tag numbers (deleted from copies of this report sent outside the Conservation Department) used in the study, and the number and percent of returns from the various groups of tags in each of the various waters.

Without discussing in great detail the results for individual waters which may be observed directly from the table, it should perhaps be mentioned that there was a slightly higher percent (14) of returns from the large size tags placed in the lower jaw than from the smaller tags placed in either the upper (10.6 percent returns) or the lower (10 percent) jaw. The very large size of the larger tags practically precludes the possibility of their being over-looked by anglers, and this may have been a factor in the results. The advantage of the larger tag is not, however, sufficient to be of particular significance. In two out of four waters where pikeperch bearing all three types of tags were stocked, the large jaw tag is superseded by the upper jaw tag in the returns. However, the larger tag produced better returns in six out of eight waters than the small tag used as a jaw tag. The small

jaw tag in turn gave better results than the maxillary tag in three out of five waters. Small numbers of fish stocked in some of these waters and large numbers stocked in others give a varying importance to these comparisons, however.

In three instances, an attempt was made to compare the maxillary type of tag with the jaw tag (both sizes considered together). Fifty fish were marked with the former and 50 with the latter, and the entire hundred stocked in the same water on the same date (Newaygo Pond, April 20; Hardy Pond, April 18; and Rogers Pond, April 21). Combined returns showed 15 returns from the maxillary tags as against 17 from jaw tags.

The obvious conclusion from the results discussed in the preceding paragraphs of this section is that the three types of tags (large lower jaw, small upper jaw and small lower jaw), as used in this study, are about equally satisfactory for marking yellow pikeperch.

Table XXXIV also breaks down the tag returns on the basis of individual plants of fish. Some variations in returns from different plants in the same waters is seen to have occurred. Percentage differences, especially when the size of the samples are considered, are too small, however, to show that the variations might have been due to differential mortality in the various plants. This is rather unlikely anyhow, since all fish were in about the same condition and were handled in the same way and at comparable water temperatures. Any significance which might be attached to the tendency toward a decreasing return with progress of the planting period in Rogers, Hardy and Newaygo Ponds, is voided by the results in Croton Pond, which show a reverse trend.

Table XXXIV.---An analysis of tag returns from yellow pikeperch, with reference to size, type, and location of tags, and to individual plants, in the Muskegon River drainage, 1947. (See text for discussion).

Stocking				"Small" tags			"Small" tags			"Large" tags			All tags		
				Upper jaw			Lower jaw			Lower jaw					
Water	Date	Miles above dam	Tag numbers	Number tagged	Number returns	Percent returns	Number tagged	Number returns	Percent returns	Number tagged	Number returns	Percent returns	Number of fish stocked on given date	Returns Number	Returns Percent
	April														
Newaygo Pond	14	12	431-471 49,604-49,612				9	1		41	6		50	7	14.0
	20	12	73-152 801-820	50	3		30	2		20	0		100	5	5.0
Subtotals				50	3	6.0	39	3	7.7	61	6	9.8	150	12	8.0
Croton Pond	14	1	326-336 338-376 378-400 33,746 33,748-33,749 27,660-27,683				27	1		73	6		100	7	7.0
	16	1	49,712-49,761 49,652	37	4		14	1					51	5	9.8
	19	1	45-62 64-65 67 70-72 675-800				24	2		126	18		150	20	13.3
	23	2.5	278-293 1,056-1,139				16	0		84	12		100	12	12.0
	25	2.5	1,259-1,358	67	10		33	9					100	19	19.0
Subtotals				104	14	13.5	114	13	11.4	283	36	12.7	501	63	12.6
Hardy Pond	14	1.5	401-430 27,684-27,700 49,601-49,603				20	3		30	8		50	11	22.0
	18	1.5	1-19 49,949-49,963 49,966-50,000 545-575	50	6		19	1		31	11		100	18	18.0

2

Hardy Pond	14	1.5	401-430 27,684-27,700 49,601-49,603				20	3		30	8				
	18	1.5	1-19 49,949-49,963 49,966-50,000 545-575	50	6		19	1		31	11		100	18	18.0
	22	1.5	268-277 965-988 990-1,000 1,051-1,055				10	2		40	6		50	8	16.0
Subtotals				50	6	6.0	49	6	12.2	101	25	24.8	200	37	18.5
Rogers Pond	16	4	49,661-49,672 49,674-49,711	28	6		22	3					50	9	18.0
	17	4	8355-8400 49,864-49,917	72	7		28	3					100	10	10.0
	20	4	153-156 821-865 867				4	0		46	3		50	3	6.0
	21	4	157-158 160-239 871-888	50	6		32	2		18	1		100	9	9.0
	22	2	240-267 892-908 910-964				28	0		72	9		100	9	9.0
	24	2	294-297 299-325 1,251-1,258 1,140-1,200	13	2		26	2		61	4		100	8	8.0
Subtotals				163	21	12.9	140	10	7.1	197	17	8.6	500	48	9.6
Big Rapids Pond	15	1	1,241-1,250 49,626-49,628 49,638 49,644 49,651 49,653-49,660				14	2		10	3		24	5	20.8
Subtotals							14	2	14.3	10	3	30.0	24	5	20.8
Pickerel Lake	15		472-500 1,201-1,209 49,613-49,616 49,618-49,625				12	6		38	10		50	16	32.0
							12	6	50.0	38	10	26.3	50	16	32.0

3

Pickerel Lake	15	472-500 1,201-1,209 49,613-49,616 49,618-49,625				12	6		38	10		50	16	32.0
Subtotals						12	6	50.0	38	10	26.3	50	16	32.0
Emerald Lake	15	1,210-1,224 1,226-1,240 49,629-49,637 49,639-49,643 49,645-49,650				20	3		30	8		50	11	22.0
	19	36-44 584-674				9	0		91	13		100	13	13.0
Subtotals						29	3	10.3	121	21	17.4	150	24	16.0
Hess Lake	17	49,762-49,825 49,828-49,863	68	2		32	1					100	3	3.0
Subtotals			68	2	2.9	32	1	3.1				100	3	3.0
Brooks Lake	17	501,544 49,918-49,948				31	2		44	2		75	4	5.3
Subtotals						31	2	6.5	44	2	4.5	75	4	5.3
Tag returns with incomplete data													9	
Total			435	46	10.6	460	46	10.0	855	120	14.0	1,750	221	12.6

In order to determine whether a pikeperch of a given size or sex showed a higher probability of return, the figures shown in Table XXXV were tabulated. Of 210 returns on which there are complete data, 80 were males and 130 were females. Males showed a 11.9 percent return and females one of 12.3 percent. Sex of pikeperch was not of importance, in this particular study, in influencing rate of return. About the same is true of the size of fish at the time of tagging. Although males in the 24-inch length group (23.0 - 24.9 inches) show a high return percent, the number of males of that length which were tagged (15) is insufficient to give reliable results. The smallest length group is not represented by returns, but here again a relatively small number of fish is involved. Some of these were not of legal size and were possibly not reported by anglers who caught them. There is a rather heavily veiled tendency for larger sizes of fish of each sex to be better represented in the returns than fish of smaller size, but, by and large, in this study, the prospects of getting a return were about equally good from pikeperch of either sex or of any size (within the length limits shown in Table XXXV).

Table XXXVI represents an attempt to demonstrate whether or not condition of the female, with regard to stage of development of the ovaries, has an influence on survival and the probability of an ultimate return of the tag. Ripe females showed a slightly higher percent of return than green or spent fish. However, the latter are very poorly represented in the total number tagged, and their departure from the average is not significant. Ripe females appear to show a slightly better return than green fish, judging by the data given. However, the difference in returns among the three is insufficient to justify selection of females showing any particular condition in future tagging programs.

XXXV
Table .--An analysis of tag returns in relation to size and sex of yellow pikeperch stocked in waters of the Muskegon River drainage, 1947

Size group	Males			Females			Combined sexes*		
	Number tagged	Number returns	Percent returns	Number tagged	Number returns	Percent returns	Number tagged	Number returns	Percent returns
13-14.9	32	0	0.0	...	...	...	32	0	0.0
15-16.9	95	11	11.6	...	...	...	95	11	11.6
17-18.9	168	17	10.1	14	0	0.0	182	17	9.3
19-20.9	250	36	14.4	85	9	10.6	335	45	13.4
21-22.9	109	12	11.0	312	37	11.9	421	49	11.6
23-24.9	15	4	26.7	368	46	12.5	383	50	13.1
25-26.9	3	0	0.0	234	33	14.1	237	33	13.9
27-28.9	...	...	...	41	5	12.2	41	5	12.2
29-30.9	...	...	...	5	0	0	5	0	0.0
Totals	672	80	11.9	1,059	130	12.3	1,731	210	12.1

* Unsexed fish not included

Table XXXVI.--Tag returns in relation to condition of female yellow pike-perch stocked in the Muskegon River Drainage, 1947.

Condition	Number tagged	Number returns	Percent returns
Green	241	21	8.7
Ripe	607	75	12.4
Spent	32	3	9.4
Total	880	99	11.3

No particular difference between the sexes with regard to migration is indicated by the relatively small amount of data available. Four males and 8 females reached Muskegon Lake or Lake Michigan, and 8 males and 11 females moved downstream a distance of over 25 miles.

V. Discussion

In the introduction of this paper, it is indicated that power dams in the Muskegon River, in their function as barriers to upstream migration of game fish, give rise to a complex and highly controversial fish management problem. It is further stated that, in order to effect a sound solution, the answers to several pertinent questions (page 5) would be very desirable. At this point it seems logical that these questions should be re-inspected, in the light of the data which have been presented in the foregoing pages, to ascertain what progress, if any, has been made toward their solution. They are repeated here in abbreviated form, and briefly discussed.

1. Do yellow pikeperch which migrate up the Muskegon River each spring originate in Muskegon Lake, or in Lake Michigan?

To obtain a direct answer to this question, it would be necessary to tag substantial numbers of pikeperch in Lake Michigan and in Muskegon Lake during mid-summer (to insure marking of native populations in each water). A record of all recoveries of tagged fish below Newaygo Dam during the following spring should clearly show the origin of the fish which migrate up the Muskegon. However, the procurement of the numbers of fish required would meet with certain difficulties. The Institute is not at present equipped to operate nets in Great Lakes waters, and the location of areas frequented by pikeperch would probably be difficult. Purchase from commercial fishermen might be the more practicable method of securing fish for tagging. At a cost of around $0.25 per pound

(pikeperch had a value of $0.18 to $0.24 per pound from 1944 to 1946), an expenditure of around $400.00 would be required for the fish alone, since a minimum of 500 fish would be required to conduct the study. Judging by the netting results of an Institute survey party at Muskegon Lake in 1936 (discussed below), the collection of adequate numbers of pikeperch for marking, from Muskegon Lake, would require a long period of time and much effort, and might not be possible at all.

In the absence of direct evidence of the origin of transferred fish the summary of available information presented below permits a strong inference concerning the origin of the transferred fish.

a). Nine out of 12 tagged fish released in the Muskegon impoundments and recovered below Newaygo Dam have been caught in Lake Michigan, and five of these have been taken in the vicinity of the mouth of the Kalamazoo River, near Saugatuck. The indication is that the fish are far-ranging, and that the majority of the fish passing downstream return to Lake Michigan.

b). The growth rate pattern of pikeperch transferred at Newaygo in 1947 is very similar to that shown by this species in Great Lakes waters which have been studied and higher than the average for inland lakes.

c). Gill nets set in Muskegon Lake in 1936 for a period of about 24 net days (one net day = 125 feet of net set for 24 hours) produced only four yellow pikeperch. Nearly 7,000 of this species were taken at Newaygo during the following spring by 21 dipnetters. Considering the inefficiency of dipnet operation, a Muskegon Lake pikeperch population capable of providing such a catch at Newaygo should have produced a much higher yield of pikeperch in the gill nets set at Muskegon Lake during the summer of the preceding year.

d). General creel census records for the Muskegon River below Newaygo Dam and in Muskegon Lake are summarized in Table XXXVII. There is no tendency toward an inverse relationship between quality of fishing in these areas and the numbers of fish transferred at Newaygo. This is shown graphically in Figure 28. In 1932, fishing quality for pikeperch was good, and the number of pikeperch transferred was small (3,151). In 1933, when about 43,000 pikeperch were transferred, fishing continued very good in the downstream areas. If these transferred fish had originated in Muskegon Lake, it is expected that depletion of its fishery would have been significant and possibly drastic. By and large, the available data show a direct rather than an inverse relationship between fishing in Muskegon Lake (and in the stream below Newaygo Dam) and numbers of fish transferred at Newaygo.

e). Total catches by dipnetters in the Muskegon River and commercial production of pikeperch in Lake Michigan show markedly similar trends for the 15-year period from 1929 to 1943, suggesting, as mentioned earlier, that the fish are either part of the same population or of related populations showing similar trends in their cycles of abundance. It is interesting to note in this regard that the pikeperch catch from the port of Muskegon closely follows the trends of southern Lake Michigan as a whole, for the period from 1937 to 1943, but not for 1935 and 1936, or 1944 to 1946. Figures for this port, for fish taken within a radius of 50 miles of the mouth of the Muskegon River for the period from 1935 to 1946 are shown in Table XXXVIII. The catch during this period fluctuated within rather narrow limits and ranged from 11,237 pounds in 1937 to 6,071 pounds in 1942, with an average of about 8,000 pounds. The reasons for the failure of the Muskegon commercial catch to reflect

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Figure 28

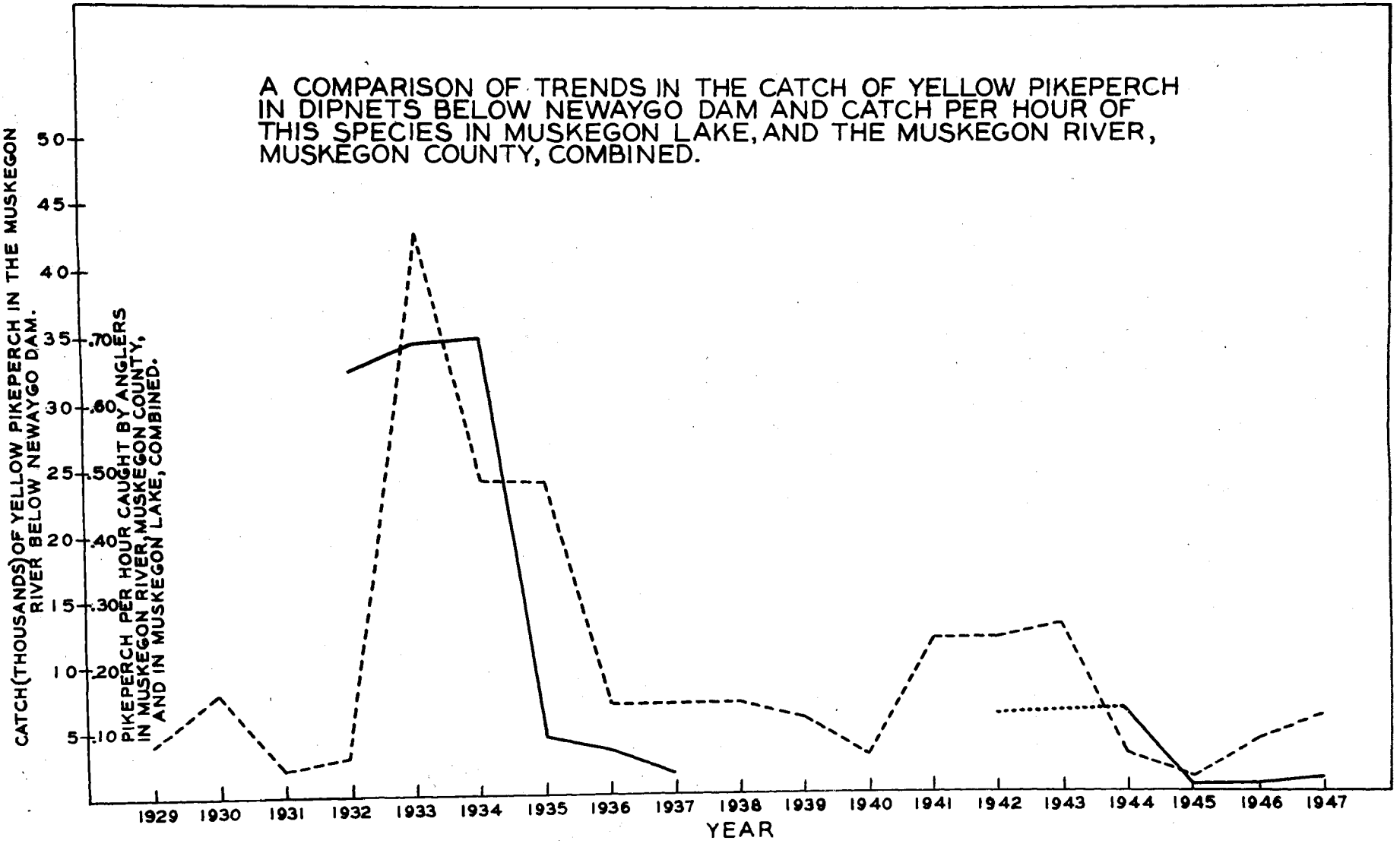

Table XXXVII.--Summary of general creel census records for the Muskegon River below Newaygo Dam and for Muskegon Lake, 1928 - 1947.*

Year	Number of anglers	Hours fished	Legal fish caught	Catch per hour	Brown trout	Rainbow trout	Brook trout	Northern pike	Yellow perch	Sauger	Yellow pike-perch	Small-mouth bass	Large-mouth bass	Pumpkin-seed	Bluegill	Rock bass	Crappie	Suckers and redhorse	Catfish and bullheads	Carp
Muskegon River, Newaygo County (Downstream from Newaygo Dam)																				
1928	1	0.2	1	5.00	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1929	4	20.0	18	0.90	...	...	...	4	...	...	3	11	...	...	...	...	...	...	...	...
1932	2	6.0	2	0.33	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...
1933	8	33.0	21	0.64	...	...	...	...	...	...	16	5	...	...	...	...	...	...	...	...
1934	33	110.0	25	0.23	...	...	...	...	...	...	17	3	...	...	1	1	1	2	...	...
1935	203	686.5	68	0.10	5	13	...	...	1	...	43	5	1	...	...	...	...	...	...	...
1936	184	732.8	152	0.21	21	37	6	6	...	...	79	3	...	...	...	...	...	...	...	...
1937	67	194.2	72	0.37	3	7	...	5	...	...	48	4	...	...	...	...	...	5	...	...
1938	11	64.0	30	0.47	...	...	...	...	20	...	10	...	...	...	...	...	...	...	...	...
1939	4	5.0	2	0.40	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1940	39	114.8	20	0.17	7	3	...	...	...	...	2	...	4	...	...	...	...	4	...	...
1941	16	131.5	19	0.14	...	...	...	...	...	...	19	...	...	...	...	...	...	...	...	...
1942	18	42.5	6	0.14	...	...	...	...	4	...	...	...	...	...	...	...	2	...	...	...
1943	7	16.0	6	0.38	...	...	...	...	...	...	6	...	...	...	...	...	...	...	...	...
1944	16	84.0	42	0.50	...	...	7	...	4	...	7	24	...	...	...	...	...	...	...	...
1945	2	6.0	2	0.33	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1946	7	34.5	12	0.35	...	...	...	3	...	...	9	...	...	...	...	...	...	...	...	...
Total	622	2,282.0	498	0.22	38	64	13	18	29	...	260	55	5	...	1	1	3	11	...	...
Muskegon River, Muskegon County																				
1932	5	23.0	25	1.09	...	...	...	2	1	...	15	6	1	...	...	...	...	...	...	...
1933	28	83.5	127	1.52	...	...	...	...	...	...	127	...	...	...	...	...	...	...	...	...
1934	50	171.5	211	1.23	...	...	...	10	...	1	190	10	...	...	...	...	...	...	...	...
1935	59	259.8	193	0.74	...	...	...	12	...	...	140	9	...	...	...	...	31	...	1	...
1936	12	46.5	30	0.65	...	...	...	5	5	...	4	11	1	...	...	...	4	...	...	...
1945	8	20.0	6	0.30	...	...	...	...	2	...	1	...	...	2	1	...	...	...	...	...
1946	4	4.0	0	0.00	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total	166	608.3	592	0.97	...	...	...	29	8	1	477	36	2	2	1	...	35	...	1	...
Muskegon Lake					White bass	Muskellunge														
1933	175	722.5	785	1.09	...	...	...	10	22	...	427	7	19	66	184	50	...	...	...	...
1934	306	1,368.5	2,674	1.95	1	2	...	13	624	...	891	57	49	131	415	335	114	...	38	3
1935	705	2,785.5	6,393	2.30	...	...	...	17	1,615	...	134	70	118	107	1,568	1,779	796	4	184	...
1936	580	2,331.5	2,698	1.16	2	...	...	29	988	3	170	95	93	198	255	561	280	...	15	...
1937	38	132.0	93	0.70	...	...	...	7	50	...	4	...	22	...	10	...	...	...	...	...
1942	91	242.5	190	0.78	...	...	...	9	1	...	30	11	1	...	21	17	...	...	...	...
1944	37	118.0	111	0.94	...	...	...	1	20	...	15	...	3	...	58	...	14	...	...	...
1945	112	464.0	1,123	2.42	...	...	...	...	1,072	...	5	...	6	...	25	5	10	...	...	...
1946	308	835.5	1,048	1.25	...	...	...	7	657	...	12	13	3	90	197	54	13	...	...	...
1947	406	942.0	3,084	3.27	3	...	...	16	2,674	...	21	...	8	...	75	148	130	...	3	...
Total	2,708	9,942.0	18,199	1.83	6	2	...	109	7,723	3	1,709	253	322	592	2,908	2,949	1,357	4	240	3

* Tabulation by Mr. K. G. Fukano, of the Institute staff.

Table XXXVIII.--Annual catch of yellow pikeperch by commercial fishermen at the port of Muskegon, Michigan, 1935 - 1946.*

Year	Production (pounds)
1935	8,640
1936	8,112
1937	11,237
1938	6,081
1939	7,771
1940	6,924
1941	10,449
1942	6,071
1943	6,778
1944	7,768
1945	9,706
1946	6,363
Total	95,900

* From data compiled by Mr. A. B. Cook, Fish Division, Michigan Department of Conservation.

the general abundance of pikeperch in southern Lake Michigan as a whole, before and after the period from 1937 to 1943, is not immediately apparent, and no explanation is here attempted. Future trends in the catches will be followed with interest.

During the course of a public hearing held at Fremont, Michigan, on December 5, 1947, it was stated that the best pikeperch fishing at Muskegon Lake occurred while the ice cover is present, and while the fish are presumably moving through this water, en route from Lake Michigan to the river above. By and large, it seemed generally agreed that the bulk of the fish transferred at Newaygo come from Lake Michigan, and for the most part contributed to the Muskegon Lake fishery only while passing through this lake on their migratory runs. In view of these observations by representatives of Muskegon Lake sportsmen, it does not appear that the source of the fish transferred at Newaygo Dam is a matter of serious contention. Taken together with the data summarized above, which appear to point strongly toward Lake Michigan as the origin of the fish, further research bearing on this matter does not seem to be required at the present time.

2. What percentage of migrating pikeperch are removed during the transfer, and is this number sufficient to deplete the fishery in downstream areas?

The percentage of pikeperch migrating to the Newaygo area which are removed during any one of the various transfers is not known. The tagging of a large number of pikeperch (at least 500) in Muskegon Lake or upstream from the lake, in February or early March, would provide good information on this point. The percentage of the total number of tagged fish recovered by dipnets at Newaygo would then indicate directly the approximate percentage of spawners migrating above Muskegon Lake which

are taken during the transfer. The approximate total numbers of pikeperch moving upstream, a matter of great biological interest, could then also be estimated.

In the absence of direct evidence at present, certain information bearing on this question is summarized here.

a). During 1947, the 12 dipnets used, if fished simultaneously, would have covered an area of about one-third of one percent of the total area of the river bottom between the extremities being fished. This is not considered sufficient to take a significant proportion of the pikeperch congregated in the area. Although it is probably true that fish mill about and cover considerable areas during their spawning activities, the probability of any given fish being caught in the nets is extremely small.

b). Mr. R. B. Quigg, then of the U. S. Forest Service, concluded by direct observation in 1936 (paper cited above) that fish tended to concentrate toward the center of the stream, rather than near shore. This would place the bulk of the fish ascending the stream out of reach of dipnets operated from shore.

c). The number of fish congregated below Newaygo Dam, at least during some years, is so large that the snagging of pikeperch by means of bare hooks dragged through the water is a widely used method of fishing among those fishermen who are without respect for fishing regulations. Over twenty arrests occurred in the area in 1947 alone. For such fishing to be attractive, tremendous numbers of pikeperch must have been present in the area, and the 5,540 taken in dipnets could hardly have a significant effect on fishing quality in downstream areas.

d). As stated above, the numbers of fish annually transferred at Newaygo and numbers caught each year by anglers below this point show no recognizable tendency toward an inverse relationship. It cannot be demonstrated that the transfer during any year has directly affected fishing quality in downstream areas.

The information at hand at present indicates that the numbers of pikeperch transferred at Newaygo are small in comparison to the total numbers migrating up the river and that they are insufficient to have a significant effect on the Muskegon Lake fishery.

3. Is the transfer justified financially, and do transferred fish contribute significantly to the upstream fisheries?

a). The average cost of transferring an adult pikeperch during the past five years has been $0.16 to the Department and $0.11 to Consumers Power. In relation to the cost of rearing pikeperch to legal size, or obtaining them by any other method, this figure is not excessive.

b). Returns from transferred fish during 1947 were slightly over 12-1/2 percent during the first fishing season. The number of tagged fish caught which have not been reported is not known, although it is certain that some anglers failed to report captures of tagged fish. For yellow pikeperch, the results show a good return and a high degree of exploitation of the transferred fish. To determine the total effect of the transfer on upstream waters, another tagging program coupled with an intensive creel census would be required, to show the relationship between native and transferred fish in the angler's catch. To date there is little information on this point. General creel census records taken by conservation officers at Hardy Pond during 1947 showed only one tagged fish among 49 legal pikeperch included in the totals. Of over 90 fish

taken by nets in Hardy and Croton Ponds, only one was tagged. However, only a small proportion of these were of legal size. One angler present at the December public hearing stated that 85 percent of the legal pikeperch which he had taken at Hardy Pond during 1947 were tagged. Estimates by boat liverymen of percentages of tagged fish among catches of pikeperch in Croton and Hardy Ponds during the latter portion of July ranged from about 25 to 40 percent.

Judging by the number of tag returns, and by the writer's general observations in the field during the summer of 1947, the transfer is making a significant contribution to the fisheries of Croton and Hardy Ponds, and the north Newaygo lakes. The fact that the fish are held, at least temporarily, above the dams responsible for these impoundments, serves to concentrate them and thus make them vulnerable to anglers. Areas of concentration are also reported by some anglers at the north Newaygo lakes. Transferred pikeperch enter the catch most heavily in July and August, when warm-water fishing in general tends to be poorer than during other months of the year.

Most transferred fish leave Big Rapids and Rogers Ponds after stocking, before being captured, and only about one-half of the fish remain in Newaygo Pond during the first season after transfer. However, stocking is probably justified in these ponds, since it gives anglers who prefer these waters a sporting chance to take the much desired large pikeperch before they go downstream. Further stocking of pikeperch in Brooks and Hess lakes is hardly justified, in view of the small returns to the anglers fishing these waters.

4. Is the transfer to upstream waters desirable, and required, to provide good fishing?

Insufficient data are at hand to show definitely whether present fishing quality can be maintained without the transfer. The impoundments are suitable habitats for pikeperch, and growth of the native population of this species is above average, showing that introduced pikeperch do not induce overpopulation of the ponds and stunting of the fish present.

Croton and Hardy Ponds (particularly the latter) showed an unusual predominance of sub-legal pikeperch of 3 years of age, and concentrations of these occurred in the immediate vicinity of the dams. Scattered past reports by anglers suggest that this condition has persisted for a number of years. If such fish pass downstream to Lake Michigan before reaching sexual maturity, it is highly probable that the Newaygo transfer is necessary in order to maintain a fishery for this species in these waters, under present legal restrictions with regard to size limit.

5. Are game fish able to return downstream to their point of origin?

Yes. Each power dam in the main stream of the Muskegon has been negotiated successfully by pikeperch of large size. Croton and Hardy dams provide the chief obstacles to downstream migration, but the other dams offer very little resistance to such movement.

6. Do pikeperch native to the impoundments move downstream?

The concentration of sub-legal fish near power dams, with marked reduction in numbers of older fish in the ponds suggests this, but definite information is lacking. The tagging of 500 pikeperch, ranging from 10 to 14 inches in length, in Hardy Dam, is strongly recommended, to determine whether such movement takes place, and to what extent. If movement to Lake Michigan occurs, future netting below Newaygo Dam, if it is continued, may reveal some very interesting information concerning

the "homing" tendencies (a tendency observed in some species, for adult fish to return to the stream in which they were hatched, for spawning) of this species. The presence or absence of this tendency in pikeperch has not been adequately studied and might have a very considerable significance in its proper management.

In conclusion, the facts at hand to date indicate that the transfer has had no harmful effects on the sport fishery either above or below Newaygo Dam, and that it is of some benefit to upstream waters. Further information (as indicated at various points in this report) is required before a definite conclusion can be reached as to the complete effects of the transfer. Unless and until future, more exacting study reveals facts which void some of the key inferences derived from indirect evidence assembled in this report, it is recommended that the transfer of pikeperch at Newaygo be continued as a regular annual operation of the Department of Conservation.

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