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A LIMNOLOGICAL AND FISH SURVEY OF THE LAKES IN THE PIGEON RIVER STATE FOREST, MICHIGAN WITH EXPERIMENTS IN FISH MANAGEMENT, AN ANALYSIS OF THE FISH YIELD AND A SPECIAL STUDY OF STUNTED PERCH POPULATIONS.

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INTRODUCTION

At various times from 1931 to 1936 a number of small lakes in the Pigeon River State Forest of Michigan has been studied by the writer to determine their limnological character and fish populations and to prepare fish management plans. These lakes have been subjected to experiments in fish management, and their fish yields have been determined by creel census methods. A special study was made of the stunted perch populations. The work has been limited to and has embraced investigations that were expected to have practical significance in improving the fishing.

Primarily, on account of the time element, this paper is a progress report. Like other experiments in the management of large populations, this one should cover a period of many years; therefore a continuation of the study is contemplated. On some of the lakes little or no fish management has yet been practiced; on others much has been done to alter the fish environment or the kinds and abundance of fish, but the results of the management practices have not been fully determined for all of these waters. Some of the information obtained and included for the sake of a complete record has not yet found application. Enough has been accomplished in this work, however, to rank it as one of the first critical studies of natural fish populations with especial reference to their yield and management. It is one of several such pioneer studies now being conducted on Michigan lakes by the Institute for Fisheries Research under the immediate direction of the writer.

The Pigeon River State Forest lies in the northern part of the Lower Peninsula of Michigan, in Cheboygan, Montmorency and Otsego counties. According to the last biennial report of the Michigan Department of Conservation (1935-1936), this forest has an area of 113,203 acres of which 76,748 acres

(68%) are state owned. The soil is chiefly sandy and is of relatively low fertility. Most of the forest consists of second growth timber (chiefly oak and poplar) and of pine plantations.

At the time of the original survey in 1931 and 1932, the lakes of the Forest could be reached only by sand trails or fire lines, and the forest was little frequented. Since that time, two C.C.C. camps have been located in the area, roads have been built and improved, the system of fire lines and truck trails has been extended. The area has therefore lost much of its "wild" appearance, and has become more frequented, with the result that the "fishing pressure" has been greatly increased.

Three divisions of the Cheboygan River system drain the area: that of the East Branch of the Sturgeon River to the west, that of the Pigeon River through the central part of the forest, and that of the Black River to the east.

As seems to be true of most Michigan state forests, the Pigeon River Forest consists primarily of "waste land" which is marginal or submarginal for agriculture and from which most of the marketable timber has been removed. At least while the trees that have been planted are small, the chief asset of the forest is recreation, in which fishing is a chief factor.

On November 16, 1931, Mr. P. S. Lovejoy submitted to the director of the Department of Conservation a memorandum urging the development of all resources in the Pigeon River Forest and the administration of these resources. On April 19, 1932 Dr. Carl L. Hubbs submitted plans for the development and management of the Pigeon River area from the standpoint of fish and fishing. Even before the memorandum and the plans were submitted a study of the waters of the forest had been initiated by the Institute for Fisheries Research. The development of the waters in the forest for fishing has been continued to the present and will, presumably, receive further consideration.

ACKNOWLEDGMENTS

Dr. Carl L. Hubbs, Curator of Fishes, Museum of Zoology, University of Michigan, and Director of the Institute for Fisheries Research during most of the period of this study, suggested and supervised the study, read the manuscript and offered valuable suggestions for its improvement. Dr. Ralph Hile, U. S. Bureau of Fisheries, and Dr. A. S. Hazzard, Director of the Institute for Fisheries Research, assisted in the preparation of portions of the manuscript.

The author was assisted in the field by the members of the lake survey party of the Institute for Fisheries Research in 1931 and 1932 and by Mr. N. W. Hosley; Dr. R. G. Janes; Mr. W. F. Carbine; Mr. J. B. Schwerdt, Project Superintendent of Camp Vanderbilt (U. S. Parks Service); several foremen of Camp Pigeon River (M.E.C.W.), and Mr. William Horsell, Superintendent of the Pigeon River State Forest. Stocking records were provided by Mr. Guy Lincoln, District Supervisor of Fisheries Operations, who also provided, in so far as possible, the fish which were requested for stocking the several lakes.

INVENTORY OF THE LAKES IN THE PIGEON RIVER STATE FOREST

The original survey of the lakes in the Pigeon River State Forest was part of a lake survey program outlined and initiated by Dr. Carl L. Hubbs soon after the Institute for Fisheries Research was organized. This project was put into effect and partly developed from 1930 to 1932 by survey parties under the immediate direction of the writer. Approximately 175 lakes have been surveyed by the Institute. This early inventory was necessarily

a general one not permitting an intensive or continued study of the individual waters. The primary purpose of the extensive survey was to prepare a fish management program for as many lakes as could reasonably be inventoried. The fish management proposals covered the environmental improvement of the waters in addition to the stocking needs. The purpose of the lake survey is discussed, with an account of the methods used, by McMurry, Eschmeyer and Davis (1933) and more recent comments on the survey are included in papers by Eschmeyer (1936) and Miller (1937).

Inventory Methods

Information collected and recorded in the original investigation of the lakes in the Pigeon River Forest includes physical, chemical and biological data pertinent to fish management.

Physical inventory-The first step in the physical inventory consisted of surveying the outline of the lake with a telescopic alidade, and preparing copies of these outlines as a base for recording further information. This method of mapping probably involved an error of several per cent in determining the area of the lake, but the difference between the actual area and the area determined was probably less than the differences in area between the high and the low water levels. The maps were prepared to a scale of 8 inches or of 16 inches to the mile, depending on the size of the lake. Enough soundings were taken to show, approximately, the topography of the bottom. Bottom samples were taken over various parts of the lake with an Ekman dredge. Depths were recorded on the map and the type of bottom was shown in color. The physical survey includes also a study of the land adjacent to the water, determination of inlets and outlets, and the location of spawning beds.

Chemical inventory.-The temperature (at the time of the survey) was recorded for each meter of depth. The amount of oxygen and carbon-dioxide, the pH, methyl orange and phenolphthalein alkalinity were determined near surface and bottom and for one or more intermediate depths. In these small lakes the chemical analysis was made only over the deepest part of the lake.

Biological inventory.-The biological inventory comprised in part a determination and listing of the vegetation and a mapping of the beds formed by plants of different ecological types. The species of fish present was determined, with a rough indication of their abundance, through gill-netting and seining. The small fish were preserved for later study. Scale samples were taken of the larger fish for a later determination of their rate of growth. Spawning and shelter conditions for the various species were noted. Efforts were also made to determine the abundance of predators.

The abundance and kind of food were only casually noted. Although a study of the organisms is obviously important, an adequate determination of the abundance of plankton and bottom organisms could not be made for lack of sufficient time. It was considered that, for the purpose of the survey, an indication as to whether or not the food supply was ample for the fish population present might be better and more directly obtained from a determination of the rate of growth of the fish.

All of the survey data were recorded on the map for each lake or on specially prepared inventory cards. Copies of the maps of the lakes in the Pigeon River Forest and a sample of the survey cards used are given as Figs. 11 to 25.

Inventory Data on the Lakes

One of the lakes under discussion was surveyed in the summer of 1931; all others were examined during the following summer. At the time of the

survey the waters examined represented all of the lakes in the forest which were on state-owned property. Several small unnamed ponds which were apparently too shallow to support fish life were not examined.

The lakes on which the inventory was taken and their location are listed below:

Dog Lake	T. 34, 35 N., R. 1 W.,	Sec. 35, 2
Pickerel Lake	T. 32 N., R. 2 W.	Sec. 11
Hemlock Lake	T. 33 N., R. 1 W.	Sec. 34, 35
Grass Lake	T. 32 N., R. 1 W.	Sec. 5
Devil's Soup Bowl	" " " " " "	" "
Hardwood Lake	" " " " " "	Sec. 11, 14
Two Acre Pond	" " " " " "	Sec. 3
Lost Lake	" " " " " "	Sec. 2, 3
West Lost Lake	" " " " " "	Sec. 3
Ford Lake	" " " " " "	Sec. 8
Section 4 Lake	" " " " " "	Sec. 4
North Twin Lake	" " " " " "	Sec. 10
South Twin Lake	" " " " " "	" "

So far as could be determined, only two of these lakes had been previously examined by fisheries workers. Under date of August 25, 1925, Dr. Jan Metzelaar[1] makes the following comments regarding Pickerel Lake:

> Vegetation: scattered bulrushes, Potamogeton. Animal life: low inshore, crayfish, big clams. Bottom: clear white sand and some marl. Temperature: 22° C. Depth: up to 11 meters sounding. Species of fish: reported to have brook trout, no pickerel, and perch and small-mouthed bass; we caught inshore 3 pumpkinseeds, 1 small-mouthed bass, many fingerling perch, 6 fine-scaled dace (Pfrille neogaea), 2 mudminnows (Umbra limi) and many Iowa darters (Poecilichthys exilis).

Metzelaar recommended stocking with small-mouthed bass in this lake.

On August 12, 1925, Metzelaar and Langlois[1] briefly examined Dog Lake, commenting:

> "No good game fish lake; not worth planting, too boggy."

Some of the survey information on these lakes gathered by the Institute is briefly discussed and tabulated below. More detailed information, for each lake, is filed in the Institute.

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[1] Unpublished.

Physiographic character of the lakes.--All except four of the lakes fit more or less perfectly into the category of pit lakes, known generally as "pot-hole lakes". Such lakes in the Forest are characterized by high, steep, sandy banks and by an almost circular outline. Their basins tend to be bowl-shaped with very limited shoal area. All except the very shallow Two-Acre Lake show thermal stratification. These lakes correspond with the description and figure of a typical pit lake as given by Scott (1921), whose discussion of these lakes is as follows:

> PITS. The term pit, as here used, signifies a depression in an outwash plain. It was probably formed by the isolation of an ice block which became covered with debris and melted later, allowing the material above to settle. The important thing in the formation of these depressions is the protective effect of a coating of earthy material on the ice. A small rock fragment on the surface of the ice absorbs enough heat from the sun's rays to become heated through and melts a depression for itself in the ice. Larger fragments or an accumulation of small ones are not able to conduct the heat to the under side and, therefore, protect the ice, and the greater the thickness of the earthy material the slower the melting.
>
> Continental glaciers are characteristically divided into two distinct zones, an upper one comparatively clean and free from debris and a lower which is heavily clogged with rock fragments. Under the sun's rays the clear ice of the upper zone melts rapidly but, when the lower zone is reached, the rock fragments protect the ice directly below them. The portions of the surface not covered with debris melt until earthy material is uncovered and finally a complete rock cover is formed which soon becomes so thick that melting proceeds at a very slow rate. This difference in the rate of melting of the upper and lower zones caused the ice of the upper zone to recede possibly several miles while that of the lower remains stagnant. Wherever the drainage from the ice was vigorous, the protective cover was removed from the stagnant ice and it melted, but where sluggish streams were depositing material, the ice was deeply buried in an outwash plain with an unbroken surface sloping gently away from the ice. The ice blocks did not underlie all of the outwash plain but were more in the nature of scattered fragments, due probably to the uneven distribution of debris in the lower zone of the glacier. Where the load was exceptionally heavy the debris accumulated on the surface until a cover was formed which protected the ice beneath so effectively that it persisted until covered with outwash. At some time subsequent to the formation of the outwash the ice blocks melted and allowed the material above to subside slowly, causing pits or depressions in the surface of the outwash.....
>
> The distinguishing features are: The basin is a depression in a plain, the materials of the plain are water deposits and, therefore, assorted and sometimes stratified, the slope from the plain to the water level is steep, the outline is roughly circular, and there is often no outlet and no important inlets, the lake being supplied and drained by the seepage of ground water through the sandy material of the outwash plain.

The 9 pit lakes on the Pigeon River Forest vary greatly in depth (2.3 meters to 21.9 meters) and range in size from 1.9 acres to 11.7 acres. All except one are still ecologically "young" enough to support trout, the other (Two-Acre) is apparently past the stage when it will support any game fish. Another pit lake basin lying on the trail between the old forest headquarters site and Ford Lake is not of interest from a fisheries standpoint, because it contains water only after heavy rains.

The 4 lakes which are not of the "pot hole" type are of varied physiographic type, but little effort was made by the writer to determine their origin. Grass Lake, however, was obviously formed or at least greatly enlarged many years ago by the beaver in building a dam across the outlet. This lake was present during the lumbering days and perhaps long before. Vegetation has become abundant here, and peat has been deposited deeply over most of the bottom.

Dog Lake is somewhat similar to Grass Lake except that it is obviously much older ecologically. It is apparently fast approaching extinction; over much of the lake the water is only a few inches deep, but the bottom is so soft and flocculent that a boat can be moved through it. Considering these features and the fact that the lake is partially surrounded by a bog, Dog Lake is peculiar in that it is alkaline. Whether or not the bottom is underlain with marl (an explanation for the alkalinity) was not determined.

A third lake of this group, Hardwood Lake, differs decidedly from all other lakes in the area in that it is acid and is surrounded by a bog about as large as the lake itself. The lake differs from the bog lake commonly illustrated (shown by Scott, 1921, on page 63) in that the open water is very shallow and is underlain by sand covered by a thin layer of peat.

Pickerel Lake differs from the pit lakes in its irregular outline, greater size and gently-sloping margins, and differs from the shallow, irregular lakes in its greater depth (10.6 meters maximum), in the presence

of a dropoff and in thermal stratification. Ecologically it appears to be more similar to the pot-holes, though in outline it more nearly approaches the irregular, shallow lakes. The bottom of Pickerel Lake is almost entirely soft marl.

Area.--The areas of the 13 lakes vary from 1.3 acres for Devil's Soup Bowl to 181 acres for Dog Lake. Eight have an area of less than 10 acres. The area of each lake, as determined by the survey, is shown in Table 1.

Connecting waters.--Eight of the lakes contain neither inlet nor outlet. Two, Grass and Pickerel lakes, have small inlets. These two also have small but permanent outlets. Three lakes, Hemlock, Hardwood and Dog, have intermittent outlets. Pickerel Lake drains through Pickerel Creek into the East Branch of the Sturgeon River; Dog Lake is drained by McMaster Creek, which empties into Black River; Hardwood Lake empties into the Black through Hardwood Creek. Grass Lake and Hemlock Lake are both in the Pigeon River drainage emptying respectively through Grass Creek and Cornwall Creek.

Depth.--The lakes vary widely in depth. The maximum dpeth found for the largest lake, Dog Lake, was only 2 meters; the maximum depth of one of the smallest lakes (Section 4 Lake) was found to be 21.9 meters. The maximum depth found for each lake is shown in Table 1.

Shoal area.--A rough estimate was made of the percentage of shoal area (water less than 2 meters deep) in each lake. These data are also included in Table 1.

Vegetation.--The abundance of vegetation varied widely in the different lakes. It was found to be relatively rare in Pickerel Lake, where the shoals are of marl, and was abundant in several of the other lakes. General comments regarding the abundance of aquatic vegetation are listed in Table 1. The kinds of vegetation present in each lake were determined and listed on the survey cards by Mr. L. M. Ashley, a member of the survey party. The location of the weed beds are shown on the maps (Figs. 11-19).

Table 1.

AREAS, ESTIMATED PERCENTAGE OF SHOAL, INLETS, OUTLETS, MAXIMUM DEPTHS, AND ABUNDANCE OF VEGETATION AS DETERMINED FOR 13 LAKES IN THE PIGEON RIVER STATE FOREST IN 1931 and 1932 BY THE INSTITUTE FOR FISHERIES RESEARCH

Lake	area (acres)	% in shoal (rough estimate)	inlet	outlet	depth (meters)	abundance of vegetation on shoal
Dog	181	100	none	intermittent	2.0	abundant
Grass	28.3	100	small	small	3.0	abundant
Hardwood	46.3	100	none	intermittent	3.0	common
Two Acre	1.9	100	none	none	2.3	common
Pickerel	40.6	25	springs	small	10.6	relatively rare
Ford	11.7	35	none	none	10.0	abundant
Devil's Soup Bowl	1.3	35	none	none	6.9	moderate
Hemlock	6	35	none	intermittent	19.2	abundant
Lost	4.6	15	none	none	15.8	common
West Lost	4	15	none	none	14.5	common
Section 4	3.3	15	none	none	21.9	common
North Twin	5.7	15	none	none	15.8	common
South Twin	4.3	15	none	none	12.7	common

Kind of bottom.--Seven of the lakes contained marl. The bottoms varied from almost completely marl in Pickerel Lake to almost completely organic bottom in Dog Lake, Two Acre Lake and Devil's Soup Bowl. The dominant kind of bottom on the shoal and slop and under deep water is shown for each lake in Table 2, and is indicated by color on the maps (Figs. 11-19).

Thermal stratification.--The waters in the 3 open shallow lakes (Dog, Grass and Hardwood) were unstratified. In all the small, protected pit lakes, other than the very shallow Two-Acre Lake, the water was stratified with the thermocline rather near the surface, starting at 3 to 5 meters. The thermal stratification, as well as acidity and clearness, is shown in Table 2.

Acidity.--One of the lakes (Hardwood) was quite acid; one (Two-Acre) was neutral; all others were alkaline.

Table 2

PRESENCE AND LOCATION OF THERMOCLINE, ACIDITY, DOMINATE KIND OF BOTTOM, AND CLEARNESS OF WATER AS DETERMINED FOR 13 LAKES IN THE PIGEON RIVER STATE FOREST IN 1931 AND 1932 BY THE INSTITUTE FOR FISHERIES RESEARCH

Lake	Thermocline (meters)	Acidity or alkalinity[1]		Dominate kind of bottom			Clearness-Disc reading (meters)
		Surface	Bottom	Shoal	Slope	Deep	
Dog	none	alka. (7.9)	alka. (7.9)	peat	...	...	bottom
Grass	none	alka. (8.2)	alka. (7.2)	mostly peat & marl mixed	...	...	bottom
Hardwood	none	acid (5.2)	acid (5.2)	sand overlain with peat	...	...	bottom
Two-Acre	none	neutral (7.0)	neutral (7.0)	peat	...	...	1.8
Pickerel	5 to bottom	alka. (8.3)	alka. (8.3)	marl	marl	marl	3.9
Ford	5 to bottom	alka. (8.2)	alka. (8.2)	sand, peat & marl	marl	peat	5.5
Devil's Soup Bowl	3 to bottom	alka. (7.8)	alka. (7.6)	peat & sand	peat	peat	5.1
Hemlock	4-8	alka. (8.1)	alka. (7.4)	peat & marl	marl	peat	4.2
Lost	4-8	alka. (7.9)	alka. (7.4)	marl	marl	marl & peat mixed	9.1
West Lost	3-7	alka. (7.9)	neutral (7.0)	peat & sand margin	marl & peat	peat	5.0
Section 4	4-7	alka. (7.9)	alka. (7.2)	marl	marl	peat	6.8
North Twin	5-9	alka. (7.5)	alka. (7.4)	sand	peat	peat	4.5
South Twin	4-9	alka. (8.1)	alka. (7.8)	sand	peat	peat	7.5

[1] Figures in parentheses indicate pH.

Clearness.--The Secchi disc readings varied from 1.8 meters in Two-Acre Lake to 9.1 meters in Lost Lake. Readings could not be taken on Dog, Grass and Hardwood lakes because of the extreme shallowness of these lakes.

Table 3

AMOUNT OF DISSOLVED OXYGEN AT VARIOUS DEPTHS IN 13 LAKES IN THE PIGEON STATE FOREST (SUMMER 1931-1932)

The range of the thermocline is indicated by the heavy line; the maximum depth by a dot.

Lake	Date	Depth in Meters: S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	19	21	22
Dog	8-5-32	6.7		•																	
Grass	8-3-32	9.4		10.8	•																
Hardwood	8-4-32		6.6		•																
Two-Acre	7-30-32	8.5	7.0•																		
Pickerel	8-4-32	8.1					9.5				9.5		•								
Ford	8-1-32	9.4					9.3					8.6°									
Devil's Soup Bowl	8-2-32	5.8		5.4		5.0	•														
Hemlock	7-28-32	8.7										6.0							2.2•		
Lost	8-1-31	8.4					7.7					11.0					0.2	•			
W. Lost	7-29-32	8.7						6.0								0.0	•				
Section 4	8-1-32	9.1						11.1								1.7				0.0	•
N. Twin	7-26-32	8.3									11.2						8.9	•			
S. Twin	7-23-32	8.4					7.9					7.0		•							

Dissolved gases and hardness.--The abundance of dissolved oxygen at the surface varied from 5.8 p.p.m. in Devil's Soup Bowl to 9.1 p.p.m. in Section 4 Lake. Of the nine lakes with thermal stratification, all contained oxygen in or below the thermocline (Table 3). All contained ample oxygen to support fish life at the bottom with the exception of Lost, West Lost, Hemlock and Section 4 lakes. The amount of dissolved oxygen found and the depths at which the samples were taken are listed in Table 3.

Free carbon-dioxide was found to be present in all lakes except Ford and South Twin. It was highest in Hemlock Lake with 10 parts per million at the surface and 39 parts per million at the bottom.

Methyl-orange alkalinity varied in parts per million from 24 in Two-Acre Lake and 45 in Hardwood Lake to 193 in Lost Lake and 198 in Hemlock Lake and Section 4 Lake.

Distribution and abundance of fishes.--The kinds of fish present were determined by netting and seining and a rough estimate of their abundance was obtained. The larger species were identified in the field; smaller ones were preserved and identified in the laboratory. The distribution of fish with an indication of their abundance is shown in Table 4.

The fish fauna in the seven land-locked "pot-hole" or pit lakes is of especial interest. In four of these lakes (North Twin, South Twin, Section 4 and Ford) perch were found to be abundant but no other species were secured, except for three common suckers taken in the survey of North Twin Lake. In the other three land-locked pit lakes (Lost, West Lost and Devil's Soup Bowl) fat-headed minnows were taken and only this species was found except in Lost Lake, where brook trout were present as the obvious results of the stocking of this lake in 1927 by Mr. William Horsell, Superintendent of the forest. According to reports no trout were present before this stocking. The uniformity in size of the trout taken by the survey party and reported taken by fishermen (in 1931 and 1932) suggests that they were all of one age class and that they were the fish which had been stocked. The suckers

in North Twin Lake may have been introduced as bait by fishermen. Examination of the data available for these lakes fails to indicate the reason for this peculiar distribution of perch and minnows in the seven pot-hole lakes. Perch were found, too, in Pickerel Lake and Dog Lake, both of which have outlets into trout streams through which the perch might have passed to reach the lakes.

Brook trout apparently reached Pickerel Lake and Grass Lake through their outlets which are trout streams, before these streams were blocked by beaver dams. Brook trout taken in gill-nets in Hemlock Lake in 1932, by the survey party, were of a large size and therefore were likely the result of the stocking of this lake with small fish in 1927 (according to Mr. Horsell). Hemlock Lake is connected with a trout stream but by an outlet that is intermittent near the lake and blocked by beaver dams where permanent.

Pumpkinseeds were taken only from Dog Lake and Pickerel Lake. Brown bullheads were taken in Dog Lake. The variety of all species of fish found in any one lake was small (see figures in Table 4). As indicated above none of the pit lakes without outlets contained more than a single species, either perch or fat-headed minnows, except North Twin which contained two species, one possibly introduced. This very small fish fauna in the pit lakes is explainable on the theory of their origin as basins formed by the melting of residual blocks of glacial ice (p. 7). The perch and fat-headed minnows, both of common occurrence in isolated northern lakes, perhaps drained into the newly formed pit lakes from temporary pools that may have existed on the surface of the sand plain as the ice front was receding.

Hemlock Lake, the one pit lake with an outlet, though otherwise much like the others, was found to have a fauna of six northern species, not including the planted brook trout. All six of these species may have entered this lake through the outlet, though some may have been in the lake since its first formation.

Three other lakes of the forest with an outlet, namely Dog, Grass and Pickerel lakes, have each a moderate fish fauna, of 7 to 10 species, most or all of which probably entered these lakes by passing through the outlets. These outlets are all trout streams (though warm near the lakes) but various warm-water species occur occasionally in trout waters through which they are certainly capable of passing.

The two lakes having no fish fauna seem ecologically unfit to support fish life. They are Hardwood Lake, a very acid, shallow pond, and Two-Acre Lake, a very shallow, muddy pit lake.

The species of fish taken by the survey party, or later stocked, include the following:

Game Fishes

Common names	Scientific names
Brook Trout	Salvelinus f. fontinalis
Northern Pike	Esox lucius
Yellow Perch	Perca flavescens
Small-mouthed Bass	Micropterus d. dolomieu
Bluegills	Helioperca macrochira
Pumpkinseed	Eupomotis gibbosus

Coarse Fishes

Common White Sucker	Catostomus c. commersonnii
Northern Brown Bullhead	Ameiurus n. nebulosus

Forage Fishes

Northern Creek Chub	Semotilus a. atromaculatus
Northern Dace	Margariscus margarita nachtriebi
Fine-scaled Dace	Pfrille neogaea
Northern Red-bellied Dace	Chrosomus eos
Golden Shiner	Notemigonus crysoleucas auratus
Northern Common Shiner	Notropis cornutus frontalis
Black-chinned Shiner	Notropis heterodon
Northern Black-nosed Shiner	Notropis h. heterolepis
Blunt-nosed Minnow	Hyborhynchus notatus
Northern Fat-headed Minnow	Pimephales p. promelas
Western Mudminnow	Umbra limi
Menona Banded Killifish	Fundulus diaphanus menona
Iowa Darter	Poecilichthys exilis
Brook Stickleback	Eucalia inconstans

Table 4

Distribution of fishes in the 13 lakes of the Pigeon River State Forest as determined by the Institute inventory of 1931 and 1932. "A" denotes abundant, "C" common and "R" rare

Lakes (and number of species not known to have been introduced)	Brook Trout	Northern Pike	Yellow Perch	Small-mouthed Bass	Pumpkinseed		Common White Sucker	Brown Bullhead		Northern Creek Chub	Northern Dace	Fine-scaled Dace	Northern Red-bellied Dace	Golden Shiner	Northern Common Shiner	Black-chinned Shiner	Northern Black-nosed Shiner	Northern Fat-headed Minnow	Western Mudminnow	Iowa Darter	Brook Stickleback
Dog (8)		C	C		C			C						C	C			C		C	
Grass (10)	R						R			R	R	A	A			C	A	A		C	
Hardwood (0)																					
Two Acre (0)																					
Pickerel (7)	C		A	C	R							R							R	R	
Ford (1)			A																		
Devil's Soup Bowl (1)																		C			
Hemlock (6)	(A)[1]									C			A				A	C		C	C
Lost (1)	(A)[1]																	A			
West Lost (1)																		A			
Section 4 (1)			A																		
North Twin (2)			A				R[2]														
South Twin (1)			A																		

[1] Stocked in 1927.

[2] Possibly introduced by anglers.

EXPERIMENTAL FISH MANAGEMENT IN THE LAKES OF THE PIGEON RIVER STATE FOREST

The original survey of the lakes in the Pigeon River State Forest was made primarily as a basis for fish management. Because they were located on state-owned land, these lakes could be managed in any manner considered feasible or desirable. The setting up of this region as a test area for developing an all-use program for idle land encouraged trial management in these lakes. The remarkable similarity of some of the pot-hole lakes as well as their small size made them especially suitable for experimental management. The location of a C.C.C. camp (Camp Pigeon River) in the area made it possible to obtain labor for creel census work and for other projects requiring considerable man power and very limited training or, as in creel census, requiring the daily patrolling of the lakes. All of these factors led to the experimental fish management program in the lakes of the Forest, and contributed to the success of the experiments.

Phases of Fish Management

The term "fish management" has come into general use only in recent years and several of its phases are of very recent origin. Fish management is based on the assumption that fish are crops and that these crops are subject to cultivation by man. It parallels, in principle and practice, the better known field of game management which has been described in some detail by Leopold (1933) and others.

Fish management, at present, embraces primarily three phases (1) stocking, (2) legal restrictions, and (3) environmental adjustment. All three phases are being used in greater or lesser degree in the experimental management of the lakes in the Pigeon River State Forest.

Stocking.--The stocking of fish in these lakes consists primarily of introducing exotic species and of planting fish of species already present

for the maintenance of the supply. Although the benefits to be derived from past and current stocking practices are now being questioned to an increasing degree, the value of stocking certain species in certain waters is obvious. As will be noted later, stocking serves as an important phase in the management of the lakes in question. The increase in the yield of desired game fish in these lakes is attributable more to this phase of fish management than to either of the other phases.

Legal restrictions.--Legal restrictions on the take of fish in the lakes of Michigan have been confined largely to the closing of lakes to fishing during certain seasons and to the limiting of the number, kind and size of fish which may be taken. It was found on the trout lakes in the Pigeon River State Forest that changes in the open season were desirable if the lakes were to produce a maximum yield of trout. At the writer's suggestion a number of the lakes were changed from undesignated lakes to trout lakes, so that fishing in these lakes was permissible at the opening of the trout fishing season (now the last Saturday in April) rather than on June 25th, the opening day of fishing on undesignated lakes. Reasons for the desirability of such a change are given later in this discussion. That legal restrictions may be injurious in some lakes is strikingly brought out in the discussion of the perch populations.

Environmental adjustments.--Lake improvement, the adjustment of the environment of lake fishes, so as to increase the yield of desirable species, has been developed on a broad scale primarily by Dr. Carl L. Hubbs and the writer, and is discussed in a comprehensive bulletin which is now in press. Lake improvement practices utilized on the lakes in the Pigeon River State Forest include: (1) an increase in food by fertilizing, by introducing forage fish, and by reducing the actual fish population through netting; (2) an improvement of the bass spawning conditions by installing gravel spawning beds; (3) an increase in protection by installing brush shelters; and (4) the replacement of the fish populations of three lakes by other species.

That the fish yield has increased through the several management practices is indicated in the discussion on yield (pp. 38 to 64).

Management Practices and Results

In the discussion below, the kind of experimental fish management practices on each lake and the results obtained from these attempts at management are listed for each lake.

Dog Lake

The survey of this lake in 1932 indicates that its maximum depth is only two meters and its average depth less than one meter, although, in area it is the largest lake in the forest. Game fish (northern pike, perch and pumpkinseed) and coarse fish (brown bullhead) were found but, according to the results of the netting and seining, none of these species appeared to be abundant. The lake is little fished and access to it is relatively difficult.

Because of the extreme shallowness of Dog Lake, no fish management was attempted or recommended here and stocking was discouraged. Deepening by means of damming the outlet or of dredging out some of the soft peat bottom seemed too impracticable to warrant proposal, because the potential amount of fishing that the lake would support when deepened would probably not justify the cost of the improvement.

Grass Lake

The small cool inlet would probably keep a very small portion of the lake suitable in temperature for trout, but the waters as a whole become too warm in summer to support trout in abundance. Water temperature in early August was 72° F. at the bottom when the air temperature was 69° F.

Only one species of food or game fish (brook trout) was found in Grass Lake, and only one individual of that species was taken by the survey party.

It was hoped that this lake could be improved for fish production by increasing the depth. Efforts were made by Camp Pigeon River to enlarge the dam originally built by the beaver, but were abandoned because of the difficulty in stopping seepage.

This warm, shallow lake, containing an abundance of vegetation, an abundance and a variety of forage fishes and areas of firm gravel bottom, appears well suited for large-mouthed bass and for bluegills. The latter were stocked in 1934 (4,000 4 months old) and in 1935 (1,000 4 months old), but the lake has not been reexamined to determine to what degree the stocking may have been successful. It is anticipated that bass too will be planted and that the effect of the stocking of both species will be determined through creel census, netting, and studies on the rate of growth.

It appears, currently, that the management of this lake involves primarily the introduction of fish suitable to the environmental conditions. Grass Lake was apparently not fished and was of little or no value for fishing at the time of the Institute's original survey of the lake in 1932.

Hardwood Lake

The survey party (1932) found no fish in Hardwood Lake and a casual examination suggested that food was extremely scarce. Because of these conditions and the rather extreme acidity of the water, it was considered improbable that this lake is suited to game fish. A plant of bass and bluegills was recommended, however, as an experiment. In 1933 the lake was stocked with 7,500 bluegills (4 months old) and 250 small-mouthed bass (4 months old). It is doubtful whether any of the fish survived, however, because extended seining in August, 1934, with a 25 foot minnow seine, produced no fish. No further recommendations for stocking fish in Hardwood Lake are contemplated.

The feasibility of improving the fish conditions in acid lakes by neutralizing the water with lime may be tested in Hardwood Lake, since almost pure marl is available in sufficient quantity in Pickerel Lake. Before such an experiment is run, however, the seasonal if not annual fluctuations of the acidity of Hardwood Lake should be determined.

Two-Acre Lake

Two-Acre Lake was found to have a maximum depth of 2.3 meters, a bog shoreline; brown, turbid water; an organic bottom, and no fish fauna. It is apparently too near extinction to be considered suitable for desirable food or game fishes. No reasonable means of effective improvement have come to mind. The lake has therefore been ignored so far as fish management plans are concerned.

Pickerel Lake

At the time of the survey, and at various times since, it was noted that Pickerel Lake was frequented to some extent. It has been fished to a minor degree for some years. The information gained from the survey indicated that Pickerel Lake contains both cold water fish (brook trout) and warm water fish (small-mouthed bass and perch), but that only perch are abundant. Forage fish are very rare; only two specimens were seen by the Institute party in the seining and netting, and the only one collected was a mudminnow, which seemed distinctly out of place in this clear marl lake, according to Adams and Hankinson(1928: 386) and Forbes and Richardson (1920: 205).

Metzelaar in his survey of 1925 noted that Pickerel Lake was reported to contain brook trout. The survey party of the Institute for Fisheries Research took 14 brook trout in a gill-net which was set for 17 hours (August 3-4, 1932) in the deeper part of the lake. One of these trout, the only one not in good condition, had a length of 19 inches; the others varied from 9 to 12 inches. The water temperature (below the thermocline)

is suitable for trout, and oxygen is apparently present in ample quantity.

Small-mouthed bass are apparently not abundant, probably because the only spawning conditions available for this bass in water of suitable depth consist of soft marl and roots of bulrushes, rather than the gravel that is usually demanded by this species.

Perch were reported by Metzelaar to be numerous, and by the Institute survey to be common. The 8 perch taken by the Institute in gill-netting in September, 1936, showed slow growth, according to age determinations.

Environmental changes recommended to increase the population of desirable fish and the degree to which these have been carried out are indicated below. These improvements are particularly needed, since the public camp site now being established on the lake by Camp Vanderbilt (U. S. Parks Service) will undoubtedly lead to an increase in the fishing intensity.

Increase of fertility.--The abundance of phosphates and other fertilizing elements was not determined, but food organisms of suitable size were indicated to be scarce by direct observation and by the slow growth of the perch. It was recommended that two tons of fertilizer high in phosphorus be applied to the lake, and this fertilizer is now being gradually added by Camp Vanderbilt. Perch will be examined for growth to determine the effects of fertilizing ~~in terms of the growth to determine the effects of fertilizing~~ in terms of the growth of the fish--the last element in the food chain. While obviously not the most certain method of determining the effect of the increased fertility, the method is regarded as having value. Differences in the growth might be due to changes in the abundance of fish or to any of a variety of other conditions, consequently a number of similar studies or more intensive studies of the food chain than the writer has been able to undertake will need to be made to determine definitely whether or not the added fertility is responsible for increased growth. The study on Pickerel Lake cannot be completed for at least another year.

Increased protection.--Vegetation was found to be scarce and protection for young fish in general to be poor. Observations made by the author[1] on other lakes suggested that the installation of brush shelters might be expected to improve conditions for the bass. A number of shelters were consequently placed in Pickerel Lake by Camp Pigeon River in 1935. The number has not been ascertained and the use made of the shelters by the several species of fish has not been determined.

Improved bass spawning conditions.--A number of bass spawning boxes (containing gravel) has been placed on the soft marl shoal in Pickerel Lake in 1935. The extent to which these are being used has not been ascertained, but use of some of these beds in Pickerel Lake has been noted. Observations on other lakes where gravel has been introduced for bass, indicate that this gravel was used to a large extent in each lake, and the preference of this species for gravel in spawning has been known to hatchery men for many years.

The extent to which the environmental changes accompanied by the stocking of the lake are affecting the fish populations is scheduled to be studied in some detail during the coming year by observation and by creel census.

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[1] Observations on Howe Lake, Crawford County, in 1934 and 1936, indicated that the perch were chasing the schools of bass fingerlings along the shore. Fishing with some of these bass fingerlings as bait produced a dozen or more perch. Removal of approximately 50 small brush shelters (surrounded by a seine before their removal) from Clear Lake, Montmorency County, showed that the young bass frequented the shelters but that the perch were generally in open water and used the shelters very little. Clear Lake resembles Pickerel Lake in many respects. According to the Michigan Lake and Streams Directory, Clear Lake is "unfit for big game fish." This 160-acre lake, however, yielded in excess of 260 legal-sized bass in 1934-1935 (one full year) and 220 legal-sized bass in 1936 according to an intensive creel census taken by Camp Presque Isle (M.E.C.W.).

Stocking.--Annual stocking with 500 brook trout yearlings or 1,000 brook trout advanced fingerlings and with 3,000 small-mouthed bass fingerlings was recommended as a result of the 1932 survey. Introduction of 5,000 blunt-nosed minnows or fat-headed minnows to increase the forage fish supply was also suggested. The stocking since 1932 was as follows:

Year	Number	Species	Age
1934	7,000	Brook trout	6 mo. old
	600	Brown trout	8 " "
	600	Rainbow trout	Yearlings
	500	Small-mouthed Bass	4 mo. old
	3,000	Bluegills	4 mo. old
1935	1,500	Bluegills	4 mo. old
	500	Brook trout	6 " "
	100	Rainbow trout	Adults
	400	Brook trout	Adults

In view of this heavy stocking, for a small lake, it will be interesting to note the composition of the catch in the creel census. On the basis of an incomplete creel census for 1936 (page 36) fishing in Pickerel Lake was fair when compared with fishing in other lakes of the area. The records indicate that 58 fisherman-days yielded 123 fish at the rate of 0.7 fish per hour. The catch consisted primarily of perch but 17 brook trout of a good average size were also taken.

Ford Lake

Experimental management of the Ford Lake fishing has consisted primarily of altering the fish populations in a number of ways. The 1932 survey indicated that Ford Lake contained an abundance of small perch and that no other species of fish were present. The management practices, briefly and chronologically are:

1933.--An experimental plant of 500 eight-months-old brook trout was made in the fall.

1934.--Netting to determine the success of the trout plant indicated that they grew slowly and suggested that many of them had died. To decrease the fish population, 1137 perch and 15 brook trout were removed by

fishing with gill nets. To increase the food approximately 15,500 forage fish were then planted. Afterwards, the lake was stocked with brook, brown and rainbow trout.

1935.--The lake was stocked with adult rainbow trout.

1936.--On being informed that the trout were fished for very little because of their very "thin" condition, the writer and others destroyed all the fish in the lake by poisoning and dynamiting. Results showed that the trout had not been very successful, but that the forage fish had doubled in number. The perch had improved in condition. The perch population was studied in detail. The lake was then restocked with Montana grayling, an exotic species.

Ford Lake furnished very little fishing at the time of the survey in 1932, when perch were abundant but too small to be attractive to the anglers. From the standpoint of increasing the fishing, the management experiments on Ford Lake met with failure; as an aid in determining the value of certain management practices, however, these management trials have been enlightening.

Since Ford Lake definitely showed thermal stratification and was found to contain abundant oxygen at all depths, it appeared that the lake was suitable for trout, but no trout were found when the survey was made. Since shoal area was extensive, covering about one-third of the lake, stocking with warm water species seemed preferable, but, as an experiment, 500 8-month-old brook trout were planted in 1933. In the summer of 1934 the lake was re-examined by the writer to determine the status of the trout which had been planted the previous year. Fishing with gill-nets for several days showed that the perch were still very abundant and suggested that the trout were not making rapid growth and were not surviving well. The stocking with trout had obviously not been very successful. In view of these findings the writer decided to continue the netting for a number of days to reduce the perch population. It was believed that a considerable decrease in the

number of fish might result in an increased growth for the remaining fish and might benefit any surviving trout or other trout which might soon be planted. Fishing for a period of 8 days with two 250-foot experimental gill-nets with meshes varying from 1 1/4 to 4 inches stretched measure, yielded 1,137 perch and 15 brook trout. The trout were between 6 and 7 inches long and therefore weremaking very poor growth compared with the trout in several of the other lakes. That their numbers had declined was evident from the ratio of trout to perch in the catch. If there was no net selectivity with reference to species (the writer has found that both species are readily taken in gill-nets) and if the 500 trout were all living at the time of the netting, the perch population consisted of almost 38,000 individuals, a total of about 3,500 perch per acre. On the basis of a study of the fish populations on South Twin Lake and Section 4 Lake such concentrations of perch in Ford Lake seemed extremely improbable.

A hundred of the 1,137 netted perch, taken at random, had an average weight of 24 grams. The total weight of the perch which were removed from Ford Lake by netting was therefore about 27.3 kilograms (60.2 pounds) or a weight of 2.56 kilograms (5.6 pounds) per acre. An examination of the perch which had been netted indicated that they also had grown very slowly, that the females grew more rapidly than the males, that the oldest fish were all females, and that the perch were in good condition despite their very slow growth.

To improve food conditions approximately 15,500 forage fish were planted in July, 1934. These fish, from a beaver pond in a very small tributary of the Pigeon River, were mostly northern dace (Chrosomus eos), although limited numbers of fat-headed minnows (Pimiphales promelas), sticklebacks (Eucalia inconstans), mud minnows (Umbra limi) and perhaps a few fish of some other species were included.

In 1934 Ford Lake was again stocked with trout, this time with 6,000 brook trout, 6 months old; 600 brown trout, 8 months old, and 600 yearling rainbow trout. In 1935, 300 adult rainbow trout were stocked in Ford Lake. The following year (1936) it was indiacted by Mr. William Horsell that trout fishing in Ford Lake was not practiced to any appreciable extent because the trout which had been caught were extremely "thin".

Since the plantings of trout in Ford Lake were obviously not successful, it was decided to destroy the perch so that other fish to be planted would not need to compete with them.

On the morning of September 9, 1936, Mr. W. F. Carbine and the writer, assisted by men from Camp Vanderbilt, poisoned the waters of Ford Lake. On the afternoon of the same day, removal of the dead fish was facilitated by discharging 500 pounds of dynamite in the water. After the poisoning and dynamiting 4,817 perch were collected; and of these 3,762 were preserved for laboratory studies. It appears to be relatively certain that the number of perch which had been present in the lake was not very much greater than the number actually collected.

Only 27 trout of the 8000 trout that had been planted were recovered; of these 24 were brook trout, 1 was a brown trout and 2 were unidentified because of their semi-decomposed condition when found. This check-up showed how futile it had been to plant large numbers of trout in a lake overpopulated with perch.

The experiment proved, however, that forage fish could become established, or at least could be temporarily increased in number, in a lake containing an abundance of under-fed perch. The number of forage fish was estimated to be 36,700 at the time of the poisoning. Since none had been taken in 1932 by the survey party, these fish presumably resulted from the stocking with about 15,500 forage fish in 1934. Including these forage fish, the lake had maintained, roughly, about 50 pounds of fish per acre.

It was found by laboratory study that the perch were still growing slowly, but that their condition was better than the condition of the perch in this same lake in 1934. It could not be determined whether this increase in "fatness" resulted from a decrease in the population (a decrease of 5.6 pounds per acre), from the introduction of forage fish or from some other environmental change which may have taken place. It seems probable that the two changes specifically mentioned brought about the improved condition of the fish. It was found too that the male perch decidedly predominated over the females in the ratio of 3:1, but that most of the perch which had attained the legal length of 6 inches were females.

The altered fish populations of Ford Lake are analyzed and discussed in greater detail on pages 83 to 94.

A determination has not yet been made of the status of the grayling, but it is anticipated that the lake will be reexamined in the very near future.

If the grayling which were stocked in Ford Lake, should survive and grow satisfactorily, after the other fish in the lake had been destroyed, a special regulation for fishing in Ford Lake will need to be made, because grayling are now fully protected by law. Since anglers in Michigan are exhibiting an intense interest in grayling, fishing on Ford Lake would undoubtedly be so intensive that the maximum daily limit per angler would need to be made low. A daily limit of two fish per angler will probably be recommended.

Should this trial stocking of grayling prove successful, a similar planting will be recommended for several of the other lakes in the area. Such recommendation would not be made on the basis of any greater suitability of the lakes for grayling than for trout, but merely because of the greater popularity of grayling and the difficulty of reestablishing this desired species in the state. In the opinion of the writer, fish management should meet the desires of the sportsmen, and should recognize that the

~~the~~ law of supply and demand applies to species of fish as well as to any other commodity. If the plant of grayling is not successful the lake will probably be experimentally restocked with trout, and if these fail again, stocking with bluegills will probably be recommended.

Devil's Soup Bowl

Management of this small pond has been limited entirely to stocking and to the designation of this lake as a trout lake. Because in extent the warm water in this 1.3 acre pond greatly exceeded the cold water, stocking with bluegills, a warm-water species, was recommended, but the lake was stocked with 5,000 5-months-old brook trout in 1933 and with 500 6-months-old brook trout in 1934. It was reported that this little lake provided some excellent brook trout fishing in 1934, and an examination of the shore late in that year indicated plainly that the lake had been much frequented. Details on the amount of fishing and on the survival of the trout were not obtained. It may be stated, however, that the limited management attempts were successful since they provided considerable trout fishing where none had existed previously.

Hemlock Lake

The management of Hemlock Lake has been limited to stocking with brook trout and to changing the designation of this lake from "undesignated" to a trout lake. A complete record of the fishing was obtained for a two year period.

According to Mr. Horsell this lake was first stocked with brook trout by William Green, Hillman, in 1927. The Department of Conservation has no record of this stocking so the number and size of trout planted is not known. It may be assumed that the fish were fingerlings. In 1932 the survey party took six trout that varied in length from 15 1/2 to 20 inches (Fig. 1). They were probably all of the 1927 stocking and therefore about 5 1/2 years old. Since it appeared highly improbable that the lake would

be restocked by natural reproduction, further planting of trout was recommended. Stocking was limited entirely to brook trout and included the following plants of 5-months-old fingerling: 5,000 in 1933, 10,000 in 1934 and 5,000 in 1935.

There is evidence that this lake was fished very little before the time of the survey in 1932.

No information is available for the fishing in 1933. Detailed data are not available for the fishing in 1934, but according to reports the fishing in Hemlock Lake was excellent in that year; observations and fishing by the writer add support to these reports. Since 1934 the fishing has very obviously declined. Only 215 trout were taken from this six-acre lake in 1935 and only 52 were caught in 1936. This decline in yield can obviously not be due to inadequate stocking. Only 1.8 per cent of the number of fish stocked in 1934 and 1935 were recovered by the anglers. Details of the fishing for the two-year period are found on pages 54 to 57.

Reasons for the decline in fishing and for the present low yield have not been ascertained. It appears that the lake contains an abundance of food and temperature and oxygen conditions appear suitable for trout. Whether or not the extremely heavy stocking may have been in any way injurious is not known.

The management of Hemlock Lake has been fairly successful but it is essential that the reasons for the steady decline in the yield be determined and that the causes for this decline be remedied. If the present trend in yield continues there will be very little fishing on Hemlock Lake in the future.

Lost Lake

The management of Lost Lake has been similar to that of Hemlock Lake in almost every respect, but the yield in Lost Lake has been very much the higher.

Lost Lake was first stocked in 1927, when Mr. Horsell planted 200 brook trout fingerlings. It is reported to have been fished very little or not at all until 1931, when the presence of trout in this lake became generally known. According to apparently reliable reports, two men fished this lake in 1931 before the season (on undesignated lakes) had "opened". It appears that these two men not only caught fish but that they found fishing exceptionally good. They are reported to have taken 58 brook trout in one day. According to information from the general census this lake supported very intensive fishing on the opening day of the season (June 25th) because of the publicity it had received as a result of the earlier fishing by the two men. The census data, collected by Conservation Officer Slade, indicate that the lake on the opening day of the 1931 season yielded 104 brook trout averaging 10 inches in length in 104 fishing hours, a catch of one trout per hour of fishing. It is reported that fishing declined rapidly after this first day, as would be expected, for at least 162 of the 200 trout which had been stocked in 1927 had been removed and there had been no further stocking. In August, 1931, an Institute party in surveying the lake caught only 4 trout, each about ten inches long. The uniform size of all the trout recovered by anglers as well as by the survey party suggests plainly that they were all of one stocking, evidently that of 1927. These fish had grown to be approximately ten inches long in about 4 1/2 years. Survival of the stocked fish must have been almost complete.

The successful establishment of the trout in Lost Lake as indicated by the fishing in 1931 led to the survey of the lakes in the area and to the later management experiments.

Further stocking of Lost Lake with brook trout was naturally recommended. Plants of brook trout made since 1927 are as follows: 5,000 5-months-old and 500 8-months-old in 1933; 6,000 6-months-old in 1934 and 5,000 5-months-old in 1935. It is reported that Lost Lake supported little fishing in 1932 and 1933. It may be stated with certainty that the lake contained almost

no trout during these two seasons except for the small trout stocked late in the second season. Lost Lake supported considerable fishing in 1934 but definite information regarding this fishing is lacking. A complete record on the fishing during the next two seasons is available however. In 1935 Lost Lake yielded 461 brook trout of an average length of 8.9 inches. It was fished by 387 anglers for a total of 1,157 3/4 hours. The yield represented 100.2 fish per acre having a weight, per acre, of 30.2 pounds. In 1936 the lake yielded only 11.85 pounds of fish per acre, a very decided decline over the previous year. The reason or reasons for this decline in the yield have not been determined.

The yield for the two seasons represented only 5.7 per cent of the trout stocked in this lake in 1934 and 1935. A high mortality of the planted fish presumably results. An inventory of the yield will presumably be continued and efforts will be made to determine the reasons for the decline in the fishing.

West Lost Lake

Fish management on West Lost Lake has been limited to stocking and to a re-designation of this lake from an undesignated lake to a trout lake. Stocking with brook trout was recommended as a result of the survey in 1932, when none were found. According to the stocking records this lake was first planted in 1934 but there is reason to believe that trout were actually first planted in West Lost Lake in 1933. Several records of fishing for 1934, in the general creel census of the state, indicate that fish of legal size were caught that season.

According to the records the stocking included a plant of 6,000 6-months-old brook trout in 1934 and a plant of 5,000 brook trout, 5 months old, in 1935. As shown in detail on pages 49 to 53, West Lost Lake yielded 199 brook trout in 1935 and 254 brook trout in 1936. These fish represent 4.5 per cent of the trout stocked in 1934 and 1935. On the basis of the number of fish

caught, the fishing in 1935 was ~~better~~ ~~caught, the fishing in 1935 was~~ better than during the previous year. In pounds per acre the yield declined very slightly, however, since the lake yielded 23.5 pounds per acre in 1935 and 22.5 pounds per acre in 1936. Judging from the trend of fishing in Lost Lake and in Hemlock Lake, both of which supported trout for a longer period than did West Lost Lake, it is probable that, for reasons unknown, the yield in West Lost Lake will gradually decline.

A study of the yield through the creel census will probably be continued for at least another year.

Section 4 Lake

Section 4 Lake was found to be similar in character to Lost Lake and West Lost Lake but similar in fish population to Ford Lake. It too was found to contain small perch in abundance. Stocking with brook trout was recommended and 300 8-months-old trout were planted in 1933. Results of this stocking were apparently similar to the results obtained in Ford Lake--slow growth and high mortality. All fish were removed in 1935 and the lake was later stocked with adult rainbow trout.

As in Ford Lake, the attempts to manage this lake met with little success (except possibly in 1936) but certain information was obtained which may be of value in managing similar waters.

Gill-nets fished in Section 4 Lake in August, 1934, yielded a total of 39 perch and 3 brook trout, the latter not over 7 inches in total length. The perch too were small. According to reports the lake yielded very few trout to the anglers in 1934 and 1935. It was decided therefore to remove the perch by poison and to restock with trout.

About 75 pounds of powdered derris root were distributed over the lake on September 19, 1935. During the next 50 hours dead fish were collected. These fish are discussed in detail on pages 95 to 98. It is probable that not all of the fish were collected since some were still coming to the surface at the time the party left after the poisoning. A

total of 1,736 fish, all perch, representing 526 fish (23.1 pounds) per acre were recovered. A study of these fish showed that they were growing slowly, that relatively few were of legal size (6 inches long), that males were decidedly the most abundant, that the females grew more rapidly and that the older fish were all females. The fish were mostly young, only seven were older than 4 summers, and these were all 5-summer-old females. The perch were in good condition even though they had grown slowly.

The lake was stocked with 150 adult rainbow trout soon after the poisoning. No information was obtained on the fishing on this lake in 1936 although it appears that the lake was little fished, probably because it was not generally known that the changes in the fish population had been made.

A gill-net was placed in this lake over-night in the fall of 1936. It yielded no perch but contained two rainbow trout which were approximately a foot long and which were in excellent condition.

It appears therefore that the perch were all killed in the poisoning of this lake in 1935, and that the trout were apparently in satisfactory condition. The small number of trout taken in the over-night net-set does not necessarily indicate that few trout were present. The deeper parts of this lake are devoid of oxygen, according to the 1932 survey, and much of the net was in this oxygenless area.

A study of the yield of Section 4 Lake for the 1937 fishing season by intensive creel census is contemplated.

North Twin Lake

North Twin Lake, like three of the other land-locked pit lakes, contained an abundance of small perch at the time of the 1932 survey. It was managed differently, however.

The stocking of trout in this lake in 1933 appeared as the result of some experimental netting in 1934 to have met with about the same lack of

success as the stockings had in the other perch-populated lakes. In an attempt to relieve the apparently severe competition for a limited food supply, this lake was fertilized in the summer of 1934 with approximately 250 pounds of "Farm Bureau fertilizer", stated to contain: 4 per cent nitrogen, 16 per cent phosphoric acid and 8 per cent potash. The fertilizer was floated in a frame at the center of the lake; approximately 50 pounds were added every week or two as it slowly dissolved.

Fertilizer has for some years been used in rearing-ponds to increase the productivity and has been found by Juday (unpublished) to increase the food in natural waters. Changes in the abundance of food organisms as a result of the fertilizing in Ford Lake were not studied, although it was observed that plankton was abundant in the vicinity of the fertilizer.

According to reports North Twin Lake yielded perch and trout of fair size in 1935. It had been heavily stocked with brook trout in 1933 (with 1,300 8-months-old and 5,000 5-months-old fish). Studies of the fish yield of this lake have unfortunately not been made. The only available information on the fishing consists of 4 fishing records for 1936 listing a catch of 21 brook trout averaging 11 1/2 inches in length and 48 perch averaging 6 1/2 inches in length, all taken in a total of 22 fishing hours. The information is too meager to be of much value but it suggests that the trout grew well and that some of them at least had survived. The perch were apparently still small.

It is not demonstrated that the fertilizer effected the growth and survival of the trout, but the showing made by the trout in this lake in comparison with that of the trout in the other three lakes seems more probably to be due to the fertilizing than to any other factor. It is anticipated that more trout will be stocked in this lake, that more fertilizer will be added, and that a creel census will be initiated here at the opening of the 1937 fishing season. North Twin Lake has been designated a trout lake to permit fishing early in the summer when the trout apparently are more

readily taken than later in the season.

South Twin Lake

Management of South Twin Lake was very similar to that of Section 4 Lake. It consisted primarily of (1) stocking with trout, (2) of removing all fish after it appeared that the planted trout were not succeeding in competition with the abundant perch and (3) of restocking them with trout, with a planting of forage fish.

Only perch were taken in this lake by the survey party in 1932. The 82 specimens taken were mostly small, and in very poor condition. As temperature and chemical conditions appeared suitable, brook trout were recommended for stocking and 5,000 5-months-old and 1,500 8-months-old brook trout were planted in 1933. When the success of this planting was tested by fishing with gill-nets for several days in the summer of 1934, a total of 263 perch and only 21 trout were recovered. The perch were obviously stunted, as indicated by their large heads and small size, and the trout also showed poor growth. The proportion of trout to perch (263:21) suggested that a heavy mortality of trout had taken place. It is thought improbable that the nets were highly selective with respect to the two species. When the lake was thoroughly poisoned and dynamited in September, 1934, to remove the stunted perch, 3,615 perch and only 2 trout could be found.

A study of the fish showed that 955 perch, weighing 29 pounds were present per acre, that 7 per cent were legal fish (54 males, 199 females), that these perch had grown quite slowly, that over three-fourths of the fish were of one age group (3 summers old), that the males predominated but that the older fish were all females, that the fish were in excessively poor condition and unusually large-headed and that the food consisted primarily of midge larvae. The evidence is that most of the fish normally died of starvation before reaching the legal size.

In the summer of 1935 the lake was stocked with about 5,000 blunt-nosed minnows (Hyborhynchus notatus) and about 50 killifish (Fundulus d. menona). A brief examination of this lake in 1936 showed that the blunt-nosed minnows had become abundant.

After the killing off of the perch and the planting of forage fish, South Twin Lake was stocked with 100 adult rainbow trout in the fall of 1935. A creel census study for 1936, discussed in detail on pages 57 to 54, indicates that 62 of these fish were caught by the fishermen during the 1936 season. The survival of these fish was therefore good.

Further creel census for this lake is contemplated and continued stocking with rainbow trout will probably be recommended, as it seems improbable that the trout will spawn successfully.

DISCUSSION

It is obvious from the foregoing discussion that the actual management of these lakes though incomplete has resulted in a number of changes in the fish populations, and that these changes have affected the yield of game fish.

Stocking was extremely successful in some of the lakes and met with almost complete failure in others. The stocking of brook trout in the four pit lakes which had previously contained only forage fish was successful in each lake and especially successful in several of them. On the other hand, stocking of trout in three pit lakes which contained an abundance of perch was not successful, for the few trout that survived grew slowly. The stocking of trout was successful in another pit lake, which contained an abundance of perch but which unlike the other lakes was enriched with commerical fertilizer.

Forage fish that were stocked in one of the lakes having a dense perch population doubled in number in two years. Forage fishes planted in a lake from which the perch were removed also survived and multiplied, even after

rainbow trout were successfully introduced.

The stocking of bluegills in an acid lake apparently failed completely. The success of bluegill plants in two other lakes has not yet been determined.

Designation of seven of the lakes as "trout lakes" seemed desirable. A majority of the trout were apparently caught after the opening of the trout season (on or about May 1) and before June 25, when fishing would have begun on these lakes had they remained without the special designation.

Certain lake improvement devices installed in one of the lakes have not yet been examined for effectiveness.

All fish were removed from 3 lakes by poisoning, supplemented by dynamiting in 2 of them, and these lakes have since been stocked with other species. In one lake this change was shown to have produced desirable results, in the other two lakes the results have not yet been determined.

Since the lakes in the Pigeon River State Forest provided relatively little fishing before the management practices were initiated and since a number of them now yield good crops of fish annually the management was, in general, successful. A continuation of the experimental management program is obviously needed and is contemplated.

A STUDY OF THE FISH YIELD OF THE LAKES IN THE PIGEON RIVER STATE FOREST

The Creel Census Method

An inventory of the fish yield of our waters is obviously essential to intelligent fish management; it occupies the same important position in the field that sales inventories occupy in business. Without a determination of the annual crop, the effects of stocking, legal restrictions and environmental improvements cannot be determined with reasonable accuracy. In Michigan, studies of the fishing, (creel census studies) are now being made on an extensive scale by two distinct types of census, the general creel census representing a sampling of the fishing over the entire state and the intensive creel census which covers all or nearly all fishing on certain waters. As the methods of taking the census and an account of the sort of information furnished by the census have been discussed in a number of publications (Eschmeyer, 1936 a, b; 1937 a, b; Hazzard and Eschmeyer 1937 a, b), they are mentioned here only briefly.

The general creel census which represents a sampling of the fishing over the entire state is taken primarily by the Conservation Officers. It was initiated in 1927, chiefly through the efforts of former Conservation Commissioner Harold Titus, and is still in progress. Approximately 20,000 individual fishing records are obtained annually by this census. The officers record only the information on fishing (for the day) up to the time the angler is contacted. The total yield cannot be obtained by this method, but such data as the kind of fishing, the relative abundance of the species in the catch and the success of fishing in terms of the catch per hour, are compiled from general census records. The trend of fishing, as related to stocking or improvement or other fish management may be determined

for parts of the state or individual waters, provided that the general census is continued for several years, as an adequate and random sample of the fishing.

The intensive census which covers all or nearly all fishing on certain waters is taken by crews of men, primarily from C.C.C. camps. This census, initiated in 1933, has provided a complete or nearly complete inventory of the winter fishing on about 35 lakes and the summer fishing on about 30 lakes. The intensive census is taken each day of the fishing season from about daylight to dark and each man on the census crew patrols a certain portion of the shoreline to contact all fishermen who leave the lake along the section assigned to him. The crews are generally of ample size to insure that all fishermen will be seen. A few anglers who are seen but are not contacted are regarded, in the final summarizing of the data, to have caught the average number and size of fish per angler in an average fishing day.

The blanks used for recording the census information are similar for both the general and the intensive census. The form now used is shown in Figure 2. The following information is obtained regarding each angler and his day's fishing: Fisherman's name, address, sex and approximate age; number and size of fish of each species caught; the date; the kind of fishing and kind of bait used; the weather conditions; the time fished and the time of day when the fishing was best.

The intensive census provides a variety of information, including means of determining, for each water: the amount of the annual crop, the catch per hour, the abundance in the catch of each species at each season, the effectiveness of the various fishing methods and of various baits, the residence of the anglers, the number of undersized fish caught (which helps to predict the fishing trend for the next year or two), the time of day when fishing is best, the relationship between weather conditions and fish "biting", the size distribution of the fish caught, and the seasonal fluctuation of each species in the catch.

Over a period of years the census tends to indicate the maximum annual catch which may be taken without injury to future fishing. Coupled with an extensive marking program, it will help indicate the total population of adult fish and the percentage of these fish removed annually. Coupled with stocking and marking, the census can, in time, provide data sufficient to evaluate the benefits derived from stocking. Coupled with lake improvement, it can similarly be made to indicate, in time, the effectiveness of lake improvement work in general, and of devices of different sorts. The census, taken on lakes at different evolutionary stages will tend to indicate the production from lakes at these stages. It will show, in time, the effect of variations in the numbers of one species on the abundance of another. If carried out on a number of representative lakes, the intensive census will help to determine approximately the combined annual fish catch for all lakes in the state. It will test the effectiveness of existing legislation and will help to indicate what restrictions would be of greatest benefit to the lake and least objectionable to the fisherman.

Where relatively complete information regarding the fishing is desired, the intensive census is decidedly preferable to the general census, which represents merely a sampling of the fishing and which gives only a portion of the information which may be obtained from the intensive census.

The establishment of a C.C.C. camp (and later a second camp) in the Pigeon River State Forest made possible the taking of an intensive census on some of the lakes in the area. Some lakes provided so little fishing that the continued patrolling of these waters during the fishing season seemed impracticable and was not recommended. On the three heavily fished lakes (Lost, West Lost and Hemlock) a creel census was taken during the 1935 fishing season. On the following year this census was extended to include also South Twin Lake, Pickerel Lake, and a portion of the Pigeon River. The 1935 census was taken by Camp Pigeon River, M.E.C.W., and the 1936 census-taking was by Camp Vanderbilt, U. S. Parks Service. Project estimates have

been submitted and approved to continue and extend the creel census for the 1937 season; the census is to be taken by Camp Pigeon River.

In 1935 one census-taker covered the fishing on Hemlock Lake and one man examined the catches on Lost Lake and West Lost Lake; the latter two lakes are only a fraction of a mile apart and one census-taker was able to obtain the fishing information on both by walking from one to the other. It is believed that almost every fisherman who used the three lakes was contacted. The method of taking the census differed somewhat in 1936. Fishing was not very intensive after the first week or two of the season and one man with a car went from lake to lake to contact the fishermen during most of the summer. This man also took a census on part of the Pigeon River but the river census was incomplete in that not all fishermen on the river were contacted. Information on the fishing on Pickerel Lake is incomplete; on the other lakes where the census was taken all or almost all of the fishermen were contacted. The pit lakes are very small and a glance at each lake will indicate whether or not anyone is fishing on it; census-taking on these waters is therefore relatively simple and calls for a very small crew.

Data on the census of the lakes in the Pigeon River State Forest, including a small amount of information obtained from the general census are listed and discussed by individual lakes below. The information obtained from the census and stressed in the discussion includes:

Total yield.--A determination of the total yield is necessary to learn to what extent the management practices have been instrumental in increasing the crop and to note whether or not the lakes are yielding a satisfactory crop. A study of the fishing to note the relative abundance of the species in the catch is not usually needed in the Pigeon River Forest for most of the lakes of this region contain only one species of game fish.

Size distribution.--The approximate size of the fish in the catch was tabulated for the season and for each month, to determine whether the fish were growing satisfactorily.

Effectiveness of baits.--The effectiveness of the various baits in catching trout is not only of considerable interest to the angler but is also of importance in fish management. The writer has found from creel census studies on other waters that certain baits are decidedly more effective than others in taking fish of certain species, also in taking fish of different sizes. The general census (Eschmeyer, unpublished) shows a close correlation between the percentage of brook trout in the catch and the mean monthly temperature; brook trout are least represented in the catch during the hottest months, hence, during the tourist and resort season. Any kind of bait which may increase the catch (yield) during mid-summer when the yield is normally low and the fishing pressure is great should be recommended to the mid-summer fishermen, unless, of course, an increase in the crop appears undesirable because of too great a removal of the brood-stock. Since fishing for trout on these lakes must be supported entirely by stocking, on account of the unfavorable spawning conditions, no "Brood stock problem" is presented.

Residence of the anglers.--The residence of the anglers is determined, primarily, to note the relative numbers of anglers who are local and who are tourists or resorters. A lake which attracts persons who live many miles away naturally may be expected to provide more revenue to the area than a lake which is fished with equal intensity by local anglers. The degree of intensity to which management is practicable depends to a considerable extent on the economic value of the fishing.

Trend of the fishing.--The trend of the fishing is noted for those lakes on which the creel census has been taken for several years. It will be noted below that the trend of the yield is downward on the three lakes

in the area on which fishing information for two seasons is available. This trend suggests that certain changes must be made in the management of these several lakes if they are to continue to produce a good crop, but unfortunately does not indicate what changes should be made. No information is yet available for the fishing on 7 of the lakes. In view of the indicated lack of game fish, it may be safely stated however, that there was no fishing, or at least no catch, on Two-Acre Lake and on Hardwood Lake, and probably none on Grass Lake. Dog Lake has apparently been supporting a small amount of fishing each season. Fishing on Ford Lake has been very limited, Devil's Soup Bowl supported a considerable amount of fishing for at least one season, and a small amount of fishing has been done in Section 4 Lake. In the following pages fishing on those lakes where the creel census has been in progress for two seasons is first discussed, followed by a consideration of the fishing on those waters where the census was taken for a single season.

Creel Census on Lost Lake

Fishing on Lost Lake was very intensive in 1935, but declined very decidedly in 1936. This 4.6 acre lake was fished for 387 fisherman-days for a total of 1,157.75 hours during the 1935 season. In 1936 it was fished by only 164 fishermen, for a total of just 500 fishing hours. In comparison with fishing on other lakes where the census has been taken, however, even this concentration is heavy. Each year the fishermen caught on the average slightly more than one fish each per day's fishing but a majority of the fishermen took no fish (64 per cent took no fish in 1935, 72 per cent took none in 1936). The catch per hour was slightly higher in 1935; the average size of the fish caught was a little larger in 1936. General information on the fishing is shown in tables 5 and 6. In 1935 the fishing season on trout lakes extended from May 1st to Labor Day, in 1936 it extended from the last Saturday in April to Labor Day (both dates inclusive both years).

The fish caught in 1935 varied decidedly in size as shown in Table 7. The one very large fish, evidently a remnant of the original 1927 plant, had therefore grown to a length of 22 inches in about 8 1/2 years. The other fish had apparently all been stocked in 1933 and 1934, the larger ones probably in 1933 or, since many undersized fish were taken, perhaps representing the 1934 plant, it is possible that almost all of the legal sized fish were of the 1933 stocking. It may be stated, at least, that the fish had grown to an average size of almost 9 inches in less than 2 1/2 years.

The 8 and 9 inch groups dominated in 1935, but in 1936 (Table 8) most of the fish were apparently in the 9 and 10 inch groups and none of 7 inches were registered as caught. This trend suggests that the recent stockings, that of 1935 and perhaps the one in 1934, had been relatively unsuccessful.

Computations of the weights of the fish given in tables 7 and 8 indicate that the lake yielded a total of 138.9 pounds of trout in 1935, 54.5 pounds in 1936. In pounds per acre the production figures are 30.2 and 11.9 respectively.

Were the total catch not known it might be assumed that Lost Lake yielded a relatively poor crop of fish since they were taken at the rate of only about one per three hours of fishing. Comparative data are lacking for fish yield in trout lakes outside of the Pigeon River area, but the yield from Lost Lake was higher than that of warm water fish from any of the lakes for which census data are available. A yield of 30 pounds per acre seems to constitute a very exceptional crop of trout.

Information on the effectiveness of the several kinds of bait used to a specified degree, as shown in tables 9 and 10, indicates that fishing with artificial flies yielded the best results in catch per hour in 1935. They were used however by only a few, probably expert fishermen.

Table 5

MONTHLY ANALYSIS OF FISHING ON LOST LAKE FOR 1935

	May	June	July	August	Total or Per Average	Per Acre
Number of fisher-man-days	155	56	114	62	387	84
Number of fisher-men taking no fish	90	30	88	40	248	...
Number of hours fished	605.5	155.25	204.5	156.5	1157.75	251.7
Number of legal fish taken[1]	206	78	93	84	461	100.2
Fish per fisherman	1.3	1.4	.82	1.4	1.2	...
Fish per hour	.34	.50	.39	.54	.4	...
Ave. size of legal fish (inches)	8.8	8.8	8.8	9.2	8.9	...
Number of under-sized fish[2]	99	30	12	24	165	36

[1] All fish caught were brook trout.

[2] Undersized fish not included in above calculations.

Table 6

MONTHLY ANALYSIS OF FISHING ON LOST LAKE FOR 1936

	April	May	June	July	Aug.	Total or Average	Per Acre
Number of fisher-man-days	53	77	8	13	13	164	35.7
Number of fisher-men taking no fish	28	61	7	11	11	118	...
Number of hours fished	163.5	256	21	21.25	38.25	500	108.7
Number of legal fish taken[1]	126	23	1	10	6	166	36.1
Fish per fisherman	2.4	0.29	0.13	0.77	0.46	1.01	...
Fish per hour	0.77	0.09	0.05	0.47	0.16	0.33	...
Ave. size of legal fish (inches)[2]	9.3	9.2	8.0	9.5	10.0	9.3	...

[1] All fish caught were brook trout

[2] The number of under-sized fish caught was not determined.

Table 7

SIZE DISTRIBUTION AND WEIGHT OF CATCH, LOST LAKE, 1935

Size (inches)	7	7¼	7½	7 3/4	8[1]	8¼	8½	8 3/4	9	9¼	9½	10
No. (May)	4		9	7	59		15	3	71		5	27
No. (June)		3	2		15		21	6	15	3		10
No. (July)				3	24	6	7		38			15
No. (Aug.)					1		8		47		17	4
No. (total)[2]	4	3	11	10	99	6	51	9	171	3	22	56
Estimated wt. per fish[3]	.141	.156	.174	.192	.211	.231	.252	.276	.300	.325	.353	.411
Total wt. (lbs.)	.56	.47	1.91	1.92	20.89	1.39	12.85	2.48	51.30	.97	7.77	23.02

Table 7 continued:

Size (inches)	10½	11	12	13	22
No. (May)		3		2	1
No. (June)	2		1		
No. (July)					
No. (Aug.)		7			
No. (total)[2]	2	10	1	2	1
Estimated wt. per fish[3] (lbs.)	.476	.548	.711	.904	4.379
Total wt. (lbs.)	.95	5.48	.71	1.81	4.38

[1] The number of fish measuring even inches is not in proper proportion with the number having fractional measurements. Obviously measurements on many of the fish were probably not correct to more than the nearest half inch.

[2] Since each sheet indicated the average size of the fish taken, the distribution as listed here is not correct. However, it approaches the actual size distribution.

[3] To convert production into pounds, the condition factor used was 1.45. This was found by L. A. Woodbury (unpublished) as average for brook trout in seven lakes in Glacier National Park. The average condition of the trout in Lost Lake was probably not less than 1.45, so the estimate of weight given here appears to be a relatively conservative one. Mr. Woodbury provided a table by which his measurements could be expressed in inches and pounds.

Table 8

DISTRIBUTION AND WEIGHT OF CATCH, LOST LAKE, 1936[1]

Size (inches)	8	9	9½	10	10½	11
Number (April)	5	80		40	2	1
Number (May)	7	5		9		
Number (June)	1					
Number (July)			6			
Number (Aug.)				6		
Number (total)	13	85	6	55	2	1
Total weight (lbs.)	2.74	25.50	2.12	22.60	.95	.55

[1] Footnotes under Table 7 apply here also.

Fishing with worms rated second in effectiveness in 1935 and was decidedly best in 1936.

The residences of the anglers were determined for both seasons, by communities the first year, by counties the next season; non-residents are listed by state only. A check of the residences of the anglers who fished Lost Lake in 1935 indicates that the lake attracted fishermen from a large number of localities. The communities from which the specified number of fishermen came in 1935 to fish in Lost Lake was as follows: Local (within an approximate 20-mile radius, including the towns of Wolverine, Afton, Onaway, Tower, Vanderbilt and Indian River) 186, Ann Arbor 3, Bay City 3, Battle Creek 3, Boyne City 14, Conway 1, Cheboygan 6, Charlevoix 1, Detroit 34, Dearborn 2, E. Lansing 1, Flint 3, Gaylord 11, Grand Rapids 4, Jones 1, Jackson 8, Kalamazoo 5, Lansing 7, Mullet Lake 1, Midland 16, Mt. Clemens 2, Mt. Pleasant 4, Monroe 1, Muskegon 2, North Star 4, Newaygo 1, Owosso 3, Oden 2, Petosky 41, Pontiac 2, Saginaw 12, Three Rivers 1, Topinabee 9, Wyandotte 3, Walcon Lake 2, Ypsilanti 4, and Vicksburg 2; Ohio 5, Indiana 4, Illinois 4 and Pennsylvania 2.

Table 9

EFFECTIVENESS OF BAITS USED ON LOST LAKE, 1935

Bait	No. using bait	No. hours bait used	No. fish caught	Fish per hour	Ave. size of fish
Insects	33	59.00	25	.42	8.5
Art. Fly	21	42.50	26	.61	8.4
Minnows	117	495.75	219	.44	9.1
Worms	78	193.25	113	.58	8.7
Spinner	4	5.25	1	.19	11.0
Plug	1	1.50	-	-	-

Table 10

EFFECTIVENESS OF BAITS USED ON LOST LAKE, 1936

Bait	No. using bait	No. hours bait used	No. fish caught	Fish per hour	Ave. size of fish
Insects	1	4.50	0	0	-
Art. Fly	3	6.25	1	.16	8
Minnows	32	106.75	20	.19	9.6
Worms	65	183.00	106	.58	9.3
Spinner	0	-	-	-	-
Plug	0	-	-	-	-

Over half of the fishermen in 1936 were from three nearby counties (Otsego, Cheboygan and Emmet). The counties represented and the number of anglers from each are: Otsego 52, Emmet 26, Cheboygan 22, Wayne 10, Kalamazoo 9, Presque Isle 7, Midland 4, Muskegon 4, Charlevoix, Calhoun and Genesee 3 each, Alpena and Chippewa 2 each, and one each from Jackson, Oakland, St. Clair and Washtenaw. Non-residents were 7 from Ohio, 5 from Indiana and 1 from Illinois.

The yield was exceptionally good in 1935, but only fair the next season. The decline in the fishing suggests that changes in the management of this lake are to be made if the fishing is to be maintained on a satisfactory level. The decline is even more striking when the limited general census data for 1931 are taken into consideration, for, in that year, two men caught 58 trout in one day before the season opened and a total of

104 trout were recorded as caught in 104 hours on the opening day of fishing. Since only 200 fish had been planted the total yield could not have exceeded that of 1935 when almost 500 fish were taken but the catch per hour was very much better in 1931. Almost all of the trout which were planted survived in 1931, but thereafter the survival from the stocking has apparently decreased constantly. Whether or to what degree this trend will continue will be determined from the further creel census on this lake.

Creel Census on West Lost Lake

Fishing on West Lost Lake differed from that on Lost Lake and Hemlock Lake in that it declined very little in 1936, when in fact, both the number of fishermen and the number of fish caught increased. The catch per hour and in pounds declined slightly however. In 1935 the fishing was concentrated in May, whereas in the next season it was distributed relatively evenly throughout the season. During the first season of the census 164 fishing records were obtained representing 582.25 hours of fishing. The fish were of a large average size (10.5 inches) and were taken at the rate of one fish per 3 hours of fishing. West Lost Lake yielded 199 trout in 1935.

In 1936 the fishing records totaled an even 200 and represented 658.25 hours of fishing. In that year the lake yielded 254 trout, at the rate of 0.3 fish per fishing hour.

In terms of pounds per acre the yield was 23.5 pounds for the first year and 22.5 pounds for the second year, a hardly significant decline of one pound per acre. Few under-sized fish were reported in either years.

General data on the fishing is shown, by months, in tables 11 and 12. It will be noted that fishing declined each month in 1935; but was apparently best in July during the next season. Good trout fishing in July seems unusual and the success during that month in 1936 cannot be explained.

Table 11

MONTHLY ANALYSIS OF FISHING ON WEST LOST LAKE FOR 1935

	May	June	July	Aug.	Total or Average	Per Acre
Number fisherman-days	95	35	26	8	164	41
Number fishermen taking no fish	54	23	19	7	103	
Number of hours fished	376	106.75	78.0	21.50	582.25	145.50
Number of legal fish taken[1]	161	23	14	1	199	50
Fish per fisherman	1.7	0.66	0.53	0.13	1.2	
Fish per hour	0.43	0.22	0.18	0.05	0.34	
Ave. size of legal fish (inches)	10.2	9.3	11.7	13.0	10.5	
Number of under-sized fish[2]	14	1	7	0	22	5.5

1/ All brook trout

2/ Not included in calculations

Table 12

MONTHLY ANALYSIS OF FISHING ON WEST LOST LAKE FOR 1936

	April	May	June	July	Aug.	Sept.	Total or Average	Per Acre
Number fisherman-days	12	55	34	42	45	12	200	50
Number fishermen taking no fish	7	33	22	23	27	9	121	
Number hours fished	34	204	112	104.75	172	31.50	658.25	164.3
Number legal fish taken[1]	17	84	28	84	37	4	254	63.5
Fish per fisherman	1.41	1.52	0.82	2.0	0.82	0.33	1.3	
Fish per hour	0.5	0.41	0.25	0.80	0.22	0.13	0.30	
Ave. size of legal fish (inches)	9.3	9.55	9.1	9.45	9.2	9.0	9.4	
Number under-sized fish[2]	9		3	1			13	3.2

1/ All brook trout

2/ Not included in calculations

In 1935 trout of a length of 11 and 12 inches were well represented in the catch. These fish had apparently been stocked in 1933 even though the records fail to indicate that West Lost Lake was stocked that year. It is improbable that the lake was stocked before 1933 because the state did not stock any of the lakes in the area with trout before that year and, so far as could be determined, the lake was not stocked by private individuals.

The smaller fish were probably of the 1934 stocking. It may be stated at least that the trout which were caught in 1935 had reached an average length of about 10.5 inches in about 2 1/2 years. The fact that the lake contained only forage fish before the stocking, and the probability that trout food was plentiful would explain such good growth.

By 1936 the average size had declined; only 4 fish longer than 11 inches are recorded. It is probable that the 1933 stocking was represented poorly if at all in the catch. The 8-inch fish were probably primarily of the 1935 stocking and the larger fish chiefly of the plant in 1934. Since scale samples to determine the ages of the fish were not taken, however, any attempt to indicate the ages of the size groups is purely hypothetical. Size distribution and weight of the fish in each group is shown in tables 13 and 14.

The effectiveness of the several baits used varied from the one year to the next; worms were most effective in 1936 but yielded relatively poor results the previous year. Data on the baits used are shown in tables 15 and 16.

The anglers came from a large number of localities. The residences listed for the 1935 fishermen, with the number from each residence, are: Local (withing a 20-mile radius) 62, Au Gres 1, Cheboygan 3, Detroit 11, Dearborn 1, Gaylord 11, Jackson 3, Lansing 22, Mackinaw 1, Muskegon 3, Oden 2, Perry 1, Petosky 13, Pontiac 5, Romeo 4, Royal Oak 2, St. Johns 2, Traverse City 3, Topinabee 4.

Table 13

SIZE DISTRIBUTION AND WEIGHT OF CATCH[1], WEST LOST LAKE, 1935

Size (inches)	7½	8	8¼	8½	9	9½	10	10½	11
No. (May)	5	14	4	10	28		20		42
No. (June)		1		1	10	5			3
No. (July)							6		
No. (Aug.)									
No. (total)	5	15	4	11	38	5	26		47
Estimated wt. per fish (lbs.)	.174	.211	.231	.252	.300	.353	.411		.548
Total wt. (lbs.)	.87	3.17	.92	2.77	11.40	1.77	10.69		25.76

[1] Comments under table 7 apply here also.

Table 13 continued:

Size (inches)	11½	12	13	13½	17
No. (May)	6	31	1		
No. (June)		1	2		
No. (July)		2		3	1
No. (Aug.)			1		
No. (Total)	6	34	4	3	1
Estimated wt. per fish (lbs.)	.623	.711	.904	1.012	2.021
Total wt. (lbs.)	3.76	24.17	3.62	3.04	2.02

Table 14

SIZE DISTRIBUTION AND WEIGHT OF CATCH[1], WEST LOST LAKE, 1936

Size (inches)	8	8½	9	9½	10	11	11½	12
No. (April)	1		10		6			
No. (May)	12		11		55	6		
No. (June)	8		9	2	8		1	
No. (July)	8	3	16	44		13		
No. (Aug.)	10	1	12	1	9	1	2	1
No. (Sept.)	1	-	1	2				
No. (Total)	40	4	59	49	78	20	3	1
Total wt. (lbs.)	8.44	1.01	17.70	17.30	32.06	10.96	1.38	.71

[1] Comments under Table 7 apply also here.

The residences, listed by counties, in 1936, indicate that over 60 per cent of the fishermen were from three nearby counties. Cheboygan County provided 72 of the anglers. The other counties, with number of anglers from each, are: Otsego 31, Shiawassee 19, Emmet 22, Ingham 15, Wayne 9, Gratiot 6, Jackson 4, Genessee 4, Mecosta 3, Saginaw 3, Charlevoix 2, Kent 2, Kalamazoo 2, Oakland 2. Four of the anglers were non-residents, all from Ohio.

Table 15

EFFECTIVENESS OF BAITS USED, WEST LOST LAKE, 1935

Bait	No. using bait	No. hours bait used	No. fish caught	Fish per hour	Ave. size of fish
Insects	2	5.0	3	.60	13.5
Art. Fly	12	36.0	36	1.0	8.7
Minnows	45	227.75	102	.45	10.9
Worms	68	206.75	54	.26	10.0
Spinner	4	7.50	-	-	-

Table 16

EFFECTIVENESS OF BAITS USED, WEST LOST LAKE, 1936

Bait	No. using bait	No. hours bait used	No. fish caught	Fish per hour	Ave. size of fish
Insects	1	4.25	-	-	-
Art. Fly	1	4.75	1	.21	8.0
Minnows	59	233.25	109	.47	9.4
Worms	30	109.0	83	.76	9.6
Spinner	1	2.0	-	-	-
Plug	2	5.50	-	-	-

Judging from the trend of fishing in Lost Lake and Hemlock Lake, both of which have had a slightly longer fishing history, it seems probable that the fishing in West Lost Lake will further decline. More definite information on the trend will eventually be available since the census will presumably be continued.

Creel Census on Hemlock Lake

The fishing on Hemlock Lake in 1935 and 1936 was disappointing. The trout recovered by the survey party in 1932 were large and in excellent condition, and some good catches were made in 1934. It was assumed, therefore, that the yield in this lake would prove to be excellent during the seasons covered by the census. However, only 215 fish were taken from Hemlock Lake in 1935 and only 52 in the next year. Compared with the Lost Lake fishing, this lake was not fished intensively and the yield was much lower. Hemlock Lake yielded one fish per day's angling in 1935 and less than one fish per day's fishing in 1936. Most of the trout were taken in May each year. The anglers took some creek chubs while fishing for trout but these fish are not included in the general data on the fishing as listed in tables 17 and 18 or in the subsequent tables.

Per acre, Hemlock Lake yielded only 8 pounds of trout in 1935 and only 4.3 pounds in 1936. It has been well stocked (perhaps too well) with trout in recent years and, ecologically it seems suited for the fish. Why fishing has been so poor in the last several years has not been explained. Most of the fish caught in 1935 averaged from 7 to 9 inches in length, and were probably most of the 1934 stocking. Fish caught by the writer in this lake in 1934 as well as fish seen by him that season averaged almost 9 inches in length after having been in the lake almost a year. It seems therefore that the fish grew more slowly after the 1934 stocking. The 8-inch group predominated in 1935 whereas the 9 inch group apparently predominated the previous year. The 10 inch group predominated in 1936, suggesting that the 1935 stocking of 5,000 brook trout had been unsuccessful or that these fish had not yet reached a catchable size. The size distribution and the weight of the catch for the two seasons are listed in tables 19 and 20.

Table 17

MONTHLY ANALYSIS OF FISHING ON HEMLOCK LAKE FOR 1935

	May	June	July	Aug.	Total or Average	Per Acre
Number of fisherman-days	123	37	44	8	212	35
Number of fishermen taking no legal trout	72	21	27	4	89	
Number of hours fished	373	116.50	110	22.50	622	104
Number of legal trout taken[1]	143	15	40	17	215	36
Fish per fisherman	1.2	.4	.9	2.1	1.0	
Fish per hour	.38	.13	.36	.78	.35	
Ave. size of legal trout (inches)	8.2	7.7	7.8	8.5	6.1	
Number of undersized trout	277	45	22	0	344	57

[1] Eleven creek chubs were also caught, but are not included in these calculations.

Table 18

MONTHLY ANALYSIS OF FISHING ON HEMLOCK LAKE FOR 1936

	April	May	June	July	Aug.	Sept.	Total or Ave.	Per Acre
Number of fisherman-days	18	37	8	8	1	3	75	12.5
Number of fishermen-taking no fish	12	23	8	6	1	0	50	-
Number of hours fished	62.50	120.50	21.50	16.50	1	19.50	241.50	40.2
Number of legal trout taken[1]	8	29	0	0	0	15	52	8.7
Fish per fisherman	.44	.78	0	0	0	5	.69	-
Fish per hour	.13	.24	0	0	0	.77	.22	-
Ave. size of legal fish (inches)	11.5	10.7	-	-	-	9.9	10.6	-
Number of under-sized fish	-	1	1	0	0	0	21	3.5

[1] A total of 25 creek chubs were also taken but are not included in the data.

Table 19

SIZE DISTRIBUTION AND WEIGHT OF CATCH[1], HEMLOCK LAKE, 1935

Size (inches)	7	7¼	7½	7 3/4	8	8½	9	9½	10
No. (May)	12	1	28	2	40	10	47	2	1
No. (June)	4	3			6		2		
No. (July)	6		15		15		4		
No. (Aug.)					2	15			
No. (total)	22	4	43	2	63	25	53	2	1
Estimated total wt. (lb.)	3.10	.62	7.48	.33	13.29	6.30	15.90	.71	.41

[1] Comments made under Table 7 apply also here.

Table 20

DISTRIBUTION AND WEIGHT OF CATCH[1], HEMLOCK LAKE, 1936

Size (inches)	9	9½	10	11	12	12½	13½
No. (April)	-	-	1	2	5	-	-
No. (May)	1	2	15	5	2	1	3
No. (June)	-	-	-	-	-	-	-
No. (July)	-	-	-	-	-	-	-
No. (Aug.)	-	-	-	-	-	-	-
No. (Sept.)	-	4	11	-	-	-	-
No. Total	1	6	27	6	7	1	3
Total weight (lbs.)	.30	2.13	11.07	3.29	4.93	.81	3.04

[1] Comments made under Table 7 apply also here.

A study of the effectiveness of the several kinds of bait which were used shows that artificial flies and insects were apparently the better baits. Data on the baits used and their effectiveness are included in tables 21 and 22.

Residences of the fishermen in 1935 were not compiled; those who fished the lake in 1936 were from 10 counties in Michigan and one was from New York.

Table 21

EFFECTIVENESS OF BAITS USED, HEMLOCK LAKE, 1935

Bait	No. using bait	No. hours bait used	No. fish caught	Fish per hour	Ave. size of fish
Insects	13	34.50	20	.58	8.1
Art. Fly	12	30.50	9	.30	7.4
Minnows	16	62.75	18	.29	8.1
Worms	122	343.50	122	.33	8.0
Spinner	5	9.25	1	.11	7.5

Table 22

EFFECTIVENESS OF BAITS USED, HEMLOCK LAKE, 1936

Bait	No. using bait	No. hours bait used	No. fish caught	Fish per hour	Ave. size of fish
Art. Fly	3	6	5	.83	10
Minnows	11	40.5	13	.32	10.4
Worms	27	95.5	15	.16	10.9
Plug	1	1	3	3	13.5

Creel Census on South Twin Lake

South Twin Lake was stocked with minnows in the summer of 1935 and with 100 adult rainbow trout in the fall of the same year. From the time of the poisoning of the fish in this lake in September 1934 to the time of this stocking the lake had been without fish.

As shown in Table 23, South Twin Lake yielded 62 trout during the 1936 fishing, it is certain therefore that at least 62 per cent of these fish had survived and it is probable that the actual percentage of survival was much higher.

The trout were caught only in the early part of the season (April and May) and in the last few days of the season (September). The lake yielded only about one fish per five hours of fishing. According to Guy Lincoln, who made the plant, these fish weighed three-fourths of a pound each when stocked.

The lake attracted fishermen from 14 different counties in Michigan and from two states (5 from Ohio, 4 from Indiana).

Table 23

MONTHLY ANALYSISOF FISHING ON SOUTH TWIN LAKE, 1936

	No. fishermen	No. fishermen taking no fish		No. Legal fish[1]	No. hours	Ave. Size	Catch per Hour	No. of fish per fisherman	Hours per fisherman
		No.	%						
April 25-30	28	19	68	26	70.0	13.7	0.4	0.9	2.5
May 1-30	93	73	78	33	287.50	14.0	0.1	0.4	3.1
June 1-3-5-25	8	8	100	-	20.75	-	-	-	2.6
July 4-23	6	6	100	-	10.0	-	-	-	1.7
August 5	1	1	100	-	1.25	-	-	-	1.3
Sept. 6	1	-	-	3	5.0	13.0	0.6	3.0	5.0
Total or ave.	137	107	78	62	394.50	13.3	0.16	0.5	2.9

[1] All rainbow trout.

Creel Census on Pickerel Lake

The census on Pickerel Lake (tables 24 and 25) was doubtless incomplete, as the census taker was chiefly engaged in checking the fishing on the trout lakes, but it is thought that the data are more than half complete for the fishing from the opening day, June 25, until September 7, when the census was discontinued although fishing was legal through the winter. Only 123 fish are recorded as having been caught. These fish were taken at the average rate of 0.7 fish per hour. Yellow perch predominated in the catch. The information, though incomplete, indicates that fishing in Pickerel Lake has been poor and that the yield has been low. It will be determined if possible whether the yield increases considerably after the fertilizing of this lake (see p. 21) has been completed. It is expected that the creel census on Pickerel Lake will be continued and will cover all fishing during the coming season.

Table 24

MONTHLY ANALYSIS OF FISHING ON PICKEREL LAKE, 1936

Date	No. fishermen	No. fishermen taking no fish		No. legal fish[1]	No. hours	Ave. size	No. of fish per fisherman	Catch per hour	Hours per fisherman
		No.	%						
June 25-30	13	3	23	68	53.0	8.1	5.2	1.3	4.1
July	36	20	55	46	91.2	8.6	1.3	0.5	2.5
August	4	3	75	2	15.5	7.0	0.5	0.1	3.9
Sept. 1-7	5	-	-	7	11.0	14.4	1.4	0.6	2.2
Totals or ave.	58	26	45	123	170.7	8.6	2.1	0.7	2.9

Table 25

NUMBER AND AVERAGE SIZE OF FISH TAKEN FROM PICKEREL LAKE, BY SPECIES, 1936

Date	Brook Trout		Yellow perch		Small-mouthed Bass		Bull-heads	
	No.	Ave. size	No.	Ave. size	No.	Ave. Size	No.	Ave. Size
June 25-30	5	9.3	63	8.0	-	-	-	-
July 1-29	5	11.4	38	8.0	1	10.0	2	12.0
August 6-7	-	-	2	7.0	-	-	-	-
Sept. 1-7	7	14.4	-	-	-	-	-	-
Totals or averages	17	11.7	103	7.7	1	10.0	2	12.0

Creel Census on North Twin Lake

No census was taken in 1936 on North Twin Lake, but fishing records for 4 fisherman-days were submitted. The two fishermen (fishing 2 days each) caught a total of 21 brook trout averaging 11 1/2 inches in length and 48 perch averaging 6 1/2 inches in length. These 69 fish were taken in 22 hours of fishing, an average of about 3 fish per hour. The information is too meager to be of much value.

Creel Census on the Pigeon River

Incomplete census figures are available for a section of the Pigeon River from near the Vanderbilt road (south line of Section 17, T. 32 N., R. 1 W.) to the old forest headquarters site (Section 10), a distance of about 2 1/2 miles (straight line distance--much longer actual stream distance). This information is included for comparison with information on the lakes and is shown in the tables below (Tables 26-29).

The information on fishing in the Pigeon River indicates however, that this fishing is not very good. The census covers only primarily the poorest period of the season for trout fishing. It is probable that the fishing was very much better in late April and May, also that it was more intensive at that season. The river is heavily fished and is fished by anglers from a wide variety of communities (tables 28 and 29). It is probable that the river would have been fished even more intensively had not the trout fishing in the other lakes been developed. The largest number of resident anglers were from Wayne County. Non-residents came from seven states and the District of Columbia.

Table 26

MONTHLY ANALYSIS OF FISHING ON THE PIGEON RIVER, 1936

	No. of fisher-men	No. fishermen taking no fish		No. legal fish[1]	No. of hours	Ave. size	No. of fish per fisher-man	Catch per hour	Hours per fisher-man-day
		No.	%						
May	3	-	-	12	9.0	8.3	4.0	1.3	3.0
June	119	78	66	178	430.25	8.5	1.5	0.4	3.6
July	86	51	59	107	259.50	8.5	1.2	0.4	3.0
Aug.	62	38	61	79	189.25	8.4	1.3	0.4	3.1
Sept.	29	11	38	53	89.0	8.2	1.8	0.6	3.1
Totals or averages	299	178	60	429	977.0	8.4	1.4	0.4	3.3

[1] 377 creek chubs also caught--not included

Table 27

NUMBER AND AVERAGE SIZE OF TROUT CAUGHT IN PIGEON RIVER, BY SPECIES, 1936

Date	Brook trout		Rainbow trout	
	Number	Ave. Size	Number	Ave. Size
May 8-17-29	11	8.3	1	9.0
June	166	8.5	12	8.0
July	97	8.6	10	7.7
August	73	8.3	6	8.7
September	41	8.1	12	8.7
Totals or Averages	388	8.4	41	8.4

1- ~~377 creek chubs also caught--not included~~

Table 28

RESIDENCE OF RESIDENT ANGLERS, PIGEON RIVER, 1936

County	May	June	July	August	September 1-7	Total
Wayne	-	54	22	13	13	102
Otsego	2	14	7	4	-	27
Cheboygan	-	2	7	3	-	12
Ingham	-	5	4	3	-	12
Genesee	-	3	2	3	-	8
Gratiot	-	1	3	4	-	8
Kent	-	1	3	2	-	6
Oakland	-	-	3	2	1	6
Oceana	-	2	-	-	4	6
St. Joseph	-	4	-	-	2	6
Emmet	-	2	-	1	2	5
Mecosta	-	4	-	-	1	5
Muskegon	-	5	-	-	-	5
Clare	-	2	-	2	-	4
Kalamazoo	-	3	-	1	-	4
Saginaw	-	2	1	1	-	4
Washtenaw	-	1	3	-	-	4
Branch	-	1	-	2	-	3
Charlevoix	-	2	1	-	-	3
Monroe	-	-	-	1	2	3
Shiawassee	1	-	2	-	-	3
Bay	-	-	-	2	-	2
Berrien	-	1	-	1	-	2
Isabella	-	-	2	-	-	2
Jackson	-	-	2	-	-	2
Macomb	-	-	-	2	-	2
Calhoun	-	-	-	1	-	1
Crawford	-	-	-	1	-	1
Gladwin	-	-	1	-	-	1
Ionia	-	-	-	-	1	1
Midland	-	-	1	-	-	1
Totals	3	109	64	49	26	251

Table 29

RESIDENCE OF OUT-OF-STATE ANGLERS, PIGEON RIVER, 1936

State	May	June	July	August	September	Totals
Ohio	-	2	8	7	1	18
Illinois	-	1	4	-	1	6
Indiana	-	4	4	2	1	11
California	-	1	-	-	-	1
New Jersey	-	-	-	2	-	2
Kansas	-	-	1	-	-	1
Pennsylvania	-	-	1	-	-	1
Dist. Col.	-	-	-	2	-	2
Totals	-	8	18	13	3	42

Discussion of the Fishing

Prior to 1930 the lakes in the Pigeon River State Forest supported almost no angling, but the Pigeon River was more or less heavily fished. The attempt to improve fishing in the lakes was prompted, partially, by the apparent over-fishing of the Pigeon River in that section of the river located in the general vicinity of the lakes. A study of the fishing history of the lakes and the river suggests the following points:

1. The Pigeon River in 1936 provided relatively poor fishing during much of the season. The average catch of 0.4 trout per hour (average length 8.4 inches) was much lower than the average catch per hour for the general area in 1935. According to the 1935 general census (data for 1936 are not yet available) the catch per hour for trout waters in the 9 northern counties of the Lower Peninsula was 0.9 fish per hour--double ~~that~~ the catch for the Pigeon River. A catch of 0.8 fish per hour was reported as average for the entire state. Because of the increased fishing in the Pigeon River State Forest, resulting from the building of better roads in the area, and perhaps from other causes, improvement of the fishing in the lakes is especially desirable.

2. The three lakes on which fishing information for two seasons is available (Lost, West Lost and Hemlock) supported 763 fisherman days

in 1935 and 439 fisherman days in 1936. The other lakes in the area supported relatively little fishing.

3. These three lakes yielded 875 brook trout in 1935 and only 472 brook trout in 1936. These figures probably represent well over 50 per cent of all fish taken from the lakes in the area.

4. The yield of the three lakes declined in 1936 over 1935. Information for each year on the catch, the pounds per acre and the average size of the trout caught, is shown in Table 30. The reason or reasons for the decline in yield have not been determined; a decline in the food supply as a result of the very heavy stocking offers one plausible explanation. Observation fails to indicate however that the forage fish have noticeably declined since the time of the survey (1931-32).

Table 30

TREND IN THE CATCH AND SIZE OF BROOK TROUT TAKEN IN LOST, WEST LOST AND HEMLOCK LAKES in 1935-36.

Lake	Year	Brook trout		Average size (inches)
		Number caught	Pounds per acre	
Lost	1935	461	30.2	8.9
	1936	166	11.8	9.3
West Lost	1935	199	23.5	10.5
	1936	254	22.5	9.4
Hemlock	1935	215	8.0	8.1
	1936	52	4.3	10.6

5. Even though the yield from several of the lakes was relatively good, 58 percent of the fishermen in 1935 and 66 percent in 1936 caught no fish in the three lakes.

6. Trout were generally caught least readily in midseason, at the

time when the tourist and resort trade is at its peak. The yield has probably been greatly increased by having these lakes designated as trout lakes to permit fishing earlier in the season.

7. No one kind of bait was found to be invariably outstanding in effectiveness and the general use of any one bait would probably increase the yield very little if at all.

8. Information on their residence indicates that the anglers came from many communities, near and far. The economic and recreational value of the fishing in these lakes cannot be even roughly estimated, but is probably considerable.

9. Information on one lake containing rainbow trout indicates that this species in lakes is most readily caught early in the season, as is the brook trout in lakes.

10. The census indicates that the attempts at managing the lakes in the Pigeon River State Forest, though incomplete, have decidedly improved the fishing in these lakes.

A STUDY OF THE PERCH POPULATIONS IN THREE LAKES OF THE PIGEON RIVER STATE FOREST

The fish that were removed from three of the lakes in the Pigeon River State Forest, when it became evident that good fishing could not be expected in these lakes without some drastic change in the fish populations or in the fish environment, were collected for laboratory study. Since the populations consisted almost entirely of perch (Perca flavescens), the study centered on this species. The few species other than perch enter into the discussions but were not studied in detail.

The populations which were studied were all taken in September, from South Twin Lake in 1934, from Ford Lake in 1936 and from Section 4 Lake in 1935. All were removed after being poisoned with powdered derris root (5 percent rotenone content). In two lakes the recovery was facilitated by discharging dynamite after the poisoning.

Studies of fish populations have been many and varied but actual studies of total populations seem to have been relatively few. Most notable of recent studies of total fish populations in America are prehaps the studies in Illinois by D. H. Thompson (unpublished) and in Lake Jesse, Nova Scotia, by Smith (1936). In Illinois the populations are being determined by fin clipping; the fish studied by Smith were killed by use of copper sulphate. The lake studied by Smith contained both yellow perch and brook trout, the same two species present in the populations studied by the writer; Lake Jesse, however, contained also a number of other species. The total production of fish in Lake Jesse as determined by Smith was 19.8 pounds per acre.

Biological studies of the American perch have been very numerous but

many of these deal primarily with the food of the species. These food studies are summarized by Adams and Hankinson (1928). Studies of the growth have been made by Harkness (1922) and by Jobes (1933) for perch in Lake Erie, by Hile (1931) for perch in a number of lakes in northern Indiana and by Schneberger (1935) for three lakes in northern Wisconsin. Greeley (1936) has given data on the growth of perch from a number of lakes in New York, but his material from any one lake is insufficient to yield a reliable growth curve. None of these authors studied any entire populations; their studies were generally limited to at most a few hundred fish from any one water.

A number of life history studies have also been made of the closely related European species Perca fluviatilis. Most noteworthy of these investigations, in so far as comparison with the studies on the perch of the lakes in Pigeon River Forest is concerned, are perhaps the studies of Jarnefelt (1921) in Tuusulasee, Finland, and the work of Huitfeldt-Kaas (1927) in Norway. Jarnefelt found the older age groups to be all females but failed to find an appreciable difference in the growth rate of the sexes. He found decided differences between the rate of growth of perch from different waters. Huitfeldt-Kaas found that the females grew somewhat more rapidly than the males and that they grew to a much lager size. He found that in the older year-classes females predominated and that, in the oldest year-classes, all perch were females. On the other hand, he found that the males not infrequently appear to be the more numerous in the youngest year-classes. The writer's findings on Perca flavescens agree with those of Huitfeldt-Kaas for Perca fluviatilis.

The writer does not agree with Huitfeldt-Kaas, however, in attributing

the apparent differences in age of the two sexes as shown by a study of the scales to the cessation of the growth of the males at a limited size and their consequent failure to form annuli. A more plausible explanation is that the males actually die sooner than females (as in other forms, humans included), on account of the greater visbility of the females (Geiser, 1924).

The inventory of about 160 lakes in Michigan, and other studies, indicate that populations of stunted perch are common. The stunting in growth is at least usually associated with an abundant population. It has been noted that predators are usually few where stunted perch are especially abundant. Perch are generally associated with the predacious northern pike, which under normal conditions especially are prehaps able to hold the perch in check. There is evidence, from reports for Otsego Lake and from the unpublished creel census of Houghton Lake, that a decline in the catch of pike tends to be associated with an upward trend in the catch of perch.

The three populations from the Pigeon River Forest Lakes were studied separately and are discussed separately on the following pages.

The Perch Population of South Twin Lake

Because the stocking of trout in South Twin Lake was found to be relatively unsuccessful it was decided to make an effort to remove all fish in this lake by poisoning with derris root, and to restock later with trout. The poisoning was resorted to because of the unsuccessful efforts to materially reduce the perch population by setting gill-nets of seven mesh sizes varying from $1\frac{1}{4}$ to 4 inches stretched measure, in this lake for several days, a few weeks prior to the poisoning and by discharging five sticks of dynamite. The perch obtained by gill-net and dynamite were placed in one lot (lot 4 of this study).

On the morning of September 20, 1934, an Institute party consisting of Milton B. Trautman and the writer distributed about 48 pounds of powdered derris root (5% rotenone content) over the surface of the lake. Most of the poison was spread by pouring an aqueous misture of the poison in the wake of an outboard motor; the remainder was broadcast by hand. About 8 hours after the poision was distributed, 100 sticks of 40% dynamite were discharded in deep water (in three lots of approximately 25, 25 and 50 sticks), with the primary purpose of assuring a thorough circulation of the poision throughout the lake.

The poision had killed a considerable number of fish before the dynamite was discharged. Many of these perch were collected and are included here as lot 1. Lot 2 was collected on the same day but after the dynamiting. Lot 3 was collected on the following day. Most of the fish which floated, or which sank in shallow water, were recovered. To check the effectiveness of the poison and dynamite, a gill-net with the same mesh sizes as the one previously used was set in the lake overnight several weeks later. Although this net took no fish, a live perch was seen at the time the net was lifted. Not all of the perch were killed, but the population seems to have been effectively destroyed, because further gill-netting in 1936 yielded no perch, and none were caught since the poisoning in this lake, on which a creel census was conducted.

All studies of the perch were made from preserved specimens.

All perch in all four lots were preserved in 10% formaldehyde and were later transferred to 70% alcohol. In addition to the perch, a few trout were taken by netting and two were recovered after poisoning. No other species were taken or are known to have been present. Data concerning the trout are not included in this study.

The entire population was probably not collected for study, because some fish presumably died on the bottom in situations from which they could not rise after decomposition had begun. The fish tended to come to the surface, when dying, and wave action tended to wash the dead fish toward the shore region where they continued to float, or sank in the shallow water. Most of the fish that sank in deeper water later rose to the surface. Although a precise estimate of the percentage of the total population recovered is not possible, it is believed that a relatively large percentage, much more than half of the population was collected.

The purpose of this study is to describe some of the characteristics of this population of stunted perch, based on the collection obtained by the several methods indicated above.

Total Population

The four lots comprised a total of 3,615 perch. In addition, 503 perch were counted lying on the bottom after the last lot had been recovered. A total of 4118 fish are therefore definitely known to have been present in the lake. This number represents 955 perch per acre. The total population was probably about 1,000 fish per acre.

The 3,615 perch had a total weight of 109.3 pounds (49,591 grams). This represents a weight of 25.4 pounds per acre. If the 503 perch which were seen but not collected were of the same average weight they represented a total of 15.2 pounds, increasing the total weight per acre to about 29 pounds. The weight of the entire population was probably about 30 pounds per acre.

Size and Age Distribution

Weight, length and age were determined for all specimens. Both standard

and total lengths were recorded to the nearest millimeter. The fish were weighed on a Welch balance graduated to tenths of grams. The small fish were weighed in groups of 2 to 90 fish but all fish older than the II group were weighed individually. The length distribution irrespective of age or sex is shown in Table 31, in which the measurements are grouped by 10 millimeter intervals. The pronounced mode at 80-89 mm. suggests that most of the fish probably belonged to one age group. Another mode at 110-119mm. suggests the presence of another age category, which proves to consist of several age groups.

Table 31

SIZE DISTRIBUTION OF ALL PERCH, SEXES COMBINED, BY 10 MM. CLASSES (STANDARD LENGTH)

Size Class	Number	Per cent of Total
50-59	3	0.1
60-69	0	0.0
70-79	144	4.0
80-89	2270	62.8
90-99	345	9.5
100-109	112	3.1
110-119	357	9.9
120-129	222	6.1
130-139	93	2.5
140-149	32	0.9
150-159	18	0.5
160-169	7	0.2
170-179	3	0.1
180-189	3	0.1
190-199	0	0.0
200-209	0	0.0
210-219	2	0.1
260-269	1	0.0
270-279	1	0.0
280-289	1	0.0
290-299	1	0.0
Total	3615	99.9

Ages were determined for all of the 3615 fish from an examination of the scales under a binocular microscope. The annuli were readily identified in the young fish (I and II groups) but were difficult to find in the scales from some of the older fish, especially in those from individuals in poor condition, since many of these emaciated individuals had apparently partially resorbed portions of their scales. For some specimens a large number of scales had to be examined before the age could be determined with any degree of certainty. Even though the scales were studied carefully, it is possible that the age determinations on some of the older fish were incorrect.

The number of the perch in each age group is shown in Table 32. The ages indicate the number of winter marks (annuli). Since most of the fish were taken on September, the fish were actually almost of not quite one growing season older than the recorded ages.

Over three-fourths (76.7%) of the fish were in one age group (II). There were more fish in the III and IV groups than in the 0 and I groups. The only age group represented by a definite mode in the length distribution is the II group.

In general, after the second year the females grew more rapidly than the males. In the I group the males were, on the average, longer and heavier than the females. In the II group the sexes were of about equal average length and weight and in all groups older than II the females were decidedly the longer and heavier. A few of the female perch reached an exceptionally large size. The single perch doubtfully of the VI group weighed more than 45 average perch in the I group and almost as much as 18 average sized male perch from the oldest group of males (IV). In his study of perch in three northern Wisconsin Lakes, Schneberger (1935)

found that the females grew much faster than the males in Silver Lake, the lake with the slowest growing population. This is in accord with data for South Twin Lake perch. In the two Wisconsin lakes (Weber Lake and Nebish Lake) where the fish grew more rapidly, the difference in growth rate of the two sexes was much less pronounced.

Table 32

NUMBER OF FEMALE AND MALE PERCH IN EACH AGE GROUP, AND AVERAGE LENGTH AND WEIGHT OF FISH IN EACH GROUP

Age group	0	I	II	III	IV	V	VI?	Over VI
Females (1530)								
Lot 1	2	27	607	24	66	13	...	2
Lot 2	...	...	284	4	31	3	...	...
Lot 3	...	...	320	6	31	2	1	...
Lot 4	...	1	27	65	13	...	...	1
Total	2	28	1238	99	141	18	1	3
Males (2085)								
Lot 1	1	45	638	132	11	...	...	...
Lot 2	...	3	497	59	32	...	...	...
Lot 3	...	10	361	108	42	...	...	...
Lot 4	...	13	40	84	9	...	...	...
Total	1	71	1536	383	94	...	...	...
Total (both sexes)	3	99	2774	482	235	18	1	3
Percent of total coll.	0.1	2.7	76.7	13.3	6.5	0.5	0.0	.1
Average Standard length in mm.								
Females	44	80.4	87.1	125.0	134.2	169.1	274.0	282.0
Males	43	89.0[1]	84.4	116.0	121.1	...	...	...
Average weight in grams								
Females	2.7	7.7	9.6	30.2	35.3	76.5	445.3	443.3
Males	2.7	11.3[1]	9.7	21.7	25.0	...	...	...
Average (app.) Total length in inches								
Females	2.1	3.8	4.1	5.9	6.3	7.88	12.49	13.83
Males	2.0	4.2	4.0	5.5	5.7	...	...	...
Average weight in ounces								
Females	.09	.27	.34	1.07	1.25	2.70	15.73	15.65
Males	.09	.40	.37	.77	.89	...	...	...

[1] A number of the males in the I group showed exceptionally rapid growth compared with the older fish and with other members of the same age group.

A number of the males in the I group showed exceptionally rapid growth compared with the older fish and with other members of the same age group.

The perch of the dominant group (II) averaged only slightly over four inches in total length, and only a little over a third of an ounce in weight.

Some of the males in the I group grew very rapidly, compared with the other fish of the same age and sex. This rapid growth of a few individuals raised decidedly the average length and weight for this group. Such unusual growth was evident also in a few perch of the II group but was not observed in the older fish. Schneberger (1935) noted a similar rapid growth in some of the young perch of Wisconsin lakes. He stated that, "In the younger fish (age-groups II and III) cases are found where the annulus is far from the focus, indicating an extremely rapid growth. However, this type is rarely found in the older fish, suggesting that the rapid growers are shorter-lived."

The approximate number and percentage of legal-sized fish in the South Twin Lake perch population was determined. Since all the perch were measured after they were preserved, it is impossible to determine exactly the number of fish of a given length because the amount of shrinkage is not known. However an approximate correction for shrinkage following preservation was obtained through the application of the shrinkage factor, 1.016, determined by Van Oosten (1928) for the lake herring. The legal length for perch in Michigan is 6 inches (152.4 mm.). This figure divided by the shrinkage factor equals 150 mm. Accordingly all perch with a length of 150 mm. or more (after preservation) are here considered to have been

of legal length. The number of perch 150 mm. or more in length, by age and sex, and the percentge of the fish of each category that were of legal size are shown in Table 33.

Table 33.

NUMBER, AGE AND SEX OF ALL LEGAL-SIZED PERCH OF SOUTH TWIN LAKES

Fish 150 mm. or more in total length when preserved are regarded as having been of legal size. No fish of the 0 or I groups were that large.

Age group	II		III		IV		V	VI?	VI
Sex	Male	Female	Male	Female	Male	Female	Fem.	Fem.	Fem.
No. of fish of legal size	4	1	31	50	19	128	18	1	3
Percent of all fish in age group	0.3	8.1	50.1	20.2	69.4	100	100	100	100

If the allowance for shrinkage was correct, 7 percent of all the fish collected, or approximately 60 fish per acre, were of legal length. Of the males only 2.6 percent were that large; of the females, 13 percent were of legal size. The ratio of legal females to legal males was approximately 4 to 1 (199 to 54). Since some of these fish had very large heads and were in poor condition, and since some were parasitized rather heavily, the percentage of desirable legal-sized fish in the total population was very small, certainly less than 5 percent.

The perch of South Twin Lake grew much more slowly than those of any other lake for which the growth of this species has been determined (Table 34). The slow growth in South Twin Lake contrasts strikingly with the growth of perch in Lake Erie, as determined by Jobes. In Lake Erie the perch had attained an average size in the II group greater than that of the South Twin

Lake perch in the V group.

Table 34

AVERAGE STANDARD LENGTH IN MILLIMETERS OF PERCH IN VARIOUS AGE GROUPS FROM SEVERAL LAKES, ALL COLLECTED IN SUMMER OR FALL.

Investigator and year of publication	Lake	Age Group I	II	III	IV	V
Eschmeyer	South Twin, Mich.	87	86	118	129	169
Harkness (1922)	Lake Erie	...	144	168	187	217
Hile (1931) [1]	Wawasee, Ind.	86	129	167	198	220
Jobes (1933) [2]	Lake Erie	161	178	198	213	250
Schneberger (1933) [3]	Nebish, Wis.	124	157	173	209	245
Schneberger (1935) [4]	Weber, Wis.	...	130	158	174	191
Schneberger (1935) [5]	Silver, Wis.	...	109	120	145	173

1/ Data for 1926, '27, '28 combined.

2/ Data for 1927 and 1928 combined.

3/ Data for 1930, '31, '32 combined.

4/ Data for 1928, '30, '31, '32 combined.

5/ Data for 1928, '30, '31 combined.

Sex Ratio

For the entire population the sex ratio was 74 females per 100 males, a ratio of approximately 3 to 4. The ratios for the different lots were:

Lot 1. (1568 fish). 89 females per 100 males.
Lot 2. (913 fish). 54 females per 100 males.
Lot 3. (881 fish). 69 females per 100 males.
Lot 4. (253 fish). 74 females per 100 males.

The ratios vary considerably from one lot to another. Incidentally lot 4 the smallest lot, showed a proportion of females to males identical with the proportion of the two sexes for all lots conbined. It is possible that the poisoning was selective for sex, because of differential susceptibility or more likely of different habitat selection. The females, like those of Ford Lake (p.117), may well have been schooling separately and in the

shallow water, so that they were first affected by the poison. The data suggest that apparently random samples of a perch population may be inadequate for the determination of a reliable sex ratio.

In this slow-growing population of perch, the larger fish were predominately females. All fish with five or more annuli were females. In the IV group the females predominate, but in the I, II and III groups the males were decidedly the more abundant. Apparently the females had a considerably longer life span than the males, a condition which is common among fishes and among many other forms of animal life as well. Geiser (1924) held that females are inherently better fitted than males to survive adverse environmental conditions. Schneberger (1935) found the large perch to be predominately females in two of the three Wisconsin populations examined by him. Three of the four populations of cisco (Leucichthys artedi) of northern Wisconsin lakes studied by Hile (1936) showed a preponderance of females. Hile stated further that "with the exception of the irregular data on Silver Lake the females tend to become relatively more abundant as age increases."

These observations strongly suggest that age composition should be given consideration in determining sex ratios. Had gill-nets been used to obtain the sample in South Twin Lake most of the young fish would not have been captured and females would have been found relatively the more abundant. The scarity of young fish in Schneberger's samples of perch from Wisconsin lakes probably accounts for the disagreement between his data on the sex ratio in the species and those obtained for South Twin Lake. Schneberger, using specimens caught by gill-nets and hook, found the ratio of females to males to be 100:126 in Nebish Lake, 100:76 in Weber

Lake and 100:71 in Silver Lake. The conclusions were based on 355, 407 and 392 fish respectively. Silver Lake, with the greatest concentration of perch and with the slowest growing perch had the greatest proportion of females (58% females). It is probable that he would have found decidedly different sex ratios had he been able to obtain a representative number of the smaller fish, which no doubt largely escaped his nets and hooks. The fact that the perch in South Twin Lake were dominately young fish (primarily the II group) certainly had a bearing on the sex ratio found for the fish in that lake, and on the disagreement between our findings and his.

Condition of Perch[1]

The coefficient of condition (K), an index of relative heaviness, was determined for individual fish. The formula $\frac{K.W \times 10^5}{3}$, was used, where W = weight in grams and L = standard length in millimeters.

Since all of the perch in the age groups 0, I and II were not weighed individually, the values of K for fish in these age groups are only approximate. The values of K were calculated individually for all older fish than those of group II. Table 35 shows the value of K for each age group.

Table 35

AVERAGE VALUE OF K FOR PERCH IN EACH AGE GROUP[1]

Age group[2]	I	II	III	IV	V	VI?	Over VI
Females	1.49	1.46	1.51	1.42	1.46	2.17	1.97
Males	1.49	1.51	1.41	1.41	....	....	....
Both Sexes	1.49	1.49	1.43	1.42	1.46	2.17	1.97

[1] Number of perch in each group shown in Table 32.
[2] 0 group not included in this table.

The values of K were identical for the males and females in the I group.

[1] Discussions of coefficient of condition and length-weight relationship are found in papers by Hile (1936) and others.

In the II group the males were in slightly the better condition but in the groups older than II the condition of the females was better than that of the males. The fish as a whole were in poorest condition in the III and IV groups.

The distributions of the individual values of K were determined for each sex in each age group older than II. Without presentation of the extensive tabular material it may be stated that for most groups the distribution is approximately that of a normal curve. In the population as a whole, the condition varies over a wide range--from a minimum of less than 1.0 to a maximum of over 2.0.

A comparison of conditions in the South Twin Lake perch with that of perch in other waters as determined by Schneberger and Hile is presented in Table 36. The fish from all the lakes were collected in summer or fall. It will be noted that, with the exception of the II group in Weber Lake, the condition of perch from South Twin Lake was poorer than that in the other four lakes. In making comparisons of the K values for South Twin Lake perch with those of other populations, it should be remembered that all the perch from South Twin Lake were weighed after preservation. There is a strong possibility that the Twin Lake perch may have lost weight on preservation and that the recorded values found for K consequently may be too low. That fish do lose weight on preservation is indicated by the observations of Hile (1936) , who found the shrinkage factor for weight of cisco in one lake (Muskellunge) to be 1.181, in another lake (Clear) to be 1.144.

Table 36

COEFFICIENT OF CONDITION OF PERCH IN SOUTH TWIN LAKE,

IN THREE WISCONSIN LAKES,

AND IN ONE INDIANA LAKE

Investigator	Lake	Age Group I	II	III	IV	V
Bschmeyer	South Twin	1.49	1.49	1.43	1.42	1.46
Hile[1]	Wawasee, Ind.	1.51	1.63	1.60	1.77	1.70
Schneberger[2]	Nebish, Wis.	1.67	1.64	1.63	1.72	1.75
Schneberger[2]	Weber, Wis.	1.65	1.44	1.54	1.61	1.65
Schneberger[2]	Silver, Wis.	....	1.57	1.60	1.61	1.65

[1] Data for 1926, '27, '28 and '29 combined.
[2] Data for 1930, '31 and '32 combined.

Head Length

Repeated observations of systematists suggest that, in normally growing fishes, the head grows more slowly, in proportion, than the body. In the stunted perch of South Twin Lake, however, the head generally grew more rapidly, in proportion, than the body (Table 37).

The South Twin Lake perch appear to be further unusual in the possession of a head relatively much larger than that ordinarily recorded for the species. Jordan (1929) stated that the length of the head of perch is contained 3 $\frac{1}{4}$ times in the standard length. In the perch in South Twin Lake the head measures about 2.9 times in the standard length.

There seems to be some correlation between the coefficient of condition and the length of the head (see Table 37). In general, the fish of this slow growing population in poor condition have relatively the larger heads.

Table 37

LENGTH OF HEAD, MEASURED INTO STANDARD LENGTH, IN PERCH FROM SOUTH TWIN LAKE, COMPARED WITH COEFFICIENT OF CONDITION (K).

Age group	I	II	III	IV	V	VI?	Over VI
Females							
Number	1	28	76	78	18	1	3
K	1.49	1.46	1.51	1.42	1.46	2.17	1.97
Length of Head	3.20	3.09	2.84	2.86	2.96	2.96	3.06
Males							
Number	13	42	121	5			
K	1.49	1.51	1.41	1.41			
Length of Head	3.11	3.10	2.90	2.78			

Because of the relatively large heads in this slow growing population, it was considered possible that the slow growth itself might be responsible for these large heads. If ~~these~~ this were true, the most rapidly growing fish of an age group might be expected to have the smallest heads. However, a study of the head length for 128 specimens of the III group (see below) indicates that the head length differs little with differences in growth. The average sizes of heads for fish of different lengths are:

Group Interval	Number of Specimens	Proportionate Length of Head
105 - 109 mm.	6	2.90
110 - 114 mm.	33	2.87
115 - 119 mm.	67	2.86
120 - 124 mm.	25	2.85
125 - 129 mm.	10	2.88
130 - 134 mm.	7	3.11
135 - 139 mm.	2	2.93
140 - 144 mm.	3	2.97

Food

No study was made of the abundance of food organisms in the lake but the stomach contents of a number of perch were examined. A considerable proportion of the larger perch contained smaller perch, most of which were undigested. They may not normally have been cannibalistic, for it is probable that the smaller perch, incapacitated by the poison before the large fish were affected,

were in consequence easily captured by the large individuals. No doubt, however, the small perch do serve as an important food item for the large individuals. It is possible that the excellent condition of the larger females (part of the IV group and all older than IV) is attributable to the fact that they had survived and grown to a size large enough to permit them to prey upon the abundant supply of perch of the II group.

A stomach analysis of 34 perch of the I group indicates that insect larvae and nymphs and small crustaceans constituted almost the entire food supply. Chironomids and Cladocera were the most common organisms. The insects included also other Diptera than Chironomidae, Ephemerida, Trichoptera, Coleoptera and Odonata. The stomachs generally contained relatively little food but only one of the 34 was completely empty. The individual stomachs contained either insects ~~of~~ or crustaceans; none were found to contain both forms.

Analysis of stomachs of 50 specimens of the II group showed that the food eaten by this group was essentially the same as that consumed by the fish of the I group, except that a greater proportion of the stomachs contained crustaceans. The insects eaten were chiefly immature Diptera and Ephemerida; a few Trichoptera were also eaten. The Crustacea were mostly Cladocera.

Stomachs of 40 fish of the III group were examined. The bulk of the food consisted of the larvae and nymphs of Diptera, predominantly Chironomidae and Corethra. Small snails and small clams were eaten to a limited extent, along with leeches, algae, Trichoptera, Hemiptera and ~~Hyzenoptera~~ Hymenoptera. Six of the stomachs were empty.

The food in the stomachs of 40 fish in the IV group was essentially similar to that eaten by the specimens of the III group. The most important items were Diptera, chiefly Corethra. Snails, clams, Odonata, Orthoptera,

Coleoptera, Ephemerida, Trichoptera, leeches and crayfish were taken in very limited quantities.

If the population is considered as a whole, it may be stated that at the time the perch were taken, Diptera constituted the chief food supply with Chironomids and Corethera apparently constituting the bulk of the food. In general the stomachs were relatively very small and contained little food. However, only 13 of the 164 stomachs were entirely empty. A scarcity of satisfactory food organisms for perch of intermediate size probably accounts for the slow growth and poor condition of the fish in this lake.

Perch Cycle

There is some reason to believe, although the evidence is not conclusive, that a definite cycle with respect to age and size composition of the stock normally occurred in the population. When the fish were killed the 0 and I groups were very poorly represented, and more than three-fourths were of the II group. It is possible that, because of the paucity of available food, the perch of the II group subsisted on the young when these were available. Had the fish not been poisoned most of the II group would possibly have died of starvation in the following year, although enough adult fish would probably have survived to assure adequate reproduction. With most of the predators removed by starvation (as indicated below), a large crop of young fish would possibly again have resulted. In such a cycle one age group would be very abundant, would keep down the following two age groups by eating the young, would die of starvation in its third year, and in dying, would make possible the survival of another group. The dominant age group of perch in South Twin Lake for successive years would then have been:

II, 0, I, II, 0, I, II, 0, I, II, provided the cycle was uniform. The dominant group would consistently have been under legal size (6 inches). Mr. William Horsell, Superintendent of the Pigeon River State Forest, wrote that in the eleven years prior to 1935 the perch in S outh Twin Lake had always been small, six inches or less in length.

Starvation

A number of factors suggest that a majority of the fish may have ordinarily died of starvation. Few fish other than young ones were normally removed by man or by predators since the lake was fished very little and predators large enough to take the larger fish were absent. Factors already mentioned which might suggest starvation of a considerable portion of the population are: (1) a decrease in condition in the III and IV group combined, (2) the poor condition of the population in general, (3) an unusually large head, especially in the groups in poorest condition, (4) small size of the food organisms in the stomachs, a fact that suggests an apparent scarcity of organisms of a size intermediate between Diptera and small perch (II group), (5) small amount of food in the stomachs, (6) apparent resorption of portions of the scales in many of the thinner individuals, (7) unusually large proportion of relatively young fish (II group) in the population, despite the fact that cannibalism was probably relatively common. In the emaciated individuals the gonads were relatively very small. Although it cannot be proven definitely that many of the fish normally died of starvation, and although none of the items mentioned above in itself proves starvation, the evidence, considered as a whole, strongly suggests that starvation was responsible for an early mortality and consequently for the observed scarcity of old fish.

Summary

Gill nets, poison and dynamite were employed to reduce in numbers and if possible to exterminate completely the perch population of South Twin Lake (Otsego County). Those perch which floated or which sank in shallow water were recovered and studied. The study showed that: (1) a total of at least 955 perch per acre, weighing 29 pounds per acre, were present; (2) seven per cent were legal fish (54 males, 199 females); (3) the fish grew quite slowly; (4) over three-fourths of those recovered belonged to age group II; (5) the proportion of females to males in the entire population was 74 to 100; (6) the young fish were dominatly males, the older ones dominantly females; (7) all fish over four winters old were females; (8) in general the fish were in poor condition; (9) they had unusually large heads; (10) the fish varied widely in condition; (11) Diptera constituted the primary food item of the fish; (12) there was possibly a definite cycle with the dominant age-group always of less than legal size; (13) there is some evidence to suggest that most of the fish normally died of starvation after their third summer.

The Perch Population of Ford Lake

Ford Lake was fished heavily with gill-nets in 1934 to reduce the population of fish present, because it was hoped that, with a decided reduction in the population, the fish might grow more rapidly and might reach a larger size. Because this action met with indifferent success, it was decided to remove the existing population by poisoning and dynamiting, and this was done in September, 1936. The fish obtained each year were studied.

Because the water level had lowered considerably since the time of the 1932 survey, Ford Lake was resurveyed late in 1936 by Mr. J. B. Schwerdt, Project Superintendent of Camp Vanderbilt. The area of 10.86 acres as determined by this survey was used in calculating the number and weight of fish per acre.

Fish Taken in 1934

A total of 1,137 perch and 15 brook trout were taken in two experimental gill-nets[1] fished continuously over the period from July 23 to July 30, 1934. The trout were not preserved or measured, but their average total length was estimated to be 6 to 7 inches. Some of the perch were discarded, but a random sample of 602 specimens was preserved in a 10% solution of formalin.

Sex determinations were made of all the preserved fish. Determinations of weight, length and age were made for a random sample of 100 individuals. The average standard length and average total length in millimeters, the average weight in grams and the average coefficient of condition (K)[2] of each age group in each sex are shown in Table 38.

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[1] The sizes of mesh (stretched measure) in each net varied from $\frac{1}{4}$ to 4 inches.

[2] See page 76a .

Table 38

THE CHARACTERISTICS OF THE PERCH POPULATION OF FORD LAKE

The average standard length in millimeters, average total length in inches, the average weight in grams, and average coefficient of condition (K) are given for a random sample of male and female perch of different ages, all taken by gill-nets in July, 1934

	Age Group	No. of Specimens	Av. Standard length (mm.)	Av. total length (inches)	Av. Wt. (grams)	Av. K
	II	19	113	5.3	24	1.67
Females	III	27	115	5.4	26	1.68
	IV	7	123	5.6	31	1.65
Total or Average		53	115	5.4	26	1.67
	I	1	108	5.2	22	1.75
Males	II	19	110	5.2	23	1.70
	III	27	111	5.2	22	1.62
Total or Average		47	111	5.2	22	1.65

If the 100 specimens constituted a representative sample of all the perch taken in the gill-nets, the following conclusions may be made regarding the perch population of Ford Lake as it existed in 1934:

Sex: The two sexes were about equally represented, of the 602 specimens, 298 were females, 304 were males.

Growth: The females grew more rapidly than the males. In all age groups with the possible exception of group I, the fish of both sexes had a very slow growth (see Table 39)[2] . The growth zones of the scales of all age

[2] See p. 94.

groups indicated that growth was moderately good during the first year and generally during the second year. After the second year the annual growth increments were small. It is probable that this change in growth resulted from a lack of food of a size suitable for larger perch.

Weight: The perch had an average weight of 24 grams or slightly less than one ounce (entire sample of 100 fish).

Condition: Despite their slow growth, the perch were in relatively good condition. In general condition differed little with either sex or age.

Length of Life: The sample suggests that the females tend to live longer than the males. Seven of the 53 females were of the IV group, but the oldest of the males were the III-group fish. This sex difference in longevity is in accord with findings of other studies of perch.

Total Weight of Sample: If the average weight of these perch was assumed to be 24 grams, the number removed (1,137) had a total weight of 27,288 grams (60.2pounds) or a weight per acre of 2,560 grams (5.6 pounds).

The ratio of trout to perch in 1934 (15:1137) was approximately 1:76. The removal of the fish in 1936 indicated a total population of approximately 5,000 perch at that time. If about the same number were present in 1933, the ratio of trout to perch immediately after the planting of 500 trout in 1933 was about 1:10. Apparently the number of trout in the population had declined very materially between 1933 and 1934, unless the difference in the two ratios (1:76 and 1:10) was due to net selectivity.

Gill-nets were fished in 1934 in an effort to reduce the population since there appeared to be a scarcity of food for the number of perch present, especially food of intermediate or large size (minnows). The perch removed in 1934 represented approximately 24% of the perch recovered in 1936. It was impossible to determine what percentage of the fish present in 1934

had been removed.

Not only was the food per fish increased by the removal of some of the perch, but a total of about 15,500 forage fish was planted in July, 1934, These fish were taken from a small stream where it had been impounded by beaver. Most of them were northern dace (Chrosomus eos), although limited numbers of fathead minnows (Pimiphales promelas), sticklebacks (Eucalia inconstans), mud minnows (Umbra limi) and perhaps a few fish of other species were also included.

Fish Taken in 1936

On the morning of September 9, 1936, Mr. W. F. Carbine and the writer, assisted by men from Camp Vanderbilt, poisoned the waters of Ford Lake with 200 pounds of powdered derris root (5% retenone content). On the afternoon of the same day recovery of the dead fish was facilitated by discharging 500 sticks of dynamite in the water (Figs. 7 and 8). The fish began to die within about an hour after the poisoning. The collection of these dead fish was started immediately and was continued for three days. All fish seen were collected, except 183 perch found on the third day along the shore, in semi-decomposed condition.

It is probable that all of the fish were killed, and it is also probable that almost all of the perch were either collected or counted. In two other lakes where weaker concentrations of derris root had been used, the entire perch population had apparently been destroyed. Nets set in these lakes in 1936 failed to produce fish. How many dead fish remained in deep water in Ford Lake is not known, but over that part of the bottom which could be seen from a boat (about a third of the entire bottom) no dead perch were seen three days after the poisoning, other than the 183 specimens mentioned above. The evidence, therefore, though not conclusive, suggests that all fish were

killed and that almost all of the perch were definitely accounted for.

Total Fish Population

Of the perch collected, 3,762 ~~was~~ were preserved in a 10 percent solution of formalin and 1,055 were discarded. At least 4,817 perch are therefore definitely known to have been present. Computations based on the average weight of 1,050 specimens taken at random give an estimated weight of 347 pounds for the total perch population, or about 33 pounds per acre.

A total of 24 rainbow trout and 1 brown trout were preserved and 2 trout (partially decomposed) were discarded. These trout had a combined weight of 7 pounds (provided the 2 trout discarded were of average weight).

Dead minnows lined the shore, especially along the wave swept side. On two representative 10 foot sections of shoreline, the dead minnows were counted by Dr. A. S. Hazzard and Mr. Carbine. According to the counts made, the lake shore contained 15.3 minnows per linear foot of shore line. Since it has an area of 10.66 acres and is nearly circular, Ford Lake had a shoreline of approximately 2400 feet. The lake therefore contained approximately 36,700 minnows. Weight determinations of 61 minnows gave an average weight of about 2 grams. The minnows, therefore, weighed approximately 73,400 grams or 162 pounds. The weight of minnows per acre was about 15 pounds.

The total fish population of Ford Lake in 1936 therefore weighed about 516 pounds, or about 50 pounds of fish per acre.

The first important evidence obtained from the collections was that the plantings of trout in Ford Lake were not very successful. A total of 8,000 trout had been planted since 1933, but only 28 were recovered in 1936 (and 15 in 1934). Relatively few had been removed by fishermen. Some of the trout may have remained on the bottom at the time of the poisoning, but

it seems safe to conclude that the survival from trout plantings in the lake was very poor. The few trout which were recovered were in relatively poor condition. At the time the minnows were stocked (in 1934), it was not expected that any of the species would become established because of the apparently unfavorable balance between fish and food. It was assumed the the minnows would soon be eaten by the perch. The minnows did serve as a food item for the perch, but apparently enough survived for them to become definitely established. All species except sticklebacks known to have been stocked in 1934 were found in 1936. The number of minnows had apparently doubled in the two years.

The large number of perch in the collection made the use of samples advisable. Sex dterminations were made for all of the 3,762 preserved perch, but the data on length and weight are based on three samples of 350 fish each, taken at random. The close similarity of the data obtained from each of these three samples (Table 39 and Graphs 1 and 2) demonstrates that the results obtained from their combination (1,050 fish) may be considered representative for the entire population. In further discussions of lenght and weight it is assumed that the averages for the 3 samples (845 males and 205 females) represent the averages of the entire population. The error which might be involved in using these samples rather than the entire populations is obviously small.

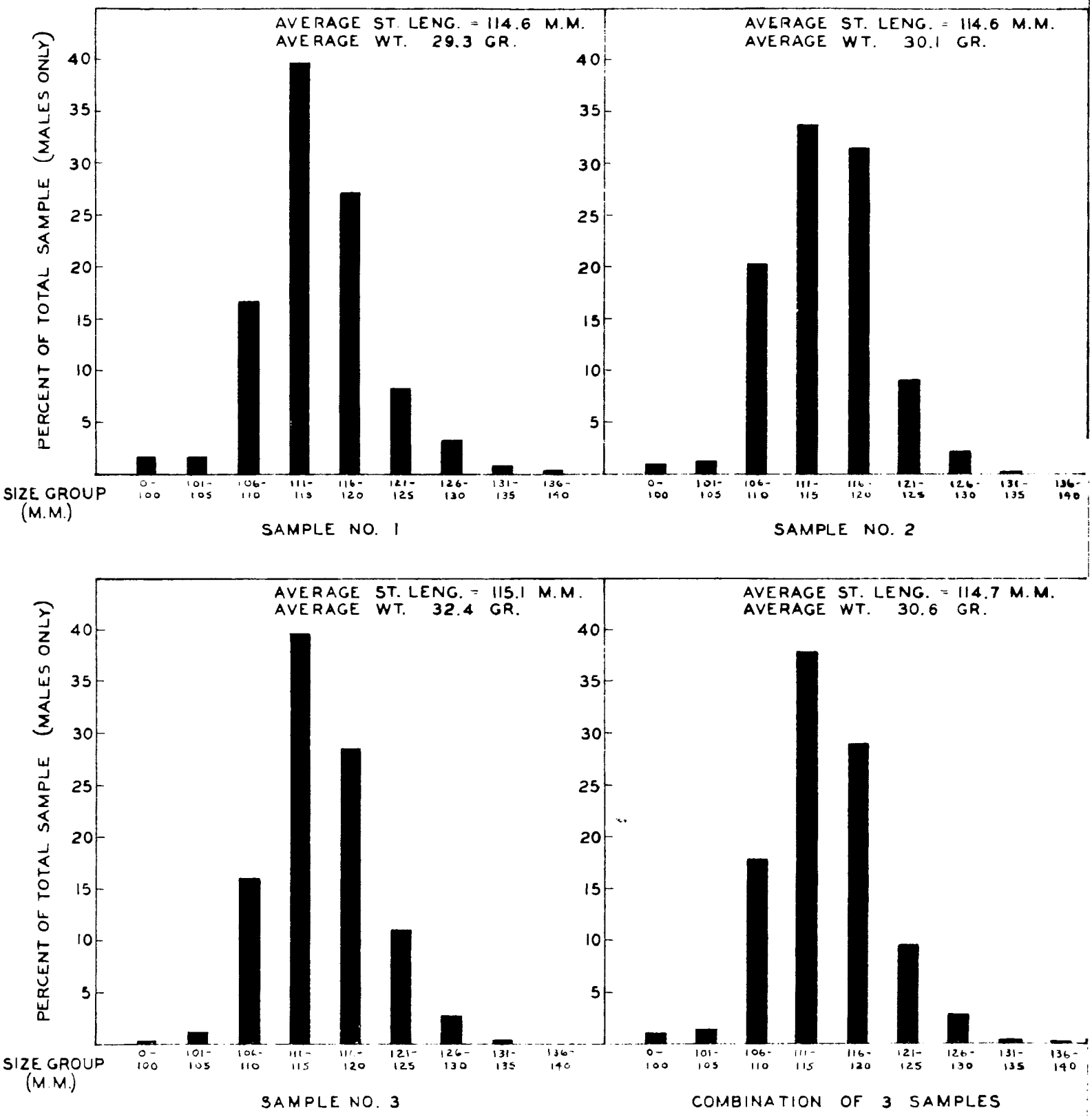

Fig. 2. Size distribution of the males in three lots of perch taken at random and size distribution of the males in the 3 lots combined (845 males).

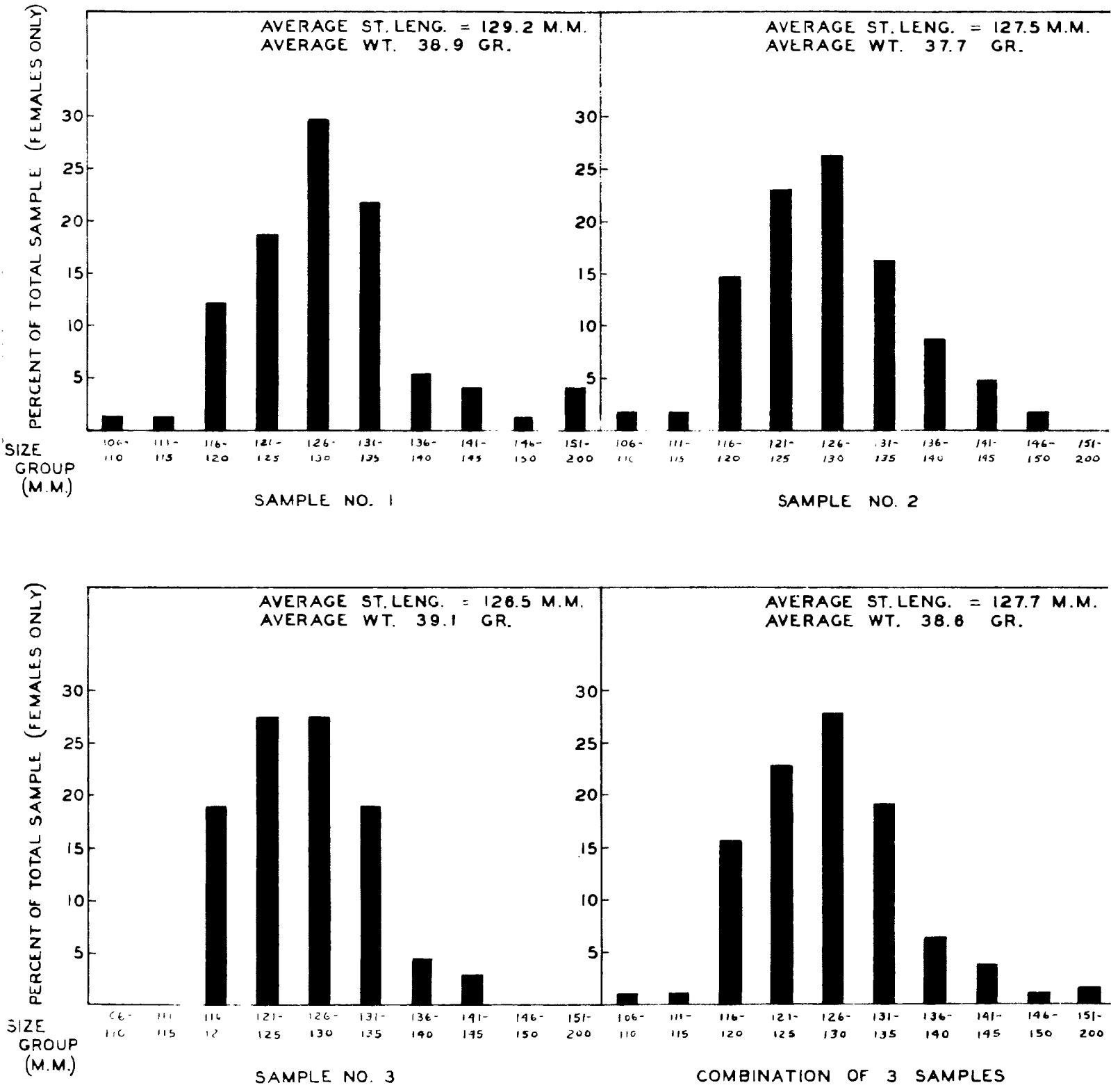

Fig. 1. Size distribution of the females in three lots of perch taken at random and size distribution of the females in the three lots combined (205 females).

Table 39

LENGTH AND WEIGHT OF PERCH TAKEN FROM FORD LAKE IN 1936

Average standard length (in millimeters) and average weight (in grams) for three random samples of male perch and three random samples of female perch and for combinations of the three samples (845 males, 205 females).

	Ave. Standard Length (mm.)	Ave. Weight (grams)
Females		
Sample 1	129.2	38.9
Sample 2	127.5	37.7
Sample 3	126.5	39.1
Combination of 3 samples	127.7	38.6
Males		
Sample 1	114.6	29.3
Sample 2	114.6	30.1
Sample 3	115.1	32.4
Combination of 3 samples	114.7	30.6

Size Distribution

The length distribution for each sex is shown in Graphs 1 and 2 and in Table 40. The distributions of both male and female perch approached a normal curve. The distribution fails to indicate more than one age group except for the faint suggestion of a second group of males (at 71-80 millimeters). On the average, the females were 13 millimeters longer than the males.

Table 40

LENGTH DISTRIBUTION OF 845 MALE PERCH AND 205 FEMALE PERCH TAKEN IN FORD LAKE IN 1936

Standard length (Millimeters)	Females		Males	
	Number	Percent of Total	Number	Percent of Total
71 - 75	...	...	2	0.2
76 - 80	...	...	2	0.2
81 - 85	...	...	...	...
86 - 90	...	...	1	0.1
91 - 95	...	...	...	...
96 - 100	...	...	4	0.5
101 - 105	...	...	12	1.4
106 - 110	2	1.0	150	17.8
111 - 115	2	1.0	319	37.8
116 - 120	32	15.6	245	29.0
121 - 125	47	22.9	81	9.6
126 - 130	57	27.8	24	2.8
131 - 135	39	19.0	4	0.5
136 - 140	13	6.3	1	0.1
141 - 145	8	3.9	...	...
146 - 150	2	1.0	...	...
151 - 155	2	1.0	...	...
156 - 160	...	...	...	...
161 - 165	1	0.5	...	...
Total	205	100.0	845	100.0
Average Standard Length	127.7 mm.	...	114.7 mm.	...

Age Determinations

An effort was made to determine the ages of the 1,050 fish contained in the three samples of the 1936 collection. For an unknown reason the annuli beyond the second year were very difficult, often impossible, to locate with certainty. The annuli were more easily located on the perch taken from Ford Lake in 1934 than on those taken from the same lake in 1936. After repeated efforts the attempt to determine the ages for the 1936 samples was abandoned except for approximately 150 specimens. Even

on these it is not certain that the annuli were invariably counted correctly. The size, weight and condition for these fish as determined for the different age groups are shown in Table 41.

Table 41

LENGTH, WEIGHT AND CONDITION OF PERCH TAKEN IN FORD LAKE IN 1936.

The values are given by sex and age for 149 specimens.

Sex	Age Group	No. of specimens	Av. standard length (mm.)	Av. total length (inches)	Av. weight (gr.)	Av. K
Female	II	1	116	5.51	37.8	2.42
	III	21	127	5.96	37.0	1.83
	IV	4	130	6.14	41.1	1.88
	V	1	131	6.30	41.7	1.85
Total or av.		27	127	5.98	37.8	1.86
Male	0	1	90	4.06	14.0	1.92
	I	1	111	5.31	32.9	2.41
	II	7	113	5.35	29.2	2.00
	III	90	116	5.51	32.7	2.08
	IV	23	119	5.63	35.3	2.11
Total or Av.		122	116	5.51	32.8	2.07

The position of the first two annuli showed that the growth was reasonably good during the first year and, in most individuals, during the second year, but was very poor in all succeeding years. The data on age groups II, III, and IV (Table 41) suggest that the females grew more rapidly than the males. Fish of the III group apparently predominated, although fish of the IV group were farily well represented. Young fish (0,I and II groups) were scarce.

The approximate number of legal-sized perch of each sex was determined

As for South Twin Lake (see p. 73), all specimens 150 mm. long or longer were assumed to have been of legal size (6 inches or more). Of the 845 males examined, 44 (5.2%) were thus indicated to have been of legal size, and 140 (68.3%) of the 205 females were computed to have been of legal size. Since the entire population of 4,817 perch (sexes were determined for 3,762 fish) was estimated to contain 3,572 males and 1,245 females, the total number of legal fish in the lake was approximately 186 males and 850 females. The ratio of females to males in the lake was approximately 1:3, but the ratio of legal females to legal males was over 4:1. The only sex and age groups whose average lengths were above the 6 inch legal limit were the IV and V group females.

It might be argued that the lake contained more males than females because few legal males were taken by the fishermen while a majority of the females were of legal length. The lake was fished so little, however, that this argument does not hold.

Sex Ratio

In the perch taken by gill nets in 1934, the two sexes were about equally divided. Nets, as stated earlier, were again set in Ford Lake just before the poisoning in 1936 and were lifted immediately after the poisoning operations had been completed. The fish taken in the nets were inadvertently placed with the dead fish collected and consequently the sex ratio of the gill-net sample could not be determined. It was noted later, however, that of those fish having gill net marks about half were females. It may be stated with assurance that the gill-nets were highly selective with respect to the sexes, probably because most of the males were too small to be caught in the nets.

The 3,762 perch which were preserved comprised 2,791 males and 971

females. There were 34.8 females per 100 males, or approxmately a 1:3 ratio. A fourth of the perch (25.8 per cent) were females.

Food

No study was made of the food available for the fish, but the stomach contents of 100 males and 100 females, taken at random, were examined. This study was especially interesting because it show a difference in the food of the two sexes.

A fourth (25) of the stomachs from females contained minnows, which were in various stages of digestion, indicating that many were eaten before the poisoning. The stomach of one female contained a partially digested perch. Eight of the stomachs from females contained a half dozen or more winged ants. It is probable that a flight of these ants had crossed the lake at some time just before the poisoning and that ants, as food, were not ordinarily available in abundance. Twenty-four stomachs contained Corethra (mostly larvae) and 22 contained chironomid larvae. Other food organisms including Ephemeridae, Amphipoda, Odonata, Coleoptera, Phyllopoda and Trichoptera were present in relatively insignificant quantities. Seventeen stomachs were empty.

Of the 100 stomachs from males, only 3 contained minnows and one contained several ants. Corethra were present in 31 stomachs and Chironomidae in 14. Odonata, Ephemeridae, Phyllopoda, Amphipoda and Cladocera were present in a very few stomachs. Over a third (36) of the stomachs were empty. Since death by poisoning is relatively rapid, it is possible that the proportion of empty stomachs was representative of normal conditions.

It may be stated that minnows constituted the chief food of the females and that Corethra larvae were the chief food ~~were~~ of the males. Earlier in

the summer, when the young minnows were smaller, they may have also served as an important food organism for the male perch. The decided increase from 1934 to 1936 in the coefficient of condition, from 1.67 to 1.86 for females and 1.65 to 2.07 for males, and the slight increase in growth in 1936 over 1934 (Tables 38 and 41) may have resulted from the introduction of minnows in 1934 or from reduction in population by netting.

Distribution of the Sexes Within the Lake

The Institute's lake survey parties have frequently observed that perch removed from single nets were primarily of one sex. Often catches of 50 or more were all of one sex. Since the sexes have different rates of growth, the dominance of one sex in the net may depend, partially, on net selectivity. It has been noted, however, that even in line fishing the fish taken may be primarily of only one sex. It would seem therefore that, to some extent at least, the two sexes tend to school separately. Since such schooling appears to take place during all or most of the summer, it apparently is not connected with spawning. The food study offers further evidence of the schooling in separate sexes of the perch in Ford Lake, and gives a plausible reason for such segregation. The minnows were apparently normally in shallow water and the ants were apparently floating on the surface. Since these two food items were prominent in the stomachs of the females, it appears probable that many of the females were feeding in shallow water. The males, on the contrary, were apparently in deeper water where they fed primarily on midge larvae. In Ford Lake, at least, a difference in the distribution of the two sexes can be explained on the basis of the differences in distribution of their favorite food organism. Differences in growth rate of the sexes may therefore account for differences in feeding habits of fish of the same age. Whether similar situations are to be found in other perch

populations remains to be determined.

The Perch Population of Section 4 Lake

On September 19, 1935 Dr. A. S. Hazzard and the writer distributed approximately 75 pounds of powdered derris root (5% rotenone content) over the lake. The first dying fish were observed one and one half hours after the introduction of the poison. Collection of the dead fish was begun immediately and continued, at intervals, for the next 50 hours. Dead perch were still coming to the surface when the party left. Nets set in this lake a year later (September, 1936) produced no perch. It seems, therefore, that all perch were killed, but not all were collected.

Total Population

A total of 1,736 perch (526 per acre) were recovered. These fish had a combined weight of 76.36 pounds or a weight per acre of 23.1 pounds. The actual number and weight of the fish present were, of course, in excess of these figures.

Size and Age Distribution

All perch recovered were measured to the nearest millimeter and weighed to the nearest tenth-gram after several months' preservation (first in 10 percent formalin and later in 70 percent alcohol). The 0 group fish were weighed in lots of 20-50 each; all other fish were weighed individually. The length distribution, by centimeter groups, is shown in Table 42. No really large perch were taken. The data suggest the presence of at least two age groups. The ages of approximately half of the samples were determined by a study of the scales. Many of the (0 and II) perch could be placed in their respective age groups without examination of the scales; this method was used for about half of this number. If any error was involved in this method, it was slight, for subsequent scale examination proved the ages

estimated for several hundred fish to be correct.

In contrast with the perch from South Twin Lake and Ford Lake, most of the fish in Section 4 Lake (Table 42) were young fish. The II group, which was represented by 957 specimens, comprised over half the fish taken, but both the 0 group and the I group were also well represented. Only age groups III and IV, represented by a total of 101 specimens, averaged of legal size (6 inches).

The females were larger than the males in all except the 0 group, in which the males were the larger. The young fish were dominantly males, but the fish of the III group were 87 per cent females and all fish in the IV group were females. Most of the legal-sized fish were females.

Table 42

LENGTH DISTRIBUTION OF PERCH FROM SECTION 4 LAKE
BY MILLIMETER INTERVALS

The dotted line represents, approximately, the dividing line between undersized and legal-sized fish.

Standard Length mm.	Females	Males	Both Sexes
49.5 - 59.5	1	...	1
59.5 - 69.5	40	51	91
69.6 - 79.5	142	180	322
79.5 - 89.5	9	25	34
89.5 - 99.5	18	72	90
99.5 - 109.5	50	200	250
109.5 - 119.5	53	539	592
119.5 - 129.5	124	122	246
129.5 - 139.5	60	12	72
139.5 - 149.5	26	1	27
149.5 - 159.5	7	...	7
159.5 - 169.5	3	...	3
169.5 - 179.5	1	...	1
Total	534	1,202	1,736

Table 43

NUMBER OF FEMALES AND MALE PERCH IN EACH YEAR GROUP, AND AVERAGE LENGTH, WEIGHT AND CONDITION OF FISH IN EACH GROUP[1]

Item	Age Group 0	I	II	III	IV
Number of fish:					
Females	192	82	171	82	7
Males	255	149	786	12	...
Total (both sexes)	447	231	957	94	7
Average standard length (mm.)					
Females	72.8	104.7	123.5	136.9	157.9
Males	76.5	100.0	115.2	131.3	...
Average Weight (grams):					
Females	6.2	17.2	28.6	41.0	63.1
Males	6.0	15.8	24.3	34.4	...
Average Total length (inches, approximate):					
Females	3.5	4.9	5.8	6.5	7.4
Males	3.6	4.8	5.4	6.2	...
Average weight (ounces):					
Females	0.2	0.6	1.0	1.4	2.2
Males	0.2	0.55	0.9	1.2	...
Average value of K:					
Females	1.66	1.53	1.54	1.59	1.60
Males	1.36	1.63	1.60	1.53	....

[1] Since these fish were taken in mid-September, they were actually almost one growing season older than the figures (annuli) indicate.

Sex Ratio

The ratio of males to females was 100:44, more than 2:1. This predominance

of males cannot be attributed to the fact that most of the legal perch were females and therefore more subject to capture by fishermen, because the lake was fished very little.

Condition of Perch

The perch of all age groups were in fair condition except that the males in the 0 group were relatively slender. In general the coefficient of condition (K) differed little between the several age groups. The females tended to improve slightly in condition after the first year, but the averages of K for males decreased slightly with increase in age.

Conclusions Regarding the Three Perch Populations

All three populations which were studied were removed in September, one each year in 1934, 1935 and 1936. Derris root was used to poison the fish in all three lakes and dynamite was used after the poisoning in two of them.

Total Populations

The fish of the two lakes which were both poisoned and dynamited were probably almost all collected or seen. The population was approximately 30 pounds per acre in the lake with very little shoal (South Twin), and about 50 pounds per acre in the lake (Ford Lake) with extensive shoal. The numbers of perch actually accounted for varied from 452 per acre in Ford Lake to 955 per acre in South Twin Lake.

Size and Age Distribution

The perch grew slowly in all three lakes. Their growth, except for the first year, was slower than the growth of perch for other waters as determined by Harkness (1922), Hile (1931), Jobes (1933) and Schneberger (1935). Since the other authors removed only a portion of the fish, data on comparative

population densities are not available. It seems probable, however, that the populations from the three lakes in the Pigeon River State Forest were more dense than were the populations in the other lakes studied.

From a fishing standpoint, all three lakes were of little value. Some of the perch in each lake (5.8 per cent in Section 4 Lake to 21.5 per cent in Ford Lake) were of legal size (6 inches) but very few had a length of 7 inches.

In two of the three lakes the young age groups (0 and I) were almost entirely absent. It is possible that most of the young perch of those lakes had been eaten by the larger fish.

In all three lakes the females grew more rapidly than the males. The females also tended to live longer than the males. The oldest fish were invariably females.

In general, the perch grew very slowly after their first or second year of life. This slow growth is attributed to a scarcity of food organisms of moderate size (except in Ford Lake in 1936).

Sex Ratio

Males predominated in all three perch populations. The ratios of males to females for each lake were: South Twin Lake 100:74, Section 4 Lake 100:44, and Ford Lake 100:35. The reason for the differences in the sex ratio in the different lakes has not been found. It cannot be attributed to the selective capture of females in sport fishing since all of the lakes were fished very little. The lake with the fish in poorest condition had twice as many females per 100 males as the lake containing perch in the best condition. The greater viability of the females in the face of adverse conditions (Geiser, 1924) would explain this difference. The predominance of males suggests that, in the early stages, the females tended to suffer a much greater morality than

the males unless, of course, the sexes were not equally represented in the fish immediately after hatching. In later years, however, the mortality of males exceeds that of the females.

Condition and Growth

The perch in South Twin Lake were in very poor condition; those in Ford Lake were in excellent condition, though of slow growth. The average value of K for Section 4 Lake perch was intermediate. Since all three populations grew slowly, the condition of these fish was not definitely correlated with their rate of growth. Apparently the fact that a fish is in good condition is not an indication that it is also growing rapidly.

SUMMARY AND CONCLUSIONS

1. A preliminary physical, chemical and biological surgey was made of 13 lakes in the Pigeon River State Forest, in Otsego, Cheboygan and Montmorency counties, Michigan.

2. It was found that the lakes varied widely in characteristics but that 9 of the lakes were similar to the extent of being pit or "pot-hole" lakes.

3. The fish fauna was found to be extremely limited with respect to species. No fish were found in two lakes, only one species was taken in six lakes (stocked species not included), 2 species were taken on one lake, and 6, 7, 8 and 10 species respectively were found present in the other four lakes. The lakes with more than 2 species all had outlets.

4. The preliminary inventory was followed, in most of the lakes, by experimental fish management. The management differed in kind and amount in the different lakes.

5. Management of the 4 pit lakes in which only forage fish had been found by the survey consisted primarily of stocking with brook trout. Similar management of 4 other pit lakes which were found to contain an abundance of small stunted perch failed to produce satisfactory fishing. The fish in three of these lakes were removed by poisoning (with rotenone) and were later stocked with trout or grayling (two with adult rainbow trout, one with Montana grayling). The fourth was enriched with commercial fertilizer.

Two lakes were stocked with bluegills. One lake was "improved" by an increase in shelter, installation of bass spawning beds, planting of vegetation and fertilizing with commercial fertilizer.

6. The yield of these lakes was very decidedly increased by the management practices.

7. Complete records of the fishing on 3 lakes were obtained for two consecutive seasons with the help of two C.C.C. camps located in the area. One year fishing records were also obtained for two lakes. Information on the fishing on each lake, by months, includes data on the number of fishermen, the average catch per hour and per angler, the average size of the fish caught, the yield per acre in pounds and in number of fish, the effectiveness of each kind of bait used and the residence of each angler.

8. On several of the trout lakes the yield tended to decline even though these lakes were heavily stocked with young brook trout. The reason for this decline was not definitely determined; the drop in the catch may have been due to a decrease in the food and may have been augmented by the exceptionally heavy stocking.

9. The perch populations which were removed from three lakes by poisoning were collected and studied in detail.

10. Of the two lakes in which the fish were both poisoned and dynamited and from which almost all of the fish were apparently recovered for study, the one with little shoal had supported about 30 pounds of fish per acre; the lake with extensive shoals yielded about 50 pounds of fish per acre.

11. The perch grew very slowly in each of the three lakes, more slowly than the perch of other waters, studied by several authors.

12. The evidence suggests that in South Twin Lake the fish normally died of starvation before they reached legal size (6 inches). This lake supported at least 955 perch per acre.

13. In all three lakes male perch were more abundant than the females. The sex ratio varied from 100 males to 74 females in South Twin Lake to 100

males per 34 females in Ford Lake.

14. The females perch grew more rapidly than the males in all three of the lakes.

15. The oldest age group of perch in each lake was composed entirely of females, indicating that the female perch definitely live longer than the males.

16. It was found that the rate of growth was not correlated with the condition of the fish. Perch which were in excellent condition nevertheless grew very slowly.

17. All three chief phases of fish management were applied. Stocking was used extensively and successfully. Legal restrictions were altered to increase the yield, by permitting fishing in late spring and early summer. In several of the waters, environmental improvement work was carried out.

18. In view of the fact that fish management must be continuous to be effective, a continuation of the studies on the lakes in the Pigeon River State Forest is contemplated.

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Illustrations

Fig. 1. Brook trout taken from Hemlock Lake with a gill-net in 1932. These trout were stocked as small fish in 1927.

CREEL CENSUS — Michigan Department of Conservation

Lake or Stream..... Fisherman's Name.....
Township..... City or Town.....
County..... Sex?..... Approximate Age?.....

SPECIES CAUGHT	LEGAL SIZE		UNDERSIZE	
	Number	Av. Lgth.	Number	Av. Lgth.
Brook Trout				
Rainbow Trout				
Brown Trout				
Large Mouth Bass				
Small Mouth Bass				
Bluegills				
Sunfish				
Yellow Perch				
Pike Perch (Walleyes)				
Northern (Grass) Pike				

(Enter other kinds taken on blank spaces above)

Date..... 193.....

Kind of Fishing:

Ice?..... Still Fishing?.....
Boat?..... Trolling?.....
Shore?..... Casting?.....
Number of persons?..... Number of lines?.....
Bait (Check if only one kind of bait used)
How many fish caught with worms?.....
Insects?..... Minnows?..... Spinner?.....
Plug?..... Artificial Fly?.....
If taken with other bait, or by spear, dipnet or other means, state how.....
Weather: Clear?..... Heavy Wind?..... Cold?.....
(Check) Cloudy?..... Light Wind?..... Mild?.....
Rain?..... Calm?..... Warm?.....

TIME FISHED _____ HRS.
A.M. 12 1 2 3 4 5 6 7 8 9 10 11 12
P.M. 12 1 2 3 4 5 6 7 8 9 10 11 12

Draw line through hours and quarter hours fished; double line through indicated time when fishing was best. Make out report whether fish are caught or not.

Fig. 2. Creel census blank used in the census work on the lakes in the Pigeon River State Forest.

Fig. 3. Brook trout taken from Pickerel Lake with gill-nets in 1932. Note the unusually large head on the large fish.

Fig. 4. Vegetation (rushes) ready for transplanting in Pickerel Lake, 1936. Vegetation was taken from one portion of the lake in making a bathing beach (by Camp Vanderbilt) and was planted elsewhere in the same lake.

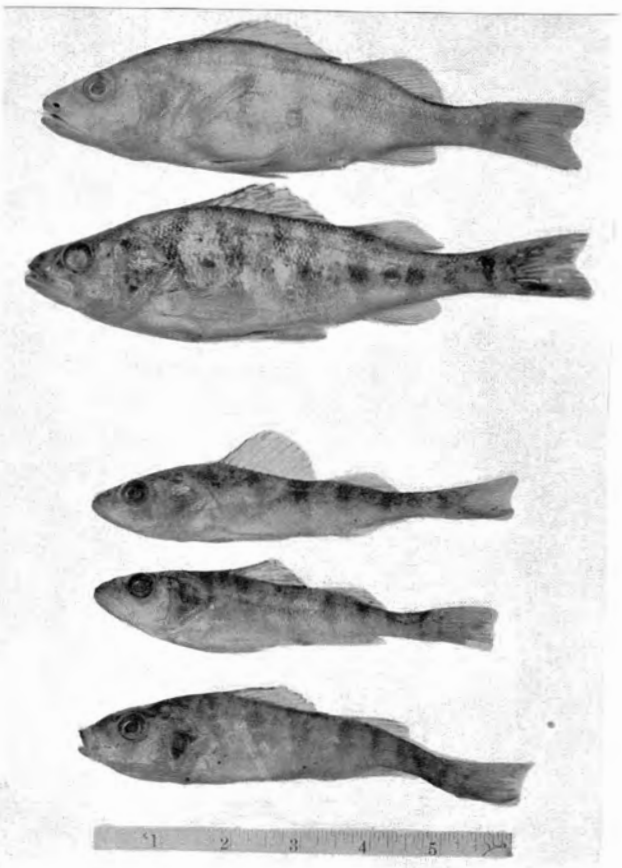


Fig. 5. Perch removed from South Twin Lake by poisoning. The fish shown are 5-year-old females. The upper two were large enough to eat perch of the II group and were in good condition; the lower three were too small to eat the smaller perch and were in very poor condition.

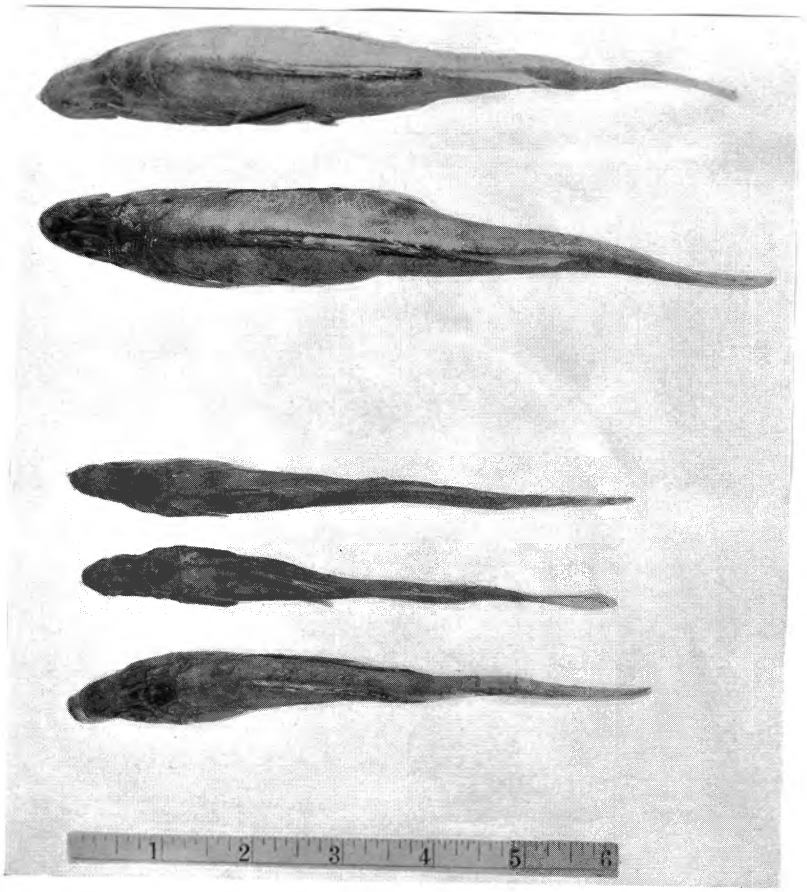


Fig. 6. Dorsal view of fish shown in Fig. 5.

Fig. 7. Preparing dynamite for use in Ford Lake, 1936.

Fig. 8. Water raised by discharge of 200 sticks of dynamite in Ford Lake, 1936.

Fig. 9. View of Ford Lake. The waves resulted from the dynamiting.

Fig. 10. Preparing perch collected in Ford Lake for preservation.

Figures 11 to 19 are maps of the various lakes and are prepared from information gathered by the lake survey party in 1931 and 1932. Two maps, those of Dog Lake and Hardwood Lake, are omitted because of their large size and because of the relative insignificance of these two lakes in the text. The maps included are:

Fig. 11. Grass Lake and Devil's Soup Bowl

Fig. 12. Two-Acre Lake

Fig. 13. Pickerel Lake

Fig. 14. Ford Lake

Fig. 15. Hemlock Lake

Fig. 16. Lost Lake

Fig. 17. West Lost Lake

Fig. 18. Section 4 Lake

Fig. 19. North Twin Lake and South Twin Lake

Fig. 11

VEGETATION BOTTOM AND DEPTH CHART.

LEGEND

- Mixed
- SAND
- MARL
- PULPY PEAT
- FIBROUS PEAT
- GRAVEL
- VEG. EXAMINATION
- EMERGENT VEG.
- FLOATING VEG.
- SUBMERGENT VEG.
- BOTTOM VEG.
- DEPTH CONTOUR
- HARDWOODS
- CONIFERS
- BEAVER DAM.

DEPTH
SHOWN IN METERS

SCALE
16 IN. = 1 MILE

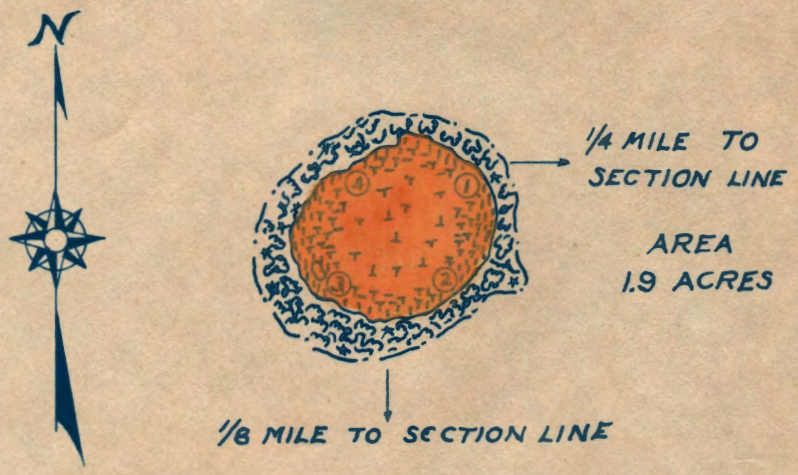
PREPARED BY
INSTITUTE FOR
FISHERIES RESEARCH
ANN ARBOR ~ MICH.

OTSEGO CO. MICH. T32N R1W SEC. 5

A

TWO-ACRE LAKE

OTSEGO CO. MICH. T.32N. R1W. SEC.3.



VEGETATION BOTTOM AND DEPTH CHART

DEPTH
MAXIMUM LESS THAN 3 METERS
AVERAGE LESS THAN 2 METERS

SCALE
.16 IN = 1 MILE

LEGEND

- PULPY PEAT
- ① VEG EXAMINATION
- I EMERGENT VEG.
- T FLOATING VEG.
- — SUBMERGENT VEG
- HARDWOODS
- * CONIFERS
- RIDGE

PREPARED BY
INSTITUTE FOR FISHERIES RESEARCH
ANN ARBOR MICH.

AUGUST 2, 1932

A.

Fig. 12

PICKERIL LAKE

OTSEGO CO. MICH. T.32N. R.2W. SEC.11

VEGETATION BOTTOM AND DEPTH CHART.

LEGEND

- SAND
- MARL
- PULPY PEAT
- MIXED
- ⑤ VEG. EXAMINATION.
- I EMERGENT VEG.
- T FLOATING VEG.
- – SUBMERGENT VEG.
- ⊥ BOTTOM VEG.
- S SHOAL
- ---5--- DEPTH CONTOUR
- LOGS
- BRUSH
- CONIFERS.
- HARDWOODS.
- ----- TRAIL

PREPARED BY.

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AUGUST 11, 1932.

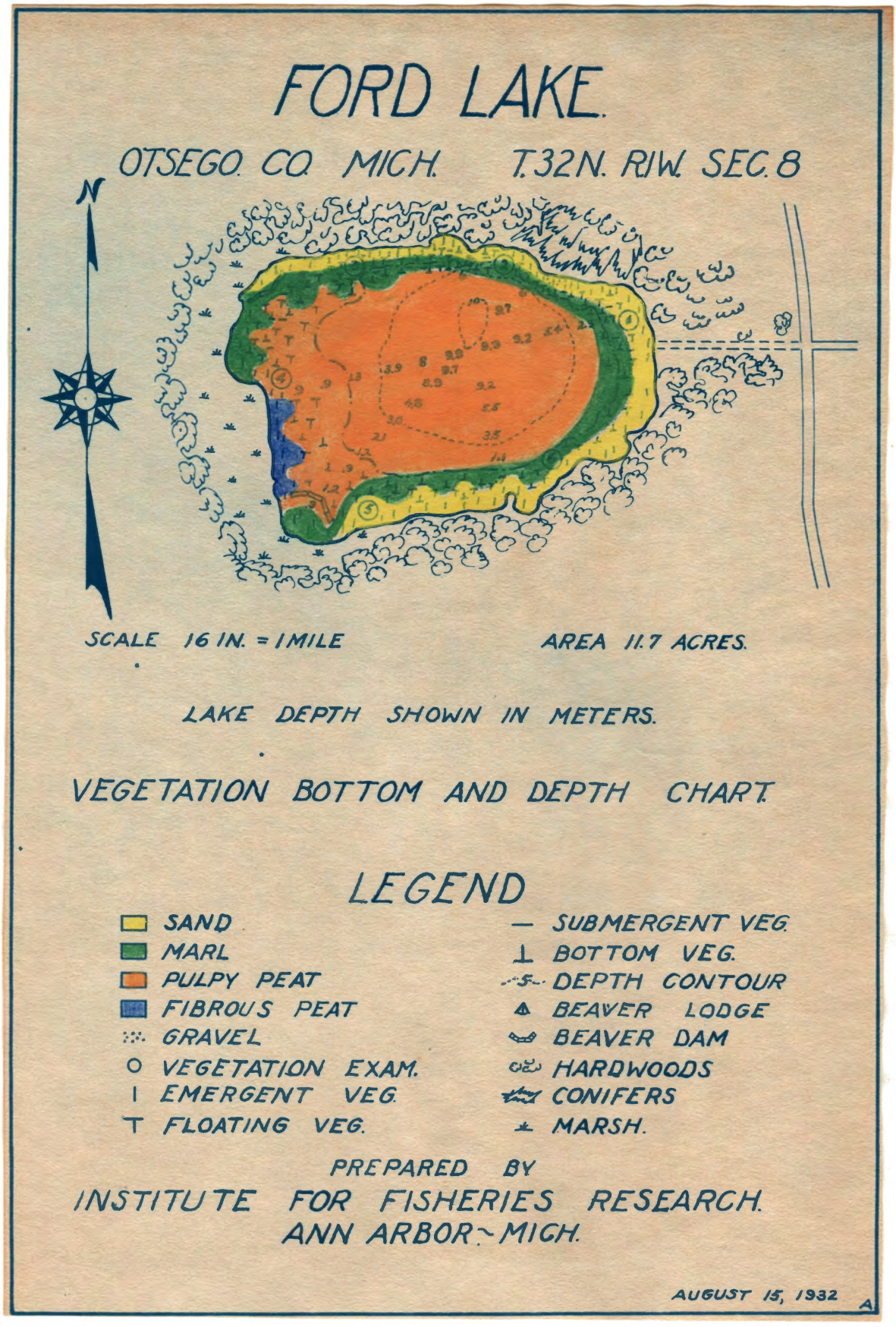

FORD LAKE.
OTSEGO. CO. MICH. T.32N. R1W. SEC. 8
N
SCALE 16 IN. = 1 MILE
AREA 11.7 ACRES.
LAKE DEPTH SHOWN IN METERS.
VEGETATION BOTTOM AND DEPTH CHART.
LEGEND
SAND
MARL
PULPY PEAT
FIBROUS PEAT
GRAVEL
VEGETATION EXAM.
EMERGENT VEG.
FLOATING VEG.
SUBMERGENT VEG.
BOTTOM VEG.
DEPTH CONTOUR
BEAVER LODGE
BEAVER DAM
HARDWOODS
CONIFERS
MARSH.
PREPARED BY
INSTITUTE FOR FISHERIES RESEARCH.
ANN ARBOR - MICH.
AUGUST 15, 1932
A

Fig. 14

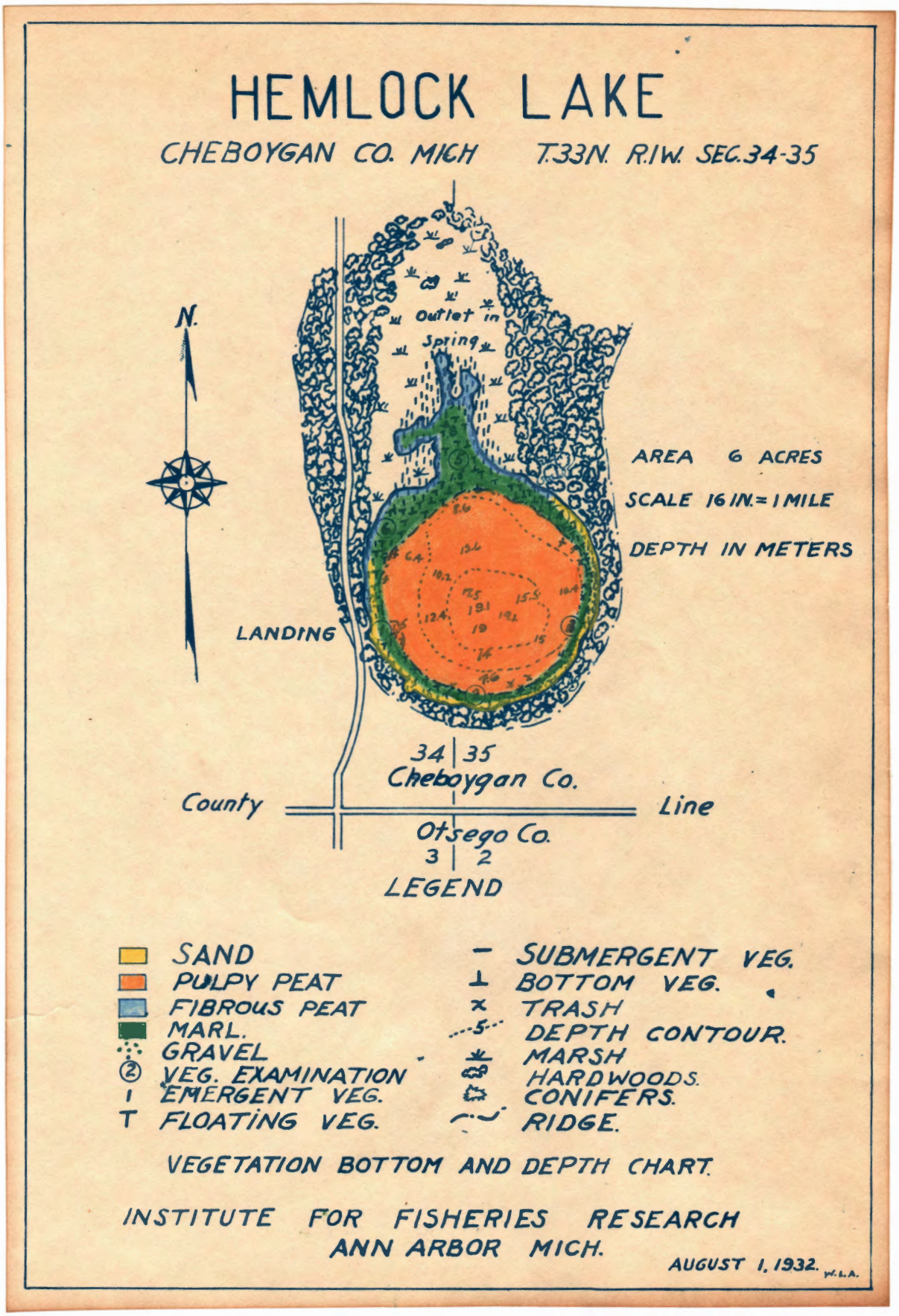

HEMLOCK LAKE
CHEBOYGAN CO. MICH T.33N. R.1W. SEC.34-35
N.
Outlet in Spring
LANDING
AREA 6 ACRES
SCALE 16 IN.= 1 MILE
DEPTH IN METERS
34 | 35
Cheboygan Co.
County Line
Otsego Co.
3 | 2
LEGEND
SAND
PULPY PEAT
FIBROUS PEAT
MARL.
GRAVEL
② VEG. EXAMINATION
1 EMERGENT VEG.
T FLOATING VEG.
SUBMERGENT VEG.
BOTTOM VEG.
TRASH
DEPTH CONTOUR.
MARSH
HARDWOODS.
CONIFERS.
RIDGE.
VEGETATION BOTTOM AND DEPTH CHART.
INSTITUTE FOR FISHERIES RESEARCH
ANN ARBOR MICH.
AUGUST 1, 1932. W.L.A.

Fig. 15

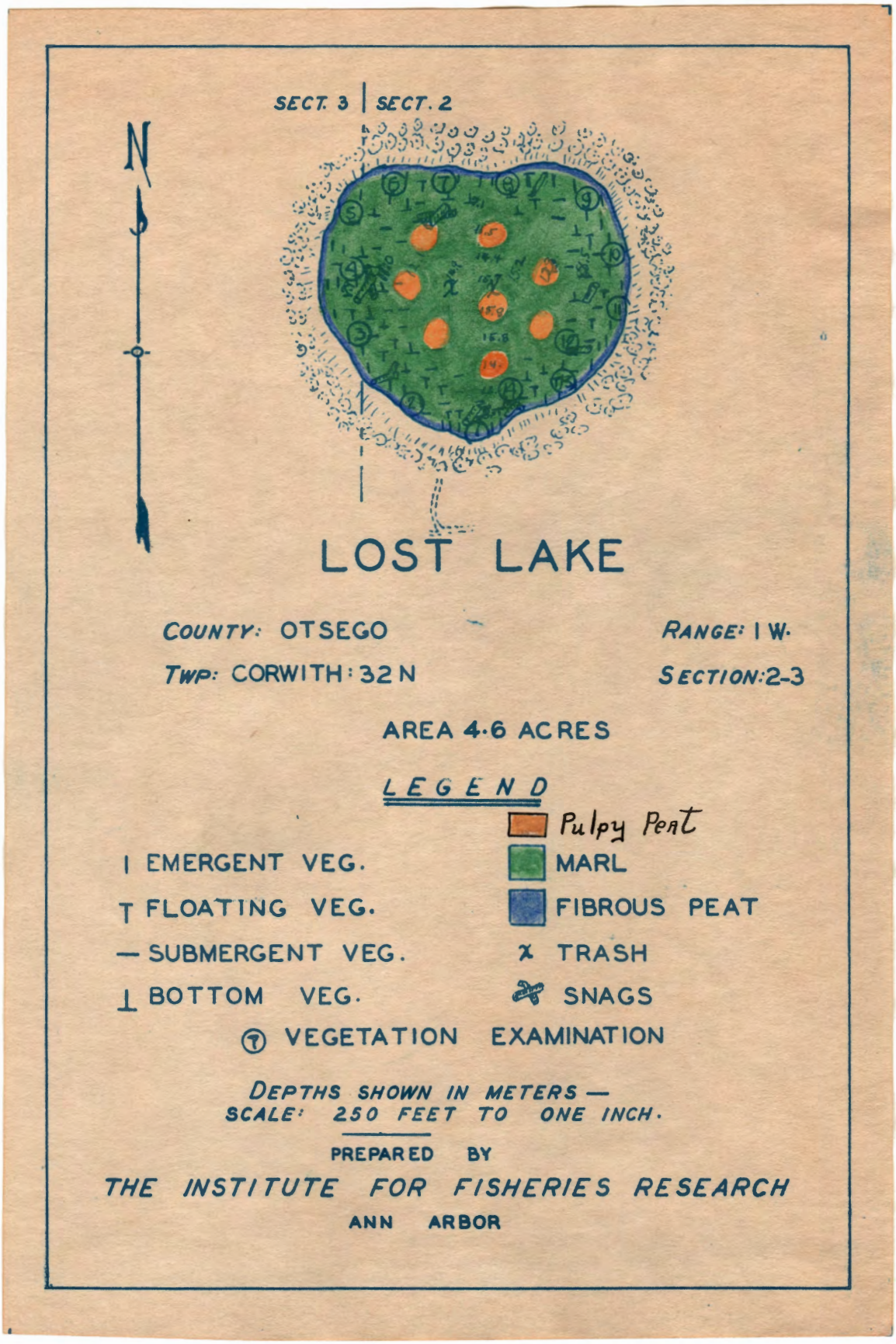
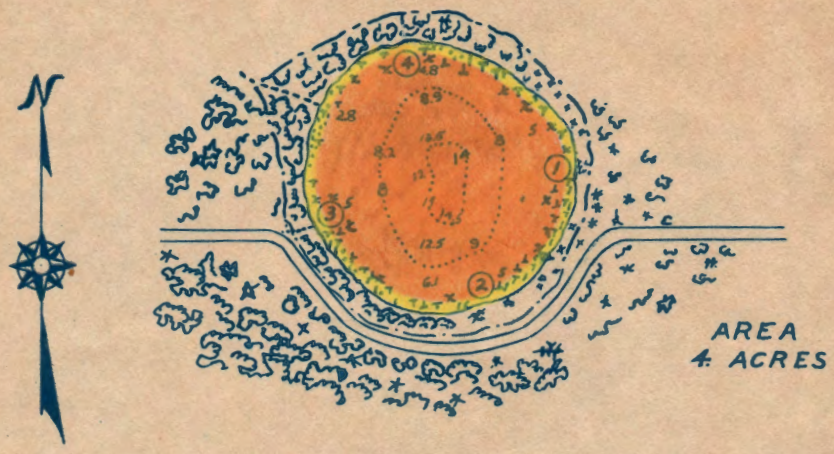

SECT. 3 | SECT. 2
N
LOST LAKE
COUNTY: OTSEGO
RANGE: 1 W.
TWP: CORWITH: 32 N
SECTION: 2-3
AREA 4.6 ACRES
LEGEND
Pulpy Peat
EMERGENT VEG.
MARL
FLOATING VEG.
FIBROUS PEAT
SUBMERGENT VEG.
TRASH
BOTTOM VEG.
SNAGS
VEGETATION EXAMINATION
DEPTHS SHOWN IN METERS —
SCALE: 250 FEET TO ONE INCH.
PREPARED BY
THE INSTITUTE FOR FISHERIES RESEARCH
ANN ARBOR

Fig. 16

WEST LOST LAKE

OTSEGO CO. MICH. T.32N. R1W. SEC.3



VEGETATION BOTTOM AND DEPTH CHART

DEPTH SHOWN IN METERS SCALE 16 IN.= 1 MILE

LEGEND

- SAND
- PULPY PEAT
- GRAVEL
- VEG. EXAMINATION
- EMERGENT VEG.
- FLOATING VEG.
- SUBMERGENT VEG
- BOTTOM VEG.
- TRASH
- DEPTH CONTOUR
- HARDWOODS
- CONIFERS
- RIDGE
- TRAIL
- SPRING

PREPARED BY

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ANN ARBOR MICH.

AUGUST 2 1932

A.

Fig. 17

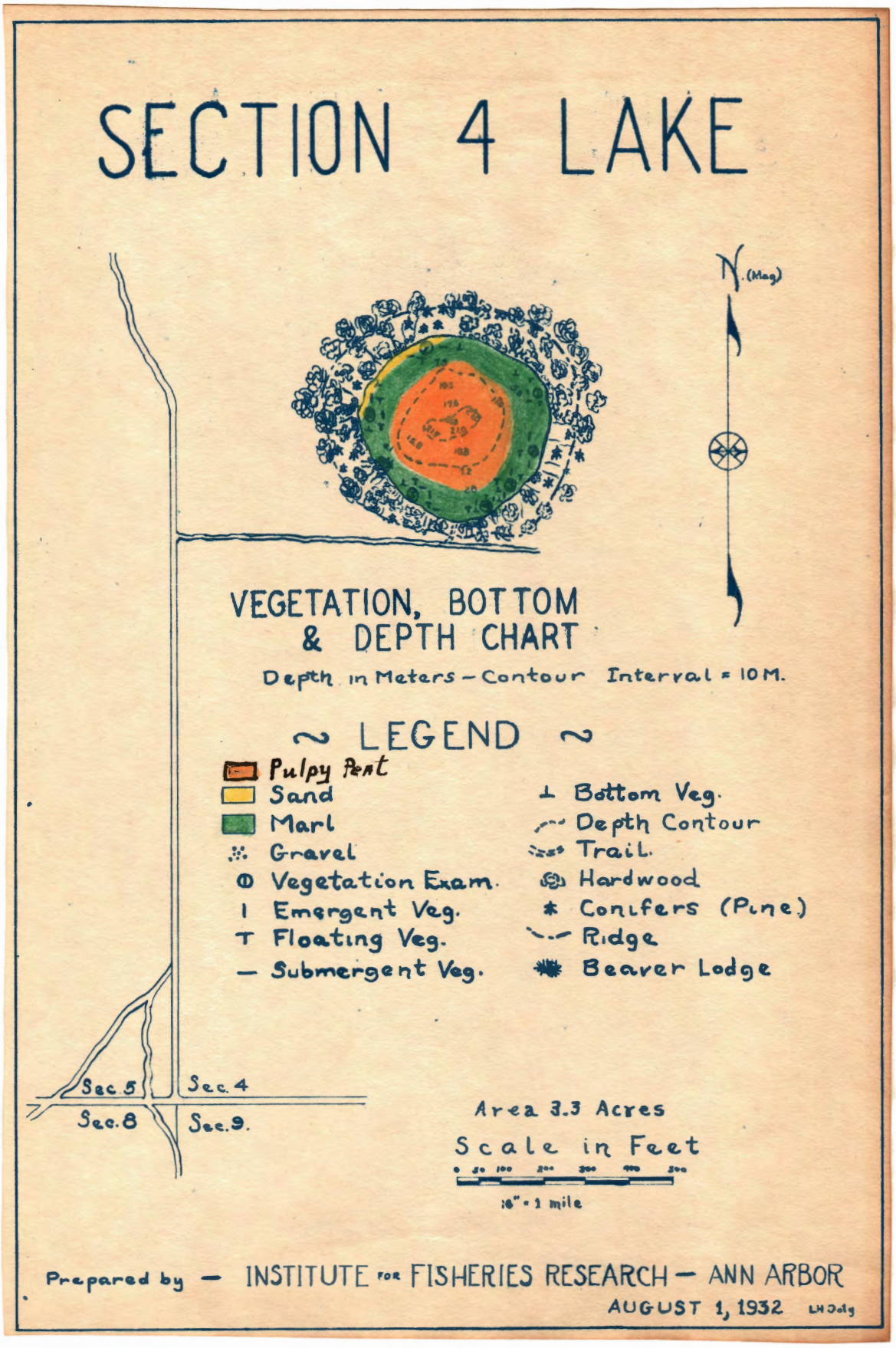

SECTION 4 LAKE
N. (Mag)
VEGETATION, BOTTOM & DEPTH CHART
Depth in Meters – Contour Interval = 10 M.
LEGEND
Pulpy Peat
Sand
Marl
Gravel
Vegetation Exam.
Emergent Veg.
Floating Veg.
Submergent Veg.
Bottom Veg.
Depth Contour
Trail.
Hardwood
Conifers (Pine)
Ridge
Beaver Lodge
Sec. 5
Sec. 4
Sec. 8
Sec. 9.
Area 3.3 Acres
Scale in Feet
16" = 1 mile
Prepared by – INSTITUTE FOR FISHERIES RESEARCH – ANN ARBOR
AUGUST 1, 1932 LH Daly

Fig. 18

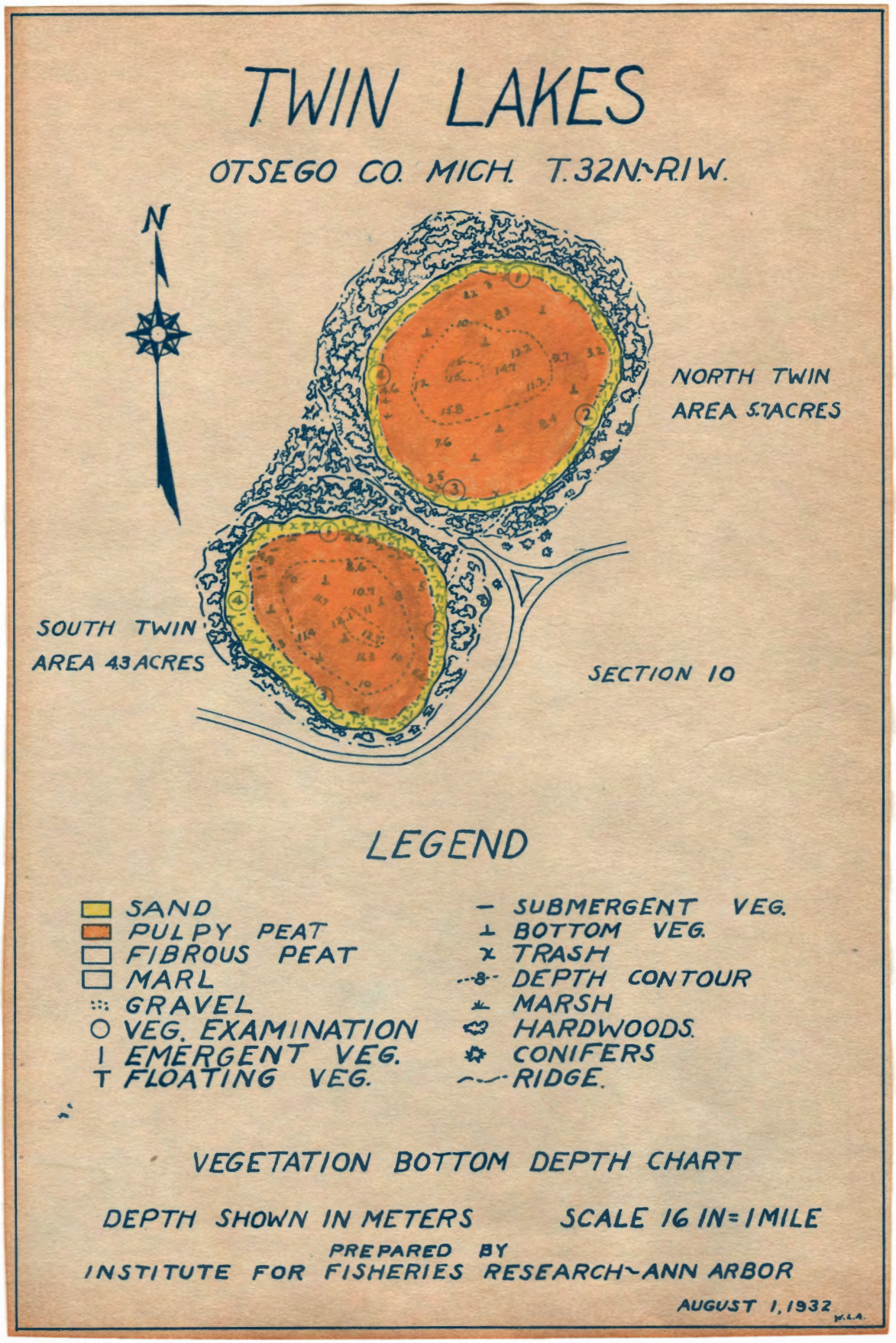

TWIN LAKES
OTSEGO CO. MICH. T.32N.-R.1W.
N
NORTH TWIN
AREA 57 ACRES
SOUTH TWIN
AREA 43 ACRES
SECTION 10
LEGEND
SAND
PULPY PEAT
FIBROUS PEAT
MARL
GRAVEL
VEG. EXAMINATION
EMERGENT VEG.
FLOATING VEG.
SUBMERGENT VEG.
BOTTOM VEG.
TRASH
DEPTH CONTOUR
MARSH
HARDWOODS.
CONIFERS
RIDGE.
VEGETATION BOTTOM DEPTH CHART
DEPTH SHOWN IN METERS
SCALE 16 IN=1 MILE
PREPARED BY
INSTITUTE FOR FISHERIES RESEARCH-ANN ARBOR
AUGUST 1, 1932

Fig. 19

Figures 20 to 25 include the set of survey cards for Lost Lake. Similar cards were prepared for each lake.

Prepared for the Fish Division
Michigan Department of Conservation

LAKE SURVEY—SUMMARY CARD

By the Institute for Fisheries Research
University of Michigan

1. County Otsego Co. Township Corwith T. & R. T 32 N, R 1 W Sec. 2 and 3
2. NAME of lake Lost Lake
3. ACCESSIBILITY Poor Nearest R. R. Station Distance miles
4. How reached by road (give distances)
5. Condition of side road Sand trails. Fair
6. TRIBUTARY TO (immediate and main drainage)
7. Prevailing fish in immediate drainage below
8. WATER SUPPLY No inlet. This is a pot-hole.
9. Fluctuations in level Almost none, if any.
10. POLLUTION Lake is very clear. No signs of pollution found.
11. DAM in outlet? No Owner - Use -
Head - Effect on level - Passable for fish? -
12. Immediate SHORE Very steep sides, 50-75 ft. high.
13. Surrounding COUNTRY Second growth timber.
14. USE OF WATER—Degree fished Now fished extensively. Fished very little until recently.
15. Ownership No State property Public fishing permitted
16. Boating None
17. Swimming None
18. Recreational dev. None
19. Other uses None
20. TEMPERATURE—Surface High Thermocline Present at 15-20 ft. Deep-water Quite cold
21. WATER—Degree roughened by storms Almost none Color Very clear blue Turbidity Exceptionally clear
22. Hardness Moderately hard Alkalinity Quite alkaline CO_2 None found, except at
23. Oxygen Quite high, except at very bottom. (very bottom.
24. SIZE—Acres 4.6 Length Lake almost perfectly round Width
25. FORM AND DEPTH—Shoals Quite narrow Width of Shoal—Min. 10' Max. 30' Ave. 15-20 ft.
26. Drop-off Quite near shore Slope Quite steep. Over 45 degree angle.
27. Deep-water Average depth about 40 ft. Maximum depth 15.8 meters
28. BOTTOM—Shoals and slope marl
Deep-water Marl with some pulpy peat.
29. COVER Quite a few tree trunks and snags in the water.

Form 3088 11-32 300

OVER

Fig. 20 Summary card. Reverse of card is shown on reverse of this sheet.

Lake Survey Summary Card (con.)

30. VEGETATION—Shoal Fairly abundant. Chiefly muskgrass and pond lilies.
Slope Fairly abundant. Chiefly muskgrass Deep-water None

31. NATURAL FOOD Minnows quite common. Some aquatic insects present.

32. SPAWNING GROUNDS None found. Not suited for trout spawning.

33. PREDATORS None seen. Evidently very few

34. FISHING—General reputation Excellent trout fishing during last season.

35. History of fishing Fished very little until last season. Then fished quite intensively for trout.

36. SPECIES OF FISH—Game fish Large brook trout, 10-15 inches long, quite common. These are excellent trout with very pink flesh. No small trout seen or taken in small mesh net.

37. Coarse fish none

38. Obnoxious fish none

39. Forage fish, etc. Quite a few minnows seen. Seining from shore impossible. A few were taken from boat, all fat-headed minnows.

CONTINUATIONS (use item numbers):

Prepared by Eschmeyer Date Aug. 18, 1931

Prepared for the Fish Division
Michigan Department of Conservation

FISH MANAGEMENT PROPOSALS FOR LAKES

By the Institute for Fisheries Research
University of Michigan

1. County Otsego — Township Corwith — T. & R. T 32 N, R 1 W — Sec. 2 and 3
2. NAME of lake Lost Lake
3. LOCAL REGULATIONS—Fish refuges Not needed
4. Special designation Recommended that this lake be designated as a trout lake
5. Creel and size regulations Those now provided appear satisfactory.
6. Fishing privileges Open to public
7. STOCKING SUGGESTIONS (Annual if not otherwise indicated) Annual stocking with 1000 brook trout yearlings or 2000 late fall fingerlings is recommended for 3 years, stocking thereafter to depend on amount fished, possible over-crowding, etc. It is recommended that no other game fish be planted here.
8. PREDATOR CONTROL Not recommended
9. GRAVEL SPAWNING BEDS Not recommended. It is doubtful whether the trout would spawn even if gravel were present.
10. FOOD INCREASE—Minnow introduction Food appears to be ample for the time being. Annual stocking with minnows might prove very desirable later.
11. Fertilizing Not recommended.
12. Slabs for minnow spawning Not recommended.

Form 3092 12-33 200

OVER

Fig. 21. Management card. Reverse of card is shown on reverse of this sheet.

Fish Management Proposals for Lakes (Con.)

13. VEGETATION INCREASE Not recommended.

14. COVER INCREASE The cutting of considerable brush near the lake and the throwing of this brush in shallow water around the edge is considered advisable. Some protection is now present but more could be used to advantage. Since very little wave action occurs here, the brush would very likely not need to be

15. REGULATION OF WATER LEVEL AND FISH MOVEMENTS (fastened in any way.

16. CHANNELS TO CONNECTING WATERS

CONTINUATIONS (use item numbers):

Prepared by Eschmeyer Date October 1, 1932.

Lake and Stream Survey

INSTITUTE FOR FISHERIES RESEARCH

DIVISION OF FISHERIES

MICHIGAN DEPARTMENT OF CONSERVATION

COOPERATING WITH THE

UNIVERSITY OF MICHIGAN

Water Analysis

County: Otsego

Lake or stream: Lost Lake

T. 32N R. 1W Sec. 2

Township Corwith

[When more than one Station is entered, locate by map or description on reverse]

Fig. 22 Chemistry card.

No.	Station	Date	Time A.M. or P.M.	Sky	Wind Dir.	Wind Velocity	Preceding Weather Period & Kind	Water Color	Water Trans. S disk Pct M?	Depth Bottom Pct M?	Depth Exam. Pct M?	Temperature C? F? Thermom. Kind	Thermom. No.	Corrected Air	Corrected Water	Oxygen Bottle No.	Oxygen c.c. thio.	Oxygen Factor	Oxygen ppm O_2	Carbon Dioxide Bottle No.	Carbon Dioxide Free CO_2	Alkalinity ph-th	Alkalinity MO	pH
		8/1 37	2:20	Dark Cloudy	S.W.	Mod.	Hot, clear	Very clear blue	9.1	14.5	S	Six	8	84	74		8.1	1.04	8.4		0	7	144	7.9
											1		9		74									
											2		4		74									
											3		1		72									
											4		18		70									
											5		5		66		7.4		7.7		0	6	145	7.9
											6		8		55									
											7		9		51									
											8		4		49									
											9		1		48									
											10		18		48		10.7		11		0	6	183	7.6
											11		5		46									
											12		8		46									
											13		9		46									
											14		4		46									
											14.5		1		46		.8		.8		6		193	7.4

ENTER OTHER ANALYSES OR REMARKS ON REVERSE SIDE

Form 5103 6-37 200

Eschmeyer, Ashley

(Analyzer)

Lake and stream survey

INSTITUTE FOR FISHERIES RESEARCH

DIVISION OF FISHERIES

MICHIGAN DEPARTMENT OF CONSERVATION

COOPERATING WITH THE

UNIVERSITY OF MICHIGAN

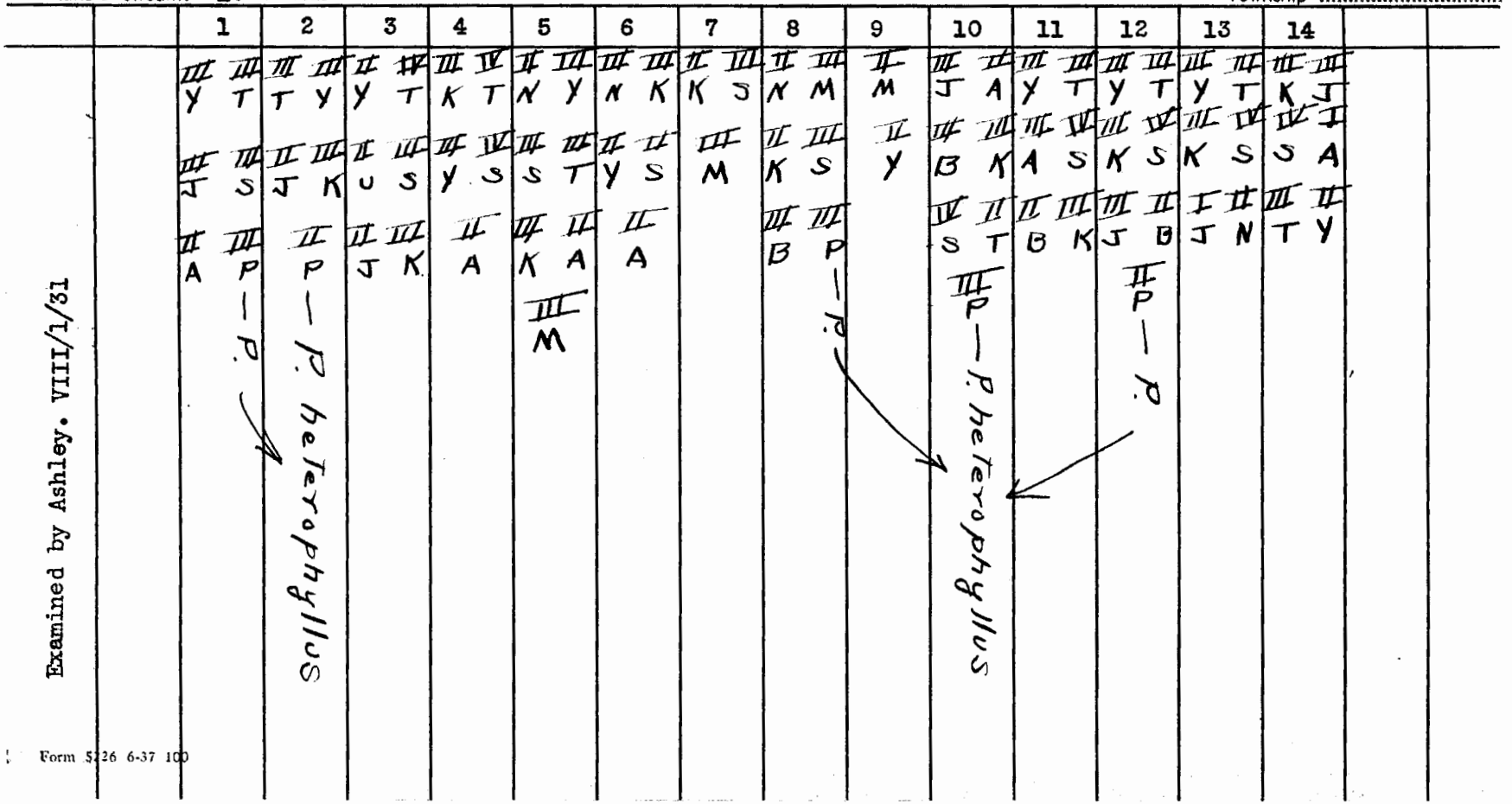
Vegetation analysis

County: Otsego

T. 32N R. 1W Sec. 24 S

Lake or stream: Lost Lake

Township Corwith



Examined by Ashley. VIII/1/31

Form 5226 6-37 100

Fig. 23 Vegetation card. Numbers refer to stations shown on map. Vegetation shown in symbol. Abundance shown by Roman numeral.

Prepared for the Fish Division
Michigan Department of Conservation

LAKE SURVEY—EXAMINATION

By the Institute for Fisheries Research
University of Michigan

County Otsego Township Corwith T. & R. T 32 N, R 1 W Sec. 2 and 3

NAME of lake **Lost**

Point of examination From shore to center

GEAR USED—kind Gill nets Length 600' Mesh 2 1/2", 3 1/2"

Area covered

Immediate SHORE Steep shore,(soft marl in water) sandy shore and wooded

TEMPERATURE—Air 82 Surface 72 Bottom 46

Weather (present and preceding) Cloudy and dark

WATER (color, siltiness, etc.) Very clear

DEPTH 1-15 meters

BOTTOM Marl on shelf, peat below shelf

COVER

VEGETATION Chara to bottom of slope

NATURAL FOOD Minnows and insects abundant

REMARKS No trout taken in smaller mesh

DATE Aug. 1, 1931 Time 9 a.m. to 4 p.m. Field No. C-8

COLLECTOR Eschmeyer - Ashley

Form 3087 6-36 1M

FISH LIST ON REVERSE

Fig. 24 Card used for fish examination. Reverse of sheet shows back of card.

LIST OF FISH CAUGHT (For data see reverse)

No.	GAME FISHES	Age	Remarks
	Brown Trout		
	Rainbow Trout		
	Lake Trout		
5	Brook Trout		10-15 inches long (4 discarded)
	Mud Pickerel		
	Northern Pike		
	Muskellunge		
	White Bass		
	Perch		
	Sauger		
	Walleye		
	Small-mouth Bass		
	Large-mouth Bass		
	Warmouth Bass		
	Green Sunfish		
	Bluegill		
	Long-eared Sunfish		
	Pumpkinseed		
	Rock Bass		
	Black Crappie		
	COARSE FISHES		
	Common Sucker		
	Lake Chub Sucker		
	Mullet (M.....)		
	Black Bullhead		
	Brown Bullhead		
	Yellow Bullhead		

No.	OBNOXIOUS FISHES	Age	Remarks
	Short-nose Gar		
	Long-nose Gar		
	Dog fish		
	Carp		
	FORAGE FISHES, etc.		
	Northern Dace		
	Fine-scaled Dace		
	Red-bellied Dace		
	Black-nosed Shiner		
	Black-chin Shiner		
	Mimic Shiner		
	Straw-colored Shiner		
	Spot-tail Shiner		
	Common Shiner		
	Golden Shiner		
	Blunt-nosed Minnow		
	Fat-head Minnow		
	Tadpole Cat		
	Mud minnow		
	Menona Killifish		
	Black-banded Top-m.		
	Log Perch		
	Johnny Darter		
	Iowa Darter		
	Least Darter		
	Silversides		
	Muddler (*bairdii*)		
	Brook Stickleback		

Prepared for the Fish Division
Michigan Department of Conservation

LAKE SURVEY—EXAMINATION

By the Institute for Fisheries Research
University of Michigan

County Otsego Township T. & R. T 32 N, R 1 W Sec. 2 and 3

NAME of lake Lost

Point of examination Boat landing, east shore

GEAR USED—kind Seine Length 15' Mesh 1/8" common sense

Area covered 25 x 12

Immediate SHORE High, sandy

TEMPERATURE—Air 74 Surface 73 Bottom

Weather (present and preceding) Pt. cloudy. Strong W. wind. Pt. Cloudy last 36 hrs. Rain previously

WATER (color, siltiness, etc.) very clear, greenish

DEPTH 2 ft. to shore

BOTTOM Marl

COVER Some snags and a raft.

VEGETATION Muskgrass abundant.

NATURAL FOOD Insects, frogs, snails and minnows abundant.

REMARKS Only 1 species of minnow taken.

DATE July 29, 1932 Time 11:45 A.M. Field No. P.R. 5

COLLECTOR Kuhne

Form 3087 6-36 1M

FISH LIST ON REVERSE

Fig. 25. Card used for fish examination. Reverse of sheet shows back of card.

LIST OF FISH CAUGHT (For data see reverse)

No.	GAME FISHES	Age	Remarsk
	Brown Trout		
	Rainbow Trout		
	Lake Trout		
	Brook Trout		
	Mud Pickerel		
	Northern Pike		
	Muskellunge		
	White Bass		
	Perch		
	Sauger		
	Walleye		
	Small-mouth Bass		
	Large-mouth Bass		
	Warmouth Bass		
	Green Sunfish		
	Bluegill		
	Long-eared Sunfish		
	Pumpkinseed		
	Rock Bass		
	Black Crappie		
	COARSE FISHES		
	Common Sucker		
	Lake Chub Sucker		
	Mullet (M.....)		
	Black Bullhead		
	Brown Bullhead		
	Yellow Bullhead		

No.	OBNOXIOUS FISHES	Age	Remarks
	Short-nose Gar		
	Long-nose Gar		
	Dog fish		
	Carp		
	FORAGE FISHES, etc.		
	Northern Dace		
	Fine-scaled Dace		
	Red-bellied Dace		
	Black-nosed Shiner		
	Black-chin Shiner		
	Mimic Shiner		
	Straw-colored Shiner		
	Spot-tail Shiner		
	Common Shiner		
	Golden Shiner		
	Blunt-nosed Minnow		
110	Fat-head Minnow		
	Tadpole Cat		
	Mud Minnow		
	Menona Killifish		
	Black-banded Top-m.		
	Log Perch		
	Johnny Darter		
	Iowa Darter		
	Least Darter		
	Silversides		
	Muddler (*bairdii*)		
	Brook Stickleback		