Original: Fish Division
cc: Mr. Loy Johnston 4-15-41 (6 more 5-1-41)
Mr. Eschmeyer 4-15-41
Education-Sand
Div. Field Adm. - Ewen 4-15-41
Mr. Leonard Erickson 6-9-41
Mr. Kronski - Gogebic - 5-1-41
County Road Commissioner
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INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
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ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

Clerk, Berglan Twp. Bd.
Berglan

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REPORT NO. 657

FISHERIES SURVEY OF LAKE GOGEBIC, ONTONAGON AND GOGEBIC COUNTIES

by
Paul H. Eschmeyer

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I. INTRODUCTION

A. Location

Lake Gogebic, the largest of the inland lakes of the Upper Peninsula of Michigan, has its surface area approximately equally divided between Gogebic and Ontonagon counties. From its southern extremity in Section 3, T. 46 N., R. 42 W., Marenisco Township, Gogebic County, the longer axis of the lake is projected in a northwesterly direction into T. 47 N. (R. 42 W.), where its waters cover all or considerable portions of Sections 34, 27, 26, 23, 22, 21, 17, 16, 15, 10, 9, 8, 6, 5 and 4. The latter two sections are immediately adjacent to the south boundary of Bergland Township, Ontonagon County, from which point the lake extends northward into T. 48 N. (R. 42 W.), entering Sections 33, 32, 31, 30, 29, 20, 19, 18, 8, 7, 6, 5 and 4. The western extremity of the lake juts into Sections 12, 13 and 24 of R. 43 W. (T. 48 N.).

Lake Gogebic lies near the headwaters of the Ontonagon River, the West Branch of which drains from the north end of the lake before joining the main stream about 18 miles northeast of this point and finally entering Lake Superior near the village of Ontonagon.

The villages of Merriweather, Lake Gogebic and Bergland are located adjacent to the north shore of Lake Gogebic, while Gogebic Station and Marenisco are four miles southeast and seven miles southwest, respectively, of the south boundary of the lake. The body of water is readily accessible both by highway and railroad. State Highway M-28 passes through the above-mentioned villages on the north side of the lake, while M-64 skirts the entire length of its west shore. Highway U.S.-2 passes within three miles of the south end of the lake, and an improved gravel road connects this highway with the southwest shore. The Duluth, South Shore and Atlantic Railroad approximately parallels Highway M-28 on the north side of the lake, and the Chicago

and Northwestern Railroad stops at Gogebic Station, four miles southeast of the water.

B. Map of Lake Gogebic

Incidental to the completion of a biological inventory of this water by the Institute for Fisheries Research in June, 1938, a shoreline, bottom contour and soil type map was prepared. The outline map was provided by the U. S. Forest Service,and the depth contours and bottom types were determined by a C.C.C. crew under U. S. Forest Service supervision. The bottom was retyped by the Institute survey party during the summer at the time the vegetation distribution was determined.

C. Survey

During the period extending from June 16 to 27, 1938, a regular biological survey was made of this lake by an Institute for Fisheries Research survey party*. The U. S. Forest Service assisted in the work by defraying a major portion of the field expenses of the party for the duration of the survey.

D. Past History of Fishing

The past history of the fishing on Lake Gogebic has been reported in part by the late Dr. Jan Metzelaar**, who made a preliminary biological investigation of Lake Gogebic in 1928. Dr. Metzelaar says in part:

> "The interesting history of the fishing on Gogebic Lake forms a story which has spread to the four corners of the Great Lakes, but on which it is hard to get accurate details. From miscellaneous information I have sifted the following notes. In the 19th century Gogebic Lake was one of the outstanding, famous bass lakes of the States. Small mouth bass predominated, next to which came large mouth bass, rock bass, followed by bluegills and sunfish. No strictly predatory fish were present, but

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*The party included Dr. Carl E. Hoffman, leader; Joe Bailey and Hugo Kilpela, assistants.

**Metzelaar, Jan. Preliminary Report on Gogebic Lake, Michigan. Department of Conservation, 1928 (manuscript).

"minnows and shiners" were abundant and in certain seasons could be found swimming inshore in large numbers.

"In 1898 (some reports say as early as 1892) grass pike (northern pike) were introduced; 84 good sized specimens of this fish, and also 18 muskies were freed in the Gogebic waters. Soon after this introduction large pike were caught and in goodly numbers, the record being 27 pounds. In later years both numbers and size dwindled and no remarkable pike have been caught since 1925 or 1924, which coincides with the rise of the Walleyes.

"Pike perch or Wall-eyed pike were successfully introduced as fry around 1913 and their history runs very much parallel to that of the grass pike. Ten years after their introduction they were caught in numbers with hook and line, the weight running up to 16 pounds. At present numbers have dwindled down and the record in recent years has been around 10 pounds.

"In both cases we find, therefore, that the second generation -- born from the first introducees -- upon reaching maturity offered splendid fishing, but that there was no sustained yield.

"What happened in the mean time with the other fishes of the lake? If we may believe the reports of seemingly trustworthy residents, their fate under the combined assaults of the two fresh predators has been anything but happy. To make a sad story brief: large mouth bass, bluegills, sunfish, minnows and shiners are no more in the lake. Diligent search in the nooks and bays probably would reveal some survivors of the bass family outside small mouth bass (which still is present in moderate numbers) and the crappie."

Other sources of information reveal that Mr. John Haskins and others living near Lake Gogebic did some commercial hook and line fishing for northern pike from 1904 to 1915. It is reported that about 125 pounds of pike per day per boat of two men was an average catch during the season, with maximum catches approaching 400 pounds. The fish were iced and shipped to Bessemer, where a price of five cents per pound was obtained.

Dr. Metzelaar lists the fishes present in the lake in 1928 as including dogfish, perch, northern pike, walleyes, black crappies, smallmouth bass, brook trout, common suckers, and rock bass. He adds further that the lawyer should probably be added to this list, but gives no records upon which this addition might be based. It is also stated in his report that bullheads were at one time fairly abundant in the lake.

In general, Lake Gogebic has had the reputation of being a good fishing lake up until 1936, and has been fair since that time. Local residents seem agreed that fishing during 1940 was considerably better than it has been for some years. Fishing is of medium intensity (as to numbers of fishermen) during the summer, and some ice fishing is done in winter.

E. Recreational Uses Other Than Fishing

As might well be expected in a lake of the size, scenic beauty and accessibility of Lake Gogebic, recreational uses of the area are not restricted to fishing. A state park, two county parks and a public fishing site are located on the lake for public use and enjoyment. Somewhat over 200 cottages, concentrated chiefly on the northwest and southwest shores, dot its periphery; and three hotels, five resorts and five boat liveries attest to the popularity of the lake for recreationists. Swimming is good and boating is popular among lake users.

Lake Gogebic is at the present time among the state's important fishing waters and it is expected that it will become more so in the future. Numbers of desirable cottage sites remain undeveloped, and with the present general trend toward expanding recreational activity, the very easy accessibility of this area should make it increasingly popular as an outdoor recreational center.

II. PHYSICAL CHARACTERS OF LAKE GOGEBIC

A. The Lake Basin

In shape the long, relatively shallow Lake Gogebic basin somewhat resembles a huge, twelve-mile-long boot, oriented with its long axis extending in a general direction somewhat west of north, with the four-mile-long "foot", located at its north end, forming an abrupt bend to the east. The "heel" represents the lake's westernmost extremity, while the "toe" extends almost due east. The basin is uniformly narrow in relation to its length, being at no point over 2½ miles wide. Only at the ends is it less than three-fourths of a mile wide.

B. Geologic Origin

The geologic origin* of Lake Gogebic appears to have not yet been conclusively determined. The body of water occupies a narrow depression between two major rock ranges of the Upper Peninsula, skirting the east end of the Gogebic Range (which is the eastward extension of the Penokee Range of Wisconsin) and extending northward to the Copper Range (which extends from the Keweenaw Peninsula southwestward into Wisconsin, roughly paralleling the Lake Superior shore).

It is believed reasonably certain that the Iron River valley and the basin of Lake Gogebic at one time formed a continuous depression, and that the Iron River drained the Lake Gogebic area through what is now a wind gap at the north end of the lake, and in which the river now has its headwaters. Subsequent glacial action, partially by depositing more morainic material in the gap north of Lake Gogebic than in that through which the Ontonagon River now flows, may have left the latter gap deeper than the former, bringing about the plugging of the Gogebic Lake gap, its abandonment, the diversinn of the stream across the divide separating the Iron River and Ontonagon River drainage systems, and the resultant flooding of the Gogebic basin.

Another conception of the origin of the lake is based on the competition with and the capture of certain weaker pre-glacial streams by stronger streams, leading to the abandonment of some of the gaps cut through the rock ranges by the former. This conception assumes that the Ontonagon River was one of the stronger streams and that its tributaries captured the upper course of the stream flowing in the Gogebic Lake—Iron River valley. Glacial scouring probably further deepened this valley to a limited extent and its ultimate

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*This discussion based on Scott, I. D., Inland Lakes of Michigan (Lansing: Wynkoop Hallenbeck Crawford Co., 1921), pp. 310-318.

flooding may have been due to glacial deposition in the course of the stream below Gogebic Lake.

From the above, one may conclude that, although the origin of Lake Gogebic has not yet been clearly worked out, its formation was probably due to both pre-glacial and glacial action. Pre-glacial streams apparently cut out most of the basin, followed by a certain amount of glacial scouring. Subsequent glacial deposition in the wind gap at the north end of the lake, or in the course of the Ontonagon River below this point, served to impound the waters which form what is now Lake Gogebic.

C. Surrounding Country

The landscape surrounding Lake Gogebic is in large part densely wooded and ranges from very hilly to swampy and flat. Rock outcrops and steep slopes rise from the shores of the lake at a number of places, while wide swampy areas are characteristic of much of the lake margin.

D. Drainage Basin

Lake Gogebic and its tributaries provide a drainage system which averages about 20 miles in length and eight miles in width, and approaches 160 square miles in area. The entire drainage basin is hilly to various degrees, and is densely wooded. Much of the soil drained is a sandy till.

The drainage area is served by a number of streams entering the lake from several sides. Entering its southern extremity is the Slate River, tributary to which are Pelton, Nelson and Marshall creeks, which extends the drainage basin southward and westward, abutting against the drainage of the Big Presque Isle River. Trout Creek, a stream 10 to 15 feet in width, enters the southeast end of the lake, opposite Alligator Point, and drains that portion of the area southeast of the lake which is not drained directly by the south branch of the Ontonagon River. Into the northwest corner of the lake empties the 20-foot-wide

Merriweather River, draining the area lying in the northwest portion of the drainage,- chiefly the southern approaches to the Copper Range and the relatively flat land lying between the Gogebic and the Copper ranges. In addition to these three major inlets, two smaller streams, Meri-ma-she Creek and Spring Creek, and four un-named streams enter the west side of the lake. The latter are very short and possibly intermittent. A small stream enters the lake from the north, near its outlet, just east of Bergland, and another enters the outlet from the south, between the lake and the dam. Two short streams enter the lake from the east, near Six-Mile Bay, while Fern Creek and another small stream enter the lake near the southeast corner.

E. Outlet

Lake Gogebic has a single outlet, the West Branch of the Ontonagon River, a stream about 50 feet in width, which flows from the water's northeast extremity. Crossing the outlet at a point about one-half mile east of the lake is a dam, owned by the Copper District Power Company, which in part controls the water supply to the Victoria reservoir about 17 miles downstream. The Gogebic dam raises the normal level of the lake about three feet. As a result, much of the shore line exhibits a flooded condition, with dead (drowned) trees and swampy margins covering wide areas.

F. Water Fluctuation

Fluctuation of the water is variable, apparently depending on the varying needs at Victoria. Maximum fluctuations do not exceed two to three feet except under unusual circumstances. With the exception of high water periods, the dam limits the movement of fish into the lake from the Ontonagon River, although a fish ladder at the dam is known to operate successfully at least during some portions of the year.

G. Area and Shoreline Development

Lake Gogebic has a total surface area of 14,781 acres, or slightly over 21 square miles, and a shore line which is 34-1/3 miles in length. These figures indicate a shoreline development of 2.04, which means that the lake has slightly over twice as much shore line as would have a perfectly circular lake of the same area. Other factors being equal, the greater the amount of shore line which a lake has in relation to its area, the higher is its biological productivity.

H. Depth

The maximum depth of Lake Gogebic is 37 feet. This major depression is located about 2½ miles from the north end of the lake, approximately 1,000 feet from the east shore, just south of what is locally known as "Tomahawk Bay" (near "Red Rock" and "Robinson's Rocks"). A second depression of a depth of over 30 feet occurs about 1,000 feet northeast of Barrett's Point, which is located south-centrally on the western shore of the lake.

I. Shoals and Bottom Soils

Shoal areas in the lake, which are almost without exception covered with sand and gravel, range in width from 20 feet at some points along the east shore to about a mile in a portion of the north end of the lake. A restricted area of shoal near the outlet and a smaller area at the entrance of the Merriweather River inlet have bottom soils of fibrous peat. About 20 per cent of the lake is shoal. The remainder of the basin has a muck bottom, except in a few restricted areas where sandy soils encroach toward the greater depths. In general it may be said that Lake Gogebic is a large, shallow body of water with a relatively regular declivity from the shore to the deeper water. Relative shallowness, taken by itself, ordinarily points toward higher productivity than great depth.

The shoal areas in the lake are fully adequate to meet the needs of the fish species present from the standpoint of providing spawning facilities, and, as will be again indicated later in this report, they are quite productive of invertebrate food.

J. Color of Water

The water of Lake Gogebic is dark brown in color, varying somewhat at various parts of the lake. A secchi disk (a white metal disk, about 6 inches in diameter), when lowered into the water, disappears from view at a depth as little as two feet in some portions of the lake, and is visible at depths up to nine feet at others. Color of the water is darkest near the mouth of the Slate River inlet, at the south end of the lake. Various waters of the Ottawa National Forest, within the boundaries of which Gogebic Lake lies, show secchi disk readings varying from 1.5 to 30 feet*. Such readings serve as criteria of the depth to which light penetrates given waters. The degree of light penetration constitutes an important factor in determining plant growth in a lake, since few aquatic plants are able to survive in the absence of all light. The dark color of the water, together with what turbidity is present in the lake, is no doubt responsible for the absence of vegetation in Lake Gogebic at depths of over 12 to 15 feet. In other clearer Michigan waters, higher plants exist at much greater depths.

Evidence indicates that wave action is quite severe on the east shore of the lake, and as a result, the growth of aquatic plants on the shoal areas there is largely restricted to protected bays and coves.

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*Moffett, James W. A Fisheries Survey and Management Suggestions for Some Lakes of the Ottawa National Forest, Michigan. Institute for Fisheries Research Report No. 630, 1940 (manuscript).

III. TEMPERATURE AND CHEMICAL CHARACTERS OF LAKE

A. Significance of Temperature and Chemical Data

As a part of the survey conducted at the lake, various physical and chemical data concerning the lake water itself were collected. Temperature of the water at various depths was observed, and pertinent information concerning the chemical composition of the water was obtained. Such data are very important in assisting to determine the degree of adaptability of a lake to the various fish species. All fish have certain ranges of temperature and dissolved gas content (specific for each gas) which they will tolerate, and within these ranges are optima. Not only the ranges, but particularly the optima, vary among the different fish species, as well as among food organisms and other organic life in the waters.

B. Temperatures of the Water

Temperatures were taken and water analyses made during the period extending from June 18 to June 24 at six different points in the lake. The results, listed in tabular form in Table I, show that the surface water at the time of the survey ranged in temperature from 59.9 to 75.0 degrees Fahrenheit. The change was due to a sudden change in weather soon after the survey began. Air temperatures taken at the same time indicate changes varying between 62.5 and 88 degrees. Bottom temperatures in the deeper waters (over 20 feet) showed but very slight variation, ranging from 60.4 to 60.8 degrees Fahrenheit.

C. Thermocline

Although several vertical series of temperatures showed the presence of a thermocline (a zone in which there is a rapid change of temperature, e.g., 1° C. per meter of depth) at the time of the survey, the relatively small difference (averaging less than 10 degrees) between bottom and surface water

temperature suggests instability and points to the possibility that the thermocline persists only during the height of the summer. This possibility is further strengthened by the fact that Metzelaar failed to find a thermocline in the lake in mid-September, 1928, and found a variation of only one degree Fahrenheit between surface (60° F.) and bottom (59° F.). Furthermore, the shallow character of the basin as compared to the extensive surface area would in itself lead one to predict a thorough circulation of the waters during most of that part of the year during which the lake is not covered with ice.

D. Oxygen and Carbon Dioxide

Chemical stratification, like thermal stratification, is another phenomenon which cannot be considered as being present in the lake to a degree sufficient to be limiting to fish movements. Oxygen is present in almost equal amounts at both surface and bottom, and is adequate for all species present. In so far as being detrimental to organic life is concerned, carbon dioxide content does not approach significance in any part of Lake Gogebic.

E. Hardness of the Water

The water in the lake was found to be "soft," as indicated by methyl orange alkalinity tests (designed to show the degree of hardness of the water, i.e., the alkalinity resulting from dissolved minerals and certain buffer salts). Methyl orange alkalinity of the water ranged from 18 to 34 parts per million. Apparently the drainage basin is very poor in lime. Phenolphthalein alkalinity tests (which measure hydroxide and carbonate in the water) showed no positive results. Soft water lakes are almost invariably much less productive than are those having moderately hard water. Aquatic vegetation and plankton (free-swimming microscopic plants and animals) appear to require considerable amounts of calcium carbonate for abundant growth, although this compound may be present in quantities sufficient to be detrimental. The optimum range for high productivity seems to lie between 100 and 200 parts per million.

TABLE I

Summary of Chemical and Temperature Conditions
in Lake Gogebic, June, 1938

Station	1	2	3	4	5	6
Location	In outlet, near lake	1/3 mile W. of Porcupine Point	Near Merriweather Creek Inlet	Major depression, 1000' W. of E. shore at Tomahawk Bay	Depression N.E. of Barrett's Point	Center of lake, 2000' N. of Slate R. Inlet
Date	6/18/38	6/18/38	6/20/38	6/21/38	6/23/38	6/24/38
Air Temperature, °F.	62.5	66.5	86	88	86	86
Surface Temp., °F.	59.9	62.5	74	74	74	75
Bottom Temp., °F.	60.4	60.8	64.4	60.4	60.4	74.1
Maximum Depth, ft.	7	23	5	30	28	9
Thermocline:						
Location	...	...	...	9-21'	3-18'	...
Temperature, °F.						
Top of	...	...	...	72.7	75.9	...
Bottom of	...	...	...	61.2	62.0	...
Oxygen(p.p.m.):						
Surface	8.0	8.1	5.5	8.2	8.4	8.6
Bottom	8.1	7.8	5.0	7.3	7.8	8.6
Carbon Dioxide, p.p.m.:						
Surface	1.0	1.0	5.0	1.0	1.0	1.0
Bottom	1.0	2.0	6.0	2.0	3.0	1.0
Methyl Orange Alkalinity:						
Surface, p.p.m.	26.0	25.0	20.0	28.0	26.0	24.0
Bottom, p.p.m.	34.0	21.0	18.0	29.0	28.0	28.0
pH:						
Surface	7.6	7.6	6.8	7.6	7.6	7.8
Bottom	7.4	7.2	6.6	7.0	7.0	7.8

F. pH

Hydrogen ion concentration, or pH, is a measurement of the intensity of acidity or alkalinity of the water, employing a scale of from 1 to 14, with 7 as the neutral point and figures greater and less than it becoming progressively more alkaline and acid, respectively, in direct proportion to the extent of their deviation from this neutral point. The pH of the water in Lake Gogebic ranges between 6.6 and 7.8, with most of the water being neutral (7.0) or slightly alkaline (above 7.0). Only at the mouth of the Merriweather River can any acidity be detected. Slightly to moderately alkaline waters are normally more productive than waters on the acid side of the neutral point, so from this standpoint the waters of Lake Gogebic are not far from optimum.

G. Pollution

Such pollution as may occur in Lake Gogebic is inconsequential. Cottages along the shore line of the lake and perhaps the village of Bergland are the only probable sources of domestic sewage, and there are no sources of industrial wastes in the vicinity of the lake.

IV. BIOLOGICAL CHARACTER OF LAKE GOGEBIC

A. Vegetation

Aquatic vegetation in Lake Gogebic is not particularly abundant, although it is probably present in sufficient quantity to be above the average for soft water lakes in the area. As has been mentioned, the dark color of the water restricts plant beds to the shallower shoal areas, and in much of the lake, such shoals have a sand bottom and are susceptible to considerable wind action,- conditions which hardly favor abundant plant growth and which are not easily altered by readily applied improvement methods. The principal plant beds are located in the northwest portion of the lake and in the shallow eastern end, near the outlet. Flooded areas along the shores and near the Slate River inlet

are likewise restricted areas supporting considerable amounts of vegetation. The abundance of invertebrate fish food in a lake is generally closely correlated with the abundance of vegetation, and plants serve as shelter, particularly for forage fish and young game fish. In the latter respect, in Lake Gogebic, large numbers of deadheads, large rocks, flooded brushy banks, and about 700 brush shelters placed in the lake by the C.C.C., supplement the shelter supplied to the fish by the vegetative cover.

TABLE II

Aquatic Vegetation Found in Lake Gogebic*

Location of Stations: (1)-White Flag Bay, at north end of lake; (2)-shore at Sandy Beach Resort, at north end of lake; (3)-north shore of Bergland Bay, at north end of lake; (4)-outlet, west of dam; (5)-north end of lake; (6)-shore just east of White City Resort, at south end of lake.

Station number	Species	Abundance	Extent of bed	Range in depth, ft.	Bottom type
7	Starwort (Callitriche sp.)	sparse	...	1-2	Fibrous peat
7	Sedge (Carex rostrata)	medium	...	1	" "
1	Sedge (Carex lenticularis)	dense	200 sq.ft.	0-1	" "
7	Spike rush (Eleocharis sp.)	sparse	...	1	" "
7	Horsetail (Equisetum fluviatile f. Linnaeanum)	dense	2½ acres	1	" "
1, 4	Horsetail (E. fluviatile f. minus)	medium	½ acre	0-2	" "
7	Hedge hyssop (Gratiola lutea)	sparse	...	1	" "
2	Quillwort (Isoetes Braunii)	sparse	...	4	" "
1	Loosestrife (Lysimachia quadriflora)	sparse	...	1	" "
4	Sweet gale (Myrica Gale)	medium	...	0-1	Muck
4,7	Water milfoil (Myriophyllum sp.)	...	...	3-4	"
4	Yellow water lily (Nuphar advenum)	medium	3000 sq.ft.	3-7	"
1,4,5	Yellow water lily (N. variegatum)	medium	7-3/5 acres	1-5	"
1,4,5,7	Pickerel weed (Pontederia cordata f. angustifolia)	medium	1-3/5 acres	2-3	"
1	Cinquefoil (Pontilla palustris)	sparse	...	½	"
7	Pondweed (Potamogeton epihydrus)	sparse	1/8 acre	3	sand
2,3,5,6,7	" (P. gramineus var. graminifolius)	medium	2-1/4 acres	1½-8	muck
2,3,5,6,7	" (P. gramineus f. maximus)	medium	2-1/4 acres	1½-8	"
6	" (P. pectinatus)	medium	1/4 acre	3	sand
3	" (P. Richardsonii)	sparse	1/8 acre	4-5	muck
7	Water plantain (Sagittaria latifolia f. gracilis	medium	...	2-3	sand
1,5,7	Sedge (Scirpus sp.)	medium	3½ acres	1-5	"
7	Sedge (S. fluviatilis)	medium	1/10 acre	1	"
5, 7	Bur reed (Sparganium eurycarpum)	medium to dense	400 sq.ft.	2	"
1	Water parsnip (Sium suave)	sparse	...	2	"
1	Figwort (Veronica connata)	sparse	...	1/12	"

*Identifications made by Miss Betty Robertson, Department of Botany, Univ. of Michigan.

B. Plankton

Plankton (free swimming, microscopic plant and animal life) was of average abundance in the lake at the time of the survey. Seasonal and often even daily changes in plankton numbers, however, prevent one from obtaining a true picture of their populations from a single group of samples. Animal plankton was the principal type observed, and the dominant organisms found were crustaceans.

C. Bottom Foods

Invertebrate fish food organisms present on the shoal areas of the lake were found to be relatively abundant. Dominant organisms on the shoals were mayfly nymphs, followed closely by small clams and midge larvae. The same animals dominated the bottom fauna of the deeper waters. Common, but less abundant than the first forms named, were snails and true fly larvae (Diptera). Occurring rarely or occasionally were aquatic earthworms, scuds, leeches, and the larval forms of the dragonfly, caddisfly, beetle, phantom midge, damselfly and moth. This apparent abundance of bottom food seems to indicate a higher productivity of fish food in the lake than the relative scarcity of vegetation would permit one to suspect. In view of the fact that the dominant fishes in the lake (walleyes, northern pike) are normally very largely piscivorous (fish-eating) as adults, the invertebrate food is probably quite adequate to meet the needs of the present fish population.

D. Fish Present in Lake Gogebic

Species of fish present in the lake and their relative abundance, as judged by their occurrence in the survey collections, and other records, are shown in Table III. Stocking for the four years previous to the survey is included.

TABLE III

List of Fishes Collected in Lake Gogebic, with an Indication of Their Abundance and Artificial Stocking

Species	Abundance	Collector	Total numbers stocked from 1934-37, incl.
Game Fish:			
Perch	abundant	1938 survey party	34,400
Walleyes	common	" " "	9,000,000
Northern pike	common	" " "	...
Smallmouth bass	scarce	" " "	...
Crappies	common	" " "	...
Cisco	abundant	" " "	...
Brook trout	rare	Creel census reports	...
Rock bass	scarce	Creel census and weir reports	...
Largemouth bass (?)	rare	Creel census reports	1,000
Forage Fish:			
Johnny darter	scarce	Metzelaar, 1928; 1938 survey party	...
Western long-nosed dace	rare	Metzelaar, 1928	...
Straw-colored shiner	rare	Metzelaar, 1928	...
Mud minnow	relatively common	Metzelaar, 1928; Bohland, 1940	...
Trout-perch	relatively common	Stomach analyses	...
Stickleback	relatively common	" "	...
Top minnow	rare	" "	...
Unidentified minnows (Cyprinidae)	relatively common	" "	...
Coarse Fish:			
Suckers	abundant	1938 survey party	
Bullheads	possibly extinct	reported by Metzelaar	...
Obnoxious Fish:			
Dogfish	rare	Metzelaar, 1928	...
Lawyer	rare	Creel census reports	...

Gill netting and shore seining resulted in the capture of more perch than any other fish species, with walleyes and northern pike also commonly occurring in the catch. Crappies were reported as being common and smallmouth bass as being scarce. Although only one specimen was collected in the survey nets, cisco

are reported to be abundant in the lake. Cisco rarely appear in fishermen's catches, as they are essentially plankton feeders. It is possible they are abundant at certain times -- as during the spawning season -- in restricted portions of the lake, but general abundance seems doubtful.

Forage fish in the lake are extremely scarce. Intensive seining both at night and by day, in all available types of habitat, resulted in the capture of none of the common species of forage fish which one might reasonably expect to find in such a water. A single specimen of johnny darter was captured along the north shore during several hours of night seining. Richard Bohland, who in 1940 operated several minnow traps at the north end of the lake, near the outlet, has reported* the presence of some numbers of mud minnows in the lake. Other occasional past collections of forage species, by seining and from preliminary reports of stomach analyses, are indicated in Table III.

Partially alleviating the serious paucity of forage fishes in the lake is the presence of an abundance of common suckers, the young of which probably become available to the game fishes for forage during at least some months of the year. Most of the suckers collected by the survey party were large (12" or over), but a few specimens of forage size were taken.

Dogfish and lawyers are the only obnoxious fishes which have been reported in the lake, and these are present only in very small numbers. None were collected by the survey party.

E. Creel census

Some numbers of creel census records have been secured since 1928 by Conservation Officers. In addition, a more intensive census was taken, in 1940,

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*Bohland, Richard. "Results from Minnow Traps." Institute for Fisheries Research, 1940 (manuscript).

which was in charge of Richard Bohland. The good cooperation obtained from boat liverymen and fishermen near Lake Gogebic contributed much to the value of the census. It is estimated that about 85 per cent of the fishing was covered by the census. An analysis of the complete results for 1940 is being made the subject of another report, by Louis Krumholz, of the Institute staff, and the results are merely summarized here.

The numbers of records taken before 1934 are insufficient to give an acceptable random sample of the fishing. Records taken since that time show the water to be very predominantly a walleye lake. During 1940, for example, almost 81 per cent of all fish taken were walleyes. The catch of 0.36 fish per hour is only one-third of that reported for the lakes and non-trout streams for the entire state during 1939* (1.1 fish per hour), but when the size of the fish caught is brought into the picture, probably an average of more pounds of fish were taken in Gogebic Lake per unit of fishing time than in most other waters in the state. An analysis of the table (Table IV) indicates that fishing was good in 1935 and became progressively poorer from that time until 1940, when the catch per hour rose sufficiently to double the all-time low of 0.18 fish per hour in 1939. These results compare favorably with the oral statements of local residents and anglers at Gogebic Lake.

In addition to walleyes, northern pike, perch and smallmouth bass showed up well in the fishermen's catches, with crappies occurring much less frequently. No brook trout have been recorded since 1938, and catches of rock bass, suckers and lawyers are about as poor. The largemouth bass appearing in the record may have been misidentified, and were very possibly smallmouth bass.

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*Clark, O. H. **Report of General Creel Census for 1939.** Institute for Fisheries Research Report No. 625, 1940 (manuscript).

TABLE IV

Creel Census Data for Lake Gogebic

Year	No. of fishermen	Taking no fish		Total hours fished	Legal fish caught	Catch per hour	Catch per fisherman	Ave. size of fish, inches	Illegal fish caught	No. of hrs. per fisherman-day
		No.	%							
1928	...	...	..	818.50	448	0.55	...	16.0	48	...
1929	...	...	..	139.00	77	0.55	...	15.6	3	...
1930	22	6	27	79.00	70	0.87	3.2	15.2	6	3.6
1931	30	...	..	132.00	63	0.48	2.1	14.3	8	4.4
1932	2	1	50	6.00	3	0.50	1.5	16.5	..	3.0
1933	6	1	17	20.00	14	0.70	2.3	13.8	..	3.3
1934	67	30	45	149.50	60	0.40	0.9	14.2	..	2.2
1935	68	15	22	119.50	153	1.28	2.3	18.4	..	1.8
1936	206	76	37	388.00	271	0.70	1.3	18.6	77	1.9
1937	505	270	53	1,226.00	429	0.35	0.8	17.6	91	2.4
1938	640	395	62	2,053.00	396	0.19	0.6	17.1	24	3.2
1939	354	210	59	1,234.00	220	0.18	0.6	17.7	57	3.5
1940*	2,276	987	43	8,050.75	2,917	0.36	1.3	17.1	1,268	3.5

Number and average size of each species

Year	Brook tr.		S.M.bass		Y.perch		Crappie		Walleye		N. pike		L.M.bass		Rock bass		Sucker		Lawyer	
	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size	No.	Size
1928	15	14.0	..	..	1	..	9	8.1	396	16.1	27	16.5	..	..	..	..	..	..	..	..
1929	..	..	..	..	5	10.0	..	..	72	15.7	..	..	..	..	..	..	..	..	..	..
1930	14	11.0	..	..	..	..	4	..	45	17.7	7	..	..	..	..	..	..	..	..	..
1931	..	..	3	12.0	15	10.0	..	..	46	15.6	2	18.5	..	..	..	..	..	..	..	..
1932	..	..	..	..	..	..	..	..	2	16.5	1	16.5	..	..	..	..	..	..	..	..
1933	..	..	1	..	4	8.0	..	..	9	16.4	..	..	..	..	..	..	..	..	..	..
1934	..	..	..	..	20	8.0	5	11.8	29	18.2	6	18.4	..	..	..	..	..	..	..	..
1935	..	..	..	..	11	8.0	..	..	136	18.4	6	16.5	..	..	..	..	..	..	..	..
1936	..	..	..	..	20	9.2	..	..	220	18.2	31	21.3	..	..	..	..	..	..	..	..
1937	..	..	..	..	5	10.2	5	11.0	390	17.7	29	18.7	..	..	..	..	..	..	..	..
1938	1	12.0	2	13.0	52	11.3	4	11.5	300	16.7	37	19.1	..	..	..	..	..	..	..	..
1939	..	..	1	11.0	10	11.5	2	12.0	151	17.9	56	18.6	..	..	..	..	..	..	..	..
1940*	..	..	72	14.1	71	11.3	31	13.3	2359	17.3	367	17.5	7**	14.7	7	7.3	1	15.0	2	17.0

*These data from intensive creel census report; remainder of material from general census.

**Identity questioned. Probably smallmouth bass, misidentified.

Taking the records of the fishing as a whole, it appears that during the period in which a census has been taken, the chance of a fisherman catching fish on any given trip has been little better than 50:50, but the chance of such fish being good-sized, i.e., over 17 inches long, has been about as good.

F. Growth Rate of Fishes of Gogebic Lake

The ages, average lengths, and, in most cases, average weights of game fish collected at Lake Gogebic in 1929, 1938, and 1940 are shown in Tables V and VII. A comparison of the growth rate of walleyes collected in 1940 in Lake Gogebic and several other northern Michigan lakes is shown in Table VI.

The growth rate study shows that the average growth of walleyes changed somewhat during the eleven-year period extending from 1929 to 1940. Whereas a walleye reached legal size (14 inches) in 1929 only after almost five summers of growth had been completed, the same length was being reached more than a full year earlier in 1940. From a growth rate in 1929 which was far below the apparent average (judging by the available data) for walleyes in northern Michigan lakes, the growth was nearer, though still below, the average in 1940. In addition to the data shown in Table VI, inconclusive data for Thousand Island Lake, Gogebic County, show that legal length is reached late in the third summer of growth, and in Pickerel Lake, Iron County, legal size is apparently reached during the second summer*.

Scale readings show that yellow perch reach legal length (6 inches) at about the middle of their second summer of growth. This constitutes very excellent growth for perch in inland waters of Michigan, and suggests that this

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*Moffett, James W. A Fisheries Survey and Management Suggestions for Some Lakes of the Ottawa National Forest, Michigan. Institute for Fisheries Research Report No. 630, 1940 (manuscript).

species should be among those encouraged in future management practices. The largest perch taken, a seven-year-old female, was 14.9 inches in length and weighed 1-7/8 pounds. Weights taken of several specimens of other age groups indicate that the perch are in good condition. Growth has been consistently good for all three years for which data are available, as shown in Table VII.

Scales collected from 12 northern pike during the summer of 1940 indicate that legal size (14 inches) is reached during the second summer of life (Table VII). This rate of growth, while based on an insufficient number of scale collections to be conclusive, compares fairly well with the average for northern Michigan lakes.

Insufficient data have been collected to give any reliable indication of the growth of other species in the lake. Further collections would be highly desirable.

TABLE V

Ages*, Average Lengths and Average Weights of Walleyes in Lake Gogebic

Year:	1929			1938			1940		
Growing seasons completed	No.* of specimens	Average length, inches	Average weight, ounces	No. of specimens	Average length, inches	Average weight, ounces	No. of specimens**	Average length, inches	Average weight, ounces
1	...	...	...	2	7.4	1.7	...	...	...
2½	9 (5)**	10.3	7.6	...	...	...	...	...	...
3	...	...	...	...	...	...	1	13.1	9.5
3½	23 (17)	12.1	9.8	...	...	...	...	...	...
4	...	...	...	...	...	...	19 (17)**	15.1	16.9
4½	18 (13)	13.8	14.1	...	...	...	2	16.4	23.7
5	...	...	...	...	...	...	13 (12)	17.5	25.1
5½	20 (14)	14.7	16.7	...	...	...	...	...	...
6	...	...	...	1	17.7	29.5	13 (10)	18.1	30.9
6½	81 (54)	15.4	19.4	...	...	...	...	...	...
7	...	...	...	1	23.1	56.0	1	18.7	...
7½	42 (32)	16.0	22.2	...	...	...	...	...	...
8	...	...	...	...	...	...	2	21.1	49.5
9	...	...	...	...	...	...	1	23.7	61.0

*Growth determinations made by W. C. Beckman.

**Figures in parentheses give number of specimens on which average weight was determined, when other than the number used to find average length (not all specimens were weighed).

TABLE VI

A Comparison of Average Lengths of Walleyes in Lake Gogebic in 1940 and Those of Walleyes in Other Waters

Growing seasons completed*	Lake Gogebic		Black Lake** Cheboygan Co.		East Twin Lake** Montmorency Co.		Long Lake** Alpena Co.	
	No.	Av.wt.	No.	Av.wt.	No.	Av.wt.	No.	Av.wt.
2	..	..	2	9.5	2	9.3	..	..
3	1	13.1	..	..	40	14.7	2	8.5
4	19	15.1	1	18.3	29	16.5	1	14.4
4½	2	16.4	..	..	..	..	..	..
5	13	17.5	4	19.4	17	18.3	1	17.6
6	13	18.1	..	..	3	20.0	1	18.4
7	1	18.7	3	20.5	..	..	..	..

*Growth determinations made by W. C. Beckman.

**Figures from Crowe, W. R. Population Analysis of East Twin Lake. Institute for Fisheries Research Report No. 590, 1940 (manuscript).

TABLE VII

Ages*, Average Lengths and Average Weights of Game Fish Other than Walleyes Taken from Lake Gogebic

Year:	1929		1938			1940		
Summers growth completed	No. of specimens	Average length, inches	No. of specimens	Average length, inches	Average weight, ounces	No. of specimens	Average length, inches	Average weight, ounces
Perch:								
2	..	..	3	8.2	4.4	..	..	..
3	..	..	1	8.3	4.7	1	10.6	10.0
3½	35	9.9	..	..	..	..	..	..
4	..	..	1	9.1	5.8	..	..	..
4½	27	10.8	..	..	..	..	..	..
5	..	..	1	11.5	15.3	5	13.6	20.6
5½	8	11.7	..	..	..	..	..	..
6	..	..	4	12.4	17.0	..	..	..
6½	17	11.9	..	..	..	..	..	..
7	..	..	3	12.4	17.6	1	14.9	30.0
7½	5	12.7	..	..	..	..	..	..
8	..	..	1	13.1	19.3	..	..	..
8½	3	12.9	..	..	..	..	..	..
9	..	..	1	13.8	24.0	..	..	..
9½	1	12.9	..	..	..	..	..	..
Northern pike:								
2	..	..	..	..	..	3 (2)**	14.9	12.0
3	..	..	..	..	..	9 (8)**	18.7	23.4
Crappie:								
6	..	..	..	..	..	1	13.4	18.0
Rock bass:								
8	..	..	..	..	..	1	11.4	..

*Ages determined by W. C. Beckman.

**Figures in parentheses give number of specimens used to determine average weight.

G. Food Habits of Gogebic Lake Fishes

A study of the food habits of the dominant fish species of Lake Gogebic is in progress at the time of this writing. The complete results will be made the subject of a separate report by Dr. James W. Moffett of the Institute staff, and only a partial summary is given in the following table (Table VIII). The table shows that the food menu of walleyes in the lake is dominated by burrowing mayflies and young perch, with ciscoes (6 to 10 inches long) forming a goodly portion of the diet of particularly large fish. Metzelaar, also, found the mayflies dominant in 15 walleye stomachs examined in 1928, but found no young perch. A young walleye was found. Perch, which are frequently piscivorous in other Michigan waters, depend almost exclusively on invertebrate food (particularly burrowing mayflies and scuds) for their sustenance. Virtually all food taken by ciscoes consisted of zooplankton, in which Daphnia (water fleas) predominated almost to the exclusion of all other forms.

TABLE VIII
Principal Food of Perch and Walleyes in Lake Gogebic

Food items*	Perch	Walleyes
Burrowing mayflies (Hexagenia sp.)	Very abundant	Very abundant
Other mayflies (Ephemera and Baetidae)	Infrequent	Infrequent
Dragonflies (Anisoptera)	...	Infrequent
Willow or alder flies (Sialis sp.)	Infrequent	...
Scuds (Amphipoda)	Abundant	...
Crayfish (Cambarus)	Infrequent	Infrequent
Mollusca	Rare	Rare
Crustacea (Leptodora)	...	Rare
Water beetle (Dytiscidae)	Rare	...
Perch (Perca flavescens)	...	Abundant
Trout-perch (Percopsis)	Common	Common
Minnows (Cyprinidae)	Common	Common
Stickleback (Eucalia and Pungitius)	...	Common
Mud minnows (Umbra limi)	...	Infrequent
Ciscoes (Leucichthys)	...	Abundant in large specimens
Top-minnow (Fundulus sp.)	Rare	Rare
Common sucker (Catostomus)	...	Infrequent
Snapping turtle (Chelydra)	...	Found once

*Analyses conducted by Bert Hunt.

H. Natural Propagation

Natural propagation of the dominant fish species in Lake Gogebic appears to be quite successful. The beds of vegetation present in the lake apparently consistently and very adequately meet the spawning needs of the yellow perch. Metzelaar collected some numbers of perch fry in 1928 and again in 1929, when his collection records make note of an "incredible number of young perch" and "thousands of perch." Considerable numbers of young perch were collected by the 1938 survey party. This consistent appearance of large numbers of perch fry can certainly not be attributed to the rather limited artificial plantings made.

The spawning habits of the walleye have never been very clearly worked out and repeated heavy annual stocking of walleye fry makes it difficult to determine the exact source of walleye reproduction. However, the consistent presence of some numbers of walleye young at various parts of the lake and the dominant position of the walleye among the game fish of the lake make it almost certain that sustained natural propagation has been characteristic of the lake ever since the species was originally introduced. Metzelaar collected walleye fry in the lake in 1928 and again in 1929, and the young were found to be fairly abundant by the survey party in 1938. Bohland* observed concentrations of walleyes in Gogebic Lake in the spring of the year which might have been exhibiting spawning behavior.

Northern pike have sustained their numbers since their original introduction entirely without the aid of artificial stocking. Spawning probably occurs in some of the extensive flooded areas along the lake shore, or at the flooded

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*Bohland, Richard. Notes on Walleye Spawning in Lake Gogebic. Institute for Fisheries Research, 1940 (manuscript).

mouths of inlet streams. It is particularly suspected that they spawn somewhat upstream from the mouth of the Slate River. At the suggestion of Roy Johnston, District Supervisor of Fisheries Operations, further investigation of the extent of spawning by game fish in this and other tributaries of the lake is to be undertaken this spring. The comparatively large numbers of northern pike caught, as shown by creel census records, and the not infrequent occurrence of yearling and juvenile specimens in the survey nets in 1938, support the conclusion that adequate spawning facilities for the pike are available.

The extensive gravelly and sandy shoal areas certainly provide favorable spawning conditions for the centrarchid fishes, which in this case are limited to the smallmouth bass, rock bass, crappie and possibly largemouth bass. Restriction of numbers of these fish is probably due to extensive predation on the young by the carnivorous fishes (walleyes, northern pike, crappies and perch), rather than inadequacy of spawning facilities.

Suckers (as well as the few brook trout present) probably migrate up the inlet streams to spawn. Not only is an abundance of adult suckers present in the lake, as shown by survey reports, but the frequent occurrence of very young suckers in collections made there, indicate not only good natural reproduction, but a return to the lake from the streams while the fish are still of forage size. Their infrequent occurrence in walleye stomachs, however, as shown in Table VIII, leaves their value as a forage fish under the conditions extant at the lake open to question.

Ciscoes require no specialized spawning facilities, since spawning takes place in late fall in the open water above shoal areas.

In summary, the lake and its inlets provide a sufficient variety of

habitats and conditions to permit the generalization that spawning facilities are adequate for all species now present in the lake.

I. Results of Fish Weir Operation

Since April, 1940, a fish weir has been in operation just above the dam in the outlet of Lake Gogebic to determine the nature and extent of fish movements to and from the lake. For some years local residents and sportsmen have suspected that walleyes were escaping each year down the Ontonagon River outlet and failing to return. Requests that measures be taken to prevent such movement led to a special study of the problem, incidental to the completion of which the weir was constructed. The complete results of its operation are being made the subject of a separate Institute Report by Mr. W. F. Carbine, and only a brief summary of the findings is shown in the table below (Table IX).

TABLE IX

Summary of Results of Operation of Weir at the Outlet of Lake Gogebic from April, 1940, to December 31, 1940

Species	Number going downstream	Number going upstream
Sucker	417	163
Walleye	56	45
Northern pike	10	11
Crappie	7	2
Perch	2	3
Rock bass	3	55
Smallmouth bass	3	2
Totals	498	281

The results clearly indicate that the movement of fish out of the lake during the last nine months of 1940 did not have any real significance. The figures do not in any way justify the erection of a barrier at the outlet of Lake Gogebic to prevent such movement.

V. MANAGEMENT SUGGESTIONS

A. Classification

Lake Gogebic is classified as a pike lake and there is no reason for changing that designation. The pike -- northern and walleye -- together with perch, completely dominate the game fish population, and present indications point toward an indefinite continuation of this dominance.

B. Stocking

The question of stocking in Lake Gogebic might best be approached by a further consideration of certain aspects of the present fish population.

Perhaps the most striking feature of Lake Gogebic from the viewpoint of the fisheries investigator is the scarcity of forage minnows. Metzelaar has indicated (1928) that up until 1900, "minnows and shiners" were reported abundant, but that since that time, numbers have become extremely limited. Collection records based on ten hauls with a 120-foot seine and extensive gill netting in that year show evidence of capture of one western long-nosed dace, one straw-colored shiner, two mud minnows, and two johnny darters. As has been mentioned, intensive day and night seining by the 1938 survey party resulted in the collection of only one johnny darter and a few young suckers, while Bohland, in 1940, reported the taking of limited numbers of mud minnows. Food studies reveal that the trout-perch, stickleback, top-minnow and common

shiner also occur occasionally as forage. Dr. A. S. Hazzard, Director of the Institute, has reported (orally) seeing some unidentified minnows schooling on shoal areas near the west shore in front of the State Park.

Irrespective of the above occasional records, the forage population in Lake Gogebic has for more than the past decade been critically low. In the absence of purely forage species, almost the entire fish production of the lake has been principally built around the yellow perch. This species, very frequently largely piscivorous in other waters, is here the predominant insectivorous bottom feeder, harvesting the adequate quantities of invertebrate food present, growing swiftly and reproducing in prolific abundance. It, in turn, provides the most important food item of the walleye (see Table VIII), the dominant food fish in the lake. Also, although no stomach samples have been collected at Lake Gogebic to permit a statistical analysis, experience in other similar waters does not allow one to doubt that young perch form the bulk of the diet of northern pike, crappies, and possibly smallmouth bass (not to mention dogfish and lawyers). Finally, in its own right, the species provides excellent pan fishing, especially in Lake Gogebic, which has acquired more than state-wide recognition among fishermen for its unusually large perch. Probably the large average size of the perch caught is due to the control of the perch population by walleyes and other predacious species, as they are not permitted to become numerous enough to become stunted.

As shown by scale studies (see Tables V and VI), walleye growth was very slow in 1929, but appeared to be much nearer the average for walleyes in northern Michigan in 1940. The reason for the change in growth rate was very probably due to a natural cycle involving a change in the relationship between

the population of walleyes and the supply of available food. It is possible that at some time, not far from 1929, the walleye reached its peak of abundance resulting in overpopulation, or the food supply, for some cause or other, had become decreased to a minimum, or perhaps both. In any event, the walleyes were very definitely stunted. When a carnivorous fish reproduces in uncontrolled abundance in a given water, a period is ultimately reached during which the food supply becomes limiting because the fish has reduced its own sustenance to the point where starvation occurs. Stunting of the population results, and continues until the population of game and forage species in some way readjusts itself, so that another cycle can begin. This readjustment may take place as a result of an increase in the food supply or a decrease in the population of the predator (or both). Since, in Lake Gogebic, the walleye growth was considerably more rapid in 1940 than in 1929, it may be safely assumed that a partial readjustment has taken place. Insufficient data have been collected at Lake Gogebic during the past two decades to permit a definite statement regarding the exact course of this partial readjustment, but a brief analysis of the possibilities on the basis of the sparse data available should not be out of order here, if this insufficiency is borne in mind and no binding conclusions are arrived at.

The first possibility -- that of an increase in the food supply -- is based on the 1928 and 1929 collection records of Metzelaar. These records show that at the Hillcrest Dock, there were collected 46 perch in July, 1928, and in July, 1929, at the same point, "thousands of perch" were collected, and note was made of an "incredible abundance of young perch." Had more collections been made at other parts of the lake during the two years, under

similar conditions, consistent similar results would permit one to conclude that there was a tremendous difference in the population of young perch during the two years. In view of the fact that in 1940 the major food of juvenile and intermediate sized walleyes appeared to be perch (see Table VIII), and since perch were not prominently mentioned in the earlier history of the lake and none were found in the stomachs of walleyes examined in 1928 (although a young walleye was found), one may arrive at the possibility that the perch finally outdistanced continued predation, built up a stock of large breeder fish, and first really became established about 1929. If that was the true course of events, the walleye since that time has thrived with the continued success of the perch.

The second possible reason for a favorable partial readjustment of the predator-prey relationship -- reduction of the population of predators -- is projected into the picture by the unusual mortality of walleyes which was reported in the spring of 1937. Figures describing the losses have ranged from a mere 500 to as many as 20,000. Unfortunately, no actual counts were made at the time of the mortality. It is possible that if the latter figure is more nearly correct, the population of adult walleyes was reduced sufficiently to provide more food and hence faster growth for the remainder. Such increase in growth, however, if it occurred, is not reflected in the scale samples of the few specimens collected in 1940 which had survived the 1937 kill.

Irrespective of the means by which the partial readjustment of the predator-prey relationship may have occurred, it has not been complete, and walleyes still show a growth rate considerably slower than one might reasonably expect for Lake Gogebic. It is very logical to assume that the absence of an adequate food supply (forage fish) is still responsible for the slow growth. This is substantiated by the extensive consumption of burrowing mayflies

(as shown in Table VIII) by a species which is under most situations almost exclusively piscivorous.

In the light of the above discussion, it is logical to here recommend the stocking of only such species as can be used for forage during some or all of their life span and which are not essentially piscivorous as adults. Metzelaar in 1928 recommended the introduction of the spot-tailed shiner (Notropis hudsonius), and this species would without doubt be a valuable addition to the lake fauna if it could be established. Other species of shiners might be tried to advantage. It is expected that the best plan would be to introduce the forage species from some neighboring water, if waters supporting an abundance of such food fish can be found. Stocking with forage species should be just as heavy as possible, to best insure the establishment of a population of food fishes in Lake Gogebic. Overstocking with such species need not be feared.

The historical record of past fishing in Lake Gogebic, related earlier in this report, indicates that bluegills and sunfish were once abundant in the lake. This occurred while biological conditions were, to the best of our knowledge, very similar to those now extant in the lake, except that the two highly predacious fishes -- the walleye and northern pike -- were absent. In view of the relative abundance of invertebrate bottom food, on which bluegills and pumpkinseeds chiefly feed, it is recommended that a deviation be made from the established policy of not stocking bluegills and pumpkinseeds in pike lakes, and that an experimental planting of several thousand bluegills (preferably adults) be made. Stocking should be undertaken behind or in dense vegetation, preferably at the north end of the lake, and several individual

plants should be made at well scattered points. Careful checking at intervals after the stocking and a continuation of the creel census would indicate the degree of success of the planting. Future policy as regards such plantings might be based on the results of this first stocking.

It is recommended that no walleyes be stocked for a period of from three to five years, until the results of such action can be ascertained and a further program decided upon. Continued study of the walleye by collection of further series of scale samples at the lake each year will reflect any change which may take place in the rate of growth. In the absence of hatchery fry, the extent of natural reproduction can be more readily and accurately estimated by the collection of fish on the shoals during the summer months. A continuation of the creel census will reflect any significant change in the catch which might be ascribed to the change in the stocking program. It is entirely possible that the continued stocking of millions of walleyes each year is acting directly to exhaust the food supply and reduce the average growth of the walleye sufficiently to hold it below keeper size for about a year longer than the average for the area. Thus, continued stocking might actually be tending to hold down the numbers of legal walleyes in the lake.

Perch in Lake Gogebic are apparently maintaining their own numbers by natural reproduction, and at the same time furnishing large amounts of food in the form of forage to predator fishes. Stocking of perch, unless undertaken in terms of several millions of fingerlings, would probably have no significant effect on the lake -- beneficial or otherwise. In view of the apparent adequacy of natural reproduction, further planting of perch is not specifically recommended. However, past stocking records for the lake lead one to infer that a precedent has by this time become established which requires that several

million walleye fry be placed in the lake each year. If strong and persistent pressure for the continuation of such a program results in spite of the above recommendation that it be discontinued, and the public relations aspect of the problem justifies the expense, perch may be substituted for walleyes and planted in almost any numbers without harm to the lake. Lake Gogebic will not become overpopulated with perch while the present populations of walleyes and northern pike persist. It should be kept in mind, however, that perch are generally carnivorous as adults and that heavy stocking with this species in place of walleyes might prevent the establishment of forage minnows and bluegills.

C. Predators

Lake Gogebic is practically devoid of predators other than the fish themselves. Very few turtles and snakes are present. Ospreys and other fish-eating birds are seen only infrequently, and do no significant damage to fish life at the lake. No control measures for predators at the lake can be justified.

D. Parasites

The 1938 survey party reported no heavy infestation of parasites in any of the fish species collected. The cause of the previously mentioned, heavy mortality of walleyes in 1937 was never clearly determined. It has been claimed by some numbers of local residents and fishermen that the loss sustained at the time can be attributed to the stripping of eggs and milt from native Lake Gogebic walleyes during the spring of that year, for use in the walleye hatchery at the south end of the lake. Others regard the loss as having been due directly to the action of violators, who are said to have used calcium carbide in large quantities to kill the fish. Both of these

explanations may be dismissed as being without foundation. In the former case, it may be noted that only limited numbers of walleyes were stripped during the hatchery operations of 1937 (nothing approaching the numbers most frequently estimated as having been killed,- namely, 10,000 or over). Also, there is no reason to suppose that careful stripping of ripe walleyes results in any appreciable mortality. In the latter case, the lethal action of calcium carbide in an open lake, to such an extended degree, is highly questionable, and it is not reasonable to suppose that such a large kill could possibly have been made without the violators having been apprehended, or the cause of death having been easily determined at the time of the kill.

A similar mortality of walleyes in several Wisconsin lakes in 1937 was reported to Dr. Hazzard by Dr. Chancey Juday, Director of the Wisconsin Natural History Survey. A bacterial disease was found to be responsible.

There is at present no infestation of parasites at Lake Gogebic sufficiently severe to justify control measures.

E. Cover

The amount of cover present seems adequate for meeting the immediate needs of the present fish population. The flooded shores are quite brushy, with deadheads and large rocks characteristic of many of the shoal areas. The vegetation, although not very abundant in the lake as a whole, is quite dense in some areas. Seven hundred brush shelters have been added to provide further shelter. Once the populations of game and forage fish become properly balanced, adequate cover will probably be present for all species.

F. Regulation of Water Level

The dam which crosses the outlet of Lake Gogebic about one-half mile below the main body of the lake raises the water level 30 inches above its

original depth. It is a decided asset to the body of water from the standpoint of the management of the dominant fish species. Its presence has resulted in the flooding of extensive shallow areas near the outlet and inlet and in the northwest portion of the lake, which provide excellent spawning grounds for northern pike, perch, and possibly other species. Although the structure permits a possible fluctuation of the water level of thirty inches, such fluctuation as results from its operation occurs chiefly during late July and thereafter, and, as a result, is not limiting or injurious to the activities of spawning fish. The fluctuation of the water level in Lake Gogebic is shown in Table X, which is taken from daily recordings made by the Gogebic County Road Commission, for a period extending from August 1, 1936 to March 1, 1941. Half-month intervals are included for the period of the year which may be assumed as being in any measure critical for the completion of the spawning and rearing of fish species indigenous to the lake.

An inspection of the table reveals a situation which has been found to be ideal for the spawning and rearing of northern pike and perch in other Michigan waters*. Water levels of Lake Gogebic are kept low until the break-up of the ice in the spring, when a very high level is attained and held until late June, at which time the waters begin to slowly recede and approach normal levels. Besides providing abundant spawning grounds, the flooded areas provide ample food and shelter for the newly hatched fry. Recession of the water is sufficiently gradual to prevent the stranding of either parent or offspring. The most rapid drop in level which the lake has experienced during the spring, since records were first taken in 1936, was during the period extending from June 5 to June 10, 1938, when the level dropped 0.5 feet in five days, or 0.1 foot per day. Even this is sufficiently slow to permit the withdrawal of any fish present from the

*Carbine, W. F. Institute for Fisheries Research Report No. 583.

shallow areas to the safety of greater depth. The maximum drop in level during any given 15-day period between the dates of April 1 and June 15, from 1937 to 1940, inclusive, has been 0.65 feet, or about 0.04 feet per day. Considering the precipitous banks which enclose most of the flooded shallows bordering the lake and thus restrict their area, it is highly improbable that a significant number of fry were left stranded as a result of such a change in water level (i.e., a change of 0.65 feet in the water level would not appreciably increase the area of the available spawning grounds and thus encourage spawning in areas where stranding would occur).

TABLE X

Fluctuation of the Water Level of Lake Gogebic from August 1, 1936 to March 1, 1941

(This table is based on figures supplied by the Gogebic County Road Commission, Bessemer, Michigan. Figures not preceded by a minus (-) sign represent the amounts in feet and tenths of feet by which the water level on the indicated date exceeded the normal, original water level of Lake Gogebic, before the dam was placed in the outlet. Negative figures indicate a water level lower than the original level.)

Day and Month	Year					
	1936	1937	1938	1939	1940	1941
Jan. 1	...	0.2	1.0	2.8	0.3	2.2
Feb. 1	...	0.5	0.9	2.9	0.2	2.3
Mar. 1	...	0.5	0.4	2.9	0.2	2.3
Apr. 1	...	0.6	3.0	2.2	0.3	...
Apr. 15	...	0.4	2.8	2.2	0.9	...
May 1	...	2.8	3.0	3.4	3.2	...
May 15	...	2.7	2.8	2.8	3.0	...
June 1	...	2.8	3.0	3.1	3.3	...
June 15	...	2.5	2.8	3.2	2.8	...
July 1	...	1.9	2.6	2.8	2.9	...
July 15	...	1.4	2.7	2.9	2.6	...
Aug. 1	1.0	1.4	2.6	2.5	2.6	...
Sept. 1	0.5	0.4	2.5	2.0	2.3	...
Oct. 1	0.2	0.2	2.3	1.3	1.9	...
Nov. 1	-0.1	0.6	2.2	1.1	1.3	...
Dec. 1	0.2	1.4	2.8	0.4	2.0	...

No information can be gleaned from the table (Table X) which might suggest that any change in the water level which has occurred during the past four years might have in any manner reduced the quality of the excellent spawning facilities available for centrarchid fishes (smallmouth bass, black crappie, and possibly largemouth bass). Without doubt, the high water levels occurring during and immediately after the spawning season furnish more shelter and food for the very young fish than would be present if such upward fluctuation did not occur.

If it is first carefully noted that the interests of certain land owners at the lake, whose properties are occasionally flooded by the high spring water levels of Lake Gogebic, may of necessity not be permitted priority in the molding of suggestions for the improvement of the fishery there, it seems logical to make the following recommendation: In view of the fact that the water at its present seasonal levels provides excellent spawning and rearing facilities for pike and perch, and probably improves such facilities for other species in the lake, it is recommended that the dam be retained at its present height and be operated in a manner not dissimilar to the manner in which it has been operated during the past four years. No further regulation of the water level seems necessary.

G. Spawning Facilities

As has been reported, spawning facilities are adequate for all species, and no improvement is recommended at the present time.

H. Operation of Fish Weir

It is recommended that the operation of the weir at the outlet of Lake Gogebic be continued throughout 1941. If the 1940 results are substantiated by 1941 figures, the use of the weir should be discontinued and the question of erection of a barrier to prevent fish movement out of Lake Gogebic dropped.

I. Suggestions for Further Investigations

As has been previously suggested, experimental introduction of forage species should be carefully followed through to determine the success of the stocking, and as soon as a food fish is discovered which appears to be able to maintain its numbers, every possible means should be used to encourage it. The solution of the problem of improving the fishing in Lake Gogebic appears to depend on the success or failure of the establishment of a forage population.

More scale samples should be collected each year from the more important species in the lake, and further stomach analyses made, covering as many months of the year as possible.

The creel census should be continued. No intensive census has been conducted over a period of years in a Michigan pike lake, and more information concerning catches in such waters would be valuable. Also, the creel census should serve as the ultimate judge of the success of any management practices followed at the lake.

Preliminary work by R. Bohland suggests that further study of the walleye at Lake Gogebic during the spawning season may reveal some as yet unknown, important details of the life history of this species.

Observations and investigations such as those suggested above, if conducted at Lake Gogebic, with its large population of walleyes and northern pike, may, over a period of years, contribute materially to our knowledge of management of Michigan pike lakes.

INSTITUTE FOR FISHERIES RESEARCH

By Paul H. Eschmeyer

Report approved by: A. S. Hazzard

Report typed by: Alma Hartrick