see reports 630-A & 630-B

Original: Fish Division
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Education-Game

INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
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UNIVERSITY MUSEUMS ANNEX
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November 14, 1940

REPORT NO. 630

A FISHERIES SURVEY AND MANAGEMENT SUGGESTIONS FOR SOME LAKES OF THE OTTAWA NATIONAL FOREST, MICHIGAN

by

James W. Moffett

12-28-1946

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Interest in the waters of the Ottawa National Forest and their increasing attraction to tourists, fishermen and campers, have resulted in a cooperative effort between the Michigan Conservation Department and the United States Forest Service, to examine some of these waters and to attempt formulation of management plans for them. The Ottawa Forest tract covers parts of Iron, Gogebic, Houghton and Ontonagon counties and contains many lakes and streams.

In its lake inventory program which the Institute for Fisheries Research is forwarding each year, 23 lakes in 6 of the river systems enclosed by the boundaries of this forest were studied during the summers of 1937 and 1938*. The results of the data thus obtained are assembled in this report. A preliminary report (No. 552), which included some of

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*The 1937 survey party personnel consisted of Horace E. Telford, leader; L. B. Shettles and Joseph Bailey, assistants. The 1938 survey was conducted by Carl E. Hoffman, leader; Hugo Kilpela and Joseph Bailey, assistants.

the lakes in this National Forest, was written by R. W. Eschmeyer in 1939. The lakes studied by the survey parties are listed below according to drainage systems. Their precise location is also given:

Paint River Drainage

Golden Lake - T. 44 N., R. 37 W., Sec. 25, 26, 35, 36. - Stambaugh twp., Iron County.

Lake Five - T. 43 N., R. 36 W., Sec. 5 - Iron River twp., Iron County.

Paint Lake - T. 46 N., R. 37 W., Sec. 25, 26, 35, 36 - Iron River twp., Iron County.

Winslow Lake - T. 46 N. R. 36 W., Sec. 25, 26, 35, 36 - Bates twp., Iron County.

East Paint Lake - T. 46 N., R. 36 W., Sec. 25, 36 - Iron River twp., Iron County.

Robinson Lake (Lake Twenty-seven) - T. 46 N., R. 37 W., Sec. 27 - Iron River twp., Iron County.

Harding Lake - T.46 N., R.37W., Sec. 23,24,25,26 - Iron River twp.,Iron County.

Brule River Drainage

Hagerman Lake - T. 42-43 N., R. 36 W., Sec. 2, 3, 10, 11, 34, 35 - Stambaugh twp., Iron County.

Pickerel Lake - T. 43 N., R. 36 W., Sec. 25, 26, 35, 36 - Iron River twp., Iron County.

Lake Seventeen - T. 43 N., R. 36 W., Sec. 17 - Iron River twp., Iron County.

Ontonagon River Drainage

Thousand Island Lake - T. 44 N., R. 41 W., Sec. 2, 3, 10, 11 - Watersmeet twp., Gogebic County.

Crooked Lake - T. 44-45 N., R. 40 W., Sec. 3, 10, 11, 34 - Watersmeet twp., Gogebic County.

Sucker Lake - T. 45 N., R. 39-40 W., Sec. 7, 12, 13 - Watersmeet twp., Gogebic County.

Beaton's Lake - T. 45-46 N., R. 40-41 W., Sec. 31, 32, 5, 6, 1, 12 - Watersmeet and Haight twps., in Gogebic and Ontonagon Counties.

Marion Lake - T. 45 N., R. 38 W., Sec. 29, 30, 32 - Carlson twp., Gogebic County.

Bass Lake - T. 45 N., R. 39 W., Sec. 9, 10, 15 - Carlson twp., Gogebic County.

Bob Lake - T. 49 N., R. 37 W., Sec. 2, 3, 10, 11 - Laird twp., Houghton County.

Imp Lake - T. 44 N., R. 38 W., Sec. 8, 9, 16, 17 - Carlson twp., Gogebic County.

Lake Sixteen (Bela) - T. 46 N., R. 37 W., Sec. 16, 21 - Iron River twp., Iron County.

Pilot Lake (Crystal) - T. 44 N., R. 39 W., Sec. 4, 5 - Watersmeet twp., Gogebic County.

Sturgeon River Drainage

Markey (Marquis) Lake - T. 48 N., R. 36 W., Sec. 10, 11 - Duncan twp., Houghton County.

Deerskin River Drainage
(Wisconsin River)

Smoky Lake - T. 43 N., R. 37 W., Sec. 21, 28, 32, 33 - Stambaugh twp., Iron County.

Carp River Drainage

Lake of the Clouds - T. 51 N., R. 43 W., Sec. 22 - Carp Lake twp., Ontonagon County.

Contour maps of these lakes were made by the U. S. Forest Service and the Institute for Fisheries Research. The Forest Service also provided transportation, board and lodging, and CCC assistance for the survey parties while they were in the field. Much of the equipment used was also supplied by the Forest Service. Mr. Walter Early, Wildlife Technician for the Ottawa National Forest, and Dr. R. W. Eschmeyer, then in charge of lake survey work for the Institute for Fisheries Research, selected the lakes for study. These lakes were chosen to represent, as far as could be determined, the various types present in the Forest and also included a number of "problem waters." Mr. Early spent as much time with the survey parties as his other duties would permit and helped the work greatly by facilitating transportation and the use of the CCC camps as headquarters. The cooperation of the U. S. Army and the various camp superintendents is also gratefully acknowledged.

Ralph Marks, ~~then~~ District Supervisor of Fisheries Operations for the Conservation Department, and Dan Raees, District Superintendent of the Department's Division of Field Administration, aided the survey parties through their knowledge of local fishing conditions and of the results of past stocking.

In the discussion of these lakes it is difficult to make any sweeping statements concerning all of them. Hence, each drainage will be taken in turn and each lake discussed individually.

The observations made on these lakes fall into three major categories, namely, physical, chemical and biological. Under physical observations are included: location of lake, direction of long axis of lake, prevailing wind direction, area of lake, maximum depth, approximate per cent of shoal, bottom types on shoals and in the depths, inlets and outlets, color of the water, relative transparency of the water as indicated by Secchi disc readings, air temperature and a series of water temperatures at known depth intervals from surface to bottom. The relation of these attributes to lake evaluation needs some explanation. From studies in the various phases of lake productivity it has been noted that the ratio between the area of shoal and area of the entire lake is a fair index of productivity. Shoals are usually the most productive regions of lakes and consequently a body of water with many shoals is generally more productive than one with little shoal and much deep water. The type of bottom on the shoals and their location in regard to the direction prevailing winds blow, condition their capacity for food production. A sandy, wave-beaten shoal will not produce as much food per unit area as will a protected mucky shoal. On the former, plants are unable to establish themselves and accumulations of organic matter are kept at a minimum by water currents. Furthermore, the almost constant shifting of a sandy bottom makes such a substratum unfit for many organisms relished by fish. In the latter, plants thrive unmolested and the bottom is not only stable, but well supplied with organic matter. This type of environment is more favorable to important fish food organisms. Inlets to, and outlets from, a lake are almost a necessity for the successful, natural maintenance of certain species of fish, especially those requiring current or streams in which to spawn. The control of water level in any body of water is dependent on relationships between inlets and outlets. Great fluctuations in level have ruined fishing in many natural and artificial lakes. The importance of water exchange in a lake and introduction of new substances by inlets cannot be disregarded in any productivity study.

Color and relative transparency of lake waters are indicators of plankton (microscopic life floating free in the water) production. Color also gives some indication of the general chemical nature of the water. Transparency is measured by a Secchi disc. This instrument is a white disc usually 6 inches in diameter, which is lowered into the water until it disappears from sight. The depth at which the disc is no longer visible is called the Secchi disc reading in the tables of this report. Transparency is also a measure of turbidity. Turbidity influences plankton production and plant growth by screening out light. Furthermore, silt deposition from highly turbid waters affects the bottom organisms by smothering. On the other hand, very clear waters are often not productive because they lack certain elements usually supplied by factors causing turbidity. There is a middle ground between the two extremes which seems best for maximum production.

Water temperatures are extremely important. Practically all of the animal life in a lake is cold-blooded. In such animals, the bodily activity, i.e., the rate of life processes, is dependent upon the temperature of the medium in which they live. All organisms have a certain temperature range in which they can survive. This range is divided into three parts -- minimum -- optimum -- maximum. An example of the temperature requirements and the delicate adjustments made by a cold-blooded organism to temperature changes is offered by the brook trout. The minimum limit at which this fish can survive is quite indefinite. Dr. A. S. Hazzard has pointed out in studies on certain western waters that these fish do not grow normally in very cold water (below 50° Fahrenheit). They were stunted and, although some were 6-8 years old, they had never attained legal length (7 inches). The optimum temperature range for brook trout is arbitrarily set at 55° F. to 70° F. A temperature around 60-65° F. seems most satisfactory for normal growth and reproduction. The maximum toleration limit for this species is set by Paul R. Needham at 75° F., but this limit can not be tolerated for any length of time. As brook trout and other cold-blooded forms warm up, their demands for oxygen increase, hence the upper toleration limit for this trout also depends on the oxygen content of the water. It should be noted here that, with increasing temperatures, the solubility of oxygen in water goes down. So much for the direct effect of thermal conditions on the organism itself. The relation of temperature to the water in a lake is equally important. It is known that as water cools it becomes heavier until just before freezing, when it becomes lighter. This phenomenon affects water circulation in lakes which are deep enough to minimize wave action in the lower waters. In winter, water in lakes is seldom warmer than 39.2° F., at which temperature it is heaviest. Near the ice-cover the temperature gradually goes down to freezing (32° F.); thus water directly under the ice is lighter and colder than water farther down in the lake. This condition continues until spring, when the ice melts and all the water becomes 39.2° Fahrenheit (the point of maximum density). Spring winds then mix the water from surface to bottom. With warmer air temperatures, surface water is warmed and becomes lighter than that underneath. This difference in density resists mixture by the wind and consequently a layer of surface water of varying thickness (in these lakes, from 3-30 ft. thick) becomes much warmer than water in the depths. Where these two waters meet there is a layer in which the temperature drops very rapidly. This layer is called a thermocline. The thermocline may be quite thick or quite thin, depending on the lake and the season of the year. The temperature must drop, at least, 1.8° F. for every 3 ft. in depth in this layer. This thermocline prevents the upper water from mixing with the lower water; hence, the lower water becomes stagnant during the summer, and if decomposition of organic matter in the bottom and the water itself is rapid, the oxygen supply of that water becomes exhausted. This exhaustion practically eliminates that whole lower region from the productive volume of the lake. This is due to the fact that fish and almost all of the food organisms on which they live require oxygen in their life processes. As the summer gives way to winter, the surface water is cooled, becomes heavier and sinks to the bottom, until, once again, the entire lake has a temperature of 39.2° F. and an abundant supply of oxygen because the surface waters are always charged to almost saturation from the atmosphere. Once covered by ice, water in a lake is cut off from the oxygen of the atmosphere, and the decomposition of organic matter and the respiration of organisms begin to deplete the available supply. During long winters, when heavy snows exclude light from the few plants remaining alive over winter, the oxygen might become so used up that fish can no longer survive and the so-called "winter kill" results.

Chemical observations consisted of tests for the oxygen content of the water, carbon dioxide content, Methyl Orange or total alkalinity, phenolphthalein or carbonate alkalinity, and pH or hydrogen-ion concentration. These tests were made at various depths in the lake. The oxygen content of water is very significant. As has been inferred above, no organisms can live without some oxygen. Carbon dioxide results from organic decomposition and respiration of organisms. It is a suffocating gas, very detrimental in large quantities to fish and fish food. However, some of it is necessary in the food manufacture of plants. Methyl Orange alkalinity, or hardness of the water, represents the alkalinity resulting from dissolved buffer salts and minerals. Phenolphthalein alkalinity measures the hydroxide and carbonate present in the water. These are generally in combination with some of the metals, such as calcium, magnesium or potassium. The hydrogen-ion concentration or pH is a measurement of the intensity of acidity or alkalinity of the water. The pH scale reads from 0-14 with 7.0 as a neutral point. From 0 - 7.0, acidity is expressed, and from 7-14 alkalinity is expressed. For example, a pH of 6.0 means the water is slightly acid; one of 8.0 means the water is alkaline. Very often a chemical stratification occurs at the same time as thermal stratification. Under such conditions, oxygen is absent from, or much reduced in, the water below the thermocline. In the thermocline the concentration increases rapidly toward the surface and it reaches near saturation in the water above the thermocline. The reason for this has already been explained. The content of carbon dioxide usually runs opposite to that of oxygen in a vertical series of tests. It is generally high at the bottom and lacking at the surface. Wherever there is carbon dioxide present, no phenolphthalein alkalinity will be found. Methyl Orange alkalinity usually increases slightly toward the bottom. The pH is lower at the bottom of most lakes, consequently the water is more acid there than at the surface. In general, the most productive waters are moderately hard and are slightly on the alkaline side of the pH range.

Biological observations included quantitative bottom samples to find out something concerning the relative productivity of the bottom at various depths, plankton samples, plant surveys, and fish collections. The value of these and other observations is minimized by the fact that they represent but one short period in the yearly sequence of events in lake history. But, on the basis of what is known from other lakes which have been studied intensively, some conjectures as to the entire seasonal history of these lakes can be made. The quantitative bottom samples indicate the productivity of fish food. This production depends on many environmental factors, too numerous to consider here. A few of these factors are: bottom type, exposure to waves and currents, depth of superimposed water, abundance of plants, chemical nature of the water, temperature and length of growing season. Plankton production depends on just as many factors and, in addition, light relationships and organic content of the water. Plants are a rough index of the productivity of a body of water. If all other things are equal, the abundance of plants is a definite indicator of fertility and productivity. Each of these biological observations will be evaluated and discussed further as each lake is considered.

Lakes of the Paint River Drainage

Golden Lake lies about 1.5 miles west of Basswood and 2.5 miles south of Elmwood in Iron County. It has an area of 580 acres and a maximum depth of 100 feet. Fishing on this lake is light both summer and winter. There is very little resort development around the lake; however, the University of Michigan Forestry School and a county park are located on its shores. The beaches are mostly sandy and should afford good swimming. It is easily accessible from highway M-2, which skirts the shore.

The long axis of its basin lies slightly east of north by west of south. The basin is very deep (100 ft.) and the shores slope precipitously into the depths, except at the north end. Golden Lake is a seepage lake and maintains a fairly constant level, fluctuating but little during an average year. There is an intermittent outlet which flows into Cooks Run, a tributary to the north branch of Paint River. The shores of the lake are wooded. Table 1 presents the general physical characteristics of this lake. Noteworthy are the clarity of the water (Secchi disc reading, 30 ft.), the lack of extensive shoals and the predominance of sand as a bottom type. All of these features are indicative of rather low productivity of both fish and fish food.

There is a definite thermocline in this lake (Table 2), but no chemical stratification is apparent. In August, water temperatures were low enough to be suitable for trout. Oxygen is present in the bottom waters in ample quantities and the carbon dioxide there is not concentrated enough to be detrimental. This means that there is not enough organic material in the water or on the bottom to reduce the oxygen supply. The water is very soft, containing only 4-7 parts per million of dissolved salts. It is also acid, as the pH (Table 2) indicates.

Biologically, the lake is quite barren. The few plants present consist of Lobelia, Isoetes, bur reeds and pond lilies. These plants are very scarce and scattered. Plankton was not abundant at the time of the survey (Table 3). Bottom organisms were also quite scarce. Midge larvae dominated the bottom fauna. Fish in Golden Lake are quite limited as to species and numbers. Four species of game fish and two of forage fish were found by the survey party. These are shown in Table 4. Table 5 gives the stocking records for this lake during 1934-1939 inclusive. The majority of the stocked fish were bluegills. It is interesting to note that despite these additions of bluegills to the lake, the survey party took no specimens in their nets. According to Table 6, showing growth rate of fish in the lakes under consideration, perch reach legal length in their late second or early third year of life in Golden Lake. By their fifth year, perch average around 7.2 inches in length and weigh 2.1 ounces. No scales were taken from other species. Spawning areas for smallmouth bass, pumpkinseeds and bluegills are numerous. Perch spawning facilities are very limited due to the scarcity of vegetation. However, submerged brush shelters, logs and debris might be adequate for the spawning needs of this species.

Occasional creel census records by Conservation Officers of catches made on Golden Lake during the years 1928-1936 show 8 smallmouth and 50 largemouth bass (these largemouth bass are thought to be smallmouth misidentified), 183 perch, 16 bullheads and 12 brook trout were caught in 137.5 hours of fishing. The average catch per hour was 1.9 fish. This catch per hour is somewhat above the average for the state, but consistent reports of poor fishing in Golden Lake seem to indicate that the records are not complete enough to show the true status of the fishing.

The productivity and productive potential of Golden Lake are very poor. The lake is too "clean" for good fish production. The abundance of deep water and lack of extensive shoal aggravate this condition. Very few suitable places for the establishment of vegetation are present and even if they were present, their sandy, bouldery nature would discourage extensive weed beds. The lack of dissolved salts in the water and its acid reaction inhibit many plants and fish foods which would normally become established.

Golden Lake is classified among the "all other" lakes. No change in designation is recommended at present. Smallmouth bass should be encouraged. Since 35,000 bluegills, placed in the lake during the past 5 years, failed to establish themselves sufficiently, further stocking of this species should be discontinued. It is suggested that an attempt be made to convert this lake to trout water. The introduction and establishment of cisco should precede, by 2-3 years, a heavy stocking of adult or near-adult lake trout. There are no objectional features in this lake as far as trout are concerned. In fact, brook trout survive there, as creel census records for 1933 show 12 of this species caught. When and if lake trout become established, or if they cannot be established, plantings of brook and rainbow trout should follow.

The problem of predators and parasites is not important. Fish from this lake were free of parasites and only one kingfisher and one painted turtle were seen during three days on the lake.

Cover and shelter in Golden Lake are adequate. Numerous submerged logs and brush shelters are around the shores, according to the survey party. Vegetation, almost completely lacking, offers very little cover. Installation of additional brush shelters between depths of 10-30 feet might be advisable, since encouraging vegetation in the lake under present conditions is almost a practical impossibility.

The water-level needs no regulation and spawning facilities for smallmouth bass in this lake are adequate. If fishing demands and general interest in this lake should increase, it could be made more productive by an extensive program of fertilization. By the addition to the lake of large quantities of limestone, the dissolved salt content of the water would be increased. This would tend to neutralize the acid condition of the water and encourage plants, certain species of which might have to be introduced. Concurrent with the limestone additions, systematic introduction of commercial fertilizers or even barnyard manure to enrich the organic content of the water and bottom deposits should be made. These will furnish plant food and enrich the food chains important to fish. The cost of such an endeavor in this lake is certainly prohibitive at present.

Experiments with various fertilizers and lime rock in Weber Lake in Wisconsin by Chauncey Juday, C. L. Schloemer and Clarence Livingston* have shown that additions of soy bean meal and crushed lime rock (from size of a pea to powder) definitely increased the plankton production and also the growth rate of perch. This lake is of the soft water type, similar in many respects to some of the lakes in this report. Quantities of each substance used depend on the size and volume of the lake in question. From 80-100 pounds per acre of each of these substances should be added. The smaller amount is sufficient for lakes 40 feet or less in depth. Lakes 100 feet deep would require the full 100 pounds per acre. This treatment should be repeated every third year in lakes having no outlet, but would be necessary each year in those having small outlets. River lakes and those lakes with large outlets should not be treated in this manner, since water exchange would soon remove the fertilizers. Juday, Schloemer and Livingston recommend placing these fertilizers around the shoals near shore where the depth is about two feet. Cost per acre for such applications usually averages about $2.00, but will vary according to local conditions and availability of materials.

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*Juday, C., C. L. Schloemer, Clarence Livingston. Effects of Fertilizers on Plankton Production and Fish Growth in a Wisconsin Lake. The Progressive Fish Culturist, U. S. Bureau of Fisheries. Aug. - Sept. 1938, pp. 24-27.

Lake Five lies about 3.5 miles west of Beechwood in Iron County. It is 360 acres in extent and has a maximum depth of 50 feet. There is very little resort development. One private cottage is located on its shores, which are wooded. Fishing intensity on this lake is medium during the summer. No winter fishing is reported. The lake is said to have afforded fair smallmouth bass fishing and still maintained that reputation at the time of the survey.

The basin of Lake Five is somewhat irregular. Its long axis runs almost due north and south. The shores are quite precipitous and the surrounding country is high and hilly. The basin drops off rapidly to a maximum depth of 50 feet in the south end of the lake, but to the north it is quite shallow, being 10-15 feet deep except for one small 20-foot pot-hole.

At the time of the survey, this lake was about 1.5 feet below its normal level. It is a seepage lake, and, during periods of drought, the level drops below an intermittent outlet which drains into the south branch of Paint River. The general physical characteristics of Lake Five are given in Table 1. The most striking of these features are the large percentage of shoal and the relative transparency of the water (Secchi disc reading - 15 ft.). Although this lake is only about half as clear as Golden Lake, it is still quite clear in comparison with some of the others under consideration. The large shoal areas, even though they are almost entirely sandy, should make the lake quite productive if other characteristics were ideal.

Water temperatures in Lake Five were low enough in late August to warrant the assumption that they might be suitable for trout (Table 2).

There was a definite thermocline between depths of 15-30 feet. Plenty of oxygen (Table 2) was found above the thermocline, but the concentration became less in the thermocline (4.9 p.p.m.) and was almost gone at the bottom (0.2 p.p.m.). Carbon dioxide concentration reached 15 parts per million in the bottom waters and indicates that decomposition of organic material was sufficient to remove the oxygen present. This is probably detrimental at least to the possibilities of trout production, but is a rough index of the amount of nutritive substances in the water and bottom materials. The water in Lake Five is very soft, containing 7-8 parts of dissolved salts per million. Furthermore, the water is acid in reaction (pH 6.8-5.3). These characteristics would tend to offset the productive potential of broad shoals, since essential substances for plant and animal growth are usually among the dissolved salts in the water.

Plants in Lake Five are quite scarce. The largest beds are located in the shallow north end. They consist mainly of Isoetes, most abundant on slopes and in deeper water; pond lilies, bulrush and pondweeds in coves and bays. The latter plants are quite scarce.

The data for Lake Five in Table 3 point out that the bottom is relatively unproductive of fish-food organisms. Predominant in the bottom population are midge larvae, but more forms are represented in the fauna than were present in Golden Lake. The plankton samples were over four times as rich as those from Golden Lake, but more adequate sampling in both lakes might change this striking contrast a little.

Only four species of fish were taken from Lake Five by the survey party. These are shown in Table 4. Creel census records show rock bass, perch and brook trout catches in addition to the species listed in the table.

Smallmouth bass are apparently the most abundant fish in this lake, although recorded catches show more perch taken than any other fish. The stocking records for the years 1934-1939 inclusive are given in Table 5. Smallmouth bass, largemouth bass and bluegills were the only species stocked. Growth-rate studies made from scales of fish captured in Lake Five are given in Table 6. From these studies it is noted that bluegills make satisfactory growth, reaching legal size in their third year of life. Only one largemouth bass was taken. It was in its fourth year of life, weighed 15.3 ounces and was 12.4 inches long. If the one specimen is assumed to be around average size for that age, this species grows well in the lake. However, not too much trust should be placed in results from one fish. Smallmouth bass grow slightly slower than average. They reach legal size in their fourth year, and, in their sixth year, average around 13 inches in length and weigh about 15 ounces.

Spawning facilities for bass, especially smallmouth bass, are abundant around the shoals, which are composed of sand, gravel and boulders. Bluegills spawn in about the same situation as bass; therefore, ample grounds are present for them. Enough spawning grounds for perch are present to maintain a population large enough for the carrying capacity of the lake.

Occasional creel census records during the years 1933 through 1936 show two smallmouth bass, 82 largemouth bass (most of these are probably smallmouth incorrectly identified), 11 rock bass, 94 perch and five brook trout, taken in 147 hours of summer and autumn fishing. The catch per hour of all fish, based on these figures, is 1.3. This rate is about average for the state and 0.6 of a fish per hour lower than the catch rate in Golden Lake.

Lake Five is probably producing as many fish as it can under present conditions. The food supply is not very abundant and a larger population of fish would certainly cause stunting. The chemical nature of the water (lack of dissolved salts or softness, especially) inhibits further extension of the plant beds and, consequently, increase of organic material in the bottom. Furthermore, the apparent paucity of forage fish may have some effect on the bass population.

This lake is classified with the "all others" group and no change in designation is recommended. Stocking of smallmouth bass should continue if it is known that natural reproduction is not adequate. The success of bass in this lake might be enhanced by the introduction of a forage fish, probably blunt-nosed minnows, fine-scaled dace or northern red-bellied dace. Sucker fry might suffice as a food for bass. No further stocking of bluegills and perch is recommended, at least for several years or until it becomes obvious that their natural reproduction is not great enough to satisfy fishing demands. Parasites and predators require no control measures.

Cover is present in this lake in the form of many logs and brush shelters. No further cover need be added if the vegetation, now quite scarce, is encouraged and increased as indicated later. Very little can be done about water level regulation in drought years. A dam could be placed in the outlet, but since the stream is intermittant, its effect would only be seasonal. It is not necessary when the level is normal. Spawning facilities are adequate for all species which should be encouraged.

Addition of soy bean meal and limestone to this lake in the manner suggested for Golden Lake would be advisable. This would encourage increase of vegetation beds and food production.

Paint Lake, 332 acres in extent, is situated about 10 miles north of Elmwood in Iron County. It is reached via Forest highway, a narrow secondary road. There are no cottages on its shores, but a service station operator near the lake has three boats for rent. A camp is situated between it and Harding Lake which lies just to the north. The general fishing reputation of this lake is good. Summer fishing intensity was rated as medium by the survey party.

The basin of Paint Lake lies almost due north and south. It is long and narrow, shaped roughly like a pear with its largest end toward the north. The southern end narrows gradually into the outlet, called Paint Creek, which enters the north branch of Paint River. The immediate shores are gravelly, sandy and brushy. The surrounding country is wooded and quite high in places. Paint Lake basin is shallow (maximum depth 15-20 ft.). There is an island in the north end. At the time of the survey the water level was down about $1\frac{1}{2}$ feet due to the removal of a dam which was in the outlet. This dam was removed by the Forest Service in an attempt to flush out the pulpy peat in the south end of the lake. This attempt failed. It is suggested that the dam be replaced and the lake restored to its former level. The area and physical features of this lake are given in Table 1. It should be noted that the lake is considered all shoal. These shoals are sandy and gravelly. The deeper, bottom areas are pulpy peat. The water is not too clear (Secchi disc reading, 7.5 ft.). The lake is fed by two inlets, one from Lake Thirty-three and another from Silk Lake. All of these attributes indicate that the lake is quite productive. This productivity is conditioned by factors yet to be discussed.

It is noted from the temperature and chemical data for this lake (Table 2), that there is no permanent thermal or chemical stratification, although a temporary thermocline was present between the three and nine foot depths at the time of the survey. Dissolved oxygen is present in ample amounts from surface to bottom, which, in a lake of this type, indicates that the thermocline is temporary. The water temperatures are probably too high during the summer months to maintain cold-water fishes. Noteworthy among the chemical features of this lake are the alkalinity, as measured by pH and Methyl Orange alkalinity tests, and the lack of carbon dioxide in measurable amounts. The effects of these characteristics are expressed in the biological data, and, in contrast with the lakes already discussed, clearly show the value of such attributes in productivity.

The vegetation in Paint Lake consists of bulrush, pond lilies, pondweeds, *Najas* and *Chara* or muskgrass. All of these plants are common. Bottom foods were not too abundant, as the data in Table 3 show, but the population of insects was probably at its lowest seasonal ebb when the lake was inventoried. In comparison with Golden Lake and Lake Five, the bottom fauna would be considered rich. Although average numbers per square foot were about the same, the volume was almost twice as great. Fresh-water shrimps, midges and may-flies predominate in the bottom population of Paint Lake. The plankton was very abundant, being greater in volume per cubic meter than any of the lakes studied. Fish, taken by the survey party, are shown in Table 4. Of the game fish, perch were the most abundant. Pumpkinseeds, smallmouth bass, largemouth bass and black crappie followed in the order named. There were many common suckers, both adults and fingerlings, taken. Dominant forage fish were mud minnows and Iowa darters. No walleyed pike were taken by the party, although stocking records (Table 5) show over a million and a half to have been planted. Other species stocked were bluegills and yellow perch. Creel census records taken occasionally during the years from 1928 through 1936 indicate that fishing was fairly good if the records can be considered as average fishing. During 99 hours of fishing, anglers took seven smallmouth bass, nine largemouth bass, ten bluegills, 14 common sunfish, 15 rock bass, 77 perch, 13 walleyed pike and 21 grass or northern pike; a total of 166 fish. The catch per hour was 1.6 fish, which is somewhat above average for the state. According to Table 6, showing growth rate of fish as determined from scale studies, perch reach legal length during their third or fourth year. The series of perch scales is too small to show a true average for each year. One perch in its eighth year was about 9½ inches long and weighed almost five ounces. This rate of growth is no better than average, if as good. All the common sunfish (pumpkinseeds) taken were over four years old. These fish probably reach legal length in their fifth or sixth year, and by the time they are in their tenth year they only average 7.3 inches in length and 4.7 ounces in weight. This is slow growth for this species. Six largemouth bass were taken, but since all of them were in their second year, no further conclusions can be drawn. Black crappie do quite well in this lake. Scale studies indicate that they reach legal size during their third year of life, and by their sixth year are 9.6 inches long and weigh almost ½ lb. Three northern pike in their second year averaged 16.8 inches in length and weighed almost a pound; while one fish, in its sixth year, was almost

30 inches long and weighed 6 lbs., 13 ounces. The growth rate of these fish is considered normal or average. Spawning facilities for most of the game fish are adequate, except for the northern pike. By replacing the dam, recommended previously, enough shallow, grassy water will be produced to adequately serve the needs of pike as well.

Paint Lake is considered quite productive in the light of data presented above. The entire lake is within the productive zone and there is an ample amount of dissolved salts to supply the needs of plants and animals in the various food chains which ultimately culminate with the fish. There might be some danger of this lake winter killing during severe years, but the danger is quite remote because of the somewhat inert nature of pulpy peat, which constitutes most of the bottom material.

Paint Lake is a designated pike lake. This designation should be retained since creel census returns, survey data and growth rate studies show that the lake is a good producer of pike. It is urged that fishermen be considerate of nesting bass during the early season. Their nests should be avoided and their nesting shoals left undisturbed by wading or boating. Stocking, if any is done, should be confined to perch and walleyed pike. However, it is believed that under present demands, natural reproduction would more than compensate for the perch removed. Parasites and predators do not affect the population enough to warrant control measures. The cover is adequate. Numerous brush shelters have been installed and the plant beds are large enough to afford good cover. There are also many submerged logs and snags. More brush shelters could be installed, but the present fishing pressure is not great enough to make this addition imperative.

Winslow Lake, 225 acres in area and having a maximum depth of 25 feet, lies in the Paint River drainage about 12 miles north and slightly west of Gibbs City. It is approximately six miles due east of Paint Lake. From Gibbs City, it is reached by following county road 657 west and north until it joins Winslow Lake truck trail, turning onto this truck trail and following it to the lake. These roads are secondary, but are usually kept in good condition. On Winslow Lake are four cottages, one resort and one boat livery. The intensity of fishing is medium in summer. No fishing is reported on this lake during the winter. Reports have it that this lake is exceptionally good fishing. The survey party also reports fishing as good, especially for bass.

The basin of this lake is quite irregular. It contains many bays and headlands. Two small islands stand above the present water surface. The shores are composed of sand and gravel in most places, but there is some fibrous peat - muskeg - encroaching shores in the north and south end. Woods surround the lake except in the low areas, which are usually occupied by muskegs. The water level remains fairly constant due to a four-foot dam in the outlet. Aside from maintaining the water level in this lake, the dam serves no other purpose. It probably acts as a barrier to fish migration upstream, especially during periods of low water.

The physical characteristics of Winslow Lake as presented in Table 1, typify a lake of average productivity for the region. There is plenty of shoal area in relation to deep water. The bottom types are not too productive, but the plants they support probably offset the lack of bottom food production. The water, being dark brown in color, cuts down light penetration (Secchi disc reading, 4 ft.), and inhibits, thereby, plant growth in the deeper waters. Thermal features of this lake at the time of the survey (Table 2) allow the assumption that the water probably becomes too warm for trout and other cold-water fish. The very narrow, temporary thermocline, between the 18-20 ft. depths, probably does not affect fish or fish food production to any great extent. The oxygen content is high enough in the upper waters, but shows a tendency to become depleted in water near the bottom. Carbon dioxide is present in insignificant amounts from surface to bottom. Its action is buffered by the salts in solution, which are adequate although not in very great concentrations (M. O. alkalinity 53-55 parts per million). The water is relatively soft and ranges from neutral to slightly alkaline in reaction (pH 7.2-7.0). These chemical characteristics are in no way inhibitory to fish life; neither do they act adversely on the food supply. In fact, combined with the physical features, they would tend to increase production.

Vegetation in Winslow Lake is considered adequate both for cover and spawning of perch. The plants present are mainly water shield, water lilies and various pond weeds. The following tabulation gives a list of the plants collected with notes on density and abundance.

Plants* of Winslow Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range in feet	Bottom types
Water marigold (Megalodonta Beckii)	1	medium	5 acres	1'-5'	sand
Water shield (Brasenia Schreiberi)	1	medium	5 acres	2'-6'	sand
Water arum (Calla palustris)	4	sparse	...	...	...
Water starwort (Callitriche palustris)	3	sparse	...	1'	...
Sedge (Carex Pseudo-Cyperus)	1,3,4	sparse	250 sq. ft.	6"-shore	sand and fibrous peat
Threeway sedge (Dulichium arundinaceum)	1	sparse	...	6"	sand
Manna grass (Glyceria canadensis)	1, 2	medium	1/10 acre	0'-5'	sand
Horsetail (Equisetum fluviatile)	2	sparse	...	1'	...
Water milfoil (Myriophyllum sp.)	1, 4	medium	1/7 acre	2'-4'	fibrous peat
Bushy pondweed (Najas flexilis)	1, 3	medium	900 sq. ft.	1'-6'	sand
White water lily (Nymphaea odorata)	1, 3	sparse	...	3'-4'	sand
Yellow water lily (Nuphar variegatum)	1,2,3,4	sparse	5 acres at Sta. 1	2'-5'	sand and fibrous peat
Smartweed (Polygonum natans)	2	dense	600 sq. ft.	1'-3'	sand
Pondweed (Potamogeton amplifolius)	1, 2	medium	5 acres	2'-5'	sand
Pondweed (Potamogeton epihydrus)	1, 4	sparse	...	2'-3'	fibrous peat
Pondweed (Potamogeton gramineus)	1	medium	1/8 acre	1'-2'	sand
Pondweed (Potamogeton natans)	1	medium	3 acres	3'	sand and fibrous peat
Pondweed (Potamogeton Robbinsii)	1, 3	dense	5 acres	1'-5'	fibrous peat and sand
Pondweed (Potamogeton Richardsonii)	1, 3	medium	3 acres	3'-6'	sand
Pondweed (Potamogeton praelongus)	1	sparse	...	3'	sand
Pondweed (Potamogeton pusillus)	1, 3	sparse	...	1'-3'	sand
Pondweed (Potamogeton zosteriformis)	1, 4	sparse	...	2'-3'	fibrous peat and sand
Pondweed (Potamogeton tenuifolius)	4	medium	400 sq. ft.	2'	sand
Arrowhead (Sagittaria latifolia)	1, 4	sparse	...	6"	fibrous peat
Bulrush (Scirpus validus)	1, 3	medium	100 sq. ft.	6"-2'	sand
Bulrush (Scirpus cyperinus)	1,3,4	sparse	... ...	6"-1'	sand and fibrous peat
Burreed (Sparganium chlorocarpum)	4	medium	800 sq. ft.	2'	sand and fibrous peat
Bladderwort (Utricularia vulgaris)	1	sparse	...	6"	sand
Wild celery (Vallisneria americana)	1,2,3	medium	5½ acres	2'-5'	sand
Muskgrass (Chara sp.)	1	sparse	...	6"	sand
Spikerush (Eleocharis sp.)	5	dense	500 sq. ft.	6"-2'	sand

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

The plankton crop at the time of the survey was about average (Table 3). It consisted of algae. The production of this plant type of plankton is probably retarded by the deep color of the water and its influence on light penetration. Bottom organisms per square foot were quite abundant. However, shoal forms were found limited at the time of the survey. Corethra or phantom midge larvae dominated the population. Aquatic earthworms and midges comprised the remaining forms present. No samples were taken from plant beds; hence, a true evaluation of the production of this lake cannot be made. It is surmised that the food supply is above average and probably adequate for the standing crop of fish maintained by the lake.

Fish taken by the survey party are listed in Table 4. Of the 140 game fish taken, 44.3 per cent were pumpkinseed sunfish, 30 per cent green and hybrid (green x pumpkinseed) sunfish, 14.3 per cent yellow perch, 3.6 per cent largemouth bass, 3.6 per cent bluegills and hybrid (bluegill x green, and bluegill x pumpkinseed sunfish) bluegills, 2.8 per cent smallmouth bass, and 1.4 per cent northern pike. It was reported by the survey party that smallmouth bass around two pounds were quite numerous in the lake. Common suckers and black bullheads are common. The forage fish, especially common shiners, are quite numerous. During the years 1934-1939 inclusive, the lake was stocked with walleyed pike, largemouth bass and bluegills. Numbers stocked are shown in Table 5. From growth rate studies of fish from this lake (Table 6), it is noted that pumpkinseed sunfish grow rather slowly, reaching legal length during their fifth year and growing about another inch during the next three years. Only two specimens of yellow perch were studied and no conclusion can be drawn from this meager information. They probably grow somewhat slower than usual. Three smallmouth bass in their sixth year averaged 15.6 inches in length and one pound 14 ounces in weight. Another, seven years old, was the same length, but weighed almost two pounds. This rate of growth is apparently satisfactory. No younger fish are represented in the collections; hence, no sweeping conclusions can be drawn. Growth of the two northern pike, from which scales were taken, shows that these fish reached legal length during their second or perhaps in their first year of life. They are approximately 23 inches long and weigh around one pound, 5 ounces by the middle of the growing season in their third year. Although the series of scale studies are inadequate for each species mentioned above, some idea of the growth rate can be obtained. Spawning facilities for the game, coarse and forage fish are abundant. Young of all the game species were taken in large numbers, which indicates that they are able to propagate naturally. From the stocking records (Table 5) it is noted that 700,000 walleyed pike have been planted in this lake. None were taken by the survey party and no reports of any of them having been caught by anglers are on record. Obviously, these fish did not become established from early plantings. Later introductions (250,000 in 1938 and 300,000 in 1939) have not had sufficient time to prove worthwhile or otherwise.

Winslow Lake is now designated as a pike lake, which designation should not be changed at this time. Further investigation and a creel census on this lake would furnish information conclusive enough to warrant a decision on the matter. Results of this survey show the lake better suited to bass and the northern pike which result from natural reproduction than walleyed pike. Evidences from other lakes of a similar sort which have been studied more intensively, show that walleyes are unsuited to such waters. Without the aid of artificial stocking, smallmouth bass have maintained their population by natural means. They also grow satisfactorily. At the time of the survey, fishing for them was excellent. There is some evidence to show that they suffer from competition with walleyes. Therefore, it is recommended that no further plantings of walleyes be made in Winslow Lake. Furthermore, it is suggested that early-season fishermen avoid any action which might destroy or disturb bass nests. Predators create no special problem on the lake and need no control measures at present. Black spot and yellow grub (Clinostomum) infestations are quite common. The worst infestations occur in perch and sunfish. No control is recommended unless the incidence of these parasites increases considerably. There are no problems of cover in this lake. The vegetation is ample and brush shelters are numerous. Logs and snags are quite abundant around the shoal areas.

East Paint Lake is about 1/8 of a mile east of Paint Lake. It has an area of 147 acres and a maximum depth of 10 feet. It is reached via the same route as given for Paint Lake. There is no resort development on its shores and the lake is seldom frequented. Fishing there is consequently light during summer and no records of winter fishing are available. The basin of this lake is somewhat irregular; its long axis running northwest-southeast. It is surrounded by woods of aspen and birch, and the immediate shores are muskeg or encroaching except around the south end and the east side. The basin in which it now lies is considerably larger than the lake itself, encroaching shores and muskeg formation having filled it. The lake is approaching extinction by encroachment both from the bottom up and from the shores. The water level fluctuates considerably and at the time of the survey was low. The physical characteristics of this lake are given in Table 1. Especially noteworthy are the shallowness of the lake, the preponderance of fibrous peat as a bottom type, the lack of inlets and the high turbidity of the water (Secchi disc reading, 2½ feet). All of these features are indicative of lake senescence, that time in lake evolution when the productivity begins to decline and, in this region, acid water conditions arise. Although the shallowness and size of the lake favor wave action, only the southeast end of the lake is being kept free of encroaching shore. Prevailing winds of the area are from the northwest; hence, wave action would be greatest on the southeast shore. The other shores are less frequently washed by heavy waves and, as a result, muskegs are left to develop in comparatively quiet water. Wave action and the resulting water circulation keep some of the bottom materials in suspension so that only five feet of clear water could be found anywhere in the lake, even though depths of 10 ft. were found by sounding. Such a flocculent substratum is a very poor food producer.

According to the data for this lake given in Table 2, the lake is homothermous, that is, the temperature is almost the same throughout and no thermocline is present. Shallow waters of this sort react rapidly to air temperature changes. Even though the temperature of the lake at the time of the survey was within the range of toleration of cold-water fish, it is almost a certainty that the water temperature rises during periods of the summer to points well above this range of toleration. Dissolved oxygen is equally distributed in surface and bottom waters. Carbon dioxide is present, but the amount is not significant. The water is quite soft, containing only 30 p.p.m. of dissolved salts (M. O. alkalinity). The pH is 7.4, which means that the lake is slightly alkaline in its reaction.

If the bottom materials were firmer, these chemical conditions would be advantageous. There are no chemical or thermal factors, for which tests were made, which limit productivity. The softness of the water might be an exception.

Vegetation in the lake is common. Emergent vegetation is continuous around the shore. Potamogeton natans and P. Robbinsii, both pondweeds, are common throughout the lake. These weeds are probably the food producers. The following tabulation gives a list of plants collected from this lake.

Plants* of East Paint Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Water arum (Calla palustris)	1	sparse	...	...	along floating mat
Sedge (Carex hystericina)	1, 2	dense	2,400 sq. ft.	6"-1'	gravel
Threeway sedge (Dulichium arundinaceum)	1, 4	dense	500 sq. ft.	6"-1'	fibrous peat and sand
Spike rush (Eleocharis palustris)	1	medium	1,000 sq. ft.	6"-1'	fibrous peat
Horsetail (Equisetum fluviatile)	2	sparse	...	6"-1'	fibrous peat and sand
Pipewort (Eriocaulon septangulare)	2	sparse	...	6"-1'	fibrous peat
Manna grass (Glyceria canadensis)	1	dense	400 sq. ft.	0 -6"	...
Rush (Juncus brevicaudatus)	4	sparse	...	1'	...
White water lily (Nymphaea odorata)	1	sparse	...	2'-5'	...
Yellow water lily (Nuphar variegatum)	1, 4	sparse	...	2'-5'	fibrous peat
Smartweed (Polygonum natans)	2	dense	1,200 sq. ft.	1'-2'	sand
Pondweed (Potamogeton natans)	1, 4	moderate	13 acres	0'-6'	fibrous peat
Pondweed (Potamogeton pusillus)	1	sparse	...	2'-3'	...
Pondweed (Potamogeton Robbinsii)	3	dense	Entire south bay - 24 acres	3'-6'	...
Arrowhead (Sagittaria latifolia)	1, 4	sparse	On floating mat	6"	fibrous peat
Bulrush (Scirpus cyperinus)	2, 4	medium	Across entire south bay	2'-6'	fibrous peat
Burreed (Sparganium chlorocarpum)	2	dense	700 sq. ft.	1'-2'	sand
Bladderwort (Utricularia vulgaris)	1	medium	1¼ acres	2'-4'	sand
Muskgrass (Chara sp.)	1	medium	1½ acres	2'-3'	sand

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

Inspection of Table 3 shows a very restricted bottom fauna present. The bottom population is quite insignificant in this case. Food for fish would have to come from some other source. The plankton crop, judged from the samples taken by the survey party, is somewhat below average. Fish taken by the party are shown in Table 4. It is remarkable that the only game fish found by them was yellow perch. These fish are fairly good sized and quite abundant. Of the coarse fish, bullheads and common suckers were taken. Forage fish appear to be quite common. Black-nosed shiners were most abundant. These were followed closely by fat-head minnows and Iowa darters. Growth rate studies for the perch in this lake (Table 6) are encouraging. Perch reach legal length in their second year, a length of about $10\frac{1}{2}$ inches and a weight of a little over $\frac{1}{2}$ lb. by their sixth year. Stocking records for this lake are given in Table 5. Bluegills and largemouth bass, the only species stocked, apparently were not able to establish themselves, if it is assumed that the netting operations of the survey party were extensive enough to have taken them had they been present.

East Paint Lake is classified in the "all others" group. No change of designation is recommended. Since this lake is not very productive and is senescent, further stocking with any species is not considered worthwhile. An extensive program of cleaning, which would involve removal of the peat and muskegs, might delay the evolution of this lake toward a marsh. However, since there are many other good fish producing lakes in the region, the work could not be justified. East Paint Lake will probably continue to produce good perch without any stocking or other improvement at least for several years, and will probably become of increasing importance for waterfowl and possibly muskrats.

Robinson Lake, often referred to as Lake ~~XX~~ Twenty-seven, is located about one mile west of Paint Lake and 10½ miles north of Elmwood. It is reached on good road via Forest highway north off U. S. 2, and then county road 657 west off the Forest highway. It is 73 acres in extent and has a maximum depth of 23 feet. The general fishing reputation of this lake has been poor for the last 15 years. Fishing is very light in summer, none in winter. Despite this report, there are 30 or more cottages on the lake. These cottages make the lake semi-public, but the general public has access to it.

The lake basin is fairly regular. Its long axis runs northeast-southwest. There is a small island in the southwestern end. Most of the shoreline is sandy, but there are a few stretches which are of encroaching bog.

The main axis of this lake runs northeast-southwest and its maximum length is about 0.6 miles. The shoreline is somewhat irregular. It is composed, for the most part, of sand, but muskegs and encroaching shore constitute about one-half the northwest shore. There is a small island in the south end of the lake. The lake is wooded round about. The one inlet is an intermittent drain from an old beaver dam. A small outlet at the north end of the lake is blocked by a beaver dam which is effectively maintaining the water level in the lake. In Table 1, other physical characters are given for this body of water. None of these characteristics are particularly unusual. They seem to typify an average lake of the region in all but one respect, that is, marl is reported by the Forest Service to be a constituent of the bottom materials. This is a rather peculiar situation, especially since the waters of this lake are so poor in calcium salts. Usually, when carbon dioxide is in solution in water it has a tendency to take marl into solution and thereby increase the Methyl Orange alkalinity.

The temperature of the water in Robinson Lake is too warm for cold-water species of fish (Table 2). There is no thermocline in the lake and it appears that circulation by waves and currents occurs to, or almost to, the bottom. This mixing of all the water is evidenced by its chemical composition at various depths (Table 2). Oxygen is plentiful from top to bottom. The concentration of dissolved carbon dioxide is uniform. Noteworthy, in the chemical nature of this water, are the low concentration of dissolved solids (10 p.p.m. M. O. alkalinity) and the acid reaction of the water as shown by pH readings of 6.0. These two attributes are probably more responsible for the relatively poor productivity in this lake than any others studied. Their effect is shown in the vegetation and other biological features found in this lake. There is very little vegetation except bottom moss in the lake. A brown algal mass covers the shoal areas and is very obnoxious.

Plants collected by the survey are listed in the following table. Notes on the extent, density and occurrence of each species are also given where such were available.

Plants* of Robinson Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Water arum (*Calla palustris*)	1	medium	patches 1'x3'	1'-2'	sand and gravel
Threeway sedge (*Dulichium arundinaceum*)	1,2,3	medium	1,200 sq.ft.	6"-2'	sand
Spike rush (*Eleocharis sp.*)	2	sparse	...	2'	...
Manna grass (*Glyceria borealis*)	1, 2	medium	1,000 sq.ft.	6"-3'	sand
Manna grass (*Glyceria canadensis*)	1, 2	medium	1,000 sq.ft.	6"-2'	sand
Rush (*Juncus effusus*)	1,2,3	medium	2,000 sq.ft.	6"-2'	sand
Water horehound (*Lycopus uniflorus*)	1	sparse	...	2'	...
Yellow water lily (*Nuphar variegatum*)	1,2,3	medium	½ acre	1'-6'	sand
Smartweed (*Polygonum coccineum*)	1	dense	200 sq.ft.	1'-2'	...
Bulrush (*Scirpus cyperinus*)	1, 3	medium	2,000 sq.ft.	1'-2'	...

Note: The survey party reports that the entire lake bottom is covered with water-milfoil (*Myriophyllum tenellum*) and bottom moss. No specimens were available for positive identification.

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

A summary of bottom fauna in Table 3 shows a great variety of organisms present, but most of these are in the bottom moss. They are probably not available to fish except at rare times of emergences or violent storms. Dominant in this community of organisms were various larvae of the group of true flies, caddis fly larvae and finger-nail clams. The plankton population was very low at the time of the survey.

According to the findings of the survey party, only four species of fish were taken from Robinson Lake (Table 4). These were all game fish. Pumpkin-seed sunfish were, by far, the most abundant, with perch, bluegills and large-mouth bass about equally represented. Largemouth bass weighing up to six pounds have been reported caught. Why no forage fish were found in the lake is a question. They should be established if successful maintenance of the game species is to be hoped for. Stocking records for this lake during the years 1934 to 1939 inclusive are listed in Table 5. Walleyed pike, bluegills, largemouth and smallmouth bass were the fish planted. The smallmouth bass and walleyed pike were not present in catches made by the survey party. Growth rate studies made from the few scale samples available from this lake are given in Table 6. Although meager, these studies show that perch reach legal length during their fifth year, a rather slow growth when compared with some perch lakes. A single bluegill was found almost legal sized during its third year of life. Pumpkinseed sunfish averaged 5.9 inches in length as they neared the close of the growing season in their fourth year. This is about average growth. One largemouth bass in its second summer was almost six inches long, which is about or slightly below average. Spawning facilities for the game species present are adequate, with the possible exception of perch, to supply the demand of rather light fishing on this lake. It is quite likely that the perch population is as large as it can become as long as their food supply is scant.

Robinson Lake is classified in the "all others" group. No change in designation is suggested. The fish already established in the lake should be encouraged, but no further stocking is recommended as long as present conditions exist. The stocking of pike perch or walleyed pike should be discontinued. This species is one of the most voracious of game fish and, with no forage fish in this lake, the few survivors, if any survive, will be forced to eat other game fish and also their own kind. Predators and parasites are not important enough in this lake to need any control measures. The cover in this lake is very scarce. Placing brush shelters along the shoals is strongly recommended. Since the vegetation is scarce, an attempt should be made to alter the chemical nature of the water according to the methods described for Golden Lake. Fertilization would tend to increase plant, plankton and bottom food production. Since this lake has an outlet, fertilization would have to be done each year. The heaviest applications should be made in the south end.

At the time of the survey, the lake level was about two feet above normal, due to a beaver dam in the outlet. Objection to this dam was raised by some cottagers because the increased water level made swimming facilities poor. It is believed that the higher level would contribute to better fish production by increasing the productivity of shoal areas through additions of flooded top soil washed onto them by waves. Spawning conditions might also be improved, especially if additional vegetation came in.

Harding Lake is a small body of water 36 acres in area and 15 feet deep. It is separated by a very narrow neck of land from Paint Lake. It is about 10½ miles north of Elmwood and is reached via forest highway and a side road (County 657) which is in good condition. One cottage is on its shores and there is a service station ¼ mile away. The intensity of fishing is described as light and no other recreational development is present. Fishing was poor at the time of the survey. Reports have it that many fish died the winter before (the winter of 1936-37), possibly because of oxygen depletion.

The long axis of this lake lies in an east-west direction and is about 0.2 mile. The shore line is somewhat irregular and the bottom is composed of sand and gravel except in the western end where muck is predominant. Surrounding the lake are woods. However, the north shore is only partially wooded, since some of the timber has been cleared for county road 657. The lake level fluctuates very little. The survey party reported a six-inch drop in level below the high water mark by the end of August, 1937. There are no dams in the outlet, which is a small stream flowing into Silk Lake. The lake is fed by springs and run-off. Other physical features of this lake are given in Table 1. From this table it is noted that the lake is quite shallow (15 ft. maximum depth) and that the entire lake is considered as shoal. Pulpy and fibrous peat constitute practically all the bottom below a water depth of five feet.

The temperature and chemical features of the water in Harding Lake are given in Table 2. A study of these factors shows the water temperature to be slightly above the optimum for cold-water fish. There is a rather sharp change in temperature from surface to bottom, so much so that a thermocline was present between the six and nine foot depths. This condition is probably transitory and subject to change by winds and storms. There is a tendency for oxygen to become depleted near the bottom. The carbon dioxide range is between four and five parts per million. Acid conditions exist in the water, as evidenced by pH readings of 6.8-6.3. The water is also quite soft, although it contains more dissolved solids than most of the other lakes in the drainage which have been considered.

Vegetation in this lake is rather abundant. It covers most of the shoals and extends throughout almost the entire west end. The bushy pond-weed (Najas) is probably dominant in this lake, but wild celery (Valisneria), yellow pond lilies (Nuphar advenum), Bur-reed (Sparganium), water milfoil (Myriophyllum) and various pondweeds (Potamogeton) are common. The plankton, at the time of the survey, was about average in abundance (Table 3). Bottom organisms were not too plentiful. Caddis fly larvae and freshwater shrimps were dominant. A true evaluation of the bottom food supply is not possible since, in August, most of the insect population has emerged. Even though bottom conditions are such that production is limited, the plants in the lake would probably produce a supply ample for the needs of a normal fish population.

The survey party found six species of game fish, one species of coarse fish and eight species of forage fish in Harding Lake (Table 4). Perch were the dominant game fish. Iowa darters and mud minnows were the most abundant forage fish. Trout were reported from this lake, but none were found by the survey. During the years 1934-1939 inclusive, 400 smallmouth bass, 500 largemouth bass and 27,000 bluegills were stocked in this lake. It is interesting to note that bluegills, stocked every year except 1938, were not found by the survey party. According to results of growth rate studies given in Table 6, perch grew to legal size during their third year. This growth is about average. Increase in size during subsequent years appears to be quite slow. Fourteen fish in their fourth year averaged only 0.2 of an inch larger than those in the third. Two fish in their fifth year were 7.8 inches long. A summarization of the attributes of this lake indicates that it is quite productive, considering the acid condition of the water. There is plenty of vegetation and the food supply is adequate despite the paucity of organisms on the lake bottom.

Harding Lake is classified in the "all other lakes" group and there is no reason, at present, for a change in its designation. It is a fair producer of perch and there appears to be no reason why largemouth bass should not do well in it. From past experience with bluegill stocking in this lake and the apparent failure of these fish to become established, it is recommended that further stocking of this species be discontinued. Other species should be able to maintain their populations without artificial aid. Parasites and predators are not serious menaces to the fish in this lake.

No control measures are considered necessary at present. Cover and shelter are adequate. Vegetation is ample to furnish cover needed by the various species of fish in the lake. Water level fluctuation is not great enough to need regulation. At the present level, there are plenty of spawning facilities for all species. Should it be found desirable in the future to attempt enrichment of this lake, the same procedure is recommended as was suggested for Golden Lake.

Lakes of the Brule River Drainage

Hagerman Lake is a rather large body of water (584 acres) which lies about eight miles south of west of Iron River. It is reached via M-73 off U.S. 2 west out of Iron River. According to reports, the lake furnished good northern pike fishing around 1928. Since that time the pike fishing is said to have gradually declined. Bass fishing has improved in these years, according to reports of a Mr. Erickson, who is familiar with the fishing history. At present, fishing is regarded as fair. There are around 50 cottages on the shores of the lake. In addition, Stambaugh Township park is located along the south end and an E. R. A. Transient camp is situated on the west shore of north bay. Covenant Point Bible Camp is also located on this lake. Fishing on the lake is medium in intensity during summer, but very light during winter. Some pike spearing is done through the ice. There is no boat livery. Boats used are probably all private. The shore line and surrounding country are wooded and, in most places, high. The basin of this lake lies in a north-south direction. It is very irregular, especially in the north end. Several small islands lie in the basin and contribute to its irregularity. There are two distinct depressions in the lake, one in the center of the lake and another in the south end. Other physical features of this lake are given in Table 1. There is nothing unusual about the physical nature of this lake. Other factors being equal, the irregularity of the basin and shore line should have a tendency to make the lake more productive, but this tendency is conditioned, to a great extent, by bottom types and water chemistry. Sand, gravel and fibrous peat on the shoal areas and pulpy peat in the depths are not too productive of bottom organisms. There are no inlets, the lake being fed by springs and run-off. One small outlet, called the "bubbling brook," drains from the south end toward Brule River. A small dam across this outlet tends to stabilize the water level of the lake.

A review of the thermal and chemical features of Hagerman Lake (Table 2) shows the water temperature to be too high for cold-water fish. Temperatures drop rapidly in the thermocline and are suited to these fish below it, but oxygen is not present there in sufficient amounts to maintain fish life. Carbon dioxide is detectable at depths where the oxygen begins to be depleted and reaches a concentration of 6.0 parts per million at the bottom where no oxygen was present. The water contains sufficient amounts of dissolved solids for the maintenance of plant and animal growth even though it would be considered rather soft in comparison with some of the hard-water lakes of southern Michigan. The pH of the water varies from 8.4, strongly alkaline, at the surface to 6.6, slightly acid, at the bottom. These thermal and chemical data indicate that the productive volume of the lake is reduced to that water above the thermocline. Excluding this disadvantage which occurs in most deep inland lakes, the chemical characteristics are considered to favor good production of those foods and conditions essential to fish life. According to the survey party, some pollution of this lake results from the sewage of a transient camp on its shore. It is felt that this pollution is moderate enough to be fully absorbed by the lake and not become a menace to fish. It might well be that additions of such organic materials do the lake more good than harm.

Vegetation beds in the lake are confined to the shallow bays, where they are quite extensive. Except for the southwest shore, a narrow band of plants skirts the drop-off, which is quite abrupt. All three main types of vegetation occur in typical ecological zonation -- emergent, floating and submerged. Potamogetons (pondweeds) are most abundant. The accompanying tabulation represents the plants collected from this lake by the survey party.

Plants* of Hagerman Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Sedge (Carex Pseudo-Cyperinus)	1	sparse	...	6"	...
Sedge (Carex sp.)	1	dense	1,200 sq.ft.	2'	...
Three-way sedge (Dulichium arundinaceum)	1	sparse	...	6"	...
Spike rush (Eleocharis sp.)	1	sparse	...	1'	...
Horsetail (Equisetum fluviatile)	1	sparse	...	6"	...
Rush (Juncus effusus)	1	sparse	...	6"	...
Bushy pondweed (Najas flexilis)	1,2,3	medium	7 acres	1'-8'	gravel and fibrous peat
White water lily (Nymphaea odorata)	1,2,3	medium	11 acres	1'-8'	fibrous peat
Yellow water lily (Nuphar variegatum)	1	sparse	...	1'-2'	...
Pondweed (Potamogeton Robbinsii)	1	dense	1 acre	15'	...
Pondweed (Potamogeton amplifolius)	4	medium	¼ acre	8'	...
Pondweed (Potamogeton angustifolius)	1	dense	1/8 acre	10'	...
Pondweed (Potamogeton foliosus)	1	dense	400 sq.ft.	1'-2'	sand
Pondweed (Potamogeton gramineus)	1	sparse	...	1'	...
Pondweed (Potamogeton natans)	1,2,3	medium	5½ acres	1'-8'	gravel; pulpy & fibrous peat
Pondweed (Potamogeton zosteriformis)	4	sparse	...	8'	...
Pondweed (Potamogeton strictifolius)	..	sparse	...	1'	...
Arrowhead (Sagittaria sp.)	1	medium	2 acres	1'-3'	...
Arrowhead (Sagittaria latifolia)	1	sparse	...	6"	...
Bulrush (Scirpus acutus)	1	dense	800 sq.ft.	6"	...
Bulrush (Scirpus validus)	1	medium	5 acres	1'	...
Bulrush (Scirpus cyperinus)	1	sparse	...	6"	gravel
Bur reed (Sparganium angustifolium)	1	sparse	...	1'-2'	...
Cattail (Typha latifolia)	1	dense	4 acres	1'-2'	...
Musk grass (Chara sp.)	4	sparse	...	3'-6'	...

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

It is thought, from a consideration of the lake basin, that vegetation is growing in practically all places where it is possible for it to become established. An attempt to increase vegetation on the narrow shoals away from the bays would not be practical. The bottom food supply of this lake is poor (Table 3). The fauna is dominated by Chironomidae (midge larvae) and fresh-water shrimps. At the time of the survey, plankton was also very scarce. This, however, does not mean that the plankton crop is always bad. August is usually the month of summer minimum in plankton production, as it is in bottom food production. It is surmised that most of the available fish food (other than forage fish) is produced by the extensive plant beds in the bays and shallow water areas.

The species of fish taken by the survey party from this lake are recorded in Table 4. Of the game fish, perch were by far the most abundant. Largemouth bass, smallmouth bass, pumpkinseed sunfish, green sunfish and bluegills follow in the order named. Blunt-nosed minnows were the most abundant forage fish. Iowa darters were second in abundance. The total stocking records for the years 1934-1939 inclusive are shown in Table 5. It is noteworthy that lake trout and walleyed pike were not taken by the survey party, although both species had been stocked. Occasional creel census records taken from 1934-1936 show 173 fish caught during 116.5 hours of fishing effort, or almost 1.5 fish per hour. Of the various species caught, perch constituted 74.6 per cent, northern pike 9.8 per cent, pumpkinseed sunfish 5.8 per cent, largemouth bass 5.2 per cent, walleyed pike and smallmouth bass 2.3 per cent each. Eight of the 17 northern pike taken were speared through the ice. All other fish were caught during the summer season. Growth rate studies on fish scales from Hagerman Lake are not too conclusive because of lack of data. The results are given in Table 6 and a few generalizations can be made from them. Perch were found to reach legal length some time late in their third, or early in their fourth, year. Two perch in their fifth year averaged almost 10 inches in length and seven ounces in weight. This growth, if representative of the population, shows that perch do very well in this lake. Nothing can be said about bluegills, since the scales of but one fish were kept. Sunfish grow very slowly. They probably reach legal length in their sixth year of life. One six-year-old largemouth bass was 13.6 inches long and weighed one pound, six ounces. This growth is about average, if anything approaching the true situation can be deduced from one fish. Smallmouth bass probably reach legal length late in their fifth year. One bass in its eighth year was 15.2 inches long and weighed almost two pounds. Such growth is somewhat below average. Spawning grounds are adequate for all game fish present. Large areas of gravel and bays with abundant floating and submergent vegetation supply ample beds for the species which should be encouraged.

Hagerman Lake is designated as a pike lake. No change in designation is suggested, but the usual warning to early season fishermen to avoid nests of bass and other spawning fish should be given. There is no use stocking lake trout or any species of trout in this lake. Thermal and chemical factors are such that they cannot survive. Temperatures above the thermocline are too warm in summer and below the thermocline there is not enough oxygen to maintain fish life for extended periods. It is quite likely that northern pike and bass will suffer and perhaps decline in competition with a large walleyed pike population, which might develop if continued stocking should establish this species.

Predators and parasites are not important enough in this lake to warrant control measures. Cover in certain areas of the lake is scarce, but, in most of the shallow bays, vegetation is abundant enough to furnish adequate shelter. Thirty-six brush shelters were placed in deep water. It is not known to the author just where these shelters are, but it should be mentioned that if they are in water deeper than 30 feet their benefits to fish are practically nil. More brush shelters should be added along the east and west shores not deeper than 20 feet. They will have to be anchored securely, since the slope is so great along these banks that they would certainly roll off into deep water. It might be well to add spawning slabs to the shoal areas for blunt-nosed minnows, although there should be enough larger stones in the gravelly areas to serve their needs.

Ottawa. Pickerel Lake (area 551 acres; maximum depth 90 feet) lies about 5½ miles west of the town of Iron River. It is reached via U.S.2 out of Iron River, M-73 southwest off U.S.2, and a side road running due west off M-73. Two parks are on its shores: Iron River township park on the north end and U. S. Forest Service Pickerel Lake picnic and camp ground. One cottage is located at the outlet. The immediate shores are wooded and sloping. Surrounding the lake are wooded areas mostly of second growth. Some of the territory immediate to the lake has been burned over recently. Fishing in the lake is fair for lake trout, whitefish and perch. Some bass and walleyed pike are taken. Whitefish spearing during early winter seems to be good. The lake basin is very deep and precipitous. Very little shoal is present around the shores. The basin is deepest in the center and the bottom slopes almost equally on all sides toward the middle. Less severe are the slopes in the northeast and southwest ends. The long axis of this lake runs northeast-southwest. Fluctuation in water level is seasonal and not great enough to cause changes vital to fisheries interests. No dams obstruct the outlet, which is permanent. This outlet forms the middle branch of the Iron River. The lake is fed by two small inlets which enter from the south. Springs also augment the volume of the lake. Other physical features of this lake are given in Table 1. Particularly noteworthy is the scarcity of shoals in comparison with the area of the lake. They constitute about 15 per cent of the total area. This lack of shoal cuts down the productive potential of the lake considerably. The bottom types of the shoals are mostly gravel and sand. Rather extensive marl beds constitute the shoal bottom along the northwest shore. Another large marl bed occupies the north end of the lake. Below the 40-foot contour the bottom is composed of muck.

The summary of thermal and chemical characteristics given in Table 2 indicates that the surface waters (0-15 ft.) reach, and might exceed, the upper temperature range for trout. Within the thermocline (15-36 ft.) the temperature drops rapidly. Accompanying this rapid drop in temperature, the oxygen content also decreases until, at the bottom of this layer, the concentration is too low for permanent fish maintenance (1.2 p.p.m.). From the thermocline to the bottom the oxygen content gradually diminishes until only 0.9 p.p.m. was found at the bottom. Carbon dioxide is present at the bottom in concentrations of 4.0 p.p.m. The Methyl Orange alkalinity tests indicate that the water of Pickerel Lake is moderately hard. It is harder than ony of the other waters included in this report. The pH range shows high alkalinity at the surface and neutral conditions at the bottom. Chemical stratification such as occurs in this lake is usually not favorable for trout, especially if the surface waters are warmed to a point above the toleration limit of these fish. However, refuge from warm water might be had in the thermocline, where oxygen is still concentrated enough to maintain fish life. Only periodic forays into the deeper waters could be made by fish. Permanent occupation of them would result in death by suffocation.

The limited shoals of this lake produce a fairly rich bottom fauna (Table 3). Snails dominate the population. They are followed by midge larvae and may flies. Deeper portions of the lake are quite unproductive. Plankton, at the time of the survey, was scarce, but this scarcity is no indication of the total production. There is generally a plankton minimum during August in lakes of this region.

Vegetation, especially Potamogeton (pondweeds), is abundant along the west shore and on the bar projecting out from the west shore. It is also quite dense in the south bay. A few scattered patches are in the north end of the lake. In other words, vegetation is growing in just about every place where it can become established. Sand and gravel are not good substrata for the growth of vegetation. Furthermore, wave action along the southeast shore would prevent extensive plant beds from becoming established.there. The following tabulation lists plants collected by the survey party. Some information on density, area of beds and depth distribution is also given.

Plants* of Pickerel Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Coontail (Ceratophyllum demersum)	3	sparse	...	4'-6'	gravel, marl
Water stargrass (Heteranthera dubia)	3,4	medium	...	2'-10'	sand and gravel
Water milfoil (Myriophyllum sp.)	1,2,3,4	medium	6½ acres	2'-12'	sand,gravel,marl
Bushy pondweed (Najas flexilis)	2, 3	medium	6 acres	6'-10'	gravel and marl
White water lily (Nymphaea odorata)	3	sparse	...	5'	marl
Yellow water lily (Nuphar variegatum)	3	medium	1/8 acre	4'	marl
Smartweed (Polygonum natans)	1, 4	medium	1,400 sq.ft.	2'-6'	sandy gravel
Pondweed (Potamogeton amplifolius)	3, 4	medium	400 sq.ft.	3'-12'	sand, gravel
Pondweed (Potamogeton lucens)	2	medium	2 acres	10'	...
Pondweed (Potamogeton natans)	1,3,4	medium	4 acres	4'-6'	sand,marl,gravel
Pondweed (Potamogeton pectinatus)	2,3,4	medium	6 acres	2'-10'	sand,gravel,marl
Pondweed (Potamogeton Richardsonii)	2,3,4	medium	3 acres	2'-10'	...
Pondweed (Potamogeton pusillus)	2	medium	2 acres	10'	...
Pondweed (Potamogeton zosteriformis)	2,3,4	medium	4 acres	6'-12'	sand,gravel,marl
Bulrush (Scirpus validus)	4	dense	¼ acre	2'-8'	sand
Muskgrass (Chara sp.)	2	medium	2 acres	10'	sand

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

It is quite probable that considerable fish food is produced in these vegetation beds. Despite good production in plant beds and on the shoals, their limited extent makes the food inadequate for a lake of this size.

Four species of game fish were collected from this lake by the survey party. In addition to the fish listed in Table 4, lake trout, and largemouth bass should be considered as inhabiting the lake. Brook trout are also reported. Perch are the dominant fish in the lake, although the whitefish population is known to be great. The dominant forage fish is the bluntnosed minnow. Stocking records for this lake during 1934-1939 inclusive, are given in Table 5. Walleyed pike, lake trout and yellow perch are the species stocked. Over a million and a half walleyes have been introduced. According to growth rate studies given in Table 6, perch grow satisfactorily in Pickerel Lake. They reach legal length in their third year and by their fifth year, average 8.7 inches in length and 4.2 ounces in weight. Three walleyed pike in their second year averaged 12.1 inches in length and 8.9 ounces in weight. This is about average. No data were available for other species. General creel census records taken occasionally during the years 1932 to 1939 inclusive, showed 475 fish caught in 180.5 hours, or 2.6 fish per hour. Of the fish caught, 82.9 per cent were whitefish, 13.0 per cent perch, 1.3 per cent each of smallmouth bass, largemouth bass and lake trout, and 0.2 per cent brook trout. All of the 394 whitefish and one lake trout were speared through the ice on December 23, 1932, December 25, 1933, and January 8 and February 23, 1934. In all, 395 fish were taken in 110 hours. The catch per hour for this winter spearing was almost 3.6 fish. Disregarding the spearing, 70 hours of fishing were recorded. During this time, 80 fish, or 1.1 fish per hour, were taken.

Of these fish, 77.5 per cent were perch, 7.5 per cent largemouth bass, 7.5 per cent smallmouth bass, 6.2 per cent lake trout, and 1.3 per cent brook trout. Fifty of the perch were caught in 14 hours of fishing during 1938, while in 1939, 15½ hours' fishing yielded no fish. Thorough checking of the so-called cisco from this lake reveals that they are whitefish. No cisco have been taken from this lake by survey parties or collectors. Hence, it is strongly suspected that cisco recorded in the original creel census records are small whitefish. The records of cisco catches have been changed to whitefish in this report. Spawning facilities for all species in the lake are adequate. It might be that good perch grounds are limited, but this is more of an advantage to this particular lake than a detriment. As long as the perch population is held in check, large perch will be produced on the food available, but, if the population becomes too large, stunted perch will result.

Pickerel Lake is designated as a pike lake. As a result of this study it is felt that no change in designation is necessary. An experimental stocking of trout should be tried and observations made on its subsequent history. If trout succeed, regular plantings should be made each year. Further stocking of other game fish need not be made. Their natural reproduction is probably sufficient to maintain the population of their kind. Parasites and predators are not abundant enough to be a problem and no control measures are recommended. Cover in the lake is somewhat scarce. There are 16 brush shelters around the east shore in from 6-12 feet of water. Addition of more of these would be wise; however, if trout are to be encouraged, no further cover is necessary. Vegetation makes quite a bit of cover on the south and west shoals. It is adequate for these areas and artificial cover need not be placed there. The present water level is best for the lake and no change is recommended.

Lake Seventeen, a lake of 156 acres with a maximum depth of 37 feet, lies in the Brule River drainage about nine miles west and slightly north of Iron River. It is reached via Old Beechwood Road (County road 436) off U.S. 2. The immediate and surrounding territory is wooded. One cottage is located on its shores. This lake is fished infrequently in summer and no records are available to show any winter fishing. Its general reputation is poor, as far as fishing is concerned, although it is reported that bass fishing was good ten years previous to the survey.

The lake basin is quite regular. It slopes evenly toward the center on all sides except the southern one, where irregularities in the shore line and an embayment alter the configuration. The long axis runs in a north-south direction. Two small inlets supply water to the lake. A small, probably intermittent, stream called Seventeen Creek drains from the south end and forms one of the headwater streams of the Brule River. The water level does not fluctuate enough to be a factor in productivity.

Physical characters of this lake are shown in Table 1. It is noteworthy that most of the bottom in the shoal areas is composed of sand and gravel with the exception of two places in the bays at the south end of the lake, where fibrous peat and some encroaching shore are evident. The bottom below the ten-foot contour is composed entirely of muck. Temperature readings (Table 2) show a definite thermal stratification between depths of 7 and 21 feet. The thermocline, thus formed, is quite near the surface. Since the lake is also chemically stratified as is indicated by the same table, the thermocline reduces the productive volume of the lake considerably by isolating the waters low in oxygen from aeration or mixing with well oxygenated water at the surface. The temperature readings also indicate that the lake is too warm for trout, cisco and whitefish. At the time of the survey, oxygen was found to be entirely lacking in waters below the thermocline. Carbon dioxide was present from the lake surface to the bottom. The water is very soft, containing only five parts per million of dissolved salts (M. O. alkalinity). It is also quite acid, ranging from 5.4 to 5.2 in pH. The thermal and chemical features of this lake do not favor productivity. Acid water conditions eliminate many of the plants which are good food producers. Dissolved salts, essential in both plant and animal production, are almost totally absent. The thermocline reduces the productive volume almost 50 per cent because it isolates the deeper waters from aeration. These waters become stagnant due to the decomposition of organic material in the water and on the bottom. Fish cannot inhabit this region because of their need for oxygen in respiration. Other animals and plants must have oxygen, although some of the bottom fauna can survive for indefinite periods without it.

The vegetation in Lake Seventeen is quite abundant around the shoals and to a depth of 10 feet. Bur reed is the dominant plant on the sandy and gravelly shoals. A few water lilies occur in areas where fibrous peat is the bottom type. Even though this vegetation is abundant, it is not the type which encourages fish food organisms. Bur reed does not present the leafy maze which certain organisms seek as a habitat. The following table gives a list of plants collected by the survey party.

Plants* of Lake Seventeen

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Water shield (Brasenia Schreberi)	2, 3	medium	7 acres	2'-5'	gravel
Water arum (Calla palustris)	1	sparse	...	6"	...
Three-way sedge (Dulichium arundinaceum)	1,2,3	dense	1/8 acre	6"-1'	gravel
Pipewort (Eriocaulon septangulare)	1, 2	dense	$3\frac{1}{2}$ acres	6"-3'	gravel
Manna grass (Glyceria acutiflora)	1,2,3	medium	$1\frac{1}{2}$ acres	2"-1'	gravel
St.John's-wort (Hypericum boreale)	1, 2	medium	1/8 acre	1"-6"	gravel
Water lobelia (Lobelia Dortmanna)	2, 3	sparse	...	6"-3'	gravel
Yellow water lily (Nuphar variegatum)	1,2,3	sparse	5 acres	1'-10'	gravel
Pondweed (Potamogeton Oakesianus)	2, 3	dense	$\frac{1}{2}$ acre	1'-8'	gravel
Bur reed (Sparganium angustifolium)	1,2,3	medium	7-1/6 acres	6"-4'	gravel
Bladderwort (Utricularia vulgaris)	2, 3	medium	$\frac{1}{2}$ acre	6"-2'	gravel

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

Midge larvae were the most common bottom organism found during the survey (Table 3). Mayfly nymphs, phantom midges, finger-nail clams, water mites and caddis fly larvae were also taken. The average number and volume of organisms per square foot of bottom approximates the general average for the lakes under discussion. The plankton was not abundant and indications are that this crop of potential food never becomes very rich, due to limitations imposed by the chemical nature of the water. Three species of game fish and three of forage fish were reported by the survey party (Table 4). Perch, largemouth bass and pumpkinseed sunfish were the only game fish found. Predominant were the sunfish, but they were generally small and showed evidences of the effects of crowding. Golden shiners were the most abundant forage fish. During the years 1934-1939 this lake was stocked with 15,700 largemouth bass and 17,000 bluegills (Table 5). The first lot of 3,000 bluegills was planted in 1936. Subsequent plantings occurred in 1937, 1938 and 1939. It will be noted that no bluegills were taken or reported by the survey party. Apparently, these fish were unable to establish themselves in this lake.

It is probable that the over-abundance of common sunfish was too much of a competitive force. Furthermore, the food supply is none too abundant. Growth rate studies made on scales taken from fish of this lake are given in Table 6. The samples are inadequate to substantiate any definite conclusions. It is conjectured, however, that perch grow fairly well. One specimen in its fifth year of life was 10 inches long, another in its seventh year was only 0.6 of an inch longer. There is a difference of one ounce in the weight of these fish. Pumpkinseed sunfish are probably stunted, since studies on three specimens indicate a cessation of growth after the fourth year of life. One fish was in its sixth, another in its seventh, and another in its eighth year of life, and the sizes of all of them were almost identical (range 6.1 - 6.4 inches in total length). Spawning facilities are adequate for all species now present in the lake.

The general productive potential of Lake Seventeen is regarded as quite poor. Results of the survey have shown a lack of essential elements and a rather high acidity in the water. The basin and bottom types are such that they could be quite productive if other conditions were favorable. It is felt that the lake is producing to capacity in its present state and further increase in productivity will depend on artificial improvement.

Lake Seventeen is now included in the "all others" classification. No change in designation is recommended. All stocking should be discontinued. Spawning facilities are adequate for all species concerned. The fishing pressure and productive capacity of this lake do not warrant further introductions or additions of any fish, except probably a few adult northern pike. Since the pumpkinseed sunfish are being stunted by their heavy concentration and active competition for food, bluegill stocking is without purpose. Previous attempts to introduce bluegills have apparently failed. Many small perch were reported by the survey party and they more than suffice to maintain the population. The largemouth bass will also be able to maintain their numbers by natural means. The introduction of a few northern pike would probably tend to relieve the congested conditions somewhat. Before the pike are introduced, it is suggested that a large series of scale samples, weights and lengths be taken from the fish in Lake Seventeen. A study of this material would certainly be imperative if the true status of the growth rate and condition of fish now in the lake is to be known. This study would furnish the evidence necessary for one to state, without reserve, that northern pike should or should not be introduced, or other population control measures adopted in a lake of this type.

Predators and parasites are not abundant enough to need control. The paucity of snails, which act as intermediate hosts to many fish parasites, keeps parasitism at a minimum in the lake. Cover and shelter are quite scarce except for occasional logs, snags and windfalls. The plants in the lake afford some cover and are probably the main type of shelter used by the game fish. The addition of a few brush shelters around the lake might have a beneficial effect. These should be placed in 8-10 feet of water. There is no need to control water level. This lake fluctuates over narrow limits and raising the level would only flood timber on its shores. Spawning facilities are adequate. No further improvement of these facilities is recommended. Because the water in this lake is very low in dissolved salts and possibly essential nutrient elements, it is recommended that a fertilization program as described for Golden Lake be undertaken. This action may not be warranted at present, since the fishing pressure is very light and there are other fairly good lakes in the vicinity which are not yet over-fished.

Thousand Island Lake is the largest of the lakes considered in this report. It has an area of 1,078 acres and a maximum depth of 81 feet. This lake lies in the Cisco Chain of lakes and is about 12 miles west of Watersmeet. It is reached via a good gravel road, the Thousand Island Lake Road, running west out of Watersmeet. Resort and cottage development is scant. Since the shores of the lake are, for the most part, privately owned, development has been retarded. There are one estate and two cottages on the lake. This estate might be classified as a private resort. No boat liveries are on the lake and fishing is allowed by permission of the property owners. The early fishing history of this lake indicates that much larger fish were taken than are taken today. Reports of northern pike weighing 18-20 pounds are common. Walleyed pike were introduced around 1930-1932 and certainly influenced the growth rate and size of the northern pike. At present, this lake offers some fair northern and walleyed pike fishing, but the fish are relatively small.

The lake basin is very irregular. It is composed of three major depressions and numerous tiny islands. Bays and back waters are quite common. This basin probably originated as a combination of moraine formation and pits made by melting of huge blocks of buried ice following recession of the glacier which once covered the entire state of Michigan. The immediate lake shores and surrounding country are heavily wooded. In addition, the surrounding area is rugged and quite hilly. A dam, built about 34 years previous to the survey, at the outlet of Cisco Lake, maintains the level of Thousand Island Lake, since the latter is connected to the former by a broad channel and the water level of both lakes is the same. At the time of the dam construction, the level of Thousand Island Lake was raised about six feet. Many dead standing and down trees are now around the shoal areas of this lake as a result of the flooding. The inlet is African Channel, which drains from the African lakes located just to the north. Other physical features of this lake are given in Table 1. Of special interest in these data are the relative scarcity of shoal waters for a lake of this type and the difference between Secchi disc readings in the outlet waters and waters of the lake proper. The combined physical attributes of this lake indicate a tendency toward productivity. Irregularities in shore line, protected bays, and sheltered leas of islands are conducive to plant production and aid in the accumulation of organic deposits, essential elements of which are used in the food cycles of fish and fish food. The only physical feature tending to restrict productivity is the lack of sufficient shoal in comparison with deep water. Shoals are the important food producing areas. They are open to light and plenty of oxygen, both of which are essential in plant and animal production. The water temperature as given in Table 2 shows the formation of a thermocline and like temperature conditions in two of the depressions in this lake. The thermocline was located between the 15 and 45 foot depths at the time of the survey. Water in and below the thermocline is suitable for cold-water fish production as far as temperature is concerned. It is interesting to note the differences in chemical nature existing between stations 1 and 2 (Table 2). Station 1, taken in 60 feet of water, near the inlet, shows plenty of oxygen to be present in and below the thermocline for rather successful maintenance of fish life. Station 2, taken in 80 feet of water, in one of the southerly depressions, shows a rather rapid loss of oxygen within the limits of the thermocline and an almost complete absence of this vital element from the bottom waters. In other chemical respects the waters of this lake are quite homogeneous. Some carbon dioxide was found at the surface and became more concentrated toward the bottom, but not excessively so. The content of dissolved salts ranges between 50 and 60 parts per million, and the pH, alkaline at the surface and slightly acid at the bottom, ranged between 7.9 and 6.6. The water is moderately soft. It is much softer than most city water supplies in Michigan. The relations of temperature and oxygen to fish has already been explained and it need be pointed out only that in the region around the inlet, cold-water fish could easily be maintained, while in the deep regions of the south portions of this lake chances for the survival of these fish are slight. Other chemical features are quite conducive to fish and fish food production.

The vegetation in this lake is quite diversified. There are at least 34 different kinds of higher plants. A complete list of the plants collected by the survey party from this lake is given in the following table.

Plants* of Thousand Island Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Water marigold (Megalodonta Beckii)	1,2,3	scarce to medium	100 sq.ft.	2'-8'	muck, fibrous peat, sand
Water arum (Calla palustris)	3	medium	300 sq.ft.	6"-1'	...
Water starwort (Callitriche palustris	...	medium	625 sq.ft.	1'-2'	sand
Sedge (Carex Pseudo-Cyperus)	1, 3	sparse	...	6"	bog mats
Sedge (Carex comosa)	1	sparse	...	shore	bog mats
Blue joint grass (Calamogrostis canadensis)	4	sparse	...	1'	sand
Sedge (Carex stipata)	...	...	½ acre	2'	gravel
Coontail (Ceratophyllum demersum)	4	dense	½ acre	6'-12'	sand
Three-way sedge (Dulichium arundinaceum)	4	medium	200 sq.ft.	1'-2'	sand
Sundew (Drosera rotundifolia)	1, 3	sparse	...	bog shore	bog mats
Spike rush (Eleocharis palustris)	1, 3	sparse	...	bog shore	fibrous peat
Horsetail (Equisetum fluviatile)	...	sparse	250 sq.ft.	6"	...
Mud plantain (Heteranthera dubia)	1,2,3	medium	1,000 sq.ft.	2'-8'	muck,sand,fibrous peat
Iris (Iris versicolor)	1, 3	medium	4,000 sq. ft.	1'	floating bog shore
Loosestrife (Lysimachia terrestris)	4	sparse	...	1'	sand
Sweet Gale (Myrica Gale)	1,3,4	medium	small floating islands	shore	...
Water Milfoil (Myriophyllum exalbescens)	1,3	medium	3 acres	1'-5'	muck, fibrous peat
Bushy pondweed (Najas flexilis)	2	medium	1,500 sq.ft.	2'-8'	sand
White water lily (Nymphaea odorata)	2, 3	medium	1,000 sq.ft.	2'-8'	sand, fibrous peat
Yellow water lily (Nuphar variegatum)	1, 3	medium	2 acres	2'-6'	muck, fibrous peat
Pickerel weed (Pontederia cordata)	1, 3	medium	3 acres	1'-3'	bog shore - fibrous peat
Pondweed (Potamogeton amplifolius)	1, 4	medium	1½ acres	3'-10'	muck, sand, gravel
Pondweed (Potamogeton epihydrus)	...	medium	½ acre	2'-10'	sand, gravel
Pondweed (Potamogeton gramineus)	2,3,4	medium	½ acre	2'-10'	sand,fibrous peat,gravel
Pondweed (Potamogeton Robbinsii)	1, 3	medium to dense	several acres	3'-6'	muck, fibrous peat
Pondweed (Potamogeton Richardsonii)	1, 2	medium	1,000 sq.ft.	2'-8'	muck, sand
Pondweed (Potamogeton pusillus)	1, 2	medium	1,000 sq.ft.	2'-8'	muck, sand
Arrowhead (Sagittaria latifolia)	3	sparse	...	2'	fibrous peat
Bulrush (Scirpus sp.)	3	sparse	...	1"	fibrous peat
Bur reed (Sparganium eurycarpum)	3	dense	5,000sq.ft.	1'-3'	fibrous peat
Bur reed (Sparganium chlorocarpum)	3	sparse	...	6"	fibrous peat
Cattail (Typha latifolia)	1, 3	medium	2 acres, scattered patches	6"-2'	fibrous peat - floating mats
Bladderwort (Utricularia vulgaris)	3	sparse	...	6"-3'	...
Wild celery (Vallisneria americana)	1, 2	medium	1,000 sq.ft.	2'-8'	muck, sand

*Identified by Betty M. Robertson, Dept. of Botany, Univ. of Michigan.

Predominant are both narrow and broad leaved pondweeds, white and yellow water lilies, sedges, water milfoil, coontail and bur reed. Aquatic plants are quite abundant on the protected shoals of this lake, especially the west shore and bays. Most of the remaining shoal areas are too gravelly or sandy to maintain plant growths. It is felt that plants are now growing in almost every place fit for them. Further extension of the beds, either by natural or artificial means, is highly improbable. Undoubtedly, these plants support a righ assemblage of fish food organisms. The organisms of the bottom, according to quantitative estimates made by the survey party, seem to be about average when compared with the lakes of this region (Table 3). Predominant in the bottom communities were midge larvae, fresh-water shrimps, mayfly nymphs and aquatic earthworms. True evaluation of this source of fish food from one set of samples is quite difficult, but it is almost certain that the various bottom types are producing to near capacity.

Nine species of game fish, one species of coarse fish and seven species of forage fish were reported from this lake by the survey party (Table 4). Of the game species, perch were the most abundant. Listed in order of abundance, based on the take by fishing gear of the party, the remaining species are as follows: walleyed pike, largemouth bass, northern pike, bluegills, rock bass, smallmouth bass, long-eared sunfish, and lake trout. Blunt-nosed minnows were far more abundant than any of the other forage fish. Common shiners followed in second place. All others were about equally represented. The total numbers of the various game fish stocked in this lake, as taken from planting records, during the years 1934-1939 are given in Table 5. Stocking has been restricted to three species, walleyed pike, lake trout and yellow perch. Growth rate studies on fish taken from this lake are given in Table 6. The studies on yellow perch are limited to three specimens. Two of these fish were found to be in their sixth year of life. They averaged 10.2 inches in length and weighed slightly over one-half pound each. One perch was in its seventh year of life, 10.7 inches long and weighed 8.6 ounces. The lack of data on smaller and younger fish prohibits any speculation on the growth rate of this species in Thousand Island Lake. Two bluegills studied were found to be in their eighth year of life and to weigh about 11 ounces each. From this meager information an opinion is ventured that the bluegills grow well. Scales from three smallmouth bass were examined. Two of these fish were found to be in their fourth year of life. They were not quite legal length and weighed about seven ounces. The remaining fish was in its fifth year of life, was 16 inches long and weighed 1 pound, 4 ounces. It is believed that smallmouth bass might reach legal length late in their third year and certainly by the middle of their fourth. Northern pike probably reach legal length in their second year of life. Five pike in their third year averaged 19.7 inches in length and four in their fourth year averaged almost 21 inches in length and two pounds in weight. This growth is considered satisfactory. From the data on walleyed pike it can be assumed that these fish reach legal length early in their fourth year in this lake. Two fish in their seventh year averaged 19.4 inches in length and weighed two pounds, 7.2 ounces. The growth rate of walleyes in Thousand Island Lake is slightly above average when compared with other lakes in the region. Studies on the rock bass are inadequate, since none of the early year classes are represented in the data. Apparently these fish do not grow much over 8.5 inches in length regardless of how long they are in the lake. One lake trout in its tenth year was 28 inches long and weighed six pounds, 4 ounces. Very few comparative data on the growth of lake trout in this region are available; hence, it cannot be stated whether the growth of this fish is good or not.

A compilation of occasional creel census records taken by Conservation Officers during the years 1928 through 1939 shows that in 772.25 hours of fishing, fishermen took 273 fish from Thousand Island Lake. Based on these figures, the catch per hour was 0.35 fish. Of the fish caught, 82 were northern pike, 76 walleyed pike, 59 smallmouth bass, 18 yellow perch, 15 lake trout, 13 largemouth bass, 7 rock bass and one bullhead. Winter fishing records furnished 175.5 hours of the total time fished. During this 175.5 hours, fishermen caught 34 fish, or 0.19 of a fish per hour. The winter catch was composed of 16 yellow perch, 10 northern pike, five lake trout and three walleyed pike. If the winter fishing is subtracted from the total, the catch per hour for summer is 0.40 fish. This catch per hour is only 1/3 as great as the average (1.21 fish per hour) for general creel census over all waters during the past eleven years. The logical conclusion would be that fishing in Thousand Island Lake is poor indeed, but such is not the case. If the yields or catches over the state and from this lake were compared on the basis of pounds of fish per hour, another opinion would be forthcoming as to the ultimate yield of this lake. For example, suppose the average bluegill wieght were 5-1/3 ounces or three fish per pound, and the average northern pike from this lake weighed two pounds. It would take 492 bluegills to equal the weight of the 82 northern pike recorded. It is easily seen that this increase in numbers would materially affect the catch in pounds per hour. The ultimate yield of a body of water should be expressed both in numbers of fish and pounds per acre, or number of fish and pounds per hour of fishing effort, rather than in numbers alone.

Thousand Island Lake is now designated as a pike lake. No change in designation is recommended. Although this lake is quite productive, it is felt that there might be too many predacious species of fish in it. As has already been mentioned, catches of large (18-20 pounds) northern pike were taken in the past, but at present the largest seem to run between three and five pounds. With the introduction of walleyed pike, a keener competition for food may have been initiated, as has been found in other waters, and the northern pike were probably checked in their growth rate to a certain extent. It is suggested that stocking of walleyed pike be curtailed somewhat, perhaps to alternate years. This will not curtail the walleyed pike population to any great extent and it might even show that the population of this species in the lake can maintain itself by natural reproduction, just as the northern pike are doing. No further plantings of pan fish are recommended. These fish can maintain themselves easily, since there is an indication in creel census returns that the fishing pressure for them is quite moderate. Predators and parasites are not abundant enough in this lake to warrant control measures. Cover and vegetation are ample for all species of fish concerned. The drowned trees on the shoals are furnishing sufficient cover and plants are growing abundantly enough on the relatively limited shoal areas of the lake. No other recommendations for the more efficient management of this water seem necessary. Considering the shortness of the growing season, all fish in Thousand Island Lake appear to be growing satisfactorily.

Crooked Lake lies about six miles west of Watersmeet. It is reached via Thousand Island Lake Road, which touches its north end. This lake has an area of 566 acres and a maximum depth of 66 feet. At the time of the survey, the major part of Crooked Lake shore line was owned and patrolled by the Sylvania Club, a private organization, to whose grounds admission is refused. A small part of the north end of the lake is owned by private individuals. The facilities of Killarney Lodge, owned by Joe Kelly of Watersmeet, are available to friends. Entrance to the lake at other points is possible only from the Thousand Island Lake Road which skirts the north shore. Fishermen must furnish their own boats, since there are no liveries on the lake. According to Mr. Jack Hagen, assistant forest ranger, this lake formerly (10 years ago) produced large numbers of black bass. This production of large fish has declined lately, although the survey party recorded several reports of large bass (both small- and largemouth bass) during the period of study in 1938.

The basin of this lake is very irregular, long and narrow. Many bays and peninsulas make its shore line quite tortuous. The basin is so irregular that various bays and deeper parts are connected, in most instances, by narrow necks of water often so shallow as to impede navigation by rowboats equipped with outboard motors. Under such conditions, each of these bays and isolated portions of this lake would function as almost completely separate units; in other words, as individual lakes. However, fish migration between these parts is not impeded. Islands and depressions are numerous throughout the lake. The surrounding country is densely wooded and in most areas the shore is rolling and bordered by woods. The drainage basin of this lake is limited. A small intermittent stream reaches the lake from Mountain Lake just to the east. Soils in this vicinity are morainic and not very productive.

Water level fluctuation is minimal. The outlet (Little Branch of the Ontonagon River) flows northward out of the lake as a stream 10-20 feet wide. At the outlet there is a natural log jam which acts as a dam, although its effect is minimal. This dam is not a barrier to fish migration. Various other physical features of this lake are presented in Table 1. None of these features are extraordinary. But a combination of the physical characters, as herein listed, indicates that this lake should be quite productive if all other factors are optimum. The great irregularities in the shore line make more shoal areas, which produce the plant beds and foods on which fish depend. Protected, shallow bays also produce conditions favorable to fish. The extensive shoals in the southern end of this lake are certainly productive enough to offset the deeper basins in the north end. Somewhat adverse to the productivity of this lake are the rather large areas of pulpy peat which form the bottom type in waters deeper than ten feet. Pulpy peat is not a good substratum for bottom food production because of its unconsolidated, flocculent, almost colloidal state. It offers very little support to organisms seeking holdfasts or abodes on, or within, it. In contrast to the peat, sandy, rubble and boulder areas in this lake are definitely suited to bottom food production.

Thermal and chemical conditions in Crooked Lake, at the time of the survey, are given in Table 2. It is noteworthy that in three of the four deep water stations listed, the thermocline began at a depth of 15 feet and extended to depths varying from 21 to 36 feet. At station 2, which is in a narrow, well protected neck of the lake, the thermocline began at nine feet and extended to 24 feet. General surface water temperatures were relatively high when the air temperatures (70-72° F. at the time these tests were made) are considered. Chemical stratification of these waters followed the thermal layers rather closely. Oxygen was found totally or almost entirely absent near the bottom in three out of four stations, and in the thermocline it dropped rapidly to around 1.0 p.p.m. At station 1, located in the widest part of the southernmost bay, 6.2 p.p.m. of oxygen were found in the bottom waters. This is probably due to wind action,which periodically mixes the relatively shallow waters of this bay and replenishes the oxygen supply. Carbon dioxide content of the water ranged from 0.0 to 10.0 p.p.m. at the various stations. At stations 2 and 3, this dissolved gas was present at the surface. The waters of Crooked Lake are moderately soft; total alkalinity varied from 50 to 74 p.p.m. Since the water was chemically stratified, the pH (acidity and alkalinity) fluctuated between 8.4 at the surface to 6.8 at the bottom. This condition means that the water was alkaline at the surface and acid in and below the thermocline.

In view of the fact that this lake is composed of several, almost isolated units, it might be expected that a great diversity of chemical and thermal conditions would be found in the various parts. Although such a diversity exists, it is not as pronounced as it could be. However, the differences in thermal and chemical conditions in the various basins, necks and bays of this lake are great enough to make possible accommodations for various cold and warm water fish. Furthermore, waters in the upper layers of the thermocline are cold enough and sufficiently charged with oxygen to maintain cold-water fish during the relatively short, hot summer period when surface water temperatures are unsuited to these fish. Data obtained from station 1, as stated above, indicate that the southernmost basin would maintain these cold-water forms, since no chemical or thermal stratification occurs there and bottom temperatures are low enough to be well within the limit of toleration. Although not indicated on the map of this lake, springs and seepages in the basin maintain low water temperatures alongshore and in the depths at various places. The rather copious water discharge from, as compared to the intermittent, small surface drainage into, the lake substantiates the above assertion. Warm water fish are easily maintained in the shallow, protected bays where temperatures rise above the toleration limit of trout or cisco. However, as will be pointed out later in the discussion on fish growth rate for this lake, the waters appear to be too cold for optimum size increase among the warm-water species.

Aquatic vegetation is quite extensive in Crooked Lake. It occurs almost exclusively in the protected bays and along the lee (west) shore, where wind and wave actions are minimal. Scattered beds of submergent plants are found along the margins of depressions in water deep enough to avoid strong wave action. Plants collected by the survey party from this lake are listed in the following table.

Plants* of Crooked Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range (ft.)	Bottom type
Waterweed (Anacharis (Elodea) canadensis)	3	medium	3/4 acres	4'	...
Water marigold (Megalodonta Beckii)	1	sparse	...	1'-3'	...
Water shield (Brasenia Schreberi)	3, 4	dense	11-1/6 acres	2'-10'	pulpy peat
Iris (Iris versicolor)	1, 7	medium	550 sq.ft.	3"-6"	sand
Water milfoil (Myriophyllum sp.)	1, 5	medium	2-1/3 acres	6'-12'	sand and muck
Bushy pondweed (Najas flexilis)	1,3,5,6	medium	8 acres	3'-10'	pulpy peat
White water lily (Nymphaea odorata)	1,2,4	sparse	10 acres	1'-6'	muck, pulpy peat
Yellow water lily (Nuphar variegatum)	1, 6	medium	5-1/6 acres	2'-10'	muck and pulpy peat
Pondweed (Potamogeton amplifolius)	1,3,5,6	medium	6-3/4 acres	2'-10'	sand,muck, pulpy peat
Pondweed (Potamogeton gramineus)	1,6,7	sparse	2 acres	6"-6'	sand, muck
Pondweed (Potamogeton natans)	1,2,3	medium	1-1/5 acres	3'-12'	pulpy peat
Pondweed (Potamogeton Robbinsii)	1, 5	dense	2½ acres	3'-12'	sand, muck
Pondweed (Potamogeton Richardsonii)	1, 6	sparse	2 acres	1'-6'	muck
Pondweed (Potamogeton pusillus)	1,5,6	dense	8 acres	2'-10'	sand, fibrous peat
Pondweed (Potamogeton zosteriformis)	5	medium	2½ acres	3'-6'	...
Arrowhead (Sagittaria latifolia)	7	medium	625 sq. ft.	6"-2'	...
Big duckweed (Spirodella polyrhiza)	4, 6	sparse	6-1/10 acres	1'-10'	pulpy peat
Musk grass (Chara sp.)	1	sparse	...	6"	sand

*Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

Fish foods, both plankton and bottom organisms, are quite plentiful, as is shown in the averages given for Crooked Lake in Table 3. Plankton consisted mainly of animal forms and, considering the time of year in which the collections were made, the concentration was somewhat above the average for other lakes under discussion. Predominant bottom organisms were fresh-water shrimps. These small, but very palatable, fish food organisms made up over 87 per cent of the average number of forms per square foot of bottom. They were followed by finger-nail clams, midge larvae, snails, true fly larvae, caddis fly larvae, leeches and phantom midge larvae, all of which constituted the remaining 13 per cent of the bottom organisms found during the survey. Although quantitative collections made from a lake over a few days' time are entirely inadequate as a basis for true evaluation of the annual crop of food organisms, it is felt that the supply of invertebrate fish food is ample.

Species of fish taken from Crooked Lake by the survey party are recorded in Table 4. Six different game fish were taken. Of these, 50.5 per cent were yellow perch; 16.3 per cent, smallmouth bass; 16.2 per cent, largemouth bass (predominantly fry); 8.7 per cent, black crappie; 8.1 per cent, cisco, and 0.2 per cent, pumpkinseed sunfish. In addition to this list, bluegills and brook trout have been taken by various members of the Institute staff. Based on the accumulated scale samples taken from fish in this lake by gill net, fyke net and some angling, cisco and suckers have been taken most often, then follow yellow perch, smallmouth bass, bluegills, black crappie, largemouth bass, pumpkinseed sunfish and brook trout, in the order named. Common suckers were quite abundant and were the only coarse fish taken by the survey.

Of the five species of forage fish seined from this lake, blunt-nosed minnows and Iowa darters were the most abundant. They were followed closely by golden shiners, muddlers and mud minnows. Forage fish appear to be quite abundant and the supply is probably adequate to fill the demands of the various carnivorous species of game fish now in the population.

The stocking records for this lake during the years 1934-1939 inclusive are summarized in Table 5. It should be noted that bluegills have been stocked in greater numbers than either perch, smallmouth or largemouth bass. Despite this stocking, bluegills constitute a very minor element in the fish population.

Growth rate studies on the fish of Crooked Lake are given in Table 6. From these data, the following points should be mentioned. Yellow perch reach legal length during the latter part of their second year or early in their third year of life. One perch in its eighth year measured 10.1 inches in length and weighed 5.5 ounces. In comparison with perch from other lakes of this region, these fish in Crooked Lake grow somewhat more rapidly during their early years of life, but are only average in size and weight during their later years. Bluegills reach legal size during their third year and become about 7.8 inches long by their fifth year. The series of scales from this species is quite incomplete, but the growth rate, as indicated, is about normal. Pumpkinseed sunfish grow rather slowly in Crooked Lake. They do not reach legal length until sometime during their fifth year. The data for this species are not complete; older or larger fish than the age group IV were not taken. The few scale readings from largemouth bass are not adequate for any definite statement on the condition of this species in the lake. It is ventured, however, that the growth rate is somewhat slow. The largemouth bass probably reaches legal size during its fourth year of life, but one specimen in its fifth year had not yet attained the necessary 10 inches in length. A larger series of scales on the smallmouth bass gives more definite information. The smallmouth reaches legal size during its fifth year. Two specimens in their ninth year averaged 14.2 inches in length and 1 pound, 5.7 ounces in weight. This growth rate is slightly slower than that for several other lakes in the region from which bass were taken. The black crappie in Crooked Lake grow to legal length during their third year. They apparently grow very well, if a comparison with the meager data on crappies from other lakes of the region can be trusted. Four specimens in their eighth year averaged 12.7 inches in length and one pound, 4.2 ounces in weight. Since information on but one brook trout was available, no definite statements can be made concerning their growth. It has been reported that trout 15 inches long are taken. The ciscoes of Crooked Lake grow satisfactorily, or even better than average, according to comparisons with results obtained by investigators in northern Wisconsin and on Lake Huron. Most of their growth is attained during the early years of life. In some of the older age groups, average lengths are slightly shorter than those of age groups younger by one year. This is not an alarming situation, since the differences are very slight and probably would be erased if the series of scale samples were more complete.

Summarizing the growth rate data on the various species of fish from Crooked Lake, it appears that all species are growing normally for the type of water and region. However, the water of Crooked Lake is probably a little too cold for the maximum growth of warm-water species. The length of growing season is curtailed in this region and slows the growth considerably. This lake is one in which thermal conditions are apparently borderline between a cold and a warm water lake. Spawning facilities for all species of fish in the lake are more than adequate. There are plenty of shoaling sand, gravel and rubble areas, as well as beds of fibrous peat and plants.

Crooked Lake is designated under the "all others" classification and no change in designation is recommended. Results of the survey indicate that conditions in certain parts of the lake are suitable for trout. A trial planting of 6-7 inch brook trout should be made.

It is suggested that further stocking be curtailed or stopped entirely. Spawning facilities for these fish are such that they can maintain their population in the face of medium fishing demands.

Predation and parasitism are not severe enough to warrant any drastic control measures. There is some infestation of the bass by the bass tapeworm, but control of this parasite is so difficult that attempts to curb the rather slight infection would not be economical.

Cover is abundant in Crooked Lake. Wind falls, deadheads and large boulders are plentiful. No further additions are recommended. Vegetation is growing in most every place which is suited to it and the total area of these beds is ample when compared with the area of the lake. The water level is it stands is most advantageous for this lake. Very little seasonal fluctuation occurs and no regulation is required.

Spawning facilities for all species of fish in this lake are more than adequate to maintain and increase the population. The addition of spawning aids might cause over-population and consequent stunting of various species such as bluegills and perch. This lake requires little or no management under present conditions.

Sucker Lake, a lake of 439 acres, lies in the Ontonagon River drainage. It is about $1\frac{1}{2}$ miles north of Sylvania Spur and $5\frac{1}{2}$ miles northwest of Watersmeet, Gogebic County. This lake is reached via the Bass Lake truck trail off highway U.S.45 near the site of Bonifas CCC camp. No resort or cottage development is on its shores and fishing has been very light except for suckers and bullheads in early spring. Interest in this lake is more from the viewpoint of duck hunting than fishing, according to reports from local sportsmen, although perch fishing is considered good.

The lake basin is quite irregular and shallow. Four islands of considerable size are present. Bays and peninsulas break the regularity of the shore line repeatedly. The surrounding drainage basin is wooded and hilly, and the immediate shore is also heavily wooded. Lost Creek, from four to ten feet wide, enters the lake from the northwest. Drawing from the north end of this lake is Sucker Creek, from six to 20 feet wide, which meets Bluff Creek and then enters the South Branch of Ontonagon River. There is no dam in Sucker Creek where it leaves the lake. Water level fluctuation in the lake is not great enough to require control. Other physical characteristics of this lake are given in Table 1. It should be pointed out that the water is very turbid (Secchi disc reading 1.5 feet). This turbidity is probably due to a rather heavy crop of algal plankton and a suspension of pulpy peat which is kept up in the water by wave action. The turbid condition does not prohibit light penetration to depths greater than 1.5 feet because extensive plant beds are found in 10-15 feet of water. It is possible that the plant beds so decrease wave and current action that the flocculent peat is not brought into suspension. The predominance of pulpy peat as a bottom type decimates the productivity of the bottom. Such a substratum is not consolidated enough to offer suitable abodes to the usual bottom fauna. Food production is limited to the plant beds, sandy shoals and bottom areas composed of fibrous peat.

A summary of chemical and thermal conditions of this lake at the time of the survey is given in Table 2. No thermocline was present and the difference in surface and bottom temperatures was only 0.4° Fahrenheit. Oxygen was present at both surface and bottom in a concentration great enough to support fish life (6.0-6.2 p.p.m.). No carbon dioxide was found. The water of Sucker Lake is moderately soft, containing 70-74 parts of dissolved salts (calcium carbonate, etc.) per million of water. It is also alkaline throughout as shown by pH readings of 8.4. Chemically and thermally, there are no objectionable features in the waters of Sucker Lake. The entire lake is habitable for fish; there is enough alkalinity in the water to make it fairly productive and concentrations of objectionable gases are either totally absent or minimal.

Aquatic plants are generally distributed in Sucker Lake. The most extensive beds occur on the west side. Submerged vegetation is the dominant type. Emergent plants are next in abundance. Plants collected by the survey party are listed in the following table.

Plants✱ of Sucker Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range	Bottom type
Sedge (Carex Pseudo-Cyperus)	4	medium	...	6"	sand
Sedge (Carex comosa)	4	sparse	...	6"	muck
Spike rush (Eleocharis calva)	4	sparse	...	1'	...
Manna grass (Glyceria grandis)	4	medium	...	6"	muck
Iris (Iris versicolor)	4	medium	...	4'	...
Soft rush (Juncus effusus)	4	...	...	6"-1'	...
Water milfoil (Myriophyllum exalbescens)	1	medium	40 acres	6'	sandy mud
Water milfoil (Myriophyllum sp.)	4	sparse	...	4'	...
Yellow water lily (Nuphar variegatum)	3	medium	¼ acre	5'	...
Pondweed (Potamogeton amplifolius)	..	medium	100 sq.ft.	5'	...
Pondweed (Potamogeton pectinatus)	1,4	medium	...	4'-6'	...
Pondweed (Potamogeton Richardsonii)	1,2,3,4	medium	1½ acres	3'-4'	...
Pondweed (Potamogeton praelongus)	..	...	small patch	10'	...
Pondweed (Potamogeton pusillus)	1	medium	40 acres	6'	...
Pondweed (Potamogeton zosteriformis)	1, 4	medium	200 acres	4'-6'	sand and pulpy peat
Arrowhead (Sagittaria cuneata)	4	sparse	...	6"	sand
Bulrush (Scirpus acutus)	2	medium	¼ acre	2'-5'	sand

✱Identified by Miss Betty Robertson, Dept. of Botany, Univ. of Michigan.

Fish foods are very scarce in this lake. Bottom and plankton samples taken during the survey are summarized in Table 3 and illustrate the paucity of available foods. The plankton crop was almost wholly algal, but since the samples taken were surface, horizontal hauls, the zooplankton which generally occurs in deeper water was not sampled. Predominant in the bottom samples were midge larvae and true fly larvae. No other organisms were found in either shoal or deep water samples. However, leeches, crayfish and insect larvae are said to be abundant on the gravel shoals from which no samples were taken. Plants normally produce large quantities of fish food and it is surmised that the rather extensive beds in this lake were also productive. No samples were taken to prove or disprove this assertion. If the plant beds are producing fish food organisms as such beds do in other lakes, it is likely that the food supply is adequate to the needs of the rather restricted fish population in this lake. Few organisms were found in the pulpy peat bottom. Production of bottom fauna by the greater part of the lake basin is, consequently, very poor.

Fish taken or reported by the survey party are listed in Table 4. Yellow perch were most abundant. They were the only game fish taken. Brook trout are recorded in creel census records from this lake. Common suckers, black bullheads and brown bullheads were the coarse fish found in this lake. The suckers were predominant in this group. Only two species of forage fish were taken. These were Iowa darters and black-nosed shiners; the former being the most abundant. Stocking records for Sucker Lake from 1934-1939 inclusive (Table 5) show 1,725,000 walleyed pike and 5,000 bluegills planted. No trace of either species was found. Apparently these fish were unable to live in the highly turbid waters.

Scales of but six perch were available for growth rate studies (Table 6). These fish were found to be equally divided between age groups IV and V. They ranged between 10 and 10.6 inches in length and 6.9-7.6 ounces in weight. From this incomplete study it appears that the perch grow satisfactorily in this lake.

Natural spawning facilities are abundant in Sucker Lake. There are plenty of weed beds, sandy and gravelly shoals and logs, brush and boulders. The perch should be able to more than maintain their population, since fishing pressure is very moderate. The lake is fished for suckers and bullheads during the early spring, either through the ice or just after its disappearance. Occasional creel census records show a very high catch per hour during this spring period. In March, 1934, during twenty-four hours of fishing with spear and dip net, 35 perch and 475 suckers were taken. The catch per hour was 21.2 fish. In May, 1935, one record of three hours of fly fishing shows seven brook trout averaging 9.5 inches in length as having been taken. On March 27, 1937, sixty hours of fishing effort with dip nets and gaffs yielded a catch of 228 suckers. The catch per hour was 3.8 fish.

Sucker Lake is designated as belonging to the "all other lakes" class. No change in designation is recommended until the following management suggestions have been applied. If it is found that northern pike become established, a change to "pike lake" classification is recommended. Further stocking with walleyed pike and bluegills should be discontinued. An attempt to establish northern pike in the lake by stocking adult or near adult fish should be made. This species is better suited to this type of lake than are walleyed pike. Although the forage fish population is small, a plentiful food supply for northern pike would be furnished by young suckers and perch.

Loons, blue herons, ospreys, kingfishers, eagles and gulls are reported as common on this lake. Since the importance of the fishery here is not great, no control measures are recommended. Results of various works on these fish-eating birds have minimized the danger of their predation except in places where fish are confined in great numbers, as in hatcheries. Neascus or black spot, and Clinostomum or yellow grub are present, as parasites, in the perch and suckers. No heavy infestations were found and since these parasites are not harmful to man, the application of control measures now known would not be economical.

Cover in the form of windfalls, deadheads, brush, boulders and vegetation is abundant in Sucker Lake. No additions of artificial devices to afford cover are recommended. The water level does not fluctuate enough to require regulation. Raising the level of this lake by damming the outlet would not better the fishing. The immediate shore is so heavily wooded, only a jungle of drowned timber would result. Spawning facilities are ample. No artificial aids are needed.

The apparent lack of interest in this lake as a fishing lake would not justify any major changes to better fishing. Some further investigations should be made to verify the report that trout occur there at least seasonally. Follow-up checks should be made after the planting of northern pike to determine whether or not they have become established.

Beaton's Lake, a body of water 323 acres in extent, lies in Gogebic and Ontonagon counties. It is about 13 miles northwest of Watersmeet and is reached via a rough, narrow side road (1937) off U.S. 2 about 11 miles west of Watersmeet. Although it has no permanent inlets or outlets, it lies in the Ontonagon river drainage. Fishing on this lake has been just fair or average for many years. There are two lodges (Caseda and Stickley) on the southwest end of the lake. These are private concerns which own most of the land surrounding the lake. Four or five boats are maintained by them and are rented to fishermen. No other resort or cottage development was on the lake at the time of the survey (September, 1937). This lake has been the object of considerable correspondence dealing with the reported presence there of land-locked salmon (*Salmo salar sebago*). These fish were planted by Mr. C. M. McDonald from small shipments obtained from the state of Maine through the U. S. Bureau of Fisheries in 1929 and 1930. Mr. McDonald reports catching several, one in 1931 which was positively identified by Dr. Carl L. Hubbs of the University of Michigan Museum, and three in 1932 which weighed 4 3/4 pounds each. These were not sent in for identification.

The basin of Beaton's Lake is quite long and narrow. It is very picturesque, being bounded by high banks most of the way around. Irregularities of the shore line are limited to the north end where the lake splits into two arms which contain several rather extensive bays. The sides of the basin are quite abrupt and the bottom is quite irregular, containing two distinct depressions. Formation of the lake was probably the result of the melting of an irregular block of ice which had been covered by glacial debris during the retreat of the last glacier from the region. Surrounding the lake are wooded hills and the immediate shore is almost wholly wooded, except for a few areas of sand and gravel. The drainage basin is very limited and the lake is fed almost entirely by springs and some minor surface run-off. Most of the soils thereabout are morainic. Since there are no major inlets or outlets on this lake, water level fluctuation is minimal. One small, intermittent outlet, called Two Mile Creek, is reported. Other physical features of Beaton's Lake are given in Table 1. Especially noteworthy among these features are the lack of shoal areas in most of the basin and the great depth of water. Shoals in this lake are quite narrow. Furthermore, sand and gravel are their main constituents. Although the basin is so situated that northwest prevailing winds do not sweep the length of it, the lake is wide enough to allow formation of waves of considerable magnitude. These waves beat the southeast shore, prohibiting plant growth and stabilization of the bottom materials. Winds from other directions, not quite as frequent as northwesterly ones, cause similar action on other shores. Most of the shoals are more or less barren because of wave and current action. Due to the depth and narrowness of the basin, the bottom slope is very abrupt in the main part of the lake.

In places, the declivity is very steep; descending to a depth of 70 feet only 300 feet out from shore. These characters and their interactions are all detrimental to productivity. Plants are excluded by wave action and the type of bottom, shifting as it does, maintains very few organisms. Steep slopes and wave action keep the narrow shoals devoid of organic matter necessary for food production.

Thermal and chemical conditions found in the waters of Beaton's Lake during the survey are summarized in Table 2. Surface water temperature was 71.2° F. when the air was 73° Fahrenheit. A definite thermocline was present between depths of 24 and 36 feet. In this twelve-foot layer the water temperature dropped from 68° to 46.9° Fahrenheit. The lake was chemically stratified, but this stratification was deeper than the thermocline. At the top of the thermocline 7.9 p.p.m. of dissolved oxygen were present, at the bottom of this layer 6.3 p.p.m. were found. Oxygen disappeared gradually below the thermocline, only 0.4 p.p.m. being present at the bottom of the lake. Carbon dioxide ranged from 1.0 p.p.m. at the surface to 15 p.p.m. at the bottom. The water was found to be very soft at all depths; only 23 p.p.m. of dissolved salts were present. The lake is also acid, as shown by pH readings of 6.5 at the surface to 6.1 at the bottom. Most of these conditions are indicative of low productivity. The temperatures in and below the thermocline are suitable for cold-water species of fish and since chemical stratification occurs at depths far below the thermocline, there is a rather wide stratum of water in which these fish could live during the hottest period of summer when surface water temperatures are too high. Acidity and softness of the water in Beaton's Lake probably do not affect the fish life directly, but do inhibit production of plants and certain phases in the food chain of these fish. The phytoplankton crop is definitely affected by these factors. Snails and clams, as well as certain other bottom organisms, are curtailed and sometimes entirely excluded by such conditions. The carbon dioxide concentration is not great enough to be serious. This gas does aggravate the acid condition of the water, since it forms an acid when in solution.

Aquatic vegetation is very sparse in Beaton's Lake. Small beds grow in sheltered bays and a very narrow, discontinuous belt of submerged plants grows around the edge of the declivity and below the limits of wave action. A positively identified list of these plants is not available, since most of the specimens were identified in the field. From the lists furnished with the survey cards, pondweeds (*Potamogeton*) are most abundant. The *Potamogetons*, as identified, are *P. spirillus*, *P. epihydrus*, *P. gramineus* and *P. praelongus*. Other plants are listed and their relative abundance given as follows: musk grass (*Nitella*) sparse, bushy pondweed (*Najas flexilis*) common, wild celery (*Vallisneria*) common, horsetail (*Equisetum*) common, quillwort (*Isoetes*) common, bur-reed (*Sparganium fluctuans*) common, yellow pond lily (*Nuphar advena*) sparse, pipewort (*Eriocaulon septangulare*) common, coontail (*Ceratophyllum*) common, water crowfoot (*Ranunculus trichophyllus*), and water marigold (*Megalodonta Beckii*). The abundance of the latter two was not stated. All of the ratings as to abundance refer to areas of plant occurrence only and not to the entire lake. There is little doubt that the aquatic plants in Beaton's Lake are very inadequate. Encouragement or propagation of more extensive beds is practically impossible because of the nature of the lake basin. Plants are now growing in almost every place suited to them.

Records of bottom and plankton samples taken from Beaton's Lake are summarized in Table 3. Density of plankton in the water, at the time of the survey, was found to be average for that time of year. Cladocera or water fleas were the predominant forms. These are good food for young fish and are probably utilized when they are drifted into shallow water by onshore winds. Bottom fauna in this lake is very scarce. Midge larvae and fresh-water shrimps were the only inhabitants found in the depths by the survey party. The midge larvae averaged 14.6 individuals per square foot and were most abundant. No samples were recorded from the rubble and gravel shoals, where, no doubt, considerable food is produced in the form of mayflies, caddis flies and other stony shoal inhabitants. Food conditions in the lake are not adequate for a large fish population. To increase the food supply would be a very difficult and expensive project, and is not warranted at present. Most of the available food for fish is produced in the plant beds and hence the food supply is directly proportional to them. Increase of aquatic vegetation would certainly increase the supply of organisms used as food by fish. The lack of shoals and the rather unproductive nature of the bottom material composing them are factors limiting production of bottom foods.

Records of fish taken during the survey of Beaton's Lake are summarized in Table 4. It will be noted that five species of game fish, one of coarse fish and five of forage fish are listed. Of the game fish, perch and rock bass were taken most often. Smallmouth bass and bluegills were next in abundance. A few pumpkinseed sunfish fry were also taken. In addition to these species, rainbow and lake trout are reliably reported. As discussed in the introduction, land-locked salmon have been taken from this lake. Common suckers are quite abundant and represent the only coarse fish in the lake. Of the forage fish, blunt-nosed minnows are most abundant, common shiners are next, Iowa darters and black-nosed shiners next, and muddlers least. Stocking records for this lake during the years, 1934-1939 inclusive, are given in Table 5. Lake trout and bluegills have been stocked most heavily. Rainbow trout, smallmouth bass and yellow perch are the other species stocked. In Table 6, the growth rate of the various game fish is given. Scale samples were inadequate in both numbers and size range to give a true picture of conditions, but an idea as to the rate of growth may be had from the available data. Yellow perch appear to grow at an average rate when compared with perch from other lakes of the region. They reach legal length during their fourth year of life and get to be 8.7 inches long in their fifth year, not growing much longer in subsequent years. Although the lengths of these fish may be average, the average weights are far below what they should be and indicate that the fish are probably starving. This contention is also supported by the fact that very little growth is made after the fifth year of life. Smallmouth bass probably reach legal length early in their fifth year of life. One specimen taken late in its fifth summer was 11.4 inches long and weighed 14.4 ounces. This rate of growth is about average. The rock bass in this lake grow slightly better than average. They are of legal size by their fifth summer and continue to grow about an inch per year. Two specimens in their seventh summer averaged 8.3 inches in length and 6.3 ounces in weight. Two rainbow trout were aged. One, in its sixth year, was 20.1 inches long and weighed approximately three pounds. Another, the age of which was quite obscure (probably eight or nine years), was 23.1 inches long and weighed two pounds, five ounces. This fish was very slender and in poor condition. Data on bluegills and pumpkinseed sunfish were not available for study.

Spawning facilities are good in Beaton's Lake for smallmouth bass and rock bass, and only passable for bluegills and perch. Rainbow trout and land-locked salmon, usually requiring streams in which to spawn, are entirely restricted because no inlets and only one small outlet are present. Lake trout are amply supplied with shoals which might be used for their reproduction.

Occasional creel census records taken on this lake are few, but quite significant in that they supply records of lake trout catches. In February and March, 1934, records of five fishermen were turned in. During 21 hours of fishing through the ice with minnows, six lake trout averaging 14 inches in length, and five eight-inch perch were taken. The catch per hour was 0.3 fish. One record for July, 1935, shows two smallmouth bass and five sunfish caught in four hours of fishing. On March 19, 1938, seven fishermen spent $32\frac{1}{2}$ hours fishing through the ice and caught no fish.

Considering the physical, chemical and biological characteristics of Beaton's Lake, it is certain that the productive capacity of this body of water is very limited. The general nature of the basin (great depth and lack of shoals); chemical stratification, softness and acidity of the water; paucity of aquatic plant beds and fish foods; and the very short growing season in this region all tend to greatly restrict productivity. Under proper control, a relatively small crop of good fish can be produced each year, but it can not be hoped that this lake will be a great producer of fish for many years.

Beaton's Lake is now designated as a trout lake. After consideration of the survey data, no change in designation is recommended. With normal control of stocking and selection of species to be stocked, this lake will produce more trout than any other desirable game fish. It is suggested that the stocking of bluegills and perch be discontinued and every effort made to curb reproduction of these and pumpkinseed sunfish. Nests and spawn should be destroyed, if possible. Such a practise will not eradicate these species, but will reduce their numbers so they will not compete too strongly with trout and at the same time achieve a faster growth because more food will be available. The present policy for stocking rainbow and lake trout should be continued. Planting legal-sized fish in the case of these last named species would be most advantageous. Populations of rainbow trout would have to be maintained by artificial stocking. Encouragement of the smallmouth bass should be avoided. These fish can and will take care of themselves in this particular lake.

Predators and parasites are negligible factors and need no curtailment. Their numbers are so few that depredations or serious infections on the fish are very unlikely.

There seems to be sufficient cover around the shoal areas of this lake. Gravel, boulders, logs and snags are almost continuous around the shore. Vegetation, as cover, is definitely insufficient, and, as stated above, would be almost impossible to increase. Cover could be added to the lake in the form of brush shelters, heavily weighted and placed in 10-15 feet of water. However, these might serve only to increase the perch and bluegill population, which would not be advantageous for trout. For this reason, and because it is not known whether they would be used at all by trout, we do not recommend the installation of brush shelters in Beaton's Lake.

There is no need for regulation of water level. The level remains almost constant and since the outlet is intermittent, a dam placed there would not be worthwhile. Raising or lowering the level of the lake would not increase the shoal area enough to make such a change worthwhile. Spawning facilities cannot be improved for trout and should not be improved for other competing species.

The further stocking of land-locked salmon is not believed worthwhile. Difficulties encountered in obtaining stock and eggs, and getting the fish started are greater than benefits derived from the presence of these fish in the lake. Furthermore, these fish cannot reproduce in the lake and would have to be maintained by periodic stocking.

Introduction of a deep water forage fish such as cisco, whitefish, or possibly smelt, is suggested. Young of these fish would furnish a source of food to trout during the summer periods when surface waters are too warm for them to forage in the shallows. Whitefish and cisco are plankton feeders and would convert a now little utilized food supply into food for trout. They do not compete with trout for food because they are plankton feeders.

Marion Lake, 318 acres in extent, lies in the Ontonagon river drainage, about four miles due east of the town of Watersmeet. It is reached via a good county road which runs north from highway U. S. 2. On its shores are about 17 cottages and one resort. This resort maintains a boat livery and also affords excellent swimming facilities for guests. The general fishing reputation of this lake is good and has maintained itself for years under medium summer fishing pressure. During the last few years, crappies have been taken, where previously they were not present in anglers' catches.

The lake basin is quite regular, sloping gradually from shore to a 40foot depression near the middle. Its long axis lies in a northwest-southeast direction. Configuration of the shore line is irregular; several large bays and peninsulas occuring around the lake. The surrounding country and immediate shores are wooded for the most part. Some marshy areas occur around the bays. The drainage basin of Marion Lake is quite restricted, extending over four square miles at the most. This drainage area is flat to gently rolling and the soils there are morainic. Entering the lake from the south is a small stream about three feet wide, which collects water from lowlands. At the extreme north tip of this lake an outlet (probably Henderson Creek) about ten feet wide flows sluggishly northward to the middle branch of the Ontonagon River. About 500 feet below the lake a beaver dam three feet high partially blocks the flow of this stream. The dam is said to have no effect on the level of the lake and to offer no impediment to fish movements. Physical features of this lake, other than those already discussed, are given in Table 1. It is interesting to note that about 75 per cent of the lake bottom is considered as shoal. This is definitely an advantage in productivity, although its effectiveness is reduced somewhat by the rather high turbidity of the water (Secchi disc reading, six feet). Bottom constituents of the shoal are predominantly sand. Gravel is generally distributed over the shallow, open shoals, being intermixed with the sand. Restricted fibrous peat beds occur in some of the protected bays. The bottom material in areas deeper than 15 feet is muck. Most of the physical features of this lake are conducive to productivity. Extensive shoals, protected bays and irregular shore line are definitely favorable to food production and plant growth. The long axis of the lake, lying in the same direction as the prevailing winds blow (northwest-southeast), exposes the southeast portion to considerable wind and wave action which inhibit plant growth and bottom consolidation. Sand, predominating on the exposed shoals, aggravates the situation, since it is unstable and shifting when exposed to wave action. Furthermore, the occurrence of sand as the predominant shoal bottom type reduces productivity even in the more protected regions, since winds from other directions, although not quite as frequent, tend to keep it in an unstable state.

Thermal and chemical conditions in this lake, as found by the survey party, are summarized in Table 2. Thermal stratification was found on July 6, 1938, rather early in the season, and the thermocline was located between the 21- and 27-foot depths. A difference in temperature of 18° F. existed between surface and bottom waters. Definite chemical stratification accompanied the temperature changes. Surface waters contained 7.8 p.p.m. of dissolved oxygen. At 21 feet (top of the thermocline) the oxygen content had dropped to 4.5 p.p.m. and at the bottom of the thermocline (27 feet) only 1.0 p.p.m. of this dissolved gas was found. Below this point the oxygen content of the water gradually decreased to 0.2 p.p.m. at the bottom. Carbon dioxide was present in concentrations ranging from one to nine p.p.m. with increasing water depth. The amount of carbon dioxide is not highly significant except when oxygen is scarce. Water in Marion Lake is very soft. It contained only 12-15 p.p.m. of dissolved salts. The water is also slightly acid, ranging from a pH of 7.2 at the surface to 6.4 at the bottom. These thermal and chemical features of the water in this lake tend to curb productivity. Under ordinary circumstances it can be expected that the thermocline will move nearer the surface as the season progresses. Such a movement would isolate more water from surface circulation and oxygen dissolved in it would rapidly become depleted, thereby increasing the unproductive volume of the lake. Waters containing less than three p.p.m. of oxygen and relatively high concentrations of carbon dioxide are untenable by most fish. Food organisms are also markedly restricted in such waters. The scarcity of dissolved salts (calcium, magnesium, sodium, etc.) in this water inhibits plant growth directly and animal growth indirectly, since the food of most animals is derived from plants. Very soft waters are always less productive than moderately hard ones. The slight acidity of the water aggravates the effects of soft water conditions on productivity.

Aquatic plants are quite restricted in Marion Lake, considering the abundance of shoal areas which might support them. Plant beds are located in sheltered bays, are generally between the surface and 10-foot depths, and are mostly of the emergent and floating types. There follows a tabular arrangement of plants as found in Marion Lake. Identifications were made by Miss Betty Robertson of the University of Michigan Botany Department.

Plants of Marion Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range	Bottom type
Water shield (Brasenia Schreberi)	1,2,3	dense	1 acre	1'-4'	fibrous peat
Sedge (Carex substricta)	1	medium	2,500 sq.ft.	1"-2"	fibrous peat
Sedge (Carex rostrata)	3	medium	3,000 sq.ft.	6"	sand
Blue joint grass (Calamagrostis canadensis)	3	sparse	...	6"	sand
Water arum (Calla palustris)	3	sparse	...	1'	sand
Leatherleaf (Chamedaphne calyculata)	1	medium	1/7 acre	6"	fibrous peat
Three-way sedge (Dulichium arundinaceum)	1	medium	1/7 acre	6"	fibrous peat
Iris (Iris versicolor)	1,3	sparse	...	2"-6"	fibrous peat
Soft rush (Juncus effusus)	1,3	medium	1/7 acre	6"-1'	fibrous peat
Water lobelia (Lobelia Dortmanna)	2	dense	1,200 sq.ft.	1'	fibrous peat
White water lily (Nymphaea odorata)	3	medium	1.5 acres	3'	fibrous peat
Yellow water lily (Nuphar advenum)	1	sparse	...	2'	fibrous peat
Yellow water lily (Nuphar variegatum)	1,3	medium	1.5 acres	2'-6'	fibrous peat
Pondweed (Potamogeton epihydrus)	3	medium	1.5 acres	2'-6'	fibrous peat
Pondweed (Potamogeton natans)	1,2,3	medium	6 acres	2'-4'	fibrous peat
Willow (Salix sp.)	1	medium	1/7 acre	6"	...
Bur-reed (Sparganium sp.)	1,3	sparse	1.5 acres	2'-3'	...
Bur-reed (Sparganium angustifolium)	1,3	sparse	...	1'-2'	...
Cattail (Typha latifolia)	3	sparse	...	1'	...
Skullcap (Scutellaria epilobiifolia)	1	medium	300 sq.ft.	2"	...
Bladderwort (Utricularia purpurea)	3	medium	1.5 acres	1'-3'	...

Vegetation in this lake is somewhat inadequate, but its abundance is limited by physical and chemical conditions which would be difficult to change.

Plankton abundance and bottom food conditions as found in Marion Lake during the survey are summarized in Table 3. The plankton crop was very poor. Crustacea dominated the organisms present. Usually at the time of year these samples were taken the plankton crop is high in lakes of the region. Therefore, it may be assumed that poor plankton production is characteristic of Marion Lake. Waters which are both soft and acid in reaction are, as a general rule, very poor in plankton. Quantitative studies of bottom foods in this lake show only average populations of these forms. During the survey it was found that midge larvae were most abundant. They were followed by phantom midge larvae (Corethra), mayflies, other true flies and fingernail clams. Undoubtedly the plant beds produce fairly large numbers of food organisms which supplement the rather limited production of the bottom areas.

Fish, taken by the survey party, are listed in Table 4. Six species of game fish, one of coarse fish and five of forage fish were recorded. Of the game species, bluegills and pumpkinseed sunfish were most abundant. Smallmouth bass were also abundant. Crappies, perch and largemouth bass were common. Most of the largemouth bass taken were fry and juvenile fish. The smallmouth bass were found to be somewhat small, seldom weighing over 1.5 pounds. Common suckers were common, but not very large. Mud minnows and brook sticklebacks were about the only forage fish in the lake proper. Red bellied dace, fine-scaled dace and northern dace were quite abundant near the inlet and outlet. Stocking records for this lake during the years 1934-1939 inclusive are given in condensed form in Table 5. Bluegills have been stocked most abundantly.

Available data on the growth rate of the various game fish found in Marion Lake are given in Table 6. Scales from but two perch show that they reach legal size during their third summer. Bluegills grow quite slowly, reaching legal length sometime late in their fourth or early in their fifth year of life. One specimen in its seventh summer was 7.9 inches long and weighed 4.7 ounces. If these results are typical, there appears to be an overpopulation of bluegills and sunfish, considering the available food supply. The pumpkinseed sunfish grow somewhat slower than the bluegills. Six fish in their fifth summer averaged 6.4 inches in length and 2.9 ounces in weight. Smallmouth bass reach legal size during their fourth year of life, but grow slowly from that age on. Ten fish early in their seventh summer averaged 13.6 inches in length and about one pound, four ounces in weight. Only one crappie was available for study. It was in its eighth summer, was 11.4 inches long, and weighed 14.3 ounces.

Natural spawning facilities for all fish in Marion Lake are adequate. There are plenty of gravelly, sandy and bouldery shoals for bluegills, smallmouth bass and sunfish. Weed beds are extensive enough to accommodate the perch and largemouth bass. Forage minnows are also well provided for in this respect. Boulders, deadheads and brush piles are plentiful enough to accommodate the species now present in this lake.

Marion Lake is now in the "all others" group. No change in this designation is recommended. Further stocking of pan fish should be stopped, since it appears that there is already an over-supply of these species in the lake. Considering the physical, chemical and food supply conditions and the relatively light fishing pressure on this lake, it is almost certain that natural reproduction is adequate to maintain the population. Stocking of bass should be restricted until the population of smallmouth bass has been reduced to the point where better growth is made.

Parasites and predators are not abundant enough to warrant any control measures. Cover is only fair. Several brush shelters (40) have already been placed in the lake and there is moderate natural cover. Aquatic plants are growing in almost every situation fit for them and their extension would require considerable modification of shoals and water conditions by artificial means. It would be necessary to introduce lime rock in rather large amounts to overcome the acidity and softness of the water. Construction of breakwaters out from headlands windward of now unprotected bays would afford plants an opportunity to become established there. At present, the importance of this lake as a fishing spot is not great enough to justify such improvements. Addition of more brush shelters might aid in protecting young fish, but it is doubtful that this should be done, because it would only tend to increase the crowding which already exists.

Water fluctuation is very slight and present structures now in the outlet seem adequate. Raising or lowering of the water level would not improve the food supply or fish population.

Spawning facilities are more than ample to fill all requirements of the fish now present in the lake. It might be well to attempt spawning control by destruction of bluegill and sunfish nests.

Bass Lake has an area of 191 acres. It lies in the Ontonagon River drainage about three miles north of Watersmeet. It is reached via highway U.S.45 out of Watersmeet. This highway skirts the eastern shore of the lake. In lumbering days, a sawmill was located on the shores of Bass Lake. During the years this plant operated, the lake was loaded with logs, slabs and other mill wastes. At present, a large portion of the lake bottom and shore line is covered with this waste material. A Civilian Conservation Corps camp (Camp Bonifas) now occupies the old mill site. Fishing on this lake has always been fair, but is said to have been much better before the mill refuse was dumped in. In addition to the CCC camp, seven cottages are located on its shores. The lake is used almost entirely for fishing, swimming and boating being very unimportant there.

The basin of this lake is shallow (maximum depth, 13-14 feet). It is shaped roughly like a triangle with its long axis running north and south, and its base toward the north. The shore line is quite regular. One small island is located in the northeast portion. A small inlet enters the lake from the west midway between the north and south ends. The outlet drains from the south end as a small, log-filled, shallow run and reaches the middle branch of the Ontonagon River after flowing about a mile. The drainage area is small (about four square miles) and wooded. Immediately adjacent to the lake are sandy, grass- and shrub-covered areas. Water level fluctuation is minimal in normal years. Other physical features of this lake are given in Table 1. It should be noted from this table that the entire lake is considered to be shoal area (maximum depth 13 feet). The water is brown and fairly turbid. A Secchi disc disappears from view at a depth of 4.5 feet. Pulpy peat is the predominant bottom type, although in the shallows sand and gravel are present. Some encroachment of the shore is beginning around the island and at various points along the shore line. Most of these characteristics are indicative of senescence in this lake, but the shallowness is conducive to productivity despite the predominance of pulpy peat, which is not a suitable substratum for good fish food production.

Chemical and thermal conditions found in this lake by the survey party are summarized in Table 2. The water was fairly cool, but probably would not support cold-water species of fish. No thermocline was present and it is almost certain that one does not form. Wave action and currents would certainly keep the shallow water in agitation. There was only 2.8° F. difference between surface and bottom waters. The oxygen content of surface and bottom waters was practically the same. Carbon dioxide was present in insignificant amounts. The water was moderately soft and acid in reaction (6.3-6.5 pH). The absence of chemical and thermal stratification makes the entire lake habitable for fish. Softness and acidity of the water are indirectly detrimental to the fish, because they influence the success of plant beds and fish food production by limiting establishment of certain of the better types.

Plant beds occur around the entire lake, but are restricted in the pulpy peat areas to a single bed in the northern part. Most of these plants are of the submerged types, although a few of the floating types are interspersed. Emergent vegetation is practically absent. The following table presents the results of field identifications and estimates on abundance at the various stations where plants were collected.

Plants in Bass Lake

Name of Plant	Station numbers	Abundance	Bottom type
Najas flexilis (bushy pondweed)	1,3,4,5	common	sand
Potamogeton spp. (leafy pondweeds)	1,2,3,4,6	abundant	sand and pulpy peat
Potamogeton spp. (grass-leaved pondweeds)	1,2,3,5,6	common	sand and pulpy peat
Nymphaea odorata (white water lily)	1	rare	sand
Nitella or Chara (musk grass)	1, 2	common	sand
Vallisneria spiralis (wild celery)	1,2,3,4,5,6	common	sand and pulpy peat
Nuphar advenum (yellow water lily)	2,3,5,6	common to abundant	sand
Sparganium sp. (bur-reed)	2,5,6	common	sand
Typha latifolia (cattail)	2, 5	sparse	sand
Myrica Gale (sweet gale)	2,4,5,6	abundant	shore
Iris versicolor (iris)	2	common	sand
Carex sp. (sedge)	2	common	sand
Potamogeton spp. (bottom pondweeds)	3,5,6	common	sand and pulpy peat
Potamogeton spp. (floating pondweeds)	4,5,6	common	sand and pulpy peat
Myriophyllum sp. (water milfoil)	5, 6	common	sand and pulpy peat
Ceratophyllum demersum (coontail)	6	sparse	pulpy peat

Plankton and bottom food summaries are given in Table 3. Production of plankton during the fall months is generally higher than in summer, which probably accounts for the very rich plankton crop found by the survey party. The predominant plankton organisms were Cladocera, animal plankton. Well oxygenated and relatively shallow waters are conducive to good zoo-plankton production. Bottom organisms were generally rare. Quantitative studies showed a poor population, only 0.25 c.c. per square foot. Predominant in the bottom community were snails, followed by fingernail clams, midge larvae, leeches, Corethra larvae and mayflies. As previously stated, both pulpy peat and sand are poor substrata for bottom food production. No samples were taken from the plant beds, but it is almost certain that these beds produce large quantities of readily available fish food. The slabs, logs and gravel on the shoals of this lake should also produce some fish foods. However, food conditions as a whole are not too good and the food available would not support a large population of fish.

Fish taken from Bass Lake are listed in Table 4. Six species of game fish, one of coarse fish and four of forage fish are reported. The game fish, listed in order of abundance, are black crappie, yellow perch, pumpkinseed sunfish, largemouth bass, smallmouth bass and bluegills. Common suckers are quite abundant. Golden shiners predominate among the forage fish; mud minnows, common shiners and Iowa darters follow, in order of occurrence. The forage fish are not very abundant. During the years 1934-1939 inclusive, yellow perch and bluegills have been stocked in Bass Lake. Total numbers of these fish placed in this lake are given in Table 5. From results of growth rate studies on fish from this lake, as given in Table 6, it is noted that yellow perch grow very slowly, not reaching legal size until their fifth summer. Pumpkinseed sunfish also grow slowly, reaching legal length during their fifth year of life. Largemouth bass grow at a somewhat faster rate. Some of them are legal size early in their fourth summer. Four specimens in their sixth year averaged 14.0 inches in length and weighed one pound, 5.6 ounces. Only one smallmouth bass was available for study. It was in its fourth growing season, was 10.6 inches long and weighed almost nine ounces. Black crappie in Bass Lake probably reach legal size during the latter part of their third or early part of their fourth growing season. No specimens in these age groups were available. The older fish attain fair size. Twelve fish in their seventh summer averaged 9.3 inches in length and 6.8 ounces in weight. None of the many bluegills stocked in this lake were available for study. Only four bluegills were taken by the survey party and three of these were found to be hybrids, crossed with pumpkinseed sunfish.

Natural spawning facilities for the various species of game, coarse and forage fish are adequate. Plant beds and the accumulated debris under them serve perch, bass, sunfish, crappies, bluegills and the forage fish well. Suckers are able to run the inlet and outlet.

It appears that this lake is somewhat overpopulated with game fish, especially sunfish and crappies. Although the crappies are growing fairly well, competition for food must retard them as it does the sunfish and bluegills. The latter species seems unable to become permanently established despite heavy stocking. A few individuals survive, but hybridize readily with the sunfish. Offspring from such crosses are usually infertile. The productive potential of the lake is quite limited because of adverse physical and chemical factors; hence, the population of fish present can easily become too great for the food supply.

Bass Lake is now in the "all others" designation. No change in classification is suggested. The water is too warm for trout and apparently pike do not inhabit the lake. Further stocking of all kinds of game fish should be stopped. Natural reproduction is more than adequate to replace losses in the population by old age, disease, and angling. It may even be necessary to discourage or control natural reproduction by nest and breeding ground destruction. The introduction of a few adult northern pike might help to relieve the population pressure. These fish will feed on bluegills, sunfish and suckers. Predators and parasites are not abundant enough to require any control.

Cover in this lake is abundant. Saw mill slabs, old logs, brush and plant beds are enough for all purposes. It might be well to attempt removal of some of these planks and logs. This removal would bring the natural bottom materials into production once again. It has been reported that this lake produced more fish before the mill operated than it ever has since. Restoration of almost all of the lake bottom now covered with slabs would possibly increase plant growth and result in a richer bottom food supply.

Water level control is not necessary. Spawning facilities need no improvement. The CCC camp empties its sewage, which is filtered, into the lake, but this source of pollution is not too great as long as the lake is not used for swimming extensively. Additions, such as this one, may have a beneficial effect, since this water appears to be low in certain essential elements which are generally found in sewage. It might also be advantageous to add lime rock to the channel of the inlet stream to raise the content of calcium salts in the lake. Ground lime rock could be placed around the shoals.

Nothing would be accomplished by placing this stone in pulpy peat areas, where it would immediately become covered and isolated from the lake waters.

Bob Lake, 120 acres in extent, lies in the Ontonagon River drainage. It is about four miles due southeast of the town of Rousseau. A county road running to the southeast from Rousseau passes within one-fourth mile of it and a small, old logging road leads directly to the lake from there. Two cottages, one a lodge, and a U. S. Forest Service park are on its shores. The immediate shores of Bob Lake are brushy, burnt-over areas now covered with some second growth timber. Surrounding areas are generally wooded, sandy plains. The drainage basin of this lake extends over about ten square miles. The shore line is quite irregular and has become encroaching along the west or windward side of the lake. Other physical features are listed in Table 1. It will be noted that the basin is very shallow. Its maximum depth is only 15 feet. Muck is shown on the map as the predominant bottom type and constitutes both the east and west shores. However, it is almost certain that this bottom type is pulpy peat rather than muck. Restricted parts of the north and south shores are sandy. A small stream enters the lake from the southeast. Springs and seepage furnish additional water. Two small outlets leave the lake from two small bays on the west shore. These later merge to form Leveque Creek, which drains into the Ontonagon River. Water in this lake is quite brown and turbid (Secchi disc reading, five feet).

According to Table 2, which presents a summary of thermal and chemical features found by the survey party, the water becomes quite warm in summer. No thermocline is formed and sufficient oxygen to maintain fish is present from top to bottom. The water is very soft, containing only 13 p.p.m. of dissolved salts. Relatively high acidity is also denoted by a pH reading of 5.8. All of these chemical and physical characteristics indicate that Bob Lake is quite senescent. In other words, it is rapidly approaching extinction. Due to the changes which occur in the water and basin of such a lake, the entire fish population is gradually changed either by direct or indirect environmental pressures. Plants are restricted both in kinds and numbers. Bottom foods become scarce and restricted in the number of species able to survive. Plankton organisms are limited in a similar manner.

The vegetation in Bob Lake occurs very close to shore in a narrow band between depths of one and four feet. Floating types are definitely in the majority. Only one species of the submergent type was collected and that was a moss. The following plants were taken by the survey party: water shield (*Brasenia Schreberi*), medium in abundance; spike rush (*Eleocharis palustris*), scarce, limited to sandy shoals; yellow water lily (*Nuphar advenum*), most abundant plant in the lake; bulrush (*Scirpus sp.*), rare; bur-reed (*Sparganium fluctuans*), common; and a moss (*Fontinalis vescurii*), taken at one station only. The vegetation is very inadequate in Bob Lake. Although the lake basin is shallow enough to accommodate plants throughout, pulpy peat bottom and very soft, highly acid water restrict to a few species the plants which can live there. The lake is very much a bog.

Bottom foods and plankton organisms were found to be only average at the time of the survey. According to the summary for this lake as shown in Table 3, phantom midge and midge larvae were the only bottom organisms present. Plankton was predominantly small unicellular plants. Acid, soft and colored water conditions interacting with pulpy peat and sand as bottom types tend to reduce and often entirely eliminate bottom fauna.

Only three species of fish were taken by the survey party. These are listed in Table 4, but are relisted here because they are so few. All fish taken were game species. Yellow perch predominated, largemouth bass and pumpkinseed sunfish were the other species. It is entirely possible that inadequate fish samples were taken; hence, it cannot be stated for sure that forage fish and other game fish were lacking from the lake. Considering physical, chemical and biological factors in this lake, it is certain that the fish fauna is definitely restricted both as to species and numbers. The total numbers of game fish stocked in Bob Lake during the years 1934-1939 inclusive are given in Table 5. The records show 96,000 bluegills stocked, none of which were reported by the survey party. Since the survey seining efforts on this lake seem to have been inadequate, a definite statement that bluegills have not established themselves cannot be made, but it seems likely that the plantings failed. No perch scales were available for growth rate studies. Pumpkinseed sunfish were found to average 7.2 inches in length and 5.2 ounces in weight in their fifth year of life. One specimen in its sixth summer was the same size as the younger age class and weighed less. From these meager results it appears that these fish are growing at an average rate. Only one largemouth bass was taken. It was in its fourth summer, was 11.7 inches long and weighed 12.8 ounces. This is fair growth, but no definite conclusions can be made about the bass population from one specimen.

Natural spawning facilities are adequate for perch. It is probable that the sunfish, largemouth bass and bluegills can use the sandy shoal areas for nesting sites. Their reproduction, although limited by bottom conditions, is probably adequate to maintain the small population which this lake can support.

Bob Lake is now among the "all others" group of lakes. No change in designation is recommended. Pike are not present and the water becomes too warm for trout. Considering the data on this lake, it is recommended that further stocking of pan fish (perch and bluegills) be discontinued. Natural reproduction more than fills the population needs to maintain a safe margin between fish and food supply. Stocking of bass should also be stopped. Predators and parasites are not abundant enough to require control measures.

Cover is scarce in this lake, being limited to the few plant beds present. Addition of brush shelters to the sandy shoals could be attempted, but these shelters should never be placed in the peaty areas, since they would sink out of useful range. Encouragement of vegetation might be possible if the lake were treated with lime rock and fertilizer as has been suggested for other lakes in this report. Removal of the pulpy peat by dredging might give the lake a new lease on life, but this action would not be economical at present.

There is about a two-foot water level fluctuation annually. Small dams in the outlet streams might regulate this fluctuation, but it is not known whether such regulation would improve the lake. Spawning facilities need no improvement as long as the lake is so unproductive of food.

Further fish collections and scale samples should be taken from Bob Lake. The data now available are not adequate to allow a definite conclusion as to growth rate and, indirectly, population density.

Imp Lake, often called Windy Lake, is 85.5 acres in extent. It lies in the Ontonagon River drainage and is about six miles southeast of Watersmeet. It is reached via U. S. Highway 2 and a short side road which takes off this highway to the south for about one-fourth mile. This lake is not fished very much even during the summer and there are no cottages, boat liveries or resorts on its shores. A camp ground, improved by the U. S. Forest Service, is available to tourists and is little used (according to the survey report in 1937). The lake is in a beautiful setting. Virgin timber surrounds it and covers the rather rolling country in the vicinity. The drainage basin of this lake is quite small, covering an area of about five square miles. A small, intermittent inlet brings surface waters to the lake and an intermittent outlet drains from it into Cedar Creek, which becomes Tamarack Creek after it passes through Tamarack Lake. The basin of Imp Lake is quite regular. Two major depressions are in this basin. A small, wooded island is located in the southeast end. The long axis of this lake runs east and west. Formation of the lake was probably the result of melting of an irregular block of ice left covered by the last, large glacier as it receded. Other physical features of Imp Lake are given in Table 1. Noteworthy among these features are the great depth of water (86 feet), the small amount of shoal area, and relatively high transparency of the water. A narrow band of gravelly, sandy shoal area skirts the entire lake out to the ten-foot contour. Otherwise the lake bottom is muck.

This lake is interesting both thermally and chemically. From chemical and temperature data given in Table 2, it is noted that thermal stratification existed at the time of the survey, and the thermocline was located between 12 and 30-foot depths. Water temperatures at the surface were about 75° F., while at the bottom they ranged between 42.3 and 42.8° F. The lake was not chemically stratified. Dissolved oxygen content ranged between 5.0 and 8.0 p.p.m. at the surface, while at the bottom the range was 5.8-6.7 p.p.m. At the bottom of the thermocline, 10.9 p.p.m. of dissolved oxygen were found. This reading is higher than those taken at the surface and bottom. To explain such findings one needs only to refer to the fact that lakes "turn over" each spring and fall as their waters approach 4.0° C., the point at which water is heaviest. At this temperature, the solubility of oxygen in water becomes great and a lake in such a state may be charged throughout with 10-12 p.p.m. of oxygen. As summer conditions follow spring, surface waters warm up, lose their ability to contain so much oxygen, and also become lighter. In this state, they do not mix with the colder, heavier water below and a thermocline is formed in the zone where these strata meet. Below the thermocline the dissolved oxygen taken up during the "turn over" remains in the water and is used by plants and animals or in decomposition of organic matter in the water or on the bottom. In such lakes as the one under discussion, oxygen removal by the above agencies is slow. Decomposition occurs more rapidly in waters near or at the bottom of the lake and becomes lessened as the thermocline layer is approached. Hence, a concentration of 10.9 p.p.m. of oxygen at the bottom of the thermocline contrasted with a concentration of 5.8 p.p.m. at the bottom of the lake is accounted for by this gradient in rate of decomposition. The water in Imp Lake is very soft. It contains only 8.0 p.p.m. of dissolved salts. It is also quite acid, as shown by pH readings which range between 6.8 and 5.2. In connection with the pH readings which are colorimetric tests, it was noted that the colors of indicators, and, hence, the results of tests, changed as the determinations were being made. Because of this change, results were somewhat inaccurate. Experience on waters with high humic acids content has shown that similar results in colorimetric determinations of pH are obtained. It is therefore assumed that the humic acids content of the waters of Imp Lake is high. This assumption is further substantiated by the fact that the carbon dioxide content of this water is rather low (2.0-5.0 p.p.m.). Acidity of most lake waters is generally due to carbonic acid, which is formed when carbon dioxide is dissolved in water.

Thermal conditions and the oxygen content of Imp Lake waters are such that fish can inhabit the entire lake. Oxygen is not depleted in the deeper, colder waters below the thermocline. Cold-water fish can safely inhabit these lower waters when surface water temperatures are higher than their toleration limit. The productivity of the waters in this lake is considered poor. Lack of dissolved salts or softness of the water, and relatively high acidity reduce the production of plants, plankton and bottom organisms. These factors also act as physiological barriers to establishment of certain species of the more productive plants and animals.

As has been previously stated, vegetation is limited to the narrow shoals surrounding this lake. Most of the plants are of the emergent type, submerged types are almost entirely lacking. The following table presents a list of the plants collected from this lake.

*Plants of Imp Lake

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range	Bottom type
Three-way sedge (Dulichium arundinaceum)	1	sparse	...	6"	sand
Manna grass (Glyceria canadensis)	1	medium	1,000 sq.ft.	0-6"	sand
Iris (Iris versicolor)	1	sparse	...	6"	sand
Soft rush (Juncus effusus)	2	sparse	...	6"	sand
Water milfoil (Myriophyllum tenellum)	3	sparse	...	15'	muck
Yellow water lily (Nuphar variegatum)	1	medium	1/8 acre	2'-4'	..
Smartweed (Polygonum natans)	1	medium	900 sq.ft.	1'-3'	..
Bulrush (Scirpus atrocinctus)	1	medium	1,200 sq.ft.	0-6"	sand
Skullcap (Scutellaria epilobiifolia)	1	sparse	...	0-6"	sand
Goldenrod (Solidago graminifolia)	2	sparse	...	0-6"	sand

*Identified by Betty Robertson, Department of Botany, University of Michigan.

Plankton and bottom organisms were found to be rather scarce at the time of the survey. Although a diversity of organisms was found on the bottom of the lake, as is shown in Table 3, none of them were very abundant. The diverse organisms were found in shallow water, one to fifteen feet in depth, while only two species were taken from greater depths. Predominant among these bottom dwellers were phantom midge larvae and true midge larvae. Aquatic earthworms, mayfly nymphs, freshwater shrimp, water mites, damsel fly nymphs and caddis fly larvae were present on the shoals, while the two predominant forms were inhabitants of the depths. As has already been stated, the chemical and physical features of this lake are detrimental to abundant food production. Shoals are very restricted. The acidity and softness of the water hamper the normal development of plants and animals requiring alkalinity for best development. Food is not adequate for a population of fish which might be expected to thrive in a lake of this size under normal or average conditions.

Fish present in Imp Lake are listed in Table 4. Lake trout are the only game fish and fine-scaled dace, red-bellied dace, mud minnows and brook sticklebacks the only forage fish taken by the survey party. Red-bellied dace were by far the most abundant forage fish in the lake. Smallmouth bass are reported present, but were not taken by the party. This lake has been stocked with lake trout, smallmouth bass, and bluegills during the years 1934-1939 inclusive (Table 5). Bluegills were stocked most profusely and may have become established, but none were taken or reported from the lake. No fish or fish scales were available for growth rate studies; hence, nothing can be said about the growth rate of warm-water fish in this water.

Spawning facilities for smallmouth bass and probably bluegills are adequate. These fish are able to use gravel or sandy shoals.

The findings of the survey concerning fish in Imp Lake further substantiate the contention that it is not very productive, especially of warm-water fish. All fish depend on the food supply and indirectly on the productive potential of the body of water in which they are located. If the water's production of essential substances and food is poor, it follows that the fish are going to be poor, stunted and unfit for angling under present laws. Some fish are able to do better in poorer waters than others and these will be recommended for Imp Lake in the discussion of management suggestions.

Imp Lake is now classified with the "all others" group of lakes. It is suggested that the lake remain in this group until an attempt has been made to establish trout. Should this attempt be successful, and it probably will be, the designation should be changed to the "trout lake" class. Reasons for this suggested change are given throughout the discussion of this lake and need not be repeated here.

Further stocking of smallmouth bass and bluegills should be stopped. There seems to be nothing to show that the bluegills have established themselves, despite the introduction of 26,000 during the past six years. It has been observed that smallmouth bass, when once established, will maintain themselves at least under moderate fishing pressure and need not be stocked. The lake should be stocked with six- to seven-inch rainbow trout. For the first test stocking, 1,000 rainbows of this size are suggested. Subsequent stocking of trout will have to be done, since spawning facilities are not available. Temperatures, oxygen content and thermocline position in this lake suit it for trout. Food conditions are more advantageous for trout than other species of fish. The introduction of plankton feeding cisco or whitefish might afford trout a food supply which is not being utilized to its fullest extent at present. Predators and parasites are minimal. Turtles, ospreys and loons were seen, but were not abundant. Parasites were almost completely absent from fish examined.

Around the shoal areas there is plenty of natural cover in the form of brush, deadheads, floating plants and some submerged plant beds. Considering the narrow shoals and the presence of bottom moss growing down to depths of 50 feet which would act as cover for small fish, no further additions of cover are recommended.

There is no need for water level control. Very minor fluctuations take place, which are not detrimental to the productivity of the lake. Spawning facilities for game species other than trout should not be improved. Their competition and increased population pressure would hamper trout growth. Since trout, other than lake trout, require streams in which to successfully spawn, no improvement of spawning grounds for them is possible. Imp Lake inlet and outlet are intermittent and small. Use of these streams by trout for spawning is quite improbable. Further investigation should be made into the condition of these streams. It is possible that they might flow enough water in early spring to encourage rainbow runs and then dry up before fry or even the adults could get back to the lake.

Lake Sixteen or Bela Lake is located in the Ontonagon River drainage. It is about 70 acres in extent and derives its name from the section of the township in which it lies. The nearest settlement is Kenton in Houghton County, which is about nine miles to the north and east. About 11 miles due south of this lake is Elmwood in Iron County. The lake is reached via Forest highway running south from Kenton and M-26, then Jumbo spur truck trail running southwest to County road 657, from which an old, narrow road running along an abandoned railroad grade leads to the lake. From highway U.S.2, the lake is reached via Forest highway, running north, and County road 657 running west to the old road on the railroad grade mentioned before.

There are neither cottages, nor resort developments of any kind on this lake. It is quite difficult to reach and has not been sufficiently productive lately to attract many fishermen. It was reported to the survey party by Mr. Barney Perry that about 15 years ago this lake produced very good trout fishing. It was 20 or more feet deep and lacked the encroaching shore and heavy vegetation now present. Lake Sixteen is now rapidly approaching extinction and is not a highly potential fishing water.

This lake is surrounded by wooded uplands and swampy lowlands.

Immediate shore areas are all of the muskeg, encroaching type except on the west side of the island (see map) and one spot on the eastern shore line. These two restricted areas are composed of sand and gravel. The long axis of the lake basin runs northwest-southeast, in the same direction as the prevailing winds blow. These winds and the wave action caused by them account for the isolated sandy, gravel spots. The present shore line is quite irregular, fingering out wherever inlets and outlets inhibit capture by vegetation. Three small islands are in the lake: two in the northwest and one in the southwest end. These islands are heavily wooded. The lake basin is very shallow (8 feet maximum depth). It receives drainage from about three square miles of the surrounding area. Most of this water enters the lake in two, small, spring-fed inlets. A tributary to Jumbo Creek drains from the lake. It is possible that beaver dams block this stream several times before it reaches Jumbo Creek proper, but no dams are in the immediate vicinity of Lake Sixteen. Other physical features are given in Table 1. The entire lake bottom, excepting the two gravelly, sandy areas mentioned before, is composed of fibrous peat. Since the lake is so shallow, all of it is considered shoal. The water is light brown and although the Secchi disc reading was only six feet, effective light penetrates to the bottom and supports submerged plants over the entire lake.

Thermal and chemical features (Table 2) of Lake Sixteen indicate that it may become too warm for trout except in localized areas near the spring-fed inlet. No thermocline is present due to the shallowness of the basin. Oxygen content at the bottom was identical with that at the surface. The water was found to be alkaline (pH 7.9) and moderately soft. Carbon dioxide was present in minute amounts.

These conditions, interacting with the physical features, tend to make the lake fairly productive, especially with regard to plants and plankton. Plants are growing so rapidly that they threaten to obliterate the lake.

Vegetation is abundant throughout the lake. It forms the encroaching shore line and has already captured over half of the original lake basin, forming rather extensive muskegs or bogs. The following table lists the various kinds of plants found by the survey party, and gives a note on abundance, density and occurrence.

*Plants of Lake Sixteen

Name of plant	Station numbers	Density of bed	Approximate area of bed	Depth range	Bottom type
Water marigold (*Megalodonta Beckii*)	1	...	...	4'-6'	fibrous peat
Water arum (*Calla palustris*)	1	sparse	...	6"	fibrous peat
Three-way sedge (*Dulichium arundinaceum*)	1	sparse	...	1'-3'	fibrous peat
Dwarf bulrush (*Juncus effusus*)	1	sparse	...	0 -3'	fibrous peat
Water milfoil (*Myriophyllum sp.*)	1,2	dense	...	2'-6'	fibrous peat
Yellow water lily (*Nuphar variegatum*)	2	sparse	...	3'-4'	fibrous peat
Smartweed (*Polygonum natans*)	1	sparse	...	3'	fibrous peat over sand
Pondweed (*Potamogeton epihydrus*)	1	sparse	...	4'	fibrous peat
Pondweed (*Potamogeton natans*)	1,2	sparse	1/8 acre	3'-8'	fibrous peat
Pondweed (*Potamogeton pectinatus*)	2	moderate	½ acre	4'-5'	fibrous peat
Pondweed (*Potamogeton praelongus*)	1,2	moderate	entire lake	2'-8'	fibrous peat
Pondweed (*Potamogeton pusillus*)	1,2	dense	23 acres	0 -8'	fibrous peat
Pondweed (*Potamogeton obtusifolius*)	1	...	...	4'-6'	fibrous peat
Crowfoot (*Ranunculus trichophyllus*)	2	sparse	...	1'-3'	fibrous peat
Arrowhead (*Sagittaria latifolia*)	1,2	moderate	900 sq.ft.	0 -1'	encroaching shore
Bulrush (*Scirpus validus*)	1,2	moderate	400 sq.ft.	0 -1'	...
Bulrush (*Scirpus cyperinus*)	2	sparse	...	6"	...
Burreed (*Sparganium angustifolium*)	1	dense	400 sq.ft.	6"-1'	fibrous peat
Big duckweed (*Spirodela polyrhiza*)	2	dense	1/4 acre	6"	fibrous peat

*Plants identified by Betty Robertson, Department of Botany, University of Michigan.

The fish food studies made on Lake Sixteen are summarized in Table 3. It should be noted that even in mid-summer when plankton populations of most lakes are comparatively low, the average quantity of plankton was 26.7 c.c. per cubic meter or 1.25 cu. in. per cubic yard. Predominant in this large plankton crop were the plant forms, microscopic algae. Bottom organisms were not so plentiful. This may be due partially to the fact that in August most insect forms are in the adult stage and emerged from the lake. Young, hatched from eggs of these adults, were too small to remain in the screen used in sampling. Predominant in the bottom assemblage were dipterous larvae. These were followed by fingernail clams, freshwater shrimps, aquatic earthworms and round worms (Nematoda) in order of abundance. One very good source of fish food, the plant beds, was not sampled. It is quite probable that food produced in the extensive plant growths of this lake is adequate for the support of a normal fish population. The fibrous peat bottom of the lake is not too good as a food producer. It has a tendency to become unstable and, with further disintegration, so flocculent that organisms cannot tolerate the resulting conditions.

Fish taken from Lake Sixteen are listed in Table 4. Two species of game fish, namely, brook trout and yellow perch, were caught. Red-bellied and fine-scaled dace, fat-head minnows, creek chubs and brassy minnows were the forage fish taken. Perch were the most abundant game fish and red-bellied dace the most common forage fish. During the years 1934-1939 inclusive, brook trout, smallmouth bass and bluegills have been stocked in this lake. Total numbers of each species stocked are given in Table 5. It cannot be stated definitely that the bluegills have not become established because most of them were stocked during 1939, after the survey was made.

Apparently the smallmouth bass did not establish themselves.

Scale and growth rate studies on the game fish of this lake are summarized in Table 6. Perch do rather well in the lake, if the meager data available are indicative. These fish reach legal size sometime during their fourth summer. Six perch in their seventh year averaged 11.5 inches in length and 8.3 ounces in weight. Two brook trout were found in fair condition. One, in its third summer, was 7.9 inches long and weighed 2.9 ounces; the other, in its fourth summer, was 12.8 inches long and weighed 14.1 ounces.

Spawning facilities for perch are very abundant. The dense vegetation beds can be utilized. Brush and roots on the encroaching shore are also available. Bluegills could use the areas where sand and gravel are exposed and even the fibrous peat might serve their needs if it is not too deep in places where it lies over sand. Brook trout formerly used the inlet as a spawning stream. It is possible that it is still suitable, although the survey party doubted its value.

It seems, in summarizing the above data, that this lake has passed or is rapidly passing from a cold water to a warm water fish lake. Filling of the basin to a point where temperature differences between surface and bottom are slight, encroachment of the shores and production of plants over the entire lake are some of the most pertinent changes which support this assumption. The taking of brook trout near the cold inlet only indicates that the lake water might have been too warm for them. Relatively good growth of the yellow perch also furnishes evidence that the water is warmer. In good trout lakes, perch in any abundance usually show signs of stunting.

Lake Sixteen or Bela Lake is now classified in the "all others" group. There is no reason for changing its designation as long as the lake is left in its present state. If, in the future, it is deemed economically advisable, the lake might be cleaned; that is, the fibrous peat could be pumped out, the muskegs stripped back and the original basin of sand and gravel restored wholly or in part. Such action would probably establish, once again, the conditions that existed twenty years ago, when, it is said, this lake was excellent trout water. Considering the light fishing pressure and the lack of demand for recreational areas in the vicinity of this lake, such a proposal would not be logical at present.

Further stocking of this lake should be done with extreme caution because it would be an easy matter to overpopulate it. The perch should be left to reproduce naturally. Northern pike should be introduced if it is noted, in subsequent years, that the perch population has become great enough to cause stunting of the individual fish. Smallmouth bass should not be stocked. The lake may have been suited to them in past years, but too much fibrous peat and too many plants are in it now. Bluegills should not be stocked until it is determined whether the 5,000 planted in 1939 have survived. If they do survive and become established, further stocking would not be necessary. Natural reproduction could certainly maintain the population. If they do not survive, further plantings should not be made.

Predators are not abundant enough to need any control measures. Parasites, especially Clinostomum (yellow grubs) are common in all the perch and some extreme cases of infestation were recorded. It is known that fish can carry large numbers of these parasites without any appreciable harm, but severe cases might be so weakened that any abrupt changes in temperature or oxygen conditions might kill them. Effective control of this parasite would involve eradication of one of the hosts necessary in its life history. The adult lives in the blue heron and other fish-eating birds to a lesser extent. Eggs from the adult worm are shed into the water, where some snail becomes infected. Details of the life history are unknown, but larval parasites finally reach the fish from a snail and encyst in the muscles, under the skin and any other convenient place in the fish's anatomy. When infected fish are eaten by blue herons or other fish birds, the adult stage is reached and the life cycle completed. It would be necessary in the control of this grub to eradicate either the birds, snails or fish. The expense and effort needed to control the birds or snails are not warranted in this lake.

There is plenty of cover in Lake Sixteen for all fish present. The extensive plant beds and encroaching shores adequately suit the requirements for shelter and hiding places.

The shape and topography of the basin of Lake Sixteen rule out the possibility of raising the lake level to overcome the processes of extinction in the lake at its present level. Construction of a dam large enough to accomplish this end would be an expensive undertaking.

Spawning facilities are adequate for perch and bluegills, and need no improvement. Since this lake will probably cease to exist in the next twenty years or sooner if capture by plants continues at its present rate, there is little need for extensive improvement of any kind. This lake is a very good example of the rate at which a lake life history can progress. Within the memory of man this body of water has aged from youth to senility and will probably become extinct or dead before a normal human life span has run its length.

One other phenomenon observed in this lake deserves mention. Many dead perch were seen by the survey party, and the cause of their death was believed to have been "night kill." This sort of kill is certainly possible in Lake Sixteen. "Night kill" results from oxygen depletion by plants during the dark hours to the point where fish can no longer survive. Although plants make oxygen rapidly during the sunny hours, they use it almost as rapidly when night comes. This lake is practically choked with vegetation and certainly the oxygen demands of such a blanket of plants would be very great. Conversely, the oxygen production of these plants would be great, but the lake water, at summer temperatures, is incapable of dissolving all of the oxygen available and it escapes to the air. There is not, then, an equal exchange between the water and plants. Further investigation would be necessary to definitely prove that oxygen depletion during the night is great enough to kill certain species of fish in this lake. It has been demonstrated in other waters by various investigators.

Pilot Lake, sometimes called Crystal Lake, lies in the Ontonagon River drainage and has an area of 23 acres. It is about 1½ miles southwest of the town of Watersmeet and is reached by traveling about ½ mile south from this town on U.S. highway 45, and then about 2½ miles southwest on an old military road which is rough and unsurfaced. At the time of the survey there were no cottages on its shores. One old flat-bottomed boat was located and found usable by the party. Fishing on this lake is very light. The surrounding country is rolling, morainic and heavily wooded, while the immediate shores of this lake are marshy at the east and west ends, and sandy along the north and south sides. The lake basin lies in an east-west direction and is quite regular in outline and contour. Water from a drainage area of about one square mile reaches the lake, but no surface inlets or outlets are present. There is very little water level fluctuation except in dry years when the level may drop a foot or so. Other physical features are presented in Table 1. Noteworthy of these features is the preponderance of pulpy peat as a bottom type. It covers all the bottom except for narrow strips in shallow water along the north and south shores. These strips are sandy and gravelly. Another interesting feature is the clarity of the water. A Secchi disc can be seen at a depth of 21 feet. Water which is very clear is generally quite unproductive. It is an indication that plankton is scarce and that dissolved, suspended or colloidal organic materials and essential salts are generally minimal. Most of the physical characteristics of this lake point toward low productivity. Pulpy peat, the predominant bottom type, is a poor substratum. The lack of inlets and outlets restricts additions of fertilizing materials from the topsoil of the watershed and prohibits removal of undesirable substances by drainage and water exchange.

Thermal and chemical features of this lake, as presented in summarized form in Table 2, show that the lake is thermally and chemically stratified. The thermocline was located between the 15 and 30 foot depths. Oxygen within the thermocline was sufficient to maintain fish life, but below this layer it was low enough to be untenable. At the bottom (40 feet), oxygen was practically absent. The water was found to contain considerable amounts of carbon dioxide, especially in the depths. The concentration of this gas in the deeper waters of the lake was not great enough to kill fish, but combined with the low oxygen content it would certainly affect the efficiency of their respiration. The waters of this lake were also very soft (9-14 p.p.m. of dissolved salts) and highly acid (pH readings ranged between 5.9 and 5.4). These thermal and chemical characteristics, interacting with the physical features already discussed, definitely restrict the productive potential of this lake.

Vegetation in Pilot Lake is very restricted and scattered. Even though effective light can penetrate to comparatively great depths in the lake, plants are limited to the shore areas and very shallow water. All plants taken from this lake were identified in the field. There follows a listing of the various species found and a statement as to their relative abundance in areas where plants were found growing.

Plants in Pilot Lake

Name of plant	Station numbers	Abundance	Bottom type
Burreed (*Sparganium* sp.)	1,3,5,6	sparse	sand and pulpy peat
Yellow water lily (*Nuphar advenum*)	1,2,3,4,5,6	sparse	sand and pulpy peat
Pipewort (*Eriocaulon septangulare*)	1,4,5,6	sparse	sand and pulpy peat
Wild celery (*Vallisneria* sp.)	2	common	sand and pulpy peat
Quillwort (*Isoetes* sp.)	1,2,3	common	sand and pulpy peat
Sedge (*Carex* sp.)	2, 5	common	sand and pulpy peat
Arrowhead (*Sagittaria cuneata*)	4,5,6	sparse	sand and pulpy peat
Moss (*Sphagnum* sp.)	7	sparse	pulpy peat
Sundew (*Drosera* sp.)	7	abundant	pulpy peat
Sweet gale (*Myrica Gale*)	7	common	pulpy peat
Iris (*Iris versicolor*)	7	sparse	pulpy peat
Pitcher plant (*Sarracenia* sp.)	7	sparse	pulpy peat

Plankton and bottom organisms were quite scarce. Predominant in the plankton were Cladocera (water fleas). The bottom organisms taken were few indeed. Phantom midge larvae were most abundant. Net wing flies and fingernail clams were the only other forms taken. Dragonfly and mayfly nymphs are reported from the sandy shoals. The food supply is certainly inadequate for a population of fish which normally would inhabit a lake of this size. Scarcity of plant beds, where much food is usually produced, makes the food situation acute at times when emergences of adult insects decimate the bottom population. Both physical and chemical factors inhibit food production. Pulpy peat is a poor substratum. Acidic and soft water restrict certain vital steps in the food chain of the bottom and plankton organisms. Oxygen depletion in the depths acts as a barrier to most forms of insects and other invertebrates.

Only two species of fish were taken from this lake by the survey party. These were smallmouth bass and mud minnows. Neither species was very abundant. Trout are reported and used to be taken frequently. Stocking records for this lake are somewhat confused. The lake was formerly known as Crystal Lake and, since there were two Crystal Lakes in Watersmeet township, it is impossible to differentiate between the various records available. No fish were available for growth rate studies.

Spawning facilities for game fish are adequate in Pilot Lake. Smallmouth bass have adequate spawning areas in the sandy and gravelly shoals along the north and south shores. Warm-water fish other than perch might use these same shoals. There is enough vegetation and brushy cover to afford perch some spawning areas. No spawning streams are available for trout.

Pilot Lake is now listed in the "all others" class and there is no reason, at present, why this designation should be changed. It is felt that with the meager population now in the lake an attempt to establish brook trout might succeed. The lake will support trout, and, although it appears from the above data that the surface waters might become too warm, there is a cool stratum in the thermocline, where oxygen is plentiful enough to support these fish during this warm period. It is suggested that 1,000 6-7-inch brook trout be planted and their progress watched closely. If it is found that these fish thrive, the designation of the lake should be changed to that of a trout lake. Periodic stocking of trout would be necessary because spawning facilities are not available for them. No other fish should be planted until the results of trout stocking are determined.

Parasites and predators are almost totally absent from this lake and no control measures are necessary.

There is plenty of cover in the form of numerous submerged logs. The scant vegetation offers some additional cover.

Fertilization of this lake with quantities of crushed lime rock and soy bean meal would improve conditions materially. The same general plan should be followed as suggested for some of the other lakes discussed in this report. More lime rock than is recommended would certainly do the lake no harm. Increase of the calcium content of the water would tend to overcome acidity and furnish plants and animals with this mineral so essential to normal growth.

Sturgeon River Drainage

Markey (Marquis) Lake, 46 acres in area, lies in Houghton County, about five miles northwest of Sidnaw, the nearest settlement. From this town it is reached by following a county road for about $6\frac{1}{2}$ miles to the northwest. This road is not designated by a number and to make sure where it leaves this town, inquiry should be made in Sidnaw for directions. The lake is reported to offer fair bass fishing and probably has been about the same for the last fifteen years. Dr. Jan Metzelaar reported good bass fishing in 1927. There were 11 cottages on its shores in 1937. Beaches, where these cottages are located, are sandy and probably offer fair swimming facilities. This lake is the largest of a group which occupies the northeast quarter of T. 48 N., R. 36 W., and is probably the most important as a public fishing water.

The basin of Markey Lake is quite irregular. Two islands are near the west shore and the deepest point is near the east shore. In the southern portion the bottom slope is steep, descending to depths of 35 to 69 feet within 300 to 450 feet from shore. The north end is rather shallow and the bottom slope more gradual. This lake lies in a morainic region and was probably formed by the melting of ice blocks buried in a morainic basin. The surrounding drainage area is wooded, hilly and quite limited. It is not over one square mile in extent. The east, south and west shores are wooded and somewhat sandy, while the north, southwest and southeast shores are swampy and encroaching. There are no surface inlets or outlets in the basin, and the lake is fed by seepage. The lake level fluctuates about two feet per year. Other physical features of this lake, as found by the survey party, are given in Table 1. The predominance of pulpy peat as a bottom type, the rather limited shoal areas, and the relatively great depth for a lake of this size are noteworthy characteristics. All of these factors would tend to reduce the productivity of this lake. As has been stated for lakes already discussed, pulpy peat is a very poor substratum on which to grow plants and bottom organisms. Limited shoals reduce the productive area of the lake bottom.

Thermal and chemical attributes of this lake, as found by the survey, are summarized in Table 2. Surface waters tend to become rather warm and are untenable by cold-water species of fish. However, a sharp thermocline was located between depths of 15 and 30 feet, in which the water temperature dropped about 31° F. Below the thermocline the water was almost uniform in temperature, varying only 2° F. from the bottom of the thermocline to the lake bottom (39 ft.). Oxygen content of the water at various depths shows a gradual decline from surface to bottom. The greatest change in oxygen content occurred between the surface waters and the middle of the thermocline. At the 42-foot depth there were 3.6 p.p.m. of oxygen. This was near the bottom at the only station where chemical analyses were made. It is possible that the oxygen becomes depleted near the bottom in deeper areas. Carbon dioxide increased from 1.0 p.p.m. at the surface to 11.0 p.p.m. at the bottom of the lake. This concentration is not great enough to be detrimental to fish. The lake water is very soft. Methyl Orange alkalinity tests showed only 7 to 20 p.p.m. of dissolved salts present. The water is also rather highly acid, as pH readings of 5.4-5.8 indicate. Most of these attributes are not conducive to productivity. Highly acid, soft waters restrict plant, plankton and bottom food production. The rather shallow position of the thermocline would reduce the productive volume of this lake tremendously, but, since oxygen depletion in the lower waters is not entire, some organisms, including certain species of fish, could survive at these depths. It is quite possible that trout would be able to tolerate conditions in the thermocline, even though the oxygen supply is reduced. Their oxygen requirements are lowered as the water temperature decreases.

Plants in Markey Lake are restricted to an area outside the five-foot contour. This area corresponds roughly to the extent of the sandy and fibrous peat bottom types. No plants occur in the pulpy peat bottom, although light penetration is great enough to allow plants to grow at depths down to 20 feet (Secchi disc reading, 17 feet). Most of the plants are of the emergent type. Floating vegetation is only common, while submerged types are quite rare. Plants taken from this lake were identified, for the most part, in the field. The following is a tabulation of the vegetation as given by the survey party.

Plants in Markey Lake

Name of plant	Station numbers	Abundance
Bulrush (*Scirpus* sp.)	1,3,4,5,7,10	common
Floating pondweed (*Potamogeton epihydrus*)	1	sparse
Yellow water lily (*Nuphar advenum*)	1,3,4,5,7,9,10	sparse
Arrowhead (*Sagittaria cuneata*)	1,5	rare
Sedge (*Carex* sp.)	1	sparse
Quillwort (*Isoetes* sp.)	1,2,3,5,6,7,8,9,10	abundant
Burreed (*Sparganium fluctuans*)	1	sparse
Horsetail (*Equisetum* sp.)	3,7,10	sparse
Spikerush (*Eleocharis palustris*)	1	sparse
Pipewort (*Eriocaulon septangulare*)	1	sparse

Quillwort (Isoetes sp.), characteristic of boggy, acid waters, was the most abundant plant. Yellow water lilies and bulrushes were next in abundance. Vegetation is believed to be growing in every place which is suitable for its culture under present circumstances. Any addition to or extension of the plant beds would require changes in the general character of the lake.

Plankton and bottom food conditions were about average. The volume of plankton per cubic meter of water was slightly above that found in some of the lakes considered in this report, but volumes were rather inaccurate, because for some reason or other the plankton did not settle properly while being measured. Cladocera were the predominant forms. Midge larvae were the most abundant bottom organisms. Corethra or phantom midge larvae and mayfly nymphs were the only other forms taken. There were more midges in this lake per unit area than any other lake discussed in this report. This is probably due to the presence of oxygen in most of the bottom waters during the majority of the year. The food supply is believed to be adequate. The question of its constant availability to fish is one which has not been answered for this or any other lake. It is doubtful that the fish get many of these midge larvae except when the pupae rise to the lake surface to emerge.

Five species of game fish were taken from Markey Lake by the survey party. These are listed in Table 4. Most abundant were smallmouth bass. Bluegill, pumpkinseed sunfish, largemouth bass and perch were equally common. No forage fish were taken, although over 1,000 feet of shoal and shore line were seined. It is believed that forage fish have never been able to reach this lake naturally. Many fingerling bass and bluegills were caught during the seining operations. Total numbers of fish stocked in this lake during the years 1934-1939 inclusive are shown in Table 5. Only two species, bluegills and largemouth bass, have been stocked during this period. Two smallmouth bass were the only fish available for growth rate studies. One of these was in its fourth summer, was 9.4 inches long and weighed 5.6 ounces. The other one was in its fifth summer, was 9.9 inches long and weighed 6.5 ounces. If these specimens can be regarded as representative of the normal population, smallmouth bass do not grow well in this lake.

Spawning facilities for the game fish in Markey Lake are believed to be adequate, considering its low productive potential. Perch are able to use the vegetation in shallow water. Fibrous peat areas are limited, but should be useful to the largemouth bass. Bluegills, sunfish and smallmouth bass could appropriate the sandy and gravelly shoals by fanning away some of the thin layers of pulpy peat.

Occasional creel census records from this lake, taken during 1930, 1931, 1932 and 1936, show a total of 89.5 hours of fishing. During this time, 43 smallmouth and 36 largemouth bass, or a total of 79 legal-sized fish, were taken. Twenty-nine small fish were returned to the lake. The catch per hour was 0.88 fish. This figure is rather high for bass fishing, but runs about 0.4 of a fish per hour lower than the average for the general creel census over the same years. All of the bass caught were only slightly over the legal size limit.

Despite the apparent success of the game species now in Markey Lake, it is felt that it is unsuited to their best growth and reproduction. More detailed information on growth rate is necessary before definite conclusions can be drawn, but the absence of forage fish, peaty bottom, scarcity of plants, and relatively cold water indicate that the growth is very slow. The available invertebrate organisms which constitute bluegill and perch foods are scant. In addition to the factors mentioned above, this food scarcity or inaccessibility must certainly curtail their growth.

Markey Lake is now in the "all others" or bass lake group. No change is recommended for the present. On the basis of the survey data, it is suggested that this lake be stocked with brook trout, preferably of legal size. If it is found that these fish grow satisfactorily, the designation should be changed to trout lake status. Stocking of other species should be stopped during this test. It might be advisable to attempt control of the populations of bass, bluegills and perch, either by nest destruction or closely supervised spot-poisoning. The likelihood that brook trout will do well in this lake makes it urgent that they be given a good trial. Furthermore, measures to enhance the bass and pan fish possibilities should be withheld entirely to give the trout the best possible chance to survive. Periodic stocking of trout would have to be done, since no spawning grounds are available. In the event that trial plantings of trout are not successful in competition with the present population, it is suggested that the lake be poisoned out entirely and a fresh start with trout be made. All conditions in this lake seem suited to trout, except for spawning. Conditions for good growth of warm-water fish are not present. Although poisoning a lake of this size would cost quite a sum, it is believed that it would be advisable, since returns in trout, following the poisoning, would soon balance the expenditure.

Parasites and predators are not abundant enough to require any control.

Since there is no outlet to this lake, control of water level is quite impossible.

This lake might also be fertilized with lime rock and soy bean meal, as suggested for some of the other lakes in this report. Overcoming the water acidity and softness would certainly make it more productive. The use of marl instead of lime rock could be substituted if it were more readily available.

Deerskin River Drainage

Smoky Lake, called Long Lake prior to 1931, is 557 acres in extent and has a maximum depth of 68 feet. It is about fifteen miles due west of Iron River, the nearest Michigan town, and is reached via Smoky Lake road west off highway U.S.2. The extreme southern end of this lake is in Wisconsin. Most of the land surrounding it is privately owned, although the public has access to it from a resort at the north end. This resort operates a boat livery. A county park is close to it, being located on Little Smoky Lake. There are about 23 cottages on the shores of Smoky Lake and on the Wisconsin end there is also a golf course. The lake is quite popular for bathing and its setting is scenic and attractive to cottage owners. It is fished only occasionally during the summer. Reports indicate that it offers fair smallmouth bass and rock bass fishing.

The basin of Smoky Lake is long and narrow. Its long axis runs slightly east northeast - south southwest. Heavily wooded, morainic hills surround the lake except at the north and south ends, where the land is relatively flat and swampy. The immediate shores are rather high, gravelly and sandy with little or no vegetation. The lake bottom is quite irregular and is characterized by very steep slopes. A major submerged bar runs directly across the basin about two-thirds of the way down from the north end. It separates the lake into two depressions. The northernmost of these depressions is the larger and also the deeper of the two. The surface drainage area of this lake is rather limited. At most, it is no greater than ten square miles. One small, swamp-fed stream about four feet wide enters the lake from the north. There is also a small spring inlet on the west side about midway between each end. No outlet is present on the surface, but the lake probably drains by seepage through a small bridge of land on the south end which separates it from Sand Lake, Wisconsin. Other physical characteristics, as found by the survey, are given in Table 1. Especially important are the very limited shoal areas and the predominance of sand and gravel in depths ranging from 0 to 40 feet. Muck is the only other bottom type except for a very small patch of fibrous peat in the extreme southern end of the lake. All of the physical characters of this lake indicate that it is a relatively unproductive body of water. It is really a young lake, as lake life history goes. Not enough organic material is present and that which is there is unable to remain on the shoals because of the steep, sloping sides. The lack of shoals and the presence of sand and gravel as predominant bottom types limit the extent of plant growth and suitable habitats for fish food organisms.

Temperature and chemical characteristics of Smoky Lake as recorded by the survey are summarized in Table 2. Surface water temperatures were found to be comparatively cool (72° F.) even when air temperature was around 80° F. A narrow thermocline was present between 30 and 39 feet.

In this nine-foot layer the temperature dropped about 18° F. Oxygen was present from top to bottom in the small south depression. It was only 2.4 p.p.m. lower at the bottom than at the surface. In the northern depression oxygen was still abundant (7.3 p.p.m.) in the middle of the thermocline, but dropped to 2.2 p.p.m. immediately below it. There was only a trace of oxygen present in waters deeper than 48 feet. Carbon dioxide was low throughout the lake. The water of the lake is very soft, containing only 10-15 p.p.m. of dissolved salts. At the surface, the lake waters were slightly on the alkaline side, ranging in pH from 7.2 to 7.4, but below the thermocline acid conditions existed. The pH range there was between 6.4 and 5.8. These thermal and chemical features tend to restrict productivity of this lake further. The combined influences of both physical and chemical factors makes the productive potential of this lake very low.

The aquatic vegetation in Smoky Lake is so scattered and limited that it might be considered absent. There are a few beds of submerged forms, but these are limited to about ten spots in the lake. The following tabulation lists all plants collected by the survey party. They were identified by Miss Betty Robertson, Department of Botany, University of Michigan.

Plants in Smoky Lake

Name of plant	Station numbers	Abundance	Approximate area of bed	Depth range	Bottom type
Spike rush (Eleocharis sp.)	1	medium	12 sq.ft.	6"	sand
Rush (Juncus brevicaudatus)	1	sparse	...	shore	sand
Rush (Juncus effusus)	1	sparse	300 sq.ft.	shore	sand
Pondweed (Potamogeton pusillus)	2,3	sparse	...	12'-18'	sand, gravel
Pondweed (Potamogeton sp.)	4	sparse	...	6'	sand
Bulrush (Scirpus pedicellatus)	1	sparse	500 sq.ft.	shore	sand
Burreed (Sparganium angustifolium)	1,5	medium	5,500 sq.ft.	1'-5'	sand
Muskgrass (Nitella sp.)	2	sparse	...	15'	sand

Plankton and bottom organisms are also quite scarce. A summary of samples taken by the survey is given in Table 3. The plankton amounted to only 1.4 c.c. per cubic meter, which is about one cubic inch per cubic yard. Such a crop, even in August, is very poor. Bottom organisms were predominantly midge larvae. Phantom midge larvae, aquatic earthworms and mayflies were the only others found.

Fish taken by the survey party are listed in Table 4. Six species of game fish, one of coarse fish and two of forage fish were caught. Of the game fish, perch were taken most frequently; then followed,in order of abundance, largemouth bass, rock bass, smallmouth bass, cisco and pumpkin-seed sunfish. Common suckers were caught quite commonly. Blunt-nosed minnows were the predominant forage fish. In the years 1934-1939 inclusive, walleyed pike, lake trout, smallmouth bass, largemouth bass, yellow perch and bluegills have been stocked in this lake. Total numbers of each species planted are given in Table 5. There are no reports of lake trout, walleyed pike or bluegills having been caught. Their existence in the lake is not entirely disproved by this fact, but it does indicate that they are very scarce if not totally absent.

Growth rate of the various species of game fish for which data were available was found to be rather slow (Table 6). Perch reached legal size during their fourth summer. Four specimens in their sixth year averaged 8.2 inches in length and only 3.6 ounces in weight. Smallmouth bass reach legal size early in their fifth summer. One, in its seventh summer, was 15.1 inches long and weighed 2 pounds, 2 ounces. Rock bass probably become legal sized in their sixth summer. By the time they are in their ninth year they are 7.5 inches long and weigh 4.2 ounces. No scales were available for largemouth bass, cisco or pumpkinseed sunfish.

Natural spawning facilities for smallmouth bass and rock bass are adequate. Spawning places for largemouth bass, bluegills and sunfish are somewhat restricted unless they utilize exposed, sandy areas.

Smoky Lake is now listed with the "all others" group as a bass lake. As long as it remains in its present state, no change in designation should be made. It is recommended that the lake be stocked again with lake trout 6-7 inches long. Fish of this size will be able to escape predation and reach adulthood,while fingerlings or fry are easy prey to the bass and perch. Introduction of a liberal number of legal-sized rainbow trout would also be advisable. The thermal and chemical conditions in the lake are favorable to the maintenance of trout. Under a policy of trout stocking, further plantings of bass, pan fish and especially walleyed pike should stop. Since no spawning facilities are available for trout, repeated stocking would be necessary. All biological data seem to indicate that this lake will support comparatively few fish. Even if the trout stocking policy is not used, curtailment in the number and kinds of fish planted is definitely recommended. It is suggested that stocking of walleyed pike and largemouth bass be discontinued. The crop of forage and subadult fish is not great enough to support a good walleyed pike population and once these fish become established, other carnivorous species will be unable to compete with them for the meager supply of food. There are few suitable spawning grounds for largemouth bass, while grounds for the smallmouth bass are abundant. Smallmouth bass have already become established, probably grow faster and reach larger size earlier than the largemouth in Smoky Lake, because this lake presents a more typical smallmouth environment. This water is definitely unsuited to bluegills. Ciscoes must be handicapped by the poor plankton crop.

There is no problem of predation or parasitism in this lake. Fish examined were found to be free of the usual parasitic forms.

Cover now in Smoky Lake consists of many submerged logs, rocks and the few scattered plant beds. Placing of numerous brush shelters in the north and south ends and across the submerged bar mentioned before would help considerably in furnishing protection for the fish. They would also encourage perch by affording spawning facilities, something which should not happen if trout are stocked. There would also be the danger of overpopulation by aiding too many young fish of other species to escape predation and reach adulthood. No brush shelters should be installed unless trout stocking fails.

Smoky Lake should be fertilized according to the plan suggested for other lakes in this region. Such an undertaking would be quite expensive and the improvement achieved would probably not warrant such an outlay at present.

Carp River Drainage

Lake of the Clouds, formerly called Big Carp Lake, is situated in the Porcupine Mountains, within two miles of Lake Superior. It is 133 acres in extent and has a maximum depth of twelve feet. It is reached via M-64 out of Ontonagon to Silver City and then M-107 from Silver City to the lake. From this last town the distance to the lake is about ten miles. This road does not continue beyond Lake of the Clouds and the same route must be used for the return trip. The route is one of scenic value as it skirts Lake Superior and then leads into the Porcupine Mountains. When this lake was inventoried, party members had to make a hard portage of one mile from the road into the lake over a poor trail. This lake is fished only occasionally and is of more value as a scenic attraction than as a fishing spot. This is probably due to the fact that automobiles cannot be driven to its shores. There are no cottages or boat facilities on the lake.

The lake basin is long and narrow. It is set in a narrow valley between two ridges. The long axis runs east-northeast by west-northwest. High, wooded cliffs border the north shore and high, wooded ground forms the south shore. Its shore line is very regular. Bays and coves are almost entirely lacking. Carp River, a sluggish stream about 25 feet wide, runs into the northeast end. Spring Creek, an intermittent stream, enters at about the same place. Carp River drains from the southwest end. Actually, this lake is a widened portion of the river. The drainage area above the lake is restricted, not being over five square miles in extent. Water level fluctuation in this lake is dependent on the river level. No dams are present in the outlet. Additional physical characters of this lake are given in Table 1. It should be noted that the lake is regarded as having 100 per cent shoal. Shore areas are composed of sand, gravel and boulders, while the deeper portions are uniformly muck. The water is light brown in color and a Secchi disc disappears from view $5\frac{1}{2}$ feet below the surface. Shallowness of the basin should be an important factor in productivity. Practically all of the lake is brought into production, rather than just the waters and shoals above the thermocline.

The temperature and chemical nature of the waters of this lake are summarized in Table 2. It is significant that there is no actual thermocline present, although there is a difference of 6° F. between the surface and bottom water. Oxygen is present in sufficient quantities to maintain fish life at all depths. Carbon dioxide is present in surface as well as bottom waters. The water is just about neutral as far as acidity and alkalinity are concerned. It is quite soft, containing but 24-26 p.p.m. of dissolved salts.

Vegetation is quite abundant in Lake of the Clouds. Almost continuous beds of emergent plants grow around the shores in shallow water. Floating types occur in the northeast and southwest ends, while most of the submerged beds are in the middle portion. Collections of plants made by the survey party have been identified and are listed in the following table. The approximate abundance and density of the various species are also given. Vegetation is adequate in this lake both for cover and food production.

*Plants in Lake of the Clouds

Name of plant	Station numbers	Density	Approximate area of bed	Depth range	Bottom type
Sweet flag (Acorus Calamus)	1	sparse	...	6"	muck
Water marigold (Megalodonta Beckii)	1	medium	...	3'	muck
Water shield (Brasenia Schreiberi)	2	medium	1.5 acres	4'-6'	muck
Sedge (Carex rostrata)	1	medium	1,500 sq.ft.	6"	sand
Three-way sedge (Dulichium arundinaceum)	1	dense	1/8 acre	6"	sand
Spike rush (Eleocharis palustris)	1	dense	...	1'	sand and muck
Horsetail (Equisetum fluviatile)	1	sparse	...	1'	sand and muck
St.Johns wort (Hypericum boreale)	1	sparse	...	3'	muck
Manna grass (Glyceria borealis)	1	sparse	...	2'	muck
Water milfoil (Myriophyllum sp.)	1	sparse	...	3'	muck
White water lily (Nymphaea odorata)	1,2	medium	1 1/4 acres	2'	muck
Yellow water lily (Nuphar advenum)	1	dense	2 1/2 acres	2'-3'	sand and muck
Pondweed (Potamogeton amplifolius)	2	medium	...	3'	muck
Pondweed (Potamogeton angustifolius)	1	dense	1/8 acre	2'-3'	sand and muck
Pondweed (Potamogeton epihydrus)	2	medium	1 1/2 acres	1'-6'	sand and muck
Pondweed (Potamogeton gramineus)	1,2	medium	1/10 acre	3'-4'	muck
Pondweed (Potamogeton natans)	1,2	medium	1/8 acre	3'-6'	muck
Pondweed (Potamogeton zosteriformis)	1	medium	1/8 acre	3'	sand and muck
Cinquefoil (Potentilla palustris)	1	medium	500 sq.ft.	2'	sand
Arrowhead (Sagittaria sp.)	1	medium	1/7 acre	3'	sand and muck
Bulrush (Scirpus acutus)	1	medium	...	6"-1'	muck
Burreed (Sparganium angustifolius)	1,2	medium	1/2 acre	6"-2'	sand and muck
Bladderwort (Utricularia vulgaris)	1	medium	2½ acres	2'-3'	muck
Fern (Osmunda regalis)	..	sparse	...	1'	sand

*Plants identified by Miss Betty Robertson, Department of Botany, University of Michigan.

Plankton and bottom organisms were not very plentiful at the time of the survey. The plankton averaged 5.4 c.c. per liter of water and consisted mainly of Crustacea (water fleas). Snails and clams were the sole bottom dwellers found in this lake. No checks were made on the vegetation, but it is suspected that a rather large number of food organisms is produced there, if the results obtained in other lakes can be applied here. Just why the bottom does not produce more organisms is not clear. Sandy and bouldery shoals would reduce the number per unit area, but they should not be entirely barren. Further investigation will be necessary to determine the exact food status of this lake.

In Table 4, the kinds of fish taken by the survey party are listed. Perch were the only game fish found. Common suckers were the coarse fish taken. Seven species of forage fish were recorded. These are, in order of abundance, black-nosed shiner, fat-head minnow, red-bellied dace, black-nosed dace, creek chub, spot-tailed shiner and northern dace. Stocking records, as summarized in Table 5, show smallmouth bass and bluegills as the only fish having been planted during the years 1934-1939 inclusive. None of these fish were taken or reported by the survey.

Growth of the perch in Lake of the Clouds is rather peculiar. Data on these fish, as given in Table 6, show them to be in their fifth summer before reaching legal length. Four fish, beginning their ninth summer, averaged 11.2 inches in length and 9.3 ounces in weight. Two fish beginning their thirteenth year averaged 15.4 inches in length and weighed almost a pound. The oldest specimen was said to be at the beginning of its fourteenth year. It was 13.7 inches long and weighed 14.6 ounces. Some difficulty is experienced in reading the scales of older fish to determine the number of annuli or year-rings present. So many accessory marks appear that they are confusing. Therefore, the age determinations of these perch are none too accurate, but it would be safe to say that they do not vary over a limit of one to two years in any case. Perch in the early age groups were not available for study.

Spawning facilities for perch are adequate. The plant beds would serve this purpose admirably. If northern pike are introduced they should find excellent spawning conditions.

The growing season is very short in northern lakes such as these under discussion; hence, the annual size increase of fish is somewhat smaller. It is probable that the growing season in Lake of the Clouds is not much over two months and four months would certainly be the extreme limit. In this lake, the growing season probably starts in the latter part of June and ceases during the month of September. Under such circumstances, production of harvestable fish is slower than it would be in the same lake with a six-month growing season.

Lake of the Clouds was designated as a "pike lake" by action of the Conservation Commission in the fall of 1940. This designation is certainly the proper one, according to the findings of the survey party. The lake is so shallow that to plant cold-water species of fish would be dangerous. Warming of the lake during summer is probably great enough to exceed the upper toleration limits of such fish. Temperatures taken in late June were high enough to lead to the conclusion that by mid-July or early August the water would be much too warm for trout.

Bluegills and smallmouth bass stocked in this lake apparently did not become established. It might be well to try a test planting of adult northern pike. Just why bluegills were unable to get started is not known, but their presence in the lake would not be advisable, since it appears that the supply of invertebrate fish food is quite low.

Painted turtles are abundant in this lake, but their control is not advisable. It has been learned that these animals are not serious predators on game fish and their competition with fish for available food is negligible. Blue herons and occasional gulls are often seen on the lake, but they are not considered a menace to the fish population.

The perch are heavily infested with yellow grubs (Clinostomum), but no losses resulting from these parasites have been reported. No control is suggested since the lake is not heavily fished and the necessary control methods are uneconomical except in heavily fished waters. The life history and suggested control measures are discussed in the report on Lake Sixteen (Bela Lake).

Cover is believed to be adequate in this lake. Vegetation is dense and abundant enough to give shelter to small fish. The boulders and windfalls around the shoals are good protection and hiding places for forage fish. No improvement structures are recommended.

Regulation of the water level in this lake is not necessary. The lake could be deepened by placing a dam at the outlet, but this would obliterate the shoals now present. The sides of the basin are so steep that no spreading or further extension of the shoals would be accomplished. Seasonal fluctuation cannot inundate and then leave dry large shore areas because of the nature of the basin.

INSTITUTE FOR FISHERIES RESEARCH

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see report 630-A

TABLE 1

Summary of Certain Physical Features
Ottawa National Forest Lakes

Lake and Drainage	Area in acres	Max. depth (ft.)	Approx. % of shoal	Bottom types: Shoal	Bottom types: Depths	Inlets	Outlets	Color of water	Transparency Secchi disc in feet
Paint River Drainage									
Golden	580	100	25	Sand	Sand and pulpy peat	None	1, intermittent	Colorless	30.0
Lake 5	360	50	80	Sand and gravel	Pulpy peat	Spring fed inlet	None	Colorless	15.0
Paint	332	15	100	Sand, gravel, pulpy peat	Pulpy peat	1 from Silk L.; 1 from Lake 33	Paint River	Colorless	7.5
Winslow	255	25	80	Gravel,sand,fibrous peat	Muck	3 small streams	Winslow Creek	Dark brown	4.0
East Paint	147	10	100	Fibrous peat, sand	Fibrous peat	None	Intermittent,to Paint L.	Colorless	2.5
Robinson (Lake 27)	76	23	95	Sand,marl,muck, f.peat	Muck	1 intermittent, very small	1, very small	Colorless	14.0
Harding	36	15	100	Sand,fibrous and pulpy peat	Fibrous and pulpy peat	None	To Silk Lake	Colorless	9.0
Brule River Drainage									
Hagerman	584	54	30	Sand,gravel,fibrous peat	Pulpy peat	None	The Bubbling Brook, small	Colorless	10.0
Pickerel	551	90	15	Sand,gravel, marl	Muck	Small creek	Middle Branch, Iron River	Colorless	10.0
Lake 17	156	37	55	Sand,marl,fibrous peat	Muck	2 small streams	1, very small	Lt. brown	7.0
Ontonagon River Drainage									
Thousand Island	1,078	81	25	Sand,gravel,fibrous peat	Pulpy peat, muck	African Channel	Cisco Chain of channels and lakes	Colorless	4-18
Crooked	566	66	40	Sand,fibrous peat,muck	Pulpy peat, muck	1, small	Branch of Ontonagon River	Colorless	7-13
Sucker	439	15	50	Sand,gravel,fibrous peat	Pulpy peat	Lost Creek	Sucker Creek	Colorless	1.5
Beaton's	330	95	30	Sand and pulpy peat	Pulpy peat	None, spring-fed	Intermittent, 2 Mile Creek	Colorless	18.0
Marion	318	40	75	Sand,gravel,fibrous peat	Muck	1, small	1, small, no name	Lt. brown	6.0
Bass	191	18	100	Sand,gravel,pulpy peat	Pulpy peat	1, small	Middle Branch,Ontonagon R.	Brown	4.5
Bob	120	15	100	Sand,fibrous peat,muck	Muck	1, small	East Branch, Ontonagon R.	Brown	5.0
Imp	86	86	10	Muck, sand, gravel	Muck	None	None	Colorless	17.0
Lake 16 (Bela)	70	8	100	Fibrous peat	Fibrous peat	Spring-fed inlet	Jumbo Cr.	Lt. brown	6.0
Pilot (Crystal)	23	50	50	Sand,gravel, pulpy peat	Pulpy peat	None	None	Colorless	21.0
Sturgeon River Drainage									
Markey (Marquis)	46	69	20	Sand, fibrous peat	Pulpy peat	None	None	Colorless	17.0
Deerskin River Drainage									
Smoky	557	68	5	Sand, fibrous peat	Muck	2 small streams	None	Colorless	15.0
Carp River Drainage									
Lake of the Clouds (Big Carp)	133	12	100	Sand, gravel, muck	Muck	Carp River, Spring Creek	Carp River	Lt. brown	5.5

TABLE 2

Summary of Chemical and Thermal Features
Ottawa National Forest Lakes

Lake and Drainage	Date	Time of day	Air temp. °F.	Water temperature, °F. Surface	Water temperature, °F. Bottom	Thermocline Location (ft.)	Thermocline Temp. at top	Thermocline Temp. at bottom	Oxygen, parts per million Surface	Oxygen Bottom	Oxygen Thermocline Top	Oxygen Thermocline Bottom	CO_2 range, p.p.m.	Methyl orange alkalinity in p.p.m.	pH range	Pollution
Paint River Drainage																
Golden	8/21/37	9:30 A	66	75.0	43.2	30-45	70.7	49.8	9.2	7.5	middle: 8.7		1-8	4-7	6.0-5.3	None
Lake 5	8/24/37	3:00 P	81	72.0	44.4	15-30	70.2	45.9	7.5	0.2	middle: 4.9		1-15	7-8	6.8-5.3	None
Paint	8/26/37	2:00 P	84	74.0	69.6	3-9	73.0	69.6	8.9	8.0	-	-	0.0	62-63	8.9-8.1	None
Winslow	8/25/38	3:00 P	63	67.0	63.9	18-20	67.5	61.9	5.2	3.8	-	-	2-4	53-55	7.2-7.0	None
East Paint	8/23/38	10:00 A	73	69.5	69.6	None	-	-	7.4	7.3	-	-	2	30	7.4	None
Robinson (Lake 27)	8/18/38	4:00 P	79	75.0	73.4	None	-	-	7.0	6.5	-	-	2	10	6.0	None
Harding	8/30/37	1:30 P	75	73.0	68.0	6-9	73.4	68.0	8.2	4.9	-	-	4-5	39	6.8-6.3	None
Brule River Drainage																
Hagerman	8/2/38	9:00 A	79	75.0	53.2	21-30	70.2	57.9	8.6	0.0	10.0	1.2	0-6	65	8.4-6.6	Sewage from Transient Camp
Pickerel	8/4/38	5:00 P	83	72.0	46.8	15-36	72.3	48.9	8.2	0.9	-	1.2	0-4	111-112	8.4-7.0	None
Lake 17	8/12/38	10:15 A	78	76.0	50.7	7-21	72.0	52.9	6.0	0.0	5.6	0.0	4-7	5	5.4-5.2	None
Ontonagon River Drainage																
Thousand Island, Sta. 1	7/26/38	11:30 A	74	72.0	45.0	15-45	70.2	46.4	6.6	3.4	6.2	6.2	1-4	50-55	7.9-6.8	None
Sta. 2	7/26/38	4:00 P	70	72.0	44.2	15-42	70.2	48.6	6.4	0.3	6.8	4.0	1-5	52-60	7.9-6.6	None
Crooked, Sta. 1	7/19/38	9:45 A	71	73.6	64.4	15-21	70.7	64.4	8.0	6.2	-	-	0.0	65-70	8.4-8.2	None
Sta. 2	7/19/38	11:30 A	70	73.7	48.6	9-24	73.0	48.9	7.6	0.4	middle: 3.5		1-10	70-74	7.9-6.9	None
Sta. 3	7/19/38	2:00 P	70	73.4	46.0	15-36	73.4	46.2	8.0	0.4	8.0	1.3	1-6	50-55	7.9-6.8	None
Sta. 4	7/18/38	2:00 P	72	74.8	46.4	15-30	73.6	51.8	7.6	0.0	3.8	1.0	0-6	55-60	8.4-6.8	None
Sucker	7/14/38	9:00 A	66	72.0	71.6	None	-	-	6.2	6.0	-	-	0.0	70-74	8.4	None
Deaton's	9/3/37	1:00 P	73	71.2	43.9	24-36	68.0	46.9	8.8	0.4	7.9	6.3	1-15	22-23	6.5-6.1	None
Marion	7/6/38	1:30 P	72	71.2	53.2	21-27	59.4	55.0	7.8	0.2	4.5	1.0	1-9	12-15	7.2-6.4	None
Bass	9/1/37	9:30 A	83	74.0	71.2	None	-	-	7.4	7.2	-	-	2-4	36-39	6.5-6.3	Filtered sewage from CCC camp
Bob	8/18/37	1:00 P	81	74.8	72.0	None	-	-	-	5.8	-	-	4.0	13	5.8	None
Imp, Sta. 1	7/11/38	9:30 A	82.5	74.0	42.3	12-30	70.9	45.1	5.0	5.8	-	-	5.0	8	5.9-5.4	None
Sta. 2	7/11/38	2:30 P	80	75.0	42.8	12-30	67.6	44.2	8.0	6.7	-	10.9	2-5	8	6.8-5.2	None
Lake 16 (Bela)	8/17/38	4:30 P	76	75.0	71.8	None	-	-	6.5	6.5	-	-	1-3	50	7.9	None
Pilot (Crystal)	9/8/37	10:45 A	73	68.0	45.0	15-30	67.1	45.5	8.8	0.3	8.6	3.8	1-17	9-14	5.9-5.4	None
Sturgeon River Drainage											middle: 4.4		1-11	7-20	5.8-5.4	None
Markey (Marquis)	8/16/37	3:00 P	77	76.1	41.4	15-30	74.1	43.5	7.2	3.6						
Deerskin River Drainage																
Smoky	8/13/38	3:00 P	80	72.0	48.6	30-39	72.0	53.6	8.5	0.0	7.3	2.2	1-4	10-15	7.4-5.8	None
Carp River Drainage																
Lake of the Clouds (Big Carp)	6/28/38	2:30 P	75	72.3	66.0	None	-	-	5.8	5.0	-	-	3.0	24-26	7.2-7.0	None

TABLE 3

Bottom Food and Plankton Summary
Lakes of Ottawa National Forest

Results are expressed in average numbers per square foot for bottom samples, in cubic centimeters per cubic meter for plankton.

Lake and Drainage	Date	Round worms	Aquatic earth-worms	Leeches	Snails	Finger-nail clams	Fresh-water shrimps	Water mites	May flies	Damsel flies	Net wing flies	Caddis flies	Beetles	Phantom midges	Midges	Other true flies	TOTAL	Volume in c.c.	Plankton
Paint River Drainage																			
Golden	8/20/37	...	...	...	...	2.0	...	0.3	...	...	0.6	...	...	...	7.4	...	10.3	0.24	5.3
Lake 5	8/24/37	...	...	...	...	1.5	0.5	...	0.5	...	...	...	0.5	0.5	5.0	...	8.5	0.26	23.1
Paint	8/26/37	...	...	0.9	...	0.4	3.6	...	1.3	...	...	...	0.4	...	1.8	...	8.4	0.42	38.5
Winslow	8/25/38	...	10.7	...	....	...	...	...	...	...	...	...	...	106.6	4.0	...	121.3	0.53	7.5
East Paint	8/23/38	...	0.4	...	0.8	0.4	...	...	...	...	...	...	...	...	...	...	1.6	0.02	8.0
Robinson (Lake 27)	8/20/38	...	0.5	...	...	7.0	1.0	1.5	2.5	...	1.0	7.5	...	4.4	4.5	9.0	38.5	0.37	3.7
Harding	8/30/37	...	...	...	0.4	0.4	0.8	...	0.4	...	...	0.8	...	...	...	...	2.8	0.12	8.1
Brule River Drainage																			
Hagerman	8/2/38	...	...	...	...	...	0.6	...	...	...	0.3	...	...	...	3.4	1.1	5.4	0.19	1.8
Pickerel	8/5/38	...	...	0.4	18.5	0.4	...	...	1.8	...	0.4	0.4	...	...	5.8	0.7	28.4	0.46	1.5
Lake 17	8/11/38	...	...	...	...	1.6	...	0.4	2.8	...	...	0.4	...	1.6	7.2	...	14.0	0.32	4.0
Ontonagon River Drainage																			
Thousand Island	7/27/38	...	0.7	...	...	0.5	2.9	...	1.3	0.2	...	0.2	0.3	...	9.5	0.2	15.8	0.34	3.7
Crooked	7/19/38	...	...	0.7	1.0	2.5	62.5	...	1.0	...	...	0.8	...	0.7	1.3	1.0	71.5	1.36	6.3
Sucker	7/14/38	...	...	...	...	...	...	...	...	...	...	...	...	...	3.2	1.2	4.4	0.20	6.4
Beaton's	9/3/37	...	...	...	...	...	0.3	...	...	...	...	...	...	...	14.6	...	14.9	0.24	6.9
Marion	6/6/38	...	...	...	...	0.3	...	...	0.3	...	...	...	...	3.7	9.4	0.3	14.0	0.53	2.4
Bass	9/1/37	...	...	0.7	5.3	2.0	...	...	0.3	...	...	...	...	0.7	1.3	...	10.3	0.25	25.3
Bob	8/18/37	...	...	...	...	...	...	...	...	...	...	...	...	120.0	4.0	...	124.0	0.5	13.3
Imp	7/11/38	...	2.4	...	...	...	0.4	0.4	1.2	0.4	...	0.4	...	4.8	4.0	...	14.0	...	1.4
Lake 16 (Bela)	8/17/38	0.8	0.8	...	...	3.2	2.4	...	...	...	...	...	...	...	...	5.6	12.8	0.08	26.7
Pilot (Crystal)	9/8/37	...	...	...	...	0.8	...	...	...	...	0.8	...	...	2.0	...	...	3.6	0.16	6.7
Sturgeon River Drainage																			
Markey (Marquis)	8/16/37	...	...	...	...	...	...	...	2.0	...	...	...	...	4.0	74.0	...	80.0	1.40	7.6
Deerskin River Drainage																			
Smoky	8/13/38	...	0.7	...	...	...	...	...	0.4	...	...	...	...	0.7	1.8	...	3.6	0.13	1.4
Carp River Drainage																			
Lake of the Clouds (Big Carp)	6/29/38	...	...	...	0.7	0.6	...	...	...	...	...	...	...	...	...	...	1.3	...	5.4
Totals		0.8	16.2	2.7	26.7	23.6	75.0	2.6	15.8	0.6	3.1	10.5	1.2	249.3	162.2	19.1	609.4	8.82	243.9
Average		...	0.7	0.1	1.2	1.0	3.3	0.1	0.7	...	0.1	0.5	0.1	10.8	7.0	0.8	26.4	0.38	10.6

TABLE 4
Fish Taken by the Survey Parties from Lakes of the Ottawa National Forest

Lake and Drainage	Cisco	Whitefish	Lake trout	Brook trout	Northern pike	Perch	Walleye	S.M. bass	L.M. bass	Bluegill	Pumpkinseed	Green sunfish	Rock bass	Black crappie	Longeared sunfish	Common sucker	Black bullhead	Brown bullhead	Long-nosed dace	Black-nosed dace	Northern dace	Fine-scaled dace	Red-bellied dace	Black-nosed shiner	Black-chin shiner	Spot-tail shiner	Common shiner	Golden shiner	Blunt-nosed minnows	Fat-head minnow	Mud minnow	Iowa darter	Muddler	Brook stickle-back	Creek chub	Brassy minnow
Paint River Drainage																																				
Golden	.	.	.	.	.	x	.	x	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	.	.	.	.
Lake 5	.	.	.	.	.	.	.	x	?	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.
Paint	.	.	.	.	x	x	.	x	x	.	x	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	x	x	.	x	x	x	x	.	.
Winslow	.	.	.	.	x	x	.	x	x	x	x	x	.	.	.	x	x	.	x	x	x	.	.	x	.	.	x	x	x	.	x	x	x	.	x	.
East Paint	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x	x	.	.	.	x	x	.	x	.	.	.	x	x	x	.	x	.	.	.	.
Robinson (Lake 27)	.	.	.	.	.	x	.	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Harding	.	.	.	.	x	x	.	x	x	.	x	.	.	x	.	x	.	.	.	.	.	x	x	x	.	.	x	x	x	.	x	x	.	.	.	.
Brule River Drainage																																				
Hagerman	.	.	.	.	.	x	.	x	x	x	x	x	.	.	.	x	.	.	.	.	.	.	.	.	.	.	x	.	x	.	x	x	.	.	.	.
Pickerel	.	x	.	.	.	x	x	x	.	.	.	.	.	.	.	x	x	.	.	x	.	.	.	x	.	.	x	.	x	.	.	.	x	.	.	.
Lake 17	.	.	.	.	.	x	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	x	.	.	.	.
Ontonagon River Drainage																																				
Thousand Island	.	.	x	.	x	x	x	x	x	x	.	.	x	.	x	x	.	.	.	.	.	.	.	x	x	.	x	.	x	.	x	x	x	.	.	.
Crooked	x	.	.	.	.	x	.	x	x	.	x	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	x	x	.	x	x	x	.	.	.
Sucker	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x	x	x	.	.	.	.	.	x	.	.	.	.	.	.	.	x	.	.	.	.
Beaton's	.	.	.	.	.	x	.	x	.	x	x	.	x	.	.	x	.	.	.	.	.	.	.	x	.	.	x	.	x	.	.	x	x	.	.	.
Marion	.	.	.	.	.	x	.	x	x	x	x	.	.	x	.	x	.	.	.	.	x	x	x	.	.	.	.	.	.	.	x	.	.	x	.	.
Bass	.	.	.	.	.	x	.	x	x	x	x	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	x	x	.	.	x	x	.	.	.	.
Bob	.	.	.	.	.	x	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Imp	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	.	x	.	.	x	.	.
Lake 16 (Bela)	.	.	.	x	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	x	.	.	.	.	.	.	x	.	.	.	.	x	x
Pilot (Crystal)	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	.	.	.	x	.	.	.	.	.
Sturgeon River Drainage																																				
Markey (Larquis)	.	.	.	.	.	x	.	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deerskin River Drainage																																				
Smoky	x	.	.	.	.	x	.	x	x	.	x	.	x	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	x	.	.	.	.
Carp River Drainage																																				
Lake of the Clouds (Big Carp)	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	x	.	.	.	x	x	.	x	x	.	x	.	.	.	x	.	.	.	.	x	.

TABLE 5
Summary of Stocking Records
Ottawa National Forest Lakes

Total stocking, 1934-1939, incl.

Lake and Drainage	Pike perch (Walleyes)	Lake trout	Brook trout	Rainbow trout	Smallmouth bass	Largemouth bass	Yellow perch	Bluegills
Paint River Drainage								
Golden	...	...	...	...	1,000	2,500	10,000	35,000
Lake 5	...	...	...	...	1,100	12,200	...	15,000
Paint	1,575,000	...	...	...	...	...	3,400	25,000
Winslow	700,000	...	...	...	...	300	...	7,000
East Paint	...	...	...	...	...	600	...	10,000
Robinson (Lake 27)	1,125,000	...	...	...	600	800	...	34,000
Harding	...	...	...	...	400	500	...	27,000
Brule River Drainage								
Hagerman	1,400,000	5,000	...	...	...	3,000	14,400	...
Pickerel	1,700,000	34,500	...	...	...	...	10,200	...
Lake 17	...	...	...	...	...	15,700	...	17,000
Ontonagon River Drainage								
Thousand Island	3,500,000	89,500	...	...	...	...	42,100	...
Crooked	...	...	...	...	12,200	4,500	17,900	118,000
Sucker	1,725,000	...	...	...	...	...	...	5,000
Beaton's	...	64,500	...	23,000	3,800	...	4,000	73,000
Marion	...	...	...	...	4,500	2,500	2,000	122,000
Bass	...	...	...	...	...	...	1,800	61,000
Bob	...	...	...	...	1,600	5,600	5,000	96,000
Imp	...	5,000	...	...	2,400	...	...	26,000
Lake 16 (Bela)	...	...	400	...	100	...	...	6,000
Pilot (Crystal)	...	...	...	...	...	...	...	...
Sturgeon River Drainage								
Markey (Marquis)	...	...	...	...	...	200	...	10,000
Deerskin River Drainage								
Smoky	1,575,000	59,500	...	...	2,900	3,000	15,800	65,000
Carp River Drainage								
Lake of the Clouds (Big Carp)	...	...	...	...	3,000	...	...	30,000
Totals	13,300,000	258,000	400	23,000	33,600	51,400	126,600	782,000

TABLE 6

Growth-Rate Studies on Fish from
Certain Lakes of the Ottawa National Forest

(Where more than 1 fish are considered in an age class, lengths and weights given are averages for the group). All age determinations were made by Mr. William C. Beckman.

Name of Lake	Age Group I			Age Group II			Age Group III			Age Group IV		
	No. of fish	Total length, inches	Weight in ounces	No. of fish	Total length, inches	Weight in ounces	No. of fish	Total length, inches	Weight in ounces	No. of fish	Total length, inches	Weight in ounces
												PER
Crooked L.	18	4.1	0.5	47	7.3	2.2	31	7.7	2.8	18	8.8	4.1
Winslow L.	..	...	...	..	...	...	1	6.6	1.8	..	...	...
Lake 16 (Bela)	..	...	...	1	5.7	1.3	2	6.1	1.3	4	7.8	3.0
Pickerel L.	..	...	...	2	5.9	1.2	2	7.5	2.3	6	8.7	4.2
Golden L.	..	...	...	..	...	...	5	6.7	1.6	11	6.8	1.7
Lake 17	..	...	...	..	...	...	..	...	...	1	10.0	5.7
East Paint L.	..	...	...	3	6.6	1.3	..	...	...	6	8.3	3.5
Robinson L.	..	...	...	2	4.6	0.5	..	...	...	2	6.5	1.5
Hagerman L.	..	...	...	..	...	...	1	7.5	6.9	2	9.9	7.0
Thousand Island L.	..	...	...	..	...	...	..	...	...	..	...	...
Harding L.	..	...	...	6	6.3	1.5	14	6.5	1.6	2	7.8	3.4
Sucker L.	..	...	...	..	...	...	..	...	...	3	10.0	6.9
Beaton's L.	..	...	...	..	...	...	2	6.8	1.7	2	8.7	4.0
Paint L.	..	...	...	..	...	...	1	8.6	3.1	2	7.7	2.3
Smoky L.	..	...	...	..	...	...	3	6.3	1.7	5	7.4	2.4
Marion L.	..	...	...	2	7.0	2.2	..	...	...	..	...	...
Bass L.	..	...	...	..	...	...	1	6.4	1.2	9	6.9	2.1
Lake of the Clouds*	..	...	...	[illegible] 1	6.1	...	[illegible] 1	8.0	3.0	[illegible] 4	11.2	9.3
												BLUEG
Crooked L.	17	3.3	0.4	9	5.6	2.1	2	7.7	6.5	4	7.6	5.9
Lake 5	3	5.6	2.4	2	6.1	2.6	..	...	...	..	...	...
Robinson L.	..	...	...	1	5.6	1.8	..	...	...	..	...	...
Thousand Island L.	..	...	...	..	...	...	..	...	...	..	...	...
Marion L.	..	...	...	..	...	...	5	5.6	1.9	7	7.1	3.7
Hagerman L.	..	...	...	..	...	...	1	5.6	2.1	..	...	...
												[illegible]
Crooked L.	4	2.7	0.3	9	4.5	1.2	2	4.8	1.5	1	6.3	3.1
Winslow L.	..	...	...	3	3.7	0.6	2	4.7	1.2	1	6.0	2.2
Lake 17	..	...	...	..	...	...	..	...	...	..	...	...
Robinson L.	..	...	...	6	4.2	0.7	13	5.9	2.4	..	...	...
Hagerman L.	..	...	...	..	...	...	2	3.9	0.8	1	5.6	2.2
Paint L.	..	...	...	..	...	...	..	...	...	..	...	...
Marion L.	..	...	...	..	...	...	2	4.7	1.2	6	6.4	2.9
Bob L.	..	...	...	..	...	...	..	...	...	3	7.2	5.2
Bass L.	..	...	...	..	...	...	1	5.6	2.3	5	6.0	3.0
												LARGEMOU
Crooked L.	15	6.0	1.8	2	9.2	5.8	4	10.7	8.9	1	9.9	6.2
Lake 5	..	...	...	..	...	...	1	12.4	15.3	..	...	...
Robinson L.	1	5.8	1.3	..	...	...	..	...	...	..	...	...
Hagerman L.	..	...	...	..	...	...	..	...	...	..	...	...
Paint L.	6	7.1	3.1	..	...	...	..	...	...	..	...	...
Bob L.	..	...	...	..	...	...	1	11.7	12.8	..	...	...
Bass L.	..	...	...	..	...	...	1	11.2	16.9	7	11.3	10.9
												SMALLMOU
Crooked L.	..	...	...	5	8.0	3.9	9	9.3	6.4	11	10.6	8.3
Winslow L.	..	...	...	..	...	...	..	...	...	..	...	...
Lake 5	2	5.8	1.5	3	7.8	3.5	1	10.7	8.3	3	11.0	9.2
Hagerman L.	..	...	...	5	6.1	1.9	2	7.9	4.2	3	8.7	5.6
Thousand Island L.	..	...	...	..	...	...	2	9.8	6.9	1	16.0	36.0
Beaton's L.	2	5.9	1.9	5	7.9	4.2	..	...	...	1	11.4	14.4
Smoky L.	..	...	...	..	...	...	2	9.2	6.6	2	11.9	12.2
Marion L.	..	...	...	6	7.4	3.0	2	10.5	8.3	1	9.9	6.5
Bass L.	..	...	...	..	...	...	1	10.6	8.9	..	...	...
Markey L.	..	...	...	..	...	...	1	9.4	5.6	1	9.9	6.5
												BROOK
Crooked L.	1	6.7	1.8	..	...	...	..	...	...	..	...	...
Lake 16 (Bela)	..	...	...	1	7.9	2.9	1	12.8	14.1	..	...	...
												BLACK C
Crooked L.	4	3.3	0.4	7	7.3	3.6	1	6.6	2.7	2	10.3	7.7
Paint L.	..	...	...	..	...	...	1	7.8	4.0	21	8.7	5.5
Marion L.	..	...	...	..	...	...	..	...	...	..	...	...
Bass L.	..	...	...	..	...	...	..	...	...	13	7.8	6.9
Crooked L.	..	...	...	3	10.6	7.5	18	10.5	7.2	19	12.4	9.4
												NORTHER
Winslow L.	1	17.5	18.0	1	22.6	41.0	..	...	...	..	...	...
Thousand Island L.	..	...	...	5	19.7	27.4	4	20.8	31.2	..	...	...
Paint L.	3	15.8	15.1	..	...	...	..	...	...	..	...	...
												WALLEYE
Pickerel L.	3	12.1	8.9	..	...	...	..	...	...	..	...	...
Thousand Island L.	..	...	...	..	...	...	2	14.5	14.9	3	16.1	22.4
												ROCK
Thousand Island L.	..	...	...	..	...	...	..	...	...	..	...	...
Beaton's L.	..	...	...	1	4.3	0.8	..	...	...	11	6.4	2.8
Smoky L.	..	...	...	..	...	...	3	4.6	1.1	..	...	...
												LAKE
Thousand Island L.	..	...	...	..	...	...	..	...	...	..	...	...
												RAINBOW
Beaton's L.	..	...	...	..	...	...	..	...	...	..	...	...

*To the ages of fish from Lake of the Clouds 1 annulus has been added. They were collected in June. The small roman numerals in the upper left corner of each age group indicate the age of fish from this lake, since they were too old to fit the table normally.

TABLE 6 CONTINUED

Name of Lake	Age Group V			Age Group VI			Age Group VII			Age Group VIII		
	No. of fish	Total length, inches	Weight in ounces	No. of fish	Total length, inches	Weight in ounces	No. of fish	Total length, inches	Weight in ounces	No. of fish	Total length, inches	Weight in ounces
CH												
Crooked L.	12	9.9	6.7	4	9.1	5.2	1	10.1	5.5	..	...	...
Winslow L.	1	7.5	1.9	..	...	...	1	10.7	8.6	..	...	...
Lake 16 (Bela)	4	9.8	6.8	6	11.5	8.3	..	...	...	..	...	...
Pickerel L.	..	...	...	..	...	...	..	...	...	..	...	...
Golden L.	3	7.2	2.1	..	...	...	..	...	...	..	...	...
Lake 17	..	...	...	1	10.6	6.7	..	...	...	..	...	...
East Paint L.	3	10.6	8.7	2	10.5	7.4	..	...	...	..	...	...
Robinson L.	..	...	...	..	...	...	..	...	...	..	...	...
Hagerman L.	..	...	...	..	...	...	..	...	...	..	...	...
Thousand Island L.	2	10.2	8.2	1	10.7	8.6	..	...	...	..	...	...
Harding L.	..	...	...	..	...	...	..	...	...	..	...	...
Sucker L.	3	10.6	7.6	..	...	...	..	...	...	..	...	...
Beaton's L.	5	8.5	4.0	3	8.3	3.7	2	8.2	3.6	..	...	...
Paint L.	3	8.3	3.2	5	8.7	3.8	1	9.4	4.9	..	...	...
Smoky L.	4	8.2	3.6	..	...	...	..	...	...	..	...	...
Marion L.	..	...	...	..	...	...	..	...	...	..	...	...
Bass L.	2	7.5	2.4	1	9.8	5.9	..	...	...	..	...	...
Lake of the Clouds*	x 5	12.0	10.8	x 2	12.0	10.0	x 2	13.3	14.4	xi 2 / xii 1	15.4 / 13.7	15.4 / 14.6
ILLS												
Crooked L.	1	7.8	5.8	..	...	...	..	...	...	..	...	...
Lake 5	..	...	...	..	...	...	..	...	...	..	...	...
Robinson L.	..	...	...	..	...	...	..	...	...	..	...	...
Thousand Island L.	..	...	...	..	...	...	2	9.2	11.0	..	...	...
Marion L.	..	...	...	1	7.9	4.7	..	...	...	..	...	...
Hagerman L.	..	...	...	..	...	...	..	...	...	..	...	...
NSEED												
Crooked L.	..	...	...	..	...	...	..	...	...	..	...	...
Winslow L.	3	6.2	3.1	3	6.6	3.3	2	7.0	4.4	..	...	...
Lake 17	1	6.1	2.5	1	6.4	2.8	1	6.2	2.4	..	...	...
Robinson L.	..	...	...	..	...	...	..	...	...	..	...	...
Hagerman L.	1	6.4	3.3	..	...	...	..	...	...	..	...	...
Paint L.	5	6.2	3.2	10	6.6	3.7	7	6.9	4.5	1	7.3	4.7
Marion L.	..	...	...	..	...	...	..	...	...	..	...	...
Bob L.	1	7.2	4.9	..	...	...	..	...	...	..	...	...
Bass L.	..	...	...	..	...	...	..	...	...	..	...	...
TH BASS												
Crooked L.	..	...	...	..	...	...	..	...	...	..	...	...
Lake 5	..	...	...	..	...	...	..	...	...	..	...	...
Robinson L.	..	...	...	..	...	...	..	...	...	..	...	...
Hagerman L.	..	...	...	1	13.6	22.0	..	...	...	..	...	...
Paint L.	..	...	...	..	...	...	..	...	...	..	...	...
Bob L.	..	...	...	..	...	...	..	...	...	..	...	...
Bass L.	4	14.0	21.6	..	...	...	..	...	...	..	...	...
TH BASS												
Crooked L.	12	11.1	11.2	5	12.9	15.9	1	14.7	8.2	2	14.2	21.7
Winslow L.	3	15.6	30.1	..	...	...	1	15.5	31.5	..	...	...
Lake 5	3	12.9	14.7	..	...	...	..	...	...	..	...	...
Hagerman L.	1	13.9	24.0	..	...	...	1	15.2	31.5	..	...	...
Thousand Island L.	..	...	...	..	...	...	..	...	...	..	...	...
Beaton's L.	..	...	...	..	...	...	..	...	...	..	...	...
Smoky L.	1	11.8	12.3	1	15.1	34.0	..	...	...	..	...	...
Marion L.	9	12.1	12.4	10	13.6	19.9	..	...	...	..	...	...
Bass L.	..	...	...	..	...	...	..	...	...	..	...	...
Markey L.	..	...	...	..	...	...	1	13.6	14.7	..	...	...
TROUT												
Crooked L.	..	...	...	..	...	...	..	...	...	..	...	...
Lake 16 (Bela)	..	...	...	..	...	...	..	...	...	..	...	...
RAPPIE												
Crooked L.	2	11.5	14.8	2	11.7	16.6	4	12.7	20.2	..	...	...
Paint L.	2	9.6	7.7	..	...	...	..	...	...	..	...	...
Marion L.	..	...	...	..	...	...	1	11.4	14.3	..	...	...
Bass L.	5	9.1	6.0	12	9.3	6.8	..	...	...	..	...	...
Crooked L.	16	13.0	11.4	30	12.7	12.0	13	13.5	14.5	1	14.4	17.1
N PIKE												
Winslow L.	..	...	...	..	...	...	..	...	...	..	...	...
Thousand Island L.	..	...	...	..	...	...	..	...	...	..	...	...
Paint L.	1	29.8	109.0	..	...	...	..	...	...	..	...	...
D PIKE												
Pickerel L.	..	...	...	..	...	...	..	...	...	..	...	...
Thousand Island L.	1	19.2	...	2	19.4	39.2	..	...	...	..	...	...
BASS												
Thousand Island L.	1	8.4	6.8	1	8.4	7.0	1	8.1	6.1	..	...	...
Beaton's L.	6	7.4	4.4	2	8.3	6.3	..	...	...	..	...	...
Smoky L.	..	...	...	1	7.0	3.6	6	7.3	4.1	4	7.5	4.2
TROUT												
Thousand Island L.	..	...	...	..	...	...	..	...	...	1	28.0	100.0
TROUT												
Beaton's L.	1	20.1	48.0	..	...	...	..	...	...	1	23.1	36.9