Original: Fish Division
cc: Mr. Roy Johnston 2-26-42
Education-Game
Mr. Eschmeyer

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

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

January 26, 1942

REPORT NO. 737

A FISHERIES SURVEY OF CRAIG AND CROOKED LAKES, BARAGA COUNTY

by

Paul Eschmeyer

Introduction

Craig and Crooked Lakes are located in T. 49 N., R. 31 W., in which the former water covers portions of Sections 21, 22, 27, 28, 33 and 34, and the latter water extends over parts of Sections 27, 34 and 35. The lakes are situated within one mile of each other, in Spurr Township, Baraga County, in the western portion of the Upper Peninsula of Michigan. Both lakes are near the headwaters and form a part of the drainage of the Peshekee River. They are situated about 6 miles north (and slightly west) of the Village of Michigamme. Highway U.S.-41 and the Duluth, South Shore and Atlantic Railroad pass 4 miles south of these lakes. From the highway, a poor logging road, scarcely passable during wet weather, extends to the south shore of Craig Lake and to within $\frac{1}{2}$ mile of Crooked Lake. The lakes are two of several lakes located within a rather small area. Other waters in the vicinity include Keewaydin, Thomas, Loon and Wagner Lakes.

The maps of Craig and Crooked Lakes, including the shore outline, shore features, bottom types, and depth contours, were made during the

period extending from July 21 to 30, 1937. Chemical and biological inventories of the waters were completed during the same interval by the same Institute for Fisheries Research survey party* which made the maps.

Both Craig and Crooked Lakes are quite isolated from population centers, and are not known to have been utilized for any specific industrial purpose. A broken logging dam in the outlet of Craig Lake makes it seem probable that its shores were at one time used as the site for a logging camp, and the lake used in a limited way for storage or transport of logs. Much of the area surrounding the lakes has been logged in the past, although the poor quality of the very few roads makes the entire vicinity a little-frequented, semi-wilderness area.

Fishing in Craig and Crooked Lakes has apparently always been poor, with yellow perch being the species most caught. No records of good catches taken from these lakes are available. Their poor reputation for fishing, as well as their inaccessibility, make them among the most lightly fished waters of the Upper Peninsula of Michigan.

As might be expected, there were no cottages, boat liveries, resorts, or hotels on either lake at the time of the survey, and the waters have little recreational value other than fishing. However, they add much to the scenic value of the semi-wilderness area in which they are located and thus increase the attractiveness of this section for the occasional "voyageurs" to whom mere inaccessibility does not constitute a prohibitive obstacle.

It seems very probable that Craig and Crooked Lakes will, in the future, increase somewhat in importance among the fisheries of the area,

---

* The survey party included Franklin Bond, leader, and John Greenbank, Wm. Beckman, and Floyd Ames, assistants.

although no extensive use can be expected as long as the present poor fishing and inaccessibility persist. However, in view of the extremely few wilderness areas yet remaining in the State, a suggestion that the lake's inaccessibility be reduced is not meant to be here implied.

Physical Characters of Craig and Crooked Lakes

Both Craig and Crooked Lakes have extremely irregular shorelines and relatively shallow depths. The former water has a maximum depth of 27 feet, while the latter has one small depression which is 33 feet deep. Craig Lake has the greater average depth, however, since about 50 per cent of the area is over 15 feet deep, whereas at least 80 per cent of Crooked Lake is less than 12 feet deep. Craig Lake has a shoreline of 7.9 miles, while Crooked Lake has 5.8 miles of shoreline. Craig Lake has a shoreline development of 3.15, and the figure for the other water is 3.28. This means that the lakes have 215 per cent (3.15 times) and 228 per cent (3.28 times) more shoreline, respectively, than a perfectly circular lake of the same area would have. The high shoreline development indicates an abundance of bays and coves, which frequently make important contributions to the fish production of a lake by providing shelter, food and spawning facilities.

Craig Lake has almost double the area of Crooked Lake, the acreages being 320 and 165 respectively. Both are about 2 miles long and each has widths ranging from 200 feet to about $\frac{1}{2}$ mile. The longer axis of Craig Lake lies in an almost due north-south direction, while that of Crooked Lake extends northwest-southeast.

The country surrounding Craig and Crooked Lakes is from moderately to densely wooded, has a rolling, glaciated topography, and sandy soils. The immediate shorelines of the lakes are likewise wooded, except for

limited sectors at various points where marshy and brushy areas encroach from the lake shore into the woods for short distances. Probably the basins of both Craig and Crooked Lakes are of glacial origin, resulting, perhaps, from the melting of huge ice blocks left by a retreating glacier.

Craig and Crooked Lakes lie near the western headwaters of the Peshekee River, a relatively short stream which enters Lake Michigamme. One of the western branches of the stream is entered by separate outlet tributaries from Craig and Crooked Lakes. The outlet of the former water leaves the extreme northeast end of the lake. An old logging dam crosses the stream near the lake but is no longer functional and is passable by fish. The natural outlet of Crooked Lake leaves the northeast end of the water.

The drainage of Craig Lake covers an area of about 9 square miles. It includes numerous small lakes (among which is Loon Lake). Three tributary streams supply Craig Lake. The most important inlet enters from the west and carries water from several lakes situated almost due west. A second inlet enters from the southeast, and the third is the outlet of a small lake lying less than 200 yards due north.

The drainage of Crooked Lake covers about 3 square miles and includes 2 small lakes, located southeast of it. These empty into Craig Lake by the latter's only inlet, near the southeast end.

Fluctuations of water levels in Craig and Crooked Lakes are limited to 2 or 3 feet, and occur only during times of abnormal precipitation or during the spring "break-up".

About 80 per cent of the area of Crooked Lake is shallow enough to be potentially able to support aquatic vegetation, and this is true of about 40 per cent of the area of Craig Lake. The shoals in both lakes

have chiefly sand or gravel bottom, except for limited areas of fibrous peat. The deeper waters of Craig Lake and about 80 per cent of the area of Crooked Lake have pulpy peat bottom deposits.

The water in both Craig and Crooked Lakes is brown in color. That in Craig is the least transparent. A Secchi disk (white metal disk about 6 inches in diameter) when lowered into the water disappeared from view at a depth of 5 feet in Crooked Lake and a depth of 3 feet in Craig Lake. The degree of transparency of the water is an important factor in determining the depth to which vegetation will grow since none of the higher aquatic plants are able to survive in the continued absence of light.

Temperature and Chemical Characters of Craig and Crooked Lakes

As a part of the surveys conducted at Craig and Crooked Lakes, various physical and chemical data concerning the lake water itself were collected. Temperature of the water at various depths was observed, and information concerning the dissolved gas, salt and mineral content of the water was obtained. Such data are very important in assisting to determine the degree of suitability of a lake to the various fish species. All fish have definite toleration ranges of temperature and dissolved oxygen content, and within these ranges are optima. Not only the ranges, but particularly the optima, vary among the different fish species, as well as among food organisms and other organic life in the waters.

A summary of the temperature and chemical data obtained at Craig and Crooked Lakes is shown in Table I.

Table I
Summary of Temperature and Chemical Conditions
in Craig and Crooked Lakes, July, 1937

Lake	Craig			Crooked	
Station	1	2	3	1	2
Location	Southeast depression	Large northeast bay	Near northwest inlet	North bay	South bay
Date	7/26/37	7/26/37	7/26/37	7/29/37	7/29/37
Air temperature, °F.	55.5	61.2	61.2	67.1	70.7
Surface temperature, °F.	59.7	67.1	67.8	67.8	68.7
Bottom temperature, °F.	64.6	55.2	68.1	45.5	67.5
Maximum depth, feet	26	22	6	32	9
Thermocline					
Location, depth in feet	20-22	15-22	...	10-20	...
Temperature					
Top of	65.5	66.9	...	66.0	...
Bottom of	56.1	55.2	...	50.3	...
Oxygen					
Surface	6.3	6.1	...	6.5	...
10 feet	...	...	...	6.3	...
15-16 feet	...	4.1	...	0.3	...
20 feet	6.1	0.9	...	0.1	...
Bottom	0.1	0.3	5.9	0.3	6.6
Carbon Dioxide					
Surface	3.5	3.5	...	3.0	...
Bottom	18.0	16.0	3.5	20.0	3.5
Methyl Orange Alkalinity					
Surface	11	12	...	12	...
Bottom	33	30	11	38	10
pH					
Surface	5.8	5.8	...	6.0	...
Bottom	5.8	5.8	5.8	5.8	5.8

The table shows that water temperatures at the time of the survey ranged from 55.2 to 68.1°F. in Craig Lake and from 45.5 to 68.7°F. in Crooked Lake. A thermocline (area of rapid change in temperature, e.g., 1°C. or more per meter of depth) was found to be present in the deeper water of both lakes. The presence of a thermocline indicates a division of the lake water into 3 different temperature strata during the summer months: the epilimnion (an area of warm, circulating water above the thermocline), the thermocline, and the hypolimnion (area of cold, non-circulating water below the thermocline). Lakes which have sufficient oxygen (4 parts per million or over) in the thermocline or hypolimnion can ordinarily be managed for either warm- or cold-water species of fish, since temperatures in these two strata ordinarily remain below 70°F. As shown in the table, only Craig Lake has over 4 parts per million or more of oxygen within the thermocline area, while the hypolimnion in both lakes has almost none of the dissolved gas. It can be predicted with certainty that the barely sufficient oxygen found by the survey party near the top of the thermocline of the northeast bay of Craig Lake in late July, also becomes dissipated during the latter part of the summer. As a result, both lakes are only fit for warm-water species of fish. Cold-water species such as trout should not be considered in the management of these waters.

Methyl Orange Alkalinity tests (made to determine the amounts of dissolved minerals and certain buffer salts in the water) showed the waters of both Craig and Crooked Lakes to be quite soft. Craig Lake showed a dissolved mineral and salt content ranging from 11 to 33 parts per million, while a range of from 10 to 38 parts per million was found in Crooked Lake. Moderately hard waters, with a Methyl Orange Alkalinity

of from 100 to 200 parts per million are generally more productive than softer waters, particularly when the management of warm-water species of fish is being considered. Aquatic vegetation and certain bottom organisms derive much of their nutriment directly from the minerals and salts dissolved in the water.

Both Craig and Crooked Lakes were found to be quite acid, with the former water having a pH of 5.8 and the latter having a range of from 5.8 to 6.0. These figures indicate a hydrogen ion concentration unfavorable for good fish production. Moderately alkaline waters (pH above 7.0, which is neutral) have generally been found to be more productive.

No pollution was found in Craig or Crooked Lakes. None would be expected, in view of the lake's far removal from sources of industrial or domestic wastes. Hydrogen sulfide gas was found to be present in limited quantities in the deeper waters of the southeast depression of Crooked Lake. The gas is a product of decomposition occurring at the bottom of the lake, and its presence gives further proof of the lack of oxygen.

Biological Characters of Craig and Crooked Lakes

In order to determine and evaluate the biological attributes of lakes, the collection of a variety of data is required. During the course of the survey of Craig and Crooked Lakes, samples of the different species of vegetation found in each lake were collected and identified, samples of plankton (microscopic free swimming and floating organisms) were obtained, bottom food collections were made, and the various species and sizes of fish present in the lake were collected, identified, aged, examined for presence of parasites, etc.

Vegetation was found to be very scarce in Crooked Lake, but in Craig Lake was well above average in abundance for lakes of its physical and chemical attributes (e.g., high acidity, soft water, infertile bottom soils). In Crooked Lake most of the vegetation was found near the inlets in the extreme southeast end of the lake, while in Craig Lake aquatic plants were scattered over much of the shallow water areas of the lake.

A list of the species of plants found in Craig and Crooked Lakes, and an estimate of their abundance at the time of the survey, are shown in Table II.

Table II
Plants Found in Craig and Crooked Lakes*

Species	Abundance	
	Craig	Crooked
Water shield (Brasenia Schreberi)	Common	Sparse
Coontail (Ceratophyllum demersum)	Sparse	...
Sedge (Carex sp.)	Very common	Common
Leather-leaf (Charnaedaphne calyculata)	Sparse	...
Three-way sedge (Dulichium arundinaceum)	Sparse	...
Creeping spike rush (Eleocharis palustris)	Sparse	Sparse
Horsetail (Equisetum sp.)	Sparse	Sparse
Pipewort (Eriocaulon septangulare)	Sparse	...
White water lily (Nymphaea odorata)	Common	...
Yellow water lily (Nuphar advena)	Abundant	Common
Smartweed (Polygonum amphibium)	Sparse	...
Leafy pondweed (Potamogeton epihydrus)	Sparse	...
Floating-leaf pondweed (Potamogeton natans)	Sparse	...
Wapato (Sagittaria latifolia)	Common	Sparse
Bulrush (Scirpus)	Sparse	...
Sedge (Scirpus atrocinctus)	Sparse	...
Bur reed (Sparganium fluctuans)	Sparse	...
Bladderwort (Utricularia vulgaris var. americana)	Sparse	...
Cattail (Typha latifolia)	Sparse	...
Water arum (Calla palustris)	...	Sparse
Wild celery (Vallisneria sp.)	Sparse	...
Iris (Iris versicolor)	Sparse	...
Water moss (Fontinalis novae-angliae)	Common-	Sparse

* Identifications by C. O. Grassl, Department of Botany, University of Michigan.

As seen in the table, although a variety of plants are present in Craig Lake, only a few have a generalized distribution (i.e., are common or abundant). Both lakes have rather limited flora--Craig Lake quantitatively, and Crooked Lake both qualitatively and quantitatively. Craig Lake apparently has adequate vegetation to provide the necessary shelter for fish and substrata for aquatic organisms. Since the shorelines of both Craig and Crooked Lakes are wooded, numerous deadheads, branches, brush, etc., add to the shelter provided by aquatic plants. Even with the "assistance" of such materials, the vegetation in Crooked Lake is far below the water's optimum cover requirements. In view of the chemical similarity and the analogous nature of the bottom soils, one would expect as much vegetation to occur in Crooked Lake as in Craig, or probably more, due to the former water's shallower depth and greater transparency. The reason for this sparsity of water weeds cannot be explained in the light of the survey data collected.

Plankton was found to be extremely limited in Craig Lake at the time of the survey, and of less than average abundance in Crooked Lake. The few samples of plankton taken during a short survey period provide insufficient data for estimating plankton abundance throughout the year.

As might be expected in waters with the very low basic fertility of Craig and Crooked Lakes, bottom foods were found to be very sparse. Three samples taken in Crooked Lake covering a total of one square foot of bottom produced only 10 organisms, all of which were phantom midge larvae. Three samples taken in Craig Lake, totalling 1 1/4 square feet, produced only 7 organisms, including 5 phantom midge and 2 other midge larvae. The samples as taken represent extremely poor bottom food production. Vegetation in Craig Lake probably harbors additional invertebrate food, but in Crooked Lake this source is almost totally lacking.

The fish collected in Craig and Crooked Lakes and an estimate of their abundance as judged by frequency of occurrence in survey collections is shown in Table III. No stocking was done during the 4 years preceding the survey, and there is no record of any stocking having been undertaken in either water before or since that time. The lakes appear to be two of the extremely few publicly owned lakes in the State which have never been artificially stocked.

Table III
Fish Collected in Craig and Crooked Lakes

Species	Abundance	
	Craig	Crooked
GAME FISH		
Yellow perch	Common	Common
Green sunfish	Rare	Very common
Pumpkinseed sunfish	Abundant	...
Pumpkinseed x green sunfish	Rare	...
FORAGE FISH		
Common shiner	Very common	Common
Creek chub	Very common	Very common
Northern dace	Common	...
Red-bellied dace	Very common	...
Black-nosed shiner	Common	Uncommon
Golden shiner	Very common	Very common
Fat-headed minnow	Abundant	Common
Iowa darter	Very common	Common
Brook stickleback	Rare	...
Black-nosed dace	Uncommon	...
Blunt-nosed minnow	Common	Abundant
COARSE FISH		
Common sucker	Abundant	Very common
Brown bullhead	Uncommon	Uncommon
Black bullhead	Uncommon	Common

An inspection of the table reveals the presence of a large forage fish fauna, a few coarse fish, and a few pan fish. All but 3 of the few perch taken were small (less than 8 inches in length). Green sunfish rarely reach legal size in Michigan. In cold, soft-water lakes, the same is generally true of pumpkinseeds. Both Craig and Crooked Lakes are producing a crop of fish which has almost no value to the angler. Even if

the lakes were very accessible, the present fish population would not be expected to furnish recreation to more than a very few indiscriminating anglers. Only a few fish obtained by the survey party were large enough to make their scales of value in growth rate determinations. Several perch were collected for age determinations from Crooked Lake, and only a few perch and a pumpkinseed comprised the Craig Lake collection. A summary of the findings is shown in Table IV.

Table IV
Growth Rate of Fish of Craig and Crooked Lakes*

Number of Annuli	Craig Lake			Crooked Lake		
	Number of specimens	Length in inches	Weight in ounces	Number of specimens	Length in inches	Weight in ounces
Perch						
III	2	6 3/4	1.6	...	...	...
IV	2	10 7/8	8.4	1	6 1/2	1.4
V	1	11 1/8	11.0	5	7 3/8	2.3
VI	...	...	...	4	7	1.8
Pumpkinseeds						
VI	1	5 1/8	1.2	...	...	...

* Growth determinations by W. C. Beckman.

The sparsity of data upon which it is necessary to base the growth rate of the fish of Crooked and Craig Lakes is unfortunate. The collection of additional specimens from both waters would be desirable. Judging by the scant data, the perch are growing quite well in Craig Lake. Although apparently not reaching legal size (6 inches) until their third summer of growth (while the average perch in Michigan reaches keeper size during the second summer of life), growth during succeeding years is accelerated. Abundant forage minnows no doubt provide ample food for the older perch, while the scarcity of bottom foods somewhat retards the younger age groups. Perch in Crooked Lake are growing at a less than average rate, even for lakes of the Upper Peninsula. Keeper size is reached during the fourth summer of life, and, unlike those in Craig Lake, the perch of Crooked Lake show no tendency to speed up their growth in the older age groups.

The growth of the one pumpkinseed kept was much below normal, as the average growth of this species for the State permits the attainment of legal size (6 inches) during the fourth summer of life. No green sunfish were aged, since the largest one taken measured only about 3 inches.

Spawning facilities in both Craig and Crooked Lakes are entirely adequate for the reproduction of the Centrarchid species. Much sandy shoal is present in both lakes, with sizable gravel beds occurring along some shores. More of the latter bottom type occurs in Crooked Lake than in the other water. Perch are reproducing well in both waters, judging by the presence of several age groups in each lake. The presence of marshy areas along the shores of both lakes, particularly near inlets and outlets, makes it seem highly probable that northern pike would reproduce naturally if they were present. Neither lake is believed to have suitable spawning areas for walleyes.

Management Suggestions

Both Craig and Crooked Lakes represent cases in which there is produced an abundance of forage fishes, but where no large predaceous species exist to transform these into fish flesh suitable for human consumption, or for sport fishing. This is only partially true in the case of Craig Lake, which appears to produce some good-sized perch. However, only limited numbers of these are apparently produced, since only 3 good-sized perch were captured in 131 hours of gill netting with an average of about 225 feet of gill net.

As a result of the abundance of forage and the practical absence of harvestable game fish, it is recommended that a predaceous fish species be introduced into each of the two lakes here being considered.

It is recommended that from 50 to 100 largemouth bass be introduced into Craig Lake. A single planting of adults would be sufficient, since natural reproduction should be adequate to perpetuate the species once it is introduced. A planting of fingerlings might fail due to the predation of perch. It is expected that the largemouth bass may grow at an average rate in Craig Lake and eventually attain sufficient numbers to keep the pumpkinseeds and perch population reduced enough to provide good fishing for all 3 species.

It is recommended that from 10 to 25 adult northern pike be introduced into Crooked Lake. Since Crooked Lake has an abundance of (probably stunted) green sunfish and what appears to be a population of rather seriously stunted perch, northern pike should be useful in cutting down the numbers of both species, as well as consuming the abundant but now little used forage fish in the lake. Good fishing for perch and pike should result. The marshy areas near the inlet at the south end of the lake should provide suitable spawning areas, and pike would probably also "run" the outlet or inlet to spawn.

Craig and Crooked Lakes are sufficiently similar, physically, chemically and biologically, so that either largemouth bass or northern pike would be expected to do well in either lake. Craig Lake has more vegetation, more deep water, more sandy shoals, a browner color, and less transparency than Crooked Lake has. Since the perch population is doing fairly well at present (i.e., at the time of the survey) the treatment of the lake (i.e., population control) needs to be less drastic than in the case of Crooked Lake. Largemouth bass are less predaceous than northern pike, under most circumstances, particularly when it comes to preying upon perch. It is therefore thought that Craig Lake would be

the more suitable water for largemouth bass. This species has been observed by the writer to do well in fairly deep, highly bog-stained waters of the western Upper Peninsula. The scarcity of vegetation in Crooked Lake makes it less suitable for northern pike than it might otherwise be, but in the presence of abundant food and what are believed to be adequate spawning facilities, northern pike should get along well.

Craig and Crooked Lakes should be investigated again 5 years after the introduction of bass and pike respectively, to determine the degree of success attained by the management procedures. If one species fails and the other makes good, the successful species should be transferred to the lake in which the experiment failed, and it would be expected to repeat its previous success, since the two lakes have many basic similarities. This is an advantage of stocking pike in one lake and bass in the other, instead of stocking the same species in both lakes.

Both Craig and Crooked Lakes are in the "all others" classification. No change seems required at the present time, but if pike become well established in Crooked Lake in the future, leaving, essentially, a pike-perch population, a change to a pike lake designation would seem desirable.

No stocking should be undertaken other than that mentioned above, unless future investigations of these waters clearly show the need for further artificial planting.

A loon, a number of kingfishers, and 2 great blue herons were seen by the survey party at the time of the inventory of Craig and Crooked Lakes. These or any other bird or mammal predators which might occur at either of the lakes would not be likely to have a harmful influence on the fishery there. No control measures are requires.

No parasites were found in any of the Crooked Lake fish examined. Some of the fish taken from Craig Lake were equally clear of parasites, while a few others (perch) were heavily infected with yellow grubs. The parasites occurred in the gills, mouth cavity, musculature and pericardial region. The yellow grub cannot be transmitted to man and apparently does not hinder the growth and development of fish. In view of the relatively light infestation present (except in a few individuals) in the fish of these lakes, and the absence of a practical method of control of the parasites, no control measures are here recommended.

Cover in Craig Lake is adequate to meet the needs of its proposed fish population. Although cover is scant in Crooked Lake, its improvement does not seem necessary at present. If pike become well established in the future, the addition of brush shelters to the lake may become desirable, to insure the survival of young game fish and the perpetuation of the forage fish population. Brush shelters would have to be placed in areas which do not have a pulpy peat bottom type, to prevent their sinking out of effective range.

Water levels in Craig and Crooked Lakes are apparently quite stable, subject only to change by umusual precipitation or the spring break-up. A change in present levels probably would not benefit either water.

Spawning facilities appear to be adequate for the natural reproduction of both the present and proposed fish populations, and no improvements are suggested.

INSTITUTE FOR FISHERIES RESEARCH

By Paul Eschmeyer

Report approved by: A. S. Hazzard

Report typed by: R. Bauch