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INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
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FISHERIES SURVEY OF CRYSTAL LAKE, BENZIE COUNTY

by
C. J. D. Brown and John Funk

Crystal Lake is located in the west central part of Benzie County near the shores of Lake Michigan. It occupies part of Benzonia, Crystal Lake and Lake townships and covers all or part of the following sections: T. 26 N., R. 15 W., Sec. 6, 7, 8, 9, 15, 16, 17, 18, 19, 20, 21, 22, 23, 26, 27; T. 26 N., R. 16 W., Sec. 1, 2, 3, 10, 11, 12, 13, 14, 15; T. 27 N., R. 16 W., Sec. 34, 35. This lake lies within the Betsie River drainage, on a small tributary to this stream. It is only 6 miles by stream from the outlet of Crystal Lake to Lake Michigan near Frankfort. The village of Beulah is located on the east end of the lake.

A biological inventory* was conducted June 5-25, 1940, with a subsequent check on the lake temperatures and oxygen conditions taken August 11, 1940. A hydrographic map showing the lake outline and soundings was prepared by R. L. McNamee and permission to use this map was generously given by him. Although this map had an inadequate number of soundings, it served as a base for plotting other information obtained during the survey. Grateful acknowledgement is here made for assistance rendered the survey

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*The personnel of the survey party was as follows: John Funk, leader; David Anderson, William Reavley and Michael Meyer, assistants.

party by the citizens of the Crystal Lake vicinity and especially to W. O. Kiracofe of the Benzie County Chamber of Commerce, and to F. C. Morrill of the Benzie County Fish and Game Protective Association.

Crystal Lake was used for the transport of logs in the early days during the lumbering period of that region. Logs were skidded down the surrounding hills and then floated to the west end of the lake to be hauled overland to Frankfort. An attempt to use the outlet and Betsie River for log transport was unsuccessful. A few deadheads dating from that time are still present in the lake. These make good cover for fish on the barren shoals, but are not numerous enough to be very effective.

The towns along the lake derive considerable profit from tourist trade. This is not confined alone to the summer, but extends through the period of ice cover, the winter attraction being the smelt fishing. Smelt dipping has been promoted by the residents of Beulah on Cold Creek.

According to reports, smelt were first introduced into Crystal Lake in 1912, and by their multiplication and movement, were probably at least partially responsible for populating the Great Lakes. Prior to the introduction of smelt, perch were the most important game fish. These are said to have averaged a much larger size than they do at present. Fishing as a whole, aside from the smelt, is rather poor, and as a result the lake is not heavily fished for other species. Summer vacationists are attracted to this lake for the fine swimming beaches and boating, rather than the fishing. Occasionally a few large northern pike and smallmouth bass are caught, mostly by local people who know the lake.

There are about 330 cottages on or near the lake shores. Some of these are permanent residences. Beulah, at the east end of the lake, is predominantly a resort town with three hotels and numerous rooming houses. There

is a large hotel in Benzonia, about a mile from the east end of the lake. Crystalia, at the west end, is an unincorporated community of cottages and permanent homes located near the Congregational Assembly. Robinson's Resort and the Christian Assembly are the largest concentrations of dwellings on the south shore.

Crystal Lake, formerly known as Cap Lake, is long and narrow with a maximum length of 8.2 miles, a maximum width of 2.3 miles, and a surface area of 9,711 acres. Its long axis approaches a northwest-southeast direction. The shoals are broad and sandy with an extremely abrupt drop-off. The basin is somewhat irregular in detail, although there is only one major depression. The center of this occurs 1¼ miles directly north of the Christian Assembly camp. The origin and age of the lake basin is described by I. D. Scott in his book, "Inland Lakes of Michigan," as follows:

> "As regards the basin, it may be stated that it is relatively old. In fact, it is certain that it was in existence before the ice made its final advance, for it was filled with a small lobe, an offshoot from the Michigan lobe, which pushed through the opening at the west end, now closed with sand. This lobe deposited a strong morainic loop around this basin, which is continuous except at the outlet and a depression on the north side which runs northward into the Platte Lake depression, in the vicinity of Round Lake. At present the lake shores do not reach the morainic hills but are separated from them by a rather broad zone of sandy terrace. This widens greatly at the east end and extends nearly two miles before it is interrupted by the moraine.
>
> "The striking physiographic characters are the predominating high cliffs from whose base the sandy terrace mentioned above extends to the water's edge. The first surmise is that this lake has stood at a higher level and further observations prove this to be correct."

The steep morainic slopes around the lake are covered with a mixed growth of conifers and hardwoods, and the surrounding country is of a similar nature. Some fine orchards exist on the slopes of these moraines.

Crystal Lake is reported to have a maximum depth of 175-200 feet. Such depths may occur, but only as very limited pockets. The survey party in its

operations found no depth greater than 162 feet. More systematic soundings will probably settle this point. The shoal (0-20 ft. depths) makes up about 25 per cent of the surface area of the lake. The bottom here is barren sand dispersed with gravel and rubble. The bottom beyond the 20-foot contour is sand and marl on the slopes and muck in the bottom of the depression.

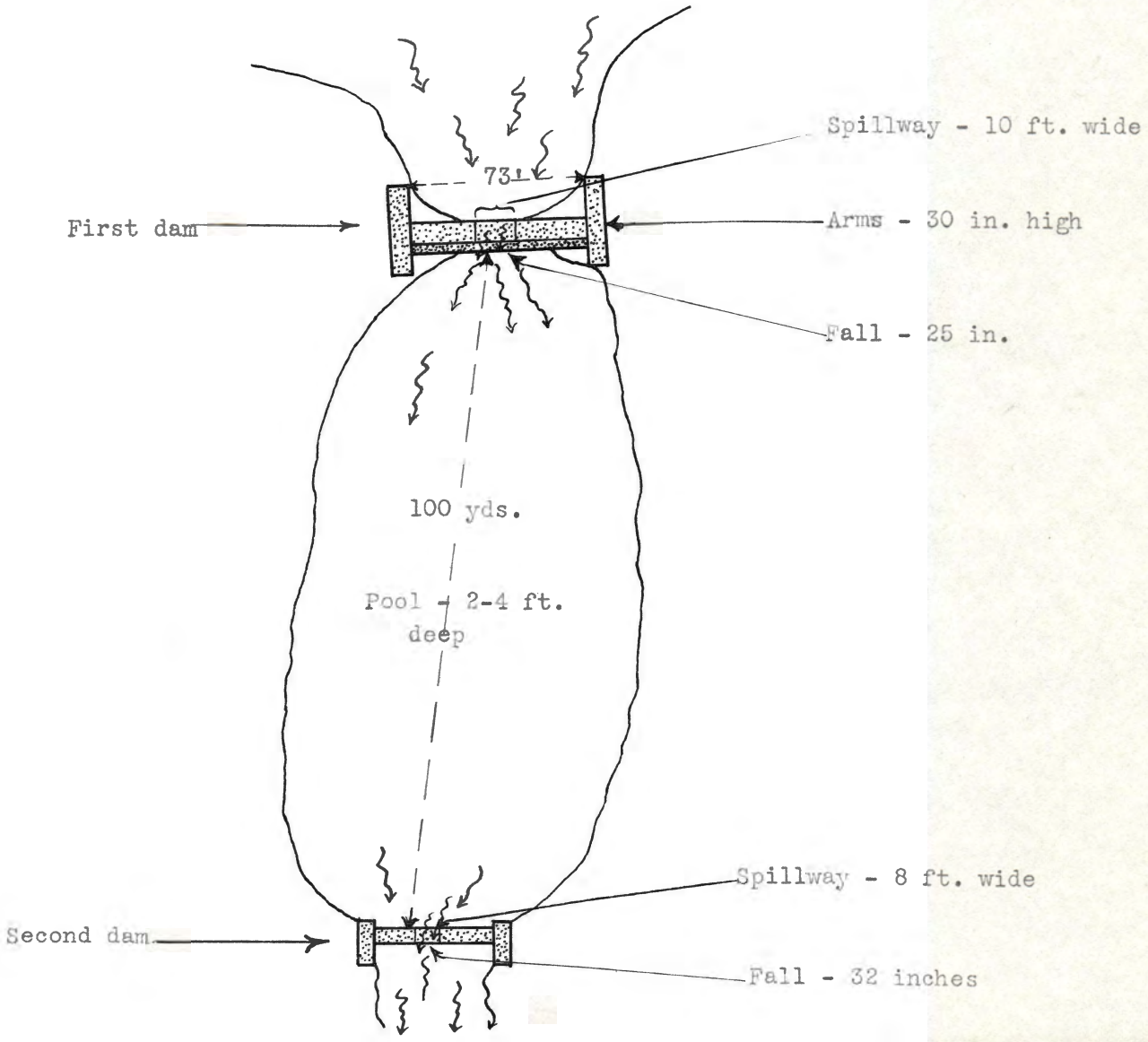
The water is colorless and very clear. On a dull cloudy day a secchi disc could be seen at a depth of 19 feet. This indicates a clearness considerably greater than the average for southern Michigan lakes.

Crystal Lake drainage is limited to the immediate surroundings and the small valley of Cold Creek at the east end. The immediate borders of the lake are quite sandy, having been part of the shoal at higher lake levels. In the flats east of Beulah the soil is predominantly muck, with celery and other vegetables being the principal crops.

The only important inlet to Crystal Lake, Cold Creek, is a stream 12 feet wide. At the time of the survey it was approximately 12 inches in depth and had a moderately swift rate of flow. According to local inhabitants, it has moderate fluctuations in level, but does not flood its banks. All other sources are small brooks (a yard or so in width and a few inches deep) draining springs. Springs are also reported in the lake proper. The level of the lake was set by court act a number of years ago after real estate title difficulties arose. During the logging days, the outlet of the stream was dredged to make it suitable for floating logs and the lake level was greatly lowered for a time. The present dam was later built and the present level has been maintained since that time. This is several feet lower than the original level, however, causing the extensive area of low ground which now surrounds the lake.

The main dam at the outlet is supported by a second one about 100 yards downstream (Sketch below). Both are solidly constructed of concrete. The relationship and dimensions of the two dams can best be explained by the accompanying sketch. At the time of the survey, about 8 inches of water was going over the spillway of the first dam and about $5\frac{1}{2}$ inches was going over the spillway of the second. A large sewer tile at the second dam accounts for the reduced overflow here.

Sketch of Dams at Outlet of Crystal Lake



The various physical factors operating in lakes, such as shape of the basin, direction of long axis, type of bottom, color of water, etc., determine to an important degree the potential fish production for each water. A steep-sided basin with little shoal does not encourage fish food production because most of the invertebrate organisms and forage fishes need these shallow waters for maximum growth and reproduction. In Crystal Lake, there is only a moderate amount of shoal. Under some circumstances this might be adequate to supply food and cover for a reasonably large fish population. However, the shoals of Crystal Lake are sand which is almost constantly in motion because of continuous wave action. Vegetation beds cannot withstand the cutting effect of the sand and as a result good cover and food are nowhere present on the shoals. The lake is oriented so that its long axis is parallel with the prevailing or most frequent winds, and this condition contributes greatly to the molar activity described above.

Clear water as found in Crystal Lake makes it possible for plants to grow at greater depths than they could in lakes with turbid or colored waters. Light penetration, however, is only one of many factors influencing plant growth. The type and fertility of the bottom, protection from wave action, etc., are important as well. The lack of organic deposits in Crystal Lake makes the bottom of the shallower areas a desert. Clean washed sand is not productive soil, either on land or under water.

The physical conditions existing in this lake are not only unfavorable to high productivity, but make angling exceedingly difficult during the summer. The very frequent rough water makes summer fishing much like that of the Great Lakes where larger boats and good seamanship are prerequisite for the fisherman.

A summary of the temperature and chemical conditions in Crystal Lake is given in the following table.

Summary of Temperature and Chemical Conditions Found in Crystal Lake

Location of Station	Station I near outlet	Station II near inlet	Station III over deepest point	
Date	6/8/40	6/8/40	6/10/40	8/11/40
Air temperature	66° F.	58° F.	64° F.	77° F.
Water temperature				
Surface	60° F.	61° F.	58° F.	74° F.
Bottom	...	...	43° F.*	43° F.*
Thermocline, middle of	none	none	none	51° F. (63 ft.)
Oxygen, p.p.m.				
Surface	10.3	9.4	10.2	8.1
Bottom	...	...	10.7*	7.2*
CO_2, p.p.m. range	0.0	0.0	0.0-3.0	0.0-6.0
Methyl orange alkalinity, p.p.m. range	112.0	117.0	106-120	106-119
pH range	8.0	8.0	7.9-8.0	7.6-8.2

The low surface temperatures existing in Crystal Lake are very probably the main cause for the delayed spawning of perch and bass living there, although the season of 1940 is not representative or average as to temperature conditions. Delayed spawning was noted in many other places in the state this year. Surface temperatures taken during August were near 74° F. This is probably the maximum for the year. Bottom temperatures remained almost constant throughout the season, at 43° F.

No thermocline (zone of rapid change in temperature) was present during

*Depth = 162 ft.

the June survey, but in August a very definite zone was established which included the layer of water between 42 and 120 feet. From the top to the bottom of this layer, the temperature declined 24° F.

There was very little chemical stratification, however. Abundant oxygen was found from top to bottom at the time both analyses were made. Free carbon dioxide was so scarce that it has little significance to fish production. The water in Crystal Lake is only moderately hard (methyl orange alkalinity, 106-120 p.p.m.). Some sparse Chara beds have been developed and there is a thin layer of marl over a small area of the bottom. The water is distinctly alkaline with a pH range of 7.6-8.0.

The temperature conditions found in Crystal Lake are definitely more suited to cold water species of fish than to the warm water ones. There is no reason, from the point of view of the temperature and chemical conditions, why Crystal Lake cannot be utilized by trout, almost from top to bottom throughout the year. There is adequate oxygen from the surface to the bottom even in late summer and the other chemical conditions are favorable for trout.

As has already been pointed out, the physical conditions existing in Crystal Lake are very unfavorable for the growth of aquatic plants. There are only a few species represented here and these are nowhere abundant. A list of the plants present is given below.

Muskgrass, Chara fragilis
Horsetail, Equisetum sp.?
Pondweed, Potamogeton natans
" " graminifolius var. myriophyllus
" " filiformis
" " pectinatus
Spike rush, Eleocharis compressa
Bulrush, Scirpus americanus
Sedge, Carex substricta
Rush, Juncus balticus var. littoralis
Bladderwort, Utricularia sp.?

Muskgrass and pondweeds were found sparsely scattered over the rubble beds on the shoals near shore. Muskgrass was rather infrequently found in the deeper water. The other species listed above were confined almost entirely to one small beach pool on the north shore.

Fish food studies included a general sampling of the lake in order to determine what kinds of fish food organisms were present and how abundant they were. Plankton samples indicated that the population of these free-floating organisms was comparatively low during the period of the survey. Zooplankton (animal forms) was predominant, although a definite phyto-plankton (plant organisms) was present. Considering the great fluctuations in plankton which exist from week to week, and place to place, it is not possible to accurately estimate the significance of a few samples. Continuous studies over a two or three year period would be necessary to determine the abundance and significance of plankton as food for fish in Crystal Lake.

Bottom samples taken on the shoal and in the deep water with a clam-shell (Ekman) dredge are summarized in the following table.

Shoal Samples

Station	Depth	Area	Bottom	Vegetation	Volume, c.c.	No. of Organisms	Mayflies	Dragonflies	Damselflies	Midges	Other flies	Stone flies	Caddis flies	Freshwater shrimp	Leeches	Snails	Clams	Crustacea	Aquatic worms	Alder flies
1.	18-20 in.	Qualitative	Sand	None	...	13	5	1	.	6	1	.	.	.	.	.	.	.	.	.
2.	14 in.	$\frac{1}{20}$ sq. ft.	Sand & gravel	None	0.3	3	.	1	.	1	1	.	.	.	.	.	.	.	.	.
3.	21 ft.	$\frac{1}{20}$ sq. ft.	Sand & detritus	Chara	1.0	173	29	.	.	78	.	.	.	56	3	6	1	.	.	.
5.	6 in.	Qualitative	Rubble	Algae	...	44	29	.	2	3	.	.	.	.	.	8	.	2	.	.
7.	6-12 in.	Qualitative	Rubble	None	...	24	14	1	.	.	.	.	9	.	.	.	.	.	.	.
8.	6-12 in.	Qualitative	Rubble	None	...	52	35	.	1	2	.	1	5	2	.	5	.	.	1	.
9.	14 in.	Qualitative	Rubble	None	...	21	13	.	.	4	1	.	2	.	1	.	.	.	.	.
10.	12 in.	1 sq. ft.	Rubble	Chara	0.5	38	15	.	.	6	.	.	1	15	1	.	.	.	.	.
11.	2 ft.	1 sq. ft.	Rubble	Chara, Potamogeton	0.8	19	12	.	.	1	.	.	4	.	1	1	.	.	.	.
12.	2 ft.	1 sq. ft.	Rubble	None	...	6	2	.	.	3	.	.	.	1	.	.	.	.	.	.
13.	16 in.	1 sq. ft.	Rubble	None	0.4	31	20	.	.	10	.	.	.	.	.	.	.	.	.	1

Bottom (70 to 160 ft.) Samples

Station	Depth	Area	Bottom	Vegetation	Volume c.c.	No.	Aquatic worms	Fresh-water shrimp	May-flies	Clams	Midges
4.	160 ft.	½ sq.ft.	Muck	None	0.7	37	10	26	1	.	.
6.	160 ft.	½ sq.ft.	Muck	None	0.5	20	4	16	.	.	.
14.	70 ft.	½ sq.ft.	Muck	None	0.3	27	7	4	1	2	13
		1½ sq.ft.			1.15	84	21	46	2	2	13

Mayflies were found to be the most abundant food organism on the rubble shoals, with midge larvae, freshwater shrimp, caddis flies and snails following in that order. The rubble patches compensated, at least in part, for the sparse vegetation and offer cover for most of the organisms mentioned. Small crayfish were fairly abundant on the rubble shoals and large ones were taken in nets in 30 or more feet of water. Stomach examinations of perch and rock bass show the crayfish to be an important food item, at least for the time of the year when the survey was made. Amphipods ("shrimps"), oligochaetes (aquatic earthworms) and midge larvae dominated the bottom mud in deep water. On the whole, the fish food supply seems fairly good, considering the dearth of vegetation.

A study of the kinds and abundance of fish present in Crystal Lake was made during the survey. Fish were collected by means of gill nets, seines, and fyke nets. A summary of the fish taken during the survey, as well as the plantings made during the last six years, is given in the following table.

Game fish	Abundance	No. stocked 1934-39 inc.
Perch	abundant	210,000
Smelt	abundant	...
Rock bass	common	...
Cisco	rare	...
Whitefish	rare	...
Great northern pike	rare	...
Lake trout	rare	45,000
Smallmouth bass	reported common	5,600
Bluegill	very rare	30,200
Pumpkinseed	reported rare	...
Black crappie	reported rare	...
Forage fish		
Lake emerald shiner	abundant	...
Spot-tail shiner	abundant	...
Straw-colored shiner	abundant	...
Blunt-nosé minnow	common	...
Johnny darter	common	...
Log perch	rare	...
Iowa darter	rare	...
Coarse fish		
Common sucker	abundant	...
Lawyer	rare	...
Bullhead	reported rare	...

A total of 7,510 fish was taken by nets from Crystal Lake; 98.3 per cent of this number were perch. The common sucker made up 1.3 per cent, and smelt, rock bass, cisco, whitefish, lake trout, northern pike and lawyer made up the other 0.4 per cent. No smallmouth bass were taken, but this species is known to be fairly common in the catches of fishermen. A number of spawning bass were observed by the survey party, building nests on June 20, 1940.

There can be little doubt but that perch are the most dominant game fish. Smelt are also very common, while lake trout and northern pike

are only rarely taken.

The common sucker is the only abundant coarse fish, and the lawyer, generally classed as an obnoxious fish, is only rarely seen. Seven species of forage fishes were captured during seining operations. The lake emerald shiner was the most abundant, while the spot-tail shiner and straw-colored shiner were also numerous.

Since 1928, 1,381 records of fishermen's catches have been submitted, in line with the state-wide general census. A summary of these reports is given below. If these records are representative, there has been no decrease in catch per hour these last two years as reported by some fishermen. As a matter of fact, there is a trend toward a steady increase in the catch per hour since 1934. Perch seem to have maintained themselves very well along with the increase in smelt taken. No other species, aside from the perch and smelt, have been of any significance in the total catch. The records, however, were taken for the greatest part during the winter and this probably explains the complete absence of smallmouth bass from these records.

Summary of Creel Census on Crystal Lake for the Past Twelve Years

Year	No. of fishermen	No. of hours fished	No. of legal-sized fish caught	Catch per hour	Catch per fisherman	Ave. no. of hours per fisherman-day
1928	2	11.00	133	12.1	66.5	5.5
1929	6	14.00	5	0.4	0.8	2.3
1930	53	83.50	118	1.4	2.2	1.6
1931	330	1,610.50	2,603	1.6	7.9	4.9
1932	1	0.50	12	24.0	12.0	0.5
1933	6	19.00	670	35.3	111.7	3.2
1934	93	176.50	2,003	11.3	21.5	1.9
1935	67	245.00	714	2.9	10.7	3.7
1936	36	96.00	306	3.2	8.5	2.7
1937	147	683.00	2,126	3.1	14.5	4.6
1938	461	1,755.50	6,492	3.7	14.1	3.8
1939	179	502.50	3,277	6.5	18.3	2.8
Total or Ave.	1,381	5,197.00	18,459	3.6	13.4	3.8

Year	Number of each species for each year							
	Yellow perch	Smelt	Crappie	Bullhead	Bluegill	Sucker	Whitefish	Redhorse
1928	13	120	..	..	..	..	..	..
1929	3	...	..	..	2	..	..	..
1930	105	...	..	13	..	..	..	..
1931	1,250	1,347	..	5	..	..	..	1
1932	.12	...	..	..	..	..	..	..
1933	20	650	..	..	..	..	..	..
1934	287	1,709	..	7	..	..	..	..
1935	231	483	..	..	..	..	..	..
1936	...	306	..	..	..	..	..	..
1937	352	1,709	65	..	..	..	..	..
1938	726	5,755	..	..	..	10	1	..
1939	239	3,031	..	..	..	6	1	..
Total	3,238	15,110	65	25	2	16	2	1

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As can be noted from the above table, the stocking for the past six years included 210,000 perch, 4,500 lake trout, 5,600 smallmouth bass and 30,200 bluegills.

A study of the growth rate of the game species captured during the survey is summarized in the following table.

Age Determinations on Crystal Lake Game Fish*

Species	Age group	No. of specimens	Average total length (inches)	Average weight (ounces)
Yellow perch	I	16	2.9	0.1
	II	5	5.2	0.8
	III	2	5.8	0.9
	IV	23	7.6	2.9
	V	20	8.1	3.5
	VI	24	8.8	4.8
	VII	5	10.0	7.3
	VIII	7	10.9	11.1
	IX	1	13.5	18.4
Northern pike	X	1	37.2	223.0
Smallmouth bass	III	3	11.7	13.3
	VII	1	18.9	68.5
Rock bass	III	1	5.2	1.5
	IV	1	6.4	2.9
	V	1	8.7	8.0
	VI	2	9.0	10.2
	VII	1	10.5	16.4
Bluegill	II	1	2.3	0.1
Lake trout	VIII	1	33.2	316.0
Whitefish	VI	1	18.4	34.0
	VIII	1	19.5	50.5
	X	1	20.3	42.0
Smelt	I	12	5.0	0.5
	II	14	6.8	1.2
	III	5	8.2	2.0

*Age determinations were made by W. C. Beckman.

Perch reach their legal length late in their third summer or early in their fourth summer. Fish of this species 8-10 inches in total length, ranged from 6 to 9 years of age. One 13.5 inch perch was 9 years old. Only one northern pike was taken. It had a total length of 37.2 inches and was 10 years old. Smallmouth bass reached legal length in their fourth summer and rock bass in their fifth summer. The only bluegill taken was in its third summer and had only reached 2.3 inches total length. A large lake trout, 33.2 inches in total length, was 8 years old. Smelt made very good growth, having attained an average of 6.8 inches total length early in their third year of life.

On the whole, the growth rate of the game fish taken from Crystal Lake was fair, especially for the cold water species: smelt, whitefish and lake trout. Smallmouth bass had made about average growth for the larger lakes of the region, while perch and rock bass, and the one bluegill were below the average.

Crystal Lake has a great expanse of spawning ground for all species of fish requiring sand, gravel and rubble shoals. These areas should be ideal for lake trout, smallmouth bass and to a limited degree for smelt and perch. In addition, smelt spawn in Cold Creek, and this would most surely be entirely adequate for smelt if dipping of the spawning fish were prohibited.

Perch have proven their ability to spawn in the lake in spite of the dearth of plants. There is no suitable place for northern or walleye pike to spawn. In so far as we know, these fish require weedy marsh or back waters for their spawning activities. There is no evidence that lake trout spawn, although conditions seem to be favorable for natural reproduction of this species. It may be that the lake trout has not been sufficiently established

and abundant enough to be observed.

While bluegills and sunfish should find plenty of suitable areas for spawning, relatively low temperatures, the complete lack of plant cover and the scarcity of food preferred by this species, make conditions in Crystal Lake very unsuited to these fish. Rock bass have found conditions suitable here for their growth and reproduction.

Management Suggestions

Crystal Lake is in the "all other lakes" classification at the present time. This means that the lake is open to fishing from June 25 to March 31, presumably giving protection to the spawning perch and smallmouth bass. According to general reports and the findings of the survey party, the spawning of these species usually carries over after June 25 or the opening of the fishing season. This is likely to occur in lakes with such low temperatures. In view of the great number of small (1-2 year old) perch, there is some doubt whether this species needs any protection. As much cannot be said for the smallmouth bass, however, which never have been very abundant in this lake. A change of designation to the pike lake classification would open the season 6 weeks earlier and close it one month earlier. This would give practically no protection to spawning perch, but would leave the bass season unchanged. The closing of this lake one month earlier in the late winter would give protection to the smelt spawning in the lake, and this would probably be a desirable change in view of the reported smelt decrease. Cold Creek should definitely be closed to the dipping of smelt, at least for two or three years. It should be understood, however, that Crystal Lake is not a good pike lake. As already pointed out, there is no suitable place for

the northern pike, and probably the walleye, to spawn. Cold lakes of this type have invariably proven their inability to carry these fish. The reason for a change to a pike lake is simply that of changing the open and closed season, and not for the stocking or encouragement of pike. It is believed that regulations similar to those operating on Charlevoix Lake would serve this lake better than either the present designation or the pike lake classification.

Perch stocking seems entirely unnecessary in this lake, as already pointed out. There is little doubt but that the number of perch produced by natural propagation is more than adequate to stock the lake to the carrying capacity for this species.

Bluegills, sunfish, largemouth bass, crappie and walleye pike should not be planted in Crystal Lake. Conditions are not suitable for these species. Lake trout of a larger size (9-12 in.) should be stocked in reasonably large numbers in an effort to thoroughly establish this species. The stocking of 7-10 inch rainbow trout is also recommended. The rainbows probably will not spawn successfully in the lake, but they should thrive there and regular stocking might well be justified. It is recommended that all trout plantings be made just before the freeze-up, as bass and other large predacious species are least active then. In conclusion then, we believe that the cold waters of Crystal Lake are more suited to lake trout, rainbow trout, whitefish and smelt, than to any of the other species present or those available for stocking. Perch will always be present in fairly large numbers and their reduction might aid in faster growth and a larger average size. Smallmouth bass will probably always maintain themselves in small numbers and the rock bass will most surely be present regardless of seasons or stocking policy.

No serious cases of predator damage or parasite infestation were observed and no control measures are recommended.

The almost complete absence of cover has already been pointed out. The great expanse of sandy barren shoal on this lake offers almost unlimited opportunity for shelter improvement. Brush shelters scattered along the entire shoal in water from 6-25 feet in depth would undoubtedly be very valuable for the protection of young game fish and the natural increase of forage fishes. Some structures designed to break the violent wave action might lead to the development of limited plant beds and thus increase the food and shelter accordingly.

There is very little fluctuation of the water level in Crystal Lake because of the presence of a dam at the outlet (described above). The present level is fixed by **court act** and so there is no concern regarding this point. Stability of lake levels is of great importance to the establishment of plants and food organisms, as well as to the spawning activities of many fish.

INSTITUTE FOR FISHERIES RESEARCH

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