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C. M. Taube

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

GERALD R. COOPER PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

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FISHERY INVESTIGATIONS AND MANAGEMENT PRACTICES ON WOLF LAKE, LAKE COUNTY, 1950-60[1]

By Clarence M. Taube

The Institute for Fisheries Research conducted various investigations on Wolf Lake from 1950 through 1960. A biological inventory was made in 1950. From 1951 through 1960, designated areas along the shore were seined annually in late summer to evaluate fish reproduction. Other collecting was done at various times with gill nets and trap nets, and samples of these collections were analyzed for information on age and growth. Some creel census data were obtained. Management practices during 1950-60 consisted of provision of shelters for fish, experimental stocking of bluegills, and an experimental closed season on bluegills.

This report describes the investigational and management work, and summarizes the results.

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[1] Beginning in 1952, financed largely with Federal Aid to Fish Restoration funds under Dingell-Johnson Project No. F-2-R.

Wolf Lake is located in township sections 26, 27, 34, and 35, Town 19 North, Range 13 West, Lake County. It lies about 7 miles north of Baldwin.

It is said that when lumbering was a major industry in this region the lake was used for the storage of logs and that a sawmill was situated on the southwest shore. Some deadheads still lie on the bottom. Presently the lake is a popular site for homes and recreation. Commercial developments include several resorts, a house trailer camp, and a boat livery combined with a fishing bait and tackle store. Several parcels of land that were reserved for general use when the frontage was platted many years ago provide means of public access. An undeveloped state-owned fishing site is located on the north shore.

Physical characteristics

Wolf Lake doubtless is of glacial origin. It is situated at the base of the gradual north slope of a high moraine. Part of the basin lies within a ground moraine, and a smaller part within an outwash or glacial channel.[2] The surrounding land is sandy, and a major share of it is forested, mainly by oaks.

When Wolf Lake was mapped, its surface area was 418 acres, and the maximum depth was 13 feet (Fig. 1). Only 8 percent (35 acres) of the basin was deeper than 10 feet. As the lake has neither an inlet

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[2] Information from "Map of the Surface Formations of the Southern Peninsula of Michigan," Geological Survey Division, Michigan Department of Conservation, 1955.

Figure 1.--Map of Wolf Lake.

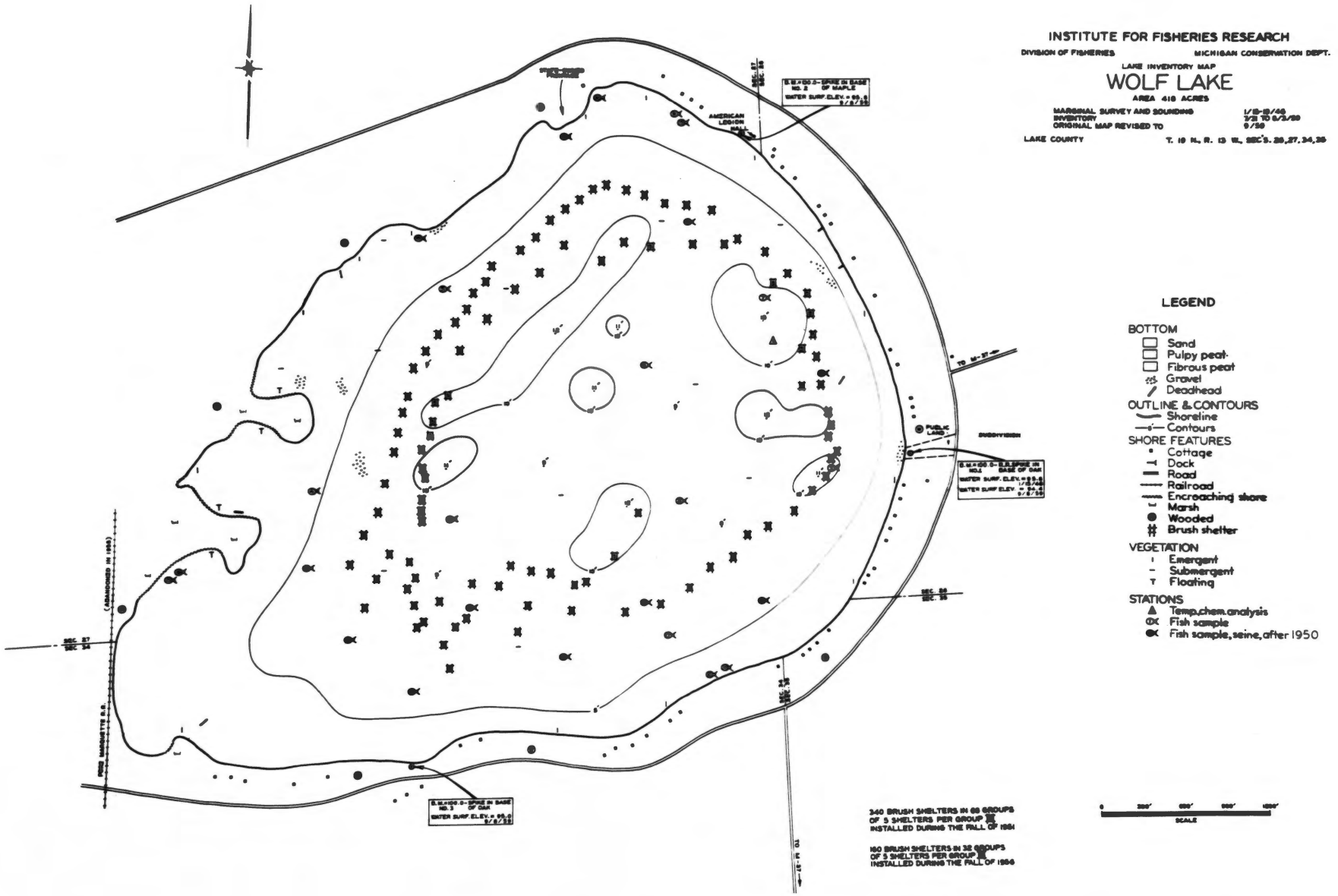
INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN CONSERVATION DEPT.
LAKE INVENTORY MAP
WOLF LAKE
AREA 418 ACRES
MARGINAL SURVEY AND SOUNDING
INVENTORY
ORIGINAL MAP REVISED TO
LAKE COUNTY
T. 19 N., R. 13 W., SEC'S. 28,27,34,35
LEGEND
BOTTOM
Sand
Pulpy peat
Fibrous peat
Gravel
Deadhead
OUTLINE & CONTOURS
Shoreline
Contours
SHORE FEATURES
Cottage
Dock
Road
Railroad
Encroaching shore
Marsh
Wooded
Brush shelter
VEGETATION
Emergent
Submergent
Floating
STATIONS
Temp.chem.analysis
Fish sample
Fish sample, seine, after 1950
340 BRUSH SHELTERS IN 68 GROUPS OF 5 SHELTERS PER GROUP INSTALLED DURING THE FALL OF 1951
100 BRUSH SHELTERS IN 32 GROUPS OF 5 SHELTERS PER GROUP INSTALLED DURING THE FALL OF 1954
SCALE

Figure 1

stream nor an outlet, presumably most of its water is supplied by seepage. The water level is fairly stable. Although recession in dry summers seems pronounced, the very gradual declivity of the basin causes reductions in level to appear greater than they actually are. Recent determinations are recorded in Table 1; except in 1946, only summer levels were determined. It seems rather unusual that the water level of this landlocked, shallow lake, which is located in a sandy area and apparently lacks springs, has been so constant. A theory on the situation is proposed under "Thermal and chemical characteristics."

The water is colorless and quite clear. When the lake was inventoried in 1950, the Secchi disk was visible all the way to the bottom at a depth of 11 feet.

The predominant bottom soil from the shoreline to the 5-foot contour is sand, and in a few places a small amount of gravel is mixed with the sand. Soft organic materials compose the uppermost deposit where depths exceed 5 feet, and also in some shallower locations.

Thermal and chemical characteristics

Wolf Lake does not stratify in the summer because its basin is shallow and large. Temperatures in this season are mostly in the 70's from surface to bottom. The dispersal of dissolved oxygen is also quite uniform. Fish in many Michigan lakes as shallow as Wolf are subject to winterkill from oxygen depletion, but mortality from this cause has never been reported for this water.

Table 1.--Water level data from Wolf Lake

Date	Lake surface elevation index*	Difference in elevation (feet) from elevation of 1-15-46
January 15, 1946	95.8	-
September 6, 1956	94.7	-1.1
September 12, 1957	94.3	-1.5
July 6, 1958	94.5	-1.3
September 3, 1958	93.8	-2.0
June 21, 1959	95.4	-0.4
September 8, 1959	94.4	-1.4
July 4, 1960	95.3	-0.5
September 15, 1960	95.1	-0.7

* The indices apply to Bench Mark No. 1, from which all determinations except those of 1960 were made. The elevations in 1960 were determined from B.M. No. 3, and were converted to B.M. No. 1 indices by calculation.

An interesting characteristic of Wolf Lake is the extreme softness of its water. This characteristic is noteworthy because Wolf Lake is not a bog lake and adjacent waters are fairly hard. The methyl orange alkalinity has varied between 2 and 4 parts per million of calcium carbonate, the lowest values that have been found in any water of Lake County. The alkalinities of 49 lakes that have been tested in this county were as follows: over 90 ppm, 29 lakes; 60-90 ppm, 7 lakes; 20-60 ppm, 3 lakes; 10-20 ppm, 3 lakes; less than 10 ppm, 7 lakes. At least several wells situated near Wolf Lake contain hard water. The methyl orange alkalinity of a sample from a 26-foot well on the west shore owned by Elmer Nill was 131 ppm; the 47-foot Thomas Buzzo well on the north shore tested 84 ppm; and the 140-foot Arnold McKey well, also on this shore, tested 110 ppm. The situation here is very similar to that of Weber Lake, Cheboygan County, where the lake water is rather soft and nearby ground water is hard.[3]

The writer once observed an excavation dug for a plumbing installation near the lake which exposed a very hard, thick layer of reddish sand several feet below the surface of the ground. Conceivably a stratum of this material, which likely resists the percolation of water, underlies the basin of Wolf Lake. Possibly this layer of sand functions as a seal between the soft water of the lake and the hard ground water

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[3] "Limnological Features of Weber Lake, Cheboygan County, Michigan," by Frank F. Hooper. Papers of the Michigan Academy of Science, Arts, and Letters, Vol. XXXIX, pp. 229-240, 1954.

beneath. This reasoning leads further to the conjecture that the water of the lake is derived from surface and near-surface sources where the soil contains little calcium. Such seal could also minimize loss of water from the lake by seepage.

Biological characteristics

Vegetation

The principal aquatic vegetation of Wolf Lake is a filamentous alga (possibly more than one species) which is abundant on and near the bottom. Rooted vegetation is scarce. Pipewort (Eriocaulon), frequently represented in the flora of soft waters, is the main rooted plant. Spike rushes grow at some locations along the shoreline, and there are a few water lilies off the west shore. Such weed beds as are associated with good fishing areas on many lakes are absent here. The softness of the water, a large amount of sand bottom, and high exposure of the lake to winds all doubtless bear some responsibility for the scarcity of rooted vegetation.

Fish-food organisms

Little information was obtained on fish foods in Wolf Lake. General observations indicate that the insect and plankton populations are small. Caddis flies, midges, and dragonflies are components of the bottom fauna, but apparently none of these insects or others are plentiful. I have never seen a plankton pulse here, nor has any of

the local people ever mentioned to me having seen a condition that would suggest a marked upsurge of plankton abundance.

Stomachs of 23 bluegills and 29 perch collected one summer were examined in detail. Those of the bluegills contained a few insects and a considerable amount of unidentified material of a consistency which suggested that it may have been filamentous algae. The perch had eaten insects, cladocerans, small fish, and crayfish; crayfish appeared most frequently and in the greatest volume. Crayfish are quite plentiful in Wolf Lake, and evidently are an important fish food here. Gross examination of stomachs revealed that perch and largemouth bass fed extensively on them.

Samples of Wolf Lake crayfish were identified as Cambarus diogenes diogenes.[4] This is a burrowing species, and opinion has generally been that it lives in lakes or streams but temporarily, particularly during the breeding period in the spring. The specimens that were identified were collected from the lake in September.

The filamentous algae probably also have an important position in the biological economy of the lake. They likely are the main food of the crayfish, and may also be consumed by fish.

The fish population in general

Yellow perch, bluegills, and largemouth bass predominate in Wolf Lake, During 1950-60, perch were plentiful and attained large

[4] Identified by Mr. Walter Momot; identification verified by Dr. Horton H. Hobbs, Jr., U. S. National Museum.

size, but as a rule, anglers caught good sized perch only in the wintertime. Though variable in abundance, bluegills rated second to perch in numbers and have grown fast. Reproduction of largemouth bass is good, but the population of harvestable bass has apparently been small. Recently bullheads from an unknown source have become established in the lake. They may eventually comprise a significant share of the total fish population. Anglers first reported catching bullheads in 1959, including several large ones. Three yellow bullheads (Ictalurus natalis) were collected with gill net and seine that year; one each of the yellow and brown (Ictalurus nebulosus) species were caught with a seine in 1960.

Other sport fish are scarce. Of these, pumpkinseeds have appeared in anglers' catches and our collections most often. A few northern pike have been caught with hook and line, and five were netted. Green sunfish, rock bass, and bluegill x pumpkinseed hybrids were collected occasionally.

The mudminnow (Umbra limi) is the only other fish known to be established here. The lake has no population of true minnows (Cyprinidae). Lone specimens of this group that have been occasionally seined (creek chub, common shiner, and fathead minnow) probably came from anglers' bait supplies.

Yellow perch

Gill-netting has afforded some evaluation of the perch population. Comparable netting effort at 3-year intervals (in 1950, 1953, 1956, and

1959) has given an insight into abundance, size, and growth rates. The aim in this collecting was to duplicate net dimensions, set locations, effort, and season of collecting as closely as possible. Catches taken by seven gill nets, each 125 feet long and 6 feet deep, were compared; mesh sizes by bar measure were 1 1/4 inches in one net, 1 1/2 inches in two nets, and four nets were of the experimental kind—each composed of one 25-foot section each of 3/4-, 1-, 1 1/4-, 1 1/2-, and 2-inch mesh. The netting locations were distributed broadly, nets of like-size mesh were set in the same general locations in the various years, and fished from the afternoon of one day until the following morning. The collecting was done either in August or early September.

The numbers of perch obtained from the seven sets in 1950, 1953, 1956, and 1959 were 58, 64, 50, and 29, respectively. Mean total lengths of these fish in the respective years were 9.2, 8.5, 9.0, and 10.1 inches; the numbers and percentages of perch that were at least 10 inches long were 26 (45 percent), 16 (26 percent), 21 (42 percent), and 17 (61 percent).

Growth rates of the perch in these collections were compared by a growth index.[5] Because the number of perch caught with the nets

[5] A number used to evaluate growth rates of fish in a given body of water. It is derived by determining the deviation between the average length of a sample (at least 5 specimens) of fish from each age class and the state-average length, adding these values, and dividing their sum by the number of age classes involved. Negative and positive results respectively indicate below- and above-average growth, except that the growth rate of small species (such as bluegills and perch) whose index falls within the range of -0.5 to +0.5 is regarded as average, as is that of large species (bass, pike, etc.) within the limits of -1.0 to +1.0. [Methods Memo No. 8, Institute for Fisheries Research, "Methods in Fish Growth Analysis," by W. C. Beckman, 1950.]

in 1959 was insufficient for reliable assessment of growth, 30 caught with hook and line at the time of this netting have been included for derivation of the index for that year. The indices for 1950, 1953, 1956, and 1959 were +1.0, +1.9, +1.1, and +1.6, respectively.[6] The indices show that growth of perch in Wolf Lake has been excellent. The approximate average lengths by age classes were: age-group II — 6.5 inches; III — 7.0; IV — 9.5; V — 11.5; VI — 12.0. Perch as old as 9 years were netted occasionally, but most of the harvestable fish have been of age groups II through VI.

Indications are that the perch population of Wolf Lake was quite stable from 1950 to 1959, although fish of nettable size (6 inches and larger) may have been less abundant in 1959 than in the preceding years of collecting.

Largemouth bass

Although the largemouth bass is well represented in Wolf Lake, its contribution to the fishery is minor. Reproduction apparently is good, but the rate of survival beyond fingerling size is low. Each year, goodly numbers of young-of-year largemouths were captured with seines (see Table 2). Many others were observed in the open lake. However, few bass of legal size are caught. Presumably an extensive loss occurs within a year following the hatch, as indications are that small bass other than young-of-year also are scarce. The reason for

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[6] Based on averages presented in Fish Division Pamphlet No. 26, "Age and Growth of Fish in Michigan," by W. C. Latta, 1958.

Table 2.--Catch of largemouth bass, perch, and bluegills at seining stations, 1951-1960*

Station and species	Year								
	1951**	1953	1954	1955	1956	1957	1958	1959	1960
	Sept. 18-19	Sept. 1 &4	Sept. 1-2	Aug. 30-31, Sept. 1	Sept. 7-8	Sept. 11	Sept. 3	Sept. 8	Sept. 15
Station #1									
Largemouth bass	40	48	140	12	46	10	30	38	44
Perch	3	0	7	0	12	0	1	0	5
Station #2									
Largemouth bass	8	46	163	11	47	6	2	11	16
Perch	0	0	1	0	25	0	0	0	0
Bluegills	0	0	3	0	16	1	0	0	1
Station #3									
Largemouth bass	10	32	37	2	79	20	5	16	47
Perch	1	1	0	0	0	0	0	0	2
Station #4									
Largemouth bass	31	66	166	113	171	11	8	3	10
Perch	117	10	7	2	11	0	1	1	2
Bluegills	0	0	0	0	0	0	0	0	1
Station #5									
Largemouth bass	3	12	0	8	1	0	2	0	11
Perch	49	2	0	3	8	0	0	0	50
Station #6									
Largemouth bass	77	72	67	83	15	66	15	78	20
Perch	145	0	10	29	24	4	0	3	0
Bluegills	0	0	1	1	0	0	0	0	0
Totals									
Largemouth bass	169	276	573	229	359	113	62	146	148
Perch	315	13	25	34	80	4	2	4	59
Bluegills	0	0	4	1	16	1	0	0	2

* A 20-foot common sense seine was used at stations 1, 2, and 3, and a 30-foot bag seine (1/4-inch mesh in the bag and 1/2-inch in the wings) at stations 4, 5, and 6, except that a 50-foot bag seine was used at the three latter stations in 1951. The stations were defined by boundaries, and a total of about 425 yards of shoreline within them were seined annually. The collecting procedures (number and direction of seine hauls, time spent collecting, etc.) were duplicated as closely as possible from year to year. The fish were mostly young-of-year; some perch and a very few bass were yearlings.

** No seining was done in 1952.

the scarcity is unknown, but extensive predation by perch on young bass during the winter is a possibility.

Information on the growth of bass in Wolf Lake is limited because few sizable fish have been collected, but what data are available suggest that the growth rate beyond the fingerling stage is above average. For example, the mean length of 8.6 inches for eight yearlings obtained in 1953 exceeded the state-average length by 2.5 inches. Young-of-year largemouth bass, in a large sample collected in seines over a period of years, had an average length of 2.9 inches (range, 1.9-4.2) near the end of summer.

Bluegills

People who fish Wolf Lake during the open-water season seek bluegills mostly. As there has been considerable local interest in improving the fishing for bluegills, several practices intended to increase their numbers have been tried since 1950. An account of these efforts follows under the section "Management practices." Predation by perch has been suspected as an important factor in limiting abundance of bluegills in Wolf Lake.

Collecting, creel census, and age and growth analysis provided information on the bluegill population. Angling provided most of the samples. Netting was not so productive. Here, as they usually are elsewhere, gill nets were inefficient in capturing bluegills. Seining near shore generally is effective in capturing

young bluegills, but at Wolf Lake very few of them were caught by this method. Trap nets were the most productive netting equipment used, but they also were ineffective at times. The catch of bluegills by trap nets amounted to 31 with 9 sets in 1953, 4 with 2 sets in 1955, and 124 with 9 sets in 1956.

Mr. Thomas Buzzo, who resides at Wolf Lake, was responsible for partial creel censuses taken in the summers of 1954, 1955, and 1956. Mr. Buzzo and other persons about the lake collected the data, and Mr. K. G. Fukano, of the Institute for Fisheries Research, tabulated them. The results appear in Table 3. The author also took censuses, on one to three successive days shortly after the bluegill fishing season opened in 1956, 1958, 1959, and 1960, and on three successive days in September 1959.

As the census data are inadequate for good statistical analysis, no definite conclusions can be made. Absence of comparable records from other lakes in the vicinity also complicates interpretation. The data are presented mainly as a matter of record, and some general comments are included.

The catch of all species per hour of fishing effort shown by Mr. Buzzo's censuses was 1.89 in 1954, 2.76 in 1955, and 2.05 in 1956; the figures for bluegills alone in the respective years were 0.13, 0.14, and 0.22. From my brief censuses, the catches per hour for "all fish" and for bluegills alone were respectively: July 1, 1956—4.60 and 1.60;

Table 3.--Results of partial creel censuses conducted by Thomas Buzzo on Wolf Lake in 1954, 1955, and 1956

Year and month	Number of anglers	Hours fished	Number of fish	Catch per hour	Species				
					Largemouth bass	Bluegills*	Pumpkinseeds	Yellow perch	Northern pike
1954									
June	65	112.00	268	2.39	-	20	-	248	-
July	108	195.75	310	1.58	-	24	2	284	-
August	120	240.50	414	1.72	1	25	-	388	-
September	15	24.50	91	3.71	1	4	-	86	-
Total or average	308	572.75	1,083	1.89	2	73	2	1,006	-
1955									
June	85	158.00	492	3.11	7	38	1	446	-
July	286	491.25	1,568	3.19	9	60	-	1,498	1
August	117	201.75	301	1.49	2	24	-	275	-
September	39	71.00	180	2.54	-	8	-	172	-
Total or average	527	922.00	2,541	2.76	18	130	1	2,391	1
1956									
June	16	32.50	30	0.92	4	1	-	25	-
July	259	412.00	965	2.34	2	126	1	836	-
August	130	238.00	415	1.74	4	25	-	386	--
September	5	8.50	4	0.47	-	-	-	4	-
Total or average	410	691.00	1,414	2.05	10	152	1	1,251	-

* Fin-clipped bluegills recorded in the catches amounted to 15 in 1954, 44 in 1955, and 1 in 1956.

July 4, 5, and 6, 1958—2.45 and 0.68; June 20 and 21, 1959—2.19 and 0.71; July 2, 3, and 4, 1960—1.58 and 0.17; September 5, 6, and 7, 1959 —3.45 and 0.22.

A comparison of restricted value can be drawn between the catch indices from Wolf Lake and those from the general creel census in the same years on non-trout lakes in Fisheries District 8 (where Wolf Lake is located) and in Region II (the northern portion of the Lower Peninsula). It should be noted that the general census included winter fishing. The figures on catch of fish per hour in District 8 and Region II, respectively, shown by the general creel census, and in Wolf Lake by Mr. Buzzo's census (in parentheses) were: 1954—1.7 and 1.1 (1.89); 1955—1.9 and 1.3 (2.76); 1956—1.8 and 1.1 (2.05).

In summary, these indices indicate that fishing success at Wolf Lake exceeded the average rate of success on other non-trout lakes in the northern part of the state, although it should be noted that the samples were not exactly comparable. Most of the fish caught at Wolf Lake were perch. Fishing for bluegills here apparently was somewhat better in 1956 than in the two preceding seasons.

The growth rate of bluegills in Wolf Lake has been above state average. Samples collected from 1953 through 1960 show the average lengths to have been approximately 6.0 inches for age-group II's, 6.5 inches for III's, 7.5 inches for IV's, and 9.0 inches for V's. The growth index was +1.3. Although bluegills as old as 10 years were collected, few were over 5 years of age. The catch consisted mostly of 2-, 3-, and 4-year-olds.

Slow-growing bluegills obtained from other lakes grew fast after they were planted in Wolf Lake. For instance, samples of age-group III bluegills from Long and Sand lakes, Newaygo County, (from which transfers were made in October 1957) averaged 4.2 inches and 4.7 inches, respectively; the state-average length of III's is 5.5 inches. The growth of these fish increased especially during the first year of residence in Wolf Lake. The average growth increment in 1958 of recaptured bluegills that had been in age-group III when planted during October 1957 amounted to 35 percent of the average calculated total length by the end of 1958; for fish of age-group II, the corresponding figure was 39 percent. The average 1958 increment of bluegills native to Wolf Lake that were of the same year class (1955) as the II's planted in 1957 amounted to 23 percent of total length attained through 1958. The slower early growth of the planted fish largely accounted for the difference in ratios, as comparison of increment measurements showed that the 1958 increments of introduced and "native" bluegills were about equal.

The accelerated growth of introduced bluegills that had grown slowly in other lakes is illustrated by Figures 2-6.

Figure 2.--Scale of an 8.4-inch, age-group IV bluegill of Wolf Lake stock. The fish was caught on June 20, 1959. Compare the growth pattern shown on this scale with the patterns of the scales in the figures which follow.

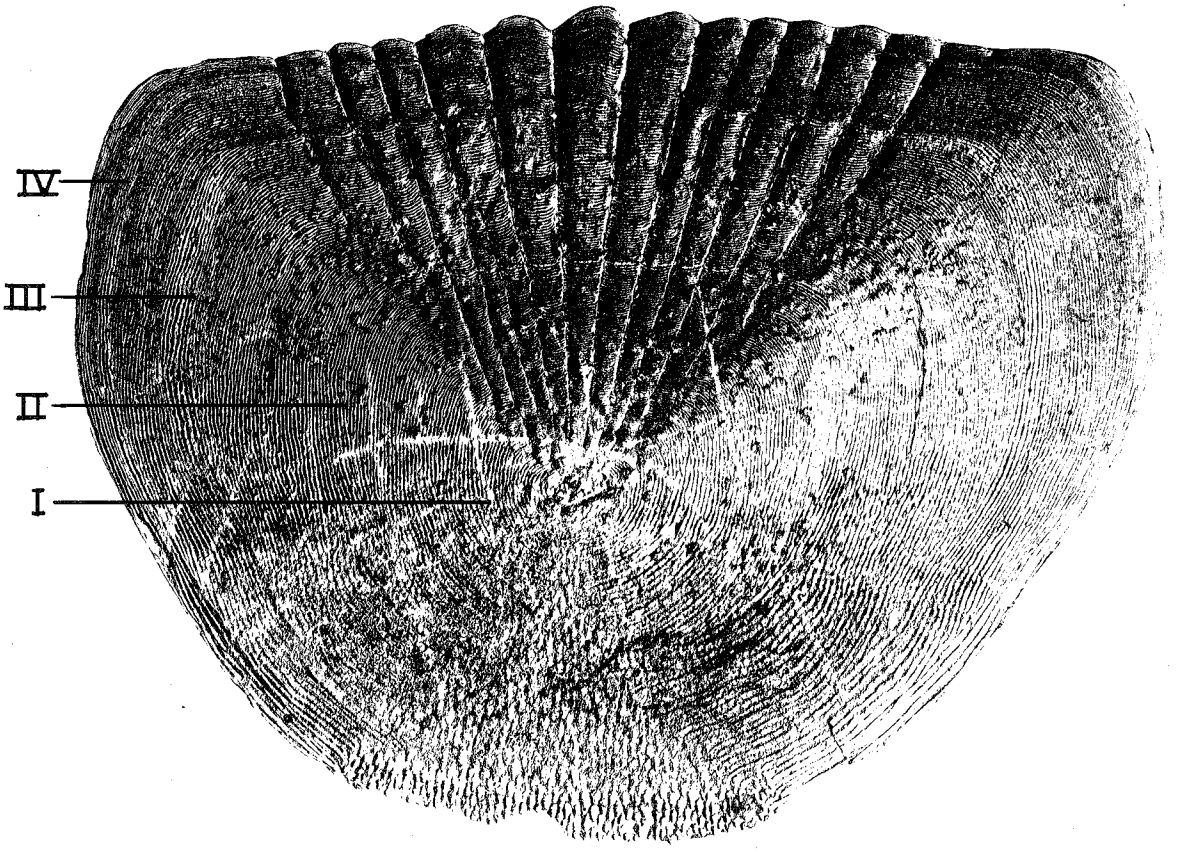


Figure 2

Figure 3.--Scale of an 8.9-inch, age-group VII bluegill. This fish came from Big Star Lake, was planted in Wolf Lake in October 1953, and was recaptured on September 7, 1956. Note the relatively slow early growth and the fast growth in the sixth year (1954).

Figure 3

Figure 4.--Scale of an 8.6-inch, age-group VI bluegill. This hatchery-reared fish was planted in Wolf Lake in October 1954, and was recaptured on September 6, 1956. Note the slow intermediate growth, followed by improved growth in the sixth year (1955).

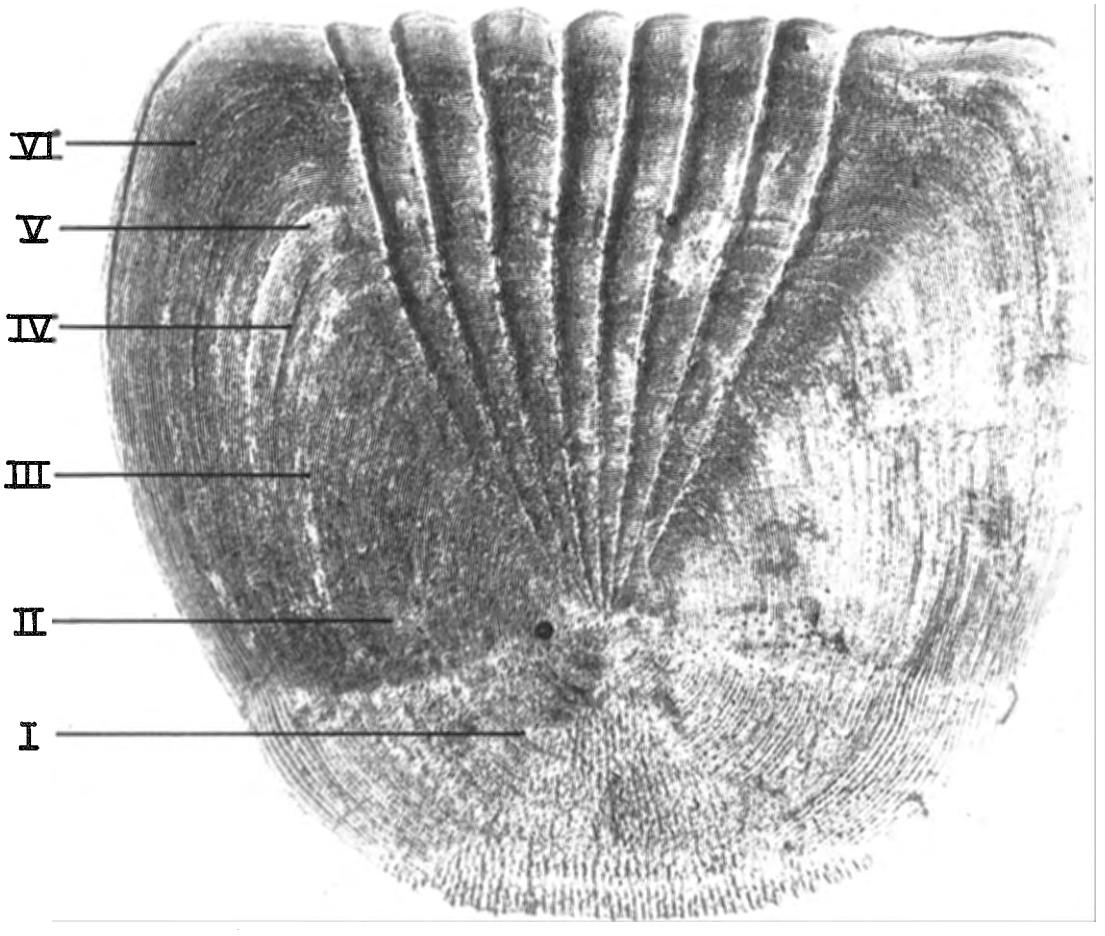
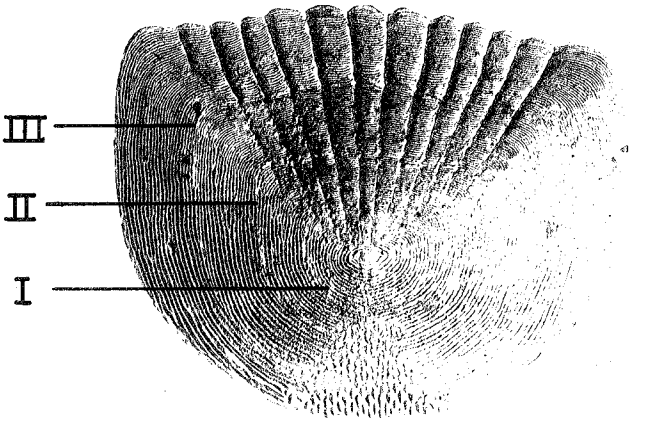


Figure 4

Figure 5.--Top: Scale of a 4.8-inch, age-group III bluegill seined from Sand Lake, Newaygo County, on September 23, 1957.

Bottom: Scale of a 4.3-inch, age-group III bluegill seined from Long Lake, Newaygo County, on September 25, 1957.



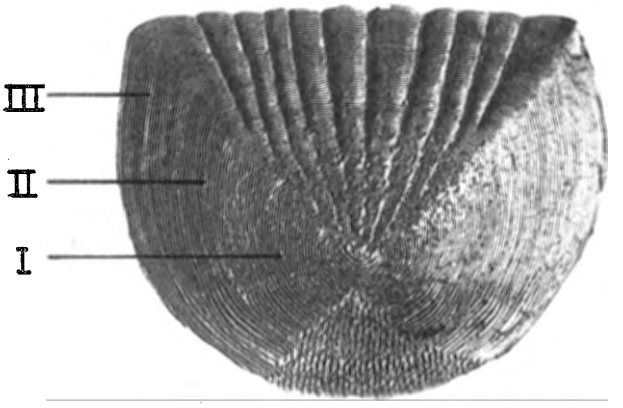


Figure 5

Figure 6.--Scale of a 6.5-inch, age-group V bluegill captured in Wolf Lake on June 20, 1959. This fish was judged as having originated either in Long Lake or Sand Lake; plantings from these sources were made in Wolf Lake in October 1957. Note the large amount of growth in the fifth year (1958), which approximately equaled the combined increments of the preceding three years.

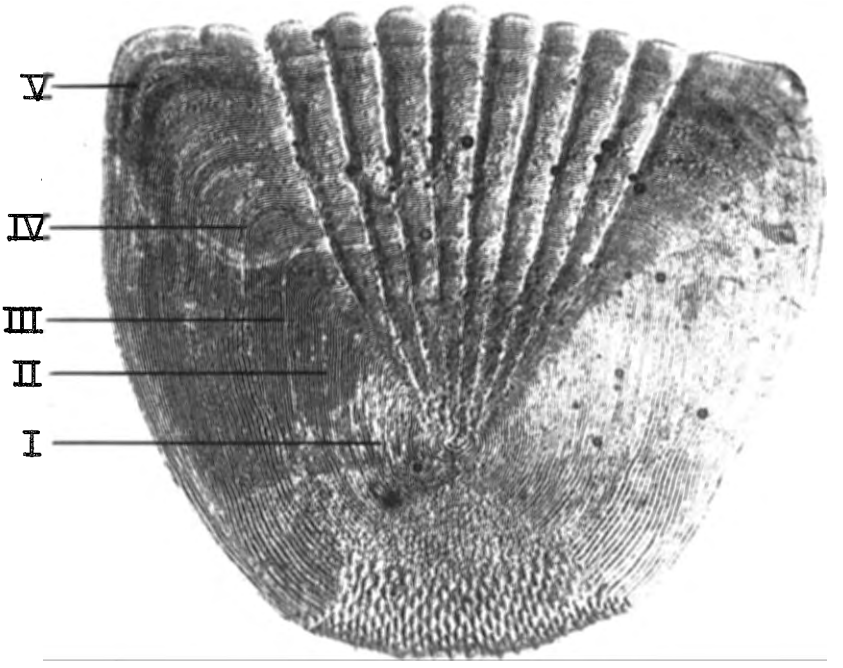


Figure 6

Management practices

Recent fishery management practices employed on Wolf Lake have been installation of brush shelters, stocking of bluegills, and closed seasons on bluegill fishing.

Brush shelters

The Lake and Stream Improvement section of the Fish Division placed 340 brush shelters in Wolf Lake in 1951, and 160 in 1956; the locations of these structures are shown in Figure 1. Local people have added brush from time to time. Brush shelters installed in the late 1930's or early 1940's, presumably by the Civilian Conservation Corps, had almost completely deteriorated by 1950.

It was hoped that the new brush shelters would improve angling by reducing loss from predation and concentrating fish of "keeper" size. Apparently they accomplished little, if anything, to increase the numbers of fish in Wolf Lake. Personal observations and reports by anglers indicated that the structures did attract bluegills and thereby provided good fishing areas for them, so one objective was at least partially attained.

Stocking of bluegills

The stocking record for Wolf Lake from 1933 through 1944 appears in Table 4. No routine planting has been done here sinee 1944, when general stocking of warm-water fish was being discontinued in Michigan.

Table 4.--Fish planted in Wolf Lake, 1933-1944*

Year	Species				
	Yellow perch	Walleye	Largemouth bass	Smallmouth bass	Bluegill
1933	5,000(6)	240,000(f)	-	-	-
1934	6,000(7)		245(4)	1,000(4)	18,000(5)
1935	3,000(7)		-	-	4,500(5)
1936	-		3,500(yr)	-	4,500(6)
1937	-		1,000(5)	-	12,000(5)
1938	3,000(6)		2,000(4)	1,235(4)	10,000(3) 12,000(5)
1939	7,000(7)		2,000(3) 1,425(1-5)	4,500(4)	10,000(3)
1940			600(4) 1,250(3)	1,500(4) 25(5")	7,000(3) 20,000(4)
1941			500(3)	1,000(5)	5,000(3)
1942			300(4)	800(3)	5,779(4)
1943			-	910(4)	-
1944			-	930(4)	-
Totals	24,000	240,000	12,820	11,900	108,779

* Codes for age and size designations: (6) = age in months; (5") = length in inches; (f) = fingerlings; (yr) = yearlings.

The bluegill population in Wolf Lake had apparently declined in the early 1950's, so an experimental planting of 2,500 bluegills seined from Big Star Lake, Lake County, was made in September and October 1953 to bolster the breeding stock. Actually, 2,900 were planted, but an estimated 400 died from handling. About 75 percent of these fish were yearlings, 20 percent were young-of-year, and 5 percent were 2 or more years old. The dorsal fin was clipped to allow recognition of subsequent recoveries.

The following September, 4,000 bluegills from the Hastings Hatchery were planted as a further addition to the breeding stock. The mean length of these fish was 6.0 inches (range 3.9-6.9), and they had been marked by removal of the right pectoral fin.

In September 1956, adult and sub-adult slow-growing bluegills (735) were transferred to Wolf Lake from Seaman Lake, Lake County. The anal fin was removed.

Three plantings of stunted bluegills were made in 1957. These fish consisted of 346 from Seaman Lake stocked in June (left pectoral fin clipped), and 30,086 and 16,575, respectively from Sand and Long (Bitely) lakes, Newaygo County, stocked in October. The bluegills of the latter two introductions were not marked. The mean length of the fish in each of the three lots was around 4 inches. No loss was observed among the bluegills from Seaman and Long lakes, but the planting crew estimated that about one-third of those from Sand Lake died shortly after transfer to Wolf Lake.

A point of some interest is the extent to which planted fish were recovered; the record is presented in Table 5. The marked bluegills reported caught in 1954 obviously were from the planting of 1953. Because the location of clipped fins was not designated on the creel census forms, the specific origin is unknown for any of the 48 marked bluegills recorded in the censuses of 1955 and 1956. Of two angler-caught and one netted fin-clipped fish I observed in 1956, one was from the 1953 transfer and two from the 1954 planting. All of the bluegills recorded in Table 5 as caught after 1956 were judged to have been originally from either Long Lake or Sand Lake on the basis of the growth patterns of their scales. (See Figs. 5-6.) Of 906 bluegills examined from 1954 through 1960, 80 (about 9 percent) were determined as having been planted.

Although the extent of direct return from the introductions is of some interest, a matter of greater importance is whether reproduction by the planted fish substantially increased the bluegill population. Unfortunately, there is no adequate basis for judgment. Little more can be done than to evaluate the significance of year-class strength as determined from scale collections. A fair amount of such information is available for the period of 1952-57.

The 1952 year class of bluegills was relatively strong, whereas the one of 1953 was weak; these fish, of course, were progeny of Wolf Lake stock. As the 1954 year class was comparatively strong, offhand judgment might assign a major share of the credit to the 1953 transfer.

Table 5.--Recovery of bluegills planted in Wolf Lake from 1953 through 1957

Year	Number of bluegills examined	Number that were planted fish*
1954	73	15
1955	138	44
1956	351	4
1957	None	-
1958	66	2
1959	62	12
1960	216	3
Total	906	80

* All except three caught by anglers.

However, dominance of young, small fish in the planting casts much doubt on the hypothesis. A weak year class in 1955, when a considerable number of fish from the 1953 and 1954 plantings might have spawned, indicates that introductions may not insure good reproduction. The 1956 year class apparently was fairly strong, and that of 1957 also good, although not as strong as the one of 1956. The 1957 year class is the latest one on which we have sufficient data for evaluation.

Closed seasons on bluegill fishing

Soon after year-round fishing for bluegills became legal in Michigan in 1954, some local people asked for a closed season on Wolf Lake. They contended that protection was needed during the main spawning period, when breeding bluegills were especially vulnerable to capture. Although research has indicated that a closed season is of little or no value in many lakes, we thought one might be justified on this lake where bluegills evidently were never very abundant, and were scarce some years. An experimental season was recommended, and the Conservation Commission subsequently provided one. This Commission order, including renewals, operated from 1955-60. Except for 1955 when it commenced February 15, the closed season began on January 1; for three years it extended through the third Saturday in June (to correspond with the bass season), and through June 30 for three years. Listed below are the inclusive dates during 1950-60 when bluegills were protected in Wolf Lake; the provisions for 1950-54 applied also to other waters of the state.

1950 - April 1 to June 24
1951 - April 1 to June 24
1952 - April 1 to April 25
1953 - April 1 to April 24
1954 - No closed season
1955 - February 15 to June 17
1956 - January 1 to June 30
1957 - January 1 to June 30
1958 - January 1 to June 30
1959 - January 1 to June 19
1960 - January 1 to June 17

The special season for Wolf Lake was of little, if any, benefit because in most years little spawning took place before the start of the bluegill fishing season. In the five years that progress of spawning was observed here, little or no spawn had been deposited by the opening date in four of them (1955, 1956, 1958, and 1960). Observations which suggest that protection of mature bluegills during the spawning season may be of little significance on spawning success include: (1) production of a strong year class in Wolf Lake in 1954 when bluegills could be caught throughout the year and (2) another good year class in 1956 with the regulation in effect but when little or no spawning had been done by July 1. No information was obtained on spawning progress in 1957 when another strong year class was produced, or on reproduction in 1959 when the peak of spawning preceded the fishing season.

Observations at Wolf Lake quite definitely showed that spawning usually occurred later than had been supposed. Hence the

closed seasons provided by legislative statutes in earlier years probably very seldom protected bluegills while spawning here or in other northern lakes.

The latest Commission order on bluegills in Wolf Lake expired in 1960. That fall some local people petitioned for continuance of protection. We recommended that an experimental closed season be tried for at least three more years, but only if it were extended to July 15, to allow for the frequent occurrence of peak spawning activity after June 30. Riparians who favored renewal of the order were opposed to this late a start of the bluegill fishing season, and thought that other people associated with Wolf Lake would also object. As the special closed season usually had not attained its objective of protecting bluegills during the main spawning period, the Conservation Commission did not renew the order.

Conclusions on management practices

Of the three management practices applied to Wolf Lake, only provision of brush shelters deserves continuation. The shelters apparently are effective in concentrating fish in this lake which has extremely little natural cover. This concentration is an advantage to anglers. Those data which are available on stocking and the experimental closed season indicate that neither procedure increased the bluegill population. No new recommendation is made at this time.

An intriguing question is what would result from converting the fish population of this lake to one consisting only of largemouth bass and bluegills. Assuming that these species are preyed upon extensively by perch, would they be more plentiful and would fast growth continue in the absence of perch? Although the pure bass-bluegill combination has shown shortcomings elsewhere, may conditions here favor its success? Presently, at least, the idea is academic because a proposal to eliminate the established population would almost surely be strongly opposed by riparians.

Another view is that the existing population structure could be ideal for this lake. Intensive predation may be necessary to provide fish of desirable size, and the current fast growth rates might be sacrificed to attain greater numbers of bass and bluegills.

Would addition of nutrients to Wolf Lake improve its fishery? Fertilization sometimes increases production in ponds very effectively. Although it has been applied less to lakes than to ponds, its possibilities as a management practice for the larger bodies of water have been explored quite intensively. In this situation, certain potential dangers of fertilization should be carefully considered. First, experience has proved that use of commercial fertilizers in lakes of northern regions is very apt to foster winterkill of fish. Second, it is likely to increase vegetation to nuisance proportions; Wolf Lake might be affected through excessive growth of algae. Because the value of this water for home sites, bathing, and boating

probably far exceeds its value for fishing (even if the fishing were much improved), it appears inadvisable to attempt a practice which could adversely affect the major assets of the lake. On the other hand, the lake might well be benefited by fertilization if nutrient materials were available which lacked the undesirable features of current agricultural formulas.

INSTITUTE FOR FISHERIES RESEARCH

Clarence M. Taube

Report approved by W. R. Crowe

Typed by M. S. McClure