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FISHERIES SURVEY OF FROG, MEAUWATAKA, AND STONE LEDGE LAKES, WEXFORD COUNTY

by

John Funk

Introduction

Frog, Meauwataka, and Stone Ledge Lakes are located in the southeastern part of Wexford County. Stone Ledge is about $3\frac{1}{2}$ miles south of Cadillac on M-115. Frog, also known as Berry Lake, is about 2 miles southeast of Cadillac. Meauwataka or Dayhuff Lake, as it is sometimes called, is 12 miles northwest of Cadillac. More specific location is as follows:

Lake	Township	Tier	Range	Section
Frog (Berry)	Clam Lake	21 N.	9 W.	11, 12
Stone Ledge	Clam Lake	21 N.	9 W.	27, 28
Meauwataka	Colfax	23 N.	10 W.	31, 32

All three of these lakes are landlocked and so have no direct connection to any drainage. Most of the land around Meauwataka is in the drainage of the Manistee River, while Frog and Stone Ledge are near the divide between the Manistee and the Muskegon drainages.

A map of Meauwataka Lake, showing outline and submerged contours, was prepared by the United States Forest Service. This was used in

charting vegetation beds and locating sampling stations during the biological inventory. The inventory was conducted by an Institute party July 5-6, 1937*

The investigations on Stone Ledge and Frog Lakes were carried on in 1941. Maps were made by an Institute mapping party on March 28 and 29, respectively. Fish collections were made in the lakes July 9-10 and 7-9, and the inventories were completed August 8 and 9.**

Because of their small size and lack of connection with other waters, extensive industrial use of these lakes seems unlikely. Numerous deadheads and several deposits of woody debris may indicate some use in lumbering operations.

Stone Ledge Lake is reported to have formerly furnished good fishing for perch and bullheads. Although bass and walleyes have been introduced, few of these fish are said to be caught, and it is now difficult to catch a perch large enough to keep. In Frog Lake the bluegills are reported to be stunted, while fishing for largemouth bass is reported as fair. Meauwataka enjoys a reputation of being a good fishing lake, although it is said to have been better in the past.

There was very little resort development on any of these lakes. There was one summer home near Stone Ledge. The terminus of a county road on Frog Lake had been equipped with picnic tables by the Road Commission. A number of boats were kept there. Boat liveries were

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* Personnel of inventory party (Meauwataka): Horace Telford, leader; Joseph Bailey and L. B. Shettles, assistants.

** Personnel of the various parties was as follows:
Mapping party: Lee Anderson, leader; Richard Wilson, Royal Howe, James Moffett, Robert Matthews, assistants.
Fish party: W. C. Beckman, leader; Lee Anderson, Pat Galvin, Micheal Pawlick, assistants.
Inventory party: John Funk, leader; Eugene Roelofs, Stanley Lievense, assistants.

maintained on both Stone Ledge and Frog by neighboring farmers. At the time of the biological survey of Meauwataka, a camper had a few boats for rent. The lakes are all rather easily accessible by paved or good gravel roads. In spite of this and their nearness to Cadillac, fishing seems to be rather light, both summer and winter. At present their importance as public fishing waters is not very great. However, if fishing could be improved, they would no doubt be used much more intensely.

Physical Characteristics

The topography of the land to the south and east of Cadillac is very irregular. Many of the hills are quite high and steep. The soil is composed chiefly of sand and gravel through which water apparently settles very readily. Many depressions which would be expected to contain lakes show no evidence of ever having held an accumulation of water. The former fine stands of pine (of which the numerous large stumps give evidence) have been removed and the poor soil now produces little vegetation to check the runoff. Frog and Stone Ledge Lakes lie in this area.

North and west of Cadillac the land is level or gently rolling and the soil seems to have greater ability to hold water. Evidence of this is shown by numerous marshy areas. Meauwataka Lake lies in this section.

A suggestion as to the geological origin of the country described above is given by Dr. I. D. Scott in his description of the surroundings of Mitchell and Cadillac Lakes. He says, "The location of the city of Cadillac is especially fortunate. It is built at the junction of a large morainic tract on the east and an extended outwash plain on the west. The surface of the outwash plain is extensively pitted, but few of the pits hold water." [*]

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[*] I. D. Scott, Inland Lakes of Michigan.

Both Frog and Stone Ledge Lakes occupy depressions between the moraines. The basins are very irregular in outline. Stone Ledge has one shallow depression in the main part of the basin. The basin of Frog includes three distinct depressions. Meauwataka is somewhat oval in outline. The chief irregularities are a bay in the southeastern part and a long point extending out from the northwest shore. The basin is rather regularly bowl-shaped with the deepest water in the western part.

The drainage basins of the lakes are very limited. Frog has one intermittent inlet entering the northwestern end of the lake. It drains an area a few acres in extent which apparently is marshy in wet weather. It was dry at the time of the survey. The chief water supply of all three lakes is seepage and runoff from the surrounding land. Since the soil is sandy and of low fertility, the amount of nutrient minerals washed in is probably quite small.

In lakes such as these, the water level is apt to fluctuate with the level of the water table. Such fluctuation is impossible to control. The problem apparently is not serious in Frog and Meauwataka. At the time of the survey, the level of Stone Ledge seemed to be 2-3 feet below normal and the lake presented a perfect example of the disastrous effect of such fluctuation. Cattails and water lilies, which normally would have been growing in 6 inches or more of water, were stranded far up the beach. Submergent plants were very scarce. The productivity of the lake was undoubtedly greatly reduced.

Additional physical characteristics are given in the following table.

Lake	Area in acres	Maximum depth in feet	Shore development	Approximate per cent of shoal	Bottom types		Color of water	Secchi disc in feet
					Shoal	Depths		
Frog	68.4	28	1.96	40	Sand, pulpy peat, debris.	Pulpy peat	Brown, clear	8
Meauwataka	95.3	45	1.31	20	Sand, pulpy peat.	Pulpy peat	Colorless, clear	10
Stone Ledge	81.6	20	2.0	25	Sand, pulpy peat.	Pulpy peat	Brown, turbid	3

The lakes are all small. Frog and Stone Ledge are relatively shallow, while Meauwataka has some rather deep water. The shore development shows the relationship between the length of the shoreline of the lake and the circumference of a circle of the same area. For instance, a shore development of about 2 (Frog and Stone Ledge) means that the shoreline is about twice as long as it would be if the lake were perfectly round. A long shoreline for the area suggests the presence of protected bays and coves which are usually the most productive parts of a lake. Other conditions being favorable, a lake with a high shore development (2 or more) should be more productive than one where the shore development is low.

The shoal of a lake is the part which is potentially able to produce plants. These lakes vary considerably in the proportion of the total area which may be considered as shoal (20-40 per cent). The chief limiting factor is the depth of light penetration, since higher plants require light for growth. Light penetration is measured with the Secchi disc, a black and white metal disc about 10 inches in diameter, which is lowered into the water until it disappears. The depth of disappearance is related to the depth of effective light penetration.

The water of Frog and Meauwataka was of about average transparency. The high turbidity of the water in Stone Ledge greatly reduced light penetration. Turbidity in a lake may be due to suspended inorganic material (silt, marl, etc.) or to tiny floating plants and animals (plankton) or both. Inorganic matter in suspension seemed to be causing most of the turbidity in Stone Ledge.

The bottom types in these lakes are in a combination commonly found. They may be quite productive if other conditions are favorable.

Temperature and Chemical Characteristics

Water temperatures have a very important bearing on fisheries management. Fish may be roughly classified according to their ability to withstand extremes of temperature. Trout cannot survive in water much warmer than 70°F., although largemouth bass and bluegills do poorly at temperatures below this point.

All species of fish make their best growth when water temperatures are near their upper limits of toleration. Fish, being "cold blooded" animals, are most active, feed most, and so grow fastest when the water is relatively warm.

During the summer, lakes frequently become thermally stratified, that is, the temperature changes in a regular way from top to bottom and the lake is divided into layers. In the top and bottom layers, temperatures vary only a few degrees. The top layer is usually warm (about the temperature of the surface) but the bottom layer may be quite cold. Between the two is a layer called the thermocline in which the temperature changes very rapidly ($\frac{1}{2}$°F. or more per foot in depth).

The thermocline has some very important effects. Circulation due to wind action, etc., is limited to the water above the thermocline.

The cold water below is cut off from all circulation while the thermocline is present. During this stagnation period, important chemical changes may take place in this lower layer.

The chemical characteristics of water most important from a fisheries standpoint are the amount of dissolved oxygen, the amount of dissolved minerals, and the degree of acidity or alkalinity.

Oxygen is necessary for fish and most other living organisms. Minimum requirements for fish are about 3-1/4 parts per million. Natural waters receive most of their oxygen supply from the air and from the photosynthetic activity of aquatic plants. Respiration of living things and the decomposition of organic matter tends to use up this supply. In summer the circulating upper water of a lake should have an adequate supply of oxygen. However, when a thermocline is present, the oxygen may be exhausted in the water below it. Respiration and decomposition continue to use up the supply and there is no opportunity for it to be replenished.

Dissolved minerals in a lake are received both from the inflowing water and by direct solution from the bottom. Productive lakes are usually moderately hard, that is, have a moderate amount of dissolved minerals. The substances causing acidity or alkalinity may be washed in or may be produced within the lake itself. Decomposition products are usually acid in reaction so that the bottom water of a lake is likely to be less alkaline than the surface. Productive lakes are usually slightly to moderately alkaline.

Temperature and chemical characteristics of the lakes under consideration are presented in the following table.

Lake	Date	Location	pH range	M. O. Alkalinity	CO_2 range		Surface	Thermocline Top	Thermocline Bottom	Bottom
Frog	8/9/41	Station 1, eastern depression	6.1-6.8	12.0-31.0	...	Depth in ft.	...	10	20	24
						Temp. in °F.	77	69	52	51
						O_2 in p.p.m.	6.8	6.6	0.0	0.0
	8/9/41	Station 2, western depression	6.0-6.8	10.0-18.0	...	Depth in ft.	...	10	17.5	22
						Temp. in °F.	77	74	64	62
						O_2 in p.p.m.	6.8	6.8	0.3	0.0
Meauwataka	6/6/37	Station 1, northeastern part	6.9-8.1	76.0-81.0	0.0-11.0	Depth in ft.	...	21	26	34
						Temp. in °F.	75	67	58	56
						O_2 in p.p.m.	8.1	...	1.8	...
	8/9/39	Station - deepest part of lake	...	82.5	0.0-9.0	Depth in ft.	...	20	25	34
						Temp. in °F.	73	71	...	54
						O_2 in p.p.m.	7.9	7.6	1.8	...
Stone Ledge	8/8/41	Station 1, deepest part of lake	7.4-8.0	20.0	...	Depth in ft.	...	...	...	12.5
						Temp. in °F.	78	...	...	67
						O_2 in p.p.m.	7.9	...	...	6.9

Analysis by A. G. Horn, United States Forest Service.
Incomplete due to inclement weather.

The upper waters of all the lakes were warm enough to promote good growth of warm-water fish. In none was there a sufficient volume of suitable cold water for trout. Thermoclines were present in Frog and Meauwataka, but in Stone Ledge stratification probably does not occur.

Oxygen was abundant in all parts of Stone Ledge and above the thermocline in Frog and Meauwataka. It was absent below the thermocline in Frog and was greatly reduced in Meauwataka.

The water of Frog and Stone Ledge was very soft (M. O. Alkalinity, 10-31 p.p.m.) and in Meauwataka was moderately soft (M. O. Alkalinity, 76-82 p.p.m.). This is to be expected since sandy soil ordinarily provides little soluble nutrient material. Frog was definitely acid in reaction (pH 6.0-6.8, neutrality is 7.0). Meauwataka varied from slightly acid at the bottom to alkaline at the surface (pH 6.9-8.1). Most of the water was alkaline. Stone Ledge was alkaline (pH 7.4-8.0).

The combinations of chemical characteristics shown by these lakes vary considerably from the average for productive warm-water lakes. Meauwataka comes nearest to our idea of the characteristics a good fish lake should have, and Frog is farthest away. The management problem is to make the best of the existing conditions.

Biological Characteristics

Vegetation plays an important part in the ecology of a fishing lake. The plants affect the fish directly by providing shelter and protection, and indirectly by supporting large numbers of fish food organisms. Within limits, the productivity of a lake can be said to vary directly with the abundance of vegetation.

Plants are not abundant in any of these lakes, as is shown by the following table.

Species	Frog*	Meauwataka**	Stone Ledge*
Spike rush (Eleocharis palustris)	...	...	Rare
Spike rush (Eleocharis Smallii)	Few	...	...
Pipewort (Eriocaulon septangulare)	Common	...	...
Quillwort (Isoetes Braunii)	Rare	...	...
Water milfoil (Myriophyllum tenellum)	Rare	...	...
Water milfoil (Myriophyllum sp.)	...	Common	...
Yellow water lily (Nuphar variegatum)	Common	...	Rare
Yellow water lily (Nuphar sp.)	...	Few	...
Smartweed (Polygonum sp.)	...	Rare	...
Large-leaf pondweed (Potamogeton amplifolius)	...	Common	Rare
Pondweed (Potamogeton angustifolius)	...	Few	...
Leafy pondweed (Potamogeton epihydrus)	Rare	...	Rare
Leafy pondweed (Potamogeton foliosus?)	...	Rare	...
Variable pondweed (Potamogeton gramineus)	...	Few	...
Pondweed (Potamogeton pusillus)	...	Rare	...
Pondweed (Potamogeton spirillus)	...	...	Rare
Flat-stemmed pondweed (Potamogeton zosteriformis)	...	Common	...
Duck potato (Sagittaria latifolia)	...	...	Rare
Bulrush (Scirpus sp.)	...	Common	...
Bur reed (Sparganium sp.)	...	...	Rare
Cattail (Typha sp.)	...	Few	Rare
Wild celery (Vallisneria americana)	...	Common	...
Musk grass (Chara sp.)	...	Rare	...

* Identified by B. M. Robertson, Department of Botany, University of Michigan.
** Identified (in part) by C. O. Grassl, Department of Botany, University of Michigan.

Six species were collected in Frog, 13 in Meauwataka and 8 in Stone Ledge. Two forms were common in Frog. One of these, pipewort (Eriocaulon septangulare) is characteristic of acid waters. Five species were common in Meauwataka and most of them were forms well adapted to furnish shelter and food organisms. All plants were rare in Stone Ledge.

Of the three lakes, Meauwataka comes nearest to having a plant population comparable to that of a good fish lake. Chemical conditions in Frog probably limit plant production and there is little that can be done to remedy the situation. In Stone Ledge, the chief limiting factor is probably the fluctuating water level, and again no remedy is practical.

Plankton is composed of the plants and animals of microscopic or near-microscopic size which float free in the water. These organisms are the chief food of all very young fish, larger fish food organisms, and

forage fishes. They are also frequently eaten by some kinds of game fish. At the time of the surveys, plankton was abundant in Frog and Meauwataka and fairly abundant in Stone Ledge. Animal organisms predominated in Meauwataka and plant organisms in the other two. Since plankton populations are known to vary greatly from week to week and from place to place in a lake, this information has only general significance.

Bottom food organisms were not very abundant in any of the lakes. Midge larvae (Chironomidae) were abundant in both shoals and depths in Meauwataka. A few phantom midge larvae (Corethra) were taken in the depths, and clams (Pelecypoda) were common on the shoals. Numerous crayfish and snails were observed. Since no attempt was made to determine the abundance of animals harbored by the vegetation, results here cannot be compared directly with those for the other two lakes. No doubt fish food organisms were more abundant than the above estimates indicate.

In Frog Lake no organisms were abundant. Some samples showed mayflies (Ephemeroptera), damselflies (Odonata) and midges to be common. The most animals were found in samples containing vegetation. A rather large variety of organisms were found on the shoal in Stone Ledge, but midge larvae were the only ones which were common. One sample produced large numbers of aquatic earthworms (Oligochaeta). Phantom midge larvae were abundant in the deeper water.

The following table lists the species of fish present in the lakes with estimates of their relative abundance and stocking records for the past seven years.

Species	Frog		Meauwataka		Stone Ledge	
	Relative abundance	Stocking 1934-1940	Relative abundance	Stocking 1934-1940	Relative abundance	Stocking 1934-1940
GAME FISH						
Northern pike (Esox lucius)	...	...	Reported	...	Rare	No
Perch (Perca flavescens)	Rare	8,000	Very abundant	5,000	Very abundant	
Walleye (Stizostedion vitreum)	...	555,000	...	385,000	Rare	fish
Largemouth bass (Huro salmoides)	Rare	1,650	Few	2,100	Rare	
Smallmouth bass (Micropterus dolomieu)	Reported	1,762	Reported	1,325	Reported	planted.
Bluegill (Lepomis macrochirus)	Very abundant	33,180	Abundant	38,300	...	
Pumpkinseed (Lepomis gibbosus)	Abundant	...	...	...	Common	
Hybrid Bluegill x Pumpkinseed	Rare	...	...	...	...	
COARSE FISH						
Common sucker (Catostomus commersonnii)	...	...	Rare	...	Common	
Black bullhead (Ameiurus melas)	...	...	Rare	...	...	
FORAGE FISH						
Black-chinned shiner (Notropis heterodon)	...	...	...	...	Rare	
Lake emerald shiner (Notropis atherinoides)	...	150,000	...	200,000	...	
Golden shiner (Notemigonus crysoleucas)	...	...	...	...	Common-abundant	
Blunt-nosed minnow (Hyborhynchus notatus)	...	...	Abundant	...	...	
Menona killifish (Fundulus diaphanus)	...	...	Rare	...	...	

The fish populations of these lakes were peculiar in that they were dominated by a few species, and other species were relatively rare. The population of Frog Lake was made up predominantly of bluegills and pumpkinseeds. This lake was also peculiar in having few, if any, minnows. In Meauwataka and Stone Ledge, perch were most abundant, with bluegills and pumpkinseeds in a secondary position. The only important forage fish collected were blunt-nosed minnows in Meauwataka and golden shiners in Stone Ledge. Suckers were rather common in Stone Ledge.

The few records in the random creel census for these lakes show that bluegills and pumpkinseeds were most frequently caught in Frog Lake. In Meauwataka, many more bluegills than perch were recorded as being caught. The discrepancy between this and the estimated relative abundance given above may be due to the fishing methods used. Perch and pumpkinseeds were the most frequently caught fish in Stone Ledge. Some pike were taken by spearing.

Age determinations were made from scale samples taken from the game fish collected. The following table in which the average length of the fish in each age class is presented gives an idea of the growth rate of each species in the lakes.

Species	Growing seasons completed*	Frog		Meauwataka		Stone Ledge	
		Number of specimens	Average length in inches	Number of specimens	Average length in inches	Number of specimens	Average length in inches
Northern pike	I	...	...	...	...	2	17.3
	II	...	...	...	...	2	21.7
Perch	I	...	...	...	...	19	2.4
	II	2	4.8	...	...	11	5.4
	III	2	6.0	1	9.5	1	6.5
	IV	...	...	...	...	2	8.4
	V	...	...	1	11.3	1	8.9
	VI	...	...	2	11.1	3	9.6
	VII	...	...	3	12.7	3	9.3
	VIII	...	...	...	...	1	11.2
Walleye	III	...	...	...	...	3	17.0
	IV	...	...	...	...	2	18.2
Largemouth bass	I	1	4.2	...	...	...	...
	II	4	7.6	3	6.5	...	...
	III	2	10.1	...	...	...	...
	IV	...	...	...	...	1	14.4
	VI	1	15.1	...	...	...	...
Bluegill	I	1	2.2	...	...	...	...
	II	20	2.6	...	...	...	...
	III	55	3.8	...	...	...	...
	IV	27	5.6	...	...	...	...
	V	2	6.1	1	7.4	...	...
	VI	...	...	2	8.8	...	...
Pumpkinseed	I	...	...	...	...	18	2.7
	II	...	...	...	...	4	4.8
	III	48	3.9	...	...	1	7.3
	IV	10	5.1	...	...	...	...
	V	1	7.7	...	...	...	...
Bluegill x Pumpkinseed	III	8	4.6	...	...	...	...

* Age determinations by W. C. Beckman

It will be noted that ages are given in growing seasons completed. Since the collections were made in the middle of the summer, all of the fish have been growing for part of an additional season. In some of the series, too few fish are included to give reliable results. However, for the more important species in each lake, it is believed that the samples are representative of conditions in the lake.

From a study of over 25,000 scale samples from all over the state, a tentative table of the age at which game fish reach legal size has been

prepared.* Results for the fish taken from these lakes are given below.

Species	Legal length in inches	Growing seasons completed	Summer of life
Northern pike	14	I	2nd
Perch	6	II	3rd
Walleye	14	II	3rd
Largemouth bass	10	II	3rd
Bluegill	6	III	4th
Pumpkinseed	6	III	4th

A comparison of the two above tables shows that the bluegills and pumpkinseeds in Frog Lake were definitely stunted. The few largemouth bass and perch were also growing slowly, being about a year behind the state average in each case. Too few fish were taken in Meauwataka to give conclusive evidence, but the perch taken seemed to be growing at about the average rate. The bluegills and largemouth bass may be somewhat below average. In Stone Ledge, the perch were about a year behind, northern pike and walleyes seemed to be making good growth, and pumpkinseeds about average.

There is an abundance of solid sand and gravel shoal in Frog Lake for fish requiring such facilities for spawning. Vegetation which might be utilized by perch and largemouth bass is not very abundant. Pike might be able to spawn in the marshy area at the west end. Areas suitable for spawning of bluegills, largemouth bass and perch are abundant in Meauwataka Lake. Facilities for pike may be limited.

Although perch are undoubtedly reproducing successfully in the lake, vegetation, etc., which is usually considered to be essential for them was very scarce in Stone Ledge. Facilities for pumpkinseeds are adequate.

* Institute Memorandum No. 124, "Age of fish upon reaching legal size in the inland lakes of Michigan", by W. C. Beckman.

No areas which appeared to be suitable for northern pike were observed. Although there are no records of plantings of fish in Stone Ledge during the past seven years, 5 walleyes, 3 and 4 years old, were taken in the collections. This would seem to indicate natural reproduction within the lake. The spawning requirements of this species are not well known. Eschmeyer found the Lake Gogebic walleyes utilizing rubble bottom which was underlaid with gravel and sand.* This type of bottom is not abundant in Stone Ledge Lake.

Management Suggestions

Stone Ledge Lake is at present designated as a pike lake and the survey results show no reason why this should be changed. Frog and Meauwataka are in the "all other lakes" classification. In spite of the program suggested below for Frog, both should retain their present designation.

Stone Ledge Lake has a population of fish which seems to be doing fairly well in spite of adverse physical and chemical conditions. They seem to be maintaining their numbers without stocking. It is suggested that a policy of "letting well enough alone" be followed in the future.

Meauwataka Lake has been receiving fairly generous plantings of fish, including thousands of walleyes. The walleyes have not survived. Conditions in the lake apparently are not suited to this species so that continued stocking would probably be wasted effort. Spawning facilities seem to be adequate for the other species stocked and natural propagation should maintain the population against any ordinary fishing pressure. It is therefore suggested that all stocking in Meauwataka Lake be discontinued.

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* Institute Report No. 695, "Notes on the natural reproduction of the walleyed pike in Lake Gogebic", by Paul Eschmeyer.

Frog Lake has received plantings similar to those put in Meauwataka. They should be discontinued for the same reasons. It is particularly important that planting of bluegills be stopped. This species is reproducing so successfully that the population is overcrowded and, as a result, stunted. Further stocking, if successful, would only aggravate this condition. It is suggested that an experimental planting of 25 or 30 adult northern pike be made in Frog Lake. It is hoped that this pisciverous species will reduce the number of small bluegills and pumpkinseeds to a point where reasonable growth will be possible, and that a balance between the two types of fish can be established.

Predators observed on the lakes were not numerous enough to warrant any control measures. Some fish parasites of various kinds were present. None of them are harmful to man and most of them cause little apparent damage to the fish. No attempts at control are suggested.

Snags and deadheads were numerous in all the lakes and furnish considerable cover. The vegetation beds were also important in Meauwataka. In Frog and Stone Ledge, the plants were not numerous enough to provide much shelter. Twenty-five or thirty brush shelters of the hollow square type in each lake might prove beneficial. The shelters should be strongly built and well scattered in water 10 - 15 feet in depth.

As was mentioned above, the problem of maintaining a constant water level is very important in Stone Ledge Lake but, as was also pointed out, no practical suggestions for control can be made. Spawning facilities are adequate for the most important species in the lakes, and no improvement attempts are advised.

If the suggested experimental planting of pike is made in Frog Lake, checks should be made from time to time to determine what affect, if any, they have had on the bluegill population.

INSTITUTE FOR FISHERIES RESEARCH

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