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

ALBERT S. HAZZARD, PH.D.
DIRECTOR

ADDRESS
UNIVERSITY MUSEUMS
ANN ARBOR, MICHIGAN

October 7, 1940

REPORT NO. 621

REPORT OF INSTITUTE FOR FISHERIES RESEARCH

During the past biennium the Institute continued to function as the research branch of the Fish Division. This organization of fisheries biologists might be compared with the research division of a modern industrial plant. Its duties are to test present methods of fisheries management and to develop and perfect new and better ways to maintain or improve fishing.

The University of Michigan has furnished office and laboratory space to the Institute since its establishment in 1930. Expansion of research during the past five years has necessitated more adequate quarters than could be provided in the Museums building. Recently, excellent space has been assigned in the Museums Annex which has increased the efficiency and comfort of the staff. The University further aids the Institute by furnishing advice and assistance from many of its departments on special problems.

Michigan State College of Agriculture and Applied Science has cooperated particularly in the investigation of fish nutrition and of water soils. Fellowships on these subjects have been supported there during the past biennium.

261

In this period approximately one hundred and fifty formal reports and memoranda covering investigations by the staff have been submitted to the Conservation Department. The factual data and recommendations contained therein have been extensively utilized by the administration in determining or advocating policies for the management of Michigan's public waters. Space does not permit detailing the results of all of these investigations. Some of the data secured have been published in scientific journals or in "Michigan Conservation." References to these are given in footnotes. There is urgent need, however, for a series of Institute bulletins which will make its findings promptly and permanently available. Precedent for such a series may be found in the publications of the California Division of Fish and Game and in reports of the New York Conservation Department and others.

Major problems attacked during the biennium are listed below with a summary of the results to date.

Fish. 60

(1) Fisheries surveys. Preparation of bottom contour maps of lakes, the first step toward the development of fisheries management plans, proceeded very satisfactorily during the past two winters. The C.C.C. under the direction of the Institute mapped 208 lakes in 20 counties in the northern part of the state. In southern Michigan, where such help is not generally available, crews of hatchery employees, who would otherwise have been laid off during the winter, mapped 194 lakes in 17 southern counties. The perfection of an electric ice drill[1] has greatly facilitated this work.

Biological investigations by summer crews were made on 76 lakes located in 31 counties. These included such important waters as Gogebic, Higgins, Long and Black lakes. Reports summarizing the conditions for

---

[1] Brown, C. J. D. and O. H. Clark. Winter Lake Mapping. Michigan Conservation, Feb., 1939.

fish life and with management recommendations are being prepared as rapidly as other duties will permit.

The entire stream system of the Huron River, and parts of the Dowagiac and Muskegon rivers were surveyed during the summers of 1938 and 1939 and reports have been or are being prepared covering the investigations.

(2) Fish Food investigations. Continued attention has been given to important problems connected with the feeding habits of game fish, and their relation to the available supplies of natural food organisms.

Additional studies were conducted on the population of Montana grayling introduced into Ford Lake, Pigeon River State Forest, during the preceding biennium. Although this experiment was complicated by the unauthorized stocking of bluegills in the lake, some useful information was derived from that act. Stomach examinations revealed that the grayling continued to feed predominantly on such predaceous aquatic insects as diving beetles and the immature stages of dragonflies, and also that after the grayling had attained a length of slightly more than nine and a half inches they began to feed on young bluegills. It was further established that the bluegills in this lake acted as direct food competitors of the grayling. 2/

In connection with efforts to assay, with adequate accuracy, the amount of fish food organisms naturally present in trout streams, on a unit area basis, a critical study of quantitative collecting methods 3/ indicated that the collapsible square-foot bottom sampler yields the

---

2/ Leonard, J.W. Further Observations on the Feeding Habits of the Montana Grayling (Thymallus montanus) and the Bluegill (Lepomis macrochirus) in Ford Lake, Michigan. Trans. Amer. Fish. Soc. 69:245-256. 1940.

3/ Leonard, J.W. Comments on the Adequacy of Accepted Stream Bottom Sampling Technique. Trans. Fourth N. Amer. Wildlife Conf., pp. 288-295. 1939.

most satisfactory results of any device now in general use, although it possesses certain undesirable features. Data obtained suggest that while a given area of stream bottom is capable of supporting a definite volume of food organisms, these may vary as to species represented within a restricted, uniform area.

An example of how adverse weather conditions may, within a brief period, seriously deplete the supply of fish food organisms was noted when a late spring freeze trapped, in a layer of ice, a large share of the emerging adult population of a midge very important in the diet of fish [4] in a small southern Michigan lake.

An aquatic insect not previously known from Michigan was encountered during the course of a survey of stream-inhabiting fish food organisms. [5]

(3) The minnow problem. Experiments were continued in methods for producing minnows for forage and for bait. Rate of reproduction and of growth have been shown to be determining factors in the choice of species. Bluntnose, fathead and golden shiners have proven to be the best minnows to use as forage in bass ponds. These can be produced at the rate of 200,000 per acre. Experiments with the common suckers and horned dace, the most popular bait minnows for pike, have demonstrated that production of the larger sizes generally requires two years. Unfortunately these species will not breed in ponds so that spawning streams must be provided or the spawn must be taken artificially.

---

[4] Leonard, J.W. Mortality of Aquatic Diptera Due to Freezing. Ent. News 50:107-108. 1939.

[5] Leonard, J.W. Lanthus albistylus (Hagen), a New Record for Michigan, with Ecological Notes on the Species (Odonata:Gomphinae). Occ. Pap. Mus. Zool., Univ. Michigan, 414:1-6. 1940.

Experimental introductions of minnows and crayfish have been made in a number of streams and lakes and results of these plantings are being determined.

Some assistance has been given bait dealers in the form of advice on methods of culture and transportation. Pamphlets have been prepared on the culture of minnows, insects, worms, crayfish and baits used in winter fishing.

(4) Fish populations. In order to know how large a crop of fish can be safely taken from a given water each year, it is necessary to determine the number, size and age of the important game and forage fish which are present. Blocking and seining limited sections of trout streams is practicable in small open, smooth-bottomed areas.

During July 4-11, 1938, twelve sample areas in a 3-mile stretch of the White River north of the town of White Cloud were blocked and seined, and during July 24-30, 1938, seven test sections of the Maple River northwest of the Pellston Mill Pond were similarly treated. In both localities the fish captured were measured, counted, and weighed, and replaced in the streams. All the sample plots were carefully mapped so that accurate computations of the numbers and pounds of fish per acre could be determined.

The White River, where sampled, was found to be carrying an average of approximately 9 times as many fish per acre as the Maple River, and about 3 1/2 times the poundage per acre (average of 20,954 fish in the White River compared to an average of 1,957 fish in the Maple River; average of 478 pounds of fish per acre in the White, average of 121 pounds per acre in the Maple). There were almost 10 times as many legal trout per acre in the White River as in the Maple River

(117 in the White, 12 in the Maple). However, from scale studies of the trout in both streams, it was determined that trout of all ages grew faster in the Maple River than in the White River, probably because of the smaller number present.

In August, 1939, a test of a coal tar derivative, as a substance for stunning the fish within a blocked area of stream, was performed on a small tributary of Hunt Creek in Montmorency County. All of the marked trout placed in the section were recaptured and were successfully revived. The method does not seem to be of general practical application because of the difficulty of recovering the fish.

Further investigations in a search for a rapid, accurate method of estimating the sporting stock of the trout streams are now being pursued at the Hunt Creek Experimental Trout Station.

Population studies in lakes were continued as a by-product of poisoning to eliminate stunted populations in waters otherwise suitable for trout. These counts are not typical of better Michigan lakes, but are nevertheless of considerable interest. O'Brien Lake, Alcona County as an example yielded a total of 31,000 fish, but of these, only 156 were legal size or 15 legal fish to the acre. Analyses of the fish populations in a number of so treated lakes are now underway and will be reported later.

On other waters where present conditions were more satisfactory, another method improved by Dr. David Thompson of the Illinois Natural History Survey has and is being used. Trap or fyke nets are employed to catch the fish alive and an identifying mark is placed upon each before returning the fish to the lake. A progressive marking and recording continues over a period of several weeks or until the daily computations of the population

develop a reasonable constancy. On one lake in Montmorency County the estimated population was 11,200 legal fish, exclusive of the perch, or 11.5 fish per acre. In Hillsdale County a 104 acre lake was estimated to contain about 12,000 legal fish or 115 per acre; in Branch County a 122 acre lake had a calculated population of 49,000 legal fish or 400 to the acre. This count followed a winter of heavy ice fishing which removed 23,049 fish.

(5) Creel census. The only way to accurately determine the results of management practices such as stocking, environmental improvements, population control, etc. is by conducting yield studies, popularly known as creel census.

Three types of creel censuses have been conducted on the waters of this state during the past biennium.[6] The first or general census constitutes a random sampling in nearly all sections of the state. This is carried on by the Conservation Officers in connection with their regular duties and has been in continuous operation since 1927. Over this period more than 183,000 fishing records have been submitted and tabulated. In 1939, 32,432 records were sent in for analysis. The average catch per hour for the entire twelve year period for all inland waters was 1.21; for 1939 it was 1.1 legal fish per fisherman per hour. As in previous years, the quality of fishing as indicated by the catch per hour was highest in the southern portion of the state, but the largest average size was recorded in the northern districts. The data from the general census records is increasing in value as more and more material becomes available for analysis. Reports for individual waters are placed on summary cards, and the twelve year accumulations for many waters give the

[6] Clark, O. H. and Albert S. Hazzard. Census--Fisheries Style. Michigan Conservation, May-June, 1940.

Department accurate information as to the most important species caught and the average size. Intensive netting or intensive censuses have invariably confirmed the evidence collected by the Conservation Officers through the general census, further proving its value. The accompanying map is derived from general census data and shows the percentage of the total catch of each of nine important game species taken in different geographical districts of Michigan. This map demonstrates graphically the variations in the composition of the average angler's catch for different sections of the state during 1939. Little change in these figures from year to year has occurred.

In addition to the general census, an effort has been made to obtain as complete a record of the anglers' take as possible on specific waters. This type has been called the intensive census and has been conducted by Department staff members and on a number of lakes and streams by the several federal agencies interested in these problems.

Intensive creel censuses were operated by the Institute and the C.C.C. on portions of six trout streams in 1938, seven streams in 1939, and five streams in 1940. In the latter season, two of the five were in the Upper Peninsula, where almost no censuses of this type have been conducted previously. The majority of the trout lakes of the Pigeon River Forest have been under intensive creel census during the biennium just concluded.

For the censused trout streams, the average catch per hour was 0.49 trout (varying from 0.26 trout to 0.55 trout) in 1938, and in 1939 anglers on the censused waters caught fish at the average rate of 0.47 trout per hour (varying from 0.32 trout to 0.63 trout). On the trout lakes of the Pigeon River Forest the catch per hour was less, but the fish taken were of larger average size.

Comparison of angling pressure from creel censuses on typical northern Michigan warm water lakes and on trout waters show that the trout streams are fished about 7 times as heavily as the lakes.

The relationship of winter fishing and summer fishing is being investigated through intensive creel census and fish population studies. Preliminary analysis indicates that in some lakes the winter catch (primarily bluegills) may be of considerable importance. On two lakes in the southern tier of counties, the catch per hour for winter fishing exceeded the summer figure. A great range in winter fishing pressure exists, however; many lakes are fished little or not at all. Where facilities are good and where the lake has a proven reputation and adequate access, the pressure is heavy and in some instances may be excessive.

Another problem of importance is being attacked by the same methods; namely, the relation of suckers to game fish in lakes. After several years of intensive creel census and study of feeding habits and growth of suckers and game fish in a lake known to have a large sucker population, the suckers will be drastically reduced in numbers and the effect upon numbers, growth and yield of the game fish will be followed through continued creel census and population estimates. The same procedure is being followed in evaluating the significance of dogfish in relation to game fish.

A third type of census, the special or volunteer, has been discontinued this past year because sufficient data has been accumulated and because of the inherent difficulties of obtaining a standardized return. This census was conducted by selected expert anglers on a volunteer basis. Each man kept his own daily fishing record on specially provided blanks and submitted them for analysis at the end of the fishing season. It was determined from these data that the expert was considerably more successful

than the average run of the mill fisherman and that this was especially true on the trout streams.

(6) Results of trout planting experiments. A number of experimental plantings of tagged or fin-clipped trout have been made mostly in streams where the intensive censuses referred to above have been in operation.

Recoveries in and adjacent to the censused areas on streams, of tagged legal-sized trout released at different seasons of the year proved that very few (not more than 5 per cent) fall-planted brook trout of legal size survive the winter to reach the anglers' creel in the following season.[7] However, from 5 to 62 per cent of the tagged adult brook trout released in the spring or during the open season were recovered by the anglers. In general, the preceding statement holds true for legal-sized rainbow trout planted in streams, and also probably for legal brown trout. More experimental work is needed with the latter species, however.

Recoveries of fish from plantings of marked fingerling trout in areas under creel census have shown that less than 2 per cent of the fingerlings planted are caught by anglers as legal trout.[8]

Data from the trout lakes on the Pigeon River Forest have demonstrated that fall plantings of legal-sized rainbow trout in suitable lakes may be expected to furnish good angling in the following season, since from 23 to 66 per cent recovery of the total planting or total number of marked fish released have been reported to creel census clerks. This conclusion is further supported by the large number (80 out of 500) of tagged fish voluntarily reported from rainbow trout planted in Burt Lake in September, 1939. Reports from this planting are still being received by mail.

---

[7] Shetter, David S. and Albert S. Hazzard. Results from Plantings ~~xxxx~~ of Marked Trout of Legal Size in Streams and Lakes of Michigan. Trans. Am. Fish. Soc., 1940 (in press).

[8] Shetter, David S. Success of Plantings of Fingerling Trout in Michigan Waters as Demonstrated by Marking Experiments and Creel Censuses. Trans. Fourth N. Am. Wildlife Conference, 1939, pp. 318-325.

270

(7) Predators. Investigations to determine which, if any, predators of fish may be deleterious to sport-fishing were continued with cooperative support from the American Wildlife Institute, the University of Michigan, and Michigan State College.

Additional studies completed on the American Merganser [9] substantiate earlier findings by the Institute that trout predominate in the food of these birds on trout streams. "Merganser drives" are described as a means for controlling abnormal concentrations of these birds on such waters. The Red-breasted and Hooded Mergansers are shown to be of little importance to fish management in Michigan.

The mud-puppy or water-dog was studied in Evans Lake, Lenawee County. [10] One hundred and five specimens collected by spearing at night in late April, 1937, had eaten mostly the larvae and nymphs ("wigglers") of aquatic insects. Other items found in considerable quantities in the stomachs of these salamanders were crayfish and earthworms. A few fish (mostly forage species), snails, frogs, and turtles had also been eaten. Indications are that the mud-puppy is not a significant predator of game fishes but rather it may compete somewhat with sport fishes for food. Control of the comparatively low populations as existing in most Michigan waters is not recommended on the basis of the present data.

A compendium of methods currently used to control fish predators at hatcheries and rearing stations was made. [11] Some of the results of the survey used to gather this information were given in the report for the previous biennium. Tests of an automatic acetylene detonator demonstrated

---

[9] Salyer, J. Clark, II, and Karl F. Lagler. 1940. The Food and Habits of the American Merganser During Winter in Michigan, Considered in Relation to Fish Management. Journal of Wildlife Management, 4 (2): 186-219.

[10] Lagler, Karl F. and Karl E. Goellner. 1939. The Mud Puppy, an Enemy of Fish? Michigan Conservation, 8 (7):3.

[11] Lagler, Karl F. 1939. The Control of Fish Predators at Hatcheries and Rearing Stations. Journal of Wildlife Management, 3 (3): 169-179.

this mechanism to be ineffective for frightening Kingfishers and members of the heron family from hatchery waters. Screening of small ponds and raceways (with screens of wire on frames near water level) was demonstrated to be effective in excluding fish eating birds. Further testing of screens (overhead on a framework of pipe) is in progress.

Completion of analyses of the food of large series of the six common kinds of aquatic turtles (semi-box, map, soft-shelled, musk, western painted, and snapping) in the state showed that the snapper alone eats appreciable amounts of fish.[12] The food in the stomachs of 186 snapping turtles was made up approximately as follows: one-third, water plants; the second third, game fish, and the last third, dead fish, and other carrion, insects, crayfish, snails and clams. Remains of water plants comprised more than nine-tenths of the food in the intestines of 278 snappers.

Turtles were considered to be a menace to the success of the artificial propagation of pond fishes.[13] Conventional turtle traps were demonstrated to be the most effective means of control.

Study of the water-snake and the gars and bowfin (fresh-water dogfish) were actively continued and an investigation of the food of the otter was begun. The otter material came as a result of the open season on this animal during the second year of the biennium.

Gal. 62

As more and more data are accumulated on the predator problem, it becomes increasingly apparent that only on rare occasions may the animals studied be in themselves the cause of depleted game fish populations. If any control of fish predators investigated is required, it is believe that this can be accomplished by alterations of environments to favor game

---

[12] Lagler, Karl F. 1940. A Turtle Loss? American Wildlife, 29 (1): 41-44.

[13] Lagler, Karl F. 1940. Turtles, Friends or Foes of Fish Culture? The Progressive Fish Culturist, 50:14-18.

species of fishes rather than by direct removal or extermination of the predators.

(8) Fish population control./ Surveys by the Institute staff often reveal lakes overrun with undesirable fish. It has been proven that in many instances these lakes may be made to provide good fishing by eradicating the undesirable species and introducing game fish better suited to existing conditions. Complete removal of a lake's fish population can hardly be achieved with nets; and most of the chemicals known to kill fish also destroy the aquatic food organisms. A certain drug which seemed especially promising was made the subject of an extensive series of laboratory experiments, from which was derived a dosage table whose application was found to result in a complete kill of fish with almost no mortality among the food organisms. [14]

Reduction in numbers of fish in waters naturally overpopulated by transfer, partial poisoning, destruction of spawning beds or introduction of predacious fishes is being tested at present and appears to offer considerable promise. Definite management methods cannot as yet be offered.

A further development in population control for trout lakes containing some cold water species as well as undesirable forms was accidentally discovered. [15] Two small private lakes in Otsego County formerly produced excellent brook trout fishing. Following the introduction of bass, rock bass, perch, etc., trout fishing declined to almost zero despite regular

---

[14] Leonard, J. W. Notes on the Use of Derris as a Fish Poison. Trans. Amer. Fish. Soc. 68:269-280. 1939.

[15] Greenbank, John. Selective Poisoning of Fish. Trans. Am. Fish. Soc., 1940 (in press).

plantings of trout fingerlings. An attempt to completely poison the lakes without first determining the volume of water apparently resulted in destruction of all warm water species but killed very few trout and suckers. Measurement of the volume later showed that from half to two-thirds of the amount of poison needed for complete kill had been used. Apparently the shore and surface waters received lethal doses while the cold bottom layers where most of the trout and suckers were at that time of year were little affected.

(9) Growth rate. During the past two years growth rate studies have been increased. A series of experiments has been started to determine the effect upon growth of the reduction of the density of fish populations as described above. The results obtained seem to give considerable promise. [16]

Work is being conducted to determine the average size of important game fish at each year of life. This study will provide a standard of growth by which to judge whether or not the fish in any lake being investigated are growing as well, better or poorer than they should. When lakes are found in which the fish are growing a great deal faster than the average, a more intensified study of the lake may be conducted to find out the cause of this increase, or vice versa if slow growth is found. In this way it may be possible to set up a requirement list for better fishing conditions which can be carried out through improvements under fisheries management.

---

[16] Beckman, William C. The Increased Growth Rate of Rock Bass (Ambloplites rupestris) Following Reduction in the Density of Population. Trans. Am. Fish. Soc. Vol. 70 (1940) 1941.

The time at which the year mark or annulus is formed on the scales of fish in various parts of Michigan is being determined. This will enable the investigators to make more accurate determinations of the age of fish in the early spring and summer collections.

(10) Winter kill. During especially severe winters, certain lakes, mostly in southern Michigan, suffer severe fish losses under the ice. Earlier investigation had shown this to be due to depletion of oxygen, but the cause of the depletion and possible methods for alleviating the condition were yet to be found.

In the winter of 1939-40 a large series of chemical determinations was made throughout the period of ice cover on certain lakes near Ann Arbor, three of which were known to have "winter-killed" during the severe winter of 1936.

In an experiment at the Drayton Plains Hatchery, light was largely excluded from a small pond by building paper, and in another a larger amount of light than normal was admitted by removing the snow cover from the ice. An experiment in pumping water into a small, private fish pond was performed in Livingston County.

Results of observations and experiments indicate that:

Winter-kill occurred in varying amounts, usually small, in several Michigan lakes in the winter of 1939-40. The winter probably was no more severe than normal, but was rather prolonged.

The contact of a relatively large proportion of a body of water with organically rich bottom materials (such as in a shallow, muck-bottomed lake) tends to bring about diminished oxygen, with the attendent danger of winter-kill.

Light entering the water through the ice has a tendency to counterbalance oxygen loss presumably by photosynthesis of aquatic plants, and any method of increasing the penetration of light may therefore be helpful in averting winter-kill.

A small stream of well water had little, if any, beneficial effect in preventing oxygen loss in a pond.

Acid bog water is more apt than hard water to show rapid and large changes in dissolved oxygen content, and thus may be more subject to winter-kill.

The cutting of holes through the ice and stirring the water rather than alleviating winter kill as originally hoped, appears to concentrate the fish at such points to the extent that depletion of oxygen may be accentuated and more fish may die than if no aeration were attempted.

(11) Life histories. Obviously fish and game cannot be managed intelligently in the wild without adequate knowledge of their habitat requirements. For instance, fish have definite temperature ranges in which they do well; in others they die or become stunted. Some must have running water to spawn successfully; others need quiet waters full of aquatic plants. So little was known of the basic requirements of certain important game fish that it was evident that life history studies would be necessary before management could be attempted. As an example, it has been difficult to explain satisfactorily the apparent increase or decrease of northern pike in certain Michigan lakes because of the lack of knowledge concerning the life history and habits of the pike.[17]

---

[17] Carbine, W. F. The Pike. Michigan Conservation . August, 1938.

Investigations started in the spring of 1939 were continued through the summer of 1939 and spring and summer of 1940 at Houghton Lake and Walled Lake (Oakland County). Observations were made on the run of adult pike, spawning habits, return of the young to the lake, feeding habits and growth of young and adults, and migrations. Capture by anglers during the following season of 20 per cent of the adult pike tagged in one ditch indicates a rather heavy fishing intensity for pike at Houghton Lake.

Great mortality among the young pike occurs between time of spawning and time of descent to lake. From an estimated 2,000,000 eggs deposited in one ditch, 7,200 young returned to lake (6,000 of these under 2 1/2 inches). Young grow at rate of about one-twelfth inch per day. They are extremely cannibalistic, starting to eat one another when little less than an inch in length.

Intelligent fish management also requires accurate knowledge of the number of eggs, fry and adults that result from natural reproduction. Observations have been made during the past three years in Deep Lake, Oakland County on the spawning habits and the number of fry produced per nest by the bluegill, common sunfish, rock bass and largemouth bass. [18]

---

[18] Carbine, W. F. Observations on the Spawning Habits of Centrarchid Fishes in Deep Lake, Oakland County, Michigan. Trans. Fourth N. Am. Wildlife Conference, 1939, pp. 275-287.

227

Number of Fry Produced in

Deep Lake, Oakland County

Species	No. nests in lake	No. nests examined	Average No. fry per nest	Estimated No. of fry produced per acre
1938				
L. M. bass	33	4	4,977	11,000
Rock bass	58	9	796	3,000
Common sunfish	188	2	8,074	101,900
Bluegill	369	17	17,914	443,600
Total	648	32		559,500
1939				
L.-M. bass	23	3	6,832	9,821
Rock bass	49	16	2,213	6,379
Common sunfish	121	10	5,990	48,319
Bluegill	621	19	16,155	668,817
Total	814	48		733,336

Gal. 63

(12) Lake soils. Accompanying the increased interest in lake improvement during the past few years, there has arisen a demand to know more concerning the bottom soils and their relation to productivity of lakes. This investigation was inaugurated in 1938 in cooperation with the Soils Section of the Agricultural Experiment Station at Michigan State College through the Conservation Institute.

278

The first phases of the investigation to receive attention dealt with finding a satisfactory means of determining fertility in bottom soils, followed by actual tests on a large series of soils collected from lakes throughout the state, and then determining the relationship between bottom soil fertility and the nature and luxuriance of the associated aquatic vegetation. This study [19] showed clearly that differences in fertility exist but the way in which these differences are reflected in the aquatic vegetation are not so apparent.

Following this preliminary study, fertilization plots were set up in the greenhouse using soils taken directly from lakes. Soils which supported little or no vegetation were used. Fertility tests were made and commercial fertilizers were applied on the basis of the fertility tests. The common waterweed (Anacharis canadensis) was used in the experiments. Results of the greenhouse tests are somewhat obscured by the fact that there seemed to be serious competition for the added nutrients between the waterweed and the algae, which in some cases, responded to the treatment to such an extent that the waterweed was completely choked out. However, the greenhouse work was supplemented by test plots constructed in the floating bog surrounding Rose Lake at the Game Division's Rose Lake Experimental Farm located northeast of Lansing. In these plots certain fertilizer treatments showed remarkable increases in both algae and the higher plants. Fertilization of some small experimental lakes will probably be the next step in this direction.

At present a comprehensive study is being conducted on four lakes in the northern part of the state. This involves further research on

---

[19] Roelofs, E. W., 1940. Available Plant Nutrients in Lake Soils. Mich. Agri. Exp. Sta. Quart. Bul. Vol. 22, No. 4.

fertility of various types of bottoms; the relationship of organic matter to fertility; a quantitative determination of the vegetation growing on soils varying in composition, fertility, and percentage organic matter; the ecology of numerous species of plants; and further determinations on the relationship of plant nutrients in the soil to the amount of the same nutrients absorbed by the plant. In addition, several improvement devices were placed on a wave-swept shoal in order to study the effect on plant growth of minimizing wave action on a barren shoal.

Another objective of the project is to establish a suitable classification of lake soils. This has received considerable attention, but it is extremely difficult to devise a classification which is adaptable to use by the average worker in the field of fisheries biology and at the same time retain much value for the technical soils investigator.

(13) Stream and lake improvement. The Institute has continued to assist various state and federal agencies and sportsmen's clubs in planning and inspecting stream and lake improvement.

During this biennium the University of Michigan Biological Station at Douglas Lake has again been used as a center of research to test lake improvement devices, particularly brush shelters.[20] Removable shelters were installed at various depths and locations. Fine-meshed seines were placed around these shelters just prior to examination so that the entire population of fish in and immediately adjacent were captured after the shelter was dragged to shore. Checks of similar areas without shelters were made for comparison. Considerable difference was found in the number

---

[20] Rodeheffer, Immanuel A. Further Studies ~~in~~ the Use of Brush Shelters By Fish in Douglas Lake, Michigan. Mich. Acad. of Sci., Arts and Letters, Vol. 25, 1939, published 1940, pp. 357-366.

and species of fish using the shelters during the day and during the night. Rock bass and pumpkinseed sunfish were found in unusual abundance around the shelters in the day, but there were only one-fourth as many at night. As the fish were equally scarce elsewhere on the shoals, a nightly migration to deeper water is suspected. Perch were more abundant around shelters than on open shoal in the day, but were not attracted to shelters at night. Of the two black bass, the largemouth showed the greatest preference for brush shelters.

In order to learn more of the movements of fish in and around brush shelters, fish were marked and recoveries were made by netting or from anglers' catches.[21] The results of this investigation indicate that there is little movement of native game fish from one part of Douglas Lake to another. Adult smallmouth bass transferred to Douglas Lake from Lake Michigan were tagged and planted at one place. They were recaptured, however, at widely separated points at some distance from where they were released. All recaptures were made at brush shelters or in weed beds.

(14) Fish movements. As mentioned in previous discussions, the movements of fish have been followed by jaw-tagging with serially numbered, monel metal tags or by removing one or more of the fins (in studies of mass movements). Many thousands of fish, including all important game species, have been marked by either of the methods and liberated in twelve inland lakes, six trout streams and in northern Lake Michigan. The Conservation Department wishes to take this opportunity to thank the many

---

[21] Rodeheffer, Immanuel A. The Movements of Marked Fish in Douglas Lake, Michigan. Mich. Acad. of Sci., Arts, and Letters, 1940 (1941). In press.

anglers who have reported the capture of tagged or fin-clipped fish and to request that they continue to cooperate in this way.

Two-way fish traps or weirs have also been used to learn about fish movements. For two years from the time of ice break-up to early summer such a trap has been operated just below the outlet dam at Houghton Lake. In 1939 some 1,200 fish went downstream out of the lake and 490 were taken going upstream. A more efficient trap was installed in 1940 and took approximately 5,000 fish which were leaving the lake and about 1,500 moving upstream. The great majority of the fish were suckers. Only a few northern pike and walleyes and other fish left the lake, and of these (all were marked), the majority returned through the trap. Similar results have been secured from a two-way weir operated at the outlet of Lake Gogebic. Weirs installed on two feeder streams of Hunt Creek have shown a considerable downstream movement of fingerling trout but very little upstream migration even during the spawning season.

(15) The Hunt Creek Experiment Station.[22] For several years the Institute has recognized the need for a field station which would serve as a base for staff workers in the northern part of the Lower Peninsula, and where intensive investigations of an experimental character could be carried on under the continuous supervision of a resident biologist. In the spring of 1939, after inspecting many possible locations, Fish Division administrators finally chose a desirable site for this station in a state-owned section of land embracing most of the headwaters of Hunt Creek, a tributary of the Thunder Bay River, in southwestern Montmorency County.

---

[22] Hazzard, Albert S. Hunt Creek Fisheries Experiment Station. Michigan Conservation, April, 1940.

The drainage area involved includes several tributaries of various sizes, three small lakes, one of which contains trout, and several beaver ponds of different sizes and ages. During the summer of 1939 staff members conducted an intensive creel census on this section of stream, installed fish counting weirs on two tributaries, and mapped the lakes. In September, construction of a combined laboratory and residence was begun, and completed about the middle of May, 1940. During the fall and early winter of 1939 the chief project, aside from construction, was the preparation of a detailed, large-scale map of the stream and its tributaries. In addition, survival and growth rate experiments were started by marking and releasing in the stream a number of trout, both wild and hatchery-reared. Seining for recoveries is continuing at monthly intervals. Throughout the year, the fish food supply has been investigated. During the fishing season of 1940 another intensive creel census is being taken. The fish counting weirs are still in operation, and have revealed a very heavy downstream movement of trout, especially in spring and fall months.

Present plans call for at least one more year of intensive analysis of existing conditions, after which various types of environmental control will be tested, with figures on original conditions serving as an accurate measure of results. Construction is under way of three stream channel diversions, with screens at either end, where controlled experiments on survival, growth rate, food selection, carrying capacities, and marking methods can be conducted under natural stream conditions. The basement of the station contains an aquarium table where small-scale indoor experiments may be carried on.

One of the chief advantages of the station lies in the fact that it will make possible detailed and almost constant investigations of winter conditions in trout streams.

(16) Diseases and parasites. Although recognized as an important problem, adequate investigation of fish diseases and parasites has not been possible during the biennium for lack of experienced personnel and necessary facilities. Unusual mortalities and specimens of diseased fish have been diagnosed as well as possible. A peculiar disease affecting only brown trout has occurred in early summer in several important streams and was responsible for a rather heavy loss, especially in 1939. It is hoped that another year a pathologist may be available to determine the cause.

Severe infestation of trout with lampreys in the Manistee River was first reported in 1937. Investigation in the spring of 1939 and 1940 revealed no definite spawning runs of adult lampreys which could be controlled. The spawning activities of the native, non-parasitic lamprey which are evident to most fishermen were observed. It was found that this lamprey is a serious pest of trout in only a limited section of the river, i.e. from about 1/4 mile above the M-76 bridge to just below the Livingstone property. An average of 35 per cent of the trout examined bore lampreys or fresh scars. Study of the habits of the larval lampreys showed them to be restricted to muck beds overlaid by one or two inches of sand which were found along the stream banks. The current was sluggish and a moderate growth of water plants occurred on these bars. It was suggested that the best method of control would probably be for fishermen to carry fine-meshed landing nets and to destroy all lampreys caught with the fish.

Digging out larvae would be difficult and destructive to the trout food supply.

(17) Swimmer's itch. During the summer of 1939 the Institute co-operated with the State Stream Control Commission by providing a fisheries biologist to ascertain the effects upon fish life of the methods used to check swimmer's itch. It was determined that the treatment of swimming beaches by copper sulphate and copper carbonate did little damage to fish life. Fish were observed to avoid the treated area. Plankton in the area treated is destroyed but is renewed from other parts of the lake within 24 hours. Most bottom organisms are killed but these are few in number and of minor importance to fish life on swimming beaches where the bottom is mainly shifting sand. A thorough ecological study of the snail which carries the parasite causing swimmer's itch has been recommended in hopes that a cheaper and more permanent method of control may be discovered.

New projects recommended for inclusion in the program for the coming biennium are:

(1) Establishment of a fish cultural experiment station to serve as a center for investigation of fish pathology, nutrition and selective breeding.

Research in these fields is badly needed in order to test present methods and to try out new ideas in fish culture.

(2) Inauguration of a district biologist plan. It is proposed to locate a fisheries biologist in each fishery district. His duties will be to assemble all stream and lake survey data to assist the District Supervisor in preparing management plans and to make biological investigations of special problems in his area with aid from the Ann Arbor staff.

It is expected that one district biologist will be added each year until all sections of the state are supplied. In this way it is hoped that science will be brought to bear directly on the problems encountered by the men in the field, enabling them to better develop management methods for the waters under their supervision.

INSTITUTE FOR FISHERIES RESEARCH

A. S. Hazzard, Director