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cc: Dr. Willis Rich
Mr. Ruhl

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REPORT NO. 496

REPORT OF INSTITUTE FOR FISHERIES RESEARCH

The Institute is the research agency of the Fish Division and operates in cooperation with the University of Michigan and Michigan State College of Agriculture and Applied Science. The Conservation Department furnishes funds for salaries, field expenses and equipment; the institutions of higher learning provide working space, access to libraries, museum collections and the advice of many specialists in the fields of aquatic biology. The cooperative arrangement between the Department and the University has been in effect during the past ten years. Cooperation with the College has been of more recent origin as the need for research in fish nutrition and water soils became apparent. The present organization of the Institute not only helps to coordinate fisheries research in the state and makes possible a larger program than could otherwise be undertaken, but also provides opportunities for students working for advanced degrees to secure experience and training in the theory and practise of fisheries biology.

Approximately one hundred reports covering investigations made by the Institute have been filed with the Department during the biennium. A number of these have been published in technical journals or in "Michigan Conservation." Space does not permit a summary of the results secured in these investigations, but the following describes the major projects undertaken and some

of the conclusions reached. References are given to certain of the important publications by the Institute staff.

(1) Lake and stream inventory.[1] Requests for surveys to serve as a

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[1] McMurry, K. C., R. W. Eschmeyer and C. M. Davis. Objectives and Methods in Lake Inventory in Michigan. Paps. of the Mich. Acad. of Sci., Arts and Letts., Vol. XVIII, 1933, pp. 259-276, 5 figs.

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basis for planting and environmental improvement have been increasing during this period. Many of the requests have come directly from property owners, civic groups and sportsmen's organizations. These surveys involve the systematic collection of data concerning the physical, chemical and biological features which appear to be most important in fish production. For example, in lake survey, the first step is to prepare an accurate bottom contour map. The Institute has received much valuable assistance in such work from the Civilian Conservation Corps and the U. S. Forest Service.[2] As sounding can be done most efficiently through the ice, winter

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[2] Miller, Donald E. Michigan Lake Survey--A Cooperative Enterprise. Trans. Am. Fish. Soc., Vol. 66 (1936), 1937, pp. 128-130.

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projects for lake mapping have been welcomed by the CCC organization. Unfortunately few camps have been established in southern Michigan, where a large proportion of the important lakes is found. However, with the aid of the Stream Control Commission a method for cutting holes rapidly with a portable drill has been worked out which will greatly reduce the labor otherwise necessary and should make it possible to sound the lakes in this area at relatively low cost.

The next stage in lake survey is to determine temperatures, water levels, oxygen supply, extent and character of weed beds, fish populations, fish parasites, predators, etc. Such work can only be done during the summer months and requires a crew of trained fishery biologists.

The practical value of lake inventory can best be illustrated by an example. In July, 1937 a survey of Birch Lake, Cass County, was made. Fishing in this lake was reported to have become progressively poorer during the last ten years in spite of liberal plantings of large-mouth bass and bluegills. The inventory showed a considerable volume of deep water with a relatively low temperature, more suited to trout than to the so-called warm water game fishes. Chemical analyses demonstrated an adequate supply of oxygen throughout the hypolimnion (i.e. in the deeper waters below the thermocline unaffected by wind action) even during the period of late summer, a condition which is not often found in southern Michigan lakes.

In the autumn of the same year, lake trout as well as legal brooks and rainbows were stocked in this lake as an experiment. This change in policy has already been justified in that these plantings were successful, a number of nice trout being taken this year. While it may not be possible for all species of trout to reproduce in this lake, the discovery of a lake in this region otherwise suitable for trout is of considerable importance.

In the period covered by this report, 114 lakes in 37 counties have been subjected to such routine surveys. This brings the total number to 302 and supplies much needed information on lakes of several districts of different soil and climatic conditions than those previously examined.

(2) Fish food investigation. Two phases of this investigation have been continued during the past biennium--studies of the feeding habits of

several important game fish and measurements of the available food supply.

In connection with general investigations of game fish production, several thousand stomachs have been collected for analysis. One phase of this study, pertaining to food of naturally hatched brook trout fry, demonstrated[3] that where spawning facilities are satisfactory, there is

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[3] Leonard, J. W. Feeding Habits of Brook Trout Fry in Natural Waters. Paps. Mich. Acad. Sci., Arts, Letts., 23:645-646, 1938.

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also an adequate supply of acceptable food organisms. A novel finding was that the diet of brook trout fry soon after yolk-sac absorption does not differ materially from that of fingerlings at the same time and place. This latter fact is of considerable importance when considering the question of what seasons are best for planting hatchery trout, and is of even greater value in answering the frequently-voiced opinion that a high mortality rate, due to insufficient supplies of suitable food, drastically reduces populations of naturally hatched trout fry.

The fate of an experimental planting of 5,000 Montana grayling fingerlings in Ford Lake, Pigeon River State Forest, has been followed closely since stocking in the fall of 1936. Three sample collections taken for stomach analysis have been reported on,[4] and a fourth is being studied. A

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[4] Leonard, J. W. Feeding Habits of the Montana Grayling (Thymallus montanus Milner) in Ford Lake, Michigan. Trans. Amer. Fish. Soc. 68 (in press).

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separate report dealing with the growth rate and condition of these fish is being prepared. An interesting outcome of the stomach analyses is

evidence which seems to indicate that grayling in Ford Lake express a dietary preference for Odonata nymphs (aquatic stages of damselflies and dragonflies), a group of insects seldom favored by game fishes.

Various fisheries workers have expressed the opinion that legal-length trout feed heavily upon trout fry and fingerlings when these are available in plenty. Proof that such cannibalistic attacks are not universal was obtained from examination of a series of stomachs of legal-length trout taken from a stream carrying an abundance of fry. Not a single stomach contained trout, although muddlers had been consumed.[5]

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[5] Leonard, J. W. Feeding Habits of Trout in Waters Containing a Heavy Population of Naturally-hatched Fry. Copeia, 1938 (3): 144.

Large series of trout stomachs collected in connection with stream census and bottom fauna investigations are at hand, and upwards of five hundred have been analyzed. Reports on the findings are now being prepared.

Collection of trout stream bottom samples, begun in 1934, was continued at selected stations and at periodic intervals throughout the winter of 1936-37. Sorting the invertebrate fish food organisms from such samples is time consuming, but no simpler way of gauging the food supply has yet been discovered. Findings obtained from this work are especially useful in determining the relative productivity of different streams and, it is hoped, will be of aid in drawing up a system of stream classification, one of the most desirable and essential contributions to intelligent and flexible fisheries management. During the biennium, four semi-popular articles on this subject have appeared in "Michigan Conservation."

(3) Fish population studies. The forester can readily check on the results of a planting of pine, but the fish culturist rarely knows how many fish are present in a stream or lake he is stocking or what the actual

results of such stocking may be. Counts of fish populations in two streams and in several lakes were made when these waters were poisoned out preparatory to stocking with more desirable fish. Sections of the two "warm-water" streams in southern Michigan yielded 19,200 and 9,500 minnows per acre of water respectively. The value of such streams in producing minnows for bait or as natural food for game fish is indicated by this study. A rather typical northern bass-sunfish lake of about thirteen acres yielded per acre 1,754 fish, having a weight of 38.1 pounds.[6] Half of another lake

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[6] Eschmeyer, R. W. Analysis of the Complete Fish Population from Howe Lake, Crawford County, Michigan. Paps. Mich. Acad. Arts, Sci., and Letts. 1938.

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made up of two connected basins yielded 1,262 fish per acre (21.8 pounds per acre) but of this number only 2.7 legal-sized game fish per acre. This lake is one of a number studied in which over-population from natural spawning had resulted in dwarfing to the point where fishing was useless. It is concluded that in a rather surprising number of lakes in Michigan better fishing may result from reduction in the fish population rather than adding to it by hatchery stock.

Sections of three trout streams were blocked and seined intensively and yielded from none to 142 legal trout per acre.[7] Repeated counts during the summer showed a great variation in the number of trout and other

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[7] Shetter, David S. and Albert S. Hazzard. Species Composition by Age Groups and Stability of Fish Populations in Sections of Three Michigan Trout Streams During the Summer of 1937. Trans. Am. Fish. Soc., 1938.

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fish in the same sections. How typical such counts are cannot be determined until a much larger number of different types of trout habitat can be investigated.

(4) Creel census (fish yield).[8] Records of individual fish catches

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[8] Eschmeyer, R. W. The Michigan Creel Census. Proceedings of the North Am. Wildlife Conf., 1937.

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have been taken by Conservation Officers and submitted to the Institute for tabulation and analysis. These are taken at random during every month of the year in connection with regular patrol duties and since they cover most of the important waters of the state, furnish a valuable index to the quality of the fishing. This type of census was begun in 1927 and has operated continuously since. More than 100,000 fishing records have been submitted during this period. For the calendar year 1936 (the last period for which the census has been compiled), 20,543 records were submitted. The average catch per hour was 1.5 legal fish. Fish were caught more readily in southern Michigan but the average size was smaller than in northern Michigan, where pike and walleyes are of greater importance in the catch. Four out of five trout reported were brook trout, although a comparison with previous years shows the proportion of brown trout to be increasing. Certain species predominate in the catch in certain districts. For example, the southern counties yield the most bluegills; the northern counties, the most pike, walleyes and perch. This variation undoubtedly reflects the natural range of these fish and indicates the waters to which each are generally best suited.

In addition to the general census, special censuses have been conducted for the Institute by the CCC or by the Department's employees. These

intensive censuses cover as near to 100 per cent of the fishing on a lake or section of trout stream as can be secured in contrast to the random sample taken in the general census. A study of the fish yield in Fife Lake for four successive fishing seasons shows a constant decline in the catch of some species and a corresponding increase in the catch of others. The total take remained relatively constant from year to year; an increase in fishing intensity of 92 per cent resulted in an increase in take of only 16 per cent.[9]

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[9] Eschmeyer, R. W. Summary of Fishing for Four Seasons on Fife Lake, Michigan. Trans. Am. Fish. Soc., Vol. 68, 1938, (in press).

The relation between summer and winter fishing is being investigated by means of intensive census. This problem has not been thoroughly studied on southern Michigan lakes but for the balance of the state censuses show that in general ice fishing cannot be held responsible for depletion of the lakes (if serious depletion ever exists). For six lakes censused in both winter and summer, more fish were removed during one day of summer than were taken during the entire winter.[10] Relatively few lakes are fished

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[10] Hazzard, A. S. and R. W. Eschmeyer. A Comparison of Summer and Winter Fishing in Michigan Lakes. Trans. Am. Fish. Soc., Vol. 66, 1936, pp. 87-97.

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in winter and the average catch per fisherman-hour is invariably much lower than in summer. Furthermore, many of the species taken most commonly in winter are of relatively little importance in summer fishing, and since they are mostly predacious, it may be that fishing for bass and bluegills is actually improved as a result of controlling the pike, walleyes, perch

and crappies which make up the majority of the winter catch.[11] In recent

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[11] Hazzard, Albert S. and R. William Eschmeyer. Analysis of the Fish Catch for One Year in the Waterloo Project Area. Paps. Mich. Acad. Sci., Arts and Letts. 1937.

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years bluegills have been taken in large numbers through the ice on certain Michigan lakes, mostly in the southern part of the state. Investigation into the extent and importance of this removal is now in progress.

A special, volunteer creel census by experts was inaugurated in 1937. Reports were received from 71 anglers. These men took almost twice as many trout per hour as the average fishermen in the 1936 general census, but only about one-fourth more warm-water fish than the average man in that census. This census also showed that even the expert draws blanks on some days--to the extent of 13 per cent of the total.

Intensive censuses were conducted for the Institute by the CCC on sections of six trout streams during the seasons of 1937 and 1938. In 1937 the average catch per fisherman-hour was found to vary from 0.2 to 0.77 legal trout per hour. The effect of experimental plantings of marked legal-sized trout in three of these streams was demonstrated by these creel censuses.[12] The catch per hour in the Pine River, where the bulk of these

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[12] Hazzard, Albert S. and David S. Shetter. Results from Experimental Plantings of Legal-sized Trout. Trans. Am. Fish. Soc., Vol. 68, 1938, (in press).

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plantings was concentrated, was better than half again as large as the average for the other streams. However, much of this increased yield appeared to be due to the greater number of wild fish taken following each

planting of large hatchery fish. If this happens generally following such stocking, there appears to be grave danger of depleting the stock of adult trout. Comparative results from fall, early spring and open season plantings of legal-sized trout are being secured from experimental stocking of marked fish and intensive censuses.

(5) Fish tagging and marking. In addition to the food habits, food supply, stream census and fish population investigations referred to in previous sections, other factors concerning the maintenance and improvement of trout fishing are being investigated. The jaw-tag method of marking trout[13] developed earlier by the Institute has been used extensively in

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[13] Shetter, David S. The Jaw-tag Method of Marking Fish. Paps. Mich. Acad. of Sci., Arts and Letts., Vol. XXI, 1935.

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a number of streams. A total of 8,156 brook trout, 4,325 rainbow trout and 200 brown trout have been tagged by this method during the past two years. Reports of capture by cooperating anglers have shown that the rainbow migrates extensively but that brook and brown trout are more sedentary. Further information on the habits of brown trout is being sought by this method. Such reports are also useful in showing the growth made by the different species after release.

Marking trout by the removal of one or more fins has proven to be useful in mass experiments where the success of a certain planting is to be determined. However, because the absence of these fins may be overlooked by many fishermen, this method cannot be used unless well-trained census crews are able to patrol the waters stocked with such fish. The following numbers of trout have been marked in this fashion: 12,271 brook trout, 7[illegible],494 rainbow trout and 1,500 brown trout.

(6) Fish predation. As stated in the Institute's report for the preceding biennium, investigations of predators of fish were interrupted when Mr. J. Clark Salyer left the Institute staff to become head of the newly established Division of Wildlife Refuges of the U. S. Bureau of Biological Survey. However, since the question of the economic significance of winter concentrations of mergansers (fish-ducks) on trout streams continued to be a vexing one, members of the staff patrolled a number of waters during the winter of 1936. Population densities were studied and, with the aid of Conservation Officers, a series of 98 mergansers was collected for stomach analysis. Results of this study[14] led to the conclusion that

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[14] Leonard, J. W. and D. S. Shetter. Studies on Merganser Depredations in Michigan Trout Waters. Trans. Amer. Fish. Soc., 1936. 66:335-337.

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merganser control measures should be adopted in special cases, but that broad control is necessary and economically justifiable only during excessively cold periods of short duration.

During February, 1937 a cooperative arrangement was made with the American Wildlife Institute and the University of Michigan whereby Mr. Karl F. Lagler is continuing the inquiry into the extent and severity of fish losses due to the activity of fish-eating birds, mammals, turtles and watersnakes.[15] A further purpose is to determine what are the effects

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[15] Lagler, Karl F. Fish Predation Investigation. American Wildlife. 1937. 26(6)86-87, 92. (Gives details of organization and summary of problems being attacked.)

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of predation of game-fish populations, and what may be done to relieve situations of harmful predation where they exist.

Data have been gathered on the animals responsible for losses of fish at hatcheries and rearing stations. The great blue heron, American bittern, kingfisher, American merganser, watersnakes and garter snakes have demonstrated themselves as capable of destroying fish in numbers vitally significant to the practical fish culturist.

The most common method currently used in predator control, which the sizable losses from predators seems to demand, is shooting. Returns on a questionnaire sent to all hatcheries in the United States show that of the 240 hatcheries replying, 227 used shooting as a protective measure against bird depredations. The effects of this practise in holding down losses of fish as well as the effect on the species of birds involved are being studied. Realizing that the wholesale execution of predatory animals about fish cultural establishments is hardly commensurate with the best in conservation ethics, devices are being tested in hopes of finding means for reducing hatchery losses by excluding predatory forms or frightening them away rather than by killing them.[16]

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[16] Lagler, Karl F. Cooperative Studies on the Predators of Fishes in Michigan. Paper presented to Michigan Acad. Sci., Arts, and Letters. March 19, 1937. (Emphasizes role of fish-eating birds at fish hatcheries and reports experimental control projects which are under way.)

The most readily accessible index to the role of fish-eating animals is a knowledge of their food habits and life-ways. To this end, detailed observations and numerous specimens of the great blue heron, American bittern, green heron, kingfisher, mergansers, and other birds, watersnakes, garter snakes, and turtles of the nine species native to Michigan have been collected from sample areas over the whole state. Detailed analyses

of the food of these animals as found in the contents of their stomachs at the time of collection are rapidly becoming available.

Better procedures in control of forms proven noxious may result from these studies. Added protection, based on fact, may be given unjustly maligned species.

(7) Trout nutrition experiments. The steadily increasing cost and scarcity of meat products which formerly made up the entire diet of hatchery trout have necessitated experimentation with meat substitutes. Research in other states and by the U. S. Bureau of Fisheries had demonstrated that a certain amount of fresh meat was required to produce healthy fish but that a combination of this meat with certain dried meals would result in larger fish and at much lower cost than with meat alone. In order to determine the applicability of this work to Michigan hatcheries and to test these diets and other combinations on a larger experimental scale than had been attempted elsewhere, the entire series of troughs at the Wolf Lake Hatchery and later the raceways at the Benton Harbor Station were turned over to the Institute during the season of 1937 following preliminary experiments at this hatchery in 1936.

Laboratory facilities at Michigan State College have been used for the analyses of food-stuffs; and specialists in animal nutrition at the College have given freely of their time and services in offering suggestions and in making chemical analyses of the diets.

Such materials as white fish meal, skim milk powder, cottonseed meal, oatmeal, alfalfa meal, dried Greenmilk, grasshopper meal, and both dry and canned dog foods have been used in different amounts as supplements for expensive fresh meats, chiefly beef liver, sheep liver and pork spleen. Excellent growth and low mortality have resulted from some of the diets containing a considerable per cent of dry material. These experiments

have demonstrated that by the use of dry meals the cost of the food required to produce one pound of trout can be reduced to two-thirds of the cost to produce trout by fresh sheep liver alone.

(8) Forage fish and bait minnow production. Forage fish, that is, the true minnows, darters and the young of other fish such as suckers and game species make up the principal food of perch, crappies, bass, pike and walleyes, etc. Likewise these forage fish, except for the young of protected species, are used to a great extent as bait "minnows." Since the number of these fish taken by bait dealers and fishermen may impair the natural food supply, it is obviously important to learn how this source of food can be increased in lakes and streams and how the most popular bait minnows can be grown artificially. This research project was begun by Mr. Gerald P. Cooper in 1934[17] but was discontinued upon his resignation.

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[17] Cooper, Gerald P. Some Results of Forage Fish Investigations in Michigan. Trans. Am. Fish. Soc., Vol. 65, 1935 (1936), pp. 132-142.

Completion in 1937 of ten identical minnow ponds at the Drayton Plains Hatchery made possible the initiation of actual experiments in forage fish culture and the investigation was resumed.

The purpose of these experiments is to obtain essential data on life history and production in order to raise forage fish for: 1. stocking depleted or deficient lakes and streams; 2. use in feeding at hatcheries; 3. supplying information to Michigan bait dealers desiring to raise or hold minnows; 4. evaluating the relative merits of the different forage fish as food for game fishes.

During the spring and early summer of 1937 and 1938, brood stocks of golden shiners, bluntnosed minnows, fat-headed minnows, mud minnows, and horned dace were obtained by seining in various lakes and streams in

southern Michigan.

Several quarts of eggs each of common sucker and northern pike were also obtained in 1937 and were successfully hatched by the jar method. The resultant fry were placed in ponds and a study was made of their growth and feeding habits.

All of the above experiments are still in operation and as yet none of the data obtained has been worked up in report form.

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In addition to these major investigations, progress has been made on a number of other problems. The cause and possible alleviation of "winter-killing" of fish under the ice has received some attention. Four lakes near Ann Arbor where partial or complete suffocation of fish occurred during 1935-36 were tested at intervals of two weeks during the winter of 1937-38. As long as the ice, though thick, remained relatively free of snow, the oxygen content was high, but during several brief periods of heavy snow cover, the amount dropped rapidly. However, as in most winters, thaws developed before a critical condition was approached so that no experiments could be carried on to determine the effectiveness of several methods which have been developed to raise the oxygen content.

Poriodic check-ups of experimental stream improvement installations have been continued and have demonstrated the types of structures best adapted to Michigan streams. A limited amount of general supervision and advice has been given the CCC in connection with the extensive improvement program carried on for the Department by this agency.

Lake improvement work had advanced during this biennium to the point where the publication of a text on this subject seemed desirable.[18]

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[18] Hubbs, Carl L. and R. W. Eschmeyer. The Improvement of Lakes for Fishing. Bulletin No. 2, Inst. for Fish. Res., Mich. Dept. of Cons., 1938; 233 pp., 74 figs.

Although many of the methods suggested have not been fully tested, it is believed that this book will fill a need in the field of lake management. At present the Institute is evaluating the use made of brush shelters by the different species of fish and the extent to which gravel spawning beds are utilized by the nest-building game fishes.

Studies of the life history and distribution of fishes in Michigan, a cooperative project involving the Museum of Zoology of the University of Michigan, has been continued actively and should eventually result in a publication on Michigan fishes which has long been needed.

Fish parasite and disease investigations have progressed slowly because of limited funds which could be devoted to these projects. In cooperation with the Department of Zoology of the University of Michigan, seasonal studies of the fish parasites in a small lake near Ann Arbor showed that contrary to popular opinion (at least in this lake), the black spot and yellow grub parasites were as numerous in winter as in summer and that in the perch apparently growth was stimulated rather than inhibited by such parasites. Experiments in the control of parasites of fish in wild waters and of hatchery diseases are considered desirable in the future research program of the Institute.

Through the cooperation of Michigan State College, an investigation of water soils was begun in 1937 and is to be expanded during the next biennium. The purpose of this research is to classify water soils in somewhat the same manner as farm soils have been classified and to determine whether it is practicable to fertilize where deficiencies are apparent in order to increase the crop of water plants which are so essential to good fish production.

The greatest need in fisheries research at present appears to be the establishment of experimental streams and lakes where methods of planting, environmental improvement and various regulations can be tested under

controlled conditions. Such waters would correspond to agricultural experiment stations where methods of planting, cultivation, fertilization, drainage, etc. are intensively investigated in check plots. Such stations should include representative waters in each major climatic or soil type. Authorization for the establishment of an initial experimental stream was granted by the Commission in 1937, but difficulties of acquisition and later budget restrictions caused postponement of the project. Until such experiment stations are established and functioning, present methods of fish management and new ideas in the field cannot be tested. Until conclusive proof is available, the value of fish planting, environmental improvement, legal restrictions, etc. must remain open to question.

INSTITUTE FOR FISHERIES RESEARCH

By A. S. Hazzard
Director

SCIENTIFIC AND BIOLOGICAL

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A-15. Fig. 1. Lake Inventory.--The first step in lake inventory is the preparation of a map showing outline, depths, vegetation, and bottom types.

A-11. Fig. 2. Lake Inventory.--What species of fish will a lake best support? Water tests help to provide an answer.

F-124. Fig. 3. Fish Populations.--By counting the fish in a measured section, the normal number per mile of stream may be calculated.

F-57. Fig. 4. Jaw Tagging.--Trout are marked with a numbered tag, then released. Upon subsequent capture, their rate of growth and their movements may be determined. Photo by Jack Van Coevering.

A-3. Fig. 5. Winter Kill.--When shallow lakes lacking inlet or outlet are thickly covered with snow and ice, fish may suffocate. Photo by F. W. Ouradnik.

K-12. Fig. 6. Winter Fishing.--Is this harmful? Creel census projects, revealing a lake's annual fish crop, provide an answer.

H-8. Fig. 7. Disease.--Fish diseases and parasites are growing in importance. Further study is most desirable.

G-6. Fig. 8. Food Supplies.--Throughout the greater part of the year, trout feed on the bottom. Abundance of food is measured to determine its adequacy.

For Biennial Report
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SCIENTIFIC AND BIOLOGICAL

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STATE OF MICHIGAN

DEPARTMENT OF CONSERVATION

LANSING

P. J. HOFFMASTER, DIRECTOR

September 8, 1938

Dr. A. S. Hazzard, Director
Institute for Fisheries Research
Ann Arbor, Michigan

Dear Dr. Hazzard:

We again have to consider the biennial report, the material for which the Director suggests should be in Mr. Paquin's hands not later than October 15. I should like to have you prepare the section of the report covering the activities of the Institute for Fisheries Research during the biennium.

It would be appropriate also to submit a series of pictures if you have them that may be typical of some aspects of the work. The Director has suggested the possible use of more pictures and I have in mind that it may be possible to group a series of small pictures on a full page or in some other style that will tell a good story.

Very truly yours,

F. A. Westerman

F. A. Westerman
FISH DIVISION

FAW:gf