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Region II, Fish
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INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

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UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

Report No. 1692

June 2, 1964

LAKE MAPPING AND LAKE AND STREAM INVENTORY IN MICHIGAN[1]

by

C. M. Taube, P. M. Earl, E. E. Schultz,

T. M. Stauffer, and W. C. Wagner

The objectives of this report are to enumerate the accomplishments of lake mapping and fishery inventory in Michigan, outline such work that remains to be done, review the methods, and recommend future procedures. The inventories that will be considered are those of a routine nature, rather than the specialized kinds that are performed in some research projects.

Several references provided basic information on the extent of our inland water resources. Brown's data (2 and 3) were used for the total numbers of lakes and miles of streams. These are the most complete numerical inventories available. A current compilation (9) of Michigan lakes promises to be more comprehensive than Brown's, but data on only 43 counties are published so far. County maps issued

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[1] Contribution from Dingell-Johnson Project F-27-R-2.

by the Conservation and Highway departments and a list of public fishing sites (1) helped to determine the number of unmapped public lakes. Information was obtained on mapping and inventory work of other states. The replies to a questionnaire sent to the fishery agencies of Indiana, Kentucky, Minnesota, New York, and Wisconsin are appended.

The Michigan Fish Commission sponsored the first fishery inventories of our lakes; these were conducted from 1885 through 1892. This work included drawing small, free-hand outlines of the lakes (including some soundings), fish collecting with gill nets, observations on the condition of the fish, available foods, etc., and recommendations on stocking. The data from each body of water were entered on a printed form. Investigations were made of 459 lakes in 34 counties of the Lower Peninsula (5). All but a few of the original records were bound in cloth (14), and now are in the library of the Institute for Fisheries Research. These accounts of the brief, pioneering studies are interesting, and have some value, especially in an historical sense. For instance, they bear proof that fishery problems existed even in the "good old days," contrary to popular opinion.

Biologists from the University of Michigan conducted some lake and stream surveys for the Department of Conservation in the early 1920's, and a full-time man (Jan Metzelaar) was employed for such work and other fishery investigations in 1924 (5). With the establishment of the Institute for Fisheries Research in 1930, lake mapping commenced

and inventory accelerated (4 and 5), and have continued as Department of Conservation functions to the present time. The Fish Division's research unit has done the bulk of this work, but the management and habitat improvement sections have performed a considerable amount of it since 1948. The Institute's programs of recent years have been substantially supported with funds provided by the Federal Aid in Fish Restoration Act (Dingell-Johnson)--since 1952 for biological inventory, and since 1953 for lake mapping.

There is little doubt as to the value of lake maps and inventory data for guidance in fishery research and management. While the records are used chiefly for these purposes, they also provide direct public services; map prints are sold at approximately the cost of printing and mailing them, and the inventories afford information that frequently is requested by anglers and other users of the inland waters.

Lake mapping

Accomplishments. As of May 1, 1964, 2,599 Michigan lakes have been mapped, including 108 that are private. Data on their distribution appear in Figure 1. Not included in the total number are a few lakes whose maps have been withdrawn from circulation, and a few others for which maps were prepared but not printed.

The policy has been to map only lakes that are accessible to the citizenry; these are classified as either "public" or "semi-public."

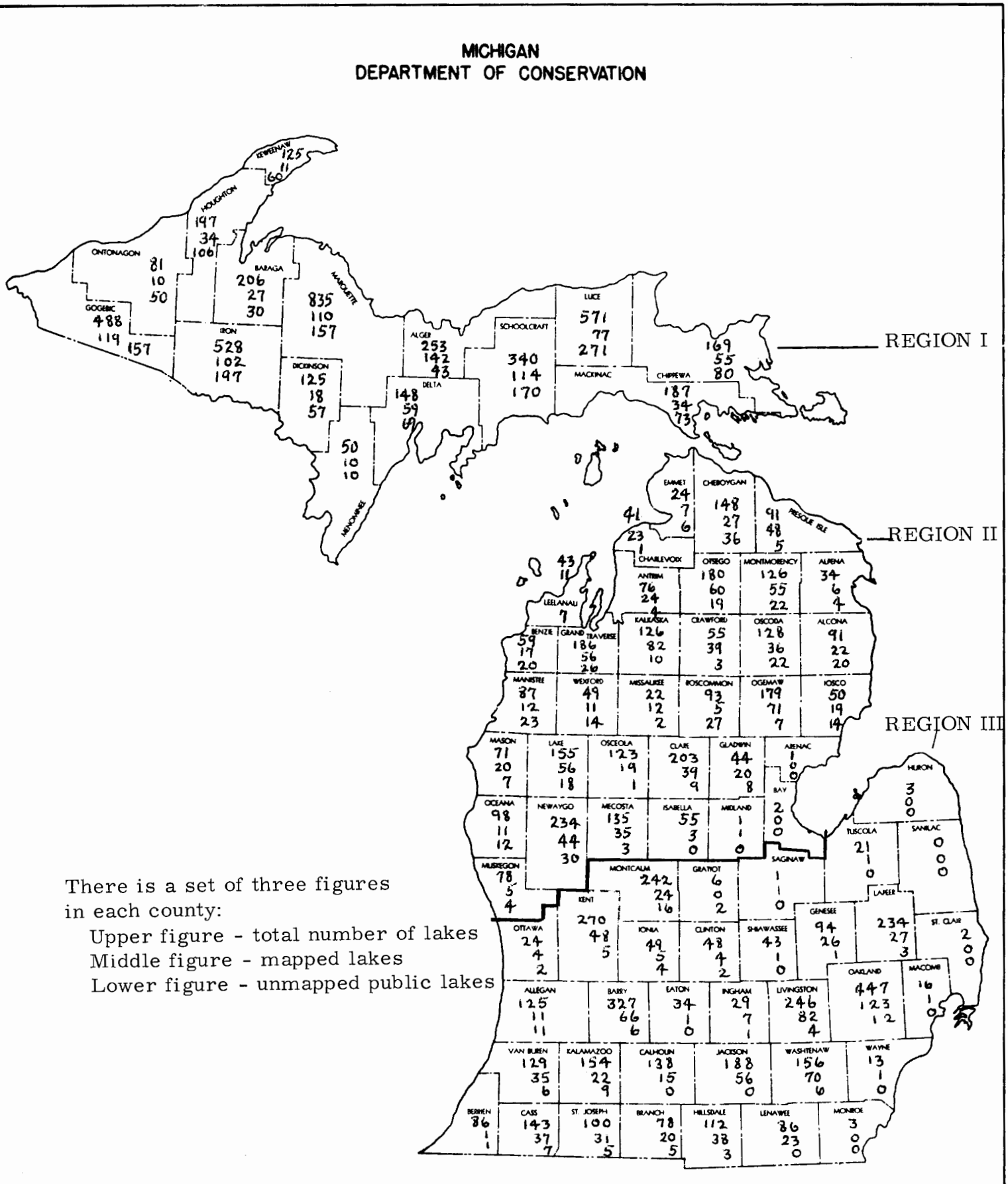

Figure 1. --The distribution of Michigan lakes: total number by county (according to Brown); mapped lakes; unmapped public lakes.

Public lakes are those on which some governmental unit owns frontage. Semi-public lakes are without such frontage, but have boat liveries or commercial resorts, or are largely owned by land-holding companies that permit public usage. Some private waters have been mapped by state employees on a consultant basis; others were charted when they were semi-public, but later became private. Extensive decline of the boat rental business within recent years has closed a considerable number of lakes to public usage.

The Fish Division has done most of the mapping, with some assistance from other divisions of the Conservation Department. The U. S. Forest Service charted approximately 530 lakes in the 1930's and early 1940's. Federal relief agencies--the CCC (Civilian Conservation Corps) and the ECW (Emergency Conservation Work)--provided personnel during the economic depression in the 1930's; there are about 440 maps of this origin. The Corrections Department furnished man power in recent years, as did the APW (Accelerated Public Works) in 1964. Charts provided by electric power companies and the U. S. Lake Survey were the bases for a few maps.

Remaining work. A reliable figure on uncharted lakes that deserve mapping cannot be determined at this time. Information on the extent of unmapped semi-public lakes is sketchy, except that we know that there are few in Region III. Although the number of unmapped public lakes can be determined closely, it is not known how many are worth mapping; many of this category are very small. Of the 508 lakes that have public fishing sites, 430 (86%) have been mapped. Of all the

unmapped public lakes (with fishing sites or other government-owned frontage), 1,530 are located in Region I, 384 in Region II, and 34 in Region III. Figure 1 illustrates their distribution by county and also shows the bounds of the Conservation Department's current administrative regions.

An undetermined number of lake maps need to be replaced because of inaccuracies. Others, of early origin, are drawn to very small scale, generally are crowded with details, and some show depths in meters rather than feet. The lakes involved in this group, numbering about 50 and located mostly in Kalkaska County, should be redone also. Some unsatisfactory maps have been replaced.

A subsidiary job deserving early attention is that of replacing old bench marks and adding new ones. The system of providing a bench mark and noting water level data for every lake as it is mapped was begun in 1943. Many of the old reference marks have become obscure (mainly from overgrowth in trees), and some are lost. Concerted effort should be made soon to find these monuments, replace obscured reference objects, and establish additional monuments. Since 1959 the mapping crews have been asked to provide three bench marks for each lake.

Methods. At first, our mapping was done on open water by traverse or triangulation and sounding from a boat. The winter method (4) has been used mostly since 1935. Some mapping has been done with

fathometers, beginning in 1953; a direct-reading instrument was employed the first year, and a recording model thereafter.

These are some of the advantageous aspects of the fathometer method: It requires only two men per crew, whereas winter mapping requires three. Sounding with the instrument progresses much faster than manually. Inclement weather is less likely to occur in the open-water seasons. Excessive snow, extremely thick ice, or too thin ice are other handicaps encountered in winter.

However, obstacles may also confront the newer technique. Very dense vegetation interferes with the function of the sonic instrument, and occasionally the aerial photos that are used for constructing the lake outline are unsatisfactory. The first disadvantage can be overcome by working on very weedy lakes in early spring or late fall. When the photo of a large lake is inadequate, mapping in winter may be required; the outlines of small lakes can be prepared over open water with a telescopic alidade.

Following is a comparison of the efficiencies of the systems. During 1953-1955, the same number of lakes (135) were done by each method. Four 3-man crews mapped in the winter of 1953, five crews in 1954, and two in 1955; the total effort amounted to about 600 crew-days. One 2-man crew did all the mapping with fathometers on open water in about 450 days. The mean area of the lakes was 105 acres (winter method) and 305 acres (fathometer method). The average rate of mapping coverage per crew-day by the respective methods was 24 acres and 91 acres.

Indiana, Kentucky, Minnesota, and New York now use the fathometer method exclusively, and Wisconsin uses it for the most part.

These figures give some idea of the cost of lake mapping: From 1953 through 1957, a total of 365 Michigan lakes (from 2 to 18,000 acres, mean of 168 acres) were charted by either of the two methods at an average cost of $300 per lake. This expenditure included charges for field work, equipment, drafting, and administration of the program.

Recommendations

1. As lake mapping is not a research activity, it should be a function of the Fish Division (or Section) rather than of the recently established Research and Development Division (or Section). By this assignment the breakdown to job responsibilities might be:
   (a) preparation of the basic maps--the district fisheries supervisors;
   (b) drafting--the Engineering Division (or Section);
   (c) distribution of prints--the Lansing office of the Fish Division's fish management unit.
2. Districts that contain the larger numbers of unmapped public and semi-public lakes should be given priority; elsewhere, mapping would be done to fill urgent needs until a major portion of it has been done in priority areas.

3. For the sake of efficiency, lake mapping in the future should be done mostly by the fathometer method. Equipment to outfit three crews probably would be adequate; the equipment and crews could be assigned to different districts from year to year. The winter-season, grid method should be employed only when the fathometer method is not practicable--for example, instances involving unusable aerial photos of large lakes, and lakes that harbor numerous protruding snags.

4. Replacement of old bench marks and addition of new ones on previously mapped lakes should be given early attention. The bulk of this work might be done in winter when other activities demand less attention.

5. The mapping crews should be furnished printed instructions to assist in the preparation of maps that will meet desirable standards of accuracy, completeness, and uniformity. The current instructions (8 and 12) need to be revised and consolidated. As the Institute for Fisheries Research has conducted the largest share of the lake mapping done in the past and therefore is the unit most familiar with the procedures, we would be willing to draw up a methods manual, with assistance from the management unit of the Fish Division.

Lake inventory

Accomplishments. Routine biological studies of lakes are classified as either "complete" or "partial" inventories. Investigations of the first order include determination of water temperatures, chemical analysis of the water, intensive fish collecting, age and growth determinations, usually an examination of the vegetation, and preparation of a Lake Summary card in detail. Partial inventories involve only a portion of such work.

Inventory has been confined to public and semi-public lakes, excepting a few private waters investigated by state employees on their own time. Some lakes that were open to public use when inventoried now are private.

Since 1930, complete inventories have been made on approximately 1,000 lakes (public, semi-public, and private) by various units of the Fish Division. Brief studies have been made on many others. Complete inventories have been conducted on 251 (49%) of the 508 lakes that have public fishing sites. The Institute's lake inventory program was sharply curtailed after 1957, and virtually discontinued after 1960, due to budgetary revisions.

The work done by the Institute during 1949-1957, when the lake program was especially active, affords some idea of the rate of accomplishment. From two to four crews (one composed of two men, the others, three) operated during three summer months annually. In

this 9-year period, complete inventories were made of 342 lakes, including 30 whose areas exceed 1,000 acres.

Remaining work. Fewer lakes have been intensively inventoried than mapped because this work has received less attention than mapping and it requires more time. A reasonably accurate figure on the lakes that are left to be done cannot be determined now. An estimate would be governed by the degree of emphasis administrators wish to give the project, whether semi-public waters will continue to be included and, if so, how many lakes there are of this status. However, if inventory is to receive major attention, we can say that a large amount of it is still to be done. Moreover, important waters that were investigated long ago probably should be reinventoried. Also, the activity might well be expanded to include explorations for additional sport fishing grounds on inshore areas of the Great Lakes.

Methods. Our procedures of routine inventory have been altered variously since the early days. Sampling of plankton and bottom fauna was discontinued long ago. The chemical and vegetation analyses have been simplified considerably, and fish collecting has been intensified. Formerly, tests were made for carbon dioxide, phenolphthalein alkalinity, and pH as well as dissolved oxygen and total alkalinity; only values of dissolved oxygen and total alkalinity are determined presently. Previously, aquatic vegetation was collected at stations and the plants identified later by a systematist; now the more important plants are identified to genus on location and the abundance of each is determined for the entire lake.

The procedures now employed by other states are similar to ours. Generally, the methods in current use appear worthy of continuation. Perhaps some new kinds of equipment would increase the efficiency of obtaining data and samples. One such item is an electrical oxygen meter. An electric shocker unit, to supplement nets and seines, may help obtain more representative samples of fish. Wisconsin uses a boom shocker in lakes; a similar model has been built and tested briefly in Michigan. If the work were extended to the Great Lakes, some special equipment and methods doubtless would be required.

Recommendations

1. Routine biological inventory of lakes also more properly belongs under the supervision of the Fish Division than under the Research and Development Division. The fish management unit has done much of this work in recent years; it is recommended that this unit be largely responsible for lake inventory in the future. The Institute for Fisheries Research could cooperate in the program to some extent--in such details as identifying the less familiar species of fish, testing new equipment, etc.

2. Initial, complete inventories probably should be confined to the more important public lakes, and those scheduled for new management practices. Evaluation of management practices likely will continue to comprise a large portion of the inventory effort. The degree of emphasis that should be placed on inventory and the personnel needs must, of course, be determined by the administrators.

3. Systematization and thoroughness in collecting materials and recording data are highly important in this work. Concrete guide lines for the field crews and close adherence to established procedures are essential. Revision of extant instructions (6 and 7) may provide sufficient guidance, or perhaps a new manual similar to the one used in Minnesota (10) should be written. The Institute, with help from the fish management unit, could assume the responsibility of preparing a manual.

Stream inventory

Accomplishments. The intensity of stream inventory also has varied considerably. Some streams have been covered quite thoroughly, but only a single, small section has been examined on many others. A significant segment of the early effort is the fish collecting that Lowe did, mostly in the Upper Peninsula, during 1920-1938 (13).

Stream-system studies represent the most intensive work that has been done in routine inventory. (For this discussion a "stream system" is defined as a major stream and its tributaries which may or may not constitute an entire "drainage system." A "drainage system" is defined as a stream, plus all of its tributaries, whose flow enters one of the Great Lakes directly.) Much of the stream-system kind of inventory was done in the 1950's on stream systems that were being considered for habitat improvement programs. Entire systems or major portions that have been investigated to date number 18 in Region I, 7 in Region II, and

3 in Region III. Of 39 major drainage systems, stream-system inventories have been made of 5 in entirety and of 16 others in part.

Other inventories have been conducted since 1955 to determine the streams that are inhabited by sea lampreys. Although the main objective was to locate larval lampreys, the procedures were similar to those of routine surveys, except that less effort was made to capture sizeable game fish. This work was done mostly in the Upper Peninsula, to a lesser extent in the northern part of the Lower Peninsula. About 150 individual streams were investigated during 1955-1960.

Beginning in 1960, studies that particularly concern pollution, but which correspond to routine inventories in some degree, have been conducted on large portions of eight southern streams.

On the whole, less inventory work has been done on Michigan streams than on lakes, and far fewer incidental jobs have been performed on streams.

Remaining work. Stream inventory would be a large program if it were decided that biological information should be accumulated on all significant streams that are accessible to the public. Michigan has over 36,000 miles of rivers and creeks of all categories (3). Drainage systems that probably deserve detailed study are the St. Joseph, Grand, Muskegon, Manistee, Boardman, Saginaw, Au Sable, Cheboygan, Manistique, Menominee, Sturgeon (in Baraga, Keweenaw, and Ontonagon counties), and Presque Isle.

It is likely that many streams require inventory to permit proper assignment to the categories outlined in a new policy for stocking trout.[2]

Public access to unnavigable streams would be an important matter in planning an extensive inventory program. If free access were a requisite, it is likely that many streams would not qualify for study, especially in the southern counties.

Methods. Our methods of stream inventory have varied widely. Some procedures of the early work, such as chemical and vegetation analyses and bottom-sampling, have been discontinued. Electric shockers have displaced seines as the principal fish-collecting gear. The original shockers operated on alternating current; DC shockers supplanted these units. Also, the system of sampling has differed significantly among contemporary crews. The main jobs now are fish collecting, age and growth analysis, and notation of physical aspects of the stream and its borders.

Development of adequate fish-collecting equipment has presented a continuous challenge. Mainly DC electric shockers of 230-volt capacity have been used in recent years in Michigan. This unit is fairly efficient in many situations, but has great limitations in large and deep streams; water of low conductance reduces its effectiveness appreciably. Further, its use generally is prohibited on creeks too small to accommodate the boat that carries the generator.

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[2] Letter to fishery personnel in Field and Staff, "Utilization of hatchery trout in Michigan," by James T. McFadden, April 6, 1964.

A capacitator-discharge shocker, powered by storage batteries and producing pulsed direct current, is now under construction. It will be less bulky than the generator model, noiseless, and fumeless. Its electric output is expected to be about equal to that of the generator-powered equipment, but perhaps the unit can be adapted to be more effective on low-conductance streams. This shocker will cost about $300; the cost of the generator unit is approximately $600.

The new shocker will be inadequate in certain situations, too, so there is need for auxiliary gear. Perhaps a specially designed shocker, similar to the boom model that has been mentioned for lakes, can be developed for large, deep streams. A back-pack unit might be used on small, brushy streams; however, the efficiency of presently available models is poor.

A report reviews evaluations made recently of various electrofishing equipment (11).

Recommendations

1. Like lake mapping and inventory, routine stream inventory should be the concern primarily of the Fish Division.

2. Investigation of trout streams that will facilitate their classification for stocking appears to be of first-order importance; information is available for some waters, but is lacking on many others. Much remains to be learned of the fishery resources and potentials of large warm-water streams; valuable knowledge of them could be obtained by inventory.

3. Improvement of uniformity in operational techniques and methods of recording data is needed for stream inventory work. Uniformity is necessary for reliable evaluation of data that are collected by various crews. For example, shocking procedures should be standardized to some degree, conductivity values should always be obtained, and the boundaries of sampling stations must be described sufficiently to allow their recognition for possible replicate studies. Specific instructions should be prepared to achieve a desirable degree of systematization. With help from the Fish Division, the Institute for Fisheries Research could undertake preparation of a methods manual.

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INSTITUTE FOR FISHERIES RESEARCH

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APPENDIX

A questionnaire sent to the fishery agencies of five states and the letters received in reply

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

GERALD P. COOPER PH.D.
DIRECTOR

March 23, 1964

ADDRESS
UNIVERSITY MUSEUMS ANNEX
ANN ARBOR, MICHIGAN

Dear Mr. _____:

Knowing that your fisheries section has conducted programs of lake mapping and lake and stream biological inventories, we would like to obtain information on each of these activities as it has been carried on in your state. We desire to know what other agencies have done because we are re-evaluating the programs for Michigan, anticipate some revision of their scope and techniques, and suppose that we can get some good ideas from other people. Following are specific questions, and perhaps the respondent would have additional comments.

1. How extensively has each lake mapping, lake inventory, and stream inventory been carried out in your state, and what is the ultimate goal as to the number of waters that are to be covered?

2. If lake mapping is done with an echo sounder, how do you obtain the shore outlines for the maps?

3. What kinds of information are obtained in your biological inventories?

4. What kinds of equipment are used for collecting fish? Have you found some particular gear or method to be especially effective? If electric shockers are used on streams, which type (or types) has been most successful in your work?

5. For which chemicals are tests made in water analyses of lakes?

6. Do you make population estimates of stream fish populations? If so, would you please describe your method briefly?

7. In each lake mapping, lake inventory, and stream inventory, have you developed special procedures or equipment that have proved highly useful? If so, would you please describe them briefly.

In anticipation that you may like to know something about our lake mapping and inventory programs, I shall comment on them.

About 2, 500 of the 11, 000 Michigan lakes have been mapped. Probably most of the public and semi-public lakes have been charted. In the beginning, mapping was done both in winter (by the grid method) and in summer (by either the baseline or traverse method and hand sounding). Later, almost all of this work was done in winter. In recent years open-water mapping was resumed to some extent, with a recording fathometer and aerial photos as bases for drawing the shore outline. The kinds and distribution of bottom soils are shown on most of the maps by coloring with crayons. Reference marks are established on shore to show the level of the lake at the time it is mapped and for future determinations of water level. Although the essential purpose of the charts is their use for fishery research and management, other sections of the Conservation Department use them also, and the citizenry can buy uncolored prints.

Routine biological inventories have been made on about 1, 000 lakes. The procedures of our so-called "complete" survey or inventory now consist of fish collecting, temperature-chemistry analysis, vegetation analysis, and assessment of ages and growth rates of fish. Fish are collected mainly with gill nets and seines, although fyke nets, angling, and rotenone are employed occasionally. Chemistry tests are performed for dissolved oxygen and total alkalinity. Aquatic plants are listed by species, including a general assessment of abundance. The inventory data are recorded on 6" x 9" file cards, a separate card being provided for each category of information (Fish Collection, Water Analysis, etc.). Typewritten copies of completed cards are provided for the central office, the research section, and the district and regional units that are concerned with the lake.

Inventory of streams has been somewhat less extensive than that of lakes, and has been largely confined to trout waters. The procedures of recent years have included: (1) fish collecting with electric shockers; (2) notation of physical factors such as stream width, depths, velocity and volume of flow, temperatures, bottom soil types, protective and stream-bank cover; (3) determination of ages and growth rates of game fish. Data record cards similar to those for lakes are filled out and distributed to administrative, research, and management units.

Formerly, only the research section of the Fish Division was responsible for lake mapping and inventories, but for some years now management biologists and technicians have taken on much of this work.

I realize that my request involves a pretty big order. Thanks in advance for what information may be provided. If you want to know more about our work, we shall gladly enlarge on what has been outlined.

Sincerely yours,

INSTITUTE FOR FISHERIES RESEARCH

Clarence M. Taube
Assistant Biologist

CMT:bal

STATE OF INDIANA

INDIANAPOLIS 9

MATTHEW E. WELSH, GOVERNOR
DEPARTMENT OF CONSERVATION
DONALD E. FOLTZ, DIRECTOR

605 State Office Building
Division of Fish and Game

April 17, 1964

Clarence M. Taube
Assistant Biologist
Institute of Fisheries Research
Michigan Department of Conservation
University Museums Annex
Ann Arbor, Michigan

Dear Clarence:

I am sorry I have not had a previous opportunity to answer your questionnaire. For the sake of time and brevity I will attempt to answer these questions by the numbers you have assigned them:

1. Lake mapping section (U.S.G.S.) informs me that they have mapped a total of 215 lakes.

2. Their mapping is done by echo-sounder, and shore outlines are obtained by transit traverse and aerial photographs.

3. Our biological surveys include information on physiography; lake areas and depths; inlets and flows; outlet and flow; dam; lake level; nature and uses of watershed; nature and uses of shorelines; temperature and oxygen levels; alkalinity; aquatic plants; plankton; bottom fauna; fish data (including size, age, rates of growth, species composition, spawning conditions, etc.); erosion and pollution; history of lake conditions and fishing; record of past impoundment; lake classification; and management recommendations. The afore-given information is collected on lake surveys, and our stream surveys have followed the I.F.R. form. I merely copied your stream survey forms when I started on our first stream surveys.

4. In collecting fish, we have in streams generally used electro-fishing methods. These have been both AC and DC shockers. We have a large shocker boat which permits us to use whichever type of current we choose. On lake surveys we probably have done more collecting with wire traps but have also used gill nets quite extensively. We have a trap net which has been used on rare occasions and on certain experimental areas we have used various fish toxicants such as rotenone, cyanide, toxaphene, and sodium

sulphite. Regarding electro-fishing gear, we are now using mostly AC 3-phase generators mounted on 16-foot aluminum boats with hanging drop electrodes on tubular booms.

5. In water analyses (of lakes) we usually test for the following: total nitrogen, total phosphorus, total potassium, total sodium, total floride, and sulphate ion. We of course also check for methyl orange alkalinity and pH.

6. We have not made population estimates of stream fish populations. We have used instead a simple measure of relative abundance. This is described in the Muscatatuck River studies which I am enclosing under separate cover along with some other reports. This is a very simple method and really tells nothing about the actual numbers of fish present. However, throughout a watershed it gives us some method of comparing the abundance of certain species. We seldom have sufficient time to make actual population estimates.

7. Our methods on lake inventories and stream inventories are not at all unique. In general, our lake surveys are patterned after those of Minnesota and our stream surveys after those of the Michigan Institute for Fisheries Research. Our lake mapping is done by the U.S.G.S. and their methods are quite original, I believe. I am also including a map of one of the lakes which they have surveyed. I have not previously seen this technique of superposing the lake contours on aerial photographs although I imagine others have probably used it. We have done no winter mapping.

I hope the foregoing has been of some help to you and should you have additional questions I will attempt to answer them more promptly next time.

Thank you very much for your inquiry.

Sincerely,

Mac

H. E. McReynolds, Supervisor
Aquatic Research

HEM/mcs

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF FISH & WILDLIFE RESOURCES
MINOR CLARK, COMMISSIONER

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April 22, 1964

Mr. Clarence M. Taube, Assistant Biologist
Division of Fisheries, Mich. Dept. of Conservation
University Museum Annex
Ann Arbor, Michigan

Dear Mr. Taube:

We did very little mapping of our lakes until 1958. Since that time we have made bathymetric maps of 15 state-owned lakes ranging in size from 8 to 325 acres. We are in the process of mapping 15 lakes ranging in size from 8 to 800 acres. We obtain our shore outlines from aerial photographs and do all of our sounding with a recording fathometer. Our ultimate goal is a bathymetric map of all of our state-owned lakes, which number about 40 at the present time and more are being constructed. These maps are distributed to boat docks and other places where sportsmen have access to them.

Fish population inventories have been conducted on all of our state-owned lakes, all of our flood control and power reservoirs and on many semi-private and a few private lakes. Although we have used various types of nets in the past we are now doing all of our sampling (in coves) with rotenone. All sampling is done at a surface temperature of 70°F or more, which usually means between June 1 and October 1, and a block net is used at all times. From the samples we determine species composition, standing crop, and other statistics which we think are important.

We are collecting information on harvest from 6 reservoirs, 15 state-owned lakes and 3 "put and take" trout streams. We have run creel surveys on approximately 10 lakes and 10 streams in the past and ran one general state-wide survey from which we received very little useful information. All of our censuses have been designed to give information on harvest and pressure.

Water quality investigations in most of our lakes have been confined to temperature profiles; dissolved oxygen, total alkalinity, and total phosphate determinations, the latter being in conjunction with our experimental fertilization of state-owned lakes.

Stream inventories in the past have been fairly extensive, however at the present they are confined to water quality and bottom fauna studies on three trout streams, and two streams that are to be impounded; and water quality and fish population inventory on a polluted stream. In all, 25 or 30 streams have been inventoried extensively including population sampling, water quality (D. O., pH, T. Alk., phosphates) and creel surveys. In our population inventories we

have used nets, creosol, cyanide, the electric shocker and rotenone. Rotenone, with potassium permanganate as a detoxifying agent, has proved to be the most effective collection method, but it is also the one from which we get the most criticism since it is hard to control. The most effective shocker we have found consists of a Homelite, 180 cycle, 230 Volt AC-DC generator and a 65 foot cable from which electrodes are suspended, with a device that enables one to vary the amperage. We do not make population estimates on streams.

We have two sections in our fisheries division, management and research, with the latter doing all of the inventorying and data gathering. Six research projects are being carried out at the present time (the first four are D. J. Projects):

Project F-14-R, State-owned Lake Investigations and Management. Objectives are: (a) to determine the physical, chemical, and biological character of a number (10) state-owned lake and (b) experimentally fertilize some of these lakes and to measure any increases in lake fertility and fish production. Includes mapping, water quality, population sampling, creel survey, fertilization, and aquatic vegetation studies. This is the first comprehensive aquatic plant study to be done in this state and its main purpose is to collect and establish a reference collection of aquatic plants that occur in Kentucky.

Project F-16-R, Pre- and Post-Impoundment Population Survey. Objectives: to determine (a) the post-impoundment fish population of three reservoirs (the pre-impoundment work has been done), (b) fishing success and total fishing pressure of three newly formed reservoirs and their tailwaters, (c) to stock and evaluate the success of stocking various species in these waters, (d) the water quality of these reservoirs (D. O., Alkalinity and Temperature). Under this project we have set up a reference collection of Kentucky fishes and have preserved specimens of all species that have been taken in this state.

Project F-19-R, Pre- and Post-Impoundment Limnological Studies and Lake Investigations. Objectives: (a) to determine the species composition of five lakes, (b) to determine the sport fish harvest at three lakes, (c) to determine the water quality and bottom fauna of two streams that are to be impounded. This project is a combination of the two mentioned above plus the bottom fauna studies.

Project F-22-R, Reservoir Research and Management. Very similar to F-14-R, but on different bodies of water.

Trout Stream Survey. An intensive survey on four "put and take" trout streams and includes water quality, bottom fauna and harvest.

Water Quality of a Polluted Stream. Objectives: to measure the effects of pollution from a municipality on the water quality and fish population of a smallmouth bass stream. Water quality includes D. O., Alkalinity, pH and ABS.

We have just completed a project (the job completion report is now being written) on the effects of brine pollution from oil fields and its abatement on the water quality, fish population and bottom fauna of a major Kentucky river.

Mr. Clarence M. Taube (3) April 22, 1964

There have been many small surveys on various bodies of water that are beyond the scope of this letter. I hope that the information I have given will be of some value, and if you need any more, please let us know.

Very truly yours,

DEPT. OF FISH & WILDLIFE RESOURCES

John F. Hall

JOHN F. HALL
Assistant Director of Fisheries

JFH/prp

STATE OF MINNESOTA
DEPARTMENT OF CONSERVATION
SAINT PAUL 1

April 7, 1964

Mr. Clarence M. Taube
Institute for Fisheries Research
University Museums Annex
Ann Arbor, Michigan

Dear Mr. Taube:

Your letter of March 23rd to Dr. Moyle was referred to me for reply.

According to our Division of Waters we have 13,871 lakes in Minnesota which are 10 acres or more in size. Of this number 5,119 lakes, as shown on the county highway maps, are 40 acres or larger. To date we have mapped about 2,650 fish lakes and about 1,750 aquatic game lakes or marshes. We have biological surveys on: about 1,475 of our 3,000 good fish lakes, about 1,750 aquatic game lakes or marshes, and about 350 streams or portions thereof (includes both warm-water and cold-water streams). In Minnesota it has been estimated that there are about 30,000 inland trout and warm-water streams.

We are now mapping and surveying our lakes on a watershed basis instead of individually as in the past.

I am enclosing the following material which I'm sure pretty well covers the questions you had in your letter:

a. Set of GF 175, pp. 1-10 and management recommendations page.
b. Game lake survey report (1962) on Edwards Lake, Pope County.
c. Game lake survey map (1962) on Edwards Lake, Pope County.
d. Set of stream survey instructions and GF Form 152.
e. Stream survey outline which includes a set of GF FORM 156 REV. 6-1-61, pp. 1-6.
f. Stream survey report (1960) on Kennealy's Creek, Dakota County.
g. Stream survey map (1960) on Kennealey's Creek, Dakota County.
h. Fish lake survey report (1962)on Ida Lake (4-105), Wright County.
i. Fish lake sounding map on Ida Lake (4-105), Wright County.
j. G.F. 155 form - Test Net Field Sheet.
k. Fish age class and growth rate form.
l. The Conservation Volunteer, March-April, 1959--see pp. 23-28, "A Map Starts Fish Management."

In game lake survey work the GF 175 forms are used in the final write-up as well as in the field. This is also true in fish lake survey work and stream survey work where we use GF FORM 153 and GF FORM 156 both in the field and the final write-up. In the final write-up of these surveys additional pages of information are attached to the reports as you can see by the enclosed material.

We don't bother aging and determining the growth rates of fish any more unless there is a specific need for this on the lake.

G. F. 155 form is used in the field from whence we get our information for the net catch tables and the length-frequency lists in the final report.

Dissolved oxygen and total alkalinity tests are the only ones we do now in lake survey work. We used to have lake water analyzed for different chemicals but now this is limited to only a few lakes.

Our electric shocking rigs are patterned after Wisconsin's. We have a small back-pack shocker for small streams and 2 Homelite generators (one 230 AC and one 230 DC) for larger streams, rivers, and lake work. We recently purchased another 230 AC Homelite generator for use this coming summer.

I am enclosing our list of waters worked on last year to give you an idea what our unit does during a summer season. This work was done mostly by 2-man crews consisting of 2 lake sounding and mapping crews, 7 watershed survey crews, 3 game lake survey crews, 1 management survey crew, and 2 miscellaneous crews.

Sincerely yours,

Henry I. Swanson

Henry I. Swanson, Fisheries Biologist
Fish and Wildlife Surveys Unit
Section of Research and Planning

HIS/ms

13 Encl.

STATE OF NEW YORK
CONSERVATION DEPARTMENT *Division of Fish and Game*
ALBANY 26, NEW YORK

HAROLD G. WILM
Commissioner
J. VICTOR SKIFF
Deputy Commissioner
CECIL E. HEACOX
Secretary

W. Mason Lawrence
Assistant Commissioner
GL 7-5690
E. L. Cheatum
Assistant Director
GL 7-5690

April 21, 1964

Mr. Clarence M. Taube
Assistant Biologist
Institute for Fisheries Research
University Museums Annex
Ann Arbor, Michigan

Dear Mr. Taube:

Your letter of March 23 to Dr. Greeley has been referred to us for reply. We regret that we have been unable to furnish you the requested information earlier or in greater detail, but hope the following will be of use to you.

1. Biological surveys of the waters in our state were begun in 1926. Different major watersheds were studied each year until the entire state had been covered by 1940. Quite likely copies of the reports of these surveys are on file in your university library and would explain the types of information collected. Studies have been continued in recent years through regional fisheries offices to keep information on waters up to date. All the ponds, lakes and streams of any consequence for public fishing, as well as some posted waters, have been inventoried in this way.

2. Shore outlines of lakes were generally obtained from USGS maps - the whole state had been mapped - while in recent years aerial photos have often been used, particularly for ponds. Rough depth-contour maps were generally made by the traverse method and hand sounding. However echo sounders are now in use and have made it possible to improve the accuracy of maps of important waters as needed.

3. Enclosed is a set of the various kinds of data sheets now used in our lake and stream survey work.

4. Gill nets, trap nets, bag seines and boat shockers are now used for collecting fish in ponds and lakes. Each type of gear has its own special advantages. On streams we generally use 230V AC shockers with alternate-polarity grids for quantitative work.

However, DC shockers (300-400V) are very useful for qualitative work and for special jobs such as collecting large trout (e.g., adult rainbows on spawning runs) without harm to the fish. Rotenone sampling has not been done extensively because of legal obstacles on privately owned waters, which happen to provide a great deal of our public fishing, and for public relations reasons.

5. The principle chemical tests on lakes are for oxygen, pH and alkalinity - see data sheets. Water temperature series, taken by means of a thermister thermometer, are considered valuable in deep or trout-type ponds and lakes.

6. In routine stream survey work, rough estimates are made of fish populations at upper, middle and lower stations on small streams or at additional points on larger streams. The shocker is used to remove the fish from a measured section at each station and a correction made for estimated efficiency (usually based on experience of the operators). When more accurate figures are needed, sections may be blocked off with nets and the shocker operated until no more fish can be found. Correction factors for various sized fish, based on previous studies, are then applied to increase the accuracy of the data. Sometimes fish in good condition taken in a section are fin-clipped and returned to the section and left for awhile before shocking is repeated, with efficiency based on the percent of marked fish recaptured. Stratified random sampling is sometimes done if precision is especially important.

7. The boat shocker might be considered one of the specially developed pieces of equipment which is proving to be highly useful in some situations. If you are interested in more detailed information, you may wish to write to A. C. Petty, Regional Fisheries Manager, NYS Conservation Department, Cortland, New York. He has had considerable experience with this gear.

The foregoing has been rather sketchy I'm afraid. If you have additional questions, I'll be glad to try to answer the. I'd like to thank you for taking the time to outline your own program to us.

Sincerely yours,

D. G. Pasko
Supervisor of Fish Management

Enc.
DGP/jk

STATE OF WISCONSIN
CONSERVATION DEPARTMENT

Madison 1
March 30, 1964

Mr. Clarence M. Taube
Assistant Biologist
Institute for Fisheries Research
University Museums Annex
Ann Arbor, Michigan

Dear Mr. Taube:

Reference is made to your March 23 letter requesting information on our survey methods. Many of your questions will best be answered by referring to the attached general letter dealing with lake mapping instructions. Besides the general letter, we shall answer your questions in the order in which they were raised.

1) We are trying to provide an inventory picture of every lake and stream in the state. This is being done by our lake and stream classification program and the end production is a waters inventory for a given county. I believe your section has been sent copies of these waters inventories in the past so we need not say any more about them. Basically, they provide about a "70 percent" picture of the body of water. Our ultimate goal would be to provide these inventories for each of the counties in the state.

Our approach to lake mapping is described in the attached general letter. At the present time about 25 percent of the lakes in the state have been mapped in a manner that could provide a quality contour map. Some of these maps date back to the 1930's now and perhaps remapping should take place. Ultimately, we would like to see mapping for all lakes. A sample of the type of map we will provide is attached.

2) The manner in which we provide outline maps for the lakes for mapping purposes is described in our general letter. Production of a map is a joint effort between Fish Management fieldmen and our Engineering Division. Most of our mapping is done with an echo sounder except for the situations which prohibit its use such as dense vegetation, stump fields or other problems.

3) Our biological inventories consists essentially of gathering data on the common species of fish. We do not attempt to gather all species of fish nor assess other types of aquatic life. Fundamentally we do not provide

a complete biological inventory - just an assessment of the fishery. This would include year class composition, growth and abundance of the common species.

4) Types of equipment used for catching fish include trap nets, seine, gill nets and boom shockers. On river systems when dealing with catfish we also use bait nets. An assessment of the fish population would usually require two or three different types of equipment. When interested in game fish we usually find trap nets set early in the season are highly effective. The trap net can also be effective for pan fish early in the season but if you wish to assess the abundance of largemouth bass, it is usually necessary to use a seine or boom shocker. The boom shocker with 220 volt AC current is especially effective at night for bass, walleye and pan fish. It is not very effective for northern pike and muskellunge unless the means of operation includes a tandem movement - combining two or three boom shocker units.

In streams we find that the 230 volt DC shocker is more effective. If soft waters cause difficulty, the effectiveness of the gear can be improved by adding some salt to the water.

5) Analysis of water for dissolved solids presents many problems because of the ephemeral nature of some nutrients and the unknown meaning of other nutrients. The literature seems to indicate that there is a good correlation between fish populations and MOA or total dissolved solids. We have therefore settled on taking MOA tests and conductivity tests for every body of water. Since either measurement is predominantly calcium, magnesium and carbonate ions, the measurement will be quite indicative of the amount of total dissolved solids. The only ion present in considerable quantities which is not measured by conductivity is silicon.

6) We make population estimates on all the streams on which research is taking place each year. All together this would amount to about six different streams. In addition, we collect population data on a number of other waters. The standard method of doing so consists of two runs with the shocking unit. During the first run all fish caught were marked by excising a portion of the fin. For simple inventory of fish populations we do not provide population estimates.

7) Some of our innovations on lake mapping appear in the attached general letter. One of them is mapping through the ice with an echo sounder. However, since this general letter was written, we have found that in some years the ice freezes with many air bubbles in it and as a consequence, clear echoes are not received by the instrument. Certainly the motorized toboggan is a boon to winter lake mapping by whatever means. All our boom shockers are rigged in such a manner that the electrodes can be moved closer together or separated more widely to accommodate the varying degrees of conductivity found in lakes and streams. Boom shocking at night is much more productive than boom shocking during the day.

If we can be of further help to you, please let us know.

Very truly yours,
FISH MANAGEMENT DIVISION

Charles N. Lloyd
Acting Superintendent

Attach.