ANNUAL REPORT

GREAT LAKES FISHERY COMMISSION

1959

GREAT LAKES FISHERY COMMISSION

MEMBERS — 1959

CANADA	UNITED STATES
A. O. Blackhurst	D. L. McKernan
W. J. K. Harkness	Claude Ver Duin
A. L. Pritchard	Lester P. Voigt

SECRETARIAT

N. S. Baldwin, Executive Secretary
Robert Saalfeld, Assistant Executive Secretary
Edith McPherson, Secretary

GREAT LAKES FISHERY COMMISSION

Established by Convention
between Canada and the United
States for the Conservation of
Great Lakes Fishery Resources.

ANNUAL REPORT

FOR THE YEAR

1959

1319 N. University Ave.
Ann Arbor, Michigan,
U. S. A.

LETTER OF TRANSMITTAL

The Chairman of the Great Lakes Fishery Commission takes pleasure in transmitting to the Contracting Parties an Annual Report of the Commission's activities during the period between the 1958 and 1959 Annual Meetings.

A. L. PRITCHARD
Chairman

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INTRODUCTION

The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries, between Canada and the United States, ratified on October 11, 1955. It was organized in April, 1956 and assumed its duties as set forth in the Convention on July 1, 1956. The Commission has two major responsibilities: the first, to develop co-ordinated programs of research in the Great Lakes and, on the basis of the findings, recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; the second, to formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Commission is composed of six members, three from each country.

Canadian Commissioners are:

A. O. BLACKHURST, *Manager*
Ontario Council of Commercial Fisheries
Port Dover, Ontario

W. J. K. HARKNESS, *Chief*
Division of Fish and Wildlife
Ontario Department of Lands and Forests
Toronto, Ontario

A. L. PRITCHARD, *Director*
Conservation and Development Service
Department of Fisheries
Ottawa, Ontario

United States Commissioners are:

D. L. MCKERNAN, *Director*
Bureau of Commercial Fisheries
United States Fish and Wildlife Service
Washington, D. C.

CLAUDE VER DUIN, *Manager*
Chamber of Commerce
Grand Haven, Michigan

L. P. VOIGT, *Director*
Wisconsin Conservation Department
Madison, Wisconsin

The Commission is assisted in its planning of the lamprey control program and general fishery research by a Scientific Advisory Committee, composed of four scientists, two from each country, with the Commission's Executive Secretary as chairman. Canadian members are K. H. Loftus of the Ontario Department of Lands and Forests and G. F. M. Smith of the Fisheries Research Board of Canada. United States members are C. A. Dambach, of the Natural Resources Institute, Ohio State University and J. W. Moffett of the Bureau of

Commercial Fisheries, United States Fish and Wildlife Service. Committees representing the fishing industry, sportsmen, government agencies, and the public at large, have been established to advise each national section.

The Commission is required by the Convention to carry out its program by working through existing agencies as far as possible and maintains a small staff, or secretariat, in Ann Arbor, Michigan. The cost of maintaining the secretariat is shared equally by the two countries.

The Commission's sea lamprey control program is supported by both countries, with the United States contributing 69 percent and Canada 31 percent of the cost. The proportions are based on the historic economic interest of the two countries in the lake trout fisheries of the Great Lakes. The program is carried out in Canada under a contract with the Fisheries Research Board of Canada, and in the United States under a contract with the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service. Co-operation between the field staffs of these agencies in developing and applying new or improved methods has been a notable feature of control operations.

Electric barriers were installed on practically all known lamprey-producing streams of Lake Superior, and about two-thirds of those in Lake Michigan by 1957. Barrier construction on Lake Michigan was halted after the first test of the chemical method in the fall of 1957 proved successful. This method, which could kill the five or more generations of young lamprey living in streams with a minimum of damage to fish, appeared to have a number of advantages, among them the early reduction of young lamprey in Lake Superior tributaries, which would reduce predation on the remaining lake trout. The decline and collapse of the fishery for lake trout in Lake Michigan in six years, and their disappearance four years later, provided a strong argument for the prompt use of chemicals in Lake Superior streams. After further trials in the first part of 1958, chemical treatments became "operational" and nine Lake Superior streams were treated in the fall of that year, seven with complete success.

The expansion of chemical treatments in Lake Superior during 1959 necessitated a reduction in the number of electrical barriers operated in Lake Michigan. However, the network in Lake Superior has been maintained to prevent re-establishment of new generations of lamprey, and more particularly to follow the anticipated changes in lamprey abundance resulting from barrier and chemical operations.

Fifty-nine barriers were operated on Lake Superior streams in 1959, 40 in the United States and 19 in Canada. A general decrease in the number of spawning lamprey was noted on the south shore. In the eastern half the runs were 14 percent below the 1958 runs, marking the second consecutive decrease on this stretch of shoreline. The decrease on the western half of the south shore was 31 percent. In

Canada, where barrier operations accounted for less than 10 percent of the total spawning lamprey taken, runs at the eastern end showed little change while runs in the northwest increased. Changes in the number of spawners on the south shore cannot be claimed as the result of barrier operations or chemical treatment for neither were expected to influence the number of subsequent spawners until 1960 at the earliest.

The 37 barriers operated on Lake Michigan streams in 1959 have shown that there are considerable natural fluctuations in this well-established population of sea lamprey.

Chemical treatments proceeded on schedule during the spring and early summer of 1959. However, the chemical or "lampricide" became less effective in July for reasons which remain unexplained. Treatments had to be postponed on all but the very small streams to avoid damage to fish and excessive use of the limited supply of lampricide. This lessening in effectiveness was expected but an improvement was anticipated in September. The improvement did not occur, however, until October when abnormally heavy rainfall greatly increased the flows in streams and the amounts of lampricide required, thus making the treatment of large streams extremely expensive. In spite of these difficulties, 37 streams were treated successfully in 1959, 8 in Canada and 29 in the United States. One stream was treated with partial success. At the end of 1959, 14 streams remained to be treated in Lake Superior, 9 in Canada and 5 in the United States.

Investigations of sea lamprey life history and use of lampricides continued to provide information useful in the application of control methods. A technique for rapid but accurate measurement of the concentration of lampricide in streams was developed in 1959. Investigations by the Fisheries Research Board of Canada, and the Michigan Department of Conservation, which is co-operating in the Commission program, have shown that populations of young lamprey occur in bays at the mouths of spawning streams and rough estimates of their numbers have been made. If these lake-dwelling individuals contribute significantly to the adult population, it will be necessary to either treat the contributing streams more frequently or devise methods for localized treatment in the bays.

The Commission has enlisted the support of agencies with fish cultural facilities in the lake trout restoration program. Lake Huron and Lake Michigan will require introduction of trout to re-establish breeding populations. Lake Superior, although it still contains lake trout, may not have sufficient mature fish in some areas to permit a rapid recovery of the trout population when lamprey are controlled. There is evidence from a comparison of experimental trawl catches in 1959 and 1953 that young-of-the-year and 1-year-old lake trout are much reduced and that natural reproduction has been damaged already. Further evidence of a weakening of natural reproduction can

be seen in the increasing proportion of hatchery-produced fish in some areas.

Mature fish in Lake Superior were once the main source of lake trout eggs for fish culture, however, the present scarcity of these has led to the development of domestic brook stocks in some hatcheries and a search for egg sources in inland lakes. These new sources are producing eggs in increasing numbers and in time are expected to provide more eggs than the present hatchery facilities in the area can rear to yearling size. The Commission has asked agencies engaged in fish culture operations in the Great Lakes to maintain their hatchery facilities at a high level of efficiency and to proceed with plans to construct additional facilities, which might, for a time, be used to produce lake trout for the re-establishment of breeding populations in the Great Lakes. The Commission has also made recommendations to the two countries regarding selective breeding of trout and investigations to evaluate and improve restoration activities.

The Commission has considered research needs for each of the Great Lakes and in 1959 presented general recommendations to the two countries for Lake Erie, Lake Michigan and Lake Superior. It has pointed out that there is no clear understanding of the biological and environmental factors at work, and of the interrelationships among the various species of fish. The scale of past research has been so limited that methods for arriving at unbiased and dependable estimates of such population characteristics as population density, age composition, recruitment, reproduction, natural and fishing mortality have not been developed. Adequate measurements of hydrographic conditions have not been made. It recommended that special emphasis be attached to the development of adequate sampling and analytical procedures of wide applicability in research on fishery problems of the Great Lakes.

The Commission has emphasized the importance of obtaining information on the catch by anglers in areas where the sport fishery is making a significant contribution to total production. It recognizes that greater production of underutilized species such as sheepshead, smelt and lake herring is desirable and has stressed the need for studies in technology and economics to permit full utilization of these species and improve the quality of fishery products generally in the Great Lakes.

The preparation of a bibliography of literature pertinent to the Great Lakes fishery, which was begun in 1957 by the University of Toronto under contract with the Commission, was completed in 1959. The bibliography is prepared on cards and cross-indexed by author, subject and locality. Additional material will be added periodically. Sets have been placed at 14 research centers located strategically in the Great Lakes area and one set provided F.A.O. in Rome, Italy.

INTERIM MEETINGS AND ACTIONS

Two meetings were held by the Commission in the interval between the 1958 and 1959 Annual Meetings. The proceedings and actions are summarized in the following sections.

Ottawa, Ontario—April 16–17, 1959

The meeting opened with an address by the Honourable J. Angus MacLean, Minister of Fisheries for Canada who expressed his pleasure at the progress that had been made in applying methods to control sea lamprey. Although reservations had been expressed regarding the complete effectiveness of these methods, many difficulties had been overcome and the Commission could be justifiably hopeful of success. The Minister stressed the lasting importance of joint research on other fishery problems not related to sea lamprey and found the atmosphere of co-operation among agencies in this area, particularly in planning lake trout restoration, extremely encouraging.

The Commission reviewed the progress of the sea lamprey program and requested the preparation of a program for 1960–61 which would include substantial chemical operations in Lake Michigan and Georgian Bay (Lake Huron). It specified that program cost be maintained at the present level.

The recommendations of the Special Committee on Lake Trout Rehabilitation, which had been received for consideration at the 1958 Annual Meeting, were reviewed. The advisability of recommending additional lake trout rearing facilities, which might not be needed after breeding populations were established in the Upper Great Lakes, was questioned by the Commission. It was pointed out that representatives from agencies concerned believed that the additional facilities could be largely justified on their need in the inland sport fishery programs in Michigan, Wisconsin and Minnesota. The Commission thereupon accepted the report of the Committee and adopted its recommendations.

The Commission received the following statement on fishery research for Lake Erie, Lake St. Clair, Lake Michigan and Lake Superior prepared by its Scientific Advisory Committee:

> Some fishery problems are found to a greater or lesser degree in all of the Great Lakes. These include the imagined, and perhaps in some instances, real conflict in interests of the commercial fishermen and sportsmen and the need for the development of methods of study. There is, for example, a great need for the development of methods which will adequately follow the changing populations of fish and their variable environment. These methods cannot be prescribed at present.
>
> Lake Erie and Lake St. Clair stand apart from all the other Great Lakes in their large fishery productivity and their biological and ecological complexity.

In spite of much work done on the lakes there is not yet a clear understanding of the biological and environmental factors at work or of the extent or importance of interrelationships of population masses of the various species. This lack of understanding has been due largely to the lack of tools or methods necessary to arrive at unbiased and adequate estimates of population parameters such as population density, age composition, recruitment, reproduction, natural and fishing mortality. It is recommended that *great importance should be attached to the development of adequate sampling procedures and the appropriate methods of analysis.* Such sampling procedures, when available, would require the fullest co-operation of all active fisheries research agencies operating on the lake. The Committee is pleased to be able to report that attempts along these lines are currently being made by the active agencies and much thought is being given to these rather formidable problems.

A limited program is already in existence and work is being done on a co-operative basis by various agencies and institutions. The Committee recommends *that the Commission commend these groups on work already done and urge the expansion of the following studies to cover the lakes.*

Lake Erie and Lake St. Clair

It is the opinion of the Committee that progress in understanding the complex biological system in Lake Erie and Lake St. Clair can only be made by a broad attack simultaneously on many fronts. This does indeed present a formidable and expensive program. However, much less is unlikely to produce results that are either sound or of lasting importance. The following studies are recommended:

1. *Investigations of the physical, chemical, and biological conditions which exert primary control over the survival, growth and reproduction of fish, and measurement of changes which may cause fluctuations.*
2. *Collection and compilation of complete and current information on the life histories of the more important species of fish (including species not commercially exploited).*
3. *Sampling of fish populations to reveal the species composition, abundance, and distribution of the various species and to measure changes to find possible interactions among the various species and the environment.*
4. *Estimation of the composition and total sport and commercial catch and development of statistical procedures based on life history and population information to explore requirements for efficient utilization of the fish stocks.*

In Lake Erie there are several species present in apparently large numbers that are not fully utilized, such as smelt and sheepshead. Two agencies have already undertaken some of the problems of fishery technology including as major parts of their programs, fish handling and processing, and investigation of effective capture of species not now efficiently harvested. Economic and marketing studies have been initiated. The Committee recommends that *the Commission encourage the technological and economic studies necessary to make possible further commercial utilization of some of the relatively unexploited species.*

Lake Michigan

A major part of Lake Michigan's fish production comes from the shallow-water commercial and sport fisheries, particularly those located in Green Bay. These fisheries are largely dependent on species that have not been seriously

affected by sea lamprey predation. The deeper off-shore fisheries of the open lake have, on the other hand, suffered grievously and are now largely dependent on the smaller and somewhat less desirable species of deep-water ciscoes which have flourished since the disappearance of the lake trout. The fisheries of these two areas are sufficiently different to warrant separate consideration in preparing research recommendations.

The changes in the deep-water population which occurred with the increase in sea lamprey and the disappearance of lake trout were extreme and changes of equal magnitude are anticipated as lake trout become established. It is important that these changes be followed, particularly in the case of the lake trout, which will have to be planted in order to establish a breeding population.

The Committee recommends that *studies of the deep-water environment and fish populations begin immediately prior to and during the re-establishment of the lake trout and that these studies be designed to provide information on the survival and reproduction of the introduced trout.*

The influence of the sea lamprey on the shallow-water fish populations is not known, but they have continued to be sufficiently attractive to the commercial fishing industry and the sportsmen. It is estimated that the catch of yellow perch by anglers exceeds that of the commercial fishery in Green Bay. The interest of the commercial fishermen and anglers in the same species has led and will continue to lead to conflicts between these two groups as long as the factors that affect the abundance of these species remain obscure. The conflict of opinions could lead to unwarranted restrictions on commercial fishing which could prove damaging to the sport, as well as the commercial fishery, and result in an unnecessary loss of production and recreational values.

The shallow-water fishery of Green Bay has a recognized potential for greater commercial production and recreational use than the lake proper. The Committee recommends that *the development of an adequate research program in Green Bay receive immediate emphasis.*

Fishery problems in Green Bay are similar to those found in Lake Erie. Many species are present, a few are utilized, and many of the latter may not be fully utilized. The abundance of certain species fluctuates widely and unpredictably over relatively short periods of time, making it difficult to conduct an efficient commercial fishery. It is therefore necessary to develop studies which will eventually explain these fluctuations.

The present program in Green Bay is almost limited to a study of the yellow perch. The Committee recommends *a broad program to include study of the principal species and the limnology of Green Bay which must exert a strong influence on the fish populations.*

The Committee is of the opinion that it is essential to develop and employ the most efficient methods possible for obtaining adequate information on a fishery that, although complex, cannot demand the attention which might be justified in a more valuable fishery. The need for improved sampling of the commercial and angler catch is most desirable, particularly, if either activity is known to take a fairly representative segment of the population or if there is reason to believe that the exploitation is influencing the abundance of a species significantly. It, therefore, recommends *the early development of adequate sampling methods to follow the abundance and age composition of the principal species in Green Bay and the chemical and physical conditions which may influence them.* The Committee further recommends *the immediate development and establishment of procedures to obtain reliable estimates of the annual production of the sport fishery in Green Bay.*

The Committee also recommends *the early completion of the tabulation and analysis of landings reported for Wisconsin waters of Green Bay during*

the period 1936–48. A tabulation has been made of landings for the State of Michigan waters, which when combined with the Wisconsin data would provide a useful background for a preliminary study of fluctuations in the fisheries.

Lake Michigan has a recognized potential for greater commercial production. This potential has been developed to a degree by a smelt marketing program instituted in 1958. The Committee recommends that *the Commission encourage technological and economic studies to make possible further commercial utilization of relatively unexploited species.*

Lake Superior

Formulation of a program for Lake Superior is hampered by our comparative ignorance of the fishery and by uncertainty as to the outcome of the operations to control the sea lamprey. In consequence, the program advanced here is of an interim nature intended to meet the obvious needs of the present. It is certain to be enlarged in scope and changed in emphasis as new needs become apparent. The recommended studies are listed below in order of priority based on present needs.

1. *Continuance of the collection of statistics on landings, fishing intensity, catch-per-unit effort and lamprey scarring rates by the various state and provincial agencies, together with subsequent analysis.*
2. *Appraisal of existing lake trout stocks by:*
   (a) *annual net-run sampling of the catches of commercial fishermen (including chub fisherman) on a lake-wide basis to demonstrate changes in year-class strengths and lamprey scarring incidence and to provide other indices which may be used to show significant changes from year to year;*
   (b) *defining the identities of the existing populations, determining their discreteness and their contribution to the various commercial fisheries of the lake by tagging and recapture of both undersized fish from the commercial catch and mature fish captured on the spawning grounds;*
   (c) *fishing experimentally with various gear to sample lake trout not adequately sampled in the commercial catches;*
   (d) *fishing experimentally with appropriate gear on known lake trout spawning grounds to assess the extent of spawning by existing stocks.*
3. *Collection of statistics on the return of marked hatchery-reared fish from the commercial catches of the lake to permit appraisal of the success of the plantings.*
4. *Appraisal of existing whitefish stocks by annual net-run sampling of the catches of commercial fishermen on a lake-wide basis to demonstrate changes in year-class strengths, scarring incidence and other statistics, and by experimental fishing to provide information on aspects of their life history.*
5. *Determination, if possible, of the species supporting the existing chub fisheries on the lake and the extent to which each contributes to the catches and initiation of annual net-run sampling of the commercial catches to provide basic information on year-class strengths, growth rates and other statistics.*
6. *Determination, if possible, of the availability of lake herring at times other than the spawning season.*
7. *Compilation of life history data on the fishes of Lake Superior, especially those not now being fully exploited, such as walleye, suckers, burbot, sauger, smelt, menominee whitefish and whitefish.*

Interpretation of data obtained in many of the biological studies outlined above will require an understanding of the physico-chemical and biological characteristics of the environment. To acquire such an understanding of the lake as a whole is a major undertaking and one which will require a major effort. It is recommended that *a program of sampling the fish populations and related environmental conditions at a limited series of index stations be carried out in order to provide some much needed guide lines for the development of a more extensive program.*

Probably the most important technological problem revolves around the handling of fish which is often poor. In consequence, quality is low and it seems likely that technological assistance could make a substantial contribution. Committee recommends that *more efficient and economical methods of capturing, handling and processing fish, particularly lake herring and smelt, be developed to permit fuller utilization.*

The recommendations were adopted by the Commission and instructions given that they be presented to the two Governments with a statement that they were of an interim nature and would be changed as additional information on the fishery was obtained.

Other matters considered by the Commission included publications on the Commission's program and the fishery in general, extension of the contract for the Great Lakes Fishery Bibliography, and a revision of the employee pension plan.

Sault Ste Marie, Ontario—August 17, 1959

Reports were received on the progress of the sea lamprey program and operational difficulties encountered in chemical treatments.

The Commission was advised that the Bureau of Sport Fisheries and Wildlife proposed building a trout hatchery in Michigan, which would provide lake trout for the restoration program, but lacked funds to proceed with the planning. The Commission agreed to urge the Government of the United States to proceed with the planning and construction of the proposed hatchery.

As appropriations to the 1959–60 program were less than the amount requested by the Commission, a reduction in program to reduce cost to $1,335,199 from $1,377,230 was considered. It was agreed that the reduction could be absorbed in the chemical program in the United States without a major change in activities.

The Commission was asked to reduce its program for 1960–61 so that the estimated cost of the United States contribution would not exceed the 1959–60 allocation and requested that a reduction in electrical barriers be considered. The reduction should not endanger an assessment of the control operations in Lake Superior.[1]

The Commission approved termination of the contract with the University of Toronto for the preparation of the Great Lakes Fishery Bibliography, as major references had been covered. It asked that various arrangements for keeping the bibliography up to date be explored.

1 A revised program costing an estimated $1,384,000 (including $46,000 for Commission administration and general research) was approved by correspondence in October, 1959.

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ANNUAL MEETING

AGENDA

1. Call to order by Chairman.
2. Introduction of advisors.
3. Adoption of agenda.
4. Approval of past minutes.
5. Report of Chairman.
6. Reports on sea lamprey control and research by:
   a. Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service.
   b. Fisheries Research Board of Canada.
   c. Michigan Department of Conservation.
   d. Wisconsin Conservation Department.
7. Review of proposed 1960–61 program.
8. Preliminary consideration of 1961–62 program.
9. Present status of commercial lake trout landings.
10. Report of Special Committee on Lake Trout Rehabilitation on restoration activities in 1959.
11. Proposals by co-operating agencies on:
    a. Future hatchery production.
    b. Future assessment studies.
12. Consideration of general recommendations on research for Lake Ontario and Lake Huron.
13. Organizational matters.
14. Time and place of next meeting.
15. Other business.
16. Adjournment.

ANNUAL MEETING

PROCEEDINGS

The Fourth Annual Meeting of the Great Lakes Fishery Commission was held in Niagara Falls, Ontario, on December 3 and 4, at the Sheraton-Brock Hotel.

Call to order and introduction of advisors. The meeting was called to order by the Chairman, Dr. A. L. Pritchard. After the Commissioners were introduced by the Chairman, Mr. D. L. McKernan (United States) and Dr. W. J. K. Harkness (Canada) introduced advisors and government staff from their respective countries. A list of those attending appears as Appendix I.

Adoption of agenda. The agenda sent out in advance of the meeting was adopted without change.

Approval of past minutes. After several additions had been made for clarification, the minutes of the interim meeting, held in Sault Ste. Marie, Ontario on August 17, 1959, were approved.

Report of Chairman. The Chairman reviewed the progress of the sea lamprey program, drawing attention to the major difficulties encountered by its agents in carrying out chemical treatments. He emphasized the need for advance information on the effectiveness of lampricide in different streams at different seasons in order to schedule treatments. In spite of the lack of this information and abnormally high rainfall in October, 38 streams were treated with only one failure, leaving 14 streams on Lake Superior to be dealt with in 1960. The role of the electrical barriers, once the only method available to control sea lamprey, had changed with increasing use of the new chemical method. Barriers, however, would continue to be important primarily for following changes in lamprey abundance and thus measure the effectiveness of the control program.

Optimism resulting from a decrease in the number of sea lamprey taken at the barriers in 1959 was countered by indications that the production of lake trout in Lake Superior had continued to decline and might not reach 1,100,000 pounds by the end of the year. Mature lake trout were scarce on known spawning grounds and young lake trout less abundant. The lake trout restoration program was, therefore, assuming greater significance on Lake Superior with this evidence that natural reproduction was already weakened. The co-operation of the agencies in the restoration program was gratifying and their plans would be of increasing interest to the Commission.

The Commission had learned that its recommendations on general fishery research in three of the Great Lakes had been favorably

received by both countries and could look forward to an extension of the research programs along the general lines indicated. It would be necessary for the Commission to become thoroughly familiar with the progress of these programs and their findings which might lead to improved management of the fishery or indicate profitable lines for further investigations.

Reports on lamprey control and research. A progress report on the lamprey program in the United States carried out by the Bureau of Commercial Fisheries, United States Fish and Wildlife Service was presented (page 35). It was pointed out at the conclusion of the presentation that streams not scheduled for treatment were found to contain ammocoetes and had been dealt with promptly. Streams treated to date in the United States encompassed about 90 percent of the 1959 spawning run.

A progress report on the program in Canada was presented (page 52) by the Fisheries Research Board. The presence of ammocoetes in the lake bottom off mouths of spawning streams and the control problems this might create were discussed at some length. Following the report the Chairman of the Board submitted a statement to the Commission suggesting that it seek a more appropriate agent to carry on its program in Canada. The Chairman of the Commission stated that it appreciated being advised of the Board's desires and would give the suggestion careful consideration. He pointed out that the Commission had been advised by the Government of Canada, when given the task of controlling sea lamprey, that the Board was the appropriate agency to carry out its program in Canada. The Commission would, therefore, seek the advice of the Government of Canada before considering other means of continuing the program.

Reports on the sea lamprey projects undertaken by the States of Michigan and Wisconsin are summarized on page 57. It was learned that opposition by anglers to the continued use of barriers would moderate if the effectiveness of the guiding devices in reducing fish kills was publicized.

The Commission was advised by its Scientific Advisory Committee that the lack of advance information on seasonal changes in effectiveness of lampricide was a serious handicap and that the chemical program in Lake Michigan should not proceed without this information.

After exploring several alternatives, the Commission approved a reduction of 2 barriers on the east shore and 11 on the north shore of Lake Michigan in the spring of 1960 and the transfer of funds thus provided to support advance bio-assays in that lake.

Reconsideration of 1960–61 program. The Commission reviewed the 1960–61 program approved by correspondence on October 21, 1959, and considered a number of changes, which experience during

the 1959 field season indicated were desirable. It was advised that there was sufficient chemical at the end of the 1959 season to treat the remaining lamprey streams on Lake Superior, with the exception of the Michipicoten, in the first half of 1960 if flows were normal. Also, if the Nottawasaga were treated in the fall of 1960 as proposed, it might cost 2 to 4 times the amount originally budgeted. The Commission agreed to drop the Nottawasaga from the 1960–61 program and consider its inclusion in the 1961–62 program. This change provided funds to cover the increased cost of treating the Michipicoten River in 1960–61.

Preliminary consideration of 1961–62 program. The Commission considered the course the lamprey program should follow after 1960–61. A recommendation from its Scientific Advisory Committee strongly urged that *chemical treatments outside Lake Superior be made only on a schedule that assured proper evaluation of the Lake Superior experiment.*

The Commission expressed its satisfaction with the general progress and direction of the program. It envisaged completion of chemical treatments on Lake Superior and a continuation of electrical barrier operations on this lake during the spring of 1960 with a review of the number to be operated following the spawning run. Operations should be transferred as rapidly as possible to Lake Michigan and Georgian Bay (Lake Huron) but such expansion should not be made at the expense of the pilot program in Lake Superior. It also agreed that it would not be advisable for the Commission to consider any budget greater than the one on which it now operated.

The Commission requested preparation of a preliminary program for 1961–62, satisfying the general requirements set forth. The program, with comments from the Scientific Advisory Committee, would be considered by the Commission at its next meeting.

Lake trout rehabilitation. The Commission received a report (page 66) from its Special Committee on Lake Trout Rehabilitation, which reviewed the progress of investigations of the trout populations in Lake Superior and the fish culture operations of agencies in 1959. At the end of the report the Committee submitted the following recommendations for the Commission's consideration:

1. Considerable basic research in comparative physiology has been conducted on stream trout species (brook, rainbow and brown trout). As a result of the development of substantial numbers of lake trout brood fish of various sizes and ages in the lake trout rehabilitation program, an unusual opportunity exists to conduct basic research on the physiology of this species. The Committee, believing that a better understanding of the general physiology of lake trout would materially benefit hatchery practice in the Great Lakes area, therefore, recommends that *the Great Lakes Fishery Commission inform the educational institutions in the Great Lakes region of the availability*

of lake trout in hatcheries and encourage them to use lake trout as subjects for experimentation.

2. The Committee realizes that maximum survival of lake trout at all stages of hatchery development is essential for full utilization of the limited number of eggs available and for minimizing the program costs. It believes that the need for efficient methods will become even more pressing as the stocking program expands into Lakes Michigan and Huron. The Committee, therefore, recommends that *governmental research agencies be encouraged to conduct more applied research on such lake trout hatchery problems as:*
   a. the effects of temperature on survival, particularly during egg development;
   b. the development of field techniques for temporary storage of eggs and sperm;
   c. the effects of light intensity on survival;
   d. the length of time development of fertilized green eggs may be safely retarded.
3. The Committee examined the commercial catch sampling program in the United States waters of Lake Superior and agreed that at the moment it appears adequate. It sees a need for more adequate information on lake trout in Canadian waters. The Committee, therefore, recommends that *the sampling program of the Bureau of Commercial Fisheries and the Wisconsin Conservation Department be continued at their present level and that the Fisheries Research Board's program be expanded.*
4. The Committee cannot find biological justification for a further curtailment of the commercial lake trout fishery in Lake Superior at present; on the contrary, it is possible that the continuation of the fishery at its current low level of intensity will permit recovery of the fishery if the sea lamprey are dealt with adequately.

   It foresees a strong public demand for extreme regulations which may eliminate the already drastically reduced commercial fishing operations. The curtailment of the fishery would create a serious problem because present assessment of the status of the lake trout populations, the success of hatchery planting, and the reduction in sea lamprey predation all depend upon commercial fishing operations for basic data.

   The Committee believes, however, that within the very near future new regulations on commercial fishing may be desirable to facilitate the rehabilitation of lake trout in Lake Superior. The Committee recommends that, *if and when new regulations are required, these should be uniformly applied by all agencies concerned, and suggests that this might best be achieved by adoption of a limited permit system.*

The reference to a "limited permit system" made in the last recommendation, was clarified by the Chairman of the Committee who stated that this in effect is a limitation on the number of commercial licenses made available by the agencies with jurisdiction over the fishery. At the moment this system appeared to be one way of regulating fishing intensity while making it possible to fish by the most efficient methods. The Committee had not attempted to discuss implementation at any length, but were certainly aware that difficulties would arise. In further discussion of the need to regulate the fishery it was learned that anglers' support of the lake trout program in the states of Wisconsin and Michigan might not continue if there was no

assurance that lake trout would be protected by improved regulation of the commercial fishery.

The Commission asked the Committee to arrange an early meeting, with administrative officers from each agency concerned with the regulations of the fishery, to determine what types of regulation should be considered. The Commission requested that the findings of this group be presented to the Commission at its next meeting, and deferred action on the Committee's recommendations.

The following agencies presented plans for future hatchery development and assessment studies in connection with the lake trout restoration program in the Upper Great Lakes. It was stated in each case, that the execution of these plans was subject to the appropriation of funds.

Fish culture:

(a) Bureau of Sport Fisheries and Wildlife, U.S.F.W.S.
(b) Wisconsin Conservation Department.
(c) Michigan Department of Conservation.
(d) Minnesota Department of Conservation.
(e) Ontario Department of Lands and Forests.

Assessment studies:

(a) Fisheries Research Board of Canada.
(b) Bureau of Commercial Fisheries, U.S.F.W.S.
(c) Wisconsin Conservation Department.

The agencies were thanked by the Chairman for their presentations which indicated that progress was being made in increasing lake trout production and assessing the results of the plantings.

Status of commercial lake trout landings. Reports on landings of lake trout in the Lake Superior and Georgian Bay areas were presented for the information of the Commission by the Ontario Department of Lands and Forests and the Bureau of Commercial Fisheries, United States Fish and Wildlife Service (page 61). Information was provided on effort and catch per unit of effort (1949–58) for Canadian waters and indices of production, abundance, and fishing pressure for the State of Michigan waters of Lake Superior.[1]

Preliminary estimates of the 1959 catch of lake trout in Canadian waters of Lake Superior indicated a decrease of about 37 percent from 1958. No estimates were available for the United States catch. A catch of less than 1,000 pounds was anticipated in Georgian Bay but fishing pressure had been so light because of the low availability of whitefish that no inferences regarding the continued decline of this remnant trout stock could be made.

[1] Presented with 1959 data on page 61

Research recommendations for Lake Ontario and Lake Huron. After studying the research recommendations for Lake Ontario and Lake Huron, submitted by the Scientific Advisory Committee, the Commission asked that they be re-submitted with fuller justifications at the next meeting.

Organizational matters. The Commission, after considering various arrangements for maintaining the Great Lakes Bibliography of fishery literature current, delegated this responsibility to its Secretariat.

Time and place of next meeting. The Commission agreed to hold its next meeting in June at Ann Arbor and the 1960 Annual Meeting at Cleveland, Ohio in early December.

Other business. The Commission considered three recommendations from the United States Section. It was advised that although there had been progress made in transferring regulatory authority over the fisheries in the Great Lakes from the legislative to executive branches of government, further action was required. The Commission agreed to again recommend to the United States Government that it continue to urge the proper governmental agencies to change laws governing the commercial and sport fisheries on the Great Lakes and connecting waters, whereby the regulatory authority would be vested in the state conservation agencies.

The Commission gave assurance that it would continue to pay close attention to the need to disseminate information to the public on the Great Lakes fisheries.

The Commission was advised of the growing importance of sport fishing in the Great Lakes and the need to develop methods for measuring the catch by anglers and referred this matter to its Scientific Advisory Committee.

Adjournment. The Chairman, after expressing his appreciation for the contributions and interest of those attending, adjourned the Fourth Annual Meeting of the Commission.

ANNUAL MEETING PARTICIPANTS

OFFICERS OF THE MEETING:
Chairman: A. L. Pritchard, Canada
Vice Chairman: Claude Ver Duin, United States

MEMBER GOVERNMENTS

Canada

Commissioners:	*Advisors:*	*Scientific Advisors:*
A. O. Blackhurst	S. Hodgkiss	G. C. Armstrong
W. J. K. Harkness	Earl Siddall	D. Brubacher
A. L. Pritchard	H. V. Sutton	J. C. Budd
		N. Carter
		W. J. Christie
		J. W. Davies
		J. R. Dymond
		R. G. Ferguson
		H. Fritz
		R. N. Johnston
		J. L. Kask
		W. A. Kennedy
		A. H. Lawrie
		K. H. Loftus*
		G. F. M. Smith*
		J. S. Tait
		J. J. Tibbles

United States

Commissioners:	*Advisors:*	*Scientific Advisors:*
D. L. McKernan	B. H. Atwood	W. F. Carbine
Claude Ver Duin	C. Clark†	C. A. Dambach*
L. P. Voigt	W. Harth	W. A. Elkins
	A. S. Hazzard	L. F. Erkkila
	Martin Hosko	Ralph Hile
	Roy Jensen	J. L. McHugh
	J. L. Kitchel	J. W. Moffett*
	Mathon Kyritsis	P. Nelson
	W. M. Lawrence	
	G. E. Sprecher	
	H. O. Swenson	
	C. G. Wenniger	
	H. M. Wood	

SECRETARIAT:
Norman S. Baldwin,* Executive Secretary
Robert W. Saalfeld, Assistant Executive Secretary

* Member of Scientific Advisory Committee.
† Representing L. S. Roach.

ADMINISTRATIVE REPORT FOR 1959

Officers and Staff. At the close of the 1958 Annual Meeting, the Commission held its biennial election of officers, in accordance with Rule 11 (a) of its Rules of Procedure. Dr. A. L. Pritchard was elected Chairman and Mr. Claude Ver Duin Vice-Chairman. Mr. Donald L. McKernan replaced Mr. Ver Duin as Chairman of the United States Section at a subsequent meeting of the Commission in Ottawa, Ontario on April 17, 1959.

During 1959 the Commission's Secretariat was composed of three permanent employees. One part-time employee left the Commission on October 16 to take a full-time position.

Pension plan. On March 16, 1958, the Commission was advised that it was liable for social security taxes under the Federal Insurance Contributions Act. As this ruling appeared to be at variance with one given to another fishery commission, and would necessitate changes in the plan provided by the International Fisheries Commissions Pension Society, the United States directors of the Society were asked to investigate the Commission's status further at the head office of the Internal Revenue Service. On January 23, 1959 the Commission was advised by the District Director of the Service that the earlier ruling had been sustained. At its meeting in Ottawa on April 16–17 the Commission approved integration of the pension plan with social security for its employees, effective May 1, 1959, and authorized payment of retroactive taxes totalling $667.59. An equal amount was paid by its employees.

Separation benefits under the pension plan have been substantially improved by an amendment covering vesting provisions. Service contributions to paid-up annuities have been increased and are now applicable after five instead of ten years of service.

Accounts and audit. The accounts of the Commission were audited and found to be in order by the firm of Icerman, Johnson and Hoffman, 303 State Savings Bank Building, Ann Arbor. The auditors' report and financial statements attached thereto are appended. Annotations have been made to the auditors' exhibits to explain the presence and disposition of several amounts.

Contributions from contracting parties to 1958–59 program. In July, 1957 the Commission submitted to the Governments of Canada and the United States a program of sea lamprey control and research for 1958–59 estimated to cost $1,414,749. An amount of $50,000 was requested for administration and general research. As a result of budget limitations in the United States, contributions totalled $1,268,115 for

the sea lamprey program and $50,000 for administration and general research. Supplemental contributions totalling $27,264 were made to the sea lamprey control and research fund to meet general salary increases granted in June, 1958 to United States Government employees.

Credits on 1958–59 contributions to the lamprey program included the return of an overpayment of $3,280 by Canada in 1957–58. Under-expenditures in the administration and general research fund during 1957–58 left a balance of $6,631.37, of which $6,063.69 was credited against 1958–59 contributions and the balance of $567.68 to 1959–60 contributions.

Expenditures in 1958–59. Agreements to carry out the 1958–59 lamprey program were made with the Fisheries Research Board of Canada through the Minister of Fisheries, and with the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, for $472,000 (Canadian) and $807,039. (U.S.), respectively. At the close of its fiscal year, the Board refunded $1,452.85 (U.S.) to the Commission. All but $147.19 of this amount was used to meet exchange charges which exceeded the reserve budgeted for this purpose. A statement of expenditures made by the Board in carrying out the agreed program is appended. A statement of expenditures by the Bureau of Commercial Fisheries also appended shows an unobligated balance of $2,413.07. Uncertainties in accounting salaries to electrical or chemical control during the period of transition from one operation to the other did not permit an accurate apportionment of costs.

Expenditures in the administration and general research fund in 1958–59 were below the amount budgeted by $6,076.00. Underexpenditures occurred principally in two categories, Printing and Reproduction, and General Research. In the former, provision had been made for the publication of a manuscript dealing with the later development of the chemical method and its early field application. The manuscript was not completed by the end of fiscal year 1959 and prospects of completing it in fiscal year 1960 are uncertain. The Commission provided $6,000 under Research for a continuation of the contract with the University of Toronto for the preparation of Great Lakes Fishery Bibliography. The cost of extending the contract from June 1 to November 30, 1959 was $4,271.33.

Changes in 1958–59 program. At the 1958 Annual Meeting the Commission gave approval in principle to changes in the Canadian program as stipulated in its agreement with the Fisheries Research Board. It subsequently gave full approval to these changes at an interim meeting in Ottawa on April 17, 1959, and authorized the purchase of lampricide with unexpended funds.

The Commission's decision to expand the chemical program in 1959–60 led to an alteration of plans for barrier operation in the United States in that year. This change in plans left the proposed operation of some barriers in the latter half of 1958–59 without purpose and they were placed on standby. Construction of four new barriers proposed in the agreement with the Bureau of Commercial Fisheries was also cancelled. The number of barriers operated on the south shore of Lake Superior was reduced from the 47 proposed to 39, and on Lake Michigan from 50 to 37. Some of the Lake Michigan barriers were again operated by staff of the Wisconsin Conservation Department.

Stream flows treated with chemical in 1958–59 totalled 1,439 cfs, considerably more than the 1,000 cfs stipulated in the agreement.

Research was carried out on all items mentioned in the agreement with one exception. No progress was made in determining minimum lethal exposure. On the other hand field techniques for nitrophenol analysis, which were found to be unreliable in certain situations, were improved considerably.

Continued heavy demand for bio-assay information in direct support of the treatment program led to an expansion of facilities at the Hammond Bay Laboratory. This raised the cost of research in 1958–59 about 25 percent above the estimate in the agreement.

Contributions to the 1959–60 program. The Commission gave preliminary consideration to a 1959–60 program in Washington on April 10, 1958. A more detailed program was approved at a meeting in Marquette, Michigan on June 10–11, 1958. Estimated cost of lamprey control and research was $1,490,300; administration and general research $51,400. This program was submitted to the two governments for their approval and support. The Commission was advised at its Annual Meeting in Ann Arbor on December 4–5, 1958 that the United States Government would be unable to contribute its share of the cost of the program because of budget limitations. A new program, was therefore prepared in which barrier operations were substantially reduced and estimated costs held to $1,377,230.00. Administration and general research costs were estimated at $50,000. This program was approved by correspondence and submitted to the two governments in January, 1959.

The Commission learned on July 7 that the United States contribution to the 1959–60 program would be $29,000 less than requested. It accordingly revised its lamprey program to maintain the cost at $1,335,199.

Agreements with agents in 1959–60. The Commission entered into an agreement with the Fisheries Research Board to carry out its 1959–60 lamprey program in Canada. An amount of $521,690 (Canadian) was provided for this purpose and an additional $53,310 set aside to cover contract administration (6 percent) and exchange charges (4 percent). Funds for operation in the period April 1 to June 30 were provided the Board by the Government of Canada on assurance that the Commission would cover expenditures when contributions were received from the two governments in July.

The Commission approved an agreement with the Bureau of Commercial Fisheries on April 17, but was obliged to modify the program as mentioned previously and reduce its costs when contributions were reduced $42,030. A revised agreement providing the Bureau with $760,200 was executed on July 3. This amount included contract administration charges of $42,870.

Program and budget for 1960–61. The 1960–61 program and budget were first considered by the Commission at its Ottawa meeting on April 16–17. It rejected the tentative program submitted by the Scientific Advisory Committee and called for the preparation of one which would include an extension of chemical control operations into Lake Huron and Lake Michigan and would cost approximately $1,427,200. This was prepared by the Executive Secretary with the assistance of the Commission's agents and circulated to the Commissioners on June 29. As the Government of the United States required budget estimates with justifications by July 15, approval of the Commission was given by correspondence and the program was submitted on the understanding that changes in the activities, but not the total budget amount, might be made by the Commission at its next meeting August 17, 1959. On August 5, the Commission was advised by the Department of State that as a result of an executive order an immediate adjustment must be made in the Commission's 1960–61 program in order that the estimated total cost of the U. S. contribution not exceed the 1959–60 allocation. A tentative adjustment reducing the chemical program in Lake Michigan was made by the Executive Secretary, but altered following instructions from the Commission at its meeting on August 17 that it be met in activities other than chemical treatment operations. A revised program costing an estimated $1,384,100 (including $46,000 for Commission adminstration and general research) was approved by correspondence on October 26 and submitted to the two governments.

Great Lakes Bibliography. On June 1, 1957 the Commission contracted with the University of Toronto for the preparation of a Great Lakes Bibliography. The cost to the Commission for the two years has been $24,000 plus $980.85 for currency exchange charges. On April 17, the Commission approved renewal of the agreement for the period

June 30 to November 30, 1959, for $4,100 (Canadian), in order to include additional bibliographic material. The University was advised that the Commission wished to terminate the agreement on November 30, 1959, but would reconsider this decision when it met on August 17. A sub-committee composed of Commissioners A. O. Blackhurst and W. J. K. Harkness investigated the advisability of continuing the agreement beyond November 30, 1959 and on June 23 recommended that it be modified and continued for two years at $6,000 a year. After study of the sub-committee's report the Commission decided to let the earlier notice of termination stand. It instructed its Executive Secretary to report at the 1959 Annual Meeting on means of continuing the collection of bibliographic materials. The proposals could include further arrangements with the University of Toronto.

Meetings. There have been two interim meetings of the Commission since the 1958 Annual Meeting, two meetings of the Scientific Advisory Committee, and one meeting of the Special Committee on Lake Trout Rehabilitation. Meetings of advisors to the United States Section were held in Baraga, Michigan and Cleveland, Ohio.

The Commission was represented by a member of its Secretariat at the annual meetings of:

Tri-State Fisheries Conference
Canadian Committee on Freshwater Fisheries Research
Ohio Commercial Fishermen's Association
Ontario Council of Commercial Fisheries
Michigan Fish Producers Association
Lake Erie Fish Management Committee
Lake Ontario Fisheries Committee
International Commission for the Northwest Atlantic Fisheries.

Reports. The Annual Report for 1957 was published in May, 1959, and distribution made to members of the Advisory Committees, government agencies, and universities in the Great Lakes area. The 1956 and 1957 Annual Reports were sent to 325 public libraries in municipalities bordering the Great Lakes.

In order to speed the flow of information on Commission operations to its advisors summaries of proceedings were issued shortly after meetings when it appeared that the minutes would take some time to prepare.

A history of the lamprey program, illustrated with six sets of color slides, was prepared for use by the Ontaria Federation of Anglers and Hunters in its conservation lecture series.

Summary of Great Lakes fishery statistics. The Commission has considered publishing statistics on the commercial catch of fish in

the Great Lakes for 1941–1960, and with it earlier data published by the International Board of Inquiry in a report now out of print. The Scientific Advisory Committee has suggested certain tabulations which require work by the agencies compiling the statistics. The Ontario Department of Lands and Forests has assured the Commission that it can provide the desired information without cost to the Commission. The Bureau of Commercial Fisheries has advised the Commission that it would require $7,500 a year for two years.

Other activities. The Executive Secretary spent about two weeks with crews carrying out the lamprey program in Canada and the United States. Brief visits were paid to fishery research groups based at Glenora, Ontario; South Bay, Ontario; Sandusky, Ohio; and Ashland, Wisconsin. The Executive Secretary served as chairman of the International Relations Committee of the American Fisheries Society during the year, and with the Commission's approval agreed to serve as secretary of the Lake Erie Fish Management Committee.

The Assistant Executive Secretary spent three days assisting in a fin-marking project at Pendills Creek Hatchery and observed spawn collecting in Crystal Lake, Michigan. He served as chairman of a meeting of fish hatchery managers held in Marquette March 24. Visits were made to fishery groups based at Minneapolis and St. Paul, Minnesota, Ashland and Madison, Wisconsin, and Lansing, Michigan.

ADMINISTRATIVE REPORT

APPENDIX I

Auditors Report to Commission

ICERMAN, JOHNSON & HOFFMAN

Certified Public Accountants
303 State Bank and Trust Building
Ann Arbor, Michigan

September 4, 1959

Great Lakes Fishery Commission
1319 North University Avenue
Ann Arbor, Michigan

Gentlemen:

We have examined the statement of financial condition of the Great Lakes Fishery Commission, Administration and General Research Fund and Lamprey Control Operations Fund at June 30, 1959 and the fund balances for the year then ended.

Our examination included tracing of receipts to the depository, verification of the bank balance by direct confirmation, tracing of expenditures to supporting vouchers and such other tests of the accounting records as were considered necessary in the circumstances.

In our opinion the accompanying financial statements present fairly the financial condition of the designated funds of the Great Lakes Fishery Commission at June 30, 1959, and the results of operations for the year then ended.

Very truly yours,
Icerman, Johnson & Hoffman

Exhibit A

Great Lakes Fishery Commission
Statement of Financial Condition
June 30, 1959

Assets:

Cash on hand and in bank	$18,617.61

Liabilities and Fund Equities:

Liabilities:			
Credits due on 1957–58 unexpended funds not credited in 1958–59:			
Administration and General Research		$567.68[a]	
Lamprey Control Operation	$11,859.05[b]		
Credit due for 1958–59 unexpended funds:			
Lamprey Control Operations	26.97		
Overpayment by Canadian Government	104.16[c]		
		$11,990.18	
			$12,557.86
Fund Equity:			
Administration and General Research			6,059.75
			$18,617.61

Note A—There was a balance of $631.37 in Administration and General Research Fund at end of 1957–58. However, the U. S. Government deducted $63.69 from its final payment in 1958–59; leaving $567.68 to be credited against 1959–60 contributions.

Note B—At the end of 1957–58, there remained a balance of $147.19 in the bank and $27,954.85 refund due from the Bureau (total $28,102.04), to be credited on the basis of 69:31 percent to the respective governments. The U. S. Government deducted $3,592.98 from the last contribution and the Bureau retained $12,650 for retroactive salary increases, leaving $3,147.42 to be credited against the 1959–60 U. S. contribution and $8,711.63 (31 percent of $28,102.04) to be credited against the Canadian contribution.

Note C—The Canadian Government, in response to a request for a supplemental contribution provided $104.16 more than the amount expended.

Exhibit B

Great Lakes Fishery Commission
Administration and General Research Fund
Statement of Revenues and Expenses
Year Ended June 30, 1959

	Actual	*Budget*	*Under or (over)*
Revenues:			
Canadian Government	$21,496.00	$21,496.00	-0-
United States Government	21,936.31	22,000.00	63.69
Canadian overpayment 1957–58	504.00	504.00	-0-
Totals	$43,936.31	$44,000.00	63.69
Expenses:			
Communications	$ 705.84	$ 1,200.00	$ 494.16
Equipment (Schedule B-1)	1,310.71	2,300.00	989.29
Audit	60.00	1,000.00	687.56
Insurance and bonding	252.44		
Rents and utilities	250.51	200.00	(50.51)
Reproducing and printing	1,449.36	3,500.00	2,050.64
Salaries (including F.I.C.A., Pension)	30,481.07	31,000.00	518.93
Supplies and equipment maintenance	1,791.66	1,100.00	(691.66)
Transportation of things	34.12	200.00	165.88
Travel	3,333.21	3,500.00	166.79
General research	1,271.33	6,000.00	1,728.67
Special reserve fund for Bibliography	6,213.75	6,230.00	16.25
Totals	$50,154.00	$56,230.00	$6,076.00
Excess of expenses over revenues	6,217.69		
Fund balance, July 1, 1958	12,845.12		
Balance, June 30, 1959	$ 6,627.43		
Credits to be applied against 1959–60	567.68		
Fund balance, June 30, 1959 (Exhibit A)	$ 6,059.75		

Schedule B-1

Equipment Purchased

Monroe Calculator	$ 932.80
Office furniture	175.33
Books and miscellaneous	124.63
Collator	31.50
Sign	24.50
Electric fan	21.95
Total	$1,310.71

Exhibit C

Great Lakes Fishery Commission
Lamprey Control Operation Fund
Statement of Revenues and Expenses
Year Ended June 30, 1959

	Actual	*Budget*	*Under or (over)*
Revenues:			
Canadian Government	$ 389,835.00	$ 389,835.00	-0-
Canadian overpayment 1957–58	3,280.00	3,280.00	-0-
United States Government	875,000.00	875,000.00	-0-
Supplementary request:			
Canada	8,556.00	8,451.84	(104.16) [A]
United States	15,155.33	18,812.16	3,656.83 [B]
Refund from Fisheries Research Board	1,452.85	-0-	(1,452.85)
Refund due from Bureau of Commercial Fisheries 1957–58	27,954.85[C]	-0-	(27,954.85)
Totals	$1,321,234.03	$1,295,379.00	$ (25,855.03)
Expenses:			
Canadian Department of Fisheries	$ 472,000.00	$ 472,000.00	$ -0-
United States Fish and Wildlife Service	791,734.15	807,039.00	15,304.85[C]
Currency exchange charges	17,702.04	-0-	(17,702.04)
Retained for salary increases	27,854.85[C]	-0-	(27,954.85)
Totals	$1,309,391.04	$1,279,039.00	$ (30,352.04)
Excess of revenues over expenses	11,842.99		
Fund balance, July 1, 1958	147.19		
Fund balance, June 30, 1959 (Exhibit A)	$ 11,990.18[A]		

Note A—See credits.

Note B—This amount represents $3,592.98 deducted from supplemental fund for lamprey control plus $63.69 deducted from Administration and General Research Fund. Total $3,656.83.

Note C—Of the 1957–58 Bureau underexpenditures, the Bureau used $12,650 for retroactive salary increases, leaving $15,304.85, which it retained until final audit completed in June 1959. The Commission deducted this amount from the last installment paid to the Bureau for fiscal year 1958–59.

Exhibit D

Great Lakes Fishery Commission
Credits to be Applied Against 1959–60 Funds

Administration and General Research

Unexpended funds from 1957–58	$ 631.37	
Deducted by United States Government	63.69	
Total (Exhibit A)		$ 567.68[A]

Lamprey Control Operation Fund

	31% Canada	69% U. S.	Total
Balance from 1957–58 in account	$ 45.63	$ 101.56	$ 147.19
Unexpended in 1957–58	8,666.00	19,288.84	27,954.84
Totals	$ 8,711.63	$19,390.40	$28,102.03
Retained for retroactive salary increases	-0-	−12,650.00	−12,650.00
Deducted from last contribution	-0-	−3,592.98	−3,592.98
Balance	$ 8,711.63	$ 3,147.42	$11,859.05
Overpayment 1958–59 to be credited to 1959–60	104.16	-0-	104.16
Balance in account, July 1, 1959	8.36	18.61	26.97
Totals (Exhibit A)	$ 8,824.15	$ 3,166.03	$11,990.18

NOTE A—Further breakdown of this credit:

	Canada	U.S.	Total
To be divided 50–50	$ 315.68	$ 315.69	$ 631.37
Amt. deducted from U.S. contributions in 1958–59	-0-	63.69	63.69
	$ 315.68	$ 252.00	$ 567.68
Credited in 1959–60 request for funds	63.68	-0-	63.68
Balance to be deducted from second installment of contributions, January 1, 1960	$ 252.00	$ 252.00	$ 504.00

U. S. Fish and Wildlife Service

Sea Lamprey Control and Research Program

Summary Report of Expenditures
July 1, 1958, through June 30, 1959

Activity	*Funds allotted for fiscal year*	*Expenditures or Obligations*	*Available Unobligated Balance*
Research	$89,900.00	$112,968.42	
Lake Trout Rehabilitation	15,000.00	11,099.34	
Control:			
Chemical	309,202.00	225,355.90	
Electrical	321,873.00	411,760.52	
Contract Administration	43,800.00	43,800.00	
Supplemental for Pay Raise	27,622.25		
	$807,397.25	$804,984.18	$2,413.07

Fisheries Research Board of Canada

Sea Lamprey Control and Research
Summary Report of Expenditures
April 1, 1958 to March 31, 1959

Activity	*Expenditure (Canadian dollars)*	*Estimated Cost in contract (Canadian dollars)*
London Headquarters . $65,005.75		
56.3 percent charged to contract.	$ 36,606.80	$ 25,500
Operations		
1. Construction and engineering Lake Superior	37,812.67	36,600
2. Operation and maintenance Lake Superior	151,789.87	200,870
3. Surveys—Lake Huron	39,791.12	58,140
4. Surveys—Lake Superior	13,500.00	12,800
5. (a) Pancake River study—Lake Superior	19,937.98	9,980
(b) Underwater studies—Lake Superior	17,262.60	17,850
(c) Lampricides—Lake Superior	10,019.57	11,500
(d) Physiological studies—General	12,536.20	19,470
(e) Electrical devices, DC—General	16,970.77	29,330
(f) Spawning studies—General	2,270.43	4,950
(g) Ammocoete studies—General	10,937.55	17,760
(h) Behaviour studies—General	9,266.92	17,290
(i) M/V "Cottus"—Lake Superior	21,005.55	9,960
	$399,708.03	
Contributions to Superannuation 6 percent of permanent salaries	7,094.57	
	$406,802.60	
Contract Administration (6 percent)	24,408.16	
	$431,210.76	$472,000
Refunded to Commission on request	1,400.00	
Authorized to be applied to purchase of chemicals for 1959–60 program	39,389.24	
	$472,000.00	$472,000

LAMPREY CONTROL AND RESEARCH IN THE UNITED STATES

U. S. Fish and Wildlife Service
by the Bureau of Commercial Fisheries

The year has seen the first full season of systematic application of selective toxicants to lamprey-producing tributaries of Lake Superior by our chemical-control group. Other investigations have been continued at previous levels or slightly reduced, but all have made satisfactory progress.

Sea lamprey control by means of electrical barriers that block spawning runs had to be terminated along the east shore of Lake Michigan in order to make funds and personnel available for the chemical control on Lake Superior, but it was possible to continue barrier operations on those Lake Michigan streams that had been under control several years. Full-scale operation of barriers on Lake Superior was continued.

Unfavorable weather and late-summer changes of water quality that reduced severely the effectiveness and selectivity of the toxicants hampered the work of the chemical-control group. They were able, nevertheless to complete the treatment of 29 streams along the south shore. They received valuable assistance from biologists of the Fisheries Research Board in the early season and in return spent much of July aiding in the treatment of Ontario streams tributary to eastern Lake Superior.

Work at the Hammond Bay Laboratory has been to a considerable degree in support of the field program of chemical control. Bio-assays in water from streams scheduled for treatment, tests of shipments of lampricide, and improvements of procedures for determining concentrations of nitrophenols in natural waters have occupied much of the attention of the staff. Additional progress was made nevertheless in the search for possibly more effective toxicants and in the study of seasonal changes of water quality that affect the action of nitrophenols.

Chemical treatments

The chemical control unit at Marquette, Michigan, began 1959 field work on April 13, operating with stocks of chemical left from 1958. A low spring run-off in northern Wisconsin made the early start possible. Two lots of chemicals were bought during the year. The purchase of 25,000 lbs. of 3-trifluormethyl-4-nitrophenol formulated as a 30-percent stock solution was made in February 1959 from the Maumee Chemical Company, Maumee, Ohio and an additional 25,000 lbs. formulated as a 35-percent stock solution was purchased in

September from the Dow Chemical Company of Midland, Michigan. The bulk of this material has been stored over winter and will be used in 1960.

Treatment of Lake Superior streams along the south shore proceeded uninterrupted except for July, when the chemical unit assisted personnel of the Fisheries Research Board of Canada in the treatments of Canadian streams along the eastern end of the lake. Along the U. S. shore, 2 streams were treated in April, 5 in May, 2 in June, 8 in August,[1] 4 in September, and 8 in October (Table 1). The number of streams treated on the south shore of Lake Superior by the end of the season was 39—10 in 1958 and 29 during 1959.

The treatment of streams in 1959 followed the methods outlined in last year's report. The procedure consists of three major steps: pre-treatment examination of the stream, application of chemical, and post-treatment survey.

The only major change in operation came from the addition to the field equipment of a mobile bio-assay laboratory constructed during the winter of 1958–59. This mobile laboratory improved and hastened treatment procedure by largely eliminating the need to send stream water to the Hammond Bay Laboratory to determine minimum effective and maximum allowable concentrations of chemical. Although the majority of pre-treatment bio-assays were done in this mobile laboratory, considerable use was made of the facilities of Hammond Bay.

Treatment of streams on both the United States and Canadian sides of Lake Superior was expedited by close cooperation between the Fisheries Research Board of Canada and the Bureau of Commercial Fisheries which resulted in the pooling of staff and equipment. Beginning in early May, the chemical-control personnel of the Fisheries Research Board assisted in the treatment of streams on the U. S. side of Lake Superior. This arrangement continued until completion of work on the Two Hearted River, Chippewa County, Michigan, on June 15, 1959. During this period members of the Board staff gained experience necessary in this type of work and at the same time provided the additional personnel and equipment needed by the Bureau group. Seven streams were treated by the combined units. During July, Bureau personnel joined the Fisheries Research Board's chemical unit in the area north of Sault Ste. Marie, Ontario. Seven streams flowing into Whitefish Bay and Batchawana Bay were treated by July 24. A 4-man group and equipment were detailed from Marquette in August to work with Board staff in the vicinity of Nipigon, Ontario. They returned to Marquette on September 1. Excessive rain and high run-off handicapped operations so much that only one stream was treated.

[1] Including re-treatment of the Sucker River.

TABLE 1.—Details on the application of the sodium salt of 3-trifluormethyl-4-nitrophenol to 29 streams tributary to Lake Superior, April-October 1959.

Stream	Date of treatment	Discharge at mouth (cfs)	Stream miles treated	Concentration (ppm)		Amount of active ingredients (pounds)	Cost of chemical
				Minimum effective	Maximum allowable		
Brule River	April 13	180	28	1.0	4.0	2,460.0	$10,824.00
Fish Creek	April 23	85	14	2.0	7.0	1,000.0	4,440.00
Big Garlic River	May 11	99	4	1.0	4.0	480.0	2,112.00
Miners River	May 16	105	6	1.5	5.0	1,100.0	4,840.00
Seven Mile Creek	May 16	17	4	1.5	7.0	260.0	1,144.00
Lowney Creek	May 17	10	2	2.0	9.0	100.0	440.00
Au Train River	May 21	208	16	2.0	7.0	2,870.0	11,068.00
Little Two Hearted R.	June 5	53	16	1.5	7.0	741.0	2,667.60
Two Hearted River	June 15	184	48	1.5	5.0	3,139.5	11,302.20
Sucker River	August 4	75	43	2.0	9.0	1,267.5	4,563.00
Sullivan Creek	August 6	5	2	3.0	9.0	68.0	245.70
Pendills Creek	August 11	20	1	1.0	4.0	107.5	386.10
Grants Creek	August 12	3	1	1.5	5.0	19.5	70.20
Galloway Creek	August 13	3	3	2.0	5.0	19.5	70.20
Ankodosh Creek	August 14	8	2	2.0	9.0	156.0	561.60
Harlow Creek	August 21	15	2	4.0	7.0	156.0	561.60
Pine River	August 25	37	3	2.0	7.0	298.5	1,074.06
Anna River	September 4	35	4	2.5	5.0	309.5	1,113.48
Salmon-Trout River	September 13	58	8	2.0	9.0	513.5	1,848.60
Little Garlic River	September 16	12	5	2.0	7.0	175.5	631.80
Elm River	September 25	27	8	1.5	7.0	234.0	842.40
Misery River	October 1	96	12	2.5	11.0	975.0	3,510.00
Salmon-Trout River	October 6	48	1	1.5	5.0	370.5	1,333.80
Traverse River	October 8	34	7	1.0	4.0	195.0	702.00
Little Gratiot River	October 11	45	6	0.5	4.0	331.5	1,193.40
Firesteel River	October 22	57	14	1.0	5.0	663.0	2,386.80
Cranberry River	October 26	32	5	1.5	4.0	273.0	982.80
E. Sleeping River	October 30	45	12	2.0	7.0	663.0	2,396.80
Potato River	November 1	20	9	1.0	5.0	195.0	702.00
Total	...	1,616	286	...	...	19,141.5	$70,004.14

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Stream	Date of treatment	Discharge at mouth (cfs)	Stream miles treated	Concentration (ppm)		Amount of active ingredients (pounds)	Cost of chemical
				Minimum effective	Maximum allowable		
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Fish Creek	April 23	85	14	2.0	7.0	1,000.0	4,440.00
Big Garlic River	May 11	99	4	1.0	4.0	480.0	2,112.00
Miners River	May 16	105	6	1.5	5.0	1,100.0	4,840.00
Seven Mile Creek	May 16	17	4	1.5	7.0	260.0	1,144.00
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Sullivan Creek	August 6	5	2	3.0	9.0	68.0	245.70
Pendills Creek	August 11	20	1	1.0	4.0	107.5	386.10
Grants Creek	August 12	3	1	1.5	5.0	19.5	70.20
Galloway Creek	August 13	3	3	2.0	5.0	19.5	70.20
Ankodosh Creek	August 14	8	2	2.0	9.0	156.0	561.60
Harlow Creek	August 21	15	2	4.0	7.0	156.0	561.60
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Firesteel River	October 22	57	14	1.0	5.0	663.0	2,386.80
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Potato River	November 1	20	9	1.0	5.0	195.0	702.00
Total	...	1,616	286	...	...	19,141.5	$70,004.14

Results from the 1959 operations give cause for continued optimism. A number of problems, that had been anticipated with the expansion of the treatment program, were overcome. Seasonal changes of water quality, however, continue to restrict operations.

The problem of communications between operating units during a treatment, particularly on the larger watersheds, was solved successfully by the use of two-way mobile radio equipment. Savings in time and effort by the use of this equipment have been considerable.

The problem of treating small tributaries, with flow less than 5 cfs, has been solved partially by the construction and use of drip feeders. Several kinds have been tried, but with all it has been difficult to maintain a steady rate of feeding. Further improvements are needed if drip feeders are to be used extensively.

In some streams survival of ammocoetes has occurred in backwaters and stream-bed springs into which little or no chemically-treated water penetrates. Several attempts have been made to "spot-treat" areas of this type, but the impossibility of controlling concentrations makes this procedure extremely hazardous if the populations of fish are large. Fortunately, the number of ammocoetes in most of these areas is small.

Most ammocoetes recovered during post-treatment studies are usually the young of native species (Table 2). Their presence in treated sections may arise from their movement from upstream sections or untreated tributaries and does not necessarily indicate failure of the treatment. Although the data from all treatments have not been fully analyzed, there is some indication that 3-trifluormethyl-4-nitrophenol may be more toxic to sea lamprey ammocoetes than to the native species. Until the reasons for survival of native ammocoetes are determined, it is impossible to use their presence or absence as a criterion of the success of a treatment.

Weather frequently disrupts the scheduling of applications. The danger always exists that rising water will dilute a bank of chemical after it has left the feeder, particularly during the summer when sudden and violent thunderstorms are frequent in the Lake Superior area. Although no treatment in 1959 was "washed out" by rain during application, some streams were treated in periods of continually rising water levels. Speed and accuracy in the determination of nitrophenol concentration in the water made possible the adjustment of application rates to take care of increasing volume.

The chemical treatment of streams from early July into September is influenced greatly by the seasonal change in water quality which lessens the effectiveness of the lampricide. This loss of biological activity and selectivity of the chemical is caused by as yet undetermined changes in most stream waters. Pre-treatment bio-assays revealed that this lessening in the effectiveness of the lampricide was

TABLE 2.—Recovery of ammocoetes in post-treatment surveys, Lake Superior, 1959.

County	Stream	Date of post-treatment survey	Area examined (square feet)	Ammocoetes taken		Young of the year (unidentifiable)
				Native species	Sea lamprey	
Chippewa	Pendills Creek	9/9	8,600	26	0	0
Chippewa	Grants Creek	9/9	3,600	0	0	0
Chippewa	Ankodosh River	9/10	3,600	0	0	0
Chippewa	Galloway Creek	9/9	4,000	0	0	0
Chippewa	Little Two Hearted R.	10/8	13,000	0	1	0
Chippewa	Two Hearted River	10/7	24,300	10	0	0
Chippewa	Sucker River	9/2	8,800	0	0	0
Alger	Sullivans Creek	9/17	4,800	0	0	0
Alger	Seven Mile Creek	9/17	7,200	0	0	7
Alger	Miners River	9/20	3,300	1	0	0
Alger	Au Train River	9/16	36,700	48	1	14
Alger	Rock River	5/20	8,500	32	3	0
Alger	Harlow Creek	9/14	6,000	1	0	0
Marquette	Little Garlic River	9/23	8,800	0	0	0
Marquette	Big Garlic River	9/14	7,000	0	0	0
Marquette	Pine River	9/14	4,000	0	0	0
Douglas	Brule River	4/19	6,400	2	0	0

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Chippewa	Grants Creek	9/9	3,600	0	0	0
Chippewa	Ankodosh River	9/10	3,600	0	0	0
Chippewa	Galloway Creek	9/9	4,000	0	0	0
Chippewa	Little Two Hearted R.	10/8	13,000	0	1	0
Chippewa	Two Hearted River	10/7	24,300	10	0	0
Alger	Sucker River	9/2	8,800	0	0	0
Alger	Sullivans Creek	9/17	4,800	0	0	0
Alger	Seven Mile Creek	9/17	7,200	0	0	7
Alger	Miners River	9/20	3,300	1	0	0
Alger	Au Train River	9/16	36,700	48	1	14
Alger	Rock River	5/20	8,500	32	3	0
Marquette	Harlow Creek	9/14	6,000	1	0	0
Marquette	Little Garlic River	9/23	8,800	0	0	0
Marquette	Big Garlic River	9/14	7,000	0	0	0
Marquette	Pine River	9/14	4,000	0	0	0
Douglas	Brule River	4/19	6,400	2	0	0

greater than had been anticipated. Because the smaller, spring-fed streams were affected less severely than large ones, it was possible to continue treatment of the smaller tributaries during this period.

Mortality among game fish was insignificant in the 29 streams treated. A few highly susceptible species such as troutperch, logperch, bullhead, sculpin, and mudminnow were greatly reduced or entirely eradicated. Invertebrates killed in numbers were fresh-water scud (Gammarus sp.), burrowing mayflies, and aquatic earthworms.

Collections of lamprey larvae were taken from most of the streams treated. The identification of larvae and the analysis of data obtained from these collections have not been completed. It is hoped that this work can be finished before the next field season begins.

Lake Superior barrier operations

This year is the seventh that electrical barriers have been used to block spawning runs of sea lamprey from streams along the south shore of Lake Superior and no new barriers were constructed this year. The coverage of significant spawning streams in Lake Superior continues to be complete. Maintenance work was necessary to repair damage from floods, winter conditions, and general deterioration at a number of structures.

A newly designed control array was installed on the direct-current diversion units at the Two Hearted, Firesteel, and Misery Rivers to provide more effective operation during periods of high water. The Bad River barrier was equipped with a cut-off device which automatically disconnects the direct-current unit during periods of peak load and allows the full generator capacity to be applied to the alternating-current field. The direct-current device on the Brule River was rebuilt to form a more effective electrical guidance field.

Barriers were operated in 40 streams and 8 others were maintained in standby status. The barriers in the Black and Nemadji Rivers served as check-weirs to determine the size of spawning runs. Fewer barriers were operating by the end of March, 17 were activated during April, and the remainder were placed in operation in May with the exception of the one on the Salmon-Trout River. This barrier, on standby status since 1956, was placed in operation June 13 when adult sea lampreys were observed in the stream. Termination of barrier operations began July 27 and was completed September 15.

The total take at barriers in 1959 was 52,173 sea lampreys (Table 3), 22 percent less than in 1958. The 14 percent reduction in the number of sea lampreys taken from 26 streams in the eastern half of Lake Superior, operated each year since 1954, marks the second consecutive year of decline. The drop of 31 percent for 7 streams of western Lake Superior was the first in that area.

TABLE 3.—Numbers of sea lampreys caught at electrical barriers in Lake Superior tributaries, 1953–1959.

[If a figure is not given, a barrier was not operated.]

Stream	1953	1954	1955	1956	1957	1958	1959
Waiska R.		32	47	71	55	70	43
Pendills Cr.	23	40	45	42	47	17	40
Halfaday Cr.		12	3	14	4	2	
Betsy R.	221	567	569	1,577	786	1,092	1,006
Little Two Hearted R.					739	460	461
Two Hearted R.	371	638	600	1,766	7,899	3,577	4,141
Sucker R.	750	1,309	1,713	4,400	3,597	1,842	2,522
Hurricane R.		8	25	99	188	29	65
Beaver Lake Cr.	8	19	19	20	49	18	
Miners R.	64	53	148	96	427	97	159
Furnace Cr.	18	47	66	209	274	41	396
Au Train R.	204	350	486	613	739	348	168
Rock R.			1,633	3,407	3,102	1,488	1,250
Laughing Whitefish R.	9	25	16	19	37	11	28
Chocolay R.		1,227	3,350	6,888	8,096	6,221	3,500
Carp R.		0	2	1	4	0	5
Harlow Cr.		1	1	0	3	3	31
Big Garlic R.		54	89	154	270	262	247
Iron R.		67	206	335	737	428	266
Pine R.		10	12	18	34	22	43
Huron R.		147	472	1,628	2,868	3,526	1,492
Salmon-Trout R.		0	1	0			68
Ravine R.		1	4	2	10	5	23
Silver R.		247	786	963	2,810	2,182[1]	878
Sturgeon R.		1	1	4	31	28	544
Otter R.		0	0	1	0	0	
Traverse R.		3	4	37	45	76	598
Little Gratiot R.		0	1	4	9	1	11
Gratiot R.		1	0	4	2	31	11
Elm R.		0	7	7	7	2	8
Misery R.			183	571	868	896	2,581
Firesteel R.		60	150	229	1,039	1,546	2,084
Flintsteel R.		2	1	1	2	2	0
Bad R.				685	2,652	6,203	4,468
White R.				219	412	231	552
Fish Cr.					520	251	428
Cranberry R.						0	14
Iron R. (Wisconsin)						0	
Reefer Cr.						1	
Fish Cr. (Orienta)						0	
Brule R.					3,988	22,842	19,389
Poplar R.					126	580	8
Middle R.					4,289	4,853	3,645
Amnicon R.					11,055	7,670	986
Black R.						4	13
Nemadji R.						3	1
Total	1,668	4,921	10,639	24,084	57,820	66,961	52,173

[1] Included 152 killed during chemical treatment.

Lampreys spawned in the Chocolay River on sand without nest construction. Eggs in all samples from this indiscriminate spawning were dead, and none had developed beyond the blastula stage.

The catch records and visual observation indicate a greater utilization of marginal streams than has occurred in the past. Adult sea lampreys were seen or reported in the following streams that do not have control devices: Sullivans Creek, Slate River, Falls River, Little Garlic River, Graveraet River, and East Sleeping River. The extent of spawning in these streams is considered insignificant with the exception of the Little Garlic and East Sleeping Rivers.

The Minnesota Department of Conservation reported adult sea lampreys in the Knife, French, Baptism, and Arrowhead Rivers, but lampreys have been reported from all of these streams during one year or another since 1950. Careful checks have failed to date to uncover sea lamprey ammocoetes in any Minnesota stream except the Pigeon River on the Canadian border.

Only one adult sea lamprey had been taken in the Salmon-Trout River, Marquette County, during 3 years of operation from 1954 through 1956. In 1959, 68 adults were taken after the standby barrier was placed in operation.

Lake Michigan barrier operations

In Lake Michigan, where coverage always has been partial, the number of barriers was reduced from 65 in 1958 to 37 (along the north and west shores of the lake) in 1959. The re-trenchment was made to permit transfer of funds and personnel to the chemical-treatment program on Lake Superior.

Thirty-five barriers were operated by the staff at Oconto, Wisconsin. Weirs on Hibbards and Lilly Bay Creeks included in the system at the request of the Wisconsin Conservation Department were operated by Wisconsin personnel.

The late spring delayed the start of operations until March 25. All control devices were activated, however, by April 4. Termination of the season's operations began June 29 and was completed August 21. The season was 18 days shorter than in 1958.

The total catch of 27,512 sea lampreys from the 37 electrical control barriers (Table 5) was 10.7 percent below the 1958 catch of 30,917 sea lampreys from 47 barriers along the north and west shores of the lake. Greatest decreases were in Green Bay tributaries. This was the second consecutive year of decline of sea lamprey catches. The trend in abundance is best illustrated by the annual take from 19 barriers operated in Green Bay and along the west shore of Lake

TABLE 5.—Sea lampreys taken at barriers in streams of the north and west shores of Lake Michigan, 1954–1959.

[Where a figure is not given, a barrier was not operated.]

Stream	1954	1955	1956	1957	1958	1959
Brevoort River				497	85	238
Davenport Creek					6	37
Hog Island Creek				77	16	93
E. Br. Black River					99	109
Black River					218	302
Millecoquins River				955	447	389
Crow River					63	67
Cataract River					59	101
Pt. Patterson					10	
Milakokia River					610	637
Bulldog Creek					330	252
Marblehead Creek[1]					48	
Bursaw Creek					737	877
Poodle Pete Creek[1]					9	
Big Fishdam River	692	459	500	835	375	409
Sturgeon River	4,113	2,534	1,610	3,503	1,280	733
Ogontz River					529	463
Squaw Creek	283	348	284	179	82	35
Whitefish River	1,489	3,408	2,638	5,263	1,681	2,293
Rapid River	574	1,377	937	1,396	546	311
Tacoosh River	11	15	8	31	4	4
Days River	205	264	192	272	120	111
Portage Creek				35	0	
Ford River			7,946	10,289	5,920	3,525
Bark River		2,420	1,712	2,484	1,255	1,047
Cedar River		13,324	16,331	12,188	8,134	6,856
Walton River				162	8	30
Johnson Creek					0	
Beattie Creek				39	44	66
Little River		128	412	142	160	195
Pensaukee River		893	1,099	520	789	681
Little Suamico River					0	
Suamico River					15	18
Ephraim Creek		13	6	14	6	16
Hibbards Creek	7,279	6,389	5,325	6,625	2,563	2,287
Whitefish Bay Creek				245	14	16
Shivery Sands Creek			2	325	15	3
Lilly Bay Creek		66	40	68	18	153
Bear Creek				66	25	
Stoney Creek					1	
Ahnapee River					57	31
Three Mile Creek		1,945	1,473	839	237	241
Kewaunee River	4,159	5,127	2,286	3,134	766	484
East Twin River	6,960	7,558	12,131	10,313	3,474	3,708
Pine Creek					2	
Fischer Creek					59	694
Sheboygan River					1	
Total	25,765	46,268	54,932	60,496	30,917	27,512

[1] Mechanical check weir.

Michigan since 1956 (only 17 control devices operated in 1955):

1955	46,268
1956	56,932
1957	58,420
1958	27,525
1959	23,092

The first sea lampreys were captured during the week of March 28–April 2 (Table 6). The catch increased gradually in the following weeks to a maximum of 8,045 or 29.2 percent of the season's total on May 2–8. Catches decreased the next 2 weeks, rose to a smaller peak May 23–29, and thereafter fell rapidly. By the end of June, 99 percent of the total catch had been taken.

TABLE 6.—Weekly catch of sea lampreys at barriers in streams of the north and west shores of Lake Michigan, 1959.

Period	Number of streams producing lampreys	Number of lampreys	Percentage of total run	
			Weekly	Cumulative
Mar. 25–27	0	0	0.0	0.0
Mar. 28–April 3	4	10	0.0	0.0
Apr. 4–10	9	14	0.1	0.1
Apr. 11–17	18	419	1.5	1.6
Apr. 18–24	22	761	2.8	4.4
Apr. 25–May 1	28	1,708	6.2	10.6
May 2–8	34	8,045	29.2	39.8
May 9–15	35	4,495	16.3	56.1
May 16–22	34	3,433	12.5	68.6
May 23–29	34	4,777	17.4	86.0
May 30–June 6	30	2,166	7.8	93.8
June 7–12	33	939	3.4	97.2
June 13–19	28	277	1.0	98.2
June –20–26	23	151	0.5	98.7
June 27–July 3	25	160	0.6	99.3
July 4–10	17	73	0.3	99.6
July 11–17	19	53	0.2	99.8
July 18–24	12	21	0.1	100.0
July 25–31	6	6	0.0	100.0
Aug. 1–7	1	2	0.0	100.0
Aug. 8–14	1	1	0.0	100.0
Aug. 15–21	0	0	0.0	100.0
Total		27,512	...	...

Power failures were decidedly fewer this year and upstream escapement was correspondingly less. Only one stream, the Sturgeon River, was without power for a considerable length of time (1 day). Seven sea lamprey nests were found above the barrier. Short

periods of power failure occurred in the Ogontz, Ahnapee, Millecoquin and Milakokia Rivers, and in Fischer Creek, but neither adult lampreys nor nests were seen in periodic examinations above the barriers. Spawning below barriers, made possible in certain streams by the receding lake level, was no greater in 1959 than in 1958. The most troublesome stream was the Whitefish River where 76 nests were counted between June 12 and July 24 in a stretch known as Johnson's Rapids. A few nests were observed below the weir sites in the following streams (numbers of nests in parentheses): Bulldog Creek (7), Squaw Creek (1), Ogontz River (2), Rapid River (8), Tacoosh River (2), Days River (4), Bark River (1), Cedar River (1), Walton River (1), and East Twin River (10).

Destruction of fish at the control installations was serious in only the Pensaukee River. Although sucker mortality in the Pensaukee was reduced 61.3 percent (from 9,470 fish in 1958 to 3,665 in 1959), it still was excessive and an operating nuisance. Additional modifications that have been made on the installation should further reduce the kill of suckers next season.

Sixty-two species of fish were handled in the operation of the barriers. Rainbow trout, northern pike, smallmouth bass, longnose suckers, and smelt were less numerous than in 1958. Alewives were taken in 4 more streams this year than last but numbers were smaller.

Direct-current diversion device

The use of direct-current devices with some of the alternating-current barriers has reduced fish mortality in the "problem" streams. Eleven of the devices were installed in Lake Superior streams and 2 in Lake Michigan tributaries. The basic design was not changed except in the Brule River, Wisconsin, where temporary modifications improved the trapping of large brown trout congregated below the control structure. The movement of the brown trout into the traps was so greatly improved that permanent modifications have been installed. The new design provides an inverted "V-type" electrical field that guides fish effectively to traps located on both sides of the river.

Observations on sea lamprey spawning runs

The size of sea lampreys did not change significantly from 1958 to 1959 in Lake Superior. The average total length and weight of 15,042 lampreys from the 10 index streams were 16.9 inches and 5.9 ounces (Table 7). Lampreys from most index streams in Lake Michigan were considerably larger this year than last. The average length increased 0.7 inches and the average weight 0.5 ounces. The mean size

of lampreys varied noticeably, however, from one geographical location to another. The largest lampreys were caught in southern Green Bay in the Pensaukee River where 681 averaged 19.0 inches long and weighed 7.9 ounces. The 2,755 individuals from 5 index streams, (Millecoquins, Milakokia, Ogontz, Rapid, and Bark Rivers) in northern Lake Michigan and northern Green Bay were intermediate—17.4 inches and 6.2 ounces. Western Lake Michigan streams (Kewaunee River, Hibbards Creek, and Fischer Creek), on the other hand, produced small lampreys; 3,488 averaged 15.5 inches and 4.1 ounces. The variability in size may reflect the availability and size of prey in the areas of Lake Michigan and Green Bay in which they grew to maturity.

TABLE 7.—Average lengths and weights of spawning-run sea lamprey captured in tributaries of Lakes Superior and Michigan, 1954–1959.

Area and year	Number measured	Average length (inches)	Number weighed	Average weight (ounces)
Lake Superior—south shore				
1954	3,939	18.1	2,474	8.0
1955	6,174	17.2	6,168	6.9
1956	9,593	17.8	9,593	7.2
1957	11,015	17.0	11,015	6.2
1958	12,985	16.8	12,985	5.8
1959	15,042	16.9	15,042	5.9
Lake Michigan—west and north shores				
1954	572	17.7	500	6.1
1955	4,972	17.2	4,972	6.1
1956	2,222	17.5	2,222	6.0
1957	14,435	16.7	14,435	4.6
1958	7,373	15.9	7,373	4.8
1959	6,884	16.6	6,884	5.3
Lake Michigan—east shore[1]				
1957	2,647	15.9	2,647	4.1
1958	3,049	15.7	3,048	4.1

[1] Barrier operations discontinued in 1959.

Males continue to dominate sea lamprey runs in both Lake Superior and Lake Michigan. The sex ratio did not change significantly in Lake Superior during 1959 (Table 8). The relative abundance of males increased slightly in Lake Michigan from 171 per 100 females in 1958 to 183 per 100 females in 1959.

TABLE 8.—Sex ratios of sea lampreys of Lake Superior and Lake Michigan.

Year	Lake Superior		Lake Michigan	
	Number of lampreys examined	Males per 100 females	Number of lampreys examined	Males per 100 females
1953	1,777	99		
1954	3,939	140	6,559	219
1955	6,174	113	4,972	151
1956	9,593	135	2,222	145
1957	11,015	136	14,435	224
1958	12,985	140	7,373	171
1959	15,042	142	6,884	183

Distribution of ammocoetes

Examination of streams tributary to the U. S. side of Lake Superior for sea lamprey larvae, continued through 1959, is nearing completion. The only major watershed containing sea lamprey larvae on which the distribution survey is incomplete is the Ontonagon River in Michigan. The normally high turbidity has delayed progress in the work. Heavy rains and high water aggravated this condition most of 1959.

In addition to parts of the Ontonagon River system, 26 small streams along the south shore of Lake Superior remain to be surveyed. Most have a discharge of less than 3 cubic feet per second and hence a low potential for the production of sea lamprey ammocoetes. An additional 24 streams on the north shore of Lake Superior between Duluth and the Canadian border were surveyed previously by the Minnesota Department of Conservation, but no ammocoetes were taken. Six of these streams have been re-surveyed with the same result.

Preliminary examination of Lake Michigan streams to determine ammocoete distribution along the north and west shore was begun by the Oconto staff after operation of the barriers was terminated. A survey of Wisconsin streams was made cooperatively with the Wisconsin Conservation Department. Streams covered in this survey together with those examined by the Michigan Department of Conservation bring to 45 the number on which ammocoete distribution information is available.

Lampricide research

The most significant project at the Hammond Bay Laboratory in 1959 was the development of a technique for the rapid but accurate

quantitative determination of halogen nitrophenols in stream water. Dependability of analysis for concentration of lampricides in streams is essential, especially where minimum concentrations are low. On occasion accuracy within 0.1 ppm may be needed. The analytical technique promotes accuracy by preventing the formulation of precipitates in the solutions and by eliminating other turbidities. Problems created by variations in the natural background color of water were solved by the use of a simple nomograph. A report on this development has been prepared for publication.

An adjunct to research on nitrophenol analyses was the determination of physical properties of all known selective lampricides, which is fundamental to the use of the compounds. A report of the study has been submitted for publication approval.

A 3-day course of instruction on the techniques of nitrophenol analysis was conducted at the laboratory in February. Seven members of the field staff and 2 staff members of the Fisheries Research Board of Canada attended. Instruction included the preparation of stock solutions, standard solutions, and standard curves, and the determinaton of unknown concentrations of the nitrophenols in various types of natural water.

The 180 bio-assays that were made between January 1 and November 7 required 9,360 individual jar tests (37,400 test animals). Since each assay series covers a 24-hour period, the entire program covered 180 working days for the laboratory staff. The 68 tests that were in support of the field program included 42 pre-treatment assays. The remaining 26 tests were quality-control assays of lots of chemicals supplied by manufacturers.

Various research projects undertaken by the laboratory staff required 112 assays as follows: 74 tests of lampricide activity in waters from tributaries of Lakes Huron, Michigan, and Superior to determine seasonal fluctuations; 13 assays to determine the effect of temperature upon the biological activity of trifluormethyl nitrophenol; 12 assays of mononitrophenols not previously tested; 6 assays of new formulations, primarily amine salts, of trifluormethyl nitrophenol; and 7 assays of other new compounds of possible value as lampricides.

Considerable progress has been made in defining the seasonal changes in the biological activity of nitrophenols. Water from representative tributaries in Lakes Huron, Michigan, and Superior was tested periodically to determine when this loss of activity occurred in different regions. Chemical and physical analysis of the water was also undertaken. Data accumulated are presently being reviewed to detect possible relationships between seasonal changes in water chemistry and the biological activity of nitrophenols. A report will be submitted early in the next calendar year. Attempts to develop means for the

reliable prediction of the influence of water chemistry upon the action of lampricides have been deferred until the findings of the previously described study have been reviewed.

Studies of the effect of temperature on the action of the lampricides were begun during the calendar year and data will be available for members of chemical-control units at the beginning of the 1960 working season.

Commercial suppliers of trifluormethyl nitrophenol have been encouraged to develop new formulations that contain greater percentages by weight of the active ingredient and possess greater resistance to crystallization at low temperatures. Six such products have been submitted for testing; all were in the form of the amine salt of the nitrophenol. Certain of these products had 50-percent stock strength and yet were stable against crystallization down to 22° F. The biological properties of these new formulations were identical with those of the sodium salt formulation presently used.

The systematic search continued for new nitrophenols having the desired biological properties. Twelve new compounds, primarily mononitrophenols containing fluorine, were synthesized or obtained from other sources. All were tested and one displayed a selectively taxic action. Eight halogen mononitrophenols that have useful biological properties are now available. Seven other compounds known to have interesting biological activities, were tested during the year. None proved to be selectively toxic to larval lampreys.

The new bio-assay laboratory, completed and put into operation during the second week of September, has contributed greatly to the amount of research that can be conducted. The Hammond Bay Laboratory now contains 8 constant-temperature troughs in which 116 simultaneous jar tests can be carried out. Numerous other improvements have been made in the bio-assay procedure. A better evaluation of the effect of water chemistry, temperature variation, and the kind and condition of test animals upon the quality and reliability of assay tests is now possible.

Studies on the physiological action of selective toxicants on sea lamprey larvae were limited during the year due to lack of trained personnel. Success of attempts to find better lampricides or to improve the use of presently known ones may depend on the knowledge of the effect of the halogen nitrophenols upon lamprey larvae. Gross pathology has been determined but this information is not sufficient. During the year a graduate student at the University of Western Ontario was encouraged to study certain phases of this problem. The Laboratory has provided him with sufficient experimental materials to begin his work and plans to give him further materials and guidance in the coming year.

Embryological studies

An experimental study of the embryology of the sea lamprey at various temperatures was completed during the year. Information so derived will contribute to a better understanding of the ecological factors of distribution of larvae and perhaps some indications as to why spawning runs of adult lamprey occur in some streams and not in others. Final revision of the manuscript describing this work was completed during the year and the paper was submitted for publication.

LAMPREY CONTROL AND RESEARCH IN CANADA

by the Fisheries Research Board of Canada

The Fisheries Research Board of Canada continued to carry out the Commission's sea lamprey control and research program in Canada during 1959. As chemical treatments were to be used on a large scale for the first time, arrangements were made to familiarize the Canadian group with techniques by having them work closely with the more experienced staff of the U. S. Fish and Wildlife Service. The two crews jointly treated a number of streams in the United States and Canada. Two staff members were seconded to the Hammond Bay Laboratory of the U. S. Fish and Wildlife Service to assist in the development of improved chemical treatment techniques.

Engineering

Considerable information has accumulated about physical characteristics at lamprey barriers including surveys of the property used and detailed descriptions of the barriers. In 1959 the information was organized so that it could be filed as engineering drawings supplemented by tables of data. The work has been completed for the Harmony, Chippewa, Batchawana, Sable, Pancake, and Big Gravel barriers. While organizing this material it became obvious that in several cases, agreements about barrier sites or access roads required clarification to avoid possible trouble with neighboring landowners; action to clarify these agreements was initiated.

Information was collected on stream flows in a number of tributaries of Lakes Superior and Huron which had been selected for lampricide treatment. Predictions of stream flows at various seasons were made to aid planning for lampricide application. Other engineering assistance was also given to the lampricide crews in designing apparatus, and adding detail to the maps required.

Lake Superior barrier operations

Electrical barriers were operated on 19 Lake Superior tributaries in 1959. Every effort was made to install barriers as soon after April 1 as possible and to maintain them in continuous operation until the lamprey run seemed to be over (August 25 to September 18). The Pancake River barrier was operated 12 months. Unusually severe flooding during April and early May delayed installation of seven barriers until about the middle of May, and until June 16 in the case of the Dog River. These conditions were mainly responsible for the non-continuous operation of 13 barriers and a total loss of 2,384 barrier-hours out of a possible 57,888 barrier-hours.

A total of 3,374 adult sea lampreys were killed and recovered at barriers compared with 3,044 in 1958 (Table 1). In the southeast end of the lake where lamprey runs have been established for some time, the numbers recovered tended to be smaller than in 1958. In the northwest end, where lampreys have more recently appeared, the runs tended to be considerably greater than in 1958.

A search was made for spawning sea lampreys in 12 of the 19 streams on which barriers were operated. Spawning adults were seen above the barrier on the Goulais and below the barrier on the Michipicoten, and a single adult was observed above the barrier on the Sable. The presence of sea lampreys above these barriers was presumably the result of interrupted operations mentioned earlier.

The fact that sea lamprey ammocoetes were found upstream of the respective barriers during chemical treatment operations in 1959 suggests that at some earlier time sea lampreys evaded barriers on the following streams: West Davignon, Big Carp, Stokeley, Harmony, Batchawana, Sable, Pays Plat, and Big Gravel.

Thirty-eight streams that had been previously surveyed and recorded as free from sea lampreys were resurveyed. A careful search with electro-shocking equipment showed sea lamprey ammocoetes for the first time in two of them, the Pearl and Pigeon Rivers.

Chemical treatment operations

Electro-shocking equipment was used to determine the distribution of sea lamprey ammocoetes in the following tributaries to Lake Superior: West Davignon, Little Carp, Goulais, Horseshoe, Stokeley, Harmony, Chippewa, Big Carp, Cranberry, Ungers, Batchawana, Sable, Pays Plat, Big Gravel, Jackfish, Pearl, McIntyre, Kaministikwia, Pigeon, and an unnamed stream adjacent to the Chippewa designated S-49. Other information needed for lampricide treatments was collected as required.

TABLE 1.—Sea lamprey recovered annually at electrical barriers on Lake Superior streams, 1954–1959.

[Where a figure is not given a barrier was not operated.]

Stream		Year					
No.	Name	1954	1955	1956	1957	1958	1959
S 1	E. Davignon Cr.	..	1	3		..	
S 2	W. Davignon Cr.	.	0	0		.	.
S 4	L. Carp R.	..	20	24	26	5	5
S 5	B. Carp R.	.	5	27	28	19	15
S 23	Cranberry Cr.	.	6	11	18	6	
S 24	Goulais R.	..	46	62	820	682	395
S 34	Haviland Cr.	.	0	3		.	
S 36	Stokeley Cr.	49	11	58	5	2	0
S 39	Harmony R.	19	29	29	16	6	8
S 42	Jones Landing Cr.	..	0	0	..	..	
S 43	Downey Cr.		0	0		..	
S 48	Chippewa R.	.	807	839	359	220	296
S 52	Batchawana R.	.	608	421	427	358	482
S 54	Sable R.	39	43	65	76	47	142
S 56	Pancake R.	.	555	717	1,073	809	816
S 93	Agawa R.	..		0	26	19	18
S 103	Coldwater Cr.	.	..		0	..	.
S 105	Baldhead R.	..	.	..	0	..	..
S 116	Gargantua R.	..	..	.	0	.	
S 130	Old Woman R.	.			0	..	
S 167	Michipicoten R.	.	.	53	372	641	371
S 202	Dog R.	.	..	..	9	0	10
S 261	Swallow R.	..	..	.	0	..	
S 278	White Gravel R.	..	.	..	0	..	
S 297	Willow R.	.	..	..	0	..	
S 322	Little Pic R.	..	..	0	0	..	
S 327	Prairie R.	.	.	0	0	0	..
S 335	Steel R.	..	.	1	0	.	..
S 351	Hewitson Cr.	..	.	0	1	1	..
S 353	McLeans Cr.	.	..	0	0		.
S 360	Pays Plat R.	..		6	3	4	32
S 368	Gravel R.	..	..	5	99	154	541
S 369	L. Gravel R.	..	.	0	2	0	0
S 374	Cypress R.	..	..	1	3	5	1
S 385	Jackfish R.	.	..	0	0	64	240
S 570	McIntyre R.	.	.	..	0	2	2
S 571	Neebing R.	..		..	1	0	0
Totals		107	2,131	2,325	3,364	3,044	3,374

When plans for chemical treatment became concrete in February, water samples were immediately taken from the rivers specified for treatment and shipped to the U. S. Fish and Wildlife Service laboratory at Hammond Bay, Michigan. There, bio-assays were conducted to determine the range of concentrations of the lampricide (3-trifluormethyl-4-nitrophenol) required to kill lampreys but not fish at "summer" water temperatures using water from each river. This information, with estimates of average river flows and average temperatures, was the basis for estimating the amount of chemical to be purchased. Unfortunately the information on the effectiveness of the lampricide on these winter samples was not applicable to summer conditions. In many cases subsequent bio-assays showed a requirement as much as four times that predicted, and in some cases indicated that a concentration strong enough to kill lamprey ammocoetes would also kill many of the fish. The problem of "loss of biological activity" had been encountered to a lesser degree in 1958 during treatment of streams in the United States, where it had been "solved" by waiting until late summer or early fall when the concentrations required became reasonable. Although the Board's application crew waited until snow made further operations impossible, bio-assays continued to indicate that abnormally large amounts of chemical would be required for successful treatment in some of the rivers.

Another serious problem was the abnormal amount of rain which fell in the Lake Superior area in 1959. Stream flows were much greater than expected so the operators had to either use considerably more chemical than had been estimated or postpone treatment.

These problems prevented completion of the treatments proposed for 1959. Of the 13 streams specified, only eight were treated: West Davignon, Big Carp, Harmony, Stokeley, Sable, Batchawana, Pays Plat, and Big Gravel. The Pearl River was also treated.

All of the treatments with the exception of the Stokeley River were considered to have been successful at their termination. This assumption was based on the following facts.

1. A lethal concentration of the toxicant was maintained, for the pre-determined period (determined by bio-assay), from the feeder sites to the estuarine area of the streams.
2. All ammocoete activity ceased during the period that the chemical was at a lethal concentration and all ammocoetes collected after that period were dead.

The minimum effective and maximum permissible concentrations or "working range" from the bio-assay are the minimum concentration lethal to 100 per cent of the ammocoetes tested in a 4- to 6-hour period and the maximum concentration tolerated by 12–25 percent of the rainbow trout (perch on Batchawana River) for an 18 to 25-hour period.

Three weeks after treatment a survey with electric shockers, carried out on the Stokeley, revealed the presence of live sea lamprey larvae above the barrier. It was evident that, in the lower third of the

treated length of Stokeley River, the lampricide had failed to kill all of the ammocoetes. Failure of this treatment was attributed to the following causes:

1. The narrow working range of toxicities of the lampricide, between fish and ammocoetes.
2. The lack of sufficient data, during the treatment, on concentrations of the lampricide in the lower half of the treated section owing to high turbidity.
3. Failure to take into account the volumetric increase of the lower three miles of Stokeley River caused by small tributaries.
4. Inaccessibility of the area.

In addition to the Stokeley, the West Davignon, Big Carp, Harmony, Batchawana, and Sable Rivers were surveyed with electro-shocking equipment for survivors following chemical treatment. Four sea lamprey ammocoetes were found on the Batchawana at the mouth of a lagoon which had been treated separately, and one ammocoete was found in an isolated pool on the Sable River.

Development of electrical devices

The development of a lamprey barrier which would collect all lamprey and fish encountering it into traps has several operational advantages. An electrical device using steady direct current showed some promise in this connection when it was tested on a Lake Erie tributary in 1958. Further field tests were conducted in 1959 on the Bridgland River (Little Thessalon), a tributary of the Thessalon, which enters northern Lake Huron. Laboratory tests carried out in support of this project showed that about twice as much voltage in a steady field is required to elicit a response in sea lamprey as when the electrical field is abruptly established and about four times as much is required to immobilize them.

Tests at the experimental device showed that the steady direct current required to create an effective lamprey barrier could not be achieved in this stream, although the kills of fish were substantial. Various electrode arrangements utilizing both pulsed and steady direct current were subsequently investigated but none showed evidence of effective guiding.

Spawning observations

The effect of artificially changing current flow over gravel suitable for lamprey spawning was noted on the Bridgland River. Several sea lampreys built nests where the current was artificially restricted to a flow of less than one-third of a foot per second, and in some cases to an imperceptible current. Under these conditions of unusually slow current, lampreys mated, eggs were deposited in at least five of the eleven nests observed, between 11 and 46 percent of these eggs developed to at least the two-cell stage, and larva hatched from between 7 and 19 percent. The ammocoetes left the nests 10 to 27 days after the eggs were laid. Although lampreys spawned in the stream where there was very little current, attempts to induce them to spawn in a pen in the open lake failed.

Ammocoete studies

Until recently, it had been assumed that ammocoetes lived in streams only. In 1959, to confirm preliminary observations made in 1958, the distribution of ammocoetes in the open lake in Batchawana and Goulais Bays, Lake Superior, was investigated. In shallow water a search was made for ammocoetes by traditional methods, namely, by electro-shocking equipment and by shovels. In deeper water a special dredge was devised for taking samples of the bottom, including ammocoetes that burrow in it. In addition, a toxicant was applied to limited areas of the bottom by skin divers who used apparatus especially developed for that purpose.

Ammocoetes were found to be much more prevalent in the open lake than had been realized. In the inshore areas of Batchawana Bay there was roughly one sea lamprey ammocoete per thousand square yards of lake bottom. Limited exploration in deeper areas indicated that they may also be as plentiful in waters up to 75 feet deep. Sea lamprey ammocoetes were less plentiful in Goulais Bay although some were found.

The information available indicates that the ammocoetes found in the open lake hatched from eggs that were spawned in neighboring streams. In spite of a thorough search there was no evidence of lamprey spawning in the open lake. Although some of the streams tributary to Batchawana Bay were treated with lampricide during the survey, the lampricide has no apparent effect on the ammocoetes in the open lake near those stream mouths.

LAMPREY CONTROL AND RESEARCH

by Co-operating Agencies

Michigan Department of Conservation

Michigan's sea lamprey research is carried out principally from the Marquette Office of the Institute for Fisheries Research. In 1959 the work was concerned mainly with a continuing study of the distribution and abundance of sea lamprey ammocoetes in streams; the

duration of the ammocoete stage; migration of ammocoetes in the Carp Lake River; and an estimate of the number of sea lamprey ammocoetes in the Ogontz River, Delta County.

Distribution and abundance of ammocoetes in streams. Field collections with a direct-current electric shocker were continued during the 1959 field season, to determine the distribution and abundance of sea lamprey ammocoetes in State of Michigan tributaries of the Upper Great Lakes, and thus facilitate the later application of selective toxicants by the U. S. Bureau of Commercial Fisheries. The 1959 work was restricted to Lake Michigan tributaries in Delta and Menominee counties, in the central Upper Peninsula. A total of 129 collections were made in the Bark, Cedar, Days, Ford, Little, Tacoosh, and Walton Rivers; in addition, 45 collections were made in Whitefish, Rapid, Sturgeon, and Ogontz Rivers, which had been surveyed previously to determine more precisely the upstream limits of ammocoete distribution.

Duration of the ammocoete stage. A study of the duration of the ammocoete stage of the sea lamprey in the Carp Lake River, Emmet County, was continued in 1959 by further collections in an inclined-plane trap near the mouth of the stream; inspection of the stream above the barrier for evidence of sea lamprey spawning; and by the collection of ammocoetes in the stream above the barrier with an electric shocker.

An inclined-plane trap has been operated near the mouth of the Carp Lake River since 1950, to capture downstream migrants and to prevent the upstream migration of adults. Newly transformed sea lampreys, as well as larvae, have been taken each year since the trap was installed. In the eight migration seasons (October to June) from 1950–51 to 1957–58, the catch of recently transformed sea lampreys averaged 6,250; the mean catch of ammocoetes was 7,965, an estimated 95 percent of which were sea lampreys (estimate based on identification of ammocoetes in representative samples from downstream runs in 1955–56 to 1958–59). The catch records are incomplete, however, because flood conditions, frequently coinciding with peaks of downstream movement, resulted in the loss of unknown numbers of both transformed adults and ammocoetes in all seasons except 1957–58. In the 1958–59 season, the inclined trap continued to yield relatively large numbers of newly transformed sea lampreys (4,796) and sea lamprey ammocoetes (5,365).

Inspection of the spawning areas above the inclined-plane trap in July 1959 and each year since 1955 has revealed no evidence of sea lamprey redds; a weir with an upstream and downstream trap operated during much of the year near the source of Carp Lake River revealed no movement of lampreys between the river and Carp Lake.

The length-frequency distributions of 167 sea lamprey ammocoetes collected with a direct-current shocker in July 1958 and 106 in July 1959 at a station about one-third mile above the Carp Lake River barrier were closely similar. Average lengths of ammocoetes during the two years were 5.1 and 4.9 inches, respectively; minimum lengths in the collections were 3.8 and 3.5 inches. The average and minimum lengths of ammocoetes in annual summer collections above the barrier have increased gradually, with minor fluctuations, since 1955. Collections at two other stations, approximately 1½ and 4½ miles above the barrier, during the same period have shown similar trends. Judging by the catch per hour with an electric shocker, the population of ammocoetes was markedly lower in 1959 at the station 4½ miles above the barrier, near the original upstream limit of ammocoete distribution, than during previous years of collection. No sea lamprey ammocoetes less than 2.1 inches long were collected in the stream above the barrier in 1955–59, although smaller specimens of other species were frequently taken.

The observations in Carp Lake River strongly indicate that the minimum age of the ammocoetes remaining in the stream is not less than 6 years. The possibility that the minimum age is 10 years or more cannot be excluded because the inclined trap may have been an effective barrier to spawning adult sea lampreys since 1950. However, this possibility is less certain because no checks of the spawning area or collections of ammocoetes were made in the stream from 1950 to 1954.

Migration of ammocoetes. In June and July 1958, 2,187 sea lamprey ammocoetes were marked by subcutaneous injections of cadmium sulfide or mercuric sulfide and released at 5 stations above the Carp Lake River inclined trap. Judging by the recapture of marked sea lampreys (87 newly transformed adults and 52 ammocoetes) in the trap during the 1958–59 migration season, 2.4 percent of the 1958 ammocoete population migrated downstream before transformation and 4.0 percent after transformation. Larger percentages of marked ammocoetes were recovered from the downstream marking stations located ½ to ⅔ mile above the trap than from upstream marking stations 2 to 3 miles above the trap. Larger ammocoetes showed a greater tendency to migrate downstream than smaller ones.

Estimates of ammocoete populations. Of the 2,187 sea lamprey ammocoetes marked in the Carp Lake River in June and July 1958, 139 recoveries were found among the 10,161 ammocoetes and newly transformed adults taken in the inclined-plane trap during the 1958–59 migration season. The resulting population estimate (by the Petersen method) was 159,800. This preliminary estimate does not take into account the apparent variation in susceptibility to recapture among

groups of specimens of different lengths and from different marking stations. The possibilities that marks may have been lost, that marked recoveries were overlooked, or that marking may have caused mortality, are also not considered, although there was no overt indication that any of these possibilities exerted an important effect on the population estimate.

A more detailed population study was conducted at the Ogontz River, Delta County, from June to September, 1959. Although the Ogontz River is small (5 cfs. discharge at the mouth), it contains ample spawning and larval habitat and sea lamprey ammocoetes were present throughout a large portion of the system. Although an electro-mechanical barrier has been operated near the mouth of the stream since 1958 by the U. S. Bureau of Commercial Fisheries, it is not believed that the original ammocoete population has been altered appreciably during the short interval since installation of the barrier.

The study area included all portions of the Ogontz River system known to contain sea lamprey larvae, as determined in surveys of the distribution of ammocoetes in the stream in 1957–59. The entire study area was measured, mapped, and sub-divided into eight strata, mainly on the basis of the physical character of the various portions of the stream. Sampling sites were selected at random within strata. Two collecting methods were used, depending on the depth of water encountered. In the estuary (4,200 feet in length), where the water was relatively deep and turbid, an orange-peel dredge was used. In the rest of the stream, ammocoetes were collected by means of circular metal enclosures (2.5 feet in diameter) which were sunk in the stream bed at the collecting sites. A lampricide (3-trifluormethyl-4-nitrophenol) was then introduced into the enclosure at concentrations of 40 to 60 parts per million. The chemical caused nearly all of the ammocoetes to emerge from their burrows. After an average waiting interval of about 1⅔ hours, the substrate inside the enclosures was passed through a screen to ensure the recovery of any additional ammocoetes killed within the substrate.

The resulting preliminary population estimate (and percentage standard error) for sea lamprey ammocoetes more than 1 inch in length was 136.00 ± 20.4 percent. Tributaries, making up 44 percent of the total length of stream (9.6 miles) studied, contained 16 percent of the ammocoetes.

In 1958, the number of sea lamprey ammocoetes in 146 acres of Ogontz Bay adjacent to the river was estimated at 5,900, on the basis of 6,150 samples taken with an orange-peel dredge. Observations this year in Ogontz River suggest that the estimate for the bay should be multiplied by a factor of about 5 because the area sampled by the dredge was less than previously assumed and only about one-third of

the lamprey ammocoetes present were captured. The population of the bay in 1958 was re-estimated at about 30,000 ammocoetes, or a little over 18 percent of the combined bay and river populations.

Wisconsin Conservation Department

The lamprey control program in the Wisconsin waters of the Great Lakes, as in previous years, was carried on through the cooperative efforts of the United States Fish and Wildlife Service and the Wisconsin Conservation Department. A total of 23 weirs were operated under this cooperative program in 1959. Ten electro-mechanical barriers were operated on streams tributary to Lake Superior, and twelve electro-mechanical, and one mechanical weirs were operated in the Lake Michigan area. The results of these operations have been included in the report by the Service.

A crew of three Wisconsin Conservation Department personnel under the direction of a U. S. Fish and Wildlife Service biologist made surveys of streams tributary to Lake Michigan to determine the distribution of larval-stage sea lampreys. The area covered in this survey included the entire shoreline of Lake Michigan from the tip of the Door County peninsula to the Illinois state line. Field identification of the larvae collected brought out an interesting distribution pattern. Sea lamprey larvae were found in some of the streams in only the northern third of the zone surveyed. Brook lampreys also showed an interesting distribution pattern in that they were found only in the northern half of this area. The streams in the southern half of the zone were devoid of lampreys of any species.

LAKE TROUT CATCH STATISTICS[1]

The collection of commercial catch records for the principal species of fish taken in the Great Lakes is carried out by state and provincial agencies. Routine tabulations of catch and catch per unit of effort are made by the Bureau of Commercial Fisheries for catches reported for New York, Pennsylvania, Michigan, Indiana, Illinois and Wisconsin waters. Ohio, Minnesota and the Province of Ontario prepare similar tabulations for their fisheries.

No commercial production of lake trout was reported for Lake Michigan or Lake Huron proper during 1959. Canadian fishermen reported a catch of 1,091 pounds for Georgian Bay and production from this area is no longer significant. The reported catch in Lake Superior

[1] Includes 1959 data compiled after the Annual Meeting.

(Table 1) dropped 23 per cent from 1958. The decline was most severe in Canadian waters where production had recovered slightly in 1958. The catch in Minnesota waters in 1959 was so low that the trout fishery is no longer significant.

Indices of production, abundance and intensity have been computed each year for State of Michigan waters of Lake Superior by the

TABLE 1.—Commercial landings of lake trout in Lake Superior by states and province, 1950–1959.

Year	(Thousands of pounds)				
	Michigan	Wisconsin	Minnesota	Ontario	Entire Lake
1950	2,400	591	202	1,508	4,699
1951	2,174	504	233	1,273	4,184
1952	2,074	521	243	1,389	4,227
1953	1,746	450	217	1,371	3,784
1954	1,609	436	211	1,266	3,522
1955	1,378	553	170	1,003	3,104
1956	1,224	479	109	527	2,339
1957	849	287	55	313	1,504
1958	767	259	33	385	1,445
1959	671	186	11	238	1,106

Bureau of Commercial Fisheries (Table 2). The 1959 indices continue to show a deterioration in the fishery. The deterioration is probably greater than the figures indicate for only the more skillful fishermen are operating now and they are concentrating on the better grounds at the best seasons. Estimates of abundance are, therefore, too high and estimates of fishing intensity too low for recent years.

TABLE 2.—Indices of production, abundance, and fishing intensity for lake trout in State of Michigan waters of Lake Superior, 1950–1959, as percentages of the 1929–1943 mean.

Year	Production	Abundance	Intensity
1950	116	80	146
1951	105	76	137
1952	101	75	133
1953	85	71	121
1954	78	64	122
1955	67	68	103
1956	59	63	98
1957	41	58	72
1958	37	60	64
1959	33	56	58

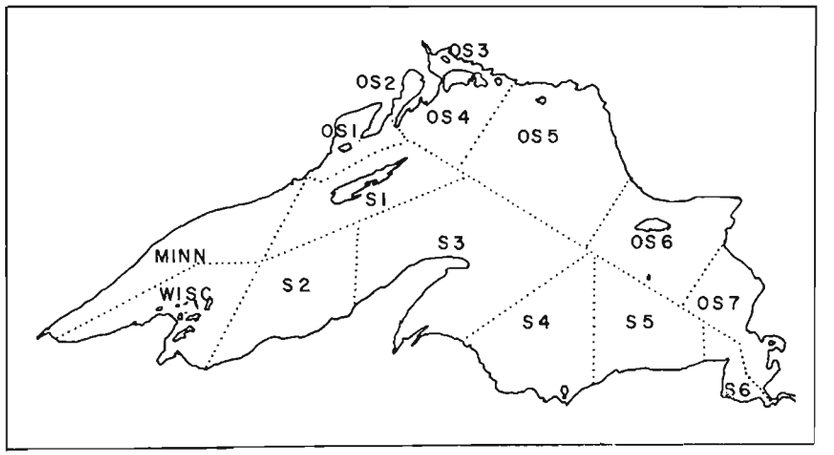

FIGURE 1.—Fishery statistical districts of Lake Superior.

Although the amount of gill net fished was less than in previous years for the entire lake (Table 3), it was higher in statistical districts S-4, OS-1, OS-3, and OS-6 (Figure 1). The catch per 10,000 feet lifted (Table 4) was well below the average in all districts except S-5 and OS-6. These districts include a number of offshore grounds in the vicinity of Michipicoten Island and south of Caribou Island, where trout continue to be relatively abundant.

TABLE 3.—Quantities of large-mesh gill nets lifted in the lake trout fishery for United States Statistical districts of Lake Superior, 1950–59, and Canadian districts, 1953–59, in units of 10,000 linear feet.

Year	Minn.	Wis.	Michigan							Ontario								
			S-1	S-2	S-3	S-4	S-5	S-6	Total	OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7	Total	Grand Total
1950	928	2,939	1,140	724	5,449	2,686	1,548	648	16,062	..	.	.	..	..	..	..	..	..
1951	1,380	2,723	1,315	706	4,557	3,102	1,701	730	16,214		.				.	..		.
1952	1,714	2,903	1,515	564	5,507	3,262	1,112	617	17,194		.		..			..		
1953	1,541	2,707	1,564	443	5,241	3,202	777	656	16,131	895	364	386	967	693	1,847	1,262	6,414	22,545
1954	1,227	2,721	1,524	320	5,209	2,991	1,121	703	15,816	895	408	393	908	306	1,508	1,253	5,671	21,487
1955	1,114	3,218	1,185	323	4,914	2,617	856	502	14,729	870	408	374	893	630	1,362	944	5,481	20,210
1956	812	3,195	1,686	448	3,970	2,381	767	475	13,734	595	311	517	813	392	421	667	3,716	17,450
1957	353	2,396	698	260	3,133	2,258	631	414	10,143	274	319	259	699	285	390	605	2,831	12,974
1958	205	1,770	444	184	3,004	1,852	722	215	8,396	387	273	310	463	330	75	749	2,587	10,983
1959	125	1,497	239	133	2,431	2,141	660	207	7,433	518	160	397	358	83	192	544	2,252	9,685
Avg.	940	2,607	1,131	411	4,342	2,649	990	518	13,585	633	320	377	729	388	828	861	4,136	16,476

TABLE 4.—Catch of lake trout per lift of large-mesh gill nets (4½-inch and greater) in U.S. statistical districts of Lake Superior, 1950–1959, and Canadian districts, 1953–59, in pounds per 10,000 linear feet.

Year	Minn.[1]	Wis.	Michigan						Ontario							
			S-1	S-2	S-3	S-4	S-5	S-6	OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7	Average [2]
1950	174	154	258	155	129	142	201	254								
1951	137	158	227	147	145	150	164	189								
1952	133	152	227	113	118	140	193	234								
1953	116	154	185	141	109	121	229	231	191	177	222	227	335	115	187	183
1954	154	145	164	118	104	111	198	216	237	172	253	213	412	161	189	190
1955	142	162	179	177	100	112	221	171	209	160	184	180	240	151	139	168
1956	115	142	126	198	97	110	213	154	154	94	115	116	211	124	98	138
1957	125	112	115	137	103	92	216	132	120	77	69	116	157	106	111	119
1958	150	136	130	163	104	102	187	165	227	126	96	199	117	221	107	149
1959	75	110	89	133	104	97	207	149	129	49	37	153	70	210	94	114
Average [2]	132	143	170	148	111	118	203	190	181	122	139	172	220	155	132	

[1] Minnesota figures published previously revised to include only those reports in which amount of net lifted is given.
[2] Unweighted mean.

LAKE TROUT REHABILITATION[1]

Assessment of lake trout stocks

Studies were carried on in Lake Superior during 1959 by the Fisheries Research Board of Canada, the Bureau of Commercial Fisheries, and the Wisconsin Conservation Department, to learn the present status of the lake trout stocks in various areas of the lake. Commercial catches were sampled at the major ports of landings in both countries. Data on age and size distribution of the fish caught were taken to provide indices of year-class strength. Scarring rates were followed in order to assess reduction in sea lamprey predation as a result of control measures. The ratio of hatchery fish to native fish in the catches was recorded to determine the relative contribution of planted trout.

The Fisheries Research Board of Canada examined the catches at the three major fishing ports of Port Arthur, Rossport and Mamainse Harbour. Net-run sampling of the commercial catches was carried out at Mamainse Harbour, where approximately 400 (12 percent undersized) lake trout were sampled each month. At Rossport, where sampling was not continuous, a total of 800 fish were examined. In the Port Arthur area about 1,000 fish were sampled from commercial landings.

There has not been sufficient time for the agencies to analyze the data collected in 1959. However, recoveries of fin-clipped trout have shown that hatchery fish have contributed significantly to the commercial fisheries near the planting areas. The percentage of hatchery trout in the commercial catches has varied from area to area and from month to month. It was consistently higher in the area extending from the Apostle Islands to the tip of the Keweenaw Peninsula, where the percentage of hatchery trout ranged from 4.5 to 46.0. However, the production of lake trout in this area has dropped by about 50 percent since 1955 and is presently at a very low level. In the Michigan waters east of the Keweenaw Peninsula, the percentage of hatchery fish in the catches was low and very few fin-clipped trout were recovered in the Isle Royale fishery. No fin-clipped trout were taken in the Canadian waters at the eastern end of the lake, but trout planted by the Ontario Department of Lands and Forests in 1958 and 1959 in the Rossport area were recovered this year in the planting area and to the west in the Port Arthur area.

During the 1959 season, the U. S. Bureau of Commercial Fisheries research vessels, the *Cisco* and *Siscowet,* operated in Lake Superior.

[1] Report by Special Committee on Lake Trout Rehabilitation prefacing its recommendations to the Great Lakes Fishery Commission on December 3-4, 1959.

The *Cisco* limited its operations to the south side of Lake Superior, east of the Keweenaw Peninsula. The primary objectives were to determine the abundance, composition, and distribution of the fish stocks, particularly lake trout and chubs. The *Cisco* repeated population studies of lake trout conducted in 1953 in order to determine what changes had taken place during the past six years. In addition, the *Cisco* devoted her last cruise to study the abundance of mature lake trout on known spawning reefs in the Marquette area.

Although the 1959 data have not been fully analyzed, there is already evidence of a scarcity of young trout along the south shore. During the entire season only 6 young-of-the-year trout were captured as compared to 318 during similar operations in 1953. In addition, only 6 one-year-old lake trout were taken as compared to 162 in 1953. Bad weather restricted the *Cisco's* study on the spawning trout, and only four lifts of gill net, each of about 4,500 feet, were possible. Only two lake trout, both ripe males, representing 0.5 pounds of spawning lake trout per 1,000 feet, were caught. Nets set in this area in 1952 and 1953 took 157 and 65 pounds of spawning lake trout per 1,000 feet of gill net, respectively.

The *Siscowet,* operating in the western end of the lake, took 165 lake trout in its sampling nets and trawls, of which 4 were young-of-the-year. Forty percent of all trout taken, and 68 percent of those between 5 and 8 inches in length, were marked hatchery fish. The *Siscowet* also lifted about 45,000 feet of gill net on nine different spawning reefs known to be productive in earlier years, and took only 20 spawning lake trout, all males, ranging from 22.6 to 33.5 inches in total length.

Egg collections

At present, hatchery facilities in the upper Great Lakes area can produce approximately 3½ million one-year-old lake trout annually. Actually this total is difficult to attain because production is currently limited by the number of lake trout eggs available. In past years eggs have been obtained from Lake Superior, but mature fish are now so scarce that other sources must be found. In order to assure a future supply of eggs, brood stocks are being developed in hatcheries and collections from various inland lake sources have been started by federal, state and provincial agencies.

There are approximately 56,000 lake trout brood fish presently retained in hatcheries by different agencies. Eight different year-classes from ages two to eleven years are represented. Although only a small percentage are now sexually mature, their egg production represented 40 percent of the total collected by all agencies this year. By 1962 this contribution will increase to possibly 75 percent. Although

present hatchery space has limited any substantial increase in brood stocks, negotiations have begun between Wisconsin and Michigan to develop a brood stock from the lake trout in Green Lake, Wisconsin, which are the only known trout of Lake Michigan origin available. These trout are deep-water spawners and mature at smaller sizes than the Lake Superior fish. They will be of prime importance in the future stocking of Lake Michigan.

The total lake trout egg collections by all agencies during the 1959 season was 4,268,000. The Michigan Department of Conservation collected 1,383,000 eggs from brood fish in hatcheries and wild fish in a number of inland lakes. The Wisconsin Conservation Department obtained 55,000 eggs from native fish in the Apostle Islands area. This number represented a substantial reduction from collections of approximately 300,000 eggs in previous years. The U. S. Bureau of Sport Fisheries and Wildlife obtained a total of 552,000 eggs from brood fish retained at its hatchery in Manchester, Iowa, composed of Lake Superior Isle Royale stock, now eight years old, and Great Slave Lake stock, now seven years old. The Minnesota Department of Conservation conducted spawn-taking operations in four inland lakes, but took only 8,000 eggs. A total of 460 lake trout were caught but most were green or spent. The total lake trout egg collection in Canada by the Ontario Department of Lands and Forests was 1,929,800 eggs. The collection included 1,899,600 from seven inland lakes, and 30,200 from hatchery brood fish. The Illinois Conservation Department does not engage in spawn-taking operations, but it again purchased 200,000 lake trout eggs for the rehabilitation program from a trout farm in Spokane, Washington. The eggs were transferred to the Bureau of Sport Fisheries and Wildlife hatchery at Charlevoix and will be used to continue a series of test plantings in Lake Michigan.

After allowance is made for mortality in the hatchery and retention, by some agencies, of a small percentage of the stock for inland lake plantings, it is estimated that about 1½ million one-year-old trout will be produced from this year's egg collections for stocking the Great Lakes in the spring of 1961.

Trout culture and planting research

Artificial propagation of lake trout on a large scale represents a new venture in fish culture and poses many problems. The maximum survival of lake trout at all stages of hatchery development is essential to fully utilize the limited number of eggs available and minimize program costs. At present there is definite need for a better understanding of the general physiology of lake trout and conditions affecting its survival. As a result of the development of substantial numbers of lake

trout brood fish of various sizes and ages in the upper Great Lakes hatcheries, an unusual opportunity exists for educational institutions in the Great Lakes region to utilize the lake trout as subjects for experimentation and for government research agencies to conduct more applied research on specific problems associated with survival in the hatchery.

The first of a series of test plantings had been made in Lake Michigan in 1959, when 35,600 yearling trout were released on Sheboygan Reef. Voluntary reports on recoveries of these fish by selected commercial fishermen are expected to provide information needed on the movements and early survival of the hatchery fish under lamprey predation. It is expected that this information will indicate when, in advance of lamprey control, lake trout can be safely planted in the lake.

In the past trout plantings in the Great Lakes were made in the open lake in waters 15–25 fathoms deep. The provision of fishing vessels from cooperating commercial fishermen, the availability of patrol vessels in Michigan and Wisconsin, and the use of the Ontario Department of Lands and Forests boats and aircraft had made this procedure possible. As the stocking program develops in Lake Superior and extends into Lakes Michigan and Huron, the numbers of fish and the areas to be planted will be greatly increased and the distribution procedures now used can no longer be followed without greatly expanding distribution facilities. Changes in present methods of planting should be investigated to avoid, if possible, the high distribution costs. The procedure of stocking yearling trout in waters 15–25 fathoms deep was based on previous research which showed that native trout of this age were found at this depth. There is no evidence to suggest that this procedure is preferable to shore plantings. It is, therefore, proposed that regular releases of distinctively marked trout planted by as many different methods as possible be made in 1960. Some groups will continue to be planted by boat in the open lake, others from docks, bridges, and possibly tributary streams. Careful selection of the shore plant locations will be necessary to avoid predation by warm-water species, assure favorable temperature conditions and ready access to deep water.

Experiments to date have shown that lake trout reared in the hatchery to yearling stage and planted in the spring survived better than trout planted at earlier ages. The present stocking program is confined to spring plantings of yearlings. However, due to the present scarcity of native trout in the lakes, it is suspected that the survival of hatchery trout planted at earlier ages might be quite good. It is proposed that groups of marked fingerlings be planted in both Lake Superior and Lake Michigan during the fall of 1960 and their survival

followed. Plantings of fingerlings in the fall is probably feasible only as long as the lake trout populations remain low and this practice, if adopted, will require re-assessment as the populations build up.

Trout breeding experiments by the Ontario Department of Lands and Forests, using speckled trout x lake trout hybrids as a basis for selection, are progressing satisfactorily. The objective is to produce a fast growing fish resembling the lake trout in appearance and behavior in most respects and the speckled trout in respect to age at maturity.

The first approach was to select those hybrids having the ability to retain gas in their swim bladders while under pressure and presumably able to live in deep water, and then retain only the early maturing individuals for breeding stock. Many of these pressure-selected fish matured this fall as one-year-olds, 9 to 11 inches long. The second approach has been to plant first generation hybrids and the progeny of first generation hybrids back-crossed to lake trout, in South Bay (Manitoulin Island) and in northern Georgian Bay, where they will be exposed to natural selection. Sea lamprey are expected to eliminate the late-maturing individuals before they reproduce while summer temperature stratification would favor the deep-swimming fish. Some 20,000 hybrids were released in South Bay and 110,000 in Georgian Bay in 1959.

Early information on the growth and survival of 157,000 hybrids planted in Georgian Bay in 1958 has been encouraging. Some recaptures were made through the ice during the winter. This spring pound netters at Killarney encountered substantial numbers of the hybrids averaging 14 inches in length, with a few approaching the legal size limit of two pounds. Later recoveries have indicated that the hybrids are becoming widely dispersed in Georgian Bay. An estimated 1,500 have been recovered from the 1958 planting.

Protection of lake trout in Lake Superior

The destruction of sea lamprey ammocoetes in Lake Superior streams by chemicals has been most encouraging, but there is no evidence yet that the population of lamprey in the lake has been drastically reduced. It is expected that a reduction in lampreys will first be shown by a decline in the catch of adult lampreys at the electrical barriers in the spring of 1961. It does not seem reasonable to restrict the commercial fishery until such evidence is available.

The lake trout fishery on Lake Superior is to a considerable degree self-regulating. Fishing must be a profitable enterprise in order to continue and it will cease to be profitable as trout become less and less abundant. The amount of large-mesh gill net lifted in Lake Superior has declined by more than 50 percent between 1953 and 1958, while

production has dropped by about 65 percent. The catch of nearly 1½ million pounds of lake trout in 1958 suggests that a substantial number of fish are still present in Lake Superior. Economic consideration, on the other hand, suggests that a further substantial reduction in commercial fishing will occur if lake trout abundance decreases even moderately below its present level.

In spite of these considerations there is a strong public demand for extreme regulations which may eliminate most commercial fishing operations on the lake. An abrupt termination of commercial fishing for lake trout would very probably destroy much of the fishery for whitefish, herring and other species which cannot alone sustain a stable fishery. Lake trout assessment studies, which are now almost entirely dependent upon the continuation of the commercial fishery for information on the status of the trout populations, would also suffer.

Although there does not appear to be any biological justification for a further restriction of the commercial fishery at the present time, improved control measures will undoubtedly be necessary in the near future to facilitate rehabilitation of the lake trout in Lake Superior.

SUMMARY OF FISHERY RESEARCH IN THE GREAT LAKES 1959

In considering Great Lakes research, a rough distinction can be drawn between investigations undertaken with the purpose of understanding the fishery problems in the Great Lakes and the more basic studies which seek an understanding of Great Lakes phenomena *per se*. The former are largely, but not exclusively, undertaken by the government agencies responsible for the development of the fishery and these are included in the summary. The latter more basic studies are carried out by university departments or institutes. Although many of these studies may provide information which will lead to a better understanding of the fishery, their pertinence is often difficult to assess and only a few are mentioned.

Lake Ontario

Investigation of the commercial fishery for whitefish and the sport fishery for walleye were continued by the Ontario Department of Lands and Forests in the eastern end of Lake Ontario during 1959. Also continued was the study of the survival of lake trout planted by the Ontario Department and the New York Conservation Department in an attempt to re-establish this species.

Study of the whitefish catch continued to show that the fishery was relatively intense. The major contribution to the catch has been made by 4-year-old fish. Extreme variations in year class strength influence the fishery considerably. An analysis of the effects of variations in fishing effort on the population was initiated in 1959 and supplementary catch-effort information collected to permit a better understanding of existing catch-effort statistics. The contribution to the fishery of whitefish fry plantings, made in the past, remains somewhat obscure because of the correlation between the density of the spawning stock and the numbers of fry planted the following spring. No final evaluation can be made until there is more information on the success of natural reproduction since plantings ceased.

A creel census of the sport fishery in the Bay of Quinte provided estimates of the harvest by anglers and information on the population of walleye. The 1955 year class which had dominated the sport fishery since 1957 continued to do so in 1959 contributing 34 percent of the catch. The 1956 year class contributed 32 percent. The creel census has also been an experiment in methodology and analyses have shown how sampling could be improved to give more reliable estimates of the anglers' catch.

Lake trout planted by Ontario and New York continue to be taken incidentally by commercial fishermen in whitefish nets. Less than 1 percent of the fish planted in 1953, 1954 and 1955 have been recovered but a relatively high return (11 percent) of the 1956 planting suggests that it has survived well. Numbers recovered in 1959 were fewer than in 1958 but there is some prospect that a few of these fish will continue to be taken for several years. However, estimates of total mortality will be difficult to obtain because of the small numbers recovered and lack of information on the size selection of the whitefish nets.

Other fishery investigations by the New York Conservation Department were concerned with the rate of removal of tagged bass by the sport fishery in southeastern Lake Ontario and the survival of Atlantic salmon planted in the Salmon River.

Hydrographic investigation begun in 1958 by the Great Lakes Geophysical Research Group provided information on heat storage and seasonal changes in the temperature structure of the lake.

Lake Erie

Government agencies concerned with the Lake Erie fishery have in the last few years established programs to study the fluctuations in the abundance of the principal species. The routine sampling of fish in the lake, observations of habitat conditions, and routine examination of the commercial catch are emphasized.

In 1959 the Bureau of Commercial Fisheries periodically visited seven index stations in the western basin of the lake and sampled the fish with trawls, gill nets and fine-mesh tow nets. Information on water temperatures, dissolved oxygen, plankton, bottom fauna and meteorological conditions was collected at the same time. Trawl hauls over a standard period appeared to give a good measure of the relative abundance of young-of-the-year fish but paired trawl hauls made in two areas of the western basin on three consecutive days in shallow, moderately deep and deep water appeared to be more reliable. The Ohio Division of Wildlife also collected fish samples and information on lake conditions at index stations in the central basin on three occasions during the year. Some inshore trawl sampling of young fish was carried out by staff of the Pennsylvania Fish Commission.

The trawl sampling during 1959 in United States waters showed young-of-the-year walleye, yellow perch and spottail shiners to be unusually abundant. The 1959 year class of walleye is the first of any consequence to appear since 1954, and should produce a significant improvement in the depressed fishery for this species. However, the improvement is likely to be temporary if this age group now entering the fishery is not supported by one of comparable strength.

The food, growth and distribution of the walleye were closely followed. The young walleye in the western basin fed almost exclusively on yellow perch, emerald shiners and spottail shiners and made exceptional growth during the year. The selection of various forage species at different periods was presumably dependent on their size relative to that of the walleye. The latter consistently took fish one-third their own length.

The discovery of low levels of dissolved oxygen in late August near the lake bottom off Lorain, Ohio, led to synoptic cruises by five vessels from four agencies. Critically low oxygen levels were found near the bottom over a 600-square mile area of the central basin. Although similar conditions may have existed in the past it appears that a greater area was involved in 1959. There are indications that certain bottom organisms in the western basin have been severely reduced as a result of local oxygen deficiency, and a resurvey of bottom fauna was undertaken by Ohio State University in 1959 to determine the nature of these changes.

Net-run sampling of the commercial catch and the experimental trawling catches in Canadian waters was carried out by the Ontario Department of Lands and Forests while the Bureau of Commercial Fisheries continued its routine examination of the landed catch on the south shore. Estimates of the angling catch were made for several heavily fished areas by the Ontario and Ohio agencies. The Bureau completed the aging of scale samples from landings of yellow perch, walleye, blue pike, white bass, and sheepshead collected since 1943.

Other special investigations included a study of the food habits of 10 species by the Natural Resources Institute of Ohio State University, under contract with the Bureau of Commercial Fisheries. The Institute also completed an age and growth study of the channel catfish for the Ohio Division of Wildlife, and continued an investigation of predation on fish larvae by copepods. Studies of smelt and blue pike spawning were carried out in Canadian waters.

Tagging of yellow perch and young walleye was carried out at two localities in Ontario and Pennsylvania waters.

Lake Huron

Fishery research in Lake Huron has been largely confined to areas where special studies have been underway for some time. However, the Ontario Department of Lands and Forests, while continuing its experimental fishery in South Bay, Manitoulin Island, extended its activities to other areas of the lake in 1959.

The experimental fishery in South Bay continued to take lake trout planted as yearlings in 1955. Survival of this group has been

surprisingly high when compared with the drastic reductions in the abundance of other year classes on reaching this age. No reduction in lamprey scarring has been noted and no reasons for this improved survival can be given at the moment. Most of the males and a few female lake trout matured in 1959, and fish were taken on the spawning grounds for the first time since 1951. A recent decrease in lake herring in the experimental fishery has been accompanied by an explosive increase in alewife.

A creel census of the sport fishery for smallmouth bass in South Bay was continued by the Department during 1959. Information on the age composition of the 1959 catch confirmed earlier predictions that the 1955 year class would be strong. Weak year classes are predicted for 1956, 1957 and 1958 and angling in the area is expected to be less productive for the next several years.

Elsewhere in Lake Huron the Department continued to sample the whitefish catch. The modest fishery for this species in the North Channel and Lake Huron proper was largely composed of 3-year-old fish. In Georgian Bay, where two distinct populations are known to exist, the fishing in the northern section continued to decline and a general survey with graded-mesh gill nets and seines did not locate any significant number of young fish in areas where they were once abundant. Aging of whitefish from northern Georgian Bay proved difficult but has been aided by the recovery of fish with a "time mark" on the scales produced by the earlier injection of lead versenate. A recently completed study of gill-net selectivity for whitefish has also proved extremely helpful.

In 1959 the Department carried out a creel census on a sport fishery for lake trout in Parry Sound on the east shore of Georgian Bay. A high proportion of the catch was composed of large fish and the population appeared to be free from heavy mortality. The persistence of this population and one other in McGregor Bay at the northwest end of Georgian Bay is believed due to their distance from major lamprey-spawning streams.

The Department continued its plants of marked "splake" (brook trout x lake trout hybrids) in South Bay and Georgian Bay. Some hybrids planted in 1958 as yearlings and recovered in 1959 had reached legal size (2 pounds round weight).

Investigations in United States waters were largely confined to Saginaw Bay where the Bureau of Commercial Fisheries continued its collection of data and materials on walleye, yellow perch and certain other species. The Michigan Department of Conservation continued to follow the incidence of the nematode *Philonema* in the yellow perch of Saginaw Bay. It also continued work with the Bureau of Commercial Fisheries to complete the analysis of results, and extract additional

information from the 1956 synoptic surveys in Saginaw Bay. The Department planted three strains of rainbow trout in an attempt to increase the runs of "steelhead," but returns were too low to provide useful information.

Lake Michigan

Research in Lake Michigan during 1959 was largely confined to Green Bay where the Bureau of Commercial Fisheries continued its study of the regional differences and annual fluctuations of walleye and yellow perch. Differences in the growth and age composition between yellow perch stocks in northern and southern Green Bay are substantial, clear-cut, and persistent year after year. The status of the stocks in central Green Bay is still uncertain and a correct interpretation of the information collected in this area may have to await the completion of extensive tagging studies.

The tagging of walleye in northern Green Bay started by the Bureau and the Michigan Department of Conservation in 1957 was continued. A total of 282 (7.7 percent) of the 3,668 fish tagged since 1957 have been recaptured, the majority in the sport fishery in northern Green Bay. For some time the rate of disappearance of year classes has been faster than would be expected from the intensity of the commercial fishery and it now appears that increased mortality is due to the growing sport fishery.

The difficulty of identifying young coregonids, particularly chubs in Lake Michigan, has led to a study of the young from known parents. Young whitefish, cisco, longjaw and shortjaw chubs have been reared in captivity and the development of potential diagnostic characteristics closely followed.

The Michigan Department of Conservation has planted rainbow trout of different strains but has found, as in Lake Huron, that the recoveries are too low to permit a comparison of their contributions.

Lake Superior

Ten cruises were made by the Bureau of Commercial Fisheries research vessel *Siscowet* in the western end of Lake Superior in 1959. Three cruises were made during the spring, summer and fall to collect information on fish, plankton, bottom fauna, and environmental conditions (water chemistry, transparency and currents) at three index stations. Samples of fish were taken with standard gill net gangs of graded mesh sizes and with trawls. Other cruises were concerned with (1) the collection of materials and early life history data on lake trout, whitefish, lake herring, and chubs; (2) the vertical distribution of

chubs in the Apostle Islands area; (3) the summer distribution of lake herring.

Although perplexing problems of chub identification were not solved, a better understanding of the difficulties involved was reached by study of materials collected in several areas, including Thunder Bay in Canadian waters. Observations of lake trout during the spawning season were handicapped by severe weather. A limited amount of gill net lifted on spawning areas in the Apostle Islands produced only five fish.[1]

The investigation of lake herring distribution, which began in 1958, continued to show that this species appeared to be widely dispersed in small isolated schools during the summer and could not be profitably fished during this period. Nearly all the herring captured were from 5 to 15 fathoms in waters 20 to 35 fathoms deep.

The Bureau's research vessel *Cisco,* after two seasons on Lake Erie, returned to southeastern Lake Superior in 1959 and carried out eight cruises primarily to determine the abundance, composition and distribution of fish stocks with emphasis on lake trout and chubs. Many of the operations carried out in 1953 were duplicated to determine changes in abundance. Limnological observations were also carried out but were less extensive than in 1953. The duplication of experimental fishing with trawls indicated that trout produced by natural spawning were scarce and marked hatchery-reared fish relatively abundant.[1]

Bad weather handicapped the *Cisco's* intended comparison of the abundance of adult trout on the spawning grounds. However, the gill net catch left little doubt that a substantial decrease in mature fish had occurred in the vicinity of Marquette.[1]

The *Cisco* was also concerned with a study of the bathymetric distribution of the various species of chubs and the collection of data and materials for all species taken in the netting operations. A small number of lake trout (98) were tagged and released.

The survey of the commercial lake trout fishery which was begun by the Bureau in 1958 was continued and net-run catches were sampled at eight fishing ports in the State of Michigan. A total of 59,075 lake trout were examined, lengths taken for 19,313, and scales from 2,500. About 500 trout, less than 17 inches, were tagged and released. Some information was collected on the capture of lake trout in small-mesh chub gill nets, which suggests that undersized trout in Lake Superior may be vulnerable to those nets at any depth shallower than 60 fathoms. Sampling of lake herring during the spawning run was continued in 1959, and analysis completed on the growth rate and body-scale relationship. Analysis of the data for whitefish, collected in

[1] See Report of Special Committee on Lake Trout Rehabilitation.

1957 and 1958, was completed and additional material collected during 1959. Considerable information on the growth rate and body-scale relationship of round whitefish collected in 1958 is now available.

Net-run sampling aboard commercial fishing vessels was carried out by the Fisheries Research Board of Canada[1] at Mamainse Harbour and landings sampled at Port Arthur and Rossport during 1959. Fish were examined for lamprey wounds and scars and for clipped fins identifying them as hatchery-reared fish. Total length and weight were recorded, and scale samples taken for aging. The length, weight and age distribution of the landed portion of the catch, which has been obtained each year since 1957, has been singularly uniform from area to area, month to month, and from year to year. Furthermore, these distributions continued to conform essentially with those derived from data collected by the Ontario Department of Lands and Forests in 1954 and 1955. As small fish were not represented in the landed catch, the sampling did not confirm evidence from other sources that natural reproduction had been increasingly restricted in the past few years.

Net-run sampling of the commercial catch by Wisconsin fishermen was initiated in 1959 by the Wisconsin Conservation Department. A total of 5,421 legal (over 17 inches) and 1,329 undersized trout were examined from March to September. Commercial catches made close to the Apostle Islands showed a higher proportion of scarred fish and hatchery fish than the catches made in the open lake. The percentage of hatchery fish in the commercial catch of legal fish was 31.3 percent. Spring-planted trout recovered in 1959 outnumbered fall-planted trout five to one.

Information on the incidence of lamprey scars was obtained by all agencies engaged in routine experimental fishing or sampling the commercial catch. Supplementary information was obtained from (1) the monthly questionnaire sent by the Ontario Department of Lands and Forests to its commercial fishermen; (2) the examination of trout taken by the Wisconsin Conservation Department during spawn-taking in October, and (3) examination by the Minnesota Department of Conservation of lake trout shipped from Isle Royale to Duluth in the fall. Interpretation of the scarring data is handicapped by ignorance of relationship between lamprey abundance, lake trout abundance and the incidence of scars. Variations in the incidence of scars have been too small in recent years to permit even tentative conclusions regarding changes in lamprey predation.

Other projects during 1959 included a tagging study of the movements and growth of whitefish, and brown and rainbow trout by the Wisconsin Conservation Department and the experimental planting of

[1] General fisheries research on Lake Superior became a responsibility of the Fisheries Research Board of Canada by agreement with the Ontario Department of Lands and Forests and the Canadian Department of Fisheries.

three strains of rainbow trout by the Michigan Department of Conservation. Recoveries of trout in the latter operation have been less than 3 percent, and it is proposed that the project be discontinued until sea lamprey predation, believed responsible for the low return, is reduced.

TABLE 2.—Recovery of ammocoetes in post-treatment surveys, Lake Superior, 1959.

County	Stream	Date of post-treatment survey	Area examined (square feet)	Ammocetes taken		Young of the year (unidentifiable)
				Native species	Sea lamprey	
Chippewa	Pendills Creek	9/9	8,600	26	0	0
Chippewa	Grants Creek	9/9	3,600	0	0	0
Chippewa	Ankodosh River	9/10	3,600	0	0	0
Chippewa	Galloway Creek	9/9	4,000	0	0	0
Chippewa	Little Two Hearted R.	10/8	13,000	0	1	0
Chippewa	Two Hearted River	10/7	24,300	10	0	0
Alger	Sucker River	9/2	8,800	0	0	0
Alger	Sullivans Creek	9/17	4,800	0	0	0
Alger	Seven Mile Creek	9/17	7,200	0	0	7
Alger	Miners River	9/20	3,300	1	0	0
Alger	Au Train River	9/16	36,700	48	1	14
Alger	Rock River	5/20	8,500	32	3	0
Marquette	Harlow Creek	9/14	6,000	1	0	0
Marquette	Little Garlic River	9/23	8,800	0	0	0
Marquette	Big Garlic River	9/14	7,000	0	0	0
Marquette	Pine River	9/14	4,000	0	0	0
Douglas	Brule River	4/19	6,400	2	0	0