ANNUAL REPORT

GREAT LAKES FISHERY COMMISSION

1960

GREAT LAKES FISHERY COMMISSION

MEMBERS — 1960

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SECRETARIAT

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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

1960

NATURAL RESOURCES BUILDING
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN,
U. S. A.

On July 5, 1960, the Great Lakes Fishery Commission lost one of its most valued members through death, namely William J. K. Harkness.

His knowledge of the problems of the Great Lakes fisheries and his devotion to the task of seeking solutions to these problems contributed substantially to the program of the Great Lakes Fishery Commission.

His friendliness and spirit of cooperation will be sorely missed by his colleagues.

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 1959 and 1960 Annual Meetings.

A. L. PRITCHARD
Chairman

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INTRODUCTION

The international nature of the Great Lakes fishery was recognized early in its development, and concern for its preservation is evident in the establishment of a joint commission in 1893, to be followed in 1908 by an international commission. These commissions recommended various measures to safeguard the development of the fishery, including a proposal that a permanent international commission be established to investigate and regulate it. The recommendations were not implemented.

A resurgence of interest led to the establishment of an International Board of Inquiry in 1940. Although the Board was not in a position to conduct detailed scientific investigations, a careful study was made of available information and recommendations were submitted to the two governments. These stressed the need for common investigation of the fishery and the formulation and testing of regulations by a common or joint agency where the fishery was shown to be dependent upon a common stock. A treaty was subsequently signed by the two countries in 1946, but was never ratified because of vigorous opposition to a provision which granted authority to a proposed commission to regulate the fisheries of all the Great Lakes. However, continuing problems of conservation and increasingly severe depredations by the sea lamprey led to further negotiations between the two countries and ultimately ratification of the present Convention on Great Lakes Fisheries in 1955. The Great Lakes Fishery Commission established by the Convention was given the following duties:

(a) to formulate a research program or programs designed to determine the need for measures to make possible the maximum sustained productivity of any stock of fish in the Convention Area which, in the opinion of the Commission, is of common concern to the fisheries of the United States and Canada and to determine what measures are best adapted for such purpose;
(b) to coordinate research made pursuant to such programs and, if necessary, to undertake such research itself;
(c) to recommend appropriate measures to the Contracting Parties on the basis of the findings of such research programs;
(d) to formulate and implement a comprehensive program for the purpose of eradicating or minimizing the sea lamprey populations in the Convention Area; and
(e) to publish or authorize the publication of scientific and other information obtained by the Commission in the performance of its duties.

The Commission was organized in April, 1956, and assumed its duties on July 1 of that year. It is composed of three members from each country and employs a small staff or secertariat since it is required, if possible, to make use of the official agencies of the two countries and their states and province in the performance of its duties.

During the period from 1946 to 1955, federal, state and provincial agencies investigated the sea lamprey and installed barriers on spawning streams to control their numbers. When the Commission assumed

responsibility for the program electrical barriers on lampreys spawning streams provided the only means of control. Barrier construction on both Lake Superior and Lake Michigan was therefore continued in 1957, but halted early in 1958 following the successful field test of a chemical treatment technique. Although greater reliance was subsequently placed on the chemical method, existing barriers were operated in 1958 and 1959, primarily to prevent spawning and the re-establishment of lamprey in treated streams and, secondly, to follow changes in lamprey abundance.

Although many technical difficulties were encountered in early operations with chemicals selectively toxic to sea lamprey, roughly half of the flowage requiring treatment on Lake Superior was dealt with by the end of 1959. While treatments were being carried out on Lake Superior in 1959, surveys were being carried out on Lakes Michigan and Huron to provide information required to treat their tributaries.

In 1960, the role of electrical barriers was changed from control to assessment after extreme floods in the early spring permitted escapement of spawning adults in many streams. The Commission, however, continued to operate many of the barriers on Lake Superior to follow changes in lamprey abundance as they provided the most reliable measure of the effectiveness of the chemical program. As barrier operations have been reduced, chemical operations have been expanded, making possible the completion in 1960 of the first series of treatments on Lake Superior[1] and an extension to Lakes Huron and Michigan.

As the absence of lake trout in many areas of the Great Lakes could delay the recovery of the population when sea lamprey were reduced, the Commission has been concerned with their re-introduction. Trout propagation with this objective is being carried out by federal, state and provincial agencies, following a program approved by the Commission. Each agency participating is represented on a committee which advises the Commission on the measures necessary. The progress of restoration and the success of plantings are being closely studied so that available hatchery facilities can be used most efficiently.

Although the disrupting effects of sea lamprey predation are evident in the fisheries for the more highly valued species in the upper Great Lakes, fluctuations in the abundance of some cannot be attributed solely to this source. A better understanding of these abundance changes is essential. The Commission is therefore concerned not only with the sea lamprey but also with the progress of studies of the fish and their environment now being carried out by agencies and institutions on the Great Lakes. It has recommended that certain lines of investigation be emphasized.

[1] Three additional streams were treated in 1961 after ammocoetes were discovered in them.

INTERIM MEETING

At its Interim Meeting in Ann Arbor, Michigan, on June 14–15, the Commission received reports from its agents on the progress of the sea lamprey control and research program in the first half of 1960. After considering the escapement of spawning lamprey through electrical barriers rendered ineffective by the abnormal floods in April and early May, it agreed that they should be operated on a reduced scale in 1961 to follow changes in lamprey abundance. The Bureau of Commercial Fisheries was requested to examine its barrier operations on the south shore of Lake Superior and report at the next meeting on the minimum number necessary to provide a reliable estimate of changes in lamprey abundance.

A program of sea lamprey control and research for 1961–62 was adopted which provided for (1) the operation of 20 assessment barriers (subject to review) on Lake Superior and 3 on Lake Michigan; (2) the chemical treatment of Lake Michigan streams with a total flow of 2,450 cfs; (3) completion of treatments on Georgian Bay (Lake Huron) and a start on Canadian lamprey streams entering the North Channel (Lake Huron). Approval was granted for re-examination of potential lamprey-producing streams on Lake Superior and continuation of a number of investigations including studies of ammocoete populations in the lake, temperature tolerance of sea lamprey, influence of chemical and physical conditions on the effectiveness of the lampricide, use of buffers and other agents in streams to increase effectiveness of lampricide, minimum lethal dose required to kill ammocoetes, and tolerance of warm-water gamefish.

An *Ad hoc* Committee on the Regulation of the Lake Superior Lake Trout Fishery,[1] asked to consider the need for additional controls of fishing, reported that it had reviewed the present and predicted status of the lake trout stocks and believed that there was definite need for new methods of regulation to control fishing intensity as the population of lake trout built up. The Committee presented the following statement:

> The following procedure for controlling lake trout fishing in Lake Superior to a level which will expedite the recovery of the lake trout population and permit sustained maximum production in the future is predicated on the continued success of the sea lamprey control program.
>
> Control of the lake trout fishery must be based on the best biological data available. Future management practices should be designed to take the harvestable crop. The most direct means of approaching this goal is by the adoption of an annual production limit. This Committee, therefore, recommends that the future management of the Lake Superior lake trout fishery be

[1] Committee members were G. E. Eddy, Director, Michigan Department of Conservation; W. J. K. Harkness, Chief, Division of Fish and Wildlife, Ontario Department of Lands and Forests; H. O. Swenson, Supervisor of Fisheries, Minnesota Conservation Department; L. P. Voigt, Director, Wisconsin Conservation Department; and R. W. Saalfeld, Chairman.

based on an annual catch limit for the lake, adopted by the state and provincial governments on the recommendation of the Great Lakes Fishery Commission; the catch limit would be reconsidered each year.

It is further recommended that the Great Lakes Fishery Commission suggest to the two countries what percentages of the catch should be taken in the four jurisdictional areas administered by the States of Minnesota, Wisconsin and Michigan, and the Province of Ontario; and that this distribution be reconsidered at intervals of not less than five years, or on the request of any agency concerned.

The direct application of a quota system may prove difficult for some agencies and it is recommended, therefore, that the catch by each agency be limited within the assigned quota by any means that is effective and convenient. Variations within the assigned quotas to the two countries and their respective states and province may be desirable because of peculiar local circumstances and should be encouraged.

The Committee also recommends that the Great Lakes Fishery Commission continue to encourage federal, state and provincial agencies in their propagation of lake trout for planting in Lake Superior.

The Commission accepted the Committee's statement and called for a further study to establish catch limits for the lake and quotas for the four jurisdictional areas.

The following general research recommendations for Lake Ontario and Lake Huron, prepared by the Scientific Advisory Committee, were approved for submittal to the Governments of the United States and Canada, with the qualification that they were preliminary and subject to revision. Additional information from current research would lead to a better definition of problems and hence more specific proposals.

Lake Ontario

The commercial fish production of Lake Ontario, the smallest of the Great Lakes, has ranged from a high of about 9 million pounds (1923) to a low of slightly less than 3 million pounds (1932) but has never exceeded 7.7 percent of the total for all the lakes. Production per unit area is only slightly more than Lake Superior, the least fertile of the Great Lakes. A large portion of the lake is deep, the bottom topography featureless, and the sport and commercial fisheries are mainly concentrated in relatively shallow water at the eastern end of the lake and the St. Lawrence River. Commercial production is largely from Canadian waters while attractive sport fisheries are found in both countries.

Lake trout and whitefish appear to be less abundant now, while chubs and cisco are no longer sought partly because of competition from more profitable fisheries for these fish elsewhere. Warm-water species such as carp and bullheads have shown a comparatively steady commercial production, while walleye, smallmouth bass and maskinonge are the important game species.

In spite of considerable fluctuations in abundance, whitefish continue to make an important contribution to the commercial fishery in Canada. The annual catch of whitefish has been as high as 2.8 million pounds (1924) but in the last 30 years has exceeded 0.7 million pounds only once. Attempts to increase production by planting whitefish fry have proved ineffectual, but the study undertaken to evaluate this practice has provided valuable information on the contribution of various year classes to the fishery. These observations

and tagging studies are providing the information required to estimate the effects of fishing on the abundance and production of whitefish and the role of other environmental factors.

The Commission recommends that *this well-advanced study continue and that emphasis be placed on lines of investigation aimed at discovering the causes of fluctuations in recruitment. It also recommends the development of experimental fishing to follow the survival of young whitefish and forecast their relative abundance before they enter the commercial fishery.*

Lake trout production reached a peak of approximately one million pounds in 1925, but has declined and lake trout are rarely taken now. In 1953 the Province of Ontario and the State of New York began annual plantings of marked lake trout to see if the population could be restored to a level where it would again contribute significantly to the commercial and sport fisheries. A surprisingly large number of these fish have been taken, incidentally, in nets set for whitefish. However, fish over four years of age are seldom caught.

The Commission recommends that *study of the survival of planted lake trout be continued to learn the factors which now limit production and the reasons for the decline in native stocks. It further recommends that both countries endeavor to increase the size of the introduced population and thus facilitate the study.*

The sport fisheries of eastern Lake Ontario and the upper St. Lawrence River have attracted anglers for many years. The newly created impoundments and the development of adjacent recreational areas are expected to attract more anglers to this region and the sport fisheries will grow in importance. Rudimentary information on the angling harvest is largely lacking with the exception of the Bay of Quinte. The Commission recommends *an expansion of creel census surveys to permit an estimate of the production of the sport fishery and to locate the more important angling areas. The collection of biological data useful in interpreting fluctuations should begin in these areas.*

Information on physical and chemical conditions is required in Lake Ontario as in all the Great Lakes, in order to understand fluctuations in fish abundance. The routine collection of this information requires a general understanding of the lake currents, temperatures and water chemistry at different locations during the year. The Commission recommends that *these general limnological studies be undertaken at an early date to provide the information required to establish a sampling system for monitoring lake conditions.*

The central and western portions of the lake which have always been less productive than the eastern end are now rarely fished. Smaller species, such as alewife and chubs, may be present in sufficient numbers to permit a fishery with trawls. The Commission recommends that *the fish production potential of the central and western areas be investigated.*

Lake Huron

Lake Huron, including Georgian Bay and the North Channel, is the second largest of the Great Lakes with a total area of 22,976 square miles. Before the establishment of the sea lamprey in Lake Huron, the major commercial species of the main lake were lake trout, whitefish, and chubs; near shore and in bays lake herring, walleyes, carp, suckers, and yellow perch were important. Today the fishing industry is suffering grave hardship because of the lamprey's destruction or serious reduction of stocks of lake trout, whitefish, and walleyes, and of suckers outside Saginaw Bay. The impact of the lamprey's depredations was softened somewhat by a temporary high abundance of whitefish (about 1947–48 in Huron proper; early 1950's in Georgian Bay) resulting from a phenomenally strong 1943 year class, but whitefish soon declined to the low abundance that had characterized the stocks since the mid-1930's. More

recently a pronounced drop in lake herring production has been associated with an explosive increase in the abundance of alewives, particularly in Saginaw Bay. Commercial fishing activities are dwindling rapidly in most of Lake Huron. Most "high-priced" species have all but disappeared. The varieties that are plentiful are most difficult to produce at a profit.

Until the early 1920's practically no research in fishery biology was undertaken. Later investigations, usually stimulated by emergencies, were given only limited support. Continuous studies which would contribute to a fundamental understanding of the fish populations were not established until the middle 1940's. Recent years have been marked by significant advances in research of environmental conditions and biota by several agencies.

Most past fishery investigations have been confined to the shallow bays of the lake. Little is known about the fish populations in the deeper waters and the environmental factors that influence their abundance. The Commission recommends that *early priority be given to a general survey of the deep-water fish populations and the development of a sampling system which will permit an estimate of population change.*

Many species not taken commercially are extremely abundant and it is most likely that they exert some influence on the abundance of the principal game and commercial fish. If improvements in methods and gear continue, these presently unused species may eventually contribute substantially to the fish production of the lake. The Commission, therefore, recommends that *routine collections of biological data be broadened to include those species such as alewife, carp, chubs, smelt, longnose sucker and white sucker which although they are presently of little commercial value are, because of their abundance and possible effects on more desirable species, an important segment of the population.*

There is reason to suspect a "competitive" relationship between alewife and herring for an increase in the former has been accompanied by a decrease in the latter in two areas of the lake. The Commission recommends that *the life histories and interrelationships of these two species be given special attention.*

The drastic reduction of the smelt population by an epizootic in the winter of 1942–43 coincided with the production of an exceptionally strong year class of whitefish which later resulted in record production of this species in the early 1950's. No significant year classes have been produced since 1943 and smelt, which rapidly became abundant after the die-off, may have been a limiting factor. The Commission recommends that *the interrelationships of smelt and whitefish be studied.*

Routine measurements of environmental conditions, particularly water temperatures, would be most valuable in attempting to explain fluctuations in abundance of the principal species. The Commission recommends that *a system be developed for routinely following the physical and chemical conditions which may influence fish production. Intermediate links with fish productivity, such as plankton and bottom fauna, should receive increasing attention as their role in production becomes more clearly defined.*

At the present time one of the major deficiencies in understanding the Lake Huron fishery is the lack of information on angling. A considerable sport fishery for warm-water fish is carried on in the more protected waters. Production by sportsmen may soon reach significant proportions with the expansion of angling in these areas (mostly for smallmouth bass) and the probable resumption of a sport fishery for lake trout. The Commission recommends that *methods for obtaining estimates of the angling harvest be developed and applied as a preliminary to a more detailed study of the important sport fisheries of the lake.*

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ANNUAL MEETING

AGENDA

1. Call to order by Chairman.
2. Introduction of advisors.
3. Adoption of agenda.
4. Approval of Minutes of Interim Meeting, June 14–15, 1960.
5. Press relations.
6. Report of Chairman.
7. Reports on sea lamprey control and research.
   - (a) Fisheries Research Board of Canada.
   - (b) Bureau of Commercial Fisheries.
   - (c) Michigan Department of Conservation.
   - (d) Wisconsin Conservation Department.
8. Reconsideration of program for balance of 1960–61.
9. Review of program for 1961–62.
10. Preliminary consideration of program for 1962–63.
11. Preliminary report on lake trout rehabilitation.
12. Report of *Ad hoc* Committee on Regulation of the Lake Superior Lake Trout Fishery.
13. Reports on the development of trawling in the Great Lakes.
    - (a) Canadian Department of Fisheries.
    - (b) U. S. Bureau of Commercial Fisheries.
14. Organizational matters.
    - (a) Change in time of Annual Meeting.
    - (b) Election of officers.
15. Other business.
16. Adjournment.

ANNUAL MEETING

PROCEEDINGS

The Fifth Annual Meeting of the Great Lakes Fishery Commission was held in Cleveland, Ohio, on December 1 and 2, at the Pick-Carter Hotel.

Call to order and introductions. The meeting was called to order by the Chairman of the Commission, Dr. A. L. Pritchard. In his opening remarks he drew attention to the death of Commissioner W. J. K. Harkness on July 5. A resolution expressing the Commission's deep sense of loss was submitted by Mr. Claude Ver Duin, and adopted.

The Chairman introduced members of the Commission and expressed his pleasure that Dr. J. R. Dymond had been appointed to the Canadian Section. Advisors were introduced by the chairman of the national sections. A list of participants appears on page 19.

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

Approval of past minutes. The minutes of the Interim Meeting, held in Ann Arbor, Michigan, on June 14–15, 1960, were approved.

Press relations. A committee, composed of Commissioners J. R. Dymond, Claude Ver Duin and the Executive Secretary, was asked to prepare statements to be issued to the press.

Report of Chairman. The Chairman reviewed the progress of the sea lamprey program, emphasizing the completion of the initial series of chemical treatments on all known lamprey-producing streams of Lake Superior. Seventy-two streams were treated on this lake since chemical operations began in 1958; 52 in the United States and 20 in Canada.

A reduction in lamprey predation could reasonably be expected in 1961 as a result of the destruction of many millions of larvae by chemical treatment in 1958 and 1959. However, a number of streams treated in 1960 had extremely dense larvae populations and their contribution to the 1961 spawning run could be substantial. Therefore, the results of the chemical program would not be fully evident until the end of the 1962 spawning run in Lake Superior. The 1960–61 program provided for the operation of most of the Lake Superior barriers in the spring of 1961, but investigations were underway to determine the possibility of using a few selected barriers as indicators of changes in lamprey abundance.

Early in 1960 the Commission agreed to extend chemical operations to Lakes Michigan and Huron. A start had already been made in Lake Michigan where seven small streams were treated and in Georgian Bay, Lake Huron, where six streams were treated. Preliminary information required before treating the remaining streams in these lakes showed that concentration of chemical required would be higher than in Lake Superior and the treatments more costly.

Theoretically re-treatment of Lake Superior streams before newly established generations of young lamprey transform and migrate into the lake need not begin before 1962. Some streams, however, might require attention in 1961. An appropriate schedule of chemical treatments on the three upper Great Lakes could not be established until current surveys provide more information on the amounts of chemical required and the magnitude of the job ahead.

Control of the sea lamprey was but one of the responsibilities of the Commission. Its broader functions were to formulate research programs, coordinate research and recommend appropriate measures on the basis of findings. Recommendations on research needs for the Great Lakes had been submitted to the two countries. These were framed in general terms and would be supplemented by more detailed recommendations when current programs indicated the most effective lines of investigation.

The re-establishment of lake trout in Lake Superior was foremost in the Commission's deliberations. The population had reached an extremely low level and the catch in 1960 was not expected to reach 600,000 pounds, roughly 15 percent of normal production. Although the population had been relieved of considerable fishing pressure and, presumably, some lamprey predation, it could not be expected to show immediate recovery for there was evidence that natural reproduction had practically failed in many areas of the lake. Young trout from natural spawning were extremely scarce and hatchery-reared fish were making up an increasing proportion of the population. Plantings of lake trout, carried out by federal, state and provincial agencies and coordinated by a committee of the Commission, were therefore becoming of greater significance. The Commission had been advised that some control over fishing intensity might expedite the recovery of the lake trout population and a report on the establishment of a quota system on Lake Superior would be considered during the meeting.

The successful control of the sea lamprey and restoration of lake trout would be of great benefit to the sport and commercial fisheries in the upper Great Lakes. A course of action which would as clearly increase the production of Lake Erie, or for that matter Lake Ontario, was not as evident although present research programs were providing some guidance. A comparison of present conditions in Lake Erie and

those recorded some thirty years ago show that the lake has become warmer and more fertile. During this period there were major changes in the abundance of many commercially important species, viz. cisco, blue pike, and whitefish. The walleye was the last of the "traditionally important" species present in any number and the present population was composed of a single year class that would pass out of the fishery in several years.

The Chairman concluded his remarks by stressing that the effects of environmental changes be learned and their trends detected so that conditions in the fishery could be forecast. In view of the environmental changes in Lake Erie, the prospects for a return of the sport and commercial fishery that existed even ten years ago were extremely poor. The economical capture and marketing of under-utilized species which were becoming abundant was a difficult problem. Biological, technological and economic studies in both countries would be helpful but the initiative, adaptability, and resourcefulness of the fishing industry were essential for full utilization of Lake Erie's fish production potential.

Reports on sea lamprey control and research. A report on the progress of the program in Canada was presented by the Fisheries Research Board of Canada (page 30), and in United States by the United States Bureau of Commercial Fisheries (page 37). The Commission was advised that scientists studying ammocoete distribution were reasonably certain that ammocoetes found in the lake and beyond the reach of stream treatments were not the result of lake spawning but of a drift out of the nearby spawning streams. Frequent re-treatments of streams in which this occurred was suggested as a means of control.

Sea lamprey studies and control operations in support of the Commission's program were described by the conservation departments of the State of Michigan and the State of Wisconsin (page 48). The agencies were commended for their contribution and the Commission also expressed its appreciation for the assistance given by the Ontario Department of Lands and Forests.

Reconsideration of program for remainder of 1960–61. The Bureau of Commercial Fisheries reported on a study of barrier catch records undertaken to determine if changes in lamprey abundance could be judged satisfactorily from catches made at a limited number of "index" barriers. Available data for such an assessment were sufficient for that section of the south shore east of the Keweenaw Peninsula only. Presentation and analyses of data were entirely in terms of catches in operating zones that included 3 to 5 streams. No search was attempted for a single index stream since the cost of operating one

barrier nearly equalled that of operating all the barriers in the zone. The results of the study were reported as follows:

> The catch of sea lampreys in each of the 5 zones of eastern Lake Superior is evaluated as an indicator of the trends of catch in the remaining 4 zones. Exclusion of the zone under test avoids, of course, the bias that arises from "self-correlation"; this bias could be highly damaging for zones that produce a considerable percentage of the 5-zone total. The presentation for each zone includes (1) a table showing annual catch in that zone and in the 4 remaining zones, together with a statement of the correlation (r) between the series, and (2) a graphical depiction of the catch in which the scales are adjusted so that given perfect correlation, all points would fall along a line that passes through the origin and intersects the axis at 45°. The distribution of points about this line give visual evidence on the extent of agreement between series.
>
> The coefficients of correlation between catches of sea lampreys in each zone with catches in the remaining zones were:

Zone	r
S–1	0.405
S–2	0.790*
S–3	0.917**
S–4	0.950**
S–5	0.796*

* Significant at 5-percent level
** Significant at 1-percent level

> Four of the 5 coefficients were significant and 2 were highly significant. If an index zone is to be substituted for operation of the full barrier system, S–3 or S–4 should be the most reliable.

The Scientific Advisory Committee urged that every effort be made to obtain a clear demonstration of the value of the control methods used on Lake Superior. The following statement was submitted:

> An evaluation of operations on Lake Superior could be obtained by continuing to capture spawning adults at electrical barriers, recording the incidence of lamprey scars, or measuring the abundance of ammocoetes in streams. It is believed that barrier operations will provide far better immediate information on changes in lamprey abundance than the others. Furthermore, the cost of obtaining a reasonable estimate of lamprey abundance by the latter two would probably exceed the cost of maintaining the present barrier network. The Committee is agreed that the operation of electrical barriers affords the best means of assessing the effects of control operations on Lake Superior in 1961 and 1962. However, assessment has now become the sole function of the barriers and it should be reviewed to determine if the operation of the entire network is necessary. The report presented by the Bureau of Commercial Fisheries was to clarify this question. It has shown that the annual catches at four of the five zones lying east of the Keweenaw Peninsula have closely similar trends. This information can be used as a basis for selecting an index zone among the four if it is assumed that the trends in the catches accurately reflect changes in abundance and that the population of sea lamprey will continue to follow the same migration behavior.
>
> The Scientific Advisory Committee believes that these assumptions cannot be accepted without serious reservations. It has been advised that the barriers,

which were operated for control and not assessment, were repeatedly modified to improve efficiency. Therefore the trend evidenced could be, to some degree, a reflection of improved operations rather than an increase in lamprey abundance. This qualification of the empirical data obscures the exact nature of the correlation. The Committee seriously questions the assumption that the migration pattern of the surviving lamprey in the next two years will conform to previous patterns. On the contrary, there is every reason that the pattern of the presumably badly dislocated population will be substantially different. It, therefore, believes that the evidence of homogeneity in the catch pattern of the four zones mentioned in the Bureau's report should not be used as a basis for selecting index barriers.

The Committee wishes to draw the attention of the Commission to several other points which indicate the risks involved in a major reduction in assessment barriers. The catches in certain rivers on the south shore have not followed the trend for the entire lake. An example is Furnace Creek which, after producing less than 400 lamprey each year for seven years, had a catch of 2,295 in 1960 for unexplained reasons. The chance that an aberrant barrier might be unknowingly selected should be considered. A substantial decline in the catch at the Brule River occurred in 1960. At the same time the barrier on the Bad River was destroyed. It is possible that in the years prior to 1960 the run in the Brule had been augmented by the diversion of some spawners from the Bad. The possibility that the elimination of certain barriers will influence the size of the spawning runs in adjacent streams should not be overlooked.

There are other compelling reasons for operating the present barrier network in 1961 and 1962. First, the treatments may not have been uniformly successful. The persistence of spawning runs in certain areas would pinpoint weakness in past operations. This information would not be obtained if barrier operations were confined to one or two areas of the south shore.

The Committee believes that there is considerable value in knowing the approximate size of the residual population in 1962. The information would come from operating the existing network.

The Committee believes that a satisfactory evaluation of the program on Lake Superior requires the continued operation in 1961 and 1962 of existing barriers with a good record of operating efficiency.

The Commission approved the operation of electrical barriers on 30 streams along the south shore of Lake Superior on the understanding that the possibility of a reduction be explored at the next meeting.

Review of program for 1961–62. Several minor internal revisions were made in the estimates for the 1961–62 program that had been adopted by the Commission at its Interim Meeting on June 14–15, 1960.

Barrier operations on the Michipicoten and Goulais Rivers were discontinued as lamprey catches at the installations were believed to reflect changes in operating conditions rather than changes in lamprey abundance.

Preliminary consideration of program for 1962–63. The Commission called for the preparation of a 1962–63 program to be considered at the next meeting in June, 1961. The cost was to be maintained at about its present level with modest increases where necessary.

Preliminary report on lake trout rehabilitation.[1] A progress report on the lake trout rehabilitation activities of various agencies in the upper Great Lakes in 1960 was presented by the Commission's Assistant Executive Secretary. He advised the Commission that its Committee on Lake Trout Rehabilitation would submit a final report at the next meeting.

Attention was drawn to the successful spawning of hybrid trout (brook trout x lake trout) in a small Ontario lake and the appearance of young fish in South Bay (Lake Huron), which could only be the progeny of hybrids planted earlier.

Report of Ad hoc Committee on Regulation of the Lake Superior Lake Trout Fishery.[2] A preliminary statement was presented by a committee of senior administrators representing the regulatory agencies on Lake Superior, which met at the request of the Commission to consider establishment of a total allowable lake trout catch and an equitable distribution to the four jurisdictional areas.

The Committee recognized the need for the quota system and for the control that a multiple-area quota system would establish. It encountered difficulties, however, when an attempt was made to apply a proportioning formula to a total lake catch set at a very low level.

The Committee recommended that the regulatory agencies support a multiple-area quota system of management for Lake Superior, but that implementation be deferred until success of sea lamprey control was evident.

The Committee further recommended that the angler catch be included in any quota system and, therefore, urged that each agency develop methods to assess the lake trout sport fishery within its jurisdiction.

The Commission agreed that all regulatory agencies should be notified that a quota system would likely be recommended by the Commission following evidence of sea lamprey control in Lake Superior, and that the agencies should be asked to seriously consider measures needed for implementation as well as the collection of information which would facilitate determination of the allowable harvest.

Reports on the development of trawling in the Great Lakes. The Commission received reports on the use of trawling gear in the Great Lakes from the United States Bureau of Commercial Fisheries and

[1] Final report on 1960 investigations given on page 54.

[2] Members of the Committee were: A. B. Cook (Michigan), H. O. Swenson (Minnesota), L. P. Voigt (Wisconsin), and W. H. R. Werner (Ontario).

the Canadian Department of Fisheries. The Bureau also presented a brief report on the economics of the trawl fishery, and the Department a progress report on an economic study of the Canadian Great Lakes fisheries.

Organizational matters. The Commission held its biennial election of officers. Mr. Claude Ver Duin was elected Chairman and Dr. A. L. Pritchard Vice-Chairman. The Commission agreed to hold subsequent annual meetings in June as future plans could be more satisfactorily discussed at that time.

Other business. The Commission, on the recommendation of the United States Section, agreed to again request that the United States Government urge the State of Minnesota to vest regulatory authority over commercial fishing in the Great Lakes in its Conservation Department.

The Commission also agreed that a study be made of the seriousness of the incidental capture of young lake trout in small-mesh chub nets and trawls, that the problem of inconsistencies in fishing regulations be examined and the possibility of obtaining a greater degree of uniformity explored. The proposals were referred to the Secretariat for action.

Adjournment. The Chairman expressed his appreciation for the interest shown by all in attendance and adjourned the Fifth 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	H. V. Sutton	J. C. Budd
J. R. Dymond		W. A. Kennedy
A. L. Pritchard	*Observer:*	A. H. Lawrie
	W. M. Sprules	K. H. Loftus*
		G. F. M. Smith*
		J. J. Tibbles

United States

Commissioners:	*Advisors:*	*Scientific Advisors:*
D. L. McKernan	W. S. Harth	K. Brouillard
Claude Ver Duin	A. S. Hazzard	W. F. Carbine
L. P. Voigt	Martin Hosko	L. F. Erkkila
	Roy Jensen	P. H. Eschmeyer
	J. H. Kitchel	M. Greenwood
	Mathon Kyritsis	Ralph Hile
	W. M. Lawrence	John Howell
	J. W. Leonard**	A. L. McLain
	D. Leedy	J. W. Moffett*
	L. S. Roach	Philip Nelson
	G. E. Sprecher	Richard Pycha
	J. A. Walstad	Edw. Schneberger
	W. H. H. Wertz	B. R. Smith
	Observer:	
	Marvin Fast	

SECRETARIAT:

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

* Member of Scientific Advisory Committee.
** Representing G. E. Eddy, Michigan Department of Conservation.

ADMINISTRATIVE REPORT FOR 1960

Membership, officers and staff. On September 2, the Canadian Government announced the appointment of John R. Dymond, OBE, MA, DSc, FRSC, to fill the vacancy in the Canadian Section left by the sudden death of Dr. W. J. K. Harkness in July, 1960.

Dr. A. L. Pritchard and Mr. Claude Ver Duin continued as Chairman and Vice-Chairman, respectively, until the Annual Meeting on December 1–2, 1960.

The Commission's Secretariat was composed of three permanent employees and one part-time typist.

Accounts and audit. The accounts of the Commission for fiscal year 1959–60 were audited by the Ann Arbor firm of Icerman, Johnson and Hoffman. The Auditors' Report appears on pages 25–27.

Contributions to the 1959–60 program. The Commission's 1959–60 program was adopted at a meeting in Marquette, Michigan on June 10–11, 1958. The estimated cost of lamprey control and research was $1,490,300, administration and general research $51,400. The program was reduced when the Commission was advised of a budget limitation in the United States. A revised program costing $1,377,230 for lamprey control and research and $50,000 for administration and general research was submitted to the two governments in January, 1959. The Commission learned on July 7 that the United States contribution would be $29,000 less than requested and revised its lamprey program to lower the estimated cost to $1,335,199.

Requests for funds, credits and contributions for fiscal year 1959–60 were as follows:

	United States	*Canada*
Sea lamprey control and research		
Share of program costs	$921,287.00	$413,912.00
Credits from 1957–58	3,166.00	8,824.00
Contributions requested	$918,121.00	$405,088.00
Administration and general research		
Share of program costs	$ 25,000.00	$ 25,000.00
Credit from 1957–58	252.00[1]	315.69
	24,748.00	24,684.31
Credits from 1958–59	3,029.88	3,029.87
Contributions requested	$ 21,718.12	$ 21,654.44

The above contributions requested by the Commission were provided by both governments.

[1] Credit of $63.69 claimed in fiscal year 1958–59.

Expenditures in 1959–60. Agreements to carry out the 1959–60 program of sea lamprey control and research were made with the Fisheries Research Board of Canada, through the Minister of Fisheries for Canada, and with the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, for $521,590 (Canadian) and $717,330 (U.S.), respectively. An amount of $96,270 (U.S.) was held to pay contract administration charges in both countries and exchange charges on funds supplied to the Canadian agent.

Statement of expenditures by both agents in fiscal year 1959–60 appear on pages 28–29. The statement of the Fisheries Research Board shows the transfer of $39,389.24 from fiscal year 1958–59, which was authorized by the Commission in April, 1959. A transfer to 1960–61 of unexpended funds estimated to be $40,000 was requested in February, 1960 and authorized by the Commission for the purchase of chemical before June 30. The earlier transfer was not considered in estimating the 1959–60 under-expenditure which was $76,864.51. The Bureau of Commercial Fisheries had an under-expenditure of $33,720.53 of which $3,890 was refunded to the Commission to meet exchange charges on payments to its Canadian agent which were slightly higher than anticipated.

In addition to statements of expenditures, the agents supplied brief reports on the discharge of contract obligations. Activities were carried out essentially as planned, with the exception of chemical treatments which were delayed by heavy rains in the fall of 1959 and heavy sustained flooding of streams in the spring of 1960. The Fisheries Research Board was unable to treat the Little Carp, Goulais, Cranberry and Kaministikwia Rivers or retreat the Stokeley, where earlier operations had not been successful. The Bureau of Commercial Fisheries was unable to treat the Waiska, Tahquamenon and Bad, but disposed of 15 smaller streams on Lake Superior which were not specified in the Agreement. The Bureau was also able to treat 6 small tributaries of northern Lake Michigan.

Expenditures for Commission Administration and General Research were $14,712.02 below estimates. The Commission's decision to limit expansion of its Great Lakes Fishery Bibliography to the accession of new material left $6,000 uncommitted. The position of clerk-typist was not filled when it became apparent that the clerical and typing duties could be handled by the secretary with part-time assistance. The postponement of a vehicle purchase and printing of a report on the lamprey program accounted for much of the remaining under-expenditure.

Contributions to the 1960–61 program. The 1960–61 program was approved by correspondence in July, 1959, and submitted to the two

governments on July 15. The estimated cost of lamprey control and research was $1,427,000, and administration and general research $46,000. The lamprey program was reduced in October to $1,338,097 when the Commission was advised that the U.S. contribution to the program would be limited to the amount appropriated in 1959–60.

A request for a supplemental contribution of $21,000 was made to the U.S. Government in July, 1960, to meet salary increases (6.5 percent) made to the staff of the Commission's agent in the United States. The Government of Canada was not asked to share in this increased cost for it was covering directly the cost of a similar increase to the staff of the Commission's agent in Canada.

Agreements with agents 1960–61. The Commission entered into agreements with the Fisheries Research Board of Canada and the U.S. Bureau of Commercial Fisheries to carry out the 1960–61 program of sea lamprey control and research.

The costs of the two agreements or contracts were as follows:

Fisheries Research Board of Canada		
Amount of contract	$479,082	(Canadian)
Provision of contract administration charge (6%)	28,744	(Canadian)
Provision for exchange	27,974	(U.S.)
Total	$535,800	(U.S.)
U.S. Bureau of Commercial Fisheries		
Amount of contract	$772,400	(U.S.)
Provision for contract administration charge (6%)	46,300	(U.S.)
Total	$818,700	(U.S.)

Program and budget for 1961–62. The Commission's 1961–62 program and budget, totaling $1,384,100, was adopted at the Interim Meeting in Ann Arbor, June 14–15, 1960. The proposed program was submitted to the two governments on July 14. The Commission was subsequently advised that the U.S. Government would consider increasing its contribution by $21,000 to meet the higher cost of personal services resulting from salary increases to the staff of the Commission's agent in July, 1960. The Government of Canada was asked on September 16 to increase its contribution by $9,434 to meet its share (31 percent). The revised cost of the 1961–62 program is $1,414,534.

The Great Lakes Bibliography. The task of maintaining the Great Lakes Bibliography on fishery literature current was assigned to the Secretariat at the 1959 Annual Meeting. A total of 57 publications have been located by means of questionnaires, and by inspection of recent periodicals and publication lists. These references have been

classified and distributed to the 20 agencies and institutions holding a set of the Bibliography.

Meetings. The Commission held an interim meeting in Ann Arbor on June 14–15, 1960. The Scientific Advisory Committee held two, one on June 13, immediately preceding the Interim Meeting and one on November 16, 1960. Two *Ad hoc* committees were established by the Commission; the first to study regulation of the lake trout fishery in Lake Superior, and the other to consider the implementation of a quota system. The reports of these committees were submitted at the Interim and Annual Meetings.

Members of the Commission's staff attended the annual meetings of the following organizations and in most instances presented reports on Commission activities:

Ontario Federation of Anglers and Hunters
Michigan Outdoor Writers Association
American Fisheries Society
Ohio Commercial Fishermen's Association
Michigan Fish Producers Association
Lake Ontario Fishery Committee
Lake Erie Fish Management Committee
Lake Superior Advisory Committee (U.S. Section)
Ontario Council of Commercial Fisheries

Members of the staff attended several regional meetings of the Michigan Union of Conservation Clubs at the request of the Michigan Department of Conservation to explain the Commission's interest in the lake trout planting program. The Assistant Executive Secretary testified before the Michigan Conservation Commission on this same matter.

The Executive Secretary was appointed permanent secretary to the informal committees on the two lower lakes and organized the program for the 1960 meeting of the Lake Erie Fish Management Committee.

Reports and publications. The Commission's Annual Report for 1958 was published in January, 1960. Publications on investigations carried out for the Commission which appeared in journals during the year were as follows:

Thomas, M. L. H. A modified anchor dredge for collecting burrowing animals. J. Fish. Res. Bd. of Canada, 17 (4): 591–594.

McCauley, R. W. The role of electrical conductivity of water in shocking lampreys (*Petromyzon marinus*). J. Fish. Res. Bd. of Canada, 17 (4): 583–589.

Smith, M. A., V. C. Applegate, and B. G. H. Johnson. Colorimetric determination of halogenated nitrophenols added to streams as sea lamprey larvicides. Anal. Chem. 32 (12): 1670–1675.

The Commission assumed the task of compiling a summary of commercial fishing regulations on the Great Lakes, carried out previously by the U.S. Bureau of Commercial Fisheries. The summary was sent to the Commissioners and to the federal, state and provincial agencies concerned with the Great Lakes fishery.

Other activities. Contacts with field operations were limited to brief visits with chemical treatment crews on Lake Superior, a bioassay crew on Lake Michigan, and the research staff at the Hammond Bay Laboratory. Fishery research groups based at Ashland, Wisconsin, Maple, Ontario, and Glenora, Ontario, were also visited during the year by the Executive Secretary.

The Assistant Executive Secretary was mainly concerned with the lake trout rehabilitation program. General and particular problems were discussed with the supervisors in each agency at least once during the year. Spawn-taking operations in Walloon and Elk Lakes, Michigan, were observed.

Auditors Report to Commission

ICERMAN, JOHNSON & HOFFMAN

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

September 19, 1960

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 Operation Fund at June 30, 1960, 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, 1960, 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, 1960

Assets	
Cash on hand and in bank	$14,712.02
Fund Equity	
Administration and General Research Fund	$14,712.02

Exhibit B

Administration and General Research Fund
Statement of Revenues and Expenses
Year Ended June 30, 1960

Revenues	*Actual*	*Budget*
Canadian Government	$21,654.44	$25,000.00
United States Government	21,718.12	25,000.00
Transfer from Lamprey Control Operations	.06	
Transfer from 1958–59 Petty Cash	.04	
Totals	43,372.66	$50,000.00
Expenses		
Communication	$ 541.34	$ 700.00
Equipment		1,500.00
Insurance, bonding and audit	384.17	500.00
Rents and utilities	151.44	200.00
Reproducing and printing	1,160.90	2,500.00
Salaries (including F.I.C.A. and Pension)	28,923.68	32,500.00
Supplies and equipment maintenance	1,445.14	1,500.00
Transportation	14.03	400.00
Travel	2,667.37	4,200.00
General Research		6,000.00
Totals	$35,288.07	$50,000.00
Excess of expenses over revenues		
Fund Balance, July 1, 1959	$ 8,084.59	
Fund Balance, June 30, 1960 (Exhibit A)	6,627.43 (A)	
	$14,712.02	
(A) Credits from 1958–59	$ 567.68	
Administration and General Research Fund balance 6-30-59	6,059.75	
Total	$ 6,627.43	

Exhibit C

Great Lakes Fishery Commission
Lamprey Control Operation Fund
Statement of Revenues and Expenses
Year Ended June 30, 1960

Revenues	*Actual*	*Budget*
Canadian Government	$ 405,087.85	$ 413,912.00
United States Government	918,120.97	$ 921,287.00
Refund—Bureau of Commercial Fisheries	3,890.00	
Totals	$1,327,098.82	$1,335,199.00
Expenses		
Canadian Department of Fisheries	$ 552,885.00	$ 552,885.00
United States Bureau of Commercial Fisheries	760,200.00	760,200.00
Currency exchange charges	26,003.94	22,114.00
Transfer to Administrative Fund	.06	
Totals	$1,339,089.00	$1,335,199.00
Excess of expenses over revenues		
Fund balance, July 1, 1959	11,990.18	
Fund balance, June 30, 1960	11,990.18	
	-0-	

Fisheries Research Board of Canada

Financial Report to Great Lakes Fishery Commission
April 1, 1959, to March 31, 1960

Administration in field:		
66.5% of cost of London Headquarters	($65,233.69)	$43,380.40
Operations		
1. Engineering services		14,132.50
2. Operation of electrical barriers		141,524.59
3. Chemical treatment operations:		
Funds from 1959–60 contract	$161,543.22	
Funds carried over from 1958–59	39,389.24	200,932.46
4. Research:		
Studies of electrical methods	26,656.38	
Studies of chemical methods	13,168.30	
Ammocoete studies	39,237.03	79,061.71
		$479,031.66
Contributions to superannuation:		
6% of permanent salaries ($120,065.51)		7,203.93
		486,235.59
Contract administration		
6% of total disbursements		29,174.14
		$515,409.73
Funds provided by Commission:		
Carried over from 1958–59	$ 39,389.24	
Payments under contract, 1959–60	521,590.00	
Supplementary payment	31,295.00	
Total funds available	592,274.24	
Costs applicable to 1959–60	515,409.73	
Carried over to 1960–61	$ 76,864.51	

Bureau of Commercial Fisheries
Sea Lamprey Research and Control Program

Report of Expenditures
July 1, 1959, through June 30, 1960

Title of activity	Funds allowed by contract	*Expenditures or obligations incurred to date* Permanent salaries	Expenditures	Total	Unobligated balance
Research	$111,960.00	$ 55,681.19	$ 23,726.09	$ 79,407.28	$ 32,552.72
Control:					
Chemical	295,790.00	126,706.37	171,185.64	297,892.01	−2,102.01
Electrical	309,580.00	150,361.37	155,948.81	306,310.18	3,269.82
Contract Administration	42,870.00	..	..	42,870.00	.
	$760,200.00	$332,748.93	$350,860.54	$726,479.47	$ 33,720.53
Refund to Commission June 15, 1960					−3,890.00
Proceeds from sale of vehicles					3,342.36
Total unobligated balance					$ 33,172.89

Bureau of Commercial Fisheries
Sea Lamprey Research and Control Program

Report of Expenditures
July 1, 1959, through June 30, 1960

Title of activity	Funds allowed by contract	*Expenditures or obligations incurred to date* Permanent salaries	Expenditures	Total	Unobligated balance
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Contract Administration	42,870.00	...	...	42,870.00	
	$760,200.00	$332,748.93	$350,860.54	$726,479.47	$ 33,720.53
Refund to Commission June 15, 1960					—3,890.00
Proceeds from sale of vehicles					3,342.36
Total unobligated balance					$ 33,172.89

LAMPREY CONTROL AND RESEARCH IN CANADA
by the Fisheries Research Board of Canada

Lake Superior barrier operations

Electrical barriers were operated in ten Lake Superior tributaries in 1960. These were not installed and operated as early in the spring as in previous years as they were to be used chiefly to assess the success of stream treatments with lampricide. The possibility of washouts by spring floods which have resulted, in the past, in interruptions of operation and in costly repair was thereby reduced. Even with this precaution, some barriers were heavily damaged by floods during and prior to operating. Unusually high spring run-off in the Wawa area prevented installation of the Michipicoten barrier until June 10. It was also turned off during the chemical treatment as a safety precaution.

In 1960, 4,810 adult migrant sea lampreys were collected from these ten barriers as compared with 3,098 in 1959 and 2,950 in 1958. Lamprey recoveries at barriers operated in the period 1954 to 1960 are given in Table 1.

As sea lamprey ammocoetes have been collected during the chemical treatments above the barriers in all streams tributary to Lake Superior on the Canadian side in which the barriers have operated, it is evident that there has been escapement through all of these electrical devices.

Chemical treatment operations

In 1960, 230 tributaries to Lake Superior were re-surveyed with electro-shocking gear to detect the development of any new runs. Sea lamprey were found in ten of them for the first time. Of these, nine were small streams tributary to Batchawana Bay in eastern Lake Superior. The ammocoetes in these streams were few and were found close to their mouths. It seems likely that they are immigrants from the lake-dwelling population known to be present in the area. In the tenth tributary, the Black Sturgeon River, ammocoetes were numerous and widespread and obviously the result of spawning in that river. These observations led to treatment of the Black Sturgeon and of Sawmill Creek, but treatment of the others was considered unnecessary.

Pre-treatment surveys to determine the distribution of sea lamprey ammocoetes were carried out on the following streams during 1960: Jackfish, Michipicoten, Black Sturgeon, and Sawmill and Lake Superior; Bar, Two Tree, Gowas, H-68, Livingstone, Root, Echo and Nottawasaga on Lake Huron. The rate at which pre-treatment surveys for distribution of ammocoetes on Lake Huron have been carried out has been slower than is desirable for the survey crew from that lake

TABLE 1.—Sea lamprey recovered annually at electrical barriers on Lake Superior streams, 1954–1960.

Stream No.	Stream Name	Year 1954	1955	1956	1957	1958	1959	1960
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	20
S 23	Cranberry Cr.		6	11	18	6		
S 24	Goulais R.		46	62	820	682	395	760
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	19
S 42	Jones Landing Cr.		0	0				
S 43	Downey Cr.		0	0				
S 48	Chippewa R.		807	839	359	220	296	1,051
S 52	Batchawana R.		608	421	427	358	482	629
S 54	Sable R.	39	43	65	76	47	142	246
S 56	Pancake R.		555	717	1,073	809	816	1,306
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	143
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	10
S 368	Gravel R.			5	99	154	541	626
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	4,810

was required to assist with the chemical treatments during 1959 and on the Lake Superior surveys for most of the 1960 season.

Post-treatment surveys to determine the effectiveness of the chemical treatments were conducted on the following streams: Pearl, Kaministikwia, Goulais, and Michipicoten on Lake Superior; Magnetawan, Still, Silver, and Naiscoot Rivers on Lake Huron. Sea lamprey ammocoetes were found in only one river, the Michipicoten, and these were located at the mouth of a large lagoon known locally as the Dead River.

A series of large-scale maps of the streams scheduled for chemical treatments has been prepared and annotated to show available information regarding access, flows, etc. These maps have been duplicated in a form suitable for field use and form the basis for recording data during field treatments. The series is complete for Lake Superior and a similar one is being prepared for Lake Huron.

Bioassay procedure has been refined so that the concentration required to produce a 99.9% level of kill can be computed with reasonable accuracy. To accomplish this, the concentrations used in the test are prepared in the form of a geometric progression and the observations are taken at time intervals that increase logarithmically. The overall number of test specimens per concentration has been increased, when available, from 8 to 24. In all of the streams treated during the 1960 season the concentration has been maintained at a level that, as indicated by the bioassay, would cause 99.9% mortality among ammocoetes subjected to the toxicant.

A second bioassay trailer was procured and outfitted, and used during the late spring and early summer when staff were available. Unfortunately, it was not possible to recruit two of the scientists required to bring the personnel establishment to full strength and the trailer was unattended for much of the year.

The weather was particularly favorable for lampricide applicaiton in 1960 and 18 streams were successfully treated, 11 on Lake Superior and 7 on Georgian Bay (Lake Huron). These operations completed the treatment of all known lamprey-producing streams on the Canadian side of Lake Superior,[1] and left only one stream, the Nottawasaga, to be treated in Georgian Bay. Staff of the United States Bureau of Commercial Fisheries assisted in the Goulais River treatment, and the Ontario Department of Lands and Forests cooperated in this and other treatments, largely through the provision of vehicles, portable radios, and aircraft for transport and reconnaissance.

Data concerning the streams treated since 1958 are presented in Tables 2 and 3. Detailed descriptions of each treatment and information on the completeness of larval distribution have been compiled. Samples of ammocoetes killed were collected during treatments from which the size composition could be determined and ages estimated; these determinations have not been made because of the pressure of work of a higher priority.

Ammocoete studies

Explorations to determine the extent of distribution of sea lamprey ammocoetes in Batchawana Bay were extended in 1960 to include types of shore previously thought unsuitable as larval habitat.

[1] Ammocoetes found subsequently in Wolf and Chippewa Rivers, treated in 1961.

TABLE 2.—Streams treated with lampricide in Lake Superior, 1958–1960.

Stream	Date of treatment	Discharge (cfs)	Stream miles treated	Concentration in ppm at		Pounds of active ingredient	Ammocoete abundance
				feeder	mouth		
Pancake	Sept. 27, 1958	43	15	2.5	1.0	212	Very abundant.
West Davignon	July 4, 1959	15	9	2.2	1.0	117	Moderately abundant
Big Carp	July 7, 1959	10	9	8.0	1.7	119	Abundant
Harmony	July 10, 1959	11	5	1.6	1.1	65	Moderately abundant
Sable	July 15, 1959	14	5	2.6	1.4	208	Abundant
Batchawana	July 20, 1959	126	7	2.6	1.4	1,567	Very abundant
Pays Plat	Aug. 26, 1959	132	7	4.3	1.0	1,580	Moderately abundant
Pearl	Sept. 1, 1959	12	4	5.0	1.8	191	Few
Big Gravel	Oct. 6, 1959	274	7	3.1	2.2	1,983	Few
Cranberry	Apr. 29, 1960	37	5	6.5	4.0	567	Few
Stokeley	May 5, 1960	104	7	4.8	3.0	780	Few
Little Carp	May 12, 1960	28	7	4.0	2.5	205	Few
Kaministikwia	June 4, 1960	1,334	48	2.3	0.9	11,895	Very abundant
McIntyre	June 8, 1960	22	6	3.0	1.5	176	Few
Goulais	June 22, 1960	800	88	2.8	1.5	6,464	Very abundant
Michipicoten	July 2, 1960	2,594	17	1.7	1.5	16,322	Abundant
Jackfish	Sept. 23, 1960	26	9	4.5	3.5	741	Moderately abundant
Black Sturgeon	Oct. 12, 1960	684	49	8.0	5.0	15,239	Very abundant
Pigeon	Oct. 18, 1960	99	4	4.0	2.3	2,145	Few
Sawmill	Oct. 28, 1960	3		4.2	3.9	16	Few
Total		6,368	308			60,592	

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Sawmill	Oct. 28, 1960	3		4.2	3.9	16	Few
Total		6,368	308			60,592	

TABLE 3.—Streams treated with lampricide in Lake Huron, 1960.

Stream	Date of treatment	Discharge (cfs)	Stream miles treated	Concentration in ppm at		Pounds of active ingredient	Ammocoete abundance
				feeder	mouth		
Magnetawan	Aug. 11, 1960	718	6	1.0	0.5	1,570	Few
Still	Aug. 16, 1960	17	18	2.3	0.9	176	Very abundant
Naiscoot	Aug. 21, 1960	27	15	2.2	1.5	156	Abundant
Chickanishing	Sept. 9, 1960	6	4	1.5	0.8	29	Few
Boyne	Nov. 13, 1960	24	5	2.2	0.9	556	Few
Silver	Nov. 30, 1960	6	6	20.0	9.0	1,402	Moderately abundant
Sturgeon	Dec. 2, 1960	26	12	35.0	8.0	1,275	Very abundant
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These shores ranged from gravel to coarse rocks and boulders. All shores, regardless of type, lying within 2½ miles of the mouth of the Batchawana River and those within 1¾ miles of the Sable River have been explored using the same method. It was found that ammocoetes were present in all types of shore up to a certain distance from the river mouth. The population density of sea lamprey ammocoetes on stony and rocky shores was similar to that for sandy shores at the same distance from the river mouth.

Previously explored in June and July of 1959, four areas lying on a sand beach between the Sable and Batchawana Rivers were re-shocked twice in 1960, in May and September. On both occasions somewhat higher population densities were found than in 1959. Both rivers had been successfully treated with lampricide prior to the initial survey; therefore, changes in population density must be attributed to readjustment of a resident lake population.

Sandy shores at the mouth of the Big Gravel River in Nipigon Bay were also investigated. *Ichthyomyzon sp.* ammocoetes were present up to one-half mile each side of the river, and sea lampreys were found half a mile to the east of the river mouth.

Dragging operations were carried out with an anchor dredge in Batchawana Bay, Pigeon Bay, and off the Big Gravel River in an effort to locate resident populations of ammocoetes in deep water. Fifty-one dredge hauls were made in Batchawana Bay in depths from 17 to 124 feet and six ammocoetes, including three sea lampreys, were collected in 40 hauls in from 8 to 47 feet of water off the Big Gravel River.

In the last two years, ammocoetes have been sought off the mouths of eight streams in which sea lampreys were known to spawn and in which ammocoetes had been collected. Sea lamprey ammocoetes were found off all but two. These ammocoetes may be reasonably attributed to parent streams on a basis of size and there is no evidence of lake spawning. Ammocoetes in the lake appeared healthy, were in a normal range of sizes (range 40 to 144 mm.) and probably represent individuals in their second year and older. Transforming specimens of other species of ammocoetes have been found in the lake. The fact that ammocoete size increased with increasing distance from the river mouth indicates that ammocoetes feed and grow normally in the lake. Ammocoetes have been found up to just over two miles from the stream mouth in all types of bottom. Dredging operations in deep water suggest that populations there may be as dense as on shore locations. Therefore it must be assumed that fairly large populations of ammocoetes exist off the mouths of some sea lamprey-producing streams.

The population of lake-dwelling ammocoetes in the area within two miles of the Batchawana River mouth is estimated in the tens of

thousands. Although data for assessing approximate relative abundance are not available for other areas, it seems more likely than not that there are similar populations at the mouth of several other lamprey-producing rivers, particularly along the south shore of the lake. Therefore, a total population of lake-dwelling ammocoetes in Lake Superior numbering in the hundreds of thousands, if not in the millions, is not inconsistent with the data.

On the other hand, roughly 60,000 adult sea lampreys have been killed and recovered annually at electrical barriers in recent years. Assuming that at least half of the lamprey in recent spawning runs were killed and recovered at barriers and assuming that natural mortalities of feeding phase lamprey are roughly comparable to natural mortalities of mature fish, these counts suggest that the adult population of sea lamprey which has almost eliminated the lake trout in Lake Superior in recent years had numbers in the low hundreds of thousands. Therefore, it is quite possible that enough adult sea lampreys can develop from lake-dwelling ammocoetes to keep predation on lake trout at an unacceptably high level.

Temperature tolerance studies

Sea lamprey eggs were successfully fertilized in the laboratory. Equipment was constructed and techniques developed to rear large numbers of ova efficiently at 15°C, 20°C and 25°C. Stages in development were defined, and optimum hatching temperatures were determined. The results were in general agreement with those of previous investigators.

Lethal temperatures of the prolarvae emerging from lots of eggs incubated at three temperature levels were determined. The curves obtained by plotting median survival time against lethal test temperature, for prolarvae reared at 15°C and 20°C, were almost identical with those for ammocoetes and adults acclimated at 20°C. The temperature at which 50% of the prolarvae survived on exposure time of 24 hours was 30.7°C (87.3°F). Prolarvae reared at 25°C were the least resistant to high temperature. A lack of healthy specimens prevented a sufficient number of tests to establish the lethal temperature-median resistance time curves of this group.

Work on the temperature tolerance of ammocoetes was continued. Preliminary work on the rate of acclimation to higher temperatures indicates a rapid acclimation of about 1°C per day above 15°C.

The work on spawning-phase adults was completed. Animals trapped at the beginning of the season displayed the characteristic high temperature tolerance of this species. However, as the season progressed this high tolerance decreased. The animals could not be thermally acclimated above 15°C and were susceptible to temperatures that could occur in streams during a summer.

LAMPREY CONTROL AND RESEARCH IN THE UNITED STATES

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

Lake Superior chemical operations

Heavy floods prohibited or interrupted chemical operations until early June. Then, during August and the first half of September, the seasonal reductions in the effectiveness of the chemical stopped treatment of Lake Superior streams. In spite of severe difficulties, the chemical treatment program on the United States shore of Lake Superior was completed by October 30, when the last stream known to contain sea lamprey ammocoetes was dealt with. Since the program began in 1958, 52 streams have been treated, two a second time when the initial treatment failed to give a satisfactory kill of ammocoetes. The aggregate flow treated was 5,886 cfs, the amount of lampricide used, 76,812 pounds (active ingredient), and the chemical cost, $263,105. The details of the treatments are summarized in Table 1.

The sodium salt of 3-trifluormethyl-4-nitrophenol (TFM) was used in treating most of the streams in the Lake Superior basin. This material was formulated variously as stock solutions containing from 30 to 45 per cent active ingredient by weight. Some streams were treated in 1960 with a liquid formulation of the amine salt of TFM containing 52 per cent active ingredient by weight. The several formulations have been satisfactory if some allowance is made for the varied conditions under which they have been stored. Ingredients in some formulations tended to crystallize at low temperatures and were difficult to dissolve after the temperature was raised. Amine salt formulations were more soluble and less affected by low temperatures.

Techniques of chemical treatment have been improved greatly during the three field seasons. Equipment used for the introduction of chemical has been simplified, greatly reduced in weight, and improved in reliability. The dependability and speed of analytical methods also have been increased markedly since 1958. The problem of treating small, remote streams (1–10 cfs) has been solved by the development of two types of chemical feeders. One is a constant-head drip feeder. The other is operated by an electrical fuel pump powered by a 12-volt battery. It feeds chemical through fixed orifices calibrated to deliver a known quantity. Both feeders are light, portable and dependable.

Ammocoetes in backwaters, in mouths of tributaries, and in stream-bed springs sometimes survived treatment because of dilution

TABLE 1.—Details on the application of sea lamprey larvicide to United States streams tributary to Lake Superior, 1958–60.

Stream	Date of treatment	Discharge at mouth (cfs)	Stream miles treated	Concentration (ppm)		Amount of active ingredient (pounds)
				Minimum effective	Maximum allowable	
Mosquito R.[1]	May 14, 1958	40	2			385
Silver R.[1]	June 11, 1958	80	5			675
Huron R.	Sept. 8, 1958	80	12	2.0	4.0	600
Iron R.	Sept. 15, 1958	59	4	2.0	5.0	374
Middle R.	Sept. 24, 1958	59	30	2.0	5.0	368
Poplar R.	Sept. 24, 1958	23	18	2.0	4.0	170
Amnicon R.	Sept. 25, 1958	27	15	3.0	6.0	347
Sucker R.	Oct. 10, 1958	88	40	2.0	7.0	424
Rock R.	Oct. 23, 1958	13	18	3.0	9.0	343
Chocolay R.	Oct. 29, 1958	150	34	2.0	5.0	2,578
Brule R.	April 13, 1959	180	28	1.0	4.0	2,460
Fish Cr.	April 23, 1959	85	14	2.0	7.0	1,000
Big Garlic R.	May 11, 1959	99	4	1.0	4.0	480
Miners R.	May 16, 1959	105	6	1.5	5.0	1,100
Seven Mile Cr.	May 16, 1959	17	4	1.5	7.0	260
Lowney Cr.	May 17, 1959	10	2	2.0	9.0	100
Au Train R.	May 21, 1959	208	16	2.0	7.0	2,870
Little Two Hearted R.	June 5, 1959	53	16	1.5	7.0	741
Two Hearted R.	June 15, 1959	184	48	1.5	5.0	3,140
Sucker R.[2]	Aug. 4, 1959	75	43	2.0	9.0	1,368
Sullivan Cr.	Aug. 6, 1959	5	2	3.0	9.0	68
Pendills Cr.	Aug. 11, 1959	20	1	1.0	4.0	108
Grants Cr.	Aug. 12, 1959	3	1	1.5	5.0	20
Galloway Cr.	Aug. 13, 1959	3	3	2.0	5.0	20
Ankodosh Cr.	Aug. 14, 1959	8	2	2.0	9.0	156
Harlow Cr.	Aug. 21, 1959	15	2	4.0	7.0	156
Pine R.	Aug. 25, 1959	37	3	2.0	7.0	299
Anna R.	Sept. 4, 1959	35	4	2.5	5.0	310
Salmon-Trout R.	Sept. 13, 1959	58	8	2.0	9.0	514

TABLE 1.—(Continued)

Stream	Date of treatment	Discharge at mouth (cfs)	Stream miles treated	Concentration (ppm)		Amount of active ingredient (pounds)
				Minimum effective	Maximum allowable	
Little Garlic R.	Sept. 16, 1959	12	5	2.0	7.0	176
Elm R.	Sept. 25, 1959	27	8	1.5	7.0	234
Misery R.	Oct. 1, 1959	96	12	2.5	11.0	975
Salmon-Trout R.	Oct. 6, 1959	48	1	1.5	5.0	371
Traverse R.	Oct. 8, 1959	34	7	1.0	4.0	195
Little Gratiot R.	Oct. 11, 1959	45	6	0.5	4.0	332
Firesteel R.	Oct. 22, 1959	57	14	1.0	5.0	663
Cranberry R.	Oct. 26, 1959	32	5	1.5	4.0	273
E. Sleeping R.	Oct. 30, 1959	45	12	2.0	7.0	663
Potato R.	Nov. 1, 1959	20	9	1.0	5.0	195
Furnace R.	May 14, 1960	35	1	1.5	4.0	195
Betsy R.	June 1, 1960	330	40	0.5	3.0	2,014
Sturgeon R.	June 19, 1960	1,189	60	1.5	6.0	9,339
Bad R.	July 1, 1960	600	75	1.5	5.0	12,396
Ontonagon R.	July 21, 1960	600	100	2.5	6.0	12,045
Eliza Cr.	July 27, 1960	3	1	2.0		18
Sand R.	Sept. 13, 1960	12	10	1.0	2.5	290
Five Mile Cr.	Sept. 22, 1960	2	1	1.0	4.0	7
Tahquamenon R.	Oct. 1, 1960	660	19	2.0	4.0	10,355
Waiska R.	Oct. 8, 1960	16	21	1.0	4.0	780
Middle Branch Ontonagon R.	Oct. 22, 1960	103	42	3.0	7.0	2,840
East Sleeping R.[2]	Oct. 25, 1960	10	13	4.0	7.0	270
Slate R.	Oct. 29, 1960	14	5	3.0	6.0	158
Ravine R.	Oct. 28, 1960	12	5	2.0	5.0	74
Falls R.	Oct. 30, 1960	53	1	3.0	5.0	478
Split Rock R.	Oct. 28, 1960	12	3	2.0	5.0	142
Total		5,886	861			76,812

[1] Experimental treatments performed by the Hammond Bay staff.
[2] Streams retreated.

or poor circulation of the chemical. The toxicant was applied in the mouths of non-treated tributaries to prevent ammocoetes from migrating into them from the main stream. Spot-treatment of some problem areas was attempted, but the difficulty of controlling concentrations made this procedure hazardous to game fish.

Differences in biological activity and selectivity of TFM among streams and seasonal variations of activity presented the most vexing problem encountered in the Lake Superior work. Seasonal variations sometimes made it necessary to reschedule stream treatments. Smaller spring-fed streams were least affected and could be treated during periods of reduced lampricide effectiveness.

The majority of the ammocoetes alive after a stream treatment were those of native species. The downstream movement of larvae of native species from above the point of treatment and from non-treated tributaries may account for this survival.

Although the mortality of game fish was usually slight, some notable exceptions did occur. The treatment of the Bad River in Ashland County, Wisconsin, killed approximately 200 walleye and 50 northern pike and muskellunge in the lower 15 miles of the stream. During the treatment of the middle branch of the Ontonagon River in Ontonagon County, Michigan, a significant mortality of spawning brown trout took place; 109 fish were recovered in the upper 1½ miles of the river. Spawning brown trout were still present in this section of the Ontonagon after the treatment was completed.

A few highly susceptible fishes such as trout-perch, logperch, bullhead, sculpin, mudminnows, stonecat, and dace were usually greatly reduced or possibly eradicated by the chemical. Invertebrates usually killed were fresh-water scuds, burrowing mayflies, aquatic earthworms, and clams.

Treatment of streams on Lake Superior was expedited by close cooperation between the Fisheries Research Board of Canada and the Bureau of Commercial Fisheries. Starting in 1959, personnel, materials, and equipment of both contracting agencies were used on either side of the lake as required.

Lake Michigan chemical operations

Treatment of Lake Michigan streams in 1960 was confined to times when conditions would not allow work on Lake Superior streams. The 7 streams treated are on the north shore. Their aggregate discharge at time of treatment was 139 cfs which required 1,750 pounds of chemical. Details of these treatments are summarized in Table 2. The techniques, materials, and equipment were essentially those used in Lake Superior.

TABLE 2.—Details on the application of sea lamprey larvicide to streams tributary to Lake Michigan, 1960.

[Toxicant included both sodium and amine salt of TFM]

Stream	Date of treatment	Discharge at mouth (cfs)	Stream miles treated	Concentration (ppm)		Amount of active ingredient (pounds)
				Minimum effective	Maximum allowable	
Johnson Creek	May 20	3.0	4	1.5	4.0	25
Snyder Creek	May 22	21.0	8	1.5	9.0	207
Marblehead Creek	May 25	25.0	14	1.5	5.0	303
Bursaw Creek	May 27	24.0	6	1.0	3.0	107
Parent Creek	May 28	22.0	6	1.0	5.0	192
Hog Island Creek	June 9	16.3	10	2.0	8.0	468
Ogontz River	Aug. 31	28.0	22	1.5	4.0	448
Total		139.3	70			1,750

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The examination of streams tributary to Lake Michigan to determine the presence of sea lamprey larvae and their distribution within streams was begun during 1960. Surveys on the north and west shores are considerably more advanced than those on the east shore. It is fairly certain that the 49 streams on the north and west shore found to contain sea lampreys are the only ones that support lamprey larvae. To date, 29 streams along the east shore have been found to contain sea lamprey larvae.

Lampricide research

The Hammond Bay Laboratory conducted about 250 bioassays, comprising 13,750 individual jar tests, during 1960. About half of the tests were in direct support of the field program; 92 to determine concentrations required for treatment and 26 to test the quality of the chemical supplied. The remainder were carried out to: follow seasonal fluctuations in biological activity of nitrophenols (49); in search of new larvicides (37); to determine the effect of water temperature on TFM (9); to learn tolerance of warm-water fishes to TFM (24); and in support of miscellaneous researches (13).

The laboratory studies showed that water temperature has little effect on the biological activity of TFM. Conversely, hardness and pH affect profoundly the activity of the larvicide.

The biological activity of TFM is generally best at a pH of about 7.1. It is impaired in waters below pH 7.0 and also tends to diminish as alkalinity increases. Attempts made experimentally to adjust pH levels in natural waters have not yielded useful results.

Ten new mononitrophenols containing halogens were tested as selective larvicides. The information was combined with available results of tests with other nitrophenols and the whole was examined to learn what relationship existed between molecular structure and biological activity. The most effective molecule contains one or more halogens substituted directly on the ring or attached in an aliphatic side-chain which contains only one nitro group on the ring. The molecule is most effective when the nitro group is *para* to the hydroxyl group.

TFM is the most effective of 30 related compounds examined, although 15 of the 30 are somewhat toxic to lampreys. The following of the 15 were selected for further study:

2-chloro-4-nitrophenol
2-bromo-4-nitrophenol
3-chloro-4-nitrophenol

All 3 could be used as larvicides. They must be applied in high concentrations (3-4 times the rate for TFM) and preliminary cost analyses indicate they would be more expensive than TFM.

The Hammond Bay Laboratory and the new mobile laboratory, completed in 1960, are making periodic bioassays in water from 31 streams tributary to Lakes Huron and Michigan to determine effectiveness of lampricide at different seasons, and thus assist greatly in the planning of treatment schedules and the estimation of needs for chemical. The streams cover a wide area and a variety of water conditions. It is almost certain now that Lake Michigan streams will require higher concentrations of TFM than Lake Superior streams and at least twice as much lampricide per cubic foot of flow may be needed to treat them successfully.

Attempts to find causative agents in the seasonal deactivation of nitrophenols have been unsuccessful. It appears that the cause may be related to seasonal variations in the abundance of one or more specific constituents of the water. Bioassays are, therefore, being done at 10-day intervals and the waters used are being analyzed for Ca, K, Mg, Na, Fe, Si, total phosphorus, sulfates, chlorides, free ammonia and organic nitrogen, total suspended solids and turbidity. Carbon filters have been installed to collect total organic fractions in samples of water taken from the same source and at about the same time as the water for bioassay. Analyses will be made of these organic constituents. All data are to be compared with bioassay results after a year of testing.

Toxicity thresholds to TFM are being determined for walleye, yellow perch, largemouth bass, smallmouth bass, bluegill, pumpkinseed, yellow bullhead, white sucker, bluntnose minnow, and fathead minnow. Three types of water—soft, medium, and hard—are being used to give experience with waters of all extremes known to occur in the Lake Huron and Lake Michigan drainages. The study is not yet completed.

Lake Superior barrier operations

No new construction was undertaken on Lake Superior streams in 1960 and barriers on 3 streams were placed on standby status for the first time. Spring floods damaged the entire barrier network shortly after its installation and necessitated extensive repairs on 5 structures. The Bad River barrier was damaged beyond repair and discontinued. Barriers on the Dead Sucker and Little Garlic Rivers were removed. Electrical barriers were installed and operated on 37 Lake Superior streams. Six barriers were maintained in standby status and 2 others on the Black and Nemadji Rivers were operated only as check weirs. Eight of the devices were in operation by the end of March and all

had been started in early June. Termination of barrier operation for the season began on July 29 and was completed by September 2.

The total of 39,781 sea lampreys taken is 15.3 per cent below that of 1959 and 34.2 per cent below the 1958 catch in the same streams (Table 3). After showing a decline for 2 consecutive years, the take from 19 streams (blocked since 1954) in the eastern half of Lake Superior increased 35.5 per cent. A significant drop of 47.8 per cent occurred in the numbers of adult lampreys taken from streams of western Lake Superior. The 1960 count may not, however, be accepted as highly dependable. The severe floods which began in the second week of April inundated traps at many barriers for periods in excess of 30 days. As a result, the early catch records are far too low to reflect the size of the run. Most sea lamprey (90.8 per cent) were taken between May 17 and July 18. The largest weekly catch (14.9 per cent of the total run) was made June 4–10.

One stream produced no sea lampreys and 4 produced 10 or fewer. Over 90 per cent of the sea lamprey were taken from 11 streams. The Brule River alone accounted for 25 per cent of the season's catch. The 22 barriers east of the Keweenaw Peninsula contributed 61 per cent of the season's total; the 13 barriers to the west accounted for the remainder.

Fish mortality below the barriers was of minor importance. The capture of a mature female bowfin (*Amia calva*) in the Middle River provided the only new species record.

The extraordinary spring rainfall made escapement possible at all barriers. Observation above the barriers confirmed escapage in 10 streams; 103 nests and 19 adult lampreys were counted. Adults were found above barriers on 3 additional streams during chemical treatment. Escapement undoubtedly occurred elsewhere.

Eleven direct-current-diversion devices were operated in conjunction with A.C. barriers on Lake Superior. The Brule River unit, modified in 1959, captured 29 different species of fish with less than 1.0 percent mortality. Changes were made in the installation of the D.C. arrays on the Two Hearted, Firesteel, and Misery Rivers resulting in earlier installation and less maintenance.

The sea lamprey from 12 index streams averaged 16.4 inches in length and 148 grams in weight representing a decrease of 0.5 inches and 19 grams from 1959 averages. Sea lampreys east of the Keweenaw Peninsula averaged 0.1 inch shorter and 8 grams lighter than those to the west. Adult sea lampreys from 12 index streams showed a continuing increase in the percentage of males from a ratio of 142 males per 100 females in 1959 to 225 males per 100 females in 1960. The predominance of males during the past season was the highest on record.

TABLE 3.—Numbers of sea lamprey caught at electrical barriers on United States tributaries of Lake Superior, 1953–1960.

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

Stream	1953	1954	1955	1956	1957	1958	1959	1960
Waiska R.		32	47	71	55	70	43	127
Pendills Cr.	23	40	45	42	47	17	40	33
Halfaday Cr.		12	3	14	4	2		
Betsy R.	221	567	569	1,577	786	1,092	1,006	705
Little Two Hearted R.					739	460	461	715
Two Hearted R.	371	638	600	1,766	7,899	3,577	4,141	4,508
Sucker R.	750	1,309	1,713	4,400	3,597	1,842	2,522	4,980
Hurricane R.		8	25	99	188	29	65	80
Beaver Lake Cr.	8	19	19	20	49	18		
Miners R.	64	53	148	96	427	97	159	411
Furnace Cr.	18	47	66	209	274	41	396	2,293
Au Train R.	204	350	486	613	739	348	168	80
Rock R.			1,633	3,407	3,102	1,488	1,250	2,646
Laughing Whitefish R.	9	25	16	19	37	11	28	42
Chocolay R.		1,227	3,350	6,888	8,096	6,221	3,500	4,216
Carp R.		0	2	1	4	0	5	5
Harlow Cr.		1	1	0	3	3	31	14
Big Garlic R.		54	89	154	270	262	247	87
Iron R.		67	206	335	737	428	266	342
Salmon-Trout R.							68	5
Pine R.		10	12	18	34	22	43	28
Huron R.		147	472	1,628	2,868	3,526	1,492	1,376
Ravine R.		1	4	2	10	5	23	8
Silver R.		247	786	963	2,810	2,182[1]	878	1,385
Sturgeon R.		1	1	4	31	28	544	161
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	12
Misery R.			183	571	868	896	2,581	761
Firesteel R.		60	150	229	1,039	1,546	2,084	276
Flintsteel R.		2	1	1	2	2	0	0
Bad R.				685	2,652	6,203	4,468	
White R.				219	412	231	552	233
Fish Cr.					520	251	428	354
Cranberry R.						0	14	50
Iron R.						0		
Reefer Cr.						1		
Fish Cr.						0		
Brule R.					3,988	22,842	19,389	9,755
Poplar R.					126	580	8	58
Middle R.					4,289	4,853	3,645	2,838
Amnicon R.					11,055	7,670	986	1,165
Black R.						4	13	21
Nemadji R.						3	1	10
Total	1,668	4,921	10,639	24,084	57,820	66,961	52,173	39,781

[1] Includes 152 killed by chemical.

Lake Michigan barrier operations

Early in 1960, the number of barriers scheduled for operation was reduced by Commission action from 37 to 24. Five additional control devices were eliminated when Wisconsin's participation was reduced. There remained only 4 barriers on streams tributary to west-central Lake Michigan and 15 devices on streams tributary to Green Bay. Barriers on 16 of the 19 streams have been operated for 6 or more years.

Barrier operation began March 29 and all structures were working by April 7. The first sea lamprey was captured April 9 in the East Twin River. The spawning migration was at its maximum from the middle of May until the first week of June, approximately a week behind the 1959 run. The last barrier was turned off August 5.

The 19 barriers captured 16,704 sea lampreys; 27.5 per cent fewer than in 1959 (Table 4). This was the third consecutive year of decline in numbers of adult sea lampreys taken, but again, full credence should not be given the 1960 records, for severe floods during April and early May created a situation similar to that already described for Lake Superior.

No new species of fish showed up at the barriers during the season. Smaller numbers and fewer species of fish were taken. Mortality was not a problem at any device.

Measurements at 5 index streams revealed a slight increase in length and weight for sea lampreys in 1960. The mean weight has increased each year since 1956 and the mean length has increased each year since 1957. This trend is opposite that in Lake Superior. The ratio of male to female sea lampreys increased for the third successive year. The number of males per 100 females was 209 in 1960 and 183 in 1959. The highest ratio recorded for Lake Michigan was 224 males per 100 females in 1957.

In compliance with the Commission's decision to reduce the Lake Michigan barrier network to 3 devices, removal of barriers was undertaken after the close of operating season. The Oconto, Wisconsin, office was closed officially October 19, 1960.

TABLE 4.—Sea lamprey taken at barriers on Lake Michigan streams 1954–1960.

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

Stream	1954	1955	1956	1957	1958	1959	1960
Brevort R.				497	85	238	
Davenport Cr.					6	37	
Hog Island Cr.				77	16	93	
E. Br. Black R.					99	109	
Black R.					218	302	
Millecoquins R.				955	447	389	
Crow R.					63	67	
Cataract R.					59	101	
Pt. Patterson Cr.					10		
Milakokia R.					610	637	
Bulldog Cr.					330	252	
Marblehead Cr.					48		
Bursaw Cr.					737	877	
Poodle Pete Cr.					9		
Fishdam R.	692	459	500	835	375	409	315
Sturgeon R.	4,113	2,534	1,610	3,503	1,280	733	910
Ogontz R.					529	463	
Squaw Cr.	283	348	284	179	82	35	23
Whitefish R.	1,489	3,408	2,638	5,263	1,681	2,293	2,419
Rapid R.	574	1,377	937	1,396	546	311	401
Tacoosh R.	11	15	8	31	4	4	4
Days R.	205	264	192	272	120	111	39
Portage Cr.				35	0		
Ford R.			7,946	10,289	5,920	3,525	3,133
Bark R.		2,420	1,712	2,484	1,255	1,047	1,065
Cedar R.		13,324	16,331	12,188	8,134	6,856	4,676
Walton R.				162	8	30	38
Johnson Cr.					0		
Beattie Cr.				39	44	66	38
Little R.		128	412	142	160	195	26
Pensaukee R.		893	1,099	520	789	681	283
Little Suamico R.					0		
Suamico R.					15	18	12
Ephraim Cr.		13	6	14	6	16	
Hibbards Cr.	7,279	6,389	5,325	6,625	2,563	2,287	989
Whitefish Bay Cr.				245	14	16	
Shivering Sands Cr.			2	325	15	3	
Lilly Bay Cr.		66	40	68	18	153	
Bear Cr.				66	25		
Stoney Cr.					1		
Ahnapee R.					57	31	
Three Mile Cr.		1,945	1,473	839	237	241	211
Kewaunee R.	4,159	5,127	2,286	3,134	766	484	323
East Twin R.	6,960	7,558	12,131	10,313	3,474	3,708	1,799
Pine Cr.					2		
Fisher Cr.					59	694	
Sheboygan R.					1		
Total	25,765	46,268	54,932	60,496	30,917	27,512	16,704

LAMPREY CONTROL AND RESEARCH

by Co-operating Agencies

Michigan Department of Conservation

Michigan's sea lamprey research program in 1960 was concerned principally with various studies of sea lamprey ammocoetes, with particular reference to their occurrence and distribution in streams in the northwestern Lower Peninsula and in certain lakes and bays; an estimate of their abundance in East Bay (near the mouth of the Sucker River, Alger County); duration of the ammocoete stage; and seasonal progress of metamorphosis. Staff members of the Institute for Fisheries Research assigned to the work included three fishery biologists, a technician, a secretary, and five seasonal employees.

Distribution and abundance of ammocoetes in streams. Field collections with a direct-current shocker were continued 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. During 1960, surveys for ammocoetes were conducted in 37 streams in the northwestern Lower Peninsula which are tributaries of Lake Michigan or of large inland lakes in this region of the State.

Sea lamprey ammocoetes in East Bay. Collections of ammocoetes in the Sucker River by a stream survey party in July and August of 1955 and 1956 indicated that it was one of the largest producers of sea lampreys among the State of Michigan tributaries of Lake Superior. The stream was treated by the U. S. Bureau of Commercial Fisheries with a sodium salt of 3-trifluormethyl-4-nitrophenol on August 4, 1959, and a post-treatment check of 8,800 square feet of the stream on the following September 2 revealed no sea lamprey ammocoetes. It seemed likely, however, that some sea lamprey ammocoetes remained in Bay, a 78-acre lake at the mouth of the stream. Their presence was confirmed by a preliminary survey by the Institute on May 10–12, 1960 and a detailed population study was undertaken from July 22 to September 1, 1960.

The Bay was divided into 13 subdivisions, based on the estimated density of ammocoetes suggested by the preliminary survey. Seven were located along the shore, where the substrate was generally sand, and six in relatively deep water (mostly over 20 feet) where the substrate was predominantly silt. In each subdivision, stations were selected randomly and the substrate was sampled with an orange-peel dredge (5,525 lifts at 299 stations), or with a metal enclosure (21 samples at 7 stations) into which a larvicide was introduced. Enclosures were used only in shallow water where aquatic vegetation interferred with the operation of the dredge.

A total of 227 sea lamprey ammocoetes were collected during the sampling (average length, 3.5 inches; range, 1.5–5.4). The preliminary estimate of the number of sea lamprey ammocoetes in East Bay was 97,000 $\pm$ 20,000, of which 62,000 $\pm$ 8,500 were in the deep-water areas. The estimate is believed to be minimal because a limited amount of comparative sampling with the dredge and the enclosures in shallow water at the Ogontz River suggested that the dredge brought up only about one third of the ammocoetes actually present; in addition, some ammocoetes very probably escaped from the dredge while it was being lifted from deep-water areas.

Sea lamprey ammocoetes in other lentic environments. In addition to the population study in East Bay, shallow-water areas in three other inland lakes tributary to the Great Lakes and at four locations in the Great Lakes were sampled with a direct-current shocker to determine whether ammocoetes were also common in these waters. The areas studied were Au Train Lake, Saux Head Lake, Otter Lake, Marquette Harbor, Huron Bay, West Neebish Cut, and Portage Bay.

Streams tributary to Au Train Lake, Saux Head Lake, Otter Lake and Huron Bay with known populations were treated with larvicide in 1958–60, but there was no known source of ammocoetes near Marquette Harbor, West Neebish Cut, or Portage Bay. Twenty-nine sea lamprey were collected in Au Train Lake and 3 in Huron Bay, but none at the other locations. All larvae collected were 3.0 inches long or longer.

Duration of the ammocoete stage. The operation of the inclined-plane "Wolf" trap near the mouth of Carp Lake River and of a weir near the stream's source (at Paradise Lake) continued in 1960. The annual midsummer inspection of the spawning area above the barrier for the possible presence of sea lamprey redds and the semiannual collections of ammocoetes in the stream above the barrier, with a direct-current shocker, were also continued.

The inclined-plane trap took 2,369 sea lamprey ammocoetes and 2,147 newly transformed adults during the 1960 migration season and, as in previous years, none were caught in the weir at the stream's source. As shown in Table 1, the catch of the trap was lower than for 1959 and considerably below the average for 1949–1959. The data are not strictly comparable for the different years, however, because of varying amounts of escapement in high-water periods during most of the years.

Annual observations of the spawning areas in July and semiannual collections of larvae in the stream above the trap in 1955–1960

TABLE 1.—Catches of young lamprey at Carp Lake River trap, 1949–1960.

Migration season[1]	Number of recently transformed sea lampreys	Number of larvae[2]
1949	7,969	492
1950	16,235	8,403
1951	15,103	12,647
1952	4,069	1,414
1953	6,861	2,838
1954	10,238	14,827
1955	3,893	3,725
1956	2,401	22,822
1957	2,640	4,884
1958	4,796	561
1959	4,796	5,640
1960	2,147	2,522
Totals	81,148	80,775
Average annual catch	6,762	6,731

[1] July 1 of previous year to June 30 of year stated.

[2] Although all species are included, sea lampreys are believed to represent 94-96 percent of the total, based on identification of representative samples of ammocoetes in 1956-1957 and on identification of the entire catch in 1958-1960.

indicated that no recruitment occurred during those years. It is also very doubtful that recruitment occurred in 1954, since no sea lamprey ammocoetes under 2.2 inches in length were found among 731 ammocoetes collected in 1955 (although a single 2.1-inch larva was found among 147 taken in July, 1956).

Observations on Carp Lake River strongly indicate that the minimum age of the ammocoetes remaining above the trap is not less than 7 years, and may be 11 years or more if the trap was an effective barrier to adult sea lampreys in 1950–1953. The progressive upward trend in size and downward trend in abundance of ammocoetes between 1955 and 1960, in semiannual collections at three stations in the Carp Lake River strongly suggest, however, that the sea lamprey population above the trap is now nearing extinction. By 1960 the remaining sea lampreys were large in size and few in number, as shown in Table 2, which compares collection data for July 7–10, 1955 and October 3–4, 1960.

Metamorphosis of sea lampreys. In early July, 1960, 406 sea lamprey ammocoetes (average total length, 5.5 inches; range, 3.9 to 6.5) were collected from Carp Lake River and divided randomly between two hatchery troughs that contained a layer of silt about 4 inches thick. From July 12 to November 1, 1960, the average daily minimum and

TABLE 2.—Size and abundance of lamprey ammocoetes taken by shocking above trap in 1955 and 1960.

Station number	Year	Length (inches)		Number taken per hour of shocking	Percentage sea lampreys
		Average	Minimum		
1	1955	4.6	2.2	336	79
	1960	5.6	5.1	5	8
2	1955	3.6	2.6	118	56
	1960	5.4	5.2	1	12
3	1955	4.2	3.2	47	51
	1960	.		0	

maximum water temperatures in the troughs were 50° and 57° F.

Initiation of external metamorphosis was visible on approximately 4 percent of the specimens at the beginning of the experiment. The ammocoetes were left undisturbed in the one trough (observations only on July 7 or 11, and November 1). In the second trough, all lampreys were examined at periodic intervals for evidence of metamorphosis (July 7 or 11, which were the installation dates; August 1 and 16; September 6 and 30; and November 1). In the second trough, more than half of the transforming ammocoetes had started development of the eyes and teeth, and the oral hood had become reduced by August 1; the oral hood had become fused with the lower lip by August 16; and the snout had elongated and the oral hood had become again enlarged by September 30.

In the two troughs, only 60 and 70 percent of the larvae transformed although it is nearly certain that all were seven years old or older. Metamorphosis of only a few individuals was complete by November 1. In contrast, external metamorphosis of 26 ammocoetes collected from Carp Lake River on October 3 was nearly complete, suggesting that transformation may have been retarded by the relatively low water temperatures in the hatchery troughs.

On November 1 the average length of metamorphosing individuals in the first trough was 5.5 inches and that of non-metamorphosing individuals was 5.3; comparable values for lampreys in the second trough were 5.7 and 5.4 inches. The longer average length of transforming individuals may be due partially to elongation of the snout. However, in the first trough, the average length of metamorphosing specimens (before elongation of the snout) was 5.4 inches, as compared to 5.3 inches for non-transforming specimens. The suggestion

was that larger ammocoetes are more likely to metamorphose than smaller ones.

The reliability of external examination to detect dye-marked ammocoetes. In June and July 1958, a total of 2,187 sea lamprey larvae were collected from Carp Lake River, with a direct-current shocker, marked by subcutaneous injections of cadmium and mercuric sulfide, and released near the point of capture. During the 1958–1959 migration season 5,365 ammocoetes and 4,796 newly transformed adults were caught in an inclined-plane trap. An inspection of the exterior of these lampreys by two observers showed that 54 ammocoetes and 87 newly transformed adults were marked. It was suspected, however, that some marks might have been obscured by skin and/or pigment. Therefore, 2,347 ammocoetes and 1,692 newly transformed adults were cross sectioned and examined internally for marks. No marked ammocoetes and only one marked adult were found. Assuming that no marks were missed by the internal examination, the results indicated that (at the 95 percent confidence level) no more than two marked ammocoetes or more than six marked adults were missed by the external examination.

A pumping device as a method of collecting larval lampreys. A modified "sandsucker" was tested to determine its value for quantitative sampling of ammocoetes in deep water (4 to 60 feet). The working parts of the "sandsucker" were a 10,000 gallon-per-hour-capacity centrifugal pump; an airtight 55-gallon barrel (mounted on a 6 by 12-foot raft); and an inverted funnel or "cup" (eight inches in diameter) which was connected to the barrel and pump by hose and pipe. In operation, the cup was lowered momentarily to the substrate, and the bottom material under the cup was sucked up through the connecting pipes into a screened cylinder inside the barrel. Water and fine sediments washed through the screened cylinder into the pump, and were discharged through an outlet pipe. Larger materials and ammocoetes were retained in the screened cylinder.

In the form used, the "sandsucker" did not prove to be an efficient collecting tool because the barrel and lines clogged frequently when sampling a substrate that contained a large proportion of woody debris, weeds, and clam shells; sampling in water over 20 feet in depth was not possible because of the excessive weight of the hose and pipe (2-inch galvanized) required to reach bottom; and the gear was not quickly adjustable for sampling at different depths.

Certain modifications in the barrel and its pipe connections may reduce the frequency of clogging, and the substitution of aluminum pipe for iron pipe would facilitate sampling in deep water and at different depths. In the form in which it was tested, however, the "sandsucker" was inferior to the orange-peel dredge for sampling in deep water.

Wisconsin Conservation Department

The lamprey control program in the Wisconsin waters of the Great Lakes was again a co-operative effort of the Wisconsin Conservation Department and the Bureau of Commercial Fisheries, United States Fish and Wildlife Service. A total of sixteen barriers were operated during the 1960 season, nine in streams tributary to Lake Superior and seven on Lake Michigan streams. The catches at these barriers are given in the report of the Bureau of Commercial Fisheries.

Three seasonal aids and three permanent employees of the Wisconsin Conservation Department participated in the program. Heavy rains in both the Lake Michigan and Lake Superior drainage areas caused severe flooding which greatly increased the work load of the employees involved. It was necessary to make major repairs to practically all of the installations at some time during the lamprey-trapping season.

The 1960 sea lamprey catch from the Green Bay, Lake Michigan area was reduced approximately 58% over 1959. Because of serious operational difficulties, this reduction in the lamprey catch cannot be considered an index to the actual sea lamprey population. Flooding caused excessive damage to the weirs during the peak of the lamprey run. The U. S. Weather Bureau figures for the Green Bay area point up the seriousness of flooding. The average rainfall for May is 2.53 inches and in May, 1960, 7.75 inches of rain were measured.

The major factor affecting the sea lamprey catch from the Lake Superior area was also the above normal flooding of the streams. Periodic flood conditions greatly effected lamprey catches on all streams and caused irreparable damage to the Bad River weir. This barrier produced 4,468 sea lamprey in 1959 and no lamprey were taken prior to its discontinuation on April 25, 1960.

LAKE TROUT REHABILITATION[1]

During 1960, the lake trout rehabilitation activities continued to be devoted mainly to Lake Superior. Biological research on lake trout was continued by the U.S. Bureau of Commercial Fisheries, the Wisconsin Conservation Department and the Fisheries Research Board of Canada.

In the United States, the Wisconsin Conservation Department continued its program of net-run sampling of commercial catches, obtaining information on lake trout caught in large-mesh gillnets, small-mesh gillnets and pound nets. A total of 5,306 legal trout and 933 under-sized trout were examined. The U.S. Bureau of Commercial Fisheries carried out a similar program while continuing its studies of lake herring, whitefish and chubs. The Bureau examined 32,052 lake trout, of which 2,241 were finclipped. Scale samples were taken from 1,929 fish.

In Canada, the Fisheries Research Board inaugurated a program of net-run sampling aboard fishing tugs in which just over half of the commercial catch (25,586 lake trout) was examined for clipped fins and lamprey scars. Smaller, though still substantial, samplings for length and age were also carried out.

Plantings of finclipped yearling lake trout by the States of Michigan and Wisconsin, the Province of Ontario and the U.S. Fish and Wildlife Service, into Lake Superior, totaled 1,050,000 in 1960, an increase of nearly 400,000 over 1959.

In Lake Michigan, two more of a series of test plantings were carried out. A total of 88,000 finclipped yearlings were released in the Fox Islands area in May and 24,000 finclipped fingerlings at South Point near Charlevoix in November. Information on the recovery of these fish is largely dependent upon voluntary reports from commercial fishermen.

Present status of lake trout fishery and stocks

Catch statistics provided by the Province of Ontario and the U.S. Bureau of Commercial Fisheries for the States of Michigan, Wisconsin and Minnesota show that the lake trout catch in both the Canadian and United States waters declined a further 55.0 percent in 1960 (Table 1). The decline was severe in all areas and in Minnesota the catch was so low that the trout fishery is practically non-existent. In the period 1950–60 the lake trout production in Lake Superior dropped from 4,699,000 pounds to 487,000 pounds—a reduction of nearly 90 percent.

[1] Report by Special Committee on Lake Trout Rehabilitation on investigations in 1960.

TABLE 1.—Commercial landings of lake trout in Lake Superior by states and province, 1950–60.

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
1960	269	109	2	107	487

Effort statistics for 1960 are not yet available so that comparisons with earlier years cannot be made. However, research agencies on both sides of the lake agree that observations made incidental to sampling the catch leave little doubt that catch-per-unit effort has also declined. It is obvious the industry is in a very critical period and it is feared that if availability declines further the fishery will collapse entirely.

Lamprey-scarring, size and age composition of catch in Lake Superior

Scarred and wounded lake trout continued to be a prominent feature of the catches in both Canadian and United States waters throughout 1960. In United States waters the pattern of lamprey scarring was highly erratic. In April and May the scarring rate was higher than in 1959 in all but two areas (West Portage Canal and Huron Islands). In September, the fresh scarring rate was higher than in 1959 in the Huron Islands and in Wisconsin waters, but was much lower off the entrance of West Portage Canal and at Marquette. The variability of lamprey-scarred fish in U.S. waters does not permit a detailed interpretation. However, it is obvious that lamprey were still abundant in the lake in 1960. The Fisheries Research Board reported a similar variability in lamprey scarring in Canadian waters. However, the usual trend, high in spring and fall and low in the summer, was evident. Comparison with the overall 1959 figures (Table 2) showed a sharp reduction in the incidence of wounded fish and a corresponding rise in the incidence of fish bearing healed scars in eastern waters. The reverse was true of western Lake Superior, although not as striking.[1]

[1] Division between east and west sections at Otter Head.

TABLE 2.—Percentages of wounded and scarred lake trout in the marketable portion of Canadian commercial catches sampled in eastern and western Lake Superior in 1959 and 1960.

[Number of fish in sample given in parentheses.]

		East		*West*	
1959	Wounds	8.31		10.49	
	Scars	6.46	(2492)	24.72	(3430)
1960	Wounds	3.96		13.19	
	Scars	27.24	(1061)	21.87	(4793)

In the United States waters a small increase in the mean size of trout caught east of the Keweenaw Peninsula and a decline in the mean size of the catch in Wisconsin waters was evident. A similar pattern was evident in Canadian waters. (Table 3).

TABLE 3.—Mean total length in inches of lake trout comprising the marketable portion of Canadian commercial catches sampled in eastern and western Lake Superior in 1959 and 1960.

[Number of fish in sample given in parentheses.]

	East	*West*	*Total*
1959	18.9 ± 0.05 (2492)	19.7 ± 0.04 (3430)	19.3 ± 0.03
1960	19.5 ± 0.04 (2384)	19.0 ± 0.02 (7162)	19.2 ± 0.02

No data on the ages of fish from United States waters are yet available. Determinations of the ages of lake trout sampled in Canadian waters has been completed by the Board for only four of the seven statistical districts. These data, grouped to facilitate comparison with 1959, are presented in Table 4.

A further reduction in the numbers of fish of spawning age occurred throughout the lake, but in the western section the reduction among older age groups was extreme.

The scarcity of mature trout on spawning reefs was evident in gillnetting during the fall by Wisconsin and the U.S. Bureau of Commercial Fisheries. Wisconsin set a total of 61,000 feet of large-mesh gillnet over some major spawning reefs in Apostle Islands and took only 21 trout, of which only 5 were females. The research vessel *Siscowet* set 24,000 feet of gillnet on other major spawning grounds in the area and took only 6 spawning trout (all small males).

In summary, these observations suggest that the decline in the native stocks of lake trout continued unabated in 1960. Western stocks, less affected until recent years, are now being rapidly trimmed down. However, the reduction in scarring rate and increase in mean

TABLE 4.—Age composition of lake trout in the marketable portion of the commercial catches sampled in eastern and western Lake Superior in 1959 and 1960.

Area	Year	Percent in Age											Sample size
		2	3	4	5	6	7	8	9	10	11	12	
East	1959		0.04	1.0	15.2	44.6	28.1	9.5	1.1	0.4		..	2877
	1960		0.5	1.6	20.9	49.1	25.9	1.8	0.2		.	..	2384
West	1959	.	0.1	2.0	17.5	38.8	32.0	7.7	1.7	0.2	0.3	0.3	3451
	1960	0.1	11.7	41.3	38.0	6.4	0.8						7367

size appearing in the eastern end of the lake, where lamprey control was undertaken first, is encouraging.

Abundance of young sea lamprey

During the lake herring fishery in the fall of 1960 the Wisconsin Conservation Department and U.S. Bureau of Commercial Fisheries interviewed commercial fishermen at various ports for their opinion as to the number of recently transformed sea lamprey (5–7 inches) seen attached to lake herring in 1960 as compared to 1959. The reports indicated that newly-transformed sea lamprey were much less common than in previous years.

Hatchery activities

Total egg collections in 1960 amounted to 5,238,000, an increase of nearly one million over 1959. About half of the collection came from brood stock held in hatcheries operated by the State of Michigan.

Recovery of planted lake trout in Lake Superior

Sufficient data on returns from certain United States plantings have accumulated to permit the U.S. Bureau of Commercial Fisheries and the Wisconsin Conservation Department investigators to generalize on the movements and survival of the planted fish. Nearly complete records of the capture of finclipped fish by three Wisconsin fishermen since 1955 and about 11,500 actual returns obtained in the intensive sampling program of both agencies in 1959 and 1960 permit estimates of recoveries from plantings made during the period 1952–1959 (Table 5).

TABLE 5.—Estimated recoveries of finclipped lake trout in United States waters of Lake Superior, 1955–1960.

Year of Planting	Location	Number Planted	Age Category	Estimated number of recoveries in 4½-inch gill net (recoveries in 2½-inch mesh given in parentheses)						
				1955	1956	1957	1958	1959	1960	Total
1952–1953	Apostle Islands	277,980	Fingerling		302	628	1,635	2,006 (60)	589 (18)	5,238
1952–1953	Marquette Bay–Laughing Fish Point	204,439	Fingerling					182	172	354
1953–1954	Apostle Island	182,153	Yearling		3,866	4,314	3,502	2,010	222	13,914
	Marquette Bay–Laughing Fish Point	203,757	Yearling					1,323	666	1,989
1954	Apostle Islands	142,323	Fingerling		95	374	1,592	4,063 (166)	1,803 (36)	8,129
1954	Marquette Bay	121,296	Fingerling					182	303	485
1955	Apostle Islands	102,794	Yearling	196	764	3,346	9,084 (2,000)	18,030 (377)	4,656 (54)	38,467
1955	Marquette Bay	60,744	Yearling					926	792	1,718
1956	Apostle Islands	200,731	Yearling			431	1,810	3,491 (1,193)	8,713 (414)	16,052
1958	Apostle Islands	183,964	Yearling					519	1,667	2,186
1958	Munising, Grand Marais, Whitefish Bay	238,114	Yearling					125	234	359
1958	Marquette Bay	60,033	Yearling					29	372	401
1959	Marquette Bay	13,424	2-year-old					77	475	552
1959	Keweenaw Bay	27,153	2-year-old					22	454	476
1959	Marquette Bay	2,888	3-year-old					10	384	394

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The planted fish have done remarkably well on the whole. A plant of 102,000 finclipped yearlings made in the Apostle Islands in the spring of 1955 has contributed an estimated 37 percent of its number to the commercial catch in six years. The high recovery is probably not a true reflection of the early survival of the plant as a proportion of the faster growing members probably have been removed by lamprey predation since the spring of 1957.

A comparison of the estimated recoveries of finclipped trout in 1959–60 from plantings made earlier in Wisconsin and Michigan (Table 6) shows that plantings in the western end have yielded consistently higher percentage returns than plantings for the same year in the eastern end of the lake. The higher returns of the western plants do not appear to be a result of greater fishing intensity in the Wisconsin waters. This differential survival is being investigated but no explanation can be offered at the present time.

In Canadian waters, 673 finclipped fish were recovered from all sources. Planted fish represented approximately one percent of the Canadian catch in 1960 and only ten percent of these were of marketable size. Their ultimate contribution, however, is indicated by the fact that they constituted 13.0 percent of the sub-legal (less than 1½ lbs. dressed weight) portion of the catch in 1960.

TABLE 6.—A comparison of recoveries from plantings of lake trout in Wisconsin and Michigan waters of Lake Superior.

Year Planted	Percent recovered in 1959 and 1960 from		Ratio Wisconsin/Michigan
	Wisconsin plant	Michigan plant	
1952–53	0.9	0.2	4.5
1953–54	1.2	1.0	1.2
1954	4.1	0.4	10.3
1955	22.2	2.8	7.9
1958	1.2	0.3	4.0

Of the recoveries, 554 could be assigned with certainty to a particular planting. Although 14 separate plantings, 7 of them in United States waters, were represented, numbers were too small to permit any comparison of survival except in the case of the most recent Canadian plants. Five hundred and ten lake trout were recovered from seven separate plants made by the Ontario Department of Lands and Forests. Two old plants, both of fall fingerlings, in 1950 and 1953, made

near Pie Island at the entrance to Thunder Bay, were represented by single recoveries in nearby waters. The plantings of yearlings made at, or near, Rossport in the spring of 1958, 1959 and 1960 were represented by 199, 262 and 10 recoveries, respectively; while plantings made in the Lizzard Island area (at the eastern end of the lake) during the same years contributed 3, 34 and 0 recoveries. Since fish from planting in both areas were, for the most part, still below legal size, a comparison of recoveries is made by using the ratios of finclipped fish to total numbers of sub-legal fish in the catches (Table 7). Canadian scientists suggest that the recovery ratio for the 1958 western plant may be over-estimated while those for the 1958 and 1959 western plant may be under-estimated. However, the maximum correction consistent with the data does not change the order of comparison within, or between, areas. Therefore, even with this qualification, it appears that the eastern plants have each yielded lower returns to the commercial fishery. These plantings all appear to be less "successful" than the majority of the United States plantings as well.

TABLE 7.—The ratios of 1960 recoveries of yearling lake trout planted by the Ontario Department of Lands and Forests in eastern and western Lake Superior in 1958, 1959 and 1960 to the total sub-legal catches in 1960 in these waters.

Year of Plant	Fin Clip	Eastern Recovery Ratio	%	Fin Clip	Western Recovery Ratio	%
1958	Ad	1/746	0.13	Ad	133/2133	6.2
1959	LV	34/746	4.6	RV	180/2133	8.4
1960	AdLP	0/746	0.0	RP	10/2133	0.5

It is apparent from the lengths of recovered finclipped fish (Table 8) that they begin to reach marketable size of from 15.5–16.0 inches two years after planting and are probably all this size or larger five years after planting. Length increments of the order of 3 to 4 inches a year appear to characterize the first three years growth in the lake, while in later years this rate appears to drop perhaps because the larger individuals are being cropped by lamprey.

Superior Shoal Tagging

A program of experimental fishing and tagging was carried out on Superior Shoal in 1960 by the Fisheries Research Board. Eight hundred and seventy-one lake trout were captured from May to October and 383 were tagged and released. Of interest is the fact that the

scarring rates on the Shoal have increased (Table 9) and at their highest in the spring approached levels for the inshore commercial fisheries.

TABLE 8.—The mean total length of finclipped lake trout recovered from Canadian waters of Lake Superior in 1960.

Year Class	Area Planted	Number Recovered	Mean length (inches)	Range (inches)
1959	Rossport	10	7.5	6 – 8.3
1958	Lizzard Is.	34	8.6	7 –13.5
	Rossport	262	10.2	6.5–16
1957	Lizzard Is.	3	12.0	10.0–13.6
	Rossport	199	15.2	7 –22
	Eastern	7	15.0	10.8–19
	Apostle Is.	1	15.4	
1955	Apostle Is.	6	17.7	14.6–20
1954	Marquette	10	10.9	17.9–22.2
1953	Pie Is.	1	22.0	
	Apostle Is.	7	19.1	17.6–21.8
	Apostle Is.	9	20.3	19.8–21
1950	Pie Is.	1	27.0	

TABLE 9.—Percentages of lake trout bearing fresh wounds and healed scars in samples taken from Superior Shoal, Lake Superior, July 1954, 1958 and 1960.

Year	Sample size	Percentage of lake trout bearing	
		Wounds	Scars
1954[1]	468	0.0	0.2
1958	717	0.8	4.2
1960	43	2.3	25.6

[1] Data from the Ontario Department of Lands and Forests.

A SUMMARY OF FISHERY RESEARCH IN THE GREAT LAKES IN 1960

Lake Ontario

Fishery investigations continued on Lake Ontario in 1960 by the Ontario Department of Lands and Forests and the New York Conservation Department, were concerned mainly with three species—whitefish, lake trout and walleye.

Application of mesh efficiency estimates to the whitefish catch of eastern Lake Ontario has shown that the 4½-inch nylon gillnets used operate more efficiently on whitefish 18.5 inches long and are only about 40 percent efficient on fish 16.3 inches long, which is the average size now taken. An estimated total annual mortality of 70–75 percent permits few fish to reach the size most readily taken in the existing gear.

Plantings of lake trout to re-establish the species in Lake Ontario were continued by Ontario and New York. A 1958 planting by Ontario was taken by the commercial fishery for whitefish in numbers which indicate a higher survival than the 1956 planting. About 22 percent of the 1956 planting has been taken; however, a rapid decline in the number of fish recovered in recent years suggests that few will be taken after 1960. Dredging and netting in the fall failed to provide evidence of lake trout spawning.

A census of the sport and commercial fishery for walleye in the Bay of Quinte has provided general information on their respective catches. The angling fishery carried out in the Bay during the summer takes 2 and 3-year-old-fish while the commercial fishery, using 4½-inch mesh gillnet takes the older fish. The routes and time of migration are not well understood, but an improved angler yield might result from increasing fishing pressure on post-spawning aggregations of fish in the Bay early in the year.

Other fishery studies and observations include: (1) migration of the American eel; (2) incidence of lamprey scars; (3) origin, dispersal, and food habits of white perch; (4) artificial hybridization in coregonids; and (5) recovery of tagged smallmouth bass.

Considerable limnological and meteorological data were collected by the Great Lakes Institute and agencies cooperating in its program. Monthly synoptic surveys were carried out at 54 stations for bacteria, plankton, bottom fauna, temperature, oxygen, phenol, conductivity, pH, bottom sediments, and meteorological data. Reports were prepared on the energy budget of the lake and its thermal regimen.

Lake Erie and Lake St. Clair

Rapid changes in the fish populations and their environment in the last 30 years have greatly increased the difficulties of research and management on Lake Erie and measurement of these changes is the basis for most of the investigations in progress.

The composition of the fish population is being studied by examining the commercial catch and by fishing experimental gear. The composition of the commercial catch is being followed by periodic sampling at dockside or aboard vessels.

The Ontario Department of Lands and Forests carried out catch sampling in 1960 aboard vessels fishing trawls (18 days), gillnets (19 days), pound nets (3 days) and trap nets (3 days). A total of 10,337 fish were examined. The catch of a vessel engaged in experimental trawl fishing for the Canadian Department of Fisheries was also sampled. Landed catches were sampled by the U.S. Bureau of Commercial Fisheries at various points during the spring and fall and 10,368 fish examined. The 1959 year class of walleye entered the fishery in both countries and during the fall composed 90 percent of the United States catch of this species. Catches consisted mainly of yellow perch, smelt, sheepshead and carp. Aging of the yellow perch sampled in 1954–1958 in Ontario was completed. Contributions during this period were made mainly by age groups II (7.5 inches) and III (8.4 inches). Preliminary estimates indicated a high natural mortality. Commercial gillnets of 2¾ and 2⅞-inch mesh, most effective when perch are 8.0 and 8.5 inches, were not operating efficiently on the sizes of perch abundant in the population.

The sport fishing survey by the Ohio Division of Wildlife on the south shore undertaken to locate the most heavily fished areas showed that the Bass Islands and the south shore from Toledo to Port Clinton received the most angling pressure. A general creel census was carried out in Ontario with emphasis on the popular Long Point Bay fishery which produced an estimated 186,000 fish, 84 percent smallmouth bass. The relatively high production of bass was due largely to the entrance of the strong 1957 year class into the fishery.

The predominant species are not fully harvested by the commercial fisheries and their abundance in the catch is not a reflection of their abundance in Lake Erie. It has been necessary, therefore, to fish experimental gear routinely at specified stations to obtain an approximation of year to year changes. Experimental trawling and gillnetting to sample fish populations were carried out by the Bureau of Commercial Fisheries at two index stations visited semi-monthly and at two stations monthly. In addition, 52 hauls were made over a 3-day period at two stations in the spring, summer and fall. A total of

645 10-minute tows were made with trawls and 104 tows with smaller nets, to take fry. Approximately 75,000 of the several hundred thousand fish taken were measured. The Ohio Division of Wildlife also carried out trawling, gillnetting and beach seining at nine stations in July and again in November. The catches of both agencies indicate that the 1960 hatches of alewife and gizzard shad were exceptionally good, smelt good, yellow perch and walleye poor, and other species at or slightly below previous levels.

The sporadic appearance of strong year classes of blue pike and walleye in recent years and the generally low abundance of these prize species in the last decade has led to studies of spawning areas and conditions that might affect early survival of young. Other studies have been made on spawning smelt and the movements of walleye in western Lake Erie and Lake St. Clair. Blue pike spawning grounds were surveyed by Ontario investigators using dredges to collect eggs. These were taken in small numbers, mainly at the end of the Long Point bar in Pennsylvania waters. The Ohio Division of Wildlife conducted a similar survey on walleye spawning grounds in western Lake Erie and took 10,500 eggs with a pump at various locations. Reefs appeared to be the principal spawning sites, although river and estuarine areas were not examined.

Agencies engaged in fishery investigations took measurements of water conditions routinely and in some cases sampled plankton and bottom organisms. However, when bottom oxygen in the central basin dropped to critical levels in late August, six agencies cooperated in a synoptic survey to assess this condition. An extensive area of critically low oxygen was found in the western portion of the central basin.

A study of bottom samples collected by the Bureau of Commercial Fisheries in the central basin from 1957–59 provided evidence that the mayfly community, which was dominant in the western end of the central basin in 1929–30, had been replaced by an oligochaete-tendipedid community.

Other projects included the tagging of walleye in Lake St. Clair to establish their migration routes, which appear to include both Lake St. Clair and Lake Huron, and the spawning of smelt on Point Pelee. Increased interest in the Lake St. Clair maskinonge fishery led to a summary of available information by the Michigan Department of Conservation.

Lake Huron

Investigations in Lake Huron were largely confined to Canadian waters with activities in the United States limited to further analysis

of data from 1956 synoptic surveys in Saginaw Bay, and the collection of scales from the commercial catch.

The Ontario Department of Lands and Forests continued the experimental fishery at South Bay, which has been used to study changes in native and introduced stocks. The study of the sport fishery, which has provided a basis for predicting the year-class strength for smallmouth bass two years in advance, was also continued.

The experimental fishery took 37 lake trout from the 1955 planting. These fish were the slow growing members of the group and the last to become fully vulnerable to lamprey predation. It can now be said that the 79,000 lake trout planted in South Bay over a 6-year period have not provided attractive angling and have failed to establish a self-sustaining population in the face of the existing level of sea lamprey predation.

Planting of hybrid trout is continuing and 196 were recaptured in the experimental fishery during 1960. Most of these fish were tagged and released. Of major importance was the capture of 5 young fish, tentatively identified as progeny from natural hybrid spawning in the fall of 1959. Other hybrids were taken at widely scattered points in Lake Huron, but few were recovered in the greatly reduced fishery.

A creel census was continued on the lake trout fishery in Parry Sound, where the 1960 catch was lower and lamprey scarring higher than in 1959.

Sampling of the catch of whitefish was carried out at a number of ports and some sub-legal fish tagged and released. The catch in Lake Huron proper was composed largely of 2 and 3-year-old fish with older fish being very scarce.

Experimental gillnetting in Georgian Bay on a random square grid pattern was again carried out in 1960. No species presently of importance to the commercial fishery were taken in appreciable numbers.

An analysis of temperature and conductivity data collected in South Bay since 1953 was begun to determine the temperature regimen and water exchange with Lake Huron. A synoptic survey which included the release of drift bottles was carried out recently in Georgian Bay. Recoveries of the drift bottles indicated a strong well-defined current from the Bay towards the North Channel.

Lake Michigan

The Bureau of Commercial Fisheries research vessel *Cisco* made 11 cruises in Lake Michigan in 1960, with the objective of reappraising chub populations. Fishing was carried out with gillnets and trawls, duplicating sampling methods used in the 1930–31

and 1954 surveys. Preliminary analysis of the catch records showed that the bloater (*C. hoyi*) continued to make up an increasingly large proportion (95 percent) of the chub population, except in the deepest water. The total number of chubs, all species combined, had not changed radically since 1954, but the average size was smaller because of the great increase in the proportion of slow growing bloaters. Consistently fair catches of whitefish in shallow water near Grand Haven suggested an increase in abundance since 1954.

Analyses were made of limnological data collected by the *Cisco* in 1960 and in 1954–55. A report on benthic organisms collected in the latter survey was completed. Thermal profiles have been prepared and a report on the thermal regimen of Lake Michigan in 1954 and 1955 is in progress. A synoptic survey, employing drift bottles to study surface currents, was carried out in Little Bay de Noc.

Tagging of walleye in northern Green Bay was continued jointly by the Bureau of Commercial Fisheries and the Michigan Department of Conservation. Recoveries (8.9 percent) from the 4,690 tagged since 1957 have been made mainly in northern Green Bay. The 1952 year class dominated the spawning fish taken during tagging in Little Bay de Noc, while the 1955 year class dominated in Big Bay de Noc. A study of recent fluctuations of year-class strength in northern Green Bay has shown four good year classes of walleye—1952, 1955, 1957 and 1959. The fishery in 1960 was dominated by the 1955 and 1957 year classes. The 1959 year class, which shows promise of considerable strength, is expected to enter the fishery in late summer of 1961. Sampling with small-mesh trawls indicates strong 1960 year classes of smelt and alewife but weak year classes of yellow perch and walleye.

Sampling of the commercial catch in the spring and fall was continued in northern Green Bay. Whitefish scale samples were collected from the commercial fishery at the entrance of Green Bay and in northern Lake Michigan.

Lake Superior

Investigations on Lake Superior in 1960 were largely concerned with the status of native lake trout and the survival and dispersal of planted lake trout. These investigations are reviewed in another section (page 54).

A general study of the distribution of the principal fish species in the western portion of the lake was continued by the Bureau of Commercial Fisheries. Surveys were carried out by the research vessel *Siscowet* using gillnets, trawls and on one occasion an electric-boom shocker. The *Siscowet* also visited three stations on three occasions and, in addition to sampling fish, took plankton, bottom organisms

and various physical and chemical data. Several cruises were made at the end of the season to study the spawning of coregonids and to obtain eggs from various species of chubs for rearing.

Several lots of *C. clupeaformis, C. zenithicus, C. artedii,* and *C. alpenae* have been successfully reared to maturity in an attempt to distinguish useful taxonomic differences. However, the young fish have shown no easily recognizable differences which would aid identification and serological comparisons are now being made.

Tabulations of the depth distribution of fish taken in gillnets by the *Cisco* during its 1959 operations have been completed. Catches of lake trout in small-mesh nets were relatively high at depths from 20 to 29 fathoms and low in deeper water. Lake trout were taken over a wider depth range by the large-mesh nets, being most abundant at 10–19 fathoms. Lake herring (*C. artedii*) were most abundant above 30 fathoms, *C. reighardi* and *C. hoyi* at 30–60 fathoms, *C. kiyi* and *C. nigripinnis* below 60 fathoms, and *C. zenithicus* taken sparsely at all depths greater than 20 fathoms.

A study of the life history of lake-run rainbow trout on the north shore of Lake Superior was initiated by the Minnesota Department of Conservation. Information was collected on the relative angling pressure on the streams and its distribution during the spawning season. A population study was made on the resident migrating fish in five important spawning streams during August and September. Rainbow trout reached a density of 30 pounds per acre in one stream.

Tagging studies of whitefish in the Apostle Islands were continued by the U.S. Bureau of Commercial Fisheries and the Wisconsin Conservation Department. Nineteen hundred sub-legal fish from commercial pound nets were tagged and released in 1960. Wisconsin also continued tagging lake-run brown and rainbow trout.