ANNUAL REPORT

GREAT LAKES FISHERY COMMISSION

1958

GREAT LAKES FISHERY COMMISSION

MEMBERS — 1958

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

SECRETARIAT

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

GREAT LAKES FISHERY COMMISSION

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

ANNUAL REPORT

FOR THE YEAR

1958

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

LETTER OF TRANSMITTAL

The Chairman of the Great Lakes Fishery Commission takes pleasure in transmitting to the Contracting Parties an Annual Report of the Commission's activities during the period between the 1957 and 1958 Annual Meetings.

L. P. VOIGT
Chairman

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INTRODUCTION

The commercial fishery in the Great Lakes has produced an average of approximately 117 million pounds of fish valued at 16.4 million dollars annually during the last 10 years. The total production of the lakes is undoubtedly higher because the catch by anglers, which is now reaching significant proportions in many areas, has not been recorded. The fishery has been plagued by violent fluctuations in most of the important species and has suffered grievously with the decline of the lake trout which provided a comparatively stable and lucrative fishery in the upper Great Lakes before the invasion of the sea lamprey.

The Governments of Canada and the United States of America, noting the decline of the fishery, the desirability of further research, and the interrelationship of their fishery conservation problems, signed a Convention on Great Lakes Fisheries in 1955 and established the Great Lakes Fishery Commission to which it gave two major responsibilities: the formulation of research programs which would determine the measures necessary to make possible the maximum sustained productivity of any fish of common concern; the formulation and implementation of a program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Commission was organized in April 1956 and began its activities on July 1, 1956. It is composed of six members, three from the United States and three from Canada.

Canadian Commissioners are:

A. O. BLACKHURST, *Manager*
Ontario Council of Commercial Fisheries
Port Dover, Ontario
W. J. K. HARKNESS, *Chief*
Division of Fish and Wildlife
Ontario Department of Lands and Forests
Toronto, Ontario
A. L. PRITCHARD, *Director*
Conservation and Development Service
Department of Fisheries
Ottawa, Ontario

United States Commissioners are:

D. L. MCKERNAN, *Director*
Bureau of Commercial Fisheries
United States Fish and Wildlife Service
Washington, D. C.
CLAUDE VER DUIN, *Manager*
Chamber of Commerce
Grand Haven, Michigan
L. P. VOIGT, *Director*
Wisconsin Conservation Department
Madison, Wisconsin

The Commission is assisted by committees which advise each of the national sections on matters of general planning and policy. On these committees sit representatives of government agencies, the fishing industry, the sporting fraternity, and the public at large. The Commission is assisted in its technical planning of the sea lamprey control program and in the formulation of research programs by a Scientific Advisory Committee composed of fishery scientists from both countries.

The Commission must not only plan but implement the sea lamprey control program. Appropriations are received from the two governments participating in the Convention, and are based on their historic economic interest in the Great Lakes fishery prior to the advent of the sea lamprey. The United States provides 69 percent of the program cost and Canada 31 percent.

The Commission is required by Article VI of the Convention on Great Lakes Fisheries to make use of existing government agencies as far as possible in the performance of its duties and accordingly maintains only a small headquarters staff, located in Ann Arbor, Michigan. Since its establishment in 1956, the Commission has contracted with the Fisheries Research Board of Canada and the Bureau of Commercial Fisheries, United States Fish and Wildlife Service, to carry out its sea lamprey control program. A contract with the University of Toronto for the preparation of a bibliography on scientific literature of the Great Lakes fisheries has also been established.

Until 1958, control measures were confined to the blocking of lamprey-spawning streams with electric barriers. In 1958 barriers were operated on 67 Lake Superior streams known to produce lamprey. Barriers were also operated on 65 Lake Michigan tributaries, leaving an estimated 35 lamprey-spawning streams in that lake unblocked.

The discovery of chemicals selectively toxic to young sea lamprey after a 3-year screening of some 6,000 compounds, led to the successful treatment of one Lake Huron tributary in the fall of 1957, a second in March 1958, and two tributaries of Lake Superior in May and June. In the latter half of 1958 a total of 9 Lake Superior streams were treated, 8 successfully and 1 with only partial success.

The Commission is now stressing the chemical method in its program to control the sea lamprey. Emphasis is being placed on the treatment of Lake Superior tributaries to destroy large numbers of young lamprey that threaten the last substantial stocks of trout in the Great Lakes.

The restoration of lake trout following control of the sea lamprey will require the introduction of hatchery-reared fish in areas where native trout have been eliminated by the sea lamprey. The Commission has called on federal, state and provincial agencies to join in a co-ordinated restocking and evaluation program. The planning and co-ordination of this work are carried on by a special committee established by the Commission.

INTERIM MEETINGS AND ACTIONS

The Commission held two meetings in the interval between the 1957 and 1958 annual meetings. The proceedings and actions taken are summarized in the following sections.

Washington, D. C.—April 9–10, 1958

The Commission met to finalize its 1958–59 program. The portion of the program covering lamprey control activities in Canada was adopted and an agreement for its execution by the Fisheries Research Board of Canada approved. Approval of the program in the United States was deferred pending additional information on the success of the new chemical method. The Commission called for the preparation of a 1959–60 program with cost approximating the amount requested for the 1958–59 program.

The contract with the University of Toronto for the preparation of a bibliography of literature pertinent to the Great Lakes fishery was renewed for one year. Requests were received for grants in aid of several research projects on the Great Lakes. The Commission found considerable merit in the proposals but agreed that it could not justify financial support because of the difficulty experienced in obtaining funds for the sea lamprey program.

The Commission discussed the appointment of an Assistant Executive Secretary and authorized the Chairman and Executive Secretary to interview the more promising candidates and fill the position.

Marquette, Michigan—June 10–11, 1958

The Commission met to hear reports on the progress of the sea lamprey program and to observe an experimental chemical treatment of the Silver River, Baraga County, Michigan.

It reconsidered the 1958–59 program in the United States and approved an agreement with the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, to carry it out. Changes in the 1958–59 program included a reduction in the number of barriers operated on Lake Michigan from 64 to 50 to provide for an expansion of the chemical treatment program on Lake Superior.

A 1959–60 program, which stressed the application of the new chemical method, was considered and adopted. Provision was made for modifications of existing barriers and their reconstruction in case of damage by floods. The operation of 71 barriers on Lake Superior and 50 on Lake Michigan was approved. Activities on Lake Huron were restricted to surveys of lamprey larvae distribution in Canadian streams. Research activities included a laboratory study of the effect

of stream conditions on the action of the selective chemicals or lampricides, and improvements in bio-assay techniques used to determine the concentrations required. Researches on lamprey behavior, movements, and distribution of lamprey adults and ammocoetes were included.

The Commission approved the appointment of Mr. Robert Saalfeld as Assistant Executive Secretary, effective July 1, 1958.

It was agreed to hold the 1958 Annual Meeting in Ann Arbor, Michigan on December 4 and 5.

1958

ANNUAL MEETING

AGENDA

1. Call to order by Chairman.
2. Introduction of advisors.
3. Adoption of agenda.
4. Approval of past minutes.
5. Press relations.
6. Report of the Chairman.
7. Reports by contracting agencies.
   (a) Lamprey control and research in Canada.
   (b) Lamprey control and research in the United States.
   (c) Great Lakes bibliography.
8. Reports by agencies co-operating in lamprey program.
9. Reports of commercial landings of lake trout on the upper Great Lakes.
   (a) Province of Ontario.
   (b) U. S. Fish and Wildlife Service.
10. Recommendations of Scientific Advisory Committee on:
    (a) Changes in 1958–59 program.
    (b) Changes in 1959–60 program.
    (c) 1960–61 program.
11. Report of Special Committee on Lake Trout Rehabilitation with comments of Scientific Advisory Committee.
12. Recommendations of Scientific Advisory Committee on material to be included in a statistical summary of Great Lakes fish production.
13. Organizational matters:
    (a) Administrative report by Executive Secretary.
    (b) Annual report for 1957.
    (c) Election of officers.
14. Time and place of next meeting.
15. Resolutions submitted by national sections.
16. Other business.
17. Adjournment.

ANNUAL MEETING

PROCEEDINGS

The Third Annual Meeting of the Great Lakes Fishery Commission was held in Ann Arbor, Michigan, on December 4 and 5, at the University of Michigan.

Call to order and introduction of advisors. The meeting was called to order by the Vice-Chairman, Dr. A. L. Pritchard, in the absence of the Chairman, Mr. L. P. Voigt who had been delayed. Advisors to the two national sections were introduced by Commissioners Claude Ver Duin (United States) and W. J. K. Harkness (Canada). A list of participants appears on page 17.

Adoption of agenda. The Commission considered adoption of the tentative agenda issued in advance of the Annual Meeting. It was advised by the Chairman that the Scientific Advisory Committee had held discussions of fishery research requirements for Lake Erie, Lake Michigan and Lake Superior on December 1, 2 and 3, with the intention of presenting recommendations to the Commission at the Annual Meeting. However, the Committee wished additional time to further study the assembled information before it and asked that the Commission defer its consideration of research needs to a subsequent meeting. The Commission adopted the proposed agenda, deleting the item on research recommendations.

Approval of past minutes. The minutes of the meeting held in Marquette, Michigan on June 10 and 11, 1958 were approved.

Press relations. The Chairman appointed a committee consisting of Commissioners Harkness and Ver Duin, and Mr. Baldwin of the Secretariat, to meet with the press and prepare an appropriate news release covering the meeting.

Report of Chairman. The Chairman reviewed the establishment of the Commission, its responsibilities, financial support and the contractual arrangements for carrying out its program to control the sea lamprey and its role in advocating other measures to make possible a higher production of fish from the Great Lakes.

He explained that the development of the new chemical method for destroying lamprey offered the opportunity of rapidly reducing young sea lamprey still present in many Lake Superior tributaries. The Commission had, therefore, stressed the application of this new method and had restricted the construction and operation of electrical barriers on Lake Michigan in order to do so. The present emphasis

on the chemical method did not necessarily mean the complete exclusion of the electrical barrier method in the future, for it might be more effective and perhaps less costly in special situations. The reports of the progress of the program to be presented by the Commission's two agents would undoubtedly influence plans to use these methods.

He drew attention to the problems of restoring the lake trout fisheries following control of the sea lamprey. The Commission's Special Committee on Lake Trout Rehabilitation had developed plans for lake trout restoration which would be considered during the meeting.

The productive shallow-water fisheries of the Great Lakes, although not seriously affected by sea lamprey, were nevertheless plagued by violent fluctuations in the abundance of important species. These fisheries would continue to be seriously handicapped as long as these fluctuations remained unexplained. The Great Lakes also contained an abundance of unexploited species which could not be taken profitably at the present time with conventional fishing gear. There was a real interest in utilizing these species, but information was required on the potential production and its stability as well as economical means of capture. He was pleased to report that government agencies were continuing to expand their research programs. The Commission should study the information provided and determine what lines of research should be followed to develop an adequate understanding of the fishery.

Reports on lamprey control and research. A progress report on the lamprey control and research program carried out in Canada, under the terms of an agreement with the Fisheries Research Board of Canada (page 27) was presented. In the questioning that followed it was learned that there were some 40 Lake Superior tributaries in Canada which could, on the basis of their physical characteristics, be expected to develop lamprey runs. These streams were being kept under surveillance.

A report on the progress of the program in the United States (page 34) carried out by agreement with the Bureau of Commercial Fisheries drew several questions. The Commission was advised that estimates of the number of lamprey larvae destroyed in a chemical treatment would be very difficult to obtain. Surveys made before treatment were followed by re-surveys to discover if there were any survivors. It was on this basis that the Bureau judged the success of the treatments.

The Commission accepted the reports of the two agencies, commending both for their efficient execution of the program.

Reports on the lamprey control and research activities of the Wisconsin and Michigan departments of conservation were also received by the Commission, and the agencies thanked by the Chair-

man for their contribution to the program. A summary of these reports appears on page 50.

Report on Great Lakes Bibliography. A brief statement on the progress of the Great Lakes Bibliography, being prepared by the University of Toronto for the Commission, was presented. A total of 1,537 references had been produced up to October 31, 1958 and some 500 were being processed. By May 31, 1959 the total would reach about 2,200. Many items, including mimeographed reports, manuscripts, theses, newspaper and anonymous articles would not be covered by that date, nor would it be possible to include additional references appearing in other bibliographies. Sets of bibliographic cards were being distributed to agencies designated by the Commission.

Catch of lake trout in the upper Great Lakes. Reports on the commercial catch of lake trout in the upper Great Lakes in 1957 were presented for the information of the Commission by the Ontario Department of Lands and Forests and the Bureau of Commercial Fisheries, United States Fish and Wildlife Service. This information is summarized on page 52.

A total catch of 1,504,000 pounds reported for Lake Superior in 1957 represented a 68 percent drop from 1950 production and a 36 percent decrease from the 1956 catch. Preliminary estimates for 1958 indicated a 25 percent increase in Canadian waters and a 10 to 20 percent decrease in United States waters.[1] The 1957 catch in Georgian Bay, Lake Huron, the only other trout-producing area in the upper Great Lakes, was 19,625 pounds. This figure represented a 96 percent decline from 1952 and a 58 percent decrease from 1956.

The catch of lake trout by anglers has been recorded for only one or two restricted areas. At the present time, however, angling for lake trout is so reduced that the catch would probably not add significantly to the total.

The Scientific Advisory Committee, having studied the reports on lake trout production, submitted the following statements to the Commission:

> Although a comparison of 1957 landings and estimates of the 1958 catch of lake trout in Lake Superior indicates a less drastic decline than in previous years, there are no grounds for believing that the rapid deterioration of the fishery has moderated. This deterioration, which began at the eastern end of the lake, is now general throughout the lake.
>
> The recent decrease in landings on Lake Superior is due more to decreasing fishing pressure than to a reduction in the availability of the fish. The latter has reached a point where fishing is unprofitable under all but the most favorable conditions. Indices of abundance based on the catch per unit of effort may, therefore, be biased upward by a concentration of fishing effort in the most productive areas at the most favorable times of the year.
>
> The decline in production in Lake Superior has been accompanied by a decrease in the average size of the fish landed. Mature trout now form only a small proportion of the catch. Although there is no firm basis for comparison, young fish appear to be more abundant in recent years and there is a good potential spawning stock present in the lake.
>
> An isolated population of lake trout on Superior Shoal appears to have a reasonably high proportion of mature fish and shows little evidence of serious sea lamprey predation.
>
> In Georgian Bay, mature trout are practically absent, except in Parry Sound, where a small isolated population fished by anglers persists. Commercial fishermen rarely encounter young fish one to three years old in Georgian Bay, and some experimental netting has indicated that these younger age groups are poorly represented. The trout population in Georgian Bay is therefore in an extremely precarious position.
>
> The Committee in its attempts to interpret the statistics on lake trout landings has felt the need for more biological information and will give this matter full consideration when recommendations for research on Lake Superior are discussed at a subsequent meeting.

[1] Completed records of the 1958 catch appear in the summary on page 53.

Lake trout rehabilitation. A Special Committee on Lake Trout Rehabilitation was established by the Commission to develop a co-ordinated program for the planting of lake trout in those areas of the Great Lakes where natural reproduction was completely lacking or insufficient as a result of sea lamprey depredations. It is composed of representatives from state, federal and provincial fishery agencies bordering the upper Great Lakes. The Committee reported that it had met on two occasions in 1958. At the first meeting, held at Higgins Lake, Michigan, on January 17, the Committee agreed on the marking and planting programs for the coming season and laid plans for lake trout spawn-taking in the fall. At the second meeting, held in Milwaukee, Wisconsin on November 18 and 19, reports were presented on the season's operations and plans made for 1959. Discussions at this second meeting led to the preparation of the following recommendations:

1. The Committee having noted that native lake trout have been virtually eliminated from several of the Great Lakes and that an opportunity is offered to introduce trout possessing superior qualities; and having heard that selective breeding of trout using hybrids of lake and brook trout can produce an early-maturing, fast-growing trout able to inhabit the strata formerly occupied by the native trout; therefore, has to recommend that the development of this work be given added emphasis with adequate facilities provided and that Lake Huron and Georgian Bay be reserved for the planting of a selected or hybrid stock until such time as the full-scale planting of trout is feasible.
2. The Committee, realizing that introductions of lake trout are required in Lakes Michigan and Huron in order to establish breeding populations following control of the sea lamprey, and that lake trout populations in Lake Superior should continue to be supplemented by hatchery-reared trout until natural reproduction is deemed adequate,

and that lack of knowledge of the survival and success of spawning of these introductions makes impossible a realistic estimate of the number required to achieve these objectives; therefore, further recommends that it is prudent to hatch and rear all available eggs.

3. The Committee having heard that production based on estimates of egg collections from brood and suitable wild stocks will provide approximately 4,500,000 yearlings by 1964, and more if new sources are discovered, and that the maximum capacity of existing facilities is calculated at 3,700,000 yearlings which is inadequate; therefore, further recommends that additional facilities be provided by 1963 for rearing 2,000,000 yearling lake trout.
4. The Committee, realizing that knowledge is required of the abundance, distribution, growth rate, sex ratio, maturity, and survival of both the native lake trout and the lots planted in order to select areas for planting, use most suitable stocks, determine where and when success has been attained, and determine if protection from fishing activity is necessary, and knowing that information collected to further the rehabilitation program will be extremely valuable in continuing studies of the re-established lake trout populations; therefore, further recommends that an adequate system of sampling the native and hatchery lake trout populations be established.

The following statements regarding these recommendations were submitted by the Scientific Advisory Committee:

> The Scientific Advisory Committee wishes to emphasize the point that the production of an early-maturing trout might prove desirable if lamprey were not completely controlled. Such a fish might persist under moderate lamprey predation.
>
> In regard to the recommendation that additional facilities be provided, the Scientific Advisory Committee can only draw attention to the fact that there is at present no basis for estimating the number of hatchery-reared trout required to re-establish trout fisheries in the upper Great Lakes. The Scientific Advisory Committee shares the opinion of the Special Committee that present facilities are likely to prove inadequate by 1963. The additional facilities recommended might rapidly reduce the time required to re-establish the fishery. However, provision of these facilities should be justified on the grounds that they will be needed in stocking inland trout waters when they are no longer useful in the lake trout restoration program.

The Commission accepted the recommendation of the Special Committee for further consideration following a brief discussion of the adequacy of spawn-taking activities and catch-sampling procedures.

Changes in 1958–59 program. The Commission considered several minor changes in its 1958–59 program of sea lamprey control and research which had been mentioned in the report on operations in Canada. It gave approval in principle to the changes and asked for a more detailed justification of the changes accompanied by estimates of the underexpenditures that would arise. It also asked that its agent supply suggestions for the use of these unexpended funds in expanding other activities in the lamprey program.

Changes in the 1959–60 program. The Commission was advised that as a result of recent budget decisions in the United States it would be necessary to reduce the 1959–60 sea lamprey program, approved on June 10 at Marquette, Michigan. After it had ascertained that the program changes about to be proposed by the Scientific Advisory Committee would not reduce the cost of the program sufficiently, the Commission asked the Committee to prepare a sea lamprey control and research program for 1959–60 which would not cost more than $1,375,000. It also stated that the program should include a continuation of the chemical treatment of Lake Superior's lamprey-producing streams to practically complete this operation by June 30, 1960.

Statistical summary of Great Lakes fish production. The Commission received the following recommendations from its Scientific Advisory Committee regarding the material that should be covered in the statistical summary of Great Lakes fish production which the Commission considered publishing in 1961–62.

1. The publication should contain both the statistical data published in the Report of the International Board of Inquiry on Great Lakes Fisheries, now out of print, and that for the period 1941–1960.
2. The catch statistics for Green Bay (Lake Michigan), Saginaw Bay (Lake Huron), Georgian Bay (Lake Huron), and North Channel (Lake Huron) should be shown separately for the period 1941–1960.
3. Adjustments of some Georgian Bay statistics, to include catches previously assigned to Lake Huron proper under an old reporting system, should be made where possible.
4. Estimates of anglers' catch for those areas where the sport fisheries are being studied should be presented separately in the proposed publication.
5. Catches of a number of species had been combined in the Report of the Board of Inquiry. Many of these species were now important and their production should be given separately.
6. The Commission should consider the publication of an annual supplement to the summary which would include data on landings by lake, species, and gear.

The Commission accepted the recommendations and asked the Scientific Advisory Committee to determine the feasibility of obtaining the desired material and report to the Commission at the next meeting.

Resolutions by national sections. The Commission was advised that the United States Section and its advisors had carefully considered the need for prompt implementation of desirable fishing regulations. At the present time implementations would require legislative approval before responsible government agencies could take action. Under this system, implementation might be delayed when it was most needed. Mr. McKernan, on behalf of the United States section, urged that the Great Lakes Fishery Commission recommend to the proper governmental agencies:

That the laws governing the commercial and sport fishing on the Great Lakes and connecting waters be changed where necessary to permit the state or provincial conservation departments to establish, as far as possible, co-ordinated regulations based on the best available information on the fisheries.

The recommendation was adopted by the Commission.

Organizational matters. The Commission met in executive session to consider certain organizational matters. In the following plenary session the Chairman reported that the Commission had accepted the Administrative Report for 1958 and that the 1957 Annual Report had been accepted and approved for publication.

The Commission held its biennial election of officers, in accordance with Rule 11 (a) of its Rules of Procedure. Dr. A. L. Pritchard (Canada) was elected Chairman of the Commission, succeeding Mr. L. P. Voigt (United States), and Mr. Claude Ver Duin (United States) was elected Vice-Chairman, succeeding Dr. Pritchard in that office.

Time and place of next meeting. The Commission agreed to hold its next meeting in Ottawa, Ontario in the early part of April, 1959. The Executive Secretary was asked to select a suitable date and advise the Commissioners.

Adjournment. The Third Annual Meeting of the Commission closed on December 5, 1959.

ANNUAL MEETINGS
PARTICIPANTS

OFFICERS OF THE MEETING

Chairman: L. P. Voigt, United States
Vice Chairman: A. L. Pritchard, Canada

MEMBER GOVERNMENTS

Canada

Commissioners:	*Advisors:*	*Scientific Advisors:*
A. O. Blackhurst	H. V. Sutton	J. C. Budd
W. J. K. Harkness		W. J. Christie
A. L. Pritchard		J. W. Davies
		R. G. Ferguson
		F. E. J. Fry
		R. Hourston
		R. N. Johnston
		A. H. Lawrie
		K. H. Loftus*
		K. Rogers
		R. A. Ryder
		G. F. M. Smith*
		J. S. Tait
		W. H. R. Werner

United States

Commissioners:	*Advisors:*	*Scientific Advisors:*
D. L. McKernan	C. Clark†	V. C. Applegate
Claude Ver Duin	G. P. Cooper	W. F. Carbine
L. P. Voigt	P. H. Eschmeyer	C. A. Dambach*
	A. S. Hazzard	L. F. Erkkila
	Martin Hosko	Ralph Hile
	R. A. Jensen	J. H. Howell
	J. H. Kitchel	J. W. Moffett*
	L. W. Kornprobst	B. R. Smith
	W. M. Lawrence	S. H. Smith
	S. S. Sivertson	
	G. E. Sprecher	
	H. O. Swenson	
	C. G. Wenniger	

SECRETARIAT

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

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

ADMINISTRATIVE REPORT FOR 1958

Officers and staff. No changes occurred in either the Commission membership or officers during the past year. In February the Commission invited applications for the position of Assistant Executive Secretary. Forty applications were received and reviewed by the Commission on April 10, and the Chairman authorized to make the selection, with the assistance of the Executive Secretary. Candidates were interviewed in Madison, Wisconsin on May 4 and Mr. Robert Saalfeld of Seattle, Washington, selected. He reported for duty on July 1 and is presently engaged in planning the lake trout restoration program.

The Commission also engaged Mrs. Grace Simpson on a part-time basis to assist with typing of reports and minutes and the location of Great Lakes bibliographic references in the University of Michigan libraries.

Pension Plan. The three members of the Commission Secretariat are now enrolled in the Pension Plan for Employees of International Fisheries Commissions, which took effect on October 1, 1957. During the year the Commission's exemption from Social Security Insurance was questioned by the Internal Revenue Service. As the Commission believed that its employees were adequately covered by the recently instituted Pension Plan, it filed a claim for exemption.

Accounts and audit. The accounts of the Commission for the fiscal year ending June 30, 1958 were audited by the firm of Icerman, Johnson and Hoffman, 201 East Catherine Street, Ann Arbor, and copies of the report were sent to the national sections for review in advance of the Annual Meeting. This report appears as Appendix I.

Administration and general research expenditures. The expenditures in several categories of the Administration and General Research account, as shown in Exhibit B of the Auditors' Report to the Commission (page 22), did not approach the 1957–58 budget estimates because the Secretariat was not fully staffed and publications were limited to the 1956 Annual Report. The University of Michigan continued to provide the Commission with office space and rents were therefore well below the estimate. Underexpenditures were offset to some degree by renewing the Great Lakes Bibliography contract with the University of Toronto in June and transferring $6,230 of funds unexpended in 1957–58 to a reserve for the second installment payment due on December 1, 1958. Satisfactory progress in the compilation of the Bibliography was made during the year, but recent reports from the University of Toronto indicate that many useful references, not

previously considered, will not be covered when the contract expires on June 1, 1959.

At the close of the fiscal year, there was a balance of $6,615 in the Commission's account for Administration and General Research, and a reserve of $6,230 to cover the cost of the second semi-annual installment of the Great Lakes Bibliography contract.

Prior to the end of the 1957–58 fiscal year, the underexpenditure was estimated at $6,000 and this amount was credited to contributions for the 1958–59 year in accordance with Financial Regulation V (b)iii.

Contributions. An accounting of the contributions received by the Commission from the participating governments during the first half of fiscal year 1957–58 appeared in the Administrative Report for 1957. A statement for the full year appears in Exhibit C of the Auditors' Report to the Commission (page 25).

On January 10, 1958, the Commission received the final installment of the Canadian contribution to the Lamprey Control and Research Fund which was $3,280 in excess of the amount required. The Government of Canada completed its contribution to the Administration and General Research Fund and supplied a supplemental amount of $504 to cover half the cost of the recently established pension fund. The latter cost was subsequently met within the original appropriation. Both amounts have been credited to the Canadian contribution for 1958–59.

The United States Government completed its contribution to both the Lamprey Control and Research Fund and the Administration and General Research Fund on March 27, 1958.

Contracts. During 1958 the Commission continued to carry out its program of lamprey control and research by agreement with official agencies of the Contracting Parties. The Agreement between the United States Section of the Commission and the Bureau of Commercial Fisheries, covering work in the United States during 1957–58 was terminated on June 30, and a new agreement for 1958–59 entered. The funds provided the Bureau for 1957–58 operations were $776,450, for 1958–59, $807,039.

Reports on the discharge of obligations under the 1957–58 Agreement have been submitted by the Bureau. The activities stipulated were carried out within the latitude prescribed, with one major variation. The Agreement called for the operation of 107 barriers on Lake Michigan in the spring of 1958. However, the construction program, which had fallen behind in the previous year, did not regain its schedule in 1957 and further construction during the winter of 1957–58 was suspended by the Commission. As a result, 65 barriers were operated in the spring of 1958. Two of these were temporary installations to check on the size of the spawning run.

At the close of fiscal year 1957–58, the Bureau reported an estimated underexpenditure of $10,835.66.[1] It also advised the Commission that its expenditures included an amount of $12,650 for retroactive salary increases awarded its employees in June, 1958. As recent salary increases to employees of the Commission's agent in Canada had been met by the Government of Canada, the Commission asked the Government of the United States to bear the cost of retroactive increases to its employees by accepting a deduction of $12,650 from credits on contributions to the 1959–60 program.

The program in Canada during 1957–58 was carried out by agreement with the Fisheries Research Board of Canada through the Minister of Fisheries. The postponement of barrier construction on the Kaministikwia River, approved by the Commission at the 1958 Annual Meeting, was the only significant variation in the stipulated program.

At the close of its fiscal year on March 31, 1958, the Board reported the expenditure of $493,160 (Canadian dollars), and refunded an unexpended balance of $3,708.29 (U.S. dollars). Exchange charges on the transfer of funds to the Canadian agent during 1957–58 were $22,791.10, leaving a balance of $147.19 in the total amount budgeted for the program in Canada.

In order that the 1958–59 program approved by the Commission continue uninterrupted through April, May and June of 1958, the Government of Canada advanced funds to the Board during the first quarter of its fiscal year (April 1–March 31) on assurances that the Commission would provide the required funds when contributions were received from the Contracting Parties in July. An amount of $472,000 was provided in the Agreement for operations in Canada in 1958–59.

Budget estimates. The 1959–60 program and estimates, adopted at the Marquette meeting on June 10, 1958, were submitted to the two governments. More detailed information and a further breakdown of estimates were supplied to the United States and two visits paid to Washington to discuss program presentation with Department of State officials.

Reports. The Annual Report for 1956 was published in February and distribution made to government agencies and advisors. A draft of the 1957 Annual Report was submitted for review to the Chairman and Vice-Chairman prior to the 1958 Annual Meeting.

Minutes of the Marquette meeting were sent to all members of the Advisory Committee on the recommendation of the Chairman. A preliminary report on the result of the larvicide test on the Silver

1 Underexpenditures at final audit were $15,304.85.

River was attached. Advisors also received a newsletter on October 22, describing the progress of the program during the summer.

Meetings. There have been two meetings of the Commission, two meetings of the Scientific Advisory Committee, and two meetings of the Special Committee on Lake Trout Rehabilitation since the last Annual Meeting. The Executive Secretary and his assistant serve as chairmen for the two committees.

The Executive Secretary attended three meetings of the Advisory Committees in the United States and four in Canada. Reports were given of Commission activities at meetings of the Michigan Fish Producers Association, the Tri-State Conference, the Upper Great Lakes Fishery Committee, the Lake Erie Fish Management Committee, and the Lake Superior Advisory Committee. The Executive Secretary also attended the Technical Sessions of the Ontario Research Foundation and the annual meeting of the American Fisheries Society.

Contacts with field program. During the spring, the Executive Secretary inspected portions of the electrical barrier network in both countries and was present at three chemical treatments. Brief visits were paid to research groups at Ashland, Wisconsin, Port Dover and Maple, Ontario.

The Assistant Executive Secretary visited a number of state, federal and provincial hatcheries engaged in the culture of lake trout in Michigan, Wisconsin, Minnesota, and Ontario during the late summer, and observed lake trout spawn-taking operations in inland lakes of the State of Michigan and Province of Ontario. Visits were also paid to research groups and administrative offices located in South Bay, Maple, and Toronto, Ontario; Minneapolis and Saint Paul, Minnesota, and Lansing, Michigan. The Assistant Executive Secretary also attended the Lake Superior Advisory Committee meeting.

ADMINISTRATIVE REPORT

APPENDIX

Auditors Report to Commission

ICERMAN, JOHNSON & HOFFMAN

Certified Public Accountants
303 State Savings Bank Building
Ann Arbor, Michigan

October 3, 1958

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, 1958 and the related statements of revenues and expenses and 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, 1958, 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, 1958

Assets

Cash on hand and in bank	$13,068.02
Refund due from Canadian Department of Fisheries	3,708.29
Total	$16,776.31

Liabilities and Fund Equities

Liabilities:		
Overpayment from Canadian Government		$ 3,784.00A
Fund equities:		
Administration and General Research Fund	$12,845.12B	
Lamprey Control Operation Fund	147.19	12,992.31
Total		$16,776.31

Note A—During the year ended June 30, 1958, the Canadian Government made an overpayment of $504.00 to the Administration and General Research Fund and an overpayment of $3,280.00 to the Lamprey Control Operation Fund. These amounts are to be credited against the 1958–59 amounts due to the respective funds by the Canadian Government.

Note B—Of this balance $6,230.00 has been reserved for a contract with the University of Toronto to be paid in the fiscal year beginning July 1, 1958.

Exhibit B

Administration and General Research Fund
Statement of Revenues and Expenses
Year Ended June 30, 1958

	Actual	*Budget*	*Under or (over)*
Revenues			
Canadian Government	$17,700.00	$17,700.00	-0-
United States Government	17,700.00	17,700.00	-0-
Total	$35,400.00	$35,400.00	-0-
Expenses			
Communications	$ 494.52	$ 800.00	$ 305.48
Equipment (Schedule B-1)	2,802.52	4,000.00	1,197.48
Insurance and bonding	125.00)	-	
Remodeling	326.00)	2,000.00	1,549.00
Rent and utilities	37.50	2,500.00	2,462.50
Reproducing and printing	792.16	3,500.00	2,707.84
Salaries (including retirement)	15,009.17	29,500.00	14,490.83
Supplies and equipment maintenance	1,407.70	1,200.00	(207.70)
Transportation	1,364.88	200.00	(1,164.88)
Travel	2,396.25	3,000.00	603.75
University of Toronto—bibliography	12,453.60	3,300.00	(9,153.60)
Total	$37,209.30	$50,000.00	$12,790.70
Excess of expenses over revenues	$ 1,809.30		
Fund balance, July 1, 1957	14,654.42		
Fund balance, June 30, 1958 (Exhibit A)	$12,845.12		

Schedule B-1

Equipment Purchased
Year Ended June 30, 1958

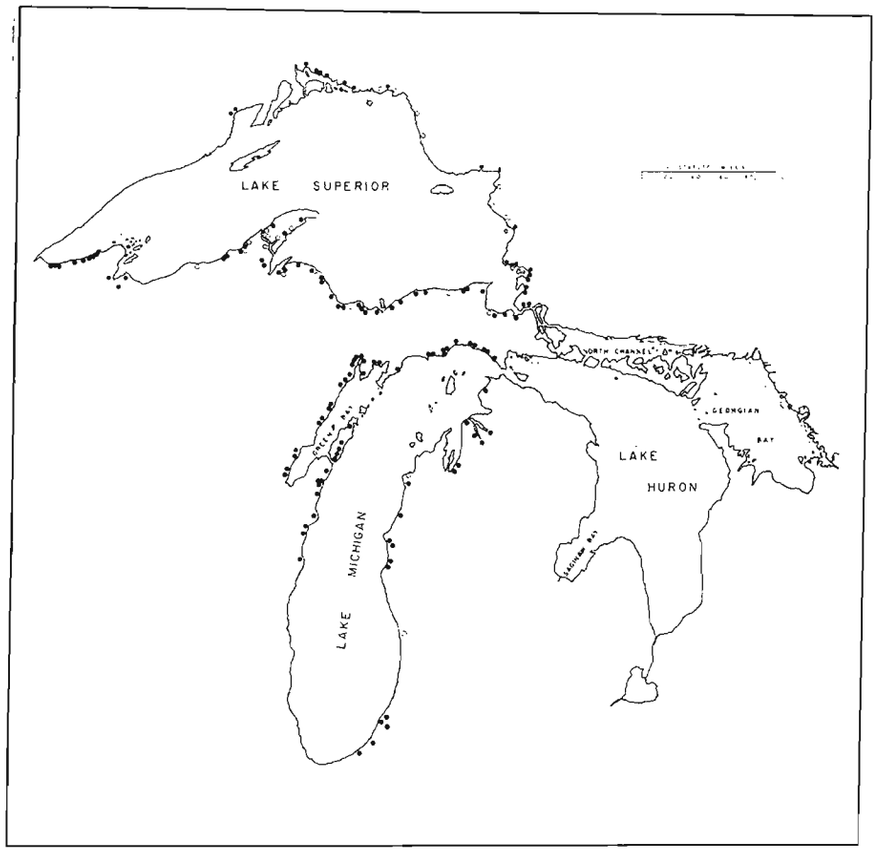
Electric Typewriter	$ 477.00
Automatic calculator	612.78
Books	101.20
Office furniture	1,522.89
Miscellaneous	88.65
Total	$2,802.52

Exhibit C

Lamprey Control Operation Fund
Statement of Revenues and Expenses
Year Ended June 30, 1958

Revenues		
Canadian Government	$399,540.00	
United States Government	889,300.00	
Refund from Canadian Department of Fisheries	3,708.29A	$1,292,548.29
Expenses		
Canadian Department of Fisheries	$493,160.00	
United States Fish and Wildlife Service	776,450.00	
Currency exchange charges	22,791.10	
		1,292,401.10
Excess of revenue over expenses		$ 147.19
Fund balance, July 1, 1957		-0-
Fund balance, June 30, 1958 (Exhibit A)		$ 147.19

Note A—This refund by the Canadian Department of Fisheries of $3,708.29 for unexpended funds of the contract for the 1957–58 year was received in August, 1958.



Electrical barriers on Lakes Superior and Michigan in 1958. Operating barriers shown as solid circles and standby barriers as open circles.

LAMPREY CONTROL AND RESEARCH IN CANADA

by the Fisheries Research Board of Canada

In 1958 the Fisheries Research Board of Canada continued to carry out the Commission's sea lamprey program in Canada. Its activities were largely devoted to operating electrical barriers on lamprey-producing streams of Lake Superior, preparing for the chemical treatment of these streams, and preparing for an extension of the program into Lake Huron. Research included studies of the physiology and behavior of sea lamprey and the development of more efficient electrical devices to block spawning runs. A scientist from the Biological Station at London worked with the staff of the Hammond Bay Laboratory of the U. S. Fish and Wildlife Service, and played an active part in both the lampricide research and early field applications conducted during the year.

Lake Superior barrier construction and engineering

No new barriers were installed on Canada's tributaries in 1958, but some modifications to existing barriers were made. The electric barrier on the Dog River was relocated on a more suitable site a few hundred yards upstream. This relocation was carried out without interruption of control by operating a temporary barrier throughout the period of reconstruction. A flood spillway was constructed at the electric barrier on the Stokeley River to accomodate the extra discharge at peak flood, thus protecting the installation. The spillwoy cannot be used by migrating lamprey even when carrying water, but as an extra precaution electrodes have also been installed in it.

The electric barriers on the Coldwater, Baldhead, Gargantua, Old Woman, White Gravel, and Willow Rivers were laid up, equipment stored on the site and generators serviced and suitably protected. To facilitate barrier operations the generators from Coldwater and Willow Rivers were transferred to the Sault Ste. Marie and Schreiber areas. The electric barriers on the North Swallow and McLeans Rivers were removed completely.

The electric barrier on the Prairie River was not replaced by a mechanical device, as originally intended. However, the necessary engineering studies were carried out, and plans and specifications drawn up. The disastrous fire of August 19, which destroyed the rented warehouse at Rossport with all the equipment it contained, severely limited this and other activities in the Schreiber area.

Direct-current barriers were not installed on either the Pancake or Michipicoten Rivers as planned. In the case of the Michipicoten River, the necessary equipment was not received from the suppliers

in time for installation and was stored at the site. In the case of the Pancake River, the device was not installed as it seemed more advisable to operate a single experimental barrier on the Little Thessalon River.

Preparatory engineering studies to determine the feasibility of installing piling electrodes were carried out and bottom core samples from the Sable and Goulais Rivers sent to consultants for analysis.

Lake Superior barrier operations

Electric barriers were operated on the following Lake Superior tributaries: Little Carp, Big Carp, Cranberry, Goulais, Stokeley, Harmony, Chippewa, Batchawana, Sable, Pancake, Agawa, Michipicoten, Dog, Prarie, Hewitson, Pays Platt, Big Gravel, Little Gravel, Cypress, Jackfish, McIntyre, and Neebing Rivers. Every effort was made to operate these barriers continuously during the lamprey run. However, interruptions ranging from two to ninety hours occurred on eleven occasions at seven barriers. Two of these failures were due to flood damage, three to mechanical failure of equipment, three to vandalism, two to lack of fuel, and in one case, a barrier was deliberately switched off for two hours to facilitate maintenance. In all, 413 barrier hours out of a total of 65,832 were lost. Spawning surveys above the barriers were carried out on all streams with a view to detecting escapement. Adults were taken in three streams and a nest found in another.

The number of adult sea lamprey recovered dead at these barriers was recorded daily and Table 1 presents the totals for 1958 as well as for previous years. The 10 percent reduction in kill in 1958 was not uniformly distributed. In the Sault Ste. Marie area, where barriers were established first, the reduction was of the order of 25 percent, in which all 11 streams shared. Further north and west, in both the Wawa and Schreiber areas, where barriers were established later, the kill approximately doubled, because of substantial increases in three streams, the Michipicoten, Big Gravel, and Jackfish Rivers. It is tempting to ascribe the reduction in the eastern end of the lake to the results of barrier operations, but it is too early for their effects to be significant and much more likely that we have witnessed a natural fluctuation. The latter view is supported by widespread reports from Lakes Huron and Michigan of a reduction of lamprey numbers during early 1958. The increases in the northwest may represent a real increase in population occasioned by increased penetration of this area, but part of the increase is probably due to more efficient operation of the barriers, and a more complete recovery of dead animals from the electrical field.

The examination of suspected spawning streams was completed in 1957 and in the normal course of events re-examination would not

TABLE 1.—Sea lamprey recovered annually at electrical barriers operated on Lake Superior streams 1954–1958.

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

STREAM		YEAR				
No.	Name	1954	1955	1956	1957	1958
S 1	E. Davignon Cr.		1	3		
S 2	W. Davignon Cr.		0	0		
S 4	L. Carp R.		20	24	26	5
S 5	B. Carp R.		5	27	28	19
S 23	Cranberry Cr.		6	11	18	6
S 24	Goulais R.		46	62	820	682
S 34	Haviland Cr.		0	3		
S 36	Stokeley Cr.	49	11	58	5	2
S 39	Harmony R.	19	29	29	16	6
S 42	Jones Landing Cr.		0	0		
S 43	Downey Cr.		0	0		
S 48	Chippewa R.		807	839	359	220
S 52	Batchawana R.		608	421	427	358
S 54	Sable R.	39	43	65	76	47
S 56	Pancake R.		555	717	1,073	809
S 93	Agawa R.			0	26	19
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
S 202	Dog R.				9	0
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 Platt R.			6	3	4
S 368	Gravel R.			5	99	154
S 369	L. Gravel R.			0	2	0
S 374	Cypress R.			1	3	5
S 385	Jackfish R.			0	0	64
S 570	McIntyre R.				0	2
S 571	Neebing R.				1	0
	Totals	107	2,131	2,325	3,364	3,044

be contemplated before 1960. No action was taken, therefore, to ensure that lamprey spawning runs were not developing in unblocked streams other than to train personnel in the appropriate survey techniques by having them participate, in surveys of ammocoete distribution.

Lake Superior stream surveys

Twenty-nine streams were surveyed during the year. Eleven of those surveyed are not now blocked by electric barriers. Sea lamprey ammocoetes were found in only one of these, the Kaministikwia River, and their distribution in that stream determined. Further survey of two of these streams is desirable. Eighteen barrier-blocked streams were surveyed, two only partially and six with sufficiently inconclusive results to warrant resurvey. The Chippewa River, on which a barrier was first operated in 1955 and from which sea lamprey larvae have been collected in each previous year, appears now to be completely free of sea lamprey ammocoetes suggesting that this barrier has been completely effective. The barriers on the Sable, Harmony and Stokeley Rivers were first operated in 1954 and in these rivers sea lamprey ammocoetes are present only in much reduced numbers, presumably reflecting the effects of the barriers on the spawning runs. These data are the first evidence of a reduction of production in Canadian streams which can reasonably be attributed to the effect of the barriers.

Careful surveys of the Prairie River and the Little Pic River have failed to reveal any sea lamprey ammocoetes in spite of the fact that adults are known to have entered both streams in the past. Both have been barrier blocked only since 1956 so that the absence of larvae can hardly be construed as a result of barrier operations. It would appear then, that neither stream can be successfully utilized by the species and that control measures on them can be discontinued.

Satisfactory determinations of larval distribution and of potential sites for larvicide application have been made on the W. Davignon, Little Carp, Cranberry, Stokeley, Harmony, Batchawana, Sable, Pays Platt, Big Gravel and Jackfish Rivers. Fortunately, the problems of access to application sites appear far less formidable than anticipated.

Lake Huron stream surveys

Surveys of practically all of the 849 Lake Huron streams not covered in 1957 were completed. The majority were located on the islands in Georgian Bay and the North Channel and had little or no potential for spawning sea lamprey. Evidence of successful sea lamprey spawning was found in only two additional streams located on the northern shore of Manitoulin Island —the Silver and Kagawong Rivers. Tentative barrier sites have

been selected for most of the lamprey-producing streams flowing into Lake Huron and Georgian Bay, but land surveys to acquire the sites are not completed. Water resistivities have been measured for most streams. The distributions of sea lamprey ammocoetes is now known for all the spawning streams of Georgian Bay except the Nottawasaga River and that survey is largely completed. Similar surveys on North Channel and Lake Huron streams remain to be done. Surveys of the distribution of sea lamprey ammocoetes in the open waters of Tenby and Moffat Bays, St. Joseph Island, were carried out. The greatest concentrations were near the mouths of the four spawning rivers entering these bays; however, sea lamprey ammocoetes were collected as far as one-half mile along the shoreline beyond the mouth of the closest stream in which lamprey are known to, or could, spawn successfully.

The study on Silver Creek initiated in the fall of 1957 was continued. Records of the movements of all species past a two-way trap located near the mouth of the stream have been maintained throughout the year. Tag and recapture methods have provided information about the movements of adult sea lamprey and rainbow trout in the stream, as well as biological data. Distribution and population density of the ammocoete populations has been sampled as has the size-age composition of young rainbow trout.

Pancake River study

Tag and recapture studies were carried out on the spawning run of lamprey in the Pancake River. Seventy-three lamprey (8 percent of the known run) were captured above the electrical barrier. However, as only one tagged animal was shown to have escaped through the barrier and that at a time when a transitory defect existed in the field, it is considered that almost all of this escapement occurred before the barrier was turned on May 1. A surprising number of sea lamprey (67, or 8 percent of the known run) were observed nesting below the barrier. Twenty-three nests were noted. Eight other nests were found several miles upstream. Data from the movements of tagged lamprey suggest that the behavior of animals prevented by the barrier from passing upstream to spawn, changes progressively with the season. Initial persistent attempts to pass the barrier eventually give way to more plastic behavior with animals wandering, or moving downstream and spawning when the opportunity is offered.

Underwater studies

A group of divers assisted materially in the installation and removal of the nets used in the Pancake River study and one diver was associated with the study continuously to aid in net

maintenance and to make underwater observations of the tagged lamprey. Detailed underwater surveys of the river bottom below the barriers on all barrier-blocked streams were carried out. In several cases, apparently suitable spawning gravel was encountered below barriers but only in Pancake River was there clear-cut evidence of its utilization by spawning sea lamprey. Incidental to these surveys, the divers inspected the barriers and their associated nets on each river and assisted the local maintenance crews in making repairs or modifications as required. During the lampricide applications at the Pancake River, the divers collected ammocoetes and followed the treated water into the lake and found that it spread out in a shallow layer on the surface of the colder lake water.

During September considerable areas of gravel adjacent to Pancake, Batchawana, and Chippewa Rivers were located at depths to thirty feet by a survey technique using divers pulled underwater on sleds. It is proposed to watch these areas for lake spawning in 1959. A technique was devised for swath poisoning the lake bottom in depths to thirty feet as a means of sampling larval populations in the open lake. Preliminary trials were encouraging.

During late October and early November, examinations were made of a small number of ships passing through the Canadian locks at Sault Ste. Marie. No "hitchhiking" sea lamprey were observed and none could be found on the walls or gates of the locks.

Application of lampricide in Pancake River

On August 26 and 27, U. S. Fish and Wildlife Service personnel teamed with Fisheries Research Board staff in carrying out chemical treatment of the Pancake River. A realistic estimate of the number of larvae killed was impossible but it might be of the order of three-quarters of a million, of which approximately one-third were sea lamprey. Post-treatment surveys failed to locate any surviving sea lamprey, although some larvae of other lamprey species were collected. These few survivors were located in limited areas in which the exchange of water with the stream proper was very slow. In the larger of the two areas concerned, it was known during the treatment that a lethal concentration of lampricide was not maintained long enough to ensure a complete kill. An attempt to treat West Davignon Creek with lampricide on November 5 failed because a torrential rainstorm greatly diluted the chemical after it had been fed into the stream.

Lamprey physiology

The studies of the effects of alternating-current fields on sea lamprey were completed. The relation of the factor of power

transfer and water conductivity was established so that the effectiveness of barrier fields may be precisely assessed knowing the voltage gradient and the water conductivity. Consultation with U. S. Fish and Wildlife Service personnel led to the adoption of standard methods of barrier assessment based on these relations. Field investigations of variations in the conductivity of Pancake River water demonstrated that perceptible changes resulted from run-off during rains but were not of sufficient magnitude to affect the barrier field.

Development of electrical devices

The direct-current barrier on Big Creek proved, so far as was possible to discover, a barrier to the upstream movement of fish and lamprey. Most ascending fish and lamprey which approached it were guided into the trap. Upon completion of the runs in Big Creek, the material and equipment were moved to a new site on the Little Thessalon River which enters the North Channel of Lake Huron, to prepare for the investigation in 1959 of several variants of electrode type and power supply. Construction at the new site was completed except for the installation and wiring of the generators.

Spawning requirements and behavior studies

Extensive renovations at the London Biological Station made it impossible to carry out laboratory studies of lamprey spawning and behavior during the period when experimental animals were available. Accordingly, progress has been restricted entirely to the acquisition and building of equipment.

Ammocoete studies

Data have been collected to determine the factors controlling ammocoete distribution and population density. Analysis of these data have begun.

A study of ammocoete migration has essentially confirmed the Michigan findings that movement is entirely downstream. Movement occurs in low water periods but increases with a rise in creek level. Movement in the winter is apparently much less than in the summer.

A measurement of the growth rate of young-of-the-year and 1-year-old animals was obtained by sampling the same population in Young's Creek each month. Ammocoetes were removed, anaesthetized, measured and returned. This information may permit a more precise analysis of the size frequency distribution to distinguish age groups and thus lead to a better estimate of the length of larval life.

Operation of M. V. Cottus

The *Cottus* and its crew served a number of projects as required. It assisted in the removal of a diesel generator from the barrier site at Willow River. Nets were installed, removed and repaired in Pancake River in connection with the tag and recapture program and general assistance was lent during the lampricide application to the river. Experimental gill-net fishing was carried out on Superior Shoal during late July and early August. Few of the trout taken were scarred by lamprey; only one percent bore fresh wounds and four percent old scars. The fish were spawning (many were spent) at the time. Finally, the *Cottus* served as a platform from which the Underwater Studies were largely carried out.

LAMPREY CONTROL AND RESEARCH IN THE UNITED STATES

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

Most noteworthy advance in 1958 has been the development of selective lampricides to the stage of practical field use. The change from experimental to operational treatment of streams has required some extensive and rather difficult adjustment in the activities of various groups. The research staff made the change from laboratory to field testing of selective lampricides, turned over the field application methods to the control group in mid-year, and then returned to a laboratory program that included considerable work in support of field operations. The control group found it necessary to include both lampricide applications and the operation of the electrical-barrier system in their activities without any appreciable increase in staff. Some reappraisal and reorientation has been required but, in the main, the necessary changes have been made smoothly and efficiently.

Lake Superior barrier construction

New installations on Lake Superior were limited to Wisconsin tributaries. Alternating-current electrical barriers were constructed on 6 streams; 5 (Fish Creek, Reefer Creek, Iron River, Black River, and Nemadji River) were installed as check weirs to determine the size of the sea lamprey runs. A delay in obtaining an easement to use private land, followed by high water, prevented construction of a check weir on the Ontonagon River. An alternating-current barrier was added to the direct-current unit on the Brule River to assure a complete block to sea lampreys in that stream. Direct-current fish-guiding devices were added to alternating-current barriers on the Sucker, Firesteel, and Misery Rivers to bring to 11 the number of direct-current units in Lake Superior streams. Maintenance work required reconstruction of 6 older barriers, one of which was relocated downstream to include a tributary.

Lake Superior barrier operations

The 1958 season was the sixth year in which electrical barriers have been used in streams on the United States side of Lake Superior. This year barriers were operated in 45 streams and 15 others were maintained in standby status. Thirty-seven of the devices were turned on in late March and early April. The remainder were activated in May except the Ravine River which was started June 3. Previous experience on the timing of runs justified the later start of operations in certain streams. Termination of the operation began August 3 and was concluded September 11. Individual weirs were closed after a period of time (usually two weeks) had passed without capture of migrant sea lampreys.

A total of 66,961 sea lampreys was taken during the season including 152 adults killed in an experimental application of lampricide on the Silver River during the period of migration. The catch of lamprey in each stream is given in Table 1. The 1958 total catch exceeded those of previous years. This gain was due to increases in several streams in the western section of Lake Superior. On the other hand a marked decline was evident in the eastern half of the lake.

Only 5 streams with barriers failed to produce sea lampreys; 6 others produced 5 or fewer. Over 94 percent (62,890) of the lampreys were taken from 12 streams and the Brule River alone accounted for 22,842 individuals or 34 percent of the season's catch. The 32 barriers operated in Michigan streams accounted for 24,171 sea lampreys (36 percent of the total) and those in Wisconsin took 42,638 lampreys (64 percent).

The first sea lamprey was taken on March 26. The upstream movement followed the established seasonal pattern. As water temperatures exceeded and remained above 40°F., the runs gained momentum and reached a peak near mid-May (Table 2). The runs declined sharply during July and ceased entirely by early September. Most of the sea lamprey, 94.7 percent, were taken between April 21 and July 4. The largest weekly catch (15,042), representing 22.5 percent of the total run, was made during the period May 10–16.

Lake Superior streams were kept under surveillance during the spawning season to detect new runs but none were discovered. Small runs are known in 5 additional streams (Tahquamenon, Seven Mile, Salmon Trout, Cranberry, and Ontonagon) and there are limited populations of ammocoetes in these. Quantitative data is lacking.

TABLE 1.—Sea lamprey taken at barriers in United States tributaries of Lake Superior, 1953–1958.

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

[1] Includes 152 killed by chemicals.

TABLE 2.—Weekly catch of sea lampreys at electrical barriers in United States streams of Lake Superior, 1958.

Period	Number of streams producing lampreys	Number of lampreys	Percentage of total catch	
			Weekly	Cumulative
Mar. 24–28	3	4	0.0	0.0
Mar. 29–Apr. 4	4	69	0.1	0.1
Apr. 5–11	10	842	1.3	1.4
Apr. 12–18	18	1,403	2.1	3.5
Apr. 19–25	19	2,563	3.8	7.3
Apr. 26–May 2	24	1,478	2.2	9.5
May 3–9	23	5,976	9.0	18.5
May 10–16	25	15,042	22.5	41.0
May 17–23	25	7,881	11.8	52.8
May 24–30	26	6,683	10.0	62.8
May 31–June 6	28	6,287	9.4	72.2
June 7–13	31	6,506	9.7	81.9
June 14–20	33	5,276	7.9	89.8
June 21–27	25	2,155	3.2	93.0
June 28–July 4	27	2,027	3.0	96.0
July 5–11	23	172	1.3	97.3
July 12–18	25	886	1.3	98.6
July 19–25	24	438	0.7	99.3
July 26–Aug. 1	25	207	0.3	99.6
Aug. 2–8	17	100	0.2	99.8
Aug. 9–15	15	52	0.1	99.9
Aug. 16–22	9	38	0.1	100.0
Aug. 23–29	6	22	0.0	100.0
Aug. 30–Sept. 5	2	2	0.0	100.0
Sept. 6–12	0	0	0.0	100.0
Total	..	66,809[1]	..	..

[1] An additional 152 adult sea lamprey were killed in the Silver River during an experimental chemical treatment on June 11.

Despite the most careful planning and operation, floods, mechanical failures, structural defects, and other factors have prevented complete blockage of all lampreys each season. In 1958 escapement is known to have occurred in the Huron, Silver, and Firesteel Rivers. In the Huron an upstream electrode was torn loose and pushed against the lower array by debris. The resultant short circuit blew the fuses and a few lampreys escaped upstream. Causes of the escapement at the Silver River are not known. Thirty-one adult sea lampreys were killed above the barrier during an experimental treatment with lampricide. The electric field was checked carefully and appeared satis-

factory. Passage over the trap during flood stage was the most likely escape route. The barrier was altered to eliminate this possibility. Some of the escapement may have been due to the lake seiche which reaches the control side, and on occasion creates a reverse water movement. The escapement of a few sea lampreys in the Firesteel River is believed to have been caused by an eddy which forms at the barrier when flow in the river is high.

A large group of spawning-run brown trout concentrated below the Brule River barrier in late August and made no effort to move upstream. These fish were the object of illegal fishing and hence a cause of strained public relations. In order to ease pressure from local conservation groups, barrier operations were discontinued August 29. Inasmuch as 32 lampreys had been caught during the two weeks prior to closure it is probable that some moved upstream after the barrier was shut down.

Other escapement may have occurred during a brief power failure on both the Two Hearted and Rock Rivers, but inspection above the barriers disclosed no lampreys. Floods were so severe one week in July at the Poplar, Middle, Amnicon, Black, and Nemadji Rivers that control may not have been fully effective for several days, but again inspection of the rivers failed to reveal escapement.

In addition to sea lampreys and native lampreys, some 42 species of fish were taken at the control barriers. As in preceding years, a record was kept, by species, of the fish trapped successfully and of those killed in the electrical fields. Although fish mortality has been reduced by the installation of more efficient trapping facilities and the addition of direct-current diversion devices, it still presents some public relations problems.

The records of the catch of fish at 9 barriers operated since 1954, give no indication that the spawning runs of any species have been reduced. Some fluctuations of catch have occurred (Table 3), but the trend thus far indicates an increase among the principal migratory species in most streams. Annual variation in their numbers probably reflects natural fluctuations.

Lake Michigan barrier construction

The extensive shoreline of Lake Michigan requires that barrier construction and operations be supervised from two offices. The north and west-shore streams are the responsibility of the Oconto, Wisconsin, field station and the east-shore streams are managed from the station at Ludington, Michigan.

New alternating-current electrical barriers were installed in 18 streams along the north and west shore, and direct-current devices were placed in the Pensaukee and Black Rivers. These installations filled a 70-mile gap in the central part of the north-shore system and

TABLE 3.—Rainbow trout, white suckers, and longnose suckers handled at control barriers in nine Lake Superior streams, 1954–1958.

Stream	1954	1955	1956	1957	1958
Two Hearted River					
Rainbow trout	80	77	162	274	184
White suckers	65	275	812	561	502
Longnose suckers	1,860	527	2,128	2,076	2,829
Sucker River					
Rainbow trout	22	59	36	31	59
White suckers	468	439	707	226	497
Longnose suckers	36	86	179	217	276
Hurricane River					
Rainbow trout	24	234	387	311	131
White suckers					
Longnose suckers	16	174	11	24	5
Miners River					
Rainbow trout	10	56	144	94	40
White suckers	176	143	123	320	14
Longnose suckers	265	795	419	581	7
Laughing Whitefish River					
Rainbow trout	12	39	71	68	43
White suckers	265	63	357	61	510
Longnose suckers	1,333	446	4,695	3,517	3,453
Chocolay River [1]					
Rainbow trout	46	86	126	62	40
White suckers	3,126	610	1,144	1,704	2,581
Longnose suckers	26,023	4,034	5,389	4,943	3,812
Huron River					
Rainbow trout	20	36	146	229	413
White suckers	285	500	333	910	2,625
Longnose suckers	3,098	2,275	5,669	8,269	10,164
Silver River					
Rainbow trout	10	30	55	64	84
White suckers	6,420	146	4,443	2,747	5,332
Longnose suckers	143	136	77	135	150
Firesteel River					
Rainbow trout	5	17	21	28	25
White suckers	642	391	595	945	1,299
Longnose suckers	1,525	1,944	3,624	3,873	2,827

[1] Catch in 1954 may be biased by more frequent clearing of trap.

extended the control network farther south along the west shore of Lake Michigan. Mechanical check weirs were erected in 2 north-shore streams to determine their use by sea lampreys. Barriers on the Pensaukee and Whitefish Rivers required reconstruction.

A construction program was started on the east-shore streams which called for the completion of 23 electrical barriers. It proceeded until mid-February when work was halted to make personnel and funds available for the proposed field testing of the lampricides. Later, toward the end of March, construction was resumed on those barriers that could be finished with a minimum of work. Ten alternating-current installations were added to the east-shore network, 2 with direct-current guiding devices.

Lake Michigan barrier operations

The Oconto and Ludington groups together operated 63 electrical barriers and 2 mechanical check weirs through the season. These installations extended from Sheboygan, Wisconsin, clockwise around Lake Michigan to Michigan City, Indiana. The first barrier went into operation March 13 and by April 3, 62 were operating. The last barrier was activated in the Galien River on April 24. Delays in the installation of the transmission line to the Platte River device prevented operation this year. Termination of barrier operations began the first week of July on the east shore and was concluded in the Green Bay area on August 29.

The north and west-shore network of 45 electrical and 2 mechanical barriers captured 30,917 sea lampreys (Table 4), and the remaining 18 units along the east shore produced 5,720 (Table 5). The season's catch of 36,637 lampreys was considerably below the 64,455 individuals taken last year from 37 barriers.

The sea lampreys in Lake Michigan first appeared at the barriers during the week of March 15–21. Catches rose to an early peak at the east-shore barriers in the week of April 12–18, then dropped sharply and rose to a maximum May 10–16 (Table 6). The lamprey catch in the north and west-shore streams did not have an important early peak. The maximum catch was reached in the same week as on the east shore, May 10–16 (Table 7). This week's catch was 37 percent of the season's total. Barrier operations in both areas of the lake had accounted for 99 percent of the season's total catch by the end of June.

Power failure made escapement through the electrical devices possible at 12 installations. Although periodic inspections of streams failed to reveal escapement in north and west-shore tributaries, some lampreys are known to have escaped upstream in the Ogontz, Sturgeon, Fishdam, and Rapid Rivers. The power failures at the other 6 barriers fortunately happened early or late in the season when few

TABLE 4.—Sea lamprey taken at barriers on north and west shores of Lake Michigan, 1954–1958.

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

[1] Mechanical check weir.

TABLE 5.—Sea lamprey taken at barriers on east shore of Lake Michigan, 1957–1958.

Stream	1957	1958
Wycamp Lake Outlet		55
McGeach Cr.	257	82
Boyne R.	225	48
Monroe Cr.	1	0
Jordan R.	579	457
Yuba Cr.	214	93
Mitchell Cr.	71	27
Betsie R.	1,704	712
Little Manistee R.		176
Lincoln R.	800	223
Pere Marquette R.		2,006
N. Br. Pentwater R.	108	208
S. Br. Pentwater R.	0	0
Paw Paw R.		10
Blue Cr.		226
Pipestone Cr.		1,068
Galien R.		41
Trail Cr.		288
Total	3,959	5,720

TABLE 6.—Weekly catch of sea lampreys at electrical barriers in streams of the east shore of Lake Michigan, 1958.

Period	Number of streams producing lampreys	Number of lampreys	Percentage of total run	
			Weekly	Cumulative
Mar. 15–21	1	1	0.0	0.0
Mar. 22–28	5	24	0.4	0.4
Mar. 29–Apr. 4	7	58	1.0	1.4
Apr. 5–11	11	123	2.2	3.6
Apr. 12–18	15	1,231	21.5	25.1
Apr. 19–25	14	1,183	20.7	45.8
Apr. 26–May 2	15	255	4.4	50.2
May 3–9	14	557	9.7	59.9
May 10–16	15	1,463	25.6	85.5
May 17–23	15	405	7.1	92.6
May 24–30	15	134	2.3	94.9
May 31–June 6	11	123	2.2	97.1
June 7–13	12	84	1.5	98.6
June 14–20	8	33	0.6	99.2
June 21–27	8	18	0.3	99.5
June 28–July 4	5	18	0.3	99.8
July 5–11	5	10	0.2	100.0
July 12–18	0	0	0.0	100.0
July 19–25	0	0	0.0	100.0
Total		5,720		

TABLE 7.—Weekly catch of sea lampreys at electrical barriers in streams of the north and west shores of Lake Michigan, 1958.

Period	Number of streams producing lampreys	Number of lampreys	Percentage of total run	
			Weekly	Cumulative
Mar. 18–21	2	2	0.0	0.0
Mar. 22–28	4	18	0.1	0.1
Mar. 29–Apr. 4	13	120	0.4	0.5
Apr. 5–11	17	376	1.2	1.7
Apr. 12–18	31	1,957	6.3	8.0
Apr. 19–25	31	1,325	4.3	12.3
Apr. 26–May 2	29	1,389	4.5	16.8
May 3–9	32	4,020	13.0	29.8
May 10–16	36	11,416	36.9	66.7
May 17–23	32	3,393	11.0	77.7
May 24–30	31	1,825	5.9	83.6
May 31–June 6	31	2,341	7.6	91.2
June 7–13	30	1,337	4.3	95.5
June 14–20	29	711	2.3	97.8
June 21–27	23	254	0.8	98.6
June 28–July 4	25	172	0.6	99.2
July 5–11	13	126	0.4	99.6
July 12–18	16	87	0.3	99.9
July 19–25	11	34	0.1	100.0
July 26–Aug. 1	5	7	0.0	100.0
Aug. 2–8	4	5	0.0	100.0
Aug. 9–15	2	2	0.0	100.0
Aug. 16–22	0	0	0.0	100.0
Aug. 23–29	0	0	0.0	100.0
Total		30,917		

lampreys were moving. Along the east shore, power failures at the Blue Creek and Pipestone Creek installations, caused by icing of propane tanks, allowed some escapement. Several nests were found above the two barriers.

Despite the favorable spawning conditions created below a few of the installations by the receding lake level, spawning activity was much less this year than last. Sea lampreys were seen spawning in patches of gravel under large tilted slabs of rock in the Whitefish, Ford, and Cedar Rivers. A very few spawned below the barriers in four other streams in the Green Bay drainage.

Fish mortality at the electrical devices was not serious in Lake Michigan streams in spite of an increase in the number operated. Three streams in which difficulties with game fish were anticipated were provided with direct-current fish-guiding devices. The addition of direct-current equipment below the alternating-current barrier in the Pensaukee River reduced the destruction of the white suckers.

Some 9,470 were killed in 1958 as compared to 158,000 in 1957. Further mechanical improvements should lower the mortality even more. No public complaints of consequence regarding game fish arose from the operation of the control system, except on the Whitefish River at the head of Little Bay de Noc. Here a local group expressed concern over the blocking of a spawning run of walleyes.

Direct-current diversion device

The direct-current diversion devices have continued to be effective in reducing mortality of migratory fish at the barriers and no changes have been necessary in the basic design.

New installations have functioned under a variety of conditions. Structures installed in streams tributary to Lake Michigan permitted the testing of the equipment under a higher range of conductivity than had previously been possible. The conductivity of Lake Superior streams in which direct-current units have been operated does not exceed 200 micromhos at 18° C. The Pere Marquette River, a tributary to eastern Lake Michigan, and the Pensaukee River, on the west shore, provided a range in water conductivity from about 217 to 387 micromhos. Some small difficulty was experienced in the Pere Marquette, a large river in which the high current load and high water conductivity combined to produce considerable electrolysis of the electrodes and connections.

Observations on spawning runs

The reduction in the number of spawing sea lampreys in the eastern half of Lake Superior in 1958 is most encouraging, but it would be unjustifiably optimistic to interpret the decrease as the result of the operation of barriers in previous years. It is more likely that the sea lamprey population has expanded to a level of stability in the eastern part of the lake, and that the decline represents only a fluctuation in abundance. This explanation seems reasonable in view of the decline this year in the catch from Lake Michigan streams that had not been under control long enough for the lamprey runs to be affected.

The take of sea lampreys from 29 streams in the eastern part of Lake Superior that have been under control since 1954, dropped 29 percent from 1957 to 1958. In preceding seasons the catches had increased markedly from one season to the next as shown in the following record:

1954	4,921
1955	8,820
1956	19,009
1957	30,069
1958	21,327

The catch of lampreys in Lake Michigan tributaries had increased slowly in 1956 and 1957, but in 1958 this dropped by more than half (53 percent). These changes are illustrated by the catch records from streams in the Green Bay and west-shore areas which have had barriers since 1955.

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

As Lake Michigan barriers have not been in operation long enough to have caused this decline, it almost surely represents a natural fluctuation in abundance. A reduction in the size of sea lamprey which was noted as the population established itself in Lake Michigan was evident on Lake Superior this year. The average length and weight of lampreys from 10 index streams were 16.8 inches and 5.8 ounces (Table 8). Length decreased sharply (0.8 inches) in Lake Michigan streams along the north and west shores, but the average weight was 0.2 ounces more than last year. The east-shore streams again produced the smallest lampreys. The average total length was 15.7 inches and the average weight was 4.1 ounces.

The predominance of males in the spawning runs when the population has reached a substantial level of abundance is apparent in the records for both Lake Superior and Lake Michigan.[1] Since the first year of barrier operations in Lake Superior in 1953 when the ratio was 99 males to 100 females, the males have been consistently the more abundant. In 1958 there were 140 males per 100 females. The ratios, however, have fluctuated irregularly and without trend.

Information on sex ratio of sea lampreys taken on the north and west shores of Lake Michigan during the period 1954–1957 has been reported.[1] In 1958 there were approximately 171 males per 100 females. Males have been consistently more plentiful than females, but here again the ratio has varied widely and without trend.

Annual variation in sex composition is also evident along the east shore of Lake Michigan. This year the sea lampreys examined had a sex ratio of 135 males per 100 females; in 1957 the ratio was 169 males per 100 females.

Development and field testing of lampricides

Field testing of lampricides, which began with the treatment of Little Billie's Creek in 1957, was resumed on April 15–16, 1958, when Carp Creek, a tributary of northern Lake Huron near Hammond Bay, was treated with Dowlap 20 (3, 4, 6-trichloro-2- nitro-

[1]Annual Report for 1957.

TABLE 8.—Average lengths and weights of spawning-run sea lampreys captured in tributaries of Lake Superior and Michigan, 1954–1958.

[No samples from east shore of Lake Michigan before 1957].

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

phenol). The chemical was applied to 1.5 miles of the stream, at a concentration of 20 ppm for 4½ hours and then at 12 ppm for 10 hours. The total application of 1,064 gallons contained 1,915 pounds of active ingredient. All captive larval lampreys placed in cages in the stream were dead after 13½ hours of exposure. Post-treatment examination of the stream indicated that no larval lampreys survived. No significant mortality of fishes was noted during or after the treatment.

In the course of this field test several techniques of nitrophenol analysis were tested. The comparison of four colorimetric instruments revealed that a Klett-Summerson Photoelectric Colorimeter and a Bausch and Lomb Spectronic 20 Spectrophotometer were best suited for this analysis.

On May 14, 1958, the Mosquito River, a tributary of Lake Superior, in Alger County, Michigan, was treated with a formulation of the sodium salt of the 3-trifluormethyl-4-nitrophenol. This formulation, known as Lamprecid 2770, was introduced into the river at a natural falls about 1¾ miles above the mouth to give a concentration of 5.5 ppm for 9 hours. A total of 45½ gallons of Lamprecid 2770 containing approximately 163 pounds of active ingredient was utilized. All captive lamprey larvae confined to cages in the stream were dead after 7¾ hours of exposure. Post-treatment examination of larval

habitat in more than 15 percent of the treated length of the stream produced only 4 live larvae where formerly there had been thousands. Fishes in the stream during the treatment included lake-run rainbow trout, resident brook and rainbow trout, and several species of minnows. During and after the treatment, only one fish was seen that could conceivably have been hurt by the lampricide. Aquatic invertebrates, such as the immature stages of dragonflies, mayflies, caddisflies, stoneflies, and dipterans and aquatic earthworms were likewise unaffected by the lampricide.

On June 11, 1958, Lamprecid 2770 was applied to approximately 5 miles of the main channel and estuary of the Silver River, a tributary of Lake Superior in Baraga County, Michigan. The lampricide was metered into the stream for 13½ hours so as to provide a concentration of 2.8 ppm at the point of introduction. All captive larvae died, and post-treatment examination of over 50,000 square feet of larval habitat in the stream and in the estuary indicated that nearly all of the larval lampreys were killed. No significant harm to any fish species resulted from exposure to the lampricide.

The Silver River experiment, which was observed by members of the Great Lakes Fishery Commission, by representatives of federal, provincial and state agencies and of sport and commercial fishing groups, and by the press, terminated the experimental field-testing by the research group. Subsequent treatments were conducted by the control group but liaison between research and control personnel continues to be close and the research staff still has responsibility for assistance and advice in the ordering of equipment and supplies, bio-assay of bulk lots of lampricides destined for field use, and bio-assays in water from streams scheduled for application of lampricides. The research staff also has served as advisors to personnel of the Fisheries Research Board of Canada in early test treatments of Ontario tributaries of Lake Superior.

The Hammond Bay staff is now developing research into the factors that control the biological activity of lampricides. Field tests have revealed a wide variability in the concentrations that must be employed. Identification of the controlling factors and quantitative determination of their effects can be of inestimable value to those who must plan field programs. Testing of potentially useful new toxicants is continuing.

Application of selectively toxic chemicals

A chemical unit has been established with headquarters at Marquette, Michigan. Personnel assignments to this new project were made from within the organization after the barrier operations were completed for the year. This action was accomplished without interrupting the scheduled maintenance and improvement of the electrical

barrier system. Some difficulties were encountered in obtaining the toxicant in a suitable formulation, but the first shipment arrived in time to permit treatment of the first stream on September 6, 1959.

Eight streams that had consistently large spawning runs and huge ammocoete populations, were treated with formulations of the sodium salt of 3-trifluormethyl-4-nitrophenol in September and October. Two formulations were used: Lamprecid 2770 which contained 45 percent by weight of the active ingredient expressed as free phenol (78 cans of this material used on one stream were reformulated to give 30 percent by weight of the active ingredient); Dowlap F40 which contained 35 percent by weight of the active ingredient.

The treatment of the streams followed a standard procedure of three major steps: pre-treatment examination of the stream; application of the chemical; and post-treatment surveys.

Pre-treatment examination includes: (1) a survey to determine the abundance and distribution of sea lamprey ammocoetes and fish; (2) measurements of rates of stream flow at selected localities on several dates; (3) determination of the chemical and physical properties of the water, including dissolved oxygen, alkalinity, pH, and temperature; (4) bio-assay tests at the Hammond Bay Laboratory in stream water to determine minimum effective and maximum allowable concentrations of the lampricide; and (5) collection of ammocoetes to be used as test animals in cages at selected stations in the treatment area.

The second step, the treatment, consists of: (1) introduction of the lampricide by means of a proportioning pump at the predetermined rate; (2) colorimetric analysis of samples of treated water for 3-trifluormethyl-4-nitrophenol at uniform time intervals to determine concentrations of the chemical at downstream stations; (3) periodic recording of condition of captive ammocoetes; (4) continual observations of stream organisms—lamprey larvae, fish, and invertebrates to determine the effect of the chemical; and (5) collection of samples of ammocoetes for biological information.

As soon as possible after the treatment of a stream system, a survey is made with an electric shocker at various stations to determine the presence or absence of larval lampreys. At this time observations are made on other stream fauna.

The post-treatment examination, will be continued periodically until it is found necessary to re-treat the stream. The eight river systems are listed in the chronological order of treatment in Table 9. These treatments required 5,324 pounds of chemical costing $23,693.64.

The results of these applications were most encouraging. Destruction of ammocoetes was nearly total in 7 of the streams and damage to fish was negligible. The eighth stream, the Sucker River, had a complete kill of larvae in the first 15 miles downstream from the point of introduction. Many thousands of dead ammocoetes were found in the

TABLE 9.—Details on the application of the sodium salt of 3-trifluormethyl -4-nitrophenol (Lamprecid 2770 or Dowlap F40) to 8 streams tributary to Lake Superior, September-October, 1958.

Stream	Date of treatment	Discharge at mouth (cfs)	Length of stream treated (miles)	Concentration at introduction (ppm)	Working range[1] (ppm)	Duration of application (hours)	Active ingredient (pounds)	Cost of chemical (dollars)	Area surveyed after treatment (sq. ft.)	Number of ammocoetes recovered
Huron	Sept. 8	80	12	4.5	2–5	8.0	600	2,808	6,000	0
Iron	Sept. 15	59	4	3.5	2–6	9.5	374	1,750	2,900	0
Middle	Sept. 24	15	10	5.5–4.0	2–5	12.0	100	468		
	Sept. 28	44	20	4.7		12.0	268	1,179	3,200	0
Poplar	Sept. 24	10	10	4.8	2–5	12.0	74	346		
	Sept. 26	13	8	5.3		7.5	96	422	1,900	0
Amnicon	Sept. 24	27	15	5.5	3–7	11.0	347	1,624	2,100	0
Sucker	Oct. 10	42–88	40	9.0	2–9	12.0	424	1,866	7,400	59
	Oct. 12			6.0		7.5				
Rock	Oct. 23	13	18	18.0	3–11	20.0	343	1,509	[2]	[2]
Chocolay	Oct. 29	150	34	6.0	2–6	19.5	1,348	6,309	[2]	[2]
	Oct. 31			6.0		12.0	1,230	5,412		
	Nov. 1			8.0		12.0				

[1] Determined by bio-assay prior to treatment.

[2] Survey not complete.

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Huron	Sept. 8	80	12	4.5	2–5	8.0	600	2,808	6,000	0
Iron	Sept. 15	59	4	3.5	2–6	9.5	374	1,750	2,900	0
Middle	Sept. 24	15	10	5.5–4.0	2–5	12.0	100	468		
	Sept. 28	44	20	4.7		12.0	268	1,179	3,200	0
Poplar	Sept. 24	10	10	4.8	2–5	12.0	74	346		
	Sept. 26	13	8	5.3		7.5	96	422	1,900	0
Amnicon	Sept. 24	27	15	5.5	3–7	11.0	347	1,624	2,100	0
Sucker	Oct. 10	42–88	40	9.0	2–9	12.0	424	1,866	7,400	59
	Oct. 12			6.0		7.5				
Rock	Oct. 23	13	18	18.0	3–11	20.0	343	1,509	[2]	[2]
Chocolay	Oct. 29	150	34	6.0	2–6	19.5	1,348	6,309	[2]	[2]
	Oct. 31			6.0		12.0	1,230	5,412		
	Nov. 1			8.0		12.0				

[1] Determined by bio-assay prior to treatment.

[2] Survey not complete.

remainder of the stream, but post-treatment surveys revealed a number still alive. The bio-assay had indicated a minimum lethal concentration of 2.0 ppm at 55°F (Table 9). This rate was maintained in spite of a rise in flow from 42 cfs to 88 cfs, but cold weather dropped the water temperature to 39°F. The colder water retarded the activity of the free phenol and ammocoetes in the lower sections were not exposed to the chemical long enough to give a complete kill.

Damage to fish was very slight with the exception of one species. Stonecat (*Noturus flavus*) were greatly reduced, if not eradicated, in the Middle, Poplar, and Amnicon Rivers in Wisconsin. Other fish found dead in small numbers included walleye, northern pike, yellow perch, small white suckers, longnose dace, blacknose dace, redbelly dance, troutperch, logperch, small burbot, northern creek chub, brook stickleback, shiners, darters, and sculpin. Invertebrates killed in numbers included freshwater scud, burrowing mayflies, and earthworms.

The data collected from the eight streams have not been thoroughly analyzed, but preliminary examination indicates that chemical methods are effective and promise early control of sea lamprey.

Lamprey ammocoetes in samples collected from the eight streams totalled 17,136 of which 10,119, or 59 percent, were sea lamprey. The percentage of sea lamprey ammocoetes ranged from 32 percent in the Iron River to 94 percent in the Amnicon River. Five percent of the sea lampreys collected were in the transformation stage.

LAMPREY CONTROL AND RESEARCH

by Co-operating Agencies

Many of the states bordering the Great Lakes and the Province of Ontario, while no longer actively engaged in attempts to control sea lamprey, have continued to assist the Commission's agents whenever possible. The states of Michigan and Wisconsin have, on the other hand, continued several lamprey projects. In 1958 the Wisconsin Conservation Department operated 18 of the electrical barriers on Lake Michigan streams. Details of the catch of lamprey, which totalled 8,170, are included in the report of the Bureau of Commercial Fisheries (page 34).

The studies carried out by the Michigan Department of Conservation have been concerned principally with the abundance, distribution and migrations of lamprey ammocoetes in both streams and bays at the mouths of streams, and also the duration of the ammocoete stage. In 1958, 10 Lake Superior streams and 7 Lake Michigan streams

were surveyed to determine the presence or absence of sea lamprey ammocoetes and the upstream limits of their distribution.

An inclined-plane trap, which has been operated in the Carp Lake River, Emmett County, since 1950 to capture ammocoetes migrating downstream, and to prevent the spawning of adults upstream, took 4,796 transformed sea lamprey. The continued presence of these ammocoetes strongly suggests that larval life of sea lamprey may be considerably longer than the 4 or 5 years commonly assigned. Unfortunately, the possibility that sea lamprey have spawned above the barrier in the period 1950–54 cannot be excluded. Annual checks of spawning areas and larval populations since 1955 have shown no subsequent recruitment to the population. A gradual increase in the average size of the ammocoetes since 1955 is further indication that there has been no recent spawning above the barrier.

A total of 1,874 ammocoetes were collected at four stations above the barrier on the Carp Lake River, marked with cadmium sulphide and released. It is expected that recoveries of these individuals in the trap, or by sampling in the streams, will provide information on population density, migrations and mortality rates.

In 1957 sea lamprey were found at several localities along the north shore of Lake Michigan, some more than a mile from the nearest stream. A more detailed examination of one of these areas in Ogontz Bay was carried out in 1958. The study area of 146 acres extended from the shore to a depth of 5 feet. Bottom samples were taken with an "orange peel" dredge. Although only nine sea lamprey were taken, and estimates of total numbers cannot be made with any degree of precision, substantial numbers appear to be present in the test area. Most of the individuals taken were more than four inches long.

Returns from the marking experiments in the Chocolay River continued to show that most, and perhaps all, of the ammocoetes move downstream and not upstream.

Examination of streams which enter the lakes of Michigan's Inland Waterway have disclosed moderate numbers of sea lamprey ammocoetes in the Maple and Sturgeon, tributaries of Burt Lake; the Pigeon River, which enters Mullett Lake; and Laperell Creek, a tributary of the Cheboygan River. Although scarred fish have been reported in recent years, no serious effects on the fish populations of the Waterway have as yet been found.

The ammocoetes of the five species of lamprey now found in the Great Lakes are difficult to identify. Characteristics used to distinguish sea lamprey ammocoetes from ammocoetes of American brook and silver lamprey have been discovered and applied with considerable confidence in field identification. Ammocoetes of two species, the

northern brook and chestnut lamprey, have continued to resist specific identification until this year. A study of an extensive series of ammocoetes of these species has been made and methods developed for separating them, largely on the basis of "pigmentation" of the tail region and lateral-line organs.

LAKE TROUT CATCH STATISTICS [1]

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

No commercial production of lake trout was again reported for United States waters of Lake Michigan in 1958. A catch of 5 pounds was reported for United States waters of Lake Huron, as against none for 1957. In Canadian waters of Lake Huron, lake trout production is now almost completely restricted to the southern half of Georgian Bay. Georgian Bay catches continued to decline in 1958 (Table 1).

TABLE 1.—Commercial landings of lake trout in Georgian Bay, Lake Huron 1948–1958.

Year	Thousands of pounds	Year	Thousands of pounds
1948	296	1954	151
1949	290	1955	70
1950	326	1956	45
1951	473	1957	20
1952	491	1958	11
1953	321		

[1] Includes 1958 data compiled after the Annual Meeting.

The decline in lake trout production continued in Lake Superior in 1958, but at a greatly reduced rate. (Table 2). The 1958 total of 1,445,000 pounds was only 59,000 pounds below the 1957 figure of 1,504,000, whereas the latter catch represented a drop of 835,000 pounds from the 1956 catch of 2,339,000 pounds. The take of trout decreased in all three states in 1958 but Ontario production rose 72,000 pounds.

Indices of lake trout production, abundance and fishing intensity have been computed by the Bureau of Commercial Fisheries for Michigan waters of Lake Superior, using the mean for the period 1929–43

TABLE 2.—Commercial landings of lake trout in Lake Superior by states and province, 1950–1958.

Year	(Thousands of pounds)				
	Michigan	Wisconsin	Minnesota	Ontario	Total
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	395	202	1,266	3,472
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

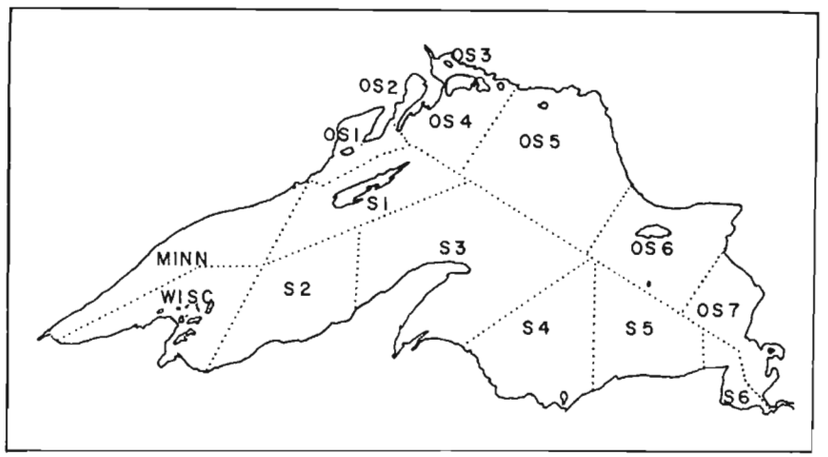
as a base of 100 (Table 3). It is probable that estimates of abundance are too high and those of fishing intensity too low, for there has been a change from cotton and linen gill nets, fished during the base period, to more efficient nylon nets. Exact information on the course of the changeover to nylon is lacking, but it apparently was rapid, and nylon nets seem to have become the dominant type by 1950.

The continued substantial decline in fishing intensity gives cause to doubt the reality of the indicated improvement of abundance in 1958. Less competent fishermen may have been forced out of the fishery by economic pressures and those remaining may well be concentrating their efforts on the best grounds at the best seasons. A reduction in the amount of gear on the fishing grounds may improve the effectiveness of the nets remaining. All these factors combine to further a fishing success not accurately descriptive of the actual abundance of lake trout.

TABLE 3.—Indices of production, abundance, and fishing intensity for lake trout in State of Michigan waters 1950–1958, as percentages of the 1929–43 means.

Year	Production	Abundance	Intensity
1950	116	80	146
1951	105	76	137
1952	101	75	133
1953	85	71	121
1954	78	64	122
1955	67	68	103
1956	59	63	98
1957	41	58	72
1958	20	60	64

The downward trend of fishing quality that has occurred throughout Lake Superior (Table 4) has been severe in some waters (S-1), but lacking in others (S-5). The districts in the United States that have provided the best fishing in recent years (S-5, S-6, and S-1) also gave the best returns per unit of effort in the period 1929–1943.



Fishery statistical districts of Lake Superior.

Trends in fishing pressure in the state of Michigan waters have varied somewhat from area to area, but the greatest drop in fishing pressure has come within the last three or four years (Table 5).

TABLE 4.—Catch of lake trout per lift of large-mesh gill nets (4½ inch and greater) in U. S. statistical districts of Lake Superior, 1950–1958, and Canadian districts, 1953–1958, in pounds per 10,000 linear feet.

Year	Minnesota	Wisconsin	Michigan						Ontario						
			S-1	S-2	S-3	S-4	S-5	S-6	OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7
1950	218	154	258	155	129	142	201	254	.	.	.	.	.	.	.
1951	169	158	227	147	145	150	164	189	.	.	.	.	.	.	.
1952	142	152	227	133	118	140	193	234	.	.	.	.	.	.	.
1953	141	154	185	141	109	121	229	231	191	177	222	227	335	115	187
1954	172	145	164	118	104	111	198	216	237	172	253	213	412	161	189
1955	153	162	179	177	100	112	221	171	209	160	184	180	240	151	139
1956	135	142	126	198	97	110	213	154	154	94	115	116	211	124	98
1957	155	112	115	137	103	92	216	132	120	77	69	116	157	106	111
1958	163	136	130	163	104	102	187	165	227	126	96	199	117	221	107
Average	161	146	179	152	112	120	202	194	190	134	157	175	245	146	139
1929–43		.	227	158	158	205	338	240							

TABLE 4.—Catch of lake trout per lift of large-mesh gill nets (4½ inch and greater) in U. S. statistical districts of Lake Superior, 1950–1958, and Canadian districts, 1953–1958, in pounds per 10,000 linear feet.

Year	Minnesota	Wisconsin	Michigan						Ontario						
			S-1	S-2	S-3	S-4	S-5	S-6	OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7
1950	218	154	258	155	129	142	201	254	..	..		..	..	..	..
1951	169	158	227	147	145	150	164	189	..	..	..	..	..	.	..
1952	142	152	227	133	118	140	193	234				..	.		
1953	141	154	185	141	109	121	229	231	191	177	222	227	335	115	187
1954	172	145	164	118	104	111	198	216	237	172	253	213	412	161	189
1955	153	162	179	177	100	112	221	171	209	160	184	180	240	151	139
1956	135	142	126	198	97	110	213	154	154	94	115	116	211	124	98
1957	155	112	115	137	103	92	216	132	120	77	69	116	157	106	111
1958	163	136	130	163	104	102	187	165	227	126	96	199	117	221	107
Average	161	146	179	152	112	120	202	194	190	134	157	175	245	146	139
1929–43			227	158	158	205	338	240					..		.

TABLE 5.—Quantities of large-mesh gill nets lifted in the lake trout fishery for United States statistical districts of Lake Superior, 1950–1958, and Canadian districts 1953–1958, in units of 10,000 linear feet.

Year	UNITED STATES									CANADA								Grand Total
	Minnesota	Wisconsin	Michigan						Total	Ontario							Total	
			S-1	S-2	S-3	S-4	S-5	S-6		OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7		
1950	928	2,939	1,140	724	5,449	2,686	1,548	648	16,062	..		.	..	..	..	..	..	16,062
1951	1,380	2,723	1,315	706	4,557	3,102	1,701	730	16,214	..	..	..	..	..	..	..	.	16,214
1952	1,714	2,903	1,515	564	5,507	3,262	1,112	617	17,194	..	..	.	.	..	..	..	.	17,194
1953	1,541	2,707	1,564	443	5,241	3,202	777	656	16,131	895	364	386	967	693	1,847	1,262	6,414	22,545
1954	1,227	2,721	1,524	320	5,209	2,991	1,121	703	15,816	895	408	393	908	306	1,508	1,253	5,671	21,487
1955	1,114	3,218	1,185	323	4,914	2,617	856	502	14,729	870	408	374	893	630	1,362	944	5,481	20,210
1956	812	3,195	1,686	448	3,970	2,381	767	475	13,734	595	311	517	813	392	421	667	3,716	17,450
1957	353	2,396	698	260	3,133	2,258	631	414	10,143	274	319	259	699	285	390	605	2,831	12,974
1958	205	1,770	444	184	3,004	1,852	722	215	8,396	387	273	310	463	330	75	749	2,587	10,983
Average	1,031	2,730	1,230	441	4,554	2,706	1,026	551	14,269	653	394	373	791	439	934	913	4,450	

TABLE 5.—Quantities of large-mesh gill nets lifted in the lake trout fishery for United States statistical districts of Lake Superior, 1950–1958, and Canadian districts 1953–1958, in units of 10,000 linear feet.

Year	UNITED STATES									CANADA								Grand Total
	Minne-sota	Wis-consin	Michigan						Total	Ontario							Total	
			S-1	S-2	S-3	S-4	S-5	S-6		OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7		
1950	928	2,939	1,140	724	5,449	2,686	1,548	648	16,062	..	..	..	..	..	..	..	..	16,062
1951	1,380	2,723	1,315	706	4,557	3,102	1,701	730	16,214	..	..	..	..	..	..	..	..	16,214
1952	1,714	2,903	1,515	564	5,507	3,262	1,112	617	17,194	..	..	..	..	..	..	..	..	17,194
1953	1,541	2,707	1,564	443	5,241	3,202	777	656	16,131	895	364	386	967	693	1,847	1,262	6,414	22,545
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SUMMARY REPORTS OF FISHERY RESEARCH ON THE GREAT LAKES IN 1958

Research by Bureau of Commercial Fisheries United States Fish and Wildlife Service

Lake Superior investigations

Routine observations of lamprey scaring on lake trout landed at Marquette has shown a halt in the upward trend noted since observations began in 1949. The scarring during October and November was considerably lower than for the same period in 1957. The decrease can be attributed, however, to a drop of over 50 percent in the average weight of the trout taken. In general, large lake trout are more likely to bear lamprey scars than small trout. Records submitted by commercial fishermen in the State of Michigan indicate increased scarring in the vicinity of Isle Royale and the Keweenaw Peninsula. For State of Michigan waters as a whole, the scarring rate increased from 27.0 percent in 1956 to 37.6 percent in 1957. Examination of the commercial catch for the collection of biological materials has been limited largely to Marquette, Michigan.

It has been possible this year to broaden observations on commercial landings of lake trout and arrange with fishermen for more efficient reporting of recaptured hatchery fish.

In the spring of 1958 the rebuilt and refitted research vessel *Siscowet* was assigned to Lake Superior. Its operations were limited to the western end of the lake where eight scheduled cruises were devoted alternately to sampling fish populations and limnological conditions, and studies of the distribution and movements of the lake herring during the summer and early fall when they are largely unavailable to the fishery. Some difficulty was experienced in locating herring in abundance, but the general movements and distribution were determined and the importance of temperature and plankton as factors influencing their distribution established.

Inquiries into the age and size composition and growth rate of whitefish from different areas has demonstrated the existence of a number of different stocks with widely different growth rates. Mean lengths at the end of six years of life ranged from as little as 15.8 inches in the Apostle Islands to 22.4 inches at Whitefish Point. Whitefish may be under-exploited in some areas because of the inability of most individuals to live long enough to reach the present legal minimum size in Michigan and Wisconsin of 17 inches.

Green Bay investigations

Study of the walleye in Green Bay continued with the completion of age determination for all collections from 1949 to 1958 and the application of these data to the catch by the commercial fishery. Calculations confirmed earlier judgment that the 1943 year class contributed approximately 3 million pounds to the commercial fishery. It was largely responsible for three successive years of record-high production in 1948–1950. The strength of year classes after 1943 fluctuated widely, and some approached the strength of the 1943 year class at early ages. Their total contributions have been limited, however, by the greatly increased mortality rate within the population. Commercial exploitation cannot account for these changes and lamprey attack may have contributed to the higher mortality. The rapid expansion of a sport fishery for walleye may also have been a factor, but dependable statistics on the sport fishery are lacking. Walleye studies in 1958 included a tagging program carried out cooperatively with the Michigan Department of Conservation.

The studies of age, year class strength, growth, and abundance of yellow perch in different areas of Green Bay continued. The collections, which were started in 1948, now have accumulated to the point that the major regional differences in age and size composition and in growth rate are well established. Problems as to the actual number of different stocks and the extent of their intermingling and seasonal movements and evidence of segregation within a single stock on the basis of sex and growth rate promise severe difficulties in more detailed analyses.

The alewife, a recent immigrant to Lake Michigan, has become tremendously abundant in the last two years. Studies of the alewife have been limited, by lack of staff and adequate facilities, to the collection of general information on spawning season, grounds and behavior, and the age and size composition of fish caught in small-mesh pound nets.

Lake Erie investigations

During 1958 the Bureau continued to collect information on the ecology and life history of 10 of the 15 principal species in Lake Erie with Ontario and Ohio agencies concentrating on the remaining 5. A contract for the study of food habits of 9 species was awarded to the Natural Resources Institute of the Ohio State University. A special study of larvae and young fish was supported with the view of developing a taxonomic key.

Experimental fishing with trawls and other gear to trace changes in size, species composition and abundance of principal species was

continued with the *Musky;* commercial landings were sampled periodically.

Limnological-fishery surveys

The *Cisco* was reassigned to Lake Erie in 1958 to carry out limnological and fisheries studies in the western region which supports the lake's most productive commercial operations. Ten 2-week cruises were carried out between April 19 and November 1. The first half of each cruise was devoted to experimental fishing and hydrographic observations. Included in the schedule were three 3-day "synoptic" cruises conducted by three or four vessels which yielded good information on the general path and variability of the course of flow from the Detroit River.

The analyses and tabulations of limnological data collected in earlier surveys, principally by the *Cisco,* have been completed in some instances, or are continuing. The status of these projects is as follows:

Light penetration. A report has been published on the relation between light penetration and Secchi-disc readings in Saginaw Bay and contiguous waters of Lake Huron.

Currents. A report on surface currents in Lake Huron in 1956, based on recoveries of drift bottles, has been completed and submitted for publication. Similar work, based on releases in Lake Michigan in 1954 and 1955 is well advanced. Several techniques have been employed in studies of currents in Saginaw Bay, Green Bay, and Lake Superior in 1958: release of drift bottles; observations of drift buoys (drogues); release of dye at the surface and at various depths (subsurface movements of dye followed by a diver); collection of vertical series of temperature records to permit comparison of observations with estimates of currents computed by the "dynamic-height" method.

Seiches. Some further work has been done on a study of seiches in Lake Michigan, based on limnographs of water-level fluctuations supplied by the U. S. Lake Survey.

Bottom sediments. Analysis has been completed of materials from Saginaw Bay, 1956, and a manuscript prepared on median particle size, deviation from median, sphericity, organic and inorganic content; and heavy and light minerals. This report has been submitted as a doctoral dissertation by Leonard Wood, Department of Geology, Michigan State University.

Bottom organisms. Organisms have been removed, sorted and identified for all collections made in 1951–1957. A report on the 1957 samples from Lake Erie has been received and another, on the Lake Michigan fauna, is expected by the end of 1958.

Plankton. The first draft of a manuscript on the vertical migration and seasonal abundance of planktonic Crustacea in Lake Michigan has been completed.

Chemistry of lake waters. Analyses have been completed as follows: Lake Michigan, 1955, Na, Ca, Mg, SiO_2; Saginaw Bay, 1956, Na, Ca, Mg, K; Lake Erie, Detroit River, Lake St. Clair, and St. Clair River, fall of 1957, Na, Ca, Mg, SiO_2, specific conductance; Lakes Erie and Superior, spring and autumn of 1958, Na, Ca, N, Mg, SiO_2, SO_4, P.

Photosynthesis. Studies have been completed on the relation between photosynthetic rate and diurnal fluctuations in light penetration in Frains Lake (highly eutrophic inland lake), Lake Erie, and Lake Michigan.

Limnological data on Lake Superior, 1952–1957. This report records extensive data but undertakes no detailed analysis. Temperature data include records of bathythermograph casts (from *Cisco* in 1952 and 1953 and by U. S. Lake Survey in 1956 and 1957), surface readings and records from thermographs on Stannard Rock, in Marquette Harbor, and at the Calumet-Hecla intake. Chemical records include Na, Ca, Mg, SiO_2, total P, dissolved N, O_2, total alkalinity, and specific conductance. Records of plankton include wet, dry, and ash weight.

Synoptic survey of Saginaw Bay. Practically all analyses have been completed of bottom fauna and water samples collected from Saginaw Bay on three synoptic surveys made in 1956 in cooperation with the Michigan Department of Conservation. A report on the currents and water masses is being prepared.

Sources of meteorologic and hydrographic data. This project is carried out under contract by the Great Lakes Research Institute, University of Michigan. Work has been completed and the final report submitted on the first phase, a listing of sources of data with records of kinds of information, period of years covered, and an appraisal of possible dependability. The second phase, a test within a limited geographical area (western Lake Erie) of the applicability of the data to limnological and fishery problems was started in mid-year.

Research by the Fisheries Research Board of Canada

In 1957 the Fisheries Research Board began the collection of biological data from near-random samples of commercial landings of lake trout at the principal Canadian fishery ports. This program was continued in 1958 and analysis of these and earlier data collected by the Ontario Department of Lands and Forests begun. Investigations

in Georgian Bay which began in 1957 in cooperation with the Department of Lands and Forests continued with sampling of the commercial catch of trout and a tagging study of an isolated lake trout population in Parry Sound.

Research by Minnesota Department of Conservation

Minnesota's fishery research activities on Lake Superior in 1958 were limited to the collection of information on the scarring of lake trout caught in the vicinity of Isle Royale and examined at Duluth. The percentage of scarred fish rose from 33.8 percent in 1957 to 39.7 percent in 1958.

Research by Wisconsin Conservation Department

Wisconsin continued to plant marked lake trout and collect information on recapture. A planting of 183,964—16-month-old lake trout brought the total number of marked fish planted since 1952 to 1,192,000. The number of recaptured fish reported reached 4,211 at the end of 1958. Most of the recaptures have come from the Apostle Islands area where the plantings were made. Several mature marked fish have been captured during spawn-collecting operations.

Tagging of undersize whitefish from commercial pound nets in Lake Superior, which began in 1955, was continued in 1958. A total of 457 fish were released in the vicinity of Red Cliff with streamer tags attached. Brown trout and rainbow trout were tagged in four Lake Superior tributaries to determine extent of migration.

A record of lamprey scarring was again kept during spawn-taking operations in the Apostle Islands area. A reduction in the percentage of fish scarred from 79.2 in 1957 to 67.4 was accompanied by a decrease in their size.

Research by Michigan Department of Conservation

Rainbow trout

The experimental stocking of rainbow trout which began in 1955 was continued in 1958. By October 2, a total of 90,418 rainbow trout had been released and 2,493 recovered (91 percent by anglers). During 1958 no further recaptures were made of fish planted in 1955, and only 28 from the 1956 plant; few additional recoveries are expected.

A comparison of returns from three strains stocked in 1957 indicates that domestic (from hatchery brood stock) and wild rainbow trout from Michigan produced substantially the same percentage of

recovery of fish showing lake growth. Steelhead from the West Coast produced only half as great a return.

The 1958 plantings included 7,477—2-year-old domestic, 500—1-year-old domestic, 3,930—3-year-old West Coast "steelhead," and 6,462 3-year-old Michigan wild rainbow trout. Most of the fish were stocked in Lake Superior where sea lamprey predation is known to be less severe than in Lakes Michigan and Huron.

An evaluation of the retention and effect of different tags on rainbow trout held in the Thompson Hatchery was continued in 1958. An inquiry into the diversion of spawning rainbow trout by lamprey barriers was continued also.

Walleye in Lake Michigan

Examination of spawning walleye in the Muskegon River in 1958 provided a few additional recoveries of tagged fish. Lamprey scars were found on 1.9 percent of the fish and approximated the same percentage as the previous four years. The incidence of lymphocystis continued its upward trend from 0.3 percent in 1952 to 7.0 percent in 1958.

A joint tagging study of walleye in the Bay de Noc area, Lake Michigan, which began in 1957, was continued in 1958. Smallmouth bass taken in these operations were also tagged.

Parasitization of yellow perch in Saginaw Bay

An interesting number of inquiries from anglers regarding a "red worm", *Philonema*, in yellow perch caught in Saginaw Bay, Lake Huron and Brest Bay, Lake Erie, has led to a study of the distribution of this nematode and the degree of infestation. About 40 percent of the perch collected from Saginaw Bay and 15 percent of those taken in Lake Huron off Alpena were infested.

Sport fishery statistics

The general creel census conducted by conservation officers, although directed primarily to fisheries in inland waters, has continued to provide some information on the species composition of the catch by anglers in the Great Lakes. In the last five years yellow perch far exceeded all others in the catches. Rock bass, walleye, northern pike and smallmouth bass occurred regularly in the anglers catch in Lakes Michigan and Huron. Pumpkinseed, smelt and largemouth bass contributed substantially to Lake Huron catches, and round whitefish and lake trout in the catches of the few anglers on Lake Superior.

Research by Ohio Department of Natural Resources

Ohio conducted a sport fishing survey of the island area of Lake Eric in 1958 to determine the extent and quality of the harvest by anglers fishing from boats. An estimated 171,200 anglers fished the 180 square mile area from June 26 to December 3, and took an estimated 5,470,000 fish. Approximately 93 percent of the fish taken were yellow perch with an estimated total weight of 1,309,000 pounds.

Trawl sampling of fish populations was continued at index stations in order to compare annually the abundance of young of various species. At the same time the development of gear and methods potentially useful for harvesting smelt was studied.

A study of the life histories of channel catfish and white bass was initiated. A search was made for smelt spawning runs in Ohio waters, but none were found. Some 32 million walleye fry were stocked in Lake Erie to determine the value of this practice in increasing the harvest of this species.

Research by Pennsylvania Fish Commission

Research on Lake Erie by the Fish Commission was concerned chiefly with the establishment of rainbow trout populations in streams tributary to Lake Erie. Trout have dispersed widely in the lake and those recovered exhibit typically rapid growth. General observations were made on the quality of commercial and sport fishing, and commercial catches were examined periodically for sea lamprey scarring.

Research by New York Conservation Department

During 1958, the State of New York continued to plant lake trout in Lake Ontario in cooperation with the Province of Ontario. A planting of 5,130 marked lake trout fingerlings from Seneca Lake was made during the fall, between Charity Shoal and Main Duck Island. A total of 405 marked lake trout, the majority from a fall planting in 1956, were recovered during 1958. Some 250 checked by biologists showed no lamprey scarring.

Research by Ontario Department of Lands and Forests

Fishery research in the Great Lakes by the Ontario Department of Lands and Forests was largely confined to Huron, Erie and Ontario, with the Fisheries Research Board assuming responsibility for research

in Lake Superior. The Department, however, continued its routine collection of information on the incidence of sea lamprey scars in all the lakes.

Lake Huron

The experimental fishery begun in South Bay in 1947 was continued in 1958. A total of 59,894 pounds of fish representing 30 species were taken. Over 1,000 fish from pound nets were tagged and released for population estimates, growth and movement studies. Since 1947 there have been marked changes in the abundance of fish which are not the result of fishing operations. The sea lamprey has become plentiful and in the last seven years, alewife have become very abundant. Native lake trout have disappeared and the cisco populations have declined markedly. The biological data for lake trout and bass have been analyzed and fluctuations in abundance interpreted, but detailed study of other species remains to be undertaken.

A creel census of the sport fishery of South Bay, which began in 1947, has provided information on the production of lake trout and smallmouth bass. The biological material collected and analyzed has shown that the strength of year classes of bass between 1944 and 1955 was correlated with deviations from long term mean air temperature. The data collected in 1958 confirmed the prediction, based on temperature, that the 1955 year class would be strong.

Studies of lake trout were concerned initially with a native population, but since its disappearance, with planted trout. Several papers dealing with the survival of lake trout under lamprey predation have been published.

When it became clear that lake trout could not survive to maturity in Lake Huron, a program to develop an early-maturing deep-swimming trout was begun, using a hybrid between the speckled trout and the lake trout, as a basis for artificial and natural selection.

Artificial selection is made first on the ability of individuals to retain gas in their swim bladders when confined for several days in a pressure tank. Individuals which mature first in this select group are retained for breeding purposes. The following groups were undergoing artificial selection in 1958: (1) fish produced by back-crossing first generation hybrids with speckled trout; (2) second generation hybrids.

Natural selection of the desired qualities is expected to take place among first generation hybrids, and the young of first generation hybrids crossed with lake trout planted in South Bay and Georgian Bay. It is probable that the shallow-swimming fish will be at a disadvantage in these waters for the temperature they prefer will be found at a considerable depth during the summer. The survivors will

be exposed to increasing lamprey predation as they grow larger and the late-maturing individuals will probably be destroyed before they reproduce. Approximately 30,000 hybrids have been planted in South Bay and 157,000 in northern Georgian Bay.

During the past decade the whitefish in Georgian Bay have gone through a complete cycle from extreme scarcity in 1947 to great abundance in 1953, and back to extreme scarcity. Tagging has shown that this population is distinct from others in adjacent waters of the North Channel, Lake Huron and South Bay, which may intermingle with them during certain seasons. Sampling of the commercial catch of whitefish in Georgian Bay was initiated in 1957 with the help of the Fisheries Research Board and continued with their cooperation in 1958. In 1958 the fish population throughout Georgian Bay was sampled with experimental gill nets in a prescribed grid pattern. Only 2 lake trout and 10 whitefish were taken in a catch of some 17,000 fish.

Difficulty in interpreting the age of whitefish has led to the injection of 262 whitefish with a lead versanate solution which leaves a reference mark on the scales. Recaptures in 1958 have shown that this technique will be helpful in scale reading.

The problem of net selectivity received attention in 1958 and a number of experiments with several species of fish were carried out in a tank. This approach proved unsatisfactory and it was later found that a plot of the girth of whitefish taken by a particular mesh size gave a near-normal curve from which the most vulnerable size could be determined.

Lake Erie

Sampling of the commercial catch, which began in 1954, was continued during 1958 by crews stationed at Port Dover and Wheatley. A special effort has been made to collect and analyze the biological material for blue pike. In 1958 some preliminary information was obtained on the early life history of this species. Major spawning areas were located, developing eggs obtained, but attempts to collect young-of-the-year were unsuccessful.

The collection of general information on smelt movements, abundance and concentrations continued. Tagging operations were shifted to Lake St. Clair to obtain information on the movement of walleye between this lake and Lake Erie, and their possible contribution to populations in western Lake Erie.

Lake Ontario

Continued study of the whitefish population in eastern Lake Ontario has provided no evidence of a relationship between commercial production and planting of whitefish fry. Analysis has now

been directed toward a measurement of factors influencing year class success. Experimental netting has been undertaken to obtain information on age classes before they enter the commercial fishery.

Marking and planting of lake trout in Lake Ontario by Ontario in co-operation with New York State was continued in 1958. Recaptures in commercial and experimental fishing have shown that initial growth and survival is excellent, but predation by sea lamprey is believed high, for few trout survive beyond their fourth year. Trout of New York origin have generally shown better survival than those from Ontario.

A population of walleye in the Bay of Quinte which is exploited by both commercial fishermen and anglers, was studied in 1957 and again in 1958 by means of experimental netting, tagging, examination of the commercial catch and a creel census of the sport fishery.

Other projects include a preliminary study of the life history and migration of the American eel in Lake Ontario and tributary waters, experimental rearing of whitefish, and the production of reciprocal hybrids between cisco and whitefish, to aid in identifying natural hybrids.

Limnological investigations

During 1958 the Department supported, on a trial basis, an expanded program of physical limnology. A research vessel on loan from the Royal Canadian Navy was operated from July 1 to November 15 in Lake Ontario. Lake-length cruises were made twice monthly and west-basin cruises weekly.

Research by the Great Lakes Research Institute
University of Michigan

The Great Lakes Research Institute of the University of Michigan continued limnological and geological studies of the Great Lakes in 1958. The following studies were in progress during 1958:

1. Seiches of the Lake Michigan-Lake Huron systems.
2. Distribution of benthic fauna in the Straits of Mackinac region in relation to the mechanical nature of the lake sediments.
3. Evaluation of quantitative methods for measuring biological productivity in the Great Lakes.

Field work was completed and manuscripts are being prepared for the following projects:

1. Water transport studies in the Straits of Mackinac.
2. Geological interpretation of the Straits of Mackinac based upon bathymetric data and the nature of surface sediments.

3. Comparative studies of primary productivity in a series of northern Michigan lakes and Lake Huron.
4. The standing crop of benthic fauna at three stations in the Straits of Mackinac.
5. The relationship of bottom slope and sediment nature to numbers of benthic organisms.
6. Preliminary observations on unusual phytoplankters in Lakes Huron and Michigan.
7. Sediments and hydrography of Grand Traverse Bay.

A report entitled "Currents and Water Masses of Lake Michigan" was published by the Institute in 1958. Another report listing collateral data, available from various sources, of possible value to fishery and hydrographical studies in the Great Lakes, was prepared under contract for the Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service.

Research by the Natural Resources Institute
Ohio State University

The Natural Resources Institute of Ohio State University is responsible for the administration of a grant for fisheries research provided by the Ohio Division of Wildlife, and for the operation of the Franz Theodore Stone Laboratory. Collateral research in fishery biology, with support from other sources, has been conducted under the auspices of the Institute.

The following studies were underway in 1958:

1. Age and growth of the channel catfish, *Ictalurus punctatus,* in western Lake Erie.
2. A study of the food habits of the white bass, *Roccus chrysops,* of western lake Erie.
3. A study of the food habits of the channel catfish.
4. The biology of Lake Erie microcrustacea.

A report by Dr. Charles C. Davis entitled "An approach to some problems of secondary production in the western Lake Erie region" was published early in 1958. Dr. Davis has also completed reports on:

1. Damage to fish fry by cyclops.
2. Osmotic hatching in the eggs of some fresh-water copepods.
3. A planktonic fish egg from fresh water.