ANNUAL REPORT

GREAT LAKES FISHERY COMMISSION

1964

GREAT LAKES FISHERY COMMISSION

MEMBERS — 1964

CANADA	UNITED STATES
A. O. Blackhurst	D. L. McKernan
J. R. Dymond	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

1964

1451 Green Road
ANN ARBOR, MICHIGAN,
U. S. A.
1966

ANNUAL REPORT FOR 1964

INTRODUCTION

The Great Lakes Fishery Commission was established by the United States and Canada in accordance with the terms of the Convention on Great Lakes Fisheries ratified in 1955. The Commission's duties are as follows:

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

During its early years, the Commission gave most of its attention to control of sea lamprey, because of its destruction of lake trout and damage to other valuable species. The program, which is supported by funds supplied to the Commission by the two countires, is carried out under contracts with the U. S. Bureau of Commercial Fisheries and the Fisheries Research Board of Canada.

The control program is based on the chemical treatment of streams in which young lamprey spend their early life before becoming parasitic and entering the lakes. The chemical is selectively toxic to sea lamprey, and at the low concentrations used, is relatively harmless to valuable fishes present during treatment.

Treatment of Lake Superior streams used by lamprey began in 1958, and in 1962, the numbers of spawning adults taken at electrical barriers which were maintained on certain streams to follow changes in abundance, dropped to about 20 percent of the average catch for the preceding 5 years. Catches in 1963 and 1964 did not show any further significant change in lamprey abundance.

The reduction in the sea lamprey population in Lake Superior resulted in an immediate improvement in survival of lake trout and an increase in their abundance and size. However, recovery of the population has been delayed by the lack of natural reproduction in many areas since 1959 and a scarcity of young fish. Hatchery-reared trout have offset to some extent the failure of natural reproduction, particularly in Wisconsin waters where substantial numbers have been planted since 1954. A resumption of spawning appears to have begun in the fall of 1964 when lake trout appeared in significant numbers on several spawning grounds and mature fish were found in greater numbers throughout the lake.

The chemical treatment program was extended to Lake Michigan and Lake Huron in 1960, but was discontinued in the latter lake to permit a greater effort on Lake Superior and Lake Michigan. Seventy-eight Lake Michigan streams, representing approximately 75 percent of those producing sea lamprey have been treated.

Several agencies were engaged in extensive investigations of the Great Lakes fishery when the Commission was established. After a review of the progress of this work in 1959 and 1960, the Commission recommended the extension of certain investigations, particularly in the field of technology and economics. In 1964, the Commission submitted a prospectus for investigation of the fishery, describing in some detail the studies required for a better understanding of the biological, technological, and economic problems of the commercial and sport fisheries, and the development of measures to improve production. At the end of 1964, the Commission began organizing technical committees for each lake, composed of representatives of the agencies concerned, to develop programs and coordinate activities on a more formal basis than had been possible previously.

In 1964, the two countries reviewed the Convention and the progress made by the Commission. It was agreed that a fourth commissioner be added by each country and that the Commission made an economic study of sea lamprey control and lake trout rehabilitation. A second review of the Convention was proposed for 1966.

1964

ANNUAL MEETING

AGENDA

1. Call to order.
2. Adoption of agenda.
3. Approval of Minutes of Interim Meeting.
4. News release on meeting.
5. Report of Chairman.
6. Progress reports on sea lamprey program.
7. Report of Lake Trout Rehabilitation Committee.
8. Review of 1964-65 program of sea lamprey control and research.
9. Consideration of 1965-66 program.
10. Prospectus for investigations of the Great Lakes fishery.
11. Report of meeting on walleye fishery in Lake Erie.
12. Administrative matters.
13. Other business.
14. Time and place of next meeting.
15. Election of officers.
16. Adjournment.

ANNUAL MEETING

PROCEEDINGS

The Ninth Annual Meeting of the Great Lakes Fishery Commission was held in Ann Arbor, Michigan on June 17-18, 1964.

Call to order. The Chairman of the Commission, Dr. A. L. Pritchard called the meeting to order at 9:00 a.m. Following introduction of the Commissioners and advisors, scientists and observers from both countries were presented.

Adoption of agenda. The tentative agenda was approved by the Commission after minor revisions.

Approval of Minutes of Interim Meeting. Minutes of the Interim Meeting held in Ottawa on December 3-4 were approved.

News release on meeting. Commissioners Claude Ver Duin and J. R. Dymond and the Executive Secretary were appointed by the Chairman to review press releases of the meeting prepared by the University of Michigan News Service.

Report of Chairman. The Chairman reported that catches of sea lamprey at barriers on Lake Superior in the spring of 1964 showed no change in the level of abundance established after the sharp decline in 1962. Some recently discovered lamprey streams had been treated, but it was not certain that this action would cause a further reduction. Lake trout populations continued to improve.

The schedule of stream treatments on Lake Michigan was being maintained despite difficulties with extensive tributary systems, dense populations of game fish, and high lampricide requirements. Although the use of a synergist had reduced the amount of chemical required, it was hard to apply accurately and risk of fish kills had limited its use.

Surveys were now completed on Lake Huron and their treatment could be resumed when the Commission decided to extend operations to that lake.

The "Prospectus for Investigations of the Great Lakes Fishery" had been completed by the Commission's staff with the assistance of scientists in both countries and would be submitted to the two governments. The Commission having indicated

the kinds of studies required should take steps to encourage the development of co-ordinated programs on the lakes.

Reports on sea lamprey program. The Commission accepted the final reports of the U. S. Bureau of Commercial Fisheries and the Fisheries Research Board of Canada describing sea lamprey operations in 1963 and received progress reports on activities during the spring of 1964.*

The Chairman emphasized the importance of studies by the Bureau on lampricide residues in plant and animal tissue. The development of analytical techniques for recovery and measurement of these residues would be an important contribution.

Report of the Lake Trout Rehabilitation Committee. The Commission considered the report of the Lake Trout Rehabilitation Committee,† and its suggestion that because of improvements in certain offshore stocks, the Commission might wish to reconsider its earlier recommendation "limiting the harvest of lake trout in Lake Superior to the fishing effort required to support necessary biological studies."

The locations of offshore populations of lake trout judged capable of supporting a moderate degree of fishing were indicated and the status of these stocks described. These populations contained a substantial proportion of mature fish and showed adequate recruitment. Few fish were of hatchery origin and the incidence of lamprey wounds was low.

The Chairman asked the National Sections to study the recommendation of the Lake Trout Rehabilitation Committee which the Commission would reconsider at the Interim Meeting.

Consideration of the 1964-65 program. The Commission reviewed the 1964-65 program approved in July 1963 and revised at the Interim Meeting in 1963, which proposed the following activities:

> Lake Superior - Treat 30 streams (15 in the United States and 15 in Canada), 4 of them for the first time; continue surveys of estuaries and stream mouths to locate ammocete populations and establish time for retreatment; operate 22 barriers in United States streams and 8 on Canadian streams.
>
> Lake Michigan - Treat 30 streams, 3 for the first time; continue surveys in streams and at their mouths to locate ammocete populations; operate 7 assessment barriers.
>
> Research - Continue testing of chemicals for use as selective lampricides and initiate studies of TFM residues in water, stream fauna and bottom sediments; develop marking techniques using radioactive materials.

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* Reports of the Bureau and Board for calendar year 1964 appear on pages 24 and 31.

† Final report of Lake Trout Rehabilitation Committee is given on page 46.

The Commission considered a reduction in the number of assessment barriers on Lake Superior as recommended by the Bureau of Commercial Fisheries. The Bureau believed barriers could be discontinued on 6 streams in the United States without seriously affecting the reliability of information on changes in lamprey abundance. This action would provide funds to reactivate several barriers on Lake Michigan. The Commission was also advised that if the number of barriers was reduced too low, the reliability of the catch data would be endangered.

At the request of the Chairman, the Scientific Advisory Committee presented the following comments on the progress of the program and plans.

> Members of the Committee, with one exception, are of the opinion that the level of lamprey abundance, as indicated by the catch of barriers this spring, is not low enough to indicate the success of the chemical program on Lake Superior. In order to reduce the population further, the Commission should provide for intensification of current activities as recommended by its agents. These might include increasing surveys, re-treatment of certain streams at shorter intervals, improvement of techniques, and treatments at high rather than low flow.
>
> The Committee recommends that 6 barriers on the U. S. shore of Lake Superior, which it was proposed to discontinue, be operated in the spring of 1965 and 1966 in order to better assess changes in the lamprey population. Since the effectiveness of chemical treatments is not fully demonstrated, the Committee believes that the number of barriers proposed on Lake Michigan is inadequate for assessment and should be increased but not at the expense of barrier assessment on Lake Superior.
>
> The Committee believes that the Commission should be advised that large lakes and impoundments, such as occur near the mouth of the Nipigon, may limit the effectiveness of chemical treatments. Reduction of ammocete populations in these situations by frequent re-treatment of contributing streams is likely to prove costly.
>
> In regard to Research, the Scientific Advisory Committee believes that emphasis should be placed on investigations aimed at making surveys and treatments more effective. However, the door should be left open to any ideas which might form a basis for new approaches to lamprey control. The Committee is not prepared at the moment to recommend any investigations not already proposed in the FY 1965 and FY 1966 programs.

The Commission agreed that chemical operations on Lake Superior be intensified and asked its agents to recommend specific measures. In regard to Lake Superior barriers, the proposed reduction from 22 to 16 in the United States had been recommended by the Bureau of Commercial Fisheries which was responsible for this operation. It had assured the Commission that their discontinuation would not materially affect the reliability of the information collected. Although the accuracy of estimates of lamprey abundance would be increased by using more barriers, it appeared that the savings realized by eliminating the 6 barriers could be used elsewhere to better advantage.

Consideration of 1965-66 program The Commission gave preliminary consideration to a sea lamprey control and research program for Fiscal Year 1965-66 which proposed the following activities:

> Lake Superior - Treatment of 21 streams, 17 in Canada and 4 in the United States; continue surveys; operate 24 assessment barriers.
>
> Lake Michigan - Complete initial series of treatments (16 streams) and re-treat small streams on the north shore as required; continue surveys; operate 7 assessment barriers.
>
> Lake Huron - Construct 14 electrical assessment barriers, 11 in Canada, 3 in the United States to measure level of lamprey abundance before chemical treatments.
>
> Lake Erie and Lake Huron - Complete surveys to locate lamprey-producing streams.
>
> Research - Continue testing of salicylanilide compounds with potential as lampricide; investigate use of salicylanilide synergist with various nitrophenols; study the effects of repeated treatments on stream and estuarine fauna; develop techniques for marking ammocetes with radioactive material.

The Commission deferred approval of the program until additional measures to intensify chemical operations were incorporated.*

Prospectus for investigations of the Great Lakes fishery. The Chairman reported that the Prospectus for Investigations of the Great Lakes Fishery had been completed and would be submitted to the two governments in July. National Sections were asked what further action should be taken by the Commission to encourage the development of research programs based on the Prospectus. A suggestion that the Commission consider an adaptation of the panel and committee organization which the International Commission for the Northwest Atlantic Fisheries had found effective was supported by both National Sections. The Secretariat was asked to draft a organization plan for consideration at the Interim Meeting.

Report of meeting on walleye fishery in Lake Erie. The Commission was advised that, in accordance with its request at the 1963 Interim Meeting, representatives of agencies administering the Lake Erie fishery had met with scientific advisors in Ann Arbor on February 11, to review information on the walleye fishery and, if possible, recommend action to encourage its recovery and investigations to obtain a better understanding of fluctuations in walleye numbers. Agreement on administrative action could not be reached on the basis of

* Program and budget for FY 1965-66 approved by correspondence July 15, 1964.

the available data and a second meeting was scheduled for July when additional data from spring investigations would be presented.

Administrative matters. The Commission considered an account of the conference on the desirability and practicability of instituting "limited entry" for the lake trout fishery in Lake Superior. The conference had been sponsored by the Commission at the request of the United States Section. The Secretariat was asked to continue to coordinate efforts of the management agencies seeking information on the application of limited entry.

Other business. The Commission received a report on the proposed introduction of kokanee into Lake Ontario and Georgian Bay, (Lake Huron), by the Ontario Department of Lands and Forests. Since there seemed to be little prospect of early improvement of the fisheries particularly in Lake Huron and Lake Ontario, the Department had considered introducing a potentially valuable species to improve the quality of both commercial and sport fishing. On the basis of careful study of a number of species, it could see little possibility of harm and good grounds for optimism about the results of an experimental introduction of kokanee.

Time and place of next meeting. The Commission agreed to hold its Interim Meeting in Washington, D. C. during the first week of December, 1964.

Election of officers. Mr. D. L. McKernan, (United States), was elected Chairman and Dr. A. L. Pritchard, (Canada) Vice-Chairman for the ensuing two years.

Adjournment: The Chairman expressed the Commission's appreciation to those who had participated in the meeting. The meeting was adjourned at 2:45 p.m., June 18th.

ANNUAL MEETING

ATTENDANCE

Officers

Chairman: A. L. Pritchard, Canada
Vice Chairman: D. L. McKernan, United States

MEMBER GOVERNMENTS

CANADA

Commissioners:
A. O. Blackhurst
J. R. Dymond
A. L. Pritchard

Scientific Advisors:
G. C. Armstrong
E. W. Burridge
R. G. Ferguson
H. C. Frick
F. E. J. Fry
R. N. Johnston
W. A. Kennedy
K. H. Loftus
F. Maher
J. K. Reynolds
W. E. Ricker
G. F. M. Smith
J. J. Tibbles
W. H. R. Werner

UNITED STATES

Commissioners:
D. L. McKernan
Claude Ver Duin
L. P. Voigt

Advisors:
D. J. Curry
Ray Full
W. J. Harth
R. A. Jensen
J. H. Kitchel
R. Kotis
W. M. Lawrence
Donald Leedy
S. S. Sivertson
G. A. Sprecher
H. O. Swenson
G. L. Trembley
C. G. Wenniger
Dale Whitesell
H. A. Woods

Scientific Advisors:
W. F. Carbine
G. P. Cooper
W. R. Crowe
C. A. Dambach
M. J. DeBoer
L. F. Erkkila
P. H. Eschmeyer
Ralph Hile
A. D. Holloway
John Howell
J. W. Moffett
P. R. Nelson
W. A. Pearce
R. A. Pycha
Edw. Schneberger
B. H. Smith
S. H. Smith

Observers: J. A. Slater, Fred Taylor, H. F. Weekley

Others:
Reeve Bailey
Senator Hilbert
E. E. Tucker
J. Beckman
Justin Leonard
Al Ming
Clare Harrington
Eugene Mason

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

INTERIM MEETING

The Commission held an Interim Meeting in Washington, D. C. on December 2-3, 1964. Progress reports on sea lamprey control and lake trout rehabilitation were presented and restrictions on fishing for lake trout in Lake Superior reviewed. The Commission also received a report on a meeting held by agencies on Lake Erie to discuss the walleye fishery, and the recommendations of a committee which had reviewed the Convention on Great Lakes Fisheries. The establishment of committees to assist the Commission in discharging its duties was considered in detail.

Progress of lamprey control and lake trout rehabilitation. The Commission, after hearing reports on the progress of the program, discussed reasons for the persistence of sea lamprey at the 1962 level. The Chairman recommended that the Bureau of Commercial Fisheries prepare a special report for the 1965 Annual Meeting describing its efforts to locate sources of recruitment.

The Commission also received reports on the increased availability of lake trout and higher catches of mature or spawning trout throughout Lake Superior. A relative high incidence of wounds on trout near the Michipicoten River suggested that a significant local source of lampreys existed in the area.

The Commission reconsidered the recommendation of the Lake Trout Rehabilitation Committee that restrictions on lake trout fishing be eased on offshore stocks, but did not believe that such action should be taken at the moment. The Commission suggested that agencies expand their sampling of these populations to obtain more information on their discreteness and condition, if they wished, but urged that the increase in catch not exceed 15,000 pounds in each country.

Lake Erie walleyes. The Commission was advised that representatives of agencies responsible for fishery management and research in Lake Erie had met in Sandusky on August 6, and considered a proposal by Ohio that the walleye fishery be closed for three years and the effects on the population studied. The proposal proved unacceptable to representatives from the eastern end of the lake on grounds that walleye in their waters were in a relatively healthy condition, and did not appear to mix with the population in the western end. It was also argued, by the Ontario representatives, that closure

of the fishery in Canadian waters as an experiment did not justify the economic loss to the fishery. Furthermore, the chances were high that other factors might act favorably during such a short closure period and give misleading results. An alternate proposal closing the fishery in years selected at random over a period of 10-15 years, was presented by Ontario representatives for consideration.

Recommendation of review committee. The Commission was advised by the Chairman that representatives of the two governments had reviewed the Convention on Great Lakes Fisheries in June and had recommended that the number of Commissioners from each country be increased from three to four. The review committee had also recommended that an assessment of the likely costs and benefits of lamprey control and lake trout rehabilitation be made. The two governments were taking the steps necessary to permit the appointment of the additional Commissioners while the Chairman of the Commission had asked each National Section to secure the services of a biologist and economist to form a planning committee for the economic study requested.

Function of committees. The Commission discussed an expanded committee organization and agreed to establish on a trial basis, (1) a Finance and Administration Committee, (2) a Sea Lamprey Control and Research Committee, and (3) a Management and Research Committee in addition to the existing Scientific Advisory Committee. The Commission also recommended establishment of a committee for each lake in which agencies responsible for fishery management and research would be represented.

It was agreed that changes required in the Commission's Rules of Procedure to establish these committees be submitted by the Chairman to the two National Sections for review before the 1965 Annual Meeting.

ADMINISTRATIVE REPORT FOR 1964

Officers and staff. At the Commission's Annual Meeting in Ann Arbor on June 17 and 18, 1964, Mr. D. L. McKernan was elected Chairman of the Commission, succeeding Dr. A. L. Pritchard. Dr. Pritchard succeeded Mr. McKernan as Vice-Chairman. There were no changes in staff.

Accounts and audit. The accounts of the Commission for 1963-64 were audited by the Ann Arbor firm of Icerman, Johnson and Hoffman (Appendix I).

Contributions to the 1963-64 program. The 1963-64 program and budget of $1,542,200 were approved by the Commission in July 1962. Contributions requested by the Commission were approved by the Government of Canada and an advance payment of $40,000 provided on June 1, 1963. The United States contribution, approved in November, was $21,350 less than requested. Funds for 1963-64, after adjustments in the Canadian contribution to maintain the sharing ratio, totalled $1,506,160.

Requests for funds, credits, and contributions for fiscal year 1963-64 were as follows:

	Canada	*United States*	*Total*
Sea lamprey control and research			
Commission request	$464,132	$1,033,068	$1,497,200
Appropriations	452,960	1,008,200	1,461,160
Credits from FY 1961-62	6,250	14,496	20,746
	$446,710	$ 993,704	$1,449,414
Administration and general research			
Commission request	$ 22,500	$ 22,500	$ 45,000
Appropriations	22,500	22,500	45,000
Credits from FY 1962-63	1,922	1,922	3,844
	$ 20,578	$ 20,578	$ 41,156

Expenditures in 1963-64. Agreements with the Fisheries Research Board of Canada ($329,575 U. S. funds) and the U. S. Bureau of Commercial Fisheries ($756,700) for 1963-64 continued in force until March 31 and June 30, respectively. Operations prescribed in the agreements were carried out with exception of the treatment of four streams in Lake Michigan (Cedar, Little Fishdam, Crow River, and Carp Lake Outlet), which the Bureau was unable to treat because of low water flows. Statements of expenditures by the Board and the Bureau appear on pages 22 and 23.

Early in FY 1963-64 the Commission purchased 60,108 pounds of TFM ($179,122) and 1,500 pounds of Bayer-73 ($8,790) for use in the United States, and 40,045 pounds of TFM ($103,717) and 1,000 pounds of Bayer-73 ($5,500) for use in Canada. Towards the end of the fiscal year both the Board and the Bureau advised the Commission that underexpenditures were anticipated. The Board subsequently forwarded a refund of $44,629 and the Bureau $4,095. These amounts were applied to the purchase of 40,500 pounds of TFM and 840 pounds of Bayer-73 for treatments in Canada which included the Nipigon River. The Bureau made a further refund of $19,215 for underexpenditures in various fiscal years from 1958-63 to be credited against FY 1964-65 contributions.

Contributions to the 1964-65 program. The 1964-65 program and budget were approved by the Commission in July, 1963. The Canadian Government approved the program and its share of the cost and forwarded the first installment of its contribution in July, 1964. The United States approved a contribution of $1,030,700 on August 31, 1964, which with the adjusted Canadian contribution, provided the Commission with $49,000 for administration and $1,458,260 for sea lamprey control and research.

Obligations in FY 1964-65. Agreements to carry out the sea lamprey control and research program were made with the U. S. Bureau of Commercial Fisheries and the Fisheries Research Board of Canada. The Commission also ordered 119,000 pounds of lampricide (TFM) from the Maumee Chemical Company, and 1,060 pounds of the synergist Bayer-73 from the Haviland Agricultural Chemical Company. Obligations incurred in FY 1964-65 up to December 31, were as follows:

Agreements with agents:

Bureau of Commercial Fisheries	$792,250
Fisheries Research Board of Canada ($374,900 Canadian)	341,300
	$1,133,550

Lampricide ordered:

For Bureau of Commercial Fisheries	
100,000 lbs. of TFM @$2.68	$ 268,000
500 lbs. of Bayer-73 @$5.85	2,925

For Fisheries Research Board of Canada	
19,000 lbs. of TFM @$2.68	$50,920
560 lbs. of Bayer-73 @$5.85	3,323
	$324,243
TOTAL	$1,457,793

Reports and publications. The 1963 Annual Report was published in December 1964. The Prospectus for Investigations of the Great Lakes Fishery was submitted to the two governments in July. A paper entitled "Synergism of 5-2'-dichloro-4'-nitrosalicylanilide and 3-trifluormethyl-4-nitrophenol", by John H. Howell, Everett L. King, Jr., Allen J. Smith, and Lee H. Hanson was published as Technical Report #8.

Auditors Report to Commission

ICERMAN, JOHNSON & HOFFMAN

Certified Public Accountants

303 National Bank and Trust Building

Ann Arbor, Michigan

September 11, 1964

Great Lakes Fishery Commission

Room 106

Natural Resources Building

Ann Arbor, Michigan

We have examined the accounts of the Great Lakes Fishery Commission Administration and General Research Fund, and Lamprey Control Operation Fund for the year ended June 30, 1964.

Our examination including 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 we considered appropriate in the circumstances. We did not verify receipts by communication with the payers.

In our opinion, the attached statements of receipts and expenditures present fairly the position of the designated funds of the Great Lakes Fishery Commission at June 30, 1964, and the results of operations for the year then ended.

ICERMAN, JOHNSON & HOFFMAN

Great Lakes Fishery Commission

Administration and General Research Fund

Statement of Receipts and Expenditures

Year Ended June 30, 1964

Receipts

	Actual	*Budget*
Canadian Government	$20,573	$20,578
United States Government	20,578	20,578
Total	$41,151	$41,156

Expenditures

Communications	$ 646	800
Equipment	48	200
Insurance, bonding, and audit	322	500
Rents and utilities	628	-0-
Reproduction and printing	1,964	2,000
Salaries (including F.I.A.C. and pension)	33,938	36,800
Supplies and materials	1,531	1,800
Transportation	21	50
Travel	2,524	2,850
Total	$41,622	$45,000A
Excess of expenditures over receipts	$ 471	
Fund balance, July 1, 1963	3,844	
Fund balance, June 30, 1964	$ 3,373B	

Note A - The total of the beginning fund balance plus the anticipated receipts equals the anticipated expenditures:

Fund balance, July 1, 1963	$ 3,844
Anticipated receipts	41,156
Total anticipated available funds	$45,000

Note B - Cash in bank $ 3,365
Petty cash 8
Fund balance $ 3,373

Great Lakes Fishery Commission

Lamprey Control Operation Fund

Statement of Receipts and Expenditures

Year Ended June 30, 1964

Receipts

		Actual	*Budget*
Canadian Government:			
Total 1963-64 funds received	$446,710		
Less advance used to cover 1962-63 obligations	10,603	$ 436,107	$ 452,960
United States Government		1,008,200	1,008,200
Returned to United States Government of overpayment		-14,496	
Refunds from U.S. Fish and Wildlife Service			
1963-64 underexpenditures		4,095	
1958-63 underexpenditures		19,215A	
Refund from Canadian Department of Fisheries for 1963-64 underexpenditures		44,629	
Total		$1,497,750	$1 461 160

Expenditures

Canadian Department of Fisheries 1963-64 contract	$ 329,575	$ 376,412
United States Fish and Wildlife Service 1963-64 contract	756,700	673,799
Lampricide purchases	401,036	416,600
Obligated for unpaid commitments of 1963-64	11,386	
Total	$1,498,697	$1,466,811
Excess of receipts over disbursements	947	
Fund balance, July 1, 1963	5,651	
Fund balance, June 30, 1964	$ 4,704	

Note A Underexpenditures as follows:

1958-62	$ 3,418
1961-62	$14,511
1962-63	$ 1,286
	$19,215

Fisheries Research Board of Canada

Financial Report to Great Lakes Fishery Commission

April 1, 1963 to March 31, 1964

Administration in field		
43.8% of costs of London Headquarters . .	($98,741.72)	$ 43,248.87
Operations		
Operation and Maintenance of Electric Barriers		66,530.56
Chemical Control		125,178.00
Stream Surveys		48,856.82
		$283,814.25
Contributions to Superannuation		
6 1/2% of Permanent Salaries.	($90,634.98)	$ 5,891.27
		$289,705 52
Contract Administration		
6% of Total Disbursements		$ 17,382.33
	(Canadian)	$307,087.85

Funds provided by Commission

Payments under 1963-64 contract		$355,418.00
Cost applicable to 1963-64		307,087.85
Unexpended Balance	(Canadian)	$ 48,330.15

Bureau of Commerical Fisheries
Sea Lamprey Control and Research Program

Report of Expenditures for All Activities
July 1, 1963 through June 30, 1964

Activity	Funds Programed	Salaries	Expenses	Total	Unobligated Balance
Program costs					
Ann Arbor Laboratory					
Chemical Control	$471,798	$332,816	$133,090	$465,906	$5,892
Barrier Operations	134,097	99,276	34,513	133,789	308
Research	90,580	71,693	17,879	89,572	1,008
	$696,475	$503,785	$185,482	$689,267	$7,208
Washington, D. C.	27,200	24,211	2,989	27,200	
General Administration and Executive Direction					
Ann Arbor	$ 37,500	$ 37,210	$ 148	$ 37,357	$ 143
Totals	$761,175	$565,206	$188,619	$753,824	$7,351

Note A—$756,700 provided by Commission
4,475 provided from equipment sales
$761,175

Note B—$4,095 refunded before end of FY
3,256 refunded after end of FY
$7,351

Bureau of Commerical Fisheries

Sea Lamprey Control and Research Program

Report of Expenditures for All Activities
July 1, 1963 through June 30, 1964

Activity	Funds Programed	Salaries	Expenses	Total	Unobligated Balance
Program costs					
Ann Arbor Laboratory					
Chemical Control	$471,798	$332,816	$133,090	$465,906	$5,892
Barrier Operations	134,097	99,276	34,513	133,789	308
Research	90,580	71,693	17,879	89,572	1,008
	$696,475	$503,785	$185,482	$689,267	$7,208
Washington, D. C.	27,200	24,211	2,989	27,200	
General Administration and Executive Direction					
Ann Arbor	$ 37,500	$ 37,210	$ 148	$ 37,357	$ 143
Totals	$761,175	$565,206	$188,619	$753,824	$7,351

Note A—$756,700 provided by Commission
4,475 provided from equipment sales
$761,175

Note B—$4,095 refunded before end of FY
3,256 refunded after end of FY
$7,351

LAMPREY CONTROL EXPERIMENT IN CANADA

by

Fisheries Research Board of Canada

The following report is based on work carried out by the Fisheries Research Board's Biological Station at London, Ontario.

Lamprey run assessment

Electrical barriers were operated on eight Lake Superior tributaries in 1964 for the purpose of assessing the relative size of the spawning population of sea lampreys. All barriers were operated continuously, for all practical purposes, from May 15 until July 31. The numbers of adult sea lampreys collected at each barrier during the period May 15 to July 31 in each of the years from 1956 to 1964 inclusive are tabulated in Table 1; subtotals are shown separately for the six streams which drain into Whitefish Bay and for the two which drain into Nipigon Bay.

The sub-totals given in Table 1 are regarded as good indices of the relative abundance of adult sea lampreys at the corresponding times and places. The Whitefish Bay sub-totals indicate a fairly stable population from 1956-61 inclusive, then a reduction to a new and lower level of abundance which has persisted since 1962. The average total annual count for the years 1956-61 was 2028, compared with 735 from 1962-64; present counts therefore average about 36% of pre-treatment level. On the basis of data reported by the U. S. Fish and Wildlife Service, and average annual count for three streams (Waiska, Pendills, Betsy) on the United States side of Whitefish Bay for 1962-64 was 32% of the average annual count for 1956-61. The difference between the 36% value derived from Canadian data and the 32% value derived from United States data is considered to be the result of chance variation and not indicative of a real difference within Whitefish Bay. Pooling United States and Canadian counts for Whitefish Bay leads to an estimate of 35% for sea lamprey abundance in 1962-64 in terms of their abundance in 1956-61. The corresponding*

* The basis for comparison is 1957-61 rather than 1956-61, since a group of barriers which have consistently contributed substantially to the total count were not activated until 1957.

Table 1. Number of sea lamprey adults collected annually at electrical barriers on eight Canadian tributaries to Lake Superior during the period May 15-July 31 between 1956 and 1964.

Stream	1956	1957	1958	1959	1960	1961	1962	1963	1964
Sault Ste. Marie Area									
Big Carp	23	23	11	15	20	6	5	2	1
Harmony	22	15	6	7	19	14	3	0	4
Chippewa	825	353	171	290	1045	453	123	222	274
Batchawana	382	408	301	467	626	561	136	336	216
Sable	58	63	36	138	241	88	10	36	5
Pancake	657	1051	750	804	1286	931	187	387	257
Sub-total	1967	1913	1275	1721	3237	2053	464	983	757
Nipigon Area									
Pays Plat	4	3	4	30	10	31	9	9	5
Big Gravel	8	101	152	537	626	799	315	64	52
Sub-total	12	104	156	567	636	830	324	73	57
(8 barriers) TOTAL	1979	2017	1431	2288	3873	2883	788	1056	814

estimate based on combined United States and Canadian counts for all of Lake Superior is 22%. Control measures seem to have had less effect on sea lamprey abundance in Whitefish Bay than in Lake Superior as a whole.

Several lines of evidence indicate that sea lampreys began multiplying in Nipigon Bay several years later than in Whitefish Bay. The substantial increases in Nipigon Bay counts year by year from 1956 to 1961, shown in Table 1, are therefore interpreted as reflecting a rapid increase in the abundance of sea lamprey adults during a period when they had already become stabilized in Whitefish Bay. Unlike the case in Whitefish Bay, the proper value for estimating pre-treatment abundance of the Nipigon Bay sea lamprey population is therefore the highest count reached, i.e., the 1961 count only, rather than an average based on several years prior to treatment.

If the 1962 count is regarded as anomalous, the best assessment of the effect of stream treatments on abundance is made by comparing the average counts for 1963 plus 1964 with the count for 1961. The former is 8% of the latter, which suggests that sea lamprey abundance has decreased about 92% in Nipigon Bay as a result of control measures. Since the lamprey count increased every year up to 1961, there is a strong possibility that had there been no control program the population would have increased even further before reaching a relatively stable level, such as was apparently reached in Whitefish Bay by about 1956. It could therefore be argued that lamprey abundance decreased, as a result of control measures, by somewhat more than 92%, considering the population that might now exist had there been no control measures. Control efforts seem to have reduced the abundance of sea lampreys in Nipigon Bay more than in Lake Superior as a whole.

Surveys

A careful search for sea lamprey ammocetes was made in each of 49 Lake Superior streams where none had previously been found. Sea lamprey ammocetes were found in one of them, Blende Creek on Sibley Peninsula.

As an aid to planning, surveys were also conducted on other Great Lakes streams, either as a careful search for sea lamprey ammocetes where none had previously been found, or to determine more exactly their distribution in streams where they were known to occur. Such surveys were carried out in 1964 on 136 Lake Huron streams, on 23 streams tributary to

the waters which connect Lakes Huron and Erie, on 174 Lake Erie streams, and on 293 Lake Ontario streams. As a result, sea lamprey ammocetes were found for the first time as follows: Lake Huron in 0 streams; Lake St. Clair in 1 stream; Lake Erie in 6 streams; Lake Ontario in 5 streams.

The search for streams in which there are previously unrecorded sea lamprey ammocete populations is an essential part of the treatment program, and will no doubt in time reveal others. However, it now seems likely that almost all of the Canadian streams which harbor sea lamprey ammocetes have already been discovered. The known streams are listed in Table 2.

An electrified beam trawl was again used to search for lake-dwelling sea lamprey ammocetes. In Batchawana Bay they were again found off the mouths of the three main lamprey-producing streams in that area. The lacustrine population of Batchawana Bay was estimated to be about 5000 individuals, which is reasonably close to an estimate made on the basis of 1963 surveys. A lacustrine population was found for the first time off the Jackfish River in Nipigon Bay. More data are needed before a reasonable estimate can be made of the size of this population. Considerable searching failed to find sea lamprey ammocetes in Michipicoten Bay.

Chemical treatment

Using techniques which are now more or less standardized, 15 Lake Superior streams were treated with lampricide in 1964. Essential details are summarized in Table 3. Note that the assessments of ammocete abundance are highly subjective estimates.

In all the larger streams the lampricide 3-trifluormethyl-4-nitrophenol, or TFM, was synergised with approximately 2% of the chemical Bayer-73. When the small amount of synergist was used, about half the amount of TFM was required for the same results. Consequently, the cost of treating most streams in 1964 was appreciably lower than earlier treatments of the same streams when TFM was used alone.

There are, however, disadvantages to using the synergist. It is barely soluble in water, and it tends to clog the apparatus used to introduce lampricide into streams. Experience soon showed that the difficulties involved, the damage to equipment, and increased chances of failing to maintain the correct strength of lampricide did not compensate for the small savings in TFM involved in the smaller streams. Therefore, in most cases TFM alone was used in the treatment of smaller streams.

Table 2. A complete list of the Canadian tributaries of the Great Lakes which are known to harbor sea lamprey ammocetes.

[Tributaries designated by a letter and numbers have no known name]

Lake Superior

1. East Davignon Creek
2. West Davignon Creek
3. Little Carp River
4. Big Carp River
5. Cranberry Creek
6. Goulais River
7. Stokeley River
8. Harmony River
9. Sawmill Creek
10. Chippewa River
11. Batchawana River
12. Sable River
13. Pancake River
14. Agawa River
15. Sand River
16. Michipicoten River
17. Dog River
18. White River
19. Big Pic River
20. Little Pic River
21. Prairie River
22. Steel River
23. Pays Plat River
24. Big Gravel River
25. Little Gravel River
26. Cypress River
27. Jackfish River
28. Cash Creek
29. Nipigon River
30. Stillwater Creek
31. Otter Cove Creek
32. Black Sturgeon River
33. Wolf River
34. Pearl River
35. Blende Creek
36. McIntyre River
37. Kaministikwia River
38. Pigeon River

Lake Huron

1. Root River
2. Garden River
3. Echo River
4. Bar River
5. H-65
6. H-68
7. Kaskawong River
8. Gordon's Creek
9. Brown's Creek
10. Watson's Creek
11. Richardson's Creek
12. Two Tree River
13. Gawas Creek
14. McBeth Creek
15. Thessalon River
16. Livingston Creek
17. Mississagi River
18. Lauzon Creek
19. H-114
20. Serpent River
21. Spanish River
22. Chikanishing River
23. Kagawong River
24. Silver Lake Creek
25. Mindemoya River
26. Manitou River
27. Bluejay River
28. Kaboni River
29. Still River
30. Magnetawan River
31. Harris & Naiscoot Rivers
32. Boyne River
33. Sturgeon River
34. Lafontaine Creek
35. Nottawasaga River
36. Silver Creek
37. Saugeen River
38. Bayfield River

Lake St. Clair

1. Thames River

Lake Erie

1. Catfish Creek
2. Big Otter Creek
3. Big Creek
4. Potter's Creek
5. Young's Creek
6. Grand River

Lake Ontario

1. Bronte Creek
2. Credit River
3. Humber River
4. Rouge River
5. Duffin Creek
6. Lynde Creek
7. Oshawa Creek
8. Harmony Creek
9. Bowmanville Creek
10. Wilmot Creek
11. Graham Creek
12. O-141
13. Gage Creek
14. Cobourg Brook
15. O-154
16. Shelter Valley Brook
17. Lakefort Creek
18. Salem Creek
19. Butler Creek
20. Smithfield Creek
21. Salmon River

Table 3. Canadian streams treated with lampricide, Lake Superior, 1964.

Name	Date	Flow (cfs)	Miles stream treated	TFM (pounds)	Synergist (pounds)	Ammocete abundance
1. Little Carp	May 16-18	12	9	101	0	Scarce
2. Cranberry	May 20-22	13	6	140	0	Scarce
3. Goulais	May 27-30	1400*	109	6,556	97	Scarce
4. McIntyre	June 15-16	140*	5	486	11	Nil
5. Pigeon	June 22-23	700*	3	2,870	60	Scarce
6. Batchawana	July 9-12	180*	8	1,463	29	Scarce
7. Sawmill	July 13	1*	-	17	0	Scarce
8. Sable	July 14-16	11	15	185	0	Scarce
9. Chippewa	July 17-18	100*	2	428	13	Scarce
10. Kaministikwia	Aug. 7-12	878*	73	9,850	164	Scarce
11. Little Gravel	Aug. 15-16	95	3	255	0	Scarce
12. Blende	Aug. 17-18	8	2	183	2	Scarce
13. Jackfish	Sept. 5-8	76	6	910	21	Moderate
14. Nipigon	Oct. 4-5	3842	8	35,194	384	Moderate
15. Stokeley	Oct. 14-15	43	8	452	0	Scarce
		7499	257	59,090	781	

* Flow estimated.

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4. McIntyre	June 15-16	140*	5	486	11	Nil
5. Pigeon	June 22-23	700*	3	2,870	60	Scarce
6. Batchawana	July 9-12	180*	8	1,463	29	Scarce
7. Sawmill	July 13	1*	-	17	0	Scarce
8. Sable	July 14-16	11	15	185	0	Scarce
9. Chippewa	July 17-18	100*	2	428	13	Scarce
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		7499	257	59,090	781	

* Flow estimated.

Some experiments pertinent to the improvement of stream treatment techniques were carried out. Laboratory and field experiments showed that withdrawal of the water which overlies the substrate into which sea lamprey ammocetes have burrowed (as when the water level of a stream drops) causes many of the ammocetes to leave their burrows. The tendency to leave burrows is greater at relatively low temperatures than at intermediate temperatures.

When the substract is alternately flooded and drained several times, there is a noteworthy decrease in the percentage of ammocetes which appear on the surface during the second and subsequent drainings as compared with the first. These experimental results were corroborated by observations connected with treatment of the Nipigon River. When the river level was dropped by withholding water at a power dam during pre-treatment tests, many ammocetes emerged immediately from the exposed substrate. When water levels were dropped during a second pre-treatment test, the number of ammocetes which emerged immediately was decidedly less. When the level was lowered a third time for the treatment, none emerged and when the exposed area was treated with TFM it was evident that the ammocetes had vacated the area, although they were present in water-covered substrate immediately adjacent. There are obvious applications of this information in stream treatments.

LAMPREY CONTROL AND RESEARCH IN THE UNITED STATES

by

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Sea lamprey control progressed well in 1964 despite severe drought conditions in the Great Lakes region. Low flow in streams delayed many scheduled treatments, but made possible a relatively economical treatment of the Muskegon River, one of the largest tributaries of Lake Michigan. Fifty-two streams discharging 6,552 cfs of water were treated with 118,840 pounds of lampricide (Table 1).

Table 1. Summary of chemical treatments in United States waters of the Great Lakes in 1964.

	Number of streams	Discharge at mouth (cfs)	Stream miles treated	Lampricide (pounds)	Synergist (pounds)
Superior[1]	25	1,637	259	18,255	113
Michigan[2]	27	4,915	1,522	100,585	212
Total	52	6,552	1,781	118,840	325

[1] Includes 17 re-treatments
[2] Includes 12 re-treatments

No significant change in the number of spawning-run sea lampreys occurred in Lake Superior; 11,969 lampreys were taken at the electric barriers compared on 11,111 in 1963. The Brule River run accounted for more than half (56.2 percent) of this total. Stream surveys, fyke net fishing, and trawling continued to indicate a general reduction in the ammocete population in streams on the south shore of Lake Superior.

Investigations of the persistence of the lampricide in streams and its effect on aquatic life were continued.

Lake Superior surveys

Thirty-two Lake Superior tributaries were surveyed in preparation for chemical treatment or to determine the distribution of re-established populations. An intensive survey of the upper Brule River found 2 transforming sea lampreys above the 1962 chemical application point. Continued examination of oxbow ponds and other backwater areas on the Ontonagon River and the Sturgeon River, revealed no isolated ammocete populations.

Re-surveys of 46 marginal streams found sea lamprey ammocetes for the first time in Reefer Creek, Bayfield County, Wisconsin. Since the size, turbidity, and depth of the lower St. Louis River in Minnesota made standard survey techniques unreliable, sea lamprey ammocetes were placed in cages in the river in midsummer to see if conditions were suitable. Dissolved oxygen content of the river dropped to 0.0 ppm, water temperatures reached the low 80's during this period, and all ammocetes died within 6 weeks. Sea lamprey spawning activity in Minnesota streams appeared to be about half that of 1963. Only the Split Rock River had more than a few nests or adults. Two streams in Wisconsin, however, were heavily used. More than 80 nests were found just above the Brule River barrier after it was shut down in mid-July. Several hundred nests were seen in the Bad River and 3 of its tributaries.

Posttreatment surveys were completed on 24 streams. Residual populations of ammocetes were located in the Ontonagon River, Furnace Creek, and McCallum Creek. Re-established populations were found in Seven Mile Creek, Beaver Lake Creek, and Mosquito River. All other streams were negative.

Lake Superior chemical treatments

Chemical treatment of streams along the south shore of Lake Superior began on April 29. Optimum conditions for treatment continued until the last week in July when low flows were encountered. Only 1 stream was treated in August, but in September and October increased rainfall improved the situation and 13 streams were treated.

Twenty-five streams with a total discharge of 1,637 cfs were treated (Table 2). Of these, 21 were treated with TFM and the remaining 4 with a synergistic mixture, (TFM-2B), containing 98 percent by weight of TFM and 2 percent 5,2'-dichloro-4'-nitrosalicylanilide (Bayer-73). Eight streams

treated for the first time contained small ammocete populations in the lower stretches. Survivors from previous treatments were not found in significant numbers in any of the 17 re-treatments. The Bad River, Ashland County, Wisconsin, was re-treated to eliminate residual ammocetes which were most abundant in one of its larger tributaries, the Potato River. Fifty-seven residual sea lamprey larvae, 2 recently transformed individuals, and many young-of-the-year larvae were recovered from the Potato River while in the other tributaries, 13 residual larvae, 1 transformed sea lamprey, and many young-of-the-year larvae were collected. The accuracy of the survey of the residual population prior to treatment was substantiated by these collections.

There was no serious fish kills during the 1964 treatments.

Lake Michigan surveys and bioassays

Re-examination of 19 potential lamprey-producing streams disclosed no new population. Surveys were completed on 29 streams scheduled for re-treatments. The distribution of ammocetes was unchanged in 14 streams, extended in 1, and reduced in 9. Five streams had no re-established larvae present. Pretreatment checks also were made on 3 large streams surveyed in 1961. Distribution limits were unchanged at 22 of 24 locations investigated. Posttreatment surveys were finished on 29 streams. Small numbers of residual sea lampreys were found in the Boardman, Crystal, Big Manistee, Pere Marquette, Pentwater, Pensaukee, Big Cedar, Ford, and Black Rivers.

In 1964, 63 bioassays were completed on 28 Lake Michigan tributaries. Of this total, 47 assays were run with TFM, 13 with TFM-2B, and 3 with TFM-1B.* All bioassays used rainbow trout as test fish except for the main Muskegon River where simultaneous assays were run with rainbow trout and brown trout. Several native species, (34 brown trout, 6 white suckers, 15 sculpin, 5 northern creek chubs, 1 hog sucker, 1 rock bass, 3 northern pike, 11 common shiners, and 3 brook trout) survived the selected concentration for 12 hours in a continuous-flow test utilizing one trough of the mobile bioassay laboratory. The subsequent successful treatment of the Muskegon River, with minimal loss of fish, confirmed the results of the assay.

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* Synergistic mixture containing 99 percent TFM by weight and 1 percent Bayer-73.

Table 2 -- Details on the application of lampricide to tributaries of Lake Superior in 1964.

Stream	Date	Discharge at mouth (cfs)	Concentration (ppm) Minimum effective	Concentration (ppm) Maximum allowable	TFM (pounds)	Synergist (pounds)
Furnace Creek	April 29	33	2.0	5.0	240	....
Buck Bay Creek[1]	May 5	15	2.5	9.0	162	....
Cranberry River	May 8	59	1.5	3.0	180	....
Traverse River	May 14	53	0.7	2.0	204	....
Smith Creek[2]	May 15	9	3.0	5.0	90	....
Mud Lake Outlet[2]	May 16	50	0.8	1.3	162	....
Union River[2]	May 17	11	2.5	4.0	72	....
Potato River	May 18	40	2.0	4.0	558	....
Little Iron River[2]	May 18	40	2.0	5.0	234	....
Tahquamenon River	July 15	290	2.0	5.0	3,330	88.5
Garlic River	July 23	12	2.5	6.0	162	....
Sand River	Aug. 26	50	2.0	7.0	936	....
Munising Falls Creek[2]	Sept. 3	2	5.0	10.0	18	....
Firesteel River	Sept. 10	73	1.5	3.5	414	11.5
Elm River	Sept. 10	15	1.5	4.0	99	2.5
Ravine River	Sept. 22	20	2.0	4.5	180	....
Slate River	Sept. 23	7	2.5	5.5	54	....
Falls River	Sept. 24	100	1.7	5.0	378	10.5
Bad River	Oct. 4	560	2.5	7.0	8,982	....
Reefer Creek[2]	Oct. 15	4	6.0	13.0	216	....
Fish Creek (Orienta)[2]	Oct. 16	1	3.0	8.0	108	....
Sand River[2]	Oct. 16	5	4.5	11.0	306	....
Arrowhead River	Oct. 19	150	1.0	1.5	594	....
Split Rock River	Oct. 19	13	2.0	4.0	162	....
Waiska River	Oct. 28	25	2.0	5.5	414	....
TOTAL		1,637	....	....	18,255	113.0

[1] Au Train River tributary treated to keep ammocetes from reaching Au Train Lake.

[2] Initial treatment.

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Garlic River	July 23	12	2.5	6.0	162	....
Sand River	Aug. 26	50	2.0	7.0	936	....
Munising Falls Creek[2]	Sept. 3	2	5.0	10.0	18	....
Firesteel River	Sept. 10	73	1.5	3.5	414	11.5
Elm River	Sept. 10	15	1.5	4.0	99	2.5
Ravine River	Sept. 22	20	2.0	4.5	180	....
Slate River	Sept. 23	7	2.5	5.5	54	....
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TOTAL		1,637	....	....	18,255	113.0

1 Au Train River tributary treated to keep ammocetes from reaching Au Train Lake.
2 Initial treatment.

Lake Michigan chemical treatments

Chemical treatments on Lake Michigan streams began in mid-April and ended in late October. Summer treatments were again handicapped by low flow in many streams. A rapid reduction in flow halted the Cedar River treatment in June with only the upper two-thirds of the river completed. Treatment of the lower one-third of the river was finished in August.

Twenty-seven streams with a total discharge of 4,915 cfs were chemically treated (Table 3). Fifteen streams received initial treatments and 12 were re-treatments. Sea lamprey larvae were noticeably less abundant in re-treated streams.

Eleven streams were treated partially or completely with the synergistic mixture TFM-2B. Maintaining a homogeneous suspension with the 2-percent synergistic mixture in TFM and pumping this mixture in precise amounts continued to be a problem in 1964. New techniques were tried experimentally in 1964, but results were no better. Appreciable mortality of brown and rainbow trout during the treatment of Pentwater River discouraged regular use of the mixture for the remainder of the season.

Three assays and 1 chemical treatment were conducted using the TFM-1B formulation. The treatment appears successful, but bioassay results indicated the necessity for more testing of this formulation.

Lake Huron surveys

The continuing survey of the St. Marys River in 1964 showed that sea lamprey ammocetes were present in the main river upstream as far as the U. S. locks, but were absent from its tributaries above Munuscong Lake. No adults or nests were observed in areas of apparently suitable habitat.

Electric barrier operations

Electric barriers were operated from April 1 to July 13 on 22 streams along the south shore of Lake Superior. The only problem encountered throughout the season was flood damage to the barrier on the Firesteel River which required extensive repairs.

The assessment barriers captured 11,969 sea lampreys (Table 4), 858 more than in 1963, 2,847 more than in 1962, but 55,261 less than in 1961. The catch is 79 percent below the 5-year average, 1957-61, before control measures became effective.

Table 3 -- Details on the application of lampricide to tributaries of Lake Michigan in 1964.

Stream	Date	Discharge at mouth (cfs)	Concentration (ppm)		TFM (pounds)	Synergist (pounds)
			Minimum effective	Maximum allowable		
Pentwater River[1]	April 16	93	2.0	6.0	1,044	14.5
Ahnapee River[1]	April 17	14	7.0	17.0	432	. . .
Three Mile Creek[1]	April 19	3	3.0	7.0	40	1.0
Pensaukee River[1]	April 21	20	3.0	7.0	288	8.0
Lincoln River[1]	May 8	107	4.0	12.0	1,815	. . .
Pere Marquette River[1]	May 25	572	5.0	16.0	19,620	. . .
Manistee River[1]	June 4	1,844	6.0	13.5	31,392	. . .
Ford River[1]	June 15	330	5.0	14.5	12,294	45.5
Arthur Bay Creek[1]	June 28	2	6.5	16.0	18	. . .
Johnson Creek	July 9	1	3.0	9.0	6	. . .
Poodle Pete Creek	July 10	2	2.0	5.0	27	. . .
Parent Creek	July 10	5	2.5	7.5	36	1.0
Gulliver Lake Outlet	July 13	3	5.0	10.0	72	. . .
Bulldog Creek	July 13	6	2.0	5.0	108	3.0
Millecoquins River	July 23	71	9.0	20.0	1,314	21.5
Mile Creek	Aug. 5	1	2.5	6.5	9	. . .
Black River	Aug. 5	13	5.0	12.0	333	. . .
Paquin Creek	Aug. 9	13	6.0	10.0	168	. . .
Brevort River	Aug. 9	5	5.0	10.0	99	. . .
Big Cedar River[1]	Aug. 12	170	3.5	8.0	5,004	56.5
Boyne River	Aug. 26	80	6.5	8.5	1,710	47.5
Yuba Creek	Aug. 30	3	8.0	18.0	54	. . .
Big Bear Creek[1]	Sept. 12	12	3.0	7.0	126	2.0
Muskegon River[1]	Sept. 15	1,485	6.0	15.0	23,454	11.5
Black Creek[1]	Oct. 15	43	5.0	12.0	684	. . .
Pigeon River	Oct. 18	11	4.0	13.0	306	. . .
Pine Creek[1]	Oct. 19	6	5.0	17.0	132	. . .
Total		4,915	. . .	. . .	100,585	212.0

[1] Initial treatment

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Ahnapee River[1]	April 17	14	7.0	17.0	432	. . .
Three Mile Creek[1]	April 19	3	3.0	7.0	40	1.0
Pensaukee River[1]	April 21	20	3.0	7.0	288	8.0
Lincoln River[1]	May 8	107	4.0	12.0	1,815	. . .
Pere Marquette River[1]	May 25	572	5.0	16.0	19,620	. . .
Manistee River[1]	June 4	1,844	6.0	13.5	31,392	. . .
Ford River[1]	June 15	330	5.0	14.5	12,294	45.5
Arthur Bay Creek[1]	June 28	2	6.5	16.0	18	. . .
Johnson Creek	July 9	1	3.0	9.0	6	. . .
Poodle Pete Creek	July 10	2	2.0	5.0	27	. . .
Parent Creek	July 10	5	2.5	7.5	36	1.0
Gulliver Lake Outlet	July 13	3	5.0	10.0	72	. . .
Bulldog Creek	July 13	6	2.0	5.0	108	3.0
Millecoquins River	July 23	71	9.0	20.0	1,314	21.5
Mile Creek	Aug. 5	1	2.5	6.5	9	. . .
Black River	Aug. 5	13	5.0	12.0	333	. . .
Paquin Creek	Aug. 9	13	6.0	10.0	168	. . .
Brevort River	Aug. 9	5	5.0	10.0	99	. . .
Big Cedar River[1]	Aug. 12	170	3.5	8.0	5,004	56.5
Boyne River	Aug. 26	80	6.5	8.5	1,710	47.5
Yuba Creek	Aug. 30	3	8.0	18.0	54	. . .
Big Bear Creek[1]	Sept. 12	12	3.0	7.0	126	2.0
Muskegon River[1]	Sept. 15	1,485	6.0	15.0	23,454	11.5
Black Creek[1]	Oct. 15	43	5.0	12.0	684	. . .
Pigeon River	Oct. 18	11	4.0	13.0	306	. . .
Pine Creek[1]	Oct. 19	6	5.0	17.0	132	. . .
Total		4,915	. . .	. . .	100,585	212.0

[1] Initial treatment

Table 4 -- Catches of adult sea lampreys for comparable periods from 22 Lake Superior streams, and from 3 Lake Michigan streams, 1959-1964.

Stream	1959	1960	1961	1962	1963	1964
Lake Superior						
Waiska River	42	122	87	10	34	47
Pendills Creek	38	30	74	10	11	3
Betsy Creek	999	696	1,366	316	444	272
Two Hearted River	3,950	4,290	7,498	1,757	2,447	1,425
Sucker River	2,436	4,683	3,209	474	698	386
Hurricane River	63	80	96	6	36	31
Miners River	127	399	220	64	107	74
Furnace Creek	350	2,211	1,012	132	142	93
Au Train River	164	74	181	179	130	84
Rock River	1,170	2,598	3,660	399	353	229
Chocolay River	3,486	4,173	4,201	423	358	445
Harlow Creek	15	10	22	89	28	38
Iron River	250	317	2,430	1,161	110	178
Pine River	39	28	70	2	20	0
Huron River	1,408	1,237	4,825	70	201	363
Silver River	753	1,271	5,051	267	760	592
Sturgeon River	539	161	427	397	1,437	375
Misery River	2,433	696	962	80	24	12
Firesteel River	2,044	250	1,118	70	178	327
Brule River	19,156	9,539	22,478	2,026	3,414	6,718
Middle River	3,598	2,815	3,502	311	48	45
Amnicon River	968	1,094	4,741	879	131	232
TOTAL	44,028	36,774	67,230	9,122	11,111	11,969
Percentage change		-16.5	82.8	-86.4	21.8	7.7
Lake Michigan						
Sturgeon River	733	910	2,378	1,650	751	823
Bark River	1,047	1,065	1,085	710	298	202
Cedar River	6,856	4,676	9,423	5,729	6,412	3,568
TOTAL	8,636	6,651	12,886	8,089	7,461	4,593
Percentage change		-23.0	93.7	-37.2	-7.8	-38.4

The spawning run was one of the earliest encountered on Lake Superior. The first adults were taken during the week of April 11. The run increased rapidly and peaked during a 10-day period from May 16 to 25 when 36 percent of the total run was captured.

The number of sea lampreys from the 17 barriers east of Keweenaw Peninsula declined 37 percent compared to 1963. The catch from the western streams, however, increased 93 percent over the previous year. Much of this increase occurred in the Brule River. Its catch nearly doubled and accounted for 56.2 percent of the total for all the barriers. Only 2 rivers, the Brule and the Two Hearted, produced more than 1,000 sea lampreys in 1964 as compared to 13 in 1961.

The 3 index barriers on streams tributary to northern Green Bay, Lake Michigan, were installed April 7 and operated to July 2. The spawning runs increased erratically with a minor peak occurring between May 6 and 10 when nearly 18 percent of the total catch was made. A major peak occurred between May 21 and 25 which produced slightly more than 32 percent, and a minor peak, between June 5 and 9, accounted for 13.3 percent of the total catch.

The 3 barriers captured 4,593 spawning migrants compared to 7,461 in 1963, 8,089 in 1962, and 12,886 in 1961. This is the third consecutive year that the catch at these barriers has declined. The most significant reduction occurred at the Cedar River which produced 78 percent of the total catch. Its barrier captured 3,568 adults in 1964 compared to 6,412 in 1963, a decline of 44 percent.

The electric barrier on the Pere Marquette River on the east shore of Lake Michigan, which had not been operated since 1958, was reactivated April 1. The spawning run developed rapidly and by May 10, over 86 percent of the total catch had been taken. The total catch was 678 adults compared to 2,006 in 1958. An electric barrier on the Ocqueoc River, which is now being operated on Lake Huron as an index device took 2,677 adult sea lampreys compared to 4,674 in 1963.

There has been no significant change during the past 3 years in the size of sea lampreys taken from 11 Lake Superior streams. Their average length has remained at 16.6 inches and weight 5.5 ounces. No difference in size was discernible between sea lampreys in streams of eastern and western Lake Superior, however, a significant reduction in the sex ratio was recorded. The percentage of males dropped from 67.1 in 1963 to 54.8 in 1964. Only in the most eastern streams did the percentage of males (63.0) remain high.

Spawning migrants from the Bark River, Green Bay, Lake Michigan, were the smallest since 1957, averaging 15.9 inches in length and 4.3 ounces in weight. The percentage of males, however, was the highest (70.3), while the total number of sea lampreys captured was the lowest. Sea lampreys taken at the barrier on the Pere Marquette River were small also. Their average length and weight were 15.7 inches and 4.3 ounces. The run contained 60.3 percent males.

Spawning migrants entering the Ocqueoc River from Lake Huron had an average length of 15.8 inches. Although comparable to Lake Michigan adults in length, their average weight (4.7 ounces) was 0.4 ounce greater. Only 54.5 percent of the adults were males.

Only 877 spawning-run rainbow trout were counted at the barriers on Lake Superior compared to 1,390 for the previous year. Numbers of white suckers, however, increased over the catch in 1963. The incidence of sea lamprey wounds on rainbow trout increased to 3.5 percent from a low in 1963 of 2.2 percent. Nine and one-half percent of the Pere Marquette River (Lake Michigan) rainbow trout run and 23.3 percent of the Ocqueoc River (Lake Huron) run were scarred.

Movement of tagged sea lampreys from the St. Marys River

The tagging operation to determine the movements of adult sea lampreys congretated below the locks in the St. Marys River was repeated. A total of 403 lampreys was captured and tagged as compared with 159 in 1963. None of the 1963 group was taken at electric barriers, but 5 were reported by commercial fishermen. Of these, 2 were caught in gill nets off Gros Cap in Whitefish Bay, Lake Superior; 2 were taken in Lake Huron; and 1 was recovered in Lake Erie near Leamington, Ontario. Thus far, 6 of the 403 adults tagged in the fall of 1964 have been recovered. One individual, tagged October 25, was taken 12 days later near Gros Cap in Whitefish Bay. The remaining 5 recoveries have been from Lake Huron.

Fyke net operations

The fishing of fyke nets in tributary streams was continued during 1964 to monitor downstream movement of larvae and young sea lampreys. Fishing in 14 Lake Superior streams amounted to 1,415 net days and produced only 18 ammocetes. Nets were fished at the same time in 5 treated and 2 untreated streams tributary to Lake Michigan. Nets in the treated

streams captured 13 recently metamorphosed lampreys; those in the 2 untreated streams caught 92 juveniles and 20 ammocetes. Unfortunately, spring fyke netting is carried on during a period when extreme fluctuations in water flows and heavy demands upon personnel maintaining barriers does not permit systematic operations required to provide comparable data from year to year.

Fyke nets fished as systematically as possible in 7 Lake Superior streams over several years during the more favorable fall season have demonstrated a substantial reduction in recruitment. A total of only 4 newly metamorphosed adults was captured in 1964 compared to 53 in 1961, representing a decline of 92.5 percent. A significant reduction in the production of young adults after initial treatments was revealed also by nets fished in 6 tributaries to northern Lake Michigan. In 1961, prior to chemical treatment, fyke nets in 5 streams captured 1,729 downstream migrants compared to 85 individuals in 1964 representing a reduction of 95.1 percent. In the remaining stream, the Ogontz River which was treated in 1960, only 5 young adults have been captured by the nets in 3 years of fishing.

Nets fished in several other tributaries to Lake Superior took 88 juvenile sea lampreys from the Brule River, 93 from the Sturgeon River, 7 from the Huron River, and 1 from the Silver River. Eighty-three of the 88 individuals taken in the Brule were captured in nets fished at a new location below a lake and above the chemical application site to pinpoint a source of contamination. Nets fished near the mouth of the stream in a manner comparable to the preceding years took 5 sea lampreys compared to 10 in 1963.

Fyke nets were fished in 6 streams (5 of them treated) along the east shore of Lake Michigan. Nets in the untreated White River captured 43 newly metamorphosed adults. Only 2 sea lampreys were taken from the 5 treated streams.

A fyke net has been operated continuously on the Ocqueoc River for 2 years. Accurate catch records of invertebrates, fish, and lampreys are being kept to compare with data obtained following chemical treatment of this stream. The 1963-64 downstream movement of sea lampreys began on November 6, and ended May 15, 1964. The net captured 3,373 recently transformed sea lampreys. The peak movement occurred between March 6 and April 24 when 2,509 individuals or 74 percent of the catch was made. A total of 626 young juveniles, nearly 19 percent of the catch, was captured between November 12 and

December 26, 1963. The 1964-65 downstream movement in the Ocqueoc River began November 3, very close to the starting date in 1963. The fall peak also closely coincided with that of the preceding year. The catch between November 9 and December 17 numbered 920 individuals as compared to 626 for the preceding year.

The large number of recently transformed lampreys in the Ocqueoc has provided the opportunity to measure the net's efficiency through a mark and recovery study. Based on recovery data from 1,320 marked individuals, the estimated production of the Ocqueoc River for the 1963-64 season is 42,000 sea lampreys.

The mechanical screen on a water intake of a chemical plant near the mouth of the Pere Marquette River was used again in 1964 as a collecting device for recently metamorphosed sea lampreys. Collections from the screen vividly illustrate the reduced production of young adults following an initial treatment with the larvicide in May 1964. The number collected during the following November dropped to 0.27 per day compared to 523.30 in 1963, a 99.97-percent reduction.

Re-establishment in treated streams

The study of larval sea lamprey populations which have become established in streams following chemical treatment was continued. No evidence of transformation was found among 4-year-old larvae in 7 streams under special study since 1960. The 1960 and 1961 year classes of larvae were present in 72 of the 77 infested Lake Superior streams. However, a significant reduction in the number of repopulated streams has occured in the last 3 years. No re-established populations have been found during this period in 26 streams and 19 streams contain only small numbers of a single year class. To date, the 1964 year class has been detected in 17 streams. Failure of sea lampreys to re-establish themselves in many of the streams may be due to a reduced spawning population, effective operation of the assessment barriers, chemical treatments during the spawning period, and adverse environmental conditions. Collections from the study streams indicate that changes take place in ammocete distribution.

The electric beam trawl was used extensively during 1964 along the north and east shores of Lake Michigan in the search for lake-dwelling ammocetes. The extremely low lake level limited the amount of coverage at several promising areas.

Over 31 hours of trawling at 22 locations produced only 13 sea lamprey ammocetes. They were captured May 19, off the mouth of Ford River. Trawling in deeper water off the Ford River failed to take sea lampreys. Native lampreys also were scarce in areas along the north shore. Only 12 were captured; 10 were taken off the mouth of Ford River, 1 off the Cedar River, and another near the mouth of the Fishdam River.

Trawling in areas along the east shore was even less productive. Only 17 ammocetes of all species were taken in nearly 29 hours. The catch contained 3 sea lampreys; 2 from the south arm of Lake Charlevoix and 1 from the east arm of Traverse Bay. Native lampreys were caught at 5 locations for the most part in the south arm of Lake Charlevoix.

Trawling in Lake Superior was limited to resurveys of potential problem areas east of the Keweenaw Peninsula. A total of 11 sea lamprey ammocetes was captured in 3 of the 12 areas examined. Of the 11 larvae, 9 were taken in Furnace Bay, 1 in Portage Canal near the mouth of the Sturgeon River, and 1 from East Bay of the Sucker River. The trawl also captured 47 native ammocetes. These were taken from 6 different locations. The lake dwelling populations found in both Lake Superior and Lake Michigan are considered small.

Sea lamprey research

Development of more effective and less costly lampricides continues to be the dominant research activity. Studies of factors affecting the activity of 3'-chloro-3-nitrosalicylanilide (33NCS), elucidation of the relationships between molecular structure and biological activity in salicylanilides, and some screening of unrelated compounds were the major features of the chemical research program.

Biological studies have been concerned with the effect of environmental influences on larval growth, attempts to raise larval lampreys of known parentage for life-history and taxonomic study, and effects of TFM on fish-food organisms.

Development of 33NCS. Evaluation of the relationship of molecular structure to biological activity in the salicylanilides resulted in the selection of the chemical 3'-chloro-3-nitrosalicylanilide (33NCS) for further development since it could be easily and economically synthesized.

A series of bioassays conducted in waters from 8 different sources in the Lake Huron and Lake Michigan drainages indicated that 33NCS is affected by water quality in much the same way as TFM. However, the selective action persisted even when relatively large amounts of the compound were required because of increasing water hardness. The action of 33NCS in simulated stream tests in flowing water raceways was not as encouraging. Although toxicity to fish remained the same, the minimum lethal concentration for larval lampreys was 0.6 ppm or almost twice that established from laboratory studies. The range of concentrations in which the compound could be used selectively was, therefore, reduced.

The reasons for the difference between laboratory and simulated stream tests results are not known. Difficulties in formulating and feeding 33NCS and analyzing for concentration may have produced variations. Improved formulations of 33NCS and better analytical techniques should allow a more effective evaluation of future raceway testing. A dye complexation technique has been developed which will permit accurate determination of concentration to at least 0.05 ppm.

Screening of new chemical compounds. Forty-seven new compounds were tested; of these, 20 were nontoxic to larval lampreys at 10.0 ppm and 27 were toxic at 10.0 ppm or less. Further testing indicated that 14 of the 27 were selectively toxic to larval lampreys.

Larval growth and transformation. It has been found that nutritional levels can affect larval transformation as well as growth. Studies are presently underway to relate these findings to other environmental factors such as temperature. Ammocetes of known age are being maintained under various programs of food and temperature regulation.

Larvae of known parentage. Identification of young-of-the-year larvae and separation of the 3 species in the Genus *Ichthyomyzon* are difficult. In an attempt to find distinguishing features, ammocetes of known parentage are being reared in the laboratory and embryological development of each species followed. Large numbers of stage 17 (burrowing) prolarvae, 29 days from fertilization, have been preserved and are being examined.

Effects of TFM on fish-food organisms. Mortality of some aquatic invertebrates and unusual emergence of some insect species during chemical treatments prompted a study of the effects of TFM on fish-food organisms. Square-foot bottom

samples have been taken on several streams immediately prior to chemical treatment, 1 week after treatment, 6 weeks after treatment, and 1 year after treatment. Similar samples have been taken from untreated streams carefully selected to provide comparable data.

Generally, representatives of all the major orders of aquatic insects except Odonata show a slight reduction in numbers immediately after chemical treatment. The greatest decline occurs among members of the order Trichoptera and Coleoptera, while smaller reductions generally take place among Diptera, Hemiptera, and Ephemeroptera. Recovery is usually rapid, with most groups returning to their pretreatment numbers within 6 weeks. All groups in streams treated prior to and during 1963 have shown a complete recovery.

TFM residues in the environment. Further development of methods to recover TFM from fish and natural waters utilizing acid hydrolyzation, solvent extraction, and ion-exchange resins, has led to a publication.*

Using these methods it has been found that fish exposed to the lampricide at low concentrations (2-4ppm) for periods ranging from 1 to 7 days and fish killed by higher concentrations contain no detectable TFM. Since it is possible that enzymatic degradation continues after death, fish are being analyzed immediately.

Samples of fish, food organisms, water, and sediments were collected from the Pentwater River, which was treated in the spring of 1963. Analysis of fish and water samples has shown no lampricide residue.

A new method of analysis for the characteristic groups attached to the benzene ring in the basic TFM structure with an infrared recording spectrophotometer has also been developed. The applicability of the technique is limited, however, because of the quantity of TFM needed in the sample for detection. A method to fractionate TFM into the pure substance, its isomers, and other impurities, by gradient elution chromatography also has been developed.

Water analysis. The first phase of a study of water quality of tributaries to Lakes Superior and Michigan was completed. From December 1962 through December 1964, analysis of stream waters were made at 136 stations on 99 tributaries

* Daniels, Stacy L., Lloyd L. Kempe, Thomas J. Billy, and Alfred M. Beeton. 1965, Detection and measurement of organic lampricide residues. Great Lakes Fish. Comm. Tech. Rep. No. 9, 18 pp.

of Lake Superior and 83 stations on 56 tributaries of Lake Michigan. Information on their conductivity, pH, alkalinity, hardness, concentration of calcium, magnesium, aluminum, copper, iron, chlorides, phosphates, nitrate-nitrite nitrogen, silica, sulfates, and tannin-and lignin-like compounds will be published shortly.

Experimental population of ammocetes. A single year class of sea lamprey ammocetes was established in the Garlic River in 1960. The population is isolated by a dam which blocks the upstream migration of spawning adults from Lake Superior. A downstream trap prevents the ammocetes from leaving the study area.

Collections taken each October from this population show a significant reduction in the rate of growth during the past 2 years (Table 5).

Table 5 -- Growth of 1960 year class of ammocetes in the Garlic River to October, 1964.

Year	Mean length	Length range	Length increment
1960	13mm	10-19mm	13mm
1961	39mm	25-54mm	26mm
1962	63mm	37-107mm	24mm
1963	80mm	52-134mm	17mm
1964	94mm	43-159mm	14mm

A substantial increase in the movement of ammocetes into the downstream trap occurred during the past year. A total of 2,847 individuals was captured in 1964 as compared to 379 in 1963. The period of major downstream drift extended from April through June.

Thus far, 3,314 ammocetes have been marked and returned to the study area. These include 318 individuals from the annual collection in October 1962, 700 in 1963, 400 in 1964, and 1,896 ammocetes captured on the downstream trap. A combination of colors and location of the marks permits the animals to be separated on the basis of time and point of release. During the 1964 collections, 59 marked ammocetes were recovered. These include 1 individual marked in October 1962, 13 marked in 1963, and 45 from the group taken at the trap in the spring of 1964. The marked ammocetes were collected within a half mile of their release. Thus far, there has been no evidence of metamorphosis.

LAKE TROUT REHABILITATION

The program of lake trout rehabilitation, carried out jointly by federal, state, and provincial agencies, continued to be concentrated in Lake Superior in 1964. For the third successive year, the States of Michigan, Wisconsin, and Minnesota, and the Province of Ontario restricted lake trout fishing in Lake Superior in order to encourage recovery of the trout, but at the same time permitted enough fishing to allow continuation of biological studies.

The general improvement in the survival of lake trout in inshore waters of the lake, first noted in 1962, continued through 1964, and as a result, more mature trout were encountered in all areas. Hatchery-reared lake trout provided a larger segment of the inshore catches than ever before, but remained virtually absent from offshore grounds. Further evidence of the comparatively healthy condition of offshore populations in both United States and Canadian waters was obtained.

In the United States waters of Lake Superior the lake trout fishery remained closed but sampling of the population for biological information was continued by licensed fishermen, operating under contracts or special permits. Slightly more than 37,600 trout weighing about 110,000 pounds were taken and examined by the research agencies. In Canadian waters the fishery operated within a 135,000-pound quota, applied by season and area. By the end of the year, the Canadian catch totalled about 109,000 pounds of which 81 percent (39,900 fish weighing about 88,800 pounds) was examined by Fisheries Research Board staff.

The most important feature of the improvement has been the steady increase in abundance of larger lake trout (24 inches and up) and relatively high level of natural spawning throughout Lake Superior reported by all agencies in 1964. The most striking example comes from the Apostle Islands region of Wisconsin where the catch of spawning fish per unit of effort on one spawning ground was 9 times greater than in 1963 and over 100 times greater than in 1960. Although males were much more abundant than females (7:1), the prospects appeared excellent that the number of eggs deposited in this area in 1964 exceeded that of any year since 1954. A significant increase in spawning activity was reported for other Wisconsin grounds. In Michigan waters the number of mature females

encountered during fall sampling was about double that in 1963. In Canadian waters the small number of mature fish and occasional spawners reported from most inshore fishing grounds represented an improvement over recent years.

Fishing success in inshore waters continued to improve in 1964 for the lake as a whole. Numbers of marketable trout caught per 10,000 feet of gillnet lifted in Wisconsin waters rose from 80 in 1963, to 86 in 1964. Michigan values rose from 42 in 1963 to 44 in 1964, but were still well below the figures observed in Wisconsin. Limited data from Minnesota indicated a similar improvement. In Canadian inshore waters, increases in the catch-per-unit effort continued in the western area and Whitefish Bay. Elsewhere in Canadian inshore waters fishing success was not greatly different from 1963. Success in the western area fell between that enjoyed by Michigan and Wisconsin, while in eastern Lake Superior it was somewhat below the Michigan level.

The incidence of lamprey-wounded lake trout in the fall catches throughout United States inshore waters in 1964 was similar to that in 1963. The fall wounding rate in Wisconsin waters (1.1 percent) although slightly higher than in 1963 was still among the lowest in the lake. In Michigan waters wounding rates were substantially lower in September but were slightly higher in late fall and winter than in 1963. Fall wounding rates in the western area of Canadian waters were down to 2-3 percent in contrast to 5-9 percent in 1963. An increase from 2.6 to 5.5 percent occurred in Whitefish Bay but this change probably reflected an increase in average size of the trout, which were essentially all from a single planting, rather than an increase in abundance of the sea lamprey. Elsewhere indices were little changed from those of a year ago, so that the overall picture in Canadian waters was one of further decline in lamprey abundance.

Hatchery-reared lake trout comprised approximately two-thirds of the legal fish (17 inches and up) taken in Wisconsin and Michigan in 1964, while over 95 percent of the undersized trout were of hatchery origin. Approximately 56 percent of all lake trout (undersized and marketable) taken in Canadian waters were from plantings. Throughout the lake, hatchery-reared trout were almost entirely confined to the inshore waters where they were planted. Less than 1 percent of both United States and Canadian catches on offshore grounds was of hatchery origin.

The offshore populations of lake trout in both United States and Canadian waters continued to show a catch-per-unit effort

substantially above those from inshore waters. Sampling of four widely separated offshore grounds in United States waters yielded values ranging from 75 to 148 marketable trout per 10,000 feet of gillnet lifted. Catch-per-unit effort values from Canadian offshore grounds ranged from 50 to 445 fish. These populations contained substantial numbers of old, mature trout and were evidently self-producing. Research agencies have recommended that most of these areas be fished commercially on a conservative level.

In 1964, state, federal, and provincial agencies planted nearly 2.6 million yearling lake trout in Lake Superior, (Table 1). Slightly more than 472,000 were planted in Canadian waters by the Ontario Department of Lands and Forests, and nearly 2.2 million were planted into United States waters by the U. S. Bureau of Sport Fisheries and Wildlife and the conservation departments of Wisconsin and Minnesota. These plantings represented an increase of 321,000 fish over 1963 and brought the total plantings in Lake Superior since 1958 to 10.8 million fish.

Table 1 -- Plantings of hatchery-reared lake trout in Lake Superior, 1964 (yearlings except as noted.)

Agency	Location planted	Number	Fin clip
Ontario Department of Lands and Forests	Rossport to Pie Island	222,000	adipose and left ventral
	Sawpit Bay, Montreal River Mica, Alona, and Michipicoten areas	250,000	adipose and left pectoral
Wisconsin Conservation Department	Apostle Islands	743,000	adipose and right pectoral
Minnesota Department of Conservation	Grand Marais (Minn.) and Hovland areas	182,000	dorsal and right ventral
	Grand Marais (Minn.) and Baptism River areas	38,000[1]	dorsal
Bureau of Sport Fisheries and Wildlife	Keweenaw Bay to Grand Marais (Mich.)	803,000	right pectoral
	Whitefish Bay	195,000	dorsal and left ventral
	Ontonogan	198,000	adipose and right ventral
	TOTAL	2,631,000	

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A SUMMARY OF FISHERY RESEARCH ON THE GREAT LAKES IN 1964

Lake Ontario

Whitefish have been traditionally the important commercial species in eastern Lake Ontario. Studies of this fishery began in 1944, and have been carried on routinely ever since. The introduction of nylon gillnet in 1950, increased the effectiveness of fishing and few whitefish now survive to reach six years of age. The fishery has, therefore, come to depend largely on a stock consisting of one or two year classes. It is not surprising, therefore, that the virtual failure of natural reproduction in 1959, 1960, and 1961 resulted in the almost complete collapse of the fishery in 1964.

Two populations of whitefish have been distinguished by tagging experiments, one spawning in the Bay of Quinte, the other on the exposed south shore of Prince Edward County. With the drastic decline of the Bay of Quinte population, the fishery has become increasingly dependent on the lake shore population and investigations to determine its distribution and migration were begun in 1963. These were discontinued in 1964 to permit tag retention tests but will be resumed in 1965.

The fishery for American eel in Lake Ontario assumed greater importance in 1964 with the decline in production of fisheries on the Atlantic. Eel were second to the whitefish in value of catch in 1964. Sampling of eel catch was begun in 1964, and tagging, marking, and aging techniques investigated.

An experiment to re-introduce lake trout and to determine what factors may have been responsible for their decline was undertaken by the Ontario Department of Lands and Forests and the New York Conservation Department in 1953. In 1963, the plantings were increased substantially with the provision of 108,000 trout by the Bureau of Sport Fisheries and Wildlife. These fish were successfully transported by air from Charlevoix, Michigan to Glenora, and released by boat. In 1964, 110,000 lake trout were again successfully flown to Glenora and planted by boat in the vicinity of Main Duck Island and Charity Shoal.

Although fishing for lake trout is prohibited, approximately 9,600 fish from the 1963 planting were taken incidentally in fishing for other species, principally whitefish, indicating good survival of trout. The surprisingly high recovery also suggests that the intensity of the whitefish fishery may play an important role in the survival of young trout.

The sport fisheries in the more protected waters, notably the Bay of Quinte, and the St. Lawrence River, have also been investigated. In the Bay of Quinte, angling for walleye in 1964 produced a very low catch, estimated by creel census to be less than 1200 fish. Trap netting, on an important spawning ground, indicated that spawning stock had declined substantially.

Routine sampling has shown low dissolved oxygen concentrations near Belleville and there is other evidence that eutrophication is proceeding rapidly in some areas of the Bay. Phytoplankton are being sampled for comparison with data collected in 1945 to determine the rate.

In Lake St. Lawrence, the creel census carried out in Canadian waters showed somewhat poorer angling success for northern pike and largemouth bass and an improvement in smallmouth bass fishing.

During the year, the Ontario Department of Lands and Forests planted Kokanee eggs from British Columbia and several western states in Shelter Valley and Wilmot Creeks. Efforts to locate suitable incubating areas in the lakes were unsuccessful and the eggs destined for lake plantings were retained in the hatchery. The resulting fry will be planted on Pigeon Shoal, Charity Shoal, and Main Duck Island and in several streams in the spring of 1965.

A general shortage of yellow perch created a market for white perch, a species which although it became abundant in Lake Ontario recently, has not been fished commercially. Net-selection studies were undertaken to determine what size mesh would yield the greatest economic return to the fishermen and a mesh of 3 1/2" was established.

During the summer, the Ontario Department of Lands and Forests assessed the sampling characteristics of the trawling gear and procedures with which it intends to monitor fish stocks. Other biological studies included the hybridization of several coregonids and an investigation of gas secretion in the swim bladder of whitefish.

Exploratory cruises to collect information on the abundance of fish and data on environmental conditions were made by the Department of Lands and Forests vessel *Namaycush*, and the

Bureau of Commercial Fisheries vessel *Cisco*. Poor catches were reported by both agencies. However, the Bureau reported large populations of mysids and amphipods and noted that calcium, sodium, and potassium concentrations were similar to those in Lake Erie. Secchi disc readings were relatively low (less than 3 meters). Despite this evidence of high productivity at lower trophic levels, dissolved oxygen was near saturation throughout most of the lake except near the outlet at the St. Lawrence River. The Bureau has concluded that Lake Ontario is morphometrically oligotrophic but that its basic productivity is that of a mesotrophic lake.

Synoptic and special cruises were also carried out during the winter of 1964 by the *Porte Dauphine*, as part of the program of the Great Lakes Institute of the University of Toronto. During these cruises, limnological and meteorological observations were made and water samples collected for chemical analysis by the Ontario Water Resources Commission.

Lake Erie

Sampling of the commercial catches was continued by the Ontario Department of Lands and Forests and the U. S. Bureau of Commercial Fisheries. Walleye, taken in good numbers by Canadian fishermen in Western Lake Erie in the spring, consisted largely of the relatively strong 1962 year class. In the fall, the catch consisted mainly of the weak 1963 year class, and further contributions to the fishery by the 1962 year class are expected to be negligible. A similar change in age composition was observed for the catch in U. S. waters.

Marked fluctuations in the year class strength of walleye has resulted in a study of their spawning in Western Lake Erie. Since 1961, the Ohio Division of Wildlife has routinely collected eggs from various areas with a pumping device. Seven major spawning reefs have been located and bottom characteristics described. In addition, measurements are made of the physical, chemical, and biological conditions in their vicinity which may affect the development of the eggs and hatching. In 1964, about 96 percent of the eggs taken came from 7 of the 23 stations sampled. The average number of eggs collected was higher and viability about the same as in the two preceding years.

During the latter half of May, 170 fry tows were made near walleye spawning grounds. These produced about 18,000 fry consisting mainly of yellow perch; only 4 walleye were taken. The small number captured preclude any estimates of abundance and the technique used appears to be inadequate for quantitative studies of walleye fry.

Trawl sampling of young fish by the Bureau's vessel *Muskie II*, indicated that the 1964 year class of walleye was slightly better than that of the poor year classes in 1957, 1958, 1960, 1961, and 1963. This observation was confirmed by the Ohio Division of Wildlife in their fall trawling survey. In early summer, catches were relatively high but declined abruptly in mid-August and remained low. It is not clear whether the young walleye moved out of the western basin or suffered severe mortality. The hatch of yellow perch in 1964 also appears to have been poor. Index stations located in each of the three basins were fished by the Ontario Department of Lands and Forests vessel, *Keenosay*. These stations were first used in 1963, and some modification of location and fishing techniques is planned.

Gillnets of graded mesh size were fished inshore to obtain information on age, growth, and distribution of various species and the selectivity of different meshes for species and sizes of fish.

Smelt, which provided the highest catch in Canada, continued to be studied intensively by the Department of Lands and Forests with emphasis on the time of spawning in various basins, age composition of spawning fish, and egg deposition. Studies were made in the eastern basin to obtain information on the depth distribution of smelt at various ages, and their food and growth. A diel rhythmn in vertical movements was observed.

A study of the food of young walleye, which was completed by the Bureau in 1964, showed a strong selection for certain sizes and species of prey. Young walleye in the extreme western part of the lake fed primarily on gizzard shad and alewife during their first summer, while walleye in the island area concentrated on yellow perch. Both groups fed on emerald shiner later in the year.

Limnological investigations in Lake Erie by the Bureau of Commercial Fisheries during 1964, included an intensive study of oligochaetes which resulted in identification of 26 species of which only 6 had been reported previously for the Great Lakes. Since members of the group can be used as indicators of polluted and unpolluted areas, the study is of special significance in the investigation of water quality changes in Lake Erie.

Low dissolved oxygen concentrations in bottom waters has led to a laboratory study of the chemical reactions and transfer

of material between the sediments and overlying water. Most of the effort by the Bureau during 1964 was spent in developing systems for continuous measurements of physical-chemical changes.

During 1964, extensive collection of data on water chemistry, bottom sediments, coliform counts, and bottom fauna were made by the U. S. Public Health Service and the Great Lakes Institute of the University of Toronto.

Lake Huron

Fishery investigations in Lake Huron during 1964 were for the most part limited to Canadian waters and were carried out by the Ontario Department of Lands and Forests. Catches of commercial fishermen were sampled at several ports on the North Channel and Georgian Bay with emphasis on the collection of whitefish data. A paper on the ecology and exploitation of whitefish in the south end of the Bay was completed and submitted for publication. With catches of whitefish low in most of Georgian Bay, fishermen turned to yellow perch, a hitherto ignored species in this area. In the North Channel, landings of whitefish were up substantially due largely to the recruitment of the relatively strong 1961 year class. An estimated 2500 trout hybrids planted in 1961 and 1963 were also taken.

A creel census of the sport fishing was continued at South Bay and Parry Sound. Growing interest in yellow perch resulted in a record catch of this species by anglers in South Bay.

Experimental fishing with a variety of gear was continued in South Bay. Alewife made up the bulk of the pound-net catch. Ninety percent of the gillnet catch consisted of yellow perch, white sucker and lake whitefish. A total of 40 splake were taken during the year.

In November, approximately 355,000 Kokanee eggs from British Columbia were planted in seven Lake Huron tributaries in Canada. Other shipments totalling 1.75 million eggs from Colorado, Washington, and Oregon were placed in hatcheries for planting in the spring of 1965. About half of the fry will be planted in South Bay where they can be closely studied.

Larval fish sampling initiated in South Bay to determine distribution and development of young fish was largely explanatory. Emphasis will be placed on whitefish.

Investigations in the United States were limited to the collection of net-run samples of yellow perch and walleye by the Bureau of Commercial Fisheries during the spring and fall

fishing in Saginaw Bay. Water samples, bottom sediments and fish were collected for an investigation of the distribution of *Clostridium botulinum* in the Great Lakes being carried out by the University of Wisconsin.

Limnological and related data were collected by the *Porte Dauphine* of the Great Lakes Institute in Lake Huron and Georgian Bay during the summer of 1964. Studies of fish populations, lake currents and internal waves were carried out at the Institutes Research Station on Douglas Point. A cooperative study with the Ontario Department of Lands and Forests on the water exchange between South Bay and Lake Huron was continued. The sediments and geological structure of South Bay were also mapped.

Lake Michigan

The coregonids, which until the recent increase in alewife were the dominant group of fish in Lake Michigan, were studied intensively by the U. S. Bureau of Commercial Fisheries. Trawling with a one meter plankton net was carried out off Saugatuck to follow the distribution of larvae. These were taken in small numbers in April, reached a peak in late June and early July, and then declined rapidly. None were taken in October. Larvae were most abundant in mid-water strata over bottom depths of 40 to 60 fathoms except in the spring when they were taken from top to bottom.

Information on mortality rates and seasonal growth of *Coregonus hoyi*, the dominant species, was obtained from the analysis of scales from fish caught in trawls by the *Cisco* off Saugatuck. Mortality rates of 0.69 and 0.81 were estimated for ages III to IV and IV to V. The similarity of age composition for the 1963 and 1964 samples indicates little fluctuation in year class strength.

During the year, both the *Cisco* and *Kaho* bottom trawled at various depths to follow the vertical distribution of ciscoes and associated species.

Identification of young coregonids using morphological features of individuals from known parents was continued. Differential growth rates of certain parts appear to be diagnostic and methods from employing these data for identification are being developed.

Work on blood serum protein separation was also continued. The serum protein of 20 coregonids from Europe and North America were separated by acrylamide electrophoresis. It appears that the mobility of the faster moving proteins provides

a basis for distinguishing three groups. Although the electrophoretic response of the various proteins has been different, their immunological cross-reactivity shows that they are closely related. Despite their widespread distribution there is a marked similarity in the patterns displayed by species formerly grouped under the Genus *Leucichthys*. The approach has been extended to consider the distribution of various molecular forms of the enzyme lactic dehydrogenase through which mutations take effect.

The recent rapid increase in alewife has now made it the dominant species in Lake Michigan and studies of its life history, particularly its early stages, have been initiated. Alewife eggs from spawning fish in the Kalamazoo River have been incubated and hatched in the laboratory. Subsequent attempts to catch larvae in the river were unsuccessful. Those collected in plankton nets in Lake Michigan were dead or died shortly after capture. Dispersion of the larvae from the river appears to have been rapid since individuals were taken 15 miles out in the lake within two weeks of the first hatch.

Other activities included the collection of net-run samples from the commercial fishery for yellow perch in different sections of Green Bay. The Wisconsin Conservation Department continued its studies of the survival and growth of rainbow trout and harvest of smallmouth bass along the Door Peninsula.

Lake Superior

Investigations in Lake Superior during 1964 were again mainly concerned with lake trout. The commercial fishery for trout has been restricted since 1963 to encourage the recovery of the population following lamprey control. It has been necessary, however, to permit some fishing with commercial gear to provide information on lake trout comparable to that taken previously in order to follow the recovery and evaluate the effect of plantings. In the United States a limited number of commercial operators are permitted to fish in a specified manner and their catches examined by state and federal biologists. In Canada, a catch limit is imposed for various areas and seasons and the catch sampled by staff of the Fisheries Research Board of Canada. Additional information was obtained by experimental fishing by the U. S. Bureau of Commercial Fishing vessel *Siscowet*. The results of these studies are summarized in the report on lake trout rehabilitation.

Other investigations on Lake Superior in 1964 include a survey of the species composition and abundance of diatoms, limnological data collection by the *Siscowet* and scale collections from landings of whitefish and herring.