Fisheries Research Board of Canada

ANNUAL REPORT

to the

GREAT LAKES FISHERY COMMISSION

of activities carried out under a
Memorandum of Agreement
during the period

APRIL 1, 1961 to MARCH 31, 1962

With Investigators' Summaries as Appendices

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Annual Report to the Great Lakes Fishery Commission for 1961-1962

This report is submitted to fulfill terms of a Memorandum of Agreement between the Fisheries Research Board of Canada and the Great Lakes Fishery Commission. Appended are detailed accounts by those responsible for specific aspects of the program.

MAINTENANCE OF ELECTRICAL BARRIERS

Barriers were installed and operated on the eight Lake Superior tributaries specified in the Memorandum of Agreement. Most of the barriers were activated during the first week in May; however, the Batchawana barrier was activated May 15 and the Pays Plat and Gravel barriers were activated between July 29 and July 31. There were few breakdowns and little flood damage, so barriers were inoperative for a total of only 90 barrier-hours out of 15,704. See details in Appendix 1.

In 1961 2,895 adult sea lampreys were killed and collected at the eight barriers operated as compared with 3,887 collected at the same barriers in 1960. No special significance is attached to this decrease in numbers.

CHEMICAL TREATMENT OPERATIONS

Surveys:

In 1961, 24 Lake Superior tributaries were surveyed to determine ammocoete distribution. No new lamprey-producing streams were discovered. Three other Lake Superior streams and 22 Lake Huron tributaries were surveyed as immediate preludes to treatment with lampricide.

Surveys were conducted on 13 Lake Superior tributaries which had been previously treated with lampricide to get information for assessing the effectiveness of such treatments. In 7 of them sea lamprey ammocoetes were found whose size indicated that they must have been present during the treatment, therefore must have survived it. Flood conditions prevented accurate surveys on several of the remaining 6 streams. This demonstration that some ammocoetes survived the original treatment has led to appropriate changes in treatment technique. See details in Appendix 2.

A mobile laboratory was used to make 64 bio-assays as a means of accumulating data on the effectiveness of lampricide at different seasons. See details in Appendix 3.

Treatment:

The two tributaries to Lake Superior specified in the Memorandum of Agreement, namely, Chippewa and Pancake, were treated. In addition, the following were treated at the request of the Commission: Batchawana, Sable and Wolf.

The following tributaries to Lake Huron specified in the Memorandum of Agreement were treated: Root, Gawas, Two Tree, Richardson's, Gordon's, Brown's, and Nottawasaga. In addition, the following were treated at the request of the Commission: Lafontaine, Serpent, Livingstone, MacBeth, Lauzon, Mississagi, and an unnamed stream designated as H-114. In order to treat streams which were not specified and to carry out certain surveys which were not originally contemplated, it was necessary to leave untreated the following Lake Huron tributaries specified in the Memorandum of Agreement: Echo, Watson's, Kaskawong, Spanish and the unnamed streams designated as H-47, H-65 and H-68.

Some information on the completeness of ammocoete destruction is indicated above under "surveys". Collections are available for determining the size of ammocoetes killed in Lake Superior, but the data have not yet been worked up. Details on stream treatments are given in Appendices 4, 5 and 6.

RESEARCH

Since Commission support for research in Canada ended on March 31, 1962, all findings of the two research projects are reviewed.

Ammocoete Studies:

It has become apparent from studies on the biology of sea lamprey ammocoetes that they are much more adaptable than was previously realized. They tend to remain in their burrows in the stream bottom during daylight and to emerge, if they emerge at all, only during darkness, particularly immediately after nightfall. They seldom leave their burrows, but do move a good deal within the stream bed. Freshets tend to dislodge them. Either active emergence from the burrow or passive movement as a result of being washed out of the stream bed result in a consistent drift downstream; they are not able to swim against even moderate currents, so any movement must be downstream. As a result, ammocoetes from comparatively short streams reach the open lake well before metamorphosis. They seem to develop just as successfully in the open lake as if they had remained in the parent stream. Lake-living populations of sea lamprey ammocoetes were found off the mouths of six of the eight streams investigated. In the adequately sampled inshore areas they occurred at a rate of approximately 17 individuals per 10,000 square yards, and the limited data available indicates comparable concentrations in offshore areas.

None of the conventional methods for determining fish ages are applicable to sea lamprey ammocoetes, since they have no scales, fins, otoliths, etc. However, information recently published in Britain has provided a clue for assessing their ages. As a result, ammocoetes in intensively-studied Big Creek (Lake Erie) are now tentatively regarded as 5½ or 6½ years old at the time of metamorphosis, and it is tentatively concluded that ammocoetes in other Great Lakes watersheds are of comparable age. There is evidence to suggest that metamorphosis takes place at a specific age rather than at a specific size, as had been assumed until recently. See details in Appendix 7.

Temperature Tolerance Studies:

The thermal tolerance of the sea lamprey has been studied during each stage in its life history. During most stages the responses of lampreys to lethal temperatures correspond to those exhibited by fish. Except in the egg stage, lampreys can, given time to acclimate, live at all temperatures between 0°C and 32.5°C. However, the temperature range within which eggs will develop is much narrower.

During 1961 experiments were concerned solely with temperature tolerance during the egg stage. In order to lengthen the period over which the eggs would be available, spawning was delayed in a number of mature sea lampreys by holding them at low termperatures until required. Unfortunately, the fertilized eggs which resulted did not develop successfully. However it was possible to demonstrate that, although eggs required temperatures between 15° and 25°C in the early stages, they will tolerate a wider range at later stages of development. This information would be useful for assessing whether lampreys could use certain streams for breeding purposes. See details in Appendices 8 and 9.

OTHER

Although not specified in the Memorandum of Agreement, certain observations were taken at the Commission's suggestion: see Appendix 10.

INDEX TO APPENDICES

SPECIES NAMED

The following species of aquatic vertebrates are mentioned in this report and its appendices; synomymy is indicated to assist the reader in identification. In most cases the "common name" is the one recommended by a committee of the American Fisheries Society. "Short names" are alternatives used for brevity or to include more than one species. An asterisk under the "common name" column indicates the designation when identification is not made to species.

Common Name	Scientific Name	Short Name
Sea lamprey	Petromyzon marinus	lamprey
Silver lamprey	Ichthyomyzon unicuspis	lamprey
Michigan brook lamprey	Ichthyomyzon fossor	lamprey
*	Ichthyomyzon spp.	lamprey
American brook lamprey	Entosphenus lamottei	lamprey
Alewife	Alosa pseudoharengus	...
Gizzard shad	Dorosoma cepedianum	...
American smelt	Osmerus mordax	smelt
White sucker	Catostomus commersoni	sucker
Longnose dace	Rhinichthys cataractae	dace
Rosyface shiner	Notropis rubellus	minnow
Common shiner	Notropis cornutus	minnow
Carp	Cyprinus carpio	...
Channel catfish	Ictalurus punctalus	catfish
Northern pike	Esox lucius	pike
Yellow perch	Perca flavescens	perch
Iowa darter	Etheosoma exile	darter
Johnny darter	Etheosoma nigrum	darter
Rock bass	Ambloplites rupestris	...
White perch	Roccus americanus	...
White bass	Roccus chrysops	...
Muddler	Cottus bairdi	sculpin
Mud puppy	Necturus maculosus	...

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Appendix 1

OPERATION AND MAINTENANCE OF ELECTRICAL BARRIERS, LAKE SUPERIOR, 1961

The L.B.O.U. operations during 1961 were carried out by two groups located at the field headquarters at Sault Ste. Marie, and a field station near Rossport, Ontario. The Wawa station, which operated in 1960, was eliminated in 1961 as the Michipicoten River barrier (maintained from Wawa) was removed from service after the 1960 season. The Rossport field station consisted of a mobile house trailer for personnel and a mobile bio-assay laboratory trailer used to perform preliminary bio-assays of tributaries to Lakes Superior and Huron for the Chemical Treatment Unit. After field operations on the electrical barriers were completed, the Rossport unit divided into two groups; one continued bio-assay work from Sault Ste. Marie and the other assisted with chemical treatment of streams and stream surveys.

The L.B.O.U. operation during 1961 was conducted as in 1960 except that two electrical barriers, namely, the Goulais and Michipicoten Rivers, were eliminated. The eight barriers operated consisted of six in the Sault Ste. Marie area and two in the Rossport area (Table I). Water conditions during the installation of barriers were near normal spring expectation; thus little difficulty was encountered except with the Batchawana River where damage to the electrodes caused a 48-hour non-operational period. The balance of the season was conducted with little trouble from high water or mechanical failures.

At the termination of the barrier operating season, the L.B.O.U. staff in the Soo area started to dismantle and remove the discontinued electrical barrier installations. The following is the list of 13 barriers which have been discontinued and removed: Little Carp (S-4), Goulais River (S-24), Stokeley Creek (S-36), Agawa River (S-93), Old Woman River (S-138), Michipicoten River (S-167), Hewitson River (S-351), Coldwater River (S-103), Baldhead River (S-105), McLean's Creek (S-363), Cypress River (S-374), McIntyre River (S-570) and Neebing River (S-571).

The total number of adult migrant sea lampreys collected during the years 1955-1961 from the eight Lake Superior barriers, that are presently being maintained and operated for assessment of the effect of the chemical control experiment on the lake population of lampreys, are listed in Table II. This table includes all lampreys collected from each river for the complete operating seasons. Table III indicates the dates of the first and last capture of lampreys at each of the eight barriers. Prior to 1960 the barriers were installed as early in the spring as possible. However, extreme difficulty was encountered in installation due to high water levels and flash flooding prevalent during April.

Table I. Dates of operation, operating hours, operating hours lost to barriers failing, evidence of escapement and use of nets to reduce fish kill for eight rivers, Lake Superior, 1961.

Stream Names	Dates of operation	Operating hours	Hours inoperative May	Hours inoperative June	Hours inoperative July	Evidence of escapement	Upstream nets	Downstream nets
Big Carp (S-5)	May 5 - July 31	2046	12	...	...	Nil	Nil	One
Harmony (S-39)	May 5 - July 31	2058	...	...	...	Nil	Nil	One
Chippewa (S-48)	May 8 - July 31*	2016	...	...	...	1 adult seen	Nil	One**
Batchawana (S-52)	May 15 - July 31	1800	48	...	...	1 adult seen	Nil	One**
Sable (S-54)	May 5 - July 31	2058	...	...	...	Nil	Nil	One
Pancake (S-56)	May 3 - July 31	2106	+	...	...	Nil	Nil	One
Pays Plat (S-360)	May 19 - July 29	1780	...	...	...	Not examined	Nil	One
Gravel (S-368)	May 19 - July 29	1750	...	30	...	Reported by anglers	Nil	One
	Totals	15,614	60	30	0			
				90				

* Chippewa River - barrier in operation on west side from May 8 to July 31, east side May 11 to July 31.

** Six-foot chain link fence stretched across river, 1960 Annual Report - Appendix 21.

Table II. Adult migrant sea lampreys recovered from eight electrical barriers, Lake Superior, 1955-1961.

	1955	1956	1957	1958	1959	1960	1961
Big Carp R. (S-5)	5	27	28	19	15	20	6
Harmony R. (S-39)	29	29	16	6	8	19	14
Chippewa R. (S-48)	807	839	359	220	296	1051	453
Batchawana R. (S-52)	608	421	427	358	482	629	561
Sable R. (S-54)	43	65	76	47	142	246	100
Pancake R. (S-56)	555	717	1073	809	816	1306	931
Pays Plat R. (S-360)	...	6	3	4	32	10	31
Gravel R. (S-368)	...	5	99	154	541	626	799
Totals	2047	2109	2081	1617	2332	3907	2895

It is apparent in Table III that the lamprey run does not start until about mid-May, presuming that the barriers have been effective in sampling the population during the early spring. As the barriers have not been used during 1960 and 1961 as the means of control, and also as the lamprey run begins later in May, the target date for installation, especially of the larger rivers that are affected by the flooding, during 1960 and 1961 was May 15. Table IV lists the number of lampreys collected at the eight barriers after July 31. Until 1961 the barriers were operated for varying periods late into the fall season. The criterion had been established that barriers would operate until a two-week period had elapsed, in which time no adult lampreys were collected. Until 1960 some barriers operated until September or October. The number of lampreys collected at these barriers after the end of July is insignificant compared to the total number for the individual barriers for each season.

On comparing the total number of lampreys (Table II) and taking into consideration the number of lampreys collected after the end of July (Table IV), it is apparent that the fluctuations in capture could be attributed to normal variations in any population.

Table III. Date of first and last lamprey collected from electrical barriers, Lake Superior, 1956-1961.

	1956	1957	1958	1959	1960	1961
Big Carp R. (S-5)	June 7* Aug. 16**	ca. May 25 ca. Aug. 31	May 7 July 9	May 20 June 15	May 18 July 5	May 21 July 14
Harmony R. (S-39)	May 24 Aug. 28	May 16 ca. Aug. 3	June 12 July 16	May 22 Aug. 13	May 18 July 4	June 7 July 14
Chippewa R. (S-48	May 24 Aug. 25	ca. May 16 ca. Aug. 31	May 5 July 31	May 21 Aug. 21	May 23 Aug. 8	May 13 July 31
Batchawana R. (S-52)	June 12 Sept. 5	ca. May 16 ca. Sept. 14	May 4 July 31	May 14 Sept. 15	May 18 Aug. 5	May 21 July 28
Sable R. (S-54)	May 24 Sept. 2	ca. May 25 ca. Aug. 31	May 12 July 29	May 14 Aug. 18	May 15 Aug. 8	May 9 July 20
Pancake R. (S-56)	May 24 Sept. 13	May 16 Sept. 3	May 5 July 31	May 11 Aug. 19	Apr. 27 Aug. 8	May 19 July 31
Pays Plat R. (S-360)	June 12 July 25	June 13 July 17	May 21 July 24	May 25 Aug. 18	May 25 July 6	May 30 July 16
Big Gravel R. (S-368)	June 11 July 21	June 4 July 22	May 16 July 31	May 26 Aug. 14	May 16 July 20	May 24 July 22
Date last barrier turned off	All off Sept. 9 Sable & Pancake Nov. 14	All off by Sept. 14	All off by Oct. 4	All off by Sept. 25 (Pancake operated all year)	All off by Aug. 29	All off by July 31

* first lamprey collected.
** last lamprey collected.

Table IV. Number of adult sea lampreys collected from electrical barriers, Lake Superior, after July 31, 1956-1961.

	1956	1957	1958	1959	1960	1961
Big Carp R. (S-5)	4	5	0	0	0	Shut off Jul. 31
Harmony R. (S-39)	7	1	0	1	0	"
Chippewa R. (S-48)	13	6	16	6	6	"
Batchawana R. (S-52)	39	19	18	10	3	"
Sable R. (S-54)	7	13	8	3	5	"
Pancake R. (S-56)	58	28	15	10	6	"
Pays Plat R. (S-360)	0	0	0	2	0	"
Big Gravel R. (S-368)	0	0	2	4	0	"
Totals	128	72	59	36	20	

The catches at the Sault Ste. Marie barriers, Big Carp to Pancake R., have remained comparable throughout the years, while there has been a decided increase from year to year at the western end of Lake Superior at the Pays Plat and Gravel Rivers near Nipigon that may indicate that the population in that area has not stabilized.

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Appendix 2

SEA LAMPREY SURVEY - LAKES SUPERIOR AND HURON, 1961

Sea lamprey surveys were conducted with electro-shocking gear, augmented with the lampricide normally used for chemical treatments of streams. The collection of live ammocoetes for bio-assays occasionally contributes survey-type information. Surveys fall into four categories:

1. Preliminary surveys: which are performed periodically, on all rivers, in which it is considered possible for lampreys to spawn but where lamprey populations have not been demonstrated.

2. <u>Distribution surveys:</u> which are carried out to determine the upstream distribution of sea lamprey ammocoetes, in the main river and its tirbutaries. These surveys are conducted prior to treatment with lampricide and determine the location of "feeder sites" for the application of the toxicant.

3. <u>Pre-treatment surveys:</u> which are performed prior to treatment with lampricide. These surveys may or may not be the distribution surveys, depending on the interval of time intervening between the distribution survey and the time of treatment.

4. <u>Post-treatment surveys:</u> which are generally conducted immediately after the treatment with lampricide to determine the effectiveness and thoroughness of the treatment. Post-treatment surveys performed immediately after treatment, with electro-shocking gear, are not satisfactory owing to the psychological blocks based on the knowledge that the majority of the lampreys, in any watershed, have been killed, especially where the concentration of toxicant has been maintained during treatment at the 99.9% level of kill as indicated in the bio-assay. These surveys are better performed one to two years after treatment. The most effective post-treatment survey is a re-treatment of the watershed with lampricide.

Preliminary stream surveys (Table I) were conducted on St. Ignace and nearby islands and on selected mainland streams in these remote areas of Lake Superior which are accessible only by boat. Many of the streams surveyed have a permanent flow and all the known requirements for lamprey habitation; however, no new lamprey streams were located.

Survey techniques have been refined considerably over the past four years. It has become apparent that more power was required in some rivers and larger portable generators have been acquired. Even these have not been satisfactory on some streams and we have resorted to the use of lampricide, which is applied at high concentrations for short periods of time. This technique was used extensively in 1961 for distribution surveys and has proven faster and more efficient in many cases. The use of TFM for survey is expensive and the chemical loses its property of selective toxicity when applied in this manner. It is imperative that a lethal concentration be attained to activate the animals over the short period of time applied. Without using bio-assay or chemical analyses, the concentrations of TFM in the streams also kill fish. This naturally limits the type of stream and area where this technique may be applied.

The survey crew was moved to Lake Superior late in September, to attempt a survey in the Marathon area, where there are numerous large streams including Big Pic, Little Pic, Steel and Prairie Rivers that have always been suspect streams but have never produced sea lamprey ammocoetes. Unfortunately, the water was turbid and the rivers were in flood after heavy rains early in September. Little was accomplished as this condition existed until late October because of continuous rains, and the survey crew was moved to southern Ontario.

Table I. Preliminary surveys, Lake Superior, 1961.

Stream No.	Stream Name	Number of Ammocoetes Collected P.m.*	Ichth.**	E.l.***	Type of Survey
S-34	Black Cr.	...	1071	...	Bio-assay specimens
S-571	Neebing R.	...	1125	...	" " "
S-305	Big Pic R.	...	...	...	Preliminary
S-306	Duncan Cr.	...	...	...	"
S-315	Mink Cr.	...	...	...	"
S-322	Little Pic R.	...	...	...	"
S-335	Steel R.	...	...	...	"
S-336	Out of Jackfish L.	...	...	...	"
S-379	Jackpine R.	...	...	...	"
S-474		...	...	...	"
S-476		...	...	...	"
S-477		...	...	...	"
Fluor Island					
S-478		...	...	...	"
S-478-1		...	...	...	"
S-479		...	...	...	"
St. Ignace Island					
S-640	Brook R.	...	...	...	"
S-641	Rainbow Lake Cr.	...	...	...	"
S-642	Tedesco Cr.	...	...	...	"
S-643	Otter Lake Cr.	...	...	...	"
S-644	Ruth Cr.	...	...	...	"
S-648		...	...	...	"
S-649		...	...	...	"
S-649A		...	...	...	"
S-651	Shelling Lake Cr.	...	...	...	"
S-652		...	...	...	"
S-652A	Iron Lake Cr.	...	...	...	"

* P.m. = Petromyzon marinus (sea lamprey).
** Ichth. = Ichthyomyzon spp. (silver lamprey and Michigan brook lamprey).
*** E.l. = Entosphenus lamottei (American brook lamprey).

The only pre-treatment survey conducted on Lake Superior, the Wolf River, is listed in Table II, while the pre-treatment surveys for Lake Huron are listed in Table III.

During the 1961 field season the majority of pre-treatment surveys were completed just prior to treatment. At times the chemical crew had to assist with and complete the survey before the lampricide could be applied.

Post-treatment surveys for Lake Superior (Table II) were conducted on all of the streams, treated since 1958, from the Pancake River to Sault Ste. Marie and on the Kaministikwia, Black Sturgeon, Jackfish, Big Gravel, and Pays Plat Rivers in western Lake Superior. Sea lamprey ammocoetes, larger than could be expected by normal growth since the time of the original treatment, were found in the Big Carp, Goulais, Batchawana, Sable, tributaries to the Kaministikwia, and near the mouths of the Harmony and Stokeley Rivers. These findings indicate the advisability of re-treating Big Carp, Goulais and Kaministikwia Rivers during 1962.

Except on the Kaministikwia, where chemical was used on the small tributaries, post-treatment surveys conducted on the streams of western Lake Superior were not conclusive, since the rivers were in flood - some two to four feet above normal. An additional survey is required on these rivers early in 1962.

The finding, in the rivers treated in 1959 and 1960, of sea lampreys larger than could be expected from normal growth, may be explained as follows: (1) Ammocoetes found in the estuarine areas, and upstream as far as the river is affected by seiche action, can in part reasonably be attributed to lake populations and to ammocoetes that escaped the lampricide in the outer estuarine area - owing to the current pattern prevalent at the time of treatment. Ammocoetes can and do migrate from the lake to the river as well as downstream into the estuarine area. (2) Sea lampreys may have been present in lagoons where they remained undiscovered during distribution surveys. Such lagoons would not be treated with lampricide. The most probable areas for recruitment to the main river are from unmapped lagoons, small tributaries and pools which, during low flow, are isolated from the main river. Even though the scale of the maps used is four inches to the mile, small tributaries and lagoons, which are not indicated on the maps, have been found when the rivers have been carefully explored.

Native lampreys, American brook lamprey and Ichthyomyzon spp. (silver lamprey and Michigan brook lamprey combined), were generally more abundant in post-treatment surveys. This was to be expected, as they are more widely distributed in the watersheds and are found upstream from feeder sites. They were also present in lagoons and tributaries which did not support sea lamprey populations. These areas were not treated with lampricide.

Treatment and survey techniques have been refined since the original applications during 1959. Sea lampreys have been located in lagoons and small tributaries that previously may have been regarded as unsuitable habitat. The streams in the Soo area in 1959 were treated at low flow. During re-treatment of the Sable River in 1961 the river was in flood. Lagoons that had been blocked off in low flow were re-connected to the river. Sea lampreys have been found in isolated pools that are connected to the river when in flood. It is evident that further refinements are required for stream surveys and treatments. A planned major refinement will be a thorough investigation of the complete watershed for small tributaries, lagoons and isolated pools prior to treatment. These are the most probable areas for contamination. The larger streams can be navigated by boat from the feeder site to the mouth; smaller streams will of necessity have to be walked from feeder site to the estuarine area. In some cases this is many miles.

Table II. Pre- and post-treatment surveys, Lake Superior, 1961.

Stream No.	Stream Name	Number of Ammocoetes Collected			Type of Survey
		P.m.*	Ichth.**	E.l.***	
S-2	W. Davignon R.	...	...	231	Post-treatment
S-4	Little Carp R.	2	...	123	" "
S-5	Big Carp R.	4	...	121	" "
S-23	Cranberry R.	...	...	42	" "
S-24	Goulais R.	30	...	430	" "
S-36	Stokeley R.	8	...	1372	" "
S-39	Harmony R.	1	...	132	" "
S-52	Batchawana R.	9	41	147	" "
S-54	Sable R.	37	...	401	" "
S-56	Pancake R.	...	...	1	" "
S-368	Big Gravel R.	...	...	...	" "
S-509	Black Sturgeon R.	...	...	...	" "
S-572	Kaministikwia R.	152	30	...	" "
S-517	Wolf R.	4	15	...	Pre-treatment

* P.m. = Petromyzon marinus (sea lamprey).
** Ichth. = Ichthyomyzon spp. (silver lamprey and Michigan brook lamprey).
*** E.l. = Entosphenus lamottei (American brook lamprey).

Table III. Pre-treatment surveys, Lake Huron, 1961.

Stream No.	Stream Name	Number of Ammocoetes Collected P.m.*	Ichth.**	E.l.***	Type of Survey
H-39	Gawas R.	...	...	...	Pre-treatment
H-50	Two Tree Cr.	145	...	665	" "
H-51	Richardson's Cr.	...	...	...	" "
H-57	Watson's Cr.	...	...	...	" "
H-58	Gordon's Cr.	217	...	268	" "
H-59	Brown's Cr.	6	...	14	" "
H-62	Kaskawong Cr.	137	...	3	" "
H-65		...	...	15	" "
H-68		...	...	52	" "
H-87	MacBeth Cr.	...	...	...	" "
H-88	Thessalon R.	3461	1764	784	" "
H-92	Livingstone R.	...	...	...	" "
H-102		...	...	...	" "
H-107	Mississagi R.	183	7	49	" "
H-114		2	...	106	" "
H-116	Serpent R.	63	100	26	" "
H-134	Spanish R.	51	1959	...	" "
H-1354	Lafontaine R.	11	...	...	" "
H-1360	Nottawasaga R.	4374	446	...	" "
H-1492	Saugeen R.	20	...	...	" "
H-1589	Lucknow R.	...	239	...	Bio-assay specimens
H-1681	Bayfield R.	215	78	...	Pre-treatment

* P.m. = _Petromyzon marinus_ (sea lamprey).
** Ichth. = _Ichthyomyzon_ spp. (silver lamprey and Michigan brook lamprey).
*** E.l. = _Entosphenus lamottei_ (American brook lamprey).

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Appendix 3

MOBILE BIO-ASSAY UNIT, 1961

A mobile bio-assay trailer was located near the Pays Plat River from May to July. This unit was transferred to Sault Ste. Marie for the remainder of the year. Sixty-four bio-assays were performed, in this unit, in an attempt to determine any trend in the seasonal loss of biological activity of the toxicant and to determine the appropriate time for future treatments. This unit was also responsible for the operation of the electrical barriers in the western end of Lake Superior.

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Appendix 4

SUMMARY OF CHEMICAL TREATMENT OF STREAMS LAKES SUPERIOR AND HURON, 1961

Twenty streams were treated with lampricide on Lakes Superior and Huron during 1961. All of the streams were treated at a concentration and for a duration of time which a bio-assay had indicated would produce at least a 99.9% level of mortality to lampreys.

Table I lists the pertinent data concerning the treatments on Lake Superior during 1961, while Table II lists the data for the Lake Huron treatments. Lafontaine Creek, Lake Huron, was treated after sea lamprey ammocoetes were collected from it for the first time in the spring of 1961. In Lake Superior, the Wolf River was experimentally treated and the Batchawana and Sable Rivers were treated ahead of schedule, as sea lamprey ammocoetes were collected from them during the post-treatment surveys. Sea lampreys were found to be relatively abundant during re-treatment of both the Batchawana and Sable Rivers. Possible explanations of the presence of large ammocoetes found is discussed under post-treatment surveys (Appendix 2).

Although summaries of all treatments are included in Appendices 5 and 6, a brief summary is included in this Appendix on the Nottawasaga River treatment, owing to the size and complexities of the watershed, and on the Wolf River because there were two experimental treatments.

Preparations to treat the Nottawasaga River were started on May 23, 1961, when a campsite was set up beside the river. A series of rain storms prevented treatment until June 18. In the intervening period many measurements and tests were performed. These included 25 bio-assays of water from the river and its main tributaries, numerous discharge measurements and dye checks, and the frequent recording of water levels at many stations.

Table I. Streams treated with lampricide for the sea lamprey control experiment, Lake Superior, 1961.

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Pancake R.	Jul. 9-13/61	37	Feeder 2.3 Mouth 1.5	369	27	988.00	Scarce	15
Gimlet Cr.	Jul. 10-11/61	2	Feeder 3.0	46	61	122.00	Moderate	2
Trib. 12	Jul. 10/61							
Lagoon 11A	Jul. 11/61							
" 9B	"							
" 9A	"							
" 8F	"							
" 8E	"							
" 8D	"			Total tribs. 41		100.00		
" 8C	"							
" 8B	"							
" 8A	"							
Trib. 2	"							
TOTALS		39		456	watershed 31	1,219.00		17
Chippewa R.	Jul. 12-13/61	174	Feeder 1.5 Mouth 0.7	667	10	1,786.00	Abundant	1.5

Table I. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Batchawana R.	Sept. 7-8/61	154	Feeder 2.3	1,829		4,902.00	Moderate	8
			Mouth 1.0					
Trib. 53	Sept. 7-8/61							
Lagoon 15-16	Sept. 7/61							
" 12-12A	"							
" 17	Sept. 8/61			Total tribs.				
" 6-7	"			885		2,372.00		
" 11-14	Sept. 9/61							
" 9-10	"							Total
" G	"							lagoons
Booster 5-1	Sept. 10/61			437		1,171.00		1.5
Lagoon 2-3	"							
Totals		154		3,151	55	8,445.00		9.5
Sable R.	Sept. 16-17/61	70	Feeder 2.0	371		994.00	Moderate	12
			Mouth 1.5					
Trib. 8A	Sept. 16/61		Feeder 2.0					Total
" above 8	"	10		Total tribs.				tribs.
" " 8	"	+ other		131		350.00		2.5
" " 2	Sept. 17/61	(springs, etc.)						
Lagoon 1-2	"							
Totals		100 at mouth		502	13	1,344.00		14.5

Table I. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Wolf R.	Oct. 5-7/61	75	Feeder 4.5	874		2,341.00	Abundant	
			Mouth 3.0					
Trib. 18-19	Oct. 5/61							
Lagoon 17	"							
" 16	Oct. 6/61			Total tribs.				
" 15	"			123		329.00		
Trib. 13	"							
Lagoon 5	"							
" 4-5	"							
" 2	"							
Trib. below 2	"							
Booster 10A-2	Oct. 7/61			137		366.00		
Totals - 1st Treatment		75		1,134	40	3,036.00		8.5
Wolf R.	Oct. 13-14/61	200*	Feeder 3.0	2,348		6,292.00	Nil	
			Mouth 2.0					
Lagoon 16	Oct. 13/61			18		49.00		
" 4	Oct. 14/61							
Totals - 2nd Treatment		200*		2,366	32	6,341.00		8.5

*Estimate

Table II. Streams treated with lampricide for the sea lamprey control experiment, Lake Huron, 1961.

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Gordon's Cr.	Apr. 29/61	4	Feeder 1.2-8.0	32	21	85.00	Moderate	1
			Mouth 1.2-3.5					
Gawas Cr.	Apr. 30/61	10	Feeder 5-10+	137	39	366.00	Few	0.5
			Mouth 4.3-10+					
Lagoon at 1A	"			8		21.00	Nil	
Swamp at 1A	"			5		12.00	Nil	
Small trib at 1A	"			8	42	21.00	Nil	
Small trib at 1	"			2	61	6.00	Nil	
Totals		10		160	watershed 43	426.00		0.5
Brown's Cr.	May 1-2/61	7	Feeder 3.5	103	40	276.00	Moderate	1.5
			Mouth 2.0					
Richardson's Cr.	May 4-6/61	12	Feeder 14.0	378	84	1,013.00	Abundant	4
			Mouth 6.0+					
Unnamed tribs								
Station 4	May 5/61			14	74	37.00	Nil	
" 5	May 5/61			46	244	122.00	Few	
Totals		12		438	watershed 98	1,172.00		4

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Two Tree Cr.	May 7-10/61	9	Feeder 14 Mouth 5	642	191	1,719.00	Moderate	9.5
Mill Pond outlet	May 7-9/61	4		205	137	549.00	Moderate	
Harmony School Cr.	May 8/61	5		218	117	585.00	Abundant	4.2
Unnamed tribs.								
Stn. 20	May 7/61			27		73.00	Nil	
14	May 9/61			24		70.00	Nil	
8	May 8/61			27		73.00	Nil	
4E	May 9/61	12		55	12	146.00	Nil	
Boosters 11	May 8/61			27		73.00	...	
4E	May 9/61			27		73.00	...	
4B	May 8-9/61			82		219.00	...	
Totals		30		1,334	watershed 119	3,580.00		14.5
Lafontaine Cr.	Jun. 11-14/61	5	Feeder 6 Mouth 3	49		165.00	Scarce	10
Boosters 8	Jun. 12/61			26		88.00		
6	Jun. 13/61			33		110.00		
Unnamed tribs. 8	Jun. 12/61			20		66.00	Nil	
3	Jun. 13/61			23		77.00	Nil	
Totals		5		151	101	506.00		10

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Nottawasaga R.	Jun. 18-25/61	106	Feeder 12 Mouth 8	4,204		11,267.00	Scarce	45
Booster 220	Jun. 22/61			2,907		7,791.00		
Sub Total				7,111	180	19,058.00		
Tributaries								
385	Jun. 19?/61	1*					Nil	0.5+
380	Jun. 19/61	1*					Nil	0.25
372	"	4*					Nil	0.25
364	"	5*					Nil	1.0
110A	Jun. 22/61						Nil	200**
72A	"						Nil	...
51A IV	Jun. 22/61						Few	...
51A III	"						Few	...
51A II	"						Nil	400**
51A I	"						Nil	400**
45A IV	Jun. 23/61	1*					Nil	...
45A III	"						Nil	200**
45A II	"						Nil	...
45A I	"						Nil	...
42B III	Jun. 23/61						Nil	...
(lagoon) 42B II	"						Nil	...
42B I	"						Nil	200**
Jacks Lake	"						Nil	0.5
42B	"						Nil	700**

*Estimate
**Feet

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
<u>Nottawasaga R. Watershed - cont'd</u>								
Lagoon 42 I	Jun. 24/61						Nil	100**
37	"						Nil	100**
37+	"						Nil	400**
1B+	"						Nil	...
Lagoons 1A1-1A2	Jun. 25/61						Nil	900**
Sub-total		____		829	___	2,809.00		
Combined chemical - main stem		118		7,940	185	21,867.00		
Boyne R.	Jun. 18-19/61	25	Feeder 12 Mouth 12	1,092	117	2,927.00	Abundant (only 1 P.m.)	3
Mad R.	Jun. 19-21/61	33	Feeder 15 Mouth 5.1-12.4	1,597		4,280.00	Abundant	50
Boosters								
136C	Jun. 21/61			176		595.00		
136B	"			78		264.00		
130	"			355		951.00		
Tributaries								
188 i	Jun. 20/61	2*					Nil	...
188 ii	"						Nil	0.25
188 iii	"	1*					Nil	...

*Estimate
**Feet

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
<u>Nottawasaga R. Watershed - cont'd</u>								
Tributaries (Mad R.)								
176	Jun. 20/61	1*					Nil	...
178	"						Nil	...
180	"	3*					Nil	1
164 i	"	1*					Nil	0.5
164	"						Few	...
166	"	1*					Nil	...
138	Jun. 21/61	5*					Nil	0.25
131D	"						Nil	...
136	"	1*					Nil	...
132	"						Nil	300**
131G	"						Nil	...
131F	"						Abundant	...
136A	"						Few	300**
136A2	"						Few	...
136A2+	"						Few	...
136A3	"						Abundant	...
136A4	"						Nil	...
125x	Jun. 22/61	1*					Scarce	0.5
125x	Jun. 23/61	1*					Scarce	0.5
Sub-totals: Feeder				1,597		4,280.00		
Booster		33		608		1,810.00		
Tribs		17*		306	___	1,036.00		
Total		50		2,511	143	7,126.00		

*Estimate
**Feet

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Nottawasaga R. Watershed - cont'd								
Noisy R. (Trib to Mad)	Jun. 19-20/61	18	Feeder 18 Mouth 9	1,775	264	4,756.00	Moderate	12
Tributaries								
203	Jun. 19/61	4*					Nil	...
199	"	1*					Nil	...
201	"	1*					Nil	...
196	"	2*					Nil	...
194	"	...					Nil	...
171	Jun. 20/61	1*				545.00	Nil	...
Totals				1,936		5,301.00		
Totals Mad R. Watershed		90 at mouth		4,447	138	12,427.00		65
Pine R.	June. 21-22/61	78	Feeder & mouth 10	3,331	114	8,926.00	Scarce	1
Bear Cr.	Jun. 20-21/61	19	Feeder 9 Mouth 7.5	364	51	976.00	Scarce	3
2nd treatment	Jun. 24/61		Feeder 11	218	31	585.00	Nil	4
Total				582		1,561.00		
Willow R.	Jun. 22-23/61	55	Feeder & mouth 8	1,824	112	6,184.00	Scarce	600**

*Estimate
**Feet

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Nottawasaga R. Watershed - cont'd								
Phelpston Cr.	Jun. 22/61	10*	Feeder 10-15	102	27	274.00	Nil	2
Lamont Cr.	Jun. 23-25/61	5	Average 15-25	564	302	1,512.00	Moderate	5
GRAND TOTALS		400*		19,883	watershed 139	55,680.00		131
Root River	Jul. 16-24/61	24	Feeder 2.3 Mouth 1.8	218	24	585.00	Abundant	15.5
Lagoon 21-23	Jul. 19/61							
Trib. 22A	"			24		64.00		
Lagoons 22	"							
Trib. 3B	"							
Booster 4	Jul. 20/61			54		146.00		
West Root	Jul. 17-20/61	5	Feeder 0.9 Mouth 1.2	54	29	145.00	Moderate	5.5
Lagoon 28	Jul. 18/61							
" 28A	"							
Pond 29	Jul. 21/61			Total tribs				
" 28A	"			41		110.00		
" 29	"							

*Estimate

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Root R. Watershed - cont'd								
W. west Root	Jul. 17/61	2	Feeder 1.4 Mouth 0.8				Moderate	5
Pond 37A	Jul. 18/61							
Pond above 44	Jul. 20/61							
" " 44	Jul. 21/61			Total W.W. Root				
" " 44	Jul. 22/61			100		289.00		
" " 44	Jul. 24/61							
Coldwater Cr.	Jul. 18-19/61	9	Feeder 1.7 Mouth 1.4	55	16	146.00	Scarce	
Trib. 19	Jul. 19/61			1		3.00		1.5
Crystal Cr.	Jul. 19/61	19	Feeder 1.3 Mouth 1.2	109	15	293.00	Moderate	6
Trib. 8A	"							
Trib. below 8A	"							
" " 8	"							
" " 5B	"			Total tribs				
Trib. 5	"			20		53.00		
" 3	"							
Totals for Root River Watershed:								
Main Root R.		24		296	33	795.00		
West Root R.		5		95	51	255.00		
West West Root R.		2		99	144	289.00		
Coldwater Cr.		9		55	17	149.00		
Crystal Cr.		19 + other (springs, etc.)		129	18	346.00		
GRAND TOTAL		70 at mouth		674	watershed 26	1,834.00		33.5

Table II. (continued)

Name		Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Serpent R.		Aug. 5-6/61	269	Feeder 1.2 Mouth 1.0	1,583		4,244.00	Moderate	8
Trib.	6D	Aug. 5/61							2.5
"	6B	"							
"	6A-6	"							
"	5A	"			Total tribs.				
"	4	"			152		~~408.00~~		0.5
"	4 up	Aug. 6/61							
"	9-9B	"							
"	9-9A	"							
Lagoon	28A	"							
"	27	"							
"	13	"							
Trib.	9B	Aug. 7/61							
Totals			269		1,735	17	4,652.00		11
H-114		Aug. 7/61	0.5*	Feeder app. 8	14	74	37.00	Nil	0.25
Livingstone Cr.		Aug. 10-11/61	0.5*		43		116.00	Moderate	3
Trib.	2A	Aug. 10/61			2		6.00		
Totals					45	244	122.00		
MacBeth Cr.		Aug. 10/61	0.5*		50	268	134.00	Moderate	0.25

*Estimate

Table II. (continued)

Name	Date treated	Flow in cfs	Concentrations in ppm during treatment	Lbs active ingredient	Cost $/cfs	Total cost chemical ($)	Ammocoete abundance	Miles stream treated
Lauzon R.	Aug. 10-11/61	5.0*	Feeder 2.0 Mouth 1.0	21	11	55.00	Moderate	0.5
Mississagi R.	Aug. 16-18/61	1800*	Feeder 1.5 Mouth 1.2	12,258		32,851.00	Abundant	
Bolton R.	Aug. 16/61		Feeder 2.4 Downstream 2.0	164		439.00		
Trib. 126A	"							
" 124	"							
" 119	"							
Lagoon 119	"							
Trib. 116	"							
" 114	"							
" 62	"							
" 61	"			Total tribs.				
Lagoon 51	Aug. 17/61			271		727.00		
" 51	"							
Mud flat 51A	"							
Trib. 38A	"							
" 38	"							
" 18	"							
" 17A	"							
" 12	"							
" 11	"							
Totals		1800*		12,693	19	34,017.00		15.5

*Estimate

The actual treatment lasted from June 18 to June 25, during which time at least one feeder was in operation at any given moment. In addition to many small tributaries, the following major streams in the Nottawasaga River system were treated: Boyne, Mad, Noisy, Pine, Bear, Willow, Phelpston and Lamont. The main stem of the Nottawasaga was treated at two points, a booster being used about half way between the main feeder and the mouth. Lampricide was applied at 50 locations in all, and a total of 131 miles of stream was treated. We were fortunate in being able to successfully treat a river of such magnitude and complexity of watershed as the Nottawasaga. It is doubtful that the Nottawasaga could be scheduled for treatment at any specific time of year owing to the effect of local climatic conditions on this watershed.

The Wolf River was treated on October 6-7, 1961. Prior to treatment we had only limited evidence of successful sea lamprey spawning in the river. The Wolf was partially surveyed in 1960 and again re-surveyed prior to treatment. Only *Ichthyomyzon* spp. ammocoetes had been collected.

Sea lamprey nests were observed in 1960 and recently-hatched lampreys were collected from them. Sea lampreys were observed spawning in the Wolf during the spring of 1961.

It was decided to experimentally treat the Wolf River from this evidence of spawning activity. This was the first river treated without the collection of identifiable sea lampreys. Since it was an experimental treatment and the river was in flood, and in order to conserve on chemical, the flow was reduced from over 200 cfs to approximately 75 cfs by means of a control dam a few miles above the feeder site - a falls that constitutes a natural barrier.

Sea lamprey ammocoetes, 20-125 mm in length, as well as *Ichthyomyzon* spp., were abundant especially in the areas where surveys had been performed.

When flow is reduced, by a control dam, a relatively large proportion of larval habitat along the banks is exposed in mud flats and in sandbars in midstream. This had been noted in other rivers where flow had been reduced to low levels to conserve on chemical, as in the Kaministikwia, Black Sturgeon, Michipicoten and Mississagi River treatments. Whether or not ammocoetes escape the toxicant when rivers are treated at an artificially reduced flow has always been a controversial subject. In an effort to determine the extent of escapement, the Wolf River was retreated on October 13-14, 1961 under flood conditions with a controlled flow of over 200 cfs. After extensive searching, no ammocoetes were found in the main river during the second treatment. Two ammocoetes were found in a lagoon near the mouth.

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Appendix 5

INDIVIDUAL STREAM TREATMENT REPORTS, LAKE SUPERIOR, 1961

The following is a list of tributaries to Lake Superior that were treated with lampricide during 1961. A brief account of each stream treatment is included.

	River Name	Date of Treatment
1.	Pancake River (S-56)	July 9-13, 1961
2.	Chippewa River (S-48)	July 12-13, 1961
3.	Batchawana River (S-52)	Sept. 7-10, 1961
4.	Sable River (S-54)	Sept. 16-17, 1961
5.	Wolf River (S-517)	Oct. 6-7, 1961
	Second treatment of Wolf River	Oct. 13-14, 1961

1. Pancake River (S-56)

Pancake River and its tributary Gimlet Creek, Townships of Herrick and Ryan, District of Algoma, were treated from July 9 to 13, 1961, with a formulation of 3-trifluormethyl-4-nitrophenol (TFM) containing about 40% by weight of the active ingredient, as supplied by the Hoechst Chemicals Company. The lampricide was applied to Pancake River at a point about 15 miles from its mouth, and to Gimlet Creek at a point about 2 miles from its junction with the river. The toxicant was also applied at eleven other points in the watershed by hand or by drip feeder. This was the second treatment of Pancake River, the first having been conducted in 1958.

Pre-treatment examination of the river included discharge measurements, dye checks, and a bio-assay of Pancake River water. Just prior to the treatment, the volumes of flow at the mouth of Pancake River and in Gimlet Creek were 39 and 2 cubic feet per second (cfs) respectively. Results of the bio-assay indicated that for an 18-hour treatment, less than 0.8 ppm of TFM would kill at least 99.9% of the lampreys, and 3.2 ppm of TFM would not kill more than 25% of the trout. These doses were the minimum effective and maximum permissible for the treatment.

Lampricide was applied by means of "Proportioneer" dual-piston feeders, beginning at 1200 hours on July 9 in Pancake River and at 0950 hours on July 10 in Gimlet Creek for periods of 18 hours in both cases. Eighty-one gallons of formulation containing 369 pounds of TFM were applied at the Pancake River feeder, 10 gallons containing 46 pounds were applied at the Gimlet Creek feeder, and 9 gallons containing 41 pounds were applied by hand and by drip feeders at miscellaneous locations. Concentrations of TFM were: below the Pancake River feeder site, between 2.1

and 2.9 ppm for 18 hours; below the Gimlet Creek feeder site, 2.4 to 9 ppm for 18 hours; and at the mouth of Pancake River, 1.1 to 2.1 ppm for 16 hours.

The main feeder sites on both Pancake River and Gimlet Creek in 1961 were at the same locations as those chosen in 1958. Both sites were accessible for four-wheel drive vehicles at the times of the treatments. The volume of flow in Pancake River during the 1961 treatment was approximately equal to that during the 1958 treatments.

Ammocoetes were much less abundant, particularly in the main river, in 1961 than in 1958, as indicated by the numbers of dead specimens collected after the treatments. In Pancake River, of 45 larvae collected, 6 were sea lampreys; while in Gimlet Creek, of 100 larvae, 24 were sea lampreys.

2. Chippewa River (S-48)

Chippewa River, Township of Tilley, District of Algoma, was treated on July 12 and 13, 1961, with the Hoechst 40% formulation of TFM. The lampricide was applied at a point about 1½ miles from the mouth above a falls which is a barrier to upstream migrating sea lampreys. There were no other sites requiring separate treatment.

Although ammocoete surveys have been made periodically since 1953, and in spite of the fact that sea lampreys have been observed spawning in Chippewa River, the first identifiable sea lamprey ammocoete was taken in 1960. Pre-treatment studies in 1961 included discharge measurement, a dye check and a bio-assay of Chippewa River water. Just prior to the treatment, the volume of flow in Chippewa River was 174 cfs. Results of the pre-treatment bio-assay indicated that, for a 9-hour treatment, the minimum effective and maximum permissible concentrations of TFM were less than 0.8 and not more than 1.6 ppm respectively.

Lampricide was applied by means of a "Proportioneer" dual-piston feeder, for a period of 11 hours, 40 minutes, beginning at 0600 hours on July 13, 1961. A total of 1465 gallons of formulation, containing 667 pounds of active ingredient, was used in Chippewa River. Concentrations of TFM prevalent during the treatment were: 1.5 ppm for 11 hours below the feeder, and at the highway bridge between 1.0 and 1.5 ppm for more than 9½ hours. Samples of treated water from the river mouth gave readings which were lower than the true values for their TFM content, because lake water which was present in the estuary reduced the background colour of the river. Considering the more than adequate treatment of the river above the estuary, it is assumed that most of the estuary was successfully treated.

Chippewa River has a natural barrier to upstream lamprey migration within 1½ miles of the mouth. Thus, in spite of being one of the larger rivers in the Sault Ste. Marie area, it was treated with a minimum of time and effort. Weather conditions at the time of treatment were ideal and water levels were low, although seasonably normal.

Ammocoetes, though abundant, were predominantly native species. Of almost 1,000 collected during this treatment, only 10 were sea lampreys.

3. Batchawana River (S-52)

Batchawana River, Townships of Fisher and Palmer, District of Algoma, was treated between September 7 and 10, 1961 with the Hoechst 40% formulation of TFM. The lampricide was initially applied at a point about 8 miles from the mouth of the river, above falls which are a barrier to the upstream migration of sea lampreys. A further application of lampricide to the already treated water was made in an area within ½ mile of the mouth. In addition, 9 lagoons and tributaries were treated by manual applications of lampricide.

This was the second lampricide treatment of Batchawana River; the first was in 1959. The decision to retreat the Batchawana this year was reached after surveys with lampricide and electro-shockers revealed the presence of sea lamprey larvae which had survived the previous treatment. Other pre-treatment studies on Batchawana River included discharge measurement, chemical analysis of river water and a bio-assay. The volume of discharge just prior to the treatment was 154 cfs. Results of the bio-assay indicated that, for an 18-hour treatment, the minimum effective and the maximum permissible concentrations of lampricide would be 1.05 and 4.0 ppm respectively.

Lampricide was applied by means of a "Proportioneer" dual-piston feeder for a period of 18 hours, beginning at 1825 hours on September 7, 1961. A total of 402 gallons of formulation, containing 1,829 pounds of active ingredient, was applied at the main feeder site. An additional 96 gallons, containing 437 pounds of TFM, were poured from a moving boat in the estuary on September 10. This application boosted the concentration of lampricide already in the area by about 1 ppm. A further 195 gallons, containing 885 pounds of TFM, were used in treating tributaries and lagoons. Concentrations of lampricide prevalent during the treatment were: below the feeder, 1.4 to 2.5 ppm for 17½ hours; in the vicinity of the electric barrier, 1.0 to 2.2 ppm for 18 hours; and at the mouth, 1.0 to 2.2 ppm for about 20 hours.

The principal difference between the two treatments was the increased amount of lampricide used in 1961. Most of this was accounted for by the greater amounts applied to lagoons and tributaries and by the booster application in the second treatment. The same site was chosen for the location of the main feeder in both cases.

The second treatment resulted in a heavy mortality of ammocoetes including 41% sea lampreys, some of which, judging by their size, must have survived the first treatment. Most of these were collected near the mouth and in the vicinity of a lagoon near the barrier and a tributary below the feeder site.

4. Sable River (S-54)

Sable River, Township of Fisher, District of Algoma, was treated on September 16 and 17, 1961 with the 40% Hoechst formulation of TFM. The lampricide was applied to the main river at a point about 12 miles from its mouth, and to a tributary from Carp Lake about 1 mile from its junction with the river. Two other small tributaries and a lagoon were also treated with lampricide. This was the second treatment of Sable River; the first was in 1959. The decision to retreat at this time resulted from the discovery, during this year's surveys with lampricide and electro-shockers, of sea lamprey larvae which had survived the previous treatment.

Other pre-treatment studies of Sable River included discharge and water level measurements, chemical analysis of the water and three bio-assays. At the time of treatment the volume of flow at the feeder site was 70 cfs, a higher than normal figure resulting from a recent flood. Results of the final bio-assay indicated that for an 18-hour treatment the minimum effective and maximum permissible concentrations of TFM would be 0.52 and 2.1 ppm respectively.

At the main feeder site, lampricide was applied by means of a "Proportioneer" feeder for a period of 13-3/4 hours, beginning at 1500 hours on September 16. Drip feeders were used on the tributaries and the lagoon was treated manually by pouring the toxicant into the lagoon from a moving boat. A total of 82 gallons of formulation containing 371 pounds of active ingredient was used in the main river, and an additional 29 gallons containing 131 pounds of active ingredient in the lagoon and tributaries.

Concentrations of TFM prevalent in the river during treatment were: below the main feeder, 1.9 to 2.2 ppm for 13 hours; in the Carp Lake Creek, 1.1 to 2.7 ppm for 14 hours; and at the mouth of Sable River, 1.5 to 1.8 ppm for 12 hours.

Comparison of the 1959 and 1961 treatments reveals that more lampricide was used in 1961, due in part to the greater volume of flow and in part to the treatment of two small tributaries and a lagoon not treated in 1959. A booster feeder, employed in 1959 to counteract the effects of dilution and attenuation between the main feeder and the mouth, was not required in 1961.

Ammocoetes collected during the 1961 treatment included, in addition to many specimens of native species, numerous sea lampreys, particularly between the electric barrier and the mouth. Although most of these were of a size that would place them in the post-1959 year classes, a significant number of survivors of the 1959 treatment were also collected. It is probable that these lampreys escaped lethal exposure to lampricide in pools and lagoons temporarily isolated from the river at the low water conditions which existed at the time of treatment.

5. Wolf River (S-517)

Wolf River, Townships of Dorion and Stirling, District of Thunder Bay, was treated on October 6 and 7, 1961, and again on October 13 and 14, 1961, with the 40% Hoechst formulation of TFM. The first treatment was made at low water level and the second at high water. Our ability to control the flow, by means of a dam located above the feeder site, made possible an experiment to test the effectiveness of treatment at low water conditions. The application was made about 8½ miles from the mouth above a falls impassable to the upstream migration of lampreys.

The decision to treat Wolf River was based on reports that sea lampreys have been observed spawning in the river during 1960 and 1961 and the collection of newly-hatched lampreys from these nests during 1960. This was the first river treated without the collection of identifiable sea lamprey larvae prior to the treatment. Other pre-treatment studies included discharge and water level measurements, dye checks, water analysis and bio-assays.

The first treatment was carried out at a stream flow of 75 cfs. The pre-treatment bio-assay indicated that for an 18-hour treatment the minimum effective and maximum permissible concentrations of TFM would be 3.5 to 5.0 ppm. A "Proportioneer" feeder applied lampricide for a period of 18½ hours starting at 1525 hours on October 5. One hundred and ninety gallons of formulation, containing 874 pounds of active ingredient, were applied at the main feeder site. An additional 30 gallons, containing 137 pounds of TFM, were introduced near the mouth as a booster application. Three small tributaries and six lagoons were also treated with a total of 27 gallons of formulation containing 123 pounds of TFM.

The first treatment resulted in the following concentrations of TFM in the river water: below the feeder, 4.5 to 6.3 ppm for 18 hours; at the highway, 2.5 to 4.1 ppm for 18 hours; and at the mouth, 2.0 to 4.8 ppm for 17 hours.

Ammocoetes were numerous during this treatment and included Ichthyomyzon spp. and sea lampreys in an overall ratio of about 2 to 1, although the latter were more numerous, relatively, in the upstream portions of Wolf River.

The second treatment of Wolf River was made at an estimated flow of 225 cfs, calculated from staff gauge readings of the fluctuating water levels correlated with current readings at lower flow rates. A bio-assay conducted just prior to this treatment indicated that for an 18-hour exposure the minimum effective and maximum permissible concentrations of TFM would be 1.9 and 6.2 ppm respectively.

Application was made from the site used in the first treatment and the same pumping equipment was used to pump chemical for 16 hours, beginning at 0400 hours on October 13. Five hundred and sixteen gallons of formulation, containing 2,348 pounds of active ingredient, were used. An additional 4 gallons containing 18 pounds were applied in two lagoons. Concentrations of TFM in the river during this treatment were as follows: below the feeder, 2.6 to 3.2 ppm for 15 hours; at the highway, 2.4 to 2.7 ppm for 14 hours; and at the mouth, 2.1 to 2.7 ppm for 14 hours. A booster feeder was not required in the second treatment, because the river was in flood and the greater flow decreased the effects of dilution and attenuation.

No lampreys were collected from the Wolf River during the second treatment. Two ammocoetes only were found in a lagoon connected to the river in the estuarine area. The first treatment was apparently successful in this instance in spite of the abnormally low water levels existing at the time.

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Appendix 6

INDIVIDUAL STREAM TREATMENT REPORTS, LAKE HURON, 1961

The following is a list of tributaries to Lake Huron that were treated with lampricide during 1961. A brief account of each stream treatment is included.

	River Name	Date of Treatment
1.	Gordon's Creek (H-58)	April 29, 1961
2.	Gawas Creek (H-39)	April 30, 1961
3.	Brown's Creek (H-59)	May 1-2, 1961
4.	Richardson's Creek (H-51)	May 4-6, 1961
5.	Two Tree River (H-50)	May 7-10, 1961
6.	Lafontaine Creek (H-1354)	June 11-14, 1961
7.	Nottawasaga River (H-1360)	June 18-25, 1961
8.	Root River (H-3)	July 16-22, 1961
9.	Serpent River (H-116)	Aug. 5-7, 1961
10.	Unnamed stream (H-114)	Aug. 7, 1961
11.	Livingstone Creek (H-92)	Aug. 10-11, 1961
12.	MacBeth Creek (H-87)	Aug. 10, 1961
13.	Lauzon River (H-112)	Aug. 10-11, 1961
14.	Mississagi River (H-102-107)	Aug. 16-18, 1961

1. Gordon's Creek (H-58)

Gordon's Creek, in Jocelyn Township, St. Joseph's Island, was treated on April 29, 1961, with the 40% Hoechst formulation of TFM. Lampricide was applied at only one point, which was about one mile from the mouth, just below a beaver dam. All ammocoetes collected from the stream below this sam in 1956, 1957 and 1958 were sea lampreys.

Pre-treatment studies included discharge measurements, chemical analysis and a bio-assay. The volume of flow near the mouth was 4.3 cfs at the time of treatment. Results of the bio-assay indicated that for a 12-hour treatment the minimum effective and maximum allowable concentrations of TFM would be 1.2 and 3.1 ppm respectively.

Application by means of a battery-powered electric fuel pump was begun on April 29, at 1030 hours, and continued for 13¼ hours. Concentrations of TFM in the river during treatment were: at the feeder site, between 1.2 and 8.0 ppm for 10¼ hours; half way to the mouth, between 1.2 and 5.9 ppm for 13 hours; and at the mouth, 1.2 to 3.5 ppm for 11 hours. Relatively wide variations in concentrations resulted from difficulty experience in regulating the output of the pump, because the formulation was viscous and contained solids. A total of 7 gallons, containing 32 pounds of active ingredient, was applied.

Ammocoetes collected during the treatment included almost equal numbers of sea lampreys and native species. Overall abundance of lampreys in Gordon's Creek was only moderate, and relatively few ammocoetes occurred in the upper third of the treated section.

2. Gawas Creek (H-39)

Gawas Creek, in the Township of St. Joseph, St. Joseph's Island, was treated on April 30, 1961 with the 40% Hoechst formulation of TFM. The feeder site was located above barrier falls which were only ½ mile from the mouth of the river. Ammocoete collections in 1956, 1957, 1958 and 1960 indicated that no sea lampreys occurred above this point, and were scarce in general.

This river had been stocked with 110 radioisotope-marked ammocoetes about three weeks prior to the treatment. It was anticipated that recovery of marked specimens would make possible an accurate estimate of the population density and a measure of migratory activity.

Preliminary discharge measurements were made and a bio-assay of the water was conducted. At the time of treatment, the volume of flow was about 10 cfs. Results of the bio-assay showed that for a 12-hour treatment minimum effective and maximum permissible concentrations of TFM would be 4.7 and 8.0 ppm respectively.

Application of lampricide by means of an electric fuel pump was begun at 1700 hours on April 30, and continued for 10-3/4 hours. At this site, 30 gallons of formulation containing 137 pounds of active ingredient were used. Two tributaries, a lagoon and a swamp were also treated, by means of drip feeders, and a total of 4.5 gallons of formulation containing 23 pounds of TFM was used.

Concentrations of TFM in the river during treatment were: at the feeder site, between 4.8 and 10 ppm for 10½ hours; and at the mouth, 3.9 to 10 ppm for over 10 hours.

Dead ammocoetes resulting from the treatment of Gawas Creek were very scarce, and in spite of intensive efforts to collect them, only five specimens were found. Two of these were found to be radioactive. Both the population density and the sample size were apparently too low for a successful marking experiment in this stream.

No particular difficulties were experienced during this treatment. Two fairly extensive swampy areas near the creek mouth and two small tributaries required manual applications of lampricide. Inclement weather in the form of snow and hail caused discomfort, but no serious operational difficulties. Access was good to the parts of the river which were undergoing treatment.

3. Brown's Creek (H-59)

Brown's Creek, Hilton Township, on St. Joseph's Island, Algoma District, was treated on May 1 and 2, 1961, with the 40% Hoechst formulation of TFM. The feeder site was located about 1½ miles from the mouth. There were no tributaries requiring treatment. Two beaver ponds were located below the feeder site; however, these did not require separate treatment.

Sea lamprey larvae had been collected from this stream in 1956, 1957 and 1958. The 1961 pre-treatment survey defined the limits of their occurrence upstream. Other pre-treatment studies included measurements of discharge and water level, analysis of water samples and a bio-assay. The volume of flow at the time of treatment was 6.9 cfs. Results of the bio-assay indicated that, for a 16-hour treatment, the minimum effective and maximum permissible concentrations of TFM would be 1.0 and 1.4 ppm respectively.

Lampricide was applied by means of a "Proportioneer" feeder for a period of 24 hours, beginning at 1100 hours on May 1. A total of 22.6 gallons of formulation, containing 103 pounds of active ingredient, was used. During the treatment concentrations of 2.9 to 3.8 ppm of TFM were maintained at the feeder site for 22 hours, and 1.7 to 3.1 ppm at the main road for over 12 hours. The long treatment period for this length of stream was necessary to ensure that the TFM in the beaver ponds was uniform in distribution and of the concentration required in the main river.

Observations made during the treatment indicated that ammocoetes were moderately abundant in Brown's Creek. Of the specimens collected, about 44% were sea lampreys. Fish mortality during the treatment appeared to be almost nil, and only two or three dead suckers were observed.

4. Richardson's Creek (H-51)

Richardson's Creek, in the Townships of Jocelyn and St. Joseph, St. Joseph's Island, was treated on May 4-6, 1961 with the 40% Hoechst formulation of TFM. The lampricide was applied at a "feeder site" about 4 miles from the mouth of the stream. Two roadside ditches were also treated near their junction with the main stem.

The river had been stocked with 400 radioisotope-marked ammocoetes about three weeks prior to the treatment. It was the second river to be treated of the three that had been chosen for this tagging experiment. From the results of electro-shocker surveys dating back to 1956, Richardson's Creek was known to have a population of sea lamprey larvae comprising 8 to 9% of the total ammocoete population, but confined to the main stem of the stream. Ammocoetes were moderately abundant upstream, but relatively scarce near the mouth.

Other pre-treatment studies included discharge measurements, bio-assays and chemical analysis of the stream water. The volume of flow part way downstream from the feeder was 12.5 cfs at the time of treatment. The pre-treatment bio-assay indicated that, for an 18-hour treatment, the minimum effective and maximum permissible concentrations of TFM would be 5.45 to 8.5 ppm respectively.

The application of lampricide, by means of a "Proportioneer" feeder, was begun at 1500 hours on May 4 and continued for approximately 18 hours. At the main feeder, 83 gallons of formulation containing 378 pounds of active ingredient were applied. An additional 13 gallons containing 60 pounds of TFM were applied in two ditches by means of drip feeders. Concentrations of TFM in the river during this treatment were: below the feeder, 12 to 22 ppm for 18 hours; and at the furthest downstream point sampled, 6.4 to 13.4 ppm for 13 hours. The relatively high concentration maintained at the feeder was required in order to compensate for dilution downstream due to springs and surface drainage. A fairly heavy mortality of young trout was caused by the high concentration of lampricide for a short distance below the feeder. Below the half way point between the feeder and the mouth, however, fish mortality was negligible.

Special efforts were made to collect as many ammocoetes as possible during this treatment for the purpose of obtaining good returns of marked specimens, as well as for routine population studies. In addition to the normal hand collections, fyke nets were installed at two locations about a mile apart in the mid-section of the treated stretch of river. Most of the ammocoetes, however, were collected by hand in the lower part of the stream. Of the 400 marked ammocoetes which were planted, 63 were recovered among a total collection of 1,329. The ammocoetes were fast-frozen for later identification of tagged specimens. At that time it was not possible to identify these ammocoetes as to species. A rather considerable mortality of stream fish including dace, darters, sculpins and fingerling brook trout occurred for a short distance below the feeder site. In the major part of the river, fish mortality appeared to be negligible.

5. Two Tree River (H-50)

Two Tree River, in the Township of St. Joseph, St. Joseph's Island, was treated on May 7 to 10, 1961, with 49 cans of the 40% Hoechst formulation of TFM and half a can of a 30% formulation supplied by Maumee Chemical Company of Toledo, Ohio. The main river was treated at a point 9.5 miles from its mouth and two tributaries, Mill Pond Creek and Harmony School Creek, were treated at distances of 1 mile and 4 miles respectively from their junction with the river.

This river had been stocked with 1,910 radioisotope-marked ammocoetes about four weeks prior to the treatment. Of the three rivers chosen for this marking experiment, Two Tree was the last to be treated.

Electro-shocker surveys conducted in this watershed from 1957 to 1960 inclusive had indicated that the relative abundance of sea lampreys was low, being less than 5% of the total ammocoete population. Additional pre-treatment surveys in 1961 established the upstream limits of the sea lamprey population. Feeder sites were located above these limits. Other pre-treatment studies included discharge and water level measurements, dye checks, bio-assays and chemical analysis of the river water. A day before the treatment volumes of flow had been: below the feeder site, 9.8 cfs; in the Harmony School branch, 5.0 cfs; and in the Mill Pond branch, 4.4 cfs. Rainfall just before the treatment increased these figures, but by the time that application was started water levels in the upstream sections of the river had dropped to their previous values. Results of the pre-treatment bio-assay indicated that for a 24-hour treatment the minimum effective and maximum permissible concentrations of TFM would be 4.8 and 7.8 ppm respectively.

Application by means of a "Proportioneer" feeder was begun on the main river at 1400 hours on May 7 and continued for nearly 24 hours. Drip feeders were started at 2130 hours on the same day at the Mill Pond outlet and at 0900 hours on May 8 at the Harmony School tributary, and continued for 28 and 24 hours respectively. The following volumes of lampricide formulation and corresponding weights of active ingredient were applied at the above sites: main river, 141 gallons (642 pounds); Mill Pond outlet, 45 gallons (205 pounds); Harmony School Creek, 48 gallons (218 pounds). An additional 60 gallons containing 269 pounds of TFM were used in four small tributaries and in three booster applications.

Concentrations of TFM in the river during the treatment were: below the main feeder, 11.4 to 16.4 ppm for 24 hours; below the Mill Pond feeder, 5.0 to 25 ppm for 17 hours; below the Harmony School Creek feeder, 5.0 to 8.6 ppm for 21 hours; and in the main river above the mouth, 4.5 to 7.7 ppm for 20 hours.

Weather conditions, topographical features and operational complications combined to make the treatment of Two Tree River a difficult one. Rainfall just prior to the application caused fluctuations in discharge and variations in turbidity during treatment. As a result it was difficult to control the concentrations of lampricide in different parts of the watershed. Numerous drains and ditches connected to the river and its tributaries required individual treatment. Special efforts had to be made to collect representative samples of ammocoetes in order to ensure that sufficient numbers of marked individuals would be taken. High turbidity added to the difficulty of collection.

Of the 1,910 isotope-marked ammocoetes planted in Two Tree Creek, 24 were recaptured. These were among a total of 501 individuals collected during the treatment. The specimens were fast-frozen for later identification of radioisotope tags. At this time it was impossible to identify these ammocoetes as to species. The mortality of stream fishes was low, being confined chiefly to the areas immediately below the feeder sites. Darters, dace and sculpins appeared to be the most seriously affected in these localities, however a few fingerling brook trout were also killed.

6. Lafontaine Creek (H-1354)

Lafontaine Creek, Tiny Township, Simcoe County, was treated on June 11 to 14, 1961 with a formulation of the sodium salt of TFM containing 30% of active ingredient, as supplied by the Maumee Chemical Company. Approximately ten miles of stream, including two small tributaries, were treated. The existence of adult spawning sea lampreys in this stream was first reported during the spring of 1961, and several sea lamprey ammocoetes were collected mainly from one area in limited electro-shocker surveys just prior to the treatment.

Other pre-treatment investigations included discharge measurements, dye checks, a bio-assay and chemical analysis of the stream water. The volumes of flow prior to the treatment were: at the feeder site, 1.4 cfs, and near the mouth, 4.5 cfs.

Results of the bio-assay indicated that for a 12-hour treatment the minimum effective and maximum permissible concentrations of TFM would be 3.0 and 5 ppm respectively.

Application by means of a "Proportioneer" feeder was begun at 1915 hours on June 11 and continued for 17-3/4 hours. At the main site 15 gallons of formulation containing 49 pounds of active ingredient were used. An additional 13 gallons containing 43 pounds of TFM were drip fed to treat tributaries and 18 gallons containing 59 pounds were used to increase the concentration of TFM in the main river to the required level. This was necessary as the concentration had dropped, owing to the presence of beaver dams and one man-made dam on the main river. Concentrations of TFM in the river during the treatment were: below the feeder, an average of 6 ppm for 18 hours; about half way downstream, 3.4 to 6.0 ppm for 18 hours; and at the mouth, 2.8 to 4.6 ppm for 12 hours. Somewhat higher concentrations occurred temporarily, for short distances, below the main feeder and the drip feeders.

Ammocoetes collected during the treatment consisted exclusively of sea lampreys, as did the pre-treatment collections, and overall abundance was low. Difficulty was experienced in maintaining steady concentrations of TFM below a large man-made pond about a mile from the feeder site. Dilution and attenuation of the lampricide occurred in this and other portions of the watershed, necessitating additional applications by means of booster feeders. Access was good to those parts of the watershed which required attention. A heavy thunderstorm occurred during the treatment, but rainfall was not of sufficient duration to create a serious dilution problem, although it caused changes in the optical density of the stream water which made colorimetric analysis awkward for a time. The treatment of Lafontaine Creek appeared to be highly successful: concentrations of TFM lethal to lampreys were maintained to the mouth of the river and mortality of fishes was very low.

7. Nottawasaga River (H-1360)

The Nottawasaga River system, in the Townships of Sunnidale, Flos, Vespra, Essa, Tosoronto and Nottawasaga, Simcoe County, was treated from June 18 to June 25, 1961, with the 40% Hoechst formulation of the sodium salt of TFM, and with two Maumee formulations, one containing 30% of the sodium salt and the other 60% of the amine salt of TFM. The following main tributaries were also treated: Boyne River, Mad River, Noisy River, Pine River, Bear Creek, Willow River, Phelpston Creek and Lamont Creek. About 50 other small tributaries, lagoons and ponds were also treated and four booster applications (one on Nottawasaga River, three on Mad River) were made. The main feeder on Nottawasaga River was located at Nicolston Dam; Boyne River was treated at Alliston, Bear River at Utopia, Pine River at Angus, Mad River at Singhampton, Noisy River near Maple Valley and Lamont Creek at Highway 26. Other tributaries were treated for distances of less than half a mile. A total of 131 miles of stream was treated in the Nottawasaga River drainage.

The start of the treatment was delayed for nearly a month by frequent rains in one part of the watershed or another. A large amount of information was accumulated during this period from numerous discharge measurements and dye checks, frequent chemical analyses of the water and 25 bio-assays. Volumes of flow just prior to the treatment were as follows: in Nottawasaga River at Nicolston Dam, 106 cfs; in Boyne River, 25 cfs; in Mad River at Singhampton, 33 cfs; in Noisy River at Maple Valley, 18 cfs; in Pine River at Angus, 78 cfs; in Bear Creek, 19 cfs; and in Willow Creek, 55 cfs. The volume of flow at the mouth of Nottawasaga River was 504 cfs. Results of the final bio-assays, expressed as minimum effective and maximum permissible concentrations of TFM for 18-hour exposures, were as follows: Nicolston Dam, 8.0 and 16.0 ppm; Boyne River, 8.0 and 16.0 ppm; Mad River, 7.0 and 10.0 ppm; Noisy River, 6.4 and 10.0 ppm; Bear Creek, 7.0 and 7.3 ppm; Willow Creek, 3.1 and 8.5 ppm; and for Nottawasaga River at Wasaga Beach, 5.4 and 9.3 ppm.

The application of lampricide was begun on June 18 at 1615 hours on Boyne River with a "Proportioneer" feeder, and at 2125 hours on Nottawasaga River (Nicolston Dam) with a "Milton Roy" feeder. The Boyne River application lasted for 18½ hours and used 240 gallons of formulation containing 1,092 pounds of TFM, while the Nicolston Dam application lasted for 17½ hours and used 924 gallons containing 4,204 pounds. Treatments of Mad River and its tributary, Noisy River, were started on June 19 at 1320 and 1415 hours respectively by means of "Proportioneer" feeders. The Mad River application lasted 17½ hours and used 351 gallons of formulation containing 1,597 pounds of TFM, while the Noisy River treatment lasted 20 hours and used 390 gallons containing 1,775 pounds. An additional 250 gallons containing 917 pounds of TFM were used in Mad River, and 49.5 gallons containing 161 pounds of TFM in Noisy River, for booster applications and the treatment of tributaries. Bear Creek was treated initially for 19½ hours, beginning on June 20 at 1145 hours. A second treatment was started at a point further upstream at 1140 hours on June 24, and terminated after 6½ hours. These treatments used respectively 80 gallons of formulation containing 364 pounds of TFM and 48 gallons containing 218 pounds. "Proportioneer" feeders were used for the treatments of Bear Creek. Pine River was treated for 18 hours, beginning on June 21 at 0130 hours, by means of a "Milton Roy" feeder. This application used 732 gallons of formulation containing 3, 331 pounds of TFM. Willow Creek was treated by means of a "Proportioneer" feeder for 12 hours, beginning at 0420 on June 22, using 324 gallons of lampricide containing 1, 824 pounds of TFM. Phelpston Creek was treated by means of a fuel pump for a period of 4-3/4 hours on June 22, requiring 22¼ gallons of lampricide (102 pounds of TFM). Lamont Creek, because of its extremely slow movement, needed several applications at different points. Its treatment by means of drip feeders lasted about 54 hours through June 23 to 25, and consumed 55 gallons of lampricide (564 pounds of TFM).

Treatment of the main stem of Nottawasaga River was boosted at a point near Angus; further downstream at Jack's Lake chemical was poured into the arms of the lake from outboard motor boats. A number of minor tributaries and lagoons along the main river were treated. These applications required an additional 894 gallons of lampricide containing 3, 736 pounds of TFM.

During these treatments, concentrations of TFM at the feeder sites and near the mouths respectively were as follows: Nottawasaga, 8.4 to 16.0 ppm for 17 hours and 8.0 to 11.7 ppm for 10 hours; Boyne River, 10.3 to 17.5 ppm for 18 hours and 8.8 to 12.2 ppm for 16 hours; Mad River, 12.5 to 25.6 ppm for 17-3/4 hours and 6.0 to 12.4 ppm for 8 hours; Noisy River, 10.5 to 28 ppm for 20 hours and 6.8 to 10.9 ppm for 17 hours; Pine River (one location), 7.4 to 11.2 ppm for 17½ hours; Bear Creek, 8.4 to 11.7 ppm for 19 hours and 7.0 to 10.0 ppm for 14 hours; Willow Creek (one location), 6.2 to 14.8 ppm for 12½ hours; Lamont Creek, 22.1 to 26 ppm for 9½ hours and 1.2 to 10.0 ppm for 21 hours.

The overall abundance of ammocoetes in the Nottawasaga River system, as revealed by these treatments, was low. Native species were fairly ubiquitous but sea lampreys, though much more restricted in distribution, usually outnumbered the others locally. Sea lampreys were very abundant in Mad River, moderately abundant in Noisy River, scarce in Bear River, and very scarce in the main stem of Nottawasaga River. Except for carp and suckers, fish mortality was very low.

The entire treatment appeared to be extremely successful, in that lethal concentrations of lampricide, sufficient for 99.9% kill of lampreys, were present at all sample stations. Weather and stream conditions were favourable throughout the operation, a situation which would be hard to duplicate by choice again.

8. <u>Root River (H-3)</u>

Root River, including four tributaries, in Tarentorus and Aweres Townships and Garden River Indian Reservation, District of Algoma, was treated from July 16 to 22, 1961. The Hoechst 40% formulation and a small amount of the Maumee 30% formulation of TFM were used in the treatment. The main river was treated at a distance of 15½ miles from the mouth; the West Root, West West Root, Coldwater and Crystal Creeks at distance of 5½, 5, 1½ and 6 miles respectively from their junctions with Root River.

Electro-shocker surveys, completed in 1960, had indicated that sea lamprey ammocoetes occurred in Root River and its above-mentioned tributaries, but that their distribution did not exceed the distance treated.

Pre-treatment studies of the Root River watershed included discharge measurements, dye checks, water analyses, and bio-assays. At the time of treatment, the volume of flow at the mouth of Root River was 70 cfs. At the mouth of the following tributaries the volumes of flow were: West Root, 5.2 cfs; in West West Root, 1.6 cfs; in Coldwater, 8.5 cfs; and in Crystal, 19 cfs. Results of the final bio-assay indicated that for exposures of 12 hours, the minimum effective and maximum permissible concentrations would be for Root River 1.2 to 1.7 ppm, for West West Root Creek 0.6 to 1.6 ppm, for West Root Creek 0.5 to 2.0 ppm, for Crystal Creek 0.6 to 1.5 ppm, and for Coldwater Creek 1.2 to 1.5 ppm.

Treatments of West Root and West West Root Creeks were started on July 17, 1961 by means of drip feeders. The movement of water in both of these tributaries was very slow and the lampricide was introduced at several points below the original feeder sites in order to shorten the time for the chemical to reach the creek mouths. In West Root Creek a large beaver flowage and several smaller ponds required manual applications of lampricide. Treatment of this tributary lasted from July 17 to July 21, and required 21 gallons of lampricide (95 pounds of TFM) which were applied at 12 different locations. Treatment of West West Root Creek, begun initially on July 17, had to be repeated at four successive upstream points, because sea lamprey ammocoetes were discovered in the vicinity of the feeder sites. Treatment of this tributary lasted until July 24 and required 25 gallons of lampricide (100 pounds of TFM) which were applied at seven different locations.

Two 18-hour applications were started on July 18, 1961 at 1000 hours in the main Root River and at 1710 hours in Coldwater Creek. "Proportioneer" feeders pumped 48 gallons of lampricide containing 218 pounds of TFM into the main Root River, and 12 gallons containing 55 pounds into Coldwater Creek. An additional 17 gallons (79 pounds of TFM) were applied to Root River and one quart (1 pound of TFM) was applied to Coldwater Creek by means of drip feeders.

Crystal Creek was treated for 18 hours, beginning on July 19 at 1800 hours by means of a "Proportioneer" feeder. This application used 24 gallons of lampricide (109 pounds of TFM). An additional four gallons (20 pounds of TFM) were used in treating tributaries and lagoons.

Concentrations of TFM during these treatments in the main river were: between 1.4 and 2.6 ppm at the feeder; 0.8 and 1.1 ppm at the mouth. In West Root Creek the concentration varied from 1.0 to 3.7 ppm at the main feeder and from 0.5 to 1.7 ppm at the mouth; in West West Root Creek from 0.5 to 1.7 ppm at the main feeder and from 0.5 to 1.0 at the mouth. These concentrations of lampricide were present for periods exceeding 14 hours in all cases. In Coldwater Creek concentrations of lampricide were between 1.2 and 2.3 ppm at the feeder site for 16 hours and between 1.2 and 1.5 ppm at the mouth for the same period. In Crystal Creek concentrations of TFM were between 1.3 and 1.7 ppm for 18 hours at the feeder site and between 1.0 and 1.4 ppm at the mouth for 16 hours.

As indicated previously, this treatment of the Root River system was prolonged and complicated by the existence of numerous beaver ponds and extensive flowages in two of the tributaries. An additional complication was the discovery of sea lampreys above the point believed to be the upper limit of their occurrence in one tributary. Treatment of the stream above this point was hampered by extreme difficulty of access.

A gravel washing plant uses water from West Root Creek and returns it, after passing through several settling ponds, to a point farther downstream near the confluence with Root River. It was observed that highly turbid water issued from these ponds at certain times. This situation occurred du ring the treatment, causing some difficulty in colorimetric analysis of water samples.

Observations made during this treatment indicated that ammocoetes were abundant in the main Root River, but only moderately plentiful in the tributaries. Of some 1,700 specimens collected, however, almost 75% were native species, although sea lampreys were relatively more numerous in a few upstream localities. Mortality of stream fishes appeared to be low and confined mainly to forage species.

9. Serpent River (H-116)

Serpent River and two tributaries, in Spragge Township, Sudbury District, were treated from August 5 to 7, 1961 with the 40% Hoechst formulation of TFM. The main river was treated at a point just above Highway #17, about 8 miles from the mouth and an additional 3 miles of tributary streams were treated.

Sea lampreys were known to occur in Serpent River from collections made in 1957. Pre-treatment surveys made in 1961 with electro-shockers and lampricide established the limits of the ammocoete population. Other pre-treatment studies included discharge measurements, dye check, water analysis and a bio-assay. The volume of flow in the main river at the time of treatment was 269 cfs. Results of the bio-assay indicated that for a 12-hour exposure, the minimum effective and maximum permissible concentrations would be 1.0 and 1.4 ppm respectively. We used a new fluorescent dye, "Rhodamine B", for the first time, in this river. It did not appear to have any advantage, at this time, over fluorescein but may be superior in water of different colour.

The application of lampricide to the first tributary (Little Serpent Creek) was begun at 1100 hours on August 5 by means of drip feeders. Because of very slow water movement, lampricide was applied at six different locations in amounts totalling 15½ gallons of formulation (70 pounds of TFM). Final application of lampricide in Little Serpent Creek was on August 6.

In the main river, 348 gallons of lampricide (1,583 pounds of TFM) were applied by means of a "Proportioneer" feeder over an 18-hour period, beginning at 2000 hours on August 5. An additional 6 gallons (27 pounds) of lampricide were applied in lagoons along the Serpent River.

A tributary, consisting of a chain of beaver flowages emptying into the south side of Serpent River near the mouth, was treated on August 5, 6 and 7. A total of 12 gallons of lampricide (55 pounds of TFM) was applied at three locations. No sea lampreys had been taken above the lowermost beaver dam during pre-treatment surveys, and when none appeared during these subsequent applications, it was concluded that a complete treatment of this extensive waterway was unnecessary.

Concentrations of TFM in the main river during the treatment were: at the feeder site, 1.0 to 1.4 ppm for 17 hours; and at the mouth, 1.0 to 1.4 ppm for 12 hours. In the Little Serpent concentrations of TFM were between 1.5 and 7.0 ppm for over 30 hours.

Ammocoetes were moderately abundant only in the mid-section of the main Serpent River, as indicated by the number of specimens collected during the treatment. In other parts of the main river and in the tributaries ammocoetes were scarce.

Moderate numbers of suckers, pike and log perch, and large numbers of leeches and mud puppies were killed during the treatment of Serpent River. Mortality of game fish, however, appeared to be ngligible.

10. Unnamed Stream (H-114)

The stream known to us as H-114, in Spragge Township, Sudbury District, was treated on August 7, 1961 with the 40% Hoechst formulation of TFM. The site of application was at the top of falls about 30 feet high and ¼ mile from the mouth. No tributaries enter this stream below this point. Sea lamprey ammocoetes had been collected from this river during surveys conducted in 1957 and 1961.

The volume of flow at the time of treatment was estimated at about 0.5 cfs. No other pre-treatment studies were made. Lampricide was applied for 9¼ hours on August 7, by means of a constant-head drip bottle and three gallons of formulation containing 14 pounds of TFM were used. Concentrations of TFM below the feeder were about 8 ppm throughout the treatment.

The entire treated length of the stream was examined both during and after the treatment. No lampreys or fish, either dead or alive, were observed. It appears likely that any ammocoets that had been present in H-114 were destroyed by the lampricide used in the stream survey on July 24, 1961.

11. Livingstone Creek (H-92)

Livingstone Creek, Striker Township, Algoma District, was treated on August 10 and 11, 1961 with the 40% Hoechst formulation of TFM. This was applied at several points as far upstream as the railroad bridge about 3 miles from the mouth. Two small tributaries, one of which was almost dry, were also treated. Sea lampreys had been collected during a stream survey by means of lampricide 3 days previously.

The volume of flow of Livingstone Creek was estimated to be 0.5 cfs. Other pre-treatment studies were not made. Four and a half gallons of lampricide were applied in the area of the mouth to about ½ mile upstream from a moving boat. An additional 5 gallons were applied manually in the upper area of the main stream and about ½ gallon in the two tributaries, making a total of 10 gallons of formulation containing 46 pounds of active ingredient.

No analysis of the treated water was made, but concentrations of TFM appeared adequate for successful treatment. Two days were required to complete this treatment, because of lack of convenient access and the presence of several beaver ponds. Ammocoetes, including small numbers of sea lampreys, were collected as far upstream as the railroad bridge, but most were within 1 mile of the mouth.

12. <u>MacBeth Creek (H-87)</u>

MacBeth Creek, Thessalon Township, Algoma District, was treated on August 10, 1961 with the 40% Hoechst formulation of TFM. The toxicant was applied at several points within ½ mile of the mouth. There were no tributaries in this stretch of river. The stream had been surveyed three days before the treatment, but no lampreys were found.

The volume of flow in MacBeth Creek was estimated to be 0.5 cfs. Results of a pre-treatment bio-assay indicated that for a 9-hour treatment the minimum effective and maximum permissible concentrations of TFM would be 4.3 and 2.2 ppm respectively. In spite of this unfavourable range, treatment was considered to be desirable because of the small extent of the area to be treated.

The upstream portion of the creek was treated by means of a drip feeder whose location had to be moved upstream several hundred yards during the application due to the appearance of ammocoetes immediately below the original site. This part of the treatment required 6 gallons of formulation containing 27 pounds of TFM. In the vicinity of the mouth 5 gallons of lampricide (23 pounds of TFM) were applied by boat.

13. <u>Lauzon River (H-112)</u>

Lauzon River, Striker Township, Algoma District, was treated on August 10 and 11, 1961 with the 40% Hoechst formulation of TFM. The site of application was the dam at the outlet of Lake Lauzon, about ½ mile from the mouth. There are no tributaries below this point.

The volume of flow of Lauzon River was estimated to be 5 cfs at the time of treatment. Results of a pre-treatment bio-assay indicated that, for a 9-hour treatment, the minimum effective and maximum permissible concentrations of TFM would be 1.8 and 2.7 ppm respectively. Water samples were also analysed.

Initially, treatment was by means of a constant-head drip feeder by which 2½ gallons of formulation (11 pounds of TFM) were applied. Analysis of the treated water indicated that concentrations of TFM below the feeder were between 2.0 and 4.5 ppm for 8½ hours. Concentrations at the mouth of Lauzon River, however, did not exceed 1.7 ppm due to dilution by incoming lake water. A second treatment of the estuarine area was, therefore, made by manual application of lampricide from a moving boat. In the latter case, 2 gallons of formulation (10 pounds of TFM) were used.

The ammocoete population of Lauzon River was sparse, as indicated by collections made during this treatment. Of 14 specimens collected, 13 were sea lampreys. There was no evident mortality of stream fishes, with the exception of a few minnows.

14. Mississagi River (H-102-107)

Mississagi River, Mississagi, Thompson, Bright and Gladstone Townships, Algoma District, was treated on August 16 to 18, 1961 with the 40% Hoechst formulation of TFM. One major tributary, Bolton River, was also treated concurrently. The main river was treated at the Red Rock power dam, about 16 miles from the mouth, while Bolton River was treated at the outlet of Bright Lake about 3 miles from the main river. In addition, 17 other places in the watershed were treated, including small tributaries, lagoons and sand flats. An intensive pre-treatment survey of Mississagi River, completed in the first week of August 1961, indicated that sea lampreys were present but generally scarce.

Other pre-treatment studies included dye checks, the recording of water levels, chemical analysis, and bio-assays of water from Mississagi and Bolton Rivers. Results of the latter tests indicated that for Mississagi River the minimum effective and maximum permissible concentrations of TFM based on an 18-hour treatment would be 1.1 and 2.0 ppm respectively, while for Bolton River the corresponding values would be 1.2 and 2.0 ppm respectively.

The volume of flow in Mississagi River is regulated by the Red Rock power dam and typically varies rather widely in accordance with the operating schedule of the power station as dictated by current loads. Through prior arrangement with the Great Lakes Power Company, the flow at Red Rock was maintained at a constant level of approximately 1800 cfs during the treatment period of about 42 hours.

In accordance with the results of the dye checks, treatment of Bolton River was started at 0100 hours on August 16, and continued for 12 hours. A total of 36 gallons of lampricide containing 164 pounds of TFM was applied. Treatment of Mississagi River was started at 1000 hours on August 16, continued for 18 hours, and consumed 2694 gallons of lampricide (12,258 pounds of TFM). An additional 60 gallons (271 pounds of TFM) were applied to various small tributaries and lagoons along the river. An unusual feature of the treatment was the application of lampricide to exposed sand bars, left in the river by the receding water. It was believed possible that ammocoetes living in these areas, when covered with water, might remain there when the surface of the sand became dry. Liquid formulation was, therefore, applied to several exposed sand bars by means of portable sprayers. No lampreys were observed to emerge from these areas and it was concluded that the animals, if present, were probably killed in situ.

Concentrations of TFM in Bolton River during the treatment were between 2.2 and 2.7 ppm for 11 hours below the feeder and between 2.0 and 2.7 ppm for 10 hours at the mouth. Concentrations of TFM in Mississagi River were: below the feeder, 1.3 to 1.8 ppm for 18 hours; and from the campsite at Highway 17 to the mouth, 1.0 to 1.4 ppm for about 18 hours.

This treatment proceeded without difficulty. Road access to that part of the river being treated was good, and weather conditions remained favourable throughout the operation. Fish mortality was negligible and was confined mainly to minnows and rough species. A few pickerel in the vicinity of the feeder appeared to be distressed, but only 3 or 4 were found dead. Ammocoetes were abundant in Mississagi River, judging from the numbers that appeared during this treatment. Sea lampreys apparently made up a large proportion of the ammocoete population, comprising 90% of the total collection.

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M. L. H. Thomas — Appendix 7

A REVIEW OF THE INVESTIGATIONS ON AMMOCOETES

For several years the Board, as agent for the Great Lakes Fishery Commission, has studied several aspects of ammocoete biology. Since the Commission has terminated its support, it seems appropriate to review accomplishments. Although there still is much remaining to be done, we now have a much more accurate picture of ammocoete biology.

Perhaps the most important knowledge gained is of a very general nature. We now know that we are dealing with a very highly adaptable species and that is is dangerous to draw any conclusions based on only limited observation or research. This adaptability applies to the entire life cycle of the sea lamprey; in the larval stage it is well exemplified by the range of habitat utilized. The ammocoete stage of the lamprey is spent as a filter feeder, which normally lives in a burrow constructed in the bottom of streams. It was, until recently, believed that this mode of life restricted larvae to reasonably soft bottoms. It is certain that ammocoetes cannot burrow into any but rather soft bottoms, but our studies show that where a typical burrow cannot be made the larvae are able to utilize almost any cover. This adaptability is great enough that ammocoetes can survive in almost all naturally occurring habitats within their range.

Early investigations centred on Big Creek, a southwestern Ontario stream tributary to Lake Erie, were concerned mainly with the gross distribution of ammocoetes within stream systems. Larvae were found in soft bottoms downstream of all spawning sites. Extent of distribution downstream appears to be dependent on stream gradient. Such a generalization probably applies to all lamprey-bearing streams.

Early investigations gave some knowledge of migration habits, but more information was needed. The subject was studied in the Big Creek watershed using several methods, for example, two-way check weirs and repeated clearance of several marked areas. It was found that migration was almost completely downstream; upstream migration was uncommon and took place only for short distances in slowly moving water. Migration exhibited a circadian rhythm, being almost entirely nocturnal. It would seem that diurnal migration only takes place when ammocoetes are mechanically scoured from the bottom and swept away. Evidence gained mainly from the recolonization of cleared areas showed that peak migrations occurred at times of high water temperature combined with high flow. It is suggested that downstream migration results from the combination of an active temperature correlated component and a passive flow correlated component. It has been shown that increased temperature results in increased free-swimming activity. It has also been demonstrated that swimming ability in ammocoetes is limited. Thus a larva leaving its burrow would tend to be swept downstream even if attempting to move against the current.

Knowledge of migration activity led to the conclusion that many ammocoetes in typical utilized streams must pass beyond the mouth before metamorphosis. This aspect is of great importance in connection with the use of lampricide in control, since ammocoetes passing into the open lake are beyond the reach of toxicants and serve as a reservoir for reinfection. This aspect of ammocoete biology was investigated off eight lamprey-bearing streams flowing into the Canadian waters of Lake Superior. Sea lamprey ammocoetes were found off six of these rivers, both close to shore and in deep water. Ammocoetes captured in the lake increased in size with increasing distance from the river mouth, indicating that growth continued in these lentic situations. It should be pointed out, however, that where ammocoetes were found the rivers emptied into relatively shallow and sheltered bays. Growth may not continue where rivers empty directly into the main body of the lake; such rivers, however, are the exception rather than the rule. The most extensive investigations were carried out in Batchawana Bay off the mouths of the rivers Batchawana and Sable. In that location the presence of a large island devoid of lamprey-bearing streams provided an ideal situation to check on ammocoete dispersion within the lake. It was found that sea lamprey ammocoetes extended up to 2-1/8 miles from the mouth of the Batchawana River and up to 1-1/2 miles from the mouth of the Sable River. Thorough investigation showed that close to shore the number of ammocoetes per unit area was little influenced by the shore type. On shores within 2½ miles of the Batchawana River mouth, there was an average of 1.7 sea lamprey ammocoetes per 1000 square yards. Numbers collected in deep water were not sufficient for a reliable population estimate, but did suggest that ammocoetes there may have been as numerous as inshore. Thus the sea lamprey population off the Batchawana River may be in the tens of thousands. It seems probable that comparable populations exist off other rivers and it is quite possible that enough adult sea lampreys can develop from these populations to maintain predation on lake trout at an unacceptably high level. However, since lampreys presumably do not spawn in the lake, these populations can be reduced if rivers are treated with lampricide at frequent enough intervals so that no larvae reach the lake. In rivers such as the Chippewa, where spawning grounds lie within a mile of the lake, evidence on migration rates gained from studies in Big Creek suggest that most ammocoetes reach the lake within a year. In such rivers annual treatment would be required to eliminate the species.

Factors affecting the distribution of ammocoetes within area where they are resident have been investigated, both in streams and in the open lake. Data collected from one tributary of Big Creek showed that the main controlling factors in that stream were bottom hardness and water velocity. A multiple regression of these factors on population density was highly significant. Age of ammocoetes was correlated, both in streams and in the lake, with distance from the spawning grounds, a consequence of migration habits. The lake bottom environment tends to be uniform over large areas, giving ammocoetes little opportunity for selection. In such areas the adaptability of the species is to its advantage, populations being found in such diverse situations as wave-beaten sandy shores, gravel, stone and boulder beaches and reed beds. Concentrations of ammocoetes were occasionally found along partial barriers such as sand ridges and sunken logs, particularly if these lay at right angles to a lake current.

Information on growth and duration of larval life in ammocoetes has long been needed for organization of control. In rivers such as the Goulais, where the course below spawning sites is so long that ammocoetes rarely reach the mouth, such information could determine the frequency of lampricide re-treatment. So far no method of aging lampreys other than by length-frequency determinations has been discovered. The length-frequency method has proved far from ideal. Large variations in growth rate occur between individuals of the same age, both within streams and from stream to stream. This makes the interpretation of length-frequency polygons very difficult after the third year of life. However, recently some progress has been made, particularly by a British worker (Hardisty, M. W., J. Anim. Ecol., 30(2): 1961) in this field, who has had access to sea lamprey ammocoetes from the Great Lakes. It has been shown that growth rate is almost linear up to the start of transformation, and this is borne out by recent collections from Big Creek. Thus fairly confident extrapolations can be made provided good growth data for the first three years is available. It is also postulated that variation in average growth rate from stream to stream results not in varying age, but in varying size, at metamorphosis, transformation taking place at the same age, on the average. If this is true, the length of life of sea lamprey ammocoetes in Big Creek is either 5½ or 6½ years. This agrees with an estimate made by Hardisty for Michigan ammocoetes. Fig. 1 illustrates data from a tributary of Big Creek and a second stream in that area.

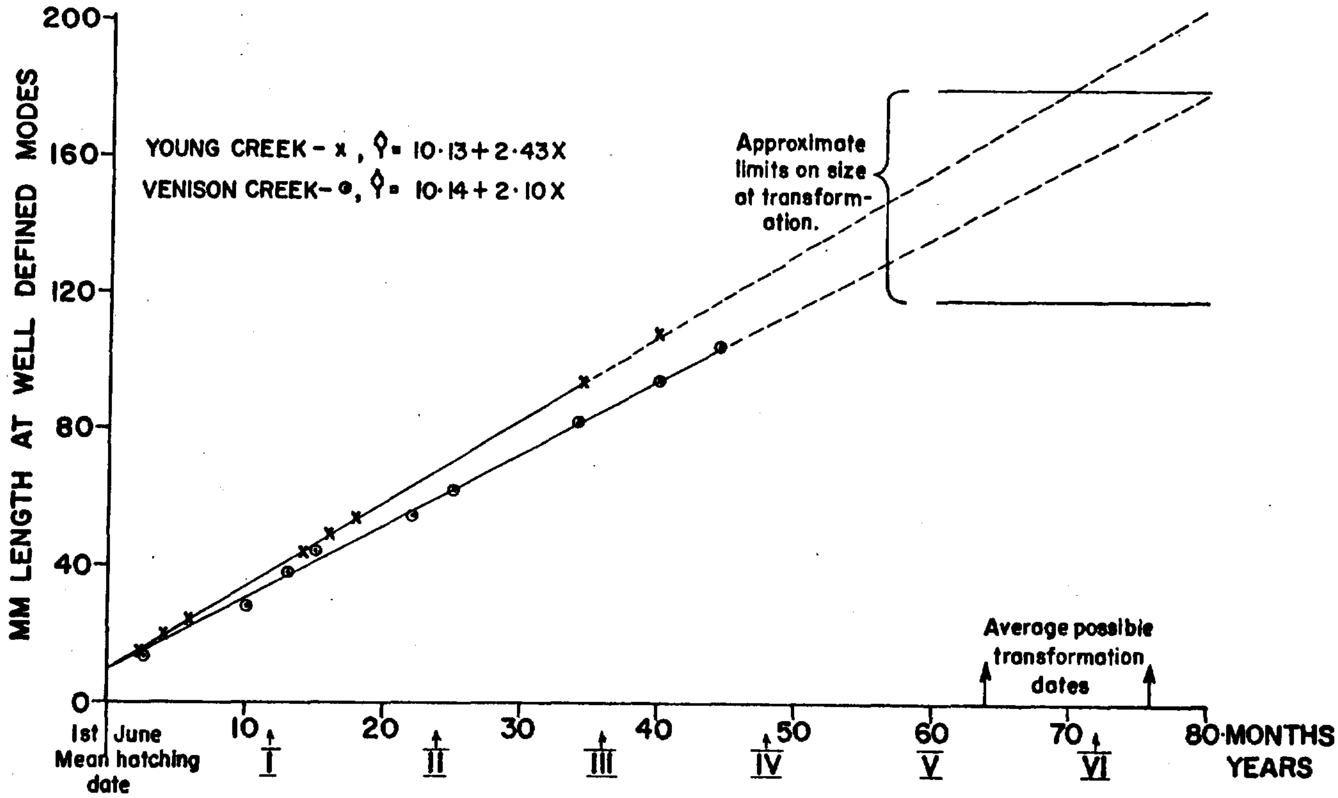

Fig. 1. Growth of sea lamprey ammocoetes in two Ontario streams.

The question of circadian activity rhythms in ammocoetes has been investigated in the laboratory under controlled conditions. It was found that free-swimming activity was entirely nocturnal and showed a maximum just after nightfall. Free swimming activity increased with temperature, but was not exhibited by an individual every day. Activity within the substrate was not confined to darkness, movement and construction of new burrows occurred at all times of day. It is thought that further work in the field of within-burrow activity would be scientifically rewarding and would give results useful to lamprey control management.

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R. W. McCauley Appendix 8

THERMAL TOLERANCE OF SEA LAMPREY EGGS

The influence of temperature on the development of sea lamprey eggs was studied using two approaches. Data were available from Piavis (1961) which indicated that lamprey eggs would develop over a range of 15°C to 24°C with an optimum in the lower part of this range. It was considered first of all necessary to repeat this experiment in order to confirm or further delimit the range for development. Temperatures chosen were 15°C, 20°C and 25°C, and additional data were obtained in a second experiment at 18°C. These results were reported in the 1960-61 Annual Report.

In the second approach the effect of changing the rearing temperatures at various stages of development was investigated. The temperature regime under which lamprey eggs develop in the stream is not constant, but is subject to both diurnal and seasonal variations (Fig. 1). Such temperature changes occurring at different stages in development may have different effects, depending on the stage at which the change occurs. A more complete description of temperature effects should include then recognition of any stages in development at which the process is particularly sensitive to temperature. A beginning was made on such a study by initially fertilizing and rearing eggs at the optimum temperature of 18°C as determined above.

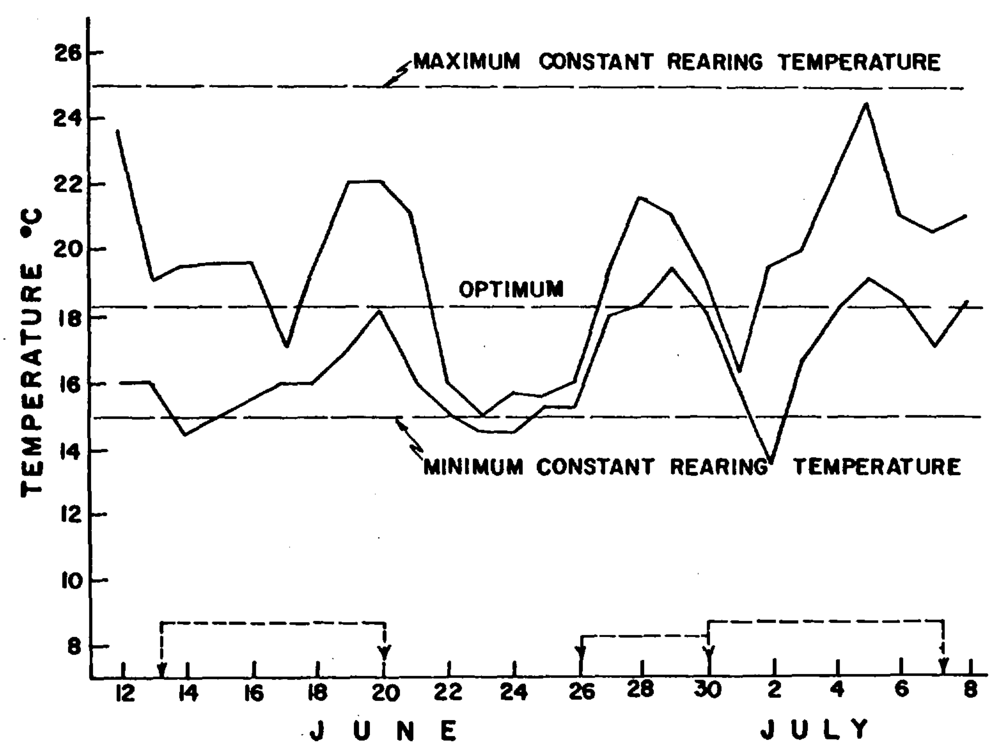

Fig. 1. Daily maximum and minimum temperatures recorded on the Thessalon River during the months of June and July, 1959. Incubation periods of samples of eggs in nests are indicated.

As the eggs developed at this temperature, subsamples of 200 were removed at various stages and transferred to constant temperatures above and below the rearing temperature. They were then allowed to continue their development at these new temperatures and the number of prolarvae which hatched in each subsample was recorded. The temperatures chosen were 12°C, 14°C, 23°C and 26°C. Unfortunately, further experiments which involved changing temperatures could not be carried out because of the lack of a supply of viable, fertilized eggs. The reproductive season of the sea lamprey is only about one month long in Big Creek. It was hoped originally to extend the period over which experiments on developing eggs could be performed by collecting spawning-phase animals early in the season and holding back their sexual maturation by cold temperature. In early May of 1961 lampreys were trapped in the Saugeen River and Big Creek and held at the laboratory in water at 5°C. The animals were subjected to a photoperiod of 12 hours. At convenient intervals during the following four months, lampreys were removed and brought to spawning condition by either holding them in cages immersed in Big and Medway Creeks or transferring them to tanks in the laboratory maintained at 20°C. By these two methods, it was possible to obtain sexually mature animals as late as September. However, the fertilized eggs arising from these specimens did not develop beyond early cleavage. No reason was found for the lack of viability of these eggs, but when the necessity of using lampreys which were collected off nests became evident the reproductive season had passed.

Table I shows the results of the experiment in which eggs are exposed to sudden changes to new levels of temperature at various stages of their development and allowed to continue their development, if possible, at these new temperatures.

Table I. Percentage hatch in subsamples of 200 eggs reared initially at 18°C and transferred to higher and lower temperatures at various stages of development. Observations on the number of embryos which hatched were made 15 days after fertilization.

Time at which transfer was made	Stage at which transfer was made	Final rearing temperatures °C (% hatched)				
		12	14	18	23	26
24 hours	64 cells	0	0	..	0	0
2 days	full blastula	0	0	..	3	0
3 "	gastrula	0	0	..	8	0
4 "	neural plate	0	1	..	12	0
6 "	head	5	2	..	14	5
8 "	prehatching	29	7	54*	25	23

*54% of the eggs left at the initial rearing temperature hatched.

At 18°C, the optimum temperature for development, 54% of the eggs hatched into prolarvae. In general, the later a subsample was transferred to the final rearing temperature, the greater was the percentage hatch. Excluding the results for 18°C and 23°C, the only temperatures within the range for some successful hatching, no prolarvae hatched from eggs transferred before the neural plate stage.

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R. W. McCauley Appendix 9

A SUMMARY OF STUDIES ON THE THERMAL TOLERANCE OF THE SEA LAMPREY

The susceptibility of the sea lamprey in all its life stages to lethal temperatures was investigated. The stages comprise fertilized egg, prolarva, larva, parasitic-phase adult and spawning-phase adult. Of these stages, the eggs have the most exacting thermal requirements. The range of constant temperatures necessary for some successful hatching is narrow, being 15-25°C. This range may be extended to 12-26°C when the eggs are allowed to develop to the neural plate stage at 18° before being exposed to higher and lower temperatures.

The prolarvae, unlike the developing eggs, have presumably a physiological mechanism which adjusts to temperature extremes. Prolarvae reared at 20°C can withstand temperatures as high as 29°C for one week or as low as 1°C for three days. The larvae, given time to acclimate, can live at temperatures ranging from 0°C to 32.5°C. There is evidence, however, that larvae cannot live for prolonged periods at temperatures at the upper part of their biokinetic range. At an acclimation temperature of 30°C, mortality in the holding baths significantly increases.

Metamorphosis for all the physiological and morphological changes it involves does not alter the high thermal tolerance of the species. Although parasitic lampreys are classified as cold living, stenothermal animals on the basis of their distribution in the lake, they have not lost the high thermal tolerance of the larvae. In the later stages of sexual maturity of the spawning-phase animals, the destructive processes of physiological degeneration may be accelerated by high temperature and individuals succumb at high but sublethal temperatures.

Lethal temperatures may possibly be encountered by lampreys during their life history at three periods. At the time of embryonic development, lethal temperatures experienced by the eggs likely control the size of the year class of larvae. Temperature may exclude the establishment of larvae from shallow, protected bays in the lake shore which, during spells of warm weather, can attain lethally high temperatures. Finally, large numbers of spawning-phase adults in advanced sexual maturity could be killed by temperatures as low as 25°C. Temperatures exceeding 25°C have been recorded during the month of June in the Bronte and Humber Rivers, Lake Ontario.

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D. P. Dodge
A. H. Lawrie

Appendix 10

WELLAND SHIP CANAL INVESTIGATION, 1959 and 1961

An investigation of the Welland Ship Canal system was initiated during December 1959 and continued during December 1961 to determine the extent, if any, to which sea lamprey adults use the Canal as a channel for migration from Lake Ontario to Lake Erie. The following records of sea lampreys in the Canal system were reported to the local Department of Lands and Forests office:

Nov. 27, 1960	-	One adult lamprey on screen of City of Welland water intake - 25.5 inches long.
Dec. 1, 1960	-	One adult lamprey in minnow dip net, Niagara River, Fort Erie - 21 inches long.
Dec. 6, 1960	-	One adult lamprey snagged in Niagara River, Fort Erie - 14 inches long.

During the navigation season, extensive investigations of the Ship Canal is impractical. However, drainage of sections of the Canal for annual construction and repairs, instituted during the winter months of the year, affords an opportunity for examining the Canal.

From December 18 to 30, 1961, a crew of three men sampled the fish population of the Welland Canal. The length of the Canal drained was 8.6 miles, commencing at Lock 7 and following in order to Lock 1 on Lake Ontario. Lock 1 was pumped rather than drained, because the bottom of this Lock is below the level of Lake Ontario. Seven points within that part of the system drained, including the recess pools behind the sills of Locks 7, 6, 3 and 2, were shocked with a portable electric generator. Each set of gates of a lock rides on a cement skid and, when closed, the bottoms of the gates come up flush to a cement sill. When each lock is drained, the water is retained in the pools between the cement skids and the sill. These pools, called the recess pools, have a depth of five to six feet, width of eighty feet, and a length of forty feet. The pools thus become a natural basin in which the fish may collect. The large pondage (1/2 acre by 3 feet in depth) above Lock 3 was also shocked. This pondage, when completely filled with water, is 20 feet deep and has a surface area of over 10 acres.

Table I lists some of the features of the Welland Ship Canal system. Tables II and III list the species of fish that were removed from various points of the Canal during 1959 and 1961. The most abundant fishes were gizzard shad, alewife, and smelt. The remaining species occurred sparingly and only one specimen of the white perch was found. The bulk of the fish were less than ½ pound; however, some gizzard shad, pike and perch reached one pound in weight.

Table I. Welland Ship Canal System.

First placed in operation	1932	
Number of lift locks (three of the above are twin flight locks)	7	
Length of lift lock	859	feet
Width of lock	80	"
Depth of water on sills	30	"
Depth of water in sills (recess pools)	5.5	"
Average lift of lock	46.5	"
Height of lower lock gates	82	"
Amount of water required for a lockage (Imperial gallons) average	21,000,000	gal
Greatest height of lock wall (between Locks 4 & 5)	130.8	feet
Width of canal at bottom - nominal	200	"
Width of waterline at surface of water - minimum	310	"
Depth of canal prism	27	"
Time to fill one lock	12 to 15	min
Height of Lake Erie above Lake Ontario	365.5	feet
Length of Welland Canal	27.6	miles
Distance Lake Ontario to: Lock 1	1.90	"
Lock 2	3.70	"
Lock 3	6.35	"
Lock 4)	7.66	"
Lock 5) Flight Locks	7.83	"
Lock 6)	8.00	"
Lock 7	8.60	"

Table II. List of fish collected from Locks 4 and 5 of the Welland Ship Canal during December 1959.

Common Name	Scientific Name	Collected from
Alewife	Alosa pseudoharengus	Locks 4, 7
Gizzard shad	Dorosoma cepedianum	Locks 4, 7
American smelt	Osmerus mordax	Locks 4, 7
Northern pike	Esox lucius	Lock 4
White sucker	Catostomus commersoni	Lock 4
Common shiner	Notropis cornutus	Locks 4, 7
Rosyface shiner	Notropis rubellus	Locks 4, 7
Channel catfish	Ictalurus punctatus	Lock 4
White bass	Roccus chrysops	Locks 4, 7
Rock bass	Ambloplites rupestris	Lock 4
Yellow perch	Perca flavescens	Lock 4

Table III. List of fish collected from the Welland Ship Canal during December 1961.

Common Name	Scientific Name	Collected from	
Alewife	Alosa pseudoharengus	Locks 1, 2, 3, 6, 7	...
Gizzard shad	Dorosoma cepedianum	Locks 1, 2, 3, 6, 7	Pondage #3
American smelt	Osmerus mordax	Locks 2, 3, 6, 7	...
Northern pike	Esox lucius	Locks 1, 3	Pondage #3
White sucker	Catostomus commersoni	...	"
Carp	Cyprinus carpio	Locks 1, 7	"
Channel catfish	Ictalurus punctatus	...	"
White perch	Roccus americanus*	Lock 7	...
Rock bass	Ambloplites rupestris	Lock 3	...
Yellow perch	Perca flavescens	Lock 3	...

*This is the first record of this species from the Welland Canal system. Furthermore, few specimens have been collected from Lake Erie.

Of the fish examined, only a few pike and carp were of a size on which lampreys would be expected to feed. However, no fish exhibited any wounds or scars, nor were any adult or larval forms of lampreys discovered. These data, however, do not indicate that sea lampreys do not use the Welland Canal. Further investigation is intended before any conclusions can be drawn.

We wish to acknowledge the cooperation shown by Mr. P. P. Ellis and men of the St. Lawrence Seaway Authority employed at the Welland Ship Canal and the Lake Erie District of the Ontario Department of Lands and Forests.

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