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, 1960 to MARCH 31, 1961

With Investigators' Summaries as Appendices

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This report is submitted to fulfill terms of the 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

Electrical barriers have been installed and operated on the ten Lake Superior tributaries specified in the Memorandum of Agreement. As it had been decided to utilize the barriers chiefly to assess the success of stream treatments with lampricide, the barriers were not installed and operated as early in the spring as in previous years. This reduced the possibility of washouts by spring floods which have resulted in the past in interruptions of operation and in costly repair. Even with this precaution, some barriers were heavily damaged by flood during and prior to operating. Owing to unusual high spring run-off in the Wawa area, it was not possible to install and operate the Michipicoten Barrier until June 10. This barrier was also turned off during the chemical treatment of the Michipicoten River as a safety precaution.

In 1960, 4,810 adult migrant sea lampreys were collected from these barriers as compared with 3,098 in 1959 and 2,950 in 1958 from the same barriers. Details on operating time of the barriers and on comparative lamprey recoveries are given in Table I of Appendix I.

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

CHEMICAL TREATMENT OPERATIONS

Surveys

In 1960, 230 tributaries to Lake Superior were resurveyed with electroshocking gear to detect the development of any new runs. The tributaries resurveyed are listed in Table I, Appendix 2. Sea lampreys were found in ten of them for the first time. Of these, nine were small streams tributary to Batchawana Bay in eastern Lake Superior. The ammocoetes in these streams were few and were found close to their mouths. It seems likely that they have been derived by immigration from the known populations of lake-dwelling ammocoetes off their mouths.

In the tenth tributary, the Black Sturgeon River, ammocoetes were numerous and widespread and obviously the result of spawning in that river. These data led to treatment of the Black Sturgeon and of Sawmill Creek, but treatment of the others was considered unnecessary.

Treatments

The nine Lake Superior streams that were specified in the Memorandum of Agreement have been successfully treated with lampricide: Little Carp, Cranberry, Goulais, Stokeley, Michipicoten, Jackfish, McIntyre, Kaministikwia and Pigeon. In addition, the Black Sturgeon River near Nipigon and Sawmill Creek near Sault Ste. Marie were successfully treated following collection of sea lamprey ammocoetes from these watersheds in 1960. Data concerning these rivers are presented in Table I, Appendix 4. This completes the treatment of the known lamprey-producing tributaries on the Canadian side of Lake Superior.

The six Lake Huron streams that were specified in the Memorandum of Agreement have been successfully treated with lampricide: Still, Magnetawan, Naiscoot, Boyne, Sturgeon and Silver. The Chikanishing near Killarney was also treated. Data concerning these streams are also given in Table I, Appendix 4. Of the tributaries to Georgian Bay with known sea lamprey populations, only the Nottawasaga remains to be treated.

Detailed descriptions of each treatment are given in Appendix 5. Such data as have been collected on the completeness of larval destruction are summarized in Appendix 5. Samples have been collected from which size could be determined and ages estimated; these determinations have not been made because of the pressure of work of higher priority.

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

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

A second bio-assay trailer was procured and outfitted. This unit was utilized during the late spring and early summer when people were available. Unfortunately, it was not possible to recruit two of the scientists required to bring the personnel establishment to full strength so the trailer was unattended for much of the year.

In 1960 the weather was particularly favourable for lampricide application. We express our appreciation to the U.S. Fish and Wildlife Service (at Marquette) for their assistance with the Goulais River treatment. We are indebted to the Department of Lands and Forests for their co-operation and assistance during several stream treatments. They graciously loaned us radios and vehicles on some treatments and greatly assisted us with the

use of their aircraft on the Kaministikwia, Black Sturgeon, Goulais, Michipicoten, Still, Magnetawan and Boyne Rivers.

RESEARCH

Ammocoete Studies

Explorations to determine the extent of distribution of sea lamprey ammocoetes in Batchawana Bay were extended in 1960 to include types of shore previously thought unsuitable as larval habitat. These shores ranged from gravel to coarse rocks and boulders. All shores, regardless of type, lying within 2-1/2 miles of the mouth of the Batchawana River and those within 1-3/4 miles of the Sable River have been explored using the same method. It was found that ammocoetes were present in all types of shore up to a certain distance from the river mouth. The population density of sea lamprey ammocoetes on stony and rocky shores was similar to that for sandy shores at the same distance from the river mouth.

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

In addition to the work carried out in Batchawana Bay, sandy shores to either side of the mouth of the Big Gravel River in Nipigon Bay were investigated. Ichthyomyzon ammocoetes were present up to one-half mile each side of the river and sea lampreys were found half a mile to the east of the river mouth.

Dragging operations were carried out with an anchor-type dredge in Batchawana Bay, Pigeon Bay, and off the Big Gravel River in an effort to locate resident populations of ammocoetes in deep water. Fifty-one dredge hauls were made in Batchawana Bay in depths from 17 to 124 feet and six ammocoetes, including three sea lampreys, were collected. In Pigeon Bay thirty hauls in depths from 10 to 116 feet yielded no ammocoetes. Five ammocoetes, three of which were sea lampreys, were collected in 40 hauls in from 8 to 47 feet of water off the Big Gravel River.

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

Interest shown in a preliminary report on the above subject matter suggests that the Commission may find useful the following assessment of its significance.

The study indicates a population of lake-dwelling ammocoetes in the area within two miles of the Batchawana River mouth, numbering roughly in the tens of thousands. They appear to thrive and develop in the lake environment. Although data for assessing approximate relative abundance is not available for other areas, it seems more likely than not that there are similar populations at the mouth of several other lamprey-producing rivers, particularly along the south shore of the lake. Therefore, a total population of lake-dwelling ammocoetes in Lake Superior numbering in the hundreds of thousands, if not in the millions, is not inconsistent with the data.

On the other hand, roughly 60,000 adult sea lampreys have been killed and recovered annually at electrical barriers in recent years. Assuming that at least half the recent spawning runs were killed and recovered at barriers and assuming that natural mortalities of feeding-phase lamprey are roughly comparable to natural mortalities of mature fish, then these counts suggest that the adult population of sea lamprey in recent years in Lake Superior (the population which has almost eliminated the lake trout) has numbered in the low hundreds of thousands.

Therefore, it is quite possible that enough adult sea lampreys can develop from lake-dwelling ammocoetes to keep predation on lake trout at an unacceptably high level.

<u>Temperature Tolerance Studies</u>

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

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

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

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

INDEX TO APPENDICES

FISH NAMES

The following species of fish are mentioned in this report and its appendices; synonymy 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.

Common name	Scientific name	Alternative common name(s)
Sea lamprey	Petromyzon marinus	lamprey
Silver lamprey	Ichthyomyzon unicuspis	lamprey
Michigan brook lamprey	Ichthyomyzon fossor	lamprey
American brook lamprey	Entosphenus lamottei	lamprey
Rainbow trout	Salmo gairdneri	trout
Lake trout	Cristivomer namaycush	trout
Eastern brook trout	Salvelinus fontinalis	trout, brook trout, speckled trout
White sucker	Catostomus commersoni	sucker
Longnose sucker	Catostomus catostomus	sucker
Longnose dace	Rhinichthys cataractae	dace or minnow
Spottail shiner	Notropis hudsonius	shiner or minnow
Sand shiner	Notropis deliciosus	shiner or minnow
Bluntnose minnow	Pimephales notatus	minnow
Brown bullhead	Ictalurus nebulosus	bullhead
Mudminnow	Umbra limi	...
Nothern pike	Esox lucius	pike
Burbot	Lota lota	...
Ninespine stickleback	Pungitius pungitius	stickleback
Brook stickleback	Eucalia inconstans	stickleback
Trout-perch	Percopsis omiscomaycus	...
Yellow perch	Perca falvescens	perch
Johnny darter	Etheostoma nigrum	darter
Muddler	Cottus bairdi	...
American smelt	Osmerus mordax	smelt
Smallmouth bass	Micropterus dolomieu	bass
Pumpkinseed	Lepomis gibbosus	sunfish

A. Carter   Appendix 1

MAINTENANCE AND OPERATION OF ELECTRICAL BARRIERS, LAKE SUPERIOR, 1960

During the 1960 operations, the L.B.O.U. consisted of three full groups with the headquarters in Sault Ste. Marie and field stations in Wawa and Nipigon, as in 1959. The Port Arthur station, which operated in 1959, was eliminated in 1960 due to the non-operation of the barriers in that area. The operational staff during the peak season consisted of seven permanent employees and approximately six term and casual employees. The permanent and seasonal staff also assisted with the chemical treatment of streams whenever extra help was required during this program. When field operations were completed the groups at Wawa and Nipigon moved to the Soo headquarters, as in latter years, for the fall and winter work program. In the fall the Wawa station was closed down and the equipment transferred to the Soo, except for the barrier, in anticipation of the cancellation of the operation of this barrier in 1961.

The L.B.O.U. operation during 1960 was conducted as in 1958 and 1959 with considerable reduction in manpower and equipment due to the reduction of barriers in 1960. Ten barriers were operated in 1960 compared with 19 in operation during 1959. Seven of these were in the Soo area, one in the Wawa area and the remaining two in the Nipigon area. High water and exceptional flood conditions delayed the installation of the barriers on the larger rivers in the Soo and Wawa areas. Flood damage was extreme on two rivers: the Batchawana with complete destruction of the electrodes; and the Michipicoten River, with extreme damage to the barrier, fence and cribs. The Goulais barrier also suffered during this high water period, with the catwalk totally destroyed and high erosion of the river banks at the site. The balance of the season was conducted with little trouble from high water or mechanical failures.

Table I shows a substantial increase in sea lampreys recovered during 1960 as compared to previous years. This table also compares the operative time of the barriers against lost hours due to mechanical failure, etc. Dates of operation and evidence of sea lamprey escapement is also included in Table I.

The nets (Table II) were of the same design as reported in 1959 and as described in the 1958 report, Appendix 5. No net was installed in the Batchawana River, with only a catch-all screen stretched across the river four feet under the surface. The fish kill at this site was greatly reduced. It is presumed that the net trapped fish in the area between the net and barrier, while the catch-all screen allowed free movement below the barrier with reduced mortality.

Table I. Dates of operation, operating hours lost to barrier failure, evidence of escapement and numbers of sea lampreys recovered from 10 rivers on Lake Superior in 1960, with recovery from 1955-59 for comparison.

S. No.	Stream Name	Dates of operation	Operating hours	----Hours Inoperative---- Apr	May	June	July	Aug	Evidence of escapement	-----Lampreys recovered------ 1955	1956	1957	1958	1959	1960
5	Big Carp	Apr 25 - Aug 8	2562	...	...	...	...	...	Nil	5	27	28	19	15	20
24	Goulais[a]	May 20 - Aug 8	1932	...	...	...	...	...	Not examined	46	62	820	692	395	760
39	Harmony[b]	Apr 22 - Aug 8	2634	...	...	...	...	...	Nil	29	29	16	6	8	19
48	Chippewa	May 18 - Aug 8	1876	...	4	...	...	...	1 adult seen	807	839	359	220	296	1051
52	Batchawana	May 17 - Aug 8	1824	...	...	...	...	...	Not examined	608	421	427	358	482	629
54	Sable[c]	Apr 28 - Aug 8	2478	...	12	...	...	...	Nil	43	65	76	47	142	246
56	Pancake	May 1 - Aug 8	2322	96	...	...	...	...	Nil	555	717	1073	809	816	1306
167	Michipicoten[d]	Jun 10 - Aug 4	1384 1/2	...	...	...	43 1/2	...	Nil	...	56	372	641	371	143
360	Pays Plat	May 16 - Aug 1	1872	...	...	...	...	...	Not examined	...	6	3	4	32	10
368	Big Gravel	May 16 - Aug 1	1824	...	...	...	48	...	Not examined	...	5	99	154	541	626
			20,708 1/2	96	16	0	91 1/2	0		2093	2227	3273	2950	3098	4810
						203 1/2									

[a] Goulais River - adults recovered during chemical treatment.
[b] Harmony Barrier in operation during 1954; sea lamprey recovered - 19.
[c] Sable Barrier also in operation during 1954; sea lamprey recovered - 39.
[d] Michipicoten River Barrier off during chemical treatment.

Table II. Rivers in which netting devices were installed to reduce migrant fish kills at barriers on Lake Superior, 1960.

Stream Number	Stream Name	Upstream Nets	Downstream Nets
5	Big Carp R.	Nil	One
24	Goulais R.	Nil	One
39	Harmony R.	Nil	One
48	Chippewa R. (each branch)	Nil	One
52	Batchawana R.	Nil	One*
54	Sable R.	Nil	One
56	Pancake R.	Nil	One
167	Michipicoten R.	Nil	Nil
360	Pays Plat R.	Nil	One
368	Gravel R.	Nil	One

* 6 ft chain link fence stretched across river about 4 ft of fence under surface to catch floating fish.

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J. J. Tibbles

Appendix 2

SEA LAMPREY SURVEY, LAKES SUPERIOR AND HURON, 1960

Two hundred and thirty tributaries to Lake Superior (Table I), previously thought to be free of lampreys, have been re-surveyed with electroshocking gear to detect the development of new runs. Sea lamprey larvae were found in 10 of these for the first time (Tables II and III): the Black Sturgeon River near Nipigon and the remaining nine streams in the Batchawana Bay area north of Sault Ste. Marie. The majority of these streams, with the exception of the Chippewa River, have been sampled repeatedly for collection of ammocoetes for bio-assay. It is not considered that the sea lamprey ammocoetes collected from these small streams originated in them, but that they have migrated upstream from Batchawana Bay, where there is a relatively large population of sea lamprey ammocoetes.

Table I. Streams re-surveyed with electro-shocker, Lake Superior, 1960.

Soo Area

S-3	Bennett
S-6-1	
S-7	
S-9	
S-11	
S-12	Prince
S-13	
S-14	
S-15	
S-16	
S-17	
S-18	
S-19	
S-21	Kelly
S-27	Boston
S-34	Black
S-35	
S-36-1	
S-37	Tier
S-40	Government
S-40-1	
S-41	Sawmill
S-42	Jones Landing
S-45	
S-46	Tiny
S-48	Chippewa
S-51	
S-53	Digby
S-54	Sable
S-55	
S-58	Westman's
S-59	Weston
S-60	Coffee
S-61	
S-62	Hidden
S-63	Hibbard Bay
S-64	Minising
S-65	
S-66	Sidehill
S-67	

Soo Area (cont'd)

S-68	
S-69	Bold Bluff
S-70	Mica Bay
S-71	
S-72	
S-73	Cozens Cove
S-74	Pt. au Mines
S-75	Queminco
S-76	Bell
S-77	Beaver
S-79	
S-80	
S-81	
S-82	
S-83	
S-84	
S-85	
S-86	

Wawa Area

S-131	
S-132	
S-133	
S-134	
S-135	
S-136	
S-137	
S-139	Salter L.
S-140	
S-141	
S-142	
S-143	
S-144	
S-145	
S-146	
S-147	
S-148	
S-149	
S-150	
S-151	

Table I. (Continued)

Wawa Area (cont'd)

S-152	
S-153	
S-154	
S-155	Noisy
S-156	
S-157	
S-158	
S-159	
S-160	
S-161	
S-162	Old Mine
S-163	
S-164	
S-165	
S-167-1	
S-168	
S-171	
S-171-1	
S-174-1	
S-180	
S-180-1	
S-181	
S-182	
S-184	
S-185	
S-187	
S-188	
S-189	
S-189-A	
S-190	Makwa
S-191	
S-192	
S-193	
S-194	
S-195	
S-196	
S-197	
S-198	
S-199	
S-200	
S-201	
S-297	

Nipigon Area

S-341	
S-345	Aquasabon
S-347	
S-348	Cooks L.
S-350	
S-350-1	
S-351	Hewitson
S-352	
S-353	McLeans
S-354	Renauds
S-355	
S-356	
S-357	Morrison
S-361	Little Pays Plat
S-369	Little Gravel
S-370	
S-371	
S-373	Little Cypress
S-374	Cypress
S-375	McGinnes
S-377	Dublin
S-379	Jackpine
S-383	
S-384	
S-385	Jackfish
S-387	Firehill
S-388	
S-389	Ruby
S-393-408	Helen L. (16 streams)
S-412	
S-418-432	Helen L. (13 streams)
S-454	
S-455	
S-457	Trout

Lakehead Area

S-509	Black Sturgeon
S-510	Big Squaw
S-512	
S-513	Morrow
S-514	

Table I. (Continued)

Lakehead Area (cont'd)		Lakehead Area (cont'd)	
S-515		S-554	
S-516		S-555	
S-517	Wolf	S-556	
S-518	Coldwater	S-557	
S-519		S-558	
S-520	Boulters	S-559	Blind
S-521	Barretts	S-560	Wildgoose
S-529		S-561	
S-530	Portage	S-562	
S-537	Sibley	S-563	
S-544		S-564	
S-545		S-567	
S-547		S-568	Current
S-548		S-569	McVicar
S-549		S-571	Neebing
S-550		S-575	Whiskeyjack
S-551		S-585	Jarvis
S-552		S-587	Cloud
S-553		S-588	Swan
S-553-A, B, C		S-589	Pine
		S-590	Lenore (Little Pine)

Pre-treatment surveys to determine the distribution of sea lamprey ammocoetes for treatment with chemical were carried out on the following streams during 1960: Jackfish, Michipicoten, Black Sturgeon and Sawmill on Lake Superior; Bar, Two Tree, Gowas, H-68-1, Livingstone, Root, Echo and Nottawasaga on Lake Huron (Tables II and III). The rate at which pre-treatment surveys for distribution of ammocoetes on Lake Huron have been carried out has been slower than is desirable since the services of the survey crew, from that area, were required to assist with the chemical treatments during 1959 and on the Lake Superior surveys for the majority of the 1960 season.

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

Table II. Ammocoetes and adult lampreys collected with electro-shockers from watersheds in Lakes Superior and Huron that have not been treated with chemical, 1960.

		% P.m.	P.m.		Icth. spp.		E.l.	
Lake Superior								
S-3		...	...		...		6	
S-9		...	...		...			1A*
S-21		...	...		...		177	
S-27	Boston	0.7	4		...		543	3A
S-34	Black	0.1	2		...		2253	16A
S-35		2.7	45		1		1610	
S-37	Tier	0.2	2		...		1078	
S-40	Government	...	...		...		568	2A
...	Black, Tier, Government**	...	...		...		244	11A
S-46		2.7	1		11		25	
S-48	Chippewa	0.4	1		1		237	
S-51		9.1	1		2		8	
S-68		18.6	14		...		61	
S-297		...	...		108	3A	...	
S-341		...	...		57		...	
S-517	Wolf	...	...		37		...	
S-537	Sibley	...	...		237		...	
S-571	Neebing	...	...		1270	11A	...	
S-587	Cloud	...	...		1		...	
	Total		70		1725	14A	6810	33A
Lake Huron								
H-3	Root	40.1	26		4		152	
H-10	Pearl (Echo R.)	26.3	387	17A	...		473	30A
H-15	Bar	...	...		2		...	
H-50	Two Tree	4.1	55		159	1A	897	1A
H-68-1	Unnamed river on St. Joseph's Is.	...	...		...		163	
H-92	Livingstone	1.8	4		...		223	
H-1360	Nottawasaga & tributaries	64.8	828	67A	442	30A	...	
	Total		1300	84A	607	31A	1908	31A

* A = Adult lamprey.
** Collection Black, Tier and Government combined for use in bio-assay.

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

Table III. Ammocoetes and adult lampreys collected with electro-shockers prior to treatment and during stream treatments with chemical, Lakes Superior and Huron, 1960.

		% P.m. ammocoetes	Total			Chemical			Shocker		
			P.m.	I. spp.	E.l.	P.m.	I. spp.	E.l.	P.m.	I. spp.	E.l.
Lake Superior											
S-4	Little Carp	3.7	24	...	630 33A	24	...	630 33A	...	...	...
S-23	Cranberry	1.3	4	4	299	4	4	299	...	...	...
S-24	Goulais	50.0	1375	102	1033	1370	102	960	5	...	73
S-36	Stokeley	1.0	9	...	895 205A	9	...	573 128A	...	...	322 77A
S-41	Sawmill	0.2	1	...	506	...	...	195	1	...	311
S-167	Michipicoten	38.1	517	837	...	512	816	...	5	21	...
S-385	Jackfish	48.9	184	192	...	131	147	...	53	45	...
S-509	Black Sturgeon	47.0	1414 25A	1575 48A	...	1278	1204	...	136 25A	371 48A	...
S-570	McIntyre	4.3	14	313 181A	...	14	313 181A	...	...	...	...
S-572	Kaministikwia	58.4	1785 2A	1261	...	1776 2A	1209	...	9	52	...
S-592	Pigeon	55.8	72	57	...	72	57	...	...	...	...
	Total	39.9	5399 27A	4341 229A	3363 238A	5190 2A	3852 181A	2657 161A	209 25A	489 48A	706 77A

(cont'd)

Table III. (Continued)

		% P.m. ammocoetes	Total			Chemical			Shocker		
			P.m.	I. spp.	E.l.	P.m.	I. spp.	E.l.	P.m.	I. spp.	E.l.
Lake Huron											
H-420	Chikanishing	20.4	176 68A	683 16A	...	176 68A	683 16A	...	...	...	...
H-726	Still	94.4	720	42	...	720	42	...	...	...	...
H-832	Naiscoot	87.5	679	97	...	679	97	...	...	...	...
H-1053	Boyne	63.6	217 1A	124	...	217 1A	100	...	...	24	...
H-1343	Sturgeon	92.6	617	49	...	617	49	...	...	...	...
H-1376	Silver	99.8	887	1	...	557	1	...	330	...	...
	Total	76.7	3296 69A	996 16A	...	2966 69A	972 16A	...	330	24	...

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

Table III lists the ammocoetes and adult lampreys of the four species encountered in the Superior-Huron watersheds that were examined with electro-shockers prior to chemical treatment, and the lampreys that were collected during the period when chemical was introduced to the rivers for sea lamprey control. Table III also indicates the percentage of sea lampreys in the collections.

In Lake Superior, the streams that are the major sea lamprey contributors, on the Canadian side, are all relatively large to extremely large rivers. In these rivers the percentage of sea lampreys is high -- 38 to 56 per cent (Table III). In the Lake Huron streams (Georgian Bay) treated to date, which are all relatively small, there is a very high percentage of sea lamprey -- 63.6 to 99.8 per cent.

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Appendix 3

BIO-ASSAY REQUIRED FOR PRE-TREATMENT INFORMATION IN APPLICATION OF CHEMICAL FOR SEA LAMPREY CONTROL

Early in 1960 we purchased two 25-foot trailers, fitted out as mobile bio-assay laboratories, for use in the field to determine the amounts of lampricide required to treat different streams. The trailers were identical in all respects, except for minor amenities. Each contained two open tanks, one on either side, fitted with water inlets and outlets. Each tank was designed to accommodate 40 rectangular, plastic test containers. When in use the containers are lined with disposable polyethylene bags. Air is supplied to each container from a vane-type compressor, by means of plastic hoses and air stones. Circulating water, supplied from outside, surrounds the test containers. There is no provision for artificial temperature control and in practice, stream water is used at its ambient temperature.

A typical bio-assay test normally consists of 40 test containers, with four replications of each of 10 concentrations of the toxicant. Test solutions are prepared by diluting a formulation of lampricide in stream water. It was found empirically that a nearly straight line relationship exists between probit kill and the logarithm of concentration. For this reason successive concentrations are prepared in a geometric series, making the interval between successive concentrations equally significant over the entire range. A convenient method of preparing such a series is to remove successively equal volumes of a stock solution, replacing the solution removed each time with an equal volume of untreated stream water. A factor of $\sqrt[3]{2}$ between successive concentrations provides sufficiently precise data and a broad enough range for our purposes. Accordingly, a volume equivalent to 0.206 of the total volume of stock solution is removed for each test concentration. Using ten concentrations, and the above factor, the highest concentration is always eight times the lowest. A suitable range can usually be chosen, through experience, on the basis of the chemistry of the stream water.

We determined empirically that, for a given dose, probit kill bears a nearly linear relationship to the logarithm of exposure time (or in some cases reciprocal time). Accordingly, the intervals between observations are usually arranged in a logarithmic series, making successive intervals equally significant over the total time range. In this case, the factor between intervals is $\sqrt{2}$. In plotting the data the actual values, both of concentration and elapsed time, are replaced by code numbers which are consecutive whole numbers. This conversion avoids tedious arithmetic. In order to extrapolate the observed mortalities to an acceptably high level of kill, use is made of the linearity, probit-wise, of the mortality data. We have arbitrarily chosen 99.9% as the desired level of ammocoete kill. Starting with the 50% mortality level, we divided the intervening probit scale into four equal intervals corresponding to the 50, 78, 94, 99 and 99.9 per cent levels of kill. The coded log times to reach these levels are computed by interpolation from the observed numerical data for 50, 78 and 94 per cent mortality. These transformed data are plotted on arithmetic paper and parallel straight lines are drawn passing just above all, or nearly all, of the corresponding points, spaced according to the average differences in coded log time between successive mortality levels. Two more lines, corresponding to the 99 and 99.9 per cent mortality of ammocoetes, are drawn parallel to and equally spaced from the other three. From the last line drawn, a pair of values may be chosen which correspond to the concentration and exposure time required to produce a 99.9% mortality of ammocoetes.

An arbitrary upper limit of 25% has been chosen as the acceptable level of fish mortality. From the observed kill of fish, time-concentration data for 25% mortality are plotted on the same graph as was used for the ammocoetes. In a satisfactory bio-assay, an area of the graph can be described in which, for appropriate values of concentration and exposure time, at least 99.9% of the ammocoetes and not more than 25% of the fish were killed.

The ammocoetes used as test specimens are normally taken by electroshocking in a stream near the one whose water is to be tested. They are sorted for average size and good condition, but not necessarily for species; no significant difference in susceptibility having been demonstrated among the species common to our waters. Fish used in our tests have usually been procured from the Provincial hatcheries, and were fingerlings, either of brook trout or rainbow trout, depending on size and availability. On several occasions, other species native to the waters being tested have been used. These include suckers, northern pike, smelt, darters, perch, sunfish and small bass. Each species of fish has a different susceptibility to the lampricide which usually decreases in the order given, with trout the lowest. We usually use 24 ammocoetes and eight fish in each concentration of the toxicant, these being the maximum numbers that can be accommodated without overcrowding.

During the 1960-61 season, one of the two trailers was used chiefly for testing waters just prior to treatment with lampricide. The second bio-assay trailer was utilized during the late spring and early summer when personnel was available. Unfortunately, we were not able to recruit two of the scientists for efficient operation and the trailer was unattended during the fall season.

A total of 67 bio-assays were conducted in both trailers during the 1960-61 season. Thirty of these were for information required for treatment, while the remaining 37 were conducted for pre-treatment information to enable the selection of more suitable periods for efficient treatment.

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Appendix 4

STREAM TREATMENTS WITH LAMPRICIDE LAKES SUPERIOR AND HURON, 1958-1960

Since 1956 sea lamprey ammocoetes have been collected, with electroshocking equipment, in 28 separate stream watersheds on the Canadian side of Lake Superior and 38 in Lake Huron and Georgeian Bay. Stream applications with chemical, for sea lamprey control, were initiated in 1958 when two streams with a total flow of 49 cubic feet per second were treated. One of these, the West Davignon, was not successful and it was retreated in 1959. During 1959, nine streams, with a total flow of 605 cfs, were treated in Lake Superior. The Stokeley River treatment was not successful and it was re-treated in 1960. Eleven streams with a total flow of 5733 cfs, in Lake Superior, and seven streams in Georgian Bay, of Lake Huron, with a total flow of 824 cfs, were successfully treated in 1960.

The following nine Lake Superior streams, specified in the Great Lakes Fishery Commission Memorandum of Agreement, have been successfully treated with lampricide during 1960: Little Carp, Cranberry, Goulais, Stokeley, Michipicoten, Jackfish, McIntyre, Kaministikwia, and Pigeon. In addition, the Black Sturgeon River near Nipigon and Sawmill Creek near Sault Ste. Marie were successfully treated following collection of sea lamprey ammocoetes from these watersheds in 1960. This completes the treatment of the known lamprey-producing tributaries on the Canadian side of Lake Superior, with the exception of the small streams in the Batchawana Bay area (see Appendix 2). It is anticipated that the Chippewa River will be treated during July, 1961 and that the remaining small streams in the Batchawana Bay area with relatively small, lake-run populations at the mouths, will receive further detailed survey to determine whether or not they warrant treatment. Sea lamprey ammocoetes have been collected, repeatedly, along the shoreline of Batchawana Bay. These ammocoetes undoubtedly originate in the larger lamprey-producing streams in the area. It is considered that the ammocoetes collected from the small streams have migrated from the lake shoreline, and that the streams will not require treatment due to the small number of sea lampreys present.

A complete summary of the rivers treated, to date, with lampricide in Lake Superior and Huron from 1958 to 1960 is presented in Table I.

Table I. Streams treated with lampricide, Lakes Superior and Huron, 1958-1960.

Name	Date treated	Flow in cfs	Concentration in ppm during treatment	Lbs active ingredient	Cost/cfs $ ¢	Total Cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Superior - 1958					
Pancake	27-VIII-58	37	Feeder 2.5	155	14.20	525.00	Very abundant.	12
			Mouth 1.0					
Gimlet	26-VIII-58	6	Feeder 2.8	57	32.10	193.00	Very abundant.	2.5
			Mouth 2.6					
	Totals	43		212	16.70	718.00 (1960 prices)		14.5
W. Davignon	5-XI-58	3	Feeder 2.3	9.5	10.70	32.10	Moderate	4.0
			Mouth <1.0					
Bennett		3	3.1	10.0	11.30	33.90	Few	5.0
(Not successful, re-treated 1959)	Totals	6		19.5	11.00	66.00		9.0
			Lake Superior - 1959					
W. Davignon	4/5-VII-59	8	Feeder 2.2	58.5	24.79	198.32	Moderate	4.0
			Mouth 1.0					
Bennett		7	Feeder 1.9	58.5	28.33	198.31	...	5.0
	Totals	15		117.0	26.44	396.63		9.0
Big Carp	7/9-VI-59	3	Feeder 8.0	58.5	66.11	198.32	Abundant	4.5
			Mouth 1.7					
Tribs. St. 15		4	Feeder 2.6	26.0	22.04	88.14	...	3.0
St. 20		3	Feeder 2.0	34.12	38.55	115.64		1.0
	Totals	10		118.62	40.21	402.10		8.5

Table I. (Continued)

Name		Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
				Lake Superior - 1959 (cont'd)						
Harmony		10/11-VII-59	10	Feeder	1.6	58.50	19.83	198.31	Moderate	5.0
				Mouth	1.1					
Trib.	St. 5A		1		1.5	4.88	16.54	16.54	...	...
	St. 3		...		1.2	1.62	...	5.50	...	...
		Totals	11			65.00	20.03	220.35		5.0
Stokeley		11/13-VII-59	11	Feeder	2.3	39.0	...	132.21	Moderate	6.5
				Mouth	0.5					
Trib.	St. 11		...		3.0	6.5	...	22.04	...	0.5
(Not successful, re-treated 1960)		Totals	11			45.5	14.02	154.25		7.0
Sable		15/18-VII-59	11	Feeder	2.6	110.5	34.05	374.60	Abundant	4.0
				Mouth	1.4					
Trib.	St. 9		3		1.8	32.5	36.73	110.18	...	1.0
Booster	St. 4		...		1.7	65.0	...	220.35		...
		Totals	14			208.0	50.36	705.13		5.0
Batchawana		20/23-VII-59	126	Feeder	2.6	1,410.5	37.94	4,781.59	Very abundant.	7.0
				Mouth	1.4					
Lagoons	St. 15-16		...*		...	58.5	...*	198.32	...	...
	St. 12-12A		...*		...	39.0	...*	132.21	...	...
	St. 9-10		...*		...	58.5	...*	198.32	...	...
		Totals	126			1,566.50	42.14	5,310.44		7.0

*Chemical applied where no flow.

Table I. (Continued)

Name	Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Superior - 1959 (cont'd)						
Pays Plat	26/30-VIII-59	132	Feeder Mouth	4.3 1.0	1,540.5	39.56	5,222.30	Moderate	6.25
Trib. St. 15C		...*		...	39.0	...*	132.21	...	0.25
	Totals	132			1,579.5	40.56	5,354.51		6.50
Pearl	1/5-IX-59	12	Feeder Mouth	5.0 1.8	63.38	17.90	214.86	Few	4.0
Booster St. 4B		...		3.5	127.72	36.08	432.97	...	...
	Totals	12			191.1	53.98	647.83		4.0
Big Gravel	6/7-X-59	274		...	325.0	4.02	1,101.75	Few	7.0
2nd Treatment		...	Feeder Mouth	3.1 2.2	1,657.5	20.51	5,618.93		...
	Totals	274			1,982.5	24.53	6,720.68		7.0
			Lake Superior - 1960						
Cranberry	29/30-IV-60	37	Feeder Mouth	6.5 4.0	527.5	51.90	1,788.22	Few	5.0
Lagoon		...*		...	39.0	...*	132.20	Few	0.25
	Totals	37			566.5	51.90	1,920.42		5.25

*Chemical applied where no flow.

Table I. (Continued)

Name	Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Superior - 1960 (cont'd)						
Stokeley	5/6-V-60	104	Feeder	4.8	780.0	25.42	2,644.00	Few	7.0
			Mouth	3.0					
	Totals	104			780.0	25.42	2,644.00		7.0
Little Carp	12/13-V-60	28	Feeder	4.0	204.75	24.78	694.05	Few	7.0
			Mouth	2.5					
	Totals	28			204.75	24.78	694.05		7.0
Kaministikwia	4/7-VI-60	1100	Feeder	2.25	10,120.5	31.19	34,308.50	Very abundant.	28.0
			Mouth	0.9					
Whitefish		115	Feeder	4.4	1,579.5	46.56	5,354.50	Abundant.	8.0
Mosquito		...		...	19.5	...	66.10	Few	0.25
Slough		...*		...	58.5	...*	198.30	Few	...
Slate		62		...	39.0	2.13	132.20	Few	3.0
Pitch		30		...	19.5	2.20	66.10	Abundant	1.5
O'Connor		27		...	19.5	2.45	66.10	Few	3.0
Oliver		...		...	19.5	...	66.10	Few	2.0
Corbett		...		...	19.5	...	66.10	Few	2.0
	Totals	1334			11,895.0	30.24	40,324.00		47.75

*Chemical applied where no flow.

Table I. (Continued)

Name	Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Superior - 1960 (cont'd)						
McIntyre	8-VI-60	22	Feeder Mouth	3.0 1.5	175.5	27.67	594.90	Few	6.0
	Totals	22			175.5	27.67	594.90		6.0
Goulais	22/25-VI-60	493	Feeder Mouth	2.75 1.5	4,465.5	30.70	15,136.90	Very abundant.	52.0
Achigan		64		...	585.0	30.98	1,983.00	Abundant	8.0
Bellevue		24		...	97.5	13.77	330.50	Abundant	1.0
Dam		40		...	390.0	33.50	1,322.00	Abundant	7.0
Northland		15		...	39.0	8.81	132.20	Few	0.25
Perry		40		...	78.0	6.61	264.40	Moderate	2.5
Rainbow		5		...	19.5	13.22	66.10	Few	0.25
Robertson		14		...	39.0	9.44	132.20	Few	1.5
Sheppard		39		...	156.0	13.56	528.80	Few	6.0
Silver		9		...	19.5	7.34	66.10	Few	0.25
Whitman		56		...	331.5	20.06	1,123.70	?	6.0
Unnamed tribs.									
St. 542		...		...	19.5	...	66.10	Few	0.25
196		...		...	39.0	...	132.20	Few	0.25
123		...		...	39.0	...	132.20	Few	0.25
65		...		...	19.5	...	66.10	Few	0.25
64		...		...	19.5	...	66.10	Few	0.25
57-58		...		...	39.0	...	132.20	Few	0.25
Slough									
St. 2		...*		...	19.5	...*	66.10	Few	0.25
19		...*		...	48.75	...*	165.25	Few	1.25
	Totals	800			6,464.25	27.40	21,912.15		88.0

*Chemical applied where no flow.

Table I. (Continued)

Name	Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total Cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Superior - 1960 (cont'd)						
Michipicoten	2/3-VII-60	ca.1800	Feeder	1.7	11,290.5	16.81	30,258.54	Abundant	13.0
			Mouth	1.5					
Magpie		763		...	4,563.0	16.03	12,228.84	Few	0.25
Trout		6		...	14.62	6.53	39.20	Few	1.0
Wawa		25		...	73.12	7.84	195.98	Few	0.25
Dead		...*		...	263.25	...*	705.51	Few	2.0
Unnamed tribs.									
St. 4		...		...	58.5	...	156.78	Few	0.25
5		...		...	58.5	...	156.78	Few	0.25
	Totals	2594			16,321.5	16.86	43,741.62		17.0
Jackfish	23/28-IX-60	26	Feeder	4.5	487.5	63.55	1,652.50	Moderate	8.0
			Mouth	3.5					
Boosted	25-IX-60	...		...	97.5	...	330.50		...
	26-IX-60	...		...	126.5	...	462.70		...
Limestone		...		...	19.5	...	66.10		0.75
	Totals	26			741.0	89.71	2,511.80		8.75
Black Sturgeon	12/16-X-60	600	Feeder	8.0	14,781.0	83.50	50,103.80	Very abundant.	40.0
			Mouth	5.0					
Larson		30		...	136.5	15.42	462.70	Few	1.0
Sucker		47		...	224.25	16.17	760.15	Nile	7.0
Mouseau		7		...	78.0	37.77	264.40	Moderate	0.75
Mound		...		...	19.5	...	66.10	Few	0.5
	Totals	684			15,239.25	75.51	51,657.15		49.25

*Chemical applied where no flow.

Table I. (Continued)

Name	Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Superior - 1960 (cont'd)						
Pigeon	18/20-X-60	99	Feeder	4.0	2,047.5	70.11	6,940.50	Few	3.5
			Mouth	2.3					
Sloughs		...*	...		97.5	...*	330.50	Few	...
	Totals	99			2,145.0	73.44	7,271.00		3.5
Sawmill	28-X-60	ca. 3	Feeder	4.2	15.6	15.68	47.03	Few	0.25
			Mouth	3.9					
	Totals	3			15.6	15.68	47.03		0.25
			Lake Huron - 1960						
Magnetawan	11/12-VIII-60	718	Feeder	1.0	1,482.0		5,023.60	Few	5.0
			Mouth	0.5					
Trib. 748		...	...		78.0		264.40		0.25
747		...	...		9.75		33.05		0.25
	Totals	718			1,569.75	7.41	5,321.05		5.5
Still	16/26-VIII-60	16	Feeder	2.3(24hr)	156.0	33.05	528.80	Very abundant.	16.0
			Mouth	0.9					
Little Still		1	...		19.5	66.10	66.10	Few	1.5
	Totals	17			175.5	34.99	594.90		17.5

*Chemical applied where no flow.

Table I. (Continued)

Name	Date treated	Flow in cfs	Concentration in ppm during treatment	Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
			Lake Huron - 1960 (cont'd)					
Naiscoot	21/26-VIII-60	20	Feeder 1.0	117.0	19.83	396.60	Abundant	11.0
Harris		7	Feeder 2.2 (Concentration 1.5 at Hwy 69 bridge, not at mouth)	39.0	18.88	132.20	Abundant	3.5
	Totals	27		156.0	19.58	528.80		14.5
Chikanishing	9/12-IX-60	6	1st Feeder 1.5	19.5	11.02	66.10	Few	3.5
			2nd Feeder 0.8	9.75	...	33.05		
			Mouth 0.8					
	Totals	6		29.25	16.52	99.15		3.5
Boyne	13/14-XI-60	24	Feeder 2.2	555.75	67.48	1,619.45	Few	5.0
			Mouth 0.9					
	Totals	24		555.75	67.48	1,619.45		5.0
Silver	26/27-XI-60	6	Feeder 20.0	507.0	431.47	1,718.70	Moderate	6.0
			Mouth 9.0	324.67		870.13		
2nd treatment	30-XI-60	...	Feeder 11.0	570.38	254.75	1,528.60		
			Mouth ...					
	Totals	6		1,402.05	686.22	4,117.43		6.0

Table I. (Continued)

Name		Date treated	Flow in cfs	Concentration in ppm during treatment		Lbs active ingredient	Cost/cfs $ ¢	Total cost of chemical $ ¢	Ammocoete abundance	Miles of stream treated
				Lake Huron - 1960 (cont'd)						
Sturgeon		2/5-XII-60	3-26	Feeder	35.0	468.0	...	1,254.24	Very abundant.	12.0
				Mouth	8.0					
Booster St.	37		10		...	643.5	...	1,724.58		
Tribs.	53		...		...	9.75	...	26.13		
	51		...		...	2.44	...	...		
	50		...		...	21.94	...	58.79		
	48		...		...	7.31	...	19.60		
	44		...		...	1.22	...	3.26		
	44 Boosted		...		...	58.5	...	156.78		
	43		...		...	1.22	...	3.26		
	43 Boosted		...		...	29.25	...	78.39		
	42		...		...	2.44	...	6.53		
	33, 34, 37		...		...	4.88	...	13.06		
	31		...		...	1.22	...	3.26		
	30		...		...	1.22	...	3.26		
	29		...		...	2.44	...	6.53		
	26		...		...	2.44	...	6.53		
	23		...		...	2.44	...	6.53		
	21		...		...	2.44	...	6.53		
	20		...		...	2.44	...	...		
	17		...		...	1.22	...	3.26		
	16		...		...	1.22	...	3.26		
	15		...		...	2.44	...	6.53		
	8		...		...	2.44	...	6.53		
	5A		...		...	2.44	...	6.53		
		Totals	26+			1,274.81	131.45	3,417.80		12.0+

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Appendix 5

STREAMS TREATED WITH LAMPRICIDE LAKES SUPERIOR AND HURON, 1960

Lake Superior

1. Cranberry River (S-23)

Cranberry River, Township of Pennefather, District of Algoma, was treated, on April 29 and 30, 1960, with a formulation of 3-trifluormethyl-4-nitrophenol (TFM) containing 30% by weight of the active ingredient, as supplied by the Maumee Chemical Company, Toledo, Ohio. The lampricide was applied to Cranberry River at a point about five miles from its mouth using a "Proportioneer" dual-piston feeder. A lagoon connected to the river about 1/4 mile from its mouth was also treated with lampricide poured from a boat.

Pre-treatment examination of the stream included the collection of ammocoetes for the years 1954-59 inclusive and the following studies in 1960: measurements of volume of flow, recording of water levels, estimation of rates of flow by means of dye, and the determination of chemical and physical properties of the water. Just prior to the treatment the volume of flow at the mouth of Cranberry River was 37 cfs. A bio-assay test was performed in a mobile laboratory using water samples obtained from the river, with ammocoetes and smelt as test animals. The results of this test indicated that a range of from 0.55 to 1.9 ppm of the lampricide for a period of 18 hours would kill 99.9% of the lampreys and not more than 25% of the fish.

The lampricide was applied to Cranberry River for a period of 14-1/4 hours, beginning at 2030 hours on April 29. A total of 162 gallons of lampricide, containing 528 pounds of active ingredient, was applied at the main feeder site. Twelve gallons of lampricide containing 39 pounds of active ingredient were applied to the lagoon on April 29, the application being timed to coincide with the arrival of the toxicant at its junction with the main river. Concentrations of TFM below the main feeder site were between 5.0 and 6.0 ppm for 12-1/2 hours; at the mouth of the Cranberry River they were between 1.0 and 3.6 ppm for over eight hours. In the lagoon the concentration of TFM was 1.7 ppm for an undetermined period.

Rain fell during most of the treatment and water levels in the river rose steadily. The effectiveness of the treatment was not impaired however, because, in anticipation of rain, the application of lampricide was begun at a higher than normal rate.

As was expected, there was a fairly heavy mortality of small fish.

Of these, the smelt were by far the most numerous, but some suckers, bullhead and small pike also were killed.

Ammocoetes collected during the treatment were mostly American brook lamprey, but about 3% of the total included equal numbers of sea lamprey and Ichthyomyzon spp. There was no post-treatment survey of the river made in 1960.

2. Stokeley River (S-36)

Stokeley River, Township of Haviland, District of Algoma, was re-treated on May 5, 1960, with the Maumee 30% formulation of TFM (as was used in Cranberry River). Stokeley River was treated at a point about 6.5 stream miles from its mouth. A small lagoon connected to the river near its mouth was also treated.

Extensive collections of ammocoetes had been made prior to the 1959 treatment of Stokeley River. Pre-treatment examination of the stream in 1960 included the measurement of volume of flow, the recording of water levels, estimation of rate of flow by means of dye, and the determination of physical and chemical properties of the stream water. Just prior to the treatment, the volume of flow at the mouth of Stokeley River was 104 cfs. Two bio-assay tests were performed in a mobile laboratory using water obtained from the stream, with ammocoetes and brook trout as test animals. The results of the first test, on water from the river mouth, indicated that a range of from 0.55 to 1.5 ppm of TFM for a period of 12 hours would kill 99.9% of the lampreys without killing more than 25% of the fish. For the second test, on water from the feeder site, the range was 0.6 to 2.0 ppm for the same period.

Lampricide was applied to Stokeley River for 12 hours, beginning at 0500 hours on May 5, 1960. A total of 240 gallons, containing 780 pounds of active ingredient, was applied. This included one or two gallons applied to the small lagoon near the mouth. Below the Stokeley River feeder site the concentration of TFM was between 2.7 and 4.9 ppm for 12 hours, at the mouth it was between 2.7 and 4.2 ppm for 13 hours.

Ammocoetes collected during the treatment were mostly American brook lamprey; there were fewer than 2% sea lamprey, and no Ichthyomyzon spp. With the exception of smelts, there appeared to be no significant mortality of fish, in spite of the rather high concentrations of TFM that prevailed in the stream.

Some difficulty was experienced in the colorimetric analysis of TFM owing to very high turbidity that developed in the water as a result of rain-fall and road construction work. The increase in blank value was calculated using a modification of the analytical technique and the colorimeter readings were corrected accordingly. As a result, errors in analysis were reduced to a minimum.

No post-treatment examination of the river was made in 1960.

3. Little Carp River (S-4)

Little Carp River, Township of Korah, District of Algoma, was treated, on May 12 and 13, 1960, with the Maumee 30% formulation of TFM. The lampricide was applied to Little Carp River at a point about seven miles from its mouth.

Ammocoete surveys had been carried out each year from 1955 to 1959 inclusive. Pre-treatment examination of the stream in 1960 included the measurement of volume of flow and the recording of water levels. A dye check was not necessary, and chemical analysis of the water was omitted. A bio-assay was performed in a mobile laboratory using water samples from the river, with ammocoetes and brook trout as test specimens. The results of this test indicated that a range of from 0.75 to 3.4 ppm of TFM for a period of 12 hours would kill 99.9% of the lampreys and not more than 25% of the fish.

The lampricide was applied in Little Carp River for a period of 16 hours, beginning at 1600 hours on May 12. A total of 63 gallons of formulation, containing 205 pounds of active ingredient, was applied at the single feeder site. Concentrations of TFM below the feeder were between 3.4 and 5.4 ppm for 16 hours and at the mouth 1.3 to 1.8 ppm for 21 hours.

Ammocoetes collected during the treatment were mostly American brook lamprey, with only 4% sea lamprey, and no Ichthyomyzon spp. Fish mortality did not appear serious and was confined mainly to darters and minnows.

Little Carp River was readily accessible at most important points, and, the weather being good, no difficulties were experienced during the treatment. A post-treatment survey of the stream was not carried out in 1960.

4. Kaministikwia River (S-572)

Kaministikwia River, its tributary rivers, Whitefish, Mosquito, Slate, Pitch, O'Connor, Oliver and Corbett, and an unnamed slough, in the Townships of Neebing, Blake, Paipoonge, O'Conner, Oliver, Conmee, Gillies and Pearson, District of Thunder Bay, were treated between June 4 and 7, 1960. The Maumee 30% formulation of lampricide was used in the Kam watershed. The lampricide was applied in the Kam itself at the main power dam, 28 miles from the mouth. The distances treated in the tributaries were as follows: Whitefish River - eight miles, Mosquito River - 0.25 mile, Slate River - three miles, Pitch River - 1.5 miles, O'Connor River - three miles, Oliver and Corbett - two miles each.

The watershed had been extensively surveyed for the occurrence of ammocoetes in 1959 in preparation for treatment scheduled for that year. Additional examination of the streams in 1959 and 1960 included the measurement of volumes of flow, the recording of water levels, the estimation of rates of flow by means of dye, and the determination of physical and chemical properties of the water.

Eleven bio-assays, eight in 1959 and three in 1960, have been carried out on water from the Kam and its tributaries. The treatment of the watershed was based on the final bio-assays of the Kam and the Whitefish, the results of which showed that concentrations of TFM in the ranges 0.85 to over 4.0 ppm and 1.6 to over 4.0 ppm respectively would kill 99.9% of the lampreys and not more than 25% speckled trout.

Lampricide was applied in the amounts shown in the following rivers for the indicated periods of time, on June 4, 1960: Kaministikwia River - 19 hours, 3114 gallons (10,120 lbs of active ingredient); Whitefish River - 18 hours, 486 gallons (1,580 lbs); Pitch River - 1-1/4 hours, six gallons (19.5 lbs); O'Connor River - over one hour, six gallons (19.5 lbs); Corbett Creek - one hour, six gallons (19.5 lbs); Slate River - 1-1/2 hours, 12 gallons (39 lbs); and Mosquito Creek - 1-1/4 hours, six gallons (19.5 lbs). A "Proportioneer" feeder was used on the kam, a "Milton-Roy" feeder on the Whitefish, and drip feeders were used on the others. A total of 3,660 gallons of formulation, containing 11,895 pounds of active ingredient, was applied in the Kam watershed.

Prevalent concentrations of TFM during the treatment of the Kam were as follows: below the main feeder 1.6 to 2.6 ppm for 14 hours, and near the mouth 0.5 to 0.95 ppm for over seven hours. In the Whitefish prevalent concentrations of TFM were as follows: below the feeder 4.3 to 8.0 ppm for 14 hours, and above the confluence with the Kam 2.5 to 2.9 ppm for 17 hours.

The main body of lampricide in the Kam was introduced into the penstocks above the power plant and discharged into the river at the tailrace. Adequate distribution in the river below this point was achieved by virtue of the fact that practically no water was allowed to pass over Kakabeka Falls. This eliminated the necessity for a second feeder above the falls. The treatment was considered to be effective as far downstream as the Great Lakes Paper Co. plant. Here thermal stratification occurred due to an incursion of cold lake water along the river bottom. Below this point, the lampricide, carried in the warmer layers of river water, could not have reached the bottom. There was little or no mortality of fish as a result of the treatment of the Kam watershed.

A post-treatment survey of the treated areas, by means of electroshockers, revealed the presence of live ammocoetes in Oliver, Pitch, O'Connor and Corbett Creeks. These streams were subsequently retreated with an additional 54 gallons of lampricide.

Ammocoetes collected during all of the treatments consisted of 60% sea lamprey and 40% Ichthyomyzon spp.

5. McIntyre River (S-570)

McIntyre River, Township of McIntyre, District of Thunder Bay, was treated on June 8-9, 1960, using the Maumee 30% formulation, as in previous treatments. The lampricide was introduced into McIntyre River at Highway No. 130, about six miles from the mouth.

The river had been extensively surveyed in 1959 with electro-shockers. Abundance of ammocoetes was low, and of a total of 200 captured, only three were sea lampreys. Pre-treatment surveys in 1961 included the recording of water levels and the measurement of volume of flow. A bio-assay test was carried out using lampreys only, in water from the McIntyre. The results of this test indicated that a concentration of 0.63 ppm for 18 hours would kill 99.9% of the lampreys exposed to the lampricide.

At the time of treatment there was a flow of 22 cfs in the river. Application of lampricide was begun at 1900 hours on June 8, 1960, and continued for 17-1/2 hours. A total of 54 gallons of formulation, containing 175.5 pounds of active ingredient, was applied with a "Proportioneer" feeder. Concentrations of TFM below the feeder site and near the mouth were 1.6 to 3.4 ppm for 17 hours and 1.5 to 1.7 ppm for 13-1/2 hours respectively.

Ammocoetes collected during the treatment consisted of 4% sea lamprey and 96% Ichthyomyzon spp. Other species of aquatic fauna did not appear to suffer significant mortality, with the exception of small numbers of minnows and bullheads.

Weather conditions were ideal during the treatment and the accessibility of the river by road was good to within one mile of the mouth.

A post-treatment survey of the river was not carried out in 1960.

6. Goulais River (S-24)

Goulais River and its major tributaries, in the Townships of Fenwick, Vankoughnet, Deroche, Hodgins, Gaudette and Number X, District of Algoma, were treated on June 22-25, 1960, using the Maumee 30% formulation, as in the previous treatments.

The following tributaries were treated to coincide with the treatment of the Goulais: Perry, Achigan, Dam, Whitman, Sheppard, Silver, Rainbow, Northland, Bellevue and Robertson Creeks; and in addition, several small creeks and sloughs designated by the following map numbers - 542, 196, 65, 64, 57, 19 and 2. Lampricide was applied to Goulais River at Whitman Dam above Searchmount, about 52 stream miles from the mouth. The combined treated length of its tributaries was about 36 stream miles.

Ammocoetes had been collected in Goulais River as early as 1954. Extensive surveys of the entire watershed were made in 1959 using electro-shockers, and in 1960 Robertson and Perry Creeks were re-surveyed. Of all the ammocoetes collected, about 6% were sea lamprey, 9% were Ichthyomyzon spp., and the remainder were American brook lamprey. Other pre-treatment surveys in 1960 included the recording of water levels, the measurement of volume of flow, the estimation of rate of flow by means of dye, and the collection of physical and chemical data. The volume of flow of Goulais River at Whitman Dam just before the treatment was 493 cfs. The combined flow in the treated tributaries was a little over 300 cfs. The dye took approximately 36 hours to move from Whitman Dam to the electric barrier. Bio-assays were carried out just prior to the treatment with water from the Goulais and its major tributaries, using ammocoetes and speckled trout as test animals. Based on an exposure of 18 hours to the lampricide, the final test of the Goulais River water indicated that concentrations between 0.6 and 2.4 ppm of TFM would kill 99.9% of the lampreys and not more than 25% of the fish. Comparable ranges for most of the tributaries were from less than 0.5 ppm and 1.3 ppm to 0.7 ppm and 4.2 ppm.

The application of lampricide was begun on June 22, 1960. In Goulais River, 1374 gallons were used and in the following tributaries - Perry, Dam, Whitman, Achigan and Sheppard Creeks - 19, 120, 102, 180 and 48 gallons were used respectively. A "Milton-Roy" feeder was used on the Goulais, a drip feeder on Whitman Creek, and "Proportioneer" feeders on the others. Duration of application was from 16-3/4 to 19-3/4 hours in the above streams. On June 23, 1960 the following tributaries were treated with drip feeders for periods ranging from one to six hours: Silver, Rainbow and Northland Creeks, and six small unnamed creeks. A total of 78 gallons was applied in these. On June 24, 1960, Bellevue Creek, two blind sloughs and one unnamed creek were treated, the first with an electric fuel pump, the others with drip feeders or by pouring the liquid out by hand. A total of 62 gallons was applied. On June 25, Bellevue Creek was again treated further upstream and Robertson Creek was treated, both with drip feeders. A total of 1989 gallons, containing 6464 pounds of active ingredient in all, was applied in the Goulais River system. Concentrations of TFM were maintained at remarkably uniform levels throughout the treated areas, considering the complexity of the watershed. Between 1.7 and 3.2 ppm of TFM were present below the main feeder at Whitman Dam for 16-1/4 hours. At the mouth of Goulais River, concentrations of TFM were between 1.0 and 1.7 ppm for over eight hours. In the main tributaries the following concentrations were present for the indicated periods: Perry Creek - 1.0 to 2.3 ppm for 20 hours, Whitman Creek - 1.0 to 1.7 ppm for an undetermined period, Achigan Creek - 1.0 to 2.0 ppm for over 18 hours, Sheppard Creek - 1.0 to 1.7 ppm for over 18 hours, Bellevue Creek - 1.0 to 2.5 ppm and Robertson Creek - 1.0 to 2.9 ppm, both for undetermined periods.

A total of 2432 ammocoetes was collected in Goulais River and its major tributaries during the treatment. Of these, 57% were sea lamprey, 39% American brook lamprey, and the remainder were Ichthyomyzon spp. Very little mortality of other aquatic fauna was evident. Numerous sport fishermen in the lower Goulais reported good catches of game fish during the treatment with no apparent mortality attributable to the toxicant.

A post-treatment survey of Goulais River and its tributaries was made on June 30, 1960 by means of electro-shockers. No live ammocoetes were found.

7. Michipicoten River (S-167)

Michipicoten River, its tributaries Magpie River, Trout Creek, Wawa Creek, two unnamed creeks and a connecting arm, Dead River, were treated with lampricide on July 2-3, 1960. The streams treated are in the Township of Michipicoten, District of Algoma. A formulation containing 45% by weight of TFM (as sodium salt), supplied by the Hoechst Chemical Company, was used in this treatment. The main feeder site on Michipicoten River was located at Scott Falls, about 13 miles from the mouth; the Magpie River feeder was just above the falls about 1/4 mile from the mouth; Trout Creek was treated at a point about one mile from its mouth; Wawa Creek and the two unnamed creeks were each treated at about 1/4 mile from their mouths, and the two miles of Dead River was treated.

Ammocoetes had been collected by electro-shocking in Michipicoten and Magpie Rivers since 1957. In 1959 an extensive survey of the watershed was carried out, and in 1960 a number of additional areas were sampled. Ammocoetes taken in these surveys consisted of about 2% sea lamprey and the remainder *Ichthyomyzon* spp. Other pre-treatment studies in 1960 included the measurement of volumes of flow, the recording of water levels, and the determination of physical-chemical properties of the water. Volumes of flow just prior to the treatment were as follows (in cubic feet per second): Michipicoten - 1800; Magpie River - 763, Wawa - 25, and Trout Creek - 6. Bio-assays were carried out with water from Magpie River and with ammocoetes and speckled trout as test animals; and from Michipicoten River with ammocoetes only. Based on exposures of 18 hours, these tests indicated that concentrations of TFM above 0.6 ppm in the Michipicoten would kill 99.9% of the lampreys, and from 0.6 to 2.5 ppm in the Magpie would kill 99.9% of the ammocoetes, and not more than 25% of the fish.

The treatment of Michipicoten River was started at Scott Falls on July 2, 1960, using a large "Proportioneer" feeder. A total of 2316 gallons of formulation (12,250 lbs of active ingredient) was applied over a period of 15-1/4 hours. Magpie River was also treated on July 2 by means of two "Milton-Roy" feeders. Nine hundred and thirty-six gallons of lampricide (4950 lbs active ingredient) were applied over a period of 15-3/4 hours. Dead River was treated on July 1, and again on July 2, by pouring chemical from a boat, a total of 54 gallons (275 lbs active ingredient) being applied in this way. Tributaries at Stations 4 and 5, Michipicoten River, were treated on July 3 by hand-pouring the lampricide, 12 gallons (63.5 lbs) in the former and 9 gallons (47.6 lbs) in the latter. Both Wawa and Trout Creeks were treated on July 3 by drip feeders. In the former 15.5 gallons (84 lbs) and in the later 42 gallons (22.3 lbs) were applied. Below Scott Falls concentrations of TFM during the treatment were between 1.0 and 1.9 ppm for 16 hours; in the estuary they were between 1.3 and 1.5 ppm for 11 hours, and below the Magpie Falls between 1.4 and 1.5 ppm for 14-1/2 hours.

A total of 1328 ammocoetes was collected during the treatment of Michipicoten River and its tributaries. Of these about 39% were sea lamprey, and the remainder *Ichthyomyzon* spp. There was little apparent mortality of other species of aquatic fauna.

This treatment did not present serious problems apart from the large volume of lampricide required. Access to all the feeder sites was made by road. Boats were used for the treatment of Dead River and for the sampling of downstream stations in the main river. A post-treatment survey made on July 19, 1960 revealed the presence of a few live ammocoetes near the mouth of Dead River.

8. Jackfish River (S-385)

Jackfish River and its tributary, Limestone Creek, in Township No. 92, District of Thunder Bay, were treated with lampricide on September 23-28, 1960. The Maumee 30% formulation of TFM was used in the Jackfish. The main river was treated first at a falls just upstream from the power line about eight miles from the mouth, and again at points about three miles, two miles, and one and a half miles from the mouth. Limestone Creek was treated at its junction with Jackfish River.

Ammocoetes had been collected in 1957, 1958 and 1959, and again in 1960 from Jackfish River. About 16% of these were sea lamprey, and the remainder Ichthyomyzon spp. Additional pre-treatment surveys in 1960 included the measurement of volume of flow, the recording of water levels, the estimation of rate of flow by means of dye, and the determination of physical and chemical properties of the water. Just prior to the treatment, the volume of flow near the mouth was 26 cfs. The dye took about 67 hours to move from the feeder site to the mouth. Three bio-assays of water from Jackfish River were carried out in 1960, using ammocoetes and speckled trout in the first two tests, ammocoetes and rainbow trout in the third. The results of the final test, based on 18 hours exposure to the toxicant, indicated that a range of concentrations of TFM between 2.3 and 4.0 ppm would kill 99.9% of the lampreys and not more than 25% of the fish.

Application of lampricide in Jackfish River was started on September 23, 1960 by means of an electric fuel pump. Over a period of 18-1/2 hours, 150 gallons containing 487.5 lbs of active ingredient were applied. A further 30 gallons (97.5 lbs active ingredient) were applied for a period of 8-1/2 hours on September 24, 1960 by means of a fuel pump located downstream. The concentration was again boosted on September 26, 1960 when 42 gallons of chemical (136.5 lbs active ingredient) were poured into Jackfish River by boat at two points about 1-1/2 miles from the mouth. Limestone Creek was treated on September 23, 1960 by means of a fuel pump. Six gallons (19.5 lbs of active ingredient) were applied just above the mouth. Concentrations of TFM were between 3.0 and 4.7 ppm for 18 hours just below the original feeder site, and between 1.0 and 3.1 ppm for 15 hours at the mouth of Jackfish River. Just below the junction of Limestone Creek and Jackfish River, concentrations of TFM were between 1.0 and 3.8 ppm for 20 hours. The application of lampricide by boat boosted the stream concentration of TFM at downstream points from 3.4 ppm to 4.4 ppm.

During the treatment ammocoetes were collected at a number of points between the upstream feeder site and the mouth. Of these, 47% were sea lamprey and the remainder Ichthyomyzon spp. There was a negligible mortality of other aquatic fauna.

The chief problem in treating Jackfish River was the inaccessibility of the upstream feeder site to wheeled vehicles. A "Bombardier" was used to reach this location. Most of the downstream sampling points could be reached by boat. There was no post-treatment survey of Jackfish River in 1960.

9. Black Sturgeon River (S-509)

Black Sturgeon River and its tributaries, Mouseau, Sucker, Mound, and Larson Creeks, in the Townships of Lyon, Hale and Nipigon, District of Thunder Bay, were treated on October 6-17, 1960 with the Maumee 30% formulation of TFM, as in the previous treatment. The main river was treated at a point about 40 miles from the mouth. Sucker Creek was treated about seven miles above its junction with Black Sturgeon River, and the other tributaries - Larson, Mouseau and Mound Creeks, were each treated within one mile of the main river.

Sea lamprey ammocoetes were collected for the first time in the Black Sturgeon in 1960. They amounted to 28% of the total, the remainder being Ichthyomyzon spp. Other pre-treatment studies included measurements of volumes of flow, recording of water levels, and the determination of physical and chemical properties of the water. Just prior to the treatment, the volume of flow in Black Sturgeon River was estimated at 600 cfs at the mouth. The flow in Larson Creek was 30 cfs, in Mouseau Creek 7 cfs, and in Sucker Creek 47 cfs. Four bio-assays were carried out in 1960 on water samples from Black Sturgeon River, using ammocoetes and either speckled or rainbow trout as test animals. Results of the final test indicated that concentrations of TFM between 5 and 6 ppm for 18 hours would kill 99.9% of the lampreys exposed and not more than 25% of the fish.

The treatment of Black Sturgeon River began on October 6, 1960 with exploratory applications of lampricide in Mouseau, Sucker and Mound Creeks. An electric fuel pump was used on the first two streams, a drip feeder on the third, to apply 13, 69 and 6 gallons of formulation (42.3, 224.3 and 19.5 lbs active ingredient) respectively. Larson Creek was treated on October 7, 1960 with 42 gallons (136.5 lbs active ingredient) applied by drip feeder. On October 12, 1960 Black Sturgeon River was treated, by means of a large "Proportioneer" feeder, with 4548 gallons (14,781 lbs active ingredient) applied over a period of 18 hours. Mouseau Creek was re-treated on October 15, 1960 with 14 gallons (45.5 lbs active ingredient) over a period of 7-3/4 hours, using the electric fuel pump.

During the treatment of Black Sturgeon River concentrations of TFM below the main feeder were between 6.5 and 9.1 ppm for 18 hours. At the railway bridge near the mouth, concentrations of 3.4 to 5.5 ppm were present for 20 hours. At the mouth of Mouseau Creek, concentrations of 3.1 to 7.1 ppm were present for seven hours.

The preliminary treatments of the tributaries indicated that sea lamprey ammocoetes occurred only in Mound, Larson and Mouseau Creeks. Mouseau Creek was the only tributary requiring re-treatment along with the main river. A dam constructed on Black Sturgeon River in 1959 at "Camp 43" had not been in existence long enough to rid the upstream reaches of sea lampreys. During the treatment from "Camp 1", sea lamprey ammocoetes were collected immediately below the dam. Of 2400 ammocoetes collected during the treatment, about 47% were sea lamprey and the remainder Ichthyomyzon spp. A fairly heavy mortality of suckers and trout-perch and a considerable kill of walleyes occurred, especially in the vicinity of the feeder sites. A post-treatment ammocoete survey of Black Sturgeon River was not carried out in 1960.

10. Pigeon River (S-592)

Pigeon River, Township of Pardee, District of Thunder Bay, was treated on October 18-19, 1960 with the Maumee 30% formulation of lampricide (the same as that used in the two previous treatments). The main feeder site was located at the Provincial Park, about 3-1/2 miles from the mouth.

A survey of the stream with electro-shockers was carried out in 1959. Four ammocoetes were collected, two of which were sea lamprey. Pre-treatment surveys made in 1960 included the measurement of volume of flow, the recording of water levels and the determination of physical and chemical properties of the water. Just prior to the treatment the volume of flow in Piegon River was 99 cfs. Two bio-assays of Pigeon River water were performed in 1960, using ammocoetes and speckled trout as test animals. The first test, made in May, when the river was in flood and the volume of flow was too high to treat economically, indicated that concentrations of TFM between 0.6 and 4.0 ppm for 18 hours' exposure would kill 99.9% of the lampreys and not more than 25% of the fish. The second test performed in October, and on which the treatment was based, gave a range of 1.6 to 3.1 ppm of TFM for the same results.

Treatment of Pigeon River was begun on October 18, 1960 with a "Milton-Roy" feeder, and 630 gallons of formulation (2,047 lbs of active ingredient) were used over a period of 24 hours. Thirty gallons (97.5 lbs of active ingredient) were poured from a boat to treat several lagoons in the lower river, on October 18, 1960. Concentrations of TFM below the feeder site were between 1.7 and 4.1 ppm for 24-1/4 hours. At the mouth they were between 1.1 and 3.0 for 21-1/4 hours.

The scarcity of ammocoetes in Pigeon River, as indicated by the pre-treatment survey, was borne out by the numbers collected during the treatment. A total of 129 were collected in the latter, of which about 44% were sea lamprey, and the remainder Ichthyomyzon spp.

The treatment was relatively simple, the feeder site being accessible by road and the lower part of the river by boat. A post-treatment survey was not done in 1960.

11. Sawmill Creek (S-41)

Sawmill Creek, in the Township of Haviland, District of Algoma, was treated on October 28, 1960 with a formulation of TFM containing 45% of the active ingredient, supplied by the Hoechst Chemical Company (the same as that used in the treatment of Michipicoten River). The point of application was at the head of a series of falls, about 1/4 mile from the mouth.

Pre-treatment surveys by electro-shocker in 1960 had resulted in the collection of one specimen of sea lamprey among some 300 American brook lampreys, and for this reason treatment was considered justifiable. Other pre-treatment studies in 1960 indicated an estimation of volume of flow (approx. 5 cfs), conductivity measurements, and a bio-assay. Results of the latter test, in which ammocoetes only were used, indicated that concentrations of TFM over 0.8 ppm for eight hours would kill at least 99.9% of the ammocoetes exposed.

The treatment of Sawmill Creek was begun on October 28, 1960, using an electric fuel pump. Over a period of six hours a total of four gallons of formulation (19.5 lbs active ingredient) was used. About two quarts were also applied to a swamp joined to the stream near its mouth. Concentrations of TFM below the feeder site were between 2.8 and 7.0 ppm for six hours, and at the mouth 3.9 to 6.5 ppm for a similar period.

During the treatment 195 ammocoetes were collected, all of which were American brook lamprey. A post-treatment survey carried out soon after the treatment resulted in several live ammocoetes. The failure to achieve the expected mortality, in spite of the high concentration of the toxicant present in all parts of the stream, is believed due to the short exposure time (about six hours). Under the conditions of low water temperature the ammocoetes may not have reacted to the irritant effects of the chemical soon enough to emerge and become exposed to the full concentration in the stream. It is also quite probable that the ammocoetes collected during the post-treatment survey migrated the short distance upstream from Batchawana Bay, where there is a relatively high population of ammocoetes.

Lake Huron

12. Magnetawan River (H-745)

Magnetawan River and several small tributaries in the Township of Wallbridge, District of Parry Sound, were treated on August 11 and 12, 1960 with the Maumee 30% formulation of TFM. The point of application was the outlet of Miner's Lake about five miles from the mouth.

Ammocoetes had been collected in Magnetawan River as early as 1956, but an extensive survey by electro-shockers was carried out in 1958. Thirty-eight per cent were sea lamprey and the remainder *Ichthyomyzon* spp., but the abundance was low. Pre-treatment studies in 1960 included the measurement of discharge and water levels, the estimation of rate of flow by means of dye and chemical analysis of the water. Three pre-treatment bio-assays of the river water were carried out in 1960. Results of the final test, in which ammocoetes, perch, sunfish, pike and bass were used, indicated that concentrations of TFM between 0.5 and 0.6 ppm for eight hours' exposure would kill 99.9% of the lampreys and not more than 25% of the fish.

Just prior to the treatment, the volume of flow was 718 cfs. A "Milton-Roy" feeder was used to treat Magnetawan River from the outlet of Miner's Lake. A total of 456 gallons of lampricide (1,482 lbs of active ingredient) was used over a period of nine hours. Two tributaries were treated with 24 gallons (78 lbs active ingredient) and three gallons (9.75 lbs active ingredient) respectively. In both cases the formulation was applied by pouring from the containers.

Below the main feeder site concentrations of TFM were between 0.8 and 1.2 ppm for nine hours. At the No. 69 Highway bridge concentrations of 0.6 to 1.1 ppm were present for 10 hours. Below the railway bridge there was an incomplete horizontal distribution of the toxicant across the river. The treated water appeared to be confined first to one side of the river, then further downstream to the opposite side. Possibly, the time of application was not sufficiently long to effect a complete replacement of the untreated water in the estuary-like mouth with the treated water from upstream; or alternately, onshore winds may have produced an influx of water from Byng Inlet up one side of the Magnetawan estuary.

There is no access by road to Magnetawan River above Highway No. 69. Above this point the river is navigable by small boats only with difficulty, and a falls below Miner's Lake presents a definite obstacle to boats. The main feeder site was reached by float plane and the tributaries were treated by boat.

A post-treatment survey by electro-shockers was carried out on September 3 and 4, 1960. No live ammocoetes were found.

13. Still River (H-726)

Still River and its tributary, Little Still River, in the Township of Wallbridge, District of Parry Sound, were treated on August 16, 1960, with the Maumee 30% formulation of TFM. The main feeder was located at the outlet of Moose Lake, about 16 miles from the mouth. The Little Still was treated at a point about 1.5 miles from its junction with the Still.

Ammocoetes were collected from Still River in 1956, but a more extensive survey of the watershed was carried out in 1958. Ammocoetes were abundant, especially in the lower six to eight miles of the river. About 75% of those collected were sea lamprey and the remainder *Ichthyomyzon* spp. Pre-treatment studies of Still River in 1960 included measurements of volumes of flow, the recording of water levels and chemical analysis of the water. Two bio-assays were carried out in 1960. Results of the second test, in which ammocoetes, perch and sunfish were used as test animals, indicated that for an exposure time of 18 hours concentrations of TFM between 0.66 and 1.9 ppm would kill 99.9% of the ammocoetes and not more than 25% of the fish.

Just prior to the treatment, volumes of flow in the Still and Little Still were 16 and 1 cfs respectively. Treatment of Still River was begun on August 16, using a "Proportioneer" feeder. Over a period of 23-1/2 hours, 48 gallons of formulation containing 156 pounds of active ingredient were applied. Treatment of Little Still River, also started on August 19, was by a swimming pool chlorinator. This application used six gallons of formulation containing 19.5 pounds of active ingredient over a period of 18-3/4 hours.

Concentrations of TFM below the Moose Lake feeder were between 1.95 and 2.65 for 25-1/2 hours. Below the feeder on Little Still River there were between 1.2 and 3.2 ppm of TFM for 17-1/2 hours. At the mouth of Still River concentrations of 0.4 to 1.1 ppm were present for 27 hours. Due to the extremely slow rate of flow in Still River (the toxicant took about 8-1/2 days to reach the mouth), considerable attenuation of the chemical occurred. Because of the initially high concentrations maintained at the feeder sites, however, concentrations at the mouth of Still River remained at the desired level for a sufficient time to produce the required kill of ammocoetes.

Ammocoetes collected during the treatment consisted of 95% sea lamprey and 5% Ichthyomyzon spp. There was a fairly heavy kill of fish, mostly young bullheads, for a short distance below the main feeder site. In the lower reaches of the river, however, mortality of fish and other aquatic vertebrates appeared to be negligible.

Access to Still River above the Little Still was difficult. The main river, strewn with log jams, was navigable only with difficulty as far as the "trolley dam". The main feeder site equipment had to be transported to Moose Lake by air.

A post-treatment survey of Still River with electro-shockers was carried out on September 5, 1960. No live ammocoetes were found.

14. Naiscoot River (H-824)

Naiscoot River and its tributary, Harris River, in the Township of Harrison, District of Parry Sound, were treated on August 21-26, 1960 with the Maumee 30% formulation of TFM. Naiscoot River was treated at the outlet of Naiscoot Lake about 11 miles from the mouth, while Harris River was treated at a point about 3.5 miles above its junction with the Naiscoot.

An extensive series of ammocoete surveys with electro-shockers had been carried out in 1958. Ammocoetes were not plentiful at that time. About 46% of the collection were sea lamprey, the remainder Ichthyomyzon spp. Pre-treatment studies of Naiscoot and Harris Rivers in 1960 included measurements of volume of flow, the recording of water levels, the estimation of rates of flow by means of dye, and the determination of physical and chemical properties of the water. Bio-assays were carried out simultaneously on water from Naiscoot and Harris Rivers, using ammocoetes and perch, darters, suckers and sunfish as test animals. In the case of Naiscoot River, results of the test indicated that for an exposure of 18 hours from 0.54 to 1.6 ppm of TFM would kill 99.9% of the lampreys and not more than 25% of the fish. Corresponding figures for the Harris were 0.4 and 0.5 ppm of TFM respectively.

Treatment of Naiscoot River was begun on August 21, 1960. Over a period of 18-1/2 hours, 36 gallons of formulation containing 117 lbs of active ingredient were applied by means of an electric fuel pump. Treatment of Harris River was started at the same time, and 12 gallons of formulation (39.0 lbs active ingredient) were applied in 18 hours by means of a swimming pool chlorinator. It was found that the first site chosen from which to apply the chemical in Harris River was below the point at which sea lamprey ammocoetes were found to occur. A second feeder site was chosen a few hundred yards upstream and the treatment of Harris River was repeated using an electric fuel pump. Over a period of 21-1/2 hours, 18 gallons of formulation containing 58.5 pounds of active ingredient were applied in the second treatment.

Concentrations of TFM in Naiscoot River below the feeder site were 0.5 to 1.8 ppm for 23 hours, and one mile below the highway bridge 0.5 to 0.95 ppm for 21 hours. In Harris River the first treatment produced 1.0 to 3.2 ppm of TFM below the feeder site for 17 hours, and the second treatment resulted in 1.0 to 2.1 ppm of TFM for over nine hours. The two blocks of treated water in Harris River merged by the time they reached the confluence with Naiscoot River. At this point from 0.5 to 2.5 ppm of TFM were present for 56 hours. Owing to the slow movement of water, concentrations of TFM in Naiscoot River were followed for only one mile below the highway bridge. In view of the more than adequate concentrations present at this point, it was deemed unnecessary to follow the treatment further.

The ammocoetes collected during the treatment consisted of 86% sea lamprey, and the remainder Ichthyomyzon spp. Apart from a few small minnows, bullheads, and numerous mud-puppies in the vicinity of the feeder sites, mortality of aquatic fauna other than lampreys was negligible.

Post-treatment surveys of the watershed were carried out by electro-shocking on September 1 and 2, 1960. No live ammocoetes were found.

15. Chikanishing River (H-420)

The Chikanishing River, in the Township of Rutherford, in Manitoulin County, was treated on September 9-11, 1960 with the Maumee 30% formulation of TFM. The main feeder was located at first at the highway bridge and then moved up to the outlet of George Lake, about 2-1/2 miles from the mouth.

During pre-treatment surveys, six sea lampreys and three Ichthyomyzon spp. were collected.

Discharge measurements and a dye check were conducted prior to treatment. The flow at the highway was 5.7 cfs and at the mouth 3.7 cfs; however, the latter reading was difficult to take and subject to error. The dye check was not completed before treatment started, and the dye eventually reached the mouth 50 hours after introduction at the highway.

A bio-assay, two days prior to treating, was conducted with ammocoetes and small perch used as test animals. For an exposure of 18 hours, 0.85 to 1.6 ppm of TFM killed 99.9% of the lampreys and not more than 25% of the fish.

Prior to feeding, it was noticed that fluoresceine dye was still present in the pool below the highway. Blank value readings on the colorimeter demonstrated only three or four units difference between this and unpolluted water from above; hence, it appeared that fluoresceine (in low concentrations) added to the treatment does not affect the analysis for TFM. This indicates that fluoresceine can be added to the lampricide as a visual indicator of its progress downstream. The feeder was started at the highway on September 9 at 2100 hours and the chemical pumped continuously for 18 hours, using a "Stewart-Warner" fuel pump. With a feed rate of 0.48 to 0.36 gph, a total of seven U.S. gallons was pumped.

Since sea lamprey ammocoetes were found just below this feeder, a second site was selected at the outlet of George Lake. At a feed rate of 0.24 to 0.32 gph, a total of 2.5 U.S. gallons was pumped in during a nine-hour period on September 10 (2040 hours to 0545 hours).

The concentrations below the first feeder ranged from 0.8 to 1.65 ppm for 18 hours. At the mouth the concentration ranged from 0.8 to 0.9 for over 12 hours. Below the second feeder the concentrations ranged from 0.8 to 1.1 ppm. At the highway they were 0.8 to 0.9 for a period of over four hours.

During this treatment, ammocoetes were collected from the mouth up to the second feeder; 180 sea lampreys and 684 Ichthyomyzon spp. were found. On this basis, sea lampreys comprised about 21% of the population. No fish were found dead.

As mentioned previously, ammocoetes were collected immediately below the first feeder. This was surprising, since it meant that adult lampreys had navigatied a set of falls thought impassable. This was not expected, as the feeder site had been selected above a falls that had been considered an impassable barrier to the upstream migration of adult sea lampreys. No sea lamprey ammocoetes had been found above these falls during the surveys conducted in 1958 with electro-shockers. The stream flowing into George Lake was checked and no lampreys were found, consequently the second feeder was set up at the outlet of George Lake. During the second treatment, sea lampreys were collected only a few hundred feet above the first feeder site.

As the river is isolated, the entire crew and equipment was flown to Killarney, a small fishing village which is in close proximity to the stream.

Post-treatment surveys were carried out after treatment and no ammocoetes were found.

16. Boyne River (H-1053)

Boyne River, McDougall Township, District of Parry Sound, was treated on November 13-14, 1960 with the Maumee 30% formulation of TFM. The application was made near the outlet of Oastler Lake, about five miles from the mouth.

Ammocoetes had been collected from Boyne River in 1956 and 1957. An extensive survey with electro-shockers was carried out in 1958, and some additional surveys were made in 1960. The ammocoetes collected in all years consisted of 37% sea lamprey and the remainder *Ichthyomyzon* spp. Pre-treatment studies of Boyne River in 1960 included the measurement of volume of flow and the recording of water levels. Just prior to the treatment, the volume of flow in Boyne River was 24 cfs. Results of a bio-assay conducted on November 11, 1960, with Boyne River water, and using ammocoetes and speckled trout as test animals, indicated that concentrations of TFM between 1.45 and 2.5 ppm would kill 99.9% of the lampreys and not more than 25% of the fish in 18 hours.

The treatment was started on November 12, 1960, using an electric fuel pump, located just below the outlet of Oastler Lake. Over a period of 35 hours, 147 gallons of lampricide, containing 555 pounds of active ingredient, were applied. A large pool of water, created by a division of the stream bed for bridge construction, was also treated by pouring in several quarts of formulation and stirring thoroughly. Fluoresceine dye was mixed with the lampricide applied at the main feeder site. Although this did not affect the analysis, the colour was sufficiently strong to permit observation of the progress and diffusion of the toxicant.

Concentrations of TFM below the feeder site were between 1.3 and 3.0 ppm for 35 hours. At the mouth, concentrations of TFM between 0.2 and 1.5 ppm were present for 25 hours. The progress of the toxicant through an inaccessible swamp below Highway 69 was observed from an aircraft. Due to the presence of dye in the treated water, the chemical could be seen to penetrate the area satisfactorily.

Ammocoetes collected during the treatment consisted of 68% sea lamprey, and the remainder *Ichthyomyzon* spp. There was some mortality of small fish, mostly minnows, near the feeder site but the overall mortality of aquatic fauna, other than lampreys, appeared negligible.

No post-treatment survey was made in 1960.

17. Silver Creek (H-1376)

Silver Creek and a small tributary in the Townships of Nottawasaga and Collingwood, Simcoe County, were treated twice on November 26 and 27.* The purpose of the second treatment was to test the efficiency of the first. A point about six miles from the mouth of Silver Creek was chosen for the first application, in which was used a formulation of TFM containing 60% by weight of the active ingredient converted to an amine salt and supplied by the Maumee Chemical Company. A small amount of the 45% Hoechst formulation of TFM was used to augment the first treatment, and the latter was used exclusively in the second treatment, made from a point about two miles above the mouth.

Ammocoetes were collected by electro-shocking from 1957 to 1960 inclusive. The collections consisted almost entirely of sea lampreys, with less than 1% Ichthyomyzon spp. Pre-treatment survey in 1960 also included the measurement of volume of flow and the recording of water levels. Just prior to the treatment the volume of flow in Silver Creek was about 6 cfs upstream and 10 cfs downstream. Bio-assays of the stream water were carried out for each of the two formulations named previously, using ammocoetes and speckled trout as test animals. For the Hoechst 45% formulation, results of the test indicated that concentrations of from 12.7 to 26 ppm of TFM would kill 99.9% of the lampreys and not more than 25% of the fish in 18 hours. Corresponding values for the Maumee 60% formulation were 16 to 19 ppm.

The first treatment, begun on November 26, 1960, used over a period of 21-3/4 hours 90 gallons of the Maumee 60% formulation and 66.6 gallons of the Hoechst 45% material, containing 507 and 324.7 pounds of active ingredient respectively. The second application, begun on November 30, used 117 gallons (570.4 lbs of active ingredient) of the Hoechst 45% formulation over a period of 12 hours.

Concentrations of TFM below the first feeder site were between 16 and 25 ppm for 22 hours, and near the mouth 7.2 to 11.7 ppm for 21 hours. The second treatment resulted in concentrations of 8.0 to 25.4 ppm below the feeder site for 11 hours and 10 to 11.5 ppm near the mouth for over six hours.

Ammocoetes collected during the first treatment consisted of about 99.5% sea lamprey and the rest Ichthyomyzon spp. During the second treatment no live ammocoetes were observed, although observations at that time were made difficult owing to adverse weather conditions. It is probably safe to conclude that the first treatment was successful in destroying nearly all ammocoetes below the feeder. As a test of the efficiency of the amine salt of TFM, however, the first treatment was not an unqualified success in that some of the sodium salt of TFM had to be used to complete the application. No mechanical difficulties were encountered in the application of the amine salt with the "Proportioneer" feeder, and it appeared to disperse satisfactorily in the stream water.

There was good access to most of the treated length of Silver Creek, except for the last few hundred yards to the first feeder site, which was reached by four-wheel-drive vehicle. The mouth of Silver Creek could be reached only on foot. Weather conditions were good at the start of the first treatment, but became very inclement during the second application. Strong winds, freezing rain and snow made travel hazardous. Ice formed in ponds and ditches, making observation and sample taking difficult.

A post-treatment survey with electro-shockers was carried out on December 6, 1960, but no live ammocoetes were found.

18. Sturgeon River (H-1343)

The Sturgeon River and its numerous tributaries, Township of Toy, Medonte and Orillia, County of Simcoe, were treated December 2-5, 1960.

The lampricide, the sodium salt of 3-trifluormethyl-4-nitrophenol containing 40% TFM, was supplied by the Hoechst Chemical Company. It was introduced into the river at the grist mill in Hillsdale, about 20-23 miles from the mouth.

In pre-treatment surveys with electro-shockers, sea lamprey ammocoetes were taken a short distance below the grist mill. Adult sea lampreys were also reported spawning below the mill.

Discharge studies showed much dilution occurred along the river. On November 17, the flow below the grist mill was 6.3 cfs; at the Black Watch camp near the mouth it was 54 cfs, an increase of nine-fold. Just prior to the treatment the flows were 3.2 cfs and 26 cfs respectively. With this amount of dilution, the chemical had to be boosted part way down. Dye checks in late November showed that 65-70 hours were required for the dye to reach the mouth of the river from the point of application at the grist mill.

Chemical analysis of the water was carried out on November 17 and 24. In both cases, the phenolphthalein alkalinity was zero, the methyl orange alkalinity was 155 and 172, the pH was 7.7, and the resistance was 4200 ohms at 52°F and 5000 ohms at 37°F respectively.

Three bio-assays were conducted on November 17-18, 22-23, and 29. The first one killed fish faster than lampreys, the range for 18 hours being 8.6 for the 99.9% level for lampreys, and 4.5 for the 25% level for fish. With the next two bio-assays the situation progressively improved. In the second bio-assay the 18-hour range was 7.8 ppm for the lampreys and 8.6 ppm for the fish. The third showed a range of 8.4 to 11 ppm respectively. It was decided to treat on the basis of the third bio-assay.

The lampricide with fluoresceine was first applied at the grist mill with a "Proportioneer" feeder. The feed rate of four gallons per hour was continued for 24 hours (from 1430 hours on December 2 to 1435 hours on December 3) to allow for attenuation in the swamp below the mill. This consumed 96 gallons of formulation (520 lbs of active ingredient). Immediately below the feeder the concentration was over 35 ppm, but below the swamp the attenuation and dilution had lengthened and lowered the concentration and it varied between 2.6 to 7.8 ppm for 31 hours. The "Proportioneer" from the grist mill had been moved to this site and was ready for boosting when the chemical appeared. A total of 132 gallons (715 lbs active ingredient), averaging nine gallons per hour, from December 5 at 0125 hours to 2140 hours, was pumped into the existing block of chemical. This boosted the concentration below this feeder to 10-20.5 ppm for a period of 23-3/4 hours. At the mouth the concentration varied between 2.0-9.5 ppm for 25-1/2 hours. The treatment of the main river was boosted at two other sites with an additional 18 gallons (97.5 lbs of active ingredient).

Twenty-two additional tributaries to Sturgeon River were treated during this period. Since most of these were relatively small, they required no more than a quart or two of lampricide. On these, a total of 11-1/3 gallons were expended.

The extremely high concentrations below both feeders resulted in some fish mortality. Dead trout, mudminnows and other small fish, and dead leopard frogs were found. The high concentration of lampricide was required because of the great amount of dilution occurring in the river. In the lower half of the river only dead lampreys were found. A total of 617 sea lampreys and 50 Ichthyomyzon ammocoetes were taken, the percentage being 92.5% and 7.5% respectively.

The river was readily accessible by road, with the exception of the long swamp below the grist mill. The weather had been cold, but fortunately little snow had fallen in this watershed despite the blizzards that hit surrounding areas. The river was mostly open, except the swamp which was partly frozen. Fluoresceine, applied two weeks earlier to determine the rate of flow through the swamp, was still visible along the edges where it had frozen into ice.

No post-treatment survey was conducted at this time owing to the inclement weather as four to five inches of snow blanketed the ground.

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R. W. McCauley Appendix 6

REARING OF LAMPREY EGGS

Spawning-phase sea lampreys were collected from the Saugeen River (Bruce County) and Silver Creek (Collingwood) during June and July, 1960. They were brought to the laboratory where, after several unsuccessful attempts, they were artificially spawned. The fertilized ova were reared in petri dishes resting on the bottoms of five-gallon aquaria filled with water from Big Creek (Norfolk County). This stream was selected as a source of water, since sea lampreys are known to spawn successfully in its waters. Circulation of water about the eggs was provided by a single air stone in the middle of each aquarium. The temperatures in each of the rearing aquaria were maintained constant and were chosen to span the temperature range over which it has been shown some embryos can hatch. The temperatures were accordingly 15, 20 and 25°C.

Figure 1 shows the relationship between percentage hatch and rearing temperature.

The data are in general agreement with the results of other observers who either artificially propagated sea lamprey eggs or made observations on stream temperatures during the development of eggs in natural waters. These results suggest that some successful hatching takes place between 13 and 25°C (55-77°F) and that the optimum temperature is in the vicinity of 18°C (65°F). However, viable, burrowing larvae developed only from eggs reared at 15 and 20°C. This again is in agreement with the results of the previous laboratory investigation in which no viable larvae were found to develop at temperatures below 60°F (15.5°C) or above 70°F (21°C).

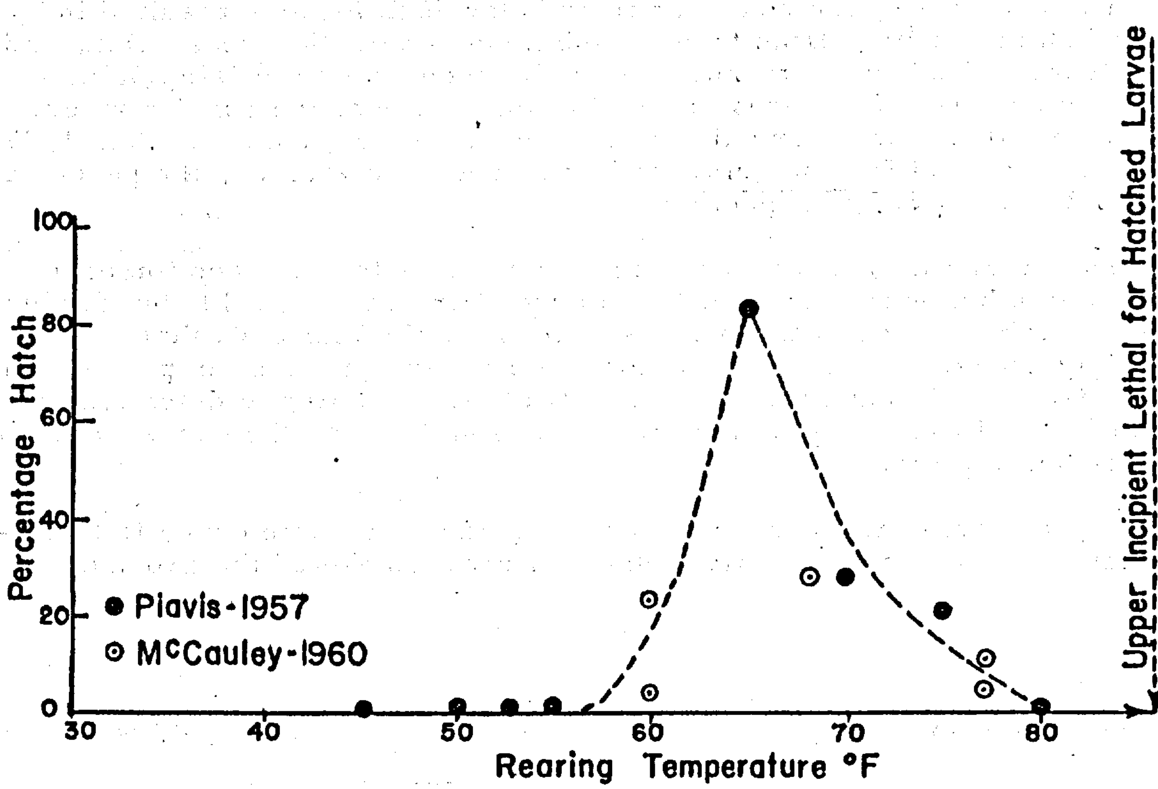

Fig. 1. Relationship between percentage hatch and rearing temperature in sea lamprey eggs.

When the embryos had developed to the prolarval stage (just before the yolk was absorbed), they were transferred to a series of lethal temperatures and their resistance to these temperatures determined. Two regression lines were derived, one for each of the 15° and 20° groups. The prolarvae were found to be more resistant to high temperatures than ammocoetes acclimated to 20°C. The upper incipient lethal temperatures for the 15 and 20°C groups were 29.1°C (84°F) and 29.9°C (86°F) respectively (exposure time five days). It would thus seem that later stages may be more resistant to high temperatures than suggested by the results of rearing experiments at constant temperatures.

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R. W. McCauley

Appendix 7

RATE OF GAIN OF HEAT TOLERANCE IN SEA LAMPREY AMMOCOETES

It has long been known that the resistance of fish to lethal temperatures depends on their thermal history. Ammocoetes which have been reared for an indefinitely long time at, say, 20°C, display a higher resistance to lethal temperatures than ammocoetes reared 10° lower. Ammocoetes may be thermally acclimated to a non-lethal temperature by holding them at this temperature for an indefinitely long time. The duration of this time may be determined by removing subsamples of ammocoetes at regular intervals and subjecting them to an arbitrarily chosen lethal temperature. For each subsample the median time to death is determined. Whenever there is no significant difference in the median time to death of consecutive subsamples, acclimation to the new temperature has been achieved.

The rate of gain of heat tolerance (acclimation) of sea lamprey ammocoetes was studied. The results are in keeping with those obtained by other authors for fish in which acclimation at high temperatures proceeds much faster than acclimation at low temperatures. On the basis of experiments on thermal acclimation in sea lamprey ammocoetes, the following schedule is presented:

4°C to 15°C	-	three weeks at 15°C.
10°C to 20°C	-	one week at 20°C.
20°C to 30°C	-	four days at 30°C.

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R. W. McCauley

Appendix 8

UPPER LETHAL TEMPERATURES OF SEA LAMPREY AMMOCOETES

Sea lamprey ammocoetes were collected from Venison Creek, the western branch of Big Creek. They were held in the laboratory under conditions which simulated, as much as possible, those prevailing in their natural habitat. Under these rearing conditions the animals appeared active and healthy. At the highest rearing temperature (30°C), mortality in the tanks rose to 10%.

Samples of ammocoetes were acclimated to 2°C, 10°C, 15°C, 20°C, 25°C and 30°C, and the resistance of each sample to lethal temperatures was tested. Figure 1 summarizes the results of these experiments. Each line shows the relationship between lethal test temperature and time to 50% mortality at each of the acclimation levels. The double line on the right terminates each of the regression lines and is obtained by joining the upper incipient lethal temperatures corresponding to each acclimation level.

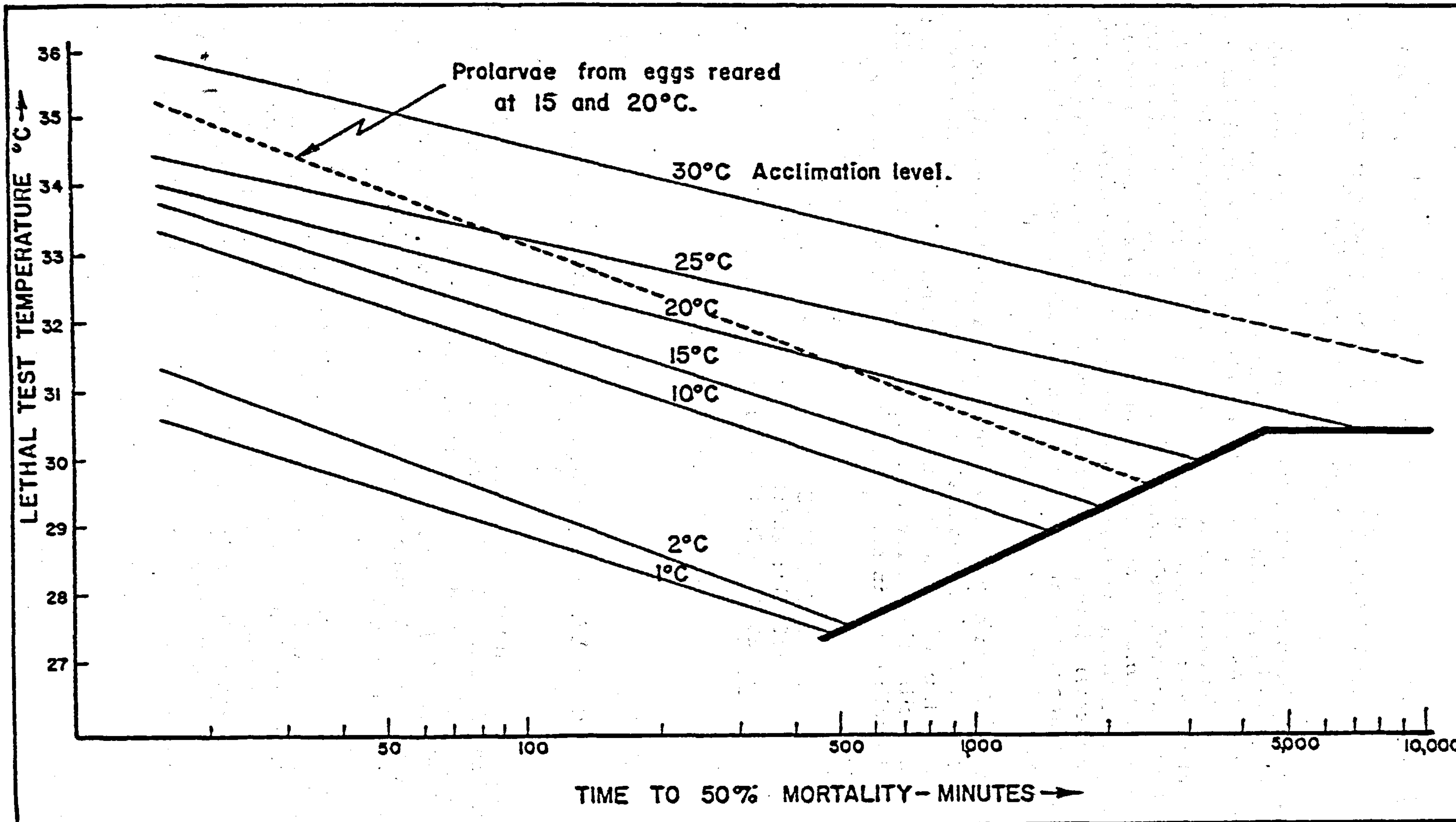

Fig. 1. Lethal temperatures of sea lamprey ammocoetes.

The results describe the response to high temperature of an animal which has a relatively high resistance to lethal temperatures. It is possible, for example, through adequate acclimation for ammocoetes to survive one week at 88°F - a temperature which is rarely encountered in the streams.

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R. W. McCauley Appendix 9

LETHAL TEMPERATURE RELATIONS OF ADULT SEA LAMPREYS (PARASITIC PHASE)

Specimens were collected from Lakes Huron, Erie, and Ontario. They were obtained from commercial fishermen who found them attached to fish in their nets. They were usually accumulated alive at a fishing port until a large enough number of specimens made it profitable to fetch them. Samples were obtained at various seasons of the year and were acclimated in the laboratory to constant temperatures (5°C, 10°C, 15°C and 20°C).

Subsamples were exposed to lethal temperatures and regression lines describing thermal resistance were derived. The regression lines were found to be similar with respect to slope and position to samples of ammocoetes acclimated to comparable levels. The upper incipient lethal temperature for lampreys acclimated to 20°C was estimated to be 30°C (86°F). This value is higher than would be expected from an animal which is found in the lake in the company of "cold water" fish (lake trout, burbot) and whose "preferred temperature" in Lake Erie is estimated to be about 12°C (54°F).

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R. W. McCauley Appendix 10

LETHAL TEMPERATURE RELATIONSHIPS OF ADULT SEA LAMPREYS (SPAWNING PHASE)

Samples of sea lampreys in the spawning phase were collected throughout May and June, 1960 from the Saugeen River and Big Creek. They were brought to the laboratory where their susceptibility to high temperatures was studied.

Samples collected during the first week of May, when river temperatures were below 10°C, were as resistant to lethal temperatures as parasitic-phase adults acclimated to 5°C, and had an upper incipient lethal temperature of 28.5°C (83°F). Samples collected later in the season displayed the outward symptoms of physiological degeneration and the responses of subsamples to lethal temperature were erratic. Mortality in the holding tanks at 20°C was high and it was found that the lampreys were incapable of thermal acclimation. Since temperatures as low as 27°C (80°F) were lethal, it is conceivable that high temperatures in some streams in the month of June could limit the numbers of the spawning population.

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M. L. H. Thomas

Appendix 11

AMMOCOETE DISTRIBUTION IN LAKE SUPERIOR

Previous investigations to determine the extent of sea lamprey ammocoete distribution in lakes have been confined to sandy and muddy shores. In 1960 hard shores in Batchawana Bay were included. Deep-water sampling was carried out in Batchawana Bay and in Pigeon Bay at the Canadian-U.S.A. border at the western end of Lake Superior. Both deep water and shore sampling were carried out off the Big Gravel River in Nipigon Bay.

Shore sampling methods were identical to those described in Appendix 21 of the 1959-60 Annual Report. For deep-water sampling the anchor dredge described in Appendix 24 of the 1959-60 Annual Report was used. All ammocoetes captured alive were measured under anaesthetic (M.S. 222 Sandoz). All ammocoetes and associated fauna were preserved.

A map of Batchawana Bay showing the rivers mentioned, the limits of sampling and the distribution of sea lamprey ammocoetes is shown in Figure 1.

Regardless of their type, all shores lying within 2-1/2 miles of the mouth of Batchawana River and those within 1-3/4 miles of Sable River were checked. The shores ranged from mud through sand and gravel to coarse rocks and boulders. Ammocoetes were found in all these shore types within a radius of just over two miles from the Batchawana River mouth, and 1-1/2 miles of the Sable River. The population density of stony and rocky shores was similar to that of soft bottoms. From a total of 43,067 square yards of shore stations within 2-1/2 miles of the Batchawana River mouth, 74 sea lamprey ammocoetes were obtained, giving an average population density of 1.7 per 1000 square yards.

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

One area to the south of the Harmony River, where ammocoetes had not been found previously, yielded sea lamprey ammocoetes.

In deep water off the rivers Sable, Batchawana and Chippewa, 51 dredge

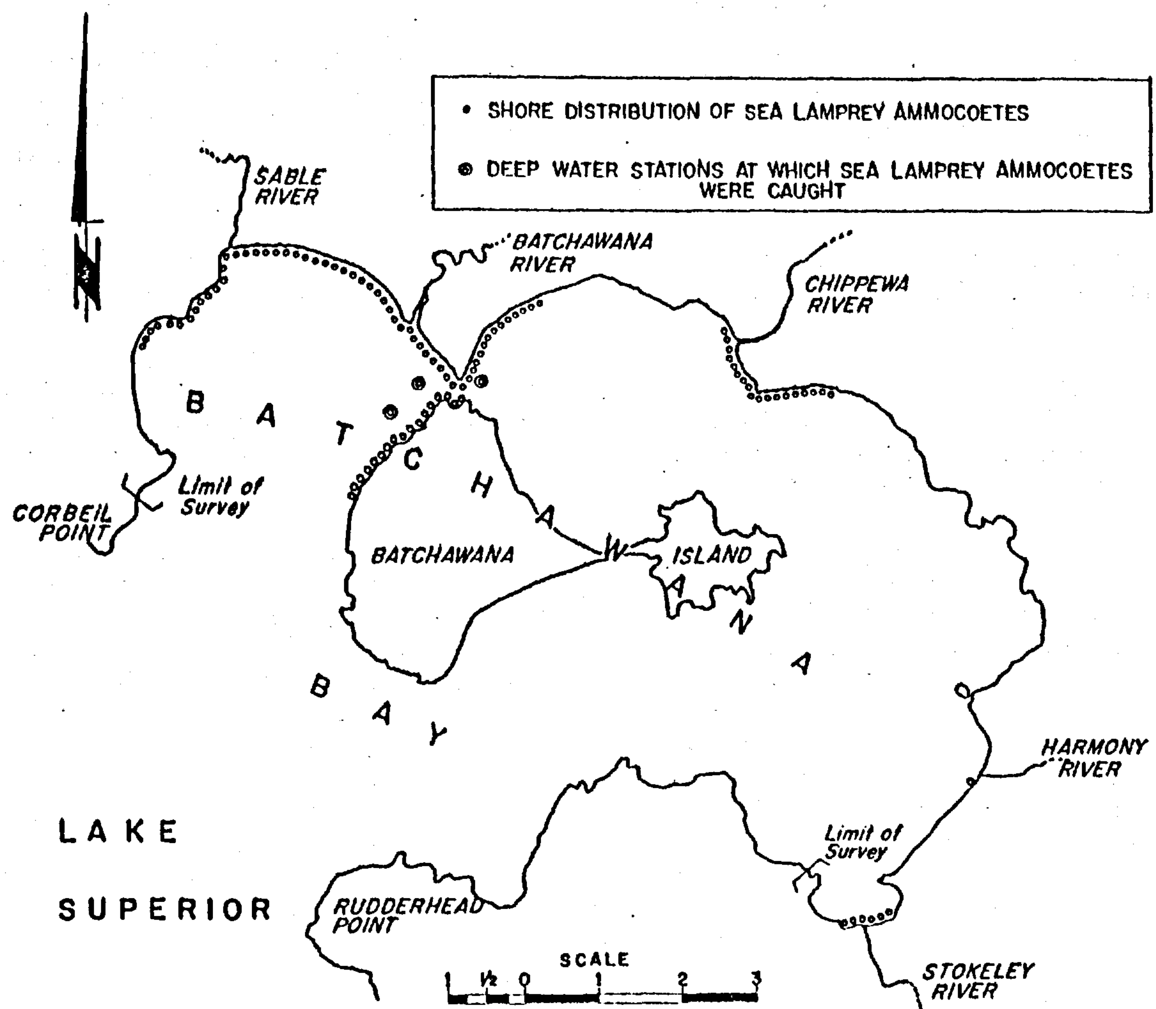

Fig. 1. Map of Batchawana Bay, Lake Superior, showing areas where sea lamprey ammocoetes were caught.

hauls were made in depths ranging from 17 to 124 feet. Three ammocoetes out of six collected were sea lamprey.

In Pigeon Bay, 30 dredge hauls in depths from 10 to 116 feet yielded no ammocoetes. No shore shocking was carried out.

Sand shores extending from both sides of the Big Gravel River mouth were investigated with the electric shocking technique. Silver lamprey and/or Michigan brook lamprey ammocoetes were present up to one-half mile from each side of the river, but sea lamprey ammocoetes were found at only one station, half a mile to the east of the river mouth.

Using the anchor dredge in deep water, 40 hauls were made in depths from 8 to 47 feet and five ammocoetes, three of which were sea lamprey, were obtained.

No evidence of lake spawning has been collected (see Appendix 14). The size of ammocoetes in the lake was proportional to their distance from the river mouth, and further evidence of their river origin was given by the relative abundance of the three genera which varies from river to river.

Eight lamprey-producing rivers flow into areas explored in this work. Sea lamprey ammocoetes were found off six of them in greatly varying numbers. It has been shown that in streams ammocoetes migrate downstream and that peak migrations occurred at times of high temperature and high water (see Appendix 33 of 1958-1959 Annual Report). In Venison Creek the average rate of migration was 1-1/2 (map) miles per annum. It would be expected, therefore, that where the spawning grounds lie within a few miles of the mouth a large number of ammocoetes in a stream would reach the lake. Two of the rivers in the area studied give evidence supporting this hypothesis. The Goulais River, where large spawning runs of sea lampreys have been recorded, is slow and meandering for many miles below the spawning grounds, producing abundant larval habitat. Very few ammocoetes have been found in the lake near to its mouth. At the other extreme is the Chippewa River which has all its spawning grounds within a mile of the lake. Although sea lamprey ammocoetes are scarce in the river itself, many were found in the lake adjacent to the mouth. Other rivers, such as the Batchawana, fall between these two extremes. It is likely, therefore, that large populations of sea lamprey ammocoetes occur in the open lake close to rivers where successfully utilized spawning grounds lie close to the mouth.

The age of ammocoetes reaching a river mouth is proportional to the distance up to the spawning grounds. The smallest larva found in the lake measured 36 mm, an individual probably in its second year. All the ammocoetes taken in the lake appeared healthy and fell within a normal range of sizes up to pre-transformation individuals. Since transforming specimens of other species were taken, there is no reason to suppose that transformation in the sea lamprey does not take place as usual.

The discovery of sea lamprey ammocoetes in Batchawana Island gave evidence that they traversed deep water. Evidence that they live there has been collected using poison and the anchor dredge. Due to difficulties in sampling a large enough area for a population estimate, numbers captured have been small. The numbers suggest, however, that ammocoetes may be as numerous in deep water as in the better sampled shore areas.

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M. L. H. Thomas Appendix 12

DIURNAL ACTIVITY IN SEA LAMPREY AMMOCOETES

Ammocoete migrations take place almost entirely during the hours of darkness. Nocturnal activity is also characteristic of newly transformed, feeding and spawning phase lampreys.

To gain more information on diurnal activity in ammocoetes, laboratory experiments are being conducted under conditions of controlled illumination, temperature and water flow in an artificial stream. Swimming movements of ammocoetes in the stream are detected using apparatus designed and built by Mr. J. Hoy of the London Station. Activity is recorded on a strip-chart recorder.

Preliminary experiments using a 12-hour illumination-darkness cycle and 10°C constant temperature have shown that, although there is not a great deal of movement, that which takes place shows a fairly constant pattern. Table I shows the pattern found during 21 days.

Table I. Periods of Activity at Times.

Darkness				Light
1800-2100	2100-2400	0000-0300	0300-0600	0600-1800
7	5	5	1	1

It has also been noted that the ammocoetes in the stream alter their burrow positions, both during illumination and during darkness, without leaving the sand. This must be accomplished by movement within the substratum.

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M. L. H. Thomas Appendix 13

GROWTH OF SEA LAMPREY AMMOCOETES IN VENISON CREEK

During 1957 and 1958, ammocoete studies were carried out mainly in the Big Creek watershed. Big Creek flows into Lake Erie in Long Point Bay. The results of this work, which have been reported in Appendix 33 of the 1958-59 Annual Report, showed the value of large repeated samples for growth and age studies. Sampling has been continued during the winters 1959-60 and 1960-61 in Venison Creek, a tributary of Big Creek.

Both this study and investigations carried out in the U.S.A. have shown that growth rate in sea lamprey ammocoetes is very variable, both within a single stream and from stream to stream. In Venison Creek ammocoetes hatched in 1960 had reached lengths from 23 to 36 mm by mid-January, 1961; those a year older varied between 38 mm and 70 mm. In older year-classes there is considerable overlap, making interpretation of length-frequency distributions difficult. Such differences in growth rate probably result in differing ages of ammocoetes at transformation.

Growth of ammocoetes during the winter months was very slight, and in the smallest ammocoetes a shrinkage of about 16% in length was observed between the end of November 1960 and the end of January 1961.

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M. L. H. Thomas Appendix 14

LAMPREY LAKE SPAWNING SURVEY 1960

During a survey in 1959 (see 1959-60 Annual Report, Appendix 22), several structures closely resembling sea lamprey nests were found in a gravel shore on Batchawana Island. At the site, lake currents of considerable magnitude made conditions quite river-like. The area was closely watched in 1960 from May 18 to July 31, during which period the temperature fluctuated between 39°F and 68°F. No sea lampreys were observed in the area during this time and evidence was obtained to indicate that the lamprey nest-like structures were produced by floating logs ground against the shore by wave, current and seiche action.

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M. L. H. Thomas Appendix 15

FAUNA OF BATCHAWANA BAY SHORES

Collections of fauna were made at all ammocoete survey stations, since some indication of suitability to ammocoetes may be given by the presence or absence of some species. Identifications of the following groups have been completed.

Fish

Table I shows the occurrence of the more abundant species of fish in terms of the number of stations, of the total of 47, at which they were caught.

Table I. Frequency of occurrence of common shore fish in Batchawana Bay, Lake Superior, 1960.

Species	No. of stations of total 47 at which present
Ichthyomyzon (Michigan brook lamprey or silver lamprey)	30
Sea lamprey	28
American brook lamprey	29
Longnose dace	16
Spottail shiner	10
Sand shiner	12
Bluntnose minnow	13
Johnny darter	45
Muddler	41

Crayfish

Two species, *Orconectes virilis* and *O. propinquus*, are common in the bay. *O. virilis* was taken at 24 stations and *O. propinquus* at 23.

Caddis Larvae

Limnephilus spp. and Pycnopsyche spp. were common.

Dragonfly Nymphs

On muddy and sandy shores Macromia spp. were common, and Cordulegaster spp. and Hagenius spp. were also found.

Stonefly Nymphs

On rocky shores Acroneuria spp. were abundant.

Mayfly Nymphs

Baetisca spp. were common on many muddy shores.

Mollusca

The Sphaeriid Sphaerium striatinum f. acuminatum was common at sandy stations. The Unionids Anadonta grandis and Ellipto complanatus were common at many stations, as was the Gastropod, Campeloma decisum.

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M. L. H. Thomas Appendix 16

FAUNA OF OFFSHORE SOFT BOTTOMS IN PIGEON BAY, MOUNTAIN BAY AND BATCHAWANA BAY, LAKE SUPERIOR

Soft bottoms of Pigeon Bay in the vicinity of the mouth of the Pigeon River, Mountain Bay in the vicinity of the mouths of the Big and Little Gravel Rivers, and Batchawana Bay in the vicinity of the mouths of the rivers Chippewa, Batchawana and Sable have been sampled using an anchor dredge. The main purpose of the sampling was to investigate the distribution of ammocoetes. In addition to the ammocoetes, all fauna obtained by the dredge was preserved and most of it has been identified.

Batchawana Bay is a relatively warm sheltered body of water, summer surface temperatures reached the mid-seventies, the thermocline in July was between 85 and 95 feet; water below it was about 43°F. Fifty-one dredge hauls were made in the bay in depths ranging from 17 to 124 feet. In all hauls deeper than 35 feet bottoms were mainly soft mud, in shallower water sand predominated.

Mountain Bay is part of the relatively shallow and protected Nipigon Bay and the water was warmed to the bottom. Surface temperatures in August were up to the low seventies. The bottom at most stations deeper than 12 feet consisted of a mixture of fine sand, mud and grey clay. Forty hauls were made in depths from 8 to 47 feet.

Pigeon Bay has a steeply sloping bottom into very deep water and is quite exposed. No well-established thermocline existed in August and surface temperatures, except in shallow water, were in the high forties. At most stations bottom temperatures were about 43°F. Thirty hauls were made at depths from 10 to 116 feet in a bottom of predominately soft brown mud. At some stations near to the river mouth large deposits of bark fragments were present.

Identifications of the following groups have been completed.

Fish

The anchor dredge is not an efficient method for collecting fish; however, 11 species have been caught in Batchawana Bay, mostly in water less than 35 feet deep. Johnny darters and muddlers were most abundant. In Pigeon Bay, muddlers and ninespine sticklebacks were caught, and in Mountain Bay muddlers and brook sticklebacks. Ammocoetes of all genera occurring were caught in Batchawana and Mountain Bays.

Crustacea

Isopoda were not abundant at any locality. Both *Asellus* spp. and *Lirceus* spp. have been taken in Batchawana Bay. *Asellus* spp. only were taken in Mountain Bay, and *Lirceus* spp. only in Pigeon Bay.

The Amphipod *Pontoporeia affinis* was frequently the most abundant animal at the deeper stations in Batchawana Bay. It was also common in Pigeon Bay, being taken at 21 of the 30 stations. In Mountain Bay it was present at many of the deeper stations. *Gammarus pseudolimnaeus* was taken in small numbers in all three bays. In Batchawana Bay *Hyalella azteca*, *G. fasciatus* and *Crangonyx gracilis* have also been taken.

Decapoda are not common in the collection; the only species caught were from Batchawana Bay. In water less than 35 feet deep *Orconectes virilis* was frequent and *O. propinquus* rare.

Mysis relicta was taken at two stations in Pigeon Bay.

Insecta

Ephemeroptera nymphs were abundant in many collections in both Batchawana Bay and Mountain Bay, but were only present at one station in Pigeon Bay. The dominant species in Batchawana Bay was *Hexagenia occulta*; *H. rigida* and *Ephemera simulans* were frequent. In Mountain Bay also *Hexagenia* spp. were most common.

Mollana spp. larvae were the most common members of the Trichoptera from both Batchawana and Mountain Bays in water less than 35 feet deep. Only one Caddis larva was collected in Pigeon Bay. In Batchawana Bay member of the Phryganeidae, Helicopsychidae, Limnephilidae, Psychomyiidae and Lepidostomaridae were also taken but were not common. Trichoptera were common at stations about 35 feet but rare at greater depths.

Members of the Dipteran sub-family Tendipedinae (=Chironominae) were frequently abundant at muddy stations in all three bays.

Mollusca

In water less than 35 feet deep in Batchawana Bay molluscs comprised the bulk of most collections. Sixteen species of Gastropods, 11 of Sphaeriids and 5 of Unionids were collected. The most common Gastropods were _Limnaea_ _(Stagnicola)_ _emarginata_ _canadensis_, _Gyraulus_ _deflectus_, _Helisoma_ _anceps_, _Valvata_ _sincera_ _nylanderi_ and _V._ _tricarinata_. At stations above the thermocline the Sphaeriid _Sphaerium_ _stratinum_ was abundant, and in deeper water _S._ _nitidum_ and _Pisidium_ _idahoense_ _f._ _indianense_ were frequent. The Unionids _Anadonta_ _grandis_ and _Lampsilis_ _siliquoidea_ were frequently abundant in water less than 35 feet deep. No Unionids were collected in Mountain Bay and Pigeon Bay. In Pigeon Bay, Sphaeriids were the dominant fauna in several collections; _Sphaerium_ _nitidum_ was abundant and _Pisidium_ _lilljeborgi_ and _P._ _idahoense_ _f._ _indianense_ were frequent. In Mountain Bay, _P._ _idahoense_ _f._ _indianense_ was the only common Sphaeriid. Gastropods from Pigeon and Mountain Bays have not yet been identified.

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