

SH
223
A120
1960/61

CONFIDENTIAL
Material in this report
is not to be quoted with-
out explicit permission.

Fisheries Research Board of Canada

ANNUAL REPORT

OF THE

BIOLOGICAL STATION

London, Ontario

for the period

APRIL 1, 1960 to MARCH 31, 1961

BY

W. A. KENNEDY

Director

With Investigators' Summaries as Appendices

SH
223
A120
1960/61

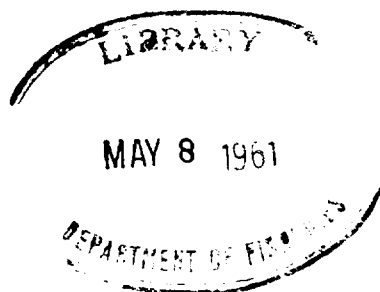
FISHERIES RESEARCH BOARD OF CANADA

ANNUAL REPORT

of the

BIOLOGICAL STATION

LONDON, ONTARIO



for the period

April 1, 1960 to March 31, 1961

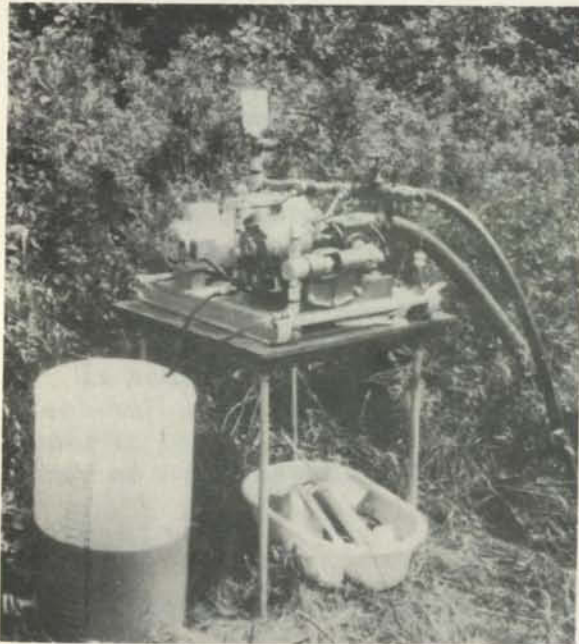
by

W. A. Kennedy, Director

With Investigators' Summaries as Appendices



1



2



3

Sea Lamprey Control - Chemical Unit

1. Living and cook trailer in the field.
2. Centrifugal and chemical proportioning pumps.
3. Lampricide feeder unit on "Unimog".

Fisheries Research Board of Canada
Report of the Biological Station, London
for 1960-61

by W. A. Kennedy

The Biological Station at London is exclusively concerned with fresh-water fisheries problems, and more particularly those of central Canada. Its own program is primarily directed at establishing the basic biological principles requisite to the sound management of the fisheries of inland lakes. The Station also carries out an experiment in sea lamprey control in the Canadian waters of the Great Lakes, and conducts associated research, in fulfillment of a contractual agreement between the Fisheries Research Board and the Great Lakes Fishery Commission.

Administrative headquarters of the Station are in a rented two-storey building at 539 Richmond Street, London, Ontario, which is shared with the London Technological Unit. To further the analysis of data and conduct of experimental work, facilities include a library, a newly established I.B.M. centre where data may be punched onto cards for machine sorting and tabulation, equipment for determining the ages of fish from their scales, several laboratories suitable for experimentation with live fish including one equipped to handle radioisotopes, and associated shops. The building serves, too, as a base for most field parties although satellite substations are also maintained for this purpose. A relatively large warehouse and workshop at Sault Ste. Marie, Ontario accommodates lamprey control crews who are permanently stationed in that area. Smaller warehouse-workshops at Wawa and Nipigon, Ontario are used seasonally by these crews. A sizeable field station at Heming Lake in northern Manitoba is occupied seasonally for research on the fish populations of the lake. A field station at Hay River, N.W.T. is permanently occupied in connection with research on Great Slave Lake.

In addition to a number of small boats, the Station has two 45-foot steel-hulled, diesel-powered motor vessels. The *Cottus* is used on Lake Superior in lamprey and fishery problems, and the *Stenodus* is used in a study of the Great Slave Lake fisheries.

HEMING LAKE

Trienophorus Control:

No specimens of the tapeworm, Trienophorus crassus, were found at Heming Lake in 1960, either as adults in the intestines of northern pike or as immature stages in the flesh of lake whitefish. This further confirms the effectiveness of heavy fishing for pike as a method of controlling this parasite in this lake as reported last year. It seems unlikely now that the lake could become re-infested even if control fishing were discontinued, and confirmation of this belief will be sought during the course of the population studies now being inaugurated.

Population Studies at Heming Lake:

One of the basic problems of fisheries biology is to develop accurate methods of predicting the availability of fish stocks from year to year. Despite much effort, on a world-wide basis, no very satisfactory solutions have been proposed. The most promising approach has involved the development of mathematical models of fish populations. Essentially, such models comprise a series of equations the terms of which are the many factors, both natural and imposed by man's activities, which could affect the fish population. The solution to this set of equations is then a prediction of the future strength of the stock.

Obviously, the usefulness of such a model depends on its appropriateness and completeness. Thus, misunderstanding of the mode of action or interaction of factors or the complete omission, through ignorance of their existence, of factors which are, in fact, important will result in a model which does not correspond to reality and cannot provide consistent, accurate predictions. Equally obviously, a completely appropriate model will only be useful when the various factors considered by it can be expressed quantitatively and measured with appropriate precision.

It seems probable that comprehensive and realistic models can be more readily developed for the small, discrete populations of minor lakes than for the large, diffuse, and often complex populations of major lakes and the oceans. It may well be that their dynamics are fully as complex, but the populations themselves are undeniably much more accessible to intimate study and even manipulation. Indeed, it may be possible, in certain waters, to capture, and permanently identify by tag, virtually every fish resident in the lake, thus starting the investigation with what amounts to a known population. Such a program was begun in 1960 at Heming Lake, which is not only small enough to be well suited but has already been continuously studied, in detail, since 1945.

During the first year of this new study, effort has been concentrated on the development of methods for the live capture and tagging of fish, with appropriate measurements and to permanently screening off inlet and outlet to ensure there will be no migration into or out of the lake.

GREAT SLAVE LAKE FISHERY

The commercial fishery of Great Slave Lake has been continuously studied since its inception in 1945, both to provide information of use to the Department of Fisheries in managing the lake and to document the changes brought about in a previously unexploited population by a commercial fishery. Most fishermen are interviewed daily to get information on catch per net and samples of their catches are taken periodically to get information on average size and age of fish taken. Confirmation and extension of the interviews is obtained through first-hand observation of the fishing operations employing the Station vessel *Stenodus* in the summer and a bombardier in the winter. In analysis the data are segregated by fishery, winter or summer, and by arbitrarily established statistical

divisions for each of which catch per net and average size are computed. Preparations have been made to record these data on I. B. M. punch cards in future so that analyses may be carried out more quickly.

The data from 1960 indicate little significant change in the average size of lake trout or lake whitefish since 1959. Thus, the relatively stable size composition reported for some years now has continued.

A recent review of data obtained earlier by tagging indicates that the great majority of the tagged fish recaptured have remained in the statistical area in which they were tagged. This distributional stability supports the utility of statistical areas for scientific study and of administrative areas for management by quotas.

LAKE SUPERIOR FISHERIES

Under the direction of the Great Lakes Fishery Commission, an international effort is being made to control the sea lamprey in the Upper Great Lakes where it has exterminated the lake trout of Lakes Huron and Michigan, and seriously depleted those of Lake Superior. If the sea lamprey control program is successful, it is hoped that the remnants of the Lake Superior trout stock will repopulate the lake in natural fashion. However, rehabilitation of the trout of Lakes Huron and Michigan will require heavy restocking programs. To speed the rehabilitation of Lake Superior stocks and to work out the techniques for use on Huron and Michigan, the Province of Ontario, the States of Michigan and Wisconsin and the U.S. Fish and Wildlife Service, co-ordinated by a Committee of the Great Lakes Fishery Commission, have been stocking approximately 1,000,000 marked yearling lake trout a year into Lake Superior. Research agencies on both sides of the lake have been studying the declining remnant of the native trout stock and gathering information to assess the success of the plantings. This Station has contributed by carrying out the studies in the Canadian waters of the lake.

Data are collected from the commercial fishermen, and to some extent from other sources, on catch per unit of effort and on the size and age distribution of the catches as well as the incidence of lamprey-marked and planted fish. For purposes of comparison, data are segregated as coming from the seven statistical areas arbitrarily set up by the Ontario Department of Lands and Forests and used by that agency in the collection of general catch and effort statistics from the fishery.

Both catch and catch per unit of effort continued to decline sharply in 1960 and the industry appeared close to the breaking point. In western lake Superior all indices pointed to a considerable worsening of the situation, while in the east there was some amelioration. Planted fish have not yet made a significant contribution to Canadian commercial landings, but do comprise 13% of the sublegal portion of the catch. Evidence was obtained to show that plantings made by the Province of Ontario in eastern Lake Superior were less successful than those made in the western end of the lake.

RADIOISOTOPES

Work was continued in 1960 on the use of radioisotopes as a means of marking living fish and lampreys so that they may be subsequently identified. Apparatus was designed to permit rapid accurate radio-assay of living fish and then employed to investigate, in detail, the suitability of injected Iron-59 and Caesium-137 as fish marks. Both isotopes were shown to be suitable marks for eastern brook trout, with effective half-lives of the order of 45 days. Thus, the mark would be detectable for about a year. It was also shown that ammocoetes of the American brook lamprey take up Caesium-137 from solution and retain it, thus becoming marked without the necessity of injection.

LAMPREY CONTROL EXPERIMENT AND ASSOCIATED STUDIES

Lamprey Barriers:

Lamprey barriers are devices, installed in streams used by sea lamprey for spawning, which create an impenetrable electrical field in the water. Adult lampreys ascending the streams are thus prevented from reaching their spawning grounds, many being killed in the attempt. Operation of these devices on the spawning streams on both sides of Lake Superior constituted the only method of lamprey control until 1958, when the use of chemical lampricides to destroy larval lampreys in the streams was successfully field tested. In 1960 the latter technique became the principal method of control and the barriers were relegated to the role of devices for sampling the lamprey runs and thus assessing the success of the control measures. In consequence, the number of barriers in operation during the run was reduced from 19 to 10 and the period of operation reduced somewhat to minimize the danger of severe and costly damage from early spring floods. A total of 4810 adult sea lampreys were recovered from these 10 barriers in 1960 compared to 3374 from the same 10 barriers in 1959. All but one of the streams shared in the increase.

Lamprey Surveys:

In view of this evidence that sea lampreys are still increasing in numbers in Lake Superior, it is necessary to systematically re-examine streams that were previously recorded as free from lampreys. Two hundred and thirty tributaries to the lake were resurveyed in 1960. Sea lamprey larvae were found in 10 streams for the first time. Of these, nine were small streams tributary to Batchawana Bay in eastern Lake Superior. The larval populations in these streams were small and found close to the mouths of the streams, evidence that they have, in all probability, been derived by immigration from the known larval populations in the open waters of the bay. The very extensive population discovered in the Black Sturgeon River, tributary to western Lake Superior, clearly resulted from spawning in that stream.

Detailed surveys were carried out on both Lake Superior and Lake Huron streams in connection with their treatment with lampricide.

Pre-treatment surveys to determine the distribution of sea lamprey ammocoetes in the rivers to be treated were carried out on four Lake Superior and eight Lake Huron streams in 1960. Post-treatment surveys to detect survivors of the chemical treatments were carried out on four Lake Superior and four Lake Huron streams in 1960.

Chemical Treatments:

The discovery by the U.S. Fish and Wildlife Service of the number of closely related chemicals which are toxic to lampreys but much less so to most species of fish has resulted in the acceptance, in the period since 1958, of chemical treatment as the principal method of sea lamprey control. Treatment of a stream will kill adult sea lampreys, if they are in the stream at the time, but the method is primarily aimed at destroying young, larval lampreys, which are usually resident in the stream in which they were spawned. It has the advantage of providing much more immediate control than do the electric barriers which prevent further recruitment to the existing lamprey population but leave it unharmed to live out its span.

A fundamental requirement in using a lampricide is proper control of the concentration in the stream. If the concentration is too strong, it kills both lampreys and fish; if too weak, it kills neither. The range of concentration which will kill lampreys but not fish varies with temperatures and also varies from stream to stream in an unpredictable way. The diluting effect of tributaries must be taken into account in planning a lampricide treatment and an unpredicted rain storm can dilute the treated stream water enough that the treatment is ineffective and must be repeated.

Among the preparations for treatment with lampricide is a careful survey of the watershed to determine the distribution of the ammocoetes, since the lampricide must be applied above the highest point at which ammocoetes occur in each tributary. It is also necessary to find how fast the water moves down each tributary to be treated; this is determined by making several trials in which a fluoresceine dye is released in the upper part of the stream and the time it passes various points is noted. The rate at which the stream flows is determined by standard instruments. The minimum concentration likely to kill ammocoetes and the maximum concentration which will likely spare the fish is determined by bio-assay. For that purpose, stream water is used to make up different concentrations of lampricide: fish and ammocoetes are kept in each of the resulting solutions at stream temperatures to see whether they live or die. The bio-assay must be made just prior to treatment, since the concentration required one week is not necessarily the same as that required another.

With all these facts at hand, decisions are made on the place or places that lampricide will be applied, the rate at which it will be applied and the time for which it will be applied. Sometimes transportation to the point of application is a major problem. Standard proportioning pumps are used to apply the lampricide at a predetermined rate. The stream water is analysed frequently to determine whether the expected concentration is in fact being maintained; if it is not, the pumps are adjusted. The chemical is fed in for the allotted time, generally about 18 hours. It may take several days for the treated water to move

downstream to the river mouth. As it moves slowly along, ammocoetes become irritated enough that after about an hour they leave their burrows, and after another hour or two most of them are dead. Although the number killed is spectacular, it is unlikely that all are killed, and indeed there is some evidence that a small proportion do survive, probably in tributaries and backwaters which the chemical does not reach.

During 1960, in successful execution of the agreement with the Great Lakes Fishery Commission, eleven Lake Superior and seven Georgian Bay tributaries were treated with lampricide. This completed the first cycle of treatments for Lake Superior with the exception of that of the Chippewa River. Only the Nottawasaga River remains to be treated in Georgian Bay. Substantial improvements were effected in the technical aspects of many phases of the operation, particularly in the conduct of bio-assays.

Lamprey Physiology:

Various aspects of sea lamprey physiology have been under investigation since 1956 to provide scientific information likely to be useful. Studies of the tolerance of lampreys to high temperature begun in 1959, were extended in 1960 by the systematic investigation of all phases of the life history from egg to spawning adult. The data obtained indicate that sea lampreys are comparatively resistant to the effects of high temperature except at the very beginning of their lives, in the early stages of egg development, and again at the very end when as spawning adults they have begun the physiological degeneration which normally leads to their post-spawning death.

Ammocoete Biology:

The demonstration, in 1957 and 1958, that sea lamprey ammocoetes (young larval lampreys) could be destroyed in streams by chemical treatment led to the use of this technique as the principal method of sea lamprey control. To be successful it was obvious that most, if not all, ammocoetes must be resident in the stream in which they were spawned and thus be vulnerable to treatment. Unfortunately, it was known from earlier work (1955) of the Station that ammocoetes could be found in the open waters of the lake in the vicinity of the mouths of at least some spawning streams. Accordingly, it became imperative to determine how widespread and abundant these lake dwelling populations were and investigations into this phase of ammocoete biology were begun in 1958 and greatly extended in 1959.

Work carried out in Batchawana Bay, Lake Superior, in 1959 demonstrated the occurrence of sea lamprey ammocoetes in sandy and muddy bottoms in both shallow and deep waters within a radius of a mile or two of the principal spawning streams entering the bay. Population density was of the order of one ammocoete per 1000 square yards. These observations were confirmed in 1960 and extended by the discovery that ammocoetes were equally common on hard bottoms ranging in type from gravel

to coarse rocks and boulders. Further, a similar situation was shown to occur in Nipigon Bay at the other end of Lake Superior. In all, the lake areas adjacent to eight lamprey-producing rivers were examined in this work and sea lamprey ammocoetes were found in six of them. It seems probable that this will be the rule whenever the spawning grounds utilized by the lampreys are not too far from the mouth of the stream.

Subsidiary studies of the biology and growth of ammocoetes have also been continued in 1960 to augment our information on this little-known phase of the life history. Growth has been shown to be highly variable from stream to stream and even within a single stream. In view of this variation, it seems probable that age at transformation, and hence the length of larval life, will also be variable.

PUBLICATIONS

- Hewson, L. C. A history of the Lake Winnipeg fishery for whitefish, *Coregonus clupeaformis*, with some reference to its economics. J. Fish. Res. Bd. Canada, Vol. 15, No. 5, pp. 625-639, 1960.
- Kennedy, W. A. Richard Birnie Miller, 1915-1959. (Obituary.) J. Fish. Res. Bd. Canada, Vol. 16, No. 4, pp. 387-390, 1959.
- Kennedy, W. A. Commercial fisheries utilization. In Land - Forest - Wildlife Conference, February 8 & 9, 1960: Transcripts, pp. 123-127.
- Kennedy, W. A. Freshwater fisheries research. Annual Review, Fisheries Council of Canada, pp. 25 & 27, 1961.
- Lawler, G. H. A mutant pike, *Esox lucius*. J. Fish. Res. Bd. Canada, Vol. 17, No. 5, pp. 647-654, 1960.
- Lawler, G. H., and G. P. McRae. A method for preparing glycerin-stored otoliths for age determination. J. Fish. Res. Bd. Canada, Vol. 18, No. 1, pp. 47-50, 1961.
- McCauley, R. W. Ontario's sea lamprey fishery. Canada Department of Fisheries, Trade News, Vol. 13, No. 4, pp. 6-7, 1960.
- McCauley, R. W. The role of electrical conductivity of water in shocking lampreys (*Petromyzon marinus*). J. Fish. Res. Bd. Canada, Vol. 17, No. 4, pp. 583-589, 1960.
- McCauley, R. W., and D. P. Scott. Removal of free chlorine from running water by sodium thiosulphate. J. Fish. Res. Bd. Canada, Vol. 17, No. 4, p. 601, 1960.
- Smith, Manning A., Vernon C. Applegate, and B. G. H. Johnson. Colorimetric determination of halogenated nitrophenols added to streams as sea lamprey larvicides. Analytical Chemistry, Vol. 32, No. 12, pp. 1670-1675, 1960.

- Thomas, M. L. H. A modified anchor dredge for collecting burrowing animals. *J. Fish. Res. Bd. Canada*, Vol. 17, No. 4, pp. 591-594, 1960.
- Vladykov, Vadim D. Description of young ammocoetes belonging to two species of lampreys: *Petromyzon marinus* and *Entosphenus lamottenii*. *J. Fish. Res. Bd. Canada*, Vol. 17, No. 2, pp. 267-288, 1960.
- Watson, N. H. F., and J. L. Price. Experimental infections of cyclopoid copepods with *Trianaenophorus crassus* Forel and *T. nodulosus* (Pallas). *Canadian Journal of Zoology*, Vol. 38, No. 2, pp. 345-356, 1960.

REPORTS

- Lawler, G. H. A history of an intensive fishery on Heming Lake, Manitoba. Presented at the 22nd Midwest Fish and Wildlife Conference, Toronto, December 5-7, 1960, 4 pp. Mimeographed.
- Smith, G. F. M. The next ten years at Heming Lake. Presented at the 22nd Midwest Fish and Wildlife Conference, Toronto, December 5-7, 1960, 5 pp. Mimeographed.

STAFF LIST ARRANGED TO SHOW ORGANIZATION AND ASSIGNMENTS

(April 1, 1960 to March 31, 1961)

ADMINISTRATION AND STENOGRAPHIC POOL

Director	W. A. Kennedy, Ph.D.
Senior Scientist	A. H. Lawrie, M.A. (Ass't Director)
Administrative Officer 2	R. B. Rush (Executive Assistant)
Administrative Ass't.	R. S. Williams
Clerk 3	K. L. Cuthbert
Clerk 1	Patricia M. Purchase (to Nov. 11)
Clerk 1	Carol A. March (from Nov. 16)
Clerk 1	J. W. Morrison
Clerk 1	Vilma Rikters
Stenographer 2	Emiliana Davis
Stenographer 2	Enid C. Dolan
Typist 2	Kathleen R. G. Dinn (to Nov. 4)
Typist 1	Caroline Boam (from Nov. 7)
Maintenance Helper	M. Thomas

SERVICESDrafting Service:

Assistant Technician 3

S. T. Zettler (from Nov. 1)

Library:

Technician 1

Annabelle R. Taylor, B.Sc.

Scale Reading:

Assistant Scientist

V. J. Wynne, B.Sc. (to July 29)

Assistant Technician 1

D. F. Devine (to Dec. 31)

Assistant Technician 1

Patricia A. Mayman (to May 31)

Assistant Technician 1

Edna M. Reyce (Apr. 4-7)

Assistant Technician 1

Barbara M. Pulham (from Feb. 1)

Assistant Technician 1

Katie M. Kennedy

Assistant Technician 1

W. Lech (to Aug. 31)

Assistant Technician 1

J. A. Myatt (from May 2)

Assistant Technician 1

Mary E. Regan (from June 1)

Assistant Technician 1

Irene D. Weir (from Nov. 1)

Divers:

Assistant Technician 3

P. J. McPherson

Assistant Technician 3

S. P. Rudicavitch (to Apr. 30)

Punch Cards

Clerk 2

A. Eleanor Gough (from Mar. 1)

Clerk 2

Lorraine J. Hamilton (from Mar. 1)

M. V. Cottus:

Technician 1 i/c

W. M. Ransbury

Assistant Technician 3

L. R. Golden

Assistant Technician 3

H. B. Chisholm (Apr. 20-Nov. 4)

INVESTIGATIONSPopulation Dynamics:

Principal Scientist i/c
Associate Scientist
Assistant Scientist

G. F. M. Smith, Ph.D.
G. H. Lawler, Ph.D.
N. H. F. Watson, M.A. (to Feb. 15)

Assistant Technician 3
Student Assistant
Student Assistant
Student Assistant
Camp Cook
Camp Cook

G. P. McRae
R. J. McLeod (May 2-Sept. 19)
B. E. Meeker (May 12-Sept. 14)
J. Solohub (May 12-Sept. 12)
Enid Campbell (May 1-Sept. 14)
Ella Hedin (Oct. 20-Nov. 11)

2 Casuals (35 man-days)

Great Slave Lake:

Associate Scientist i/c

J. J. Keleher, M.A.

Technician 2
Assistant Technician 3
Clerk 1
Clerk 1

K. G. Roberts
C. G. Haight
Norma Bond (Apr. 1-Apr. 22)
Marlene E. Kennings (May 16-Jan. 2)

Student Assistant
Student Assistant
Student Assistant
Student Assistant
Student Assistant

F. O. Bastian, B.A. (May 16-Sept. 20)
R. P. Francis, B.A. (May 16-Sept. 17)
P. H. Heese, B.A. (June 2-Sept. 3)
D. A. Pringle, B.A. (June 2-Sept. 16)
J. W. Snarr (June 2-Sept. 16)

Lake Trout - Lake Superior:

Assistant Scientist i/c

A. Rojo, Ph.D.

Technician 2
Assistant Technician 3
Assistant Technician 3
Assistant Technician 3

R. M. Hanson
C. C. Parker (from Dec. 5)
A. G. Ryder (from Dec. 5)
T. P. Van Dyk (from Nov. 21)

Radioisotopes:

Associate Scientist i/c
Technician 1

D. P. Scott, Ph.D.
J. Hoy

Lamprey Taxonomy:

Principal Scientist V. D. Vladykov, Ph.D. (May 1-Sept. 28)

LAMPREY CONTROL EXPERIMENTLamprey Physiology:

Assistant Scientist i/c R. W. McCauley, M.A.
Student Assistant J. A. Sholdice (May 16-Sept. 16)

Ammocoetes:

Assistant Scientist i/c M. L. H. Thomas, B.Sc.

Lamprey Chemical:

Associate Scientist i/c J. J. Tibbles, Ph.D.
Assistant Scientist R. A. Bams, Drs. (transferred to
Nanaimo July 31)
Assistant Scientist H. Elizabeth Cormack, M.A.
Assistant Scientist S. M. Dustin, M.S. (from Nov. 4)
Assistant Scientist B. G. H. Johnson, M.Sc.
Assistant Scientist A. Lamsa, B.A.

Technician 2 J. R. Miron
Technician 2 D. L. Holmberg
Technician 1 F. R. Green
Technician 1 W. Pratt
Assistant Technician 3 R. W. Gibbons
Assistant Technician 3 M. J. McCarthy
Assistant Technician 3 C. M. Tiede
Student Assistant R. M. Christie, B.Sc. (May 2-Aug. 31)
Student Assistant D. P. Dodge (May 2-Aug. 31)
Student Assistant D. C. Marsh (May 16-Oct. 1)
Student Assistant D. O. Ziegler, B.Sc. (May 23-Sept. 1)
Assistant Technician 2 W. Paul (Sept. 19-Dec. 15)
Assistant Technician 2 G. N. Torrence (May 2-Sept. 15)
Cook J. A. Breckenridge (Apr. 29-Dec. 15)
Cook's Helper R. G. Breckenridge (May 10-Dec. 15)

L. B. O. U.

Technician 4 i/c A. W. Carter
Technician 2 J. D. Berridge (to Oct. 19)
Technician 1 R. L. Paul (to Aug. 31)
Technician 1 G. E. Smith

L. B. O. U. (continued)

Assistant Technician 3
 Assistant Technician 3
 Assistant Technician 3
 Assistant Technician 3
 Storeman 2

Assistant Technician 3
 Assistant Technician 3
 Assistant Technician 3

Assistant Technician 3
 Assistant Technician 3

1 Casual (49 man-days)

W. J. McGaughey (to Sept. 30)
 P. M. Neveau
 U. W. Dube (from Mar. 1)
 C. C. Rivers (from Mar. 1)
 L. King

C. Beckett (Apr. 19-Aug. 17)
 Y. Desjardin (May 2-Aug. 26)
 U. W. Dube (May 13-Sept. 6)
 (Sept. 26-Mar. 1)

A. A. Higo (Apr. 20-Aug. 17)
 C. C. Rivers (May 2-Dec. 29)

Engineering:

Associate Scientist i/c
 Technician 1

W. J. Lenson, B.Sc. E.E. (to Oct. 31)
 N. Boychuk (to Aug. 31)

INDEX TO APPENDICES

<u>Item</u>	<u>Appendix</u>	<u>Page</u>
Fish Names.		15
Fishing Effort and Pike Reduction at Heming Lake . .	1	16
Incidence of <u>Triaenophorus</u> in Northern Pike in Heming Lake	2	19
Incidence of <u>Triaenophorus crassus</u> in Heming Lake Whitefish	3	21
High Temperature Mortality of <u>Triaenophorus</u>	4	22
Ecto and Endoparasitic Observations on Heming Lake Fish	5	23
Wapun Lake Experiment	6	23
Taxonomic Studies at Heming Lake	7	24
Tagging Studies at Heming Lake.	8	24
Fish Fences at Heming Lake	9	26
The 1959-60 Winter Commercial Fishery at Great Slave Lake	10	26
The 1960 Summer Commercial Fishery at Great Slave Lake	11	27
The 1960-61 Commercial Winter Fishery at Great Slave Lake	12	28
Actual Observations on Summer Commercial Fishing. .	13	28
Some Results of Tagging Great Slave Lake Fish. . . .	14	29
Great Slave Lake Commercial Catch Regulations Review	15	29
Forecast of Lake Trout Production in Lake Superior .	16	30
Commercial Lake Trout Fishery in Lake Superior in 1960	17	31
Assessment of Planted Lake Trout in Lake Superior. .	18	33

<u>Item</u>	<u>Appendix</u>	<u>Page</u>
Experimental Catches from Superior Shoal	19	36
The Radioisotope Project	20	36
Maintenance and Operation of Electrical Barriers, Lake Superior, 1960	21	40
Sea Lamprey Survey, Lakes Superior and Huron, 1960	22	42
Bio-Assay Required for Pre-Treatment Information in Application of Chemical for Sea Lamprey Control	23	49
Stream Treatments with Lampricide, Lakes Superior and Huron, 1958-1960.	24	51
Streams Treated with Lampricide, Lakes Superior and Huron, 1960	25	61
Rearing of Lamprey Eggs	26	79
Rate of Gain of Heat Tolerance in Sea Lamprey Ammocoetes.	27	81
Upper Lethal Temperatures of Sea Lamprey Ammocoetes.	28	81
Lethal Temperature Relationships of Adult Sea Lampreys (Parasitic Phase).	29	83
Lethal Temperature Relationships of Adult Sea Lampreys (Spawning Phase).	30	83
Ammocoete Distribution in Lake Superior.	31	84
Diurnal Activity in Sea Lamprey Ammocoetes	32	87
Growth of Sea Lamprey Ammocoetes in Venison Creek.	33	88
Lamprey Lake Spawning Survey, 1960	34	88
Fauna of Batchawana Bay Shores.	35	89
Fauna of Offshore Soft Bottoms in Pigeon Bay, Mountain Bay and Batchawana Bay, Lake Superior.	36	90

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.

<u>Common name</u>	<u>Scientific name</u>	<u>Alternative common name(s)</u>
Sea lamprey	<i>Petromyzon marinus</i>	lamprey
Silver lamprey	<i>Ichthyomyzon unicuspis</i>	lamprey
Michigan brook lamprey	<i>Ichthyomyzon fossor</i>	lamprey
American brook lamprey	<i>Entosphenus lamottei</i>	lamprey
Rainbow trout	<i>Salmo gairdneri</i>	trout
Lake trout	<i>Cristivomer namaycush</i>	trout
Eastern brook trout	<i>Salvelinus fontinalis</i>	trout, brook trout, speckled trout
Inconnu	<i>Stenodus leucichthys</i>	...
Cisco	<i>Leucichthys</i> sp.	...
Lake whitefish	<i>Coregonus clupeaformis</i>	whitefish
White sucker	<i>Catostomus commersoni</i>	sucker
Longnose sucker	<i>Catostomus catostomus</i>	sucker
Longnose dace	<i>Rhinichthys cataractae</i>	dace or minnow
Spottail shiner	<i>Notropis hudsonius</i>	shiner or minnow
Sand shiner	<i>Notropis deliciosus</i>	shiner or minnow
Bluntnose minnow	<i>Pimephales notatus</i>	minnow
Brown bullhead	<i>Ictalurus nebulosus</i>	bullhead
Mudminnow	<i>Umbra limi</i>	...
Northern pike	<i>Esox lucius</i>	pike
Burbot	<i>Lota lota</i>	...
Ninespine stickleback	<i>Pungitius pungitius</i>	stickleback
Brook stickleback	<i>Eucalia inconstans</i>	stickleback
Trout-perch	<i>Percopsis omiscomaycus</i>	...
Yellow perch	<i>Perca flavescens</i>	perch
Yellow walleye	<i>Stizostedion vitreum</i>	walleye
Johnny darter	<i>Etheostoma nigrum</i>	darther
Muddler	<i>Cottus bairdi</i>	...
Miller's thumb	<i>Cottus cognatus</i>	...
American smelt	<i>Osmerus mordax</i>	smelt
Smallmouth bass	<i>Micropterus dolomieu</i>	bass
Pumpkinseed	<i>Lepomis gibbosus</i>	sunfish

FISHING EFFORT AND PIKE REDUCTION AT
HEMING LAKE

The original objective of the Heming Lake study begun in 1945 was to reduce the northern pike population to a level which would result in a significant decrease in the incidence of Triaenophorus crassus in the lake whitefish. The numbers of pike captured annually since 1945 are shown in Table I. The numbers of pike captured annually increased slowly during the early years of the fishery, but during the past five years increased at a startling rate until in 1960 over 7300 pike were taken. Part of the increase is accounted for by an increase in fishing effort, as fishing in the years prior to 1950 was restricted to one or two months in the early spring, whereas since 1950 intensive fishing has been carried on for approximately 4-1/2 months annually.

Table I. Catch of northern pike in Heming Lake, Manitoba.

<u>Year</u>	<u>Captured</u>	<u>Percent 18 inches in length and over</u>	<u>Pounds per acre</u>
1945	563	82	2.2
1946	571	58	1.8
1947	931	48	2.3
1948	705	56	1.9
1949	490	59	1.2
1950	1071	39	2.3
1951	1026	47	2.7
1952	1468	41	3.4
1953	1376	48	3.4
1954	1394	44	3.4
1955	1948	37	4.2
1956	2479	22	4.4
1957	3700	9	4.8
1958	7175	0.9	4.0
1959	2378	5.1	2.4
1960	7336	5.0	4.0 approx.

During the first few years of the study fishing effort was mainly confined to fishing hoop nets in or near creek mouths where pike were known to spawn. This type of fishing only removed the larger mature pike. Since 1950, when the fishery was vigorously expanded, more and more emphasis has been placed on the use of gill nets which permitted more flexibility in choice of mesh size. Trammel nets have proven useful in shallow areas when the pike were inshore.

The intensive fishing pressure exerted on the pike population in the

past few years has resulted in a decrease in the number of large pike in the lake. Whereas in 1951, 47% of the catch was composed of fish over 18 inches in length, in 1960 less than 5% of the catch exceeded this length. There was a marked increase in the catch of small-sized pike following the removal of the larger pike and it became necessary to fish more and more small mesh nets to keep pace with the production. The large mesh nets have been fished every year to compare with past catches, even though the yield from these nets did not justify the work involved in fishing them. The annual yields of pike since 1955 are shown in Table II.

Table II. Catch and fishing effort for pike during 1955-1960, Heming Lake.

<u>Year</u>	<u>Yield pounds</u>	<u>Pounds per acre</u>	<u>Fishing effort</u>	<u>Number of fish</u>
1955	2,496	4.2	45,100	1,926
1956	2,598	4.4	80,900	2,479
1957	2,823	4.8	150,000	3,700
1958	2,424	4.0	239,600	7,175
1959	1,481	2.5	246,000	2,343
1960	...	4.0 approx.	251,000	7,336

The yield of pike in pounds per acre during the period 1955 to 1958 remained relatively constant at approximately 4 pounds per acre, decreased to 2.5 pounds in 1959 and then increased again to approximately 4 pounds in 1960. The catch of pike in 1960 was nearly three times as great as in 1959, when 2300 pike were captured. Such a large increase in catch cannot be accounted for by increase in effort as 251,000 yards of gill net were fished, an increase of only 5,000 yards over 1959. It is assumed, until age determinations have been made, that the increase in catch has resulted from the presence of an unusually strong year-class. The length-frequency distribution showed that the greater part of the catch consisted of fish about 10 inches in length.

Other species of fish, associated either directly or indirectly with the pike, have been affected by the intensive fishing, as it is impossible in a small lake such as Heming Lake to discriminate between species with so many yards of gill net extant. When it became apparent that the populations were being inadvertently manipulated, it became a point of interest to see whether the fishing effort could be applied in such a way that yellow walleye would replace pike as the dominant predator. The attempt was unsuccessful and the walleye population has continually declined since 1954 when the spawning population of walleyes was almost completely wiped out when rapidly receding water left the spawning fish stranded on dry land. The catch of walleyes declined from 258 in 1959 to only 3 in 1960. The sucker population continued to increase in 1960 when 17,000 were removed (Table III).

Table III. Number of fish captured in Heming Lake 1950-1960.

<u>Species</u>	<u>1950</u>	<u>1951</u>	<u>1952</u>	<u>1953</u>	<u>1954</u>	<u>1955</u>	<u>1956</u>	<u>1957</u>	<u>1958</u>	<u>1959</u>	<u>1960</u>
Northern pike	1071	1026	1468	1376	1394	1948	2479	3700	7175	2378	7336
Lake whitefish	378	608	1201	1236	1053	1081	769	972	1990	611	165
White sucker	220	314	789	2085	1663	2444	3300	7013	9349	16716	17000
Yellow walleye	206	211	588	732	1495	1035	1380	1307	771	258	3
Yellow perch	125	112	91	494	394	490	985	1953	5485	5054	6252
Cisco	125	74	304	230	406	337	232	142	81	279	32
Burbot	57	...	...	59	31	44	59	171	277	590	585

Over 6,000 yellow perch were removed in 1960, an increase of 1,000 over 1959. The catch of burbot was approximately the same in 1960 as in 1959, when the catch was double the highest in any previous year. The catch of ciscoes and whitefish were the lowest ever recorded.

G. H. Lawler

Appendix 2

INCIDENCE OF TRIAENOPHORUS IN NORTHERN PIKE
IN HEMING LAKE

Both Triaienophorus crassus and T. nodulosus reach maturity in the intestine of the northern pike, so the annual examination of pike intestines provides a reliable index of the abundance of these parasites. Pike intestines of all pike captured between mid-August and September are carefully examined and the numbers of T. crassus and T. nodulosus recorded. The results of these examinations for the past nine years are shown in Tables I and II.

For the past three years no T. crassus parasites have been found in pike intestines. There is no doubt now but that the life-cycle of T. crassus in this lake has been broken. There cannot be much of a reservoir of T. crassus parasites in the flesh of coregonines, as no parasites were found in the 1960 samples. The decline in the infection in pike has resulted from an actual decline in the numbers of the parasites in lake whitefish, coupled with a reduction in the population of larger pike which maintain the life-cycle by eating infected coregonines.

Table I. The percentage of pike infected with T. crassus during the years 1952-60.

<u>Year</u>	<u>Percentage of infected pike containing <u>T. crassus</u></u>	<u>Percentage of all pike examined containing <u>T. crassus</u></u>
1952	14.2	9.7
1953	18.7	8.3
1954	14.7	9.7
1955	6.2	5.1
1956	1.2	1.1
1957	0.4	0.4
1958	0.0	0.0
1959	0.0	0.0
1960	0.0	0.0

Continued fishing pressure has resulted in a pike population, the average size of which is considerably under 15 inches. Previous reports have shown that very few pike under 15 inches carried T. crassus. At this stage, even if the fishing pressure was relaxed and assuming that there were still some parasites present in the whitefish, it is almost certain that the parasites would not be viable by the time the pike had grown to a size when they would be capable of eating the whitefish.

The fluctuations in abundance of Triaenophorus nodulosus have been followed in conjunction with the observations on T. crassus, as they both occur as adults in the gut of the pike. T. nodulosus has always been more prevalent than T. crassus and the difference is probably due to the pike's feeding habits. The yellow perch, burbot and miller's thumb all serve as intermediate hosts for T. nodulosus and the yellow perch and burbot are very common food items in pike stomachs. Pike can only obtain T. crassus by eating infected coregonines and these have never been found too frequently.

The incidence of T. nodulosus (Table II) was higher in 1960 than in the past two years, showing that there is considerable variation in infection in different years. In the nine years that the parasite population has been under investigation, there were two years, 1953 and 1958, in which less than 50% of the pike population contained T. nodulosus and two other successive years, 1956 and 1957, in which over 90% were infected.

Table II. The percentage of pike infected with T. nodulosus during the years 1952-1960.

<u>Year</u>	<u>Percentage of all pike containing <u>T. nodulosus</u></u>
1952	62.9
1953	38.8
1954	61.2
1955	81.5
1956	97.4
1957	94.5
1958	47.0
1959	77.0
1960	82.0

INCIDENCE OF TRIAENOPHORUS CRASSUS IN
HEMING LAKE WHITEFISH

The degree of infection of a lake whitefish with T. crassus is obtained by filleting the fish, slicing the fillet in thin sections and then carefully counting the number of cysts in each fillet. The rate of infection is calculated on the basis of the number of cysts per 100 fish and the number of cysts per 100 pounds. Following determination of the ages of the whitefish, the rate of infection for each year-class is calculated, making it possible to follow the infection level of each year-class while it remains in the fishery.

In the early years of the study the annual rate of infection was determined from whitefish samples taken in the spring and again in the fall. With continued increasing fishing effort after 1950, whitefish were taken throughout the entire fishing season and it has been possible to calculate weekly and monthly rates of infection. For year to year comparisons, only the total infection level is considered.

Heming Lake originally had an exceptionally high level of infection of 293 cysts per 100 pounds of fish and 521 cysts per 100 fish (Table I) when examined in 1945.

Table I. Rate of infection of T. crassus in Heming Lake whitefish for the years 1945-1960.

<u>Year</u>	<u>Number examined</u>	<u>Cysts per 100 fish</u>	<u>Cysts per 100 lbs fish</u>	<u>Per cent infected</u>
1945 ✓	263 -	521	293	82 ✓
1946	143	294	151	68
1947	226	243	159	68
1948	312	316	188	81
1949	181	347	194	83
1950	378	192	155	57
1951	608	168	172	56
1952	1201	201	160	56
1953	1236	181	222	38
1954	1053	360	594	38
1955	1081	262	385	41
1956	769	160	223	35
1957	972	43	82	14
1958	1988	5	15	3
1959	610	1.5	3	0.5
1960	165	0	0	0
1961	28	0	0	0

After the initial year of fishing the infection rate was 50% lower than it had been the previous year, and it was hoped at that time that a marked decrease in infection rate, resulting in improved quality of the whitefish, would be noted in the near future. This was not to be, however, as the infection level remained about the same, with very minor fluctuations until 1954 when the degree of infection took a sharp upswing with the number of cysts per pound, considerably greater than when the investigation started. Analysis of the age composition of the whitefish sample indicated that the 1949 and 1950 year-classes of whitefish were heavily infected and were the cause for the sudden increase in the infection level. These year-classes of whitefish in their very early years had received such large quantities of tapeworms that their presence in the fishery influenced the overall infection rate until 1957. The effect was still evident in 1959, when one large whitefish (5 lb) belonging to the 1950 year-class appeared in the catch and contained most of the tapeworms found that year.

In the years 1958 and 1959 it was reported that the T. crassus population was near extinction and less than 1% of the whitefish in 1959 contained tapeworms. In 1960 no infected whitefish were found and it is considered that the life-cycle of T. crassus in Heming Lake has been broken. The catch of whitefish was the lowest every recorded and was composed mainly of one and two year old fish, with very few from the older age groups. As these especially young fish contained no tapeworms and as there were no tapeworms found in pike in 1960, we feel that the life-cycle has been completely broken. In future years the whitefish population will be followed very closely to observe whether or not the Triaenophorus population will build up again in the lake and if it does, its growth will be followed as part of the population study.

N. H. F. Watson

Appendix 4

HIGH TEMPERATURE MORTALITY OF TRIAENOPHORUS

Several lines of investigation suggest that high temperatures may be a factor limiting the distribution of Triaenophorus spp. This has been postulated in the formulation of a line roughly corresponding to the 70° July isotherm. A possible mechanism of temperature control was found by another investigator, where viable procercooids in copepods died after short exposures to temperatures of 30-34°C.

Some data of a similar nature were collected in the summer of 1960. Eggs of T. crassus and T. nodulosus were exposed to temperatures of 24°, 29°, 30°, and 32°C for 48 hours. The numbers of viable, hatched and dead eggs were observed at 0, 6, 24, 30 and 48 hours from commencement of the experiment. Hatching rates were retarded and mortalities

were considerable in all samples compared to similar samples held in refrigerated storage. There is some indication that eggs would not hatch very successfully above 30°, as the eggs die at a rate that precludes any appreciable hatch. A report including the data determined from this experiment is on file.

G. H. Lawler

Appendix 5

ECTO AND ENDOPARASITIC OBSERVATIONS ON HEMING LAKE FISH

Although the study of Triacnophorus in its several hosts has been the main object of the study of fish parasites at Heming Lake, in recent years some attention has been given to recording the incidence of some of the common internal and external parasites.

Darkly pigmented cysts have been observed on the spottail shiner, yellow perch, burbot, darters, sculpins, pike, troutperch and suckers. Pike, troutperch and suckers appeared to have smaller numbers of these cysts than the previously mentioned species. Among the perch, pike and burbot populations, the smaller sized fish had heavier infections than the larger fish. This parasite has not been identified and has been described in the field as "black spot" disease.

The incidence of Ligula, an intestinal parasite, has been recorded in the sucker and spottail shiner populations. The parasite, although internal in nature, can be easily recognized in spottail shiners even without opening the fish as the parasite is so large in relation to its host that the belly region is usually badly distended.

By maintaining these observations over a period of years, it will be possible to learn whether there are unusual variations in abundance.

G. H. Lawler

Appendix 6

WAPUN LAKE EXPERIMENT

Wapun Lake, Manitoba is near the headwaters of the water system flowing into Heming Lake and limnologically seemed more suitable for coregonine fish than Heming Lake, yet none were found. Eyed eggs of lake whitefish were planted in Wapun Lake in 1951 and 1953 by the Fisheries Branch, Province of Manitoba, (1) to study the effectiveness of such an introduction in a lake formerly devoid of coregonines, (2) to follow the rise

and growth of a Triacnophorus population in a lake originally free of the parasite, and (3) to determine the effect that transplantation to a new environment would have on the morphometrical characters of whitefish. Both plantings were considered complete failures, as intensive fishing in subsequent years did not yield any whitefish. In 1959 another attempt was made to establish a whitefish population by planting newly hatched fry which had been flown to the lake by the Manitoba Fisheries Branch. When planted the fry appeared to swim vigorously away from the boat. It was expected that if these fish survived, they might have appeared in the catch in 1960; however, the experimental fishing carried out during the past summer did not yield any whitefish and for the present we must assume that the planting was again unsuccessful.

G. H. Lawler

Appendix 7

TAXONOMIC STUDIES AT HEMING LAKE

In 1959 taxonomic measurements were made on 100 burbot which have been appearing in increasing numbers in the catch during recent years. In attempting to analyze the results, we were unable to compare the Heming Lake burbot with other burbot populations as standard taxonomic measurements were recorded for the Heming Lake population, while in the published data a special set of measurements peculiar to burbot were used which were not compatible with our measurements. As most of the taxonomic studies on burbot have been centred in the central and northwestern regions of North America, it was felt that a good series of measurements from the central region of the fish's distribution would be of considerable value in further determining its taxonomic status. In the summer of 1960, taxonomic measurements were made on 160 burbot which will allow comparison with previously published information.

The catch of pike in Heming Lake was carefully observed and the occurrence of "silver" pike and/or possible crosses of "silver" x normal pike was noted.

G. H. Lawler
G. F. M. Smith

Appendix 8

TAGGING STUDIES AT HEMING LAKE

During the summer of 1960, as time permitted, some preliminary work was carried out to familiarize field crews with tagging and fishing techniques that would be used in the population studies to begin in 1961. In the past our efforts were directed towards reducing fish populations;

however, in the early years of the new study, we will be using live capture methods of fishing, exerting as little mortality as possible.

A smelt trap net (5/8" mesh) on loan from the Research Station at South Bay Mouth, Ontario was fished successfully and nets patterned after this type will be put into regular use in 1961. Other live-capture methods of fishing included the hand seine and trammel net.

Dart and streamer type tags were tested. The dart type consisted of a serially-numbered tube of vinyl plastic attached to a vinyl barb (5/8" long). The dart tag was inserted into an applicator needle and then thrust into the expaxial musculature in such a fashion that the barbed end of the tag passed between the interneural processes of the dorsal fin and offered good anchorage. The streamer tag, commonly used in fisheries work in North America, was attached to the fish by either limp monofilament or braided nylon. The nylon was inserted in the region of the back immediately below the dorsal fin, looped through the fish and then knotted against the plastic identifying disc. The tag dangled freely from the fish's body.

The results of the tagging are shown in Table I.

Table I. Tagging at Heming Lake in 1960.

Species	Dart-type Tag			Streamer-type Tag		
	No. Tagged	No. Recovered	% Recapture	No. Tagged	No. Recovered	% Recapture
Sucker	426	83	19.5	438	80	17.8
Perch	74	3	.4	107	14	13.0
Pike	43	24	55.8	62	30	48.4
Burbot	11	Nil	...	8	Nil	...

Approximately 18% of each type of tag were recovered from the tagged portion of the sucker population. Less than 1% of the perch tagged by the dart method were recaptured while 13% of the perch tagged by the streamer method were returned. As the average length of perch marked with dart tags was only about 5 inches, it is possible that the tags were too large for this size of fish and caused considerable mortality. The high return (approximately 50%) of both dart and streamer tagged pike would appear to indicate that both methods had no detrimental effects on the fish themselves and also serves to indicate that the fishery for pike was most efficient. Because of the paucity of tagged burbot in the lake, no inferences can be concluded from the fact that neither type of marked fish was recaptured.

FISH FENCES AT HEMING LAKE

To prevent movement of marked fish out of Heming Lake, it was necessary to screen the inlet and outlet regions of the lake with fences that would have a minimum life-span of 10 years. The screens must remain functional throughout the year, particularly during the period in the spring immediately following break-up of the ice when water levels rise and fish movement is active. As the ice goes out in the creeks before the lake break-up, the ice pressures on the fences should not be large.

The major fencing operation was at the main inlet to the lake. A meandering stream 8 to 10 feet wide and about 8 feet deep flows through a muskeg flat which is almost 400 feet wide. Restriction at the lake's outlet causes the water level to rise a foot or so above the muskeg soil surface in the spring. This inundated area serves as a spawning area for the pike. The organic muskeg soil had insufficient strength to support a suitable screen structure, so it was necessary to drive piles through the muskeg to firm bottom. This work was carried out in late fall when freezing temperatures froze the muskeg which then supported workers and equipment. After the piling was completed across the 400 foot width of muskeg, heavy sheet piling was driven to a depth of about 3 feet and fastened to the pile structure. In the area immediately adjacent to the creek itself, the sheet piling was driven through the muskeg to the hard bottom in order to prevent undercutting. It is intended that the total flow will be passed through a cleanable rack section 35 feet long by 8 feet deep in the channel. The slats in the rack are spaced at 1/2" intervals which should prevent the escape of any tagged fish. Extremely severe weather conditions in late November prohibited installation of the racks and this work will be completed before break-up in the spring of 1961.

Fencing at the other inlet and in the outlet region did not present any difficult engineering problems. At these locations, each roughly 60 feet in width, steel chain mesh fencing was attached to pilings driven into the stream bed. The stream bottoms were scoured out and bedlogs were set in the depression to prevent fish from escaping under the fence. The wire screening was attached in such a fashion that it can be easily replaced when it begins to deteriorate.

THE 1959-60 WINTER COMMERCIAL FISHERY AT GREAT SLAVE LAKE

Information collected during the 1959-60 winter fishing is gradually being analyzed. The total landings for the season were 1.8 million pounds of round fish. Lake whitefish comprised 3/4 of this amount and lake

trout 1/10. Slightly less than half of the allowable quota was therefore taken. Other species taken in reasonable quantities were northern pike and inconnu.

These landings were effected by an average of 43 fishing crews operating throughout the season. The average crew size was three men, making an average fishing force of 127. The size of the fishing force during the winter fishery is definitely diminishing. According to figures of the Department of Fisheries, the average number of licenses issued per winter season from 1946-47 to 1957-58 is 286. It is probably now impossible to accurately estimate the change in effective fishing force, since in the early years there were many sporadic fishermen, whereas now the force appears to be more permanent.

Landings were unevenly derived from the lake. Nearly 50% came from statistical Areas A and D. Areas E and K provided another 25% and the remainder came from seven other areas, no fish being recorded from C and O.

The first attempt to estimate the amount of gear used in this winter fishery is being made. A suggested figure for the 1959-60 winter season is 60,000 nets. Therefore, the catch per unit of effort was about 3 lb of trout, 22 lb of whitefish, 1 lb of inconnu and 3 lb of pike. This generalized figure smooths over the differences that exist between areas, time-period and fishing crews.

The average size of winter-caught trout and whitefish was considered the same as that found for the previous winter.

J. J. Keleher

Appendix 11

THE 1960 SUMMER COMMERCIAL FISHERY AT GREAT SLAVE LAKE

A study of the Great Slave Lake summer commercial fishery was carried out for the 16th consecutive year. The fishery started in the region of Big Island on May 17 and was terminated on the legal closing date of September 25. The quotas for two of the four administrative areas were filled. It would appear that the major part of the catch was derived from the western portion of the lake.

The seasonal average size of trout and whitefish, the only indices so far computed, showed no large differences from the values recorded for the previous summer.

J. J. Keleher

Appendix 12

THE 1960-61 COMMERCIAL WINTER FISHERY AT
GREAT SLAVE LAKE

The study of the winter fishery was again maintained by the collection of weight samples of the whitefish at the company plants and by field work.

The number of fishing crews was certainly no higher than the year previous but the landings, at least of whitefish and trout, appear to be slightly increased.

Provision was made for the landing figures to be entered on I. B. M. cards, so that not only will the results be available sooner, but more time will be available to consider them.

J. J. Keleher

Appendix 13

ACTUAL OBSERVATIONS ON SUMMER COMMERCIAL
FISHING

Most of the information collected on the summer commercial fishery is, of necessity, derived at fish collection points. Traditionally, seasonal and other personnel have occasionally accompanied the fishermen on their trips, so as to acquire and maintain familiarity with fishing conditions.

Last summer the number of such trips were increased and observations on certain aspects of fishing were systematically recorded. Particular attention was devoted to the number of non-saleable fish caught, this information usually being derived from fisherman estimates, and the actual duration of fishing. By the use of a stopwatch, the individual times for lifting 159 nets and setting 116 were established.

None of the information has been analyzed. It is readily apparent, however, that a 100 yard net can be lifted or set in a matter of minutes. This indicates that if the fishery could devote more time to the actual fishing operation, the production would be increased.

SOME RESULTS OF TAGGING GREAT SLAVE LAKE FISH

During five summers from 1946 to 1955 previous investigators tagged some Great Slave Lake fish. In preparation for a definitive analysis, all information has been checked against original sources and prepared in a workable arrangement. Some interim results are now available.

The release locations of the tagged fish have been grouped into 25 sites. They occur in 10 of 13 statistical areas and five of the nine commercially closed ones. Computation of the distance between the release and recapture of the individual fish has not yet been made. Of the 3622 fish tagged, 1807 were lake whitefish, 1000 were lake trout, 330 were longnose suckers and 485 were seven other species. Twenty-two per cent of the trout were reported recaptured, 17 per cent of the inconnu, 11 per cent of whitefish, longnose sucker and burbot, and less than 10 per cent for each of the other species.

Comparison of the release and recaptures according to the statistical areas indicate that the fish do not move very far. Seventy-one per cent of the trout were recaptured in the original release area, as were 80 per cent of the whitefish and 89 per cent of the other species. No apparent major pattern of movement was observed for those taken outside of their original area. Three fish left the lake. The greatest movement recorded within it was 200 miles.

The average time at large for trout was 1.3 years, with one fish being at liberty over 11 years. Longnose sucker and whitefish were recaptured on the average within 1.2 and 0.8 years. The extreme recapture time was over six years for both these species. The period at large appeared to be independent of the year or place of release.

This analysis of the tagging study confirms, in the main, the utility of the statistical areas for the scientific study and the administrative areas for management by quotas.

GREAT SLAVE LAKE COMMERCIAL CATCH REGULATIONS REVIEW

It has been indicated previously that a review of the regulations affecting the commercial, domestic and angling fisheries on Great Slave Lake had been commenced. The first part of this series, concerning the commercial catch regulations, has been completed.

FORECAST OF LAKE TROUT PRODUCTION IN LAKE SUPERIOR

Acquisition of the ability to predict catches is one of the most useful results of fisheries research. An important part of developing reliable prediction techniques is the comparison of statistics with tentative predictions. It therefore seems useful to compare actual catches in Lake Superior with catches predicted in Appendix A of the Annual Report submitted in April 1956 from the Board's station that was then in Sault Ste. Marie.

The appendix entitled "A forecast of lake trout production in Lake Superior" predicted the way in which catches in Lake Superior would decline as a result of sea lamprey predation. Predictions were based on data then available which included tentative production figures to the end of 1954. Figure 1 shows a comparison between the predicted decline in annual catches and the actual decline, including tentative figures for 1960. There has been reasonable agreement between the predicted catches and the actual catches.

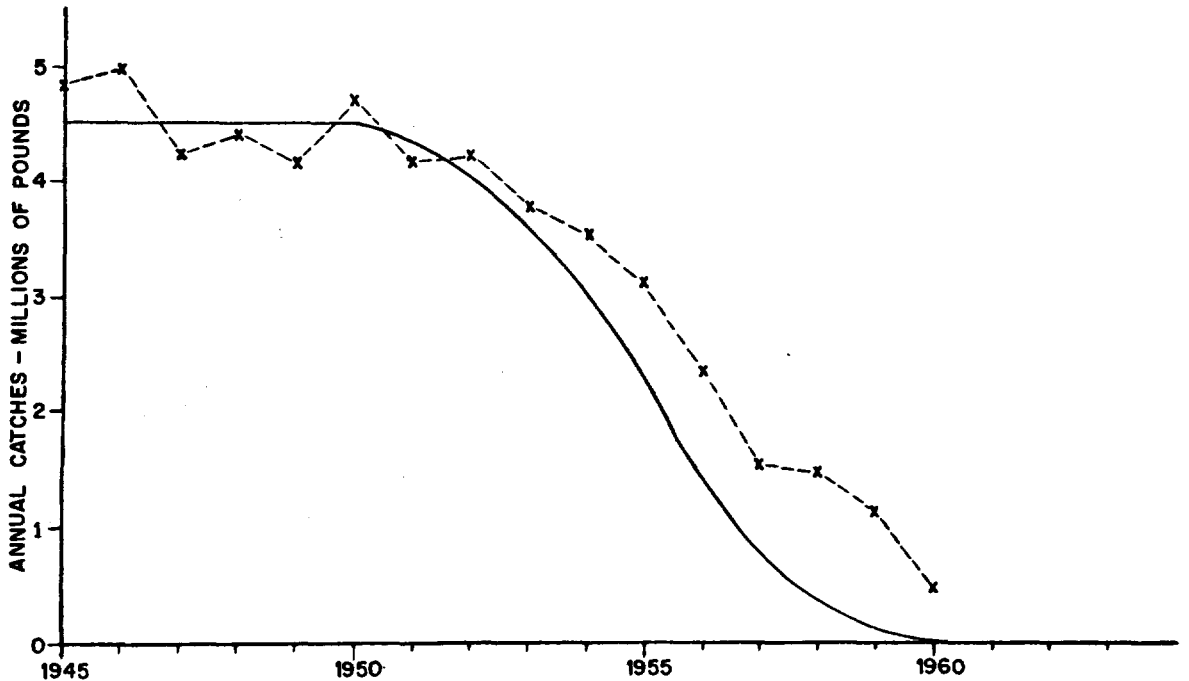


Fig. 1. Comparison of actual annual catches of lake trout in Lake Superior (Canadian and U.S.A. catches combined) with predicted catches. Solid line represents known long-term average production until 1950 and predicted decline, because of sea lamprey, thereafter. Crosses joined by dotted line represent actual annual catches.

A. H. Lawrie
A. Rojo

Appendix 17

COMMERCIAL LAKE TROUT FISHERY IN
LAKE SUPERIOR IN 1960

Sampling of the commercial catches of lake trout from the Canadian waters of Lake Superior was continued in 1960. For the first time, selected fishermen were employed to sample their own catches. An average of six samplers were so engaged throughout the season, although the number at any one time varied from three to ten. So far as possible, sampling was distributed uniformly over the fishery. Supervision was provided by permanent personnel who spent approximately one week with each sampler at intervals of three weeks.

With few exceptions, sampling involved the examination of whole catches, net run. The ratios of fin-clipped fish and of lamprey-marked fish to total numbers, as well as the usual catch and effort data, were obtained from every catch examined. Length data were taken for an entire catch by each sampler each week and scale samples were taken from an entire catch every three weeks or more often, usually by permanent staff.

In all, 477 catches were examined, involving approximately 25,000 individual fish. The landed portion of these catches weighed 54,396 pounds, so that 50% of the estimated total landings of 106,914 pounds was examined for one purpose or another.

Preliminary estimates from the catch statistics now being tabulated by the States of Michigan, Wisconsin and Minnesota, and the Province of Ontario indicate that the lake trout catch in both United States and Canadian waters declined a further 55% in 1960. Table I presents the U.S. and Canadian landed catches from 1958 to 1960.

Table I. United States and Canadian landings of lake trout from Lake Superior, 1958-60.

<u>Year</u>	<u>U. S. Landings</u>	<u>Can. Landings</u>
1958	1,059,000	385,045
1959	868,000	238,000
1960	388,000*	106,914*

*Provisional estimates only.

Effort statistics for 1960 are not yet available so that precise comparisons with earlier years cannot be made. Observations made incidental to sampling the fisheries, however, leave little doubt that catch per unit effort has also declined. In Canadian waters, the Quebec Harbour (Michipicoten Island) fishery closed in mid-June, the Mamainse Harbour

fishery sharply curtailed its effort in mid-July, and everywhere the fishery closed in mid-October, a month or more early. Thus, the industry appears to have entered a critical period in which any further decline in availability will provoke a precipitous collapse.

Scarred and wounded lake trout continued to be a prominent feature of the catches throughout 1960. In Canadian waters the usual seasonal trends in the percentage of marked fish, high in the spring and fall and low in the summer, were evident. Comparison with the overall 1959 figures shows (Table II) a sharp reduction, in eastern waters, in the incidence of wounded fish and a corresponding rise in the incidence of fish bearing healed scars. The reverse is true of western Lake Superior, although the figures are not as striking.

Table II. Percentages of wounded and scarred lake trout in the marketable portion of commercial catches sampled in eastern and western Lake Superior in 1959 and 1960. Sample sizes in brackets.

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

In Canadian waters the mean lengths of marketable fish appear to have increased in the eastern end of the lake and decreased in the west (Table III).

Table III. Mean total lengths (and Standard Errors of the Means) of lake trout comprising the marketable portion of commercial catches sampled in eastern and western Lake Superior in 1959 and 1960. Sample sizes in brackets.

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

Determinations of the ages of lake trout sampled in Canadian waters in 1960 have been completed for only four of the seven statistical areas. These data, grouped to facilitate comparison with 1959, are presented in Table IV.

Table IV. Age determinations of lake trout in the marketable portion of the commercial catches sampled in eastern and western Lake Superior in 1959 and 1960. Figures given are percentages.

Area	Year	-----A g e-----											Sample Size
		2	3	4	5	6	7	8	9	10	11	12	
East	1959	...	0.04	1.0	15.2	44.6	28.1	9.5	1.1	0.4	...	...	2877
	1960	...	0.5	1.6	20.9	49.1	25.9	1.8	0.2	...	...	...	2384
West	1959	...	0.1	2.0	17.5	38.8	32.0	7.7	1.7	0.2	0.03	0.03	3451
	1960	0.1	7.2	23.0	44.1	22.3	3.3	0.1	...	...	...	...	1399

At both ends of the lake a further reduction in the numbers of fish of spawning age has occurred, but in western Lake Superior the reduction among older age groups has been extreme.

Consideration of the above data suggests that the decline in the native stocks of lake trout continued unabated in 1960. Western stocks, less affected until recent years, are now being rapidly trimmed down with consequent contraction of the upper end of the age distribution and a reduction in mean size. The apparent reduction in scarring rate and increase in mean size in the eastern end of the lake, where lamprey control was undertaken first, is encouraging but the comparisons between years are not entirely rigorous owing to differences in sampling methods.

A. H. Lawrie
A. Rojo

Appendix 18

ASSESSMENT OF PLANTED LAKE TROUT IN LAKE SUPERIOR

The program of lake trout rehabilitation was continued in 1960 with plantings of hatchery-reared, yearling lake trout by the States of Michigan, Wisconsin and Minnesota, the Province of Ontario, and the U.S. Fish and Wildlife Service totalling 1,050,000, an increase of nearly 400,000 over 1959. All planted lake trout have been marked by having various fins, or combinations of fins, removed to permit ready recognition. Data on the return of these fish provides a basis for assessing the success of the plantings.

In Canadian waters reports of the occurrence of fin-clipped fish were received both from the sampling done by the Fisheries Research Board and from the voluntary returns of commercial fishermen. Six hundred and seventy-three hatchery-reared fin-clipped fish were recovered from all sources. At present, planted fish represent approximately one per cent of the Canadian catch and only ten per cent of these are of marketable size. Their ultimate

contribution, however, is indicated by the fact that they now constitute 13% of the sublegal (less than 1-1/2 pounds dressed weight) portion of the catch.

Of the recoveries, 554 could be assigned with certainty to a particular planting. Although fourteen separate plantings, seven of them in American waters, were represented, the numbers are too small to permit any comparison of survival, except in the case of the most recent Canadian plants. Five hundred and ten lake trout, marked by the Ontario Department of Lands and Forests and planted in seven separate plants, were recovered. Two old plants, both of fall fingerlings, in 1950 and 1953, made near Pie Island at the entrance to Thunder Bay were represented by single recoveries in nearby waters. The plantings of yearlings made at, or near, Rosspoint (western Lake Superior) in the springs of 1958, 1959 and 1960 were represented by 199, 262 and 10 recoveries respectively; those made in the Lizzard Island area (eastern Lake Superior) during the same years by 3, 34 and 0 recoveries. A more meaningful comparison is obtained if the ratios of fin-clipped fish to total catch are compared. Moreover, since fish from both sets of plantings are, for the most part, still below legal size the comparison is made more rigorous by using the ratios of fin-clipped fish to total numbers of sublegal fish in the catches. For those recoveries where this information is available the data are presented in Table I.

Table I. The ratios of 1960 recoveries of yearling lake trout planted by the Ontario Department of Lands and Forests in eastern and western Lake Superior in 1958, 1959 and 1960 to the total sublegal catches in 1960 in these waters.

Year of Plant	Fin Clip	Eastern		Western		
		Recovery Ratio	%	Fin Clip	Recovery Ratio	%
1958	Ad	1/746	0.13	Ad	133/2133	6.2
1959	LV	34/746	4.6	RV	180/2133	8.4
1960	Ad + LP	0/746	0.0	RP	10/2133	0.47

Careful consideration of the data from which this table is derived suggests that the recovery ratio for the 1958 western plant may be over-estimated, while those for the 1958 and 1959 eastern plants may be under-estimated. However, the maximum correction consistent with the data does not change the order of comparison within, or between, areas. Therefore, even with this qualification, it appears that the eastern plants have each yielded lower returns to the commercial fishery. Comparison with U.S. Fish and Wildlife Service data suggests that these plantings have been less "successful" than the majority of American plantings as well. A possible explanation lies in the fact that the yearling trout planted in the Lizzard Island area are substantially smaller than those used elsewhere in the lake. This difference

appears to persist at least until Age III, when they are about three inches shorter in mean length (ca. 12 inches) than their counterparts from other plants.

Table II presents the mean total lengths for all fin-clipped fish from Canadian waters which can be assigned to a particular planting. In general, with the exception noted above, it appears that fish of the same age are of the same order of mean length regardless of origin. It is interesting to note that the planted fish begin to reach marketable size (15.5-16.0 inches) two years after planting and are probably almost entirely this size or larger within five years after planting. Increments in mean length with age of the order of three to four inches appear to characterize the first three years or so, while in later years this appears to drop perhaps because of size determined differential mortalities occasioned by lamprey predation. Unfortunately, comparable data on the mean length of native trout at a given age are not yet available from the 1960 samples.

Table II. The mean total lengths of fin-clipped lake trout recovered from the Canadian waters of Lake Superior in 1960.

<u>Year Class</u>	<u>Planting Agency</u>	<u>Area Planted</u>	<u>Age at Planting</u>	<u>Fin Clip</u>	<u>Number Recovered</u>	<u>Mean Length (inches)</u>	<u>Range (inches)</u>
1959	ODLF	RosSPORT	Yearling	RP	10	7.5	6 - 8.3
1958	ODLF	Lizzard I.	Yearling	LV	34	8.6	7 - 13.5
	ODLF	RosSPORT	Yearling	RV	262	10.2	6.5 - 16
1957	ODLF	Lizzard I.	Yearling	Ad	3	12.0	10.0 - 13.6
	ODLF	RosSPORT	Yearling	Ad	199	15.2	7 - 22
	FWS	Eastern	Yearling	LP	7	15.0	10.8 - 19
	WCD	Apostle I.	Yearling	RP	1	15.4	...
1955	WCD	Apostle I.	Yearling	RP	6	17.7	14.6 - 20
1954	FWS	Marquette	Yearling	Ad + LV	10	19.9	17.9 - 22.2
1953	ODLF	Pie I.	Fingerling	Ad + LP	1	22.0	...
	WCD	Apostle I.	Fingerling	RP	7	19.1	17.6 - 21.8
	WCD	Apostle I.	Yearling	LP	9	20.3	19.8 - 21
1950	ODLF	Pie I.	Fingerling	Ad + RP	1	27.0	...

EXPERIMENTAL CATCHES FROM SUPERIOR SHOAL

A program of experimental fishing and tagging was carried out on Superior Shoal, in 1960, by the Fisheries Research Board. Eight hundred and seventy-one lake trout were captured in twelve lifts of standard gangs of gill nets from May to October, and 383 were tagged and released. It is hoped that the data obtained from this study of a single discrete population fished in a consistent manner throughout the season may provide guidelines to more rigorous and productive examination of data from the highly variable commercial fishery. Analysis of the data is in progress at present. Of interest is the fact that scarring rates on the Shoal have increased from previous samples (Table I) and at their highest (in the spring samples) approached those characteristic of the inshore commercial fisheries.

Table I. Percentages of lake trout bearing the fresh wounds and the healed scars of lamprey attack in samples taken from Superior Shoal, July 1954, 1958, 1960.

<u>Year</u>	<u>Sample Size</u>	<u>Percentage of Lake Trout bearing</u>	
		<u>Wounds</u>	<u>Scars</u>
1954*	468	0.0	0.2
1958**	717	0.8	4.2
1960**	43	2.3	25.6

* Data from the Ontario Department of Lands and Forests.

** Data from the Fisheries Research Board of Canada.

THE RADIOISOTOPE PROJECT

During 1960-61, the radioisotope project had several major objectives. In order, these were:

1. the development of a reliable and reproducible method of radio-assay of fish containing gamma-ray-emitting radioisotopes;
2. a more critical assessment of the use of radioactive iron as a fish tag; and
3. studies of the use of radioactive caesium as a tag for fish and lamprey ammocoetes.

Radioassay Methods

In radioassaying a living fish, two criteria must be satisfied. First, the geometrical relationship between fish and detector must be stable and reproducible, and second, the fish must not be damaged during the process. The latter criterion practically eliminates any possibility of accurately radioassaying the fish out of water, in that counting times for the assay are usually too long for the fish to stand the exposure. This is not to say that a yes or no answer may not be obtained as to whether the fish contains some radioisotope, but a quantitative measurement cannot usually be done. A method of radioassaying fish accurately while holding them in water had to be developed in order to get quantitative measurements for determining the biological half-lives of iron and caesium.

Figure 1 shows the constant-geometry radioassay apparatus which was developed to meet our needs. It consists primarily of an annular stainless steel tank, inside wall diameter 30", outside wall diameter 36", thus leaving a ring-like tank 3" wide. The detector, either a gamma-ray-sensitive Geiger-Muller tube or a scintillation detector, is placed at the centre (axis) of the ring. Fish placed in the annular tank are thus at a reasonably constant distance from the detector, although still able to move about the circle. Although we have only one tank, depending on the size of specimen, the tank could be made larger or smaller to match conditions. Provided that radioisotopes emitting gamma rays above 0.250 Mev (million electron volts) are used, detection efficiency is high enough to provide good statistical data for analysis of biological loss of radioactive materials.

In our experiments, we have fed the detector pulses either to a recording ratemeter (used with Geiger tube) or to our 200-channel pulse height analyzer (used with scintillation detector). The former system is much to be preferred for long-term experiments with single isotopes, since the drift in the electronic measuring circuits is practically negligible. The alternative system, using the pulse height analyzer, must be used for the assay of fish containing more than one radioisotope; however, its electronic stability is much lower than the ratemeter, and requires frequent restandardization. For this reason, the system should be used only for very short-term experiments, or where constant supervision of the apparatus is possible, i.e., in strictly controlled laboratory conditions.

Iron-59 Experiments

In order that a radioisotope may be useful as a fish mark, three criteria must be satisfied. These are:

1. the biological turn-over of the element must be reasonably slow;
2. an isotope of the element must exist with a reasonably long physical half-life, such that the effective half-life* is not less than one-tenth of the length of time the mark must persist; and

*The relationship between physical half-life (T_p), biological half-life (T_b) and effective half-life (T_e) is as follows:

$$\frac{1}{T_e} = \frac{1}{T_p} + \frac{1}{T_b}$$

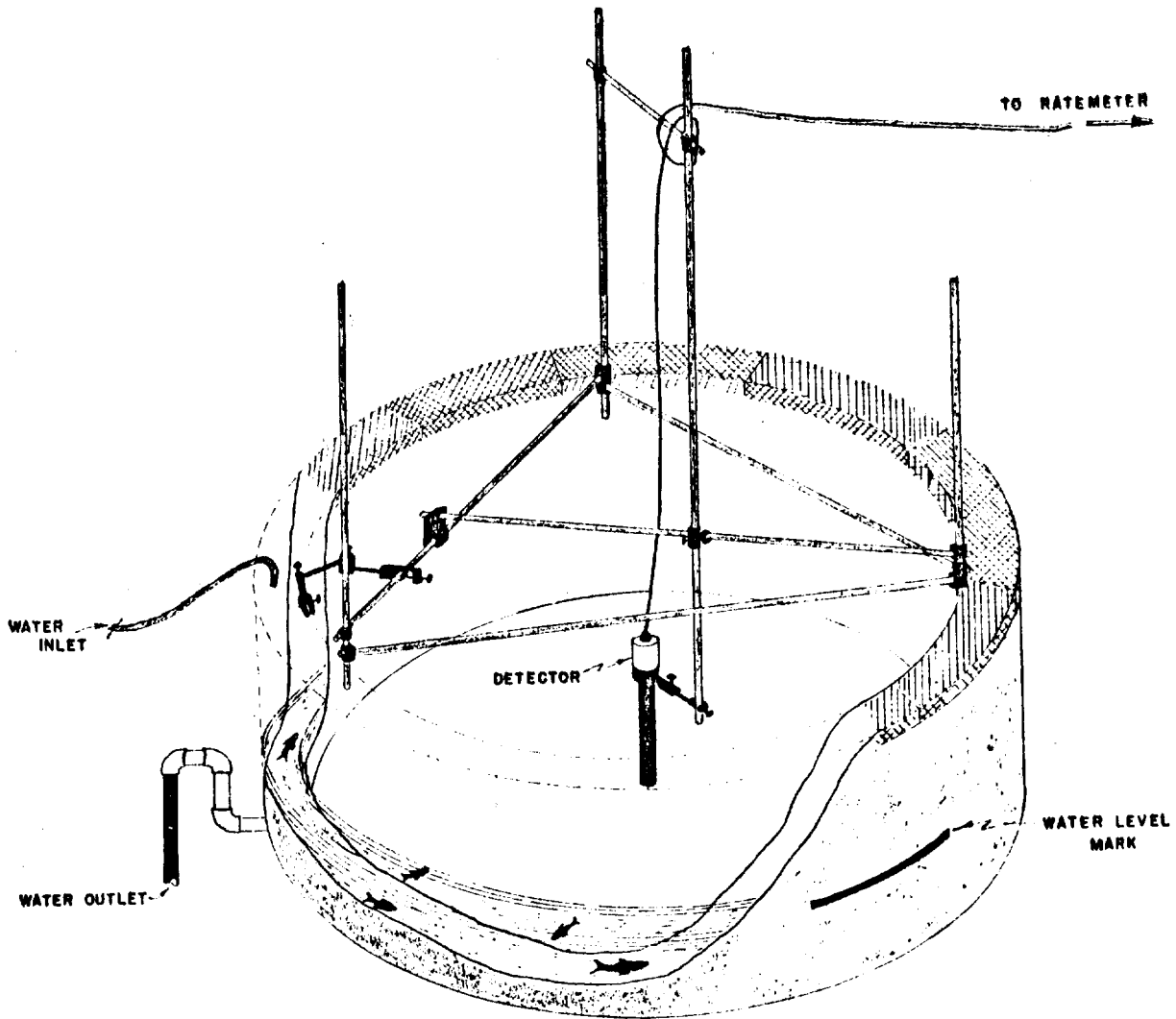


Fig. 1. Constant Geometry Tank.

3. the radioisotope used must give off a reasonably energetic radiation, so that detection is possible without recourse to destruction of the animal.

A series of experiments were carried out during the year, using iron-59 injected into the body cavities of eastern brook trout. Iron-59 was used for the experiments since it emits three energetic gamma rays which are easily detectable; although its physical half-life is short (45.1 days), it was the more suitable of the two available radioisotopes, since iron-55 emits only a very weak X-ray from the daughter manganese-55. As a field mark, however, iron-55 would be more suitable since it has a physical half-life of 2.94 years. The complication of a weak radiation may be solved by the development of sensitive, portable, transistorized X-ray spectrometers.

The results of the experiments indicate that the biological half-life of iron in brook trout is approximately 1000 days. Using iron-59 as the radioactive tag, the resultant effective half-life is 43.2 days; taking ten half-lives as a useful limit, the mark should last approximately 1.18 years. On the other hand, if iron-55 is used, then the mark should last approximately 14 years. These figures neglect any loss from damage or relative dilution from growth of the specimen. However, it may be seen that a very long-term mark can be achieved with iron-55, and a somewhat shorter term mark with iron-59. The results of these experiments were reported in detail in a paper presented for publication in the Journal of the Fisheries Research Board on November 9, 1960.

Caesium-137 Experiments

Following the completion of the iron-59 experiments, a series of trials were undertaken using caesium-137 to determine the biological half-life of caesium in brook trout. Six different caesium isotopes exist which could have been used for the trials; however, caesium-137 has a long physical half-life (26 years) and an energetic gamma ray emission, and is the most suitable for experimental work. It is also the cheapest.

The caesium solution was injected into the body cavities of the trout, as with the iron-59. The fish were radioassayed in the same apparatus as before, and calculation shows that the effective half-life is approximately 47.2 days. In this case, the biological and effective half-lives are to all intents equal, the very long physical half-life having no discernible effect on the results. As a result of the above findings, it is probable that caesium-137 will only be useful as a short-term mark, like iron-59.

In another experiment, 20 American brook lampreys were placed in a caesium-137 solution for 24 hours, then permitted to burrow into the mud in a small artificial stream in the laboratory. The ammocoetes took up some of the radioisotope, and it is hoped that they will retain enough to permit the use of this isotope as a short-term mark for population estimates of ammocoetes in streams. It is planned that, if the mark lasts more than one month, a full-scale field trial will be made early in 1961-62 on a stream on St. Joseph's Island near Sault Ste. Marie,

Ontario, in conjunction with the lamprey control program. The results of the various parts of the caesium-137 experiments will be reported in a paper during 1961-62.

A. Carter

Appendix 21

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 escape-ment is also included in Table I.

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-----					Evidence of escapement	-----Lampreys recovered-----							
				Apr	May	June	July	Aug		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	June 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														

^aGoulais River - adults recovered during chemical treatment.

^bHarmony Barrier in operation during 1954; sea lamprey recovered - 19.

^cSable Barrier also in operation during 1954; sea lamprey recovered - 39.

^dMichipicoten River Barrier off during chemical treatment.

The nets (Table II) were of the same design as reported in 1959 and as described in the 1958 report, Appendix 29. 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 II. Rivers in which netting devices were installed to reduce migrant fish kills at barriers on Lake Superior, 1960.

<u>Stream Number</u>	<u>Stream Name</u>	<u>Upstream Nets</u>	<u>Downstream Nets</u>
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.

J. J. Tibbles

Appendix 22

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.

<u>Soo Area</u>		<u>Soo Area (cont'd)</u>	
S-3	Bennett	S-68	
S-6-1		S-69	Bold Bluff
S-7		S-70	Mica Bay
S-9		S-71	
S-11		S-72	
S-12	Prince	S-73	Cozens Cove
S-13		S-74	Pt. au Mines
S-14		S-75	Queminco
S-15		S-76	Bell
S-16		S-77	Beaver
S-17		S-79	
S-18		S-80	
S-19		S-81	
S-21	Kelly	S-82	
S-27	Boston	S-83	
S-34	Black	S-84	
S-35		S-85	
S-36-1		S-86	
S-37	Tier		
S-40	Government		
S-40-1			
S-41	Sawmill	S-131	
S-42	Jones Landing	S-132	
S-45		S-133	
S-46	Tiny	S-134	
		S-135	
S-48	Chippewa	S-136	
S-51		S-137	
S-53	Digby	S-139	Salter L.
S-54	Sable	S-140	
S-55		S-141	
S-58	Westman's	S-142	
S-59	Weston	S-143	
S-60	Coffee	S-144	
S-61		S-145	
S-62	Hidden	S-146	
S-63	Hibbard Bay	S-147	
S-64	Minising	S-148	
S-65		S-149	
S-66	Sidehill	S-150	
S-67		S-151	

Table I. (Continued)

<u>Wawa Area (cont'd)</u>		<u>Nipigon Area</u>	
S-152		S-341	
S-153		S-345	Aquasabon
S-154		S-347	
S-155	Noisy	S-348	Cooks L.
S-156		S-350	
S-157		S-350-1	
S-158		S-351	Hewitson
S-159		S-352	
S-160		S-353	McLeans
S-161		S-354	Renauds
S-162	Old Mine	S-355	
S-163		S-356	
S-164		S-357	Morrison
S-165		S-361	Little Pays Plat
S-167-1		S-369	Little Gravel
S-168		S-370	
S-171		S-371	
S-171-1		S-373	Little Cypress
S-174-1		S-374	Cypress
S-180		S-375	McGinnes
S-180-1		S-377	Dublin
S-181		S-379	Jackpine
S-182		S-383	
S-184		S-384	
S-185		S-385	Jackfish
S-187		S-387	Firehill
S-188		S-388	
S-189		S-389	Ruby
S-189-A		S-393-408	Helen L. (16 streams)
S-190	Makwa	S-412	
S-191		S-418-432	Helen L. (13 streams)
S-192		S-454	
S-193		S-455	
S-194		S-457	Trout
S-195			
S-196		<u>Lakehead Area</u>	
S-197		S-509	Black Sturgeon
S-198		S-510	Big Squaw
S-199		S-512	
S-200		S-513	Morrow
S-201		S-514	
S-297			

Table I. (Continued)

<u>Lakehead Area (cont'd)</u>		<u>Lakehead Area (cont'd)</u>	
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-591	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.

		<u>% P. m.</u>	<u>P. m.</u>	<u>Icth. spp.</u>	<u>E. l.</u>
<u>Lake Superior</u>					
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	...
	T o t a l		70	1725 14A	6810 33A
<u>Lake Huron</u>					
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	...
	T o t a l		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.

		<u>% P.m. ammocoetes</u>	<u>T o t a l</u>			<u>C h e m i c a l</u>			<u>S h o c k e r</u>		
			<u>P.M.</u>	<u>I. spp.</u>	<u>E.l.</u>	<u>P.m.</u>	<u>I. spp.</u>	<u>E.l.</u>	<u>P.m.</u>	<u>I. spp.</u>	<u>E.l.</u>
<u>Lake Superior</u>											
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	...	...	...	...
	T o t a l	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)

		<u>% P.m. ammocoetes</u>	<u>T o t a l</u>			<u>C h e m i c a l</u>			<u>S h o c k e r</u>		
			<u>P.m.</u>	<u>I. spp.</u>	<u>E.l.</u>	<u>P.m.</u>	<u>I. spp.</u>	<u>E.l.</u>	<u>P.m.</u>	<u>I. spp.</u>	<u>E.l.</u>
<u>Lake Huron</u>											
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	...	...
	T o t a l	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.

J. J. Tibbles
B. G. H. Johnson

Appendix 23

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 $\frac{3}{2}$ 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 $\bar{2}$. In plotting the data the actual values, both of concentration and of 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.

J. J. Tibbles

Appendix 24

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

Since 1956 sea lamprey ammocoetes have been collected, with electro-shocking equipment, in 28 separate stream watersheds on the Canadian side of Lake Superior and 38 in Lake Huron and Georgian 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 re-treated 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 22). 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 Lakes Superior and Huron from 1958 to 1960 is presented in Table I.

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

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>		<u>Lbs active ingredient</u>	<u>Cost/cfs \$ ¢</u>		<u>Total cost of chemical \$ ¢</u>		<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
<u>L a k e S u p e r i o r - 1 9 5 8</u>											
<u>Pancake</u>	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		14.5		
(1960 prices)											

<u>W. Davignon</u>	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		

<u>L a k e S u p e r i o r - 1 9 5 9</u>											
<u>W. Davignon</u>	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		

<u>Big Carp</u>	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				
	Totals	10			118.62	40.21	402.10		8.5		

Table I. (Continued)

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>		<u>Lbs active ingredient</u>	<u>Cost/cfs</u> \$ ¢	<u>Total cost of chemical</u> \$ ¢	<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
Lake Superior - 1959 (cont'd)									
<u>Harmony</u>	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

<u>Stokeley</u>	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

<u>Sable</u>	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

<u>Batchawana</u>	20/23-VII-59	126	Feeder	2.6	1410.5	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			1566.50	42.14	5,310.44		7.0

*Chemical applied where no flow.

Table I. (Continued)

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>		<u>Lbs active ingredient</u>	<u>Cost/cfs</u> \$ ¢	<u>Total cost of chemical</u> \$ ¢	<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
Lake Superior - 1959 (cont'd)									
<u>Pays Plat</u>	26/30-VIII-59	132	Feeder	4.3	1540.5	39.56	5,222.30	Moderate	6.25
			Mouth	1.0					
Trib. St. 15C		...*		...	39.0	...*	132.21	...	0.25
	Totals	132			1579.5	40.56	5,354.51		6.50

<u>Pearl</u>	1/5-IX-59	12	Feeder	5.0	63.38	17.90	214.86	Few	4.0
			Mouth	1.8					
Booster St. 4B		...		3.5	127.72	36.08	432.97	...	...
	Totals	12			191.1	53.98	647.83		4.0

<u>Big Gravel</u>	6/7-X-59	274		...	325.0	4.02	1,101.75	Few	7.0
2nd treatment		...	Feeder	3.1	1657.5	20.51	5,618.93		...
			Mouth	2.2					
	Totals	274			1982.5	24.53	6,720.68		7.0

Lake Superior - 1960									
<u>Cranberry</u>	29/30-IV-60	37	Feeder	6.5	527.5	51.90	1,788.22	Few	5.0
			Mouth	4.0					
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)

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>		<u>Lbs active ingredient</u>	<u>Cost/cfs \$ ¢</u>		<u>Total cost of chemical \$ ¢</u>		<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
Lake Superior - 1960 (cont'd)											
<u>Stokeley</u>	5/6-V-60	104	Feeder	4.8	780.0	25.42	2,644.00	Few	7.0		
			Mouth	3.0							
	Totals	<u>104</u>			<u>780.0</u>	<u>25.42</u>	<u>2,644.00</u>		<u>7.0</u>		

<u>Little Carp</u>	12/13-V-60	28	Feeder	4.0	204.75	24.78	694.05	Few	7.0		
			Mouth	2.5							
	Totals	<u>28</u>			<u>204.75</u>	<u>24.78</u>	<u>694.05</u>		<u>7.0</u>		

<u>Kaministikwia</u>	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	<u>1334</u>			<u>11,895.0</u>	<u>30.24</u>	<u>40,324.00</u>		<u>47.75</u>		

*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)									
<u>McIntyre</u>	8-VI-60	22	Feeder	3.0	175.5	27.67	594.90	Few	6.0
			Mouth	1.5					
	Totals	22			175.5	27.67	594.90		6.0

<u>Goulais</u>	22/25-VI-60	493	Feeder	2.75	4,465.5	30.70	15,136.90	Very abundant.	52.0
			Mouth	1.5					
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)

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>		<u>Lbs active ingredient</u>	<u>Cost/cfs</u> \$ ¢	<u>Total Cost of chemical</u> \$ ¢	<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
Lake Superior - 1960 (cont'd)									
<u>Michipicoten</u>	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

<u>Jackfish</u>	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

<u>Black Sturgeon</u>	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	Nil	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)

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>		<u>lbs active ingredient</u>	<u>Cost/cfs \$ ¢</u>		<u>Total cost of chemical \$ ¢</u>		<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
Lake Superior - 1960 (cont'd)											
<u>Pigeon</u>	18/20-X-60	99	Feeder	4.0	2,047.5	70.11	6,940.50	Few	3.5		
			Mouth	2.3							
<u>Sloughs</u>		...*		...	97.5	... *	330.50	Few	...		
	Totals	99			2,145.0	73.44	7,271.00		3.5		

<u>Sawmill</u>	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											
<u>Magnetawan</u>	11/12-VIII-60	718	Feeder	1.0	1,482.0		5,023.60	Few	5.0		
			Mouth	0.5							
<u>Trib. 748</u>		...		...	78.0		264.40		0.25		
<u>747</u>		...		...	9.75		33.05		0.25		
	Totals	718			1,569.75	7.41	5,321.05		5.5		

<u>Still</u>	16/26-VIII-60	16	Feeder	2.3 (24hr)	156.0	33.05	528.80	Very abundant.	16.0		
			Mouth	0.9							
<u>Little Still</u>		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)

<u>Name</u>	<u>Date treated</u>	<u>Flow in cfs</u>	<u>Concentration in ppm during treatment</u>	<u>Lbs active ingredient</u>	<u>Cost/cfs</u> <u>\$ ¢</u>	<u>Total cost of chemical</u> <u>\$ ¢</u>	<u>Ammocoete abundance</u>	<u>Miles of stream treated</u>
Lake Huron - 1960 (cont'd)								
<u>Naiscoot</u>	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

<u>Chikanishing</u>	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

<u>Boyne</u>	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

<u>Silver</u>	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+

J. J. Tibbles
B. G. H. Johnson
A. Lamsa
E. Cormack
S. Dustin
R. Bams

Appendix 25

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 rainfall 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, Paiponge, 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 re-treated 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 lampicide.

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 (4,950 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 latter 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 Pigeon 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 were 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 navigated 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 to 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.

R. W. McCauley

Appendix 26

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).

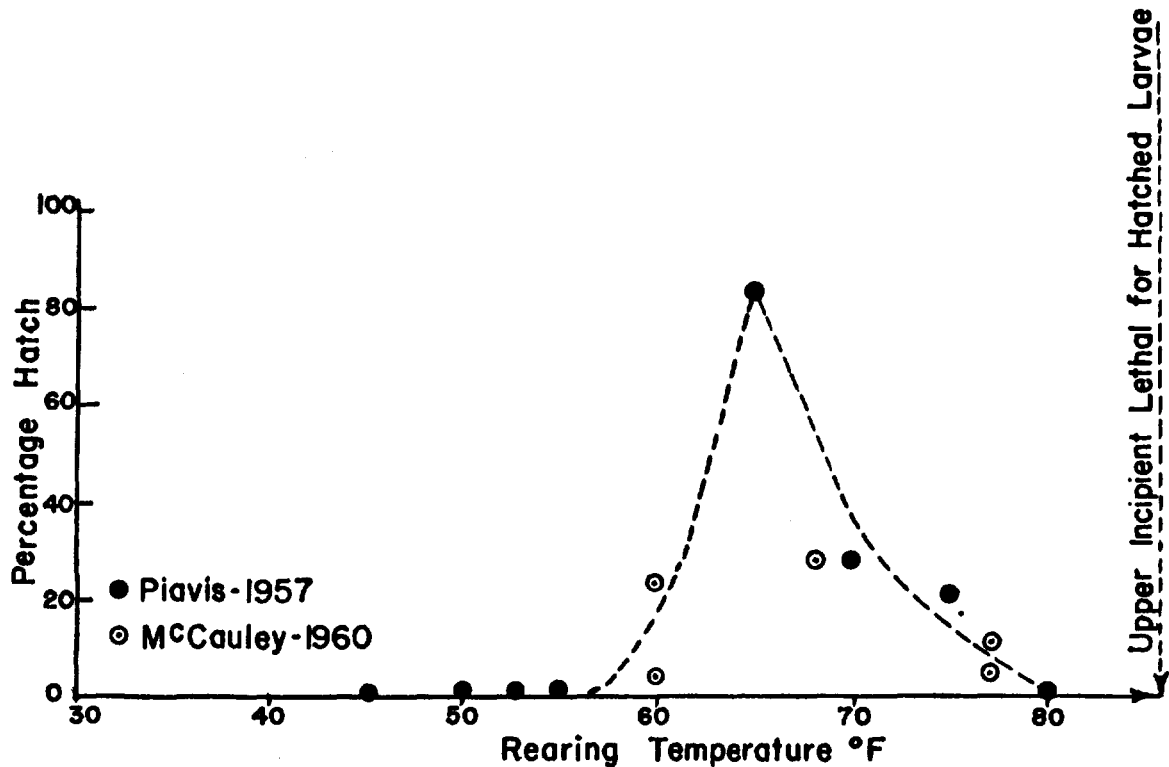


Fig. 1. Relationship between percentage hatch and rearing temperature in sea lamprey eggs.

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.

R. W. McCauley

Appendix 27

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.

R. W. McCauley

Appendix 28

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.

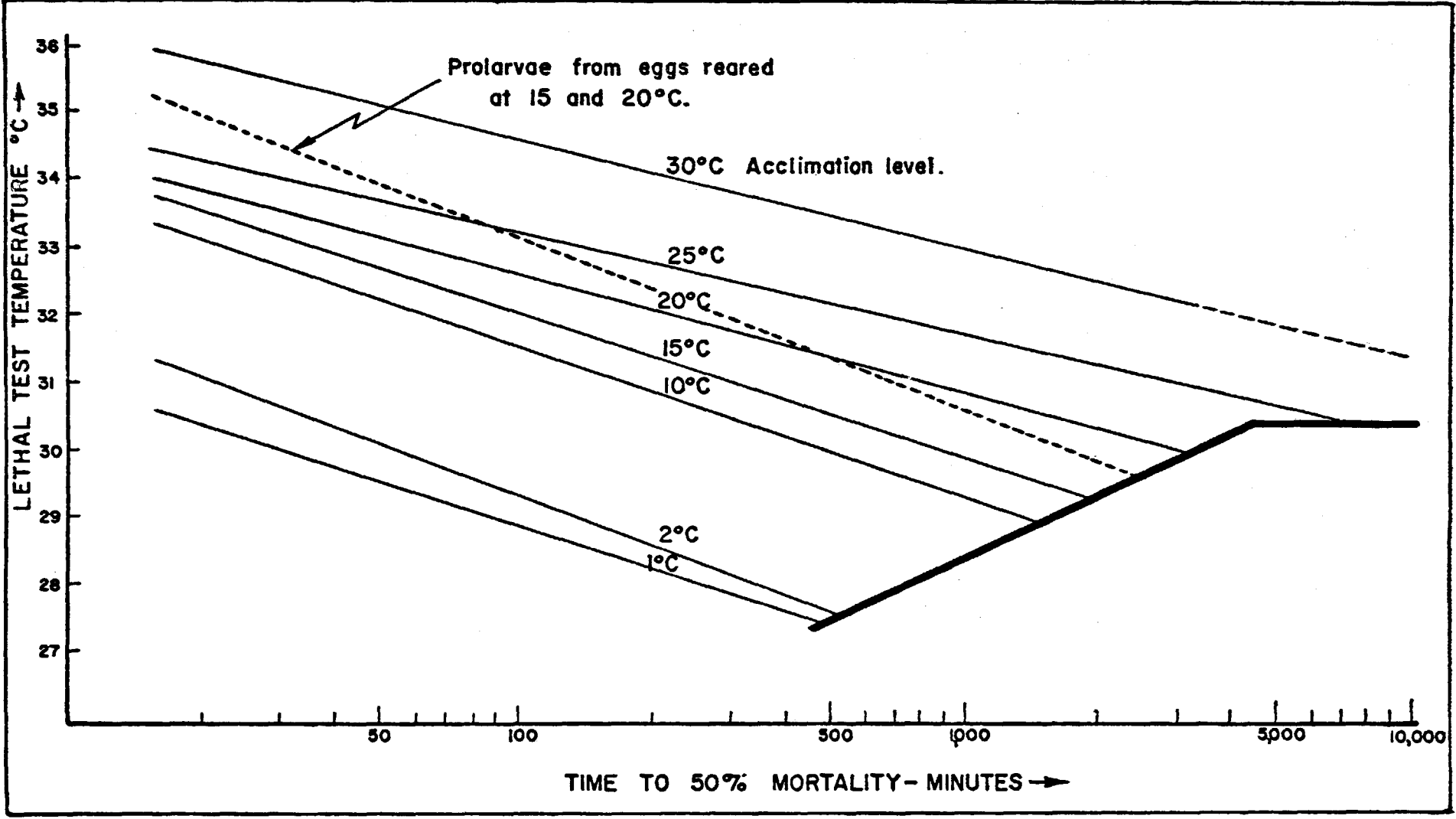


Fig. 1. Lethal temperatures of sea lamprey ammocoetes.

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.

R. W. McCauley

Appendix 29

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).

R. W. McCauley

Appendix 30

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.

M. L. H. Thomas

Appendix 31

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 52 of the 1959-60 Annual Report. For deep-water sampling the anchor dredge described in Appendix 55 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

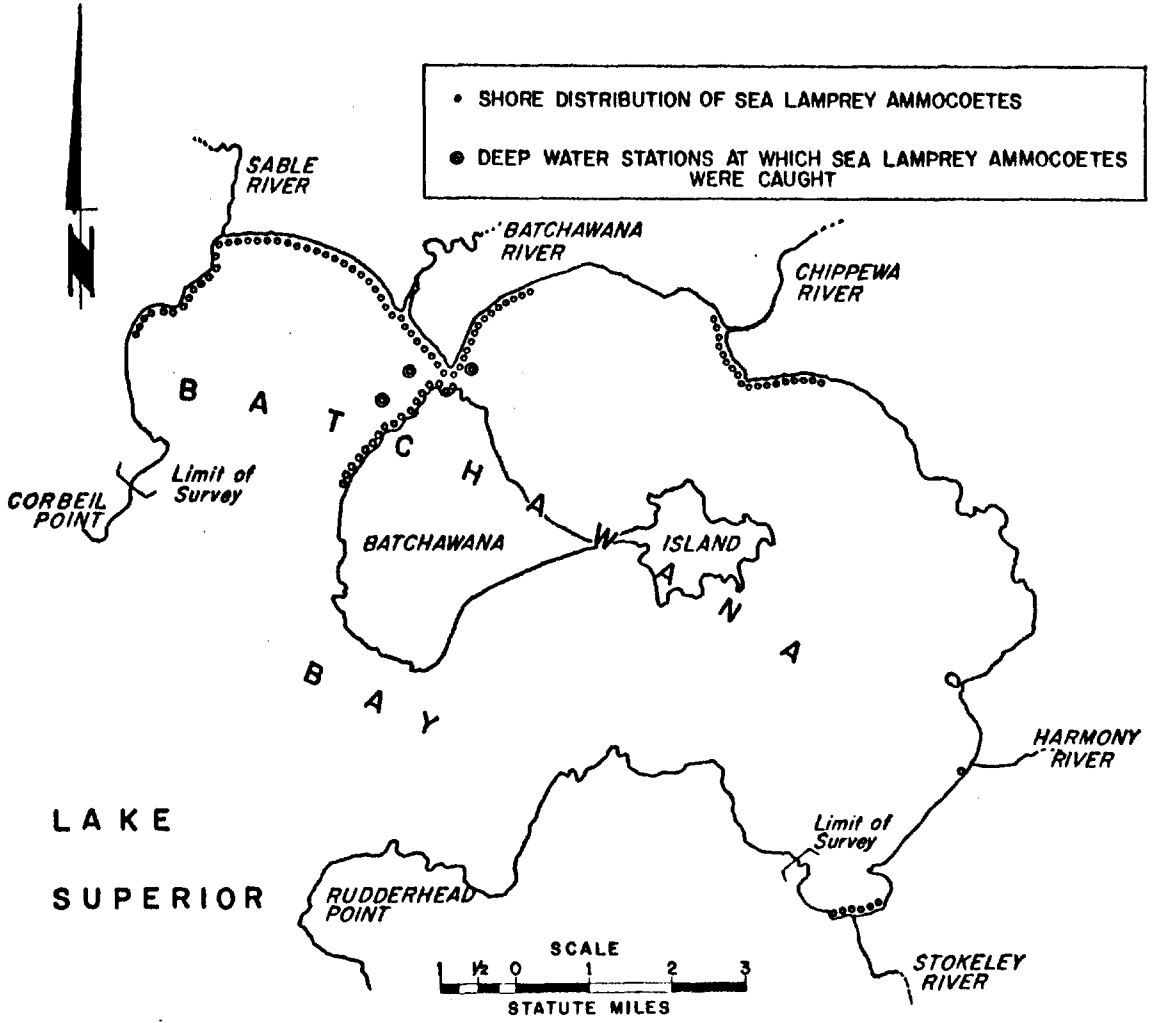


Fig. 1. Map of Batchawana Bay, Lake Superior, showing areas where sea lamprey ammocoetes were caught.

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 34). 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 57 of 1958-59 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.

M. L. H. Thomas

Appendix 32

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.

----- D a r k n e s s -----				---Light---
<u>1800-2100</u>	<u>2100-2400</u>	<u>0000-0300</u>	<u>0300-0600</u>	<u>0600-1800</u>
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.

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 57 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.

LAMPREY LAKE SPAWNING SURVEY 1960

During a survey in 1959 (see 1959-60 Annual Report, Appendix 53), 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.

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.

<u>Species</u>	<u>No. of stations of total 47 at which present</u>
<u>Ichthyomyzon</u> (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 station 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 station, as was the Gastropod, Campeloma decisum.

M. L. H. Thomas

Appendix 36

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 Hyaella 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 members of the Phryganeidae, Helicopsychidae, Limnephilidae, Psychomyiidae and Lepidostomariidae 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.
