Appendix VI

GLFC ANNUAL MEETING
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AGENDA ITEM 5

SEA LAMPREY MANAGEMENT IN THE GREAT LAKES 1991

by

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Great Lakes Fishery Commission

CONTENTS

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This is a joint report that summarizes sea lamprey management activities conducted by the Department of Fisheries and Oceans Canada and the U.S. Fish and Wildlife Service. The following activities were conducted in 1991: lampricide treatments, initiation of the sterile male release technique, population assessment of lampreys in the larval, parasitic, and spawning life stages, barrier dam maintenance, adult velocity barrier studies and assessment of the effects of lampricides on non-target organisms. Lampricide treatments were completed on 51 tributaries of the Great Lakes (Table 1). In Canadian waters, two treatments were deferred due to unsatisfactory discharge or environmental concerns. In United States waters, two treatments were deferred, one due to unsatisfactory discharge and one because of other priorities. An operational field trial of the sterile male release technique was initiated as a supplemental control method to lampricide treatments. A total of 10,950 sterilized male lampreys were released into 10 streams of Lake Superior (3,434) and the St. Marys River (7,516); (Table 19). Surveys to assess populations of larval lampreys were performed in 361 tributaries as well as 2 instream lakes and 20 offshore areas. Habitat-based estimates of the production potential of larvae were completed on six of the major lamprey producing streams in Lake Superior. A total of 5,578 parasitic-phase sea lampreys were collected from commercial (2,904) and sport (2,674) fishermen in the Upper Great Lakes. Assessment traps placed in 67 tributaries captured 69,360 spawning-phase sea lampreys (Table 2). An estimated 27,545 spawning-phase lampreys were present in U.S. waters of Lake Superior. The Bad River Tribe of Chippewa Indians and the Great Lakes Indian Fish and Wildlife Commission provided about 3,000 hours of cooperative assistance to the Service control program on the Bad River (Lake Superior). Long-term monitoring of the effects of lampricides to the mayfly Hexagenia and other organisms continued in four streams.

Table 1. Summary of chemical treatments in streams of the Great Lakes in 1991. [Lampricides used are in kilograms/pounds of active ingredient.]

Lake	Number of Streams	Discharge m^3/s	Discharge f^3/s	TFM kg	TFM lbs	Bayer 73 Powdered kg	Bayer 73 Powdered lbs	Bayer 73 Granular kg	Bayer 73 Granular lbs	Distance km	Distance miles
Superior	16	29.3	1,034	4,927	10,862[a]	-	-	0.1	0.2	468.6	290
Michigan	13	90.9	3,207	14,746	32,509	-	-	71.0	157.0	566.5	352
Huron	12	117.6	4,146	19,980	44,051	60	132	31.4	69.8	268.0	166
Erie	3	8.3	293	2,780	6,128	-	-	3.1	6.9	84.3	53
Ontario	7	59.4	2,098	6,780	14,946	71	157	0.2	0.4	108.3	67
Total	51	305.5	10,778	49,213	108,496	131	289	105.8	234.3	1,495.7	928

[a]Includes 108 TFM bars (23 kg, 50 lbs) applied in 3 streams.

Table 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of the Great Lakes in 1991.

Lake	Number of Streams	Total captured	Number sampled	Percent males	Mean Length(mm) Males	Mean Length(mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
Superior	23	3,241	1,098	48	425	427	191	192
Michigan	11	15,824	1,698	47	481	483	252	256
Huron	12	41,332	570	41	460	471	208	233
Erie	7	607	215	53	482	492	281	292
Ontario	14	8,356	1,581	53	478	471	256	254
Total	67	69,360	5,162	49	466	466	238	240

LAKE SUPERIOR

Larval Assessment

United States

Surveys monitored reestablished and residual populations of larval sea lampreys, prepared for lampricide treatments, and searched for new infestations of larvae in 59 Lake Superior tributaries. Sea lamprey had re-established in at least 32 streams.

Surveys to assess recruitment of the 1991 year class were conducted in 55 streams and young-of-the-year larvae were recovered in 20. Surveys to assess recruitment of the 1991 year class in 3 streams were postponed until 1992 due to inclement weather and high stream flows. Young-of-the-year larvae have not been detected for 5 or more years in 6 streams that have been examined annually.

Surveys to schedule lampricide applications (pretreatment) were conducted in 21 streams and to assess past applications (posttreatment) in 2 others. Pretreatment surveys resulted in 4 streams treated in 1991, 12 scheduled for future treatment, and 5 deferred indefinitely.

Residual lampreys were found in 19 streams, but comprised less than 5% of the total number of larvae collected in all streams. Of those streams, Red Cliff Creek will require treatment in 1992, about two years ahead of schedule.

Original surveys to search for infestations were conducted in three streams. No larvae were found.

Upgrading the electrofishing gear began in the late 1980s and was completed in 1991. Electroshockers used since the late 1960s were replaced with the Advanced Backpack Fish Shocker (Model Abp-2), which has greater power output capabilities and more optional stimuli features. The equipment upgrade significantly improves the reliability of larval assessments.

The populations of larval sea lampreys were estimated in six tributaries of Lake Superior through a random transects habitat-based technique in 1991. These studies determined the amounts of habitat for larvae (three types) and the number of larvae and transformers inhabiting each river. The tributaries included: Chocolay, Iron, Salmon Trout, Firesteel, Bad and Amnicon rivers. Study on the Bad River was conducted cooperatively with the Great Lakes Indian Fish and Wildlife Commission and the Bad River Band of Chippewa Indians. Densities of larval lamprey were determined with backpack and deepwater electrofishing gear. Length frequency data provided a basis to estimate the number of lamprey in each age class, the number that have reached minimum length for transformation (120 mm), and the number of transformed lampreys that would be expected to migrate into Lake Superior. All rivers were treated in 1991.

Amount of habitat in the streams was estimated by random selection of a 5-foot (1.5 m) wide transect across the river at equally spaced intervals throughout the stream. The amount and type of substrate (sand, silt, gravel, clay, etc.) along the transect were recorded. From these measurements, the substrates were divided into three broad categories based on potential for habitation by lamprey larvae: type I habitat was considered optimal, type II was acceptable though not preferred, and type III was uninhabitable.

Lamprey densities at each transect were determined by a depletion method of sampling. Areas of types I and II habitat in each transect were sampled one or more times with electrofishing gear. The diminishing number of lampreys captured in each sample site in successive passes with the gear was used to estimate lamprey density. All lampreys captured in each depletion were identified, counted, measured for total length, and removed from the stream. The total area of the stream, the percent of each habitat type, and the mean lamprey density in each habitat type were used to calculate the total number of larvae and larvae ≥120 mm (the size when transformation may occur) in each river. The number of transformers was calculated as the percentage of those lampreys ≥120 mm that would be expected to transform in each stream (based on past collections of larvae during lampricide treatments for each river). The estimated number of larval lampreys ranged from 69,859 in the Iron River to 1,048,208 in the Bad River (Table 3).

The second year of a three-year study of the larval lamprey population in the Firesteel River was completed in 1991. The study has three objectives: to estimate the population of larval lampreys, to estimate the number of residual larvae after the 1991 lampricide treatment, and to estimate mortality of larval lampreys. The study began in 1990 and included a habitat evaluation and a larval density assessment with electrofishing gear. These data were used to estimate the larval lamprey population in the river. All lamprey captured were marked with a dye and returned to the river. In 1991, the larval density assessment was repeated except the larvae were marked with a tail clip. The river was treated with lampricide in September, and an extensive collection of dying and dead larvae was conducted. These were used in a mark-recapture estimate of the larval lamprey population. More larvae were estimated by mark-recapture (513,362) than larval density assessment (328,553). Examination of the mark-recapture data indicated that mortality for the 1988 and 1989 year classes of larvae was 48 percent from 1990 to 1991. In 1992, a posttreatment assessment will be conducted to estimate the residual population of larvae.

The performance of the Abp-2 backpack electrofishing gear was assessed in the Firesteel River. Electrofishing gear was used to capture larvae from 1 m^2 plots. Then a suction dredge removed those larvae not captured in electrofishing. At the 95% level of confidence, the average efficiency for electrofishing was 92% (range, 48-100%; n=34).

A cooperative project with the Department of Fisheries and Oceans Canada, USFWS National Fisheries Research Center-La Crosse, and the Hammond Bay Biological Station was conducted in Batchawana Bay, Ontario to assess the effectiveness of a new formulation of granular Bayer 73. Assessment gear and methods specifically developed to assess populations of larval lampreys in deep water were used in this study. Details of the project will be reported by the National Fisheries Research Center-La Crosse.

Canada

Surveys were conducted on 35 Lake Superior tributaries, one instream lake and offshore of six streams in preparation for chemical treatments, to monitor re-established, residual and untreated populations, to evaluate barrier dams and to look for new infestations.

able 3. The estimated amount of habitat (ft^2) for sea lamprey larvae, density (larvae/ft^2), total number of year classes in the population, total larvae and transformers in the population, number ≥120 mm, and number of transformers for six tributaries of Lake Superior, 1991. (The 95% confidence intervals for total numbers, number ≥120 mm, and Transformers are listed in parenthesis below each respective estimated value.) The methods of estimation include techniques listed as random transects and mark and recapture, and each is described in the footnotes.

River	Method of Estimation	Area of Habitat Types[1] I	Area of Habitat Types[1] II	Area of Habitat Types[1] III	Density of Larvae[2] I	Density of Larvae[2] II	Year[3] Classes	Total Larvae[4] and transformers	Number[5] ≥120 mm	Number of[6] transformers
hocolay	Random transects[7]	1,559,696	2,142,557	249,346	.1907	.0750	3	458,126	14,075	1,239
								(1,239-866,701)	(9-34,974)	(0-3,078)
ron	Random transects	725,835	575,412	19,414	.0838	.0157	4	69,859	4,573	-
								(192-132,588)	(5-10,636)	
Salmon Trout	Random transects	785,344	1,113,524	40,732	.2819	.0139	3	236,866	135	-
								(121,087-348,836)	(1-409)	
Firesteel	Random transects	1,042,827	3,947,620	1,364,382	.2367	.0207	3	328,553	9,594	269
								(163,074-506,316)	(44-27,154)	(1-760)
	Mark and Recapture[8]							513,362	-	-
								(425,751-600,973)		
Bad	Random transects	9,282,144	33,360,186	6,941,775	.0813	.0088	2	1,048,208	18,739	9,163
								(548,227-1,548,189)	(3,104-34,374)	(1,518-16,809)
Amnicon	Random transects	779,715	2,484,492	289,638	.5622	.0341	3	523,077	7,031	408
								(281,057-737,835)	(15-13,781)	(3-811)

[1]Type I habitat is considered optimal for sea lampreys, type II is acceptable though not preferred, and type III is uninhabitable.

[2]The density of larvae in type III habitat is 0 for all streams.

[3]The number of year classes of larvae in the stream generally is a result of the number of years since the last treatment. Young-of-the-year larvae are not included as a year class. Some residuals also are present in all populations, but these also are not included in the year classes because exact measurement of age of each residual is impractical.

[4]The estimated number of larvae does not include young-of-the-year.

[5]The number ≥120 mm was estimated separate from the value for total larvae and is based on the actual number ≥120 mm taken in the various sampling procedures.

[6]The number of transformers was estimated as either the number taken in the sampling procedures, or the percentage of those larvae ≥120 mm that were undergoing transformation that were collected during treatments of 1991 or previous years. The percentage is different for each stream and ranges from 3% for the Firesteel River to 49% for the Bad River. No data existed to calculate values for the Iron and Salmon Trout rivers.

[7]The random transect method is a measurement of the amounts of habitat on randomly selected 5-foot wide transects across the river at 250-foot intervals or areas randomly selected near access sites, and the amounts are expanded to include the unmeasured area.

[8]The mark and recapture technique involves the use of a simple Petersen formula where larvae are marked and released before a lampricide treatment and recaptured during the treatment.

Distribution surveys were completed on the four steams tentatively scheduled for treatment in 1992 (Pays Plat, Jackfish, Nipigon and Kaministiquia rivers). The distribution in Whitefish River, a tributary to the Kaministiquia River, has expanded considerably over that of recent years. An additional 42 km of stream will require treatment in 1992.

Treatment evaluation surveys done on the 12 streams treated in 1990 found moderate numbers of residuals in the Batchawana and Goulais rivers, low numbers in the Cypress River and the Neebing McIntyre Floodway, and none in the other eight streams. Of these 12 streams, only four (Harmony, Chippewa and Pic rivers and Cranberry Creek) have not re-established with the 1990 year class of sea lamprey larvae.

Surveys done upstream of dams on Gimlet Creek (Pancake River), Black Sturgeon and Wolf rivers indicated that all three dams continue to be effective at blocking spawning sea lamprey. The low head barrier dam on Carp River failed to block the 1990 spawning run.

Routine surveys of four streams with no previous history of sea lamprey production were all negative.

Surveys indicate that significant lentic populations of sea lamprey larvae continue to persist in Helen Lake (Nipigon River), Mountain Bay (Gravel River) and Mackenzie Bay (Mackenzie River).

Chemical Treatment

United States

A total of 11 streams with a combined flow of 25.2 m^3/s were successfully treated in 1991 (Table 4, Figure 1). Most minimum lethal concentrations now are based on an average of alkalinity prediction chart values and the new pH prediction chart values. This typically results in stream lampricide concentrations slightly lower than those resulting from use of only the alkalinity prediction chart. Low stream discharge was present during the treatments of the Two Hearted, Little Two Hearted, Bad, Firesteel, Sand, Iron and Chocolay rivers and compounded problems caused by beaver dams and pools. Lampricide concentrations were difficult to maintain on these streams and may have resulted in some larvae surviving the treatments.

Another complication of most treatments was the unavailability of TFM bars due to a delay in the current registration process. Some of the minor application sites normally treated with TFM bars were not treated due to insufficient staff.

Sea lamprey larvae were abundant on the Bad, Two Hearted, Salmon Trout, Chocolay and Firesteel rivers. Non-target mortality was low during all stream treatments.

Canada

Lampricide treatments were successfully completed on five Lake Superior tributaries in 1991 (Table 4, Figure 1).

The scheduled treatment of the upper Nipigon River was deferred. Citing major environmental disturbances caused by a recent land slump and concerns about the possibility of non-target mortality during a major walleye transfer project to Nipigon Bay and the lower Nipigon River, the Ontario Ministry of Natural Resources requested postponement to 1992.

With the exception of the Gargantua River, each stream had been treated a number of times and are considered regular sea lamprey producers. This was the first treatment of the Gargantua River, following the initial documentation of sea lamprey larvae in the system in 1990.

Larval sea lamprey were observed as being abundant in Gargantua River, moderate in the Pearl and Little Gravel rivers and Cash Creek, and scarce in Stillwater Creek. Non-target fish mortality was light in all treatments.

Spawning-phase Assessment

United States

Assessment traps placed in 20 tributaries of Lake Superior captured 3,211 spawning-phase sea lampreys (Table 5, Figure 1), an increase of 404 from 1990 (2,807). Catch of lampreys increased in the Tahquamenon, Betsy, Misery, Firesteel and Brule rivers (average increase of 65%), decreased in the Ontonagon, and Bad rivers, and remained about the same in the other streams. A trap was placed for the first time in the Raspberry River, but no lampreys were caught. The Otter River (Sturgeon River) was excluded from spawning-phase assessment in 1991 because no lampreys were caught in 1989 and 1990. The average length and weight of lampreys sampled from Lake Superior tributaries was similar to that of 1990. The percentage of males increased from 43 in 1990 to 48 in 1991. Spawning runs were monitored in 12 streams (Red Cliff Creek, Nemadji, Amnicon, Middle, Raspberry, Bad, Ontonagon, Firesteel, Misery, Traverse, Silver and Huron rivers) through a cooperative agreement with the Great Lakes Indian Fish and Wildlife Commission, and in the Brule River through a cooperative agreement with the Wisconsin Department of Natural Resources.

The total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior for the sixth consecutive year (Table 6). The estimate, based on a significant relation of average stream discharge (x) and the estimated number of adult lamprey (from mark-recaptures) that enter tributaries (y), was calculated separately for streams east and west of the Keweenaw Peninsula. An estimated 20,927 lampreys were present ($y=7.64$; P 0.05, $r=0.926$) in western waters, while 6,618 lampreys were estimated ($y=2.60$; P 0.05, $r=0.799$) east of the Keweenaw Peninsula. The total estimate of 27,545 sea lampreys was calculated using a combined flow of 6,060 cfs (3,394 cfs west and 2,666 cfs east), and compares with 30,704 lampreys estimated in 1990.

Table 4. Details on the application of lampricides to streams of Lake Superior, 1991.
[Number in parentheses corresponds to location of stream in Figure 1. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM kg	TFM lbs	Bayer 73 kg	Bayer 73 lbs	Distance km	Distance miles
UNITED STATES									
Salmon Trout R.(6)	June 14	1.0	35	148	326	0	0	12.9	8
Iron R.(5)	June 17	1.6	58	135	297	0	0	4.8	3
Two Hearted R.(2)	July 25	3.1	110	618	1,362	0	0	87.1	54
Little Two Hearted R.(1)	July 27	0.7	25	83	183	0	0	19.4	12
Bad R.(10)	Aug. 23	9.9	350	2,117	4,668	0	0	203.2	126
Firesteel R.(9)	Sept. 20	0.7	26	271	598	0	0	37.1	23
Silver R.(7)	Sept. 24	0.5	18	63	139	0	0	8.1	5
Falls R.(8)	Oct. 3	1.6	55	107	235	0	0	1.6	1
Chocolay R.(4)	Oct. 8	4.7	165	630	1,390	0	0	35.5	22
Sand R.(3)	Oct. 19	0.3	10	79	174	0	0	6.5	4
Amnicon R.(11)	Oct. 20	1.1	37	96	211	0	0	16.1	10
Total		25.2	889	4,347	9,583	0	0	432.3	268
CANADA									
Gargantua R.(16)	June 26	0.3	11	29	64	0.1	0.2	1.7	1
Little Gravel R.(15)	July 8	1.2	42	67	148	-	-	6.9	4
Stillwater Cr.(13)	July 10	0.5	18	41	90	-	-	1.2	1
Pearl R.(12)	July 12	1.0	36	165	364	-	-	3.7	2
Cash Cr.(14)	July 14	1.1	39	278	613	-	-	22.8	14
Total		4.1	145	580	1,279	0.1	0.2	36.3	22
GRAND TOTAL		29.3	1,034	4,927	10,862	0.1	0.2	468.6	290

Canada

Three streams were trapped on the Canadian shoreline (Table 5, Figure 1), but the collection from one, the Wolf River, was incomplete and results are not discussed. Combined catch from the Carp River (18) and Stokely Creek (12) was 30 spawning-phase adults, down dramatically from the 234 taken from these two tributaries in 1990.

Trapping efficiency is reported by the Centre as the ratio between the number of recaptures and the number of adults marked and released, while population estimates are a modification of the stratified method of Schaefer. For 1991, efficiency and stratified population estimates were only available for the Carp River, since the Stokely Creek yielded insufficient recaptures. Efficiency for the Carp River permanent trap was 0.235, which was low in comparison with previous years. The population estimate suggested a run of 26.

Table 5. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Superior, 1991. [Letter in parentheses corresponds to location of stream in Figure 1]

Stream	Number captured	Number sampled	Percent Males	Mean Length(mm) Males	Mean Length(mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
UNITED STATES							
Tahquamenon R. (A)	572	168	67	442	443	220	229
Betsy R. (B)	137	58	55	423	423	203	216
Sucker R. (C)	2	0	-	-	-	-	-
Miners R. (D)	23	8	13	455	400	175	270
Rock R. (E)	526	349	41	421	420	191	186
Big Garlic R. (F)	18	7	43	396	371	147	134
Iron R. (G)	6	1	0	-	390	-	139
Huron R. (H)	14	2	50	345	381	120	135
Silver R. (I)	29	6	33	351	382	125	157
Traverse R. (J)	33	3	67	396	430	140	190
Misery R. (K)	336	107	51	397	430	168	192
Firesteel R. (L)	86	24	46	377	406	144	166
Ontonagon R. (M)	18	1	0	-	425	-	210
Bad R. (N)	121	29	17	378	394	108	144
Red Cliff Cr. (O)	15	1	100	430	-	162	-
Raspberry R. (P)	0	0	-	-	-	-	-
Brule R. (Q)	1,195	324	48	435	441	185	196
Middle R. (R)	4	0	-	-	-	-	-
Amnicon R. (S)	67	10	70	396	386	167	154
Nemadji R. (T)	9	0	-	-	-	-	-
Total or average	3,211	1,098	48	425	427	191	192
CANADA							
Wolf R. (U)	- Incomplete Data -						
Carp R. (V)	18	0	-	-	-	-	-
Stokely Cr. (W)	12	0	-	-	-	-	-
Total or average	30	0	-	-	-	-	-
GRAND TOTALS	3,241	1,098	48	425	427	191	192

Table 6. Mean discharge for U.S. streams located east and west of Keweenaw Bay in Lake Superior from May 6-June 30, 1986-1990, ranked as primary and secondary producers of sea lampreys, and the estimated number of spawning phase sea lampreys in 1991.

[Population estimates were calculated from results of stratified multiple tag and recapture techniques in 14 streams with assessment traps and a linear regression for all streams based on the relation of mean stream discharge and the number of lampreys entering tributaries.]

PRIMARY STREAMS

Stream	Discharge CFS	Population Estimate Mark/Recapture	Population Estimate Regression
WEST			
Nemadji R.	490	-	3,745
Amnicon R.	240	413	1,834
Middle R.	50	-	382
Poplar R.	35	-	268
Brule R.	195	2,161	1,490
Red Cliff Cr.	1	48	8
Fish Cr.	78	-	596
Bad R.	437	3,806*	3,340
Ontonagon R.	1,031	-	7,880
Firesteel R.	59	265	451
Misery R.	49	737	375
Subtotal (West)	2,665	7,430	20,370
With Traps	981	7,430	7,498
Without Traps	1,684	-	12,872
EAST			
Traverse R.	21	238	55
Sturgeon R.	607	-	1,578
Falls R.	61	-	159
Silver R.	69	61	179
Slate R.	19	-	49
Ravine R.	21	-	55
Huron R.	109	53	283
Salmon Trout R.	56	-	146

SECONDARY STREAMS[b]

Stream	Discharge[a] CFS	Population Estimate Regression
WEST		
Washington Cr.	29	22
Arrowhead R.	347	265
Poplar R.	45	34
Gooseberry R.	3	2
Split Rock R.	10	8
Sand R.	11	8
Black R.	97	74
Cranberry R.	60	46
Potato R.	36	28
East Sleeping R.	26	20
Elm R.	21	16
Salmon Trout R.	44	34
Subtotal (West)	729	557
EAST		
Big Gratiot R.	12	3
Eliza Cr.	1	0
Dead R.	50	13
Sand R.	16	4
Five Mile Cr.	2	1
Beaver Lake Outlet	17	4
Sable Cr.	10	3
Galloway Cr.	4	1

(continued)

Table 6. Continued.

Stream	PRIMARY STREAMS Discharge CFS	Population Estimate Mark/Recapture	Population Estimate Regression
Iron R.	99	-	257
Big Garlic R.	15	51	39
Little Garlic R.	11	-	29
Harlow Cr.	20	-	52
Chocolay R.	103	-	268
Laughing Whitefish R.	25	-	65
Rock R.	33	1,364	86
Au Train R.	107	-	278
Furnace Cr.	6	-	16
Miners R.	38	45	99
Sucker R.	75	-	195
Two Hearted R.	217	-	564
Little Two Hearted R.	34	-	88
Betsy R.	74	243	192
Tahquamenon R.	659	1,690	1,713
Waiska R.	54	-	140
Subtotal (East)	2,533	3,745	6,584
With traps	1,018	3,745	2,646
Without traps	1,515	-	3,938
Primary Lake Total	5,198	11,175	26,954
Secondary Lake Total	862		591
Total South Shore Discharge:			6,060
Total South Shore Population Estimate:			27,545

Stream	SECONDARY STREAMS Discharge[a] CFS	Population Estimate Regression
Pendills Cr.	21	5
Subtotal (East)	133	34

[a]Average flows taken during past chemical treatments.

[b]Electrical weirs on secondary streams had collected one-tenth of the sea lampreys per cubic foot of flow as primary streams, and the regression estimate reflects the decrease.

*Regression of catch per unit effort vs. weekly population estimate was plotted for 1987-1990. Catch per unit effort values for available weeks in 1991 were fitted to the regression and population estimates calculated. Unavailable weeks data was obtained from percentage of run missed as determined from past years (1987-1990).

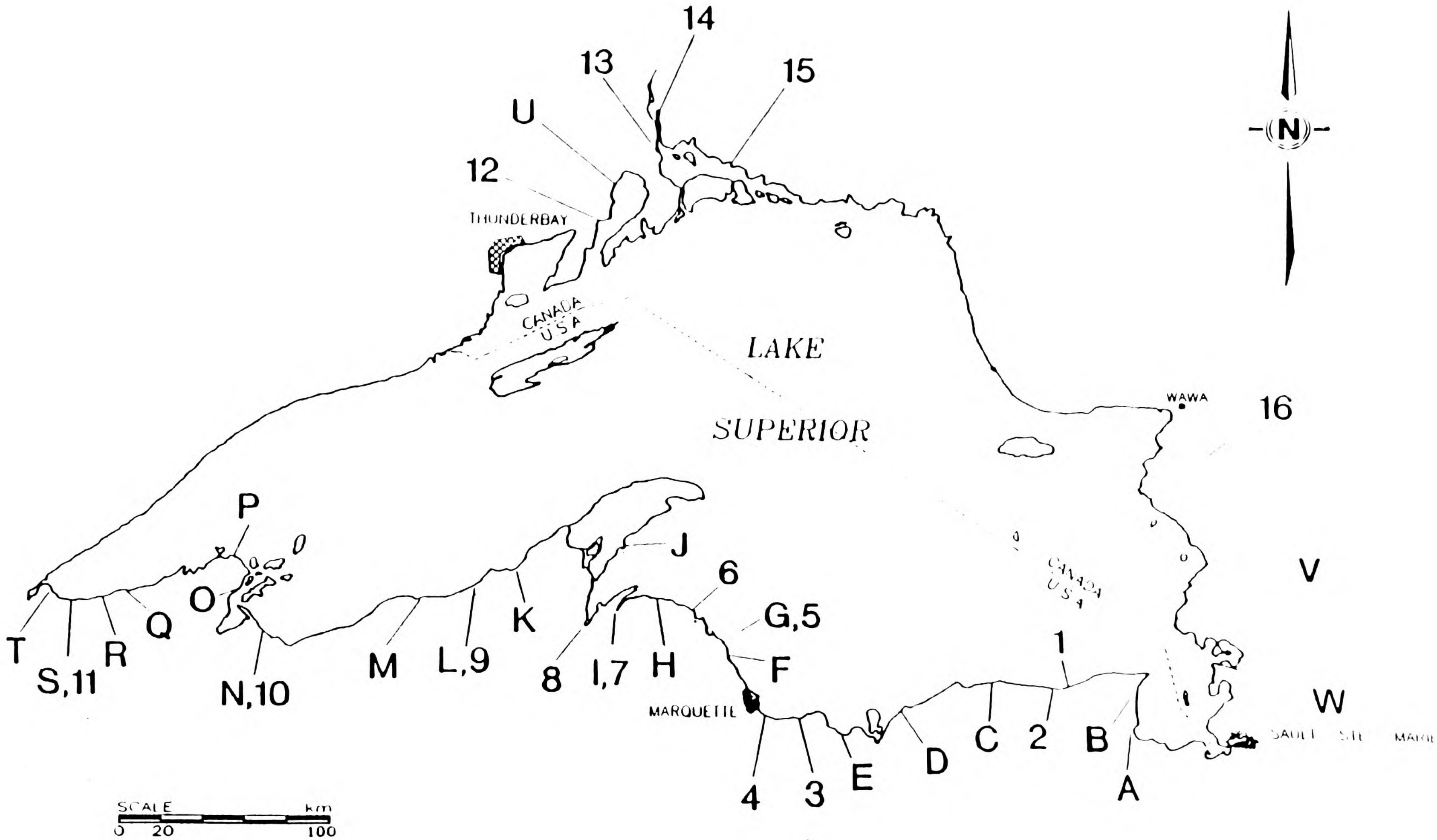


Figure 1. Location of Lake Superior tributaries treated with lampricides (numerals; see Table 4 for names of streams), and of streams where assessment traps were operated (letters; see Table 5 for names of streams) in 1991.

Parasitic-phase Assessment

United States

A total of 161 parasitic-phase sea lampreys were collected from Lake Superior commercial fishermen in 1991 (Table 7), compared with 216 taken in 1990. The largest number of sea lampreys were collected from fishermen in the Wisconsin management unit of WI-2 (Apostle Island area), 73 in 1991 vs. 57 in 1990. Fishermen from the management units of MI-4, 5 and 6 (east side of Keweenaw Peninsula, Marquette and Munising, Michigan areas) captured 49 lampreys in 1991, a continuing decrease from 76 taken in 1990 and 157 in 1989. Fishermen in management units MI-7 (Grand Marais, Michigan area) and MI-8 (Whitefish Bay, Michigan area) also collected decreasing numbers of sea lamprey from 79 taken in 1990 to 27 in 1991. Most lampreys were collected by fishermen using gill nets (68%), during April-June (52%), and primarily were attached to lake trout (40%) and lake herring (31%).

Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen. Therefore, lampreys that would spawn either in the present or succeeding two years may be found in the catch. Spawning year was determined for the 161 parasitic-phase sea lampreys captured in 1991 (76 would have spawned in 1991 and 85 in 1992). A total of 122 lampreys of the 1991 spawning year class have been collected (46 in 1990 and 76 in 1991) and represent a continuing decrease when compared to the numbers of the 1989 and 1990 spawning year classes (334 in 1989 and 268 in 1990) captured by commercial fishermen.

Sport fishermen captured or reported 186 parasitic-phase sea lampreys in 1991 (Table 8), compared with 156 taken in 1990. Of the total, 135 were from the charterboat fishery and 51 were from noncharter fishermen. Fishermen from management unit MI-2 (Black River Harbor to Ontonagon, Michigan area) contributed the largest number of sea lampreys (69). Most lampreys were collected or reported by fishermen during July-August (73%), and primarily were attached to lake trout (90%). The Michigan Department of Natural Resources provided data on the occurrence of parasitic-phase sea lampreys in Michigan charterboat catches.

Presence of sea lampreys was reported by charterboat operators in 6 of the 8 management units of Michigan (Table 9). The operators reported 1.6 and 8.0 lampreys attached per 100 lake trout and chinook salmon respectively.

Barrier Dams

Canada

Maintenance was conducted as required on the barrier dam network in Lake Superior. On the Carp River, additions were made to the corners of the low crest overhang. A conceptual design was completed for an adult sea lamprey trap at the Alexander Generating Station on the Nipigon River. Preliminary surveys were conducted on the McIntyre River where a velocity barrier study is being proposed for 1993.

Table 7. Number of parasitic-phase sea lampreys collected in commercial fisheries in 1991 and year lampreys would have spawned[a].

Lake Superior			Lake Michigan			Lake Huron		
Unit	Spawning Year		Unit	Spawning Year		Unit	Spawning Year	
	1991	1992		1991	1992		1991	1992
M-1	-	-	MM-1 59	59	133	MH-1	69	963
M-2	0	0	MM-2	1	2	MH-2	8	118
M-3	2	1	MM-3	6	12	MH-3	-	-
WI-1	1	0	MM-4	-	-	MH-4	9	150
WI-2	16	57	MM-5	0	5	MH-5	-	-
MI-1	-	-	MM-6	-	-	MH-6	-	-
MI-2	-	-	MM-7	0	17			
MI-3	8	0	MM-8	-	-			
MI-4	3	2	WM-1	-	-			
MI-5	0	0	WM-2	5	63			
MI-6	23	21	WM-3	0	34			
MI-7	17	1	WM-4	0	4			
MI-8	6	3	WM-5	-	-			
			WM-6	-	-			
			Ill.	-	-			
			Ind.	-	-			
Total	76	85		71	270		86	1,231

[a]Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen; therefore, lampreys that would have spawned in either the present or succeeding two years may be found in the catch.

Table 8. Number of parasitic-phase sea lampreys collected in sport fisheries in U.S. waters of the Upper Great Lakes in 1991[a].

Lake Superior			Lake Michigan			Lake Huron		
Unit	Charter	Noncharter	Unit	Charter	Noncharter	Unit	Charter	Noncharter
M-1	8	4	MM-1	1	9	MH-1	172	316
M-2	0	12	MM-2	-	-	MH-2	190	290
M-3	1	0	MM-3	14	15	MH-3	323	231
WI-1	4	3	MM-4	19	0	MH-4	52	49
WI-2	5	9	MM-5	85	2	MH-5	163	41
MI-1	19	0	MM-6	108	16	MH-6	22	8
MI-2	60	9	MM-7	66	4			
MI-3	-	-	MM-8	197	1			
MI-4	0	1	WM-1	3	16			
MI-5	20	12	WM-2	4	2			
MI-6	17	1	WM-3	1	8			
MI-7	1	0	WM-4	6	21			
MI-8	-	-	WM-5	13	11			
			WM-6	2	7			
			Ill.	-	-			
			Ind.	-	-			
Total	135	51		519	112		922	935

[a]The Michigan Department of Natural Resources provided data on the occurrence of parasitic-phase sea lampreys in Michigan charterboat catches.

Table 9. Incidence of sea lampreys and numbers of lake trout and chinook salmon[a] taken by operators in the Michigan charterboat fishery, 1991.[b]

[Incidence of sea lampreys is the number of lampreys attached per 100 fish; includes lampreys that were brought in the boat and those that were observed but dropped off the fish.]

Lake and Unit[c] District[b]	Incidence on lake trout: Sea lampreys per 100 trout	Incidence on lake trout: Number of trout	Incidence on chinook salmon: Sea lampreys per 100 salmon	Incidence on chinook salmon: Number of salmon
UNITED STATES				
Superior				
MI-1	0.8	1,574	40.0	15
MI-2	2.3	2,527	1.9	52
MI-3	0.0	204	0.0	2
MI-5	1.3	1,537	0.0	14
MI-6	2.4	718	0.0	4
MI-7	0.3	307	0.0	0
All Units	1.6	6,867	8.0	87
Michigan				
MM-1	0.0	0	0.6	161
MM-3	2.4	584	0.0	237
MM-4	0.9	1,500	1.3	445
MM-5	1.3	4,423	0.4	7,135
MM-6	1.2	6,890	0.3	8,533
MM-7	0.8	6,166	0.4	4,465
MM-8	1.4	13,478	0.1	5,660
All Units	1.2	33,041	0.3	26,636
Huron				
MH-1	19.3	57	21.6	744
MH-2	14.9	276	13.4	1,115
MH-3	6.3	1,846	13.6	1,526
MH-4	7.2	456	7.9	242
MH-5	3.8	2,747	10.2	571
MH-6	25.0	12	9.7	196
All Units	5.7	5,394	14.0	4,394

[a]Lake trout and chinook salmon are the primary target species of the charter fishery of the Upper Great Lakes.
[b]The Michigan Department of Natural Resources provided data on the occurrence of parasitic phase sea lampreys in Michigan charterboat catches.
[c]Data were not obtained from units MI-4, MI-8 and MM-2.

LAKE MICHIGAN

Larval Assessment

United States

A total of 90 Lake Michigan tributaries and 4 offshore areas were surveyed in 1991 to prepare streams for lampricide treatment, assess annual recruitment and residual populations of larvae, and search for new infestations. Sea lamprey had re-established in at least 59 streams.

Surveys to assess recruitment of the 1991 year class were conducted in 72 streams and young-of-the-year larvae were recovered in 32. Recruitment in 19 other streams with a history of sea lamprey infestation had not occurred since their last lampricide treatments.

Pretreatment surveys were conducted in 35 streams. Of these, 8 later were treated in 1991, 17 are scheduled for treatment in 1992, and the remaining 10 were deferred for treatment until 1993 or later.

Lentic areas were examined for the presence of sea lampreys. A few larvae were found off the mouths of the Boyne River and Porter Creek (Lake Charlevoix). Few larvae were recovered from surveys of areas offshore of the Manistique River and may be a result of intensive trapping of spawning lampreys at the dam.

Posttreatment surveys were conducted on four streams to evaluate the effectiveness of recent treatments. Moderate numbers of residual larvae were recovered from high water channels in the Ford River, while few or none were found in the Millecoquins and Black rivers and Valentine Creek.

Habitat-based population estimates for larval sea lampreys was conducted on Jordan River, Brandywine Creek and Trail Creek in 1991. Since 1989, a Smith-Root electrical barrier has been operated in the Jordan River during the spawning run of adult lampreys. Annual surveys showed re-establishment of the 1989-91 year classes of larvae upstream of the weir and an estimated 138,532 larvae were present in the river in 1991. Populations of larvae in Brandywine and Trail creeks were estimated at 68 and 4,805 respectively.

A study was conducted to evaluate a pump-shocker device used for sampling deepwater habitats for larvae in the Muskegon River. The pump-shocker was effective for depletion sampling in water too deep for a backpack shocker. A population of 19,587 larvae was estimated in an area of 20,000 ft^2 downstream from Bigelow Creek. Some problems occurred from high stream velocity and underwater structures that prevented the device from tracking well.

Examination of all tributaries that previously had no history of sea lamprey infestation continued in 1991. Four streams were examined and although no sea lampreys were found, the streams appeared to have favorable environmental conditions for lampreys.

Chemical Treatment

United States

Lampricide treatments were completed on 13 streams (Table 10, Figure 2) with a combined discharge of 90.9 m^3/s (3,210 ft^3s). Most minimum lethal concentrations now are based on an average of alkalinity prediction chart values and the new pH prediction chart values. This typically results in stream lampricide concentrations slightly lower than those resulting from use of only the alkalinity prediction chart. Larvae were relatively abundant in Crockery Creek (Grand River), Black, Betsie, White, Peshtigo, Pere Marquette and Boyne rivers. Low populations were present in the remainder of the streams. Bayer 73 wettable powder was used with TFM to minimize impact to burrowing mayflies and reduce costs during treatments of the Betsie, White, Peshtigo, Lower Boardman and Boyne rivers.

Problems during treatment operations reduced effectiveness of some treatments. Beaver dams and difficult access to application points were encountered during some treatments in the Upper Peninsula of Michigan. Several live lampreys were found below beaver dams following treatment of the Millecoquins River. A section of the Black River received less than the defined minimum lethal concentration of TFM probably because of influx of water from small untreated tributaries. TFM bars typically would have been used to treat these tributaries, but a sufficient supply of bars was not available due to a delay in the current registration process. A large spawning population of lampricide-sensitive gizzard shad delayed treatment of the Lower Boardman River for a month. Heavy rains complicated treatment of the White River and Hospital and Crockery creeks. A more extensive treatment on the White River was necessary because of an additional 42 km of larval infestation upstream of a dam at Hesperia, Michigan. (The dam had washed out in 1986 and was not replaced until 1989.) The Pentwater River treatment was deferred until 1992 because of a shift in priority to treat the Chippewa River (Lake Huron).

Studies of caged sea lamprey larvae at selected stations indicated high mortality during treatments of Crockery Creek, Betsie, White, Pere Marquette and Boyne rivers. No significant non-target mortality occurred during treatment of any tributaries.

Spawning-phase Assessment

United States

A total of 15,824 sea lampreys were captured in assessment traps placed in 6 west shore and 5 east shore tributaries in 1991 (Table 11, Figure 2), 1,102 less than the number taken in 1990 (16,926). The percentage of males and the average length and weight of lampreys from Lake Michigan tributaries remained about the same as samples taken in 1990.

Along the west shore, a sea lamprey was caught for the first time in the Fox River, confirming the presence of a spawning run. Catches increased in the East Twin, Peshtigo and Menominee rivers, and decreased in the Oconto and Manistique rivers. For the eighth year the number of spawning-phase sea lampreys in the Manistique River was estimated, and showed a decrease from 28,462 in 1990 to 22,092 in 1991.

The total catch of sea lampreys increased in streams along the east shore of Lake Michigan. This increase was attributed to modifications in methods and number of traps in place downstream of the experimental electric barrier in the Jordan River, and an increase in catch of lampreys of 32% in the Betsie and 27% in the St. Joseph rivers when compared to catch in [illegible]

Table 10. Details on the application of lampricides to streams of Lake Michigan, 1991.
[Number in parentheses corresponds to location of stream in Figure 2. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m³/s	Discharge f³/s	TFM[a] kg	TFM[a] lbs	Bayer 73 kg	Bayer 73 lbs	Distance km	Distance miles
Millecoquins R. (6)									
Upper	May 4	1.6	57	317	699	0	0	19.4	12
Lower	June 2	3.3	115	534	1,177	0	0	16.1	10
Deadhorse Cr. (5)	May 17	0.3	10	37	81	0	0	1.6	1
Valentine Cr. (2)	May 19	0.4	14	19	41	0	0	3.2	2
Boardman R. (9)									
Hospital Cr.	June 1	0.3	12	109	240	0	0	6.4	4
Lower Boardman	July 18	7.6	270	1,151	2,537	13	28	1.6	1
Black R. (7)	June 2	0.9	30	209	460	0	0	22.6	14
Betsie R. (10)	June 12	6.5	230	1,194	2,633	10	21	19.3	12
White R. (12)	June 22	18.7	660	4,279	9,434	25	56	160.9	100
Poodle Pete Cr. (3)	June 28	0.1	1	6	13	0	0	1.6	1
Peshtigo R. (1)	June 28	25.5	900	2,025	4,466	19	42	16.1	10
Parent Cr. (4)	June 28	0.1	3	16	35	0	0	3.2	2
Pere Marquette R.(11)	July 26	22.7	800	3,867	8,525	0	0	236.6	147
Boyne R. (8)	Aug. 28	2.0	70	431	951	4	10	6.4	4
Grand R. (13)									
(Crockery Cr.)	Sept. 8	1.0	35	552	1,217	0	0	51.5	32
Total		90.9	3,207	14,746	32,509	71	157	566.5	352

[a] Includes 108 TFM bars (23 kg, 50 lbs) applied in 3 streams.

Table 11. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1991.
[Letter in parentheses corresponds to location of stream in Figure 2]

Stream	Number captured	Number sampled	Percent Males	Mean Length(mm) Males	Mean Length(mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
West Shore							
East Twin R. (A)	15	15	27	456	481	186	259
Fox R. (B)	1	1	100	587	-	365	-
Oconto R. (C)	23	22	45	464	485	229	264
Peshtigo R. (D)	376	373	51	472	491	243	267
Menominee R. (E)	83	83	57	475	487	242	281
Manistique R. (F)	13,994	0	-	-	-	-	-
East Shore							
Carp Lake R. (G)	31	0	-	-	-	-	-
Jordan R. (H)	81	0	-	-	-	-	-
Deer Cr.	66	65	63	496	488	294	295
Boardman R. (I)	28	26	35	485	490	243	266
Betsie R. (J)	756	737	46	468	467	238	235
St. Joseph R. (K)	370	370	41	516	502	286	274
Total or average	15.824	1,698	47	481	483	252	256

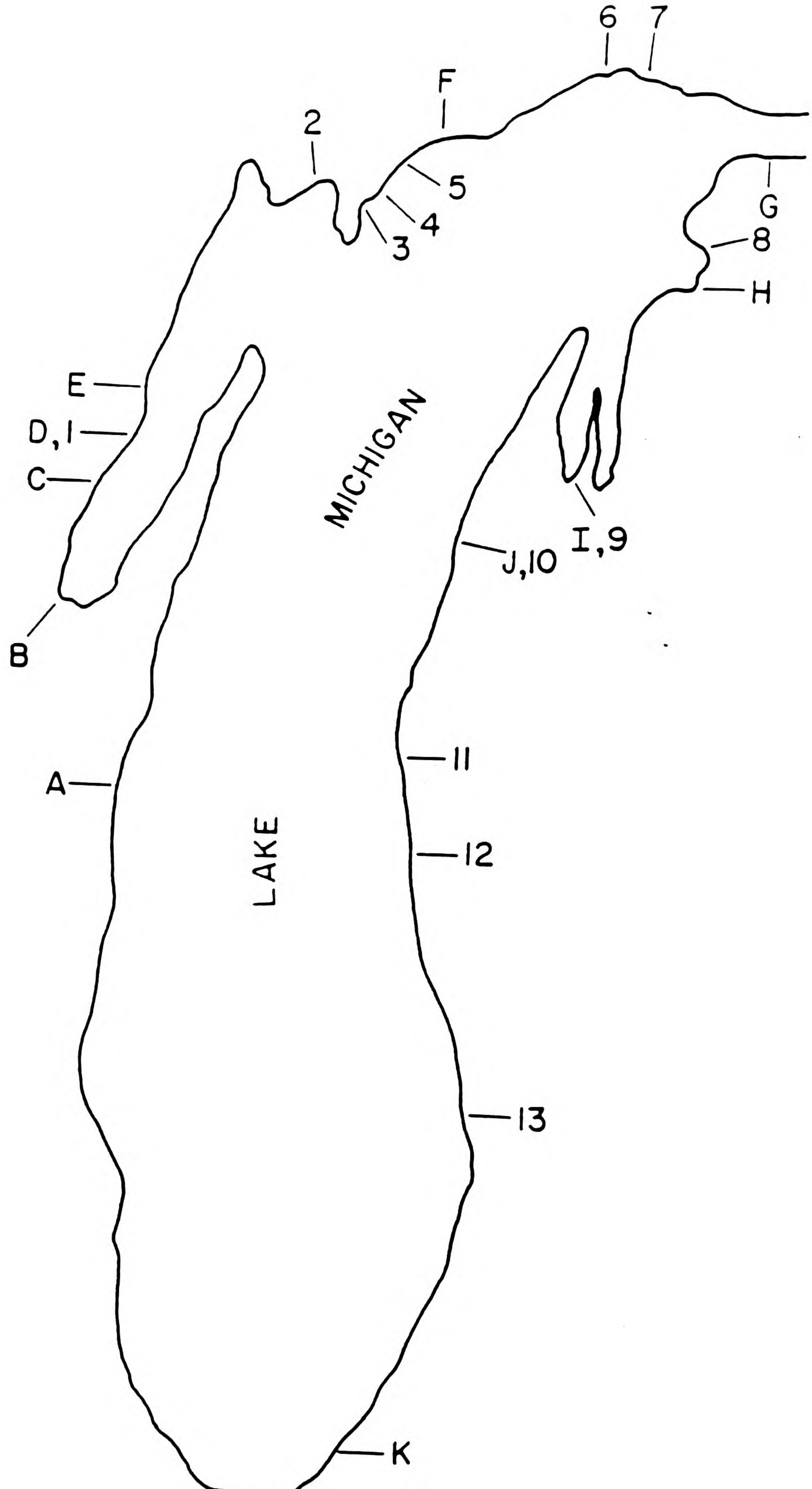


Figure 2. Location of Lake Michigan tributaries treated with lampricides (numerals; see Table 10 for names of streams), and of streams where assessment traps were operated (letters; see Table 11

Parasitic-phase Assessment

United States

Lake Michigan commercial fishermen captured 341 parasitic-phase sea lampreys in 1991 (Table 7), compared with 312 in 1990. Of the total, 81 were collected from Lake Michigan and 260 from Green Bay, compared with 175 and 137 respectively in 1990. The largest number of sea lampreys were collected from fishermen in the Michigan management unit of MM-1 (Menominee-Gladstone-Fairport, Michigan area), an increase to the number taken in 1990 (115 in 1990 vs. 192 in 1991). Most lampreys were collected by trapnet fishermen (74%) during May-July (63%), and primarily were attached to lake whitefish (40%) and cisco species (21%).

Spawning year was determined for the 341 parasitic-phase sea lampreys. Of these, 71 would have spawned in 1991 and 270 in 1992. A total of 223 of the 1991 spawning year class have been collected (152 in 1990 and 71 in 1991) and represent a decrease when compared to the number of the 1990 spawning year class (381) captured by commercial fishermen.

A total of 631 sea lampreys were collected or reported from the Lake Michigan sportfishery in 1991 (Table 8), compared with 873 taken in 1990. Of the total, 519 were from the charterboat fishery and 112 were from noncharter fishermen. (Variation in the collection of sea lamprey data from Michigan and Wisconsin requires that the assessment data be treated separately.) The Michigan management unit which contributed the largest number of sea lampreys was MM-8 (Holland to New Buffalo, Michigan; 198), while the Wisconsin management unit of WM-4 (Algoma to Manitowoc, Wisconsin area) contributed the largest number (27). Most lampreys were collected or reported by fishermen during June-August (80%), and primarily were attached to lake trout (73%).

Information on the incidence of sea lampreys was reported by the charterboat fisheries for 7 of the 8 management units of Michigan (Table 9). Fishermen reported 1.2 and 0.3 lampreys attached per 100 lake trout and chinook salmon, respectively.

LAKE HURON

Larval Assessment

United States

A total of 53 Lake Huron tributaries and 4 offshore areas were surveyed for larval sea lampreys to prepare streams for lampricide treatment and to assess annual recruitment and residual populations. Sea lampreys are reestablished in at least 28 streams. Surveys to assess recruitment of the 1991 year class were conducted on 35 streams. Young-of-the-year larvae were found in 16 streams. Pretreatment surveys to schedule treatments were completed on 16 streams; 5 later were treated in 1991, and the others are scheduled for treatment in 1992-93 or deferred indefinitely.

Surveys to assess the effectiveness of recent treatments (posttreatment) were conducted on four streams in 1991. Residual sea lampreys were collected from 3 of the 4 streams and also from another 2 streams during surveys to assess annual recruitment. Large numbers of residual lamprey larvae were recovered from backwater areas of the Au Sable River, but few were found in the other streams.

Surveys continued in 1991 to monitor populations of larval sea lampreys in the St. Marys River. A total of 13 index locations of 0.2 ha each were surveyed with Bayer 73 granules, and 502 larval and 2 transformed sea lampreys were collected. An additional 12 locations were sampled in the Little Rapids Cut, North Channel, and Lake Nicolet areas where 178 larval and 1 transformed sea lamprey were collected.

Original surveys were conducted in 11 streams in the Lower Peninsula of Michigan. No larval sea lampreys were found.

The Smith-Root electric barrier in the Ocqueoc River was not operated in 1991. Young-of-the-year and yearlings are present in the river upstream of the barrier site.

Lentic areas off the mouths of four Lake Huron tributaries were examined with a submersible camera and electroshocker. Small numbers of larvae were seen off the Cheboygan and Ocqueoc rivers. The submersible has proven to be a valuable tool for qualitative lentic surveys.

A project conducted cooperatively with the Hammond Bay Biological Station assessed and improved the quantitative performance of the deepwater shocker unit. The unit, which was described in the Annual Report for 1990, consists of a section that is lowered from a boat to the river or lake substrate, a flexible hose, suction pump, Abp-2 electroshocker, and a filtration screen. Preliminary tests in 1990 indicated the deep water shocker was effective with 0.8 v/cm and a 10% duty cycle. In 1991, the unit was tested at a voltage gradient of 0.6 to 0.8 v/cm and a 10% duty cycle and proved again to be highly effective in the capture of larval sea lampreys. At the 95% level of confidence, efficiency for 1 activation was 74% (55.3% - 94.2%), based on 179 samples.

Tests also were conducted to document and improve the effectiveness of Abp backpack electroshocker gear for use in streams with water temperatures less than 10°C. Larval lampreys are lethargic in cold water, and emergence of larvae is slow and has been difficult to assess in past surveys. Pulsed direct current stimuli were tested to determine their effect on several age groups of lampreys. Larvae generally emerged from substrates within 5 seconds at the following operation of the gear: 125 volt output, 5 pulses per second, 10% duty cycle and a burst pulse train of 2 on and 2 off. The settings of 125 volts, 40 pulses per second, and 10% duty cycle immobilized larvae after they emerged from their burrows.

Canada

Surveys were conducted on 50 Lake Huron tributaries, one instream lake and six off-shore areas in preparation for chemical treatment, to monitor re-established, residual and untreated populations, to evaluate barrier dams and to look for new infestations.

Distribution surveys were completed on three streams (Root, Boyne and Pine rivers) in preparation for scheduled 1991 treatments. Distribution surveys were also completed on five other streams tentatively scheduled for treatment in 1992 [Thessalon, Naiscoot and French (Old Voyageur Channel) rivers and Gordon and Brown's creeks]. No Significant changes in distribution were found in these.

Treatment evaluation surveys done on eight streams treated in 1990 found moderate numbers of residuals in the Garden River, low numbers in Blue Jay and Spragge creeks and none in Echo, Two Tree and Manitou rivers, and Watson and Silver creeks.

Of the eight streams treated in 1990 only three have re-established with the 1990 year class of sea lamprey larvae (Garden and Echo rivers and Blue Jay Creek). In addition, the Sauble River, last treated in 1985, and Livingstone Creek, last treated in 1967, have also re-established with the 1990 year class.

An extensive survey of the large and complex lower French River system found sea lamprey larvae in the traditional locations, Wanapitei River and the lower reaches of the Western Channel, but a single larva was also collected from the main outlet. This suggests the Dalles rapids as another possible spawning area although the numbers of larvae in this outlet are not thought to be high.

Surveys of the Nottawasaga River system found that in addition to the Pine River, which was treated in 1991, three other tributaries and the main river are also infested. Although densities appear very low, the large amounts of habitat in the 90+ km of main stem that may be infested could contain a significant larval population. The Nottawasaga River sea lamprey population will be watched closely.

Surveys done at 16 index sites on the St. Marys River indicate a fairly stable larval population.

Routine surveys of 10 Lake Huron tributaries with no history of sea lamprey production were all negative.

Small populations of sea lamprey larvae continue to be present in Tenby Bay off Watson, Gordon and Brown's creeks and in Echo Lake off the upper Echo River. Small numbers of larvae were also found for the first time in Milford Haven off the Koshkawong River. Lentic surveys off the mouths of the Serpent River and Spragge Creek were negative.

The presence of a small number of the 1990 year class of sea lamprey larvae upstream of the Echo River dam indicates that it is still not 100% effective. Barrier dams on the Koshkawong and Still rivers continue to be effective at blocking spawning lamprey.

Chemical Treatment

United States

Lampricide treatments were completed on 8 Lake Huron streams during 1991 (Table 12, Figure 3), with a combined discharge of 55.3 m^3/s (1,946 ft^3/s). Most minimum lethal concentrations now are based on an average of alkalinity prediction chart values and the new pH prediction chart values. This typically results in stream lampricide concentrations slightly lower than those resulting from use of only the alkalinity prediction chart. Larvae were abundant in the Devils, Au Sable and Chippewa rivers, and relatively less abundant in the remaining streams. The Au Sable River was the only stream treated with a combination of TFM and Bayer 73 wettable powder.

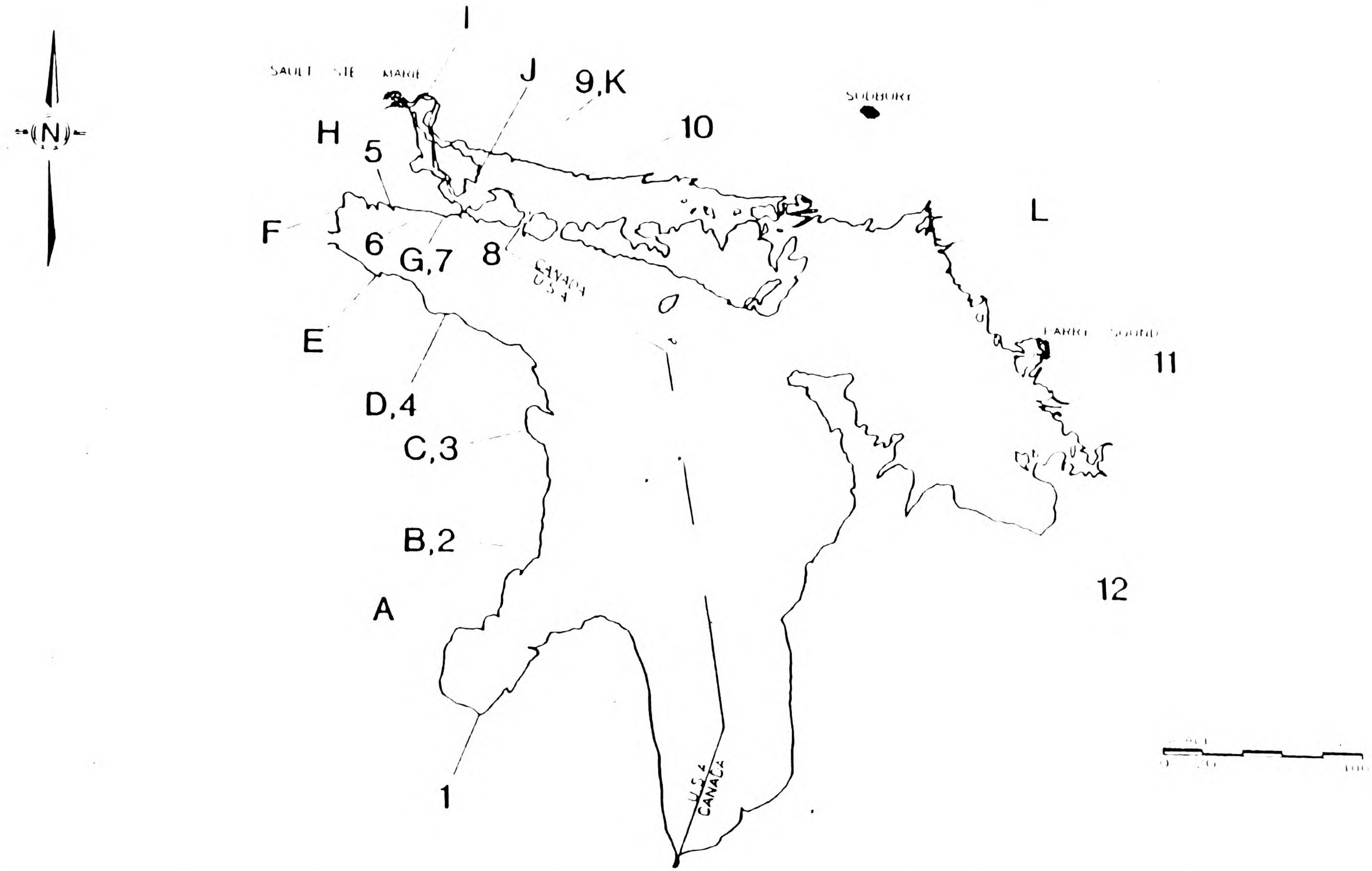


Figure 3. Location of Lake Huron tributaries treated with lampricides (numerals; see Table 12 for names of streams), and of streams where assessment traps were operated (letters; see Table 13 for names of streams) in 1991.

Changing water levels delayed and complicated lampricide treatments. The Chippewa River treatment was postponed for two weeks due to heavy rains. Low water caused deferment of treatment of Black Mallard Creek until 1992. The Devils River was treated after being postponed two consecutive years for research studies conducted by Hammond Bay Biological Station. The Au Sable River was treated after being postponed twice in 1990.

Cold weather conditions during treatment of the Chippewa River led to difficulties applying the isopropanol formulation of TFM. Freezing air temperatures increased the viscosity of the chemical, reducing application pump performance. Some batches of the chemical crystallized and clogged filters and hoses.

Non-target mortality during lampricide treatments was low. Mortality of a few non-game fish occurred below some application sites.

Canada

Four Lake Huron streams (two North Channel, two Georgian Bay) received treatment with lampricide in 1991 (Table 12, Figure 3). Treatment of the Root River, in the North Channel, was deferred due to unsatisfactory treatment discharge.

Moderate numbers of lampreys were observed in the Pine and Boyne rivers. The Pine River, a tributary to the complex Nottawasaga River in southern Georgian Bay, had not been treated since 1968, whereas the Boyne River, in central Georgian Bay, was last treated in 1976.

High numbers of sea lamprey were observed in the Mississagi and Thessalon rivers. The Mississagi River continues to be a prolific producer of sea lamprey larvae. Fortunately, treatments on this watershed are very effective. The lower portion of the Thessalon River requires treatment on a regular basis, however, the upper section treated in 1991 had not knowingly produced lamprey for approximately 20 years. During this time period, a dam situated at Rydal Bank, approximately 25 km from the river mouth, served as a barrier to spawning sea lamprey. Removal or misalignment of stop-logs, coincident with spawning runs in the past three to four years, may have allowed lampreys to pass through the dam.

No significant mortality of non-target fishes occurred during the treatments on Lake Huron.

Table 12. Details on the application of lampricides to streams of Lake Huron, 1991.
[Number in parentheses corresponds to location of stream in Figure 3. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM kg	TFM lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	Bayer 73 Granular kg	Bayer 73 Granular lbs	Distance km	Distance miles
UNITED STATES											
Devils R. (3)	May 4	2.2	77	399	880	-	-	0	0	12.9	8
Caribou Cr. (8)	May 17	0.6	20	39	86	-	-	0	0	1.6	1
Albany Cr. (7)	May 17	0.6	20	70	154	-	-	0	0	4.8	3
Beavertail Cr. (6)	May 19	0.9	30	211	466	-	-	0	0	4.8	3
Hessel Cr. (5)	May 21	0.1	4	28	62	-	-	0	0	1.6	1
Au Sable R. (2)	Aug. 21	24.1	850	5,109	11,264	-	-	31.0	69.0	19.3	12
Ocqueoc R. (4)	Sept. 20	1.3	45	337	744	-	-	0	0	6.4	4
Saginaw R. (1) (Chippewa R.)	Oct. 19	25.5	900	8,464	18,660	-	-	0	0	114.3	71
Total		55.3	1,946	14,657	32,316	-	-	31.0	69.0	165.7	103
CANADA											
Boyne R. (11)	May 29	1.1	38	27	59	-	-	-	-	1.7	1
Pine R. (12)	June 3	3.0	107	1,269	2,798	-	-	0.2	0.5	30.9	19
Thessalon R. (9)	June 17	1.7	60	171	377	-	-	-	-	34.2	21
Mississagi R. (10)	July 30	56.5	1,995	3,856	8,501	60	132	0.2	0.3	35.5	22
Total		62.3	2,200	5,323	11,735	60	132	0.4	0.8	102.3	63
GRAND TOTAL		117.6	4,146	19,980	44,051	60	132	31.4	69.8	268.0	166

Spawning-phase Assessment

United States

During the 1991 spawning season, 24,863 sea lampreys were captured in assessment traps placed in eight tributaries of Lake Huron (Table 13, Figure 3), compared to 36,837 in 1990. The Cheboygan River accounted for 86% of the decrease from 1990 to 1991 (32,696 vs. 18,805). An estimated 29,452 sea lampreys comprised the spawning run in the Cheboygan River in 1991 compared to 52,414 in 1990. The Carp and Devils rivers were trapped for the first time in 1991 and produced catches of 489 and 107 sea lampreys. Assessment actions in the Carp River were conducted cooperatively by the Chippewa/Ottawa Treaty Fishery Management Authority Intertribal Fisheries and Assessment Program. A population estimate conducted in the St. Marys River in cooperation with the Department of Fisheries and Oceans, Canada shows an increase in the number of lampreys in 1991 compared to 1990 (35,582 vs. 23,052). The average length and weight of sea lampreys sampled from Lake Huron tributaries in 1991 increased slightly from 1990. The percentage of males decreased from 52% to 47%.

The sea lamprey barrier on Albany Creek apparently was not successful in stopping all of the spawning run in 1991. One adult sea lamprey was seen upstream from the barrier during the May lampricide treatment. The District Fisheries Biologist of the Michigan Department of Natural Resources was notified of the sighting.

Table 13. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1991. [Letter in parentheses corresponds to location of stream in Figure 3]

Stream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
UNITED STATES							
East Au Gres R. (A)	94	8	13	410	487	105	242
Au Sable R. (B)	288	45	24	490	496	192	220
Devils Cr. (C)	107	107	40	452	460	196	222
Ocqueoc R. (D)	3,698	0	-	-	-	-	-
Cheboygan R. (E)	18,805	0	-	-	-	-	-
Carp R. (F)	489	212	42	471	475	220	240
Albany Cr. (G)	113	82	54	427	443	186	225
St. Marys R. (H)	1,269	0	-	-	-	-	-
Total or average	24,863	454	41	460	470	205	233
CANADA							
St. Marys R. (H)	13,523	0	-	-	-	-	-
Echo R. (I)	897	0	-	-	-	-	-
Koshkawong R. (J)	496	103	43	463	479	218	233
Thessalon R. (K)	1,522	0	-	-	-	-	-
Still R. (L)	31	13	31	445	444	233	225
Total or average	16,469	116	41	461	474	220	232
GRAND TOTAL	41,332	570	41	460	471	208	233

Canada

Five streams were trapped (Table 13, Figure 3), capturing 16,469 spawning-phase adults. Because the catches from the St. Marys, Echo and Thessalon rivers were committed exclusively to the sterile male programme, complete biological data and mark-recapture estimates were obtained only for the Koshkawong and Still rivers. The male sex ratios from these two streams were very low this year (0.43 and 0.31 respectively) compared with previous years, while animal size was similar. Although not verified by incision of animals, it was possible to develop sex ratios for the other three streams based on the external morphological examination used to sort out males for sterilization. Accuracy of better than 95% was considered realistic. These could neither support nor deny any perceived shift, with the St. Marys River ratio of 0.53 similar to low values found in 1986 and again in 1988. The Echo River ratio of 0.48 was the lowest in a continual down-trend since 0.67 was measured in 1987, and the Thessalon ratio of 0.60 was similar to the high ratios attained in 1987 and 1988.

The trap efficiencies (from the ratio between numbers recovered to those marked and released) and stratified population estimates (modification of the Schaefer Method) were:

Koshkawong River	0.179	1,091
Still River	0.500	42

It would seem that the unexpectedly large runs monitored in 1987 and 1988 in the Still River have not recurred.

Parasitic-phase Assessment

United States

A total of 1,317 parasitic-phase sea lampreys were collected by commercial fishermen in the U.S. waters of Lake Huron in 1991 (Table 7), compared with 1,326 taken in 1990. Fishermen from management unit MH-1 (DeTour-Rogers City, Michigan area) contributed the largest number of sea lampreys (1,032), a decrease from the number taken in 1990 (1,190). The number of sea lampreys collected by commercial fishermen in the management units of MH-2 (Alpena, Michigan area) and MH-4 (Tawas City-Bay Port, Michigan area) increased from 44 and 92 respectively in 1990, to 126 and 159 respectively in 1991. Most lampreys were collected by trapnet fishermen (76%) during August-October (62%), and the lampreys primarily were attached to lake trout (53%), and lake whitefish (34%).

Spawning year was determined for the 1,317 parasitic-phase sea lampreys. Of these, 86 would have spawned in 1991, and 1,231 in 1992. A total of 1,212 of the 1991 spawning year class have been collected (1,126 in 1990 and 86 in 1991), and represent a decrease when compared to the number of the 1990 spawning year class (1,440) captured by commercial fishermen.

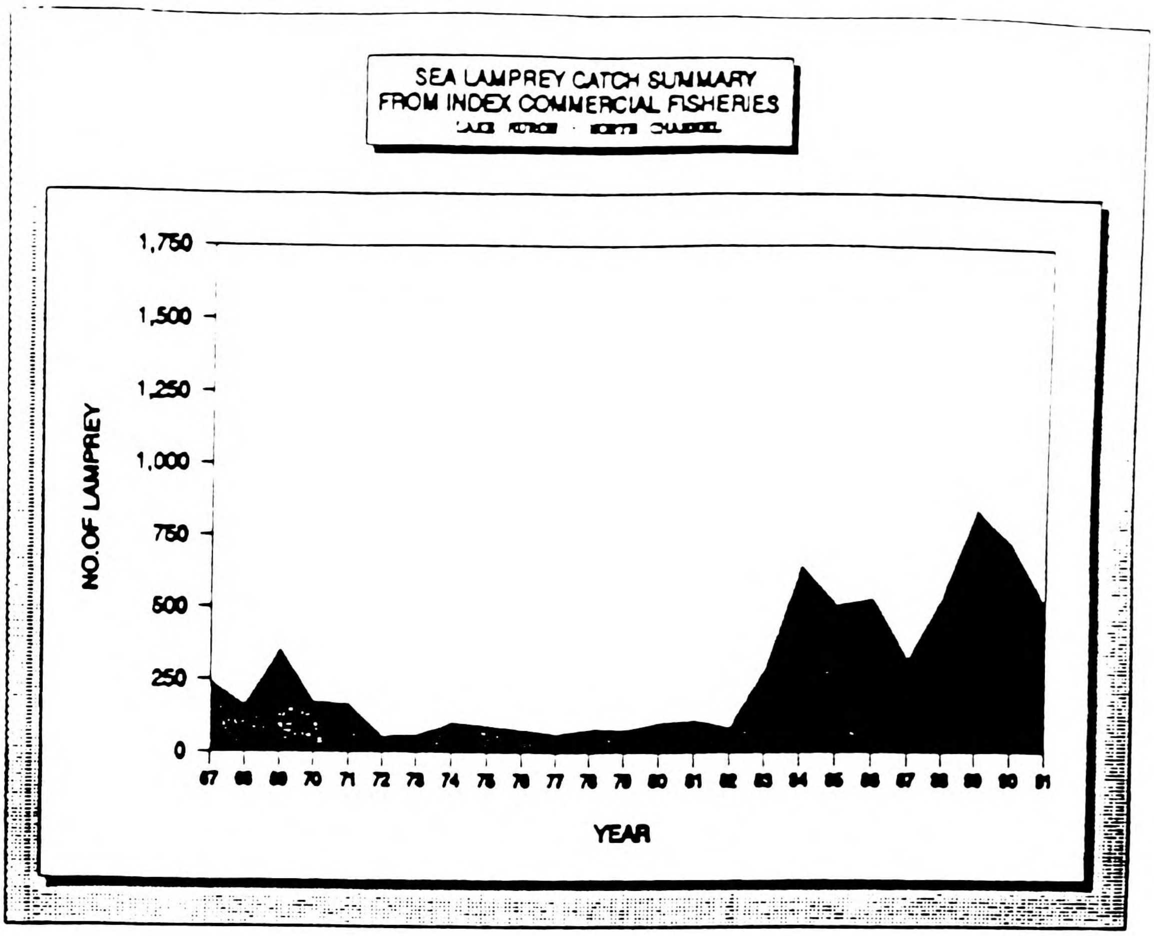
Sport fishermen on the U.S. side of Lake Huron captured or reported 1,857 parasitic-phase sea lampreys (922 from charter and 935 from noncharter fishermen) in 1991 (Table 8), compared with 3,165 taken in 1990. Fishermen from management unit MH-3 (Harrisville to Oscoda, Michigan area) contributed the largest number of sea lampreys (554). Most lampreys were collected or reported by fishermen during July-August (79%) and primarily were attached to chinook salmon (75%).

Occurrence of sea lampreys on fish was reported by charterboat operators in all six management units (Table 9). The operators reported 5.7 and 14.0 lampreys attached per 100 lake trout and chinook salmon, respectively, a decrease from 6.6 and 18.7 in 1990. The management units of MH-1, MH-2 and MH-3 reported the largest number of lampreys per 100 lake trout and chinook salmon (7.7 and 15.3 respectively), as compared to management units MH-4 (Saginaw Bay area), MH-5 (Harbor Beach, Michigan area) and MH-6 (Port Sanilac-Port Huron, Michigan area) 4.4 and 9.5 respectively.

Canada

Commercial Fisheries

By the end of calendar 1991, collections had been received from nearly all Lake Huron fisheries cooperating in this long-standing activity. Preliminary counts stand at 1,085 (710 from the North Channel, 370 from the main basin, and 5 from Georgian Bay). Final values are likely to be increased by five percent or so. Submissions have fallen by one-half again, for the second year, from a 1989 peak. When the analysis is limited to those counts provided from the North Channel and northern main basin by our long-term index fisheries, the same trend is shown. The submissions from each region are now similar to the relatively stable numbers provided through the mid-1980's (Figure 4).


SEA LAMPREY CATCH SUMMARY
FROM INDEX COMMERCIAL FISHERIES
NO.OF LAMPREY
1,750
1,500
1,250
1,000
750
500
250
0
YEAR

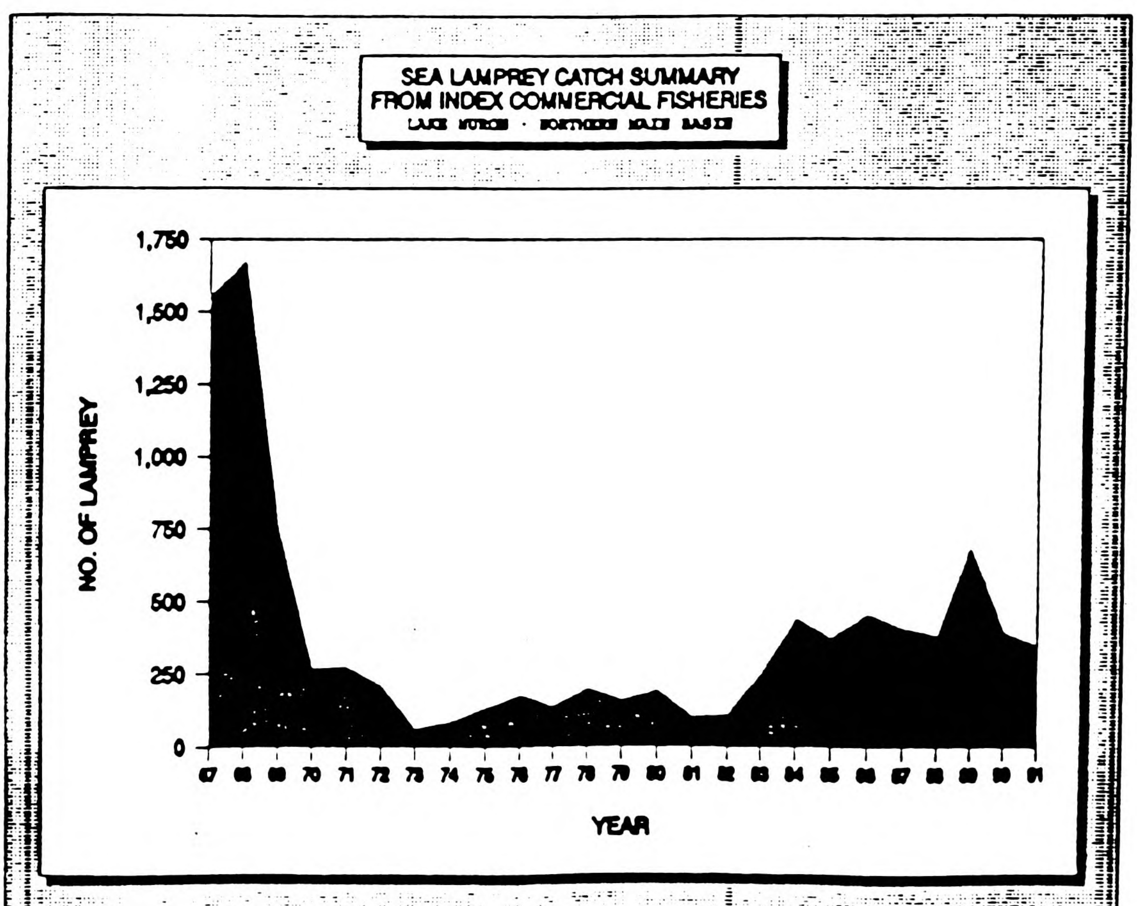

SEA LAMPREY CATCH SUMMARY
FROM INDEX COMMERCIAL FISHERIES
NO. OF LAMPREY
1,750
1,500
1,250
1,000
750
500
250
0
YEAR

Figure 4

Sport Fisheries

Only one derby, the Stroh's King Salmon Derby of Sault Ste. Marie, Michigan (formerly called The Coors Derby) was monitored this year. Between August 24 and September 7, weigh station attendants sampled 205 chinook salmon. Seasonal (A1-A3) wounding rates of 22.9 percent wounded and 28.8 wounds/100 fish, were the lowest obtained in seven years. They continue a major down-trend that began in 1989.

Sterile Male Programme (SMP)

St. Marys River

This technique and its implementation are discussed later in this report. Although the south shore of Lake Superior was the focus of this management technique for 1991 (the first year of implementation), the St. Marys River was also designated as a target because of the late spawning run in this river. The approximately 5,000 male lampreys caught in this river are therefore not useful in Lake Superior tributaries.

Post-Release Evaluation

Trap Results

Of the 7,516 sterile males released into the river, the Canadian traps in the St. Marys River captured 1,187 sterile males. Ten were dead, which is a significant rate of mortality for these devices. Those yet alive were returned to the river to rejoin the spawning population. These animals were not identified by any additional mark, so it cannot be determined what fraction of the total number represents multiple recapture. If all 1,187 captures of sterilized males were for the first time the recapture rate would then be 0.16, well below the recovery rate of 0.24 obtained from the ratio of Canadian trap recaptures (71) to releases from the U.S. Fish and Wildlife instream mark/recapture study (301). This might be attributable to the minor delay in timing of releases for sterilized specimens over those for the instream study, resulting in different behavioural responses, but could be due to some post-release mortality.

Spawning-Ground Observations

a) Adult Observations/Collections

This year, observations were confined to the Sault Rapids, for no SCUBA diving or underwater camera work were undertaken. First sightings of adults occurred on July 15 (despite nests first appearing some two weeks earlier), and continued until July 29. In that time 67 individual observations of adults were made and thirty-six adults were collected. Of the 36 adults sorted and sexed, two were sterile and 18 were normal males, for a sterile to normal male ratio of 1:9. Of the 16 females, one was from the U.S. Fish and Wildlife Service instream mark/recapture study.

b) Nest Sampling

The first positive nest (a nest containing embryos) was located in the Sault Rapids on July 2. Stream cruises were continued until August 16, at which time discharge studies by Environment Canada and the U.S. Corps of Engineers prevented further surveys until August 26. The largest discharges, resulting from the progressive opening of the compensating gates at the head of the Rapids, were found to have shifted the substrate about, with the loss of all remaining nests under scrutiny, and the consequent termination of observation on August 29. However, sufficient prior information was collected to calculate hatching success for most nests.

In all, 26 positive nests were located. However, from June 28 to July 2 the river experienced a dramatic drop in temperature from 17° to 11°C, undoubtedly caused by strong easterly winds turning over Whitefish Bay. As this occurred just at the start of the nesting season, the effects persisted for two weeks, and the temperatures remained well below those shown to be damaging to embryological development. Seven nests monitored during this period were later omitted from the index. These nests experienced a hatching success of 0.14.

For the remaining 19 nests located, once seasonable water temperatures were again attained, development could not be followed satisfactorily in three, leaving 16 nests for an index. Although three were only marginally successful at the time the surveys had to be discontinued, they had good prospects, and were deemed successful. Six other nests were unquestionably successful, suggesting a hatching rate of 0.56. From 1987 to 1990 hatching rates averaged 0.81.

Barrier Dams

Canada

Work continued on the velocity barrier concept of preventing adult sea lamprey from migrating upstream but allowing non-jumping fish passage. Specifically, the swimming performance of adult sea lamprey was further studied, using the denil fishway flume set up on the Thessalon River (Figure 3-9,K). Swimming attempts of sea lamprey were timed and measured between May and July. Tests were made at a number of different velocities from 1.87 m/s to 3.5 m/s. Performance differences were noted through a temperature range of 9.5°C to 25°C.

In 1992 work is planned to complete the data set for velocities of 0.8 m/s to 1.7 m/s. This range is preferable for the design of practical instream velocity barriers. The study will be carried out at the Sea Lamprey Control Centre in a 20 to 30 m long flume.

LAKE ERIE

Larval Assessment

United States

A total of 13 Lake Erie tributaries were surveyed in 1991 to assess sea lamprey populations and search for new infestations. Pretreatment surveys were conducted on two streams. No larvae were found in Delaware Creek and few were found in the Grand River. Both rivers will be deferred from lampricide applications until larval populations reach a size and number that warrant treatment.

Surveys to assess recruitment of the 1991 year class were conducted in 10 streams. Cooperative surveys by personnel from the Pennsylvania Fish Commission recovered the 1991 year class at an index site in Crooked Creek. No young-of-the-year larvae were found in the other nine streams.

Posttreatment surveys were conducted on the West Branch of Conneaut Creek. Some residual larvae were recovered from isolated areas in the stream. The numbers and distribution of the larvae indicate a remedial treatment will not be necessary.

Surveys were conducted on five streams that previously had no history of sea lamprey infestation or with small but never treated infestations. Although no larvae were found on Buffalo and Chagrin rivers and Arcola, Eighteen Mile, and Wheeler creeks, the streams appeared to have conditions favorable to larvae.

Canada

Surveys were conducted on nine Lake Erie tributaries in preparation for chemical treatment, to monitor re-established and residual populations and to evaluate barrier dams.

Distribution surveys were finalized on Big Otter and Clear creeks prior to their treatments in May 1991. Distribution surveys were also done on Big Creek in preparation for treatment in 1992. Although distribution is similar to its historical maximum, the numbers of larvae appear to be much lower. Nonetheless, it continues to be the major sea lamprey producer on the north shore of Lake Erie.

A few residual larvae are still being found in East Creek, treated in 1987, but no recent year classes have been found.

Low head barrier dams on Clear, Forestville and Normandale creeks were all effective at blocking the 1990 spawning run of sea lamprey.

Chemical Treatment

Canada

Three Lake Erie tributaries, each having been treated for the first time either in 1986 or 1987, were again successfully treated in 1991 (Table 14, Figure 5).

Treatment of Young's Creek, under higher than normal flows, reduced lampricide dilution caused by spring water seepage, an occurrence which created problems during the 1987 treatment.

Compared to the initial 1986 treatment, the Clear Creek treatment was shortened, since sea lamprey larval distribution was reduced by more than 50%. A low head dam, installed 0.5 km above its mouth in 1989, will greatly reduce or eliminate future treatments.

Similarly, treatment of Big Otter Creek, and its major tributary Little Otter Creek, was simplified compared to the 1986 treatment. The larval distributional range was reduced, resulting in some 30 km less stream to treat.

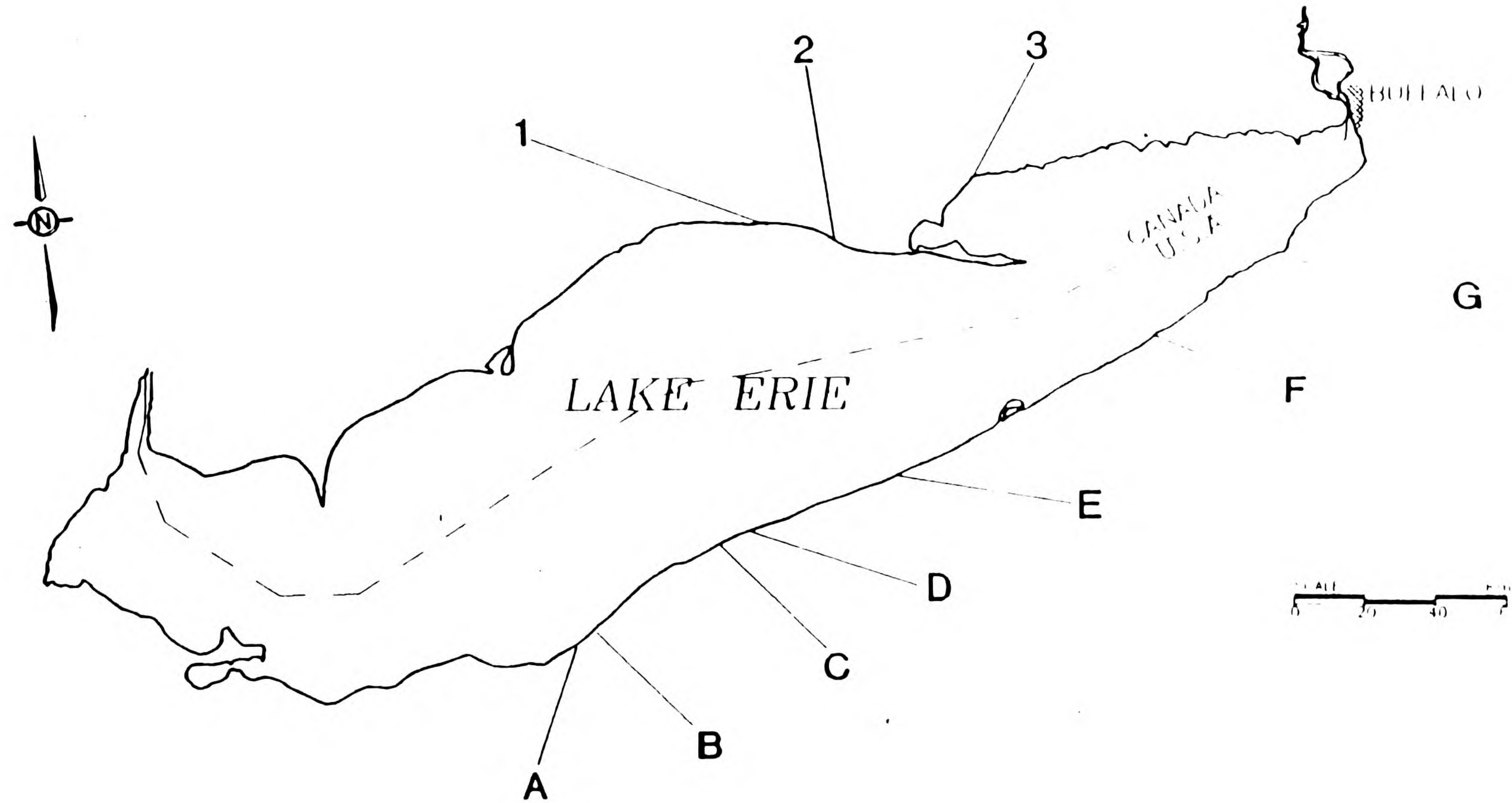


Figure 5. Location of Lake Erie tributaries treated with lampricides (numerals; see Table 14 for names of streams) and of streams where assessment traps were operated (letters; see Table 15 for names of streams) in 1991.

69

Even so, some 72 km of stream was identified as requiring treatment. Fortunately, a wetter spring reduced the need for extensive irrigation of vegetable and tobacco crops. A large number of irrigators (who use water directly from Big Otter Creek) were inconvenienced during the last treatment. A low head dam constructed on the Little Otter tributary in 1990 should eliminate this major tributary as a sea lamprey producer.

Based on treatment observations, larval abundance was ranked as scarce in each stream treated. Non-target mortality was very light in each treatment.

Table 14. Details on the application of lampricides to streams of Lake Erie, 1991.
[Number in parentheses corresponds to location of stream in Figure 5. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m^3/s	f^3/s	TFM kg	lbs	Bayer 73 Granular kg	lbs	Distance km	miles
CANADA									
Clear Cr. (2)	April 30	0.9	32	256	564	-	-	7.8	5
Big Otter Cr. (1)	May 1	6.1	215	2,180	4,806	2.8	6.2	72.1	45
Young's Cr. (3)	May 2	1.3	46	344	758	0.3	0.7	4.4	3
TOTAL		8.3	293	2,780	6,128	3.1	6.9	84.3	53

Spawning-phase Assessment

United States

A total of 607 sea lampreys were captured in assessment traps placed in seven tributaries of Lake Erie in 1991 (Table 15, Figure 5), compared to 279 in 1990. The increase reflects a larger catch in Cattaraugus Creek, from 222 in 1990 to 533 in 1991. Through a cooperative effort with the Pennsylvania Fish Commission, spawning runs were monitored in Conneaut, Crooked, and Raccoon creeks. Canadaway Creek was trapped for the first time in 1991. The mean length and weight of lampreys remained about the same.

Efforts were initiated to obtain flow data and population estimates for Lake Erie tributaries in an attempt to assess the lakewide population of spawning-phase sea lampreys in U.S. waters. Insufficient instream population estimates and discharge data were compiled to establish the mathematical relation.

Canada

No spawning-phase assessment was conducted in 1991 and parasitic-phase investigations were terminated midway through the season. Although 16 sea lamprey and three silver lamprey were submitted by the commercial fishery, these represented returns from less than one-half of the year's total fishing effort, and so cannot be used in any trend analysis.

Table 15. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1991.

[Letter in parentheses corresponds to location of stream in Fig. 5]

Stream	Number captured	Number sampled	Percent Males	Mean Length(mm) Males	Mean Length(mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
UNITED STATES							
Chagrin R. (A)	5	1	100	597	-	289	-
Grand R. (B)	50	10	60	276	362	270	267
Conneaut Cr. (C)	1	0	-	-	-	-	-
Raccoon Cr. (D)	0	0	-	-	-	-	-
Crooked Cr. (E)	18	6	50	429	510	180	311
Canadaway Cr. (F)	0	0	-	-	-	-	-
Cattaraugus Cr. (G)	533	198	53	495	497	284	293
Total or average	607	215	53	482	492	281	292

Barrier Dams

Canada

Minor maintenance was conducted, as required, on the low head structures now in place on five Lake Erie tributaries (Little Otter, Clear, Forestville, Normandale and Young's creeks).

LAKE ONTARIO

Larval Assessment

United States Agent

Surveys were conducted on several Lake Ontario (New York State) tributaries to search for new sea lamprey infestations and to monitor existing larval populations. Salmon Creek (near Rochester, New York) was examined after a report that adult sea lampreys were observed in the stream, but no larvae were found. Several tributaries of the Oswego River and Oneida and Finger Lakes system were examined, but no sea lampreys were found at any of the locations.

Carpenter, Cold Springs, and Crane brooks, all tributary to the Seneca River were surveyed to monitor existing larval populations. Two year classes of larval sea lampreys were recovered in Carpenter and Cold Spring brooks. Since the mid-1980s no larvae have been found in Crane Brook.

Canadian Agent

Surveys were conducted on 46 Lake Ontario (New York and Ontario) tributaries in preparation for chemical treatment, to monitor re-established, residual and untreated populations, to evaluate barrier dams and to look for new infestations. An estimate of the number of larvae inhabiting the Rouge River estuary was made.

Distribution surveys were finalized on several streams prior to their 1991 treatments with no significant changes found. Distribution surveys were also done on 12 streams tentatively scheduled for treatment in 1992. In many of these, upstream distribution is at or beyond historical limits with the 1990 year class of larvae dominant. This is probably due to the relatively wet spring and early summer of 1990 which allowed spawning lamprey to access the headwaters of streams that lack physical barriers.

Treatment evaluation surveys done on the ten Lake Ontario tributaries treated in 1990 indicate that treatment was highly successful in all but three. Moderate numbers of residuals were collected from Lynde Creek and low numbers from Mayhew and Lindsey creeks. Evaluation surveys of three streams treated in 1991 (Black River, Ninemile and Sterling creeks) found small numbers of residuals in the Black River only.

Of the ten streams treated in 1990 all but two, Sodus and First creeks, have since re-established. In addition, Big Bay, Red, Oak Orchard (Marsh) and Salmon creeks, last treated in 1988, are now re-established.

Surveys of two streams with a history of sea lamprey production but which have never been treated found 33 larvae in Carpenter Brook (tributary to the Seneca River) and none in the Napanee River. Carpenter Brook may be a contributor to the parasitic stocks in Lake Ontario.

Barrier dams on Duffins, Bowmanville, Graham, Port Britain, Grafton, Shelter Valley, Colborne and Catfish creeks and on the Little Salmon River were all effective at blocking the 1990 spawning run. The Credit River dam in Streetsville was not effective, as the 1990 year class of larvae was found upstream of it during the 1991 treatment.

An estimate was made of the number of sea lamprey larvae inhabiting the estuary of the Rouge River at the time of the 1991 treatment. Six hundred and sixty two tail clipped sea lamprey larvae were randomly released in a 1.4 km section of the 2.3 km long estuary below Hwy. 401 approximately 96 hours before the lampricide treatment. Larvae are rarely found in the lower 0.9 km of estuary, hence none were released there.

During the treatment, 39 marked and 196 unmarked larvae were collected from the study area using scap nets and an additional 10 unmarked larvae were collected from the lower 0.9 km stretch. By lumping all estuarian collections a simple Petersen estimate of 3,500 larvae was derived.

Most of the unmarked larvae (95%) collected from the estuary were of transformable size i.e., >120 mm. Data collected during a fall 1983 treatment of the Rouge River suggest a high transformation rate. At that time 31% of the larvae >120 mm collected during the treatment were undergoing transformation. At a similar rate of transformation, the larval population of the Rouge River estuary, if left untreated, had the potential to produce 1,030 transformed sea lamprey in 1991.

Chemical Treatment

United States

Three streams tributary to the United States side of Lake Ontario received applications of lampricide (Table 16, Figure 6). Optimum spring discharge allowed for the effective treatment of Ninemile and Sterling creeks. Moderate numbers of sea lamprey larvae were observed in these streams.

The Black River treatment, conducted in late June, was complicated by erratically fluctuating discharge. Manipulation of flow regimes for hydro electric power generation made regulation of target concentrations of lampricide at the main application point very difficult. Diurnal cycling of pH levels and poor mixing in the impounded area above the Village of Dexter contributed to some escapement of larval sea lamprey, however, post-treatment surveys suggested the number of residual ammocoetes was low. The Black River continues to be a very prolific producer of sea lamprey larvae.

Mortality of non-target fishes was insignificant during these treatments.

Canada

Lampricides were applied to four streams tributary to Canadian waters of Lake Ontario (Table 16, Figure 6). All treatments produced moderate numbers of sea lamprey larvae and were conducted at optimum spring discharge, allowing for very effective treatments.

The Credit and Rouge rivers and Port Britain Creek historically have required regular treatment, whereas lamprey production in the Salmon River had been limited by an old mill dam situated near the mouth of the river at the village of Shannonville. The dam, repaired and modified in 1974 to serve as a lamprey barrier, had prevented the passage of spawning sea lampreys until the last three to four years.

Since the last treatment on the Credit River (1987), only the 1990 spawning run of adult sea lampreys appear to have passed the modified mill dam at Streetsville. The necessity to apply lampricide to an additional 25 km of stream and notify numerous commercial irrigators adds considerable complexity to the Credit River treatment.

The only non-target fish mortality of significance consisted of post-spawning common white suckers on the Rouge River. Stream temperatures rose substantially immediately prior to and during the treatment, and even though the treatment level and duration were lowered accordingly, approximately 1,200 specimens were killed.

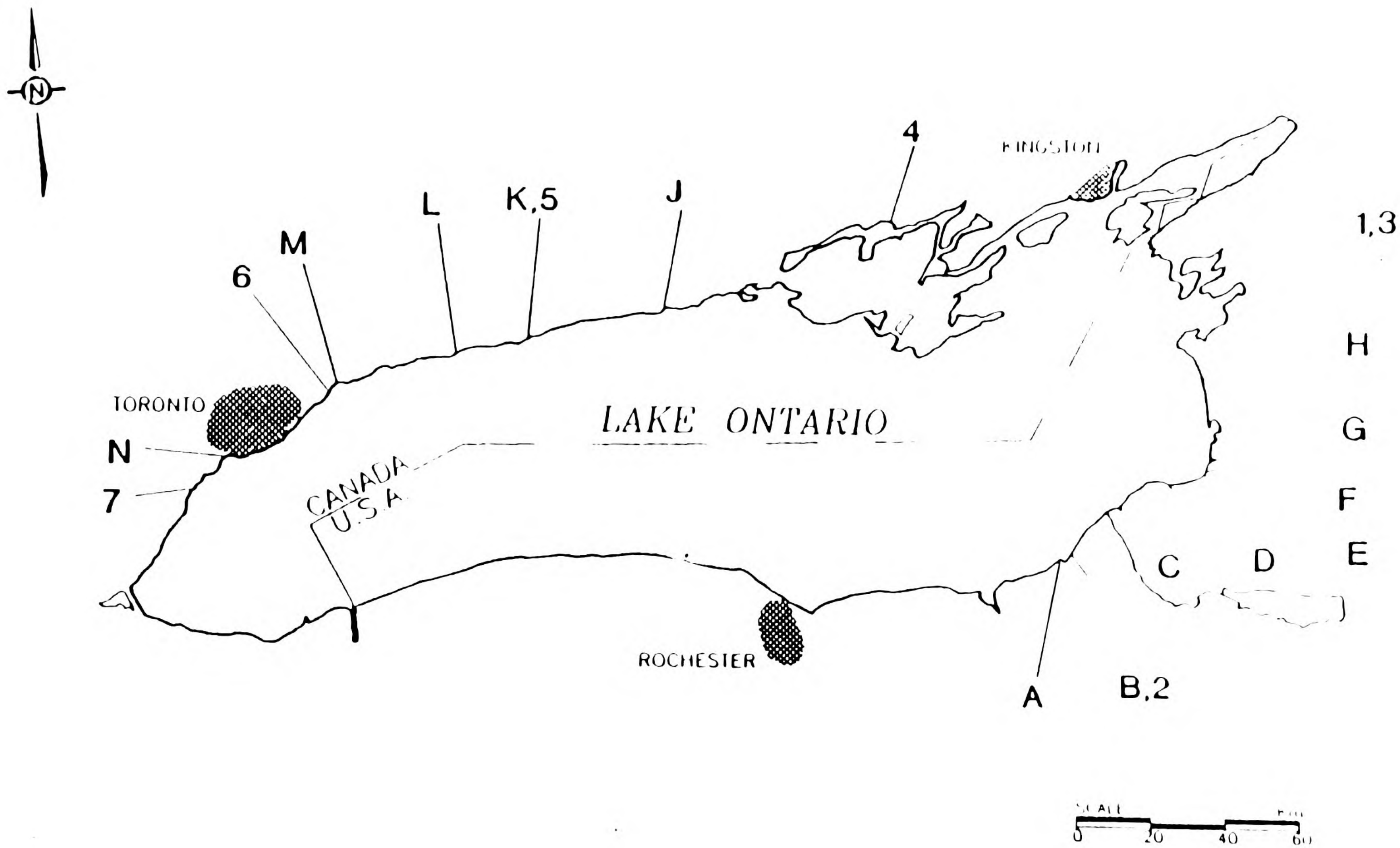


Figure 6. Location of Lake Ontario tributaries treated with lampricides (numerals; see Table 16 for names of streams) and of streams where assessment traps were operated (letters; see Table 17 for names of streams) in 1991.

Table 16. Details on the application of lampricides to streams of Lake Ontario, 1991. [Number in parenthesis corresponds to location of stream in Figure 6. Lampricides used are in kilograms/pounds of active ingredient].

		Discharge		TFM		Bayer 73 Powder		Bayer 73 Granular		Distance treated	
Stream/Lake	Date	m^3/s	f^3/s	kg	lbs	kg	lbs	kg	lbs	km	miles
UNITED STATES											
Sterling Cr.(1)	May 2	2.4	84	586	1,292	-	-	-	-	7.3	4
Ninemile Cr.(2)	May 4	1.2	43	248	547	-	-	-	-	14.0	9
Black R.(3)	June 24	40.7	1,439	2,984	6,578	51	112	-	-	14.9	9
CANADA											
Port Britain Cr.(5)	May 8	0.3	10	123	270	-	-	0.06	0.1	7.8	5
Rouge R.(6)	May 13	1.3	47	255	562	-	-	-	-	9.7	6
Credit R.(7)	May 31	7.6	268	1,592	3,510	12	28	0.10	0.2	41.2	26
Salmon R.(4)	June 3	5.9	207	992	2,187	8	17	0.03	0.1	13.4	8
TOTALS		59.4	2,098	6,780	14,946	71	157	0.19	0.4	108.3	67

Spawning-phase Assessment

United States

A total of 1,786 sea lampreys were captured in assessment traps placed in nine tributaries of Lake Ontario in 1991 (Table 17, Figure 6), compared to the catch of 1,981 in 1990. Catches increased in South Sandy Creek, the Little Salmon and Black rivers, and Beaverdam Brook, a tributary to the Salmon River. Catches decreased in Oswego River and Sterling, Sterling Valley and Grindstone creeks.

Efforts continued for the fourth consecutive year to estimate the total number of spawning-phase sea lampreys in Lake Ontario using a modified method developed for Lake Superior. This technique is based on the relation between average stream discharge and the number of lampreys that enter tributaries to spawn. While all the discharge data was available, corresponding in-stream population estimates of lamprey spawning runs remain insufficient. Continued information collection likely will provide a sufficient amount of data to produce a significant correlation in 1992.

Canada

Trapping was confined to the same five streams monitored in 1990 (Table 17, Figure 6). Catches were up dramatically at all sites except Shelter Valley Creek. The total number collected (6,570) nearly doubled last year's count of 3,434. The ratio of males/females fell just below even (to 0.49) for the first time since 1978, while the mean size of the adults has remained fairly stable for several years.

Measures of trap efficiency (the ratio between numbers recovered to those marked and released) and spawning run abundance (modification of the Schaefer Method) were:

Humber River	0.32	6,801
Duffins Creek	0.79	2,417
Bowmanville Creek	0.14	3,543
Port Britain Creek	0.31	932
Shelter Valley Creek	0.71	695

Efficiencies are in keeping with those determined for 1990, other than for Shelter Valley Creek, which returned to normal after an unusually low value of 0.48 in 1990. While Bowmanville Creek returns yielded the very same efficiency estimate as in 1990, the population estimate is surprisingly high. Unfortunately, the permanent trap has only been in operation for two years, and no mark-recapture studies were undertaken during the years that portable traps were in use.

Table 17. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1991. [Letter in parentheses corresponds to location of stream in Figure 6]

Stream	Number captured	Number sampled	Percent Males	Mean Length(mm) Males	Mean Length(mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
UNITED STATES							
Sterling Cr. (A)	78	0	-	-	-	-	-
Sterling Valley Cr. (B)	439	65	71	473	478	256	276
Oswego R. (C)	1	0	-	-	-	-	-
Catfish Cr. (D)	0	0	-	-	-	-	-
Little Salmon R. (E)	58	1	0	-	490	-	312
Grindstone Cr. (F)	95	0	-	-	-	-	-
Salmon River							
Beaverdam Br. (G)	17	0	-	-	-	-	-
South Sandy Cr. (H)	5	0	-	-	-	-	-
Black R. (I)	1,093	197	75	473	449	271	261
Total or average	1,786	263	74	473	458	268	266
CANADA							
Shelter Valley Cr.(J)	504	106	44	487	481	253	265
Port Britain Cr. (K)	292	63	57	495	487	286	272
Bowmanville Cr. (L)	617	122	48	491	479	261	256
Duffins Cr. (M)	2,049	411	49	487	478	267	265
Humber R. (N)	3,108	616	50	471	463	239	238
Total or average	6,570	1,318	49	480	472	253	253
GRAND TOTALS	8,356	1,581	53	478	471	256	254

Barrier Dams

Canada

Maintenance work, as required, was conducted on the barrier dam structures now in place on 11 Canadian Lake Ontario tributaries. Most significant was the placing of concrete in seepage areas under and on the dam at Shannonville on the Salmon River. These were the suspected means of passage for adult sea lamprey in recent years.

LAKES SUPERIOR, MICHIGAN, AND HURON

Sterile Male Release Technique

Research on the application of the sterile male release technique to sea lamprey control has been in progress since 1971. Experimental field and laboratory studies from 1971-76 demonstrated that intraperitoneal injection of bisazir sterilized sea lampreys but did not affect spawning behavior. The technique reduced production of lamprey larvae in streams at a predictable rate. Additional methods to sterilize lampreys (chemicals, hormones, immunology, and irradiation) were studied during 1977-83, but none proved adequate. A Sterile Male Release Task Force was authorized by the Great Lakes Fishery Commission in 1984 to coordinate studies, select test sites, and propose funding levels. Lake Superior best met the requirements of a suitable site (low number of lampreys, a relatively isolated population, and high probability to evaluate the technique). In 1987 the Commission approved the lake as the primary application site when the technique became fully operational. Field studies in 1987-88 examined the effects of location, method, and date of release on dispersal and behavior of spawning male sea lampreys.

The United States Congress provided a special appropriation of funds in 1990 for construction of the sterilization facility at the Fish and Wildlife Service Hammond Bay Biological Station. The contract was awarded in October 1990 with a projected completion date of March 15, 1991.

The Task Force met on October 31, 1990 and concluded details of experimental implementation of the technique in Lake Superior streams and the St. Marys River for April-August 1991. (The St. Marys River was added as an additional test site for the technique because about 5,000 male lampreys are captured each year in assessment traps and, because of the late spawning run in the river, the lampreys are not useful in tributaries of Lake Superior.) The Department of Fisheries and Oceans Canada later declined involvement in implementation of the technique in Lake Superior due to inadequate funding levels with the result that no sterilized lampreys would be released in Canadian tributaries of Lake Superior in 1991. The proposal for release of sterilized males into U.S. streams of Lake Superior and the St. Marys River was presented to and adopted by the Lake Superior Technical Committee on January 31, 1991, and the Great Lakes Fishery Commission at the Annual Meeting in Ottawa, Canada on May 7-8, 1991.

Streams selected for release of sterilized males were those that are difficult to treat effectively and result in survival of some sea lamprey larvae. Of 733 tributaries to Lake Superior in the United States, sea lamprey larvae were found in 92 and 85 have been treated with lampricides at least once. Presently 36 are treated consistently on a 3-4 year cycle. Lamprey larvae commonly survive treatments in 21 of the 36 routinely treated streams. These 21 streams are where most of the parasitic lampreys are produced on the United States side of Lake Superior (Table 18).

The total number of male sea lampreys available for sterilization (from Lakes Michigan and Huron) and the number of resident spawning lampreys in each of the 21 streams (Lake Superior) where sterilized lampreys would be released were projected based on historical data from 1986-90. A projected total of 20,300 male sea lampreys would be available from the Manistique (6,700), Cheboygan (12,900), and Ocqueoc (700) rivers for sterilization. The 21 streams had projected spawning runs of 21,664 adults (8,666 males) combined and the individual runs ranged from 57 (23 males) in the Potato River to 6,076 (2,430 males) in the Bad River. The ratio of sterile to normal males therefore was predicted at 2.3:1, and represented a theoretical 70% reduction in production of larvae in the streams. The proposed schedule of release was from May 10 to June 11.

The St. Marys River has an annual spawning run of about 22,000 lampreys (55% males) with about 9,000 of these removed each year by assessment traps in Canada and the United States (based on 5-year average, 1986-1990). About 9,000 male lampreys were projected to be available from the St. Marys (5,000), Thessalon (2,500), and Echo (1,500) rivers for sterilization and release in the St. Marys River in 1991 for a sterile to normal ratio of 1.5:1. The projected schedule of release was June 19 to July 30.

A total of 25,297 male lampreys were transported to the Hammond Bay Biological Station from May 5 to July 2, 1991 and were held in raceways prior to sterilization (Table 19). Construction of the facility was completed on May 16 and all equipment was installed by June 13. The start of sterilization was one month later than planned and the proposed schedule to release sterilized lampreys in Lake Superior was reevaluated. The decision was made (on June 14) to release sterilized males in only 10 eastern tributaries, and the Chairman of the Lake Superior Technical Committee was notified. The tributaries of the eastern area of the lake generally are smaller and cooler than those in the west and therefore the spawning run peaks slightly later in the east than the west.

Sterilization of lampreys began on June 15. Operations occasionally were delayed when key system components either failed or did not perform at peak efficiency (primarily the auto-injector, lake water pumps, and aeration and water effluent filter systems). These problems resulted in extra operating expenses, increased mortality of lampreys, and further schedule delays.

Male lampreys were held in iced water (<2°C) prior to injection to reduce their activity. Each lamprey was weighed and placed into the auto-injector and injected with 100 mg of bisazir/kg of lamprey. Lampreys then were held in 1,325 L tanks for at least 48 hours, the time necessary to excrete or metabolize the bisazir.

Precautions were taken to prevent exposure of workers to bisazir or release of the contaminant to the environment. Access to the contained part of the facility was restricted to four trained personnel. Personnel wore hooded powered air purifying respirators and water repellent outer clothing. A health monitoring program was established for facility personnel. Water effluent from the contained portion of the facility (tank, injection, and decontamination rooms) was carbon filtered before return to Lake Huron. Air in the facility was exchanged at a high rate (12 to 15 exchanges per hour) and passed through carbon filters before returned to the environment. Bisazir solutions and crystals were exposed to the air in only closed and vented compartments.

Air, water, and lamprey tissues were monitored for bisazir contamination to insure safe working conditions for facility personnel, to protect against discharges of bisazir to the environment, to verify expected levels of bisazir, and to comply with State of Michigan water discharge permit. Air within the facility was monitored continuously with five sampling devices (rotated among seven locations). Effluent from the carbon filters was monitored for 10 days. Water from the sump (unfiltered waste water) was monitored for bisazir for two days. Water from one holding tank was sampled for two days. Tissues from 10 lampreys 48 hours after injection were homogenized and analyzed for bisazir concentrations.

The monitoring tests showed continuous safe operation in the facility in 1991. Bisazir was not detected in water discharged from the carbon filters. Bisazir concentrations in the sump ranged from 196 µg/L to less than the detection limit (<20 µg/L). A maximum concentration of 300 µg/L of bisazir was observed in the primary holding tank while lamprey were being injected and placed into the tank. Bisazir concentrations in the tank diminished steadily after injections stopped, and were less than the detection limit after 16 hours. Results are pending on analysis of air and lamprey tissue samples.

A total of 10,950 sterilized male lampreys were released in the 10 eastern tributaries of Lake Superior (3,434, June 17-21) and the St. Marys River (7,516, June 24-July 29; Table 19). Also, 1,156 sterilized lampreys died before being released and were frozen and later incinerated in compliance with State of Michigan regulations for medical waste.

Implementation and application of the sterile male release technique in sea lamprey control in 1991 were successful because: (1) all cooperating fishery agencies and groups involved in Lake Superior and the St. Marys River supported and endorsed the method of implementation; (2) following the completion of the facility and installation of equipment, lampreys were sterilized and processed through the facility at the predicted rate (about 1,000 per day), therefore processing time will not be a limiting factor in future years; and (3) the logistical coordination of capture and transport of male lampreys to the facility and the distribution of the sterilized males to target streams proved successful and occurred within the predicted rates. A study to determine the fate of sterilized lampreys after release is designed and will be conducted in 1992.

Final modifications of the sterilization facility were started in August 1991. Concrete pads (1,335 ft^2) were poured outside the facility to protect underground fixtures from the weight of trucks and to provide a surface on which to place additional holding tanks. Pipes were plumbed outside the facility to provide supply and drains for additional tanks. The pumping system for the lake water was modified to provide more water to the facility. A security fence was erected around the perimeter of the parking and loading area of the facility. An auto telephone dialer was installed to alert personnel of the failure of major systems or security violation. The auto injector has been returned to the manufacturer for necessary modifications identified through operation. Additional improvements planned for 1992 include intrafacility communications, aeration for holding tanks, modification of potable water supply, and a filter system for contaminated water.

Table 18. U. S. streams of Lake Superior proposed for sterile male release in 1991 at ratio of 2.3:1 sterile to normal male lampreys.

Stream	Estimated Resident Population	Proposed Number of Sterile Males	Estimated Number of Normal Males[1] (40%)
East			
Waiska River	222	200	90
Two Hearted River	610	580	244
Sucker River	256	240	102
Au Train River	375	340	150
Chocolay River	353	320	141
Salmon Trout River	200	180	80
Huron River	340	320	136
Ravine River	115	100	46
Sturgeon River	1,455	1,340	582
Traverse River	123	120	49
Subtotal	4,049	3,740	1,620
West			
Misery River	700	640	280
East Sleeping River	431	400	172
Firesteel River	799	740	320
Ontonagon River	5,000	4,620	2,000
Potato River	57	60	23
Cranberry River	89	80	36
Bad River	6,076	5,600	2,430
Poplar River	541	500	216
Middle River	784	720	314
Amnicon River	2,138	1,980	855
Nemadji River	1,000	920	400
Subtotal	17,615	16,260	7,046
TOTAL	21,664	20,000	8,666

[1]40% of resident population.

Table 19. Number of adult male lampreys received at the sterilization facility, injected with bisazir and released in selected streams in 1991.

Date	STREAM LAMPREYS RECEIVED FROM: Echo & Thessalon	St. Marys	Manistique	Cheboygan	Ocqueoc	INJECTED: No.	died[1]	STREAM LAMPREYS RELEASED INTO: Waiska	Two Hearted	Sucker	AuTrain	Chocolay	Salmon Trout	Huron	Ravine	Sturgeon	Traverse	St. Marys
5/05					58													
5/06					18													
5/07					1													
5/10				8														
5/13	223			405	450													
5/14				675	450													
5/15			1,700	562														
5/16				94	180													
5/17	159		1,200	721	52													
5/20			1,200	676	75													
5/21			1,000	376	19													
5/22	236			387	64													
5/23				675														
5/24				675	118													
5/28			1,000	675	78													
5/29				495														
5/30	311			657														
5/31				394														
6/03			400	372	36													
6/05				302	27													
6/06				153	4													
6/07				84	11													
6/10	72	823		45	16													
6/11				1	1													
6/12		874		4	1													
6/13				5	1	218	7											
6/14		350		5	1	500	17											
6/15						600	49											
6/16						753	86											
6/17				1	2	1,002	152	200			174	320						
6/18				1		752	80		551									
6/19						74	22											
6/20																667		
6/21	15	896				764	95			200			150	250	72	730	120	
6/22						261	13											
6/24		689																
6/25		808				348	13											969
6/26		644																
6/27		666				415	5											
6/28		450				1,202	21											335
6/29						1,302	30											
6/30						855	25											
7/01																		992
7/02		270																949
7/10						1,024	210											1,752
7/11						1,039	132											
7/12		154				297	63											
7/13																		423
7/14																		843
7/15		361																455
7/17		477																
7/22		208																
7/26						700	136											234
7/28																		
7/29																		404
																		160
Total	1,016	7,670	6,500	8,448	1,663	12,106	1,156	200	551	200	174	320	150	250	72	1,397	120	7,516

[1] Lampreys that died between the time of injection and release.

Total male lampreys received: 25,297

Total sterile male release in Lake Superior: 3,434

Total St. Marys River release: 7,516

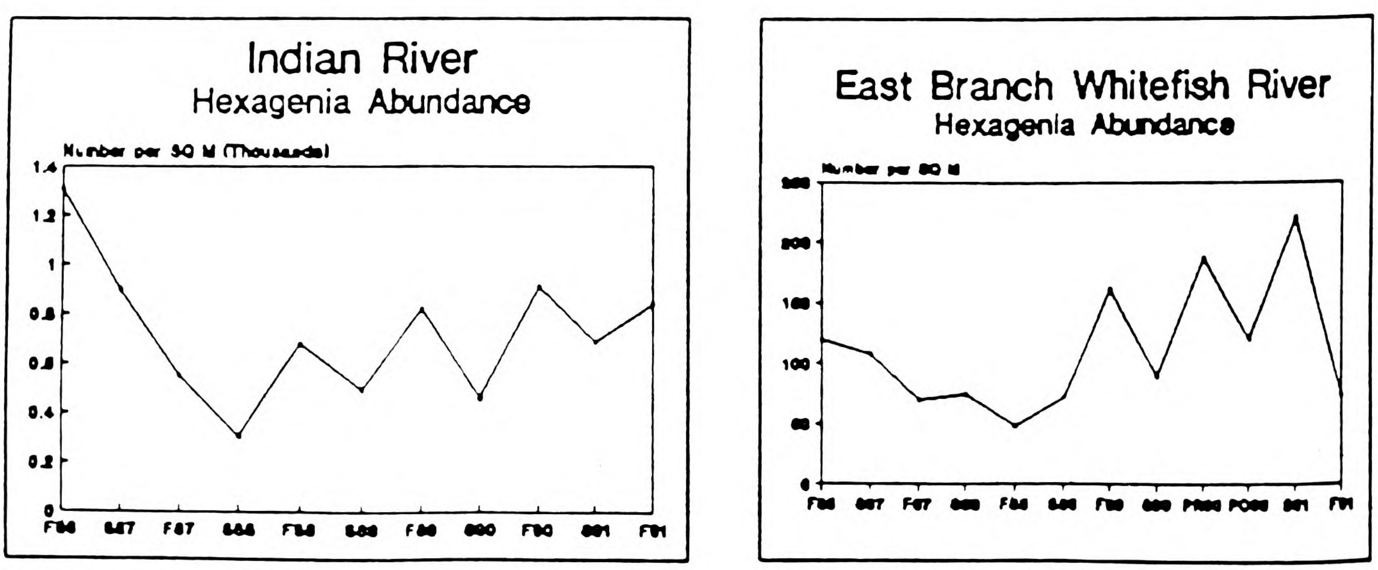
Treatment effects on Non-target Organisms (short-term test)

Mayflies-Hexagenia--Samples of Hexagenia have been collected annually since 1987 on the Pere Marquette River (Lake Michigan) to determine recovery of the population following lampricide treatments. The collections have shown that total population declined soon after treatment but fully recovered to pretreatment levels in three years. The stream was treated again in 1991 which resulted in a decline of 26% immediately following the treatment.

Treatment effects on Non-target Organisms (long-term test)

Mayflies-Hexagenia--Since 1984, samples of Hexagenia have been collected in the spring and fall in the East Branch of the Whitefish River (Lake Michigan) to determine long-term effects of lampricides on the population. An untreated portion of the nearby Indian River, a tributary of the Manistique River, was selected as a control area. Because Hexagenia population trends in the treated and control sites were similar from 1986 to 1991, environmental conditions rather than lampricide treatments appear to be a more significant factor in determining the strength of Hexagenia populations in the East Branch of the Whitefish River.

Figure 7. Abundance of Hexagenia nymphs in the East Branch of the Whitefish River and at a control site in the Indian River, 1986-1991. Samples were taken in the fall and spring and before and after a 1990 lampricide application in the East Branch.



Riffle community Index--Index areas of invertebrate communities were established in treated and control sections in the Whitefish (Lake Michigan) and Brule rivers (Lake Superior) in 1985. Samples are taken up and downstream of lamprey barriers in both rivers. The Sturgeon River (a tributary of the Cheboygan River, Lake Huron) also was selected. Because of problems associated with comparability of control and treated areas in this stream, a control area was selected in untreated portions upstream of dams in the Boardman River (Lake Michigan).

Samples have been collected in the spring and fall and before and after lampricide treatments at these areas using the standard traveling kick method. These are long-term studies in invertebrate community structure that require the establishment of several years of data to draw conclusions that relate to stream treatments. Thus far, the results have shown little difference in invertebrate populations between control and treated areas (Tables 20-24). Samples collected in the Whitefish River in 1990 and 1991 will be presented upon completion of processing in later annual reports.

Table 20. Mean number of organisms from five samples taken by kick nets in riffle communities in the Sturgeon River in April 1990 in areas that are periodically treated and in areas that are not treated (control).[a]

[The Sturgeon River, a tributary of the Cheboygan River on Lake Huron, was treated in October 1988; the control area is in the Boardman River on Lake Michigan.]

Taxa	Treated Area (Sturgeon River) Spring	Control Area (Boardman River) Spring
Ephemeroptera		
Baetidae		
Baetis	118	123.6
Pseudocloeon	11.2	
Oligoneuriidae		
Isonychia		
Heptageniidae		
Epeorus	0.2	
Rithrogena	44.8	6.8
Stenomena	8	1.4
Ephemerellidae		
Ephemerella	130.6	645.4
Seratella	6.2	42
Leptophlebiidae		
Paraleptophlebia	1.2	2.8
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus		1.4
Plecoptera		
Pteronarcyidae		
Pteronarcys	0.6	0.4
Taeniopterygidae		
Strophopteryx	0.4	
Nemouridae		
Nemoura		0.8
Ostrocerca	14	
Capniidae		
Paracapnia	0.2	
Perlidae		
Paragnetina	2	
Acroneuria	1.6	
Perlodidae		
Isogenoides	6.4	3.2
Isoperla	6.8	2.6

(continued)

Table 20. Continued

Taxa	Treated Area (Sturgeon River) Spring	Control Area (Boardman River) Spring
Megaloptera		
Corydalidae		
Nigronia	0.6	0.2
Trichoptera		
Hydropsychidae		
Ceratopsyche	2.6	4.8
Rhyacophilidae		
Rhyacophila	1	2.6
Glossosomatidae		
Protoptila	1.8	160.2
Hydroptilidae		
Hydroptila		23.8
Brachycentridae		
Brachycentrus	2.6	5.4
Micrasema	5.6	95
Lepidostomatidae		
Lepidostoma	0.6	2.4
Limnephilidae		
Hydatophylax	0.2	
Neophylax		4.4
Helocopsychidae		
Helicopsyche	4.4	
Leptoceridae		
Oecetis	0.2	
Coleoptera		
Elmidae		
Optioservus larvae	147.4	108
Optioservus adult	11.2	30.2
Diptera		
Tipulidae		
Antocha	10.6	2.6
Simulidae		
Prosimulium	0.4	15.6
Simulium		1.4
Chironomidae	46.2	126.6
Athericidae		
Atherix	9.6	103.6
Empididae		
Chelifera	0.6	19.2
Hemerodromia	0.6	2.2
Pupae		4.4

(continued)

Table 20. Continued.

Taxa	Treated Area (Sturgeon River) Spring	Control Area (Boardman River) Spring
Miscellaneous		
Annelida		
Oligochaeta	61.4	28.2
Isopoda		
Asellus	0.6	0.6
Amphipoda		
Gammarus		0.2
Hydracarina	4.6	13
Gastropoda		
Physidae		
Physa		5.6
Hydrobiidae		
Amnicola	0.4	
Ancylidae		
Ferrisia	1.4	0.6
Pelecypoda		
Sphaerium		
Sphaerium	0.2	3.4
Total	667	1,594.6
Total taxa	40	37

[a]Samples from Sturgeon and Boardman rivers in 1991 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 21. Mean number of organisms from five samples taken by kick nets in riffle communities in the Sturgeon River in September 1990 in areas that are periodically treated and in areas that are not treated (control).[a]

[The Sturgeon River, a tributary of the Cheboygan River on Lake Huron, was treated in October 1988; the control area is in the Boardman River on Lake Michigan.]

Taxa	Treated Area (Sturgeon River) Fall	Control Area (Boardman River) Fall
Ephemeroptera		
Baetidae		
Baetis	130.2	63.4
Pseudocloeon	22.4	8.8
Oligoneuriidae		
Isonychia	0.2	
Heptageniidae		
Rhithrogena	25	
Stenomena	45.8	3.8
Ephemerellidae		
Ephemerella	32.6	29
Eurylophella	2	
Seratella	9.4	7.2
Leptophlebiidae		
Paraleptophlebia	0.6	3.2
Tricorythidae		
Tricorythodes	0.2	0.2
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus		0.6
Plecoptera		
Pteronarcyidae		
Pteronarcys	1.8	1.2
Taeniopterygidae		
Taniopteryx		0.2
Nemouridae		
Nemoura	0.2	
Perlidae		
Paragnetina	2	
Acroneuria	2.4	
Perlodidae		
Cultus	1	
Isogenoides	10.2	1.2
Isoperla	25	5
Unknown		0.2

(continued)

Table 21. Continued.

Taxa	Treated Area (Sturgeon River) Fall	Control Area (Boardman River) Fall
Megaloptera		
Corydalidae		
<u>Nigronia</u>	0.8	0.6
Trichoptera		
Philopotamidae		
<u>Dolophilodes</u>	14.1	1.2
Hydropsychidae		
<u>Ceratopsyche</u>	87.2	15.6
Rhyacophilidae		
<u>Rhyacophila</u>	1.6	1.2
Glossosomatidae		
<u>Protoptila</u>	22.6	173.6
Hydroptilidae		
<u>Hydroptila</u>	0.8	7
<u>Leucotrichia</u>	0.2	
Brachycentridae		
<u>Brachycentrus</u>	9.8	4.8
<u>Micrasema</u>	8.6	12.6
Lepidostomatidae		
<u>Lepidostoma</u>	0.2	0.4
Limnephilidae		
<u>Neophylax</u>		0.6
Helocopsychidae		
<u>Helicopsyche</u>	54	
Pupae	0.8	
Coleoptera		
Elmidae		
<u>Optioservus</u> larvae	547	233.8
<u>Optioservus</u> adult	134.8	46.6
<u>Curculionidae</u>		0.2
Tipulidae		
<u>Tipula</u>	0.4	
<u>Antocha</u>	48.2	2
Simulidae		
<u>Prosimulium</u>	1.4	1.8
<u>Simulium</u>	6.2	21.6
Chironomidae	52.4	71.4
Athericidae		
<u>Atherix</u>	15.6	58.4
Empididae		
<u>Chelifera</u>	3.8	11
<u>Hemerodromia</u>	1	0.6
Pupae	4.4	5.4

(continued)

Table 21. Continued.

Taxa	Treated Area (Sturgeon River) Fall	Control Area (Boardman River) Fall
Miscellaneous		
Annelida		
Oligochaeta	67.6	29.4
Isopoda		
Asellus	30.4	0.2
Amphipoda		
Gammarus	0.2	1
Hydracarina	3.2	10.4
Gastropoda		
Physidae		
Physa	0.4	12.2
Hydrobiidae		
Amnicola		0.6
Ancylidae		
Ferrisia		0.2
Pelecypoda		
Sphaeriidae		
Sphaerium		0.6
Terrestrials	0.8	0.4
Pisces	0.2	0.2
Total	1,430	849.4
Total taxa	47	44

[a]Samples from Sturgeon and Boardman rivers in 1991 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 22. Mean number of organisms from five samples taken by kick nets in riffle communities in the Brule River in 1989 in areas that are periodically treated and in areas that are not treated (control). Samples in 1989 were taken in the spring and before and after an August lampricide application.[a]

	Brule River					
	Treated area			Control area		
Taxa	Spring	Before	After	Spring	Before	After
Ephemeroptera						
Baetidae						
Baetis	8.2	78	61.2	13.2	90	114.6
Pseudocloeon		135.6	117.2		107.2	120.2
Oligoneuriidae						
Isonychia		1	0.2		1.4	0.8
Heptageniidae						
Leurocuta	0.2	3	1.4		2.2	1.8
Rhithrogena	7.6	2.2	4.8	7.2		1
Stenomena	3.6	2	2.8	4.4	2.2	4.8
Ephemerellidae						
Ephemerella	145		0.2	218.8	1	1.4
Seratella	13.2	11.8	7.2	9.6	6.2	7.8
Tricorythidae						
Tricorythodes		4.2	1		9.8	4.4
Caenidae						
Caenis					0.2	
Leptophlebiidae						
Paraleptophlebia	0.4	0.2		0.2	0.2	0.6
Ephemeridae						
Ephemera		0.2	1		0.2	0.2
Odonata						
Anisoptera						
Gomphidae						
Ophiogomphus	5.2	6	4.8	5.6	7.6	5.6
Zygoptera						
Calopterygidae						
Calopteryx		0.4				
Plecoptera						
Pteronarcyidae						
Pteronarcys		0.2		0.4	0.2	0.6
Taeniopterygidae						
Strophopteryx	0.4			1.2		
Taniopteryx					1.6	

(continued)

Table 22. Continued.

Taxa	Brule River Treated area Spring	Before	After	Control area Spring	Before	After
Plecoptera, continued.						
Perlidae						
Paragnetina	0.2	0.4	0.2			0.2
Acroneuria	4	30	32.4	10.6	21.6	21.2
Perlinella	0.4		0.2		0.4	0.4
Perlodidae						
Isogenoides	0.4					
Isoperla	1.6	0.2		1.4		0.2
Unknown		0.4			0.4	0.2
Megaloptera						
Corydalidae						
Nigronia		1.4	1		0.2	
Trichoptera						
Psychomyiidae						
Psychomyia	0.6	2	1.6	0.4		0.4
Polycentropodidae						
Neureclopsis					0.2	
Hydropsychidae						
Ceratopsyche	8.2	43.4	39.6	20.6	87.8	92.4
Cheumatopsyche	6.8	8.6	6.8	3	5.2	7.8
Glossosomatidae						
Protoptila	321.4	58.2	134.8	285.6	61.6	65.8
Hydroptilidae						
Hydroptila	5.4	9.6	5.8	10.6	14	7.2
Leucotrichia	5.4	6	2.8	2.8	2	1.6
Mayatrichia		0.6			1.6	0.4
Neotrichia		2.8	0.4		4	3.4
Phryganeidae						
Brachycentridae						
Brachycentrus	1.2		0.8	5	0.8	0.4
Micrasema	0.2	0.8	0.6	0.2		0.4
Lepidostomatidae						
Lepidostoma	3.4	0.8	0.6	6.6	2.6	2.8
Limnephilidae						
Pycnopsyche				0.2		
Helocopsychidae						
Helicopsyche	68.6	91.8	131.2	25.8	26	25.8

(continued)

Table 22. Continued.

Taxa	Brule River					
	Treated area			Control area		
	Spring	Before	After	Spring	Before	After
Trichoptera, continued.						
Leptoceridae						
Ceraclea		0.4			0.2	
Oecetis	0.4			0.2		0.2
Setodes	15	1		11.2	3	2
Pupae		5.4	3.8		10.8	8.8
Coleoptera			3.6			
Elmidae						
Optioservus larvae	26	74.4	59	26.6	71.8	70
Optioservus adult	13	30.4	30.4	8.8	20.6	19.6
Stenelmis larvae	0.2	1.8	3.2	0.8	0.8	2.8
Stenelmis adult		0.4				0.2
Promoresia adult		0.2	0.4			
Curculionidae						
Stenopelmus					0.2	
Diptera						
Blephariceridae						0.2
Tipulidae						
Tipula	0.2	1.4	0.2		0.2	
Antocha	12.6	9.4	8.8	26	6.6	4
Hexatoma	4.8	1.4	1	7.8		
Limonia					0.2	8.6
Ceratopogonidae		0.8	0.2		0.4	0.4
Simulidae						
Ectemnia	0.2	0.2	0.2			
Prosimulium	3.4	3.6	0.2	10.6	0.4	4.2
Simulium		7.4	2.6	0.2	6.8	8.2
Chironomidae	36.6	234.4	132.8	50	356	402
Athericidae						
Atherix	51.4	60.4	45.2	23.4	13.6	8.4
Empididae						
Chelifera	0.4			0.2	0.2	
Hemerodromia	0.8	1.4	1.2	1	2.6	0.6
Pupae	0.2	4.4	0.2	0.4	16.6	12.8
Adult		1			2.6	

(continued)

Table 22. Continued.

Taxa	Brule River: Treated area Spring	Before	After	Control area Spring	Before	After
Miscellaneous						
Nematoda						0.4
Annelida						
Oligochaeta	4.4	102.2	26.6	2.6	34	37.4
Amphipoda						
Gammarus	0.4	0.4	0.4	1		
Hydracarina	1.2	6.6	3	0.4	9.8	14.6
Gastropoda						
Physidae						
Physa	1		0.2	0.4	0.8	
Ancylidae						
Ferrisia	36	10.4	9	21	9.8	15.8
Pelecypoda						
Sphaeriidae						
Sphaerium	1.6	0.2	0.4	1.6	0.2	0.6
Terrestrials		1.6	0.6		1.8	0.6
Pisces		2.8	0.2			
Total	821.4	1,061.8	898.8	827.6	1,038.8	1,116.8
Total taxa	45	55	52	42	54	52

[a]Samples from the Brule River in 1991 will be given, upon completion ofprocessing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 23. Mean number of organisms from five samples taken by kick nets in riffle communities in the Brule River in April 1990 in areas that are periodically treated and in areas that are not treated (control).[a]

Taxa	Brule River Treated Area Spring	Brule River Control Area Spring
Ephemeroptera		
Baetidae		
Baetis	13.8	38
Heptageniidae		
Leurocuta		0.4
Rhithrogena	6	7.4
Stenomena	0.6	1.8
Ephemerellidae		
Ephemerella	81.8	161.4
Seratella	6.4	8.6
Leptophlebiidae		
Paraleptophlebia	0.6	1.2
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus	5.8	3.6
Plecoptera		
Pteronarcyidae		
Pteronarcys		0.4
Taeniopterygidae		
Strophopteryx		0.2
Perlidae		
Paragnetina		0.2
Acroneuria	8	10.6
Perlodidae		
Isogenoides		0.2
Isoperla	0.4	1
Unknown	0.4	0.4
Hemiptera		
Corixidae	0.2	
Megaloptera		
Corydalidae		
Nigronia	0.2	
Trichoptera		
Psychomyiidae		
Psychomyia	1.4	1.8

(continued)

Table 23. Continued.

Taxa	Brule River Treated Area Spring	Brule River Control Area Spring
Hydropsychidae		
Ceratopsyche	3.4	19
Cheumatopsyche	3.6	2.2
Glossosomatidae		
Protoptila	116.6	84.6
Hydroptilidae		
Hydroptila	1.4	4.8
Leucotrichia	0.4	2.4
Brachycentridae		
Brachycentrus	2.4	4.2
Micrasema	0.2	2
Lepidostomatidae		
Lepidostoma	1	6.4
Helocopsychidae		
Helicopsyche	40.8	22.4
Leptoceridae		
Setodes	10.2	8
Pupae		
Coleoptera		
Elmidae		
Optioservus larvae	73.2	97
Optioservus adult	2.6	7.8
Stenelmis larvae	0.2	
Stenelmis adult	0.4	0.2
Diptera		
Tipulidae		
Antocha	3.4	30
Dicranota	0.8	
Hexatoma	1.6	15.8
Ceratopogonidae	0.4	0.2
Simulidae		
Ectemnia		0.2
Prosimulium	1.4	4.6
Simulium	0.2	2.6
Chironomidae	51	135.2
Athericidae		
Atherix	26.4	22.8
Empididae		
Hemerodromia		0.2
Pupae		2.2

(continued)

Table 23. Continued.

Taxa	Brule River Treated Area Spring	Brule River Control Area Spring
Miscellaneous		
Turbellaria		
Planaria	0.2	
Annelida		
Oligochaeta	3.6	6.8
Amphipoda		
Gammarus		0.4
Astacidae		0.2
Hydracarina		3.8
Gastropoda		
Physidae		
Physa	0.2	
Ancylidae		
Ferrisia	7.2	12.8
Pelecypoda		
Sphaeriidae		
Sphaerium	4.2	0.6
Terrestrials		
Pisces		
Total	482.6	736.6
Total taxa	40	45

[a]Samples from the Brule River in 1991 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

Table 24. Mean number of organisms from five samples taken by kick nets in riffle communities in the Brule River in September 1990 in areas that are periodically treated and in areas that are not treated (control).[a]

	Brule River	
Taxa	Treated Area Fall	Control Area Fall
Ephemeroptera		
Baetidae		
Baetis	90.6	60.4
Pseudocloeon	35	21.4
Heptageniidae		
Leurocuta	0.2	
Rhithrogena	1	1.4
Stenomena	1.4	3.6
Ephemerellidae		
Ephemerella	1.4	5.8
Seratella	8.8	6.8
Leptophlebiidae		
Paraleptophlebia	0.2	
Ephemeridae		
Ephemera	0.6	0.2
Adults	0.6	
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus	3.4	9.6
Plecoptera		
Pteronarcyidae		
Pteronarcys	0.2	0.4
Perlidae		
Acroneuria	24.6	25.8
Perlodidae		
Isoperla	0.4	0.2
Megaloptera		
Corydalidae		
Nigronia	1	1
Trichoptera		
Psychomyiidae		
Psychomyia	0.4	1.4
Hydropsychidae		
Ceratopsyche	17.8	41.8
Cheumatopsyche	2	2.8
Rhyacophilidae		
Rhyacophila		0.2
Glossosomatidae		
Glossosoma	1.2	1.2
Protoptila	268.4	402.6
Hydroptilidae		
Hydroptila	8	26.2
Leucotrichia	0.8	2.6
Neotrichia	1	0.4

(continued)

Table 24. Continued

Taxa	Brule River Treated Area Fall	Brule River Control Area Fall
Brachycentridae		
Brachycentrus	1.4	4.6
Micrasema	0.2	0.8
Lepidostomatidae		
Lepidostoma	1.2	4.8
Helocopsychidae		
Helicopsyche	148.6	86
Leptoceridae		
Ceraclea	0.2	
Setodes	3.4	7.2
Pupae		0.4
Lepidoptera		
Pyralidae	0.2	
Coleoptera		
Elmidae		
Dubiraphia larvae		0.2
Optioservus larvae	148.4	140.2
Optioservus adult	29.8	27.4
Stenelmis larvae	1.4	1.8
Stenelmis adult	0.2	
Diptera		
Tipulidae		
Tipula	0.8	
Antocha	5.8	17.6
Hexatoma	2.8	5.2
Ceratopogonidae	1	
Simulidae		
Prosimulium		0.2
Simulium	0.6	0.2
Chironomidae	29.2	32.2
Athericidae		
Atherix	77.4	25.4
Empididae		
Hemerodromia	1.2	1.6
Pupae	1	1.2

(continued)

Table 24. Continued

Taxa	Brule River Treated Area Fall	Brule River Control Area Fall
Diptera		
Adult	0.2	
Miscellaneous		
Turbellaria		
Planaria	1	
Annelida		
Oligochaeta	20.8	3.4
Isopoda		
Asellus		0.2
Amphipoda		
Gammarus	0.4	0.6
Hydracarina	0.8	0.6
Gastropoda		
Physidae		
Physa	0.2	0.8
Gyralus	0.2	
Hydrobiidae		
Amnicola		0.2
Ancylidae		
Ferrisia	20.8	25.8
Pelecypoda		
Sphaeriidae		
Sphaerium	1.2	1.6
Terrestrials	0.2	
Total	969.6	1006
Total taxa	53	47

[a]Samples from the Brule River in 1991 will be given, upon completion of processing, in later annual reports. Several years of data are required to evaluate the effects of lampricide treatments on the invertebrate community in streams. Index areas will be sampled annually each spring and fall, and before and after application of lampricides in the year treated.

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