GLFC Annual Meeting
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Agenda Item 3

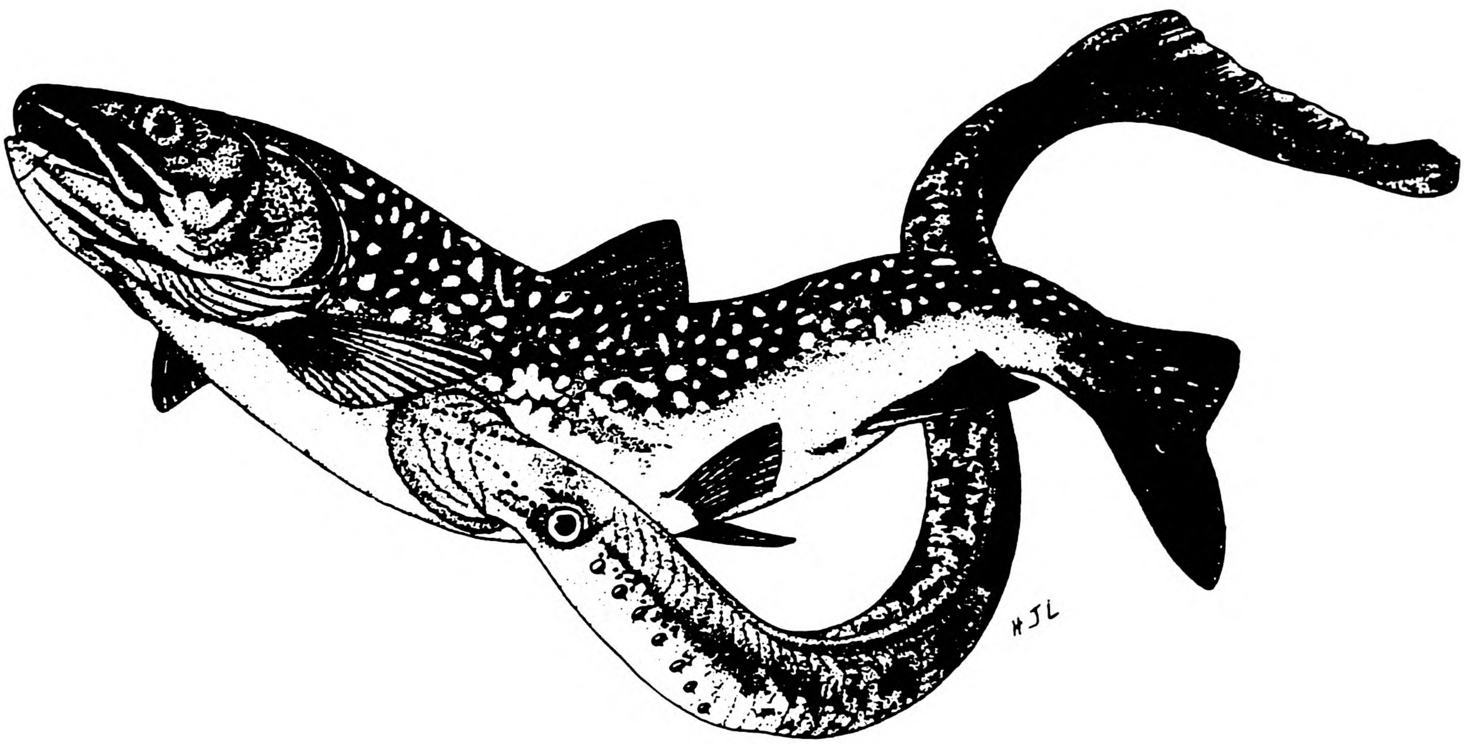
APPENDIX III

SEA LAMPREY MANAGEMENT IN THE GREAT LAKES IN 1992

ANNUAL REPORT

TO

GREAT LAKES FISHERY COMMISSION



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CONTENTS

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This is a joint report that summarizes sea lamprey management activities conducted by the United States Fish and Wildlife Service and the Department of Fisheries and Oceans Canada. The 1992 management activities included larval assessment, lampricide treatment, spawning-phase assessment, parasitic-phase assessment, maintenance of low-head barrier dams, implementation of a control strategy for the St. Marys River, continuation of the sterile male release technique, and assessment of the effects of lampricides on nontarget organisms. Larval assessment surveys were completed on 510 Great Lakes tributaries, 1 inland lake, and 8 offshore areas of streams. Lampricide treatments were completed on 56 tributaries to the Great Lakes (Table 1). In U.S. waters, 1 lampricide treatment in a Lake Huron tributary was postponed because of low water. In Canadian waters, 2 treatments were postponed on tributaries to Lakes Superior and Huron because of environmental concern and low discharge. Assessment traps placed in 60 tributaries to the Great Lakes captured 83,286 spawning-phase sea lampreys (Table 2). A total of 6,385 parasitic-phase sea lampreys were collected from commercial and sport fishermen in Lakes Superior, Michigan and Huron. A control strategy for sea lampreys in the St. Marys River for 1992-95 was developed and implemented. The sterile male release technique successfully was continued as a supplemental control method to lampricide treatments. A total of 25,807 sterilized male lampreys were released into 27 streams of Lake Superior (21,299, Table 21) and the St. Marys River (4,508). Tests of the short-term effects of lampricides on nontarget organisms were concluded in the Pere Marquette River. Long-term monitoring of the effects of lampricides to the mayfly Hexagenia and other organisms continued in two streams.

Table 1. **Summary of chemical treatments in streams of the Great Lakes in 1992.** [Lampricides used are in kilograms/pounds of active ingredient.]

Lake	Number of Streams	Discharge m³/s	Discharge f³/s	TFM kg	TFM lbs	Bayer 73 kg	Bayer 73 lbs	Distance km	Distance miles
Superior	16	126.2	4,453	13,129	28,944[1]	119	263.0	329.9	205.
Michigan	18	89.3	3,153	20,996	46,288	56.7	125.0	535.9	333.
Huron	10	13.4	470	1,584	3,491	2.4	5.2	114.0	71.
Erie	1	5.4	191	1,720	3,792	-	-	95.0	59.
Ontario	11	43.7	1,540	5,007	11,036	-	-	185.1	115.
Total	56	278.0	9,807	42,436	93,551	178.1	393.2	1,259.9	783.

[1]Includes 686 TFM bars (147.7 kg, 324.7 lbs.) applied in 20 streams.

Table 2. **Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of the Great Lakes in 1992.**

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	18	5,616	2,326	48	428	422	188	183
Michigan	11	20,590	1,331	44	483	488	253	273
Huron	11	50,572	2,275	53	470	473	222	234
Erie	5	674	248	67	515	500	290	275
Ontario	15	5,834	1,148	50	487	481	259	251
Total	60	83,286	7,328	49	456	455	217	221

LAKE SUPERIOR

Larval Assessment

United States

Surveys prepared for lampricide treatments, assessed the success of past treatments, monitored reestablished populations of larval sea lampreys, and searched for new infestations of larvae in 83 Lake Superior tributaries. Surveys to schedule lampricide applications were conducted in 18 streams. Of these, 4 were successfully treated, 13 were scheduled for treatment in 1993, and the remaining 1 was deferred. Sea lamprey larvae that remained from past treatments were found in 21 streams, but comprised less than 5% of the total number of larvae collected in all streams. Of those streams, the Firesteel River was treated in 1992 to destroy a residual lamprey population from the 1991 treatment. Larvae had reestablished in 39 of the streams that were surveyed. Original surveys to search for new infestations were conducted in 15 streams, and no larvae were found.

Surveys to assess recruitment of the 1992 year class were conducted in 66 streams and young-of-the-year larvae were recovered in 21 streams. Young-of-the-year larvae have not been detected for 5 or more years in 11 streams that have been examined annually.

Beginning in 1988, development of estimation of basic production levels of sea lamprey larvae between cycles of lampricide treatments began for the major lamprey producing tributaries in U.S. waters of Lake Superior. There are 33 major production tributaries and work was completed on 23 of these tributaries by the conclusion of 1992. Also, production levels have been estimated in two secondary lamprey producing tributaries. The techniques to develop the production levels continually were refined and have been reported in previous annual reports. Also, the number of larvae that remained 1 year after a lampricide treatment has been estimated in 3 tributaries. The work is projected to be completed in 1994, with production levels estimated in 3 major and 1 secondary tributary in 1993 and 2 major tributaries in 1994. (The difference between the number of major lamprey producing tributaries and the number in which the work is being conducted--33 vs. 28--occurs because 5 tributaries either receive annual lampricide treatments and too few larvae survive to practically estimate population abundance or a barrier prevented adults from access to gravel areas.)

The populations of larval sea lampreys were estimated in five tributaries of Lake Superior through a random transects habitat-based technique in 1992. These studies determined the amounts of habitat (three types) for larvae and the number of larvae and transformers inhabiting each river. The tributaries included the Ontonagon, Miners, Salmon Trout (Houghton Co.), East Sleeping and Waiska rivers. Densities of larval lampreys were determined with backpack and deepwater electrofishing gear. Length frequency data provided a basis to estimate the number of lampreys in each age class, the number that had reached minimum length for transformation (120 mm), and the number of transformed lampreys that had been expected to migrate into Lake Superior. All rivers were treated in 1992, with the exception of the Waiska River which was deferred to 1994.

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 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 type 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 sea lampreys ranged from 101 in the Salmon Trout River (Houghton Co., Michigan) to 794,736 in the Ontonagon River (Table 3).

The population of larvae in the Bad River was estimated at 1,048,208 (548,227-1,548,189) in 1991 and the river was treated with lampricide later in the year. The population of larvae that survived the treatment was estimated at 24,904 (1,239-39,032) in 1992. Of these, about 3,995 were ≥120 mm (potential transformers) and 1,954 were transformers. Larvae inhabited 126 miles of river in 1991 and the work in 1992 was conducted in 92 miles of river. Larvae were scarce in the other 34 miles in 1991 and the area was not reexamined in 1992. This work largely was conducted by members of the Great Lakes Indian Fish and Wildlife Commission and the Bad River Band of Chippewa Indians.

A three-year (1990-92) examination of the sea lamprey larvae population in the Firesteel River was completed in 1992. The Firesteel River is in the western section of the upper peninsula of Michigan. The river was selected because it is treated regularly with lampricide, is difficult to treat effectively, and is suspected of the annual production of significant numbers of larvae. The objectives of the examination included estimation of the population of larvae in each year, determination of natural mortality between 1990 and 1991, and estimation of the number of residual larvae that remained after a lampricide treatment in 1991.

The examination achieved the objectives. The population was estimated at 323,745 (109,664-537,825) larval lampreys in 1990. The previous treatment of the Firesteel River occurred in 1987 therefore only two year classes were present, 1988 and 1989. The population in 1991 was estimated at 328,553 (163,074-506,316) with 3 year classes (1988-90). Length frequency analysis showed natural mortality of about 50% for the 1988 and 1989 year classes between 1990 and 1991. The river was treated with lampricide late in 1991, and the population of residual larvae was estimated at 10,027 (1,239-17,199) in 1992. Of these, about 3,908 were ≥120 mm (potential transformers) and 344 were transformers. Prior to

Table 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 5 tributaries of Lake Superior, 1992. (The 95% confidence intervals for total numbers, number ≥120 mm, and transformers are listed in parenthesis below each respective estimated value.)

River	Method of Estimation	Area of Habitat Types[1] I	II	III	Density of Larvae[2] I	II	Year[3] Classes	Total Larvae[4] and transformers	Number[5] >120 mm	Number of[6] transformers
Ontonagon	Random transects[7]	3,847,708	31,564,498	1,513,973	.1401	.0081	4	794,736	64,661	8,891
								(310,450-1,279,022)	(21-135,984)	(3-18,698)
Miners	Random transects	47,445	181,630	9,346	.0961	.0155	4	7,375	43	2
								(2,909-11,191)	(2-110)	(0-4)
Salmon Trout (Houghton Co.)	Random transects	17,297	49,735	70,000	.0341	.0000	4	101	18	2
								(11-297)	(2-66)	(0-6)
East Sleeping	Random transects	116,248	507,647	65,187	.1392	.0167	3	24,659	6,711	1,527
								(1,583-49,895)	(47-14,959)	(11-3,403)
Waiska	Random transects	308,039	309,275	206,760	.0013	.0004	4	524	185	23
								(27-1,210)	(1-553)	(0-69)

[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 1992 or previous years. The percentage is different for each stream and ranges from 4% for the Miners River to 23% for the East Sleeping River.
[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.

the treatment larvae inhabited 47 miles of river and in 1992 larvae were found only in the lowermost 17 miles. The river was treated with lampricide in 1992 to remove the population of residual larvae.

Canada

Surveys were conducted on 117 Lake Superior tributaries, 1 instream lake, and offshore of 8 sea lamprey producing streams in preparation for chemical treatment in 1993, to monitor reestablished, residual and untreated populations, to evaluate barrier dams and to look for new infestations.

Distribution surveys were completed on five streams tentatively scheduled for treatment in 1993 (Little Carp, Carp, Goulais, Pancake and Black Sturgeon rivers). The distribution of larval sea lamprey in Little Carp and Carp is considerably reduced over that of earlier years while remaining essentially unchanged in the other three.

Treatment evaluation surveys were done on the five tributaries treated in 1991 (Gargantua, Little Gravel and Pearl rivers and Cash and Stillwater creeks). One residual larva was collected from each of the Gargantua and Little Gravel rivers and none from the other three streams. The Gargantua and Little Gravel rivers and Stillwater Creek were also found to have reestablished with the 1991 year class of larval sea lamprey.

Reestablishment surveys done on nine other streams last treated in 1990 or earlier were positive on the Chippewa, Pic and Pine rivers and negative on West Davignon, Cranberry and Stokely creeks as well as Harmony, Sand and White rivers.

Barrier dams on Stokely and Gimlet creeks and on Carp, Wolf and Neebing rivers were all effective at blocking the 1991 spawning run. Remedial work done on the Carp River dam in 1990 and 1991 appears to have been effective.

Routine surveys of 81 streams with no history of sea lamprey production were all negative. Some of these streams, located between Wawa and Marathon appear to have excellent lamprey potential. Interestingly, none of the streams in this area support native lamprey populations either.

Lentic populations of larval sea lamprey in Batchawana, Mountain and Mackenzie Bays and in Lake Helen (Nipigon River) have the potential to be significant contributors to parasitic stocks in Lake Superior.

Quantitative Assessment

In 1986 a mark-recapture population estimate was made of the delta area where the Nipigon River enters Lake Helen. The area was surveyed with granular Bayer 73 at the same time that a TFM treatment was affecting the delta. This application of granular Bayer was done in an attempt to force larval lamprey from the delta substrate into the water column where the TFM would increase mortality.

Surveys between 1974-86 indicated that the population of larval sea lamprey was concentrated on approximately 4 hectares on the immediate river delta. Other areas in Lake Helen harbour low concentrations of larval sea lamprey but this estimate is limited to the delta proper. In 1986 3 hectares were surveyed and 7,336 larval sea lamprey, including 21 transforming larvae, were collected. The population estimate was 523,057 (95% C.L. 261,528-784,585) including 708 transformers (0.14%).

In 1992 6,370 larval sea lamprey collected from New York State streams were measured, weighed, marked with a tail clip, and released to the Nipigon delta. The marked larvae were released in 3 areas (a total of 1.2 hectares) representing the larval distribution of the delta. During the 1992 TFM treatment of the Nipigon River, a granular Bayer survey again was conducted. The sea lamprey population was estimated to be 32,665 (95% C.L. 29,878-35,441) larvae including 40 (0.12%) transforming individuals. Extrapolation to the total area provided a total estimate of 108,883 larvae and 133 transformers.

The larval sea lamprey population of the Nipigon River delta appears to have been significantly reduced since the 1986 survey/treatment. After 6 years the 1992 population was estimated to be only 21% of the 1986 level. Transformation rates (the percent over 120 mm) decreased from 0.93% to 1986 to 0.32% in 1992.

A weight-length analysis of the larval sea lamprey collected from New York State showed an increase in weight per unit length over two months of release on the delta. The growth relationship $Y=aX^b$ where Y=weight in grams and X=length in millimeters were virtually identical for the two groups of larvae at the end of August. When released on July 7 the New York larvae had a weight-length relationship of $Y=9.1915 \times 10^{-6} X^{2.6335}$, $R^2=.9883$, N=439. In August the New York larvae were represented by $Y=8.9634 \times 10^{-6} X^{2.6509}$, $R^2=.9848$, N=324; for the delta larvae, $Y=7.5788 \times 10^{-6} X^{2.6831}$, $R^2=9928$, N=490. In real terms, a 150 mm larvae released in July weighed 4.9447 g (on average), by the end of August it weighed 5.2621 g (a 6.4% increase) and the resident larvae weighed 5.2276 g.

Chemical Treatment

United States

Lampricide treatments were completed on 13 streams during 1992 (Table 4, Fig. 1) with a combined discharge of 36.1 m^3/s (1,271 f^3/s). All treatments were successful due to favorable flow conditions except Red Cliff Creek because of low discharge.

Sea lamprey larvae were abundant in the Brule, East Sleeping, Sucker, and Ontonagon rivers. Nontarget species mortality during most treatments was not significant. Some juvenile salmonids appeared stressed during the treatment of the Ontonagon River.

Several studies were completed on the Brule River to investigate the effects of pH and alkalinity on sea lamprey and several nontarget species, including the river ruffe. Bioassay tests indicated ruffe were more sensitive to TFM than most native fish species. Caged and trawling studies also indicated that a significant portion of the ruffe were killed during the treatment of the Brule River.

Table 4. **Details on the application of lampricides to streams of Lake Superior, 1992.**
(Lampricides used are in kilograms/pounds of active ingredient.)
[Number in parentheses corresponds to location of stream in Fig. 1.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[1] kg	TFM[1] lbs	Bayer 73 kg	Bayer 73 lbs	Distance km	Distance miles
UNITED STATES									
Galloway Cr. (1)	June 27	0.1	3	10	21	-	-	1.6	1
E. Sleeping R. (9)	July 11	0.4	14	121	266			20.9	13
Red Cliff Cr. (12)	Aug. 6	<0.1	1	1	3	-	-	1.6	1
Brule R. (13)	Aug. 12	4.8	170	641	1,414	-	-	9.7	6
Salmon Trout R. (6)	Aug. 19	0.9	30	97	214	-	-	1.6	1
Sucker R. (2)	Aug. 22	1.6	55	191	421	-	-	9.7	6
Miners R. (3)	Aug. 26	0.7	25	91	199	-	-	1.6	1
Furnace Cr. (4)	Sept. 9	0.2	8	44	98	-	-	3.2	2
Ontonagon R. (11)	Sept. 20	20.1	710	2,653	5,849	-	-	156.1	97
Harlow Cr. (5)	Oct. 15	0.3	9	30	65	-	-	1.6	1
Falls R. (8)	Oct. 22	2.8	100	280	618	-	-	1.6	1
Firesteel R. (10)	Oct. 24	1.9	66	239	528	-	-	19.3	12
Silver R. (7)	Oct. 27	2.3	80	170	374	-	-	8.0	5
Total		36.1	1,271	4,568	10,070	-	-	236.5	147
CANADA									
Jackfish R. (16)	July 22	5.8	205	473	1,043	-	-	9.7	6
Kaministiquia R. (14)	Aug. 22	31.8	1,123	2,825	6,228	38	84	70.8	44
Nipigon R. (15)	Aug. 29	52.5	1,854	5,263	11,603	81	179	12.9	8
Total		90.1	3,182	8,561	18,874	119	263	93.4	58
GRAND TOTAL		126.2	4,453	13,129	28,944	119	263	329.9	205

[1]Includes a total of 383 TFM bars (74 kg, 164 lbs.) applied in 10 streams.

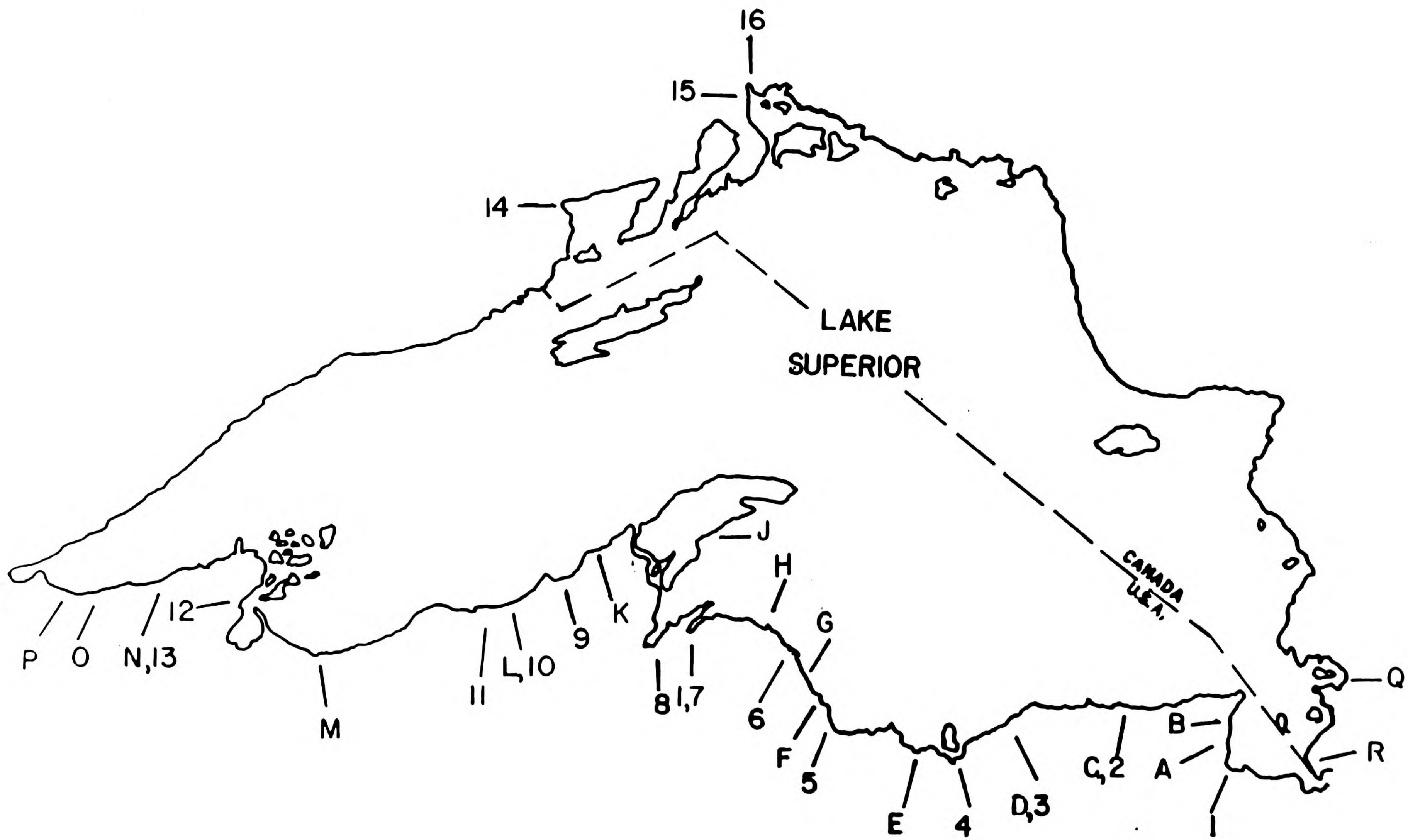

Figure 1. Location of Lake Superior tributaries treated with lampricides (numerals; see Table 4 for names of streams), and of streams where assessment traps were fished (letter; see Table 5 for names of streams) in 1992.

During the treatment of the Miners River, the TFM concentration was kept near the minimum level as predicted by the pH/alkalinity table (significantly lower than by prediction by the alkalinity table). The treatment successfully eradicated the sea lamprey population with only minimal numbers of larvae surviving the treatment.

Canada

The Jackfish, Nipigon and Kaministiquia rivers were successfully treated in 1992 (Table 4, Fig. 1). The Nipigon and Kaministiquia rivers are two of the largest and most costly streams to treat on Lake Superior. Treatment of the Pays Plat River was deferred when residents of the First Nation's village of Pays Plat, who use the river as a potable water source, requested that lampricide not be administered to the system. Regrettably the system harbours areas of high densities of larval sea lamprey. Negotiations with the Pays Plat Band continue in an effort to reschedule this stream for treatment in 1993.

Larval abundance was ranked high in the Nipigon and Kaministiquia rivers and moderate in the Jackfish River. Non-target mortality was light in all treatments with trout-perch being identified as the most susceptible fish species.

Powdered Bayer 73 was used with TFM to reduce treatment costs on the Nipigon and Kaministiquia rivers. Ontario Hydro, with generating facilities on these rivers, provided reduced flows during the treatment period, resulting in significant cost savings as well. Considerable public relations efforts were expended to inform the public of these two treatments.

Spawning-phase Assessment

United States

Assessment traps placed in 16 tributaries of Lake Superior captured 5,456 spawning-phase sea lampreys (Table 5, Fig. 1), an increase of 2,245 from 1991 (3,211). Catches of lampreys increased in the Amnicon, Middle, Brule, Bad, Misery, Silver, Huron, Rock, Miners, Sucker and Betsy rivers. Trap catches decreased in the Firesteel, Traverse, Iron, Big Garlic and Tahquamenon rivers. The percentage of males remained the same (48%) as recorded for 1991. The average length and weight of males (428 mm, 188 g) and females (422 mm, 183 g) remained about the same as in 1991.

Spawning runs were monitored through cooperative agreements in eight streams with the Great Lakes Indian Fish and Wildlife Commission (Amnicon, Middle, Bad, Firesteel, Misery, Traverse, Silver and Huron rivers), and in the Brule River 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 seventh 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. In western waters, an estimated 20,357 lampreys were present ($y=7.63$; $P<0.05$, $r=.853$), while 8,181 lampreys were estimated ($y=3.24$; $P<0.05$, $r=0.834$) east of

Table 5. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Superior, 1992.

(Letter in parentheses corresponds to location of stream in Fig. 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)	468	88	74	442	443	220	229
Betsy R. (B)	151	151	55	427	426	209	206
Sucker R. (C)	13	13	46	436	436	212	224
Miners R. (D)	65	21	67	425	415	208	197
Rock R. (E)	801	792	45	422	421	179	182
Big Garlic R. (F)	16	4	75	427	387	207	179
Iron R. (G)	5	0	-	-	-	-	-
Huron R. (H)	41	8	13	475	389	178	137
Silver R. (I)	36	3	33	403	365	160	114
Traverse R. (J)	11	0	-	-	-	-	-
Misery R. (K)	907	759	43	426	425	184	186
Firesteel R. (L)	43	5	80	428	402	206	300
Bad R. (M)	236	190	36	414	411	169	151
Brule R. (N)	2,550	257	63	440	432	196	191
Middle R. (O)	12	2	50	363	435	126	186
Amnicon R. (P)	101	33	91	456	403	189	214
Total or average	5,456	2,326	48	428	422	188	183
CANADA							
Stokely Cr. (R)	36	0	-	-	-	-	-
Carp River (Q)	124	0	-	-	-	-	-
Total	160	0	-	-	-	-	-
GRAND TOTALS	5,616	2,326	48	428	422	188	183

Table 6. Mean discharge for U.S. streams located east and west of Keweenaw Bay in Lake Superior from May 6-June 30, 1986-90, ranked as primary and secondary producers of sea lampreys, and the estimated number of spawning-phase sea lampreys in 1992.

[Population estimates were calculated from results of stratified multiple tag and recapture studies 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 River	490	-	3,739
Amnicon River	240	1,394	1,831
Middle River	50	172	382
Brule River	195	3,398	1,488
Red Cliff River	1	-	8
Bad River	437	2,651	3,335
Ontonagon River	1,031	-	7,867
East Sleeping River	26	-	198
Firesteel River	67	113	511
Misery River	49	1,771	374
Subtotal (West)	2,586	9,499	19,734
(w/traps)	1,038	9,499	7,921
(w/o traps)	1,548	-	11,813
EAST			
Traverse River	21	-	68
Sturgeon River	607	-	1,968
Falls River	61	-	198
Silver River	69	110	224
Slate River	19	-	62

SECONDARY STREAMS

Stream	Discharge CFS	Population Estimate Regression
WEST		
Washington Creek	29	22
Arrowhead River	347	265
Poplar River	45	34
Gooseberry River	3	2
Split Rock River	10	8
Sand River	11	8
Black River	97	74
Cranberry River	60	46
Potato River	36	27
Elm River	21	16
Salmon Trout River	44	34
Fish Creek	78	60
Poplar River	35	27
Subtotal (West)	816	623
EAST		
Big Gratiot River	12	4
Eliza Creek	1	0
Dead River	50	16
Sand River	16	5
Five Mile Creek	2	1

(continued)

Table 6. Continued.

PRIMARY STREAMS

Stream	Discharge CFS	Population Estimate Mark/Recapture	Population Estimate Regression
Ravine River	21	-	68
Huron River	109	132	353
Salmon Trout River	56	-	182
Iron River	99	-	321
Big Garlic River	15	26	49
Little Garlic River	11	-	36
Harlow Creek	20	-	65
Chocolay River	103	-	334
Rock River	33	1,518	107
Au Train River	107	-	347
Furnace Creek	6	-	19
Miners River	38	108	123
Sucker River	75	93	243
Two Hearted River	217	-	703
Little Two Hearted River	34	-	110
Betsy River	74	480	240
Tahquamenon River	659	2,103	2,136
Waiska River	54	-	175
Subtotal (East)	2,508	4,570	8,130
(w/traps)	1,192	4,570	3,864
(w/o traps)	1,316	-	4,266
PRIMARY LAKE TOTAL	5,094	14,069	27,863

SECONDARY STREAMS

Stream	Discharge CFS	Population Estimate Regression
Beaver Lake Outlet	17	6
Sable Creek	10	3
Galloway Creek	4	1
Pendills Creek	21	7
Laughing Whitefish River	25	8
Subtotal (East)	158	51
SECONDARY LAKE TOTAL	974	674

TOTAL SOUTH SHORE DISCHARGE: 6,068

TOTAL SO. SHORE POPULATION ESTIMATE: 28,538 the Keweenaw Peninsula. The total estimate of 28,538 sea lampreys was calculated using a combined flow of 6,068 cfs (3,402 cfs west and 2,666 cfs east) and compares with 27,545 sea lampreys estimated in 1991.

Canada

Two streams were trapped in Canadian waters (Table 5, Fig. 1). Catches of adults were 124 from the Carp River and 36 from Stokely Creek. The catch at the former is more in keeping with recent counts than the low of 18 taken last year, while that at the latter is the largest since the barrier and trap commenced operation in 1981.

Trap efficiency for the Carp River was 59.5%, while that for Stokely Creek was 58.3%. Population estimates, calculated with a modification to the Schaefer (stratified) Method, were 174 and 51, respectively.

The numbers do not reflect any substantive change in the spawning population running Batchawana Bay area streams.

Parasitic-phase Assessment

United States

A total of 144 parasitic-phase sea lampreys were collected from Lake Superior commercial fishermen in 1992 (Table 7) compared with 161 taken in 1991. The largest number of sea lampreys were collected from fishermen in management unit MI-6 (Munising, Michigan area), 45 in 1992 vs. 44 in 1991.

Fishermen from Wisconsin management unit WI-2 (Apostle Island area) captured 38 lampreys in 1992, a decrease from 73 taken in 1991. Fishermen in management units MI-7 (Grand Marais, Michigan area) and MI-8 (Whitefish Bay, Michigan area) collected similar numbers of sea lampreys, 30 in 1992 and 27 in 1991. Most lampreys were collected by fishermen using gill nets (77%), during April-June (62%), and primarily were attached to lake trout (62%) and lake whitefish (32%).

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 144 parasitic-phase sea lampreys captured in 1992 (94 would have spawned in 1992 and 50 in 1993). A total of 179 lampreys of the 1992 spawning year class have been collected (85 in 1991 and 94 in 1992) and represent an increase when compared to the number of 1991 spawning year class (122) captured by commercial fishermen.

Sport fishermen captured or reported 83 parasitic-phase sea lampreys in 1992 (Table 8), compared with 186 taken in 1991. Of the total, 57 were from the charterboat fishery and 26 were from noncharter fishermen. Fishermen from management unit MI-2 (Black River Harbor to Ontonagon, Michigan area) contributed the largest number of sea lampreys (22). Most lampreys were collected or reported by fishermen during June-August (75%), and primarily were attached to lake trout (91%).

Table 7. Number[1] of parasitic-phase sea lampreys collected in U.S. commercial fisheries in 1992 and year lampreys would have spawned[2].

Lake Superior			Lake Michigan			Lake Huron		
Unit	Spawning Year		Unit	Spawning Year		Unit	Spawning Year	
	1992	1993		1992	1993		1992	1993
MN-1	-	-	MM-1	54	51	MH-1	286	1,388
MN-2	2	0	MM-2	0	3	MH-2	0	103
MN-3	1	0	MM-3	2	16	MH-3	-	-
WI-1	0	1	MM-4	-	-	MH-4	5	52
WI-2	22	16	MM-5	4	9	MH-5	-	-
MI-1	-	-	MM-6	-	-	MH-6	-	-
MI-2	9	2	MM-7	0	41			
MI-3	0	2	MM-8	-	-			
MI-4	11	1	WM-1	-	-			
MI-5	1	1	WM-2	2	20			
MI-6	34	11	WM-3	4	36			
MI-7	12	0	WM-4	0	0			
MI-8	2	16	WM-5	-	-			
			WM-6	-	-			
			Ill.	-	-			
			Ind.	-	-			
Total	94	50		66	176		291	1,543

[1]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.

[2]A zero (0) indicates sampling effort with negative results and a dash (-) indicates no effort.

Table 8. Number[1] of parasitic-phase sea lampreys collected in sport fisheries in U.S. waters of the Upper Great Lakes in 1992[2].

Lake Superior			Lake Michigan			Lake Huron		
Unit	Charter	Noncharter	Unit	Charter	Noncharter	Unit	Charter	Noncharter
MN-1	2	7	MM-1	-	-	MH-1	92	58
MN-2	0	2	MM-2	-	-	MH-2	181	39
MN-3	1	0	MM-3	11	2	MH-3	166	146
WI-1	1	0	MM-4	4	0	MH-4	16	0
WI-2	1	7	MM-5	37	15	MH-5	140	27
MI-1	5	0	MM-6	45	9	MH-6	15	6
MI-2	22	0	MM-7	17	6			
MI-3	-	-	MM-8	109	1			
MI-4	-	-	WM-1	0	6			
MI-5	10	8	WM-2	5	3			
MI-6	12	2	WM-3	19	9			
MI-7	3	0	WM-4	21	4			
MI-8	-	-	WM-5	11	13			
			WM-6	18	6			
			Ill.	1	0			
			Ind.	-	-			
Total	57	26		298	74		610	276

[1]The Michigan and Wisconsin Departments of Natural Resources provided data on the occurrence of parasitic-phase sea lampreys in charterboat catches.

[2]A zero (0) indicates sampling effort with negative results and a dash (-) indicates no effort.

Presence of sea lampreys was reported by charterboat operators in 7 of the 8 management units of Michigan (Table 9; reported here courtesy of Michigan Department of Natural Resources). The operators reported 0.9 and 0.0 lampreys attached per 100 lake trout and chinook salmon respectively.

Barrier Dams

Canada

Minor maintenance, as required, was conducted on the barrier dam network on Lake Superior. Surveys and flow measurements were done at the site of the proposed experimental sea lamprey velocity barrier on the McIntyre River, in Thunder Bay, Ontario.

LAKE MICHIGAN

Larval Assessment

Surveys prepared for lampricide treatments, assessed the success of past treatments, and monitored reestablished populations of larval sea lampreys in 100 Lake Michigan tributaries. Surveys to schedule lampricide applications were conducted in 41 streams. Of these, 15 were successfully treated, 7 were scheduled for treatment in 1993, and the remaining 19 were deferred. Sea lamprey larvae that remained from past treatments were found in 8 streams, but comprised less than 5% of the total number of larvae collected in all streams. Moderate numbers of larvae were recovered from tributaries of the St. Joseph and Pere Marquette rivers and few were found in the remaining six streams. Larvae had reestablished in 47 of the streams that were surveyed.

Surveys to assess recruitment of the 1992 year class were conducted in 76 streams and young-of-the-year larvae were recovered in 31 streams. Young-of-the-year larvae have not been detected in 8 other streams with a history of reinfestation after lampricide treatments.

Lentic areas offshore of five rivers were examined for the presence of sea lampreys. A few larvae were collected off the mouths of the Boyne River and Porter Creek (Lake Charlevoix). No larvae were collected off the mouth of Bear Creek (Petoskey Harbor). Relatively large numbers of larvae were observed off the Boardman and Carp Lake rivers using a submersible camera and electroshocker.

The populations of larval sea lampreys were estimated in four tributaries of Lake Michigan through a random transects habitat-based technique (Table 10). The estimated populations were Deer Creek--25,824, Bear Creek--7,252, Gurney Creek--2,588, and Duck Creek--951.

Chemical Treatment

Lampricide treatments were completed on 18 streams during 1992 (Table 11, Fig. 2) with a combined discharge of 89.3 m^3/sec (3,153 ft^3/sec). Larval abundance was high in the Muskegon, Jordan, Ogontz and Platte rivers, and medium or low in the other streams. Mortality of nontarget fish was insignificant during all treatments. The Muskegon and Jordan rivers were treated with TFM combined with Bayer 73 wettable powder, and the remaining streams with TFM only.

Table 9. Incidence of sea lampreys and numbers of lake trout and chinook salmon taken by operators in the Michigan and Wisconsin charterboat fishery, 1992.[2]

[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[3] District[2]	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	621	0.0	0
MI-2	1.1	2,052	0.0	30
MI-3	0.0	88	0.0	1
MI-4	0.0	145	0.0	25
MI-5	0.5	1,960	0.0	17
MI-6	1.7	706	0.0	3
MI-7	1.9	162	0.0	0
All Units	0.9	5,734	0.0	76
Michigan				
MM-1	0.0	0	0.0	109
MM-3	0.9	871	2.3	129
MM-4	0.1	1,141	0.7	428
MM-5	1.1	2,882	0.1	5,144
MM-6	0.8	3,577	0.3	4,604
MM-7	0.4	3,495	0.1	2,290
MM-8	1.0	10,389	0.1	2,116
WM-2	0.0	25	0.2	2,482
WM-3	1.8	800	0.2	2,996
WM-4	0.5	3,826	0.1	3,631
WM-5	0.1	6,056	0.0	5,879
WM-6	0.3	5,897	0.0	1,231
Ill.	0.5	198	0.0	194
All Units	0.6	39,157	0.1	31,233
Huron				
MH-1	1.8	56	25.1	362
MH-2	7.5	186	17.4	959
MH-3	6.1	806	11.9	981
MH-4	1.1	187	14.9	94
MH-5	4.3	2,124	8.2	596
MH-6	0.0	7	5.0	302
All Units	4.7	3,366	13.8	3,294

[1]Lake trout and chinook salmon are the primary target species of the charter fishery of the Upper Great Lakes.

[2]The Michigan and Wisconsin Departments of Natural Resources provided data on the occurrence of parasitic phase sea lampreys in charterboat catches.

[3]Data were not obtained from units WI-1, W[illegible] MI-8, MM-2, WM-1 and Indiana

Table 10. The estimated amount of habitat (ft²) for sea lamprey larvae, density (larvae/ft²), total number of year classes in the population, total larvae and transformers in the population, number ≥120 mm, and number of transformers for 4 tributaries of Lake Michigan and 1 tributary of Lake Huron, 1992. (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 footnotes.

LAKE River	Method of Estimation	Area of Habitat Types[1] I	II	III	Density of Larvae[2] I	II	Year[3] Classes	Total Larvae[4] and transformers	Number[5] >120 mm	Number of[6] transformers
MICHIGAN										
Gurney Creek	Random transect[7]	11,165	11,571	6,293	.2318	0	5	2,588 (377-4,799)	11 (1-20)	-
Duck Creek	Random transect	168,987	216,146	7,860	.0056	0	4+	951 (12-2,027)	317 (4-676)	-
Bear Creek	Random transect	85,869	314,853	81,178	.0689	0	6	7,252 (2,796-11,708)	41 (16-66)	-
	Mark and recapture[8]							7,884 (3,186-12,582)	263 (106-420)	-
Deer Creek	Random transect	41,699	51,230	26,211	.4897	.1054	3	25,824 (17,506-34,144)	77 (4-102)	-
	Mark and recapture							34,299 (27,094-41,504)	630 (498-762)	11 (9-13)
HURON										
Big Salt River	Random transect	-	1,301,879	2,968,036	-	.0056	5+	7,308 (2,691-11,925)	665 (242-1,073)	233 (85-376)

[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 from the number taken in the sampling procedures.
[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 the modified Petersen formula where larvae are marked and released before a lampricide treatment and recaptured during the treatment.

Table 11. Details on the application of lampricides to streams of Lake Michigan, 19

(Lampricides used are in kilograms/pounds of active ingredient.)
[Letter in parentheses corresponds to location of stream in Fig 2.]

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[1] kg	TFM[1] lbs	Bayer 73 kg	Bayer 73 lbs	Distanc km	Distanc miles
Tacoosh R. (3)	May 8	0.4	16	89	196	-	-	6.4	4
Rapid R. (2)	May 9	2.1	75	443	976	-	-	41.8	26
Whitefish R. (4)									
Bills Cr.	May 12	0.8	30	29	64	-	-	9.7	6
Pole Creek	May 19	0.6	22	82	181	-	-	6.4	4
Haymeadow Cr.	May 20	1.1	40	81	179	-	-	11.3	7
Dexter Cr.	May 20	0.6	20	184	406	-	-	8.1	5
Mainstream	May 29	4.8	170	1,596	3,518	-	-	48.3	30
East Branch	Sept. 9	1.7	60	416	917	-	-	19.3	12
Kalamazoo R. (16)									
Sand Cr.	May 20	0.1	3	25	55	-	-	4.8	3
Bear Cr.	May 21	0.3	9	59	131	-	-	4.8	3
Trail Cr. (18)	May 30	1.8	63	511	1,126	-	-	24.0	15
Ogontz R. (5)	June 12	0.2	6	34	75	-	-	14.5	9
Platte R. (13)									
Lower	June 24	4.0	140	1,201	2,647	-	-	4.8	3
Middle	July 10	4.0	140	855	1,885	-	-	1.6	1
Upper	July 12	6.5	230	1,372	3,025	-	-	14.5	9
Hog Island Cr. (9)	June 27	0.1	1	10	23	-	-	3.2	2
Millicoquins R. (8)									
Furlong Cr.	June 28	0.3	12	59	129	-	-	11.3	7
Swan Cr. (7)	July 25	0.1	1	3	7	-	-	1.6	1
Pentwater R. (14)									
North Branch	July 26	1.5	55	383	844	-	-	37.0	23
Lit. Fishdam R. (6)	July 26	0.1	3	11	25	-	-	4.8	3
Porter Cr. (11)	Aug. 8	0.1	5	42	93	-	-	1.6	1
Jordan R. (12)	Aug. 9	5.4	190	1,743	3,843	8.2	18	27.4	17
Carp Lake R. (10)									
Lower	Aug. 19	0.1	4	39	86	-	-	3.2	2
Muskegon R. (15)									
Mainstream	Sept. 2	39.6	1,400	7,237	15,954	48.5	107	77.3	48
St. Joseph R. (17)									
Mill Cr.	Sept. 13	0.9	32	261	576	-	-	16.1	10
Brush Cr.	Sept. 15	0.5	18	116	256	-	-	8.1	5
Brandywine Cr.	Sept. 26	0.6	20	92	203	-	-	11.3	7
Paw Paw R.	Oct. 9	10.2	360	3,849	8,486	-	-	98.2	61
Bark R. (1)	Oct. 2	0.8	28	173	382	-	-	14.5	9
Total		89.3	3,153	20,996	46,288	56.7	125	535.9	333

[1]Includes a total of 368 TFM bars (71.8 kg, 158.2 lbs.) applied during 8 treatments.

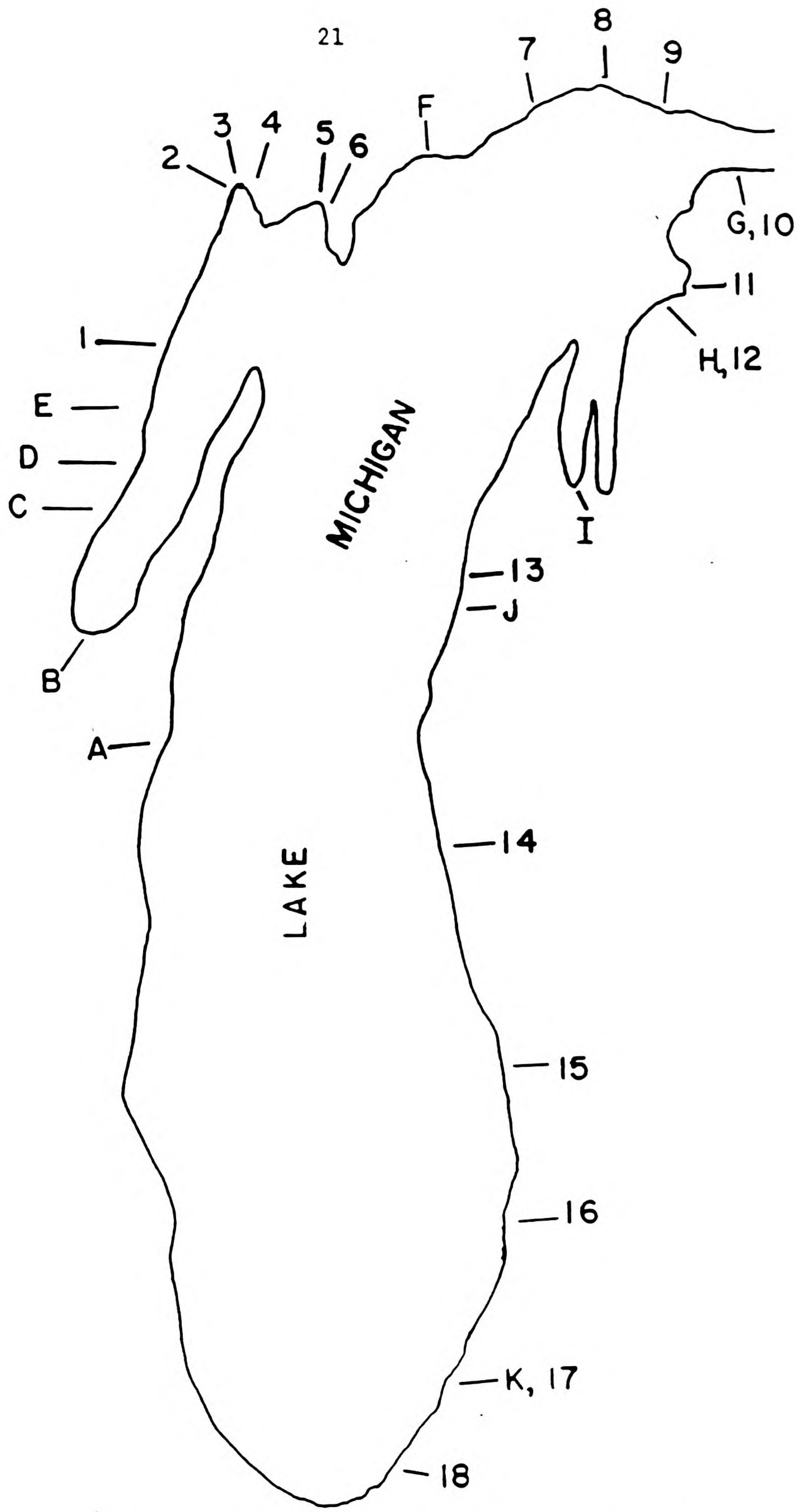

Fig. 2. Location of Lake Michigan tributaries treated with lampricides (numerals; see Table 11 for names of streams), and of streams where assessment traps were fished (letters; see Table 12 for names of streams) in 1992.

Treatments of the Platte and Paw Paw rivers were planned to include Bayer 73, but a shortage of the lampricide early in the season prevented its use on the Platte River and low water temperatures precluded its use on the Paw Paw River.

Minimum lethal concentrations (MLC) of TFM required to kill the lampreys were derived by averaging the MLC predicted by the pH/alkalinity table and the alkalinity table. Caged sea lamprey larvae were placed in many streams to test treatment effectiveness. All treatments were successful. Additionally, the effectiveness of the MLC predicted from the pH/alkalinity table only was examined during treatment of six rivers. These predicted values generally are lower than those indicated on the alkalinity table. The studies showed treatments based on the table were effective in these 6 rivers, a predicted MLC derived from the average of the 2 tables is more applicable to most stream treatments because of daily variations in pH in most streams.

Water levels caused difficulty in lampricide treatment of many Lake Michigan tributaries. Rainfall during the treatment delayed or increased the work on the upper Platte River and two tributaries to the Paw Paw River. A prediction of rain caused an unplanned release of water at the Croton Dam on the Muskegon River five hours after the TFM application had been completed. This surge of water overtook and diluted part of the block of lampricide, but adequate lethal concentrations were maintained to the downstream limit of sea lamprey distribution. The lack of rain resulted in record low stream flows during the treatments of Hog Island Creek, Ogontz and Whitefish rivers. The Paw Paw River required 4 separate treatments over a 6-week period. This effort could be reduced to 1 treatment in a 5-day work period with the restoration of the dam in Watervliet.

Spawning-phase Assessment

United States

A total of 20,590 sea lampreys were captured in assessment traps placed in 6 west shore and 5 east shore tributaries of Lake Michigan in 1992 (Table 12), 4,847 more than captured in 1991 (15,743). The percentage of males (44%) decreased from 1991 to 1992 and the average length and weight of male lampreys (483 mm, 253 g) and female lampreys (488 mm, 273 g) from Lake Michigan tributaries increased.

Along the west shore, catches increased in the East Twin, Oconto and Manistique rivers (18,575, largest recorded catch for river), remained the same in the Fox River, and decreased in the Peshtigo and Menominee rivers. The number of spawning-phase sea lampreys was estimated in the Manistique River for the eighth year (24,523 in 1992 vs. 22,092 in 1991).

The total catch of sea lampreys increased in all streams along the east shore of Lake Michigan. The increase in the Boardman River, from 28 in 1991 to 171 in 1992, may be attributed to a modification in trap placement. The Jordan River, previously monitored through a cooperative agreement with the Michigan Department of Natural Resources, was not trapped in 1992 due to budget and personnel constraints of the Department.

Table 12. **Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1992.**

(Letter in parentheses corresponds to location of stream in Fig. 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 River (A)	69	69	39	458	469	229	238
Fox River (B)	1	1	0	-	600	-	505
Oconto River (C)	33	33	42	498	506	289	312
Peshtigo River (D)	247	246	74	501	512	262	304
Menominee River (E)	77	77	49	481	475	251	281
Manistique River (F)	18,575	0	-	-	-	-	-
East Shore							
Carp Lake River (G)	171	0	-	-	-	-	-
Jordan River							
Deer Creek (H)	92	92	36	506	509	297	298
Boardman River (I)	171	171	40	469	476	243	249
Betsie River (J)	642	642	46	478	480	248	262
St. Joseph River (K)	512	-	-	-	-	-	-
Total or average	20,590	1,331	44	483	488	253	273

Parasitic-phase Assessment

Lake Michigan commercial fishemen captured 242 parasitic-phase sea lampreys in 1992 (Table 7), compared with 341 in 1991. Of the total, 115 were collected from Lake Michigan and 127 from Green Bay, compared with 81 and 260 respectively in 1991. The largest number of sea lampreys were collected from fishermen in the Michigan management unit of MM-1 (Menominee-Gladstone-Fairport, Michigan area), a decrease from the number taken in 1991 (192 in 1991 vs. 105 in 1992). Most lampreys were collected by trapnet fishermen (77%), during June-August (58%), and primarily were attached to lake trout (44%) and lake whitefish (40%).

Spawning year was determined for the 242 parasitic-phase sea lampreys. Of these, 66 would have spawned in 1992 and 176 in 1993. A total of 336 of the 1992 spawning year class have been collected (270 in 1991 and 66 in 1992) and represent an increase when compared to the number of the 1991 spawning year class (223) captured by commercial fishermen.

A total of 372 sea lampreys were collected or reported from the Lake Michigan sport fishery in 1992 (Table 8), compared with 631 taken in 1991. Of the total, 298 were from the charterboat fishery and 74 were from noncharter fishermen. The management unit which contributed the largest number of sea lampreys was MM-8 (Holland to New Buffalo, Michigan area), 110 in 1992 vs. 198 in 1991. Most lampreys were collected or reported by fishermen during May-August (92%), and primarily were attached to lake trout (78%).

Information on the incidence of sea lampreys was reported by the charterboat fisheries for 13 of the 16 management units (Table 9; reported here courtesy of Michigan and Wisconsin Departments of Natural Resources and Illinois Department of Conservation). Fishermen reported 0.6 and 0.1 lampreys attached per 100 lake trout and chinook salmon respectively.

LAKE HURON

Larval Assessment

United States

Surveys prepared for lampricide treatments, assessed the success of past treatments, monitored reestablished populations of larval sea lampreys, and searched for new infestations of larvae in 43 Lake Huron tributaries. Surveys to schedule lampricide applications were conducted in 16 streams. Of these, 2 were successfully treated, 10 were scheduled for treatment in 1993, and the remaining 4 were deferred. Sea lamprey larvae that remained from past treatments were found in 6 streams, but comprised less than 5% of the total number of larvae collected in all streams. Moderate numbers of residual lamprey larvae were recovered from the Au Sable River. Larvae had reestablished in 31 of the streams that were surveyed.

Surveys to assess recruitment of the 1992 year class were conducted in 40 streams and young-of-the-year larvae were recovered in 14. No annual surveys were conducted to monitor annual recruitment of larval sea lampreys in the St. Marys River because effort was reprogrammed to a pilot study for a high priority element identified in the document Strategy for Control of Sea Lampreys in the St. Marys River, 1992-1995.

At the direction of the Sea Lamprey Integration Committee and the St. Marys River Control Task Group, a pilot study was conducted to determine the feasibility of development of a map of density of sea lamprey larvae in the St. Marys River. The work used deepwater electroshockers from two pontoon boats and each boat used either a LORAN or geographic positioning system (GPS) to locate geographic position. Work was confined to upper Lake Nicolet where 339 samples were taken in an area of about 750 ha using a random transect method of sampling. An average of 26 samples (range 21-31) was collected daily from each boat and information was electronically recorded (datalogged) on a portable computer. Data collected from the pilot study were entered into a geographic information system (GIS) and plotted on a contoured basemap. Results of the program showed that the 1992 effort was insufficient to support contouring to map larval densities. The pilot study provided the necessary information to implement sampling at a higher intensity in 1993.

A submersible camera and electrofisher probed lentic areas off the Cheboygan River and Mill Creek. A total of 17 unidentified lampreys were observed offshore of the Cheboygan River, and no lampreys were observed offshore of Mill Creek.

The population of sea lamprey larvae was estimated in the Big Salt River (Saginaw River). An estimated 7,308 sea lamprey larvae and 233 transformers were present in the mainstream and one tributary (Table 10).

Canada

Surveys were conducted on 93 Lake Huron tributaries in preparation for chemical treatments, to monitor reestablished, residual and untreated populations, to evaluate barrier dams and to look for new infestations of larval sea lampreys.

Distribution surveys were completed on seven streams tentatively scheduled for treatment in 1993. There was no significant change in distribution in the Serpent, Mindemoya, Koshkawong, Magnetawan and Lauzon rivers and Timber Bay Creek. The Nottawasaga River (not treated since 1976) requires additional work to determine which reaches require treatment. At present, 4 tributaries and the main branch, totalling about 132 km, are infested. Paradoxically, the Mad River, the tributary system that produced the bulk of the larval sea lamprey in the past, is not presently infested.

Treatment evaluation surveys done on the four Lake Huron tributaries treated in 1991 found a small number of residual sea lamprey larvae in the Mississagi, Upper Thessalon, and Pine rivers and none in the Boyne River. All four streams were found to have reestablished with the 1991 year class of larvae.

Reestablishment surveys done on 10 other streams last treated prior to 1991 were positive for Blind and Manitou rivers, Richardson, Watson and Silver creeks and negative for Bar, Two Tree and Chikanishing rivers and Hog and Lafontaine creeks.

Routine surveys of 56 streams with no history of sea lamprey production were all negative.

Low-head barrier dams on the Echo, Koshkawong, Still and Sturgeon rivers were effective at blocking the 1991 run of adult lampreys. Successful spawning did however occur downstream of the dams in all four rivers.

The current Echo River barrier built in 1986, and its predecessor built in 1971, have been inconsistent in preventing spawning in the upper reaches of this fairly complicated river system. The reasons for this failure are not conclusive, but are thought to have been due to holes through or around the barrier. It has also been speculated, but not demonstrated, that sea lamprey might be completing their life cycle within the river and lake system above the barrier. Parasitic lamprey had been observed feeding on northern pike in Solar Lake in 1969 and have access to a larger and deeper Stuart Lake.

Despite several lampricide treatments of the Echo River above the barrier, the latest being in 1990, and treatments of Solar Lake using granular Bayer (1971) and TFM (1973), a significant residual larval population persists, particularly in Solar Lake. Solar Lake is a small (31.6 ha) relatively shallow (7.9 m maximum) instream lake located about 17 km upstream of the Echo River barrier dam.

In June 1992, large numbers of parasitic lampreys were again documented in Solar Lake feeding on northern pike. Eighty-five percent of fish caught by angling (32) had feeding sea lamprey attached. However by late August, lamprey predation seemed to have ceased when none of 15 pike angled had lamprey attached or bore fresh wounds. Eighty percent of these fish were however, scarred. The fate of the parasitic lamprey in 1992 is unknown, although the stomachs of some of the pike caught in 1969 did contain lamprey remains. Almost all of the pike caught in 1992 were released alive.

With the dam apparently an effective barrier since 1991, surveys are scheduled for above Solar and Stuart lakes in 1993 to look for larvae of the 1991 or 1992 year classes that might have come from a resident population of sea lamprey. Improvement to the barrier dam in early 1993 will hopefully ensure its status as a barrier to spawning-phase sea lamprey.

Chemical Treatment

United States

Lampricide treatments were completed on 5 streams during 1992 (Table 13, Fig. 3) with a combined discharge of 4.6 m^3/sec (164 ft^3/sec). Larval abundance was high in Black Mallard and Silver creeks (Tawas Lake Outlet), and lower in the remainder of treated streams. Mortality of nontarget fish species was insignificant for all treatments, but some burrowing mayflies died during treatment of Silver Creek. The Maple River was treated with TFM and Bayer 73 wettable powder, the other rivers with TFM.

Minimum lethal concentrations (MLC) required to kill sea lampreys were derived by averaging the MLC predicted by the pH/alkalinity table and the alkalinity table. Six toxicity tests during treatments also aided in determining treatment concentrations. Caged sea lampreys were placed in streams to test effectiveness of treatments. All treatments were successful.

Treatments of Black Mallard and Green creeks were complicated by numerous beaver impoundments. Both treatments required additional applications to stream segments flowing into these impoundments. The Black Mallard Creek treatment had been postponed in 1990 due to a research study and in 1991 because of low water. The application point on Cold Creek was placed 1 1/2 miles below the limit of sea lamprey distribution to avoid treating through a densely populated trout farm. Treatment of the Trout River was deferred because of low water.

Canada

Five streams tributary to the North Channel were treated with lampricide in 1992 (Table 13, Fig. 3). Treatment of the Naiscoot River, a Georgian Bay tributary, was deferred due to low discharge. In the French River, lampricide was applied only to a short reach of the multi-channelled lower system, in an effort to control a small localized population of sea lamprey larvae.

All treatments provided satisfactory levels of ammocoete mortality with minimal impacts on nontarget organisms.

Table 13. **Details on the application of lampricides to streams of Lake Huron,** 1992
[**Lampricides used are in kilograms/pounds of active ingredient.**]
(**Number in parentheses corresponds to location of stream in Fig.** 3.)

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[1] kg	TFM[1] lbs	Bayer 73 kg	Bayer 73 lbs	Distanc km	Distanc mile
UNITED STATES									
Black Mallard Cr. (2)	May 9	1.1	41	116	255	-	-	9.6	6
Green Cr. (3)	May 9	0.2	8	18	39	-	-	3.2	2
Tawas Lake Outlet (1)									
Cold Cr.	June 13	0.2	6	30	65	-	-	3.2	2
Silver Cr.	June 15	1.0	35	239	526	-	-	8.0	5
Elliot Cr. (4)	July 10	0.3	9	51	113	-	-	3.2	2
Cheboygan R. (5)									
Maple R.	Aug. 20	1.8	65	349	769	2.4	5.2	12.8	8
Total		4.6	164	802	1,767	2.4	5.2	40.0	25
CANADA									
Gordon Cr. (8)	June 11	0.1	2	6	13	-	-	1.2	1
Thessalon R. (9)	June 22	4.9	171	523	1,153	-	-	29.6	18
French R. (10)	June 24			46	101	-	-	1.0	1
Root R. (6)	July 7	3.4	120	169	373	-	-	38.6	24
Brown's Cr. (7)	Sept. 29	0.4	13	38	84	-	-	2.6	2
Total		8.8	306	782	1,724	-	-	74.0	46
GRAND TOTAL		13.4	470	1,584	3,491	2.4	5.2	114.0	71

[1]Includes 5 bars applied (1 kg, 2.2 lbs) in 1 stream.

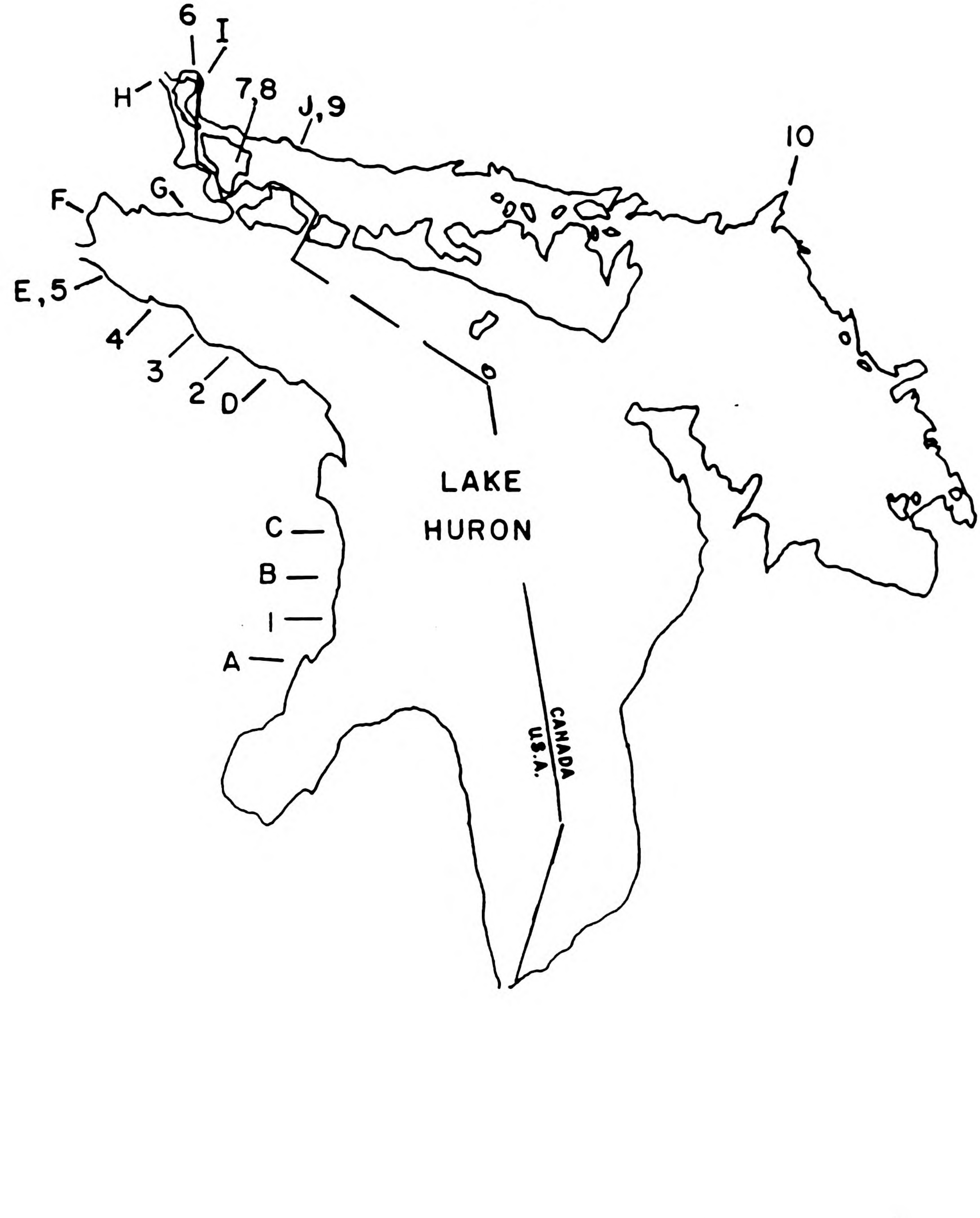

Fig. 3. Location of Lake Huron tributaries treated with lampricides (numerals; see Table 13 for names of streams), and of streams where assessment traps were fished (letters; see Table 14 for names of streams) in 1992.

Spawning-phase Assessment

United States

During the 1992 spawning season, 42,097 sea lampreys were captured in assessment traps placed in 8 tributaries of Lake Huron (Table 14, Fig. 3) compared to 24,863 in 1991. A record number of lampreys captured in the Cheboygan River accounted for 86% (36,047) of the total catch. An estimated 51,477 sea lampreys comprised the spawning run in the Cheboygan River in 1992 compared to 29,452 in 1991. The Carp River had a total of 4 nets set at 3 locations and captured 1,352 sea lampreys (operated through a cooperative agreement with the Chippewa/Ottawa Treaty Fishery Management Authority). The 1992 estimated population for the Carp River was 12,969 compared to 6,477 in 1991. A population estimate conducted in the St. Marys River shows a decrease in the number of lampreys in 1992 compared to 1991 (19,508 vs. 35,582). A mark/recapture study on the Au Sable River estimated the sea lamprey population at 1,849. The percentage of males in Lake Huron tributaries increased from 41% in 1991 to 53% in 1992 (sample size 2,052). The average length and weight of male sea lampreys (463 mm, 213 g) sampled from Lake Huron tributaries increased, and the average length and weight of female sea lampreys (468 mm, 228 g) decreased.

Canada

Three streams, the St. Marys, Echo and Thessalon rivers, were trapped in 1992, capturing 8,475 spawning-phase adults (Table 14, Fig. 3). The Koshkawong and Still rivers, trapped in previous years, were not monitored in 1992. Most of the males from the three streams were dedicated to the sterile male programme.

The catch of only 6,416 adults in the St. Marys River is considerably down from the 13,523 caught in 1991. Because of the very cool weather throughout the spring and summer, the catches in the St. Marys were slow to begin and were very drawn out in time. No mark-recapture study was undertaken in 1992, but the U.S. Fish and Wildlife Service (USFWS) estimated a resident population of 19,508 from a 5-year regression, down substantially from last year's high. Percent males, at 58% (determined by external examination), when blended with results from the USFWS traps, remained similar to recent years.

Biological sampling was conducted on both the Echo and Thessalon river catches this year. Percent males, at 49% and 61% respectively, were virtually unchanged from last year, although determined in somewhat different fashion. A population estimate of the Echo River run was 2,463, with a trap efficiency at the dam of 36%. On the Thessalon River, its principal tributary, Bridgeland Creek, had a run estimated at 3,074 spawners, but the study broke down on the main stem because of insufficient recaptures.

In support of a mark-recapture study investigating the value of coded-wire tagging (CWT) and the prospects that sea lamprey home to their natal stream (555 transformers were released from the Devil River, Michigan, in fall 1990), 792 specimens were screened from the Echo/Thessalon river operations. One CWT recapture was found. All 6,416 adults captured at the Canadian St. Marys River traps were screened, as were 1,149 from the U.S. traps. Seven CWT animals were recaptured in the Canadian traps and none in the U.S. traps.

Table 14. **Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1992.**
(Letter in parentheses corresponds to location of stream in Fig. 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							
St. Marys R. (H)	1,149	1,144	60	-	-	-	-
East Au Gres R. (A)	360	360	44	459	460	206	207
Au Sable R. (B)	329	78	67	461	450	225	221
Devils Cr. (C)	46	46	35	463	463	200	222
Ocqueoc R. (D)	2,771	0	-	-	-	-	-
Cheboygan R. (E)	36,047	0	-	-	-	-	-
Carp R. (F)	1,352	381	41	470	484	217	247
Albany Cr. (G)	43	43	37	445	431	224	234
Total or average	42,097	2,052	53	463	468	213	228
CANADA							
St. Marys R. (H)	6,416	0	58[1]				
Echo R. (I)	1,176	122	49	480	477	239	248
Thessalon R. (J)	883	101	61	504	516	259	293
Total or average	8,475	223	53	492	492	249	265
GRAND TOTAL	50,572	2,275	53	470	473	222	234

[1]Percent males determined by examination of secondary external sexual characteristics. Data not included in Canada Total or average nor in Grand Total.

Spawning Ground Studies

Spawning ground surveys in the International Rapids continued for the sixth consecutive year. Adult sightings and nesting activities and success rates were documented. These studies were augmented this year by underwater camera and SCUBA operations in other areas of the Sault Basin. This was a joint venture of the U.S. Fish and Wildlife Service and the Department of Fisheries and Oceans, and utilized the Scamp II submersible from Ludington and the Marquette dive team.

The camera work improved our understanding of the varieties of habitat and of larval populations along the channel margins, and obtained some valuable video sequences of adults engaged in nest building/spawning. The dive team was more successful at operating in the main current and broadened our knowledge of general habitat and spawning locations in these areas.

Parasitic-phase Assessment

United States

A total of 1,834 parasitic-phase sea lampreys were collected by commercial fishermen in the U.S. waters of Lake Huron in 1992 (Table 7), compared with 1,317 taken in 1991. Fishermen from management unit MH-1 (Detour-Rogers City, Michigan area) contributed the largest number of sea lampreys (1,674), an increase from the number taken in 1991 (1,032). 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) decreased from 126 and 159 respectively in 1991, to 103 and 57 respectively in 1992. Most lampreys were collected by trapnet fishermen (57%), during August (37%) and December-Janaury (40%), and the lampreys primarily were attached to lake whitefish (50%), and salmon species (39%).

Spawning year was determined for the 1,834 parasitic-phase sea lampreys. Of these, 291 would have spawned in 1992, and 1,543 in 1993. A total of 1,522 of the 1992 spawning year class have been collected (1,231 in 1991 and 291 in 1992), and represent an increase when compared to the number of the 1991 spawning year class (1,212) captured by commercial fishermen.

Sport fishermen on the U.S. side of Lake Huron captured or reported 886 parasitic-phase sea lampreys (610 from charter and 276 from noncharter fishermen) in 1992 (Table 8), compared with 1,857 taken in 1991. (Numbers of sea lampreys are not comparable for the noncharter fishermen, as half of the collection sites were not set up until August.) Fishermen from management unit MH-3 (Harrisville to Oscoda, Michigan area) contributed the largest number of sea lampreys, 312 in 1992 vs. 554 in 1991. Most lampreys were collected or reported by fishermen during July-August (81%) and primarily were attached to chinook salmon (77%).

Occurrence of sea lampreys on fish was reported by charterboat operators in all six management units (Table 9; reported here courtesy of Michigan Department of Natural Resources). The operators reported 4.7 and 13.8 lampreys attached per 100 lake trout and chinook salmon, respectively, a decrease from 5.7 and 14.0 in 1991. The northern management units of MH-1, MH-2, MH-3 and MH-4 reported the largest number of lampreys per 100 chinook salmon (16.2) as compared to the southern management units of MH-5 and MH-6 (7.1)

Canada

Commercial Fisheries

Collections for calendar year 1992 have been received from nearly all cooperating fisheries. For northern Lake Huron and the North Channel, counts to date stand at 2,824 (1,959 from North Channel, 863 from the main basin, and 2 from Georgian Bay). Submissions this year are more than double last year's, and well exceed the 1989 record for collections for the last two decades. The trend is best depicted by the submissions from our long-term cooperators.

Sport Fisheries

The Stroh's Salmon Derby out of Sault Ste. Marie, Michigan, was monitored for the eighth consecutive year. From August 29 to September 12, weigh station officials sampled 286 chinook salmon. Seasonal (A1-A3) wounding rates of 19.9 percent wounded and 33.2 wounds per hundred fish were measured. The first index rate is down from last year's, while the second is only slightly up, which does not support a change in activity in keeping with that suggested by the commercial fishery findings.

Barrier Dams

Significant repairs and modifications were completed on the Echo River lowhead dam. New piling sections were added to the existing wings and considerable "landscaping" of the site was conducted. The old dam immediately upstream of the newer structure is to be removed in the early winter of 1993.

Minor maintenance, as required, was conducted on the remainder of the Lake Huron dam network.

A study of sea lamprey swimming performance was carried out at the Centre using a 30 m long flume and water pumped from the St. Marys River. Tests were done throughout a range of water velocities (0.7-1.6 m/s) and temperatures (9.5-17°C) with a total of 312 spawning-phase sea lamprey. Several different non-attachable materials were tested. The swimming performance information will be utilized in the development of a velocity barrier to adult spawning sea lamprey.

St. Marys River

The Control Agents of the Great Lakes Fishery Commission have been monitoring and acting on the issue of sea lampreys in the St. Marys River for almost 30 years. The recent development of Fish Community Objectives, Lake Trout Rehabilitation Plans, State of the Lake Reports, and Lake Fishery Management Plans by Commission cooperators has heightened awareness of the issue of sea lampreys in the St. Marys River throughout the Great Lakes community. Lake trout rehabilitation goals in Lake Huron are not being met and predation by sea lampreys is a primary factor in this continuing failure. The Lake Huron Technical Committee has recommended a 75% reduction in sea lamprey abundance in Lake Huron by 2000 and a 90% reduction by 2010. The best information of the Commission's Agents and cooperators points toward the St. Marys River as the source of these sea lampreys.

- There are more parasitic sea lampreys in Lake Huron than the other four Great Lakes combined. The northern area of the lake contained an estimated 250,000 in 1982, and current assessments show as many or more lampreys in 1992.

- Few lake trout survive to maturity in Lake Huron. Annual mortality currently exceeds 70% in the northern part of the lake.

- Wounding rates on lake trout in Lake Huron are about 25 A1-A3 marks per 100 fish. Data from Lake Ontario show rehabilitation of lake trout cannot occur when marks exceed 10 per 100 fish.

- Parasitic lampreys are attached to 1 of 5 chinook salmon in Michigan waters of Lake Huron. Fewer than 1 of 100 chinook salmon host lampreys in the other Great Lakes.

- An estimated 6.8M larvae (age 2 years and older) existed in the St. Marys River (1984); current assessment indicates a similar population.

- Rate of transformation of this larval population into parasitic adults is estimated at 4% annually (1988).

- The Agents control sea lampreys in tributaries of Lake Huron (excluding the St. Marys River), and assessments show the level of control in these streams is comparable to that found in the other Great Lakes.

The Sea Lamprey Integration Committee (SLIC) recognized the significance of the sea lamprey problem in Lake Huron and at its October 21-23, 1991 meeting directed the Agents to form a St. Marys River Control Task Group to recommend management actions for the Commission. The assigned objectives of the Task Group were to: 1) identify control options, 2) predict the effectiveness and costs of the control options, and 3) identify information needs required to assess the control options prior to and after implementation.

The Task Group held meetings on January 14-15 and March 12, 1992 to formulate a strategy. The removal of lampreys by trapping, barriers, sterile male release, traditional chemical control, and other techniques were discussed as integrated control options. The strategy was approved by SLIC at the April 8 meeting in Detroit, Michigan, and accepted in principle by the Commission at the May 5-6 Annual Meeting in Washington, D.C.

The strategy proposes integrated sea lamprey control actions that use a progressively increasing combination of proven and experimental techniques. These techniques focus on actions that: 1) achieve reduction in reproductive potential of spawning adult lampreys through the use of several options, and 2) develop information to predict effectiveness and costs of various lampricide treatment options. The strategy outlines a schedule of implementation for 1992-95.

Theoretically, some measure of lamprey control is now being achieved. Removal of adult lampreys by trapping is being coupled with the sterilization and release of the captured male lampreys. While it is estimated that these combined actions reduce the reproductive capability of the adult lamprey population by 65%, trapping remains unproven as a control technique and the introduction of sterile males is experimental at present. Both techniques require a comprehensive assessment as to their effectiveness, however funding is currently limited for this effort. Without evaluation, successful control relying solely on these techniques is uncertain. Accepting that trapping is contributing to control, improvements at the current trapping site below the Great Lakes Power (GLP) hydroelectric facility, Sault Ste. Marie, Ontario, and the construction of a new lamprey barrier and trap below the lower St. Marys Rapids would enhance present effectiveness. This, coupled with an increase in the number of sterilized males introduced into the river to produce higher rates of sterile-to-normal males, could theoretically reduce reproductive capability to as high as 90%. A barrier below the St. Marys Rapids could also prevent spawning and parasitic phase adults from gaining access to the Rapids and Lake Superior through the compensating works.

The effectiveness of a conventional TFM treatment of the entire St. Marys River to control larval lampreys is unknown. Certainly the complexity and costs of a TFM treatment of the river would far exceed that of any past treatment conducted by the Control Agents. More investigations about the population of larvae and flow patterns of the river are required to predict theoretical treatment effectiveness throughout the system. Some portions of the river infested by larvae may need to be handled by different types of lampricides and/or application techniques. Some portions of the river may be effectively treated with a bottom toxicant. Further development and registration of an effective treatment formulation of Bayer 73 is of high need. The concurrent actions of treatment modelling and quantitative estimates of the larval population will produce data necessary to analyze treatment costs and effectiveness. Maps would be produced that present the predicted varying levels of effectiveness of lampricides and of the estimated spatial distribution of larvae. By overlaying these maps, the Commission would have the capability to fix costs towards control (in segments) of the larval population.

Implementation of the strategy began following the Annual Meeting of the Commission. Task Group meetings were held on August 4-5 and September 30 to review progress and recommend actions to fulfill the schedule for 1992. The Task Group Chairman reviewed progress for Commissioners and several high-level members of the U.S. Army Corps of Engineers at the Commission's Annual "Think Tank Meeting" in Sault Ste. Marie, Ontario, on October 7.

The following outlines progress and actions on the strategy schedule for 1992:

1. Trap adult lampreys and introduce sterilized males for theoretical 65% reduction of reproductive potential.

   - Captured 7,565 spawning-phase sea lampreys in traps (Table 14)
   - Released 4,508 sterilized male lampreys (p. 51)
   - Combined removal by traps and release of sterilized males resulted in theoretical reduction in reproductive potential of 63% (p. 51)
   - Predicted ratio of sterile:normal male lampreys was 0.6:1 and observed ratio was 0.3:1 (p. 55)

2. Continue present larval index studies.

   - Examined six index stations in Canada that indicated stable population
   - Reprogrammed index assessments in U.S. to higher priority pilot study (see Item 6, p. 37)

3. Design and solicit funds for enhanced trap at GLP facility.

   - Commission authorized $10,000 for design at December Interim Meeting
   - Great Lakes Power Company agreed to cooperate in design, siting, and construction of trap

4. Introduce concept of lamprey barrier in St. Marys River rapids to Commission's Sea Lamprey Barrier Task Force and conduct preliminary cost estimate. Solicit aid from the U. S. Corps of Engineers to estimate costs and potential design.

   - Corps of Engineers prepared draft proposal
   - Estimated $250,000 to prepare feasibility study including Environmental Impact Statement
   - Agents participated in review of proposal and provided concepts for barrier and trap design
   - Estimated $1,000,000 to construct barrier

5. Conduct small scale trial with divers to observe/collect adults attached to GLP walls.

   o Commercial divers observed lampreys attached to walls

   o No lampreys were collected

6. Conduct pilot study for quantitative spatial estimate of larvae that includes distribution, abundance, and age structure. This study will primarily utilize deep-water electrofishers and associated technology.

   o Conducted pilot study in August (p. 25)

   o Surveyed 750 hectares

   o Used GIS technology

   o Agents directed by Commission at December Interim Meeting to reprogram $200,000 in FY93 to conduct quantitative spatial estimate

   o Scheduled workshop including 5 outside experts in GIS and statistical analysis for January 20-22, 1993 to design procedure

7. Examine nesting sites.

   o Spawning ground observations continued for sixth consecutive year (p. 32)

   o SCUBA divers and submersible mobile camera increased Agent knowledge of lamprey nesting activities

8. Consult technical experts on potential of flow/velocity model.

   o Consulted with Dr. Hung Tao Shen, Department of Civil and Environmental Engineering of Clarkson University. Dr. Shen originally designed a model of a hypothetical oil spill in the St. Marys River for the U.S. Army Corps of Engineers

   o Dr. Shen states model can be modified to simulate movements of TFM

   o Estimated cost at $20,000.

9. Continue to conduct research necessary for support of registration of bottom release formulation of Bayer as a treatment tool.

   o Research to support registration continuing at National Fishery Research Center, La Crosse, Wisconsin

10. Begin process to secure additional funds for short-term information needs (i.e., dye study, assessments).

   o Included in enhanced budget proposals for FY94 and FY95

11. Contact potential suppliers to determine methods of bulk shipping of TFM.

    o No action taken

12. Review information on target and nontarget species, including past toxicity data.

    o No action taken

13. Inform and secure support of Commission cooperators, various associated agencies, and private concerns for lamprey control strategy for St. Marys River.

    o Process continuing

LAKE ERIE

Larval Assessment

United States

Surveys prepared for lampricide treatments and searched for new infestations of larvae in 10 Lake Erie tributaries. Surveys to schedule lampricide applications were conducted in five streams. Of these, four were deferred indefinitely and Cattaraugus Creek will be reexamined in 1993. Access permission was denied in 1992 for a key tributary, Clear Creek, and survey of the tributary is essential prior to the schedule of a lampricide treatment. Original surveys to search for new infestations were conducted in the Clinton River and few larvae were found.

Surveys to assess recruitment of the 1992 year class were conducted in 9 streams and young-of-the-year larvae were recovered in 4. Young-of-the-year larvae have not been detected for 5 or more years in 2 streams that have been examined annually.

The Michigan Department of Natural Resources is planning to install a fish ladder in a dam on the Huron River (presently a barrier to sea lampreys). The area upstream of the dam to the next barrier (10 miles) was inspected for potential spawning sites and larval habitat. Spawning sites were abundant but larval habitat appeared marginal.

Canada

Surveys were conducted on 8 Lake Erie and 2 Lake St. Clair tributaries to monitor re-established, residual and untreated populations of larval sea lampreys and to evaluate barrier dams.

Treatment evaluation surveys done on the three streams treated in 1991, Big Otter, Clear and Young's creeks, found no residual larvae. Young's and Big Otter creeks have reestablished with the 1991 year class of larvae, whereas Clear Creek has not. Five other small tributaries, last treated prior to 1991, East, South Otter, Forestville, Normandale and Fishers creeks have not reestablished. A single sea lamprey larva collected from Fishers Creek is thought to be a residual from the 1987 treatment.

Barrier dams on Little Otter (tributary to Big Otter), Clear, Forestville and Normandale creeks all appear to have been effective at blocking the 1991 spawning run.

A survey of Komoka Creek, a small tributary to the Thames River, in which larval sea lamprey were first found in 1988, was negative this year. It appears that the one or two year classes present in 1988 and 1989 have matured and left.

The Canadian waters of the St. Clair River were surveyed for the first time in July 1992. Thirty-two individual plots totalling 3.67 ha were surveyed using granular Bayer. Fifty-five sea lamprey larvae were collected from 15 positive sites suggesting a low density but widely distributed population. With a surface area of 6,000 ha, about 40% (2,400 ha) of which is estimated to be suitable larval habitat, the St. Clair River may be a significant contributor to parasitic sea lamprey stocks in Lake Erie. No assessment work was done on the large delta in Lake St. Clair. More assessment work is required to better estimate the larval population and the potential transformer production from the St. Clair River.

Chemical Treatment

Canada

Only one tributary, Big Creek, required treatment in 1992. Favourable weather and stable discharge aided in the success of this 95 km, 8-day treatment (Table 15, Fig. 4). Larval sea lamprey distribution was similar to past treatments with densities varying throughout the system. Numbers however appeared less overall than in earlier treatments. Nontarget mortality was very light with low numbers of brown bullheads most affected.

One small sea lamprey tributary, which feeds a man-made pond, and which is the town of Delhi's sole source of water, remains untreated.

Spawning-phase Assessment

United States

A total of 622 sea lampreys were captured in assessment traps placed in 3 tributaries of Lake Erie in 1992 (Table 16, Fig. 4) compared to 607 sea lampreys from traps in 7 tributaries in 1991. The increase was most noted in the Grand River (50 in 1991 vs. 144 in 1992), and resulted in a population estimate of 527 compared to 155 in 1991. The traps placed in Cattaraugus Creek caught 57 fewer lampreys in 1992, from 533 to 476. The population present in Cattaraugus Creek in 1992 was estimated to be 1,238. The percentage of males (67%), mean length and weight of male lampreys (515 mm, 290 g) and mean length of female lampreys (500 mm) increased, but the mean weight of female lampreys (275 g) decreased.

Efforts continued to obtain flow data and population estimates for Lake Erie tributaries in an attempt to estimate the lakewide population of spawning-phase sea lampreys in U.S. waters.

Table 15. Details on the application of lampricides to streams of Lake Erie, 1992.

[Lampricides used are in kilograms/pounds of active ingredient.]
(Number in parentheses corresponds to location of stream in Fig. 4.)

Stream	Date	Discharge		TFM		Bayer 73		Distance	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
Big Creek (1)	May 30	5.4	191	1,720	3,792	-	-	96.6	60

Table 16. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1992.

(Letter in parentheses corresponds to location of stream in Fig. 4.)

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. (C)	2	0	-	-	-	-	-
Grand R. (B)	144	24	58	440	470	217	236
Cattaraugus Cr. (A)	476	224	68	421	505	296	281
Total or average	622	248	67	515	500	290	275
CANADA							
Big Otter Cr. (D)	Incomplete Data						
Young's Cr. (E)	52	0	-	-	-	-	-
Total	52	0	-	-	-	-	-
GRAND TOTAL	674	248	67	515	500	290	275

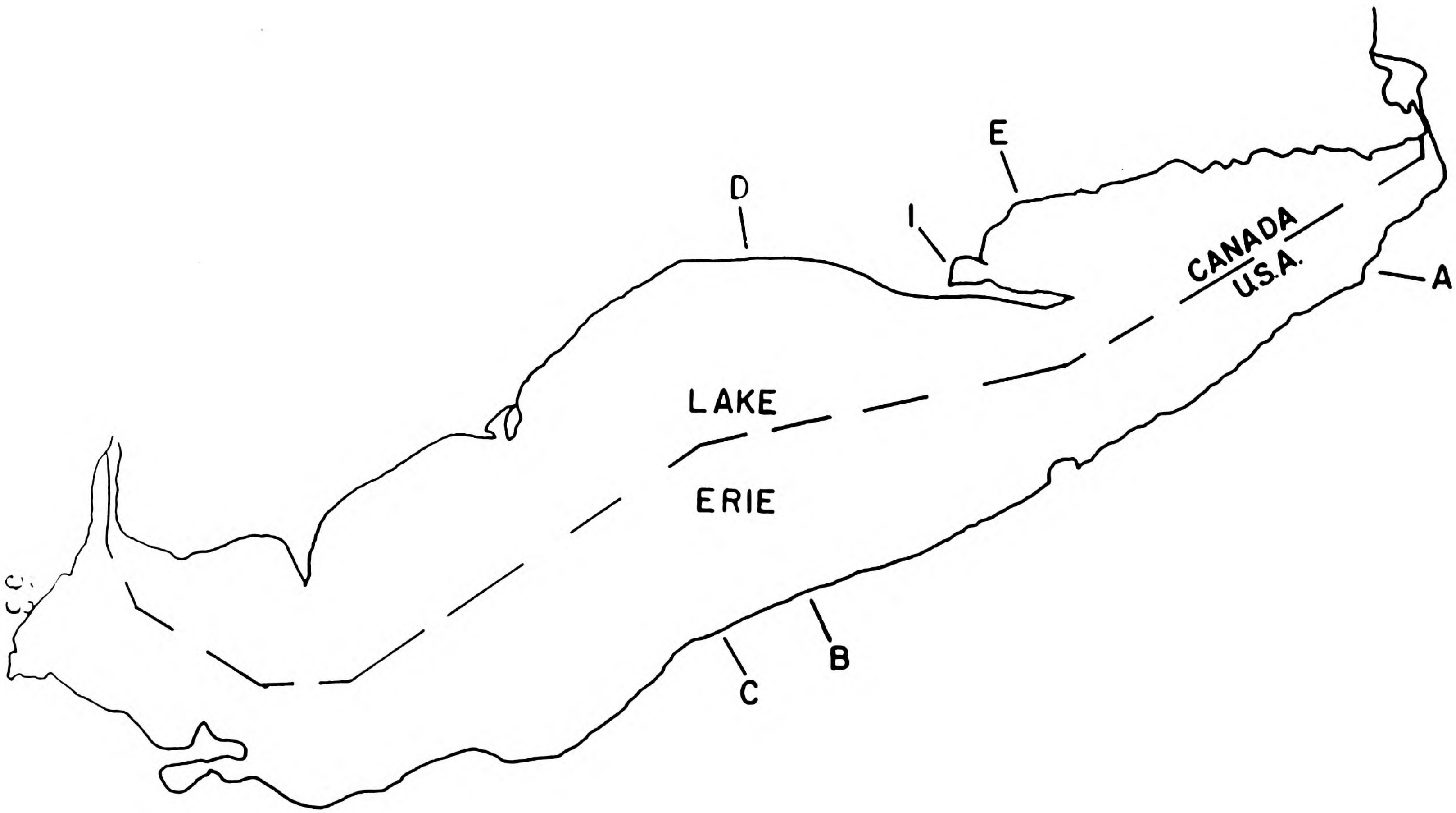

Fig. 4. Location of Lake Erie tributaries where lampricides were applied (numerals; see Table 15 for names of streams) and assessment traps were fished (letters; see Table 16 for names of streams).

Canada

Trapping operations were reinstated on two streams (Table 16, Fig. 4) in an effort to maintain some index in Canadian waters. Two portable traps were fished at the Young's Creek barrier with 52 adults being captured; a mark-recapture study yielded a traditionally-calculated efficiency of 17.3% and a population estimate of 142. The much reduced size of the run since treatment control was instituted on this lake appears to be quite stable.

A trap in the Little Otter Creek barrier (tributary to Big Otter Creek) was also operated but was fraught with problems as the water intake continually fouled. No adult lamprey were caught, and the only fish captured from this productive stream were six creek chub, on the final day of operation. Even crayfish seemed to avoid it. Remedial work was carried out to eliminate the problem, but only another year of operation can test the success of the effort.

LAKE ONTARIO

Larval Assessment

United States

The U.S. Agent has the responsibility to monitor sea lamprey larvae in all tributaries of Lake Ontario that have not been treated with lampricide. Since the mid-1980s, a few sea lamprey larvae have been recovered from the upper Niagara River. Surveys were conducted on the Niagara River around the Grand Island area in 1992, but no sea lampreys were recovered. Submergent vegetation in the surveyed areas may have prevented some of the Bayer 73 granules from reaching the substrate and may have affected the ability of the lampricide to irritate larvae from their burrows.

Carpenter and Cold Springs brooks, tributaries to the Seneca River, were surveyed to monitor existing larval populations. Two year classes of larval sea lampreys were recovered in each tributary.

Canada

Surveys were conducted on 51 Lake Ontario tributaries in preparation for chemical treatment, to monitor re-established, residual and untreated populations and to evaluate barrier dams.

Final distribution surveys were completed on four of the 11 streams scheduled for treatment in 1992: Lynde, Bowmanville and Mayhew creeks and Cobourg Brook, and on the 11 streams tentatively scheduled for treatment in 1993: Salem, Oshawa, Wilmot, Duffins, South Sandy, Lindsey, Fish, Skinner, Big Bay, Salmon and Catfish creeks. In most streams the distribution is similar to that of earlier years. One exception is Salmon Creek, New York, where sea lamprey are now well established in two tributary systems, West and Otis creeks, that were not used prior to the last (1988) treatment. Treatment of this system will now entail an additional 32 km, more than triple the length of stream requiring treatment, while increasing its complexity immensely.

Treatment evaluation surveys done on the seven streams treated in 1991: Rouge, Credit, Salmon and Black rivers and Port Britain, Sterling and Ninemile creeks, found low numbers of residuals in the Credit River and Sterling Creek, but none in the other streams. All seven streams have reestablished with the 1991 year class of larvae present. Fall index surveys done on eight of the Lake Ontario tributaries treated in 1992: Bronte, Bowmanville, Little Sandy, Deer and Snake creeks as well as, Cobourg Brook and the Little Salmon and Salmon rivers (New York), suggest that all treatments were successful.

Barrier dams on Duffins, Bowmanville, Port Britain, Grafton, Shelter Valley, Colborne and Catfish creeks were all effective at blocking the 1991 spawning run. The Credit River dam at Streetsville may also have been effective in that no larval sea lamprey were found at eight stations surveyed above it in May 1992. However, the timing of the 1991 lampricide treatment of the Credit River may have been a contributing factor to this. The effectiveness of the dam in 1992 has not been assessed.

The dam at Shannonville on the Salmon River (Canada) was not effective at blocking the 1991 spawning run, but fall index surveys suggest it may have blocked the 1992 run. Remedial work had been done to this dam in the fall of 1991.

Larval sea lamprey were found above the Little Salmon River dam at Mexico, New York, for the first time since the 1979 treatment. Adult sea lamprey were observed, and larvae of the 1991 year class were collected in May. Fall surveys found large numbers of larvae of 1991 and 1992 year class larvae. There is no visible fault in this stone structure which had minor repairs in 1978. Its failure increases the length of stream requiring treatment from 12.5 km to about 77 km. The Little Salmon River will likely require retreatment in its entirety in 1994.

Chemical Treatment

Canada

Lampricide treatments were completed in the six streams scheduled for treatment in 1992 (Table 17, Fig. 5). Larval abundance was ranked as moderate in all streams with the exception of Lynde Creek which was ranked low. This stream, last treated in 1990, was retreated in 1992 when larval distribution was found to extend upstream of limits set for the 1990 treatment.

Temperature stratification in the lower reaches of Bronte and Bowmanville creeks prevented complete lampricide mixing throughout the water column and resulted in some degree of larval escapement potential.

Table 17. **Details on the application of lampricides to streams of Lake Ontario,**

[Lampricides used are in kilograms/pounds of active ingredient.]
(Letter in parentheses corresponds to location of stream in Fig. 5.)

Stream	Date	Discharge m^3/s	Discharge f^3/s	TFM[1] kg	TFM[1] lbs	Bayer 73 kg	Bayer 73 lbs	Distance km	Distance miles
UNITED STATES									
Snake Cr. (4)	April 30	0.2	7	69	152	-	-	12.9	8
Little Sandy Cr. (1)	May 5	3.4	120	209	461	-	-	17.7	11
Salmon R. (3)	May 8	27.6	974	1,964	4,329	-	-	51.5	32
Deer Cr. (2)	May 11	1.4	48	110	243	-	-	14.5	9
Little Salmon R. (5)	May 27	3.1	108	259	571	-	-	12.9	8
Total		35.7	1,257	2,611	5,756	-	-	109.5	68
CANADA									
Farewell Cr. (8)	April 30	0.7	25	204	450	-	-	4.8	3
Bowmanville Cr. (9)	May 5	2.6	92	835	1,841	-	-	12.9	8
Lynde Cr. (7)	May 8	0.8	28	197	434	-	-	16.1	10
Bronte Cr. (6)	May 12	3.2	113	916	2,017	-	-	27.4	17
Cobourg Br. (10)	Aug. 6	0.6	21	229	505	-	-	11.3	7
Mayhew Cr. (11)	Aug. 8	0.1	4	15	33	-	-	3.2	2
Total		8.0	283	2,396	5,280	-	-	75.6	47
GRAND TOTAL		43.7	1,540	5,007	11,036	-	-	185.1	115

[1]Includes 1 bar used on 1 stream (0.2 kg, 0.4 lb).

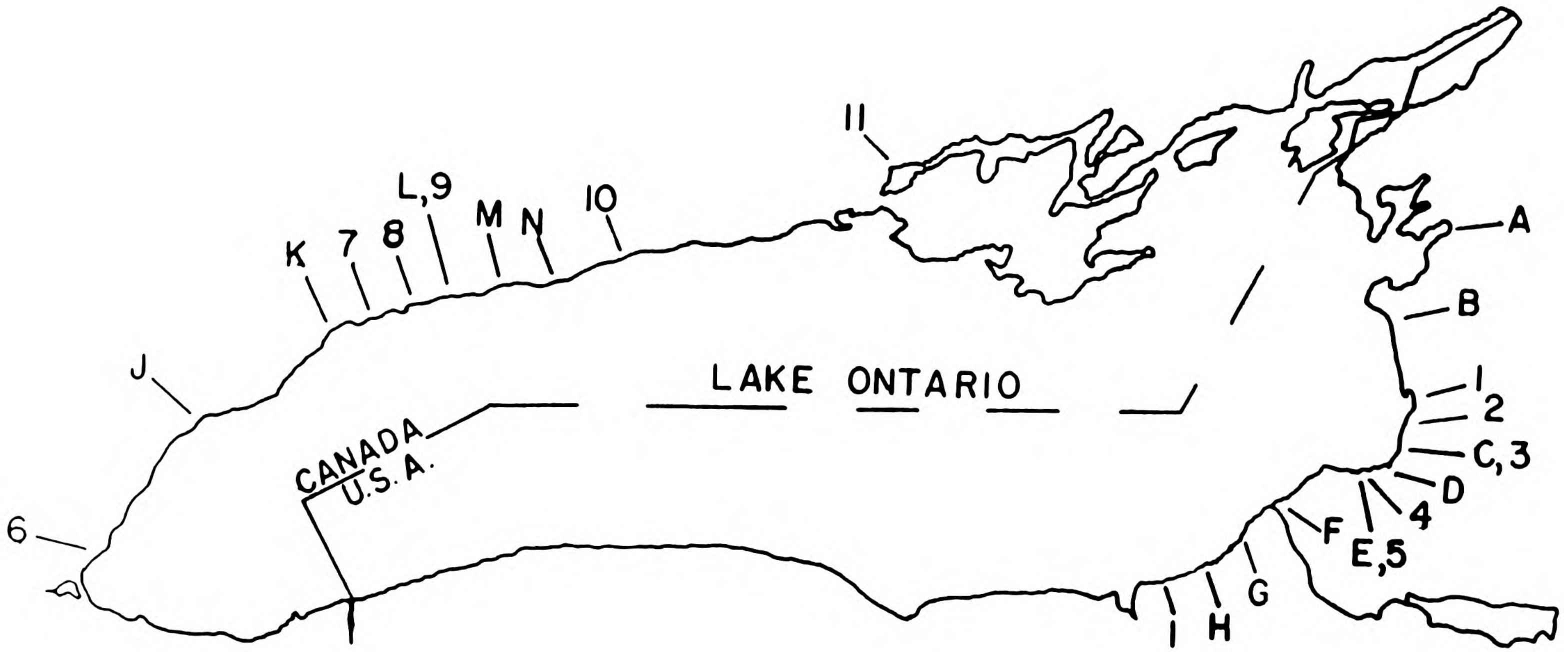

Fig. 5. Location of Lake Ontario tributaries where lampricides were applied (numerals; see Table 17 for names of streams) and assessment traps were fished (letters; see Table 18 for names of streams).

Nontarget mortality was light in each stream treated. Treatments of Bronte, Farewell, Lynde and Bowmanville creeks were completed under cool water and air temperatures which reduced the stress of lampricide on susceptible spawning white suckers. Treatment of Mayhew Creek and Cobourg Brook were conducted later in the season after the spawning migration of suckers.

United States

Five streams tributary to Lake Ontario, New York, received treatment with lampricide in 1992 (Table 17, Fig. 5). Excessive May rainfall resulted in above average treatment discharge for the majority of streams. Although the high discharge required application of additional lampricide, the increased flows facilitated movement and dispersal of lampricide in numerous impounded areas on the Salmon River tributaries and Snake Creek, thus enhancing treatment effectiveness.

Abundant numbers of sea lamprey larvae were observed in the majority of treated streams, with the Salmon River continuing to be a prolific producer of ammocoetes.

Mortality of non-target fishes appeared to be negligible on all treatments.

Barrier Program

Canada

Minor maintenance work, as required, was conducted on the barrier dam structures and traps on Lake Ontario tributaries. Inspection trips were made to presently ineffective dams at McConnellsville on Fish Creek and at Mexico on the Little Salmon River (both New York tributaries), and the Credit River in Ontario. It is not readily apparent as to how adult lamprey are penetrating these structures but it is likely they could be made lamprey-proof if funding allowed.

Spawning-Phase Assessment

United States

A total of 698 sea lampreys were captured in assessment traps placed in 9 tributaries of Lake Ontario in 1992 (Table 18, Fig. 5), and this catch is a decrease from the catch of 1,786 in 1991. Catches increased in Catfish and South Sandy creeks and Little Salmon River, and decreased in Oswego, Salmon (Beaverdam Brook) and Black rivers and Sterling, Sterling Valley and Grindstone creeks. Compared to 1991, population estimates conducted in Lake Ontario tributaries showed a decrease in the Black River (1,087) and increases in Sterling (1,101) and Sterling Valley (5,662) creeks. The percentage of males (48%), mean length and weight of males (470 mm, 213 g), and the mean weight of females (230 g) decreased, and the mean length of females (490 mm) increased.

Table 18. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1992.

(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							
Sterling Cr. (I)	66	0	-	-	-	-	-
Sterling Valley Cr. (H)	297	0	-	-	-	-	-
Oswego R. (F)	0	0	-	-	-	-	-
Catfish Cr. (G)	3	0	-	-	-	-	-
Little Salmon R. (E)	83	1	-	-	-	-	-
Grindstone Cr. (D)	33	0	-	-	-	-	-
Salmon R. Beaverdam Br. (C)	5	5	40	440	480	154	180
South Sandy Cr. (B)	10	10	40	460	480	202	227
Black R. (A)	201	201	48	470	490	214	231
Total or average	698	217	48	470	490	213	230
CANADA							
Humber R. (J)	2,595	437	53	487	470	265	257
Duffins Cr. (K)	1,274	235	46	493	475	270	254
Bowmanville Cr.(L)	388	74	55	486	474	258	248
Graham Cr. (M)	258	57	51	495	496	272	277
Port Britain Cr. (N)	131	30	53	514	490	272	257
Shelter Valley Cr. (H)	490	98	50	491	496	259	290
Total or average	5,136	931	51	490	477	266	261
GRAND TOTAL	5,834	1,148	50	487	481	259	251

Canada

This was the first year that all operations on Lake Ontario were handled by private contractors, since the Great Lakes Fishery Commission (GLFC) staff formerly assigned those duties were required for the Lake Superior sterile male programme. Graham Creek (not monitored since 1989) was added to the list of five streams trapped in 1991. While total catch for all 6 streams trapped in 1992 was 5,136 (Table 18, Fig. 5), for the 5 trapped in 1991 it was 4,878, a drop of 26% from that year's total. Catches were down at all five sites, varying from little to appreciably. The ratio of males:females was 51%.

Measures of trap efficiency (recovered to released) and population estimates were:

Humber River	38.7%	6,194
Duffins Creek	39.5%	3,043
Bowmanville Creek	27.4%	1,175
Graham Creek	50.0%	452
Port Britain Creek	71.4%	138
Shelter Valley Creek	80.0%	588

The mark-recapture work suggests that the Duffins Creek trap was not very efficient this year and the run was actually very large (a peak since estimates have been conducted). On the other hand, Port Britain Creek had a high efficiency, with a rather small run. The other streams showed nothing very surprising.

Quantitative Assessment

Seven streams were sampled in 1992 in an attempt to more quantitatively assess larval sea lamprey populations in select Lake Ontario tributaries. Where applicable, each stream system was divided into reaches for sampling. Randomly selected transects were used to establish sampling protocol and depletion sampling with the Wisconsin AbP-2 electroshockers was used to determine larval lamprey densities. Larval habitat was classified, for this report, into two categories, suitable (type I and II) or non-suitable (type III) for larval use. Table 19 summarizes areas, habitat, larval densities and population estimates for the seven streams studied.

Sixteen Mile Creek, last treated in 1982, has a very scarce population of larval sea lamprey that was not detected through random sampling. Lindsey Creek, last treated in May 1990, had two year classes present, all within the middle reach of the stream. Marsh Creek, last treated in May 1988, had a very scarce larval population not detected with random sampling. Orwell Brook, last treated in May 1992, had a residual population of 3,767 and a recruited young-of-the-year population of 27,720. Salmon Creek, last treated in May 1988, had a larval population estimated at 4,746 with 418 transforming sea lamprey in the main stream only. Several tributaries to this system have significant larval sea lamprey populations that will not be quantified until spring 1993. Skinner Creek, last treated in May 1990, had a reestablished year class estimated at 2,760. Trout Brook, last treated in June 1992, had a residual population estimated at 127.

Table 19. Population and habitat estimates on seven Lake Ontario tributaries, 1992.

Stream		Year Classes	Area m^2	Habitat % I & II	Habitat % III	Density	Estimate	Confidence Limits 95%
16 Mile Cr.	R1		427,618	7.4	92.6	0		
	R2		362,678	65.2	34.7	0		
			790,296					
Lindsey Cr.	R1	2	288,996	14.1	18.4	0	13,240	3,657-28,281
	R2		65,209	94.6	5.3	0.215		
	R3		28,691	67	31.1	0		
			382,896					
Marsh Cr.	R1		63,291	22.2	77.9	0		
	R2		37,742	89.9	10.1	0		
			101,033					
Orwell Br.	R1	0 plus residuals	59,727	55.2	44.8	0.791	26,092[1]	8,797-60,674
	R2		24,727	23.5	76.5	0	0	
							1,628[2]	0-6,865
	R3		83,043	53.8	46.2	0.036	27,720	
			167,497					
Salmon Cr.	R1	3 plus transformers	148,972	85.1	14.9	0.003	363	0-1,036
	R2		53,557	54.4	45.6	0.15	4,383	0-15,943
			202,529				4,746[3]	
Skinner Cr.		1	235,223	54.6	45.6	0.021	2,760	84-6,080
Trout Br.	R1	residuals	84,491	54.5	45.6	0.002	83	0-290
	R2		37,998	35	65	0.003	44	0-126
	R3		52,044	30.2	69.8	0	0	
			174,533				127	

1 Includes 3,479 residuals.
2 Includs 288 residuals.
3 Includes 418 transformers.

LAKES SUPERIOR, MICHIGAN AND HURON

Sterile Male Release Technique

The sterile male release technique successfully was implemented in Lake Superior and the St. Marys River in 1992. Male sea lampreys were captured in 6 tributaries of Lakes Michigan and Huron, transported to the Hammond Bay Biological Station, sterilized with bisazir (the chemosterilant) and decontaminated within the sterilization facility, and released into the 27 major lamprey producing tributaries of Lake Superior (U.S.-21, Canada-6) and the St. Marys River. Also, the success of the interaction of the sterilized males with resident female lampreys was monitored in four tributaries of Lake Superior and the St. Marys River.

The sterilization facility at Hammond Bay met the needs of the Sea Lamprey Control Program to successfully sterilize the number of male lampreys collected from the six source rivers. A total of 29,874 spawning-phase male lampreys were transported to the facility during May 5 to August 10. The predicted number of lampreys to capture and transport to Hammond Bay was 27,000. Male lampreys were acquired from assessment trap operations on the Manistique River of Lake Michigan (7,600) and the following tributaries of Lake Huron: Cheboygan (16,200), Ocqueoc (1,200), Echo and Thessalon (703), and St. Marys (4,171) rivers. Lampreys were sorted by sex and their dorsal fins were clipped (to later identify sterilized lampreys after they were released). Within the facility, lampreys each were injected with 100 mg/kg of bisazir and then held in tanks for 48 hours before transport to streams of release. A total of 26,500 lampreys were sterilized and 25,807 later were released. Mortality of 693 sterilized lampreys occurred prior to release and resulted either from lampreys escaping from a holding tank because of improper placement of a cover (397), or unknown causes that probably were stress related (296; 1% of total injected).

Water from Lake Huron continually is pumped through the facility to provide fresh water for holding tanks for sterilized lampreys and for other processes such as waste, rinse, and clean-up within contained areas. Waste water where bisazir potentially is present is collected in a sump, then pumped through carbon filters to remove the bisazir. The filtered effluent is released back to Lake Huron.

Water in the facility was monitored for presence of bisazir to comply with the water discharge permit of Michigan, to insure safe working conditions for facility personnel, and to insure sterilized lampreys were free of bisazir prior to release in streams. A series of four protocols monitored for presence of bisazir. First, the effluent daily (4 times at 6 hour intervals, composited into 2-12 hour samples) was monitored to comply with the discharge permit. Second, unfiltered water from the sump was monitored on 2 days (hourly for 20 and 28 hours, respectively) to determine concentrations of bisazir in the waste system prior to carbon filtration. Third, during 11 days water randomly was sampled from the holding tanks 1 to 36 hours after lampreys were injected. The sequence of sampling was hourly for 12 to 36 hours that ranged from 1-12 to 21-36 hours after injection. Fourth, water randomly was sampled from holding tanks after the 48-hour period after injection and immediately prior to the removal of lampreys from the facility.

The requirements of the discharge permit were met, safe operation situations for personnel were maintained, and lampreys showed no presence of bisazir prior to release. Bisazir was not detected in facility effluent. Bisazir also was not detected in the sump during the first set of samples (acid used in standard decontamination procedures probably destroyed bisazir prior to sampling) and was detected at a maximum of 350 μg/l in the second set. Bisazir concentration in the holding tanks prior to 48 hours after injection did not exceed expected concentrations (about 650 μg/l) except when water inlet lines became plugged (Table 20). Bisazir was not detected in holding tanks following 48 hours after injection.

The predicted number of sterilized males for release into Lake Superior was 18,500 and 21,299 were released (Table 21). The predicted ratio of 1.8 sterile:1 normal male lamprey was achieved. The release of sterilized lampreys occurred within the predicted schedule. The first release of sterilized males was scheduled for May 15 and occurred on May 18. Failure of the autosterilizer delayed production of sterilized males during two periods of scheduled peak operation. Sterilization of lampreys was interrupted during May 22-25 and June 3-7. Operations remained slightly behind schedule until June 11. The predicted final day of release in Lake Superior tributaries was June 14 and the scheduled number of lampreys was released into all tributaries on this date. A total of 2,799 sterilized male lampreys above the predicted number were released into 5 of the 27 tributaries, and June 23 was the final day of release into Lake Superior.

The predicted number of sterilized males for release into the St. Marys River was 5,800 and 4,508 were released. The first release of sterile males was June 19 (predicted June 15) and the final release was on August 13. The predicted final date of release was July 24. The extended time of release occurred because unseasonably cool water temperatures prolonged the spawning run.

The estimated resident population of spawning-phase sea lampreys in the St. Marys River was 19,508 (11,354 males) and assessment traps removed 7,565 lampreys (4,402 males) for a reduction of 39% of the spawning population. An estimated 6,952 resident males remained in the river and the release of 4,508 sterilized males achieved a ratio of 0.6 sterile:1 normal (a theoretical 39% reduction of the remaining reproductive potential). The combination of removal by traps and release of sterile males resulted in a theoretical reduction in reproductive potential of 63%.

The long-term effectiveness of the technique in Lake Superior is being determined through occurrence of lamprey wounds on fish and fish and lamprey abundance. Short-term measurements are necessary to identify fine tuning of operations between treatment seasons. Observations of sterile and normal lamprey interactions were conducted on four tributaries of Lake Superior (U.S.--Silver and Salmon Trout rivers, Canada--Pancake and Batchawana rivers; Table 22). The objectives were to determine: 1) the ratio of sterile to normal males that engaged in spawning activities on nests, and 2) the reduction in viable eggs (to the hatching stage) from matings by sterile males.

Table 20. Concentrations of bisazir found in water in holding tanks that contained sterilized male sea lampreys during the first 36 hours after the lampreys were injected with bisazir. Tanks were randomly sampled and the sequence of sampling was hourly. The first hour began after the first lamprey was placed into a tank and it took about 3 hours to complete injection and placement of lampreys in the tank.

Date Sampling Started	Number of Sterilized Lampreys in Tank	Range of Hours Sampled	Peak Concentration of Bisazir ($\mu g/L$)	Concentration of Bisazir ($\mu g/L$) at final hr.
5/14	310	1-24	550	48
5/15	200	1-21	850[1]	145[1]
5/18	350	1-23	560	<25
5/21	342	1-20	1,100[1]	89
5/22	342	21-36	240[1]	195[1]
5/27	350	1-20	2,000[1]	1,100
5/28	350	21-28	60	<50
6/01	349	1-12	650	190
6/02	349	13-28	<25	<25
6/09	380	1-12	1,300[1]	<25
6/10	380	13-25	125	<25

[1]Level of bisazir resulted from inadequate water replacement rate in tank due to clogged inlet line. Predicted highest concentration was about 650 $\mu g/l$ of bisazir.

Table 21. The predicted and actual number of sterile male sea lampreys released into 27 tributaries of Lake Superior in 1992, and the theoretical reduction in sea lamprey progeny based on the estimated number of resident males. The predicted ratio of sterile to normal males for Lake Superior tributaries in 1992 was 1.8:1 and the predicted theoretical reduction in sea lamprey progeny was 64 percent.

River	Predicted Resident Males	Predicted Sterilized Males	Released Sterilized Males	Estimated Resident Males	Estimated Ratio	Theoretical Reduction (Percent)
United States						
Waiska	68	121	121	72	1.7:1	63
Two Hearted	273	485	696	289	2.4:1	71
Sucker	94	167	165	100	1.7:1	63
Au Train	134	239	239	143	1.7:1	63
Chocolay	129	230	230	137	1.7:1	63
Salmon Trout	70	125	125	75	1.7:1	63
Huron	137	243	243	145	1.7:1	63
Silver	86	154	154	92	1.7:1	63
Sturgeon	764	1,355	1,794	809	2.2:1	69
Traverse	26	47	47	28	1.7:1	63
Misery	198	352	352	157	2.2:1	69
Firesteel	239	424	423	189	2.2:1	69
East Sleeping	105	186	186	84	2.2:1	69
Ontonagon	2,000	3,544	4,624	3,311	1.4:1	58
Potato	16	28	28	12	2.3:1	70
Cranberry	26	47	47	19	2.5:1	71
Bad	1,770	3,138	3,170	1,404	2.3:1	70
Poplar	142	252	252	112	2.3:1	70
Middle	202	359	318	161	2.0:1	67
Amnicon	972	1,723	1,723	771	2.2:1	69
Nemadji	800	1,418	1,417	1,574	0.9:1	47
Canada						
Pigeon	80	142	160	80	2.0:1	67
Wolf	200	354	369	200	1.8:1	64
Nipigon	1,000	1,772	2,611	1,000	2.6:1	72
Pancake	100	177	177	100	1.8:1	64
Batchawana	400	709	709	400	1.8:1	64
Goulais	400	709	919	400	2.3:1	70
Totals	10,431	18,500	21,299	11,864	1.8:1	64

Table 22. Observations of interactions of released sterilized male sea lampreys and normal resident sea lampreys in tributaries to Lake Superior in the U.S. (Salmon Trout and Silver rivers) and Canada (Pancake and Batchawana rivers). Nests were categorized by the type of mating observed: normal, sterile, or unobserved. Nests that were used for multiple matings were not included in the nest count and were not examined for viability. Eggs were retrieved from nests after developing to about the hatching stage (about 13 days) and examined for viability to determine the percent success.

	Silver	Salmon Trout	Pancake	Batchawan
Estimated resident males	92	75	100	400
Sterile males released	154	125	177	709
Estimated ratio	1.7:1	1.7:1	1.8:1	1.8:1
Theoretical reduction (%)	63	63	64	64
Observed male lampreys spawning:				
Normal	5	23	11	1
Sterile	1	5	0	0
Nests in which mating was with:				
Normal male	5	16[1]	8	1
Sterile male	1	4[1]	0	0
Unobserved mating	33	43[2]	35	21
Total	39	63	43	22
Average percent (range) survival of eggs in nests in which matings were with:				[3]
Normal males	27 (9-43)	42 (4-66)		
Sterile males	10 (10)	4 (0-6)		
Unobserved matings	36 (2-80)	38 (4-38)		

[1]Nests on which more than one spawning was observed were not examined and therefore are less than the number of observed male lampreys spawning.
[2]Four nests were washed out by high water before the eggs were removed.
[3]Survival data was not available for nests in Canada.

The male lampreys used in the study were trapped from the Manistique River (delivered to Hammond Bay on May 21), the Thessalon River (delivered to Hammond Bay on May 27) and the Cheboygan and Ocqueoc rivers (delivered to Hammond Bay between May 5 and May 28). The lampreys were sterilized on May 28-29 and were released in the streams on June 1.

Observations in the streams began on May 26 and the first nest was sighted on June 2 in the Silver River. Spawning activity appeared to peak for each river during the following days: Silver, June 13; Salmon Trout, June 12; Pancake, June 8; and Batchawana, June 11. Nests were categorized as sterile, normal, and unknown based on presence of sterile or normal males and when nests were found but no lampreys were present. Eggs were collected from all nests when they were about to hatch, and success was calculated for each category of nests based on the percent of eggs that were found to be viable.

Sterile male lampreys successfully mated with resident females and resulted in matings that produced no viable eggs, but were not observed in the predicted ratios (Table 22). The predicted ratio of sterile to normal males in the U.S. streams was 1.7:1 and the ratio for observed matings was 0.2:1 (6 sterile:28 normal). No sterile males were observed spawning in streams in Canada (0 sterile:12 normal), but 3 were observed along the stream bottom (Batchawana--2, Pancake--1). The small number of observations in the Silver, Pancake and Batchawana rivers limits the usefulness of data from those streams.

Examination of eggs produced in the three categories of nests also verified that sterilized males did not mate with the resident population in the predicted ratio. A total of 1 sterile nest produced 0 viable eggs and the other 5 had 2-10% viable (due to eggs that at the time of removal from the nest had not yet developed to the stage when death generally occurred or unobserved additional mating by a normal male). The range of survival in the normal nests overlapped survival in the sterile nests and made interpretation of viability from unobserved matings as impractical. Severe fluctuations of water temperatures caused by unseasonable cold air temperatures after spawning of lampreys probably resulted in mortality of eggs in nests in the Pancake and Batchawana rivers and made examination of eggs unuseable for the objectives of this study.

The interaction of sterile and resident male lampreys also was observed in the St. Marys River. A total of 4,508 sterilized males were released during June 19-August 13, and about 3,000 were released after the first observed spawning on July 21. The observed ratio of sterile to normal males in the St. Marys River was 0.3:1 (16 observed matings, 4 sterile and 12 normal) and compares to a predicted ratio of 0.6:1.

The Sterile Male Release Task Force has determined a variety of factors likely caused the inconsistency between predicted and observed actions of implementation of the technique. The probable causes in the lower than expected ratios of sterile to normal males in the study streams were a combination of the following factors: lampreys were held in raceways at Hammond Bay too long before sterilization and cold water temperature in the raceways impeded maturation of the males; sterilized lampreys were placed in the study streams before resident lampreys were present and the sterilized lampreys left the river; the study streams in the U.S. were streams with barriers about two miles upstream of the mouth and the barriers may affect retention of sterilized lampreys in the streams of release; and, predation by sea gulls and otters.

The Task Force continues to modify procedures in the implementation of the technique to increase success in 1993. The sterilization facility has received a lake water filtration unit to enhance capability of the contaminated water filtration system and eliminate plugging of water lines to holding tanks. The capture, injection, and release process will be reviewed and modified to ensure handling time and stress to the lampreys are maintained at minimum levels. Additional sources of male lampreys are being examined. Male sea lampreys from the Atlantic coast will be brought to Hammond Bay to study disease, behavior, and efficacy for sterilization with bisazir. The Carp River of Lake Huron is a high potential source in the Great Lakes but conflict with the laws of the National Wild and Scenic Rivers Act of 1990 thus far has limited proposed action of the Task Force to install a temporary electronic barrier in the river. The Task Force will focus a short-term study in 1993 on addressing the issues raised from the field observations of 1992.

Treatment effects on Nontarget 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 recover to pretreatment levels in three years. The pretreatment mayfly density in 1987 was $577/m^2$ compared to $852/m^2$ in 1991. This short-term study was concluded in 1992.

Treatment effects on Nontarget 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 1992, 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.

Riffle community Index--Index areas of invertebrate communities were established in the Brule (Lake Superior), Boardman and Whitefish (Lake Michigan), and Sturgeon (Lake Huron) rivers in 1985. Samples are taken up (control) and downstream (treated) of lamprey barriers in the Brule and Whitefish rivers. Samples are collected from a treated area of the Sturgeon River. A control area was selected in untreated portions upstream of dams in the Boardman River because of problems associated with comparability of control and treated areas in the Sturgeon River.

Samples have been collected in the spring and fall and before and after lampricide treatments at the rivers 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 23-24). Samples collected in the Whitefish and Sturgeon/Boardman rivers in 1991 and 1992 and the Brule River in 1992 will be presented upon completion of processing in later annual reports.

Table 23. Mean number of organisms from 5 samples taken by kick nets in riffle communities in the Brule River in April 1991 in areas that are periodically treated and in areas that are not treated (control).[1]

Taxa	Brule River Treated Area Spring	Brule River Control Area Spring
Ephemeroptera		
Baetidae		
Baetis	71.8	49.2
Heptageniidae		
Leurocuta	0.2	0.8
Rhithrogena	9.4	6.0
Stenonema	1.0	2.2
Ephemerellidae		
Ephemerella	92.2	363.6
Seratella	7.8	13.0
Caenidae		
Caenis	0.2	
Leptophlebiidae		
Paraleptophlebia	1.2	0.4
Ephemeridae		
Ephemera	0.2	0.4
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus	3.6	7.6
Plecoptera		
Pteronarcyidae		
Pteronarcys		0.4
Taeniopterygidae		
Strophopteryx	0.8	0.2
Perlidae		
Paragnetina	0.2	
Acroneuria	5.4	17.4
Perlodidae		
Isoperla	0.2	0.6
Megaloptera		
Corydalidae		
Nigronia		0.2
Trichoptera		
Psychomyiidae		
Psychomyia		0.6
Hydropsychidae		
Ceratopsyche	9.0	17.2
Cheumatopsyche	0.6	3.2
Glossosomatidae		
Protoptila	76.6	98.2
Hydroptilidae		
Hydroptila	0.6	5.8
Leucotrichia	1.6	2.0

(continued)

Table 23. Continued.

Taxa	Brule River Treated Area Spring	Brule River Control Area Spring
Brachycentridae		
Brachycentrus	2.4	2.6
Micrasema	0.2	1.4
Lepidostomatidae		
Lepidostoma	1.4	3.2
Helocopsychidae		
Helicopsyche	23.0	25.0
Leptoceridae		
Setodes	3.4	2.4
Pupae	0.2	0.2
Coleoptera		
Halipidae		0.2
Elmidae		
Optioservus larvae	63.4	73.6
Optioservus adult	5.2	7.4
Stenelmis larvae	0.8	
Diptera		
Tipulidae		
Antocha	7.0	18.4
Hexatoma	2.8	2.4
Simulidae		
Ectemnia		0.4
Prosimulium	1.0	4.4
Simulium	0.8	
Chironomidae	47.6	62.6
Athericidae		
Atherix	33.8	28.4
Pupae	1.6	1.2
Miscellaneous		
Nematoda	0.2	
Annelida		
Oligochaeta	4.8	3.0
Amphipoda		
Gammarus	0.4	1.0
Hydracarina	0.2	0.4
Gastropoda		
Physidae		
Physa	0.2	
Ancylidae		
Ferrisia	4.2	4.2
Pelecypoda		
Sphaeriidae		
Sphaerium	0.8	1.0
Total	488.0	832.4
Total taxa	42	41

[1]Samples from the Brule River in 1992 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 5 samples taken by kick nets in riffle communities in the Brule River in September 1991 in areas that are periodically treated and in areas that are not treated (control).[1]

	Brule River	
	Treated Area	Control Area
Taxa	Fall	Fall
Ephemeroptera		
Baetidae		
Baetis	30.8	28.6
Pseudocloeon	23.4	20.2
Oligoneuriidae		
Isonychia	0.4	
Heptageniidae		
Rhithrogena	7.4	6.2
Stenomena	0.6	0.8
Ephemerellidae		
Ephemerella	5.2	4.2
Eurylophella	0.2	
Seratella	1.4	1.0
Odonata		
Anisoptera		
Gomphidae		
Ophiogomphus	2.4	2.8
Plecoptera		
Pteronarcyidae		
Pteronarcys	0.2	
Perlidae		
Acroneuria	8.2	7.4
Perlodidae		
Isoperla	0.4	
Plecoptera Family	0.2	0.4
Trichoptera		
Psychomyiidae		
Psychomyia	0.6	0.6
Hydropsychidae		
Ceratopsyche	10.6	7.2
Cheumatopsyche	0.8	0.8
Glossosomatidae		
Glossosoma	3.4	3.2
Protoptila	16.6	37.0
Hydroptilidae		
Hydroptila	1.8	2.8
Leucotrichia	0.8	1.0
Mayatrichia		0.2
Neotrichia	0.6	
Ochrotrichia		0.4
Brachycentridae		
Brachycentrus	0.2	1.2
Lepidostomatidae		
Lepidostoma	0.6	1.4
Helocopsychidae		
Helicopsyche	2.4	3.6

(continued)

Table 24. Continued.

Taxa	Brule River Treated Area Fall	Brule River Control Area Fall
Leptoceridae		
Setodes	0.6	1.6
Pupae		0.2
Coleoptera		
Elmidae		
Optioservus larvae	41.8	53.2
Optioservus adult	7.8	4.8
Stenelmis larvae	0.2	
Stenelmis adult		0.4
Diptera		
Tipulidae		
Antocha	1.6	5.0
Hexatoma	2.8	4.8
Ceratopogonidae	0.2	0.4
Simulidae		
Simulium	0.4	0.2
Chironomidae	15.0	25.6
Athericidae		
Atherix	11.8	11.6
Empididae		
Hemerodromia		0.8
Pupae	1.2	1.0
Miscellaneous		
Annelida		
Oligochaeta	5.4	7.0
Hydracarina	0.2	0.6
Gastropoda		
Hydrobiidae		
Amnicola	0.2	0.2
Ancylidae		
Ferrisia	0.4	0.4
Terrestrials		0.6
Total	208.8	249.4
Total taxa	39	39

[1]Samples from the Brule River in 1992 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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