APPENDIX XVIII

GLFC ANNUAL MEETING
WASHINGTON, D.C.
April 30 - May 3, 1990

SEA LAMPREY MANAGEMENT IN THE GREAT LAKES 1989

by

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Great Lakes Fishery Commission

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ABSTRACT

This is a joint report that summarizes sea lamprey management and control efforts conducted by the United States Fish and Wildlife Service and the Department of Fisheries and Oceans Canada. The 1989 management activities include: larval assessment, chemical treatment, spawning-phase assessment, parasitic-phase assessment, construction of low-head barrier dams, and assessment of the effects of lampricides on nontarget organisms. Larval assessment surveys were completed on 625 Great Lakes tributaries, one instream lake and four offshore areas. Chemical treatments were completed on 65 tributaries to the Great Lakes (Table 1). In U.S. waters, 11 chemical treatments on rivers and streams were postponed because of low water levels and funding levels (Lake Erie). In Canadian waters, four chemical treatments were postponed on tributaries to the Great Lakes (all due to inadequate discharge). Assessment traps placed in 65 tributaries to the Great Lakes captured 74,478 spawning-phase sea lampreys (Table 2). A total of 5,935 parasitic-phase sea lampreys were collected from commercial and sport fishermen in the Upper Great Lakes (including Lake Erie). Tests of the short-term effects of lampricides on nontarget organisms were conducted in treated and control sections of three streams in two lake basins. Long-term monitoring of the effects of lampricides to the mayfly <u>Hexagenia</u> and other organisms continued in four streams.

LAKE SUPERIOR

Larval Assessment

United States

Surveys monitored reestablished and residual populations of larval sea lampreys, prepared for chemical treatments, and searched for new infestations on 138 Lake Superior tributaries. Sea lampreys had reestablished in at least 38 streams.

Surveys to assess recruitment of the 1989 year class were conducted in 65 streams and young-of-the-year larvae were recovered in 27. Few larvae were found in most streams, possibly as a result of near drought conditions. More index sites were added on several large stream systems in 1989 to better assess larval recruitment. Young-of-the-year larvae have not been detected for 5 or more years in 15 streams that are examined annually. Recruitment of young-of-the-year larvae in the Laughing Whitefish River was the first since 1983. Additional surveys on the Waiska, Miners, and Laughing Whitefish rivers were completed to assess 1988-89 larval recruitment that was not evident at index sites.

Surveys to schedule (pretreatment) lampricide applications were conducted on 15 streams. Pretreatment surveys were conducted on 5 streams for treatment in 1989 (4 later were successfully treated) and 10 for future treatment. An evaluation of treatment (posttreatment survey) was completed on the Huron River.

The number of larvae in the Huron River was estimated by three methods in 1988, including a mark and recapture technique during the treatment in October. During the day following treatment, personnel collecting dead larvae (to complete the estimate technique) occasionally observed live larvae. As a result, a Table posttreatment survey was conducted in July 1989. Marked and unmarked residual larvae were collected in this survey. A comparison of the ratio of marked to unmarked larvae in collections during and after the treatment suggested the treatment was at least 98% effective with about 10,000-20,000 residuals remaining in the river. Of these, about 200 would be expected to transform and leave the river in 1989 plus several thousand more prior to the next treatment in the normal 3-year cycle (1991). The river was retreated in September 1989 and collection of marked and unmarked residual larvae confirmed the number of residuals estimated from the posttreatment surveys of July 1989. But, the percentage of the larvae >120 mm (the length where transformation may begin) was larger than estimated from the survey of July. Therefore, about 400 transformers were prevented from entering Lake Superior because of the treatment in 1989.

Residual lampreys were found in 14 additional streams, but were less than 5% of the total number of larvae collected in all streams except in the Sucker River (about 10%). The number of residual lampreys in the other streams did not indicate a need for retreatment.

Many small streams of Lake Superior are not routinely surveyed because previous surveys found no sea lampreys. Some have not been examined since initial surveys at the start of the control program. Natural or manmade changes

Table 1. Summary of chemical treatments in streams of the Great Lakes in 1989. [Lampricides used are in kilograms/pounds of active ingredient.]

Lake	Number of Streams	Discharge m3/s	Discharge f3/s	TFM[a] kg	TFM[a] lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	GB kg	GB lbs	Distance Treated km	Distance Treated mi
Superior	20	38.86	1,369	4,827	10,641	21.3	46.9	0.3	0.60	185.8	115.5
Michigan	11	101.40	3,622	15,999	35,275	71.7	157.0	-	-	371.7	231.0
Huron	*20	129.98	4,604	16,714	36,847	34.6	76.3	-	-	591.4	367.3
Erie	2	6.65	235	2,761	6,086	-	-	-	-	102.5	63.7
Ontario	12	49.84	1,761	6,612	14,576	-	-	.15	0.33	248.1	154.2
Total	64	326.73	11,591	46,913	103,425	127.6	280.2	0.45	0.93	1,499.5	931.7

[a]Includes 1,472 TFM bars (307.7 kg., 677.3 lbs.) applied in 33 streams.
*Includes Trout pond on Tawas River.

Table 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in 65 tributaries of the Great Lakes in 1989.

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	20	7,299	1,769	44	433	429	183	181
Michigan	13	17,094	2,384	44	485	486	258	266
Huron	10	46,380	4,488	54	483	484	246	253
Erie	7	319	289	60	470	475	270	258
Ontario	15	3,386	760	61	483	484	262	272

in stream character could make the stream more favorable to sea lampreys. A 3-year plan to survey all such tributaries began in 1989 and 71 streams were examined, primarily along the Minnesota shore. No new populations were found although 16 of the streams appear to have favorable environmental conditions for sea lampreys.

The populations of larval sea lampreys were estimated in seven Lake Superior tributaries through habitat-based techniques in 1989. These studies determined the numbers of larvae and transformers inhabiting each river and compared the feasibility and effectiveness of two habitat-based methods (random transects and representative reach). The tributaries included: Little Garlic, Big Garlic, Falls, Sturgeon, Brule, and Middle rivers, and Red Cliff Creek (Table 3). All rivers were scheduled for treatment in 1989, but the Middle River and Red Cliff Creek were deferred until 1990 because of low water. A mark Creek were deferred until 1990 because of low water. A mark and recapture estimate was used on the Little Garlic River to verify the habitat-based techniques. Deep water areas were present in the estuaries of four streams (Little Garlic, Brule, and Middle rivers and Red Cliff Creek) and the number of larvae in these areas was estimated using a bottom filtration system in a stratified random sampling design. The number of larvae in the areas off the mouths of the Sucker and Falls rivers also was estimated by the bottom filtration technique. The procedures for each technique will be described in turn.

The random transects method was used on each of the seven tributaries. Amounts of habitat in each stream were estimated by randomly selecting a 5-foot wide transect across the river at 500-foot intervals. The amount and type of substrate (sand, silt, gravel, clay, etc.) along the transect were recorded. From these measurements, the substrates were divided into three broad categories based on potential for habitation by lamprey larvae: Type I habitat was considered optimal, Type II was acceptable though not preferred, and Type III was uninhabitable. Lamprey densities at each transect were determined by a depletion method of sampling. The area in the transect was sampled three or more times with electrofishing gear, and the diminishing number of lamprey captured in successive passes with the gear was used to estimate lamprey density. 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 lampreys in each river. The number of larvae >120 mm (the size when transformation may occur) was estimated by the percentage of larvae of that length in the electrofishing collection, and the number of transformers was calculated as the percentage of those >120 mm that would be expected in each river (based on past collections of larvae during lampricide treatments for each river).

The representative reach technique was used on the Little Garlic and Brule rivers and Red Cliff Creek. The method divides the river into similar sections (known as macrohabitat sections) based on characteristics such as sinuosity, gradient, and substrate size. A representative portion (reach) of each macrohabitat section is selected and sampled for habitat type and lamprey density. Quantification of habitats and lamprey densities and abundance measurements (including the total number in the population, those >120 mm, and transformers) was the same as in the random transects method. The number of lampreys in each river was obtained by adding the estimates for each macrohabitat section.

A mark-recapture technique was used on the Little Garlic River to verify the habitat-based estimates. Larval lampreys were captured throughout the stream and estuary with electrofishing gear, marked with a dye, and released into the stream prior to chemical treatment. Recapture was made during the chemical treatment and the Petersen formula was used to calculate the estimated population.

The number of lampreys inhabiting the estuaries of the Little Garlic, Brule, and Middle rivers, and Red Cliff Creek and the lentic areas off the Sucker and Falls rivers was determined using a bottom filtration system and a stratified random sampling design. SCUBA divers place a 1 m^2 template on the stream bottom at predetermined random locations. The divers remove the bottom sediments within the template to a depth of eight inches using a hose attached to a suction pump mounted in a boat. The substrate passes through the pump and onto a screen mounted on the side of the boat. Larval lampreys are filtered onto the screen and the fine sediments returned to the water. The sampling yielded a mean density of lampreys per 1 m^2 and was expanded by the portion of the estuary or offshore area inhabited by lampreys.

Larval population estimates derived by the random transects technique ranged from 0 in the Falls River to 352,065 in the Sturgeon River (Table 3). In general, the number of lampreys in the population was related to the discharge of the river and the total area inhabited by larvae. The Sturgeon River had the largest number of transformers (3,732). Although a larger number of lampreys was estimated with the representative reach technique than the random transects technique (where both methods were used; Brule, Little Garlic rivers, and Red Cliff Creek), the difference was not significant. The mark and recapture technique estimated 83,418 lampreys in the Little Garlic River (including the estuary) which was larger than the other techniques. The number from the mark and recapure technique likely is high because of an incomplete retention of the marking dye on some of the larvae.

Lampreys were relatively abundant in estuaries of all seven streams and one of two offshore areas. The number of lampreys in the estuary areas ranged from an estimated 4,857 (Red Cliff Creek) to 45,001 (Brule River). Population estimates were similar for the mark/recapture (5,800) and bottom filtration (6,455) techniques in the estuary of the Little Garlic River. Larvae were more abundant off the mouth of the Falls River (5,511) than the Sucker River (1,046).

Table 3. The estimated amount of habitat (ft[2]) 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 eight tributaries of Lake Superior, 1989. The information compiled for two rivers in 1988 also is listed as a comparison of results. (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 offshore, random transects, representative reach, estuary, and mark and recapture, and each is described in the footnotes.

Year and 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
1989										
Sucker	Offshore[7]	30,000	-	-	0.03	-	1	1,046 (551-1,540)	0	-
L. Garlic	Random Transects[8]	118,148	191,877	280,331	0.15	0.01	3	20,837 (4,144-37,535)	2,312 341-4,282)	195 (40-361)
	Representative Reach[9]	258,251	145,854	206,158	0.30	0.01	3	44,751 (17,548-73,936)	1,549 (227-4,160)	131 (40-351)
	Estuary[7]	54,381	-	-	0.12	-	3	6,455 (3,184-9,725)	0	-
	Mark and Recapture[10]	-	-	-	-	-		83,418 (67,631-99,205)	-	-
Big Garlic	Random Transects	386,600	277,400	60,200	0.04	0.01	3	16,788 (7,474-27,189)	651 88-1,484)	55 (8-124)
Falls	Random Transects	13,627	73,066	98,688	0.00	0.00	0	0	-	-
	Offshore	152,465	-	-	0.04	-	1	5,511 (2,886-8,136)	727 (381-1,073)	102 (53-150)
Sturgeon	Random Transects	1,918,498	12,476,761	1,199,523	0.16	0.01	3	352,066 (228,213-475,920)	38,469 (16,492-61,643)	3,732 (1,600-5,980)
Red Cliff	Random Transects	28,183	48,771	22,986	0.01	0.01	4	564 (267-780)	157 (3-411)	-
	Representative Reach	15,990	68,959	14,991	0.16	0.05	4	8,482 (329-28,835)	515 (34-1,757)	-
	Estuary	507,944	-	-	0.01	-	4	4,857 (1,327-8,388)	751 (205-1,298)	-
rule	Random Transects	274,798	464,548	1,312,298	0.28	0.02	2	86,563 (54,593-140,693)	1,603 (594-2,612)	224 (83-365)
	Representative Reach	170,513	696,569	735,760	0.54	0.05	2	125,050	826	116
	Estuary	473,014	-	-	0.10	-	2	45,001 (25,699-64,304)	540 (308-772)	76 (43-108)
Middle	Random Transects	110,830	221,760	549,160	0.24	0.01	2	29,732 (2,395-65,813)	1,721 (410-3,032)	123 (16-230)
	Estuary	467,438			0.02	-	2	9,069 (4,662-13,478)	0	-

Table 3. (Cont'd)

Year and 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
88										
rlow	Random Transects	53,100	248,100	54,900	0.58	0.13	4	62,023 (10,463-113,765)	2,804 (472-5,136)	309 (52-566)
	Mark and Recapture	-	-	-	-	-		68,000 (47,900-88,100)	-	-
ron	Random Transects[11]	210,900	1,010,700	724,839	0.99	0.40	4	614,869 372,263-857,475)	5,463 (3,307-7,619)	183 (111-255)
	Mark and Recapture	-	-	-	-	-		321,081 (259,916-382,246)		

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

The density of larvae in type III habitat is 0 for all streams and methods.

[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 that were undergoing transformation that were collected during treatments of 1989 or previous years. The percentage is different for each stream and ranges from 7% for the Middle River to 14% for the Falls and Brule rivers. No data existed to calculate a value for Red Cliff Creek.

[7]The offshore and estuary methods involved the use of a bottom filtration method where SCUBA divers filtered larvae from the bottom sediments and incorporated a random stratified sampling design.

[8]The random transect method is a measurement of the amounts of habitat on randomly selected 5-foot wide transects across the river at 500-foot intervals, and the amounts are expanded to include the unmeasured area.

[9]The representative reach technique divides the river into similar sections based on physical characteristics and habitat and larvae density are measured in representative portions.

[10]The mark and recapture technique involves the use of a simple Petersen formula where larvae are marked and released before a lampricide treatment and recaptured during the treatment. The estimated number of larvae and transformers (83,418) combines separate mark and recapture techniques in the river and estuary.

[11]The number of year classes (4) and the estimated larvae and transformers (614,869) include young-of-the-year larvae.

Canada

Surveys were conducted on 32 Lake Superior tributaries and on one instre lake in preparation for chemical treatments in 1989 and 1990 and to monit re-established, residual and untreated populations. An estimate of larval s lamprey numbers was made for one stream.

Distribution surveys were completed on 10 streams recommended f treatment in 1990. In the Neebing River (Neebing-McIntyre Floodway), t upstream distribution significantly changed from that of recent years. S lamprey larvae were found above a low sheet pile dam that previously function as a barrier to spawning sea lampreys since its construction by the Lakehe Region Conservation Authority in 1968. An additional 13.5 km of strea complicated by several tributaries and numerous beaver impoundments, wi require treatment in 1990.

Treatment evaluation surveys were done on five streams treated in 198 Only the Wolf R ver was found to have significant numbers of residual se lamprey. As a sult of these findings this river has been re-scheduled f treatment in 1990.

Re-establishment surveys were conducted on eight streams treated in 19 and early 1988. All but the Little Carp and Kaministiquia Rivers ha re-established. The Kaministiquia River was once considered to be one of t major producers on the north shore of Lake Superior. However in recent year its production has been steadily declining. A fairly extensive survey in 19 yielded only two larvae, both of which were probably residuals of the la (August 1987) treatment. Continued pollution in the lower river and in Thunde Bay harbour, as well as extremely high water temperatures (30°C plus), may discouraging lamprey production in this large river.

The size of the Pigeon River larval population was estimated conjunction with the 1989 treatment. Two independent estimates were made t days apart. The first was a habitat based pre-treatment estimate using mark larvae in 11 randomly selected survey plots of larval habitat. The plots we surveyed with granular Bayer 73; average densities were calculated; and a who river estimate of 95,900 larvae was extrapolated. The recovery of marked larv was low (0 to 8%) with an average rate of 3.1%.

The second estimate was a Petersen type with 1,000 Bismark Brown mark larvae randomly released throughout the river. During the lampricide treatme six marked and 1,817 unmarked sea lamprey larvae were collected giving calculated estimate of 302,800.

The low numbers of recoveries in both estimates precludes the applicati of confidence limits. Considering the various possible sources of bias a error it is likely the true estimate falls between the two made this year.

Surveys done above the five low-head barrier dams on Lake Superio Stokely, Gimlet and Sheppard Creeks and the Carp and Wolf Rivers, indicate th all blocked the 1988 and 1989 spawning runs of sea lamprey.

Chemical Treatments

United States

A total of 13 tributaries were successfully treated in 1989 (Table 4, Figure 1). The primary difficulty during treatments was low water, which resulted in incomplete treatments of the Potato, Cranberry, and Nemadji rivers and postponement until 1990 of the Traverse and Middle rivers. The Huron River was retreated in 1989 because high water during the 1988 treatment resulted in an unacceptable number of residual larvae. Lampreys were relatively more abundant in the Sucker and Sturgeon rivers than in the other streams.

The Sturgeon River was treated after a one-month delay to examine the effects of TFM on lake sturgeon. Seven toxicity tests were conducted to determine treatment levels lethal to sea lampreys yet tolerated by lake sturgeon. The river was successfully treated and no dead sturgeon were found.

Canada

Chemical treatments were conducted on seven Lake Superior tributaries during the 1989 field season (Table 4, Figure 1).

With the exception of the Pigeon River, an effective TFM block was achieved throughout sea lamprey distributional limits in each system. Thermal stratification prevented TFM mixing in the deeper channelized mouth area of the Pigeon River, a situation observed in previous treatments.

The Cloud and Prairie Rivers were last treated in 1976 and 1972, respectively, but the remaining five rivers have been on a four-year treatment schedule. Larval sea lamprey were abundant in the Pancake River, scarce in the Steel River, and of moderate abundance in the remaining five streams. Non-target fish mortality was negligible in all treated streams.

Treatments of the Pic and Batchawana Rivers were deferred in 1989 because of extremely low water discharge throughout late summer and fall.

Spawning-phase Assessment

United States

Assessment traps placed in 17 tributaries of Lake Superior captured 6,932 spawning-phase sea lampreys (Table 5, Figure 1), about double the 1988 catch (3,459). Trap catches decreased in the Amnicon, Bad, Traverse, and Huron rivers and increased in the other 12 tributaries that were monitored in 1989 (largest increase occurred in the Brule River, from 1,260 to 3,697). Although the catch of lampreys declined in the Bad River (likely due to high water), the estimated number of lampreys in the river was larger than in 1988 (9,300 vs. 7,128). Traps placed in the Otter River (tributary of Sturgeon River) for the first time since 1978 captured no sea lampreys. The average length and weight of lampreys from Lake Superior tributaries was similar to 1988, but the percentage males increased from 33 to 44%. Spawning runs in 10 streams (Amnicon, Middle, Bad, Firesteel, Misery, Traverse, Sturgeon (Otter), Silver, and Huron rivers) were monitored through cooperative agreements with the Great Lakes Indian Fish and Wildlife Commission and in the Brule River through the Wisconsin Department of Natural Resources.

Table 4. Details on the application of lampricides to streams of Lake Superior, 1989. [Number in parentheses corresponds to location of stream in Figure 1. Lampricide use in kilograms/pounds of active ingredient.]

Stream/Lake	Date	Discharge		TFM		Bayer 73 Powder		Bayer 73 Granules		Dist. trea
		m^3/s	f^3/s	kg	lbs	kg	lbs	kg	lbs	km
UNITED STATES										
Cranberry R. (11)	July 20	<0.1	1	48	106	-	-	-	-	1.6
Potato R. (10)	July 21	<0.1	1	73	161	-	-	-	-	1.6
Harlow Cr. (3)	Aug. 2	0.1	2	16	36	-	-	-	-	1.6
Brule R. (12)	Aug. 14	4.5	160	577	1,271	-	-	-	-	9.7
Silver R. (7)	Aug. 27	0.5	17	64	142	-	-	-	-	4.8
Falls R. (8)	Aug. 28	1.3	45	83	184	-	-	-	-	1.6
Sucker R. (1)	Sept. 8	1.6	55	215	475	-	-	-	-	9.7
Sable Cr. (2)	Sept. 10	0.2	7	21	46	-	-	-	-	1.6
Huron R. (6)	Sept. 22	0.3	12	63	138	-	-	-	-	14.5
Sturgeon R. (9)	Sept. 25	8.5	300	1,389	3,061	-	-	-	-	66.0
Nemadji R. (13)	Oct. 9	0.7	25	120	265	-	-	-	-	11.3
Big Garlic R. (5)	Oct. 18	0.4	15	121	266	-	-	-	-	6.4
Little Garlic R. (4)	Oct. 24	0.4	13	73	160	-	-	-	-	8.0
Total		18.6	653	2,863	6,311[a]	-	-	-	-	138.4
CANADA										
W. Davignon Cr. (20)	May 11	0.29	10	25	55	-	-	-	-	5.6
Big Carp R. (19)	June 20	0.33	12	37	82	-	-	0.1	0.2	7.2
Pancake R. (18)	June 27	1.67	59	134	295	-	-	-	-	8.3
Cloud R. (15)	July 7	0.31	11	60	132	-	-	0.1	0.2	7.4
Pigeon R. (14)	July 10	9.93	351	635	1,400	9.4	20.7	-	-	4.9
Prairie R. (17)	July 14	0.96	34	273	602	-	-	0.1	0.2	3.9
Steel R. (16)	July 18	6.77	239	800	1,764	11.9	26.2	-	-	10.1
Total		20.26	716	1,964	4,330	21.3	46.9	0.3	0.6	47.4
GRAND TOTAL		38.86	1,369	4,827	10,641	21.3	46.9	0.3	0.6	185.8

[a]Includes 354 TFM bars (73.9 kg., 163 lbs.) applied in 8 streams.

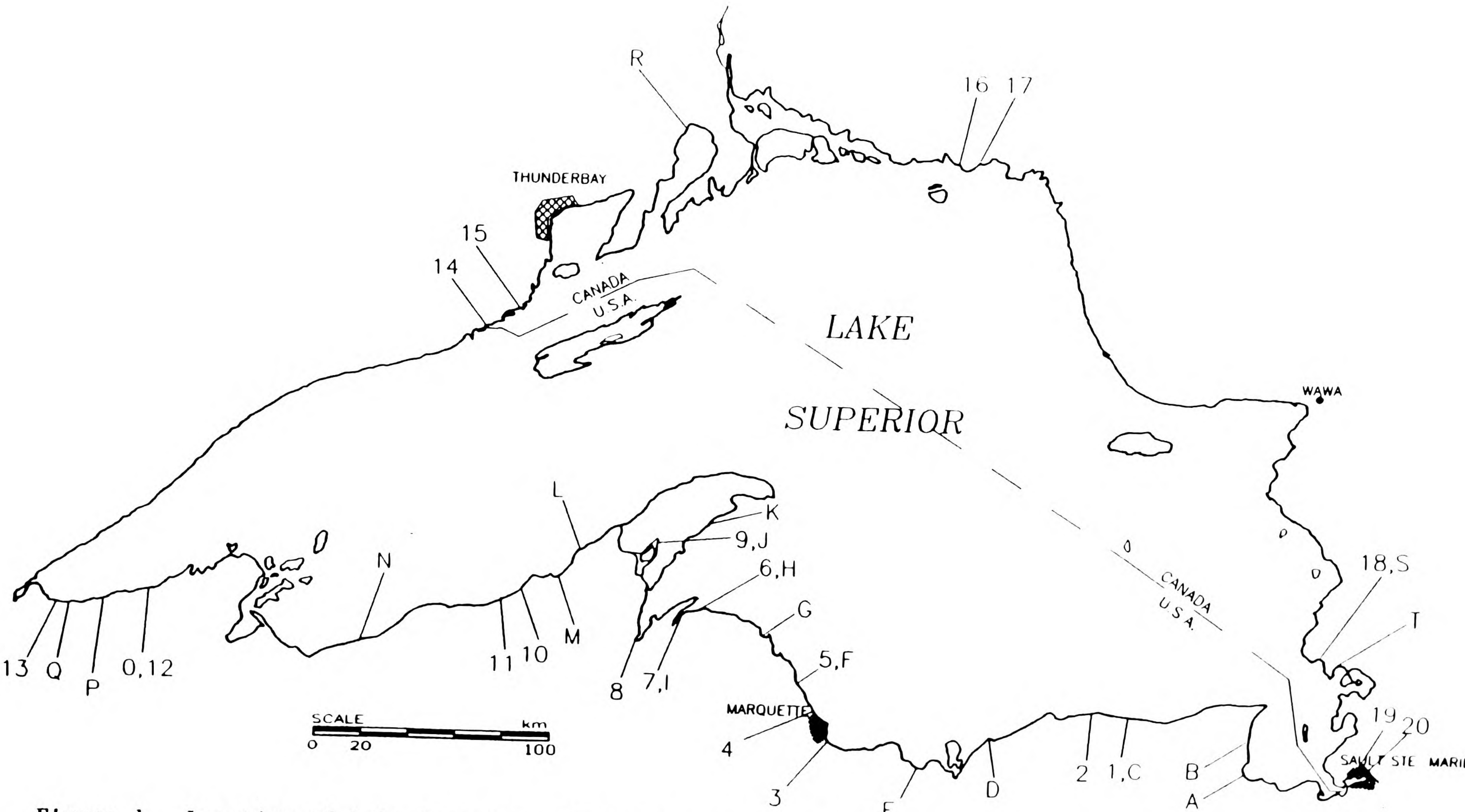

Figure 1. Location of Lake Superior tributaries treated with lampricides (numerals; see Table 4 for names of streams), and of streams where assessment traps were fished (letters; see Table 5 for names of streams) in 1989.

Table 5. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Superior, 1989.

[Letter in parentheses corresponds to location of stream in Figure 1.]

Stream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
UNITED STATES							
Tahquamenon River (A)	490	110	60	452	457	201	220
Betsy River (B)	119	38	53	438	412	194	180
Sucker River (C)	30	1	0	-	314	-	62
Miners River (D)	83	38	50	417	394	188	167
Rock River (E)	1,179	937	43	425	428	173	180
Big Garlic River (F)	65	30	33	420	404	186	156
Iron River (G)	6	0	-	-	-	-	-
Huron River (H)	6	1	0	-	459	-	85
Silver River (I)	6	1	100	508	-	185	1
Sturgeon River (J)							
Otter River	0	0	-	-	-	-	-
Traverse River (K)	10	1	100	430	-	132	-
Misery River (L)	265	66	35	422	416	163	162
Firesteel River (M)	40	1	100	426	-	153	-
Bad River (N)	684	172	27	422	422	153	159
Brule River (O)	3,697	230	47	451	442	207	198
Middle River (P)	249	73	56	423	410	190	193
Amnicon River (Q)	3	2	0	-	457	-	193
Total or average	6,932	1,701	44	431	428	181	179
CANADA							
Carp River (T)	91	0	-	-	-	-	-
Pancake River (S)	4	0	-	-	-	-	-
Wolf River (R)	272	68	50	468	458	237	224
Total or Average	367	68	50	468	458	237	224
GRAND TOTAL OR AVERAGE	**7,299**	**1,769**	**44**	**433**	**429**	**183**	**181**

Spawning-phase Assessment (Continued)

United States

The total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior for the fourth consecutive year. The estimate, based on a significant relation of average stream discharge (x) and the number of adult lampreys that enter tributaries (y), was calculated separately for streams east and west of the Keweenaw Peninsula. In the western waters, an estimated 47,458 lampreys were present ($y=13.50x$; $P<0.01$, $r=0.98$) while 7,574 were estimated ($y=2.36x$; $P<0.05$, $r=0.71$) in the east. The total estimate of 55,032 sea lampreys was calculated using a combined flow of 6,718 ft^3/s (3,516 west and 3,202 east) and compares with an estimated 42,870 sea lampreys in 1988.

Canada

The spawning runs of three Lake Superior tributaries were sampled with trapping devices in 1989 (Table 5, Figure 1). A total of 367 adults were captured.

The start-up of operations was delayed by as much as a month because of extended runoff from heavy winter snows. Higher-than-normal water levels reduced the effectiveness of the partial weir in the Pancake River, resulting in a total catch of only four adults. The Carp River yielded 91 sea lamprey compared to 110 in 1988, but no estimate of the total run was made.

The Wolf River, with a catch of 272, was 66% effective; the total population was estimated to be 398, lower than 1988, when the population was estimated to be 547. The Wolf River sea lamprey population had a high percentage of males (50%) compared to south shore streams.

Parasitic-phase Assessment

United States

A total of 295 parasitic-phase sea lampreys were collected from commercial fishermen in Lake Superior in 1989 (Table 6), compared with 304 taken in 1988. The largest number of sea lampreys were collected from fishermen in statistical district MS-4 (Munising, Michigan, area), similar to the number taken in 1988 (104 in 1988 vs. 107 in 1989). Most lampreys were collected by fishermen using gill nets (87%) during April-June (59%), and primarily were attached to lake trout (61%) and lake whitefish (36%).

Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen. Therefore, lampreys that would spawn in either the present or succeeding two years may be found in the catch. Spawning year was determined for the 295 parasitic-phase sea lampreys captured in 1989 (197 would have spawned in 1989 and 98 in 1990). A total of 334 lampreys of the 1989 spawning year class have been collected (137 in 1988 and 197 in 1989), and represent an increase when compared to the number of the 1988 spawning year class (273) captured by commercial fishermen.

Parasitic-phase Assessment (Continued)

United States

Sport anglers in Lake Superior captured 32 parasitic-phase sea lampreys 1989 (Table 6), compared to 75 in 1988. The compilation of the data that yiel the number of sea lampreys attached per 100 lake trout and chinook salmon incomplete at the time of this report.

Table 6. Number of parasitic-phase sea lampreys collected in commercial a sport fisheries in U.S. waters of the Upper Great Lakes in 1989.

Lake Superior

District	Spawning year[a] Commercial 1989	Commercial 1990	Sport 1990
M-1	-	-	5
M-2	4	1	1
M-3	2	1	0
Wis.	38	26	11
MS-1	-	-	-
MS-2	-	-	5
MS-3	44	6	-
MS-4	65	42	9
MS-5	43	1	-
MS-6	1	21	1
Total	197	98	32

Lake Michigan

District	Spawning year[a] Commercial 1989	Commercial 1990	Sport 1990
MM-1	30	19	-
MM-2	-	-	-
MM-3	1	33	11
MM-4	-	-	7
MM-5	-	-	33
MM-6	-	-	53
MM-7	0	116	23
MM-8	-	-	53
WM-1	-	-	-
WM-2	4	23	10
WM-3	13	18	32
WM-4	29	2	71
WM-5	0	10	66
WM-6	-	-	11
Ill.	-	-	11
Ind.	-	-	2
Total	77	221	383

Lake Huron

District	Spawning year[a] Commercial 1989	Commercial 1990	Sport 1990
MH-1	34	1,038	30[illegible]
MH-2	1	112	59[illegible]
MH-3	-	-	44[illegible]
MH-4	20	90	21[illegible]
MH-5	-	-	10[illegible]
MH-6	-	-	2[illegible]
Total	55	1,240	1,700

[a]Parasitic sea lampreys are collected throughout the year from commercial fishermen; therefore, lampreys that would spawn in either the present or succeeding years may be found in the catch. Those lampreys taken in the sportfishery are collected primarily in the summer when only lampreys that would spawn the following year are present.

Biological Studies

Canada

The numbers of larval sea lamprey in the Pancake River were estimated, utilizing a random site selection criteria and the depletion estimate of larval densities at each site, adjusted by comparison to observed densities during lampricide treatment.

A total of 16 days were spent electrofishing the river prior to the June 29 lampricide treatment. A total of 730,000 larvae were estimated to be present in the river, 71% being sea lamprey. From the treatment collection of 1,154 sea lamprey ammocoetes, only 2.7% were larger than 120 mm. Three of the sites sampled by electrofishing for the population estimate had prime larval habitat confined using fyke nets and were sampled using hand nets during chemical treatment. The densities estimated using electrofishers were 2.2, 3.0, and 5.7 per square meter, averaging 3.5 per meter of suitable habitat. During treatment these sites yielded 2.9, 23.0, and 18.6 ammocoetes per square meter, averaging 12.9 per square meter.

Barrier Dams

Canada

Five low-head sea lamprey barrier dams on Lake Superior were maintained. Preliminary hydrology studies, and a design proposal were completed for a proposed low-head barrier and fishway on the Cypress River.

LAKE MICHIGAN

Larval Assessment

United States

A total of 195 Lake Michigan tributaries and 4 offshore areas were surveyed in 1989. Sea lampreys are present in 52 streams, and larvae of the 1989 year class were detected in 28 of 80 of the surveyed index streams. Surveys to determine reestablishment of sea lamprey larvae showed no evidence of recruitment in 27 streams since their last chemical treatment. Pretreatment investigations were conducted on 25 streams; 7 were treated in 1989 and 9 are scheduled for treatment in 1990. The remaining nine were deferred for treatment in 1991.

Posttreatment surveys were completed on six streams to evaluate the effectiveness of recent treatments. The Muskegon River has many springs and rivulets that offer refuge to larvae and hinder effective treatment of the system. A total of 561 residual larvae were collected from the river in 11 hours of electrofishing. Small numbers of residual larvae also were recovered from the Galien and Ogontz rivers while none were found in Gulliver Lake Outlet or the Rapid and Tacoosh rivers.

Surveys were conducted on Haymeadow Creek (Whitefish River) and the Jordan and Pere Marquette rivers to evaluate the effectiveness of electric barriers operated during 1989 by the Michigan Department of Natural Resources. Larvae of the 1989 year class were present upstream of each barrier. The presence of the

1989 year class reveals that the barriers were not effective in blocking a
migrant adult lampreys. Young-of-the-year larvae also were found downstream
the barriers on the Jordan and Pere Marquette rivers.

Sea lampreys were collected in the upper Manistique and Rabbit (Kalamazo
rivers and Casco (Kewaunee River) and Mitchell creeks. The flume on t
Manistique River that serves Manistique Paper Co. has gradually deteriorate
Some movement of lampreys into the upper River probably has occurred annual
for several years. This situation may worsen in the future as the compa
apparently has no plans to repair or upgrade the flume. A small population
transformers and large larvae was detected in the upper Rabbit River, a stre
last treated in 1981. Sea lampreys were found for the first time in Casc
Creek, but the population is small with no evidence of recent recruitment.
barrier dam currently under construction on the Kewaunee River will preve
future recruitment to the upper river and Casco Creek. A few larvae >120
were found in Mitchell Creek during surveys in early May and necessitate
treatment of the stream in 1989.

Bear River enters Lake Michigan through Petoskey Harbor. The harbor wa
commercially dredged in 1989 and 10 sea lampreys were found in the sedimen
taken from a small area in the harbor. A subsequent survey in the harbor usi
Bayer 73 granules and an electric deep-water shocker yielded 1 larva although
were observed caught by sea gulls. A few larvae and transformers were collect
during surveys in Lake Charlevoix off the mouths of the Boyne River and Port
Creek. No sea lampreys were recovered in Elk Lake Outlet during surveys with t
deep-water bottom shocker.

A plan to examine all tributaries to Lake Michigan that previously had
past history of sea lamprey infestation was begun in 1989, and 108 streams we
surveyed. No sea lampreys were found in any of the streams, but about hal
appeared to have suitable habitat.

The population of larval lampreys was estimated by habitat-based techniqu
for Gurney Creek. Habitat distribution was determined by 31 random transec
over 1,395 m (4,576 ft.) of stream, and lamprey density was determined
depletion samples. An estimated 177 sea and 5,352 American brook lampreys we
present. Sea lampreys were found within 500 m (1,640 ft.) of Lake Michigan.

Chemical Treatment

United States

Chemical treatments were completed on 11 streams (Table 7, Figure 2
Larvae were abundant in the Whitefish, Sturgeon, and Fishdam rivers, common
the other streams. Mortality of nontarget fish was low on all treatment
Bayer 73 wettable powder was used with TFM to reduce costs on the Manistiqu
Boyne, and Muskegon rivers. The poor quality of the (PEG)-TFM formulati
plagued chemical applicators throughout the field season. Many additional wo
hours were required to dilute the compound before use and remove sludge whi
accumulated on the bottom of the containers.

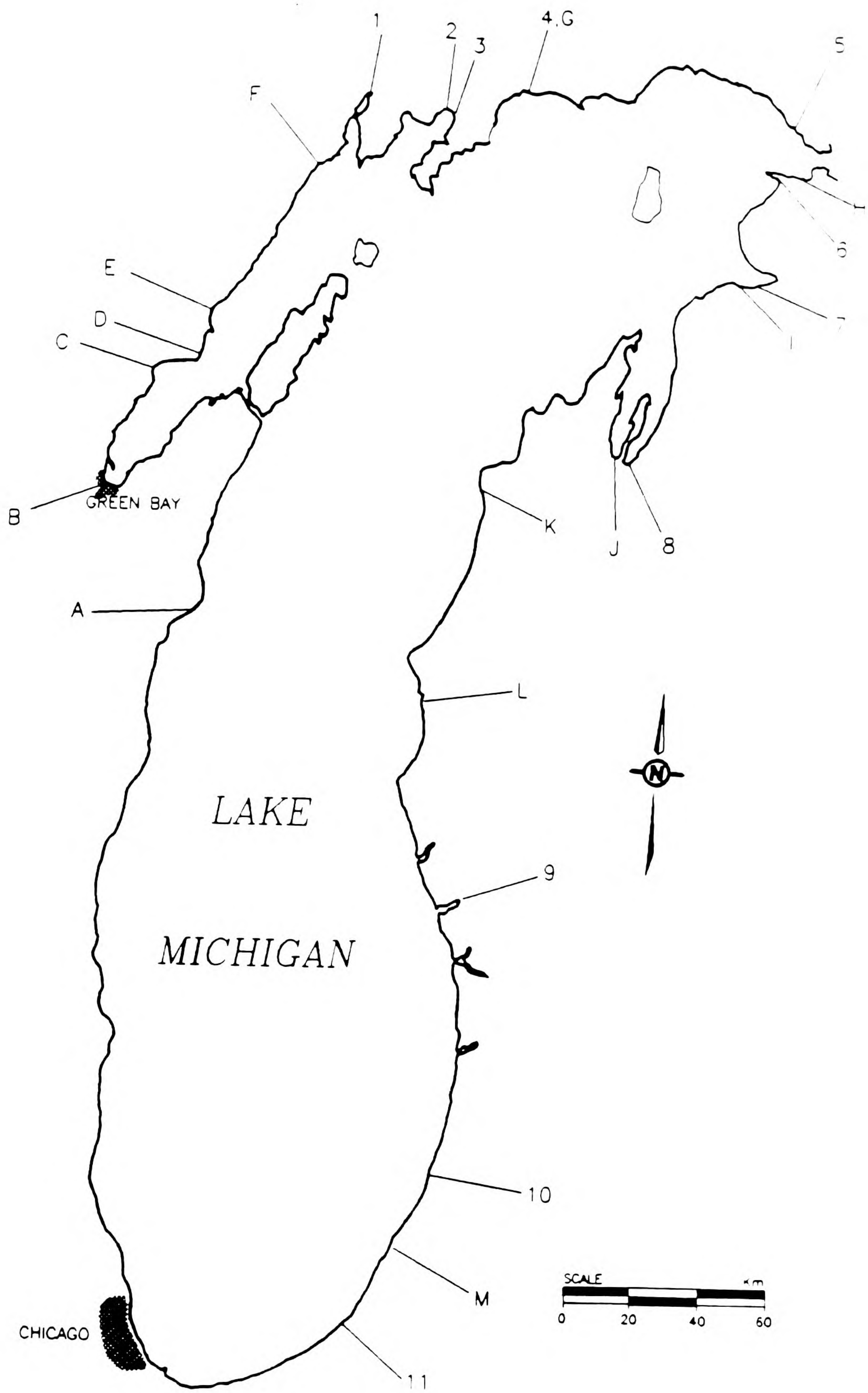

Figure 2. Location of Lake Michigan tributaries treated with lampricides (numerals; see Table 7 for stream names), and of streams where assessment traps were fished (letters; see Table 8 for stream names) in 1989.

Chemical Treatment (Continued)

Several conditions altered lampricide treatments during the field season. Treatment of the East Branch of the Whitefish River was postponed until 1990 to avoid interference with the completion of a long-term study of the effects of lampricides on the Hexagenia mayfly. Treatments of Hudson and Swan creeks were deferred because of low water. Hudson Creek was rescheduled to 1990 and Swan Creek was deferred indefinitely because of low numbers of sea lamprey larvae. The Boyne River was retreated in 1989 (previously treated in 1988) because of a large number of residual larvae in Lake Charlevoix. The treatment schedule of this river was upgraded to annual treatments to reduce recruitment of larvae to the lentic areas.

A remote sensing device was deployed in several rivers to record diurnal fluctuations in oxygen, pH, conductivity, and temperature. Some diurnal pH and oxygen fluctuations occurred on most streams but not enough to cause alteration of treatment plans or results.

Table 7. Details on the application of lampricides to streams of Lake Michigan, 1989.
[Number in parentheses corresponds to location of stream in Figure 2. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge m3/s	Discharge f3/s	TFM kg	TFM lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	Distance treated km	Distance treated miles
Galien R. (11)									
South Branch	Apr. 29	1.8	64	462	1,019	-	-	20.9	13
Brevort R. (5)	May 8	3.9	140	407	897	-	-	14.5	9
Black R. (10)									
Middle Branch	May 10	1.7	60	378	833	-	-	19.3	12
Big Sucker Cr. (6)	May 20	0.2	8	35	78	-	-	4.8	3
Whitefish R. (1)									
Pole Cr.	June 17	1.4	49	104	230	-	-	3.2	2
Bills Cr.	June 18	0.8	30	47	104	-	-	4.8	3
Haymeadow Cr.	June 19	1.4	50	106	234	-	-	11.3	7
Mainstream	June 28	10.6	380	2,256	4,974	-	-	48.3	30
Mitchell Cr. (8)	June 28	0.3	11	123	271	-	-	6.4	4
Sturgeon R. (2)	July 9	3.8	135	801	1,766	-	-	96.6	60
Muskegon R. (9)	July 21	40.3	1,440	7,668	16,905	44.0	97.1	101.4	63
Boyne R. (7)	Aug. 11	2.0	70	376	828	4.1	9.1	6.4	4
Manistique R. (4)									
Weston Cr.	Aug. 11	1.8	65	417	920	-	-	1.6	1
Mainstream	Aug. 24	30.8	1,100	2,660	5,865	23.0	50.8	1.6	1
Fishdam R. (3)	Aug. 13	0.6	20	159	351	-	-	30.6	19
Total		101.4	3,622	15,999	35,275[a]	71.1	157.0	371.7	231

[a] Includes 542 TFM bars (113.3 kg, 249.3 lbs.) applied in 4 streams.

Spawning-phase Assessment

United States

A total of 17,094 sea lampreys were captured in assessment traps placed in seven west shore and six east shore tributaries of Lake Michigan in 1989 (Table 8, Figure 2), about the same as the number taken in 1988 (16,776). The percentage males in samples from Lake Michigan tributaries increased slightly over 1988 (from 40 to 44%), whereas the average length and weight (sexes combined) was similar.

Catches of sea lampreys decreased in most of the west shore tributaries. The largest decreases occurred in the Manistique (15,223 vs. 14,323) and Peshtigo (580 vs. 48) rivers. The smaller number taken at the powerhouse in the Peshtigo River may have been due to construction of horizontal steel racks over the entrance to the turbine draft tubes designed to prevent injury to spawning lake sturgeon; the activity delayed placement of traps until after the peak period of the lamprey spawning run. A stratified mark and recovery system used for the sixth consecutive year to estimate the number of spawning-phase sea lampreys in the Manistique River indicated a smaller spawning population in the river than in 1988 (20,293 vs. 18,769). No sea lampreys were captured in the Fox River (eleventh consecutive year) and a trap placed in the Oconto River for the first time since 1980 captured 17 lampreys.

The total catch of sea lampreys in streams along the east shore of Lake Michigan increased significantly from 1988 (from 834 to 2,599). Catch of lampreys increased in each tributary; the largest increase occurred in the Carp Lake River (from 378 to 1,379). Assessment traps and hoop-fyke nets placed below the experimental electric barrier operated by the Michigan Department of Natural Resources in the Pere Marquette River captured 296 sea lampreys. An estimated 1,387 (95% confidence intervals; 389, 4,886) adult lampreys were at the weir during the assessment period.

Parasitic-phase Assessment

United States

Lake Michigan commercial fishermen captured 298 parasitic-phase sea lampreys in 1989 (Table 6), compared with 280 in 1988. Of the total, 222 were collected from Lake Michigan and 76 from Green Bay, compared with 184 and 96 respectively in 1988. Most lampreys were collected by trapnet fishermen (65%) during May-July (76%) and the lampreys primarily were attached to lake trout (67%) and lake whitefish (24%).

Spawning year was determined for the 298 parasitic-phase sea lampreys. Of these, 77 would have spawned in 1989, and 221 in 1990. A total of 249 of the 1989 spawning year class has been collected (172 in 1988 and 77 in 1989) and represents a decrease when compared to the number of the 1988 spawning year class (328) captured by commercial fishermen.

Sport anglers in Lake Michigan captured 383 parasitic-phase sea lampreys in 1989 (Table 6), compared to 351 in 1988. The compilation of the data that yields the number of sea lampreys attached per 100 lake trout and chinook salmon was incomplete at the time of this report.

Table 8. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1989. [Letter in parentheses corresponds to location of stream in Figure 2.]

Stream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
West Shore							
East Twin River (A)	9	4	25	505	518	229	234
Fox River (B)	0	0	-	-	-	-	-
Oconto River (C)	17	17	59	497	481	294	281
Peshtigo River (D)	48	48	52	499	510	283	304
Menominee River (E)	39	39	62	488	492	269	308
Ford River (F)	59	58	31	489	496	270	292
Manistique River (G)	14,323	1,125	43	482	480	260	267
East Shore							
Carp Lake River (H)	1,379	136	43	462	463	222	219
Jordan River (I)							
Deer Creek	89	88	26	502	500	292	290
Boardman River (J)	55	55	44	483	487	264	268
Betsie River (K)	370	345	40	484	485	249	259
Pere Marquette River (L)	296	59	53	474	498	265	276
St. Joseph River (M)	410	410	48	494	498	258	268
Total or average	17,094	2,384	44	485	486	258	266

LAKE HURON

Larval Assessment

United States

A total of 143 Lake Huron tributaries were surveyed to determine distribution of larval sea lampreys, search for newly-infested streams, prepare streams for chemical treatments, and assess annual recruitment and residual populations. Sea lampreys are present in 29 streams, and young-of-the-year larvae were found in 15 streams. Pretreatment investigations were completed on 16 streams; 4 were treated in 1989 and the others either are scheduled for treatment in 1990-91 or postponed indefinitely. Posttreatment surveys recovered a few larvae in Laperell Creek and the Sturgeon (Cheboygan), Ocqueoc, Trout, Tawas, AuGres, and Chippewa (Saginaw) rivers, but not enough to warrant retreatment. Two larvae were collected 2.1 km (1.3 miles) south and 1.6 km (1 mile) offshore of the Au Sable River. No young-of-the-year sea lampreys were found upstream of the electric barrier on the Ocqueoc River or the barrier dam on East Au Gres River.

Over 200 tributaries to Lake Huron in the Lower Peninsula of Michigan have no history of sea lamprey infestation. Surveys of 87 of these tributaries from the Mackinac Bridge south to Saginaw Bay produced no new infestations. Some of these streams appeared to have the proper environmental conditions for sea lamprey production, and periodically will be reexamined. The remainder of the more than 100 streams will be examined over the next three years.

An experimental device to sample larvae in deep-water areas was tested in the Au Sable River. The device combines an electrofishing unit and submersible pump mounted on a sled with a base of about 3 x 3 feet. The sled is towed behind a boat and as larvae are irritated out of the sediments by the electrofishing unit, they are drawn into a collection bag by the suction pump. The device was 40-60% efficient in tests using marked larvae in predetermined transects. Further tests will determine optimum voltage gradient and towing speed.

Habitat-based techniques were used to estimate a population including 368 larval and 31 transforming sea lampreys in Mulligan Creek. Habitat distribution was determined by 36 random transects (6 m, 19.7 feet width) over 1,656.3 m (5,434 feet) of stream, and lamprey density was determined by depletion samples. Larvae were found in only eight of the transects and about 13% of the stream length was sampled.

Surveys continued in 1989 to monitor populations of larval sea lampreys in the St. Marys River. A total of 14 index locations of 0.2 ha (0.5 acre) each were surveyed with Bayer 73 granules and 811 larval and 8 transforming sea lampreys were collected. Many larval lampreys remain in the side channels of the Little Rapids Cut following the 1988 TFM survey of the area.

A larval growth and transformation study in the St. Marys River continued in 1989. Cages placed in the river in spring 1988 with Age 0 and larvae >120 mm were raised in September 1988, and May and September 1989. The larvae were measured, transformers removed, and the cages and remaining larvae returned to the river. Mortality averaged 87% for the age 0 larvae and 33% for larvae >120 mm during the initial 17 months of the study. From May to September 1988, transformation of larvae >120 mm was 42% and from May to September 1989 the rate was 22% (11 of 50). Prediction of the incremental growth of larvae in their first year was inconclusive because of low survival. Additional larvae (Age I) were added to the cages prior to replacement in the river.

Fyke netting in the St. Marys River to capture emigrating parasitic-phase lampreys continued in fall 1989. Nets were installed on October 11 and removed on November 17. The nets were set in the Middle Neebish (7 locations) and Munuscong (12 locations) channels and 143 transformed lampreys were netted from 18 of 19 locations. Nets fished at the same locations in 1988 captured 132 lampreys. After adjustment for the difference in hours fished (nets in 1988 were set October 27), the catch rates (lampreys/hour) for both years were similar.

During October 18-November 14, recently transformed sea lampreys were captured in the St. Marys River by trawling. The objective was to determine the number of lampreys migrating through the Munuscong Channel and correlate the migration with catch in fyke nets during the same period. A total of 114 lampreys were caught in 207 tows for an average of 0.6 lampreys/tow, similar to a rate of 0.7 lampreys/tow in 1988. Trawling was effective in sampling downstream migrants in the St. Marys River, and can be an integral tool to assess future control techniques in the river system. The Hammond Bay Biological Station has prepared a detailed report of the study.

Larval Assessment (Continued)

Canada

Surveys were conducted on 36 Lake Huron tributaries in preparation for chemical treatments in 1989 and 1990, to monitor re-established, residual and untreated populations and to look for new infestations.

Distribution surveys were completed on three streams scheduled for treatment in 1989 and on six streams recommended for treatment in 1990. The Rydal Bank Dam on the Thessalon River, at the outlet of Ottertail Lake, has failed to block spawning sea lamprey since 1983 and an additional 39.2 km of stream requires treatment in 1990. Prior to treatment, the Rydal Dam will be examined for structural deficiencies and remedial repairs will be undertaken if feasible.

Treatment evaluation surveys done on all eight streams treated in 1988 found no significant numbers of residual sea lamprey larvae. Four of the streams, Naiscoot, Magnetewan and lower Thessalon Rivers and Gordon Creek have reestablished with the 1988 year class of larvae.

Routine surveys of the Nottawasaga River in southern Georgian Bay discovered several year classes of sea lamprey larvae in a tributary, the Pine River, and immediately downstream of the confluence. No larval sea lamprey had been found within the large Nottawasaga system since the 1976 treatment of another tributary, the Mad River. A 23.2 km section of the Pine River is scheduled for treatment in 1990. No other new populations were found on Lake Huron in 1989.

Twenty-seven index sites on the St. Marys River were surveyed with granular Bayer in 1989. The upstream distribution of sea lamprey larvae appears unchanged, whereas there has been a slight extension of the downstream distribution in the St. Joseph Channel. Analysis of the catch data for eight index stations located between St. Marys Rapids and Lake George and surveyed in each of the last four years suggests a stable population in this "high density" area (Figure 3).

Surveys conducted upstream of the low-head barrier dams on the Echo and Still Rivers indicate that both were effective in blocking the 1988 and 1989 spawning runs. Low-head dams on two other Lake Huron streams, the Sturgeon and Koshkawong Rivers, have been effective at blocking sea lamprey spawning runs; these streams were treated from the dams in 1989.

Observation and collection of lamprey larvae during the Spanish River treatment supported the contention that the findings of surveys conducted prior to treatment using granular Bayer 73 did not identify the high densities of sea lamprey larvae, nor the older year classes. It appears that organic substances were present that decreased the efficacy of Bayer 73.

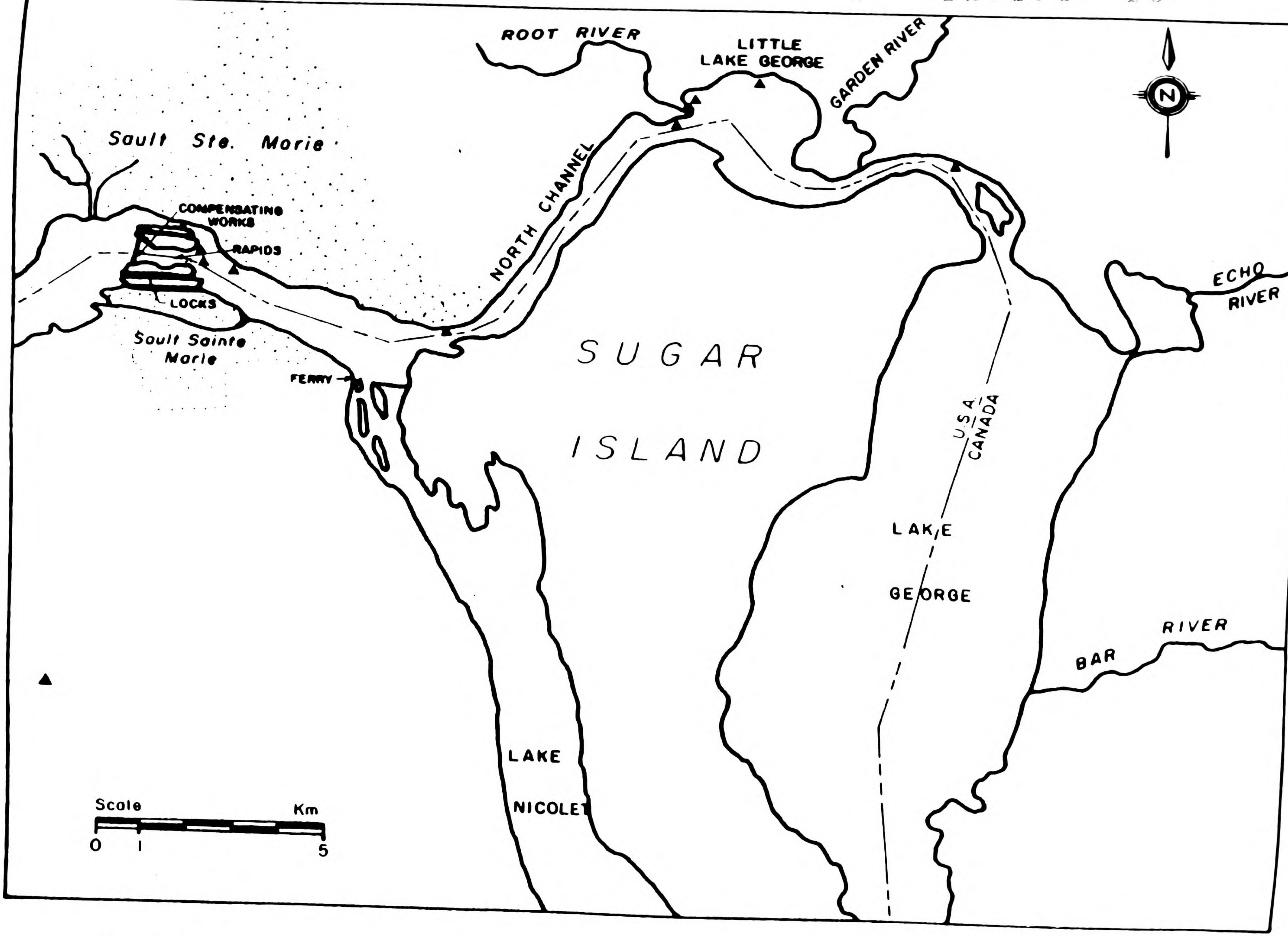

Figure 3. Map of St. Marys River (central section) showing the approximate location of eight index stations that have been surveyed in each of the last four years.

Chemical Treatment

United States

Chemical treatments were completed on nine streams and one pond (Table 9, Figure 4) with a combined discharge of 32.9 m^3/s (1,176 f^3/s). Sediment and viscosity problems associated with the Poly-ethylene glycol (PEG)-TFM formulation occurred during most treatments. Sea lamprey larvae were abundant in Trout Creek and the Rifle and Maple (Cheboygan River) rivers. Lamprey were common to scarce in the remainder of the streams. The mainstream of the Au Gres River was deferred from treatment because of unacceptable alkalinity and pH measurements and low water levels; the tributaries Cedar and Porterfield creeks were treated. Treatments of the Devils and Black rivers were deferred due to low water. The Au Gres and Devils rivers are rescheduled for treatment in 1990, but the Black River was deferred indefinitely due to low numbers of lamprey larvae.

Treatments of the Pine and Rifle rivers presented other problems in 1989. Many lampricide application sites, separate treatment of individual tributaries, and beaver impoundments caused treatment of these systems to be labor intensive. A flood in 1985 destroyed the Flowage Lake Dam on the West Branch of the Rifle River and larvae were found several miles upstream of the site.

Nontarget mortality to fish was negligible in all treatments except for brown trout in Silver Creek (Rifle River). The affected area was limited to 900 feet (.27 km) immediately downstream of the application point. About 500 fingerling brown trout were stocked by the Michigan Department of Natural Resources in the area shortly after treatment.

Canada

Ten Lake Huron streams (five North Channel, two main basin and three Georgian Bay) were treated with lampricide in 1989 (Table 9, Figure 4). Watson Creek, a small North Channel tributary situated on St. Joseph Island, was not treated due to inadequate discharge. All treatments were highly successful except for a portion of Grassy Creek, tributary to the Serpent River. Larval sea lamprey were abundant in the Spanish, Wanapitei, and Chikanishing Rivers and Timber Bay Creek, and moderate in the remainder. All treatments experienced insignificant mortality of non-target fish, with the exception of a portion of the aforementioned Grassy Creek, where there was a high mortality of dace, suckers, darters and shiners. A low discharge and rapid re-building of breached dams by beaver caused a loading of TFM in some of the impounded areas of the stream.

By far the most significant lampricide treatment of 1989 was that of the very large (52 km treated) Spanish River system. This river had not been treated in its entirety since 1972, but its major tributary, the Aux Sables River has regularly required treatment. Prior to the late 1970's, the potential for sea lamprey production in the main river was limited by severe pollution from a paper mill in Espanola. During the late 1970's and early 1980's, this mill, E. B. Eddy Forest Products, began significant pollution abatement. In 1983, following a spill which caused considerable fish mortality, and probably lamprey mortality, additional pollution abatement measures were initiated by this paper mill. Surveys since 1984 verified improving water and habitat quality and a gradually expanding larval sea lamprey population in the main river.

Table 9. Details on the application of lampricides to streams of Lake Huron, 1989. [Number in parentheses corresponds to location of stream in Figure 4. Lampricides used are in kilograms/pounds of active ingredient.]

Stream/Lake	Date	Discharge m^3/s	Discharge f^3/s	TFM kg	TFM lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	Bayer 73 Granules kg	Bayer 73 Granules lbs	Distance treated km	Distance treated mi
UNITED STATES											
Pine R. (8)											
Bear Cr.	May 6	0.4	4	78	172	-	-	-	-	12.9	8
Black Cr.	May 8	0.7	25	39	87	-	-	-	-	6.4	4
North Branch	May 10	0.8	30	22	48	-	-	-	-	8.1	5
Mainstream	June 4	4.8	170	684	1,508	-	-	-	-	112.7	70
Carp R. (7)	May 20	5.0	180	1,335	2,943	-	-	-	-	96.6	60
Cheboygan R. (6)											
Meyers Cr.	May 22	0.2	7	46	101	-	-	-	-	1.6	1
Laperell Cr.	May 23	0.1	4	24	53	-	-	-	-	1.6	1
Maple R.	June 6	3.6	130	438	966	5.7	12.6	-	-	11.3	7
Pigeon R.	June 16	7.0	250	2,063	4,547	8.8	19.3	-	-	53.1	33
Schmidt Cr. (5)	June 4	0.3	9	70	154	-	-	-	-	1.6	1
Trout R. (4)	June 21	0.8	27	205	453	-	-	-	-	3.2	2
AuGres R. (2)											
Cedar/Porterfield Crs.	July 8	0.1	4	16	35	-	-	-	-	1.6	1
Tawas R. (3)											
(Trout Pond)	Aug. 16	-	N/A	7	15	-	-	-	-	-	N/A
Rifle R. (1)	Aug. 25	9.0	320	3,546	7,818	7.5	16.6	-	-	177.1	110
Trout Cr. (9)	Aug. 27	0.1	1	5	12	-	-	-	-	1.6	1
Albany Cr. (10)	Aug. 29	0.1	5	67	148	-	-	-	-	4.8	3
Total		32.9	1,176	8,645	19,060[a]	22.0	48.5	-	-	494.3	307
CANADA											
Mindemoya R. (16)	June 21	1.34	47	291	641	-	-	-	-	3.7	2.3
Timber Bay Cr. (17)	June 22	0.08	3	39	86	-	-	-	-	1.7	1.1
Chikanishing R. (18)	June 25	0.43	15	13	29	-	-	-	-	1.4	0.9
Sucker Cr. (13)	June 27	0.06	2	15	33	-	-	-	-	0.8	0.5
Richardson Cr. (11)	June 28	0.11	4	36	79	-	-	-	-	2.6	1.6
Koshkawong R. (12)	June 29	0.20	7	36	79	-	-	-	-	1.6	1.0
Serpent R. (14)	July 11	9.41	332	329	725	-	-	-	-	11.5	7.1
Wanapitei R. (19)	July 19	16.79	593	852	1,878	12.6	27.8	-	-	6.2	3.8
Spanish R. (15)	July 25	68.10	2,405	6,285	13,856	-	-	-	-	66.1	41.1
Sturgeon R. (20)	Aug. 22	0.56	20	173	381	-	-	-	-	1.5	0.9
Total		97.08	3,428	8,069	17,787	12.6	27.8	-	-	97.1	60.3
GRAND TOTALS		**129.98**	**4,604**	**16,714**	**36,847**	**34.6**	**76.3**	-	-	**591.4**	**367.3**

[a]Includes 576 TFM bars (120.5 kg, 265 lbs.) applied in 4 streams.

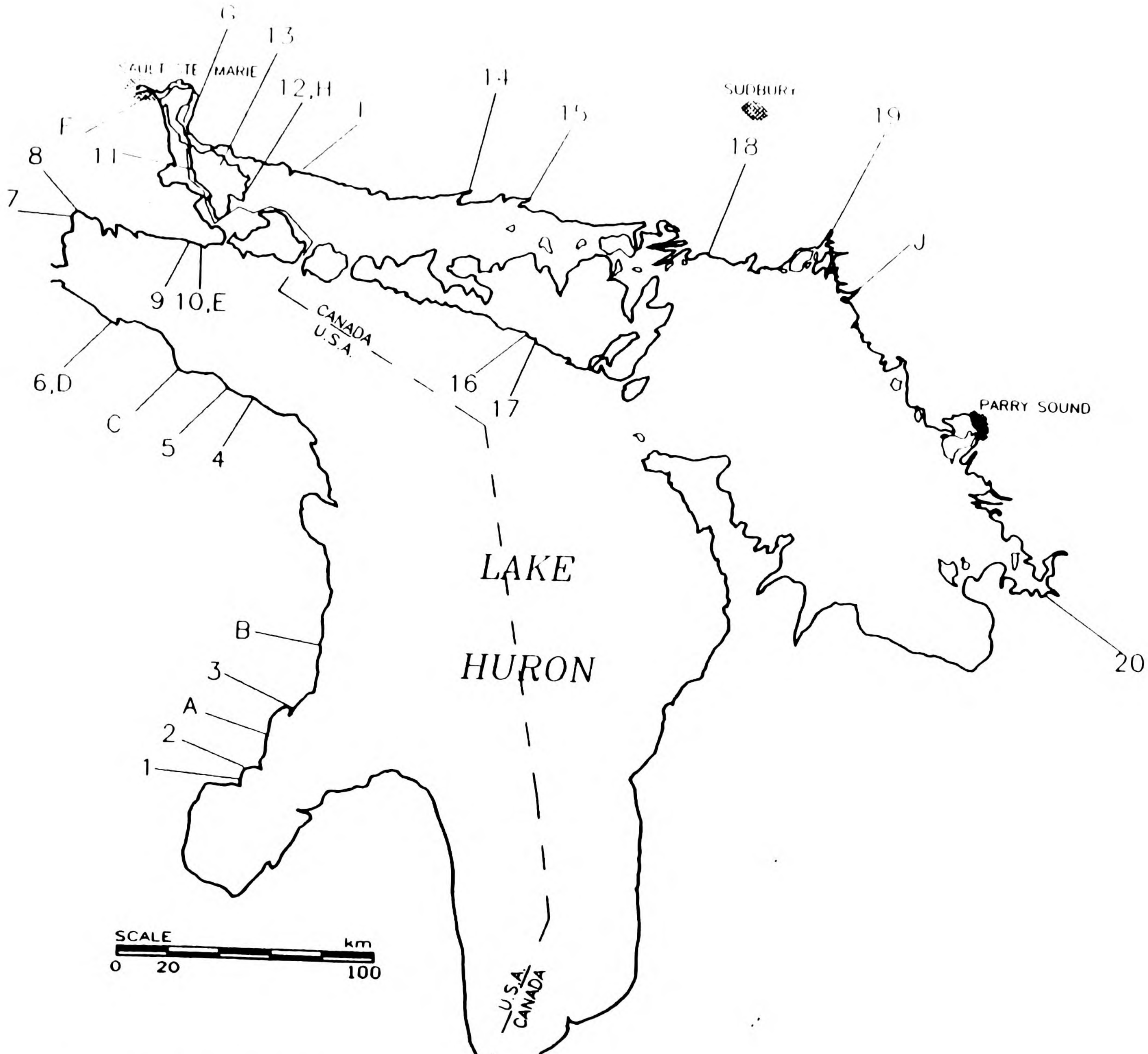

Figure 4. Location of Lake Huron tributaries treated with lampricides (numerals; see Table 9 for names of streams), and of streams where assessment traps were fished (letters; see Table 10 for names of streams) in 1989.

Chemical Treatment (Continued)

Canada

Originally scheduled for treatment in 1986, it was deferred that year because of excessive discharge. Treatment was deferred since 1986 because the charges against E. B. Eddy for the 1983 fish kill were not resolved until February, 1988. This did not allow for the scheduling of this large treatment until fiscal year 1989.

The 1989 treatment involved an intensive effort by an expanded treatment unit. Thanks to a steady controlled discharge of 55 m^3/s (1,950 f^3/s) at Espanola, provided by INCO Ltd., and permission to access E. B. Eddy's plant facilities to apply lampricide, a smooth treatment resulted. The main block of lampricide passed intact through the large estuary six days after initial application. Birch Creek, because of its complexity, was treated separately, whereas the Aux Sables tributary was treated coincidentally. La Cloche Creek was not treated due to low flow and beaver impoundments.

Larval sea lamprey were extremely abundant throughout the entire 66 km of treated stream, with large numbers of animals in stages of transformation. Some of the apparent recent upswing in the number of parasitic phase sea lampreys in the North Channel may be a result of escapement from this large producer. It is likely that the Spanish River will now revert to a normal four to five year treatment cycle, because of its obviously improved ability to produce large numbers of sea lamprey.

Spawning-phase Assessment

United States

During the 1989 spawning season, 30,604 sea lampreys were captured in assessment traps placed in six tributaries of Lake Huron (Table 10, Figure 4), compared to 29,067 in 1988. The increased catch largely is due to a 10% increase in the catch of lampreys in the Cheboygan River (25,411 in 1988 vs. 28,224 in 1989.) A stratified mark and recovery system used to estimate the number of spawning-phase sea lampreys in the river (sixth consecutive year) indicated that lampreys were slightly more abundant than in 1988. An estimated 38,907 sea lampreys comprised the spawning run in 1989 compared to 36,645 in 1988; trap efficiency has remained at about 70% during the past three years. Catches of lampreys declined slightly in Albany Creek and the Au Sable River by 24 and 27 lampreys, respectively. The catch of lampreys in the St. Marys River increased from 698 in 1988 to 1,622 in 1989 primarily because intermittent stream discharges in the powerhouse tailrace that lowered trap efficiency in 1988 did not occur in 1989. A population estimate conducted in cooperation with the Department of Fisheries and Oceans, Canada, indicated an increase in the estimated number of spawning-phase sea lampreys present in the river compared to 1988 (21,224 in 1988 vs. 26,919 in 1989). A hoop fyke net was operated downstream of an electric weir (Smith-Root) for the third consecutive year in the Ocqueoc River and captured 530 sea lampreys, a significant reduction from 2,771 lampreys taken in 1988. The average length and weight of sea lampreys sampled from Lake Huron tributaries in 1989 remained about the same as those taken in 1988 whereas the percentage males in the sample decreased from 51 to 47%.

Spawning-phase Assessment (Continued)

Canada

Five Lake Huron streams were trapped during the 1989 season, resulting in the capture of 15,776 adult spawners (Table 10, Figure 4). The Still River failed to yield any adults this year. Trapping efficiency was compromised when low stream flows left the trap entrance above the stream level.

The St. Marys River operation yielded 10,154 adults, the largest catch to date. The Echo River count, down 27% from 1988, was still higher than any of the annual catches made from 1966 to 1971 at the former electric barrier. The Thessalon River equalled its record high for the previous ten years (set in 1985), and the Koshkawong River provided its second highest count in 22 years.

Trap efficiencies and population estimates were:

St. Marys River	37.2% - 26,919
Echo River	23.4% - 1,684
Koshkawong River	41.7% - 1,052
Thessalon River	26.7% - 14,627

Table 10. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1989. [Letter in parentheses corresponds to location of stream in Figure 4.]

Stream	Number	Number captured	Percent sampled	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
UNITED STATES							
St. Marys River (F)	1,622	657	52	472	476	259	268
East Au Gres River (A)	100	98	40	455	457	224	229
Au Sable River (B)	76	67	48	450	436	238	211
Ocqueoc River (C)	530	48	40	462	454	210	196
Cheboygan River (D)	28,224	778	43	472	477	216	232
Albany Creek (E)	52	51	47	451	449	193	203
Total or average	30,604	1,699	47	469	472	235	241
CANADA							
St. Marys River (F)	10,154	1,420	60	486	489	249	261
Echo River (G)	644	103	53	485	493	242	263
Koshkawong River (H)	547	137	45	480	468	233	228
Thessalon River (I)	4,431	1,129	57	496	501	256	27
Still River (J)	0						
Total or Average	15,776	2,789	58	490	493	251	26
GRAND TOTAL OR AVERAGE	**46,380**	**4,488**	**54**	**483**	**484**	**246**	**25**

Parasitic-phase Assessment

United States

A total of 1,295 parasitic-phase sea lampreys were collected by commercial fishermen in Lake Huron in 1989 (Table 6), compared with 1,195 taken in 1988. Fishermen from statistical district MH-1 (DeTour-Rogers City, Michigan, area) ontributed the largest number of sea lampreys (1,072) an increase from the number taken in 1988 (843). The number of sea lampreys collected by commercial fishermen in statistical district MH-2 (Alpena, Michigan, area) increased from 1988 (67) to 1989 (112). Fishermen from the statistical district MH-4 (Tawas City-Bay Port, Michigan, area) captured 110 lampreys in 1989, a decrease from 285 taken in 1988. Most lampreys were collected by trap net fishermen (63%) during August-October (65%), and the lampreys primarily were attached to chinook salmon (26%), lake trout (26%), and lake whitefish (41%).

Spawning year was determined for the 1,295 parasitic-phase sea lampreys. Of these, 55 would have spawned in 1989, and 1,240 in 1990. A total of 994 of the 1989 spawning year class have been collected (939 in 1988 and 55 in 1989), and represents a decrease when compared to the number of the 1988 spawning year class (1,230) captured by commercial fishermen.

Sport anglers in Lake Huron captured 1,700 parasitic-phase sea lampreys in 1989 (Table 6) compared to 2,526 in 1988. The compilation of the data that yields the number of sea lampreys attached per 100 lake trout and chinook salmon was incomplete at the time of this report.

Canada

Commercial Fisheries

During 1989, the cooperator programme on Lake Huron involved 11 fisheries, mostly from the North Channel and northern portion of the main basin. The central and southern portions of the main basin were represented by only one cooperator each, while Georgian Bay was not represented. The count for the North Channel was 1,187 and for the main basin 719 (675 from the northern, 32 from the central and 12 from the southern portions, respectively). This catch for the North Channel is the largest since the monitoring program began in 1967, while the count from the main basin is the largest since 1969.

Sport Fisheries

The two annual chinook salmon derbies in the St. Marys River were monitored. Although catches turned into the De Tour Village weigh-station have become an increasingly important component of the Coors Light King Salmon Derby (August 19 to September 9), the Centre monitored only the Sault station to maintain continuity with previous data. Three hundred and eighty seven chinook sampled had 50 wounds per 100 fish with 40% of the fish wounded. Wounding rates have not changed significantly for the past five years. The number of lamprey reported attached to salmon was down to a record low of 2.1/100 fish.

The Can-Am Team Salmon Tournament (September 15 to 17) had 76 chinook checked. Rates were 63 wounds per 100 fish with 34% wounded, unchanged from last year. Lamprey attachments were observed at the rate of 6/100 fish, slightly below last year's rate.

Combined results show that for 463 chinook sampled, the rates were 52 wounds/100 fish and 39% wounded, down from 1988 but slightly above the previous four-year mean.

Table 10. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1989.
[Letter in parentheses corresponds to location of stream in Figure 4.]

Stream	Number	Number captured	Percent sampled	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight(g Males	Mean Weight(g Female
UNITED STATES							
St. Marys River (F)	1,622	657	52	472	476	259	26
East Au Gres River (A)	100	98	40	455	457	224	22
Au Sable River (B)	76	67	48	450	436	238	21
Ocqueoc River (C)	530	48	40	462	454	210	19
Cheboygan River (D)	28,224	778	43	472	477	216	23
Albany Creek (E)	52	51	47	451	449	193	20
Total or average	30,604	1,699	47	469	472	235	24
CANADA							
St. Marys River (F)	10,154	1,420	60	486	489	249	26
Echo River (G)	644	103	53	485	493	242	26
Koshkawong River (H)	547	137	45	480	468	233	22
Thessalon River (I)	4,431	1,129	57	496	501	256	27
Still River (J)	0						
Total or Average	15,776	2,789	58	490	493	251	26
GRAND TOTAL OR AVERAGE	**46,380**	**4,488**	**54**	**483**	**484**	**246**	**25**

Biological Studies

Canada

Spawning-phase sea lamprey from the Canadian traps in the St. Marys River were released at a site near Pine Island, some 35 km downstream. Two hundred and ten adults released over a two-week interval had a 25% recapture rate. In 1987 a similar test with 69 adults over a two-week interval had a 23% recapture rate. Study of the recapture rates by week suggests that early in the run lamprey are willing to swim the entire St. Marys River, but as the season progresses, the numbers returning to the trapping sites diminishes.

In 1988, 1,500 imported males were released at Sugar Island and five of these (0.33%) were recovered in the St. Marys Rapids. Ten (0.41%) of 2,426 marked lampreys released in 1989 at Sugar Island were recovered from the Rapids. The ratio of marked adults to unmarked in the Rapids was 6.1% in 1989 and 4.1% in 1988.

Nest surveys in the St. Marys Rapids to determine prolarval production showed that 19 of 21 positive nests yielded early stage prolarvae, for a success rate of 91%. This compares with success rates of 86% in 1987 and 82% in 1988. Extending observations until the final prolarvae stage (Stage 17) yielded a success rate of 67%. Nest probing has proven to be a suitable index for measuring spawning success in a stream.

Biological Studies (Continued)

Canada

Contracted filming of lamprey activity in the tail waters of the Great Lakes Power generating station showed sea lamprey involved in mate pairing and nest construction in 8 to 10 meters of fast water.

Transformer Netting

Fyke nets were fished in the Munuscong Channel area of the lower St. Marys River to assess the degree of emigration of parasitic phase sea lampreys, specifically in those areas of the channel outside of the dredged shipping lanes. From October 24 to November 24, 11 nets yielded one transformer. A single net (operated by USFWS personnel) attached to a shipping lane buoy at the same transect, captured eight transformers during the period October 11 to November 17. Results suggest that transformers emigrate principally via the shipping lane.

Coincidentally, four fyke nets were fished in St. Joseph Channel, north of St. Joseph's Island. These nets caught 10 transformers from October 25 to November 15. On November 27, following prolonged gales beginning on November 16, an additional eight transformers were removed from the nets. This channel is obviously a significant path of out-migration in the lower St. Marys River.

Barrier Dams

Canada

Several low-head barrier dams were maintained including placement of some 700 tons of rip rap at the Still River barrier. This should eliminate the problems with the adult trap operation experienced in 1989.

Preparations were made for a lamprey-trapping fishway experiment to take place at Little Rapids on Bridgeland Creek, a tributary to the Thessalon River. These included installing a gravity water feed and distrubtion on site and design and construction of the fishway and lamprey trap at the Sea Lamprey Control Centre. All work so far has been done by Sea Lamprey Control Centre staff. The experiment will be carried out with the cooperation of the Algoma Fish and Recreation Association.

LAKE ERIE

Larval Assessment

United States

A total of 29 tributaries of Lake Erie were surveyed in 1989 to assess sea lamprey populations and to search for new infestations. Pretreatment surveys were conducted in eight streams along the south shore, and the number and size of larvae found in Conneaut, Raccoon, Crooked and Cattaraugus creeks indicated the need for treatment in 1989. Recruitment of lampreys apparently has not occurred in the Grand River, Halfway Brook, and Delaware and Canadaway creeks since treatment in 1986. Index surveys scheduled after October 1 to assess recruitment of the 1989 year class were cancelled because of uncertainty of funding levels for Fiscal Year 1990.

Surveys were conducted in 21 southeast Michigan tributaries with no history of sea lamprey infestations. Most of the streams showed no potential for sea lamprey production, but six (La Plaisance, Sandy, Swan, Little Lake, and Flat creeks and Hooper Run) appear to have favorable environmental conditions for lampreys and periodically will be examined in the future. The Michigan Department of Natural Resources reported the capture of three transformed sea lampreys in the North Branch of the Clinton River (Macomb County) during electrofishing operations. Further investigations will be conducted on this system in 1990.

Canada

Surveys were conducted on eight Lake Erie tributaries in preparation for chemical treatments in 1989 and anticipated treatments in 1990, to monitor re-established, residual and untreated populations and to look for new infestations.

Distribution surveys were completed on two streams scheduled for treatment in 1989 and on five streams which were potential candidates for treatment in 1990. The distribution in Big and Forestville Creeks was essentially unchanged from that in their initial treatments in 1987. No sea lamprey larvae were found in Normandale and Fishers Creeks and larvae in Big Otter, Clear and Young's Creeks were essentially small, sparsely distributed and quite scarce (the few large larvae collected from Big Otter Creek came from a small tributary, Stoney Creek, that was not treated in 1986). As a consequence, none of these five streams were recommended for treatment in 1990.

Surveys of South Otter Creek indicate that it has still not re-established since the October, 1986 treatment.

Lake St. Clair

The main stream of the Thames River and several of its tributaries were surveyed. Komoko Creek, a small spring-fed tributary near London, Ontario produced low numbers of larval sea lamprey. A single sea lamprey ammocoete had been collected from this tributary for the first time, in 1988. The significance of this population, a long way up the Thames River, is thought to be minimal, but it will be periodically monitored.

Chemical Treatment

United States

Treatments of 4 streams (Conneaut, Raccoon, Crooked, and Cattaraugus creeks) were deferred to 1990 because of uncertainty of funding levels for Fiscal Year 1990.

Chemical Treatment (Continued)

Canada

Two streams on the Canadian side of Lake Erie were treated in 1989 Table 11, Figure 5). Forestville Creek, a very small stream, was successfully treated despite a relatively high flow. Big Creek, a large, complex system (99.5 km treated length), required the services of two 14-person treatment units. Although the treatment was conducted with substantial discharge and under threat of rain, it was deemed to be successful, although local rain showers on Venison Creek, a major tributary, increased flow and reduced TFM concentrations below theoretically lethal lamprey levels at its lower end. Since larval lamprey were scarce in these lower reaches, escapement is thought to be minimal. Relatively wet spring conditions, in contrast to the extremely dry conditions experienced during the 1987 treatment, eliminated the requirement for private irrigators to use TFM laced waters from Big Creek. This considerably reduced pretreatment landowner negotiations. However, two schools under the authority of the Norfolk Board of Education continue to draw water from Big Creek. Each had to make special provision to supply untreated water to students and staff during the passage of treated waters.

Larval sea lamprey were relatively scarce in both Forestville and Big Creeks. While larvae were also scarce in Forestville Creek during its initial treatment in 1987 Big Creek appeared to have significantly lower numbers of larvae than in its initial treatment.

Table 11. Details on the application of lampricide to streams of Lake Erie, 1989.

Stream/Lake	Date	Discharge m^3/s	f^3/s	TFM kg	lbs	Bayer 73 Powder kg	lbs	Granules kg	lbs	Distance treated km	mi
CANADA											
Forestville Cr.(2)	May 26	0.28	10	73	161	-	-	-	-	3.0	1.9
Big Cr.(1)	May 29	6.37	225	2,688	5,925	-	-	-	-	99.5	61.8
TOTALS		6.65	235	2,761	6,086	-	-	-	-	102.5	63.7

Spawning-phase Assessment

United States

A total of 235 sea lampreys were captured in assessment traps placed in three tributaries of Lake Erie in 1989 (Table 12, Figure 5) compared to 1,903 lampreys in 1988 (a 90% decrease). The reduction is due to the first-time lampricide applications to the sea lamprey producing streams in 1987-88. The average length and weight of sea lampreys from Lake Erie tributaries in 1989 declined over those taken in 1988, (average, 32 mm shorter and 27 g lighter), while the percentage males remained about the same.

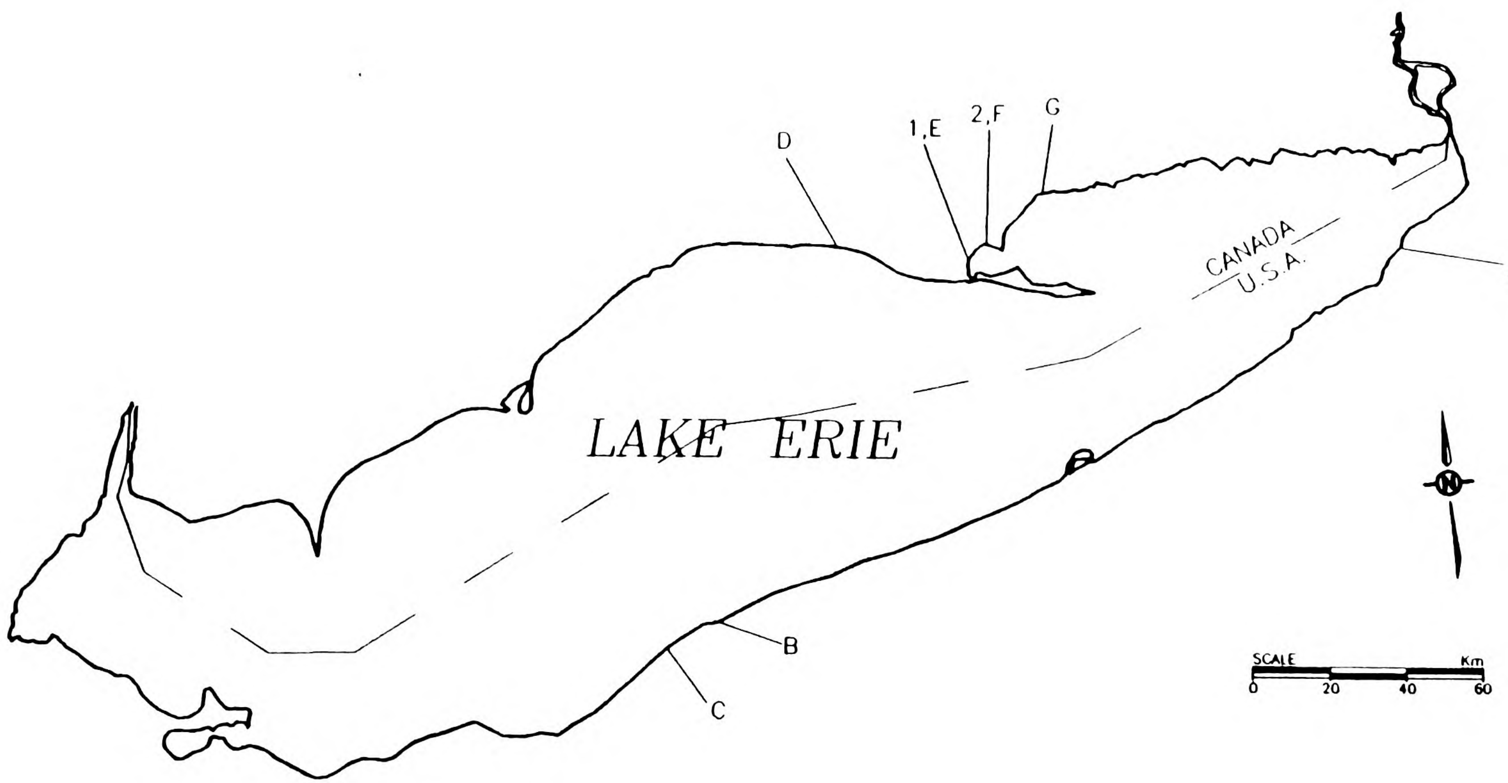

Figure 5. Location of Lake Erie tributaries treated with lampricides (numerals; see *Table 11* for stream names) and streams where assessment traps were fished (letters; see Table 12 for stream names) in 1989.

Spawning-phase Assessment (Continued)

Canada

The Lake Erie trap network consisted of four streams this year, resulting in the capture of 84 spawners (Table 12, Figure 5). It was in 1986 that trapping was last attempted on this lake. Big Otter Creek was considered one of the two largest larval producers on the Canadian side when first treated in October of 1986, with Little Otter Creek its main producing tributary. Trapping that spring yielded three sea lamprey from Little Otter and one from the main. For 1989, a superior trap site and effort yielded only one adult. The portable traps used in past years on Big Creek (the other major producer) did not adequately depict the true size of the run in those years. Therefore this past spring, a partial weir was installed at Quance Dam in Delhi in an attempt to improve on trapping effectiveness at this site. While the resulting count of 44 was below average compared to the last two attempts at full-season at this location (92 in 1980; 58 in 1981), a TFM treatment passed through on June 5, while the adult run was in progress.

With Forestville Creek considered a marginal producer even prior to the first-ever treatment in May 1987, it was not unexpected to catch only one adult at the newly constructed (fall 1988) dam. Fishing here (with a portable trap) was also affected by a lampricide treatment in May.

Young's Creek is regarded as the only comparable Canadian trap index on the lake. Previous counts of 115 in 1980, 856 in 1981, and 183 in 1986 are high compared to the catch of 38 made this year, the first post-control measure at the site.

Mark-recapture work on Young's Creek showed a trap efficiency of 29% with a population estimate of 129. In 1986, trap efficiency was determined to be 26%. If efficiency does not vary, then the run was assuredly down.

Table 12. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1989. [Letter in parentheses corresponds to location of stream in Figure 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							
Cattaraugus Creek (A)	192	192	60	485	484	268	263
Grand River (B)	42	42	67	396	442	311	282
Chagrin River (C)	1	1	100	536	-	279	-
Total or Average	235	235	62	469	477	276	266
CANADA							
Big Otter Creek (D)	1	1	100	477	-	209	-
Big Creek (E)	44	28	54	484	459	261	231
Forestville Creek (F)	1	1	100	456	-	204	-
Young's Creek (G)	38	24	38	463	473	205	232
Total or Average	84	54	48	475	467	238	231
GRAND TOTAL OR AVERAGE	**319**	**289**	**60**	**470**	**475**	**270**	**258**

Parasitic-phase Assessment

Canada

Commercial Fisheries

A preliminary count of 26 adults was submitted by the Lake Erie cooperating fisheries this year. While returns from the eastern and east-central basins are lower than all previous catches (the eastern basin dramatically so), submissions from the western and west-central basins are about average.

Barrier Dams

Canada

A new low-head barrier dam with a built-in lamprey trap was constructed on Clear Creek several hundred meters upstream from the Lakeshore Road bridge. The steel sheet piling barrier incorporates the concrete abutment walls and slab of an older breached concrete dam at the site but with greater hydraulic conveyance. It was built at a cost of $16,177. and should eliminate lampricide treatments of this stream.

LAKE ONTARIO

Larval Assessment

United States

Surveys scheduled in October to assess recruitment of the 1989 year class and monitor existing populations of sea lamprey larvae at index sites on tributaries of the Oswego River (Carpenter, Spring, and Crane brooks) were cancelled because of uncertainty of funding levels for Fiscal Year 1990.

Canada

Surveys were conducted on 43 Lake Ontario tributaries in 1989 in preparation for chemical treatment, to monitor re-established, residual and untreated populations, and to look for new infestations.

Distribution surveys were completed on seven streams scheduled for treatment in 1989, all but one (First Creek) of which were subsequently treated. Distribution surveys were also done on nine streams recommended for treatment in 1990. The only significant change in distribution from previous treatments was on Snake Creek, where a large beaver dam apparently blocked spawning runs from 1986 to 1988, thus shortening the 1989 treatment by about 10.5 km.

Treatment evaluation surveys were done on the 11 streams treated in 1988. In only two, Skinner and Lindsey Creeks, were significant numbers of residual larvae found. Both are scheduled for re-treatment in 1990.

Of the 10 tributaries treated in the spring of 1988 only four, Port Britain, Colborne, Skinner and Lindsey Creeks, re-established with the 1988 year class of sea lamprey larvae. Most surveys were done too early to detect the 1989 year class.

Larval Assessment (Continued)

The low numbers of larvae found in surveys of the Credit River suggest that treatment is not justified at this time. Surveys of the Black River (New York) continue to show residuals of the August 1987 treatment as well as strong 1988 and 1989 year classes.

Surveys done above the five low-head barrier dams in place on Lake Ontario tributaries in the spring of 1989, Duffins, Graham, Shelter Valley, Colborne, and Grafton Creeks, found that all had been effective at blocking the 1988 spawning run. A few large residual larvae from the last (1986) treatment are still present above the Shelter Valley Creek dam.

Chemical Treatment

United States

Lampricide treatments were conducted on five tributaries to the New York side of Lake Ontario and on Fish Creek, a tributary to Oneida Lake (Table 13, Figure 6). First Creek, a very small stream, was not treated due to inadequate discharge. Excessive rain during May extended the proposed spring treatment period, however successful treatments were eventually conducted on the Salmon and Little Salmon Rivers, and Little Sandy, Deer and Snake Creeks. No significant changes were observed in ammocoete abundance relative to previous treatments, with the Salmon River continuing to be a very prolific producer of sea lamprey larvae.

Fish Creek, a large, complex tributary, was treated in late September, under optimum treatment conditions. Efforts to treat this stream in 1988 were negated due to excessive discharge. A similar situation seemed imminent in 1989, when flood stage conditions resulted from heavy rain during pretreatment operations. Fortunately, the flood crest quickly receded and the additional discharge actually facilitated the treatment of Little River, a historically impounded tributary. Sea lamprey larvae and metamorphosing specimens were extremely abundant throughout the entire Fish Creek system.

Non-target fish mortality was minimal in all New York treatments.

Canada

A total of six Canadian Lake Ontario tributaries were treated during the 1989 field season, three in the spring and three in late summer (Table 13, Figure 6).

Treatments were considered to be highly effective, with one exception. Heavy rain reduced TFM concentrations below lethal levels in the lower reaches of Farewell Creek. Larval densities in the lower section of this system have fluctuated widely over the years but most recent documentation suggests very low numbers of larvae inhabiting this lower portion.

Larval sea lamprey were very abundant in Salem and Bronte Creeks, moderately abundant in Wilmot, Cobourg and Bowmanville Creeks and scarce in Farewell Creek.

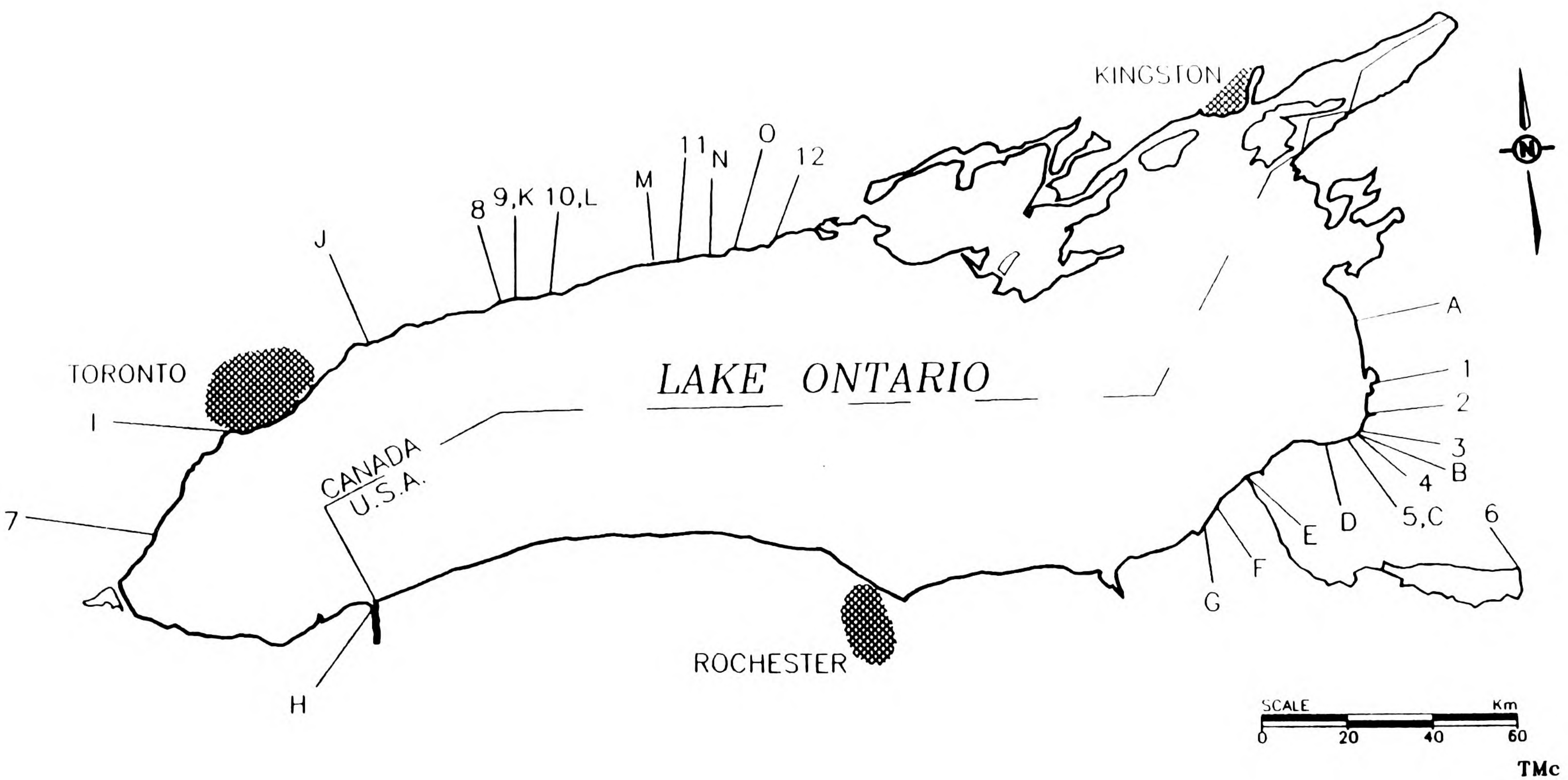

Figure 6. Location of Lake Ontario tributaries treated with lampricides (numerals; see Table 13 for names of streams), and of streams where assessment traps were fished (letters; see Table 14 for names of streams) in 1989.

Chemical Treatment (Continued)

Non-target mortality was light in all streams treated with the exception of Bronte Creek, in which many stonecats (Noturus flavus) were killed. While TFM concentrations were not excessive, they were lethal to numbers of this susceptible species (mortality to these members of the catfish family has been documented during lampricide treatments of certain other streams). Spawning phase rainbow trout in the three streams treated in April/May were apparently unaffected by treatment concentrations of TFM.

All streams treated were on a three year treatment rotation, having last been treated in the fall of 1985 or spring of 1986. Transforming sea lamprey collected in the three August treatments indicate that a three year treatment rotation is valid for Lake Ontario streams.

Table 13. Details on the application of lampricides to streams of Lake Ontario, 1989. [Number in parentheses corresponds to location of stream in Figure 6. Lampricide used is in kilograms/pounds of active ingredient.].

Stream/Lake	Date	Discharge m^3/s	Discharge f^3/s	TFM kg	TFM lbs	Bayer 73 Powder kg	Bayer 73 Powder lbs	Bayer 73 Granules kg	Bayer 73 Granules lbs	Distance treated km	Distance treated mi
UNITED STATES											
L. Sandy Cr. (1)	Apr. 27	1.48	52	143	315	-	-	-	-	12.4	7.7
Deer Cr. (2)	Apr. 29	0.48	17	75	165	-	-	-	-	16.5	10.3
Snake Cr. (4)	May 4	0.42	15	45	99	-	-	-	-	3.8	2.4
Salmon R. (3)	May 6	25.18	889	1,443	3,181	-	-	-	-	51.5	32.0
L. Salmon R. (5)	May 26	1.63	58	293	646	-	-	-	-	12.5	7.8
Fish Cr. (6)	Sep. 26	14.14	499	2,320	5,115	-	-	-	-	82.8	51.5
Totals		43.33	1,530	4,319	9,521	-	-	-	-	179.5	111.7
CANADA											
Bowmanville Cr. (9)	Apr. 27	1.94	69	723	1,594	-	-	-	-	9.3	5.8
Farewell Cr. (8)	Apr. 29	1.06	37	109	240	-	-	0.01	0.02	6.3	3.9
Bronte Cr. (7)	May 4	2.40	85	992	2,187	-	-	0.13	0.29	28.4	17.6
Salem Cr. (12)	Aug. 24	0.10	4	54	119	-	-	0.01	0.02	2.1	1.3
Wilmot Cr. (10)	Aug. 26	0.51	18	218	481	-	-	-	-	11.0	6.8
Cobourg Br. (11)	Aug. 28	0.50	18	197	434	-	-	-	-	11.5	7.1
Totals		6.51	231	2,293	5,055	-	-	0.15	0.33	68.6	42.5
GRAND TOTAL		**49.84**	**1,761**	**6,612**	**14,576**	-	-	**0.15**	**0.33**	**248.1**	**154.2**

Spawning-phase Assessment

United States

A total of 139 sea lampreys were captured in assessment traps placed in tributaries of Lake Ontario in 1989 (Table 14, Figure 6), a slight decrease fro the number taken in 1988 (193). Trap catches increased in Sterling and Sout Sandy creeks and the Little Salmon River whereas the catch decreased in Sterlin Valley and Grindstone creeks. No sea lampreys were captured for the secon consecutive year in the Oswego River and Catfish Creek.

In 1989, efforts were made for the second consecutive year to estimate th total number of spawning-phase sea lampreys in U.S. waters of Lake Ontario usin the method developed in Lake Superior. The method is based on the relatio between average stream discharge and the number of adult lampreys that ente tributaries to spawn. While all the flow data necessary to conduct the estimat model was collected, in-stream estimates of lampreys could not be calculate because too few of the marked lampreys were recaptured. The lack of recapture lampreys also resulted in insufficient data on the biological characteristics o the lampreys.

Canada

Assessment traps on eight streams (Table 14, Figure 6) captured 3,247 sea lampreys. Individual counts in general were down from 1988 and the total coun is continuing to decline since 1987. Significant decreases were evident in the Humber River, Duffins, Bowmanville and Shelter Valley Creeks. All operations were delayed by a very cold spring. Efforts to fish the Niagara River at the Sir Adam Beck Generating Station with standard traps failed to yield a single adult. If spawners run the Niagara River it will probably require a departure from portable trapping to assess.

A new permanent trap associated with the Bowmanville Creek fishway created problems in servicing and reduced trapping capability. Remedial work in late summer eliminated most of these problems. The Wilmot Creek trap was moved several times part way into the migration before making any significant catches.

Trap efficiency/population estimates, provided the following: Humber River, 41%/4,193; Graham Creek, 80%/115; Grafton Creek, 58%/31; and Shelter Valley Creek, 62%/808.

Trap counts from streams on the United States and Canadian sides of Lake Ontario that have operated with considerable consistency since 1983 suggest that the numbers of lampreys present in the northwest portion of the lake have been increasing relative to those in the southeast portion. This relationship persists despite the recent downtrend in catches lakewide.

Table 14. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1989.
[Letter in parentheses corresponds to location of stream in Figure 6.]

Stream	Number captured	Number sampled	Percent Males	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight(g) Males	Mean Weight(g) Females
UNITED STATES							
Sterling Creek (G)	75	1	100	470	-	187	-
Sterling Valley Creek(F)	37	1	100	521	-	192	-
Oswego River (E)	0	0	-	-	-	-	-
Catfish Creek (D)	0	0	-	-	-	-	-
Little Salmon River (C)	11	0	-	-	-	-	-
Grindstone Creek (B)	10	0	-	-	-	-	-
South Sandy Creek (A)	6	0	-	-	-	-	-
Total or average	139	2	100	496	-	190	-
CANADA							
Niagara River (H)	0	0					
Humber River (I)	1,724	350	61	472	474	247	261
Duffins Creek (J)	699	183	62	483	482	276	273
Bowmanville Creek (K)	113	34	56	492	493	263	281
Wilmot Creek (L)	53	20	50	484	483	254	274
Graham Creek (M)	99	26	62	494	517	268	294
Grafton Creek (N)	20	6	67	473	488	218	251
Shelter Valley Creek (O)	539	139	59	507	500	286	289
Total or average	3,247	758	61	483	484	262	272
GRAND TOTAL OR AVERAGE	**3,386**	**760**	**61**	**483**	**484**	**262**	**272**

Biological Studies

Canada

Adults from the Humber River traps were tagged, transported to Bronte Creek and released under the QEW bridge in order to estimate the size of the Bronte Creek spawning run. The data was analysed in two phases (pre- and post-treatment) and then summed to obtain a combined Petersen estimate of 3,093. This number is comparable to past estimates made for the spawning runs in the Humber River (4,000 to 9,500) and in Duffins Creek (1,800 to 2,500).

Nest survey work on Lake Ontario was hindered by high water and turbidity. The Trent River was difficult to investigate with only the side channel on the west bank permitting a superficial look on three occasions. Where considerable spawning activity had been observed in 1988, nothing could be seen in 1989. In Salem Creek 18 of 23 nests yielded prolarvae, and 17 of these nests yielded appreciable numbers of Stage 17 prolarvae. Success rate was determined to be 74%. Only two of 13 nests on the Humber could be visited a second time, and another nest was lost because of near flood conditions. While the survey crew

Biological Studies (Continued)

noted that the number of nests constructed was down, one of the nests yield good numbers of Stage 13 prolarvae. Ten nests were located on Bronte Creek b persistent rains prevented a revisit of any of them. In contrast, low wat levels on the Niagara River exposed ledges associated with the stream bank where possibilities for spawning were thought to exist. The main bed of th river can only be surveyed by SCUBA divers or remote camera.

Four streams tributary to Lake Ontario were selected as candidates assess the ability to estimate larval sea lamprey populations using random si selection, electrofishing gear and the depletion format to calculate densitie The four streams selected were Bronte, Oshawa, Wilmot and Salem Creeks. All b Oshawa Creek were subsequently treated with lampricide in 1989. Bronte, Wilm and Salem Creeks had three year classes present during sampling; Oshawa Cre had only two year classes. Oshawa Creek is scheduled for treatment in 1990.

Bronte Creek was the largest system surveyed (36 km in length) but it h minimal larval habitat available (18% of a total area of 656,000 square meters, Oshawa Creek was 24.5 km long and 43% of 222,000 square meters was suitab larval habitat. Wilmot Creek, an important salmonid producing stream, was 15 long with 48% of 125,000 square meters suitable as larval habitat. Salem Cree the shortest stream surveyed, was less than 3 km long and 59% of 14,000 squa meters was suitable larval habitat.

Larval densities measured via the depletion method were adjusted accordi to a regression comparison with densities measured during treatment at select survey sites. The relationship was described by the formula Y = .6892 X^.54 where Y was the depletion estimate and X was the observed estimate duri treatment. The goodness of fit (R2) was .7324 with 10 data entry points.

The final adjusted population estimates were: Bronte Creek - 260,00 Oshawa Creek - 220,000; Wilmot Creek - 50,000; and Salem Creek - 1,110,00 Only Wilmot and Salem Creeks were treated at a time when transforming se lamprey were present in the population. Wilmot Creek had 8% of the collecti transforming (27% of those over 120 mm in length). Salem Creek had 2% of th collection transforming (14% of those over 120 mm in length). The total numbe of transforming sea lamprey in Wilmot and Salem Creeks was calculated to 4,000 and 22,000, respectively.

Annual assessments of larval sea lamprey populations in Salem Cree (conducted annually since 1985) were completed in 1989. Results are bein evaluated and will be presented in a Centre technical report.

Barrier Dams

Canada

Six low-head barrier dams and the built-in adult traps on the Humber Rive dam were maintained in 1989.

A new low-head barrier dam was constructed on Port Britain Creek 1.0 from the mouth. The concrete structure, with a built-in adult trap, wa constructed at a cost of $32,545.

LAKES SUPERIOR, MICHIGAN, AND HURON

Treatment Effects on Nontarget Organisms (short-term tests)

Caged studies--Routine monitoring of the immediate effect of lampricides upon nontarget organisms continued in 1989. In situ assays were completed by caging fish in the Potato (Lake Superior) and Pine (Lake Huron) rivers and a tributary of the Pine River, Elmhirst Creek.

Small fish (<22.8 cm, 9 inches) were collected by electrofishing or acquired from hatcheries. Only uninjured specimens were used in the test. As a control, specimens were placed in the areas to be treated the day before lampricide application. These were removed the day of treatment and replaced by additional specimens. A total of 14 species of fish were caged to monitor the effects of the lampricide on nontarget fish (Table 15). These included 13 species collected from the streams and rainbow trout from a hatchery of the Michigan Department of Natural Resources.

Mortality was low among caged fish collected from the streams in both control (2 of 122) and treatment (1 of 130) tests. Rainbow trout caged in the Pine River suffered a 33% mortality (3 of 9) during the treatment test. The fish had been obtained about seven days earlier for use in pretreatment toxicity tests and the same fish were used for control and treatment tests. Rainbow trout did not die during earlier toxicity tests and the mortality probably was because the fish were overly stressed prior to the test.

Mayflies--Samples of *Hexagenia* were collected in the Pere Marquette River (Lake Michigan) to determine recovery of the population following the lampricide treatment in 1987. Total abundance of nymphs in 1987 declined 69% from pretreatment ($754/m^2$) to posttreatment ($230/m^2$) samples. Abundance of nymphs in 1989 averaged $654/m^2$ or 87% of pretreatment levels. These nymphs (1988 cohort) primarily are the descendents of the year class (1986 cohort) most affected by the 1987 treatment. The Pere Marquette River is scheduled for treatment in 1991 and futher sampling will determine if *Hexagenia* populations make a full recovery between the treatments.

Invertebrate drift--Invertebrate drift can increase several fold during lampricide applications when compared to pretreatment levels (GLFC Annual Report 1987). The treatment of the Rifle River (Lake Huron) in 1989 provided an opportunity to examine if the increased invertebrate drift caused by treatments contributes to increased mortality of the invertebrates due to consumption by fish.

Yearling brown trout were collected by electrofishing Houghton and Vaughn creeks (Rifle River tributaries) before and immediately after a treatment in late August. Vaughn Creek also was sampled during, and about 48 hours after, the treatment. Stomach contents of 100 fish (Vaughn Creek - 60 fish, 45 per time period; Houghton Creek - 40 fish, 20 per time period) were removed by gastric lavage. The fish were marked and released after stomach contents were removed. Drift nets were set before, during, and after treatments (also used in conjunction with the study of riffle invertebrate communities in the River) to determine availability of potential food items.

Table 15. Number of fish alive and dead of those caged for 24 hours before treatment (control), and the number alive and dead after treatment of those caged during TFM application (treatment) in the Potato River (Lake Superior), the Pine River (Lake Huron) and its tributary, Elmhirst Creek in 1989.

Species of fish	Potato River				Pine River				Elmhirst Creek			
	Control		Treatment		Control		Treatment		Control		Treatment	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
Rainbow trout *Oncorhynchus mykiss*					9	0	9	3				
Central mudminnow *Umbra limi*	1	1	1	0	5	0	5	0	2	0	2	0
Hornyhead chub *Nocomis biguttatus*	3	0	1	0								
Pugnose minnow *Notropis emiliae*					2	0	2	0	1	0	1	0
Northern Redbelly dace *Phoxinus eos*					9	0	9	0	2	0	7	1
Fathead minnow *Pimephales promelas*					12	0	12	0				
Blacknose dace *Rhinichthys atratulus*	9	0	9	0	20	0	20	0	3	0	5	0
Creek chub *Semotilus atromaculatus*	3	1	5	0					5	0	5	0
Pearl dace *Semotilus margarita*					9	0	9	0				
White sucker *Catostomus commersoni*	8	0	9	0								
Burbot *Lota lota*	3	0	3	0								
Brook stickleback *Culaea inconstans*					4	0	4	0				
Rock bass *Ambloplites rupestris*	7	0	7	0								
Mottled sculpin *Cottus bairdi*					13	0	13	0	1	0	1	0

Aquatic invertebrates representing 18 orders, terrestrial insects, and fish (including sea lampreys) were found in brown trout stomachs in Houghton and Vaughn creeks (Table 16). Terrestrial insects (grasshoppers) comprised the bulk of trout food items in Vaughn Creek before treatment. During treatment, large numbers of *Chimmarra* sp. and *Dolopholodes* sp. were eaten by trout (none were present in pretreatment samples), and the trend continued 48 hours after treatment. Annelids and amphipods also increased in abundance in the diet during treatment.

Trichopterans (primarily *Brachycentrus* sp. and *Oecetis* sp.) were the major pretreatment organisms found in the stomachs of trout in Houghton Creek before treatment. The contribution of these food items to the diet changed markedly between sample periods (from 46% in pretreatment samples to 19% in posttreatment samples). Mayflies (*Baetis* sp. and *Litobrancha* sp.) and Dipteran larvae (Chironomids and Simulids) increased as food items and, together with caddisflies, comprised nearly 70% of the organisms in stomachs after treatment. Grasshoppers became an increasingly important component from pretreatment and posttreatment samples (from 1% to 13%).

In general, the organisms found in the trout stomachs during and after treatment are those that enter the drift because of sensitivity to TFM. Trout apparently selected these components because of the organisms' increased availability to predation during drift.

Riffle invertebrate communities--The Rifle River (Lake Huron) is a complex system and typically is treated with lampricide over a period of about four weeks. In 1989, first the eastern tributaries were treated, then the western, and finally the mainstream. As a result, some sections of the mainstream received sublethal doses of lampricide within days or weeks prior to the mainstream treatment. Macroinvertebrate communities in riffles in the mainstream were examined to determine if composition of the communities changed as a result of exposure to low concentrations of TFM followed at a later time by higher concentrations. Random samples were collected at each of 5 riffles using a circular depletion sampler, at 4 riffles by the a traveling kick net method, and at 1 riffle by drift nets. Samples were collected before, during, and after each treatment occasion. Analysis of the samples currently is incomplete. This study is conducted in cooperation with Central Michigan University as partial fulfillment of a Master of Science degree of a student enrolled in the Fish and Widlife Service Cooperative Education Program.

Treatment Effects on Nontarget Organisms (long-term tests)

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 effects of lampricides on the population. Random samples (3 from each of 10 silt beds at a control and a treated area, or 60 samples) were collected with an Eckman dredge. Originally, Scott Creek (Whitefish River tributary) was selected as the control area in 1984. The site was later abandoned because beavers caused the area to flood. An untreated portion of the nearby Indian River, a tributary of the Manistique River, replaced Scott Creek as the control area in fall 1986. The Whitefish River was treated in 1989 (prior treatment, 1986) but, the East Branch was deferred from treatment to determine if lengthening the interval between treatments (from three to four years) would improve abundance of the *Hexagenia* population.

Table 16. Percentage of food items in brown trout stomachs before and after lampricide applications in Houghton and Vaughn creeks (Rifle River, Lake Huron) in 1989.

	Rifle River					
	Houghton Creek		Vaughn Creek			
Taxa	One day before treatment	One day after treatment	One day before treatment	Day of treatment	One day after treatment	Two days after treatment
Collembola	0.24	0.33	4.75			
Ephemeroptera	9.76	17.06	12.97	1.02	10.70	6.67
Odonata				0.06	0.02	6.67
Plecoptera		0.33	1.27	0.06	0.05	
Megaloptera			0.32	0.06	0.05	1.33
Hemiptera			0.32			2.67
Trichoptera	45.85	18.73	15.51	72.79	75.89	50.67
Coleoptera	0.73	1.34	3.48	0.06	0.16	1.33
Lepidoptera				0.06		
Diptera	25.85	33.44	1.58	0.90	0.57	16.00
Nematoda	0.73	0.33				
Annelida		2.01	4.11	6.79	3.85	1.33
Isopoda	2.20	1.00	0.95	0.17	0.11	2.67
Amphipoda	0.73	1.00	5.70	11.60	7.72	6.67
Decapoda			0.32			1.33
Hydracarina	0.24	1.00				
Gastropoda	11.95	6.02		0.17	0.05	1.33
Pelecypoda		0.33				
Terrestrial insects	1.46	13.38	48.73	4.30	0.39	
Pices						
Cottus bairdi	0.24					
Evcalia inconstans						1.33
Petromyzon marinus		3.68		1.98	0.44	

Total abundance of Hexagenia nymphs in the East Branch of the Whitefish River reversed the downward trend exhibited since a 1986 chemical treatment. The number of nymphs increased 231% from $49/m^2$ in October 1988 to $162/m^2$ in October 1989. Currently, the abundance of Hexagenia nymphs is about the same as that of October 1985 and suggests a four-year treatment cycle rather than three may be required to allow full repopulation of the nymphs. The East Branch is scheduled for treatment in 1990 and additional measures will be taken to safeguard the Hexagenia population.

At the Indian River control site,the number of nymphs continued an increase first noted in October 1987 after a year of substantial decline (total abundance dropped 58% from $1,309/m^2$ in 1986 to $556/m^2$ in 1987). Abundance has increased 64% from $556/m^2$ in October 1987 to $912/m^2$ in October 1989. Some of this fluctuation in abundance at the control sites likely is due to the drought conditions of 1988-89.

Riffle Community Index--Index areas of invertebrate communities were established in treated and control sections of the Whitefish (Lake Michigan) and Sturgeon (a tributary of the Cheboygan River, Lake Huron) rivers in 1985. Initial samples were collected in fall 1985 at control and treated areas upstream and downstream of the lamprey barrier in the Whitefish River. Because of problems associated with comparability of control and treated areas in the Sturgeon River (little diversity in numbers of species and inadequate samples of the species present at the control area), a control area was selected in an untreated portion upstream of dams in the Boardman River (Lake Michigan) in spring 1986.

Samples have been collected in the spring and fall at areas using the standard travelling kick method. Collections were taken before and after chemical treatments of the index streams (Whitefish River, June 1989, and Sturgeon River, October 1988). Samples from the Whitefish River have been sorted and identified through 1988 and from the Sturgeon River through spring 1989. These long-term studies in invertebrate community structure require the establishment of several years of data to draw conclusions that relate to stream treatments. Thus far, the results have shown similar changes in invertebrate populations in both control and treatment areas (Tables 15 and 16).

The construction of a lamprey barrier on the Brule River in 1985 provided the opportunity to design a study on invertebrate communities that included index sites upstream and downstream of the barrier in a regularly treated stream. Initial samples were collected in fall 1985 (the sampling schedule includes spring and fall collections through a minimum of two treatment cycles). Collections were taken from each site before and immediately after lampricide application in 1986 that included both areas of the river. The river again was treated in 1989 but included only the area downstream of the barrier. Samples were sorted, identified, and reported through the 1988 collection (GLFC Annual Report 1988). Samples collected in 1989 have not been processed and data will be presented in later annual reports.

Table 17. Mean number of organisms from five samples taken by kick nets in riffle communities in the Whitefish River in 1988 in areas that are periodically treated and in areas that are not treated (control).[a]

	Whitefish River			
	Treated area		Control area	
Taxa	Spring	Fall	Spring	Fall
Collembola				
Entomobryidae		0.2		0.2
Ephemeroptera				
Baetidae				
Baetis	46.8	0.6	13.2	0.6
Pseudocloeon	0.4	10.2		12.8
Oligoneuriidae				
Isonychia	3.6	39.0	1.6	55.6
Heptageniidae		0.2		
Epeorus	32.6	94.6	13.6	22.4
Leurocuta	21.6	45.4	12.6	85.2
Rhithrogena				
Stenacron	0.2			1.2
Stenonema	25.4	103.0	10.2	113.0
Ephemerellidae				
Drunella	50.2		4.2	
Ephemerella	163.0	1224.6	116.8	399.0
Eurylophella	2.0	0.8	1.2	9.2
Serratella	42.6	249.8	4.6	11.6
Caenidae				
Caenis	11.6	2.0	2.2	22.0
Leptophlebiidae				
Paraleptophlebia	22.0	118.0	16.2	83.2
Ephemeridae				
Ephemera	0.2	1.2		
Adults				
Odonata				
Gomphidae				
Ophiogomphus	7.8	10.0	4.0	7.2
Stylogomphus	5.6	2.8	0.6	2.4
Calopterygidae				
Calopteryx			0.2	

(continued)

Table 17. Continued.

Taxa	Whitefish River			
	Treated area		Control area	
	Spring	Fall	Spring	Fall
Plecoptera				
Taeniopterygidae				
Taeniopterx		0.8		6.6
Strophopteryx	3.0	1.8	2.6	3.4
Nemouridae				
Ostrocerca	22.4		5.2	0.4
Shipsa	2.4		3.0	
Paracapnia		0.2		3.2
Perlidae				
Neoperla	0.8	0.4	2.2	
Paragnetina	5.4	4.6	0.8	2.0
Phasganophora	8.2	7.0	4.2	6.8
Acroneuria	14.4	20.6	12.2	22.8
Perlinella	1.8	8.4	0.8	3.0
Perlodidae				
Isoperla	14.0	3.4	22.4	13.2
Unknown		0.2	0.2	1.0
Megaloptera				
Corydalidae				
Nigronia	5.0	10.6	2.6	2.0
Trichoptera				
Philopotamidae				
Chimarra	1.2	8.8	0.6	14.6
Dolophilodes		3.0		1.2
Psychomyiidae				
Psychomyia		0.6	0.6	
Polycentropodidae				
Polycentropus		0.2		
Hydropsychidae				
Ceratopsyche	40.4	261.0	28.2	87.8
Cheumatopsyche	18.8	27.8	5.4	7.4
Rhyacophilidae				
Rhyacophila	0.6	1.0	0.6	0.2
Glossosomatidae				
Glossosoma	61.6	41.6	35.6	11.0
Protoptila	0.4			
Hydroptilidae				
Agraylea	1.0	1.0		0.2
Hydroptila	1.4	9.2	3.8	6.8
Leucotrichia	20.0	11.0	2.4	0.6
Stactobiella	48.6		3.4	0.4

(continued)

Table 17. Continued

Taxa	Whitefish River			
	Treated area		Control area	
	Spring	Fall	Spring	Fall
Trichoptera (continued)				
Brachycentridae				
Brachycentrus	1.0	1.0	1.4	4.0
Micrasema	1.4		0.8	
Lepidostomatidae				
Lepidostoma	13.0	2.0	8.6	6.8
Limnephilidae				
Neophylax	80.6		15.2	
Hydatophylax		1.0		0.2
Odontoceridae				
Psilotreta	6.4	14.6	5.0	15.0
Helicopsychidae				
Helicopsyche	7.0	3.6	2.0	1.6
Leptoceridae				
Ceraclea	3.6	11.4	1.2	5.8
Oecetis	0.4	0.2		
Setodes		0.4		
Pupae	0.8	8.8	1.0	0.8
Coleoptera				
Psephenidae				
Ectopria	0.4		0.4	
Psephenus	3.0	5.0	5.0	5.4
Dryopidae				
Helichus				0.2
Elmidae				
Dubiraphia (l)	0.2			
Optioservus (l)	39.6	129.6	17.2	72.8
Optioservus (a)	26.6	82.0	4.6	8.6
Gonielmis			0.2	
Stenelmis (l)	0.8	1.0	0.4	1.6
Stenelmis (a)	4.4	5.0	0.4	1.4
Curculionidae				0.2
Bagous	0.2			
Stenopelmus	0.2			
Diptera				
Tipulidae				
Tipula				1.6
Antocha	9.2	23.4	12.0	11.0
Hexatoma	0.4	2.2	0.6	2.8
Ceratopogonidae	0.4	0.2	0.4	0.8
Simuliidae				
Ectemnia			0.2	
Prosimulium	193.2		333.2	0.2
Simulium	0.2	0.4	0.6	0.6
Chironomidae	277.6	111.8	90.0	248.8
Tabanidae				
Chrysops				0.2
Athericidae				
Atherix	17.4	34.4	2.4	5.4

(cont[illegible]

Table 17. Continued

Taxa	Whitefish River			
	Treated area		Control area	
	Spring	Fall	Spring	Fall
Diptera (continued)				
Empididae				
Chelifera	0.2		0.6	
Hemerodromia	3.2	2.6	0.8	4.0
Clinocera	0.4			
Pupae	14.4		3.6	2.2
Adult				0.2
Miscellaneous				
Turbellaria				
Planaria	1.4			2.6
Nematoda				0.2
Annelida				
Oligochaeta	8.2	11.2	4.0	8.6
Branchiobdellidae	0.4	0.4		0.4
Amphipoda				
Hyalella	0.4			
Decapoda				
Astacidae	0.6	1.0	0.4	1.0
Hydracarina	1.2	2.6	1.0	
Gastropoda				
Physidae				
Physa	4.4	3.2	2.4	23.8
Gyralus	0.6			
Hydrobildae				
Amnicola			0.2	
Ancylidae				
Ferrisia				0.2
Pelecypoda				
Sphaeriidae				
Sphaerium	4.2	1.0	1.2	3.0
Terrestrial		1.0		1.0
Pisces	0.8	0.8	0.2	0.2
Total	1435.2	2786.6	855.0	1463.2
Total Taxa	76	67	67	72

[a]Data from Whitefish River samples in 1989 will be presented 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 18. Mean number of organisms from five samples taken by kick nets in riffle communities in the Sturgeon River in 1988 and 1989 in areas that are periodically treated and in areas that are not treated (control).a

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

	Treated area (Sturgeon River)				Control area (Boardman River)		
	1988			1989	1988		1989
Taxa	Spring	Fall	Post	Spring	Spring	Fall	Sprin
Collembola							
Entomobryidae		0.4					
Ephemeroptera							
Baetidae							
Baetis	94.6	0.4	1.0	88.8	157.4	11.4	114.
Pseudocloeon		3.8	2.6	5.4		3.0	0.
Oligoneuriidae							
Isonychia			2.6				
Heptageniidae							
Epeorus					0.4	0.2	
Leurocuta	0.6						
Rhithrogena	51.0	15.4	14.8	32.6	7.2	2.4	1.
Stenonema	1.2	11.6	19.2	1.6	1.2	1.6	0.
Ephemerellidae							
Drunella	95.2			3.8	95.4		18.
Ephemerella	85.4	86.4	68.6	49.0	384.4	546.4	320.
Serratella	7.2	70.2	84.0	2.4		3.0	0.
Leptophlebiidae							
Paraleptophlebia	0.4	0.8	1.0	0.2	4.6	17.4	2.
Odonata							
Gomphidae							
Ophiogomphus					0.6	0.8	0.
Plecoptera							
Pteronarcyidae							
Pteronarcys	1.4	2.4	1.4	2.2	0.8	0.4	1.
Taeniopterygidae							
Taeniopteryx		2.6	2.4	0.2		23.0	
Strophopteryx		0.2	0.4	0.8			
Nemouridae							
Amphinemura							0.
Nemoura							0.
Ostrocerca	1.8			3.0			
Capniidae							
Paracapnia						0.2	
Perlidae							
Acroneuria			0.6	0.2		0.2	
Paragnetina	1.6	2.4	2.4	0.6			
Perlinella							0.
Perlodidae							
Isogenoides	7.4	13.8	9.4	2.0	0.2	7.6	0.
Isoperla	5.4	5.6	5.2	3.0	2.4	4.6	4.
Unknown		1.0	0.6				

(continued

Table 18. Continued.

Taxa	Treated area (Sturgeon River) 1988 Spring	Treated area 1988 Fall	Treated area 1988 Post	Treated area 1989 Spring	Control area (Boardman River) 1988 Spring	Control area 1988 Fall	Control area 1989 Spring
Megaloptera							
Corydalidae							
Nigronia		1.0	0.8		0.6	0.6	
Trichoptera							
Philopotamidae							
Dolophilodes		7.8	2.8				0.2
Hydropsychidae							
Ceratopsyche	7.8	182.8	148.6	2.2	11.6	17.8	0.4
Cheumatopsyche		1.4			0.2		
Rhyacophilidae							
Rhyacophila	3.0	2.4	2.6	2.8	1.4	0.6	0.8
Glossosomatidae							
Protoptila	22.8	370.6	219.2	18.2	105.2	106.2	169.4
Hydroptilidae							
Hydroptila	1.2	3.2	3.0	0.6	8.8	23.8	2.0
Brachycentridae							
Brachycentrus	0.6	14.4	15.6	3.6	8.0	4.8	4.8
Micrasema	36.4	14.8	10.0	4.2	212.4	16.8	15.4
Lepidostomatidae							
Lepidostoma	0.4	1.4	2.0	0.2	4.0	22.0	6.0
Limnephilidae							
Neophylax	3.2	0.2		10.0	0.8		1.8
Helicopsychidae							
Helicopsyche	146.2	175.0	114.4	23.0			
Leptoceridae							
Oecetis	0.4	0.6	0.2	0.2			0.2
Setodes		0.2					
Pupae	1.0	1.4	0.4	0.8	2.8	0.4	0.6
Coleoptera							
Elmidae							
Optioservus(larvae)	90.0	474.4	414.0	69.8	17.4	77.4	22.4
Optioservus(adult)	53.0	220.8	160.4	21.0	22.2	23.0	12.0
Diptera							
Tipulidae							
Tipula					0.2		0.2
Antocha	13.8	100.0	80.6	11.2	2.4	9.2	0.8
Dicranota						0.2	
Hexatoma	0.2				2.4		
Ceratopogonidae							
Bezzia					0.2		

(continued)

Table 18. Continued.

Taxa	Treated area (Sturgeon River) 1988 Spring	1988 Fall	Post	1989 Spring	Control area (Boardman River) 1988 Spring	1988 Fall	19[illegible] Spri[illegible]
Diptera (continued)							
Simuliidae							
<u>Ectemnia</u>					0.6		0.
<u>Prosimulium</u>		0.8	0.2	0.2	1.0		1.
<u>Simulium</u>	0.2	3.4	0.8		2.0	3.0	
Chironomidae	58.8	149.4	67.4	51.0	188.8	582.4	159.
Athericidae							
<u>Atherix</u>	11.6	28.0	28.4	6.2	124.2	127.0	87.
Empididae							
<u>Chelifera</u>		1.2	1.4	1.0	3.4	7.8	4.
<u>Hemerodromia</u>	6.2	3.0	2.6	0.4	4.0	6.4	1.
Pupae			0.4	4.2	7.2	9.6	7.
Adult					0.2		0.
Miscellaneous							
Turbellaria							
<u>Planaria</u>		1.4	0.6		0.2	0.4	
Nematoda							0.
Annelida							
Oligochaeta	87.2	55.2	54.6	49.2	40.2	161.4	29.
Hirudinea		0.4		0.2			
Isopoda							
<u>Asellus</u>	1.4	12.8	4.8		0.2		0.
Amphipoda							
<u>Gammarus</u>	0.2	0.2	0.8	0.4	0.4	1.2	0.
Hydracarina	3.8	4.2	1.4	0.6	4.0	16.8	3.
Gastropoda							
Physidae							
<u>Physa</u>	0.2	5.4	3.2	0.2	4.0	3.0	3.8
Hydrobildae							
<u>Amnicola</u>	9.6	16.8	15.6	2.4	0.2	0.2	0.2
Ancylidae							
<u>Ferrisia</u>	0.6	0.8	1.4	0.4	1.0	1.2	0.6
Pelecypoda							
Sphaeriidae							
<u>Sphaerium</u>	0.4	0.4	1.2	1.2	1.6	1.0	2.2
Terrestrial			0.2			0.2	
Pisces	0.2	0.8	0.6		0.4	0.4	
Total	913.8	2,073.6	1,574.0	481.2	1,438.8	1,847.4	1,004.
Total Taxa	41	50	49	44	47	46	46

[a]Data from fall samples from the Sturgeon and Boardman rivers in fall 1989 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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