APPENDIX IV

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SEA LAMPREY MANAGEMENT IN THE GREAT LAKES IN 1986

ANNUAL REPORT

TO

GREAT LAKES FISHERY COMMISSION

by

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The activities in calendar year 1986 by the sea lamprey control units of Canada and the United States are summarized in this joint report. The sea lamprey management program consists of five essential activities: larval and adult assessment, chemical treatments, barrier dam development, and biological studies. Biological studies are generally conducted with ongoing projects and focus upon the distribution, movement, growth, and abundance of sea lampreys as well as on the effects of lampricides on nontarget organisms.

Sea lamprey management programs are now in place on all of the Great Lakes. Activities of the program in 1986 were highlighted by the first treatments of 10 tributaries of Lake Erie. Also, an estimate of the sea lamprey population was made during the initial treatment of two of these streams (327,000 larval and 137,000 metamorphosed sea lampreys were in Conneaut Creek and 8,500 larval and 800 metamorphosed sea lampreys were in Halfway Brook). A total of 77 tributaries of the Great Lakes were treated (Table 1). Larvae were collected during surveys for the first time in nine tributaries, including five Lake Erie streams and also the Niagara River. Record rainfall in the Lower Peninsula of Michigan washed out 11 dams, 5 of which were barriers to sea lampreys. As a result of the flood, an additional 185 km (115 miles) of streams are open to spawning sea lampreys. Assessment traps captured 54,145 spawning-phase sea lampreys from 58 tributaries (Table 2). A total of 5,724 parasitic-phase sea lampreys were collected from the commercial and sport fisheries.

This report describes, by lake, the sea lamprey management activities in 1986.

Table 1. Summary of chemical treatments in streams and lentic areas of the Great Lakes in 1986.

[Lampricides used are in kilograms/pounds of active ingredient.]

Lake	Number of treatments	Discharge		TFM[a]		Bayer 73			
						Powder		Granules	
		m^3/s	f^3/s	kg	lbs	kg	lbs	kg	lbs
Superior	26	161.9	5,708	15,565	34,316	161	355	151.3	338.5
Michigan	14	139.3	4,924	33,643	74,167	109	238	-	-
Huron	15	9.9	350	2,898	6,386	-	-	27.2	60.0
Erie	10	39.8	1,404	12,577	27,729	-	-	-	-
Ontario	12	32.9	1,163	5,172	11,403	-	-	5.4	12.0
TOTAL	77	383.8	13,549	69,855	154,001	270	593	183.9	410.5

[a]Includes 1,190 TFM bars (248 kg, 547 lbs) applied in 17 streams.

Table 2. Number and biological characteristics of adult sea lampreys captured in assessment traps in 58 tributaries of the Great Lakes in 1986.

Lake	Number of streams	Total captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
					Males	Females	Males	Females
Superior	14	8,777	1,026	38	427	426	183	180
Michigan	13	10,781	3,381	41	486	494	253	277
Huron	10	26,851	4,228	47	472	474	227	235
Erie	8	1,535	1,060	53	505	506	284	291
Ontario	13	6,201	2,293	66	499	495	267	272

LAKE SUPERIOR

Larval Assessment

Surveys were conducted in 110 tributaries and 13 lentic areas of Lake Superior in 1986 in preparation for chemical treatments, to monitor reestablished and residual populations, and to search for new infestations. Pretreatment investigations were carried out in 27 streams: 6 were later treated and 21 are tentatively scheduled for treatment in 1987 or 1988.

Reestablishment surveys showed no evidence of recruitment in the past four or more years in 35 streams. Reestablished populations were present in at least 41 U.S. streams (Table 3) and 7 streams in Canada at the end of the 1986 field season. Reinfestation appeared to be most significant in the Two Hearted, Sucker, and Bad rivers based on the number, size, and distribution of ammocetes. A small reestablished population of larvae of the 1985 and 1986 year classes was in the Rock River upstream of a privately-owned dam that had been an effective barrier to spawning-run adults since 1976. High water levels in Lake Superior are suspected as the cause of adults bypassing the dam.

Moderate numbers of residual sea lampreys were found in the Brule, Middle, and Bad rivers and fewer residual larvae were observed in 16 other streams. The Brule and Middle rivers were treated later, and the Bad River is scheduled for treatment in 1987 or 1988.

Examination of the St. Louis River, which has not been treated, yielded 44 sea lamprey ammocetes (28-144 mm) from a 9.6-km (6-mile) stretch of stream downstream of the dam at Fond du Lac. A single larva was taken in 1985 and it was theorized that pollution had reduced larval populations. It now appears that cold water and interaction with streambed materials may have reduced the effectiveness of Bayer granules in 1985.

No sea lampreys were found during reexamination of Lamond and Pike rivers and Roxbury Creek, three small tributaries with no history of sea lamprey production.

Table 3. U.S. tributaries of Lake Superior with reestablished populations of sea lampreys, and the maximum number collected per hour with an electric shocker.

[B indicates the presence of a year class recovered with Bayer 73.]

Stream	Date of last treatment	Year class			
		1983	1984	1985	1986
Waiska River	10/27/82	1	11	29	7
Pendills Creek	9/20/82	179	21	32	5
Grants Creek	7/21/63	0	1	0	0
Naomikong Creek	7/23/63	5	0	0	0
Galloway Creek	7/12/83	70	0	3	0
Tahquamenon River	7/7/83	3	18	12	21
Betsy River	9/17/82	46	58	84	50
Little Two Hearted River	8/5/83	2	17	8	25
Two Hearted River	8/6/83	18	168	129	29
Sucker River	10/9/84			264	65
Sable Creek	10/5/84			40	8
Sullivans Creek	10/16/75	96	25	45	0
Beaver Lake Outlet	7/30/86				3
Miners River	6/29/82	22	63	69	20
Anna River	5/18/65	3	2	1	2
Five Mile Creek	8/5/81	2	0	0	0
AuTrain River	8/22/85				12
Rock River	11/1/78	0	0	20	27
Sand River	7/29/85			1	0
Chocolay River	9/19/84			52	28
Carp River	7/20/63	6	0	1	0
Harlow Creek	9/21/85				132
Little Garlic River	9/19/85				46
Big Garlic River	9/25/85				30
Iron River	6/29/83	90	52	30	102
Salmon Trout River	7/26/85			214	28
Pine River	9/27/72	40	0	1	0
Huron River	9/6/84			135	15
Sturgeon River	6/18/86				68
Traverse River	6/15/86				118
Little Gratiot River	8/6/72	0	1	0	0
Salmon Trout River	6/11/84		91	3	19
Elm River	6/10/84		2	0	0
Misery River	6/29/85			59	48
Firesteel River	7/1/85			106	18
Ontonagon River	7/11/85			3	23
Cranberry River	6/13/86				12
Black River	8/8/81	B	B	0	0
Bad River	8/1/84			135	80
Amnicon River	5/29/84		20	40	43
Nemadji River	6/27/86				2
Total number of streams in which year class was collected		16	16	26	30

Sea lampreys were collected from 4 of 13 offshore areas examined in Lake Superior. Eighty-eight ammocetes (59-161 mm) were taken from 6 of 10 plots (12,150 m^2) off the Sucker River, and abundance seemed relatively unchanged since 1985. Twenty-one larvae were collected off the Falls River before it was treated, and 1 and 2 larvae were captured off the Little Garlic and Ravine rivers, respectively. Nine inland lakes were examined and sea lampreys were taken from five--Beaver, Little Beaver, Au Train, Harlow, and Pine lakes. Lowney Creek, a Beaver Lake tributary, and Bismark Creek, a Harlow Lake tributary, were treated to reduce further recruitment to the lakes. Streams associated with the other lakes are scheduled for treatment in 1987.

Larval sea lamprey populations were estimated in Cypress Bay and two areas of Helen Lake by recapturing marked sea lampreys with granular Bayer 73. A population of 2,527 larvae, including 258 undergoing adult transformation, was projected in a 1.7-ha (4.2-acre) area in the bay. In Helen Lake the 3-ha (7.4-acre) area of the Nipigon River delta (west shore) contained a larval population of 523,028, including 708 transforming adults. An 0.7-ha (1.7-acre) area on the east side of the lake adjacent to the river delta had an estimated population of 10,025 larvae, of which 42 were transforming.

Larval sea lampreys (age III) were collected in June 1986 from the Sturgeon River (Baraga County, Michigan), a major tributary of the south shore of Lake Superior. The mean total length of the 79 larvae was 144 mm (range 123-180 mm). The ammocetes were held in two aquaria at the Marquette Station until September to determine the rate of transformation. The aquaria were at room temperature and aerated, but larvae were not fed. At the completion of the study, 25 (32%) had undergone transformation. Previous studies have suggested that transformation might begin at age III in some streams, but this is the first definitive evidence we have for transformation of age III ammocetes taken from a Lake Superior tributary.

Chemical Treatments

The lampricide TFM was applied to 20 streams and granular Bayer 73 was used to treat 6 six lentic areas (Table 4, Fig. 1). Most treatments were routine, but low water levels caused some inconvenience. Despite a controlled flow in the Michipicoten River, high flows in the two major tributaries (Trout Creek and Magpie River) taxed the treatment unit considerably. The treatment of the Nipigon River was trouble free because Ontario Hydro maintained a reduced and steady flow during the treatment. Concentrations of TFM lethal to sea lampreys were difficult to maintain in one upstream section of the Brule River. Mortality to nontarget fish (white suckers and blacknose dace) was limited to the area of Big Lake in the Brule River. The reconstructed barrier dam in the Brule River should prevent the need for future treatments in the upper river.

Larval sea lampreys were collected in all streams treated, but few metamorphosed lampreys were found. Larvae were numerous in the Nipigon, Carp, and Brule rivers; a total of 6,466 larvae were collected, of which 4,011 were from the Brule River (31 stations). Low to moderate numbers were collected in the other treated streams.

Granular Bayer 73 treatments in Polly Lake and Mackenzie and Cypress Bays produced low numbers of larval sea lampreys. Moderate numbers of larvae were observed in granular Bayer treatments of Mountain and Batchawana Bays. Treatments in Helen lake, off the mouth of the Upper Nipigon River, produced a total of 7,809 larval sea lampreys. This population in Helen Lake appears to be large in size and distribution.

Table 4. Details on the application of lampricides to streams and lentic areas of Lake Superior, 1986.

[Number in parentheses corresponds to location of stream or lentic area in Figure 1. Lampricides used are in kilograms/pounds of active ingredient.]

Stream or lentic area	Date	Discharge		TFM[a]		Bayer 73				Stream treated		Area treated	
						Powder		Granules					
		m^3/s	ft^3/s	kg	lbs	kg	lbs	kg	lbs	km	miles	ha	acres
UNITED STATES													
Potato R. (22)	June 13	0.6	20	120	264	-	-	-	-	16.1	10	-	-
Cranberry R. (23)	June 13	0.4	14	140	308	-	-	-	-	16.1	10	-	-
Traverse R. (20)	June 15	0.7	25	40	88	-	-	-	-	12.9	8	-	-
Sturgeon R. (19)	June 16	14.2	500	1,996	4,400	-	-	-	-	161.3	100	-	-
Nemadji R. (26)													
Black R.	June 27	3.3	115	170	374	-	-	-	-	6.5	4	-	-
Beaver Lake Outlet (14)													
Lowney Cr.	July 30	0.6	20	80	176	-	-	-	-	3.2	2	-	-
Furnace Cr. (15)	Aug. 14	0.2	8	41	91	-	-	-	-	4.8	3	-	-
East Sleeping R. (21)	Aug. 17	0.6	20	160	354	-	-	-	-	4.8	3	-	-
Silver R. (17)	Aug. 19	0.5	17	62	136	-	-	-	-	3.2	2	-	-
Falls R. (18)	Aug. 20	1.3	45	70	154	-	-	-	-	1.6	1	-	-
Brule R. (24)	Aug. 29	7.1	250	1,154	2,545	-	-	-	-	104.8	65	-	-
Blueberry Cr.	Jun. 29	0.4	14	20	44	-	-	-	-	4.8	3	-	-
Sucker R. (13)	Sept. 12	2.0	70	344	759	-	-	-	-	9.7	6	-	-
Middle R. (25)	Sept. 12	1.7	60	151	334	-	-	-	-	19.4	12	-	-
Harlow Cr. (16)													
Bismark Cr.	Nov. 5	0.1	2	5	11	-	-	-	-	1.6	1	-	-
Total		33.7	1,180	4,553	10,038	-	-	-	-	370.9	230	-	-
CANADA													
Carp R. (11)	July 2	0.7	25	87	192	-	-	-	-	9.6	6	0.7	2
Gravel R. (8)	July 9	9.7	343	616	1,358	10	22	0.3	0.7	16.1	10	-	-
Cypress R. (7)	July 11	1.8	64	112	247	-	-	-	-	5.5	3	-	-
Pearl R. (2)	July 13	0.4	14	145	320	-	-	-	-	5.0	3	-	-
Michipicoten R. (10)	July 26	60.2	2,126	3,400	7,496	50	110	0.1	0.2	19.6	12	-	-
Nipigon R. (3)	Aug. 20	55.4	1,956	6,652	14,665	101	223	0.1	0.2	12.9	8	-	-
Polly Lake (4)	Aug. 12	-	-	-	-	-	-	7.9	17.4	-	-	0.7	2
Mountain Bay (9)	Aug. 13	-	-	-	-	-	-	36.3	80.0	-	-	3.0	7
MacKenzie Bay (1)	Aug. 14	-	-	-	-	-	-	22.7	50.0	-	-	1.9	5
Cypress Bay (6)	Aug. 15	-	-	-	-	-	-	20.4	50.0	-	-	1.7	4
Helen Lake (5)	Aug. 19	-	-	-	-	-	-	45.4	100.1	-	-	3.7	9
Batchawana Bay (12)													
Off Chippewa R.	Sept. 3	-	-	-	-	-	-	18.1	39.9	-	-	1.5	4
Total		128.2	4,528	11,012	24,278	161	355	151.3	338.5	68.7	42	12.5	31
GRAND TOTAL		161.9	5,708	15,565	34,316	161	355	151.3	338.5	439.5	272	12.5	31

[a]Includes 275 TFM bars (57 kg, 126 lbs) applied in six U.S. streams.

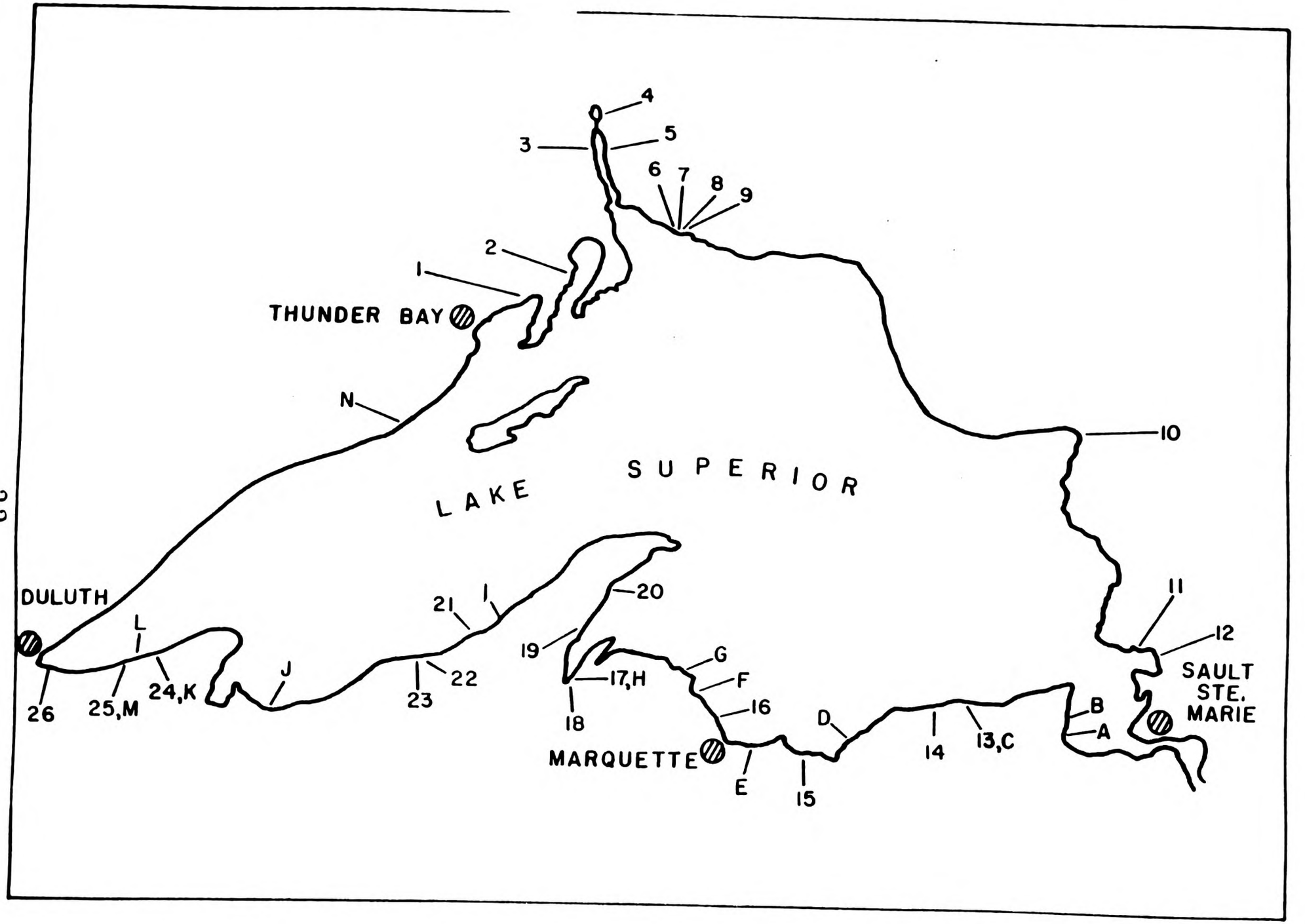

Figure 1. Location of streams treated with lampricides (numerals; see Table 4 for names of streams), and of streams where assessment traps were fished (letters; see Table 5 for names of streams) in 1986.

Spawning-phase Sea Lampreys

Assessment traps in 14 tributaries of Lake Superior captured 8,777 adult sea lampreys in 1986 (Table 5, Fig. 1), compared with 1,637 in 1985. The increase largely was due to two factors: the number of rivers with traps increased from 10 to 14, and the capture of 7,006 sea lampreys in a permanent trap in the newly completed sea lamprey barrier/fishway in the Brule River (site not monitored in 1985). As a comparison to 1985, the catch from the 9 streams sampled in both years declined 18% (from 1,637 to 1,347). The average length and weight of sea lampreys and the percentage of males remained the same as in 1985. Spawning runs in six streams were monitored through cooperative agreements with the Great Lakes Indian Fish and Wildlife Commission (Arrowhead, Middle, Poplar, Bad, and Silver rivers) and the Wisconsin Department of Natural Resources (Brule River).

Table 5. Number and biological characteristics of adult sea lampreys captured in assessment traps in U.S. tributaries of Lake Superior, 1986.

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

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
				Males	Females	Males	Females
Tahquamenon R. (A)	161	14	79	445	480	194	241
Betsy R. (B)	125	17	18	407	432	138	179
Sucker R. (C)	20	0	-	-	-	-	-
Miners R. (D)	9	0	-	-	-	-	-
Rock R. (E)	435	137	32	424	428	155	167
Big Garlic R. (F)	20	5	40	385	409	143	154
Iron R. (G)	74	8	38	438	416	207	164
Silver R. (H)	0	-	-	-	-	-	-
Misery R. (I)	423	239	29	419	412	168	169
Bad R. (J)	184	56	18	391	399	123	139
Brule R. (K)	7,006	422	49	432	445	202	204
Poplar R. (L)	0	-	-	-	-	-	-
Middle R. (M)	315	128	34	423	419	163	174
Arrowhead R. (N)	1	0	-	-	-	-	-
TOTAL OR AVERAGE	8,777	1,026	38	427	426	183	180

Evidence of isolated, open-lake spawning of sea lampreys was reported in 1986 and the discovery may have Great Lakes-wide implications. On August 4, acting on a report by a local swimmer, divers discovered four adult lampreys which had completed spawning and three nests at the outflow of the power plant in the City of Marquette. This power plant discharges directly into Lake Superior. Water temperature was 25.6° C (78° F.) at the time. Granular Bayer was applied and the area was electrofished on September 3, but no larvae were recovered. Erosion of sand from the beach had covered two of the nests and the remainder contained only dead eggs. Water temperature at the outflow at this time was 25° C (77° F.). In past laboratory tests, no viable burrowing larvae

were produced from eggs exposed to a constant temperature above 21.1° C (70° F.) and complete mortality was observed within 2 days at 25.3° C (77.5° F.). Due to the warm temperature of the discharge, it is doubtful that larvae are produced at the Marquette Power Plant in the summer. It is more likely, however, that the right combination of flow and temperature for the production of larvae does exist at other times of the year at the Marquette Power Plant as well as at other power plants or industries discharging water into the Great Lakes.

As a recommendation of the Workshop to Evaluate Sea Lamprey Populations, the total number of spawning-phase sea lampreys was estimated in U.S. waters of Lake Superior in 1986. The work was a cooperative effort among the U.S. Fish and Wildlife Service, the Great Lakes Indian Fish and Wildlife Commission, and the Wisconsin Department of Natural Resources. The estimate was based on a statistically significant relation between average stream discharge and the number of spawning-phase sea lampreys that enter tributaries. Five steps were used to arrive at the estimate.

First, historical records of data on chemical treatments, stream surveys, electrical weirs, and trap catches were reviewed to determine those tributaries which showed a consistent and significant production of sea lampreys in U.S. waters of Lake Superior. From this evaluation, 34 tributaries were designated as primary producers of sea lampreys (includes 13 streams with assessment traps) and 21 as secondary producers.

Second, the total number of spawners was estimated for each of the 13 streams with assessment traps. A weekly stratified mark and recapture procedure which can be applied when a population has constant recruitment was used to calculate each stream estimate. An estimated 19,347 lampreys were present in these streams (Table 6).

Third, the daily discharge for the 34 primary producers was estimated from a regression developed between current meter measurements and staff gauge readings from April 28 through July 11. A current meter was used to measure stream discharge biweekly (six readings on each stream). Staff gauges were read from three to five times per week for each stream. To relate discharge to lamprey numbers, the average discharge value for each stream was used for the period when 95% of the lampreys were captured in traps (May 11 to June 28). These 34 primary streams had a total discharge value of 157.3 m^3/s (5,554 cfs; Table 6).

Average flows from past chemical treatments (24.4 m^3/s, 862 cfs) were used for the discharge of secondary streams. Numbers of lampreys captured per cubic meter per second of flow were compared for primary and secondary streams from electrical weir data for 1954-60. Weirs on secondary streams collected one-tenth of the sea lampreys per cubic meter per second of flow as primary streams, and the flow for these streams was adjusted to 2.4 m^3/s (86 cfs). The average flow for all streams combined was 159.7 m^3/s (5,640 cfs; Table 6).

Fourth, a regression was plotted from the spawning run estimates and the discharge averages for the 13 assessment streams. The regression was linear, $y = 10.73\ x$ (where y is the estimated population of spawning sea lampreys and x is the average discharge), and was significant at $P < 0.001$ ($r = 0.82$).

Table 6. Mean discharge for U.S. streams of Lake Superior from May 11 to June 28, 1986, ranked as primary and secondary producers of sea lampreys, and the estimated number of spawning-phase sea lampreys in 13 streams with assessment traps.

[Estimates were calculated from results of a tagging and recapture study that used stratified multiple samples.]

Primary streams				Secondary streams		
	Discharge		Population		Discharge[a]	
Stream	m^3/s	f^3/s	estimate	Stream	m^3/s	f^3/s
Nemadji River	29.9	1,055	-	Washington Creek	0.8	29
Amnicon River	9.6	339	-	Arrowhead River	9.8	347
Middle River	3.4	121	852	Poplar River	1.3	45
Poplar River	2.0	69	10	Gooseberry River	0.1	3
Brule River	9.9	349	8,672	Split Rock River	0.3	10
Fish Creek	4.1	145	-	Sand River	0.3	11
Bad River	15.7	555	5,397	Black River	2.7	97
Ontonagon River	21.9	775	-	Cranberry River	1.7	60
Firesteel River	1.2	44	-	Potato River	1.0	36
Misery River	1.1	38	766	East Sleeping River	0.7	26
Traverse River	0.6	20	-	Elm River	0.6	21
Sturgeon River	15.9	560	-	Salmon Trout River	1.2	44
Falls River	1.0	37	-	Big Gratiot River	0.3	12
Silver River	1.2	42	100	Eliza Creek	<0.1	1
Slate River	0.3	10	-	Dead River	1.4	50
Ravine River	0.1	5	-	Sand River	0.5	16
Huron River	1.2	43	-	Five Mile Creek	0.1	2
Salmon Trout River	1.0	37	-	Beaver Lake Outlet	0.5	17
Iron River	2.0	69	527	Sable Creek	0.3	10
Big Garlic River	0.4	15	52	Galloway Creek	0.1	4
Little Garlic River	0.2	7	-	Pendills Creek	0.6	21
Harlow Creek	0.4	14	-			
Chocolay River	4.0	142	-	Mean discharge[b]	24.4	862
Laughing Whitefish R.	0.5	16	-			
Rock River	0.7	24	715	Adjusted discharge	2.4	86
Au Train River	3.7	132	-	(24.4 x 0.1)		
Furnace Creek	0.3	11	-	(862 x 0.1)		
Miners River	1.0	35	50			
Sucker River	2.2	79	49			
Two Hearted River	5.4	189	-			
Little Two Hearted R.	1.0	34	-			
Betsy River	2.5	88	850			
Tahquamenon River	11.4	403	1,307			
Waiska River	1.5	52	-			
Total (with traps)	53.5	1,887	19,347			
Total (no traps)	103.8	3,667	-			
PRIMARY TOTAL	157.3	5,554	19,347	SECONDARY TOTAL	2.4	86

[a]Average flows taken during past chemical treatments.

[b]Electrical weirs on secondary streams had collected one-tenth of the sea lampreys per cubic meter of flow as primary streams, and the flow for these streams was adjusted to correspond to the lower sea lamprey production.

The final step was to determine the 1986 spawning run of sea lampreys for U.S. waters of Lake Superior by the regression equation. The total estimate was 60,517 spawning-phase sea lampreys based on the average discharge of 159.7 m^3/s (5,640 cfs) in U.S. streams of Lake Superior that produce sea lampreys.

Parasitic-phase Sea Lampreys

A total of 219 sea lampreys were collected from U.S. commercial fishermen in Lake Superior through October 1986 (Table 7), compared with 260 taken in 1985. In addition, only three lampreys were taken from Canadian waters. Fishermen in statistical districts MS-4 (Munising, Michigan, area) and Wisconsin collected most sea lampreys from U.S. waters of Lake Superior--130 and 59, respectively. In 1985, 128 lampreys were taken in MS-4 and 72 in the Wisconsin district. Although the number of sea lampreys collected in MS-4 remained the same, spring wounding rates on lake trout decreased substantially (from 11.3% in 1985 to 2.5% in 1986, data from Michigan Department of Natural Resources). No explanation was apparent for the differences. The slight decrease in parasitic-phase sea lampreys collected in Wisconsin corresponds to a small decrease in the spring wounding rates on lake trout (3.1% in 1986 vs. 3.7% in 1985, data from Wisconsin Department of Natural Resources).

Parasitic-phase sea lampreys are collected throughout the year from commercial fishermen, therefore, lampreys that would spawn in either the present or succeeding 2 years may be found in the catch. To define the relation of the catch of feeding lampreys to the number of spawning-phase lampreys taken in assessment traps, spawning year was determined for the 219 parasitic-phase sea lampreys captured in 1986; 157 would have spawned in 1986 and 62 in 1987 (Table 7). In addition, 82 lampreys of the 1986 spawning year were taken in 1985, bringing the total collected for this spawning year to 239.

Lake Superior sport fishermen captured 63 parasitic-phase sea lampreys in 1986 (Table 7), compared with 46 in 1985 and 21 in 1984. Of the total, 14 were from charter captains and 49 were from noncharter fishermen. Seventeen charter-boat captains provided information on occurrence of sea lampreys and lamprey wounds in their catches of fish. Lake trout are the primary target species in the charter fishery of Lake Superior, and captains reported 0.7 lamprey attached per 100 trout in their catch (Table 8). Fresh wounds (Type A, Stage I-III) were observed at 5.2 per 100 trout in the spring, 3.7 in the summer, and 4.2 in the fall (Table 9). Sea lampreys were attached to chinook salmon at a rate of 0.4 per 100 fish.

Barrier Dams

No barrier dams were constructed in Canadian tributaries of Lake Superior in 1986. Minor maintenance work was done on the low-head barrier dams in the Gimlet, Sheppard, and Stokely creeks and the Carp River. A concrete pad was added to one bank near the Stokely Creek barrier dam. The steel lip was elevated on the low crest portion of the Carp River barrier dam.

Table 7. Number of parasitic-phase sea lampreys collected in commercial and sport fisheries in 1986, and year lampreys would have spawned.[a]

LAKE SUPERIOR				LAKE MICHIGAN					LAKE HURON				
	Spawning year				Spawning year					Spawning year			
	Commercial		Sport		Commercial			Sport		Commercial			Sport
District	1986	1987	1987	District	1986	1987	1988	1987	District	1986	1987	1988	1987
M-1	-	-	9	MM-1	37	67	3	-	MH-1	104	545	3	262
M-2	-	1	5	MM-2	-	-	-	-	MH-2	3	82	3	426
M-3	1	-	-	MM-3	-	19	5	6	MH-3	-	-	-	883
Wis.	40	19	15	MM-4	-	-	-	3	MH-4	12	84	-	239
MS-1	-	-	-	MM-5	-	-	-	43	MH-5	-	-	-	236
MS-2	-	-	6	MM-6	-	-	-	198	MH-6	16	-	-	23
MS-3	21	2	1	MM-7	-	41	-	62					
MS-4	93	37	25	MM-8	-	-	-	36					
MS-5	-	-	2	WM-1	2	1	-	12					
MS-6	2	3	-	WM-2	1	29	-	33					
				WM-3	1	17	-	42					
				WM-4	80	1	-	240					
				WM-5	-	-	-	80					
				WM-6	-	-	-	7					
				Ill.	-	-	-	13					
				Ind.	-	-	-	5					
Total	157	62	63		121	175	8	780		135	711	6	2,069

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

Table 8. Incidence of sea lampreys, and numbers of lake trout and chinook salmon[a] taken by captains in the charter boat fishery, 1986.

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

Lake and district[b]	Incidence on lake trout		Incidence on chinook salmon	
	Sea lampreys per 100 trout	Number of trout	Sea lampreys per 100 salmon	Number of salmon
Superior				
M-1	0.7	551	0.0	61
M-2	0.6	161	0.0	40
Wis.	0.4	678	0.0	80
MS-3	0.9	114	0.0	5
MS-4	0.8	835	1.8	57
All districts	0.7	2,339	0.4	243
Michigan				
MM-3	0.0	36	0.0	22
MM-5	0.7	598	1.0	1,123
MM-6	0.9	540	0.4	1,875
MM-7	0.3	724	0.2	1,996
MM-8	0.3	1,008	0.0	1,928
WM-3	0.0	36	0.8	950
WM-4	0.2	437	1.7	952
WM-5	1.5	263	0.1	1,084
WM-6	0.7	543	0.0	365
Ill.	0.0	212	0.0	482
Ind.	0.2	522	0.0	430
All districts	0.5	4,919	0.4	11,207
Huron				
MH-1	2.4	254	9.3	935
MH-2	2.2	227	12.7	339
MH-3	1.9	2,229	11.5	740
MH-4	1.7	584	2.4	83
MH-5	2.5	200	13.0	246
MH-6	16.7	12	2.8	282
All districts	2.0	3,506	9.8	2,625

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

[b]Data were not obtained from districts M-3, MS-1, MS-2, MM-1, MM-2, MM-4, WM-1, and WM-2.

Table 9. Number of sea lamprey wounds per 100 lake trout or chinook salmon, and number of fish (in parentheses) taken by captains in the charter boat fishery, 1986.[a]

[Wounds are the marks of Type A, Stages I-III; spring is before July 1, summer is July 1 to September 1, and fall is after September 1.]

Lake and district[b]	Sea lamprey wounds per 100 fish					
	Lake trout			Chinook salmon		
	Spring	Summer	Fall	Spring	Summer	Fall
Superior						
M-1	7.3 (232)	4.8 (231)	0.0 (88)	3.3 (30)	0.0 (16)	0.0 (15)
M-2	9.1 (11)	2.6 (114)	0.0 (36)	-	0.0 (9)	0.0 (31)
Wis.	1.2 (159)	1.0 (202)	3.5 (317)	0.0 (44)	0.0 (12)	0.0 (24)
MS-3	13.3 (15)	0.0 (37)	6.4 (62)	-	0.0 (3)	0.0 (2)
MS-4	5.1 (138)	8.6 (116)	5.2 (581)	0.0 (2)	0.0 (4)	2.0 (51)
All districts	5.2 (555)	3.7 (700)	4.2 (1,084)	1.3 (76)	0.0 (44)	0.8 (123)
Michigan						
MM-3	0.0 (36)	-	-	-	0.0 (12)	0.0 (10)
MM-5	1.8 (276)	4.1 (319)	66.7 (3)	0.5 (217)	1.6 (803)	1.0 (103)
MM-6	8.8 (297)	0.8 (242)	0.0 (1)	1.1 (783)	1.3 (996)	0.0 (96)
MM-7	7.2 (545)	1.8 (169)	0.0 (10)	1.8 (894)	0.8 (800)	1.6 (302)
MM-8	8.5 (625)	3.5 (346)	2.7 (37)	0.6 (1,389)	0.2 (445)	0.0 (94)
WM-3	-	0.0 (20)	0.0 (16)	-	0.0 (432)	0.4 (518)
WM-4	17.5 (154)	9.5 (220)	9.5 (63)	5.7 (212)	1.6 (486)	3.9 (254)
WM-5	4.9 (41)	4.9 (41)	2.8 (181)	0.6 (342)	0.9 (328)	0.2 (414)
WM-6	5.9 (253)	5.1 (217)	2.7 (73)	0.5 (186)	0.0 (132)	0.0 (47)
Ill.	2.6 (76)	1.5 (133)	0.0 (3)	1.4 (209)	1.7 (175)	0.0 (98)
Ind.	10.1 (317)	1.0 (205)	-	3.4 (298)	0.0 (132)	-
All districts	7.7 (2,620)	3.6 (1,912)	4.1 (387)	1.4 (4,530)	1.0 (4,741)	1.0 (1,936)
Huron						
MH-1	11.0 (208)	4.4 (45)	0.0 (1)	18.2 (33)	15.3 (523)	4.7 (379)
MH-2	12.4 (178)	22.4 (49)	-	13.0 (46)	30.2 (285)	25.0 (8)
MH-3	15.0 (922)	8.5 (1,307)	-	18.7 (123)	28.9 (471)	21.2 (146)
MH-4	13.8 (224)	9.4 (360)	-	11.9 (42)	8.8 (34)	14.3 (7)
MH-5	17.9 (145)	20.0 (55)	-	22.3 (193)	37.1 (35)	44.4 (18)
MH-6	41.7 (12)	-	-	16.3 (270)	58.3 (12)	-
All districts	14.5 (1,689)	9.3 (1,816)	0.0 (1)	18.0 (707)	23.9 (1,360)	10.8 (558)

[a]Lake trout and chinook salmon are the primary target species of the charter fishery of the Upper Great Lakes. Little data are reported on lake trout in the fall because of a closure on sport fishing for the species after August 15 in many areas of Lakes Michigan and Huron.

[b]Data were not obtained from districts M-3, MS-1, MS-2, MM-1, MM-2, MM-4, WM-1, and WM-2.

LAKE MICHIGAN

Larval Assessment

Surveys were conducted on 120 Lake Michigan tributaries to assess populations of larval sea lampreys. Seventeen streams were examined in preparation for chemical treatments; 6 were treated and 11 are scheduled for treatment. Larvae of the 1986 year class were collected in 32 streams. Reestablished populations are present in 36 of the 66 tributaries on the north and west shores of Lake Michigan that are monitored annually (Table 10).

Residual sea lampreys were found in 18 streams, but in most streams the numbers were small and no remedial action was needed. However, 1,029 residual lampreys were taken from refuge areas in the Muskegon River. This relatively large number demonstrates the necessity for special control efforts in such areas and individual attention is required.

Surveys to assess the effectiveness of sea lamprey barrier dams continued in 1986 on the Whitefish and Days rivers. Sea lampreys were not found upstream of either barrier, indicating that they effectively block upstream migration.

Surveys off the mouths of 16 streams demonstrated the presence of sea lampreys in five areas. Twenty-seven sea lamprey larvae and 9 transformed individuals were collected off Ogontz River, and 50 sea lamprey ammocetes and 2 transformed individuals were taken off Days River. The Ogontz River also contains residual sea lampreys and is scheduled for treatment in 1987. The catch per unit of effort off the Days River was one of the highest since we began offshore surveillance. Recent installation of a barrier dam may have altered stream conditions enough to influence offshore drift. Three transforming sea lampreys were taken in Lake Charlevoix off the mouths of Boyne River and Porter Creek and 84 sea lamprey ammocetes were collected off Bear River in Emmet County.

Twenty-five streams with some potential for sea lamprey production were examined, and all surveys were negative. Surveys continued on the Fox River because of a suspicion that improving water quality may allow sea lampreys to spawn successfully. Thirty-one stations were examined with Bayer granules or electroshockers and no sea lampreys were recovered.

Severe flooding and the destruction of 11 dams in the Lower Peninsula of Michigan will undoubtedly extend the upstream distribution of sea lampreys in several streams. Beginning on September 9, 30 cm (12 inches) of rain fell on central Lower Michigan in 36 hours and rain continued for 27 consecutive days. Five of the washed-out dams were barriers to sea lamprey migration. Twenty-seven tributaries of 4 streams contain 185 km (115 miles) of suitable habitat that will be available to adult sea lampreys in 1987. Construction permits have been issued for the Hart Dam on the Pentwater River and Hesperia Dam on the White River, and a permit is expected soon for the Danaher Dam on the Pere Marquette River. Completion dates for rebuilding the dams are uncertain.

Larval sea lampreys (age IV) were collected in May 1986 from Whitefish Bay Creek, a tributary of the west shore of Lake Michigan in Door County, Wisconsin. The mean length of the 120 larvae was 145 mm (range 120-175 mm). The ammocetes were held in two aquaria at the Marquette Station until September to determine the rate of transformation. The aquaria were at room temperature and aerated, but larvae were not fed. At the completion of the study, 46 (38%) had undergone transformation. A transformation rate of 2% was observed in a similar study conducted in 1985 when the larvae were age III.

Table 10. Tributaries of the north and west shores of Lake Michigan with reestablished populations of sea lampreys, and the maximum number collected per hour with an electric shocker.

[B indicates the presence of a year class recovered with Bayer 73.]

Stream	Date of last treatment	Year Class			
		1983	1984	1985	1986
Brevort River	5/6/82	28	5	2	12
Paquin Creek	6/8/78	6	1	2	6
Hog Island Creek	7/8/82	30	1	32	2
Black River	5/10/82	17	12	88	5
Mile Creek	9/27/72	0	0	0	1
Millecoquins River	6/9/85			54	17
Rock River	5/22/83	0	0	4	0
Hudson Creek	5/11/84		0	29	0
Swan Creek	7/10/61	0	76	0	0
Gulliver Lake Outlet	6/12/77	1	0	40	0
Marblehead Creek	8/13/81	0	6	2	0
Manistique River	8/12/85				14
Deadhorse Creek	6/28/77	0	3	24	0
Parent Creek	5/20/83	0	0	29	0
Poodle Pete Creek	9/4/75	0	0	12	10
Valentine Creek	6/26/77	0	1	6	0
Fishdam River	10/22/85				28
Sturgeon River	10/5/85				110
Ogontz River	10/20/85				38
Hock Creek	5/7/81	0	2	0	0
Rapid River	10/21/84			38	0
Tacoosh River	5/13/66	9	1	1	0
Days River	9/3/82	1	7	4	3
Portage Creek	6/5/83	0	3	1	0
Ford River	9/9/85				61
Sunny Brook	5/1/71	0	34	0	0
Bark River	6/3/83	0	10	0	0
Bailey Creek	8/18/77	0	20	0	0
Beattie Creek	8/19/77	10	21	7	11
Menominee River	8/21/77	B	B	0	0
Peshtigo River	7/30/85			0	14
Hibbards Creek	5/13/79	77	31	20	13
Whitefish Bay Creek	4/22/63	0	11	5	1
Door County #23 Creek	5/11/79	9	1	0	0
Kewaunee River	5/10/75	1	0	1	1
East Twin River	7/9/82	4	20	2	0
Total number of streams in which year class was collected		13	21	22	18

TFM (liquid formulation) was used experimentally just before treatment to survey two tributaries of Burns Ditch in Indiana. Plastic sheeting was used at the upper and lower ends of a 30-m (98-foot) test plot in each stream. TFM was applied to each plot; Coffee Creek yielded 40 sea lampreys and the Little Calumet River none. Preliminary evaluation suggests that this method is labor intensive and has limited application.

A new backpack electroshocker (ABP-1) was designed by the University of Wisconsin primarily for use in highly conductive streams. The unit uses digital closed-loop circuitry to provide a number of programmable options. The options include individually and independently adjustable pulse rates and duty cycles for both slow and fast output circuits, a voltage setting for collecting larval lampreys (0-100 V), a voltage setting for collecting other fish (0-250 V), and a LCD panel readout that shows peak output current, peak output voltage, and battery terminal voltage. A series of LED indicator lights and a buzzer warn of malfunctions in battery voltage, circuit overload, and elevated internal case temperature. As a safety feature, the unit shuts off when a malfunction or immersion occurs and remains inoperable until it is manually reactivated.

A recently developed deep-water shocker was modified to improve its efficiency by the addition of 7.6-cm (3-inch) metal rods to the electrodes that penetrate the substrate. The shocker was tested in the laboratory. The rods help to confine and concentrate the electrical field within the trap area and to prevent ammocetes from burrowing laterally.

General observations indicated that the unit was more effective in trapping American brook lampreys than sea lampreys. Recovery during a 2-minute trial was 18% for American brook lampreys and 12% for sea lampreys. Larval American brook lampreys were used in a field study on Coffee Creek, a stream with relatively high conductivity in Indiana. Three plots with 20 larvae each were surveyed for 1 minute each with the deep-water shocker. A total of 12 larvae were recovered from the plots. The plots were surveyed two more times for 1 minute each to recover the remaining larvae. Seven larvae were recovered in the second trial and 7 in the third. The cumulative percentage total for larvae recovered from all trials was 43.

Chemical Treatments

Chemical treatments were completed on 14 streams (Table 11, Fig. 2). Most treatments were routine and only typical problems were encountered. High discharges complicated treatments in the Muskegon, Lincoln, and Cedar rivers and Gurney Creek and Burns Ditch, whereas low discharges hindered treatments in the Whitefish and Milakokia rivers. Floods from a record rainfall in September delayed treatment of the Lincoln River until late October. The high water level of Lake Michigan created problems in maintaining lethal concentrations in estuaries.

Sea lamprey larvae were abundant in the Muskegon, Manistee, Little Manistee, and Lincoln rivers and Gurney Creek and low to moderate in the other treated streams. The numbers of sea lampreys collected included 3,866 at 19 sites in the Muskegon River, 3,739 at 29 sites in the Manistee and Little Manistee rivers, 803 at 10 sites in the Lincoln River, and 1,327 at 7 sites in Gurney Creek. Transformed larvae were collected in the Manistee (11) and Lincoln (47) rivers.

Table 11. Details on the application of lampricides to streams of Lake Michigan, 1986.

[Number in parentheses corresponds to location of stream in Figure 2. Lampricides used are in kilograms/pounds of active ingredient.]

Stream	Date	Discharge		TFM[a]		Bayer 73 powder		Stream treated	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles
Galien River (12)	May 10	2.5	90	1,367	3,014	0	0	64.5	40
Crow River (4)	May 16	1.3	45	279	616	0	0	1.6	1
Millicoquin River (5)									
McAlpine Creek	May 16	0.3	11	60	132	0	0	1.6	1
Milakokia River (3)	May 19	0.8	30	529	1,166	0	0	25.8	16
State Creek (13)	May 23	0.3	10	30	66	0	0	1.6	1
Burns Ditch (14)	May 26	2.1	75	709	1,562	0	0	40.3	25
Muskegon River (11)	July 11	42.2	1,492	7,834	17,270	29	63	106.5	66
Manistee River (7)	Aug. 5	57.7	2,038	12,544	27,654	70	154	98.4	61
Whitefish River (2)	Aug. 15	5.1	180	1,922	4,238	0	0	96.8	60
Casey Creek	May 30	0.1	2	10	22	0	0	3.2	2
Haymeadow Creek	May 31	0.3	11	90	198	0	0	8.1	5
East Branch	June 1	1.8	63	529	1,166	0	0	24.2	15
Pole Creek	June 2	0.2	7	60	132	0	0	8.1	5
Little Manistee R. (8)	Aug. 19	6.8	240	988	2,178	10	21	16.1	10
Carp Lake River (6)	Aug. 28	0.2	6	62	137	0	0	3.2	2
Gurney Creek (10)	Sept. 20	0.8	29	110	242	0	0	3.2	2
Cedar River (1)	Sept. 26	13.3	470	4,953	10,920	0	0	177.4	110
Lincoln River (9)	Oct. 29	3.5	125	1,567	3,454	0	0	29.0	18
TOTAL		139.3	4,924	33,643	74,167	109	238	709.6	440

[a]Includes 345 TFM bars (72 kg, 159 lbs) in three streams.

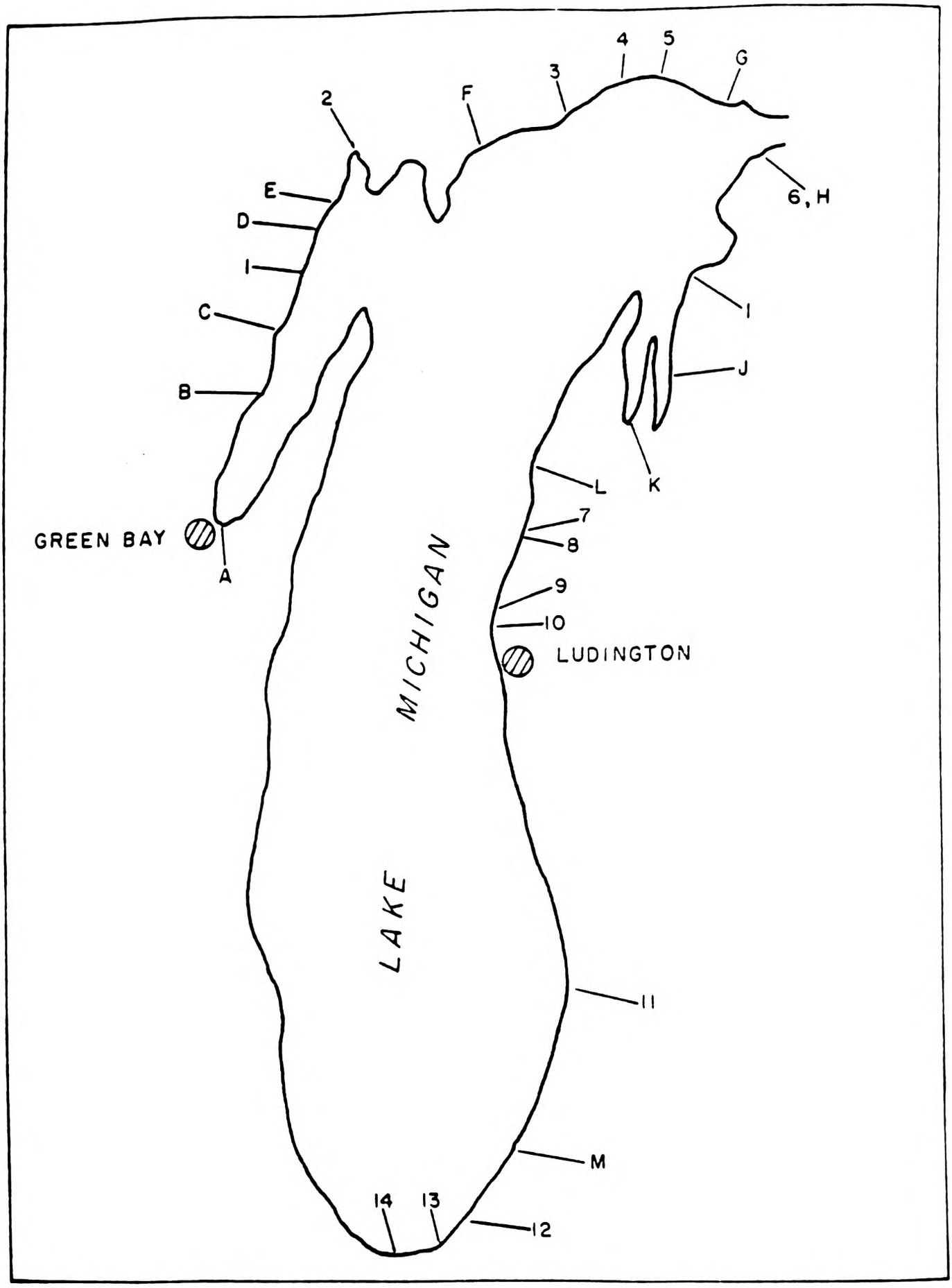

Figure 2. Locations of streams treated with lampricides (numerals; see Table 11 for names of streams), and of streams where assessment traps were fished (letters; see Table 12 for names of streams) in 1986.

The 2-year treatment cycle for the Muskegon River resulted in a pronounced decline in numbers of large residual sea lampreys. The percentage of large larvae (>119 mm long) in collections during treatments decreased from 30.2 in 1982 to 4.4 in 1984 to 0.5 in 1986. The 1985 year class contained 98% of the sea lampreys collected in the 1986 treatment.

Fish mortality was significant during the treatments of Galien and Crow rivers, but negligible in the other treated streams. Species most affected in the Galien River were johnny darters, white suckers, logperch, and blacknose dace, whereas in the Crow River, white suckers and longnose suckers were affected.

Spawning-phase Sea Lampreys

A total of 10,781 sea lampreys were captured in assessment traps placed in seven west shore and six east shore tributaries of Lake Michigan in 1986 Table 12, Fig. 2). Along the west shore, the catch of sea lampreys declined significantly over the number taken in 1985 in the Manistique (9,080 vs. 13,291) and Menominee (327 vs. 500) rivers. A stratified tag and recovery system was used for the third consecutive year in 1986 to estimate the number of spawning-phase sea lampreys in the Manistique River (23,725, Table 13) and verifies the concurrent decrease in trap catch. No lampreys were captured for the eighth consecutive year in the Fox River.

The catch of sea lampreys also declined in streams along the east shore of Lake Michigan over the number taken in 1985 (988 vs. 1,327). The trap catch increased in the St. Joseph River (505 vs. 406), but decreased in the other tributaries monitored (483 vs. 921). Traps were operated in the Elk River for the first time since 1978, and captured five lampreys. The average length of adult lampreys taken throughout Lake Michigan during 1986 was similar to that of lampreys taken in 1985, but the average weight of specimens (sexes combined) in 1986 increased 21 g over those taken in 1985.

Parasitic-phase Sea Lampreys

Lake Michigan commercial fishermen captured 304 sea lampreys through October 1986 (Table 7), compared with 366 in the same period in 1985. Of the total, 164 were collected from northern Lake Michigan and 140 from Green Bay, compared with 210 and 141, respectively, in 1985.

Spawning year was determined for the 304 parasitic-phase sea lampreys; 121 would have spawned in 1986, 175 in 1987, and 8 in 1988 (Table 7). In addition, 194 lampreys of the 1986 spawning year were taken in 1985, bringing the total collected for this spawning year to 315.

A total of 780 sea lampreys were obtained from the sport fishery, 50 from charter and 730 from noncharter fishermen (Table 7), compared with 720 (43 charter, 677 noncharter) in 1985. As in 1985, most lampreys were recovered from statistical districts WM-4 and WM-5 (Algoma to Milwaukee in Wisconsin) and MM-6 (Arcadia to Little Sable Point in Michigan). Also, most lampreys were captured from July to September.

Table 12. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Michigan, 1986.

[Letter in parentheses corresponds to location of stream in Figure 2.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g	
				Males	Females	Males	Females
West Shore							
Fox River (A)	0	-	-	-	-	-	-
Peshtigo River (B)	376	326	46	500	503	260	279
Menominee River (C)	327	324	39	500	492	268	270
Cedar River (D)	8	6	33	433	516	236	293
Ford River (E)	2	2	50	544	442	347	200
Manistique River (F)	9,080	1,788	48	485	490	251	273
Brevort River (G)	0	-	-	-	-	-	-
East Shore							
Carp Lake River (H)	23	20	45	441	428	196	178
Jordan River (I)							
Deer Creek	111	108	31	468	511	244	318
Elk River (J)	5	5	20	470	480	254	285
Boardman River (K)	96	86	28	433	496	214	297
Betsie River (L)	248	220	19	420	494	211	293
St. Joseph River (M)	505	496	31	505	502	264	275
Total or average	10,781	3,381	41	486	494	253	277

Table 13. Estimated number of spawning-phase sea lampreys in four U.S. tributaries, 1984-86.

[Estimates were calculated from results of a tagging and recapture study that used stratified multiple samples.]

Stream	Lake	1984	1985	1986
Manistique River	Michigan	24,659	38,260	23,725
Cheboygan River	Huron	25,457	39,626	28,293
Ocqueoc River	Huron	-	13,065	9,038
St. Marys River	Huron	-	23,852	16,812

Information on occurrence of sea lampreys and lamprey wounds on fish was reported by 102 charter captains (Tables 8 and 9). Lakewide, 70% of the collected lampreys were attached to chinook salmon. The number of lampreys per 100 lake trout increased from 0.3 in 1985 to 0.5 in 1986, but the number per 100 chinook salmon remained at 0.4. Fishing success of the charters was identical for the two years, 1.4 salmonids per hour. Lakewide, wounds per 100 lake trout and per 100 chinook salmon remained nearly the same (5.6 and 1.1 in 1985 vs. 5.4 and 1.1 in 1986, respectively; seasonal rates were combined).

LAKE HURON

Larval Assessment

Surveys for larval sea lampreys were conducted in 78 Lake Huron streams (59 in U.S. and 19 in Canada). Pretreatment surveys were completed on 11 streams; four were later treated and the others are scheduled for treatment. Postreatment surveys in the United States accounted for a few residual sea lampreys in 10 streams, moderate numbers in 6, and large numbers in Albany Creek and the Trout River. Residual sea lampreys were not recovered in similar surveys in five Canadian streams (Richardson and Watson creeks and Kaskawong, Mindemoya, and Sturgeon rivers). Reestablished populations of sea lampreys were present in 17 of the 19 streams surveyed in Canada. The population of sea lampreys above Rydal Mill dam in the Thessalon River is minimal and is represented only by the 1985 year class. Surveys produced 63 sea lampreys (46-91 mm long) and 864 native lampreys. The 1986 year class was recovered from 22 U.S. tributaries of Lake Huron. Reestablished populations are in 10 of the 23 north shore tributaries in the United States that are monitored annually (Table 14).

Table 14. U.S. tributaries of the north shore of Lake Huron with reestablished populations of sea lampreys, and the maximum number collected per hour with an electric shocker.

Stream	Date of last treatment	Year class 1983	1984	1985	1986
Charlotte River	10/22/81	0	0	2	0
Little Munuscong River	6/14/85			50	2
Albany Creek	5/4/86				9
Trout Creek	5/13/84		0	39	2
McKay Creek	5/14/84		1	5	4
Ceville Creek	5/12/78	0	0	52	1
Hessel Creek	5/2/86				3
Nunns Creek	10/19/82	2	1	9	0
Pine River	6/2/85			92	31
Carp River	5/19/85			182	144
Total number of streams in which year class was collected		1	2	8	8

Ten U.S. streams with some potential for sea lamprey production but previously found negative were examined and sea lampreys were discovered in one. Seventy-four sea lamprey ammocetes of the 1985 and 1986 year classes were taken in Saddle Creek, a small stream on the north shore between DeTour and Cedarville.

Sea lampreys were collected from six of seven offshore areas examined. Single ammocetes were collected off Nunns Creek and the Pine River (Mackinac County), whereas 16 were taken off Albany Creek and 22 off Carp River. Lentic surveys adjacent to the Mindemoya and Kagawong rivers also revealed small populations of sea lamprey larvae.

Evaluation of barrier dams continued on four streams in 1986. Young-of-the-year sea lampreys were taken upstream of the recently completed barrier on Albany Creek. A population was found upstream of the Van Etten Dam on the Pine River, a tributary of the Au Sable River. The Pine River was last treated in 1979. The dam is now open from fall to spring to minimize ice damage on Van Etten Lake and to allow upstream movement of rainbow trout. The 1985 year class of sea lampreys was taken in the East Au Gres River upstream of the barrier that was constructed in 1983. The barrier was opened during portions of the lamprey spawning runs in 1984 and 1985 to reduce illegal snagging of rainbow trout that were concentrated at the site. The Michigan Department of Natural Resources completed major modifications to improve the barrier in 1986, including construction of a coffer dam just downstream of the main structure that would aid upstream movement of rainbow trout and block sea lampreys. A trap fished downstream of the coffer dam caught 441 adult lampreys, although none were observed or captured in a trap between the coffer dam and barrier. Extensive surveys above the barrier on the Echo River showed that this dam has not been an effective barrier and spawning has continued in the upstream tributaries of the Echo River and above Solar Lake. Lampreys are not reestablished in two tributaries (Bar and Elm creeks) of the lower Echo River.

The sea lamprey population in the Chippewa River, a tributary of the Saginaw River system, continued to increase markedly since a dam at the Dow Chemical Company in Midland, Michigan, was modified in 1983. The catch of sea lamprey larvae per unit of effort increased from 34 in 1985 to 85 in 1986. The 1986 year class was found at all 15 sites sampled. Fifty-three age I larvae were longer than 119 mm, indicating exceptional growth. The stream is scheduled for treatment in 1987 because of abundance and growth of ammocetes.

Thirty-four index stations, 0.2 ha (0.5 acre) each, were selected in the Canadian waters of the St. Marys River. Locations were recorded with a Loran "C" receiver; depths, water velocities, and substrate types were documented for each station. Twenty of these index stations were surveyed and 1,029 larval and 6 transforming sea lampreys were collected. Five stations totaling 0.8 ha (2 acres) outside the index regime also were surveyed and 1 larval and 2 transforming sea lampreys were collected.

A study to examine growth and transformation rates of sea lamprey ammocetes in Brown Creek was begun in August. The 1985 and 1986 year classes of larvae were identified; the 1985 year class averaged 42 mm long (16-66 mm) and the 1986 year class averaged 11 mm long (9-13 mm).

TFM was used experimentally to survey four stations in the St. Clair River and yielded two sea lampreys, one Ichthyomyzon, and five American brook lampreys. Granular Bayer surveys of 13 plots yielded 15 sea lampreys, 12 Ichthyomyzon, and 107 American brook lampreys. The experiment demonstrated that granular Bayer is probably more efficient than TFM in recovering lampreys in large rivers such as the St. Clair. TFM surveys are labor intensive, require more equipment, and present safety hazards when attempted from small boats.

Chemical Treatments

TFM was applied to 12 streams and granular Bayer 73 was applied to 3 lentic areas of Lake Huron (Table 15, Fig. 3). The Spanish River was deferred from treatment due to high water levels. Extreme low discharges hampered treatments in the upper portions of four streams--Black Mallard, Mulligan, and Albany creeks and the Au Gres River. An unanticipated release of water from an impoundment overran the chemical bank in the Au Gres River. The other treatments were routine except for problems with beaver dams and limited access on some streams.

Numbers of larval sea lampreys were abundant in the Ocqueoc River and Mulligan, Black Mallard, and Greene creeks, moderate in the Au Gres River and Blue Jay Creek, and scarce in the other treated streams. The granular Bayer 73 treatments of Echo Lake and Tenby and Michael Bays produced relatively low numbers of larval sea lampreys.

Blacknose dace and creek chubs were killed in the headwaters of Mulligan and Black Mallard creeks.

Spawning-phase Sea Lampreys

During the 1986 spawning season, 26,851 sea lampreys were captured in assessment traps placed in 10 tributaries of Lake Huron (Table 16, Fig. 3). The total number captured in the seven U.S. tributaries (18,872) is similar to the number taken in 1985 (18,783). The catch of lampreys increased in the Cheboygan River in 1986 over 1985 (14,126 vs. 9,972), but largely was due to improved trapping efficiency by the completion of bank stabilization by the U.S. Soil Conservation Service. The trap catch of lampreys decreased in the St. Marys, Ocqueoc, and East Au Gres rivers by 2,308, 1,629, and 239, respectively, from the numbers taken in 1985. The catch in the East Au Gres River declined because the trap efficiency was reduced during the trapping period after structural improvements were made by the Michigan Department of Natural Resources to the barrier dam. Traps were operated in the Thunder Bay and Au Sable rivers and captured 3 and 20 lampreys, respectively. A trap placed at the newly completed sea lamprey barrier in Albany Creek captured 98 lampreys. Lampreys taken from assessment traps in 1986 averaged 17 mm shorter and 13 g lighter than those taken in 1985. The percentage of males was 9% lower than in 1985.

Trapping operations collected 7,979 adult sea lampreys from three Canadian tributaries in 1986. The total number of adults declined 39%, the number of males in the population decreased 8%, the average length decreased 1%, and the average weight decreased 2% when compared with the 1985 catch. Trapping studies on the Thessalon River showed the trap on Bridgeland Creek was 18% efficient and the trap at Rydal Mill dam was 15% efficient. The sea lamprey spawning run in the Thessalon River was estimated to be 11,500 (8,000 in Bridgeland Creek and 3,500 at Rydal Mill dam). Experimental trapping in the Whitefish Island Channel of the St. Marys River captured 33 adult sea lampreys from June 9 to August 5; 24% were males. No spawning activity or nests were observed in the channel during three visual surveys

Table 15. Details on the application of lampricides to streams and lentic areas of Lake Huron, 1986.

[Number in parentheses corresponds to location of stream or lentic area in Figure 3. Lampricides used are in kilograms/pounds of active ingredient.]

Stream or lentic area	Date	Discharge m^3/s	Discharge f^3/s	TFM[a] kg	TFM[a] lbs	Bayer 73 granules kg	Bayer 73 granules lbs	Stream treated km	Stream treated miles	Area treat ha	a
UNITED STATES											
Hessel Cr. (11)	May 2	0.1	3	20	44	-	-	1.6	1	-	
Big Munuscong R. (15)											
Taylor Cr.	May 2	0.7	25	204	449	-	-	12.9	8	-	
Albany Cr. (13)	May 4	0.1	5	70	154	-	-	9.7	6	-	
Carlton Cr. (14)	May 5	0.2	8	40	88	-	-	1.6	1	-	
Beavertail Cr. (12)	May 5	0.4	15	220	484	-	-	8.1	5	-	
Black Mallard Cr. (8)	June 6	0.2	6	53	116	-	-	9.7	6	-	
Mulligan Cr. (9)	June 9	<0.1	1	10	22	-	-	4.8	3	-	
Green Cr. (10)	June 9	0.1	2	10	22	-	-	6.5	4	-	
Au Gres R. (6)	June 21	3.5	125	1,188	2,618	-	-	74.2	46	-	
Ocqueoc R. (7)	Aug. 29	2.5	90	725	1,599	-	-	48.4	30	-	
Total		7.9	280	2,540	5,596	-	-	177.5	110	-	
CANADA											
Bluejay Cr. (4)	May 24	0.6	20	160	353	-	-	7.9	5	-	
Manitou R. (3)	May 24	1.4	50	198	437	-	-	1.0	1	-	
Michael Bay (5)	June 25	-	-	-	-	3.4	7.5	-	-	0.3	
Echo Lake (1)	July 29	-	-	-	-	13.6	30.0	-	-	1.1	
Tenby Bay (2)	July 30	-	-	-	-	10.2	22.5	-	-	0.8	
Total		2.0	70	358	790	27.2	60.0	8.9	6	2.2	
GRAND TOTAL		9.9	350	2,898	6,386	27.2	60.0	186.4	116	2.2	

[a]Includes 275 TFM bars (57 kg, 126 lbs) applied in six U.S. streams.

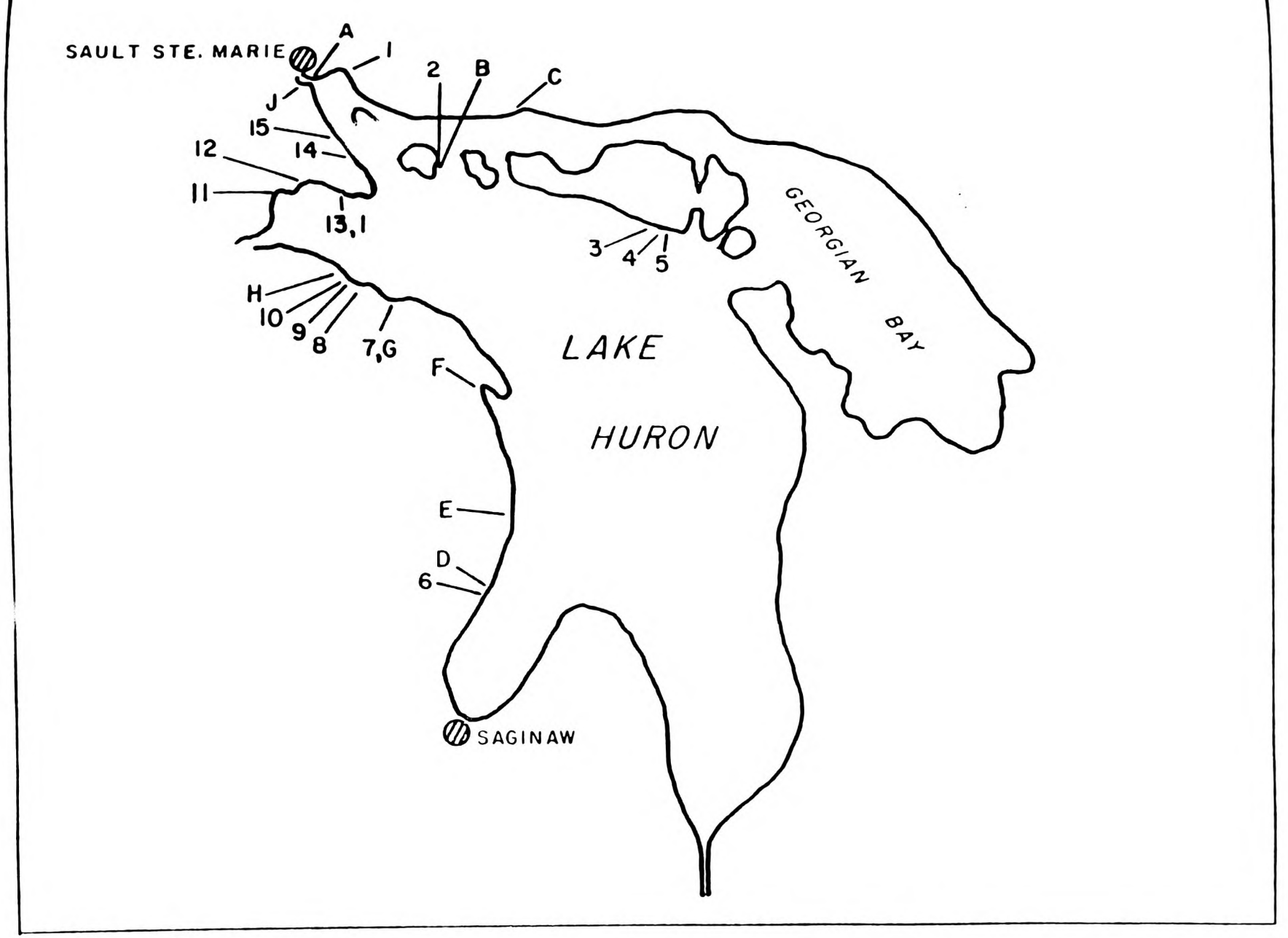

Figure 3. Location of streams treated with lampricides (numerals; see Table 15 for names of streams) and of streams where assessment traps were fished (letters; see Table 16 for names of streams) in 1986.

Table 16. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Huron, 1986.

[Letter in parentheses corresponds to location of stream in Figure 3.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
				Males	Females	Males	Females
UNITED STATES							
East Au Gres R. (D)	441	437	42	423	428	205	208
Au Sable R. (E)	20	19	42	462	491	199	248
Thunder Bay R. (F)	3	3	33	440	459	232	224
Ocqueoc R. (G)	3,064	950	44	474	479	220	232
Cheboygan R. (H)	14,126	515	36	467	468	211	221
Albany Cr. (I)	98	52	40	435	453	187	220
St. Marys R. (J)	1,120	117	57	475	493	235	258
Total or average	18,872	2,093	42	461	465	215	224
CANADA							
St. Marys R. (A)	4,935	1,071	52	482	482	239	248
Kaskawong R. (B)	349	255	38	484	489	235	240
Thessalon R. (C)	2,695	809	53	479	489	234	248
Total or average	7,979	2,135	51	481	485	237	247
GRAND TOTAL OR AVERAGE	26,851	4,228	47	472	474	227	235

Estimates of the number of spawning-phase sea lampreys were calculated from results of a tagging and recapture study that used stratified multiple samples in three Lake Huron tributaries (Table 13). An estimated 28,293 sea lampreys were present in the spawning run of the Cheboygan River in 1986 compared with an estimated 39,626 in 1985. Estimates also were made of the total number of spawning adults in the Ocqueoc (9,038 vs. 13,065 in 1985) and the St. Marys (16,812 vs. 23,852 in 1985) rivers. The estimate of the total population of spawning-phase sea lampreys in the St. Marys River was a joint project by the U.S. and Canadian agents. Trapping efficiency was estimated to be 35% at the power dam locations (U.S. Corps of Engineers and the Clergue Generating Station).

An experiment was conducted in the St. Marys River Rapids area between the newly constructed berm and Whitefish Island to determine if spawning sea lampreys attract migrant adults. Two hundred spawning lampreys (100 males, 100 females) were confined to a chamber/trap beside a control chamber/trap with no lampreys. Each week the spawning lampreys were rotated between the two chamber/trap systems. Of the 115 lampreys captured, 110 were taken in one trap. This experiment demonstrated that flow hydrology was a greater guide/attractant than the presence of spawning lampreys. The ratio of marked/unmarked lampreys was 3.5% in the rapids/channel area compared with 12.7% in the powerhouse trapping locations. The sex ratio also differed at these locations; males composed 37% of those taken in the rapids/channel area vs. 53% of those at the powerhouse locations.

Parasitic-phase Sea Lampreys

A total of 3,902 sea lampreys were collected (1,833 by commercial and 2,069 by sport fishermen) in Lake Huron (2,921 in U.S. and 981 in Canada), compared with 4,602 in 1985. Of the 981 sea lampreys submitted by Canadian commercial fisheries, 638 were from the North Channel, 341 from Lake Huron proper, and 2 from Georgian Bay. The lack of sea lampreys from Georgian Bay is a measure of fishing effort, not necessarily a measure of the sea lamprey population. A mild winter allowed fishing through December-January and more specimens are expected. It is anticipated that the 1986 catch will equal or exceed the catch of 1,237 in 1985.

A total of 852 sea lampreys were collected by commercial fishermen in U.S. waters of Lake Huron (Table 7). This collection represents the fewest parasitic lampreys taken in Lake Huron since 1982, but does not reflect a reduction in the lamprey population in the lake. The Agreement for Entry to Consent Order of 1985 of the State of Michigan restricted several state-licensed commercial fishermen from further fishing activities in statistical district MH-1 in 1986. As a result, the four fishermen that collected most of the lampreys in previous years are no longer in operation. The number of sea lampreys collected by commercial fishermen in statistical district MH-2 (Alpena, Michigan, area) decreased from 108 in 1985 to 88 in 1986. Sea lampreys collected in MH-4 (Tawas City-Bay Port, Michigan, area) increased from 83 in 1985 to 96 in 1986. Spawning year was determined for the 852 parasitic-phase sea lampreys collected by the U.S. commercial fisheries--135 would have spawned in 1986, 711 in 1987, and 6 in 1988 (Table 7). In addition, 1,310 lampreys of the 1986 spawning year were taken in 1985, bringing the total collected for this spawning year to 1,445.

Three fishing derbies in Canada were sampled: the Parry Sound Budweiser Derby (May 24-June 1), the Sault Ste. Marie Strohs Light Salmon Derby (August 16-September 13), and the twin Sault's Can-Am Salmon Tournament (September 5-7). In Parry Sound, 15 native and 76 backcross lake trout were sampled. No wounds were observed. The scarring rates were 10/100 for native and 5/100 for backcross lake trout. Native trout averaged 2 kg (4.4 lbs.) and ranged from 0.8 to 5.4 kg (1.8 to 11.9 lbs.), 76% larger than the backcross trout which averaged 1.1 kg (2.4 lbs.) and ranged from 0.6 to-3.5 kg (1.3 to 7.7 lbs.). The Sault Ste. Marie tournaments provided 648 chinook salmon from the Strohs derby and 88 from the Can-Am derby. During the Strohs derby 40 chinook (6%) were carrying 44 sea lampreys. The wounding rate was 44/100 fish; 67/100 fish bore additional lamprey marks. During the Can-Am derby 7 chinook (8%) were carrying seven sea lampreys. The wounding rate was 40/100 fish; 73/100 fish bore additional lamprey marks.

Sport fishermen on the U.S. side of Lake Huron captured 2,069 parasitic-phase sea lampreys (188 from charter and 1,881 from noncharter fishermen) in 1986 (Table 7), compared with 2,000 (233 charter, 1,767 noncharter) in 1985. Lampreys were collected from all statistical districts of the lake, but more were taken from MH-3 (Black River to Au Sable Point, Michigan, area; 883) than any other district. With the loss of a significant portion of the assessment of parasitic lampreys in the commercial fishery of Lake Huron, the collection of information through the sport fishery becomes increasingly important.

Information on occurrence of sea lampreys and lamprey wounds on fish was reported by 38 U.S. charter captains (Tables 8 and 9). Lampreys were taken more often on chinook salmon than lake trout in all but one statistical district of Lake Huron (Table 9). Lakewide, 83% of the lampreys were attached to chinook salmon (the same percentage as reported in 1985). The number of lampreys attached per 100 fish increased (lake trout, 1.3 in 1985 to 2.0 in 1986; chinook salmon, 6.7 in 1985 to 9.8 in 1986). These increases were evident in the charter fishery even though the catch of salmonids declined from 1.1 per hour in 1985 to 0.8 in 1986. The rates of fresh lamprey wounds on lake trout and chinook salmon were high in all areas of the lake.

Barrier Dams

A low-head sea lamprey barrier dam with a built-in sea lamprey trap was constructed on the Still River which enters Byng Inlet near the north end of Georgian Bay. The dam and downstream energy stilling box are composed of steel sheet piling. A new trapping concept was incorporated into the dam. It is anticipated that a flow of water through a 15-cm (6-inch) diameter pipe, which runs from the trap to the far side of the dam, will funnel lampreys into the trap. The cost of construction was $86,657.

A low-head sea lamprey barrier dam, which has a trapping system similar to the Still River barrier, was constructed in the Echo River, a major tributary of the St. Marys River. This steel sheet piling barrier is 14 m (46 feet) downstream of a timber crib dam that was not effective in preventing migration of sea lampreys. The cost of construction was $46,375.

LAKE ERIE

Larval Assessment

In preparation for initial lampricide treatments, 335 Lake Erie tributaries were surveyed in 1986 to assess larval lamprey populations. Of 323 watersheds surveyed in Canada, 10 were found to be sea lamprey producers. Five of these streams (Catfish, Big Otter, Big, Cranes, and Young creeks) were historic producers. Sea lamprey ammocetes were discovered for the first time in South Otter, Clear, Forestville, and Fishers creeks and stream No. E-78. All of these streams are between Port Stanley and Port Dover. Big and Big Otter creeks have the largest populations of larval sea lampreys, and Catfish, Forestville, Fishers, Cranes, and E-78 creeks support only marginal populations. In Catfish Creek sea lamprey ammocetes were found in one small tributary, Bradleys Creek. The Grand River, which is the largest watershed on the Canadian side of Lake Erie, was surveyed intensively. Despite reports of adult sea lampreys observed in some tributaries, no larval lampreys were found.

Lentic surveys conducted off the mouths of the Grand River and Big Otter and South Otter creeks were negative. These areas contained poor larval habitat. One larval sea lamprey was collected from the Welland River channel and may have originated from the Niagara River.

Larval surveys were conducted in 12 U.S. tributaries of Lake Erie. Seven streams were treated in 1986 and the Grand River in Ohio is scheduled for treatment in the spring of 1987. The Buffalo River system was surveyed to monitor the larval sea lamprey population first detected in 1985 in Cayuga Creek. The population still appears to be sparse and confined to the lower section of the creek. A total of 10 sea lamprey larvae (65-120 mm) were recovered from four of six sites offshore of Conneaut Creek. Sea lampreys were not recovered in surveys of three streams with no history of sea lamprey production.

Posttreatment surveys were initiated in six of the seven U.S. tributaries treated in 1986. Residual lampreys were collected only in Clear Creek (35 larvae, 57-118 mm), a tributary of Cattaraugus Creek, and probably survived treatment during high water. The upper section of Crooked Creek was not treated because of beaver impoundments and three larvae (110-143 mm) were collected in this area.

An estimate of the sea lamprey population was made in conjunction with the initial chemical treatment of Conneaut Creek in October 1986. In August, survey personnel captured, dye-marked, and released 8,031 sea lamprey larvae throughout the areas to be treated in October. Subsequent treatment collections accounted for 12,551 larval and recently metamorphosed sea lampreys. Estimates using a modified Petersen mark and recapture method indicated a total stream population of 464,431 sea lampreys (327,229 larvae and 137,202 metamorphosed lampreys). The estimates for the Ohio portion of the stream were 47,891 larval and 34,966 metamorphosed sea lampreys, and for the Pennsylvania portion, 279,338 larval and 102,236 metamorphosed lampreys.

The population of sea lampreys in Halfway Brook also was estimated in conjunction with a chemical treatment. A total of 128 larval and 7 transformed sea lampreys were marked and released in three study sites 1 day before treatment. Based on a modified Petersen method, an estimated 8,514 larval and 806 transformed sea lampreys were in the 4-km (2.5-mile) section of stream that was treated.

Chemical Treatments

Lampricide treatments were performed on 10 Lake Erie tributaries for the first time in the fall of 1986 (Table 17, Fig. 4). The number of larval and metamorphosed lampreys collected was high in Conneaut and Crooked creeks and in Halfway Brook, moderate in Big Otter, Clear, South Otter, and Raccoon creeks, and scarce in the others (Table 18).

All treatments were hampered by short periods of daylight and the lack of historical treatment data. Discharges were favorable during the treatments of the three Canadian tributaries, but a multitude of freshets and tributaries increased the flow from source to mouth. Lethal concentrations of TFM for sea lampreys were attained throughout the inhabited sections and the treatments were successful. Significant numbers of stonecats and mudpuppies were killed during the treatment of Big Otter Creek.

Table 17. Details on the application of lampricides to tributaries of Lake Erie, 1986.

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

Stream	Date	Discharge		TFM[a]		Stream treated	
		m^3/s	f^3/s	kg	lbs	km	miles
UNITED STATES							
Raccoon Cr. (10)	Sept. 28	0.1	2	39	87	8.1	5
Crooked Cr. (8)	Oct. 1	0.5	17	131	289	11.3	7
Delaware Cr. (7)	Oct. 4	0.8	30	100	220	9.7	6
Canadaway Cr. (6)	Oct. 7	2.5	90	291	642	4.8	3
Halfway Br. (5)	Oct. 9	0.3	10	45	100	3.2	2
Cattaraugus Cr. (4)	Oct. 12	22.4	790	5,219	11,506	48.4	30
Conneaut Cr. (9)	Oct. 18	2.0	70	946	2,085	125.8	78
Total		28.6	1,009	6,771	14,929	211.3	131
CANADA							
Clear Cr. (3)	Oct. 17	1.0	35	521	1,149	22.2	14
South Otter Cr. (2)	Oct. 20	1.7	60	792	1,746	23.5	14
Big Otter Cr. (1)	Oct. 24	8.5	300	4,493	9,905	102.3	64
Total		11.2	395	5,806	12,800	148.0	92
GRAND TOTAL		39.8	1,404	12,577	27,729	148.0	92

[a]Includes 505 TFM bars (105 kg, 232 lbs) applied in five U.S. streams.

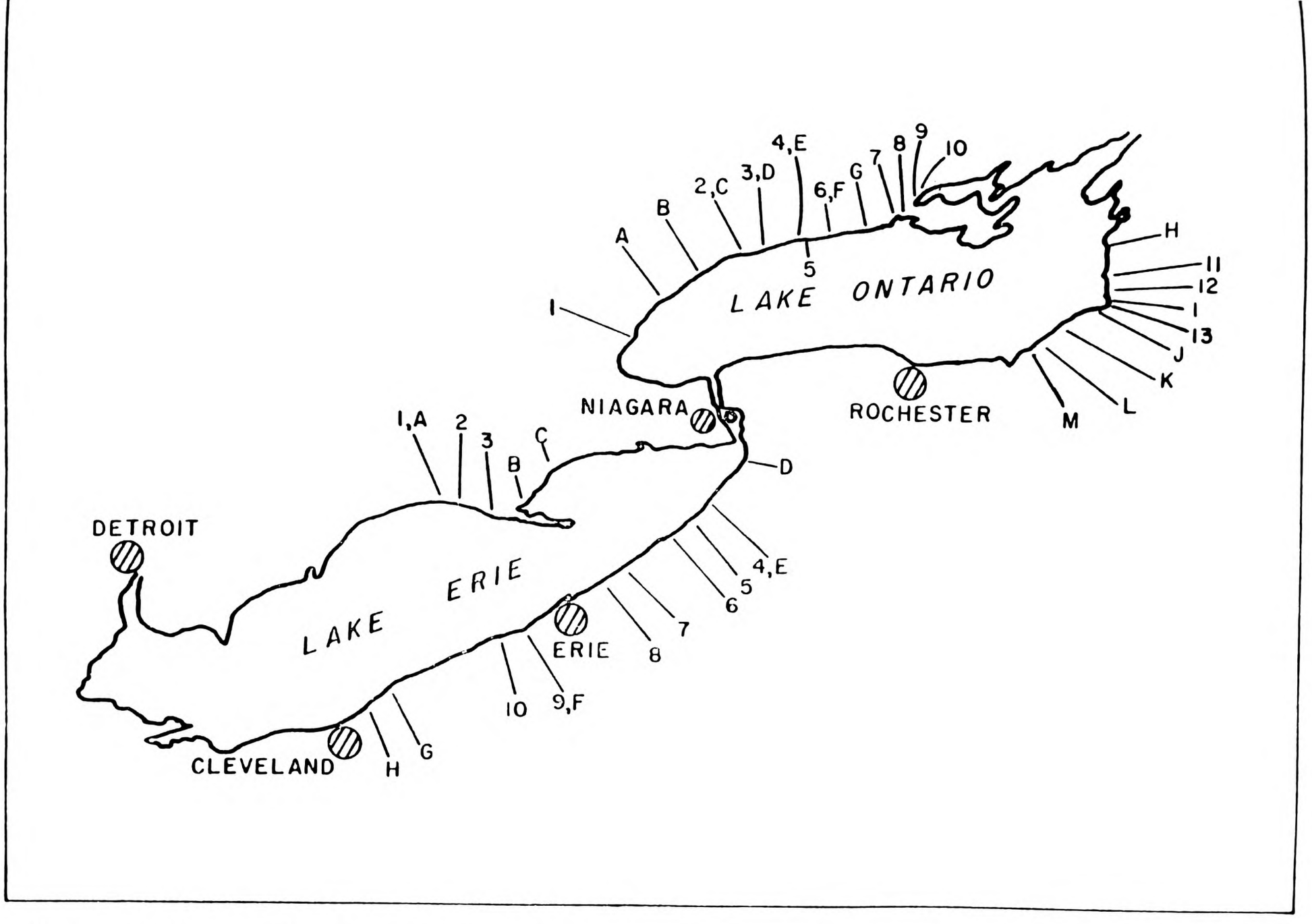

Figure 4. Location of streams of Lakes Erie and Ontario treated with lampricides (numerals; see Tables 17 and 20 for names of streams), and of streams where assessment traps were fished (letters; see Tables 19 and 21 for names of streams) in 1986.

Table 18. Number and length range of larval and metamorphosed sea lampreys collected during the initial application of lampricides to tributaries of Lake Erie, 1986.

Stream	Number of collection sites	Larval		Metamorphosed	
		Number collected	Length range (mm)	Number collected	Length range (mm)
UNITED STATES					
Conneaut Creek	70	12,551	32-198	3,014	127-201
Crooked Creek	8	662	50-160	324	113-169
Raccoon Creek	19	358	43-181	217	114-170
Halfway Brook	18	358	34-170	185	132-185
Cattaraugus Creek	19	118	64-176	11	137-182
Delaware Creek	9	7	111-157	3	186-197
Canadaway Creek	5	2	105-114	0	-
Total or range	148	14,056	32-198	3,754	113-201
CANADA					
Big Otter Creek	37	1,015	16-201	332	121-186
South Otter Creek	18	671	21-196	98	141-191
Clear Creek	17	399	21-191	112	121-186
Total or range	72	2,085	16-201	542	121-191
GRAND TOTAL OR RANGE	220	16,141	16-201	4,296	113-201

Persistent rain and high stream discharge hampered treatments in all New York tributaries--Cattaraugus, Delaware, and Canadway creeks and Halfway Brook. Accurate pretreatment data (stream discharge, water chemistry, dye times, and bioassays) were extremely difficult to obtain because of rapidly changing flows. Most of the information that was obtained was of little use during the actual treatments. Several problems were encountered during the treatment of Cattaraugus Creek and its tributaries. Because of severe flooding, TFM was introduced at Gowanda, New York, rather than at an upstream site at Springville Dam. A combination of excessive flows, lack of ammocete habitat, and an abundance of spawning salmon near Springville Dam influenced the decision to lower the application point. High water and poor roads prohibited treatment of two major tributaries, South Branch and Spooner Creek, and numerous small tributaries. Rapidly increasing flows overran the treatment of another tributary, Clear Creek, and a re-treatment was necessary to assure concentrations of lampricides were lethal to sea lampreys.

Low stream flows and rapidly fluctuating discharges complicated treatments of Raccoon, Crooked, and Conneaut Creeks in Pennsylvania. Some upstream sections of Crooked and Conneaut creeks could not be treated. Low flows in the upper section of Conneaut Creek contributed to mortality of nongame species of fish such as suckers, minnows, and bullheads. In the lower river, mudpuppies were the most prominent species affected by the treatment.

Personnel from the New York Department of Environmental Conservation, Pennsylvania Fish Commission, and the Ohio Department of Natural Resources provided valuable assistance in public relations, landowner notification, chemical application, and in the collection of biological data.

Sea lamprey ammocetes (<120 mm long) and transforming larvae collected during the treatments of Clear, South Otter, and Big Otter creeks were examined to determine their sex, length, and weight. These populations of larval lampreys had never been subjected to lampricide. A total of 541 transforming larvae were collected; males represented 30% of the collection and had an average length of 155 mm and an average weight of 6.1 g. The females were slightly larger, averaging 160 mm and 6.8 g. A total of 1,106 ammocetes over 120 mm were examined; males comprised 23% of the collection and averaged 148 mm and 5.4 g. The females averaged 150 mm and 5.6 g.

Spawning-phase Sea Lampreys

During the 1986 spawning season, 1,535 sea lampreys were captured in assessment traps in eight tributaries of Lake Erie (Table 19, Fig. 4). Traps were operated for the first time in Conneaut Creek and two tributaries of the Buffalo River (Buffalo and Cayuga creeks), but only 13 lampreys were taken. The number of sea lampreys captured in the other U.S. tributaries decreased 45% from the number taken in 1985, and the largest decline was in Cattaraugus Creek (from 1,732 to 1,224). The average length and weight of lampreys and percentage of males remained about the same as in 1985.

Portable traps fished on three tributaries in Canada collected 209 sea lampreys. Continuous high discharge hampered collecting at all trapping sites; only 4 sea lampreys were taken from two sites in Big Otter Creek and 22 from four sites in Big Creek. The catch at Young Creek was 183, compared with 115 in 1980 and 856 in 1981.

Parasitic-phase Sea Lampreys

The Ontario Ministry of Natural Resources initiated a mandatory daily reporting program in 1985 for commercial fishermen operating out of Lake Erie ports. Collections from 67 fisheries included 453 sea lampreys and 8 silver lampreys.

Technical assistance was provided to the Pennsylvania Fish Commission and New York Department of Environmental Conservation to develop programs to monitor parasitic-phase sea lampreys captured incidentally in their sport fisheries. Anglers in Pennsylvania returned 62 lampreys (primarily from the Fairview/Erie areas) and anglers in New York returned 13 (mainly the Barcelona and Dunkirk areas).

Table 19. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Erie, 1986.

[Letter in parentheses corresponds to location of stream in Figure 4.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
				Males	Females	Males	Females
UNITED STATES							
Buffalo R. (D)							
Buffalo Cr.	3	2	50	534	540	268	340
Cayuga Cr.	0	-	-	-	-	-	-
Cattaraugus Cr. (E)	1,224	922	55	505	506	284	293
Conneaut Cr. (F)	10	8	50	529	552	277	333
Grand R. (G)	76	70	44	503	493	287	267
Chagrin R. (H)	13	12	50	492	530	251	306
Total or average	1,326	1,014	54	505	506	284	292
CANADA							
Big Otter Cr. (A)	4	2	75	503	492	289	344
Big Cr. (B)	22	10	40	467	504	297	282
Young Cr. (C)	183	32	28	511	514	249	278
Total or average	209	46	35	499	511	269	278
GRAND TOTAL OR AVERAGE	1,535	1,060	53	505	506	284	291

LAKE ONTARIO

Larval Assessment

A total of 41 tributaries (21 in Ontario and 20 in New York State) with a history of regular sea lamprey production were surveyed. Surveys also were conducted in the Niagara and Oswego rivers and 70 smaller tributaries in New York State with no history of sea lamprey production.

Posttreatment surveys identified residual lampreys from two of the seven streams treated in Ontario in 1985. A large population of the 1985 year class of sea lampreys in the Credit River may not have been exposed to the chemical because the primary application had to be moved to accommodate a request from a landowner or they were spawned/hatched after the early May treatment. Only two residual sea lampreys were found in Grafton Creek. Residual sea lampreys were not taken in similar surveys of two streams treated in 1986.

Posttreatment surveys in New York State found residual sea lampreys in Skinner, Lindsey, Little Sandy, and Ninemile creeks. Two of these streams, which had been treated in October 1985, held significant numbers of residual sea lampreys.

Reestablishment surveys in Ontario found all streams treated in 1985 (8 streams) had been reestablished with the 1985 year class (Credit River and Port Britain, Grafton, Lakeport, and Smithfield creeks) or 1986 year class (Duffin, Farewell, and Salem creeks). All age classes were identified in Mayhew Creek (a tributary of the Trent River) last treated in 1983, which prompted a treatment in the fall of 1986.

Reestablishment surveys in New York State revealed that all streams treated in the spring of 1985 (Little Sandy, Grindstone, Ninemile, and Sterling creeks) had been re-populated by the 1985 year class of sea lampreys. Residual lampreys were taken during surveys in June in three streams treated in October 1985 (Little Salmon River and South Sandy and Lindsey creeks), but it was too early to monitor if the 1986 year class became established in these streams. Larval lampreys (1985 year class) became established in Black Creek, a tributary of the Oswego River, for the first time since the chemical treatment in 1981. Two tributaries of Oneida Lake treated in the spring 1984, Fish and Big Bay creeks, contained reestablished and residual sea lampreys. Year classes of sea lampreys reestablished annually in Fish Creek since 1984.

In Ontario, larval sea lampreys were not taken in surveys conducted upstream of the barrier dam (constructed in 1984) in Lakeport Creek. The chemical treatment in 1985 was successful and no adult lampreys have negotiated the barrier. No larval sea lampreys were found in Gages Creek, which was last treated in 1971. Heavy rains during the fall of 1986 destroyed the Vanstone Dam on Bowmanville Creek, and an irregularly maintained stop log dam at the Goodyear manufacturing plant is the only deterrent to block sea lampreys from many kilometers of prime larval habitat.

A study was conducted during September 25-27 in 1.4-ha (3.5-acre) section of Salem Creek to estimate the population of larval lampreys of the 1986 year class; in excess of 100,000 ammocetes were estimated in the reestablished population. Density of the young-of-the-year larvae averaged 8.3/m^2 (0-148 m^2). The larvae had a mean length of 25 mm (9-38 mm). The smallest ammocetes, 9-11 mm, supports the contention of late summer or fall spawning of sea lampreys in some streams.

In New York State, sea lamprey larvae were collected for the first time from the Niagara River and Salmon and Oak Orchard creeks. Seventeen sea lampreys (56-147 mm) were collected from the Niagara River along the north shore of Buckhorn Island, 4.8 km (3 miles) upstream of the falls. In Salmon Creek, 18 sea lampreys (54-178 mm) were collected from 14.5 km (9 miles) of stream; in Oak Orchard Creek, 66 ammocetes (38-181 mm) were collected from 6.4 km (3.4 miles) of Marsh Creek (a tributary).

Chemical Treatments

Chemical treatments were completed on 12 Lake Ontario streams during the field season (Table 20, Fig. 4). Mayhew Creek, a tributary of the Trent River, was treated with TFM. In addition, an area of sea lamprey infestation in the Trent River adjacent to the confluence with Mayhew Creek was treated with granular Bayer.

High lake levels, seiche action, and thermal stratification eroded blocks of lampricide in the estuaries of Bowmanville, Graham, and Bronte creeks. These large estuaries harbor significant populations of larval sea lampreys and escapement from the chemical is possible. In the other treated streams the estuaries were small or contained few larval sea lampreys.

The treatments of three streams in New York State (Salmon River and Snake and Deer creeks) were difficult because of numerous feeder tributaries, beaver impoundments, and the need for supplemental applications of lampricide. The treatment of Black River, also in New York State, was deferred because many spawning chinook salmon were present. The stream has been rescheduled for 1987.

During the spring treatment of Graham Creek, numerous spawning-phase sea lampreys were killed above the barrier dam which had been erected in 1983-84. Vandalism and high lake levels contributed to the passage of lampreys. Remedial works following the treatment and lowering lake levels should stop any further lamprey migration.

During treatments in the fall of five streams (Trent River and its tributary Mayhew Creek, Shelter Valley Brook, and Proctor and Smithfield creeks) only 0.3% (13) of the larvae collected were metamorphosing.

Mortality of nontarget fish was negligible in all streams except Snake Creek where mortality of bullheads, dace, and common white suckers were recognized.

A treatment in September of Shelter Valley Brook killed three spent sea lampreys (two males and 1 female). Spawning sea lampreys also have been killed during chemical treatments in September in 3 out of the last 4 years--Harmony (Chippewa) River, September 13, 1983; Salem Creek, September 18, 1985; Shelter Valley Brook, September 17, 1986. This evidence, coupled with length-frequency data from Salem Creek, September 25, 1986, strongly supports the hypothesis that any year class of sea lampreys could be composed of spring- and fall-hatched larvae.

Spawning-phase Sea Lampreys

A total of 6,201 sea lampreys were captured in assessment traps placed in 13 tributaries of Lake Ontario in 1986 (Table 21, Fig. 4) compared with 5,719 taken in 1985, or an 8% increase. Most of the lampreys were taken from the north shore (91%) in 1986 (92% in 1985), but increased only 7% from 1985. Although only 574 sea lampreys were taken on the south shore, the catch increased 23% from that taken in 1985. The Humber River has traditionally supplied the bulk of the catch from the lake (49% in 1985 and 33% in 1986). The catch increased greatly at the new dam on Shelter Valley Brook over the catch in 1985. This stream contributed 41% (2,531) of the total catch in 1986, whereas it contributed only 2% (123) of the total in 1985. Continued surveillance of this system will determine if the efficiency of the trap increased or if the catch increased abnormally in one year.

Table 20. Details on the application of lampricides to streams and lentic areas of Lake Ontario, 1986.

[Number in parentheses corresponds to location of stream or lentic area in Figure 4. Lampricides used are in kilograms/pounds of active ingredient.]

Stream or lentic area	Date	Discharge		TFM[a]		Bayer 73 granules		Stream treated		Area treated	
		m^3/s	f^3/s	kg	lbs	kg	lbs	km	miles	ha	acres
UNITED STATES											
Snake Cr. (11)	May 30	0.1	4	42	93	-	-	12.6	8	-	-
Salmon R. (13)	June 3	25.0	883	1,471	3,243	0.05	0.11	50.4	31	-	-
Deer Cr. (12)	June 8	0.6	21	107	236	-	-	17.5	11	-	-
Total		25.7	908	1,620	3,572	0.05	0.11	80.5	50	-	-
CANADA											
Bowmanville Cr. (2)	May 1	1.8	64	886	1,953	0.15	0.33	10.6	7	-	-
Graham Cr. (4)	May 3	0.5	18	476	1,049	0.30	0.66	17.4	11	-	-
Cobourg Cr. (5)	May 7	1.3	46	402	886	-	-	10.8	7	-	-
Wilmot Cr. (3)	May 9	0.8	28	316	697	-	-	18.1	11	-	-
Bronte Cr. (1)	May 12	1.4	49	747	1,647	0.03	0.07	26.9	17	-	-
Proctor Cr. (7)	Sept. 14	0.3	11	117	248	0.03	0.07	5.9	4	-	-
Smithfield Cr. (8)	Sept. 15	0.2	7	120	265	0.06	0.13	5.3	3	-	-
Trent R. (10)	Sept. 12	-	-	-	-	4.54	10.01	-	-	0.4	1
Mayhew Cr. (9)	Sept. 16	0.3	11	66	146	0.05	0.11	3.5	2	-	-
Shelter Valley Cr. (6)	Sept. 17	0.6	21	422	930	0.22	0.49	20.1	12	-	-
Total		7.2	255	3,552	7,831	5.38	11.87	118.6	74	0.4	1
GRAND TOTAL		32.9	1,163	5,172	11,403	5.43	11.98	199.1	124	0.4	1

Table 21. Number and biological characteristics of adult sea lampreys captured in assessment traps in tributaries of Lake Ontario, 1986.

[Letter in parentheses corresponds to location of stream in Figure 4.]

Stream	Number captured	Number sampled	Percent males	Mean length (mm)		Mean weight (g)	
				Males	Females	Males	Females
UNITED STATES							
South Sandy Cr. (H)	10	10	90	495	498	286	274
Grindstone Cr. (I)	69	67	70	490	478	270	257
Little Salmon R. (J)	4	4	100	481	0	267	0
Catfish Cr. (K)	2	2	50	564	545	355	390
Sterling Valley Cr. (L)	412	366	68	493	487	269	268
Sterling Cr. (M)	77	76	63	485	487	264	269
Total or average	574	525	68	491	487	269	268
CANADA							
Humber R. (A)	2,069	440	64	489	487	250	258
Duffin Cr. (B)	615	273	65	496	491	253	259
Bowmanville Cr. (C)	155	146	62	494	492	261	270
Wilmot Cr. (D)	93	53	68	515	501	284	292
Graham Cr. (E)	122	27	59	466	476	222	231
Shelter Valley Br. (F)	2,531	787	67	514	509	282	293
Lakeport Cr. (G)	42	42	43	490	469	251	218
Total or average	5,627	1,768	65	502	497	267	273
GRAND TOTAL OR AVERAGE	6,201	2,293	66	499	495	267	272

A trapping efficiency and population estimate were conducted in the Humber River. Results showed that the two traps were 36% efficient in capturing adult sea lampreys, and an estimated 5,000 lampreys were in the river in 1986.

Parasitic-phase Sea Lampreys

On the south shore of Lake Ontario, one captain in the charter sport fishery in Oswego, New York (statistical district NO-2) examined 941 fish and observed 1 feeding lamprey, or 0.1 lamprey per 100 fish which represents a significant decline from past years (1.3 in 1984 and 1985 and 0.1 in 1986). No parasitic sea lamprey information was collected from the north shore commercial or sport fisheries.

Barrier Dams

The Graham Creek dam was elevated and a curved steel lip added to stop any further migration of lampreys. Minor maintenance of dams on the Humber River, Shelter Valley Brook, and Lakeport and Duffin Creeks was carried out.

LAKES SUPERIOR, MICHIGAN, HURON, AND ERIE

Treatment Effects on Nontarget Organisms

Short-term tests--Routine monitoring of immediate effects of lampricide applications upon nontarget organisms continued in 1986. In situ assays were completed by caging organisms in the Brule River (Lake Superior); Bear Creek, a tributary of the Manistee River (Lake Michigan); and the upper section of Conneaut Creek (Lake Erie).

As a control, invertebrates and fish were caged in the area to be treated before lampricide application. These organisms were removed and replaced by additional specimens during treatment. Small fish (<22.8 cm, <9 inches) were collected by electrofishing and invertebrates were dislodged from the substrate into a kick net. Uninjured specimens were placed in cages the day before treatment.

Mortality of caged fish in Bear Creek included a single blacknose dace, but mortality was considerably higher in Conneaut Creek (Table 22) because concentrations of TFM were much higher. Concentrations in Conneaut Creek averaged 1.7 times minimum lethal concentration (MLC) for 19 hours, including 10 hours which were 2.1 times the MLC. Concentrations in Bear Creek included 11 hours above the MLC and did not exceed 1.5 times the MLC. Only the very resistant Centrarchidae and rainbow trout escaped without mortality in Conneaut Creek. All caged brassy minnows, common shiners, stonerollers, northern hog-suckers, johnny darters, rainbow darters, and blackside darters died during treatment. Mortality also was high for most other species tested.

Among invertebrates, susceptible organisms in 1986 were similar to previous years, and in general, with the exception of Isonychia and Physa, those taxa which were not susceptible were unaffected by even the higher than normal concentrations of lampricides in Conneaut Creek (Table 23). The net-spinning caddisfly Chimarra and the case-building Glossosoma were susceptible in both rivers. Planariidae and Isonychia were susceptible in the Conneaut Creek and Physa and Simulium were affected in Bear Creek. Hexagenia, which can be susceptible to lampricides, were not affected by concentrations of 1.5 times MLC in the Brule River.

To better define the short-term effects of lampricides on invertebrate drift, samples of drift were collected the day before and day of treatment in the Brule and Whitefish rivers and Bear Creek. Drift samples were collected every 2 hours for 14 to 18 hours. (Length of the sampling period was determined by length of the bank of lampricide). These samples are currently being sorted and identified.

Long-term tests--Spring and fall samples of Hexagenia were collected from the Whitefish River (Lake Michigan) to determine recovery after lampricide application. Random samples (3 from each of 10 silt beds at a control area and a treated area, or 60 samples) were collected with an Ekman dredge.

Table 22. Number of fish caged before lampricide application in two tributaries, and number live after treatment, 1986.

Species of fish	Lake Michigan Manistee River[a] Number Caged	Number Live	Lake Erie Conneaut Creek Number Caged	Number Live
Rainbow trout			1	1
Brassy minnow			3	0
Blacknose dace	9	8	14	6
Common shiner	5	5	1	0
Creek chub			10	7
Redside dace			4	4
Stoneroller			4	0
Northern hogsucker			10	0
White sucker			4	2
Smallmouth bass			1	1
Green sunfish			2	2
Johnny darter	10	10	2	0
Rainbow darter			20	0
Fantail darter			2	1
Blackside darter			1	0
Mottled sculpin	14	14		

[a]Fish were caged in Bear Creek, a tributary.

Table 23. Number of invertebrates caged before lampricide application in three tributaries, and number live after treatment, 1986.

Taxon	Lake Superior Brule River Number		Lake Michigan Manistee River[a] Number		Lake Erie Conneaut Creek Number	
	Caged	Live	Caged	Live	Caged	Live
Ephemeroptera						
Baetidae						
Baetis			15	15		
Pseudocloeon			7	7		
Oligoneuriidae						
Isonychia			9	9	21	11
Heptageniidae						
Stenacron					7	7
Stenonema			5	5	15	15
Leucrocuta			5	5		
Tricorythidae						
Tricorythodes			8	8		
Ephemeridae						
Hexagenia <15 mm	25	25				
Hexagenia >15 mm	25	25				
Trichoptera						
Philopotamidae						
Chimarra			9	0	20	0
Hydropsychidae						
Ceratopsyche			10	10	6	5
Cheumatopsyche					1	1
Hydropsyche					3	3
Macrostemum					10	10
Glossosomatidae						
Glossosoma			20	11	5	0
Brachycentridae						
Brachycentrus			10	10		
Helicopsychidae						
Helicopsyche					10	10
Coleoptera						
Psephenidae					9	9
Psephenus					1	1
Ectopria						
Elmidae					1	1
Gonielmis (adult)			10	10	12	12
Optioservus (adult)			1	1	17	17
Optioservus (larvae)					7	7
Stenelmis (adult)					3	3
Stenelmis (larvae)						

(continued)

Table 23. Continued.

Taxon	Lake Superior Brule River Number Caged	Live	Lake Michigan Manistee River[a] Number Caged	Live	Lake Erie Conneaut Creek Number Caged	Live
Diptera						
Tipulidae						
Tipula					10	10
Simuliidae						
Simulium			20	15		
Athericidae						
Atherix					21	20
Gastropoda						
Physidae						
Physa			10	6		
Ancylidae						
Ferrissia					10	10
Hydrobiidae						
Amnicola			5	5		
Pelecypoda						
Sphaeriidae						
Sphaerium					15	15
Tricladida						
Planariidae					1	0

[a]Organisms were caged in Bear Creek, a tributary.

The Whitefish River was treated in June 1986 just before the emergence of the nymphs. Mortality of age II nymphs held in a cage during treatment was 81%. The abundance of nymphs declined from 236/m^2 to 49/m^2 after treatment. Some of this decline resulted from emergence of nymphs between the pretreatment and posttreatment sampling. Abundance remained similar in the control area of Scott Creek, a tributary of the Whitefish River, before and after treatment, 36/m^2 and 32/m^2, respectively.

Abundance of nymphs declined 27% in the Whitefish River, from 163/m^2 in September 1985 to 119/m^2 in September 1986. The larger nymphs of the 1984 cohort which would have produced the 1986 cohort were depleted most seriously. Lower mortality of the 1985 cohort, which were smaller at the time of treatment, resulted in that year class becoming the more numerous. As a result of the 1986 TFM application and depletion of the 1986 hatch, production of nymphs may be lower in succeeding odd-numbered years.

Samples of Hexagenia were collected in a similar manner from a portion of the Indian River, a tributary of the Manistique River (Lake Michigan), which had not been treated. An estimated 1,309 nymphs/m^2 were collected--five times as many as were found before treatment in the Whitefish River. The Indian River contains better substrate for Hexagenia nymphs, so direct comparisons are not possible. It does appear, however, that Hexagenia do not reach carrying capacity in the Whitefish River in the 3 years between treatment.

A bioassay was conducted on Hexagenia (ages I and II) during treatment of the Whitefish River to better predict mortality. The 24-hour LC50 for age II nymphs was 4.1 mg/L of TFM; however, for age I nymphs, 50% of the nymphs survived at the highest concentration tested (9 mg/L). Concentrations of TFM were above the minimum lethal (5.1 mg/L) for 11 hours during treatment and averaged 6.0 mg/L during this period. The standard bioassay would have predicted less than 5% mortality of age II nymphs at this concentration in 12 hours, but mortality was 81% during treatment.

A bioassay which was more representative of stream treatment and could better predict mortality was conducted in the fall of 1986. Hexagenia nymphs were collected from the Sturgeon River (Lake Michigan) and tested in water from the Whitefish River. Lampricide was added slowly to the containers for 7 hours, maintained at desired concentrations for 12 hours, and then reduced slowly for 6 hours. The 12-hour LC50 for this bioassay was 7.6 mg/L TFM compared with 10.6 mg/L for the standard bioassay.

Index sites of invertebrate communities were established in treated and control sections of the Brule (Lake Superior), Whitefish (Lake Michigan), and Sturgeon (Lake Huron) rivers in 1985. Sites on the Boardman River (Lake Michigan) were added to this index network in 1986. Samples were collected in the spring and fall at all sites. Additional samples were collected before and after treatment in the Brule and Whitefish rivers. These samples are currently being sorted and identified.